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## Water & Sewage Systems for the Farm

George McPhee

Louis Lubinus

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# Water & Sewage

## Systems for the Farm

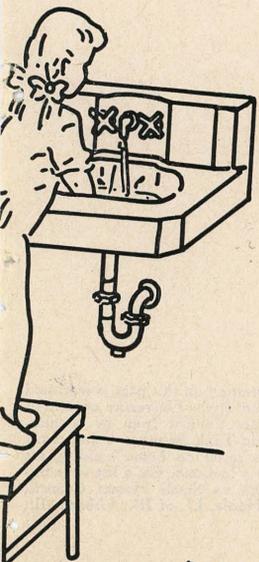
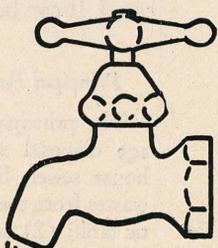
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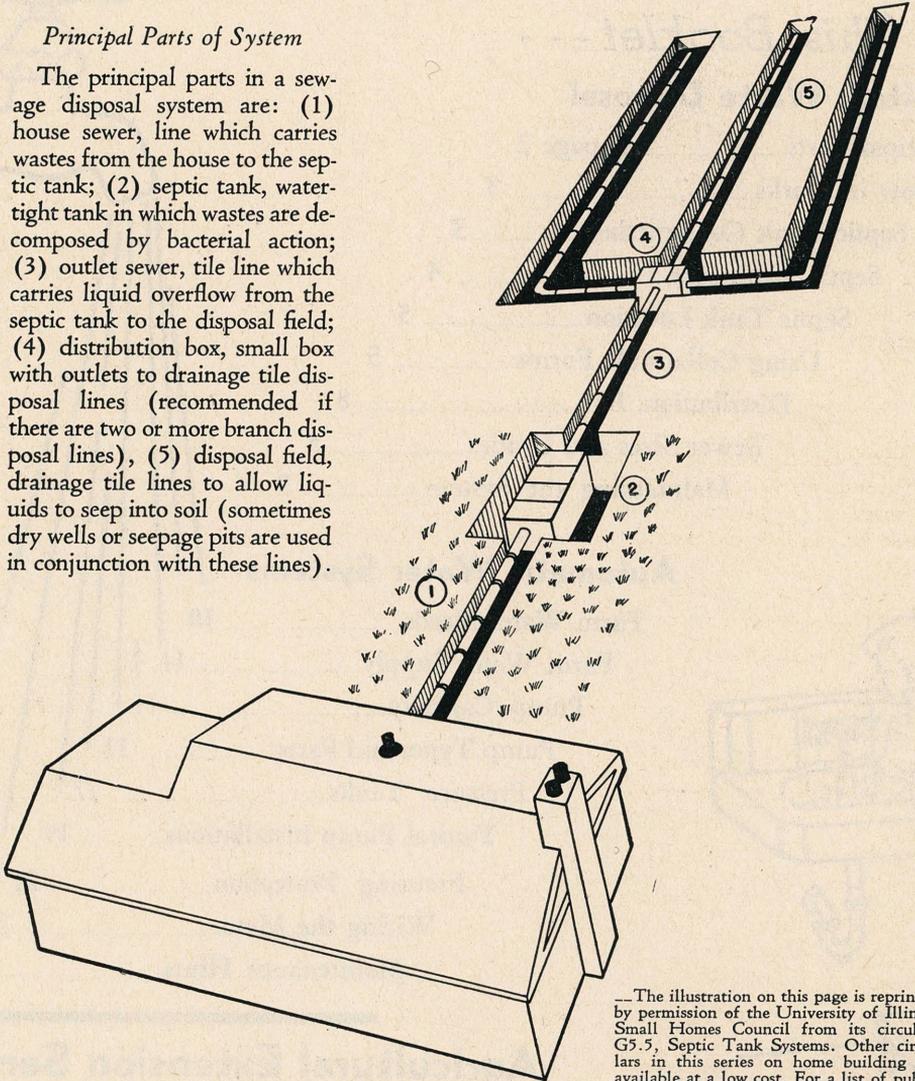
# Sanitary Waste Disposal

By GEORGE MCPHEE and LOUIS LUBINUS\*

In order to enjoy the use of running water in a modern kitchen and bathroom on the farm, a means of sanitary sewage disposal is necessary. Such a system is not complicated. It can be installed wherever a public sewer is not available.

## Principal Parts of System

The principal parts in a sewage disposal system are: (1) house sewer, line which carries wastes from the house to the septic tank; (2) septic tank, water-tight 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 disposal lines (recommended if there are two or more branch disposal lines), (5) disposal field, drainage tile lines to allow liquids to seep into soil (sometimes dry wells or seepage pits are used in conjunction with these lines).



—The illustration on this page is reprinted by permission of the University of Illinois Small Homes Council from its circular, G5.5, Septic Tank Systems. Other circulars in this series on home building are available at a low cost. For a list of publications write to Small Homes Council, Mumford House, U. of Ill., Urbana, Ill.

\*Extension REA Specialist and Agricultural Engineer, respectively.

## How the Disposal System Works

Raw sewage and wastes from the house flow into the septic tank. There 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 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 three feet below the ground sur-

face 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 mild 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, two features can be added to the system. They are: (1) a grease trap—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, (2) a separate drain and sewer line for the laundry which connects into the outlet sewer beyond the septic tank.

## Septic Tank—Construction, Size, and Location

This bulletin emphasizes a poured concrete tank using collapsible forms, but the tank may be made of metal, brick, clay tile, concrete block, or concrete silo staves. Sufficient size,

durability, and reasonable water-tightness are the important features to have. Tile, brick, concrete block, or staves should be sealed on the inside with a coat of cement mortar.

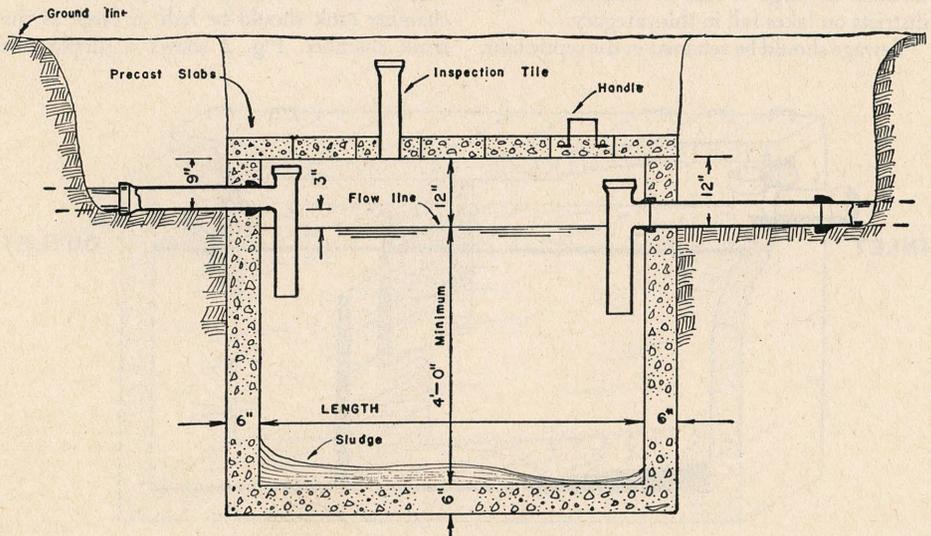


Fig. 1—Single chamber septic tank

Table 1—Septic tank information

CAPACITIES, DIMENSIONS, AND CONCRETE MATERIALS FOR SEPTIC TANKS SERVING INDIVIDUAL DWELLINGS								
Maximum number of persons served	Liquid capacity of tank in gallons	Recommended inside dimensions				Materials for concrete 1 : 2½ : 4 mix		
		Width	Length	Liquid depth	Total depth	Cement sacks	Sand cubic yds	Gravel cubic yds
4 or less	540	3'-0"	6'-0"	4'-0"	5'-0"	16	1½	2½
6	630	3'-0"	7'-0"	4'-0"	5'-0"	17	1¾	2¾
8	790	3'-6"	7'-6"	4'-0"	5'-0"	19	2	3
10	895	3'-6"	8'-6"	4'-0"	5'-0"	21	2¼	3¼
12	1150	4'-0"	8'-6"	4'-6"	5'-6"	24	2¼	3½
14	1215	4'-0"	9'-0"	4'-6"	5'-6"	25	2½	3¾

A single chamber tank is easiest to build and is satisfactory for almost all the farms in this state. However, a two chamber tank is more efficient because: (1) it holds the sewage longer allowing more complete bacterial action, (2) the tank overflow liquid is clearer which reduces danger of clogging the tile disposal field or contaminating water sources, (3) the tank will operate longer between cleanings. Wherever individual sewage disposal systems must be close together because of limited area, the two chamber tank is preferable. Installations in small towns, out-lying districts of large towns, or summer cottage districts on lakes fall in this category.

Sewage should be retained in the septic tank

from 48 to 72 hours to allow sufficient time for the solids to decompose. For this reason the tank should have ample capacity. The smallest single chamber tank recommended is 6 feet long, 5 feet deep and 3 feet wide, inside dimensions. This size gives a liquid capacity of about 540 gallons and is suitable for a family of four or five. See Fig. 1. Table 1 gives the recommended dimensions for single chamber tanks (or the main chamber of two chamber tanks) in relation to the size of the family. This table also shows approximate amount of materials needed for single chamber tanks of various sizes. The second chamber of a two chamber tank should be half as large as the main chamber. Fig. 2 shows a simple two

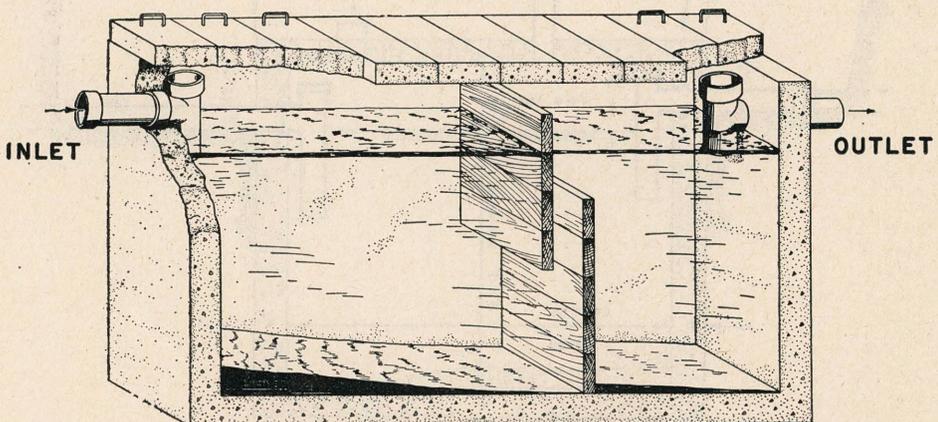


Fig. 2—Double chamber septic tank

chamber tank, it is similar to the corresponding single chamber tank except that it is longer and has a wooden partition to separate the chambers. South Dakota Extension Circular 307 describes a two chamber tank of another design.

The most suitable site for the disposal field governs the location of the septic tank. This is an individual problem of each farm, the principal considerations are: the lay of the ground, location of the well, type of soil and vegeta-

tion. Gentle unshaded slopes away from the house and water source and free of trees or shrubs are best. If the ground is level it is well to locate the tank close to the house to get the necessary minimum grades in both the house sewer and outlet sewer without going too deep. About 15 feet from the house is a good practical distance for the tank. It should be approximately 75 feet from the well. With ideal conditions a minimum distance of 50 feet is allowable.

### How To Use Collapsible Septic Tank Forms

The selected site is leveled and an excavation frame laid out. Fig. 3 shows an excavation frame in place. The frame serves as a guide for digging and protects the sides from caving.

The inside dimensions of the frame should equal the outside dimensions of the tank. The walls of the hole should be dug straight and smooth because they serve as the outside

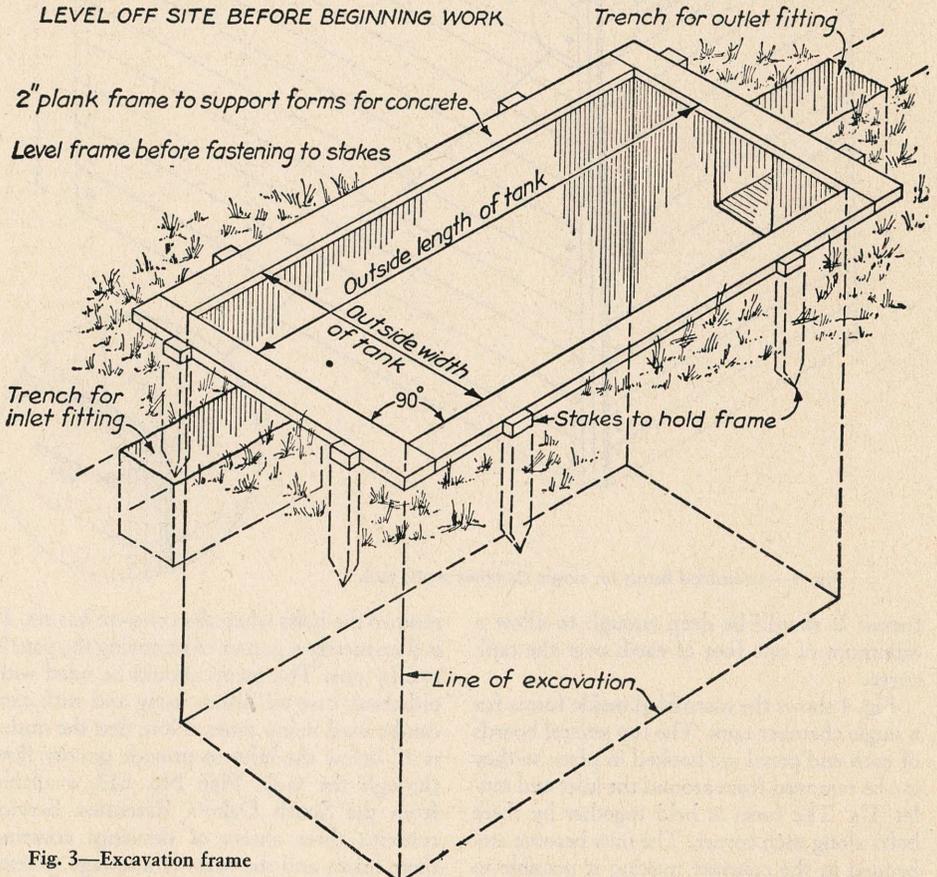


Fig. 3—Excavation frame

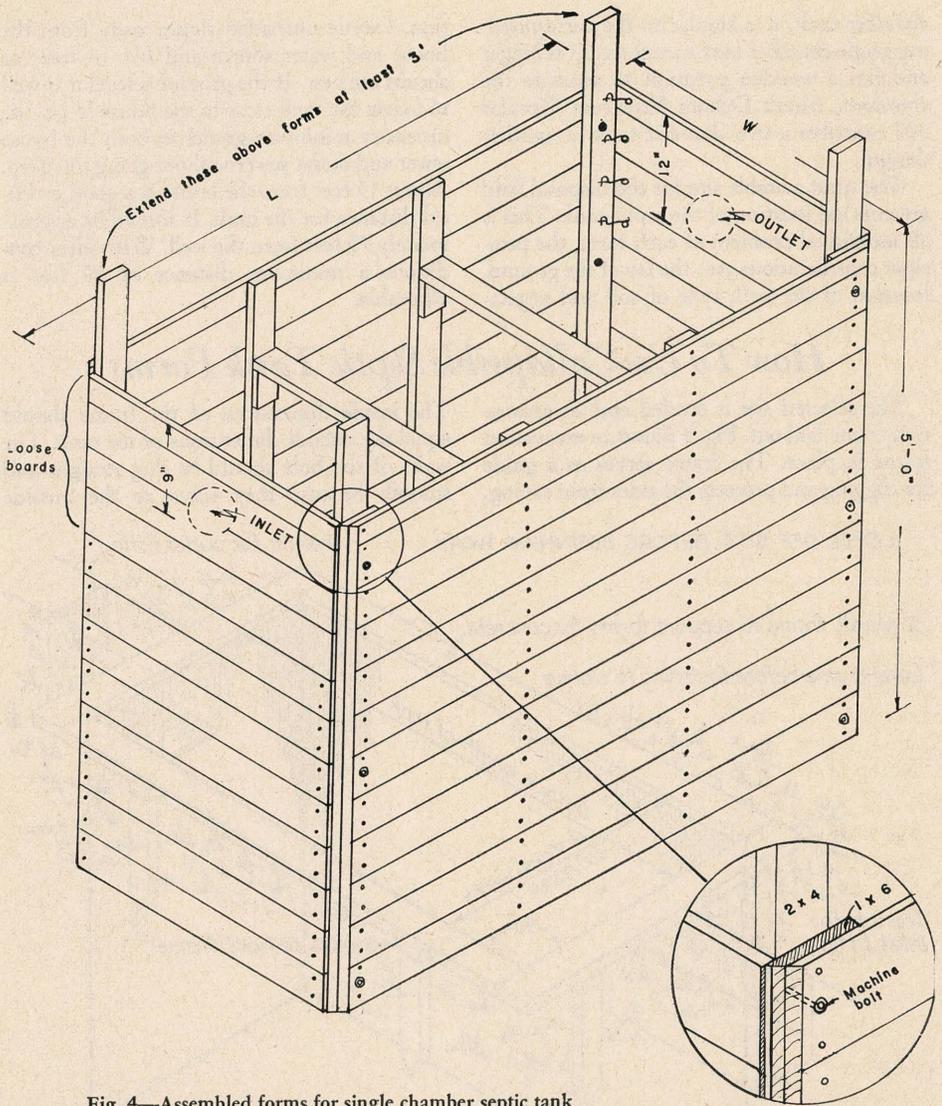


Fig. 4—Assembled forms for single chamber septic tank

forms. It should be deep enough to allow a minimum of one foot of earth over the tank cover.

Fig. 4 shows the assembled inside forms for a single chamber tank. The top several boards of each end panel are hooked in place so they can be removed from around the inlet and outlet T's. The form is held together by three bolts along each corner. The nuts become embedded in the concrete making it possible to

remove the bolts when the concrete has set. It is then merely a matter of removing the panels one by one. The forms should be oiled with old crank case oil before using and with care can be used many times. Note that the outlet is 2" below the inlet to provide gravity flow through the tank. Plan No. 613, available from the South Dakota Extension Service contains three sheets of drawings covering these forms and the parts of a sewage system.

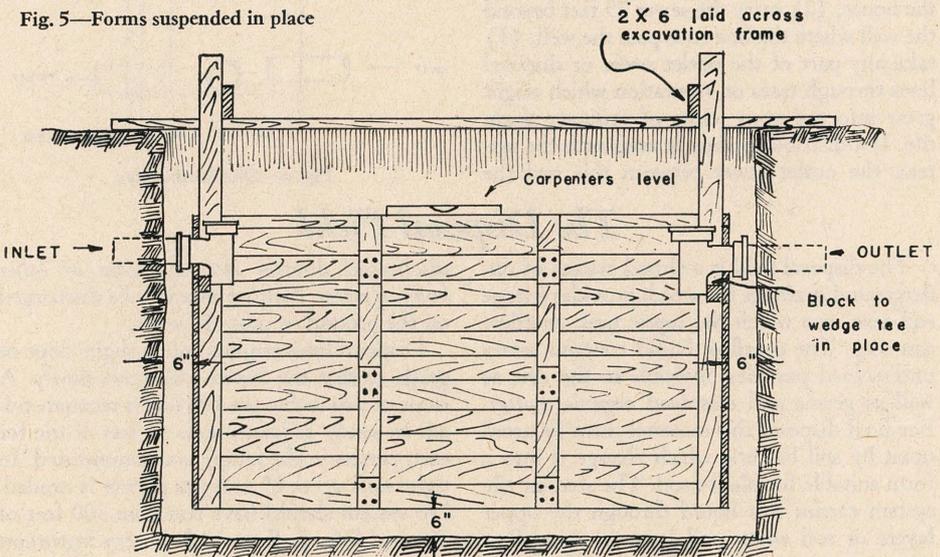
Collapsible forms for a two chamber tank can be made similar to those in fig. 4. They should be  $1\frac{1}{2}$  times as long however in order to provide a second chamber one-half as large as the main chamber. Wood strips of 1" x 2" material nailed to the outside of the forms provide slots in the finished concrete wall in which to put 2" wooden partition members to separate the two chambers. See fig. 2 to determine approximate location for nailing strips to forms.

The inside forms are suspended from the excavation frame as shown in fig. 5 and leveled. When properly centered in the excavation there will be approximately 6" between the form sides and the walls and bottom of the excavation. Cast iron or tile T's are wedged in place in the inlet and outlet holes. The T's are recommended because they permit the flow of waste without disturbing the surface scum. If T's are not available lengths of regular tile can be used for the inlet and outlet, and wooden baffles can be installed across each end of the tank to protect the surface scum. Holding slots for the baffles are provided in the finished concrete walls by nailing wooden strips to the outside of the forms in the proper location. The top of the baffle should be even with the

top of the opening it serves and should extend downward about 20 inches. Elbows can also be substituted for T's but a hole should be made in the bend so that the elbow is vented to the space above the scum.

The proper way to install a concrete tank is in one operation to eliminate leaky joints. A 1:2 $\frac{1}{4}$ :3 mix is recommended with just enough water to make it workable. To secure dense watertight concrete spade it along the form sides. A good procedure is to place about 18 inches of the wall first. Then place and level the floor making sure that the forms do not become imbedded in it. This gives the 18 inches of concrete in the walls time to take a slight set and enables it to better resist the pressure from the concrete above which is placed in the walls at this point. The cover slabs can be precast or made at this time in simple forms made of 2" x 4"s on the edge. Each slab 12" wide, 3 $\frac{1}{2}$ " thick and as long as the outside width of the tank. To give strength each slab should have two three-eighth inch round reinforcing rods placed near the bottom of the slab. Convenient handles can be made by bending short pieces of rod into semi-circles and sticking the ends in the slabs. An inspection pipe can be provided by

Fig. 5—Forms suspended in place



setting the smooth end of a bell joint tile in one slab. A removable wooden plug can be made for the bell joint end. The collapsible forms can be removed safely about 48 hours

after the concrete is placed. Both the cover slabs and the tank should cure slowly; it is well to keep them moist for a week after the forms are removed to prevent rapid drying out.

## 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; four inch is the minimum. The proper grade or slope is 1" 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 four inch drop in the first 8 or 10 feet is recommended to help the overflow liquid clear the tank outlet rapidly.

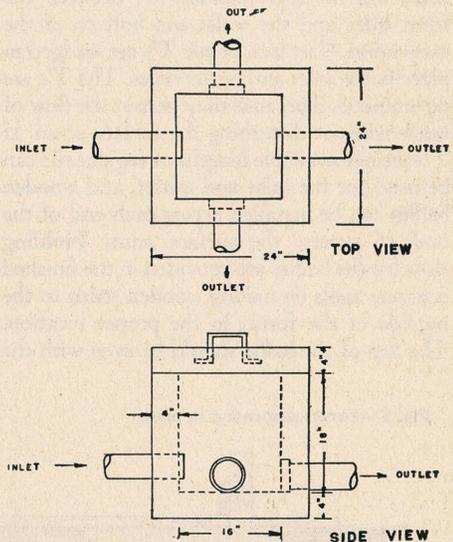


Fig. 6—Distribution box

## 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 two 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 the joints all 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 six inch layer of gravel or cinders under the tile is recommended. See fig. 7. The tile is laid with a  $\frac{1}{8}$  to  $\frac{1}{4}$  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 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 a tile line. A dry well has open con-

struction with unmortared blocks or masonry units and no floor. Seepage pits should only be located where they will not contaminate water sources.

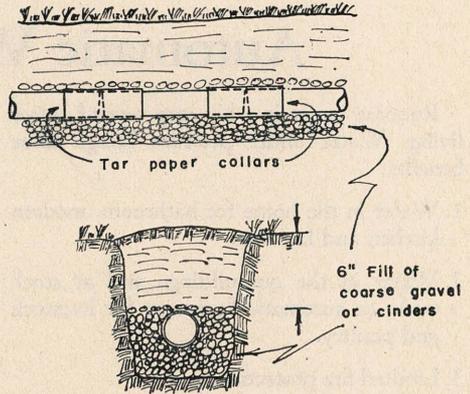


Fig. 7—Placing drain tile in disposal field (24 to 36 inches deep)

## 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 that 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 for severe winter conditions.

# Automatic Water Systems

Running water is a big step toward better living. Water under pressure brings these benefits:

1. Water in the home for bathroom, modern kitchen and laundry.
2. Water in the outbuildings and at stock tanks or automatic fountains for livestock and poultry.
3. Limited fire protection.

4. Water for special purposes such as sprinkling the lawn and shrubs, watering the garden and washing machinery or cars.

Rural electrification is expanding rapidly in this state and the future for electric power development is promising. On most farms the water supply for pressure systems will be pumped with electricity. For these reasons, this bulletin is devoted to electric water systems.

## Daily Water Needs of Farm

Abundant water wherever needed should be the goal in planning a farm water system. The amount of water needed each day depends on the number and kinds of livestock, the size of the family, and the various additional ways in which use of water is planned. Table I is a guide to help you estimate the daily needs on your farm. Using this estimate as the basis, it is possible to determine whether the water

source will supply enough water and to select a pump with the proper capacity.

*Do not underestimate!* A common mistake is to select a pump that is too small. An ordinary faucet turned on fully will deliver water at a rate of 300 gallons per hour. When running water is always available merely at the turn of a faucet the ordinary family will use much more water than before.

TABLE I. Daily Water Requirements on the Farm

Gallons Per Day		Example of Water Used Daily	
Each member of family .....	50		
Each horse .....	12		
Each milk cow .....	25		
Each beef cow .....	12	5 persons at 50 gallons .....	250
Each hog .....	4	10 milk cows at 25 gallons .....	250
Each sheep .....	2	40 hogs at 4 gallons .....	160
Each 100 chickens .....	4	2 horses at 12 gallons .....	24
Each 100 turkeys .....	7	200 chickens .....	8
	Gallons Per Hour	Total daily requirement for farm..	692 gallons
1/2 inch hose with nozzle .....	200		
3/4 inch hose with nozzle .....	275—300		
Lawn sprinkler .....	200		

## Farm Water Supply

An electric water system cannot fulfill its purpose completely unless there is a pure, dependable and adequate supply of water for all farm purposes. The water should be suitable for drinking and household use. The source should provide an ample supply to meet the daily estimated needs. If there is doubt about the dependability of a well it can be checked by a continuous period of pumping and the output measured; if the source is a spring, by measuring the flow.

Wells, whether they are dug, drilled, driven, or bored, should be on a high, well drained location. They should be curbed and covered to prevent entrance of surface drainage water. If a spring is used as the water source, it should be protected from surface drainage in the same way. As a general rule, all wells should be 100 feet away from contaminating sources such as cesspools, privies, manure piles, or tile sewage disposal fields. There is less danger of contamination if the well is deep or the soil tight.

More complete information on a safe reliable water supply is contained in Farmers' Bulletin No. 1978 "Safe Water for the Farm." This is available from the Government Printing Office, Washington 25, D. C., for 15 cents.

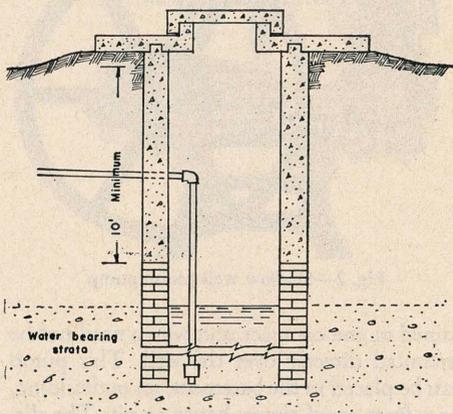


Fig. 1—Properly-curbed dug well

## Pump Capacity

The output or flow of the well or other water source establishes the rate at which water can be pumped. *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 preceding example, the daily needs were 692 gallons; this figure divided by two is 346 gallons. If the water source is adequate, a pump with a capacity of 350 gallons per hour would be the practical selection.

In this state there are some deep drilled artesian wells which are cased with small pipes. The frequent result is that it is impos-

sible to install a pump cylinder or jet assembly that will pump water at the desired capacity. If the well is inadequate in any way, the problem should be solved in the manner most practical under the circumstances. You can (1) improve the well, (2) put down a new one, or (3) select a pump that can be installed or is of a capacity equal to the well's output and provide a large pressure storage tank or gravity tank to carry the farm over those daily periods when the demand for water is greatest. In small cased deep wells there is some choice in the selection of equipment. This is covered later.

## Pump Units, Types and Parts

Pumps are divided into two general classes: (1) shallow well pumps and (2) deep well pumps. They are further classified into types according to mechanical design. The two most popular types of electric water systems are (1) centrifugal pumps and (2) piston

pumps, both of which are made for either shallow well or deep well operation.

*Shallow well pumps*, as the name implies, are for shallow wells where, as a general rule, the suction-lift does not exceed 22 feet at sea level. The electric motor and pump are con-

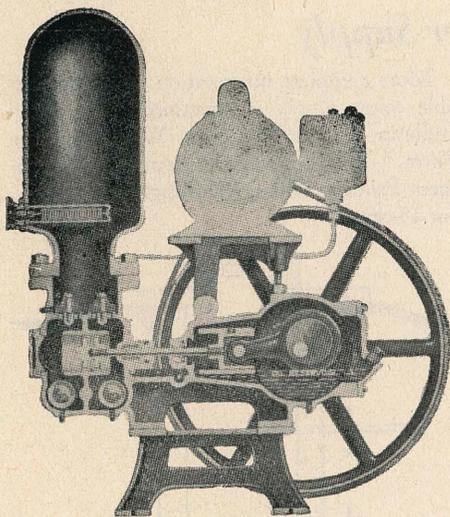


Fig. 2—Shallow well piston pump

tained in one compact unit which need not be mounted directly over the well. This pump can be placed in the basement, an outbuilding, or a frost-proof pump house or pit. The distance it can be located from the well is governed by the depth of the water level and the friction loss in the pipe leading from the pump to the well. *Suction lift is the vertical distance from the pump to the water level plus the friction loss of the suction pipe.* The water level to consider is the "draw down" level or the level maintained in the well when it is pumped at the desired rate. The figure of 22 feet for

maximum practical suction lift is an arbitrary one since the 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 where the suction lift exceeds 22 feet and for some types of pumps 22 feet is too great.

*Deep well pumps* are for use where the suction lift exceeds 22 feet. A part of the pumping mechanism—piston cylinder, jet assembly or turbine impeller—must be located within 22 feet of the water level. In a practical installation, it usually is immersed in the water. Piston, helical, and turbine type pumps are set directly over the well. Jet type pumps need not be directly over the well.

### Piston Pumps

*Piston pumps* are made as single acting or double acting pumps, having a piston which moves back and forth in a cylinder. In operation, the single acting pump piston fills the cylinder with water on the suction stroke and displaces it on the next into the discharge pipe. Thus a single acting pump delivers water once in every two strokes. The double acting pump has valves arranged so the piston in a single stroke displaces water ahead of it while a new quantity from the well fills the cylinder behind it. The pump delivers water on each stroke; its capacity depends on the size of the cylinder and the number of strokes per minute.

*The shallow well model* (See fig. 2) is a double acting pump with the motor and pump in one compact unit and a suction pipe set down in the water. It need not be placed directly over the well.

*The deep well model* (See fig. 3) has the pump working head and motor located as a unit directly over the well. The pump cylinder containing the piston and valves is located in the well below water level and connected to the pump by means of a long connecting rod inside the

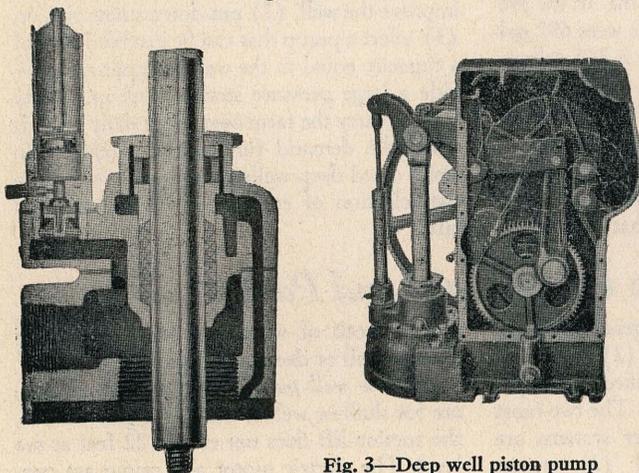


Fig. 3—Deep well piston pump

drop pipe. The single acting cylinder usually is used although the double acting cylinder also is made.

There also are closed top and open top cylinders. The open top cylinder is preferred for power pumps because the piston and valves can be pulled up through the drop pipe for repairs whereas with the closed top cylinder the entire assembly, including the drop pipe must be pulled up.

In some pipe-cased artesian wells the casing is too small to admit a regular open or closed top cylinder in a size large enough to deliver the quantity of water required. A tubular well cylinder is made for such an installation; it has a rubber expander which seals the cylinder against the well casing and the casing acts as the drop pipe. (See Figure 4c.)

The most desirable characteristic of the piston pump is that it delivers a constant capacity at all discharge pressures. Discharge pressure is limited only by the power of the motor and the pump construction. The deep well model will work at great depths as well as moderate depths.

### Centrifugal Pumps

Electrically powered units have the following general characteristics. The pump unit is compact with a high speed electric motor (usually 3450 rpm) direct-connected to the impeller, the only moving part. The impeller is made up of a hub and curved blades revolving in a close fitting housing. Principal impeller designs, (fig. 5) are: (a) open type, (b) semi-open, or, (c) enclosed.

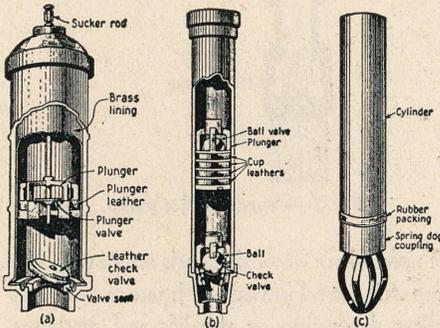


Fig. 4—(a) Closed type cylinder, commonly used on hand pumps. (b) Open type cylinder, popular in many sections on power pumps. (c) Tubular well cylinder.

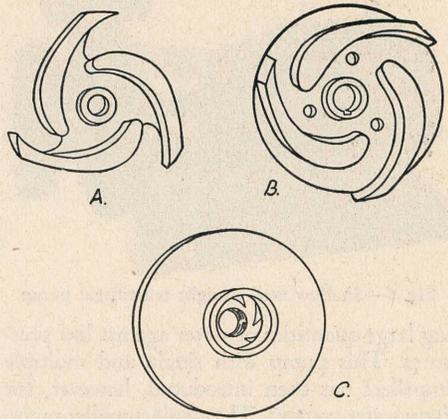


Fig. 5—Principal impeller designs. (a) open type. (b) semi-open. (c) enclosed.

type usually is used with water system pumps. The other types are used with pumps for stiff liquids such as oil or liquids containing screened solids such as muddy water or wastes and sewage.

Water enters the impeller at the hub or center and is whirled out at the ends of the blades into a circular channel or passage around the outer edge of the impeller. Movement of water away from the center or hub reduces pressure there and creates suction. The discharge pressure depends on the diameter and operating speed of the impeller. The capacity depends on the size of the water passages through the impeller and its speed.

Pump capacity decreases rapidly as the suction lift or the discharge pressure is increased even between the normal "cut in" and "cut out" pressures of farm water systems. (20 to 40 lbs. per square inch.) Manufacturers normally rate centrifugal pumps for minimum suction lifts and discharge pressures. Therefore, to get the desired operating capacity, care must be exercised in selecting a pump suited for the average pumping conditions to be met. Shallow well pumps of this type should be located as close to the well and water level as is practical to reduce suction lift. The turbine pump is a variation of this type and has special characteristics covered later.

Straight Centrifugal Pumps, single stage (one impeller), normally are used for pump-

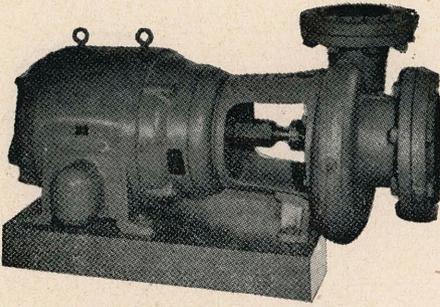


Fig. 6—Shallow well straight centrifugal pump

ing large quantities of water against low pressures. This pump with single and multiple impellers has been introduced, however, for farm water systems. The single impeller pump loses capacity rapidly as the discharge pressure increases toward the normal upper operating limits of water systems (30 to 40 lbs. per square inch). In multiple impeller pumps, each impeller boosts the water pressure in turn and helps maintain the pump's capacity against higher discharge pressures. The multiple impeller pump does not lose capacity as rapidly as the single impeller pump when pumping against normal water system pressures. It is for use on farms where water demands are heavy. This is strictly a shallow well pump for suction lifts up to about 15 feet. It will handle water containing silt and sand but these materials will shorten its life.

The *Centrifugal-Jet Pump* is essentially a straight centrifugal pump with an ejector or jet added as an auxiliary unit. The jet modifies the normal operation of a centrifugal pump so as to make it more suitable for water system service. The effect of the jet is to more nearly stabilize the capacity of a centrifugal pump throughout normal pressure range of farm water systems (20 to 40 lbs. per sq. inch) by decreasing the pump's normally-large low pressure capacity and extending the pressure range in which it will deliver water. The jet also increases suction lift to a practical limit of about 20 feet.

This type pump is made in both shallow well and deep well models. The shallow well model usually has a single impeller with the jet connected immediately beneath or built into the impeller housing. Shallow well models with more than one impeller (multistage)

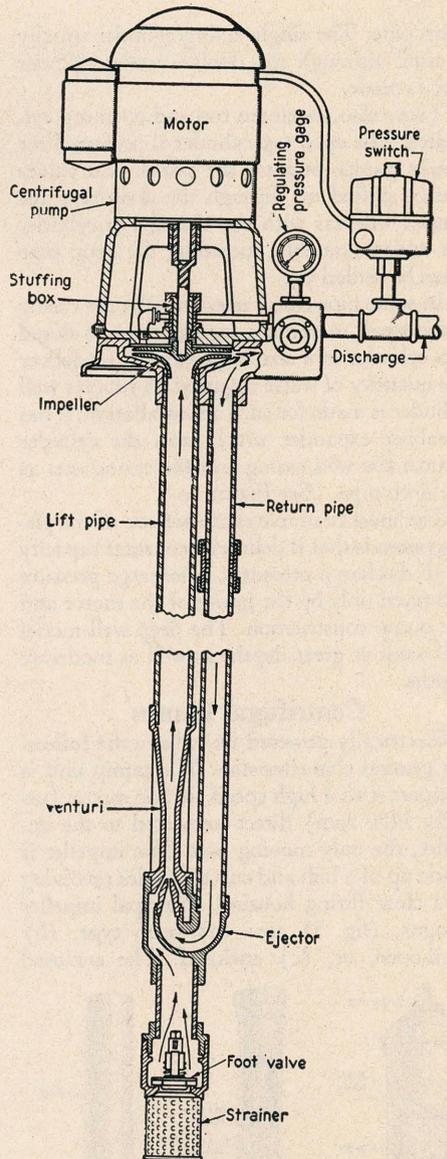


Fig. 7—Centrifugal jet pump

are used where water demands are heavy. The deep well model is made with one or more impellers depending on the lift and discharge pressure conditions to be met. It is most suitable for wells from 22 to 85 feet deep. Fair efficiency can be gotten for depths over 85 and

up to 120 feet, but above that efficiency drops rapidly.

In operation, some of the water discharged by the impeller is diverted to the jet under high pressure through a return pipe. This water is converted into a high velocity stream by the jet nozzle creating a partial vacuum and therefore suction around the nozzle. (See fig. 8.) Water from the well is drawn into this space and is caught up by the fast-moving stream and carried into the expanded end of the venturi tube; in moving through the expanding venturi tube the water mixes and velocity is converted back to pressure which boosts the water up the pipe to the impeller. Here some of the water taken from the well is delivered to the pressure tank and the balance recirculated to the jet nozzle. Most manufacturers have 2 or 3 different ejectors to use with any one deep well pump size. These jets are

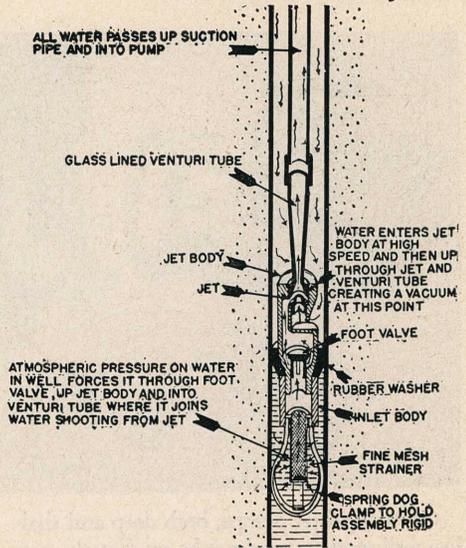


Fig. 9—Single pipe jet

designed for low lift, medium lift, and high lift and are used with different well depths. The low lift jet is most efficient; about 1.3 gallons of water circulates in the jet cycle for each gallon taken from the well while the high lift circulates about 2.5 gallons for each gallon taken from the well. There are also 2-pipe and single-pipe jets. (See figs. 9 and 10.) The 2-pipe is best where well size will permit. The single pipe is used for small cased wells of 2", 2 1/2", 3", or 4".

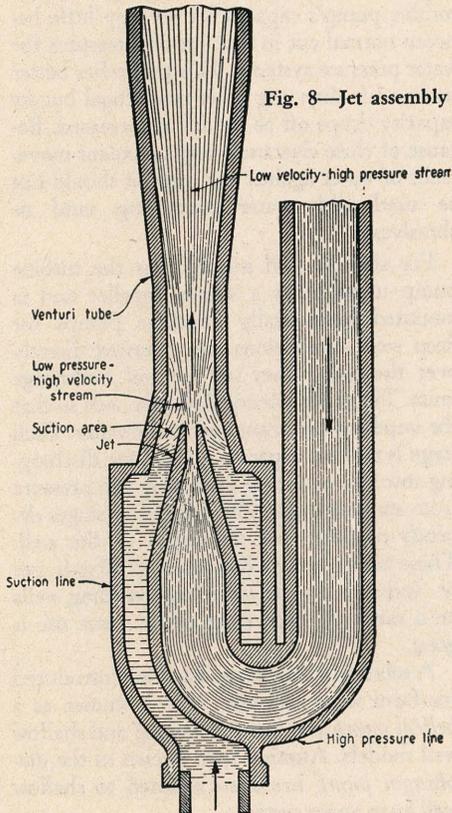


Fig. 8—Jet assembly

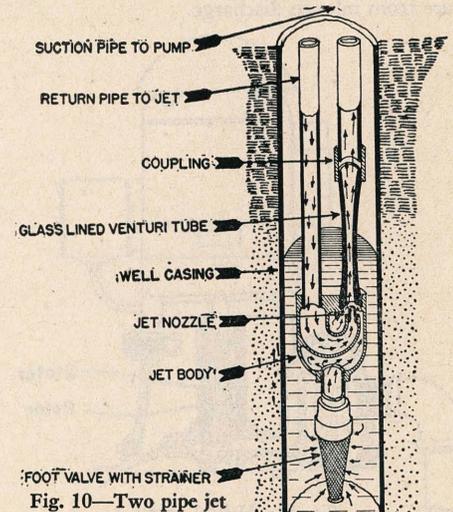


Fig. 10—Two pipe jet

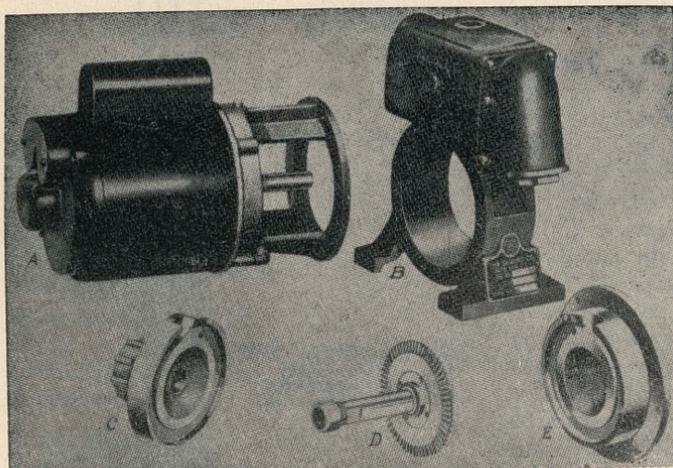


Fig. 11—Shallow well turbine pump. (a) electric motor. (b) end bearing and ring liner. (d) impeller. (e) outboard end and ring liner.

Centrifugal jet pumps, both deep and shallow well models, need not be set directly over the well. They are quiet in operating, non pulsating, and can be used with relatively small wells.

*Turbine type centrifugal pumps* have an impeller of special design. It is a disc with vanes on the rim which move in a channel formed by a close fitting housing. Rotation of the impeller forces the water to move with the vanes in the channel from the inlet point to discharge point. Both of these points are at the rim of the impeller. Constant recirculation of the water past the vanes increases its pressure from inlet to discharge.

Electric units usually have a medium speed (1750 rpm) motor direct-connected to the impeller. Unlike other centrifugal pumps, the turbine pump's capacity varies very little between normal cut in and cut off pressures for water pressure systems. This pump has better suction lift than any other centrifugal but its capacity drops off as the lift is increased. Because of close clearances and turbulent movement of water against the vanes it should not be used with water containing sand or abrasives.

For shallow well installations the turbine pump usually has a single impeller and is mounted horizontally. Turbine pumps for deep well installations are mounted directly over the well. They are vertical multistage units. The shaft extends down the well so that the impellers are immersed in the water. Each stage is really a separate pump, one discharging into the next and increasing the pressure from stage to stage. The number of stages depends primarily on the depth of the well. These are high capacity pumps (900 gals. per hr. and up) for use with large yielding wells on a ranch or large farm where water use is great.

A relatively new pump has been introduced for farm water systems. This is known as a *helical pump* and is made in deep and shallow well models. Another type known as the *diaphragm pump* has been adapted to shallow well farm water systems.

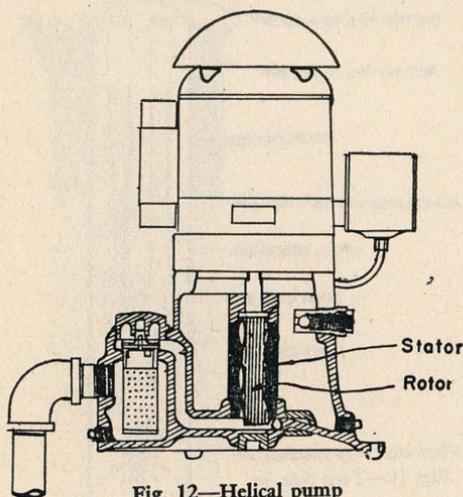


Fig. 12—Helical pump

The *helical pump* combines the characteristics of the centrifugal and piston pumps. The pumping element is composed of a stator and a rotor, both of which have a helical or spiral shape. The stator is of general cylindrical shape with a double worm-like thread on the inside. The rotor fits inside the stator and has a corresponding single thread. In action, it rolls 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 is designed to pump large capacities from small diameter wells, it

will pump from great depths or against high discharge pressures. The deep well installation is similar to a turbine pump installation. The shallow well model need not be placed over the well.

The *diaphragm pump* has two diaphragms instead of a piston. It gives positive displacement and has the same characteristics as a piston pump. It is now being made for shallow well farm water systems. This pump will handle water containing sediment better than any other type.

## Pressure Tank and Accessories

The *pressure switch* controls the electric motor. For farm water systems the pump is cut-in normally when the pressure drops to 20 lbs. per square inch and is shut off when a pressure of 40 lbs. per square inch is reached. Pressure switch settings should not be changed without consulting the pump manufacturer's representative or your dealer.

The *pressure tank* performs two functions; it provides water storage so that the pump does not have to operate each time a faucet is opened momentarily. This prevents much "start and stop" wear on the motor. The tank also provides the air pressure cushion for the entire water system. The tank is two-thirds filled with water and one-third with air at a pressure of 40 lbs. per square inch. Approximately one-fifth of the total capacity of the tank can be used before the pressure drops to 20 lbs. per square inch. A 42 gallon tank is the standard size for farm water systems. This size provides an active water supply of approximately eight gallons. Larger tanks sometimes are needed where water demands are heavy or where additional storage is needed because the hourly output of the well is insufficient.

The *air volume control* is a device mounted on the tank to maintain the proper amount of compressed air in the tank. The air gradually is absorbed by the water making it necessary to replenish the air constantly. Otherwise the tank becomes water logged. There are three common types of air volume control.

Deep well piston pumps have a small plunger type air pump which supplies air to the

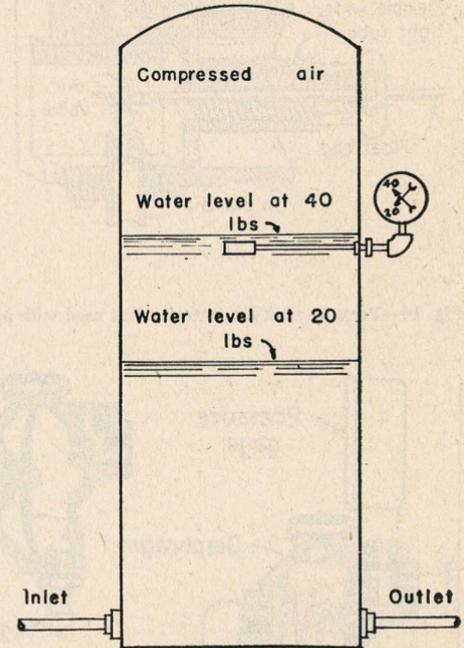


Fig. 13—42-gallon pressure tank

water entering the tank when the pump operates. A float-controlled air escape valve allows air to escape when there is too much. (See b, fig. 14.)

Shallow well piston pumps usually have a float-controlled air valve connected to the suction side of the pump by a small copper tube. When the air supply gets low the water level rises in the tank and the float opens the air

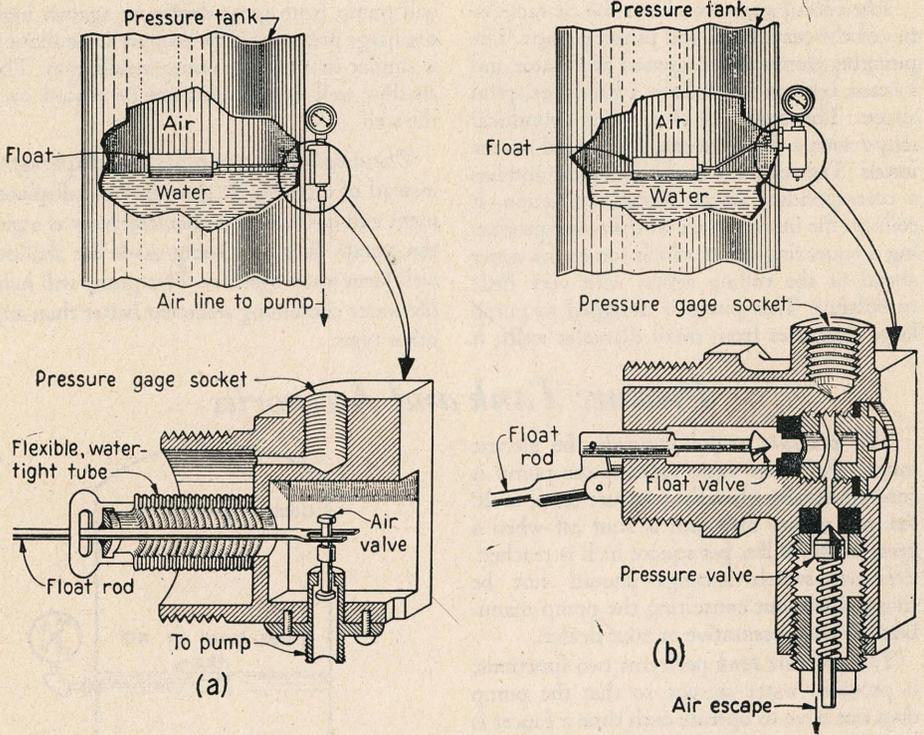


Fig. 14—Pressure tank air control valves used with piston pumps. (a) shallow well type. (b) deep well type.

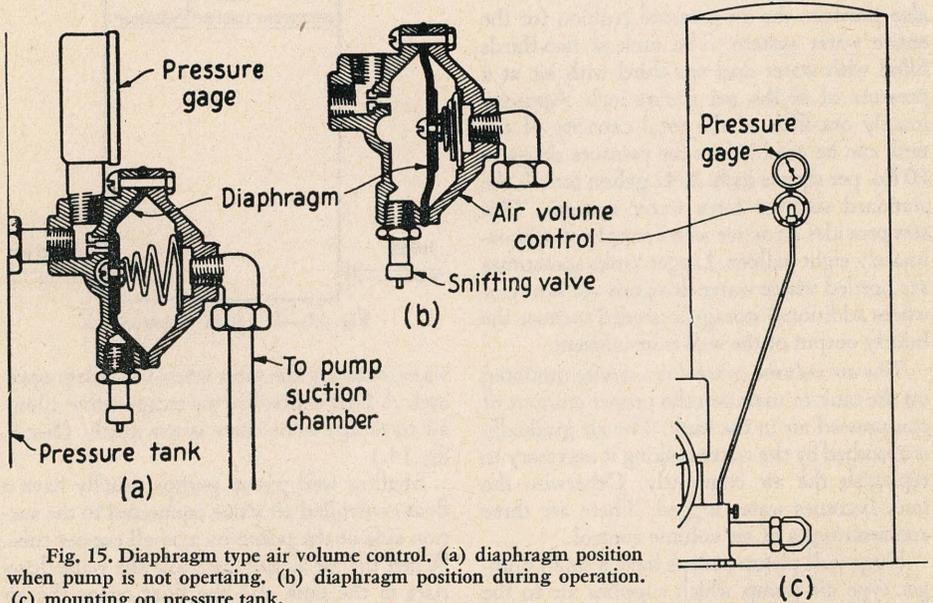


Fig. 15. Diaphragm type air volume control. (a) diaphragm position when pump is not operating. (b) diaphragm position during operation. (c) mounting on pressure tank.

valve on the end of the copper tube outside the tank. This allows the pump to suck in air until the proper water level is established in the tank. (See a, fig. 14.)

Centrifugal and centrifugal-jet pumps usually have a small diaphragm air pump connected to the pump suction by a copper tube.

Each time the pump starts, the suction displaces the diaphragm and it takes in a small charge of air. If air is needed in the tank a float-controlled valve allows this charge of air to escape into the tank when the pump stops releasing the diaphragm to normal position. Fig. 15 shows this type.

## Typical Pump Installations

The following examples show some of the more common pump installations. The location and the depth of the well determine to a large extent the most suitable arrangement to use. Shallow well pumps need not be placed directly over the well. This is also true of deep well centrifugal-jet pumps. Often the well is close enough to the house to have the pump and pressure tank in the basement where they are readily accessible and safe from freezing. If the well is located near another building the equipment can be located there in an insulated room. Either way is desirable if it eliminates a pump house or pump pit. Deep well piston

pumps, helical pumps, and turbine pumps must be placed directly over the well. If the well is deep enough to require one of these pumps a frost proof pit or pump house is necessary.

Friction losses in suction lines and in discharge lines are important considerations in planning an installation. See Table II for friction loss data. Wherever there is a horizontal run of suction pipe from the well to the pump the pipe should slope gradually up toward the pump to prevent an air trap. (See figs. 16-19.)

TABLE II. Pipe Friction per 100 Feet of Ordinary Iron Pipe Expressed as Feet of Head and as Pounds Pressure for Various Rates of Flow

Flow, gallons per minute	½ inch		¾ inch		Size of pipe							
	ft.	lbs.	ft.	lbs.	1 inch		1¼ inch		1½ inch		2 inch	
					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 of water head. 1 foot water head = .43 pounds pressure. An elevated gravity tank 92.4 feet high would supply the same pressure at an outlet as a pressure tank when the pressure is at 40 pounds per square inch.

## Typical Installations

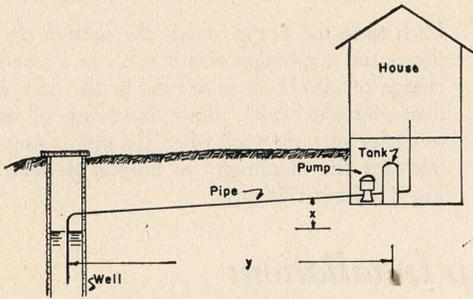


Fig. 16. Shallow well installation; Pump and tank in basement. Vertical lift in X, plus friction loss in Y feet of suction pipe should not exceed 22 feet.



Fig. 17. Shallow well installation—(Pump in pit over well with tank in basement.) This installation can be used where the well is lower than the house and it is necessary to have the pump at the well in order not to exceed its suction lift. The pump operates at higher pressure than the pressure gauge at the tank reads. This extra pressure is due to the vertical distance Z from the pump to the tank plus the friction loss in Y feet of discharge pipe between the pump and tank.

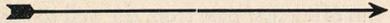
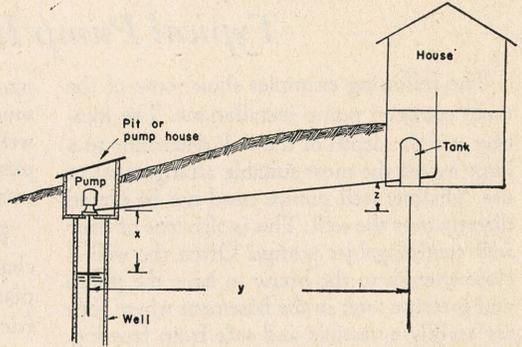


Fig. 18. Deep well installation—centrifugal-jet pump (pump and tank in basement). In this installation a small pit is necessary at the well for installing the jet body. The size of the suction and the pressure return pipes should be checked carefully to eliminate excessive friction loss when the pump is installed away from the well.

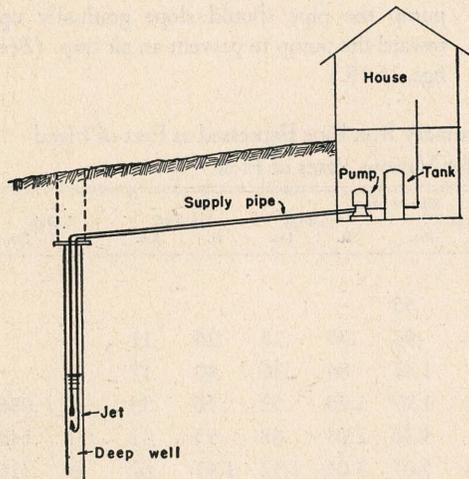
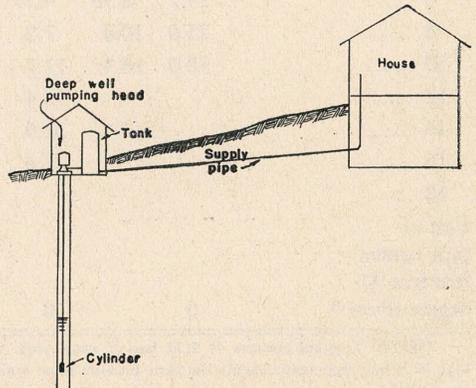


Fig. 19. Deep well installation—piston pump. (Pump and Tank in pump house over well.) If the well is located near the house, the tank is sometimes located in the basement. Wherever a piston pump and the pressure tank are separated by a long discharge pipe, it is advisable to put in a check valve and air chamber to reduce the pulsations from the pump.



## Freezing Protection

In South Dakota, six feet is the minimum depth for water system pipes to prevent freezing. It is a good idea to find out the experience of the nearest city water system. The pump and pressure tank also must be protected from freezing. When the pump can be located away from the well, the house basement or an insulated room in an outbuilding can give this protection. However, it frequently is necessary to build a pump house.

Above ground installation of the pump and pressure tank unit is preferable because (1) ventilation and drainage is easier, making it clean and sanitary, and (2) the equipment is readily accessible for maintenance and repairs. For these reasons, plus the fact that there is less danger of damage from flash floods, the above ground pump house is more desirable than a pump pit.

Figures 20 and 21 illustrate two types of pump houses. The walls and ceiling should be constructed of 2" x 6" framing.

sheathing material and siding can be used. A vapor-proof paper must be installed between the inside sheathing and the studding. Fill the space between the studding and ceiling members with commercial fill insulation.

The insulated pump house need not be very large. Check the size of the assembled pump and pressure tank before starting to build the pump house. A pump house five feet square will fit most pressure systems up to a 66 gallon tank size. Five and one-half feet square will serve for tank size up to 120 gallons. The height will be governed by the height of the tank.

The cost of heating in extremely cold weather is very low when 5½ inches of insulation is used in the walls and ceiling. During the daytime, when water is being used, there usually is very little need for supplementary heat. However, it is wise to install 250 to 500 watts of heat, controlled by a good heating type thermostat. The thermostat should have

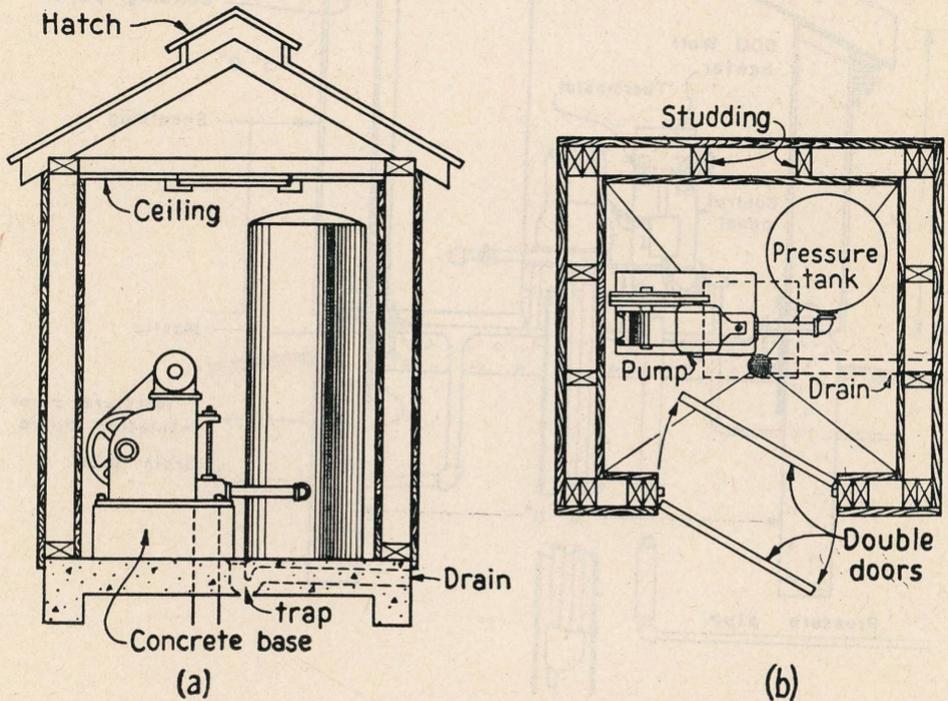


Fig. 20—(a) Insulated type pump house. (b) floor plan.

a range down to about 20° F. These are available from most heating or refrigeration equipment dealers. Set the thermostat to turn on the heating elements at about 34° F.

A complete farm water system almost always calls for a hydrant in the yard or in unheated shed where it is a problem to keep the

riser pipe from freezing. Fig. 22 illustrates a frost-proof yard hydrant which has the shut off valve and a drain below frost level. Riser pipes in cold locations can be kept from freezing by wrapping with electric heating cable or a new product, pipe-warming electric tape. Also available are electrically heated automatic drinking fountains for outdoor use.

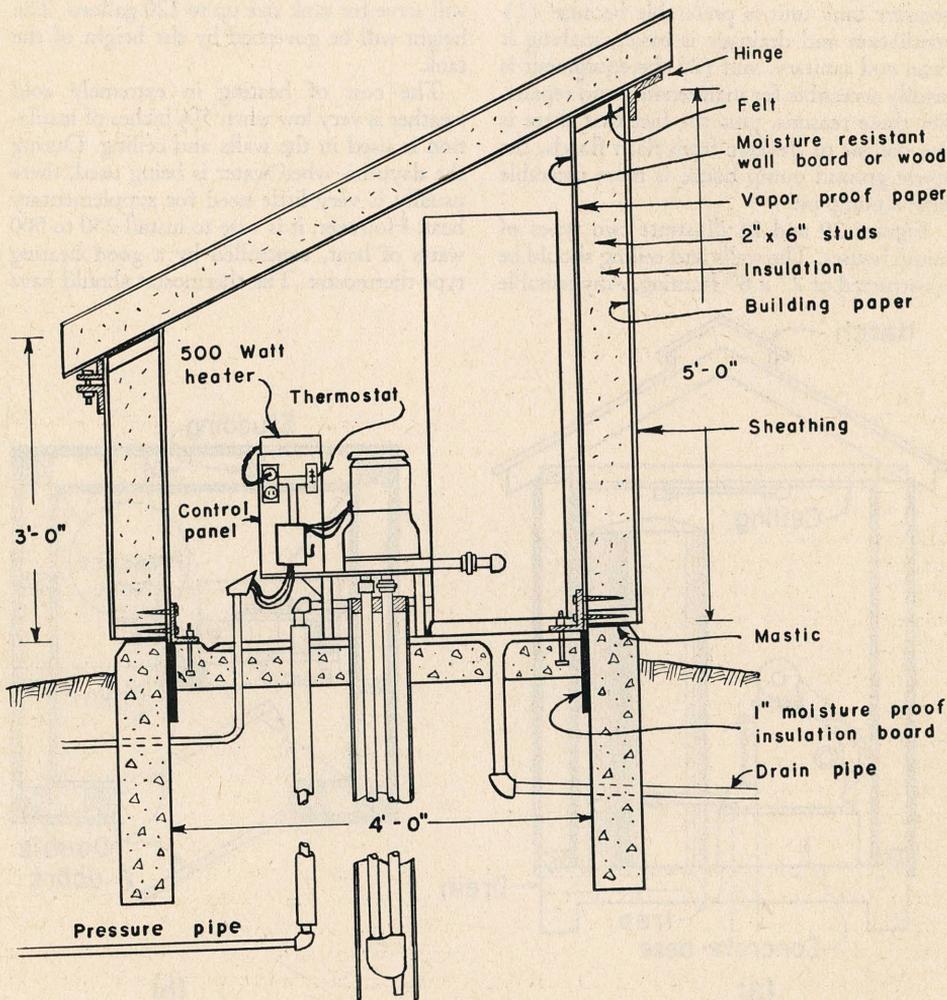


Fig. 21—A properly constructed insulated pump house

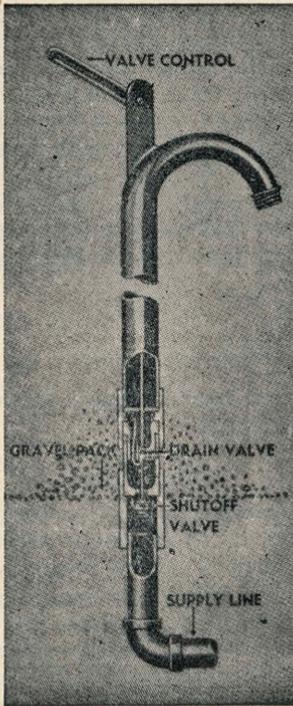


Fig. 22—Frost-proof yard hydrant with shut-off valve and drain below frost level.

### Underground Discharge

A recent development in protecting the well and pumping equipment from freezing is the underground discharge fitting as shown in Fig. 23. The use of this discharge fitting eliminates the need for a frost-proof pit or an insulated pumphouse.

Construction of this discharge can be of two types. The one shown in Fig. 23 is an especially-manufactured underground discharge fitting which provides a special withdrawable casting. This type allows the use of a drop pipe smaller than the cylinder and facilitates pulling the drop pipe and cylinder in case repairs are needed. The other type is fabricated from stock materials. It requires a cylinder of the tubular type with a drop pipe the same size as the cylinder.

With either type, a small above-ground pumphouse should be provided to protect the pump motor from the weather.

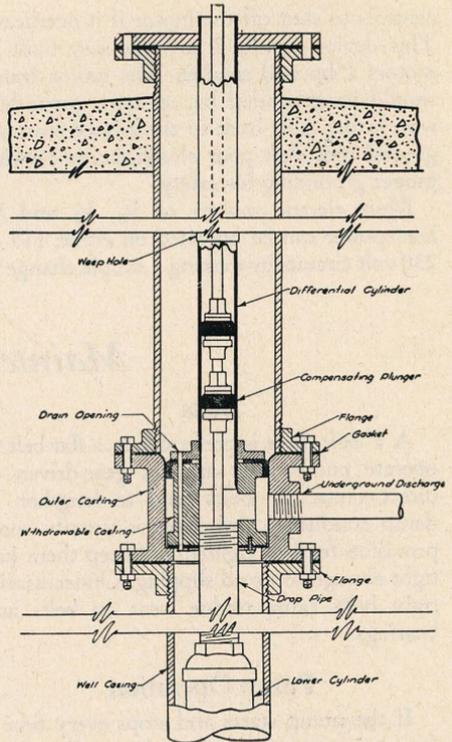


Fig. 23—Properly constructed drilled well with underground discharge arrangement.

### Wiring the Motor

The size of the motor depends on the pumping conditions such as water capacity required, depth of the well and discharge pressures. When you buy an electrically operated pump the motor is matched to the pump in accordance with the type of service for which it is intended. If you intend to change a hand pump or gas engine operated pump to electric operation you should consult a reliable pump dealer.

The pump should be supplied with electricity by a feeder wire directly from the yard pole. This makes it independent of feeders to the various buildings or circuits in those buildings. If there is a fire in a building the pump circuit is independent insuring continuous fire protection. There should be a disconnect switch at the pump and automatic overload

controls to shut off the motor if it overheats. This device usually is an accessory built in motors 1 hp and smaller. The motor frame should be grounded by an extra grounding wire in the cable back to the service entrance ground rod. Ask your electrician to provide proper grounding for safety.

Most electric motors of  $\frac{1}{4}$ ,  $\frac{1}{3}$  and  $\frac{1}{2}$  horsepower can be operated on either 115 or 230 volt circuits by making a simple change in

the winding leads. All motors  $\frac{1}{2}$  horsepower or larger should be operated on 230 volt circuits. At this voltage, the feeder wires to the motor can be smaller and it is easier to maintain the proper voltage to the motor especially if the feeders must run several hundred feet. The voltage drop in the wire from the yard pole to the pump motor should not be over 3 percent. Check this with your electrician to be sure the feeder wires are large enough.

## Maintenance Hints

### Belts

A *V-belt* drive is preferable to a flat belt to operate pumps that are not gear-driven or direct-connected. Belts tend to lengthen in damp conditions and there is usually some provision for belt tightening. Keep them just tight enough to avoid slipping. Unnecessarily tight belts cause undue wear on belts and bearings.

### Pump Operation

If the pump starts and stops every time a faucet is opened the tank is usually waterlogged (insufficient air in tank) which means the air volume control isn't working. This must be repaired, and the tank drained and then refilled. If water squirts at the faucet there is probably too much air in the tank. It may be due to a faulty air volume control or a leak in the suction line. If the pump loses capacity check for the following: (1) loose belt, (2) lowering water level in well, (3) worn valves or obstruction in valves, (4) air lock in suction pipe, (5) leak in pump or suction line, (6) partially plugged jet nozzle or obstruction to water passage through the impeller.

A foot valve in the lower end of the suction

line is good insurance against frequent priming of the pump.

### The Motor

Electric motors properly installed and wired give extremely reliable and trouble-free service. If the motor cuts out frequently it is usually due to overload or low voltage at the pump. Overload can be caused by (1) heavy oil in wintertime, (2) tight bearings or belts, (3) improper alignment of belts or shafts, (4) increased pressure switch settings. Sometimes the motor stops due to simple electrical trouble such as a blown fuse, loose connections, dirt in the windings or worn and sticky brushes. If the trouble is more serious call a service man.

### Lubrication

*Lubrication* of pump and motor should be done according to the manufacturer's instructions. Centrifugal type pumps are usually water lubricated. The working head of piston pumps require oil lubrication. Electric motors require oil only at the shaft bearings. Usually if there are outside oil cups, 10 or 12 drops of SAE-10 engine oil every 10 to 12 months is sufficient.