Water Supply for the Country Home

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Water Supply for the Country Home

INTRODUCTION

Back to the Farm—Professor H. C. Solberg, of Brookings, South Dakota, says: "For many years the writer has been quietly observing the various forces set in motion by the Federal Government as well as the forces set in motion by the great captains of industry for the purpose of assisting in improving the conditions of farm life. He has carefully observed the results obtained and has come to the conclusion that the reasons for the exodus from the farm to the cities do not depend so much on economic or financial conditions as upon conditions incidental to home life. Further, that the only remedy, if a remedy is possible, consists in constructing a residence on the farm, containing all the modern conveniences, the same as is possible in a city home. This is rather a delicate subject to discuss, and it will undoubtedly meet with some opposition, but it cannot be avoided if the best results are to be obtained.

"There is a vast number of farms throughout the central west with magnificent barns, including conveniences of all kinds for the handling of stock, large and convenient granaries and machinery of all kinds about the place for doing farm work. But when it comes to the home for the mother and children, it is mostly a small hut, without conveniences of any kind whatsoever. The result is that the life of the woman on the farm is unnecessarily made a continuous hardship. THE WATER SUPPLY IS USUALLY MUCH CLOSER TO THE BARN THAN TO THE HOUSE. There is no machinery for doing housework of any kind. Because of lack of any toilet conveniences, the wife and children are compelled to expose themselves in poorly constructed outhouses to the most severe weather conditions during the long and stormy winter
season, a condition that is well nigh unbearable to a strong person, to say nothing of subjecting a person in delicate health to such treatment. This unbearable state of affairs soon becomes a horror so strong that neither wealth nor other advantages can counterbalance it.

"The rural mail delivery, the telephone, good roads, and the automobile, all combine to annihilate distance. This will also enable the consolidation of the rural schools to be brought about and will bring them to the standard of the city schools. The last condition remaining for making the farm home equal to or better than the city home, is the installation of modern conveniences consisting of a heating system, a water system, a sewage system, with toilet and bath rooms, power washing and sweeping machines and churns, and a lighting plant. The farm house will then become the ideal home, a home where bodily strength, manhood and character can be developed to the highest standard of perfection, free from the contaminating evils that are rampant in the larger centers of population. Why should not the subject of a suitable and respectable home for mother and the children be considered as important and as suitable a subject for discussion as the accommodations for the horses and cattle, the hogs, and the chickens?"

In short, if you wish to keep the boys and girls on the farm, make the farm home fully as attractive, fully as convenient, fully as desirable, as the city home. There will then be no cry of "back to the farm", for there will then be no exodus from the farm.

Water and Disease—The farmstead, being the source of supply of the food of the world, deserves to have special attention paid to its needs. Of these needs, few are greater than the need for pure water. It would seem that the farming regions, which are usually remote from the thickly settled districts, would find no difficulty in securing such a supply. But we find that many of our intestinal diseases, such as diarrhoea, dysentery, typhoid fever, and the like, diseases whose germs may be distributed, disseminated and carried long distances by water or by milk and vegetables which have been contam-
inated by water, are as prevalent, if not more prevalent in the country districts than in the cities. This can mean but one thing—the farming community is very careless about its water supply.

These diseases are also spread over restricted areas by flies and other insects which breed in refuse and filth. It would seem, then, that the vital problems confronting the farmer are (a) the problem of securing a water supply that is sufficient in quantity and that is at all times safe and wholesome, and (b) the closely related problem of the careful and economical disposal of the wastes in which flies breed and on which they feed.

The problem of the disposal of farmhouse wastes has been treated in a previous bulletin,* and this bulletin will be confined to a discussion of the Water Supply for the Country Home. Technical discussion will be avoided as much as possible and only such matter will be included as is necessary to an understanding of the subject in hand.

SECTION I.

SOURCES OF SUPPLY

The ultimate source of practically all the waters of agricultural regions is rainfall. While this is true, there is very little attempt to collect the rainwater as it falls for general domestic purposes as the taste is usually disagreeable, and the appearance not desirable. Instead of such direct collection of the rain water, provision is usually made for securing a supply of water from waters which have been absorbed by the ground or which have flowed a considerable distance over its surface.

The sources of supply, then, will be considered under four heads:

1. Direct Collection of Rainfall. Such direct collection is often found in regions where the ground waters and surface waters are very hard. Here cisterns are usually filled with

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*State College of Washington, Bulletin No. 5. Series I. Engineering Division, Dept. of Extension.
rainwater to be used for washing and for other purposes, for which extremely hard water is not suitable. Occasionally, also, such waters are used for drinking and for general domestic purposes. This source of supply is chiefly resorted to as a temporary arrangement to be used until such time as a well can be dug or other source made available. Only in isolated cases will rain be depended upon continuously for the water supply.

2. **Surface Waters.** In nearly all regions, and especially in arid and semi-arid regions, water for domestic purposes is taken from lakes, streams, or other waters found on the surface of the ground.

3. **Springs.** Springs have been treated separately because many springs are neither surface waters, such as we find in lakes and streams, nor yet ground waters, such as are found in the underlying soil strata.

4. **Ground Waters.** Probably the most common source of supply of water used on the farms of the country is the water found in the underlying layers or strata of the soil and obtained by sinking wells into such strata.

**SECTION II.**

**QUALITY OF SUPPLY**

**Rainfall.** Waters obtained by the direct collection of rainfall are usually taken from the roofs of buildings and stored in cisterns. Such waters may or may not be wholesome, according to the weather conditions just prior to and during the time of collection. Practically all water so collected is neither palatable nor of good appearance, but has a peculiar taste and color, due to the absorption of gases and the picking up of dust particles from the air.

After a period of dry weather, the air becomes loaded with soot, dust particles from chimneys, roads, streets, and other sources. These particles carry with them into the air such bacteria as are present at their starting points, so that, at such times, the air is literally full of bacteria of all kinds. Also
quantities of various gases, given off from chimneys, decaying organic matter, etc., are diffused through the atmosphere. The roofs become covered with dust so that the roof may be called a collecting place for dust and bacteria. Then a shower comes; the air is washed clean of its dust and bacteria and the roof is washed clean of its accumulated load and all this must be carried by the water as it flows from the roof. Under such conditions, it is evident that the water obtained cannot be wholesome; also, at such a time, the disagreeable tastes and colors are more pronounced.

On the other hand, if there has been a period of rainy weather so that the air and the roofs have been thoroughly washed and cleaned, the water obtained from the roofs may be reasonably wholesome, although the taste and color has not entirely disappeared.

In any case, it is best to carefully filter all water collected from the roofs before it is allowed to enter the storage cistern and the cistern itself should be carefully cleaned and purified at least once a year, at the close of the dry weather, and before beginning to store the new year’s supply. Even when a good filter is used between the roof and the cistern, care should be taken to provide a waste from the roof that may discharge freely and not through the filter.* (See Fig. 1.) Then the water, which first comes from the roof after a long dry spell may be wasted, thus carrying away the greater portion of the

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*For the methods of construction of filters see the section on "Purification of Water".
dust and dirt from the roof, and, at the same time, save the filter from becoming clogged so quickly. In its passage through the filter, the dust and bacteria in the water will be removed, thus making the water wholesome. Also, the water will lose some of its color and taste.

**Surface Waters.** Under the term "surface waters" is included not only the waters found in basin-like depressions, such as lakes and ponds, but waters flowing along the valleys as streams. Such waters include not only the water which runs directly from the surface of the ground at the time of rainfall, but also that larger quantity of water coming from the ground in the form of springs and seepage, water which at first was absorbed by the ground but later set free.

Besides the natural bodies of water,—lakes, ponds, streams—we have the artificial ponds and reservoirs formed by dams or other artificial obstruction. We shall include these under surface waters.

Lakes.—The waters of lakes are generally good except when polluted by the discharge into them of sewage or other contaminating matter from some large city or town. Solid matter carried into the lakes by the inflowing streams rapidly settles to the bottom, due to the check of the velocity of the carrying water, and since the water in the lake remains comparatively quiet, the matter is not again picked up. This sediment carries with it the bacteria adhering to the solid particles and thus the bacterial purification keeps fairly close pace with the sedimentation. Besides this, the surface movement under the action of the winds, favors the aeration of the water and promotes the oxidation of dangerous impurities. Sunlight, also, has a tendency to destroy bacteria in the water to the depth to which there is direct penetration of the light. As a result of these processes of purification, the water which entered the lake in a polluted state may become so changed that on leaving the lake it is both palatable and wholesome. It is unfortunate that the old, half true saying: "Running water purifies itself" has been popularly interpreted to mean that still water is neces-
sarily impure. For the truth is that the water of the ordinary lake, especially near the outlet end, is much more nearly pure than the water of the streams flowing into the lake.

Farm houses, even when in the vicinity of lakes, are placed on high land, so that it becomes necessary either to haul the water used for domestic purposes or to install a comparatively expensive pumping plant for pumping it to the house, if the lake supply is utilized. For this reason, and because of the old saying, we find that lake supplies are chiefly valued as stock watering supplies.

Ponds.—What has been said of lakes may be said to a lesser degree of those small lakes commonly called ponds. Being smaller and shallower, the water is not so quiet and sedimentation is not so rapid nor so complete. In times of high wind or high water, the pond may be disturbed in its entire depth and over its total area, thus bringing back into the water a great part of the matter which has settled out of it in the calm weather. This could not be true of lakes of even moderate depth. The extreme shallowness of many ponds also promotes the growth of water vegetation, thus introducing a possible new element of contamination. Under the conditions indicated above, it is evident that a small, shallow pond does not furnish a safe source of supply, while the deeper ponds and lakes ordinarily furnish excellent supplies.

Some small ponds, however, are fed directly by springs and, under proper precautions to prevent the entrance of polluted surface drainage waters, furnish first class water for domestic purposes.

Artificial ponds are subject to the same chances as natural ponds and to be safe must be as carefully guarded from pollution as the natural ones. A careful guarding of the source of supply of the pond, as well as the pond itself, is absolutely necessary if the water is to be used for domestic purposes.

Streams.—Over a great portion of the country, streams form a most available source of supply. Water flowing in streams does not purify itself so quickly as water in a lake, but the
alternation of pools, where the water is comparatively quiet and where sedimentation takes place, with rapids where the water is foaming over a stony bottom, thus inducing the absorption of oxygen and the oxidation of dissolved matters, tends to purify the water. Also, in streams open to the sun, there is probably a greater action by the sunlight than in lakes, for constantly new portions of water are brought within the depth of sunlight penetration.

In farming regions along rivers that have no towns on the river above them, the principal danger comes from the location of outhouses on the banks of the streams and from stock wading in the stream. Many people think of a flowing stream as a quick and easy way to dispose of all kinds of waste matter from the house or the toilet, and most farmers wish their stock to have access to any stream crossing their farms. We see cattle and horses wading in the stream and hogs wallowing in the mud of the banks; and not infrequently, we see the privy close to, or overhanging the banks, and the waste pipe from the kitchen or toilet emptying directly into the stream.
PLATE I. — Pollution of Streams and Ponds.
Canals.—Canals are open to the same sources of danger as are streams, and usually in greater degree. Besides this, the canal does not offer the same opportunity for purification as the natural stream. From the very requirements of its construction, it has not the succession of pools and rapids, but instead has a nearly uniform rate of flow, so that it tends to keep in suspension all matter once picked up and carried by it. For these reasons, the use of canal water for domestic purposes is always questionable and the water from streams or canals should not be used for such purposes except after treatment to remove the impurities.

The first step toward purifying the waters of a stream or canal is to remove, if possible, all direct sources of pollution, such as we have mentioned. Then, there should be as great a distance as possible between the remaining sources of pollution and the point at which the water is taken from the stream or canal. And last of all, the supply should be thoroughly filtered and possibly chemically treated before being used.

If the supply is to be pumped, quite a large filter may be constructed below the bed of the stream or canal and the whole supply for the farm passed through it. This will be found more convenient and much safer than to try to filter only the small amount used in the farm house. The cost of the large filter will not be much greater than the cost of the small one.*

In some cases, the supply is taken from a high line canal and conveyed to a storage reservoir or cistern near the house. If the canal does not carry water the year around, the cistern must be large enough to hold a supply to carry over this dry period. In such cases, a filter may be constructed in the pipeline between the canal and the cistern and all the water passing into the cistern must pass through the filter. The water thus stored in the cistern may be treated chemically if desired.

Springs.—The term "spring" is properly applied to water emerging from the ground at a single point or within a restricted area, but the distinction between springs and gen-

*For the methods of constructing Filters and for chemical treatment, see the section on "Purification of Water."
eral seepage is not always very sharp. We often hear the expression "springy ground" applied to large areas where there is considerable seepage water coming to the surface. There are all gradations between the concentrated outflow characterizing the true springs and these extended damp areas known as "springy ground".

For the purpose of this bulletin, we will divide springs into three classes:

First Class. This class of springs is that in which the water, in its lateral movement, is brought to the surface at the outcrop of a porous stratum where it is underlain by a relatively impervious one. If the surface of the impervious layer be irregular, the flow will be marked in the valleys of the impervious layer and large true springs may result. If, on the other hand, the impervious layer be regular, there may be nothing but a long "seepage line", the concentration of water at any point not being more than enough to keep the surface soil damp. (See Fig. 2.)

![Fig 2](image)

Second Class. Under this class are considered those springs where the water-bearing stratum is confined between two more or less impervious ones. These springs are artesian in character. In this class of springs the water finds its way to the surface, where the upper impervious layer is wanting, or through breaks or cracks in this upper layer. (See Fig. 3.)
Third Class. This class of springs includes those in which the porous stratum in the vicinity of the spring is neither overlain nor immediately underlain by an impervious one. They are mere overflows of the ground water and occur whenever the carrying capacity of the porous material is insufficient to convey the entire flow. Naturally they are somewhat intermittent in character, often disappearing entirely in dry periods and reappearing some time after wet weather has set in. The normal outflow of normal ground waters in valleys along stream lines is of this type, but true springs may develop wherever the conditions of the underlying strata are such as to cause concentration of the flow.

In sparsely settled regions, springs, if protected at their outcrop, usually furnish safe sources of supply. In thickly settled regions, where there may be many houses along the line of the underground flow, and above the outcrop of the spring, we often have springs contaminated by the drainage from privy vaults and cesspools. (See Fig. 4.) This is particularly true in limestone regions, for in such regions the underground water flows along openings and cracks in the rock, and is not filtered through the soil at all. The chief danger comes from pollution or contamination, at and near the immediate outlet of the spring. When the water comes close to the sur-
face, percolating water carrying pollution from the surface may mix with it, and also as it comes through the surface soil it may pick up considerable pollution, particularly if the surface about the spring outlet is exposed to the tramping of stock or disturbance by other means.

The first step then, in insuring a wholesome supply from a spring, is to protect the outlet of the spring. The outlet of the spring should be surrounded by a fence to keep stock and other disturbing and polluting sources from approaching close to the spring. The surface of the ground around the spring should be so formed as to keep all surface drainage from passing into or over the outlet of the spring. The outlet should be further protected by being surrounded with a box, preferably of masonry, extending two or more feet into the ground, and covered tightly over the top so as to exclude leaves, dust, vermin of all kinds, and larger animals which might enter the spring. (See Fig. 5.)

In many cases where the spring is of the seepage type or where the emergence is not at a single point, the spring may be made to yield a much larger amount of water, and at one point, by putting in open joint drain tile in a trench three or four feet deep, dug along and just above the line of outcrop of the seepage, and across the line of flow of the seepage water. In this way the discharge is brought to one point. The water
may be brought to the surface through an iron or other pipe, thus preventing the possible pollution of the water at the outlet by surface drainage, or by stock.

**Fig. 5**

*Spring Properly Protected*

**Ground Water.** Water falling upon the surface of the ground is carried away in three ways: by evaporation, by surface flow, and by percolation. The water which percolates into the ground and passes beyond the reach of vegetation, obeying
the law of gravitation, passes on down until it reaches a layer of earth which is impervious or until it reaches a layer which is already full of water. When this layer is reached, the water will begin to move down the slope of this layer just as surface water moves down the surface slopes. The accumulation of water which thus exists in the ground is called ground water, and its surface is called the ground water level, or the water table.

The form of the water table is evidently very closely the form of the impervious layer underneath it, and as there is a rough agreement between the surface slopes and the slopes of the underlying layers of earth, the water table roughly agrees with the surface forms. But we must keep in mind that the lower layers of earth, in many places, slope in exactly the opposite direction from the surface, and hence in these places the flow of underground water is opposite in direction from the flow of surface water. This fact is of importance in the selection of a location for a well, as the ground water should not flow from a slophole or other source of pollution toward the well.

If the water could flow through the soil as readily as it can flow over the surface, the ground water would quickly concentrate in the valleys of the impervious layers, just as surface water concentrates in the valleys of the surface; but the flow of water through soil varies from a few feet per year, in clay and similar soils, to possibly one hundred feet per day through coarse sand or gravel. These flows are so slow that the rains and other applications of water on the surface are sufficient to maintain the ground water in a vast sheet underneath the surface instead of in narrow channels. Evidently, there will be a greater concentration of water in the water table valleys than on the hills or slopes, and wells in the valleys will yield more water than wells on the slopes and hills. On the other hand, since surface pollution is washed into the valleys, there is a much greater danger of pollution in valley wells than in wells on slopes or hills.
Since ground water is supplied by percolation from the surface, anything which increases the surface supply of a region increases the ground water of that region. This is plainly seen in the rise of the water table with the progress of the irrigation season and its fall soon after the close of the season; also in the plentiful supply in wells in wet years and the scant supply in dry years. This same cause operates when water is supplied to the surface in a very restricted area, but in this case instead of the ground water level rising over a whole region it rises only in this restricted area, causing a small mound or hill in the water table. The water flows down this hill on all sides, and thus we find the flow on one side opposite to that of the general flow. A cesspool may cause such a hill and thus pollute the water of a well actually up the main slope from it, as shown in Figure 6.

So far, we have spoken of ground water as though it were confined to a region above the first impervious layer. In many places, we find several layers of earth, alternately pervious and impervious, each with an outcrop on the surface somewhere. Under such conditions, each pervious layer will contain water to a greater or lesser degree. As the lower layers probably outcrop at a greater distance away, these layers
will be much less liable to pollution than the surface layers, and it is for this reason that deep wells usually yield safer supplies than shallow wells. (See Fig. 7.)

![Fig 7](image)

Just as we have surface depressions that fill with water, forming lakes, so we have depressions in the impervious strata underneath the surface that must fill with water up to the rim of the impervious strata. If such a depression is found in successive pervious and impervious layers, as described above, the water in the intermediate pervious layers will be under pressure and the water will rise in a well sunk into one of these layers. If the ground surface is below one of the rims of the depression, a flowing well will result. Such depressions are called artesian basins. Figure 8 shows a section across the great Dakota Artesian Basin. The upper rim of this basin is along the foot hills of the Rocky Mountains in Montana, and the lower rim is in eastern Dakota and western Minnesota.

![Fig 8](image)
Wherever the underlying impervious layer comes close to the surface of the ground, as is often the case in valleys or along their margins, we will find either marshes or damp, springy ground; if the layer actually outcrops, we have a seepage line or some well defined springs. Some springs are of an artesian nature, being formed by natural breaks in the upper impervious layer of an artesian area. (See Fig 3.)

Wells. Wells are probably the most common source of water supply for the farm and when properly placed and cared for are certainly very convenient and furnish dependable, wholesome supplies. Although no two wells are exactly alike in all particulars, there are, in reality, only a few distinct types, and for the purposes of this bulletin we will classify all wells under two heads, (1) open wells and (2) closed wells. We will define open wells as those having a surface opening of twelve inches or more in diameter, and closed wells as those wells having a surface opening of less than twelve inches in diameter.

The open type well is usually a dug well from three feet to six feet in diameter. (See Fig. 9.)
This type is adapted to localities where the water is near the surface, and particularly where the water occurs as small seeps in clayey material so that a considerable storage capacity is needed to accumulate water for occasional heavy pumping. Dug wells are seldom more than fifty or sixty feet deep.

The advantages and disadvantages of this type are:

**Advantages**
- Ease of construction, can be located, sunk and cased by the owner.
- No special outfit or apparatus needed in sinking.
- No expensive material required for curbing; stone, brick or tile being used.
- Ease of entrance of water and utilization of small seeps.
- Large storage capacity.
- Quick response to rainfall.
- Accessibility for cleaning.

**Disadvantages**
- Limitation to soft material except at great cost.
- Liability to caving while being dug.
- Slight depth to which it may be sunk except at high cost.
- Occasional failure in time of drought. (This can frequently be remedied by deeper digging.)
- Ease of entrance of polluting matter, thus requiring that the well be located at some distance from house, barn, cesspool or privy, and requiring special precautions to exclude surface drainage.
- Necessity for frequent cleaning and danger from gas while cleaning.

(Iowa type bored wells belong under this head. The ad-
vantages and disadvantages are the same as above except that special apparatus is required.)

The closed well is usually either driven or drilled; occasionally we find punched wells, or wells sunk by the use of a water jet.

The driven well is adapted to soft and fine materials, especially to sand or similar porous material, carrying considerable water at relative slight depths. As no storage is provided for, the flow of water in the water-bearing layer must be comparatively free if the well is to stand the test of hard pumping. This type of well is sunk by driving down a small tube—1¼ to 4 inches in diameter. The lower end of the tube is provided with a drive point and a screen. The tube is usually driven either by hand or by a simple horsepower apparatus. Driven wells are seldom over 125 feet deep. (See Fig. 10)

The advantages and disadvantages of this type are:

**Advantages**

Cheapness and ease of construction, often sunk in a few hours.

Outfit inexpensive and can be quickly put up, no skilled labor required.

Much safer from pollution than open wells.

Can be located near sources of pollution if sunk through an impervious layer preventing the access of contaminating matter to the water bed.

Cleaning seldom necessary.

If driven deep, water supply more permanent than usual dug well.

**Disadvantages**

Limitation to soft materials.

Utilization of a single water-bearing layer.

Limitation to open porous water beds, due to absence of storage.

Slower response to rainfall than open type.

Possible clogging through entrance of very fine sand and difficulty of cleaning in case of clogging.

Corrosion or incrustation of pipes and screens.
Driven Well

Fig 10
The drilled well is applicable to all but the softest material, but is particularly adapted to rock work, especially at great depths. The standard drilled well is sunk by percussion of a heavy drill, two inches to twelve inches or more in diameter, lifted and dropped from a portable rig by horse or steam power. These wells are cased with iron pipe in soft materials; usually not cased in rock except just far enough to exclude from the well the water flowing along the rock surface.
The advantages and disadvantages of the drilled well are:

**Advantages**
- Adapted to all rocks.
- No ordinary limitations as to depth.
- Can be readily deepened, little affected by droughts.
- Can utilize all seeps in rock below casing.
- Pollution is practically shut out when properly cased.
- Can be located anywhere.

**Disadvantages**
- Expensive, requiring an elaborate outfit operated by skilled labor, costly casings.
- Difficulties in drilling.
- Cleaned with difficulty.
- Slight storage capacity.
- Corrosion and incrustation of pipes and screens.
- Slow response to rainfall.

Well Casings—The materials usually used for casing the open type of wells are rock, brick, tile, and wood; for the closed type, wood or iron are usually used.

Wood is never a desirable material, although it may be very cheap. Near the surface of the ground it shrinks so that wide cracks are open for the entrance of vermin and polluted surface water, and it soon rots out at the water line. The rotting of the wood favors the development of bacteria.

Rock, brick, or tile, when laid with uncemented joints, offer easy entrance to vermin and polluted surface water. In this respect they are no better than wood, but they will not rot. If laid in cement mortar, they form a tight, durable casing that will exclude all vermin and all pollution, except that entering at the bottom. For open wells of large diameter, rock
or brick laid in cement mortar are recommended; for open wells of smaller diameter, glazed tile with cement joints are easier to place and just as good as the stone or brick. In all cases, the earth just outside the casing should be puddled so as to close the opening between casing and excavation. (See Fig. 9.)

Iron casing with screw joints forms a water-tight casing that excludes all polluting matter except that entering at the bottom. Carefully placed iron casings of the stovepipe pattern are very good, but not so good as the screw pattern. For wells having a bore of six inches or less, iron is practically the only material used.

Selection of Type of Well.—The type of well is the first and perhaps the most important point to be decided. Each type has its advantages and its disadvantages and these must be considered along with the peculiar soil conditions of the locality where the well is to be sunk and the methods which may be used to sink the well. The principal factors to be considered are the amount of water needed, character of materials penetrated, depth to which the well must be sunk, the cost of sinking, and the safety of the supply obtained. The last, which is very often not considered at all, should be one of the important considerations.

If we grant that there is a sufficient flow of ground water, the size of the storage and the facility with which the water enters the well will determine the amount of water which may be drawn from the well at any time.

The character of the water-bearing layer is of the greatest importance in determining the yield of a well. A close textured clay, although it contains as much as fifty per cent of its volume of water, will give up very little of it, while an open textured sand, although it may contain as little as twenty-five per cent of its volume of water will readily give up the greater part of it. The well in the sand layer would yield abundantly while the well in the clay would be unsatisfactory unless provided with large storage. Again, quicksands contain a great amount of water, but as the sand moves with the water, the
water is obtained with difficulty. In rock, other than very porous rock, such as sandstone, bedding planes and joints, furnish the greater part of the water obtained; in limestone, solution passages often furnish an abundant supply, but the water flowing in these passages is frequently contaminated by surface water entering through sinkholes and therefore is to be avoided.

PLATE IV.—Sewer Emptying into Sinkhole in Limestone Regions.

In loose materials, water enters stone-curbed or other loosely curbed wells, most readily and scarcely less readily into tightly curbed wells open at the bottom. If the water bed is a strong one, and the material of the bed such as not to be readily car-
ried by the flow, the water will freely enter the bottom of an iron cased well. In weaker beds, long screens may be necessary to permit the entrance of the required amount. In rock, where the wall will stand without casing, the water enters at any point below the casing, without hindrance.

In weak water beds and in beds where water enters the well as seeps, a large storage capacity will be necessary. In regard to this matter, it must be kept in mind that the storage of a well three feet in diameter is nine times that of a well one foot in diameter, and two and one-fourth times that of a well two feet in diameter.

Protection of Wells.—The safety of a well depends on the purity of the water at its source, and on the protection of the well itself from surface pollution. Polluting matter enters a well in a variety of ways: direct percolation from barnyards, cesspools, privies and slop holes; percolation from nearby pools at watering troughs, direct contamination from matter dropping from the feet of persons or animals passing over the open cover of the well; direct contamination through the entrance of surface wash through holes in the casing at or near the surface of the ground; entrance of frogs, snakes, or rodents through these same holes. All these and more must be guarded against.

Wells should be protected from contamination both above ground and below. Beneath the surface of the ground, the well should be tightly cased, either with iron or with brick, stone, or tile, set in Portland cement mortar to a depth of not less than ten feet. Should a water bed giving a sufficient flow of water be encountered at a greater depth than this, the well should be tightly cased down to this bed. If the well is of the dug type, the opening between the brick, stone, or tile casing and the sides of the excavation should be carefully filled with puddled earth as the casing is being put in, so as to shut off all chance of surface water entering the well hole and passing down outside the casing into the water of the well. (See Fig. 9.) The driven well, in the process of sinking, is tightly cased for its entire depth. (See Fig 10.) The drilled well
should be cased tightly for some feet into the rock, the casing being made to fit the rock bore as tightly as possible.

The open type of well is especially liable to contamination from the top, because of its large opening, and because of carelessness in covering this opening.

About the opening of all types of wells, the earth should be banked up high enough to make the surface slope away from the well for twenty feet or more in all directions. (See Figs. 9 and 10.) In this way, all water falling on the ground near the well opening is quickly carried away, and all surface wash is prevented from flowing into the well or near its opening. The well opening should be tightly covered with a water-tight cover, having a diameter two feet or three feet greater than the opening itself. This cover should rest firmly and tightly upon the casing beneath so as to prevent the entrance of rodents or vermin of any kind. In fact, the cover should go down over the casing like the cover to a bucket.

It is a good plan to place the pump in a shallow well to one side of the water well, as shown in Fig. 9 a. If this is not done, care should be taken to seal or calk the pump into the cover in such a way as to prevent water passing through the pump opening.

The closed type of well, on account of the small well opening, is much more easily sealed than the open type, but the same precautions as to banking about the well and to covering and sealing the well opening should be taken as in the open type.

The whole aim should be to exclude all surface water from direct entrance into the well, to exclude all vermin from the well, and to exclude all matter which may be brought near the well opening by stock or by persons coming to the well for water, and to keep this matter removed from the vicinity of the well opening.

Wood is probably most often used for the well cover, but it is not a suitable material. By shrinking and warping, it opens the well to the direct entrance of vermin and of filth, which may be carried on to the cover by persons or stock. A
reinforced concrete slab makes an ideal cover. (See Figs. 9 and 10.)

Safety Distance.—By safety distance is meant the distance from a source of pollution at which a well may be sunk with a fair degree of safety. It is evident that this distance varies with the character of the earth and with the direction of the well from the source of pollution, that is, whether the well is above or below the source of pollution, as referred to the ground water slope. If the well is above the source of pollution, it must be far enough away so that the formation of a hill in the water table, as described on page 20 and shown in Fig. 6, will not cause the water from this source to flow up the general slope far enough to reach the well. On the other hand, if the well is below the polluting source, the distance from source to well will have to be much greater, as all the polluting matter is carried down the slope contaminating the earth for an ever increasing distance. If the earth is reasonably uniform, without any well defined channels along which the water passes, the safety distance is from 75 to 100 feet above the source of pollution to from 200 to 250 feet below the source. If there are well defined water channels in the earth, no distance below the source of pollution is safe. Should a well that is not subject to continuous pollution become contaminated by the accidental entrance of polluting matter from the surface, probably the best treatment is to introduce into the well a small quantity of chloride of lime, as described under “Chemical Treatment of Water”, and then pump the well hard so as to remove as much of the contaminated water as possible. The chloride will destroy any harmful bacteria that may be present. Care should then be taken to preclude the possibility of a second pollution. If the well is subject to continuous pollution, the only sure treatment is to fill it up and dig a well in a safe place or else remove the source of pollution and apply chloride, both to the source and to the well.
SECTION III.

PURIFICATION OF WATER

Methods of Treatment. There are two general methods for the treatment of water for the removal of impurities: (a) mechanical treatment, treatment by screens and filters, and (b) chemical treatment.

Mechanical Treatment. Filters.—Faucet screens and filters are of almost no value in the purification of water. Comparatively coarse particles of mineral matter and long slender threads of green or blue algae may be removed from the water by passing it through the set of four or five fine brass wire screens, such as can be purchased, ready for attachment to the faucet, at the five and ten cent counter of any variety store or from an oily tongued agent at twenty-five to fifty cents. So far as real purification is concerned, THESE ACCOMPLISH NOTHING. The same results could be obtained by straining the water through two or three thicknesses of cheese cloth. There is only one type of faucet filter that accomplishes an appreciable purification. This type consists of an inner tube of unglazed stone ware, or porcelain, and an outer metal casing, tightly attached to the outlet of the supply pipe, to protect the earthenware filter and to bring all parts of the filter into equal use. (See Fig. 11.)

Its operation is very slow, requiring several minutes to pass a teakettle full of water. To maintain its efficiency both as to passing and as to purifying water, it must be boiled out once or twice a week. Because it operates so slowly, it is an aggravation to anyone wishing to secure water, and for this reason but few of them are found in use.

Larger filters of a similar type are sometimes constructed so as to furnish a filtered water supply for drinking purposes only. The stoneware filter is quite large, so that the amount required at one time for drinking can be had without waiting for the filter. The outside container itself may be of a semi-porous character so that the evaporation of the water from its outer surface will keep the water within the con-
Pasteur Filter

Fig. 11
tainer cool enough for use; the cooling principle is the same as that involved in the use of the canvas water bag.

If the supply is taken from a well and requires to be filtered as described above to insure its wholesomeness, the best treatment is that suggested in the paragraph on "Safety Distance" in the section on Wells.

The Sand Filter.—Where comparatively large quantities of water are to be filtered the sand filter is the type of filter used. The general plans for the construction of such a filter are shown in Fig. 12.

The materials used in construction should be either good concrete or else good brick laid in cement mortar. The inlet and outlet and overflow pipes should be built into the walls of the filter so that there can be no leakage around them. The open spaces in the crushed rock or coarse gravel shown in the bottom of the filter furnishes a collecting basin so that the whole area of the filter is brought into operation. The sand layer, at the time of construction, should not be less than about three feet deep, and depths greater than five feet are costly without giving added safety. The water should be kept at a depth of two feet or more over the top of the sand so that the surface of the sand will not be disturbed by any possible currents from the entering water or from other sources. The sand required for a filter is about the same as is commonly called "a good plastering sand". This sand should be screened through a sieve of ten or twelve meshes per linear inch (fly screen), to remove all vegetable matter, coarse particles, clay lumps, etc. The best results are obtained by using for the filter sand a sand that will pass through a screen having about 20 meshes to the inch, and will not pass a screen having 50 meshes to the inch (screens Nos. 20 and 50), but such screening materially increases the cost. The chamber "B" (Fig. 12) is necessary to make it possible to control the rate of flow of water through the filter. The rising outlet pipe in this chamber should be a piece of flexible rubber hose with the upper end held at the proper height by being fastened to the wall of the filter by a cord or wire.
SAND FILTER. FIG. 12a.
Vertical Section on B-B

Water Surface

Sand

Crushed Rock or Gravel

SAND FILTER. FIG. 12b.
Operation of the Filter.—When the filter is completed, raise the end of the rubber hose pipe above the level of the inlet pipe, then fill the filter with water, taking care to disturb the surface of the sand as little as possible. Now, lower the end of the outlet pipe about one and one-half inches below the level of the inlet, and turn on the water in the inlet pipe and the filter is in operation. The water passing through the filter for the first two or three days should be allowed to waste, after which time it may be turned into the cistern or reservoir. The filter gives best results when operating continuously at a fixed rate. To make this possible, the reservoir or cistern should be provided with an overflow.

The rate of operation should be about fifty gallons per square foot per day. The head “h” (Fig. 12) required to pass this quantity of water will vary with the sand used and with the length of time the filter has been in operation. When the filter is new or has just been cleaned, “h” should not be over two inches; after one month of service it may be twenty inches. The filter should then be cleaned.

Cleaning the Filter.—Close the inlet pipe and draw off the water from the filter. With a square pointed shovel or similar instrument, carefully remove the upper one-half or three-fourths inch of sand. Then fill the filter with filtered water, if possible, pouring the water into the filter through the discharge chamber. When the filter is full open the inlet pipe, set the end of the discharge pipe just below the level of the inlet and the filter is in operation again. If the filter is filled with raw water, the flow for two or three days must be wasted, as previously described.

Size Required.—If the house is not provided with pressure water, but all water has to be pumped from the cistern as used, the domestic use will average from ten to fifteen gallons per person per day. If the house is provided with pressure water and fitted with bath, toilet, and other conveniences which go with pressure water the use will be from thirty to fifty gallons per person per day. Taking all kinds of stock into consideration, the use will be about six gallons per head.
per day in winter and about sixteen gallons per head per day in summer. Using the average of the above figures and assuming that water must be stored for use for one-half of the year, a family of five people having twenty head of stock will require as follows:

**When Pumping Water From Cistern as Used:**

<table>
<thead>
<tr>
<th>Use</th>
<th>Regular</th>
<th>Storage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family use</td>
<td>60</td>
<td>60</td>
<td>120</td>
</tr>
<tr>
<td>Stock use</td>
<td>220</td>
<td>220</td>
<td>440</td>
</tr>
<tr>
<td>Waste</td>
<td>20</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

**Size of Filter Required at 50 Gal. per sq. ft. per Day**

<table>
<thead>
<tr>
<th>Use</th>
<th>Regular</th>
<th>Storage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family use</td>
<td>200</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Stock use</td>
<td>220</td>
<td>220</td>
<td>440</td>
</tr>
<tr>
<td>Waste</td>
<td>80</td>
<td>80</td>
<td>160</td>
</tr>
</tbody>
</table>

The waste from leaks in pipes, etc., in pressure water systems is usually quite large.

Modifications can be made in the above for different quantities of stock and a greater or lesser number in the family.

Construction.—The filter tank may be constructed of any material that is not subject to rapid decay. Occasionally we find one built of wood painted with asphaltic paint. Often they are built of brick laid in cement mortar but the best material to use in their construction is concrete. The concrete should be a rich mixture,—one part cement to two parts sand to four parts crushed rock or gravel. The crushed rock or gravel should contain no stones larger than one and one-half inches in greatest dimension. Rounded stones screened from gravel will be found to work better than the sharp angular ones of crushed rock. The concrete should be well tamped as it is placed in the forms.

If possible, when constructing the filter tank of concrete, the excavation should be made just equal to the outside dimensions of the tank, the side of the excavation being used for the outside forms. The bottom of the excavation is
carefully smoothed to the desired shape. The forms for the side walls and the division wall are set first and these walls are put in first. At the same time, the inlet and outlet and overflow pipes are carefully set in their proper places. Some concrete should be allowed to crowd out at the bottom of the wall forms, so that the bottom of the tank, which is next put in place, will have a good bond to the side walls.

After a few days the forms are removed and the interior of the tank plastered with a mortar consisting of one part cement to one part sand, the walls being thoroughly wet before the mortar is put on. Whenever fresh concrete is to be joined to that which is set, the surface of the old concrete should be thoroughly cleaned and wet and covered with mortar before the fresh concrete is put in place.

A good concrete slab cover is preferable but a well made wooden cover will serve very well.

**Chemical Treatment.** There are a great many different chemicals used in the purification of water, but most of them require an expert operator to apply them so as to get results. Some others are so injurious to health that they may be used only in carefully determined quantities and by a skilled chemist. Leaving these two classes out of consideration, we have only one or two chemicals which are available for use on the farm.

**Hypochlorite Process.**—For the destruction of all dangerous bacteria which may be in the water, nothing equals in efficiency and convenience ordinary Chloride of Lime. This may be obtained from almost any grocery store in 10 cent cans and the amount required is so small as to make the cost almost negligible. It should be used in the following manner:

One tablespoonful of the Chloride of Lime is dissolved in ten quarts of water. This quantity is sufficient to treat 1000 gallons of water, and the operation is carried out by simply pouring the clear solution into the water to be treated and stirring thoroughly. This solution is a powerful germicide and its action is very rapid—ten minutes or so being all the time required to carry out the purification. One quart of this
solution is sufficient to treat effectively a tank containing 100 gallons of water, and one pint of it stirred into a 50-gallon barrel full of water will destroy any dangerous germs and make the water safe for drinking purposes.

One is cautioned against using too much of the chemical, not because it is dangerous at all, but because an undesirable odor or taste may be imparted to the water where too large amounts are used. The strength of solution indicated above, used in the manner described, will be found perfectly satisfactory. The qualities of the water will in no wise be impaired and no undesirable conditions will arise from its use. On the other hand, dangerous water may be made safe and much sickness prevented.

The solution loses its strength if left standing open for any time, but may be kept for several days if kept in a tightly stoppered bottle. If so kept, it becomes a very handy germicide to use during the harvesting and threshing season. The water used about the cookhouse and for drinking purposes in the field and about the threshing machine can be made safe and the amount of typhoid fever and other intestinal trouble made much less.

Lime Process.—Lime is sometimes used for purification of water. About two to three pounds of quick lime is required for 1000 gallons of water. If the water is very hard, a larger amount must be used. The quick lime is slaked in a pail of water and is then added to the cistern or reservoir full of water, and stirred in thoroughly. The action of lime is much slower than that of the Chloride of Lime, as the lime requires about 24 hours to sterilize the water. The chief difficulty in the use of lime is the accumulation of sediment in the bottom of the reservoir due to the settling of the lime. The bulk of sediment is many times the bulk of the lime used and frequent cleaning is necessary. The hypochlorite treatment is recommended rather than the lime treatment.
SECTION IV.

THE WATER SUPPLY SYSTEM

Pumps and Pumping. In general, there are only two types of pumps: (a) pumps in which the water is lifted by the action of a roughly star shaped runner, or runners, revolving rapidly within a somewhat closely fitting case, the centrifugal type. (See Fig. 18.)

(b) Pumps in which the water is lifted by the action of a sliding piston or plunger, the reciprocating type.

The ordinary centrifugal pump is not adapted for use in deep wells, but is well adapted to pump from shallow wells or from streams and canals. The lower end of the intake pipe of a centrifugal pump should be fitted with a good foot valve or else it will be necessary to prime the pump every time it is
used unless the pump itself is below the water level. The efficiency of centrifugal pumps when properly installed and operated is about the same as that of reciprocating pumps.

Reciprocating pumps are commonly divided into two classes: the lift or suction pump (Fig. 13) and the force pump (Fig. 14).

![Fig. 13 - Lift Pumps](image)

In both classes of pumps the water is drawn into the cylinder by suction, therefore the cylinder cannot be much over 25 feet above the water and work at all, and for good service it should not be over 20 feet above the water. The closer the cylinder is to the water the better.

Deep Well Pumps.—As the available power is always limited, pumps intended for use in deep wells or for raising water to great heights are made with cylinders of smaller diameter than those intended for use in shallow wells. In this way a greater
The intensity of pressure may be had from the available power and consequently the water may be lifted or forced to greater heights.

The Air Lift.—While not a pump in the accepted use of the word, it is sometimes used for raising water from wells. This manner of raising water consists in forcing compressed air through a small pipe inserted within the casing of the well and the air emerging from the pipe near the bottom of the
well can escape only by passing upward between the air pipe and the casing. As the air rises the water is carried along with it and is forced out at the top of the casing, as shown in Fig. 15. For good service the height of lift above the surface of the water in the well should not be over one-half the depth of the air discharge below that surface. The air lift is not recommended except for unusual conditions.

Hydraulic Ram.—All the methods of raising water so far given have required some form of power. The hydraulic ram uses the water itself as motive power. The hydraulic ram may be used when the water from a flowing well or spring, or other source may be supplied to the ram under a head of 4 feet or more. There must be free drainage away from the ram. The supply head should not be less than 4 feet and the supply not less than 4 gallons per minute. Two typical forms of ram installation are shown in Fig. 16.

The amount of water delivered by a good ram, properly installed, may be estimated from the following table taken from the catalog of one of the
large manufacturers of hydraulic rams. In this table the height of the storage reservoir above the ram is given in terms of the supply head "h" (See Fig. 16) and the water delivered to the storage reservoir is in gallons per day per gallon per minute supplied to the ram.

<table>
<thead>
<tr>
<th>Height of reservoir</th>
<th>2h</th>
<th>3h</th>
<th>4h</th>
<th>5h</th>
<th>6h</th>
<th>7h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallons stored</td>
<td>540</td>
<td>336</td>
<td>240</td>
<td>192</td>
<td>160</td>
<td>137</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height of reservoir</th>
<th>8h</th>
<th>9h</th>
<th>10h</th>
<th>15h</th>
<th>20h</th>
<th>30h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallons stored</td>
<td>120</td>
<td>107</td>
<td>96</td>
<td>64</td>
<td>43</td>
<td>24</td>
</tr>
</tbody>
</table>

If you wish to find out whether a ram can be used in your case, and how much water you may expect to deliver into your reservoir should you install a ram, proceed as follows:

1. Determine the capacity of a washtub or other large vessel and then find out how long it takes your supply to fill it. From this you can find the supply in gallons per minute.

2. Find the difference between the level of the surface of the water in the source of supply and the place where the ram is to be installed, that is, find the supply head "h"
(See Fig 16). (The ram should be placed reasonably close to the source of supply.)

3. Determine the height above the ram that the water is to be delivered to the reservoir and divide this height by the supply head "h."

4. In the table, multiply the number of gallons found underneath this quotient by the number of gallons per minute of supply, and the result will be total gallons per day delivered to the reservoir.

To illustrate—Suppose we find (1) the supply to be 7 gallons per minute; (2) the supply head "h" to be 5 ft.; (3) height of reservoir above ram 45 ft. Then 45 divided by 5 equals 9. Underneath 9h in the table we find 107, whence the number of gallons per day delivered to the reservoir is found to be 107 multiplied by 7 equals 749.

The hydraulic ram when once installed and put in operation, operates continuously, night and day with the minimum of expense for repairs; its life is long and its first cost is not great. Wherever conditions are at all favorable for its installation, it is highly recommended.

Sources of Power. The sources of power used on the farm are: windmill, gasoline engine, electric motor, steam engine, and water power. Any of these may be used both for pumping and for operating machines about the farm. For this reason, when selecting the source of power to be used for pumping we should consider the service which may be had from that source when the pump is not in operation.

Water Power.—Wherever there is an opportunity to install a water power plant on the farm, it is found to be a most economical and dependable source of power; and when combined with an electric generator and other electric appliances, the power system is the most convenient possible. As the opportunities for farm water power installations are very few, a further discussion will not be undertaken.

In discussing the sources of power, we will consider, first
cost, operating expense, dependability, serviceability and convenience.

A windmill ranks high in economy, the operating expense being almost negligible, but on account of varying wind velocities it is not dependable. In the hot summer days, when water is most needed, there is usually less wind than in the colder weather when water is less needed. It is not uncommon that the farmer who depends upon the windmill for his pumping, is forced to resort to hand pumping at the time of year when he can least afford the time, or else he must have a small gasoline engine for use at such times. To avoid this difficulty, a very large storage reservoir is needed. This reservoir must hold enough water to tide over any probable period of calm weather. A windmill used in connection with such a reservoir and with a proper distributing system may make a very convenient water supply system.

On account of the variable power output of a windmill, it is limited in service. Many attempts have been made to devise methods of storing the excess output at times of high wind and making it available in times of calm, but all attempts, so far, have been only partially successful. The most successful attempts have been made in using a power windmill to drive an electric generator.

"A windmill electric power plant requires:

1. A windmill of a size sufficient to develop the amount of power required: A 12 foot or 16 foot steel wheel on a tower sufficiently high to raise it above any nearby trees or buildings will generally be sufficient.

2. A speed regulator, the object of which is to so control or transmit the varying speed of the mill as to produce a constant speed for generation, even though the load of the generator may be varied.

3. A generator suitable to the amount of power developed by the mill, and also designed to work with the governor pulley being used.

4. A storage battery of a size sufficient to store a supply
of electricity to be used during calm days. With this outfit, energy might be used from two to ten days without wind, depending, of course, upon the amount of current used and the size of the storage battery.

"5. A switchboard conveniently placed and so connected with the apparatus that the entire charging operation is automatic.

"The following points must be kept in mind before a windmill electric lighting and power outfit is made a success:

"1. A good wind velocity (20 miles per hour) must be at hand at least six hours during every week.

"2. The erection and use of an efficient mill.

"3. The necessity of a device which would work as a check valve, permitting electricity to flow into the battery, but not permitting it to go out again when the wind stops blowing. The automatic cut-out and cut-in must be ready for operation at any time and should not have any coils in circuit with the battery when not in use.

"4. An automatic, self-regulating switchboard.

"5. A practical method for storing the energy several days."

The following table shows the number of hours a good 16 foot mill must run, utilizing various winds, to store up enough electricity to light 10 sixteen-candle power lights for five hours:

<table>
<thead>
<tr>
<th>Velocity of wind miles per hour</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time required</td>
<td>10</td>
<td>3.5</td>
<td>1.7</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The cost of such a plant, including windmill, generator, storage battery, and housing, is about the same as the cost of a plant of the same capacity, consisting of a gasoline engine, generator, storage battery and housing—$400 and up.

With such a plant the power generated by the windmill is stored so as to be used when desired, not only for pumping water, but for running the fanning mill, chop mill, grindstone, cream separator and other farm machines as well as to run the washing machine, the electric sweeper, the ice cream
freezer, the electric flat iron, and other equipment installed to lighten the work about the house.

With such a plant, the windmill adds dependability and convenience to its economy of operation and becomes a most desirable source of farm power.

Experiments are now being conducted at the State College of Washington in an attempt to devise a simpler speed control and simpler automatic devices for the switchboard than those now in use. The results already obtained give promise of complete success.

Gasoline Engine.—The modern gasoline engine is nearly, if not quite, as dependable as the steam engine and thus takes high rank in dependability. When properly mounted on a small truck, it can be moved about the farm and used for many purposes. In this way it becomes very convenient and serviceable. Its first cost is not high but it is comparatively short lived and its operating cost is fairly high. When operating at its rated capacity the gasoline engine does its work efficiently and cheaply, but it will not carry any overload at all. When operating at less than full load the fuel cost is very high, being nearly or quite the same as when fully loaded. The convenience of the gasoline engine may be increased by combining it with an electric generator, but the cost is correspondingly increased.

The steam engine is dependable but its first cost is high, its operating expense is high, especially when used only a short period at a time, and because of its size and the difficulty of moving it about, its convenience and serviceability are very much less than some other sources of power.

Electric Motor.—Electric power is the most convenient and serviceable, and whenever such power can be obtained from a cross country line it is very dependable. Electric motors are not high in first cost and are comparatively long-lived, having an ordinary life of twice that of a gasoline engine. As with the gasoline engine, the high operating cost is its one draw-
back. The following table gives a comparison between a gasoline engine and an electric motor of the same horsepower:

<table>
<thead>
<tr>
<th>H.P. of Motors</th>
<th>Weight in Engine Pounds</th>
<th>Floor Space, Inches, Approx.</th>
<th>Price Engine</th>
<th>Price Motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1200</td>
<td>30x50 28x36</td>
<td>$175.</td>
<td>$100. $150.</td>
</tr>
<tr>
<td>3</td>
<td>650</td>
<td>25x45 23x28</td>
<td>80.</td>
<td>70. 90.</td>
</tr>
<tr>
<td>2</td>
<td>350</td>
<td>24x30 21x24</td>
<td>60.</td>
<td>60. 90.</td>
</tr>
<tr>
<td>1</td>
<td>200</td>
<td>18x30 16x20</td>
<td>50.</td>
<td>50. 65.</td>
</tr>
<tr>
<td>1/2</td>
<td>60</td>
<td>12x16</td>
<td>35.</td>
<td>45.</td>
</tr>
</tbody>
</table>

A gasoline engine requires about 0.18 gallons of gasoline per brake horse-power hour. An electric motor requires about 0.9 kilowatt hour per brake horse-power hour. On this basis gasoline at 20 cents per gallon is the equivalent of electricity at 4 cents per kilowatt hour. But we should remember that an electric motor will last as long as two gasoline engines and for this reason we can afford to pay a little more for electricity; that the electric motor will always deliver its full rated capacity and for short times will carry a 25% overload without difficulty; that the motor operates at all times without noise or vibration; that the gasoline engine is dependent upon proper adjustment of valves and sparking to give even rated capacity, and that there is always a great deal of noise and vibration.

A one-half H.P. motor is sufficiently large to run any one of the small farm machines, such as fanning mill, food chopper, cream separator or churn. When it is learned that a one-half H.P. motor can be carried easily from one place to another by one man its great convenience is seen. When the farm buildings are once wired a small motor becomes of service anywhere.

Several companies are now putting out farm lighting plants consisting of a gasoline engine, an electric generator, a storage battery and switchboard. These are set up, connected and arranged with automatic controls ready for use. They are usually of small size as they are intended to produce only sufficient power for lighting the house and other farm buildings, and are not intended for general power purposes. The same
arrangement, with larger capacity, could be used for a general power plant.

Storage of Water. That the water may be convenient for use it is necessary that a pressure system be installed. Some sort of storage is necessary unless water is obtained from a large spring or similar source located at a point above the house. There are three common ways of providing for this storage: (1) The hill reservoir. (2) The elevated tank. (3) The pneumatic pressure tank. The first two of these operate alike and are here treated separately only because they are applicable to different local conditions.

The Hill Reservoir.—This is valuable only for such houses as have a hill nearby that is considerably higher than the peak of the house and other farm buildings. An excavation large enough to hold several days supply of water is made in the earth at the top of the hill. The excavation is lined with brick set in cement mortar, or better with a 6-inch wall of concrete and then covered over with a concrete slab or brick arch. All inlet, outlet and overflow pipes should be carefully built into the walls. The cover of the reservoir should be about two feet underground. This depth of earth cover prevents freezing in winter and keeps the water in the reservoir from becoming warm in summer. An opening of about two feet in diameter should be brought up to the surface of the ground, so that access may be had to the reservoir for purposes of examination or possible cleaning. With a force pump water is forced into this reservoir and from the reservoir is distributed to all parts of the farmstead. A pressure water heater may be installed in the house and hot and cold water may be had in the kitchen, bath room and laundry, and water may be had at the stock trough or other places at the barn, simply by opening a cock.

If the source of power operating the pump is not very dependable the reservoir should be large enough to hold sufficient water to tide over any probable period of scant supply. Generally the reservoir should have two chambers, each connected with the inlet, outlet and overflow pipes. In this way one
chamber can be used when the other is being cleaned or repaired and a supply of water is insured at all times.

The Elevated Tank.—A wooden or metal tank large enough to hold the necessary supply of water may be constructed on the top of a tower sufficiently high to furnish the desired pressure. Its operation is exactly the same as that of the hill reservoir, the tower, instead of the hill, furnishing the necessary elevation. But the elevated tank is not protected from changes in temperature and the water becomes warm in summer and is liable to freeze in winter. Unless the tank and the connecting pipes are carefully surrounded with frostproofing there will be some trouble with broken pipes in cold weather. If it is desired to use the water for lawn sprinkling or fire protection purposes the tank tower should not be less than 30 feet high.

PLATE V.—Elevated Tank Water System.
The Pneumatic Pressure Tank.—Water and air are pumped into a large water and air-tight tank. The outlet pipe from this tank is at the bottom.

Since the discharge from a hill reservoir or an elevated tank is by the action of gravity only, it is necessary to increase the height of the reservoir hill or the tank tower to increase the pressure. On the other hand, since the pressure tank operates in opposition to gravity it is only necessary to pump more air and water into the tank to increase the pressure. In this respect the pressure tank has an advantage over the other ways of storage, since the pressure may be increased at will without additional cost.

It is customary to place the pressure tank in the basement of the house or barn, or to bury it in the ground with one end projecting into the basement. It must be fitted with a water gauge so that the quantity of water in it may be determined at any time. It must also be fitted with a pressure gauge so that the pressures may not run so high as to burst the tank, nor run so low that there is no discharge of water. The pressure gauge should be in a conspicuous place, such as immediately over the kitchen sink, so that the pressure will be under observation at all times.

When the tank is placed in the basement or buried in the ground, there is very little chance for the water in it to freeze in winter or to get warm in summer. The principal objection to the tank is that the pressure falls off rapidly as water is drawn from the tank.

Tanks may be had of any capacity between 100 gallons and 20,000 gallons. The operating capacity of any tank is only three-quarters the rated capacity, as there must always be sufficient air in the tank to provide the required pressure. Any good force pump may be used to force the water into the tank, but it is best to secure a pump made for use with these tanks. These pumps are provided with an air valve through which the proper amount of air is drawn into the pump and forced into the tank with the water to keep up the pressure. Unless
such provision is made, it will be necessary to force the required air into the tank with a small air pump. (The regular pump would operate as an air pump for this purpose, if the suction pipe below the cylinder could be taken from the water.)

PLATE VI.—Pneumatic Water System.

There will be but little difference in the cost of construction of the three types. A very high tower or large tank will be costly, but so will be a large sized pressure tank or a long
line of pipe to the top of a distant hill. The local condition determines the cost.

The advantages and disadvantages may be summarized as follows:

<table>
<thead>
<tr>
<th>Hill Reservoir</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Constant temperature.</td>
<td>Limited availability.</td>
</tr>
<tr>
<td>Constant pressure.</td>
<td></td>
</tr>
<tr>
<td>Low upkeep cost.</td>
<td></td>
</tr>
<tr>
<td>Water in reservoir always available for use.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Elevated Tank</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Constant pressure.</td>
<td>Water warm in summer and freezes in winter. Consequently high upkeep cost.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure Tank</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantages</strong></td>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td>Constant temperature.</td>
<td>Variable pressures.</td>
</tr>
<tr>
<td>Complete pressure control.</td>
<td>Water in tank not all available.</td>
</tr>
<tr>
<td></td>
<td>Medium upkeep cost.</td>
</tr>
</tbody>
</table>

From this summary, it is evident that the hill reservoir is to be recommended wherever there is opportunity to construct it. When the hill reservoir cannot be had, the constant temperature and moderate upkeep cost of the pressure tank probably outweigh the constant pressure of the elevated tank.

4. Household Conveniences. As suggested in the introduction to this bulletin, probably the greatest need and the greatest possible convenience about the farm home is running water, piped to all parts of the house so that it may be had where it is needed by simply opening a faucet. A pressure water system provides for this and at the same time provides for the same conveniences about the barn and other farm buildings.

With a pressure water system, hot and cold water are both "on tap" at the kitchen sink and at the lavatory and bathtub. The inside toilet, with its privacy, protection and convenience, replaces the old outhouse with its semi-public approach, its exposure, and its inconvenience. In the two-story house, water may be had on the second floor as well as on
the first, thus saving the labor of carrying water up and down long flights of stairs. A laundry may be provided in the basement or in some other part of the house, if desired, since it will be no longer necessary to keep near the pump to avoid the long carry of the large amount of water used on wash day. In fact, the labor involved in preparation of vegetables, in cooking, in scrubbing, in washing, and in all other work about the house where water is used, will be much reduced.

The woman in the house is as much entitled to pressure water as the man on the farm is entitled to the combined harvester or the header or other machines for reducing his labor. Besides helping the woman so much, the installation of a pressure water system helps the man about the barn. The watering trough is always full of water or quickly and easily filled without the labor of pumping. Water is handy at the hog lot and at the slop mixing barrel. In short, the help afforded by the convenience of pressure water about the barn is almost as great as that about the house. A pressure water system is not a one-sided help, as are most farm machines, but it is a help to the whole family.

Plate VI. shows the installation of some of the household conveniences that have been mentioned. In the figure, a pressure tank is the indicated source of supply, but a hill reservoir or an elevated tank would serve just as well.

Figure 17 shows the best method of making the connections to a pressure water heater tank. In the figure, pipe A is the main supply pipe, pipe B leads from the heater to the water back or heating coils in the kitchen range, pipe C leads from the heating coils to the storage tank. The pipe C should always slope up from the heating coils toward the tank. D is a small hole in the main supply pipe to prevent siphonage. With the connections as shown, hot water may be had in a very few minutes after the fire in the range is started.

**Fire Protection.** It is not probable that any water supply system that may be installed on a farm will be adequate to put out a fire that is once under good headway; but taken
Pressure Water Heater Connections

Fig 17
at the beginning, the fact that a large supply of water is available for immediate and continuous use, makes it possible to put out a fire that could not be checked by pump and bucket methods. It should be kept in mind that large pipes give much better service than small ones in putting out fires. For this reason, it is true economy to make the main pipes large enough to supply all the taps at the same time.

SECTION V.

COSTS

For the filter shown in Fig. 12, the following quantities of materials are needed:

For the filter box:
Portland cement ........................................... 7.0 bbls.
Sand .......................................................... 2.0 cu. yds.
Crushed rock or screened gravel for concrete—4.2 cu. yds.

For the filtering material:

Crushed rock or screened gravel................. 1 cu. yd.
Sand (for a depth of three feet).................... 3.0 cu. yds.

Quantities rather than costs have been given as the prices of the materials may vary from time to time or from place to place.

Pumps. The cost of lift or force pumps of such sizes as are usually used on the farm, is only a few dollars. There are so many different sizes and styles of pumps used that the actual cost prices cannot be given in this bulletin. For hand pumps, ready to operate when installed, the prices range from $3.00 for an ordinary pitcher pump, to $35.00 or $40.00 for a good, brass cylinder, deep well outfit. Windmill pumps range from $15.00 for a shallow well to $40.00 or $50.00 for a deep well pump. Power pumps range from about $25.00 on up, depending upon size and type. A pump jack, for connecting any ordinary pump to a gasoline engine or an electric motor, will cost about $12.00.
Centrifugal pumps usually cost a little less than reciprocating ones of the same rated capacity.

Probably the best hydraulic ram manufactured, of a size for use under the conditions set forth in the illustrative problem in this bulletin, will cost from $50.00 to $55.00 for the ram itself. Installation and piping will cost about the same as installation and piping for a windmill pump. The cost of hydraulic rams varies from about $45.00 for an installation where the water supply is four gallons per minute, to $700.00 where the supply is over 400 gallons per minute.

**Power.** A ten-foot windmill, with fittings for direct connection to a pump and set on a steel tower 40 feet high, will cost about $100.00, plus the erection. A twelve-foot mill, under the same conditions, will cost about $130.00. Power windmills cost a little more than pumping mills, but are more efficient.

Approximate costs of gasoline engines and electric motors are given in the body of the bulletin. The higher prices of motors are for single phase alternating current motors; the lower prices are for direct current motors. Before purchasing a motor, always consult the company furnishing the electricity, as the motor must be of the type required by the current furnished.

**Storage.** The hill reservoir can be entirely constructed by the farmer, himself, with the assistance of his regular help. In this case, the money outlay would be for materials only. An excavation fourteen feet long, seven feet wide, and ten and one-half feet deep would be required for a reservoir of sufficient size to contain 4000 gallons. A reservoir of this size should be divided into two chambers, as described in the bulletin.

If a concrete lining is to be used, the excavation should be carefully trimmed to the given dimensions and the earth used for the outside forms for placing the concrete. The side walls should be six inches thick with a small amount of reinforcement to prevent cracking; the bottom, six inches thick, with
sufficient reinforcement to prevent cracking caused by settlement; the top, six inches thick, reinforced to carry the two feet of earth cover safely; the partition wall twelve inches thick will require a small amount of reinforcement to prevent cracking when one chamber is empty. This construction leaves the water chambers each six feet by six feet by eight feet deep. The materials required for the concrete lining are as follows:

Portland cement ................ 72 sacks or 18 bbls.
Sand ................................. 5.5 cu. yds.
Screened gravel or crushed rock ........ 10.6 cu. yds.

The amount of reinforcement required will depend somewhat on the character of the soil in which the excavation is made. For average conditions, the top slab will require three-eighths inch round steel rods spaced five inches apart running one way across the slab and one foot apart the other way. In good firm earth, the bottom slab should have about the same reinforcement. For the side walls, vertical rods spaced one foot apart for half the height from the bottom and two feet apart for the remainder should be sufficient in any soil.

The total amount of excavation required is forty cubic yards.

A wooden tank, of the same capacity as the hill reservoir noted above, placed on a steel tower thirty feet high, will cost approximately $275.00 exclusive of erection.

A 2000-gallon pressure tank will cost about $300.00 exclusive of installation.

The cost of the piping and installation for the three types under circumstances favorable to each, would be about the same and would depend entirely on local conditions.

Conveniences. Since the cost of installation is usually one of the largest factors in the total cost of sanitary household equipment, it will be necessary to consult your local dealer or plumber to determine the cost of pressure water heaters, bathtubs, sinks, and other household equipment.
CONCLUSION

If pumping is done by hand from a well of any considerable depth, the cylinder must be of small diameter and the discharge will be correspondingly small. Even when a windmill is used in direct connection with a pump, it is best to use a cylinder of small diameter so that the mill will pump with light winds (eight miles to twelve miles per hour). But when a gasoline engine or an electric motor is used, power is supplied at a constant rate and the pump should be selected to use this power. This allows the selection of a pump with larger cylinder and consequently less time is required to do the pumping. A 2 H. P. motor, connected to a pump of proper size, will deliver about 150,000 gallons of water one foot high in one hour. This is the same as pumping 1500 gallons per hour to an elevation 100 feet above the surface of the water in the well. The motor will require from 5 to 6 KW. hours of electricity to do this pumping. Or, if a gasoline engine is used, it will require from one and one-fourth to one and one-half gallons of gasoline.

Should you attempt to pump this quantity of water by hand at one time, you would become tired out long before the job was completed. Thirty cents worth of gasoline and the wear and tear on the engine are the dollars and cents offset against extreme weariness and a scant water supply. Convenience cannot be measured in dollars and cents. Besides the saving of time and strength, there is a satisfaction in having what you need, and this satisfaction is increased by the pleasure which replaces the drudgery.

Note: We wish to acknowledge our indebtedness to the following texts and bulletins, which have been consulted and freely used:

Public Water Supplies, Turneaure and Russel.
Home Water Works, Lynde.
Bulletin No. 105, North Dakota Ag. Exp. Sta.
LIST OF BULLETINS

Published by the Extension Department,
The State College of Washington
Pullman, Wash.

4. Forest Windbreaks as a Protection to the Light Soils of the Columbia River Basin.
7. Care of Milk on the Farm.
8. How to Organize a Club and Keep Up Interest.
10. The Products of the Farm Slaughter House, Sausage Kitchen and Smoke House.
12. The Culture of Carrots.
15. Lime Sulphur Plant for the Manufacture of Lime Sulphur at Home.
16. The Hot School Lunch for Rural Schools.
17. Simple Forms of Table Service.
19. Pea Growing in Spokane County.
CONCLUSION

If you choose to have a hand pumped well at any considerable depth, the cylinder must be a small diameter and the charge will be correspondingly small. Even when a windmill is used, it will be necessary to have a cylinder of small diameter, because it is not possible to pump with high winds (eight miles to ten miles per hour). But when a gasoline engine or an electric motor is used, power is supplied at a constant rate and the pump may be selected to meet this need.

This is a self-erecting automatic centrifugal pump, and the required one horse power will deliver about 250,000 gallons of water, and 100,000 gallons of water is delivered in one hour. The water will be self-circling, obtaining a sufficient supply of water in the well. The motor will start with automatic control and automatic regulation to do the work when it is used. It will require from one and one-half to two and one-half gallons of gasoline.

Should you attempt to receive this quantity of water per day of any time, and you have no automatic control, you will have to make some provision for this. There are many kinds of automatic control, and the one horse power will deliver the water that is needed. This is a small motor and it cannot be measured in dollars and cents. Simply the fact that a small motor costs a few dollars and the electricity is spent, and the motor is a self-circling, automatic control, which explains the economy.

A number of firms are producing what they call automatic control, and no one of them is doing it. We are to determine our necessity for the following laws and conditions, which have been suggested and which are well known.

1. The time and pressure of the water delivered to the well, and the motor that are self-circling, automatic control, which explains the economy.

2. The time and pressure of the water delivered to the well, and the motor that are self-circling, automatic control, which explains the economy.

3. The time and pressure of the water delivered to the well, and the motor that are self-circling, automatic control, which explains the economy.

4. The time and pressure of the water delivered to the well, and the motor that are self-circling, automatic control, which explains the economy.

5. The time and pressure of the water delivered to the well, and the motor that are self-circling, automatic control, which explains the economy.