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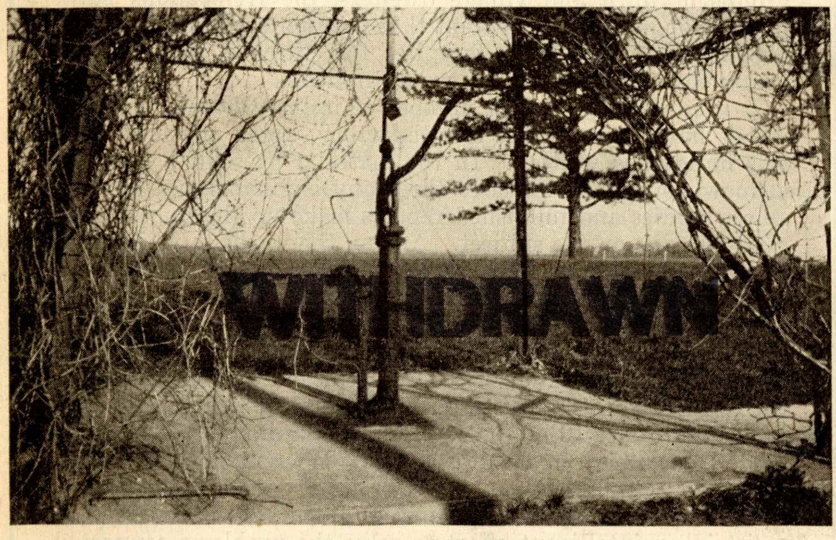
Water Supply for the Isolated Home

LINDON J. MURPHY



Bulletin 114
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Iowa State College Ames, Iowa

THE individual home water supply is still very important in Iowa. Despite our growing urbanization we are still a state of small communities and isolated homes, and as such we are largely dependent upon private water supplies.

That practically one half of the homes in the state must rely on such a supply is evidenced by the fact that 1,184,000 of Iowa's 2,471,000 people live outside of municipalities having public water supplies. 393 organized communities depend upon individually owned wells, and a large number of homes situated on the outskirts of other cities have not yet been reached by water main extensions. Add to these two large groups of town and village dwellers, the tremendous rural population, and it is apparent that the number of Iowa homes dependent upon private supplies for water is large; much larger than a casual survey would indicate.

It is to serve this great number of isolated homes, many of which have unsafe and unsatisfactory water supplies, that this bulletin is written. In the material presented, grateful acknowledgment is made to the many engineers and authors whose studies and published reports make up the public store of knowledge on the subject. Among the works to which particular reference has been made are: The Report of the Iowa Geological Survey, Vol. XXI, on "Underground Waters of Iowa"; Circular No. 14 of the Illinois Department of Public Health on "Dug, Drilled and Driven Wells," by C. D. Gross and Harry L. Ferguson; the U. S. Dept. of Agriculture Bulletin No. 1448 on "Farmstead Water Supply"; and engineering bulletin No. 10 of the Division of Sanitary Engineering, State Department of Health by A. H. Wieters on "Iowa Public Water Supplies."

A study of the general principles given here is intended to assist in an intelligent effort to solve the problems connected with a home water supply and their economic solution.

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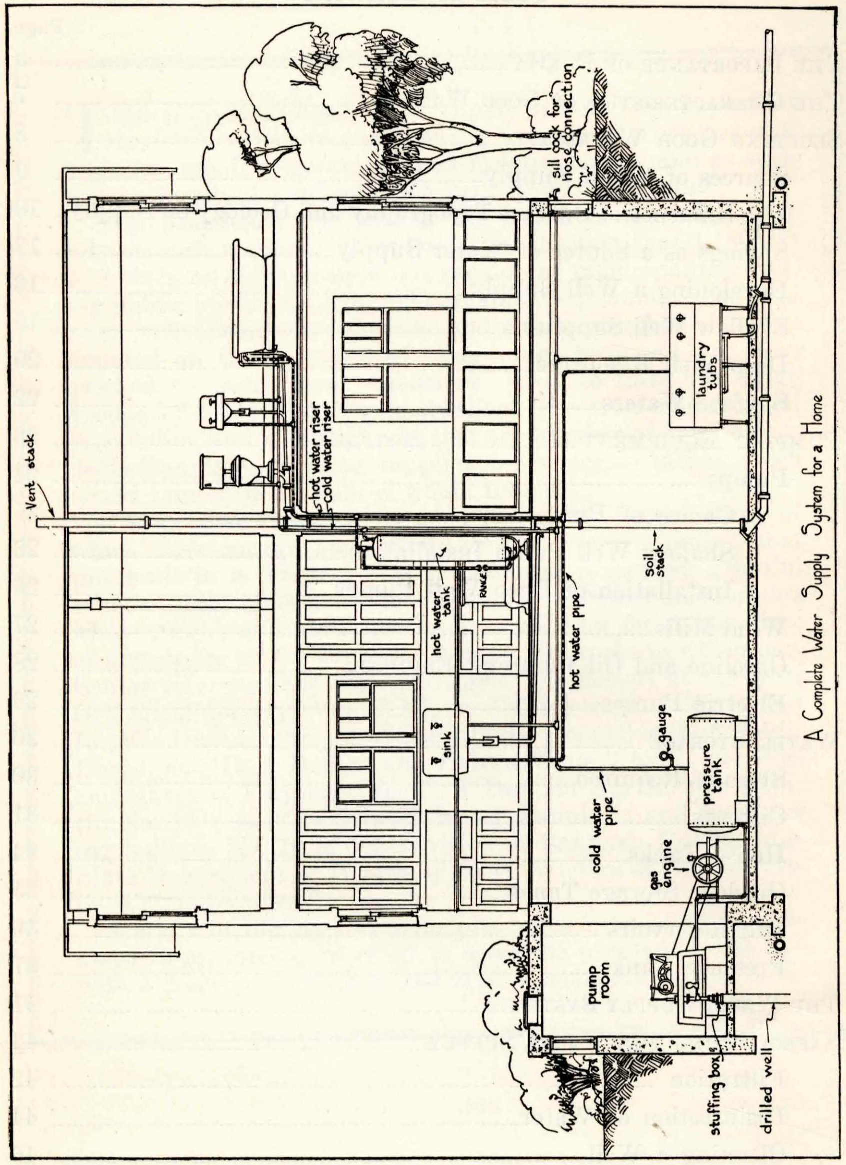

A Complete Water Supply System for a Home

Water Supply for the Isolated Home

LINDON J. MURPHY

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Water is one of the essentials of life. Every home must have a water supply, and to maintain health, that water must be wholesome. Without doubt one of the most important factors in the health and welfare of the modern home is an abundant supply of clean, pure water readily available when and where it is needed.

Because a water supply is our most used utility, the utmost care is warranted in securing the best water available, in protecting the supply against pollution, and in conveying it to the points where it is needed.

Surveys in the midwest have disclosed the startling fact that three out of four existing homestead water supplies show definite indications of pollution. They are bacterially unsafe for human use. The surveys have also shown that only one out of eight farms have water piped into the house. Counting both urban and rural homes the proportion is only one-half. It is obvious that there is still much which needs to be done to make pure water readily available for the isolated residence.

The Importance of Purity

Because appearances are often deceptive the importance of purity in the water is frequently overlooked. Many waters which appear to be clean and colorless, may yet be teeming with harmful bacteria. Disease epidemics and deaths have been traced to the use of water which seemed to be unsatisfactory. A few cases will serve to illustrate this point:

Eight cases of typhoid, one of which ended fatally, were traced to two private wells in a north Iowa town. These wells drew their supply from a limestone formation, and it was discovered later that disease bacteria were reaching the wells through crevices in the limestone from a sewage polluted stream.

One water supply secured from a nicely located and apparently tightly covered dug well began to smell and taste foul, and became the cause of intestinal disorder* An examination disclosed sixteen live frogs and six more or less decomposed. After the well had been

*Reported by the U. S. Dept. of Agriculture.

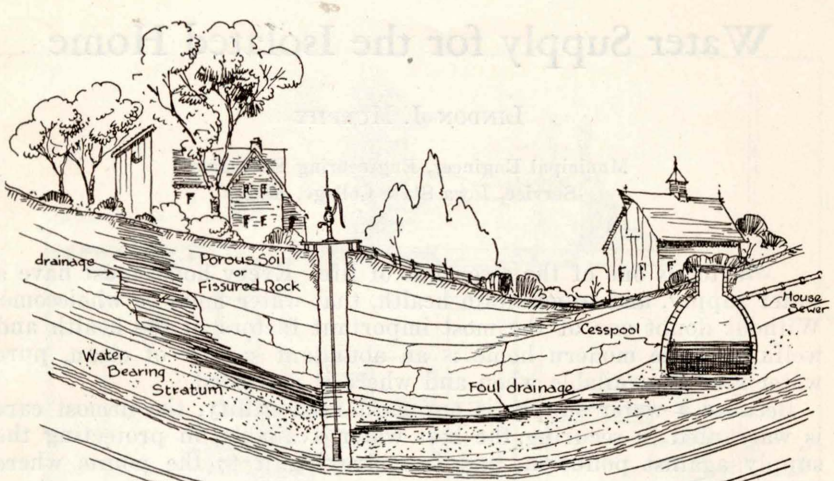

Fig. 1. How Wells Become Polluted.

The drainage from privy, cesspool or barn may seep thru porous soil and follow underground crevices and passageways for long distances to reach a well.

cleaned and pumped out several times the water was entirely satisfactory.

In another community in western Iowa seven cases of typhoid were traced to one well. It was situated on low ground, subject to flooding, and the disease bacteria had gained entrance with other surface contamination through the poorly protected well top and curbing.

These cases merely illustrate the ease with which pollution gains entrance into a well and the hazard of using a water of unknown or questionable quality. It is evident therefore that the purity of the water should be of primary consideration, and it is a sad commentary that this is seldom realized until its importance is brought forcibly to mind by the sickness or death of a loved one.

Disease germs are minute organisms, so small that they cannot be seen by the naked eye; in fact, so tiny that thousands may lurk in a drop of water or in a piece of waste the size of a pinhead. And it is from these unseen germs, lurking in impure water, that we may contract typhoid fever, dysentery, diarrhea, cholera and other intestinal diseases. These bacteria being out of sight are too often out of mind.

With three out of every four isolated water supplies showing sufficient pollution to be unsafe it is evident that most of them should be critically examined. Tests show conclusively, that ditches, ponds and other surface supplies are sure to become contaminated, either directly or indirectly from surface wash. Wells and springs are polluted thru open or loose tops and by foul drainage underground. Particular care must therefore be exercised both in the selection of the source of a water supply and in the protection of a developed one.

The Characteristics of Good Water

Obviously the characteristics of good water depend upon the purpose for which it is to be used. While a water supply may be utilized for many purposes its primary function is for drinking and cooking; therefore its most important qualities are those of healthfulness and safety. Freedom from disease producing bacteria is essential, and it is also desirable that the water be clear, colorless, and cool. It should be free from any mineral substances which would make it hard and unsuitable for washing, and should have no objectionable taste nor odor, and be neither strongly acid nor alkaline.

These characteristics, however, should never be assumed as proof of purity, for a water may possess them all and yet contain millions of disease-producing bacteria. If the water is for any reason suspicious it should be rejected or disinfected until a sample can be tested by a competent sanitary authority such as the town or State Board of Health.*

*Requests for instructions and containers for water samples to be tested should be made to the Water Laboratory Division, State Hygienic Laboratories, Iowa City, Iowa.

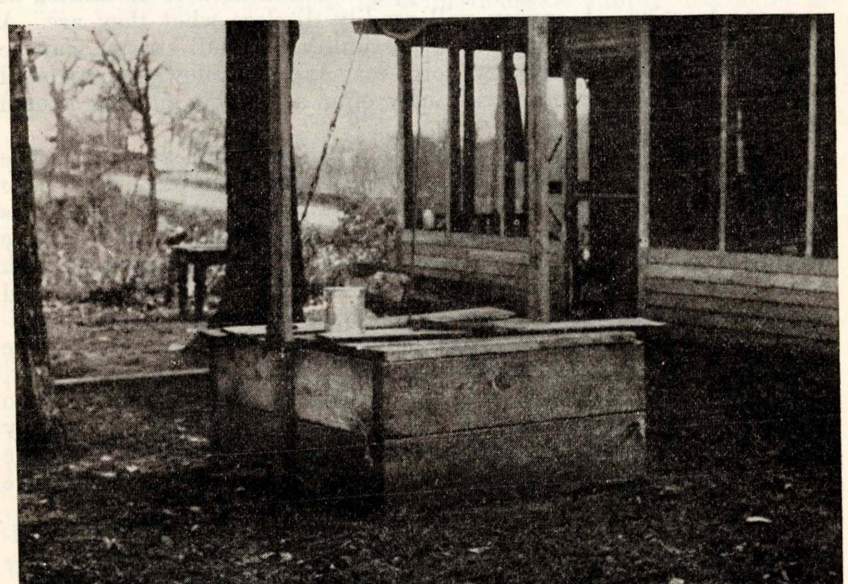

Fig. 2. An Unsafe Water Supply.

Certain to be contaminated by dust, vermin and filth from the hands clinging to the rope and bucket.

Securing Good Water

A satisfactory supply is of such tremendous importance, that one is warranted in going to considerable length to secure a water of proper quality and quantity. While almost every homestead has a water supply of some kind, that supply may be far from satisfactory. It may fail to measure up to modern requirements for health and safety, in that the quantity may have been gradually decreasing until the supply is inadequate; the taste, odor or mineral content may be objectionable, or the existence of pollution may be suspected, with the possibility of afflicting the family with a dread water borne disease. Under any of these circumstances a new water supply may be highly desirable. Where can such a supply be secured?

To answer this question specifically for any one rural home or farmstead, will of course require an individual study of that particular location, as the conditions in various parts of the state differ widely, and the factors affecting the location of a satisfactory supply may vary greatly even between several homesteads in one locality.

We are usually limited in our search to water sources which may be located on the premises, and it is convenient to have the source of water near the house or stock tanks. Likewise economy of development dictates that a source close at hand be secured if possible.

The sources of a satisfactory supply are thus seen to be limited at any one location. A survey will readily disclose what they are. A spring or flowing well may be a possibility; a small stream may be near at hand; an exploratory point may tap a shallow underground supply; or a convenient ravine may offer a suitable site for a dam and reservoir.

In seeking a location the record of existing water supplies in the vicinity may be consulted. Many of our water supplies have been secured thru trial and error methods. Inquiry will disclose details of the trials made and their success. In many sections of the state shallow dug wells have encountered water bearing sand strata which have yielded adequate supplies. Frequently in valley bottoms, sand points driven a few feet into the underlying sands have secured sufficient water. At other localities shallow and even deep wells have failed to get water and impounding reservoirs have been a necessity.

Whatever the sources may be the evidence is usually obtainable to the discerning seeker. Sources which are being utilized successfully for farmstead water supplies may reasonably be expected to prove satisfactory for nearby supplies where the topographic and geologic conditions are similar.

Most well drillers have gained thru experience an intimate knowledge of the underground water resources in the locality in which they operate. Their recommendations are therefore ordinarily sound as to possible sources which may be developed. The Iowa Geological Survey has conducted accurate and painstaking surveys of the water

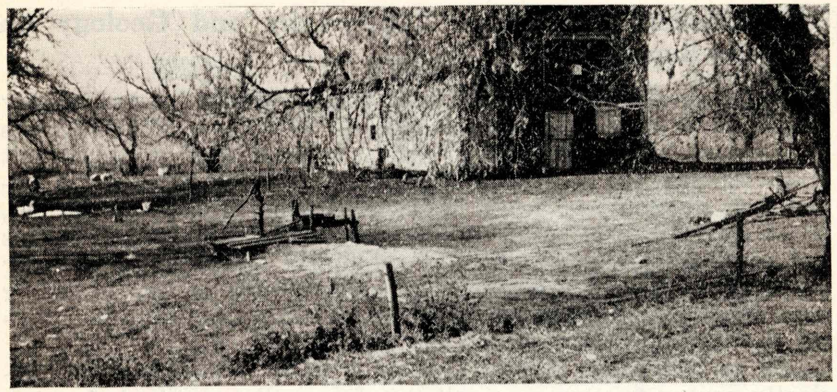

Fig. 3. An Unsafe Farm Well.

Washings from the barnyard are likely to gain entrance to this unprotected and poorly located well.

supply resources of the state, and should be consulted where there is doubt as to possible sources of water.

Sources of Water Supply

All of the water which is used for domestic supply originates as rain or snow. After falling to the earth, part runs off to water courses and streams, and the rest evaporates or seeps into the ground, where it is taken up by plant roots or percolates to lower strata. Much of this moisture is retained locally in porous silt or in layers of sand and gravel found scattered throughout the underlying glacial drift. Part of the water makes its way eventually to the rock formations which in most places underlie the loess and drift of the Iowa plains. Most of the water, however, in these rock passages and storage reservoirs, called aquifers by the geologist, finds entrance into the stream valleys of Iowa, Minnesota and Wisconsin where the formations outcrop at the surface.

It is evident, then, that water for a domestic supply may be sought anywhere from the point at which it may fall as rain, to the deep lying rock formations where it may have penetrated. The decision as to whether it shall be caught on the surface, as in a cistern or impounding reservoir, or whether it shall be intercepted a few feet underground in soil or sand layer, or possibly hundreds of feet down in rock, depends of course on the quality and quantity available at any one stage, and the cost of developing it for use as a water supply.

As the rainfall over Iowa varies but little—decreasing slightly from southeast to northwest—it can be seen that the water resources of the state are largely determined by surface topography and by the underlying geological formations. It may therefore be advisable to examine these briefly in order that we may understand the potentialities in any particular locality.

The Influence of Surface Topography and Geology on Water Supply

The topography of Iowa has been largely molded by two mighty forces. First came five great ice invasions which covered all or parts of the state, leaving deposits of glacial drift as they melted. Great rivers followed the ice sheets cutting large valleys and leaving stratified beds of sand and gravel in their bottoms. The many streams, which originate in or border on the state, follow these ancient valleys and continue this erosion and deposition. In searching for a water supply on or near the surface we are aided greatly by understanding these mighty agencies which have been at work thru the ages forming the very aquifers which we seek.

The surface of the state is covered with till which may be sufficiently porous to serve as a collector for small quantities of water. This is likely to be meager, however, and may fail altogether during prolonged dry periods. Most homesteads must depend, therefore, upon underlying sand and gravel beds in the glacial drift and upon rock aquifers for well supplies.

While all of the great sheets of drift deposited by the glaciers contain some sand and gravel strata scattered at different levels, in the main, water bearing beds are to be expected at the base of the drift where dense, dark grey clays serve to retain the water, thus forming underground reservoirs of varying extent and capacity.

The oldest and hence the deepest-lying glacial drift which has been traced in Iowa is known as the Nebraskan. It covers the entire state, and its deposits form a large proportion of the total drift, particularly in western Iowa. The drift consists of dense, pebbly clay, with occasional deposits of sand and gravel. Where these latter beds are of generous size, and the sand not too fine, they form excellent reservoirs and yield water readily to wells which penetrate the overlying till.

Southern and Western Iowa. The surface drift of southern and western Iowa discloses a second glacial drift sheet, the Kansan, which covered all of Iowa except the extreme northeast corner. It overtops the Nebraskan and is separated from it by a fine textured, dark grey clay, which acts as a floor for the basal sands of the Kansan. These beds constitute the source of many of the shallow wells of southern and western Iowa.

The Kansan and Nebraskan drifts are extremely thick in this section, reaching a depth of over 500 feet in southwest Iowa. While the original drift plain was relatively level, the topography is now marked by deep erosion. Wells on the upland usually reach water in sand or gravel beds in the drift, altho occasionally they may have to be sunk entirely thru to the sand beds at its base in search of water. This is particularly true near the "breaks" along the rivers where water is to be expected only at great depth.

In the deep, wide valleys of this area, shallow wells supply many homesteads. Even here some failures must be expected and it may be

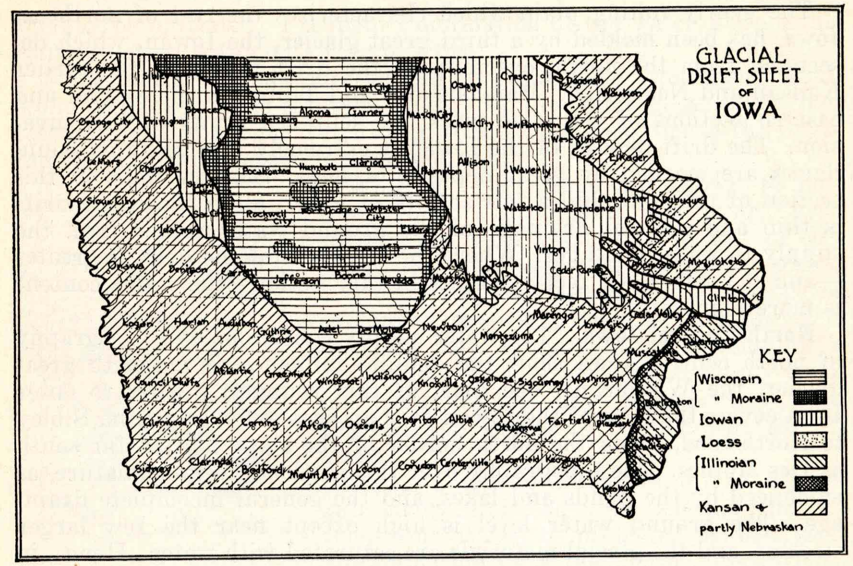

Fig. 4. Glacial Drift Sheets of the State.

Ground water conditions are largely determined by the glacial drifts which cover Iowa. Their extent and character are shown above.

necessary to resort to a ponded supply. Everywhere in southern and western Iowa, the porous, yellow or blue-gray loam (scientifically called loess) which covers the glacial drift is utilized as a source of water for shallow wells. The supply is usually meager, but it may be sufficient for domestic and stock use. In general, water supply conditions in this section are more uncertain than any other part of the state.

Southeast Iowa. The evidence of another glacial invasion has been found in southeastern Iowa, where the drift over a narrow strip between Fort Madison and Princeton (just south of Clinton) has been identified as Illinoian. In general character it resembles the older Kansan and Nebraskan drifts. It is also similar in being topped by a dense, gray gumbo clay, and in containing beds of sand which form a source of water supply. In the bottoms along the Mississippi and tributary streams, well points and dug wells usually find abundant water within a few feet.

Northeast Iowa. In the extreme northeast corner of Iowa we find the only section of the state not covered by glacial drift later than the Nebraskan. The topography is extremely rugged, and much of the drift has been eroded away. The upland covering is thin and well drained, hence most wells find insufficient water in it, and so must penetrate the underlying country rock. The valleys contain considerable coarse material which supplies abundant water to wells.

The gently rolling plain which characterizes the rest of northeast Iowa, has been molded by a third great glacier, the Iowan, which descended from the north, overtopping the drift plains of the earlier Kansan and Nebraskan. Marshalltown and Tipton in the central and eastern sections of the state mark the southern limits of this invasion. The drift deposit of the Iowan is extremely thin altho its boundaries are marked by great deposits of loess. Shallow wells in this section of the state find a fair supply of water, altho where the drift is thin and natural drainage of the ground water rather free, the supply to wells is meager. Where the thickness of the drift is greater —and it reaches 300 feet at points in this section—the water content is more abundant.

North Central Iowa. The water supply conditions and topography of north central Iowa show the definite influence of a fourth great glacier, the Wisconsin. The drift of this youngest glacier to enter Iowa covers the loess of the Iowan over an area extending from Sibley to Northwood, along the north border of the state, and as far south as Des Moines. The topography over this section is very immature, as evidenced by the ponds and lakes, and the general incomplete drainage. The ground water level is high except near the few larger streams, and the glacial materials are saturated with water. Hence, in general, shallow wells find an abundant supply.

Northwest Iowa. Bordering the deposits of loess which mark the west boundary of the Wisconsin glacial drift, is a lobe of the Iowan drift. The covering here is thin and the supply to shallow wells meager. Some wells find water in the porous, fine-textured silt (loess) overlying the older drift sheets, altho most water supplies come from the basal sand layer or a gravel which lies immediately underneath the loess.

Springs as a Source of Water Supply

In a few localities at widely scattered points over the state, springs may be a possible source of water supply. They are merely the emergence on the surface of underground waters and may or may not be satisfactory for water supply.

Many of the springs in Iowa come from limestone formations. Rainwater seeps into the soil, reaches rock, and follows a crevice or channel and later it may emerge in the form of a spring. Sink holes are quite common in limestone regions, and surface water may thus gain entrance and flow for long distances underground in the solution passages of the rock, remaining largely unchanged and unpurified. Hence springs in limestone or dolomite are with good reason looked upon with suspicion. The chances of contamination are so great that they should not be utilized for domestic supply until the purity of the water has been verified by repeated tests. The turbidity of the water should be particularly noticed after rains as pollution may

thereby be indicated. Frequent examination of the water for possible contamination is the only safe practice.

Some of the springs outcropping in Iowa come from sand, sandstone or gravel. The sanitary quality of the water is generally better than that of spring water from rock formations, due to the filtering and purifying action of sand and soil.

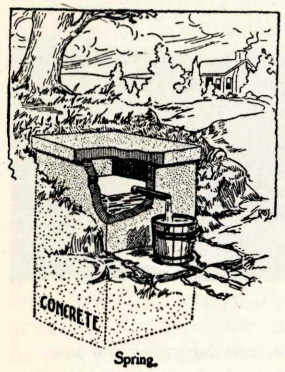

Fig. 5. Protection of a Spring.

Showing the tight curb and cover and the raised fill about the curb.

While a few springs are known to flow continuously throughout the year, most springs are very responsive to wet or dry spells, flowing freely after continued rains, and even stopping altogether in periods of prolonged drouth. Hence it is inadvisable to make any investment in developing a spring for use as a permanent supply until its yield during dry periods has been checked and shown to be sufficient for all needs.

When a spring measures up to all requirements and has been selected for development, it can be protected against local contamination by a few simple precautions. Stock can be fenced away from the immediate vicinity, and a protecting structure erected around the spring. This structure may merely consist of a large size clay or concrete pipe with a cover, or a square reinforced concrete box may be built on top of a stone or brick curb. In either case the top should fit tightly, keeping out all dirt and debris. It would be well to fasten the cover down in such a manner as to even preclude dipping or bailing, and so that water would be available only thru the outlet pipe or by pumping. It is important that the overflow pipe be screened to keep out bugs and rodents.

Developing a Well Supply

Wells are by far the most common source of water supply in Iowa. Because the rainfall over the state is generous, and because the character of the soil and of the underlying glacial drift is such as to favor the storage of water, wells sunk in many sections of the state are likely to encounter water bearing strata.

The development of a satisfactory supply from one or several of the underground aquifers which may be tapped is a matter where experience and judgment enter. It is here that the experienced well driller can be of very real assistance. A location for the well can be selected which will minimize the danger of contamination from surface wash and underground seepage from privy or barn yard. A

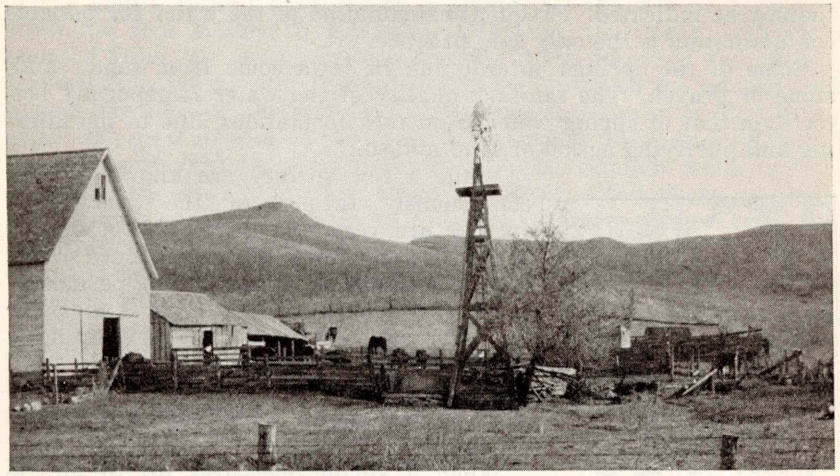

Fig. 6. A Farm Well.

Poorly located so that it is certain to receive the drainage from barnyard and lots.

type of well can be chosen which will utilize most fully the available water resources. There are certain to be many cases in which deeper drilling will reach aquifers yielding more abundantly and in which the level of water in the well will come much nearer the surface. Likewise there will be cases where the opposite will be true, where a sufficient supply might be lost by draining into a porous stratum at a lower elevation. Hence it is often economy to secure the best technical assistance available in locating and sinking the well.

The home owner living in any one of the many small towns or on the outskirts of the larger cities of Iowa is unfavorably situated with regard to securing a satisfactory well supply. Where the location of the well is limited to one small lot, and where there may be improperly constructed privies nearby, the danger of pollution is very great. There is such an opportunity for disease bacteria to find their way into these wells, that a community supply offers the only safe solution to the water problem. And where such a supply is available or where it can be reached by the extension of existing water mains, the protection of health of the individual and family demands the abandonment of the old single lot supplies.

Location. Proper location of the well is one of the simplest ways of avoiding much possible contamination. In general, it should be placed on high ground on the side of the house opposite to the location of the toilet or cesspool, and as far distant as possible from house and barnyard, so that surface drainage from these sources of pollution may be away from and not toward the well. A valley well should be located so it will not be subject to stream overflow for all surface

water is contaminated, and flood flows often contain sewage. Where the ground at the well is apt to be water logged at certain seasons, the danger of pollution getting into the well is increased.

Shallow Well Supplies

Shallow wells serve a very large proportion of the homes in Iowa. They are merely holes in the ground which penetrate to a layer of earth which is saturated with water. As a hole is dug into this saturated stratum, the water runs out and fills the hole. When it is pumped or lifted out the hole again fills. The supply tapped may be large or it may be small. There are few underground streams reached by shallow wells, but in the main, the supply is determined by the character, depth, and water bearing properties of the formation tapped.

Many wells merely penetrate the upper soil. This soil is in most places rather porous and contains a meager quantity of water which may suffice for limited needs. The water taken up from such a well is usually that which fell as rain on the ground within a few hundred feet and then gradually seeped into the ground until it reached clay or other impervious material. Here it is held, the saturated earth forming the water bearing layer which is tapped in digging the well.

It is apparent that the water supply will fluctuate with the rainfall and the season; it may fail entirely in dry weather. Obviously, when the water level falls below the bottom of the well, the well goes dry.

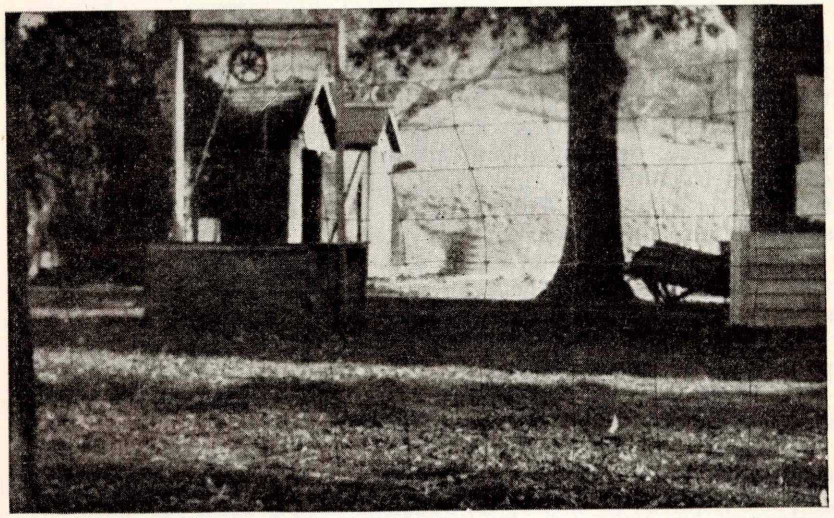

Fig. 7. A Shallow Bucket Well.

Inadequate and rotting wooden curbing; subject to contamination from nearby privies.

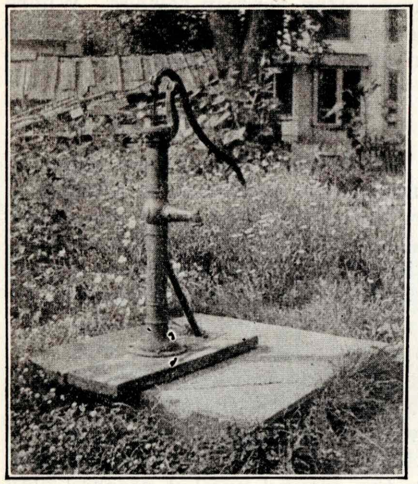

Fig. 8. Private Well Showing Imperfect Concrete Cover.

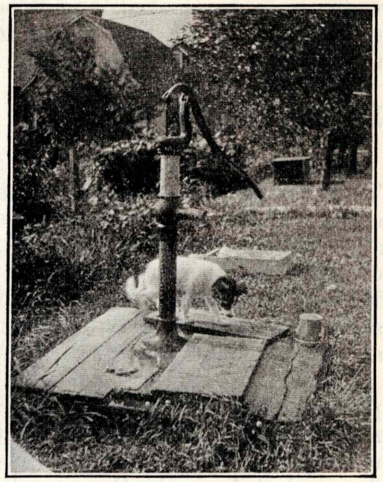

Fig. 9. Many Wells Are Subject to Pollution From Small Animals.

Because the soil is porous, any pollution falling on the surface nearby may also find its way into the well. Hence while such a well is easy to dig and cheap to develop, its supply is likely to be uncertain and its purity questionable.

Many other shallow wells, finding the seepage of the top soil insufficient, penetrate the underlying clay till. Here the deep drift of the Kansas glacier serves as the medium for collecting and holding underground water in quantities much more abundant than that supplied by the surface loess. Exploratory drilling may encounter deposits of sand, pebbles or boulders left at random by the glacier, or stratified beds of sand and gravel deposited by the streams coming from the melting ice. Where these beds are underlaid by impervious strata, as they are over most of Iowa, they serve as excellent aquifers.

The valley bottoms, underlaid with sand and gravel, and covered with porous loess in which the water level is ordinarily near the surface, furnish abundant supplies to well points or shallow dug wells.

Construction of Dug Wells. Dug wells are particularly subject to pollution—about nine out of ten showing evidence of contamination—hence special care must be exercised, not only in the location of such a well, but in its construction and protection.

The method of constructing a dug well is dependent somewhat upon the character of the soil in which the well is to be sunk, and the depth and size required to develop an adequate supply from the water bearing stratum. With a shallow dug well of ordinary size the usual method is to have one man dig and shovel the material into a bucket which is hoisted to the surface by means of a block and tackle or

windlass. Where there is any indication of caving, the well should be carefully braced to guard against accident. In loose sand a well may sometimes be sunk by using a sand pump. A curb pipe is mounted on a sharp shoe which sinks as the sand is pumped out. Additional curb pipes are added at the top as needed.

Curbing is advisable in all dug wells in Iowa. Wood soon decays, and may thus permit the entrance of pollution. Vitrified clay pipe, corrugated or cast-iron pipe, brick, concrete block or concrete are commonly utilized. With a well of small diameter, the vitrified clay pipe forms a curb which is particularly satisfactory. It is durable, tight, clean and low in cost.

Whatever the type of curbing, it is usually supported on brick or stone masonry laid without mortar. After the curbing is in place, the space between the curb and sides of the well should be filled with clean gravel and sand, the coarse material being placed at the bottom for the full depth of the water bearing stratum. The upper ten feet should be sealed with clay or concrete. To prevent surface contamination the curbing should be carried at least a foot above ground and should be topped with a tight concrete platform. This cover should slope from the center and the area around the well should be graded up in such a way as to facilitate quick drainage of pump drippings and surface water.

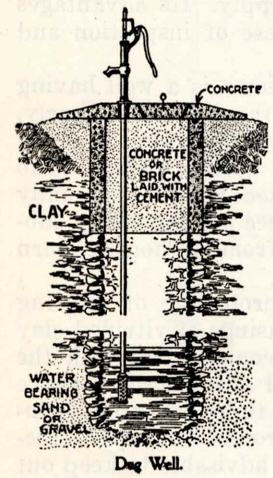

Fig. 10. Protection of a Dug Well.

The concrete well top should be at least 4 inches thick, and may well project a foot beyond the sides of the well. Proportions of 1 part cement to 4 parts clean pit-run gravel are suggested for the concrete mixture. No. 9 fencing wire, spaced 6 inches apart and 1 inch above the bottom of the concrete, will serve for the reinforcing. A tin can may be imbedded in the concrete to serve as a sleeve for the pump. Concrete is built up around this sleeve to a height of several inches to form a sturdy and watertight base for the pump which is later fastened in place by expansion or anchor bolts set into the fresh concrete.

A manhole in the top of the well is not necessary, but if one is desired it must be made watertight. The Sanitary Engineering Division of the State Department of Health recommends a cast-iron or steel manhole cover which overlaps the sides, and can be locked in place. The manhole and cover can be constructed of concrete, altho this type is not advisable unless the cover can be sealed in place with asphalt. While such a manhole is simple and economical to construct, it has the disadvantage of not being entirely water-tight.

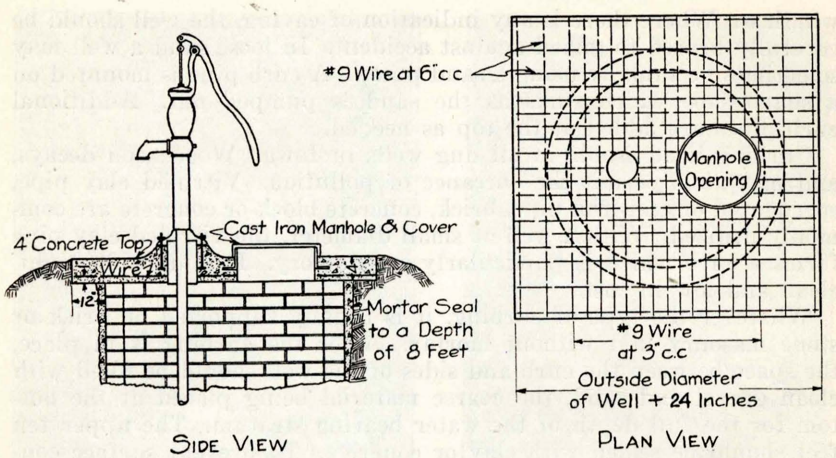

Fig. 11. Details of Well Top Construction.

Hence, unless the cover is sealed on, and this is often impracticable, there is the possibility of pollution gaining entrance to the well.

Where properly located, constructed and protected, a dug well may be entirely satisfactory as a source of water supply. Its advantages are: low first cost, long life, soft water, and ease of inspection and cleaning.

The Bored Well. Very common in western Iowa is a well having many characteristics of the dug well, namely, the bored well. It is made with what is called a well auger, a machine boring a hole 1½ to 3 feet in diameter. Such wells are usually located on low land, hence are especially subject to contamination from outhouses, barn yards and surface wash.

The suggestions for protection of the dug well apply here also. Casings of vitrified clay or concrete pipe are recommended, with the top of the casing carried at least a foot above the ground surface. A tight cover and concrete or asphalt seal around the upper sections of pipe casing are advisable to keep out drippings and surface drainage.

Most bored wells secure their supply from the slow seepage of the glacial drift, hence they may prove inadequate in dry years. As solution to this difficulty it is suggested that instead of a single hole, a series of holes be bored. These should be spaced about 25 feet apart and can be connected by horizontal holes 1 or 2 inches in diameter reaching from the bottom of one to the bottom of another. A single pump in one well may thus draw water from all of them. Iron pipes placed in these horizontal holes will help to keep them open, yet if the pipes are somewhat smaller than the holes, they will not interfere with the considerable infiltration which will seep into these connecting holes. While this method is expensive, it will often be more economical than pumping installations in each of the wells.

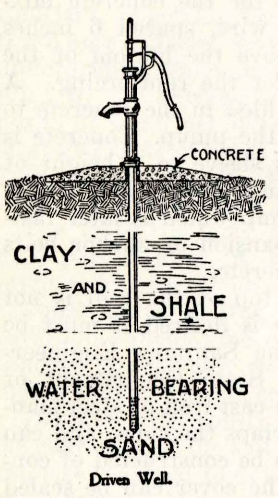

Fig. 12. Construction of a Driven Well.

Construction of Driven Wells. Driven wells are particularly adapted to areas where porous material is found at relatively shallow depths. They are therefore much in favor in the various valley bottoms over the state. In their simplest form they are known as "sand points", and consist merely of a wrought iron pipe, 1 to 3 inches in diameter, with a perforated screen and pointed shoe on the lower end. This pipe with point is driven into the ground till the screen reaches the stratum of water bearing sand and gravel. The pump is mounted directly on the pipe. Where the supply of ground water is generous and where there is no rock, the driven well is the quickest, safest and most economical method of obtaining a water supply. However, with such wells, the strainer frequently becomes corroded and choked within a few years, hence the well may have to be abandoned, or the pipe pulled and redriven.

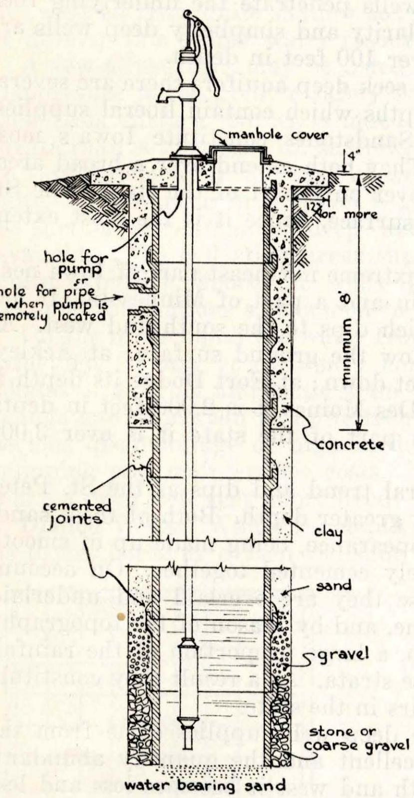

Fig. 13. Construction of a Shallow Well Using Pipe Curbing.

Deep Well Resources

A few isolated homes in Iowa are unable to secure a satisfactory water supply from shallow sources and must therefore look to the deeper lying aquifers. In certain localities in the state, particularly in the southwest section, wells must be drilled several hundred feet deep to reach the water bearing sands and gravels of the glacial drift. Ordinarily, however, the deeper wells penetrate the underlying rock formations. For the purpose of clarity and simplicity deep wells are arbitrarily assumed to be those over 100 feet in depth.

Fortunately for those who must seek deep aquifers there are several rock strata available at known depths which contain liberal supplies. The St. Peter and the Jordan Sandstones constitute Iowa's most abundant deep water resources. They both extend over a broad area, altho they are readily accessible over only part of the state. The St. Peter formation is nearer to the surface, hence it is the most extensively utilized.

This sandstone outcrops in the extreme northeast part of Iowa near McGregor, as well as in Wisconsin and a part of Minnesota. It has the form of a shallow trough which dips to the south and west. At Dubuque it is about 100 feet below the ground surface; at Ackley, 140 miles southwest, it is 1,400 feet down; at Fort Dodge its depth is about the same as at Ackley; at Des Moines it is 2,000 feet in depth and in the extreme southwestern part of the state it is over 3,000 feet below the ground surface.

The Jordan has the same general trend and dips as the St. Peter altho it is found at about 500 feet greater depth. Both of these sandstones are rather distinctive in appearance, being made up of smooth and even particles of silica, loosely cemented together. On account of their porous character, because they are overlaid and underlaid with impervious shales of limestone, and by reason of the topography of the area in which they outcrop, a large proportion of the rainfall in this section percolates into these strata. As a result they constitute the greatest underground reservoirs in the state.

In northeast Iowa most of the deep well supplies come from the St. Peter. Its quality here is excellent and the quantity abundant. As the formation dips to the south and west it becomes less and less desirable as a source for water supply. The water comes in contact with limestone, gypsum, coal and iron deposits and absorbs more and more of the minerals. Hence in southwest Iowa the water in this stratum contains so much iron, calcium and magnesium carbonate and sulphate, that it is unsuitable for domestic use. In places the sulphate content alone is so high as to make the water unpleasant for drinking purposes. The depth of the St. Peter is also so great in central and southwest Iowa, that the cost of its development for a private water supply is almost prohibitive.

Over the Mississippi basin some other minor resources are developed for deep well supplies. Along the river valleys deep wells frequently find local deposits of limestone and gravel underlaid with shale or impervious limestone. These are doubtless fed by percolation thru the overlying porous material and the yield may be meager or abundant.

Deep wells in the extreme northwest part of the state find an abundant supply in the Dakota sandstones. While most farmstead supplies are secured from quite shallow sources, a few have found it advisable to develop this deeper water resource.

A few advantages may be listed for deep well supplies. Of major importance is the greater safety from the health standpoint. Pollution from surface sources is much less likely to reach water bearing strata than is the case with shallow wells. An exception must be made to this statement in the case of wells penetrating limestone or dolomite, for pollution may travel a great distance in these formations. A further advantage of deep wells is the greater supply usually available. The collecting areas supplying these wells are frequently quite extensive, hence the wells do not experience the pronounced seasonal fluctuations so common to shallow wells.

On the other hand, the water from deep wells may be far from satisfactory. It may be extremely hard, containing carbonates and sulphates of calcium and magnesium as well as compounds of iron and manganese which can be quite troublesome. Deep wells also have the serious disadvantage of high initial cost, and in many cases higher pumping and maintenance costs. In addition, corroded casings may make a deep well very short lived.

Drilled Wells. Where the depth to water bearing strata is so great as to bar bored or driven wells, or where rock must be penetrated, it

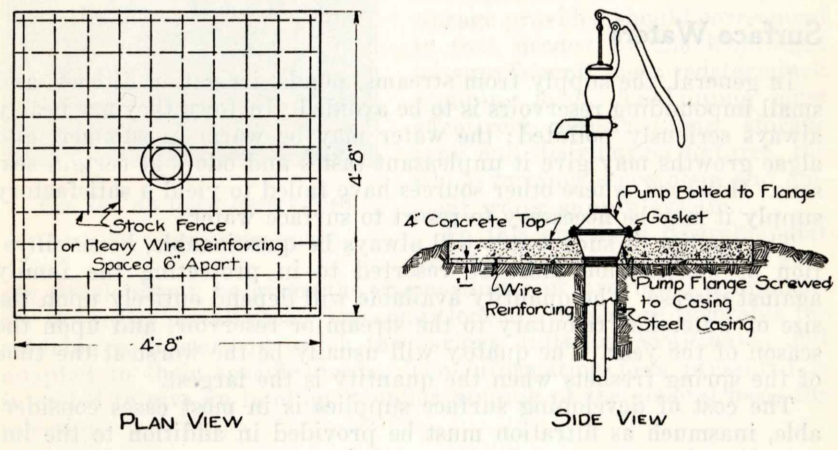

Fig. 14. Details of Well Top Construction for a Drilled Well.

is necessary to use the drill. Drilled wells are common over sections of the state where the drift is deep or where the St. Peter sandstone, the Dakota sandstone, or the scattered limestone formations are relatively near the surface. Drilled wells in the drift reach the deeper beds of sand and gravel from which water is frequently secured under pressure. Where the water bearing material is coarse, such wells are satisfactory; in some, however, the sand is so fine that it rises when the water is pumped. In rock, drilled wells extend thru the drift and penetrate the water bearing sandstones, or seek the joints and solution passages in limestone, which may be charged with abundant water.

Wells drilled into the deeper strata may reach water of excellent quality, inasmuch as the collecting gallery is often extensive in area and at some distance away. The water has thus percolated thru many feet or even many miles of filtering material. The exception to this obviously is the drilled well in limestone formations where little or no purification may have taken place. A second advantage of the deeper drilled wells is that their yield is usually abundant and permanent. It is little influenced by seasonal fluctuations. The water in such wells is ordinarily under sufficient pressure to raise the level high above the bottom of the well, thus reducing the required lift.

The purity of water from a drilled well is dependent largely upon the protection which is provided against the entrance of pollution. Tight, durable casings are the first requisite. They should be of cast iron, wrought iron, or screw joint steel, and should extend to the water bearing stratum in a drift well or be sealed into a solid rock formation. Similar precautions against contamination thru the well top must be observed as suggested for dug, bored or driven wells.

Surface Waters

In general, the supply from streams, ponds, irrigation ditches, and small impounding reservoirs is to be avoided. In Iowa they are nearly always seriously polluted; the water may be warm in summer, and algae growths may give it unpleasant tastes and odors at certain seasons. However, where other sources have failed to yield a satisfactory supply it may be necessary to resort to surface water.

The quality of such water will always be questionable, hence filtration or sterilization must be resorted to in protecting the family against disease. The quantity available will depend entirely upon the size of watershed tributary to the stream or reservoir, and upon the season of the year. The quality will usually be the worst at the time of the spring freshets when the quantity is the largest.

The cost of developing surface supplies is in most cases considerable, inasmuch as filtration must be provided in addition to the impounding dam, pump, and water conduit.

Pumping Equipment

With a satisfactory water supply developed, attention must next be given to means of making that supply available for use. The old fashioned and unsanitary method of drawing water by means of buckets lowered by a rope into the well is now obsolete. With contamination a certainty the danger to health is too great. The hand pump is still much in evidence, altho where the water supply system is extensive the labor involved is arduous, particularly if it must be performed by women. Likewise pumping by hand into a small storage tank is hard work, tho economy may make it necessary. The windmill, gasoline engine, and electric motor all find extensive use in Iowa. The local situation in each case must determine the most convenient and economical means of making the water supply available. Some factors which must be taken into account are the source of supply, the quantity of water required, the power units on hand or those which may be purchased for a pumping installation, and the cost of fuel or electrical energy.

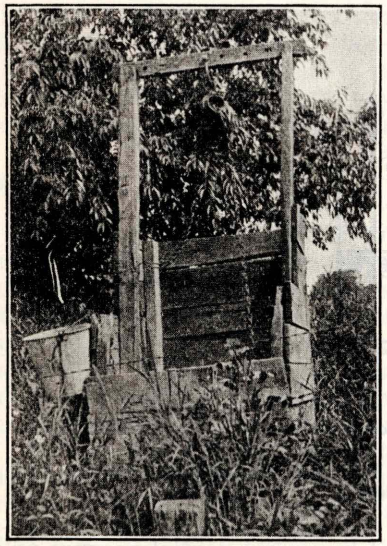

Fig. 15. An Open Bucket Well.

Unsafe for a home water supply.

In addition, it is important that the various units be correlated, that the pump be selected not only for the special conditions of the water source, but that the power unit combine with the pump to give economical and efficient service. Likewise, it is of concern that the storage provided should correspond to that needed by the homestead to supplement the predetermined pumping load. The piping must effectively connect pump, storage tank and distribution fixtures, the whole forming a complete and efficient water supply sysetm.

To this end it is desirable that one firm, experienced in water supply development, be given the responsibility of providing equipment for the entire installation. The conditions are thus more favorable for securing equipment in which the various units are coordinated and adapted to their specific needs. The information here presented is intended to give an intelligent understanding of the general basis for selection.

Pumps

In Iowa, most water pumps are of the suction or force types. A suction pump has the cylinder set at the top and it raises the water merely to the elevation of the cylinder, but does not pump against pressure. The ordinary cistern pump is of this type. The force pump may have the cylinder at the top of the well or at a considerable depth, and it can raise water above itself and against pressure. The accompanying illustrations (Fig. 16) show the essential features of these two types of pumps.

The elevation of most of the state is in the neighborhood of 1,000 feet above sea level. The air pressure at this elevation is such that if a perfect vacuum could be created in a pump cylinder, water would rise behind a pump plunger to a vertical height of 32.6 feet. Practically, the suction lift of most pumps is limited to 2/3 this height, or about 22 feet.

It is evident then, that where a pump is more than 22 feet above the water, it will be necessary to lower the cylinder. By lengthening the pipe and rod and by using a small cylinder, lowered near or into the water, this type of force pump can be used in wells 75 feet or more in depth.

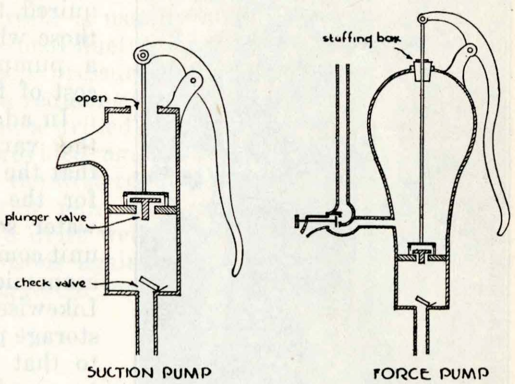

Fig. 16. Essential Features of Suction and Force Pumps.

In **force pumps** (also called reciprocal and plunger pumps) water is delivered by the movement of a plunger within a cylinder. As the plunger moves the space vacated by it becomes a partial vacuum and due to atmospheric pressure on the surface of the water in the well, some water is forced up into the vacuum left by the plunger. When moving in the opposite direction the plunger pushes the water ahead of it. The flow of water from the pump may be intermittent or continuous, depending upon the number and arrangement of valves. This type of pump is best adapted to pumping relatively small quantities of water and may be used under high pressures. Its capacity is determined by the plunger displacement and by the speed of operation.

The **centrifugal pump** finds an occasional use in supplying residential water systems, tho it is best adapted to larger capacities. In principle the centrifugal or rotary pump secures action thru the centrifugal force of a rapidly moving impeller, housed in a stationary casing. The flow from the pump is continuous. For low suction heads a small pump of this type may operate very satisfactorily and economically in conjunction with a home water supply system.

The **air displacement pump** is used in a few of the deeper wells in Iowa. The outfit consists of an air compressor with suitable power, an air receiver, an air displacement cylinder submerged in the well, and valves for admitting water into the cylinder, for turning on the compressed air and for allowing the air to exhaust after it has forced out the water. An air line connects the pump cylinder with the air receiver, and a water line runs from the cylinder to the distribution system. When a faucet is opened, compressed air forces water up thru the pump and out the faucet. Advantages of this method are that it is automatic, hence there need be no storage of water; that it can be used for both well and cistern; and that the power unit does not have to be located directly over the well. Its disadvantages are that it is comparatively expensive to operate, and that because of the number of valves required for automatic action, it is necessarily complicated and likely to get out of order.

Choice of Pump

A choice is usually limited to plunger pumps, centrifugal pumps, or compressed-air lifts. As the plunger pump satisfactorily meets all ordinary requirements, it is chosen for the large majority of residential pumping installations, while the centrifugal and air-lift pumps are utilized for the special conditions under which they operate to best advantage. Where the water pumping requirements are at all extraordinary, expert advice should be sought in order to insure that the pump selected may be both efficient and economical.

In choosing a pump the following information will be helpful: the kind of well and its diameter; the depth to bottom, depth cased, depth to water (both quiescent and when pumping); the maximum quantity of water required per hour or day; the yield of the well which can be depended upon for sustained pumpage; the kind of power; the distance and difference in elevation from the well to the proposed location of the pump; and also the distance from the pump to the storage tank and the required lift.

In selecting a plunger pump for a shallow well with low lift, a large diameter, short stroke cylinder is most suitable, and for a deep well a small diameter, long stroke cylinder is best. The depth of the well and the length of stroke will determine to some extent the rate at which the pump can operate. Forty strokes per minute should be the maximum, and a lesser number will usually give better results.

Shallow Well Pump Installation

Considerable latitude is possible in the location of a shallow well pump, inasmuch as it is not necessary to place the head directly over the well. The pump may be conveniently placed in a pump house or in the basement where it is free from the danger of freezing. Where an advantageous well site is at some distance from the desired pump location, the limiting factors are merely the suction lift, the friction loss, and the difficulty of maintaining tight joints. The greater the horizontal distance the less the vertical lift may be, due to friction loss. A suction line up to 1,000 feet is practicable provided the pipe is of ample size, and a gradual slope is maintained from the well to the pump so that there may be no opportunity for the formation of air pockets. Obviously, all pipe joints must be air tight.

A combination foot valve and strainer is recommended at the lower end of the suction line. The foot valve will keep the pipe and pump chamber full of water while the strainer will hold out objectionable foreign matter which might otherwise be drawn into the pump and water supply system.

Installation of Deep Well Pumps

In contrast to shallow well installations, with a deep well the pumping head must be placed directly over the well. Power driven pumps are used in most such wells where the water is far below suction lift. The pump rod and drop pipe are lengthened so the lower cylinder can be set in or near the water. Submergence is desirable as it keeps the pump primed and the valve leathers pliable. The need of a foot valve is also eliminated. As most deep well pumps are single acting, an upper cylinder is usually placed in or just below the working head to equalize the work between strokes. The water is lifted by the lower plunger and forced out the discharge pipe by the down strokes of the upper plunger. A strainer is recommended at the bottom of the suction pipe to prevent the entrance of any large particles of foreign matter.

The pump head and motor may be housed at the surface of the ground or in a pit. A ground level pump house, carefully insulated so as to avoid trouble from freezing, is preferable to a pit which may involve some danger from surface water backing up and contaminating the well. However, where a pump pit seems to best suit particular conditions, it can be constructed so as to minimize the hazards. It can be built of concrete or masonry and the walls can be extended above the ground level so as to prevent the entrance of surface water. It should be large enough to facilitate repairs and deep enough to avoid freezing. Ventilation of the pit is important and can be provided thru the cover. Where the well can be located close to the house, the pump pit can then be connected directly with the cellar as shown in Fig. 27. This arrangement is particularly desirable if an

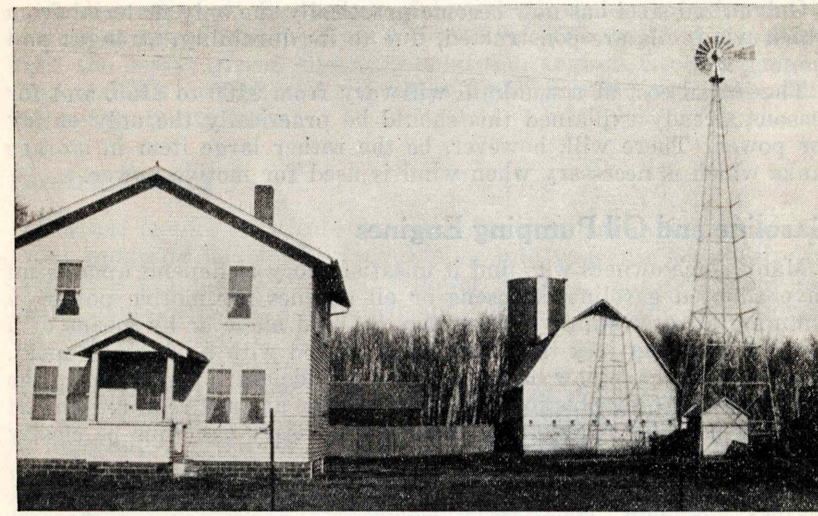

Fig. 17. A North Iowa Rural Water Supply.

Windmill operated system; pump and stand-by gasoline engine housed for protection.

electric motor or a gasoline engine is to be used, as it provides a convenient location for the pumping machinery and eliminates the danger of freezing.

Windmills

The windmill has long been a popular means of furnishing power for rural water supplies, because the wind is free and the expense of operation therefore practically nil; because the initial cost is moderate and repairs few; and because the structure is sturdy and simple in operation.

Objections to this system are based mainly upon its unreliability. Frequently when water is most needed the wind may not have sufficient velocity to operate the pump. This is especially serious during the hot summer months when the water demand is the greatest and breezes are noticeably light. Desirable wind velocities for pumping rarely prevail even one-half of the time. It is evident, then, that large storage is necessary where these devices are used for power.

The windmill has been largely standardized in design, varying only in size and height. The power needs of the particular pumping installation will of course govern the size of the wheel and the prevailing winds will influence the height of the tower. To secure the greatest efficiency, and to utilize wind from every direction, the tower should have sufficient elevation to place the wheel 10 feet above trees and nearby buildings.

Galvanized steel has now become practically the only material from which windmills are constructed, due to its durability, strength and economy.

The initial cost of a windmill will vary from $100 to $125, and for reasons already explained this should be practically the only outlay for power. There will, however, be the rather large item in storage tanks which is necessary when wind is used for motive power.

Gasoline and Oil Pumping Engines

Many home owners who find it unsatisfactory to depend upon wind have adopted gasoline, kerosene or oil engines for motive power in pumping a water supply. They may be used alone or by means of a suitable pumping jack they may be connected with a windmill outfit. These engines have now been developed in efficient form and have the advantage of being able to pump water in the amount required and at the time needed. The storage capacity necessary can thus be closely estimated.

Internal combustion engines, as now constructed, are simple and sturdy in design and may be operated with very little attention They have a wide range of usefulness and if mounted on skids or trucks they may be moved and used to drive any light machinery when not needed for pumping. For this one purpose alone a two horsepower engine will be large enough, tho for general service four to six horsepower may be desirable.

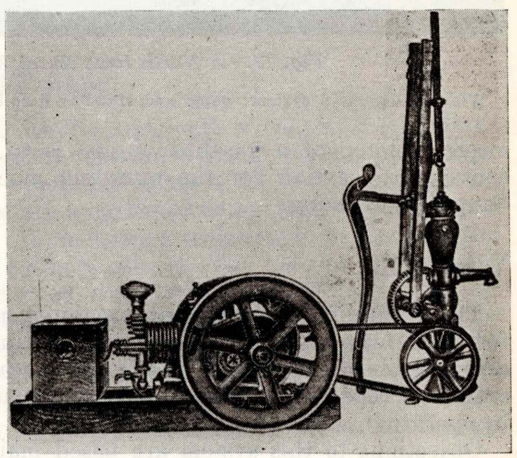

Fig. 18. Auxiliary Gasoline Engine Stand-by Unit

For use with a windmill installation.

The cost of operation of this kind of power consists largely in expenditures for fuel, and this is determined by the load which the engine is carrying and upon the adjustment of the fuel feed valve. Many internal combustion engines use less than a pint of fuel per horsepower-hour, tho it is easy to double this amount by running the engine on a light load or by poor adjustment of the fuel supply valve. The cost in the operation of kerosene and crude oil burning engines is less than that of gasoline engines because of the cheaper fuel, altho somewhat more attention is required in starting and operating.

Good gasoline or oil engines of two or three horsepower may be secured at prices ranging from $75 to $100. Tho this first cost is not high, the useful life of internal combustion engines is comparatively short and this coupled with the rather high operating cost makes their use relatively expensive.

Electric Pumps

Electric motors constitute the latest development in the residential water pumping field. They are coming into wide use where electric current is available from nearby power lines. In addition many isolated homesteads have installed individual generator and storage battery sets.

Electric pumps have many advantages. They are convenient and quiet in operation, clean in use, require a minimum of attention, and occupy little space. They require no fuel, are free from heat and odor, and can be made automatic by self-starting and stopping devices. They are attractive in appearance, and because of their small size may be conveniently placed in a basement or pump house.

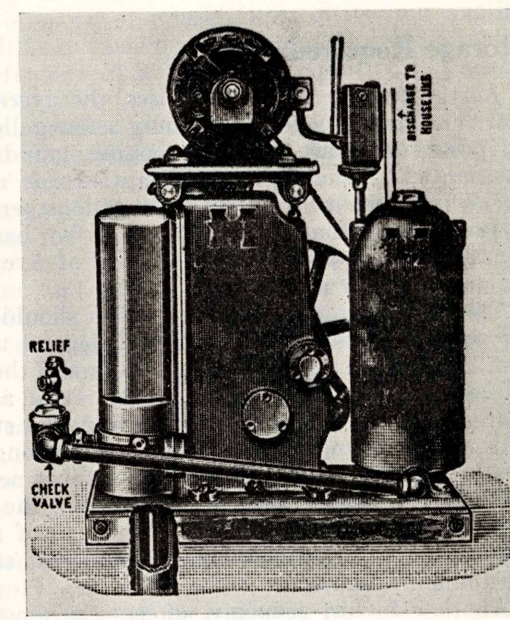

Fig. 19. Electric Deep Well Pumping Unit.

Automatically controlled by pressure switch on the small cushion tank shown on the right.

Obviously, the type of electric motor depends upon whether alternating or direct current is used, and the size depends on the volume of water to be pumped and upon the lift. In selecting the motor it will be well to secure the advice of an engineer as to whether direct gearing, belt-drive, or chain drive is best suited to the type of pump to be used.

Where connection to a power line is possible, and only the electric motor must be purchased, the cost is moderate. The first cost of a storage battery installation is much higher, ranging from $300 to $600. Operating costs are low. The economy in the use of electrical power is apparent when viewed over a period of years, as electric motors are relatively durable, their ordinary life being several times that of a gasoline engine. The power and maintenance charges compare very favorably with other power units.

Water Storage

The demand for water is far from uniform and for a short period may considerably exceed the yield of pump or well. Hence a storage reservoir in the water supply system will serve to tide over short time loads and may render adequate a well or other sources of supply which might not otherwise meet maximum demands. Storage also makes possible the use of smaller capacity pumps and motors.

Storage Required

As the standard of living rises, the average Iowa family is using more and more water. While only a few gallons are used for drinking purposes, many are used for cooking, laundry, bathroom, sprinkling, cooling, etc. The daily consumption for an average Iowa family varies from about 20 gallons to 40 gallons per person. Each individual in some families may use as high as two barrels per day. Using the average figure, 40 gallons, a family of five would use 5 x 40 = 200 gallons of water a day.

The reserve storage capacity which should be provided for the water supply of any one family will depend upon several factors. Of first importance will be the continuity and the reliability of the source of supply. Where water must come from a rainfall or any surface source, such as a stream or reservoir, the supply may vary widely, and may even cease altogether for prolonged periods during dry weather, hence the storage container must necessarily be large.

Of further importance in determining the reserve necessary is the short time demand. Where for a period of a few hours or days the water used will exceed the yield, sufficient storage must be provided for the emergency.

Another factor, economy, affects the amount of storage which is desirable. Sizeable storage capacity, adequate to extraordinary demands, will permit the use of smaller well pumps and motors. Where this factor alone is to be considered, the cost of additional storage can be balanced against the saving secured thru smaller pumping units.

For any individual homestead, the water storage requirements can be determined, then, by considering the inequalities of yield, the variations in demand, and the economy of storage as against pumping costs, the advisable storage capacity may thus be found to vary from a few hours supply to that sufficient for three or four months. With well supplies, storage for from 2 to 4 days is customary. With a cistern or surface water storage basin, the capacity is made as large as conveniently possible, being limited only by the yield, the space available, and the cost.

Cisterns

A cistern may be used for the underground storage of water from any source, altho it is commonly considered as the collecting basin for rain water. In parts of the state, well water is extremely difficult to secure, and when obtained at all is unpleasantly hard. For this reason many householders in these sections have constructed cisterns to hold rain water.

Such water has the advantage of being soft, and when proper precautions are taken it may be suitable for domestic use. It has the disadvantages, however, of being of uncertain quantity and quality. In amount the supply will be as variable as the rainfall, and in quality it may be far from satisfactory. The danger of pollution is perhaps the most serious drawback.

Contamination may gain entrance thru cracks in the sides or top of the cistern, altho most of the filth is washed in from the roof. It is surprising the amount of dust, soot and dirt of all kinds which will collect on a roof between rains, hence if the first washings from the roof are allowed to enter the cistern, a large amount of polluting matter is bound to be carried along. This foul drainage will furnish food to microscopic plant and animal life, giving the water a disagreeable taste, odor and color. To avoid this the downspout leader should be provided with a waste pipe and a valve similar in appearance to a stove damper. When a rain begins the valve should be turned so as to waste the first washings. After the roof is thoroughly cleaned, the rain water can safely be turned into the cistern. Clean water, placed in a clean cistern, will remain fresh for weeks.

Several suggestions may be made on the construction of a cistern which will help to make it a safe receptacle for the storage of a domestic water supply:

First, it should be absolutely watertight, as to top, sides and bottom. Concrete or masonry are the common construction materials, wood being objectionable because of its tendency to leak, rot and to encourage bacterial growth. Also, while a wood cistern costs practically as much as masonry or steel, its life is much shorter.

Second, the cistern should be provided with devices for excluding the first washings from the roof during each rain, and with screens for inlet and outlet pipes.

Third, there should be no connection between the waste pipe of the cistern and any sewer or drain which might bring in impure substance.

Fourth, it may be advisable to provide a first class filter of clean, fine sand to catch any impurities which come thru the downspout.

TABLE A

Capacity of Cisterns and Tanks Per Foot of Depth

DIAMETER OR WIDTH	SHAPE	
	ROUND	SQUARE
5 ft. 0 in.	147 gal.	187 gal.
5 ft. 6 in.	178 gal.	227 gal.
6 ft. 0 in.	212 gal.	262 gal.
6 ft. 6 in.	248 gal.	317 gal.
7 ft. 0 in.	288 gal.	367 gal.
7 ft. 6 in.	331 gal.	421 gal.
8 ft. 0 in.	376 gal.	479 gal.
8 ft. 6 in.	424 gal.	541 gal.
9 ft. 0 in.	477 gal.	607 gal.

In constructing a cistern many of the details such as shape, depth, thickness of walls, and methods of procedure are determined by convenience and by the particular requirements of material and local conditions.

Brick cisterns are usually made round in shape and set upon sturdy concrete foundations, 6 inches in depth. The walls should be 8 inches thick, with joints thoroughly filled with mortar, left rough to receive heavy plaster coats of portland cement mortar. The inside is troweled while green to a hard, impervious surface. A thinner wall or omission of the plaster coats is likely to result in a leaky cistern, which will allow water to escape or may permit the entrance of contamination.

Concrete cisterns may be either round or square, the latter shape being easier to form but requiring somewhat more material. They may be made from precast blocks with joints carefully pointed, or from concrete poured on the job. Fig. 20 shows the general design and arrangement which is suggested for a concrete cistern. Table A gives capacities for various sizes of cistern per foot of depth. To determine the total capacity, multiply the volume given in the table for the contemplated diameter of cistern by the desired depth. Thus for a 7′-6″ round cistern 7′-6″ deep the total capacity would be $331 \times 7\frac{1}{2} = 2472\frac{1}{2}$ gallons.

To be watertight the cistern must not only be correctly designed as to thickness, reinforcing, etc., but it must be properly constructed. This latter includes proportioning and mixing concrete of the desired quality, placing in the forms, and curing.

As the water-cement paste largely determines the quality and water-tightness of the concrete, the amount of water used must be strictly limited. Not over one pail of water should be used for each pail of cement required.

Clean pit-run gravel, containing from 1/3 to 2/3 sand, as it does in most Iowa deposits, will be entirely satisfactory for the coarse material in the concrete. Proportions of about six parts sand and gravel to each part cement are suggested, altho the proportions of sand and gravel may be increased or decreased as necessary to secure concrete which when thoroughly mixed is plastic and jelly-like. Too much sand or stone will result in dry, coarse concrete, difficult to place, and having porous spots. Concrete with too little sand and gravel will be equally faulty. It will be "soupy" and the material will segregate, forming sections which leak badly. A middle consistency is therefore desirable, and is relatively easy to secure.

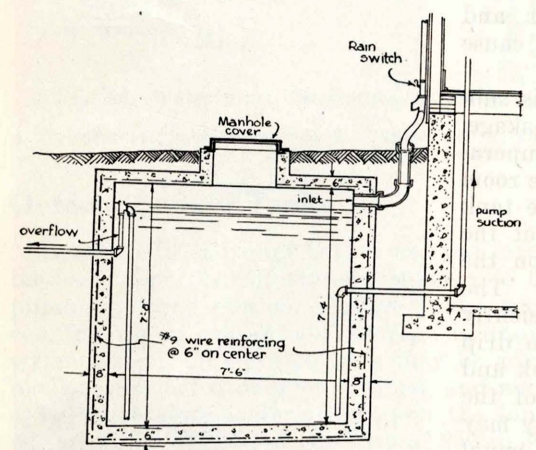

Fig. 20. Typical Rain-Water Cistern.

Dimensions may be varied to suit local conditions and desired capacity.

Ready mixed concrete is now available thru many local contractors, and it is likely to be of more uniform quality than that mixed on the job. To ascertain the cost of concrete delivered at the site it is merely necessary to tell the contractor the purpose for which the concrete is desired so that he may know the quality on which to quote prices.

Placing of concrete is also important. It should be poured continuously and must be carefully tamped in place to insure uniform and watertight walls. Where a construction joint is necessary, as between floor and walls, it is well to mix and place a cement grout on the joint before continuing the pouring of concrete. This grout will help seal the joint, so that it may not be a source of leakage.

The newly constructed cistern should be allowed to cure for a month or more before using. Occasional sprinkling will aid in converting the free lime in the cement to carbonate of lime, which is only slightly soluble in water. The cistern should then be filled and pumped out two or three times before the water is used for drinking.

Every cistern, no matter how well constructed and safe-guarded, will need to be thoroughly cleaned out at least once a year. The sediment and impurities which collect in the center of the bottom should be pumped out at even more frequent intervals.

House Tanks

To secure pressure at house fixtures a small storage tank (250-500 gal.) is often placed in the attic of the dwelling. This is perhaps the simplest method of securing pressure and storage adequate for a small household. The method has several drawbacks, however.

First, the tank must be limited in size and capacity as a large tank would impose a severe strain on the floor and column posts and might cause ceiling and wall cracks.

Second, an attic tank is subject to "sweating" and leakage. When the difference in temperature between the air of the room and the cold water in the tank is marked, condensation of the air moisture will occur on the outside of metal tanks. The "sweating" may be sufficiently copious to cause water to drip down the sides of the tank and endanger the plastering of the room below. This difficulty may be overcome by using a metal lined wooden tank, or by covering a metal tank with material such as asbestos cement.

Third, water stored in an attic tank may become very unwholesome, as it is likely to receive contamination from dust, dirt and insects.

Fourth, attic tanks have a further disadvantage in that they provide only rather low pressure. This is particularly noticeable at second floor faucets and fixtures.

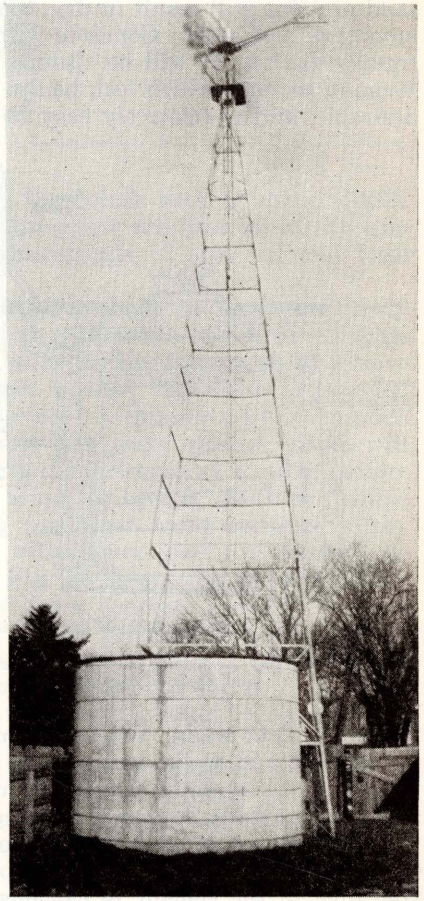

Fig. 21. Outdoor Water Storage Tank.

An elevated location is necessary to give gravity pressure to the water system.

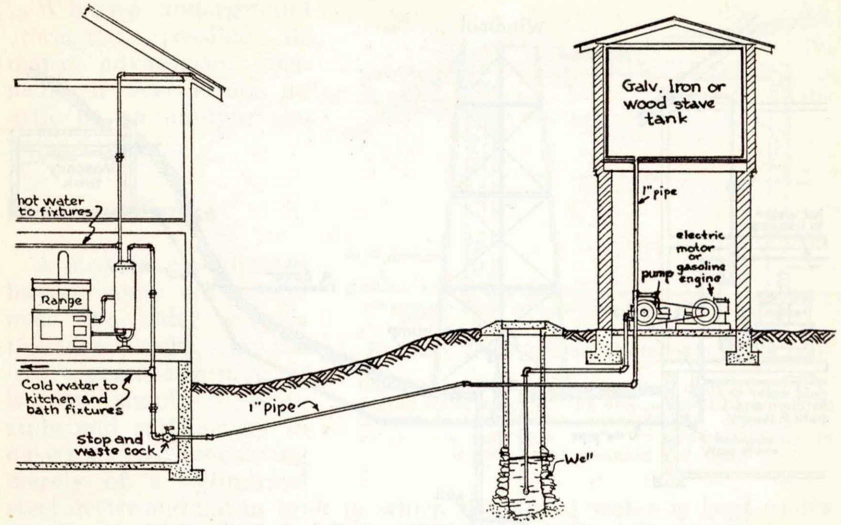

Fig. 22. Water Tank Installation Utilizing an Outdoor Elevated Tank.

A typical rural installation with a shallow well remotely located from the residence and pump house.

Outdoor Storage Tanks

To secure pressure for both house and farmstead water lines, and at the same time provide storage capacity to tide over periods between pumping, large outdoor storage tanks may be provided. In level country where considerable storage is desired with pressure on the water system, an elevated tank may be advisable. The tank is ordinarily constructed of steel or wood, and may be supported on towers of corresponding material or upon the top of a silo, milk-house or masonry foundation. A capacity of 250 to 500 gallons is sufficient for the requirements of the average family, tho a much larger tank is often desirable.

Where the pressure on water lines is important, the height of the elevated tank should be carefully determined. In addition to an allowance for friction, the tank should be placed at an elevation 2.3 feet above the water outlets for every pound of pressure desired. Thus for ten pounds pressure at a given faucet the water level in the tank would have to be at least 23 feet higher in elevation.

Elevated tanks have their disadvantages. In some cases they are unsightly, forming quite a blot on the landscape. Unless regularly painted they deteriorate rapidly and leak badly. In winter, trouble may be experienced thru frozen feed pipes and the formation of ice in the tank. In summer the water becomes stagnant and unpleasantly warm. For the single residence the outdoor elevated tank is a rather costly, and only moderately satisfactory, method of storage.

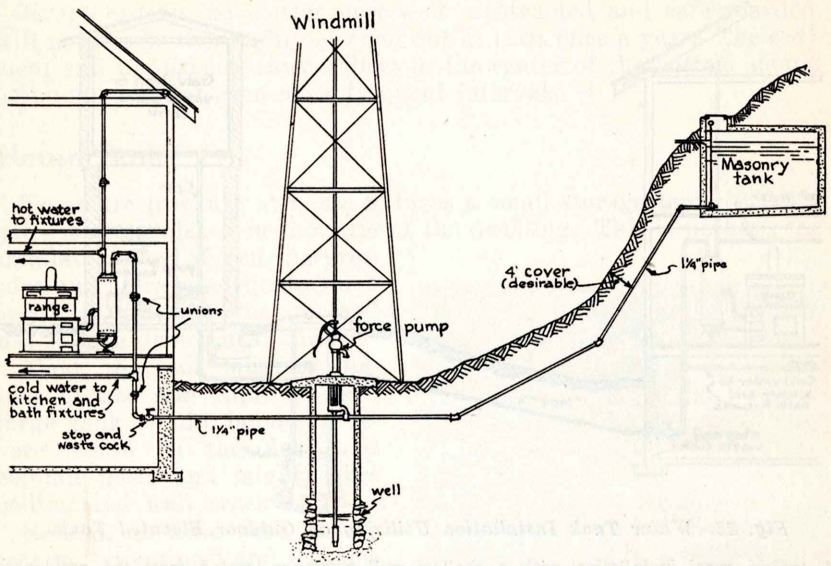

Fig. 23. A Water Supply Installation With a Hill Reservoir.

An ideal set-up where a site is available nearby for an underground hill tank giving gravity pressure to the house water system. The power for pumping may be furnished by a windmill as shown here or by an internal combustion engine or electric motor.

Hill Reservoirs

Fortunate indeed is the householder who is able to locate a sizeable underground storage basin on a nearby eminence, thus providing gravity pressure to the water supply system, economy of construction, and protection to the stored water. A hill of some height near the house is the ideal location, as it makes possible a permanent gravity pressure system at relatively low cost. The construction of a masonry basin, including excavation, is considerably less than the more expensive tank, towers and foundations required for an elevated structure. Also being underground, the former makes possible the easy and effective protection of the stored water.

Concrete or masonry are the common materials from which an underground storage basin is constructed. Plans for a typical structure are shown in Fig. 24. It will be noted that the tank is protected both with a concrete top and an over-load of earth. Tight coverage gives protection against dust, vermin and sunlight. The insulation provided by the cover and the over-load of earth gives a tempered supply thruout the year, avoiding trouble from both heat and cold.

An overflow pipe, properly screened, is included by some. To facilitate emptying and cleaning, a waste pipe and outlet valve should be installed.

Where underground storage is possible, its many advantages commend it over either an attic or an outdoor elevated tank.

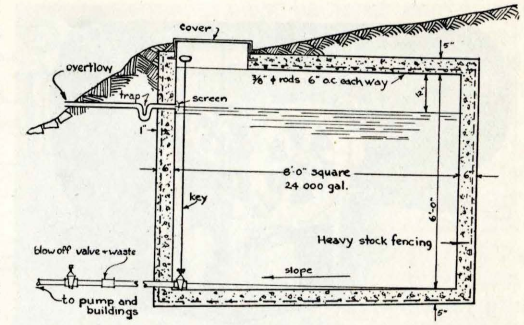

Fig. 24. Underground Water Storage Tank.

Plan for a reinforced concrete tank suitable for residential water storage. The dimensions may be varied to suit local conditions and desired capacity. A waste pipe and blow off valve are convenient in emptying and cleaning the tank.

Pressure Tanks

A modern development having many advantages over the older gravity pressure tanks, is the hydro-pneumatic tank. It is very simple in principle and satisfactory in operation, consisting merely of a cylindrical steel or wrought iron tank in which the stored water is kept under air pressure. The diameter and length may be varied widely according to the storage required. Any location may be selected which will give protection from freezing. The tank may be placed in the basement of the residence in a room adjacent to the pump house, or it may be buried in the ground outside of the foundation with merely the head and gages projecting inside the cellar wall. Only two requirements are made as to the tank location. It must be in a place where there is no danger of freezing, and within reach of an ordinary force pump.

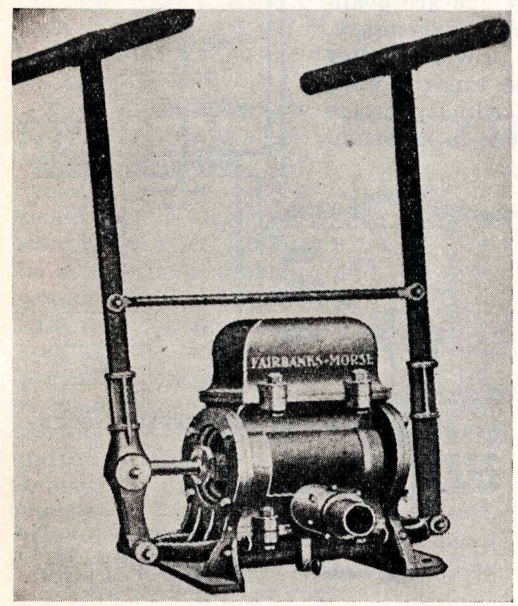

Fig. 25. Double-action Hand Pump.

Used to force water to a gravity or pressure tank.

Any available motive power may be used to fill and provide air pressure in the tank—wind-

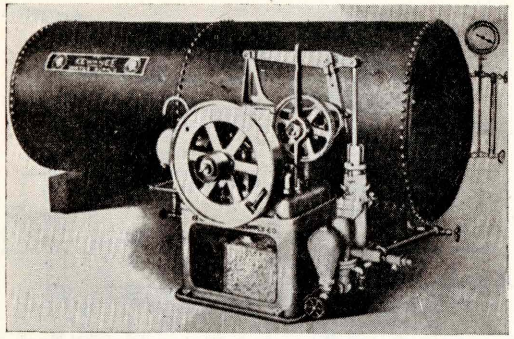

Fig. 26. Hydro-pneumatic Tank for Residential Installation.

Shown connected to a gasoline engine power unit.

mill, gasoline engine, electric motor or hand pump. The tank is air tight, and compressed air is introduced to force the water thru the supply pipes to the points where it is needed. Obviously, the pressure within the tank is increased by pumping in water and released as it is drawn out. The pump used with this system should preferably be equipped so as to pump a little air at each stroke in addition to the water.

A typical pneumatic outfit suitable for the average residence is shown in Fig. 26. The tank is 32 inches in diameter and 8 feet long. It contains 335 gallons, of which about 225 are available for use before refilling is necessary. With the storage this tank provides, water pumped only two or three times a week will be sufficient. Extraordinary usage such as that which may occur in mid-summer will necessarily increase the frequency of pumping.

The cost of an outfit, such as that shown, with a simple hand pump, will be in the neighborhood of from $75 to $100. With a gasoline engine or electric motor for power the cost will be much higher.

The increasing preference which is being given to pneumatic tanks is based upon clear-cut advantages which may be summarized briefly. It can be located wherever it

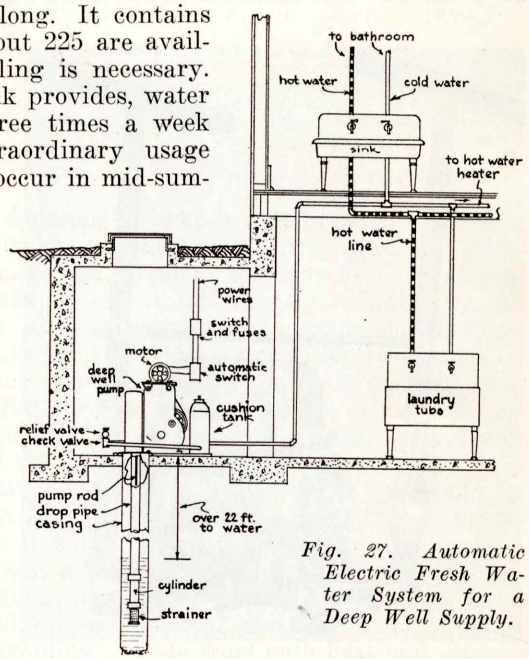

Fig. 27. Automatic Electric Fresh Water System for a Deep Well Supply.

Suitable where the deep well can be located adjacent to the house. The pneumatic tank is usually small, holding only 30 to 75 gallons. The motor is started automatically when a small quantity of water is drawn from a faucet

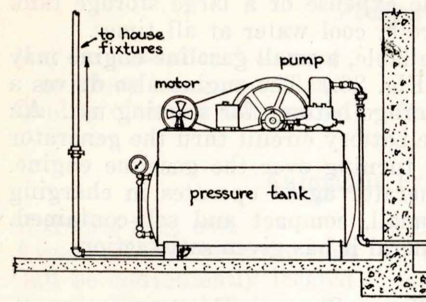

Fig. 28. Automatic Electric Water System for a Shallow Well.

Motor and pump mounted on a small 40 gallon storage tank.

may be most convenient and can be placed practically on the ground. The necessity for towers and heavy foundations as required with the elevated outdoor or attic tank with its accompanying danger of tank falling, collapsing or leaking is thus eliminated. Economy of construction and safety of operation are assured. And because the tank is closed and usually located in a basement or under cover, the quality of water is safeguarded. Contamination is prevented and the water is protected from seasonal temperature changes. In fact, the water supply from a pneumatic system has a nearly constant temperature thruout the year. Lastly, because the tank and pump are out of sight, they do not detract from the exterior view of the residence.

The **automatic electric pressure system** is a recent development. It consists merely of a small electric motor operating a small pump with or without a small pressure tank. A pressure controlled switch operates the motor and pump. When a faucet is opened the pressure is released and the motor is started. Pumping continues until the faucet is closed and the predetermined pressure accumulated, when the motor is automatically stopped. Many automatic systems include a small tank of 40 to 75 gallons capacity which provides sufficient storage to prevent the motor from starting every time a small amount of water is drawn. Advantages of this system

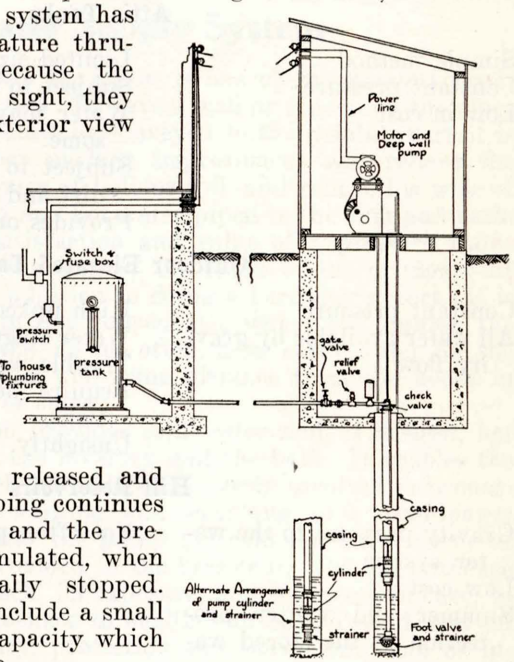

Fig. 29. Automatic Deep Well Installation.

Adapted to use where the well is located remotely from the house. The deep well pump shown here has a frost proof attachment and is placed in a ground level pump house.

are that it is moderate in cost, the expense of a large storage tank being eliminated, and it assures fresh, cool water at all times.

Where electric current is not available, a **small gasoline engine** may be used with the pumping unit. (Fig. 26.) The engine also drives a generator which charges a small storage battery for starting use. An automatic starting switch closes the battery circuit thru the generator which acts as a starting motor in turning over the gasoline engine. After starting the engine, the generator again operates in charging the battery. The installation is small, compact and self-contained. Its operating cost is low, and in general it has given satisfaction.

Comparative Merits of Water Storage Facilities

Advantages	*Disadvantages*
Cisterns	
Soft water	Water of uncertain quantity and quality.
	Water not under pressure.
Attic Tanks	
Simple method	Limited size.
Constant pressure	Subject to sweating and leakage.
Low in cost	Water may get warm and unwholesome.
	Subject to contamination from dust, dirt and insects.
	Provides only low pressure.
Outdoor Elevated Tanks	
Constant pressure	High upkeep cost.
All water available by gravity flow	Water stagnant and warm in summer.
	Trouble with freezing in winter.
	Require heavy towers and foundations.
	Unsightly.
Hill Reservoirs	
Gravity pressure to the water system	Not often possible.
Low cost	
Summer and winter protection to the stored water	
Constant pressure	
Water in reservoir always available for use	

Advantages	*Disadvantages*
Pressure Tanks	
May be located in basement or where most convenient	Variable pressures.
Quality of water safeguarded	Moderate but constant upkeep cost.
	Only part of the water in tank available for use.
Automatic Pressure System	
Moderate first cost	Current necessary for an electrical installation.
Avoids a large pressure tank	A gasoline engine system is noisy and requires attention and fuel.
Can be conveniently located	
Practically noiseless when electricity available	
Water always fresh	
Upkeep cost low	
Automatic in action	
Reliable and needs little attention	

The Water Supply System

Running water piped into the house is one of the greatest needs in many Iowa suburban homes. To have a well or cistern on the place is not enough. The water must be conveyed to the points where it is needed. Probably no other modern improvement will relieve the home owner of so many hours of tedious toil, and relieve his wife of so much discomfort, as cold and hot water piped to the sink and bath. We cannot measure the satisfaction and value of a pressure water system which will relieve the men of the house of the drudgery of carrying water to stock in addition to doing a hard day's work; it is equally difficult to evaluate this convenience which will lighten the burden of the housewife, who, all too often, must carry water for the cooking and cleaning from a well some distance from the house in weather good or bad, cold or storm.

A pressure water system provides cold water and, if desired, hot water to the kitchen sink, the lavatory and the bath. It enables the housewife to eliminate much of the labor formerly involved in preparing vegetables, in cooking, washing, and scrubbing, so it is no longer necessary to do washing near the pump to avoid the heavy carry of water, a laundry can be provided in the basement. The old outhouse with its semi-public approach, its exposure, and its inconvenience, to say nothing of its actual menace to health, can be abolished, and an inside toilet with its privacy, protection and convenience can be installed.

The usefulness of water piped to the stock tanks is readily apparent to every farmer. Water piped into the home is even more useful and important to the housewife. Often the installation of a water supply system has been delayed because of a lack of knowledge of how to plan a system, and how to install it when planned. Fortunately, the expense need not be excessive; the time required to make the installation is not great; and the work of installation is such that almost any man who is handy with tools can do it.

The accompanying sketches and descriptions show a very simple cold water system for the kitchen and also extensions of this system to give complete hot and cold water facilities for the entire house. It is thus possible to start with a small, inexpensive system which may be extended as time permits and funds become available.

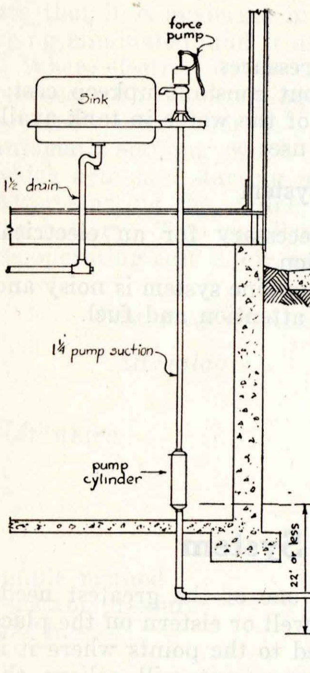

Fig. 30. Simple Kitchen Water Supply System.

For use with a shallow well. The water can be obtained only when the pump is operated. Where the water level in the well is within 22 feet of the kitchen sink, the pump cylinder may be placed at the pump head. With a somewhat deeper well the pump rod must be lengthened and the cylinder lowered to within 22 feet or less of the water surface.

Safeguarding the Water Supply

First in importance in safeguarding the water supply is protection against the possibility of pollution. The necessity for location of the supply where it will not be directly subject to contamination from barnyard, outhouse or flood water has been stressed, as has the value of an elevated tight cover, proper curbing, and protection around the water source.

Filtration

A device which can sometimes be used for safeguarding the water supply is a porcelain, sand, or charcoal filter. In its simplest form it consists merely of some substance which strains out dirt and sediment as the water passes thru. The better filters also catch a large proportion of the bacteria, and are helpful in removing color, taste and odor from the water.

Sand is one of the best and most readily available filtering materials in Iowa. It may range in size from fine to coarse. The finer the

grading of the sand, the more effective it is in filtering out impurities. Many of the sands found in Iowa sand pits are suitable in quality and grading for a small residential filter. A depth of 2 feet of fine sand, carefully washed to remove all clay, silt, loam, and vegetable matter, is suggested.

Filters naturally operate very slowly, and they must not be forced. To do so is to destroy the effectiveness of the filter and possibly to open up passageways thru which pollution may enter. A rate of 50 gallons per square foot of filter in 24 hours is a maximum which may be expected. It is important that the water level be maintained above the filter, as it is in the layer of silt and organic matter on the surface and immediately below that most of the purification takes place.

As the surface of the filter becomes clogged, so that water is allowed to go thru at much less than the normal rate, it will be necessary to scrape off the top ⅛ of an inch of soiled sand. This may be continued until the bed is reduced to a depth of 12 inches, when the sand should be removed and the filter built up again with new, clean sand.

Fig. 33 illustrates a simple and effective filter of the gravity type. It operates by natural flow at a low rate and under low head.

Wood charcoal is utilized is some household filters as it is particularly effective for re-

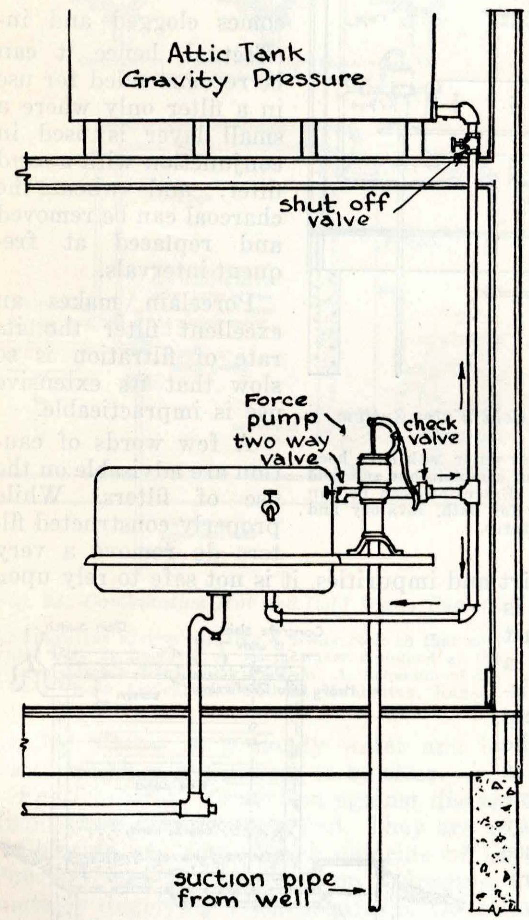

Fig. 31. Simple Cold Running Water System.

An overhead tank and pressure line have been added to the system shown in Fig. 30 with only slight additional expense and labor. The tank can be pumped full when convenient, and running water will then be available at the faucet until the tank is empty.

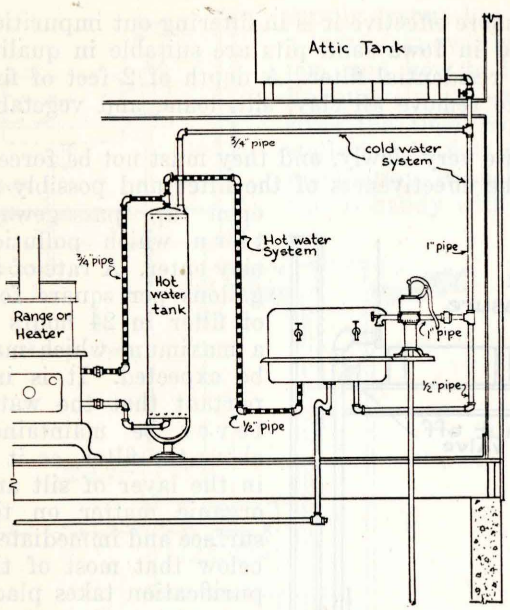

Fig. 32. Simple Hot and Cold Water System.

Hot water pipes, heater and hot water tank have been added next, giving a simple but complete hot and cold water system for the kitchen. Extensions can be run from either hot or cold lines for bath, lavatory and laundry fixtures.

moving color, taste and odor. The charcoal must be well burned and the pieces should be very fine, averaging about the size of oat grains. This material soon becomes clogged and ineffectual, hence it can be recommended for use in a filter only where a small layer is used in conjunction with a sand filter, and when the charcoal can be removed and replaced at frequent intervals.

Porcelain makes an excellent filter tho its rate of filtration is so slow that its extensive use is impracticable.

A few words of caution are advisable on the use of filters. While properly constructed filters do remove a very large proportion of all dirt and impurities, it is not safe to rely upon them where the water is polluted. The supply must either be secured from a protected source or a disinfectant used following filtration. In general, the use of household filters is not recommended for home water purification as they tend to give a false sense of security. They are reliable only for the removal of suspended matter and clarification of the water.

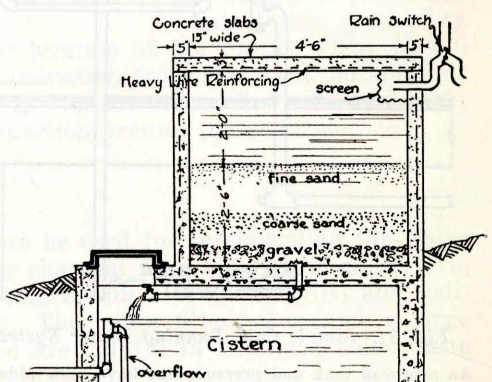

Fig. 33. Typical Sand Filter.

Designed for use with a rain-water cistern. Recommended only for the clarification of water.

Disinfection of Water

Where a well or cistern is under suspicion it will

be advisable either to discontinue use of the water or to disinfect it until a check on the purity can be secured. Several effective disinfectants may be suggested, tho it should be understood that they are merely emergency measures.

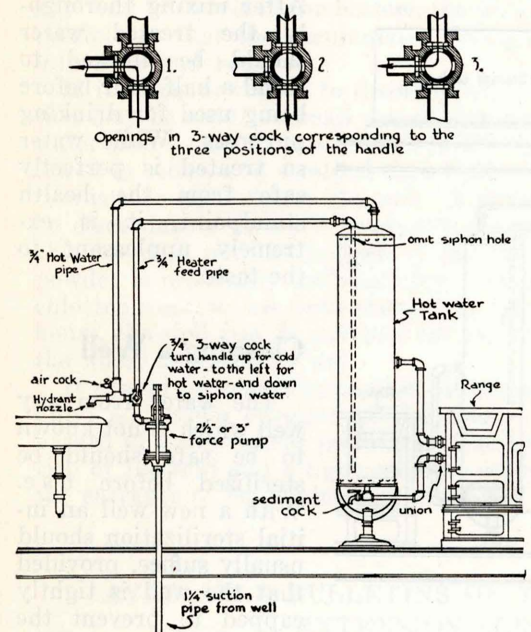

Fig. 34. Combination Hot and Cold Water System.

An ingenious system utilizing a 3-way cock so that cold water may be pumped, or warm water siphoned at the kitchen faucet. Devised by Prof. W. A. Etherton of the Kansas State Agricultural College, Manhattan, Kansas.

Boiling is the simplest method of killing any disease-producing bacteria which may be present in water; however, as boiling of large quantities of water is inconvenient and usually impossible, it is frequently desirable to use a chemical disinfectant.

It is well to understand that chemical treatment may vary in effectiveness. Waters of varied mineral and physical characteristics react differently when treated with the same amount of chemical. Where the content of iron, or other oxidizable matter is high, the purity of the water may be little affected by a dosage of chemical which would be amply sufficient to disinfect a clear, soft water. Much of the chemical may be used by sediment or suspended matter in a cloudy water and by oxidizable material in a water which might appear to be clear.

For temporary protection against disease two methods of chemical disinfection may be suggested. They are as follows:

Chloride of Lime—Fresh chloride of lime (also called Bleaching Powder) may be secured from a druggist and a sterilizing solution made by dissolving 1 teaspoonful of the powder in 1 quart of water. One and one-half teaspoonfuls of this solution, mixed thoroughly, will disinfect an ordinary pail full of water. A half hour should be allowed to elapse before the water is used for drinking.

The stock solution should be kept in a tightly stoppered bottle, and must be replaced weekly as it rapidly loses its strength.

Tincture of Iodine—Found in most medicine cabinets and obtainable from any druggist, this drug makes an excellent disinfectant for drinking water. One drop of ordinary tincture of iodine, which contains approximately 7 per cent of iodine, will sterilize one quart of water. This is equivalent to 12 drops in each large pail of water. After mixing thoroughly the treated water should be allowed to stand a half hour before being used for drinking purposes. While water so treated is perfectly safe from the health standpoint, it is extremely unpleasant to the taste.

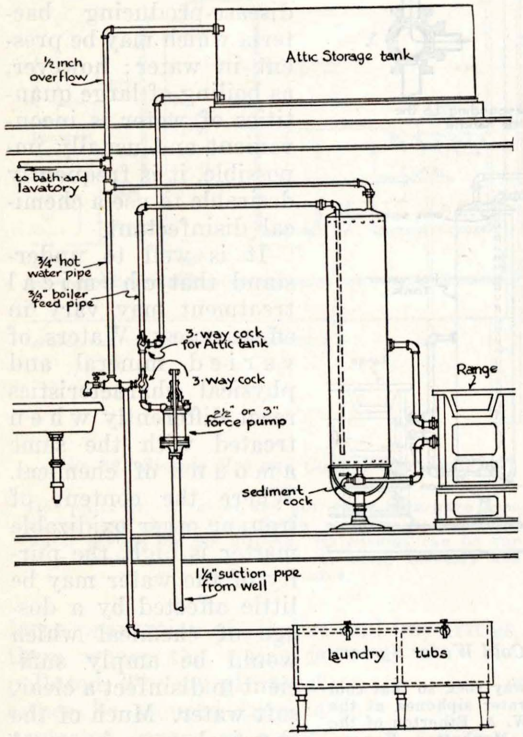

Fig. 35. Complete Combination Hot and Cold Water System.

An attic tank has been added to the system shown in Fig. 34, together with extensions to the bath, lavatory and laundry. Cold and hot water can be supplied to any number of fixtures thru a single pipe by proper adjustment of the 3-way cocks. Water can also be siphoned to the sink, laundry and other fixtures that are lower than the hot water tank.

Cleaning a Well

The water from any well which is not known to be safe should be sterilized before use. With a new well an initial sterilization should usually suffice, provided that the well is tightly capped to prevent the entrance of polluting matter.

An exception is the case of the shallow dug well in loam, which must occasionally be cleaned out, as a certain amount of clay and silt may be expected to be washed in with the ground water. Before entering the well, preparatory to cleaning, the safety of such descent should be assured. A visual inspection of the curb can be made with the aid of a mirror by directing sunlight on the walls under inspection. If the curbs are seriously defective it may be dangerous to enter. A test should also be made to determine the possible presence of harmfuly gases, by lowering a candle or small bird into the well. Failure of the candle to burn, or either death or

exhaustion of the bird indicates the existence of dangerous gases, which must be removed by ventilation before it will be safe to descend.

When the removal of gases has been assured by test, a ladder may be lowered into the well, and the curb scrubbed from the top down with a stiff brush. It should then be rinsed thoroughly. To clean out any mud or debris in the bottom, the well should be pumped as low as possible so that the accumulated foreign material may be shoveled into pails and removed.

If it seems advisable to disinfect the well, a chloride of lime solution may be used. A small can of this material is mixed with a little water into a smooth paste. This is dissolved in a gallon of water, allowed to settle, and strained thru finely woven cloth. The clear solution is then poured into the well. A pungent odor of chlorine should be discernable; this will gradually disappear. The adequacy of the chlorine dose may be judged by the fact that 1 ounce of bleaching powder is ordinarily sufficient for 1,000 gallons of water. After the chlorine solution has been allowed to remain in the well at least two hours, the well may be pumped out rapidly several times, after which the water is ready for use.

It should be remembered that disinfection is a temporary measure only, and while effective at the time, is no assurance against the hazard of a subsequent pollution. The best safeguard is proper location of the well and a tight concrete cover which will protect against the entrance of contaminating substance.

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