THE UNIVERSITY OF MISSOURI BULLETIN

ENGINEERING EXPERIMENT STATION SERIES

VOLUME 1 NUMBER 2

WATER SUPPLY FOR COUNTRY HOMES

BY

KARL A. MCVEY

UNIVERSITY OF MISSOURI

COLUMBIA, MISSOURI

June, 1910

Reprinted, October, 1913

THE UNIVERSITY OF MISSOURI BULLETIN

ENGINEERING EXPERIMENT STATION SERIES

VOLUME 1 NUMBER 2

WATER SUPPLY FOR COUNTRY HOMES

BY

KARL A. MCVEY

UNIVERSITY OF MISSOURI

COLUMBIA, MISSOURI

June, 1910

Reprinted, October, 1913

The Engineering Experiment Station of the University of Missouri was established by order of the Board of Curators July 1, 1909.

The object of the Station is to be of service to the people of the State of Missouri.

First: By investigating such problems in Engineering lines as appear to be of the most direct and immediate benefit and publishing these studies and information in the form of bulletins.

Second: By research of importance to the manufacturing and industrial interests of the State and to Engineers.

The staff of the Station consists at present of a Director and four research assistants together with a number of teachers who have voluntarily undertaken research under the direction of the Station.

Suggestions as to problems to be investigated, and inquiries will be welcomed.

Any resident of the State may on request obtain bulletins as issued or if particularly interested, may be placed on the regular mailing list. Address the Engineering Experiment Station, University of Missouri, Columbia, Missouri.

WATER SUPPLY FOR COUNTRY HOMES.

An improvement is noticeable at the present time in the sanitary surroundi ıgs of farmers' homes. This improvement is the natural outgrowth of the increased requirements for comfort and refinement in the home. The healthful pleasure of life in the country, either at the country residences or on the farm, so often marred by the absence of comforts which in city life come as a matter of course, is being brought about by what is known as "modern conveniences." The introduction of these improvements depends largely on having or providing an abundant supply of pure water. It is a great step toward insuring the health of the household dependent upon the water, and increasing the wholesomeness and healthfulness of the milk, butter, cream, and other products used on, and sold from, the farm.

The idea is general that water supply and house sanitation are extremely expensive. This, however, is far from being the case, and in the installation of a water system, if it be kept within the bounds of utility, avoiding that which is luxurious, the cost is considerably less than might be anticipated.

It is the purpose of this bulletin to outline some methods of water supply, draw attention to the importance of the sanitary aspect of the supply and to give an idea of the cost of making such improvements.

The methods of supply described are not new but have all been tried for some time, nor are any claims to originality made. It is believed, however, that the different methods are not generally known and an exposition would be of value. The costs, which have been given, of course can only be taken as approximations, but at this time and place are reasonably close to those which would prevail in the rural districts of the state. The question of water supply naturally leads to a consideration of sanitation and sewage disposal, which phase of the question will be taken up in a following bulletin.

SPRINGS.

Springs are the natural outlets at which underground water flows out at the surface. In some parts of the country springs yielding pure water are numerous and are a cheap and valuable source of supply. As a rule their waters are palatable, wholesome, and free from organic impurities owing to the natural filtration going on while it passes through the subterranean strata before it reaches the surface. It is best and most convenient if springs are found located at an elevation considerably higher than the house and grounds to be supplied, for then the water may flow by gravity and the necessity of some form of pumping machinery is done away with.

In contemplating a water supply obtained by tapping a spring, it is of importance to give attention to the variation in the yield of the spring, which occurs almost regularly at the different seasons of the year. It is much safer in all cases to defer the gauging of the spring until after dry weather has set in, and to select a spring only in case it yields, even at such times of drought, an excess of water over the maximum supply required.

To protect the spring against contamination it is necessary to wall it in, or still better, to construct a small storage basin in which the night flow can be stored, thus providing a reserve. This should have a reasonably tight cover to exclude surface impurities, dust, and animals. A cheap method of obtaining this storage would be to direct the flow from spring into a sunken barrel and from this have the supply pipe leading to the house. This pipe should enter the side of reservoir about six inchs from the bottom, thus permitting a settling of suspended matter to the bottom from which it can be periodically removed. A strainer should be placed on the outlet pipe, inside the barrel or other reservoir provided, to prevent any foreign matter entering which the covering has failed to exclude.

In the popular mind springs are supposed to represent the purest of supplies, but under certain circumstances this type of ground-water may not be wholly pure. Often in rough and rocky districts the depth and thoroughness of percolation over and through rock masses is so limited that the water may not equal in purity the normal ground-water. Generally, spring waters before exposure to surface of soil are deficient in micro-organisms, as they represent filtered waters, but as they appear at the surface, the water comes again in contact with organic matter and soil bacteria, and they receive a considerable number of organisms from this course.

Thus can be readily seen the importance of walling in a spring where it issues from the ground and making the surface drainage good in the vicinity of the spring, forestalling the possibility of contamination by surface waters from cultivated, manured fields.

WELLS.

Wells are used in the country probably more than any other source of supply. Water from them is really rain water which has percolated through the soil down to a water bearing stratum; it is in some cases purified by its percolation through the soil, in others it is changed in character and made "hard" by reason of having dissolved and taken up mineral constituents from the geological strata through which it flows. While springs are natural outlets, wells may be considered artificial ones, for they have to be sunk, dug, driven, or drilled to the water bearing stratum, and furthermore, the water must be lifted by pumping to be of use, except in the case of true artesian wells which occur rarely in this state.

It is usual to distinguish between shallow and deep wells, yet there is no sharp demarcation between the two; the designations "shallow" and "deep" really refer more to the nature of the underground strata which the well pierces. Wells to a depth of from 15 to 30 feet, to water flowing in a superficial layer of gravel or sand which rests upon an impervious stratum are considered shallow wells. These wells should be looked upon with suspicion because they are liable to become polluted, particularly in densely settled regions, but not to a lesser degree on the farm, if they be located close to outhouses, cesspools, stables, or in close proximity to cultivated, manured fields.

These wells are either dug and lined with brick or stone, or "driven," that is, a pipe bearing a pointed perforated shoe is driven into the ground to a depth of the underground supply. These driven pipes are often only wrought iron tubes from one to three inches in diameter, and it may be mentioned here that the diameter of wells has not so great an influence on the yield as is commonly supposed. Very large supplies may be obtained from wells only 4, 6, or 8 inches in diameter.

In most cases the driven is superior to the dug well, because there is not the same amount of danger of pollution by surface leakage.

Deep wells sunk in gravelly or sandy soil, are driven or bored with tools similar to an auger or else a casing is forced through the earth into which the well pipe is inserted after the proper depth has been reached. In other cases, prevailing in most instances, when wells are sunk through rocky strata, chisel drills are used which are alternately raised and lowered, at the same time being rotated. Wells of this type are often wrongly designated artesian wells, as this term can with propriety be applied only to those wells in which water flows out at the surface.

Contamination of Wells—In locating a shallow dug or driven well, it is of importance that the sanitary aspect of surroundings be taken into consideration. It is generally believed that wells located above, that is, on a higher level than privy vaults and cesspools, are free from pollution by these sources. This, however, is not always true for "above" and "below" refer, not to the surface slope, but to the direction the water flows underground, and to the relative level of the porous or water bearing strata. When a large quantity of water is pumped from a well the underground conditions of flow may be altered. The water in the well would not alone be lowered, but also the surface of the underground water sheet for a distance all around the well. This distance increases with the amount of pumping, and while cesspools might under ordinary conditions be without the zone of contamination, pumping much water from the well will bring them into this zone. The fact whether a connection between well and cesspool exists may be established by several tests; one of the simplest being the salt-test, in which a large quantity of salt is thrown into the cesspool, then testing the water in the well by a chlorine test. Another is in the use of fluorescent "uranine," which gives to the well water a bright aniline green color.

The importance of protecting the farm well from surface pollution can not be overestimated. To bear out this statement we cite the results of the work of the Geological Survey of the United States Government in examining the farm water supplies in the State of Minnesota. Of 79 supplies examined, 20 were good and 59 polluted. In an examination of 28 dug wells, 15 had poor surface drainage and for other reasons 20 out of the 28 have a poor sanitary aspect. The drilled and cased wells show up much more favorably. It is safe to assume that the same results would be shown by an examination in the rural districts of Missouri. The remedy in most cases is easy; and lies in providing a tight impervious covering to shed all surface water and by giving the upper end of the well a water-tight lining to a depth of several feet. This can be done to the old well, or the new one under construction, by having the upper courses laid in a good cement mortar, and the surface, preferably the outside, covered with a coating of cement about three-fourths inch thick to a depth of 4 or 5 feet. The surface of ground surrounding the well should be given a gradual slope in all directions from the well curb.

The purification of a water supply is not of much interest to the dweller of a country house, for in most cases a pure supply is readily obtainable. However, there is one item under this subject well worth considering and that is, the growth of algae which is likely to occur in pure waters. Algae is a species of subaqueous fungus growth which usually appears as a green scum. While this is not considered detrimental to health, it gives to the water a peculiar, fishy flavor which makes it unpleasant for drinking. There is a cheap and very efficient remedy for the treatment of this condition, which consists in making a dilute solution of copper-sulphate (blue-vitriol) in the water affected. The usual method of doing this is to immerse in the affected spring, pond or tank, a coarse bag containing an amount of copper-sulphate sufficient to make a strength of about one in four millions—something like one and one-half grains in weight of the sulphate to each 100 gallons of water. The growth of this fungus may be so prolific as to stop up the pipes from the tank or springs.

CISTERNS.

In localities where underground water is hard to obtain and unfit for use, cisterns are a very common form for farm water supplies. They are used for the storage of water from various sources but usually for rain water. They may be constructed of brick and mortar, concrete, stone under-ground, or of galvanized iron placed in any convenient place. If well located and protected the latter should be satisfactory. It is the common practice to place these iron tanks above ground and during the summer season the temperature is higher than that of the water in the underground types, and the growth of organisms, which are usually present in waters collected from roofs is encouraged rather than discouraged. A roof which catches the water for a cistern also collects anything carried in the air. The character of the materials deposited there will, of course, depend upon the locality and season of the year. Some of the most common are dust, dead insects, excreta of birds, and spores of plants. The water from new roofs is in nearly all cases unfit for use, and will have to be discarded for the first few rains.

The opportunities for pollution, after the water enters the cistern depend chiefly upon the construction and protection of the types of cistern in use. Leaks offer one of the greatest opportunities for pollution if the cistern be located beneath the surface, for sometimes ground water has free entrance. Ground water around cisterns is very frequently polluted, for in its passage through the surface soil, very little if any, purification is effected. It is better if cistern be so constructed that no surface water is allowed to filter into it. The quality of the cistern water can be much improved by installing a device for turning away the water caught during the first part of a shower. There are many automatic devices for accomplishing this, but few are in common use. A simple two-way valve at the bottom of the down spout to be turned by hand is a common and efficient contrivance if properly used.

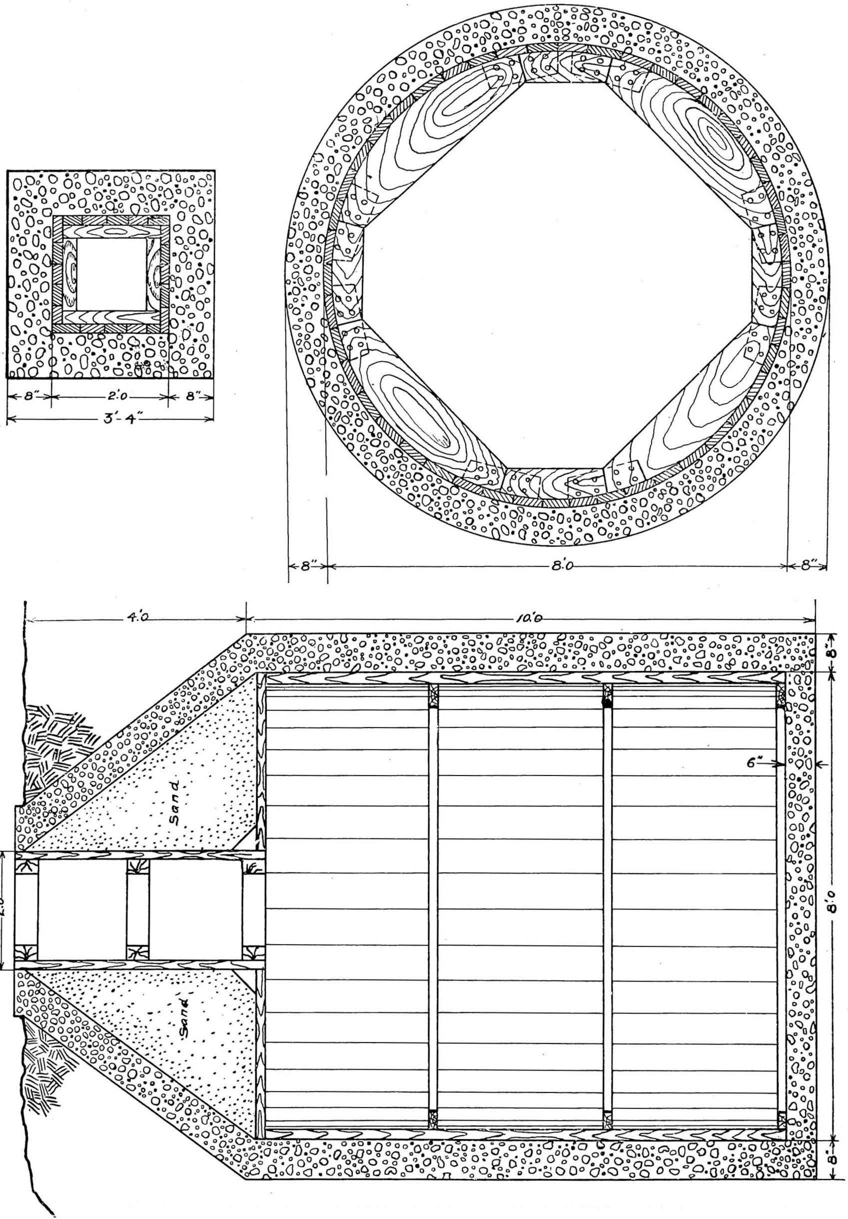
While the absence of lime salts renders it desirable for cooking, and its softness recommends its use in the laundry, rain water on the whole is not to be considered as suitable as a pure ground water for domestic supply.

From a sanitary viewpoint, the safest and most durable underground cistern is probably that made of concrete. The designs for two of this type, together with the probable cost will be gone into.

Concrete Cistern.—Make a circular excavation 16 inches wider than the desired diameter of the cistern and say 14 feet deep. Make a cylindrical inner form the outside diameter of which will be the diameter of the cistern. This form for a 13 foot hole should be about 10 feet long. Saw this form into sections for convenience in handling. Lower these sections into the cistern and then unite them to form a near perfect circle, blocking them up 6 inches from the bottom. (See figure 1.)

Make a concrete of Portland cement one part, clean sand 2½ parts, and gravel or broken stone 5 parts—which is known as a 1:2½:5 mixture. Mix in small batches just soft enough to pour. Fill in space between form and earth with concrete, and ram or puddle with a narrow scantling to keep from forming rock pockets. To construct the conical portion, build a floor across the top of the cylindrical form, leaving a hole in the center two feet square. Brace this floor well with uprights from the bottom of the cistern. Around the edges of the hole, and resting on the floor described, construct a vertical form extending a little above the surrounding ground. Build a cone shaped mold of earth or sand wetted good from the outer edge of flooring to the top of form around square hole and smooth well with a trowel or float. Place a layer of concrete 4 or 5 inches thick over the cone of sand and smooth to outer edge of side wall. After setting for a week one of the floor boards can be removed and the cone form of sand will fall gradually to bottom of cistern from where it can be easily removed together with the rest of the lumber used for forms. The bottom should be laid of same material as walls about six inches thick. If the water comes to the cistern from the house roof, and a kitchen pump is used, these pipes should be placed through the forms before concrete is put in so that they may be rigidly held in place. The materials for two different sized cisterns and their approximate cost is shown in table 1.

Fig. 1.



CONCRETE CISTERN SHOWING ARRANGEMENT OF FORMS.

TABLE I.

Cisterns—MATERIAL AND COST.

14′ deep (10′ cyl. 4′ cone) 8′ diameter, Capacity 3800 gals.

	Parts.	Amount.	Cost.
Cement........................	1	43 bags	$17.20
Sand...........................	2½	4½ cu. yds.	6.75
Gravel.........................	5	9 cu. yds.	27.00

Lumber for forms, 225 bd. feet.

13½′ deep (10′ cyl. 3½′ cone) 6′ diam., Capacity 2100 gals.

	Parts.	Amount.	Cost.
Cement........................	1	31 bags	$12.40
Sand...........................	2½	3 cu. yds.	4.50
Gravel.........................	5	6½ cu. yds.	19.50

Lumber for forms, 200 bd. feet.

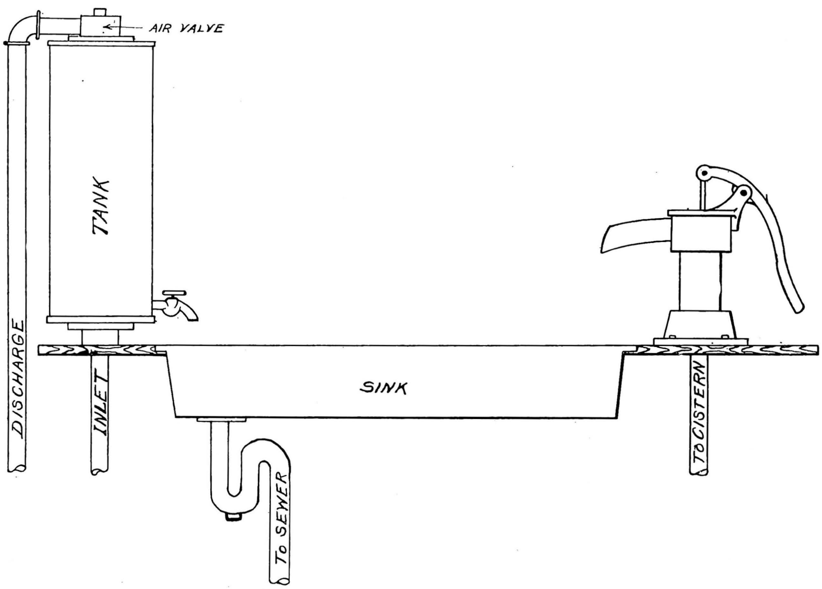
The cost of a cistern can be made close to the cost of materials provided the sand and gravel, and the lumber for forms are easily obtained. The labor item will probably equal that of any type of cistern but scraps of lumber can be used in the forms, or new can be bought and when through with can be used for other purposes. If there is a neighboring creek, sand and gravel can be had from it, but care must be exercised in collecting or it must be washed clean before making into concrete. Thus it will be possible that only the cement will have to be purchased on the market.

A farmer in central Missouri built a concrete cistern 16 feet deep by 10 feet in diameter at a cost of $70, exclusive of the labor of his helper. As his system is ingenious and can be duplicated on many farms throughout the state, we will outline it here.

Advantage is taken of a hill which rises higher than any of the barn yards. On this was erected the concrete cistern, half above the ground and half below. This is filled by a 6 foot windmill erected over a nearby dugout spring, which runs almost continuously. From this cistern pipes are laid and water flows by gravity to three concrete watering troughs situated at convenient points in the barn yard. The water level in each trough is controlled by an automatic float valve. As the cistern is large, storage enough is provided to tide them over the days during which there is insufficient wind to work the mill.

Use of Kitchen Pump.—A small force, or pitcher spout pump placed at one end of the kitchen sink, with the suction pipe reaching to the cistern, is a convenient means of getting the soft water supply if the more expensive method of using a gravity tank or a pneumatic tank and piping the soft water to wash basins and bath tub are not desired. Figure 2 shows in outline such an arrangement supplemented by what is known as an automatic house tank. This tank is placed at end of kitchen sink and water from windmill pump runs through it and then to stock tanks or barns. An air-valve at top of tank lets out any trapped air and tank fills with water. This allows the freshest and coolest water in house for drinking. The capacity of the tank should be 25 or 30 gallons to provide a reserve if the mill should stop pumping. A relief valve is placed in line pipe in well and is so arranged as to open at a certain pressure. It has no connection with working of the tank except in cases of extreme pressure, when it opens to relieve tank and insures against bursting

Fig. 2.



should the pipes become clogged or frozen. An estimate of the cost of such an installation as shown in figure 2 is as follows:

Cistern pump, 3 inch cylinder	$ 8.00
Kitchen sink, 18 x 30 inches	6.00
Tank complete, with air and relief valve	11.00
Pipe, say 25 ft. 1¼ inch galv	5.50
Pipe, say 30 ft. 1 inch galv	4.80
Installing above	4.00
Total	$39.30

The last three items, of course, can only be roughly estimated, as the locations of cistern and well will determine the length of pipes needed.

ELEVATED TANKS.

House Tanks.—The water required at the farm buildings may be stored in inside tanks, which may be located in the attic or in the barn. These tanks are of wood, lined with copper, or of wrought iron or steel. The wood tanks while usually constructed square or oblong for use in the attic of the house, can be made in most any shape and be adapted to utilize any available space under the roof of the house. The objection to inside tanks is that their size must necessarily be limited, not only to the want of space but also because of the heavy weight of water which can not always be safely carried. This is more readily appreciated when reduced to figures. Say a tank holding 200 gallons is placed in the attic; this means a weight of 1666 pounds, exclusive of the tank which weighs about 125 pounds; which means that provision has to be made in the construction of the house to sustain this safely and this in the majority of cases can not be done without considerable expense. This objection is not so much the issue if the tank be placed in the barn where the necessary supports can be conveniently erected.

Another objection to placing the tank indoors is the so-called "sweating" which occurs when the tank is filled with cold water. It is especially bad in the case of bare iron tanks. This phenomenon is due to the condensation of the moisture in the air, on the outside of the tank. When the difference in temperature between water in the tank and the surrounding air is great, this condensation may be collected in such quantities as to run down the sides of the tank, endangering the plastering of the rooms below. This may be of little consequence in barns. This difficulty is overcome by using metal-lined wood tanks, or providing a covering of some kind—the frost-proofing would serve this purpose.

Outdoor Tanks.—For the majority of farm buildings water can be raised into, and stored in outdoor elevated tanks. These may be made of wood or sheet steel and the supporting structure be of wood, steel, or masonry. Combinations often occur such as a wooden tank on steel tower, or an iron tank on a wooden tower. If left open and bare, elevated tanks often mar the landscape, so in nearly all cases they are covered and ornamented in some way. Since protection has to be afforded from frost, this wood covering can be nicely finished and painted, when it will add, rather than detract anything from the scenic value. Tank towers should be proportioned and constructed so as to be amply strong to carry their heavy load. They must be on firm foundations carried below the frost line to resist the heavy wind pressures to which they are subjected. The height of tower is determined by the pressure under which the water is to be delivered.

Wooden tanks of any appreciable size are always built round, because the circular shape is the best to secure tightness. Cypress lumber is used largely in the southwestern states, while in the East white pine is preferred. The strength of wooden tanks depends chiefly on the hoops which are either flat or round. The round hoops are the best because they can be easily examined, and protected from rust by frequent painting. It is essential in the erecting of a wood tank to support all its weight on the bottom. This is done by laying sleepers short distances apart across the entire base, and sawing them off a few inches inside the tank circumference.

The reasons why wooden tanks are preferred to steel tanks is that the latter are more difficult to erect, they give trouble by sweating, and have to be painted frequently to keep from rusting. It is also harder to protect a steel tank from freezing. Where large capacities are necessary, of course steel tanks are used, but on country estates the wooden ones are preferred. In practice it is found they will last from 15 to 20 years, and they can be bought and put up for much less money than can the steel tanks.

PNEUMATIC SYSTEM.

In addition to the attic and tower tanks which are now so generally used to supply country houses, there is another system, known as the pneumatic water supply, which has many advantages over the older methods. This system is of comparatively recent origin and depends in its operation upon compressed air. The use of this system is dependent only on one condition, and that is, the ability to secure a good supply of water from well, cistern, or spring, from which it can be pumped. The most important advantage of this system is the fact that the tank may be located anywhere; either in the cellar, stable, underground, or at any other place where there is no danger of freezing.

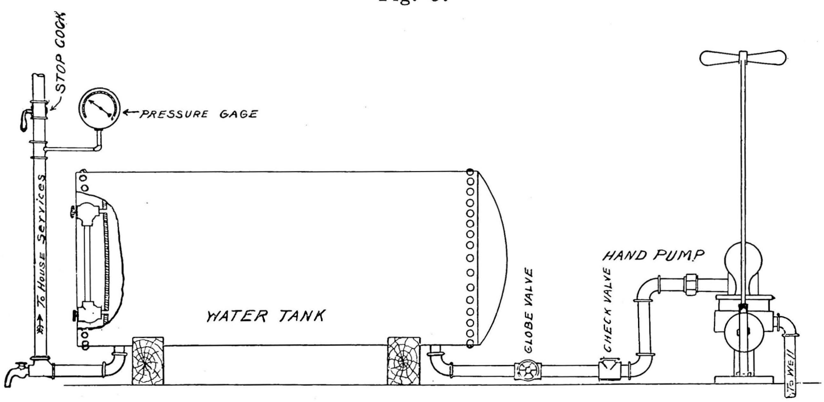
This allows the water in the piping to be maintained under pressure without using an elevated tank with its attendant evils, such as danger of leakage, straining of timbers under its great weight, etc. The tank is of wrought iron or steel, air-tight, and can be filled by windmill, power pump driven by gasoline engine, or by hand. Either a horizontal or vertical tank may be used, as suits the convenience.

Principle of Action.—Water is pumped into the bottom of this air-tight tank, and as the water rises the air above it is compressed. The expansion of this compressed air will force the water through the supply pipes at the bottom of the tank to points where the water is required. The pressure in tank is increased by pumping water into it and decreased by drawing it off. The correct amount of air can be supplied and maintained by an automatic air valve, by a pump that forces both air and water into tank at the same time, or by a hand air valve. This is necessary to prevent tank being completely filled with water, a condition called "water-logged," which will prevent any pressure being gotten up.

If the tank is supplied by a windmill, an automatic pump should be used which will throw the wheel out of gear when a certain pressure is reached, and when water is drawn, the reduction of pressure will throw it in gear again. An installation of this kind has been in use on a Cooper county farm for the past four years. The windmill, an 8 foot mill on a 25 foot galvanized steel tower, and automatic pump erected cost $100. The pneumatic tank, capacity 6 barrels, was put in by a local firm for $60. The owner advises that the operation has been excellent, requiring practically no attention and since tank is underground, has experienced no inconvenience during freezing weather.

In Figure 3 is shown a complete outfit for the average sized country home. The tank is 30 inches in diameter by 8 feet in length, having a total capacity of 295 gallons and will deliver about 200 gallons without refilling.

Fig. 3.



As the space taken is small, it can be located in the basement. The water is pumped with a small hydro-pneumatic hand pump which is satisfactory provided the lift is not over 20 feet. On this pump a hand air valve is provided, so that by opening this and pumping the correct amounts of air and water can be maintained.

The approximate cost of an outfit of this kind ready to connect to service pipes in house is about $64, being proportioned as follows:

Pneumatic tank, 30 in. x 8 ft., cap. 295 gal.	$42.00
Hand pump, 3 in. cyl. 1¼ in. suction	10.00
Gage and water glass fittings on tank	5.00
Pipe fittings (shown in figure)	7.00
Total	$64.00

The advantages of a pneumatic system are many. It not only does away with the attic tank but allows the apparatus to be located conveniently to the pump, where the operation can be watched; the danger of freezing, common to elevated tanks placed outdoors is avoided, also the expense of erecting towers to support such tanks. The advantage to be gained by placing the tank underground, is that water delivered by it has nearly a constant temperature through the year. The application of this system covers a wide range, for it may be used on the farm to supply not only the house, but also the stables, wash room, dairy, lawns, and gardens

If demand is not too great, one large tank may be used, otherwise the pressure will have to be pumped up oftener. It is good practice to have pumping time come but twice a week by having a tank large enough to hold supply for three days.

HOT WATER SUPPLY.

A hot water supply may be furnished by an independent heater and boiler in the basement, by connection to a coil in the furnace, or as is usual in country houses which have neither basement nor furnace, by a boiler and water back attached to the range in kitchen.

Whenever the house supply is from an attic tank, the hot water supply must be under tank pressure, in the use of which system an expansion pipe is necessary. In figure 4 is shown the arrangement of pipes for a successful water heating and circulating system.

The cold water should always enter the boiler at some distance below the entrance point for hot water from the range water back. The kitchen boiler is simply a storage tank to keep a supply on hand so that it can be drawn when needed. Certain hard waters will rust out a galvanized boiler in a few years while a copper boiler will last indefinitely, but its cost is prohibitive, and in nearly all cases these kitchen boilers are galvanized iron of 30 to 40 gallons capacity. As difference in price is small it is preferable to install the larger tank.

The upper pipe connecting the water back and boiler should not sag but have a continuous rise from range to boiler, entering boiler as high as is practicable, and be of reasonably large size, in order that circulation will be good and water in boiler will heat rapidly. To prevent pounding and the consequent noise in the boiler, the expansion pipe is provided to allow steam and air a ready escape. Any sediment accumulating in boiler can be drawn off at the faucet at base of boiler, which in all cases should be provided.

Since when using an attic tank the available water is limited, it is desirable to draw hot water from faucets at the instant of opening, without having to wait until a long pipe is emptied with the consequent waste of water. The use of circulating pipes, if properly installed obviates this disadvantage. As shown in the figure, the hot water pipe is started from the top of the boiler, where the hottest water is, carried up to highest fixture, then down to base of boiler. Since it is preferable to use the least pipe, bath room should be located directly above the kitchen, as it not only simplifies piping but secures a much safer plumbing installation.

For simplicity, only the hot water piping is shown in the figure. A reputable plumber furnishes the writer with the cost of this installation as follows:

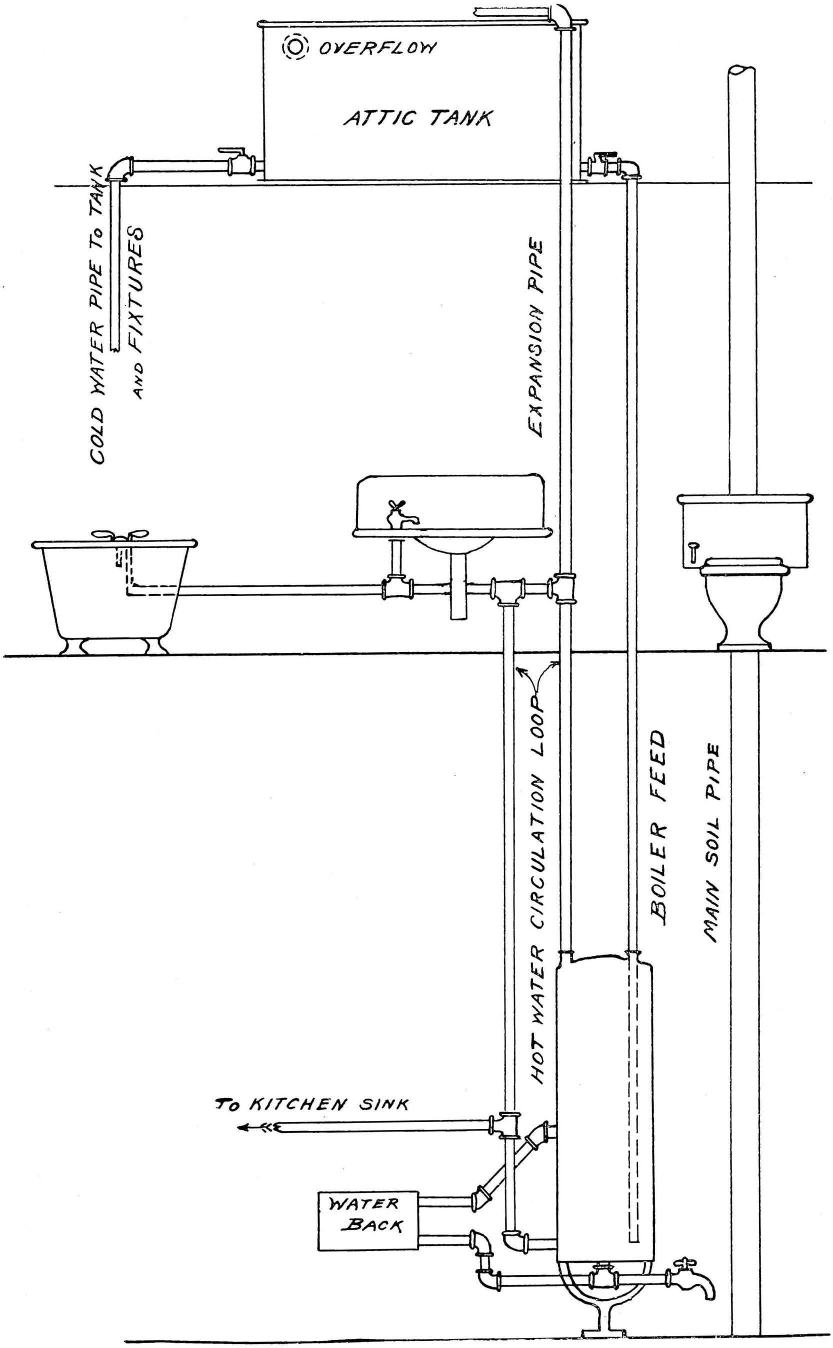


Fig. 4. ARRANGEMENT OF HOT WATER PIPING.

Attic tank, capacity 150 gals.	$ 6.50
Kitchen boiler, capacity 40 gals.	10.00
Kitchen force pump.	8.00
Boiler connection to range.	3.50
Piping, approximate.	35.00

He estimates the total cost of installing the water and sewer conncetions to fixtures as shown, at $130.

If the house has a basement, the heating arrangement can be supplemented by a small water heater in basement to be used when hot water is needed and it is not convenient to have a fire in the kitchen range.

AVAILABLE POWER.

In each case the situation will determine what will be the most economical and convenient means of forcing water into the storage tank. The source of supply, the amount required, the available fuel and labor cost will all have a bearing on the matter. The hydraulic ram and the windmill have the advantage of operating without fuel, but fall must be available to use the ram, while with the windmill the daily supply is not always under control. Gasoline and kerosene engines require fuel and attention, but the supply is easily regulated to suit varying demands.

Windmills.—A good and simple way of securing a supply of water is by the use of a windmill. Where the machine is properly constructed it will pump large quantities of water without cost practically, for the wind is free and the cost of repairs is very small. To be most efficient and to take advantage of the wind from any direction the tower should lift the wheel about ten feet above the tallest obstruction. The galvanized steel towers have proved durable and are fast taking the place of wood towers.

A combination tower carrying both wheel and tank is being made by many of the manufacturing companies under the name of "suburban outfit." Like all outside tanks, these have to be guarded against frost and the pipes leading to them have to be protected. Pipes are protected by enclosing in two or more wood casings with air spaces between. Combination pumping and power mills are also on the market at an additional cost, that will pump water, grind feed, shell corn, saw wood, etc.; but the heavier work must be done when there is a strong breeze. For pumping water in the central part of this state, where the average hourly wind velocity is about 9 miles per hour, 8-foot wheels on 35-foot towers are the most common in use. A division of the cost of one of these mills would be about as follows:

Thirty-five-foot galv. steel tower.	$25.00
Eight-foot mill wheel.	34.00
Pump, 2½″ cyl., 3 way valve.	14.00
Cost of erection.	12.00
Total.	$85.00

The following suggestions on windmill pumping may be of value. One of the most desirable features in this work is the efficiency of the mill in light winds. A pump used in connection with a windmill should be of smaller size than when operated by hand, for when hand pumping is resorted to, we want a pump which will elevate the maximum amount in the shortest time.

The requirements are different, however, in the use of windmills, for generally the windmill need not run but three or four hours a day to supply the tank with the necessary amount of water. During certain seasons of the year there are many days during which the wind is very light, in this locality, in July and August. During these times the windmill should be under as light a load as possible in order that it may be certain to perform some work. Therefore a small pump, even though unable to furnish but half that which could be pumped by hand during the same period, will prove most satisfactory. This small pump will allow the windmill to work a great number of hours during light breezes, and will be found to pump more water during the twenty-four hours of a day than a larger pump would.

The character of the well and its depth should be known—whether it is a driven, drilled, or dug well; if drilled, the inside diameter of casing should be known; the height and distance through which water is required to be raised. This last dimension is taken from the water level in well to the base of the elevated tank. The amount of water entering well during dry seasons should be known, the capacity of tank to be used, and the height of tower necessary to raise wheel free from obstructions. All this information should be given the manufacturer when purchase is contemplated as they determine the cost of outfit, and allow an intelligent estimate to be made.

Gasoline Engines.—Small gasoline, also kerosene, engines are now manufactured for the express purpose of doing pumping and other work about the farm. They have one distinctive advantage over other kinds of power, in that the water can be pumped in the quantities and at the time wanted, and the size of storage tank can be very accurately chosen. An engine can be selected which will burn natural gas, gasoline, kerosene, or alcohol. These engines do not require a great amount of skill to run them. They require little fuel and can by used for driving other light machinery when not needed for pumping water.. Since there are many uses to which they can be put, it is well to select one of the many portable types now on the market, if gasoline or kerosene is to be the fuel used. They are mounted on skids or trucks and can be easily attached to churns, feed mills, corn shellers, grain fans, etc. For the sake of general utility, it is best to choose an engine of from 4- to 6-horse power. If only pumping is required or wanted, a 2- or 3-horse power engine will furnish ample power. With the advent of denatured alcohol, there is a possibility of a more economical fuel. A good 2- or 3-horse power engine can now be purchased at a cost of $80 to $100.

With any good, small, stationary gasoline engine working under favorable conditions, a fuel consumption as low as one pint of gasoline and 1.4 pints of alcohol per horse power hour may be reasonably expected, and the difference is slight with the well constructed engines now on the market. Any gasoline engine of the ordinary types can be run on alcohol fuel without any material change in the construction of the engine. The difficulties likely to be encountered are in starting and in supplying the correct amount of alcohol fuel, which is considerably larger than the quantity of gasoline required. The fuel consumption, which governs the cost of operation, depends chiefly upon the horse power at which the engine is being run and upon the setting of the fuel supply valve. It is easily possible to double the cost of fuel used, either by running the engine on a load below its full power or by a poor setting of the fuel supply valve.

On a dairy farm in Boone county a gasoline engine of 4-horse power pumps water from a nearby creek to a cistern on a hill, from which water flows to the house and barns by gravity. The owner operates engine a few hours twice a week, and states that the average fuel cost is only 15 cents per week, and that three dollars a year will cover the cost of repairs to pumping plant.

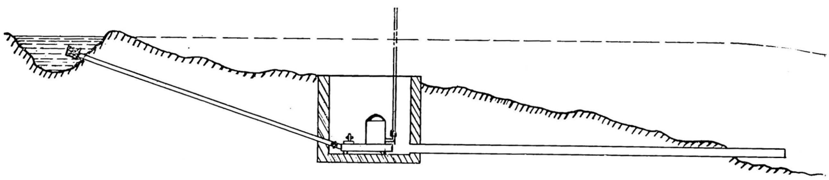
Hydraulic Rams.—Where some means of pumping has to be used to furnish the water supply, probably the most economical method lies in the installation of a hydraulic ram. It can be used to fill the storage tank if the source of supply is a spring, flowing well, or running stream from which enough fall to supply the power can be obtained. In a proposed installation the first items to be considered are the supply and the available fall. Its use is practicable with a flow of only two gallons per minute and a fall of 18 inches. These are the lower limits and any increase in quantity and fall only betters conditions; increasing the amount pumped and the distance and height through which it can be elevated. The relation between the height of spring or supply, above the ram and the elevation to which the water is to be delivered, determines the proportion of water raised to that which runs to waste.

Water falling from higher to lower levels has energy in amount depending upon the distance it falls and the quantity falling. In the hydraulic ram this energy is made to pump and elevate water, thus utilizing to advantage that which otherwise runs continuously to waste. The power which operates the ram is created by the velocity of the water supplied to it, hence it is necessary to have a fall or head of water the same as if a small water wheel was to be operated.

In operation, the ram is a combined pump and water motor, working in pulsations by a kind of water hammer caused by the abrupt stopping of the flow in the drive pipe. The energy the water has acquired is spent in forcing part of the water which drives it up into the tank or other reservoir through the delivery pipe.

The best locations for a ram are at the hillside spring, where the natural fall of the land furnishes a working head, or near a natural fall in a stream; leading supply from stream above falls to ram, and then letting it run back into stream below the falls. If spring is the source, the

Fig. 5.



LOCATION OF HYDRAULIC RAM.

fall can be increased by walling in with brick or concrete, provided this does not materially decrease the flow. In the figure the natural fall is increased by placing ram in pit and letting waste water out through ordinary drain tile.

For the average farm house using say, 150 gallons per day, a ram which will operate on four gallons per minute will furnish the supply, and that too—through a thousand feet of pipe. It may be safely calculated that conveying water from 50 to 60 rods, one-tenth to one-fourteenth of the supplied water can be raised and discharged at an elevation ten times the fall. A rule given by one of the most prominent ram manufacturers reads thus: "To find the quantity of water which a ram will deliver, multiply the fall in feet from the spring to the ram, by the number of gallons per minute supplied to it; divide this product by twice the height to which the water is to be forced, and the result will be the quantity of water (in gallons) per minute delivered by the ram at point of discharge.

Appended is a table showing the sizes of rams now on the market and the approximate cost of same.

Hydraulic Ram Sizes.

Gal. per min. to operate.	Size of drive pipe in inches.	Size of discharge pipes in inches.	Price.
1½ to 4	1	½	$ 8.00
6 to 14	2	1	18.00
10 to 25	2½	1¼	25.00
20 to 60	4	2	45.00
30 to 120	6	2½	75.00

POSSIBILITY OF INTRODUCING PLUMBING INTO HOUSES ALREADY BUILT.

It goes without saying that plumbing can be put into a house more conveniently at the time the house is being built; but if this has not been done there is nothing to prevent its being installed afterward. Installing the plumbing may conflict with the household routine for a few days, but as all pipes should be run exposed for sanitary reasons, aside from cutting through ceilings and floors, little inconvenience is met with in putting the fixtures and pipes in place. A water back can be placed in almost any kitchen range and attached to a hot water boiler.

As an illustration of the cost of introducing such conveniences, some actual cases are cited. In an eight-room two-story house having in bathroom a lavatory, bathtub, and watercloset, one lavatory in bedroom; in kitchen a sink and 30-gallon range boiler; and in laundry one cold water faucet, these fixtures were set up with complete supply and waste pipe connections for $180.

In another six-room cottage employing an attic tank, water is supplied to bathroom fixtures, consisting of lavatory, bathtub, and watercloset, the kitchen sink and hot water heating tank, the total cost was $115.

Electric Pumping.—There are many suburban residences on the outskirts of towns and villages to which the electric light mains have been extended, or could be very easily. If this condition prevails and advantage is taken of same for lighting the house; electricity can be made the power to do the water pumping. If an electric motor be used, the arrangement should be such that it will be automatic in its action. Whether the system be elevated-tank or pneumatic, it should be so arranged that the level of water in the elevated tank would not rise or fall below certain heights, nor the pressure in the pneumatic system vary more than a few pounds.

These pumps are rather attractive in appearance so would not be unsightly or take up much space if it were necessary to place it in the basement. Pump and motor are made in compact units either for belt or gear drive and are practically noiseless in operation. The size of the motor of course will depend upon the capacity of the pump; and the type, on the available current. Purchase of the whole unit had best be made from one firm, as motor and pump must be adapted to each other, and information as to the type of motor required gotten from the company furnishing electricity or from a local electrician.

A one-half horse power motor direct connected to a 2-inch by 4-inch cylinder pump has a capacity for ordinary lifts near 300 gallons per hour.

The first cost is comparatively large but the power cost and maintenance charges will probably be smaller than for any other except when hand power is used.

Conclusion.—There are many modifications of the systems outlined, where soft and hard water piping is used, which are more or less complicated. In one of these hard water is supplied from a deep well and is used for laundry, kitchen and sanitary purposes, in the house, for watering stock and other outside purposes. The pneumatic tank is connected with a windmill or other pumping device, and is supplemented by a soft water tank in the basement. Water from the hard water tank is used to operate a water-lift which pumps from a cistern into the soft water tank in basement. This water lift is so constructed that when the pressure in the soft water tank equals the pressure in the hard water tank the lift will stop working and will not again start until water has been drawn off and the pressure reduced. Any system of this kind can best be worked out by a good plumber.

The requirements of no two families or homes are ever alike, but these suggestions are made with the hope that they may be a help in solving the question of water supply. The importance of sanitation and purity of supply have been emphasized, but none too strongly. The labor saved by having the water carried to the house, barn and garden will soon pay for the installation of some good system, while the value of the healthfulness secured by a supply of pure water and sanitary plumbing cannot be estimated in dollars and cents.

THE UNIVERSITY OF MISSOURI BULLETIN

ENGINEERING EXPERIMENT STATION SERIES

EDITED BY

E. A. FESSENDEN

Acting Director, Engineering Experiment Station.

Issued Quarterly

Some Experiments in the storage of Coal, by E. A. Fessenden and J. R. Wharton. (Published in 1908, previous to the establishment of the Experiment Station.)

Vol. 1, No. 1—Acetylene for Lighting Country Homes, by J. D. Bowles, March, 1910.

Vol. 1, No. 2—Water Supply for Country Homes, by K. A. McVey, June, 1910.

Vol. 1, No. 3—Sanitation and Sewage Disposal for Country Homes, by W. C. Davidson, September, 1910.

Vol. 2, No. 1—Heating Value and Proximate Analyses of Missouri Coals, by C. W. Marx and Paul Schweitzer. (Reprint of report published previous to establishment of Experiment Station.) March, 1911.

Vol. 2, No. 2—Friction and Lubrication Testing Apparatus, by Alan E. Flowers, June, 1911.

Vol. 2, No. 3—An Investigation of the Road Making Properties of Missouri Stone and Gravel, by W. S. Williams and R. Warren Roberts.

Vol. 3, No. 1—The Use of Metal Conductors to Protect Buildings from Lightning, by E. W. Kellogg.

Vol. 3, No. 2—Firing Tests of Missouri Coal, by H. N. Sharp.

Vol. 3, No. 3—A Report of Steam Boiler Trials under Operating Conditions, by A. L. Wescott.

Vol. 4, No. 1—Economics of Rural Distribution of Electric Power, by L. E. Hildebrand.

Vol. 4, No. 2—Comparative Tests of Cylinder Oils, by M. P. Weinbach.

Vol. 4, No. 3—Artesian Waters of Missouri, by A. W. McCoy.

Entered as second-class matter, August 24, 1912, at the postoffice at Columbia Missouri, under act of August 24, 1912. 3000

University of Missouri Libraries
University of Missouri

MU Engineering Experiment Station Series

Local Identifier	McVey1910

Capture information

Date captured	2018 February
Scanner manufacturer	Ricoh
Scanner model	MP C4503
Scanning software	
Optical resolution	600 dpi
Color settings	Grayscale, 8 bit
File types	Tiff

Source information

Format	Book
Content type	Text
Notes	Digitized duplicate copy not retained in collection.

Derivatives - Access copy

Compression	LZW
Editing software	Adobe Photoshop
Resolution	600 dpi
Color	Grayscale, 8 bit
File types	Tiffs converted to pdf
Notes	Greyscale pages cropped and canvassed. Noise removed from background and text darkened.