Systems of Water Supply for a 320-Acre Dairy Farm

Agronomy

B. S.

1914
SYSTEMS OF WATER SUPPLY FOR A
320-ACRE DAIRY FARM

BY

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THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

AGRONOMY

COLLEGE OF AGRICULTURE

UNIVERSITY OF ILLINOIS

1914
UNIVERSITY OF ILLINOIS

June 5, 1914

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Glenn Wilson Schroeder

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Systems of Water Supply For a

320-Acre Dairy Farm

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF

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I. Introduction

To own a farm, to succeed on it, and after 25 years spent in tilling it to your best advantage, to leave it for a house in town, speaks poorly for the richness of country life. The attitude while on the farm is often that of the toiler in a far country, "I'll make enough here to live comfortably on the rest of my life, and then back to God's country". The farm is accepted as a means to an end, not the end. The farmer plans to work hard, to have comparatively few enjoyments, and when the period of drudgery is over to live a retired life in town. The writer's personal idea is somewhat different from this. He intends to own a farm, succeed on it, and also to live on it. Any lack of real living on this farm will be due to some factors, of which there will be many no doubt, that are beyond his control.

One of the most important contributions which a man can make toward a comfortable farm living is the providing of conveniences. In town gas or electric lighting, running water, and sewage systems are all looked upon as necessities. If these were provided on a farm how much easier would be the duties of the housewife! The hardest work on a farm is hers. When she moves to town she no longer need keep a boarding house for the men, and may enjoy all the pleasures and comforts of modern conveniences. Change this order about and we have solved one of the problems of living on the farm.
II. Conditions of the Problem

The farmstead upon which the calculations are based is one which was designed by the writer. It is to be for a diversified stock farm, 320 acres in size, with the dairy as the main department. Of the other three departments, sheep, swine, and horses, the first two were stocked up with that number of head so that all three required about the same amount of time for the regular chores. With three men working, each would have a separate department, besides dividing the milking. The cattle feeding, as well as the care of the milk, would be done by the operator in addition to managing the farm.

The following stock would represent the maximum figures: 100 sheep, 45 cows, 35 young stock, 16 horses, and 250 swine. About all the crops grown on the farm could be used as feed for this amount of stock. The buildings and their grouping were planned with this in view. As is shown in Figure I, the central 60' round barn is divided into two parts, one half for the horses, and one half for the young stock and dry cows. Just west lies the 70' dairy barn with a shed between for the young stock, bull, feed, and milk rooms. The cattle in both barns will be run loose and the cows stantioned only at milking time. There is an 18' concrete silo in the center of the dairy barn and a 12' S curler silo in the other. Further west is the sheep shed open at the south.

The southeast corner of the granary is used for shell- ing, grinding, and corn chopping. A line shaft runs from this room through the power house to the workshop in the
northwest corner of the machinery shed. An 8 H.P. gasoline engine furnishes the power. Northwest of the granary and furthest from the house is the hoghouse. The chicken shed is south of the machine shed. Two outdoor circular cisterns lie between the horse barn, machinery shed, and granary to receive the rainwater from all three. There is no surface water supply available such as ponds, creeks, etc. The well for hard water supply is located in the power house and is 100' deep with 30' of water.

The dwelling house is situated with the chicken shed handy, 120' from the horse barn, and with the dairy barn and machine shed but little further away. The plan is the one selected by the Minnesota State Art Society for livable farm houses and provides for a maximum of ten people.

III. The Water Supply in General

There are four types of water systems suitable for farms, the type being determined by the method by which the pressure is obtained. These are: (1) elevated source of supply, (2) elevated tank, (3) hydro-pneumatic system, and (4) the pneumatic system. The first case is by far the cheapest and most efficient but it is not available for this farm. The best adaptation which could be made of each of the other types was selected as all three serve the present conditions, the object being to find that system or combination of systems which offers the most efficient service in the most economical way. Before any system was accepted it had to deliver the required maximum amount of water to the
stock tanks and furnish hard and soft running water to the house at all times of the day. The drinking water had to be pure and the soft water supply from the rainfall.

**Water Requirements per Day, Maximum.**

<table>
<thead>
<tr>
<th>Animal Type</th>
<th>Requirements per Day</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 sheep</td>
<td>1 1/4 gal. per day</td>
<td>125 gal.</td>
</tr>
<tr>
<td>45 cows</td>
<td>12 1/2 gal.</td>
<td>560 gal.</td>
</tr>
<tr>
<td>35 young stock</td>
<td>5 3/4 gal.</td>
<td>200 gal.</td>
</tr>
<tr>
<td>16 horses</td>
<td>12 1/2 gal.</td>
<td>200 gal.</td>
</tr>
<tr>
<td>250 swine</td>
<td>1 7/8 gal.</td>
<td>475 gal.</td>
</tr>
<tr>
<td>10 Persons</td>
<td>30 gal.</td>
<td>300 gal.</td>
</tr>
<tr>
<td>Washing in the milk room</td>
<td></td>
<td>100 gal.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1960 gal.</strong></td>
</tr>
</tbody>
</table>

150 gal. of the house requirement is for soft water and comes from the cistern supply, the remainder, 1810 gal., is from well water.

The discussion and costs are confined to only one complete system in each case. Where more than one method is allowable within the same system for the same operation, the one best suited for the conditions of the farm is taken, with the idea in mind to use the most economical method available. The cost of piping, plumbing, fixtures, etc. in the house was omitted, the water being brought only up to the house in each case. The prices submitted represent the lowest at which the grade of materials required could be bought for by the average farmer, laid down at his nearest railroad station. In most cases they are prices given by a producing company f.o.b. the factory plus a 15% increase which would include the freight,
incidentals and an agent's reasonable profit. The expense of hauling to the farm and the labor required for installing was not estimated. The prices for the concrete work represent the job complete in every case.

The factors for efficiency for farm water systems have been outlined as follows:

1. First Cost
   a) cost of equipment
   b) cost of installation

2. Running Expenses
   a) cost of operation
   b) cost of maintenance

3. Short Time High Pressure
   a) amount of pressure
   b) capacity of flow
   c) length of time of capacity flow

4. Serviceability
   a) efficiency for cooling
   b) fresh drinking water at the house
   c) amount of water on hand
   d) chances of injuries
   e) time for repairing

The discussion of the three water supply systems, after a brief description and tabulation of costs, will follow this order.
IV. System No. 1 Elevated Tank.

Description - A 60' windmill tower supporting a 12' wheel extends up through the roof of the power house. The well is drilled, 4" in diameter and fitted with a pair of differential cylinders having a pumping capacity of 323 gal. per hour. A belt drive deep well is used which may be worked by hand, by a belt from the line shaft, or by the windmill. The water is pumped through a check valve into the piping system which is connected by a stand pipe to a 5000 gallon tank on top of the 18' concrete silo in the dairy barn. Opening from the piping system there are the following watering tanks and hydrants besides the house supply:

1 hydrant at the hoghouse
1 " " machinery shed
1 " " cow barn
1 " " chicken house
1 " " milk room
1 " " garden
1 concrete tank 2.2 1/2.8' at the hog house
1 steel " 2.2.8' " young-stock yard
1 concrete " 2.2.8' " horse barn
1 concrete " 2.2.4' " cow barn
1 steel " 2.2.4' " sheep shed

All tanks fitted with float valves.

The soft water supply is obtained from the concrete cisterns. The water is either pumped to a pressure tank underground at the power plant or to an attic storage
in the house. The force pump used is so arranged that it can be worked from the same pump head as the deep well pump and is located adjoining it in the dry well at the power house.

Operation—By an indicator the amount of water in the tank on the silo is shown and by leaving the mill in gear when low, the tank is kept filled. Should the tank run dry when the men are away, water can be obtained at the house by hand pumping and carrying it from the well. The pump is fitted with a three way cock so the water may either be drawn directly from the well as pumped, or forced into the piping system. In times of low wind, the supply can be pumped daily into the tank by means of the 8 H.P. engine and shafting. The differential cylinders apply very well in this case, the lower cylinder raising the water to the surface, the other forcing it against the 30' head of the storage tank.

With a good wind the soft water force pump can be run by the windmill in addition to the deep well cylinders. If the wind is too light, pump each in succession, or if too light for the well pump, run the force pump with it. There is always the gas engine to fall back on. Both elevated and soft water tanks are large enough to supply an average two days run with one filling.

See data on wind pressure necessary for pumping, page 19.
Summarized Cost of Hard Water Supply

System No. 1

1. Drilling and casing 100' bored well, 4" diam. $169.00
2. 12' foot windmill on a 60' tower 132.00
3. 1 pair of differential cylinders 2 3/4.6" 12.43
4. 75' of 1 1/4" drop pipe & 7/16" pump rod 15.75
5. 1 belt drive deep well pump 30.10
6. 5000 gal. concrete tank on silo 200.00
7. 60' of stand pipe and frost proof boxing 50.00
8. 6 hydrants and 900' of 1" piping 123.75
9. 5 stock tanks See page 8 38.75

Total $771.82

Summarized Cost of Soft Water Supply

System No. 1

1. 530' of 4" gutter and conductor pipe $21.42
2. 50' of 4" sewer tile 5.20
3. 2 concrete cisterns 14.12' diam.
   350 bbl. total capacity 487.50
4. 110' of 1 1/4" piping to pump 13.65
5. 1 suction force pump 3.4" 14.40
6. 260' of 1" piping to house 20.48
7. 1 attic storage tank 5.5' diam. (10.93)
   or
7. 1 42" x 3' pressure storage tank
   extra piping for same 11.97

Total using attic tank $573.58
Total using pressure tank $627.02

# See appendix for itemized prices, page 34.
Total Water Supply for System No. 1

1. With attic tank for soft water
   hard water $771.82
   soft water 573.58
   --------
   1345.40

2. With pressure tank for soft water
   hard water $771.82
   soft water 627.08
   --------
   1398.84

V. System No. 2 Hydro Pneumatic Pressure Tank.

Description- The pumping, piping, watering tanks, and hydrants are the same as in the elevated tank system. Underground at the power house will be the hydro pneumatic tank. This is piped so as to receive the water from the well pump through a check valve. From the tank the water is forced through the piping system and the supply is used in the same manner as with system No. 1.

The soft water supply is the same also, as is used in system No. 1.

Operation - All of the water used will be pumped into the pressure tank by the windmill. In times of insufficient wind the gasoline engine can be used for power. The pressure obtained by the pressure tank is sufficient to force water all through the house. As the water is lowered in the stock tanks the float valves open so keeping these tanks full of water.
Summarized Cost of Hard Water Supply #

System No. 2.

1. Drilling and casing 100' bored well 4" diam.  $169.00
2. 12' windmill on a 60' tower  132.00
3. 1 pair of differential cylinders 2 3/4 . 6"  15.43
4. 75' of 1 1/4" drop pipe and 7/16" pump rod  15.75
5. 1 belt drive deep well pump  30.10
6. 60" . 24' pressure tank 24 Hr. capacity  284.40
7. 1 automatic stopping and safety device  9.80
8. 6 hydrants and 900' of 1" piping  123.79
9. 5 stock tanks See page 8  38.75

Total using a 24 Hr. cap. tank  $816.02

or

6. 72" . 34' pressure tank 48 Hr. cap.  add 219.50

Total using a 48 Hr. cap. tank  $1035.52

Total Water Supply for System No. 2
A. Using a 24 Hr. capacity tank

1. With attic tank for soft water
   - hard water  $316.02
   - soft water  573.58
   ______
   1389.60

2. With a pressure tank for soft water
   - hard water  $316.02
   - soft water  627.02
   ______
   1443.04

# See appendix, page 34.
B. Using a 48 Hr. cap. tank

1. With attic tank for soft water

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>hard water</td>
<td>$1035.62</td>
<td>$1035.62</td>
</tr>
<tr>
<td>soft water</td>
<td>-573.58</td>
<td>-1809.20</td>
</tr>
</tbody>
</table>

2. With pressure tank for soft water

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>hard water</td>
<td>$1035.62</td>
<td>$1035.62</td>
</tr>
<tr>
<td>soft water</td>
<td>-327.02</td>
<td></td>
</tr>
</tbody>
</table>

VI. System No. 3  Pneumatic Pressure Tank.

Description - The pump used in this system is a pneumatic pump or "Auto-pneumatic Pump" as it is styled by the U.S. Dept. of Agr., and is operated by compressed air. An air compressor in the power house which is run by the gasolene engine, pumps air into a storage tank up to a pressure of 100 lbs. From the tank air pipes lead to two pneumatic pumps, one in the well for the hard water supply, the other in the cistern for the soft water supply. A 3" casing is used in the well to admit the proper sized pump. With this system use is made of the fresh water by putting in a cooling tank in the milk room, and the piping is changed accordingly. Otherwise the same piping, stock tanks, and hydrants are used as in system No. 1.

Operation - Windpower would provide too variable a speed for the compressor so no attempt is made to use a windmill. Once a day the engine is started operating the compressor. When the maximum pressure in the reserve tank is attained the automatic gasolene engine circuit breaker stops the ignition. The air pressure line runs from the tank
to the pump in the well and to the cistern pump. At each of these pumps an air pressure reducer maintains the correct working pressure for the pump while the supply in the tank lasts. From the former the hard water piping leads to the hydrants, house, and cooling tank. This line of piping may be used for sprinkling, washing implements, or for fire protection. Another line of pipe supplies the various stock tanks by a gravity flow from the cooling tank. In this way there is a considerable flow of fresh cold water through the cooling tank. The soft water supply is obtained from a second pump located in the bottom of the cistern. This provides a pressure sufficient to force water all through the house. The action of these pumps is entirely automatic. When the compressed air is first turned on the pumps operate until the pressure in the connecting piping just balances the pressure of the air admitted by the air pressure reducer from the supply tank. Opening a faucet in the piping furnishes an outlet for the water and the pressure is thereby lowered. This starts the pump working and it operates until after the faucet is closed.
Summarized Cost of Hard Water Supply\#.

System No. 3.

1. Drilling and casing 100' bored well 6" diam. $285.00
2. 7 hydrants and 1080' of 1" piping 183.95
3. 5 stock tanks See page 8 38.75
4. Cooling tank 2 1/2 .3 .12' 12.60
5. Complete pneumatic pump outfit 534.80
   1) 1 pump 85.00
   2) 1 - 48".16' pressure tank 124.30
   3) 1 Air compressor 200.00
   4) 1 auto. gasoline engine circuit breaker 10.00
   5) Fittings, gauges, etc. 50.07
   6) Freight on above and local dealers profits 55.43

$1,045.10

Summarized Cost of Soft Water Supply\#.

System No. 2.

1. 340' of 1" piping $30.24
2. 530' of 4"gutter and conductor pipe 28.32
3. 2 concrete cisterns 14 . 12' diam. 487.50
4. 1 pump 85.00

Total Water Supply for System No. 3.

Hard water $1,045.10
Soft water $629.36

$1,674.46

# See appendix, page 34.
VII. Discussion - Taking them as a whole, any one of these three systems would give efficient service. The prices are given for a pressure tank for soft water and also for an attic tank system. The better is an unsettled question. With the money on hand it would be worth while to install the former as the advantages are greater. With rather limited means and having a high pressure water system in the house also, the writer would decide in favor of the attic tank so from now on the costs will be based upon this system for the soft water supply.

In first costs the systems range as follows: No.1 - $1345.40, No.2 - $1389.30 for 24Hr. service or $1309.20 for a 48 Hr. service, and No.3 - $1674.46. The farmer could do most of the work in installing any of these systems. His outlay of cash and labor in addition to the prices already given would probably be the least in system No.1 and greatest in system No.3. The installation alone would cost more in system No.2 than in No.3 as the former requires the setting of a large tank and the erection of the windmill, while neither is required for No.3. This would in part offset the $65.00 difference in first cost and since you would also have a cooling tank and fresh water in the house, taken altogether there are apparently more conveniences in system No. 3 for the money than in system No.2. This is figuring on a 48 Hr. service all through.

In the maintenance of the three we get a marked advantage for No.1 and No.2, because of the utilization of wind power. The best data we have on this is the record of the work done in one year by a 15' windmill, published by
the University of Wisconsin in their bulletin No. 68. The minimum wind velocity which was necessary for pumping varied from 8 to 10 miles per Hr. Applying the work done by that mill as a comparison for the pumping which we could expect to be done by the 15' mill on this farm, the following figures are obtained:

<table>
<thead>
<tr>
<th>Consecutive No. of Hrs. considered</th>
<th>No. of times per year with insufficient pumping wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>36</td>
</tr>
<tr>
<td>36</td>
<td>30</td>
</tr>
<tr>
<td>48</td>
<td>18</td>
</tr>
<tr>
<td>72</td>
<td>4</td>
</tr>
</tbody>
</table>

A 48 Hr. service is used as the basis for the water supply. The 18 times when there would be too little wind for pumping for over that length of time would require 31 pumpings of a daily supply to maintain the system. Using a 24 Hr. service as a basis, the 36 times of low wind for over 24 Hrs. would require 71 pumpings of a daily supply. Thus there is 2 1/3 times the extra for times of low wind by using the smaller capacity. Again should you desire water for a special purpose or should an accident occur in the system there would be but a small amount available. The writer's experience has been that any decrease in the capacity of service under 48 Hrs. results in a more than corresponding increase in the time and care necessary. In short, the economy, servicability, and convenience of the 48 Hr. capacity system warrents its selection over a smaller one. On the other hand a higher than 48 Hr. service is not warrented since the cost for larger tanks increases very
rapidly and even a 5 day capacity tank would fail four times during the year. It is better to have an engine available and not attempt a system with a capacity so large that one relies wholly on the wind. As the following calculations show the purchase of the windmill in addition to a gasoline engine, is justified by the saving in operating costs. The fuel requirement of an 8 H.P. engine under a 2 H.P. load is 1.49 Pts. per H.P. Hr. On the pumping 2 H.P. will be the average brake H.P. required and with a pumping capacity of 323 Gal. per hour it would require 5 1/2 Hr. of pumping daily to supply the 1810 gallon requirement. This makes 11 H.P. hours per day or 4015 per year. At 1.49 pints per H.P. hour the gasoline consumption would be 5982 pints per year or 748 Gal. which at $.15 per Gal. totals $112.20. The lubricating oil, 5 pints, would cost $.30. The number of years service by the engine would not be appreciably lowered from this work and as the engine is necessary for other work no interest nor depreciation is charged for pumping. With this rough estimate the cost of doing all the pumping by engine power is $112.50. Allowing 25 years for the life of a windmill, the maintenance charges for the one used are $13.32 including interest and depreciation. For the 31 daily pumpings by an engine necessary when the wind fails, the fuel and oil cost is $9.55 or a total pumping cost of $22.87 using a windmill. This makes a saving of $89.63 per year over using an engine entirely, besides the addition of several added conveniences which the windmill allows. We turn the windmill in gear and it fills the tank; by an auto-
matic cutoff it is thrown out of gear at the right time. Again if the garden or lawn needs watering, by utilizing a windy day we may have almost any amount of water with no extra cost. Taking it as a daily average the attention and time that a windmill requires is considerably less than what an engine would need. In this question of maintenance then, the systems No. 1 and 2 are superior to No. 3.

By "Short Time High Pressure" is meant the pressure which can be raised in case of fire. With system No. 1 and No. 3 the pressure remains the same regardless of the extra power available at the pump, while with No. 2 it can be raised as high as the system will stand. In regard to the capacity of flow with system No. 3 it can be varied but little, the pump working only so fast. The limiting factor with either No. 1 or No. 2 is the size of the water has been already pumped. With system No. 1 the pressure will be maintained for some time but with No. 2 if the flow is greater than the small pumping capacity the pressure will decrease. Because of the greater flow and longer continued high pressure, then, the elevated tank system is the best for fire protection. If one had time enough the pressure in system No. 3 could be raised to make it an excellent system but ordinarily the tank pressure will not be high and because of the size of the tank the time would not be available at a fire for materially increasing the pressure.

In regard to cooling, the elevated tank system is poor. To get the proper use of the tank the water would be stored there such a length of time that the temperature
would raise to over 65° in summer. With system No. 2 the water would be cooler; it would have to stand in the tank some time however, so that when used its cooling power would be much reduced. With system No. 3 the full benefit is obtained. Almost the whole supply of hard water would come to the cooling tank directly from the well.

Lastly there is trouble liable from injuries to the system. With No. 1 and No. 2 we have both a windmill and a gasolene engine for power. The former is the most reliable machine to operate which we have. It practically never has a breakdown and the liability of both the windmill and the engine being laid out for repairs at the same time is negligible. With system No. 3 there are both the engine and the compressor to maintain, and the latter unless especially studied might be difficult to repair. On the pumping side with No. 1 and No. 2 we have the ordinary deep well cylinder with an equally simple additional cylinder at the surface, both familiar to the average town hardware man. With system No. 3 an injury to one of the pumps unless it could be repaired on the farm, would stop its use for some time. There would always be the second pump to fall back on and an ordinary cylinder could be installed with a gasolene engine for an emergency. This would have to be done speedily as no supply would be on hand, hence it would be of considerable inconvenience. On the whole though, even with system No. 3 the trouble from injuries would have but small weight in selecting a system.

Summing up the three systems the following can be said:
1. For the most conveniences, system No.3 is the best.

2. For economy in operation, No.1 and No.2 are better.

3. For economy in first cost No.1 is best, No.2 is next, and No.3 last. This relation would be more pronounced were the water requirement low.

4. For reliability of operation No.1 and No.2 are better.

5. For fire protection No.1 is best.

These are the regular types of farm water supply in use and accepted where some pressure is demanded. Where but little stock is on hand or where economical electrical power is available the writer does not see how they could be materially improved, but on the farm in question they did not suit. In the first place the cost was too high. You have to pay for what you get of course and this holds true for water supply. To have convenient hydrants and stock tanks there is a fixed charge for piping and tanks which will be the same in any system. Drilling a well is another fixed charge but a 4" is cheaper than a 3". For storing up soft water for winter or for a protracted drouth in summer you must have cisterns. A generous use of soft water should be allowed, its convenience comes every day and its accumulating benefits go far to make a home wholesome. These cisterns will be a fixed charge. There is a $50 saving in having the attic tank rather than the pressure tank. The windmill has been shown to be both an economical investment and
an excellent convenience yet with these systems we can not use it and also have efficient cooling. To avoid the trouble of the standpipe freezing and the cost of an elevated tank we must use a still more expensive pressure tank. If we want cooling and fresh drinking water in the house we must be without the windmill service and have to buy a good sized pressure tank, pumps at $85 apiece, and invest an extra $113 in the well.

Then there is an other objection to all three of these systems. The same amount of power is used per gallon of water where the water is merely flowing into a cooling tank where no pressure is desired, or where running into a lavatory on the second floor of the house. In other words, where only 1/10 of the hard water is wanted at a pressure, the whole amount must be pumped against it. We could do away with hard water in the house and thus get around it but that would leave us without any pressure available for outside use, since we could not use soft water for this purpose. The cisterns already cost too much for that. So the inconvenience of having no hard water in the house together with no outdoor supply is too great to consider this omission. Meeting these and other objections which arose the following adaptations and substitutions were made resulting in what is here termed "The Combination System".

VIII. System No. 4 Combination System.

Description — The well and pumping arrangement is the same as with the elevated tank system. The distribution of the water is different as for all the stock except the hogs,
the water first passes through a cooling tank to a 48 hr. capacity storage tank, and then to the stock tanks. The gravity flow which operates the distribution is explained in figure VI. The hog tank, being lower than the cooling tank and on the same piping, is kept full all of the time. All tanks are fitted with float valves to restrict any overflow to the dairy tank where a drain is provided. This arrangement is suitable for level land, or for hilly land providing the cooling and storage tanks are placed at as high an elevation as any other. By means of a three way cock at the well the water may be forced into a small pressure tank from which the house pressure piping system is supplied, or allowed to flow, under no pressure, into the cooling tank. The water may also be drawn from the well pump.

The soft water system is the same as in system No.1, the attic tank being used to furnish the necessary head of water.

Operation - To best get at the conveniences of the operation of this system suppose it be taken through the ordinary day. The first thing in the morning the windmill is put in gear to pump into the cooling tank. From it the water flows into the storage tank, and from here completely fills all stock tanks. Any time during the day that the storage tank is filled, the water is shut off from this and the pump connected with the pressure tank. By this means, 9/10 of the water used need only be pumped against a head of four feet, so utilizing as light a wind as possible. The
pressure tank is fitted with an automatic device whereby when the maximum pressure is obtained the windmill is thrown out of gear. In this way it is left until morning. The soft water pump may be worked either along with the well pump or separate from it, depending upon the velocity of the wind. All the care and attention needed to maintain the complete water supply with this arrangement is to stop two or three times a day at the power house to make these small adjustments. Should the wind remain too light for pressure tank service all through the 24 hours, the tank may be filled by starting the engine and connecting up both well and cistern pumps. The circuit cutoff automatically shuts off the engine when the tank is pumped up to its maximum pressure, and this amount of pumping will approximately maintain the soft water supply. The windmill may then be left connected up to the well pump for stock water supply and if even this slight power is not furnished, the engine may be used for this too. The engine will not be needed for this however, more than twice in three weeks on the average as proven by the Wisconsin experiment, and probably not that often since the 12' wheel used here furnishes relatively more power.

Should water be wanted for watering the lawn, gardens, or for washing out buildings, cleaning vehicles etc. a time may be chosen when the wind is good or the engine may be used for power. Connect the hose to any hydrant and by closing down the nozzle so that the flow will equal the pumping rate, the pressure will be maintained indefinitely. The tank is of such small size that even if low at first, in
30 minutes the pressure will be up. In this way an unlimited amount of water may be had, at whatever pressure is desired, and but a short time after starting the pump.

Summarized Cost of Hard Water Supply.

System No. 4.
1. Drilling and casing a 100' well 4'' diam. $169.00
2. 12' windmill on a 60' tower 132.00
3. 1 - pair of differential cylinders 2 3/4 . 6'' 12.43
4. Automatic stopping device and safety valve 9.80
5. 75'- 1 1/4'' drop pipe and 7/16'' pump rod 15.75
6. Belt drive deep well pump 30.10
7. 1 - pressure tank 42''.8' 62.40
8. 1250' of 1'' piping and 5 hydrants 143.33
9. Stock, cooling, and storage tanks 101.75

Total $676.56

# See appendix, page 34

Soft Water Supply (See page 10) Total $573.58

Total Water Supply $1250.14

Discussion - In this system we have reduced the cost of equipment to $1250.14 as against $1345.40, $1609.20, and $1674.46 for systems No.1, 2, and 3 respectively. This cost includes the cooling tank which systems No.1 and 2 do not provide. As no large pressure tank has to be put in, the installation cost will be as low as with any other system, so regardless of the conveniences, system No.4 is $100 cheaper than any other in regard to first cost.

The lightest wind possible is used for power, and the equipment is of permanent construction. Hence the maintenance cost will compare favorably with that of any other
The convenience of operation which also comes under maintenance is easily greater here than in system No.1 or 2 and allowing for ordinary engine troubles with No.3 it would compare well with that system also.

By restricting the flow in case of fire, there would be no limit on the amount of water nor on the pressure, the rate of flow being equal to the pumping capacity. Besides this there would be available for bucket use on an average about 3000 gallons from the reserve and stock tanks, and also the soft water on hand.

Since the water flows directly into the cooling tank from the well its full cooling power is realized and this will insure extensive cooling. Should certified milk or a special trade be supplied it would be worth while to use ice in the cooling of the milk. Also somewhat better cooling than described would be obtained by filling the cooling tank twice a day at each milking time. It has been proven by experience however that with a considerable flow through the tank even once a day, the milk or cream will be kept satisfactorily for condensing, creamery or ordinary milk shipping trade. The pressure tank for the house supply is located underground and is of such a small capacity that it can be fresh every day thus providing good drinking water in the house.

The danger from leaks in the system is small since no pipes are required for carrying air and for stock watering the pressure will only be a 3' head. All pumps can be easily repaired by the local pumpmen. In regard to danger from leaks/
attic tanks, by installing a heavy galvanized steel tank as herein provided the chances of leaking are negligible. For special occasions the piping could be drained but ordinarily with furnace heat there will be no danger from water in pipes or tank freezing.

Another good feature of system No. 4 is its elasticity. In its installation one can utilize nearly all of whatever water system would be already in use on a farm, and while designed for an extensive stock farm it may be adapted for a much smaller water supply. With for example, a 3 or 4" well, the ordinary well cylinder, and the stock and cooling tanks already in place, the outlay to secure a good water system will be $215.06 not including the engine. Every farm should have a gasolene engine. In dairying one is essential; it can also be used for household conveniences, corn chopping, cleaning grain and various labor-saving operations. No additional cost is allowed here for the engine on water supply. It would better come under some other head since the power for pumping is such a small part of its utility.

In the case above outlined the expense for the soft water supply will be $25.33 which includes the suction pressure pump and the attic tank, the piping and the extra house plumbing fixtures being additional. The changes to the hard water supply will include differential cylinders, belt drive pump, pressure tank of 575 gallons capacity, hydrants, piping, and the automatic stopping and safety device. This amounts to $189.73 making the total $215.06. It would not
pay to change the size of the windmill because the former smaller size would provide water for the stock and part of the time for the pressure tank. The expense of the additional power pumping for the pressure tank due to the 10' windmill would not warrant a heavier tower and a larger wheel. With this slight difference one would have all the services of a $1600 water system at the cost of the price of a good horse and the expenditure of some labor. An efficient water system is not a luxury but a necessity and when it may be had at this price how better can one invest its cost!
IX Acknowledgements.

The working out of the various systems was original in every case. In the material several new features are employed which were so recently released that university and U.S. Dept. of Agr. bulletins had not yet described them and their uses. The producing company was corresponded with in most cases and it is from this source that most of the material was obtained. The writer wishes to acknowledge his indebtedness to the following for their aid in obtaining the best uses and the prices of the various parts of the water systems herein described:

Mr. McIntosh, of the United Pump & Power Co. of Chicago.
Mr. Yelton, of the Inland Supply Co. of Danville, Ill.
Mr. Ennis, of the Kewanee Water Supply Co.
Mr. Steenrod, of the Woodmanse Mfg. Co. of Freeport, Ill.
Mr. Handwerk, of Bush and Handwerk of Joliet, Ill.
Mr. Hutchins, of Taylor Hardware Co. of Champaign, Ill.
Mr. Ebert, Well Driller, of Washington, Ill.
Mr. Warford, Cement Contractor, of Geneva, Ill.

In the design of the buildings and their arrangement the writer is indebted to Mr. Crouch of the U. of I. for his suggestions. Many others were sought in seeking the answers to questions which arose and their kindness is also appreciated.
## Appendix.

### Itemized Costs

1. **Drilling wells**
   
   **A. 4" well**
   
   1) drilling and casing at $1.50 per foot $150.00
   
   2) expense for water, coal, etc. 5.00
   
   3) board for two men - 2 weeks 14.00
   
   **Total** 169.00
   
   **B. 6" well**
   
   1) drilling at $2 per foot, includes board $200.00
   
   2) casing at $1.80 per foot 80.00
   
   3) coal, water, etc. 5.00
   
   **Total** 285.00

2. **Windmill #**
   
   Includes a back geared mill, 8" stroke, 12' wheel heavy tower, pump rod, and anchor posts $132.00

3. **Differential cylinders #**
   
   Includes lower cylinder 2 3/4" by 6" stroke, and upper cylinder, all brass, with connections $12.43

4. **Belt drive deep well pump #**
   
   Pump head with handle for hand pumping, stub pump rod, discharge pipe, single pulley $30.10

5. **Concrete water tank on silo**
   
   Capacity 5000 bbl. job complete, estimated by concrete contractor $200.00

6. **Stand pipe and boxing**
   
   A sixty foot frost proof standpipe and boxing complete estimated by contractor $50.00
7. Concrete watering tanks
   A. for cows - 2 by 2 by 4' inside measurements, walls and bottom 6" thick, cost estimated at $.35 per cubic foot of concrete for job complete $5.43
   B. for horses - 2 by 2 by 8' inside measurements. Walls and bottom 6" thick, cost estimated as in A. $9.63
   C. for hogs - 2 by 2 1/2 by 8' inside measurements. Walls and bottom 6" thick, cost estimated as above $10.75
   D. for storage - 8 1/2 by 4 by 10' inside measurements. Includes cooling tank, walls 7" thick, bottom 6" thick, cost estimated as above $63.00

8. Pressure tanks, black #
   60" by 24' tank 3520 gallons capacity $284.40
   72" by 34' "  7190 " "  504.00
   42" by 8' tank 575 gallons capacity 62.40
   48" by 16' "  1500 " "  124.30

9. Steel stock tanks #
   A. for sheep 2 by 2 by 4', 90 gal. cap. $3.32
   B. for young stock 2 by 2 by 6', 135 gal. capacity 4.72

10. Concrete cisterns
    2 - 12' daim. 14' deep, 325 bbl. capacity each, cost estimated at $.75 per bbl. cap. for the job complete $487.50
11. Costs of piping ##

1" standard galv. pipe, per foot $0.065
1 1/4" " " " " 0.085
1" elbows each, .12
1 1/4" " " .15
1" tees " .14
1" cross " .20
1" side outlet, each .20
1" faucet 1.00
hydrants, 4' under ground, each 7.18
1" float valves, each 1.00
1" globe valve, each 1.50

12. Gutter and conductor pipe ##

4" galv. gutter pipe $.28 per 10'
3" " conductor pipe .32 " 
4" " " .43 " 
4" " end pieces each $.07
4" " " with outlets, each .16
4" " elbows, each .09
3" " " .07

13. Suction force pump #

3" cylinder, 4" stroke, capacity 244 gallons
per hour, brass lined with air cylinder, $14.40

# Price includes freight and dealers commission.
## Net prices, 15% to be added for freight and dealers commission.