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Cost and Uses for Electricity on South Dakota Farms

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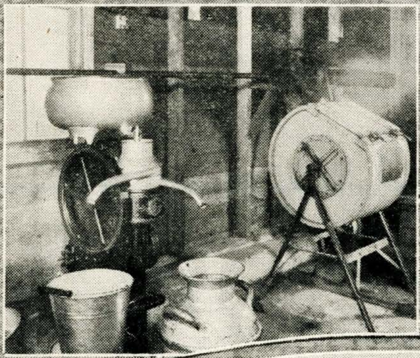
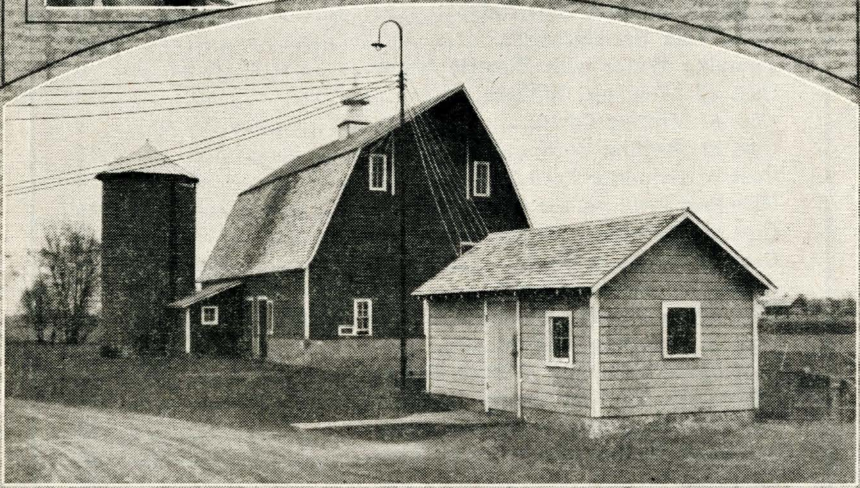
Costs and Uses *for* ELECTRICITY on South Dakota Farms





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BROOKINGS, S. D.

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Costs and Uses for Electricity on South Dakota Farms

The use of electricity on the farm for both power and light is becoming common over the United States. A cooperative movement is now being made over the country to offer this service to the farmer in a better and more efficient way than has been done in the past. This will depend upon whether the service can be made profitable both to the farmer and to the power company.

This bulletin contains cost figures and other records of electricity used for farm purposes. The figures and information are primarily for the land owner who wants to know what electricity would cost him on the farm and what it could be used for.

Most of the cost records are taken from the farm homes and farm barns of the patrons on the farm electric test line at Renner. Other results were obtained from work done at the South Dakota State College Experiment Station at Brookings by the department of agricultural engineering.

The figures from the Renner farm line were obtained by having a separate meter installed for every piece of electrical equipment so that the exact amount of electricity each piece used could be measured. Reading of the meters were taken as often as necessary by field men who were kept on the line during the summer seasons of 1924, 1925 and 1926. For some studies the meters were read as often as three times a day; for others they were read less frequently.

Purpose of the Test

The purpose of the electric test line and the studies was to find out:

1. What electricity would cost for various farm purposes.
2. How many things electricity could be used for on the farm to good advantage.
3. How much the speed and efficiency of farm work would be increased by electric light and electric power.
4. Whether more ways for using it efficiently could not be found for the farm or adapted to farm operations.
5. How much electricity a power company could expect would be used by a farmer each month if electric lines were built for farm service.

The College and the power companies were both interested in these points. The college was particularly interested in the first four. This study was therefore carried on in a cooperative way. State College has had entire charge of all testing work and of the publication of the results.

The Renner Test Line

(For further description of this line see Extension Circular No. 232)
RALPH L. PATTY

The farm electric test line at Renner was built expressly for farm service, for the purpose of studying the five points previously mentioned. It covers a farming territory about two to three miles wide by six miles long surrounding the village of Renner, S. D. Renner is approximately seven miles north of Sioux Falls, S. D., where the district office and power plant of the Northern States Power Company which built the test line, are located. The original line is 8.4 miles long and has 17 farms connected to it. This is an average of two farms to the mile.

The question as to whether an electric power line is practical for farm service depends on how much farm use can be made of electricity in addition to that required for lights. If electricity is to be used for lights only, the power line service is not practical. It will be too expensive for the farmer and a losing investment for the power company because the cost of distribution is too high. (See Extension Circular 232). The same copper wire that carries the small amount of electricity to the farm for lights can just as well carry a great deal more electricity to the farm to be used for power and other appliances.

If enough electricity can be used the power company can afford to sell it at a low price. Electric power is the most efficient power we have today when the cost of distribution is reasonable. This is evidenced by the fact that it is displacing other forms of power in industry. The amount of electricity that will be used in agriculture will depend primarily upon two things: (1) the number of farms to be connected for each mile of line, and (2) the number of purposes for which electricity can be used to good advantage around the farm.

Kilowatt Hour, Unit of Measure for Electricity

Electricity is paid by the Kilowatt Hour. The kilowatt hour, abbreviated KWH, is the unit of measurement for electricity when it is bought and sold, just as the bushel is the unit of measurement for corn or oats.

If, for example, a single electric light uses five KWH of electricity in a month and it costs 15 cents per kilowatt hour, then the cost of burning that light for the month is 75 cents. If an electric motor uses 20 kilowatt hours of electricity in a month and it cost three cents per KWH, then the cost of running that electric motor for the month is 60 cents. The number of kilowatt hours used is measured by the electric meter.

There is nothing difficult or mysterious about the measuring of electricity or the cost of it. All that is necessary is to know that electricity is paid for at so much per kilowatt hour. It will be necessary for the reader to remember only this one thing in order to understand the following discussion and cost figures.

A Study of Farm Line Rates

At the very beginning of this farm line study the question of rates was taken up. It was decided to use the same rate of charge on the South Dakota test line that was already being tried out on the Red Wing test line in Minnesota. This rate, which follows, was the result of considerable investigation and study.

Briefly, the power company builds the main line for distribution of the electric current and maintains it permanently. This includes all the transformers. The power company also looks after trouble and **reads** the meters.

The patron having a three kilowatt transformer pays a flat rate of $7.55 per month for the above line maintenance and costs. This is the monthly distribution charge so often referred to in the following cost charts, and is based on an average of two farms for each mile of main line. If the farms were closer this charge would be less; if they were farther apart this charge would have to be more. The charge is the same regardless of how much electricity is used by the patron. It is not for electric energy, but for the cost of the line.

The patron builds the stub line from the highway to his buildings and furnishes his own wiring system for the buildings. The charge for watt hour for the first 30 KWH used each month; three cents per kilowatt hour for all additional electricity used each month.

The first 30 kilowatt hours each month is figured to take care of all the lights in the house, barn, and other buildings, as well as such small appliances as the electric flat iron, the electric toaster, the vacuum cleaner, and possibly the washing machine.

The three-cent electricity is figured for electric power and electric cooking. Electric motors up to five-horse power can be used on a farm with a three-kilowatt transformer. When a larger transformer is requested, allowing larger motors to be used, the line-charge per month is increased proportionately.

In figuring the costs of electricity for lights and small electrical appliances on the farm electric line in this test, the energy charge of five cents per kilowatt hour is used. In figuring the cost of running electric motors for power, the energy charge of three cents per kilowatt hour is used. The distribution charge must be taken into consideration in figuring the total cost of the electric service. But in order to furnish comparable figures of cost for the various operations this is impossible. When the monthly distribution charge is figured in, the actual cost of electricity for pumping water, for instance, might vary all the way from five cents per kilowatt hour for the man who uses 400 KWH, to 11 cents per kilowatt hour for the man who uses but 100 KWH. This would mean nothing to those who are interested in learning the cost.

Rate Plan Satisfactory

The rate plan outlined above seems to have worked out very satisfactorily on the South Dakota line. It has proven satisfactory in its five years of use both to the patrons on the line and to the power company that built the line and furnishes the power. It is as low, if not a lower energy rate, than is being tried out elsewhere in the middle west. The rate encourages the farm patron to use more electricity. This is desirable from every standpoint of efficiency. If we have an expensive distribution line and use it for only a small amount of electricity, it is a tremendous waste. In fact, it is impossible.

The distribution rate of $7.55, based on an average of two customers per mile of main line, encourages the use of electricity for power. This is evidenced by the fact that the average consumption per farm has

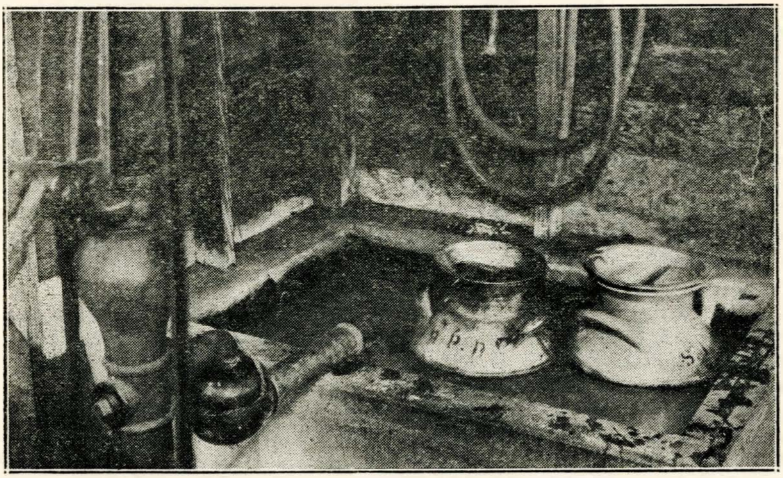

FIG. 1.—COOLING TANK SUPPLIED WITH FRESH WATER BY ELECTRIC POWER
This is an excellent way to reduce the temepraturе of the milk quickly when it is fresh. That is what counts in keeping milk sweet. A turn of the switch starts the pump and fresh water.

steadily increased during the past five years of service up to approximately 150 kilowatt hours per customer. This is an excellent average considering that there are three rented farms on the line with practically no electrical equipment.

With this rate, electricity really costs one of the customers on the line only three cents per kilowatt hours when he uses it for power. This may be readily seen. All the patrons on the line are paying the monthly distribution charge for the light and house service anyway, and those using any amount of electricity for power of course use a great deal more than 30 kilowatt hours per month. Now if any one of these patrons considers the cost of electricity for an extra motor which he might buy, he would figure that electricity at three cents per KWH. Because the three cents would be exactly the extra cost.

Pumping Water With Electric Motor

Fourteen of the 17 farms on the test line pump water with electricity and some of them have two or three electrically driven pumps. Ten of these pumping motors were connected with individual meters in order that the amount of electricity used by each motor could be measured for each week, month, or year as desired. Accurate records of the amount of water pumped as well as the electricity used were kept on three pumping plants only. The figures for it are given in Table I. Records on 33 different "runs" were made on the three pumps. The wells were shallow, the average lift being 20 feet. A total of 4,320.7 gallons of water was pumped. The average size of each motor was one-half horse power. It took .334 kilowatt hours of electricity for each 1,000 gallons of water pumped. Figuring the electricity at three cents per KWH, electricity used in pumping 1,000 gallons of water cost one cent.

TABLE I.—COST OF PUMPING WATER WITH ELECTRIC MOTOR (LABORATORY TESTS)

Total No. of Tests	Total Amount Pumped in Gals.	Av. Size Motor Used	Av. Lift in Feet $1.43	Electricity Used per 1,000 Gal.	Av. Cost per 1,000 Gal. Energy Charge at 3c
33	4320.7	½ HP	20	.334	$ .01

Records were kept on eight other pumping motors and the figures are given in Table II. For each pump is given the total lift in feet, the size of the motor, the length of the test, the total amount of livestock watered, the total amount of elecriciy used in kilowatt hours and the cost of the electricity used per month in pumping water for that amount of livestock. It will be noticed that the deep wells required a much larger motor and used a much larger amount of electricity. Such variation as was found with the same sized motor and the same depth of well will probably be explained by looking at the livestock column of the table, or it may be due to a difference in the type of pump-jack used or

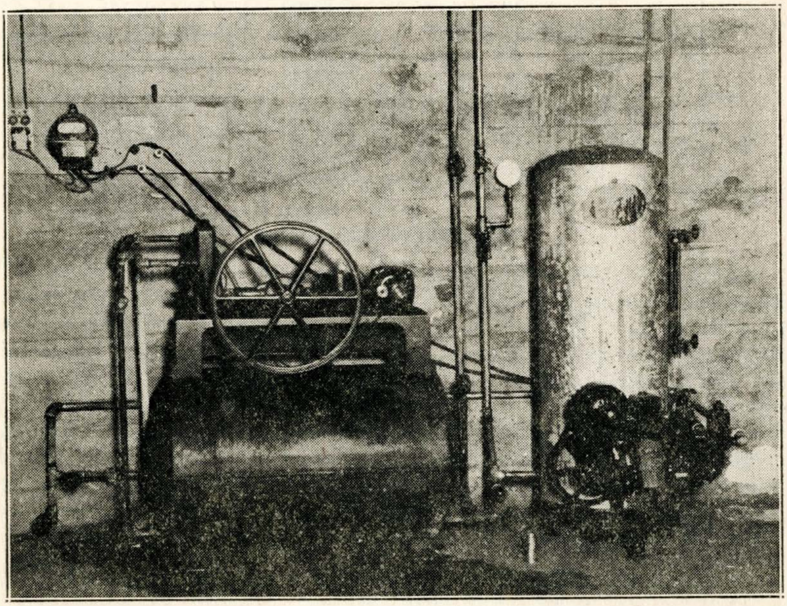

FIG. 2.—A TYPICAL PRESSURE TANK SYSTEM OF WATER SUPPLY ON THE POWER LINE

Both hard and soft water are furnished at all points in the house under pressure. The ¼ H. P. electric motors start and stop automatically and the pressure is maintained at any point desired. The motor driving the soft-water system used 34.3 K. W. H. of electricity in one year. At the 3-cent rate this would cost $1.03 per year for electricity.

to the pump itself. A brief study of Table II will give a very good idea of what can be expected of electric motors for pumping water.

TABLE II.—COST OF PUMPING WATER WITH ELECTRIC MOTOR AS SHOWN BY METERS ON FARM PUMPS
(Monthly Distribution Charge Not Included)

Pump Tested	Depth of Well	Size of Motor	No. of Days Pumping	Total Amount of Stock Watered	Total Electricity Used in KWH	Cost of Electricity per Month. Energy Chg. at 3c
A	20 Ft.	1-3 HP	135	6 Horses 60 Hogs 20 Cows	47.7 KWH	$1.43
B	20 Ft.	1-3 HP	162	15 Cows 7 Hogs 3 Horses	23.75 KWH	$0.71
C	20 Ft.	½ HP	91	18 Cows 12 Heifers 90 Hogs 6 Horses	16.5 KWH	$0.495
D	25 Ft.	½ HP	91	65 Hogs	4.8 KWH	$0.144
E	250 Ft.	2 HP	91	25 Cows 6 Horses	230.8 KWH	$6.92
F	25 Ft.	1-3 HP	91	14 Cows 35 Hogs 5 Horses	36.5 KWH	$1.095
G	22 Ft.	½ HP	91	20 Cows 15 Young Stock 60 Hogs 30 Sheep 8 Horses	31.0 KWH	$0.93
H	Deep Well	1 HP	91	80 Beef Cattle 28 Cows 140 Hogs 9 Horses	100.2 KWH	$3.006

Cost of Washing Clothes

A total of 160 tests were made to find out how much it costs to drive the washing machines for the family washing by electric motor. (See Table III.) These tests were made on washing machines in eight different homes on the test line. The average number in the eight families was six persons. The average length of time the electric motor was actually running for each washing was one hour and forty-five minutes. The average electricity used for each washing was .541 KWH and the energy charge for the electricity per washing was 2.7 cents when figured at 5 cents per KWH. The electric washing machine is used in every home on the line and has been since the first few months. It was the first piece of electrical equipment that was used by all the patrons.

TABLE III.—COST OF ELECTRICITY FOR WASHING MACHINE
(Monthly Distribution Charge Not Included)

Total No. of Tests	No. of Families Testing	Washing per Av. Time	Av. No. in Family	Av. Size Motor	Av. Electricity Used per Washing	Cost per Washing. Energy Chg. at 5c per KWH
106	8	1 Hr. 45 m.	6	¼ HP.	.541 KWH	$ .027

Cost of Milking Cows

Seven of the electric milking machines on the line were equipped with meters for measuring the amount of electricity used. Accurate records were made on four of these machines on the amount of milk, the time of milking, the weight of strippings, and the amount of electricity used. (See Table IV). A special long detailed test was made of the small portable milking machine listed as machine A. Exact records were kept on this machine for a period of 60 consecutive milkings and are averaged in the top row of figures. The very small amount of electric energy used by this machine is remarkable. Machines C and D were tested for 4 and 5 milkings respectively and consequently the average figures submitted for them are not as reliable as the average figures for a larger number of tests. The figures for E, F and G machines, an average of 60 tests, are more reliable.

It should be said that the plant for machine F gave considerable trouble throughout the period of the test. Motors of two to five horse power were used on the machine; so its cost figure is probably much too high. The figures nevertheless are offered just as the meters registered them. The fact that machine B is the same make as F would indicate that machine F was not working satisfactorily.

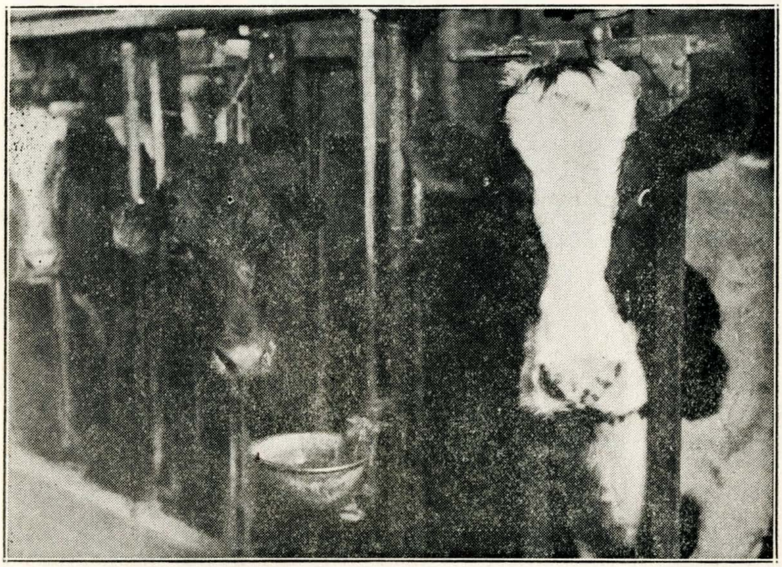

FIG. 3.—DRINKING CUPS USED IN MANY BARNS ON THE RENNER LINE
These cups are made possible by water systems that are pumped with electric motors.

Four different makes of machines are represented in the test. A is the only portable machine included. B and F are of the same make. Machines C, E, and G are of the same make. And D is still a different make. The cost of electricity for driving milking machines is given in the last column. The figure given is the cost of electric energy for one

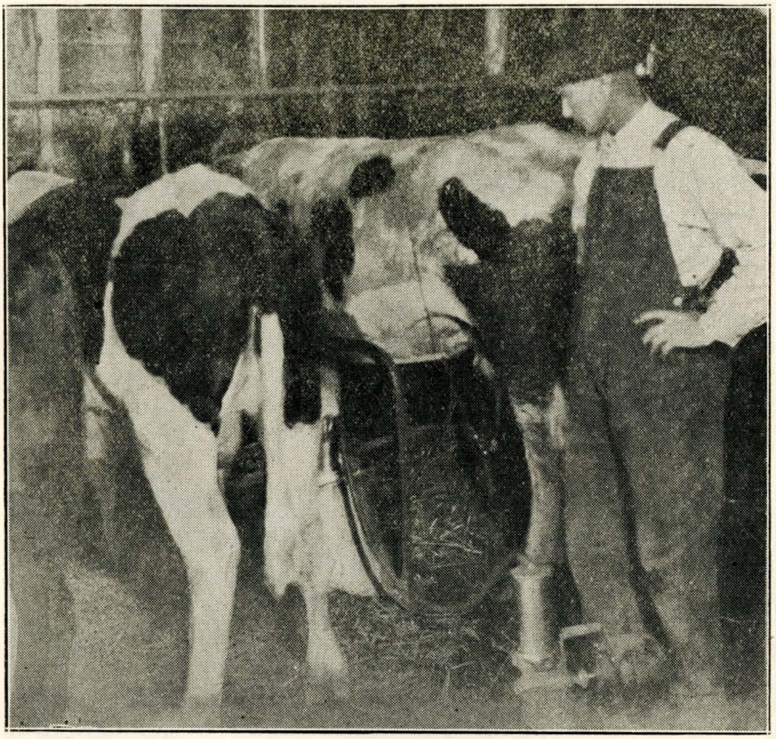

FIG. 4.—PORTABLE ELECTRIC MILKING MACHINE ON THE FARM OF S. P. BRENDE.
This little machine furnished the power for milking cows at a cost of 5½ cents per cow per month. (See Table IV.)

cow per month, with only the energy rate at three cents per KWH considered. Electric power has proven the most satisfactory power for milking machines ever used by the patrons on the line.

Cost of Shelling Corn

A two-hole corn sheller has been driven by a five-horse electric motor on the farm of C. F. Eggers since the line was installed. An electric meter was installed on the truck of the portable motor and records were taken of the electricity used in shelling 935 bushels of ear corn. (See

TABLE IV.—COST OF MILKING COWS WITH ELECTRIC MILKING MACHINE
(Monthly Distribution Charge Not Included)

Milking Machine Tested	Type of Machine	Size of Electric Motor	Total No. of Milkings in Test	Av. Time of Milker per Cow	Av. No. of Cows Milked	Total Wgt. of Milk	Av. Wght. of Strippings per Cow per Milking	Electricity Used per Cow per Milking	Cost of Electricity for Milking One Cow per Month, Energy Rate at 3c
A	Portable	¼ HP	60	3.28 Min.	13	5953.8 Lbs.	1.67 Lbs.	.0091	$.0546
B	Stationary	3 HP	9	2.8 Min.	21	1745 Lbs.	1.45 Lbs.	.061	.366
C	Stationary	3 HP	4	1.9 Min.	26	191 Lbs.	1.50 Lbs.	.023	.138
D	Stationary	¾ HP	5	3.08 Min.	18	690 Lbs.	1.12 Lbs.	.045	.27
E	Stationary	2 HP	60	4.14 Min.	29	no figures	no figures	.0345	.207
F	Stationary	Varied	60	5.32 Min.	11	no figures	no figures	.157	.942
G	Stationary	3 HP	60	3.58 Min.	21	no figures	no figures	.040	.24

FIG. 5.—A LARGE STATIONARY ELECTRICALLY DRIVEN MILKING MACHINE ON O. VOLDEN'S FARM.

The electricity required to drive the large milking machines varied all the way from 20 cents to 37 cents per cow per month. One machine cost as high as 94 cents per cow per month. The average of these is less than one cent a day per cow milked.

Table V). The result is given in the cost per 1,000 bushels shelled. The electric motor used 32 kilowatt hours per 1,000 bushels shelled. The electric energy cost Mr. Eggers 96 cents per 1,000 bushels shelled.

TABLE V.—COST OF SHELLING CORN WITH ELECTRIC MOTOR
(Monthly Distribution Charge Not Included)

Total No. of Tests	Place	Type of Sheller	Total Bu. of Shelled Corn	Size of Motor	Electricity Used per Bu. Shelled in K. W. H.	Electricity Used per 1,000 Bu. Shelled	Cost of Electricity per 1,000 Bu. Energy Charge at 3c per KWH
15	C. F. Eggers	2-hole	935 Bu.	5 H.P.	.032 KWH	32 KWH	$ .96

Cost of Elevating Grain

Very little testing work was done on elevating grain with the electric motor, although a considerable amount of elevating was done with them. The reason more tests were not made on this type of farm work was because of lack of meter installations. When grain was to be elevated utility motors were pressed into service and meters were difficult to install for this temporary set-up. A single test was made, however, on the farm of A. P. Brende. A total of 630 bushels of small grain was elevated into a bin with a portable drag elevator. (See Table VI). The lift was 11 feet. A two-horse motor, smaller than is ordinarily used for farm elevators, was used in this test. The motor required 3.6 kilowatt hours of electricity per 1,000 bushels elevated. The energy cost 10 cents at the three-cent rate.

TABLE VI.—COST OF ELEVATING GRAIN WITH ELECTRIC MOTOR
(Monthly Distribution Charge Not Included)

Total Bushels Elevated	Place	Type of Elevator	Size of Motor Used	Electricity Used for 630 Bu. in KWH	Electricity Used per 1,000 Bu. Elevated in KWH.	Cost of Electricity per 1,000 Bu. Energy Charge at 3c per KWH.
630	A. P. Brende	Portable Drag	2 HP	2.314 KWH	3.6 KWH	$ .10

Cost of Grinding Feed

Five tests on the cost of grinding feed with electricity were made on three different feed-grinding installations on the test line. All of them used five-horse motors and all were six-inch burr mills. The amount of electricity used varied little for the three machines and for that reason the data is combined and the average figures given for the five tests on the three machines. Mixed grains of barley, oats and corn were ground and the following data taken and recorded: (1) time of grinding, (2) amount of feed ground, (3) amount of electricity used as registered by the electric meters. (See Table VII). The average amount of grain ground was 18.5 bushels for each test. The average time for grinding this amount of mixed grain with a six-inch burr mill and a five-horse motor was 66 minutes. The amount of electricity used to grind each bushel was .166 KWH. The average cost of electricity per bushel ground was one-half cent, or 50 cents per 100 bushels ground at the energy rate.

This rate of grinding was slow and the patrons on the line have not generally adopted the practice. At the same time the cost of electrical power for grinding, as determined from these mills and also from those at the experiment station at State College, is approximately 24 per cent less than the cost of tractor power. Two of these installations were made almost entirely automatic in operation. Feed hoppers of considerable capacity were installed so the grain would feed from above as it was ground. One of these grinders was located just under an overhead grain bin in the granary. The grinders were also equipped with "wagon box" elevators which took the ground feed away and elevated it into a receiving bin. With a "hammer mill" type of grinder this set-up would have been entirely automatic as long as the supply of grain lasted in the hopper overhead. With the "burr mill" type there is, of course, always some danger of a rock or piece of iron going into the grinder and dam-

FIG. 6.—ANOTHER MODERN USE OF ELECTRICITY ON THE FARM. These daughters of Mr. and Mrs. J. F. Wehde know how to use other equipment on the farm as well as the electric curling iron. Perhaps this is one of the things that will help keep the American girls on the farm.

arging it. For this reason the attendant hardly felt free to leave the grinder while it was grinding, and the slow speed therefore interferred with the efficiency. The study "for adapting farming operations to better utilization of electric power" was mentioned at the first of this bulletin. Feed grinding offers a good problem in this line.

TABLE VII.—GRINDING FEED WITH ELECTRIC MOTOR (Farm Line)
(Monthly Distribution Charge Not Included)

Total No. of Tests	Size of Motor	Size of Grinder	Kind of Grain Ground	Av. Length of Time	Av. No. of Bushels Ground	Av. Elec. Used Per Bushel	Av. Cost per Bushel Ground	Av. Cost per 100 Bu. Ground Energy Charge at 3c
5	5 HP	6" Burr	Barley Oats Corn	66 Min.	18½ Bu.	.166 KWH	$ .005	$ .506

Grinding Feed on the College Farm

A further and very accurate feed-grinding test was made on small electrically driven grinders at the State College experiment station at Brookings. A four and one-half inch burr mill was driven by a two-horse electric motor for grinding feed. A total of 81 test runs were made on this installation—35 on shelled corn, 41 on barley and five on soy beans.

The purpose of running this test on a small grinder is important. It has to do with that phase of the study mentioned before as "adapting farm power operations to better use of electric power." Why should we do this? What is the object of our trying to make electric power ef-

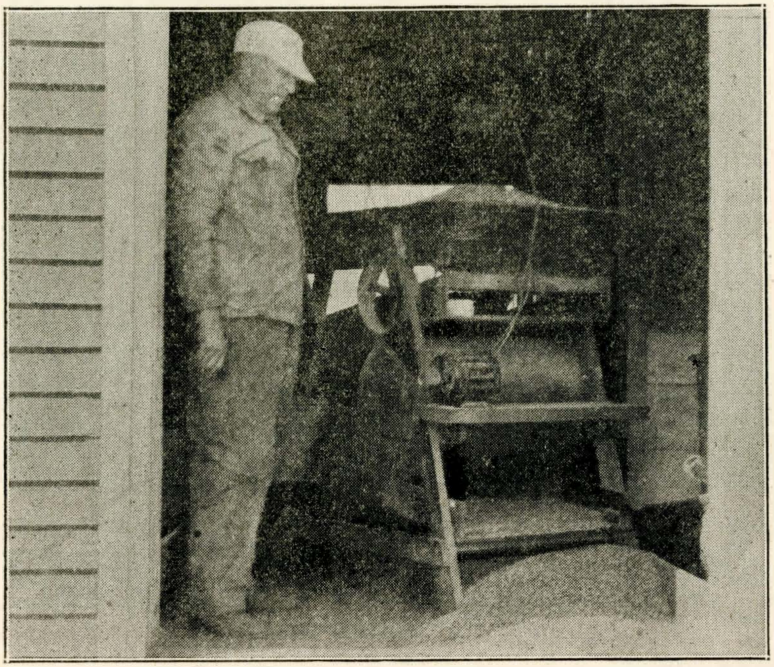

FIG. 7.—USING THE ELECTRIC MOTOR FOR DRIVING THE FANNING MILL.
Mr. O. T. Nesson was the first on the line to employ electric power this way. A ¼ H. P. motor handled the farm grain cleaning problem nicely on the test line. This one cleaned 185 bushels in 5 hours and 7 minutes and used 1¼ K. W. H. of electricity. This electricity cost Mr. Nesson 4 cents.

ficient on the farm? The answer is, if we can do this we can have the electric lights and the many home uses for electricity for nothing. The saving in money on power will pay for this home service. If electric power can be used in smaller quantities at a time, and can be spread out over a longer period of time throughout the day, it will cost less money. Less expensive equipment is needed and the power company will sell the electric energy for less money. Experimental work is being done with motors smaller than two-horse in some states.

The small feed grinder used in this set-up was equipped with a good sized feed hopper that would hold enough grain to supply the grinder for several hours, and with an elevator for taking away the ground feed and elevating it into a bin or other receptical. The machine was there-

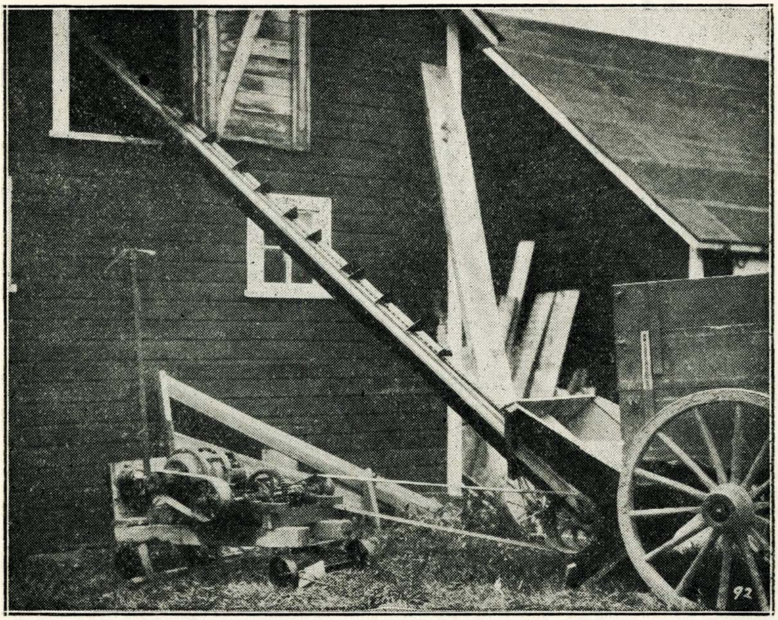

FIG. 8.—A PORTABLE 3-HORSE MOTOR ELEVATING GRAIN ON THE FARM.

The electric motor makes excellent power for elevating grain. It starts and stops with a turn of the switch. To be economical the motor must have several other jobs besides driving the grain elevator and that is why it is on wheels. The average cost of power for elevating small grain with the electric motor was one cent per 100 bushels elevated.

fore semi-automatic. The motor was equipped with an electric meter for measuring the amount of electricity used in grinding. Accurate scales and timepiece were used. The degree of fineness to which the feed was ground would, of course, greatly affect the amount of power required for grinding and also the rate of grinding. This was tested with the seven sizes of standard screens as approved by the American Society of Agricultural Engineers. The fineness modulus recorded in Table VIII is rather fine. All the grains were ground slightly finer than the average grinding practice on the farm. The moisture content of the grain was determined and found to average 12.05 per cent for shelled corn, and 10.52 per cent for barley. This was good dry grain and in favorable condition for grinding. The moisture content for the soy beans was not obtained.

It will be noticed that the shelled corn ground fastest and used the least electricity. Soy beans came next and barley last. If oats had been ground they would have ground slightly slower than the barley. Other grains will fall in between shelled corn and oats. The amount of electricity required to grind shelled corn alone on this small machine was 25.93 kilowatt hours per 100 bushels ground. Barley took 37.97 kilowatt hours per 100 bushels and soy beans, 27.48 kilowatt hours. (See Table VIII).

TABLE VIII.—COST OF GRINDING FEED WITH ELECTRIC POWER
(College Farm)
(Figured at Same Rate as or Line)

Total No. of Tests	Size of Motor	Size of Grinder	Kind of Grain Ground	Total Am't. Ground-Bushels	Rate— Bu. per Hour	Fineness Modulus*	Elec. Used per 100 Bu. in KWH.	Cost of Elec per 100 Bu. Ground. Energy Rate 3c per KWH.
35	2 HP	4½ in. Burr	Shelled Corn	Bu.	4.5	3.37	25.93 KWH	$ .778
41	2 HP	4½ in. Burr	Barley	807.75	2.66	3.61	37.97 KWH	$1.139
5	2 HP	4¼ in. Burr	Soy Beans	171.08	3.64	3.21	27.48 KWH	$ .824

*"Modulus of Fineness" determined by standard rating of American Society of Agricultural Engineers.

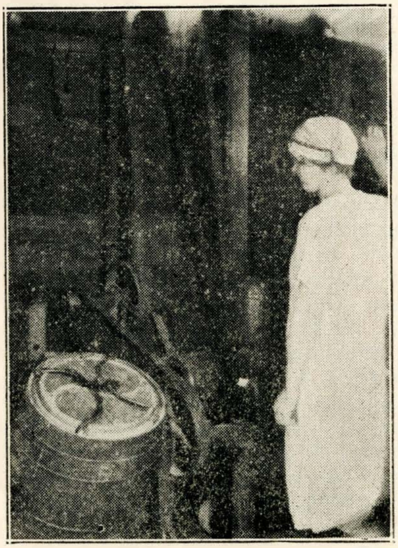

FIG. 9.—ONE-HORSE POWER UTILITY MOTOR ON THE FARM OF J. F. WEHDE.

Notice the motor drives the line-shaft above, from which are driven a churn, a washing machine, a cream separator and a grindstone. This motor separated the milk 153 times, washed 12 times and churned 16 times, using only 37½ K. W. H. of electricity. The energy used at 5 cents per K. W. H. cost Mr. Wehde $1.87 for the 76-day period.

Cost of Churning With Electric Motor

On the cost of churning 23 tests were made, all on the same churn. The observations made on other churns on the line indicate that these figures are representative. This churn was driven from a line shaft by a one-horse power electric motor. This is a typical set-up for churning as every patron on the line who churned butter at home drove the churn from a line shaft. No doubt this is because churning at home is not such a common practice any more and churns are not generally equipped with individual electric motors—motors installed right on the churn—as is the case with the cream separators today. An individual meter was provided for the motor. This meter had been calibrated so that the meter reading could be taken by counting the rotations of the disc. This, of course, was necessary owing to the fact that the small amount of electricity consumed in one churning was hardly enough to read accurately on the ordinary house meter. Accurate records were kept on 23 churnings. (See Table IX). Record was made of the time required for each churning, the weight of cream or butter churned, and the electricity used. The latter was reduced to amount of electricity used per hour and the cost was figured at an energy charge of five cents per kilowatt hour.

TABLE IX.—COST OF CHURNING WITH THE ELECTRIC MOTOR
(Monthly Distribution Charge Not Included)

Total No. of Tests	Place	Type of Churn	Av. Time of Churning	Av. Amt. of Butter in Lbs.	Elec. Used per Churning in KWH.	Av. Cost per Churning. Energy Charge at 5c	Av. Cost per Hour. Energy Charge at 3c
[illegible]	S. S. Bliss	Rotating Type	44.2 Min.	16	.296	$ .0148	$ .02

Cost of Grinding Meat

One use of electric power not anticipated on the farms of the test line was that of grinding meat. A surprising amount of fresh meat was ground during the year by the patrons. In all cases the meat grinder was driven from the line shaft of the utility motor and it was hard to get the exact meter readings for them. Only two tests were made on the power required for this purpose. While the average of only two tests would not be very accurate, the figures as recorded (see Table X) will give an idea of the power required for a small grinder of the capacity indicated. The grinder showed a capacity of 252 pounds in 52.5 minutes, or nearly one hour. This grinder was driven by a one-half horsepower motor and used exactly one kilowatt of electricity in grinding the 252 pounds of meat. This is at the rate of .4 KWH per 100 pounds of meat ground. The energy cost for 100 pounds, if figured in as a part of the first 30 kilowatts (see paragraph on rate) at five cents per KWH, would be exactly two cents.

TABLE X.—GRINDING MEAT WITH ELECTRIC MOTOR
(Monthly Distribution Charge Not Included)

Total No. o Tests	Place	Size of Motor	Total Am't. Meat Ground in Lbs.	Total Time of Grinding	Total Elec. Used in KWH.	Elec. Used per 100 Lb. Meat	Cost of Elec. per 100 Lbs. Meat. Energy Chg. at 5c per KWH
2	O. T. Nesson	½ HP.	252	52.5 Min.	1 KWH	.4 KWH.	$ .02

Cost of Separating Cream

A total of 191 cream separations were made in getting the average figures shown in Table XI. The set-up was typical. A reliable and popular home separator was used in this study. It was equipped with its own motor, a one-fourth horse-power motor installed on the separator frame. A separate electric meter was provided for the separator from which all records of electricity used were read. A total of 18,055 pounds of milk was skimmed with this electrically driven machine in the 191 separations. (See Table XI). It took a total of 2,561 minutes to skim this amount of milk which is at the rate of 7.05 pounds per minute. This is almost one gallon per minute. A total of 6.5 kilowatt hours of electricity was used for the 18,055 pounds of milk, or an average of .36 KWH per 1,000 pounds separated.

TABLE XI.—COST OF SEPARATING CREAM WITH ELECTRIC MOTOR
(Monthly Distribution Charge Not Included)

Total No. of Tests	Type of Separator	Size of Motor Used	Total Time in Operation	Am't. of Milk Separated. Lbs.	Elec. Used per 1,000 Lbs. Milk Separated	Cost of Elec. per 1,000 Lbs Separated. Energy Charge at 3c
191	Centrifugal Bowl With Multiple Discs	¼ H. P.	2561 Min.	18,055 Lbs	.36 KWH	$0.0108

Cost of Operating One-horse Utility Motor

As would be expected, the motor and line-shaft set-up became popular soon after the electric farm line was installed. There are seven of these on the farm test-line. The electric motors used range from one-half horse power to two horse power, but most of them are one-horse motors. The motor is installed to drive a line shaft by belt. The pulley on the line shaft is usually three to six times as large in diameter as the pulley on the motor. The reason for this is to reduce the speed of the line shaft from which the different machines are to be driven. Different machines are then driven from the line shaft by small belts. Machines most commonly driven from such a line shaft are the churn, washing machine, cream separator, pump, emery wheel, electric drill, grind stone, meat grinder and buffer.

The study was made on a typical set-up of this kind on the farm of John Wehde. The one-horse motor was mounted in the milk house or utility building just back of the dwelling house and opposite the grade

TABLE XII.—COST OF OPERATING ONE HORSE POWER UTILITY MOTOR—ON LINE SHAFT
(Monthly Distribution Charge Not Included)

Total No. of Tests	Place	Size of Motor	Total Minutes Run	Total Am't. Elec. Used in KWH.	Total Cost of Elec. Used. Energy Chg. at 5c per KWH.
Separated 153 Times. Washed 12 Times. Churned 16 Times	John Wehde	1 HP.	Separator 1,539 M. Washer 2,033 M. Churn 1,045 M Total, 76 hrs. 57 M.	KWH. $1.87	37.55

FIG. 10.—CHICKENS HATCHED IN AN ELECTRIC INCUBATOR ON THE TEST LINE.
The average electricity used by this sized incubator in hatching chicks was 69.7 K. W. H. per hatch. At the 3-cent power rate this electricity cost $2.09 per hatch.

door into the kitchen. Four machines are driven from this line shaft. They are: cream separator, washing machine, churn and grind stone. No records were made on the grind stone but the following very accurate records (see Table XII) were made on the other machines. The purpose of this study was to find out the amount of electricity required by such a line-shaft or utility motor. Records were taken on this motor during the time in which cream was separated 153 times, the washing machine used for the family laundry 12 times, and 16 churnings were done. During this time the motor was running a total of 76 hours and 57 minutes. The meter registered 37.55 kilowatt hours of electricity used and, figured on the basis of five cents for the energy charge, the cost for electricity was $1.87.

Cost of Hatching Chicks

Only four tests were made in this study but the figures give an idea of the amount of electricity used on the average for the small incubator. The 500-egg size incubator used an average of 69.7 kilowatt hours of electricity per hatch and the 250-egg size used 39 kilowatt hours per hatch. The average cost per 1,000 eggs hatched is given in Table XIII. The larger incubator is more efficient from the standpoint of electricity used. The cost of the electricity, on the basis of energy charge alone, was $4.18 per 1,000 eggs hatched. For the smaller incubator the cost per 1,000 eggs was $4.68.

TABLE XIII.—COST OF HATCHING CHICKS WITH SMALL ELECTRIC INCUBATOR
(Monthly Distribution Charge Not Included)

Total No. of Tests	Size of Incubators	Av. Elec. Used per Hatch in KWH	Av. Elec. Used per 1,000 Eggs KWH	Av. Cost of Elec. for 1,000 Eggs. Energy Charge at 3c per KWH.
1	500-Egg	69.7	139.4	$4.18
1	250-Egg	39	156.	$4.68

Cost of Cooking With Electric Range

Intermittent tests of one to three months duration were made on two electric ranges on the line. One of these ranges was in the home of B. E. Cornue and the other in the S. S. Bliss home. During the tests the ranges were used for all the cooking done in the homes. Water was heated for cooking purposes, such as making hot drinks and for cooking vegetables, but not for laundry purposes. In order that there would be no temptation for the cooperators in these tests to use the kitchen range, instead of the electric range, the electricity was furnished to them free. A special electric meter was connected for each electric range and detailed records were kept on the items cooked for each meal during a part of the test. Space does not permit a complete record of these. The food cooked was typical of well-to-do South Dakota farm families who milk quite a few good cows. The average figure for the amount of electricity used per month when all the cooking is done by electricity, is the im-

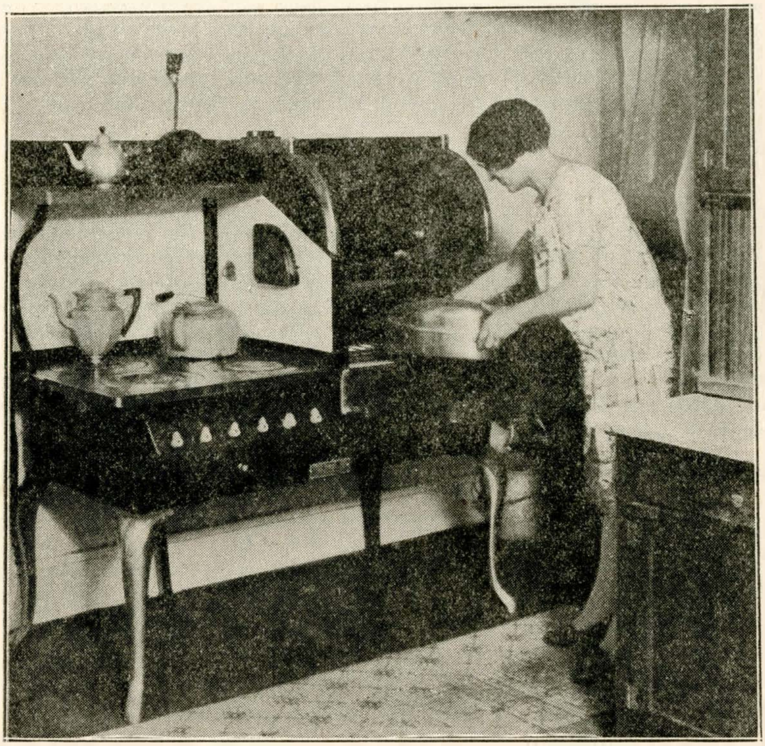

FIG. 11.—ELECTRIC RANGE IN THE HOME OF B. E. CORNUE.

Mrs. Cornue was the first lady on the line to have an electric range. This range used an average of 216 K. W. H. of electricity per month when all the cooking was being done on it for an average of four persons in the family.

portant figure in this table. (Table XIV). Range A used 216 kilowatt hours per month on the average with a family of four. Range B used 173.4 kilowatt hours per month on the average with a family of five. The average electrical consumption of the two ranges was 194.7 kilowatt hours per month, and the average cost of the electricity, at a three-cent energy charge, was $5.84 per month. The size of the stove is rated by the number and size of burners on each range. However, the size of the range does not necessarily indicate the amount of electricity it will use. This will depend upon the length of time the burners are in use.

TABLE XIV.—COST OF COOKING WITH ELECTRIC RANGE
(All the Cooking Was Done on These Ranges But No Water Was Heated For Laundry Purposes.)

Electric Range Tested	Total No. Burners on Range	Total Capacity or Size of Burners in Watts	Size of Family	Av. Am't of Elec. Used per Month in KWH	Cost of Elec. per Month. Energy Chg. at 3c per KWH.
Range A	4	1 small 1,000 watts 1 large 1,800 watts 2-oven 1,500 watts Ea. Total 5,800 watts	4	216	$6.48
Range B	6	2 (each) 1,500 watts 2 (each) 1,000 watts 1 large 2,000 watts 1 small 660 watts Total 9660	5	173.4	$5.20

Electricity Used by Motors, Appliances, in Year

In addition to making detailed tests of electric machines on the farm test line, some records were kept of the yearly consumption of electricity. Each electric motor or machine had a separate meter installed for it so that the total electricity it had used for the entire year could be recorded at the end of the year. While the exact cost per unit for doing certain work with electricity is important, we believe the figures for the yearly consumption are also important. A certain sized motor doing a certain kind and amount of work will use just about the same amount of electricity regardless of the farm on which it may be used. This is especially true of such machines as the electric milking machine, the electric refrigerator, the electrically driven water pump and many others. The figures shown in the following table (see Table XV) are typical cost figures. The high-consuming machines were tested and recorded as well as those of low consumption. The three H. P. motor driving the milking machine used 1,147 kilowatt hours per year, as shown in the table below, and was the highest consuming machine on the line. The type of machine this motor was driving is by far the hardest pulling milking machine on the line. It requires more than double the amount of electricity that some other types do.

Farm Changes Due to Electric Power

At the beginning of this study in 1924 a careful survey was made of the farms that were being connected with the power line. Records were made of all livestock and power machinery on the line, and also of crops, hired help used on the farms and of the houses that were equipped with bathrooms. In 1928 or four years later another survey was made showing certain changes in the test farms that are very interesting. No men-

TABLE XV.—AMOUNT OF ELECTRICITY USED IN EXACTLY ONE YEAR BY ELECTRIC MOTORS AND APPLIANCES ON THE FARM LINE

Name of Equipment	Place	Used For What	Indication of Amount of Work	Electricity Used in Exactly One ear KWH
1 H. P. Motor on Line Shaft	John Wehde	Cream Separator Washing Machine Churn	Family of 12	148. KWH
3 H. P. Electric Motor	B. Mekvold	Milking Machine	Dairy Herd of 35 Cows	663.8 KWH
1 H. P. Electric Motor on Line Shaft	B. Mekvold	Washing Machine Meat Grinder Emery Wheel Electric Drill	Family of 6	52.1 KWH
2 H. P. Electric Motor	B. E. Cornue	Milking Machine	Dairy Herd of 33 Cows	564.7 KWH
¼ H. P. Electric Motor	S. S. Bliss	Cream Separator	8 Dairy Cows	13.2[illegible] KWH
¼ H. P. Washing Machine	Mrs. G. Renner	Laundrying	Family of 4	15.7 KWH
½ H. P. Electric Motor	A. Christiansen	Water Pump	60 Head of Horses 20 Head of Cattle 60 Head of Hogs	85.8 KWH
½ H. P. Electric Motor	Ed Flamoe	Hard Water Pressure System	Family of 5	76.5 KWH
⅓ H. P. Electric Motor	Ed Flamoe	Soft Water Pressure System	Family of 5	32.3 KWH
3 H. P. Electric Motor	C. Renner	Milking Machine	25 Dairy Cows	1147.1 KWH
⅓ H. P. Electric Motor	Gus Nelson	Water Pump	7 Hogs 15 Dairy Cows 3 Horses	54. KWH
½ H. P. Electric Motor	O. T. Nessan	Water Pump	20 Head of Cattle 8 Head of Horses 50 Head of Hogs	108.8 KWH
¼ H. P. Motor	S. S. Bliss	Electric Regrigerator	Cubical Content of Box—11.5 Cu. Ft.	436 KWH

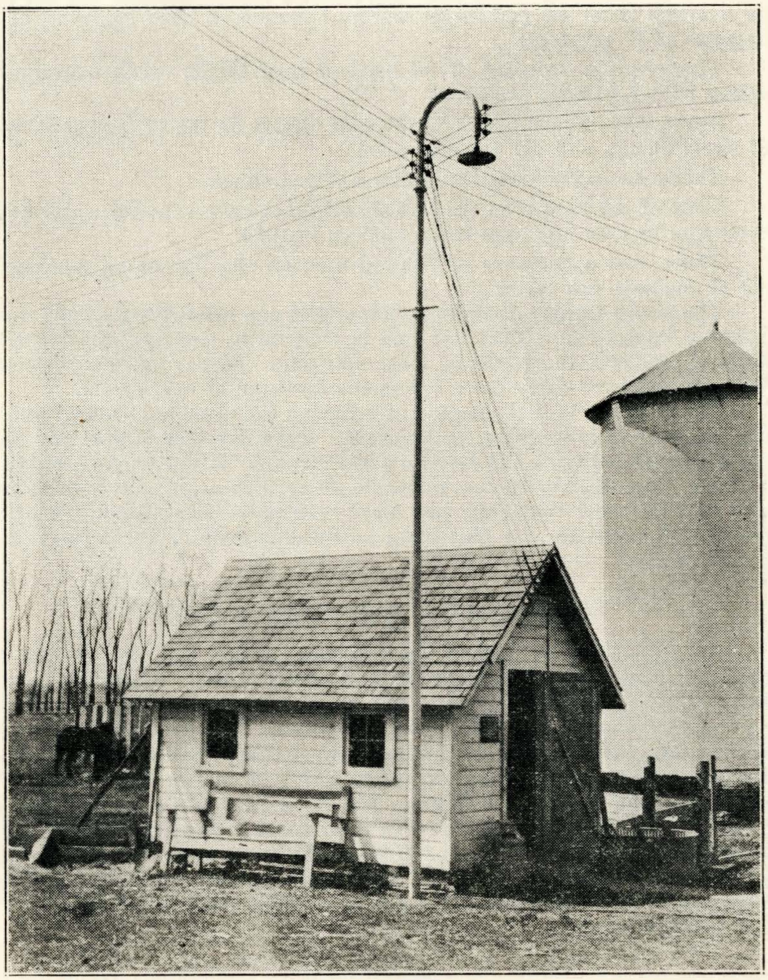

FIG. 12.—YARD LIGHT ON THE S. P. BRENDE FARM.

One of the luxuries of electricity for lights on the farm is the yard light. It is also useful and affords protection to the chicken roost. The cost of burning this light on the electric power line would be so small as to be negligible. The cooling tank shown in Figure 1 is located in this pump house.

tion was made to the patrons of this intention to record such changes. Most of them can be attributed to the use of the electricity on the farms.

On the 17 farms there was a net increase of 65 dairy cows or an average of four and one-third cows per farm; a net increase of 205 hogs, or an average of 13 2-3 per farm; and an increase of 1,155 chickens, or an average of 77 per farm.

There was a decrease of 93 head of beef cattle, or an average decrease of 6 1-5 cattle per farm.

There was an increase of 72 acres of alfalfa on the 17 farms, 51 acres of sweet clover, and 147 acres of corn.

There was a decrease of 29 acres of red clover.

Four of the homes on the line that did not have running water and a bathroom in 1924 had been made modern in 1928.

There was a decrease of 2 hired men on the line or an average of .12 of one man per farm.

The above figures show some important and interesting trends in the farming operations. The first one is that with electric power and the milking machine, there will be more dairying. This is indicated not only in the increase of dairy cows but in the decrease of beef cattle.

The next one is that, instead of reducing the hired help to any extent, the tendency is to increase the business. More livestock is kept and more crops are tended since the electric service came. It has been prophesied by some that electric service would do away with some of the hired help. The records show that only two hired men have been eliminated on account of the service, but that more business is done on these farms as a result of it.

Increased Use of Electricity on Line

As stated before, one of the purposes of this test was to find out how much electricity would be used on these farms. Since the patrons had to buy their own equipment and pay for their electricity, the figures on the increased demand are very indicative. The load on the line has been building up steadily and indications are that it will continue to do so. During the first year a total of 13,345 KWH of energy were used. During the second year 22,840 KWH. The third year this amount was increased to 25,774 KWH. The fourth year it was increased to 33,593 KWH. And for the fifth year a total of 37,935 KWH were used. (See Fig. XIII). The average electricity used per month per customer was 65.4 KWH in 1924, 107.1 KWH in 1925, 115.7 KWH in 1926, 145.5 KWH in 1927, and 157.4 KWH in 1928.

Summary

In this experiment station bulletin an attempt has been made to put the results in the easiest possible form so they will be of service. While some of the readings on the test line were not taken under the extremely exacting conditions that are required in the research laboratories of the college, yet most of them were. The figures here presented are reliable and typical of South Dakota farms, where a considerable number of cows are milked or a considerable amount of livestock is bred.

The purpose of this experimental work on "electric lights, power, and appliances for the farm" was to find out what they would cost, and also whether a farmer could afford to have this powerline service. It was also to find out whether the power company could afford to furnish it.

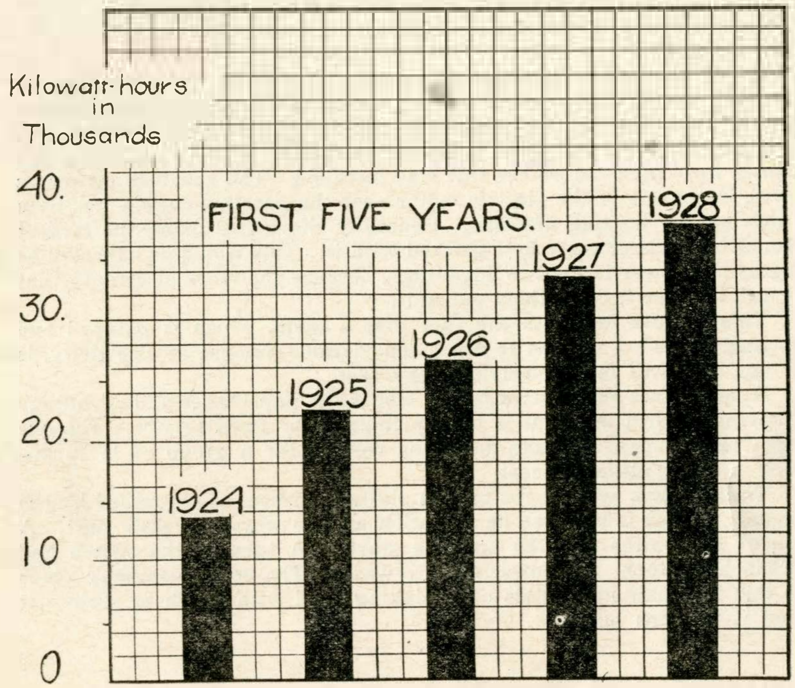

FIG. 13.—INCREASED USE OF ELECTRICITY ON TEST LINE.

This chart shows that the farmers on the line used more electricity each year. It is excellent evidence that they were satisfied that electricity could be used efficiently on the farm.

The figures and tables indicate the cost of this service in kilowatt hours of electricity used, as well as in dollars and cents based on the straight energy charge as used on the line.

Records were not taken on the cost of electricity for the lighting and small home appliances, but this would average about 30 KWH per month. If figured at the five-cent energy charge, the 30 KWH would cost $1.50 per month.

The farms were practically all dairy or livestock farms and have made the electric service very practical. In the case of two renters on the line having no electrical equipment except the lights, washing machine, and iron, the service figures rather high per kilowatt hour used.

They are not taking advantage of the three-cent power rate and are therefore using the electricity as a luxury. Their average bill for the past year including the monthly distribution charge was $8.94 per month. This, however, is no higher than the average cost of operating the individual farm plant.

The patrons on the line are more than pleased with the service. Some of them went into it with some misgivings and are now very enthusiastic about it.

A few that use a considerable amount of electric power maintain that they are saving enough money, owing to the displacing of other kinds of power, to pay the cost of the electricity for lights and home appliances. That this is true is indicated on farms where two or three gas engines were used before the line was installed. The greatest saving on power, in the use of the electric motor over the gasoline engine, has been in driving the milking machine. Generally the farms using the largest amount of electricity are best pleased with it. This would be expected as long as the power is used to advantage, because the more electricity that is used, the less it costs them per unit.

This in turn suggests the fact that a farm, which is planned and operated in such a way as to use a considerable amount of electricity, is the one that will make electricity pay best.

Another fact emphasized by the test is the importance and advantage of having a farm line that is built primarily for farm service. The one large transformer, stepping down the voltage for a group of 17 farms, helps in distributing the cost.

The greatest advantages of this electric service, as expressed by the patrons, is that it requires no attention and no worry on their part. A turn of the switch and the machine starts. A turn of the switch and the machine stops. No power goes to waste. The power company keeps the line in repair and builds up a sinking fund with which to replace it when it is worn out.