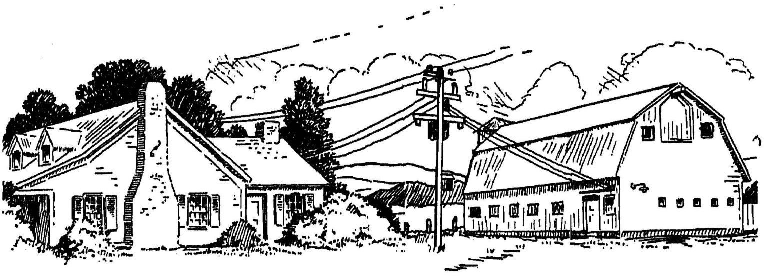
UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BULLETIN 268

The Use of Electricity on Missouri Farms



COLUMBIA, MISSOURI
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DEFINITIONS

Volt. A volt is the unit of electrical pressure which causes electric current to flow.

Ampere. An ampere is the unit of rate of flow of an electric current (coulomb per second).

Watt. A watt is the unit of electrical power, 746 watts being equivalent to 1 horse-power.

Kilowatt. A kilowatt is equal to 1000 watts.

Kilowatt-hour. (KwH) A kilowatt-hour is the common unit of electrical energy. If an appliance requiring one kilowatt of power is operated for an hour, one kilowatt-hour of energy will be used.

CONTENTS

FOREWORD

The Missouri Committee on the Relation of Electricity to Agriculture was organized in January, 1927, as a part of a national movement to investigate the possible uses of electricity in agriculture. This committee was composed of representatives of farm organizations, of equipment manufacturers, of electric utility companies, and of the Missouri College of Agriculture. An executive committee of five members was selected to direct the work of the committee and to formulate a program of study and investigation for the rural electrical problems of Missouri.

It was first intended to confine the studies to a test line where practical farm problems could be worked out under average Missouri conditions. It was finally decided, however, to conduct tests on some rather widely separated individual farms at different points in the state. This procedure was considered to have a special advantage in that it offered opportunity to study different types of farms and farm operations. Records were kept and comparisons were made of power problems on the different farms.

MISSOURI TEST FARMS

Missouri Test Farms were selected on the basis of their present and probable future use of electricity. An effort was made to select representative rather than exceptional farms.

Most of the farms were receiving service from central station power lines. On these farms new equipment was installed and studied in places where it was thought likely to prove practical. Extreme care was taken to increase the farm electrical load in a natural way and to avoid securing information on a theoretical basis of farm use and consumption.

For many years, service from central station power lines will not be available to every Missouri farm. Individual plants will play an important part in bringing modern conveniences to those farms so situated that electric lines cannot be built to them economically. In supplementing the work done by the Missouri Agricultural Experiment Station on individual farm lighting systems* farms using individual plants were selected, meters were installed for measuring the quantity of electricity used, and records were kept on the fuel used and service secured from the systems.

*Missouri Agricultural Experiment Station Bulletin 243.

THE USE OF ELECTRICITY ON MISSOURI FARMS

R. R. Parks

The farm woman is more and more depending on power conveniences to eliminate unnecessary drudgery in connection with her housework. "Luxuries of yesterday are necessities of today". Too, the farmer is more and more depending on power machinery to eliminate expensive man labor and to reduce operating cost to a minimum. There is a great possibility for the use of electricity on the farm, now. With the advent of practical electric power for field work the possibility will be greater.

BATTERY CHARGERS AND RADIOS

Radios bring a great amount of satisfaction to farm life. Through the radio the farmer can keep posted on markets, news events, and weather forecasts which he otherwise would receive late, if at all.

Fig. 1.—A radio on Farm 2 besides furnishing entertainment, is used for receiving market reports and weather forecasts.

The radio battery on Farm 2 receives a regular weekly charge. The length of time necessary to charge the battery varies from 7 to 9 hours.

TABULATED REPORT OF SURVEY OF TEST FARMS.*—SECTION I.
Missouri Project on Rural Electrification

Key:
X—Yes I—Iced
C—Coal O—Oil
D—Dairy S—Stove
E—Electric St–Steam
G—Gasoline W–Windmill
H—Hand

Cooperator	Farm Number	General Information											Number of:				
		Post Office	No. in Family	Rooms in House	Basement	Furnace	Water to Kitchen	Bath Room	Type of Farming	No. Acres in Farm	Tractor	Automobile	Milk Cows	Chickens	Beef Cattle	Hogs	Work Stock
N. H. Shepard	1	Columbia	5	9	X	X	X	X	Dairy	246	X	X	40	30			6
J. E. Bedford	2	Columbia	3	5					Dairy & Poultry	80		X	11	400			3
W. W. Riggs†	3	Columbia	3	7			X	X	General	200		X	3	200		40	7
Ed Clenin †	6	California	4	4					Dairy	70		X	24	150			3
H. F. Wehrs	7	Concordia	4	6	X	X	X	X	General	130		X	13	300		40	6
H. W. Bechtold	8	Boonville	8	7			X	X	Dairy	125		X	25	60		6	2
Aubrey Fellows	9	Salisbury	4	7	X	X	X	X	Stock & Poultry	160	X	X	3	500		220	5
C. D. Heinlen	10	Mexico	4	5					Dairy	120		X	30	100			4
H. A. Orr	11	Mt. Leonard	3	7	X	X	X	X	Stock	449		X	6	70	100	400	9
L. A. Ransburger	12	Mt. Leonard	2	5	X	X	X	X	Stock	138		X	6	100	62	85	4
A. Ransburger	13	Mt. Leonard	2	7	X	X	X	X	General	160		X	3	50	80	50	3
H. Nierman	15	Concordia	9	6	X	X	X		Dairy	240		X	20	400		40	8
M. F. Duvall	21	Clarksville	3	5					Dairy	100	X	X	15			15	6
P. P. Palmer	22	Ethlyn	6	6					General	160		X	15	750		10	6
R. E. Brown	23	Ethlyn	8	6					General	240		X	12	150			4
E. P. Finck	24	St. Charles	5	6			X		Dairy & Poultry	40		X	17	700			2
Wm. Nolle	27	St. Charles	3	5	X	X	X	X	Grain	125	X	X	3	300		6	4
Dave Peterein	28	Hematite	11	8	X		X		Dairy	188		X	21	100		40	7
H. S. LeCompte	34	Springfield	5	7	X	X	X	X	Dairy	100		X	25	250			4
W. B. French	39	Springfield	3	7	X	X	X	X	Dairy	160		X	50	60		10	7

TABULATED REPORT OF SURVEY OF TEST FARMS—SECTION II.
Missouri Project on Rural Electrification

Key:
X—Yes I—Iced
C—Coal O—Oil
D—Dairy S—Stove
E—Electric St—Steam
G—Gasoline W-Windmill
H—Hand

			Farmstead Equipment																
Cooperator	Farm Number	Post Office	Milking Machine	Feed Grinder	Water Pumps	Refrigerator	Cook Stoves	Washing Machine	Iron	Radio	Percolator	Toaster	Sweeper	Heating Pad	Fan	Curling Iron	Bottle Washer	Separator	Water Heater
N. H. Shepard	1	Columbia		E	H		C	E											S
J. E. Bedford	2	Columbia			H		C	E	E	X								E	
W. W. Riggs†	3	Columbia			W		W	E	E	X			E						S
Ed Clenin†	6	California	E		E	I	C		E								H		
H. F. Wehrs	7	Concordia		E	E&E		C	E	E			E				E		H	S
H. W. Bechtold	8	Boonville	E	G	G&E	E	C	E	E								E	E	S&G
Aubrey Fellows	9	Salisbury			W&E	E	O&E	E	E	X			E						S
C. D. Heinlein	10	Mexico	E	E	H	I	C	E	E	X							E	H	DE
H. A. Orr	11	Mt. Leonard		E	W&E	E	C&E	E	E	X		E	E					H	S&E
L. A. Rassburger	12	Mt. Leonard			W&E	E	C		E	X	E				E				S
A. Ransburger	13	Mt. Leonard		G	W	E	C		E	X			E						S
H. Nierman	15	Concordia	E	G	E&E		C&E	E	E							E	St	E	DSt
M. F. Duvall	21	Clarksville	E	E	E	DE	C&E		E	X	E							E	DSt
P. P. Palmer	22	Ethlyn	E	E	E	E	W	E	E									E	
R. E. Brown	23	Ethlyn	E	E	H		W&E	E	E									H	
E. P. Finck	24	St. Charles	E	E	E		C	E	E				E						
Wm. Nolle	27	St. Charles		G	E	E	C	E	E	X	E	E	E			E			S
Dave Peterein	28	Hematite	E	G	G		C	E	E	X		E			E	E			
H. S. LeCompte	34	Springfield	E		E	E	E	E	E	X	E	E	E			E		E	S
W. B. French	39	Springfield	E		E	I	C	E	E	X	E	E		E			E	E	DE

*Information on farms not listed here is given in section of report covering test work on those farms.
†Individual light plant owners.

Over a period of twelve months the average energy used per month in charging this battery was 3.6 kilowatt-hours, the maximum being 7 kilowatt-hours and the minimum being 2 kilowatt-hours.

Alternating current receiving sets are becoming more popular than battery operated radios because they require less attention and care. This fact will cause them to be operated over longer hours than will the direct current radios.

BOTTLE WASHERS

Electric bottle washers can be made by fastening a bottle brush to the shaft of a ¼-horse power motor. The motor should be protected from the water spray by a metal shield through which the shaft can extend. Another type of bottle washer which is not subject to so much bearing strain on the motor can be made by belting the motor to a brush which has its own shaft and bearings.

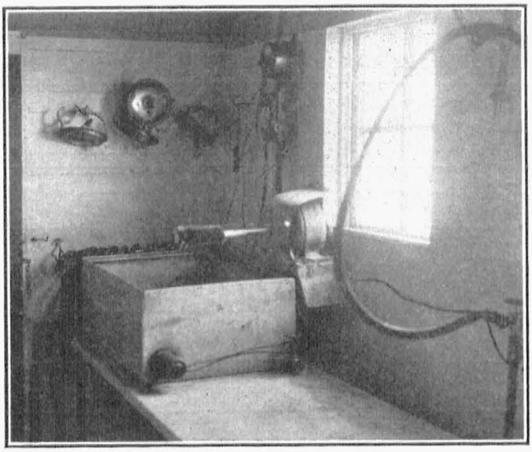

Fig. 2.—An electric bottle washer and water heater speed up the work on Farm 39. A 3 Kw immersion heater is used in a built-up tub.

On Farm 10 there is a washer of the first type mentioned. Approximately 300 bottles are washed per day. Since April, 1928, this washer has consumed an average of 4 kilowatt-hours of electricity a month. About once each year the bearings on this motor have to be renewed at a cost of $1 each time.

On Farm 9 there is a washer of the second type mentioned. Approximately 175 bottles are washed per day, using a ⅙-horse power motor. Since June, 1928, this washer has consumed an average of 1.4 kilowatt-hours of electricity a month. This motor is belted to the brush so that its speed is approximately 800 revolutions per minute.

On Farm 39 there is a washer with the brush fastened to the shaft of the motor, similar to the one on Farm 10. Approximately 312 bottles are washed per day. In two years of service no trouble has been experienced with the bearings in the motor.

CHICK BROODERS

Electricity for chick brooding is desirable because it is clean and requires very little attention on the part of the operator. However convenient a source of heat energy electricity might seem for the poultryman, interruptions in electric service for the poultry farm might cost the operator much loss in baby chicks and eggs.

On Farm 28 a comparative test of an electric brooder and an oil brooder was made. The results of this test are given in Table 1. This is what the operator said about his kerosene brooder: "Not very convenient, needs good ventilation through the roof to keep down bad odors, difficult to care for and keep burning." Of the electric brooder he said. "In my opinion the operation of the electric brooder was perfect. It held a constant temperature and required no attention at all. The cost was very reasonable and I would like to recommend it to any poultry raiser."

TABLE 1.—COST STUDIES OF OPERATING OIL AND ELECTRIC BROODERS FARM 28

	Electric Brooder	Oil Brooder
Chick capacity	500	500
Type of house used	Missouri 10 x 12	Missouri 10 x 12
Date of starting	March 9, 1928	March 21, 1928
Number of chicks started	400	290
Health of starting birds	"poor"	"healthy"
Date birds were turned out	May 8, 1928	May 20, 1928
Number of brooding days	60	60
Percentage of mortality	16.7%	1.7%
Cost of operation	342 KwH at 3c—$10.26	90 Gal. Ker. at 12c—$10.80
Energy cost per chick	3.1c	3.8c

CREAM SEPARATORS

One of the small jobs of the dairy farm, yet a big job for the one who "turns the crank", is cream separating. Driving a cream separator in most cases can be done with a ¼ H. P. motor mounted either on the separator or on a portable stand. Mounting on the separator is to be preferred because of belt troubles that arise when attempting to use small portable motors on stands.

Farm 2 sells cream to a local dairy. All of the milk from 12 cows is separated. The electricity used for separating this milk has averaged 0.41 kilowatt-hours per 1000 pounds.

On Farm 34 the excess milk from a retail dairy route is separated. On this farm the electricity used for separating the milk has averaged 0.39 kilowatt-hours per 1000 pounds.

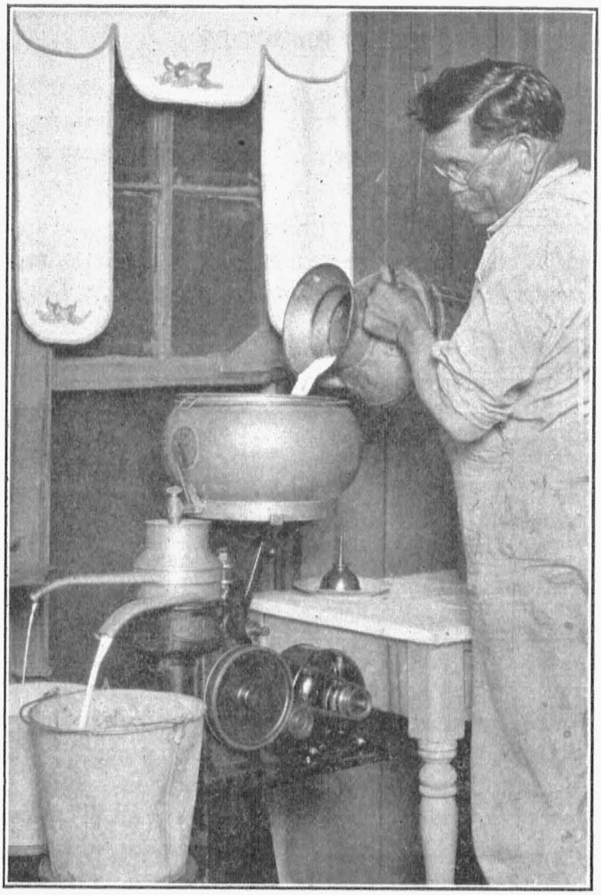

Fig. 3.—A motor driven cream separator used on Farm 2. At 10c a KwH it costs less than ½c a day to separate 14 gallons of milk.

DISH WASHERS

One of the disagreeable tasks of house keeping is dishwashing. The Missouri farm woman spends approximately one hour a day every day washing dishes which a machine could wash.

Since September, 1928, a dish washer made by the Friedley-Voshardt Company has been used in the kitchen of Farm 11. This washer is 19½ inches in diameter and 21 inches high. It sits at one end of the

TABLE 2.—ENERGY USED FOR SEPARATING MILK.—FARM 2.

1927-28	Pounds of milk separated	Kilowatt-hours used
Sept.	4704	1.8
Oct.	3998	1.2
Nov.	3305	1.5
Dec.	3613	1.5
Jan.	3987	1.7
Feb.	3918	1.4
Mar.	3535	1.5
April	3130	1.2
May	4260	1.3
June	5302	2.3
July	6005	2.6
Aug.	7084	4.0
Total	53814	22.0

Energy used per 1000 pounds of milk separated, 0.41 KwH.

kitchen sink so that the drain is over the sink drain. It has a rubber hose that attaches to the hot water faucet and carries water to the washer bowl. Any excess water flows into the overflow drain of the washer so that when rinsing the dishes the water can be left running through the

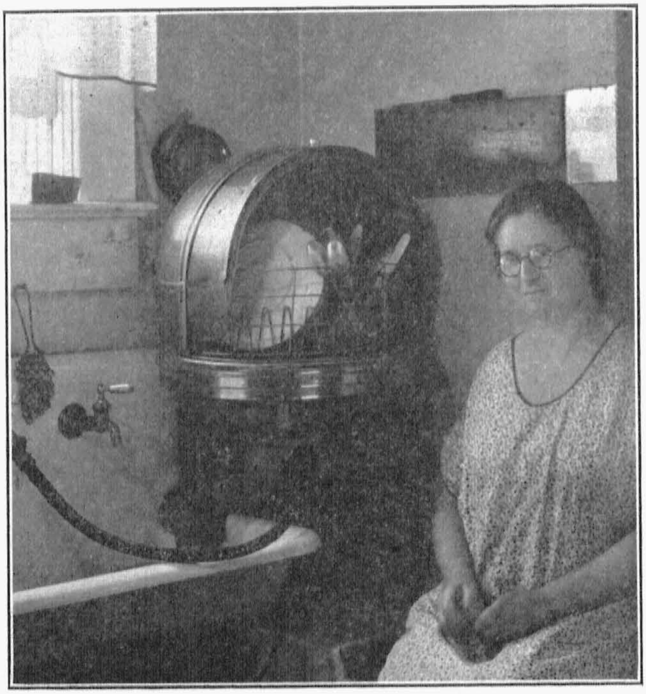

Fig. 4.—An electric dish washer saves much time and work on Farm 11. The hose is attached for running hot water into the bowl of the washer. A motor and pump below the bowl of the washer force water through a set of nozzles under the basket of dishes.

washer. It is equipped with a 1/6 H. P. motor which drives a centrifugal pump in the bottom of the washer. This pump circulates the water through a set of revolving nozzles just under the basket of dishes.

The dishes from the table are placed in a round wire basket which fits into the machine. About half a gallon of water is poured into the machine and soap powders are added. Then the machine is closed and allowed to run for two minutes. At the end of the two minutes the drain is opened and the soapy water is allowed to run out. Half a gallon of rinse water is then added and the machine allowed to run for another two minutes, after which the top of the machine is left open for the dishes to dry. The glassware and silver are wiped with a cloth.

The washer consumes an average of 2.3 kilowatt-hours of electricity per month and saves approximately 15 minutes of time each day.

ELEVATORS AND HOISTS

The use of electric power to elevate hay and grain on the farm makes it possible to perform this work with a minimum of man labor. There are many different types of elevator equipment on the market so the prospective buyer should have no difficulty in finding something for his needs.

On Farm 1 a system of handling dairy feed is being tried out with the view of making more use of the hay hoist. This hay hoist has a lifting capacity of 500 pounds or more, which makes it possible to hoist a wagon load of hay or grain in four or five hoist loads. For elevating grain the hay fork is replaced by a grain-tight car built 3 feet square by 3 feet high and with a hopper bottom. This car is taken to the ground at the rear end of the barn, loaded at the back end of the wagon with a shovel, and is then elevated and taken to the front end of the barn where a trap door in the bottom is tripped and the grain is allowed to run into bins built for that purpose. From these storage bins the feed is carried by gravity to a small type hammer mill placed in the feed room below. The hay hoist is placed in the loft. It is driven by a 3 H. P. motor mounted on a shelf in the feed room below. After hoisting is done the motor is belted to a small hammer mill for grinding the elevated grain.

At the University Farm, studies have been made on a drag type portable elevator used for elevating sacked grain and bales. This elevator is operated by a 3 H. P. motor. It is reversible through gears, and has a power lift for changing the angle of the elevator body. The body is made of structural steel and the slide is covered with sheet metal. The elevating is accomplished on an endless chain belt made of two parallel link chains connected with steel cross slats. The main weight of sacks and bales rides on these slats when being elevated. Two men are required to operate this machine, one to feed the elevator at the bottom, the other to keep the hay or grain cleared away at the top. Under test this elevator required 0.3 kilowatt-hours to elevate 2,000 pounds of baled straw to a vertical height of 14 feet. The time required was 9.5 minutes. Men feeding this machine do not often work fast enough to load it to capacity.

Fig. 5.—A sack and bale elevator built for temporary use on Farm 1. A 2 H. P. motor used for driving the shaft was set inside the barn loft.

A sack and bale elevator similar to the one on the University Farm was needed on Farm 1. Since the University elevator cost more than the cooperator on Farm 1 was willing to spend it was decided to build a less expensive one. Figure 5 shows this elevator in operation. The body of this elevator is built of two by six pieces braced to each other through the center. The bearings for the sprocket shafts are placed in the ends of these two pieces and the chain belt conveyor is put over the sprocket wheels. Legs on the bottom end and a platform on the top end are attached by off-setting pieces to miss the chains on each side. A cultivator wheel is used on the top shaft for a pulley wheel. The belt is taken to a 2 H. P. motor inside the loft floor over an idler pulley at the side of the elevator platform. After the elevator is taken down from the building it is made ready for transporting by placing an extra cultivator wheel on the top shaft and pulling the pins out of the drive sprockets.

In the fall of 1928 a combined corn crib and granary was built on Farm 11. It has a center driveway lengthwise through the building. At the mid-point of this driveway is a pit elevator which receives the grain as it is dumped out of the back end of a wagon. From here the elevator takes the grain to a distributor pipe in the top of the building where it is allowed to fall into any one of several bins in the building. On one side of the driveway approximately half of the space on the first floor level is left for a corn crusher, sheller, and other machinery. The other half of this side and the whole of the opposite side is for ear corn. The corn cribs have floors sloping toward the driveway so that they can be emptied

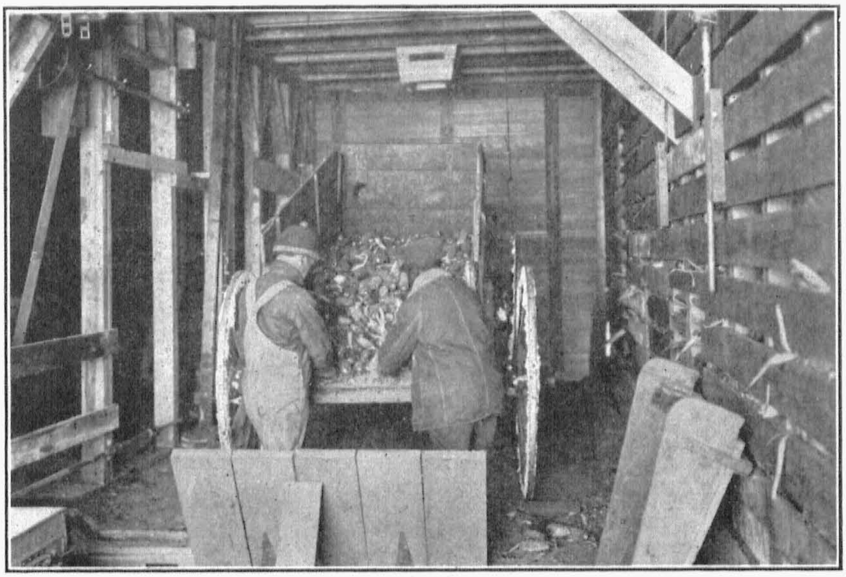

Fig. 6.—Elevating ear corn into storage bins on Farm 11. The front of the wagon is hoisted so the corn will run out the back. The elevator is driven from a line shaft shown on the left. Later other pulleys were added to the shaft for driving a corn crusher and sheller. A portable 5 H. P. motor was used for power.

into a movable drag conveyer which carries the corn to the elevator pit. From here it can be elevated again and placed into other bins. Directly over the space for the corn crusher and sheller is a hopper-bottomed bin from which they are fed. Directly over the driveway is a row of three hopper-bottomed bins for holding grain. Grain in these bins can, of course, be readily drawn out by gravity. The elevating machinery for this building cost $588 exclusive of the 5 H. P. motor which is used as utility motor for other work about the farm.

Electric power is well adapted to hay hoisting. In July, 1928, an electric hay hoist was operated on Farms 11 and 14. In both cases the hoist was located in the driveway of the hay barn and was driven by a farm utility motor. The hoist is manufactured by the Louden Machinery Company. It is equipped with two drums, one to hoist the load, the other to return the carrier to the end of the barn after the load is hoisted. There is a brake which can be used on the hoisting drum, but it was removed for this work because it made unnecessary friction in pulling the carrier back to the end of the barn. The carrier was pulled back by hand, principally because when using the hoist to return the carrier, the speed was entirely too fast. It was an easy task to pull the carrier back by hand. The man on the load operated the hoist. First he went to the motor and started it. Then he returned to his load, "stuck" the fork in the hay and pulled the hoisting rope. The pull on the hoisting rope engaged the

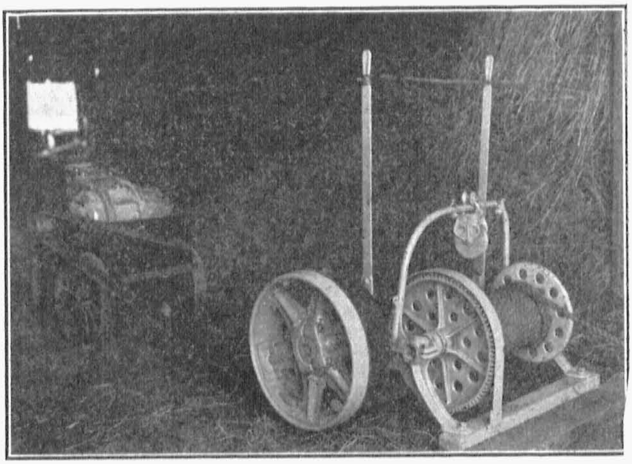

Fig. 7.—Hoisting hay on Farm 11. The man on the load operates the hoist, with the motor running. The hoisting operation is controlled by means of a rope and coil spring attached to the hoisting drum clutch lever. The man on the load pulls the rope to engage the hoisting clutch. When his pull is released, the coil spring returns the clutch lever to its original position disengaging the clutch.

clutch of the hoisting drum and the loading was hoisted. (The clutch on the hoisting drum was normally held out by a coil spring attached to the clutch lever.) As soon as the load was hoisted and had reached the desired point in the hay mow, the pull on the hoisting rope was released and the fork trip rope was pulled.

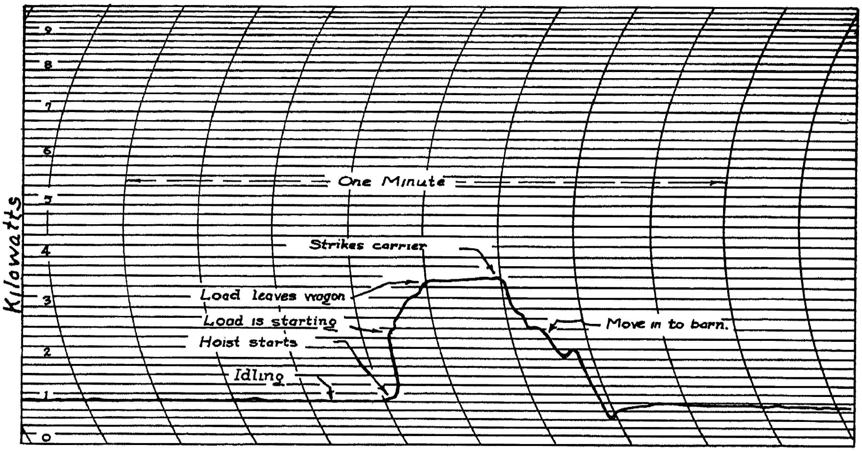

Fig. 8.—Typical load curve of 5 H. P. single-phase motor operating a hay hoist.

Many different load conditions were met in hoisting the hay. In hoisting much of the clover hay a 2 H. P. motor would have had ample capacity for the rope speed of 200 feet per minute which was used. On the other extreme, when a first cutting of timothy hay was moved into the barn from a stack, the maximum load demand was 6 H. P. In most of the work a 3 H. P. motor would have been large enough because an electric motor will stand considerable overloading for short periods. Figure 8 shows a typical load curve of one of the 5 H. P. motors hoisting hay. A 3 H. P. motor would have hoisted this load.

The time required for hoisting hay with electric power depends mostly on the speed of the man on the load. Approximately ¾ of a minute will elapse from the time he pulls the hoisting rope until the load is placed in the barn. The rest of the time will be taken up in bunching another fork full of hay on the load. One load of timothy hay which was representative of the loads hoisted was unloaded in five fork loads and required 10.5 minutes. The hoist was in operation 1.7 minutes or 16% of the total time. The total energy used was 227 watt-hours, of which 80 watt-hours, or 35% of the total, were used in hoisting the hay, the rest being consumed in idling. The total energy cost of hoisting this load of hay was 0.7c, (3c KwH). The small additional cost of letting the motor run continuously while the load was being unloaded was not important.

On Farm 14 over a period of two days 13 loads of hay were hoisted, consuming 5.4 kilowatt-hours of electricity. The energy cost was 16.2 cents (3c KwH) or a cost of 1.2c a load for hoisting.

ENSILAGE CUTTERS

Ordinarily, filling silos is considered an expensive farming operation. Large machines are engaged to do the cutting and several neighbors are called in with their wagons and teams to help with the work. This system of filling silos is not altogether satisfactory. The machine costs vary from $15 to $25 a day. Loss of time from machine breakage and bad weather very often add to the cost of the job. Then the cost and care of feeding such crews is not a minor item of expense.

Recent developments in the building of more efficient ensilage cutters and the use of farm electric motors to drive them have made it possible for the farmer to use his own machinery and his own farm crew of two or three men to fill the silo. If such a practice is adopted the cost of filling the silo can be lowered, the care and planning of the present system can be eliminated, and as a whole, a more efficient system of filling will result. A cutter on each farm will add to the machinery investment per farm, but the advantages of a better grade of silage from being cut at the proper time, an increased use of silage from refilling the silo late in the season, and a lowering of other items of cost connected with filling may

TABLE 3.—SILO FILLING WITH A FIVE HORSEPOWER ELECTRIC MOTOR

Farm No.	Size of silo	Tons cut	Hours required	KwH used	Tons cut† per hour	KwH used per Ton	Average‡ power KW
8	13½ x 30	70.29	16.0	74.3	4.40	1.06	4.6
7	12 x 40	73.37	14.2	73.6	5.16	1.00	5.2
6	12 x 30	49.41	8.2	54.9	6.02	1.11	6.7
34	12 x 40	70.74	14.0	71.0	5.06	1.00	5.1
34	12 x 40	70.94	13.3	75.0	5.34	1.06	5.6
39	16½ x 40	32.00	5.5	28.0	5.81	0.87	5.1
35	15½ x 40	141.27*	26.9	123.6	5.26	0.87	4.6
24	12 x 40	83.09	20.0	85.0	4.15	1.02	4.3
23	12 x 31	51.70	13.0	66.0	3.98	1.28	5.1
22	11½ x 30	52.15	12.0	60.0	4.35	1.15	5.0

*All of the corn put in this silo was weighed over scales, the rest of the weights were calculated from measurements, using tables in Missouri Agricultural Experiment Station Bulletin 164. Kafir was put in this silo whereas field corn was put in the others. On Farm 24 a Century 5 H. P. motor was used to drive a Model F. I. H. C. ensilage cutter. On Farms 23 and 22 a Wagner 5 H. P. motor was used to drive a Model 81 Papec cutter. Both motors were mounted on wood skids. On each of the other farms a Model 127 Papec cutter was used with a 5 H. P. motor mounted on the frame of the cutter.

†These figures are actual tons per hour (total tons put into the silo divided by the number of hours required to do the work) and not simply rates based on short test of a few minutes duration.

‡These figures are the average kilowatt demand at the motor (total kilowatt-hours consumed divided by the number of hours of operation). Roughly, these figures can be taken as H.P. output.

nearly if not altogether offset the cost of owning a cutter. A cutter driven by an electric motor will last longer because of the lower speed at which it is operated and the steadier power which is used.

It has been found that low speeds for ensilage cutters are desirable. The efficiency of a cutter increases as the operating speed is decreased; however, there is a minimum speed below which the cutter will not elevate. Electric motors are especially adapted to operating ensilage cutters, because their speed is practically constant regardless of load conditions. As will be shown later, a Model 127 Papec cutter (45-inch diameter fan) when operated at speeds below 400 revolutions per minute gave better efficiencies than when operated at higher speeds; however, care had to be exercised in feeding at these lower speeds, because the machine was more easily clogged.

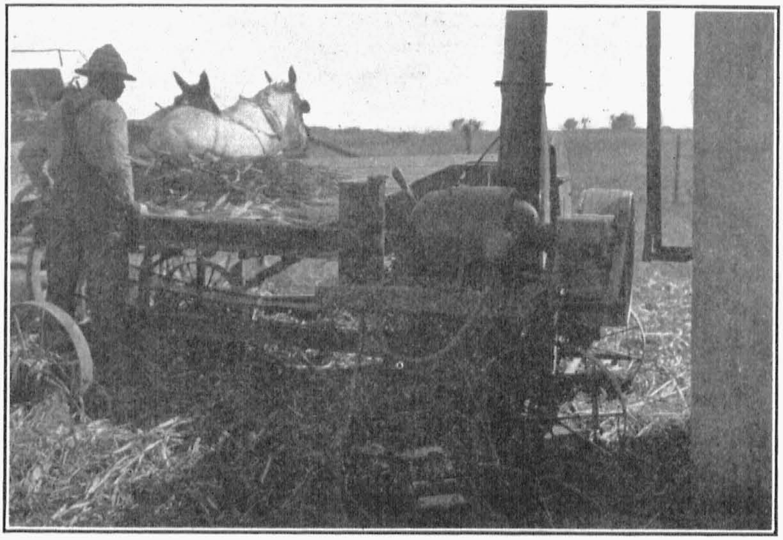

Fig. 9.—A 5 H. P. silo filling unit in use on Farm 35. The frame for mounting the motor on the cutter is not regular equipment.

Blower pipes have been made smaller on late model cutters. The reason for this, it would seem, is that higher air velocities have been needed rather than such large quantities of air to move *with* the cut silage as it leaves the fan tips. Large diameter blowers can be operated at lower speeds than can small diameter blowers because of the speed of the cut silage as it leaves the fan.

Electric motors have a very desirable characteristic for ensilage cutting. Their efficiency varies but little from 50% to 150% load and they can carry large overloads for short periods of time without injury. This makes it practical to load a motor, on the average, to its rated horse-power. Motors can be protected from overload injury so that inexperienced help can operate them without danger to the machine.

Table 4.—Effect of Cutter Speed on the Rate and Efficiency of Cutting and Elevating Kaffir Corn 40 Feet. Papec 127 Cutter Used.

Length of cut *Inches*	Speed of cutter *R. p. m.*	Rate of cutting *Tons per hour*	Power used *Kilowatts*	Efficiency *Tons per Kw H*
½	520	3.9	5.08	0.76
½	490	4.6	5.76	0.94
½	410	5.3	5.00	1.06
½	380	5.0	4.30	1.16

Table 6.—Effect of Length of Cut on the Rate of Cutting and Tons Cut per Kilowatt-hour Used. Kaffir Corn Being Cut and Elevated 40 Feet With a Papec 127 Cutter

Length of cut *Inches*	Speed of cutter *R. p. m.*	Rate of cutting *Tons per hour*	Power used *Kilowatts*	Efficiency *Tons per Kw H*
¼	410	5.03	5.16	.97
½	410	5.34	5.00	1.06
¾	410	6.22	5.05	1.23

During the silo filling season of 1928, tests were made to secure information on the use of 5 H. P. electric motors for driving ensilage cutters. To carry on field tests a Model 127 Papec cutter was equipped with a motor mounted on the cutter frame. A motor truck was used to transport the outfit from one test farm to another. Besides this unit three other units were tested in the field. The results of these tests are given in Table 3.

A 5 H. P. motor was found to have ample cutting capacity for many farm crews. The way 5 H. P. cutting outfits were received in the field can best be expressed by the statements of a few cooperators. The owner of Farm 7* said, "If we fill with our own help, 5 H. P. is enough. For crew filling a little larger would be better." On this farm the corn was bound in bundles which made it possible for the man on the load to feed the cutter without having a man at the machine. The owner of Farm 22 said, "We filled this year with about half the worry and expense of former years. I think our 5 H. P. is large enough." The owners of Farms 22 and 23 are neighbors. They bought cooperatively a small size cutter and a 5 H. P. motor. Another well pleased cooperator was the owner of Farm 34. He said, "Dependable power at low cost; very satisfactory

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*Refer to page 6 for name etc.

power; 5 H. P. is plenty large". On Farm 24 the silo was filled in eight days, using one wagon. The owner and two other men did all the work.

In general, the cutters tested could be depended upon to cut and elevate 5 tons of corn an hour. As many as 8 tons an hour were cut and elevated, apparently without injury to a 5 H. P. motor. An average load of 5 horse-power on the motors for half day at a time was not uncommon where farm help fed the machines. Successful silo filling with a 5 H. P. electric motor depends on the design of the cutter, its adjustments, the voltage supplied to the motor, the speed at which the cutter is driven,

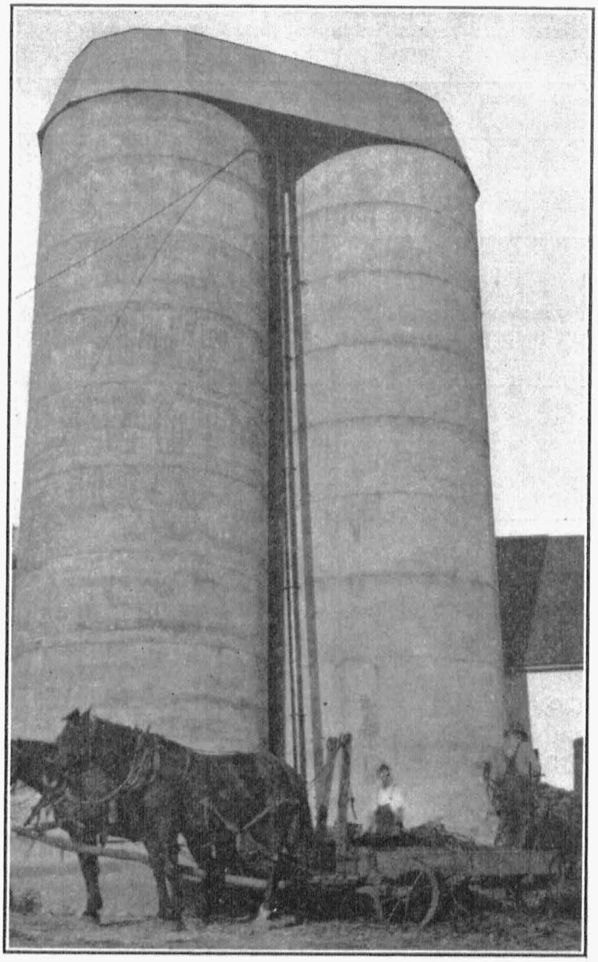

Fig. 10.—Filling 40-foot silos on Farm 34. A 5 H. P. motor and 16-inch cutter were used. The two 12 x 40 silos were filled in 27.3 hours.

and the drive. If the following recommendations are carried out, a 5 H. P. motor should have ample power for the small crew on the average Missouri farm:

1. Plan to drive the cutter at slow speed. Small diameter fans require higher speed to elevate to a given height than large ones. Variation in the height of the silo is of little importance between 35 and 45 feet. It was found that the maximum rate of cutting and also the maximum efficiency with a cutter having a 45-inch diameter fan was obtained at 360 revolutions per minute; however, the machine was more easily clogged at that rate than at higher speeds.

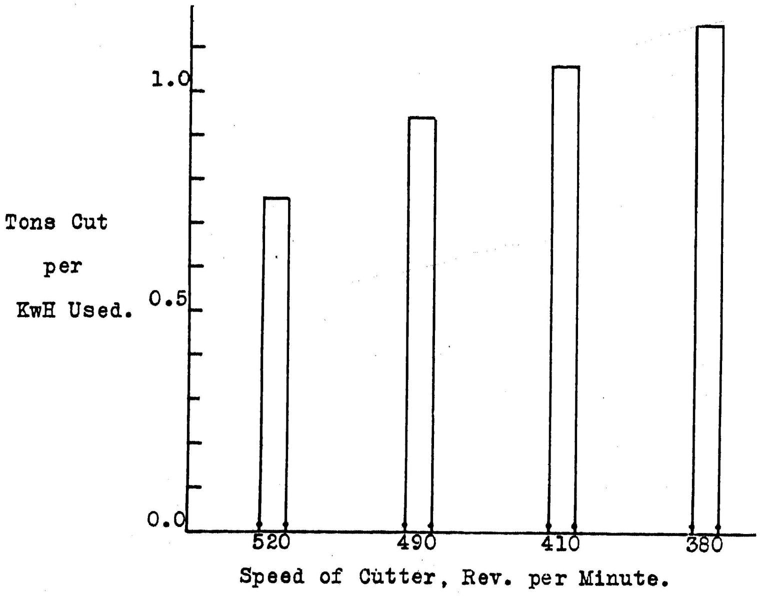

Fig. 11.—Effect of cutter speed on the tons of silage cut per KwH used. Kafir corn being cut and elevated 40 feet with a Papec Model 127 cutter.

2. The cutter should have a small blower pipe, not over 7 inches in diameter, and preferably smaller.

3. The fan blades should fit the bottom fan housing so that the tips will clear not over 1/8 inch and edges not over 3/16 inch.

4. The knives should be sharpened after every half-day's run or 20 loads of corn put through the machine. Keep the original bevel on the knives.

5. Adjust the knives to just clear the shear bar without scraping.

6. Use a fiber motor pulley, not less than 5 inches in diameter.

8. Use a flexible belt, single-ply leather or 4-ply rubber covered, 5 or 6 inches wide. Standard 5 h.p. motor pulleys are 6¾ inches wide.

9. Mounting the motor on the cutter frame is very desirable; however, little trouble will be had with belt slippage and alignment if care is taken in setting the motor. Run with the tight belt on the bottom and have at least 15 feet between pulley centers.

10. Voltage at the motor should not drop below 210 on full load. Use 5 K. V. A. transformer. If the motor is more than 100 feet from the transformer, the secondary wires need to be No. 4 or larger.

11. Use magnetic type switch with thermal overload relay.

12. See that the cutter is fed an even stream of corn.

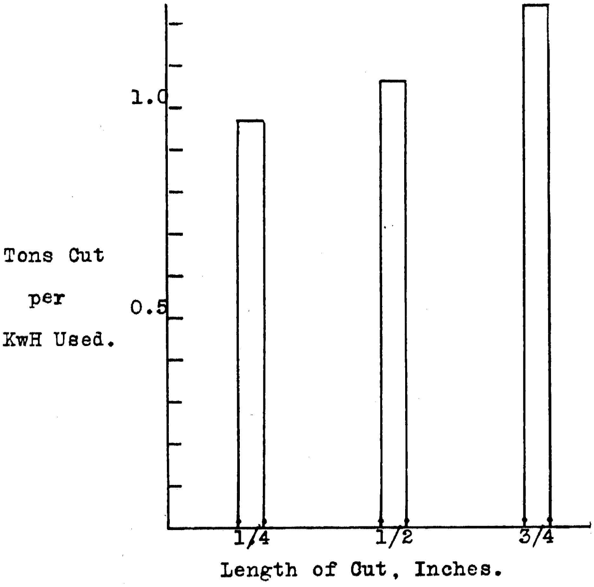

Fig. 12.—Effect of length of cut on the tons of silage cut per KwH used. Kafir corn being cut and elevated 40 feet with a Papec Model 127 cutter.

FEED GRINDERS

The first consideration of the prospective buyer of feed grinding equipment is to investigate the value of ground feed for his particular stock. The advantage of grinding is that there is less waste and that the digestibility of the feed is increased by exposure of greater portions of its fiber to the action of the digestive juices in the animal. Some feeds have more available nutrients than others, therefore, for each feed there is a difference in the allowable cost of grinding. These costs can be determined by feeding experiments. According to tests made by several of the mid-west agricultural experiment stations, it does not seem practical to grind hay and corn fodder for dairy stock fed for production. Little work has been done on grinding feed for beef stock. Many farmers allow hogs to follow these cattle. Grinding of small grains for hogs is recommended. Grinding corn and small grains for dairy cattle is quite important. McCandlish and Weaver* say 100 pounds of corn meal is equivalent for butterfat producing purposes to 125 pounds of corn and cob meal, or 140 pounds of ear corn. With corn selling at 80 cents a bushel, $1.43 worth of shelled corn ground into corn meal (medium ground) is equivalent for butterfat producing purposes to $1.43 worth of ear corn ground into corn and cob meal (medium ground) or $1.60 worth of ear corn whole. This allows 17 cents a hundred pounds for grinding either the shelled corn or the ear corn. When corn is selling at $1.00 per bushel this difference would be 21 cents a hundred pounds.

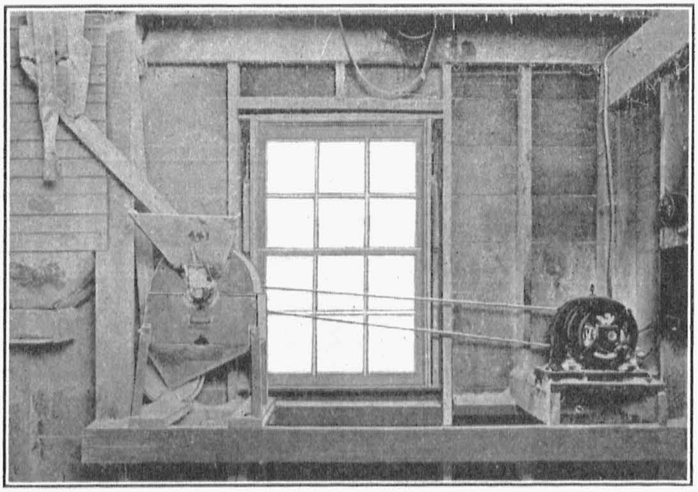

Fig. 13.—An experimental feed grinding outfit on Farm 1. The spout on the left feeds shelled corn or small grains to the mill. The hopper-bottom bin on the left receives the ground feed from a blower on the back end of the mill.

Then the second consideration of the prospective buyer of feed grinding equipment is his cost of grinding. Knowing that with corn worth 80 cents a bushel there is a margin of probably 17 cents a hundred for grinding, he must select equipment with which he can grind feed at the lowest practical cost. Where only tractors or large engines are available for power, large size mills are often desirable because feed is ground

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*The Preparation of Corn for Dairy Cows, Bulletin 195, Iowa State College of Agriculture and Mechanic Arts.

in large quantities with long intervals of time between. Where electric equipment is available, small capacity mills can be used because grinding is done at odd times and a small quantity of feed is always available. There is a prejudice against small capacity grinding equipment among some farmers because most of them have been used to seeing large capacity mills in operation and they have not stopped to analyze their own grinding requirements. Recent investigations in the field of feed grinders have been responsible for the development of several small grinders, requiring 5 H. P. and less, but having ample capacity for most Missouri feeders. These small mills and power units are low in first cost and operating expense, making it possible for the farmer to grind his own grain at a fraction of the cost of getting it done at most custom mills.

Referring to Table 6, the cost of electricity for grinding ear corn is approximately 3.4c per hundred pounds (10c per kilowatt-hour). The corresponding cost of grinding shelled corn is 1.7c per hundred pounds.

TABLE 6.—GRINDING FEED WITH 2 TO 5 H. P. ELECTRIC MOTORS

Farm No.	Type of Mill	Motor *H. P.*	Feed ground	Pounds per hour	Power* *Kw*	Energy used *KwH per 1000 lbs.*
7	No. 2 hammer	2	Ear corn	531	1.9	3.5
			Shelled corn	1200	1.8	1.5
			Bran (for chick feed)	520	2.1	4.0
			Oats (fine grinding)	100	1.8	18.0
22	8 in. buhr	3	Ear corn	852	2.9	3.4
			Oats	240	3.0	12.5
23	8 in. buhr	3	Ear corn	855	2.9	3.4
			Shelled corn	1974	2.5	1.7
24	8 in. buhr	3	Ear corn	520	1.8	3.5
			Shelled corn	956	1.4	1.5
	6 in. buhr	5	Ear corn	1200	5.0	4.2
			Oats	630	3.6	5.7
			Soy beans	1880	4.3	2.3
18	8 in. buhr	5	Ear corn (fine grinding)	985	5.9	6.0
			Oats (poor grinding)	1100	6.6	6.0

*Roughly, these figures can be taken as H.P. output.

Add to these costs not over 5 cents per hundred pounds for machinery and interest costs and the result will be a saving of 9 to 15 cents on the hundred pounds for the man's labor grinding corn. If this feed were taken to the mill in town the cost of grinding would be 15 to 20 cents per hundred pounds plus the cost of hauling it in and out again.

Grinding can be done with the same motor that runs the hay hoist, ensilage cutter, or wood saw. These other jobs would be a consideration in the size of equipment to be purchased. Electric motors vary but slightly in their efficiency from 40 per cent load to full load, so a 5 H. P.

single phase motor would be nearly as efficient as a 3 H. P. motor on a 3 H. P. load.

For grinding shelled corn and small grains an inexpensive system can be installed which can be operated satisfactorily with a motor of from one to three horse power capacity. Such a system includes an overhead bin and space beneath the mill for the ground feed to fall. Some of the better systems have large capacity bins on the loft floor above the feed room. From here it is fed by gravity to a mill on the floor below. The mill is equipped with a blower or elevator which elevates the feed again to the sacking or storage bin.

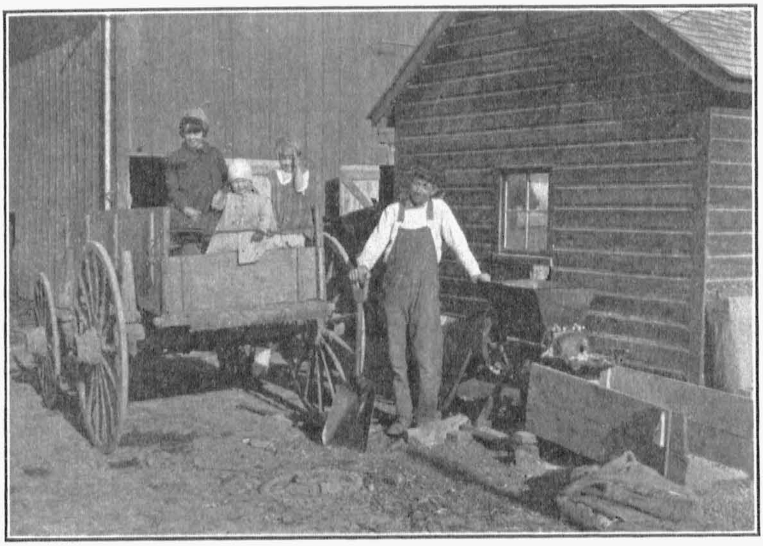

Fig. 14.—A 3 H. P. feed grinding outfit will grind a week's supply of ear corn for 12 cows in less than an hour. Here an 8-inch buhr mill is shown, belted from a 3 H. P. motor inside the pump house.

There are a great many tractor size feed mills on Missouri farms. Because of the desirability of electric power for feed grinding, many of these mills are being changed over to electric drive. It does not seem practical to use larger than 7½ H. P. motors on such farm grinders, since a 7½ H. P. system should have a capacity of 30 to 35 bushels of ear corn per hour. By driving buhr mills at from 400 to 600 revolutions per minute and feeding them so as not to overload the breakers they can be operated with a 3 to 5 H. P. motor.

Grinding systems using from 2 to 5 H. P. motors are popular on Missouri farms. Many farmers are interested in a grinding system which is low in first cost and operating expense, yet has large enough capacity to keep one man reasonably busy in feeding it and sacking or otherwise taking care of the ground grain. Table 4 gives the results of several months tests on representative farm grinding installations which are being used for grinding ear corn and small grains.

GENETIC EFFECTS OF X-RAYS

All plant and animal improvement by breeding has been brought about by the selection and combinations of variations which normally occur. The greater the range of variations, the greater are the possibilities of breeding certain characteristics into plants or animals. These variations result from changes in heredity (mutations) which have occurred spontaneously in nature. Mutations are extremely rare and no external factor has previously been shown to increase their frequency. Experiments with the genetic effects of X-rays have shown a number of results of practical value to the crop grower.

Dr. L. J. Stadler of the field crops department can best state the nature of the work he has been carrying on with the breeding experiments. "Our work on the practical applications of this method (X-ray treatments) of affecting heredity is being done mostly with corn and apples. In corn we are treating the most productive inbred strains available, in order to produce new variability which will permit a further increase in productivity to be made by selection.

"The most promising practical application appears to be in the vegetatively propagated fruit trees in which up to the present time no breeding methods have given notable results. If bud mutation can be induced in these plants in the way we have already shown it to be produced in barley, new variants will result which may be propagated in pure form by grafting. The possibilities of improvement by breeding would be increased several hundred-fold by this method. A large number of apple buds have been treated during the past year and the results of the experiment will begin to show within two years."

Work on the stimulation and external disinfection of crop plant seeds by X-ray treatment has made much progress during the past year. Mr. W. R. Tascher, working under Dr. Stadler, has been investigating the possibilities for such use of X-rays, with many different plant seeds. Results so far indicate that more exact treatments than are possible with present equipment are desirable.

INDIVIDUAL GAS-ELECTRIC PLANTS

For the isolated farm which cannot get central station service economically, the individual plant offers a solution of the power problem of lighting, pumping water, operating small feed grinders and milking machines.

Farm light plants are usually bought in either of two sizes, 750-Watt corresponding to approximately 1 horse-power output, or 1500-Watt corresponding to approximately 2 horse-power output. These plants can be had for 32-volt or 110-volt service, in either automatic, storage battery, or combination types. Where a gas engine is used for pumping water, operating a milking machine or doing other regular chores a small generator can be belted from the fly-wheel to charge a set of storage batteries for lighting service.

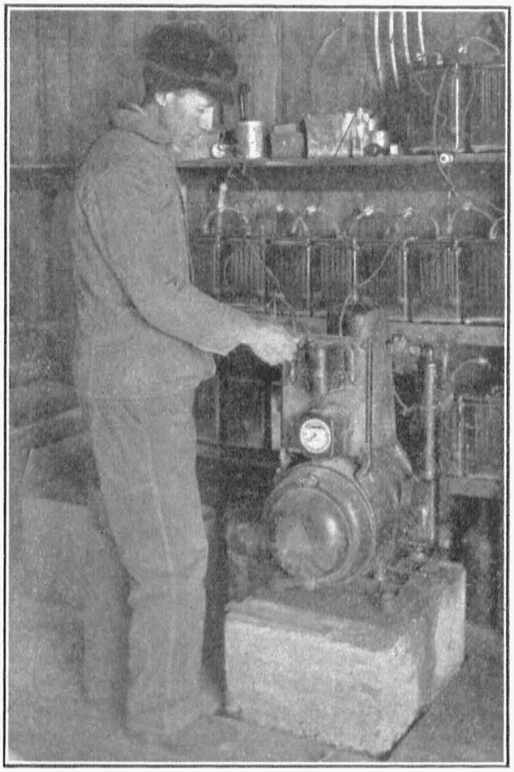

Fig. 15.—The farm light plant brings modern conveniences to many farm homes. This plant is used on Farm 4.

The cost of electricity from individual plants varies considerably. The care of light plant equipment has much to do with the life of the machine and battery, consequently the cost of service. It is estimated from several surveys that the average life of the farm plant is 10 years and the average life of the battery is 5 years. The fuel and oil cost for generating energy will probably be between 8 and 10 cents a kilowatt-hour. Assuming an energy consumption of 15 kilowatt-hours per month for lighting and operating small appliances the prospective buyer can get an idea of the possible cost of service from an individual plant.

TABLE 7.—FUEL AND OIL COSTS OF OPERATING INDIVIDUAL PLANT ON FARM 6

1928	Gasoline *Gallons*	Kerosene *Gallons*	Oil	Operating Total cost	Total electricity used *KwH*
January	38.0	15.5	3.0	$10.09	140
February	55.0	50.0	1.0	14.76	140
March	50.0	15.0	2.0	11.56	144
April	----	----	2.0	2.00	116
May	48.0	25.0	3.0	13.66	114
June	30.	10.0	4.0	9.71	110
July	32.0	15.0	3.0	9.58	104
August	28.0	6.0	4.0	9.19	104
September	38.0	15.5	5.0	11.49	110
October	38.0	15.5	5.0	11.89	120
November	35.0	12.0	5.0	12.44	110
December	37.5	15.0	3.5	11.21	160
Total	429.5	194.5	40.5	127.58	1472

Fuel and Oil cost per KwH 8.7 Cents.

Note: The gasoline and kerosene are mixed in the fuel tank 1 gallon of kerosene to 2½ gallons of gasoline

The plant data given in Table 7 come from Farm 6, a retail dairy farm two miles northwest of California. The owner has a 32-volt, 850-watt, battery-equipped plant which operates a two-unit milking machine through a ½ H. P. motor and a water pump through a ¼ H. P. motor. The plant is allowed to run while the milking machine is in operation. Twenty-two cows are milked. The only household equipment besides lights is an iron which is used very little. The electric energy consumption on this farm is high in comparison with the consumption on other farms using farm lighting plants.

The plant data given in Table 8 came from Farm 4, five miles southwest of Columbia. The owner raises stock and conducts a general farming business. He has a 32-volt, 750-watt, battery-equipped plant which is used for general lighting service, operating a washing machine, iron, sweeper and radio. The energy used by the radio is not included in the meter readings. The electric energy consumption on this farm is low in comparison to that used by similar farms receiving central station servvice. There are four in the family in a modern six-room house.

TABLE 8.—FUEL AND OIL COST OF OPERATING INDIVIDUAL PLANT ON FARM 4

1928	Fuel and oil used, gallons			Electricity used, kilowatt-hours
	Gasoline	Kerosene	Oil	
Jan.	---	7.5	0.12	13.3
Feb.	0.2	6.5	.25	9.8
Mar.	---	4.0	---	7.2
April	---	4.5	---	7.0
May	---	5.0	---	5.0
June	0.2	3.5	---	4.0
July	---	4.5	.37	5.0
Aug.	---	3.0	.12	5.5
Sept.	---	5.5	---	6.8
Oct.	0.2	7.0	.12	7.7
Nov.	---	6.0	.12	12.0
Dec.	---	7.5	---	10.0
Total	0.6	64.5	1.10	93.3

Cost: Gasoline at 18c a gallon, $0.11; kerosene at 12c a gallon, $7.75; oil at $1 a gallon, $1.10. Total $8.96.

Electricity used: Metered for lights etc, 93.3 KwH; estimated for radio 10.0 KwH. Total 103.3 KwH.

Fuel and oil cost per kilowatt-hour, 8.7c.

LIGHTING FOR THE FARMSTEAD

Correct lighting for the farm is a specialized problem in itself, and each farm has its particular problems of building arrangement and conditions to be met. However, there are a few principles of service, safety and convenience to be observed and which the farmer should insist on when his wiring contract is let. After the original wiring is done, additions are expensive.

Glaring lights are to be avoided in any farm building. Reflector shaded lamps will place approximately 40% more light where needed than will the same size open ones. Strong, low hung open lamps are hard on the eyes. Service wall switches will prevent breakage of hanging fixtures. The fixtures can be placed up out of the way of mechanical injury, and many steps can be saved by controlling lights from wall switches near doors. Toggle switches are to be recommended for farm use, especially where gloved hands will operate them.

Lighting the Home.—The home has as many lighting problems as it has rooms. In the living room, shaded soft lights are to be desired. Reading lamp shades should answer three purposes: they should be open at the top to allow a beam of light to the ceiling, and yet should protect other people, passing through the room, from a direct beam of light. The central lighting fixture of the living room should throw a diffused light to all parts of the room, but because of the more desirable individual lamps, will not be used except occasionally.

In the dining room a good type of fixture is the shaded one which is swung low enough to light the table well, but not so low as to obstruct the view, and which will not cast a direct beam of light to the eye. There should be a convenience outlet in the floor under the table for attaching table appliances.

In the kitchen, a dome fixture should be sufficient to give a diffused light to all parts of the room. White walls and ceiling in the kitchen add greatly to the lighting and general appearance of the room. Convenience outlets should be provided for the refrigerator, possibly a dish washer, and other appliances which find their way to the much used kitchen.

The bed room should have a small center fixture, but should also have wall bracket lamps on each side of the dressing mirror. There should be a duplex convenience outlet for attaching a sweeper, and reading or bed lamp.

In the basement, reflector shaded lamps should be used in front of the furnace door, in the coal room, and over the work bench. A separate light should be provided over the washing machine stand, besides a convenience power outlet.

Three-way switches should be installed where there are entrances from opposite sides of a room, especially in long hallways and stairways. This allows the light to be turned off or on from either of two points. Lights on stairs should be so placed as to avoid shadows. Every closet and storeroom should have a small light, not necessarily expensive but serviceable.

A well planned lighting system for the home will make more people happy and satisfied than any other electric service.

Lighting the Yard.—Where electric lights are used, the farmer can spend more day hours in the field through busy seasons, or get home late from town without much worry about seeing to do the chores. Yard lights are of great value in passing from one building to another, and can be controlled from two or more places with a small amount of wiring. Yard lights should be easily accessible for repairs, and should be weather proof. Experience has shown that wind and hail will loosen screw joints in yard lights and for this reason the shade should be fastened to the lamp socket permanently and if possible lock sockets should be used for holding the bulb.

Lighting the Dairy Barn.—Where the cows face in, a row of reflector shaded lamps should be used in each side of the barn. They should be located one foot behind the gutters. In this position they will throw a good light on the cow flanks and also light the alley behind the cows, where most of the work is done. The feed alley will receive plenty of light from the two rows.

Where the cows face out, it is best to have a row of lights down the center alley with somewhat closer spacings than in the first case. Spacing of the fixtures in a dairy barn will depend on the area to be lighted, the reflecting walls, ceiling and floor. In general, 40-watt reflector shaded units can be spaced twelve feet apart. A saving of light energy can be had in the dairy barn if different sections of the barn are wired on separate circuits. In this way it is only necessary to operate lights where they are needed.

Lighting the Poultry House.—Lights are being used in poultry houses to make the winter days more comparable in length to summer days, and to change a few dark winter days into regular working days, for the hens. The poultry house lighting unit should be a 40-watt reflector shaded lamp for each 200 square feet of floor area in the house. The shade should be shallow in comparison to its diameter so that when it is hung approximately 7 feet in front of the dropping boards and just high enough to miss the attendant's head it will throw a good beam of light on the roosts. Lamp locations and sizes will vary with the type and arrangement of the house; however, a good plan to follow is to use the ratio of 1-watt lamp capacity to 5 square feet of floor area.

All service buildings on the farm should be wired for lights and a supply of extra lamps kept on hands at all times. Such a practice will reduce the fire hazard from oil lamps and matches.

MILKING MACHINES

More time is required for milking cows than any other chore on the dairy farm. Where 10 cows or more are milked, machines can be used to reduce the man-hours required and thus reduce the cost of producing milk. There are many different makes of machines on the market.

TABLE 9.—TOTAL TIME REQUIRED FOR MILKING COWS BY HAND

Farm No.	Length of test period months	Avg. No. cows milked	Avg. Lbs. milked per cow milking	Avg. Man-Minutes per cow milking	Avg. Man-Minutes per 10 lbs. milk
34	5	19.6	11.12	7.89	7.15
7	5	10.9	10.73	10.19*	9.47
8	½	10.5	12.8	8.10	6.34
18	1	12.0	8.7	6.46	7.45
37	5	8.0	7.06	6.66	9.61
1	2	38.0	12.32	10.95*	9.10*
Average	-	16.5	10.45	8.37	8.19

*Includes the time of weighing and recording the weights of milk from individual cows. In all other tests the milk production weights were obtained from the cow tester or from weighing the total milk for the milking.

Each has its particular feature of operating the teat cup, easy cleaning, or light running. The majority of pumping units are stationary and operate the milkers from a pipeline. A few machines on the market are portable, the small motor and pumping unit being carried on the milker lid or on a separate stand. A connector cord is used to "plug in" to a power outlet at some convenient point behind the row of cows.

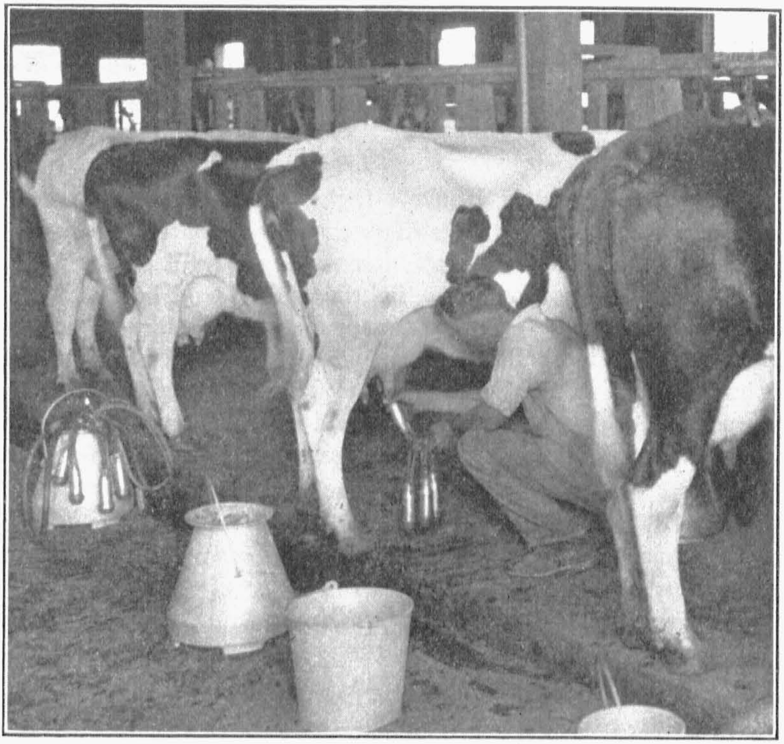

Fig. 16.—Milking machines have been found to reduce the man-hours required for hand milking, 45%. This is a pipe line milking machine used on Farm 1. The motor and pump are placed on the loft floor above. The single unit milkers make it possible to keep individual, daily records.

Table 9 summarizes the data from several farms where milking was done by hand. Three of these farms afterward furnished data for Table 10 on machine milking. Machine milking has its limitations. A careless operator cannot be expected to produce cleaner milk or do a better job with a machine than by hand. On 10 or more cows the labor cost will be reduced but the other factors will depend on the individual doing the work. Ordinarily one man operates two milker units; although some men can handle as many as four units and strip the cows after the machine. Much depends on the habits of the cow in giving the milk down to the machine. Quite often a heavy producing cow will milk out as fast as a light producing cow. Which fact makes double unit milkers more

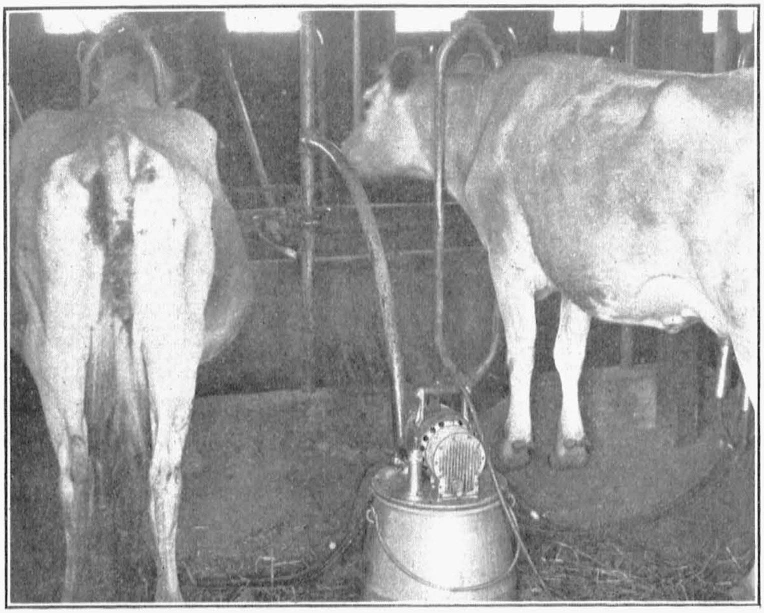

Fig. 17.—A portable milking machine can be operated with much less electricity than a pipe line machine requires. The motor and pump of this unit are fastened to the lid of the milker pail. Notice the attachment cord for connecting the motor to any one of several power outlets along the sides of the barn.

TABLE 10.—TIME REQUIRED AND ELECTRICITY USED IN MILKING COWS BY MACHINE

Farm No.	Length of test period, months	Avg. No. cows milked	Avg. lbs. milked per cow milking	Man-Minutes per cow milking	Avg. Man-Minutes per 10 lbs. milk	KwH 10 cows per month
1	5	40.0	10.79	6.12*	6.48*	30.6
21	5	15.2	9.32	5.73	6.40	13.8†
4	3	8.2	10.30	5.60	5.50	(6.4 Gal. gas)‡
24	6	11.8	14.42	4.13	2.88	58.4§
36	3	20.1	11.55	4.62	4.10	----
28	5	15.2	13.00	2.94	2.31	57.6§
8	3	17.3	12.49	4.41	3.68	20.2
22	8	12.8	9.97	4.13	4.25	28.8
23	7	8.5	17.70	4.88	2.77	35.2
34	5	15.5	11.89	3.60	3.08	29.5
Average		16.5	12.14	4.61	4.14	

*Includes the time for weighing and recording the weights of milk from individual cows.

†A portable double unit milker is used on this farm.

‡A gas engine is used for power on this farm.

§Double pipeline milker used on these farms.

practical than some would believe. Mechanical washers in the milk room save time and ordinarily insure a cleaner grade of milk where long rubber parts are used with the milk.

PORTABLE MOTORS

Due to the seasonal power needs on the farm, portable motors which can be moved to any point on the farmstead, are desirable. For single phase motors of 5 H. P. or larger, a wheeled truck should be used for the motor mounting. This motor will probably be used for ensilage cutting, wood sawing, feed grinding, and hay hoisting. It should have a truck that can be easily held in place on any kind of belt work. Three H. P. and smaller motors can be carried by two men if they are mounted properly. Several such motors on Missouri test farms are mounted on platforms made by nailing one-inch boards over 2-by-4 skids. The 2-by-4 pieces have "grips" cut on the ends to fit the hand. The material is cut away from the bottom of the stick rather than the top, so that the motor can be set down without the pinching of fingers. It is not necessary to fasten these motors to the floor with the belt running in a horizontal or nearly horizontal position. It is only necessary to nail guide strips to the floor on each side of the platform and one in front for holding the motor in place. The belt can be tightened by raising on the back of the platform, placing wedges in front and then allowing the motor weight to hold the belt tight. Small portable motors for washing machines, and separators are not to be recommended. They are very often used on smooth floors where the pull on the belt makes it difficult to keep them in line. Belt slippage problems from water or dirt may make them very troublesome at times; besides there is more danger of catching clothing in a more or less exposed belt and pulley.

COOKING WITH ELECTRICITY

Electric ranges eliminate the task of carrying fuel to burn or cleaning ashes and dirt after a wood or coal fire. Cooking utensils are more easily kept clean where electricity is used rather than coal, wood, or oil. Modern electric ranges can be equipped with temperature and time control apparatus so that the housewife is free to do other housework while foodstuffs are cooking. Many farm women put their meat or vegetables in the oven or cooker and go to the other part of the house or to the back yard to work, or even to town. Another freedom which some farm women have in cooking with electric heat is serving breakfast from their seats at the table, using their electric appliances.

Many reasons have been presented why electric ranges are not more common in the farm kitchen than they are. During summer months women who have them will use electric ranges to avoid unpleasant heat from the coal or wood ranges. In the winter months some go back to the coal or wood ranges because they are necessary to heat the kitchen. Others use them because of the added warmth to the house even though a furnace is in operation. After reasonable rates have been established for farm electric service the proper and adequate use of any electrical equipment is a matter of learning all that can be done with it, conveniently and economically.

Fig. 18.—An electric range on Farm 9, used for all cooking purposes, relieves the operator of much care and many chores connected with other means of cooking. Notice the temperature and time control switches for operating the cooking oven.

At present very few farms in Missouri can be expected to use their electric ranges for all cooking except through the summer months, unless kitchens are adequately heated by furnaces. Table 11 gives the energy consumption during the summer months on a number of Missouri farms when nearly all of the cooking is done with the electric range. Since the canning season on the farm occurs during July and August, probably 20 per cent more energy will be used then than in any of the winter months.

TABLE 11.—ENERGY USED BY ELECTRIC RANGES DURING SUMMER MONTHS

Cooperator	Post office	Farm No.	No. in Family	KwH used Summer 1928			
				June	July	Aug.	Sept.
Aubrey Fellows	Salisbury	9*	6	264	151	223	226
H. S. LeCompte	Springfield	34*	5	125	156	124	147
A. Mueller	Ferguson	41*	3	106	156	108	64
Carle Korte	Florrisant	42	3	92	98	144	74
G. W. Grueninger	Florrisant	45	3	196	266	186	70
Frank Neihaus	Florrisant	46	5	78	198	228	160
Andrew Cosserman	Jefferson Bks.	47	5	144	160	226	122
E. Geisdman	Jefferson Bks.	48	6	176	106	142	44
Fred Ehlers	Jefferson Bks.	49	5	74	114	104	46
O. Tutenhaupt	Jefferson Bks.	50*	5	192	184	240	216
T. A. Gerhardt	E. Matte	51	2	30	76	100	40
Chas. Ollein	Ferguson	52	3	94	106	112	54
Average			4.25	131	148	162	105

*These farms depend on the electric range for all cooking, winter and summer.

REFRIGERATORS

Electric refrigeration for the farm is clean and convenient, and in many cases saves foodstuffs from spoiling. It is difficult to analyze the cost and savings in household refrigeration. It is sufficient to say that

Fig. 19.—An electric refrigerator placed in the kitchen saves many steps on Farm 34. For the hottest month in 1928 it cost $1.93 (3c a KwH) to operate the refrigerator.

despite the high first cost of electric refrigerators, every housewife is looking forward to owning one some day. The cost of operation will probably not be higher in any case than the cost of ice.

In selecting a refrigerator for domestic farm use, it should be remembered that the cost of operation does not increase directly with the inside volume of the box. Often times it is desired to store such farm products as sweet cream and fresh meat or vegetables ready for market. These possible uses should be a consideration in determining the size of box to buy. Experience in field and laboratory tests has shown that the insulation of a refrigerator box and its location with respect to hot or cold parts of the house ordinarily have more to do with the amount of energy it consumed than any other factors in its operation. Probably the best place for a farm refrigerator is in a cool pantry or small room connected with the kitchen. Here it will be free from kitchen heat and yet will be easily accessible in either winter or summer months.

Table 12 shows the energy consumption of several farm domestic refrigerators. Where this type of refrigerator is operated for twelve months of the year, the annual consumption should not be over 600 kilowatt-hours for average Missouri farms.

TABLE 12.—ENERGY USED BY ELECTRIC HOUSEHOLD REFRIGERATORS

Farm No.	No. of persons	Location of box	Inside* volume	Length of test; from............to	Energy Used per Month KwH Max.	Min.	Avg.
9	6	pantry	9.1	12—19—27 — 12—17—28	105	20	52
34	5	kitchen	7.5	4— 2—28 — 12— 3—28	64	40	49
11	4	pantry	6.7	5—23—28 — 12—27—28	67	33	55
13	3	porch	9.2	5—23—28 — 12—27—28	68	36	54
14	3	pantry	6.7	5—23—28 — 12—23—28	63	16	37
22	6	porch	18.2	6— 1—28 — 12— 1—28	64	20	48

*Total inside volume including cooling chamber.

SPRAY MACHINES

Paint spray machines are replacing brushes on many different kinds of work. One operator with the machine shown in Fig. 21 can paint as much flat surface in a day as four men using brushes. Windows in buildings have to be covered as a protection from the spray of paint. The machines can be equipped with other nozzles for spraying disinfectants and other liquid materials. The compressed air can also be used for tire and blower needs. Although the first cost of such a machine is high, its extended use might make it a very profitable piece of machinery for the larger farms or a good partnership investment for small farms.

There are other spray machines on the market selling for $4.50 up, depending on their size. The smaller ones are attachments for vacuum cleaners. They are used for painting furniture and odd pieces in the home. For $50 a fairly good complete motor-driven small outfit can be purchased for inside painting and small jobs.

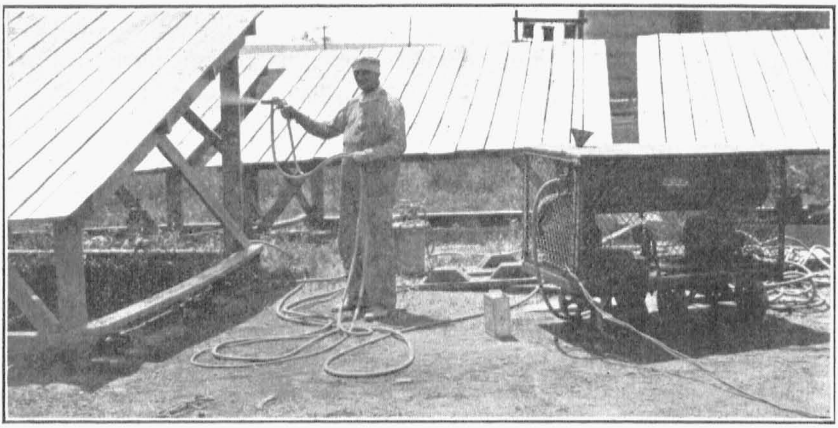

Fig. 20.—A spray paint machine in operation on the University Farm. An operator with this machine can paint as fast as four men can with brushes. At the right is shown the 3 H. P. air compressor unit. Behind the operator is the paint container.

WIRING FOR THE FARMSTEAD

The success of rural electrification both for the power company and the farmer is generally conceded to depend on quantity use of electricity on the farm. Farm wiring, therefore, is a very important consideration. Without adequate farm wiring, much of the possible work for electricity will be handicapped by low voltage conditions, makeshift wiring, and poorly controlled power; all of which might be dangerous as well as unsatisfactory. Good wiring for the farmstead implies safety and service —safety from fire risks and danger of bodily injury to men and animals; service in convenient location, adequate capacity, and sufficient number of outlets.

The transformer location is a primary consideration in securing an efficient system of distribution. It has much to do with the cost of wiring necessary to secure proper voltages at all points where electricity is to be used. Although the greatest energy consumption on the farm will probably be in the farm home, the greatest temporary demands for power will probably be at the barns or silos. For this reason the transformer location should be between the house and points where large motors are to be used.

The master meter location will be influenced by the location of the transformer. Locating the meter in a weather-proof box on the transformer pole has special advantages for running secondary wires to all parts of the farm load with a minimum of expense. If it is necessary to locate the meter elsewhere, there is no advantage of a central location for the transformer. In this case, back porches are desirable for meter and distribution panel locations. Haphazard arrangement of meters and service switches should be avoided. Ammonia fumes from manure and dust around barns make them undesirable for meter locations.

The distribution wiring of the farmstead should be based on a three-wire, single-phase system. For the house, 220-volt service should be supplied to the water heater and electric range. For other buildings a 220-volt service should be supplied to motors of ½ H. P. and larger. For lighting and operating small appliances 110-volt service will be needed in all buildings. In anticipating the future farm demand, probably 60-ampere service should be specified for wiring the farm home. The future use of large farm motors requires that careful consideration be made of all outside wiring to farm buildings. The small additional cost of using a No. 6 or a No. 4 wire instead of smaller sizes could be classed as good insurance against having poor voltage conditions and making changes later.

The type of interior wiring to be used in each farm building depends on the use to which that building is put. Knob and tube wiring should not be considered unsafe in farm buildings as a whole; however, knob and tube wiring is subject to mechanical injury which armored cable is not, and the cost of the completed cable job will not be more than 25 to 50 per cent greater than the knob and tube work. Switches and fuses should be enclosed in weather-proof boxes.* If farm wiring is not being done by the power company supplying service, a competent contractor should be employed for the job. His work should be supervised and inspected by the power company before service connections are made.

WOOD SAWS

Wood saws can be operated by a 3 H. P. motor if care is taken in sawing sticks larger than 6 inches in diameter. A 5 H. P. motor is large enough for most any requirements of wood sawing and can be operated on such work with satisfaction because of its overload capacity. The season's sawing on Farm 11 was done with a 5 H. P. motor belted to a 26-inch diameter saw. No difficulty was experienced except that a few pieces had to be turned because the saw would not reach through them. Ten kilowatt-hours of energy were used in 3 hours time of sawing.

*Regulations of the National Board of Fire Underwriters.

WASHING MACHINES

The importance of the electric washing machine as a labor-saver in the farm home is demonstrated by the fact that nearly every farm has one. The difference in the amount of energy required to operate different types of machines is of small importance. In selecting a washing machine the following are the most important factors to consider: the labor re-

Fig. 21.—An electric washing machine saves much hard work on Farm 23.

TABLE 13.—TIME REQUIRED FOR OPERATING WASHING MACHINES

Farm No.	No. in family	Lbs. of clothes	Time required per washing	No. of tubfulls	Avg. KwH used per month	Type washer
7	7	35.0	2 hr. 5 min.	7	2.1	single-tub dolley
11	4	30.1	1 hr. 10 min.	6	---	single-tub dolley
22	8	56.0	2 hr. 5 min.	6	2.2	single-tub dolley
32	8	29.7	2 hr. 7 min.	7	---	single-tub dolley
51	4	40.5	2 hr. 45 min.	9	---	single-tub dolley
23	8	53.0	2 hr. 0 min.	9	3.0	double-tub dolley
8	9	48.0	3 hr. 0 min.	7	---	cylinder
9	5	34.5	2 hr. 8 min.	6	---	single-tub rocker type

quired to operate them, their durability, their first cost, their wear and tear on clothes, and the quality of work done. Probably the cost of operating most washing machines is not over 2½c an hour when electricity is selling at 10c a kilowatt-hour.

IRONS

For the capital invested, probably the electric iron has the greatest service for the buyer of labor-saving equipment. Irons with built-in temperature controls are desired by some farm women. With electricity at 10c a kilowatt-hour the cost of operating an iron is approximately 5c an hour.

WATER HEATERS

Electric water heaters are gaining in popularity in Missouri farm homes and dairies because of their convenience. At the present time the cost of operating electric heaters is probably higher than many farmers can afford to pay for such service, but as larger quantities of electricity are used on the farm the unit cost will probably be reduced so that the cost of operating heaters will be more nearly equalled by the value of the service rendered. Already a few farm homes are using electric water heaters in connection with electric ranges during the summer months. In dairies where water is heated for washing utensils and equipment, electric heaters are convenient and fast.

TABLE 14.—COST STUDIES ON HEATING WATER FOR WASHING DAIRY EQUIPMENT

Farm No.	No. cows milked	Type of heater used	Daily washing to be done	Heat energy used per month av.
10	25	3 Kw immersion heater*	322 bottles, 7 pails and cans, separator parts, 1 double-unit milker	142 KwH at 4c--------------$5.68
8	20	Coal heater and gasoline fire pot	175 bottles, 14 pails and cans, 1 cooler, 0 single-unit milkers	128 lbs. coal at .3c-------------$0.38 6.3 gal. gas at 18c-------------$1.13 Total-----------$1.51
20	27	10-gal. storage type heater, 1250 watt	8 pails and cans, 2 double-unit milkers	72 KwH at 4c---$2.88
39	50	3 Kw immersion heater*	312 bottles, 6 pails, cooler, 8 10-gallon cans, 4 single-unit milkers.	454 KwH at 3c-$13.62

*Used in built-up rectangular galvanized iron tubs.

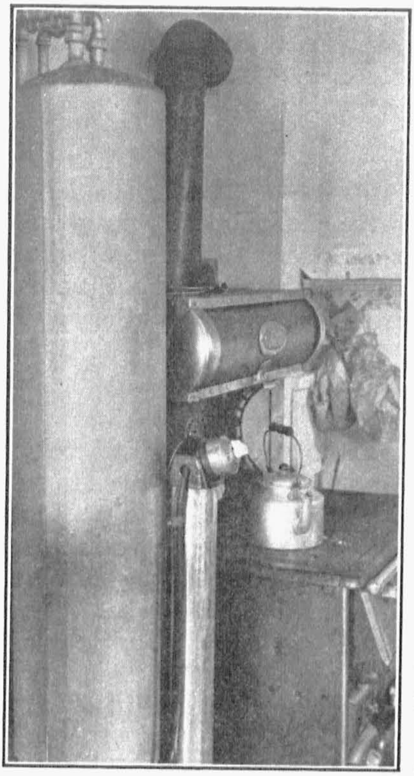

Fig. 22.—A circulating type electric water heater used on Farm 11. Normally, a hot water front in the stove heats the water in the tank. The elctric heater is used in connection with an electric range during summer months and for emergencies or convenience during other months.

On Farm 11 an electric heater is connected to the hot water tank which ordinarily is heated by the coal range. During the summer months, when an electric range is used for all cooking purposes, the electric water heater is used. The heater was installed August 15, and during the next two months it averaged 143 kilowatt-hours a month, with a maximum of 158 kilowatt-hours in October. This heater is shown in Figure 22.

On Farms 10 and 39 electric immersion heaters are used to heat the dairy wash water. These heater units have three different heats for controlling the temperature of the water. The tubs are built of galvanized iron. The one on Farm 10 is 16 x 22 inches by 11 inches high. The one on Farm 39 is 17 x 20 inches and 10 inches high. Both heaters are giving very satisfactory service. Figure 22 shows the heater used on Farm 39. Table 14 gives cost studies on operating these heaters.

WATER PUMPS

The first consideration for the farm with electric service should be an adequate water system. In planning a water distribution system for the farm the completed work should be kept in mind, but it is not necessary to wait indefinitely to install the most needed units. To begin with, a kitchen sink and drain can be installed and water piped to it under pressure. That is the most important unit. It carries fresh water in and the waste water out without spending the energy of the housewife. From there the system can be added to; an extra line for hot water, a shower in the basement, inside lavatories, and finally the completed bathroom with fixtures, and a septic tank.

In many cases the farmer can install the first units of his water system by himself. He can get information from the Missouri College of Agriculture on how to lay out his system and protect it from freezing.

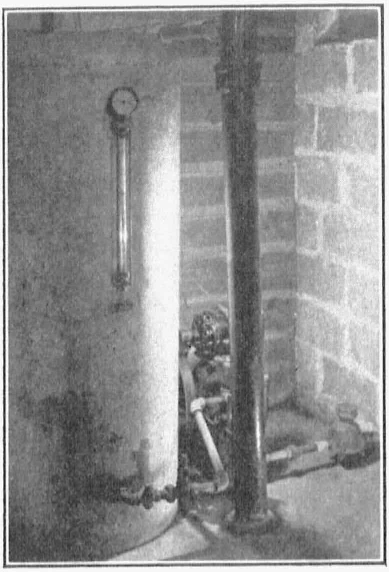

Fig. 23.—An automatic water system used on Farm 7. A ¼ H. P. motor drives the pump. The soil pipe from the bath room above obstructs the view of the pump and automatic switch. Notice the water meter at the right used for measuring the quantity of water pumped.

TABLE 15.—ENERGY USED FOR PUMPING WATER FOR HOUSEHOLD PURPOSES

Farm No.	No. in family	Gallons of water used per month			Kilowatt-hours used	
		Max.	Min.	Average	Average per month	Per 1000 gal.
15	9	3051	2041	2200	3.1	1.4
7	4	1497	1120	1285	1.3	1.0

Note: In each case water was pumped from a cistern into an air pressure tank. by a ¼ H. P. motor operating a reciprocating pump. The water was stored under 20 to 40 pounds pressure. The system on Farm 15 had worn parts which caused it to operate more frequently than should be necessary for efficient operation.

TABLE 16.—ENERGY USED IN PUMPING WATER FOR GENERAL FARM USE

Farm No.	Total water lift. ft.	Size motor used H. P.	Gallons of water pumped		Kilowatt-hours used	
			per hour	per month (estimated)	Avg. per month	per 1000 gal.†
7	90	2	250	4530	13.6	3.0
11	65	1	240	4630*	11.8	2.5
24	30	1	337	4370	9.7	2.2

*Electric motor is used as stand-by to wind mill.

†Calculated from short test of 2 to 5 minutes duration.

Note. The pump on Farm 7 is operated by a 2 H. P. motor (which is larger than necessary) through a line shaft and pump jack. Water is pumped into open water tanks on the farm.

The pump on Farm 11 is operated by a 1 H. P. motor through pump jack. Water is pumped to open tanks for cattle and by a manipulation of valves pumps to a pressure tank at the house.

The pump on Farm 24 is operated by a 1 H. P. motor through a pump jack and pumps to open tank only.

SUMMARY

The cost of electricity for the farm is dependent, first, on the cost of operating and maintaining electric lines to the farm, and second, on the cost of generating electricity and delivering it to the farm over farm lines. It is evident that the first cost remains about the same regardless of the quantity of electricity which is used. Therefore no matter what the basis of charge is, the cost per kilowatt-hour of electricity delivered to the farm decreases with the quantity used. This fact is recognized and allowance is made in most rural rates to compensate for the decreased cost per kilowatt-hour when large quantities of energy are used. Referring to Figure 27, the charge for the first 35 kilowatt-hours used per month (according to this rate) is $4.55, the charge for the next 35 kilowatt-hours used per month is $1.75, and the charge for the next 130 kilowatt-hours used per month is only $3.39, making a total of 200 kilowatt-hours for $9.69.

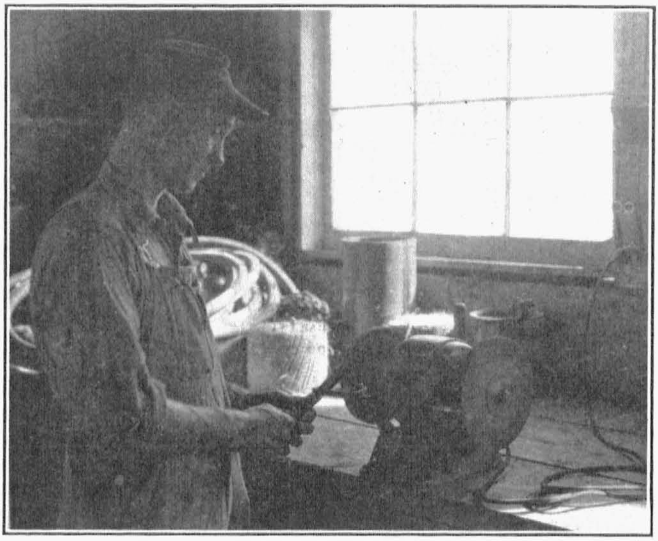

Fig. 24.—Grinding tools in the farm shop of Farm 35. The motor is ½ H. P.

The above mentioned farm rate is used by one of the companies serving farmers in Missouri. Assuming that a typical farm is being served by that company, what will the probable cost be if there are five in family, the home modern, water is pumped for all purposes, and 15 dairy cows are fed and milked, in addition to a general farming business? The following table gives estimated amounts of energy that would be reasonable to expect would be used, if rather complete use should be made of electricity. The various items are added in the order an average farm would probably add them.

TABLE 17.—COST OF ELECTRICITY FOR A REASONABLE FARM ELECTRIC LOAD, WHEN FIGURED ACCORDING TO A TYPICAL RURAL RATE USED IN MISSOURI.

(Aside from domestic use with 5 in family, it is assumed that 15 dairy cows are fed and milked on the farm.)

Lighting the house and barns	25 kilowatt-hours—	$3.25
Operating the radio, sweeper, etc.	10 kilowatt-hours—	1.30
Pumping water for general use	8 kilowatt-hours—	0.40
Operating the washer and iron	6 kilowatt-hours—	0.30
Grinding feed for the cows	12 kilowatt-hours—	0.60
Operating the milking machine	45 kilowatt-hours—	1.53
Operating the refrigerator	50 kilowatt-hours—	1.50
Cooking with electricity	150 kilowatt-hours—	4.50
Total electricity used per month	306 kilowatt-hours—	$13.38

READING YOUR OWN METER

It is interesting to be able to check the readings on your own electric service meter and to be able to calculate the load which is going through the meter at any one time. A very small amount of energy is used in driving the meter disk which can be seen through a glass near the top of the meter. For every revolution which this disk makes, a certain quantity of energy has gone through the meter. This quantity is known as the *meter constant* and the local electric company can tell you what it is. The rate at which this meter turns is the indication of the load that is going through it.

For instance, a 3 H. P. motor is being operated on a feed grinder and you desire to check the rate at which energy is being used. Assuming that the service meter has a disk constant of 3.0, and that by counting you find that it turns 15 revolutions per minute; then multiplying 3.0 (the disk constant) by 15 (revolutions per minute) by 60 (minutes in an hour) you find that energy is being used at the rate of 2700 watt-hours per hour, or simply the motor is drawing 2.7 kilowatts. It is unsafe to operate motors drawing appreciably more than 1000 watts per rated horse power for long periods of time, so this simple calculation might help in determining the safe load for farm motors. Since the 3 H. P. motor in the above case is using 2700 watts it is not quite fully loaded.

The meter disk is connected through a worm gear to the set of dial hands which are on the face of the meter. Beginning with the dial on the right each consecutive dial hand on the left is connected with a gear ratio of 10 to 1, so that the right hand goes around 10 times to make the one next to it turn around once.

The reading of the meter represents the number of kilowatt-hours of electricity which have gone through the meter. Figure 25 shows a set of meter dials which read 1375. Figure 26 represents the same set of dials one month later, and now the meter reads 1519. The difference between these two readings is 144 indicating that 144 kilowatt-hours have been used through the meter that month. Note that because the set of dial hands are all connected through gears and driven from the right that a number on the dial is not read until the hand is on it or has passed over it. In the case of the 19 on the last reading, it will not be 20 until the right hand has come directly over the naught.

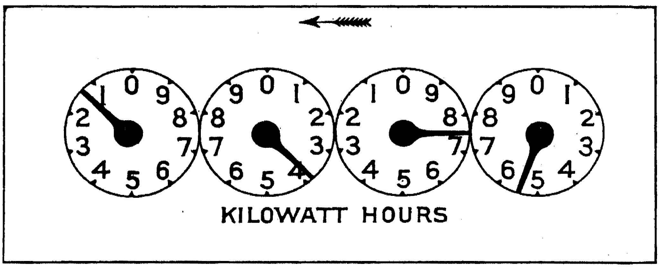

Fig. 25.—This meter reads 1375 kilowatt-hours.

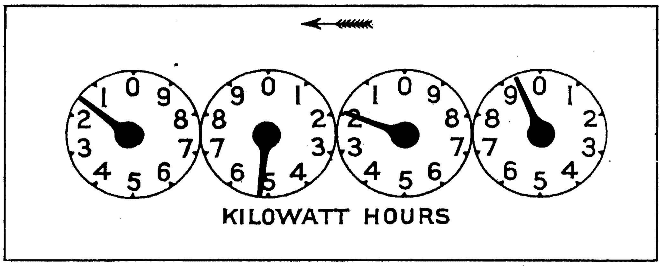

Fig. 26.—This meter reads 1519 kilowatt-hours.

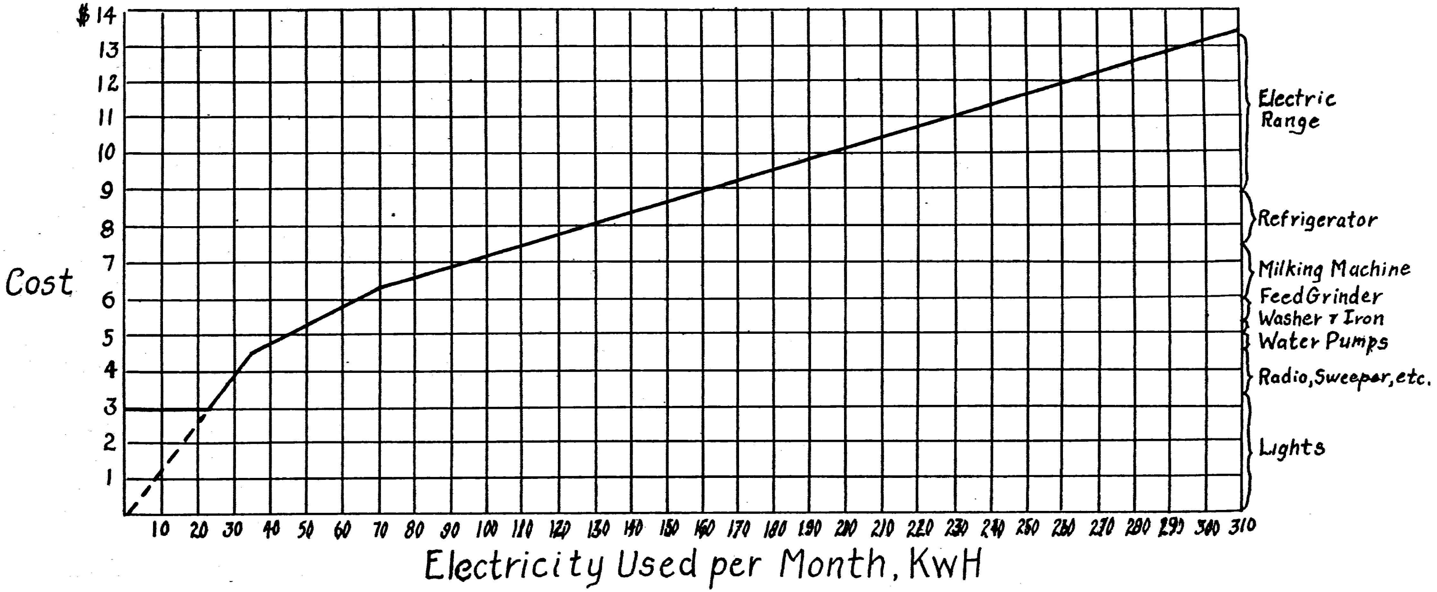

Fig. 27.—Cost of electricity for a reasonable farm electric load, when figured according to a typical rural rate used in Missouri. Besides domestic use with five in family, it is assumed that fifteen dairy cows are milked and fed on the farm.