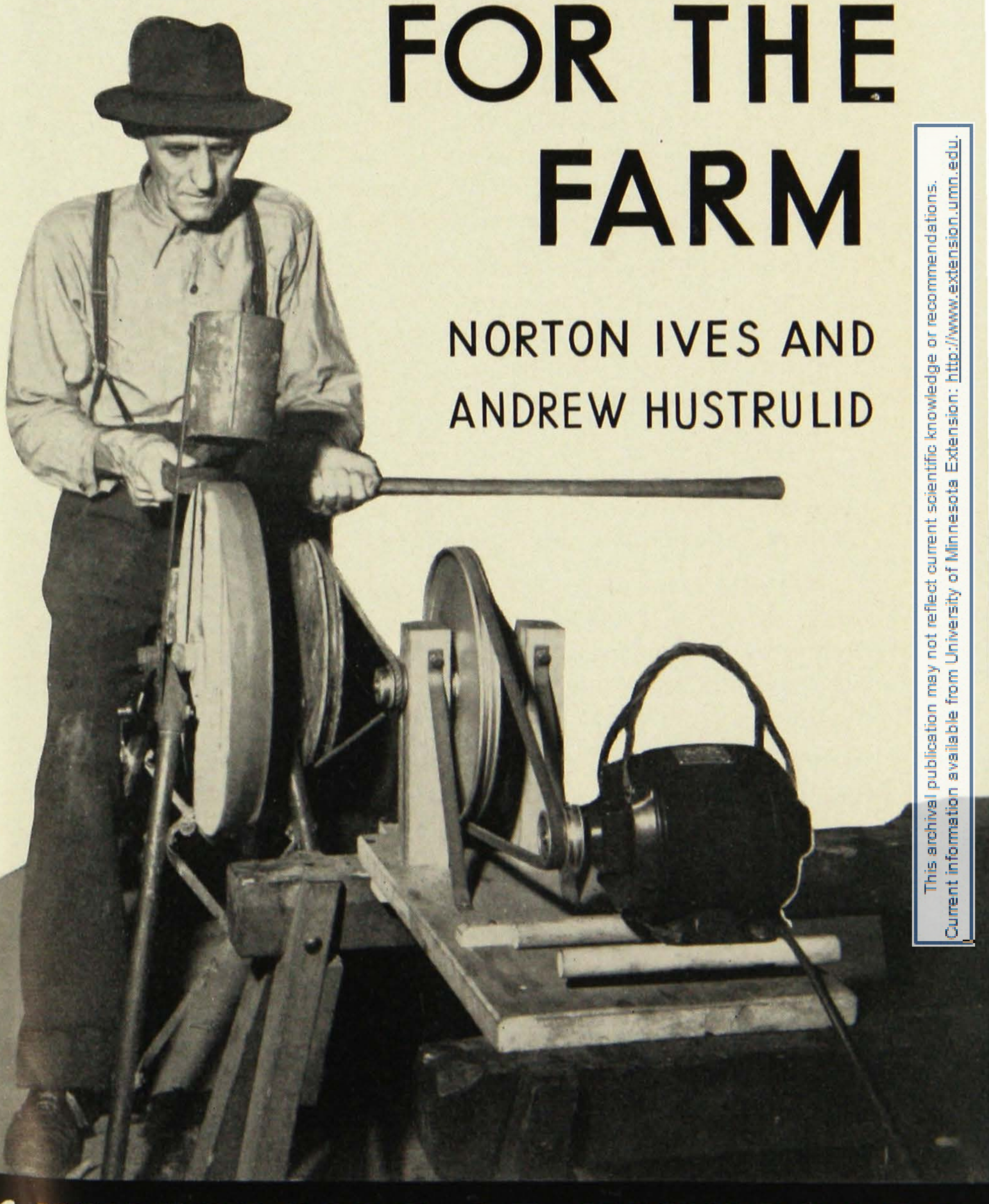
Electric Motors FOR THE FARM



NORTON IVES AND
ANDREW HUSTRULID

UNIVERSITY OF MINNESOTA
Agricultural Extension Service
U. S. DEPARTMENT OF AGRICULTURE

Make Electricity Serve You

RURAL electrification has brought to the farm a new type of energy which can serve the modern farmer with light, power, and heat. While most farmers use electricity for light, and for power for small household appliances, they overlook many larger jobs that electrical power could do for them cheaply and efficiently.

Rural electrification has been quite aptly defined as "Electricity at work on farms." One kilowatt-hour of electricity, by furnishing power for a motor, can do more work than any man can perform in a ten-hour day! The human muscle cannot compete with electricity as a source of power.

Electricity saves time and labor. It can relieve farmers of such work as pumping and carrying water, milking, separating, and grinding feed. It can be one of the most dependable and handy sources of power ever made available to the farmer.

Not only is electricity a good source of power for jobs formerly done by hand, but it is also practical and economical for larger belt jobs. Moreover, using electricity for productive purposes pays for itself and helps pay the cost of electricity for lights and small household appliances.

Two portable motors—one small, the other large—can operate practically all farm machines that do not have a permanently attached motor. Ordinary motors can be made portable right on the farm, and with proper care and protection, they will last from 20 to 30 years.

Make electricity serve you! Electrical power, properly used, will more than pay for itself. It will make your work easier and it will furnish you and your family with many modern conveniences.

Electric Motors for the Farm

Norton Ives and Andrew Hustrulid

RURAL ELECTRIFICATION has brought to the farm a new type of energy which can serve the farmer with light, heat, and power. Many farmers, however, have failed to take full advantage of the possibilities of electrical power because they have not appreciated the wide range of jobs that electricity can perform cheaply and conveniently. The average rural user still looks upon electricity mainly as a source of light, with some consideration as a source of heat and power for household appliances such as the flatiron, washing machine, vacuum cleaner, and refrigerator.

The purpose of this bulletin is: (1) to show that electricity can be an economical and practical source of farm power; (2) to aid in the selection of electric motors for farm jobs; and (3) to describe how electric motors can be made portable for greater convenience.

Electricity Can Produce Work

Electricity is measured by kilowatt-hours just as wheat is measured by the bushel or gasoline by the gallon. The average consumer, however, has little conception of what he is getting when he buys a kilowatt-hour of electricity until the kilowatt-hour is measured in terms of the work it can do. No matter how hard a man works in a 10-hour day he cannot equal the amount of work that can be done by one kilowatt-hour of electricity. The human muscle is a puny form of power, yet how much work that electricity could do satisfactorily and cheaply is still done by hand! Adapt the electric motor for these jobs on the farm.

Electric Power Is Not Expensive

Using electricity for power on the farm is not expensive. A list of farm jobs that one kilowatt-hour of electricity (ordinarily costing less than five cents) can perform when properly used to run good machines is given on page 5.

To estimate the energy cost per hour to run an electric motor operating at full load, use the following simple rule: Multiply the horsepower of the electric motor by the rate per kilowatt-hour. Roughly a kilowatt-hour will produce a horsepower for an hour or a horsepower-hour of work. For example, if electricity costs four cents per kilowatt-hour, the cost of operating a 3 horsepower motor running at **full load** will be approximately:

H. P. x cost per kw.-hr. = cost per hour
3 x 4¢ = 12¢ per hour

Under most rate schedules, the average rate per kilowatt-hour decreases as more and more electricity is used.

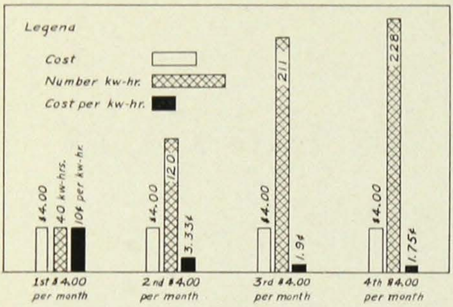


FIG. 1. THE THIRD "MINIMUM BILL" BUYS OVER FIVE TIMES AS MUCH ELECTRICITY AS THE FIRST "MINIMUM BILL"

Naturally when electricity is used for power on a farm, there is a large increase in the monthly consumption. However, as shown in figure 1, which is plotted according to an average farm rate schedule, the cost of this increase is less than might be expected. For instance, figure 1 shows that an additional 120 kilowatt-hours per month added to the first 40, which are usually used for lights and a few household appliances, can be purchased at only double the "minimum bill." An additional 211 kilowatt-hours per month can be secured for the next $4.00.

Furthermore, using this additional amount of electric energy for power and other productive purposes will help increase the farm income and thus help pay for the cost of electricity.

Advantages of Electric Motors

Perhaps the outstanding advantages of an electric motor are its long life and its dependability. There are only two bearings and two or three other moving parts, and even these are subjected to only light wear. With proper lubrication and a clean, dry operating location, a good electric motor should last from 20 to 30 years if it is protected against overheating. During this long life, there is very little servicing, no fuel to carry, no tanks to fill, no oil to be changed, and no radiators or water jackets to freeze.

An electric motor is easy to start, both in summer and winter (often automatically), and it is free from noise, dust, and poisonous fumes. Its direction of rotation can be changed, and it has a high overload capacity for short periods of time.

Electric motors are easily made portable because they are light in comparison to the power they develop. The outstanding disadvantage of electric motors on a farm is that they must always be connected to the source of power by copper conductors.

FIG. 2. GRINDING FEED AND PUMPING WATER ARE ONLY TWO OF THE MANY EVERYDAY JOBS ELECTRICITY CAN DO FOR THE FARMER

What One Kilowatt-hour of Electricity Can Do

1. Perform one large weekly washing
2. Run a household refrigerator one day
3. Run a sewing machine for two months
4. Ventilate a 25-cow dairy barn for one-half day
5. Milk 20 cows
6. Separate 2,000 pounds of milk
7. Cool 10 gallons of milk for one day
8. Pump and force 750 gallons of water under pressure to any faucet on the farmstead
9. Grind 60 to 300 pounds of grain
10. Hoist two tons of hay
11. Cut and elevate one ton of ensilage
12. Saw one-half cord of wood
13. Shell 20 bushels of corn
14. Mix two cubic yards of concrete
15. Clean and grade 100 bushels of grain
16. Paint 700 square feet of surface with a pressure sprayer
17. Run a one-fourth horsepower motor at full load for three hours
18. Run a three horsepower general utility motor at full load for 20 minutes

What Electric Motors Can Do

Machines, tools, and household appliances requiring stationary power units may be roughly classified into two groups. The first consists of machines which should have electric motors permanently attached to them for the convenience offered by automatic operation or frequent use. The second group consists of machines and tools which are periodically or seasonally operated, making it too expensive or impractical to connect the motor permanently to the machine. The ease with which electric motors may be made portable makes it possible to do the many farm jobs falling into the second group with little sacrifice in convenience. Table 1 gives a representative list of the farm and home jobs that electric motors can perform, the type and size of motor most commonly used, and the amount of electricity required per unit of work.

Size and Type of Motor and Equipment

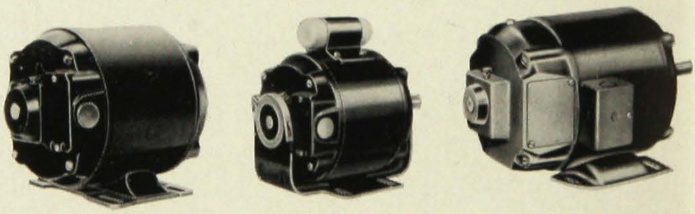
Type of Motor

To many people a motor is just a motor, but there are many different types of electric motors. If the wrong type is chosen for a certain job, the results probably will be unsatisfactory and the motor itself may be injured. Most farms obtaining electricity from the highline have single-phase, 60 cycle alternating current.

The fundamental types of single-phase electric motors are the split-phase, capacitor, and repulsion-induction motors. Other types are slight variations from these three main types. The primary difference between these different motors is their starting windings, for all three are induction type motors when running at full speed.

Split-phase.—The starting winding in the split-phase motor is quite simple in construction, making it the least expensive single-phase motor. However, because of this type of starting winding, the motor has a small starting torque (force) and a high starting current. That is, the current flowing through the windings of the motor is sometimes four to eight times greater when the motor is starting than when running at full load and rated speed. Therefore, this motor is used for appliances that start easily and is usually available in sizes from 1/60 to 1/3 horsepower.

Capacitor.—The capacitor starting type motor has a condenser in the starting winding, and the starting current is only about four times or less the



	SPLIT-PHASE	CAPACITOR	REPULSION-INDUCTION
Cost	Low	Medium	High
Construction	No brushes	No brushes Has condenser	Brushes
Size most used	1/20–1/4	1/6–3/4 Larger ones coming on the market	1/6–10
Starting ability	Low and medium	Medium and high	High
Use	Jobs with low starting force: fans, washing machines, grindstones, etc.	Good starting torque; refrigerators, pumps, and cream separators, etc.	For starting heavy load and for large power requirements. The WORK HORSE of electric motors.

Fig. 3. Outstanding Characteristics of the Three Principal Types of Single-phase Motors

Table 1. Type and Size of Motors Needed for Farm Work and Amount of Electricity Used

Machine	Size of Motor — Horsepower	Type of Motor Commonly Used*	Amount of Electricity Used — Kilowatt-Hours
Permanently Attached Motor:			
Barn ventilator	⅛ to ½	S.P. or C.	2 to 3 per cow per month
Cream separator	⅛ to ¼	C.	½ per 1000 lbs. of milk
Milk cooler	¼ to 3	C. or R.I.	25 to 30 per month at 10 gallons per day
Milking machine	¼ to 3	C. or R.I.	1½ to 3 per cow per month
Refrigerator (household)	1/6 to ¼	C.	20 to 40 per month
Vacuum cleaner	1/10 to ⅛	Special	3 per year
Washing machine	¼	S.P.	⅓ per person per month
Water system (shallow)	¼ to ½	C.	1 to 2 per 1000 gallons
Water system (deep well)	½ to 2	C. or R.I.	1 to 3 per 1000 gallons
Small Portable Motor:			
Concrete mixer	¼ to ½	S.P. or C.	½ per cu. yd. of concrete
Corn sheller, one or two holes	¼ to ½	S.P. or C.	1 per 300 lbs. of shelled corn
Drill press	⅛ to ½	S.P. or C.	1 per 2 to 8 hours used
Emery wheel	¼	S.P.	1 per 4 hours used
Grain cleaner	¼ to ½	S.P. or C.	⅔ to 1¾ per 100 bushels
Lathe	¼ to ½	S.P. or C.	⅓ to ½ per hour
Meat grinder	⅛ to ¼	C.	1 per 250 pounds of meat
Paint sprayer	¼ to 2	C. or R.I.	1 per 700 square feet
Potato grader	½	C.	1 per 300 to 500 bushels
Pump jack	¼ to ½	C.	1 to 5 per 1000 gallons
Large Portable Motor:			
Corn husker and shredder	5 to 7½	R.I.	5 per ton
Ensilage cutter or hay chopper	5 to 7½	R.I.	1 to 3 per ton
Feed grinder	½ to 7½	C. or R.I.	1/5 to 1¼ per 100 pounds of feed
Cylinder corn sheller	3 to 7½	C. or R.I.	1 per 15 to 25 bushels
Grain elevator (installed)	½ to 3	C. or R.I.	1 to 4 per 1000 bushels
Grain elevator (portable)	3 to 7½	C. or R.I.	2 to 7 per 1000 bushels
Hay baler	5 to 7½	R.I.	2 to 4 per ton
Hay hoist	3 to 5	C. or R.I.	1 per 7 to 10 tons
Irrigation	3 to 30	C. or R.I. or 3-phase	2 to 4 per acre foot per foot lift
Circular wood saw	3 to 7½	R.I.	1 to 2½ per cord

* Abbreviations: S.P., Split-phase; C., Capacitor; and R.I., Repulsion-Induction.

current at full load and rated speed. The starting force of this motor is one and one-half to two times that of a split-phase motor.

Until recently most capacitor motors were sold only in sizes less than one horsepower. However, new developments in the construction of the condensers permit these motors to be practical in sizes as high as 5 or 7½ horsepower, and consequently larger motors are being placed on the market.

Neither split-phase nor capacitor starting types of motors have brushes, so neither type should interfere with radio reception.

Repulsion-Induction.—The repulsion-start induction motor has a wound rotor with commutator and brushes. When the motor is near three-fourths full speed, the commutator bars are short-circuited and the brushes may or may not be lifted. This type of motor develops a high starting force which is from four to five times the force it develops at full load, or two to three times that of a split-phase motor. It also has a low starting current from two to three times the full load current and has a considerable overload capacity. Because it can start heavy frictional loads or machines already under load and can develop the greatest overload capacity, the repulsion-induction motor has been the most popular general purpose farm motor in sizes one horsepower and over.

Size of Motor

Size is the first consideration in choosing an electric motor. Many of the farm and home appliances are purchased already equipped with the proper size and type of motor permanently attached. However, for the newly electrified farms there invariably arises the problem of displacing a gasoline engine with the proper size and type of electric motor. Table 1 gives the size of motor most commonly used for many farm jobs.

The manufacturers' recommendations should be followed when available as to power and speed required. Since horsepower is merely a standardized unit of measure of power, an electric motor and a gasoline engine of the same horsepower will develop the same amount of power at a full load. However, gas engines have little overload capacity, and so it may be possible under certain conditions to replace, for example, a 10 horsepower gas engine with a 7½ horsepower electric motor. The power needed by the machine at its rated capacity may have been 7½ horsepower, but to take care of the probable overloading of the machine, a larger gas engine was required. A 7½ horsepower repulsion-induction electric motor can develop 10 horsepower and more for very short intervals and still maintain 90 per cent of its rated speed. This characteristic, along with the fact that an electric motor loses neither power nor efficiency with age, usually makes it possible to replace a gasoline engine with an electric motor of a smaller power rating. This does not mean to infer any miraculous power-giving characteristics of electric motors. The motor of the correct size should always be chosen. Too small a motor will be overloaded and may burn out, while too large a motor will mean unnecessary expense.

Often the question arises whether or not the present power shaft line should be maintained by replacing the old gas engine with an electric motor large enough to run all the machines. It is more convenient to have a separate motor for each machine if it is used frequently or if automatic operation is desirable. Some day these machines will be replaced with new ones already equipped with a motor. For these reasons it is usually undesirable to main-

Table 2. Efficiency of a 5 Horsepower Motor Running at Less Than Full Load

Load	Input* Watts	Efficiency Per Cent
Full	4700	79
Three-quarters	3680	76
One-half	2590	72

* See footnote in table 3 for explanation of input.

tain the line shaft. However, operating a large motor at three fourths or one half its rated load does not reduce its efficiency as much as might be expected, as is shown in table 2. Table 3 shows the efficiencies of small motors compared with large motors. The wattage inputs are given for the general purpose type of motors. Motors less than one horsepower vary greatly in efficiency according to the purpose for which they are designed.

A motor smaller than ½ horsepower should be operated with 110 volts; a motor between ½ and 1 horsepower may be operated with either 110 or 220; and motor of 1 horsepower and larger with 220 volts. Local regulations sometimes require 220-volt service for motors ½ horsepower and larger. When the voltage for a given motor is changed from 110 to 220 volts, the current required to furnish the same amount of power is reduced to one half, which means smaller lead wires may be used for installing a motor on 220 volts than on 110 volts. It is of utmost importance, especially for the larger motors, to have adequate wire size between the transformer and the motor to avoid excessive voltage or pressure drop and to protect against overheating the wire.

Size of Wire

Most companies specify that their motors will deliver their rated power without heating only when the voltage regulation does not exceed a plus or minus 5 per cent. This means that the voltage should not decrease or increase

Table 3. Input in Watts and Efficiency for 1750 R.P.M., 60-Cycle, Single-Phase General Purpose Electric Motors, and the Relation Between Volts, Amperes, Power Factor, Watts, and Horsepower for Electric Motors at Full or Rated Loads

Volts	Amperes	Power Factor Per Cent	Input* Watts	Output Horsepower	Efficiency† Per Cent	Approximate Cost New‡
			Split-Phase			
110	1.5	56	92.5	1/20	41	$ 9.00
110	2.2	50	121.0	1/12	51	9.00
110	2.4	59	156.0	1/8	60	8.00
110	2.6	69	197.0	1/6	63	8.00
110	3.4	75	280.0	1/4	67	8.00
			Capacitor			
110	2.5	62	170.0	1/8	55	10.00
110	3.0	60	198.0	1/6	63	10.00
110	3.6	60	238.0	1/5	63	10.50
110	4.0	66	290.0	1/4	64	11.00
110/220	5/2.5	67	368.0	1/3	67	17.00
110/220	7.2/3.6	69	546.0	1/2	68	22.00
110/220	10.4/5.2	70	801.0	3/4	70	29.00
			Repulsion-Induction			
110/220	11.6/5.8	81	1030.0	1	72	40.00
110/220	15.2/7.6	92	1540.0	1½	73	54.00
110/220	18.8/9.4	95	1965.0	2	76	71.00
110/220	27.8/13.9	94	2875.0	3	78	91.00
110/220	46/23	93	4700.0	5	79	143.00
220/440	35/17.5	93	7160.0	7½	78	207.00
220/440	45/22.5	93	9210.0	10	81	257.00

* For any single-phase electric motor volts x amperes x power factor equals wattage input.

† Efficiency $= \frac{\text{output}}{\text{input}}$. One horsepower is equivalent to 746 watts.

‡ Average retail prices without accessories. Individual prices for any type may vary considerably according to its efficiency and starting torque or force.

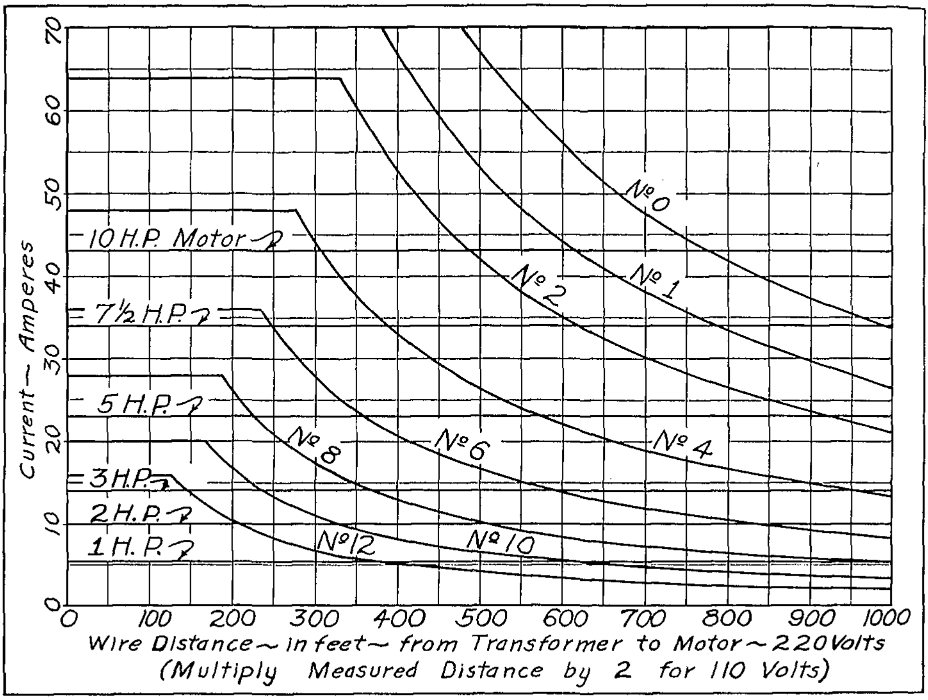


FIG. 4. CHECK FOR PROPER WIRE SIZE

Use this graph to check the size of motor that can be used with your present wiring system or the size of wire needed for a given motor. For further explanation see pages 10 and 11.

more than 5.5 volts for a 110-volt circuit, or more than 11 volts for a 220-volt circuit. If highlines are properly constructed and the transformer is the correct size (consult power company or cooperative concerning proper size of transformer), the proper voltage will exist at the transformer. However, by the time the current has flowed through a few hundred feet of wire, the pressure may be reduced considerably if the wire is too small.

Figure 4 shows the correct wire sizes to use under different conditions. It may be used either to check the size motor that can be used with the present wiring system or to find the size of wire necessary to provide (1) sufficient current carrying capacity to prevent overheating of wires and (2) proper voltage at the motor.

Current Carrying Capacity.—In figure 4, note that horizontal lines run completely across the chart for different size motors. The lines are plotted according to the amperes of current required to run these motors at 220 volts and full load. For 110 volts, the motors require twice the amperage indicated on the chart.

What size wires are needed to carry this required amperage to the motor? The other heavy lines, which run horizontally only a part of the way across the chart, are plotted for wire sizes 0, 1, 2, 4, 6, 8, 10, and 12 A. W. G. (American Wire Gauge). The intersection of these lines with the ampere scale on the left hand side gives recommended maximum carrying capacity of different size wires in rubber covered extension cord. For instance, the smallest size wire that could be used in any part of a circuit connecting the transformer to a 220 volt, 3 horsepower motor would be No. 12.

Voltage Regulation.—The wires must also be large enough to deliver the proper voltage at the motor. In the example above, the No. 12 wire could be used all the way only if the distance between the transformer and the 3 horsepower motor were 150 feet or less. If the distance were greater, the size of the wire in part of the circuit, at least, would have to increase. (The smaller the gauge number, the larger the wire.)

Suppose, for example, the distance between the transformer and the motor were 500 feet including 20 feet of extension cord between the motor and power outlet, 180 feet (measured along the path of the wire) between the power outlet and meter, and 300 feet between the meter and transformer. In figure 4 the point of intersection of the vertical line corresponding to 500 feet with the horizontal line corresponding to the 3 horsepower motor is between the No. 8 and No. 6 curves. This means that No. 8 wire is too small and No. 6 satisfactory when the motor alone is connected to this circuit. If the wire system is to run other large appliances simultaneously with the motor, the wire sizes and switches should be proportionately larger in that portion of the circuit through which the extra current will flow.

Thus, with a 3 horsepower motor operated on 220 volts, a No. 12 wire is the smallest size permissible in any part of the circuit, while the major portion of wire should be No. 6 or larger to take care of the voltage drop. This would mean for this installation that the 20 feet of extension cord would probably be No. 12, as larger sizes of moisture resistant rubber covered extension cord are much more expensive, while that portion of the circuit running to the meter would be No. 6, and that from the meter to transformer, No. 4.

Remember.—The smaller the gauge number the larger the wire; the larger the wire the less the resistance; the less the resistance the less the voltage drop. Finally, this voltage drop for electric motors should not exceed 5 per cent of the voltage stamped on the name plate of the motor.

Look at the Name Plate

When buying a new motor or when servicing or ordering parts for an old motor, always check the information on the name plate. All name plates give the following information, either directly or indirectly:

The manufacturer of the motor.

Type of motor.—Some motors have the type written directly on the name plate. Others have only the type letter, such as DK, FJ, or SCR. This makes it necessary to refer to the manufacturer's information before you can specifically determine the type unless you are well enough acquainted with motors to determine the type from its construction.

Serial number which should always be given in ordering repairs.

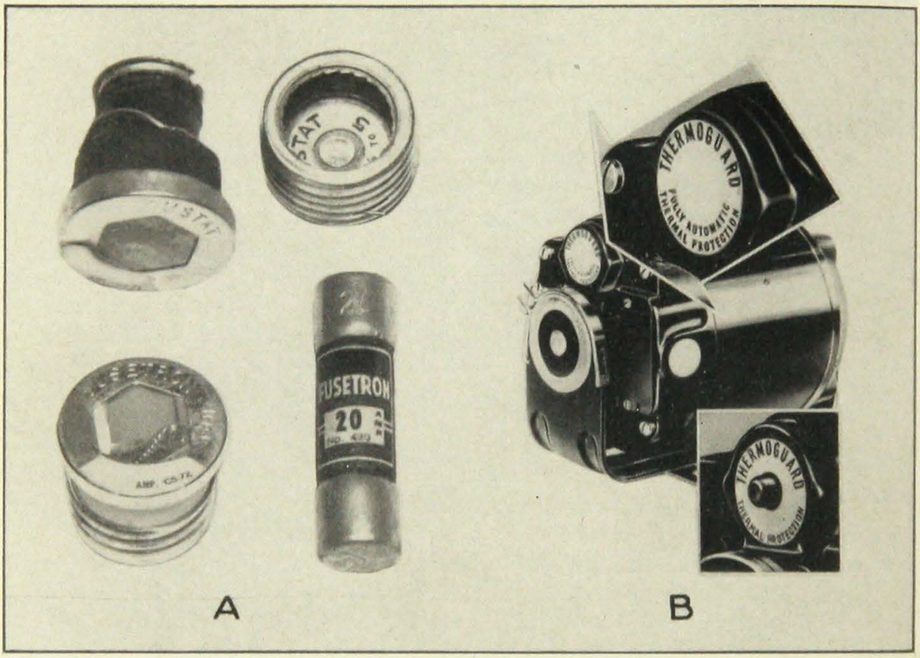


FIG. 5. PROTECTION DEVICES WILL PREVENT OVERHEATING
(A) Fusetrons and fusestats and (B) Thermal protection unit incorporated in the motor.

Phase.—(Single-, two-, or three-phase)—Most farms have single-phase circuits which require single-phase motors.

Cycle.—Most farm lines have 60-cycle alternating current which demands a 60-cycle alternating current motor.

Speed at F.L. (full load)—Constant speed motors may be secured with full load speeds of 3450, 1750, or 1160 revolutions per minute. However, the common speed of general purpose motors is between 1725 and 1800 R.P.M.

Volts.—Split-phase and capacitor-type motors are either 110-volt or 220-volt motors (there are some capacitor-type motors on the market which incorporate the dual-voltage feature) while the repulsion-induction motor may be connected to either voltage by the proper lead wire connections. A diagram is usually on the name plate to show these different connections which can easily be made.

Amp.—This abbreviation stands for amperes, or expresses the rate of current flow through the motor when it is operating at full load and proper voltage. Note on the name plate that any motor when operated on 220 volts uses only half as much current to deliver the same power as when operated on 110 volts.

H.P.—This stands for the horsepower which the motor is designed to deliver at full load under proper operating conditions such as correct voltage and speed.

Continuous 40° C.—A specification made by the manufacturer that the temperature of the motor winding will not rise higher than 40° C. or 72° F. above the surrounding air when the motor is operated at full load under normal conditions.

Direction of rotation.—A feature incorporated in most general purpose motors which makes possible either *clockwise* (CW) *or counter clockwise* (CCW) rotation of the motor. On split-phase or capacitor motors the connection diagram indicates the different connections for each direction of rotation. On repulsion-induction motors the direction of rotation is changed by removing the end cover of the motor (if there is one), loosening one or more of the clamping screws, and rotating the brush-holding frame 20 or more degrees as indicated by the marks on the brush-holder and frame.

Protection Against Overheating

One of the outstanding features of an electric motor is its simplicity and durability. Its useful life of operation, as far as mechanical features are concerned, is almost indefinite. However, there is one hazard to which even the best designed motor is vulnerable if it is not properly protected. Under certain conditions, an electric motor may become too hot, melting the insulation on the copper windings, which causes a short-circuit, and thus ruins the motor. In the case of a small motor, it is as cheap to buy a new motor as to pay for a rewind job, and for large motors rewinding is expensive. Therefore, some form of motor protection against excessive temperature is a wise investment.

Overheating is usually caused by excessive current flow resulting from one or a combination of the following conditions: (1) failure of the motor to start turning when the switch is turned on; (2) running at speeds below normal because of continuous overloading or **low voltage;** and (3) too frequent starting.

Improper ventilation caused by dust and dirt collecting in the vent opening in the motor frame or by too high a surrounding air temperature may also result in overheating. The manufacturer specifies that the motor temperature will not exceed 40° C. above the temperature of the surrounding air under normal operating conditions. However, these many adverse conditions to which a general purpose farm motor may be subjected make proper protection desirable. The devices on the market used to protect motors from excessive temperatures may be purchased as an integral part of the motor, may be added to the motor, or may be placed in that portion of the line through which only the current to the motor flows, usually at the starting switch. Some of these devices including the fusetron and fusestat are shown in figure 5.

Motors may be purchased at slight additional cost with a thermal protection unit incorporated in the motor.

If fusetrons or fusestats or other similar "plug-type" devices of the proper size (determined by the full-load amperage of the motor) are placed in a fuse box located somewhere in the motor circuit, they will provide adequate protection against overloading or low voltage. Like fuses they are cheap and must be replaced when blown.

The fusestat has an insert which once placed in the socket cannot be removed.

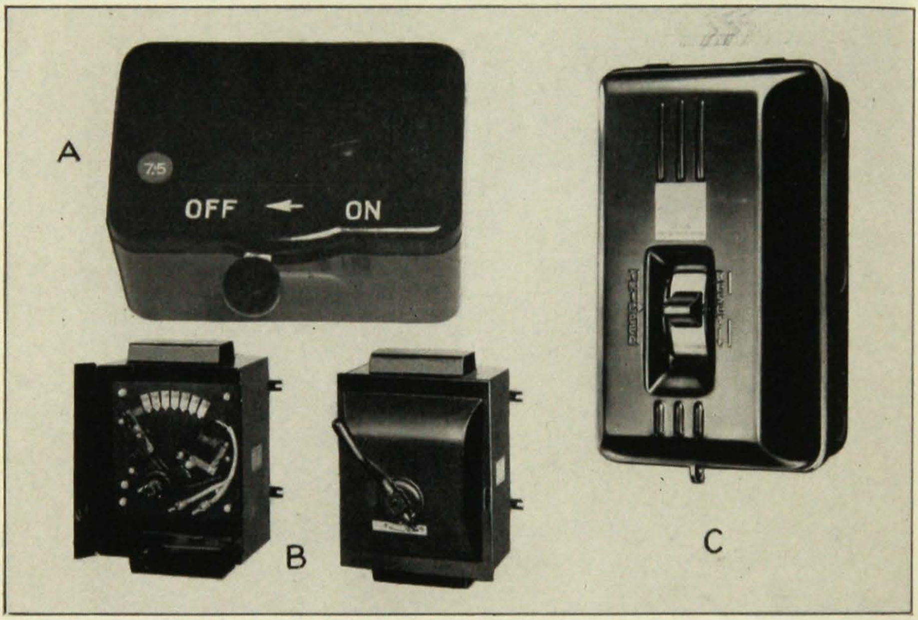


FIG. 6. PROPER CONTROLS PROTECT MOTOR

(A) Switch and thermal protection, (B) Resistance starter, and (C) Manual control and thermal protection.

When it is blown, it can be replaced only with another fusestat of the same size. A fusestat differs from a fuse in that it contains a small pot of solder which requires excessive current flow over a period of time to melt the solder and blow out. Therefore, these devices will carry the high starting current of a motor for a short time without blowing, and yet a small overload of the motor over a period of time will blow them, thus protecting the motor from overheating.

Ordinary fuses give virtually no protection against overheating because the current necessary to start motors may be from four to eight times the normal operating current at full load for a short time. Therefore, a fuse must be large enough to carry the largest starting current or it will blow every time the motor is started. However, if a fusetron or fusestat is not used in the fuse box a fuse of proper rating should be used to protect the circuit wires against overloading and shorts.

Motor Controls

Starting switches with thermal protection units may be purchased for motors up to one horsepower for $1.00 to $2.00. These small motor controls serve both as a switch and as protection against overheating. See figure 6—A.

For 1 to 3 horsepower motors, a larger motor control operating on the same principle as that described above should be used to serve both as a starting switch and protection device against excessive temperatures. The cost for these varies from about $7.00 for a 1 horsepower motor to $9.00 for a 3 horsepower motor. See figure 6—C.

For 1 to 7½ horsepower and even larger motors, a magnetic motor control which serves both as a starting switch and a thermal protection unit can be used. It may be operated by a pushbutton mounted on the switch-box or on an extension cord at any distance from the switch. In this type of a control the pushbutton operates an electromagnet in the large switch-box which in turn connects the motor directly across the line. The cost of this type of control varies from $15.00 for a 1 horsepower motor to about $35.00 for a 7½ horsepower motor.

For 7½ horsepower motors power companies and cooperatives often specify that a resistance starter (Fig. 6—B) must be used. The resistance starter limits the current flow into the motor while starting. This, in turn, prevents a heavy load from coming on the line suddenly as would occur with other types of switches all of which place the motor directly across the line. This switch has a low voltage release, but it offers no protection against excessive current flow. Therefore, some form of thermal protection should be provided. The approximate cost of a rheostat starter for a 7½ horsepower motor is $35.00.

Pulley Sizes

Most general purpose electric motors run at 1750 revolutions per minute, a speed much too fast for most farm machines or appliances. Consequently, cheap and practical devices for speed reduction are often necessary. For small motors a simple and economical speed reducer is shown in figure 7. For most larger motors, the proper speed is usually obtained by using the proper size of driver and driven (motor

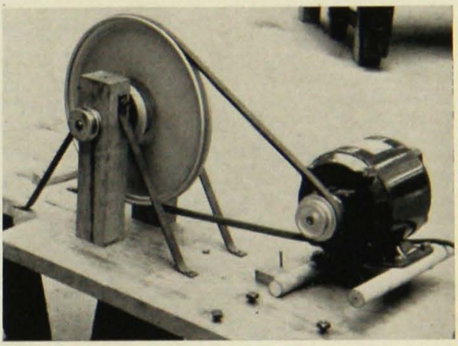


FIG. 7. A SIMPLE, INEXPENSIVE SPEED REDUCER

and machine) pulleys. A simple method to figure the proper pulley diameter is illustrated in figure 8.

Belts

Since electric motors operate at high speeds, light pliable belts should be used. V-type belts are most popular because they are light and pliable and will not slip off when the motor starts.

Table 4 may be used to determine the required number of V-type belts for any size motor and motor pulley. For example, a 3-inch pulley on a 3 horsepower motor would require three

Table 4. Horsepower a V-type Belt Can Transmit for Various Drive Pulley Diameters

Diameter of Motor or Drive Pulley	Horsepower Per Belt Motor Speed = 1750 R.P.M.	
Inches	Type A (1/2" x 11/32")	Type B (21/32" x 7/16")*
2	0.5	*
2½	0.7	*
3	0.9	*
3½	1.1	*
4	1.33	*
4½	1.43	*
5	1.63	*
5½	1.7	2.3
6	1.84	2.4
7	2.1	2.8
8	2.2	3.2

* Not recommended for pulleys smaller than 5.4 inches diameter.

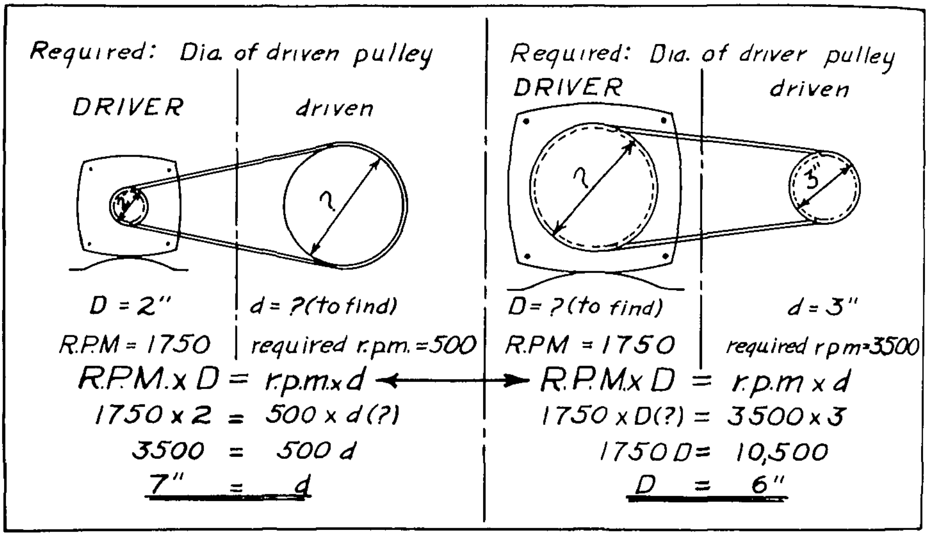


Fig. 8. Examples of Figuring Proper Pulley Diameter

DRIVER (D) refers to the electric motor, driven (d) to the machine being run, and R.P.M. or r.p.m. to revolutions per minute of DRIVER and driven, respectively.

type A belts; a 4½-inch pulley would require two type A belts; and a 7½-inch pulley would require one type B belt. Pulleys less than 3 inches in diameter should not be used for motors 1 horsepower and larger, and pulleys larger than 8 inches should not be used on 1750 R.P.M. motors or the belt speed will become too high. The outside diameter may be used to figure V-type pulley sizes.

Installation and Care of Motors

Motors should be installed permanently **only** in dry places relatively free from dust, dirt, dripping water, or damp air. The switch and other equipment may be chosen for convenient operation.

Periodic care and attention are required to insure the long life possible for electric motors. Motors should be oiled according to instructions with a good grade of mineral (petroleum) oil, using SAE 10 or 20 W in cold weather and SAE 20 or 30 W for hot weather. **Don't oil too much.** Too much lubrication, rather than too little, is a common cause of trouble. Excess oil may enter the windings or commutator and cause the motor to burn out.

Ventilated motors unavoidably operating in dusty places should have the dust removed to insure necessary air movement to prevent overheating. Thermal protection devices in the starting switches will not keep the motor from overheating if air circulation is poor.

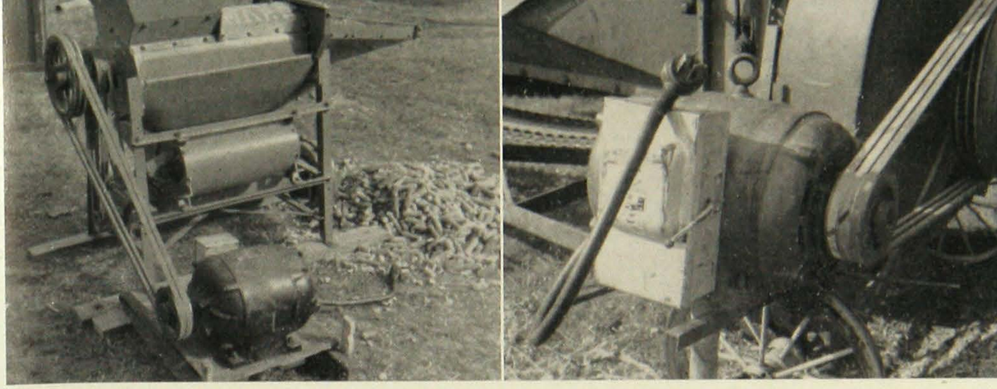


Fig. 9. A Large Portable Motor Will Simplify Shelling Corn and Filling Silo

Portable Motors

With careful planning most farm work that does not require machines with permanently attached motors can be handled by two portable electric motors. One should be a 1/4 to 1/2 horsepower motor which can do all jobs that formerly were done by hand. The other should be a 3, 5, or 7 1/2 horsepower motor.

SMALL PORTABLE MOTORS

A small 1/4 or 1/3 horsepower motor costs from $8 to $16 depending upon the type and thermal protection. The cost of the extra equipment to make the motor portable would amount to another dollar or two. One of the outstanding features of the small portable motor is that it can be used almost anywhere without overloading the circuit.

The small portable motor can easily perform any task previously done by a man turning a crank at a cost of one to three cents an hour. Figure 10 shows a completed portable motor ready for use on the farm. Heavy insulated wires are used to make the carrying handle, and broomsticks, etc., may be used to make the base.

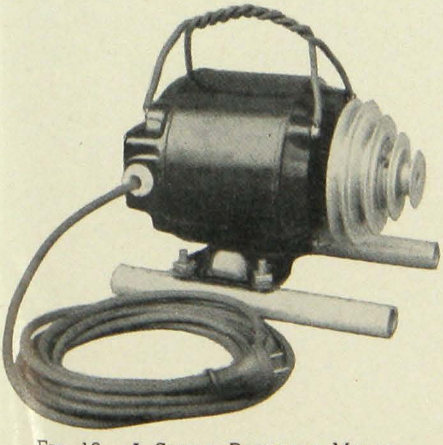


Fig. 10. A Small Portable Motor

LARGE PORTABLE MOTORS

In choosing a larger motor to be made portable, the farmer must decide whether a 3, 5, or 7 1/2 horsepower motor will serve his needs best. Present wire size is another important consideration in choosing the large motor.

With the exception of the corn husker or shredder, ensilage cutter, hay chopper, and hay baler, the 3 horsepower motor would furnish enough power for all ordinary machines if these machines were purchased or fixed

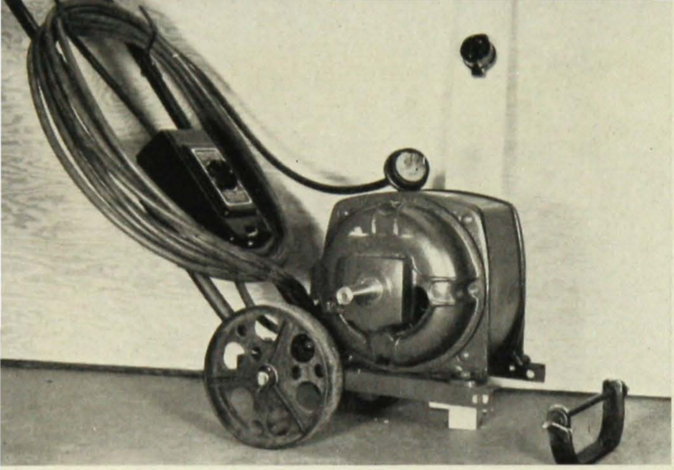


FIG. 11. A LARGE PORTABLE MOTOR

A portable chassis for a large electric motor can be made at home. The yoke and power outlet are located at each machine.

up with this in mind. Many farm wiring systems were not planned for large power uses, and consequently a 5 or 7½ horsepower motor would require a partial rewiring job to supply adequate wire size. It also might be necessary to change transformers. Moreover, 5 and 7½ horsepower motors cost more and operate less efficiently on light jobs.

For farms having a tractor a 7½ horsepower motor would probably mean unnecessary duplication of power. However, if a tractor is not available for ensilage cutting, hay chopping, and similar work, it would be wise to skip the 5 horsepower size and purchase the 7½ horsepower motor. The 5 horsepower has proved, in many cases, to be slightly small for these heavier jobs.

Requirements for a Large Portable

Figure 11 shows a large portable motor ready for use. Besides the motor, which will cost from $90 to $200, there are several other accessories necessary for the large portable. These include:

Motor Controls.—Motor controls consist of a starting switch and thermal protection unit. These have been discussed earlier in the bulletin, and figure 6 shows several types of motor controls. Cost of motor controls varies from $6 to $40.

Extension Cord.—About 20 to 40 feet of type R or RP moisture resistant rubber-covered extension cord is necessary. Two-wire extension cord may be used, but if it is, the motor frame should be connected to a ground stake in order to ground the motor. This inconvenience usually merits the additional cost of a three-wire extension cord, one wire of which is used to ground the motor back through the neutral wire.

Three-wire No. 10 extension cord costs about 17 to 25 cents a foot; three-wire No. 8, 32 to 45 cents a foot; two-wire No. 10, about 15 cents a foot; and two-wire No. 8, 25 to 35 cents a foot.

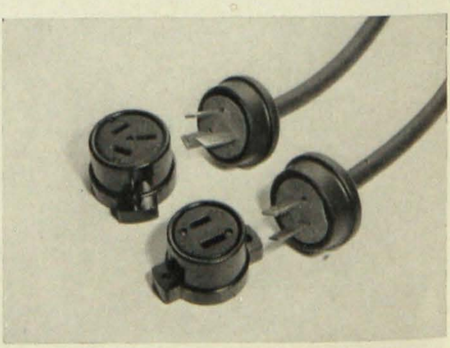


FIG. 12. A TWO- AND THREE-WIRE PLUG AND RECEPTACLE

One heavy duty plug for the motor and a receptacle at each machine is necessary equipment.

FIG. 13. A WEATHER-PROOF RECEPTACLE NECESSARY FOR OUTSIDE MOUNTING

Power Plugs and Outlets.—One heavy duty plug and a receptacle placed at each machine is necessary for the portable motor. A plug and receptacle that is to be used in buildings or in places protected from the weather costs about $3.50. A weather-proof receptacle and plug for a 5 or 7½ horsepower motor costs around $10. See figures 12 and 13.

Portable Chassis.—A portable chassis for a large electric motor may be made from 8 to 10 feet of ½ or ¾-inch gas pipe; 3 feet of 1¼" x 1¼" x ¼" angle iron with a few bolts; a ¾"-steel rod 4 feet long for the hinge pin and wheel axle; and 20 inches of 2" x ¼" bar iron for the yoke; and 2 wheels. Figure 11 shows a portable chassis.

Farm Jobs Performed

Large portable motors can be used for many farm jobs. Special information about some of these jobs follows:

Grinding Feed.—Figure 2 shows a portable 5 horsepower motor connected to a hammermill. The capacity or power requirements of a hammermill depend a great deal on the fineness of grinding, and the kind, and the moisture content of the grain. Table 5 shows the capacity of 2 and 5 horsepower hammermill outfits based on carefully conducted tests.

It should be appreciated that small electric feed mills will not keep one person busy. Therefore, some means of automatic feeding as shown in figure

FIG. 14. A PORTABLE DOES MANY JOBS

This 5 horsepower motor, which is being used to saw wood, shows another way to make a portable chassis.

Table 5. Capacity of and Amount of Electricity Used by 2 and 5 Horse-power Hammermill Outfits Grinding to Medium Fineness

Grain	Kw. Hrs. Per 100 Lbs.		Pounds Per Hour	
	2 H.P.	5 H.P.	2 H.P.	5 H.P.
Oats	1.03	.93	197	553
Soybeans	.34	.23	589	2,046
Shelled corn	.27	.24	768	2,233
Wheat	.43	.25	472	2,136
Barley	.77	.64	255	784

2 should be used. With an automatic installation labor is greatly reduced and the farmer may do his chores or other work while the feed is being ground.

Sawing Wood.—Figure 14 shows a 5 horsepower portable motor sawing wood. A good rule to remember in computing proper pulley sizes for a circular saw is that a speed of 1½ miles per minute should be maintained at the point of the teeth. The belt may be tightened by means of a rope or wire stretcher fastened to the rear of the chassis and a stake driven into the ground or by a jack-block placed in front of the chassis.

Filling Silo.—When operating an ensilage cutter with a 5 or 7½ horse-power motor, it must be run at a slow speed to conserve power. The speed should be such that the corn will just be elevated into the silo.

The cost of buying a large groove pulley for V-belts may be eliminated by placing grooves in a fiber pulley. A simple way to do this is by running the pulley as a lathe and using a screw driver or small chisel and guide to cut the grooves. Placing two or three grooves along the inner edge of a fiber pulley, 6 or 8 inches wide, should not interfere seriously for future use with flat belts. See figure 9.

Table 6. Minimum Speeds for Various-Sized Ensilage-Cutter Fans to Elevate Into Silos of Different Heights

Diameter of Cutter Fan in Inches	Height of Silo in Feet 25	30	35	40	45
	R.P.M. of Cutter Fan				
30	500	530	575	610	650
32	465	495	540	575	610
34	440	465	510	540	570
36	415	440	480	510	540
38	390	415	450	480	510
40	370	395	430	460	485
42	355	380	410	435	465
44	340	360	390	415	440
46	325	345	375	400	425
48	310	330	360	380	405

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