ROTHAMSTED RESEARCH

The Use of Electricity in Agriculture

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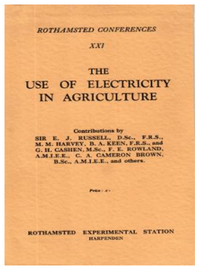

Electric Motors for Farm Machinery

F. E. Rowland

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ELECTRIC MOTORS FOR FARM MACHINERY

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Introduction

The convenience of electric motors is such that their use for driving machinery in farm buildings is assured, provided electricity is available at suitable tariffs. There is a great deal of misconception as to the price at which it is economical to use electric drive, and for ordinary purposes tariffs up to 2d. a unit are economical in use. The great advantages of electric motors compared with other sources of power, such as ease of starting from any position and at any time, elimination of fire risk, the facility with which they can be placed in any position owing to the absence of fumes, vibration and noise, and the lack of the necessity of adjustment or periodical overhaul, appeal readily to farmers. Electric motors also have the feature that their efficiency does not drop appreciably when they are only used at low loads, and consequently the cost of running is proportional to the amount of work which is done, whilst their constant speed and absence of vibration lessens the wear and tear on driven machines and ensures a uniform standard in the finished product. Absence of fumes, vibration and noise, are particularly valuable features on dairy farms, eliminating the risk of contaminating milk or disturbing the cows, whilst constant speed ensures the best results with such appliances as milking machines. For pumping electric drive provides a service which requires little attention, and with float switch control fully automatic supply is provided.

With the great development in the distribution of electricity in rural areas which has taken place in recent years, the number of motors which have been installed on farms has increased greatly, and the rate of increase should be even greater in the future. Statistics of electric motors and engines installed on farms are unfortunately only available up to 1931, the following figures being taken from "The Agricultural Output of England and Wales, 1930-1931."

Number of Agricultural Engines or Motors returned as used on farms in England and Wales—1925-1931.

	1925	1931	*Increase or decrease*
Steam	3,731	2,246	−40%
Oil or petrol	56,744	65,725	+16%
Electric	700	2,475	+254%
Tractors for stationary work only	2,116	2,466	+17%

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Owing to the great increase in electrical development in rural areas since the date of this report, the number of electric motors installed at present must exceed the above figures very largely.

The use of electric motors on farms has increased greatly throughout the world of recent years. This is exemplified in the case of Germany where the increase from 1925 to 1933 was 56%—from 746,000 to 1,169,000. In that country 93% of agricultural power units are now electric and 80% of farms are connected to supply mains (Hamburg World Economic Archives).

Types of Motors

Electric motors used on farms fall roughly into three categories :

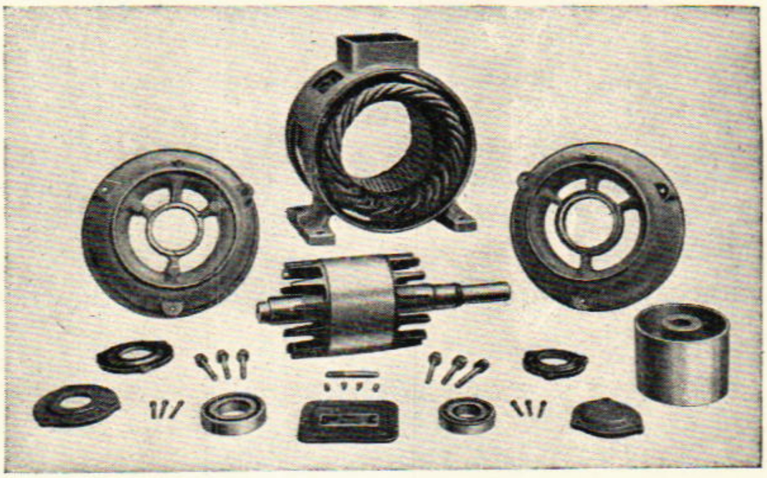

Fig. 1. Components of squirrel cage induction motor showing simple and robust construction.

Single Phase	Up to 1 h.p.
Three Phase, Squirrel Cage ..	1 h.p. to 7½ h.p.
Three Phase, Slip Ring	Over 7½ h.p.

The type used in specific cases depends upon the requirements of local supply authorities, and is largely governed by the maximum starting current permissible, which may be influenced by the position of a farm in relation to the electricity distribution network. For instance, the requirements might be less exacting for a farm supplied from its own transformer than for one situated at the end of a long feeder supplying several consumers. Small single-phase machines may be connected to the same supply as the lighting and heating installation and are employed for pumps, incubators, bottle washers, etc. Three-phase squirrel cage motors are the simplest in design and maybe used for the majority of barn drives, but when

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starting current has to be limited with higher powers, slip-ring machines must be employed. Although it is usual for motors of

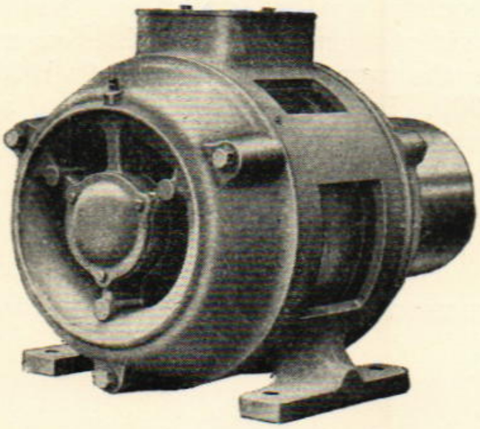

Fig. 2. Protected type squirrel cage induction motor.

over 1 h.p. to be three-phase, sometimes only a single phase supply is available, which necessitates the employment of a more expensive type of motor.

The rating of power output of an electric motor depends on its

Fig. 3. Totally enclosed slip-ring induction motor.

temperature rise ; consequently a standard protected machine in which there is ample provision for ventilation will give a greater output than a totally enclosed motor of the same dimensions. Totally enclosed machines, therefore, are considerably larger and more expensive than protected type. A recent introduction is the cowl-cooled motor in which a totally enclosed design is used, with a cowl containing a fan, covering part of the frame. This arrange-

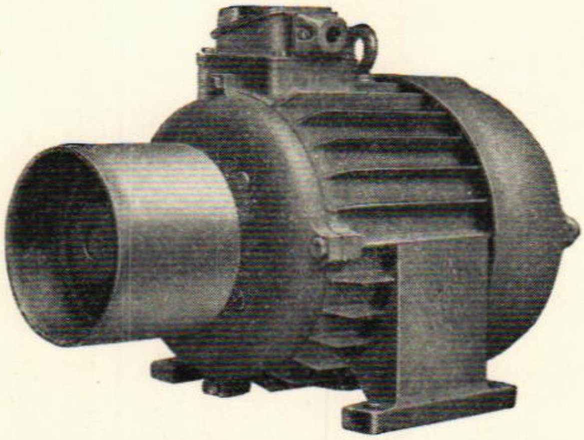

Fig. 4. Cowl-cooled squirrel cage induction motor.

ment provides additional ventilation and results in the size and price of the motor being less than a totally enclosed machine.

The difference in prices between various types of motors and variation in size between protected and totally enclosed machines is shown below :

Comparison between Squirrel Cage Protected and Totally Enclosed, and Slip-Ring Protected Motors.

400/440 volts, 3-phase, 50 cycles 960 r.p.m.

H.P.	*Squirrel Cage*				*Slip Ring*	
	Protected		*Totally Enclosed*		*Protected*	
	Frame	*Price*	*Frame*	*Price*	*Frame*	*Price*
		£		£		£
3	A	12	C	18	C	30
5	B	15	I	24	C	30
7½	C	18	K	32	D	33
10	D	21	O	41	G	37
15	H	28	Q	58	H	44

Squirrel Cage motors include star-delta starters, pulley and slide rails.

Slip-Ring Motors include rotor and stator starting panels, pulley and slide rails.

The figures are typical for comparison.

As an example it will be observed that a 3 h.p. totally enclosed squirrel cage motor has the same frame size as a 7½ h.p. protected type and that the prices of these two types are similar, whilst the use of a slip-ring in place of a squirrel-cage motor necessitates a considerable increase in price.

Control and Overload

Fig. 5. Push-button direct-to-line starter.

Starting and control of electric motors is extremely simple, in many cases being effected by operating a switch or pressing a button, whilst even the most complicated operation consists only of moving a lever through two positions. The type of starter adopted

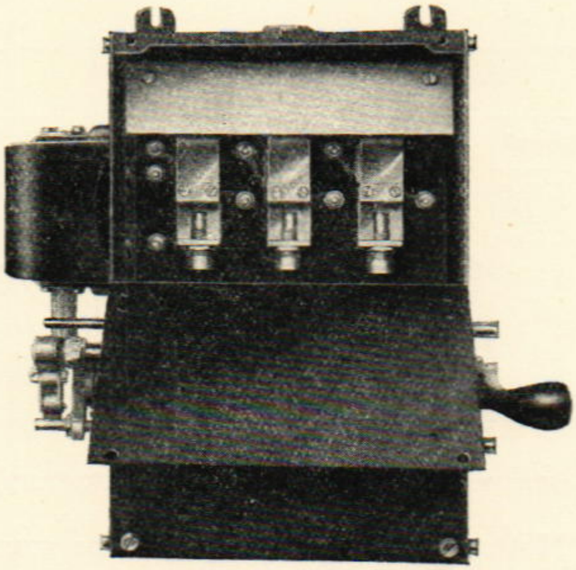

Fig. 6. Air break Star-Delta starter showing hinged lid.

is governed by the maximum current it is permissible to take from the mains when starting. It is usual to start motors up to approxi-

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mately 3 h.p. by switching them direct on to the line, and motors

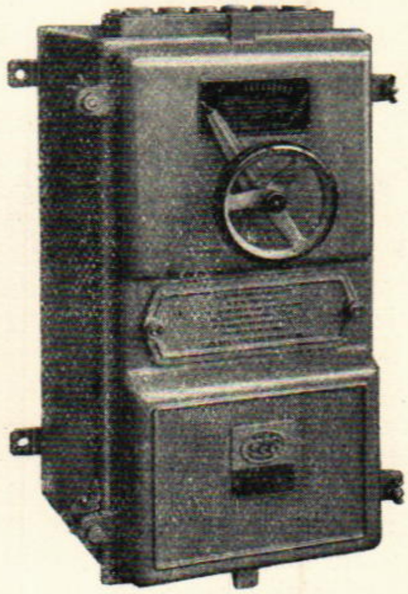

Fig. 7. Air break rotor and stator starting panel.

up to 7½ h.p. may be controlled by star-delta starters, whilst machines of larger sizes are of the slip ring type with rotor and stator starting panels. Typical starting characteristics of standard 3-phase motors are shown below :

Type of Motor	*Method of Starting*	*Starting Current*	*Starting Torque*
Squirrel Cage	Direct Switching	Approx. six times full load	Approx. 130% of full load
,,	Star-delta	Twice full load	40% of full load
Slip Ring	Rotor and Stator	Full load	Full load

Electric motors are able to withstand considerable temporary overload, the following figures being typical :

Overload	*Time*
25%	15 Mins. to 2 Hours according to h.p. and speed
50%	1 Min.
100%	15 Secs.

The provision of suitable protection in starting equipment ensures that motors are disconnected from the supply in the event of excessive overload ; this not only protects the motor but also the driven machinery from damage. The inclusion of a no-volt feature ensures that in the event of an interruption to the supply to a motor, the starter is tripped and when the supply is resumed, the motor will not start again until the starter is operated. This prevents the possibility of accident through machines being re-started from a remote situation. All motors with a rating exceeding $\frac{1}{2}$ h.p. should be provided with overload and no-volt protection.

Motor Speeds

An electric motor is essentially a fast running machine, and standard designs are available from 580 r.p.m. to 2800 r.p.m., the price for slow speeds being greater than for high. For the types used on farms, the most economical speed as regards the first cost is approximately 1400 r.p.m. However, as the majority of farm machines run at slow speeds, it is usual for motors on farms to be of 960 r.p.m. and this reduction has not a very material effect on the first cost.

Maintenance

The maintenance of electric motors is extremely simple, all that is required being a little grease in the bearings at intervals of a few months and a periodical examination every six or twelve months, according to the situation, to ensure that the interiors are not excessively clogged with foreign matter, which can generally be removed by blowing out with a pair of bellows.

Fixed Motors

In this country, the majority of farms are equipped with counter-shafting from which existing barn machinery, pumps, etc., are driven, and when electricity becomes available it is the usual practice to instal an electric motor to drive this shafting when the existing engine requires replacing. Standard protected machines

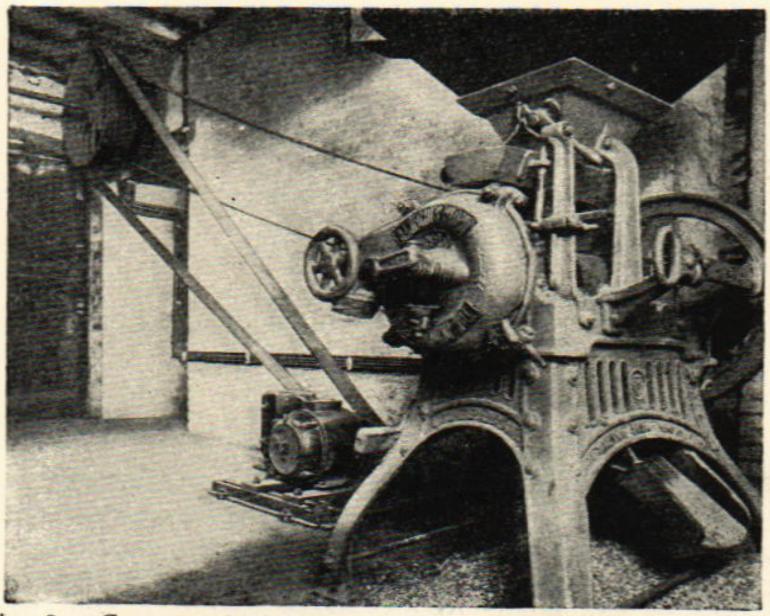

Fig. 8. Countershaft drive. Starter mounted on motor.

are generally used, running at about 960 r.p.m., although when such motors are working in very dusty or dirty situations, it is recommended that they should be totally enclosed, pipe ventilated or cowl cooled.

Portable Motors

Portable motors are employed when one source of power is required to drive various machines in different parts of farm buildings, but their use is not as widespread in this country as is sometimes imagined. The equipment should be of robust construction and a satisfactory compromise established between portability and stability when driving. Two wheeled trucks may be employed up

Fig. 9. 5 h.p. portable motor and countershaft on two-wheeled truck.

to 7½ h.p., whilst over this size, due to the greater weight, four-wheeled construction is preferable. Although the majority of designs are a combination of trucks on which the motor and control gear are mounted, there is one notable exception, namely the

" Drumotor " in which the whole unit is in the form of a steel drum,

Fig. 10. 5 h.p. portable farm " Drumotor " in transit.

which enables it to be transported with particular facility. When a portable motor is to drive several machines working at different speeds and the full variation cannot be obtained by means of various sized pulleys, slow speed countershafts or gearing with interchangeable pulleys may be incorporated in the portable unit.

For threshing in yards and other heavy duties when portable

Fig. 11. 20 h.p. heavy duty portable motor driving thresher.

motors are required, equipment of 15 h.p. to 30 h.p. of heavy construction with a four-wheeled bogey is employed.

When it is desired to move a motor only at occasional intervals and the elaboration of a portable unit is not essential, a useful compromise is that of a "Skidmotor" in which the motor and

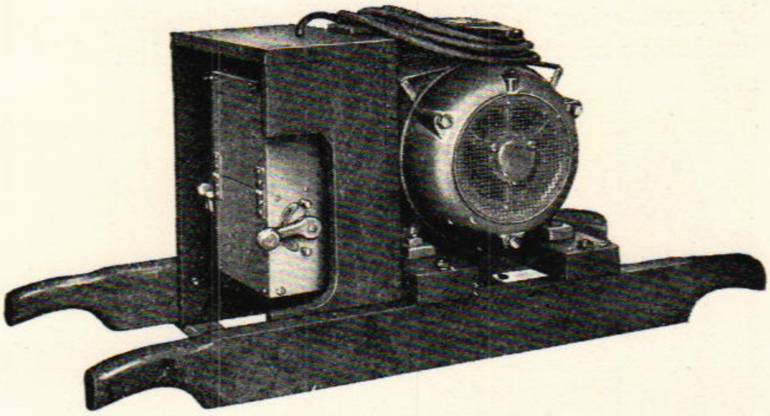

Fig. 12. 5 h.p. "Skidmotor."

control gear are mounted on wooden skids. These units, although not as readily transported as portable motors, have the advantage of being less expensive and are easily moved when the occasion requires. The design of portable motors should be sufficiently robust to stand up to rough usage and the electrical equipment and connections of a quality to ensure reliability and safety. Flexible leads should be kept as short as possible by the provision of plug connections adjacent to the positions where the motor is to be used.

Direct Coupled and Built-in Motors

Machines with direct coupled motors occupy a minimum of

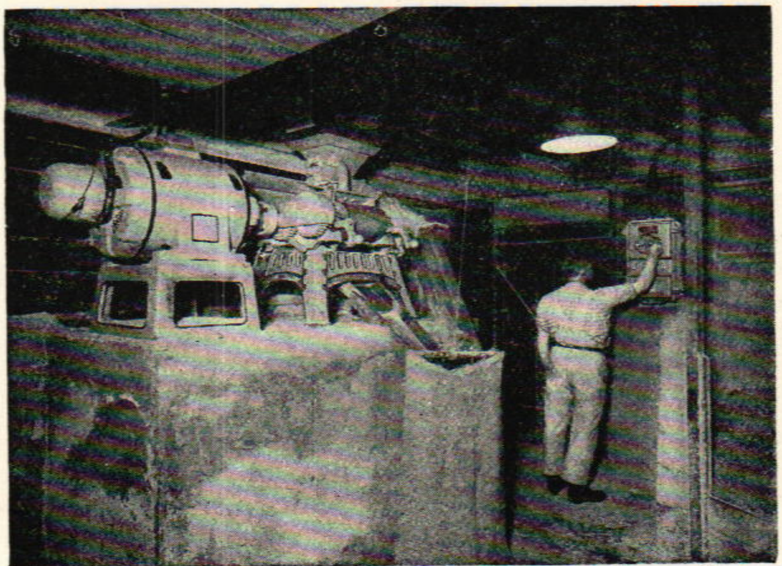

Fig. 13. 10 h.p. motor direct-coupled to grinder and crusher.

space, whilst transmission losses associated with belts, counter-shafting and gearing are eliminated. When machines are used sufficiently to warrant the provision of a separate motor, this arrangement may be used with advantage, whilst when the expense of direct drive is too great a very satisfactory compromise may be effected by employing " V " rope drive which enables considerable speed reduction to be obtained with the motor and machine mounted at close centres.

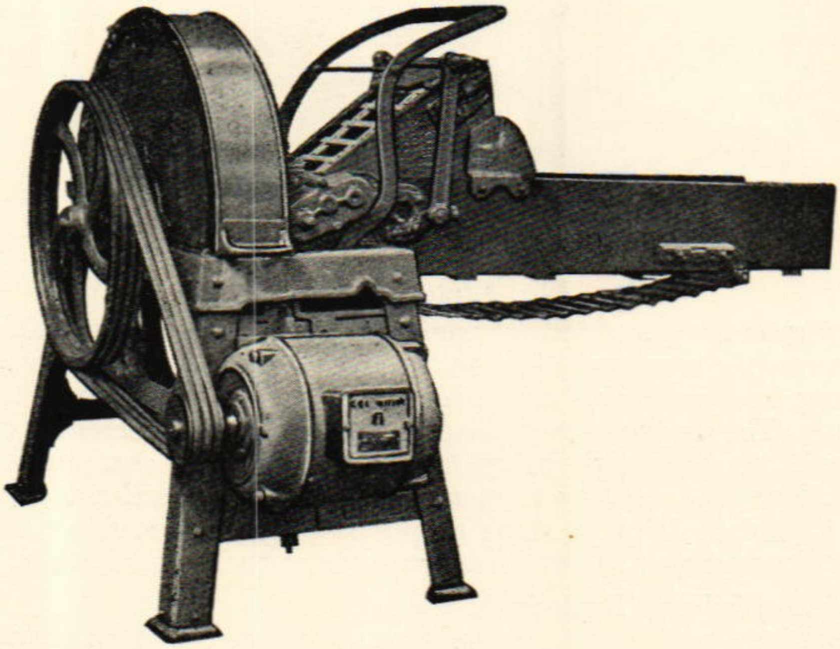

Fig. 14. Chaff cutter with vee rope motor drive.

A further step in the evolution of electric drive is the provision of machines with motors built into them and forming part of the main design. This practice is, of course, common in other industries where electrification is more widespread and has been established for longer, and will no doubt be adopted in the agricultural industry in the future. Machines of this description have been developed in France where there is a considerable market amongst a large number of small peasant farmers. To secure the maximum benefit from this development, it will no doubt be necessary to redesign many machines, so as to obtain the greatest efficiency from the high speeds and smooth torque obtainable with electric drive. Hammer mills and cream separators lend themselves readily to this arrangement on account of their high speeds, but such machines as chaffers and pulpers which are essentially slow running would require considerable modification.

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Power and Output

The size of motor and output for various typical barn machinery are shown in the table below :

Machine	*Machine Pulley Speed r.p.m.*	*Size of Motor h.p.*	*Output per h.p. per hour*	*Output per unit of electricity*
Cake Breaker	160	2–4	20 cwt.	22 cwts.
Chaff Cutter :				
Self Feed	120–250	2–8	7 ,,	8 ,,
Hand Feed	120–250	2–8	3½ ,,	4 ,,
Crusher ..	400–600	2–12	5½ bushels	6 bushels
Grinder ..	400–600	2–12	2 ,,	2½ ,,
Kibbler ..	400–600	2–12	7 ,,	8 ,,
Mixer	140	1–5	20 cwts.	22 cwts.
Root Cutter	80–120	2–4	35 ,,	39 ,,
Thresher ..	1,000–1,200	5–25	4 bushels	4½ bushels

The figures given above apply to types of machinery generally in use and may vary in some instances.