

# MAINTENANCE AND CARE OF ELECTRICAL PLANT IN A SUGAR FACTORY

BY J. B. M. GODFREY

In choosing this subject I considered a paper on the maintenance and care of electrical plant might prove interesting. A maintenance engineer's ambition is to attain that 100% mill operating time efficiency, and to keep maintenance charges at a minimum thereby lowering the production costs.

The conditions in a sugar factory are not ideal, from an electrical point of view, where cleanliness is most essential. Dirt, moisture and oil are the most destructive elements to all electrical apparatus. Carbon (burnt trash) enters the factory, also fine particles of bagasse, and carbon from the flue gases. This has been reduced very considerably during the past few years due to the ever-increasing efficiency of the combustion in the boiler furnaces. Sugar in suspension in the atmosphere is responsible for a large percentage of trouble.

Motor rotors are excellent dust collectors. The rotor bars are easily clogged with dirt. If not blown out every week-end, and regularly attended to, trouble is bound to result. In the curing house it is not possible to keep the windings free from sugar dust and dirt, even with compressed air at 70lbs. sq. inch.

Knowing our troubles, we have to protect the plant as far as possible, and I shall suggest, under the following headings, how most of the trouble can be eliminated:—

- Generators.
- Motors.
- Switchgear and starting equipment.
- Transformers.
- Cables.
- Transmission Lines.

But before considering these subjects let us examine some other important factors which should be taken into consideration when studying the maintenance cost in a factory.

## (1) Specifications and Tenders.

In my opinion it is essential in the first instance to purchase plant which will prove serviceable and give a minimum of trouble.

It is imperative to issue a detailed specification advising the manufacturer exactly what is required, and on receipt of tenders to examine them most

carefully before making a decision. One will generally find the very low priced plant is junk, and should always be discarded, as it is costly to maintain.

## (2) Location of Plant.

Where ever possible, it is advisable to keep the motor and starters away from steam traps and pipe joints. Where this is not possible specify drip proof motors when indenting. Unfortunately, this type of motor is not always available locally, and as the extra cost is so very small, I think local agents knowing our troubles, should stock such plant, as this would eliminate the home-made covers which are known to some as "electrical umbrellas."

## (3) Installation and Connections.

Great care should be taken in the erection of all plant. It is essential that the foundations for motors should be level, all starters and motors should be plumbed. The installation of starters and switchboards should be effected in locations free from excessive vibration.

Vertical belt drives should be avoided, and also short drives. Excessive belt tension causes bearing troubles and a short belt life. It is important that slide rails be installed and motors should be connected to their respective starters and switchgears by means of paper insulated lead covered and armoured cable. Although cable costs a little more than screwed conduit very little of the electrician's time is taken into consideration for cutting and screwing the tubing, yet, in my opinion, this extra cost is justified, for when using tubing condensation takes place in some parts of the factory in the conduit, which later results in deterioration and breakdown of the insulation.

Included on the staff should be an electrician who is able to rewind a burnt-out or damaged motor.

All motors should be repaired locally and not sent to Durban for repair, although on this point probably Durban firms won't agree with me, as it is most costly and inconvenient to send repairs a long distance, and I don't agree that it is necessary or cheaper to purchase new motors to replace damaged ones. When a breakdown occurs, and a duplicate motor is not available, a temporary drive must be arranged and the damaged motor rewound when convenient. I have not always found it con-

vient to work continuously on a repair until it is completed. Invariably this has to be fitted in with other work, and when the necessary repair has been satisfactorily effected, the motor can be re-installed at a week-end.

All motor repairs are carried out at Mount Edgecombe by a member of the staff. With over 200 motors to maintain, of an aggregate output of 10,000 h.p., we have been fortunate in not having had a motor burnt out for three years.

It is essential that a department should be self contained in this respect.

All apprentices who pass through at Mount Edgecombe are capable of rewinding a motor by the time their indentures expire.

#### (4) Earth detectors.

It is very important that every factory should have an earth detector. Personally I would not be without this instrument; for low and medium pressures a cheap one could be built up with lamps, but this type only gives one an indication of an earth on the system.

The system adopted at Mount Edgecombe on the 500 V, 2,200 V, 22,000 V systems is a single phase transformer, the primary winding of which is connected in series with the neutral point of the generating plant and earth; the transformer secondary winding is short circuited through a fuse and connected to the secondary terminals is a voltmeter, lamps and bell signals. The detectors or voltmeters are located in the centre of the main switchboard in the power station, and half-hourly readings are taken and logged. Normally the voltmeter reads zero.

Partial earths give a low reading. When an earth appears on the system it is immediately located by drawing momentarily the feeder switches, this has always been done without stopping the mill, and when located the repair often only takes a few minutes to effect, but if left might develop into a major breakdown.

The absence of an earth detector makes it impossible to have bad insulation on the system without being aware of the fact.

Not only does the single phase transformer provide for a very efficient earth detector; but by choosing a transformer of suitable size it is also used for earthing the neutral point of the system and by so doing it protects human life as well as the plant.

If it is found necessary, relays can be installed to trip a feeder with an earth fault.

On the 550 V supply the neutral of the generator is connected to the earthing transformer by means of a double throw link. The same transformer can be connected to the neutral point of the coupling transformer after changing over from our own bus bars to the Durban Corporation supply at week-ends.

The 2,200 V system is earthed in a similar way.

For the 22,000 V system the single phase earthing transformer is connected in series with the neutral of the secondary side of the step-up transformers and earth. Trailing cables, cranes and power transmission lines accounted for a total of three earth faults last year. To get accurate voltmeter readings it is very necessary to earth all motor frames, switch, starter and transformer cases, also the lead and armouring of all cables and conduit.

Without an earth detector one would more or less work in the dark, and it is therefore essential to the well-being of every industrial concern to be in possession of an instrument of this description.

#### Generators.

If a generator is of the totally enclosed type with forced ventilation, it is essential when the machines are shut down, even for short periods, that the windings are kept above atmospheric temperature by installing heaters of the strip type at the air inlet end of the generator. It should be so arranged that on opening the generator switch at a week-end or any other time when machines are shut down, the heating elements automatically come into commission, thus dispensing with the human element, it is easily arranged by fixing contacts on the operating mechanism of the generator switch. The windings should be thoroughly cleaned during every off crop and sprayed with insulating varnish. A good type of spray gun is essential, not only does it use less varnish, but the varnish will get into corners where a brush cannot penetrate.

Clearances between rotor and stator should be measured periodically and logged, and the oil rings examined for flats, and it should be seen that the joints in the oil rings are tight.

After taking generators off the bus-bars at week-ends, insulation resistance tests of stator, rotor and exciter should be made and logged. It is advisable to examine all slip rings, commutators and their respective brushes.

Commutator segments ought to be kept free from copper dust, dirt and undercut when necessary, and when out of truth the slip rings and exciter commutators should be ground true. My notes regarding motors in this respect also apply to generator slip rings.

If air filters are provided, it is important that they are cleaned frequently, for by so doing, the machine windings are kept free from dirt.

Temperature-indicating instruments for the windings are essential and the hand should never be relied upon for taking temperatures. If pyrometer coils have not been imbedded in the stator winding and stator iron, a dial type thermometer could be placed in the generator-air discharge duct. When necessary dry out with the stator short-circuited, and be sure to have the switchboard instruments in circuit. The temperature and all instrument readings should be taken every 15 minutes during the drying-out period.

#### **Motors.**

As oil, dirt and moisture account for quite a number of breakdowns, special care must be taken when issuing a specification for purchase of motors.

In my opinion, prespahn slot insulation should be avoided in our humid climate. Rotor bars should have a continuous taping from the slots to the end of bars; this is very important and will reduce rotor troubles considerably. I have proved this myself. Rotors of the slip ring type account for a high percentage of motor troubles. It is amazing the number of rotor breakdowns in the sugar industry which are chiefly due to dirt and carbon collecting between adjacent bars.

#### **Cleaning and Drying out.**

All motors should be dismantled in the off-season, and the windings cleaned and sprayed with varnish, before the crop commences. To dry out all motors in position with the use of lamps or strip heaters so arranged that the heat is evenly distributed is important. Strip heaters are preferable to lamps for this purpose, as the life is indefinite, and the cost of, say a 500 watt heater, is not much more costly than a 500 watt lamp. The size of the heater required is determined by the size of the motor to be dried out. Two or three small ones could be used in preference to one large one. The heater should be kept away from the windings, otherwise the insulation would become hard and brittle. Motors which have been out of commission for long periods, and also new ones, should be dried out before being put into use, even if the insulation resistance tests are high in value after testing with a megger. Following the application of heat, the resistance will drop considerably, and in some cases to zero. During the drying out process the motors ought to be covered completely, except for an opening on top which will enable the moisture to escape. If, after drying out for long periods, the insulation resistance does not rise—switch off the drying out and allow the motor to cool right down and then heat up again. If no improvement is apparent open up the taping of a

few coils to allow the moisture to escape. We have to do this every year to one particular motor after washing the sugar off with water. After drying out, re-tape the coils. The temperature during the process should not exceed 147° F. Motors should be blown out every week-end during the crop, by a compressed air pipe line leading to all sections of the factory. The oil and oil rings, also the general condition of the motor should be examined.

#### **Slip rings and brushgear.**

It is particularly important that slip rings should run faultlessly, and they require careful attention and must be freed of all oil and dirt. It is essential for brushes to have a free movement in the holders, and if they appear to be tight, the only remedy is to clean and replace. Brushes must not be slack, and correct spring tension is of great importance. If the tension is too great, the brushes and rings wear rapidly, scoring takes place, and also overheating due to increased friction, but on the other hand it must not be too light, otherwise blackening and burning of the rings takes place as well as disintegration of the brushes.

Brush pressures vary. There is no standard, some makers recommend 2 lbs. per sq. inch, while others consider higher pressure more satisfactory. The pressure can be tested with a small spring balance, on the replacement of brushes, they must be of the correct grade of carbon. A burnt or worn ring should be ground true immediately, and by using a resurfacer this only takes a few minutes, no matter how badly damaged it is. If a grinding lead is available to hold the stone, a better and truer job is made by grinding the ring with the rotor revolving in its own journals. However, if no grinding lead is available, hand application is satisfactory. Where the ring is burnt it is advisable to use, firstly, the coarse grade of stone followed by the medium and finest with the polishing stone. By applying a special type of stone at the back of the brushes, they can be bedded in, and the whole operation is done without taking the motor out of service. I cannot speak too highly of these stones as they have helped me out of many a difficult situation.

I suggest motors with totally enclosed rings should be opened regularly for inspection, and the metallic dust removed.

I have inserted heavy glass in slip ring covers and this has reduced maintenance. With totally enclosed rings it is impossible to see what is taking place inside, whereas with an inspection plate or open rings arcing at the brushes, is seen at once. There are advantages and disadvantages which result from the use of internal and external slip rings, and judging from my own experience, the advantages derived from the use of the former far

outweigh the disadvantages from the use of the latter type of slip ring.

### Bearings.

When, on measuring the air gap of each motor every off crop and logging the results, it should be discovered that the gap is unequal, due to a slightly worn bearing, the clearances should be taken more frequently, as a dangerous pull is caused between rotor and stator. In small motors when the clearance between the bearing and shaft exceeds 0.005 in. a new bearing should be fitted or the shell re-metalled.

Correct lubrication is very important, and has a considerable influence on the wear.

It is false economy to purchase a cheap grade of oil especially as the quantity used is so small.

Consequently, choose an oil with the correct viscosity for the conditions under which the motors are operating.

Inspect the oil level daily, also see that the rings revolve freely. Never over-oil a motor, as it is just as injurious to over-oil a bearing as to have insufficient oil, because the oil is gradually drawn into the motor in the former case and damages the insulation. During the off season it is important to fill up with new oil, and if dirt is excluded it will not require renewing during the crop. If the belt drive is too tight it will also tend to cause excessive wear of the bearings.

### Ball and roller bearings.

The amount of attention required for ball bearings is very small, these only require examination every off crop. When dismantling motors for overhauling, every ball and roller should be very carefully examined, the bearings washed with petrol, then replaced and packed with a make of grease recommended by the bearing manufacturers. Bearings should only be two-thirds filled with grease. If completely filled the bearing rises to an excessive temperature and decomposition of the grease takes place.

Use a specially designed bearing drawer when removing a bearing from the shaft. Some motor designers should pay more attention to the way bearings are fitted, and the small clearance at the back of the bearing in which to insert a drawer.

### Connections.

Recessed porcelain terminal blocks on motors are a source of trouble in dirty locations. The dirt settles and it is possible to have a short circuit across the three phases; at Mount Edgecombe all porcelain terminal blocks have been discarded, and the stator connections coupled direct to the cable by means of lugs bolted together.

### General.

All motors, large and small, should have ammeters in circuit as they are most helpful in case of trouble. Sometimes ammeters are not installed on small units, but every maintenance engineer should possess a portable tongs ammeter. Readings can be taken on the three phases without disconnection of the leads.

To operate a plant successfully it is essential to have certain spare plant available, the number of different makes of motors should be kept as low as possible.

If some motor manufacturers did not alter the dimensions from time to time I would recommend standardising in one make of motor only in a factory. Why they make this alteration I do not quite know but it would appear that motor designers lack maintenance experience.

It is advisable to keep records of all motor repairs, also all work done during the night, so that it may be inspected the following day.

The smallest details should be recorded. A history card for each motor is essential and the following is a specimen of those used at Mount Edgecombe.

Duty	Model No.	Type
Make		
No.	Volts	Amps.
H.P.		R.P.M.

### Insulation Tests.

	megohmno to earth			megohmno between phases		
Stator						
Rotor	"	"	"	"	"	"
Starter	"	"	"	"	"	"
Cables	"	"	"	"	"	"
Remarks				Air gap		

### Commutator Motors.

At Mount Edgecombe we have five of the largest commutator variable speed motors that have ever been built. With careful attention the upkeep of these motors is no more costly than a slip ring motor, with the exception of renewing commutator brushes.

Brush consumption, we hope will be reduced by half during the forthcoming crop. For two years we have been experimenting with different types of brushes. I took this matter up with the makers while I was overseas.

With the exception of the first crop the mill motors have attained a time efficiency of 100%, and the contactor starting equipment has been trouble-free except for a few minor adjustments, in fact, the operating time efficiency for the whole factory has never been below 99.98%. I mention

this for the benefit of others who have not electrified to any extent and might think electricity is troublesome.

Manufacturers' agents should stock drip proof motors locally, the small extra cost is warranted and it would eliminate the covering of motors by means of iron plates, and a neater appearance would result.

Totally enclosed fan-cooled motors should be installed where sugar dust is troublesome.

### Switchgear and Motor Starting Equipment.

Switches and starters must be reliable, of robust construction and like the protective devices, they must be totally enclosed. If a switch starter fails to operate with an overload, probably the motor is burnt out. Motors have been seriously damaged through using cheap, inefficient starting equipment. Switches and starters should be oil immersed. The extra cost is justified.

Overload trips and under voltage release should be on all equipment and fuses must not be used on three phase systems.

It is important to standardise in starting equipment as in motors, the disadvantage of installing a number of different makes entails stocking such a large number of spare contacts, coils, springs, etc.

It is essential for all equipment to be overhauled every off crop, renew contacts where necessary, see that contact is made over the whole area, then test with feelers. Badly-fitted contacts are sometimes the cause of motors operating single phase with disastrous results. With normal operation the oil is filtered annually, but where switches have operated under heavy short circuit currents, filter more often. It is important that the oil is maintained at a correct level.

For rotor starters use a good quality oil of low viscosity with high flash point and high boiling point. Switch and rotor cases must be earthed preferably to a main water pipe.

I have found it advisable to filter switch and starter oil every off crop extracting any moisture and carbon deposit. Great care should be taken when overhauling switches, that the contacts on all three phases make and break at the same time. Burnt contacts can be built up by an arc welding equipment. This is a source of great saving as it is then unnecessary to make or purchase new contacts.

### Interlocks.

The starter switch, rotor starter and slip rings should be either mechanically or electrically inter-

locked so that it is impossible to start the motor except in the proper sequence of operations. Slip ring motors can be stopped by opening the stator switch and not by means of the starter.

Undervoltage release coils do break down at times, in some cases through the plunger sticking through dirt, resulting in many times the normal current passing through the coil. It pays to make an occasional inspection of these coils. Rotor starters should be connected so that the motors start up on the first notch, in other words, on closing the stator switch, a rotor should never be open circuited.

Some designers of switchgear should pay more attention to the design from a maintenance point of view, for the following reasons. Some switches and starters are too compact, before starting the repair, too many parts have to be dismantled; an unnecessary number of springs and toggle gear to maintain; there is insufficient clearance between piston in dashpot of overload relays, and switches should be made dustproof. Where horizontal terminal boards are fitted, especially when above the oil level, these should not be recessed where the terminal studs enter the terminal board, as it forms a pocket for the accumulation of dirt.

I recommend air tight switches and star-delta starters should be fitted with a vent pipe, with the outlet and closed with just a thin piece of mica to exclude dust. This would protect the switch from becoming seriously damaged, if it was operated under short circuit conditions and there was no outlet for the gases formed. This actually happened to me, and the switch cover was broken into a number of pieces.

### Transformers.

The life of a transformer, if properly cared for, is indefinite, and the upkeep is exceptionally low. A proper routine for cleaning, inspections and the reading of all instruments including temperature indicators is important.

A point of importance is the cleansing of transformer insulators weekly as a thin coating of dust reduces the insulation value considerably. The oil must always be kept at a correct level.

It is vital that oil temperatures of 75°C. should not be exceeded. When temperature indicators are not fitted the transformer must not be overloaded. For medium and large transformers a concrete foundation should be provided and when wheels are fitted they should rest in channel iron. All four wheels if not firmly supported tend to cause a rocking motion which would put undue strain on the external copper connections and insulators, especially if these are made of heavy hard drawn copper bars. Power transformers should be

housed in a chamber of ample size and particular attention must be given to the ventilation, otherwise overheating will occur. Expansion tanks should be installed and where breather pots are fitted the calcium chloride should be changed when necessary.

Oil is hygroscopic and absorbs moisture from the air and if this is allowed to proceed uncontrolled, the insulating materials as well as the oil may be affected. The dielectric strength as well as the oil should be tested at least every twelve months, samples should be drawn off from the bottom of the tank into perfectly dry glass bottles, after testing, the breakdown voltage to earth of each sample should be logged.

A simple way of testing oil for moisture is to insert a small quantity of copper sulphate in the sample.

Another method which may be adopted is to heat a test tube containing oil, and if moisture is present a crackling noise will be heard. This test, however, is not reliable when the quantity of water present is small. If the oil contains moisture the most satisfactory way of testing oil is to determine the dielectric strength by means of electric oil testing equipment.

The most common method of purifying the oil is by filtering. A centrifugal filter is ideal not only for moisture, but solid matter as well. I think it is preferable in every respect to the plate press with blotting paper.

It is not advisable to dry out transformer oil by heating it to high temperature as it oxidizes, and also undergoes considerable deterioration.

#### **Power Transmission Lines.**

To ensure continuity of service, power lines should be patrolled at regular intervals and the results logged in a special log provided. A pair of good field glasses are very useful in this connection and by their use we detected cracked insulators, but with the naked eye it is not always possible.

Any leaning poles must be plumbed and stay wires kept tight. Periodical tests should be made of earth plates and all earth connections, and steel poles, cross arms and clamps should be painted, when necessary.

When erecting new lines it is advisable to follow the estate road as far as possible, as this expedites maintenance work.

Costs for construction and maintenance of power lines can be greatly reduced by using Government wooden creosoted poles.

These have been well tested out at Mount Edgecombe, we have about 300; the first lines to be built with these poles was set up 10 years ago.

Recent inspections prove that the poles are in excellent condition below as well as above ground level and so far ants have done no damage whatever.

The numbering of all poles is a valuable aid in maintenance.

#### **Lighting.**

A factory should be well lighted as this tends to assure more efficient work being done and the final product is of better quality.

Light should be well distributed with no dark corners, although in a sugar factory it is difficult to get uniform lighting owing to the congested state of the plant.

Lamp construction is a very important item and it is essential to use lamps that give the longest useful life and stand up to extremes in temperatures, vibration and dirt. To arrive at this satisfactory state, we must obtain samples of different makes and types, and then install them in the worst parts of the factory. Carefully test them out by logging the date of each lamp when fitted also log the date of lamp failure. By carrying out systematic tests one can arrive at the best value for money.

When the electrification was carried outside the factory, it was decided that all outside lighting such as Hospital, Bachelor quarters and all staff houses should have a pressure of 220 V. The pressure used in the factory is 110 V; this eliminated any possible leakage of factory lamps for outside purposes, and it affords greater security than any locking device. Where there is excessive vibration, lamps should be suspended and not supported rigidly on the buildings.

Last but not least:

#### **Safety First.**

At Mount Edgecombe great attention has been paid to the safety of all employees as well as plant. Transformers with a secondary pressure of 30 volts have been installed in the boiler houses specially for use with portable hand lamps for men working in the boiler drums. This also applies to the loco shed, evaporators and vacuum pans.

Danger labels are placed on isolating switches when work is being carried out on starters, etc. The handles of the isolating switches are also removed as an extra precaution.

On the 2,200 V and 22,000 V systems a scheme has been devised whereby application, permit and completion forms are filled in in duplicate and signed before work is commenced. This fixes the responsibility and ensures greater safety. In this way very little time is either wasted or lost.

## APPLICATION

NATAL ESTATES, LTD.

Date .....

Time .....

Mr. .... Switchboard Attendant,

Please isolate the following apparatus.....

for the purpose of.....

and the above mentioned apparatus is not to be made alive without written instructions from me.

Signed.....

Chief Electrician

## PERMISSION

NATAL ESTATES, LTD.

Date .....

Time .....

Mr. ....

The following apparatus and/or lines have been made dead

Before commencing any work same must be properly earthed using the continuous earth wire on overhead lines for this purpose.

Signed.....

Switchboard Attendant  
Chief Electrician

## CLEARANCE

NATAL ESTATES, LTD.

Date .....

Time .....

Mr. .... Switchboard Attendant

The work on the following apparatus and/or lines .....

..... has been completed, inspected by me, all earthing gear has been removed. Please close the following

Signed.....

Electrician.  
Chief Electrician**Magnetic Drum.**

Although the subject of the magnetic drum is probably outside the scope of this paper, I would like to mention briefly that the magnet installed last crop for extracting tramp iron from the cane has proved satisfactory and with the alterations now being made in the location of the magnet we expect even better results in future. Before the magnet was installed it was the custom to spend Saturday nights welding up the damaged rollers, especially the fifth mill. Sunday mornings steam had to be raised for turning the grooving of the rollers after welding, but last crop this was not found necessary at any week-end.

Large quantities of iron have been extracted from the cane in size from a pin to railway material weighing 30 lbs. I suggest an interesting paper

on this subject might be read next year. A Magnetic drum must reduce maintenance costs very considerably on the mechanical side. However, I find the only difficulty lies in the arrangement of a suitable location.

**Conclusion.**

In conclusion I would like to stress that a fully trained efficient staff is essential, to maintain and operate plant successfully at a high state of efficiency and in this respect the full co-operation of the staff is an outstanding factor.

To arrive at this it is desirable to make provision for the necessary amenities and bring about a feeling of contentment and comfort, i.e., suitable housing accommodation, sport, and medical attention, also if possible a pension scheme.

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The PRESIDENT: We are very much indebted to Mr. Godfrey for his paper. A few years ago we had a paper from him on the actual plant. Now he has completed the whole matter by giving us an account of his running experience. I think this paper should be very helpful.

Mr. Godfrey mentioned his difficulty about getting manufacturers to standardise. The difficulty is the difference between manufacturers and consumers. Some firms come along and design a cheap motor which the factories buy. Some other firm has got to go and design a still cheaper one to get the business. If you can get the users to insist on good machinery well and good, but if plant is bought in the cheapest market one cannot also have quality. The paper is now open for discussion.

Mr. WILSON: Mr. Chairman, and gentlemen, I would like to congratulate Mr. Godfrey on his very interesting paper in connection with the maintenance of electrical plant in a factory. There is nothing much I can say, because he has covered so thoroughly a very wide field regarding maintenance, and it is practically what we do ourselves out at the Refinery. There is one point he mentions about short drive; that has not been overcome by the V belt drive.

Mr. GODFREY: Yes, we are gradually eliminating belt drives by installing gear boxes with the motor directly coupled to the gear box.

Mr. WILSON: I don't think there is much to say. Mr. Godfrey has covered his field very well, and I would like to congratulate him on bringing a paper like this forward to our Conference, because it should be very helpful to the electrical engineers in the factories.

Mr. GODFREY: I would like to mention again the re-surfacers, they have not been obtainable out here very long. They are made of a special stone, not carborundum, and one can get a good polish on a commutator with this type of stone, and in a very short period we get that much-coveted chocolate finish on the commutator. The dust of these stones is not a conductor, and it does not matter how badly burnt the ring is on a slip ring motor, there is no need to take that motor out of service, it can all be done in situ, by grinding it up in its own journals. The re-surfacer is called the "Ideal." For those who don't know, and have never used one, I mention this fact. I call it a real electricians friend. A badly-burnt ring can be ground up in four or five minutes, whereas with a file and sand paper it takes very much longer. The supplier is Reid Brothers, Durban.

Mr. RISHWORTH: Mr. Chairman, as a mechanical man, Mr. Godfrey's paper serves one purpose, namely, it lets the mechanical engineer see that the electrician does quite a bit of work round the factory. Usually the idea obtains that the electrical apparatus just goes on running. On point interests me—it is this, that you make a practice of drying out new motors before putting into commission. If you do, what size do you start from, also what are your ideas about brush lifting and short-circuiting gear?

Mr. GODFREY: We dry out every motor, even a fractional horse-power motor. Take the motor out of the case, as I have done, you probably get a very good test. After heat has been applied to the motor insulation resistance drops if moisture is present, sometimes, but it does not show up when it is cold. I strongly advise that not only motors, but new stators too, should always be dried out, never mind what test you get. It is interesting to find, when you do heat a motor what test you get afterwards. Brush lifting—that is a very open

question. As a matter of fact, there are advantages and disadvantages of both. Personally I prefer the internal type of slip rings inside the end shield. My reasons are that if you have no internal leads in the shaft, you get an accumulation of dirt, probably moisture, and the insulation has been known to break down, especially in a sugar mill. And another point, with external slip rings you have got to draw your rings from the shaft, sometimes they are very tightly fitted. To take these off, you have to take off a lot of gear to get off your end shield to examine the bearing, whereas with the internal type it is not affected—you simply take out the bolts, and the end shield is off in a matter of minutes. Of course, as far as brush-lifting gear goes, you can have that on the internal slip ring as well. Brush-lifting gear, if properly attended to, is what I recommend, but with Indians and other operating motors, the tendency is to leave the brushes on, and if the slip rings are not continuous rated heating may occur. I am just judging from my own experience. We put in about 30 motors in 1921. These slip rings had never been touched. They had got no brush-lifting device. They are internal. I think it is a matter of choice. It all depends upon the location. What applies to one job does not apply to another. There is no doubt about it there is a saving in brushes if brush-lifting gear is fitted. Where you have a brush-lifting device, it is very essential to have an interlock between brush and stator switch, so that it is not possible to close the stator switch with the brushes in the off position.

The PRESIDENT: If there is nothing more to say, I wish you to record a very hearty vote of thanks to Mr. Godfrey. We know the difficulties in a sugar factory, with bagasse and carbon and moisture. We know what they are up against. I think this paper is a very valuable addition to our proceedings.

*(Applause).*