MAINTENANCE OF ELECTRICAL INSTALLATIONS

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1. ABSTRACT

This paper considered the maintenance of electrical installations by identifying the types, the components and the various possible schemes of maintenance. It went ahead to consider various aspects of the installation, various faults and possible remedy. The paper did not however deal exhaustively with certain aspects of electrical installations – more especially special installations for power stations, closed systems/alarms, substations, earthling, instruments, safety and meters. However, the paper adequately dealt with the fundamentals as a springboard to handling such other systems.

2. INTRODUCTION

By electrical installation we mean the sum total of the wiring subsystem, the various components (switches, lamps, fuses, CBs, motors, poles, transformers, generators) for a particular purpose. These can either be of the domestic or industrial types and such other special ones like marine, aviation etc for the purpose of providing lighting and for power requirements. Irrespective of the type common features abound. For the purpose of durability, reliability, safety and cost effectiveness there is need to take proper care and pay adequate attention to such installations. Also there is the need to protect the environment within which these installations are provided. The aforementioned is the business of maintenance so that the desired aims and objective of the installation would be attained. Various practices exist for the maintenance of electrical installations viz: breakdown (or corrective maintenance), preventive maintenance (scheduled, condition monitor, condition based) and design-out (or improvement) maintenance respectively. It is therefore of essence that the maintenance personal must of necessity be adequately trained so that a thorough understanding/knowledge of the system is at his/her disposal. This will guarantee effective maintenance practice and management of the system such that availability will be guaranteed. Aside availability also, maintenance (which may involve repair, replacement or renewal of the system) will ensure that the installation functions at all times or most of the time as though it was new.

3. ELECTRICAL INSTALLATIONS

3.1 TYPES

They can generally be grouped as domestic, industrial and special installations respectively. Also these can be of the temporary or permanent type of installation. Irrespective of the type of installation the basic parts/components are about the same.

3.2 COMPONENTS

The make up of any electrical installation will include the controls (switches, sockets), the cables, the protective components (fuses, breakers), meters (energy meters, voltmeters, ammeters as the case may be); other accessories (saddles, clips, lamp holders) and the load points (lamps, cookers, water heaters, airconditioners etc). Maintenance will therefore be a function of what aspects are considered. However, the application of a certain maintenance scheme often times will be a function of the overseer of the installation and/or the corporate objective of the firm. Also for some heavy installation, transformers/substations will be involved.

4. MAINTENANCE SCHEMES

The name of the various schemes is a function of the desired goal and include: breakdown or corrective; preventive (scheduled, condition monitor, condition based) and design-out or improvement maintenance scheme respectively.

4.1 BREAKDOWN OR CORRECTIVE SCHEME

Here the system or component is allowed to fail before any attention is given to it. Electric lamps, loosely suspending lamp holders etc suffer this fate.

4.2 PREVENTIVE SCHEME

Irrespective of the sub-type, the system/component is routinely checked and any observed abnormalities are promptly attended to before failure occurs such as in the spring mechanisms of certain gear switches.

4.3 DESIGN-OUT SCHEME

This scheme aims to eliminate the cause of maintenance (whereas the earlier schemes aim at minimizing the effect of failure). This scheme therefore has a high scientific value and overall cost implications since it encourages the elimination, modification or replacement of certain parts that hitherto were problematic.

5. MAINTENANCE OF ELECTRICAL INSTALLATIONS

It worthy to note here that **natural aging, wear and tear** beside **maloperation** of electrical installations are responsible for all the possible problems that may hereinafter be catalogued. Also how easy or difficult it is to maintain the installation is a function of how well or how bad the installation was effected. This in turn will dictate the extent of maintenance (repair, replacement or renewal) to be carried out. In very bad situations though, it will be very necessary/economical to replace the entire installation.

Generally, to maintain the system/component, one may need to carry out physical examination, tests (pr-repair/post repair) and take appropriate notes before and after each exercise. This will ensure continuity, and certainty and efficiency.

5.1 MAINTENANCE OF LIGHTING INSTALLATIONS

These include fittings, fans and all low power appliance (shavers etc) circuits.

5.1.1 MAINTENANCE OF SWITCHES, CEILING ROSES AND LAMP HOLDERS

1. SWITCHES

Common types include ON/OFF, push button, dimmer, rotary etc. The basic requirements/component parts are the same. Its function is to open or close the particular circuit. However they require infrequent checks/maintenance. The commonest fault is loose connection due to improperly screwed screw which may lead to sparking, interference, improper performance of lighting fitting (sometimes leading to burnout). The remedy is to fasten the screw and/or replace the switch. Other faults include broken contact, broken ceramic casing, stiffness etc. Note that the switch quality will necessitate some of these problems. Bad quality switches must be replaced with good ones. In switches with spring controls (such as a tumbler switch), grease maybe applied from time to time in order to enhance it operation.

2. **LAMPHOLDERS**

This holds the lamp in place properly such that the lamp experiences uniform pressure and also makes the required contact. This guarantees some life to the lamp. A lampholder that does not meet this standard must be replaced.

3. **CEILING ROSE/JUNCTION BOXES**

Ceiling rose serve as inter-links to lamps. Junction boxes serve as take-off sources/continuity points for some circuits. In both units there maybe loose connections resulting in sparking. This may burn the insulating ceramic casing. In case of loose contact, rescrew and replace all burnt units.

5.1.2 MAINTENANCE OF LAMPS

Lamps include filament (tungsten filament type) and discharge (fluorescent, high pressure mercury- vapor, sodium vapour) types respectively. Other lamps include high voltage sign and tungsten-halogen lamps. The light output from a lighting fitting is reduced by absorption by the fitting itself, by the wall and by the surface of the ceiling. Also, due to accumulation of dirt on reflecting surfaces and aging of the lamps, the amount of useful light is reduced, hence the need for maintenance.

Maintenance is required when the lamp ceases to light. The cause(s) of this is a function of the type of lamp and maybe due to the lamp itself and for fluorescent fitting, it maybe due to a fault in the auxiliary equipment (choke, starter, etc). Also, in large installations, fittings maybe installed at not very accessible positions. In such cases, group replacement of all lamps is recommended at regular prescribed intervals. At such intervals also, cleaning of fitting, is recommended. Failure in some lamps maybe due to an open circuit (high impedance across the choke) or short circuit (low impedance across the choke).

Table1 shows possible symptoms and possible causes of fault in fluorescent lamp circuits. Discharge lamp circuits have cokes and capacitors and thus the fault symptoms, cause and recommendable cure may inadvertently be the same. Appendix I details some common problems and remedies for fluorescent Lamps.

6. MAINTENANCE OF POWER INSTALLATION

6.1 MAINTENANCE OF HEATING SYSTEM

These include:

1. Air Heaters
   - (i) **Storage or Indirect**: Storage radiators, centrally sited warm air units, and underfloor warming.
   - (ii) **Direct Systems**: Radiant fires, panel heaters, tubular heaters, oil-filled radiators, convector, fan, infra-red and ceiling heaters respectively.
2. Water Heating Systems
   - (i) Immersion Heaters
   - (ii) Electrode Heaters
3. Non-pressure storage Heaters
4. Instantaneous Water Heaters

Generally, heater installations may have the following components: heating element (heat source), heat exchanger, insulator, cables, switch control etc. In some types heat control (thermostats etc) are included. Central heating systems may incorporate grill, pipework, valves etc. From the aforementioned, maintenance of heating system will be a function of that component or subsystem that is faulty. This range from a faulty heating element, leakages due to break in power cable/heating element, or the insulating or refractory material. Due to the latter, excessive heat may be lost. Also, uneven heat distribution may be due to localized heating (resulting from break in parts of the element, poor grill orientation or faulty enhancement fan) in forced heating systems.

6.2 MAINTENANCE OF SWITCHGEARS, CHANGEOVER SWITCHES AND ISOLATING SWITCHES

In the absence of factory problems during design, manufacturing and/or assembly or transportation, these units hardly give problem. The same is true if they are properly installed. However, even with the above such switches suffer due mainly to improper handling and installation respectively.

6.2.1 IMPROPER HANDLING

This has to do with the manner of switching itself. Most knife edge switches require to be homed-in if the contacts are to carry their rated currents. Most changeover switches and the like require to be homed-in after the handle has been moved and the failure to do this has resulted in several burnout of terminals especially in fully loaded heavy duty industrial changeover switches usually installed in very large establishments, factories etc. Note that inability to home-in properly maybe due to stiff springing mechanism(s) or loose contacts.

6.2.2 IMPROPER INSTALLATIONS

Improper terminations usually involving terminals that are not properly tightened leads to arcing. This results in excessive heating which finally fuses the threads and ruins the terminal block. Also, unnecessary vibrations may result in loose contacts.

6.3 DISTRIBUTION BOARDS

Various types exist namely: MCB (Miniature Circuit Breaker) Boards and fuse Boards. In choosing the appropriate MCB or fuse size overloads should be avoided by using at all times the correct fuse and/or circuit breaker rating. With additional loads, expansion of the board/or circuit should be embarked upon.

From time to time, short circuits may occur within the board (just like in junction boxes in lighting installation) due to an electrocution of a wall-gecko or rat or cockroach in the vicinity of the installation. To rectify such a fault may just require the removal of the electrocuted prey replacing the fuse or resetting the CB though if the board had been properly installed and the board cover securely in place, this fault might have been avoided.

6.4 SOCKET OUTLETS

Many outlets abound in the installation ranging from 5A to 15A at homes, offices and factories though the most common power socket outlet is rate 13A. The most common fault that can be experience is non-tightness of screw terminals. This may result in excessive voltage drop when supply is required of the socket. Re-tightening of the screw may remedy the situation otherwise, the entire socket unit maybe replaced. It is worthy to note that very bad quality units exist in the market today resulting in damage due to excessive heat on the insulating casing and the contacts respectively. Such must be discarded and replaced.

7. MAINTENANCE OF CABLES

Cables are suppose to deliver rated current at full-load and at all times without overheating and excessive voltage drop. Many types of cables abound made up mainly of the conductor(s) and an insulating sheath(s) as the case maybe. It is required at all times that the cable be properly sized and installed to avoid over heating and excessive volt drop. Overheating may damage the insulation resulting in leakage of current to an otherwise dangerous area. This may also result in a short/an open in the conductor.

8. MAINTENANCE OF MOTORS

Motors have been used for various drive operations today and they form a very vital basis for automation mass productivity in the industry. The importance of motors cannot therefore be over emphasized whether of the a.c. or d.c. types, single or three phase respectively. Their maintenance is a function of the component that is faulty and the symptoms and remedies are as detailed in Appendix II.

9. CONCLUSION

Electrical installation is very extensive and more involving than has been handled in this lecture. So too is the maintenance aspects. However, the paper has adequately covered fundamentals on most issues as they concern electrical installations. It is the view of the writer that proper training, installation and operation of such installations will go a long way to preserve the system. However, the undue presence of very inferior electrical components and accessories in the market has seriously affected on the practice and has even complicated maintenance management. However, with new and adaptive trends, there is some hope in the direction and business of equipment and infrastructure maintenance and management.

10 REFERENCES

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APPENDIX IA

Fault Finding in Fluorescent Lamp Fittings

If a fitting fails to operate correctly, check as follows :—

Step No.	Item	Tests to be applied
1.	Supply and fuse	Check supply voltage at input to fitting. Check polarity of incoming supply and ensure frame is earthed. If fuse has blown, suspect circuit or components and find the fault before replacing fuse.
2.	Lamp	Check lamp in a good fitting and if proved faulty replace with a new lamp. Remember, never try a new lamp in a fitting which has faulty components or circuit.
3.	Circuit	Examine wiring inside the fitting and if possible check against the wiring diagram. Check insulation resistance between the circuit and the metal frame of the fitting. The resistance should be above 2 megohms. If an earth fault is found, trace the cause, and replace the component.
4.	Ballasts Chokes	Examine for signs of overheating, if possible check continuity of windings and insulation resistance. Compare the impedance or inductance against a good replica.
5.	Capacitors	Examine for leakage or damage. If possible check the capacitance and check that the discharge resistor has a value between ½–1 megohm. The insulation resistance between case and terminals should be above 2 megohms.
6.	Starter Switches	Check operation of starter in another good circuit and, if found faulty, fit a new replacement.
7.	Ambient Conditions	Remember that normal fluorescent fittings may overheat if the surrounding temperature is above 30–35°C. Lamp starting may be difficult with some types of circuit if the temperature is below 5°C.

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Fault Finding in Switch-start Fluorescent Lamp Circuits

Faults most likely to cause given symptom are marked: •; other possible faults are indicated: ×

If trouble is encountered, first look below for symptoms

Symptom	Faulty lamp: Air leak or cracked tube	Faulty lamp: Broken electrode or lamp cap	Faulty lamp: Mercury deficient	Faulty lamp: Low emission	Faulty lamp: Life expired	Faulty starter: Contacts stuck together	Faulty starter: Air leak or open-circuit fault	Faulty starter: Short-circuited suppressor	Faulty starter: Internal fault	Faulty starter: [illegible]	Faulty choke: Open-circuited winding	Faulty choke: Earth fault	Faulty choke: Short-circuited turns	Faulty choke: Wrong type or tapping	Faulty p.f. capacitor: Open circuit	Faulty p.f. capacitor: Earth fault	Faulty p.f. capacitor: Short circuit	Faulty p.f. capacitor: Wrong capacitance	Faulty p.f. capacitor: Faulty discharge resistor	Faulty wiring or circuit: Short-circuited lamp-holder	Faulty wiring or circuit: Components wrongly connected	Faulty wiring or circuit: Loose connections	Faulty wiring or circuit: Earth on wiring	Faulty wiring or circuit: Crossed wiring in two-lamp units	Faulty wiring or circuit: Wrong supply voltage	Faulty wiring or circuit: No supply or fuse blown	Temperature too low
...mp does not attempt to ...rt; no glow from ends	×	•			×		×		×		•	×									×	×	×		•	•	
Lamp flashes on and off				×	•				×					×						×	×			×	×		×
Lamp ends glow steadily but lamp does not start						•		•	•												×		×				
...int glow at one end of ...np		×																				×					
...amp lights but is dim			×		×									×											×		×
Lamp takes excessive time to start				×	×				×					×						×		×	×		×		
...mature end-blackening of lamp													×	×						×	×		×	×	×		
...oke overheats												×	×	×							×		×		×		
Supply fuse blown or lamp electrodes fused												×	×			×	×		×		×		×				
...w power factor															×			×							×		
...cessive radio interference					•				×												×	×					
When possible fault has been ...at make these tests to ...nd ...hich component is ...ult	LAMP: Check lamp in good circuit and if proved faulty replace with a new lamp; see note below					STARTER: Check operation of starter in good circuit and if found faulty, fit new replacement.					CHOKE: Check insulation resistance, continuity and, if possible, impedance. Make sure tapping and ...ung are correct				CAPACITOR: Check, if possible, insulation resistance and capitance; measure value of discharge resistor					CIRCUIT: Check circuit against wiring diagram; examine all connections and terminals. Check fuses, supply voltage and, if possible, insulation resistance of complete fitting							

Remember: Ne... ...lamp in a circuit which has symptom... ...H, or I until it has been established that components or circuits are not faulty ...supply fus... ...suspect circuit or compon... ...find fault before replacing fuse

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APPENDIX I C

Fault Finding in Switchless-start Fluorescent Lamp Circuits

Faults most likely to cause given symptom are marked: •; other possible faults are indicated: ×

Symptom	Faulty lamp: Air leak or cracked tube	Faulty lamp: Broken electrode or lamp cap	Faulty lamp: Wrong lamp type or grade	Faulty lamp: Low emission	Faulty lamp: Life expired	Faulty quick-start: Open circuited winding	Faulty quick-start: Short-circuited windings	Faulty quick-start: Wrong type or connections	Faulty quick-start: Earth fault	Faulty quick-start: [illegible]	Faulty choke: Open-circuited winding	Faulty choke: Earth fault	Faulty choke: Short-circuited turns	Faulty choke: Wrong type or tapping	Faulty p.f. capacitor: Open circuit	Faulty p.f. capacitor: Earth fault	Faulty p.f. capacitor: Short circuit	Faulty p.f. capacitor: Wrong capacitance	Faulty p.f. capacitor: Faulty discharge resistor	Faulty wiring or circuit: Fault in lampholder	Faulty wiring or circuit: Components wrongly connected	Faulty wiring or circuit: No proper earth near lamp	Faulty wiring or circuit: Earth on wiring	Faulty wiring or circuit: Crossed wiring in two-lamp units	Faulty wiring or circuit: Wrong supply voltage	Faulty wiring or circuit: No supply or fuse blown	Temperature too low or high
...s not attempt to ... glow from ends	×	•				×	×	×	×			×								×	×		×			•	
...cker ...loes not ...e et ...lows red		×		×	•	×			×											×	×			×	×		
...ts gl... steadily doe... start			•	×	•			×													×	•	×		×		×
...ne end of lamp		×																		×	×						
...ts b... dim					×									×											×		×
...akes ...xcessive ...rt			×	×	×			×												×		×			×		×
...end-blacken...p			×					×					×	×						×	×			×	×		
... quick-start			×				×	×	×			×	×	×							×		×	×	×		×
...se ...wn or ...rode ...sed								×	×			×	×			×	×		×		×		×				
...r factor					•										•			×							×		
...radio interference					•																×						
...ault ...s been ...the ...sts to ...omponent is	LAMP: Check lamp in good circuit and if proved faulty replace with a new lamp; see note below					QUICK-START TRANSFORMER: Test windings for continuity, insulation resistance, and, if possible, secondary volts; check correct ...ing, rating					CHOKE: Check insulation resistance, continuity and, if possible, impedance. Make sure tapping and ...ung are correct				CAPACITOR: Check, if possible, insulation resistance and capacitance; measure value of discharge resistor					CIRCUIT: Check circuit against wiring diagram; examine all connections and terminals. Check fuses, supply voltage and, if possible, insulation resistance of complete fitting							

Remember: Never try a new lamp in a circuit w...th has sym... ...until it has been established that components or circuit are not faulty
If supply fuse has blown, suspect circuit or comp... ...replacing fuse

APPENDIX IIC

(*d*) Check that all holding-down bolts are tight; if direct coupled, look for the cause in the driven machine; uncouple the motor and check when running light.
(*e*) This trouble may be met with when replacement brushes are fitted; the whole contact area of the brush must 'bed' positively on the commutator.
(*f*) This is extremely unlikely to happen after a motor has been running satisfactorily; after a re-skim it may be discovered that the commutator is not true, or the fault may be due to some form of shrinkage due to faulty manufacture; in any case, the commutator must be turned true as a cure.
(*g*) The obvious correction is that the brush-rocker must be rotated to its correct position as previously described.
(*h*) This again is an unlikely occurrence in the normal run of events, but one which would cause permanently bad commutation. The best way to tackle a job of this description is separately to excite the field system, and then check the volt drop on each coil; the drop should be approximately the same, and any serious deviation, i.e., a low reading on one coil, will give an indication of the faulty unit.
(*i*) This fault will give a very poor commutation on load and is rectified by reconnection as given in a previous example.
(*j*) Various grades of brushes are fitted depending on the voltage, design and size of a machine. Always fit the grade of brush recommended by the maker.

3-PHASE MACHINES.

...cati... The motor refuses to start.

...ible Cause (*a*) Open circuit in the line brought about by blown fuse-elements, etc.
(*b*) Open circuit in the motor stator winding.
(*c*) Open circuit in the rotor winding with a slip-ring motor.

...c...n (*a*) Check line voltage with a voltmeter and examine for blown fuse-elements.
(*b*) Test the stator circuit for continuity by means of a 'megger' or test lamp.
(*c*) Test the rotor circuit for continuity, including the rotor winding itself.

...cati... The motor attempts to start but runs slowly and rapidly overheats.

...ible ...use (*a*) One phase short circuited or earthed.
(*b*) Overload at starting.

...ification (*a*) Test for a short circuit or for phases down to earth; these faults can only be remedied by a winding repair.
(*b*) Examine the driven machinery with a view to finding out what has brought about the increased starting load.

...cati... On load, the motor overheats.

...ible ...use (*a*) Overload.
(*b*) Excessive amount of [illegible]
(*c*) Stator short circuit [illegible]

...ification (*a*) Check over the exter[illegible] has caused the [illegible]crease.
(*b*) [illegible] is a very lik[illegible] in saw mills [illegible] into the moto[illegible] clogs up the ventilat[illegible] the result that the motor overheats; the [illegible] clean-out for the motor, or better still, insta[illegible] tota[illegible] closed motor.
(*c*) Test for a short circuit or earth as previously described.

...cati... The motor starts with difficulty, and when load is applied there is an excessive drop in speed.

...ible ...use [illegible] motor [illegible] loose.
[illegible] motor the rotor winding has an open [illegible]

Rectification (*a*) Examine the rotor for cracks or loose bars.
(*b*) Test across all three slip-rings for equal voltage drop; examine the motor starter for breaks in the rotor circuit; examine rheostats, etc.

5. Indication On closing the main switch, fuse-elements are blown or the main circuit-breaker trips. Do not immediately replace fuse-elements or circuit-breaker, and try again. First look for a possible cause, there is a reason for everything.

Possible Cause (*a*) A short circuit between stator phases or an earth.
(*b*) A short circuit in the leads between the main switch and the starter.
(*c*) The slip-rings of a slip-ring motor are short circuited.
(*d*) Some fool has left the starter handle tied over in the full 'on' position.

Rectification (*a*) Test for a short circuit or earth as previously described.
(*b*) Test for a short circuit in the connecting leads.
(*c*) This can best be discovered by lifting the motor brushes and applying a reduced voltage to the stator; if the motor runs at all then a short circuit exists.
(*d*) Get the under-voltage release coil repaired at once; this malpractice of locking the starter handle over should always be stamped on, as it cuts out any vestige of under-voltage and overload protection to the motor.

APPENDIX IIA

Common Faults and Their Rectification

The following notes are intended to act as a very general guide to the observation of the more common faults likely to be met. Briefly, the observations fall into two classes: (*A*) The installation of new or repaired motors, (*B*) Apparent faults after a period of satisfactory service.

(A) THE INSTALLATION OF NEW OR REPAIRED MOTORS

D.C MACHINES

1. Indication At starting, excessive heat is generated in the rheostatic starter accompanied by a current surge on the last stud which probably blows the fuse-elements.

Possible Cause (*a*) The starting conditions are too heavy for the starter.
(*b*) There is a break in the field circuit.

Rectification (*a*) Check the starting current, and either install a larger starter or reduce the starting load.
(*b*) Check for continuity of field circuit both in the motor and in the external wiring.

2. Indication At starting, as the starter handle is moved over, the motor runs first in one direction, then stops and reverses direction of rotation.

Possible Cause The compounding is reversed.

Rectification Re-connect and check polarity of shunt and series windings.

3. Indication On load, the motor overheats.

Possible Cause The load is too much for the motor.

Rectification Read motor current with an ammeter, check with the rating-plate, and either install a bigger motor or reduce the driven load.

4. ...ation Sparking on load.

... (*a*) Wrong voltage.
(*b*) Overload.
(*c*) [illegible] reversed.
(*d*) Wr[illegible]

...ectification (*a*) With a voltmeter, check [illegible] voltage is in accordance with the motor rating-plate.
(*b*) With an ammeter, check the armature c[illegible]nt, and if in excess, reduce the driven load or install a larger motor.
(*c*) Check connections and test the polarity of the compoles with a compass needle; with a motor these should be the same polarity as the preceding main pole taken in the direction of rotation.
(*d*) See that the brushes are in the neutral position; this position is attained when the white line on the brush-rocker is coincident [with] the white line on the end-sh[illegible] [F]or variable-speed motors the best [illegible] may not, of necessity, be the actual neutral position but, never[theless], the desired brush position is marked as above.

3-PHASE MACHINES.

1. Indication — The motor refuses to start.

Possible Cause
- (a) Open circuit in one of the lines: resulting in single-phase connection.
- (b) Breaks in the rotor circuit with slip-ring motors.

Rectification
- (a) Check line voltage with a voltmeter and examine for blown fuse-elements.
- (b) See that rotor circuit is complete from brushes to starter.

2. Indication — The rheostatic starter of a slip-ring motor becomes excessively hot during the starting period.

Possible Cause
- (a) The rheostat is not large enough for the starting conditions.
- (b) The starter has not been ordered to suit the rotor volts and amps.
- (c) Oil has not been put in an oil-immersed starter.

Rectification
- (a) Measure the starting current, and either change the starter or reduce the starting load.
- (b) Check that the rotor volts and amps. are the same for both motor and starter.
- (c) Fill to the required level with insulating oil.

3. Indication — On load, the motor overheats.

Possible Cause — The load is too much for the motor.

Rectification — Read motor current with an ammeter, check with rating-plate and either install a bigger motor or reduce the driven load.

4. Indication — Starting difficulty coupled with excessive slip on load.

Possible Cause
- (a) Wrong voltage.
- (b) Motor being run in the star connection instead of delta connection.

Rectification
- (a) With a voltmeter, check that the supply voltage is in accordance with the motor rating-plate.
- (b) Make the necessary alteration to the motor connections.

B) APPARENT FAULTS AFTER A PERIOD OF SATISFACTORY SERVICE

D.C. MACHINES

1. Indication — The motor refuses to start.

Possible Cause
- (a) More often than not line trouble, usually a blown fuse-element.
- (b) Worn and sticking brushes.
- (c) Break in motor field circuit.
- (d) Bearing seized in driving machine.

Rectification
- (a) Examine and replace fuse-elements where necessary.
- (b) Clean, and replace worn brushes, they should be a sliding fit in the [illegible]-boxes and there should be good commutator contact.
- (c) [illegible] field [illegible] for continuity—do not forget to include the starter [illegible] circuit test.
- [illegible] Endeavour to rotate the machine by hand.

2. Indication — [illegible] starts with difficulty [illegible] rheostatic starter.

Possible Cause
- (a) [illegible] in the [illegible] field circuit.
- (b) [illegible] the motor or starter.
- (c) The brush-rocker has moved from the correct position.

Rectification
- (a) Check the whole field circuit for continuity.
- (b) Disconnect the motor and starter, lift the brushes, and with a 'megger' test the armature, brushes, fields and starter for earth.
- (c) Re[illegible] the brush position: should, by any chance, the marking [illegible] have become obliterated, then very roughly the brushes should contact the commutator bar op[illegible] pole; final adjustment by trial and error can be resorted to.

3. Indication — The motor refuses to start on the first few starter studs, then suddenly races away. Excessive burning of the starter studs is observed.

Possible Cause — Some of the starter resistors are burnt out and open-circuited.

Rectification — Either have the resistors rewound or replace with a new rheostatic starter.

4. Indication — The motor gives an erratic starting performance and takes an excessive current both at starting and running.

Possible Cause — The armature windings have developed a short circuit.

Rectification — Repair is inevitable; a rough and ready check on this state of affairs can be carried out as follows: raise the brushes from the commutator and move the starter handle right over, thus fully exciting the fields. Remove belt and rotate the armature by hand, and if the armature is short circuited considerable resistance to rotation will be felt at two or more particular points on the armature surface.

5. Indication — On load, the motor overheats.

Possible Cause — The load is too much for the motor.

Rectification — Read motor current with an ammeter; should this be excessive, then check over the driven load and endeavour to find out what has brought about the increased load.

6. Indication — On load the motor takes excessive current, and it is observed that certain armature coils heat up after a short run.

Possible Cause — Commutator bars are short circuited.

Rectification — Examine the commutator for a short circuit caused by foreign material—should all the bars be separated by clean mica then the fault is internal and the commutator and/or armature winding must be repaired.

7. Indication — The motor sparks excessively with a 'climbing' type of spark; the mica between certain commutator segments is burnt.

Possible Cause — This is almost certain indication of an open circuit in the armature.

Rectification — Examine the armature to commutator connections for breaks, if a break cannot be seen then the fault is in the armature winding.

8. Indication — On load, certain brushes overheat and spark, when others remain normal.

Possible Cause — Brushes of varying grade have been fitted.

Rectification — Replace the wrong brushes; for a given machine all the brushes should be of the same grade and quality.

9. Indication — On load, the motor sparks, with the result that the commutator is blackened.

Possible Cause
- (a) Protruding commutator bars or high micas.
- (b) Incorrect spacing of brushes.
- (c) Brushes sticking in brush-boxes.
- [illegible] Vibration.
- (e) Brush[illegible] not bedding properly.
- (f) [illegible] or out of truth.
- (g) Brush-rocker misplaced.
- (h) A field coil may [illegible] required.
- (i) [illegible]
- (j) Wrong [illegible] fitted.

Rectification
- (a) This fault [illegible] usually be detected by sound or by [illegible] pencil [illegible] over the commutator surface when the machine [illegible] running. If the fault is a 'high' mica, this can be cured by undercutting; on the other hand should protruding commutator bars be the trouble, then the commutator will have to be re-skimmed.
- (b) This may happen after a repair, the point to bear in mind is that the brushes on two adjacent brush-holder arms must be spaced exactly a pole pitch apart; a very small deviation will result in [illegible].
- (c) This can be [illegible] by the elimination of dirt, d[illegible] [illegible] a comfortable sliding fit in their boxes.