Chapter I

D.C. ELECTRIC MOTORS

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. The purpose of this chapter is to provide general information on motors of orthodox construction (*fig.* 1) which, although they may vary individually, have certain items common to all.

DESCRIPTION

Field system

2. The magnetic system consists of a hollow cylindrical yoke in the bore of which the pole pieces are mounted. The latter, usually laminated and held securely in position by fixing screws, house the field coils which, suitably insulated, are wound round them. The ends of the coils are brought out to the appropriate terminals.

End frames

3. The end frames, secured to the yoke by through bolts or screws, house the bearings in which the armature shaft rotates. One end frame also houses the brush gear, access to the brushes being obtained through an aperture covered by a window strap.

Brush gear

4. The brush gear is insulated from the end frame which is usually slotted to allow slight circumferential movement of the brushes for adjustment. Pressure is maintained by springs which in some cases are adjustable.

Bearings

5. Bearings may be oil or grease lubricated, and may be fitted with a spring device for taking up end play. An oil thrower is sometimes fitted on the shaft on the inner side of the bearing to prevent oil or grease leaking on to the commutator.

Armature assembly

6. A conventional armature consists of laminations of soft iron built up on the main shaft. The windings are carried in skewed slots and are secured against centrifugal stress by slot wedges and steel binding wires. The leads from the armature windings are soldered to the appropriate commutator risers. The copper segments forming the commutator are insulated from the shaft and from each other by mica or micanite strips.

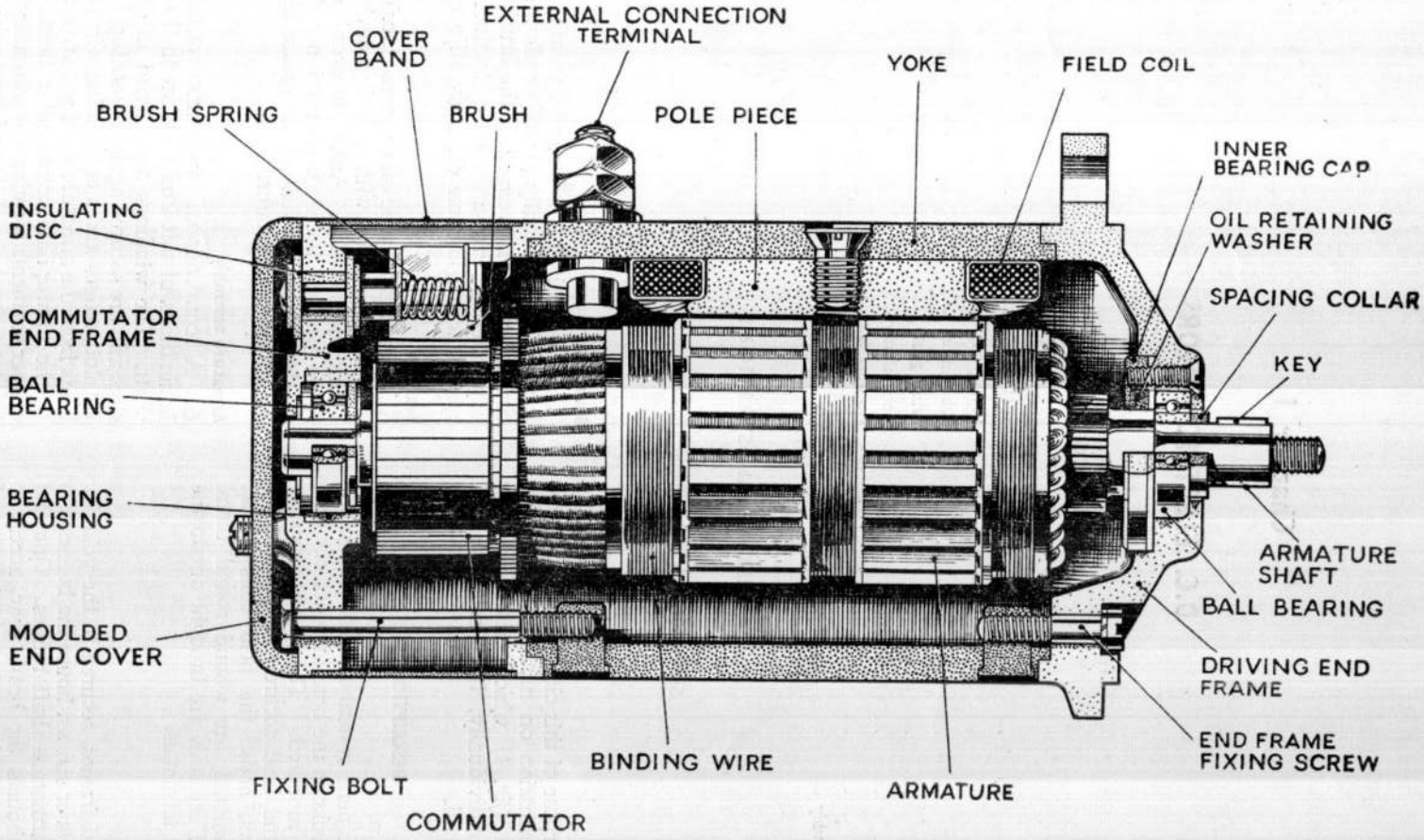

Fig. 1. Sectional view of typical motor

SERVICING

7. Since the general principle of design is similar for all electric motors used on aircraft, the following servicing instructions will apply, except where otherwise stated in a particular chapter.

8. Throughout the life of a motor, absolute cleanliness of the commutator and brush gear should be maintained and any small defect should always be rectified without delay, before it has time to cause further damage. During storage, motors should be kept dry and should not be situated near batteries, since the corrosive fumes which are emitted will, in time, cause damage to the motor.

Drying out

9. If, due to dampness, the insulation resistance of a motor should be found to be low, it should be dried out by the application of gentle heat. The temperature of the motor must, however, be maintained sufficiently low to enable a hand to be applied to any part of the exterior without discomfort.

Lubrication

10. Grease lubricated bearings are generally packed during manufacture and should not require any further attention except at major servicing periods. If, however, the bearings are repacked during servicing, it is important to ensure that they are never filled more than half full as the excess of grease will exude and cause electrical failure. The grease used must be completely free from moisture and grit.

11. With oil lubricated bearings, if the nipple is not easily accessible, the spring loaded ball may be held depressed with a piece of clean copper wire, the oil being allowed to run down the wire into the bearing.

Brush gear

12. The brushes must be free to move in their boxes and must bear evenly on the surface of the commutator; if the brushes stick, the inner surface of the boxes should be wiped with a cloth moistened with lead free gasoline. Never use waste which may deposit pieces of fluff in the motor. Persistent sticking may be cured by rubbing down the surface of the brush with fine glasspaper. The brushes should be examined regularly for wear and should be renewed before maximum wear has taken place, in order to ensure correct operation between inspection periods. It is also important that only brushes of the correct grade and type should be employed. The brush connections should be examined for looseness and frayed ends, and the brush spring pressure should also be checked. Where the brush springs are attached to moulded bars across the windows in the commutator end housing, the bars themselves should be examined for cracks.

13. When new brushes are fitted, they should be bedded down on the commutator by wrapping a piece of glasspaper (grade 00) round the circumference of the commutator in a direction opposite to the normal direction of rotation, so that the friction of the brushes, when the armature is turning, will cause the paper to tighten up on the commutator. The abrasive side of the paper should face the brushes. If possible, the glasspaper should be moved along the brush surface in the direction of normal rotation only, rather than to and fro. When new brushes are fitted, they should be examined again after a few hours' running in order to ensure that they are still free to move in their boxes, and are bedding down over the whole contact surface of the brush.

Commutator

14. Throughout the life of the motor, every opportunity should be taken to remove all loose carbon and copper dust by means of a pair of bellows or a blower. This procedure cannot be carried out too frequently and should always be done after adjustment of the brushes. Apart from this treatment, no further cleaning nor use of abrasives is permissible.

15. If the commutator has become pitted owing to sparking, or if flats have developed on the face, it must be removed from the housing and trued up in a lathe; this operation, however, is normally undertaken only at a repair depot. Instructions for this procedure will be issued in the appropriate chapter of Volume 6 of this publication. It is important, however, to locate the cause of the excessive sparking.

Location of faults

16. If the motor should fail to function, the terminal voltage should be checked in

order to ascertain whether the fault lies within the motor or the associated wiring. If no current is flowing but voltage is present, the defect may prove to be within the motor, and all connections, including those to the brushes and field coils, should be examined. The brushes should also be inspected to check that they are bedding down satisfactorily on the commutator. If the motor fails to function but a heavy current flows, a short-circuit may be suspected within the motor, or, if an automatic brake is fitted, the trouble may be due to the brake sticking on. Motors with series windings (most aircraft motors are of this type) should never be allowed to run without a load on more than half the rated voltage.

17. If these tests fail to reveal the cause of the trouble, the fault-finding chart (App. 1 to this section) should be consulted. If the cause of the trouble cannot be ascertained, the motor should be returned to a maintenance unit for reconditioning. When undertaking tests on electric motors, a growler (Stores Ref. 5G/2252), an armature drop tester (Stores Ref. 5G/2251) and a commutator mica undercutter (Stores Ref. 3A/1017) may be used where available. Information concerning this equipment will be found in A.P.4343S, Vol. 1.

Appendix I

FAULT FINDING (D.C. AND A.C. COMMUTATOR MACHINES)

Symptoms	Probable causes	Remedies
1. Sparking at the commutator.	Brush sticking in holder.	Clean with lead-free gasoline or rub down with fine glasspaper.
	Brush wrong way round in holder or improperly bedded.	Reverse brush or bed in correctly.
	Incorrect brush pressure.	Adjust to correct value. Ensure that brush is free in holder.
	Edge of brush broken away.	If long enough, re-bed, or fit new brush.
	Brushes worn to limit.	Fit new brushes and bed in correctly.
	Dirty brush or commutator.	Clean as described in para. 12 and 14.
	Where brushes are duplicated, one set overloaded due to poor contact of other set.	See that connections are tight and that pressure is correct on all brushes.
	Brush rocker loose or incorrectly set.	Adjust position of rocker and lock firmly.
	Brush holder damaged or loose.	Tighten up. If damaged, return to depot.
	Commutators uniformly blackened.	Return to depot for skimming.
	Proud micas.	Return to depot for undercutting.
	Grooved commutator.	Return to depot for skimming.
	Flat on commutator.	Return to depot for skimming.
	Grooves worn on commutator.	Return to depot for skimming.
	Commutator eccentric (brushes move up and down as armature rotates).	Return to depot.
	Broken coil or end connection (causes heavy sparking and local discoloration).	Drop test armature. If open or short circuited, return to depot.
	Excessive armature current.	Check that motor is not overloaded and that field current is normal. If correct, disconnect from supply and test insulation resistance; if low, dry out.
	Brushes of wrong size or grade.	Fit correct brushes.

APPENDIX 1—Fault finding (D.C. and A.C. commutator machines)—*contd.*

Symptoms	Probable causes	Remedies
2. Low torque.	Dirty commutator.	Clean as described in para. 14.
	High resistance or open circuit in field.	Test winding for continuity, see that connections are clean and tight.
	Friction.	Check bearings, automatic brakes and gearing for freedom.
3. Chattering brushes.	High or low commutator bars.	Return to depot for skimming and undercutting.
	Proud micas.	Return to depot for undercutting.
	Loose commutator bars.	Return to depot.
	Grooves or flats on commutator.	Return to depot for skimming and undercutting.
4. Overheating.	Overload.	Reduce load.
	Low insulation resistance.	Test insulation, clean and dry out; if ineffective, return to depot.
	Partial short circuit in one or more field coils.	Return to depot.
5. Shunt or compound motor runs overspeed.	Weak field.	Check field connections and insulations.
6. Motor runs below normal speed.	Overload.	Reduce load.
	Defective armature coil.	Drop test armature; if faulty, return to depot.
	Friction.	Check bearings, automatic brake and gearing for freedom.
7. Motor fails to start.	Failures of supply.	Check fuses, controls, gear, etc.
	Motor stalled due to overload.	Reduce load.
	Friction.	Check bearings, automatic brake and gearing for freedom.
	Open circuit in field or armature.	Return to depot.
	Short circuit in field coil.	If damp, dry out; otherwise return to depot.
	Brushes not in contact with commutator.	Clean brushes and holders, check spring pressure.
	Brush rocker out of adjustment.	Adjust and lock.
8. Motor runs in wrong direction.	Reversed connections.	Reverse connection to armature or field, but not both.

29542 435553 4470 5/54 3250 CWSLtd789 Gp539-2

Appendix 2

FAULT FINDING (A.C. INDUCTION MACHINES)

Symptoms	Probable causes	Remedies
1. Motor fails to start.	In multi-phase machine, one phase of supply open-circuited. Indicated by loud humming but failure to start unless assisted manually.	Ensure that all lines are live. If one has no supply, check fuses, control gear and connections. Open circuit may be between motor terminals and windings.
	In split-phase or capacitor single-phase motors, no supply to starting winding. Indicated by loud humming but failure to start unless assisted manually.	Check control gear or centrifugal starting switch if fitted. If in order, test starting windings for continuity. If faulty, return to depot.
	Friction. Motor hums loudly but will not start.	Check drive and automatic brake, if fitted.
	Overload.	Reduce load.
	In slip-ring motors, open-circuited rotor circuit. Loud humming and failure to start against load.	See that brushes are bearing on slip-rings. If correct, check that rotor resistances are not burnt out and that all connections are sound.
2. Motor overheats.	Overload.	Reduce load.
	Split-phase or capacitor motor running with starting winding still in circuit.	Check control gear of centrifugal starting switch.
	Open circuit in one phase of supply to multi-phase motors.	Test with voltmeter at motor terminals and see that all lines are live. If not, check fuses, control gear and connections. Check between motor terminals and windings.
	In multi-phase motor, one phase of stator winding open-circuited.	Test resistance between stator terminals; results obtained should be similar. Alternatively, for large motors check current in each line with motor running; results obtained should be similar.
	In multi-phase slip-ring machine, one phase of rotor winding open-circuited (associated with low torque).	No general test—see that brushes are seated correctly and connections to control gear sound. If trouble persists, return to depot.
	Supply voltage too high.	Check with voltmeter; if high, report to appropriate authority.
	Supply frequency below normal.	All induction motors on circuit affected. Report to appropriate authority.

APPENDIX 2 —Fault finding (A.C. induction machines)—*contd.*

Symptoms	Probable causes	Remedies
3. Motor runs below normal speed.	Overload; motor will overheat.	Reduce load.
	Low supply voltage.	Check with voltmeter; if incorrect, report to appropriate authority.
	Supply frequency below normal.	All induction motors on circuit affected. Report to appropriate authority.
	Pole-charge switch (if fitted) incorrectly wired.	Check connections.
	Slip-ring resistance not completely cut out.	Check controller.
4. Motor runs above normal speed.	Supply frequency above normal.	All induction motors on circuit affected. Report to appropriate authority.
	Pole-charge switch (if fitted) incorrectly wired.	Check connections.
5. Single-phase motor with centrifugal starting switch hunts at speeds below normal.	Overload. When starting winding is cut out, torque is insufficient to maintain normal speed.	Check drive and automatic brake, if fitted.
6. Loud buzzing while motor is running.	Loose laminations.	Return to depot.
7. Low torque.	Low supply voltage.	Check with voltmeter. If incorrect, report to appropriate authority.
	Control gear incorrectly connected (three-phase motor winding connected in star instead of delta).	Check and correct connections.
	Friction.	Check bearings, gearing and automatic brake, if fitted.
	In slip-ring motors, rotor resistance not completely cut out.	See that rotor controller functions correctly.
8. Sparking at slip-rings.	Incorrect brush pressure.	Adjust springs.
	Brushes incorrectly bedded.	Bed correctly.
	Flats on slip-rings.	Return to depot.
9. Motor runs in wrong direction.	Three-phase motor, reversed connections.	Reverse connections of two only of the supply lines.
	Single-phase motor, reversed connections.	Reverse connections to starting or running windings, but not both.

18811 38400 3412 7/53 3150 CWSLtd493 Gp539-2