CHAPTER 1

Care and servicing of aircraft generators

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Introduction

1. Generators are the basic source of supply for all electrical and radio equipment on an aircraft and it is absolutely essential that their operation is reliable. No adjustment or fault correction can be carried out during flight and every precaution must therefore be taken before flight to ensure that the generator will operate satisfactorily.

2. Although generators vary considerably in design and output certain servicing operations are common to all, and others to certain classes of generator. This common servicing information is contained in the following paragraphs. For detail servicing instructions, however, the section and chapter dealing with the particular machine must be consulted.

Two principles for reliable generator operation can be laid down briefly as follows:—

(i) Absolute cleanliness of all parts, particularly the brush gear and commutator, is essential.

(ii) Any defect, however small, should be immediately investigated and remedy effected.

3. Generators in store must be kept in a dry place and away from any acid as corrosive fumes might attack the metal and insulation. Generators should never be stored near accumulators or in charging rooms. If a generator is damp it should be kept in a dry atmosphere for some hours at a temperature not exceeding 100° C before being run up on load.

4. A special tool kit (Stores Ref. 5U/1201) is available for work on generators. A list of tools is given below.

Stores Ref. No.	*Nomenclature*	*Detail*	*Quantity*
*5U/1202	Blocks, stripping and assembly		1
5U/1203	Boxes, tool		1
	Drifts, ball race assembling:—		
5U/1204	No. 1	$\frac{7}{8}$ in. dia.	1
5U/1205	No. 2	$1\frac{1}{8}$ in. dia.	1
5U/1254	No. 3	0·63 in. bore	1
5U/1206	Extractors, ball race		1
	Spanners:—		
	Box, special:—	For commutator end	
5U/1207	$\frac{5}{16}$ in. B.S.F.		1
5U/1253	$\frac{1}{2}$ in. B.S.F.		1
5U/1208	Ring	For driving end	1

* Stores Ref. 5U/1202 consists of a block with splined hole for accepting the driving end of the shaft and supports the generator while dismantling and assembling.

Field system

5. The majority of aircraft generators are self-exciting, that is, they are dependent on the residual magnetism in the pole pieces for their initial excitation. If the pole pieces or yokes are subjected to a shock or sustained vibration the residual magnetism may be destroyed in which case the generator will fail to excite. There is also a marked possibility of the polarity being reversed once a machine has lost its residual magnetism. A test for reversed polarity is given in para. 27 (i).

6. Some generators are separately excited. These machines depend upon a separate source of supply for the excitation of the field coils.

7. Connections between the field coils and to the terminal block should be checked to see that they have sustained no damage, say by careless insertion of through bolts. All terminal block connections should be properly secured to prevent damage by vibration or chafing. If there is break in continuity within the coil winding, the coil should be renewed by authorized personnel only. Also if the coil is loose on the pole shoe insulation failure may result, the generator therefore must be passed to the authorized personnel for attention.

Bearings and lubrication

8. It is most important that the bearings should be free from dust and grit, as this and lack of proper lubrication, constitute a very common cause of bearing trouble. Detail inspection for mechanical defects is also of primary importance.

9. When a generator is dismantled the bearings should be carefully drawn off the armature shaft, using the ball race extractor provided in the tool kit. They should be then thoroughly washed out in Primer thinner, Stores Ref. 33B/510 (home) or 33B/512 (overseas), and blown clean by compressed air, if available. Examination should then be made for the following points:—

(i) Roughness or excessive play

(ii) Wear or fracture of cages

(iii) Slack fit on shaft or bearing turning in its housing.

For defects under the first two of these points the bearing should be renewed. If the conditions of sub-para. (iii) apply the bearing should be regarded as beyond Unit capacity for repair.

10. Bearings should be a light driving fit on the armature shaft. After a bearing has been refitted to the shaft it should be checked by rotating the outer race by hand. If it feels tight or rough, the bearing is probably too tight a fit on the shaft, and if another bearing of better fit is not available the generator should be returned to a Maintenance Unit. The driving end bearing should be a **light** driving fit, and the commutator end bearing a **close** sliding fit in their respective housings. If in any doubt as to bearing fit, the generator should be returned to a Maintenance Unit.

11. Where grease lubrication is used one quarter only of the available space in the bearing is to be packed with grease (Stores Ref. 34A/89) (1 lb. tins), surplus grease being removed. The inner and outer races are then to be rotated in opposite directions to distribute the grease evenly around the race surfaces. Any grease which has exuded during this operation is to be replaced evenly between the races.

12. Where oil lubrication is used, all the felt pads on both sides of the bearing should be thoroughly soaked with oil (Stores Ref. 34A/60) (1 quart tins), any surplus oil being wiped off. A small quantity of oil should then be introduced into the bearing itself and worked in by hand, after which the reservoirs and bearing should be assembled. It is most important that all the parts of the oil reservoir system should be replaced correctly, and if the felts which make contact with the shaft are worn, new felts should be fitted.

13. Special care should be taken to keep the bearings free from dirt or swarf when they are being lubricated and refitted. Most generators require to be dismantled completely or partially in order to be lubricated, and the work is therefore best done when the generator is dismantled for inspection at the appropriate inspection period. In a few installations, however, experience may indicate that more frequent lubrication is necessary.

Brush gear

14. Cleanliness of all internal parts of a generator is of the utmost importance in ensuring satisfactory operation. All dirt and brush dust should be removed by means of a clean cloth or small brush, particularly from the insulating surfaces of the brush rocker, terminals, and connecting rings (if fitted). If contaminated with oil or grease, the parts should be washed with a small quantity of clean petrol and dried thoroughly, by compressed air if available. Several washings may be necessary. Brushes which have been contaminated with even a small quantity of oil or grease should never be refitted, but should be replaced by new ones. If this is not done the oil will exude from the contaminated brushes when they warm up again in service, and will almost certainly cause trouble. For corrosion of brush springs see para. 19. Check the brush spring pressure against the figures quoted in the chapter dealing with the particular generator.

15. Brushes should generally be replaced when they have worn down to approximately half their original length. This can best be checked by comparison with a new brush. In general, partly worn brushes should be renewed if there is any doubt about their being able to give satisfactory service for the requisite number of running hours before the generator will again be due for inspection. If it is decided to replace the original brushes, they should be marked before being detached from the generator, so that each may be replaced the correct way round and in the same box from which it was removed. This is most important. All connections from the brush gear to the terminal block should be checked and made secure against damage by vibration or chafing.

16. Most types of generator brushes are supplied with the contact faces already shaped to fit the commutator. It is only necessary to fit these into the boxes and run the generator for a short time for bedding purposes. They should then be removed and any high spots carefully scraped off. Brushes on some older type generators are not shaped and must be bedded down. This should be done by cutting a piece of fine glass paper to the width of the commutator and long enough to pass completely round it with a considerable overlap. The glass paper is wrapped round the commutator in a direction opposite to the direction of rotation, so that when the armature is turned the friction of the brushes will tighten up the glass paper on the commutator. The armature is then rotated, preferably by hand, with the brushes in position and with the normal spring pressure applied; it must be rotated in the normal direction only and not backwards and forwards, so that the brushes will be bedded down in exactly the position in the boxes that they will occupy in operation. After the brushes have been roughly shaped in this way the glass paper should be removed and the generator run for a short time with the brushes in position, after which the contact surfaces should be examined and any high spots rubbed down. When new brushes have been fitted they should be examined again after a few hours' running to ensure that they are still free in the boxes.

17. Owing to the atmospheric conditions obtaining at high altitudes it is found that standard brushes on aircraft generators frequently wear at an excessively rapid rate. **On aircraft which fly at altitudes in excess of say 25,000 ft., special high altitude brushes must be used.** These are impregnated with a compound which provides a certain amount of lubrication and to a large extent prevents the excessive wear Generators fitted with such brushes should be marked with the words "HA BRUSHES" in 1 in. white letters. Care must be taken to renew these brushes when necessary with the correct type.

Method of checking brush position

18. (i) In order to obtain satisfactory commutation and avoid reversal of polarity, which may occur through retarded brushes, the brushes on d.c. engine-driven shunt-wound generators should be set between one half and one commutator segment in advance of the neutral position, i.e. moved in the direction of rotation from the neutral position.

(ii) On generators now being manufactured the correct brush position is, or should be, marked by corresponding white paint lines painted on the brush rocker and on the commutator end frame or on some part rigidly attached to the end frame or by some similar method.

If this has not been done, the correct brush position should be found as follows:—

(iii) Check that all brushes are bedding over their full width and at least 80 per cent of their area. If they are not, the generator must be run on the test bench with about one-quarter full load until this condition is attained.

(iv) Connect an accumulator of the appropriate voltage for the generator, through a tapping key, across the field winding. Ensure that the accumulator connections are made to terminals of corresponding polarity on the generator.

(v) Connect a millivoltmeter (say a Testmeter type "D" on the 0·15 volt range) directly across two adjacent brushes.

(vi) Make and break the field circuit and note the direction and magnitude of the throw of the millivoltmeter needle at "make". Turn the armature slightly and repeat for about six positions of the armature. Always turn the armature in its normal direction of rotation in order to maintain the brush seating.

(vii) Slacken the brush rocker clamping nuts or screws, move the brush rocker slightly and repeat (v) and (vi). If the average throw is increased, the rocker has been moved away from the neutral position; if decreased, towards it. If the throw is reversed the rocker has passed through the neutral position. Adjust the position of the rocker until the throw is approximately zero. (Actually no brush position will be found for which the millivoltmeter deflection is zero for any position of the armature. The neutral position is that in which, when "making" the field circuit, roughly as many deflections are obtained in one direction as are obtained in the other, for various positions of the armature).

(viii) Mark the neutral position thus obtained by pencil or other suitable means.

(ix) Rotate the brush rocker **in the direction of rotation of the generator** by between half and one commutator segment. Tighten the clamping screws or nuts and lock them.

(x) Mark the position of the brush rocker relative to the commutator end frame as outlined in (ii). Replace covers.

Cooling

19. Most aircraft generators employ a blast cooling system in which air passes over the commutator and brush gear. This often leads to corrosion of the brush springs. The latter should, therefore, be inspected and if necessary replaced with new.

20. Anti-corrosive treatment is to be applied to all air pipe caps, ring nuts and air pipe unions on airborne engine-driven generators. These parts are to be coated all over with pigmented lanolin (Stores Ref. 33C/524, 1 gal.; 33C/576, 2 gall.; 33C/585, 5 gall.), before and after assembly, whenever a generator is replaced in an aircraft and at each appropriate inspection period.

21. As air pipes are usually of thin aluminium they are often and easily damaged. Particular care should be taken to see that they are not bent or restricted, except as designed, especially at the intake or outlet apertures.

Commutator

22. Commutators must always be kept in good condition; they must be clean and must run perfectly true. Any dirt or irregularity will cause sparking which will quickly become worse and finally cause serious damage.

23. A commutator in good condition has a smooth brown surface, which should not be disturbed unless absolutely necessary. If it becomes uniformly blackened by sparking or by grease it should be cleaned with a rag sparingly moistened with petrol. The brushes should also be cleaned in the same way. If this treatment fails to remove the blackening the commutator must be lightly rubbed with fine glass paper. This should be done by folding a strip of fine glass paper over a piece of wood with a flat end and pressing it lightly on to the rotating commutator, the brushes having been removed. The width of the wood and glass paper should be less than that of the commutator and they should be moved from side to side to obtain an even action. No attempt must be made to remove more than the surface film of the commutator by this method. If the surface is irregular or if there is bad local blackening, the generator must be sent to a repair depot to have the commutator skimmed in a lathe.

24. The slots between the commutator segments, which have been formed by the cutting away of the mica insulation should be cleaned out with a penknife blade or piece of hacksaw blade which has been ground down to a suitable width so that it does not cut the copper segment. After this operation the surface of the commutator should be polished lightly with fine glass cloth (Grade 00) (Stores Ref. 33C/890)

Armature

25. If there is any sign of solder having been thrown from the binding wires or commutator risers, or, if the commutator surface is worn or scored, or the splines on the driving shaft are worn, the generator should be regarded as being beyond Unit capacity for repair. An armature should not be washed in petrol or other liquid as this usually results in driving brush dust further into the windings, thus encouraging breakdown. If the surface of the commutator is oily, however, it may be cleaned with a rag lightly damped with clean petrol.

Insulation resistance

26. After the various parts have been examined and cleaned, and before assembly, the following tests of insulation resistance should be made with a 250-volt insulation resistance tester.

(i) Field winding to frame
(ii) Brush gear and terminals to frame
(iii) Armature winding to shaft.

The resistance in each case should not be less than 0·01E megohms (where E is the output voltage of the generator being tested) or 0·2 megohms, whichever is the greater. The insulation resistance of armatures may sometimes be found to be lower than the values given above although the armatures may otherwise be in good order. This is almost invariably due to the presence of moisture, and the trouble can usually be overcome by keeping the armature in a dry atmosphere at a temperature not exceeding 100° C. for some hours. If after this treatment the insulation resistance fails to recover to the values given above the armature should be replaced.

TESTS

27. Before installing a new, or serviced generator, the following tests should be carried out, a bench testing set being used to drive the generator. Details of test circuits, equipment, and generator loadings are given in the individual generator chapters.

(i) Test for correct polarity by connecting a suitable moving coil voltmeter across the output terminals. Run the generator in its correct direction of rotation. The voltmeter readings should confirm the terminal markings. A central zero meter should not be used for this test owing to the possibility of confusion in interpreting the polarity. This test may be carried out simultaneously with test (iii).

(ii) See that the armature rotates freely without contact occurring at any point between the driving end oil thrower (if fitted) and fixed parts, or excessive play in the bearings. A very small radial play which can just be felt by the hand is permissible, provided the movement lies within the bearing and not between the bearing and either the shaft or the housing.

(iii) Connect the generator in the appropriate test circuit and run up on no load to approximately 4,000 r.p.m. Check that the correct voltage is attained and there is no hesitation in build up.

(iv) Switch on full load keeping the speed at approximately 4,000 r.p.m. In this condition no sparking should be visible at the brushes.

(v) Increase the speed to approximately the maximum value for *continuous* running. At this speed and with full load output there should not be more than slight pinpoint sparking at the brushes. The maximum speed of test set (Stores Ref. 5G/112), i.e. 6,450 r.p.m. is permitted for this test.

(vi) Run the generator with the commutator covers in place at its minimum speed for full load output for a period quoted under Testing in the individual generator chapter (usually about 10 minutes) without cooling air. At the end of this test the brushes should slide

freely in their boxes. The insulation resistance of all live parts together to the frame should then be measured with a 250-volt insulation resistance tester. The reading should not be less than 0·01E megohms (where E is the output voltage of the generator being tested), or 0·2 megohms whichever is the greater. If the insulation resistance of any generator is less than the figure specified it should be returned to a Maintenance Unit.

N.B.—The generator should not be run above the period specified for the foregoing test without cooling air or there will be serious risk of overheating and consequent damage.

(vii) All screws and nuts should have been tightened prior to the preceding tests, and these should now be locked where this is required.

28. TABLE OF FAULTS AND REMEDIES

Indication—Sparking at the commutator

Possible cause	*Remedy*
(i) Brushes and brush-holders:—	
(*a*) Brush not free in holder.	(*a*) If brush fits tightly it should be carefully rubbed down with fine glass paper until it is an easy fit in the holder, but not too loose.
(*b*) Brush inserted wrong way round in holder.	(*b*) See that efficient contact is obtained between brush and commutator over the whole brush area.
(*c*) Brush not properly bedded down.	(*c*) Bed down the brush as described.
(*d*) Insufficient pressure on brush.	(*d*) See that the full pressure of the spring is acting on the brush, that the fingers (if any) are not sticking at the pivots, and that the springs are not catching on the brush holder.
(*e*) Edge of brush broken away.	(*e*) Bed brush down as described until the full area of contact is obtained. If too much is broken away for this to be done a new brush must be fitted. The cause of breakage should be ascertained. It may be:— Defective brush—Brush should be changed. Proud mica (See (ii) (*c*)) High commutator segment—return generator to repair depot.
(*f*) Brushes worn away and too short in holder.	(*f*) Replace by new brushes and bed down as described. Unduly rapid wear of brushes is an indication of other trouble such as a rough or uneven commutator.
(*g*) Dirt collected on brush.	(*g*) Brush and commutator should be thoroughly cleaned.
(*h*) Where brushes are duplicated, one set overloaded, due to poor contact of the other set.	(*h*) Examine the other set of brushes and their connections.
(*i*) Brush rocker loose or moved to incorrect position, resulting in bad commutation.	(*i*) If the brush rocker has been marked to show its correct position it should be replaced in that position and securely locked, otherwise return the generator to repair depot for re-adjustment.
(*j*) Brush-holder not rigid.	(*j*) Tighten up all screws, bolts and nuts holding the brush-holder in position.
(*k*) Brush-holder damaged or bent, resulting in small contact area between brush and commutator.	(*k*) The generator must be returned for overhaul and repair.

Table of Faults and Remedies—*cont.*

Indication—Sparking at the commutator—*cont.*

Possible cause	*Remedy*
(ii) Commutators:—	
(*a*) Uniformly blackened.	(*a*) Clean the commutator as described in para. 23.
(*b*) Blackened or pitted locally.	(*b*) Return the generator to repair depot.
(*c*) Mica insulation between commutator bars projecting above the surface of the commutator ("proud mica"). This produces intermittent contact between brush and commutator..	(*c*) Return the generator to repair depot.
(*d*) Wear on the commutator by the brushes forming a shoulder against which the brushes may bear.	(*d*) Return the generator to repair depot.
(*e*) Formation of a flat on the commutator by continuous sparking, a blow, or by improper cleaning.	(*e*) Return the generator to repair depot.
(*f*) Commutator out of truth, as shown by up-and-down movement of brushes in their holders.	(*f*) Return the generator to repair depot.
(iii) Armature:—	
(*a*) A broken coil or end connection. This will produce heavy sparking in one place on the commutator which will rapidly pit the affected bar. It is readily distinguished from sparking due to other causes.	(*a*) Test the armature windings by the voltage drop method applied between commutator segments. If an open-circuit or short-circuit is detected the generator must be returned to depot for repair.
(*b*) Armature current excessive due failure of insulation.	(*b*) Disconnect the generator from the external circuit and test the insulation resistance. If the insulation resistance of the armature or field windings to earth, or between any two separate windings is low (see para. 26), the generator should be returned for repair.

29.

Indication—Low terminal voltage

(i) Failure to excite. A low voltage, derived only from the residual magnetism, is obtained. The failure may be due to:—	
(*a*) Dirty commutator.	(*a*) Clean the commutator and brushes as described.
(*b*) A hard glazed surface of high resistance may have been formed on the brushes if the generator has been run for a considerable period unexcited.	(*b*) Remove the hard surface by the method described for bedding down brushes.
(*c*) Disconnection or high resistance in field circuit.	(*c*) Ensure that all connections are clean and tight and test the windings for continuity.
(*d*) Incorrect direction of rotation.	(*d*) Ensure that the direction of rotation is correct.
(*e*) Loss of residual magnetism.	(*e*) Remagnetise the field by connecting an accumulator across the shunt field winding only, negative to negative.

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