Chapter I

AIRBORNE D.C. GENERATORS

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Introduction

1. Generators are the basic source of supply for all electrical and radio apparatus on an aircraft and it is essential that their operation be reliable. No adjustment or fault correction is possible during flight, consequently every precaution must 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. It is the servicing information which is common to aircraft d.c. low-voltage generators which appears in the following paragraphs. For detailed servicing instructions relating to a particular type of generator, reference should be made to the appropriate chapter in A.P.4343A, Vol. 1, Sect. 3.

General

3. Two principles for reliable generator operation are:—

(1) Absolute cleanliness of all parts, particularly the brush gear and commutator.

(2) Any defect, however small, should be investigated immediately and remedied.

STORAGE

4. Generators should be stored in as dry a place as possible. They should not be placed near any acid because of the effect of the corrosive fumes given off. For example, they should never be stored in battery charging rooms, or near batteries. If, on being removed from store, a generator is damp, it should be kept in a dry atmosphere, such as an oven, for some hours at a temperature not exceeding 100 deg. C. before being run up on load.

FIELD SYSTEM

5. The majority of aircraft d.c. generators are self-exciting: that is, they are dependent upon residual magnetism in the pole pieces for their initial excitation. If the pole pieces or yoke are subjected to a shock or sustained vibration the residual magnetism may be destroyed. The generator will then fail to excite. There is also a probability of the polarity of the generator becoming reversed if it is run with no residual magnetism in the pole pieces.

6. The polarity of a generator may be tested as follows. Connect a suitable moving coil voltmeter across the output terminals. Run the generator in its correct direction of rotation. The voltmeter readings should confirm that the terminal markings are correct. A centre-zero meter should not be used for this purpose owing to the possibility of confusion in interpreting the polarity.

7. Connections between the field coils and to the terminal block should be checked to see that they are secure, free of all rotating parts, and that they have sustained no damage due to vibration, chafing, or careless handling. If there is a break in continuity within the coil winding, the coil should be renewed by authorized personnel only. If the coil is loose on the pole piece insulation failure may result. Such a coil should therefore be made secure.

8. Some generators are separately excited. These machines depend upon a separate source of supply for the excitation of their field system.

BEARINGS AND LUBRICATION

9. It is current practice for the armature shaft in aircraft d.c. generators to be supported at each end by a ball or roller bearing. These bearings are lubricated with grease or with oil. It is of obvious importance that the bearings be kept free from dirt and foreign matter at all times as this, and lack of proper lubrication, constitute common causes of bearing trouble.

10. It is strongly recommended that bearings which are apparently satisfactory should not be removed from the shaft, but should be cleaned and re-lubricated in situ. If a bearing is faulty, it should be removed, using an appropriate extractor; bearings removed from the shaft, however, should not normally be re-fitted. Bearings should be thoroughly washed in clean, non-leaded gasoline or primer thinners, after which they should be blown clean with compressed air, if available. An examination should be made for roughness in turning; if this persists after successive washings, the bearing should be removed and discarded. Examination should also be made for obvious signs of damage to races and balls, and particularly for hair-line cracks in the ball-retaining cage. The outer ring of the ball bearing should be examined for signs of serious scratching and fretting corrosion. This corrosion has the red appearance of rust, and indicates that the housing is oversize and will need renewing.

11. On no account should bearings be fitted by hammer and drift. The recommended method is to heat the bearing in an oil bath to 90 deg. C., smear the shaft with light lubricating oil, slide on the bearing, and secure with the retaining nut, if fitted. The bearing should be slid squarely on to the shaft, taking care that no dirt is trapped between the inner ring of the bearing and the shaft flange, the whole operation being performed quickly before the shaft has time to warm up. Any bearing which does not slide on at this temperature should not be fitted, as it would be too tight on the shaft. After the bearing has thoroughly cooled, its normal lubricant should be applied.

12. Where grease lubrication is used, one quarter only of the available space in the bearing is to be packed with grease, surplus grease being removed. The inner and outer races should then be rotated in opposite directions to distribute the grease evenly around the race surfaces. Any grease which has exuded during this operation should be put back evenly between the races.

13. Where oil lubrication is used, the correct quantity and grade of oil should be applied to the bearing. It is usual for the oil to be put into a reservoir which consists of several felt pads fitted on both sides of the bearing. For specific instructions relating to this operation, reference should be made to the chapter in A.P.4343A, Vol. 1 which deals with the particular type of generator. After lubricating the reservoirs, a further quantity of oil may be introduced into the bearing itself, and worked in by hand, prior to assembling the reservoir and bearing.

14. Most generators require to be dismantled completely or partially before the bearings are accessible for lubrication. The work is therefore best done when the generator is dismantled for inspection at the appropriate servicing period. In certain instances, however, experience may indicate that more frequent lubrication is necessary.

BRUSH GEAR

15. During servicing, all dirt and brush dust should be removed, by use of a clean cloth, or small brush, particularly from the insulating surfaces of the brush rocker, terminals, and brush gear inter-connecting rings (if fitted). Any parts that are contaminated with oil or grease should be washed with clean non-leaded gasoline 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; they should be replaced with new. If this is not done, the lubricant will exude from the brush when it becomes warm during operation of the generator and will almost certainly cause trouble.

16. Brushes should generally be renewed when they have worn down to half their original length. This can best be checked by comparing the worn brush with a new one. Brushes which are partly worn should be renewed if there is doubt that they will function satisfactorily until the generator is next inspected. If it is intended to refit the existing brushes, they should be marked before being detached from the generator, so that each may be put back the correct way round and in the same box from which it was removed. This is important.

17. Most types of generator brushes are supplied with the contact faces already shaped to fit the commutator. In installing this type of brush it is necessary only to fit them in the brush boxes and then run the generator for a short time so that the brushes become bedded down. Next, remove the brushes and carefully scrape off any high spots. Brushes on certain older generators are not shaped and must be bedded to the contour of the commutator as follows.

18. Cut a piece of fine glass paper to the width of the commutator and long enough to pass completely round it with a considerable overlap. Wrap the glass paper round the commutator in a direction opposite to the direction of rotation of the commutator, so that, when the armature is turned, the friction of the brushes will tighten the glass paper on the commutator.

19. The armature should next be rotated, preferably by hand, with the brushes in position and with normal spring pressure applied. The armature must be rotated in the normal direction of rotation, so that the brushes will take up the exact position in the boxes which 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. The contact surfaces should now be examined and any high spots rubbed down. When new brushes have been fitted, they should be examined after a few hours' running to ensure that they are still free in their boxes.

20. Each brush in a generator is held in contact with the commutator by a spring, usually of the coiled clock-type, one end of which bears on the top of the brush. The pressure exerted by these springs is the same in each generator but varies from type to type.

21. The usual requirement, which should be checked during servicing, is that the brush spring pressure should lie within certain limits; these limits are quoted in the chapter dealing with the individual type of generator. The pressure may, in most instances, be checked by using a 4 lb. spring balance. The balance should be hooked beneath the brush spring at the point where it bears on the top of the brush and the reading taken when the spring is lifted, in a direction parallel to the centre line of the brush, just clear of the brush.

22. Most aircraft generators employ a blast cooling system in which air from the slipstream passes through the generator. This may lead to corrosion of the brush springs. The latter should therefore be inspected and, if necessary, renewed. Information concerning anti-corrosive treatment is given in para. 30.

METHOD OF CHECKING BRUSH POSITION

23. To obtain satisfactory commutation and to avoid reversal of polarity, which may occur through a retarded brush setting, the brushes on aircraft d.c., 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.

24. On most generators now in service the correct brush position is marked by corresponding white lines (or some similar marking) painted on the commutator end frame, or a part attached to the end frame, and on the brush rocker. The brush rocker is usually adjustable. Hence, to obtain the correct brush setting, move the brush rocker until the two markings line up and lock it in that position.

25. In some older machines there is no indication of the correct brush setting. It may be found by applying the following procedure:—

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

(2) Disconnect the field from the brushes.

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

(4) Connect a centre zero reading instrument (such as a millivoltmeter or galvanometer) directly across the brush bus-rings.

(5) 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 on the armature. Always turn the armature in its correct direction of rotation so that the brushes remain seated properly.

(6) Slacken off the brush rocker and move it slightly. Secure it temporarily in this new position. Now repeat tests (4) and (5). If the average throw of the needle 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.

(7) Adjust the position of the rocker until the throw is at a minimum. (Actually, no brush position will be found for which there is no deflection of the millivoltmeter needle at any armature position. 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.)

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

(9) The correct brush position relative to neutral is given in the chapters on individual generators in A.P.4343A, and the brushes should be set accordingly. Remove any old markings, mark the new position in pencil, and after the first bench running test mark permanently with white paint.

(10) Lock the brush gear in this position.

COMMUTATOR

26. 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 may finally cause serious damage.

27. A commutator in good condition has a smooth brown surface which should not be disturbed unless absolutely necessary. Carbon dust should be thoroughly removed, using an air blast, but no further cleaning nor use of abrasives is permissible. If the surface is irregular or if there is bad local blackening, the generator must be sent to a repair depot so that the commutator may be skimmed in a lathe.

ARMATURE

28. 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 despatched to the appropriate Unit for repair. An armature should not be washed in gasoline or other liquid, for this usually results in brush dust being driven further into the windings, thus encouraging breakdown. If the surface of the commutator is blackened, however, it may be cleaned with a cloth moistened with clean gasoline.

COOLING

29. Most aircraft generators employ a blast cooling system in which air passes over the commutator and brush gear or is passed through the yoke of the machine. In some instances a fan is also used. The passage of air in this manner is liable to cause corrosion of the brush springs; they should, therefore, be inspected and if necessary replaced with new.

30. 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 protective PX-3 (Stores Ref. 34B/584, 1 gall.; 34B/576, 2 gall.; 34B/585, 5 gall.), before and after assembly, whenever a generator is refitted in aircraft, and at periods specified in the relevant Servicing Schedule.

31. As air pipes are usually of thin aluminium they are easily damaged. Particular care should be taken to see that they are not bent or restricted, otherwise than as designed, especially at the inlet or outlet apertures.

INSULATION RESISTANCE

32. If the generator has been dismantled, the following insulation resistance test should be applied after the parts have been examined and cleaned, but before they are assembled. Use a 250-volt insulation resistance tester and measure the resistance of:

(1) Field winding to frame

(2) Brush gear and terminals to frame

(3) Armature winding to shaft.

The resistance in each instance should not be less than 0·01E megohms (where E is the voltage of the generator being tested) or 0·2 megohms, whichever is the greater.

33. The insulation resistance of armatures may sometimes be found to be lower than this figure, though the armatures are otherwise in good order. This is very often due to the presence of moisture; the trouble can usually be overcome by keeping the armature in a dry atmosphere at a temperature not exceeding 100 deg. C. for some hours. If, after this treatment, the insulation resistance fails to recover to the values quoted above, the armature should be replaced with new.

TESTS

34. Before installing a new or serviced generator, certain tests should be made, using a bench testing set to drive the generator. As these tests vary with each type of generator, the tests are detailed in the chapters dealing with particular types of generator; these chapters appear in A.P.4343A, Vol. 1, Sect. 3.

TABLE 1

Table of faults and remedies

INDICATION—SPARKING AT THE BRUSHES	
Possible cause	**Remedy**
(1) Brushes and brush-holder:	
(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 in holder	(b) See that efficient contact is obtained between brush and commutator over the whole brush contact face area
(c) Brush not properly bedded down	(c) Bed down brush as described in para. 18 and 19
(d) Insufficient pressure on brush	(d) See that the full pressure of the brush 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 down brush as described in para. 18 and 19 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 the breakage must be ascertained. It may be: Defective brush—Brush should be renewed Proud mica—Refer to sub-para. (2) (c) High commutator segment—Send the the generator for repair

TABLE 1—Table of faults and remedies—*contd.*

INDICATION—SPARKING AT THE BRUSHES—*contd.*	
Possible cause	**Remedy**
(1) Brushes and brush-holder—*contd.*	
(f) Brushes worn away and too short in holder	(f) Substitute new brushes and bed down as described in para. 18 and 19. 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 (*para.* 15 *and* 27)
(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 moved to that position and securely locked. Otherwise, return the generator to a repair depot
(j) Brush-holder not rigid	(j) Tighten the screws 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 sent to a repair depot
(2) Commutator	
(a) Uniformly blackened	(a) Send the generator to a repair depot
(b) Blackened or pitted locally	(b) Send the generator to a repair depot
(c) Mica insulation between commutator bars projecting above the surface of the commutator ("proud mica"). This produces intermittent contact between the brushes and the commutator	(c) Send the generator to a repair depot
(d) Wear on the commutator by the brushes forming a shoulder against which the brushes may bear	(d) Send the generator to a repair depot
(e) Formation of a flat on the commutator as a result of continuous sparking, a blow, or improper cleaning	(e) Send the generator to a repair depot
(f) Commutator out of truth, as shown by an up-and-down movement of the brushes in their holders	(f) Send the generator to a repair depot
(3) 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 sent to a repair depot

TABLE 1—Table of faults and remedies—*contd.*

Possible cause	Remedy
INDICATION—SPARKING AT THE BRUSHES—*contd.*	
(3) Armature—*contd.*	
(b) Armature current excessive due to failure of insulation	(b) Disconnect the generator from the external circuit and test the insulation resistance. If the insulation resistance of the field windings to earth, or between any two separate windings is low (*para.* 32), the generator must be sent to a repair depot
INDICATION—LOW TERMINAL VOLTAGE	
(1) 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 in para. 15 and 27
(b) A hard glazed surface of high resistance may have been formed on the surface of the brushes if the generator has been run unexcited for a considerable period.	(b) Remove the hard surface by the method described for bedding down brushes (*para.* 17)
(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) Remagnetize the field by connecting a battery across the shunt field winding only, negative to negative