# GROUP B.1 GENERATORS AND BATTERIES

(CODE GA)

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### Equipment employed

**1.** The major components employed in the generators and batteries circuit of this aircraft are listed below, together with the relevant Air Publications to which reference should be made for a detailed description and the necessary servicing required for the components concerned:—

| | |
|---|---|
| Generators, Type 515, 28V, 6 Kw. | *A.P.4343A, Vol. 1, Sect. 3* |
| Batteries, Type C, 12V, 25 A.H. | *A.P.4343A, Vol. 1, Sect. 11* |
| Voltage regulators, Type 94 | *A.P.4343B, Vol. 1, Book 1, Sect. 1* |
| Differential cut-outs, Type A, Mk. 1 | *A.P.4343B, Vol. 1, Book 2, Sect. 10* |
| Circuit breaker, 200 A *(gen. main)*, Type D | |
| Circuit breaker, 10 A *(gen. field)*, Type A.2 | |
| Voltage trimmer, Type 3; 5 ohm | *A.P.4343B, Vol. 1, Book 1, Sect. 1* |
| Relay, Type R *(battery)* | *A.P.4343C, Vol. 1, Book 2, Sect. 3* |
| Relay, Type S, No. 3 *(hold-off and crash)* | |
| Relay, Type 9B, No. 1 *(regulators)* | |
| Tumbler switch, D.P/C.O. *(normal-reset)*, Type XD.757/2 | *A.P.4343C, Vol. 1, Book 1, Sect. 1* |
| Warning lamp, Type B *(power failure)* | *A.P.4343E, Vol. 1, Sect. 18* |
| Magnetic indicator, Type A.2 | |
| Tumbler switch, S.P/ON-OFF *(battery master)*, Type XD.779/3 | *A.P.4343C, Vol. 1, Book 1, Sect. 1* |
| Relay, Type S, No. 1 *(fire extinguisher)* | *A.P.4343C, Vol. 1, Book 2, Sect. 3* |
| Suppressor, Type X3 | *A.P.4343C, Vol. 1, Book 3, Sect. 5* |
| Suppressor, Type B4 | |
| External supply plug | |

## DESCRIPTION

### Generators and batteries

#### Supply

**2.** Two d.c. generators, mounted on and driven by the engine accessories gearbox, supply the power for all the electrical services of this aircraft. The generators are connected in parallel and charge two batteries, which are connected in series and are mounted on a platform in the radio bay. To minimize radio interference, the main and field supplies from each generator are taken through a suppressor and a further suppressor is connected in the load balancing line from each generator. These four suppressors are located two on each side of the centre fuselage just aft of the generators. To enable earth return equipment to be used, the generator negative supplies are earthed to the aircraft structure at earth points 10 and 16 located adjacent to the generators.

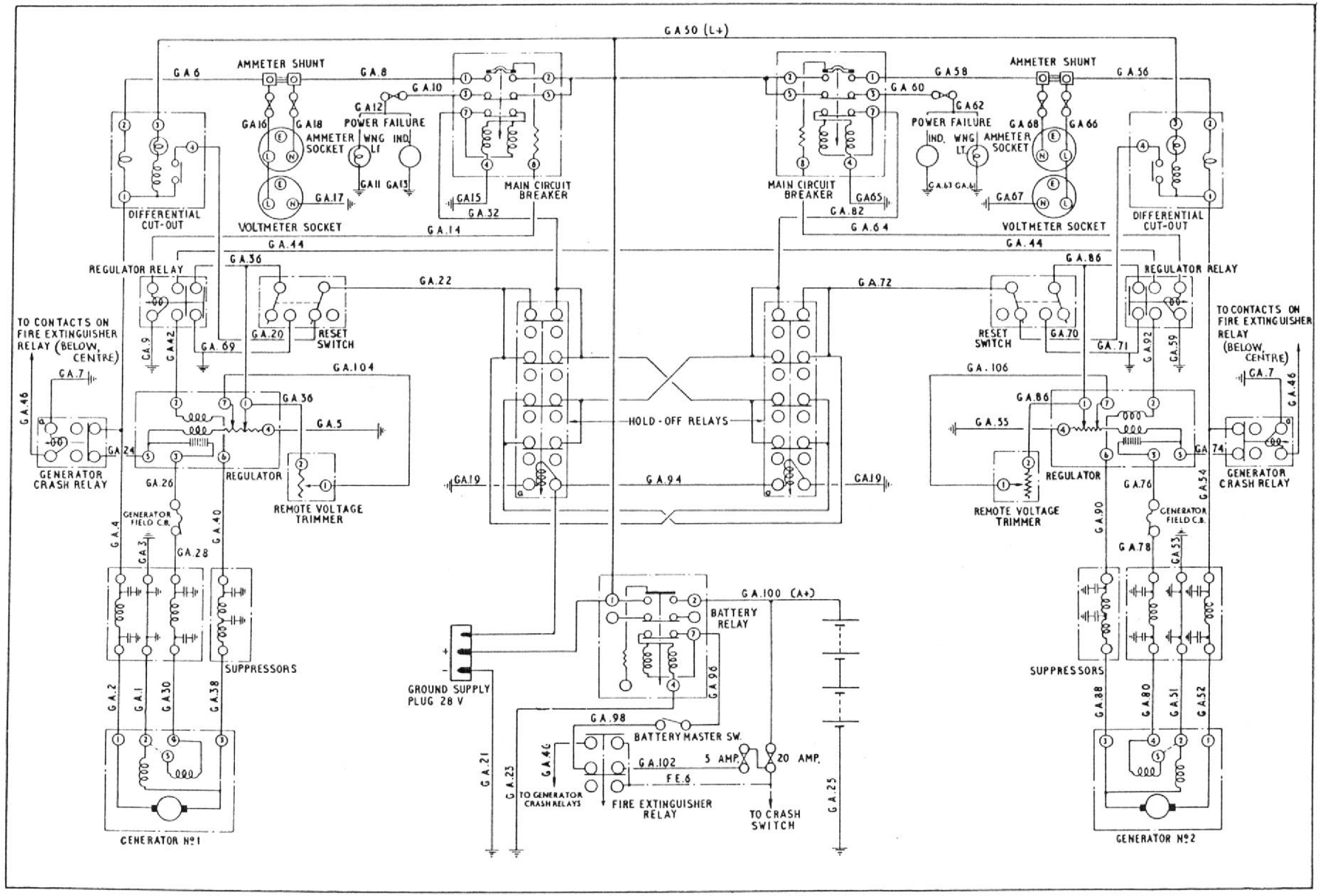


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**Fig. 1. Generators and batteries (theoretical)**

#### Generator controls

**3.** The generator controls are mounted on a panel located on the starboard side of the radio bay. This control panel covers the front of the supply panel, to which it is hinged at the top, and anchored at the bottom by four Dzus fasteners. Each generator is provided with its own set of control equipment. This comprises a voltage regulator with external trimmer, a differential cut-out, and circuit breakers for the generator main output line and the generator field windings, respectively. There are, in addition, a re-set switch, control relays, a power failure magnetic indicator and test sockets. Two eightway fuse blocks, containing the control fuses, are also mounted on this control panel, together with a tenway terminal block which is used to link all the earth leads of the control equipment.

**4.** A battery master switch is located on the leg panel in the cabin. When placed in the OFF position, this switch isolates the aircraft batteries from all the electrical services, with the exception of the essential load line and fire extinguisher circuit. The generator power failure warning lamps, which light whenever a failure of the respective supply circuit occurs, are also located on the leg panel. An external supply socket is provided, on the battery support structure, to enable an external supply to be connected to the aircraft services. It is most important that an external supply is used whenever an electrical supply is required for servicing, thus preventing the aircraft batteries being discharged.

### Operation

#### General

**5.** When two generators are operating in parallel it is essential, to ensure equal load sharing and stable operation, that they are regulated and aligned so that their outputs are as near equal as possible under all operating conditions. Each generator is, therefore, provided with its own control equipment and, although it operates as an independent unit having its own characteristic, when correctly regulated and aligned, it will tend to operate in conjunction with the other generator to share the load.

**6.** To bring a generator into operation on a line to which another generator is already connected, it is necessary to momentarily boost the regulator controlled voltage of the incoming generator so as to overcome the electromotive force of the first generator, which tends to oppose the current flow from the incoming generator. This boost is automatically obtained by increasing the resistance in series with the operating coil of the voltage regulator and consequently reducing the resistance in series with the generator field windings. This operation is effected by a trimmer resistance in the voltage regulator. During normal operation of the generator, contacts 5 and 6 of the regulator relay, which are closed because the relay is energized, automatically short-circuit the trimmer. During alignment of the generators, this trimmer may be short-circuited by use of the re-set switch *(para. 17)*. Additionally, contacts 3 and 4 of the relay serve to complete the load balancing line when the relay is closed *(para. 9)*.

#### Generation

**7.** As each generator control circuit is duplicated, it is only necessary to follow the operation of one generator and its control equipment to fully understand the circuit. When a generator commences to rotate, an increasing voltage is developed across the output terminals, due to the residual magnetism in the field. This output is fed to the differential coil of the cut-out and the operating coil of the voltage regulator, via the normally closed contacts *(2 and 2A)* of the generator crash relay, N or P *(para. 13)* and to the generator field windings, via the carbon-pile resistance in the voltage regulator. The generator field windings receive extra energization by this current which permits the output voltage to rise rapidly and this voltage builds up in opposition to the battery current passing through the differential coil windings and ballast lamp in the cut-out.

**8.** The differential coil windings are such that, when the generator output rises to a figure of 0·35 to 0·75 volt above that of the batteries, the current in the operating coil polarizes the armature sufficiently to cause it to move over and so close the contacts. This action energizes the closing coil of the main circuit breaker, via the re-set switch and hold-off relays, thus closing the main contacts so that the differential coil and ballast lamp are shorted out. The current now flows from the generator, through the series coil which holds the armature in the contacts-closed position, and in this position the polarizing magnets also bias the armature to this position.

**9.** At the same time, the auxiliary contacts of the circuit breaker are opened, thus inserting the hold-in coil into circuit and breaking the circuit to the power failure warning lamp and magnetic indicator. As the circuit breaker main contacts close, a supply is fed to energize the regulator relay, thus removing the regulator voltage boost *(para. 6)* and completing the circuit of the load balancing coil in the voltage regulator, when the second generator is also on the line. The load balancing coils are connected in series between the inner ends of the generator interpole windings.

**10.** The action of the operating coil in the voltage regulator is to adjust the resistance of the carbon-pile in series with the generator field windings, relative to the current drain and thus maintain the voltage constant throughout the range of operating speed and output. The function of the load balancing coil is such that it acts on the carbon-pile to reduce the voltage of the generator when it is overloaded in relation to the other generator and to increase the voltage when it is underloaded, thus the output is varied according to the load imposed and the load is shared more or less equally between the two generators.

#### Power failure

**11.** Power failure is indicated by one warning lamp and one magnetic indicator for each generator. When the generator voltage falls below that of the batteries, a reverse current flows in the series coil of the cut-out and this reverses the polarity of the armature and

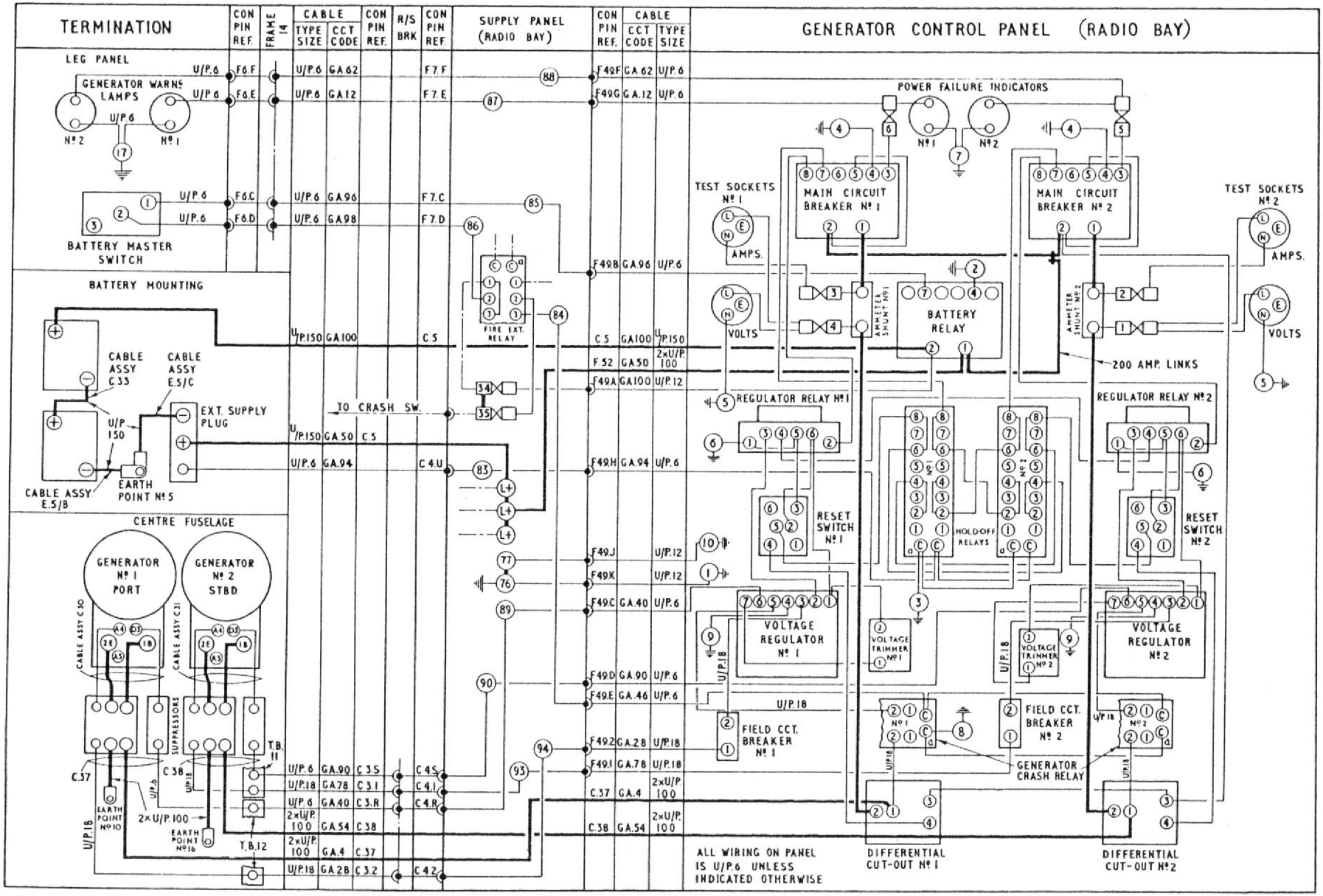


Fig. 2. Generators and batteries (routing)

opens the contacts. This action de-energizes the hold-in coil of the circuit breaker and breaks the main contacts, thus disconnecting the generator from the batteries. The contacts feeding the power failure warning lamp and magnetic indicator are made when the main contacts break and the lamp and indicator operate to indicate failure. At the same time, the regulator relay is de-energized to break the load balancing line and connect into circuit the trimmer in the voltage regulator, thus providing voltage boost, which, if the fault was of a temporary nature, will enable the generator to recommence operation in the normal manner. When the generator is shut-down *(i.e., engine stopped and batteries isolated)*, the armature of the cut-out is biased in the open position by the polarizing magnets.

**Batteries**

**12.** The batteries are connected to the positive bus-bars via the battery relay which is energized from the battery essential load line and controlled by the fire extinguisher relay and battery master switch. Placing the master switch in the ON position, with the fire extinguisher relay de-energized *(i.e., in its normal condition)*, energizes the closing coil of the battery relay and causes the main contacts to close and the auxiliary contacts to open. The batteries are thus connected to the bus-bars through the main contacts while the hold-on coil of the battery relay is energized by the breaking of the auxiliary contacts.

**Off-loading**

**13.** In the event of a crash landing, the inertia switch in the fire extinguisher circuit *(Group C.2)* will operate and energize the fire extinguisher relay which, apart from operating the fire extinguisher, will also break the supply to the battery master switch and battery relay, thus opening the main contacts of the battery relay and isolating the batteries from all but the essential load line and fire extinguisher circuit. At the same time, the fire extinguisher relay makes the supply to the generator crash relays, which become energized and break the supply to the voltage regulator operating coils, thus off-loading the generators.

**External supply**

**14.** When an external supply is connected to the external plug for testing the aircraft electrical equipment, the coils of the hold-off relays are fed from the external supply, via a 'loose' positive link, before the main positive connection is made. The hold-off relays are thus energized and break the feeds to the generator circuit breakers, the main contacts of which open to isolate the generators so preventing the external supply from attempting to 'motor' the generators. It is also advisable to place the battery master switch to the OFF position when the external supply is connected, to prevent the aircraft batteries being discharged should the external supply voltage fall below that of the batteries.

**Test sockets**

**15.** Voltmeter and ammeter test sockets, together with an ammeter shunt, are provided for each generator for use when adjusting the circuit *(as described in para. 17)*.

## SERVICING

**General**

**16.** For general servicing of the circuit as a whole, reference should be made to Group A.1 of this Chapter. Absolute cleanliness of all parts, particularly the generator brush gear and commutator, together with the immediate remedy of any defects, however small, is essential for the reliable operation of the circuit. The contacts of the cut-outs, circuit breakers and relays must be kept clean and the terminals of all components must be kept tight and free from corrosion. For functional tests and detailed servicing of the standard components used, reference should be made to the relevant Air Publications *(listed in para. 1)*.

**Paralleling of generators**

**17.** The generating circuit should always be paralleled after the fitment of a new generator, a new voltage regulator, a new cut-out or after any servicing which may have disturbed the alignment of the circuit and also when a check indicates that adjustment is necessary. The procedure, after the units have been adjusted on the bench as described in the relevant Air Publications *(listed in para. 1)*, and using an external supply, is as follows:—

**Note . . .**

*Before commencing operations, ensure that the aircraft batteries are at least 80% charged.*

(1) Start the engine in accordance with the instructions given in G.H.N. *(Ground Handling Notes)* and in A.P.4282, Vol. 1.

(2) Connect the test lead to a 0-30 volt voltmeter to No. 1 generator voltmeter test socket.

(3) With the engine running at normal cruising speed *(6,000 r.p.m.)* and No. 1 generator re-set switch set to RE-SET *(generator off-load)*, adjust the external voltage regulator trimmer resistance until $28 \pm 0{\cdot}25$ volts is indicated on the voltmeter.

(4) Increase and decrease the engine speed at least three times and then check the voltage again at the original r.p.m. to ensure that it is still at $28 \pm 0{\cdot}25$ volts.

(5) With the engine running at approximately 6,000 r.p.m., check the load balancing coil by connecting a voltage of 0·25 volts across terminals 2 and 6 of No. 1 generator voltage regulator, terminal 2 being connected to the positive side of the supply. The regulated voltage should be reduced by 2 to 2·5 volts.

(6) With the engine still running at 6,000 r.p.m., check that the regulated voltage is increased by $1 \pm 0{\cdot}25$ volts whenever the re-set switch is set to NORMAL.

(7) Slow down the engine to idling speed and remove the voltmeter from No. 1 generator voltmeter test socket and connect it to No. 2 generator voltmeter test socket.

(8) Adjust the voltage regulator for No. 2 generator by repeating operations (3), (4), (5) and (6).

(9) Remove the top cover of No. 1 generator cut-out.

(10) Slowly increase the engine speed until the cut-out contacts close. This should occur when the generator voltage is 0·35 to 0·75 volts above that of the positive bus-bars, as measured between terminal 1 of the cut-out and terminal 2 of the main circuit breaker.

**Note . . .**

*An instrument such as the testmeter, Type D (Ref. 10S/10610) should be used for this purpose.*

(11) Should the differential voltage be slightly above the top limit of 0·75 volts, it is not recommended that any attempt be made to reset the value within the above limits, as no harm will result.

(12) If, however, the figure obtained in operation (10) is well outside the range quoted, the adjusting screw in the relay adjacent to the ballast lamp should be re-set until the armature snaps over at the required value.

**Note . . .**

*When the correct setting is obtained, operation (10) should be repeated a few times to ensure that the setting is stable.*

(13) Slow down the engine to idling speed, set No. 2 generator re-set switch to NORMAL and No. 1 generator re-set switch to RE-SET.

(14) Remove the top cover of No. 2 generator cut-out and adjust this cut-out by repeating operations (10) to (12) inclusive.

(15) Disconnect the external supply.

(16) Reduce the engine speed to 2,750±100 r.p.m. and adjust the cut-out, by means of the adjustable contact screw, so that its contacts open at this speed.

(17) Connect the test leads of an ammeter to the ammeter test socket of No. 1 generator. Check that, with the cut-out contacts open, a reverse current of 15 to 25 amps. is indicated on the ammeter.

**WARNING**

Before inserting the ammeter, it is important to ensure that the voltmeter is not in circuit, as damage may be caused to the ammeter should its shunt be isolated due to the non-fitment or failure of its fuse while both instruments are in circuit.

(18) Adjust No. 2 generator cut-out by repeating operations (16) and (17).

(19) The cut-outs are now adjusted and the adjusting screws should be sealed with shellac varnish and the top covers re-fitted.

**Note . . .**

*The covers should not remain off longer than necessary.*

(20) Both generators are now correctly regulated and are ready for paralleling.

(21) Slow down the engine to idling speed, place both re-set switches to the NORMAL position.

(22) Increase engine speed gradually to the full engine speed of 7,950 r.p.m. and note that the power failure magnetic indicators on the generator control panel and the warning lamps in the cabin are operating approximately together.

(23) Slow down the engine to idling speed and insert voltmeters into both voltmeters test sockets. Increase engine speed and check that the voltage indicated on both instruments is approximately equal at all speeds.

(24) Again slow down the engine to idling speed and remove the voltmeters. Insert ammeters into both ammeter test sockets and increase engine speed gradually to the full engine speed. Check that the current indicated on both instruments is approximately equal at all speeds.

(25) Check the voltage regulators for stability by switching on a typical flight load *(e.g. flight instruments, radio and radar ranging)*. At an engine speed of 6,000 r.p.m., switch one of these loads *(e.g. flight instruments)* on and off at least three times. Under these conditions the regulators should respond without any tendency to hunt.

(26) The generating circuit is now aligned and the engine may be stopped and the voltmeters and ammeters removed.

## REMOVAL AND ASSEMBLY

### General

**18.** The removal of the generator control panel, which carries the majority of the equipment forming the generating circuit, is covered in Group A.2 of this Chapter. The removal of the batteries is given in the following paragraph. Once clear access has been obtained, the removal of the generators and other components of the circuit, should present no special difficulties.

### Changing batteries

**19.** The two batteries are carried on platforms located in the radio bay in the front fuselage and access may be gained via the radio access doors *(Sect. 2, Chap. 4)*. The procedure for changing the batteries is as follows:—

(1) Ensure that the battery master switch is in the OFF position.

(2) Disconnect the leads from each battery and place in such a position so that they will not short on the aircraft structure. *(Use dummy stowages if fitted.)*

(3) Release each battery and carefully remove from the mounting platforms.

(4) Place the replacement batteries on the platforms and reverse the procedure in sub-paras. (2) and (3).