Chapter 9 D.C. POWER SUPPLIES

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

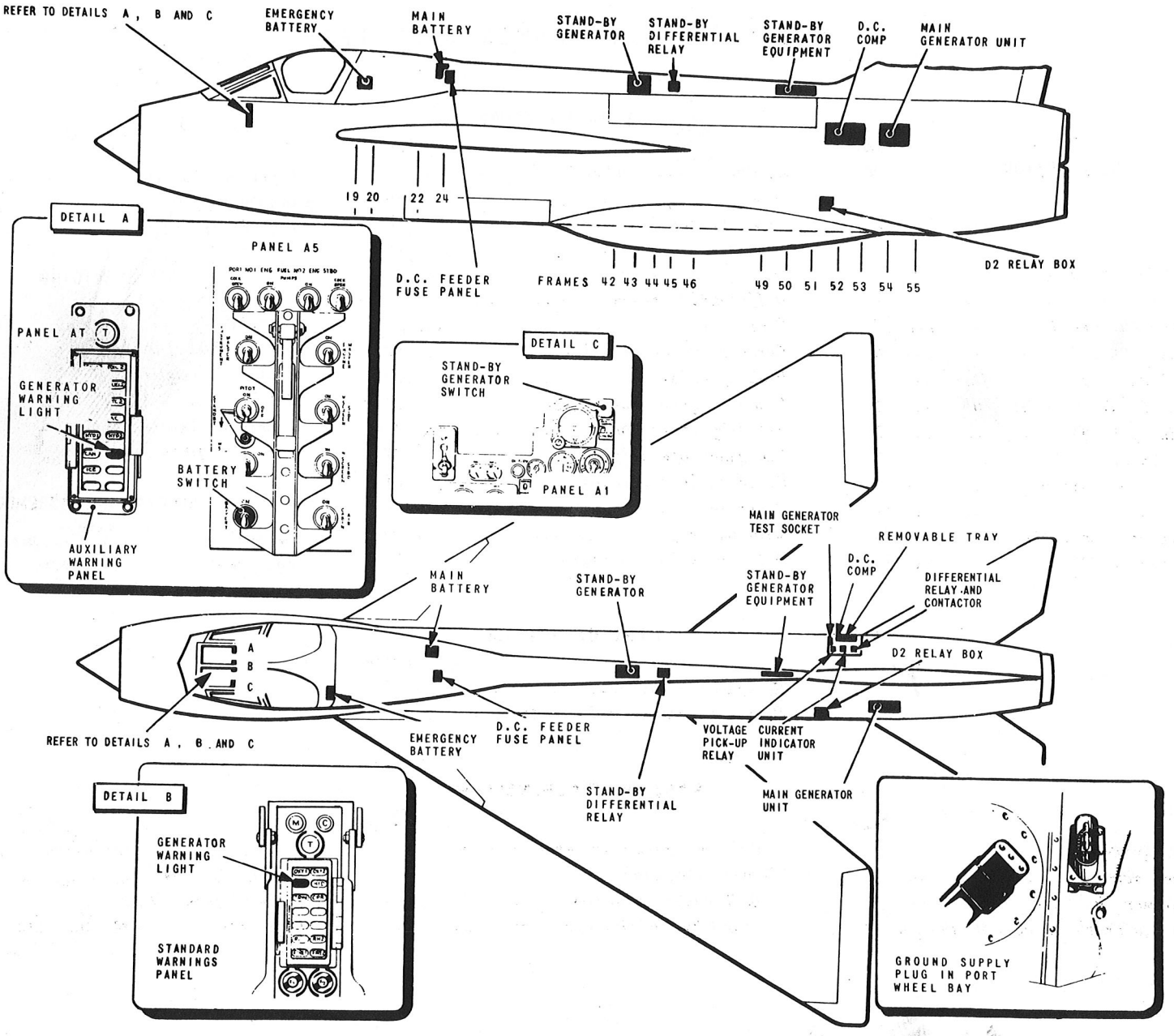

FIG.1. D.C. POWER SUPPLIES

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lay are a heavy current coil, and a pair of contacts which open when the coil is sufficiently energized by the current flow through it.

Main generator operation

9. The generator output is applied to the coil of the voltage pick-up relay via two resistors which set the pull-in voltage at 16 to 18 volts. When the relay operates, the auxiliary contacts open, connecting a further two resistors in series with the coil, which reduce the hold-in current and determine the drop-out voltage. The main contacts close, connecting the generator output to the voltage coil in the differential relay and contactor. The voltage coil is then connected between the generator output and the busbars via the overload relay contacts and coil.

10. The reverse potential existing across the differential relay energizes the overload relay, connecting the overload resistor in series with the voltage coil to limit the coil current. As the generator voltage approaches the busbar voltage, the overload relay closes. When the generator voltage exceeds the busbar voltage, by 0.3 to 0.6 volt, the differential relay, actuated by the voltage coil, closes to energize the main contactor coil. The contactor then closes, connecting the generator to the busbars. Closing of the contactor also short-circuits the voltage coil, the differential relay being held in by the current coil in series with the contactor.

Shut-down

11. When the generator output voltage falls below the busbar voltage a reverse-current of 15 amp. in the current coil results in the dropping out of the differential relay and the contactor. The overload relay then operates, protecting the differential coil until the generator is finally isolated from the busbar when the voltage pick-up relay drops out between 10 and 15 volts.

Voltage regulator operation

12. The voltage regulators used in both main and stand-by systems are essentially similar except for the location of their voltage setting trimmers. In the main system the trimmer is a separate component whilst that for the stand-by system is integral with the regulator unit. The following description of voltage regulator functioning is applicable to the regulators used in both systems.

13. The field current and hence the generator output is controlled by operation of a carbon pile. When the carbon pile is contracted, its resistance decreases and increases when the pile is extended. Two coils, one for coarse adjustment and one for fine trimming, vary the setting of the pile according to the generator output voltage. The coarse coil is connected in series with a resistor, which can be varied for setting up the voltage initially, across the generator output. A rise in output voltage increases the current in the coil which causes the pile to extend, increasing its resistance, thus reducing the field current and hence the generator voltage. The secondary winding of a transformer is connected in series with the coil and control resistor. The transformer primary is connected in parallel with the generator field so that a changing current in the field winding produces a transient output from the transformer secondary. This output is fed to the coil to stabilize the generator output and reduce the tendency to overshoot. In this manner the output voltage is controlled at approximately 28 volts which is then accurately trimmed to the required limits by the fine coil and transistorized circuit.

14. The base of transistor T1 is held at constant potential, irrespective of changes in output voltage, by the zener diodes. The base of transistor T2 is connected to a tapping on the potentiometer across the generator output. A rise in output voltage increases the base-to-emitter voltage of transistor T2, causing an increased current to flow in the T2 collector-emitter circuit which raises the emitter potential. This increased potential is also applied to the emitter of T1 and, since the base potential is held constant, the base emitter current decreases. The collector current also decreases whilst the collector potential increases and is applied to the base of T3. The collector current, which is also the base emitter current of T4, increases and the subsequent rise in T4 collector current is used to extend the carbon pile by means of the fine trim coil. The generator voltage is thus trimmed to set the voltage at the busbars to 28

volts. The trimmer on the stand-by regulator and the remote trimmer for the main regulator are used to compensate for the cable resistance in the aircraft installation.

Generator test socket

15. A three-pin socket for use when making functioning checks on the main generator system is fitted on the aft face of frame 52 in the d.c. compartment.

STAND-BY GENERATOR SYSTEM

General

16. The stand-by power supply is provided by a turbine/generator unit installed with its control equipment in No.2 engine hatch. The turbine air supply is controlled by a shut-off valve installed between frames 43 and 44 starboard, and an isolation valve installed between frames 46 and 47, starboard. Both valves are solenoid-operated components.

Stand-by turbine/generator unit

17. The Type BT.0102 turbine/generator unit consists of a 28-volt, 3.5 kW d.c. generator, Type B.3601, and a five-inch axial turbine coupled to its extended armature shaft. The turbine air supply is bled from the compressor stages of both engines. Restriction on the size of the turbine wheel limits the generator to a maximum output of 2.8 kW (100 amp). Selecting the stand-by generator switch to STANDBY operates the shut-off valve to open the air supply line to the turbine, and a governor-controlled valve maintains the generator speed at approximately 12,000 rev/min by regulating the turbine input pressure according to the output load. The turbine wheel is designed to disintegrate at critical overspeed to protect the generator. In this event a rotating shroud fractures, and the turbine blades are released and contained within the turbine housing. The isolating valve protects the stand-by system in the event of a burst pipe in the main turbine supply system. Energizing (closing) of the isolating valve ensures that the turbine can be driven from at least one engine by preventing both engines feeding into the burst pipe *(refer to fig.6)*.

Generator

18. The Type B.3601 generator is a shunt-wound unit, internally suppressed against radio interference, which is cooled by blast air piped from outside the fuselage. It is controlled by a voltage regulator, differential relay, contactor, and voltage pick-up relay. The circuit also incorporates a current indicator relay used in the generator failure warning system. The generator field circuit is connected to the voltage regulator via the crash relay which opens if the inertia switches operate during a heavy landing.

Voltage regulator

19. Automatic voltage control of the stand-by generator is effected by a Type 31/63553Z voltage regulator. Except that it embodies an integral trimmer for voltage adjustment, this unit is essentially similar to the main generator voltage regulator described in para.4.

Differential relay

20. This relay, Type F.8001, mainly comprises a solenoid/resistor assembly,

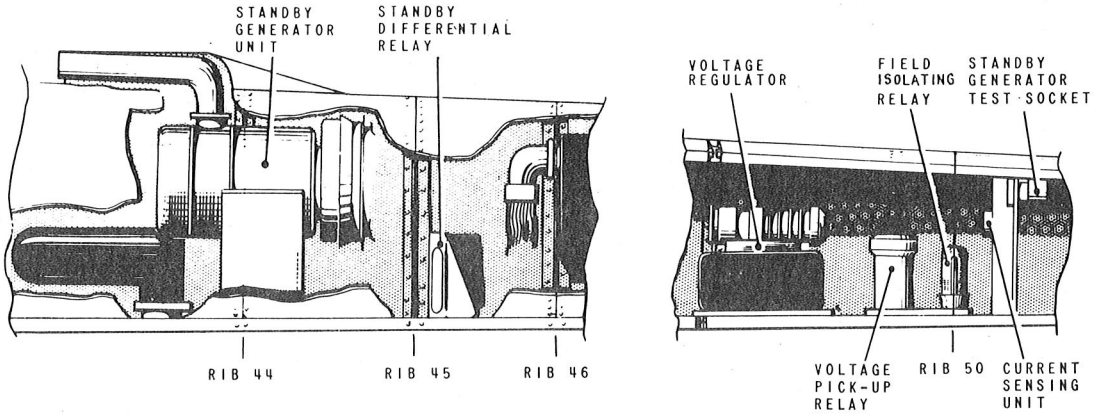

Fig.3. Stand-by equipment in rear spine

DESCRIPTION

Introduction

1. The aircraft 28-volt d.c. power supply is normally provided by a main generator having a rated output of 4.5 kW. In the event of failure of the main generator, a stand-by generator providing a maximum supply of 2.8 kW can be brought into operation. Two batteries, a main and an emergency, are installed. The main battery maintains the d.c. supply during the change-over from main to stand-by operation and provides sufficient power for a double start of the engines. The emergency battery supplies the power to operate the stand-by U.H.F. system, emergency cockpit lighting, and stand-by flight instruments.

MAIN GENERATOR SYSTEM

General

2. The normal d.c. supply is provided by a Type B.3002/1 generator which is a shunt-wound, blast-cooled unit with an output of 4.5 kW over a speed range of 7600 to 8400 rev/min. The generator is driven through a gearbox by the same turbine as the a.c. generator and is installed at the port side in the rear fuselage, between frames 53 and 55. With either engine running at 48% maximum rev/min, sufficient air is fed to the turbine to bring the generator on to line. On shut-down, the generator is disconnected when the engine speed falls below approximately 40% maximum rev/min, depending on loading and the state of the battery.

Generator control circuit

3. Control of the main generator is effected by a voltage regulator, a combined differential relay and contactor, and a voltage pick-up relay, all installed in the d.c. compartment between frames 52 and 53, starboard. The voltage regulator, together with its separately-mounted trimmer, three relays and a number of terminal blocks, are assembled on a tray below the other components. Also incorporated in the generator circuit is a current indicator relay, used in the generator failure warning circuit, and a field isolating relay which is connected in the inertia crash switch circuit.

Voltage regulator

4. The output of the main generator is automatically controlled to 28.5 volts by a Type 31/63705Z voltage regulator incorporating a carbon pile, main and auxiliary coils, and a transistorized amplifier. Voltage adjustment is effected by the separate trimmer, fitted to the equipment tray, which provides for a variation of approximately 0.5 volts above or below 28.5 volts. The regulator operates in conjunction with a field isolating relay and the inertia crash switch circuit.

Field isolating relay

5. Two normally closed contacts of this Type 7CZ/107791 relay (No.5 in the D2 relay box on frame 53 port) are paralleled and connected in series with the voltage regulator and generator field circuit. In a heavy landing which causes the inertia switches to operate the relay becomes energized and its contacts open, breaking the field circuit and shutting down the generator.

Differential relay and contactor

6. The main components in this Type F.2236 unit are a differential relay, overload relay, and contactor which operate with the voltage pick-up relay. At a predetermined generator voltage, the pick-up relay closes to energize the differential relay and initiate a switching sequence connecting the generator to the main busbar PL. Auxiliary contacts on the contactor are arranged to control the main generator failure warning circuit of the auxiliary warnings system.

Voltage pick-up relay

7. The Type F.3133 pick-up relay is employed as a protective device in the generator circuit; it consists mainly of an operating coil, two pairs of contacts, two swamping resistors, and two economy resistors which are shorted out until the coil is energized. The contacts controlling the differential relay and contactor close between 16 and 18 volts as the generator voltage increases, and open between 15 and 10 volts as the voltage decreases.

Current indicator relay

8. Indication of both main and stand-by generator failure is given by the standard warning system which is jointly controlled by a Type F.8101 current indicator relay in series with the differential relay and contactor and the main busbar PL, and an identical indicator relay in the stand-by generator circuit. The main components of the re-

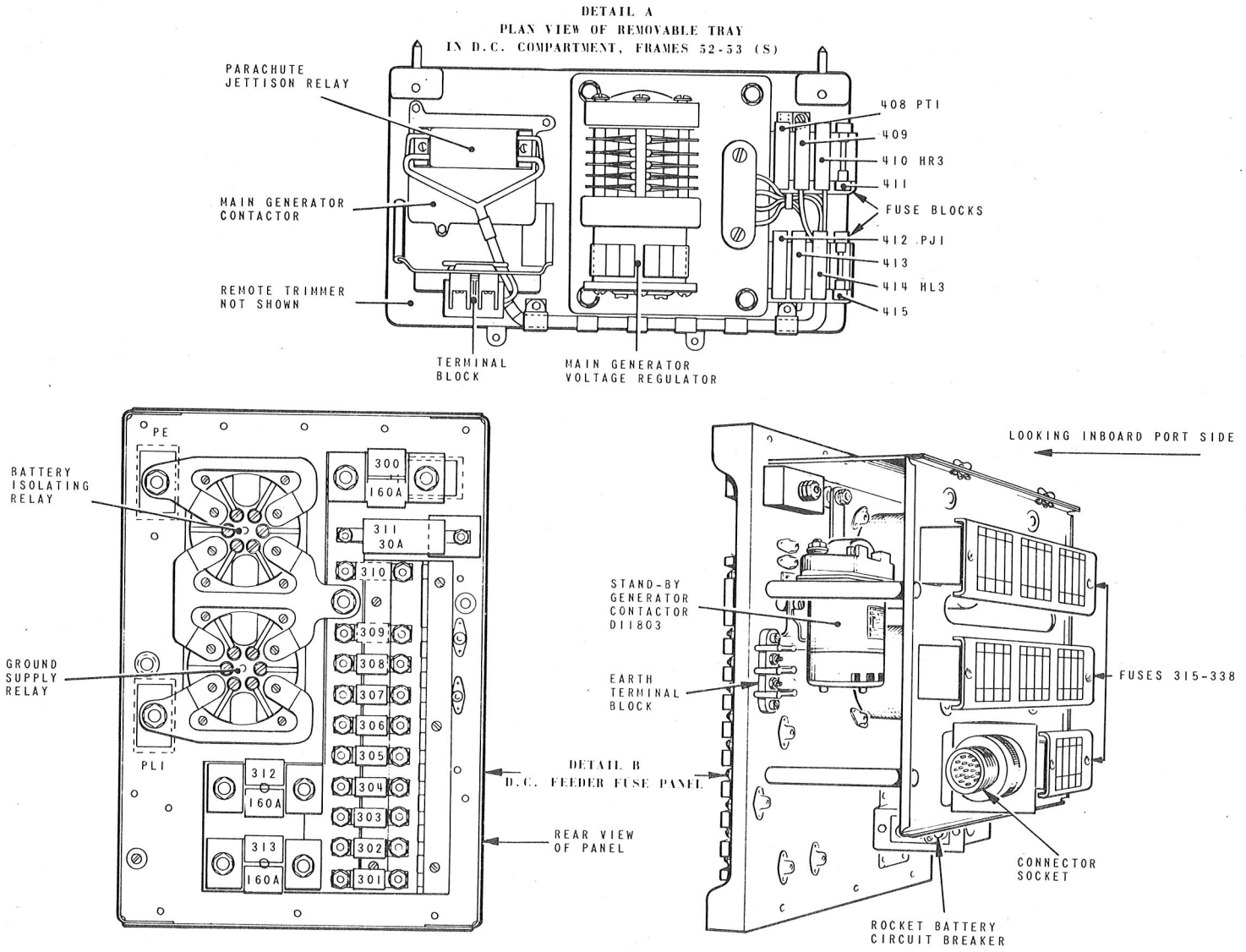

FIG. 2 D.C. EQUIPMENT DETAILS

F2520-1

a series coil carrying the generator output, and a pair of contacts which, when closed, complete the circuit to the main contactor. The solenoid/resistor circuit is energized through the closed auxiliary contacts of the contactor unit, and the contacts of the pick-up relay when this is closed. The relay closes when a differential between 0.2 and 1 volt is present across the solenoid coil, and opens when a reverse current between 8 and 12 amp passes through the series coil.

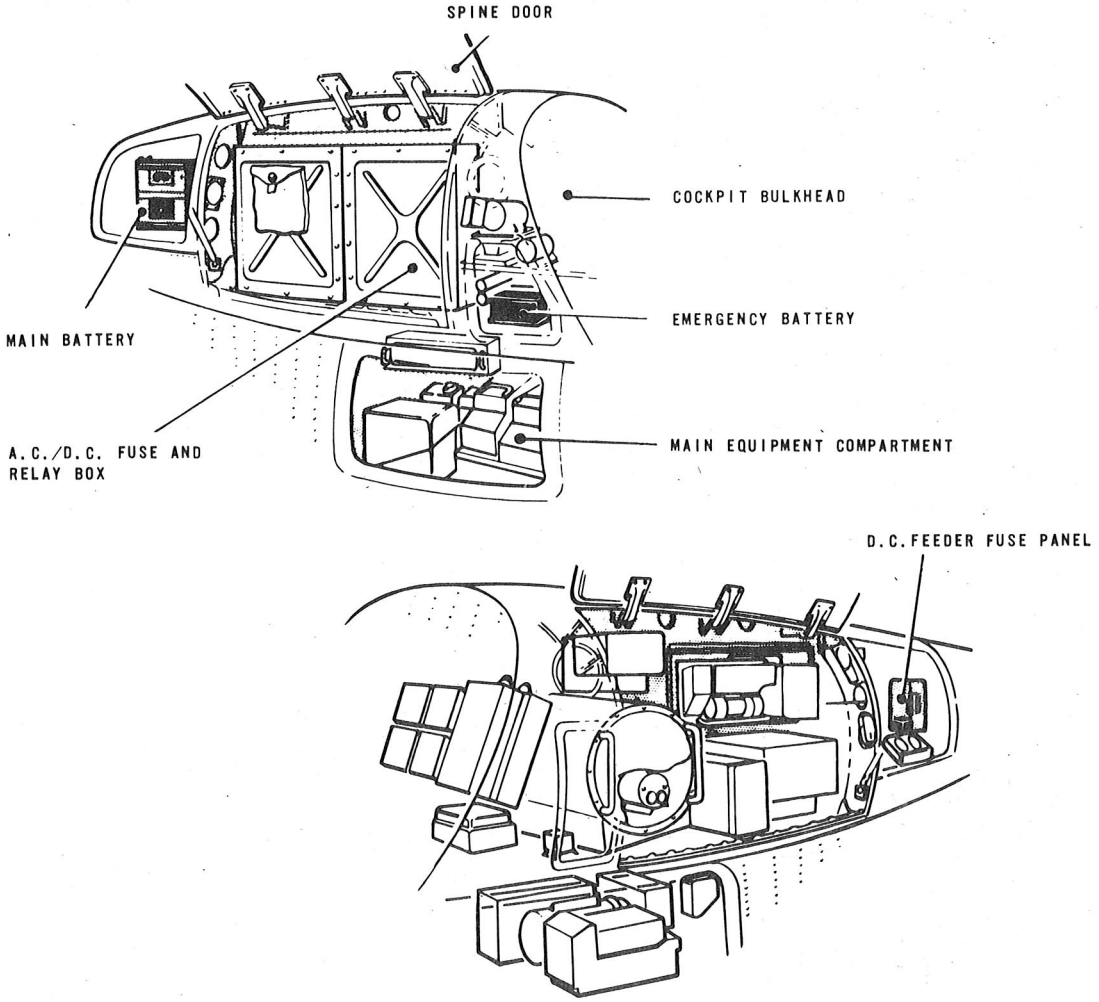

Fig.4. D.C. equipment in forward spine E2516-2

Contactor

21. Connected in series with the current indicator relay and busbar PL, the Type D.11803 contactor is a solenoid-operated unit having heavy contacts which carry the generator output and two sets of auxiliary contacts, one set of which is used in the differential relay circuit and the other in the current indicator circuit.

Current indicator relay

22. A Type F.8101 current indicator relay, identical with that used in the main generator circuit and described in para.8, is connected in the generator output line between the differential relay and the contactor.

Pick-up relay

23. The Type F.7901/1 pick-up relay, which is employed to protect the generator circuit, incorporates four pairs of contacts operated by a solenoid, a thermistor/resistor circuit, and a diode rectifier which provides protection against reversed polarity of the generator output. The relay pulls in between 20.5 and 22 volts and drops out between 9 and 11 volts. When energized and closed it completes the negative earth circuit to the differential relay coil and the positive circuit to the coil via the contacts of the main contactor, provided that the latter is de-energized and open.

Stand-by generator switch

24. Primary control of stand-by operation is effected by the stand-by gen-

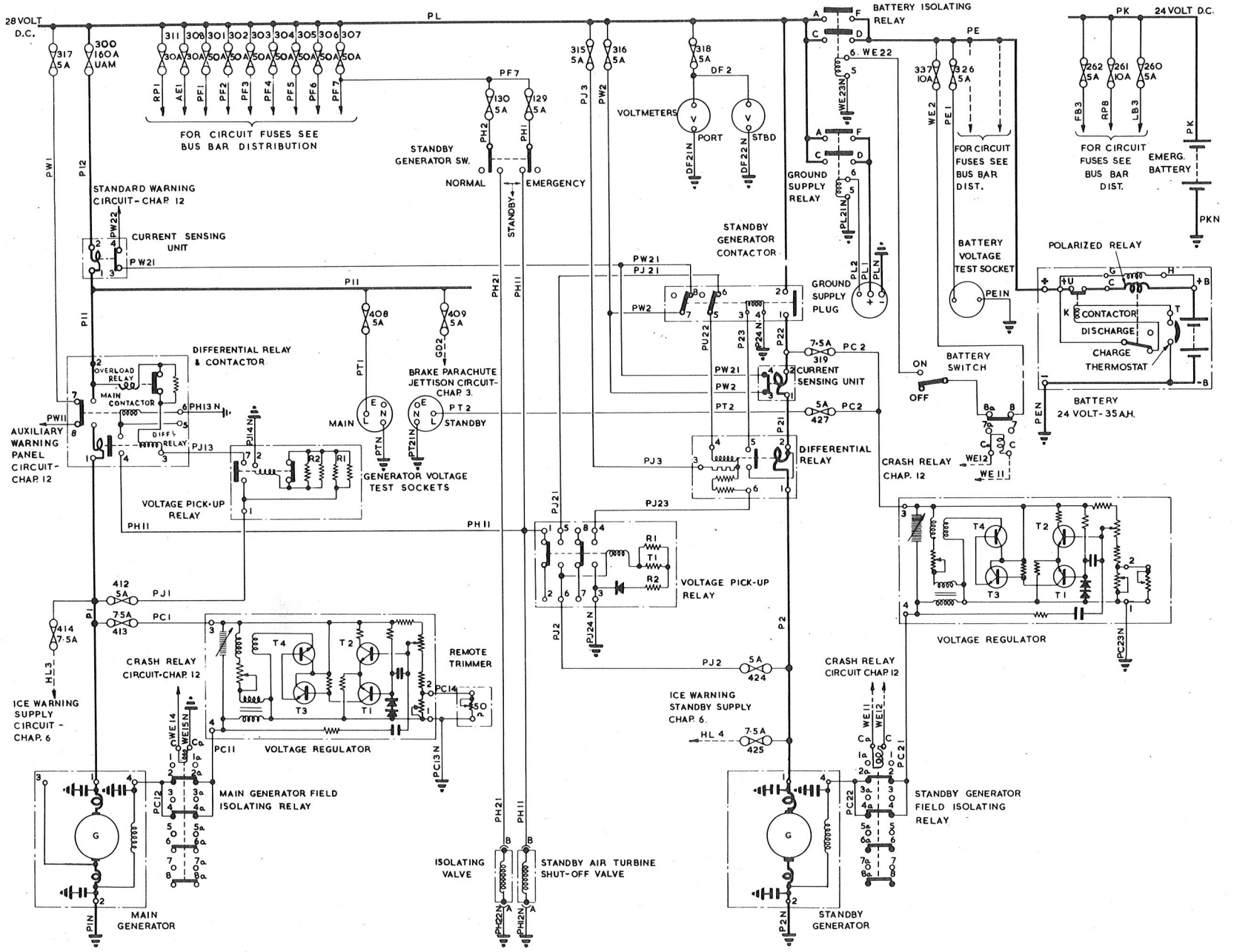

FIG. 5. D.C. POWER SUPPLIES

erator switch on panel A1 in the cockpit. The switch, labelled NORMAL - STANDBY - EMERGENCY, is fitted with a guard to prevent inadvertent operation.

Stand-by operation

25. When the generator switch is selected to STANDBY the shut-off valve is de-energized (opened), air is fed to the turbine, and the generator runs up to speed. The generator output is applied to the coil of the pick-up relay which closes when the output has built up to between 20.5 and 22 volts. Resistors R1 and R2 and the thermistor T1 form a compensating network which stabilizes the operating voltage against changes in ambient temperature. The rectifier prevents the relay operating in the event of generator output polarity reversal. Closing of contacts 3 to 4 and 5 to 6 applies the generator output to the differential relay coil via the auxiliary contacts on the contactor.

26. The differential relay is magnetically polarized and adjusted to operate at a forward differential of 0.3 to 1.0 volt. When the generator voltage exceeds the busbar voltage, the differential relay closes, and is held in by the line current in the series coil. The three resistors form a potential divider which determines the operating voltage. One of the resistors, which is non-inductively wound on the relay bobbin, provides temperature compensation. Operation of the differential relay energizes the main contactor which closes, connecting the stand-by generator to the busbars. As the contactor closes, the differential relay coil is open-circuited, the relay being latched in magnetically. On shut-down a reverse current of 8 to 12 amp in the current coil breaks the latch and the main contactor drops out. The generator is isolated when its terminal voltage falls below 9 to 11 volts, dropping out the voltage pick-up relay.

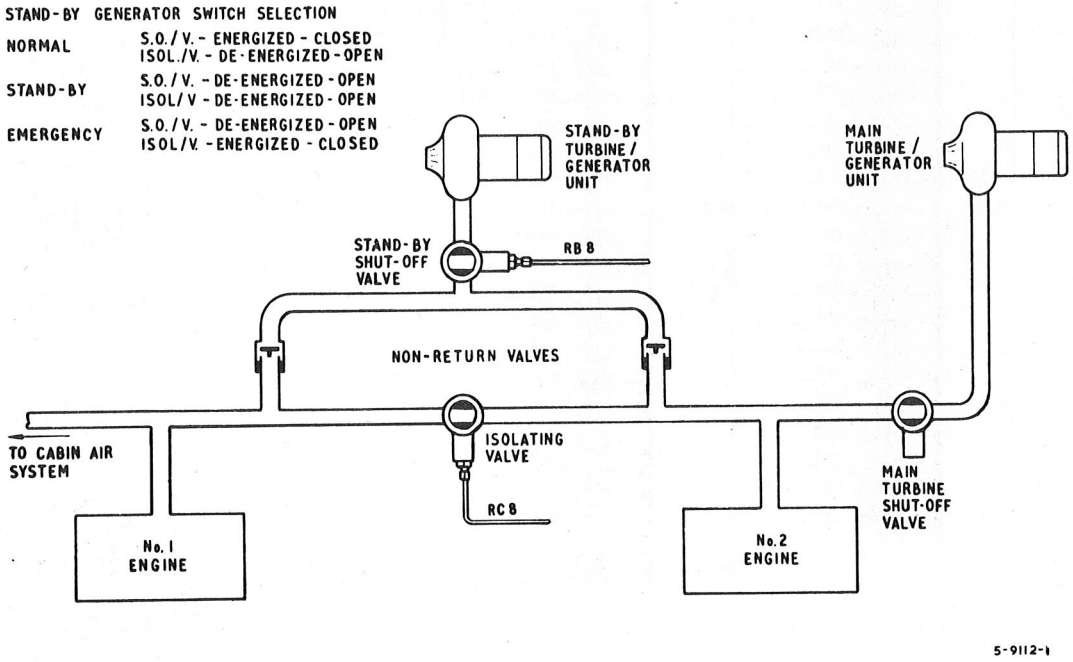

Fig. 6. Stand-by turbine air system

Emergency operation

27. The air which drives the stand-by generator turbine is fed via non-return valves from two supplies, one from each engine, which are changed into a common supply by the normally-open isolating valve. Should the air supply from one engine fail, the turbine will operate from the other engine after selecting the stand-by generator switch to EMERGY. This energizes the isolating valve which closes to separate the failed supply from the useful supply. The appropriate non-return valve will close automatically to prevent loss of air into the failed supply line.

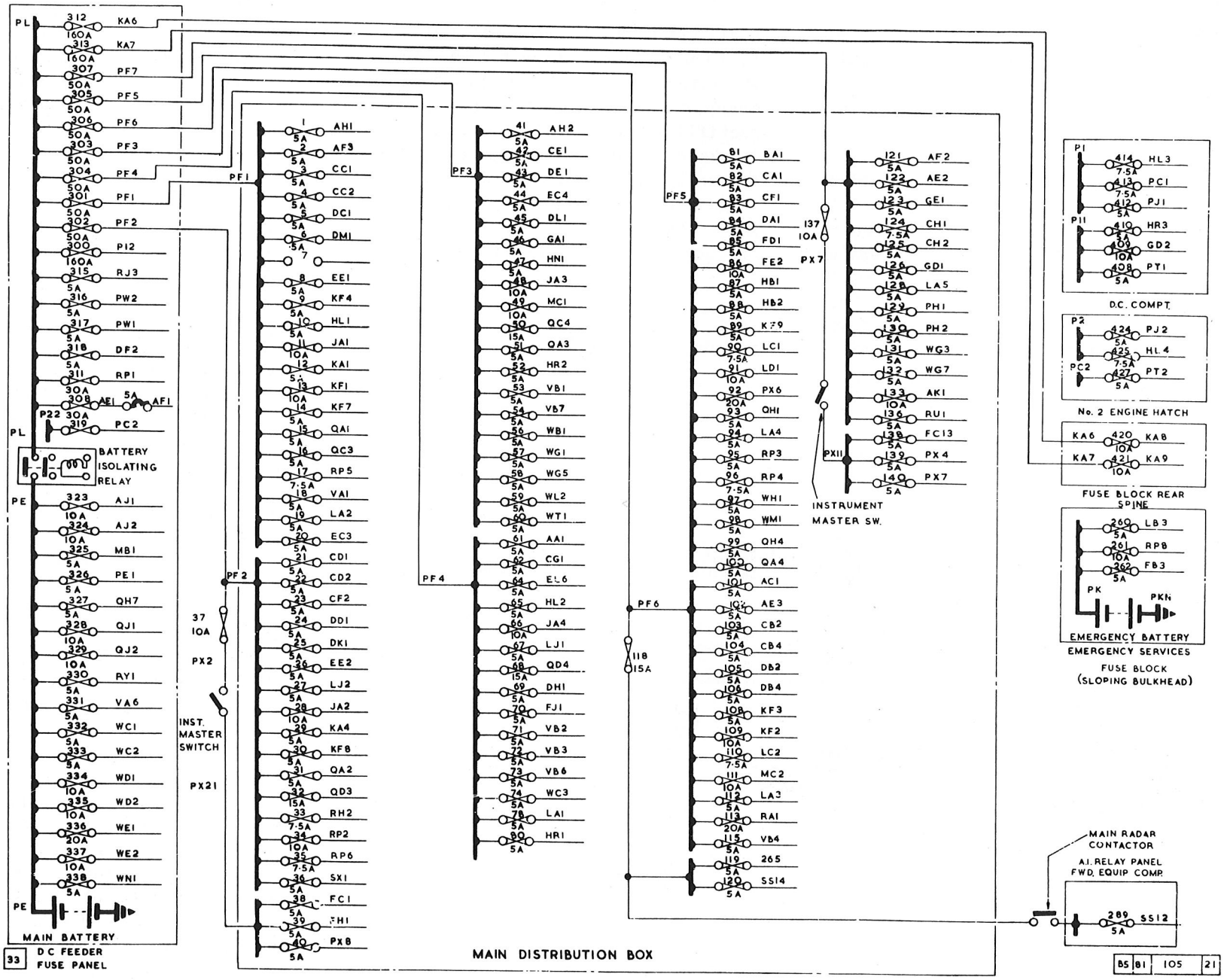

FIG.7. D.C. POWER DISTRIBUTION

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Power failure warning

28. Indication of the failure of the main generator is given by the GEN warning lamp on the auxiliary warnings panel to starboard of the main flight panel. The lamp lights when the differential relay opens and its auxiliary contacts 7 and 8 (PW1 – PW11) close. Failure of both main and stand-by generators is shown by the GEN lamp on the standard warning panel fitted to panel A4 in the cockpit. The lamp lights when the main generator current indicator relay is de-energized (PW21 – PW22 connected) and the stand-by current indicator relay and/or the contactor is de-energized and circuit PW2 – PW21 is completed.

Voltmeters

29. Busbar voltage is indicated by two voltmeters in the cockpit. One for the instructor's use is fitted on panel A1 and the other, for the pupil, on panel A2.

Main battery

30. The main battery is a Type K2, 35 amp. hr, alkaline unit installed between frames 23 and 25 starboard, in the forward spine compartment. The battery incorporates a polarized relay, contactor, and thermal switch which ensures that when the battery temperature rises to a predetermined figure, it is automatically disconnected from the busbar until its temperature has returned to normal. Should the generator fail whilst the battery is off line, the polarized relay will automatically reconnect the battery to the aircraft busbar irrespective of battery temperature. A battery test socket is provided, adjacent to the battery, for checking battery voltage during servicing. An alternative method for checking the battery voltage is provided by connecting the battery test extension cable, Ref. No. 10HG/2143 *(fig.9)*, to the telebriefing socket, in the starboard wheel well, and connecting a voltmeter to the terminal ends.

Battery isolation circuit

31. Connection between the main battery and the generator busbar is made or broken by a Type T100B relay installed on the d.c. feeder fuse panel in the forward spine bay. The relay is controlled normally by the battery isolating switch on panel A5, and in emergency by the crash relay *(Chap.12)* if the inertia switches operate in a heavy landing.

32. In a heavy landing which causes the crash relay to operate, the battery isolation relay will open and disconnect the main battery from all services except the essential circuits fed from busbar PE. At the same time the field relays serving the main and stand-by d.c. generators and also the a.c. generator open and shut down the systems.

Note...

To prevent discharge of the battery by circuits permanently connected to the d.c. busbars, the BATTERY switch should be selected to OFF when the aircraft is on the ground with the engines at rest.

Emergency battery

33. Power for emergency services is provided by a Type K, 7 amp hr alkaline battery installed between frames 17 and 19 in the forward spine compartment. The battery is connected to busbar PK which carries the fuses for the stand-by U.H.F. system, emergency cockpit lighting, and stand-by flight instruments.

Ground supply

34. The ground supply circuit includes a supply plug installed in the port wheel bay and a Type T100B relay on the d.c. feeder fuse panel in the forward spine bay. Connecting a ground supply to the plug energizes the relay which then closes, completing the supply to the main busbar PL. On removing the ground supply the relay automatically opens and breaks the circuit. During alighting gear retraction tests, the normal ground supply plug cannot be used, therefore an alternative method for connecting the ground supply is provided by an extension cable *(Chap.1)* which connects to the aircraft's main battery connector. Use of this cable avoids the necessity for frequent replacement of discharged aircraft batteries during prolonged alighting-gear tests and adjustments.

D.C. distribution

35. Primary power supplies are fed to busbar PL in the d.c. feeder fuse panel and distributed to the various services through a total of seven main fuse groups in the a.c. and d.c. fuse and relay box. The d.c. busbar PL is fed from the battery busbar PE through the contacts of the battery isolation relay when this is energized and closed by selection of the battery isolation switch to ON. All essential services such as armament jettison and fire protection, which must be always live and not controlled by the battery isolation relay, are fed through fuses connected directly to the battery busbar PE.

SERVICING

WARNING

The relevant safety precautions detailed on the LETHAL WARNING marker card must always be observed before entering the cockpit or performing any operations upon the aircraft.

General

36. In addition to the normal routine checks on the installation for security,

damage, and general condition of cables and components, functioning tests on the d.c. supply system must be made at the appropriate servicing periods or whenever any major item of the system has been changed. Battery voltage must be checked regularly and the batteries serviced in accordance with A.P.4343A. Vol.1, Sect.12, Chap.5 (main battery) and Sect.12, Chap.9 (emergency battery).

ELECTRICAL FUNCTIONING TESTS

Equipment required

37. The following equipment is required when making functioning tests on the systems:-

Tong test ammeter, 0-100 amp Ref.5Q/38 *(A.P.4343S, Vol.1, Sect.24, Chap.15)*

Voltmeter, 0-30 volts

Test procedure

Note...

(1) Owing to a momentary break in the supply during change-over from main generator to stand-by generator or vice versa, the attention lamps may flash but the GEN warning on the standard warning panel will remain off.

(2) When using the tong tester, the tongs should be opened and closed smartly, immediately before taking a reading of direct current. This action has the effect of reducing the error due to hysteresis, which otherwise may be considerable if the current in the conductor is increasing or decreasing slowly. The indication obtained should be corrected by applying the d.c. constant marked on the dial of the tester. This constant usually has a negative value that remains approximately the same over the effective scale, and must be subtracted from the indication to obtain the correct value of the current in the conductor.

Before starting engines

38. The following operations should be carried out before starting the engines:-

(1) Connect a ground supply trolley and check that its d.c. voltage is between 27.5 and 29 volts.

(2) Ensure that the stand-by generator switch is selected to NORMAL.

(3) Select battery isolating switch to ON.

With engines running

39. Make the following checks when the engines are running:-

(1) Run one engine at 65% rev/min and the other at any convenient speed below 65%.

(2) The GEN warning lamp on the auxiliary warnings panel and GEN lamp on the standard warning panel should go out when the main generator comes on line.

(3) Remove the d.c. ground supply.

(4) Check generator voltage at the voltmeter test socket in the starboard rear equipment compartment and adjust to 29 volts by means of the trimmer adjacent to the voltage regulator.

(5) Check that the generator is on line by measuring its output current with the d.c. tong test ammeter *(refer to Note 2)*.

(6) Select STANDBY on the stand-by generator switch. The main generator should go off line and the GEN warning lamp on the auxiliary warnings panel should light.

(7) Check the stand-by generator voltage at the test socket in the spine and adjust to 28.5 volts by means of the trimmer on the stand-by voltage regulator.

(8) Check that the stand-by generator is on line by measuring its output current with the tong test ammeter *(refer to Note 2)*.

(9) Run both engines at 65% rev/min, then throttle back No.2 engine to 50% rev/min. The A.C. and TURB warnings on the auxiliary warnings panel should remain off.

(10) Increase No.2 engine rev/min to 65% then select EMERGENCY on the stand-by generator switch.

(11) Check that the stand-by generator is still on line by using the tong test ammeter.

(12) Throttle back No.2 engine to 50% rev/min.

(13) The A.C. and TURB warnings on the auxiliary warnings panel should light.

(14) Increase No.2 engine speed to 65% rev/min. The A.C. and TURB warnings should go out.

(15) Return the stand-by generator switch to NORMAL.

(16) The main generator should come back on line and the GEN auxiliary warning lamp should go out.

(17) The stand-by generator should go off line. Check for current flow with the tong test ammeter.

(18) To check that the isolating cock has opened, run both engines at 65% rev/min then throttle back No.2 engine to 50% rev/min and check whether the A.C. and TURB failure lamps remain off. If the lamps light the isolating valve has not re-opened.

(19) Reduce engine speeds to ground idling. The GEN lamp on the auxiliary warnings panel and the GEN lamp on the standard warning panel should both light.

(20) Stop the engines and put the battery isolating switch to OFF.

Note...

If during the foregoing checks the required voltage setting cannot be obtained using the voltage regulator trimmer, attempts must not be made to adjust a regulator otherwise. A suspect regulator must be replaced by one that is serviceable.

REMOVAL AND ASSEMBLY

Generators

40. Removal and assembly of both main and stand-by generators is described in Book 1, Sect.4, Chap.1. Before removing a generator its leads must be disconnected and safely stowed to prevent damage.

Equipment

41. Removal and assembly of the other equipment is generally straightforward. The removal of panel 60S gives access to the main generator test socket, and the tray carrying the main voltage regulator and its remote trimmer, a relay, and a number of fuses. On removing its two securing screws the tray can be withdrawn sufficiently to provide access to the main differential relay and the voltage pick-up relay.

TABLE 1

Equipment details

Equipment	Type or reference	Location	Access	Air Publications
Main generator system				
Generator	B.3002/1	Frames 53-55, port d.c. compartment	77P	4343A, Vol.1, Sect.3
Voltage regulator	31/63705Z	Frames 52-53 starboard	104S	4343B, Vol.1, Book 1, Sect.1
Differential relay & contactor	F2236			N.A.
Voltage pick-up relay	F3133			4343C, Vol.1, Book 2, Sect.3
Current indicator relay	F8101			4343C, Vol.1, Book 2, Sect.3
Field isolation relay	7CZ/107791	D.2 relay box	60B	4343C, Vol.1, Book 2, Sect.3
Stand-by generator system				
Generator	B3601	No.2 engine hatch	No.2 engine hatch	4343A, Vol.1, Sect.3
Voltage regulator	31/63553Z			4343B, Vol.1, Book 1, Sect.1
Differential relay	F8001			4343C, Vol.1, Book 2, Sect.3
Contactor	D11803/2			4343C, Vol.1, Book 2, Sect.3
Voltage pick-up relay	F7901/1			4343C, Vol.1, Book 2, Sect.3
Current indicator relay	F8101			4343C, Vol.1, Book 2, Sect.3
Field isolation relay	20B			4343C, Vol.1, Book 2, Sect.3
Turbine shut-off valve		Frames 43-44 starboard		
Turbine isolating valve		Frames 46-47 starboard		
Main battery	Type K2		Forward spine compartment	◀ 113C-0303-1
Emergency battery	Type K			113C-0367-13A ▶
Battery isolation relay	T100B	D.C. feeder fuse panel		4343C, Vol.1, Book 2, Sect.3
Ground supply relay	T100B			
Voltmeters	5Q/107	Panels A1 and A2	Cockpit	

TABLE 2

Fuses, circuits and location

Fuse No.	Rating	Code	Circuit	Location
129	5A	PH1	Stand-by shut-off valve	A.C./D.C. fuse and relay panel
130	5A	PH2	Isolating valve	D.C. feed fuse panel
300	160A	P12	Main generator	
301	50A	PF1	Busbar supply	
302	50A	PF2	Busbar supply	
303	50A	PF3	Busbar supply	
304	50A	PF4	Busbar supply	
305	50A	PF5	Busbar supply	
306	50A	PF6	Busbar supply	
307	50A	PF7	Busbar supply	
315	5A	PJ3	Stand-by diff. relay	
316	5A	PW2	Failure warning	
317	5A	PW1	Failure warning	
318	5A	DF2	Voltmeters	
319	7.5A	PC2	Stand-by gen. voltage regulator & fuse 427	
326	5A	PE1	Battery test socket	
337	10A	WE2	Battery isolation	D.C. compartment
408	5A	PT1	Main gen. test socket	
412	5A	PJ1	Main gen. pick-up relay	
413	7.5A	PC1	Main gen. volt. reg.	
424	5A	PJ2	◀ Stand-by generator voltage pick-up relay ▶	No. 2 engine hatch
427	5A	PT2	Stand-by gen. test socket	

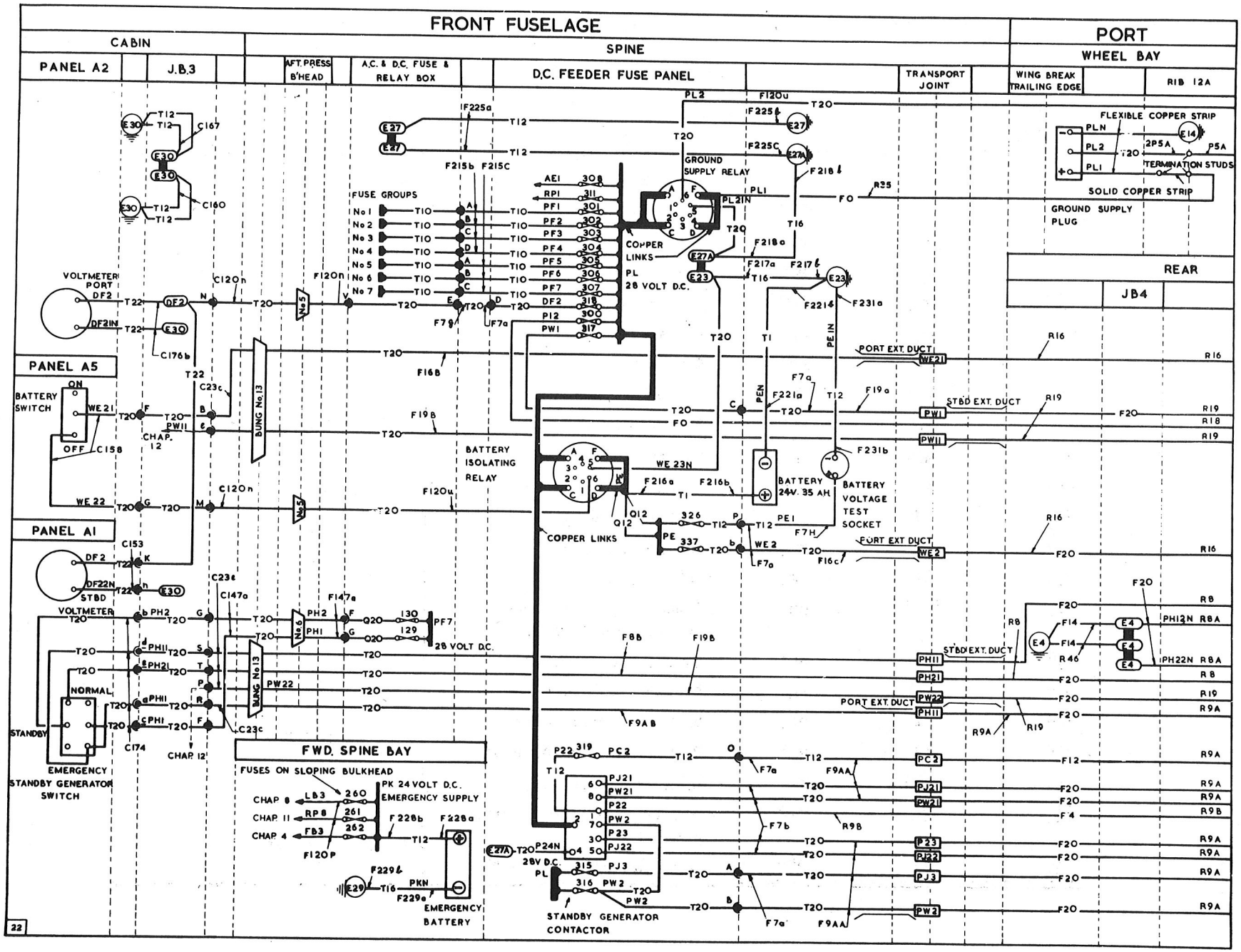

FIG.8. D.C. POWER SUPPLIES

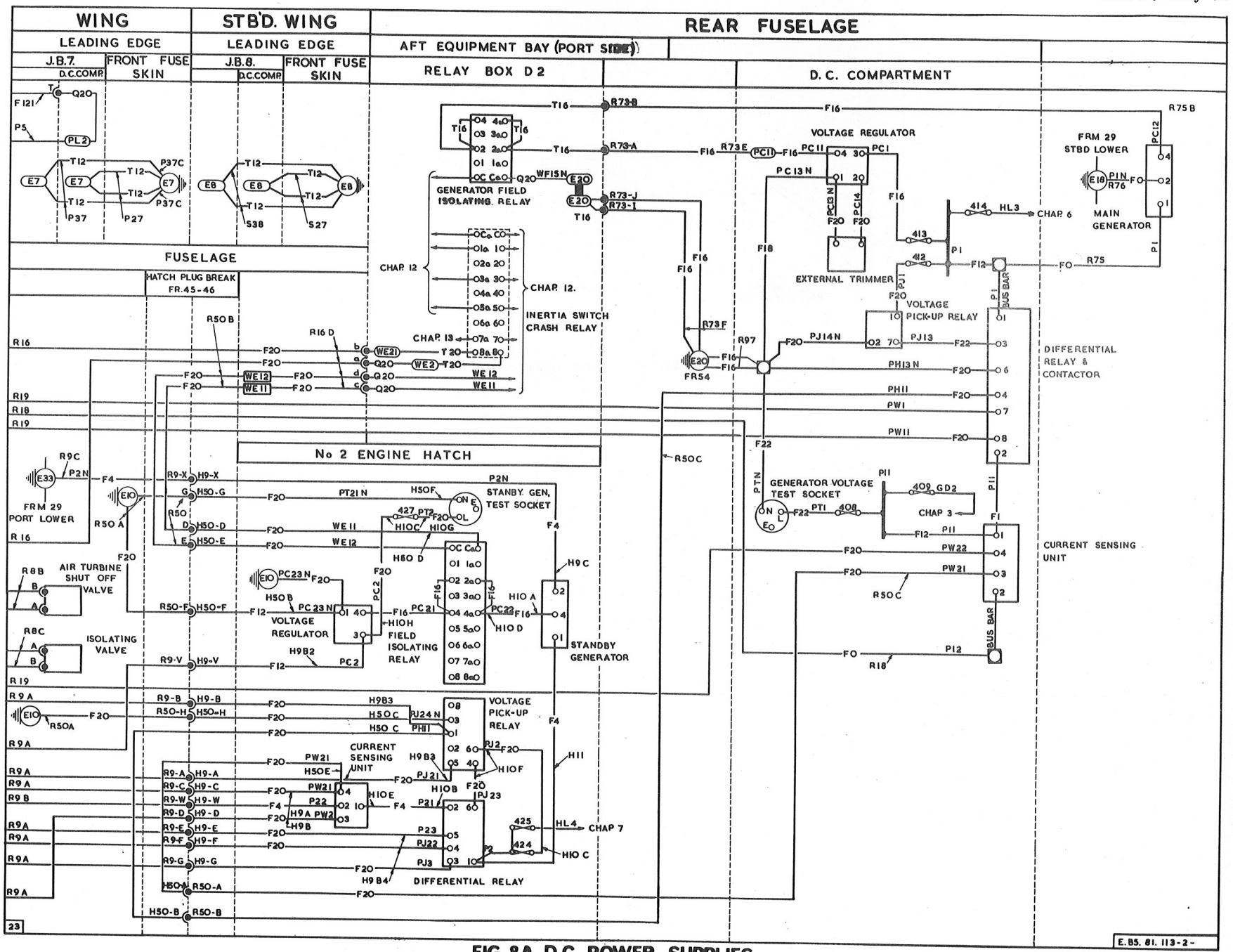

FIG. 8A. D.C. POWER SUPPLIES

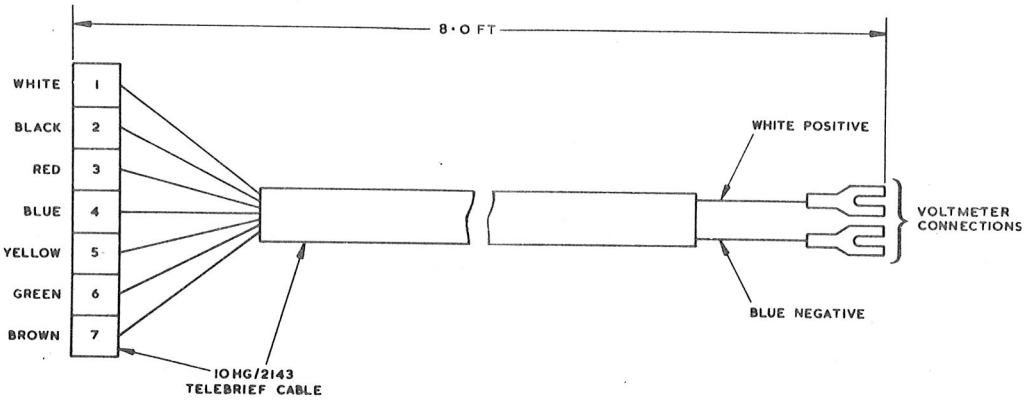

Fig. 9. Battery test extension cable

◀ APPENDIX I D.C. POWER SUPPLIES MOD.4092, 4094 AND 4586 ▶

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

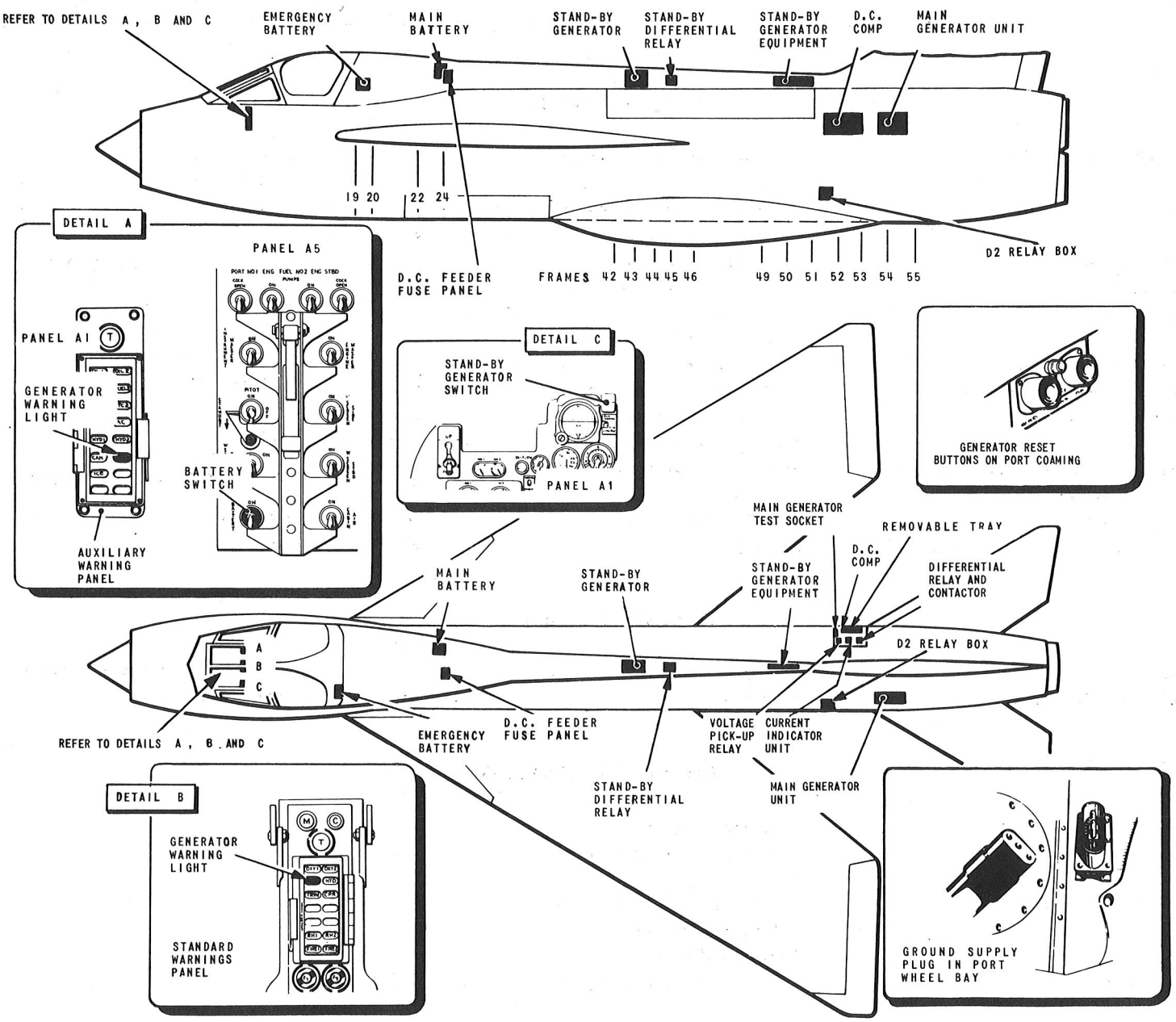

FIG. 1. D.C. POWER SUPPLY DETAILS

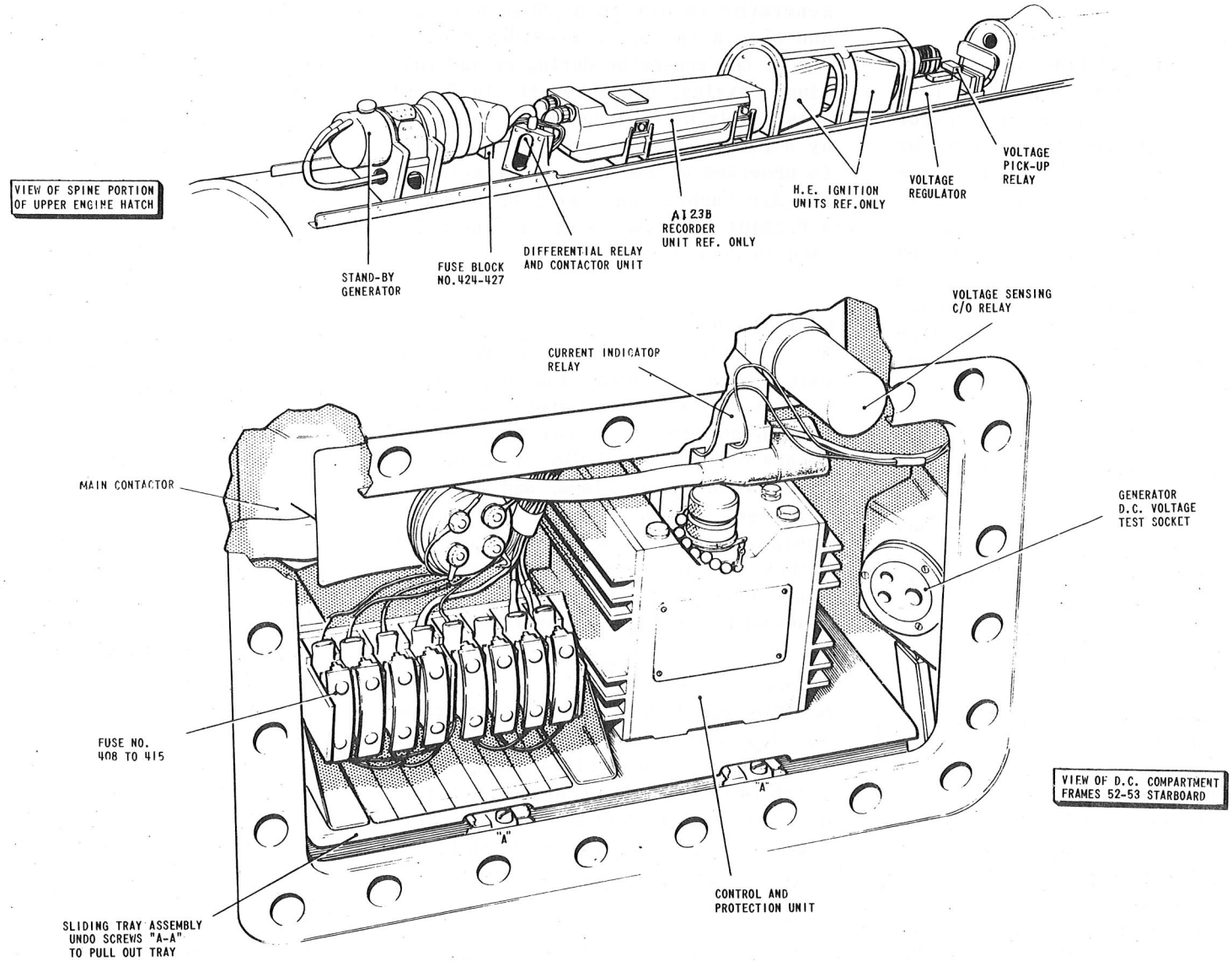

FIG. 1A D.C. POWER SUPPLY DETAILS

DESCRIPTION

Introduction

1. Under normal conditions the aircraft main 28-volt d.c. power supply is provided by a 6 kW brushless generator mounted on and driven from a gearbox integral with a speed-controlled air turbine unit installed in the rear fuselage. In the event of the failure of the main generator system, a 2.8 kW stand-by generator can be brought into operation. Both generator systems operate in conjunction with the standard and auxiliary warning circuits to provide visual indication of generator failure.

2. Two batteries are installed. The main battery provides the d.c. supply when the generators are off line and enough power for a double start of the engines, whilst the emergency battery, is used for emergency operation of the stand-by artificial horizon, cockpit lighting, and stand-by U.H.F. radio.

Main generator system

Air turbine unit

3. This unit operates from compressor air fed from both engines and runs at a speed of approximately 16,000 rev/min. Non-return valves fitted in each air supply line serve to protect the supply in case of the failure of one engine in flight or during engine ground running with one engine stopped or idling. The turbine speed is controlled by guide vanes which are adjusted automatically by a governor embodied in the unit.

4. The turbine unit incorporates a reduction gearbox, through which the generator is driven at 8000 rev/min, and also a fan which provides cooling air to the generator during ground running, taxying, and take-off. In flight this supply of cooling air is by-passed by a flap valve and generator cooling is provided by ram air. Information on the air turbine unit will be found in A.P.2240A and details of its installation in Sect.3, Chap.8.

Control equipment

5. In addition to the generator, the main components comprising the installation are a control and protection unit, a main contactor, a voltage-sensing change-over relay, field isolating and current indicator relays, and a generator reset switch. Most of the control equipment, and also a generator test socket, are located in the d.c. compartment between frames 52 and 53 at the starboard side in the rear fuselage.

Main generator

6. The Type AE.2519 brushless generator is basically a three-stage a.c. unit incorporating integral rectifiers, and which provides a controlled rectified d.c. output of 200 amp at 28 volts (nominal). The generator is cooled by blast air from an intake at the base of the fin.

7. The voltage developed in the generator first stage by a permanent magnet exciter, circuit P1-P2-P3, is fed into the power supply module and the voltage regulator in the control and protection unit. The resultant output is fed back to the field circuit M1-M2 to excite the second-stage three-phase rotor. The output from the latter is then rectified by rectifiers integral with the rotor, and the outgoing d.c. supply energizes the third-stage rotating field used to excite the final five-phase stator. The five output phases are connected to a full-wave rectifier bridge and associated smoothing capacitors installed in the generator unit. The resultant d.c. output negative is earthed to the airframe whilst the positive is fed, via the main contactor, current indicator relay coil and the main fuse, to busbar PL.

Control and protection unit

8. Voltage control and circuit protection of the d.c. power supply is provided by a Type AE.7023 control and protection unit in which voltage regulation, under and overvoltage sensing and other functions are carried out by separate circuit modules embodied in the unit. The generator output is normally controlled at 28 volts ± 0.5 volt. The overvoltage circuit will cause the generator to shut down if its output rises above 30.5 volts ± 0.5 volt, whilst the undervoltage circuit will cause generator shut-down should the output fall below 25.5 volts ± 0.5 volt at normal turbine speed. The unit incorporates a test socket for use when making functional checks on the system.

Voltage-sensing change-over relay

9. Selection of the voltage-sensing point for the functioning of the control and protection unit is controlled by a

Type BS.115B-1C/2 voltage-sensing relay installed in the d.c. compartment. The relay incorporates an operating coil and a number of contacts of which only those numbered 5, 6 and 7 are used in the generator control circuit.

10. With the relay de-energized, its contacts 5 and 7 are connected and voltage-sensing is taken from the generator positive line P1. When the relay is energized and contacts 5 and 6 are connected, the voltage-sensing point is then the 28-volt busbar via the main fuse, which now includes the voltage drop caused by the long cable and other equipment in the generator positive line.

Main contactor

11. The connection between the generator positive line and the aircraft busbar PL is controlled by a Type 6042H-152 contactor fitted in the d.c. compartment. The contactor embodies one pair of contacts which carry the generator current, and two pairs of auxiliary contacts, one pair of which are used in the generator failure warning circuits whilst the others control the operation of the voltage-sensing change-over relay.

Field isolating relay

12. The connection between the generator secondary field circuit M1-M2 and the control and protection unit is through the normally-closed contacts of a relay, Ref.No.7CZ/107791, housed in the D2 relay box. Should the relay operate and open the field circuit, the main generator will close down immediately. The relay is energized by undervolting at normal speed or overvolting of the system at any speed, both of which will cause the control unit overvoltage latch relay to close, or by closing of the crash relay by operation of the inertia switches if they should be tripped in a heavy landing.

Current indicator relay

13. Indication of main generator failure is controlled initially by a Type F8101 current indicator relay in the d.c. compartment. The unit consists mainly of a heavy current coil and contacts which are opened and closed by the amount of current passing through the coil, which is connected in the main generator positive line between the main contactor and the busbar main fuse. The contacts of the relay open when the current through the coil rises to between 15 and 25 amp and close when the flow falls to between 10 and 5 amp.

Generator reset switch

14. In the event of the generator going off-line as a result of under or overvolting conditions which may be transient, it may be possible to bring the generator back on line by pressing the generator reset switch fitted on the coaming at the port side of the cockpit.

Generator test socket

15. A three-pin socket for use when making checks on the main generator system is located on the aft face of frame 52 in the d.c. compartment. The voltage measured at the socket is that which appears at terminal R6 (voltage-sensing terminal) of the voltage regulator in the control and protection unit.

Operation

16. When the engines are started and the air turbine is running up to speed, the generator pilot exciter voltage builds up and the operating coil of the main contactor is energized via circuit P1-PJ41-PJ55A-PJ55 and PJ56. Closing of the main contacts of the contactor connects the generator positive to the main d.c. busbar via the current indicator relay coil and the main fuse. The operation of the main contactor auxiliary contacts completes circuit P1-PJ58 to energize the voltage-sensing change-over relay and breaks circuit PW1-PW11 to the GEN warning on the auxiliary warnings panel. At this stage the GEN warning will not go out as circuit PW1-PW11 is also connected to terminals L1-R1 of the undervoltage and time delay module in the control and protection unit.

17. When the generator voltage reaches approximately 25 volts, the undervoltage and time delay module will operate to break circuit PW1-PW11 and the GEN warning on the auxiliary warnings panel will then go out.

18. Voltage regulation of the main generator output during normal operation requires that voltage sensing is taken from the 28-volt busbar and this includes the voltage drop inherent in the

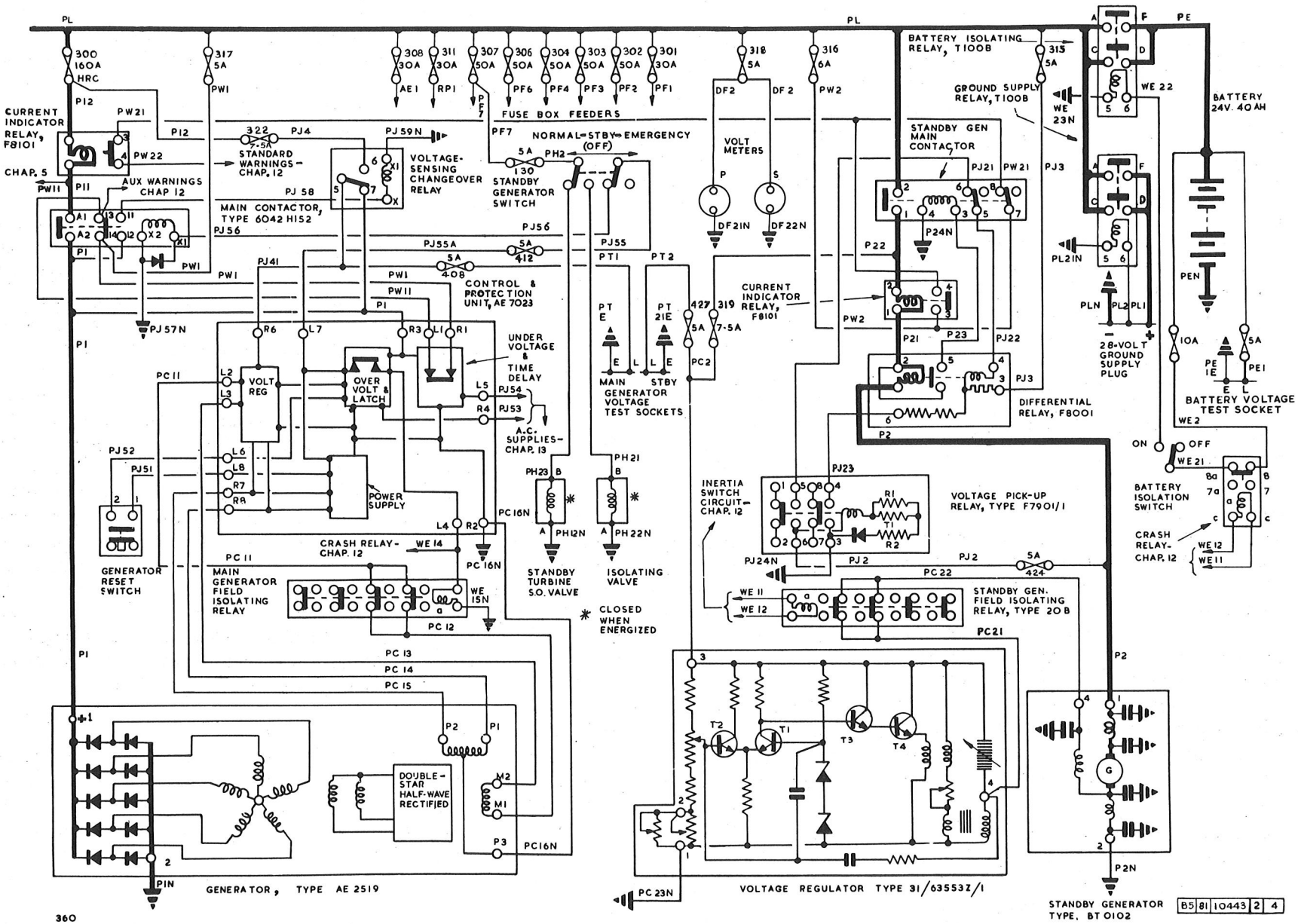

FIG. 2. D.C. POWER SUPPLIES

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long cable and the associated equipment in the generator line. Should the air turbine underspeed sufficiently to operate the underspeed relay *(Chap.13)*, circuit PJ53 and PJ54 to the control and protection unit will be broken and inhibit shut-down of the generator when undervoltage occurs.

19. During system checks with engines running and the main generator operating normally, the selection of STANDBY GEN breaks the main contactor operating-coil circuit and the contactor opens to disconnect the generator from busbar PL. The auxiliary contacts of the contactor also open to break the coil circuit P1-PJ58 of the voltage-sensing change-over relay with the result that the voltage sensing point for the voltage regulator is transferred from busbar PL to the generator positive line P1 which does not include the voltage drop associated with the generator cable etc. This transfer of the voltage-sensing point prevents malfunction of the generator voltage regulation system when the generator output is open-circuited by opening of the main contactor.

Stand-by generator system

General

20. The stand-by power supply is provided by a turbine/generator unit installed with its control equipment in No.2 engine hatch. The turbine air supply is controlled by a shut-off valve installed between frames 43 and 44 starboard, and an isolation valve installed between frames 46 and 47, starboard. Both valves are solenoid-operated components.

Stand-by turbine/generator unit

21. The Type BT.0102 turbine/generator unit consists of a 28-volt, 3.5 kW d.c. generator, Type B.3601, and a five-inch axial turbine coupled to its extended armature shaft. The turbine air supply is bled from the compressor stages of both engines. Restriction on the size of the turbine wheel limits the generator to a maximum output of 2.8 kW (100 amp). Selecting stand-by operation operates the shut-off valve to open the air supply line to the turbine and a governor-controlled valve maintains the generator speed at approximately 12,000 rev/min by regulating the turbine input pressure according to the output load. The turbine wheel is designed to disintegrate at critical overspeed to protect the generator. In this event a rotating shroud fractures, and the turbine blades are released and contained within the turbine housing. The isolating valve protects the stand-by system in the event of a burst pipe in the main turbine supply system. Energizing (closing) of the valve ensures that the turbine can be driven from at least one engine by preventing both engines feeding into the burst pipe.

Stand-by generator

22. The Type B.3601 generator is a shunt-wound unit, internally suppressed against radio interference, which is cooled by blast air piped from outside the fuselage. It is controlled by a voltage regulator, differential relay, contactor, and voltage pick-up relay. The circuit also incorporates a current indicator relay used in the generator failure warning system. The generator field circuit is connected to the voltage regulator via a Type 10B, No.15 relay which opens if the inertia crash switches should operate during a heavy landing *(Chap.12)*.

Voltage regulator

23. Automatic control of the stand-by generator is effected by a Type 31/63553Z voltage regulator incorporating a carbon pile, main and auxiliary coils, and a transistorized amplifier. Voltage adjustment is by an integral trimmer which provides for a variation of approximately 0.5 volts above or below 28.5 volts.

Differential relay

24. This relay, Type F.8001, mainly comprises a solenoid/resistor assembly, a series coil carrying the generator output, and a pair of contacts which, when closed, complete the circuit to the main contactor. The solenoid/resistor circuit is energized through the closed auxiliary contacts of the contactor unit, and the contacts of the pick-up relay when this is closed. The relay closes when a differential between 0.2 and 1 volt is present across the solenoid coil, and opens when a reverse current between 8 and 12 amp passes through the series coil.

Contactor

25. Connected in series with the current indicator relay and busbar PL, the Type D.11803 contactor is a solenoid-operated unit having heavy contacts which carry the generator output, and two sets of

auxiliary contacts, one set of which is used in the differential relay circuit and the other in the current indicator circuit.

Current indicator relay

26. A Type F.8101 current indicator relay, identical with that used in the main generator circuit, is connected in the generator output line between the differential relay and the contactor.

Pick-up relay

27. The Type F.7901/1 pick-up relay, which is employed to protect the generator circuit, incorporates four pairs of contacts operated by a solenoid, a thermistor/resistor circuit, and a diode rectifier which provides protection against reversed polarity of the generator output. The relay pulls in between 20.5 and 22 volts and drops out between 9 and 11 volts. When energized and closed it completes the negative earth circuit to the differential relay coil and the positive circuit to the coil via the contacts of the main contactor, provided that the latter is de-energized and open.

Stand-by generator switch

28. Primary control of stand-by operation is effected by the stand-by generator switch on the starboard console. The switch, labelled NORMAL-STANDBY-EMERGENCY, is fitted with a guard to prevent inadvertent operation.

Stand-by operation

29. When the generator switch is selected to STANDBY the shut-off valve is de-energized (opened), air is fed to the turbine, and the generator runs up to speed. The generator output is applied to the coil of the pick-up relay which closes when the output has built up to between 20.5 and 22 volts. Resistors R1 and R2 and the thermistor T1 form a compensating network which stabilizes the operating voltage against changes in ambient temperature. The rectifier prevents the relay operating in the event of generator output polarity reversal. Closing of contacts 3 to 4 and 5 to 6 applies the generator output to the differential relay coil via the auxiliary contacts on the contactor.

30. The differential relay is magnetically polarized and adjusted to operate at a forward differential of 0.3 to 1.0 volt. When the generator voltage exceeds the busbar voltage, the differential relay closes and is held in by the line current in the series coil. The three resistors form a potential divider which determines the operating voltage. One of the resistors, which is non-inductively wound on the relay bobbin, provides temperature compensation. Operation of the differential relay energizes the main contactor which closes to connect the stand-by generator to the busbars. As the contactor closes, the differential relay coil is open-circuited, the relay being latched in magnetically. On shut-down, a reverse current of 8 to 12 amp in the current coil breaks the latch circuit and the main contactor drops out. The generator is isolated when its terminal voltage falls below 9 to 11 volts, and causes the voltage pick-up relay to drop out.

Emergency operation

31. The air which drives the stand-by generator turbine is fed via non-return valves from two supplies, one from each engine, which are changed into a common supply by the normally-open isolating valve. Should the air supply from one engine fail, the turbine will operate from the other engine after selecting the stand-by generator switch to EMERGY. This action energizes the isolating valve which closes to separate the failed supply from the useful supply. The appropriate non-return valve will close automatically to prevent loss of air into the failed supply line.

Generator failure warnings

32. Indication of failure in the main generating system is given by lamps labelled GEN on the standard warning panel and the auxiliary warnings panel. As the voltage output from the main generator falls, the current sensing unit will become de-energized and its contacts will complete the circuit PW21-PW22 to the GEN indicator on the standard warning panel. At the same time, the GEN indicator on the auxiliary warnings panel will light via contacts 13 - 14 of the main contactor, indicating that the stand-by generator should be brought into use. After selecting the stand-by generator switch to STANDBY and the generator has come onto line, the GEN warning on the standard warning panel will go out via the now broken contacts

of the stand-by system current sensing unit and the main contactor.

Note...

The GEN indication on the auxiliary panel will remain on as long as a failure exists in the main generating system.

Voltmeters

33. Busbar voltage is indicated by two voltmeters in the cockpit. One for the instructor's use is fitted on panel A1 and the other, for the pupil, on panel A2.

Main battery

34. The main battery is a Type K2, 35 amp hr alkaline unit installed between frames 23 and 25 starboard, in the forward spine compartment. The battery incorporates a polarized relay, contactor, and thermal switch which ensures that when the battery temperature rises to a predetermined figure, it is automatically disconnected from the busbar until its temperature has returned to normal. Should the generator fail whilst the battery is off line, the polarized relay will automatically reconnect the battery to the aircraft busbar irrespective of battery temperature. A battery test socket is provided, adjacent to the battery, for checking battery voltage during servicing. An alternative method for checking the battery voltage is provided by connecting the battery test extension cable, Ref.No.10HG/2143, *(main chapter, fig.9)*, to the tele-briefing socket, in the starboard wheel well, and connecting a voltmeter to the terminal ends. ▶

Battery isolation circuit

35. Connection between the main battery and the generator busbar is made or broken by a Type T100B relay installed on the d.c. feeder fuse panel in the forward spine bay. The relay is controlled normally by the battery isolating switch on panel A5, and in emergency by the crash relay *(Chap.12)* if the inertia switches operate in a heavy landing.

36. In a heavy landing which causes the crash relay to operate, the battery isolation relay will open and disconnect the main battery from all services except the essential circuits fed from busbar PE. At the same time the field relays serving the main and stand-by d.c. generators and also the a.c. generator open and shut down the systems.

Note...

To prevent discharge of the battery by circuits permanently connected to the d.c. busbars, the BATTERY switch should be selected to OFF when the aircraft is on the ground with the engines at rest.

Emergency battery

37. Power for emergency services is provided by a Type K, 7 amp hr alkaline battery installed between frames 17 and 19 in the forward spine compartment. The battery is connected to busbar PK which carries the fuses for the stand-by U.H.F. system, emergency cockpit lighting, and stand-by flight instruments.

Ground supply

38. The ground supply circuit includes a supply plug installed in the port wheel bay and a Type T100B relay on the d.c. feeder fuse panel in the forward spine bay. Connecting a ground supply to the plug energizes the relay which then closes, completing the supply to the main busbar PL. Removal of the ground supply de-energizes and opens the relay. During alighting gear retraction tests the normal ground supply plug cannot be used therefore an alternative method for connecting the ground supply is provided by an extension cable *(Chap.1)* which connects to the aircraft's main battery connector. Use of this cable avoids the necessity for frequent replacement of discharged aircraft batteries during prolonged alighting gear tests and adjustments. ▶

D.C. distribution

39. Primary power supplies are fed to busbar PL in the d.c. feeder fuse panel and distributed to the various services through a total of seven main fuse groups in the a.c. and d.c. fuse and relay box. The d.c. busbar PL is fed from the battery busbar PE through the contacts of the battery isolation relay when this is energized and closed by selection of the battery isolation switch to ON. All essential services such as armament jettison and fire protection, which must be always live and not controlled by the battery isolation relay, are fed through fuses connected directly to the battery busbar PE.

SERVICING

WARNING

The relevant safety precautions detailed on the LETHAL WARNING marker card must always be observed before entering the cockpit or performing any operations upon the aircraft.

General

40. Routine checks should be made on the complete generator installation for the security and serviceability of the cables and equipment. System checks are described in the functioning test procedures which follow. As an aid to system fault investigation, additional information in table form has been intro-

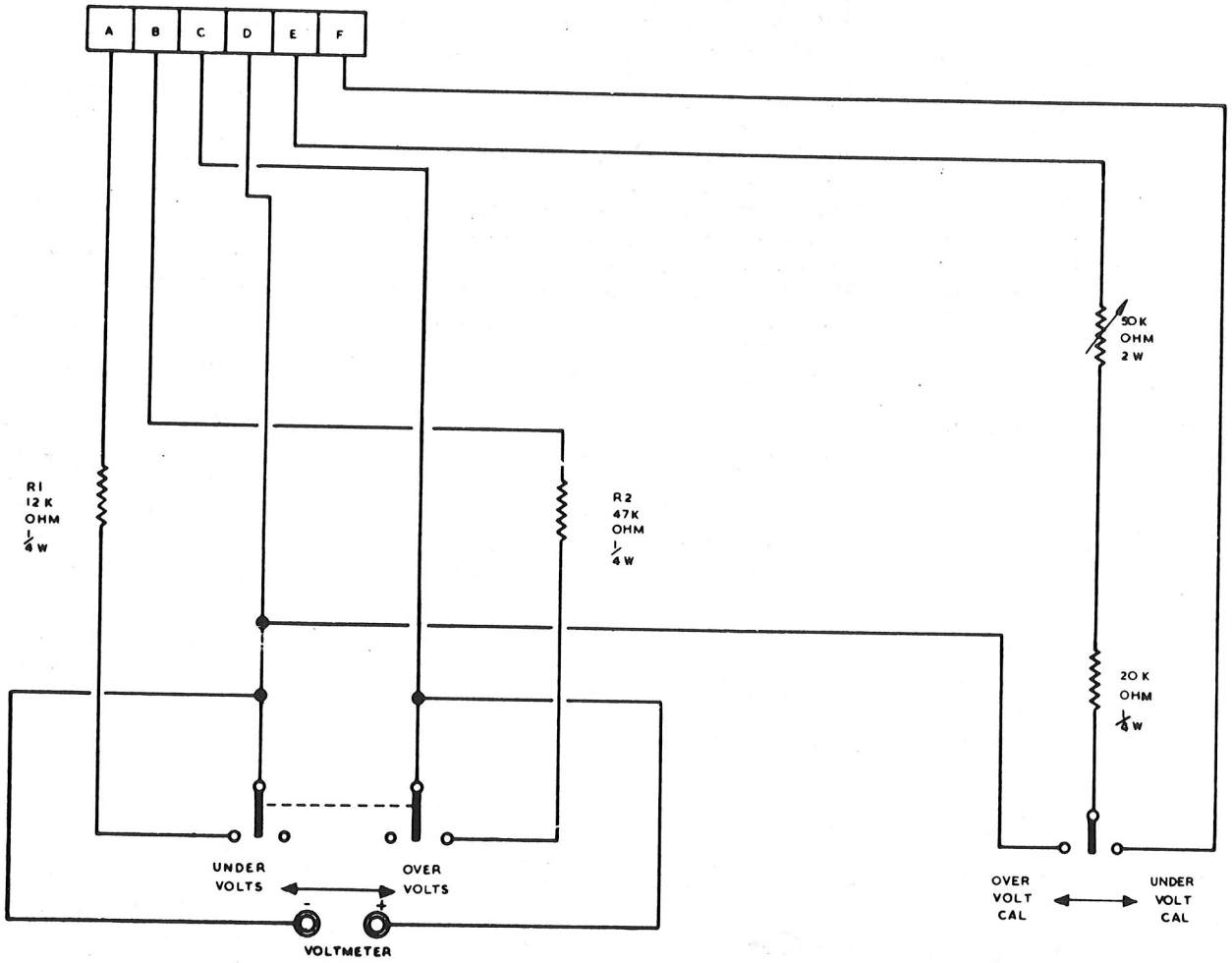


FIG. 3. D.C. SYSTEM TEST BOX

duced. Table 3 provides details of the testmeter readings which could be expected when checking voltages at various points in a serviceable system whilst Table 4 details the voltages which may be encountered during the investigation of trouble in a faulty system.

41. Functioning tests must be made at the appropriate servicing period or when any major component in the installation is changed, and are carried out with the engines running.

Functioning tests

Equipment required

42.

D.C. generator system test box, B.A.C. Ref. No. AP6J11/760 *(fig.3)* or test box of local manufacture.

Two d.c. voltmeters, range 0-30 volts

Intercomm, set for communication between cockpit operator and ground operator.

Suitable d.c. ground supply trolley

Preparation

43.

(1) Connect the d.c. test box to the test socket on the control and protection unit.

(2) Connect the d.c. ground supply trolley to the aircraft and ensure that its output voltage is between 27.5 and 29 volts.

(3) Connect one voltmeter to the main generator test socket and the other to the stand-by generator test socket.

(4) Select the stand-by generator switch to NORMAL and check that both GEN failure warnings are showing.

(5) Select the BATTERY switch ON.

(6) Check that the standard warning panel is unmuted.

Procedure

44.

Note...

During the tests which follow, a fault which energizes any of the warnings on the standard warning panel should automatically cause the attention lamps to flash and the audio warning to be heard. When the fault is removed or cancelled the warning should cease.

(1) Whilst one engine is idling, run the other to 65 per cent rev/min. Both GEN warnings should disappear when the main generator comes on line.

(2) Disconnect the d.c. ground supply trolley.

(3) Check that the voltage of the main generator at its test socket is 28.5 volts ± 0.5 volt.

(4) Select overvoltage trip on the d.c. test box. The generator should go off line and the GEN warning appear on the standard warning panel. The GEN warning on the auxiliary warnings panel should also appear when the busbar volts, as read at the main generator test socket, fall to 25 volts ± 1 volt.

(5) Return the selector switch on the d.c. test box to OFF and check that the GEN warnings remain on.

(6) Press the generator reset switch. The generator should come on line and the GEN warnings should disappear.

(7) Select undervoltage trip on the d.c. test box. Both GEN warnings should appear.

(8) Return the d.c. test box switch to OFF. The GEN warning on the standard warning panel should remain on. The GEN warning on the auxiliary warnings panel may go off if the busbar voltage exceeds 25 volts ± 1 volt.

(9) Press the generator reset switch. The generator should come on line and both GEN warnings should disappear.

(10) Select the stand-by generator switch to STANDBY. The main generator should go off line and the GEN warning appear on the auxiliary warnings panel.

(11) Measure the stand-by generator voltage at the test socket in the spine and, if necessary, adjust to 28 volts by means of the trimmer on the voltage regulator.

(12) Run both engines at 65 per cent rev/min then select the stand-by generator switch to EMERGENCY.

(13) Throttle back No. 2 engine to ground idling. The A.C. and TURB warnings on the auxiliary warnings panel should appear.

(14) Increase No. 2 engine rev/min to 65 per cent. The A.C. and TURB warnings should disappear.

(15) Return the stand-by generator switch to NORMAL. The main generator should come on line and the GEN warning on the auxiliary warnings panel should disappear. Check that the stand-by generator voltage at the test socket has fallen to zero.

(16) Throttle No.2 engine back to ground idling and check that the TURB warning does not appear.

(17) Throttle No.1 engine back to ground idling. The GEN warning on the auxiliary warnings panel should appear when the battery volts fall to 25 volts ± 1 volt (checked at the main generator test socket). The GEN warning on the standard warning panel may appear.

(18) Shut down both engines and select the BATTERY switch OFF.

Note...

As a result of the momentary break in the supply during the change-over from main to stand-by generator, the attention lamps on the standard warning panel will flash.

Batteries

45. Battery voltage must be checked regularly and the batteries serviced in accordance with A.P.4343A, Vol.1, Sect. 12, Chap.5 (main battery) and Sect.12, Chap.9 (emergency battery). Spilt battery electrolyte must on no account be allowed to contaminate the aircraft structure. When spilt electrolyte is found it must be immediately removed, using the approved procedure.

REMOVAL AND ASSEMBLY

Generators

46. A description of the removal and reassembly of the generators will be found in Sect.3, Chap.8. Before the removal of the units their cables must be disconnected and safely stowed.

Equipment

47. The removal and assembly of the generator control equipment in the d.c. compartment is generally straightforward. The removal of panel 104S at the starboard side of the rear fuselage provides access to the main generator test socket and the sliding tray which carries the control and protection unit, the main contactor, the current indicator relay, and the associated equipment. After removing two securing screws the tray can be withdrawn sufficiently for the control equipment to be accessible.

TABLE 1

Equipment details

Equipment	Location	Access	Air Publication
Main generating system			
Generator, Type AE.2519	On the air turbine unit fr.53 port	Panel 77P	113B-0205-16
Control and protection unit, Type AE.7023	D.C. compartment fr.52-53 stbd.	Panel 104S	113D-0736-1
Voltage sensing c/o relay, Type BS.115B1B1C/2	D.C. compartment fr.52-53 stbd.	Panel 104S	113D-1394-1
Main contactor, Type 6042H152	D.C. compartment fr.52-53 stbd.	Panel 104S	113D-1208-1
Underspeed relay, Type BS115B-1B-1C/2	Rear spine compartment	Via spine hatch cover	113D-1394-1
Current sensing unit, Type F8101	D.C. compartment fr.52-53 stbd.	Panel 104S	113D-1353-1
Main generator field isolating relay, Type 7CZ/107791	D2 relay box	Panel 87P	113D-1311-1
Generator reset switch, Ref.No.5CN/5086	Port shroud extension panel	Cockpit	4343C, Vol.1, Sect.1
D.C. Voltmeters, Ref.No.5Q/107	Panel A2 (pupil)		
	Panel A1 (instructor)	Cockpit	
Main generator test socket, Ref.No.5CY/3002	D.C. compartment, fr.52-53 stbd.	Panel 104S	
Stand-by generating system			
Generator, Type BT0102M	Spine portion of No.2 engine hatch	Engine hatch cover	4343A, Vol.1, Sect.3, Chap.18
Voltage regulator, Type 31/63553Z/1	Spine portion of No.2 engine hatch	Engine hatch cover	4343B, Vol.1, Book 1, Sect.1
Voltage pick-up relay, Type F7901/1	Spine portion of No.2 engine hatch	Engine hatch cover	4343C, Vol.1, Book 2, Sect.3
Differential relay, Type F8001	Spine portion of No.2 engine hatch	Engine hatch cover	4343C, Vol.1, Book 2, Sect.3
Field isolating relay, Type 20B	Spine portion of No.2 engine hatch	Engine hatch cover	113D-1309-1
Turbine shut-off valve	Frame 43-44, starboard	Engine hatch cover	
Turbine isolating valve, Type FGB/A/16	Frame 46-47, starboard	Engine hatch cover	
Main battery, SAFT 20-V0-35, Type K2	Front fuselage spine compartment	Panel 15P	113C-0303-1
Battery isolation relay, Type T100B	D.C. feeder fuse panel	Panel 16P	113D-1397-16
Battery isolation switch, Type 8810/B104	Starboard leg panel	Cockpit	4343C, Vol.1, Sect.1
Battery test socket	Adjacent to main battery	Panel 15P	
Ground supply plug (5CY/5314)	Port wheel well	Port wheel bay	
Ground supply relay, Type T100B	D.C. feeder fuse panel	Panel 16P	113D-1397-16
Emergency battery, SAFT 19-V07-7AH	Main equipment compartment	Panel 16P	◀ 113C-0367-13B ▶

TABLE 2

Fuses, circuits and locations

Fuses No.	Rating	Circuit ident	Circuit	Location
130	5A	PH2	Stand-by generator control	D.C. feeder fuse panel
300	160A	P12	Main generator busbar	
301	30A	PF1	Main feeder, forward fuse box	
302	50A	PF2	Main feeder, forward fuse box	
303	50A	PF3	Main feeder, port fuse box	
304	50A	PF4	Main feeder, port fuse box	
305	50A	PF5	Main feeder, starboard fuse box	
306	50A	PF6	Main feeder, starboard fuse box	
307	50A	PF7	Main feeder, starboard fuse box	
315	5A	PJ3	Stand-by differential relay	
316	5A	PW2	Stand-by generator failure warning	
317	5A	PW1	Main generator failure warning	
318	5A	DF2	Voltmeters (port and starboard)	
319	7.5A	PC2	Stand-by generator voltage regulator	
322	5A	PJ4	Voltage-sensing relay	
326	5A	PE1	Battery voltage test socket	
337	10A	WE2	Battery isolation switch (via crash relay)	
408	5A	PT1	Main generator test socket	Fuse block in d.c. compartment
424	5A	PJ2	Voltage pick-up relay, stand-by generator	Fuse block in No.2 engine hatch
427	5A	PT2	Stand-by generator test socket	Fuse block in No.2 engine hatch

TABLE 3

Voltage measurements - serviceable system

The voltages quoted are measured at the terminals of the control and protection unit on a serviceable system with the turbine operating at normal speed.

Terminals checked	Voltage reading	Meter range	Circuit reference	Remarks
R1-R2	28V-28.5V	100V D.C.	PW1-PC16N	Auxiliary warnings circuit (from supply)
R3-R2	28V-30V	100V D.C.	P1-PC16N	Input to protection sensing
R4-R2	0.6V-1.0V	2.5 D.C.	PJ53-PC16N	Undervoltage trip circuit - voltage measured is across a conducting transistor. **Note...** *Under turbine underspeed conditions voltage across terminals R4-R2 will be zero.*
R6-R2	28.5V	100V D.C.	PJ41-PC16N	Input to voltage regulator sensing
R7-R2	32V-36V	100V A.C.	PC15-PC16N	Pilot exciter output (half winding) — Pilot exciter output is proportional to speed and will be lower under turbine underspeed conditions.
R8-R2	32V-36V	100V A.C.	PC14-PC16N	Pilot exciter output (half winding)
R7-R8	64V-72V	100V A.C.	PC14-PC15	Pilot exciter output (full winding)
L1-R2	Zero V	100V D.C.	PW11-PC16N	Auxiliary warnings circuit (to indicator)
L2-L3	1V-5V	10V D.C.	PC11-PC13	Main exciter field voltage
L4-R2	Zero V	100V D.C.	WE14-PC16N	Field isolating coil voltage
L5-R2	0.6V-1.0V	2.5V D.C.	PJ54-PC16N	Undervoltage trip circuit. Remarks identical with those for terminal check R4-R2
L6-R2	Zero V	10V D.C.	PJ52-PC16N	Reset circuit
L7-R2	23V-27V	100V D.C.	PJ55A-PC16N	Main contactor coil supply via stand-by generator switch. This supply is derived from the pilot exciter and its voltage may fall below the limits quoted under turbine underspeed conditions.
L8-R2	6.8± 0.5V	10V D.C. (pre Mod.4572)	PJ51-PC16N	Reset circuit
L8-R2	24V nominal	100V D.C. post Mod.4572)	PJ51-PC16N	Reset circuit

Note...
It is recommended that voltage measurements are taken with a Type 1 Multimeter, using the 100-volt range for the higher readings and selecting the lower ranges only when necessary.

TABLE 4

Voltage measurements - unserviceable system

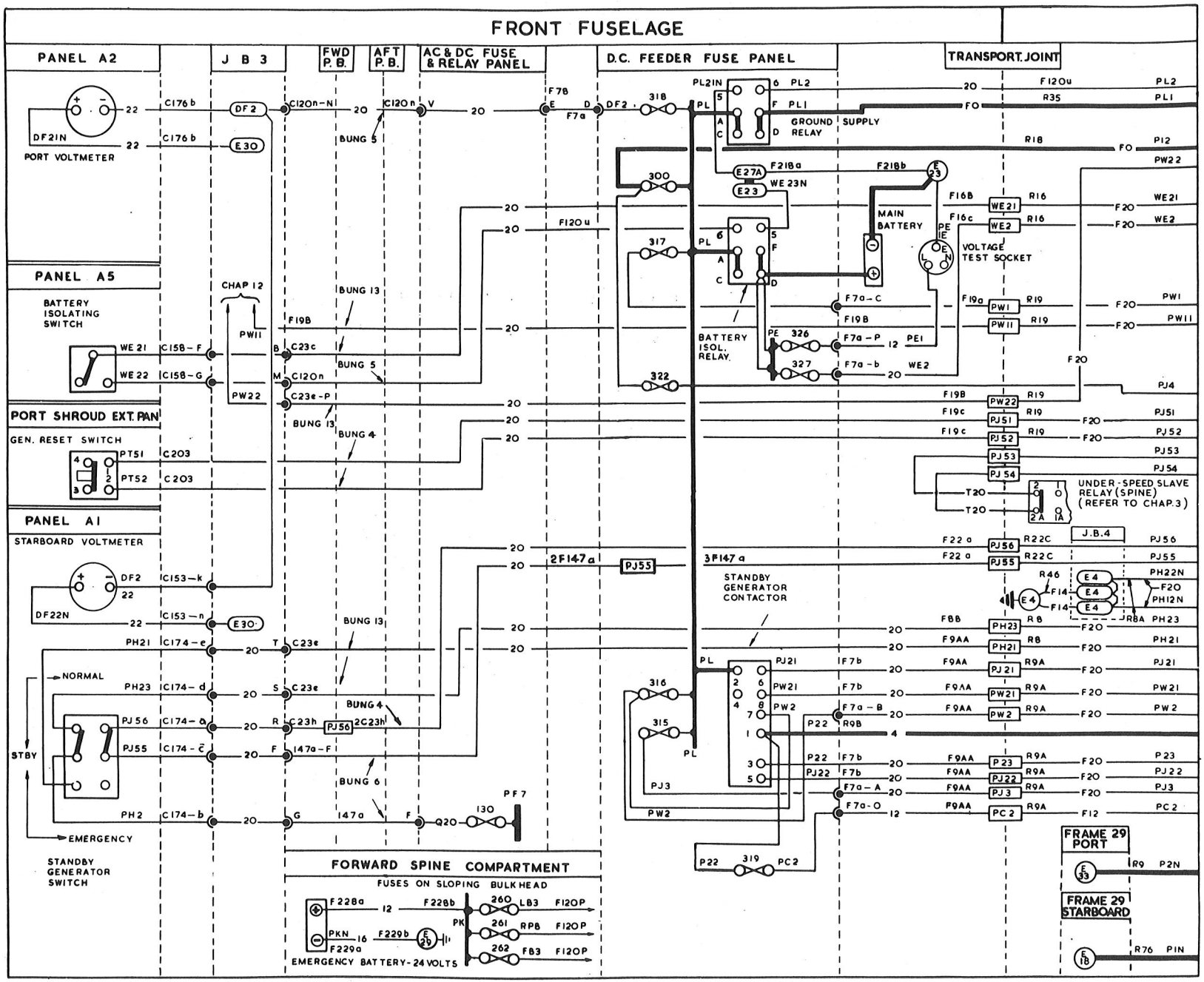
The voltages quoted are those which may be measured at the terminals of the control and protection unit on an unserviceable system with the turbine operating at normal speed.

Terminals checked	Voltage reading	Meter range	Circuit reference	Remarks
R1-R2	0V-28.5V	100V D.C.	PW1-PC16N	Voltage measured should be busbar voltage
R1-R2	Zero V	100V D.C.	◀ PW1-PC16N	If no auxiliary warning - check fuse 317 ▶
R3-R2	0V-28.5V	100V D.C.	P1-PC16N	Voltage measured will be busbar volts with contactor closed and generator volts if contactor is open.
R4-R2	23V-27V	100V D.C.	PJ53-PC16N	Trip condition due to undervoltage; if maintained without generator shut-down the overvoltage relay circuit or the field relay and its associated wiring may be faulty.
R4-R2	2V-20V	100V D.C.	PJ53-PC16N	Undervoltage output transistor not being switched on fully - under-voltage relay probably faulty.
R4-R2	Zero V	2.5V D.C.	PJ53-PC16N	Underspeed relay faulty or not being de-energized.
R6-R2	0V-28.5V	100V D.C.	PJ41-PC16N	Remarks identical with those for terminal check R3-R2.
R7-R2	Less than 30V	100V A.C.	PC15-PC16N	Indicates excessive current drawn from pilot exciter - Disconnect leads from terminals R7 and R8 and measure the voltage between each lead and R2; this should be between 30 and 36 volts.
R8-R2	Less than 30V	100V A.C.	PC14-PC16N	
L1-R2	28.5V	100V D.C.	PW11-PC16N	If the main contactor is closed and the line voltage (R3-R2) exceeds 26 volts the undervoltage relay is faulty.
L2-L3	10V-20V	100V D.C.	PC11-PC13	Indicates excessive field current - generator probably faulty.
L2-L3	40V-50V	100V D.C.	PC11-PC13	Field circuit broken
L4-R2	23V-27V	100V D.C.	WE14-PC16N	Field relay should be energized
L5-R2	23V-27V	100V D.C.	PJ54-PC16N	Represents undervoltage condition. If voltage between R3 and R2 is above 26 volts, then the undervoltage relay is faulty.
L5-R2	2V-20V	100V D.C.	PJ54-PC16N	Undervoltage output transistor not being switched on fully - the undervoltage relay probably faulty.
L5-R2	Zero V	2.5V D.C.	PJ54-PC16N	Undervoltage relay faulty.
L6-R2	6.8V ± 0.5V	10V D.C.	PJ52-PC16N	Voltage should appear only when reset switch is pressed.
L7-R2	Outside limits 23V-27V	100V D.C.	PC15-PC16N	Faulty internal power supply in A.E.7023 or fault in contactor coil resulting in excessive current being drawn. High voltage may result from earth fault on terminal L8 circuit.
◀ L8-R2	Outside limits 6.8V ± 0.5V	10V D.C. (pre Mod.4572)	PJ51-PC16N	Faulty internal power supply in A.E.7023; fault in reset switch circuit; or cable fault resulting in current drain.
L8-R2	24V nominal	100V D.C. (post Mod.4572)	PJ51-PC16N ▶	

Note...
It is recommended that voltage measurements are taken with a Type 1 Multimeter, using the 100-volt range for the higher readings and selecting the lower ranges only when necessary.

FIG.4. D.C. POWER SUPPLY SYSTEM

(illustration overleaf)



404

FIG. 4. D.C. POWER SUPPLY SYSTEM

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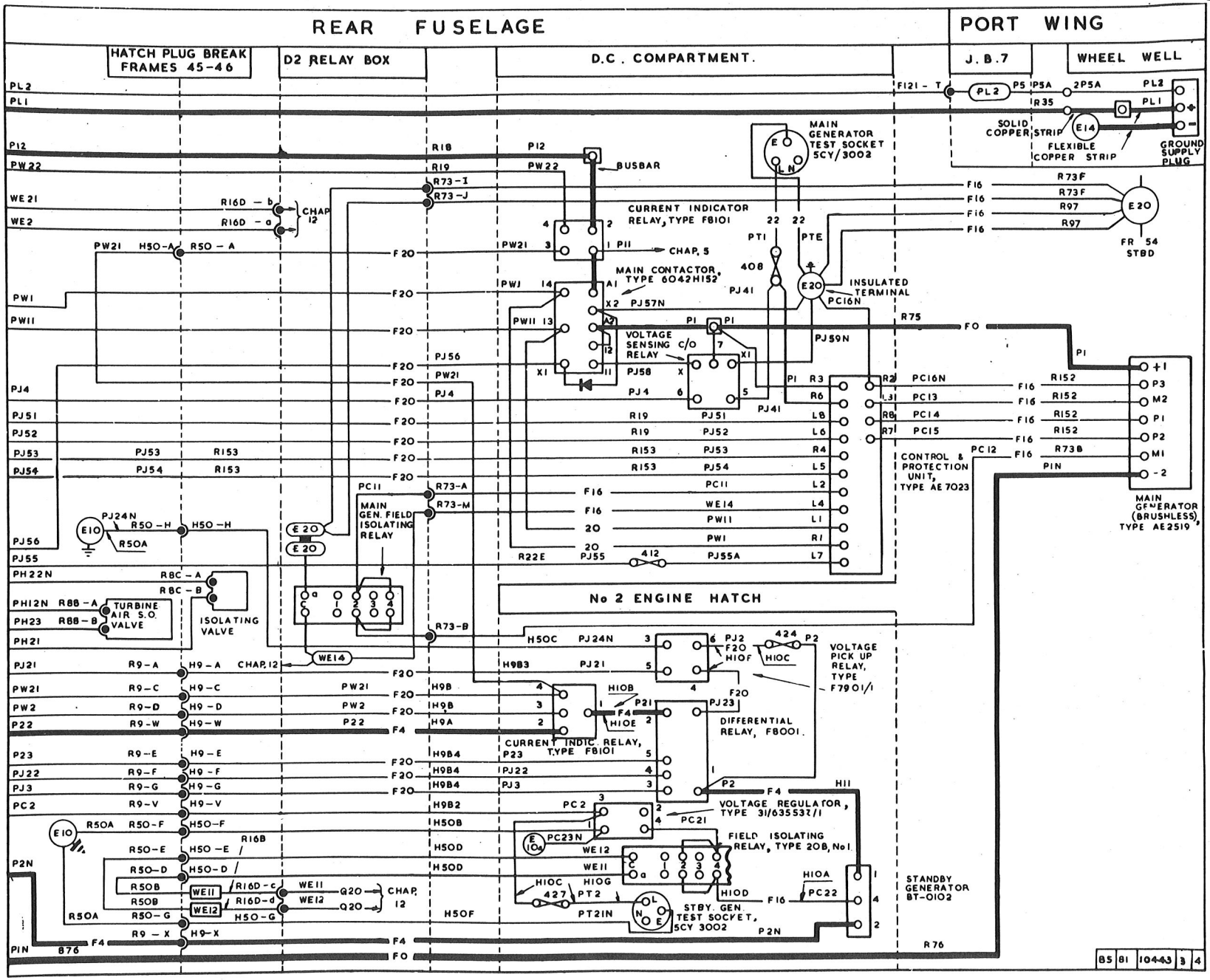

405

FIG. 4A. D.C. POWER SUPPLY SYSTEM

◀ MOD 4586 EMBODIED ▶