Group B.1

GENERATORS AND BATTERIES (CODE GA, A+ B+ AND L+)

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LIST OF ILLUSTRATIONS

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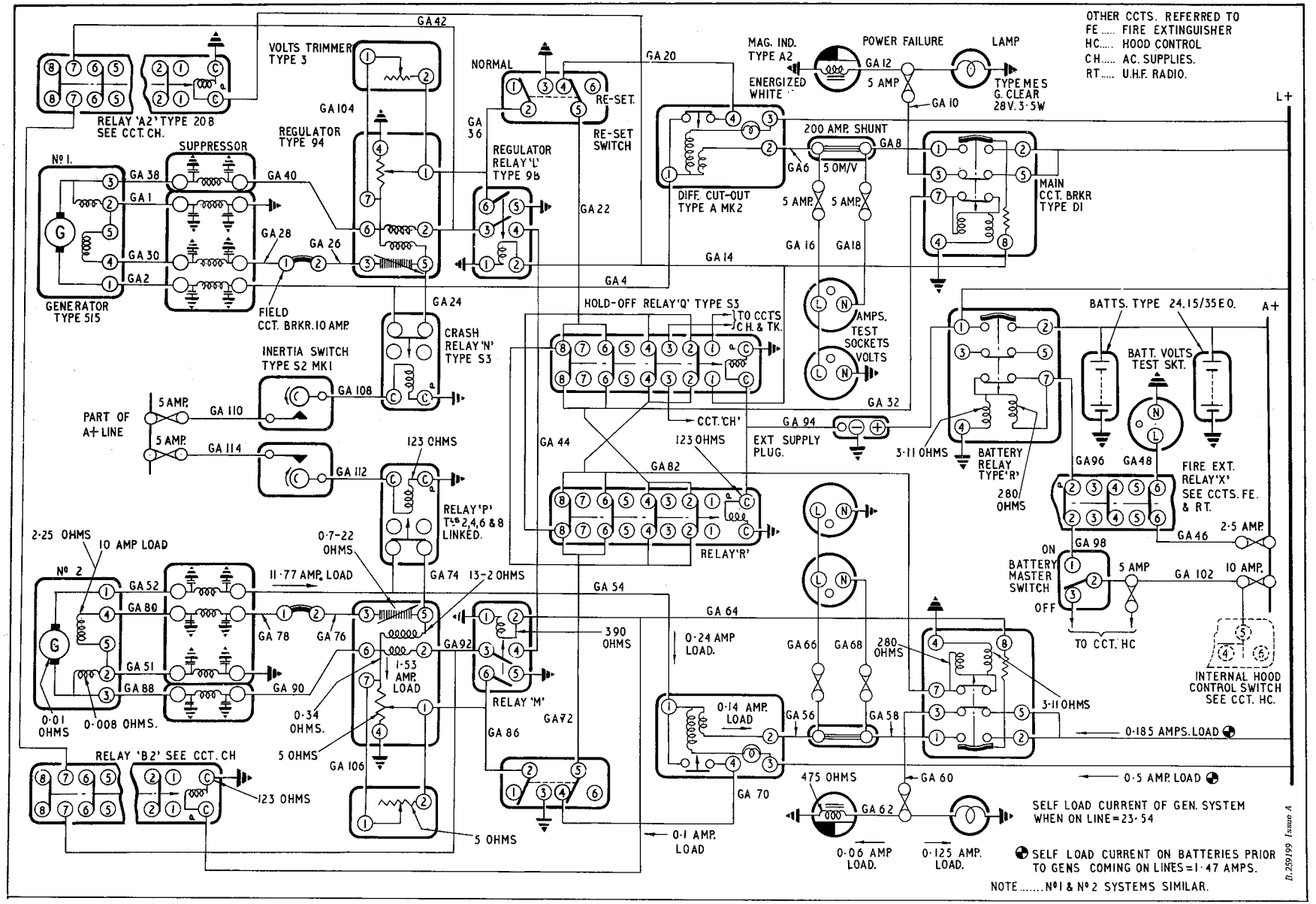

Fig. 1 Generators and batteries (theoretical)

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Introduction

1. This Group contains the description and operation of the generators and batteries circuit of this aircraft, together with information on the servicing required to maintain the equipment in an efficient condition. Routeing and theoretical circuit diagrams are also included. For a general description of the aircraft electrical system, reference should be made to Groups A.1, A.2 and A.3. Detailed information on the standard items of equipment used in the circuit will be found in the Air Publications listed in Table 1.

TABLE 1

Equipment type and Air Publication reference

Equipment Type	Air Publication
Generators, Type 515A, 28 volt, 6 kilowatt	A.P.4343A, Vol.1, Sect.3
Main batteries, Type 24.15/35EO Standby batteries, 12 volt, 4 amp.	A.P.4343A, Vol.1, Sect.11
Suppressors, Type X.3 and B.4	A.P.4343C, Vol.1, Book 3, Sect.5
Voltage regulators, Type 94 Remote voltage trimmers, Type 3, 5 ohm.	A.P.4343B, Vol.1, Book 1, Sect.1
Differential cut-outs, Type A, Mk.2 Main circuit breakers, Type D.1,200 amp. Field circuit breakers, Type A, 10 amp. Main feeder line protection circuit breakers, Type A, 45 amp.	A.P.4343B, Vol.1, Book 2, Sect.10
Battery relay, Type R Hold-off and crash relays, Type S, No.3 Inertia switches, Mk.1, Type 8C Regulator relays, Type 9B Relays A.2 and B.2, Type 20B	A.P.4343C, Vol.1, Book 2, Sect.3
Re-set switches, C.W.C., Type XD.789, No.3 Battery master switch, C.W.C., Type XD.778, No.4	A.P.4343C, Vol.1, Book 1, Sect.1
Power failure warning lamp, Type B Power failure warning magnetic indicators, Type A.2	A.P.4343E, Vol.1, Book 4, Sect.18

DESCRIPTION

Generators and batteries

Main 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 are mounted on a platform in the radio bay. To minimise 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, after passing through the suppressors, are earthed to the aircraft structure at earth points 10 and 16 located adjacent to the generators.

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

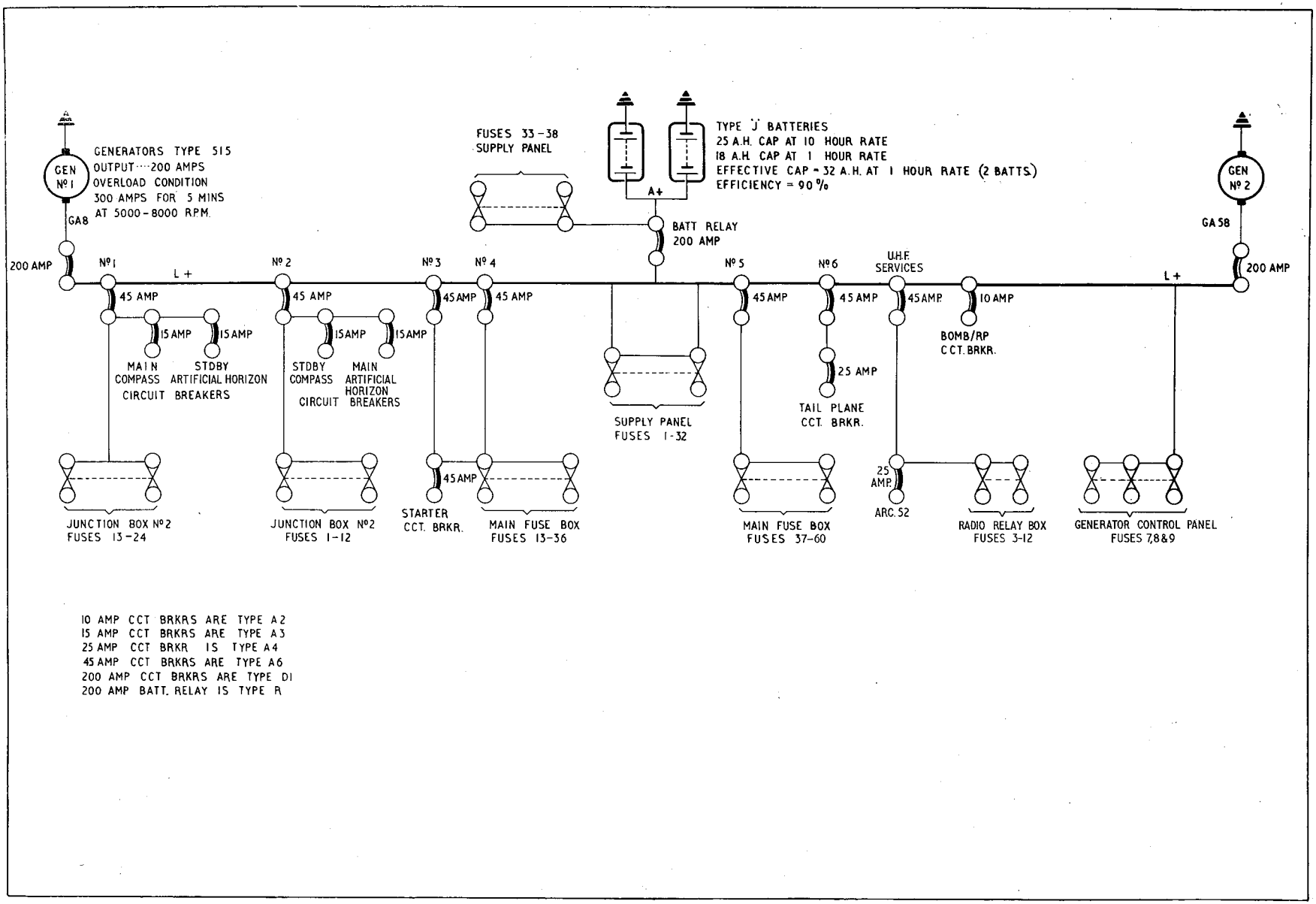

Fig. 2. Distribution (theoretical)

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generator field windings, respectively. There is, in addition, a re-set switch, control relays, a power failure magnetic indicator and test sockets. Two eight-way fuse blocks, containing the control fuses, are also mounted on this control panel, together with a ten-way 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, on the port underside of the cross member adjacent to frame 18A, enables 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. As no specific gravity check is possible on the batteries installed in this aircraft, a test socket is provided on the aft face of frame 15 in the radio bay, for checking the state of charge by voltage, as described in para.21.

Automatic off-loading

5. In the event of a crash landing, the generators and batteries are automatically isolated from the electrical system by the operation of relays controlled by inertia switches. Each generator is isolated by its own crash relay and inertia switch so that only one generator is lost in the event of accidental operation of the switch. The generator inertia switches are located in the radio bay. The batteries are isolated from all but the essential load line (A+), to prevent the possibility of fire, by the operation of the fire extinguisher relay. This relay is energized by two series connected inertia switches as described in Group C.2. These inertia switches are wired in series to eliminate the danger of accidental operation and are connected, one in the positive supply to the relay coil and the other in the negative return line of this coil. When the batteries are so isolated, only the essential load line is left connected to them - i.e. the fire extinguisher bottle.

Standby supply

6. A pair of 12 volt, 4 amp. hour batteries, wired in series are provided as a 24 volt standby supply for certain electrical services of this aircraft. These are carried in a battery box supported on quick-release mountings attached to the starboard rear face of frame 15 in the radio bay. Their main function is to maintain operation of the standby artificial horizon *(Sect.5, Chap.2)*, should the aircraft's normal electrical supply system fail, but they are also employed as a supply for the cabin emergency lighting *(Group F.1)* The batteries are brought into use by the operation of the appropriate control switches for the services concerned.

Distribution and earth return

7. The distribution of power from the positive bus-bar (L+), located above the supply panel between frames 16 and 17A, is indicated in fig.2 and 5. Distribution is on a ring main system, the main feeds being protected by six 45 amp. circuit breakers located adjacent to the supply panel and feeds carrying smaller loads having fuse protection only. The earth return leads from the various electrical services of the aircraft are wired back from the equipment to the junction boxes and panels where they are connected to a ring earth line, which is connected to the aircraft's structure at a limited number of main earth points. All the main earth points are numbered and may be located on the earth routeing charts given in fig.7 and 8 and on the location illustrations contained in Group A.3.

Operation

General

8. 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 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.

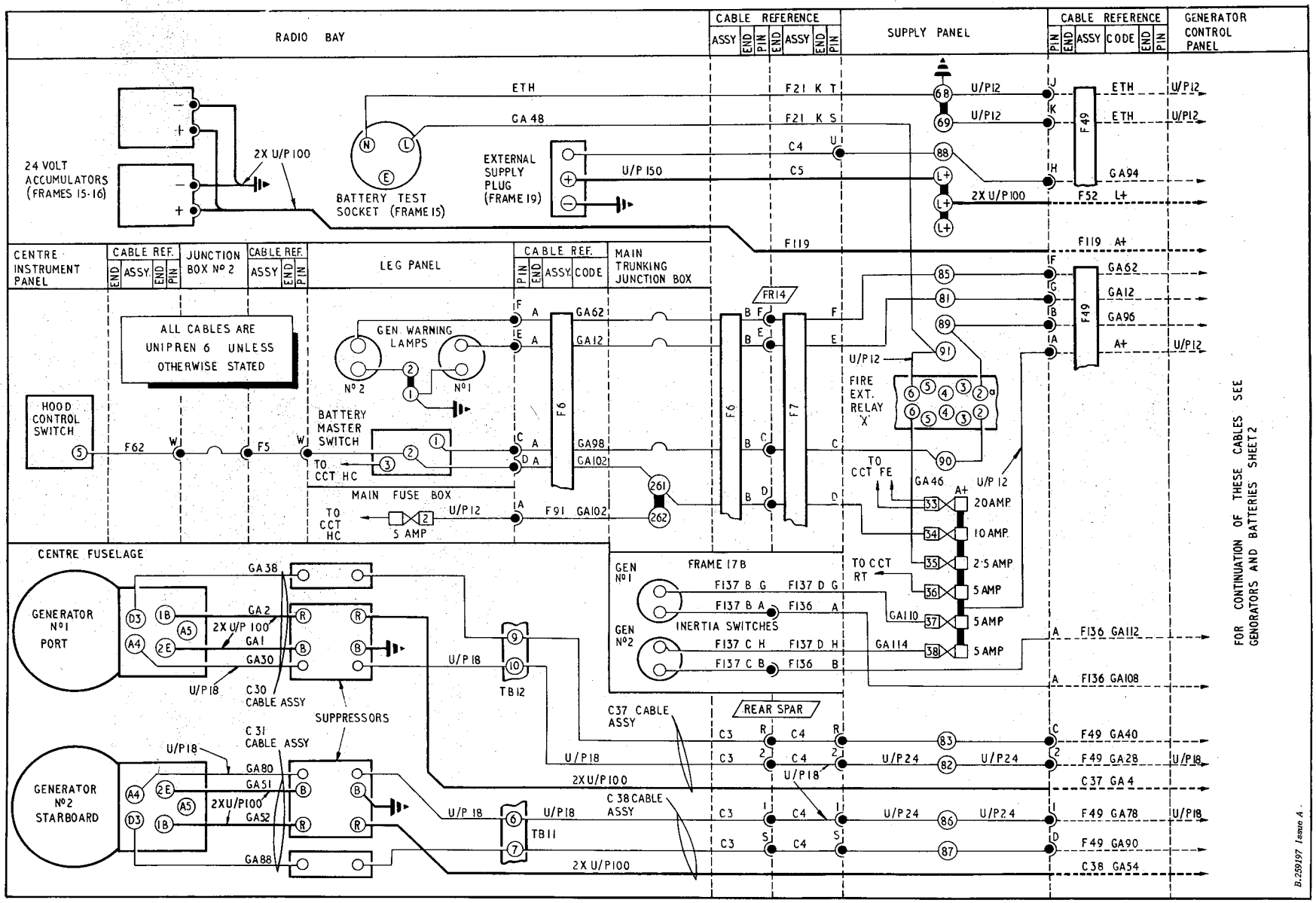

Fig. 3. Generators and batteries (routeing sheet 1)

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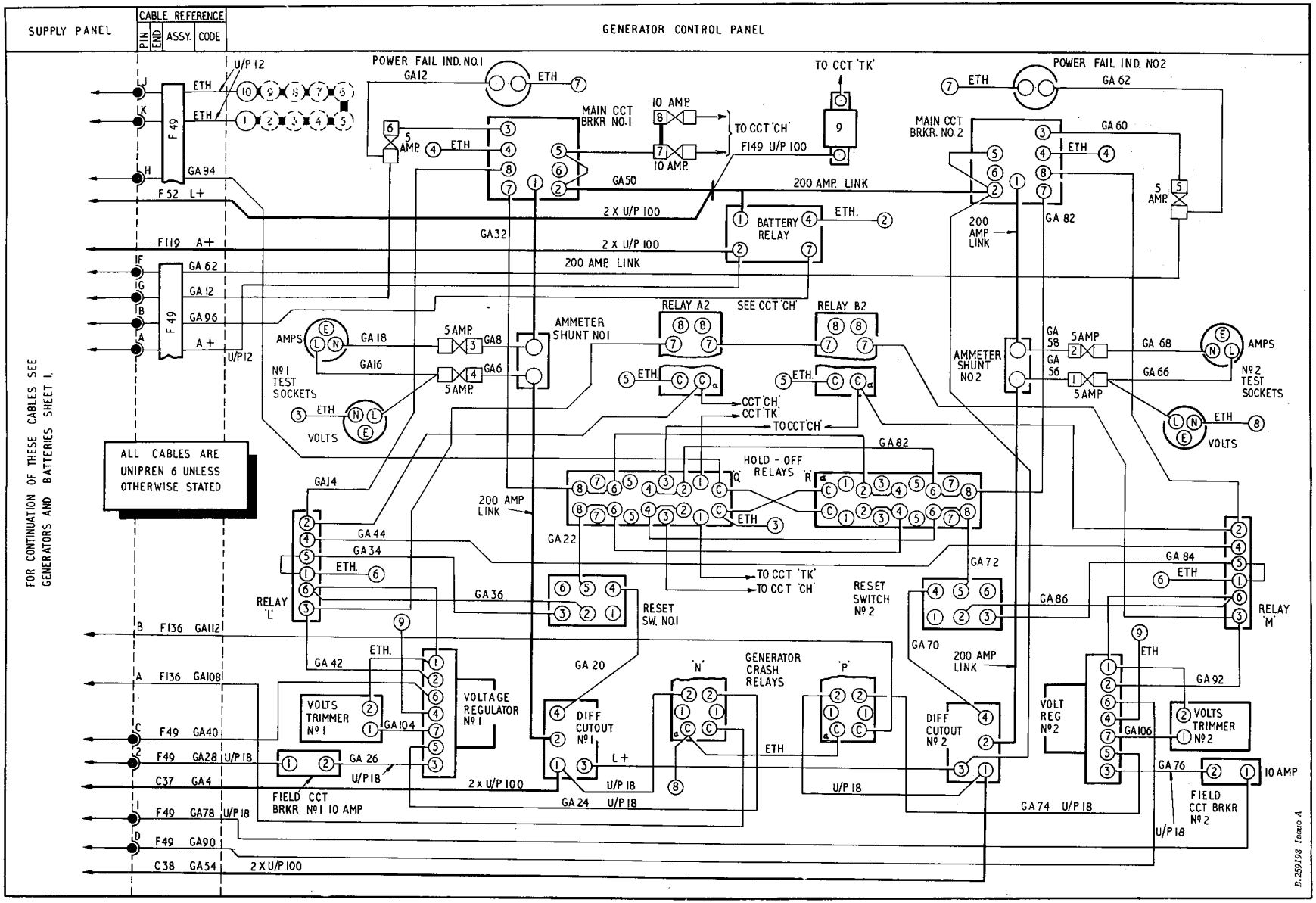

Fig.4. Generators and batteries (routeing sheet 2)

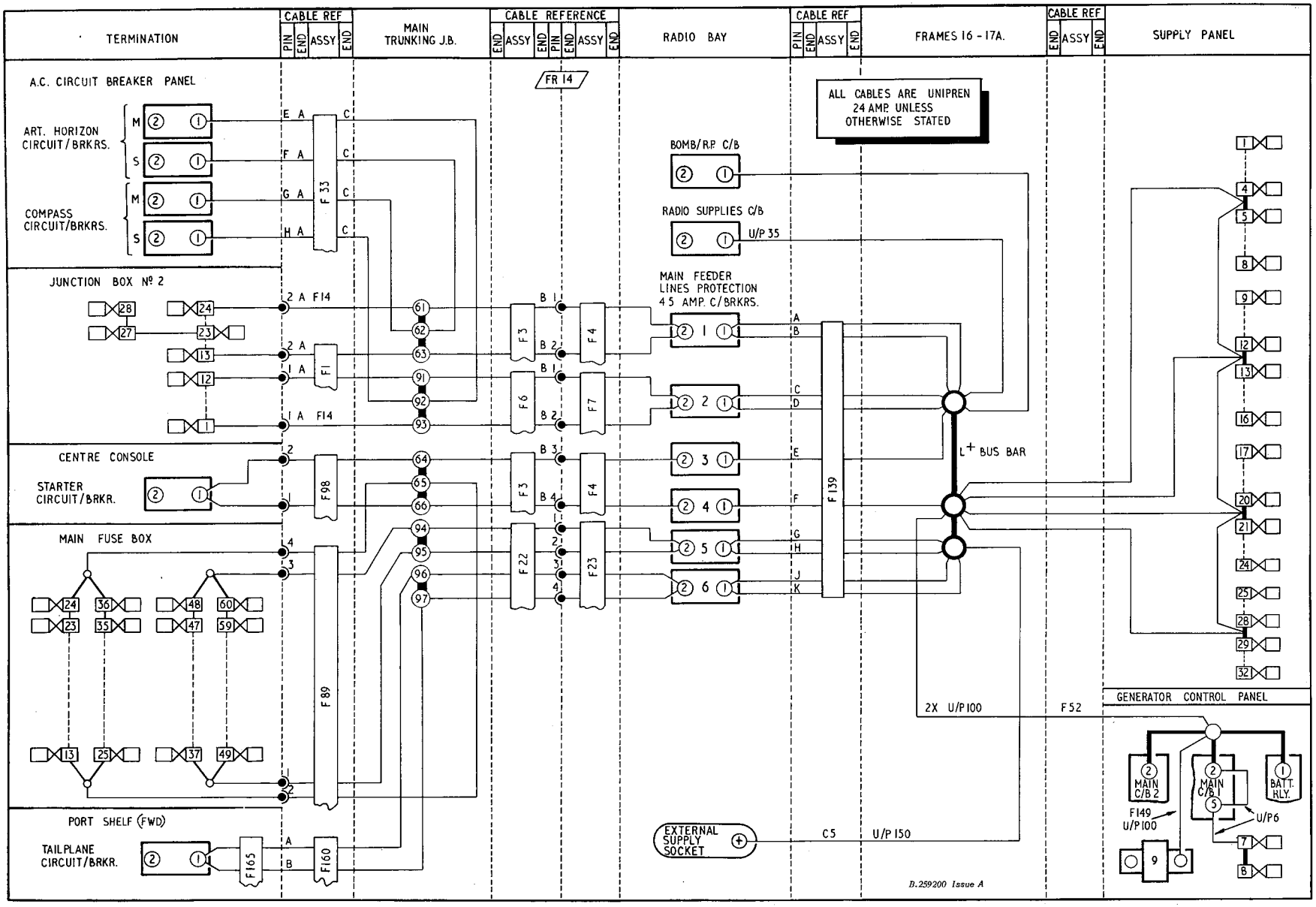

Fig. 5. L + distribution (routeing)

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9. 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, which is only in circuit prior to operation of the generator on the line. During normal operation of the generator, contacts 5 and 6 of the regulator relay, (L or M), 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.23)*. Additionally, contacts 3 and 4 of the relay serve to complete the load balancing line when the relay is closed *(para.12)*.

Generation

10. 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.16)* 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.

11. The differential coil windings are such that, when the generator output rises to a figure of 0.35 to 0.75 volts 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.

12. 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.9)* and completing the circuit of the load balancing coil in the voltage regulator, when the second generator, is also on the line. The supply to the regulator relay also energizes relays A.2 and B.2, contacts 7-7a of which complete a duplicate load balancing line. The remaining contacts of relays A.2 and B.2 are used in the a.c. supplies control circuit as described in Group E.1. The load balancing coils are connected in series between the inner ends of the generator interpole windings.

13. 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

14. 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

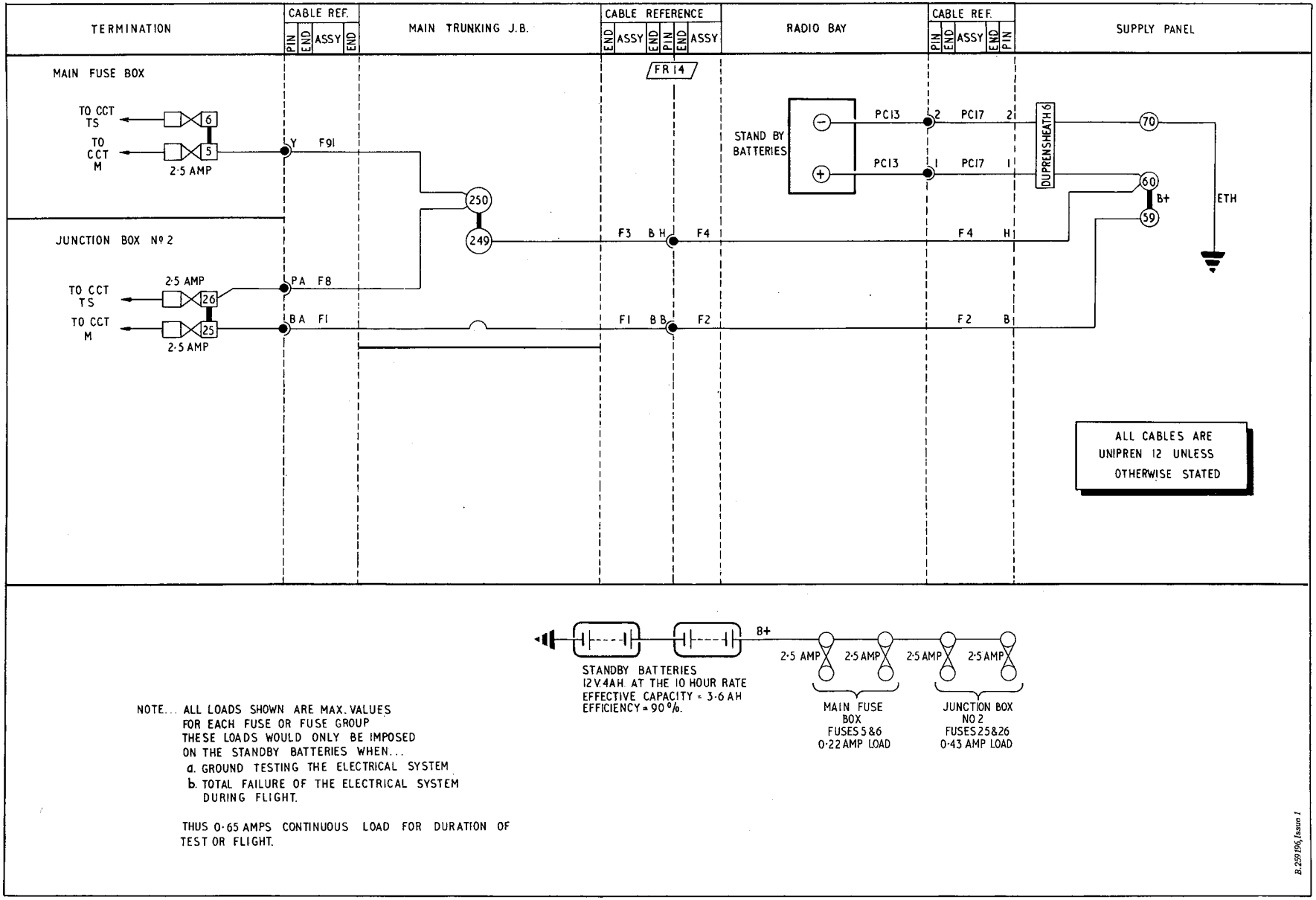

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Fig.6. B + distribution

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the cut-out and this reverses the polarity of the armature and 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 and relays A.2 and B.2 are 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

15. The main 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

16. In the event of a crash landing, a pair of inertia switches, which are fed from the essential load line will operate and complete the supply to the generator crash relays, which will be energized and break the supply to the voltage regulator operating coils, thus off-loading the generators. At the same time, the inertia switches 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.

External supply

17. 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.

Note . . .

Contacts 1-1 and 3-3 of hold-off relays Q are wired to the inverter test switches, which are used to energize relays A.2 and B.2 when ground testing the a.c. supplies circuit, as described in Group E.1.

Test sockets

18. 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.23.

Standby supply

19. The operation of the standby supply circuit (B+) will be obvious, once reference is made to the theoretical diagram given in fig.6 and to Group F.1 of this chapter. Reference should also be made to Sect.5, Chap.2, for a description of the standby battery supply to the artificial horizon.

SERVICING

General

20. For general servicing of the circuit as a whole, reference should be made to Group A.1. 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

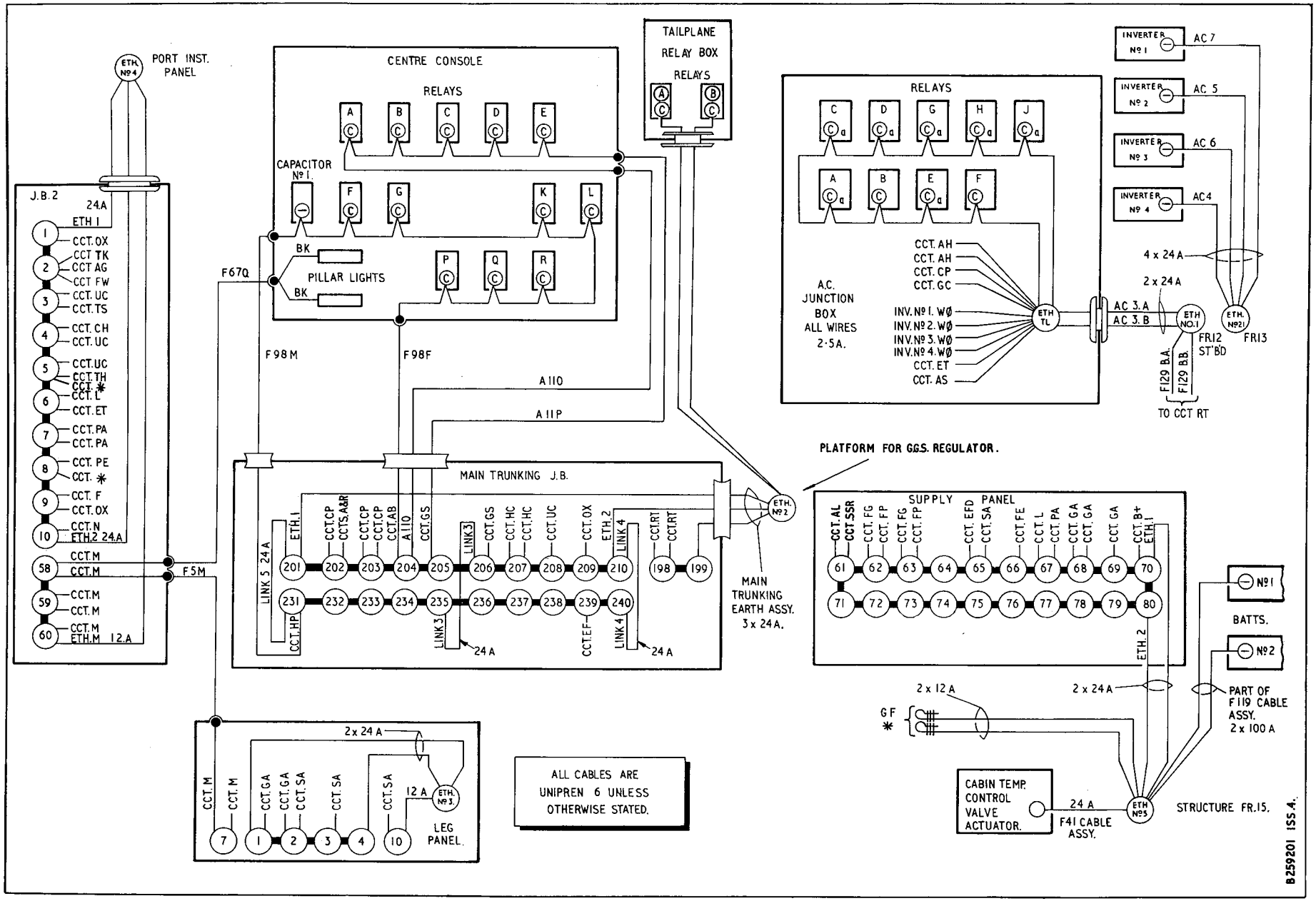

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Fig.7 Earth return (routeing — sheet 1)

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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 appropriate Air Publications listed in Table 1.

Servicing main batteries

21. The state of charge of the main batteries installed in this aircraft is determined by voltage, as no check of specific gravity is possible. A small three-pole test socket is located adjacent to the batteries for this purpose. When using this socket, it is essential to check one battery at a time and this may be accomplished by removing the Elcon plug from one of the batteries while checking the other and vice versa. After test, ensure that both Elcon plugs are reconnected to the batteries.

22. The open circuit voltage of a fully-charged battery is 25.8 to 25.1 volts, a quarter to half-discharged battery is 25.1 to 24.5 volts and a half discharged battery is 24.5 to 24.2 volts. To obtain more definite information on the state of charge, an off-load reading should be taken immediately after taking a reading with the battery connected to a load of approximately 20 amp. for 15 seconds *(i.e. radio, navigation lamps and cabin lamps switched on).* The increase in reading from on load to off load should be approximately 1 volt. If the aircraft is not flown or the engine is not run-up for more than two weeks, the batteries must be removed and returned to the battery charging bay. Under no circumstances should the batteries be left installed in aircraft beyond the normal battery servicing period or serious deterioration will result. For detailed servicing of the batteries, reference should be made to the Air Publication listed in Table 1.

Paralleling of generators

◀ **23.** The generating circuits should always be ensured parallel 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 circuits and also when a check is indicated as being necessary. Using a Multimeter Type 12889 or similar test equipment, the procedure for checking the generator control system is as follows:-

Note . . .

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

(1) Start the engine in accordance with the 1304 instructions detailed in AP 101B-1305-12 1306 *(Ground handling notes).* Ensure both generator failure warning lamps extinguish at an engine speed of 3 000 rev/min ± 200 rev/min and that the power failure magnetic indicators operate correctly.

(2) Run the engine at the normal cruising speed of 7 800 rev/min.

(3) Select No. 1 generator re-set switch to RE-SET, *(No. 1 generator off-load, warning lamp illuminated, power failure magnetic indicator indicating white),* connect the testmeter to No. 1 volts test socket and ensure a voltage of 27.5V d.c. $^{+0}_{-0.5}$V d.c., adjusting the external voltage trimmer as necessary to obtain this figure. Select No. 1 generator re-set switch to NORMAL, checking that the regulated voltage momentarily rises by approximately 1 volt as the generator output is boosted to enable it to come on line. Disconnect the testmeter from the test socket.

Note . . .

The voltage boost is removed immediately the main contactor closes and is therefore evident for a very short period. Some testmeters may not respond quickly enough to fully show the temporary increase.

(4) Select No. 2 generator re-set switch to RE-SET, *(No. 2 generator off-load, warning lamp illuminated, power failure magnetic indicator indicating white),* connect the testmeter to No. 2 volts test socket and ensure a voltage of 27.5V d.c. $^{+0}_{-0.5}$V d.c., adjusting the external voltage trimmer as necessary to obtain this figure. Select No. 2 generator re-set switch to NORMAL, checking that the regulated voltage momentarily rises by approximately 1 volt as the generator comes on line. Disconnect the testmeter from the test socket. ▶

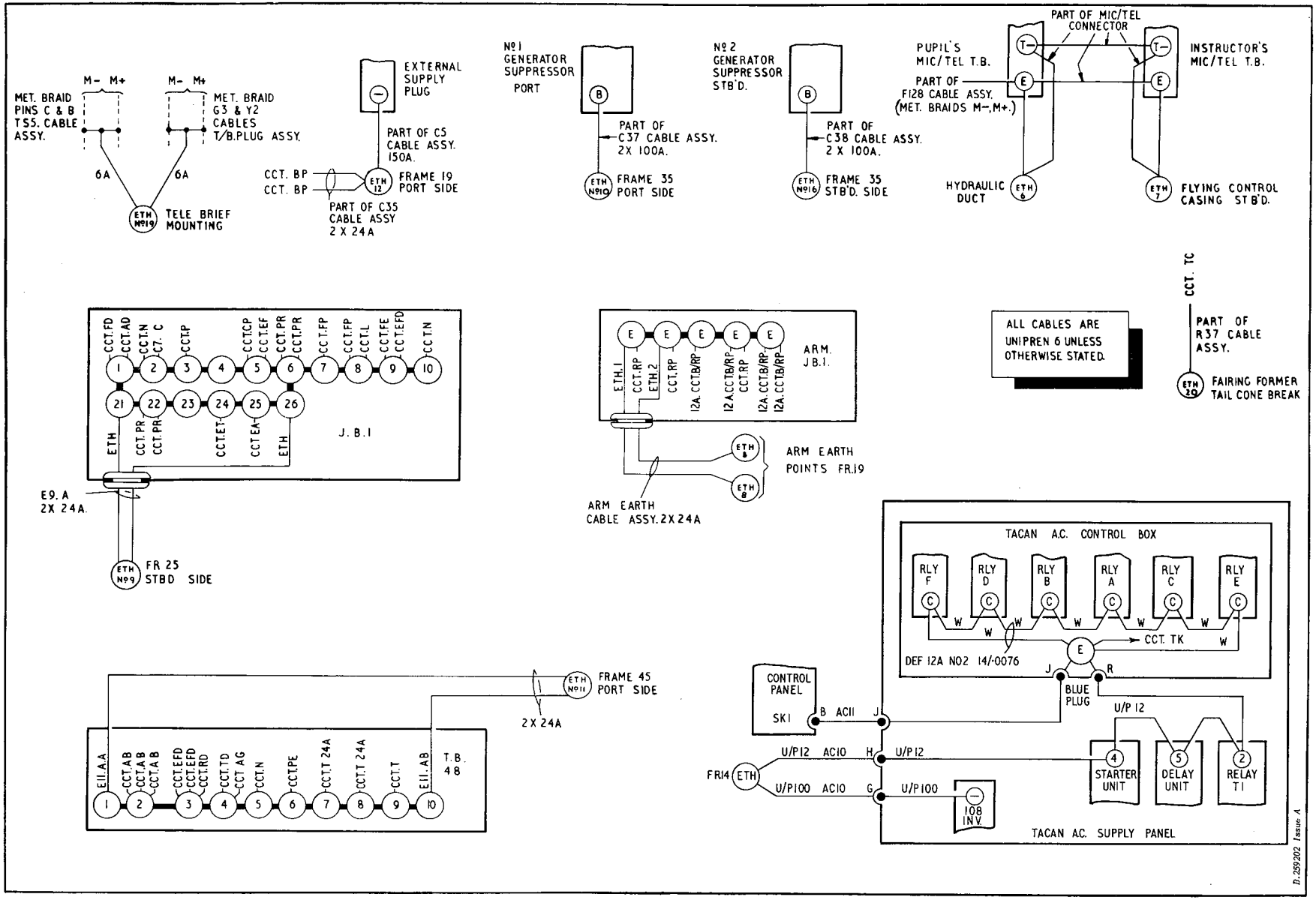

Fig. 8 Earth return (routeing sheet 2)

◀ (5) Increase the engine speed to maximum and repeat sub-para. (3) and (4) ensuring a voltage of 27.5V d.c. $^{+0}_{-0.5}$V d.c. Reduce the engine speed to 3 700 rev/min.

(6) With the testmeter disconnected from the volts test sockets and both generator re-set switches selected to NORMAL, connect ammeters to the ammeter test sockets. Ensure a load of at least 50 amp, including battery charging, is imposed on the L+ bus-bar. Increase the engine speed to maximum, checking that the load current difference between No. 1 and No. 2 generators does not exceed 10 amp throughout the engine speed range.

Note . . .

If this figure is exceeded, the procedure detailed in sub-para.(2), (3) and (4) should be repeated followed by a further load sharing check.

(7) With the ammeters still connected, reduce the engine speed to idling. Shut down the engine and as the speed reduces through approximately 2 950 rev/min, ensure the cut-out contacts open, illuminating the power failure warning lamps and operating the power failure magnetic indicators. During this period, check that the reverse current reading on the ammeters is between 15 amp and 25 amp. The generating circuits are now aligned and the ammeters may be removed from the ammeter test sockets. ▶

REMOVAL AND ASSEMBLY

General

24. 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 paragraphs. Once clear access has been obtained, the removal of the generators and other components of the circuit, should present no special difficulties.

Changing main batteries

25. The two main batteries are carried on platforms located in the radio bay in the front fuselage and access may be gained via the radio access doors (Book 1, 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 vent pipes from each battery.

(3) Remove the Elcon plugs from each battery and place in such a position so that they will not short on the aircraft structure.

(4) Disengage the special quick-release bolts securing each battery and carefully remove the batteries from their mounting platforms.

(5) Examine the replacement batteries to ensure that their voltage is within ± 0.5 volts of each other. Place the replacement batteries on the platforms and reverse the procedure in sub-para (2) to (4).

Note . . .

Before attempting to connect the batteries, ensure that the Elcon plugs are not shorting against the aircraft structure.

Removal of standby batteries

26. These batteries are carried in a box located in the radio bay and access may be gained by opening the radio access doors. To remove the batteries, proceed as follows:–

(1) Render the aircraft electrically safe, as described in Group A.1.

(2) Disconnect cable assembly PC.13 from cable assembly PC.17 at the plug and socket connection on the side of the battery box.

(3) Withdraw the two draw bolts at the top of the box from the mounting structure and lift the box upwards to disengage its lower mountings.

(4) Remove the box and batteries from the aircraft.

(5) The batteries may be removed from the box by opening the lid and disconnecting the leads of cable assembly PC.13 from the battery terminals.

Refitting generators

27. When refitting generators, reference should be made to the accessories gearbox installation instructions given in Book 1, Sect.4, Chap.1. If cable assembly C.31 extending from No.2 generator to its suppressor has been disturbed, care must be taken to ensure that the P-clips securing the cable to the hydraulic external supply valves support bracket are facing aft, i.e. the cable is laying aft of the rear face of the bracket. This is necessary to prevent the possibility of a foul between the cable and the engine throttle linkage *(Ref.S.T.I./Hunter/280).* To prevent chafing of the cable by the engine access door it is also important to ensure that the cable passes in front of the engine low pressure fuel filter drain pipe *(S.T.I./Hunter/299).*