Group 14

E.C.M. POWER SUPPLIES

(Completely revised)

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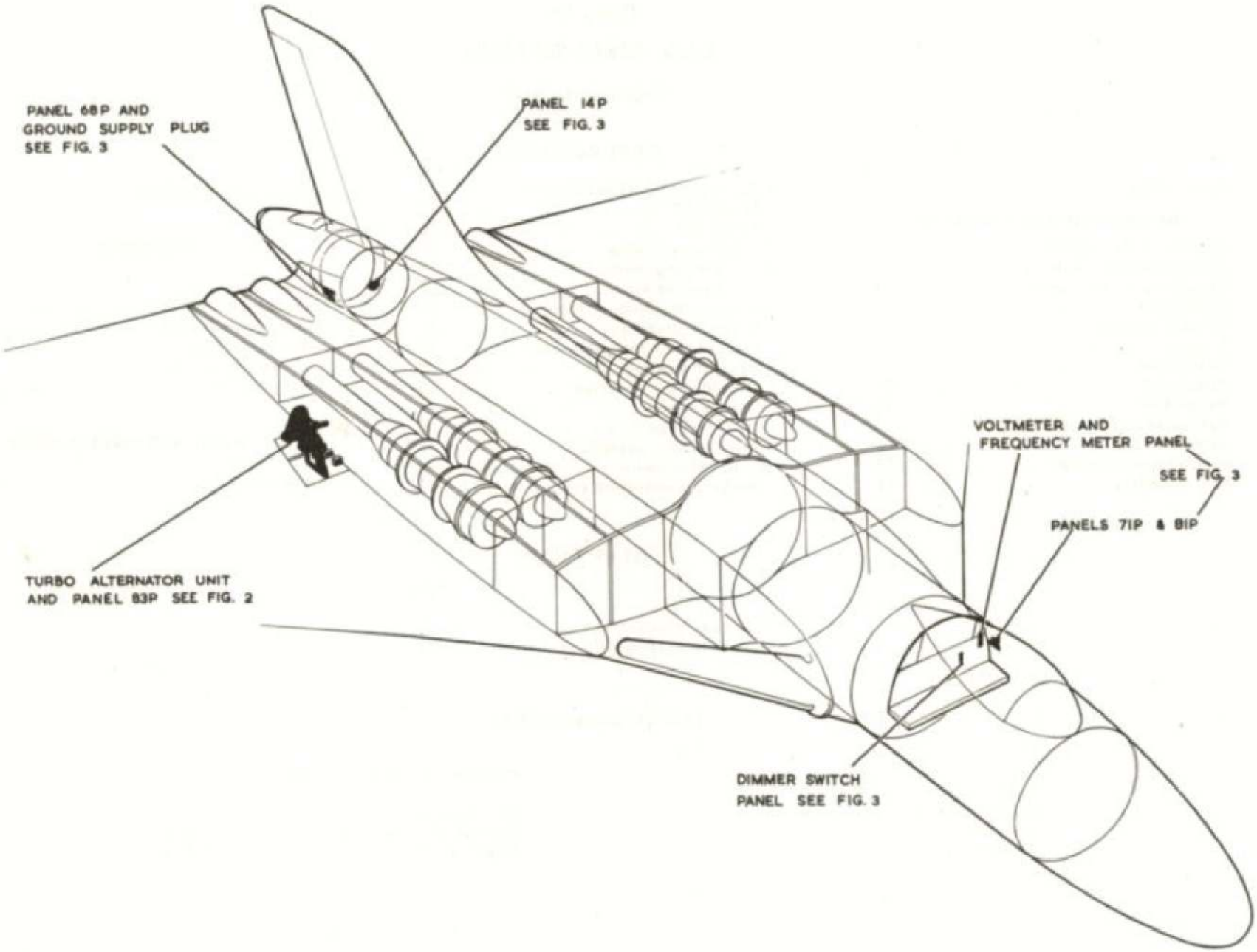

Fig. 1 Location of equipment

Introduction

1. On those aircraft which have been converted to Mk.1A by the embodiment of Mod.613, E.C.M. equipment is installed which requires power supplies at 200 volts, 400 c/s, 3-phase a.c. and 28 volts d.c. This group contains descriptive and servicing information for the power supply and distribution services to the equipment.

OUTLINE OF THE SYSTEM

2. The 28-volt d.c. supplies to the E.C.M. equipment are obtained from the bus-bars of the aircraft system via suitable fuse-banks on the distribution panels. The 200-volt, 400 c/s, 3-phase a.c. supplies are obtained from a turbine-driven alternator unit, installed in the compartment aft of the starboard main wheel bay. The turbine is driven by air bled from the pressurisation and anti-icing supply from the No.3 and No.4 engines.

3. Two switch panels 71P and 81P, a voltmeter and frequency meter panel and a dimmer switch panel comprise the control panels for the E.C.M. installation supplies. Detailed illustrations of these panels are provided in fig.3.

4. The fuse distribution and main sub-contactor panels for the installation, (panels 68P, 14P, 44P) are all located in the extended rear fuselage section of the aircraft, adjacent to the various units of each A.R.I.

Turbo-alternator unit

5. The turbo-alternator unit, Type T.G.A.30, is installed in the compartment aft of the starboard main wheel bay as shown in fig.2. The complete unit comprises an inward flow radial turbine driving a 30 kVA alternator, Rotax Type N0313, via a speed reducing gearbox. The installation of the unit on the aircraft is described in Book 1, Sect.3, Chap.16, whilst the unit itself is described in A.P.2240C, Vol.1.

6. Control of the air supply to the turbo-alternator unit is by means of a two-position electrically-actuated bleed valve, Teddington Type FMP A5091, situated in the main supply line to the unit as shown in fig.2. The bleed valve actuator is controlled by means of a switch on 71P.

7. The output frequency of the alternator is maintained to within $\pm$ 2% of 400 c/s using a butterfly throttle valve, in the air inlet to the turbine, to control the turbine speed. The throttle valve is mechanically-linked to a hydraulic servo which incorporates and is controlled by a differential electro-mechanical relay in circuit with a frequency control unit, Type C.P.S.3 Mk.2.

Frequency control unit

8. This unit, Type C.P.S.3 Mk.2 is described fully in A.P.4343B, Vol.1 and only general details of the circuit operation are given here. Connections from the red and blue phases of the alternator output are taken to the primary of a split secondary transformer within the unit, and each secondary is connected to a separate preset circuit. One circuit resonates at 500 c/s, and the other at 300 c/s. Each circuit then operates one control grid of a double triode valve, thus providing an anode current fluctuation varying with, and respective to, any change from 400 c/s to higher or lower frequency.

9. Since the characteristics of the two triodes in a double triode valve are never identical, a variable resistance is provided for matching purposes. The outputs of the two triodes, 500 and 300 c/s respectively, are each fed to a separate pentode amplifying valve. The outputs from the amplifier valves are then used to operate the control coils of the Muirhead relay-operated butterfly valve in the air inlet to the turbine. The valve closes when the frequency is increased and opens when the frequency is decreased. The frequency of the alternator is therefore kept constant within the limits given in para.7.

Overspeed

10. Turbine overspeed conditions, which could be caused by a failure in the frequency control system, are catered for by the inclusion of an overspeed shut-off valve which is incorporated in the throttle valve body. The overspeed valve is mechanically linked to a centrifugally operated overspeed trip which is connected to a drive taken off the main speed reducing gears.

11. If the overspeed trip operates, the

With this amendment the alterations due to the following modifications have been incorporated.

Mod.1849 - provision for airborne overspeed trip reset, and emergency control of speed.

Mod.1884 - replacement of frequency control unit Mk.1 by Mk.2.

Mod.1973 - change of contactors, Ref.Nos.5CW/6283 and 5CW/6843 replaced by 5CW/6944.

DESCRIPTION AND OPERATION

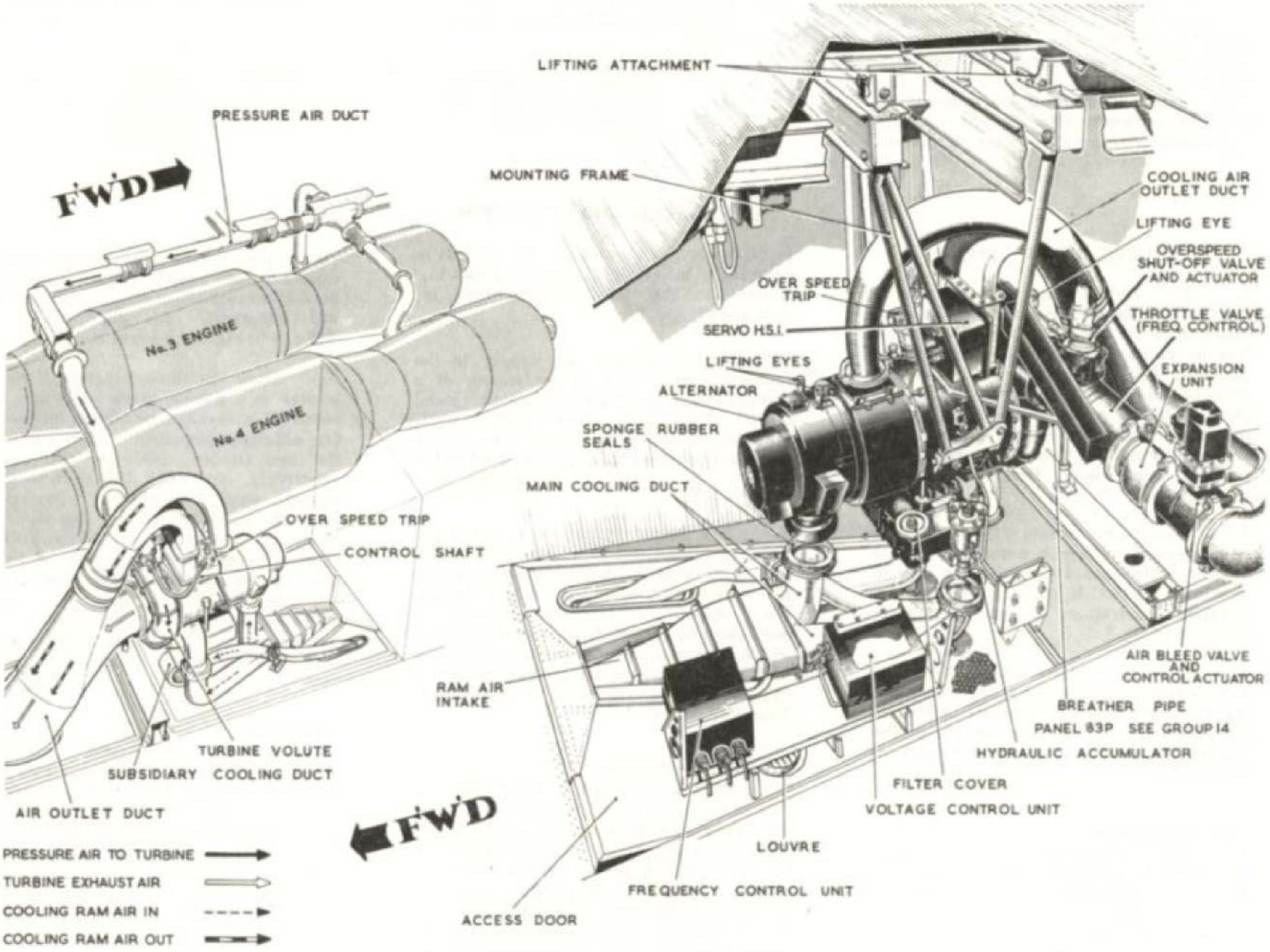

Fig. 2 Turbo-alternator unit
(‹ Mod 1849 ›)

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selection of the turbine air bleed control switch to TRIP will automatically cause an electrically-operated actuator to reset the shut off valve and overspeed trip. If the overspeeding is due to a fault in the frequency control unit, the unit can be isolated from the system and an emergency control established by using the turbine air bleed valve to vary the air flow.

Voltage control

12. The output voltage of the alternator is maintained within the limits of 195 and 205 volts by means of a voltage control unit, Rotax Type U.3711, mounted on a shelf in the turbo alternator compartment. This control unit incorporates transducers and transformer rectifier units for field current control, over and under-voltage control and also provides a control over the external loads circuits. A Merz-Price protection system is included in the alternator and main supply wiring, to provide protection in case of line-to-line or earth-to-line fault conditions. Full details for the voltage control unit are contained in A.P.4343B, Vol.1, Book 2, Sect.8.

NOTE...

A resistance unit, Type ZA.6002, is connected in series with the control unit to improve the field flashing facilities. The resistance unit is located on the aft face of the rear undercarriage bulkhead.

Cooling

13. Cooling of the alternator gearbox and voltage control unit is by ram air ducted from the slip stream, via a flush intake integral with the forward portion of the access door, to the turbo-alternator compartment. The air is exhausted via an outlet in the aft portion of the door. Further details of these features appear in Book 1, Sect.3, Chap.16 of this publication.

Test panel

14. A test panel, (83P), is installed in the turbo-alternator compartment adjacent to the electrical components shelf. This panel houses a bank of fuses and a test socket to enable the alternator output to be checked on the ground. The panel is shown in fig.2 and further information on its use will be found under the main heading 'Servicing'.

Panel 71P

15. The turbine air and alternator control panel, 71P, houses the following control switches and indicators:-

Turbine air bleed control switch	-	a 3-position, single pole, spring loaded to centre-off, labelled TRIP, RUN
Speed switch	-	a similar switch labelled INC., DEC.
Emergency switch	-	a 2-position, double pole switch, labelled NORM., EMERG.
Alternator control	-	a 2-position single pole, labelled ON, OFF.
Air bleed valve indicator	-	a 3-position magnetic indicator, Type C5175Y Mk.1 displaying OPEN, SHUT and when de-energised, black and white cross hatching.
Alternator supply indicator	-	a 3-position magnetic indicator, Type C5175Y Mk.2 displaying ON, OFF, and when de-energised, black and white cross hatching.
Ground supply indicator	-	a 3-position magnetic indicator similar to above.

Panel 81P

16. The E.C.M. power supplies panel (81P), is located immediately below panel 71P, and houses the ON-OFF push-switches for each A.R.I. This panel also houses ON-OFF push-switches and indicators for the rear equipment cooling system. The purpose of the cooling system switches and indicator are described under the heading 'Cooling system controls' (Group 15).

Voltmeter and frequency meter panel

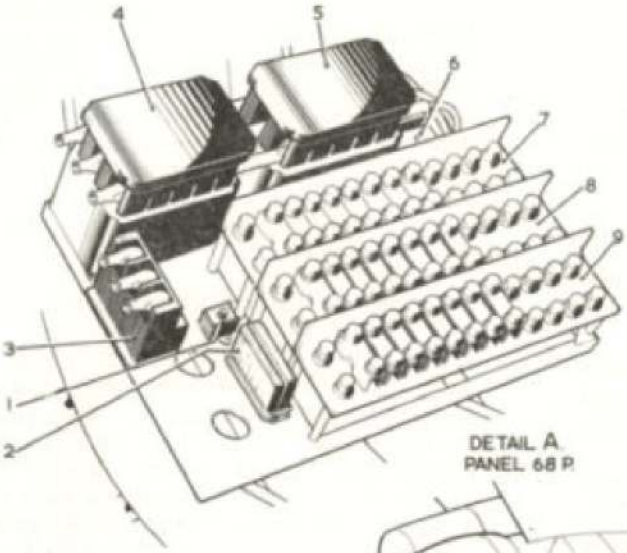
17. Two Sangamo-Weston meters, a Type S109/6/60 for frequency and a Type S78/5/577 for voltage, are fitted to a panel Avro Part No.1/S2384. This panel is located at the port end of the navigator's panel and is labelled BLEED AIR TURBINE. These instruments show the voltage and frequency output of the turbo-alternator unit and are protected by fuses 1094F and B located on panel 68P.

Dimmer switch panel

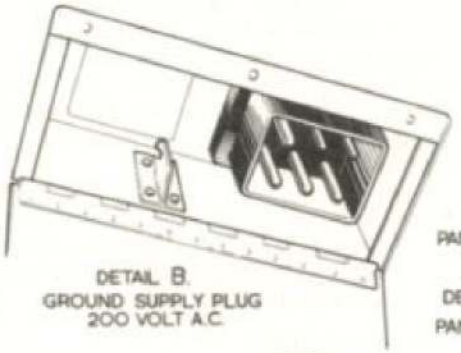
18. Two rotary dimmer switches are mounted on a panel, Avro Part No.1/S2386, located at the A.E.O.'s portion of the navigator's panel. The switches are labelled DIMMER TAIL WARNING and DIMMER AIRBORNE WNG., the traverse of both being marked MIN-MAX. The former switch controls illumination of the A.R.I.5919 indicator Type 6935, the latter controls illumination of the A.R.I.18105 control unit Type 9562. Each switch comprises two ganged variable resistors to which separate supplies are fed from fuses in panels 3P and 4P. These supplies are connected via TB.863 which is mounted on the underneath side of an extension to the navigator's panel at the rear of the A.E.O's position.

D.C. supplies

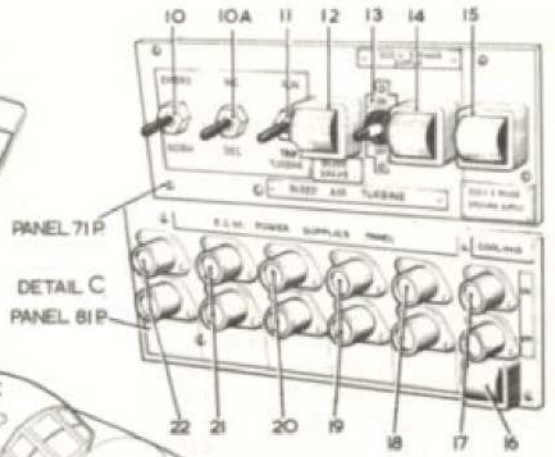
19. 28-volt d.c. supplies to the E.C.M. equipment, which are required for contactor control, alternator field initial excitation, actuator operation etc., are obtained from the aircraft bus-bars. The



DETAIL A.
PANEL 68 P.

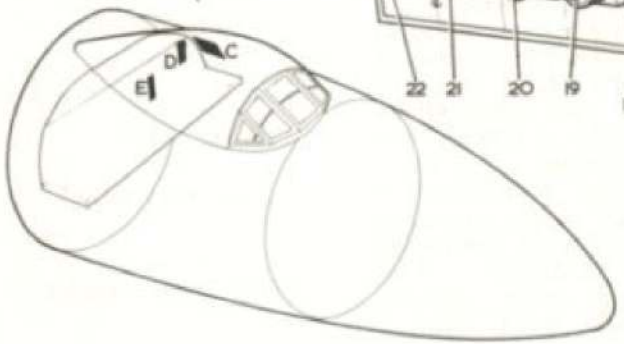


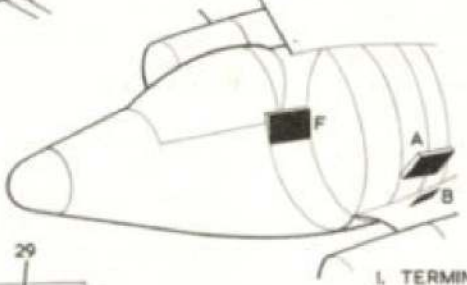
DETAIL B.
GROUND SUPPLY PLUG
200 VOLT A.C.

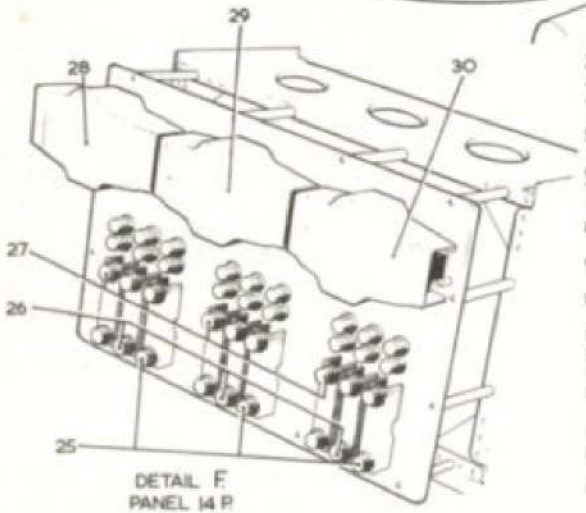


PANEL 71 P.

DETAIL C.
PANEL 81 P.







DETAIL F.
PANEL 14 P.

KEY.

1. TERMINAL BLOCK N°1295
2. RELAY No. 689.
3. CURRENT TRANSFORMER.
4. CONTACTOR No.93. TYPE 6Y No. 2.
5. CONTACTOR No.94. TYPE 6Y No. 2.
6. RELAY No. 656. TYPE 9B.
7. RED PHASE. FUSE No. 1094 TO 1111.
8. YELLOW PHASE. FUSE No.1094 TO 1111.
9. BLUE PHASE. FUSE No. 1094 TO 1111.
10. NORMAL EMERGENCY SWITCH.
10 A. TURBINE SPEED SWITCH.
11. TURBINE CONTROL SWITCH.
12. BLEED VALVE INDICATOR.
13. ALTERNATOR CONTROL SWITCH.
14. POWER SUPPLY INDICATOR.
15. GROUND POWER SUPPLY INDICATOR.
16. COOLING SYSTEM WARNING INDICATOR.
17. COOLING SYSTEM.
18. A.R.I. 5919.
19. A.R.I. 18105.
20. A.R.I. 18076 No.3. & A.R.I.18075 No.2.
21. A.R.I. 18076 No.2. & A.R.I.18075 No.1.
22. A.R.I. 18076 No.1. & A.R.I. 18074.
23. A.R.I. 5919.
24. A.R.I. 18105.
25. BLUE PHASE. FUSE No. 1112 TO 1120.
26. YELLOW PHASE. FUSE No.1112 TO 1120.
27. RED PHASE. FUSE No. 1112 TO 1120.
28. CONTACTOR No. 620. TYPE D 6702/2.
29. CONTACTOR No. 621. TYPE D 6702/2.
30. CONTACTOR No. 622. TYPE D 6702/2.

DETAIL E.
DIMMER SWITCH
PANEL

DETAIL D.
VOLTAGE & FREQUENCY
METER PANEL

Fig. 3 Distribution control and switch panels

(A.M.O. 884 b)

bulk of the control fuses are contained in a fusebox installed adjacent to 3P in the cabin. These fuses (1124 to 1130) are fed via circuit breaker No.3 which is arranged so that these fuses, with the exception of fuse 1129, do not come 'alive' until the alternator output is at the correct level and switched ON. The remainder of the d.c. supplies at 28-volts are obtained from individual fuses in panels 3P, 4P and 26P. A list of all the distribution fuses for the complete installation is given in Table 2.

A.C. supplies and distribution

20. The controlled output from the turbo-alternator is fed via three Unipren 100 cables, twisted into a spiral, which are routed along the inboard wall of the turbo-alternator compartment to the rear spar structure. At this point the cables are carried by suitable conduits, over the No.3 and 4 engine jet pipes into the bomb bay at bomb arch 343.3 in. The cables continue along the starboard side of the bomb bay, through the aft power compartment, into the rudder motor compartment in the rear fuselage.

21. At this point the cables connect into the main fuses and contactors on panel 68P and supplies are then fed via panel 14P to the E.C.M. installations and panel 44P to the main cooling system. It should be noted that supplies to the A.R.I.5919 are connected via contactor No.630, Type D6702, located on panel 44P. Supplies to the A.R.I.18105 are connected via contactor No.631, Type 7CZ/105411/2, which is mounted with TB.863 (para.17). Panels 68P and 14P are illustrated at fig.3. Panel 44P is described and illustrated in Group 15 of this chapter.

Panel 68P

22. Located on the starboard side of the rudder P.F.C. motor compartment in the extended rear fuselage, this panel houses the main a.c. distribution fuses and contactors for the installation as follows:-

Main supply contactor No.93	Ref.No.5CW/6944 Type 6Y No.4
Ground supply contactor No.94	Ref.No.5CW/6944 Type 6Y No.4
Current transformer	Type P6601
Horizontal pattern fuses No.1096 to 1103	
Relay No.656	Ref.No.5CW/6543
Relay No.689	Ref.No.5CW/6724

23. The 3-phase supplies from the main distribution fuses are fed to the rear fuselage consumer loads via a sub-distribution panel (14P) located on the port side of the extended rear fuselage between formers 487.5 in. and 22.25 in.

Panel 14P

24. This sub-distribution panel houses a bank of fuses and three contactors as follows:-

Contactors, Type D6702/2	No.620, 621 and 622
Horizontal pattern fuses	No.1112, 1115 and 1118
End on pattern fuses	No.1113, 1114, 1116, 1117, 1119 and 1120

These fuses and contactors supply the rear fuselage units A.R.I.18074, 18075 and 18076.

Ground supply plug

25. A multi-pin plug, Ref.No.5CY/5371, is installed on the lower starboard side of the rear fuselage between formers 461 and 471. External access to the plug is provided by a hinged door marked 200 V A.C. GROUND SUPPLY. The circuit is arranged so that when a 200-volt, 3-phase a.c. ground supply is connected, an indicator on panel 71P will register 'on' and the aircraft alternator supply contactor is locked out of circuit. Full details of the lock out circuit are provided under the main heading 'Ground supply control'.

Circuit arrangements

26. The arrangement of the complete circuit includes the following control and protection features:-

(1) An electrical interlock is provided so that the turbine air bleed valve control switch must be at the RUN position, before the alternator ON-OFF switch is effective.

(2) The alternator field initial excitation supply is obtained from the aircraft 28-volt bus-bar, and the alternator becomes automatically self-exciting when generation is established.

(3) An undervoltage protection device is incorporated which de-energises the main contactor should the alternator output fall below 180 volts. This circuit also controls the d.c. supply to the main contactors of the consumer loads.

(4) Provision is made to de-energise the alternator should over-voltage conditions (above 220 volts) exist.

(5) The alternator is de-energised and the main contactor opened if a line-to-earth fault of approximately 40% full load current, or a line-to-line fault of approximately 20% full load current occurs between the alternator and the main contactor.

27. Certain relays within the voltage control unit form an essential part of the automatic switching and protection control for the external circuit. Only brief de-

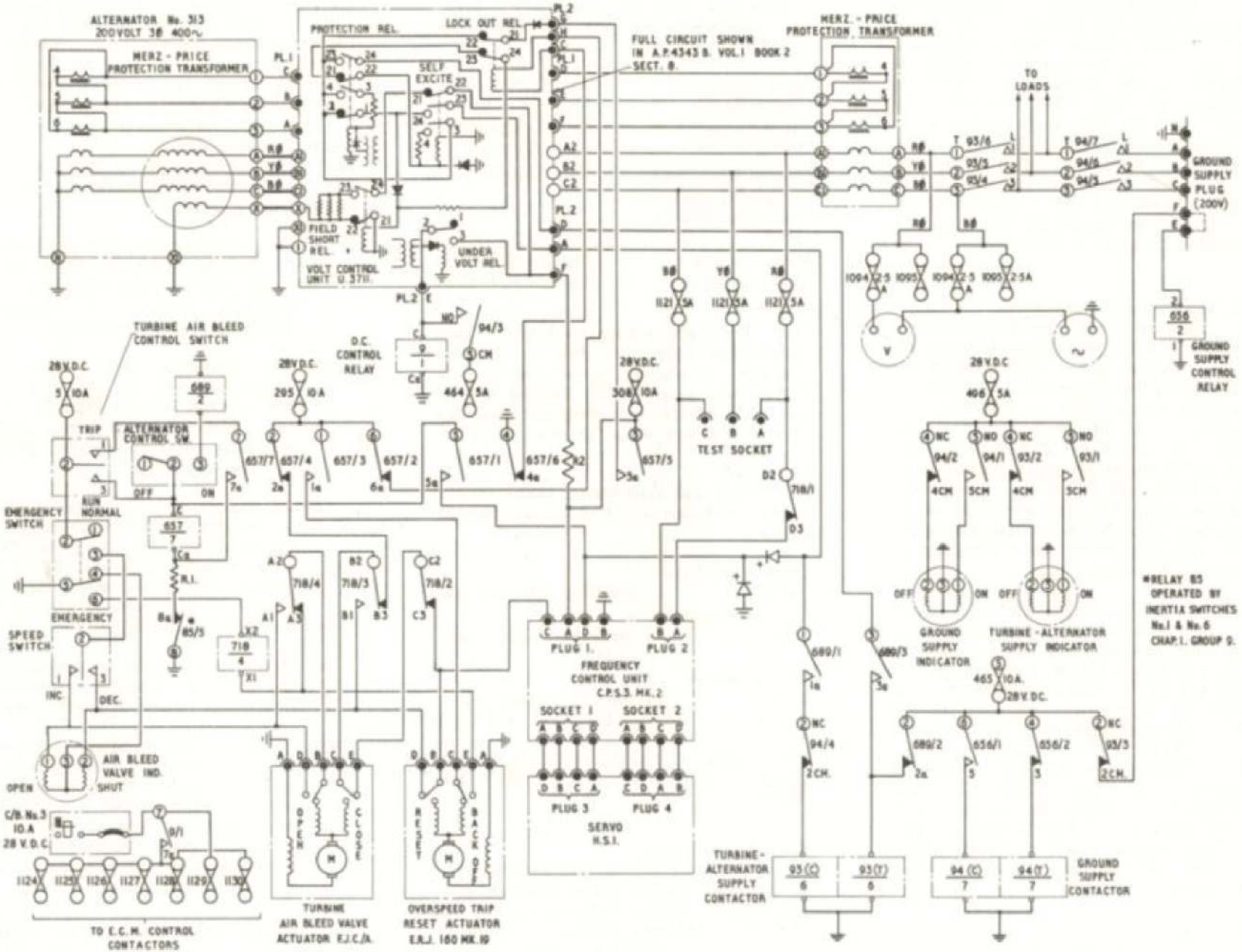


Fig.4 Power supplies control
(◄Mod 1849, 1884 and 1973►)

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tails are given here for the circuit operation of the voltage control unit, and reference should be made to A.P.4343B, Vol.1, Book 2, Sect.8, Chap.14, for full details.

Circuit operation

28. The circuit operation outlined in the following paragraphs should be read in conjunction with the circuit diagram contained in fig.4. It will then be seen that:-

(1) Both sides of the alternator field are connected to earth, the supply end via the normally closed contacts 21-22 of the field short relay within the voltage control unit.

(2) A 28-volt d.c. supply from fuse 308 is available within the voltage control unit for field initial excitation purposes, via the resistance unit, PL2, pin F, contacts 22/21 of the separate excitation relay and contacts 24-23 of the field short relay.

(3) A 28-volt d.c. supply from fuse 308 is fed to the frequency control unit valve heater circuit via PL1, pin A.

Running the turbo-alternator

29. The 'at rest' conditions of the turbine air bleed valve and overspeed trip reset actuators prior to starting up are given as an aid of the understanding of the circuit. The turbine air bleed valve actuator is in the closed position with one contact arm connecting pin B to the open field. The overspeed trip reset actuator is in the reset position with one contact arm making pins B-D and the other contact arm connecting pin C to the back-off field. The air bleed valve indicator displays SHUT. The supply for this comes from fuse No.295 via contacts 657/4, contacts 718/3, pins C-E of the air bleed valve actuator, contacts 718/2 and pins B-D of the overspeed trip reset actuator. It should also be noted that the lock out relay in the voltage control unit, is energised immediately the aircraft supplies are available at the d.c. fuse 295.

30. Assuming that the aircraft is airborne, when the spring-loaded turbine air bleed control switch is momentarily selected to the RUN position, the following circuit action occurs. A 28-volt d.c. supply from fuse 5 passes via terminals 2-3 of the control switch to energise the coil of relay 657, the negative for which is obtained via the normally closed contacts 85/5 (relay 85 is controlled by crash switches Nos.1 and 6 and serves as an isolation switch in the event of a crash landing). The energising of relay No.657 initiates the following circuit action:-

(1) Contacts 657/2 and 657/6 open to de-energise the lock out relay, in the voltage control unit.

(2) Contacts 657/4 open to remove the supply from pin C of the turbine air bleed valve actuator and hence from the SHUT coil of the air bleed valve indicator.

(3) Contacts 657/1 close to provide a hold-in circuit for relay 657 with a supply from plug No.2-A of the voltage control unit (see para.31(3)). At the same time the supply is made available to the alternator control switch.

(4) Contacts 657/5 close to connect a supply from fuse No.308 to plug No.2-G at the voltage control unit. From plug No.2-G the supply passes across the now closed contacts 21-22 of the lock out relay to appear at the following points:-

(a) Contact 23 of the protection relay.

(b) Contact 4 of the protection relay.

(c) Contacts 2-1 of the protection relay and from there to the points detailed in (d), (e) and (f).

(d) The coil of the field short relay, this action removes the short from the alternator field and the field is flashed by the resistor network.

(e) The coil of the self excite relay via contacts 24-23 of the lock out relay and contacts 21-22 of the protection relay.

(f) Contacts 24-23 of the now energised self excite relay to appear at plug No.2-A.

(g) Contacts 3-4 of the self excite relay, to provide a hold-in supply for the relay.

(5) Contacts 657/3 close to provide a supply from fuse 295 to pin C, to operate the back-off field of the overspeed trip reset actuator. When the actuator operates, the arm connecting pins B-D opens and isolates the SHUT coil of the air bleed valve indicator. At the same time the supply from pin C passes via pin E to the following points:-

(a) The coil of relay 718. This relay does not become energised, at this point in time, due to the 'open circuit' in the earth line caused by the position of the emergency switch.

(b) Pin B of the turbine air bleed valve actuator via normally closed contacts 718/4. This results in the opening of the valve, the supply then passes from pins B-D of the actuator

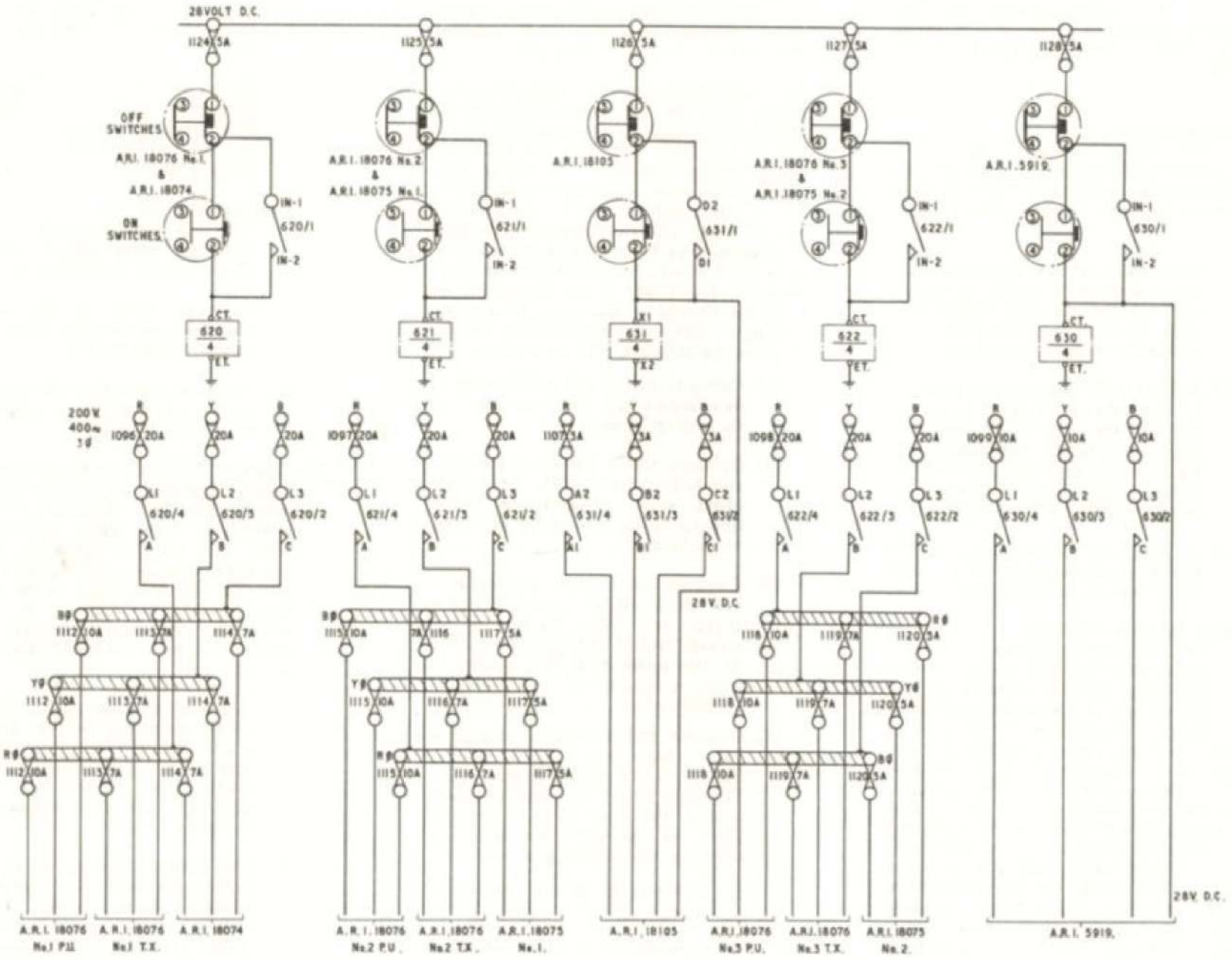

Fig. 5 Power supplies distribution

(◄ Fuse rating increased ►)

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to the OPEN coil of the air bleed valve indicator. The indicator displays OPEN and the turbine increases from idling to operating speed.

(6) Contacts 657/7 close to prime a path for the trip circuit when the turbine is shut down.

Field excitation

31. With the turbine now approaching its operating speed, the energising of the field short relay (para.30(4)) opens contacts 21-22, removing the short from the alternator field, and closes contacts 23-24 to provide a 'flash up' current from fuse 308, passing via plug No.2-F and contact 22-21 of the self excite relay, to enable the alternator to commence generation. The energising of the self excite relay in addition to the actions already detailed in para.30(4) (f) and (g) also opens contacts 23-24 to remove the initial excitation supply, coming from plug No.2-F, from the alternator field. The supply from plug No.2-A (see para.30(4) (f)) passes to the following points:-

(1) Terminal 1 of contacts 689/1.

(2) Plug No.1-D at the frequency control unit, this supply operates two relays within the unit.

(3) The coil of relay 657 and the alternator control switch, via contacts 657/1.

32. As the terminal voltage of the alternator rises to above 180 volts, a d.c. output, from one of the transformer-rectifier units within the voltage control unit, is fed to the coil of the undervolt relay. Contacts 2-3 of the undervolt relay close to allow a supply, from fuse 308 via plug No.2-F, to energise the d.c. control relay 9. Contacts 9/1 of the control relay close to complete the circuit from circuit breaker No.3 to fuses 1124-1128 and 1130.

Switching on the alternator

33. The alternator output should now be maintained at its correct level, indication of this will be shown on the voltmeter and frequency meter at the A.E.O's station. The alternator control switch can now be placed to the ON position with the following circuit action:-

(1) A supply from fuse 308 passes, via the path described in para.30 (3) and (4), across terminals 2-3 of the alternator control switch to energise relay 689.

(2) Contacts 689/2 open to isolate the trip coil of contactor relay No.93 from the d.c. supply fuse 465.

(3) Contacts 689/1 close to connect a supply from plug No.2-A of the voltage control unit (para.31 (1)) to the close coil of contactor relay 93, via normally closed contacts 94/4.

(4) Contacts 689/3 close to prime a safety circuit which, in the event of a fault, would result in the tripping of contactor relay 93 (para.37 (1)).

34. When the contactor relay 93 close coil is energised, para.33(3), the following circuit action takes place:-

(1) Contacts 93/2 open to isolate the OFF coil of the 200-volt 3-phase supply magnetic indicator from fuse 496.

(2) Contacts 93/1 close to connect a supply from fuse 496 to the ON coil of the 200V. 3ϕ supply magnetic indicator which then gives the ON indication.

(3) Contacts 93/3 open to isolate pin F of the ground supply plug, and hence the ground supply control relay 656, from fuse No.465. A supply from fuse 465 passing across the normally closed contacts 656/2 to the trip coil of contactor relay 94 thus ensures the isolation of the 200-volt 3-phase ground supply circuit.

(4) Contacts 93/4, 93/5 and 93/6 close to connect the alternator supply to the main distribution fuses on 68P.

Circuit protection

35. As previously stated in para.25, certain forms of circuit protection are provided by units within the voltage control unit and alternator viz:-

Overvoltage
Undervoltage
Lock-out

The following paragraphs cover the main circuit operation features of the protection devices.

Merz-Price protection

36. Referring to the circuit diagram, fig.4, it will be seen that both the alternator and the distribution panel 68P are equipped with current transformers for line-to-line or line-to-earth fault protection on the 3-phase main supply wiring.

37. Should any fault of this nature occur within the alternator or the supply wiring, the protection relay within the voltage control unit will be energised by a d.c. supply from the Merz-Price transformer. This results in the following circuit action:-

(1) Contacts 23-24 close to provide a supply from fuse 308 (passing out of the voltage control unit via plug No.2-D) to energise the trip coil of contactor relay 93.

(2) Contacts 3-4 close to provide a hold-in circuit for the protection relay (this is only momentarily effective, see para.40 and 45 (5)).

(3) Contacts 21-22 open to de-energise the self excite relay.

(4) Contacts 1-2 open to de-energise the field short relay.

38. The above initial circuit actions cause the following results:-

(1) The de-energising of the field short relay opens contacts 23-24 and closes contacts 21-22, with the result that the field short is replaced and the alternator ceases to generate.

(2) The de-energising of the self excite relay results in the following:-

(a) Contacts 3-4 open to break the hold-in circuit.

(b) Contacts 23-24 open to isolate the supply, passing from plug No.2-9 via the lock out relay and the protection relay, to plug No.2-A.

(c) Contacts 21-22 close to prepare a 'flash up' circuit for the alternator field on restart.

(3) The removal of the supply from plug No.2-A isolates the following points:-

(a) The hold-in circuit for relay 657, with the consequent de-energising of the relay.

(b) The coil of relay 689, via the alternator control switch terminals 2-3.

(c) The frequency control unit (plug No.1-D), this causes the relays within the unit to bias the servo valve towards the shut position.

39. From the foregoing circuit action, it will be seen that the de-energising of relay 689 will cause the contactor relay 93 to be tripped (if not already tripped by the operation of the self excite relay, para.37 (1). A supply from fuse 465 passes via the now closed contacts 689/2 to the trip coil of the relay, resulting in the isolation of the external loads from the alternator lines.

40. At the same time the de-energising of relay 657 will close the turbine air bleed valve, reset the overspeed trip (if necessary), disconnect the feed from fuse No.308 to plug No.2-G and cause the turbine air bleed valve indicator to display SHUT. It will also feed a supply into the frequency control unit, via plug No.1-C, which results in the servo valve being biased to the open position, ready for a restart. The circuit action outlined here is given in more detailed form in the paragraphs dealing with manual shut down.

Overvoltage

41. Should the alternator output exceed 200 $\pm$ 2 volts, the protection relay will again be energised with a rectified output from the alternator via the overvoltage transductor winding. This action will again disconnect the alternator from the external load, end the field excitation and shut down the turbine in a similar manner to that outlined in para.37-40.

Undervoltage

42. Should the controlled voltage output of the alternator fall below 180 volts, the undervolt relay will be de-energised. This action interrupts the supply to the coil of relay 9 and contacts 9/1 open to isolate the bank of fuses 1124-1128 and 1130 from the bus-bar; the external loads will be taken 'off line'. This condition will remain until the voltage output of the alternator returns to normal. The external loads can be re-engaged by operating the appropriate push-switches on 81P.

Crash switch operation

43. In the event of conditions causing the operation of both No.1 and No.6 inertia (crash) switches, relay 85 will be energised and contacts 85/5 will open. Referring to fig.4 it will be seen that this action de-energises relay 657 and shuts down the turbine (para.46).

Manual shut down

NOTE...

It is important that all switches be placed to the off position before reducing the air supply to the turbine.

44. Normal shut down of the turbo-alternator is accomplished by first switching off all loads, then switching off the alternator, and finally closing the valve controlling the turbine air supply. The following paragraphs detail the circuit action.

45. Assuming that the loads have been switched off, it will be seen (fig.4) that when the alternator control switch is selected to the OFF position the following circuit action takes place:-

(1) Relay 689 becomes de-energised.

(2) Contacts 689/1 and 689/3 open to isolate the coils of the contactor relay 93 from the voltage control unit.

(3) Contacts 689/2 close to connect a supply from fuse 465 to the trip coil of relay 93; the relay trips and the alternator output is isolated from the distribution circuit.

46. Finally, when the turbine air bleed control switch is selected to the TRIP position, the following circuit action occurs:-

(1) The hold-in circuit for relay 657 is cancelled by a supply positive fed from fuse 5 via terminals 2-1

of the control switch and contacts 657/7 to the earth side of the relay coil (Resistance R1 prevents a short circuit to earth). The relay is de-energised.

(2) Contacts 657/1 open to break the original hold-in circuit.

(3) Contacts 657/7 open to remove the positive (see (1)) from the earth side of the relay coil.

(4) Contacts 657/3 open to remove the supply from the OPEN coil of the air bleed valve indicator. (This supply passed via pins C-E of the overspeed trip reset actuator, normally closed contacts 718/4 and pins B-D of the air bleed valve actuator to the indicator).

(5) Contacts 657/5 open to isolate the supply from fuse 308 to plug No.2-G at the voltage control unit.

(6) Contacts 657/2 and contacts 657/6 close to energise the coil of the lock out relay with the result that contacts 21-22 and contacts 23-24 open.

(7) Contacts 657/4 close to provide a supply from fuse 295, passing via the normally closed contacts 718/3, to pin C of the air bleed valve actuator. When the valve closes the supply passes from pin C via pin E and normally closed contacts 718/2 to the following points:-

(a) Plug No.1-C at the frequency control unit. This supply trips a relay within the unit and in doing so, causes the servo valve to be biased to the open position in preparation for a restart.

(b) Pin B of the overspeed trip reset actuator. When the actuator reset field has operated the supply passes from pin B to pin D and hence to the SHUT coil of the air bleed valve indicator. The indicator displays SHUT.

Emergency operating procedure

47. If the turbine overspeeds, due to a fault in the frequency control unit, a form of emergency control can be maintained by converting the air bleed valve from being normally open or shut to an inching valve. How this is done will become apparent when following the events described below.

48. Assuming that the turbine and alternator are functioning normally, when the turbine starts to overspeed (or when a fault in the frequency control unit simulates this condition) the emergency switch is selected to EMERGENCY; this results in the following circuit action:-

(1) A supply from fuse 5 passes via terminals 2-3 of the emergency switch to the speed switch.

(2) Terminals 5-6 of the emergency switch complete the earth line for relay 718 and the relay becomes energised.

(3) Contacts 718/1 open to isolate the a.c. supply from the frequency control unit (plug No.2-A and B). and contacts 718/2 open to isolate plug No.1-C of the unit.

(4) Contacts 718/3 change over from contact B3 to contact B1 and contacts 718/4 change over from contact A3 to contact A1. This action takes away the control of the actuators from contacts 657/3 and 657/4.

(5) The operation of the emergency switch breaks the earth connection for the air bleed valve indicator to render the indicator inoperative.

49. The speed switch, which is spring-loaded to centre-off, can be selected (and held) in either of two positions, DEC. for a decrease in turbine speed or INC. for an increase in turbine speed. Sub-para.(1) gives the circuit action for the DEC. selection and sub-para.(2) that for the INC. selection.

(1) A supply from fuse 5 passes via terminals 2-3 of the emergency switch, terminals 2-3 of the speed switch and contacts 718/3 to appear at pin C of the air bleed valve actuator. The actuator moves the valve towards the closed position until either the speed switch is released or the fully closed position is reached. The turbine can be slowed down by this means until the alternator frequency approximates that desired.

(2) A supply from fuse 5 passes via terminals 2-3 of the emergency switch, terminals 2-1 of the speed switch and contacts 718/4 to appear at pin B of the air bleed valve actuator. When this happens, providing the valve is not already fully open, the actuator will move the valve towards the fully open position until either the speed switch is released or the fully open position is reached.

50. It will be seen from the foregoing circuit description that careful manipulation of the speed switch makes it possible to vary the operating speed of the turbine, by controlling the air feed as it enters the turbine assembly. The frequency of the alternator is based upon the speed of rotation, so that it is possible in an emergency to bring the frequency within limits by the means described above.

Ground supply control

51. To enable the E.C.M. equipment to be operated and serviced on the ground,

without having to run the engines, a suitable 200-volt ground supply must be connected to the ground supply plug provided on the starboard side of the rear fuselage.

52. Referring to fig.4, it will be seen that connection of the ground supply socket interconnects pins F and E of the A/C ground supply plug. A supply will then be fed from fuse 465, via normally closed relay contacts 93/3, to energise the coil of relay 656 resulting in the following circuit action:-

(1) Opening of normally closed relay contacts 656/2 will disconnect the trip coil of the ground supply contactor No.94 from the supply at fuse 465.

(2) Closing of relay contacts 656/1 will connect a supply from fuse 465 to the close coil of contactor No.94 which will be energised.

(3) Opening of normally closed relay contacts 94/2 and closing of contacts 94/1 will transfer the supply via fuse 496 from the off coil to on coil of the indicator.

(4) Closing of contacts 94/3 will connect a supply from fuse 464 energise the coil of relay 9 and closing of contacts 9/1 will, in turn, connect a supply from CB3 to fuses 1124 to 1128 and 1130.

(5) Opening of normally closed contacts 94/4 will isolate the close coil of contactor 93.

(6) Closing of contacts 94/5, 6 and 7 will connect the 200 volt, 3-phase a.c. supply at pins A, B and C of the ground supply plug, to the distributor system.

53. The circuit action at para.52 (5) will ensure non-operation of the alternator supply contactor No.93 whilst the ground supply is being employed. It thus prevents connection of a 200-volt, 3-phase a.c. supply from the aircraft alternator simultaneously with that from a ground source.

SERVICING

Precautions

54. The servicing of the power supplies system for the F.C.M. equipment consists of regular testing of the electrical components and circuits at the intervals laid down in A.P.4505A, Vol.4. Ground running of the turbo-alternator unit is subject to restrictions which vary according to whether a ground supply of ram air is available for cooling. Without a supply of ram air, running time is restricted to 5 min. at 80% R.P.M.

55. Particular attention should be paid to all components having contact assemblies, e.g., relays and contactors etc., for signs of worn or burnt contacts. Suspect items should be replaced with serviceable units of the correct type.

56. All heavy duty cables should be examined for signs of chafing, loose connections and general security; in particular the 200 volt heavy duty fuses should be examined for signs of overheating and security of busbar connections. Careful checking of the system wiring and components will reduce fault conditions to a minimum.

Turbo-alternator unit

57. Due to the nature of the electro-mechanical controls of the turbo-alternator unit, it is essential that the closest co-operation be maintained between the engine and electrical tradesmen during servicing operations on this unit. This will ensure that repetitive servicing is reduced to a minimum and that a high degree of serviceability is maintained.

58. Mechanical checks for the turbo-alternator unit will be found in A.P.2240C, Vol.1, and in Book 1, Sect.3, Chap.16, of this publication. These two publications should be consulted before carrying out any tests outlined in this Group.

Overspeed trip test

59. The overspeed trip mechanism is tested by inducing artificially a stage of unbalance in the anode circuits of the valves in the frequency control unit. The following test equipment is required:-

(1) Frequency meter - 200-volt, 300-500 c.s.

(2) Testmeter, Type D.

(3) Jack plug, Bulgin Type P38.

60. The testmeter, Type D should be set to the a.c. 0 - 20 m.A. range, and the jack plug connected to the testmeter by a suitable length of 2-core cable (INNER terminal to positive and OUTER terminal to negative). The test procedure should then be carried out as outlined in the following paragraph.

61. After gaining access to the turbo-alternator compartment equipment shelf, insert the jack plug into the socket immediately below the toggle switch on

the front face of the frequency control unit. Next connect the frequency meter to the alternator output line, and proceed as follows:-

(1) Run the turbine up to its rated speed (switching on procedure as in para.29-33), and ensure that all loads are switched OFF.

(2) Measure the anode current balance of the frequency control unit by operating the toggle switch one way and then the other. The current should be 10 m.A.

(3) Next reduce the turbine speed until the alternator frequency falls to approximately 390 c/s. operate the toggle switch first one way and then the other to determine on the testmeter the lower of the two anode currents. Leave the switch set to the LOWER current.

(4) Increase the turbine speed until the air pressure at the inlet is approximately 28 p.s.i.g. (ground level conditions), to ensure that no load is connected to the alternator.

(5) Finally remove either one of the milliameter leads from the testmeter, when the turbine should immediately overspeed, and the trip should operate.

Alternator checks

62. Servicing of the alternator whilst it is installed on the aircraft is restricted to a check for general security, tightness of connections, brush wear and insulation resistance. Full details of the method of carrying out these checks will be found in A.P.4343A, Vol.1.

Voltage control unit

63. Servicing instructions for the voltage control unit Rotax Type U.3708 will be found in A.P.4343B, Vol.1, Book 2, Sect.8, Chap.14.

Test panel 83P

64. To the test socket in panel 83P, connect a voltage and frequency test set, Ref.No.5G/3198. With a supply of cooling air available, run the alternator turbine up to its rated speed. Allow a period of time for voltage stabilisation, and then ensure from the test set, that the voltage is 200 $\pm$ 5, and the frequency is 400 $\pm$ 8.

REMOVAL AND INSTALLATION

General

65. Access to the components is straightforward, but the following points should be observed. When it is necessary to remove or replace any components, secure all loose connectors to the adjacent aircraft structure to prevent damage. Full removal instructions for the F.C.M. components are contained in Book 1, Sect.3, Chap.16.

TABLE 1

A.C. FUSE DISTRIBUTION

200-VOLT 3-PHASE 400 C.P.S. SUPPLY

Fuse No.	Rating	Service	Location	Type
1094	2.5	Voltmeter and frequency meter (R and B only)	68P	EO
1095	-	Spare	68P	FO
1096	20	Feeder for fuses 1112, 1113 and 1114 in 14P	68P	H
1097	20	Feeder for fuses 1115, 1116 and 1117 in 14P	68P	H
1098	20	Feeder for fuses 1118, 1119 and 1120 in 14P	68P	H
1099	10	Supply for A.R.I.5919	68P	H
1100	60	Vapour cycle package compressor	68P	H
1101	-	Spare	68P	H
1102	-	Spare	68P	H
1103	-	Spare	68P	H
1104	5	De-icing heater for air intakes	68P	EO
1105	5	No.2 water-glycol pump	68P	EO
1106	5	No.1 water-glycol pump	68P	EO
1107	3	Supply for A.R.I.18105	68P	EO
1108	-	Spare	68P	EO
1109	-	Spare	68P	EO
1110	-	Spare	68P	EO
1111	-	Spare	68P	FO
1112	10	A.R.I.18076 No.1P.U	14P	H
1113	7	A.R.I.18076 No.1 T.X.	14P	EO
1114	7	A.R.I.18074	14P	FO
1115	10	A.R.I.18076 No.2 P.U.	14P	H
1116	7	A.R.I.18076 No.2 T.X.	14P	EO
1117	5	A.R.I.18075 No.1 T.X.	14P	FO
1118	10	A.R.I.18076 No.3 P.U.	14P	H
1119	7	A.R.I.18076 No.3 T.X.	14P	EO
1120	5	A.R.I.18075 No.2 T.X.	14P	EO
1121	5	Alternator output test socket	83P	EO

TABLE 2

D.C. FUSE DISTRIBUTION

28-VOLT D.C. SUPPLY

Fuse No.	Rating	Service	Location	Type
5	10	Turbine control valve	3P	S
23	5	E.C.M. control units lighting	3P	S
1045	5	E.C.M. control units lighting	4P	S
1124	5	A.R.I.18074 and A.R.I.18076 No.1 control	3P	S
1125	5	A.R.I.18076 No.2 and A.R.I.18075 No.1 control	3P	S
1126	2.5	A.R.I.18105 control	3P	S
1127	5	A.R.I.18076 No.3 and A.R.I.18075 No.2 control	3P	S
1128	7.5	A.R.I.5919 control	3P	S
1129	10	Cooling system control	3P	S
1130	2.5	Cooling pumps control	3P	S
464	5	Supply to relay No.9	26P	S
465	10	Main contactor control	26P	S
491	5	A.R.I.5919 cooling	26P	S
496	5	Indicator supply	26P	S
295	10	Turbine valve actuator supply	16P	S
308	10	Alternator and control supply	16P	S

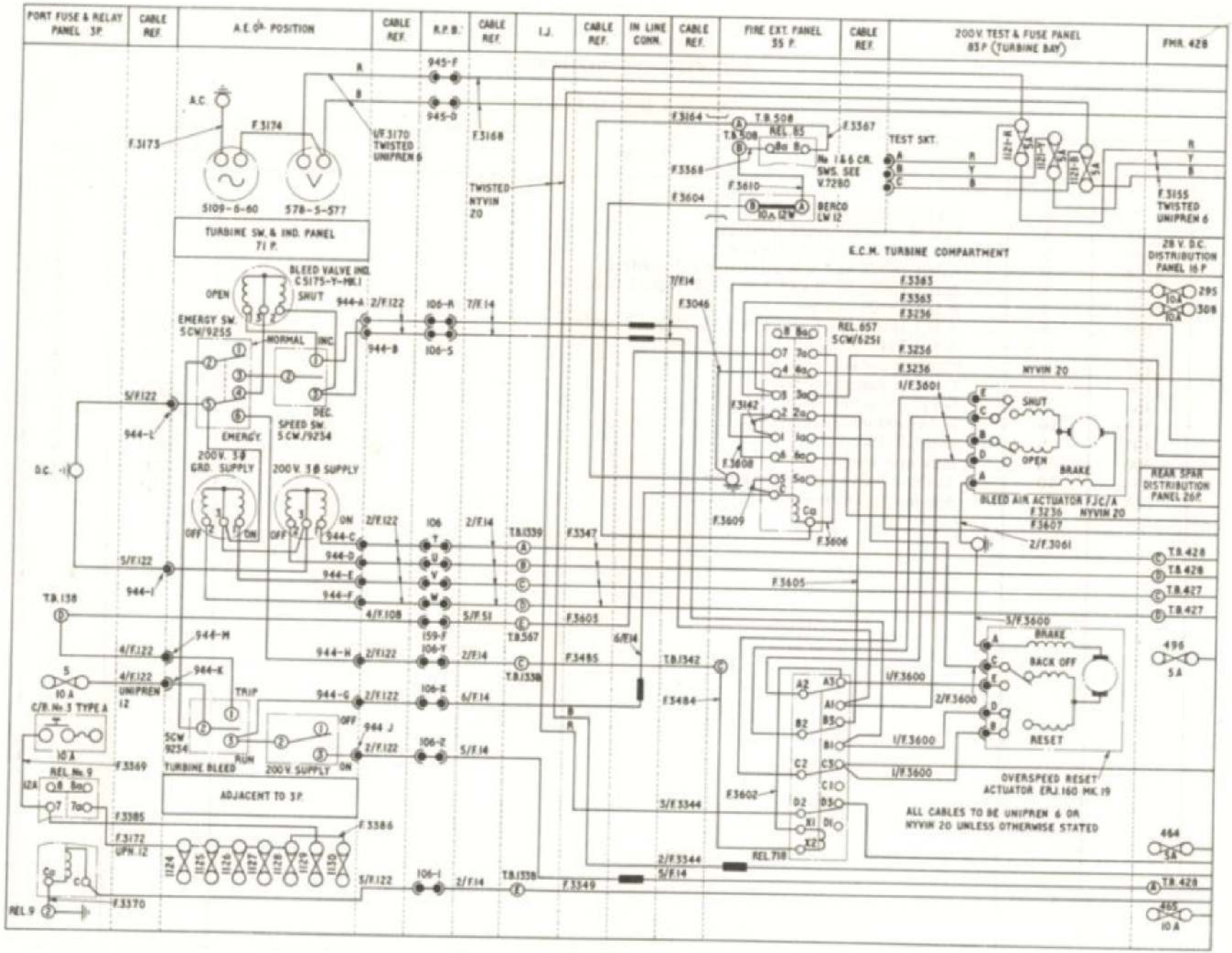

Fig.6 (1) Control of power supplies
(◀ Mod 1049, 1884 and 1973 ▶)

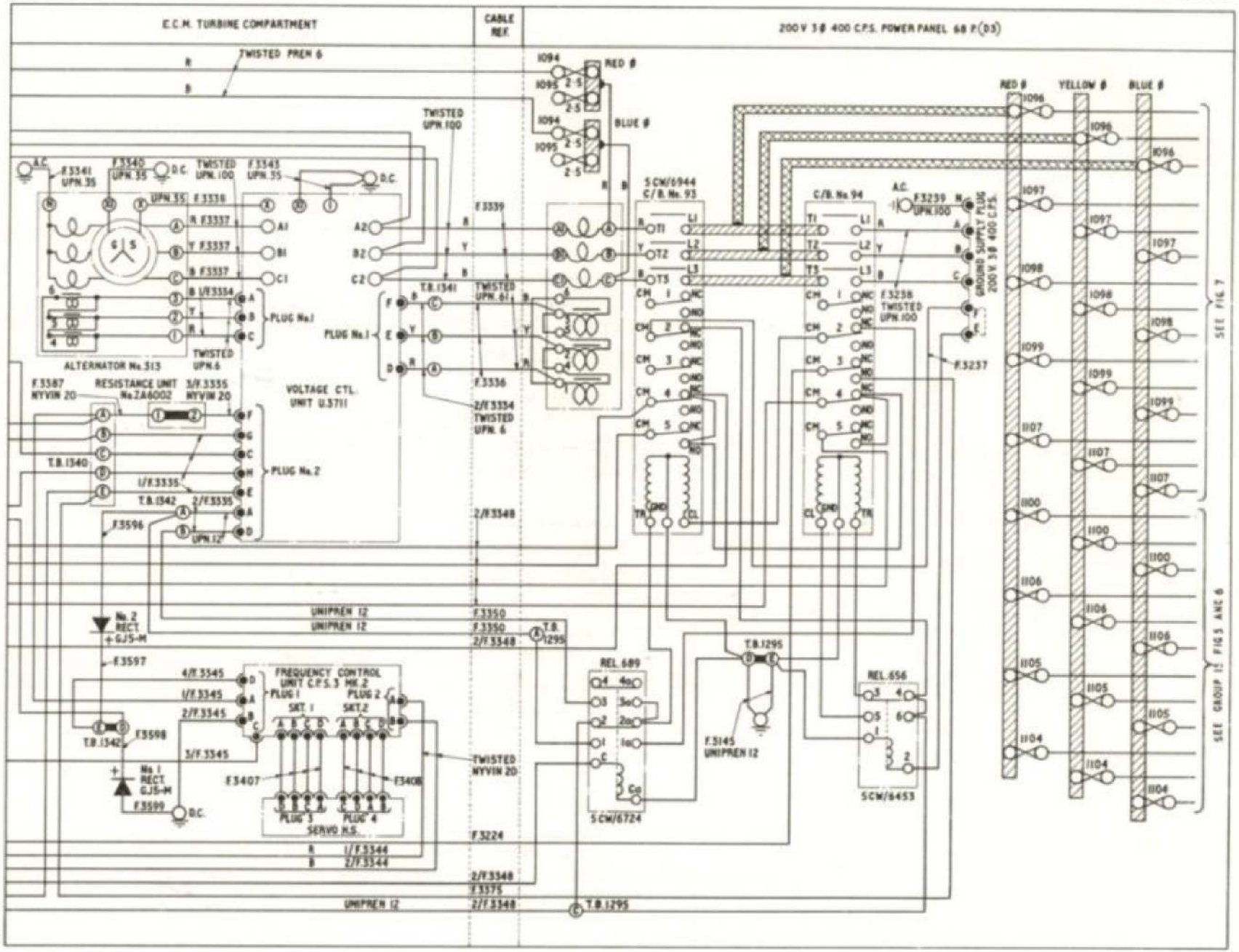

Fig. 6 (2) Control of power supplies
(▲ Mod. 1849, 1864 and 1973 ▶)

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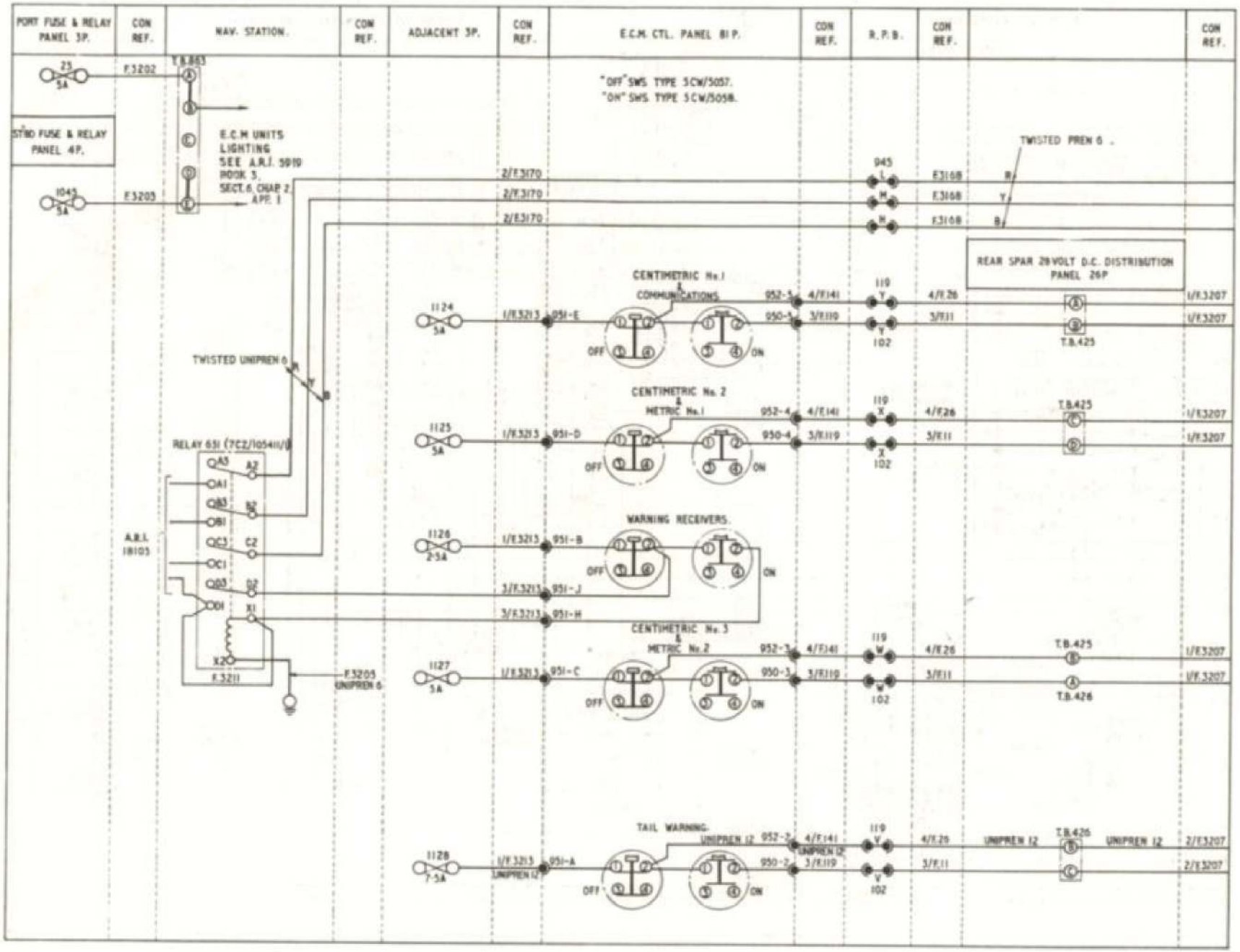

Fig.7 (1) Power distribution

(◄ Fuse rating increased ►)

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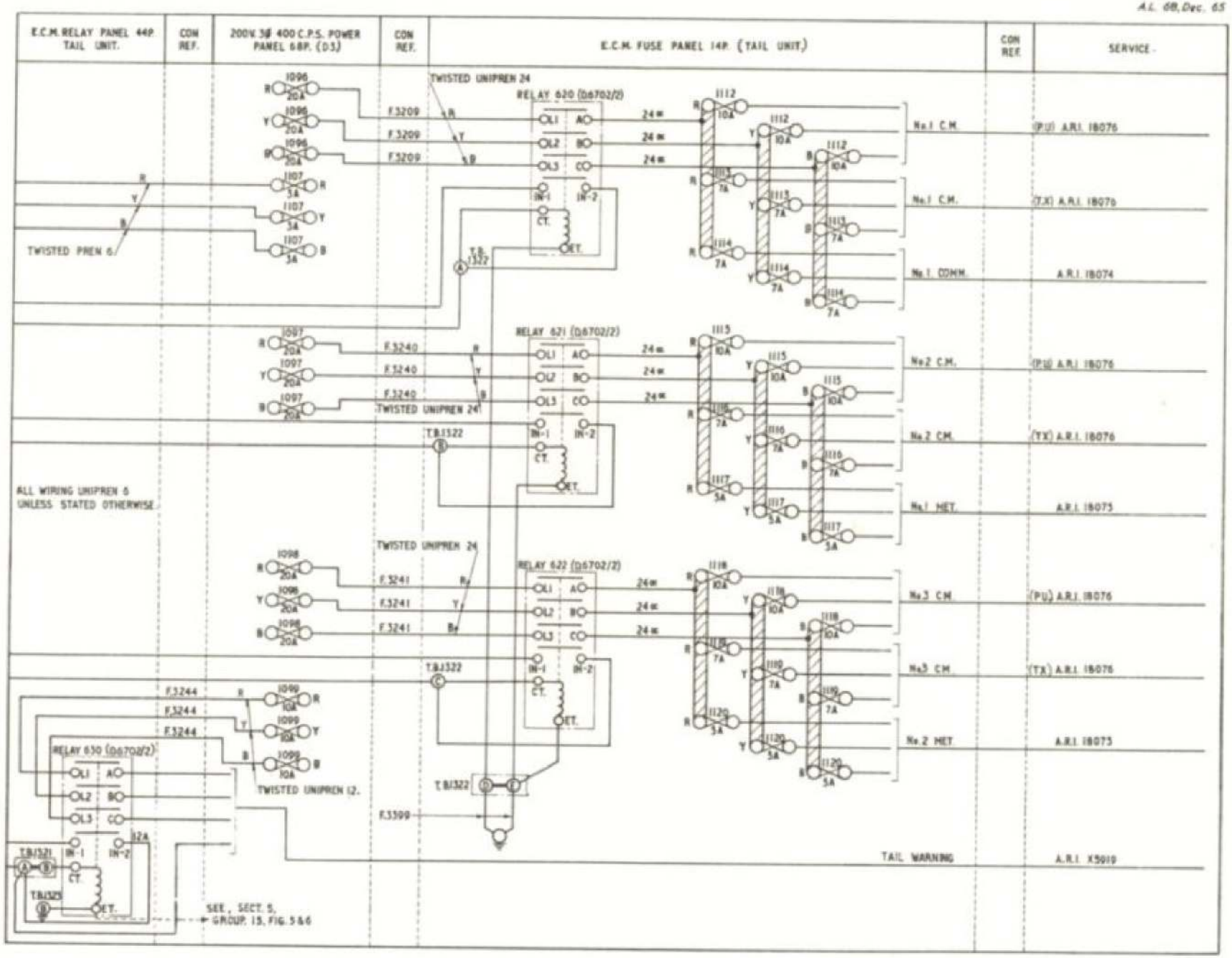

Fig. 7 (2) Power distribution
(◄Fuse rating increased►)

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