Chapter 2
A.C. MAIN GENERATION

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

Introduction

1. This chapter contains descriptive and servicing information on the main generation system and also gives a preliminary outline of all the sources of power on the aircraft, in order that wide appreciation of the system may be obtained. Illustrations giving the location and details of the equipment are provided, together with theoretical circuit diagrams, which present the circuit operation in simplified form. The necessary routing charts follow the text at the end of the chapter.

2. The primary or main power supplies are obtained from an English Electric constant frequency a.c. system, which provides 200-volt, 3-phase, 400 Hz a.c. from four alternators driven through constant speed drive units from the aircraft engines. Detailed information on the constant speed drive units is given in A.P.103E-0106-16A. The following modifications which affect this chapter are all incorporated:

Mod. 975 - Introduction of switch magnetic, Type 6Y No.4 (5CW/4400312) in lieu of Type 6Y No.2 (5CW/6283).

Mod.1011 - Introduction of switch box generator control unit Ref. 5CW/6943 in lieu of 5CW/5737

Mod.1551 - Introduction of S.C.R. voltage regulator 5UC/7392 in lieu of carbon pile voltage regulator 5UC/6852.

Mod.2175 - Introduction of voltage regulator 5UC/8926 Mk.2 in lieu of and by conversion of Type 125, Ref. 5UC/7392. (Elec.B712).

Mod.2197 - Introduction of brushless alternator Type 175 (E.E. Type AE2033 Mk.3) in lieu of and by conversion of alternator Type 158B (E.E. Type AE2023 Mk.2) or alternator Type 158B (E.E. Type AE2023 Mk.1) and regulator, Type 129 in lieu of and by conversion of regulator, Type 125.

Mod.2211 - To make provision for alternator switch boxes modified to STC. Mod. Elect/089/BC by the introduction of cable assemblies Pt. No.408/V7909.

Mod.2307 - To introduce cable loom assembly Pt. No. V16319 in lieu of and by conversion of cable loom assembly Pt. No. V10560 for Extra Supplies Relay Panel 74P, and to introduce cable Pt. No.4147/V7909.

Mod.2329 - To introduce modified voltage regulator Type 129 (Ref. No. 5UC/1984075) embodying new capacitor C13 and to increase working voltage on capacitor C20 to accept high voltage transients (Rotax Mod. EE6/60804).

Mod.2378 - To introduce a phase sequence unit, Type AE5601 to give protection against incorrect phase sequence of ground power supplies. (Com Mod/Vulcan 0246/STC).

Mod.2428 - Introduces a switch in the alternator failure indication circuit to enable automatic load shedding of E.C.M. equipment to be made inoperative.

Mod.2451 - Introduces Type 31/V9900 alternator failure warning unit incorporating new type of transistor.

Mod.2481 - Revised earth connections for C.S.D.U. temperature sensors.

PRIMARY AND SECONDARY SUPPLIES

Sources

3. A schematic diagram of the aircraft's power supplies is shown in fig.1, which gives an overall picture of both primary and secondary sources of power. Reference to this diagram will show that seven primary sources of 200-volt power can be connected to the aircraft busbar, viz:-

(1) Main supply - four 40 kVA engine driven alternators.

DESCRIPTION AND OPERATION

(2) Emergency supply (high altitude) - one 22 kVA ram air turbo-alternator.

(3) Emergency supply (low altitude) - one 40 kVA gas turbine driven alternator.

(4) Ground supply - one 60 kVA diesel driven alternator.

4. Since sources (2), (3) and (4) are auxiliary supplies, and will only be connected to the busbar under certain conditions, an interlock system of control is incorporated to ensure that they cannot be paralleled with the main supply or with each other. The four main alternators, however, can be synchronized for parallel running by manual selection, but this is not normally carried out in flight.

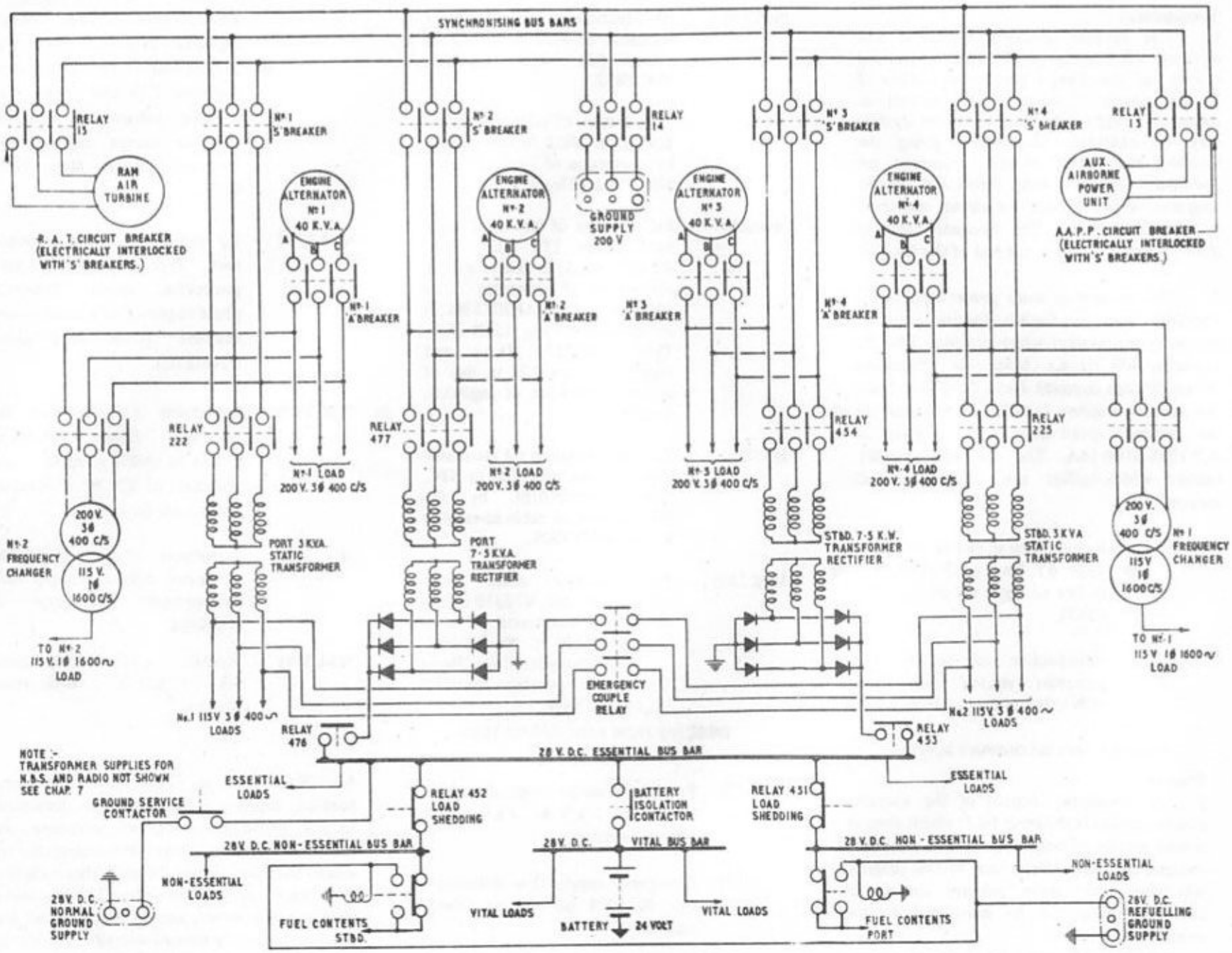

Fig. 1 Primary and secondary supplies

Main power supplies

5. The engine alternators supply all normal services on the aircraft either direct or by transformation. Each alternator supplies its own load and is connected to its main busbar and the synchronising busbar by latched circuit breakers. Manual switching controls for the system are located on 10P and are described under the appropriate heading.

Secondary supplies

6. Three sources of secondary supplies are provided as follows:-

(1) 115-volt, 400 c/s from two 3 kVA transformers.

(2) 115-volt, 1,600 c/s from two frequency changers.

(3) 28-volt d.c. from two transformer-rectifiers.

In addition to these, secondary supplies for certain radar installations are obtained from local transformer units. The a.c. supplies (1) and (2) are described in Chapter 4 and the d.c. supplies (3) are dealt with in Chapter 6.

7. A 24-volt battery, Type K, provides the supply for vital services required in conditions of emergency. The battery is located in the nosewheel bay and is charged by the transformer-rectifier units in normal flight. A battery isolation switch on 50P connects the battery to the 28-volt busbar. Further information on the battery supplies are contained in Chapter 6.

Emergency power supplies

8. In the event of complete engine failure resulting in total failure of the main alternators, emergency supplies will be provided by either the Ram Air Turbine (R.A.T.) or the Auxiliary Airborne Power Plant (A.A.P.P.) depending upon the altitude of the aircraft. In these conditions, while the aircraft is flying above 40,000 ft., the R.A.T. will be selected for ejection into the slipstream and a 200-volt supply will be available on the aircraft busbar immediately. At the same time all non-essential loads will be automatically shed.

9. When the aircraft descends to 40,000 ft., the A.A.P.P. will be started by pressing the appropriate starter button. At an altitude below 30,000 ft., the 200-volt output of the A.A.P.P. may be switched on to the aircraft busbar, when the R.A.T. supply will be automatically disconnected. A description of the R.A.T. and A.A.P.P. installation is contained in Chap.5.

Ground power supplies

10. Ground supplies are fed from a 6-pin plug for 200-volt a.c. and a 3-pin plug for 28-volt d.c., located under the port rear fuselage. A further 3-pin plug is situated on the starboard side of the fuselage adjacent to the nosewheel bay to permit 28-volt d.c. to be connected to the refuelling circuits without energizing the aircraft busbars (Chap.6 para 36).

CONSTANT FREQUENCY A.C. SYSTEM

Principles

11. A constant frequency a.c. system utilising four 200-volt alternators provides the main generation, and ensures that the respective outputs are controlled and fault protected under varying conditions. Each alternator is driven at an input speed of 6,000 r.p.m. from a constant speed drive unit, and the assembly comprising both components is mounted on the underside of each engine as indicated in fig.2. Provision is made for air cooling the alternators in flight and during ground engine running periods.

12. The system can be regarded as four separate sources of supply and control, operating independently of each other, but which can be synchronised for parallel running when required. As previously indicated, however, this facility is not normally used in flight. For take-off and low level flying, the system is operated with No.3 alternator on the synchronising busbar (para.14), and at altitude No.4 alternator is substituted for No.3 on the synchronising busbar.

13. Each alternator is protected against undervolting, overvolting, underspeeding and overspeeding, and line-to-line or line-to-earth faults. In addition, for parallel running, facilities are provided to maintain equal load sharing of both the real and reactive components of the load.

14. Two heavy duty circuit breakers are provided in each alternator main line, one identified 'A' (alternator) and the other 'S' (synchronous). The circuit breakers are energised from the 28-volt supply; the 'A' breaker connects the alternator to its associated load, and the 'S' breaker connects the alternator to the synchronising busbar. When a 200-volt ground supply is connected to the aircraft, the supply is fed to the busbar loads via each alternator 'S' breaker, so that in these circumstances the 'S' breaker will be closed to connect the load, and the 'A' breakers will be open to isolate the alternators from the supply.

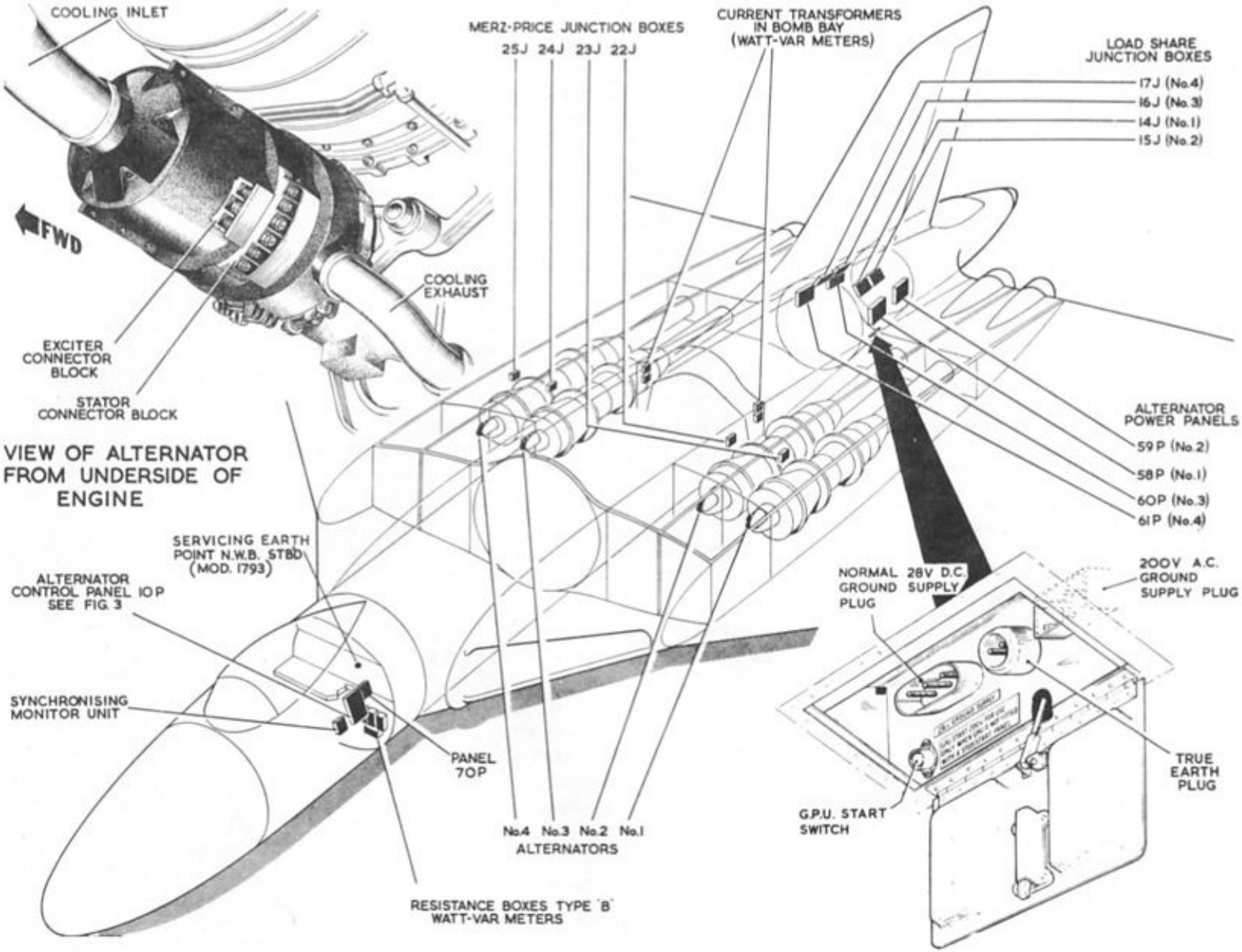

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Fig. 2. General location of equipment.
► *Ground supply detail changed* ◄

ALTERNATORS

15. Each alternator, Type 175 (EE. Type AE 2023 Mk.3), is fitted with its constant speed drive unit on the underside of the engines as shown on fig.2. This type of alternator is a conventional brushless rotating field machine with an integral d.c. exciter, and is rated at 40 kVA, delivering 200-volt, 3-phase 40 c/s. Control of the line voltage is effected by a silicon controlled voltage regulator, ▶ Type 129. Descriptive and servicing information for the alternators is given in A.P.113B-0122-1, and the regulators are covered in A.P.113D-07107-1. ◀

16. Connections from the alternator are made from two terminal blocks, a 6-way and a 3-way mounted on the yoke. Both ends of each stator winding are brought out on the 6-way block to terminals A2, B2, C2 and A1, B1, C1; the former provide the output connections, the latter are connected to earth via a Merz-Price junction box. In the case of the exciter, the associated terminals A+, A– and F are located on the 3-way block.

Alternator cooling

17. In flight, cooling is effected by ram air fed from an inlet scoop forward of each engine bay. The air is fed to the exciter end of the machine in each case, then ducted from the drive end to outside atmosphere. Ground cooling during engine runs is controlled by an actuator-operated inducer valve fitted at the starboard side of each engine. The valves are energised in the open position from the alighting gear DOWN selector button to allow compressed air from the engine to flow through the outlet duct, thus inducing air from the inlet scoop. Further details of the cooling system are provided in Sect.4, Chap.1, of this publication.

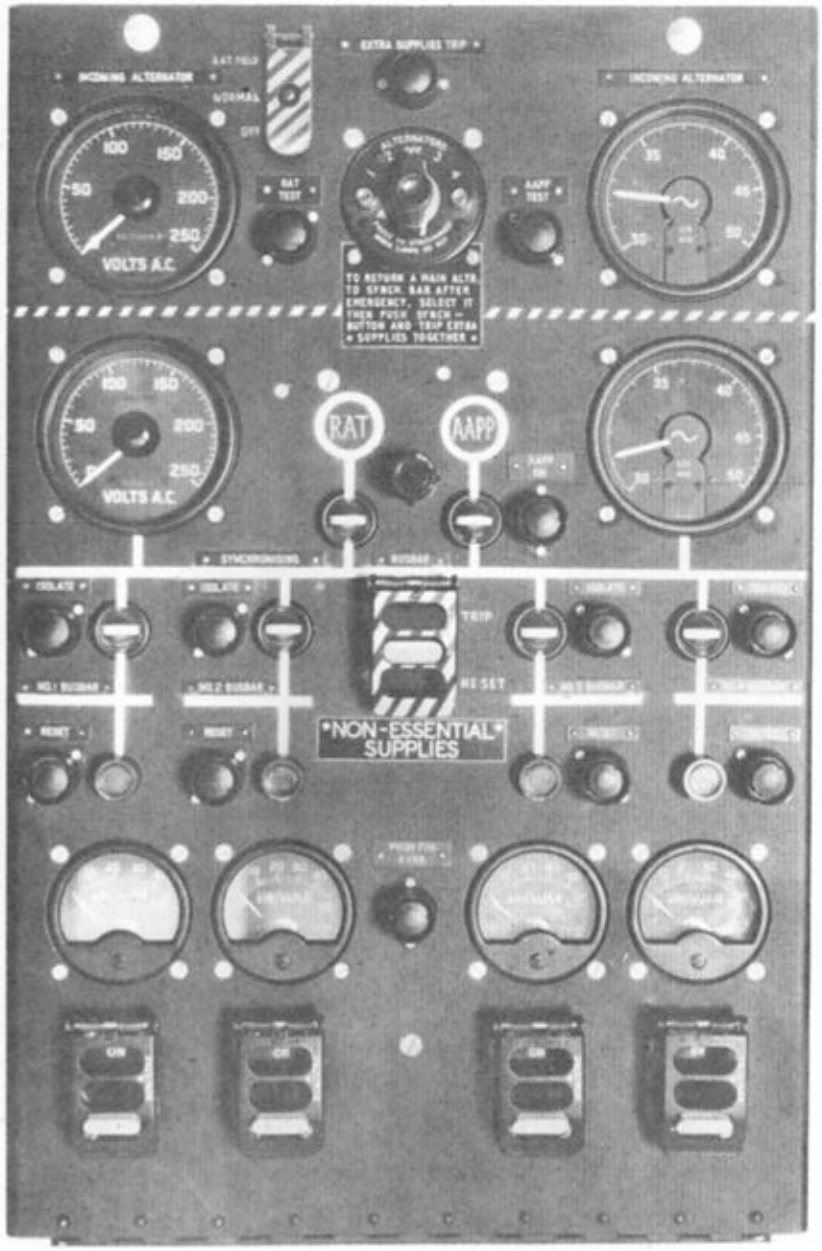
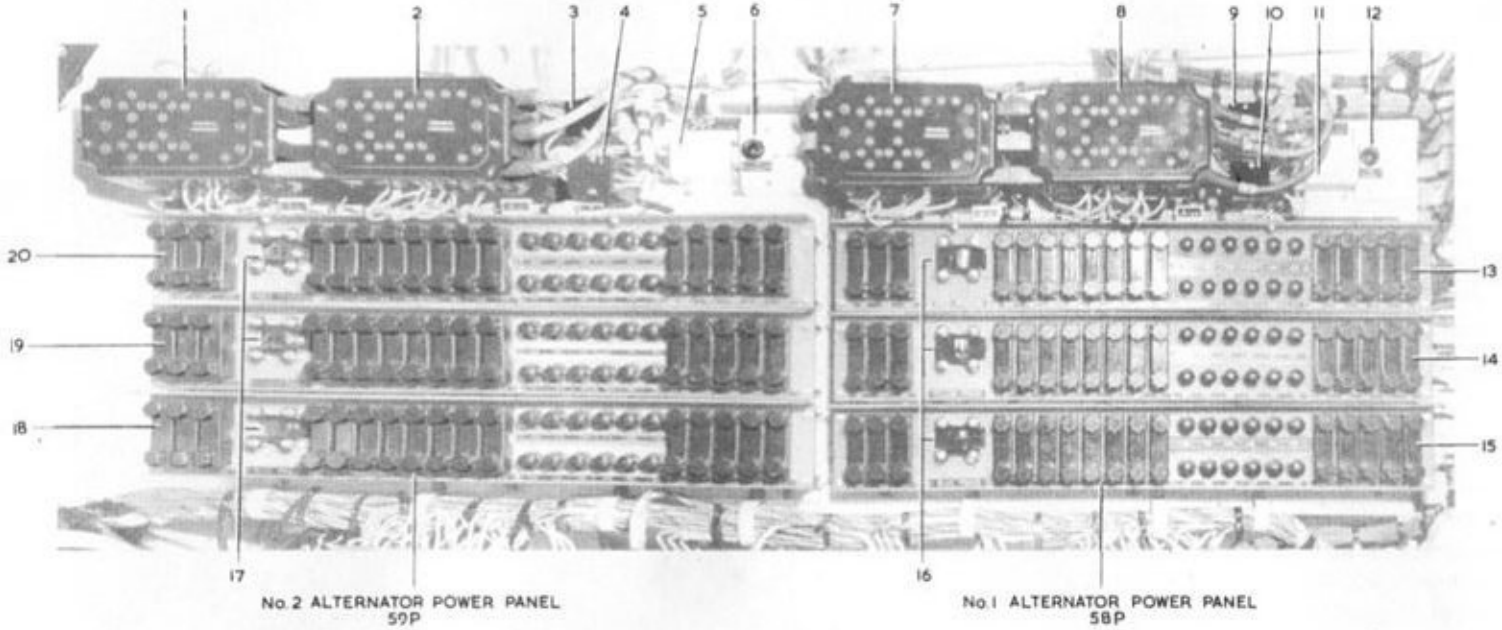


Fig.3 Alternator control panel
▶ *SEM/Vulcan/STC (Mod.2503)* ◀



KEY

1. NO.2 ALTERNATOR 'S' BREAKER
2. NO.2 ALTERNATOR 'A' BREAKER
3. RELAY 57
4. RELAY 58
5. 33 OHM RESISTOR (FAILURE WARNING)
6. LIVE BUSBAR INDICATOR
7. NO.1 ALTERNATOR 'S' BREAKER
8. NO.1 ALTERNATOR 'A' BREAKER
9. RELAY 55
10. RELAY 56
11. 33 OHM RESISTOR (FAILURE WARNING)
12. LIVE BUSBAR INDICATOR
13. FUSES 21 to 48 (200-VOLT, RED PHASE)
14. FUSES 21 TO 48 (200-VOLT, YELLOW PHASE)
15. FUSES 21 to 48 (200-VOLT, BLUE PHASE)
16. MERZ-PRICE TRANSFORMERS
17. MERZ-PRICE TRANSFORMERS
18. FUSES 57 TO 84 (200-VOLT, BLUE PHASE)
19. FUSES 57 TO 84 (200-VOLT, YELLOW PHASE)
20. FUSES 57 TO 84 (200-VOLT, RED PHASE)

Fig. 4 No.1 and 2 power panels

KEY TO FIG.5

1. VOLTAGE REGULATOR, TYPE 129 (NO.2)
2. JUNCTION BOX 19J
3. FREQUENCY AND LOAD CONTROLLER, TYPE 41 (NO.2)
4. ALTERNATOR SWITCH-BOX, TYPE 450, MK.5 (NO.2)
5. ALTERNATOR SWITCH-BOX, TYPE 450, MK.5 (NO.1)
6. FREQUENCY AND LOAD CONTROLLER, TYPE 41 (NO.1)
7. JUNCTION BOX 18J
8. VOLTAGE REGULATOR, TYPE 129 (NO.1)

Constant speed drive units

18. The constant speed drive unit is a governed hydraulic transmission giving a constant speed output of 6,000 r.p.m. for engine speed varying between 3,000 and 8,100 r.p.m. The output speed is controlled primarily by a centrifugal governor using flyweights to operate a valve. Operation of the valve varies the oil pressure which alters the stroke of a pump on the drive unit, and thus alters the output shaft speed. This action is further precision trimmed by a servo-motor for correction of real load and frequency variations as applied by the frequency controller (para.33). Connection to the servo motor is made from a plug on the underside of the unit. Oil temperature gauges are fitted on a panel complete with pillar lights and dimming facilities above panel 70P as shown in fig.6. A routing chart for the C.S.D.U. oil temperature system is contained in fig.33.

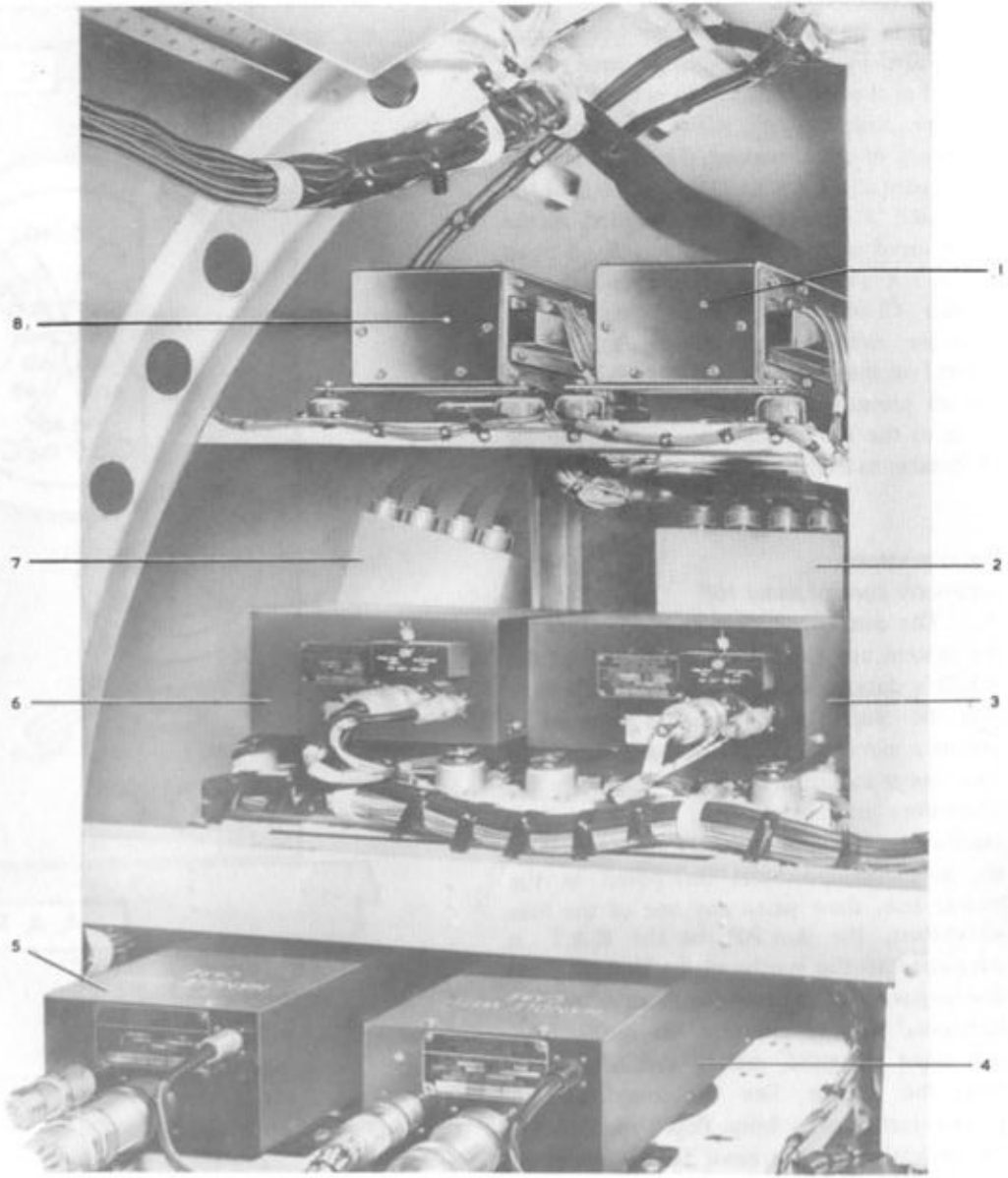


Fig. 5 Remote control equipment

Underspeed switch

19. Protection against underspeed conditions is provided by an oil-operated pressure switch located at the top of the drive unit. In the low pressure position, i.e., when conditions are stationary or in underspeed, the switch is made across contacts A - B and the TRIP coil of the associated 'A' breaker will be energised. As the input speed is increased, contacts A - B open and A - C close under pressure, and the 'A' breaker CLOSE coil will be energised. In excessive overspeed conditions, a lock-out control on the drive unit will operate to relieve the oil pressure from the switch, which will move to the low pressure position to trip the 'A' breaker as in the underspeed condition.

Cabin controls

Alternator control panel 10P

20. The control switches and indicators for the system are located on panel 10P at the A.E.O.'s station. Reference to fig.3 will show that the centre of the panel is arranged to present a mimic plan of the busbar system with four amber indicator lamps showing when the alternators are not on line, i.e., when their associated 'A' circuit-breakers are open. Also six magnetic indicators interposed in the busbar line, show when any one of the four alternators, the A.A.P.P. or the R.A.T. is connected to the synchronising busbar. When de-energised, the magnetic indicators present horizontal bars to interrupt the busbar line, and when energised, present vertical bars so that the busbar line is completed. A press-to-test warning lamp, Page Type C80-A7, for indication of alternator failure is located above the busbar line.

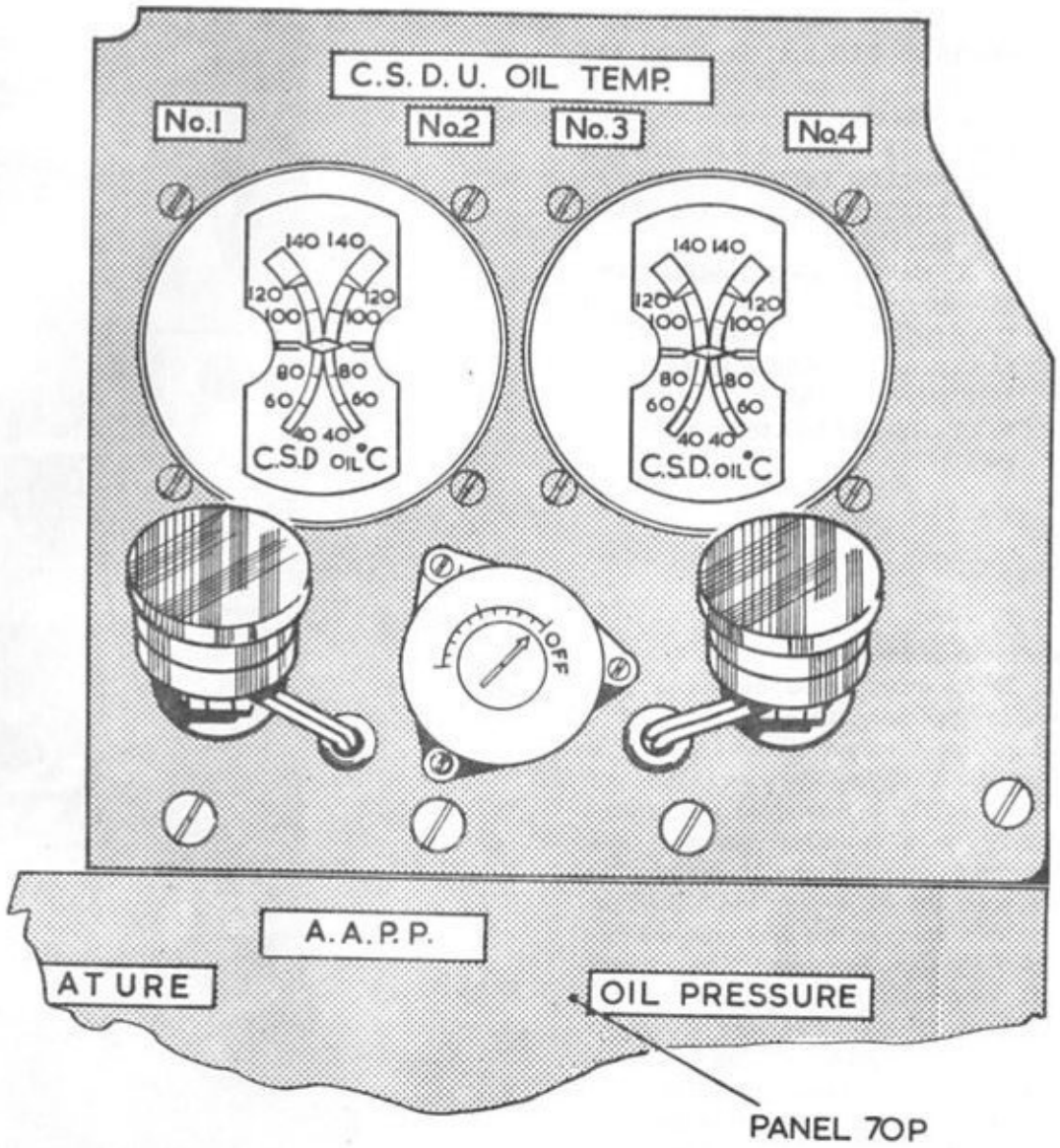


Fig. 6 C.S.D.U. oil temperature panel

21. Each alternator is supplied with a control switch, labelled ON-OFF, and two push-buttons, labelled RESET and ISOLATE respectively. In addition, a rotary selector switch, Dowty Type C7044Y Mk.2, is provided for switching the alternators on to the synchronising busbar. The switch is 5-positioned including centre OFF, selection of the appropriate alternator to be synchronised being made by turning the switch knob and pressing it. Other controls include a non-essential supplies reset switch, and two push-buttons, labelled respectively, A.A.P.P. ON and EXTRA SUPPLIES TRIP.

22. Two sets of indicating instruments, each comprising a voltmeter and a frequency meter, are mounted on the upper portion of the panel. One set indicates the voltage and frequency of the incoming supply from any of the four alternators as selected by the synchronising switch; the other set gives permanent indication of the voltage and frequency of any supply connected to the synchronising busbar. Provision is also made for reading incoming supplies from the A.A.P.P. or R.A.T. on the first set of instruments by means of two push-buttons. Note that phase-to-earth voltage of supplies is read in each case, i.e., 115-volts.

23. On the lower portion of the panel are fitted four watt/var meters with a scale calibration 0-50. These instruments normally give indication of the loading of each alternator in kilowatts, and also the reactive loading in kilovars when the associated push-button is pressed. Further information on the various control switches and indicators is given in the paragraphs dealing with the circuit operation.

Equipment in power compartment

24. The alternator outputs are taken via load share junction boxes to four power panels, 58P, 59P, 60P and 61P. These correspond to No.1, 2, 3 and 4 alternators respectively, and are mounted, two on each side of the power compartment. Remote control equipment, comprising voltage regulators, frequency and load controllers and alternator switch-boxes are situated at the forward end of the compartment. Illustrations of the power panels and remote control equipment for No.1 and 2 alternators are provided in fig.4 and 5.

Power panels

25. Each power panel contains the 'A' and 'S' circuit breakers for the associated alternator, the red, yellow and blue phase fuses for the main and synchronising busbars, and the Merz-Price protection transformers on the outgoing phases. In addition, located at the top of the panel, is a live busbar neon indicator connected via a 62 k/ohm dropper resistor to the red phase busbar, and a 33 ohm resistor which is used in the failure warning circuit.

26. The 'A' and 'S' circuit breakers, Type 6Y No.4, (Ref.5CW/6944), are of the latch type, and have three main and five auxiliary sets of contacts. Connection for the main auxiliary contacts are shown on the appropriate routing charts.

VOLTAGE REGULATORS

27. Four voltage regulators, Type 129 (Ref.5UG/1984075), are installed in the aft power compartment as shown on fig.5. These regulators are of the S.C.R. (silicon controlled rectifier) type, and control the alternator exciter field current. The trigger signals which control the silicon controller rectifiers are derived basically from the alternator output line. Suitable shaping and phasing of the trigger signals made by various circuit functions, and brief details of these are contained in the following paragraphs. Comprehensive information on the regulator and its operation is given in A.P.113D-07107-1.

28. Initially, the exciter (fig.11A) is excited from A+ via the four sets of normally closed contacts of relay S1, the closed contacts of the exciter control relay in the alternator switchbox and the shunt wound exciter field. As the alternator builds up , transformer T1, which is connected across the red and yellow phases, will be energised and a voltage will be induced in the three secondary windings SEC 1, SEC 2 and SEC 3. The supply from SEC 3 will energise relay S1 via diodes D17 and D18 and zener diode ZD7, which will conduct when the alternator output reaches approximately 160-volts, the return path being made via the centre tap on the winding. With the contacts of relay S1 open, the exciter field current will be fed from the rectifier bridge connected across SEC 1 when the appropriate trigger signals are applied to the base of silicon controlled rectifiers SCR1 and SCR2.

29. The output of SEC 3 also provides alternate negative signals to the base of transistors Q2 and Q3 in push-pull, via diodes D13 and D14, the d.c. supply being fed from a rectifier bridge connected across SEC 2. This circuit produces a square waveform which is applied to transductor T6, the transductor output being fed to a pulse limiting network which produces a series of uni-directional pulses to trigger SCR 1 and SCR 2.

30. Two d.c. control windings control the transductor output, one connected to a voltage reference circuit and the other to the alternator reactive load sharing circuit. The voltage reference circuit senses change in the alternator voltage and may be regarded as the main controlling factor of the system. This circuit is fed by three transformers T3, T4 and T5 connected star/delta, the primary being connected across the alternator output. The secondary output is rectified and smoothed and applied to a sensing and amplifier circuit consisting of zener diodes ZD1 and ZD2, transistor amplifier Q1 and resistors R7 to R10. During run-up, alternator under-voltage is sensed by the reference circuit and full pulse width is applied to SCR 1 and SCR 2, thus allowing the alternator to attain normal 200-volts output as quickly as possible. The pulse width shortens to reduce excitation as the correct voltage output is reached. With the alternator running normally, any under or overvoltage will be sensed by the reference circuit to increase or decrease the pulse width and adjust the excitation accordingly.

31. The control circuit for reactive load sharing is provided by transformer T2 and associated network. The transformer primary is connected across the alternator red and yellow phases, the circuit on the secondary being connected into the reactive loop across resistor R1, via the current transformer around the alternator blue phase.

Frequency and load controllers

32. The four frequency and load controllers, Type 41, provide the means of controlling the frequency of the alternators and the real load sharing aspects of the system. The units are fitted on anti-vibration mountings.

33. Each unit contains a magnetic amplifier whose output is fed to the speed trim servo motor on the associated constant speed drive unit. The amplifier has two control windings, one for frequency control which is connected to a frequency discriminator circuit, and the other for real load sharing control which is connected to a transformer-rectifier circuit operating in conjunction with a current transformer looped around the red phase of the alternator.

Alternator switch-boxes

34. The four alternator switch-boxes, Type 450, (Ref.5CW/12676) contain the exciter control relay EC/6 for each alternator. This relay is a latched contactor and provides the main switch-on and trip control for the alternator. Other components include the Merz-Price and other protection relays, a torque switch for undervoltage control, and an overvoltage circuit which is operated from a current transformer looped around the alternator yellow phase. The functions of the various components are dealt with in those paragraphs describing the circuit operation.

Load share junction boxes

35. The current transformers used in the overvolt protection, real load and reactive load sharing circuits referred to in the previous paragraphs, are contained in four load sharing junction boxes, 14J, 15J, 16J and 17J located above the power panels. Each box provides a link between the associated alternator and its power panel, and contains three transformers looped one around each phase. In addition a number of circuit control fuses are connected from the busbars. No.1 load share junction box (14J) is illustrated in fig.7.

Junction boxes

36. Four junction boxes, 18J, 19J, 20J and 21J are located on the bulkhead behind the frequency controllers. The boxes contain terminal blocks, which provide the necessary connecting points for the remote control equipment (para.24).

Merz-Price protection

37. The Merz-Price system of differential protection is employed in the event of line-to-line and line-to-earth faults across each alternator output. This consists of three loop circuits, one for each phase, using three current transformers surrounding the feeder lines of the alternator, connected to three similar transformers surrounding the neutral lines. Three relays are connected, one across each loop, and any one, when energised, will disconnect the alternator from the busbar.

38. Under normal operating conditions, currents induced by the transformers in each loop will be equal, and will circulate around the loop. Should a line fault occur, however, the current induced by the transformer at the feeder end will be in excess of that induced by the transformer at the neutral end. This excess current will take the path through the relay, which will be energised to trip the 'A' circuit breaker. The current transformers on the feeder lines are located on the power panels (para.25), and those on the neutral sides are installed in the Merz-Price engine bay junction boxes 22J, 23J, 24J and 25J. The associated relays DP/A, DP/B and DP/C are contained within the alternator switch-boxes. An illustration of No.1 Merz-Price juntion box (22J) is provided in fig.8.

Warning indicators

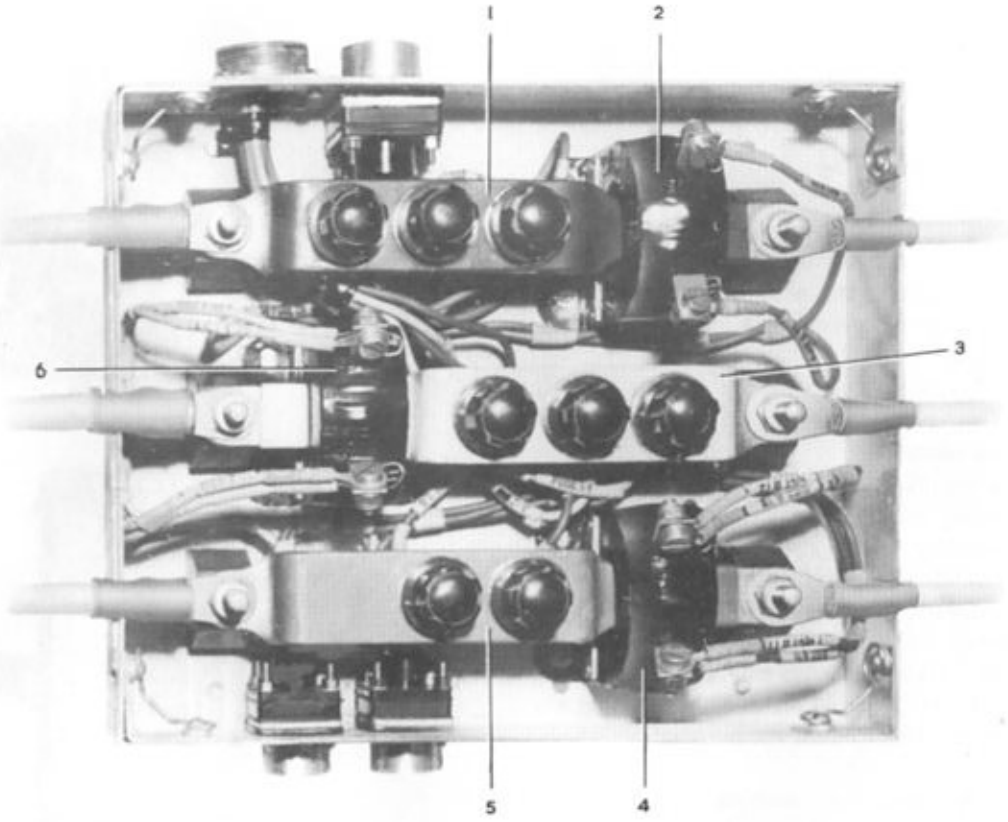
Alternator failure warning

39. Indication of alternator failure is given by two red warning lamps, one on the pilots' centre instrument panel (Page - Type C331-A), and one on 10P at the A.E.O.'s station (para.20). A press-to-test facility on the A.E.O.'s warning lamp enables both lamps to be tested during normal flight.

40. On the failure of any single alternator, the lamps will give a steady indication. A second or further alternator failure, however, will cause the lamps to flash to indicate more serious conditions. In the event of failure of all four alternators the R.A.T. release toggle will be operated to bring the R.A.T. on to the synchronising busbar, and at the same time the warning lamps will go out. This prevents the pilots' attention being diverted since he is already aware of the emergency. Should one or more alternators be brought back on line, the warning system will be restored whenever the non-essential loads reset switch on 10P is operated.

41. The warning system incorporates an alternator failure warning unit, H.S.A. Part No.30/V9900, located on the extra supplies panel 74P in the power compartment. This unit provides the flasher circuit for the warning lamps and also controls certain E.C.M. relays for the purpose of load shedding when two or more alternators have failed. The flasher circuit contains a Diamond H Type relay and a transistorised multivibrator circuit.

42. When the aircraft is on the ground and a 28-volt ground supply is connected, or the internal battery is switched on, the lamps will flash continuously. Further details are provided in the paragraphs dealing with the circuit operation.



KEY

1. FUSES 1, 2, 3 (200-VOLT, RED PHASE)
2. REAL LOAD CURRENT TRANSFORMER
3. FUSES 1, 2, 3 (200-VOLT, YELLOW PHASE)
4. REACTIVE LOAD CURRENT TRANSFORMER
5. FUSES 1, 2 (200-VOLT-BLUE PHASE)
6. OVERVOLT CURRENT TRANSFORMER

Fig. 7 No.1 Load share junction box

'A' breaker indicator lamps

43. Four amber indicator lamps on 10P show when the associated 'A' breakers are open. The lamps are connected from the NC contacts of the 'A' breakers, and will be lit when the aircraft is on the ground with 28-volt supplies connected.

Watt/var meters

44. Four thermo watt/var meters provide continuous indication in kilowatts of each alternator load. Each instrument comprises an indicator, scaled 0-50, a Type B resistance box, and a current transformer looped around the associated alternator red phase. The reactive alternator load in kilovars may also be read on the indicators (located on 10P) by pressing a push-button provided for the purpose.

45. This type of watt/var meter is a single-phase instrument consisting of two thermo-couples connected in series opposition across a d.c. milli-voltmeter, which measures the difference in output between the couples. The output of the first thermo-couple is generated from the sum of two currents, one proportional to the supply voltage, the other proportional to the load current produced by the current transformer. The output of the second thermo-couple is a function of the difference between the same two currents.

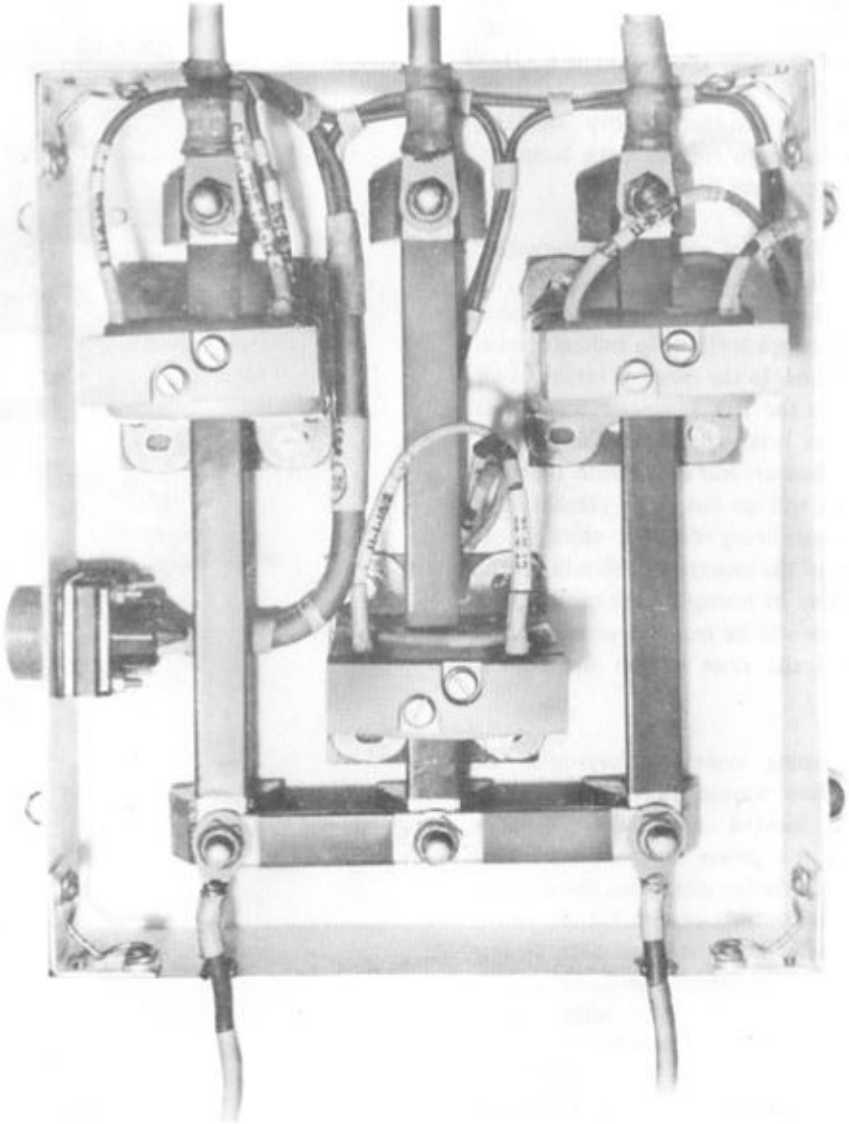


Fig. 8 No.1 Merz - Price junction box

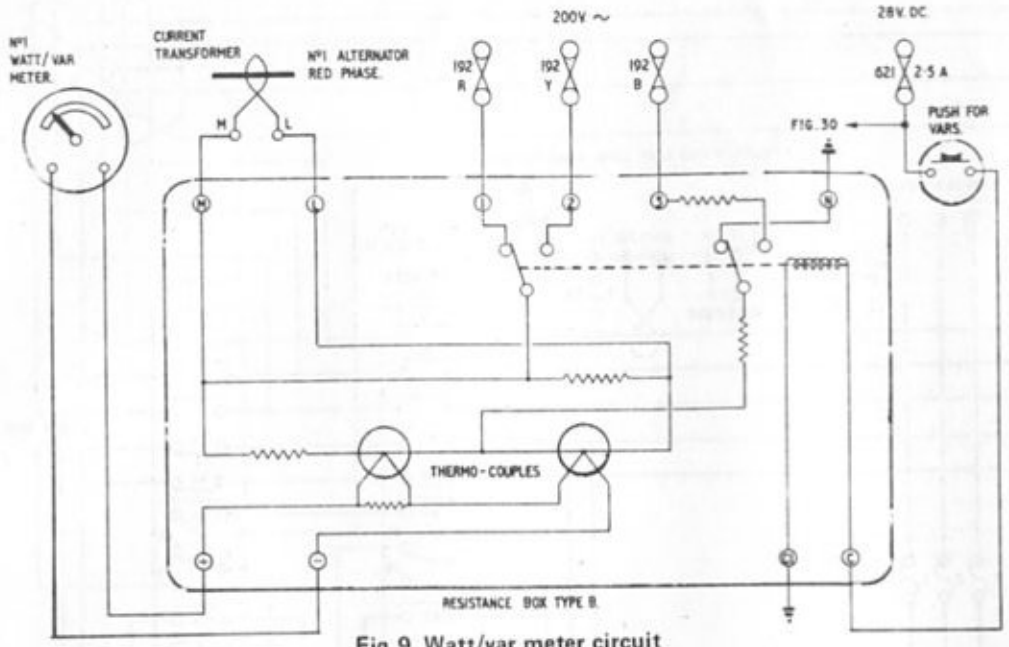


Fig.9 Watt/var meter circuit

46. Supplies of 200-volt, 3-phase a.c. are fed to the instrument, but for k/watt measurements, the circuit is connected between one phase and neutral (earth). For the purpose of measuring k/vars, a 28-volt d.c. relay is energised by pressing the push-button. This action connects the circuit across the other two phases via a resistance to drop the line voltage (fig.9).

47. The resistance boxes are fitted on a panel with anti-vibration mountings located under the navigator's panel on the port side of the cabin. A cover over the front of the panel is retained by four knurled screws. The current transformers are fitted midway in the bomb bay, two on the port side and two on the starboard side. A full description of the watt/var meters will be found in A.P.4343J, Vol.1, Sect.1.

NOTE . . .
The indicator and resistance box for each instrument are supplied as a matched pair, with identical serial numbers, under Ref. 5Q/15658 and must always be fitted or replaced as such.

Ground supply phase sequence unit (Post Mod.2378)

47A. With Mod.2378 incorporated an undervoltage phase sequence unit, Type AE5601 fitted to a mounting bracket above panel 82P, gives protection against incorrect phase sequence of the 200-volt ground supplies. The unit consists of two transformers a relay and potentiometer. The relay contacts close at 178 ± 5.75 volts and open at 173 ± 1 volt, allowing the 200-volt ground supply to be switched on to the synchronising busbar providing the input voltage and phase sequence are correct. For further details of the unit reference should be made to A.P.113D-0710-1.

Circuit operation

48. The following paragraphs describe the circuit operation for bringing No.1 alternator on line and also the functioning of the system as a whole. The operation is described commencing with the connection of the 200-volt ground power unit and a Palouste air starter trolley as required for normal engine ground starting.

49. The battery isolation switch will first be pressed to ON to connect the battery to the 28-volt busbar (Chap.6). A supply from fuse 490 (fig.10) will then be made via diode RE4 in the No.1 alternator switch-box, contacts 5-6 of the alternator control switch and relay contacts M/5 to energise relay 56/2. Contacts 56/1 will close to connect the supply to the trip coil of the 'A' breaker, and contacts 56/2 will open to isolate the close coil. At the same time the supply will be made via contacts 5 of the 'A' breaker, relay contacts M/3 and 55/1 to energise the close coil of the 'S' breakers. In addition, the four 'A' breaker indicator lamps will light and the two alternator failure lamps will flash (para.98).

Switching on the ground supplies

50. When the start push-switch on the ground power unit is pressed (fig.12) a 28-volt supply from the G.P.U. will energize the internal relay, and will also energize relay 389, via pole E of the ground supply plug. (Post Mod.2378 the supply from pole E of the supply plug is fed via the relay contacts within the phase sequence unit (P.S.U.) to the energizing coil of relay 389. The relay contacts within the P.S.U. will be closed providing the voltage and phase sequence of the ground supply is correct). With relay 389 energized contacts 389/2 will close, connecting a supply from fuse 482 via the synchronizing voltage pick-up unit contacts A-E to the close coil of relay 14 which will latch in. The supply from fuse 483 is now fed via relay contacts 390/4, and 14/2, pole F of the ground supply plug and normally closed stop push-switch contacts of the G.P.U. to provide a hold-in supply for the G.P.U. internal relay, and also via pole E of the ground supply plug to hold-in relay 389. The G.P.U. start push-switch can now be

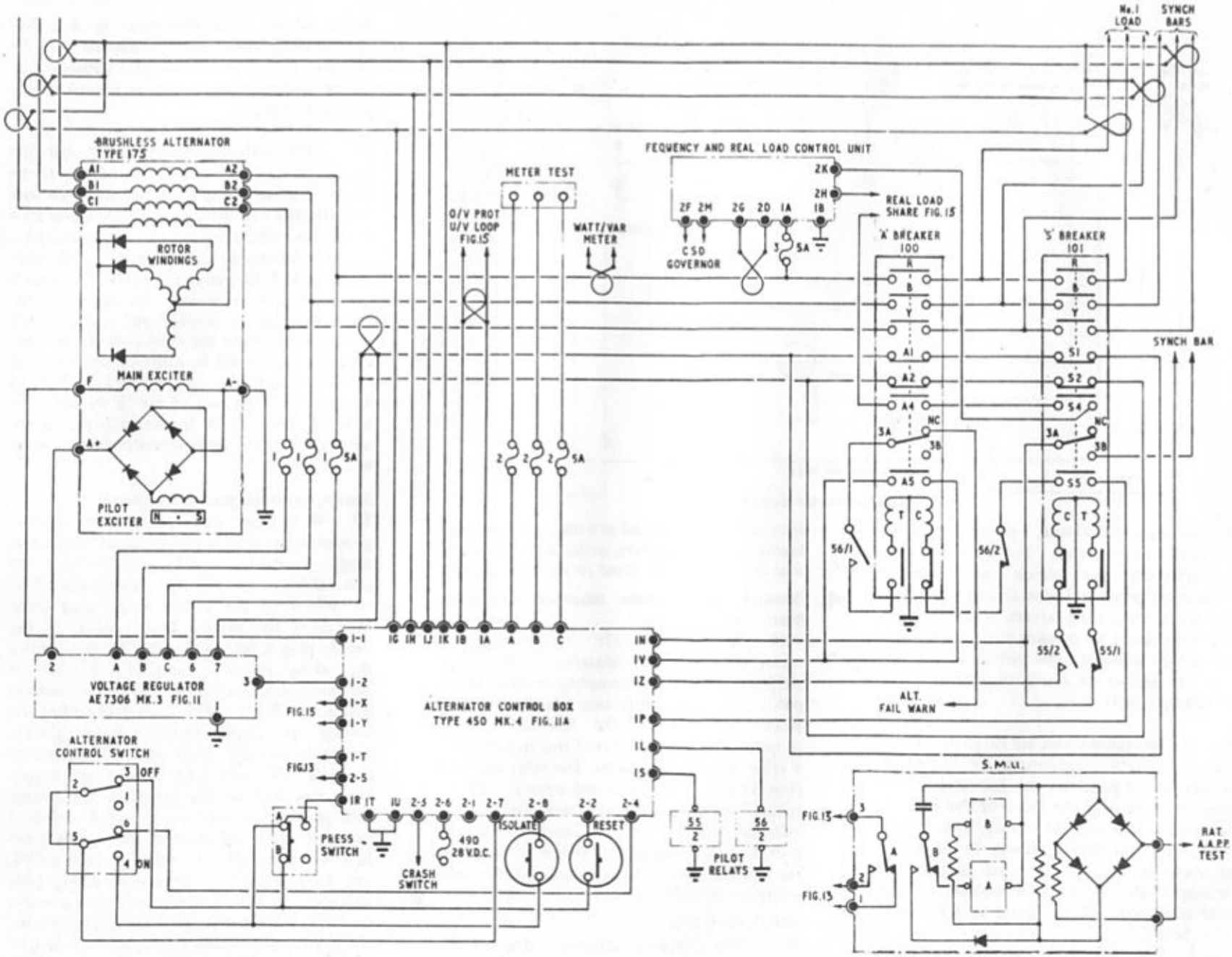


Fig.10 No.1 Alternator control circuit

released, and the ground supplies switched on to the synchronizing busbar. With the introduction of Mod.2074, a G.P.U. start push-switch is fitted on the aircraft ground supply panel (Chap.6). This facility is for use overseas with G.P.U.'s not fitted with a start/stop panel. When the push switch is pressed, relay 389 will be energized from fuse 483 via contacts 390/4 and poles F-E of the ground supply plug, which are linked together at the G.P.U. (Chap.5). Post Mod.2378 relay 389 will only be energized if the internal contacts of the P.S.U. are made. The associated routing chart is contained in Chap.5

51. The synchronizing voltage pick-up (fig.13) will now be energized, and its four sets of normally closed contacts will open to (a) isolate the synchronizing selector switch, and (b) isolate the close coils of relays 13, 14 and 15 for the A.A.P.P., G.P.U. and R.A.T. respectively. The No.1 and 2 T.R.U.'s will then be switched on, and also the No.1 and 2 3 kVA transformers in order to provide supplies for the fuel pumps and other circuits required for engine starting. It is now assumed that the engines are started and running.

Switching on No.1 alternator

52. Normally the exciter control relay EC/6 in the alternator control panel will be latched in, and the alternator will be self-exciting (fig.10). Should conditions be otherwise, the relay will be closed by pressing the reset switch. A supply from fuse 490 will be fed via RE4, the alternator control switch contacts 2-3, the reset switch, and contacts LO/1 and LO/4 to the close coil of the relay.

53. With relay EC/6 closed, conditions are now as follows:-

(1) Contacts EC/1 close to prepare the circuit to the trip coil of the relay.

(2) Contacts EC/2 close to complete the exciter field circuit from A+ through the regulator circuit to F.

(3) Contacts EC/3 close to energise relay LO/5.

(4) Contacts EC/4 close to prepare the circuit from connection C of the underspeed switch to the coil of relay TD/1 via contacts M/1.

(5) Contacts EC/5 close to prepare the circuit to the coil of the overspeed relay AVSR/2.

(6) Contacts EC/6 open to remove one of the supply paths to relay 56/2.

54. On releasing the reset switch, relay LO/5 will be de-energized and relay EC/6 will remain latched in. When the alternator builds up to 178-volts, the transistorised unit UVSR/1 will be energized to prepare the circuit to the coil of the master relay M/5 from the underspeed switch.

55. With the alternator control switch now placed to ON and the underspeed switch in the normal pressure position, the supply will be made via contacts 5-4 of the control switch, contacts A-C of the underspeed switch, and contacts EC/4 and UV/1 to energize relay M/5. At the same time relay 56/2 will be de-energized to open contacts 56/1 and close contacts 56/2. The following sequence of events will now take place:-

(1) Contacts M/4 close to energize relay 55/2 via contacts 5 of the 'A' breaker.

(2) Contacts M/3 and 55/1 open to isolate the close coil of the 'S' breaker.

(3) Contacts 55/2 close to trip the 'S' breaker.

(4) Contacts M/2 close to energize the 'A' breaker via the now closed contacts 5 of the 'S' breaker and contacts 56/2.

(5) Contacts 5 of the 'A' breaker open to de-energize relay 55/2.

(6) Contacts M/5 open to further isolate the coil of relay 56/2.

(7) Contacts M/1 open to isolate the coil of relay TD/1.

56. Closing of the 'A' breaker will bring No.1 alternator on line and any loads on No.1 alternator busbar, previously being supplied by the G.P.U. via the synchronizing busbar, will be transferred to the alternator, which is now isolated from the synchronizing busbar by the opening of the 'S' breaker contacts. The other three alternators will be brought on line by similar circuit action.

Switching off the ground supplies

57. When the ground supplies are switched off and the G.P.U. stop push-switch is pressed, the internal relay and relay 389 will be de-energized. Contacts 389/2 will open, isolating the close coil of relay 14 and contacts 389/3 close to trip the relay. The ground supply socket can then be withdrawn.

58. Note that when the ground supplies are switched off, the synchronizing V.P.U. will be de-energized and No.2 alternator will be automatically connected to the synchronizing busbar as indicated in the next paragraph.

Stand-by supply

59. The system is arranged so that a stand-by supply from No.2 alternator will be automatically connected to the synchronizing busbar in the absence of any other supplies on

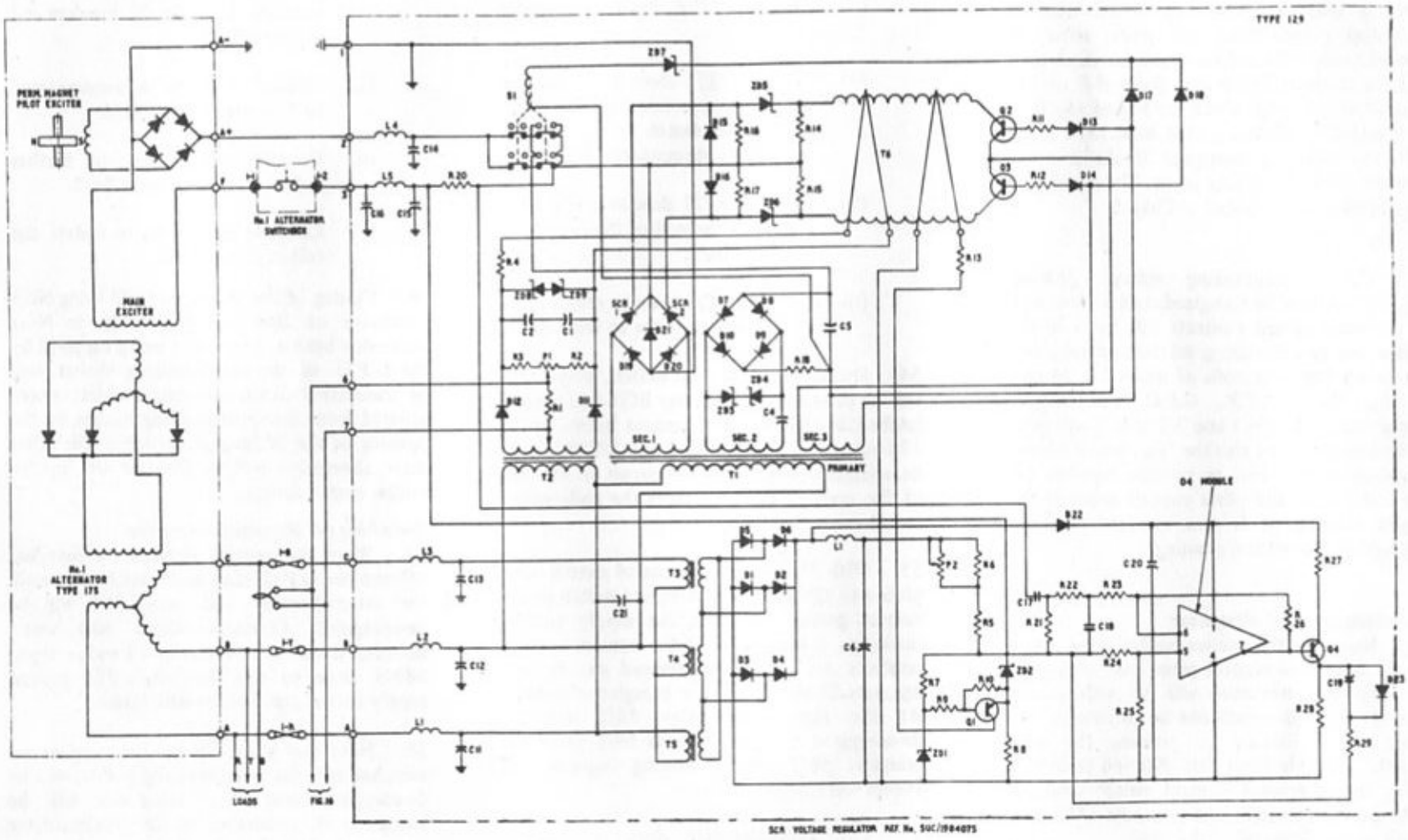


Fig.11 S.C.R. voltage regulator circuit, Type 129

the busbar. Under these conditions, a supply from fuse 485 (fig.13) will be fed via relay contacts 14/1, 15/2, 13/1, contacts G-D of the synchronising V.P.U. (de-energised) and contacts 389/1 to energise relay P/1 in the No.2 alternator switch-box. Contacts P/1 will then close to energise the close coil of No.2 'S' breaker via contacts 57/1. The 'S' breaker will close and No.2 alternator will be connected to the synchronising busbar in addition to its own busbar.

Synchronising the alternators

60. The alternators can be synchronised for parallel running by operating the synchronising selector switch on 10P (para.21). For normal pre-flight tests, the four alternators will be synchronised for load sharing checks, then No.2 and 3 alternators will be isolated from the synchronising busbar, leaving No.1 and 4 connected in parallel. Since No.2 alternator will already be connected to the synchronising busbar, however, the following paragraphs describe the synchronising of No.1 alternator with No.2.

61. The function of synchronising two or more alternators is controlled initially by the operation of relay B in the synchronising monitor unit (fig.13). This relay is connected via a bridge rectifier across pins A and B of the unit, and will be energised when a voltage appears between the synchronising busbar and the incoming machine. This voltage will vary with the out-of-phase relationship existing between the two sources of supply.

62. By selecting the synchronising selector switch to 1, a path for energising relay B is created between yellow phase fuse 167, the S.M.U. rectifier, the coil of relay B, the normally closed contacts of the A.A.P.P. and R.A.T. meter push-buttons, terminals 10 and 2 of the selector switch and No.1 alternator yellow phase fuse 3. With the selector knob now held pressed, No.1 and 2 alternators will be synchronised in the manner described.

63. Relay B, being connected across the output of the rectifier, will be energised when the two voltages are out of phase, and de-energised when the voltages are synchronised. During the period when the relay is energised, contacts B will change over to connect the capacitor C across the rectifier output and the capacitor will be charged.

64. When relay B is de-energised, contacts B will revert to their normal position to connect relay A across the capacitor. The charge on the capacitor will now energise relay A and its contacts will be made across 2-3. A supply from fuse 485 will then be made via relay contacts 14/1, 15/2, 13/1, terminals 2-3 of the S.M.U. and the synchronising push-switch to energise relay P/1 in the No.1 alternator switch-box. Contacts P/1 will close to energise the close coil of No.1 'S' breaker via contacts 55/1 (fig.10). No.1 alternator will now be connected to the synchronising busbar and the No.1 magnetic indicator on 10P will be energised to complete that part of the busbar line on the mimic plan.

65. The remaining alternators can then be synchronised in turn in similar manner. On completion of load sharing checks, No.2 and 3 alternators will be isolated from the synchronising busbar by pressing the associated isolation switches to trip the respective 'S' breakers.

66. When synchronising the alternators, the synchronising push-switch will be held in until the magnetic indicator on 10P shows that the incoming machine has been connected to the synchronising busbar. Provision is made for fitting a synchronising indicator lamp inside the switch, but this facility is not used. Should it be necessary to fit a replacement selector switch, therefore, the lamp should first be removed.

67. If the incoming machine is exactly in phase with the synchronising busbar it will be necessary to switch on a resistive load. This will cause a slight variation in frequency sufficient to enable the S.M.U. to operate.

Busbar meters

68. The output of the alternator selected for synchronising will be shown on the incoming voltmeter and frequency meter (fig.13). The meters are fed via the normally closed contacts 3-4 of the A.A.P.P. and R.A.T meter push-buttons, and can be connected in turn to each alternator yellow phase by operation of the synchronising selector switch. The meters will also read the output of the A.A.P.P. and R.A.T. by pressing the associated push-button to make contacts 1-2 in each case.

69. The synchronising busbar voltmeter and frequency meter are fed from fuses 167R and B via an isolating transformer, Ferranti RD/7146, Type 123, and will read whichever supply is connected to the synchronising busbar. A similar transformer is also provided for reading the A.A.P.P. output. The transformers are identified 1 and 2 respectively, and are contained in 82P. It should be noted that the readings on both voltmeters will be the equivalent of phase to earth, i.e., 115 volts.

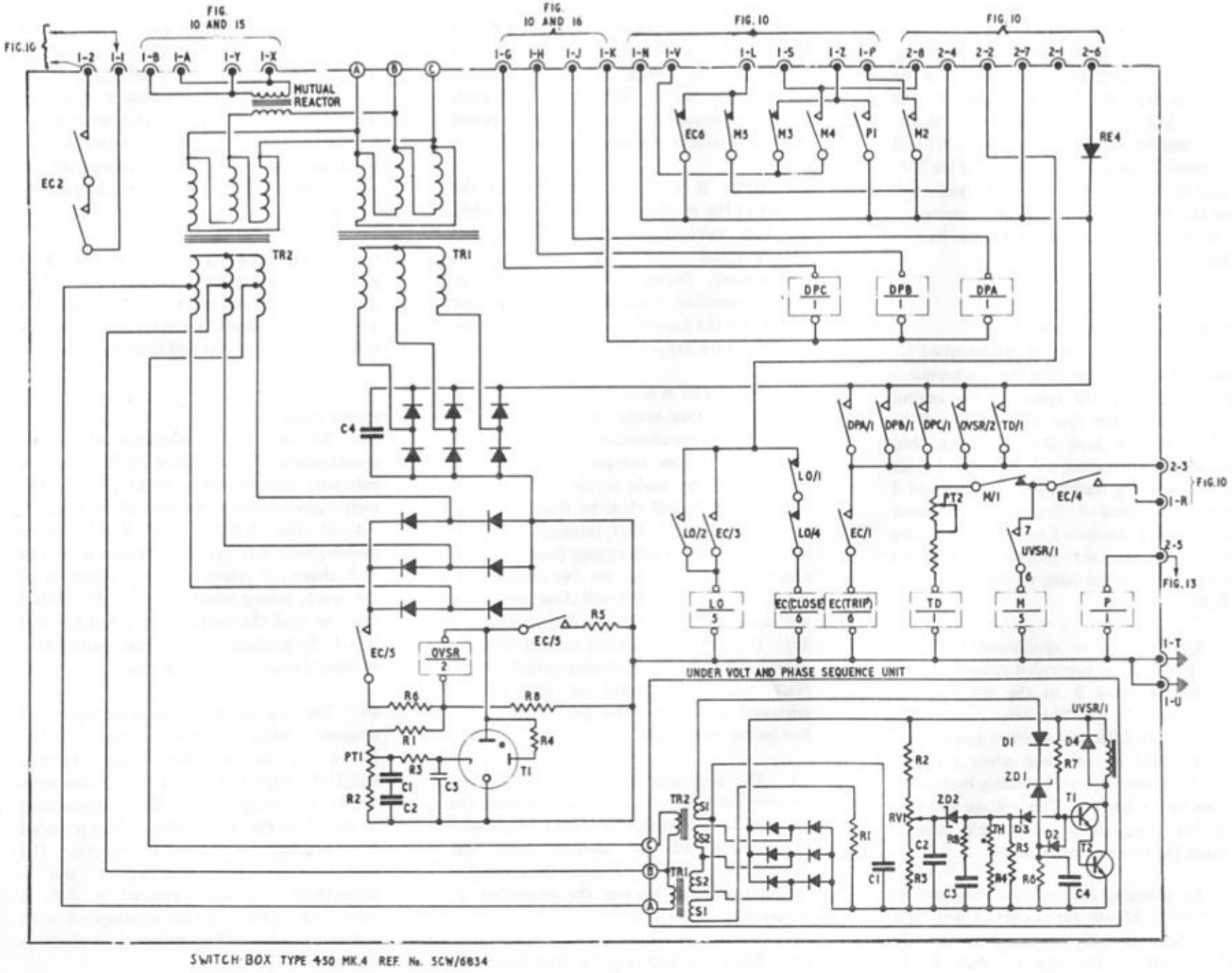


Fig.11A Alternator control switchbox, Type 450 Mk.4

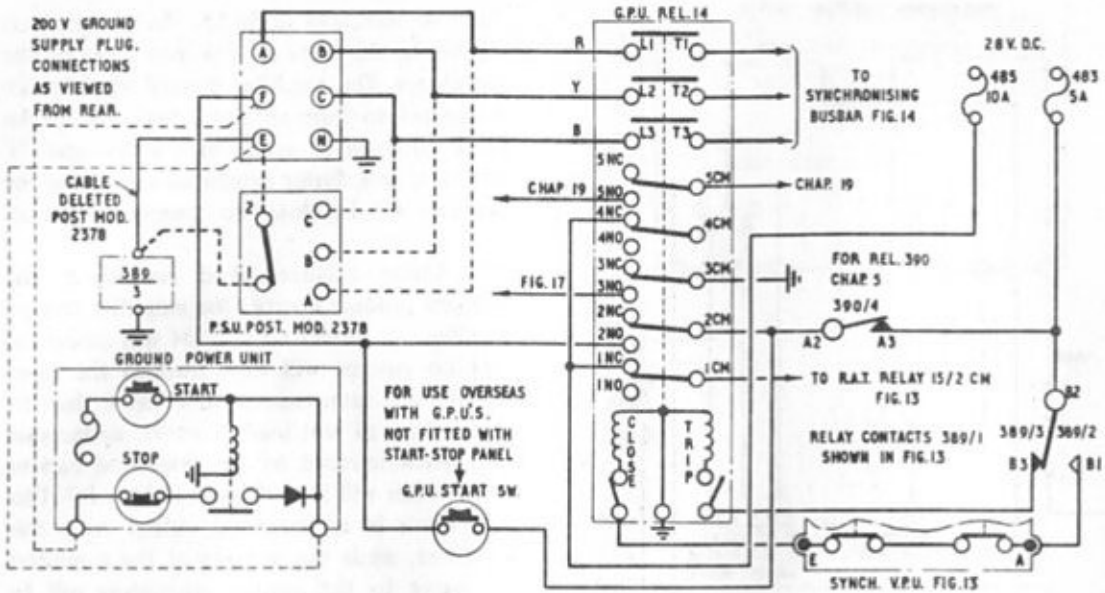


Fig.12 200 volt ground supply controls

Interlocking controls

70. As stated in para.4, a system of interlocking controls prevent coupling of the auxiliary supplies with each other or with the main alternators. This is fully described in Chapter 5. In addition, during alternator failure conditions, provision is made for two further considerations:-

(1) If No.2 alternator output is available, the R.A.T. cannot be connected to the synchronizing busbar. Alternatively, if the R.A.T. is on the synchronising busbar, and the output from No.2 alternator is regained, the R.A.T. will be automatically disconnected from the busbar and replaced by No.2 alternator.

(2) With the No.2 alternator 'A' breaker open, i.e., No.2 alternator failed or switched off, pressing the A.A.P.P. ON button will not isolate the No.2 loads from the synchronizing busbar and the No.2 'S' breaker magnetic indicator will continue to indicate 'closed'.

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71. In both cases reference should be made to fig.21 of this chapter and fig.5 of Chapter 5. Taking case (1), assuming that No.2 'A' breaker is closed, a supply from fuse 491 will be fed via No.2 alternator switch-box and contacts 3 of the 'A' breaker to energize relay 391. Contacts 391/1 will thus be closed to maintain a supply from pin D, plug 4 of the R.A.T. control unit on the trip coil of the R.A.T. relay 15, via contacts 390/3.

72. In case (2) when the A.A.P.P. ON button is pressed, a supply from fuse 917 will energize relay 392. At the same time a supply from fuse 491 is fed via the No.2 alternator switch-box, contacts 5 of the 'A' breaker and relay contacts 392/4 to energize relay 57. Relay contacts 57/1 open to isolate the close coil of No.2 'S' breaker, and contacts 57/2 close to connect a supply from fuse 491 to trip 'S' breaker.

Synchronizing busbar

73. The synchronizing busbar (fig.14) is in effect a ring main feeder system providing three parallel fused links between each alternator. This can be readily seen by tracing out the paths between similar phases of any two alternators. The degree of protection offered by this method is such that load sharing will be maintained despite two faults on the same phase. In normal flight, the busbar will carry only the out of balance loads between paralleled alternators.

74. Emergency supplies to the busbar are connected via three paralleled fuses from the A.A.P.P. and two paralleled fuses from the R.A.T., the ground supplies are connected direct. Note that the only outgoing fuses from the busbar are 167R, Y, B and 168Y. These fuses feed the synchronizing V.P.U. and the No.1 transformer for the busbar meters.

Real load sharing

75. In overspeed conditions an alternator will increase its frequency and take on more real load. In this system, equitable sharing of real load is maintained by four current transformers, one around each alternator red phase, connected to its associated frequency and load controller. Each transformer in conjunction with a transformer-rectifier unit, operates one of two control windings of a magnetic amplifier, which in turn controls the speed trim servo motor on the constant speed drive.

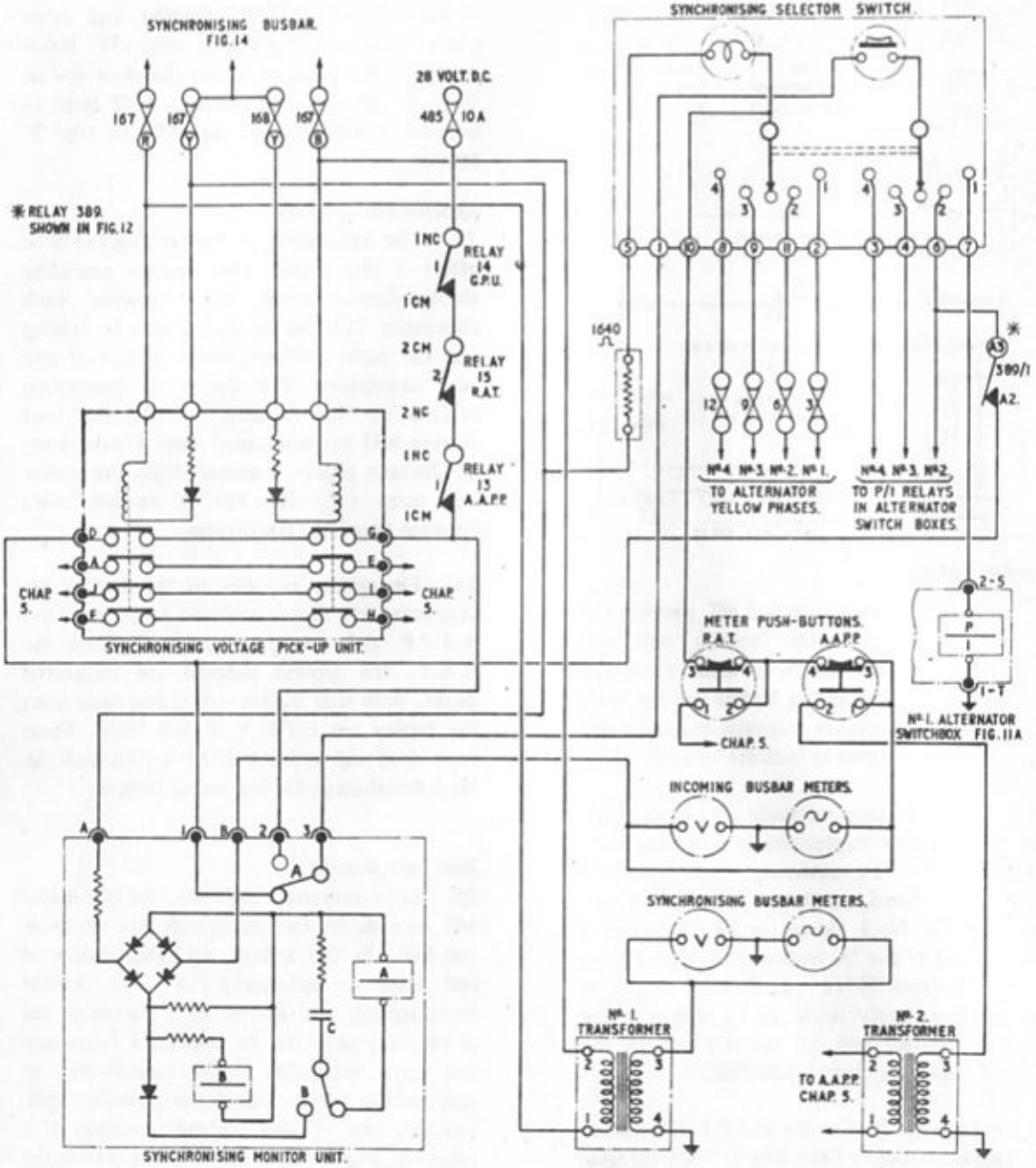


Fig.13 Synchronising control circuit

76. As indicated in fig.15, the transformers T1 within the units are fed from fuses on the red phases. The amplifier control windings are connected to form an equalising loop via the No.4 contacts in series of the 'A' and 'S' breakers, and during synchronous running the contacts will be closed to complete the loop.

77. Under balanced load conditions, the voltages produced across the amplifier control windings via diodes D3 and D4 will cancel out and no current will flow through the loop. Should one alternator assume more than its equal share of real load, however, an increase in current induced by the associated current transformer will flow through resistor R7. This will result in an increased output from this amplifier, while the outputs of the amplifiers belonging to the healthy alternators will be correspondingly reduced. Current will thus circulate around the loop and a measure of control will be applied to the speed trim servo motor to stabilise the system. Any alternator not on the synchronizing busbar will have its section of the loop isolated by the No.4 contact of the 'S' breaker being open.

78. In underspeed conditions where an alternator assumes less than its equal share of real load, the control applied to the servo motor will be in the opposite sense. The system will function to permit a maximum out of balance of ± 3 kW from the mean of the paralleled machine loads.

Frequency control

79. Control of the alternator frequency is effected by a second control winding in the amplifier connected to a frequency discriminator circuit, consisting of two choke capacitance circuits tuned for resonance at

frequency limits 450 and 350 c/s respectively. At 400 c/s the rectified output of the circuit will be zero. However, should the frequency tend towards the upper or lower limit, a current will flow in the control winding to increase the saturation of one core and decrease it in the other according to its direction. The appropriate amount of control in the correct sense will thus be applied to the speed trim servo motor. Frequency runaway is prevented by an overspeed stop on the constant speed drive unit, which is set at 425 ± 5 c/s.

Reactive load sharing

80. An increase in alternator voltage due to over-excitation will cause an increase in its reactive loading. The control circuit for reactive load sharing consists of a current transformer around each alternator blue phase, connected across resistor R1 in the associated voltage regulator to correct the line voltage. The current transformers are connected in a continuous loop, the function of which is controlled by the operation of the No.1 contacts of the alternator 'A' and 'S' breakers (fig.16).

81. During synchronous running, No.1 contacts of the 'A' and 'S' breakers will be open and the circuit will be operative. With equitable load sharing, a nominal current will circulate between transformers in the loop. An increase in the reactive loading of one alternator, however, will cause an increase of induced current in the associated current transformer and the difference of currents within the loop will flow through the resistor R1 in opposite sense, i.e., in one direction through resistor R1 and in the opposite direction through the others. This current will be applied to the control windings of the voltage regulators to reduce the terminal voltage of the affected alternator and increase that of the others so that the balance of reactive loading will be restored. Where an alternator is not connected to the synchronising busbar, the associated current transformer and mutual reactor will be connected across No.1 contacts of the 'S' breaker to short out that section of the loop.

82. In conditions of under-excitation where an alternator assumes less than its equal share of reactive load, a current will be applied to the control windings of the voltage regulators to increase the voltage of the affected machine and reduce that of the others, thus restoring the balance as before. The system will function to permit a maximum out of balance of ± 2½ kVAR from the mean of the paralleled machine loads.

Overvolt protection

83. Overvolt protection for the system during parallel running is maintained by four current transformers, one around each alternator yellow phase and looped together across a mutual reactor in each alternator switch-box (fig.15). The mutual reactor controls the operation of an overvoltage unit comprising principally of a relay OVSR/2 in the anode circuit of a trigger tube supplied through a bridge rectifier RE2 from a 3-phase transformer TR2.

84. With the circuit de-energised, the current transformers are shorted out by the No.2 contacts of the 'A' and 'S' breakers. When the alternators are running and synchronised the contacts will be opened to connect the transformers in a continuous loop.

85. Under balanced conditions a nominal current will flow around the transformer loop. If, due to over-excitation, an alternator overvolts and assumes excessive reactive load, an increased current will be induced in the associated current transformer, resulting in an increased voltage being applied by the mutual reactor to the primary of TR2. This will cause the trigger tube to fire and energise relay OVSR/2 via contacts EC/5 (closed). Contacts OVSR/1 will close to by-pass the relay coil current, and OVSR/2 will close to trip the exciter control relay EC/6 and thus bring the alternator off line.

86. As the reactive loading on the faulty alternator increases, it will decrease proportionally for the other alternators on the synchronising busbar. The voltage applied to their overvoltage units will thus be reduced, preventing the sound alternators from being tripped off line. Where an alternator is not connected to the synchronising busbar, the associated current transformer and mutual reactor will be connected directly across No.2 contacts of the 'S' breaker to short out that section of the loop. The overvoltage circuit will operate at 220 ± 1 volt.

Undervolt protection

87. Undervolt and phase sequence protection is provided by a transistorized unit which will sense undervoltage and incorrect phase rotation. The circuit consists of a d.c. amplifier which controls a relay UVSR/1 fitted internally to the unit. When the generator system is functioning correctly the relay will be energised. When either undervoltage or incorrect phase rotation is sensed, the relay will be de-energised and contacts 6-7 will open to de-energise relay M5; contacts M1 will then close to energise time delay relay TD/1 and the associated alternator will be brought off line.

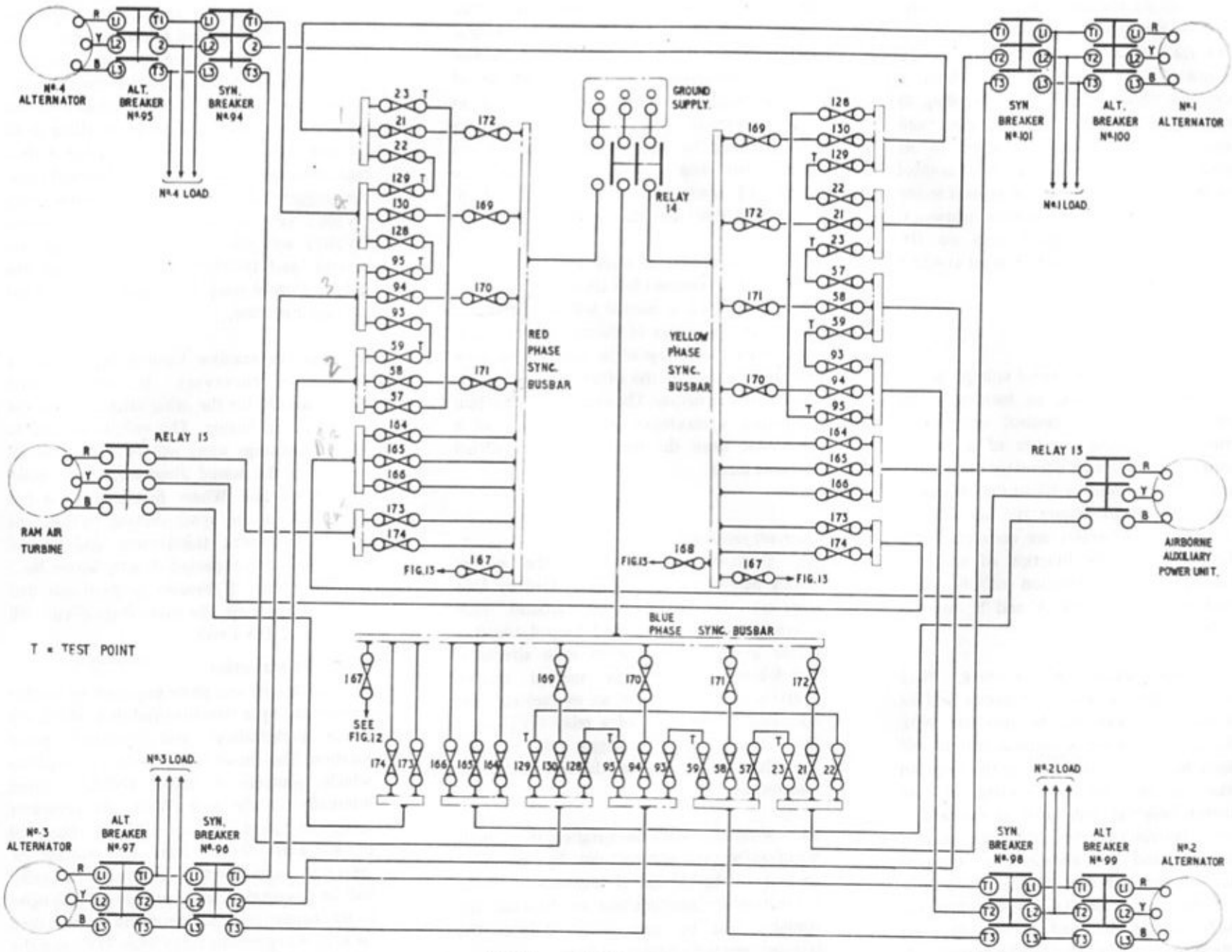


Fig.14 Synchronising busbar

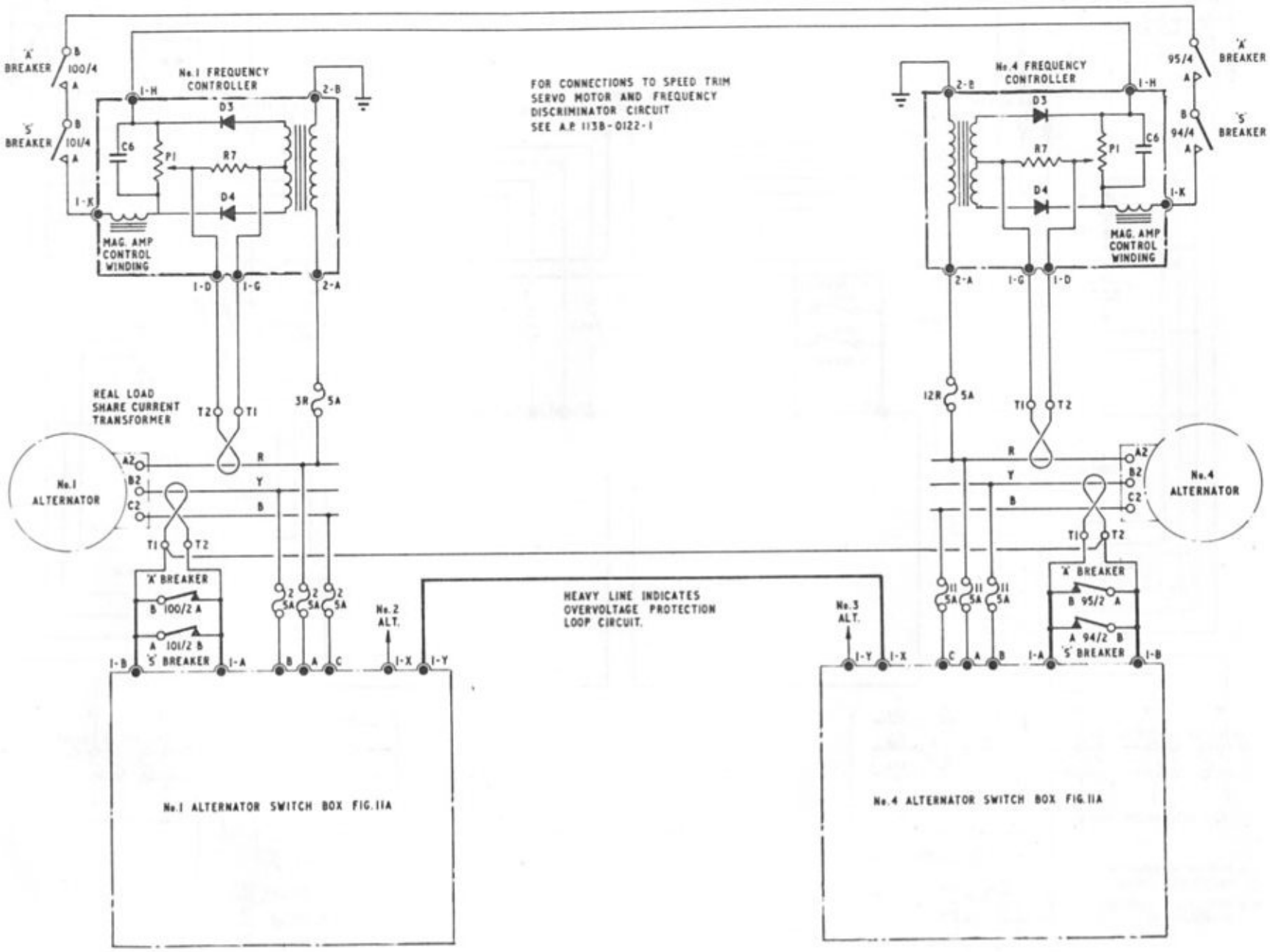


Fig.15 Real load sharing and overload protection

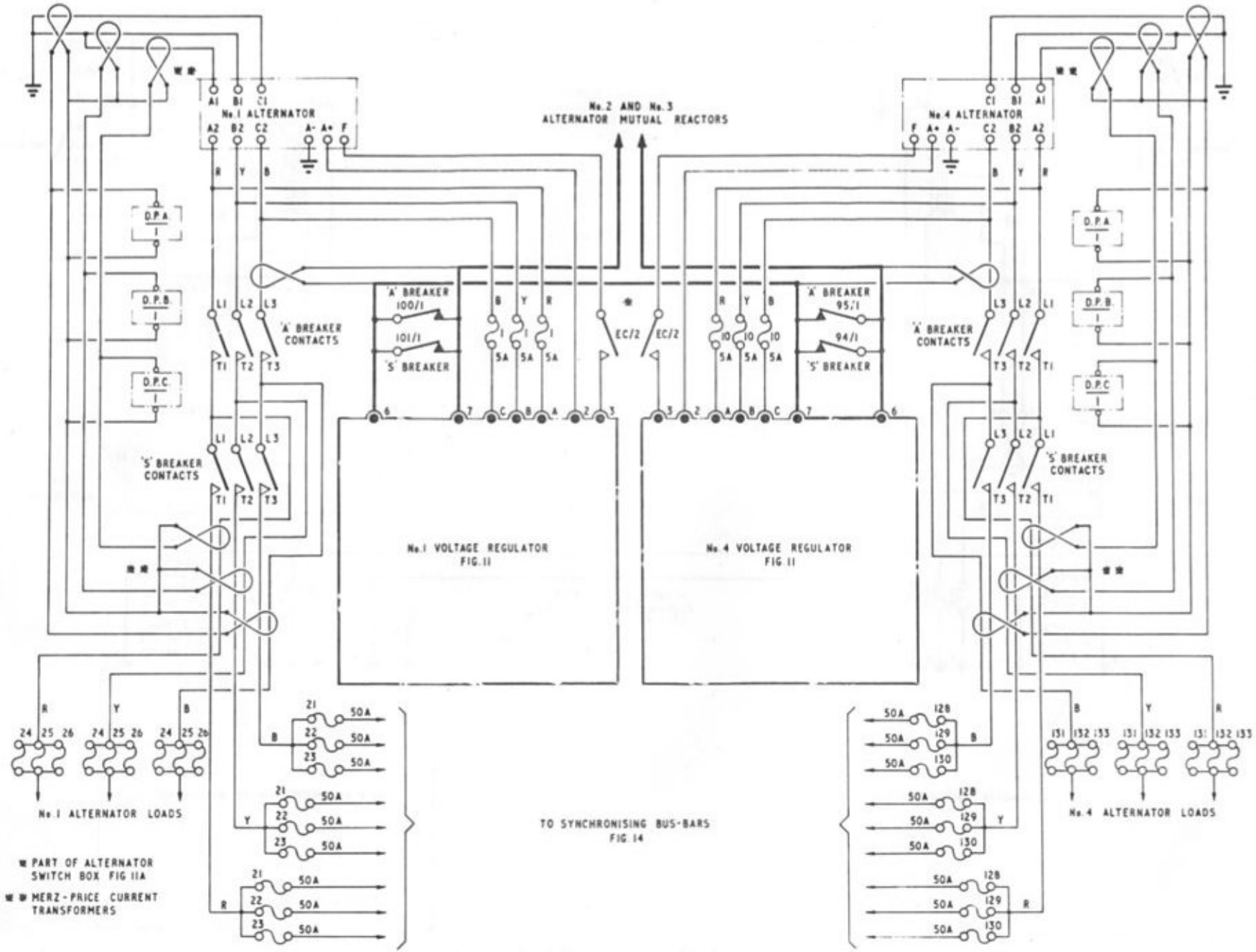


Fig.16 Reactive load sharing and Merz - Price system

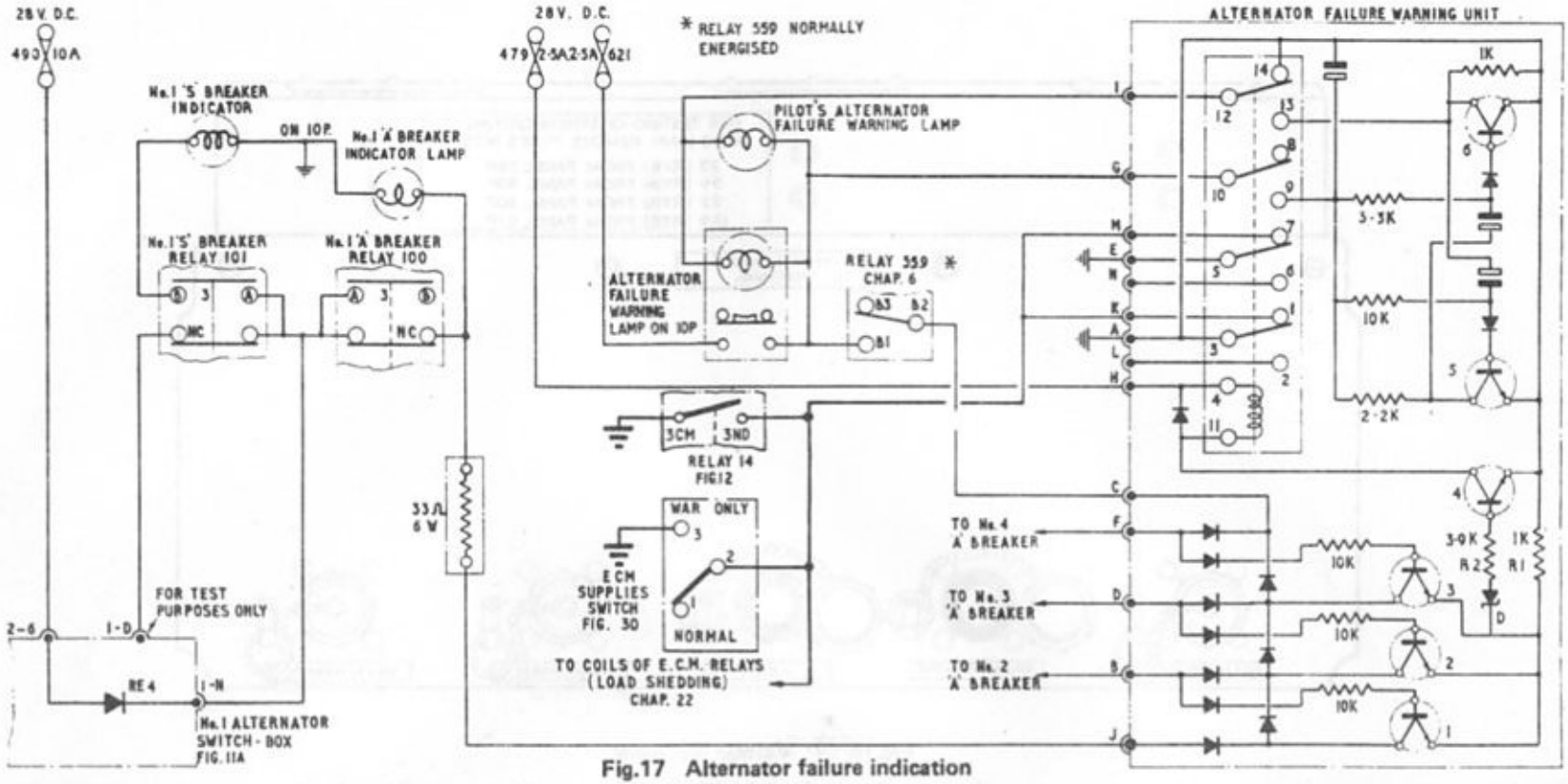


Fig.17 Alternator failure indication

► *(Post Mod.2428)* ◄

88. With reference to fig. 11A transistors T1 and T2 will conduct when both zener diodes ZD1 and ZD2 are conducting in reverse. ZD1 will conduct in reverse when the relationship between R1, C1 and R6 is such that the larger current will flow through R6 when correct phase rotation is applied from S1 windings of transformers TR1 and TR2. ZD2 will conduct in reverse when sufficient voltage is dependent upon the output of the 3-phase bridge rectifier which in turn is a function of the 3-phase output of the associated alternator. It will follow that RV1 will be set to enable ZD2 to operate in and out of its zener characteristic in relation to the correct voltage or undervoltage of the alternator output. Due to ZD1 and ZD2 conducting in reverse, the voltage developed across resistors R5 and R6 prevents the base of transistor T1 going negative via diodes D2 and D3. Base emitter current will flow via R7 and transistors T1 and T2 will conduct and relay ZD1 or ZD2 cease to conduct in reverse due to fault conditions, D2 or D3 will conduct allowing the base of T1 to go negative thus limiting base emitter current flow and subsequently de-energising relay UVSR/1.

89. When contacts TD/1 close, a supply will be made to trip relay EC/6 via contacts EC/1. Contacts EC/6 will then close to energise relay 56 (in this case), the action of which will trip the 'A' breaker and bring the alternator off line. At the same time the exciter field will be de-energised by the opening of contacts EC/2.

Underspeed and overspeed protection

90. The underspeed switch for each alternator operates at frequencies of 360 ± 10 c/s for underspeed protection and 533 ± 33 c/s for excessive overspeed protection, i.e., in the event of overspeed stop failure. Referring to No.1 alternator circuit (fig.10), operation of the underspeed switch will open contacts A - C to de-energise relay M/5 and close contacts A - B to energise relay 56. The 'A' breaker will then be tripped to bring the alternator off line.

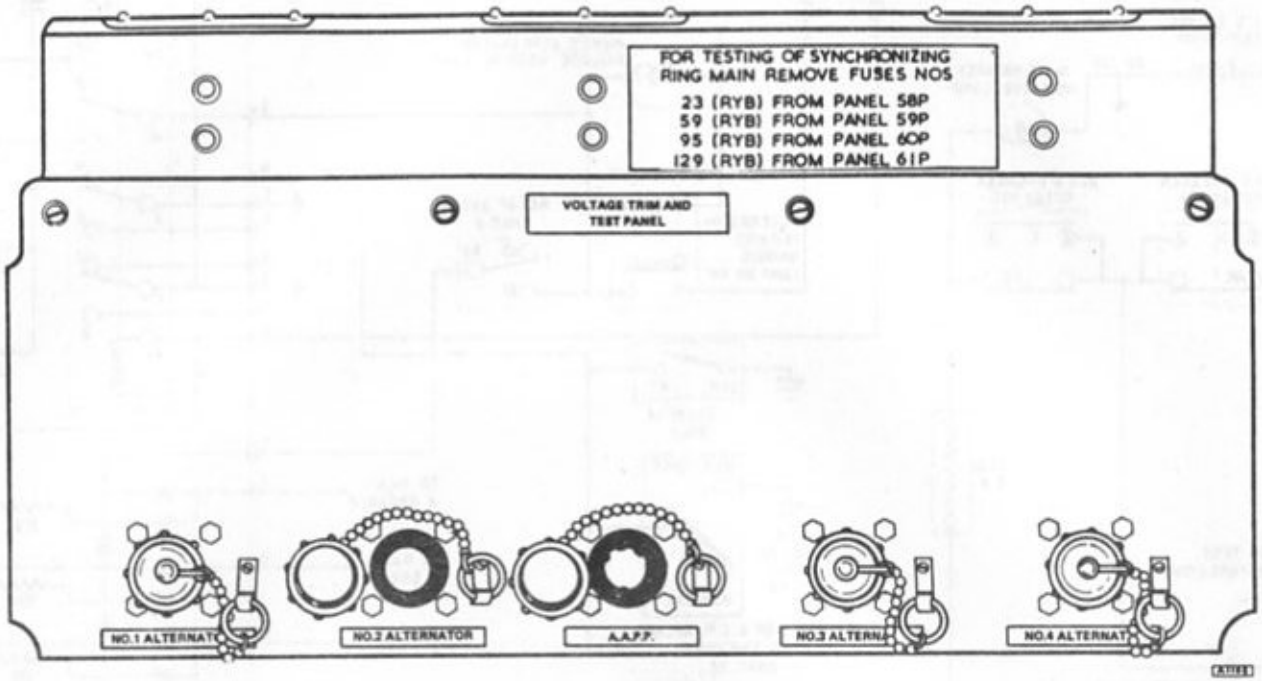


Fig.18 Voltage test panel

Merz-Price protection

91. Sensing of line-to-line and line-to-earth faults occurs at 36 to 48 amp. fault current. Under these conditions, operation of relays DP/A, DP/B or DP/C in the alternator switch-box (para.37-38) will de-energise relay EC/6. The alternator will then be disconnected from its busbar and the field circuit de-energised.

Crash switch protection

92. Crash switch protection for the system is afforded by crash switches No.2, 3, 4 and 5 for alternators No.1, 2, 3 and 4 respectively. In the event of crash switch operation, a supply will be fed to trip relay EC/6 in the associated alternator control panel. The alternator will then be disconnected from its busbar and the field circuit de-energised.

Alternator failure indication

93. Failure of any one alternator will result in the associated 'A' breaker being tripped by the action of the protection circuits. Assuming that No.1 alternator has failed a 28-volt supply will be made from fuse 490 via RE4 in the alternator switch box and contacts N-C of the 'A' breaker to light the associated indicator lamp on 10P (fig.17).

94. At the same time, the supply will be made to light the two failure warning lamps via the 33 ohm resistor, pins J and C of the alternator failure warning unit, relay contacts 559/2 (B2-B1), the two failure warning lamps, pin I of the warning unit, contacts 12-14 of the internal relay and pin 'A' to earth.

95. The alternator failure warning unit is fully transistorized, the circuit shown in fig.17 basically consists of a d.c. amplifier and multivibrator. The d.c. amplifier (transistors 1, 2, 3 and 4) controls a diamond H relay (fitted internally) which connects the alternator failure warning lamps to the multivibrator circuit (transistors 5 and 6) and causes the lamps to flash intermittently. The diamond H

relay will only operate when two or more alternators have failed.

96. Transistor 4 is made to conduct when sufficient voltage is developed across the common emitter load R1. The current flowing through R1 is dependent upon the conductive state of transistors 1, 2 and 3 either independently or combined. With reference to fig.17 it will be seen, assuming that alternators 1 and 2 have failed, that a d.c. supply by way of the associated 'A' breakers will be connected to the base and collector of transistor 1 via the diode network and thus cause the transistor to conduct, this in turn produces a voltage across R1 which will be sufficient to cause reverse current to flow through the zener diode D and cause base emitter current to flow through transistor 4, thereby allowing sufficient collector emitter current to flow to energise the relay. The collector supply to transistor 4 is derived from fuse 479.

97. When the internal relay is energised, contacts 10-9 and 12-13 are closed, the alternator failure warning lamps are connected in series with the collector of transistor 6 and a positive d.c. supply is made to the low frequency multivibrator circuit which commences to operate. The indicator lamps will now have formed the collector load of transistor 6 which is one half of the multivibrator, the other half of the multivibrator is formed by transistor 5 and associated circuitry. The action of the multivibrator is conventional in that positive feedback is provided by the capacitive cross-coupling from the collector of each transistor to the base of the other transistor, therefore free running. It will follow that the lamps will light whenever transistor 6 fully conducts, the frequency being controlled by the capacitive cross-coupling time constants.

98. The warning lamps will continue to flash in the event of further alternator failures. In the case of failure of all four alternators, the R.A.T. will be selected for ejection. This action will de-energise relay 559 (Chap.6, load shedding) to open contacts 559/2 and isolate the indicator lamps. If subsequently, however, alternator power is restored and the non-essential supplies reset switch is operated, relay 559 will be re-energised to restore the warning system. When the aircraft is on the ground and 28-volt supplies are switched on, the 'A' breakers will be open, causing the warning lamps to flash continuously.

E.C.M. loading shedding

99. The earth side of the coils of certain E.C.M. relays (Chap.22) is normally completed via contacts 7-5 and 1-3 of the failure warning unit internal relay. Thus, when the relay is energised by failure of two or more alternators, the opening of these contacts will de-energise the E.C.M. relays to shed that part of the load. This shedding is prevented when the E.C.M. supplies switch, introduced by Mod.2428, is placed in the WAR ONLY position. During ground testing operations, the earth side of the relays will be connected via No.3 contacts of the G.P.U. relay 14.

Live busbar indicators

100. To provide servicing personnel with indication of live busbars, four neon indicators are located, one on each alternator power panel in the power compartment. Four similar indicators, connected from the alternator busbars, are also fitted, two in 27P and two in 28P at the forward end of the bomb bay. The indicators are fused and connected to the alternator red phases via suitable dropper resistors, and will be lit when the associated 'A' breakers are closed. A routing chart is contained in fig.31.

Alternator ground cooling

101. The operation of the inducer valve actuators on the engines is controlled by the alighting gear selector switch via relays 480 and 447, located in 15P and 16P respectively. A routing chart of the circuit is provided in fig.22.

102. With the aircraft on the ground and a 28-volt supply switched on, a supply from the alighting gear selector switch DOWN button will energise the two relays. Supplies will then be fed via the relay contacts to open the valves. In flight with the UP button selected, the relays will be de-energised and the supplies will be fed to close the valves.

SERVICING

General

103. Servicing of the alternators and associated equipment whilst installed on the aircraft is restricted to examination of the components for general security, cleanliness and correct functioning. Servicing details which include instructions for bench testing of components will be found in the relevant manual of the A.P.113 series. A mobile ground test rig provides the means of testing an alternator/C.S.D. unit removed from the aircraft or testing an aircraft alternator channel in situ. Information on the rig and its application is provided under the appropriate paragraph heading.

104. All heavy duty cables should be examined periodically for signs of chafing, loose connections and general security. In particular the main busbar fuses should be checked for signs of overheating and security of busbar connections. Careful checking of the system wiring and components will reduce fault conditions to a minimum.

NOTE . . .
Servicing personnel should be aware at all times of the danger present when working in close proximity to live busbars or connections, and are advised to take precautions against possible shock. It is important to ensure that all live busbar indicators are kept serviceable to provide warning of live conditions.

WATT/VAR METERS

105. Servicing instructions for the watt/var meters, which include pre-installation and calibration checks, are contained in A.P.113A-0311-1.

GROUND CHECKS

106. Ground checking of the system for correct voltage and frequency output, phase rotation and load sharing, should be carried out during engine running periods at the intervals laid down in A.P.101B-1902-4, and also when the performance of the system is suspect or when certain components have been changed. A voltage test panel situated at the forward end of the power compartment, (fig.18) contains Mk.4 type sockets for checking the outputs of the four alternators and the A.A.P.P.

107. Two test sets are available for checking the outputs of the system. One, a voltage and frequency test set Ref.5Q/3198, is connected to the alternator test sockets and provides indication of the phase rotation, voltage and frequency. The other, a frequency trim test set, Ref.5G/3393, is connected to the two cable assemblies of the frequency and load controllers and enables the basic governor setting on the constant speed drive units to be checked by applying a signal to raise or lower the frequency. A description of the test sets will be found in A.P.120A-1001-1. The procedure for testing the system is given in the following paragraphs.

Phase rotation, voltage and frequency

108. With the 200-volt ground supplies connected and the engines running, the alternators should be allowed to run excited but switched off for twenty minutes. If necessary the associated reset switches may be pressed to complete the excitation circuit (para.52). Testing for correct phase rotation, voltage and frequency should then be carried out as follows:-

(1) Connect the voltage and frequency test set to No.1 alternator test socket and check that phase roation is R.Y.B. Check that the voltage is 200-volts and the frequency 400 ± 4 c/s.

(2) Repeat (1) for No.2, 3 and 4 alternators.

(3) Select each alternator in turn on the synchronising selector switch and check that the cabin voltmeter (incoming) reads 115.5 volts.

C.S.D. basic governor setting

109. This check should be made when the voltage and frequency tests outlined in the previous paragraph are being carried out.

(1) Disconnect the 2-pin plug from No.1 frequency and load controller and check that the frequency of No.1 alternator drops to 390 ± 2 c/s.

(2) Disconnect the 12-pin plug from the frequency and load controller

and connect the frequency trim test set to the disconnected 2-pin and 12-pin cable assemblies.

(3) Apply a signal from the test set to reduce the frequency, which should read 390 ± 2 c/s as in (1).

NOTE . . .
If it is necessary to adjust the constant speed drive basic governor to obtain this figure, reference should be made to A.P.4670A.

(4) Apply a signal from the test set to increase the frequency, which should then read between 420 and 430 c/s.

(5) Disconnect the test set and reconnect the 2-pin and 12-pin cable assemblies to the frequency and load controller. Observe that the frequency returns to 400 ± 4 c/s.

(6) Repeat (1) to (5) for No.2, 3 and 4 alternators.

Load sharing

110. The following checks for load sharing between alternators ensure the correct functioning of the system as a whole. All engines should first be running and the alternators switched on.

(1) Remove the 200-volt ground supplies from the synchronising busbar by pressing the extra supplies trip push-button.

(2) Check that No.2 magnetic indicator on 10P is now energised to complete that part of the mimic busbar, thus indicating that No.2 alternator is connected to the synchronising busbar.

(3) Check that the synchronising voltmeter is reading 115.5 volts.

(4) Synchronise and parallel all four alternators. The four associated magnetic indicators on 10P should now be energised to complete the mimic busbar line.

(5) Switch on all fuel pumps and P.F.C. motors.

(6) Observe that real load sharing between alternators is being maintained within ± 3 kw of the mean, i.e., the total load divided by the number of wattmeter readings.

(7) Press the kVARS push-button and observe that reactive load sharing is being maintained within ± 2.5 kVARS of the mean.

(8) Switch off No.1 alternator. Observe load sharing readings as in (6) and (7). Switch on the alternator and re-synchronise.

(9) Repeat (8) by switching off No.2, 3 and 4 alternators in turn.

(10) Repeat (8) by switching off alternators 1 and 4, leaving alternators 2 and 3 load sharing.

(11) Repeat (8) by switching off alternators 2 and 3, leaving alternators 1 and 4 load sharing.

(12) Switch off alternators 1, 2 and 3 simultaneously and observe that No.4 alternator sustains the total load.

(13) Switch on and synchronise No.1 alternator.

(14) Switch on alternators 2 and 3.

(15) Observe that alternators 1 and 4 are load sharing and 2 and 3 are supplying their respective loads.

(16) With all four alternators synchronised, raise each engine speed in turn to take-off, then as rapidly as possible reduce the r.p.m. to 'flight idling'. Check that each alternator remains connected to the synchronising busbar.

(17) Switch off P.F.C. motors and fuel pumps used for alternator loading.

(18) Isolate No.2 alternator.

(19) Isolate No.1, 3 and 4 alternators. Observe that No.2 alternator is automatically connected to the synchronising busbar as at beginning of check.

Engine shut-down

111. The function of the 'A' breakers on engine shut-down should be checked as follows:-

(1) Select the incoming voltage and

frequency of No.1 alternator by turning the synchronising selector switch to 1.

(2) Shut down No.1 engine and check that No.1 'A' breaker lamp lights when the voltage falls below 172 ± 3 volts and the frequency is 360 ± 10 c/s.

(3) Repeat (1) and (2) for No.2, 3 and 4 alternators.

Alternator failure indication

112. The operation of the two alternator failure warning lamps can be observed during load sharing checks. A steady indication by both lamps should be given when any one alternator is switched off. With two or more alternators switched off, the lamps should flash continuously. A check on the function of the lamps when all four alternators are switched on can be made by pressing the A.E.O's warning lamp to complete the test circuit.

Synchronising busbar fuses

113. In order to check the integrity of the synchronising busbar, periodically testing of the fuses is essential. The amount of work involved in fuse testing can be considerably curtailed by making a continuity test of the system. This can be done by removing twelve fuses and testing for continuity of supplies on the remaining network.

114. The fuses to be removed are identified on a label fitted above the voltage test panel in the power compartment as shown in fig.18. The test should be carried out as follows:-

(1) Remove fuses 23, 59, 95 and 129 from the red, yellow and blue phases.

(2) Energise the synchronising busbar by connecting a 200-volt ground supply to the aircraft.

(3) Using a neon test prod and referring to fig.14, check for supply at each point marked T. The neon lamp should light to prove that in each case the three fuses in series with the synchronising busbar and the test point are intact.

(4) Switch off and remove the ground supply.

(5) Check the continuity of the twelve fuses removed by means of a battery test lamp.

(6) Replace the fuses and ensure that the securing screws are tight.

115. Testing of those fuses connecting the A.A.P.P. and the R.A.T. to the synchronising busbar should be made by removing the fuses and checking for continuity as in (5) and (6) of the previous paragraph.

MOBILE GROUND TEST RIG

116. The means of testing an alternator with constant speed drive unit and associated control equipment is provided by a mobile ground test rig, Part No.1/U1571. The rig is designed for 40 kVA constant frequency a.c. systems as installed in Vulcan Mk.2 and Victor Mk.2 aircraft and offers the following facilities:-

(1) Testing of individual alternator and constant speed drive unit removed from the aircraft.

(2) Testing of alternator control equipment removed from the aircraft.

(3) Testing of each aircraft alternator channel in situ.

(4) Testing the parallel operation of two alternators by coupling two rigs together.

(5) Testing the parallel operation of two aircraft alternator channels by coupling two rigs to the aircraft.

117. The test rig is a self contained trailer unit powered by a 200 H.P. Dorman Diesel engine. Side panels and end doors permit access for operation and servicing, and for operation of the rig inside a hangar, a 30 ft. long exhaust extension consisting of five 'quick-disconnect' sections is provided. A full description of the rig, including operating instructions, will be found in A.P.120N-0101-1

Controls and equipment

118. The rig is equipped with all the necessary controls and equipment required for a constant frequency a.c. system. The operating controls for the rig are located on the front panel of a control console which is hinged to allow access to the interior. Two equipment racks, fitted adjacent to the console, contain the control equipment for the alternator. The upper rack contains the Merz-Price junction box, load share box, circuit breakers, synchronising monitor unit and voltage pick-up unit. The lower rack contains the voltage regulator,

frequency controller and alternator switch-box, and also carries duplicate mountings to enable similar components to be fitted for testing.

Supplies for engine circuits

119. Supplies at 24-volts for the engine starting and control circuits are fed from two 12-volt 100 A/H batteries connected in series. Two engine driven 28-volt d.c. generators provide power for charging the batteries and supplying a fan motor in the constant speed drive cooling system. A ground supply plug enables the batteries to be charged from an external source.

Loading crates

120. Inductive loading for the alternator is provided by 24 grid coil resistors and 12 single-phase chokes housed within two separate crates. The load is applied to the alternator in 8 kW stages up to 32 kW full load via four control switches on the control panel. Similarly the load can be applied to the aircraft busbar for checks on the aircraft alternator channels.

Trailing cables

121. The rig carries two trailing cables wound on separate reels. One, the aircraft cable, is used to connect the rig to the aircraft alternator control system, or to interconnect two rigs for parallel operation. The other, the load cable, connects the loading crates to the busbars in the aircraft power compartment. The reels are manually rotated to unwind and rewind the cables. Two plugs on the rig provide the connections for the cables to the rig circuits. A third plug labelled SYNCH. provides an alternative connection for the aircraft cable and is used when it is required to operate two rigs in parallel.

122. The aircraft cable (17-core) connects to the aircraft alternator and C.S.D. leads via a plug connection Part No. U1646, which is fastened to the alternator mounting on the engine when the unit comprising the alternator and C.S.D. is removed. In order to facilitate the operation, the cable is first connected to the plug connection and the assembly hoisted into position using the alternator hoisting sling. The plug connection is then secured to the mounting utilising the securing bolts for the alternator (fig.19).

123. The load cable (3-core) connects to the busbars of the respective alternator power panel in the power compartment via an extension lead, Part No. 5/U1652. The extension lead terminates in three forked lugs which are suitably shaped for clamping to the busbars under the fuse carriers as shown in fig.19. The plug connection and extension lead are supplied with the rig as loose equipment.

Aircraft selector switch

124. A 7-pole selector switch on the control console provides the means of switching over the alternator output and C.S.D. leads from rig application to the aircraft alternator channel as required. The switch is 4-positioned, offering a choice of two positions for selection to TRAILER or AIRCRAFT, and is operated by a hand wheel.

125. In the TRAILER position of the switch the connections are made for the rig control circuits. When the switch is selected to AIRCRAFT, the six alternator output leads are switched over to the aircraft cable and three relays are energized via the seventh contact to change-over the exciter field and C.S.D. connections. Indication that the switch is at AIRCRAFT is given by a lamp on the control panel.

Fitting and testing an alternator

126. Instructions for fitting an alternator and C.S.D. along with the procedure for carrying out all the necessary checks including the testing of duplicate control equipment (para.118) will be found in A.P.120N-0101-1 and A.P.120N-0106-1.

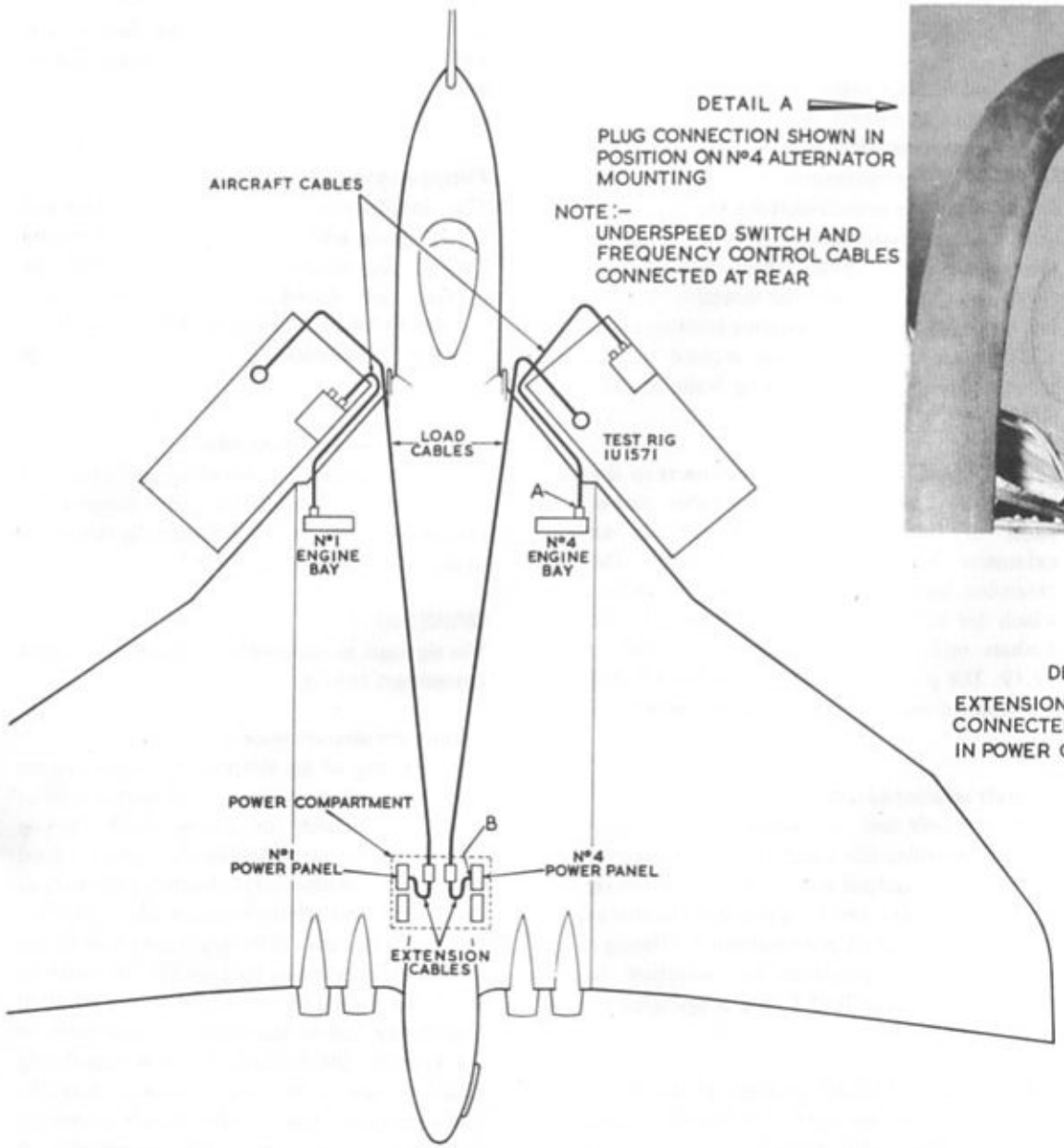
Operating two rigs in parallel

127. The method of connecting and operating two rigs in parallel for the purpose of synchronising two alternators is fully described in the A.P's listed in para.126.

WARNING . . .
The rig must be isolated from the aircraft when component testing.

Testing the aircraft system

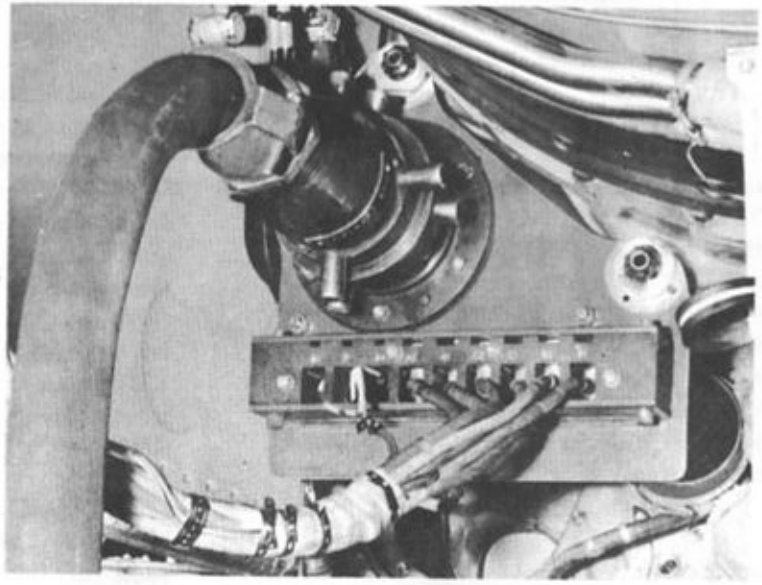
128. Testing of an alternator control system on the aircraft may be required during normal inspection periods or during fault finding operations. As stated previously, one rig is used for testing one alternator channel, and two rigs for testing two alternator channels in parallel. The rig or rigs should be positioned near to the engine air intakes as appropriate, in order to allow the rig cables to extend to the required engine bay and to the power compartment of the aircraft. The method of connecting the rig cables to any of the four alternator channels, and subsequent tests on the aircraft system are described in the following paragraphs. A portable i/c set, for use by the operators stationed at the rig and in the aircraft, will be required.



DETAIL A

PLUG CONNECTION SHOWN IN POSITION ON Nº4 ALTERNATOR MOUNTING

NOTE :–
UNDERSPEED SWITCH AND FREQUENCY CONTROL CABLES CONNECTED AT REAR



DETAIL B

EXTENSION LEAD SHOWN CONNECTED TO BUS BARS IN POWER COMPARTMENT

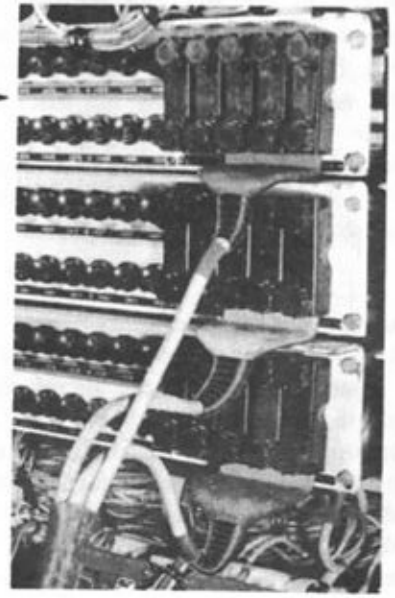


Fig.19 Connection of mobile ground test rig to aircraft

Connecting the rig to the aircraft

129. When the rig has been suitably positioned the procedure should be carried out as follows:-

(1) Remove the assembly comprising the alternator and constant speed drive from the appropriate engine on the aircraft as detailed in Sect.4, Chap.1, and install on the test rig.

(2) Run out the aircraft and load trailing cables to the engine bay and power compartment respectively.

(3) Connect the aircraft trailing cable to the AIRCRAFT plug on the control console, and to the 17-pin plug on the plug connection supplied with the rig.

(4) Using the alternator sling (aircraft ground equipment) hoist the plug connection and cable to the alternator assembly mounting on the engine.

(5) Secure the plug connection to the mounting using the two existing nuts and washers. A tool, Part No. 46/U1571, is supplied in the loose equipment box to facilitate fitting and removal of the nuts. (A slave mounting may be used if the engine is not installed).

(6) Connect the aircraft alternator leads, the underspeed switch lead and the C.S.D. servo motor lead to the respective fittings on the plug connection.

(7) Connect the load trailing cable to the load connector on the starboard side platform of the rig.

(8) Remove ALL distribution fuses from the appropriate power panel in the aircraft power compartment. (Fuses 167 R, Y, B, 168Y and all other fuses on the synchronising busbar to be left intact).

(9) Attach the extension cable supplied with the rig to the power panel by securing each forked lug to its correct busbar under three distribution fuse carriers, each containing a 50 amp. fuse as follows:-

Power Panels	Fuses
No.1 - 58P	46, 47, 48
No.2 - 59P	82, 83, 84
No.3 - 60P	118, 119, 120
No.4 - 61P	153, 154, 155

(10) Connect the other end of the extension cable to the load trailing cable.

(11) Connect the test rig to ground earth from the earthing socket at the rear of the rig.

(12) Connect a 28-volt d.c. supply to the aircraft at the appropriate ground supply plug in the nose-wheel bay.

Tests using single rig

130. The tests outlined in this paragraph refer to a single rig connected to any aircraft alternator channel. Voltage and frequency readings should be taken at the appropriate alternator test socket in the power compartment. Loading of the alternator and fault simulating checks are controlled from the rig. The procedure should be as follows:-

Starting the rig

(1) (a) Place the aircraft selector switch on the rig to AIRCRAFT.

(b) Switch on the instrumentation supply switch and note that the amber warning lamp at the top of the control panel is lit.

(c) Start the rig as detailed in the operating instructions hand-book, and allow to idle for 5 minutes.

(d) Increase the C.S.D. input speed to 5 000 r.p.m.

Phase rotation, voltage and frequency check

(2) (a) Allow the rig alternator to run excited, but switched off, for twenty minutes. The associated reset switch on 10P may be pressed to complete the excitation circuit if required.

(b) Carry out the test as outlined in para.108, on the appropriate alternator channel. (Note that if No.2 channel is being checked, the No.2 'S' breaker will be automatically closed).

C.S.D. basic governor setting check

(3) (a) Carry out this check as outlined in para.109, on the appropriate alternator channel.

Load check

(4) (a) Place the respective alternator control switch on 10P to ON.

(b) With the input speed at the rig maintained at 5,000 r.p.m. apply 32 kW load in four stages of 8 kW. Record the steady state voltage and frequency at each stage from no load.

(c) Check readings on aircraft watt/var meters.

(d) Repeat (b) with the input speed maintained at 3,000 r.p.m.

(e) Repeat (b) with the input speed maintained at 8,100 r.p.m.

(f) In each case the steady state values of voltage and frequency should be 200 ± 5 volts and 400 ± 4 c/s.

(g) With half load applied to the alternator, adjust the speed from 3,000 to 8,100 r.p.m. at the maximum rig acceleration limits. Check that the frequency recovers to 400 ± 4 c/s within 1.5 secs.

Underspeed switch check

(5) (a) With full load on the alternator, reduce input speed to 3,000 r.p.m. Press the engine stop push-button until the 'A' breaker opens to trip the alternator. This should operate at 2,100 r.p.m. (360 ± 10 c/s). At the same time the 'S' breaker should close. Observe indication given by the 'A' breaker indicator lamp and the 'S' breaker magnetic indicator on 10P.

(b) Switch off all load, restart rig and raise input speed to 5,000 r.p.m.

Crash switch check

(6) (a) Operate the associated aircraft crash switch (No.2, 3, 4 or 5 as applicable).

(b) Check that the 'A' breaker has tripped and the alternator is de-energised.

(c) Place the alternator control switch to OFF. Press the reset push-button. Place the alternator control switch to ON.

Undervoltage trip check

(7) Check the value at which the undervoltage trip operates by increasing the resistance in series with the alternator field as follows:-

(a) On the rig control panel, set rheostat R2 to the centre position.

(b) Place the under/over voltage control switch to ON.

(c) Trim rheostat R3 to obtain a zero setting on the under/over voltmeter.

(d) Engage the under/over voltage test push-switch.

(e) Re-trim rheostat R3 to obtain alternator voltage of 200 volts.

(f) Place the alternator control switch to OFF and then to ON in order to stabilise the alternator.

(g) Reduce the voltage to 178 volts by slowly adjusting rheostat R3. Further decrease the voltage and check that the 'A' breaker trips at 172 ± 5 volts.

(h) Trim rheostat R3 to obtain 200 volts.

(i) Place the alternator control switch to OFF. Press the reset push-button. Place the alternator control switch to ON.

(j) Pull out the under/over voltage test push-switch.

(k) Place the under/over voltage control switch to OFF.

Overvoltage trip

(8) Check the value at which the over-voltage trip operates by decreasing the resistance in series with the alternator field as follows.-

(a) Repeat operations (7) (a) to (7) (f) inclusive.

(b) Increase the voltage to 218 volts by slowly adjusting rheostat R3. After 30 seconds, further increase the voltage to 220 ± 1 volt, when the 'A' breaker should trip between 3 and 7 seconds.

(c) Trim rheostat R3 to obtain 200 volts.

(d) Place the alternator control switch to OFF. Press the reset push-button. Place the alternator control switch to ON.

(e) Pull out the under/over voltage test push-switch.

(f) Place the under/over voltage control switch to OFF.

Merz-Price protection system check

(9) Simulate an earth fault from one phase to earth as follows:-

(a) Switch on 16 kW load.

(b) Select one phase on the Merz-Price phase selector switch.

(c) Close the 3.5 ohms switch. The 'A' breaker should not trip. Open the 3.5 ohms switch.

(d) Close the 2.2 ohms switch. Check that the 'A' breaker has tripped and the alternator is de-energised.

(e) Open the 2.2 ohms switch.

(f) Place the alternator control switch to OFF. Press the reset button. Place the alternator control switch to ON.

Conclusion

(10) At the conclusion of the preceding checks, proceed as follows:-

(a) Switch off all load and shut down rig.

(b) Place the alternator control switch to OFF.

(c) Remove the 28-volt ground supply.

(d) Disconnect and remove the C.S.D./alternator plug connection and the rig cables from the aircraft. Stow in position on rig.

(e) Replace all fuses and the C.S.D./alternator unit on the aircraft.

(f) Remove the ground earth from the rig.

Tests using two rigs

131. The following tests refer to two rigs connected to any two alternator channels. When tests are required on all four channels, the rigs would normally be connected in turn to channels 2-3, 1-3 and 1-4. Connection of the rigs to the appropriate channels should be effected as outlined in para.128 and the tests carried out as follows:-

Individual channel checks

(1) (a) Carry out the checks outlined in para.130 (1) to (9) on each of the two appropriate channels in turn.

(b) Place the two respective alternator control switches to OFF.

(c) Stop both rig engines.

Paralleled running checks

(2) (a) Disconnect the alternator failure warning circuit at the 'A' breakers of the two channels not being used. (This is necessary in order to check the warning circuit as at (8)).

(3) (a) Start up both rigs.

(b) Synchronise the two machines by operating the aircraft synchronising selector switch.

(c) Apply 16 kW to each alternator.

(d) Measure the line voltage and frequency, the kW and kVAR loading of each machine at the following speed settings:-

(i) Both machines at 3,000 r.p.m.

(ii) Both machines at 5,000 r.p.m.

(iii) Both machines at 8,100 r.p.m.

(iv) One machine at 3,000 r.p.m. and one at 8,100 r.p.m.

(v) The reverse of (iv).

During these tests the calibration of the aircraft voltmeters and frequency meters should be checked against the test set connected to the test sockets in the power compartment, and should be within ± 2%. The aircraft watt/var meters should agree with the corresponding rig instruments within ± 3%. Load sharing should be within ± 3 kW and ± 2.5 kVAR of the mean value.

(4) (a) With 32 kW load on each machine and one running at 5,000 r.p.m., vary the input speed of the other from 3,000 to 8,100 and back to 3,000 r.p.m. at the maximum acceleration rate of the rig. Check that neither alternator becomes isolated or trips off line.

NOTE . . .
If either alternator does trip off line, the loads must be shed within 5 seconds to avoid over-heating of the healthy alternator and C.S.D.

(5) (a) With 16 kW load on each machine and both running initially at 8,100 r.p.m., reduce the speed of one to 3,000 r.p.m. and press the engine stop push-button until the associated 'A' breaker trips. This should occur at an input speed of 2,100 r.p.m. (360 ± 10 c/s). The load should be taken by the other machine.

(b) Repeat (5) (a) by reducing the speed of the other machine.

(6) (a) With each machine at 5,000 r.p.m. and loaded to 16 kW, raise the voltage of one slowly until the overvoltage trip operates. At this instant the line voltage should be 210 ± 2 volts. Note that the overvolting machine should be taking nearly all the reactive load (approx. 17.6 kVAR), but the real load sharing should be virtually unaffected. The voltage must be raised very slowly as there is a delay of approx. 5 seconds in the overvoltage trip at its minimum operating value. Reset alternator after returning voltage to normal.

(b) Repeat (6) (a) by overvolting the other alternator. Reset alternator after returning voltage to normal.

(7) (a) With each machine loaded to 16 kW at an input speed of 8,000 r.p.m., reduce the voltage of one until the undervoltage trip operates. The line voltage at this instant should be 186 ± 2 volts. Note that the normal

machine should be taking nearly all the reactive load (approx. 17.6 kVAR), but the real load sharing should be unaffected. Reset alternator after returning voltage to normal.

(b) Repeat (7) (a) by undervolting the other machine. Reset alternator after returning voltage to normal.

(8) (a) Switch off all load.

(b) Switch off one alternator and observe that a steady indication is given by the pilots' and A.E.O.'s failure warning lamps.

(c) Switch off the other alternator and observe that both lamps are flashing.

(d) Check that the E.C.M. relays remain un-energised.

(e) Shut down the rig and replace equipment as outlined in para. 130 (10).

(f) Re-connect the alternator failure warning circuits at the associated 'A' breakers.

INTERLOCKING CONTROLS

132. The following tests determine the function of the interlocking control circuits between the main and auxiliary power supplies. Supply conditions will be simulated by utilising one mobile ground test rig to supply No.2 alternator channel, and providing substitute a.c. supplies at the R.A.T., A.A.P.P. and G.P.U. circuit breaker. The normal 28-volt d.c. ground supply will be required at the R.A.T. control panel. The procedure is as follows:-

R.A.T., A.A.P.P. and No.2 alternator checks

(1) (a) Connect the rig to No.2 alternator channel by carrying out the procedure outlined in para. 128.

(b) Connect a switched 200-volt, 3-phase, 400 c/s a.c. supply to terminals L1, L2 and L3 of the R.A.T. circuit breaker (relay 15) in place of the cables connected to these terminals. Check for correct phase sequence of the supply leads. Leave the supply switched OFF.

(c) Connect a switched 200-volt, 3-phase, 400 c/s a.c. supply to terminals A, B and C of the A.A.P.P. control unit, Type U3301/1, in place of the cables connected to these terminals. Check for correct phase sequence of the supply leads. Leave the supply switched OFF.

(d) Remove plug 4 (cable assembly 4/F2068) from the R.A.T. control unit, Type U3702/1, and connect a switched 28-volt d.c. supply to pin D of the removed plug. Leave the supply switched off.

(e) Check that the following fuses are fitted:-

917	- 3P
482, 483, 485	- 26P
954	- 62P
167R, Y, B	- 29P
168Y	- 29P

(f) Check that all alternator switches are OFF.

(2) (a) With the 28-volt d.c. aircraft ground supply switched on, check that the four 'A' breaker lamps are lit, the four 'S' breaker indicators are energised, and the R.A.T. and A.A.P.P. breaker indicators are de-energised.

(b) Switch on the supplies from the rig. Select No.2 channel on the synchronising selector switch and check that the incoming voltage and frequency meters are reading 115.5 volts and 400 c/s respectively.

(c) Place No.2 alternator switch to ON. Check that the No.2 'S' breaker remains closed and that the 'A' breaker closes. The synchronising busbar voltage and frequency

meters should now read the same as the incoming meters.

(d) Switch on 8 kW load. Switch on the a.c. supplies connected to the R.A.T. and A.A.P.P. circuit breaker. Switch on the 28-volt d.c. supply connected to pin D of the R.A.T. plug.

(e) Check that the A.A.P.P. and R.A.T. control unit blower motors are operating, so that cooling air is being drawn through the former unit and blown through the latter.

(f) Press and hold in the No.2 alternator isolation switch. Note that No.2 'S' breaker opens, and that supplies to the synchronising busbar meters are cut off. Note also that the R.A.T. circuit breaker remains open.

(g) Release the isolation switch. The No.2 'S' breaker should reclose. Switch off No.2 alternator. Note that the 'A' breaker opens and the 'S' breaker remains closed. Note also that the R.A.T. breaker has closed and the supply is indicated on the synchronising busbar meters.

(h) Switch on No.2 alternator. Note that the 'S' breaker opens and the 'A' breaker closes, followed by the opening of the R.A.T. breaker and closing of the 'S' breaker in that order.

(i) Press the A.A.P.P. ON switch. Note that No.2 'S' breaker opens followed by the closing of the A.A.P.P. breaker. The A.A.P.P. supply should be indicated on the busbar meters.

(j) Switch off No.2 alternator. Note that the A" breaker opens, the 'S' breaker closes, and the R.A.T. breaker remains open.

(k) Press the EXTRA SUPPLIES TRIP switch. Note that the A.A.P.P. breaker opens, followed, when the switch is released, by the R.A.T. breaker closing.

(l) Press the A.A.P.P. ON switch. Note that the R.A.T. breaker opens, followed by the A.A.P.P. breaker closing.

(m) Switch off the 200-volt a.c. supply to the A.A.P.P. Note that the A.A.P.P. breaker opens, followed by the R.A.T. breaker closing.

(n) Switch on the 200-volt a.c. supply to the A.A.P.P. Remove and retain fuse 482 from 26P. Press the A.A.P.P. ON switch, and observe that the R.A.T. breaker remains closed and the A.A.P.P. breaker remains open.

(o) Remove fuses 167 R, Y, B and 168Y from 29P. Press the A.A.P.P. ON switch. The R.A.T. breaker should remain closed and the 'A' breaker open.

(p) Replace fuses 167 R, Y, B and 168Y. Switch on No.2 alternator. Note that the 'A' and 'S' breakers close and the R.A.T. breaker opens as in (i).

(q) Press the A.A.P.P. ON switch. Note that No.2 'S' breaker remains closed and the A.A.P.P. breaker remains open.

(r) Replace fuse 482 in 26P.

(s) Switch off No.2 alternator.

(t) Switch off the 200-volt a.c. supplies to the R.A.T. and A.A.P.P. breaker, and also the 28-volt d.c. supply to the disconnected plug 4 at the R.A.T. control unit.

G.P.U. interlock check

(3) (a) Connect a ground power unit to the 200-volt ground supply plug.

(b) Press the start push-button on the ground power unit.

Check that the G.P.U. breaker has closed and that the ground supply is reading on the synchronising busbar meters.

(c) Switch on No.2 alternator. Note that the 'S' breaker opens and the 'A' breaker closes.

(d) Press the EXTRA SUPPLIES TRIP switch. The G.P.U. breaker should open, followed by the closing of No.2 'S' breaker.

(e) Switch off the 8 kW load.

(f) Switch off No.2 alternator.

(g) Disconnect and remove the a.c. and d.c. supplies provided for the R.A.T. and A.A.P.P.

(h) Reconnect the R.A.T. and A.A.P.P. circuit breakers and the R.A.T. control unit plug 4.

▶◀

(i) Remove the 28-volt ground supply.

(j) Disconnect and remove the rig.

SERVICING EARTH POINT

133. An earth point is located on the airframe situated on the starboard side of the nose wheel bay as shown in fig.2. This will enable the aircraft to be earthed during servicing, refuelling and bombing up operations.

134. The earthing point consists of a nut and bolt assembly together with a wing nut for easy connection of a ground earth cable.

REMOVAL AND INSTALLATION

General

135. The removal and assembly of most of the electrical components confined to this chapter presents no difficulty and no detailed instructions for removal operations are required. Sufficient access to the voltage regulators, alternator switchboxes, frequency controllers and other items of equipment in the power compartment enable these units to be efficiently and speedily removed.

136. It is important to ensure, prior to the removal of equipment, that all supplies are switched off and that disconnected cables are insulated and carefully stowed. When cables are being re-connected the relevant routing chart should be consulted for correct terminal and cable reference numbers.

Alternators

137. Full instructions for removing the alternator, either by itself or complete with constant speed drive unit, are provided in Sect.4, Chap.1.

Watt/var meters

138. Care must be taken to ensure that, in the event of removal and replacement of the watt/var meters, the indicators and thermo-couple units (resistance boxes) are retained in matched pairs; para.47 refers.

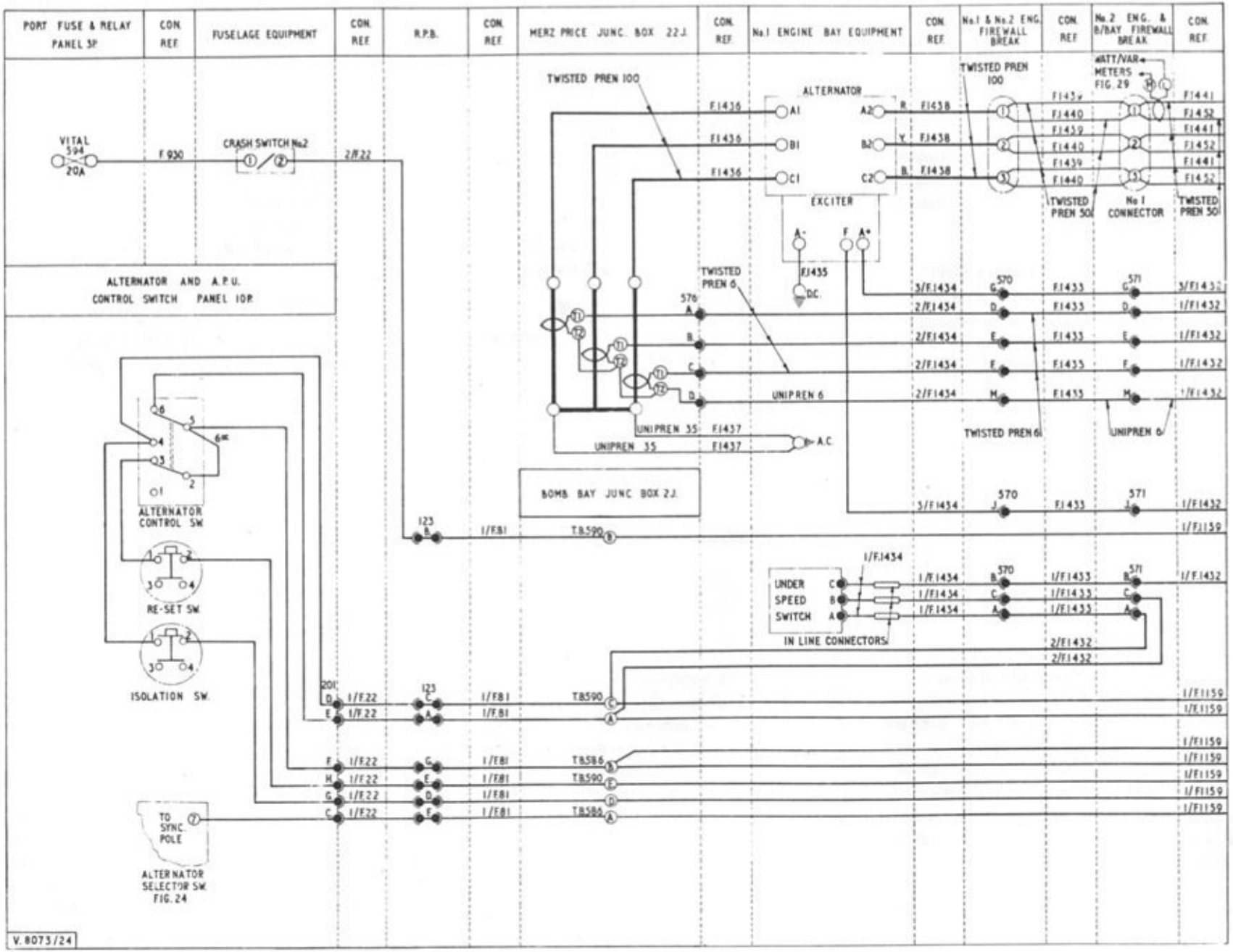


Fig. 20 (1) No.1 Alternator control

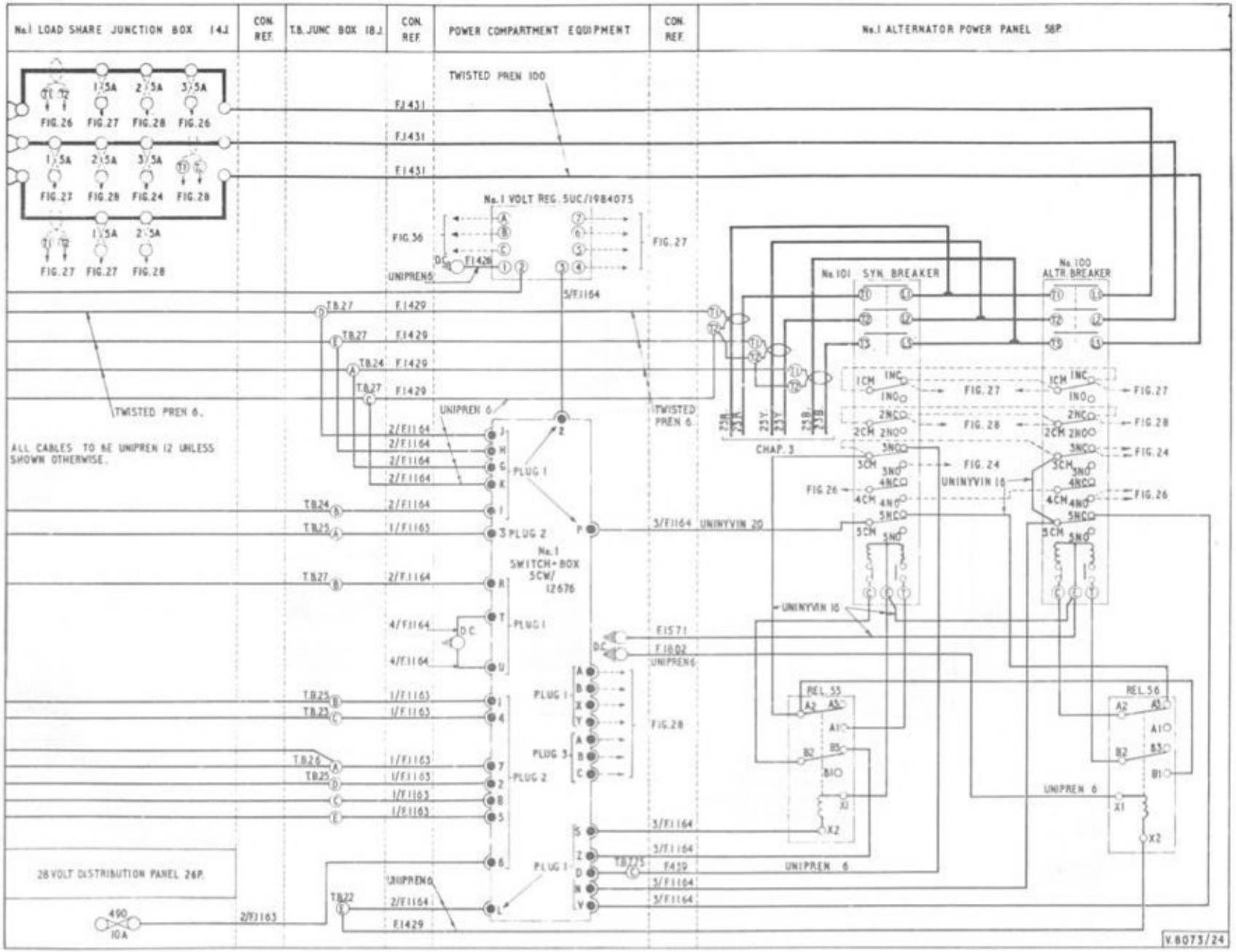


Fig. 20 (2) No.1 Alternator control

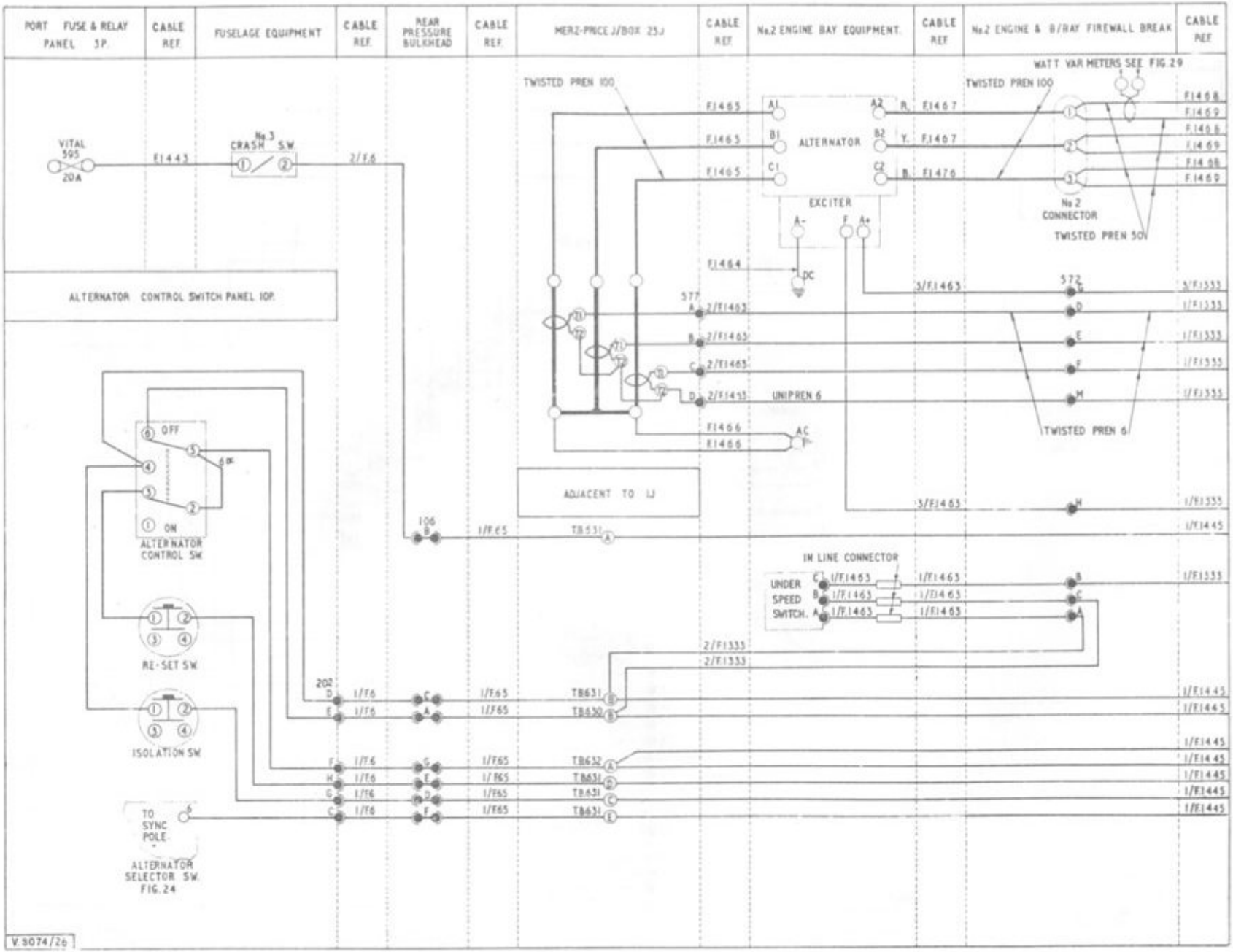


Fig. 21 (1) No.2 Alternator control

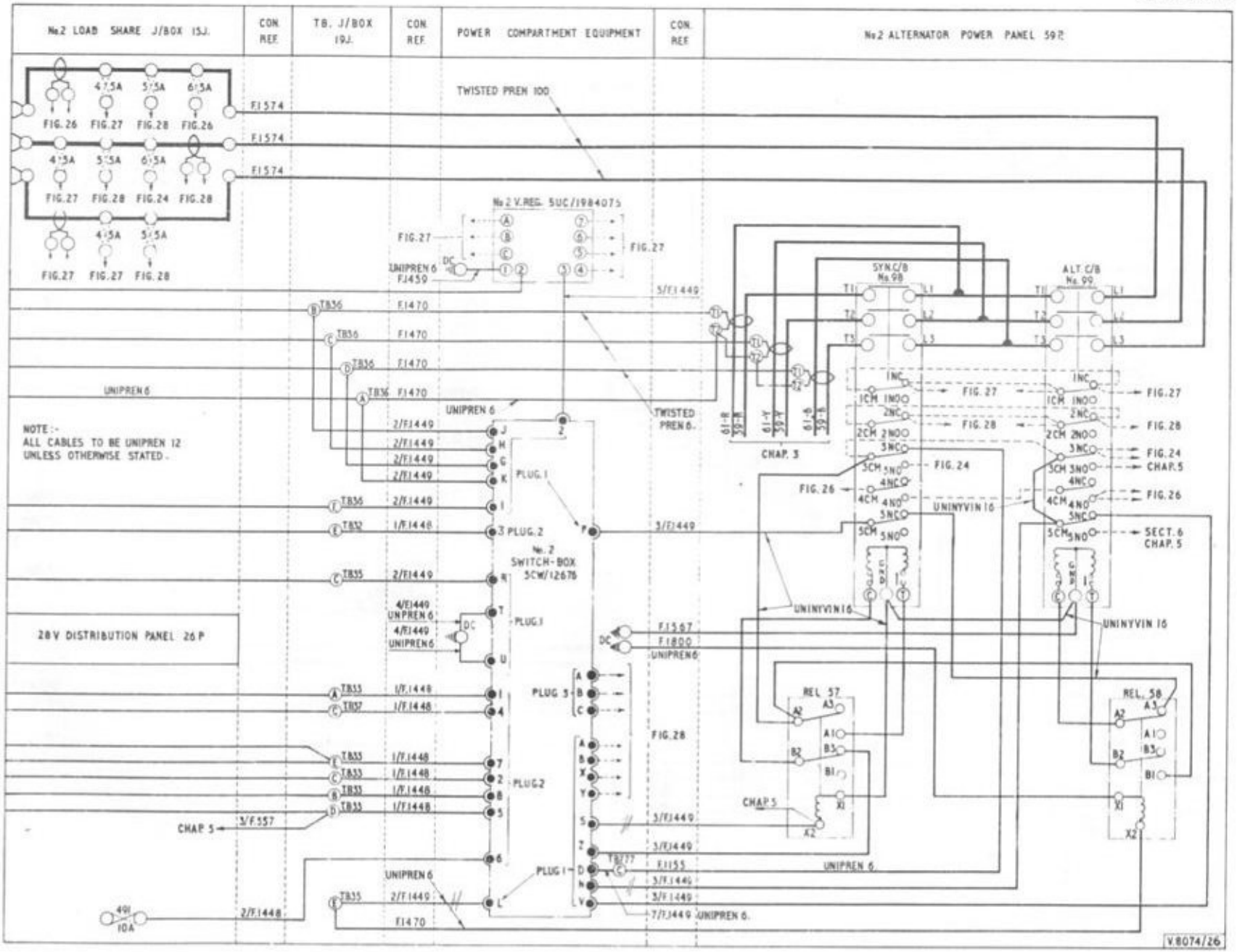


Fig. 21 (2) No.2 Alternator control

RESTRICTED

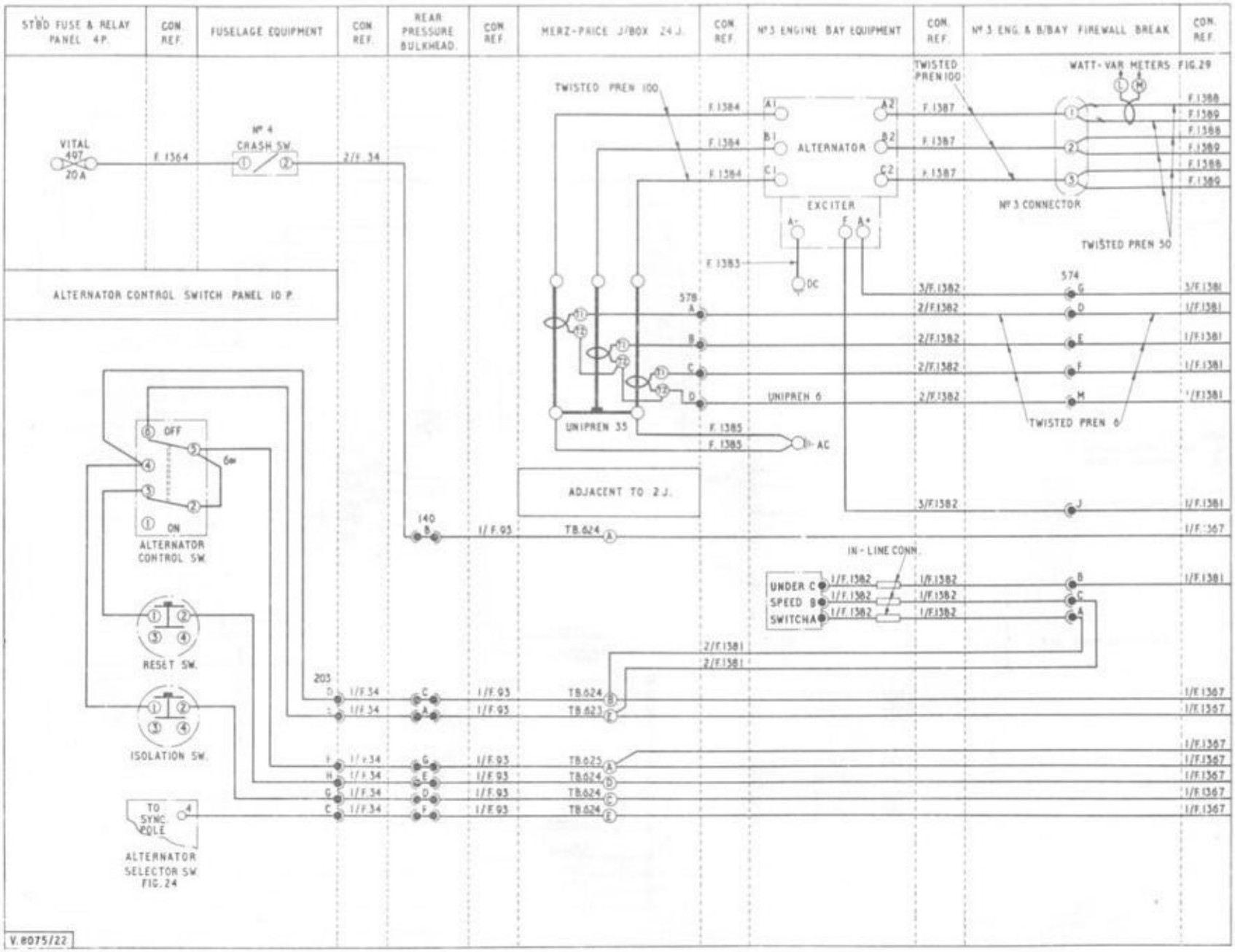


Fig. 22 (1) No.3 Alternator control

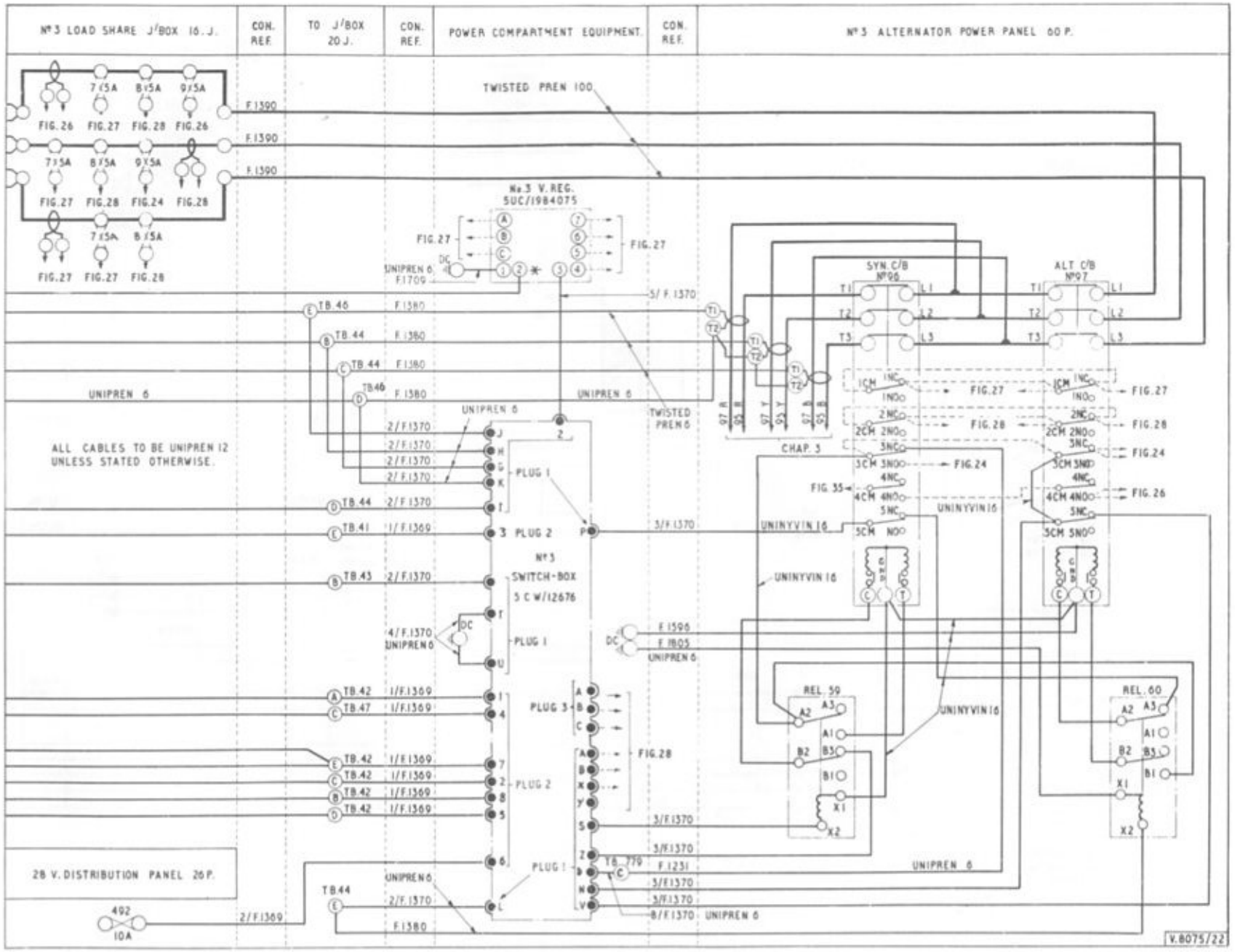


Fig. 22 (2) No.3 Alternator control

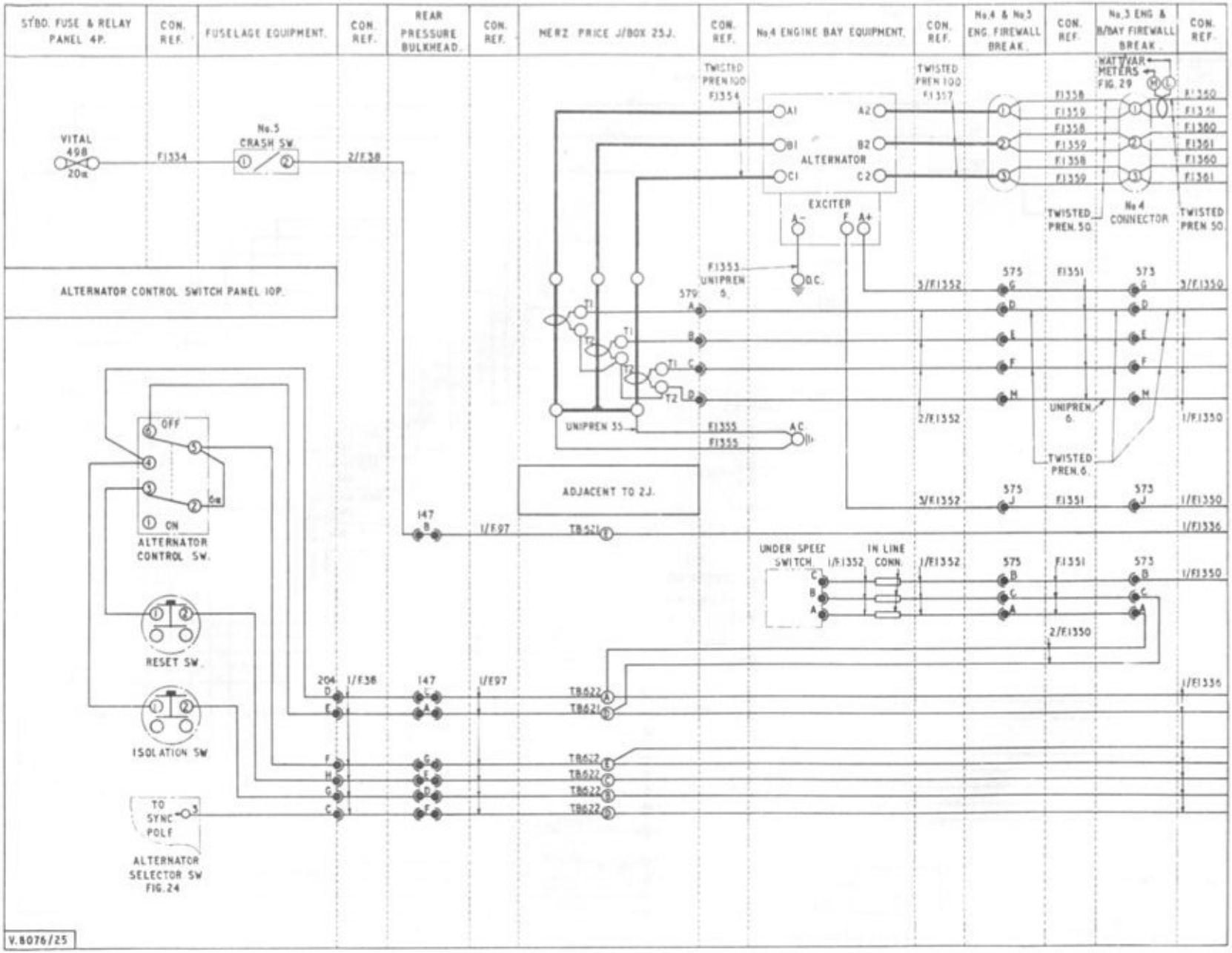


Fig. 23 (1) No. 4 Alternator control

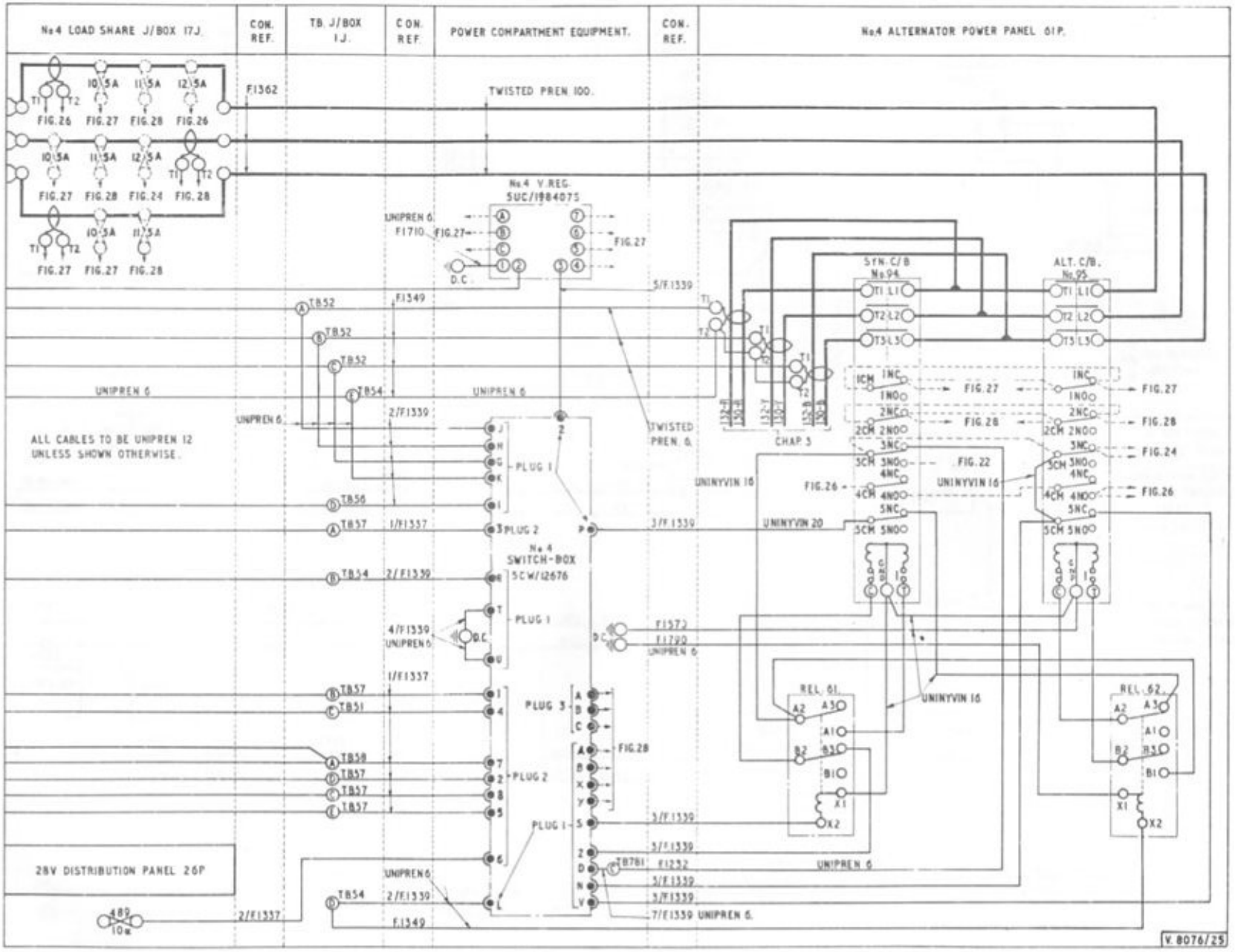


Fig. 23 (2) No. 4 Alternator control

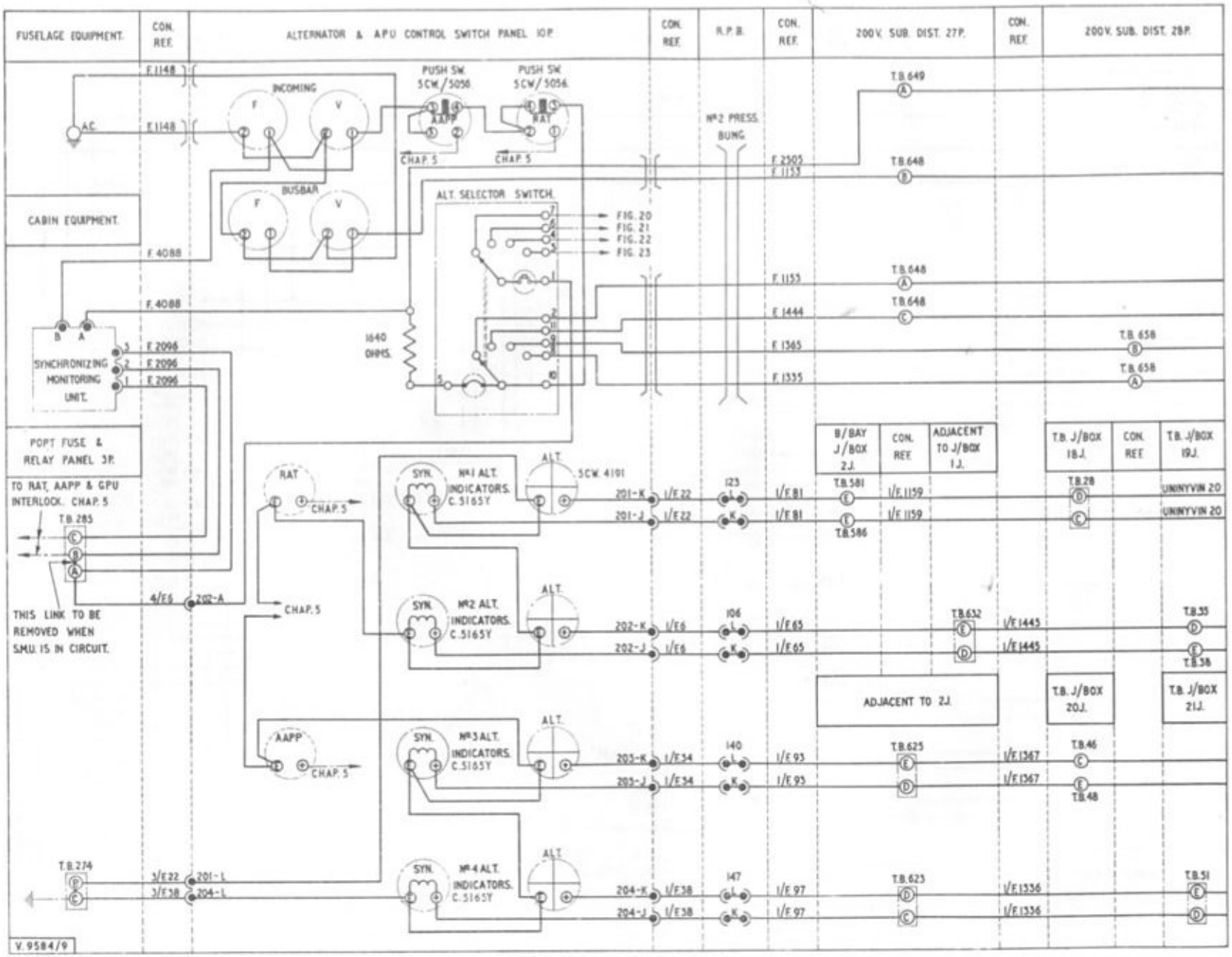


Fig. 24 (1) Synchronising controls

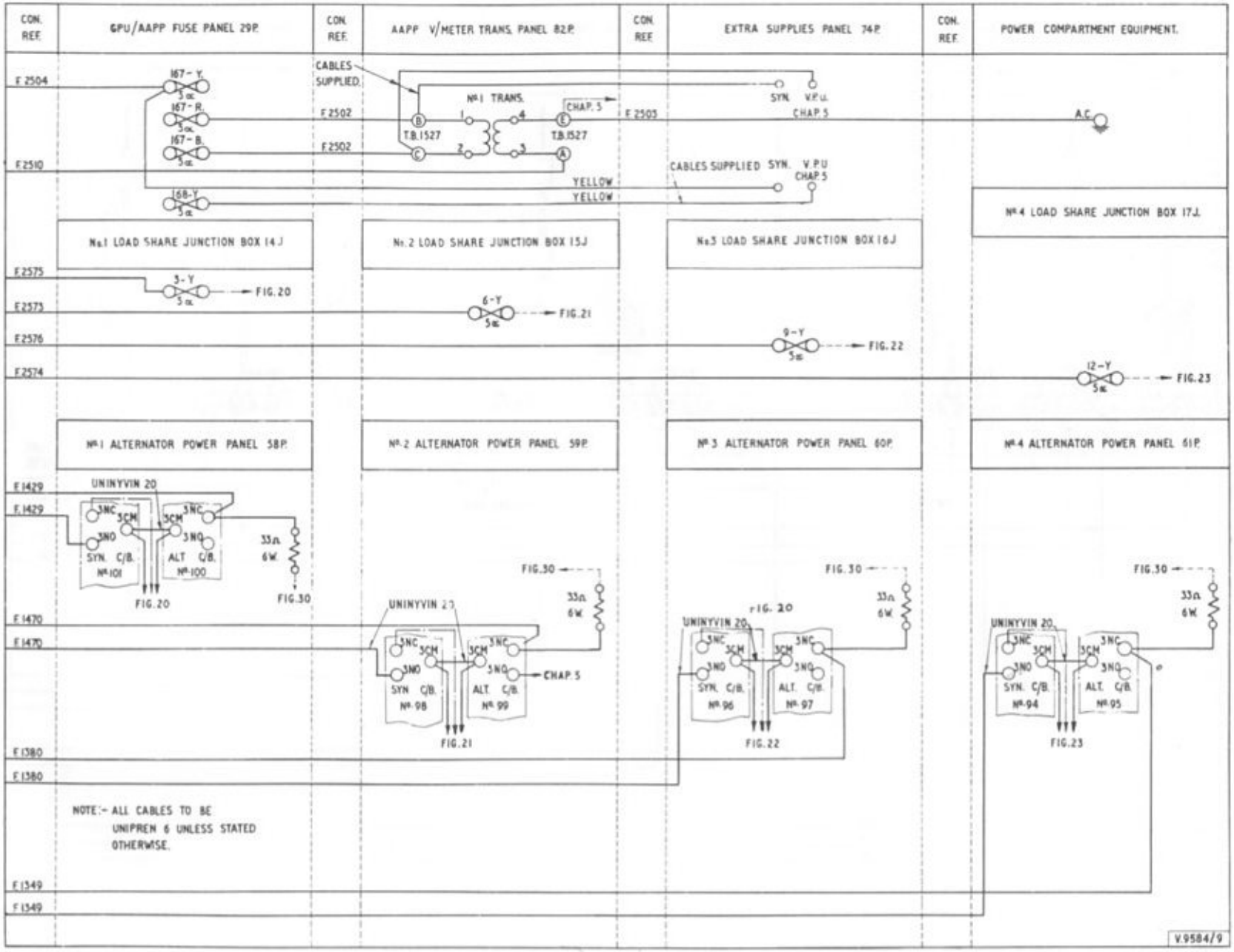


Fig. 24 (2) Synchronising controls

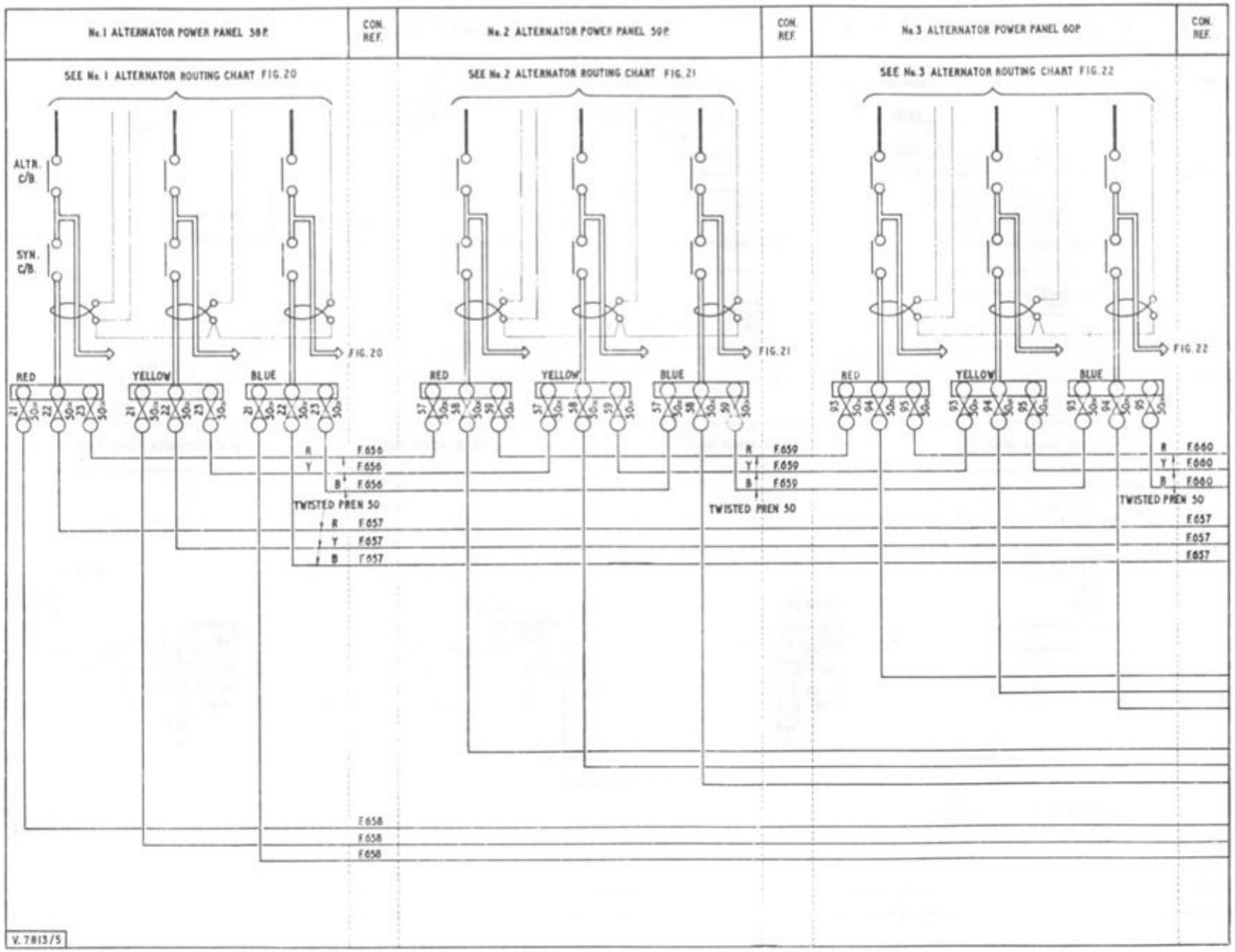


Fig. 25 (1) Synchronising bus-bar system

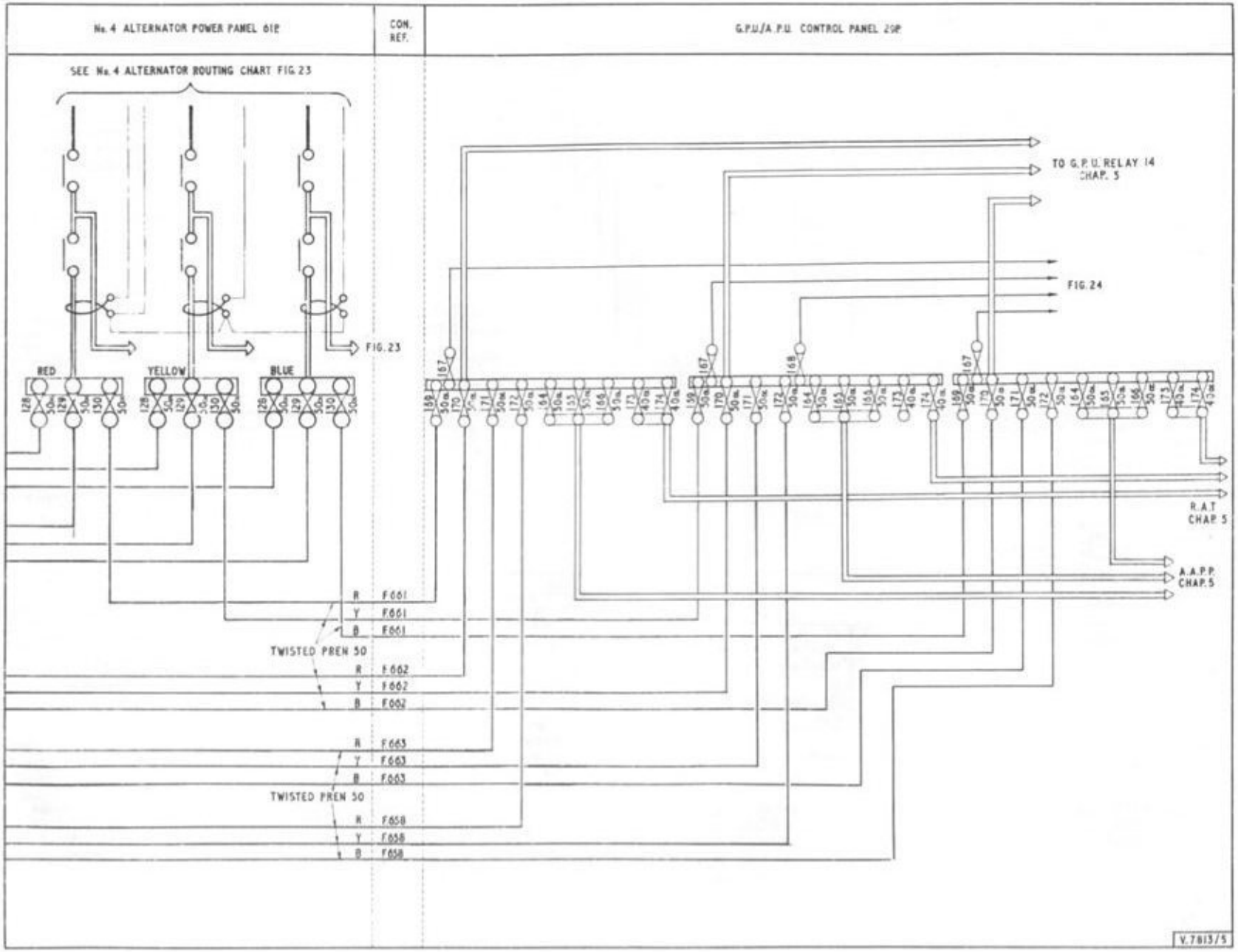


Fig. 25 (2) Synchronising bus-bar system

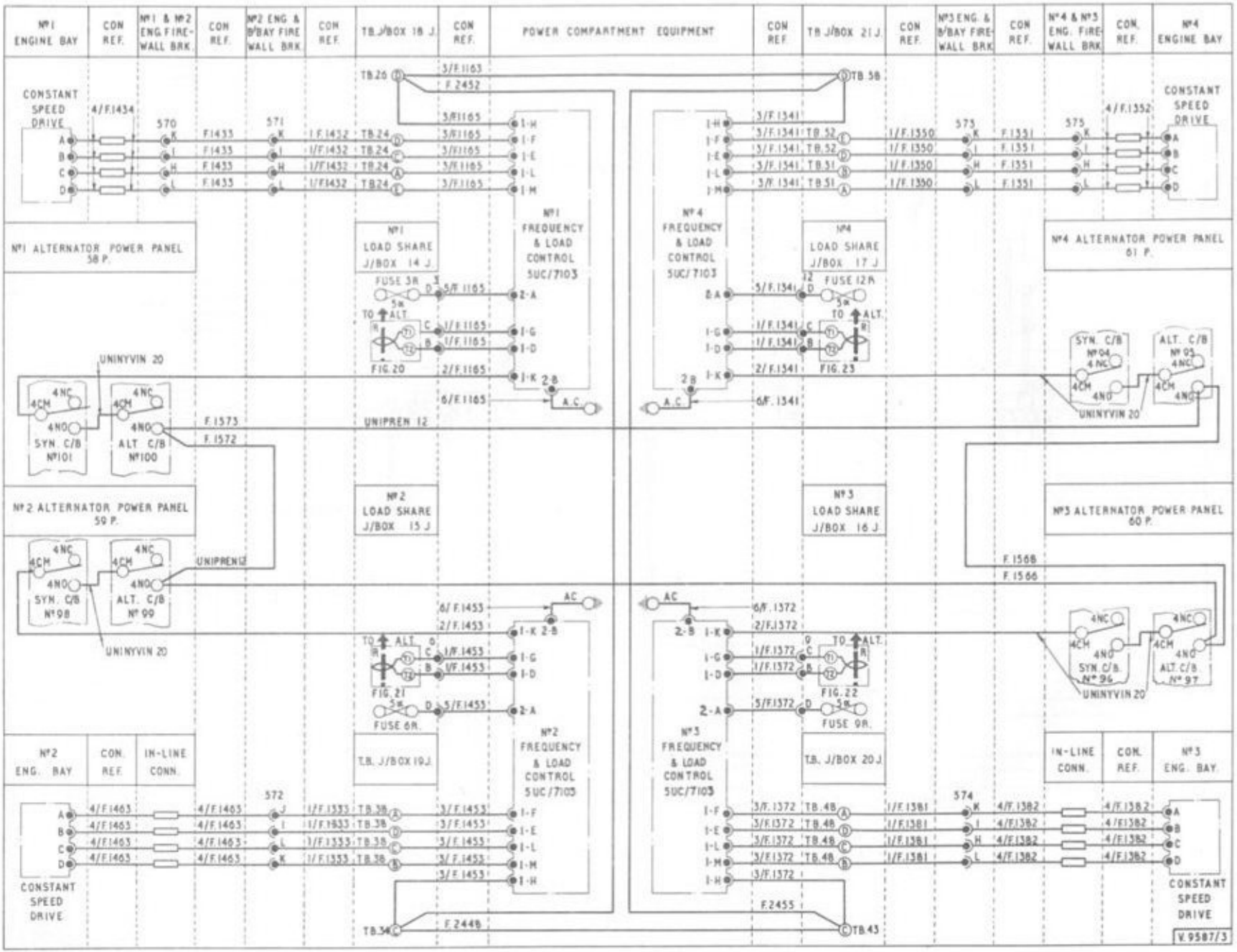


Fig. 26 Real power equalizing circuit

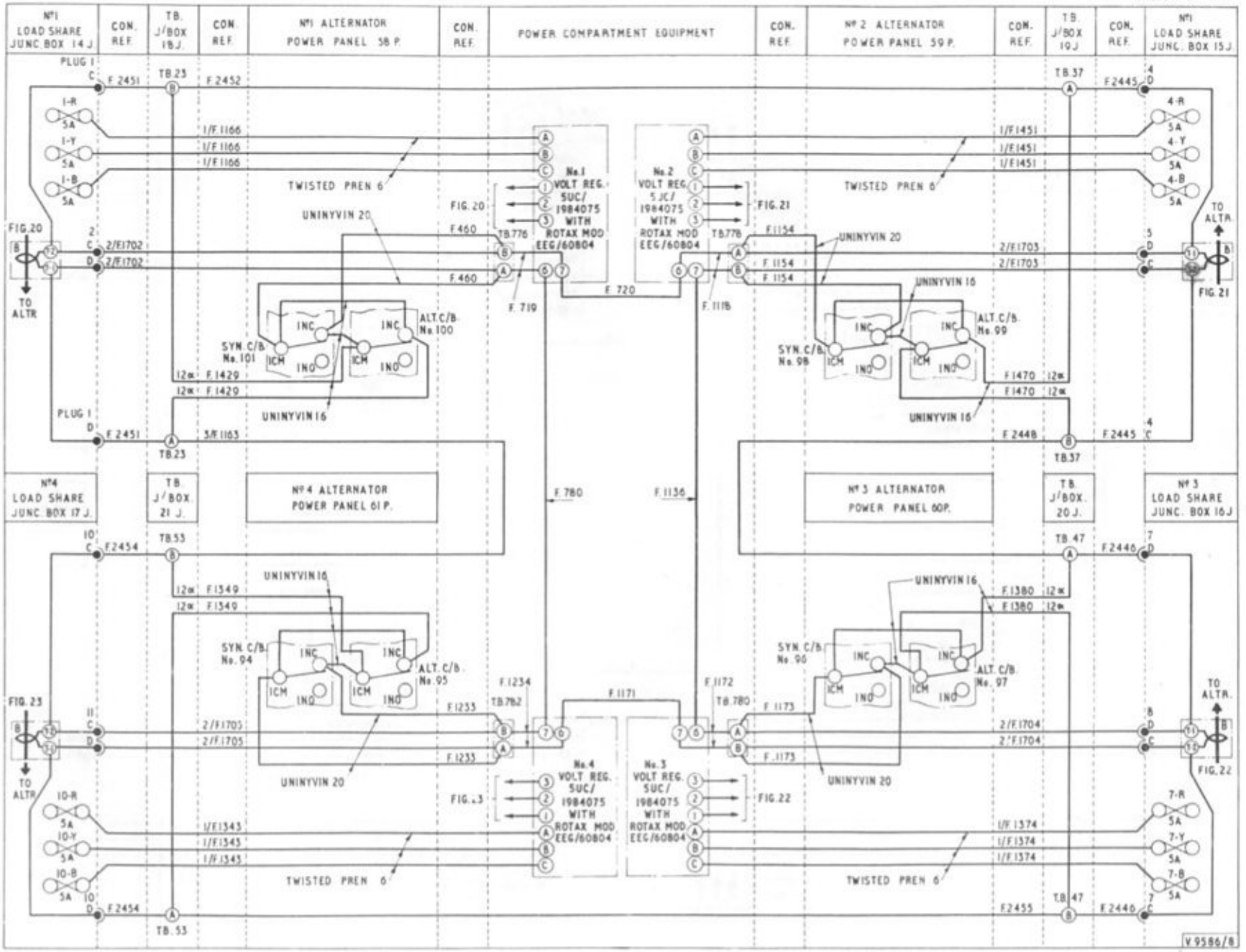


Fig. 27 Reactive power equalising circuit

‹ Mod 2329 added ›

RESTRICTED

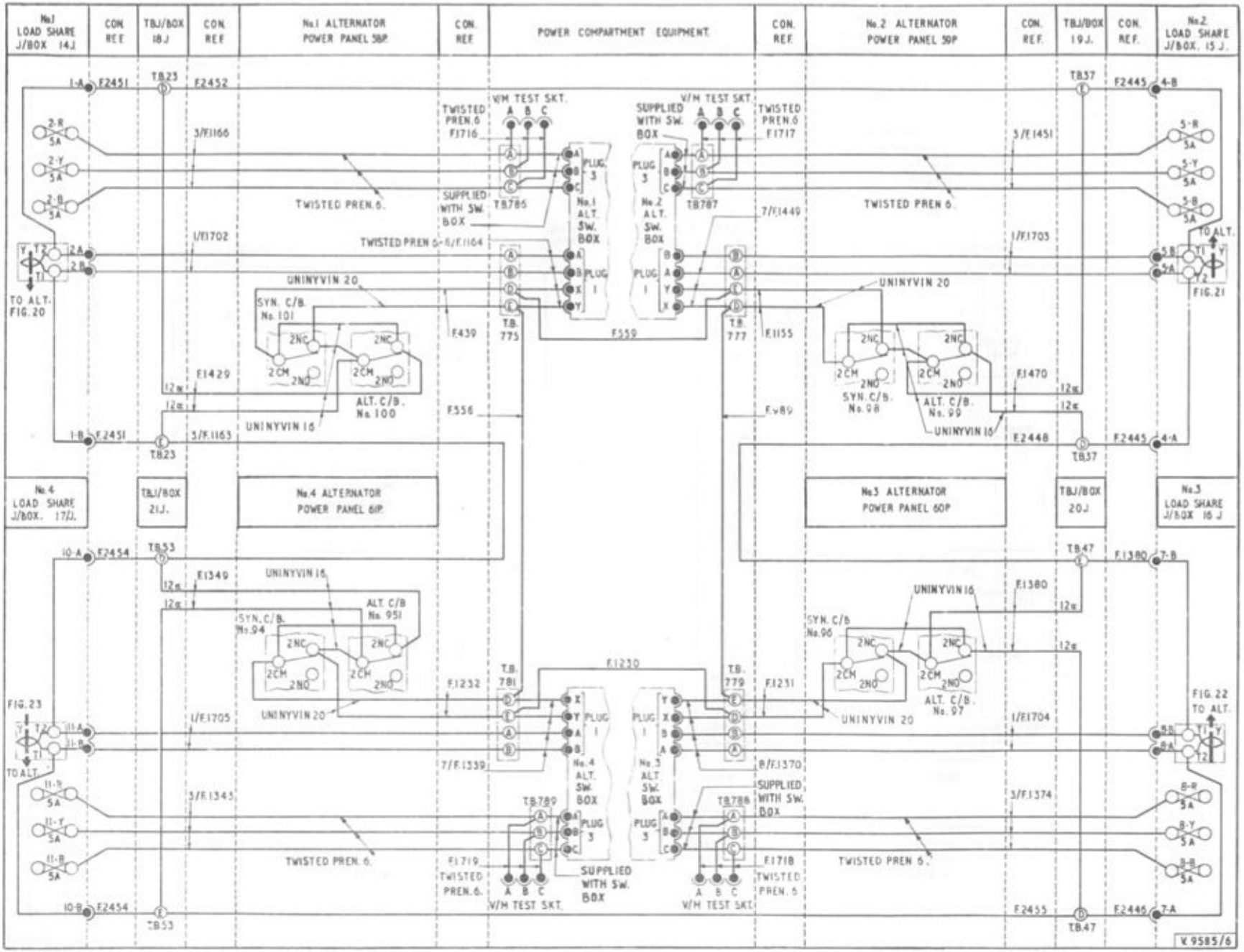


Fig. 28 Overvolt protection

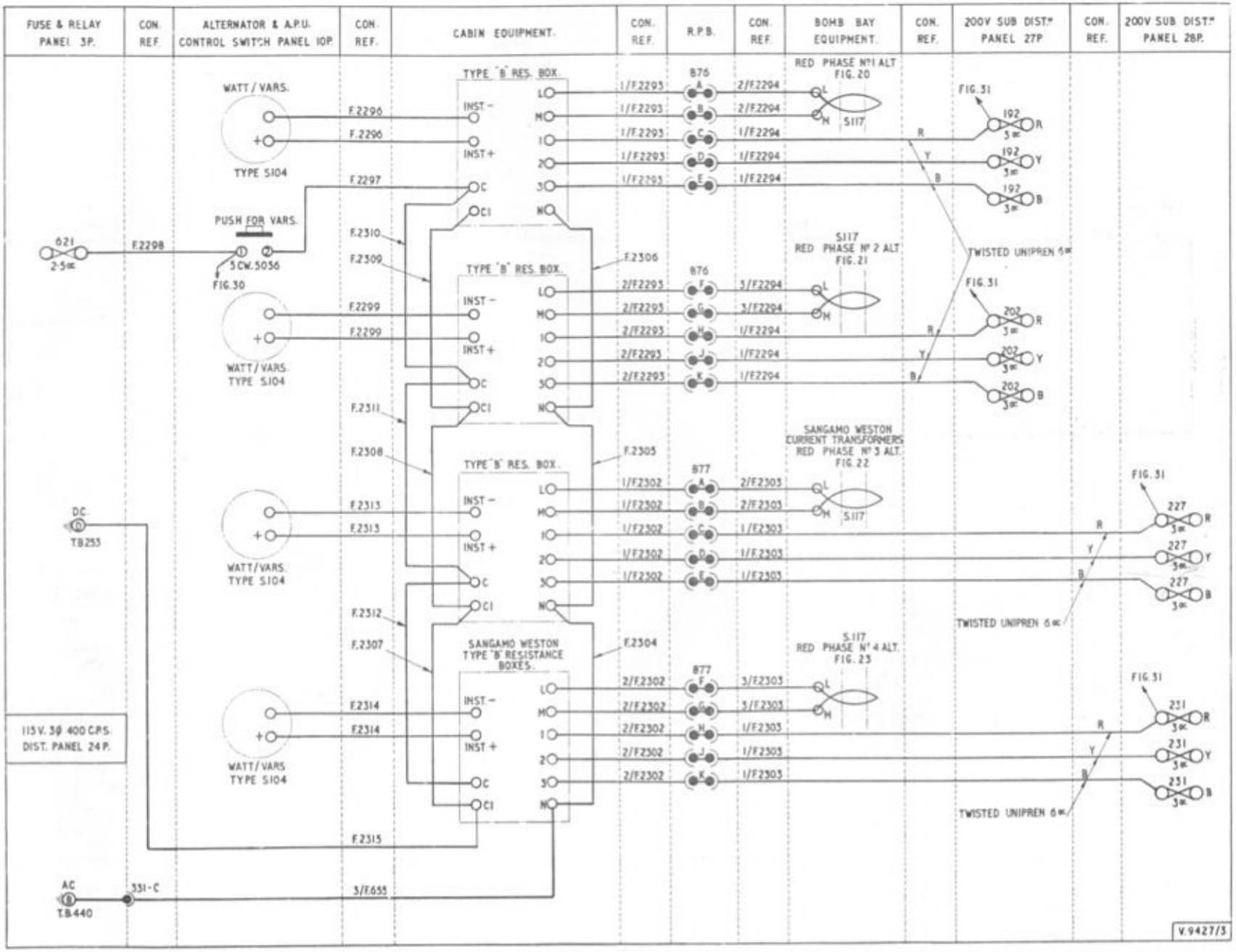


Fig. 29 Watt/var meters

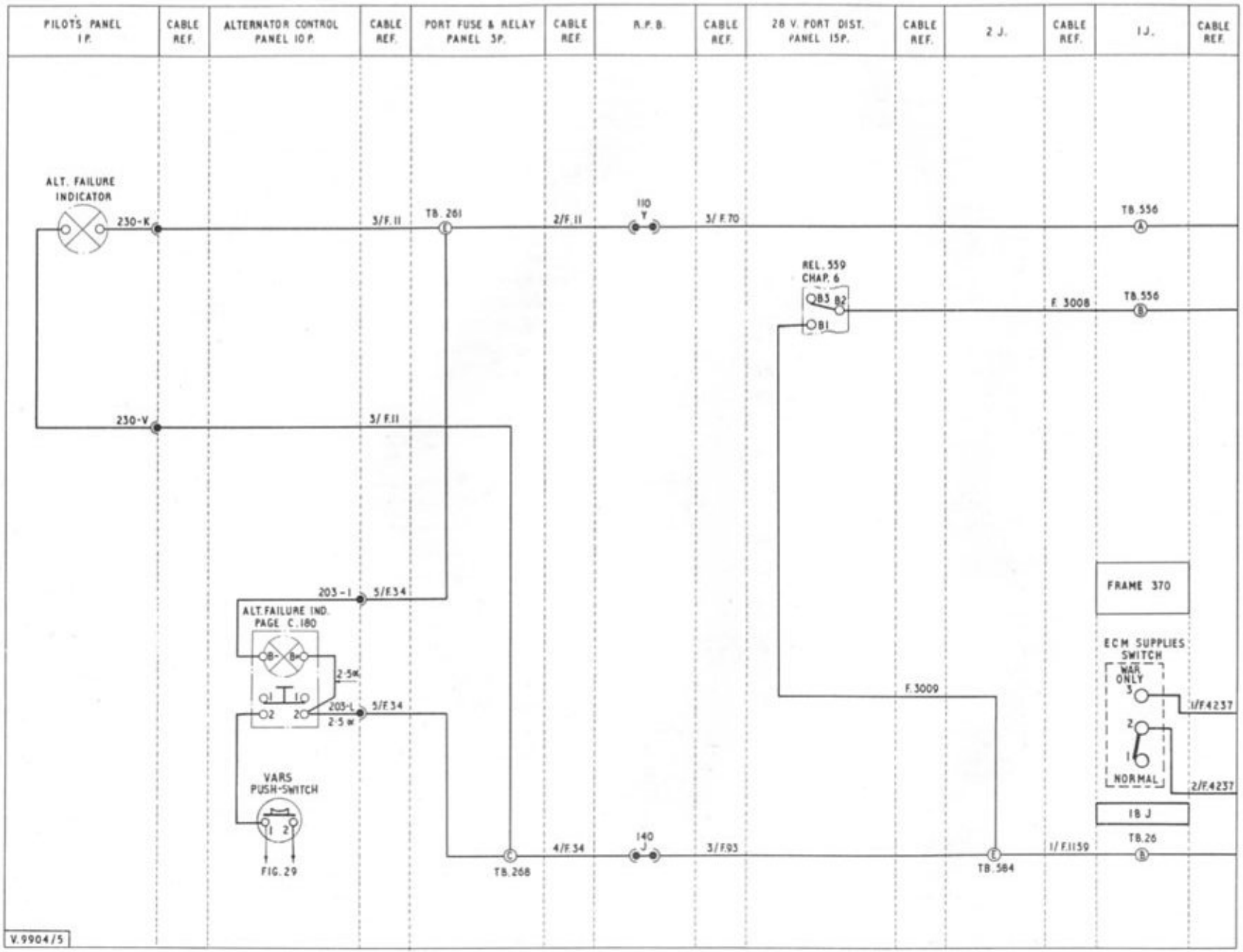


Fig. 30 (1) Alternator failure indication

▶Mod 2428◀

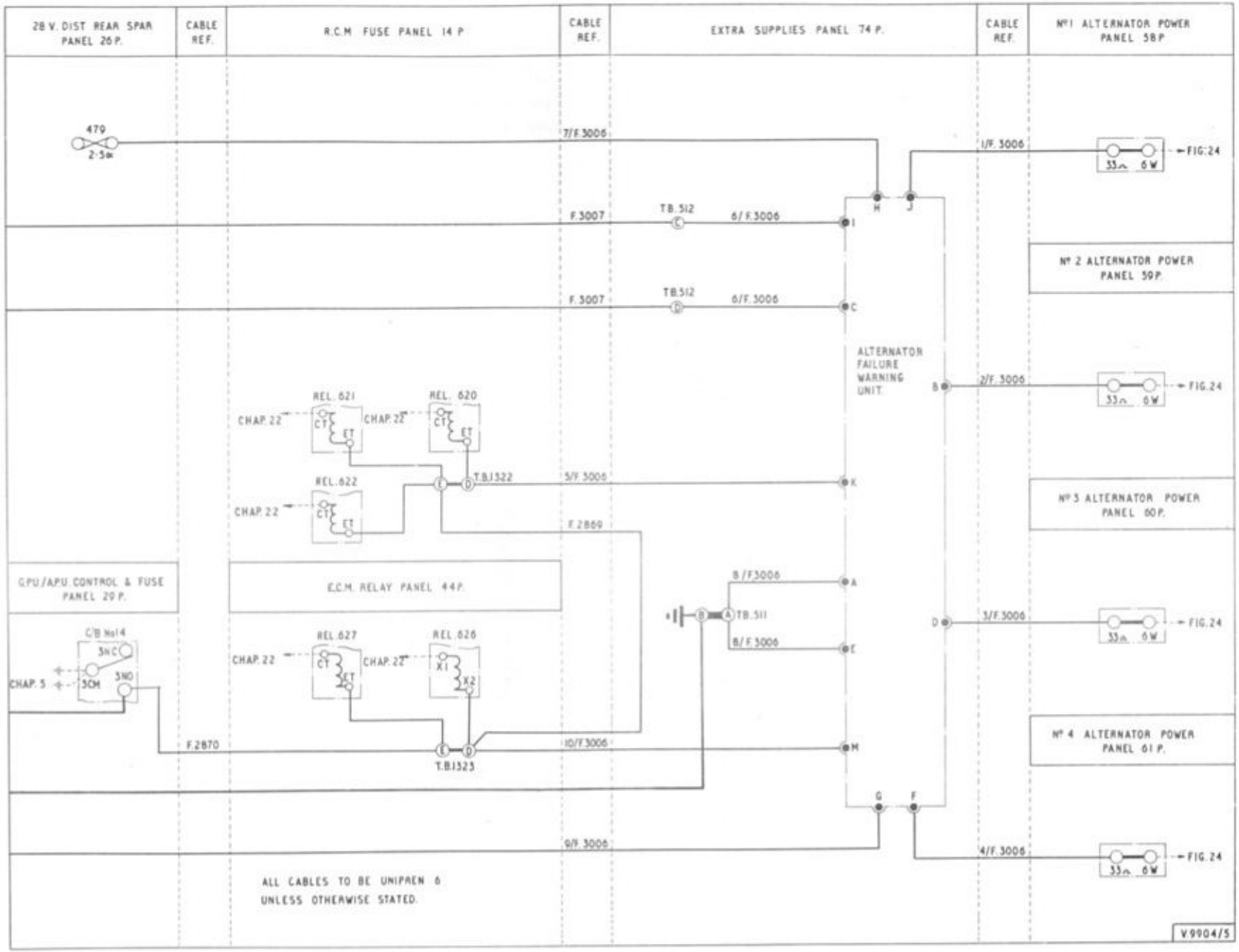


Fig. 30 (2) Alternator failure indication
▶ Mod 2428 and 2451 ◀

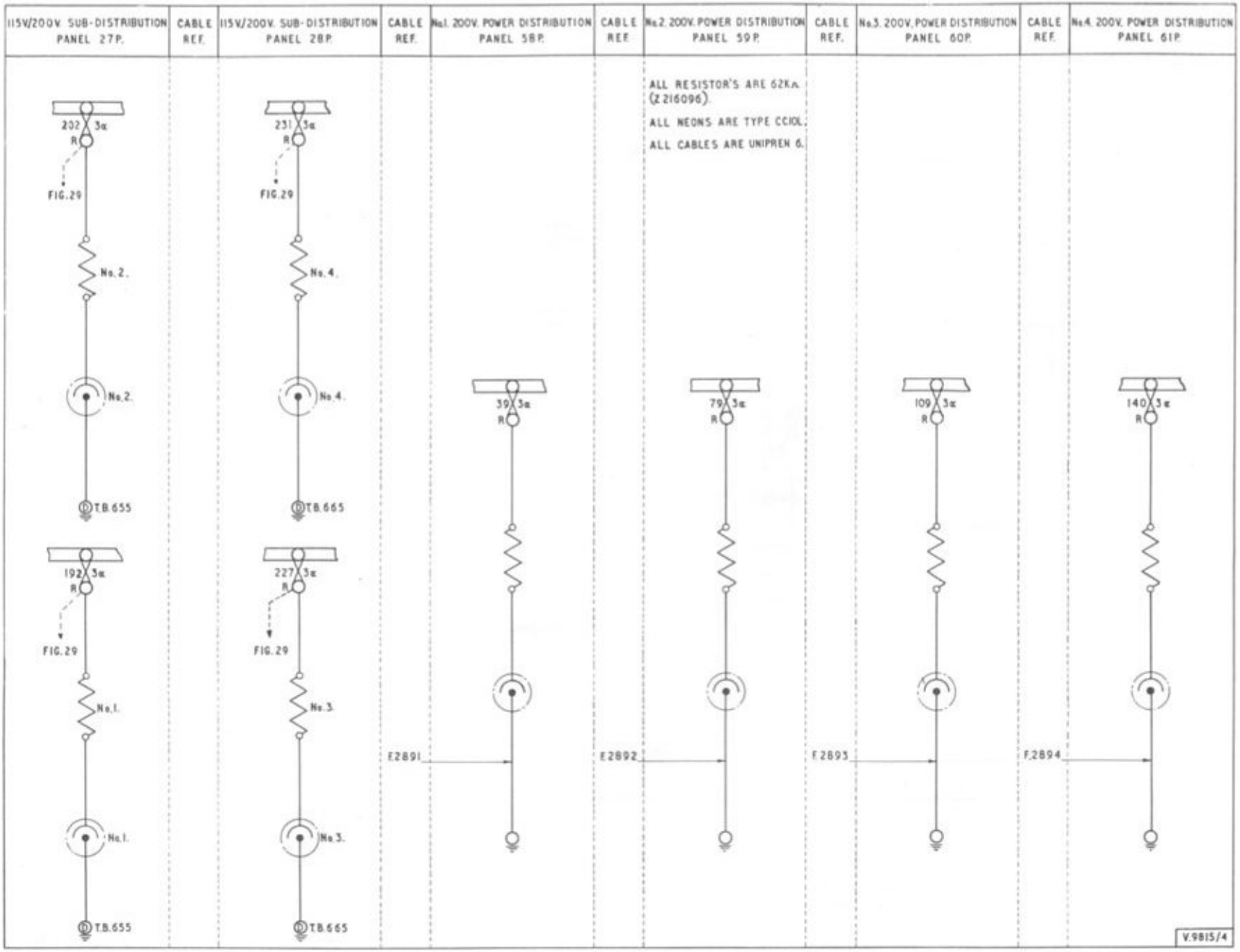


Fig. 31 Live bus-bar indicators

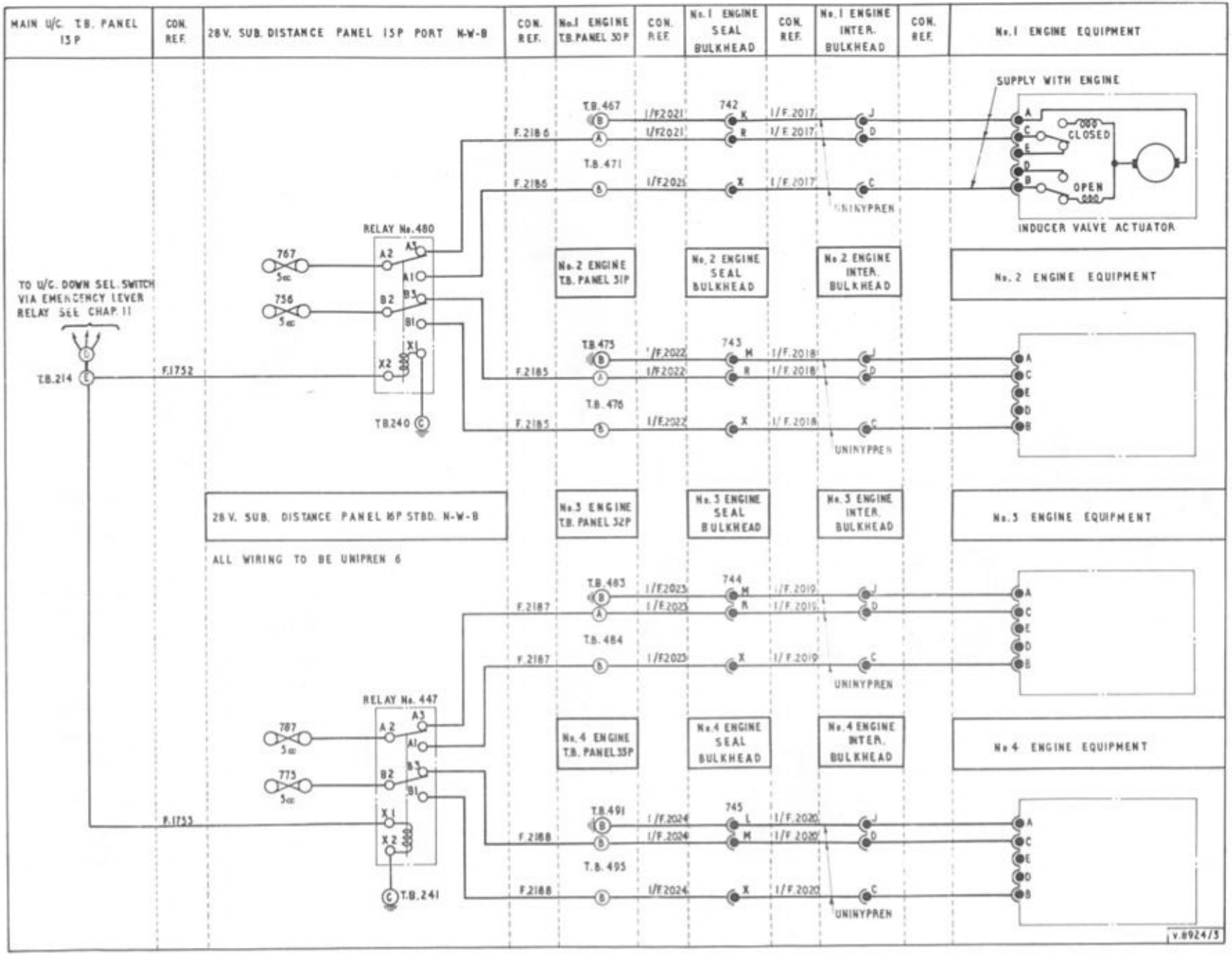


Fig. 32 Alternator ground cooling

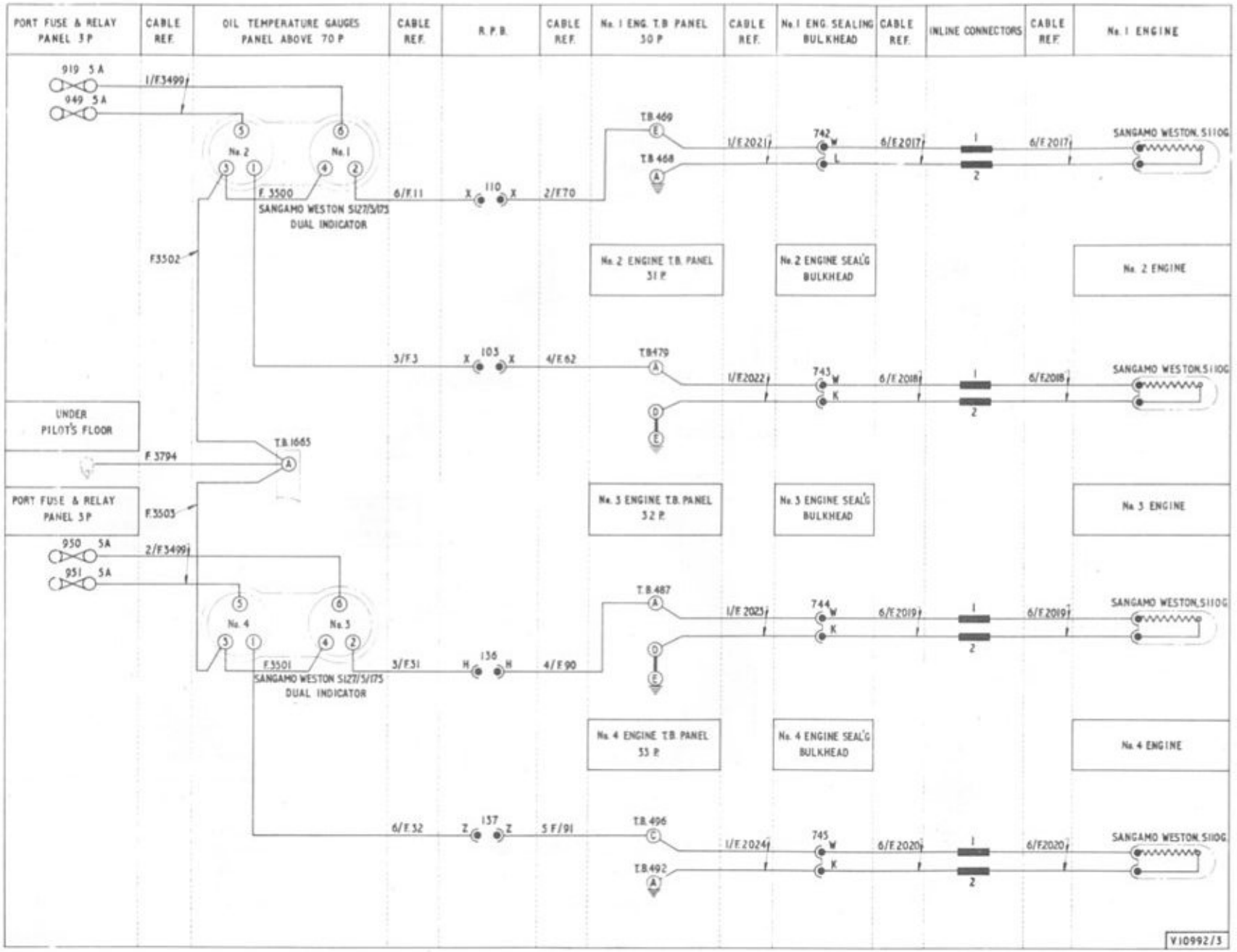


Fig 33 C.S.D.U. thermometers

▶ *Changes to earth connections Mod 2481* ◀