Group 5A

FUEL SYSTEM CONTROLS (INCORPORATING FLIGHT REFUELLING)

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Introduction

1. This group contains descriptive and servicing information on the electrical controls and equipment for aircraft with a ground and flight refuelling system embodied (Mods. 38, 274 and 951). For aircraft with ground refuelling only, reference should be made to Group 5. Location illustrations are provided, together with theoretical circuit diagrams and routing charts. The mechanical aspect of the system is described in Book 1, Sect.4, Chap.2.

2. In order to expedite the embodiment of Mod.951, the first eight chosen aircraft were modified to manufacturer's SK drawings (issued for trials aircraft) as distinct from production drawings. The associated SK routing charts, therefore, are included in fig.43 to 43J at the end of this group, and are in line with the latest production mod. standard. Note that these routing charts apply only to the following aircraft:-

XH477	XH500	XA904
XH478	XH505	XA912
XH481	XH506	

DESCRIPTION AND OPERATION

GENERAL DESCRIPTION

3. Fourteen fuel tanks are provided to hold the engine fuel. The tanks are mounted on each side of the aircraft and are suitably numbered to assist in identification. For the purpose of normal fuel demands the fourteen tanks are divided and suitably interconnected to form four groups. Each of these four groups is then associated with a particular engine as shown below:-

Engine	Group No.	Tanks forming the Group
No. 1	1	Port tanks No. 1,4,5,7
No. 2	2	Port tanks No. 2,3,6
No. 3	3	Stb'd. tanks No. 2,3,6
No. 4	4	Stb'd. tanks No. 1,4,5,7

4. Although each group is normally associated with one particular engine, cross feed cocks are fitted between each group so that if a tank group should fail, fuel from another group may be delivered to the engine concerned, thus preventing an engine failure. A tank location diagram is contained in Fig.1.

5. Each tank is fitted with a main fuel booster pump for pumping fuel to the engines. In addition, the wing tanks (No.3,4,5,6 and 7) are each fitted with a secondary fuel pump. These secondary pumps feed fuel to their associated main fuel pumps so that a continuity of fuel flow is maintained irrespective of the aircrafts attitude. No.1 and 7 tanks are also equipped with fuel transfer pumps.

6. To enable the fuel pump motor currents to be monitored, a ten-turn coil is introduced in the supply line to each motor. The test coils are mounted on the top of panels 19 and 20P on the aft face of the front spar in the bomb bay (Fig.12). A clip-on type ammeter is provided for testing, details of which will be found under the heading 'Servicing'.

7. Instruments are provided which indicate the state of the fuel system. Fuel contents information is provided for the pilots and crew members by gauges at the pilot's station and the navigator's station. The pilot's gauges are capable of displaying individual tank contents information in addition to the normal group contents information. The navigator's gauges show group contents only. The fuel flow rate and the total fuel consumed are presented on two suitable indicators at the pilot's station.

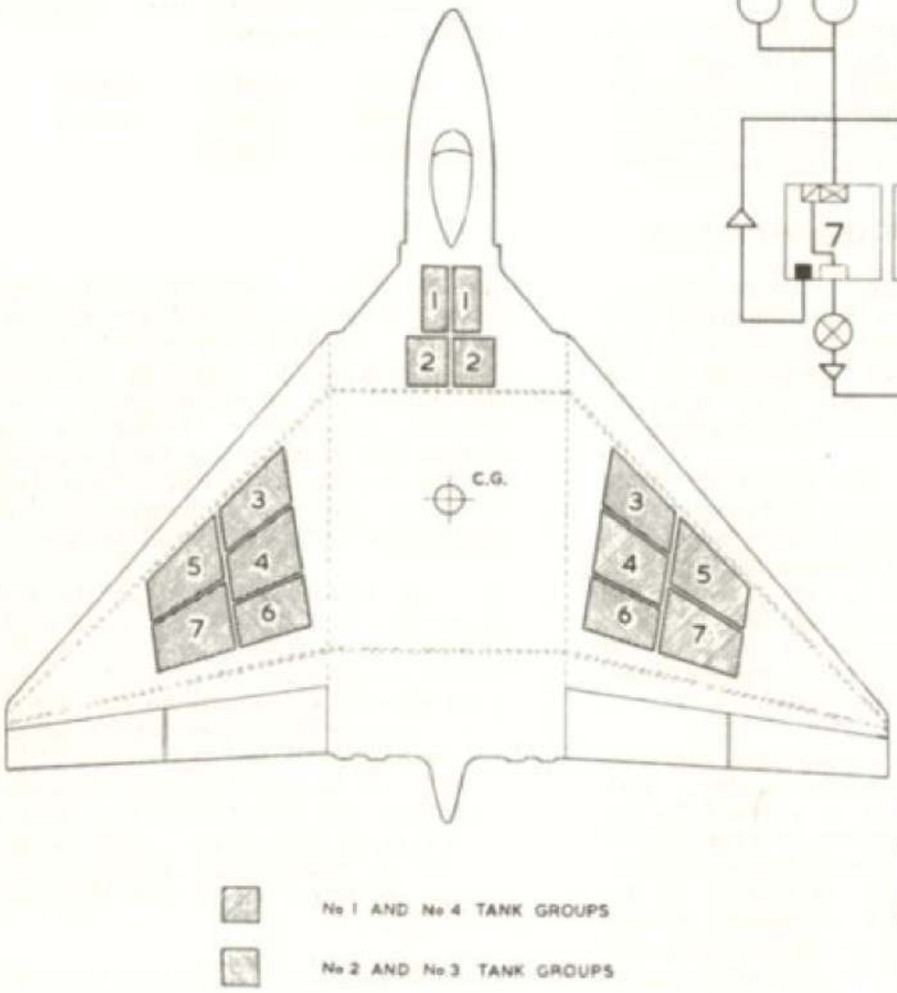
8. Due to the large quantity of fuel carried and the disposition of the fuel tanks, the aircraft's C. of G. is largely dependent upon the distribution of fuel. Certain controls are necessary to maintain the C. of G. when fuel is being withdrawn from the system and also when refuelling. One set of controls ensure that during ground refuelling all tanks are filled to the same percentage of their maximum capacities. Further controls ensure that when fuel is being supplied to the engines the quantity drawn from each tank during a 5 minute cycle is proportional to the capacity of the tank.

9. A visual indication of the fuel C of G is provided by a C of G. indicator at the pilot's station. The indicator is operated by a C. of G. computor which is embodied in the fuel system. If a nose or tail heavy indication is given, a correction in the fore and aft line of the aircraft can be made by transferring fuel from No.1, the most forward tank, to the No.7 tank, or vice versa. This transfer of fuel is performed by transfer pumps which are fitted one in each No.1 and No.7 tanks.

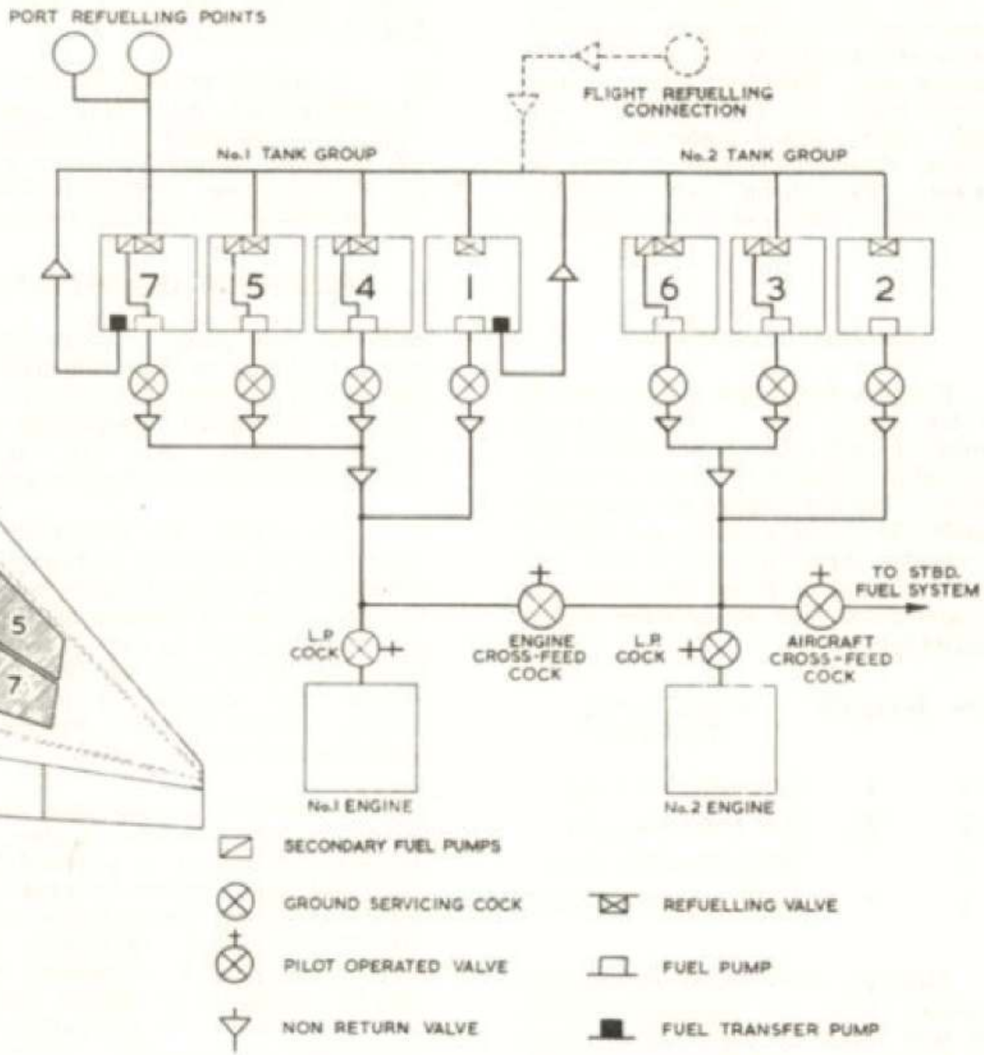
10. During flight refuelling, when the tanks are automatically replenished to their maximum capacities, the stability of the C. of G. in both the fore and aft line and athwartships can be maintained within reasonable limits.

Controls and indicators

11. With reference to fig.3 it will be seen that most of the fuel system control switches are mounted on the retractable



ARRANGEMENT OF TANKS



PORT FUEL SYSTEM DIAGRAM

Fig. 1 Fuel system

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centre console 5P in the pilot's compartment. Painted upon the upper surface of the panel is a plan view of the distribution of fuel to the fourteen fuel tanks as they are sited in the aircraft. The plan is painted in contrasting colours so that the tanks forming a particular group may be easily identified. The area representing any one tank contains the fuel pump toggle switch for that tank and the tank contents push switch. Interconnecting pipe lines between the groups are also shown on the plan. The cross feed cocks are represented by magnetic indicators which break the continuity of the lines when the cross feed cocks are shut. The following control switches and indicators are mounted on the panel:-

Fuel pump switches	-	14
Individual tank contents push switches	-	14
Cross feed cock switches	-	3
Cross feed cock indicators	-	3
Fuel flowmeter push switches	-	4
Manual/Auto control switches	-	4
C.G. transfer switches	-	2
C.G. control switch	-	1

12. The low pressure fuel cocks are controlled by four switches mounted on the pilot's coaming; the fuel contents gauges for the pilot are located on the instrument panel 2P, and those for the navigator are fitted on the plotter's panel. The controls are illustrated in fig.3.

13. The flight refuelling control switches and indicators are arranged on the starboard console as shown in fig.8. The controls and indicators may be listed as follows:-

Flight refuelling master switch
Nitrogen purge switch
Tank pressurisation switch
Nitrogen switch (prior to Mod.171 only)
Flight refuelling indicator
Flight refuelling probe pressure gauge
Tank pressure indicators

Fuel boost pumps

14. The fuel pumps are controlled by the fourteen fuel pump toggle switches on 5P. When the switches are selected to PUMP both the main and secondary fuel booster pumps will be connected to the 112-volt d.c. supply via their respective control relays. All the main pumps are capable of being run at two speeds, depending upon the position of the AUTO-MANUAL switches on 5P. The speed of the secondary pumps cannot be altered and remain constant at all times. The main pumps are Type S.P.E.808 Mk.2, and the secondary pumps Type S.P.E.106 Mk.1.

15. Speed variation on the main booster pumps is achieved by switching in and out a resistance unit connected in series with the armature winding. With the resistance unit shorted across by the normally closed contacts of the change speed relays, the motor will run at full speed to deliver fuel at 10 p.s.i. When the change speed relays are energised the resistance unit will be connected in series with the armature with a resultant decrease in speed and consequently reduced fuel pressure.

16. The change speed relays will be de-energised and the pump motors will run at maximum speed whenever the AUTO-MANUAL switches are set to MANUAL. Selecting the switches to AUTO will place the change speed relay coils under the control of a sequence timer, which by means of cam operated contacts, will energise and de-energise in turn the change speed relays, with a subsequent increase and decrease in fuel pressure from tanks to engine in a set sequence.

Sequence timer units

17. Two sequence timer units, Type D. 10706, are fitted one in each Main wheel bay, adjacent to the refuelling panels. Each sequence timer deals with the automatic control for the port and starboard side of the aircraft fuel system. By alternately energising and de-energising the change speed relays the pumps are controlled in such a manner that only one pump from each fuel tank group is delivering fuel to the engine associated with that particular tank group at any one time. In addition the sequence timer will ensure that over a 5 minute period, the quantity of fuel pumped from any one tank to the engine concerned will be directly proportional to the capacity of the tank.

18. Each sequence timer consists of a camshaft on which are mounted seven cams. The camshaft is driven, through suitable reduction gearing, by a squirrel cage induction motor. The gearing is arranged to give a camshaft speed of 0·2 r.p.m. or one revolution in approximately 5 minutes.

19. Each of the seven cams controls a pair of contacts, the cam profile being calibrated to produce an open contact period consistent with the capacity of the associated tank. This means that in the case of the No.2 tank which has a capacity almost twice that of any other tank, two open contact periods are provided for each revolution of the cam. Consequently the No.2 tank pump will run at maximum speed for two periods during each revolution of the cam.

20. As the seven tanks controlled by any one sequence timer are divided into two groups, so the sequence timer contacts are divided into similar groups. Each group of contacts is provided with a 28-volt d.c. supply via one of the AUTO-MANUAL switches as shown in fig.5. The

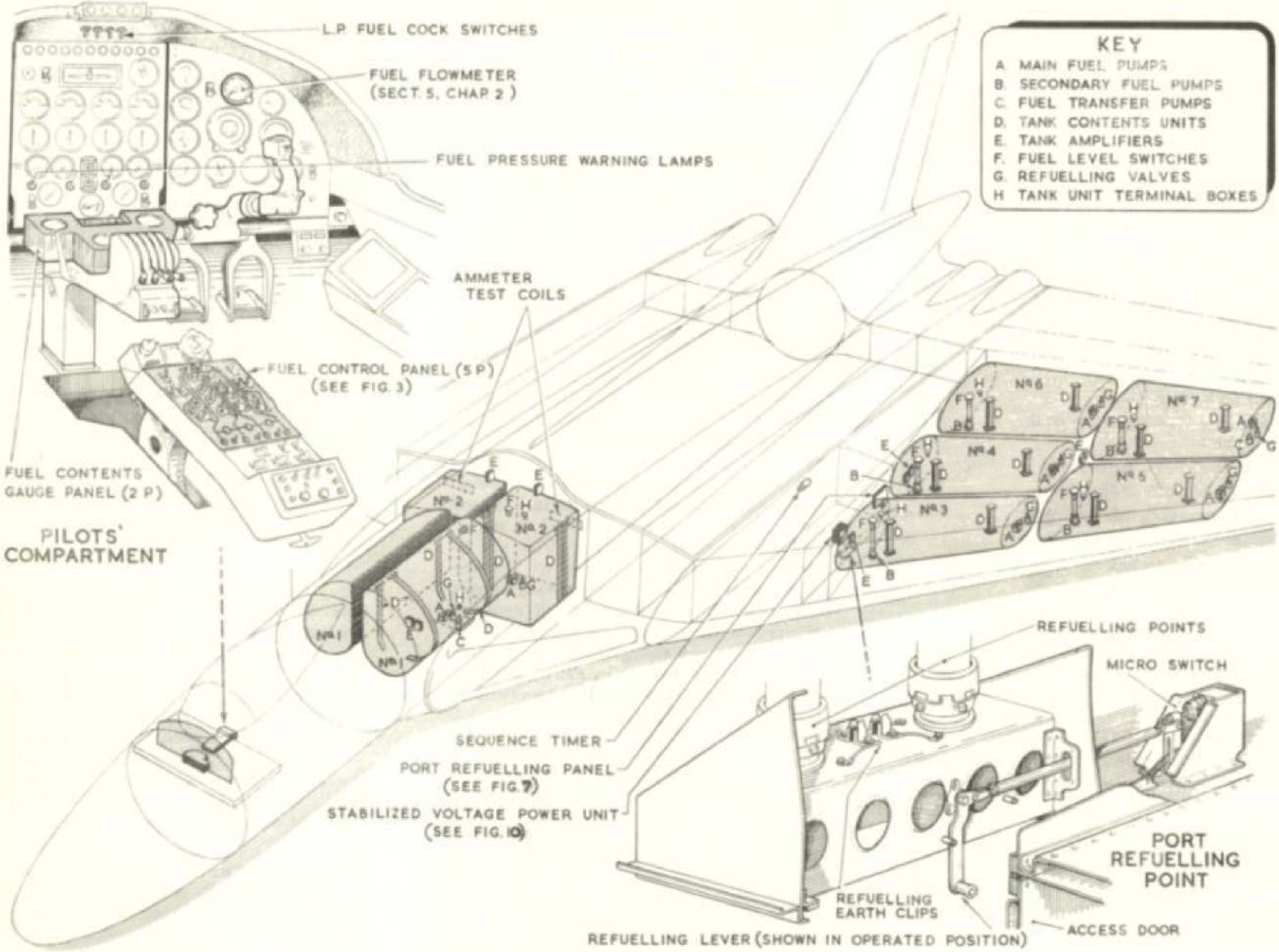

Fig.2 Location of components

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sequence timer motors are each connected to a 115-volt, 3-phase, 400 c/s a.c. supply., the internal connections of the sequence timer are contained in fig.5. The sequence timers are described in A.P.4343D, Vol.1, Book 4.

Fuel transfer pumps

21. Two three-position switches, labelled C.G. TRANSFER-FWD/AFT, control the fuel transfer pumps Type B.P. 8 Mk. 4. The switches are spring loaded to the centre OFF position. When either switch is held to the FWD position, the associated fuel transfer pump in No.7 tank will be switched on: at the same time, the No.1 refuelling valve will be energised to open. The fuel transfer pump will now deliver fuel into the refuelling pipeline, and through the refuelling valve into the No.1 tank. A fuel level switch within the tank prevents overfilling of the tank by de-energising the refuelling valve when the tank is full.

22. It should be noted that during flight refuelling the C.G. transfer switches perform a slightly different function. Further details will be found in para.81.

23. The fuel transfer pumps are described in detail in A.P.4343C, Vol.1, and the theoretical circuit diagram of the fuel transfer system is contained in fig.5.

Fuel cock controls

24. Seven electrically operated Vickers fuel cocks are employed in the fuel system. They consist of three cross feed cocks, and four low pressure fuel cocks. Each assembly contains a motor driven actuator of the split field series type. Description details for the actuators will be found in A.P.4343D, Vol.1, Sect.16. Indication that the cross feed cocks are switched on is provided by three electro-magnetic indicators mounted on the centre console 5P. The indicator circuits are completed through the appropriate relays Type Q3. The cross-feed cocks are controlled by three single-pole toggle switches mounted on the centre console, each switch controlling a Q3 relay, the contacts of which are in the main supply lines to the actuator open or closed fields.

25. The low pressure cocks are controlled by four two-way double-pole switches, fitted on the coaming above the pilot's centre instrument panel. The supplies for actuators are obtained from the 28-volt bus-bars, via fuses in panels 3P and 4P.

Fuel pressure warning indicators

26. Four fuel pressure warning indicators fitted to the pilot's panel, are connected to a fuel pressure switch, Type T.P. 5202, one on each engine. If the fuel pressure in any one engine falls below 5 p.s.i. the contacts of the switch will close, and energise the appropriate magnetic indicator Ref.No. 5CZ/5073.

FUEL CONTENTS GAUGING SYSTEM

27. A Smith Waymouth type fuel contents gauging system is fitted to the aircraft. Integral tank units and a separate amplifier, Type F.C.A., are provided for each tank. Co-axial cables connect the tank units to the amplifier via trimmer boxes, the outputs of which are fed to the fuel contents gauges fitted in the pilot's and crew's compartment. A complete description of the Smith Waymouth system will be found in A.P.1275A, Vol.1, Sect.18.

28. Referring to fig.1, which shows the complete fuel tank installation in diagram form, it will be seen that each tank group consists of three (groups 2 and 3) or four (groups 1 and 4) individual systems. Each system has its own tank units, cable box, F.C.A. amplifier and co-axial cables. Before reaching its respective indicator the output from each amplifier passes through a computor box and associated relay which is push-button controlled.

29. The computor box proportions the current relationship between the amplifier outputs to achieve aircraft fuel balance. A proportion of the current flowing from each amplifier is used to operate a C.G. indicator whilst the relays permit individual tank readings to be obtained. Further information on the computor boxes is given in para.82.

Individual tank systems

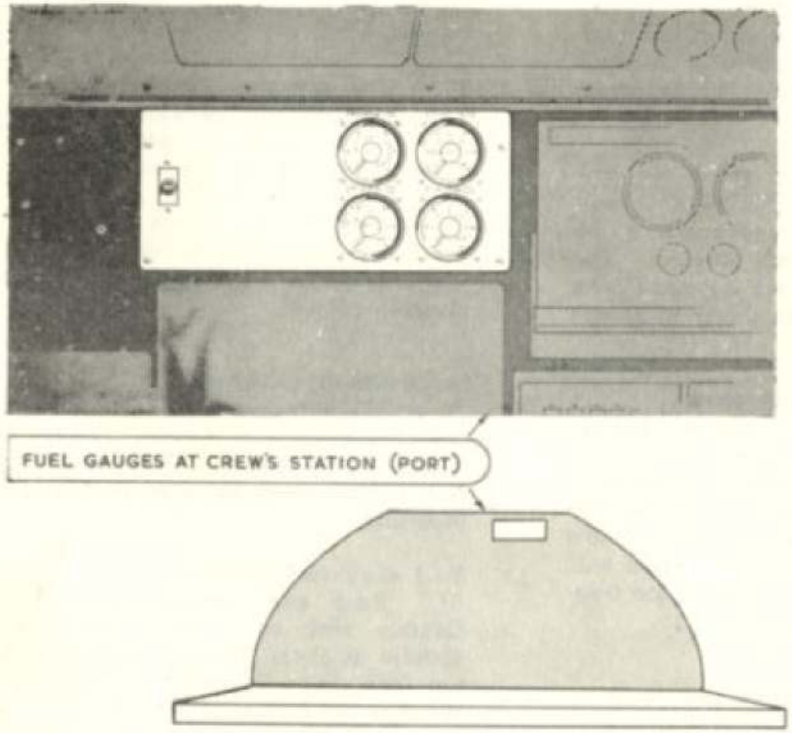
30. The description that follows is concerned with the port side installation only. Except where stated in the text the operation of the starboard side installation is identical.

No.1 and 2 tank systems

31. Each tank contains two pairs of flexible tank units which are fitted in special pockets running vertically down the tank walls. A JM3 tank terminal is fitted to the bottom skin of the No.1 tank. Insulated flexible wiring connects the tank terminal to the tank units. The JM3 tank terminal for No.2 tank is fitted to the top skin of the tank. The terminal is connected to the tank units by insulated flexible cable. Co-axial cables run from the JM3 terminals to the F.C.A. amplifier via an associated cable box.

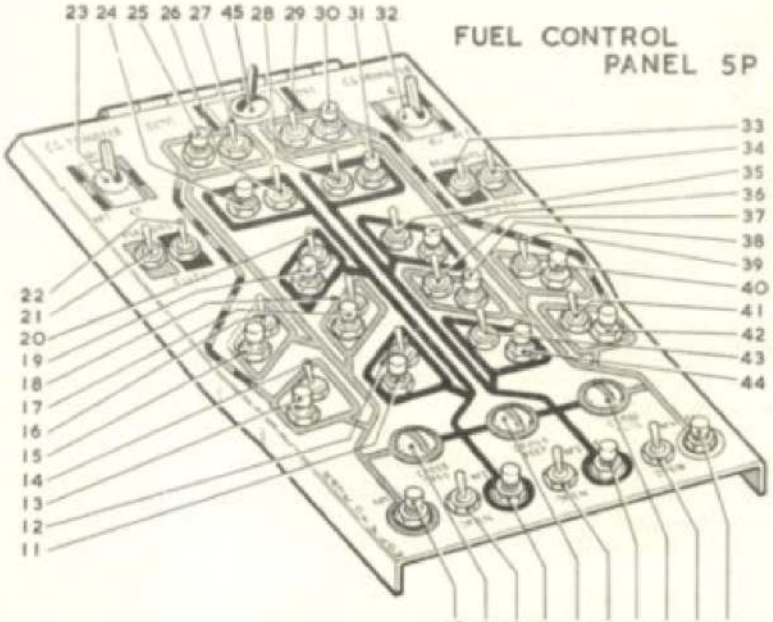
No. 3,4,5 and 6 tank systems

32. Each of these tanks contains two channel type tank units. The two ends of each unit have rubber flanges which fasten by rubber press-studs to the top and bottom tank skins, thus securing each tank unit in a vertical position. The tank units are connected in parallel to the JM3 tank terminal which is bolted to the bottom skin of the tank. A co-axial cable connects the tank terminal to a cable box and thence to the F.C.A. amplifier.



COLOUR CODE

BLUE	▬	No.2 AND No.3 ENGINE TANK GROUP
AMBER	▭	No.1 AND No.4 ENGINE TANK GROUP
BLUE AND AMBER	▬▭	TRANSFER-FUEL TRIM



KEY TO CONTROLS ON 5P

1. NO.4 ENGINE RATE-OF-FLOW PUSH-SWITCH
2. STARBOARD CROSS-FEED FUEL COCK SWITCH
3. STARBOARD CROSS-FEED FUEL COCK INDICATOR
4. NO.3 ENGINE RATE-OF-FLOW PUSH-SWITCH
5. AIRCRAFT CROSS-FEED FUEL COCK SWITCH
6. AIRCRAFT CROSS-FEED FUEL COCK INDICATOR
7. NO.2 ENGINE RATE-OF-FLOW PUSH-SWITCH
8. PORT CROSS-FEED FUEL COCK SWITCH
9. PORT CROSS-FEED FUEL COCK INDICATOR
10. NO.1 ENGINE RATE-OF-FLOW PUSH-SWITCH
11. NO.6 PORT TANK CONTENTS PUSH-SWITCH
12. NO.6 PORT TANK FUEL PUMP SWITCH
13. NO.7 PORT TANK CONTENTS PUSH-SWITCH
14. NO.7 PORT TANK FUEL PUMP SWITCH
15. NO.5 PORT TANK CONTENTS PUSH-SWITCH
16. NO.5 PORT TANK FUEL PUMP SWITCH
17. NO.4 PORT TANK CONTENTS PUSH-SWITCH
18. NO.4 PORT TANK FUEL PUMP SWITCH
19. NO.3 PORT TANK CONTENTS PUSH-SWITCH
20. NO.3 PORT TANK FUEL PUMP SWITCH
21. NO.2 GROUP AUTO/MANUAL CONTROL SWITCH
22. NO.1 GROUP AUTO/MANUAL CONTROL SWITCH
23. PORT FUEL TRANSFER PUMP SWITCH
24. NO.2 PORT TANK CONTENTS PUSH-SWITCH
25. NO.1 PORT TANK CONTENTS PUSH-SWITCH
26. NO.2 PORT TANK FUEL PUMP SWITCH
27. NO.1 PORT TANK FUEL PUMP SWITCH
28. NO.2 STARBOARD TANK FUEL PUMP SWITCH
29. NO.1 STARBOARD TANK FUEL PUMP SWITCH
30. NO.1 STARBOARD TANK CONTENTS PUSH-SWITCH
31. NO.2 STARBOARD TANK CONTENTS PUSH-SWITCH
32. STARBOARD FUEL TRANSFER PUMP SWITCH
33. NO.3 GROUP AUTO/MANUAL CONTROL SWITCH
34. NO.4 GROUP AUTO/MANUAL CONTROL SWITCH
35. NO.3 STARBOARD TANK FUEL PUMP SWITCH
36. NO.3 STARBOARD TANK CONTENTS PUSH-SWITCH
37. NO.4 STARBOARD TANK FUEL PUMP SWITCH
38. NO.4 STARBOARD TANK CONTENTS PUSH-SWITCH
39. NO.5 STARBOARD TANK FUEL PUMP SWITCH
40. NO.5 STARBOARD TANK CONTENTS PUSH-SWITCH
41. NO.7 STARBOARD TANK FUEL PUMP SWITCH
42. NO.7 STARBOARD TANK CONTENTS PUSH-SWITCH
43. NO.6 STARBOARD TANK FUEL PUMP SWITCH
44. NO.6 STARBOARD TANK CONTENTS PUSH-SWITCH
45. FLIGHT REFUELLING C.G. CONTROL SWITCH

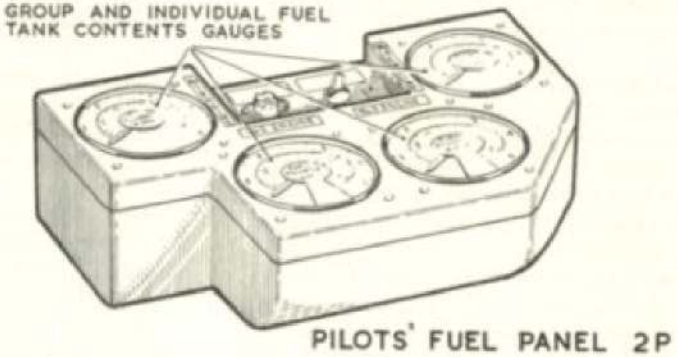


Fig 3 Pilots' controls and indicators

No.7 tank system

33. The No.7 tank contains four channel type tank units mounted vertically and fixed to the top and bottom skins by rubber press-studs. They are connected in parallel to the tank terminal which is mounted on the bottom skin of the tank. Two co-axial cables connect the tank terminal to the F.C.A. amplifier via a cable box.

F.C.A. amplifiers

34. The fuel contents gauge amplifier is an electronic converter whose current output is directly related to the capacitance of the tank units. The circuit essentially consists of an oscillator, discriminator and a d.c. amplifier. The frequency of the oscillator is controlled by the external dielectric capacity of the tank units, the resultant frequency is connected to a discriminator circuit, which rectifies the oscillator output producing a small d.c. voltage, the amplitude of which is proportional to a specific frequency range. The d.c. output of the discriminator is then applied to the control grid of the d.c. amplifier thereby controlling the amount of current flowing through the valve and fuel contents indicator.

Cable boxes

35. These boxes provide facilities for matching up the initial (empty) and range (full) capacitances of the tank circuit to that of the F.C.A. amplifier. In the case of the JY1, 2, 6, 8 and 9 cable boxes this is effected by a fixed capacitor, a variable capacitor, and a tapped inductance coil. Cable boxes JY3, 4 and 5 perform a similar function utilizing a fixed and variable capacitor only.

Contents gauges

36. The contents gauges in the aircraft are in effect milliammeters, calibrated in pounds X1000 and specially designed to record the current output from the F.C.A. amplifier.

37. The four gauges mounted on the pilots' fuel contents panel 2P, normally indicate tank group contents. Individual tank readings may be obtained by operating the appropriate push-switch on the centre console 5P. A further four gauges are fitted to the plotter's panel in the crew's compartment. These gauges are not capable of indicating individual tank contents and so show group contents at all times. The contents gauge type Nos. are as follows:-

No.1 group (pilots')	-	Type A.O.10
No.1 group (crew's)	-	Type A G.14
No.2 group (pilots')	-	Type A.O.12
No.2 group (crew's)	-	Type A.G.15
No.3 group (pilots')	-	Type A.O.12
No.3 group (crew's)	-	Type A.G.15
No.4 group (pilots')	-	Type A.O.10
No.4 group (crew's)	-	Type A.G.14

Tank group contents

38. Each of the pilots' gauges is marked with two scales, an inner scale and an outer scale. The inner scale will register the total weight of fuel contained by the whole group, and the outer scale will when selected, show the contents of an individual tank in the group.

39. The F.C.A. amplifier outputs of a tank group are connected together via the normally closed contacts of the selector relays and then directed to the group contents gauge. As full scale deflection is obtained with a current of 7mA, a shunt resistor is connected across the indicator through the contacts of a shunt relay so that full scale deflection is obtained when all tanks are full.

Individual tank contents

40. The contents of an individual tank in any group will be displayed on the appropriate pilots' gauge when the individual tank push switch on 5P has been pressed. Referring to fig.6 assuming that No.3 individual tank push switch is operated it will be seen that sequence relay 299 will be energised via the push switch and fuse 59. Closing of contacts 299/2 will energise the shunt relay No.301 via fuse 353. Operation of contacts 301/3 will disconnect all F.C.A. amplifiers except No.3 from the pilots' gauge. No.3 amplifier will remain connected to the gauge via contacts 299/3, the moving coil relay MC(A), and contacts 301/2. Contacts 301/1 will maintain the positive supply to tank F.C.A. amplifiers 2 and 6, via crew's gauge and fuse No.48, to prevent movement of their mechanisms, and contacts 301/4 will disconnect the shunt from the pilots' gauge.

41. The largest tank in the group will give full scale deflection when full. Other tanks in the group will give a deflection proportional to their fuel capacities.

CAUTION. . .

The contents gauge may be damaged if two push switches in a tank group are operated at the same time. By this action two amplifier outputs will be applied to the gauge with the shunt resistor disconnected.

GROUND REFUELLING

42. During ground refuelling each tank is filled to the same percentage of its maximum capacity in order to maintain a correct CG position. To prevent the aircraft tilting nose up, the forward tank of each group is the first tank to be filled when refuelling begins. When the refuelling of the aircraft is completed the system is automatically switched off.

43. Only one tank of each group is filled at a time, automatic change-over to the next tank in the group being made by a moving coil relay. One coil of this relay is connected to a stabilized voltage

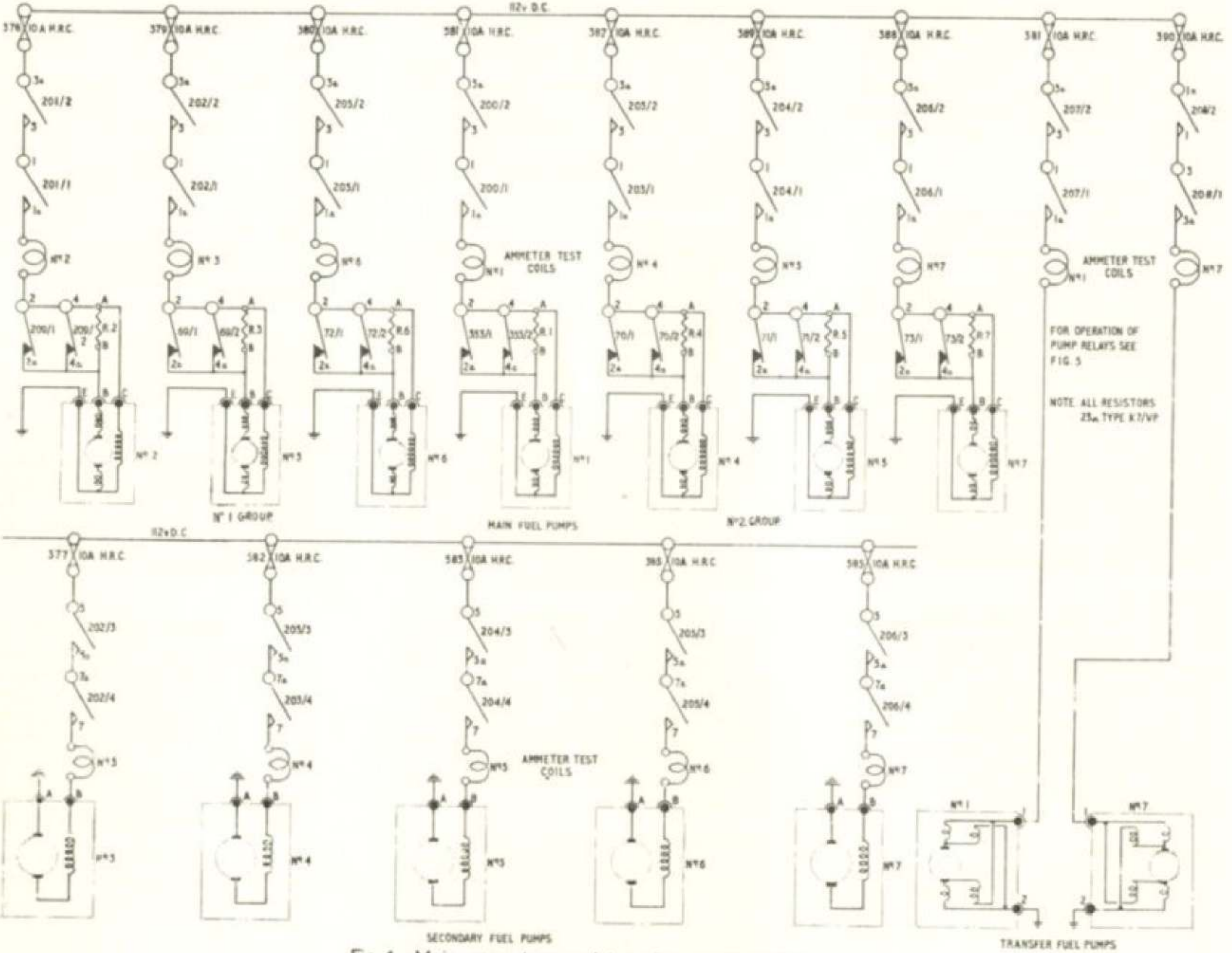


Fig. 4 Main, secondary and transfer pumps - port

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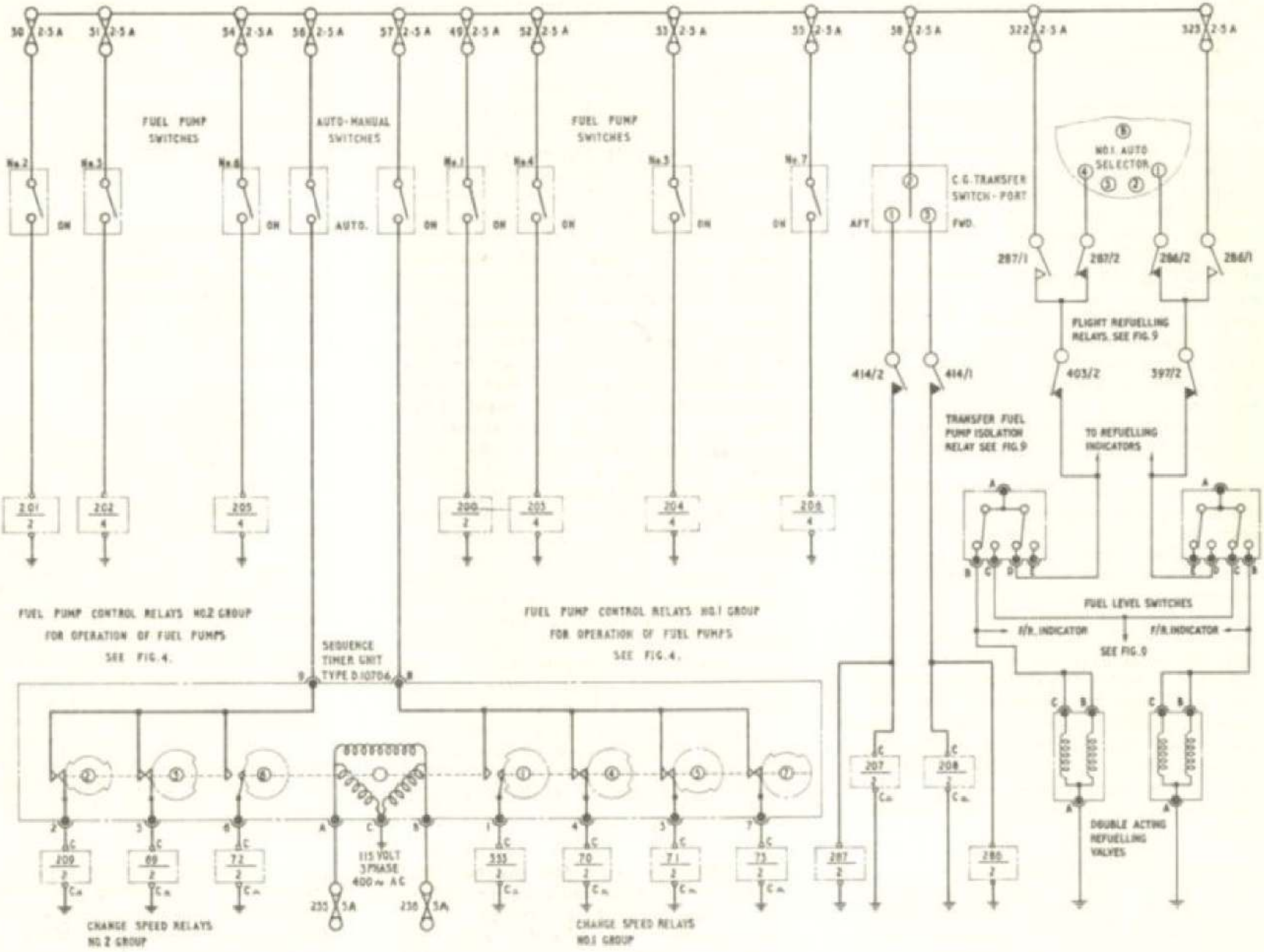

Fig 5 Sequence timer and fuel transfer (port)

power unit via a resistance network, the resistance of the whole network may be set to operate the relay at any percentage of tank contents, from empty to full, by means of an external selector.

Refuelling control and resistance network

44. Each moving coil relay has two windings, one connected in series with the group fuel contents gauge, and F.C.A. amplifier, the other connected to the stabilized power supply via a resistance network. The stabilized power supply will be switched on via a micro switch controlled by the operating handle at the port refuelling point. The stabilized supply can be varied between 0-50 volts by an integral refuelling selector control which is graduated from 0-100 per cent. When a tank is selected for refuelling the relevant selector relay will connect the moving coil relay to the stabilized supply, through a fixed and trimmer resistance.

45. The current in the control coil of the moving coil relay MC(B) is dependent upon the voltage selected at the stabilized voltage power unit and the total resistance of each arm in the resistance network. The current in MC(A) is dependent upon the output from the F.C.A. amplifier which, in turn, is dependent upon the quantity of fuel in the tank being refuelled. As the two coils of the moving coil relay are in opposition, when the current in MC(A) rises to 2mA above the current flowing through MC(B), the contacts MC/2 will operate to close. This action will energise a ledex autoselector switch to shut off the selected tank.

Stabilized Voltage Power Unit

46. This unit, Ref.No.26DC/8710, provides a stabilized voltage output which can be set to any value between 0 and 50 volts by means of a selector potentiometer. The unit is fitted in the port main wheel bay adjacent to panel 36P as shown in fig.7. A circuit diagram of the unit is provided in fig.11, whilst fig.10 shows the physical appearance of the unit.

General Description

47. The power unit consists of a synchronous self-rectifying vibrator pack and associated power transformer, the resultant H.T. output being applied to the valves of the associated stabilization circuit via a low pass-filter. The vibrator operates at a frequency of 110 c/s the output of which is stepped up by the power transformer and fed back to the rectifying contacts of the vibrator, providing approximately 400 volts d.c. after filtering, the actual voltage being dependent upon the power unit input voltage. The first part of the stabilization circuit can be described simply as a resistive chain connected across the 400-volt d.c. output of the vibrator pack, with an earth connection interposed about the centre of the chain, thereby producing a split load with a common earth. The earth is interposed at such a point in the resistive chain, that a potential difference of +220 volts with respect to earth and also -180 volts with respect to earth is obtained. The current flowing through the split loads is controlled by valves connected in a series parallel configuration, the resultant action being to stabilize the -180-volt line. The second circuit is similar except the now stabilized -180-volt line is used to back off the +220-volt line via a potentiometer calibrated 0-100% and so produce a variable 0-50 volts stabilized output. Both circuits are described in detail later in the text.

48. When in use the potentiometer centred on the front panel of the unit, is set to the desired percentage of full fuel capacity. A voltmeter, also calibrated in percentages, is provided on the front face of the unit so that the output volts may be checked against the potentiometer setting. A tolerance of ± 2% is permissible in this reading. The output voltage is stable to less than 0·5-volt with an aircraft supply variation between 22 and 29 volts. As soon as the required voltage is available two COMMENCE REFUELLING indicators will light. One of these indicators is positioned on the port refuelling panel 36P, the other is positioned on the starboard refuelling panel 37P.

49. On completion of refuelling the access duct to the refuelling point is prevented from closing until the micro switch control lever has been returned to the off position. This ensures that the power unit is not inadvertently left switched on.

Circuit operation

50. Referring to fig.11, it will be seen that a 28-volt d.c. input supply is applied via a fuse and series resistor R1 to the driving coil and contacts of a synchronous self-rectifying vibrator pack. The resistance R1 is used to limit the current on initial start of the vibrator and then switched out by the delayed action of the slugged relay, thus providing protection against heavy starting currents and consequent arcing across the points. Protection is also provided against arcing on normal running of the vibrator by the action of capacitor C12 and resistor R22, connected in series across the contacts. The 3 amp fuse provides protection for the main fuse 353 when a fault develops on the vibrator pack, thereby preventing unnecessary disruption of supplies to the refuelling circuits.

51. Resulting from the action of the driving arm, a pulsating d.c. voltage is applied via the primary contacts to the centre-tapped primary winding of the power transformer. The change of field polarity necessary to induce a voltage in the secondary windings is obtained by

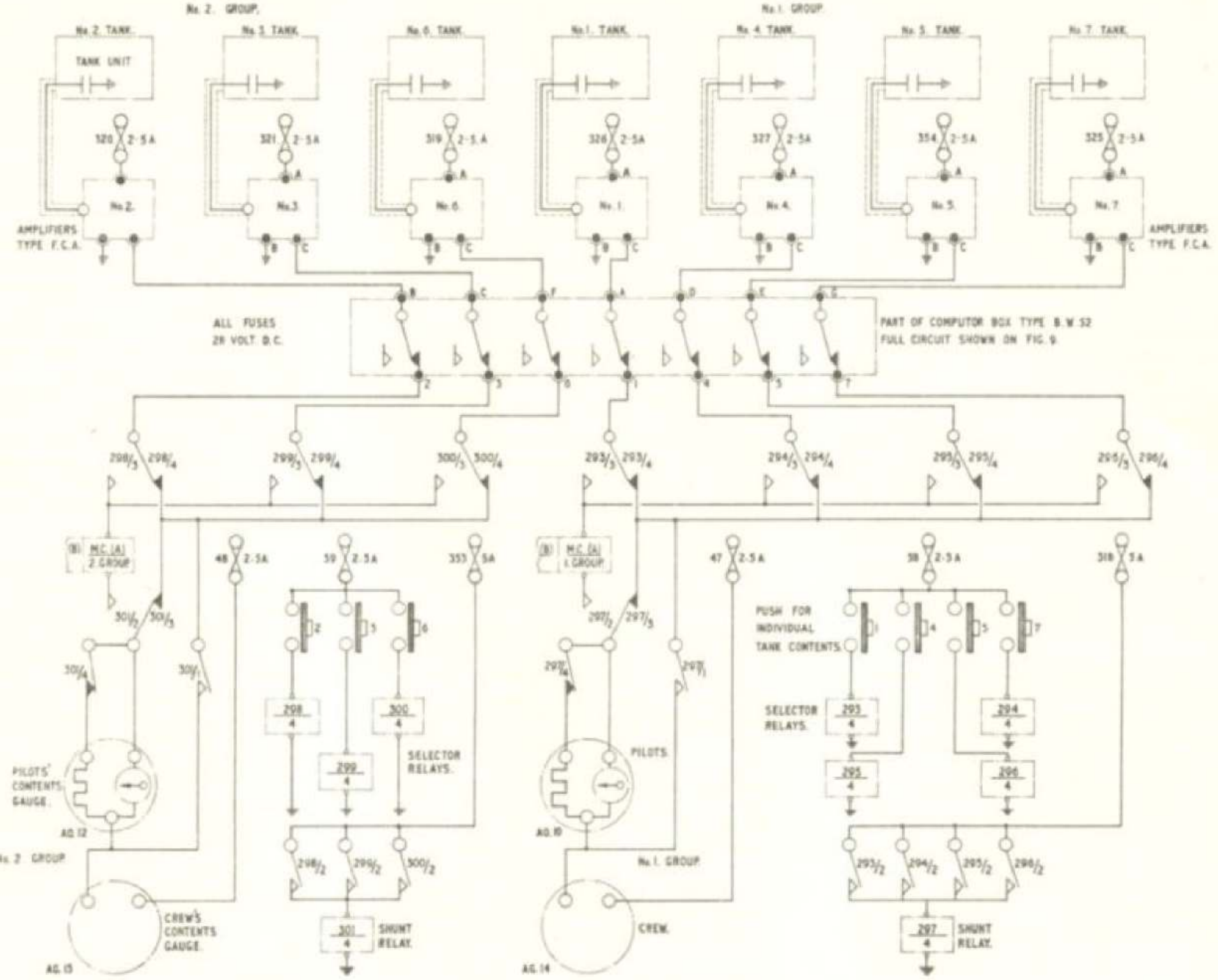

Fig.6 Fuel contents gauging circuit (port)

connecting the centre tap of the primary direct to one pole of the input, and the ends of the primary to each of the primary contacts. The action of the driving arm will then apply the other pole of the input to alternate ends of the winding. A "buffer" capacitor C2 is fitted across the primary contacts to improve the waveform and prevent arcing at the contacts.

52. The resultant stepped up a.c. voltage developed across the centre tapped secondary winding is connected to the rectifying contacts of the vibrator. Due to the rectifying arm being mechanically coupled internally to the driving arm, thus synchronised, a rectifying action will be brought about, converting the stepped up a.c. voltage to unsmoothed d.c. Adequate smoothing is provided by electrolytic capacitors C3 and C4 and a low frequency choke, connected as a low pass filter network. The filtered d.c. output is approximately 400 volts. The supply for the valve heaters is derived from an additional secondary winding which provides an output of 6·3 volt a.c. Capacitor C5 and resistor R23 which are connected in series across the rectifying contacts are used to suppress arcing across the points.

53. The voltage stabilization section of the power pack which consists of four pentodes, two neon stabilizers and associated components, readily divides into two circuits. When the first circuit is functioning normally potentiometer R8 will have been adjusted to set the negative H.T. line to -180 volts with respect to earth. R4 and R9 will also have been adjusted to ensure V3 and V1 are operating at the correct working point on their characteristic curves. V3 cathode will be held constant at + 85 volts with respect to the -180-volt line by the action of the cathode load R7 and Neon stabilizer V5. The action of stabilizing the -180-volt line can now be followed. If the output voltage of the power pack decreases due to the input voltage decreasing, the voltage on the control grid of V3 will drop porportionately via the slider of R9, the resultant rise in anode voltage due to the grid going negative will cause the control grid of V1 to go more positive with respect to the cathode allowing V1 to drive harder with a consequent increase in current flow through V1, R8, R9 and R11. The -180-volt line which is derived from the current flowing through R8, R9 and R11 will rise in proportion to the original decrease, thus the -180 volts with respect to earth is maintained and therefore stabilised. When the output voltage of the power pack increases, a proportional increase in voltage on V3 control grid will result in a fall of voltage at V3 anode, subsequently the control grid of V1 goes more negative with respect to cathode resulting in a decrease of current flowing through V1, R8, R9 and R11, the corresponding fall in the -180-volt line will be proportional to the original increase, therefore maintaining -180 volts with respect to earth, stabilization having been achieved regardless to the variations of the input supply.

54. The second circuit which consists of V2, V4 and V6, utilises the stabilized -180 volts in order to produce the final stabilized 0-50 volts variable output, subsequently used in the refuelling circuits. When the circuit is functioning normally, potentiometers R14 and R18 will have been set initially to allow potentiometer R20, calibrated 0-100% to control the output from zero to 50 volts. The output being constantly monitored by the built in voltmeter also calibrated 0-100%. V4 and V2 will have been set to their correct working point on their respective characteristic curves by suitable adjustment of R4. The cathode of V4 is held constant at + 85 volts with respect to the stabilized -180-volt line by the action of neon stabilizer V6 and cathode load R15. The action of stabilizing the output can now be followed. Due to varying loads applied across the output terminals via the action of the refuelling circuits, V4 control grid will follow the changes by a proportional amount. With the cathode of V4 held at + 85 volts a corresponding change in V4 anode voltage will be presented to the control grid of V2, consequently the current allowed to flow through V2 will be proportional to the load imposed across the output terminals. For example, if the voltage at the output terminals decreases due to loading, the voltage at the control grid will also decrease by a small amount, the grid will now go more negative with respect to the cathode causing a decrease in the flow of current through V4. The resultant voltage rise at V4 anode will be presented to the control grid of V2 driving V2 harder, subsequently more current is allowed to flow through the whole circuit with a consequential rise in voltage at the output terminals, thus compensation to the output has been achieved automatically.

55. The action of components not mentioned in the circuit description are now described as follows. The capacitors C7 and C10 will assist in reducing ripple and also offset sudden surges which may appear on the H.T. lines. Resistors R7 and R15 determine the cathode potential of V3 and V4, while associated capacitors C8 and C9 suppress small fluctuations which may occur on the + 85 volt reference line. Resistors R3 and R13 form the anode load of V3 and V4, while resistors R2 and R12 are used as grid stoppers for V1 and V2 suppressor grids. Parasitic oscillations which may occur within the circuit are effectively suppressed by the action of C13.

56. A bleed path is formed by the indicator relay coil and resistor R10 and is connected between earth and the -180-volt line. Current will only flow when V1

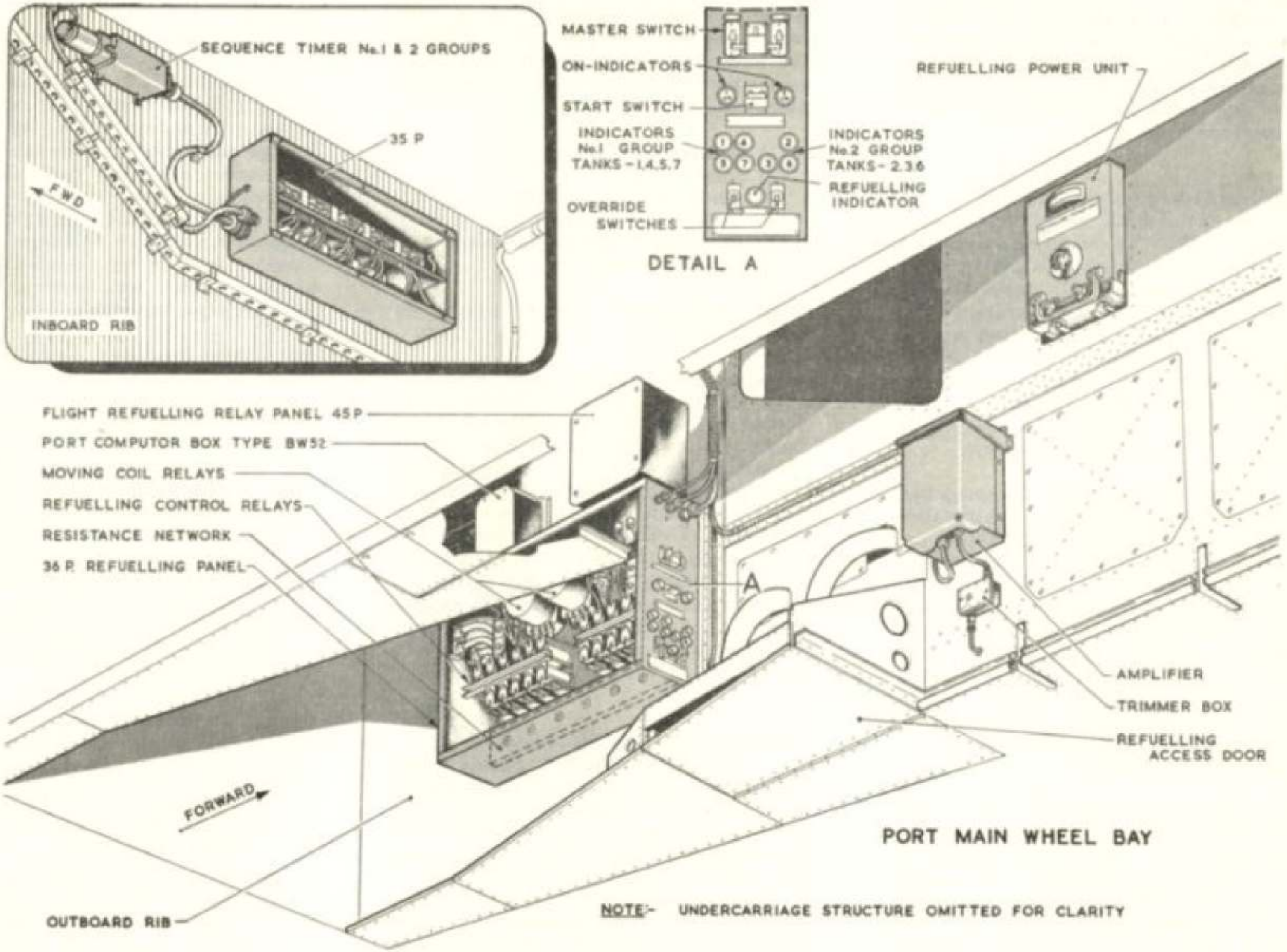

Fig. 7 Ground and flight refuelling controls

is conducting, thereby energising the indicator relay and subsequently closing the relay contacts. By this action a 28-volt d.c. supply is connected to two indicator lamps each positioned in the port and starboard refuelling panels. This will provide visual indication that the stabilized power unit is functioning and that refuelling can commence.

Refuelling selector circuit controls

57. A double-bank ledex rotary auto selector controls the refuelling valves and tank selector relays in each group of fuel tanks. Each auto selector is operated by a relay which in turn is controlled by the MC/2 contacts of the associated moving coil relay. A solenoid operated master switch connects a positive supply to each group refuelling circuit, a start switch is used to operate the auto selector into the correct starting position.

58. When the last tank in the group has been refuelled, the auto-selector automatically steps to a contact which shorts out the hold-on solenoid for the master switch, thus switching off the refuelling circuit for the group. Fuel level switches connected in series with the refuelling valves prevent accidental overfilling and possible damage to the tanks should a failure occur in the refuelling circuit. As an additional safety factor the fuel level switches and refuelling valve are of the double acting pattern.

59. The double acting fuel level switches are wired in series so that the refuelling valve will be de-energised by the opening of either switch. The switches are fitted in the tank so that one switch will be operated at the tanks full level and the other switch at a slightly higher level. This arrangement ensures that the valve will be closed by the rising fuel level even if one switch should stick in the closed position.

60. All the ground refuelling switches, resistance networks and moving coil relays are housed in two refuelling panels 36P and 37P which are located one in each main wheel bay; 36P port; 37P starboard. The forward end of each refuelling panel houses the following control switches and indicators:-

(1) Master switch
(2) Start switch
(3) Group ON indicators (2)
(4) Tank group indicators (7)
(5) Commence refuelling indicator
(6) Override switches

Panel 36P and the various controls are shown in Fig.7.

Ground refuelling external supply plug

61. A 28-volt external supply plug, located on the port side of the aft power compartment, and accessible from outside the aircraft, is used for connecting an external power supply during ground refuelling. The external supply plug is connected to the main 28-volt bus-bar which feeds distribution panels 15 and 16P. Fuses in panels 15 and 16P supply the ground refuelling controls and fuel contents gauging system. For further information reference should be made to Group 2A (D.C. Power and Distribution) of this publication.

Ground refuelling circuit operation

62. The ground refuelling circuit operation of the port three-tank group (No.2) is described in the paragraphs that follow which should be read in conjunction with the theoretical circuit diagrams fig.9 and 9A. The operation of groups 1, 3 and 4 is similar except that in the four-tank groups (1 and 4) an additional refuelling valve, fuel level switch, and auto selector contact has been provided. Throughout the following circuit operation the flight refuelling relay panel will be ignored. It will also be assumed that a 28-volt d.c. supply is connected to the ground refuelling supply plug.

Starting

63. Operation of the handle adjacent to the hose connector at the port wing refuelling point (fig.2) will cause the micro switch to make contacts 2-3 and connect a supply from fuse 353 to the stabilized voltage power unit. When the power unit has warmed up and is ready for use, the commence-to-refuel indicator lamps on each refuelling panel will light. At this stage the sensitive voltmeter should be checked against the selected percentage to ensure that both readings agree, or are within the acceptable limits of ±2%.

64. When the group refuelling MASTER switch is placed to ON, a hold-in coil is energised from fuse 353, via the master switch contacts, and the switch will be held in the ON position. The same supply will be directed to the 'A' bank of the auto selector and to the START switch via the normally closed contacts 291/3 of the master relay. Repeated operation of the START switch will operate the auto selector until it reaches contacts A1 and B1. At this position the start relay, No.292, will be energised from fuse 353 via the MASTER switch and contacts A1 of the auto selector.

65. The closing of relay contacts 292/2 will bring about the following circuit action prior to Mod.1406 being embodied.

(1) The master relay No.291 will be energised and locked in, via its own contact 291/1.

(2) A supply from fuse 353 will pass, via the MASTER switch contacts and relay contacts 292/2, to the No.2 group ON indicator, the moving coil relay contacts, and to the B bank of the auto selector, via relay contacts 695/1 and the Diamond H relay.

The closing of relay contacts 292/2 will bring about the following circuit action, when Mod.1406 has been embodied.

(1) The master relay No.291 will be energised and locked in via its own contacts 291/1.

(2) A supply from fuse 353 will pass, via the MASTER switch contacts and relay contacts 292/2, to the No.2 group ON indicator, the moving coil relay contacts, and to the B bank of the auto selector, via the diamond H relay contacts 10-8. The same supply will also be connected via relay contacts of the diamond H relay, and No.2 resistor, to capacitors No. 6,7,8, thus allowing a charge to build up on the capacitor plates associated with the delay circuit described in a later paragraph.

The opening of relay contacts 291/3 will isolate the start switch, thus preventing the auto selector from being operated past the start position. The closing of contacts 291/2 will prepare the circuit to the OVERRIDE switch.

66. The No.2 tank sequence relay No. 298 will be energised from contacts A1 of the auto selector via the now closed relay contacts 292/1 and the following circuit action will take place:-

(1) The shunt relay No.301 will be energised via contacts 298/2.

(2) All amplifiers will be disconnected from the contents gauge by the opening of contacts 301/3.

(3) The No.2 tank amplifier will be re-connected to the contents gauge via contacts 298/3, the moving coil relay MC(A) and contacts 301/2.

(4) A positive supply will be maintained on the remaining amplifiers (3 and 6) by contacts 301/1.

(5) The shunt will be disconnected from the contents gauge by contacts 301/4.

(6) The B coil of the moving coil relay will be connected to the stabilized voltage power unit via contacts 298/1 and resistor chain R2.

67. The output from the No.2 tank amplifier passes through the moving coil relay, MC(A) and the contents gauge, which will continually register the contents of the tank during ground refuelling operations. The No.2 tank refuelling valve is energised by a supply from contact B1 of the auto selector. This same supply is fed to the tank indicator lamp which will now light to indicate that the valve is open and refuelling may commence.

68. It was stated in the previous paragraph that the group contents gauge will register the contents of the particular tank being refuelled. Because of this it is essential that none of the tank contents push-switches be pressed during refuelling, as the increase in current may cause the M.C. relay to operate before the tank has been refuelled to its selected percentage. This will result in incorrect fuelling and if the total current is more than 7mA the contents gauge may be damaged.

Shut off and re-selection (Pre-Mod.1406)

69. When the current in the (A) coil of the moving coil relay exceeds the current flowing through (B) coil by 2mA, the relay will operate to close contacts C-H, a supply will pass through the closed contacts C-H energising the relief relay No. 289. The parallel contacts of 289/1 and 289/2 will close, to energise the override relay No.290 and relay No.695. The closing of contacts 290/1 will energise the auto selector which will then step to contacts A2 and B2. Movement of the A contact will de-energise the No.2 sequence relay and energise the No.3 sequence relay. Movement of the B contact would normally de-energise the No.2 refuelling valve and energise the No.3 refuelling valve. This however, is prevented by the time delay circuit formed by relay 695 and the Diamond H relay. These items will be treated fully in the next paragraph. Relay contacts 290/2 will close to by-pass the current flowing through the moving coil relay MC(A) which in turn will open contacts MC/1. The opening of contacts MC/1 will de-energise relay 289 and the next refuelling cycle will commence.

Shut-off and re-selection (Post Mod.1406)

70. When the current flowing through the (A) coil of the moving coil relay exceeds the current flowing through (B) coil by 2 milliamps, the relay will operate to close contacts C-H, a supply will pass through the closed contacts C-H energising the relief relay No.289. The parallel contacts of 289/1 and 289/2 will close to energise the override relay No.290. The closing contacts 290/1 energise the auto selector which then steps to contacts A2 and B2. By this action the No.2 sequence relay de-energises and the No.3 sequence relay will be energised via contacts A2, at the same instant the No.2 refuelling valve de-energises to close and the No.3 refuelling valve is energised to open via contact B2. The action of the No.3 refuelling valve opening, however, is delayed by the operation of a delay circuit associated with the Diamond H relay, a full description of this delay circuit will be given in the next paragraph. Relay contacts 290/2 close to by-pass the current flowing through the

moving coil relay MC(A) which in turn will open contacts MC/1. The opening of contacts MC/1 will de-energise relay 289 and the next refuelling cycle will commence.

Time delay operation

71. The operation of the 'B' contact as described in the previous paragraph (closing of No.2 valve and immediate opening of No.3 valve) is perfectly acceptable providing that the new tank selected requires fuel. If however this and the subsequent tanks are already filled to selected percentage, then the following undesirable effects may appear. As the No.3 valve is opening a cancellation signal will be fed from the No.3 amplifier to the moving coil relay. The relay will then be energised to bring about the override cycle, thus snapping the valve shut as the auto selector contacts move on. This rapid opening and closing of the valve gives rise to 'flick' pressures which have a tendency to build up to high pressure as the action is repeated at subsequent tanks.

Circuit operation (Pre-Mod.1406)

72. To prevent the formation of 'flick' pressures a Diamond H relay No.694, and relay 695 are connected in the supply line to the B contact, which controls the refuelling valves. The supply to the B contact is first broken when relay 695 is energised along with relay 290. Contacts 695/1 open to break the supply whilst relay contacts 695/2 close to connect the supply to the coil of the Diamond H relay, via the No.2 and No.4 resistors and the tantalum capacitors. Energising the coil of the Diamond H relay will then open contacts 10-8 of the relay. Meanwhile the auto-selector will have moved to the next contact, the selector relay will be energised, and the moving coil relay shorted out by contacts 290/2. As relay 289 is de-energised by contact C-H opening, the supply to relays 290 and 695 will be broken, thus re-making contacts 695/1 and breaking contacts 695/2. At this point the tantalum capacitors will discharge through the coil of the Diamond H relay, via the No.4 resistance, and by so doing prevent the closing of contacts 10-8. This delay will be long enough for the cancellation signal to bring about the energising of the override relay and so move the auto-selector on to the next contact, without the opening of any valve.

Circuit operation (Post Mod.1406)

73. With the introduction of Mod.1406 a new circuit arrangement has been incorporated which deletes relay No.695. The new circuit, which alters the operation of the delaying action of the Diamond H relay is described as follows Reference should be made to Fig.9A throughout the following text.

(1) The Diamond H relay is energised for a brief period via relay contacts 290/1 and a diode, this will open contacts 10-8 and break the supply to the B bank of the auto-selector switch and refuelling valves, at the same instant the capacitors No.6,7 and 8 are allowed to discharge through resistor No.2 and parallel contacts 3,2 - 5,6 and finally the coil of the Diamond H relay, this will allow the Diamond H relay to hold on after the initial supply via contacts 290/1 has been removed. It will follow, that the Diamond H relay will remain energised for a period determined by the time constant of resistor No.2 and capacitors No.6,7 and 8. The current passing through the Diamond H relay coil will steadily decrease due to the capacitors losing their charge, and when the current flowing through the Diamond H relay coil has dropped to a level, whereby, the relay returns to the de-energised position, the supply to the B bank of the auto-selector and refuelling valves is restored, also capacitors No.6,7 and 8 are allowed to recharge in time for the next operation of relay 290.

(2) The delayed operation of the Diamond H relay will provide sufficient time for the cancellation signal to bring about the energising of the override relay 290, and so move the auto-selector to the next position, without the opening of any valve.

(3) The action of the diode, referred to in (1) is to ensure that capacitors No.6,7 and 8 discharge through the coil of the Diamond H relay only, the high backward resistance of the diode prevents the capacitors from being discharged through the auto-selector switch solenoid.

Completion of refuelling

74. When No.6 tank has been filled to the percentage of its capacity the auto-selector will be operated to contacts A4 and B4. This action will connect a supply to the other side of the master switch coil, which will de-energise and open the master switch, so isolate the refuelling circuit. The No.6 sequence relay (300), will be de-energised and subsequently the shunt relay will be de-energised and the contents gauge will return to summating the tank fuel group contents.

75. The supply to the stabilized voltage power unit will remain on until the refuelling hoses have been removed and the micro switch operating handle has been returned to its normal horizontal position.

This action will switch off the power unit and the warning lamps will be extinguished.

Fuel level switches

76. Should any tank become overfilled during the refuelling operation the appropriate fuel level switch will operate to close the refuelling valve. The override relay 290 will be energised, causing the auto-selector to step round to the next tank.

Override switch

77. The selector override switch is provided as a means of operating the auto-selector for servicing purposes. The master switch must be ON and the auto-selector stepped to the beginning of the cycle by the start switch before the override switch becomes operative. Each operation of the override switch will step the auto-selector through its normal refuelling sequence until the final operation trips the master switch. The override switch must not be operated during normal ground refuelling operations, or the auto-selector will step to the next tank before the selected tank is filled to the required percentage capacity.

FLIGHT REFUELLING

78. Flight refuelling is carried out by the drogue and probe method as outlined in A.P.4611, Vol.1. The probe on the receiver aircraft is fitted to the metal nose fairing, and from the probe main intake pipe, branch pipes connect to the fuel tanks, via the normal ground refuelling valves. A probe fuel pressure gauge is provided on the starboard console 7P.

79. After the aircraft has been flight refuelled, the fuel remaining in that section of the pipe line in the cabin area is purged by nitrogen pressure into the No.2 tanks.

80. Since the fuel tanks on the aircraft are flight refuelled until they are full, and all tanks are filled together, a C.G. indicator and fuel balancing circuits are provided to enable the correct C.G. to be maintained during flight refuelling operations. Details of these circuits are found under their respective headings.

Controls

81. The control switches for the flight refuelling portion of the fuel system are located on the starboard console 7P as shown in fig.8. The C.G. controls are mounted on the centre console, and the pilots' indicator is mounted on the pilots' centre panel.

Flight refuelling master switch	This consists of two single-pole 2-position switches and is the primary control for the complete system.
Nitrogen purge switch	This single-pole centre-off switch controls the supply to the nitrogen valve actuator relay and the No.2 tank refuelling valve.
Air release valves control switch	This single-pole switch controls the pressurisation valves in the main fuel tank pressurisation system.
Tank pressure indicators	Four magnetic indicators, one for each tank group, are positioned on the flight refuelling panel to provide positive indication that all tanks have been depressurised. The indicators are energised white when the tanks are depressurised.
Flight refuelling indicator	The indicator has fourteen red lamps, each representing a fuel tank and arranged in plan form as the tanks are situated in the aircraft. The lamps light when the refuelling valves open, and go out as each tank is filled and refuelling valve closes.
C.G. control switch	This switch is labelled PORT - OFF - STARBOARD and is spring-loaded to the centre-OFF position. Operation of the switch to PORT will stop refuelling on tank 6 and 7 on the starboard side of the fuel system. Operation of the switch to STARBOARD will stop refuelling on tanks 6 and 7 on the port side of the fuel system thus allowing a correct lateral C.G. to be maintained.
C.G. transfer switches	Two of these switches are fitted, one for each side of the fuel system. They normally control fuel trim between tanks 1 and 7, but when the flight refuelling master switch is in the ON position, the normal transfer circuit is isolated. If FWD. is then selected, refuelling will cease on tanks 6 and 7 and continue on tanks 1; 2; 3; 4 and 5. If AFT is selected, refuelling will cease on the fuselage tanks and continue

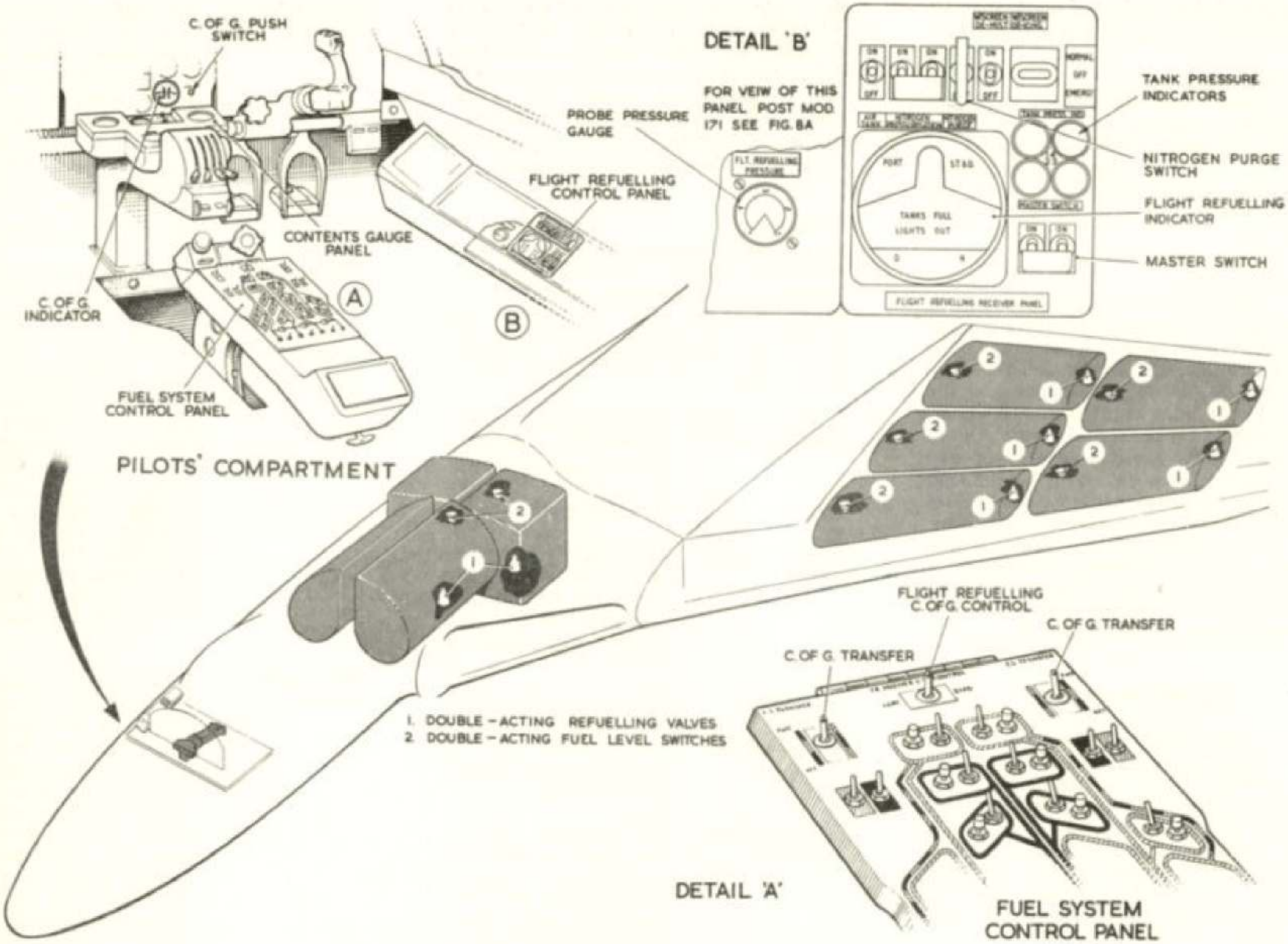

Fig. 8 Flight refuelling equipment

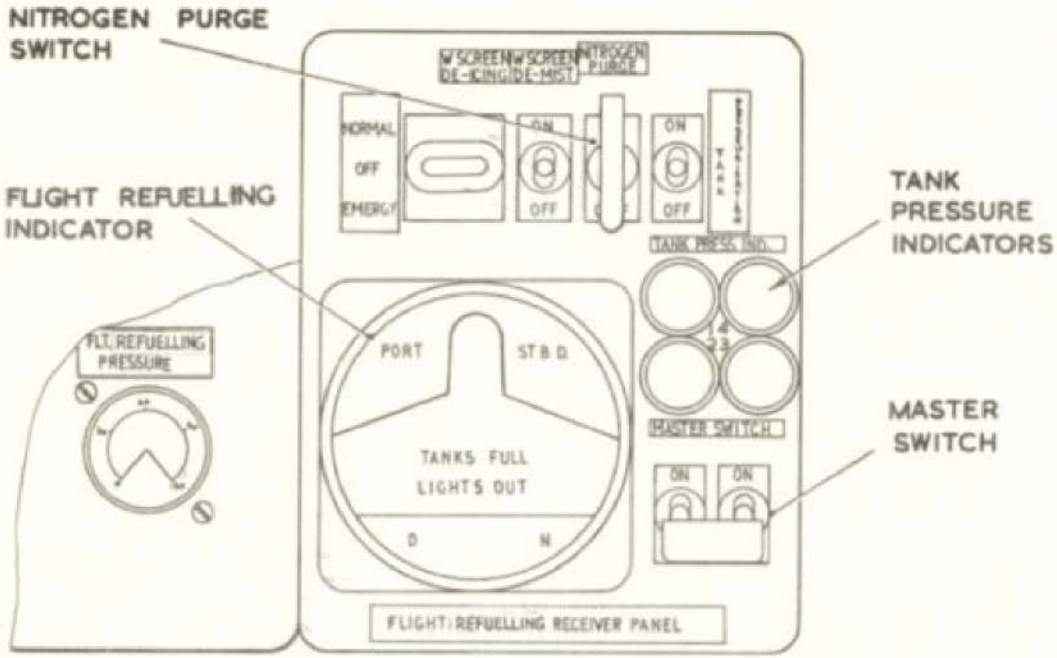

Fig.8A Flight refuelling panel (post Mod.171)

on the wing-tanks, thus enabling the aircraft fore and aft C.G. to be maintained.

C.G. indicator and computor boxes

82. A C.G. indicator Type S128/5/62 is fitted on the pilots' centre panel, as illustrated in fig.8. The indicator has two movements, one for each side of the fuel system. Signals for each movement are provided by the F.C.A. amplifiers via computor boxes.

83. The computor boxes, Type BW.52 are installed one in each main wheel bay, adjacent to the ground refuelling panels, as shown in Fig.7. Each box is an analogue computor which contains a resistance network and a number of change-over relays, and is connected between the tank amplifiers and the indicator circuits of the Smith Waymouth fuel contents gauging system. The output signal when displayed on the C.G. indicator provides a visual indication of the state of the balance of fuel in the pitch axis.

84. The output signal is produced by taking the output current from each amplifier and multiplying this by a fraction. The amplifier output is a function of the weight of fuel in its associated tank and the fraction is proportional to the distance of the tank from a horizontal datum passing through the desired C.G. The sum of these currents is proportional to the total moment of the weight of the tank system about the datum line. When the moment is zero, the C.G. of the tank system is in the required position. If the moment is not zero, a signal is fed to the indicator. The signal is a representation of the magnitude and direction of the displacement of the C.G. of the tank system.

85. The change-over relays within each computor box are normally de-energised during flight so that the amplifier outputs are fed to the contents gauging systems. When, however, the flight refuelling master switch is in the ON position, the change-over relays are energised and the amplifier outputs are switched to the computor boxes. Resistors within the boxes split the output currents so that a proportion of the currents return to the positive supply, whilst the remainder return to a common point from which it flows to the positive supply via the appropriate coil of the C.G. indicator.

86. The resistors, are so chosen that the contribution of current received by the C.G. indicator coils from any amplifier is proportional to the moment about the lateral axis, through the aircraft C.G., of the mass of fuel in the corresponding tanks.

87. Since tanks 1 and 2 are forward of the aircraft C.G., while the remaining tanks are aft of it, one C.G. indicator coil will carry a current proportional to the total moment of tanks forward of the nominal fuel C.G. whilst the other coil will carry current proportional to the moment of the tanks aft of the nominal fuel

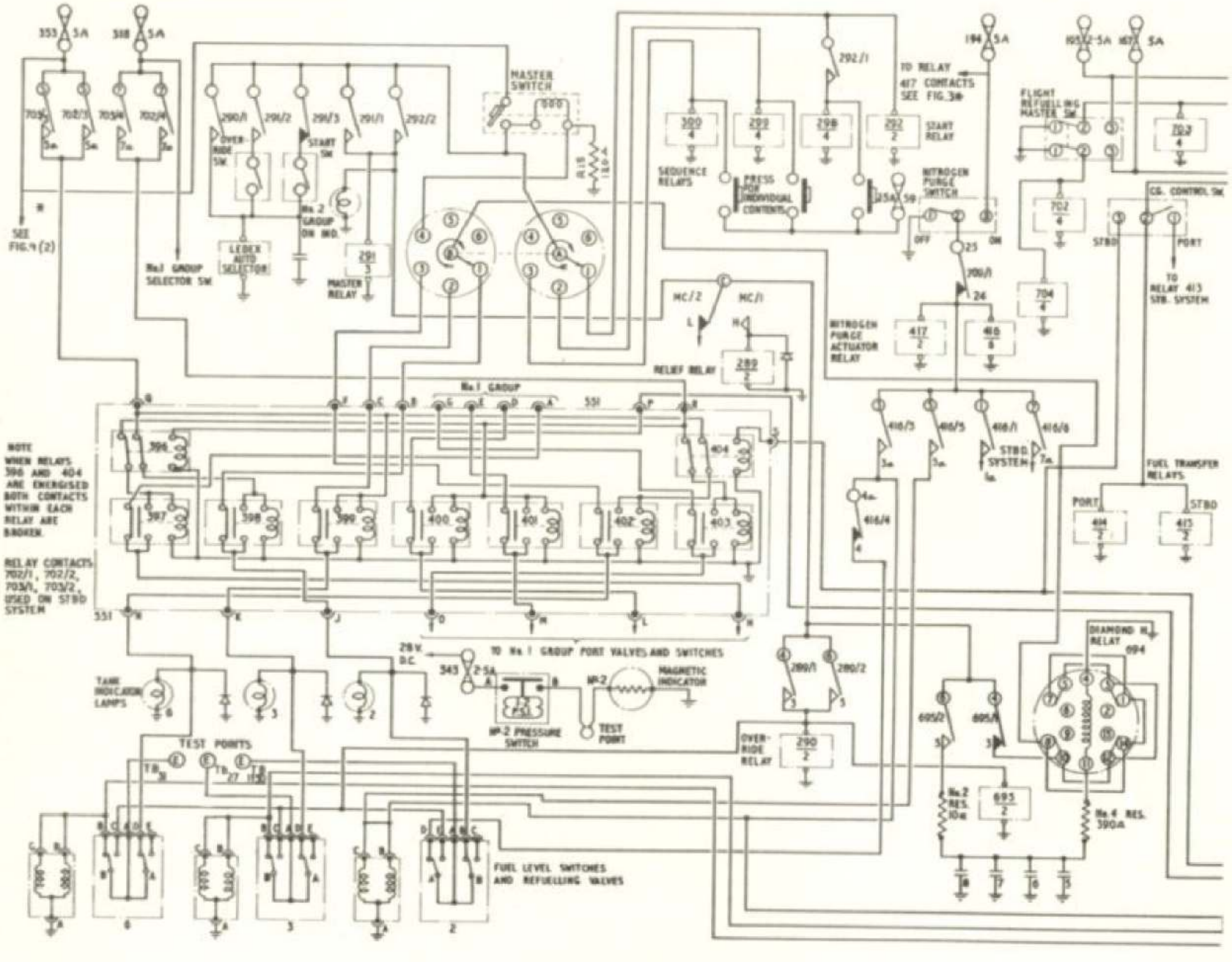

Fig.9 (1) Ground and flight refuelling circuits (pre. Mod. 1406)

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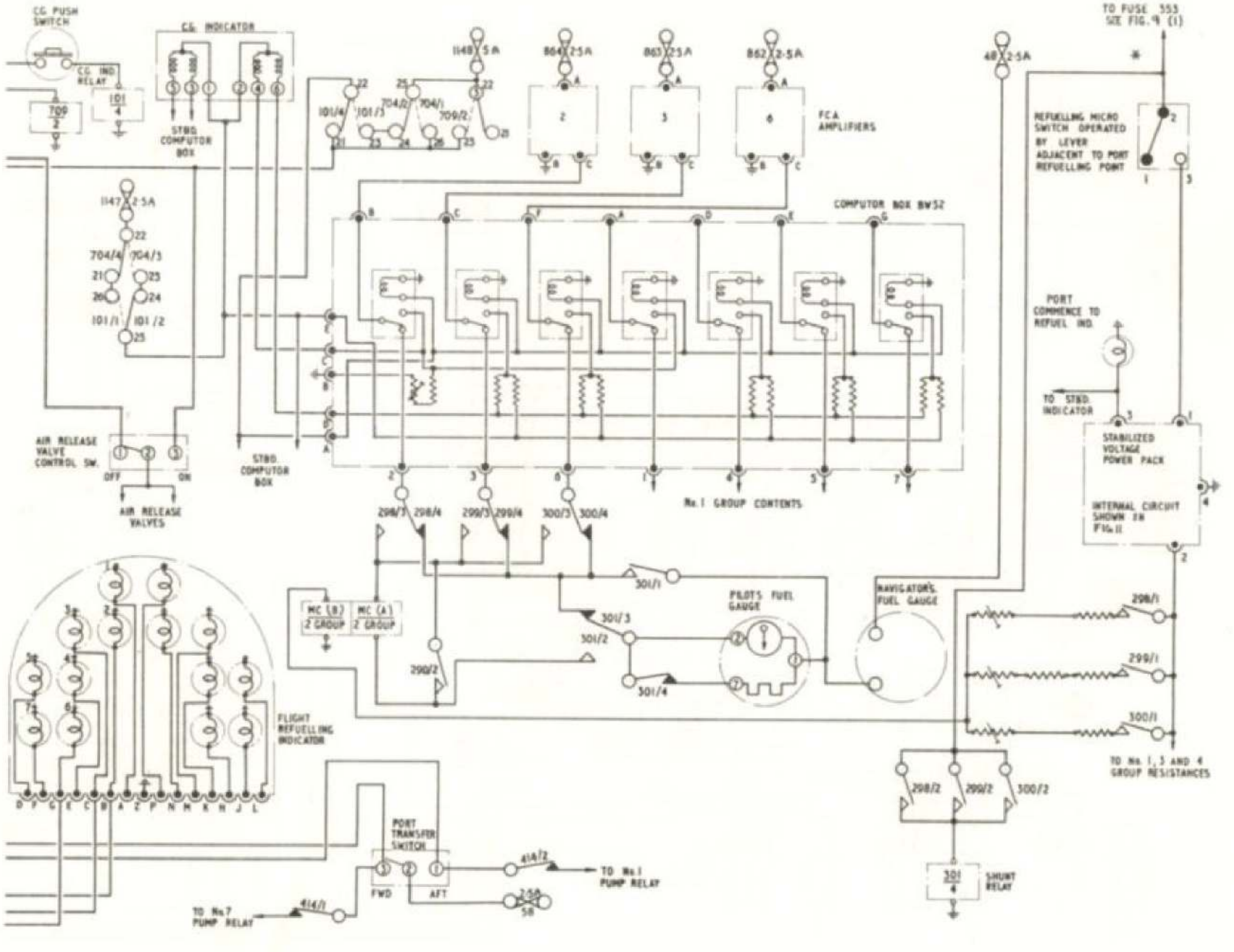

Fig.9(2) Ground and flight refuelling circuits (pre Mod 1406)
(◄ Correction to indicator pins P-N ►)

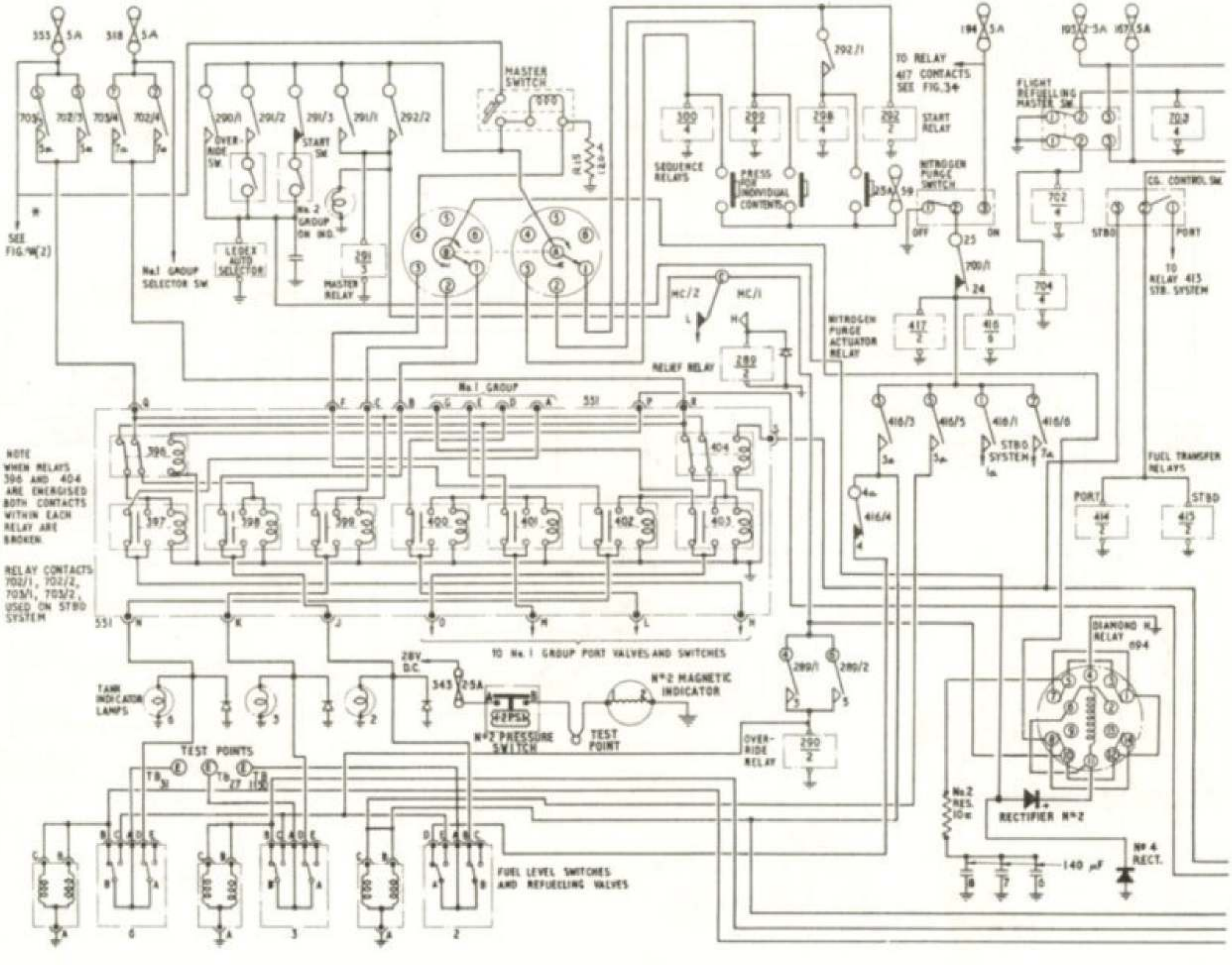

Fig. 9A (1) Ground and flight refuelling circuits (post Mod. 1406)

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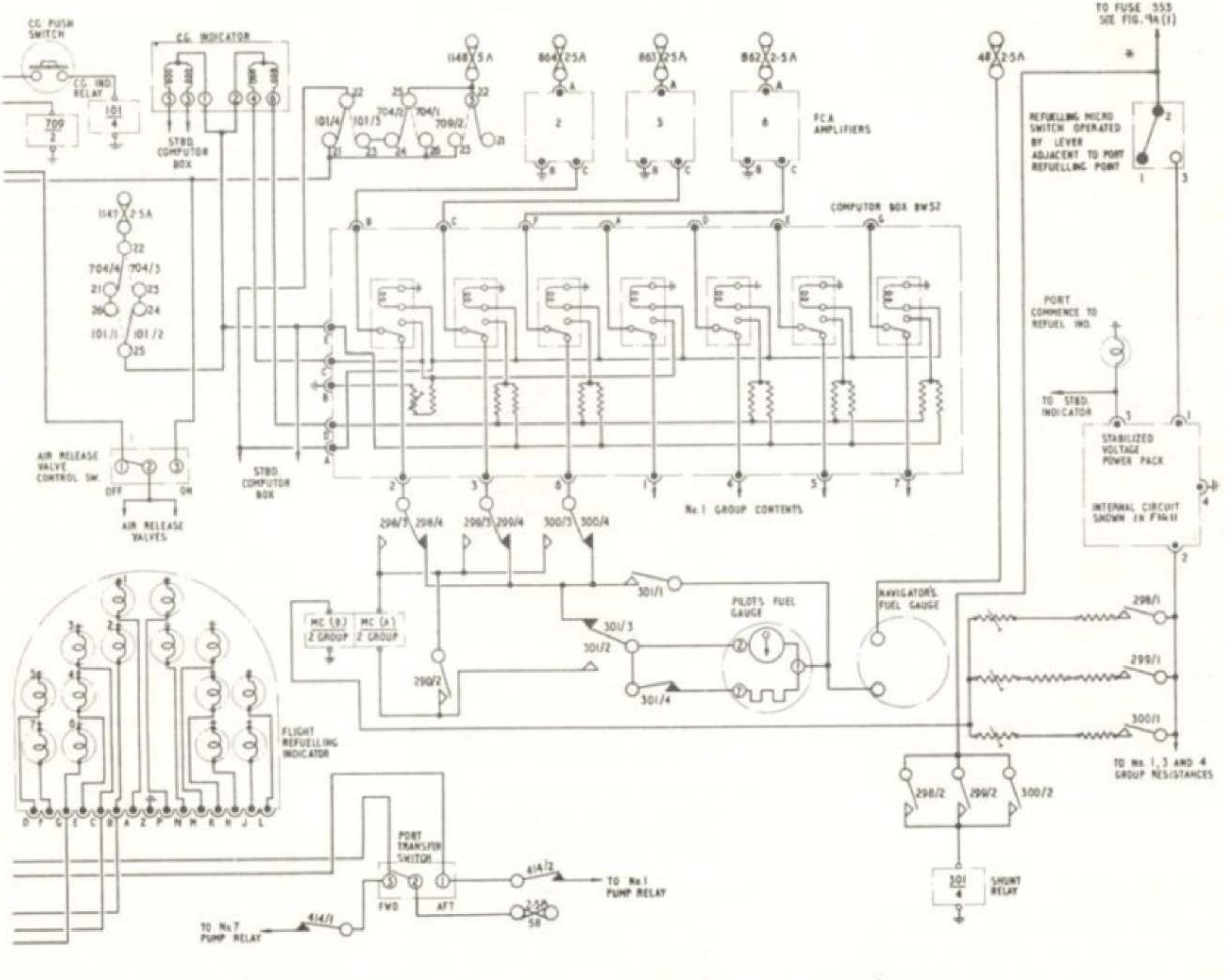

Fig.9A(2) Ground and flight refuelling circuits (post Mod 1406)
(◄ Correction to indicator pins P-N ►)

C.G. Thus, when the moment of tanks 1 and 2 are equal to the moment of the other tanks, the indicator will show no deflection. Out of balance, when the two moments are not equal, will be indicated by an appropriate deflection on the indicator.

88. Owing to the proportion of the current required, and to the fact that each amplifier delivers 2mA when the tanks are empty, the resulting unbalanced current in the C.G. indicator is offset by means of a little extra current drawn by an adjustable resistor connected to the coil receiving currents from tanks 1 and 2.

C.G. push-button

89. Should C.G. indications be necessary during normal flying conditions, a push-button labelled C.G. CHECK, is provided adjacent to the C.G. indicator. Operation of the push-button energises relay 101, which in turn energises the relays in both computor boxes, thus transferring the amplifier outputs, via the computor box network to the C.G. indicator coils. During the period the push-button is depressed, no indication is presented on the fuel contents gauges. In conditions of flight refuelling, when the flight refuelling master switch is on, the C.G. indicator registers automatically while supplies to the contents gauges are cut off. Should the C.G. push-button then be pressed, however, supplies to the C.G. indicator will be cut off and restored to the contents gauges.

Panels 45P and 46P

90. The necessary control and change-over relays for the refuelling valves and transfer circuits are fitted into suitable panels (45P port and 46P starboard) mounted in the wheel bays adjacent to the ground refuelling panels.

Circuit operation

91. The circuit operation outlined in the following paragraphs should be read in conjunction with the theoretical circuit diagram fig.9. Note that the circuit given is for No.2 (port) tank group, operation of the other groups being similar.

Switching on

92. When the flight refuelling master switch is placed in the ON position, the fuel system is prepared in the following manner:-

(1) Relay 704 is energised, allowing the amplifier output from each tank to be connected to the C.G indicator, via the computor boxes.

(2) Relay 709 is energised and a supply is made available to the port and starboard C.G. control switch.

(3) A supply is connected to the fuel transfer isolation relays (414 and 415) to isolate the fuel transfer pumps.

(4) The nitrogen purge circuit is isolated by the opening of the normally closed relay contacts 709/1 as relay 709 is energised.

(5) A supply is connected to the air release valves, via the associated control switch, thus de-pressurising the fuel tanks (para.108-113).

(6) Relays 702 and 703 are energised, their contacts closing to give a 28-volt d.c. supply to the port and starboard refuelling panels (45P and 46P).

C.G. indication

93. When the refuelling master switch is placed to the ON position, a supply from fuse 1148 will be fed via relay contacts 704/1 and 101/4 to the coils of the relays in the port and starboard computor boxes. The seven relays in each box will be energised and their contacts will disconnect the amplifier outputs from the contents gauging system, and connect them, via the resistance networks, to the coils of the C.G. indicator. At the same time a supply from fuse 1147 will be fed via contacts 704/3 and 101/2 to the C.G. indicator and the resistance networks. The indicator will now present fore and aft C.G. of the fuel system. (Note that should the C.G. push-button be pressed, relay 101 will be energised to restore fuel contents indication and isolate the C.G. indicator).

Refuelling valve operation

94. With the master switch still in the ON position, a supply is fed from fuse 318 via contacts 702/4 and 703/4 to energise relays 397; 400; 401 and 403. Relays 398; 399 and 402 are energised via contacts 702/3 and 703/3 from fuse 353. Operation of these relay contacts will disconnect the ground refuelling circuitry from the fuel level switches and refuelling valve solenoids, and connect a supply direct to the refuelling valves, via the closed switches of the fuel level switch. As each refuelling valve is energised to open, the appropriate indicator lamp in the flight refuelling indicator will light.

95. Flight refuelling may begin when all the lamps in the indicator are lit, and the magnetic indicators are energised white, and also proper contact has been made with the tanker aircraft (A.P.4611, Vol.1). As each fuel tank is filled, the associated fuel level switch will operate to close the refuelling valve and switch

off the appropriate lamp in the indicator, thus indicating the tank is full.

96. The refuelling operation will be completed when all the lamps in the indicator are out and the aircraft may then disengage from the tanker. When this has been done the flight refuelling master switch should be set to OFF.

Switching off

97. Placing the master switch to the OFF position will cause the fuel system circuits to revert to their previous state, i.e., the fuel contents system will again function as normal, and the fuel transfer system between tanks 1 and 7 will again be available, the fuel tanks will be re-pressurised, and supply be made available for the nitrogen purge system.

Nitrogen purging

98. Operation of the nitrogen purge control switch to ON will open No.2 tank refuelling valves and nitrogen valves, so that residual fuel in the cabin area fuel lines is purged into No.2 tanks. Circuit operation as follows:-

(1) Moving the nitrogen purge switch to the ON position, will energise relays 416 and 417.

(2) The contacts of relay 417 will operate the nitrogen valve actuator, thus admitting nitrogen to the fuel lines.

(3) At the same time, the operation of relay contacts 416/1, 416/3, 416/5 and 416/6 will energise both coils of the No.2 refuelling valves. The valves will open and allow the purged fuel to enter the tanks, and at the same time the No.2 tanks refuelling lamps will light.

(4) Note that the opening of relay contacts 416/4 will isolate the fuel level switches.

99. When the purging operation has been satisfactorily completed, the control switch is returned to the OFF position. This action will shut off the nitrogen supply, and close the No.2 tanks refuelling valves, also the No.2 tanks refuelling lamps will be extinguished.

C.G. balance during flight

100. As stated in paragraph 80, due to the fact that all tanks are refuelled together until they are full, it is necessary to provide some means of controlling the fuel flow to the tanks if the correct aircraft C.G. is to be maintained. Details of the two control circuits are provided in the following paragraphs.

Maintaining lateral C.G.

101. During the flight refuelling period, a supply is fed from fuse 1148, via contacts 709/2 to the centre terminal of the C.G. control switch. The C.G. control switch is spring-loaded to the centre OFF position, but may be selected to two positions, PORT or STARBOARD. Holding the switch in the STARBOARD position will energise relay 404. This action will open the relay contacts, and interrupt the supply to relays 402 and 403 (45P). Consequently the port refuelling valves of tanks 6 and 7 will be de-energised and refuelling stopped, meanwhile, refuelling will continue on the remaining tanks.

102. A similar sequence of operations will take place when the switch is moved to PORT. In this case refuelling will cease on tanks 6 and 7 of the starboard side. By these means the pilot is able to control the lateral C.G. during flight refuelling.

Fore and aft C.G.

103. Longitudinal or fore and aft C.G. is maintained during the flight refuelling period by use of the two fuel transfer switches, labelled FWD. and AFT, located on centre console 5P.

104. Moving the master switch to the ON position, will energise relays 414 and 415 to isolate the transfer relays. If both port and starboard transfer switches are now selected to FWD., refuelling will be stopped completely on wing tanks 6 and 7, but will continue on the remaining tanks. Moving the switches to AFT will cut out the fuselage tanks 1 and 2 and continue refuelling on the wing tanks.

105. When the port transfer switch is selected to FWD., this will energise relay 404 in 45P. Closing of its contacts will interrupt the 28-volt d.c. supply to coils of relays 402 and 403, and this in turn will de-energise their respective refuelling valves and refuelling will cease. Selecting the switch to AFT will energise relay 396 in 45P and this in turn will de-energise relays 397 and 398, so closing the fuselage tank refuelling valves.

106. By these means fore and aft C.G. may be controlled throughout the whole refuelling period. Note that in all cases of C.G. balance, when refuelling valves are de-energised, the appropriate lamps will be out, thus providing a cross-check that the system is functioning correctly.

Probe pressure gauge

107. A fuel gauge Type S.149/1/55 is fitted on the starboard console 7P to provide the pilot with probe fuel pressure information during the flight refuelling operation. The indicator is operated by a Type S.122 transmitter which is fitted in the flight refuelling pipe line. The gauge is electrically operated and is pro-

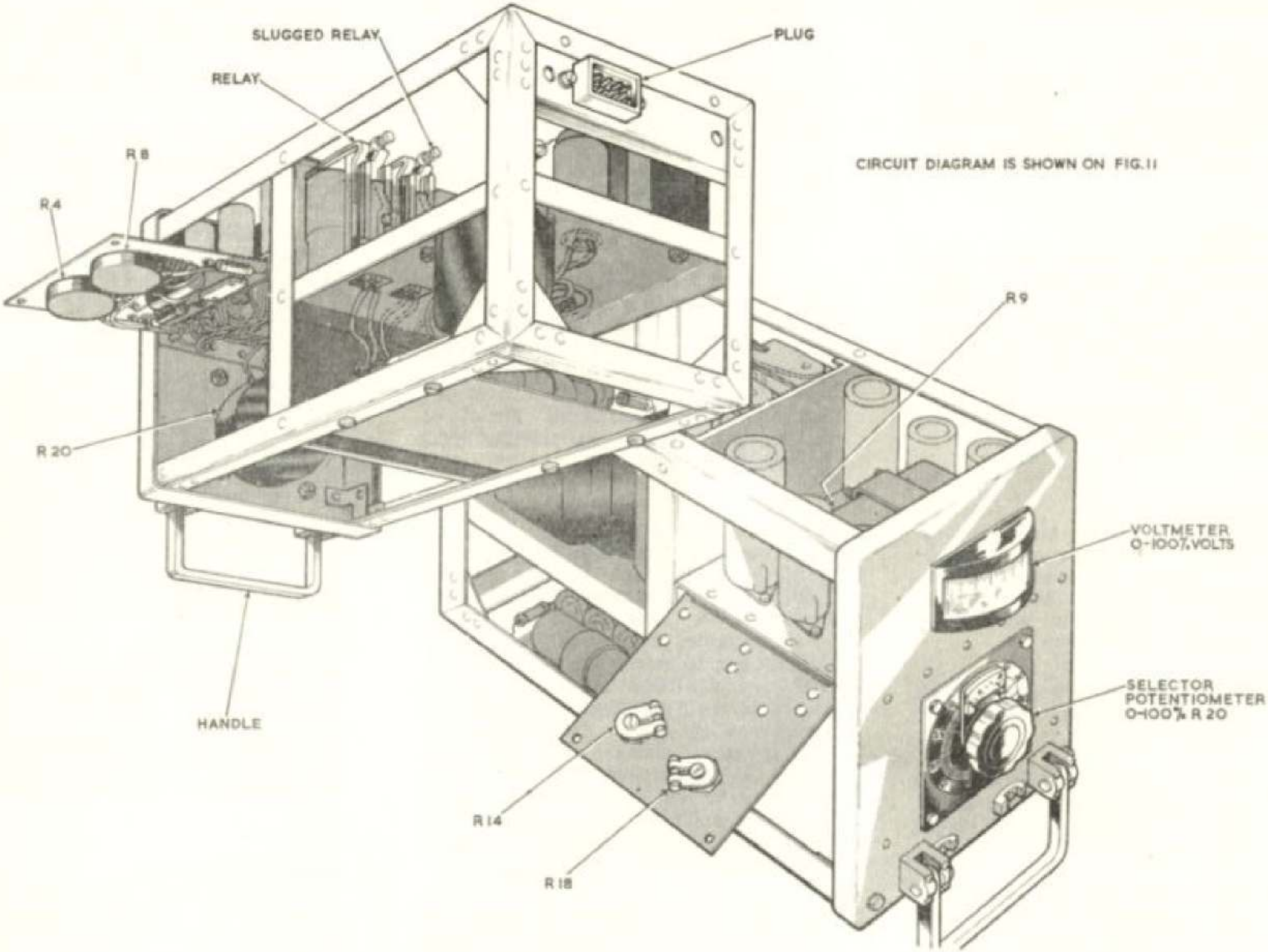

Fig. 10 Stabilized voltage power unit

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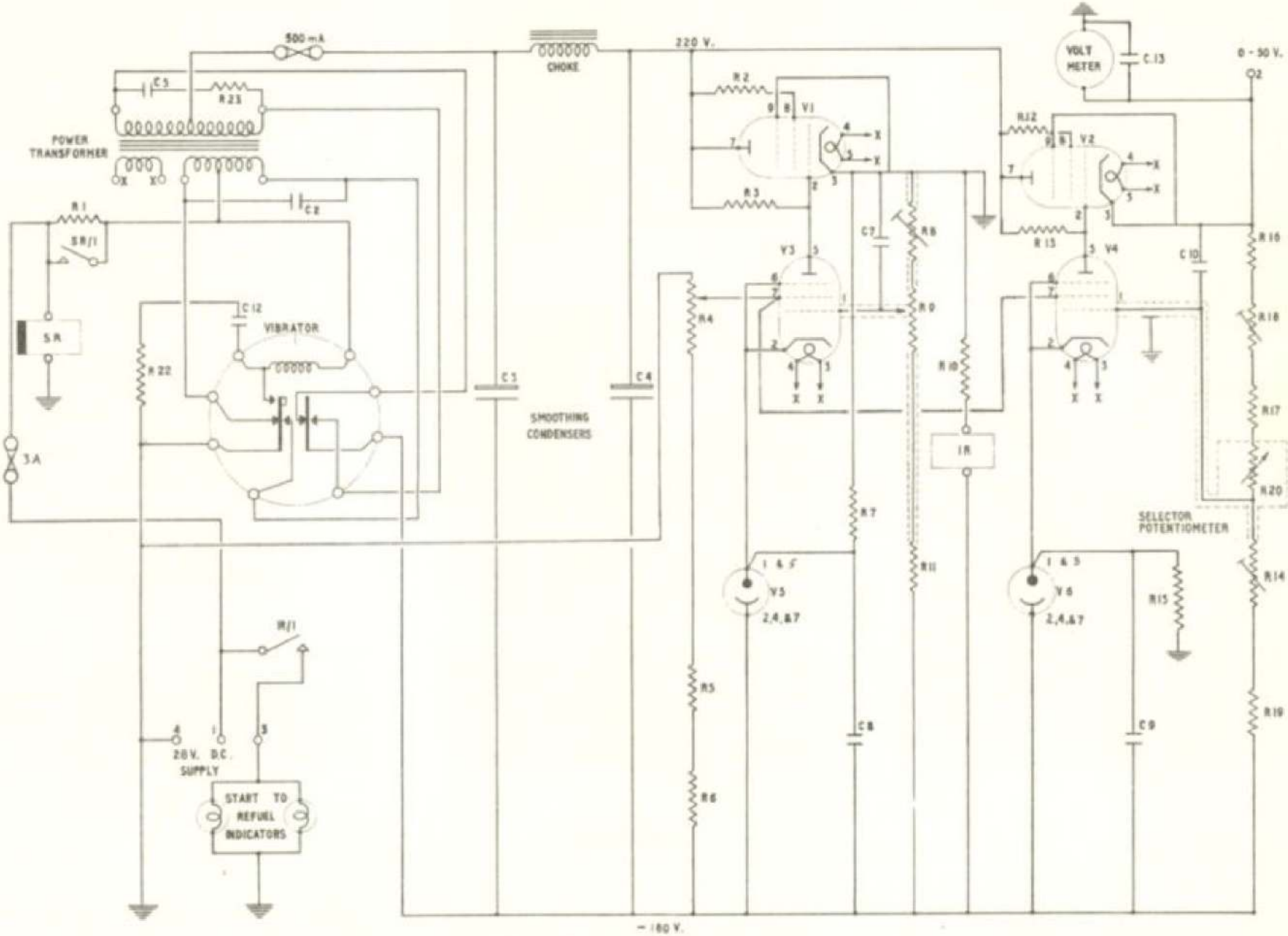

Fig. 11. Stabilized voltage power unit circuit

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vided with a 28-volt d.c. supply from fuse 1046 in panel 4P (fig.35).

FUEL TANKS PRESSURISATION

108. On early Vulcan Mk.1 aircraft the fuel tanks are pressurised by a mixture of nitrogen and engine air. With the embodiment of Mod.171 (Explosion protection) however, the nitrogen system is deleted and pressurisation is by air only. The circuit, both pre and post Mod.171, is shown in fig.36 and 37. For a full description of the tanks pressurisation system, reference should be made to Book 1, Sect. 4, Chap.6.

Air release valves

109. Four pressure relief valves, one to each group of fuel tanks are used to relieve tank pressure during conditions of ground or flight refuelling, or when the aircraft is about to land. The valves are then energised to close the air pressurising lines, at the same time allowing the tanks to be vented to atmosphere. In normal flight the valves are de-energised, the pressure lines opened, and all venting closed. The valves, Teddington Type ES/A/390, are mounted, two on each pressurisation panel in the compartments aft of the mainwheel bays, and the associated control switch is fitted on the starboard console. Indication that all tanks have been de-pressurised is provided by four magnetic indicators mounted on the starboard console panel, each indicator is energised by the operation of a pressure switch fitted to the vent line of each tank group. When the pressures in the vent lines drop to 1.2 p.s.i. the associated pressure switches close to connect a 28-volt d.c. supply via fuses 307, 343, 344 and 347 and thereby energise the respective indicators white. Note that where the tanks pressurisation system is described in Book 1, the valves are referred to as de-pressurisation solenoids.

Pre-Mod.171

110. Nitrogen is fed to the aircraft fuel tanks via two master valves, one port and one starboard. The valves are actuator operated, each consisting of a Dunlop valve, Type SK.25101, and a Plessey Panther actuator, Type CZ.54709, fitted adjacent to the bank of nitrogen cylinders in the compartments aft of the mainwheel bays. Selection of the master valves to the open or close position is made from two control switches on the starboard console. Further information on the Dunlop valves will be found in the appropriate volume of A.P.4303 series; the actuators are dealt with in A.P.4343D, Vol.1, Sect.16.

111. Reference to fig.36 will show that with the air and nitrogen pressurisation switches in the OFF position, a supply will be made from fuse 167 (fig.30) to energise the air release valves and close the nitrogen actuator valves. Thus in this condition no pressure will be applied and the tanks will be vented to atmosphere. When the switches are placed to ON, the air release valves will be de-energised and the same supply will be made to open the nitrogen valves via relay contacts 533/2 and 533/4. Air and nitrogen will then be fed to the tanks and tank venting will be closed.

112. During flight refuelling operations, the flight refuelling master switch (fig.9 and 30) will be on and a supply from fuse 193 will be made via the switch contacts to energise relay 709. A supply from fuse 1148 will then be made via contacts 709/2 to initiate the following action:-

(1) The air release valves will be energised via contacts 3-2 of the control switch, which is on in flight. (Note that relay 704 will also be energised by the master switch, and a parallel path from fuse 1148 is made via contacts 704/1).

(2) The nitrogen valves will be closed by a supply from fuse 166 via contacts 533/1 and 533/3.

Post Mod.171

113. The nitrogen valves are deleted (fig.37) and the function of the air release valves remains as described for pre Mod. conditions. The circuit is also shown in the theoretical circuit diagram, fig.9.

SERVICING

General

114. Due to the operation of the electrical and mechanical controls of the fuel system being so closely allied it is essential that co-operation of the highest order is maintained between the airframe, electrical and instrument trades. This will ensure that a high degree of serviceability is maintained, and also obviate unnecessary repetition of function tests etc., during inspection periods. Servicing and test functioning of the electrical components of the system is dealt with in the following paragraphs; servicing for the mechanical portion of the fuel system is contained in Book 1, Sect.4, Chap.2 of this publication.

FUEL BOOSTER PUMPS

115. Servicing information for the fuel booster pumps, Type S.P.E.808 Mk.2 is contained in 4343D, Vol.1, Sect.8, to which reference should be made for details of power consumption, pressure, rate of delivery and testing precautions.

116. As stated in para.6 of this Group, ammeter test coils are provided to enable the current consumption of each fuel booster pump to be checked. The test coils are located in the bomb bay on the aft face of the front spar. The current consumption of each pump motor should be checked periodically, using a tong-type ammeter, (Ref.No.5Q/38), at the 0-50 amp. range. The reading on the ammeter must be divided by 10 to give the current consumption of the fuel pump motor under test.

117. Pumps calibration and feed line checks will be found in Book 1, Sect.4, Chap.2. Although these checks are almost wholly mechanical they call for use of the sequence timer test box, Ref.No.26DC/-95250, and the electrical tradesman will be required to connect the box and give any other necessary assistance.

118. A description of the sequence timer test box is given in A.P.4343V, Vol.1, Sect.4. With this item it is possible to check the sequence timers for correct operation of the cam switches during normal functioning of the aircraft fuel system. A.P.4343V, Vol.1, Sect.4, gives the recommended test procedure, together with the open-contact period times for the sequence timers. Servicing instructions for the sequence timers are given in A.P. 4343D, Vol.1, Book 4.

CONTENTS GAUGING SYSTEM

119. Apart from a routine check on the cleanliness and security of all the wiring and connections of the electrical components employed in the electrical portion of the fuel system, little servicing is required. The co-axial cables connecting the tank units to the amplifiers should be checked periodically for ingress of moisture, abrasion of the outer insulation, and general security. Panel covers should not be removed for longer than necessary, and replaced securely after inspection of the components.

120. It will be realised from the nature of the fuel contents gauging system, that its accuracy depends on:-

(1) Equalities in system manufacture

(2) The physical properties of the fuel being used

(3) A reasonably stable voltage supply.

Any small inaccuracies which may exist will usually stem from these three sources.

Functioning check

121. Whenever the aircraft is to be refuelled check the readings of the fuel contents gauges before refuelling begins. At the completion of refuelling note that the new readings are equivalent to the quantity of fuel delivered by the bowser.

Calibration of the gauging system

122. At the periods laid down in A.P. 4505A, Vol.4, or whenever any major unit of the contents gauging system has been changed, carry out the following check. This check ensures that the contents gauges read zero when the tank units are wet, with the tanks emptied down to unusable fuel without draining the refuelling galleries. The calibration is based on a kerosene fuel having a permittivity of 2·10 and a specific gravity of 0·779 at a temperature of 20 deg.C.

123. Connect to the aircraft a ground supply capable of being set to supply 28 volts ± 1 volt. Switch the power supply on at least 45 minutes before beginning the checks. This will ensure that the amplifier output is stable when the checks are made.

124. With the tanks drained to unusable fuel, but with fuel still in the refuelling galleries and the tank units wet, press each individual tank selection push switch in turn. Check that the gauges read zero. Any gauge which fails to read zero should be adjusted by means of the variable capacitor in the trimmer box. Note that on no account must any fuel gauge be set to read above zero. Any slight tolerance should be below the zero mark.

125. Access to the trimmer is gained by removing the screwed sealing plug fitted in the trimmer box lid, thereby exposing the slotted top of the trimmer. By inserting a screwdriver, engaging the trimmer and turning either way, the capacitance of the tank circuit is alternatively increased or decreased and the amplifier circuit to the indicator varied. Should the indicator fail to give a zero contents reading after maximum adjustment of the trimmer the fault location checks outlined in para.126 should be applied.

Fault location checks

126. A Smith Waymouth test set, Ref. No.6C/864, is available for checking the system and a description of the test set and a general approach to the test procedure is contained in A.P.1275T, Vol.1, Sect.5.

Capacitance check on amplifier and indicator

127. The first part of a fault location check is carried out by connecting the test set between the amplifier and the power supply as shown in fig. 3B of A.P. 1275T, Vol.1, Sect.5. The selector switch on the test set is then moved to position

1, and then position 2, thereby checking the power supply voltage and current respectively into the amplifier by noting the reading on the test set meter.

128. To test the circuit between the amplifier and indicator, turn the test set selector switch to position 3. As the output of the FCA amplifier varies between 2 and 7mA over the range 'tanks empty' to tanks full', it follows that the test set meter reading should lie between these two limits, depending on the amount of fuel in the tank.

129. If a satisfactory reading is not obtained, the fault could lie either with the amplifier and its associated tank circuit or with the indicator. To check which of these two is at fault, move the test set selector switch to position 4. This will cut-out the circuit to the indicator, and if a satisfactory reading is still not obtained the fault must lie in the amplifier or tank circuit. If a satisfactory reading is obtained, the fault lies in the indicator circuit.

130. The foregoing procedure is explained at greater length in A.P.1275T, Vol.1, Sect.5, and is summarised in a table on the lid panel of the test set.

131. Now disconnect the tank circuit co-axial cable from the amplifier, and substitute the co-axial cable supplied with the test set, connecting the other end of the cable to either of the two co-axial sockets on the test set. This arrangement is shown in fig.3C of A.P.1275T, Vol.1, Sect.5. As the test set's co-axial cable has a capacitance of 150pf, if the variable capacitor on the test set is adjusted to 1350pf, a capacitance of 1500pf will be fed into the amplifier. Thus if the selector switch is placed at position 3 or 4, the test set meter should read about 2mA. This procedure should be repeated for each of the settings given in Table 5, and the amplifier checked for approximate accordance with the values given. Note that the method of checking each amplifier and indicator is identical.

Check on tank circuits

132. It will be seen from fig.13, that every connection or test point is numbered, starting at the trimmer box and working to the tanks. The numbers will be found in Table 7 together with the capacitance that must be connected at each point to give an indication of approximately 2mA on the test set meter, and therefore a reading of zero contents on the indicator. Note that when testing beyond point 3 it is essential that the tanks are drained of all normally usable fuel.

133. If the amplifier has proved serviceable, reconnect the aircraft tank co-axial cable to the amplifier and disconnect it at point 1. The test set co-axial cable must now be connected to the aircraft cable as shown in A.P.1275T, Vol.1, Sect.5, using the double socket clipped to the inside of the test set lid.

134. The variable capacitor should then be set to 1500pf less the capacitance of the co-axial cable connecting the amplifier to its trimmer box, the test set cable and the adaptor. If the cable connecting the amplifier to its trimmer box is serviceable, the aircraft indicator should now read zero contents and the test set meter 2mA. This procedure, using the relevant capacitance values should be followed at each of the remaining check points throughout the system until the faulty unit(s) is found.

135. Table 7 gives both the theoretical values to connect in at each point, and also the capacitance at each point when using the test co-axial cable and the various adaptors necessary. This has been done for clarity, but the capacitance of the adaptors which are necessary are as follows:-

Double Pye co-axial cable, Type CR4: 10 ± 2pf.

Pye Waymouth adaptor, Type CC1: 8 ± 2pf.

Double Waymouth co-axial cable, Type CA4: 10 ± 2pf.

It should be noted however, that the test set co-axial cable should be used whenever possible, as its inductance has been taken into consideration in the design of the test set. The standard items of equipment supplied with the test set and their capacitance values are as follows:-

6-core cable with plug and socket, Type CG114 - N/A

Co-axial cables with plugs, Type CE150: 150 ± 3pf.

Double Waymouth adaptor, Type CC3: 4 ± 2pf.

136. The capacitance values given in Table 7 have the total tolerance at each particular point quoted alongside. The desired meter reading of 2mA., therefore, should be obtained with the variable capacitor setting within these limits, provided that the system trimmers are correctly adjusted. On no account should the trimmer box settings be altered, these settings should only be adjusted during a functional check.

137. Referring to Table 7, the values quoted in column A are the true capacitances to be connected at each point whilst those in column 'B' are the true capacitances less the capacitance of connecting cables and/or socket, i.e.,

the 'B' values are the actual test set variable capacitor settings, and the 'A' values are the theoretical values. Both are given so that the operator may make allowances accordingly, should he use a different method of connection.

138. The test set is not intended to serve as a standard for calibrating purposes, but rather as an aid to fault finding. However, the test set can be used for testing individual units, providing an additional tolerance of 3 per cent is allowed on the test figures quoted in Table 1 to 7.

Individual unit checks

Tank units

139. The capacity and range of the tank units are given in Table 1. An insulation resistance of at least 20 megohms, using an insulation resistance tester, Type C, should be obtained for a new or replacement tank unit before installation, and at least 3 megohms for a single unit and 1 megohm for two or more units when tested in situ.

Tank terminal units

140. The capacitance of the tank terminal units, Type JM3, should be 21·1 ± 3pf. The terminal units should have an insulation resistance of not less than 20 megohms.

Complete tanks

141. The insulation resistance of each complete fuel tank, measured from the tank terminal unit should be at least 1 megohm. Note that the tanks should be completely drained of all fuel before attempting this test.

142. The capacitance values of each tank should be in accordance with the following figures:-

No.1 tanks (port and starboard)

Capacitance installed, empty and dry - 1236 ± 35pf.

Capacitance installed with unusable fuel - 1242 ± 35pf.

Unusable fuel - 3 gallons.

No.2 tanks (port and starboard)

Capacitance installed, empty and dry - 1194 ± 35pf.

Capacitance installed with unusable fuel - 1194 ± 35pf.

Unusable fuel - 3 gallons.

No.3 tanks (port and starboard)

Capacitance installed, empty and dry - 781 ± 20pf.

Capacitance installed with unusable fuel - 793 ± 20pf.

Unusable fuel - 5 gallons.

No.4 tanks (port and starboard)

Capacitance installed, empty and dry - 1074 ± 20pf.

Capacitance installed with unusable fuel - 1080 ± 20pf.

Unusable fuel - 5 gallons.

No.5 tanks (port and starboard)

Capacitance installed, empty and dry - 917 ± 20pf.

Capacitance installed with unusable fuel - 917 ± 20pf.

Unusable fuel - 2 gallons.

No.6 tanks (port and starboard)

Capacitance installed, empty and dry - 890 ± 20pf.

Capacitance installed with unusable fuel - 899 ± 20pf.

Unusable fuel - 10 gallons.

No.7 tanks (port and starboard)

Capacitance installed, empty and dry - 1072 - 35pf.

Capacitance installed with unusable fuel - 1092 ± 35pf.

Unusable fuel - 10 gallons.

Co-axial cables

143. The co-axial cables connecting between the tank terminal units, trimmer boxes and amplifiers should have an insulation resistance of at least 20 megohms whether new or installed. The capacitance values for these cables are given in Table 2.

Trimmer boxes

144. The trimmer boxes, Type JY3, JY4 and JY5 should have an insulation resistance of not less than 20 megohms, whether in situ or bench tested. Trimmer boxes, Type JY1, JY2, JY6, JY8 and JY9 each contain a coil which is connected to earth, therefore no insulation resistance test is possible on these units. These trimmer boxes may be considered serviceable provided that they conform to the capacitance figures given in Table 3 and 4.

145. The capacitance of the trimmer boxes should be checked in accordance with the procedure laid down in Sect.5, Vol.1, of A.P.1275T, and the figures given in Tables 3 and 4. Note that before checking a trimmer box in accordance with the values in Table 4, the trimmers must be adjusted to their nominal value (mid-setting). Range into, and out of the box is the increase in capacitance above 2mA.

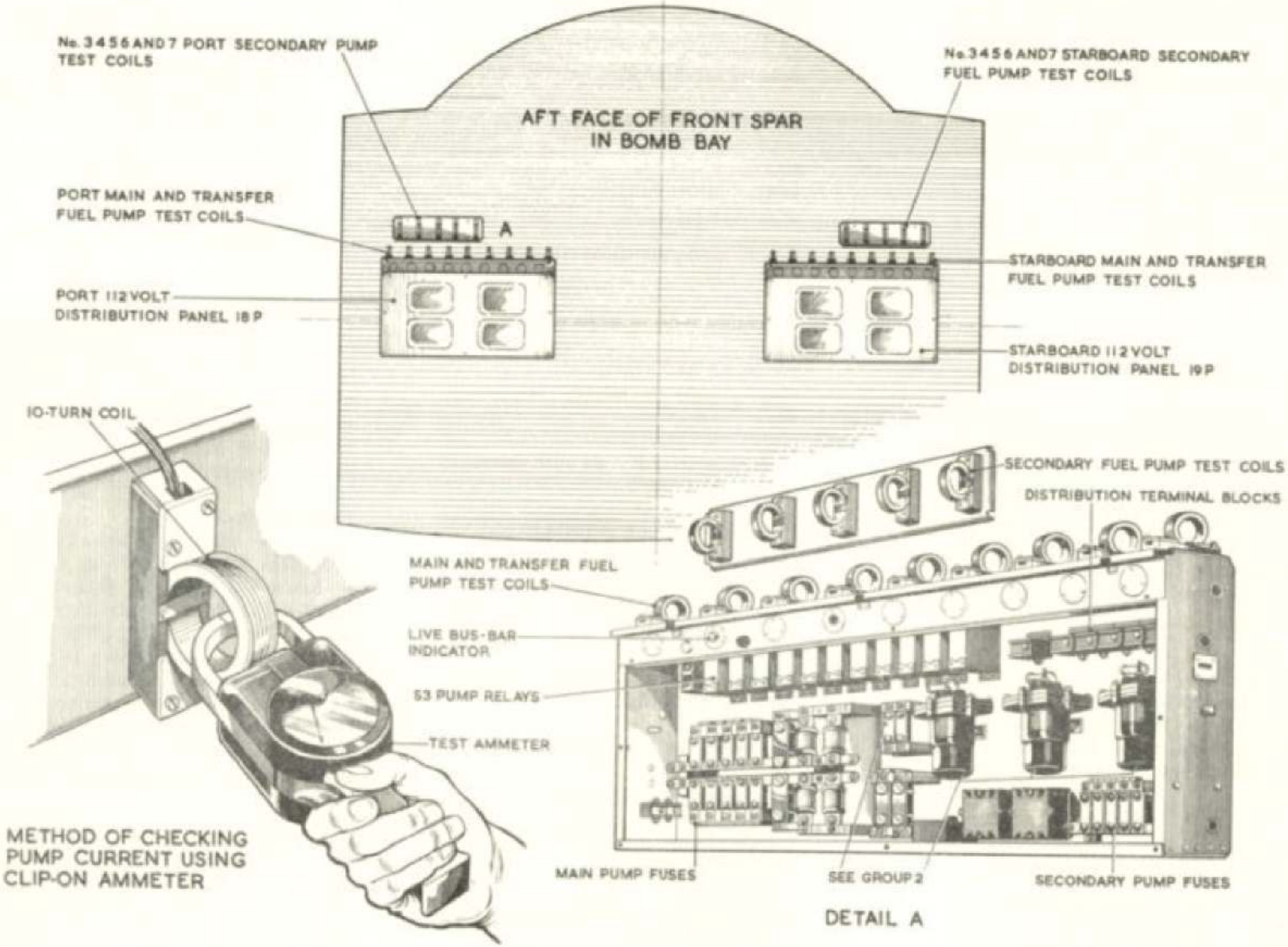

Fig.12 Fuel pump test coils

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146. As no 'range' value is applicable to boxes JY3, JY4 and JY5, they may be considered serviceable if they conform to the input socket values given in Table 3. It will be seen from Table 3 that the 'capacitance out of box' figure is the 'tanks empty' capacitance of the amplifier less the capacitance of the connecting cable.

Amplifiers

147. As the amplifier, Type FCA, contains a 150-volt working condenser, which would be damaged by the higher insulation tester voltage, an insulation resistance test on these units must not be attempted. The amplifiers may be considered serviceable if they conform to the capacitance/indicator current test figure given in Table 5, using the test procedure outlined in A.P.1275T, Vol.1, Sect.5.

Contents indicators

148. An insulation resistance test must not be attempted on these units. They may be considered serviceable if they conform with the figures laid down in Table 6, using the test procedure outlined in A.P.1275T, Vol.1, Sect.5.

GROUND REFUELLING SYSTEM

149. Apart from the usual checks on the components of the refuelling panels 36P and 37P, and a check on the wiring for damage, security and cleanliness, little servicing is necessary to maintain the ground refuelling portion of the fuel system in a serviceable condition. It is important that the panel covers should not be removed for longer than is necessary, and replaced securely after inspection periods.

150. The ground refuelling system is calibrated and set up along with the contents gauging system at the contractors works during flight trials, and under normal circumstances, no further calibrations or adjustments will be necessary. Should fault conditions develop however, or any major component be replaced or renewed for any reason, the tank or group of tanks affected should be re-calibrated. The calibration and setting up procedure must be carried out in conjunction with the airframe and engine tradesmen responsible for the aircraft, observing all the precautions for handling the fuel system laid down in A.P.4505A & C, Vol.1, Book 1.

Setting up the refuelling system

151. The following calibration and setting up procedure is given on the assumption that a fuel tank or tanks replacement has been necessary, but the same principle will apply for any major component change. The number of tanks to be refuelled and defuelled will be determined by:-

(1) The number of tanks being newly installed.

(2) Maintenance of the aircraft C of G.

(3) The necessity to refuel the tank preceding the installed tank so that the system is primed.

152. To calibrate the ground refuelling system both the 112-volt and 28-volt external supplies must be connected, the ground refuelling tender connected to the refuelling connections and the stabilized voltage power pack switched on. Then proceed as follows:-

(1) Ensure that the aircraft is at approximately 5° wing incidence.

(2) Disconnect the fuel feed piping to the appropriate engine, upstream of the King coupling, and fit a length of flexible hose with a manually operated ON-OFF cock at the outlet end. The hose should be of sufficient length to reach a 50 gallon drum calibrated in 10 gallon divisions.

(3) It is now necessary to ensure proper wetting of the tank unit prior to setting the contents gauges to zero. Select 100% on the stabilised voltage power pack, set the bowser 'gallons gone' to zero, and commence refuelling of tanks in the group. Each tank should be filled to 90-95% capacity and the fuel allowed to soak for approximately ten minutes. When a particular tank has been filled to the required capacity the override switch on the refuelling panel should be employed to select the next tank in the group requiring fuel. Record the quantity of fuel delivered to each tank. Note that any pipes which have been disconnected should be checked for leaks when the pressure at the refuelling connection is approximately 50 p.s.i. This pressure must not be exceeded.

(4) The fuel in the tanks now requires to be emptied down to unusable fuel but without draining the refuelling galleries. To do this close all the ground servicing cocks except that of the new tank. Open the defuelling cock and with the assistance of the booster pump defuel from the newly installed tank the quantity of fuel delivered to the tank (3) less 20 gallons. Note that it may be necessary at this stage to defuel from other tanks to maintain the aircraft C of G. As each tank is defuelled only the ground service cock of that tank must be open.

(5) After completion of the defuelling, close the defuelling cock and open all the ground servicing cocks. Open the L.P. cock for the tank group, and, with the aid of the booster pump, drain the fuel remaining in the newly installed tank via the pipe fitted upstream of the King coupling. As the flow from the tank is reduced to a very low flow of pencil thickness, the pump should be switched off. Repeat the operation for any other tanks refuelled in (3). Alternatively in cases where it is inconvenient to break down the engine feed pipe, fuel may be pumped out to a bowser via the defuelling cock. The booster pumps only should be used, and NO suction from the bowser should be introduced. Pumping should be continued until flow ceases, as indicated on the bowser 'gallons gone' indicator.

(6) Set the contents gauge for the newly installed tank to zero as outlined in para.124. Note that the gauge unit must never be set to give a reading above zero; any slight tolerance should be below the zero mark. It is important also that the gauge be set to read zero immediately after draining, while the tanks are still wet.

(7) Disconnect the cable attached to terminal H on the group moving coil relay. This action will isolate the relief relay, thus making percentage refuelling selection inoperative to permit fuel to reach the level of the fuel float switches in the tanks.

(8) Disconnect the feed to the override relay from the fuel level switch of the new tank. Connect a test lamp between terminal A of the fuel level switch and earth. Select the new tank on the refuelling panel and set the refueller gallons-gone meter to zero. When ready for refuelling, check that the indicator lamp for the new tank (flight refuelling indicator panel) is lit. Check also that the test lamp is lit.

(9) Commence refuelling at the normal rate then as the lower float switch level is reached reduce the rate of refuelling. Keep a careful record of the gallons gone and immediately the indicator lamp on the flight refuelling panel goes out refuelling should stop. If the lower switch only has broken the test lamp should still be lit. If both lamps are out this indicates that the upper level switch has operated before, or at the same time as the lower level switch. This may indicate a faulty switch and further checks should be made.

(10) Assuming that the switch has operated correctly connect a temporary wire link between pin A of the switch and pin B or C of the refuelling valve. This shorts out the lower level switch and the flight refuelling indicator lamp should now light. Leave the test lamp connected as before and continue refuelling at a slow rate, again keeping a careful record of the gallons gone. The upper float switch level will be indicated by both lamps going out and the cessation of flow. The amount of fuel delivered between the operation of the lower float switch and operation of the upper float switch should be between 1 and 7 gallons.

(11) Drain a measured 10 gallons, plus the additional gallons delivered between operation of the upper and lower float switches, from the new tank.

153. Due to variations in specific gravity of fuels that can be used in the aircraft, table 9 has been compiled to provide a setting for the refuelling stabilized voltage power unit with respect to the S.G. of the fuel used at the time of calibration.

NOTE...

The results obtained in Table 9 are derived from the formula:-

$$\text{Refuelling Power Unit Setting in \%} = \frac{100 \times \text{S.G. of fuel used}}{0{\cdot}8}$$

154. The next step in the calibration procedure is to check the current differential of the tank group moving coil relay, and then set the newly installed tank circuit to this value. The most convenient tank to check for the differential, which may be checked on any tank within the group, is the No.4 tank for groups 1 and 4 and the No.3 tank for groups 2 and 3. For a clearer understanding of the calibration technique used, the No.2 tank group will be considered, therefore, the No.3 tank will be used to check the differential and the No.6 tank will be considered as being the newly installed tank. In the event of other tank groups requiring calibration, the appropriate tank identification number must be substituted into the following procedure.

(1) Disconnect the co-axial cable from the tank terminal unit of tank No.3.

(2) Check and record the S.G. of the fuel drained in para. 152(11).

(3) Connect the Q.A.A. test set Ref.No.6C/864 to the disconnected co-axial cable (1).

(4) Adjust the stabilized voltage unit to a percentage setting in accordance with Table 9 and (2).

(5) Select tank No.3 by repeated operation of the override switch on the associated refuelling panel. Slowly increase the capacitance on the Q.A.A. test set until the moving coil relay operates to select the next tank, in this case, No.6 tank. At this point decrease

the test set capacitance by 20 pF.

(6) Re-select tank No.3 as in (5) and then increase the capacitance of the test set very, very slowly until the moving coil relay just trips again.

(7) Disconnect terminal H on the moving coil relay and then again re-select No.3 tank as in (5).

(8) Measure the current differential between coils A and B using a high grade 0-10 milliammeter in the following way:-

(a) Connect the milliammeter in series between the positive terminal of moving coil B and the cable disconnected from it, the reading should be carefully noted.

(b) Re-connect the normal connections to coil B and then connect the milliammeter in series with coil A, just as with coil B. Measure the current passing through coil A, and carefully note the reading.

(9) The differential can now be determined by subtracting the figure noted in 8(a) from the figure noted in 8(b). The differential should be 2mA ± 80 micro-amps, and the exact value noted.

(10) With the milliammeter still connected in series with the A coil, disconnect the co-axial cable from the Q.A.A. test set and reconnect the cable to the No.3 tank terminal unit. Check the exact current flowing in coil A, then subtract from this the differential obtained in (9). Note the figure obtained and set coil B to this figure via the associated resistance trimmer. Re-connect the milliameter in series with coil A.

(11) With the newly installed tank No.6 refuelled in accordance with para.152, select the new tank on the refuelling panel. Check the current passing through the 'A' coil then subtract from this figure the differential found in (9).

(12) Set coil B to the figure derived in (11) via the associated resistance trimmer. Lock the trimmer and check that the current value is still correct.

(13) The same procedure outlined in (11) and (12) should be carried out on the remaining tanks within the group to ensure correct operation of the auto-selector at the chosen percentage setting.

(14) Disconnect the milliammeter and reconnect the cables to the moving coil relay and terminal H. Remove the test lamps and refuelling equipment fitted in para.152 and reconnect the fuel level switches.

155. With the refuelling selector set as in para.154, and wiring to terminal H on the moving coil relay reconnected. Select the first tank in the group on the refuelling panel. If the trimmers are set correctly the auto-selector should operate and each tank should trip in turn.

156. Defuel the tanks as in para.152; note that it may be necessary to defuel other tanks to maintain the aircraft C of G; then check that the contents gauges read zero.

157. Refuel the new tank to 20, 40, 60, 80 and 100% selection. Record the quantities of fuel indicated on the refuelling tender flowmeter subject to condition imposed in the next paragraph, and the aircraft contents gauges at each percentage level. Note that Table 8 provides the design value for the fuel tank capacities.

158. As stated in para.122, the gauging system is calibrated to give maximum accuracy with a Kerosene fuel having a permittivity of 2·10 and a specific gravity of 0·779 at a temperature of 20 deg.C. Due to the variations in the fuel used, it will be necessary therefore to correct the refuelling tender flowmeter readings before comparing them with the aircraft contents gauge readings. To do this, measure the S.G. of the fuel being used, and correct as follows:-

Gallons gone x S.G. x 10 = calculated weight of fuel

At 100% selection the bowser gallons should be within ± 10 gallons of the theoretical 100% figures given in table 8. At all percentage selections the gauge readings should agree with the calculated weight of fuel within ± 6% of the 100% value. The gauge tolerance at any selection is found as follows:-

$$\text{gauge tolerance} = \pm \frac{\text{calculated weight of 100\% fuel} \times 6}{100}$$

The group contents should be noted at each percentage filling and the gauge error should not be more than ± 4% of the group 100% calculated weight.

Panels 36P and 37P

159. A test panel Ref.No. 26DC/95206 is available for checking panels 36P and 37P throughout their full working range. The panel is not designed for 'in situ' testing and will normally be used in a suitably equipped test house. A full description of the panel and its method of use will be found in A.P.4343V, Vol.1, Sect.4.

Stabilised voltage power unit

160. Should it become necessary at any time to adjust the power unit, it must be removed from the aircraft, and set up in the following manner:-

(1) Connect the power unit to a d.c. supply variable between 22 and

29 volts, allowing sufficient time for warm up and stable operation.

(2) Using a Test meter Type D set to the 400-volt d.c. range, measure the -180-volt line with respect to earth, and set to -180 volts by adjustment of R8 and R9.

(3) Check that a range of 0-50 volts can be obtained at the output terminals when the selector potentiometer (R20) is adjusted, also that the voltage range is proportionately read in conjunction with the built in voltmeter calibrated 0-100%. If the range 0-50 volts or 100% cannot be obtained, adjust R14 and R18 in the following manner:-

(a) If the selector potentiometer is at the end of its travel and a reading of less than 50 volts or 100% is obtained, correction can be achieved by setting the selector potentiometer to 50%, adjust R14 so that 55% indication occurs on the built in voltmeter, then adjust R18 to restore the reading on the built in voltmeter to 50%. For optimum setting the procedure for R14 and R18 should be done several times. Check that readings for 50 volts or 100% can now be obtained.

(b) If the output voltage exceeds the required voltage at the output terminals, the procedure is to set the selector potentiometer to 50%, adjust R14 to read 45% in the built in voltmeter, and then restore the reading to 50% by adjustment of R18. Check that reading for 50 volts or 100% can now be obtained, slight adjustment of R14 and R18 may also be necessary for optimum setting of 50 volts or 100% output.

(4) To obtain optimum regulation, potentiometer R4 may be adjusted. In the event of regulation falling off as the selector potentiometer is positioned towards 100% output, the -180-volt line must be reduced by a small amount by R8 and R9. The potentiometer R14 and R18 must then be reset to allow the selector potentiometer to control the correct range of the output. Once R8 and R9 have been set for optimum regulation they must not be altered. Any subsequent adjustments must be made via R14 and R18 only. To check for optimum setting, vary the input voltage from 22 to 29 volts and note the change in output. The output should be maintained within 0·5 volt of the original output setting.

NOTE . . .
When a defective valve is to be replaced, it must be replaced with one of the exact type specified, and under no circumstances should a valve of near similar characteristics be used.

161. A test panel Ref.No.26DC/95205 is available as a means of checking the on-load output, voltage characteristic of the stabilized voltage power unit. The unit is fully described in A.P.4343V, Vol.1, Sect.4. The appropriate test procedure will be found in the same chapter.

FLIGHT REFUELLING SYSTEM

Functioning check

162. Prior to flight refuelling operations taking place the electrical parts of the system must be ground checked. Proceed in the following manner:-

(1) Ensure that a 28-volt d.c. ground supply is connected to the aircraft, and that the 28-volt bus-bar is live.

(2) Allow sufficient time to elapse for the tank amplifiers to attain a stable output.

(3) Press the C.G. check push-button. Note that the C.G. indicator is reading and the fuel contents gauges are switched off. Release the push-button.

(4) Place the flight refuelling master switch to ON, check that:-

(a) All fourteen lamps in the flight refuelling indicator are lit.

(b) The normal fuel contents gauges are not reading.

(c) The C.G. indicator operates to show fuel C.G.

NOTE . . .
The fuel tanks will be automatically de-pressurised when the flight refuelling master switch is placed to ON (para.91). The tank pressurisation tests are fully outlined in Book 1, Sect.4, Chap.6.

(5) Hold the C.G. control switch to PORT and then to STARBOARD, check that the appropriate tank refuelling valve lamps in the flight indicator are operating correctly. (PORT - 6 and 7 port lamps are out).

(6) Hold both fuel transfer switches to FWD and then to AFT, check that the appropriate refuelling valve lamps in the indicator are operating

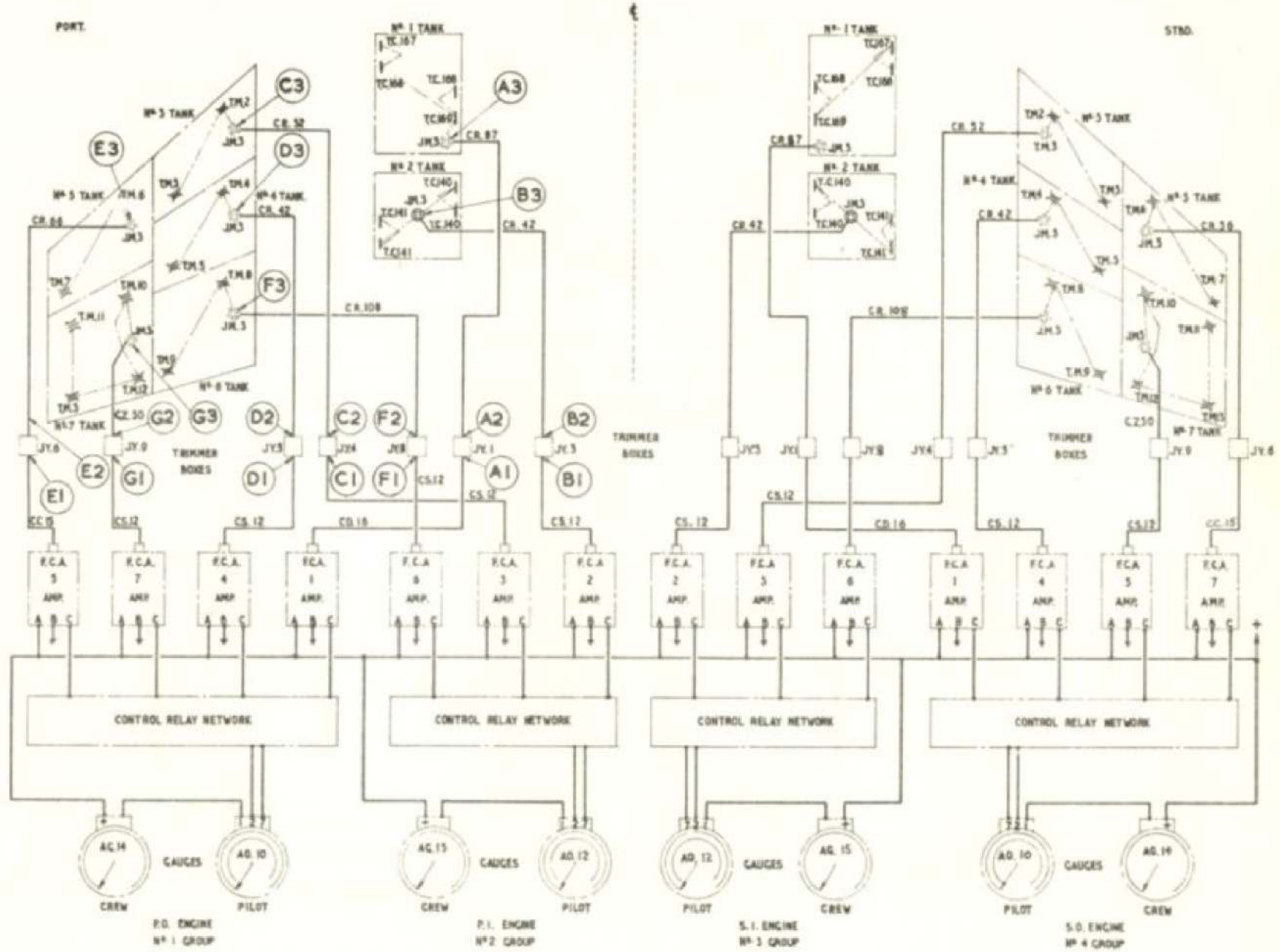

Fig 13 Tanks cabling diagram

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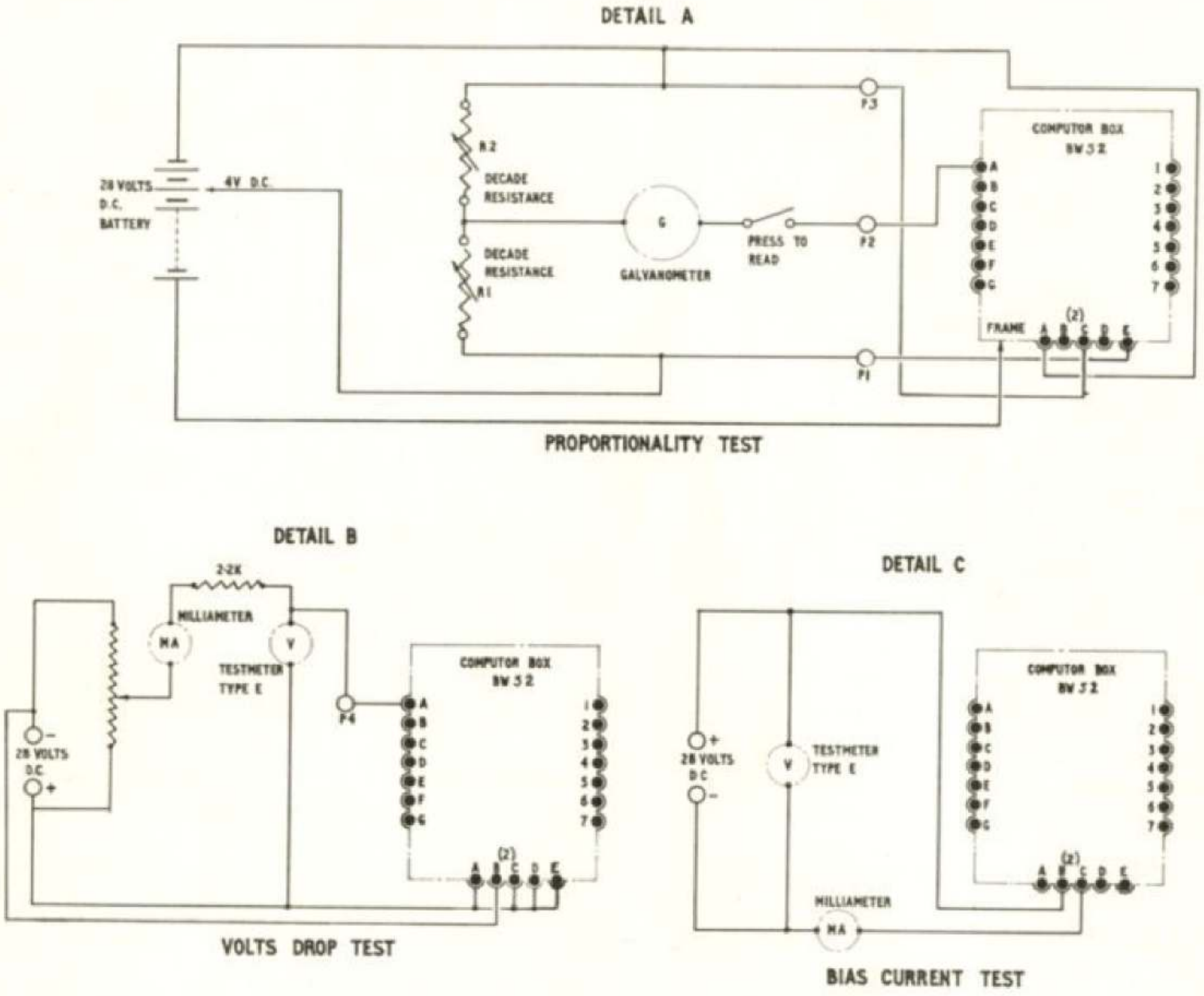

Fig.14 Test equipment connections

correctly. (FWD - 6 and 7 port and starboard lamps out. AFT - 1 and 2 port and starboard lamps out).

(7) Press the C.G. push-button. Note that the fuel contents gauges are reading and the C.G. indicator is switched off. Release the push-button.

(8) At the conclusion of these checks switch the master switch to the OFF position, check that the C.G. indicator is not reading, and that the fuel contents gauges again present the group fuel contents.

C.G. indicator calibration

163. The C.G. indicator should be set to zero whenever the tanks are drained in readiness for calibrating the fuel contents indicators (para.124). Proceed as follows:-

(1) Mechanically set the indicator to zero by means of the screw adjusters on the front face of the indicator.

(2) With the C.G. check switch pressed, set the indicator needles to zero by means of the bias trimmers in the computor boxes.

Refuelling indicator

164. When carrying out the above functional checks ensure that all filaments in the indicator give a positive indication of serviceability. Any faulty or suspect filaments must be replaced immediately with a serviceable filament of the correct type. To replace a faulty filament the procedure is as follows:-

(1) Press inwards and rotate the bezel ring on the front of the indicator in an anti-clockwise direction to its fullest extent.

(2) The face cap assembly may now be withdrawn, together with the lampholder and lamp.

(3) Withdraw the faulty lamp from its holder and insert a serviceable filament.

(4) Replace the face cap assembly in the body of the indicator and ensure that the face cap is locked in position.

NOTE . . .
When fitting the face cap it is important to ensure that the two projections of unequal width, formed in the rim of the light shield, engage with their mating slots in the contact base.

Refuelling panels 45P and 46P

165. The wiring to the panels, including plugs and sockets, should be examined periodically for cleanliness and general security. Operation of the relays within the panel will be evident during the functional checks outlined in paragraph 159. A test panel Ref.No. 26DC/95206 is available for checking panels 36P and 37P throughout their full working range, may also be adapted for testing panels 45P and 46P. Reference should be made to A.P.4343V, Vol.1, Sect.4, for further details.

Computor boxes, Type BW.52

166. Correct function of the port and starboard computor boxes will be observed when the functional checks outlined in paragraph 159 are carried out. If a fault is suspected the boxes should be subjected to tests outlined in the following paragraphs.

167. The complete boxes should be removed from the aircraft to a suitably equipped test house before applying the following tests. The method of connection for each test is given in fig.14.

Insulation resistance check

168. Check the insulation resistance of each computor box by connecting an insulation resistance tester Type C between the following pins of the large plug. Reading should not be less than 20 megohms.

Earth (frame)	to pins	A	B	C	D	E	F	G
Pin A	to pins		B	C	D	E	F	G
Pin B	to pins			C	D	E	F	G
Pin C	to pins				D	E	F	G
Pin D	to pins					E	F	G
Pin E	to pins						F	G
Pin F	to pins							G

It should be noted that the pins on the small plug (used in the subsequent tests) identified A, B, C, D, E are referred to as A2, B2, C2, D2 and E2.

Proportionality test

169. Connect up the computor box as shown in fig.14 detail A. Then with relays energised, set R1 to the values given in Table 10. Adjust R2 until the galvanometer gives a zero deflection. At this point check the value of R2 with the value given in Table 10. Its value should be within ±4% of the specified value.

Volts drop test

170. The circuit diagram fig.14 shows the method of connection for applying the volts drop test. The voltmeter shown is a testmeter Type E, set to 2·5 volts d.c. With the point P4 connected as specified in Table 11, and all the computor box relays energised, adjust the current to the value specified in the Table. The voltage drop should not be more than 1·2 volts.

Bias current test

171. The circuit diagram fig.14 shows the

method of connection for applying the bias current test. The voltmeter is a testmeter Type E set to the 100-volt range, while the ammeter is a testmeter Type E set to the 1mA range. From the voltage and current readings calculate the resistance between B2 and C2 for extreme positions of variable resistor. This should not exceed 18.8K in the minimum position nor be less than 27K in the maximum position. Access to the variable resistor is provided on the front cover of the computor box.

Continuity check

172. Since the tests detailed in paragraph 165 and 166 necessarily include continuity of relay contacts in the energised state, a check should be made to prove the continuity of the computor box with the relay de-energised. Continuity should be obtained between the following pins of the two large plugs:-

1 and A
2 and B
3 and C
4 and D
5 and E
6 and F
7 and G

173. The most likely fault to develop in the computor box, Type BW.52, will be in the form of an open circuit relay contact or open circuit resistor. Open circuited relay contacts will be revealed by the volts drop test and by continuity checks. Open circuit resistor will be found by the proportionality test and the bias current test.

REMOVAL AND INSTALLATION

General

174. The removal and installation of the major components in the various systems is straightforward and no special instructions are required. The safety precautions in Group 9A must be carried out before entering any tank to remove or refit internal units.

Table 1

Tank unit capacitance values

Tank unit	Initial capacitance (pf)	Range (pf)	Location
TC166	285 ± 3	273 ± 3	No.1 tank (p & s)
TC167	258 ± 3	249 ± 3	No.1 tank (p & s)
TC168	280 ± 3	271 ± 3	No.1 tank (p & s)
TC169	256 ± 3	247 ± 3	No.1 tank (p & s)
TC140	268 ± 5	278 ± 3	No.2 tank (p & s)
TC141	245 ± 5	251 ± 3	No.2 tank (p & s)
TM2	400 ± 3	401 ± 3	No.3 tank (p & s)
TM3	293 ± 3	291 ± 3	No.3 tank (p & s)
TM4	580 ± 3	593 ± 3	No.4 tank (p & s)
TM5	408 ± 3	418 ± 3	No.4 tank (p & s)
TM6	491 ± 3	499 ± 3	No.5 tank (p & s)
TM7	332 ± 3	331 ± 3	No.5 tank (p & s)
TM8	491 ± 3	505 ± 3	No.6 tank (p & s)
TM9	324 ± 3	329 ± 3	No.6 tank (p & s)
TM10	297 ± 3	298 ± 3	No.7 tank (p & s)
TM11	195 ± 3	194 ± 3	No.7 tank (p & s)
TM12	278 ± 3	280 ± 3	No.7 tank (p & s)
TM13	191 ± 3	193 ± 3	No.7 tank (p & s)

Table 2

Co-axial cable details

Cable	Length (inches)	Capacitance (pf)
CS12	12	22±3
CC15	15	28±3
CD16	16	30±3
CD24	24	43±3
CR42	42	76±3
CZ50	50	90±3
CR52	52	94±3
CR57	57	103±3
CR66	66	119±3
CR87	87	156±3
CR108	108	194±5

TABLE 3

Trimmer box details

Trimmer box type	Tanks empty capacitance into box at input socket			'Tanks empty' capacitance out of box
	Trimmer at min. not less than	Box input nominal value	Trimmer at max. not more than	
JY1	1433pF	1388pF	1343pF	1470pF
JY2	1380pF	1335pF	1290pF	1457pF
JY3	270pF	1268pF	150pF	1478pF
JY4	649pF	874pF	559pF	1478pF
JY5	369pF	1154pF	279pF	1478pF
JY6	1081pF	1036pF	991pF	1472pF
JY8	1132pF	1087pF	1042pF	1478pF
JY9	1224pF	1179pF	1134pF	1478pF

TABLE 4

Trimmer box ranges

Trimmer box type	Range out of box	Range into box
JY1	1000pF	1055pF)
JY2	1000pF	1055pF)
JY6	850pF	884pF)±1%
JY8	790pF	824pF)
JY9	890·5pF	1024pF)

TABLE 5

Amplifier details

Type FCA

Power supply

Nominal voltage 28 volts

Current at 28 volts 0·7 amp.

Capacitance

Initial input at tanks empty - 1500pF

Tanks full input - 2500pF

Range - 1000pF

Relationship between indicator current and capacitance with a power supply of 28 volts:-

Capacitance (pF)	Indicator current (mA)
1500	2·0 ± ·03
1700	3·0 ± ·05
1900	4·0 ± ·05
2100	5·0 ± ·05
2300	6·0 ± ·05
2500	7·0 ± ·05

TABLE 6

Fuel contents indicator details

Indicator Type A.O.10

Indication inner scale (pounds x 1000)	Indicator current (mA)	Indication outer scale (pounds x 1000)	Indicator current (mA)
0	8·00	0	2·00
1	8·60	0·2	2·12
2	9·39	0·4	2·26
3	10·49	0·6	2·45
4	11·51	0·8	2·67
5	12·57	1·0	2·87
6	13·63	1·2	3·09
7	14·70	1·4	3·30
8	15·78	1·6	3·51
9	16·86	1·8	3·73
10	17·94	2·0	3·94
11	19·03	2·2	4·16
12	20·14	2·4	4·38
13	21·16	2·6	4·59
14	22·25	2·8	4·81
15	23·30	3·0	5·02
16	24·33	3·2	5·25
17	25·38	3·4	5·46
18	26·42	3·6	5·67
18,224(F)	26·70	3·8	5·89
		4·0	6·10
		4·2	6·30
		4·4	6·51
		4·6	6·72
		4·8	6·92
		5·0	7·11

TABLE 6 (contd.)

Indicator Type A.O.12

Indication inner scale (pounds x 1000)	Indicator current (mA)	Indication outer scale (pounds x 1000)	Indicator current (mA)
0	6·00	0	2·00
1	6·53	0·2	2·09
2	7·16	0·4	2·21
3	7·87	0·6	2·34
4	8·55	0·8	2·48
5	9·26	1·0	2·62
6	9·99	1·2	2·76
7	10·71	1·4	2·90
8	11·42	1·6	3·05
9	12·16	1·8	3·20
10	12·89	2·0	3·33
11	13·64	2·2	3·48
12	14·38	2·4	3·63
13	15·11	2·6	3·77
14	15·83	2·8	3·91
15	16·55	3·0	4·06
16	17·22	3·2	4·21
17	17·85	3·4	4·35
17,964(F)	18·67	3·6	4·49

TABLE 6 (contd.)

Indicator Type A.O.12			
Indication inner scale (pounds x 1000)	Indicator current (mA)	Indication outer scale (pounds x 1000)	Indicator current (mA)
		3·8	4·65
		4·0	4·79
		4·2	4·94
		4·4	5·09
		4·6	5·22
		4·8	5·37
		5·0	5·50
		5·2	5·65
		5·4	5·80
		5·6	5·95
		5·8	6·09
		6·0	6·24
		6·2	6·40
		6·4	6·54
		6·6	6·66
		6·8	6·80
		7·0	6·93
		7·2	7·08
		7·4	7·22

TABLE 6 (contd.)

Indicator Type A.G.14		Indicator Type A.G.15	
Indication (pounds x 1000)	Indicator current (mA)	Indication (pounds x 1000)	Indicator current (mA)
0	8·00	0	6·00
1	8·60	1	6·53
2	9·39	2	7·16
3	10·49	3	7·87
4	11·51	4	8·55
5	12·57	5	9·26
6	13·63	6	9·99
7	14·70	7	10·71
8	15·78	8	11·42
9	16·86	9	12·16
10	17·94	10	12·89
11	19·03	11	13·64
12	20·14	12	14·38
13	21·16	13	15·11
14	22·25	14	15·83
15	23·30	15	16·55
16	24·33	16	17·22
17	25·38	17	17·85
18	26·42	17,964(F)	18·67
18,224(F)	27·70		

TABLE 7

Tank circuit testing values

Tank No.	Test point	Test capacitance 'A' (pF)	Test capacitance 'B' (pF)	Adaptors and cables used	Approximate reading on Aircraft indicator	Test set meter
1 Port	A1	1470 ± 3	1312 ± 8	CE150-CC1	Zero contents	2mA
	A2	1398 ± 38	1230 ± 45	CE150-CC1-CR4	Zero contents	2mA
	A3	1242 ± 35	1084 ± 40	CE150-CC1	Zero contents	2mA
1 Stbd.	A1	1457 ± 3	1299 ± 8	CE150-CC1	Zero contents	2mA
	A2	1445 ± 38	1277 ± 45	CE150-CC1-CR4	Zero contents	2mA
	A3	1242 ± 35	1084 ± 40	CE150-CC1	Zero contents	2mA
2 Port and Stbd.	B1	1478 ± 3	1320 ± 8	CE150-CC1	Zero contents	2mA
	B2	1270 ± 38	1102 ± 45	CE150-CC1-CR4	Zero contents	2mA
	B3	1194 ± 35	1036 ± 40	CE150-CC1	Zero contents	2mA
3 Port and Stbd.	C1	1478 ± 3	1320 ± 8	CE150-CC1	Zero contents	2mA
	C2	887 ± 23	719 ± 30	CE150-CC1-CR4	Zero contents	2mA
	C3	793 ± 20	635 ± 25	CE150-CC1	Zero contents	2mA
4 Port and Stbd.	D1	1478 ± 3	1320 ± 8	CE150-CC1	Zero contents	2mA
	D2	1156 ± 23	988 ± 30	CE150-CC1-CR4	Zero contents	2mA
	D3	1080 ± 20	922 ± 25	CE150-CC1	Zero contents	2mA
5 Port and Stbd.	E1	1472 ± 3	1314 ± 8	CE150-CC1	Zero contents	2mA
	E2	1036 ± 23	868 ± 30	CE150-CC1-CR4	Zero contents	2mA
	E3	917 ± 20	759 ± 25	CE150-CC1	Zero contents	2mA
6 Port and Stbd.	F1	1478 ± 3	1320 ± 8	CE150-CC1	Zero contents	2mA
	F2	1093 ± 25	925 ± 32	CE150-CC1-CR4	Zero contents	2mA
	F3	899 ± 20	741 ± 25	CE150-CC1	Zero contents	2mA
7 Port and Stbd.	G1	1478 ± 3	1320 ± 8	CE150-CC1	Zero contents	2mA
	G2	1182 ± 38	1014 ± 35	CE150-CC1-CR4	Zero contents	2mA
	G3	1092 ± 35	934 ± 40	CE150-CC1	Zero contents	2mA

TABLE 8

Fuel tank capacities

Tanks	Gals. Fuel S.G. 0·8	LB. Fuel S.G. 0·8	Gals. Fuel S.G. 0·78 0·75	LB.			
				Fuel S.G. 0·78	Fuel S.G. 0·77	Fuel S.G. 0·76	Fuel S.G. 0·75
1	2X621	2X4968	2X631	2X4922	2X4859	2X4796	2X4733
2	2X944	2X7552	2X954	2X7441	2X7345	2X7250	2X7155
3	2X624	2X4992	2X634	2X4945	2X4882	2X4818	2X4755
4	2X624	2X4992	2X634	2X4945	2X4882	2X4818	2X4755
5	2X503	2X4024	2X513	2X4001	2X3950	2X3899	2X3847
6	2X729	2X5832	2X739	2X5764	2X5690	2X5616	2X5542
7	2X537	2X4296	2X547	2X4267	2X4212	2X4157	2X4102
TOTAL	9,164	73,312	9,304	72,640	71,640	70,708	69,778

TABLE 9

Power Unit Selection - Fuel S.G.

S.G. of Fuel used	Refuelling Power Unit Selection for 'B' Coil Trimming
0·8	100%
0·79	98·75%
0·78	97·5%
0·77	96·25%
0·76	95·0%
0·75	93·75%

TABLE 10

Proportionality test - resistance values

Tank No.		1	2	3	4	5	6	7
Connect computor box terminals to points	P1	E2	E2	E2	E2	E2	E2	E2
	P2	A1	B1	C1	D1	E1	F1	G1
	P3	C2	C2	D2	D2	D2	D2	D2
R1 (ohms)		infin	infin	197	195	275	1250	513
R2 (ohms)		zero	zero	1940	370	300	150	170

TABLE 11

Volts drop test - current values

Tank No.	1	2	3	4	5	6	7
Connect P4 to computor box terminals	A1	B1	C1	D1	E1	F1	G1
Current (mA)	7·00	7·14	5·50	6·98	6·25	6·03	6·47

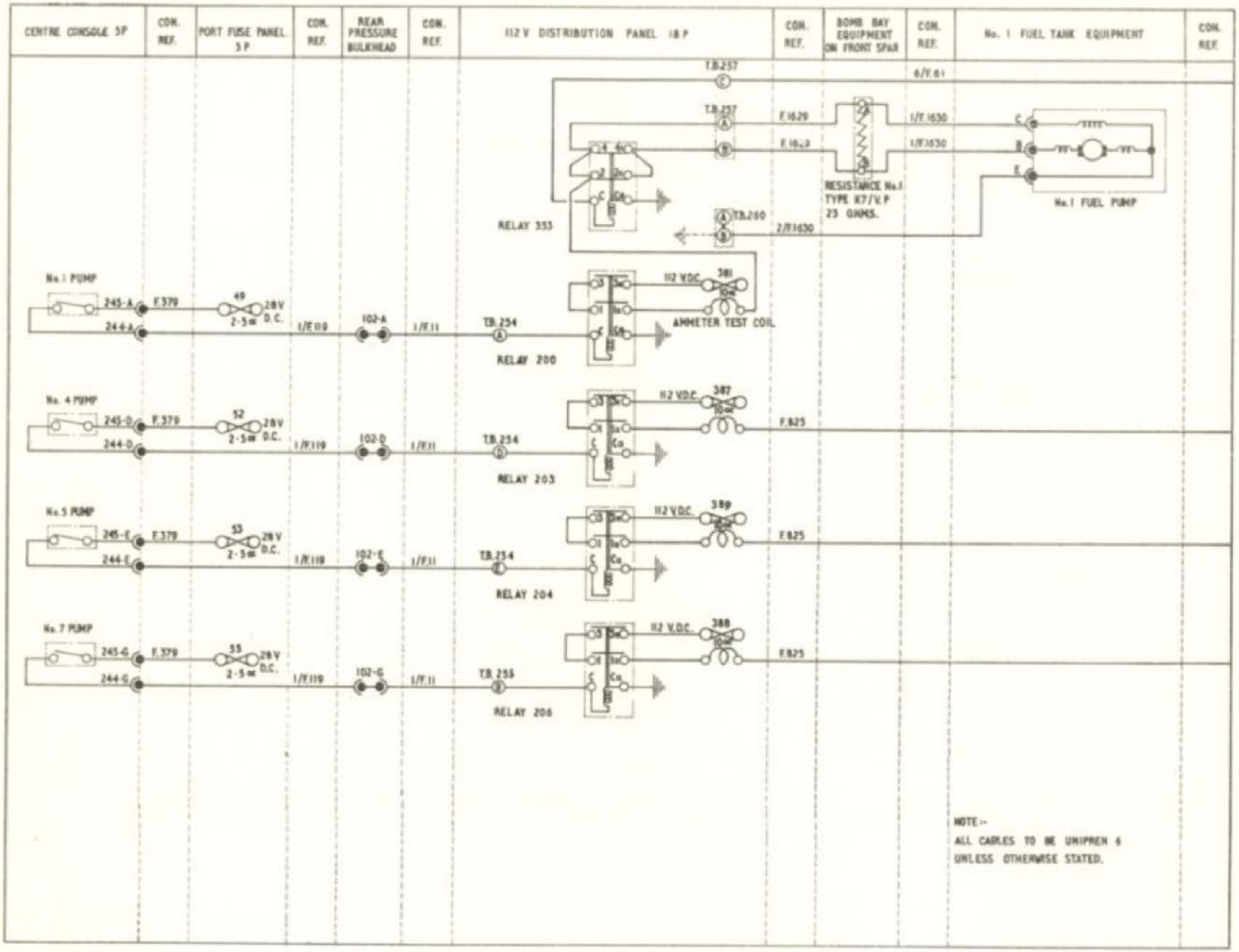

Fig 15 (1) Nº 1, 4, 5, and 7 port fuel pumps

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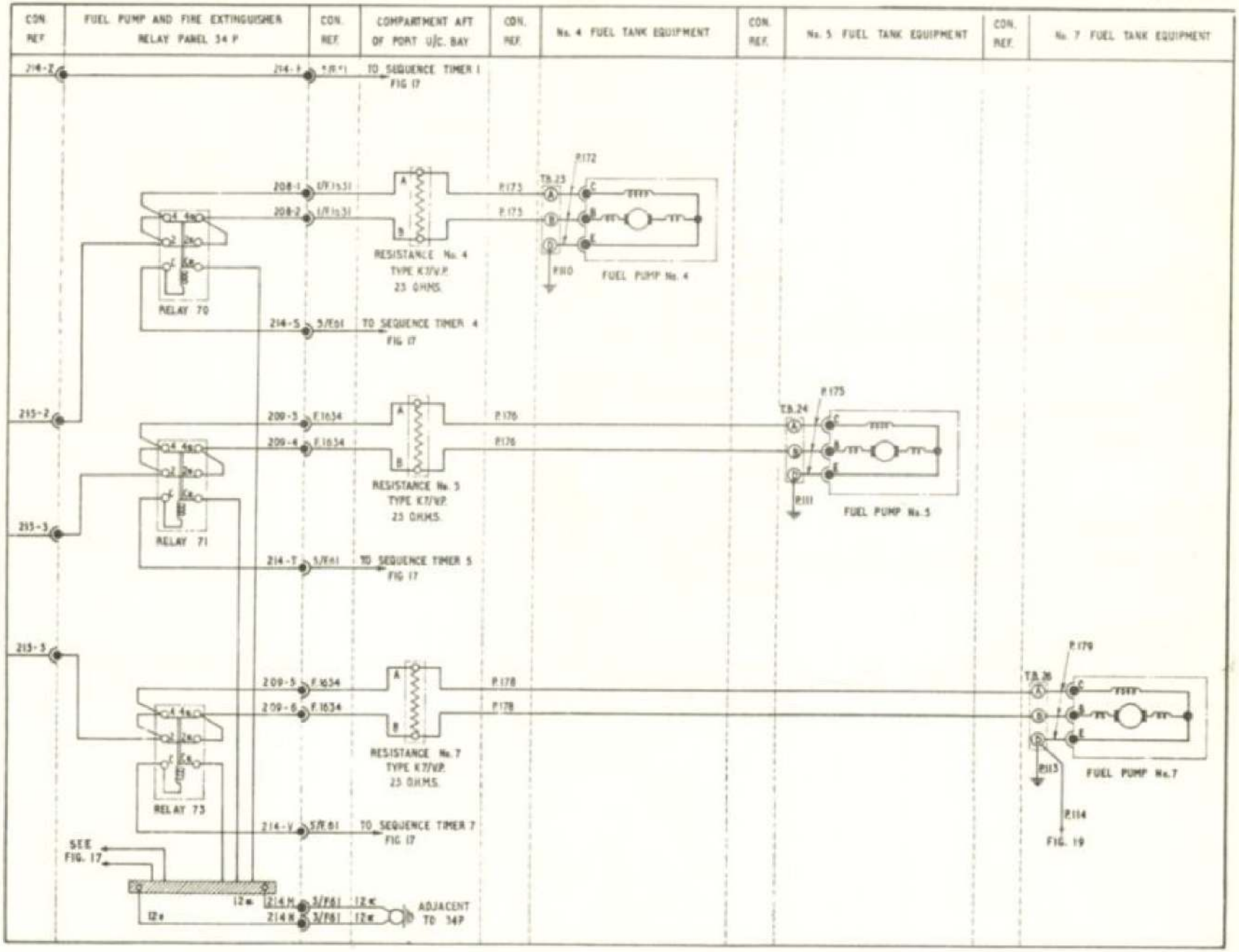

Fig. 15(2) Nº 1, 4, 5, and 7 port fuel pumps

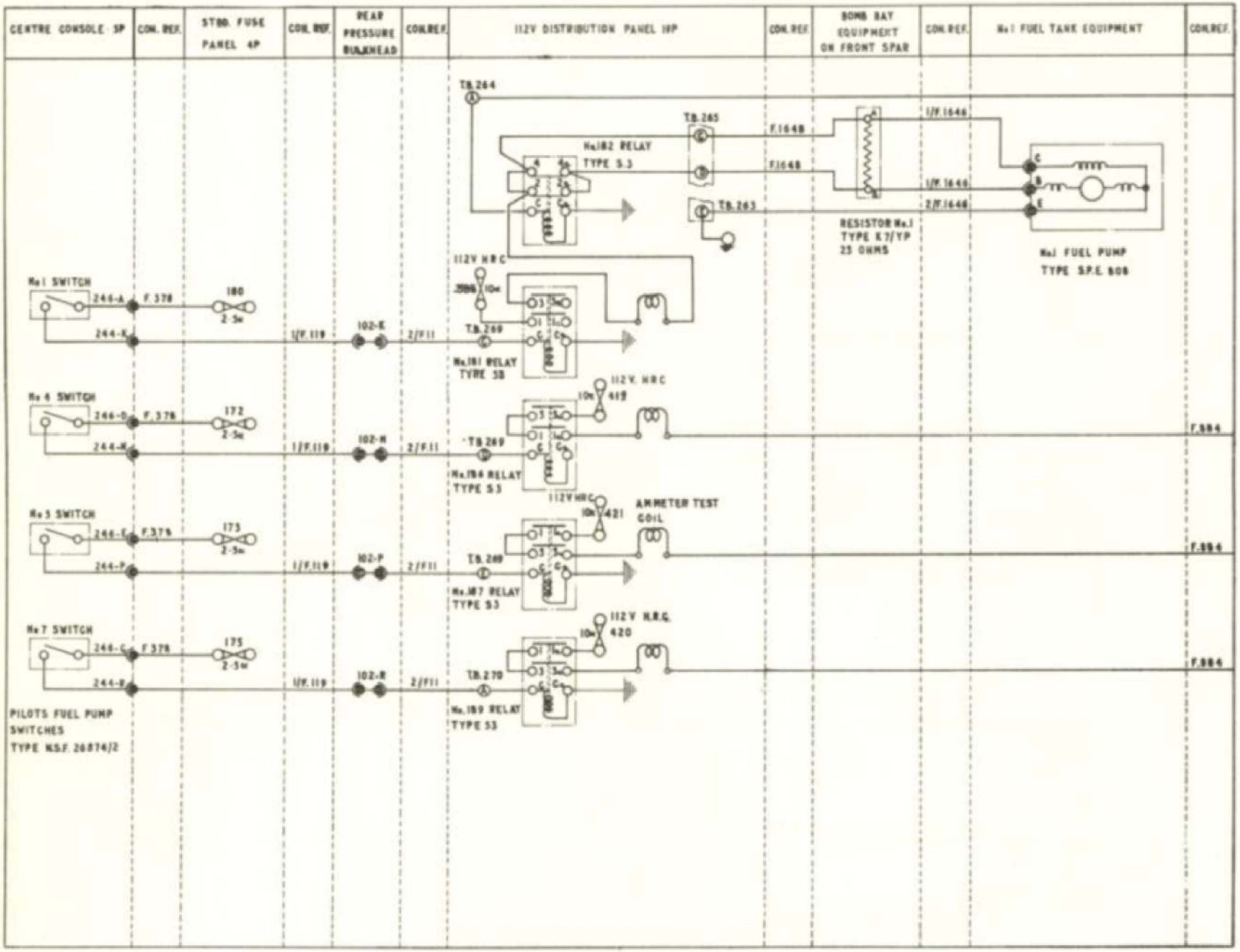

Fig. 16 (1) Nº 1.4, 5 and 7 starboard fuel pumps

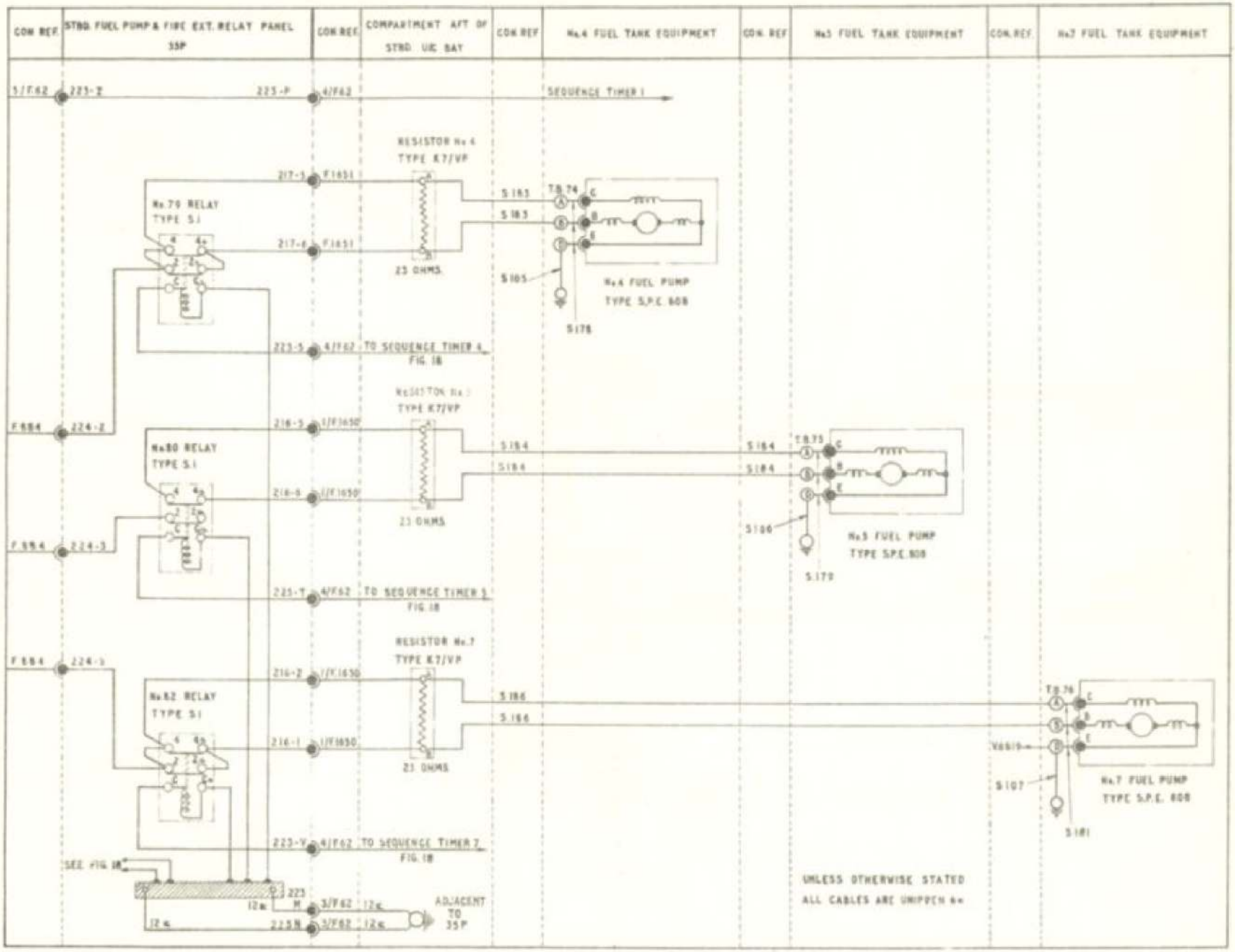

Fig. 16(2) No 1, 4, 5 and 7 starboard fuel pumps

RESTRICTED

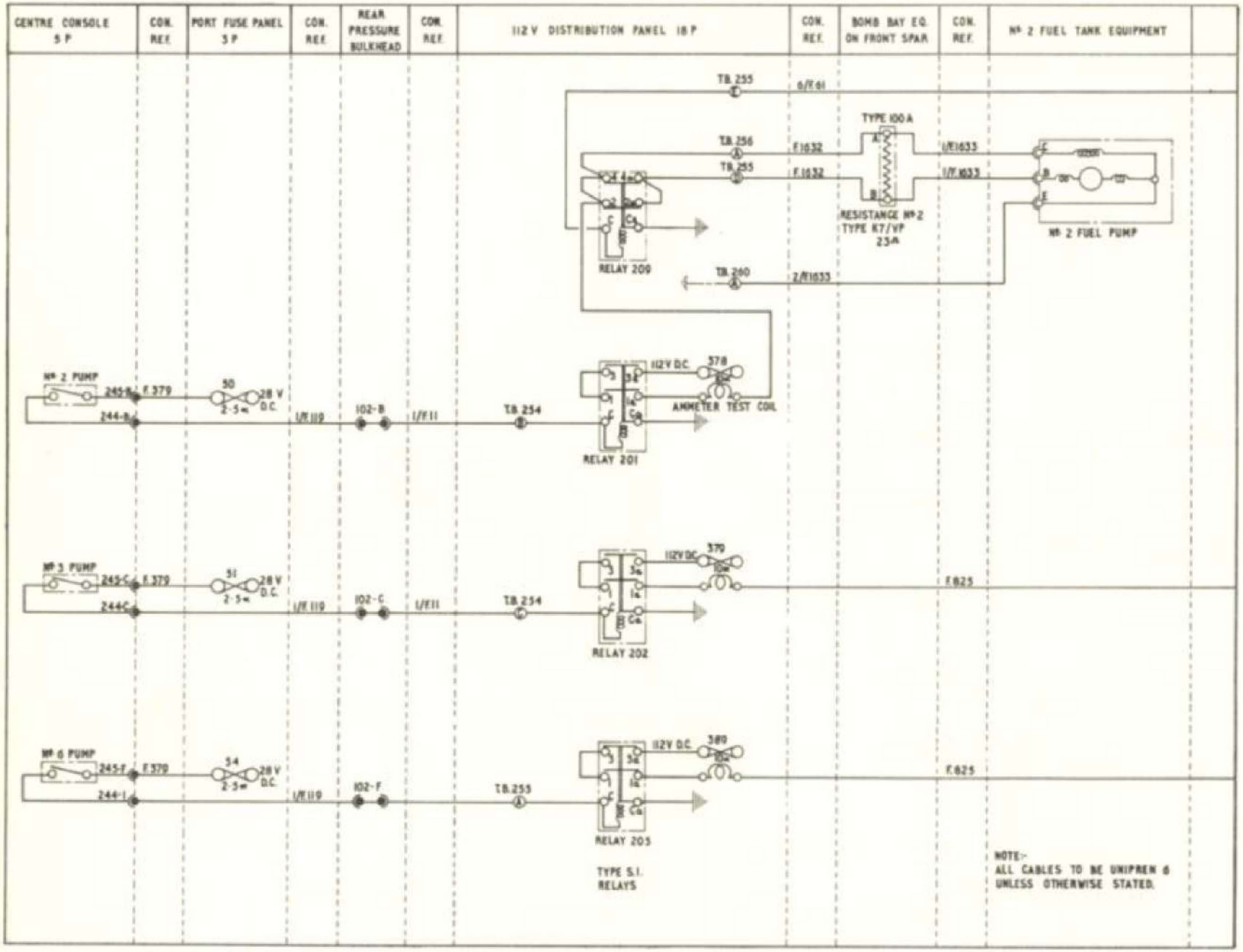

Fig. 17 (1) Nº 2, 3 and 6 port fuel pumps

RESTRICTED

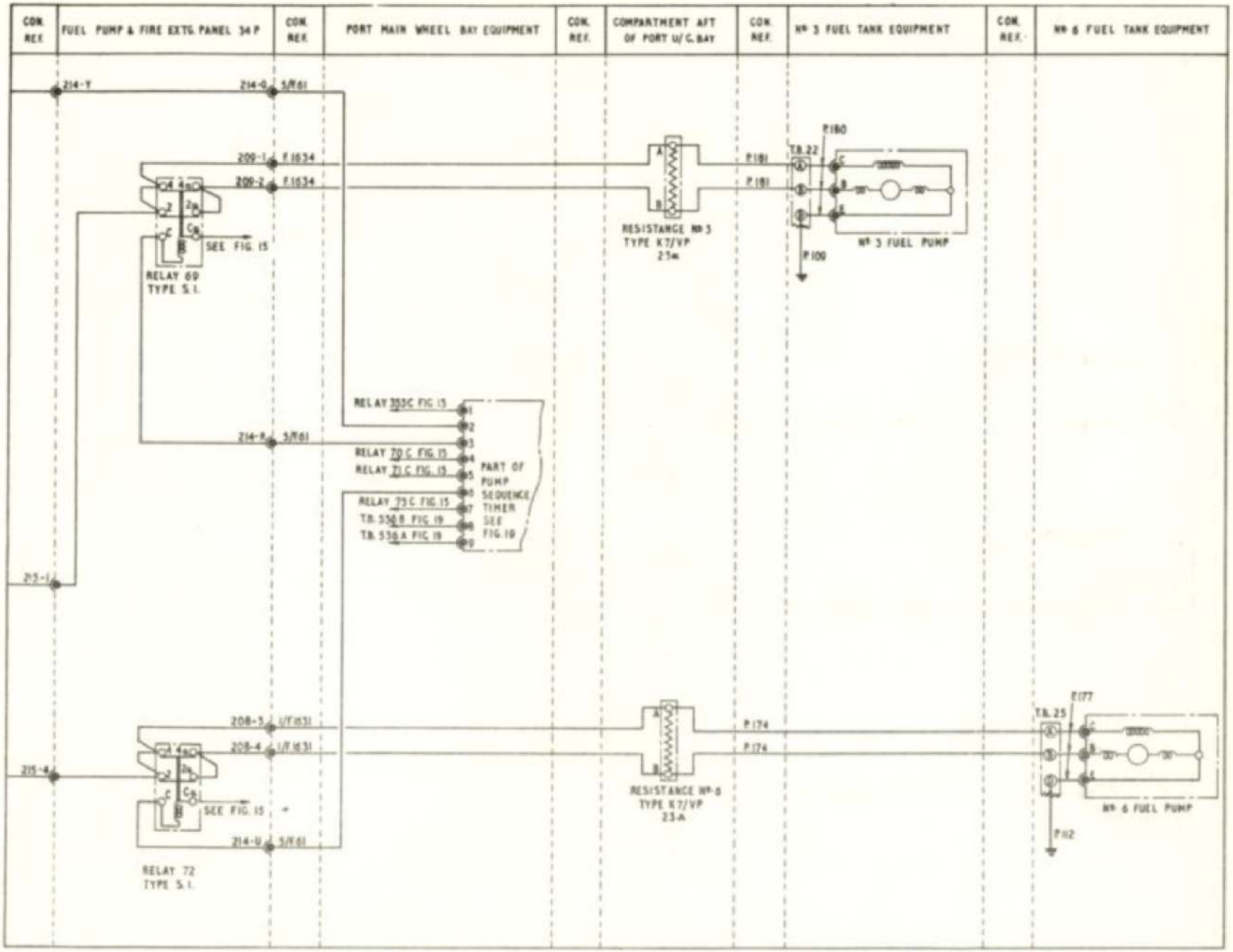

Fig 17 (2) Nº 2, 3, and 6 port fuel pumps

RESTRICTED

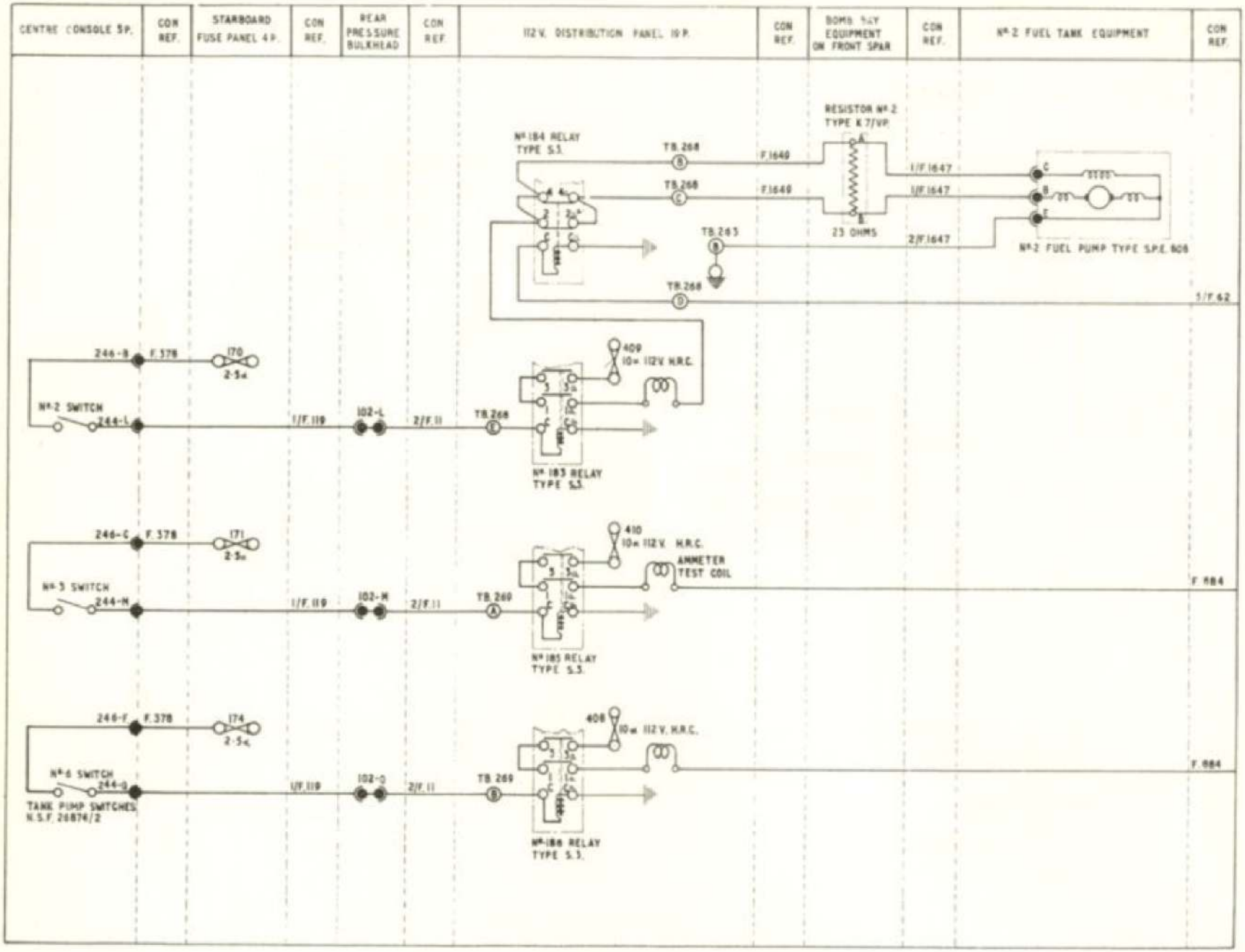

Fig.18 (1) Nº 2, 3 and 6 starboard fuel pumps

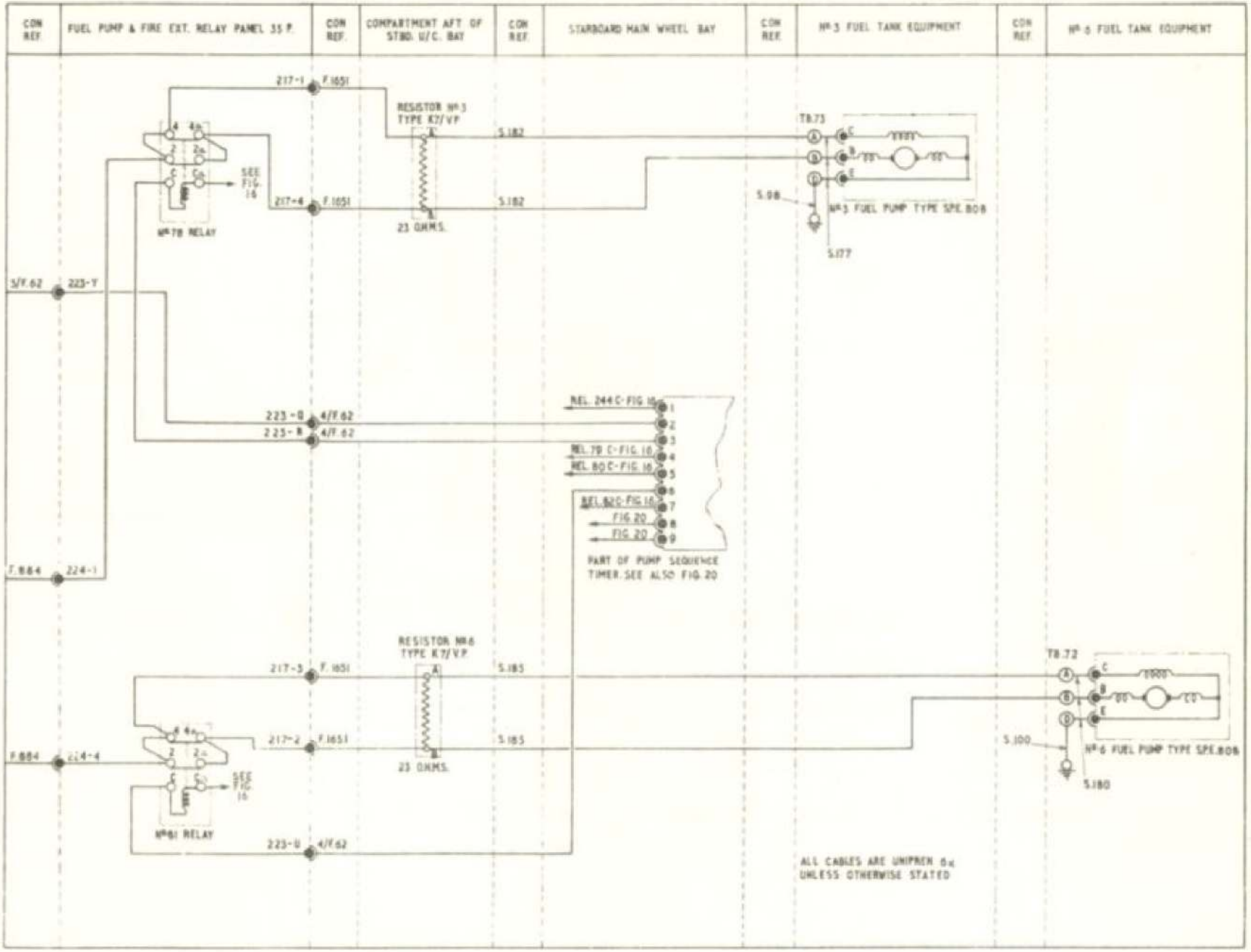

Fig 18 (2) Nº 2, 3, and 6 starboard fuel pumps

RESTRICTED

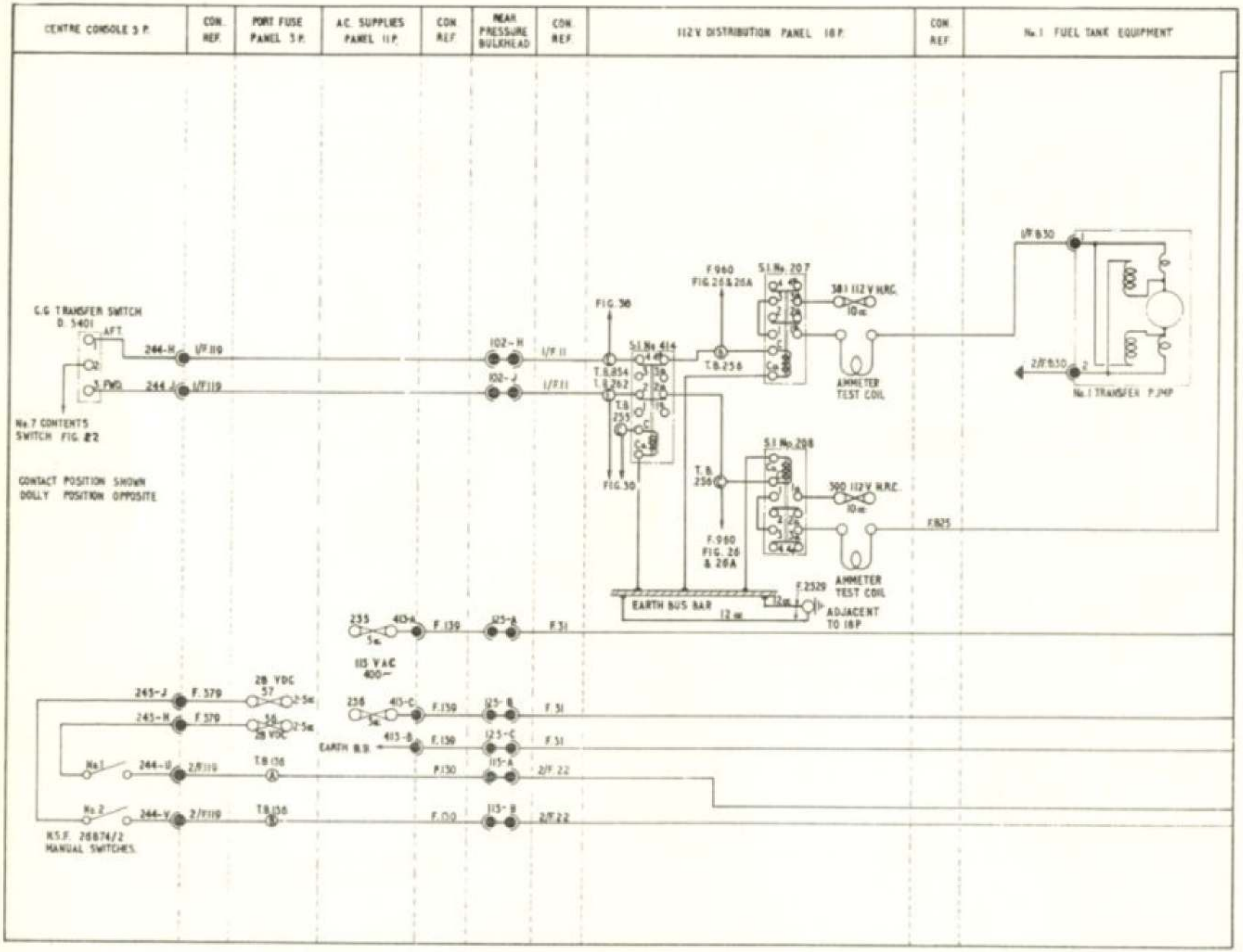

Fig.19(1) Nº 1 and 7 port transfer fuel pumps

RESTRICTED

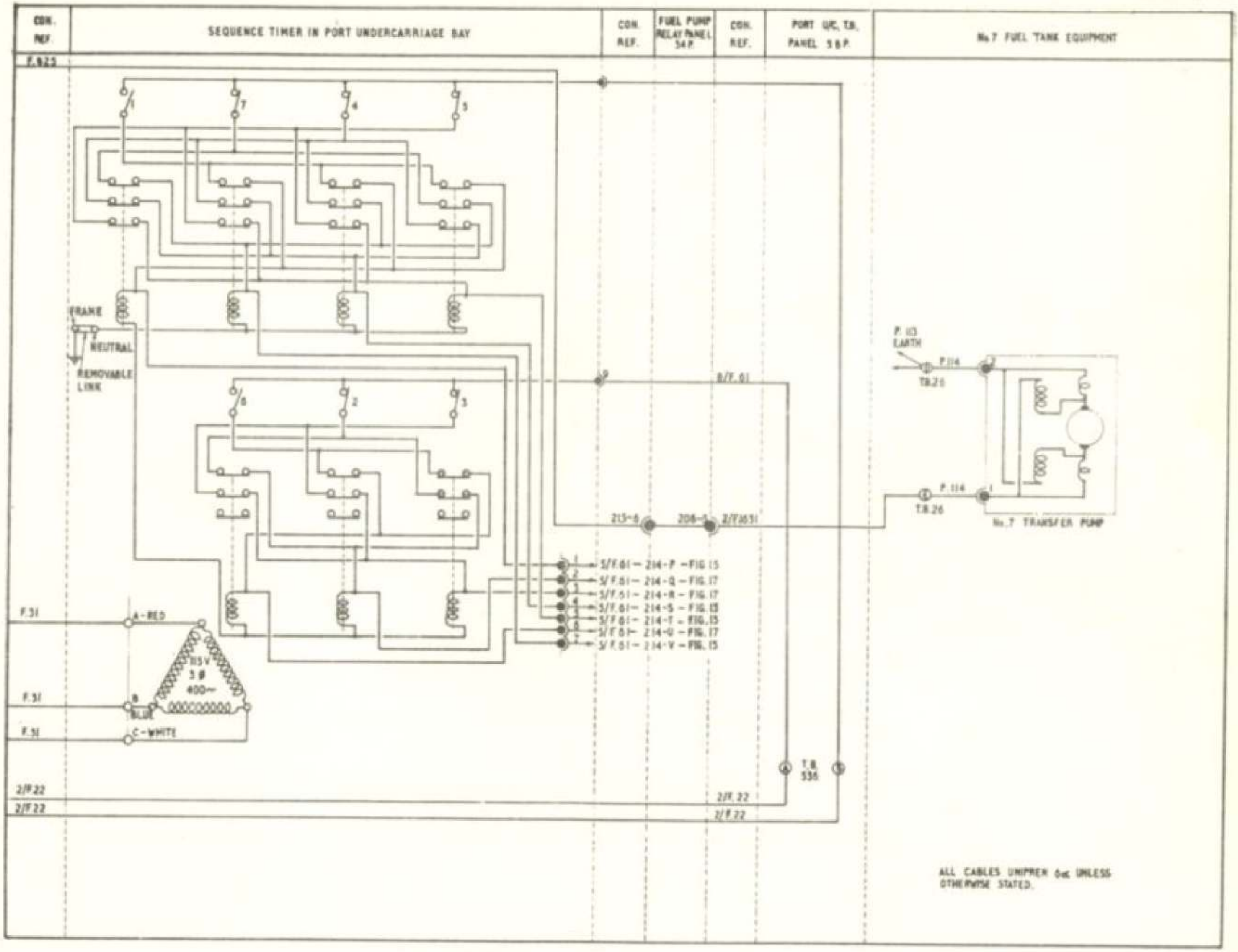

Fig 19(2) No 1 and 7 port transfer fuel pumps

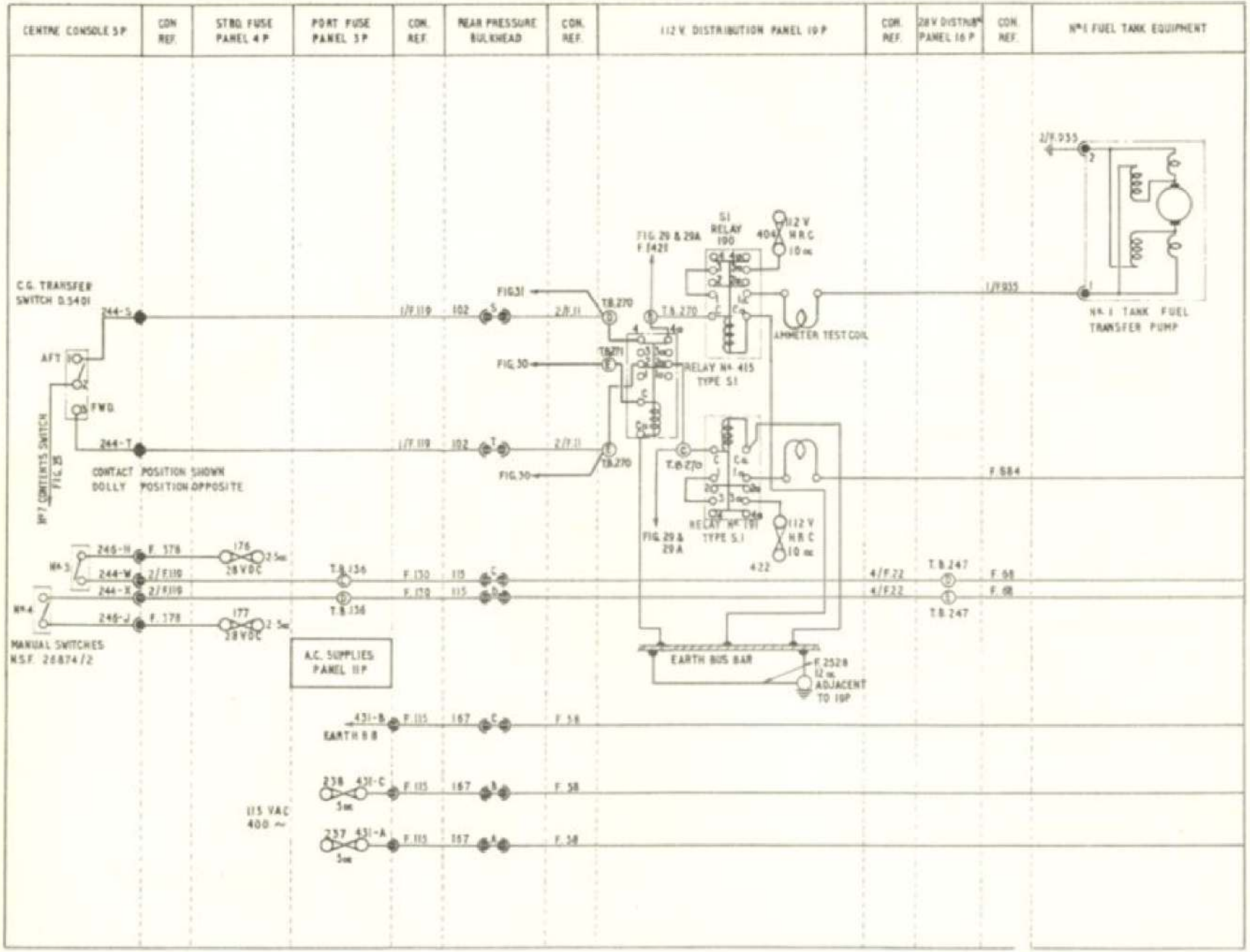

Fig. 20(1) Nº 1 and 7 starboard transfer fuel pumps

RESTRICTED

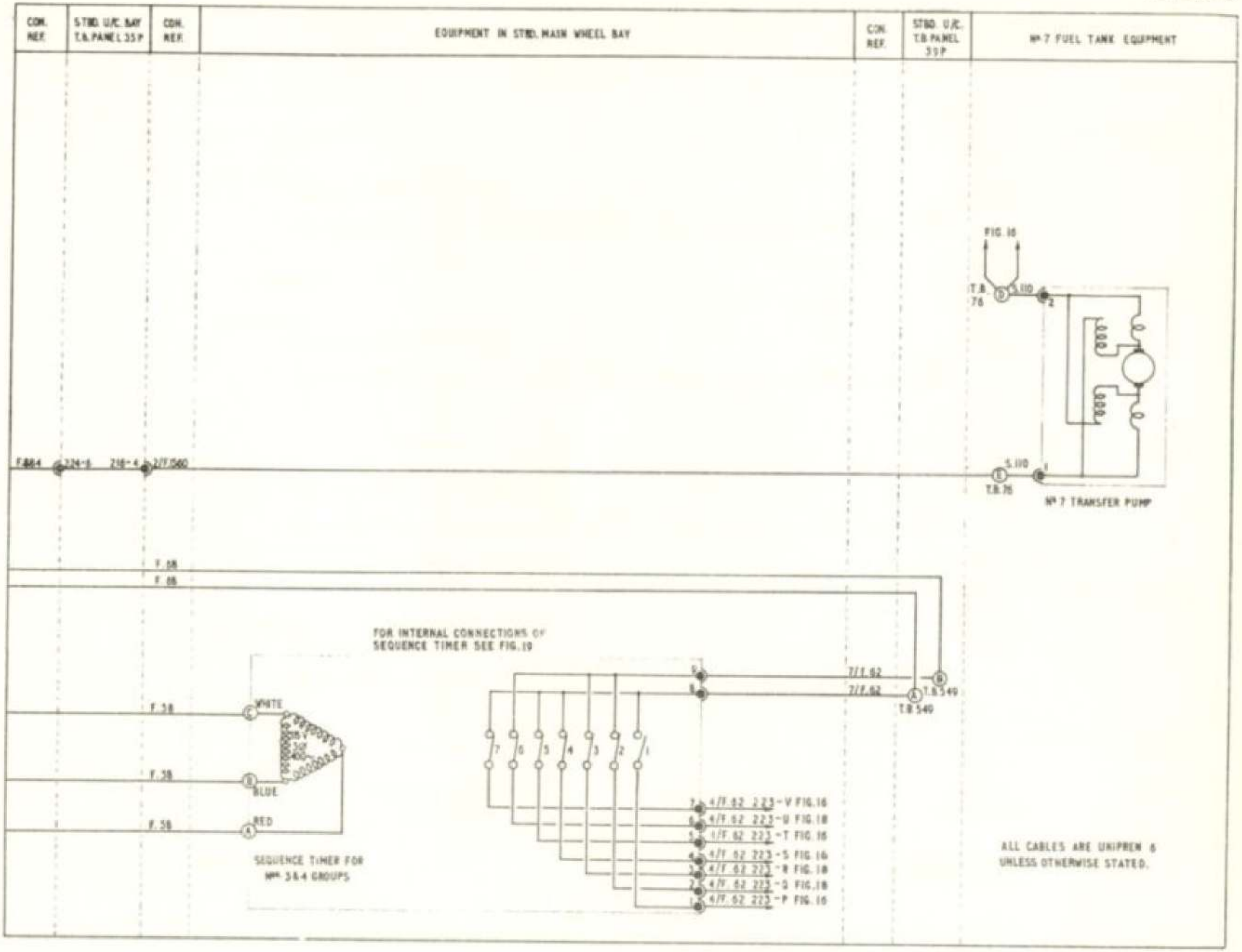

Fig. 20 (2) Nº 1 and 7 starboard transfer fuel pumps

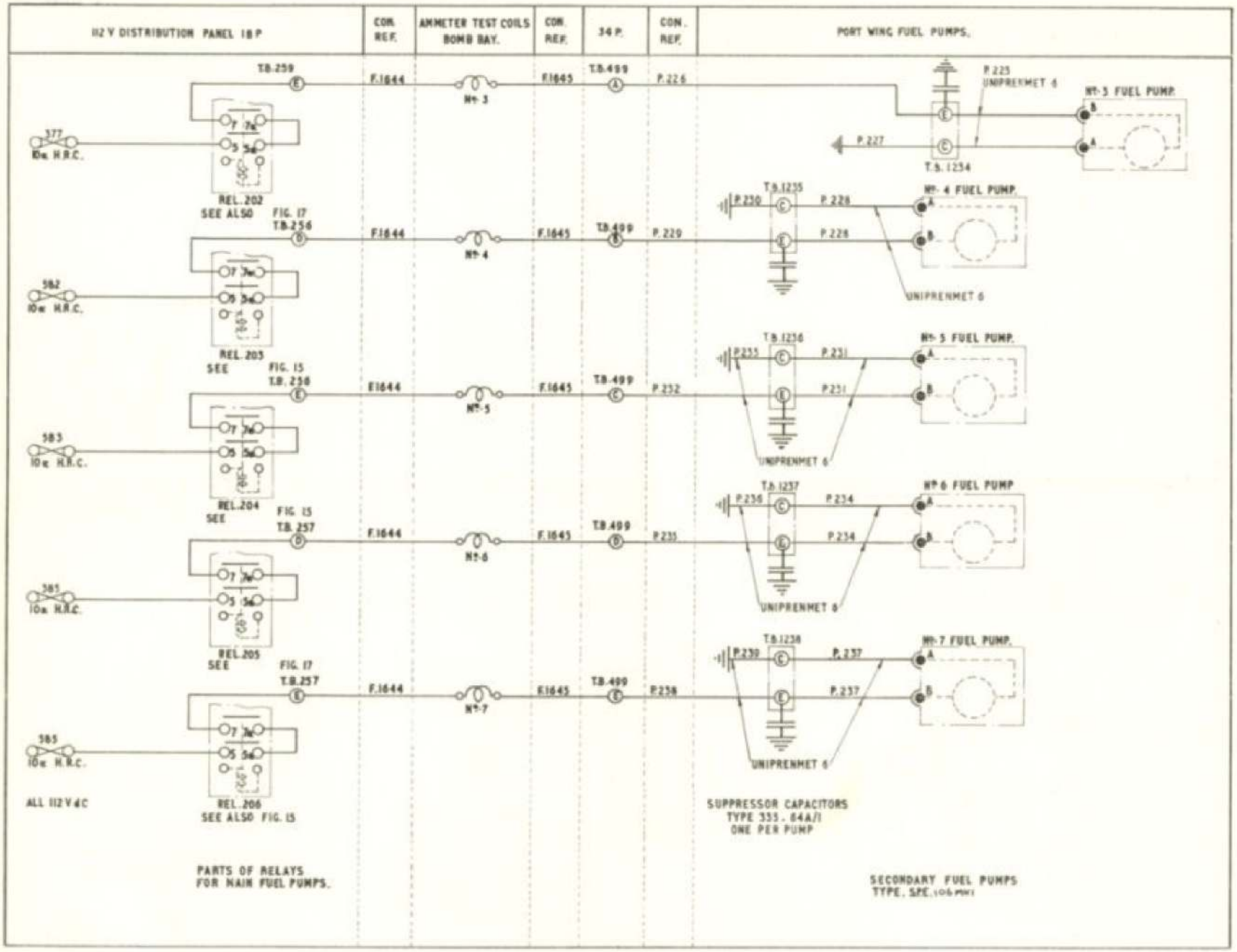

Fig. 21(1) Secondary fuel pumps

RESTRICTED

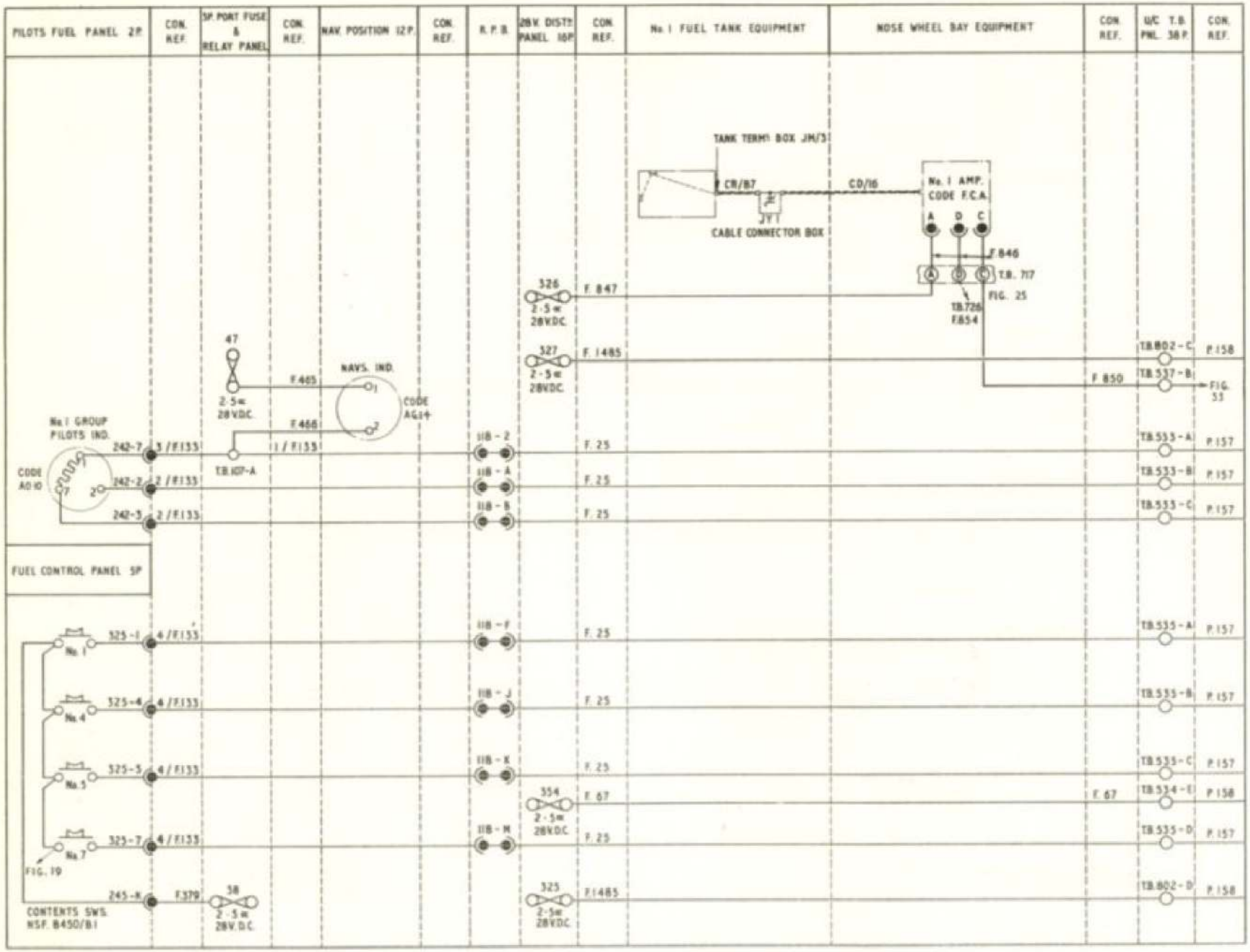

Fig 22 (I) Fuel contents Nº I group

RESTRICTED

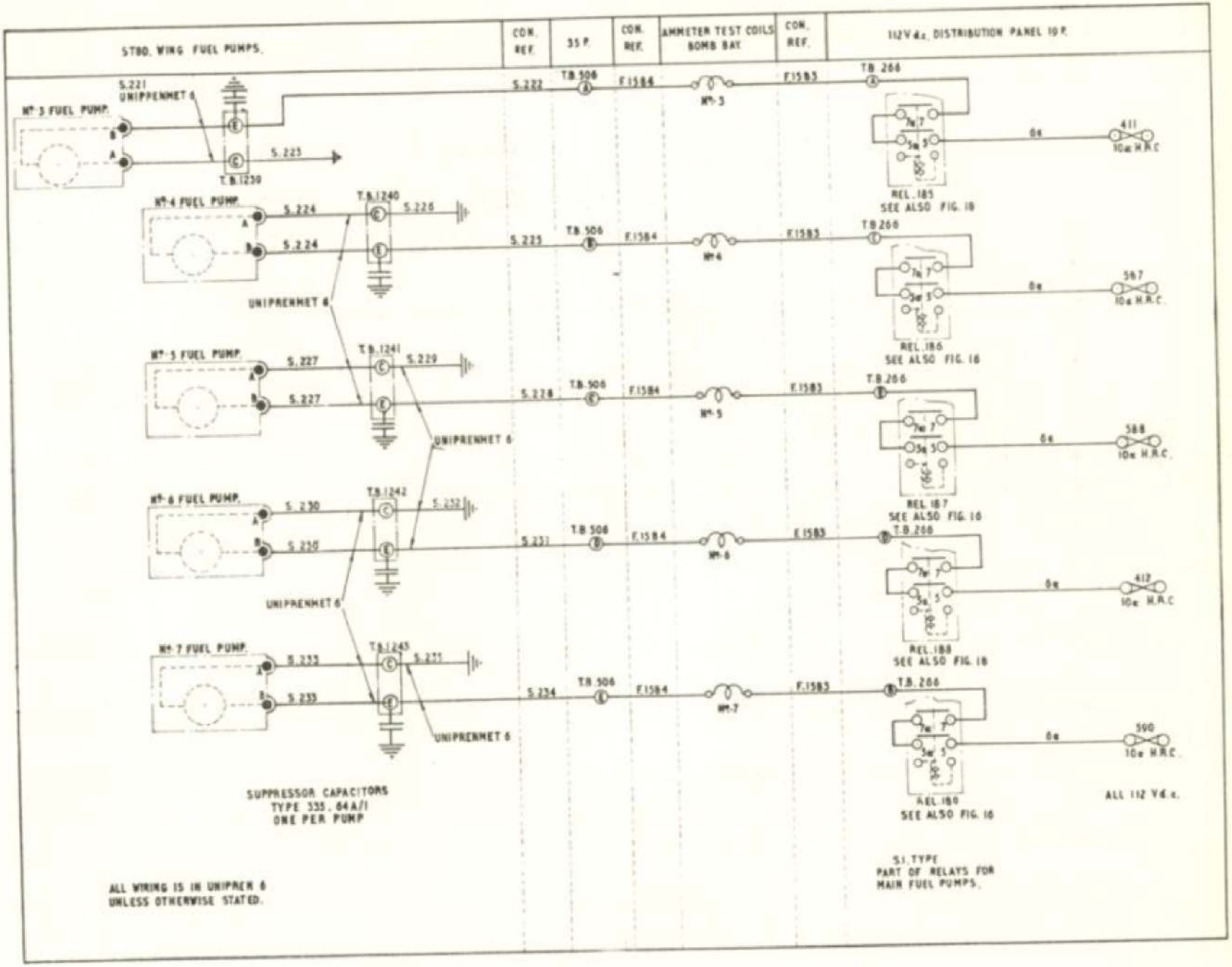

Fig 21(2) Secondary fuel pumps

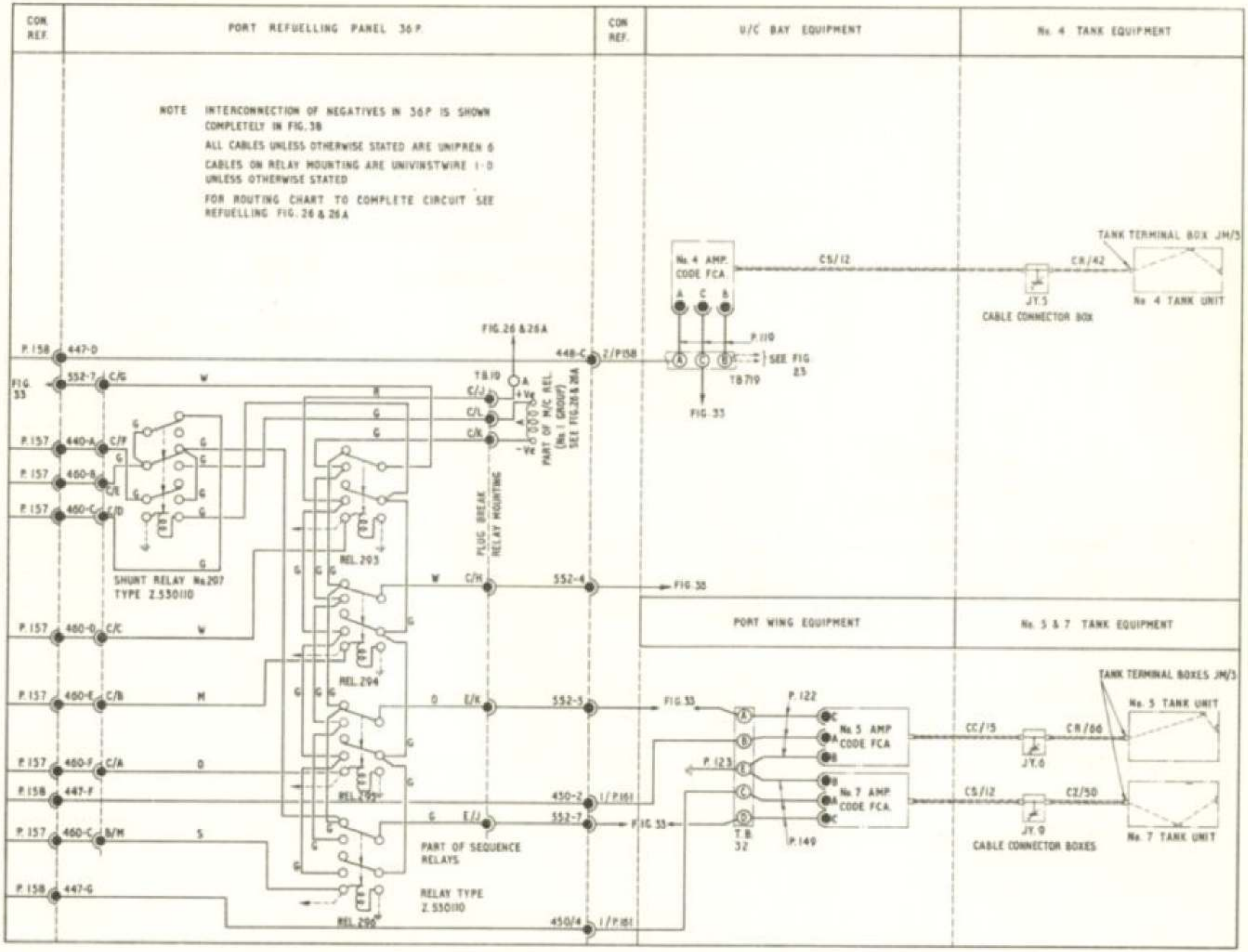

Fig 22(2) Fuel contents Nº 1 group

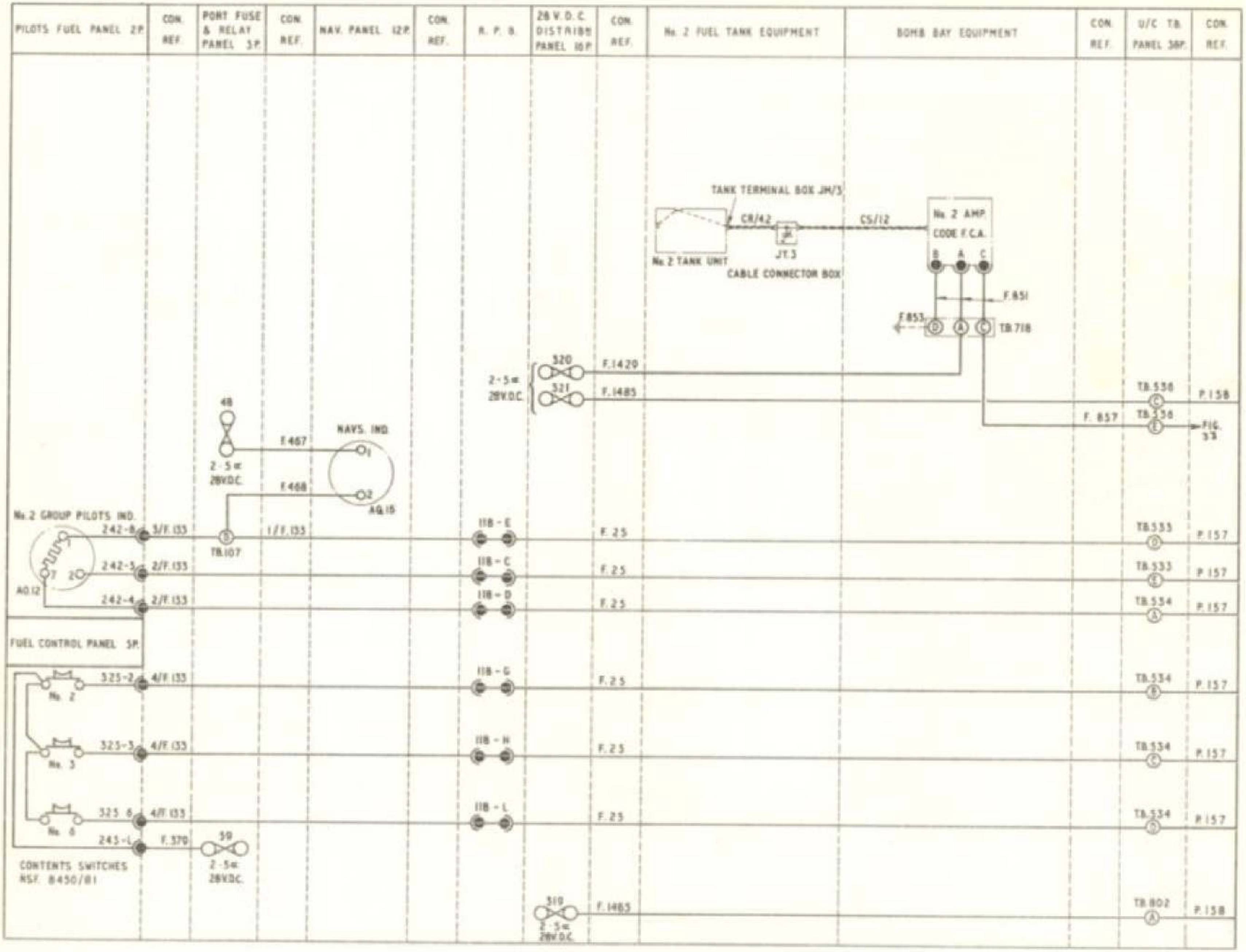

Fig 23(1) Fuel contents Nº 2 group

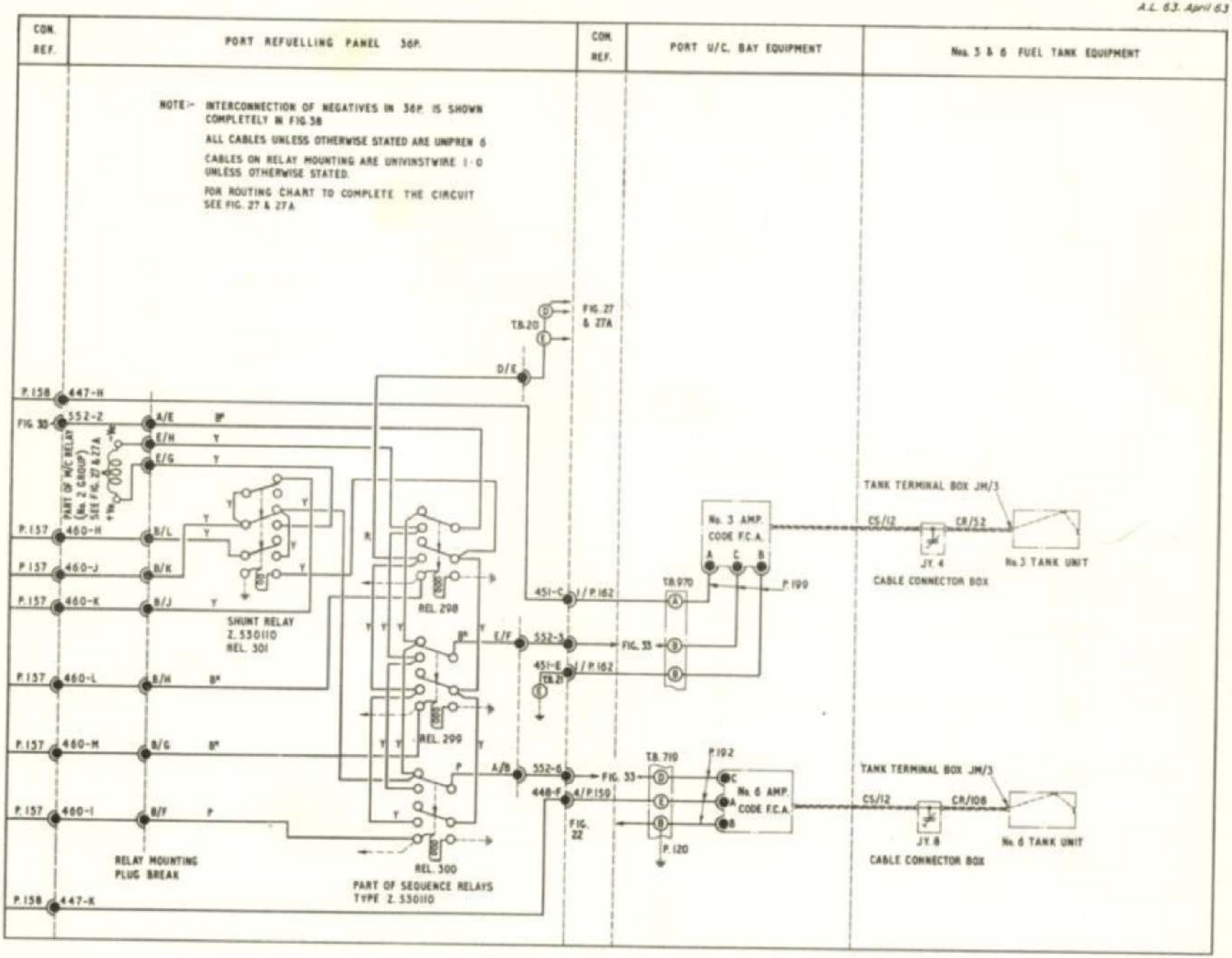

Fig. 23(2) Fuel contents No 2 group

RESTRICTED

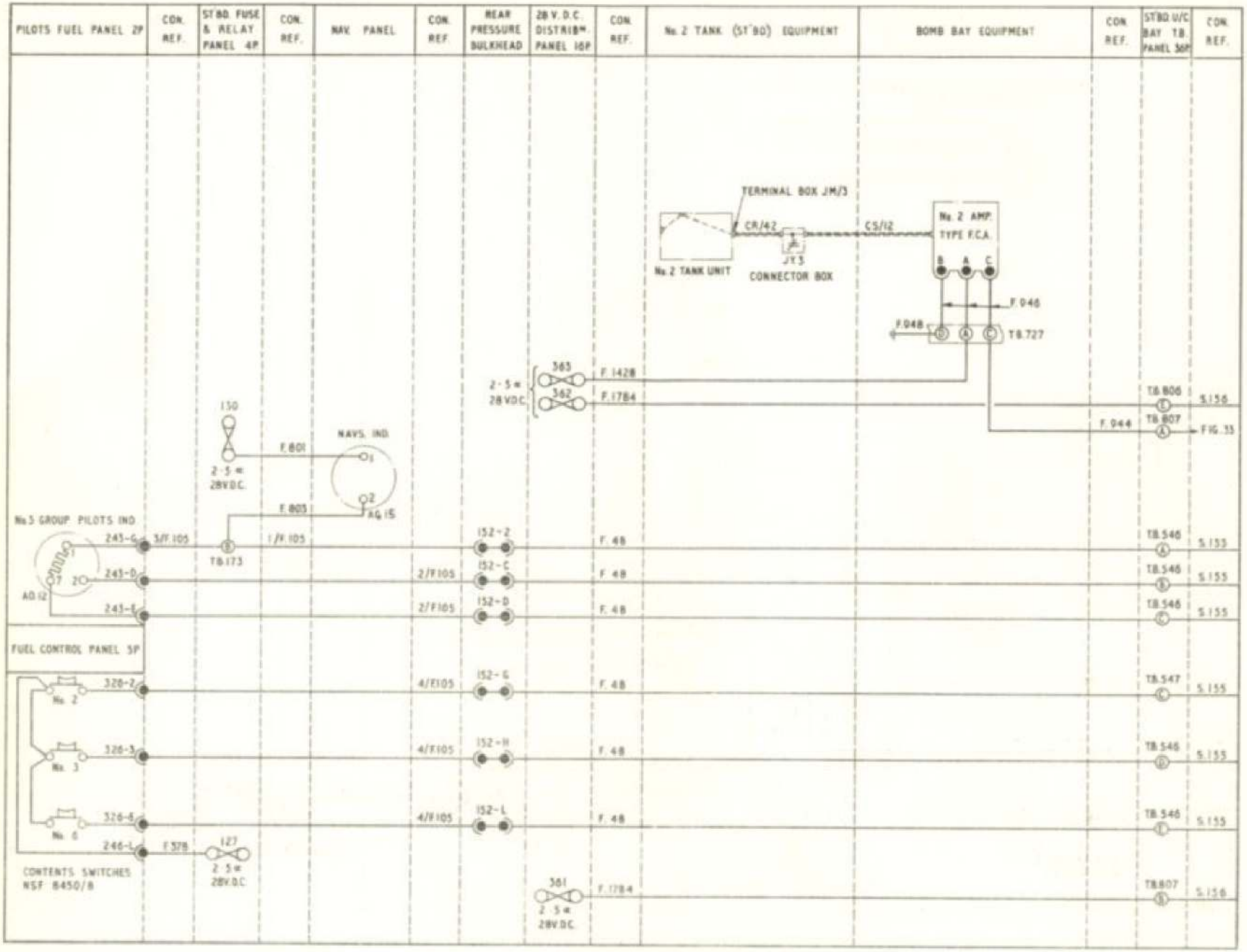

Fig 24(1) Fuel contents Nº3 group

RESTRICTED

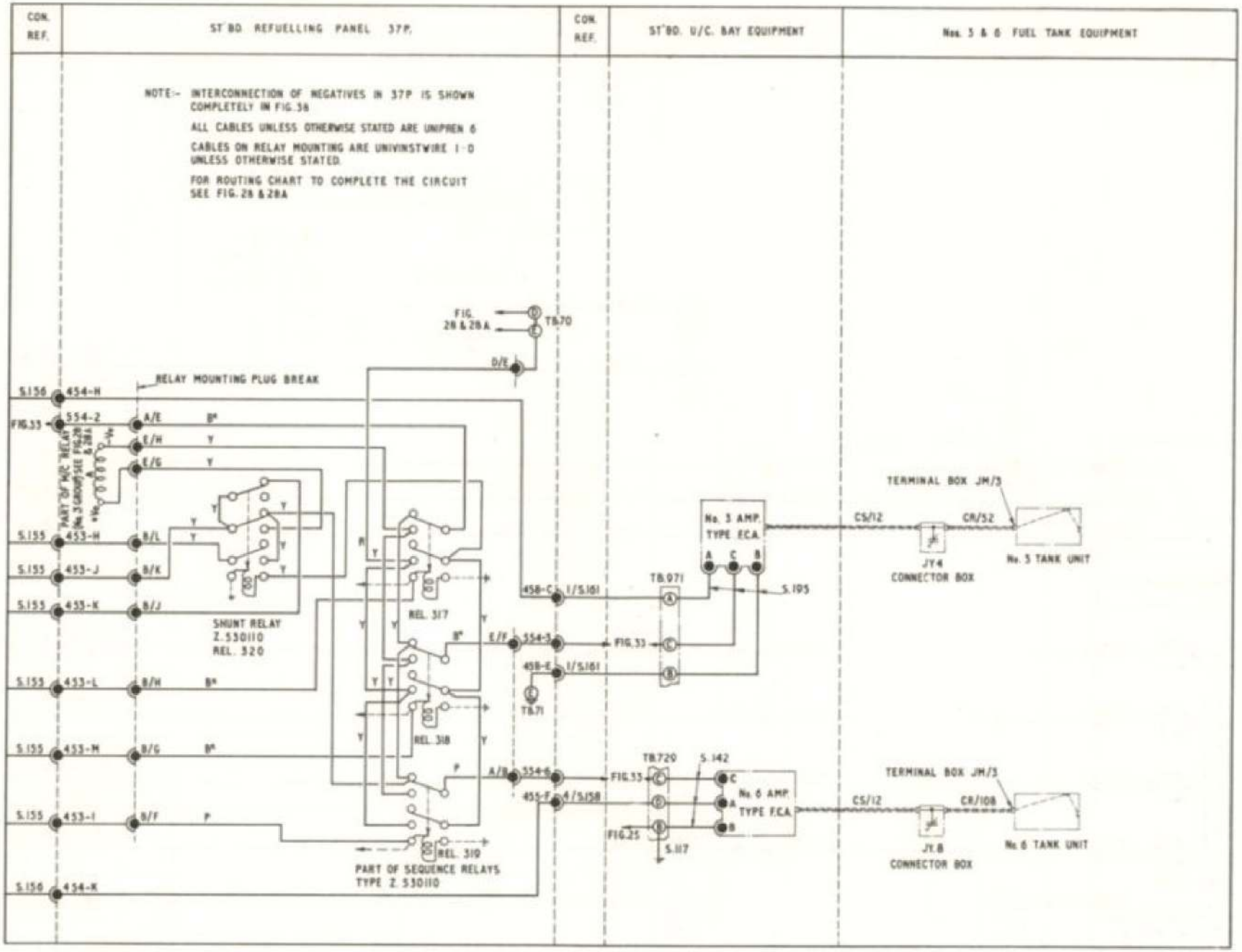

Fig.24 (2) Fuel contents No. 3 group
(◄ Correction to Group ref. ►)

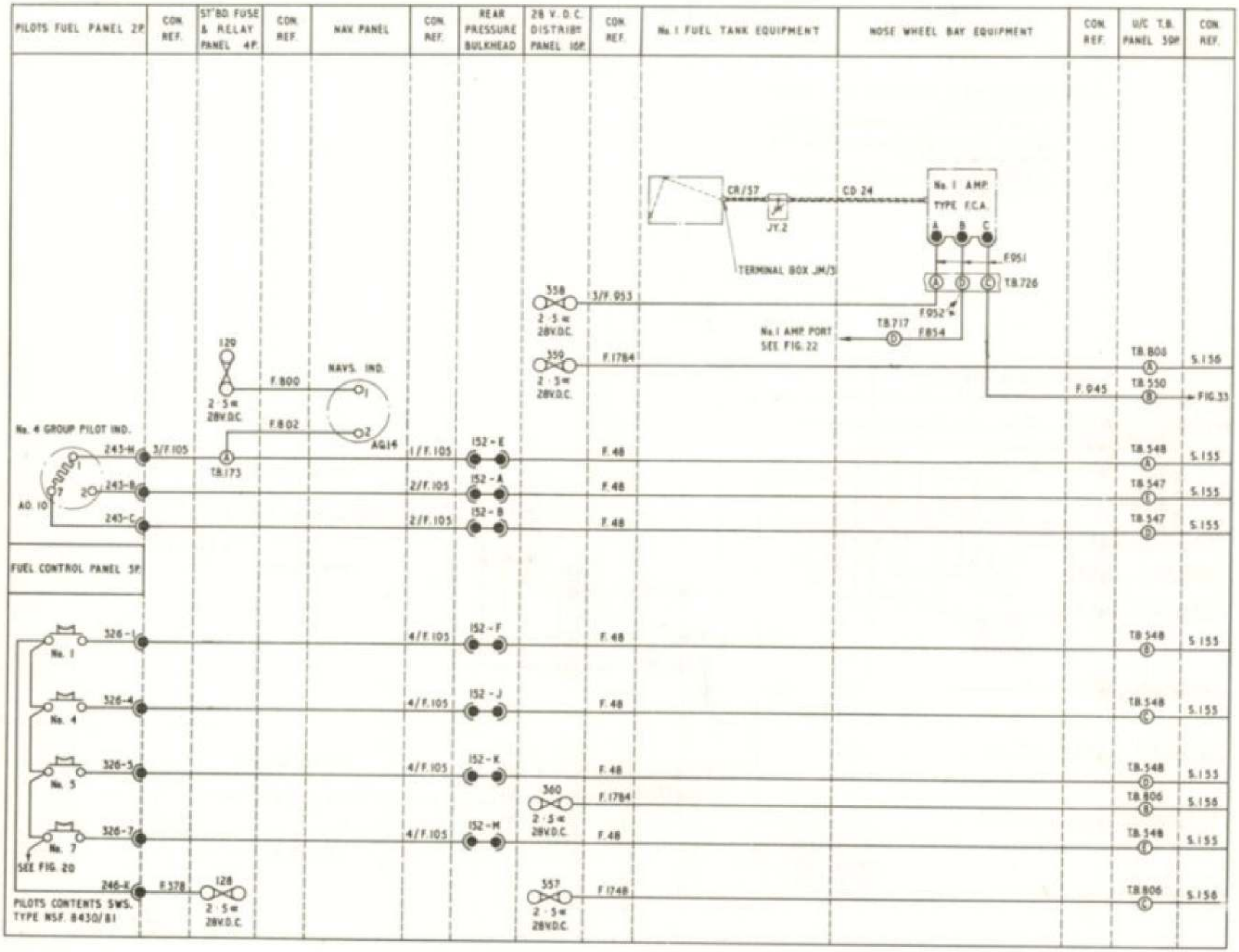

Fig. 25 (1) Fuel contents Nº 4 group

RESTRICTED

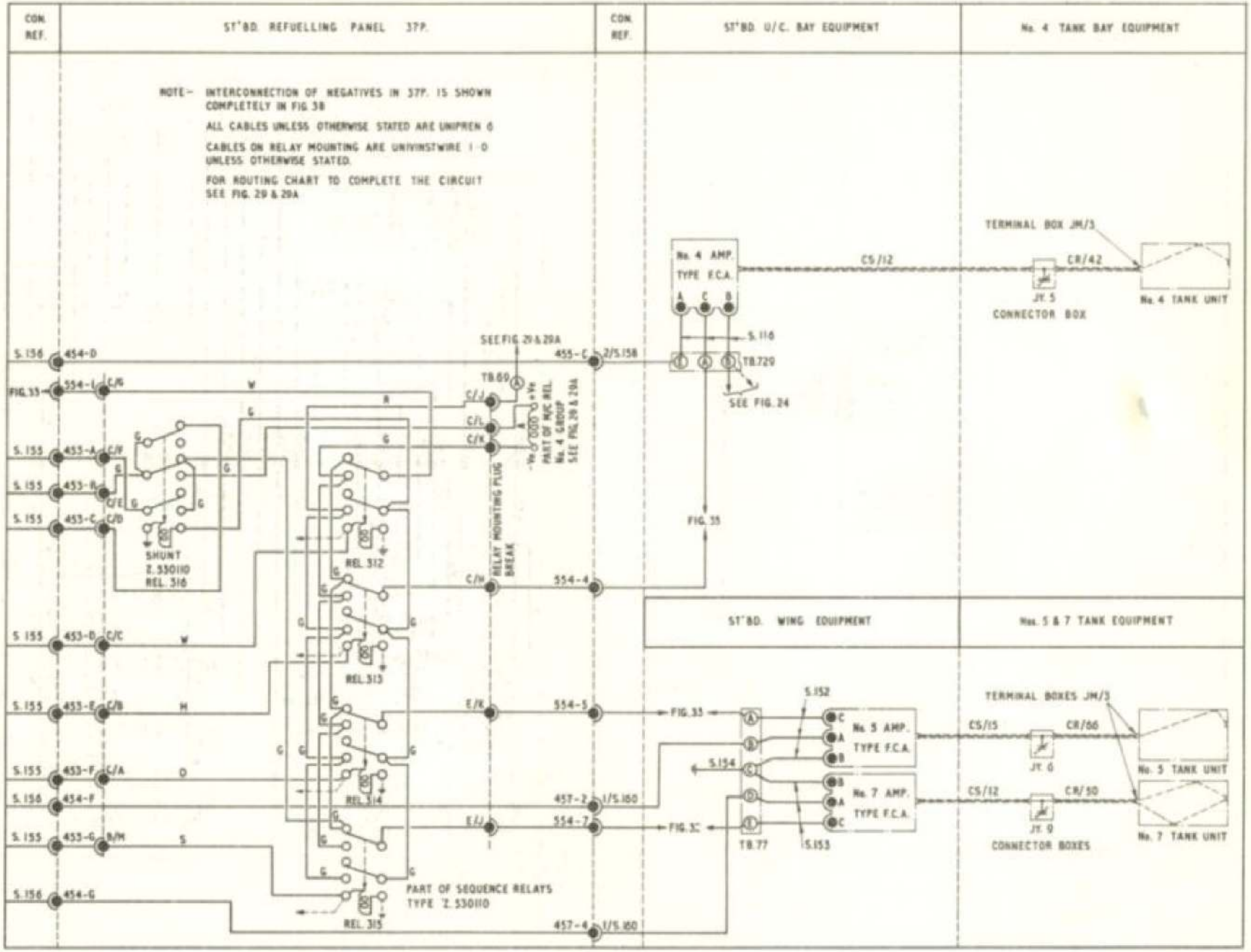

Fig 25(2) Fuel contents No. 4 group

RESTRICTED

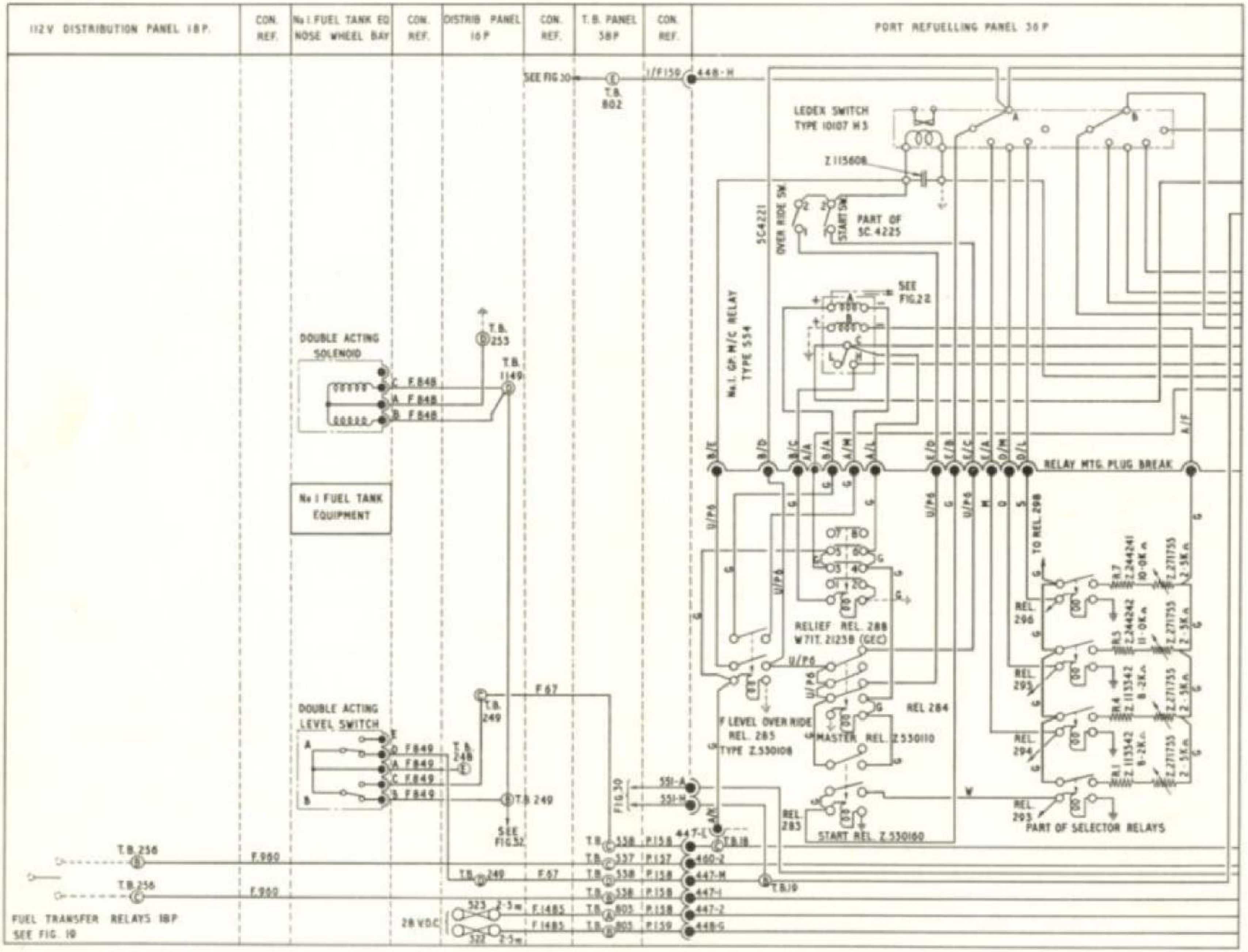

Fig. 26 (I) Refuelling - Nº1 group (pre. Mod 1406)

RESTRICTED

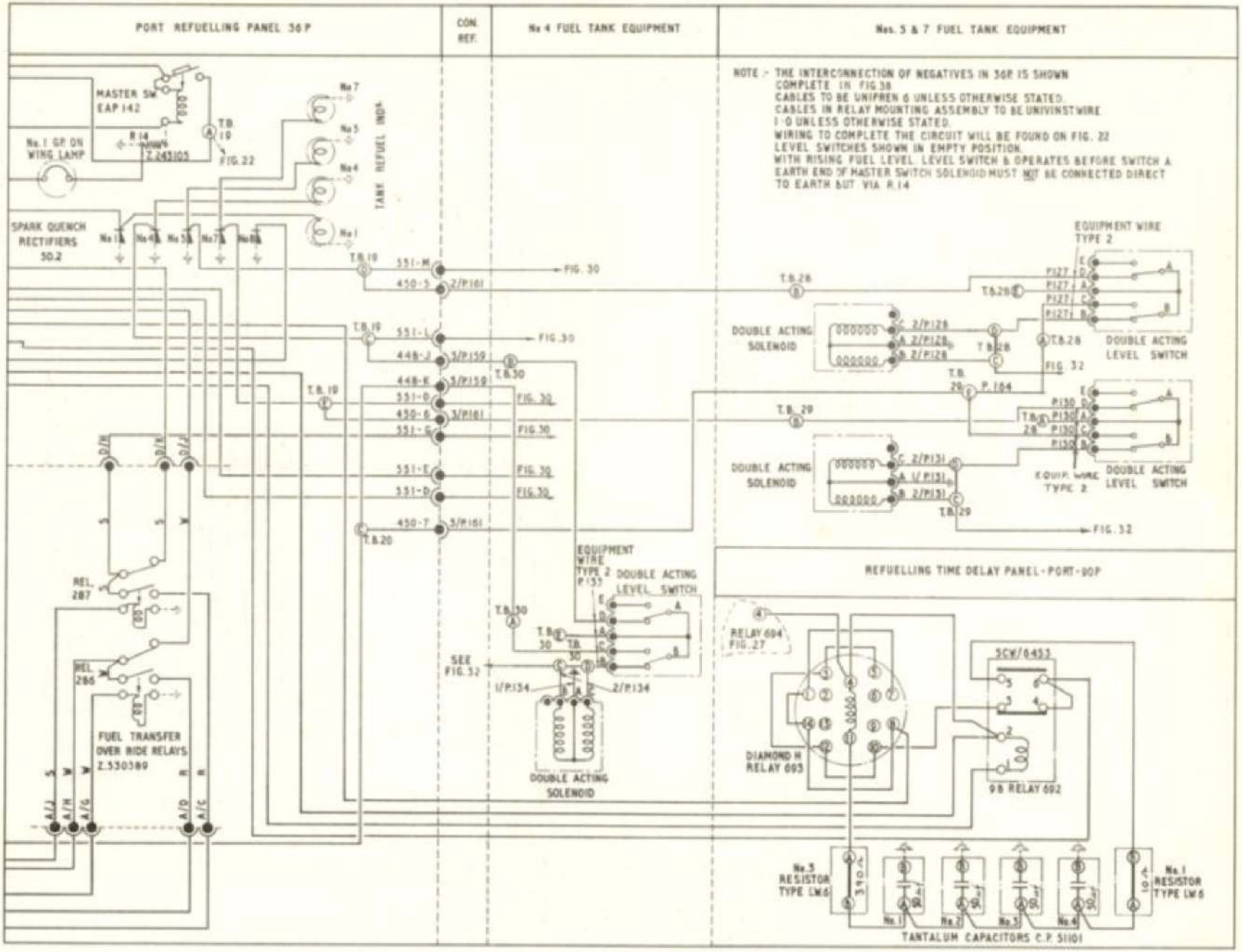

Fig. 26 (2) Refuelling - No1 group (pre. Mod. 1406)

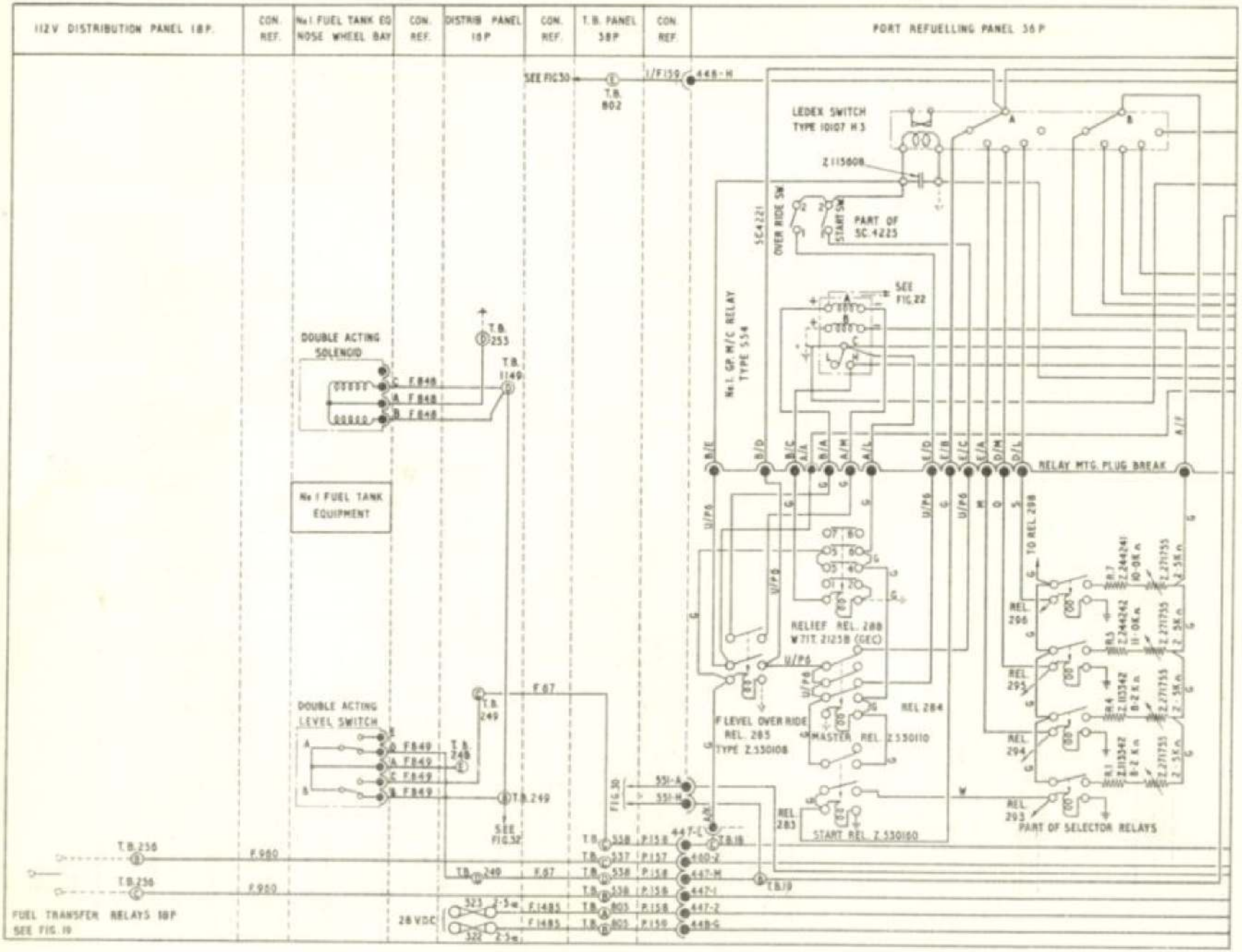

Fig.26A(1) Refuelling-Nº1 group (post Mod.1406)

RESTRICTED

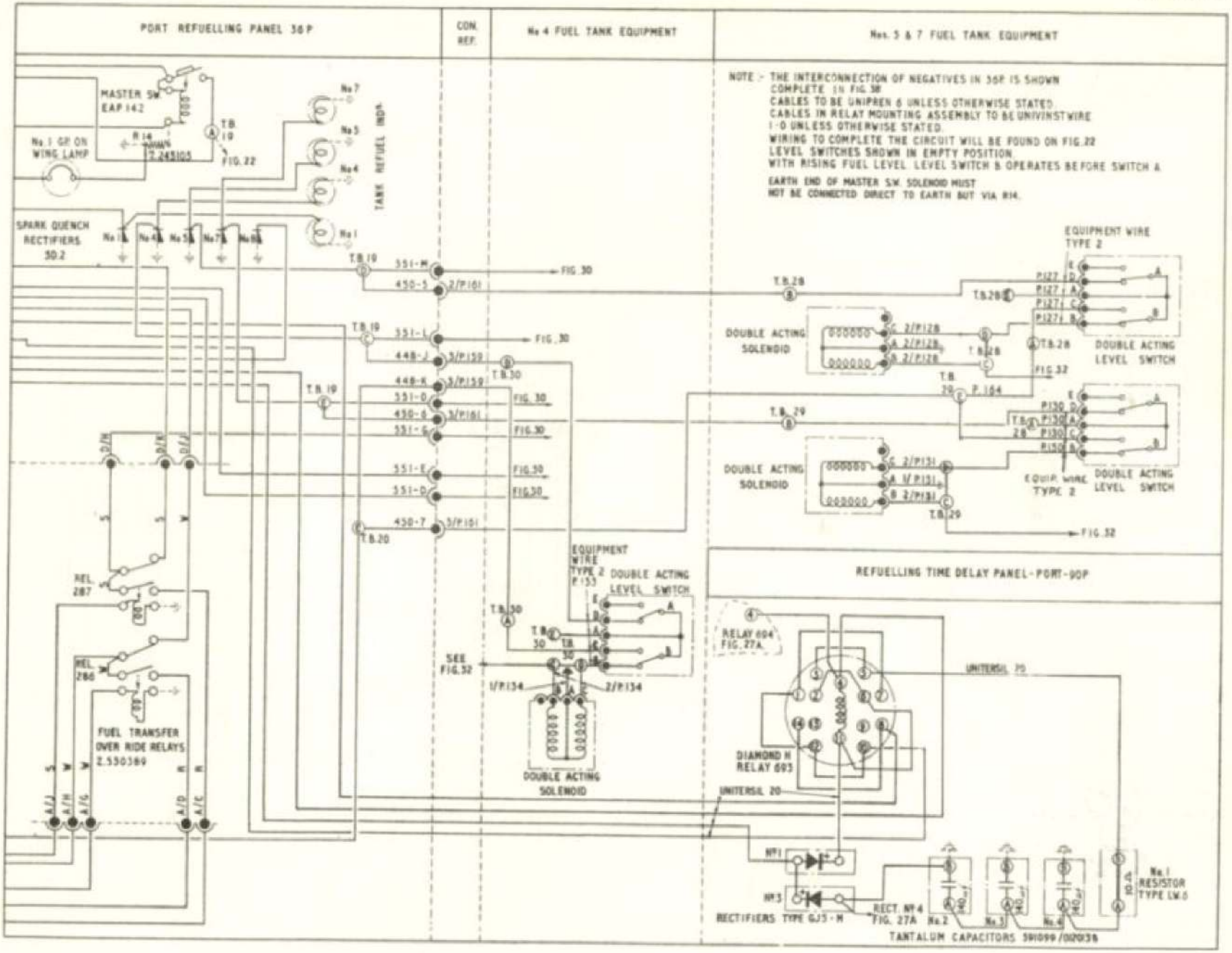

Fig. 26A (2) Refuelling - No. 1 group (post Mod. 1406)

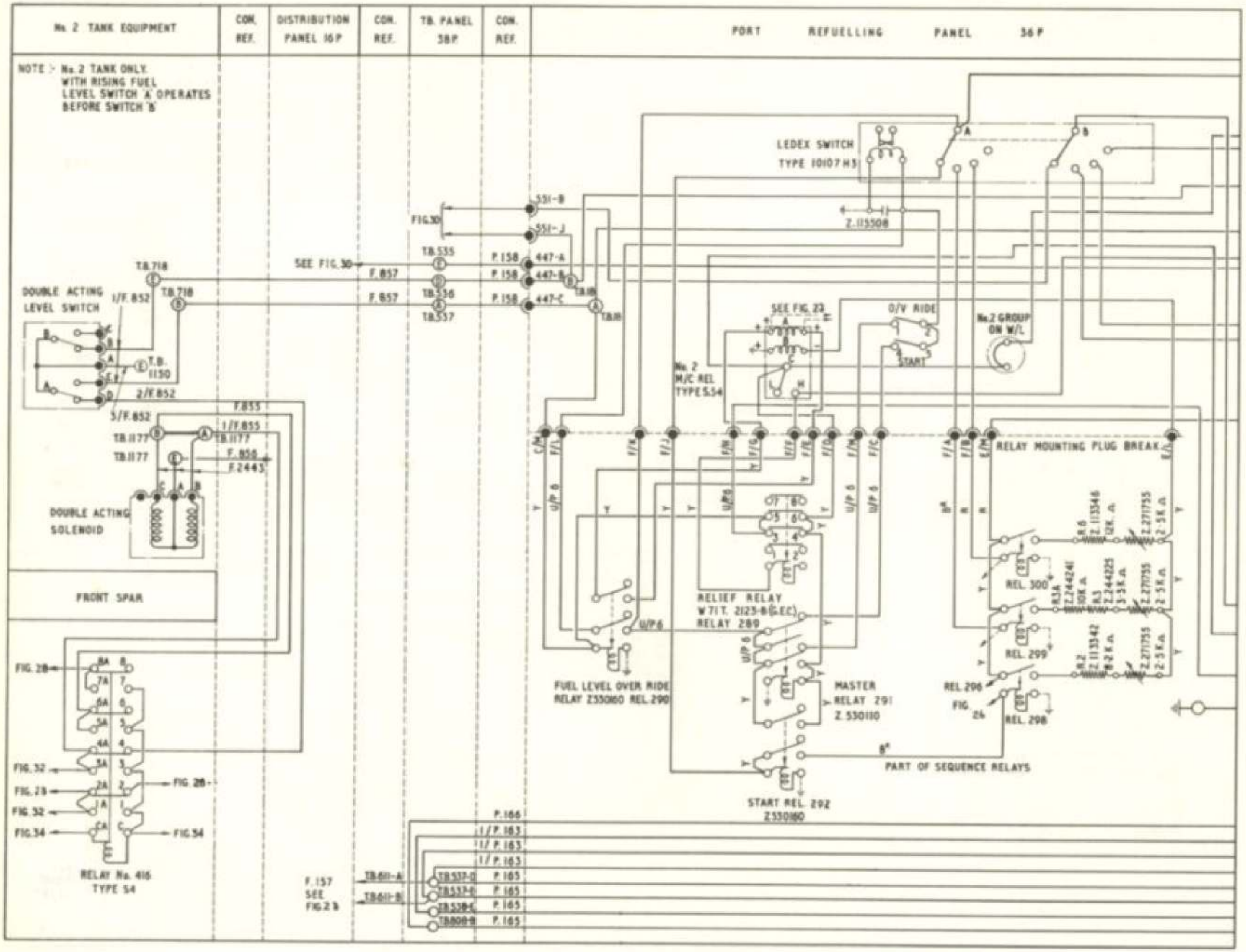

Fig 27(1) Refuelling-Nº2 group (pre. Mod. 1406)

RESTRICTED

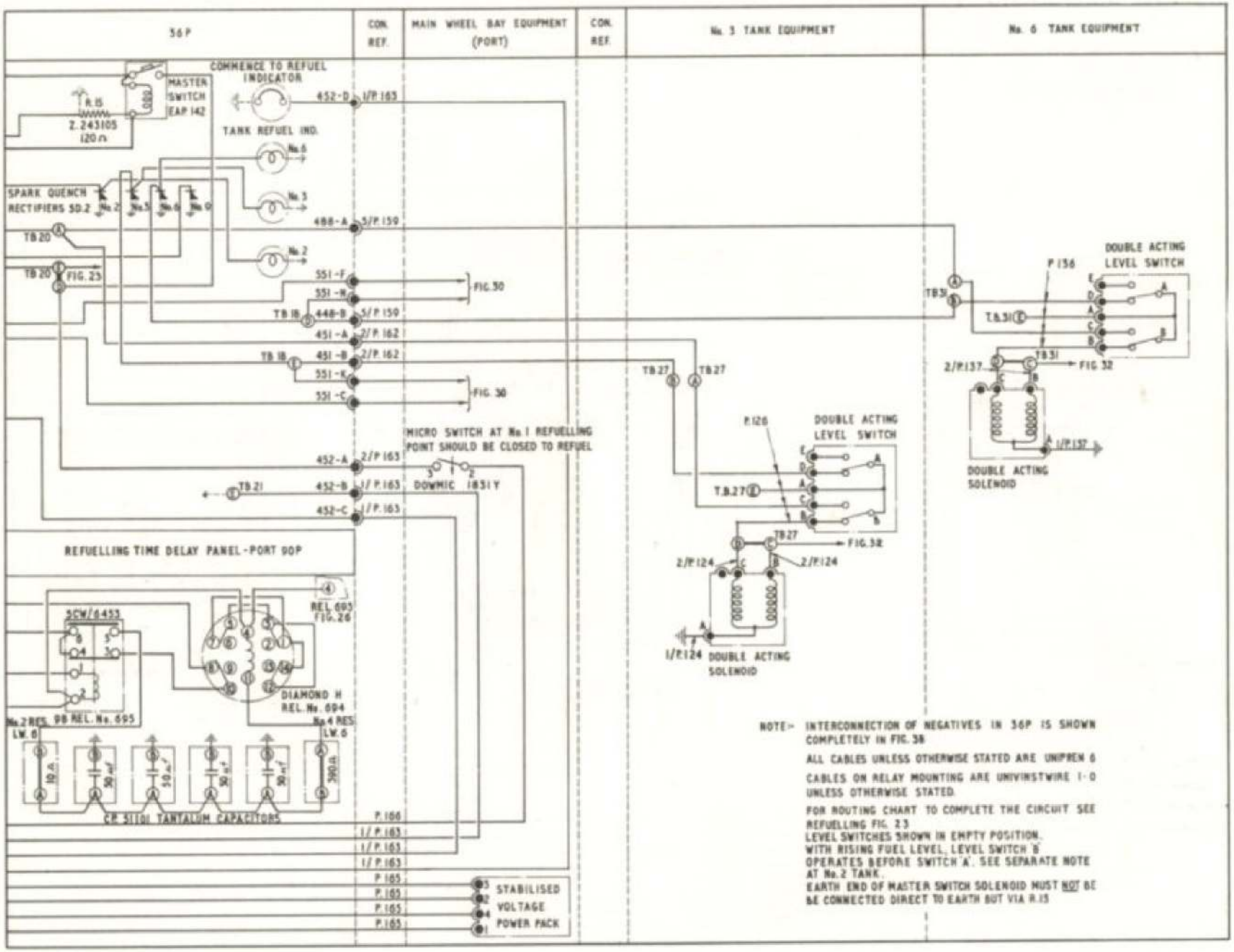

Fig.27(2) Refuelling-No.2 group (pre. Mod.1406)
(◄Link added at master switch►)

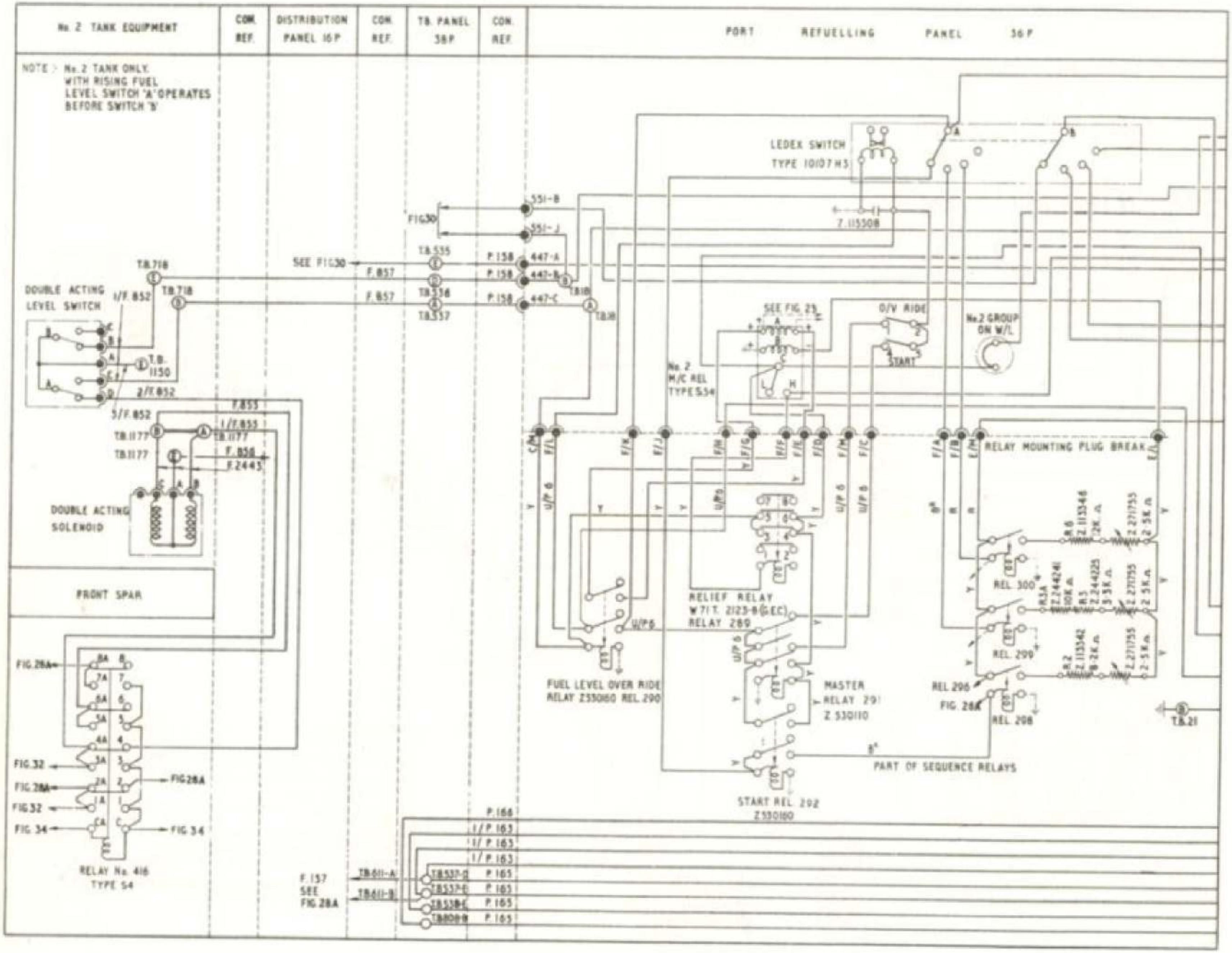

Fig. 27A(1) Refuelling-No. 2 group (post Mod. 1406)

RESTRICTED

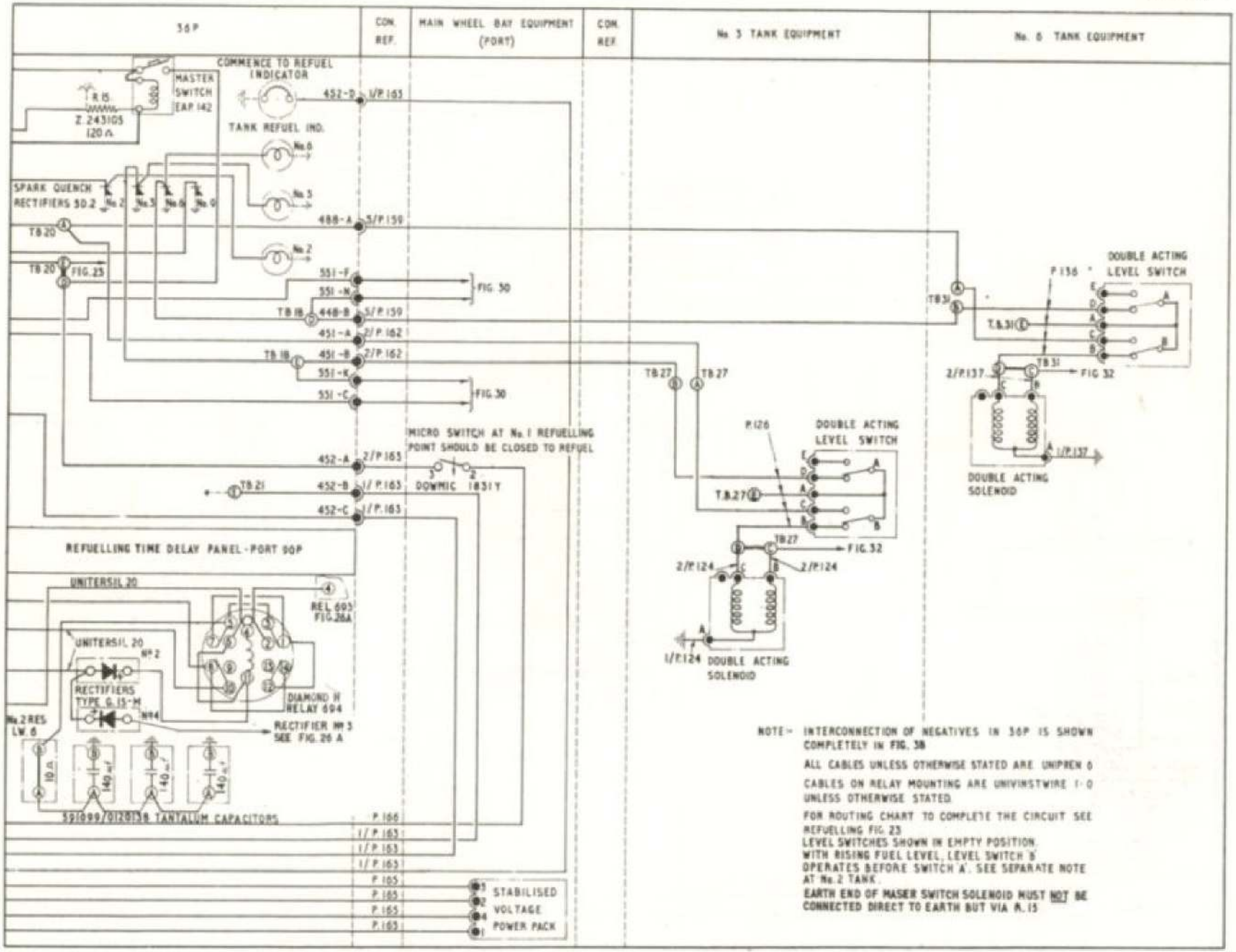

Fig. 27A(2) Refuelling-No. 2 group (post Mod. 1406)
(← Link added at master switch →)

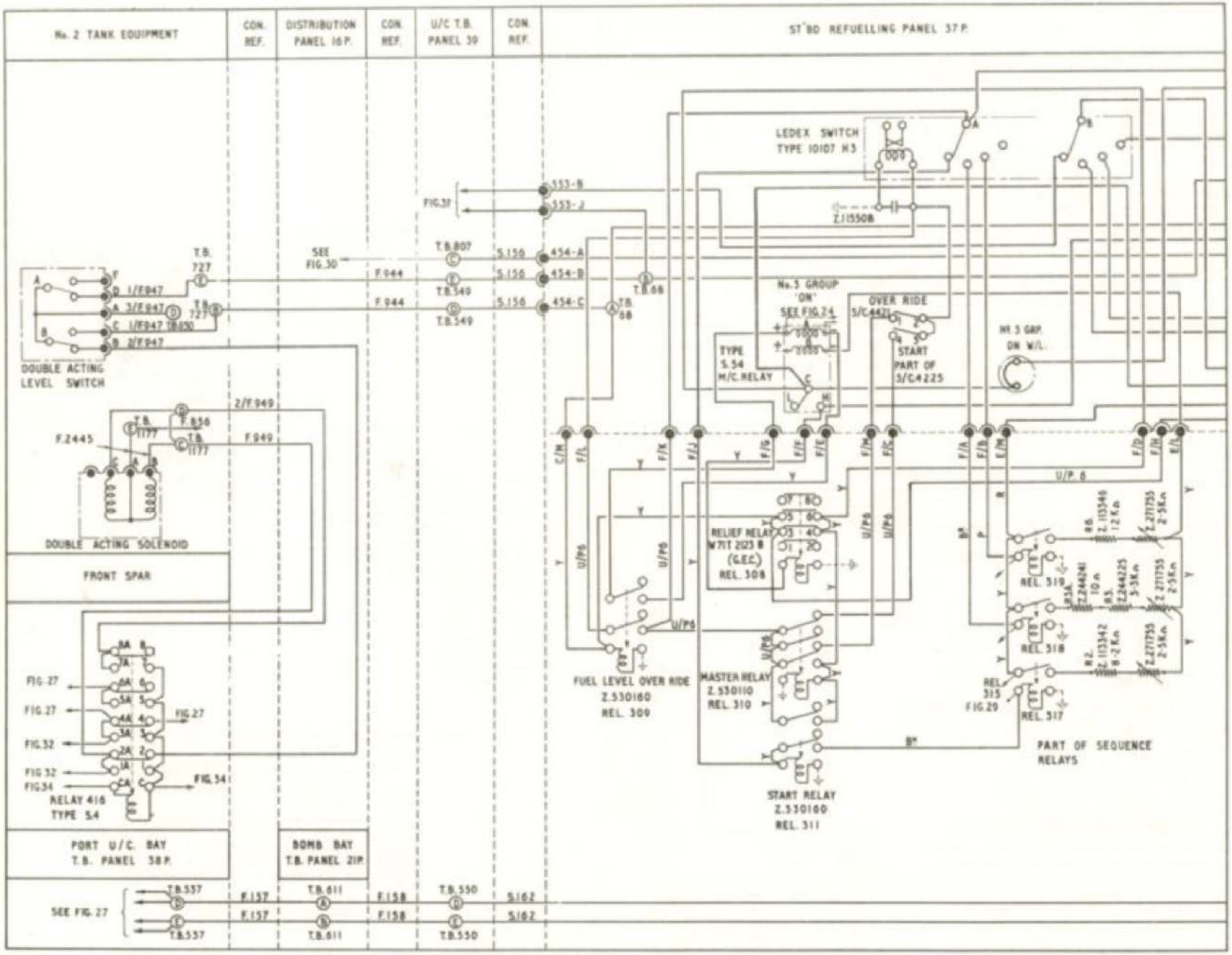

Fig. 28 (1) Refuelling-No. 3 group (pre. Mod. 1406)

RESTRICTED

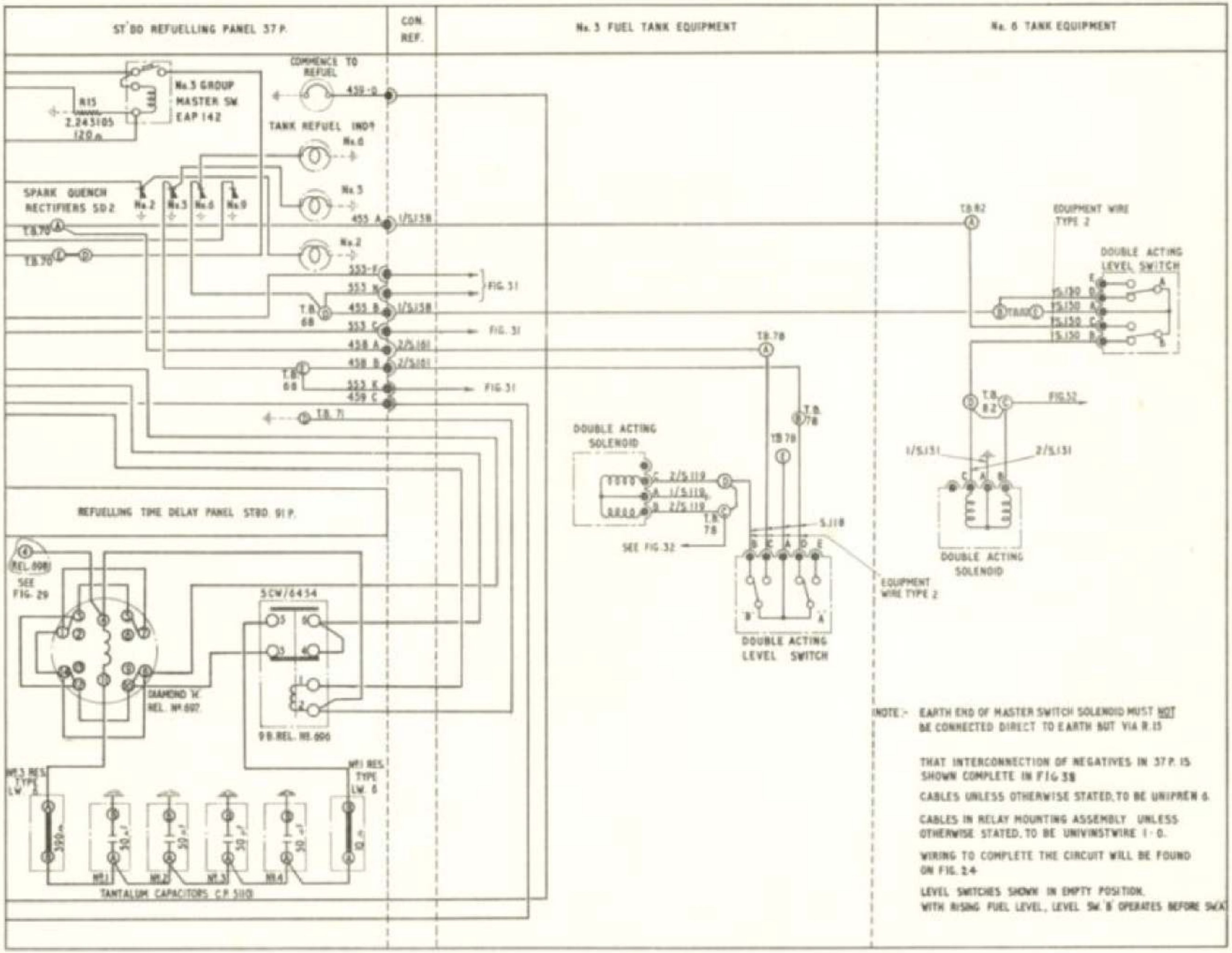

Fig. 28(2) Refuelling- Nº3 group (pre. Mod.1406)

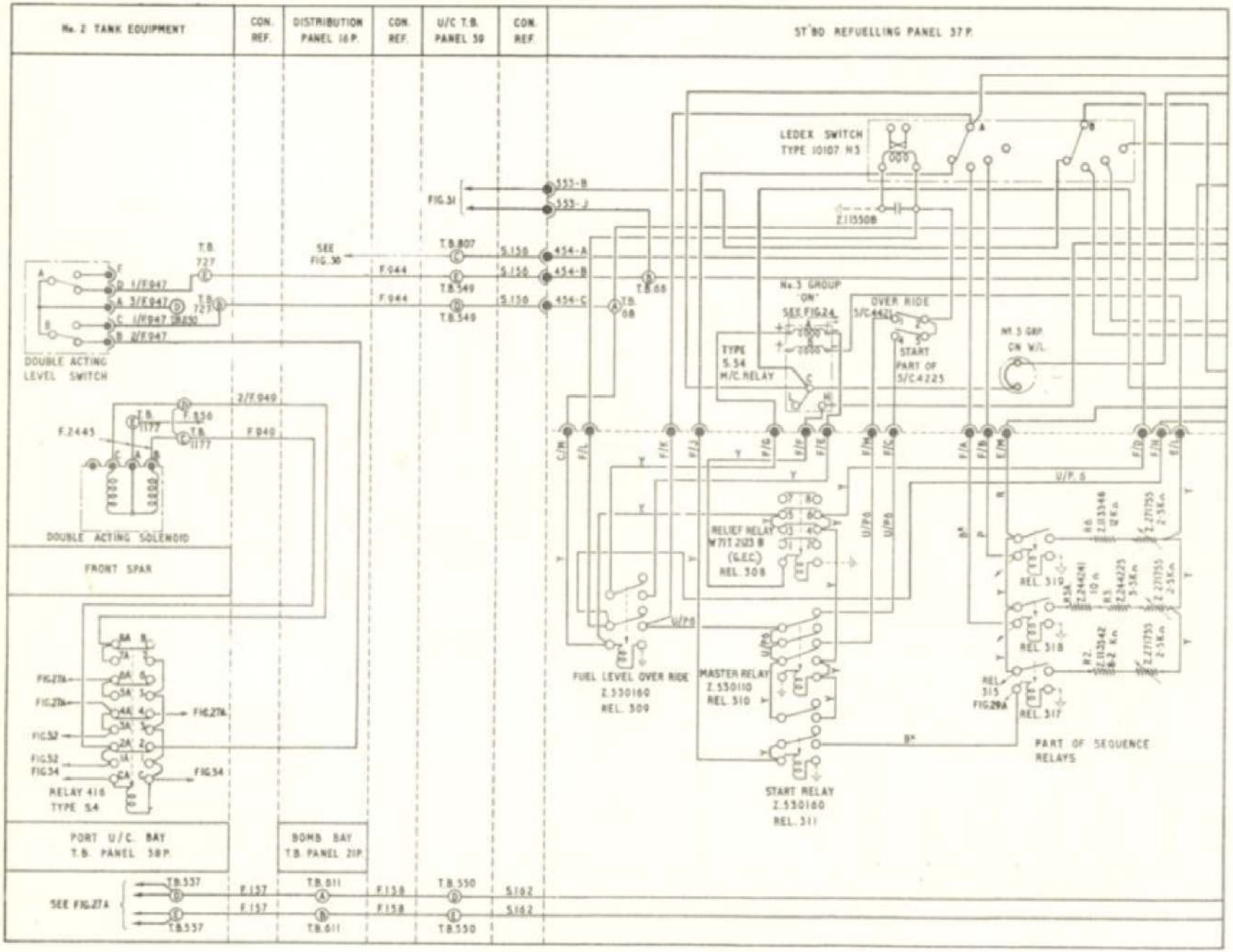

Fig.28A(1)Refuelling-No 3 group (post Mod.1406)

RESTRICTED

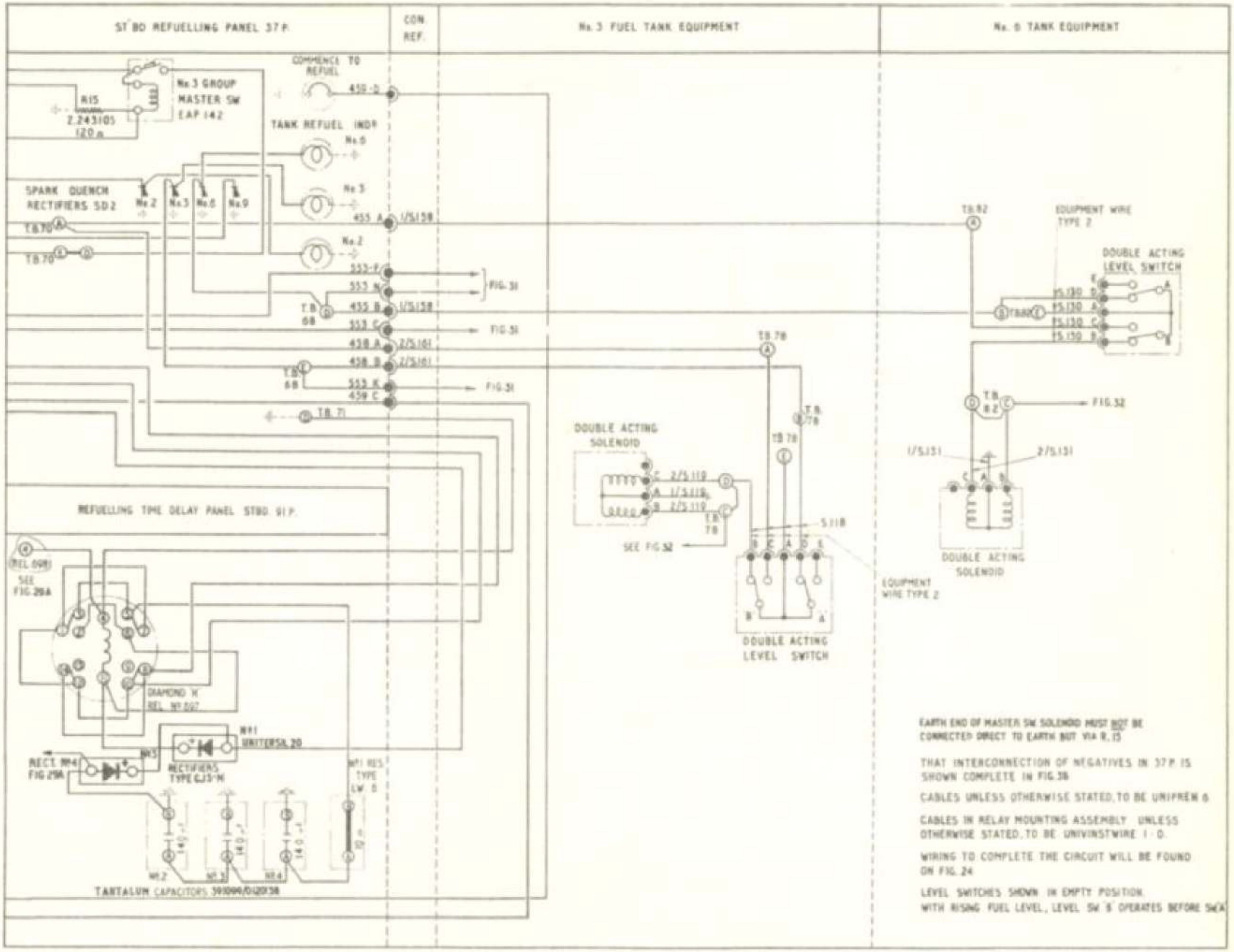

Fig 28A (2) Refuelling-Nº 3 group (post. Mod. 1406)

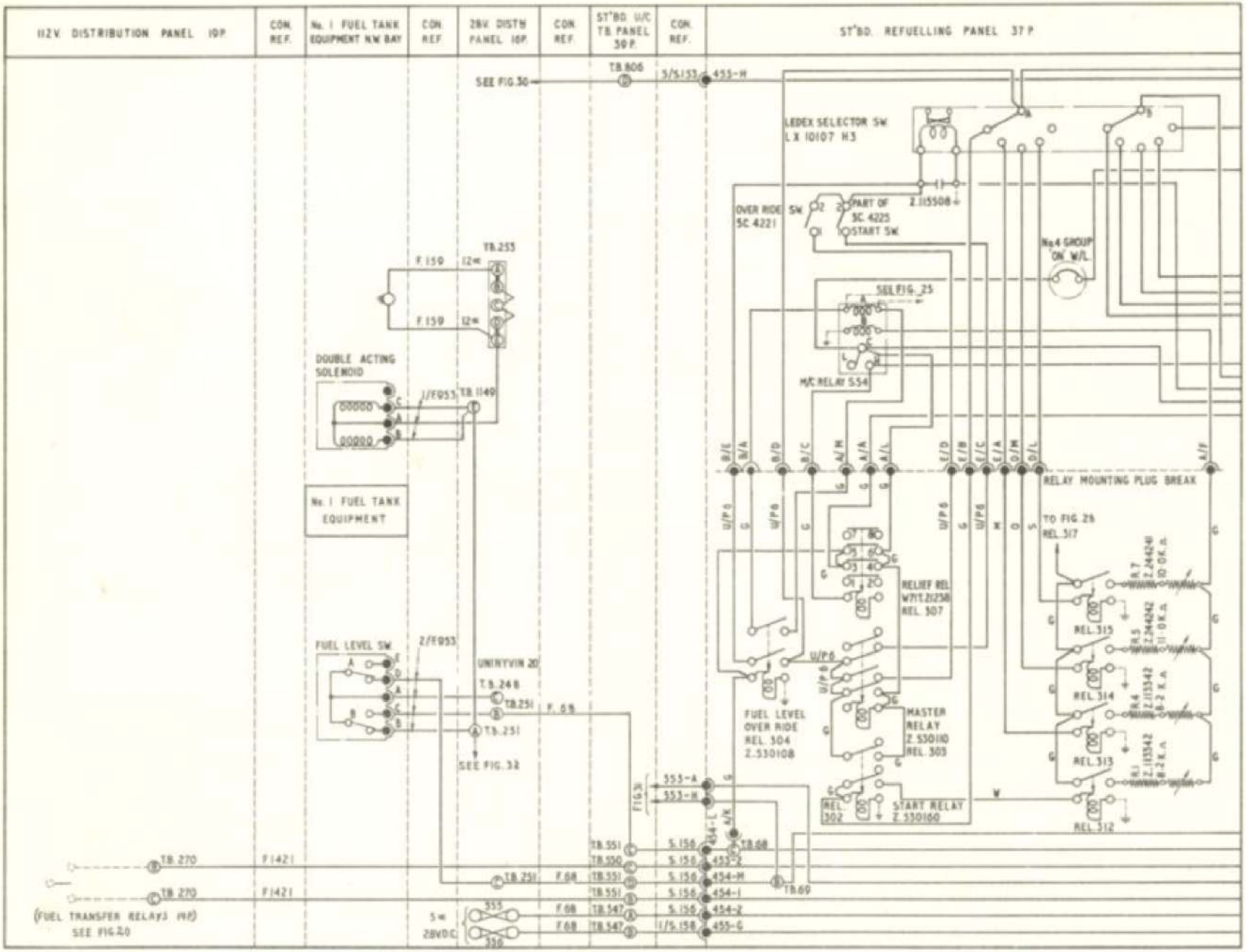

Fig. 29(1) Refuelling-No4 group (pre. Mod. 1406)

RESTRICTED

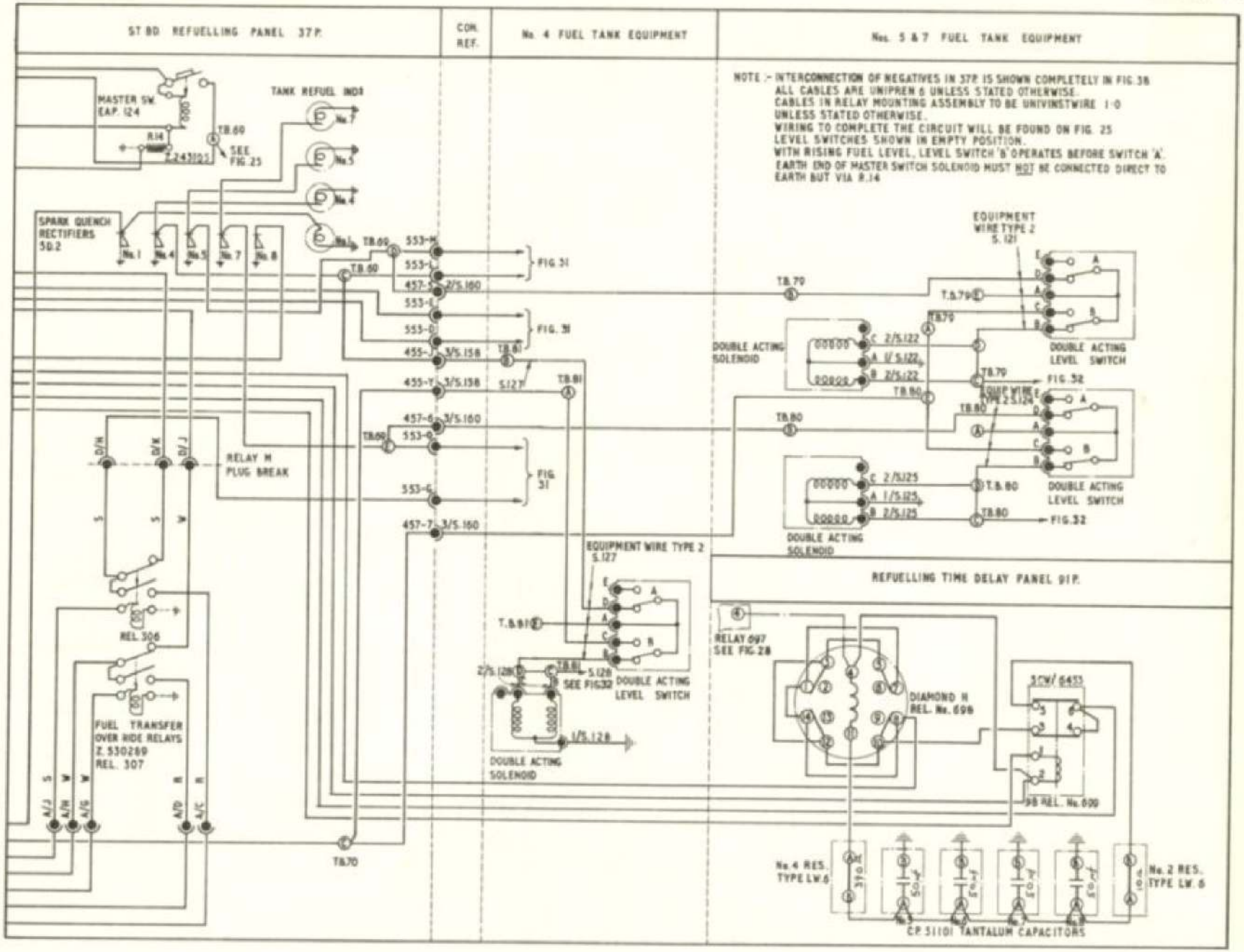

Fig. 29(2) Refuelling-No. 4 group (pre. Mod. 1406)

RESTRICTED

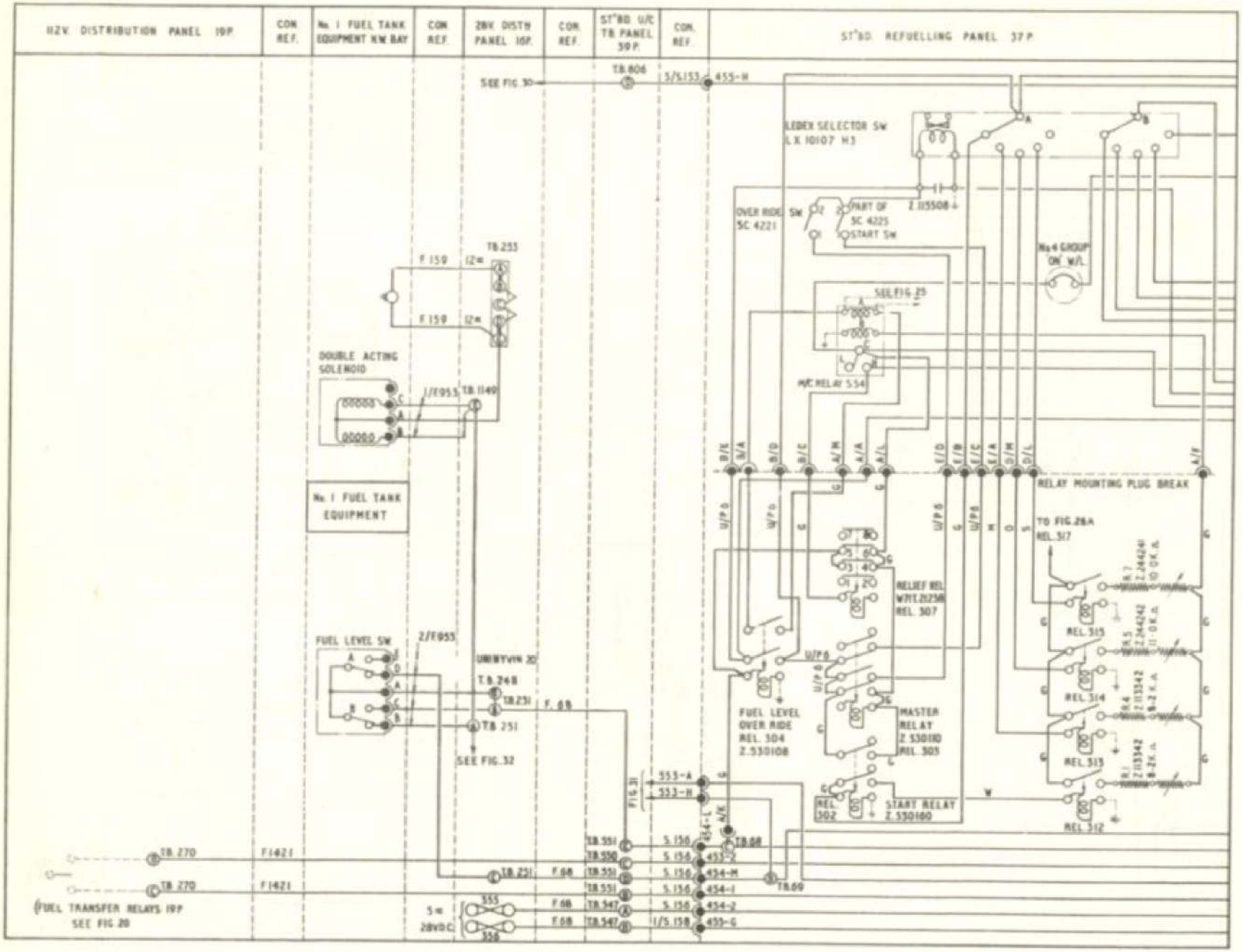

Fig 29A(1) Refuelling-No. 4 group (post. Mod 1406)

RESTRICTED

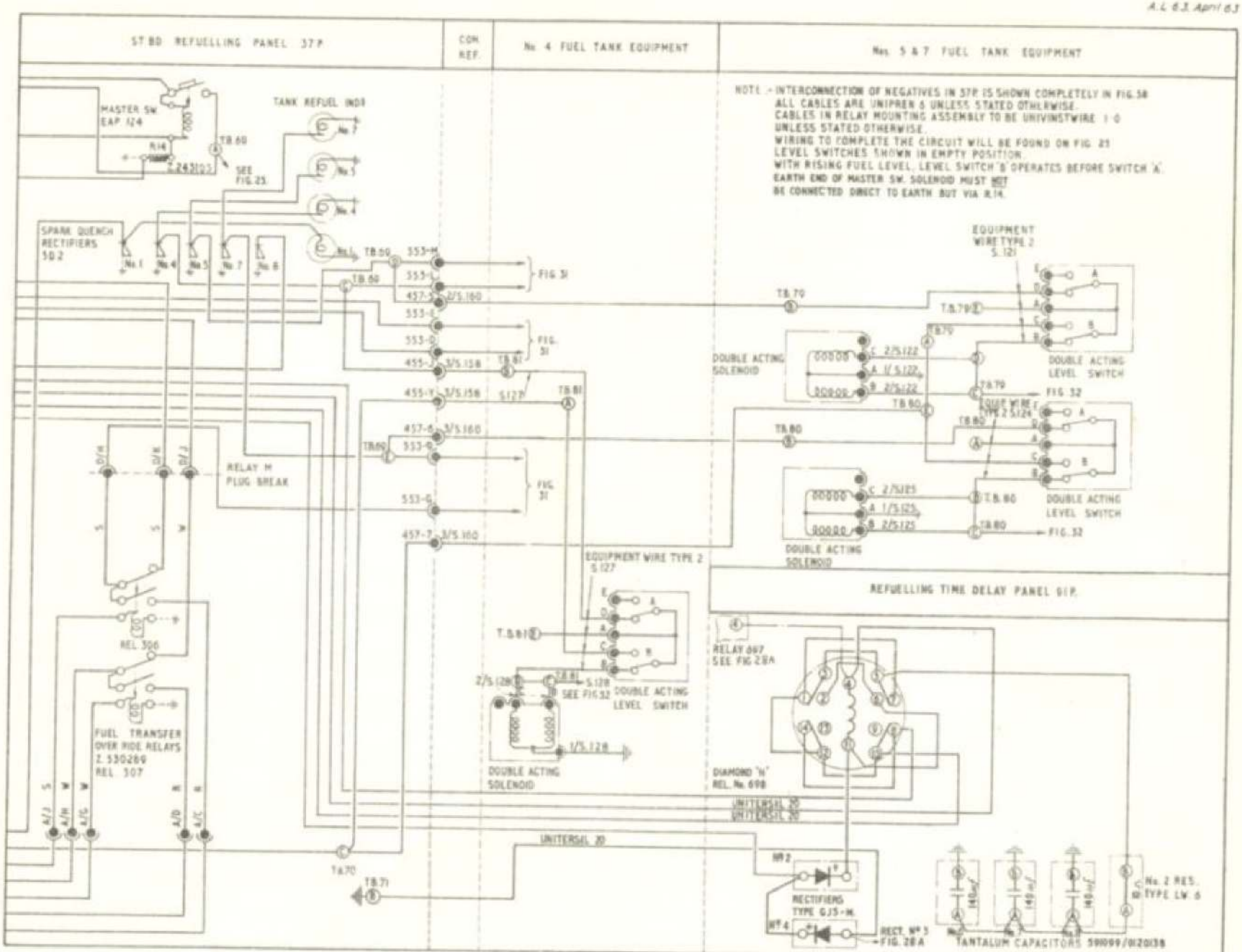

Fig. 29A (2) Refuelling - No 4 group (post. Mod 1406)

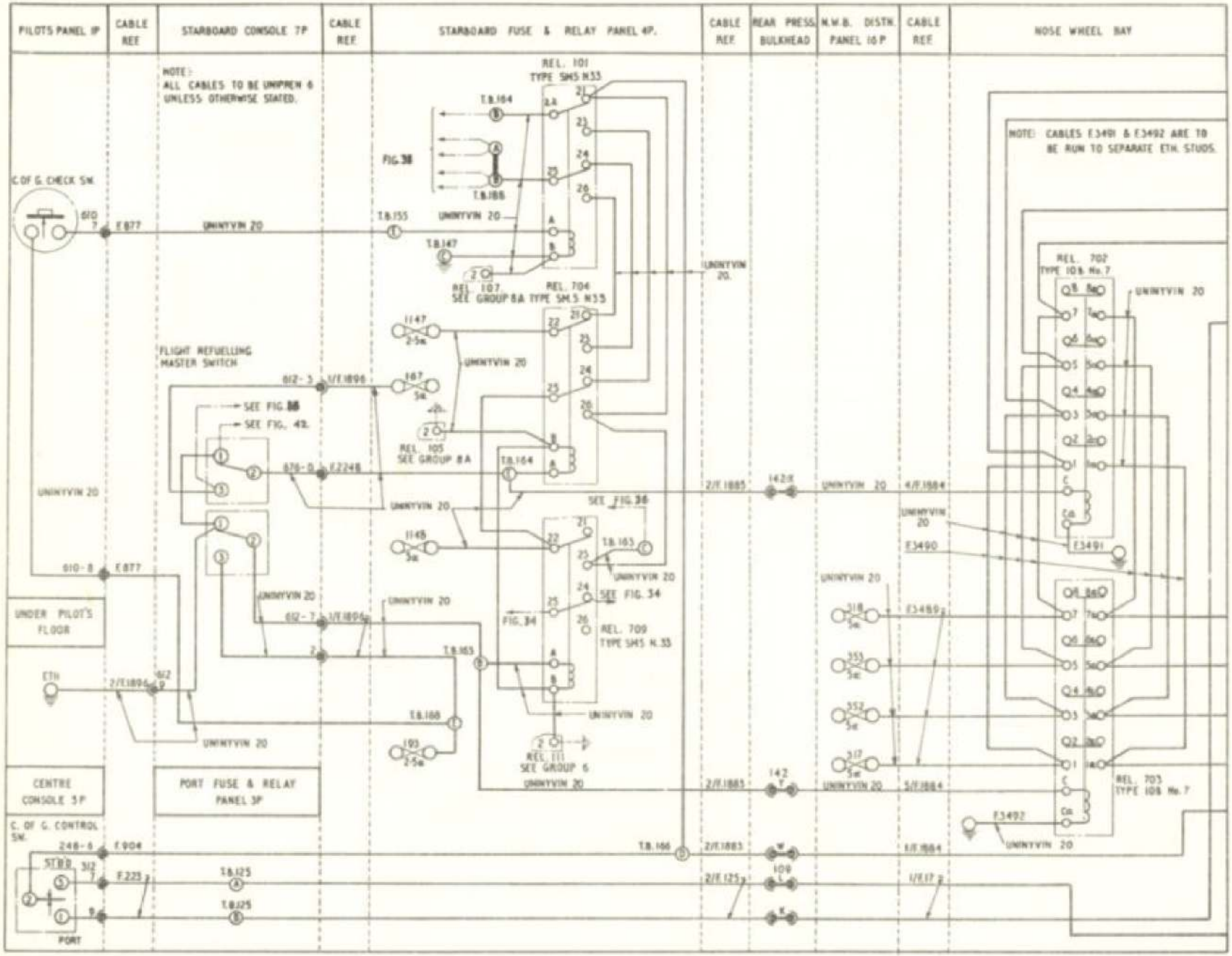

Fig 30(1) Flight refuelling -port

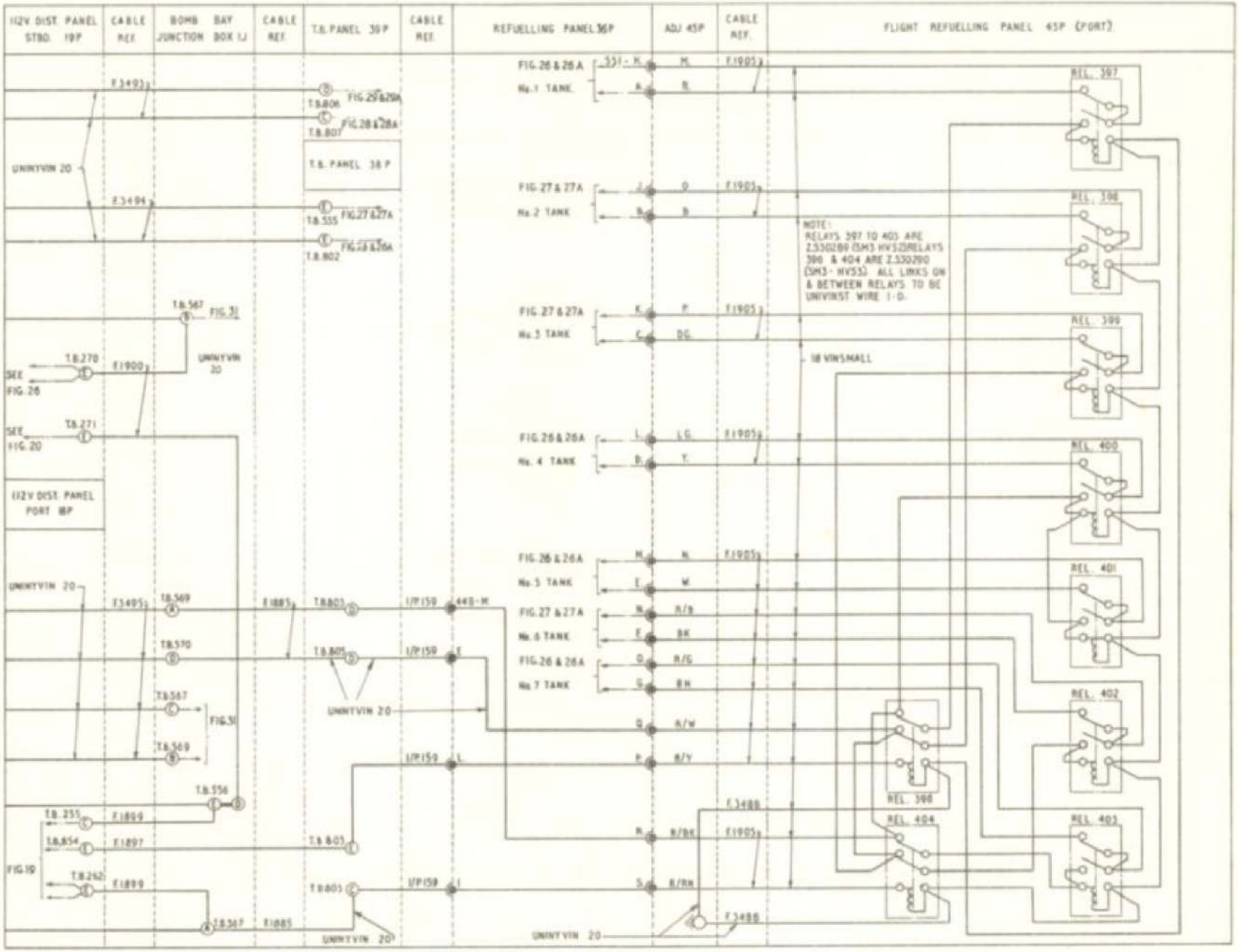

Fig. 30 (2) Flight refuelling- port

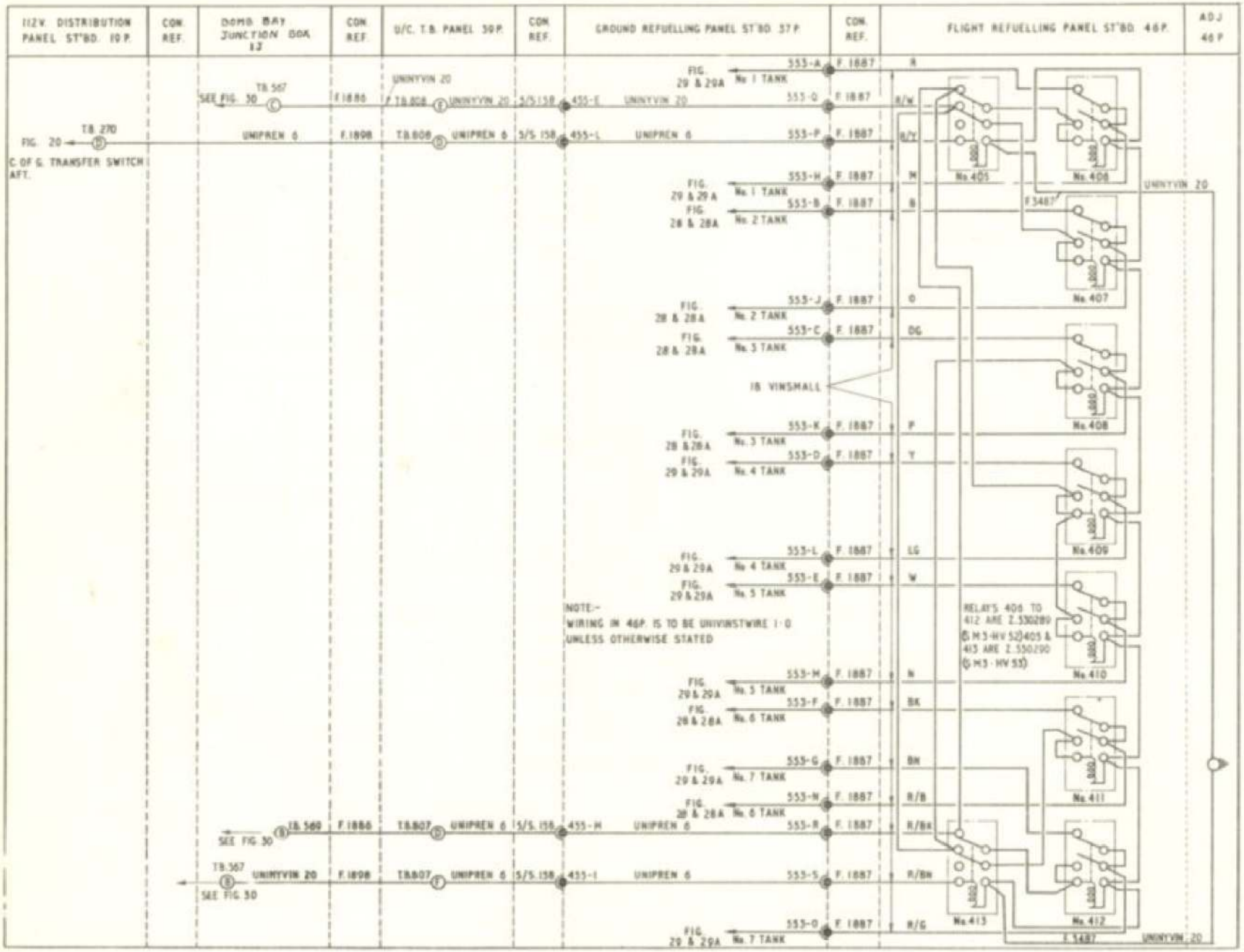

Fig. 31 Flight refuelling - starboard

RESTRICTED

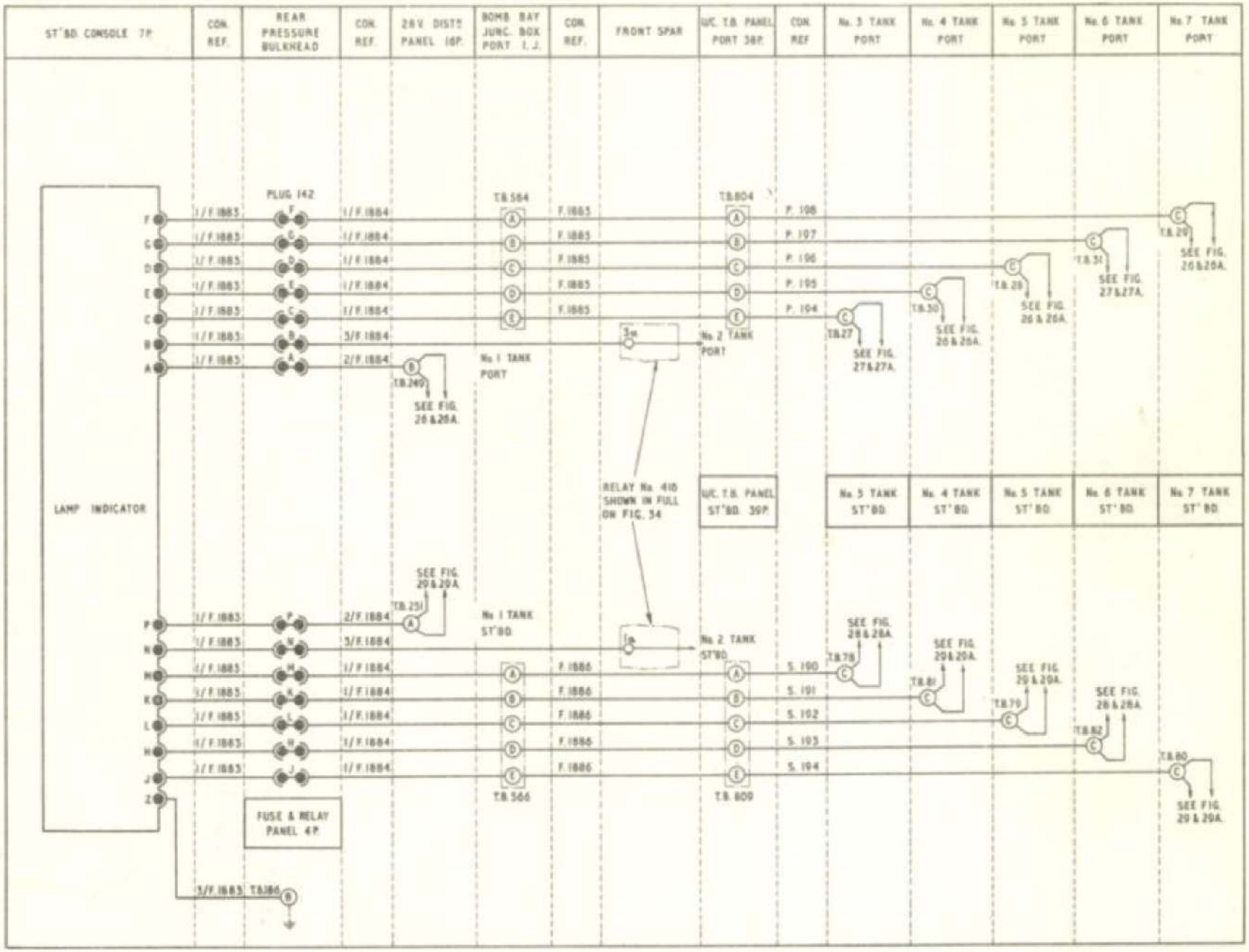

Fig.32 Flight refuelling indication

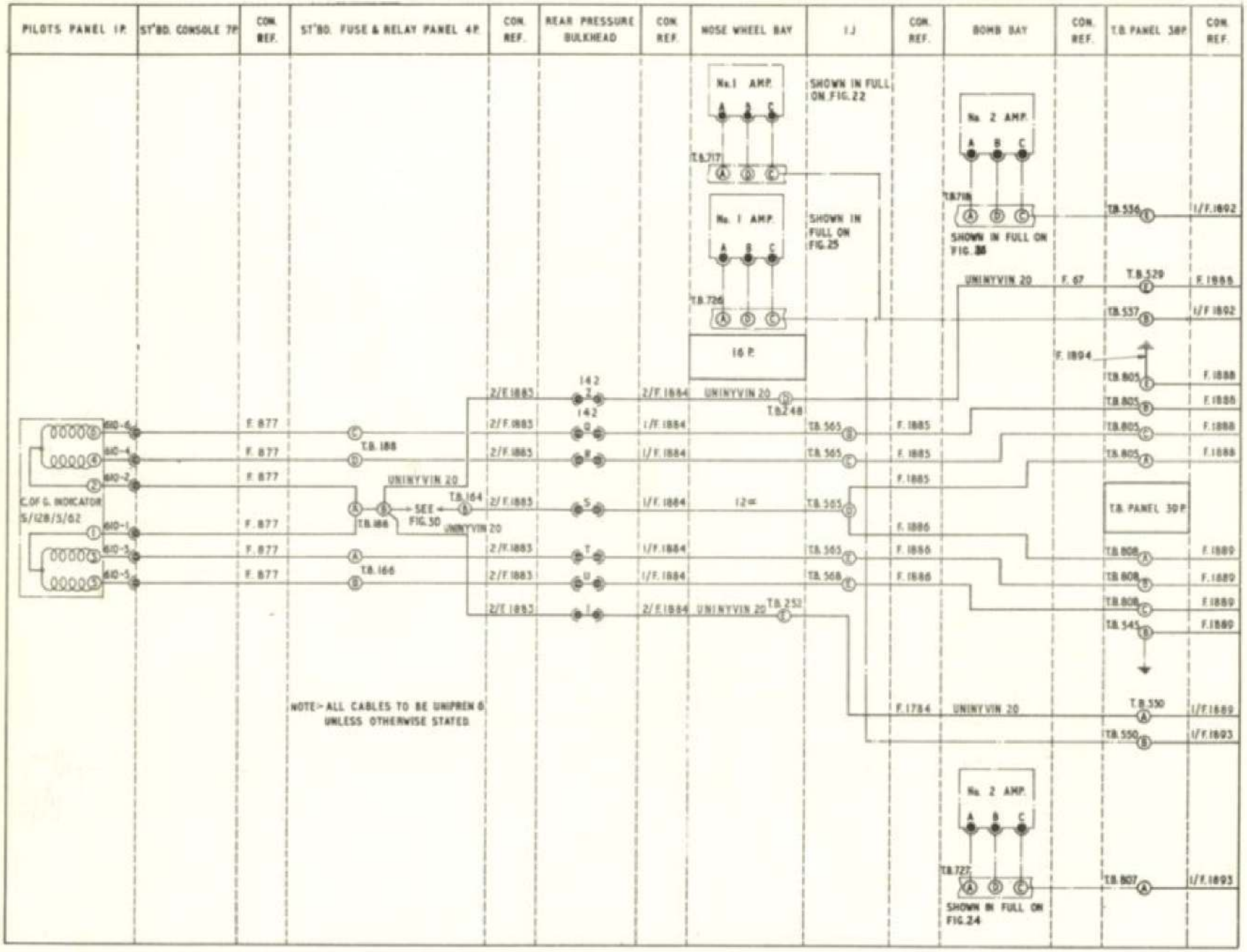

Fig. 33 (1) Fuel centre of gravity

RESTRICTED

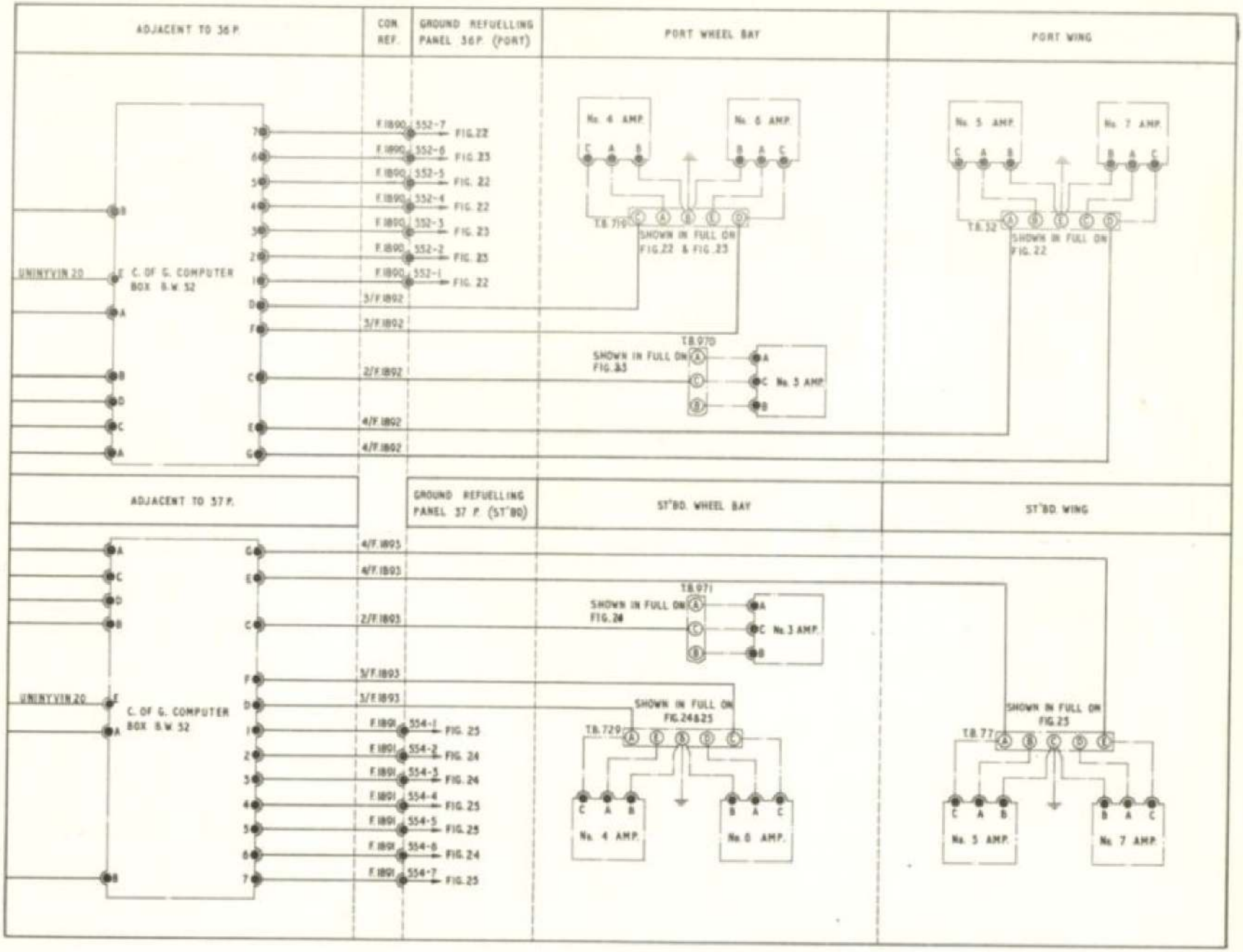

Fig. 33 (2) Fuel centre of gravity

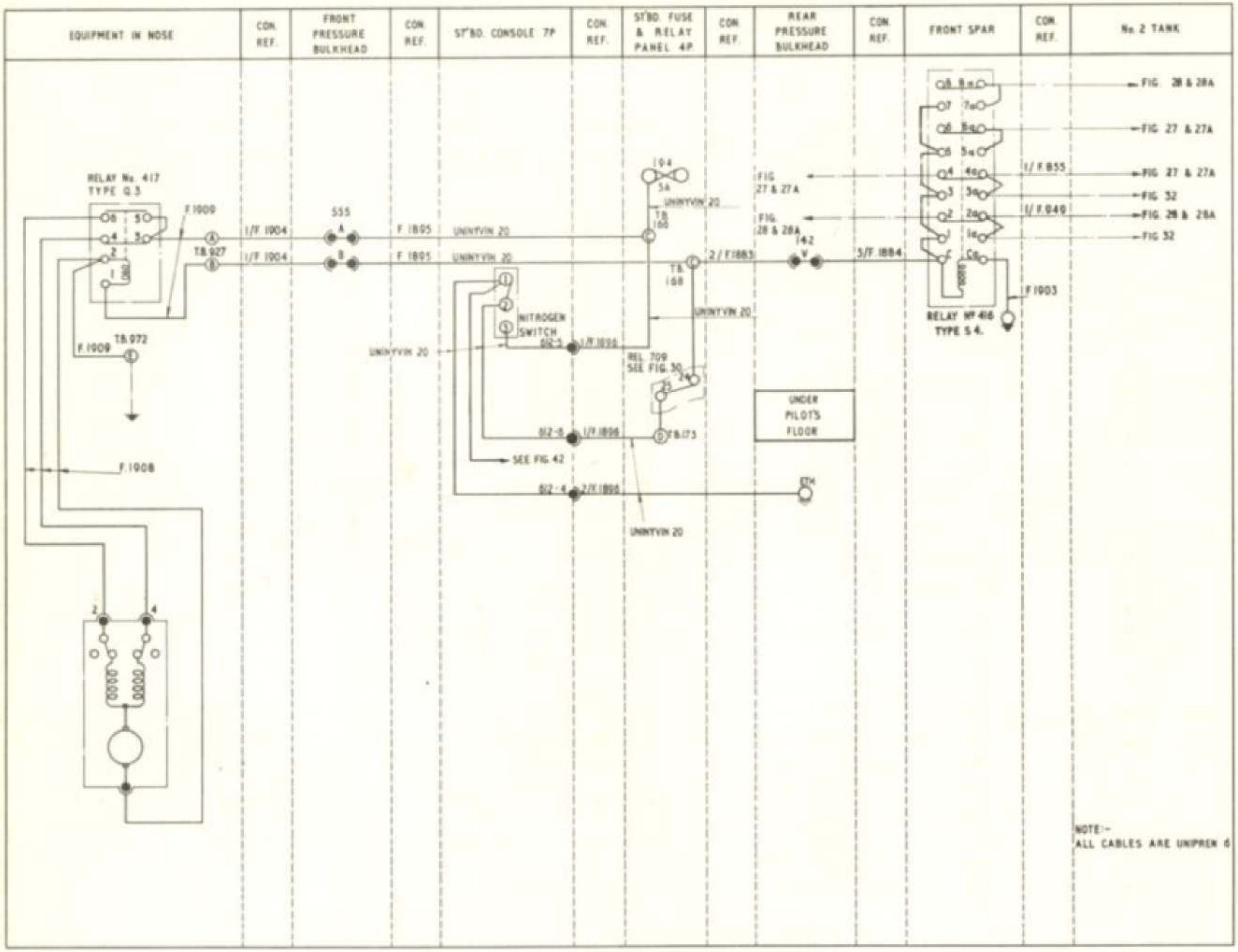

Fig. 34 Nitrogen purge for flight refuelling

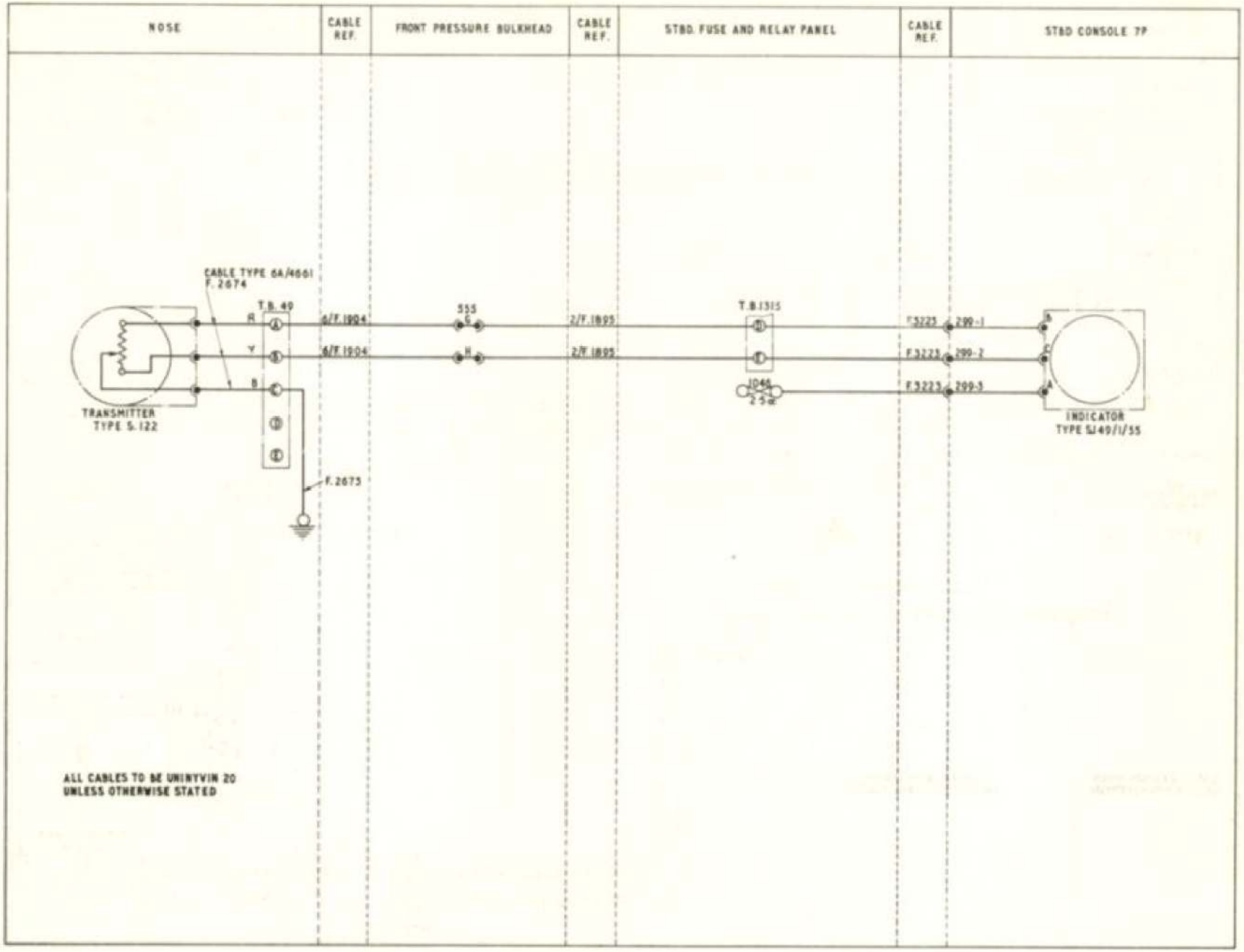

Fig.35 Probe fuel pressure

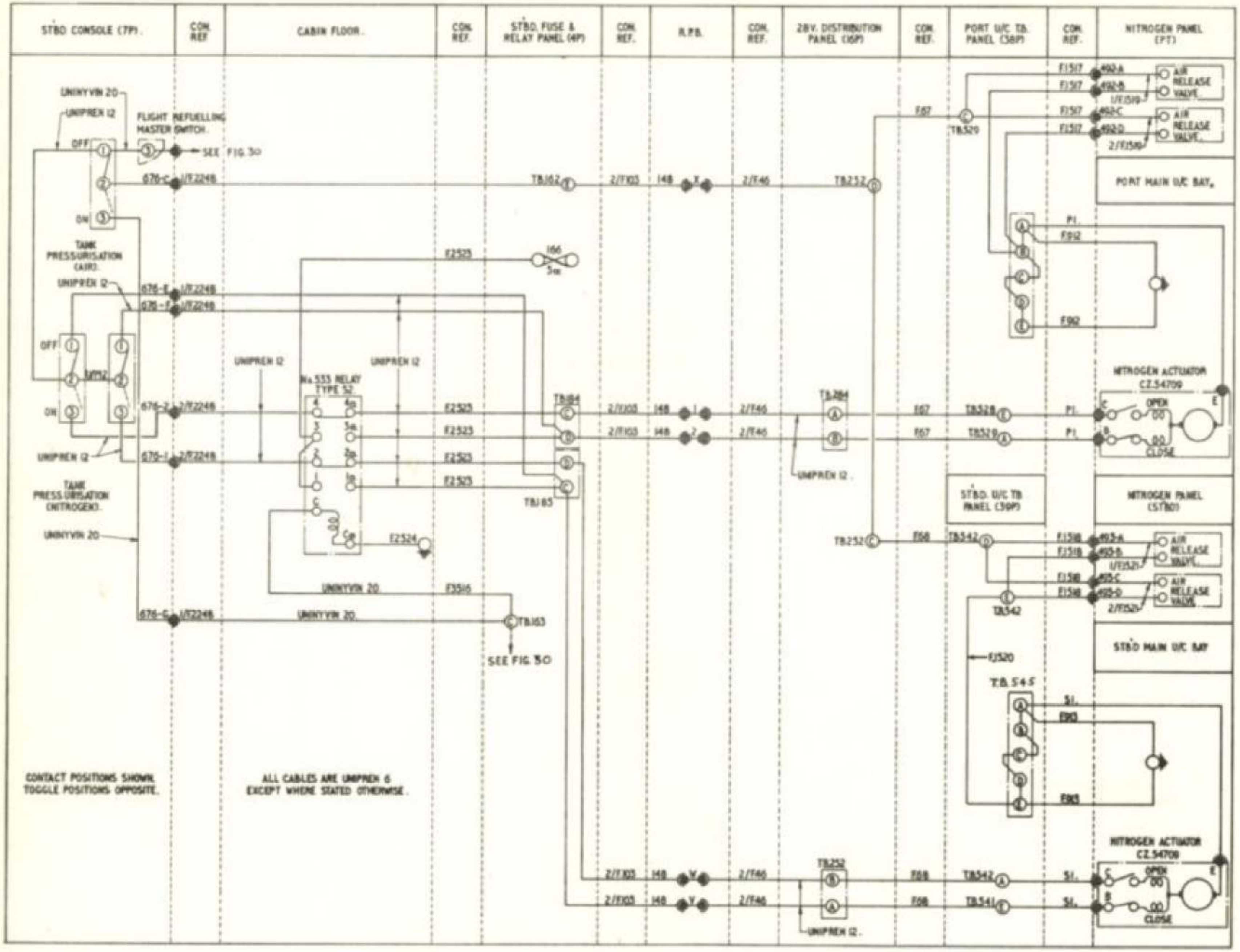

Fig. 36 Fuel tanks pressurisation (pre. Mod. 171)

RESTRICTED

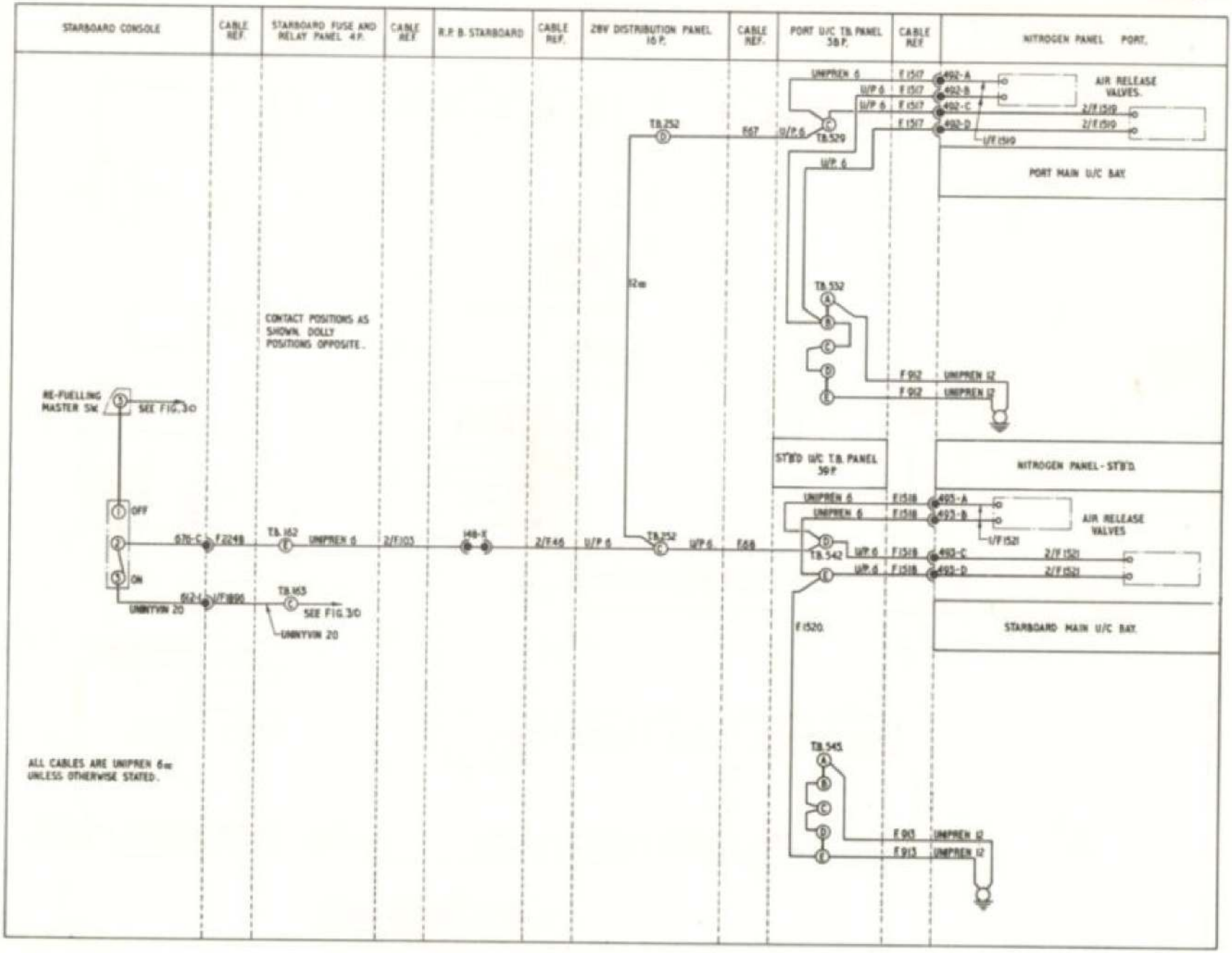

Fig 37 Fuel tanks pressurisation (post. Mod. 171)

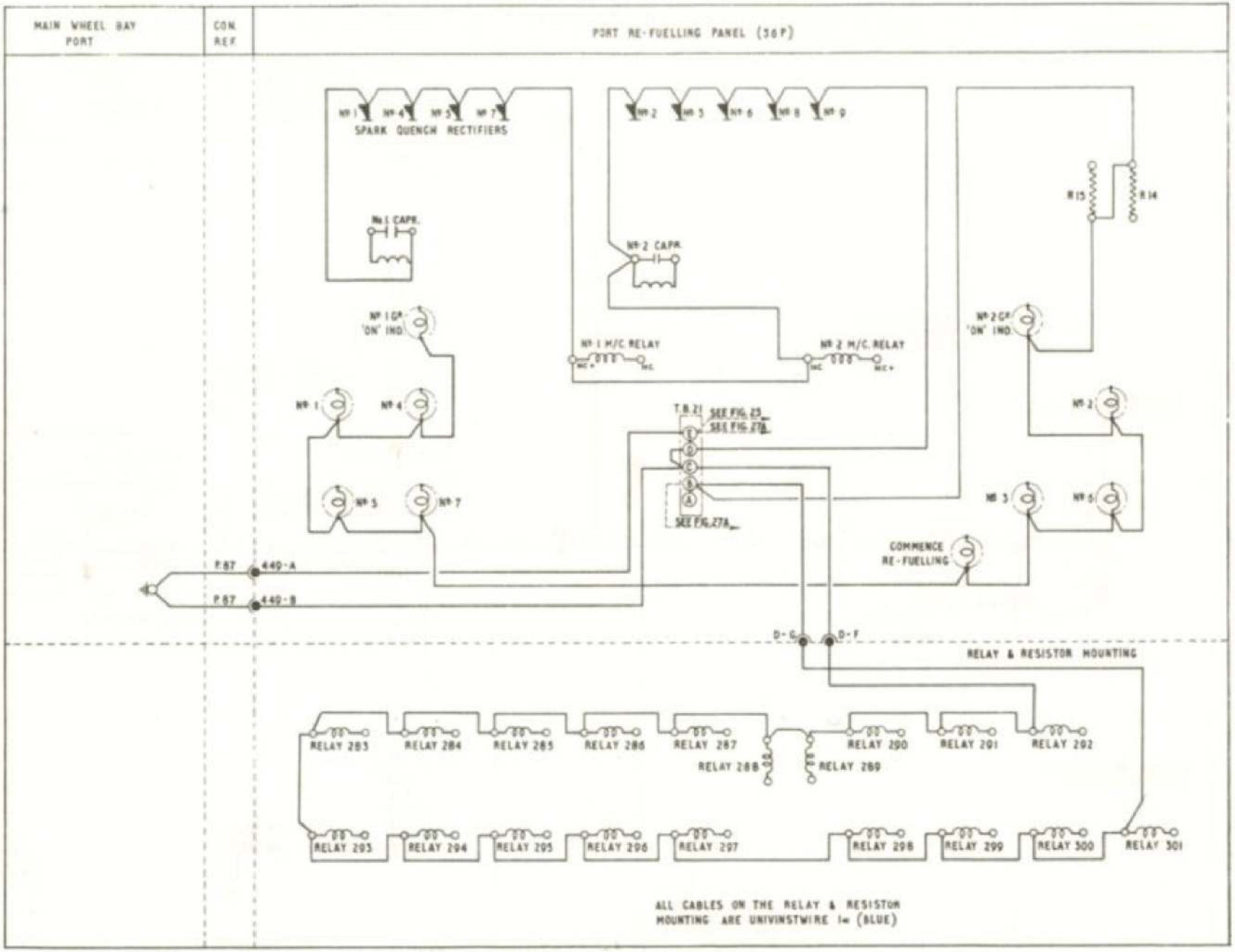

Fig. 38 (1) Negative distribution

(◄ *Alterations to relay wiring* ►)

RESTRICTED

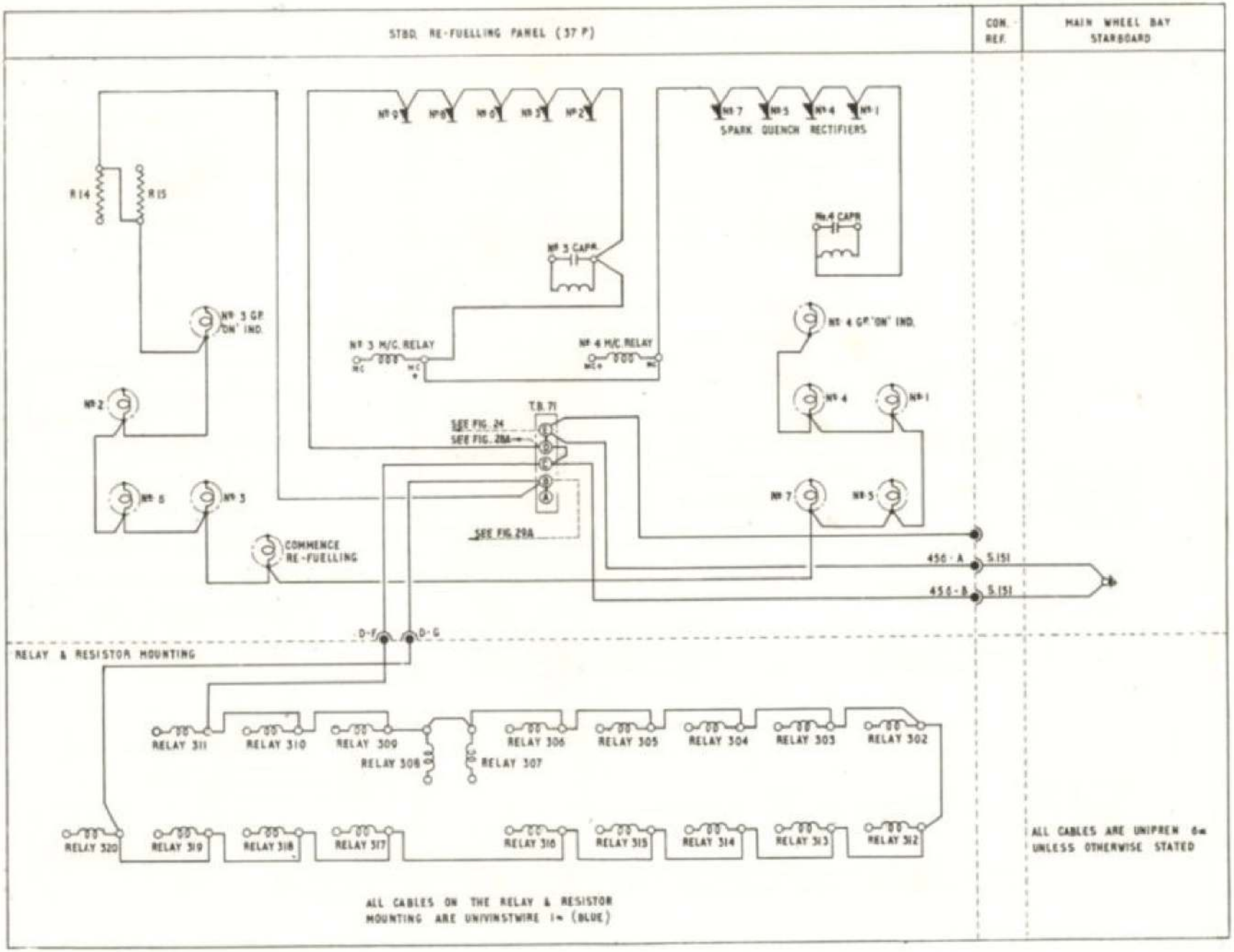

Fig. 38 (2) Negative distribution
(◄ *Alterations to relay wiring* ►)

RESTRICTED

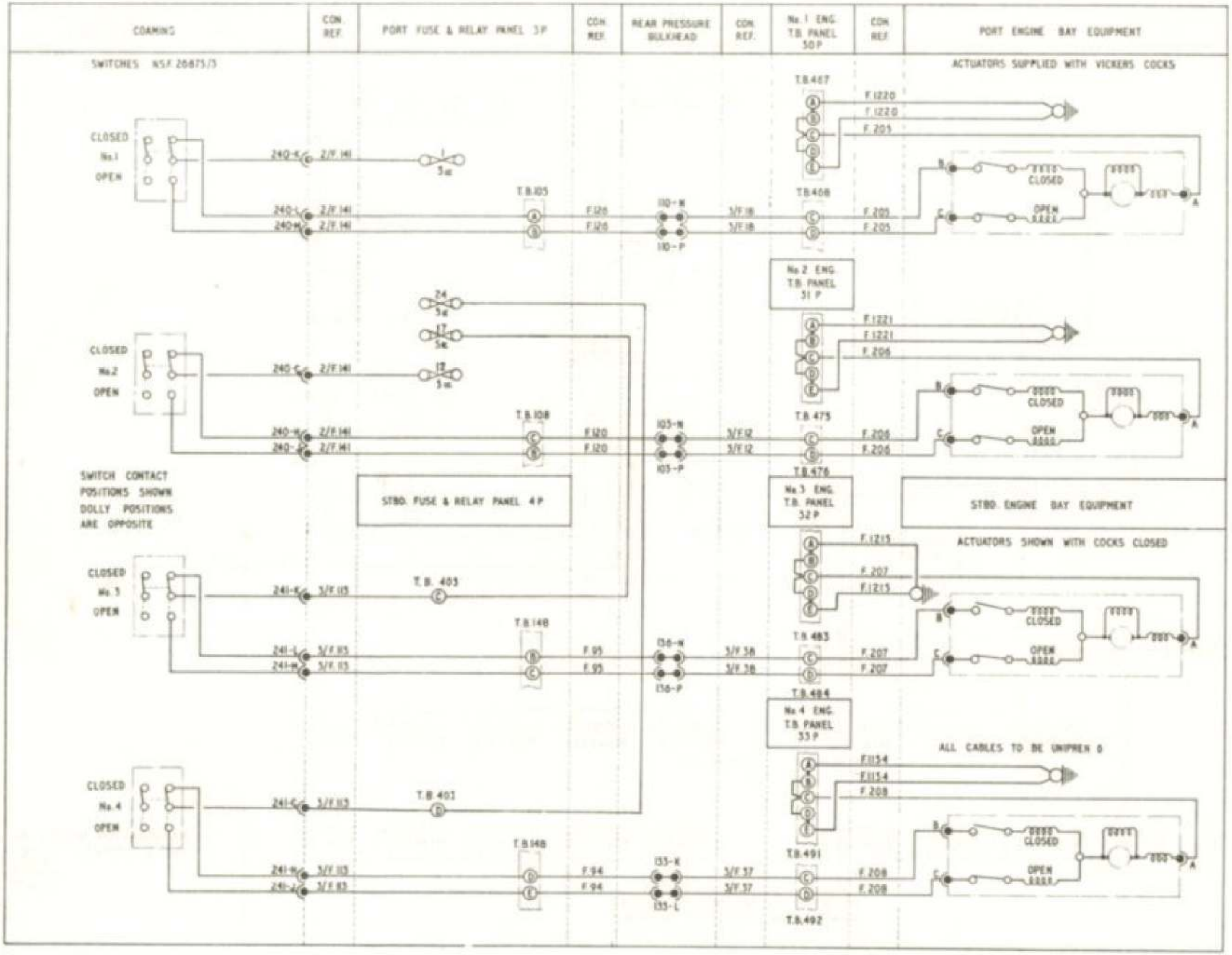

Fig. 39 L.P. fuel cock controls

RESTRICTED

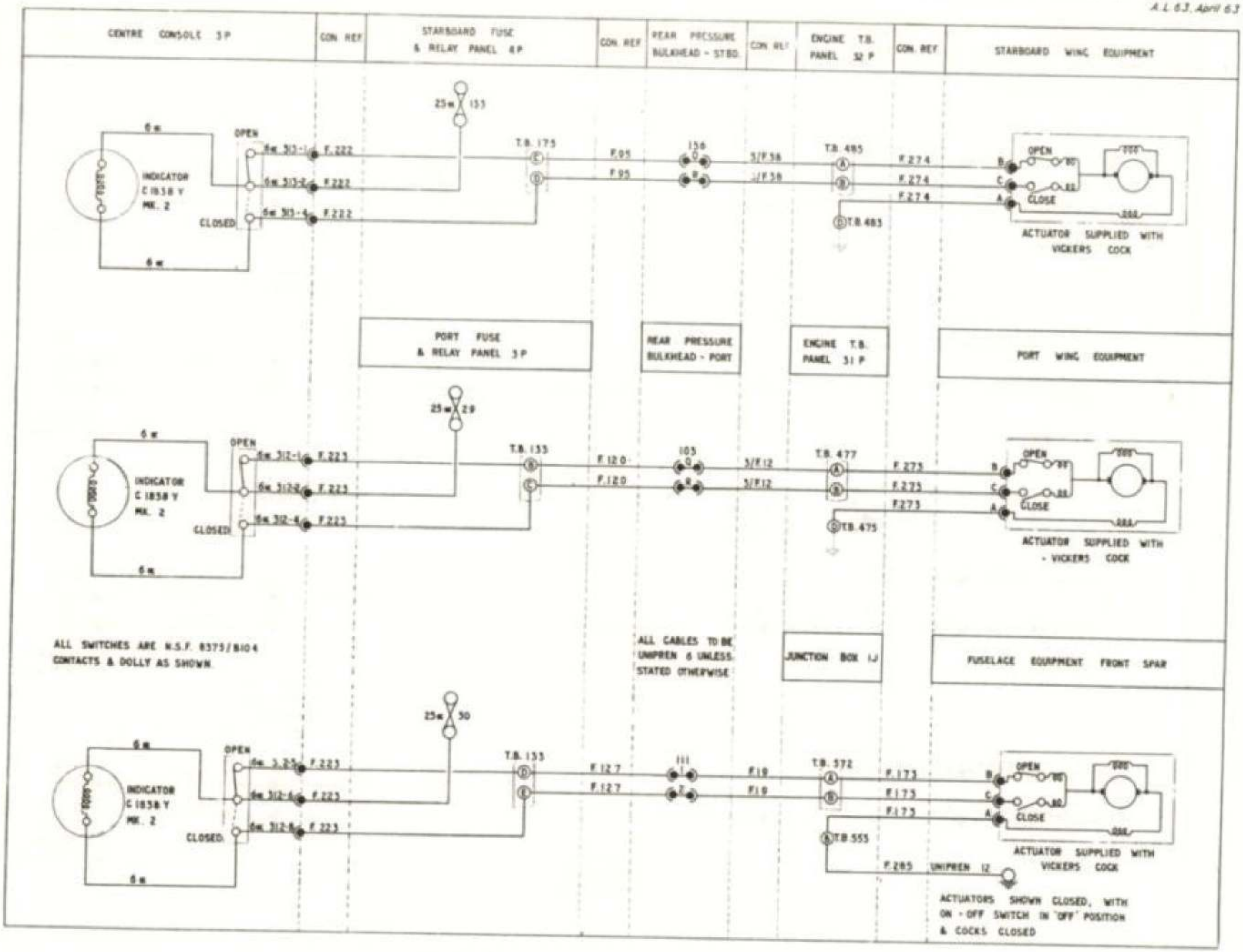

Fig.40 Cross-feed fuel cock controls

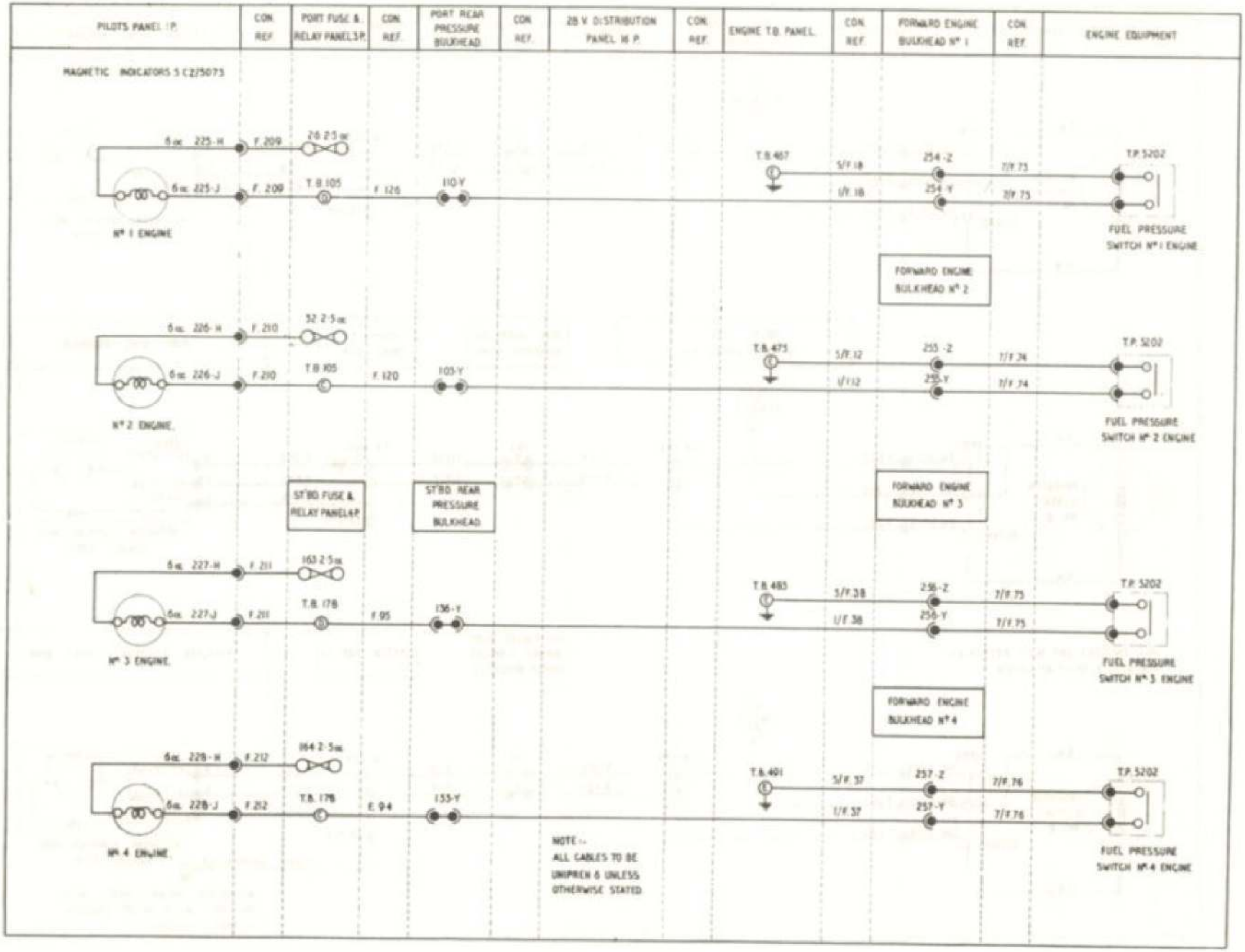

Fig. 41 Fuel pressure warning

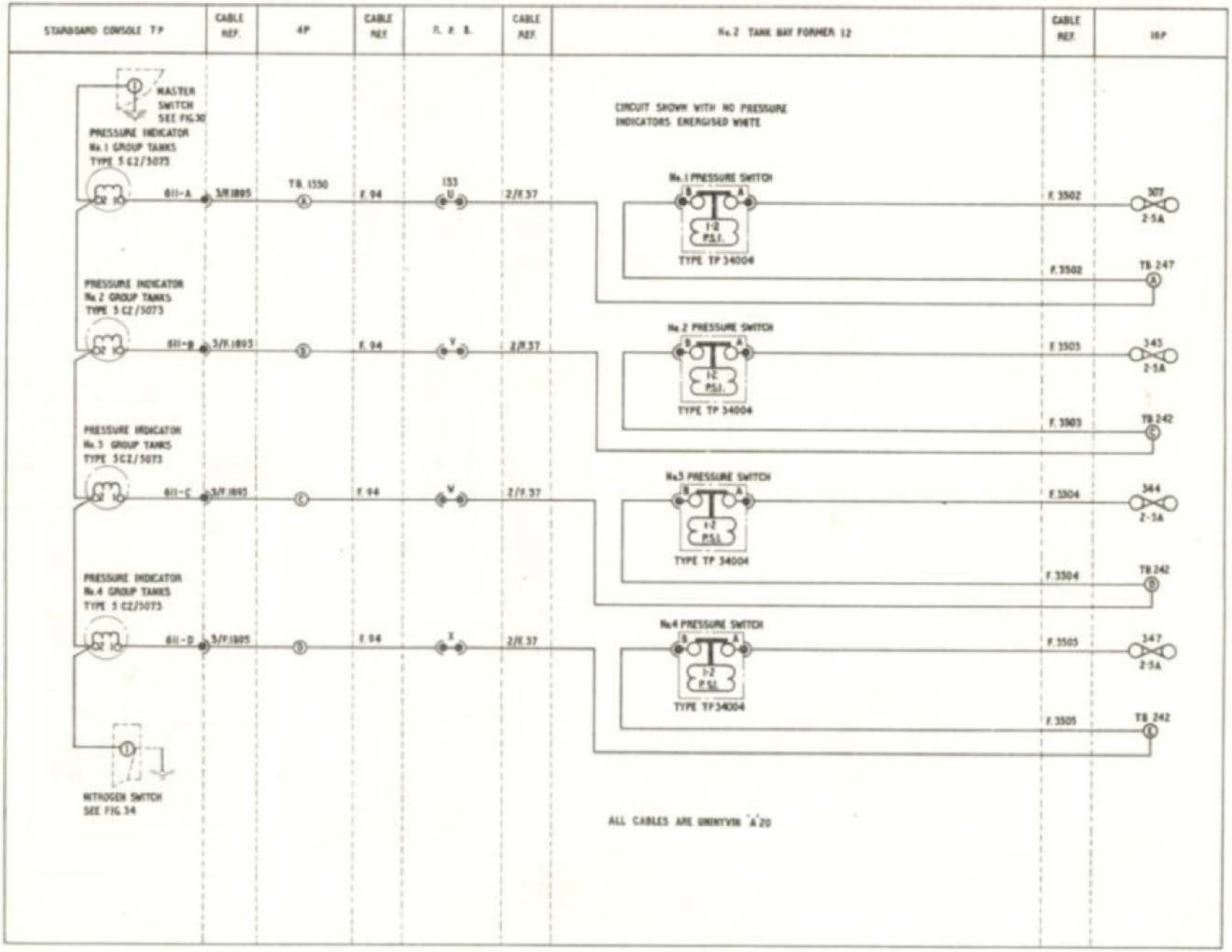

Fig. 42 Fuel tank pressure indication

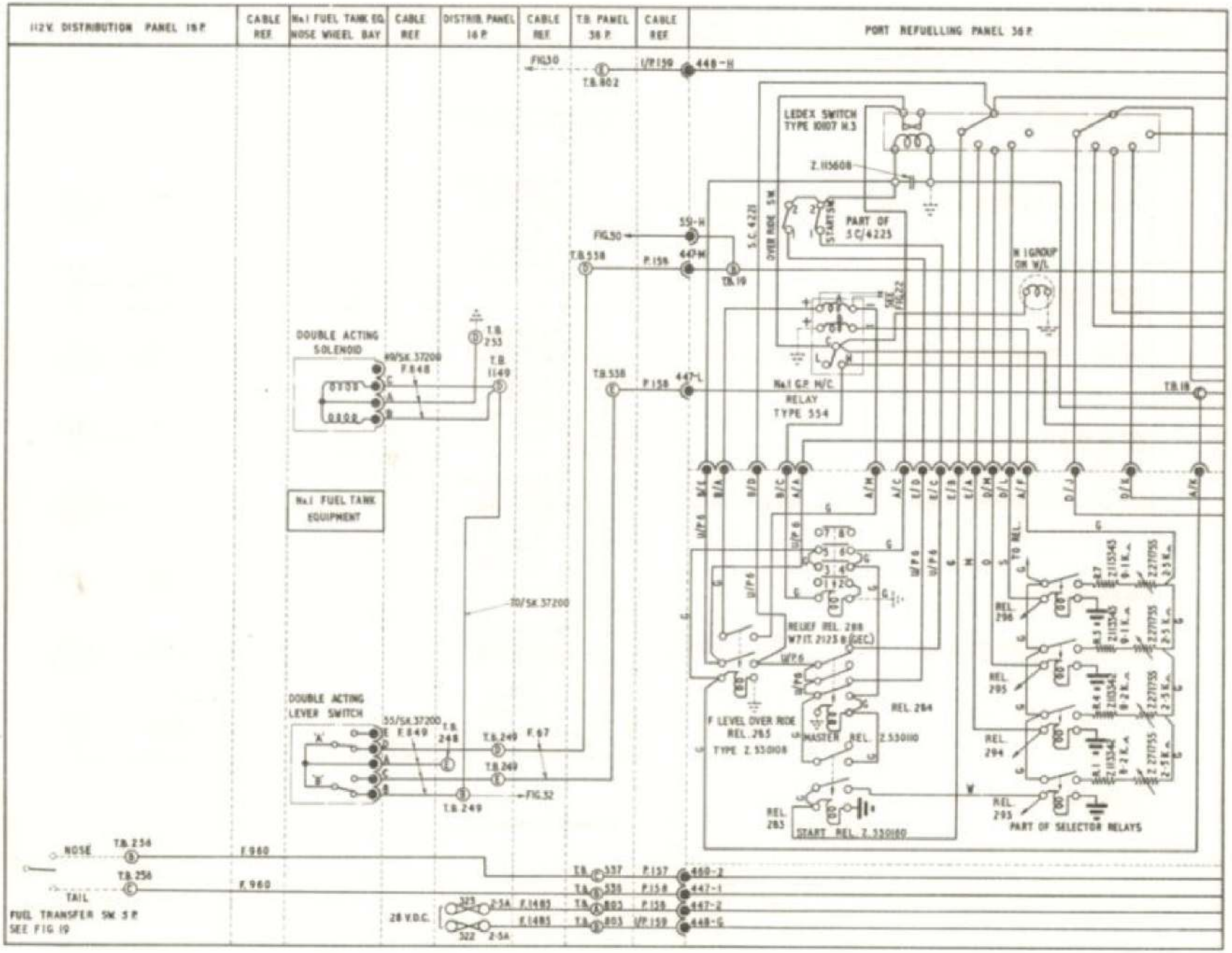

Fig 43. (1) Refuelling– Nº 1 group (SK)

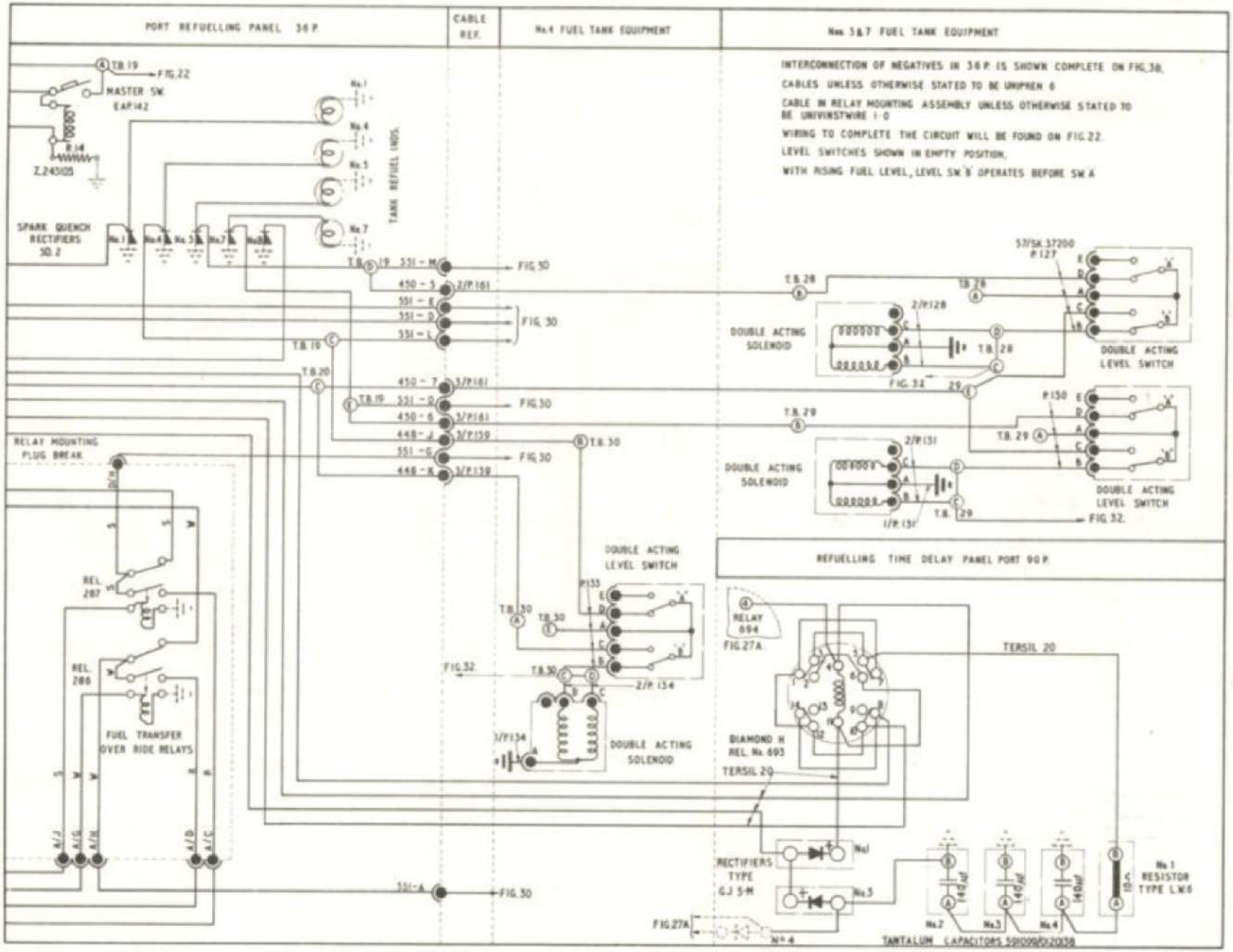

Fig 43. (2) Refuelling – Nº1 group (SK)

RESTRICTED

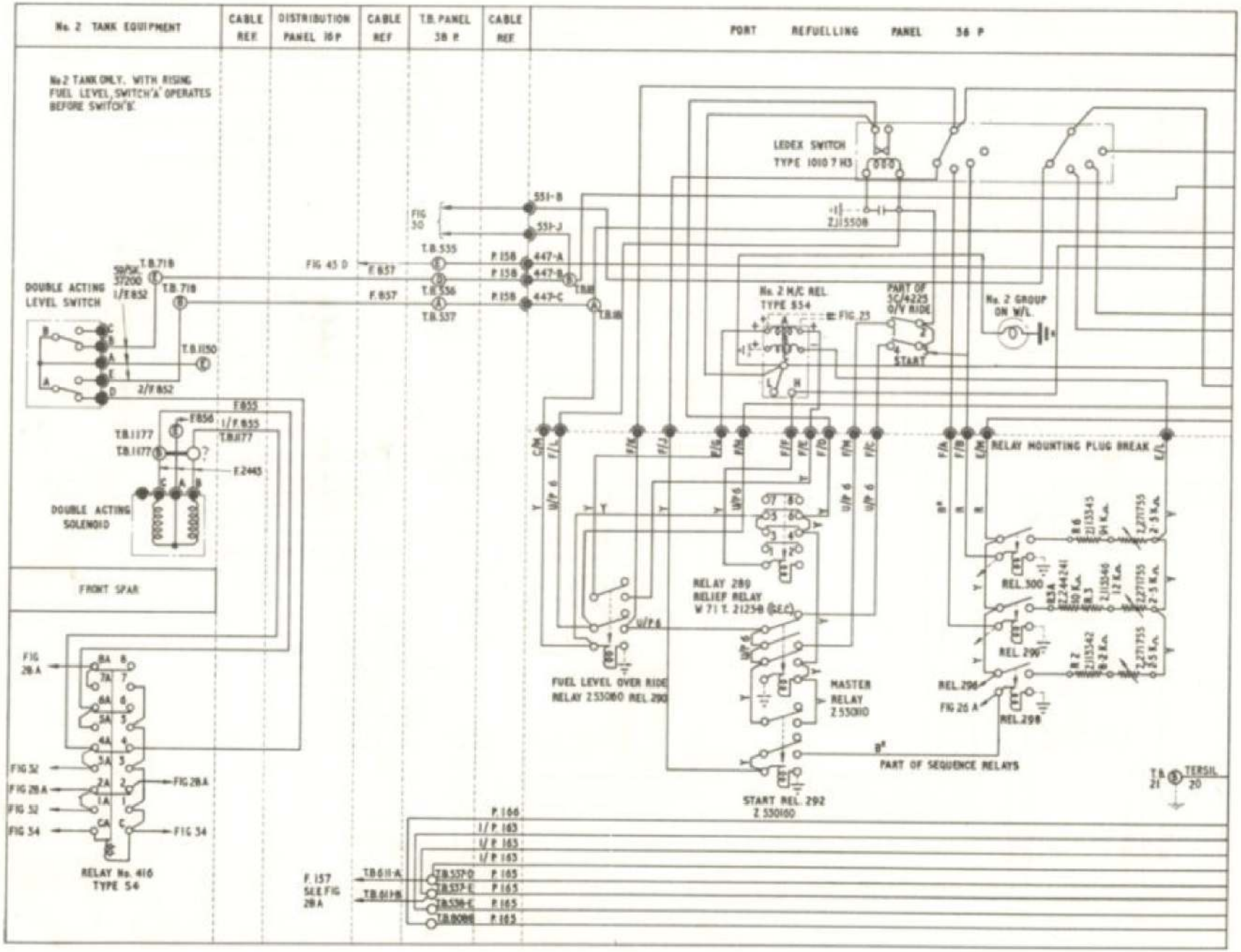

Fig 43A. (1) Refuelling – Nº 2 group (SK)

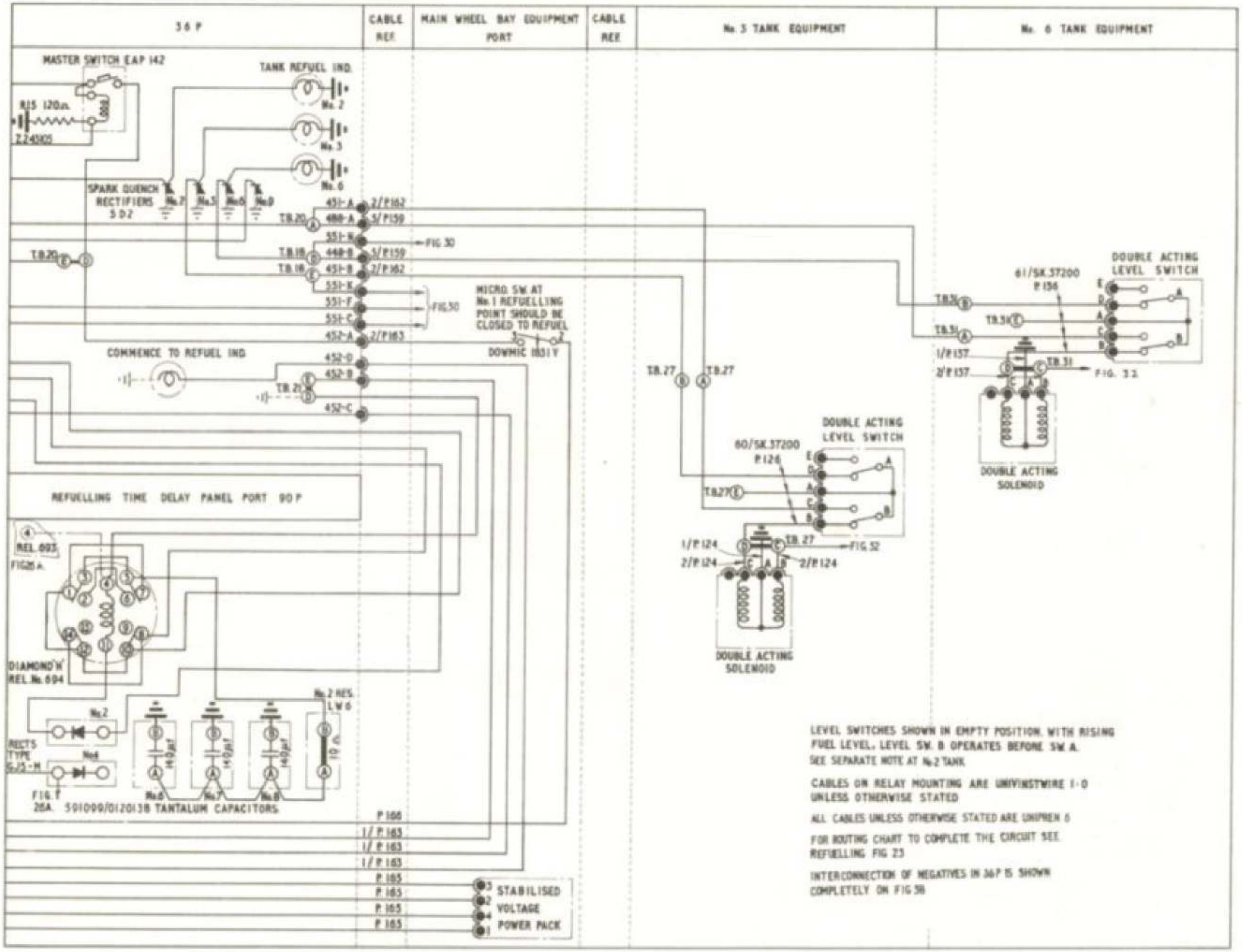

Fig 43 A. (2) Refuelling – No 2 group (SK)

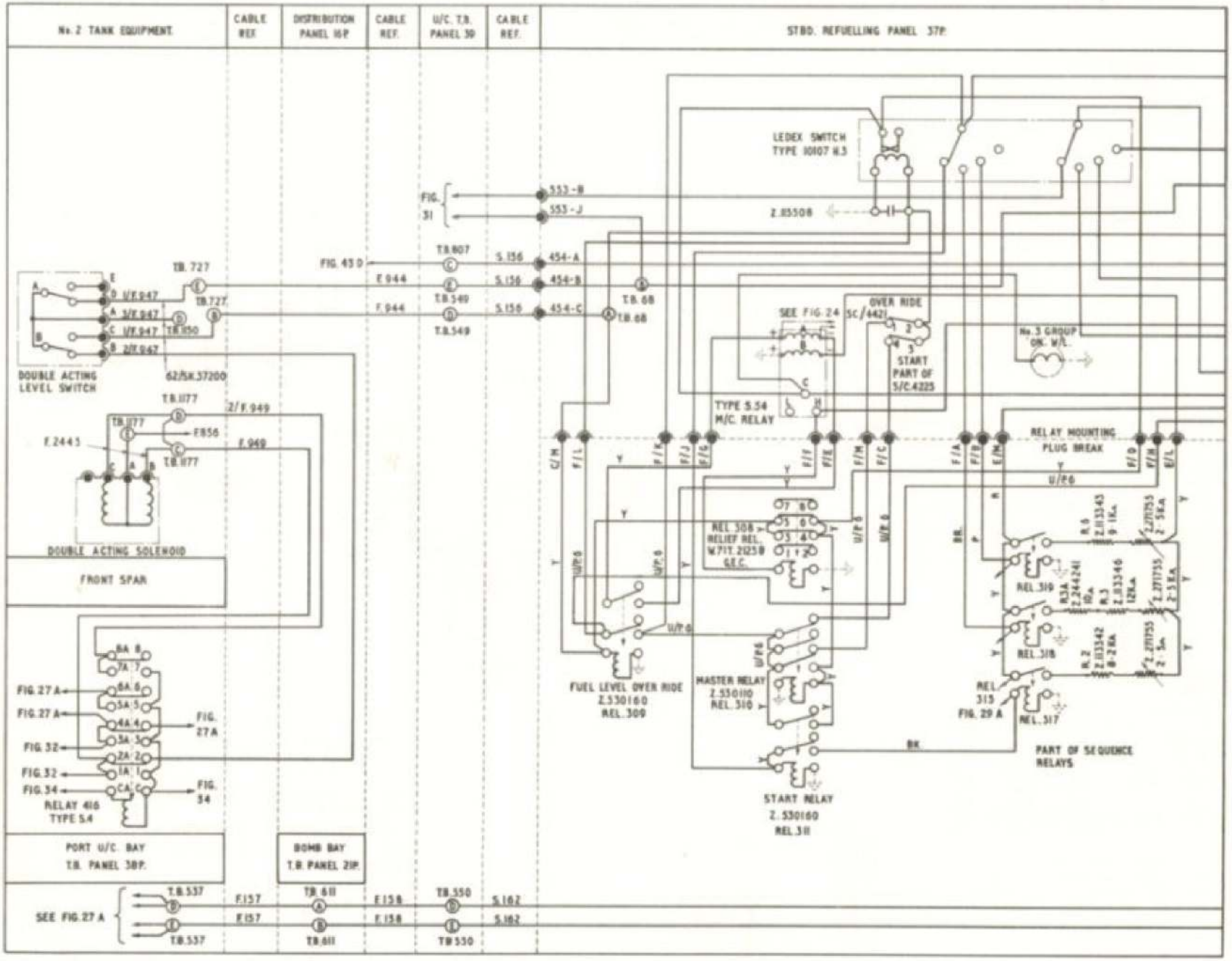

Fig. 43 B. (1) Refuelling– Nº 3 group (SK)

RESTRICTED

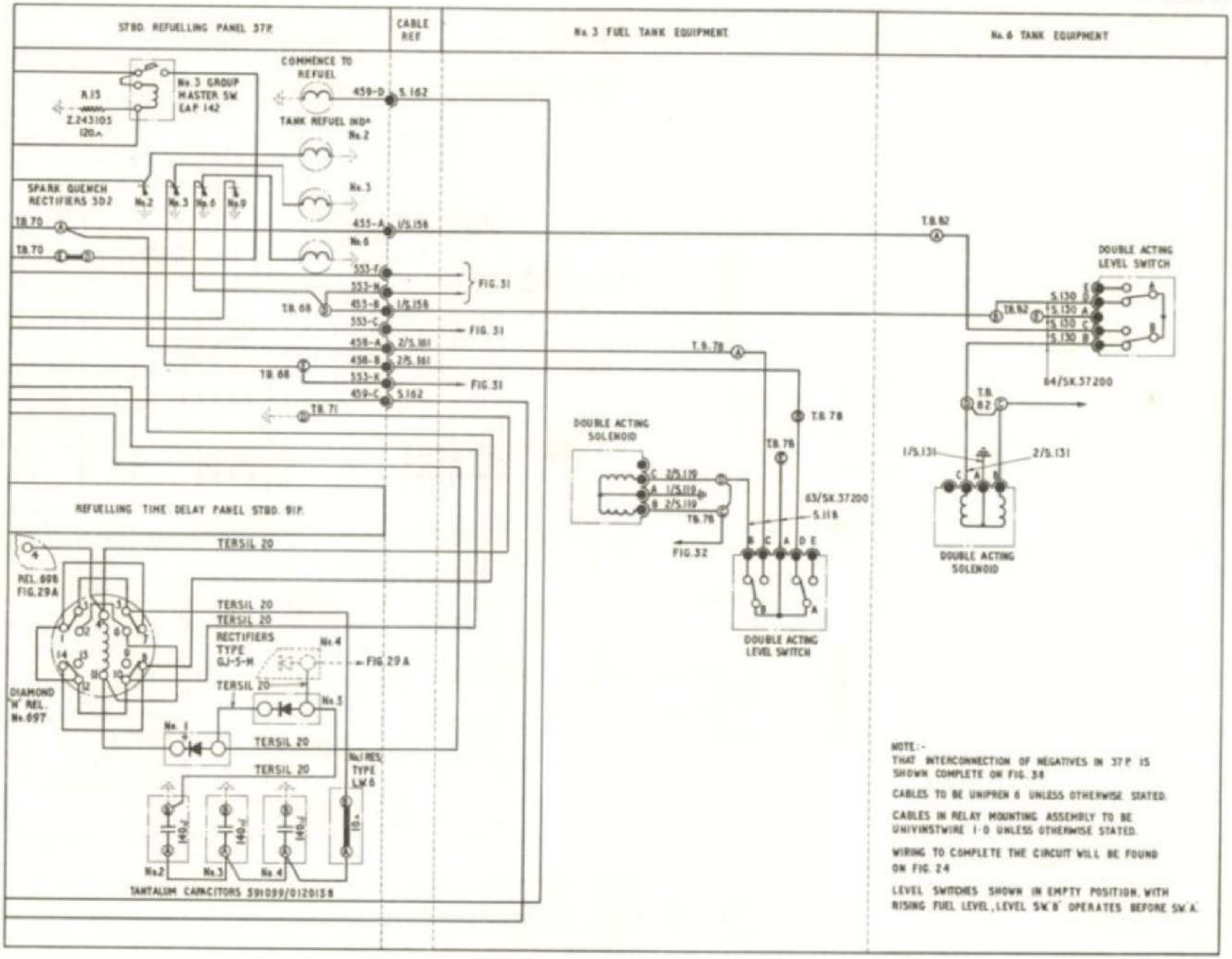

Fig 43B. (2) Refuelling – Nº 3 group (SK)

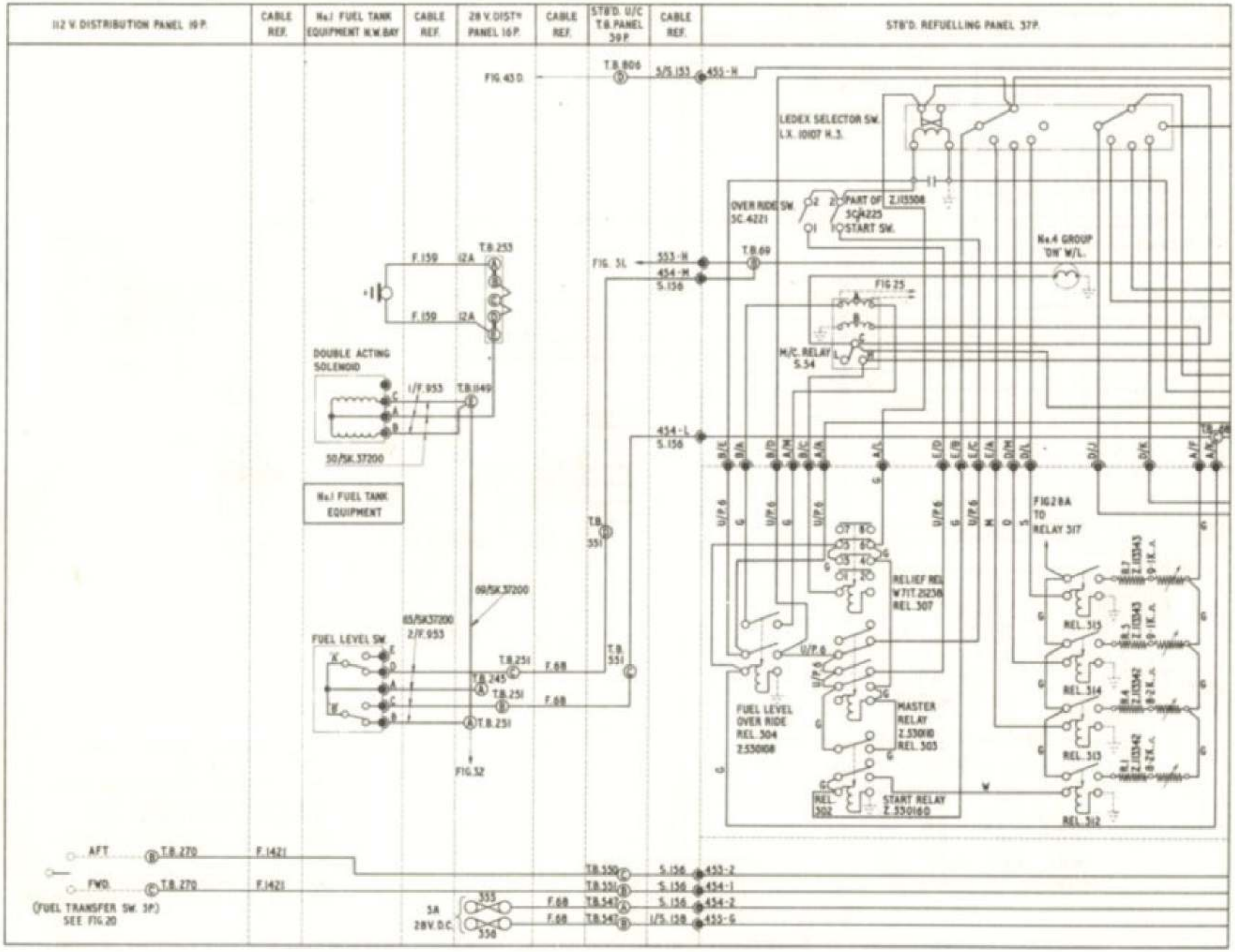

Fig 43C. (1) Refuelling – Nº 4 group (SK)

RESTRICTED

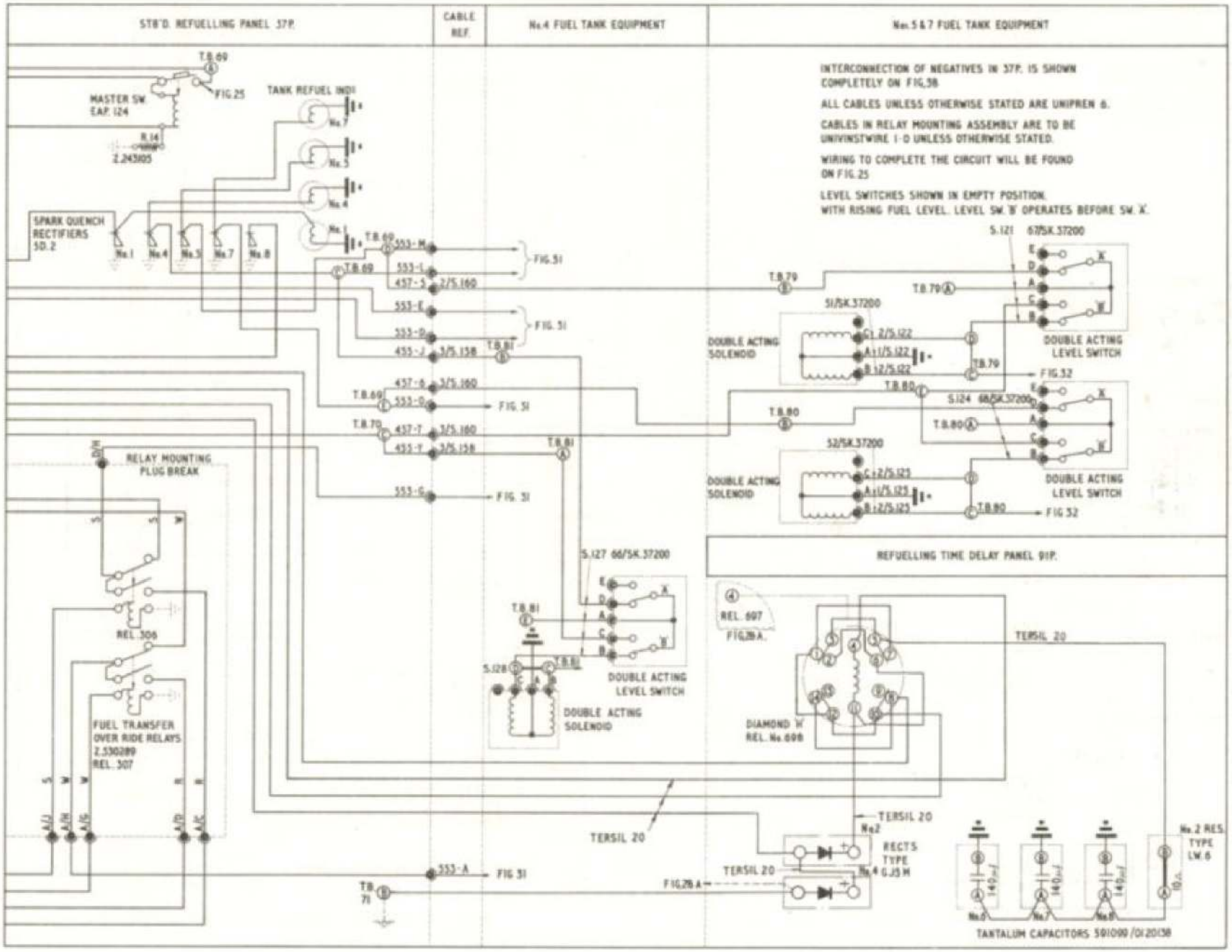

Fig. 43C. (2) Refuelling – No. 4 group (SK)

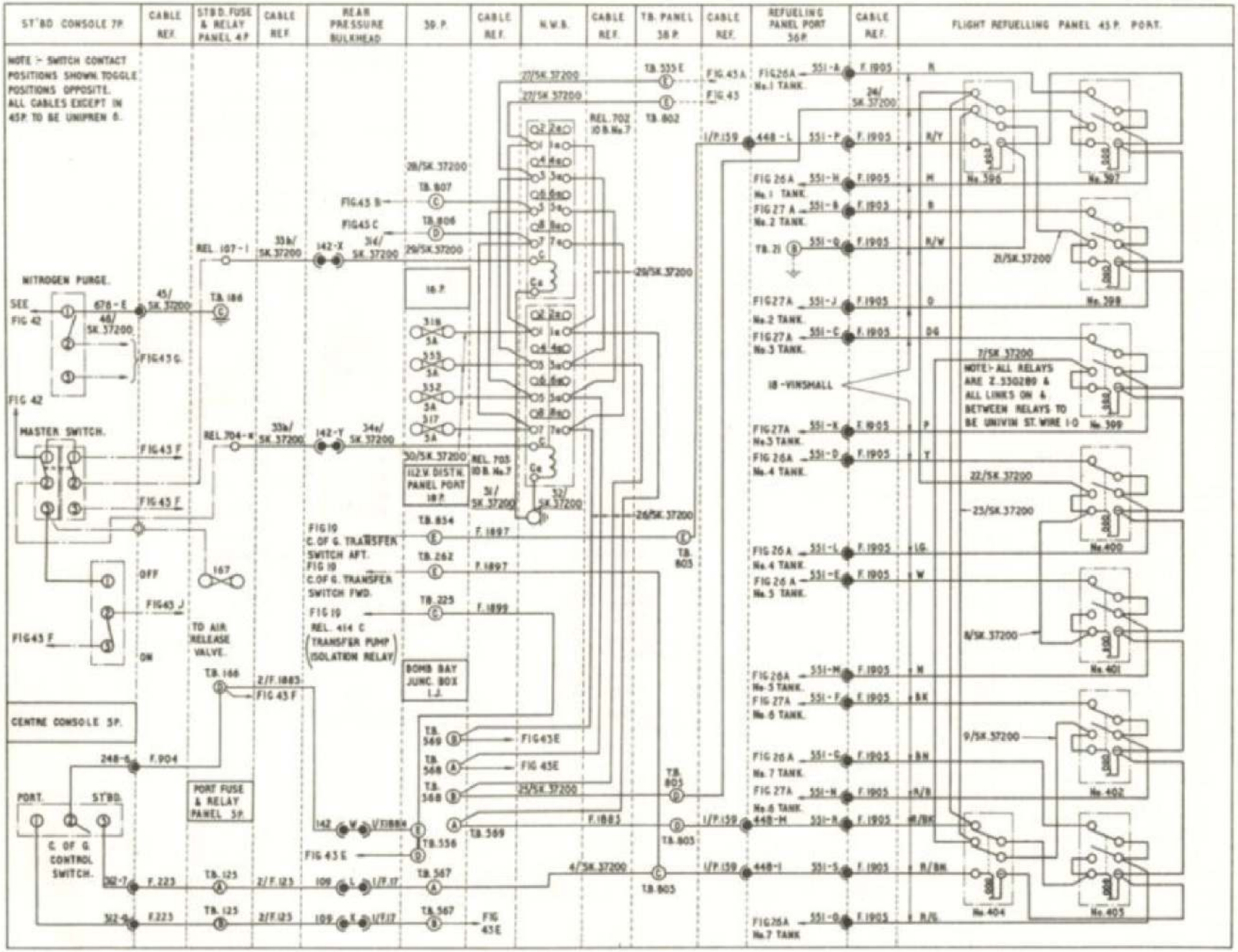

Fig. 43D. Flight refuelling - port (SK)

RESTRICTED

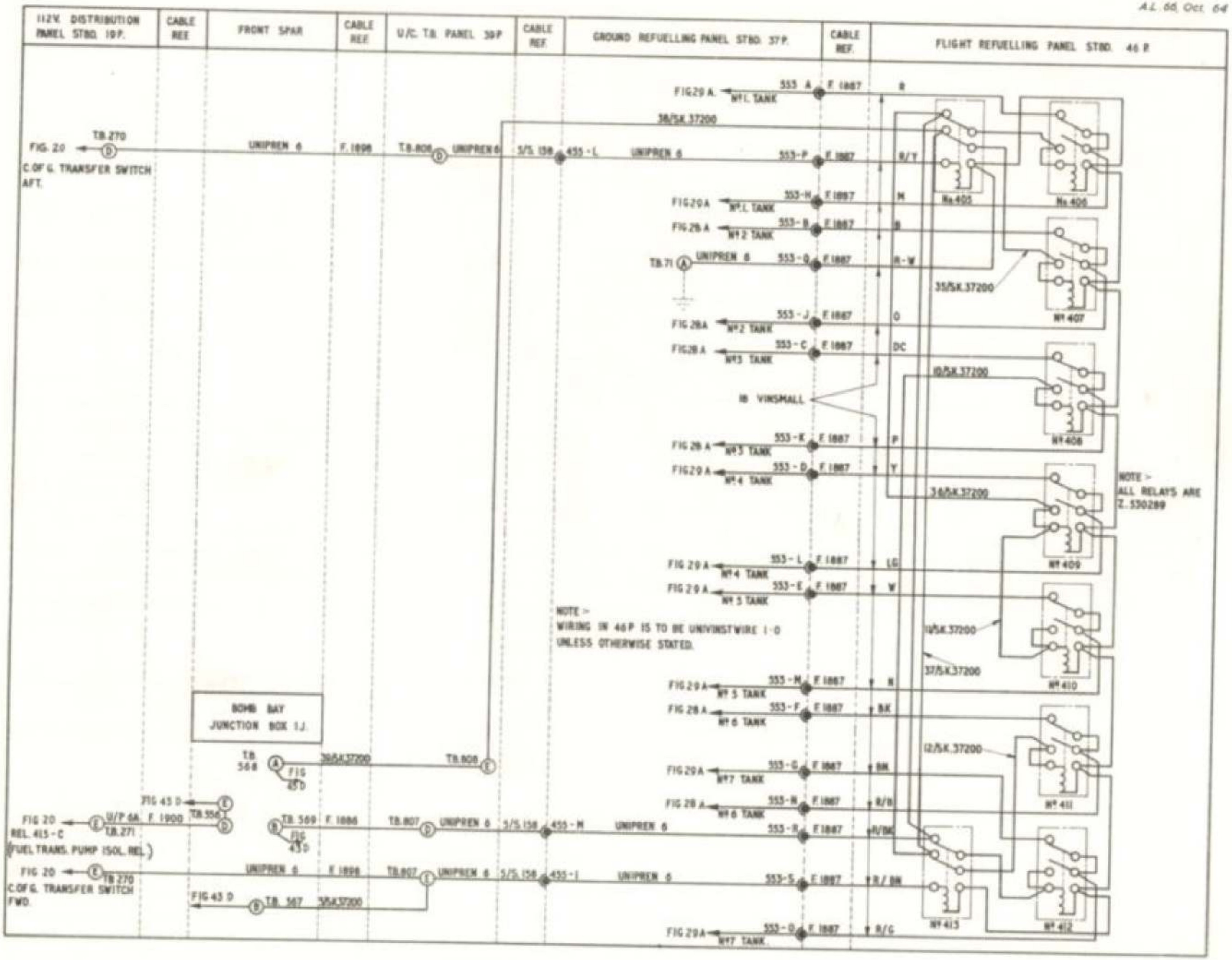

Fig. 43E. Flight refuelling- starboard (SK)

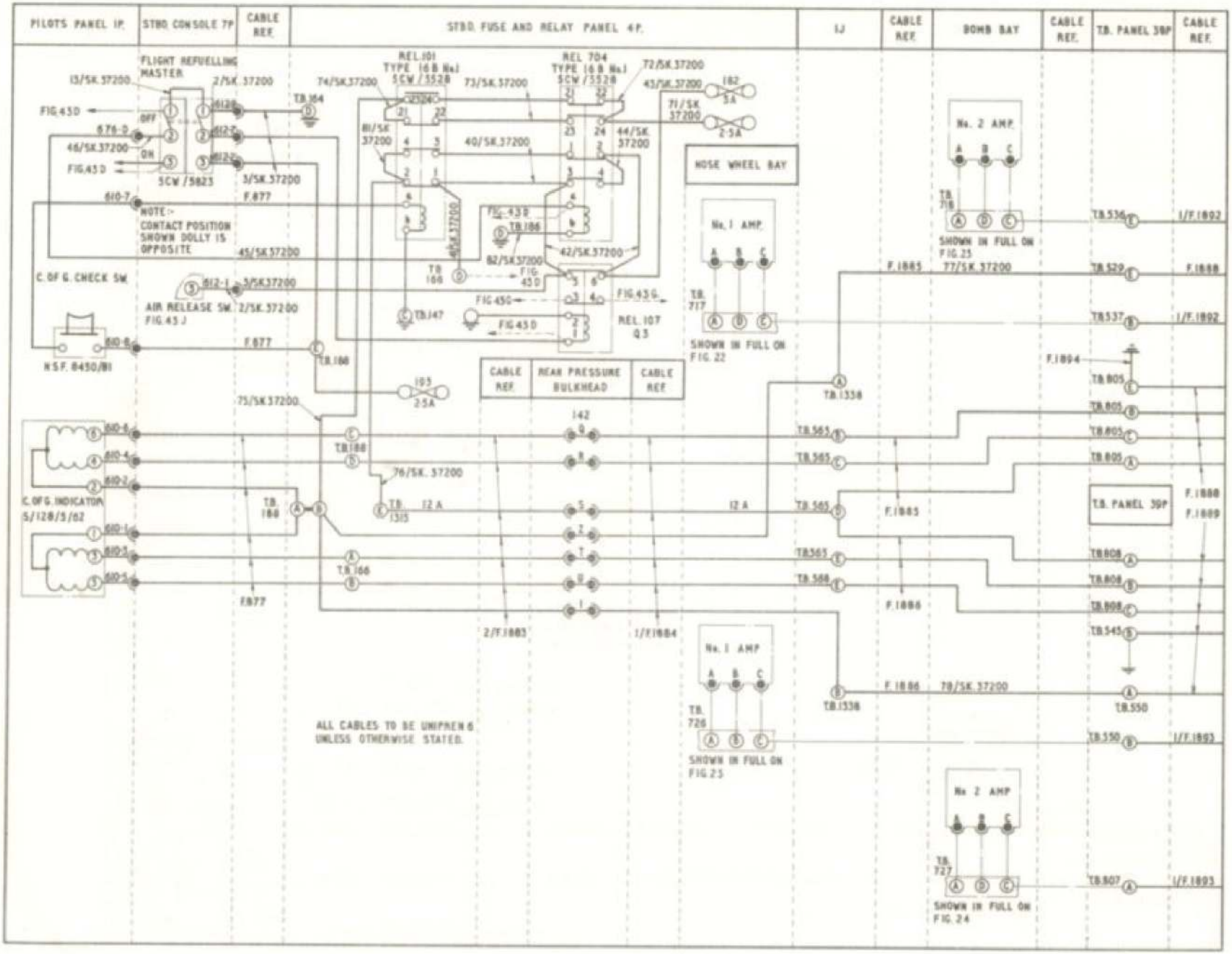

Fig. 43F. (1) Fuel centre of gravity (SK)

RESTRICTED

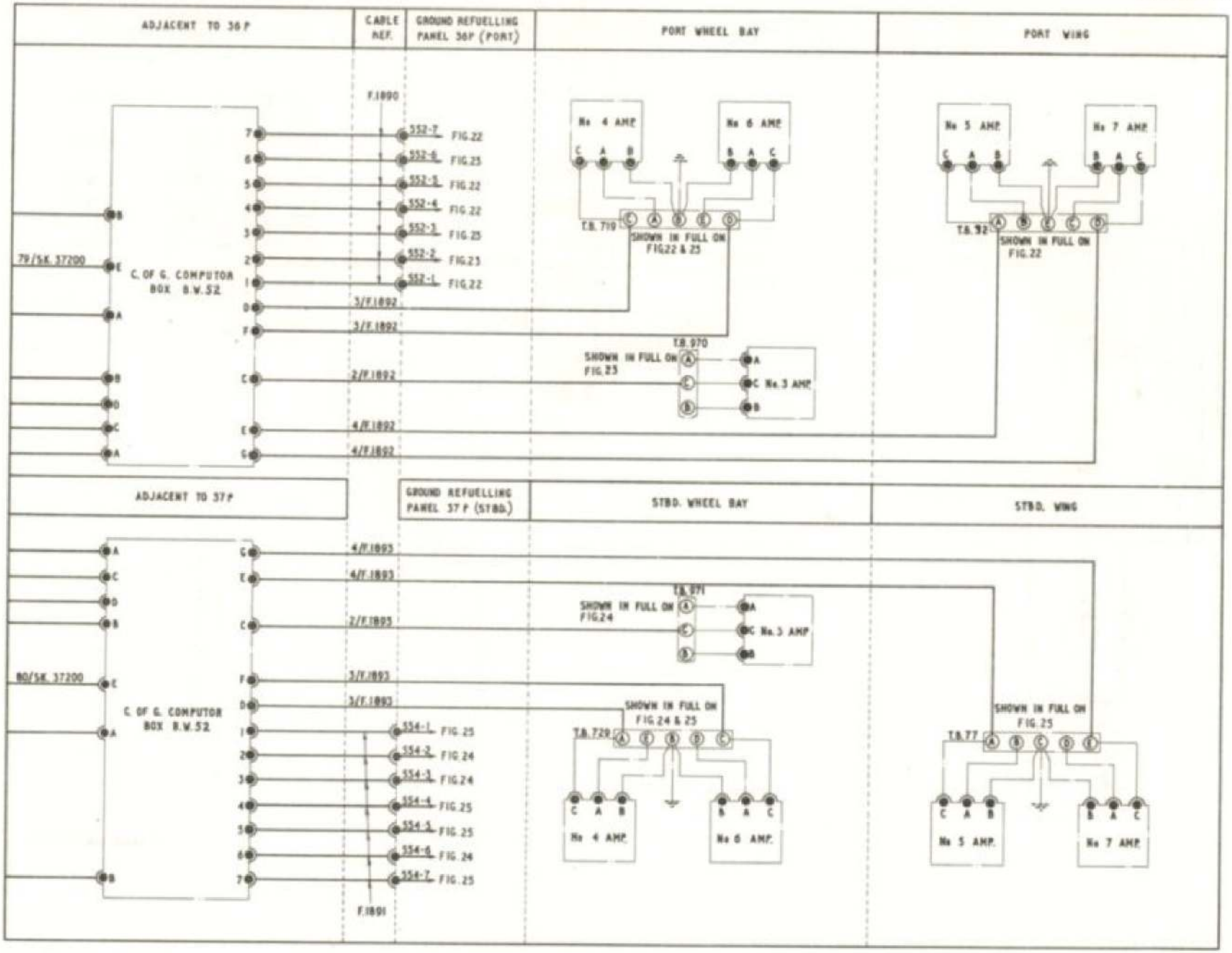

Fig. 43F. (2) Fuel centre of gravity (SK)

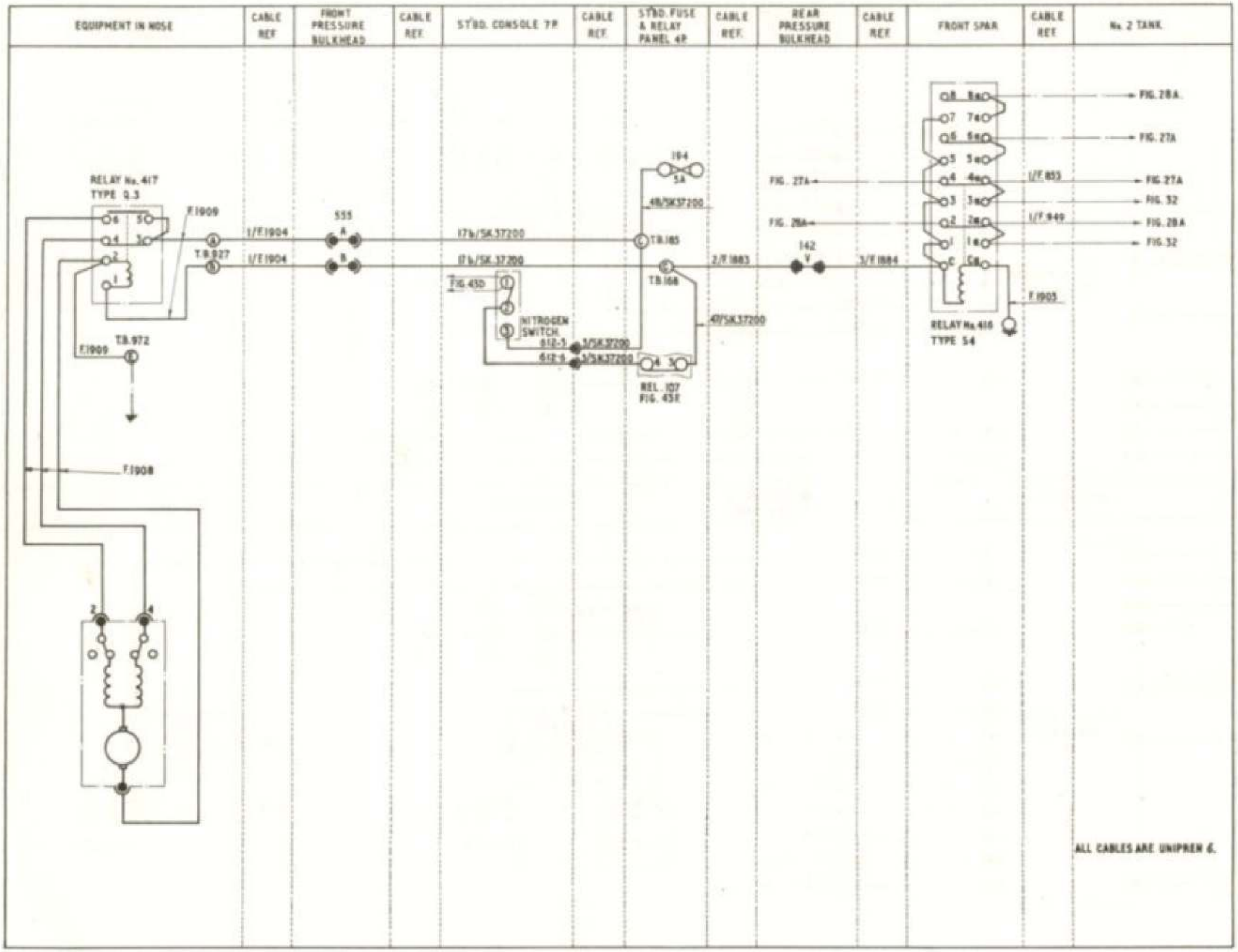

Fig. 43G. Nitrogen purge for flight refuelling (SK)

RESTRICTED

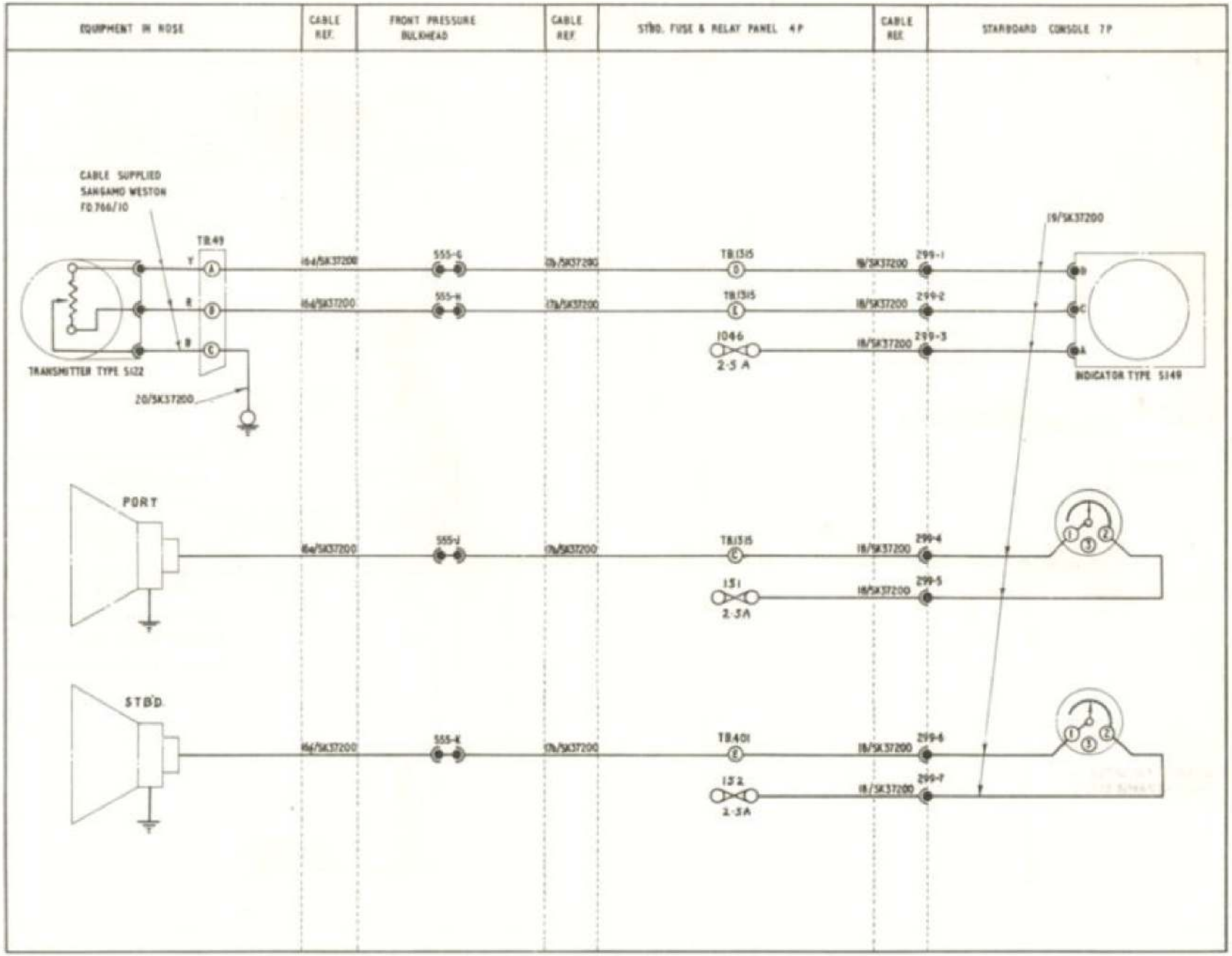

Fig. 43H. Probe fuel pressure and lighting (SK)

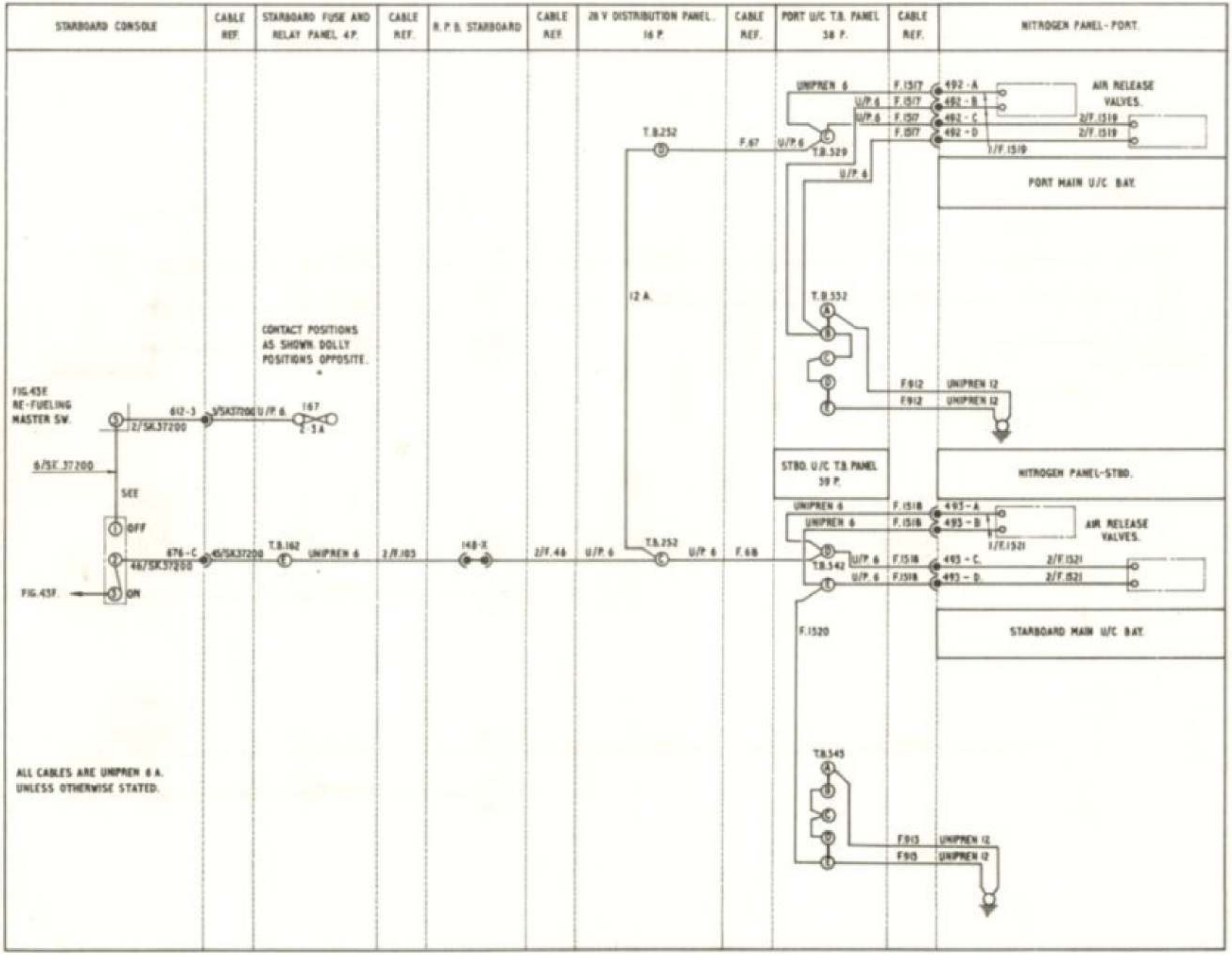

Fig.43J. Fuel tanks pressurisation (SK)


J-1712