Chapter 9
FUEL SYSTEM CONTROLS

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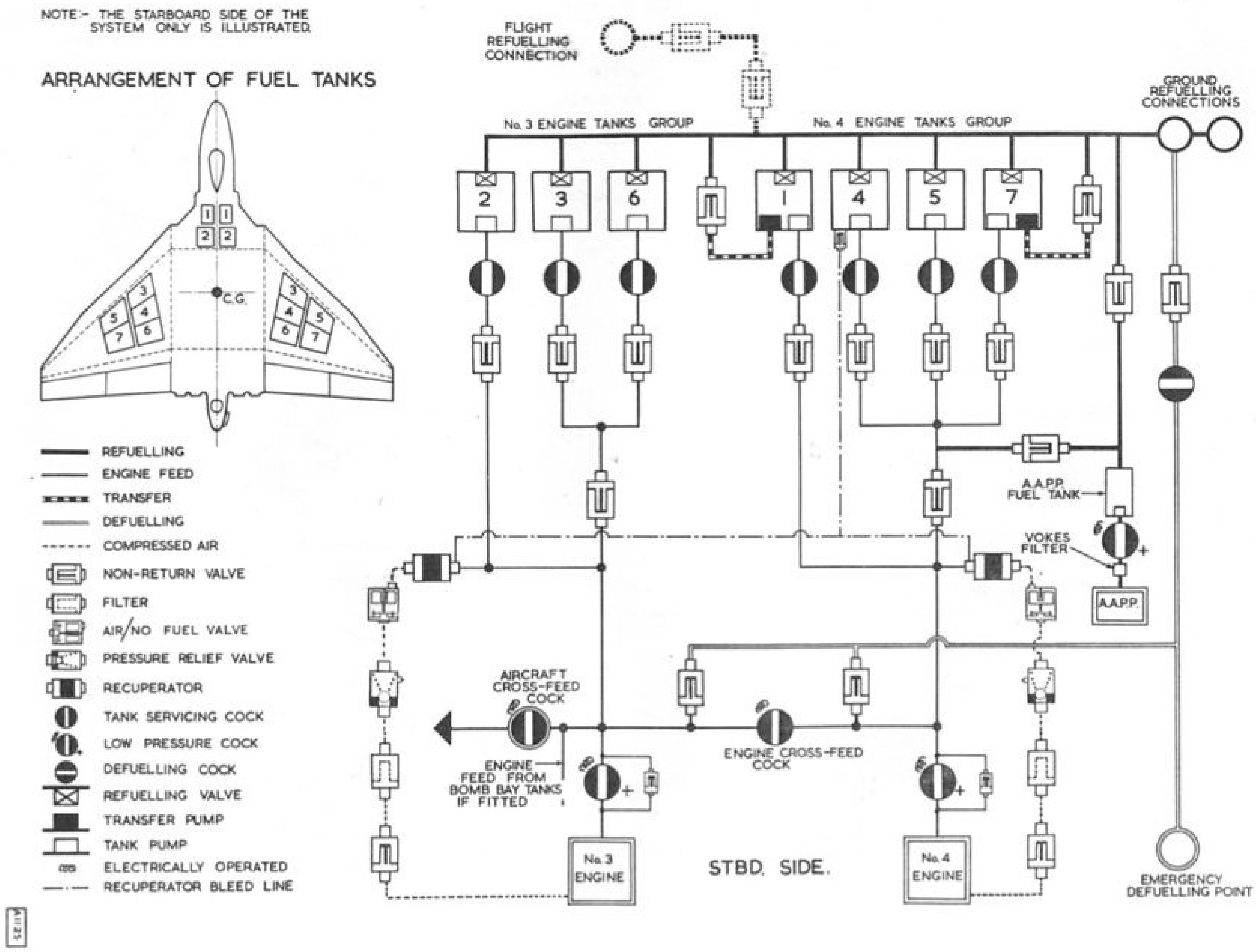

Fig. 1. Fuel system diagram

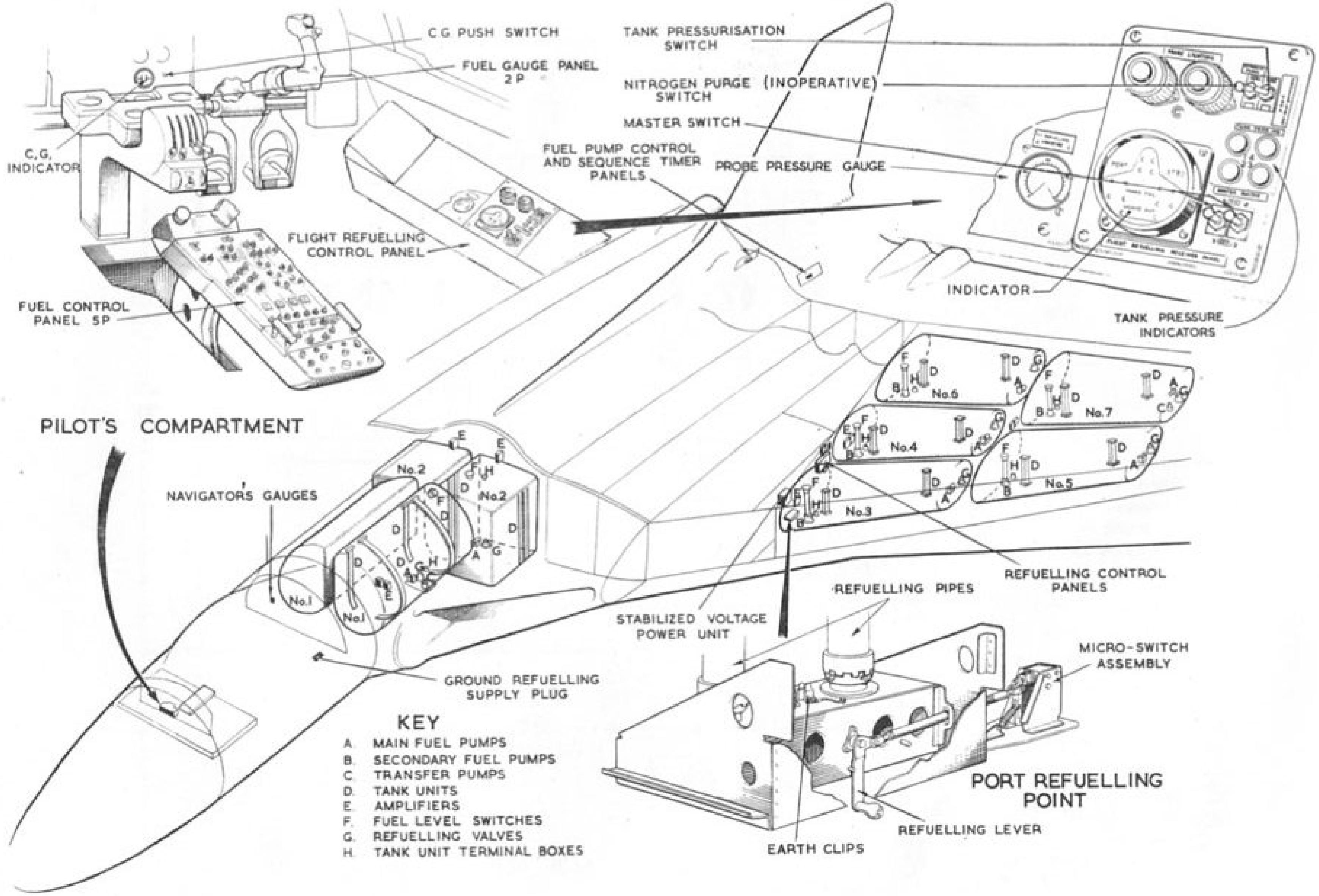

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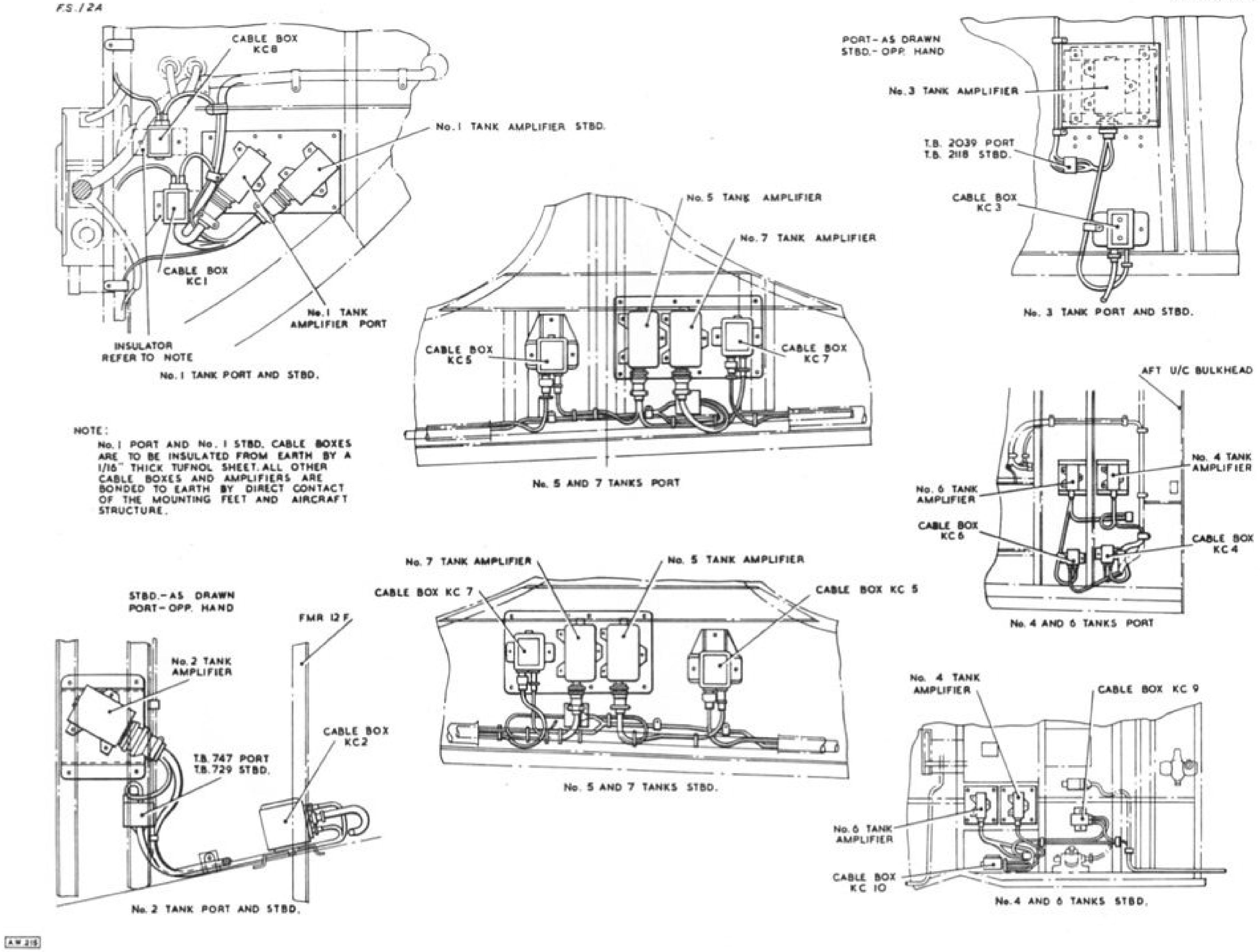
Fig. 2 Location of components

► Title change, and Mod. reference deleted ◄



◄ Fig. 2A Location of amplifiers and cable boxes ►

Introduction

1. This chapter contains descriptive and servicing information on the electrical circuits which control the fuel system. For a better understanding of the complete system this chapter should be read in conjunction with Sect.4, Chap.2 of this publication which gives full details of the physical side of the system. Illustrations showing the various controls and associated equipment are provided, together with simplified circuit diagrams.

2. A number of tables have been compiled to assist in calibrating various items of equipment. These tables will be found in the servicing section of this chapter, together with instructions for their use. The information included in this chapter incorporates Mod.526, 527, 528, 1509, 1552, 2005, 2006, 2013. 2014. 2015. 2086. 2255. 2281, 2283, ▶ 2302, 2373, 2417 and 2479. ◀

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. Provision for fitting one or two removable bomb bay fuel tanks has been made to increase the range of the aircraft when required. For the purposes 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.

5. Each tank is fitted with a main fuel booster pump for pumping fuel to the engines. In addition to the main pump each wing tank (No.3, 4, 5, 6 and 7) is fitted with a secondary pump. These secondary pumps feed fuel to their associated main pumps so that a continuity of fuel flow is maintained irrespective of the aircraft's attitude. An electrically actuated L.P. cock is fitted in each engine supply line.

6. 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.

7. Owing 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 ensures 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 five minute cycle is proportional to the capacity of the tank.

8. 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. computer 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.

9. 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

10. With the aid of fig.3 it will be seen that most of the fuel system control switches are mounted on the retractable centre console, 5P. Painted upon the upper surface of the panel is a plan view of the fourteen tanks as they are

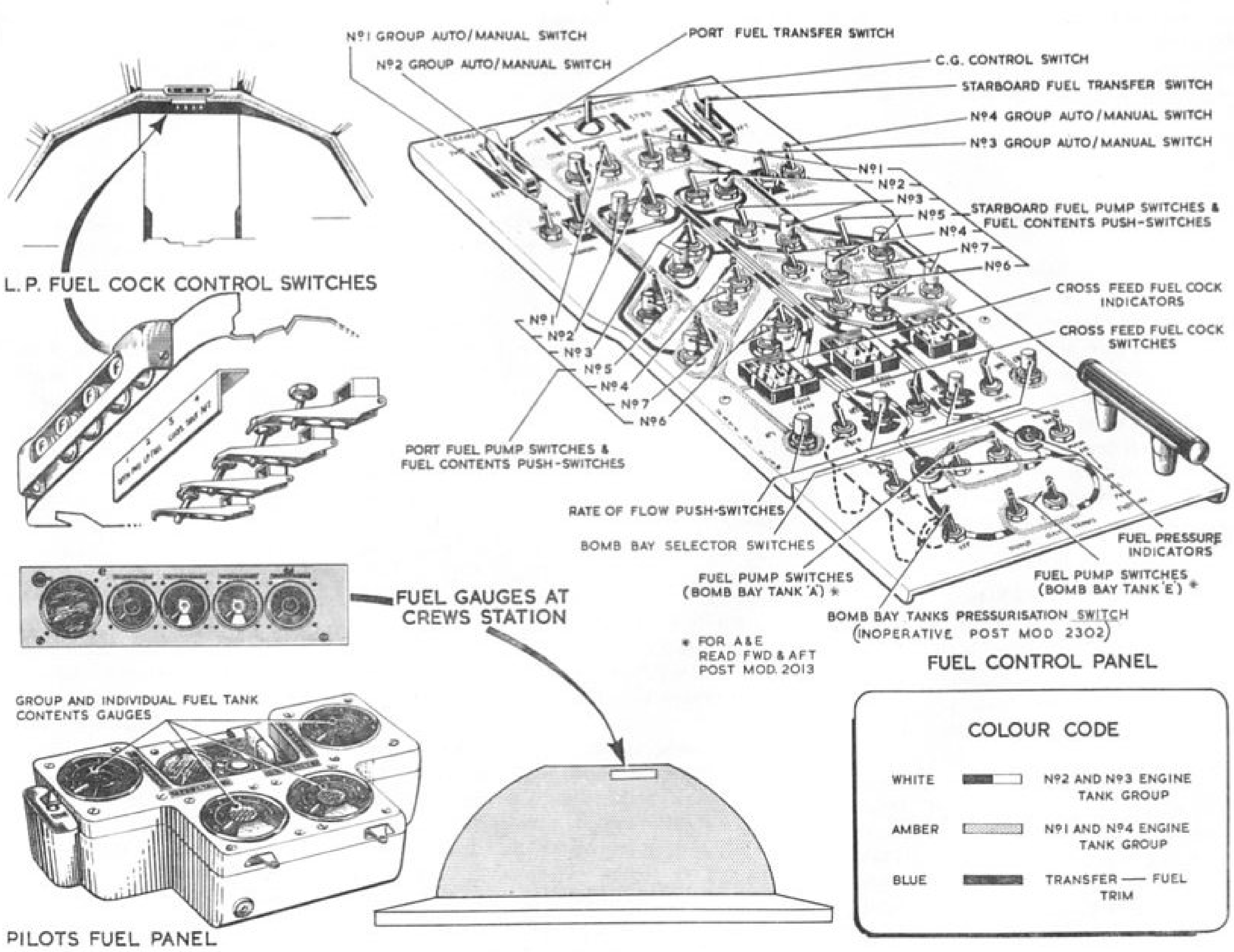


Fig. 3 Pilots' controls and indicators

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 3-position magnetic indicators, which complete or break the continuity of the interconnecting pipe lines whenever the cocks are open or shut respectively. The indicators will also show a cross hatched pattern when the d.c. supply is disconnected from the aircraft bus-bar. The following control switches and indicators are mounted on the panel.

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

The low pressure fuel cocks are controlled by four switches mounted on the pilot's coaming.

11. The lower or aft portion of the panel carries the control switches and indicators for the bomb bay fuel system. These consist of:-

Bomb bay main toggle switches	-	2
Fuel pump control toggle switches	-	4
Pressurization control toggle switch	-	1
Fuel pressure indicators	-	2

12. The four fuel contents gauges at the pilot's station are mounted side by side on panel 2P which is fitted on the retractable centre console, slightly forward of panel 5P. The navigator's fuel contents gauges are fitted on a small panel immediately above the navigator's instrument panel.

▶◀

13. The flight refuelling control switches and indicators are arranged on the starboard console as shown in fig.2. The controls and indicators may be listed as follows:-

Flight refuelling master switches

▶ Nitrogen purge switch (inoperative) ◀

Tank pressurization switch

Flight refuelling indicator

Flight refuelling probe pressure gauge

Tank pressure indicators

Fuel booster 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 the secondary fuel booster pumps will be connected to the supply. 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, however, remains constant at all times. The main pumps are Type PAC 1200 Mk.4 and the auxiliary pumps, Type PAC 100 Mk.3. Both pumps are described in ▶ A.P.113E-0479-1. ◀

15. Speed variation on the main booster pumps is achieved by equipping each pump motor with two field windings. One a six-pole winding and the other an eight-pole winding. The six-pole winding when connected to the 400 Hz a.c. supply gives a synchronous speed of 12 000 r.p.m. The eight-pole winding on the other hand gives a synchronous speed of 8 000 r.p.m. when connected to the same supply.

16. The selection of either winding is by means of change-over relays connected into the supply lines to the pumps. The six-pole windings are connected across the normally closed contacts of their respective change-over relays, while the eight-pole windings are connected across the normally open contacts. This means that the pumps will run at maximum speed whenever the change-over relays are de-energized and vice-versa.

17. The relays will be de-energized and the motors will run at maximum speed whenever the AUTO-MANUAL switches in 5P are set to MANUAL. Selecting the switches to AUTO will place the relay coils under the control of a sequence timer which, by means of cam operated contacts, will control the d.c. supplies to the relays so that they are energized and de-energized in sequence.

Sequence timer units

18. Two sequence timer units, Rotax Type D10705, are fitted in the power compartment, one on panel 40P, the other on panel 41P. These panels are mounted on the port and starboard sides of the compartment respectively as shown in fig.9. Each sequence timer controls the seven main fuel pumps on its particular side of the aircraft. By alternately energizing and de-energizing the speed change relays the pumps are controlled in such a manner that only one pump from each fuel tank group is delivering fuel to its associated engine 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 its associated engine will

be directly proportional to the capacity of the tank.

19. Each sequence timer consists of a camshaft on which are mounted seven cams. This camshaft is driven, through suitable reduction gearing, by a cage type induction motor. The gearing is arranged to give a camshaft speed of 0.2 r.p.m. or one revolution in approximately 5 minutes.

20. 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.

21. The seven tanks controlled by any one 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.6. The sequence timer motors are each fed with a 200-volt, 3-phase, 400 Hz a.c. supply. The port sequence timer on panel 40P is fed from fuses 72R, Y and B in panel 59P while the starboard sequence timer on panel 41P is fed from fuses 108R, Y and B in panel 60P. The supplies are fed to the sequence timer motors via two relays Nos. 36 and 48. The relays will be energized and the motors will run whenever AUTO is selected on any AUTO-MANUAL switch. The purpose of the bomb bay system selector switch in the circuit is explained in para. 118. The sequence timers are described in A.P.113E-03181-1.

Transfer pumps

22. Two three-position switches, labelled C.G. TRANSFER-FWD/AFT, control the fuel transfer pumps, Type P.A.C.500 Mk.3. 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 the No.7 tank will be switched on, and at the same time, the No.1 tank refuelling valve will be energized to open. The transfer pump will now deliver fuel into the refuelling pipe line, through the refuelling valve, and into the No.1 tank. Overfilling of the tanks is prevented by a fuel level switch within the tank which de-energizes the refuelling valves when the tank is full.

23. 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.80.

24. The fuel transfer pumps are described in detail in A.P.113E-0479-1, and a theoretical circuit diagram of the transfer system is contained in fig.6.

Fuel cock controls

25. Three cross-feed cocks and four low pressure cocks are employed in the fuel system. Each of these is an electrically-operated cock containing a motor-driven actuator, Type ERG/60 Mk.19. A description of the actuators will be found in A.P.113E-0267-1. An indication that the cross-feed cocks are switched on is provided by three electro-magnetic indicators, Dowty Type C, 5175Y, Mk.7, fitted on 5P. The indication circuits are completed through the built-in limit switches of the actuators. Each actuator circuit is fed with a separate 28-volt d.c. supply, No.1 actuator from fuse 520 in panel 4P and Nos.2 and 3 actuators from fuses 622 and 633 in panel 3P.

26. Four two-way double-pole switches, fitted on the coaming above the pilot's centre instrument panel, control the four low pressure fuel cocks. Each switch is fed with a 28-volt d.c. supply, No.1 and 2 switches from fuses 591 and 592 in panel 3P, No.3 and 4 switches from fuses 495 and 496 in panel 4P. No indicators are provided for the L.P. cock circuits.

Fuel pressure warning indicators

27. Four fuel pressure warning indicators, Type 5165Y Mk.1, are mounted on the pilot's centre instrument panel. Each indicator is operated by one of four fuel pressure switches, mounted one on each engine. The switch contacts will close to energize the appropriate indicator whenever fuel pressure to any engine falls below 5 p.s.i.

FUEL CONTENTS GAUGING SYSTEM

28. A Smith Waymouth Type 7 fuel contents gauging system is installed in the aircraft. Integral tank units, for measuring the tank contents and a separate bridge amplifier, Type KA5, are provided for each tank, the tank unit being connected to its associated amplifier via a cable box using co-axial cables. The outputs from the amplifiers are fed to fuel contents gauges on panel 2P. A complete description of the Smith Waymouth Type 7 system will be found in A.P.112G-0762-1.

29. The fuel contents system is split up into four groups, groups 1 and 2 form the starboard system and groups 3 and 4 the port system.

Each tank group consists of three (groups 2 and 3) or four (groups 1 and 4) individual systems. Each individual system has its own tank units, cable box, bridge amplifier and co-axial cables. Before reaching its respective indicator the output from each amplifier passes through a computer box and an associated relay, which is push button controlled (fig.7). For location of amplifiers and cable boxes refer to fig.2A.

30. The computer box proportions the current relationship between the amplifier outputs to achieve aircraft fuel balance. A proportion of the current from each amplifier is used to operate the C.G. indicator, whilst the relays permit individual tank readings to be obtained. Further information on the computer boxes is given in para.81.

Individual tank systems

31. 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

32. 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.

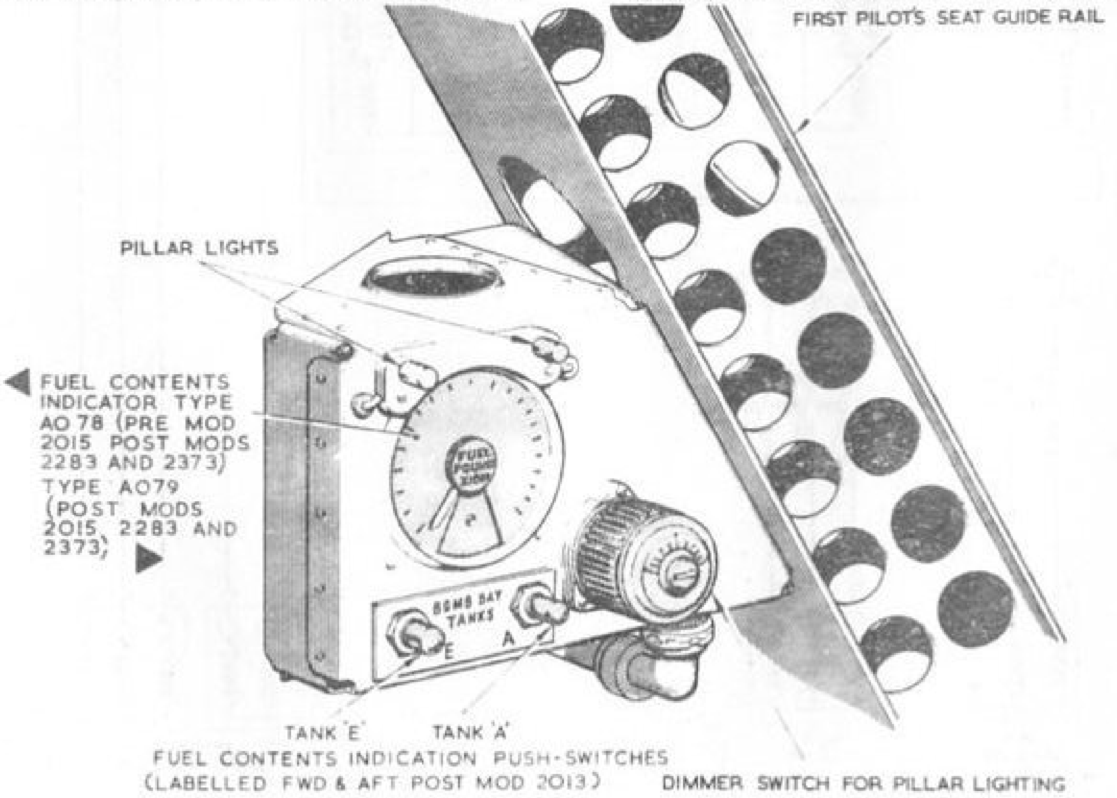


Fig.4 Bomb bay fuel contents panel

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 KA5 amplifiers via an associated cable box.

No.3, 4, 5 and 6 tank systems

33. 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. Co-axial cables connect the tank terminal to the KA5 amplifier via an associated cable box.

No.7 tank system

34. 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. Co-axial cables connect the tank terminal to the KA5 amplifier via a cable box.

Bridge amplifier Type KA5

35. The bridge amplifier, Type KA5, converts the tank unit capacitance of the fuel gauging system into an equivalent electrical current output. Variations of tank capacitance, due to a change in fuel contents are converted by the amplifier from dialectric capacitance to milliamps and fed to a moving coil indicator calibrated in units of fuel quantity. The front panel of the amplifier houses a 19-pole plug, to connect the amplifier to the fuel gauging system and two trimmers labelled 'E' (empty) and 'F' (full) respectively for adjusting the amplifier output.

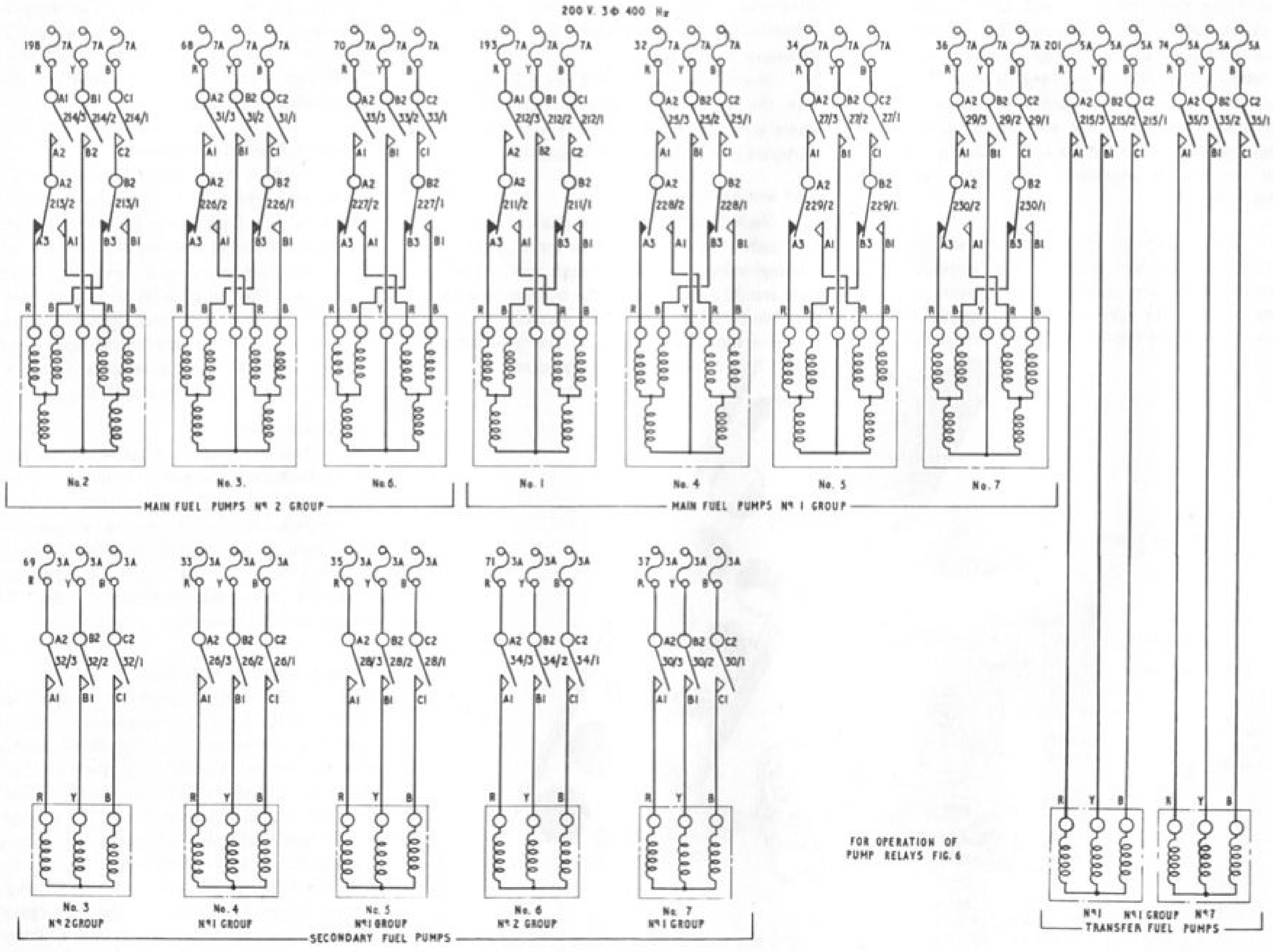


Fig. 5 Main, secondary and transfer fuel pumps (port)
◄ *Fuel pump annotation clarified* ►

Cable boxes

36. Cable boxes, Type KC1 to KC10, are fitted between the tank circuits and associated amplifiers to provide facilities for matching up the initial (empty) and range (full) capacitance of the tank circuit to that of the KA5 amplifier. This is effected by a trimming capacitor labelled 'E' (empty) fitted beneath a cover plate on the top face of the cable box.

CAUTION ...
No.1 port and No.1 stbd. cable boxes are insulated from earth by a 1/16 in thick tufnol sheet (fig.2A). All other cable boxes and amplifiers are bonded to earth by direct contact between the mounting feet and the aircraft structure. (Refer to para.212).

Contents gauges

37. The contents gauges fitted in the aircraft are in effect milliammeters, calibrated in pounds X1000 and specially designed to record the output from the KA5 amplifiers.

38. The four gauges mounted on the pilot's 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 installed on the main instrument panel at the crew's station. These gauges are not capable of indicating individual tank contents and so show group contents at all times. The contents gauge type No. are as follows:-

No.1 group (pilot's)	- Type AO69
No.1 group (crew's)	- Type AG14
No.2 group (pilot's)	- Type AO70
No.2 group (crew's)	- Type AG15
No.3 group (pilot's)	- Type AO70
No.3 group (crew's)	- Type AG15
No.4 group (pilot's)	- Type AO69
No.4 group (crew's)	- Type AG14

Tank group contents

39. Each of the pilot's 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 while the outer, more easily read, scale will, when selected, show the contents of an individual tank in the group.

40. The amplifier outputs are connected together via the operating 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

41. The contents of an individual tank in any group will be displayed on the appropriate gauge when the individual tank push-switch on 5P has been pressed. Referring to fig.7, assuming that No.3 individual tank push-switch is operated, it will be seen that the sequence relay 299 will be energized via the push-switch and fuse 861. Closing of contacts 299/2 will energize the shunt relay No.301 via fuse 769. Operation of contacts 301/3 will disconnect all amplifiers except No.3 from the 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 amplifiers 2 and 6 to prevent movement of their mechanisms, and contacts 301/4 will disconnect the shunt from the gauge.

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

NOTE . . .
The contents gauge may be damaged if two push-switches are operated at the same time. By this action two amplifier outputs will be applied to the gauge with the shunt resistance disconnected.

GROUND REFUELLING

43. During ground refuelling each tank is filled to the same percentage of its maximum capacity in order to maintain a correct C.G. 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.

44. Only one tank is filled at a time, automatic changeover to the next tank being made by a moving coil relay. One coil of this relay is connected to a resistance network refuelling circuit which 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

45. Each moving coil relay has two windings, one connected in series with the group fuel contents gauge, the other connected to the resistance network. The resistance network receives its supply from a stabilized voltage power unit which is controlled by a micro switch and operating handle at the port refuelling point. The stabilized voltage supply from the power unit 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

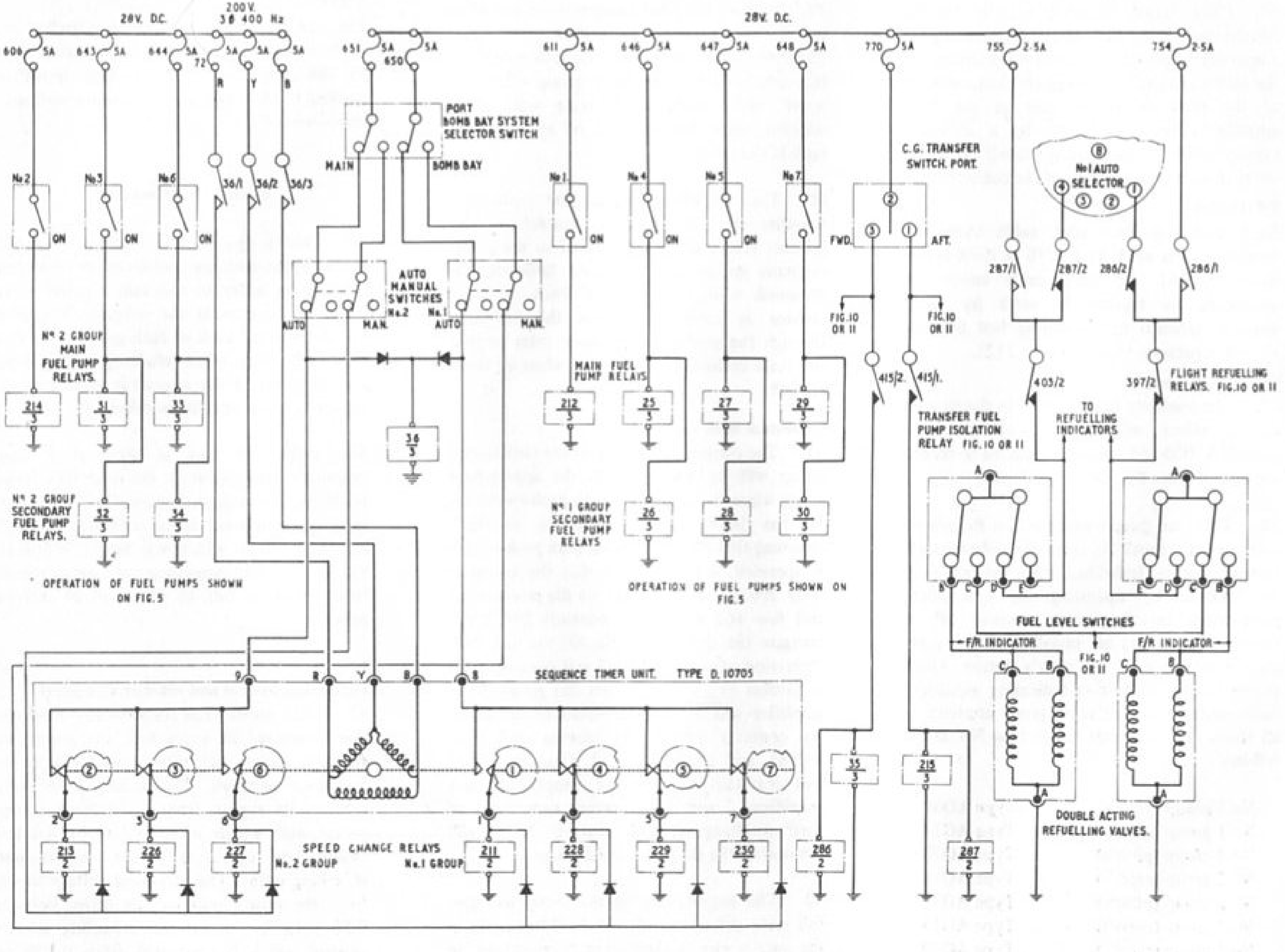


Fig. 6 Port sequence timer circuit

◄ Fuel pump relay annotation amended ►

relevant selector relay will connect the moving coil relay to the stabilized supply, through a fixed and trimmer resistance.

46. 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 fuel contents 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 2 mA above the current in the control coil, the contacts MC/2 will operate to close. This action will energize a Ledex auto-selector switch to shut off the selected tank.

Stabilized voltage power unit

47. This unit, H.S.A. Part No. 40/V6604 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.8. A circuit diagram of the unit is provided in fig.13 while fig.12 shows the physical appearance of the unit.

General description

48. 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 Hz 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.

49. When in use the potentiometer, centred on the front panel of the unit, is set to the designed 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-volts with an aircraft supply variation between 22 and 29-volts. As soon as the required voltage is available two COMMENCE REFUELLING indicators will be switched on. One of these indicators is on the port refuelling panel 36P the other is on the starboard refuelling panel 37P.

50. On completion of refuelling, the access door to the refuelling points 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

51. Referring to fig.13, 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 769 when a fault develops on the vibrator pack, thereby preventing unnecessary disruption of supplies to the refuelling circuits.

52. 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 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.

53. The resultant stepped up a.c. voltage developed across the centre-tapped secondary

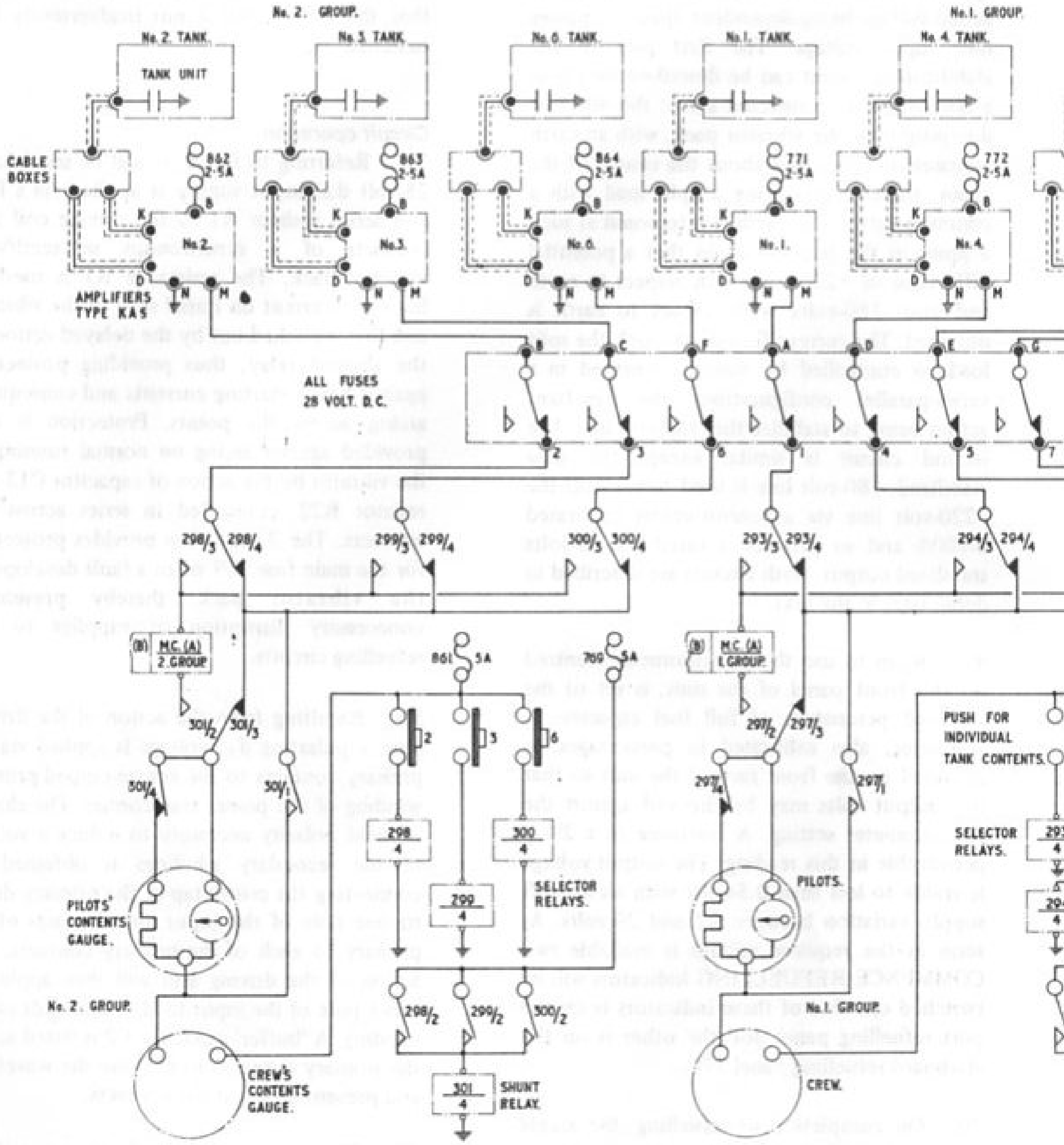


Fig.7 Fuel contents gauging (port)

◄ No. 1 Group selector relay numbers corrected ►

winding is connected to the rectifying contacts of the vibrator. Due to the rectifying arm being mechanically coupled internally to the driving arm, thus synchronized, 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.

54. 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 proportionately 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, stabilized. 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.

55. 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.

56. 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.

57. 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 is conducting, thereby energizing the indicator relay and subsequently closing the relay contacts. By this action a 28-volt d.c. supply is connected to two

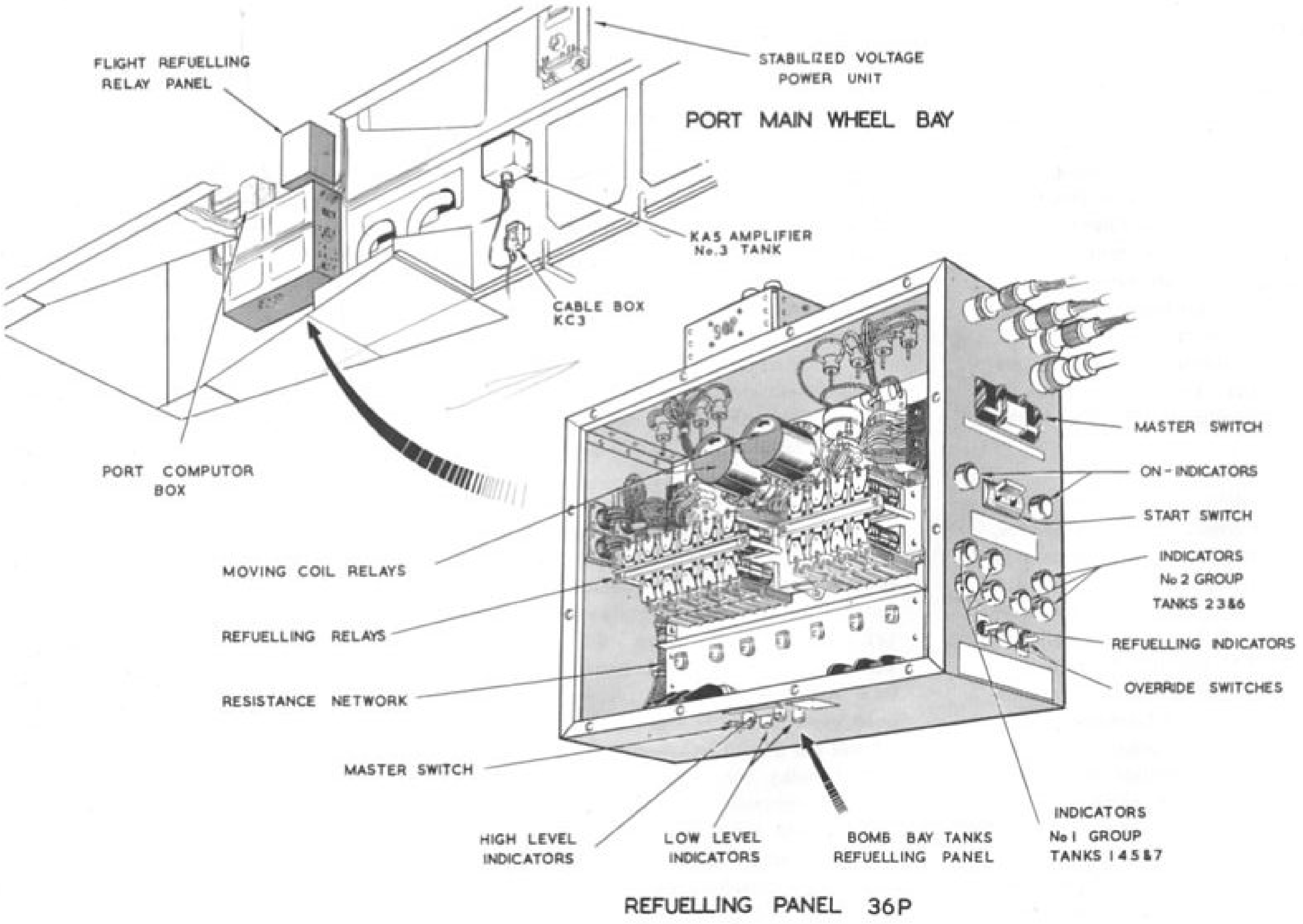


Fig. 8 Refuelling controls

◄ *Mod. 2283 incorporated* ►

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

58. A double-bank Ledex rotary auto-selector controls the refuelling valves and tank selector relays in each group of 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 and a start switch is used to operate the auto selector into the correct starting position.

59. When the last tank in the group is 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 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.

60. The double acting fuel level switches are wired in series so that the refuelling valve will be de-energized 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.

61. All the ground refuelling control switches, resistant 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.8.

Ground refuelling external supply plug

62. A 28-volt external supply plug, located on the starboard side of the nosewheel bay, and accessible from outside the aircraft, is used for connecting an external power supply during ground refuelling. The external supply plug is connected via the contacts of suitable changeover relays to the bank of fuses in 15 and 16P which supply the ground refuelling controls and fuel contents gauging system. A theoretical diagram of the circuit is shown in fig.19.

Ground refuelling circuit operation

63. 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 diagram fig.11. The oper- ◀ ation of groups 1, 3 and 4 is similar except that in the four-tank groups (1 and 4) an additional refuelling valvé, fuel level switch and auto selector contact would be provided. Throughout the following circuit operation the flight refuelling relay panel (45P) and the port computer box will be ignored. It will also be assumed that a 28-volt d.c. supply is connected to the ground refuelling supply plug.

Starting

64. Operation of the handle adjacent to the hose connector at the port wing refuelling point will cause the micro switch to make contacts 2-3 and connect a supply from fuse 769 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 voltmenter should be checked against the selected percentage to ensure that both readings agree, or are within the acceptable limits of ± 2%.

65. When the group refuelling MASTER switch is placed to ON, a hold-in coil is energized from fuse 769, 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 energized from fuse 769 via the MASTER switch and contacts A1 of the auto selector.

66. The closing of relay contacts 292/2 will bring about the following circuit action:-

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

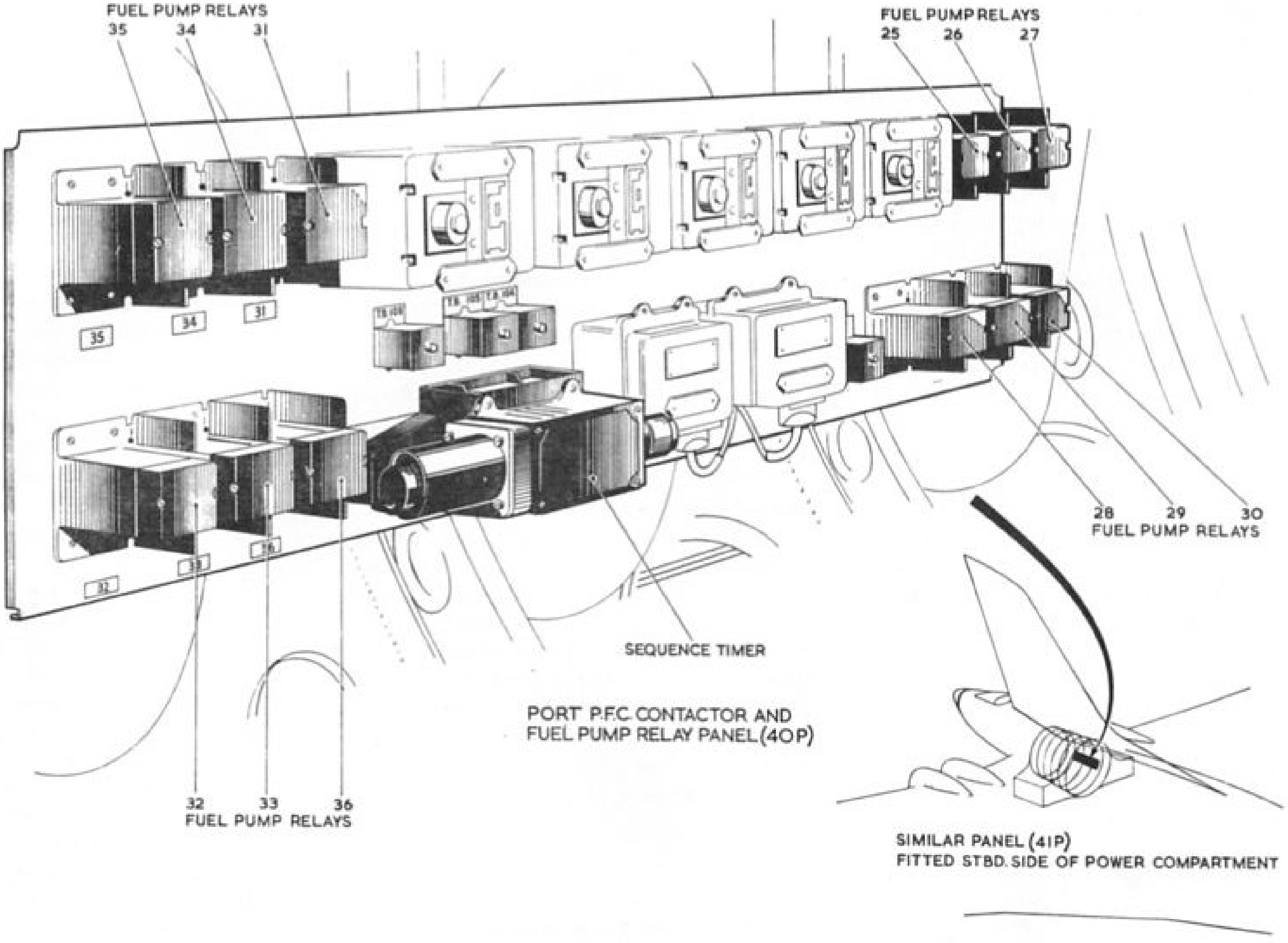


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Fig. 9 Sequence timer (40P and 41P)

(2) A supply from fuse 769 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.

67. The No.2 tank sequence relay, No.298 will be energized 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 energized 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 reconnected 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 the resistance branch R2.

68. The output from the No.2 tank amplifier passes through the moving coil relay, MC(A) and the contents gauge which registers the contents of the tank. No.2 tank refuelling valve is operated by a supply from B1 of the autoselector. The same supply is fed to the tank indicator lamp which lights to indicate that the valve is open and refuelling may commence.

69. 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 pushed 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

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 energizing the relief relay No.289. The parallel contacts of 289/1 and 289/2 will close to energize the override relay No.290. The closed contacts 290/1 energize the auto selector which then steps to contacts A2 and B2. By this action the No.2 sequence relay de-energizes and the No.3 sequence relay will be energized via contacts A2, at the same instant the No.2 refuelling valve de-energizes to close and the No.3 refuelling valve is energized to open via contact B2.

71. 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-energize relay 289 and the next refuelling cycle will commence.

Time delay operation

72. The operation of the 'B' contact as described in the previous paragraphs 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 the 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 energized 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 pressures as the action is repeated at subsequent tanks.

73. With the introduction of Mod.1406, however, the circuit is revised and 'flick'

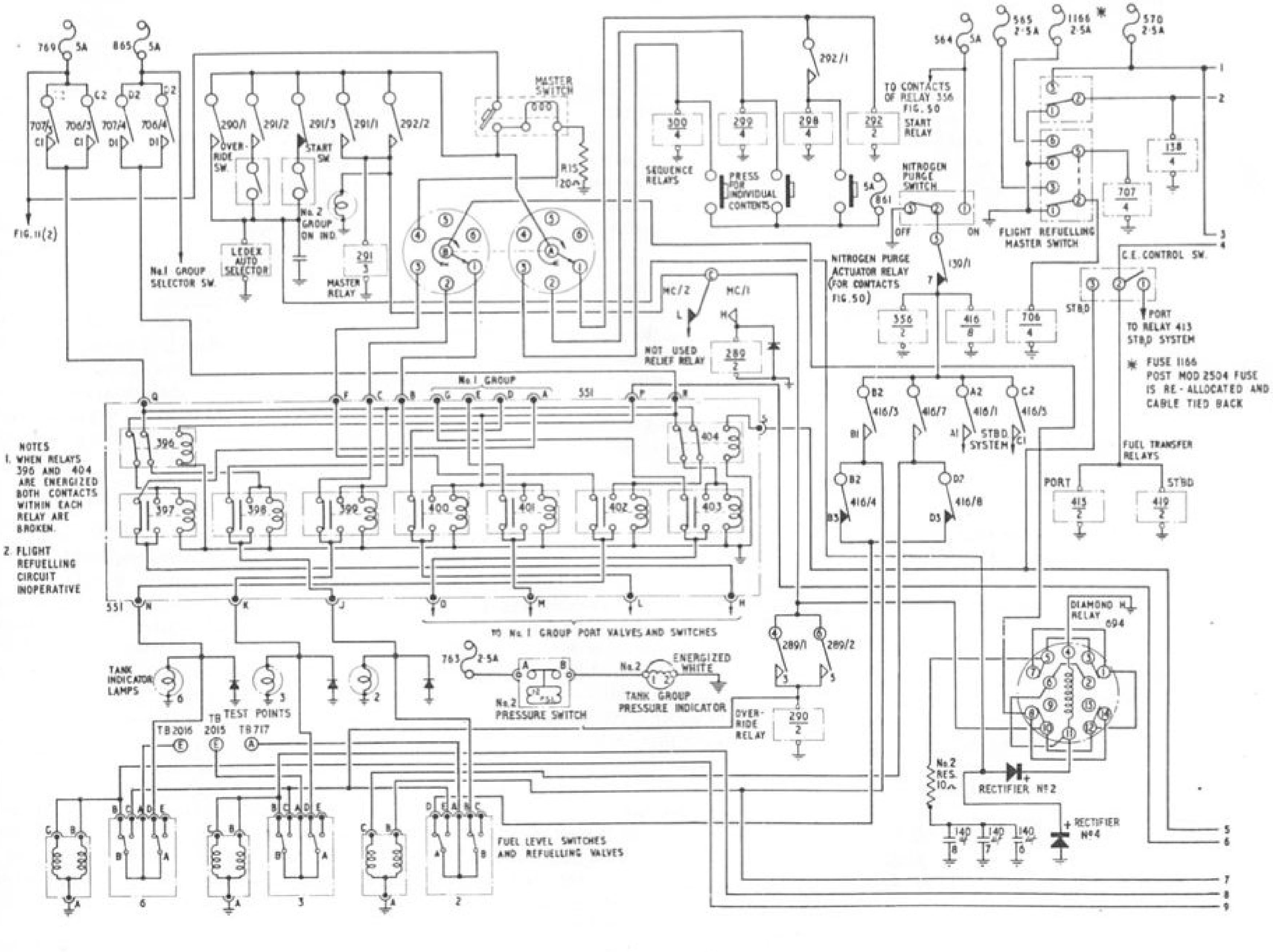


Fig II (1) Ground and flight refuelling circuit
▶ Title changed notes added ◀

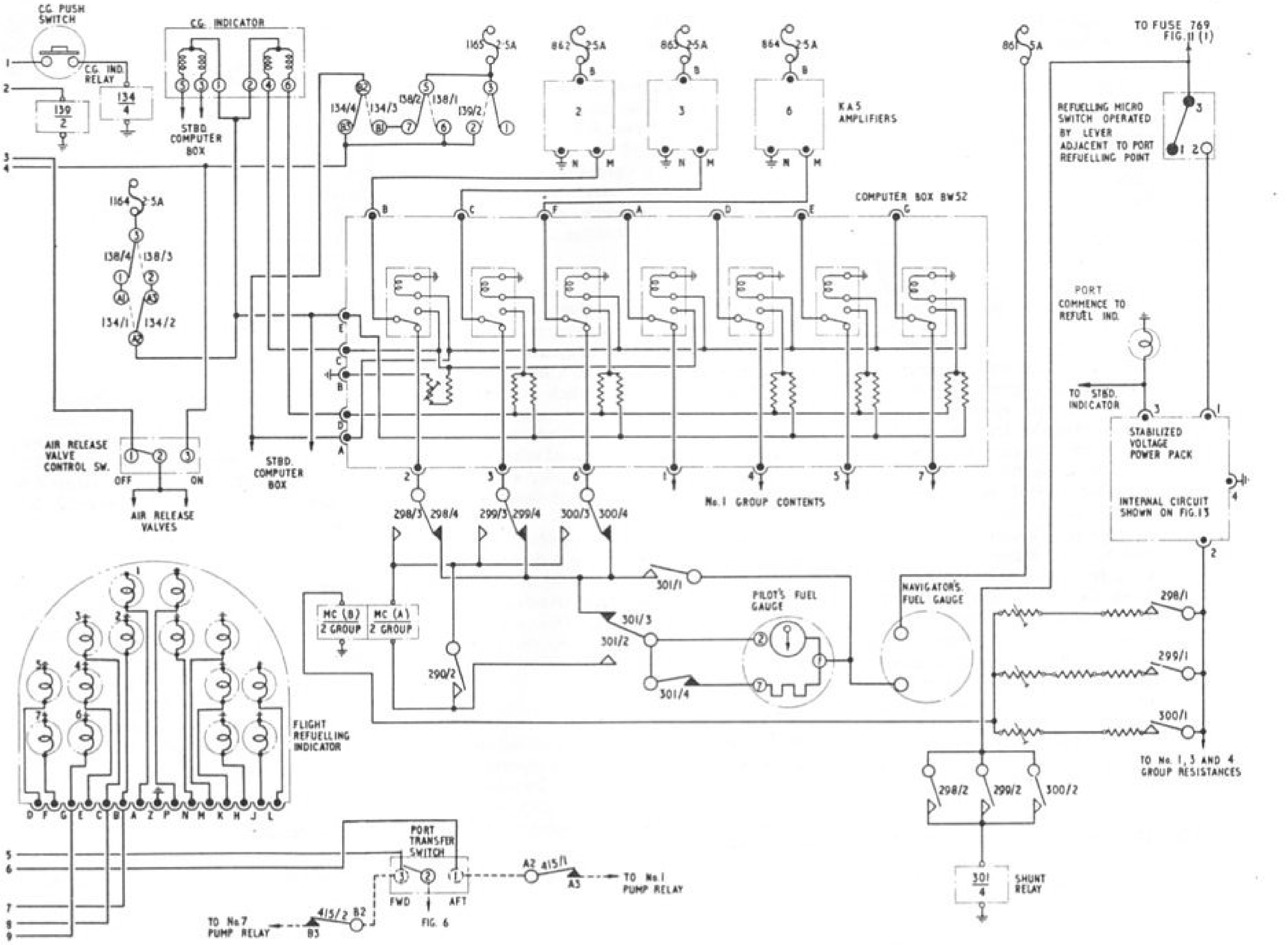


Fig 11 (2) Ground and flight refuelling circuit

▶ Title change ◀

pressures are eliminated. The circuit operation, which should be read in conjunction with fig.11 is as follows:-

(1) The diamond H relay No.694 is energized 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 5-6, 3-2 and finally the coil of the diamond H relay. This will allow the diamond H relay to hold in after the initial supply via contacts 290/1 has been removed. It will follow, that the diamond H relay will remain energized 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-energized 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 energizing 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 selected 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 and the switch contacts will operate to isolate the re-fuelling circuits. The No.6 tank sequence relay (300) and subsequently the shunt relay, will be de-energized and the contents gauge will return to summating the tank group fuel contents.

75. The supply to the stabilized voltage power unit will remain on until the refuelling hoses have been removed and the microswitch operating handle has been returned to its normal horizontal position. This action will switch off the power pack and the warning lamp 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, No.290, will be energized, causing the auto-selector to step 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 correct percentage capacity.

FLIGHT REFUELLING (INOPERATIVE)

NOTE . . .
The flight refuelling system and probe nitrogen purge system have been rendered inoperative by embodiment of Mod.2417. The folllowing description and circuitry is retained for information and identification purposes. Certain flight refuelling circuit fuses have subsequently been re-allocated to other services.

General description

78. Flight refuelling is carried out by the drogue and probe method. The probe on the receiver aircraft is fitted to the metal nose fairing, and from the probe main intake pipe, branch pipes run aft to connect to the fuel tanks, via the normal ground refuelling lines. A probe fuel pressure gauge is provided on the starboard console.

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. A description of the physical side of the nitrogen purge system will be found in Sect.4, Chap.2 of this publication.

Controls

80. As stated in para.13 the main controls and indicator for the flight refuelling system are mounted on or adjacent to a small panel on the starboard console, as shown in fig.2. The C.G. controls are mounted on the centre console and the indicator is mounted on the pilot's centre panel.

▶◀

▶ Flight refuelling master switches	These switches, which comprise one single-pole and one double-pole switch are operated together to perform the function of primary control switch for the complete system (para.13) ◀
* Nitrogen purge switch	This single-pole centre-off switch controls the supply to the nitrogen valve actuator relay and the No. 2 tank refuelling valves.

NOTE . . .
** Inoperative Post Mod.2417.*

Air release valves control switch	This single-pole switch controls the pressurization valves in the main fuel tanks pressurization system.
Tank pressure indicators	Information is presented on four magnetic indicators, one for each tank group. When pressurization of any tank group is reduced to 1.2 lbf/in² the magnetic indicators are energized white. The pressure switches are fitted in the fuel tank vent line of each tank group, thereby providing a positive indication that all fuel tanks are de-pressurized before commencement of flight refuelling.
Probe pressure gauge	This instrument is calibrated in lb. per sq. in. from 0-120 and reads the pressure of fuel passing through the probe.
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 are open and go out as each tank is filled and the refuelling valve closes.
C.G. control switch	This switch is labelled PORT – OFF – STARBOARD and is spring-loaded to the OFF position. Selecting the switch to PORT closes the refuelling valves of tanks 6 and 7 on the starboard side; selecting the switch to STARBOARD closes the refuelling valves of tanks 6 and 7 on the port side. By this means lateral C.G. of the aircraft may be maintained.
C.G. transfer switches	These two switches, previously described in para.22, normally control fuel trim between tanks 1 and 7. This is not so when the flight refuelling master switch is selected to ON. In this condition the normal transfer circuits are isolated and when the switches are moved to FWD. refuelling is stopped on wing tanks 6 and 7 while refuelling continues on the other tanks. Selecting the switch to AFT stops refuelling into fuselage tanks 1 and 2 while refuelling continues on the other tanks.

C.G. indicator and computer boxes

81. A C.G. indicator, Type S128/5/99, is fitted on the pilot's centre instrument panel as shown in fig.2. The indicator has two movements, one for each side of the fuel system. Signals for each movement are provided by the KA5 amplifiers via computer boxes.

82. The computer boxes, Type BW.52, are installed one in each main wheel bay, adjacent to the ground refuelling panels, as shown in fig.8. Each box is an analogue computer 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

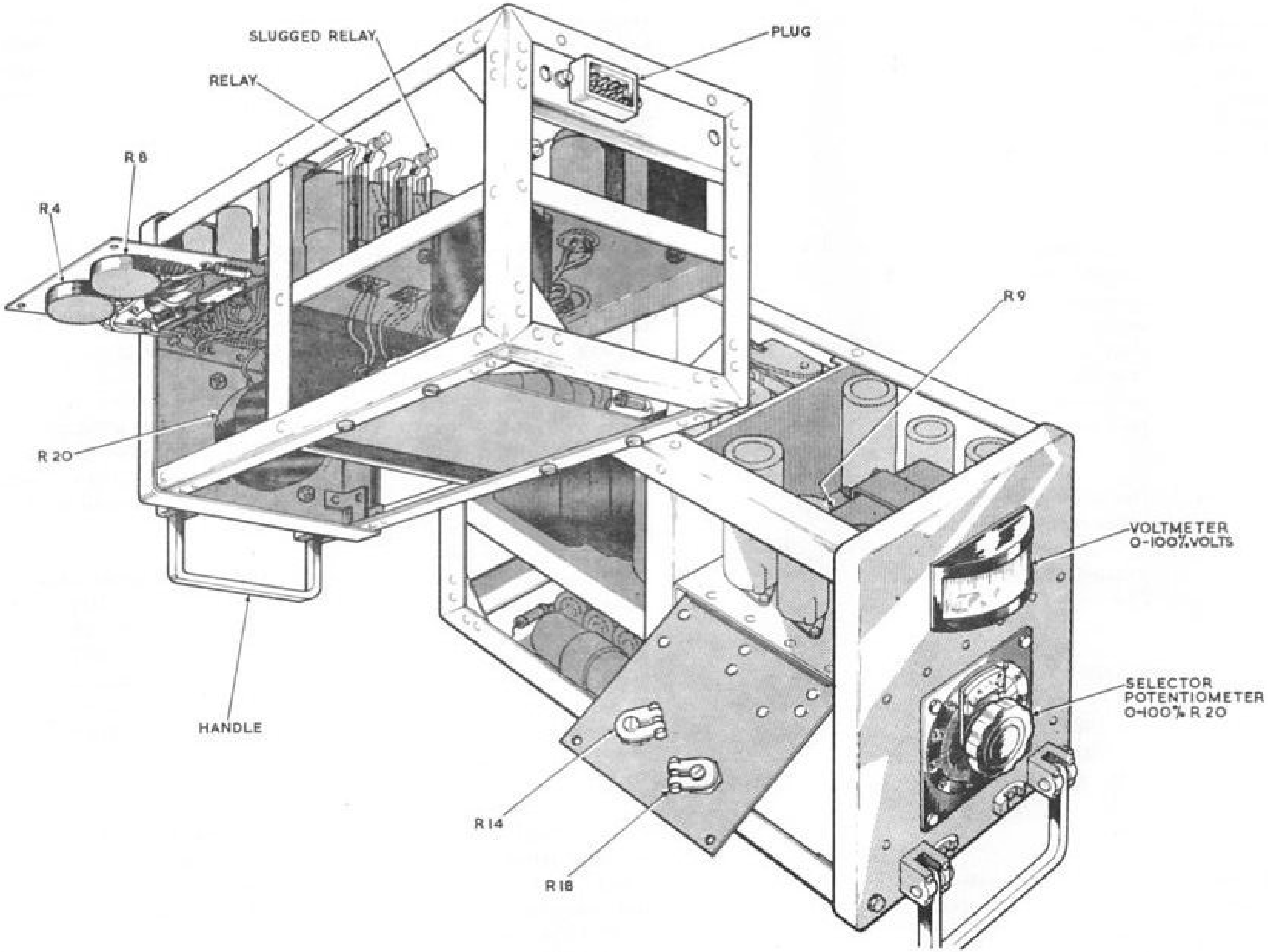


Fig. 12 Stabilized voltage power unit

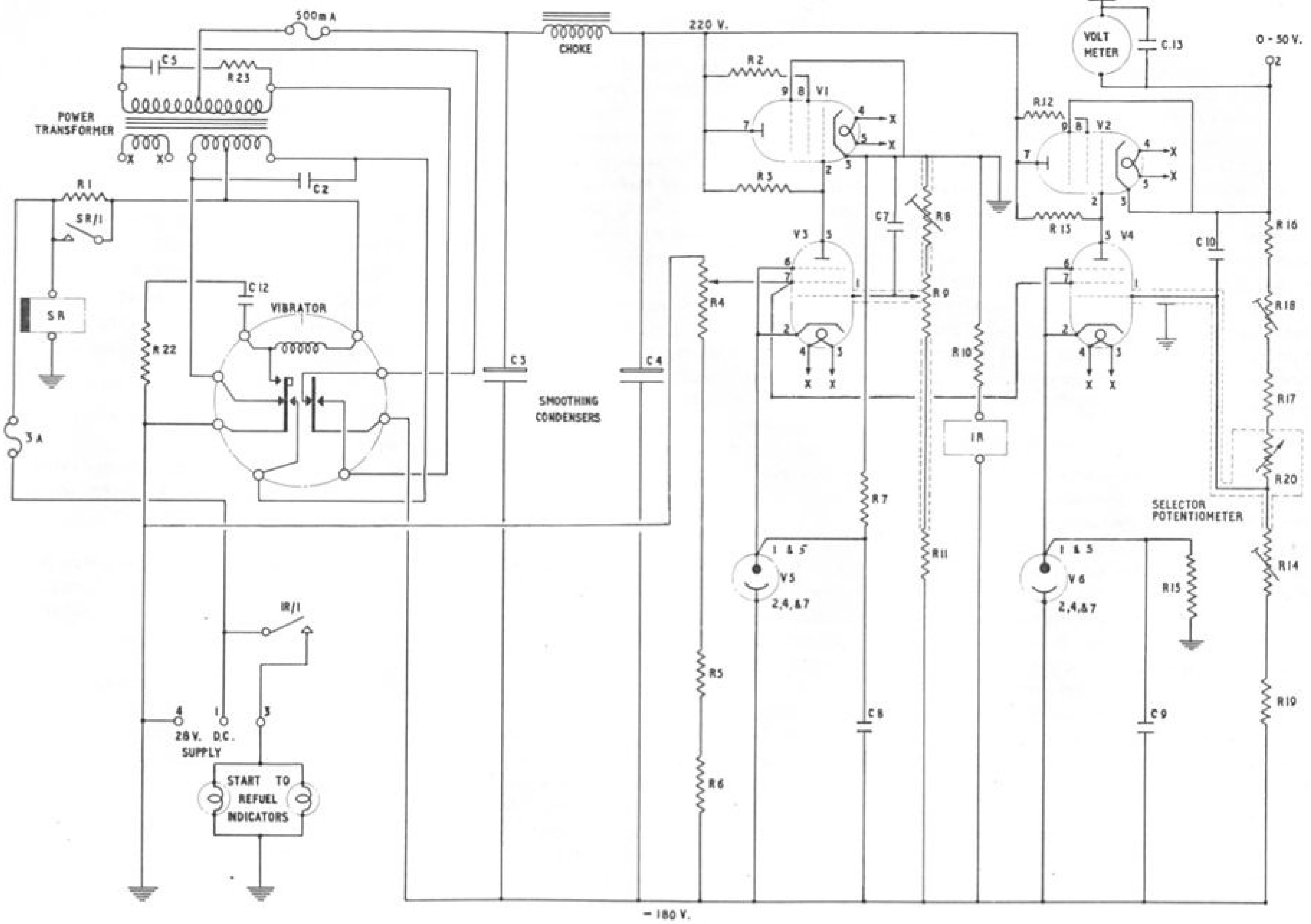


Fig. 1 3 Stabilized voltage power unit circuit of the state of the balance of fuel in the pitch axis.

83. 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 line passing through the desired C.G. The sum of these fractional currents is then proportional to the total moment of the weight of the tank system about the datum line. When this 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. This signal is representative of the magnitude and direction of the tank system C.G. displacement.

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

85. 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 fuel C.G. of the mass of fuel in the corresponding tanks.

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

87. Owing to the proportion of 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

88. If a C.G. indication is required during normal flight a push-button labelled C.G. CHECK is provided adjacent to the C.G. indicator. Operation of the push-button energizes relay 134, which in turn energizes the relays in both computer boxes, thus transferring the amplifier outputs via the computer 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. During flight refuelling when the flight refuelling master switch is on, the C.G. indicator registers automatically and the supplies to the contents gauges are cut off. Should the C.G. push-button then be pressed however, the supplies will be transferred from the indicator to the fuel contents gauges.

Panels 45P and 46P

89. The necessary control and change-over relays for the refuelling valves and transfer circuits are housed in suitable panels (45P port and 46P starboard) which are fitted in the main wheel bays adjacent to the ground refuelling panels as shown in fig.8.

Circuit operation

90. The circuit operation outlined in the following paragraphs should be read in conjunction with the theoretical circuit diagram fig.11. Note that the circuit operation given is for the No.2 (port) tank group, operation of the other groups being similar.

Switching on

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

(1) Relay 138 is energized allowing the amplifier output from each tank to be connected to the C.G. indicator via the computer boxes.

(2) Relay 139 is energized and a supply from fuse 1165 is fed to the port and starboard C.G. control switch via contacts 139/2.

(3) A supply is connected to the fuel transfer isolation relays (415 and 419) to isolate the fuel transfer pumps.

(4) The nitrogen purge circuit is isolated by the opening of the normally closed relay contacts 139/1 as relay 139 is energized.

(5) A supply is connected to the air release valves, via the associated control switches, thus depressurizing the fuel tanks.

(6) Relays 706 and 707 are energized to provide 28-volt d.c. supplies to the port and starboard flight refuelling panels (45P and 46P).

C.G. indication

92. When the refuelling master switch is placed to the ON position, a supply from fuse 1165 will be fed via relay contacts 138/1 and 134/4 to the coils of the relays in the port and starboard computer boxes. The seven relays in each box 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 1164 will be fed via contacts 138/3 and 134/2 to the C.G. indicator and resistance networks. The indicator will now register the fore and aft C.G. of the fuel system. (Note that should the C.G. button be pressed, relay 134 will be energized to isolate the C.G. indicator and restore the fuel contents indication).

Refuelling valve operation

93. With the flight refuelling master switch in the ON position, a supply from fuse 570 is fed to the port flight refuelling panel 45P via the flight refuelling master switch and closed relay contacts 707/3 and 4. Within 45P the supply is directed via the normally closed contacts of relays 404 and 396 to energize the coils of the other seven relays (397, 398, 399, 400, 401, 402 and 403). The energizing of these relays will disconnect the fuel level switches and refuelling valves from the ground refuelling controls and, at the same time, provide a direct supply to open the valves via the fuel level switches. As each refuelling valve is energized to open, the appropriate lamp in the flight refuelling indicator will light.

94. Flight refuelling may begin when the four magnetic indicators are energized white and all the lamps in the indicator are lit, and also proper contact has been made with the tanker aircraft (A.P.4611). 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 that the tank is full.

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

Switching off

96. Placing the flight refuelling 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 be connected to the amplifiers, the fuel transfer pumps will operate, the fuel tanks will be re-pressurized and the d.c. supply will be available for the nitrogen purging system.

Nitrogen purging

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

(1) Moving the nitrogen purge switch to ON will energize relays 416 and 356.

(2) The contacts of relay 356 will operate to energize 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 416/7 will energize both coils of the No.2 tanks refuelling valves so that the valves will open and allow the purged fuel to enter the tanks, and at the same time the lamps for the No.2 tanks on the flight refuelling indicator, will light.

(4) Note that the opening of relay contacts 416/2, 416/4, 416/6 and 416/8 will have isolated the circuit to the fuel level switches.

98. 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.

◀ *NOTE . . .*
System inoperative Post Mod.2417. ▶

C.G. balance during flight refuelling

99. When the aircraft is being flight refuelled, all fuel tanks are filled simultaneously. It is necessary, therefore, to have 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.

100. With the master switch in the ON position and relays 138 and 139 energized a supply is fed from fuse 1165 to the centre terminal of the C.G. control switch on the

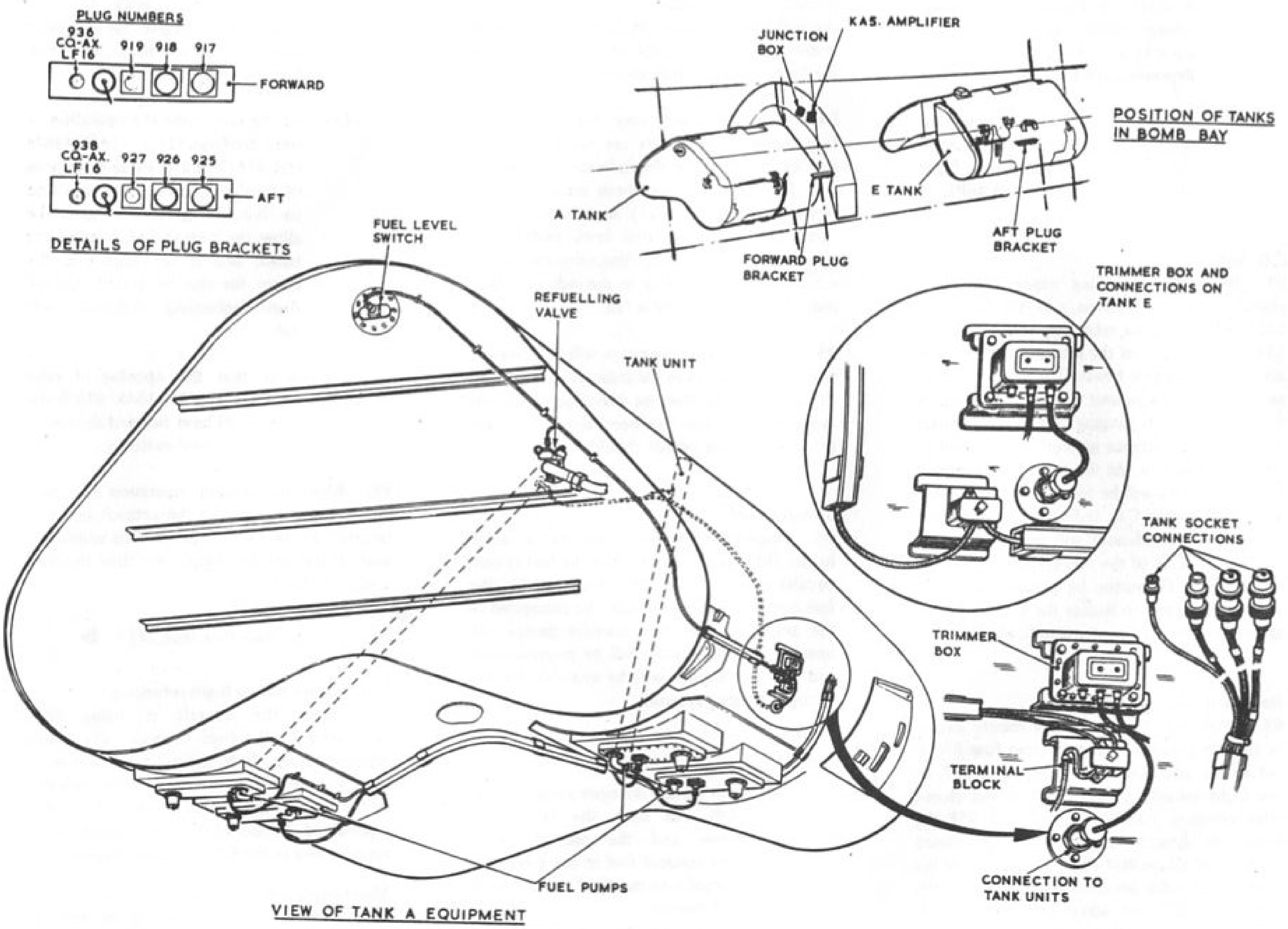


Fig. 14 Bomb bay saddle tanks

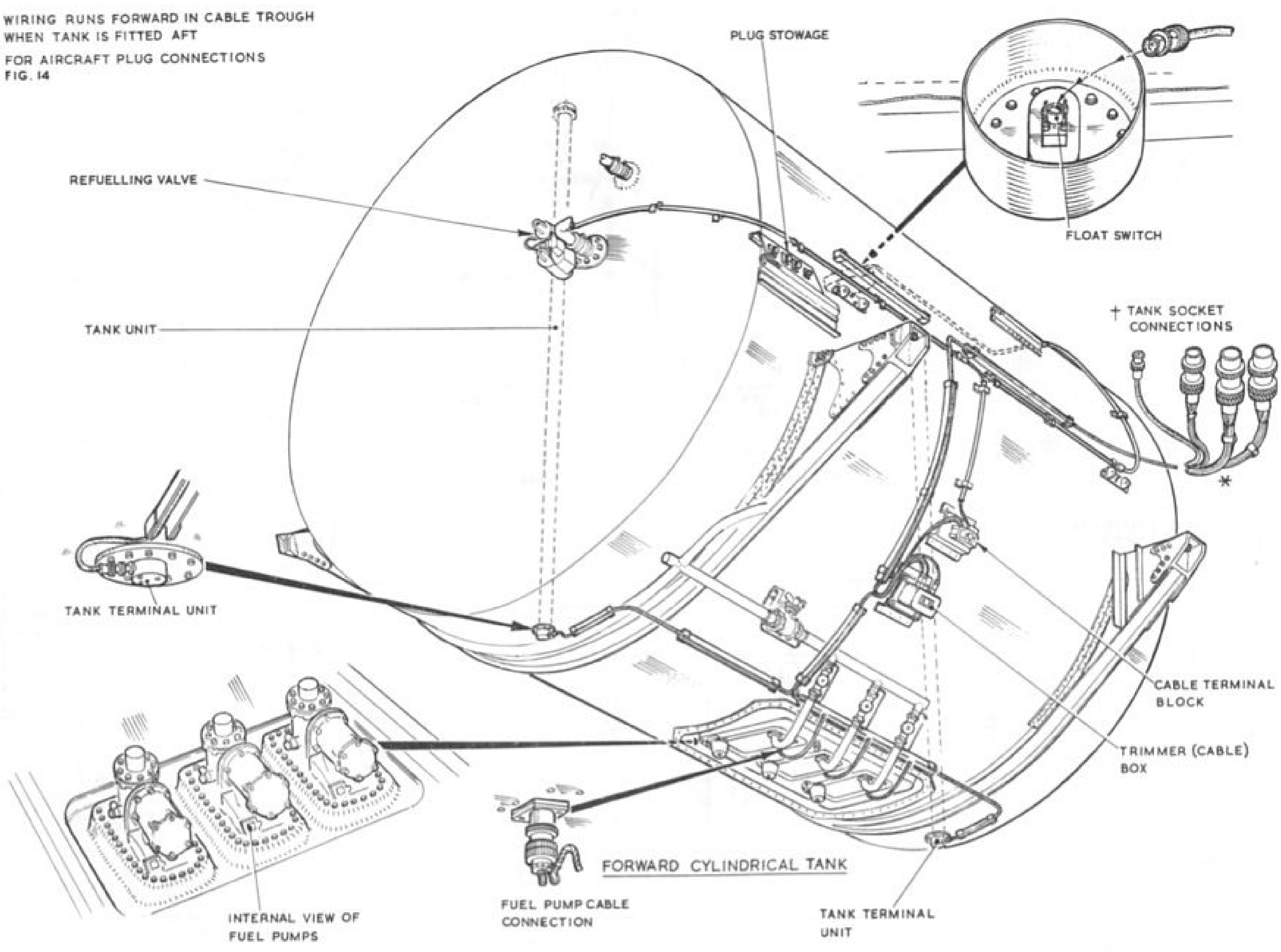


Fig. 15 Bomb bay cylindrical tank.

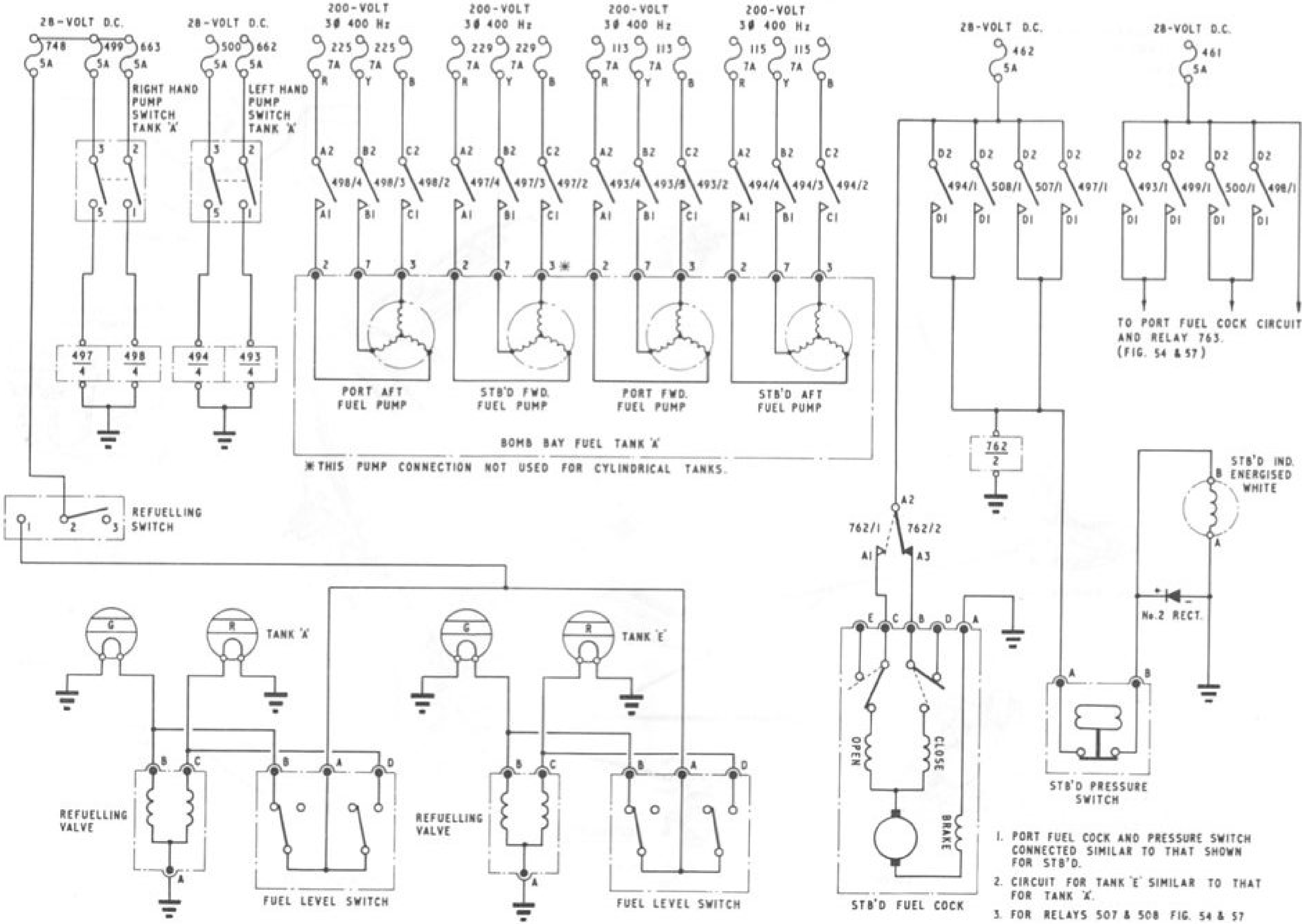


Fig. 16 Bomb bay tanks control circuit.

◂ *Re-drawn* ▸

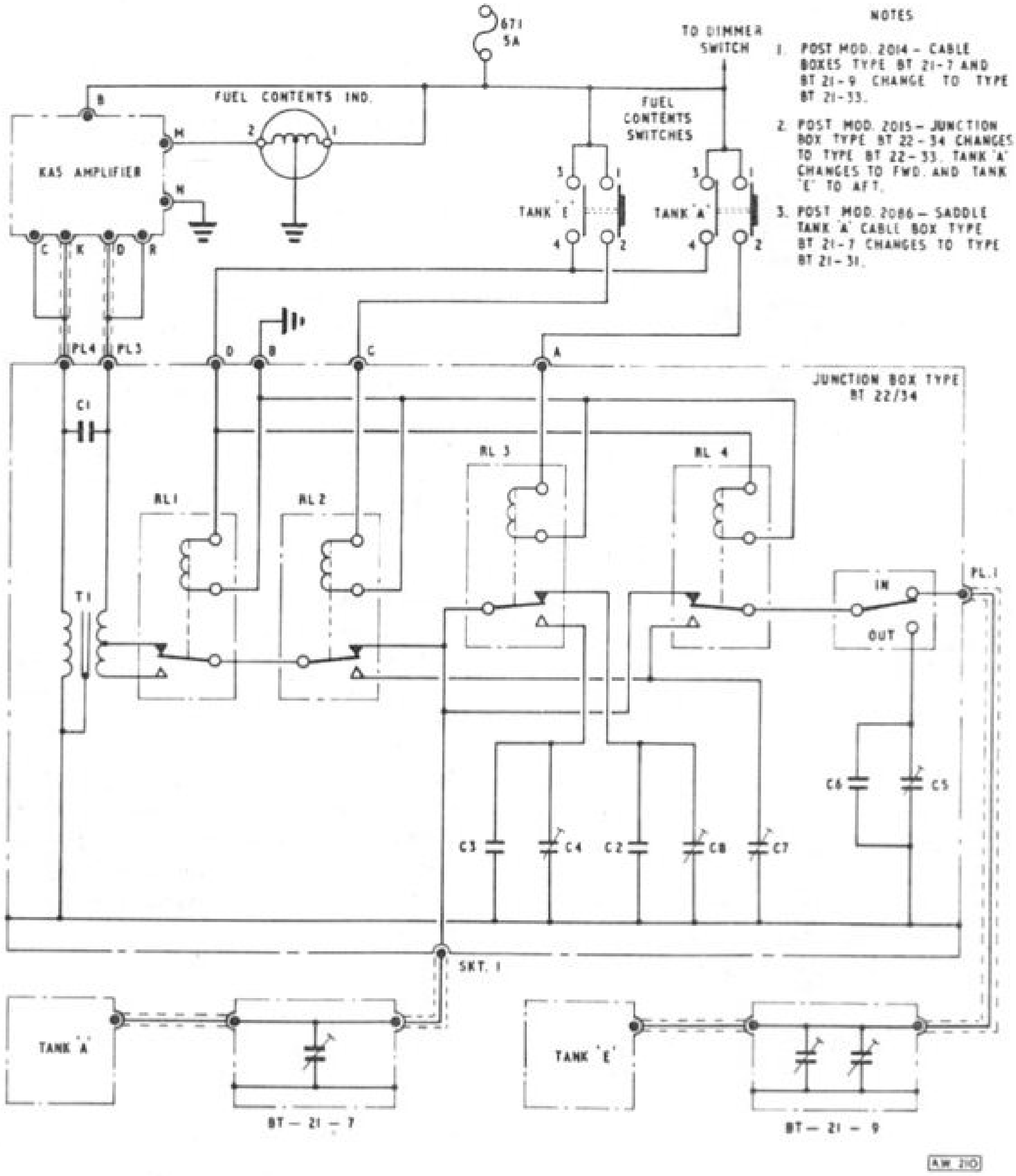


Fig. 17 Bomb bay fuel contents circuit

centre console. The C.G. control switch is spring-loaded to the centre OFF position but may be selected to either of two positions; PORT and STARBOARD. Holding the switch to the STARBOARD position will energize relay 404 (45P) so opening both contacts of the relay and breaking the supply to relays 402 and 403. This action will de-energize the refuelling valves of tanks 6 and 7 on the port side of the aircraft thus stopping entry of fuel into the tanks. Meanwhile refuelling will continue on all other tanks.

101. A similar sequence of operations will take place when the switch is selected to PORT. In this case refuelling will stop 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.

102. The two C.G. transfer switches mounted on the centre console are used for controlling the fore and aft C.G. during flight refuelling. These switches normally control the fuel transfer pumps but take on a different role when the flight refuelling master switch is moved to ON.

103. Moving the master switch to ON will energize relays 415 and 419 to isolate the transfer pumps. If both port and starboard transfer switches are now selected to FWD, refuelling will be stopped on tanks 6 and 7 in both the port and starboard systems. Moving the switches to aft will cut out the fuselage tanks on both sides of the aircraft. In both cases refuelling will continue on the other tanks.

104. When the port transfer switch is selected

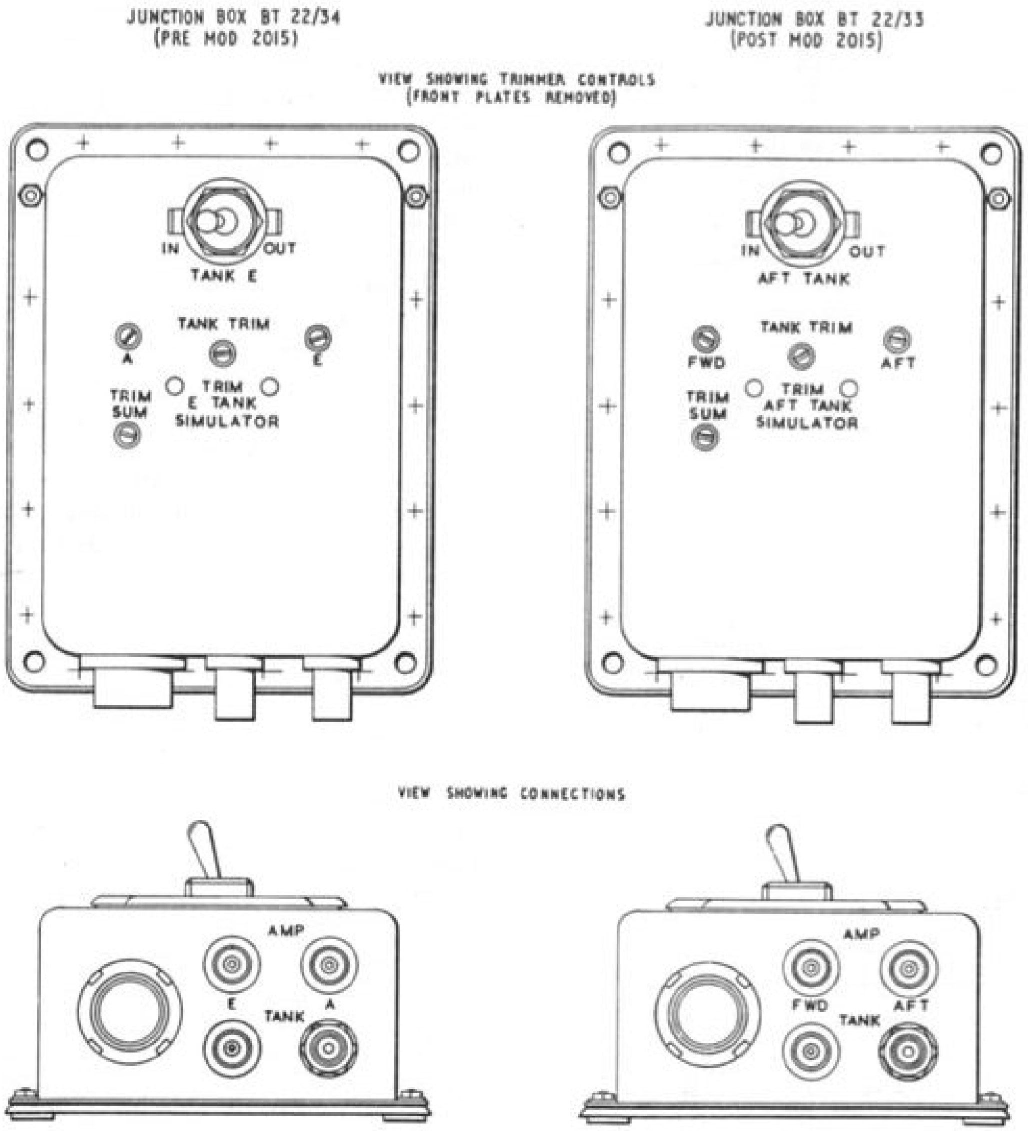


Fig. 18 Bomb bay junction boxes

to FWD., relay 404 in the flight refuelling panel 45P will be energized. Energizing this relay will break the supply to relays 402 and 403, and this in turn will de-energize the refuelling valves of tanks 6 and 7 in the port wing. Selecting the switch to AFT will energize relay 396 in panel 45P and this in turn will de-energize relays 397 and 398 so closing the valves of the port fuselage tanks, 1 and 2.

105. By these means the fore and aft C.G. of the aircraft may be controlled throughout the whole refuelling period. An indication that the C.G. balance circuits are operating correctly is provided by the lamps on the flight refuelling indicator. When a refuelling valve is de-energized the appropriate lamp in the indicator will go out.

Probe pressure gauge

106. A fuel pressure gauge, Type S149/1/55, is fitted on the starboard console to provide the pilot with probe fuel pressure information during the flight refuelling operation. The indicator is operated by a Type S-22 transmitter which is fitted in the flight refuelling pipe line at bulkhead 470. The gauge is electrically operated and is provided with a 28-volt d.c. supply from fuse 1163 in panel 4P. A routing chart of the circuit is provided in fig.52.

FUEL TANKS PRESSURIZATION

107. During normal flight the fuel tanks are pressurized by air from a fuel tank pressurization system which is described in Sect.4, Chap.6. Pressurization of the tanks is controlled by two air release solenoids which are mounted one on each tank pressurization

control panel in the main wheel bays. When the solenoids are energized the pressure is cut off and the tanks vented to atmosphere. This is done automatically during flight refuelling as described in para.91 Indication that all tanks have been de-pressurized is provided by four magnetic indicators mounted on the starboard console panel. Each indicator is energized by the operation of a pressure switch fitted to the vent line of each tank group. When the pressure in any of the vent lines drops to 1.2 p.s.i. the pressure switches close to connect a 28-volt d.c. supply via fuses 762, 763, 765 and 766 to magnetic indicators and thereby energize the respective indicators white.

108. Manual control is provided by the air release valves control switch on the flight refuelling panel. With the switch in the OFF position a 28-volt d.c. supply is fed from fuse 565 to energize the valves, via terminals 1-2 of the switch. Moving the switch to ON breaks the supply thus allowing the valves to close and pressure to build up in the tanks. In this position the valves are also connected to the flight refuelling circuits so that if these circuits are switched on then the valves will again be energized.

BOMB BAY FUEL SYSTEM

General

109. When special stores are being carried, it may be necessary to increase the capacity of the fuel system for longer range. This is achieved by the installation of removable tanks in the bomb bay to form a bomb bay fuel system. One or two tanks may be fitted depending on the role of the aircraft and the number of stores carried. Two types of fuel tanks are available, saddle tanks and cylindrical tanks. Five alternative configurations may be used as follows:-

(1) Two cylindrical tanks.

(2) One cylindrical tank (fwd.).

(3) One saddle tank (fwd.), one cylindrical tank (aft).

(4) One saddle tank (fwd.).

(5) Two saddle tanks forward and aft.

Saddle tanks are designated A and E for front and rear positions respectively in the bomb bay, and are not interchangeable. Cylindrical tanks are designated FWD. and AFT, and may be interchanged by securing the connecting cables towards the rear of the tank in the forward position, and towards the front of the tank in the rear position (fig.14 and 15). Information on tank installation is given in Sect.4, Chap.2.

110. The installation of the bomb bay tanks is effected by the following modifications:-

Mod.526 - Installation of fixed fittings for bomb bay saddle tanks.

Mod.527 - Installation of forward saddle tank A.

Mod.528 - Installation of aft saddle tank E.

Mod.1509 - Installation of fuel contents gauge for bomb bay saddle tanks.

Mod.2013 - Part A, installation of fixed fittings for bomb bay cylindrical tanks on aircraft with Mod.526 embodied.
Part B additional to Part A on aircraft without Mod.526. Installation of pressurization and fire extinguisher systems for bomb bay tanks.

Mod.2014 - Installation of one cylindrical tank forward or aft. Two Mod. sets are required to fit two cylindrical tanks.

Mod.2015 - Change of bomb bay fuel contents gauge, Type A060, to Type A076, and J.B., Type BT22-8 to Type BT22-30 for cylindrical tanks.

Mod.2086 - Change of tank trimmer box, Type BT21-7 to Type BT21-31 on saddle tank A when used with a cylindrical tank.

Mod.2281 - Provision for fitting of saddle tanks to free fall aircraft.

Mod.2283 - To introduce KA5 bridge amplifiers in lieu of F.C.A. amplifiers and to fit a junction box, Type BT22-34, in lieu of junction box, Type BT22-8, for aircraft Pre Mod.2015 and a junction box, Type BT22-23, in lieu of junction box BT22-30 for aircraft Post Mod.2015.

Mod.2302 - To make bomb bay tank fuel pressurization system inoperative.

◀ Mod.2373 - Part A, to introduce bomb bay tank gauge, Type A078 Ref.No. 6A/6208550, in lieu of Type A060.
Part B, to introduce bomb bay tank gauge, Type A079 Ref.No. 6208551, in lieu of Type A076. ▶

111. The bomb bay fuel supply is normally used before that of the main fuel system. Whichever arrangement is fitted, fuel from the bomb bay tanks is fed into the main fuel system pipelines through a centre cross feed pipe in the bomb bay. Fuel flow is controlled by two electrically-operated cocks, which are energized at the same time as the fuel pumps in the tanks are switched on. Indication of fuel contents is given on a gauge located behind the 1st pilot's seat (fig.4).

Tank components

112. The components integral with both saddle and cylindrical tanks, consisting of fuel pumps, fuel contents tank units, fuel level switch and refuelling valve, are listed in Table 9. Note that the saddle tanks each contain four fuel pumps (two port and two starboard) while cylindrical tanks each contain three fuel pumps (forward centre and aft). The tanks are connected to the aircraft wiring via plug connections on two brackets located on the port side of the bomb bay (fig.14 and 15).

Control switches and indicators

113. The control switches for the bomb bay fuel system are located next to the main fuel system control panel at the aft end of the centre console (fig.3). These are as follows:-

Bomb bay selector switches (2), each labelled MAIN – BOMB BAY.

Fuel pump switches (4), two forward labelled A, two aft labelled E. With Mod.2013 embodied, the labels are changed to FWD. and AFT respectively.

Pressurization switch, labelled PRESN-OFF. (Inoperative Post Mod.2302).

Fuel pressure indicators (2), Ref. No. 5CZ/5073.

Bomb bay fuel cocks

114. Two fuel cocks, operated by electrical actuators, are fitted one in the port and one in the starboard delivery pipes at the forward end of the bomb bay. The actuators are energized to open the fuel cocks when any one of the four fuel pump switches is selected to ON. Fuel will then flow from the tanks into the main system pipelines for delivery to the

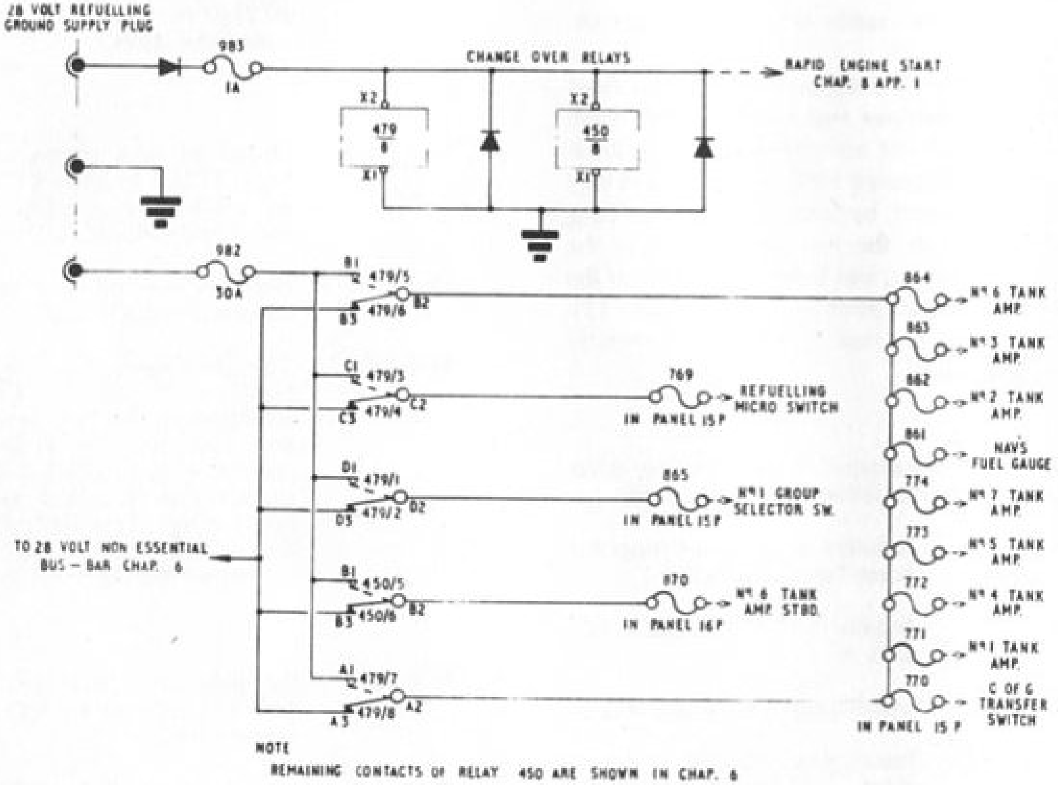


Fig.19 Ground refuelling supply controls

engines. The circuit for the starboard fuel cock is shown in fig.16.

Fuel pressure indication

115. Indication of the pressure of fuel being supplied from the bomb bay tanks is given by two magnetic indicators on the centre console (para.113).

116. The indicators are operated by two pressure switches fitted alongside the fuel cocks in the port and starboard delivery pipes. The pressure switches, Type 1001/3PG/10 are set to close at 10 p.s.i.g. on a falling pressure, when the indicators, normally black, will be energized to show white. The circuit is fed from fuse 461 (port) and fuse 462 (stbd) when any one of the four fuel pump switches is selected to ON (fig.16).

Fuel delivery

117. The fuel in the bomb bay tanks is used before that of the main fuel system, during which time the main fuel pumps are switched to slow running speed. This is achieved by selecting BOMB BAY on the two bomb bay selector switches and AUTO on the four auto-manual switches. This will override the action of the sequence timers by continuously energizing the speed change relays (fig.6) and allowing the main fuel pumps to run on the slow speed windings.

NOTE . . .

Pending the installation of bomb bay tanks, the speed change relays are disconnected from the bomb bay tanks circuit and cable links are connected to the associated terminal blocks in 26P (fig.25 and 26). When the tanks are installed, the relays should be reconnected and the links removed.

Ground refuelling

118. The bomb bay tanks are refuelled from the refuelling point in the port main wheel bay, the operation being controlled from a refuelling panel on the underside of 36P (fig.8).

119. The panel carries a single-pole refuelling master switch and four indicator lamps, two green for low level and two red for high level. Note that the bomb bay tanks cannot be flight refuelled.

Circuit operation

120. Reference to fig.16 will show that with the tanks empty and the master switch on, a supply will be fed from fuse 748 via the closed contacts of the fuel level switches to energize both sides of the refuelling valves, thus fully opening the valves. At the same time the four indicator lamps will be lit.

121. As each tank is being filled, the low level contact of the fuel level switch will open to de-energize one side of the tank refuelling valve to partially close the valve. Also the green indicator lamp will go out. Fuel will now enter the tank at a much reduced rate, the level rising slowly until the high level contact of the fuel level switch opens. This action will de-energize the other side of the refuelling valve to shut off the fuel supply to the tank when the red lamp will go out.

Fuel pumps and cocks operation

Saddle tanks

122. In the case of tank A (fig.16), when the two associated fuel pump switches are selected to ON, relays 493, 494, 497 and 498 will be energized. The respective contacts of these relays will then close to connect a 200-volt, 3-phase a.c. supply to the four fuel pumps in the tank. At the same time, the port and starboard fuel cocks will be opened as follows:-

(1) Parallel contacts 494/1 and 497/1 will close to energize relay 762 from fuse 462, and also connect a supply to the starboard pressure switch.

(2) Contacts 762/2 will open and 762/1 will close to open the starboard fuel cock.

(3) Parallel contacts 493/1 and 498/1 will close to energize relay 763 from fuse 461, and also connect a supply to the port pressure switch.

(4) Contacts 763/2 will open and 763/1 will close to open the port fuel cock.

Should the fuel pressure fall to 10 p.s.i.g. (para.115), the pressure switches will close to energize the two indicators white.

123. The circuit operation for tank E is initiated by selecting the two tank E fuel pump switches to ON, the circuit action being similar to that described for tank A.

Cylindrical tanks

124. With cylindrical tanks fitted, the circuit operation is similar to that for tanks A and E except that since each cylindrical tank has only three fuel pumps, the pump connections fed from 3-phase fuses 229 and 195 via the respective contacts of relays 497 and 507 are not used. Thus the right-hand fuel pump switch for each tank will control the centre and rear pumps.

NOTE . . .
When cylindrical tanks are fitted, 3-phase fuses 229 and 195 should be replaced by dummy fuses as instructed in fig.56.

Bomb bay tanks fuel contents

125. A Smith Waymouth Type 7 fuel contents gauging system similar to that for the main tanks is installed for the bomb bay tanks. Units fitted inside the tanks are connected via cable boxes (trimmers) to a junction box whose output is a function of the sum or individual di-electric capacity of the tanks. A KA5 bridge amplifier provides the necessary signal amplification to operate a fuel contents gauge located behind the 1st pilot's seat. The junction box and amplifier are mounted together in the forward port side of the bomb bay.

Fuel contents panel

126. The fuel contents gauge is mounted on a panel attached to the 1st. pilot's seat rail (fig.4). The gauge has two scales, an inner and outer, calibrated in lbs fuel x 1000. Prior to Mod.2015 and post Mod 2283 and 2373 the gauge, Type A078, is graduated 0-12 inner scale and 0-6 outer scale. Post Mod 2015, 2283 and 2373 the gauge, Type A079, is graduated 0 to 16 on the inner scale and 0 to 8 on the outer scale.

127. The fuel contents sum of the tanks automatically registers on the inner scale. Individual tank contents is selected for outer scale reading by two push-switches, Dowty Type C5162Y, Mk.16, fitted below the gauge. Prior to Mod.2013, the push-switches are labelled A and E; post Mod.2013 the labels are changed to FWD. and AFT respectively. Illumination for the gauge dial is provided by a 2-pillar lamp bridge, Ref.No. 5CX/5352, controlled by a dimmer switch, Ref.No. 5CW/725. The panel is illustrated in fig.4.

Junction box

128. The junction box, Type BT22-34 (Pre.Mod.2015) or Type BT22-33 (Post Mod.2015), is used to connect the di-electric capacities of the tanks to the amplifier. Four relays within the box are energized to give fuel contents readings for individual tanks when the associated push-switches are pressed. Capacitor trimmer controls, located under a removable front plate, are provided for setting up the system prior to the tanks being installed. Details and the internal circuit for each type of box are shown in fig.17 and 18 respectively.

129. A switch, labelled IN-OUT on the front of the box, enables selection to be made for one (forward) or two-tank installations. With the switch selected to OUT, the E or aft tank is switched out of circuit and replaced by two capacitors within the box to simulate conditions of zero fuel for that tank position. For this configuration, the gauge will show fuel contents of the forward tank only on the inner scale. This reading will be switched to the outer scale with the A or FWD. push-switch pressed, but zero contents will be shown with the E or AFT push-switch pressed. With the switch selected to IN, the E or aft tank is reconnected to complete the circuit for two-tank indication.

Fuel contents operation (saddle tanks)

Sum contents

130. Reference to fig.17 will show that with the four relays de-energized, the output of both tanks are connected in parallel via the IN-OUT switch and the normally closed contacts of relays RL1, RL2 and RL4 to the centre tap of transformer T1. Capacitor C2 and trimming capacitor C8 are connected across the output of the tank unit via the normally closed contacts of RL3. The output from transformer T1 is connected via plugs PL3 and PL4 to the bridge network of the amplifier circuit. Thus the sum contents of the tanks will be shown on the inner scale of the fuel contents gauge, the circuit being energized from fuse 671.

Individual tank contents

131. Fuel contents reading for individual tanks is obtained by pressing the appropriate push-switch on the fuel contents panel as follows:-

Tank A

When tank A push-switch is pressed, relays 1, 3 and 4 will be energized by a supply from fuse 671 via push-switch contacts 1-2 and 3-4. The following circuit action will take place:-

(1) Relay RL1 contacts will change over to connect tank A output across the full winding of the transformer T1.

(2) Relay RL3 contacts will change over to connect capacitor C3 and trimming capacitor C4 in parallel with tank A output.

(3) Relay RL4 contacts will change over to isolate tank E output.

Under these conditions the contents of tank A only will be shown on the outer scale of the fuel contents gauge.

Tank E
When tank E push-switch is pressed relays RL1, RL2 and RL4 will be energized by a supply from fuse 671 via push-switch contacts 1-2 and 3-4. The following circuit action will take place:-

(1) Relay RL1 contacts will change over to connect tank E output across the full winding of transformer T1.

(2) Relay RL2 contacts will change over to isolate the output from tank A.

(3) Relay RL4 contacts will change over to connect trimming capacitor C7 in parallel with tank E output.

Under these circuit conditions the contents of tank E only will be shown on the outer scale of the fuel contents gauge.

Fuel contents operation (cylindrical tanks)
132. The fuel contents operation for saddle tanks can be applied to cylindrical tanks reference being made to fig.17. Where one saddle tank and one cylindrical tank are fitted fig.17 is also applicable noting the change of trimmer box on the saddle tank (Mod.2086).

SERVICING

General
133. As the electrical and mechanical controls of the fuel systems are closely allied, it is essential that full co-operation be maintained between the electrical and mechanical trades when servicing the system. This co-operation will prevent the needless repetition of test procedures.

134. Each fuel system is treated separately in the text that follows. These are:-

(1) Fuel pumps

(2) Contents gauging

(3) Ground refuelling

(4) Flight refuelling

(5) Bomb bay

The tests for some systems are almost entirely mechanical in operation, although the assistance of an electrical tradesman is frequently required. Tests of this nature will be found in Sect.4, Chap.2.

FUEL PUMPS SYSTEM

135. The tests recommended for the booster pumps, transfer pumps and secondary pumps are almost wholly mechanical and details will be found in Sect.4, Chap.2. Pressure checks are made on the booster pumps; rate of flow checks on the transfer pumps, and direction of flow checks on the secondary pumps. During the tests a sequence timer test box, Ref. 26DC/95250 is used and should be connected and controlled by the electrical tradesman. It will also be necessary at times to remove the fuses in the 3-phase supply to the sequence timer. Further details will be found in the test instructions detailed in Sect.4, Chap.2. Servicing details for the individual pumps will be found in A.P.4343D, Vol.1, Book 2.

136. A description of the sequence timer test box will be found in A.P.120N-0145-1. With this test box it will be possible to check the sequence timer for correct operation of the cam switches during normal functioning of the aircraft's fuel systems. The recommended test procedures together with open-contact period times for sequence timers, Type D10705, are also covered in A.P.120N-0145-1. Servicing instructions for the sequence timers are in A.P.4343D, Vol.1, Book 4, Sect.21.

CONTENTS GAUGING SYSTEM

137. Apart from a routine check on the cleanliness and security of all the wiring and electrical components, little in the way of normal servicing is required. The co-axial cables should be checked for ingress of moisture, abrasion of the outer insulation and general security. Panel covers should not be removed for longer than is necessary and refitted and secured after inspection of components.

Functioning check
138. 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.

Empty trimming check

139. At the periods laid down in A.P.101B-1902-4 carry out the following procedures.

140. Drain the aircraft fuel tanks to unusable fuel level. If bomb bay tanks are fitted these must be drained first.

141. Connect to the aircraft a d.c. ground supply capable of being set to supply 28 ± 1-volt. Switch the power supply on at least 15 minutes before beginning the check to allow the amplifier to stabilize.

Wing and fuselage tanks

142. With the tanks drained to unusable fuel, but with fuel still in the refuelling galleries, press each individual tank selection push-switch in turn. Check that the gauges read zero (Table 1). If any selected tank reading is not zero, but does not exceed 4% of full scale deflection (F.S.D.), adjust the trimmer on the appropriate KC type cable box (Table 4) to achieve zero.

CAUTION . . .
On no account must the E trimmer on the bridge amplifier be used for EMPTY trimming.

143. If any reading is in excess of this tolerance a possible fault condition is indicated. Refer to Fault Location, (para.144).

NOTE . . .
The calibration is based on a kerosene fuel having a permitivity of 2.10 and a specific gravity of 0.779 at a temperature of 20 deg.C.

Fault location checks

144. Fault location checks are carried out by substitution, using the test set QC 345 to simulate the tank systems (A.P.112G-0753-1). Checks on individual units of the system, removed from the aircraft, are detailed in the relevant chapter of A.P.112G-0725-1 and A.P.112G-0762-1.

Indicator circuit check

145. For the purpose of determining whether the fault in a particular tank system is on the tank side or the indicator side, the first part of the fault location check is carried out using the test set to substitute the tank circuit, at the input to the appropriate KC cable box.

146. Disconnect the capacitor input cable to the KC cable box and connect test cable CGA 347 between the test set PL1 and the input socket on the cable box. Connect test cable CGA 260 between the test set EARTH and a convenient earth point on the aircraft.

147. With a d.c. ground supply of 28 ± 1-volt connected to the aircraft. Switch on and allow a fifteen minute period for the amplifier to stabilize.

148. Using test set controls CV1, S1 and S2 set the input capacitance given in Table 4, Col.3 for unusable fuel.

TABLE 1

Push-switch selections

Tank selector push-switch	Outer scale of pilots' gauge
1S, 4S, 5S, 7S	A069 (Starboard outer engine)
2S, 3S, 6S	A070 (Starboard inner engine)
1P, 4P, 5P, 7P	A069 (Port outer engine)
2P, 3P, 6P	A070 (Port inner engine)

TABLE 2

Tank unit capacitance values

Tank Unit	Initial Capacitance (wet) (pF)	Range (fully immersed) (pF)	Tank
TC274	244 ± 3	251 ± 3	2 Port and Starboard
TC275	282 ± 3	273 ± 3	1 Port and Starboard
TC276	256 ± 3	249 ± 3	1 Port and Starboard
TC277	278 ± 3	271 ± 3	1 Port and Starboard
TC278	254 ± 3	247 ± 3	1 Port and Starboard
TC279	268 ± 3	274 ± 3	2 Port and Starboard
TC280	260 ± 3	266 ± 3	2 Port and Starboard
TM2	400 ± 3	401 ± 3	3 Port and Starboard
TM3	293 ± 3	291 ± 3	3 Port and Starboard
TM4	580 ± 3	593 ± 3	4 Port and Starboard
TM5	408 ± 3	418 ± 3	4 Port and Starboard
TM6	491 ± 3	499 ± 3	5 Port and Starboard
TM7	332 ± 3	331 ± 3	5 Port and Starboard
TM8	491 ± 3	505 ± 3	6 Port and Starboard
TM9	324 ± 3	329 ± 3	6 Port and Starboard
TM10	297 ± 3	298 ± 3	7 Port and Starboard
TM11	195 ± 3	194 ± 3	7 Port and Starboard
TM12	278 ± 3	280 ± 3	7 Port and Starboard
TM13	191 ± 3	193 ± 3	7 Port and Starboard

NOTE . . .
The test cable CGA 347 capacitance (marked on cable) must be subtracted from the figures given in Table 4, Col. 3 and the resultant capacitance set on the test set. Check that the appropriate fuel gauge reads zero when the appropriate selector switch is operated.

149. Adjust the test set capacitance to the FULL capacitance value given in Table 4, Col. 4, making allowance for the capacitance of the test cable, and check that the appropriate fuel gauge reads FULL ± 2% of F.S.D.

150. If the fuel gauge shows a fault with the tank circuit substituted with the test set, replace each unit in the indicating circuit, i.e. amplifier, cable box and indicator in turn until the faulty unit is detected. Should this procedure fail to locate the fault, check all wiring from the cable box to the fuel gauge according to the relevant routing chart.

151. If the fuel gauge reads correct, with the tank circuit substituted, then the fault lies in the tank circuit.

Tank circuit check

152. If the fault lies in the tank circuit, re-connect the aircraft cable to the KC cable box and disconnect the aircraft cable from the appropriate tank terminal JM3 (fig.20). Check the aircraft cable by connecting test cable CGA 345 between the test set SK1 and the now free end of the aircraft cable.

153. Using the test set controls CV1, S1 and S2, apply an input capacitance for the appropriate tank circuit, to the capacitance figure given in Table 4 for unusable fuel, less the capacitance of the particular aircraft cable (Table 3).

NOTE . . .
The capacitance of test cable CGA 345 must be subtracted from the total of the above figures.

154. Check that the aircraft fuel gauge reads zero when the appropriate selector switch is operated.

155. If the fuel gauge reads incorrectly then the fault lies in the aircraft cable between the tank terminal box JM3 and the appropriate KC cable box. If the fuel gauge reads correct then the fault is in the tank terminal or the tank units and checks on the individual units should be carried out.

Individual unit checks

Tank units

156. An insulation resistance of at least 20 megohms using an insulation resistance tester,

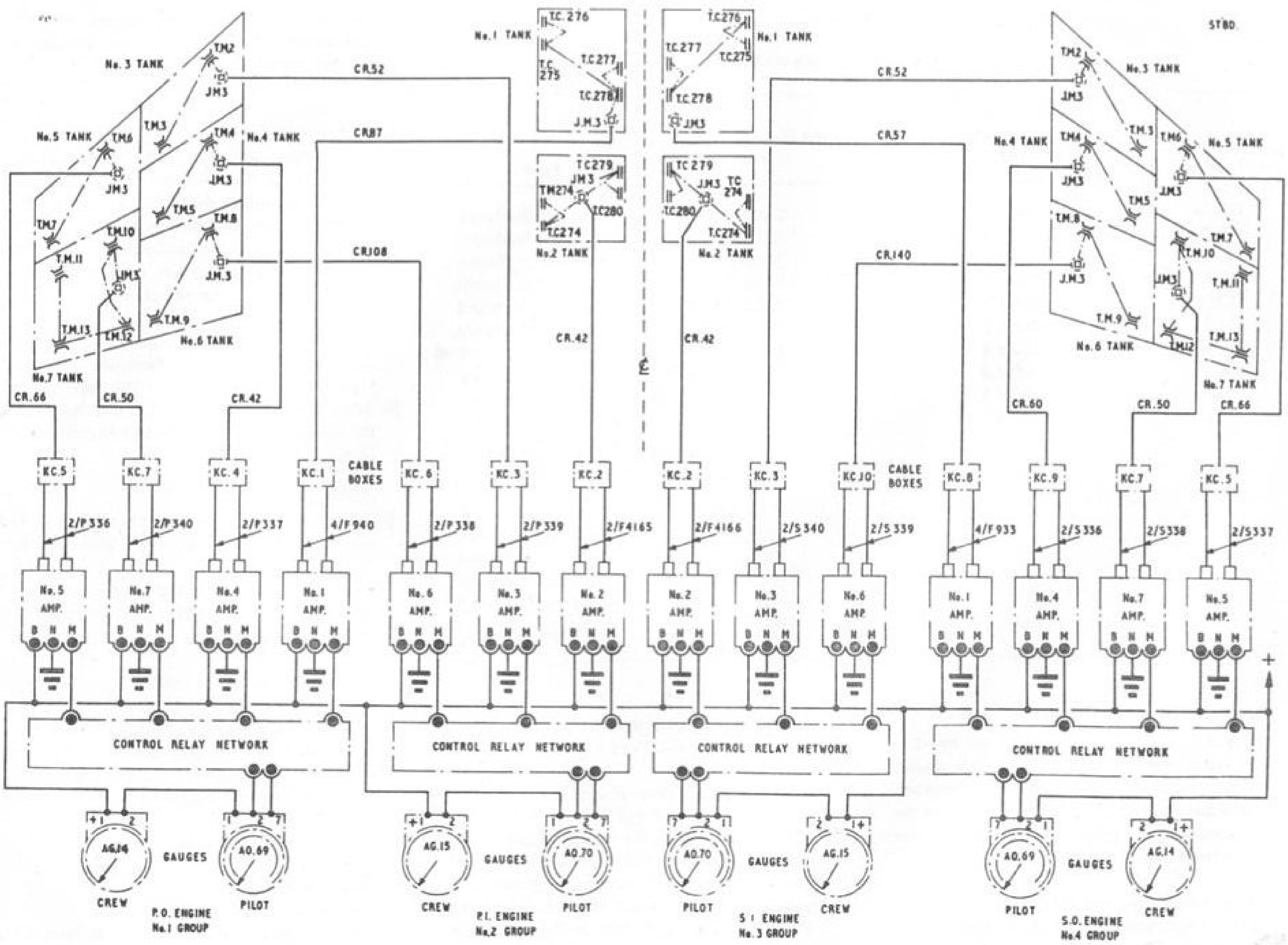


Fig.20 Tanks cabling diagram

▶ STI Vulcan 356 ◀

Type C, should be obtained with a new or replacement tank unit before installation. At least 3 megohms for a single unit, and 1 megohm for multiple units should be obtained when units are tested in situ.

Tank terminal units

157. 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

158. The insulation resistance of each complete fuel tank measured from the tank terminal unit should be at least 1 megohm. The tanks should be drained completely before carrying out this test.

159. The capacitance values of each tank should be in accordance with the following ▶ figures measured at the tank terminal unit:- ◀

No.1 tanks (port and starboard)

Capacitance installed, ▶ empty and dry	1241 ± 45 pF.
Capacitance installed with unusable fuel	1247 ± 45 pF.
Unusable fuel	2 gallons.

No.2 tanks (port and starboard)

Capacitance installed empty and dry	1194 ± 45 pF.
Capacitance installed with unusable fuel	1197 ± 45 pF
Unusable fuel	3 gallons.

TABLE 3

Co-axial cable details

Tank	Cable	Capacitance pF
1S	CR57	103 ± 3
2S	CR42	76 ± 3
3S	CR52	94 ± 3
4S	CR60	108 ± 3
5S	CR66	119 ± 3
6S	CR140	252 ± 5
7S	CZ50	90 ± 3
1P	CR87	156 ± 3
2P	CR42	76 ± 3
3P	CR52	94 ± 3
4P	CR42	76 ± 3
5P	CR66	119 ± 3
6P	CR108	194 ± 5
7P	CZ50	90 ± 3
Bomb bay A	LJJ 113	203 ± 3
Bomb bay B	LUA 248	446 ± 5
Connector	LF16	2 ± 1

No.3 tanks (port and starboard)

Capacitance installed, empty and dry	792 ± 30 pF.
Capacitance installed, with unusable fuel	795 ± 30pF.
Unusable fuel	5 gallons

No.4 tanks (port and starboard)

Capacitance installed, empty and dry	1090 ± 35 pF.
Capacitance installed, with unusable fuel	1096 ± 35 pF.
Unusable fuel	5 gallons

No.5 tanks (port and starboard)

Capacitance installed, empty and dry	929 ± 35 pF.
Capacitance installed, with unusable fuel	929 ± 35 pF.
Unusable fuel	2 gallons

No.6 tanks (port and starboard)

Capacitance installed, empty and dry	898 ± 35 pF.
Capacitance installed, with unusable fuel	907 ± 35 pF. ◀
Unusable fuel	15 gallons

No.7 tanks (port and starboard)

Capacitance installed, empty and dry	1083 ± 35 pF
Capacitance installed, with unusable fuel	1103 ± 35 pF
Unusable fuel	10 gallons

Co-axial cables

160. The co-axial cables which interconnect the tank terminal units, and KC 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 3.

Lining-up procedure - wing and fusalage tanks

161. The lining up procedure should be carried out whenever a tank unit, cable box or cable assembly (between tanks and KC cable boxes) has been changed Lining up is not necessary when an amplifier or indicator is changed.

162. Disconnect the capacitance input cable from the KC cable box and connect the test set QC 345 using test cable CGA 347 between the test set PL1 and the cable box input connector. Connect cable CGA 260 between the test set EARTH and a convenient earth point on the aircraft.

163. Connect a d.c. ground supply of 28-volt to the aircraft and switch on. Allow fifteen minutes before beginning checks to allow the amplifier to stabilize.

164. Using the controls CV1, S1 and S2 on the test set, adjust the capacitance to the value given in Table 4, Col.3.

NOTE . . .
The test cable CGA 347 capacitance (marked on cable) must be subtracted from the figures given in Table 4 and the resultant capacitance applied to the cable box.

Check that the appropriate gauge reads zero when the relevant selector push-switch is operated (Table 1). If not, adjust the appropriate KC cable box trimmer.

165. Disconnect the test set and cable from the box and re-connect the aircraft cable. Check that, with the tanks drained to unusable fuel level, the appropriate gauges read zero (para.142).

TABLE 4

Tank circuit testing values

Tank	Cable Box	Input Cap. at Unusable fuel (pF)	Input Cap. at tank FULL (pF)
1S	KC 8	1349 ± 50	2395
2S	KC 2	1273 ± 46	2271
3S	KC 3	889 ± 34	1887
4S	KC 9	1195 ± 44	2193
5S	KC 5	1048 ± 40	2094
6S	KC 10	1163 ± 40	2209
7S	KC 7	1193 ± 44	2338
1P	KC 1	1403 ± 50	2449
2P	KC 2	1273 ± 46	2271
3P	KC 3	889 ± 34	1887
4P	KC 4	1172 ± 44	2170
5P	KC 5	1048 ± 40	2094
6P	KC 6	1101 ± 40	2147
7P	KC 7	1193 ± 44	2338

GROUND REFUELLING SYSTEM

166. 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 system in a serviceable condition. It is important that the panel covers should not be removed for longer than necessary and refitted securely after inspection periods.

167. The ground refuelling system is calibrated and set up along with the contents gauging system during flight trials. Under normal circumstances no further calibrations or adjustment will be necessary. However, should fault conditions develop or any major

components be removed and refitted or replaced for any reason, the tank or group of tanks affected should be calibrated in accordance with the instructions that follow. The calibration and setting up procedure should be carried out in conjunction with the airframe and engine tradesmen responsible for the aircraft, observing all the fuel handling precautions.

Setting up the system

168. The following calibration and setting up procedure is given on the assumption that a fuel tank, or tanks, replacement has been necessary. The number of tanks to be refuelled and defuelled will be determined by:-

(1) The number of tanks being installed.

(2) Maintenance of the aircraft C of G.

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

169. To calibrate the ground refuelling system a 200-volt a.c. and 28-volt d.c. ground supply must be provided, and the ground refuelling bowser connected to the refuelling points, and the stabilized voltage power pack functioning, proceed as follows:-

(1) Ensure that the aircraft is at 2 deg. 30 min. wing incidence.

(2) Disconnect the fuel piping to the appropriate engine, upstream of the King coupling, and fit a length of flexible hose having a manually operated ON/OFF cock at the outlet end. The hose should be long enough to reach a 50 gallon drum calibrated in 10 gallon divisions. At the same time fit a flexible pipe to the sump drain plug of each appropriate tank (para.168). Each pipe should be fitted with an adaptor for screwing into the sump drain plug and have an ON/OFF cock at the outlet end.

(3) Connect the refuelling bowser to the aircraft and prove that the refuelling valve of the new tank is mechanically closed when the electrical supply to the solenoids is disconnected. Check this by disconnecting, at the terminal block, the supply to pole B of the refuelling valve. Now attempt normal refuelling at approximately 50 p.s.i. The only flow should be that through the servo-port and this should not exceed 2 g.p.m.

(4) Re-connect the feed to pole B and disconnect the feed to pole C. Again attempt normal refuelling at approximately 50 p.s.i. noting that the only flow should be through the servo-port and this should not exceed 2 g.p.m. Re-connect the feed to pole C then make a final check on all the valves in the group. With all the refuelling valves de-energized and approximately 50 p.s.i. ground refuelling pressure, check for at least one minute that no fuel is being delivered by the bowser to the group under test.

(5) It is now necessary to ensure proper wetting of the tank unit prior to setting the contents gauges to zero. Select 100% on the stabilized 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.

(6) The fuel in the tanks now requires to be emptied to unusable fuel but without draining the refuelling galleries. Close all 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 (5) less 20 gallons. Note that it may be necessary at this stage to defuel from other tanks to maintain aircraft C of G. As each tank is defuelled only the ground service cock of that tank must be open.

(7) After completion of the de-fuelling close the de-fuelling 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 pump 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 (5). 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 the flow ceases, as indicated on the bowser 'gallons gone' indicator.

(8) Set the contents gauge for the newly installed tank to zero as outlined in para.142. Note that the gauge 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 zero immediately after draining, while the tanks are still wet.

(9) 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 float switches in the tanks.

(10) Disconnect the feed to the override relay from the fuel level switch of the new tank. Connect a low wattage test lamp between terminal A of the fuel level switch and earth. Select the new tank on the refuelling panel and set the bowser 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.

(11) 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 contacts only have opened, 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 switch. This may indicate a fault in the switch or connector and further checks should be made.

(12) Assuming that the switch has operated correctly, connect a temporary wire link between pole A of the switch and pole B or C of the refuelling valve. This shorts out the lower switch and the flight refuelling indicator lamp should now light. Leave the test lamp connected as before (10) and continue refuelling at a slow rate, again keeping a careful record of the gallons gone. Operation of the upper float switch 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.

(13) Drain the quantity of fuel delivered between operation of the lower and upper switches, plus ten gallons, from the newly installed

TABLE 5

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%

tank, with the aid of the flexible pipe fitted to the sump drain plug. Re-connect the cable to terminal H of the moving coil relay (9).

170. Due to variations in specific gravity of fuels that can be used in the aircraft, Table 5 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 5 are derived from the formula:-

Refuelling Power Unit Setting in %

$$= \frac{100 \times \text{S.G. of fuel used}}{0.8}$$

Setting refuelling circuit trimmers

171. 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, 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 in 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.169 (13).

(3) Connect the QC 345 test set, to the disconnected co-axial cable (1).

(4) Adjust the stabilized voltage unit to a percentage setting in accordance with Table 5 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 QC 345 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 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 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 2 mA ± 80 microamps, of the exact value noted.

(10) With the milliammeter still connected in series with the A coil, disconnect the co-axial cable from the QC 345 test set and re-connect 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 trimmer resistance. Leave the milliammeter connected in series with coil A.

(11) With the newly installed tank No.6 refuelled in accordance with para.169, 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 trimmer resistance. 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 re-connect the cables to the moving coil relay and terminal H. Remove the test lamp and refuelling equipment fitted in para.169 and re-connect the fuel level switches.

172. With the refuelling selector set as in para.171; 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.

173. Defuel the tanks as in para.169; 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.

174. Refuel the new tank to 20, 40, 60, 80 and 100% selection. Record the quantities of fuel indication on the refuelling bowser flowmeter, (subject to condition imposed in the next paragraph) and the aircraft contents gauges, at each percentage level.

175. As previously stated 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 fuel used it will be necessary therefore to correct the refuelling bowser flowmeter readings before comparing them with the aircraft's 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 6. 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:-

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.

TABLE 6

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	2 x 610	2 x 4880	2 x 620	2 x 4836	2 x 4774	2 x 4712	2 x 4650
2	2 x 935	2 x 7480	2 x 945	2 x 7371	2 x 7277	2 x 7182	2 x 7088
3	2 x 630	2 x 5040	2 x 640	2 x 4992	2 x 4928	2 x 4864	2 x 4800
4	2 x 630	2 x 5040	2 x 640	2 x 4992	2 x 4928	2 x 4864	2 x 4800
5	2 x 515	2 x 4120	2 x 525	2 x 4095	2 x 4042	2 x 3990	2 x 3937
6	2 x 745	2 x 5960	2 x 755	2 x 5889	2 x 5814	2 x 5738	2 x 5663
7	2 x 565	2 x 4520	2 x 575	2 x 4485	2 x 4427	2 x 4370	2 x 4312
TOTAL	9260	74080	9400	73320	72380	71440	70500

Refuelling panels

176. A test panel Ref. 26DC/95206 is available for checking panels 36P and 37P throughout their full working range. The panel is not designed for 'in situ' testing. A full description of the panel and its method of use will be found in A.P.120N-0145-1.

Stabilized voltage power unit

177. 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 of between 22 and 29-volt, allowing sufficient time for warm up and stable operation.

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

(3) Check that a range of 0 to 50-volt can be obtained at the output terminals when the selector potentiometer (R20) is adjusted, also that the voltage range is read in conjunction with the built-in voltmeter calibrated 0-100%. If the range 0 to 50-volt 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-volt or 100% is obtained, correction can be achieved by setting the selector potentiometer to 50%, adjust R14 so that 55% indication occurs on the voltmeter, then adjust R18 to restore the reading on the voltmeter to 50%. For optimum setting the procedure for R14 and R18 should be carried out several times. Check that readings for 50-volt 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% on the voltmeter, and then restore the reading to 50% by adjustment of R18. Check that readings for 50-volt or 100% can now be obtained. Slight adjustment of R14 and R18 may also be necessary for optimum setting of 50-volt or 100% output.

(4) To obtain optimum regulation, potentiometer R4 may also be adjusted. In the event of regulation falling off as the selector potentiometer is moved towards 100% output, the neg. 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-volt 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 one of the exact type specified, and under no circumstances should a valve of near similar characteristics be used.

A test panel, Ref.26DC/95205, is available as a convenient method of checking the on-load output voltage characteristics of the stabilized voltage power pack. The unit is fully described in A.P.120N-0145-1. The appropriate test procedure will be found in the same A.P.

FLIGHT REFUELLING SYSTEM (INOPERATIVE)

Functioning check

NOTE . . .
The flight refuelling system and probe nitrogen purge system have been rendered inoperative by embodiment of Mod.2417. The following description and circuitry is retained for information and identification purposes. Certain flight refuelling circuit fuses have subsequently been re-allocated to other services.

178. Prior to flight refuelling operations taking place the electrical 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 busbar is live.

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

(3) Press the C.G. check push-switch. Note that the C.G. indicator is reading and that the fuel contents register zero.

(4) Place the flight refuelling master switch to ON (para.13) check that:-

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

(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-pressurized when the flight refuelling master switch is placed to ON (para.91). The tank pressurization tests are contained in Sect.4, Chap.6.

(5) Hold the C.G. control switch to PORT and then to STARBOARD, check that the appropriate tank refuelling valve indicator lamps in the flight refuelling indicator are operating correctly. (PORT – lamps 6 and 7, starboard out, STARBOARD – lamps 6 and 7, port, 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 correctly. (FWD. – lamps 6 and 7, port and starboard, out. AFT – lamps 1 and 2, port and starboard, out).

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

(8) At the conclusion of these checks operate the master switches 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, also that all four tank pressure magnetic indicators are de-energized when all the tanks are re-pressurized.

Refuelling indication

179. When carrying out the above functioning check ensure that all indicator lamp filaments are serviceable. Any faulty or suspected filaments must be replaced. To replace a 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 cap assembly may now be withdrawn with the lampholder and the filament.

(3) Withdraw the faulty filament from its holder and replace.

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

NOTE . . .
It is important when fitting the cap 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.

Setting the C of G indicator to zero

180. Whenever any major component of the C of G indicator has been changed the indicator must be set to read zero by means of the bias trimmer in the computer boxes. Prior to this the tanks should be emptied down to unusable fuel but without draining the refuelling galleries. The C of G indicator should first be mechanically set to zero by means of the screw on the front face of the indicator, then press the check switch and adjust to zero by means of the bias trimmers in the computer boxes.

Refuelling panels, 45P and 46P

181. The wiring to these panels, including the plugs and sockets, should be examined periodically for cleanliness and general security. Operation of the relays within the panels will be evident during the functional checks outlined in para.176. The test set quoted in para.176, which is provided for testing panels 36P and 37P, may also be used for testing panels 45P and 46P. Reference should be made to A.P.120N-0145-1, for further details.

Computer boxes, Type BW52

182. Correct functioning of the port and starboard computer boxes will be observed when the functional checks outlined in para.176 are carried out. If a fault is suspected

the boxes should be subjected to the tests outlined in the following paras.

183. The complete boxes should be removed from the aircraft to a suitable servicing bay before applying the following tests. The method of connection for each test is given in fig.21.

Insulation resistance check

184. Check the insulation resistance of each computer box by connecting an insulation resistance tester, Type C, between the following poles of the large plug. Readings should not be less than 20 megohms.

Earth (frame)	to poles	A,B,C,D,E,F and G
Pin A	to poles	B,C,D,E,F and G
Pin B	to poles	C,D,E,F and G
Pin C	to poles	D,E,F and G
Pin D	to poles	E,F and G
Pin E	to poles	F and G
Pin F	to pole	G

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

Proportionality test

185. Connect up the computer box as shown in fig.21, detail A. Then with the relays energized, set R1 to the values given in Table 7. Adjust R2 until the galvanometer gives a zero deflection. At this point check the value of R2 with the values given in Table 7. Its value should be within ± 4% of the specified value.

Volts drop test

186. The method of connections for applying the volts drop test is shown in fig.21, detail B. The voltmeter shown is a testmeter, Type E, set to 2.5-volt d.c. With the point P4 connected as specified in Table 8 and all the computer box relays energized, adjust the current to the value specified in the table; the voltage drop should not be more than 1.2-volt.

TABLE 7

Proportionality test – resistance values

Tank No.		1	2	3	4	5	6	7
Connect computer box pins to points	P1 P2	A2 A1	A2 B1	A2 C1	A2 D1	A2 E1	A2 F1	A2 G1
R1 (ohms)		infin	infin	197	196	275	1250	513
R2 (ohms)		zero	zero	1940	370	300	150	170

TABLE 8

Volts drop test – current values

Tank No.	1	2	3	4	5	6	7
Connect P4 to computer box pin	A1	B1	C1	D1	E1	F1	G1
Current (mA)	7.00	7.14	5.50	6.98	6.25	6.03	6.47

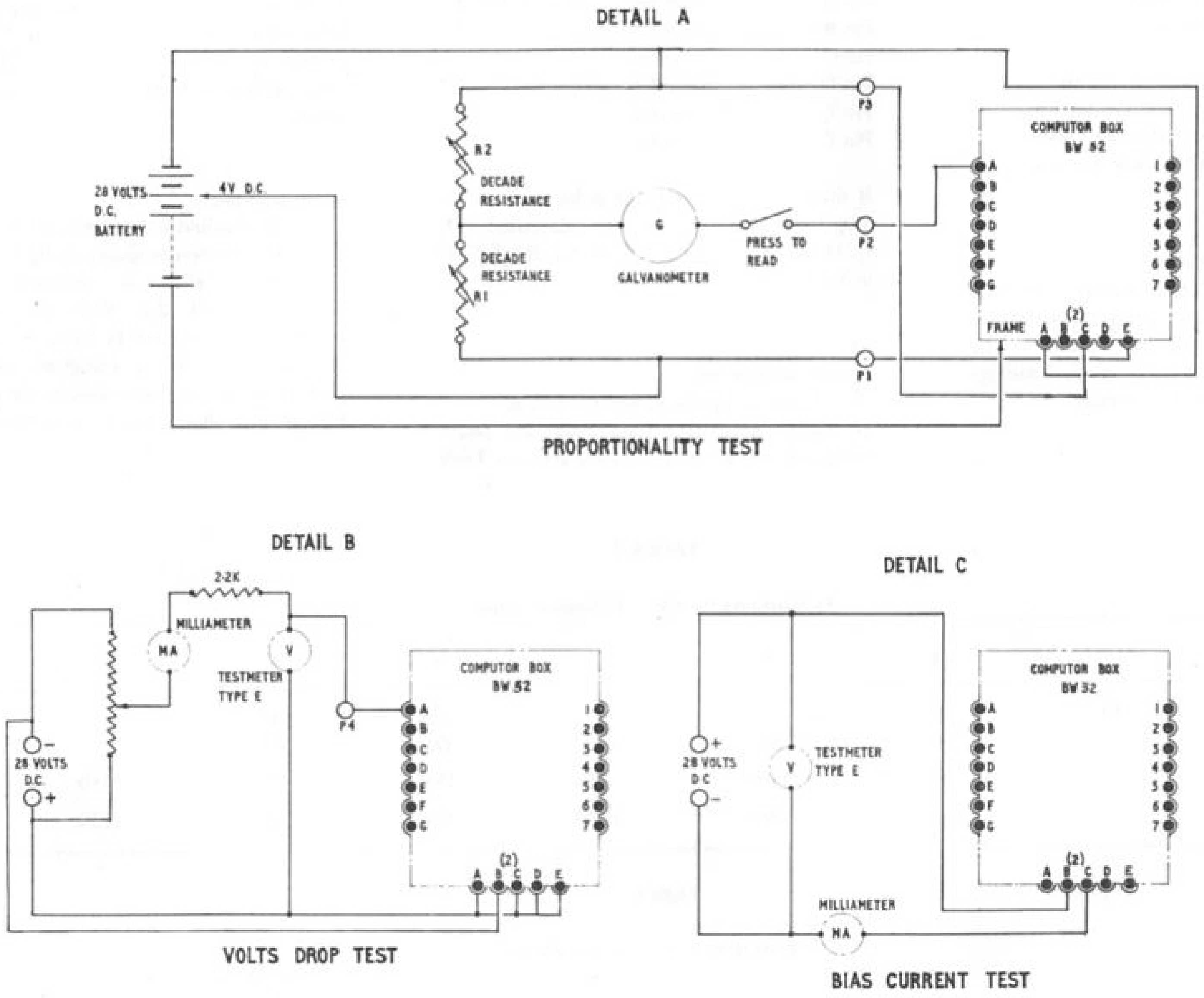


Fig. 21 Test equipment connections

Bias current test

187. The circuit diagram fig.21 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 1 mA range. From the voltage and current readings calculate the resistance between B2 and C2 for extreme positions of the 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 computer box.

Continuity check

188. Since the tests detailed in para.186 and 187 necessarily include continuity of relay contacts in the energized state, a check should be made to prove the continuity of the computer box with the relay de-energized. Continuity should be obtained between the following poles 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		

189. The most likely fault to develop in the computer box BW 52 will be in the form of an open circuit relay contact or resistor. Open circuit relay contacts will be revealed by the voltage drop test and by continuity tests. Open circuit resistors will be found by the proportionality test and the bias current test.

BOMB BAY FUEL SYSTEM

General

190. The exterior wiring and connections on the tanks and associated circuit wiring should be examined periodically for cleanliness and security. The system can be checked for correct operation when the tanks are refuelled in accordance with the instructions given in Sect.4, Chap.2.

191. Capacitance values of the various co-axial connectors, tank trimmer boxes and tank units are given in Table 10, to which reference should be made when checking items for correct values. Current values for the indicators, Type A078 and A079, are given in Table 13.

TABLE 9

Bomb bay tanks equipment

Saddle tank A

Fuel pumps (4), Type PAC 1200, Mk.3 or 4
Fuel level switch, Type 351-0100/3, Mk.10 Ref. No. 5CW/7419
Refuelling valve, Type C1140025 or C1140125
Trimmer box, Type BT21-7 (With Mod.2086, Type BT21-3)

Saddle tank E

As for tank A except trimmer box, which is Type BT21-9

Cylindrical tank

Fuel pumps (3), Type PAC 1200, Mk.4
Fuel level switch, Type 351-0100-4
Refuelling valve, Type 1140111
Trimmer box, Type BT21-33

Functioning checks

192. If bomb bay tanks are not fitted to the aircraft, the bomb bay gauge will read below zero. No trimming is necessary as the bomb bay tank system must be lined up to the correct capacitance value (paras.194 to 204).

193. If bomb bay tanks are fitted, ensure that they are drained to unusable fuel level. Operate push-switches A (fwd), or E (aft) on the fuel contents panel and check that the fuel gauge reads zero (outer scale for A (fwd) and inner scale E (aft)) within 4% of F.S.D. Readings in excess of this figure indicates a fault condition (refer to Fault Location, para.206).

Lining-up procedure

194. The alternative configurations of fuel tanks in the bomb bay may be as follows:-

(1) One saddle tank A (fwd), Post Mod.527.

(2) Two saddle tanks A (fwd), Post Mod.527, and E (aft) Post Mod.528.

(3) One saddle tank A (fwd), Post Mod.2086 and one cylindrical tank E (aft), Post Mod.2014.

(4) Two cylindrical tanks A (fwd), Post Mod.2014 and E (aft), Post Mod.2014.

(5) One cylindrical tank A (fwd), Post Mod.2014.

195. Lining-up the bomb bay fixed fittings (without tanks installed) should be in accordance with the configuration of tanks to be fitted. Table 11 shows the lining-up

TABLE 10

Capacitance values - bomb bay tanks

Saddle tank A (Post Mod.527)

Cable box	BT21-7	68 ± 31 pF
Tank Unit	57TN	518 ± 5 pF
Tank unit	57TN	518 ± 5 pF
Tank terminal	LF17	2 ± 1 pF
Cables	PA24	40 ± 4 pF
	PW62	103 ± 10 pF
	LUA10	18 ± 3 pF
	LJJ48	86 ± 3 pF
	Total dry	1 353 pF
	Unusable fuel	4 pF
	Total of unusable fuel	1 357 pF

Saddle tank E (Post Mod.528)

Cable box	BT21-9	141 ± 62 pF
Tank units	59TN	259 ± 3 pF
	59TN	259 ± 3 pF
	60TN	259 ± 3 pF
	60TN	259 ± 3 pF
Tank terminal	LF17	2 ± 1 pF
Cables	PA80	133 ± 13 pF
	PA80	82 ± 13 pF
	PW54	90 ± 9 pF
	LUA10	18 ± 3 pF
	LJJ33	59 ± 3 pF
	Total dry	1 694 pF
	Unusable fuel	3 pF
	Total of unusable fuel	1 697 pF

capacitance figures to be applied to the LF16 connectors. It must be noted that the figures given do not take account of the capacitance values of test cables. The capacitance figures marked on the test cables must be subtracted from the values given in Table 11.

LINING-UP BOMB BAY FIXED FITTINGS, TANKS NOT INSTALLED (POST MOD.526, 2013 AND 2283)

Tank A (fwd.)

196. Disconnect the blanking cap (LF36) from the LF16 bulkhead connector marked A on forward tank. Connect the test set QC 345, plug PL1, using cable CGA 349 to the LF16 bulkhead connector. Connect cable CGA 260 between the test set and the convenient earth point on the aircraft.

NOTE

For convenience, test set cable CGA 350 can be used to operate the relays in the cable box instead of the push-switches on the fuel contents panel, providing a 28-volt d.c. supply is available to connect to CGA 350.

197. Connect the aircraft 28-volt d.c. ground supply and switch on, allow fifteen minutes before beginning the check to allow the amplifier to stabilize.

198. Using the test set controls CV1 and switches S1 and S2, set input capacitance to the figure given in Table 11 (minus the value of CGA 349).

199. Operate push-switch A (fwd) on the fuel contents panel (or S1 on CGA 350). The bomb bay gauge should read zero ± 1% F.S.D. If not, gain access to the tank A trimmer on cable box

TABLE 10 (Cont'd)

Saddle tank A (Post Mod 2086)

Cable box	BT21-31	723 ± 31 pF
Tank units	57TN	518 ± 5 pF
	57TN	518 ± 5 pF
Tank terminal	LF17	2 ± 1 pF
Cables	PA24	40 ± 4 pF
	PW62	103 ± 10 pF
	LJA10	18 ± 3 pF
	LUA48	86 ± 3 pF
	Total dry	2008 pF
	Unusable fuel	4 pF
	Total at unusable fuel	2012 pF

Cylindrical tanks (Post Mod 2014)

Cable box	BT21-33	64 ± 29 pF
Tank units	237TA	738 ± 10 pF
	238TA	748 ± 10 pF
Cables	LJJ72	130 ± 3 pF
	LJJ72	130 ± 3 pF
	LJJ92	166 ± 3 pF
	Total dry	1976 pF
	Unusable fuel	36 pF
	Total at unusable fuel	2012 pF

BT22 - 34 or BT32 - 33, and adjust until gauge reads zero. Release the push-switch.

Tank E (aft) simulation

200. With the test set still connected for the A (fwd) tank and the capacitance input as in Table 11 applied (minus value of CGA 349) set the switch on the cable box BT22 - 34 or BT22 - 33 to OUT and check that the bomb bay gauge reads zero. If not, adjust the TRIM AFT TANK SIMULATOR trimmer until gauge reads zero.

Tank E (aft)

201. Disconnect the test set from A or forward tank LF16 bulkhead connector and connect the test set to the E or aft LF16 bulkhead connector.

202. Set the switch on the cable box BT22 - 34 or BT22 - 33 to IN. Using the test set controls CV1 and switches S1 and S2, set input capacitance to the figure given in Table 11 (minus the value of CGA 349).

203. Operate push-switch E (aft) on the fuel contents panel (or S2 on CGA 350). The bomb bay gauge should read zero ± 1% F.S.D. If not, gain access to the TANK E trimmer on cable box BT22 - 34 or BT22 - 33 and adjust until gauge reads zero.

Tanks A (fwd) and E (aft) summation

204. With the test set QC 345 connected to the A (fwd), tank LF16 bulkhead connector and the switch on cable box BT22 - 34 or BT22 - 33 set to IN, set the input capacitance, using test set controls CV1, S1 and S2, to the value given in Table 11 (minus the value of CGA 349). With the push-switches E (aft) and A (fwd) (S1 and S2 on CGA 350) in their normal open state (not operated), the bomb bay gauge should read zero ± 1% F.S.D. If not, gain access to the TRIM SUM trimmer on cable box BT22 - 34 or BT22 - 33 and adjust until gauge reads zero.

LINING-UP BOMB BAY TANKS - NOT INSTALLED

205. Since this operation is carried out on the tanks remote from the aircraft, a separate 28-volt d.c. supply is required for the KA5 amplifier as shown in figs.22, 23, 24 and 25. Proceed as follows:-

Saddle tank A (fwd) Post Mod.527

(1) Connect the test set QC 345 to a KC7 cable box, KA5 amplifier, milliammeter and a 28-volt d.c. supply as shown in fig.22. Do not

TABLE 11

Lining up capacitance figures — bomb bay tanks — wet

Tank configuration	Capacitance pF to line up EMPTY A (fwd) at LF16 (A)	E (aft) at LF16 (E)	Summation value at LF16 (A) with cable box switch to IN	Full capacitance (pF) A (fwd) at LF16 (A)	E (aft) at LF16 (E)
One saddle tank A (fwd)	1357	SIMULATE, zero gauge with cable box switch to out	2754	2518	-
Two saddle tanks, one A (fwd) and one E (aft)	1357	1697	2754	2518	2858
One saddle tank A (fwd) and one cylindrical tank E (aft)	2012	2012	4024	3558	3558
Two cylindrical tanks one A (fwd) and one E (aft)	2012	2012	4024	3558	3558
One cylindrical tank A (fwd)	2012	SIMULATE, zero gauge with cable box switch to OUT	4024	3558	-

connect the tank circuit to the test set at this stage.

(2) Switch on the 28-volt d.c. supply, allow fifteen minutes before beginning checks to allow the amplifier to stabilize.

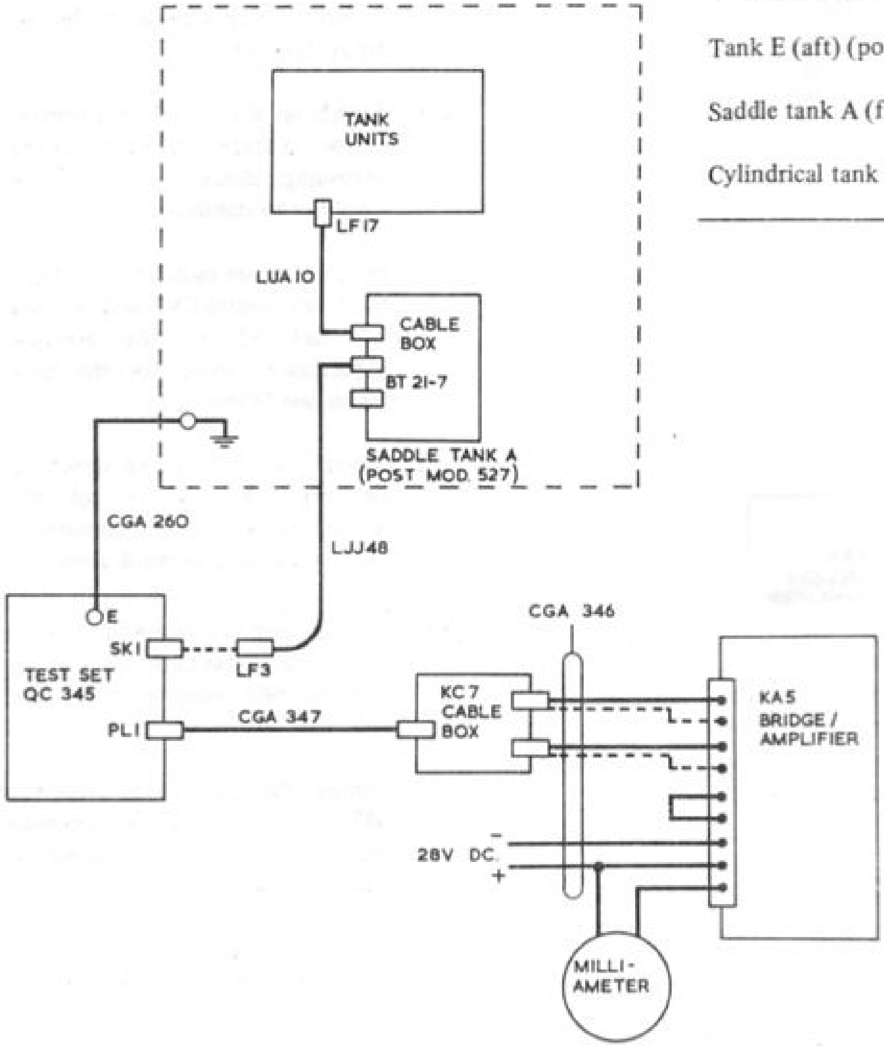


Fig. 22 Lining up bomb bay tank - not installed - saddle tank A (Fwd.) Post Mod.527

TABLE 12

Lining up capacitance figures – bomb bay tanks – dry

Tank configuration	Capacitance at undrainable fuel (dry) Total tank circuit
Saddle tank A (fwd) (post Mod 527)	1353 pF
Tank E (aft) (post Mod 528)	1694 pF
Saddle tank A (fwd) (post Mod 2086)	2008 pF
Cylindrical tank (fwd) and (aft) (post Mod 2014)	1976 pF

(3) Set the test set to CV1 + CV2. Set control CV2 and switches S4 and S5 to the nominal capacitance figure for the tank under test (Table 12).

(4) Adjust control CV1 and switch S2 on the test set to set the milliammeter to a convenient reading, i.e. on a cardinal point.

(5) Set the test set switch S3 to CV1 and connect the tank circuit to the test set SK1, using tank cable LJJ 48.

(6) Adjust the trimmer on cable box BT21 - 7 so that the milliammeter reads the same as noted in operation (4).

(7) Switch off the power supply and disconnect the test equipment.

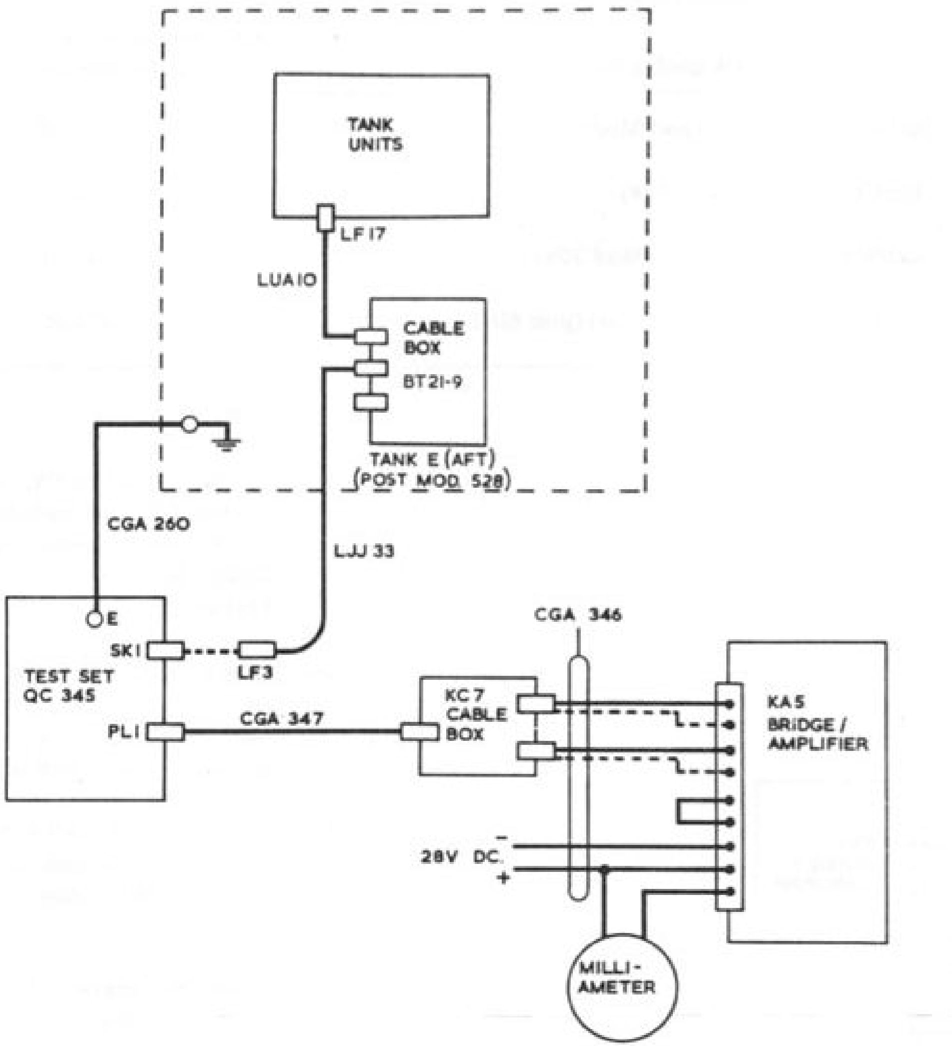


Fig.23 Lining up bomb bay tank - not installed tank E (Aft) Post Mod.528

Tank E (aft) Post Mod.528

(1) Connect the test set QC 345 to a KC7 cable box, KA5 amplifier, milliammeter and a 28-volt d.c. supply, as shown in fig.23. Do not connect the tank circuit to the test set at this stage.

(2) Switch on the 28-volt d.c. supply, allow fifteen minutes before beginning checks to allow the amplifier to stabilize.

(3) Set the test set switch S3 to CV1 + CV2. Set control CV2 and switches S4 and S5 to the nominal capacitance figure for the tank under test (Table 12).

(4) Adjust control CV1 and switch S2 on the test set to set the milliammeter to a convenient reading, i.e. on a cardinal point.

(5) Set the test set switch S3 to CV1 and connect the tank circuit to the test set SK1 using the tank cable LJJ 33.

(6) Adjust the trimmer on cable box BT21 - 9 so that the milliammeter reads the same as noted in operation (4).

(7) Switch off the power supply and disconnect the test equipment.

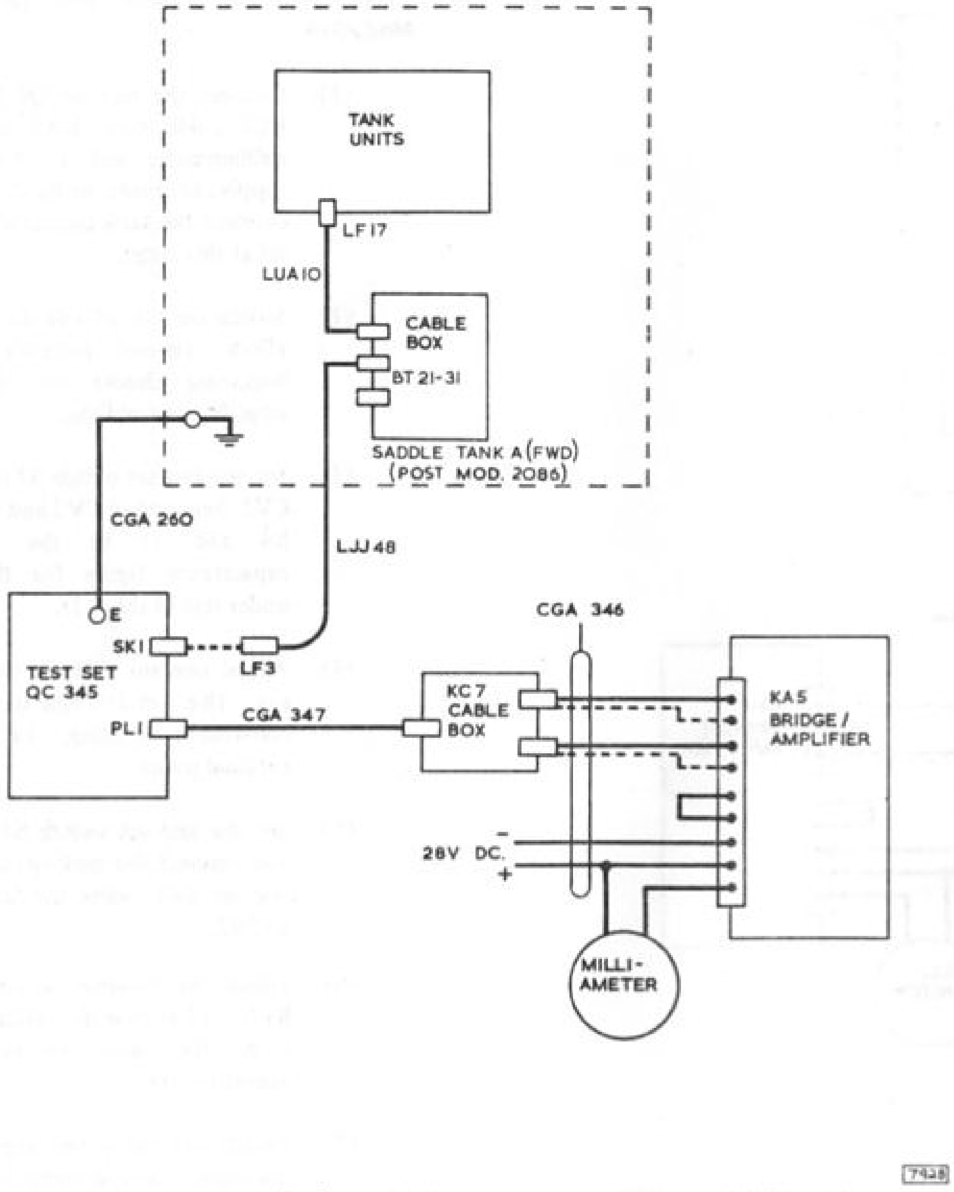


Fig. 24 Lining up bomb bay tank - not installed - saddle tank A (Fwd.) Post Mod.2086

Saddle tank A (fwd) Post Mod.2086

(1) Connect the test set QC 345 to a KC7 cable box, KA5 amplifier, milliammeter and a 28-volt d.c. supply, as shown in fig.24. Do not connect the tank circuit to the test set at this stage.

(2) Switch on the 28-volt d.c. supply, allow fifteen minutes before beginning checks to allow the amplifier to stabilize.

(3) Set the test set switch S3 to CV1 + CV2. Set control CV2 and switches S4 and S5 to the nominal capacitance figure for the tank under test (Table 12).

(4) Adjust control CV1 on test set to set the milliammeter to a convenient reading, i.e. on a cardinal point.

(5) Set the test set switch S3 to CV1 and connect the tank circuit to the test set SK1, using the tank cable LJJ 48.

(6) Adjust the trimmer on cable box BT21 - 31 so that the milliammeter reads the same as noted in operation (4).

(7) Switch off the power supply and disconnect the test equipment.

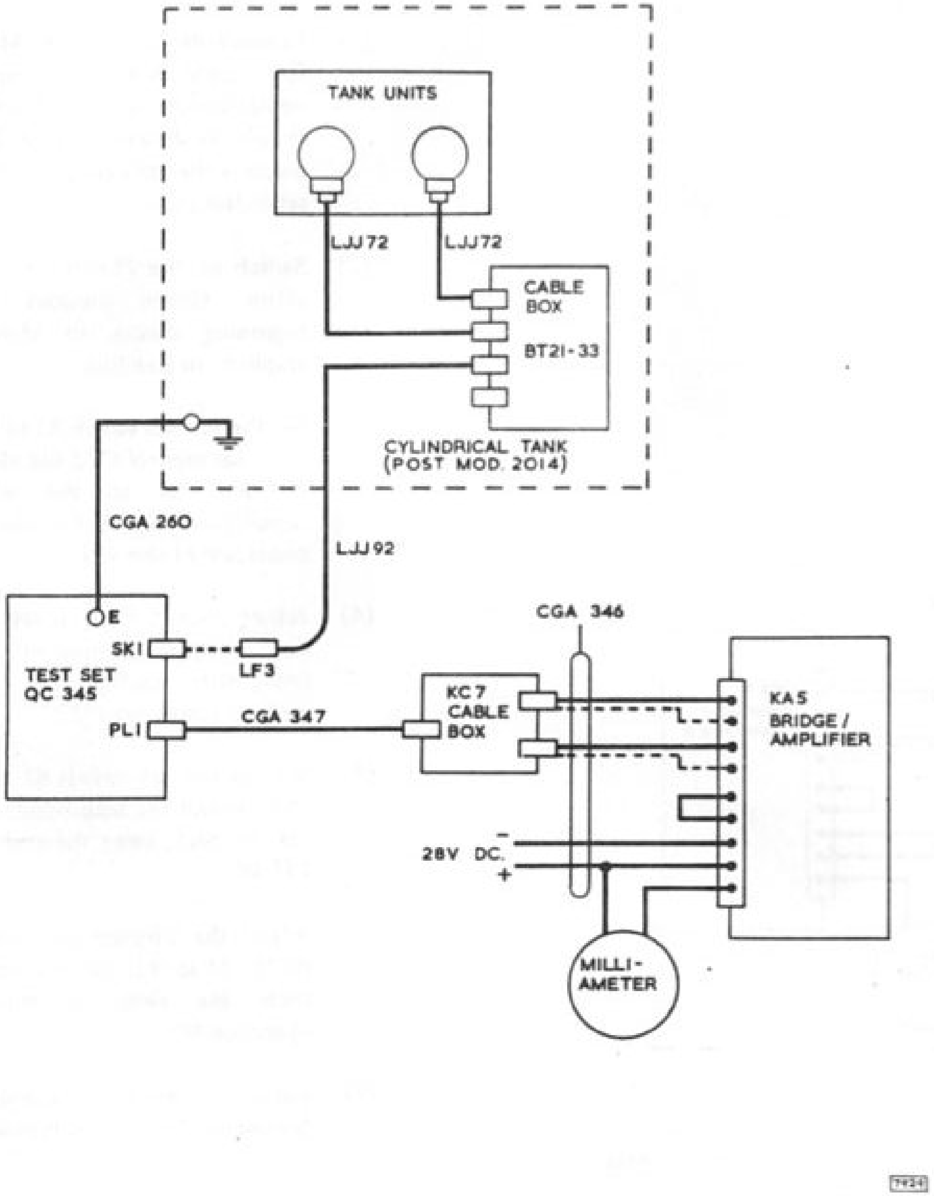


Fig. 25 Lining up bomb bay tank - not installed - cylindrical tank (Fwd.) and (Aft.) Post Mod.2014

Cylindrical tank (fwd) and (aft) Post Mod.2014

(1) Connect the test set QC 345 to a KC7 cable box, KA5 amplifier, milliammeter and a 28-volt d.c. supply, as shown in fig.25. Do not connect the tank circuit to the test set at this stage.

(2) Switch on the 28-volt d.c. supply, allow fifteen minutes before beginning checks to allow the amplifier to stabilize.

(3) Set the test set switch S3 to CV1 + CV2. Set control CV2 and switches S4 and S5 to the nominal capacitance figure for the tank under test (Table 12).

(4) Adjust control CV1 on test set to set the milliammeter to a convenient reading, i.e. to a cardinal point.

(5) Set the test set switch S3 to CV1 and connect the tank circuit to the test set SK1, using the tank cable LJJ 92.

(6) Adjust the trimmer on cable box BT21 - 33 so that the milliammeter reads the same as noted in operation (4).

(7) Switch off the power supply and disconnect the test equipment.

TABLE 13

Fuel contents indicator details (bomb bay tanks)

Indicator Type A078 (Pre. Mod. 2015, Post Mod. 2283 and 2373)

Inner Scale Indication (pounds x 1000)	Indicator Current (mA)	Outer Scale Indication (pounds x 1000)	Indicator Current (mA)
0	2.00	0	2.00
2	2.83	1	2.85
4	3.67	2	3.7
6	4.50	3	4.51
8	5.33	4	5.29
10	6.17	5	6.13
12	7.00	6	7.00

Indicator Type A079 (Post Mod.2015, 2283 and 2373)

Inner Scale Indication (pounds x 1000)	Indicator Current (mA)	Outer Scale Indication (pounds x 1000)	Indicator Current (mA)
0	2.00	0	2.00
2	2.62	1	2.64
4	3.29	2	3.28
6	3.88	3	3.88
8	4.47	4	4.47
10	5.06	5	5.07
12	5.70	6	5.69
14	6.37	7	6.37
16	7.00	8	7.00

FAULT LOCATION

Bomb bay fixed fittings

206. If a fault occurs in the bomb bay tank circuit, carry out the lining-up procedure detailed in para. 196 to 204. Additionally, apply the full capacitance values given in Table 11, and check that the contents gauge reads full ± 2% F.S.D. This will establish if the fault is on the tank side of the LF16 connector or on the indicator side. If the checks are satisfactory, the individual bomb bay tank should be removed from the aircraft and checked (para.205).

207. If lining-up is not possible at the LF16 connectors, a further check should be made at the input connectors of cable box BT22 - 34 (Pre. Mod.2015) or BT22 - 33 (Post Mod.2015) using the same procedure for lining-up as in para. 197 to 204. Test cable CGA 349 can be used in either SK1 or PL1 on test set QC 345, depending upon which tank circuit is being simulated at the cable box. The capacitance input at the cable box should be as given in Table 11, plus the value of the aircraft cable from the LF16 connector to the cable box and the value of the LF16 connector (Table 3).

208. If the bomb bay fuel gauge shows a fault with the tank circuit substituted with the test set, replace each unit in the system in turn until the faulty unit is detected. Should this procedure fail to locate the fault, check all wiring according to the aircraft routing chart (fig.58).

Bomb bay tanks - not installed

209. To locate a fault on a particular bomb bay tank, first check that the tank can be lined-up as detailed in para.205. If lining-up is not possible, carry out capacitance checks by the method of substitution using the test set QC 345. Measurement by substitution can be carried out using the following procedure.

NOTE . . .

Depending upon the value of capacitance to be measured, the values set on CV1 and CV2 may be varied to ensure that the capacitance input to the KC cable box is within the range of the cable box (Table 4) and the capacitance to be measured can be conveniently read off CV2.

(1) Connect the test set QC 345, a KC7 cable box, a KA5

bridge/amplifier and milliammeter as shown in fig.22.

(2) Set test set switch S3 to CV1 + CV2.

(3) Turn CV1 to its lowest level.

(4) Set CV2 to a nominal capacitance value of the unit on test (Table 10).

(5) Adjust CV1 to set the milliammeter to a convenient reading.

(6) Set test set switch S3 to CV1.

(7) Connect the unit on test to the test set, SK1.

(8) Check that the milliammeter reads the same as in (5).

(9) If necessary, CV1 may be adjusted within the tolerance value of the unit on test.

210. After satisfactory completion of lining-up checks, the tanks may be installed in the aircraft and connected, without further trimming being necessary. With the unusable fuel levels accurately established the indicator should read zero within ± 1% of F.S.D. The switch on the junction box should be selected to IN if the E (aft) tank is fitted, and to OUT if the E (aft) tank is not fitted.

TABLE 14

Fuel tank capacities (bomb bay fuel system)

Tanks	Gals. Fuel S.G. 0.8	L.B. Fuel S.G. 0.8	Gals. Fuel S.G. 0.78-0.75	Fuel S.G. 0.78	Fuel S.G. 0.77	Fuel S.G. 0.76	Fuel S.G. 0.75
A	708	5 664	718	5 600	5 529	5 456	5 385
E	711	5 688	721	5 624	5 552	5 480	5 408
Cylindrical	-	-	995	7 761	7 661	7 562	7 462

REMOVAL AND INSTALLATION

General

211. The removal and installation of the major components in the various systems is straightforward and no special instructions are required. The safety precautions given in A.P.4117A, Vol.16, must be carried out before entering any tank to remove or refit internal units.

KA5 amplifiers and cable boxes Type KC

212. The following points should be observed when replacing any amplifiers or cable box.

(1) When replacing the No.1 port or No.1 stbd. cable box, a 1/16 in thick tufnol sheet Part No. 101/V9472 is to be fitted between the mounting feet and aircraft structure to insulate these two cable boxes from earth.

(2) All other cable boxes and amplifiers are bonded to earth by direct contact, between the mounting feet and the aircraft structure. Before fitting, the mounting surfaces must be thoroughly cleaned and scraped free of oil, grease, paint or protective treatment. After fitting, the joint between the mounting feet and aircraft structure is to be coated with thiokol sealant (PR 1422 BT½).

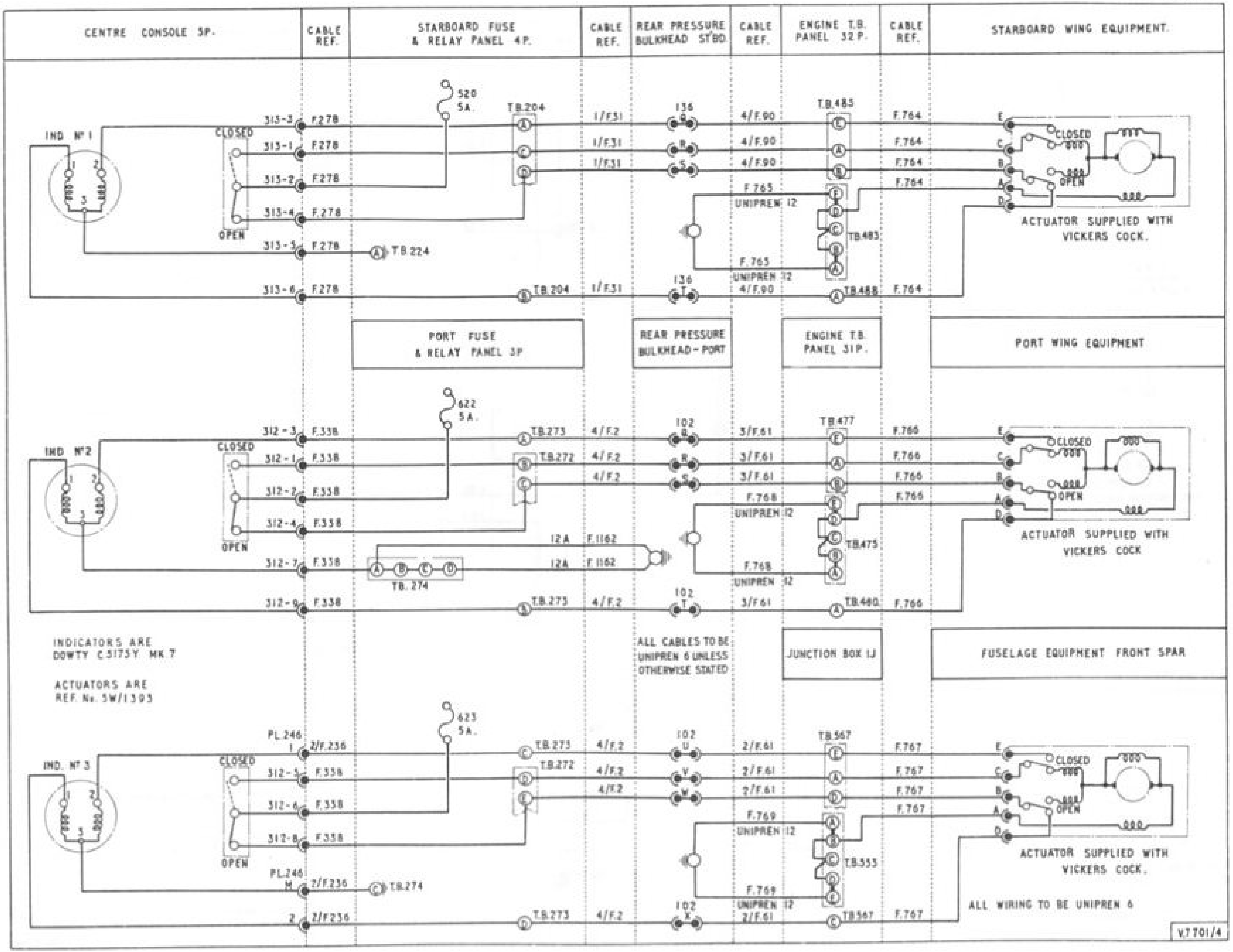


Fig. 26 Cross feed cocks

◂ Minor alterations ▸

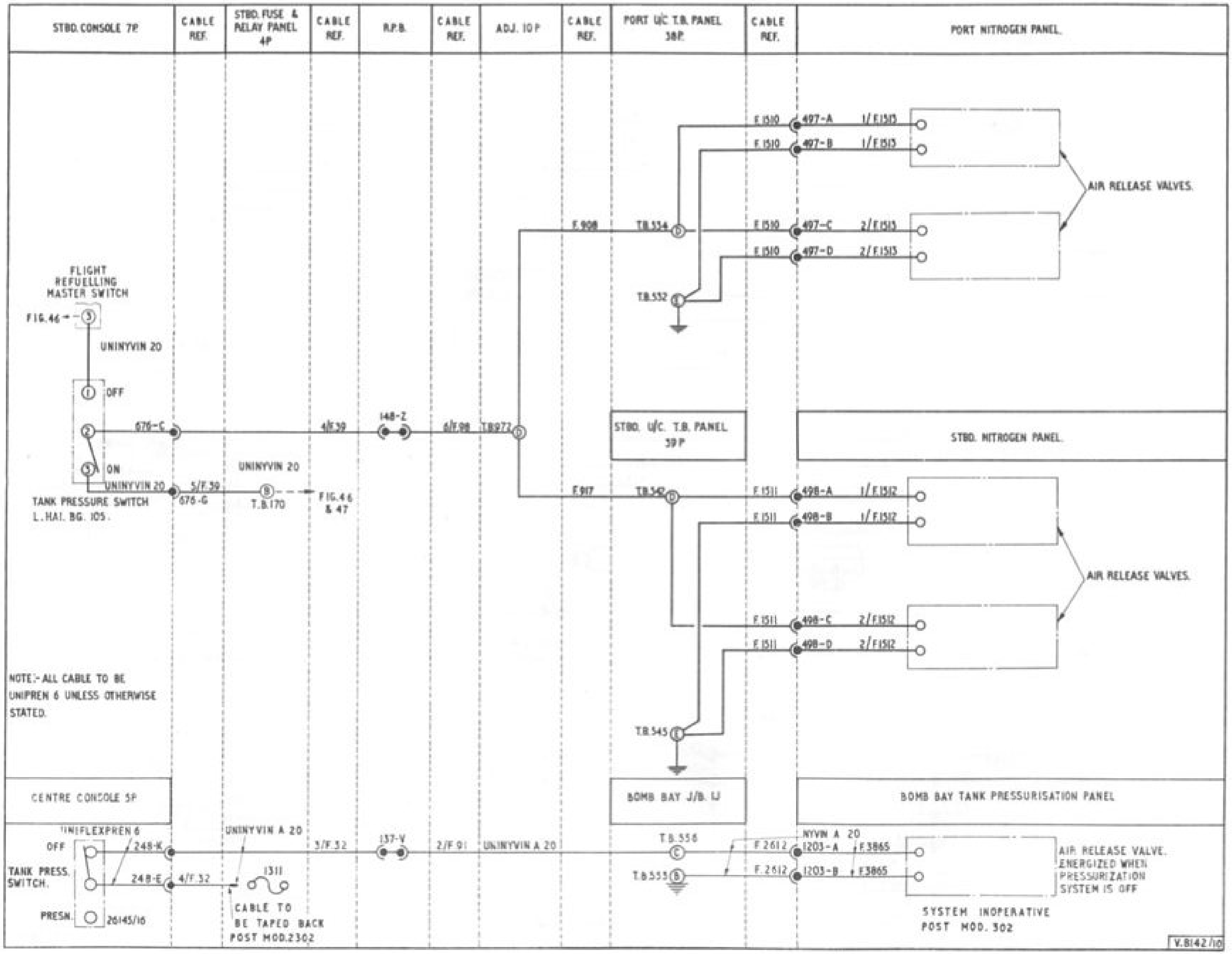


Fig. 27 Fuel tank pressurization

• Mod. 2302 incorporated •

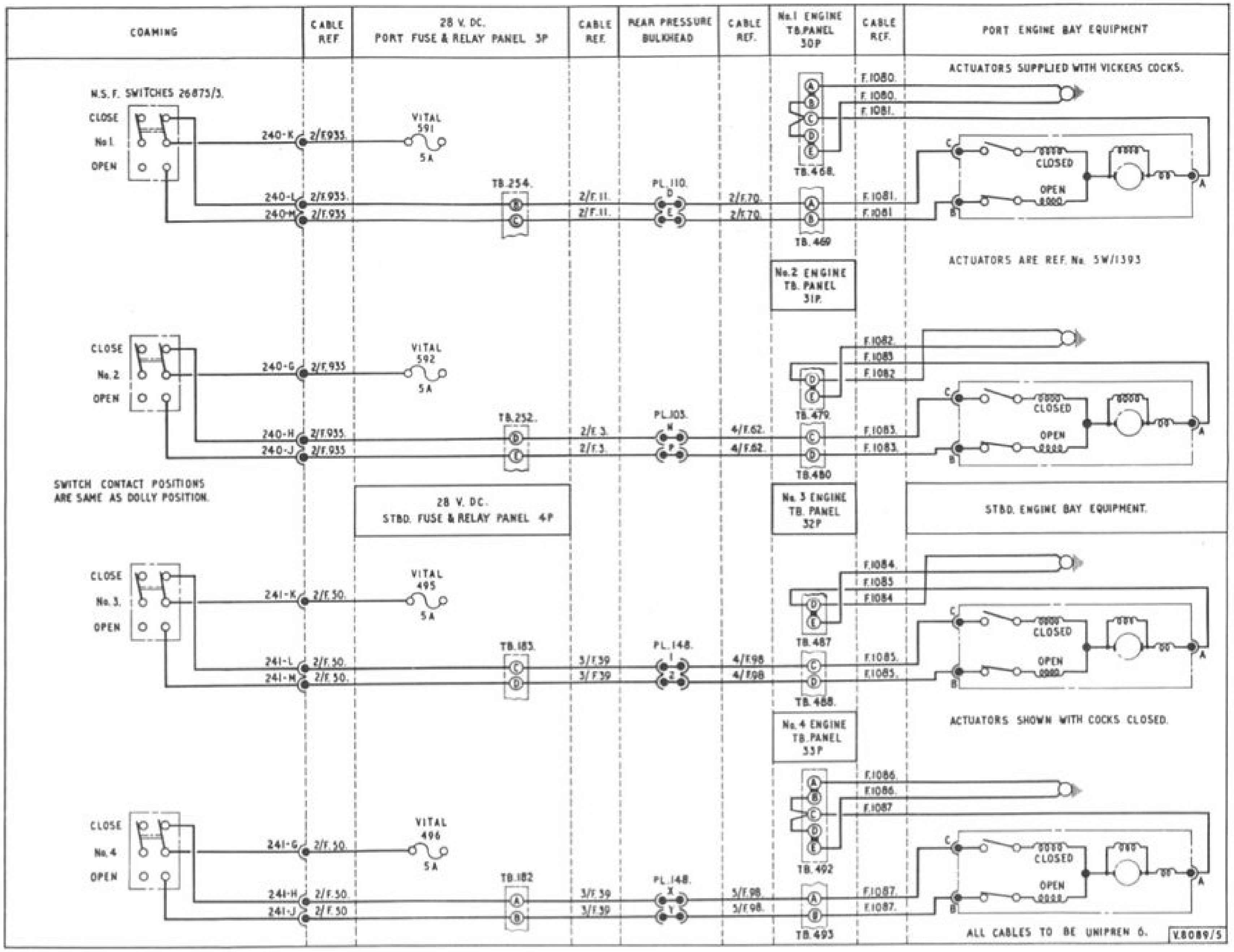


Fig. 28 L.P. fuel cocks

◄ *Minor alterations* ►

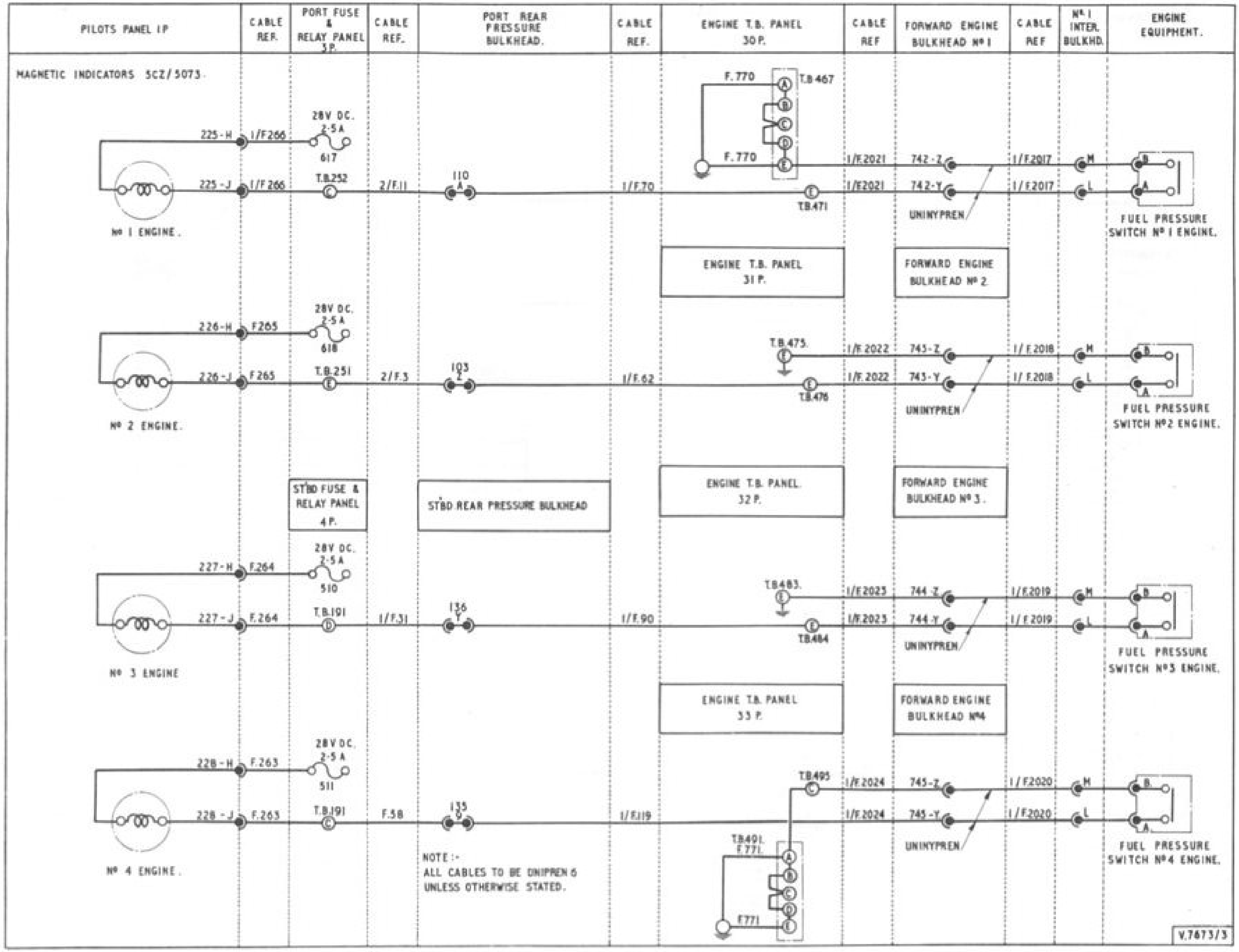


Fig. 29 Fuel pressure warning

◄ Minor alterations ►

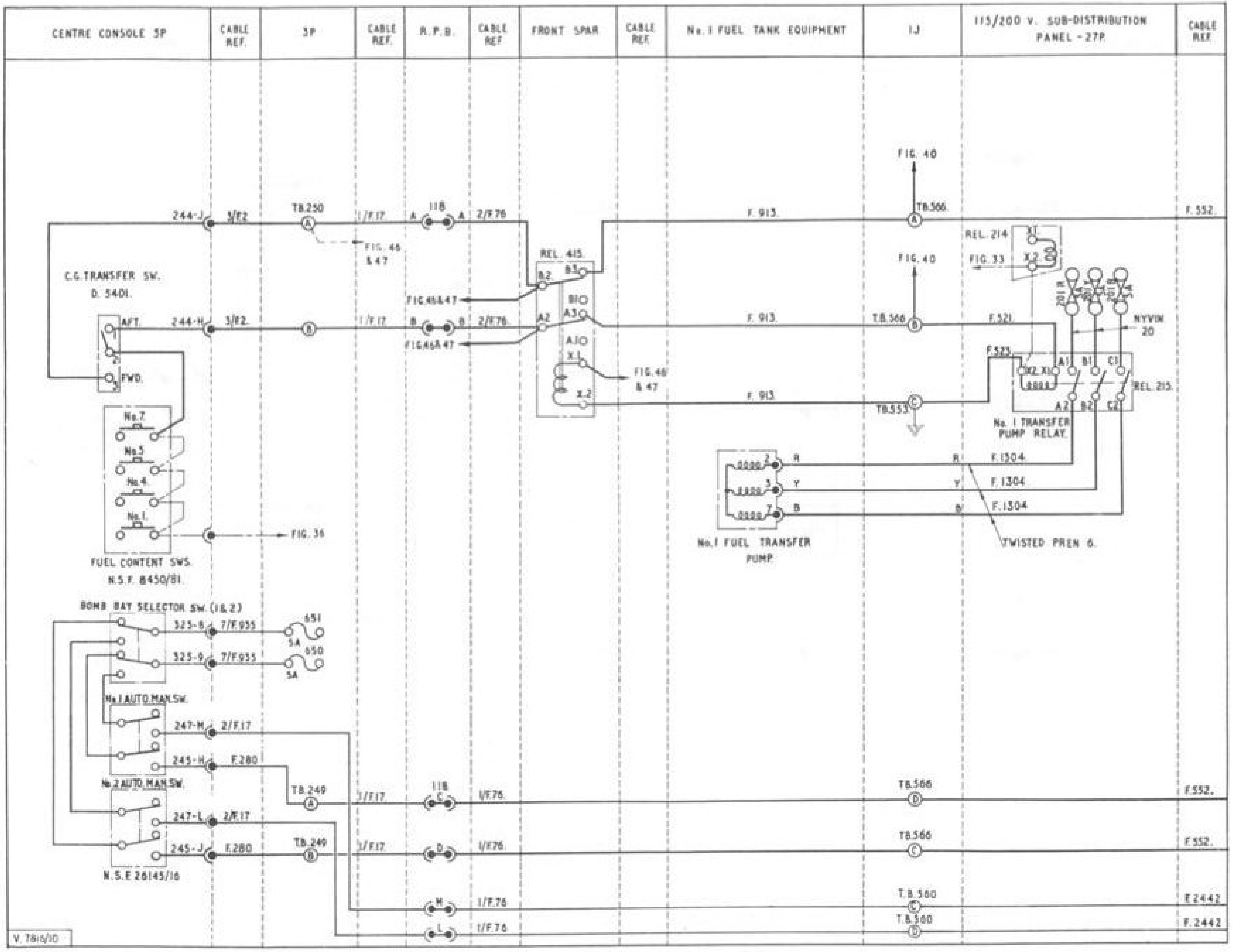


Fig. 30 (1) No 1 and 7 transfer pumps (port)

◂ Cross references changed ▸

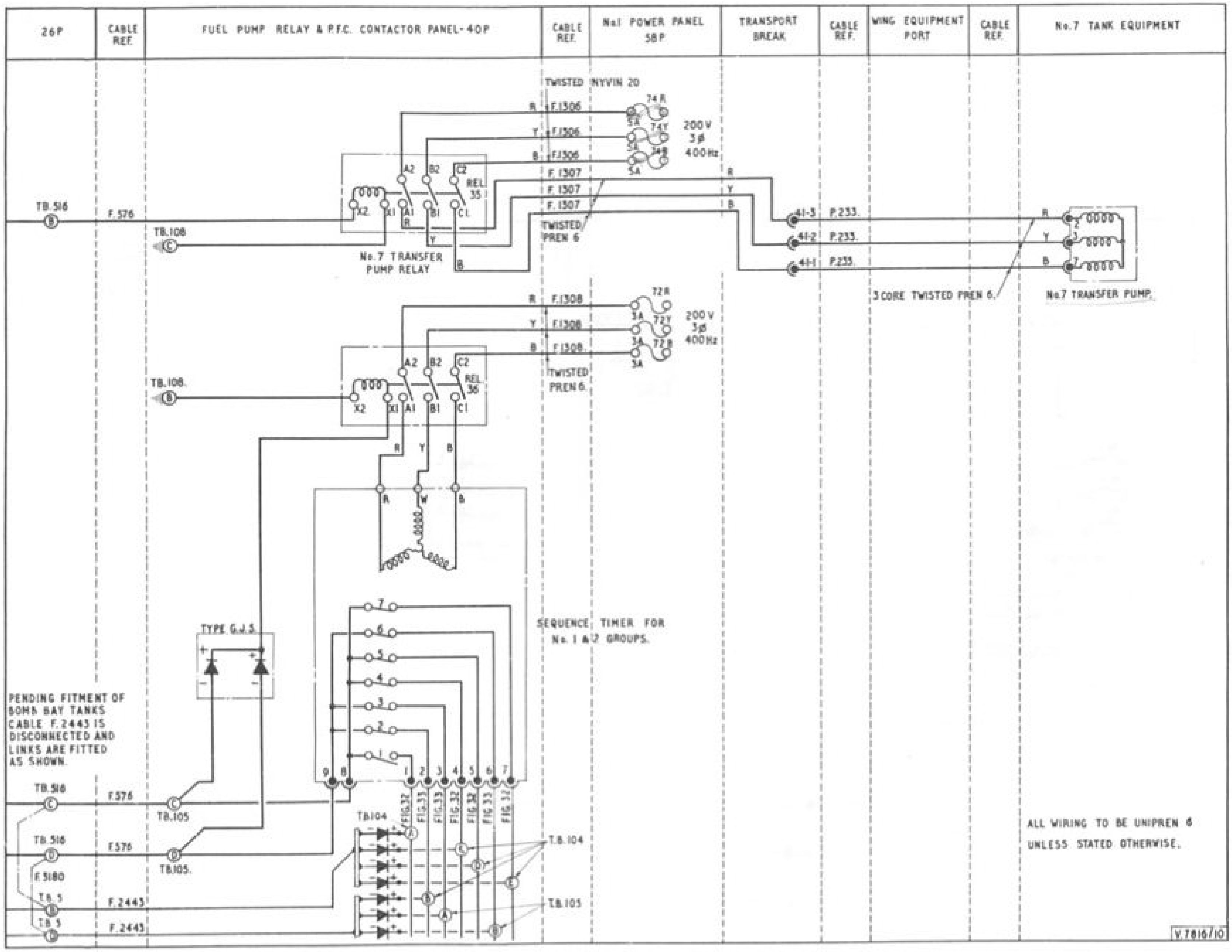


Fig 30(2) No.1 and 7 transfer pumps (port)

◂Cross references changed▸

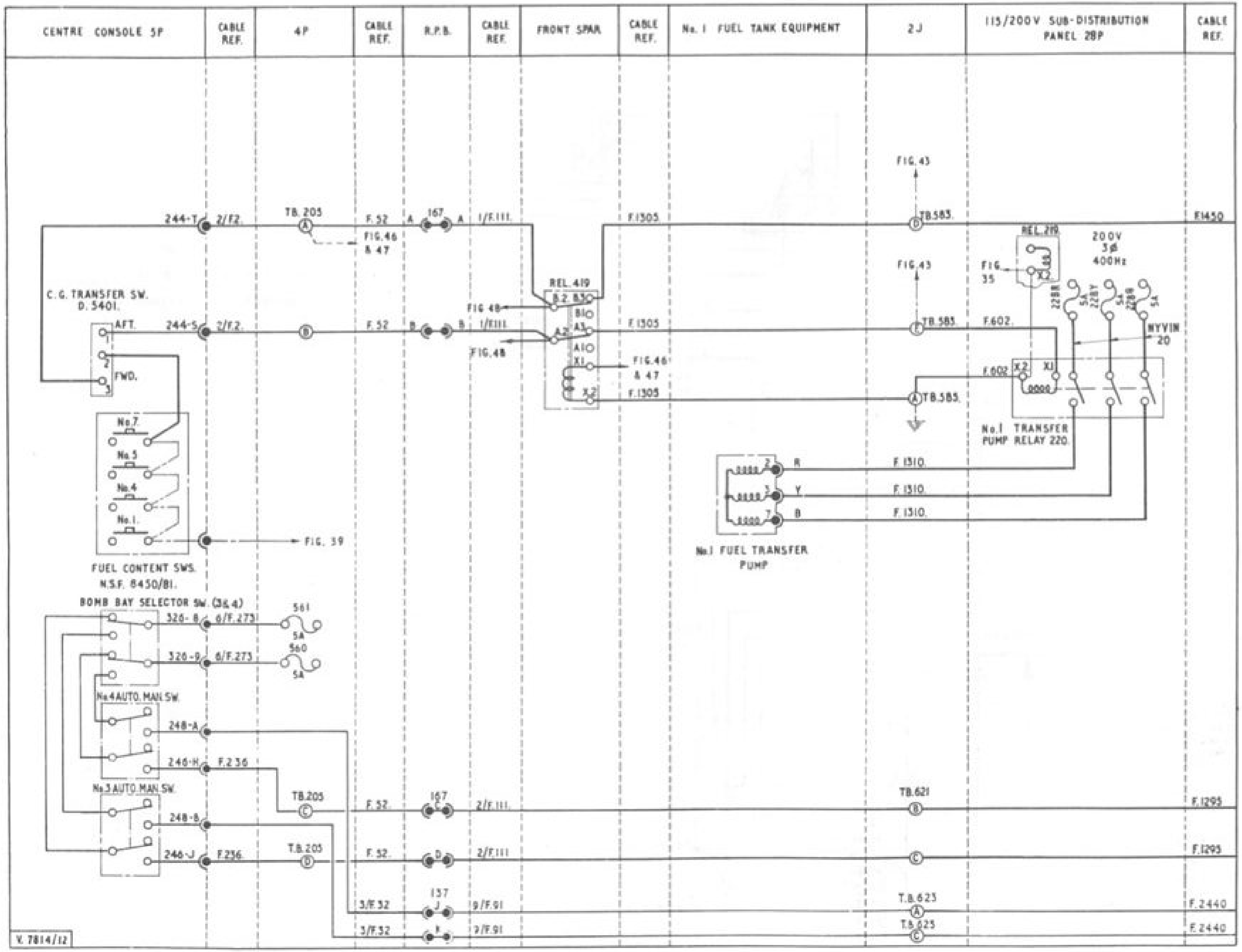


Fig. 31 (1) Nº1 and 7 transfer pumps (stbd.)

Cross references changed

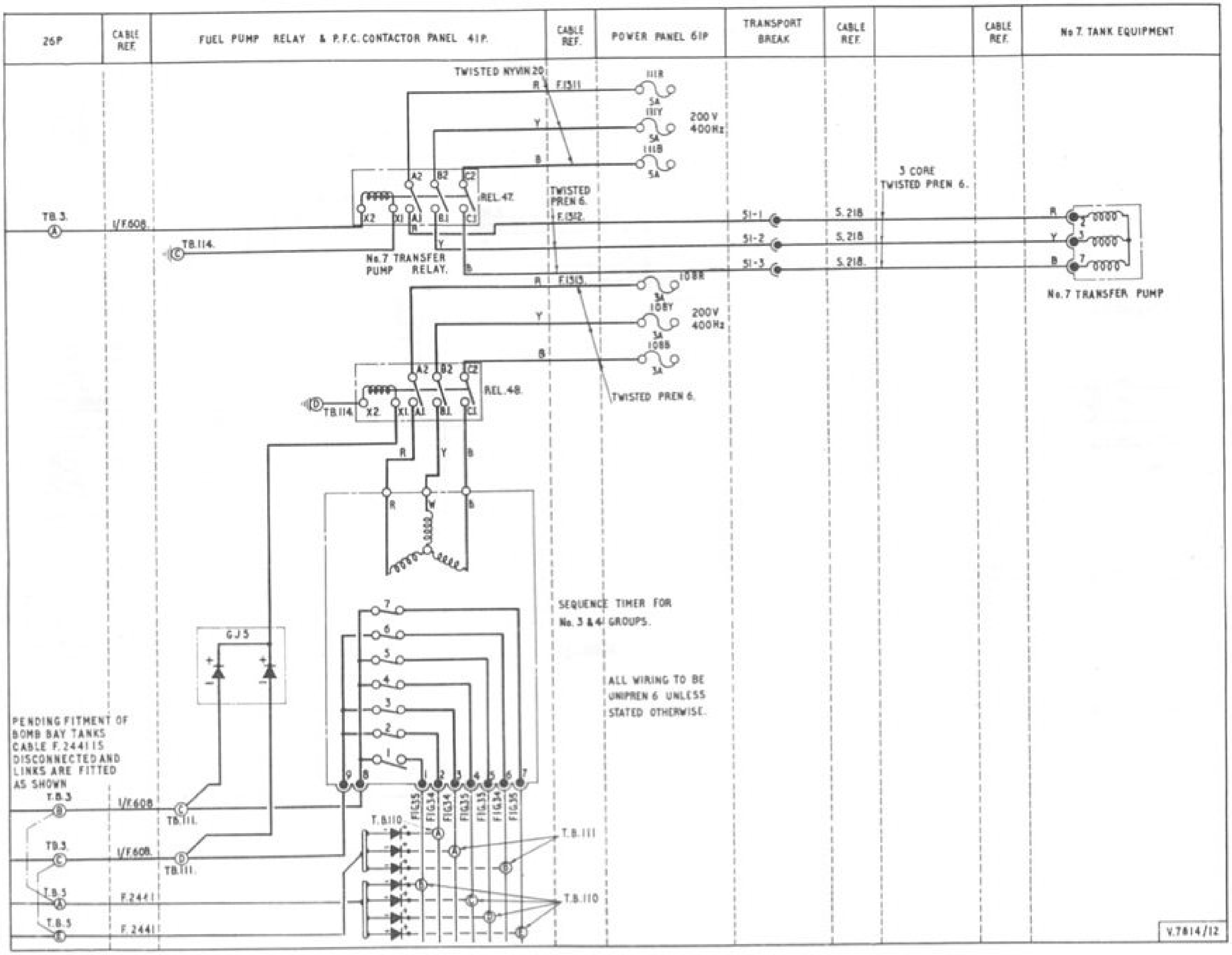


Fig. 31 (2) No. 1 and 7 transfer pumps (stbd.)

◂ Cross references changed ▸

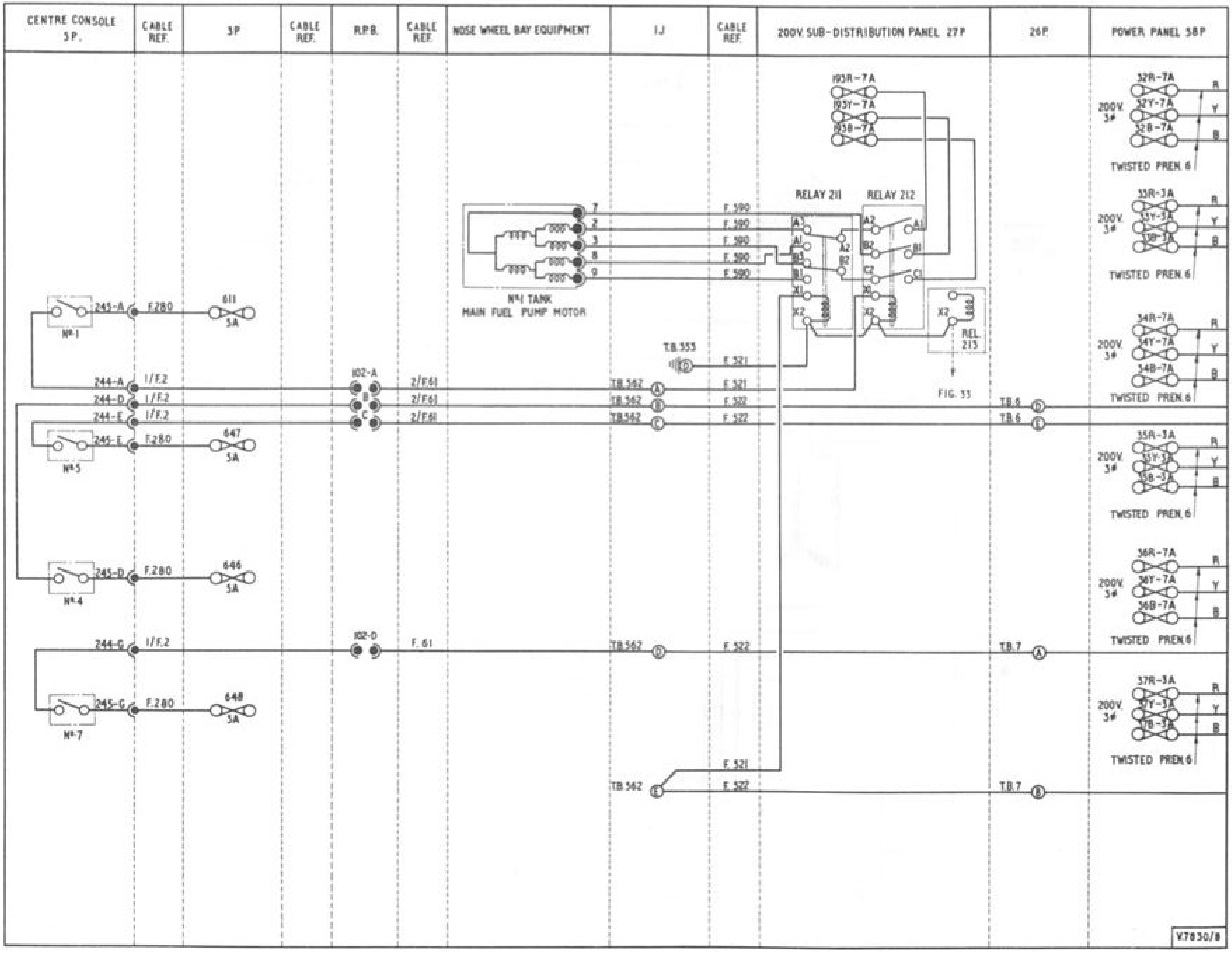


Fig. 32 (1) Main and secondary fuel pumps, Group I

◂ Cross references changed ▸

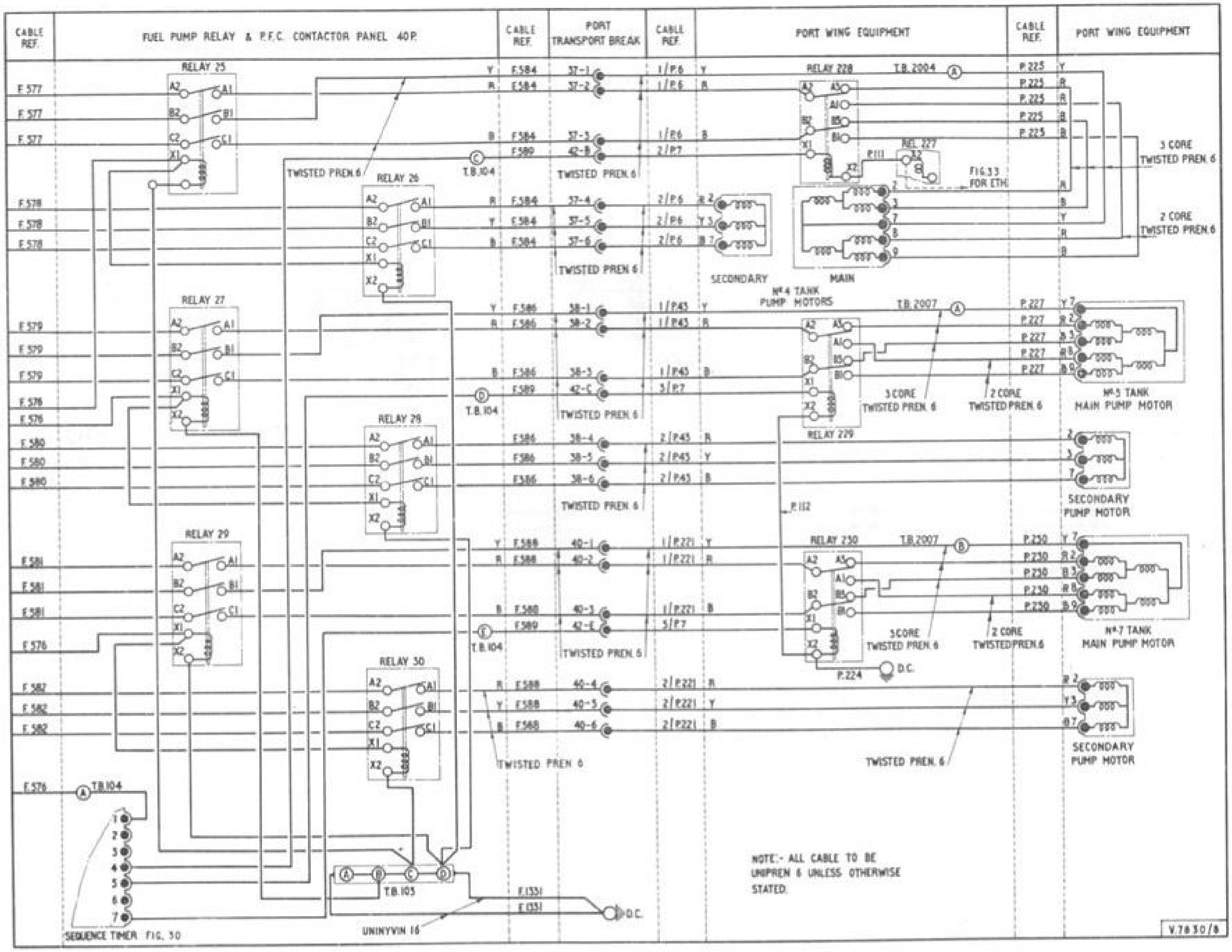


Fig. 32 (2) Main and secondary fuel pumps, Group I

* Cross references changed *

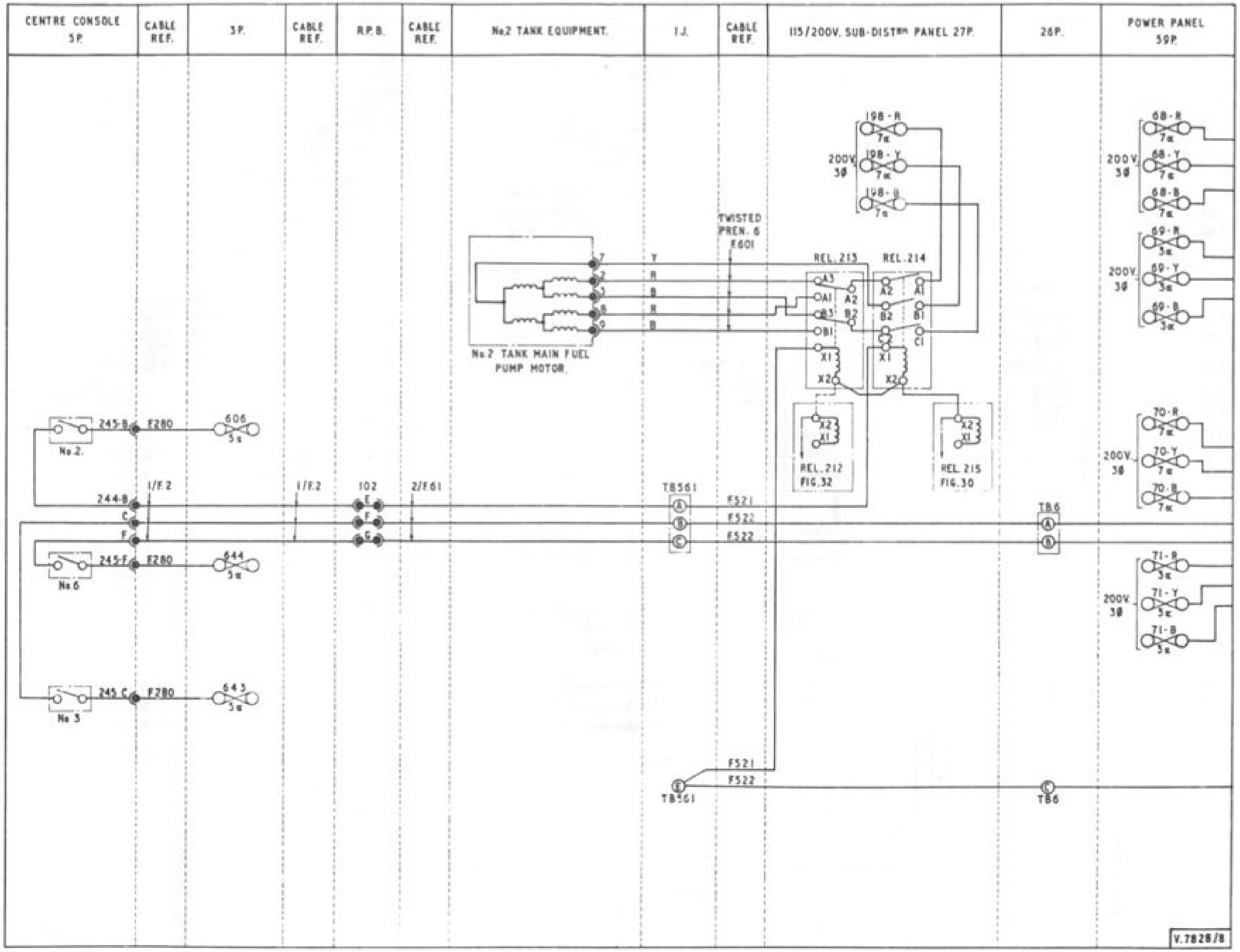


Fig. 33 (1) Main and secondary fuel pumps, Group 2

‹ Cross references changed ›

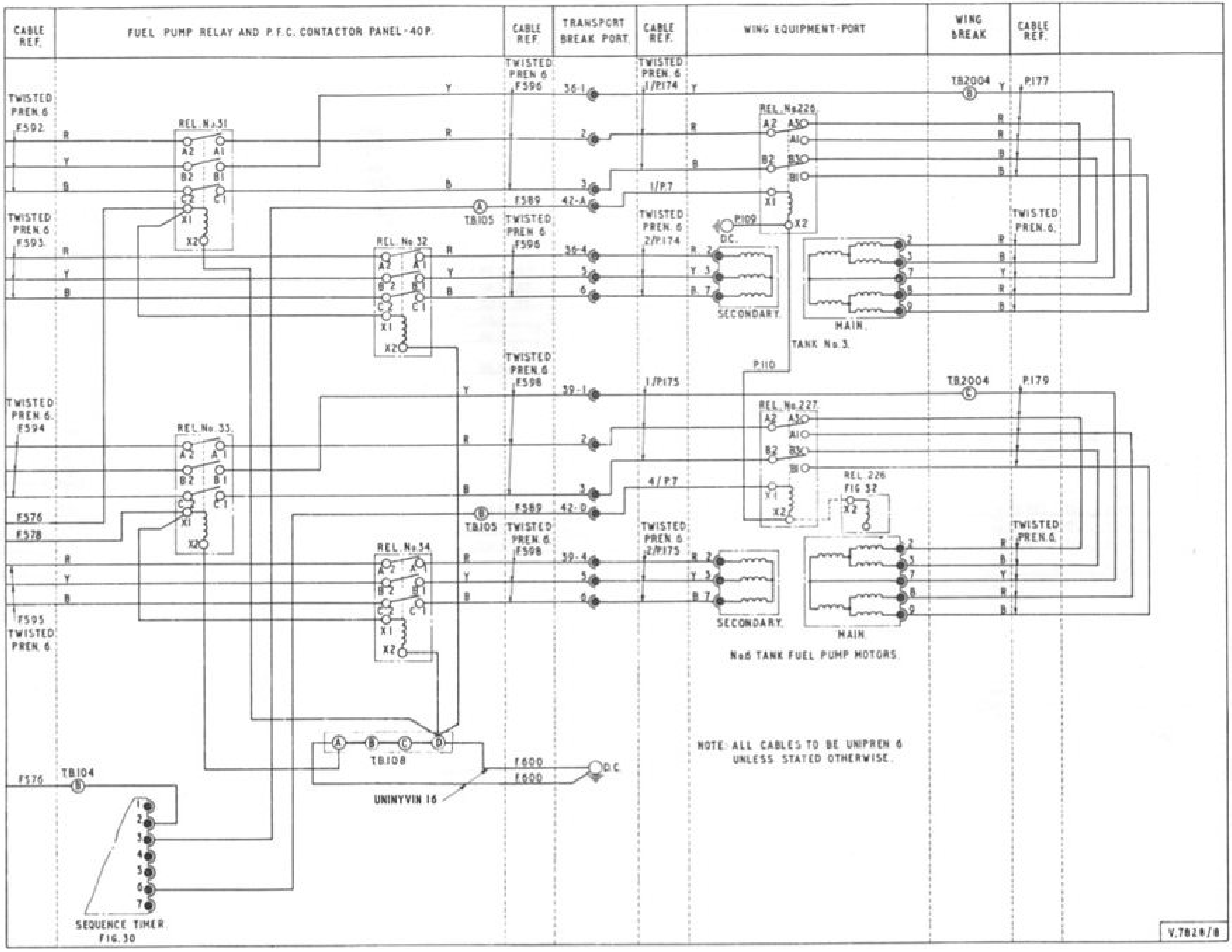


Fig. 33 (2) Main and secondary fuel pumps, Group 2

• Cross references changed •

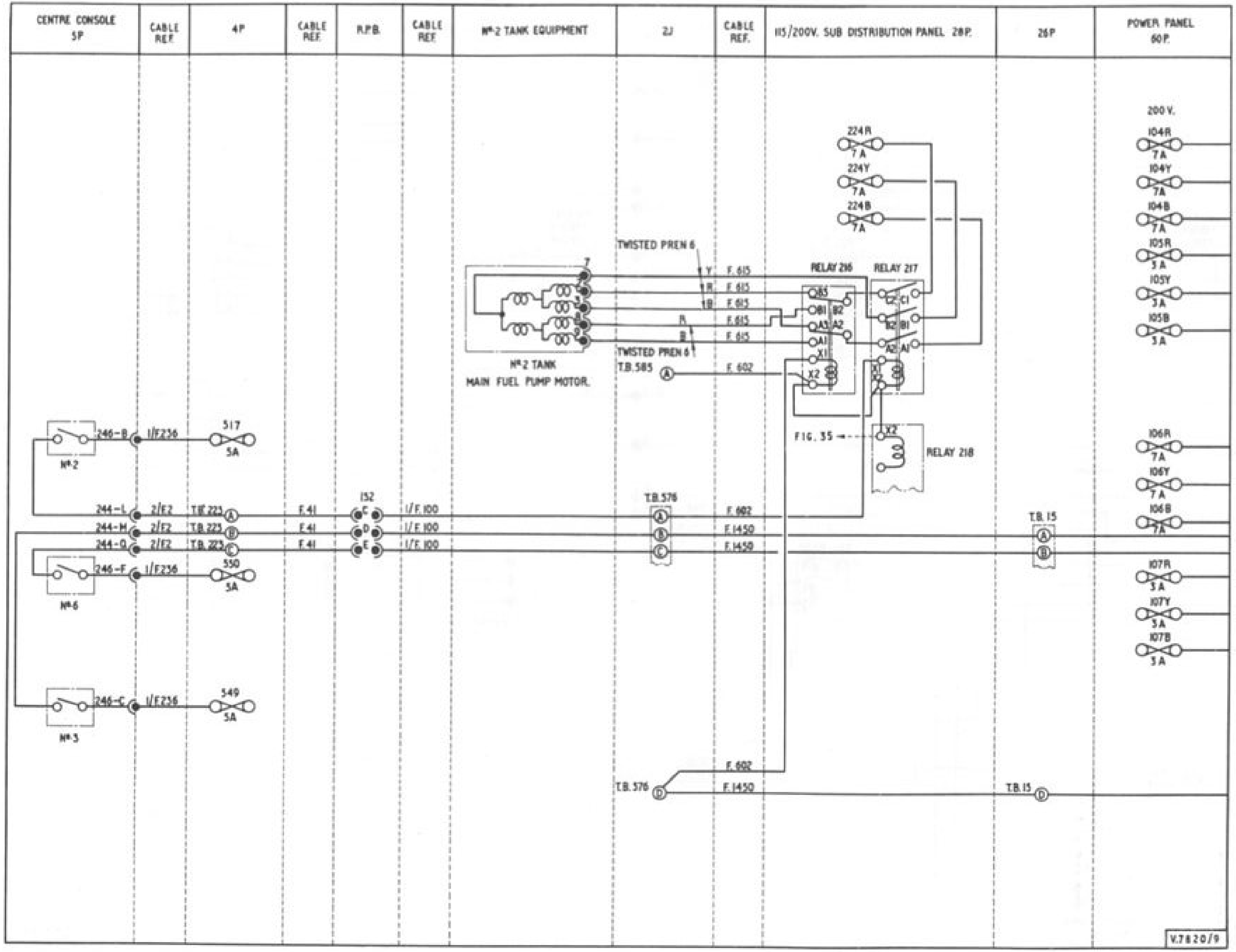


Fig. 34 (1) Main and secondary fuel pumps, Group 3

◄Cross references changed►

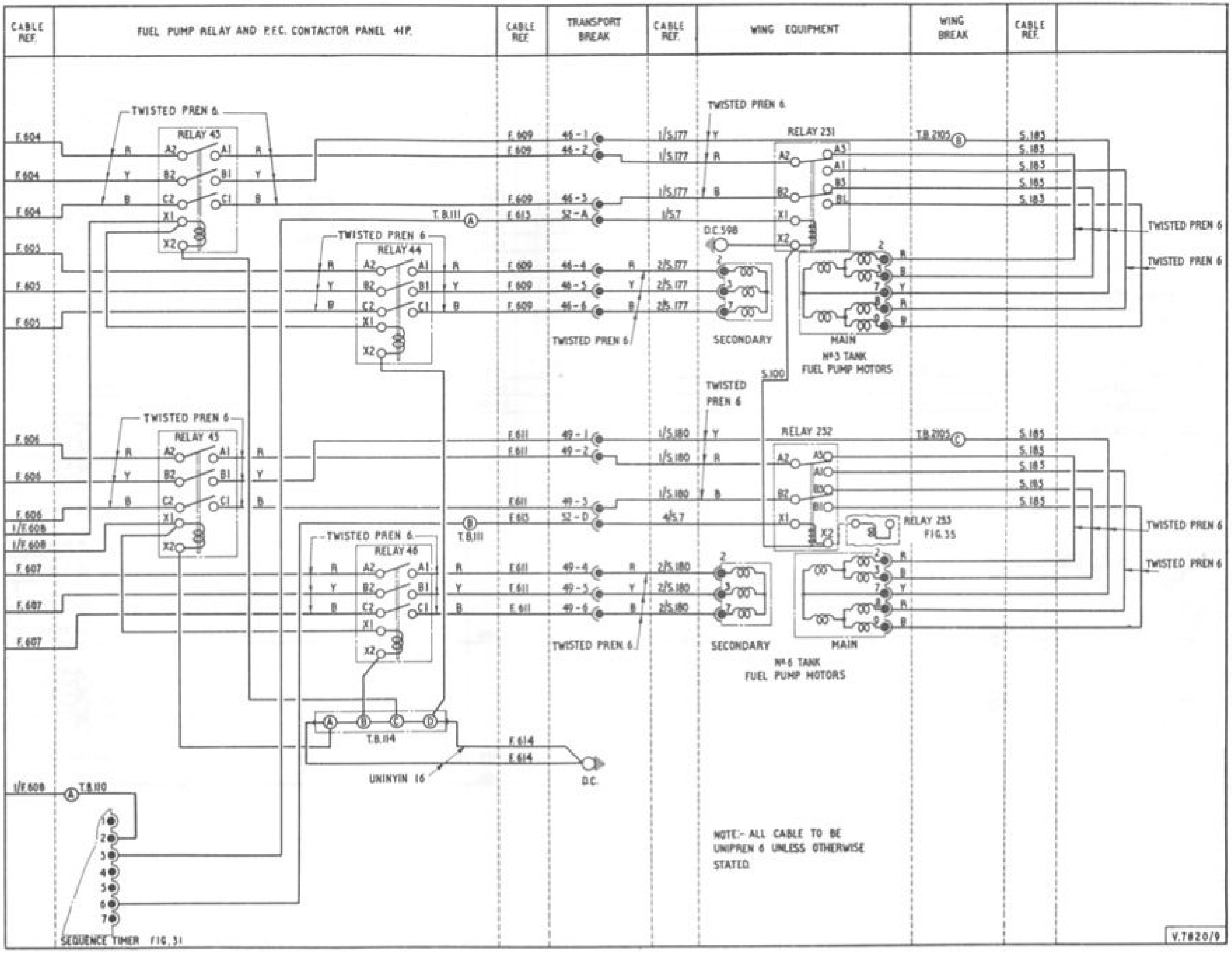


Fig. 34 (2) Main and secondary fuel pumps, Group 3

◂ Cross references changed ▸

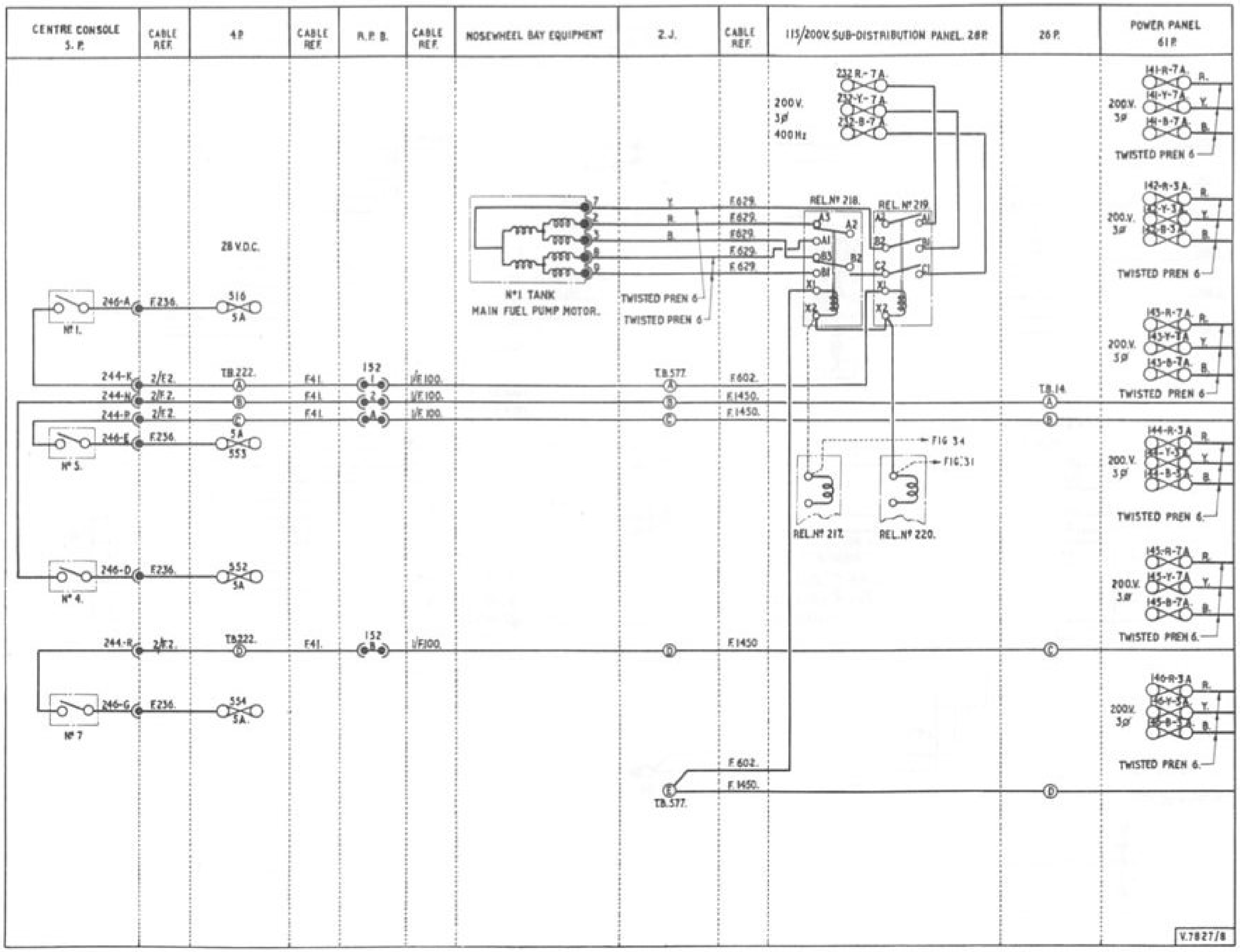


Fig. 35 (1) Main and secondary fuel pumps, Group 4

◂ Cross references changed ▸

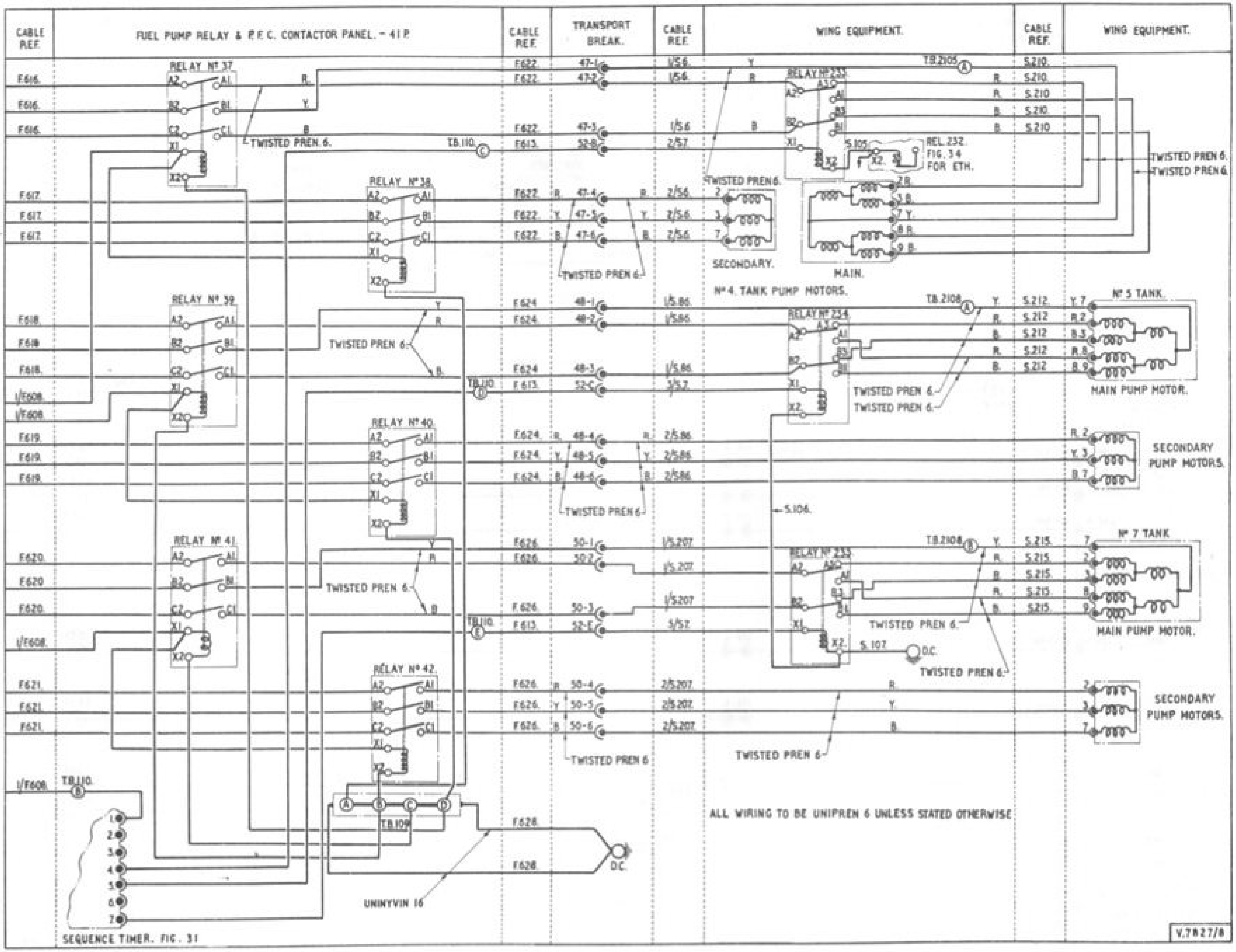


Fig. 35 (2) Main and secondary fuel pumps, Group 4

◄ Cross references changed ►

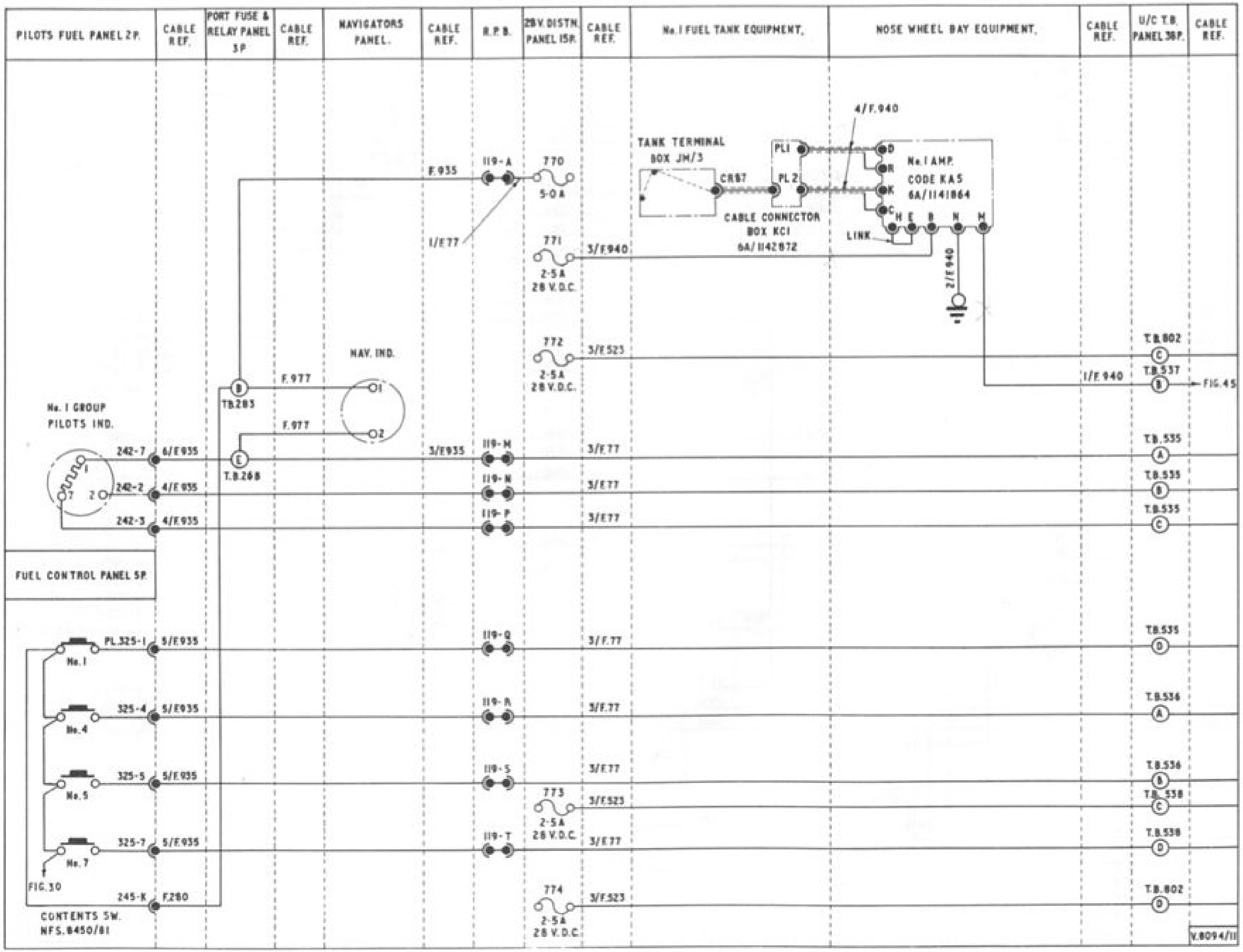


Fig. 36 (I) Fuel contents, Group I

◄ *Mod 2283 incorporated* ►

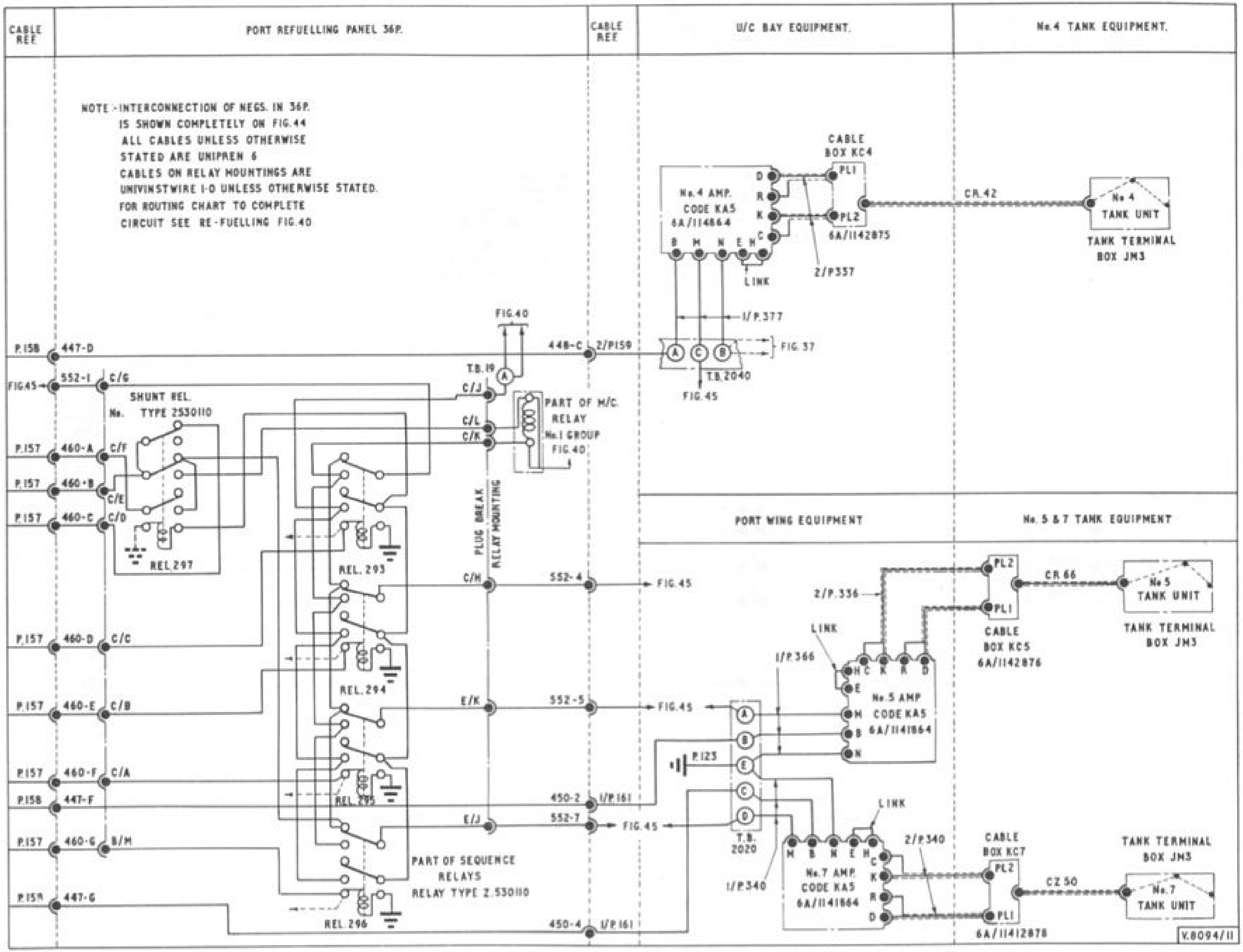


Fig. 36(2) Fuel contents, Group 1
◂ *Mod 2283 incorporated* ▸

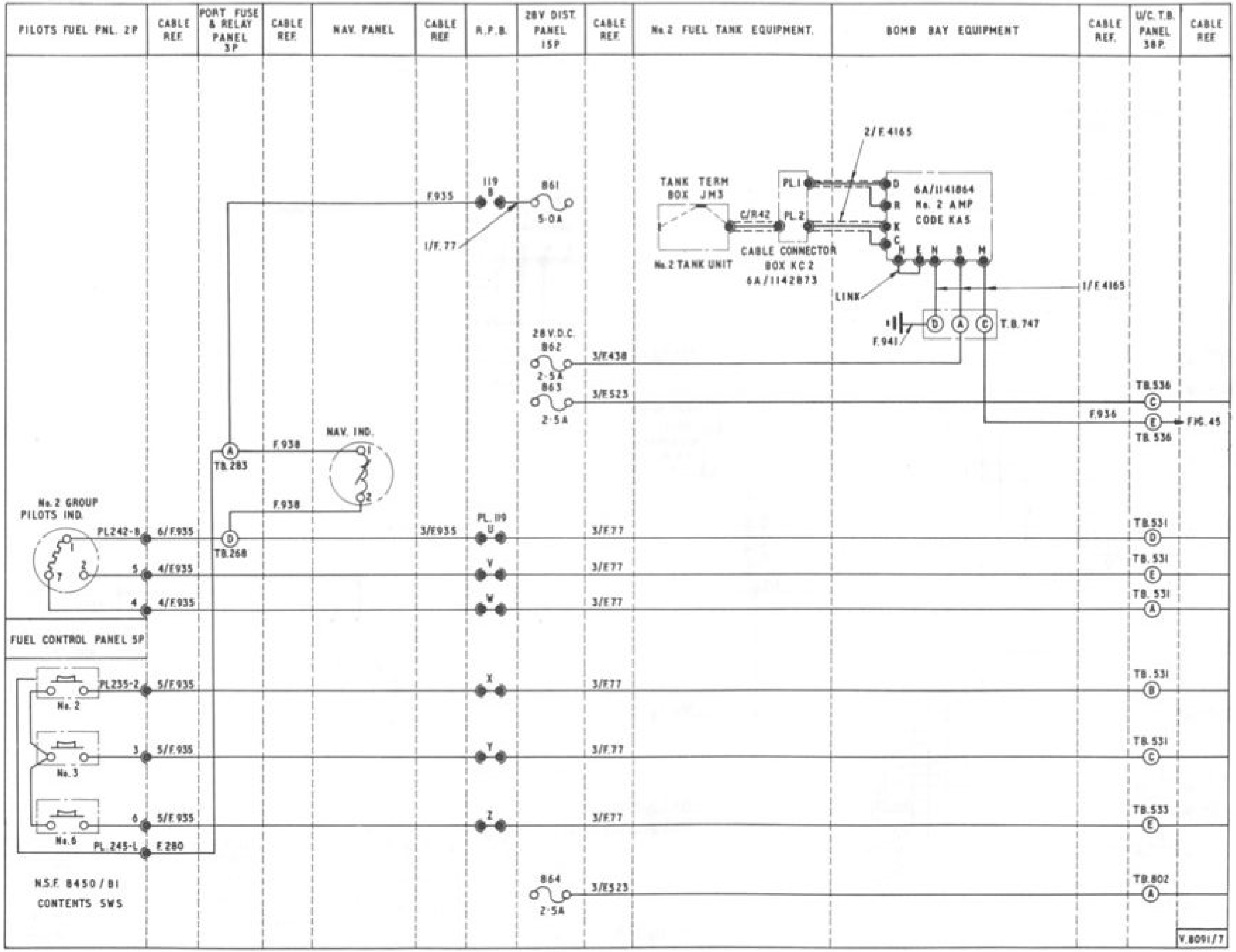


Fig. 37 (1) Fuel contents, Group 2

◂ Mod 2283 incorporated ▸

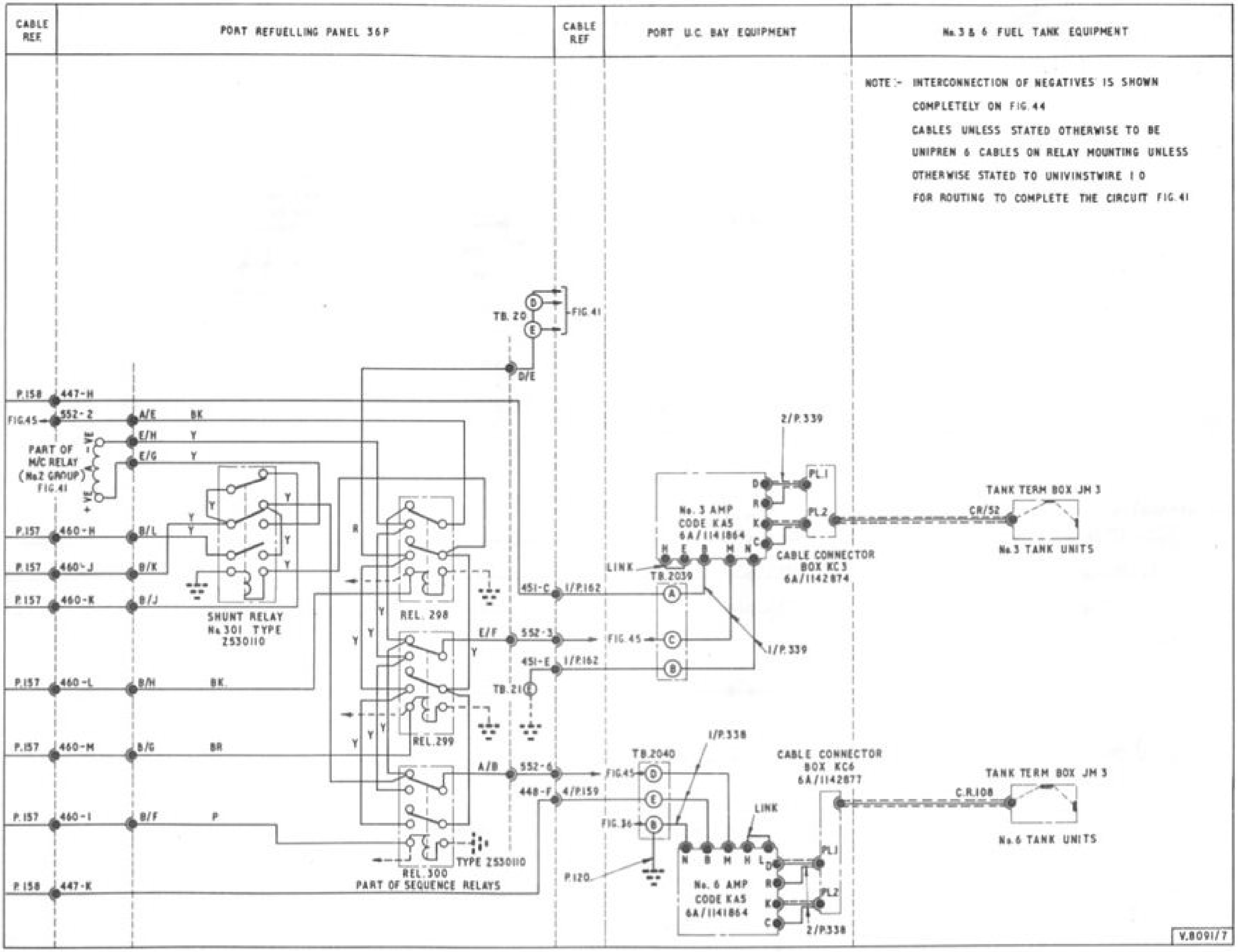


Fig. 37 (2) Fuel contents, Group 2

◄ *Mod 2283 incorporated* ►

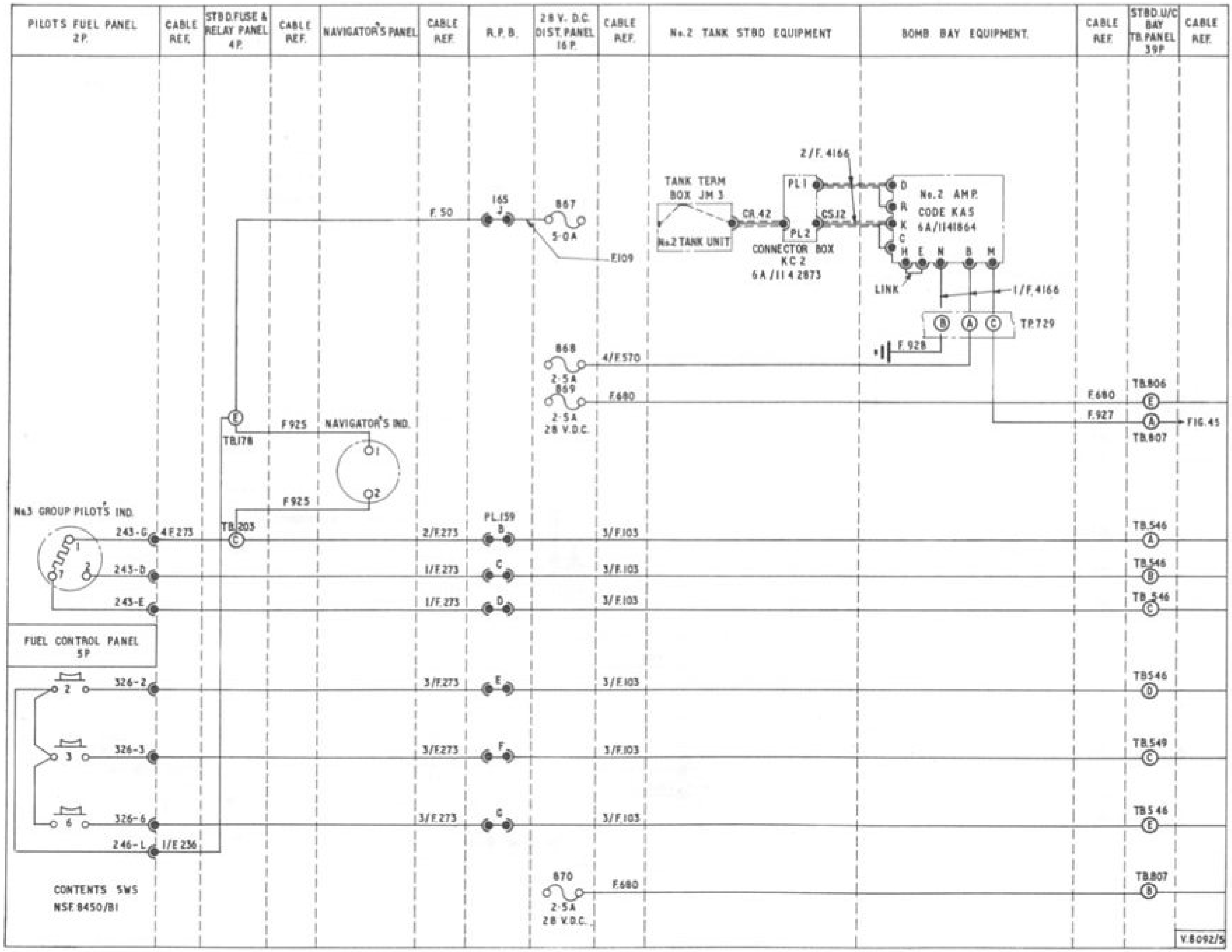


Fig. 38 (1) Fuel contents, Group 3

◂ Mod 2283 incorporated ▸

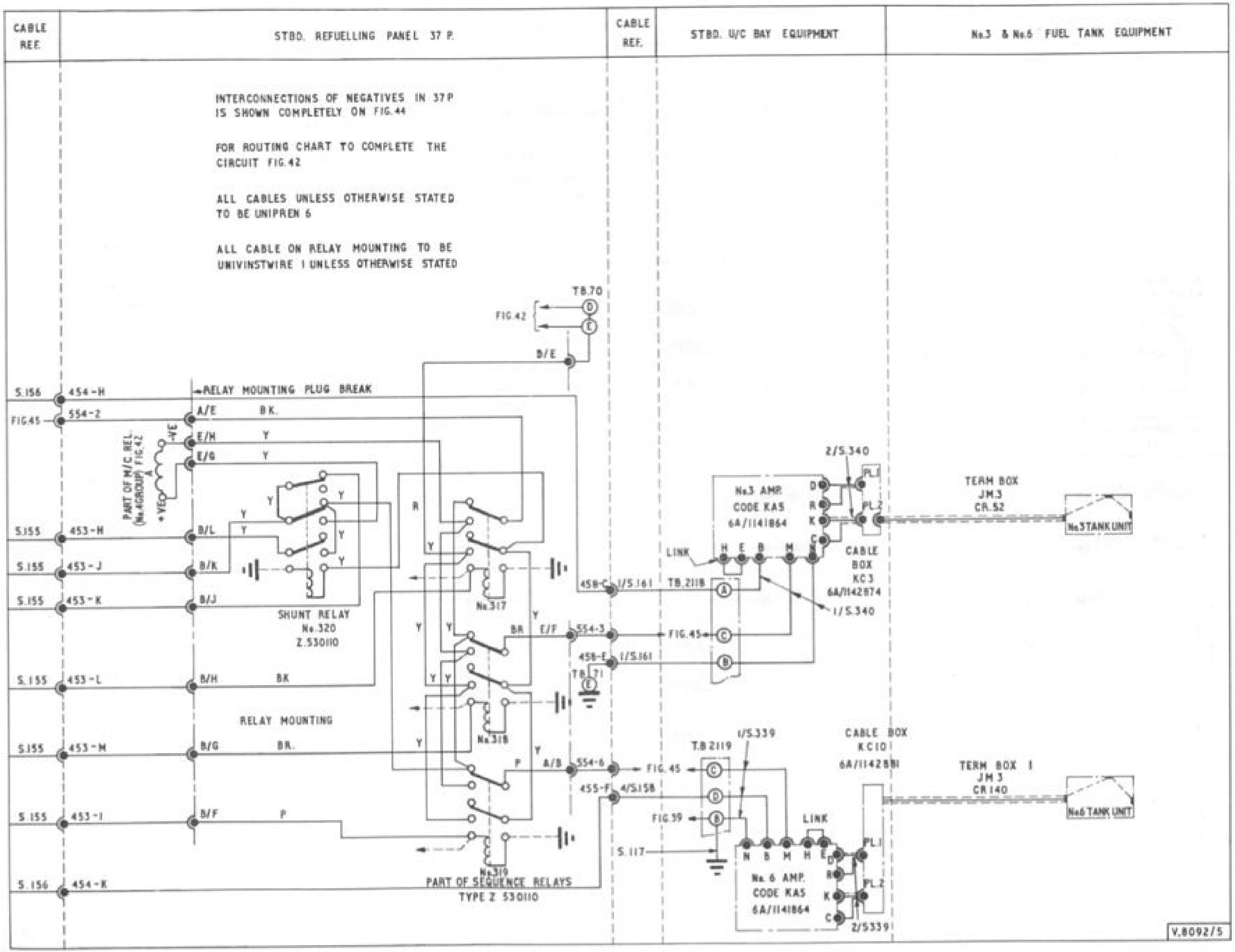


Fig.38 (2) Fuel contents, Group 3

◂ *Mod 2283 incorporated* ▸

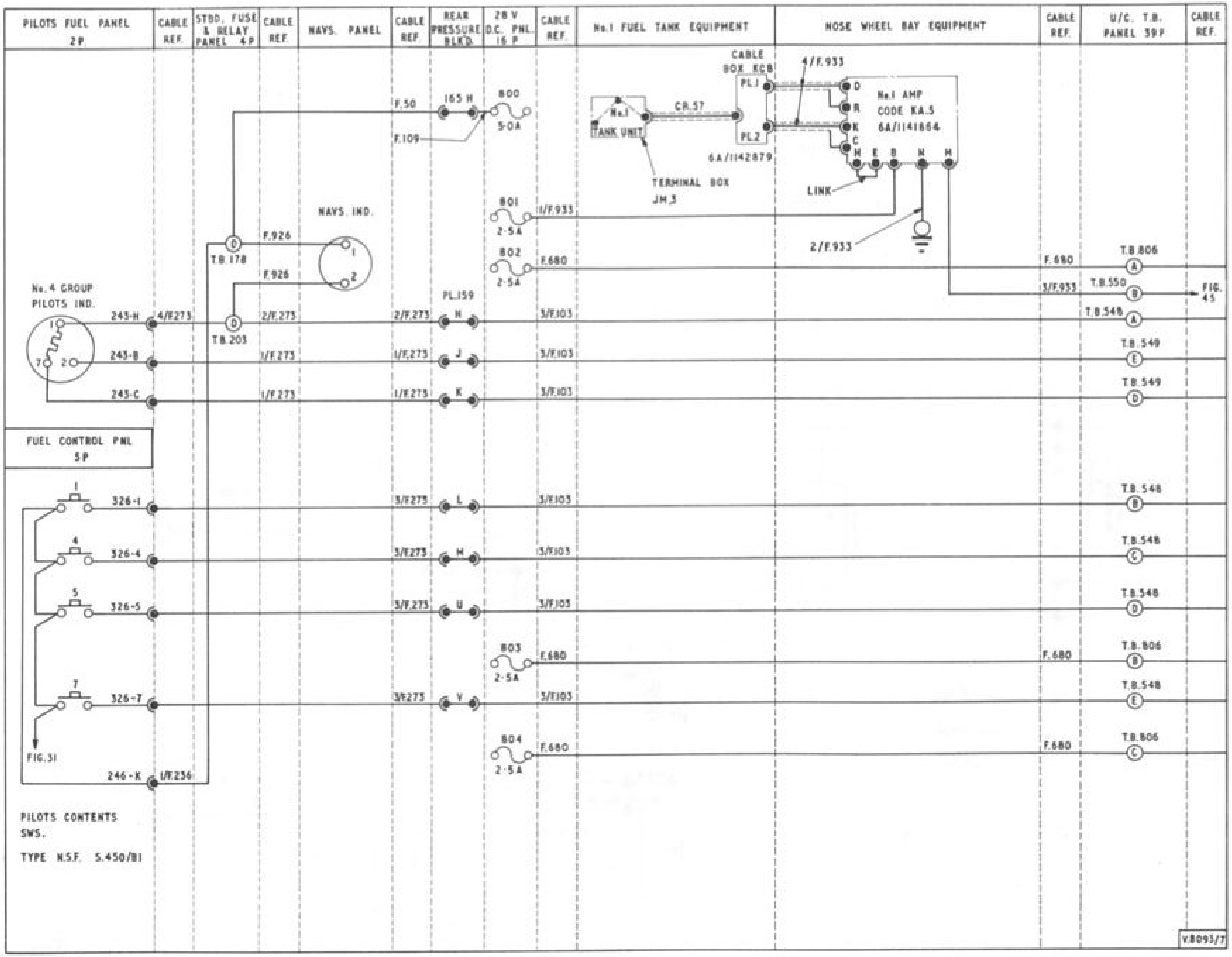


Fig. 39 (1) Fuel contents, Group 4

◂ *Mod 2283 incorporated* ▸

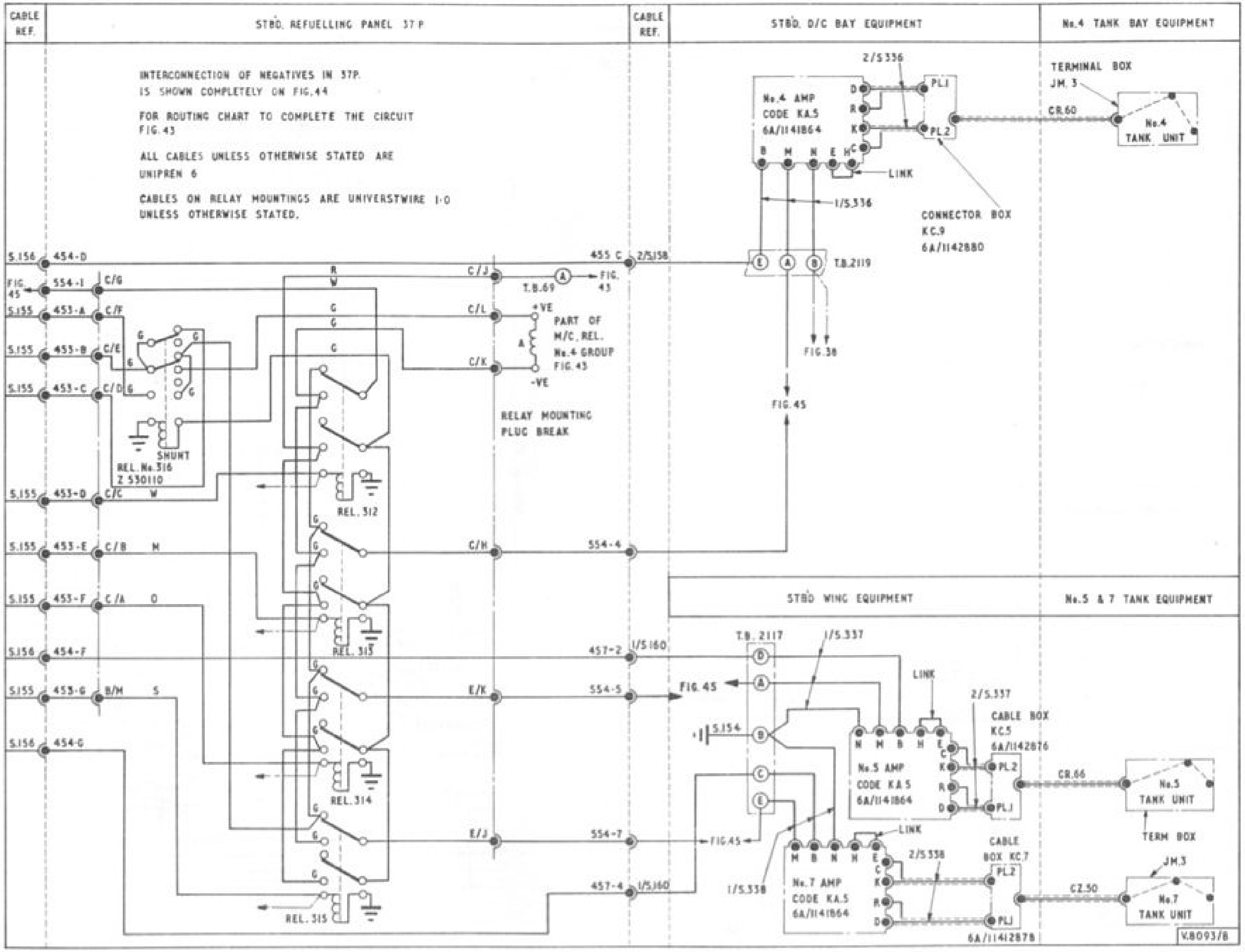


Fig.39 (2) Fuel contents, Group 4

◀ T.B. 2117 terminals A and D reversed ▶

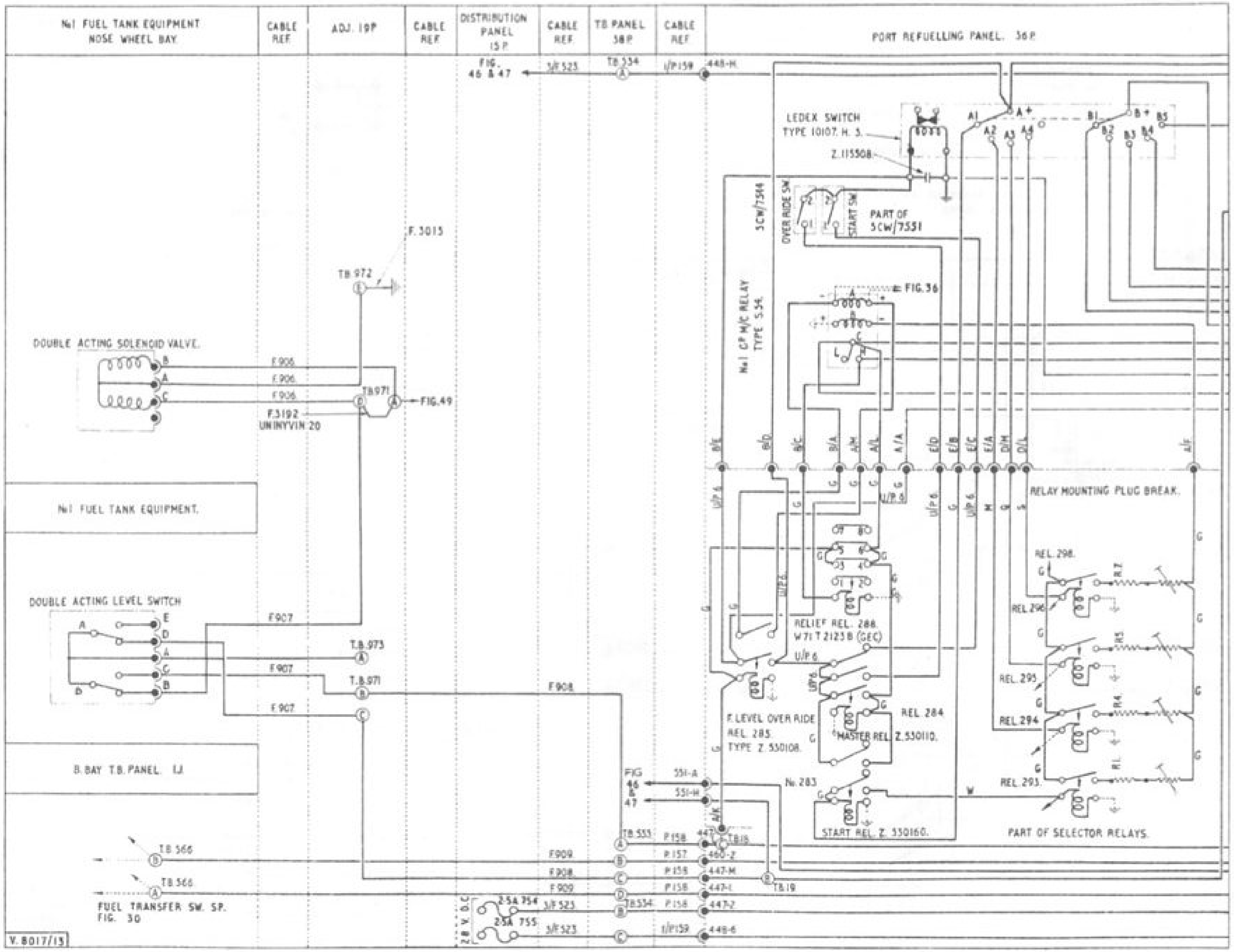


Fig. 40 (1) Refuelling, Group I

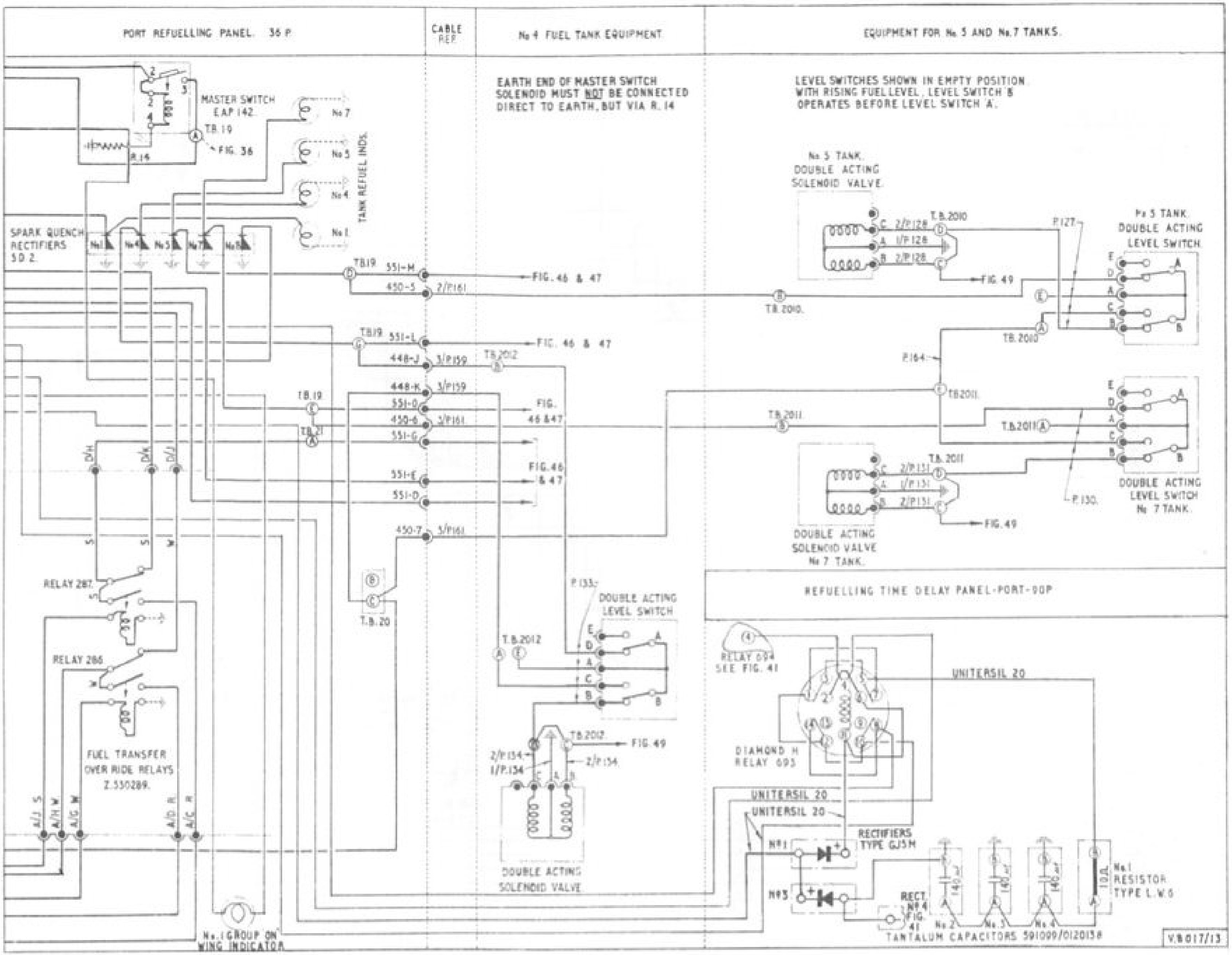


Fig. 40 (2) Refuelling, Group 1

◂ Minor alterations ▸

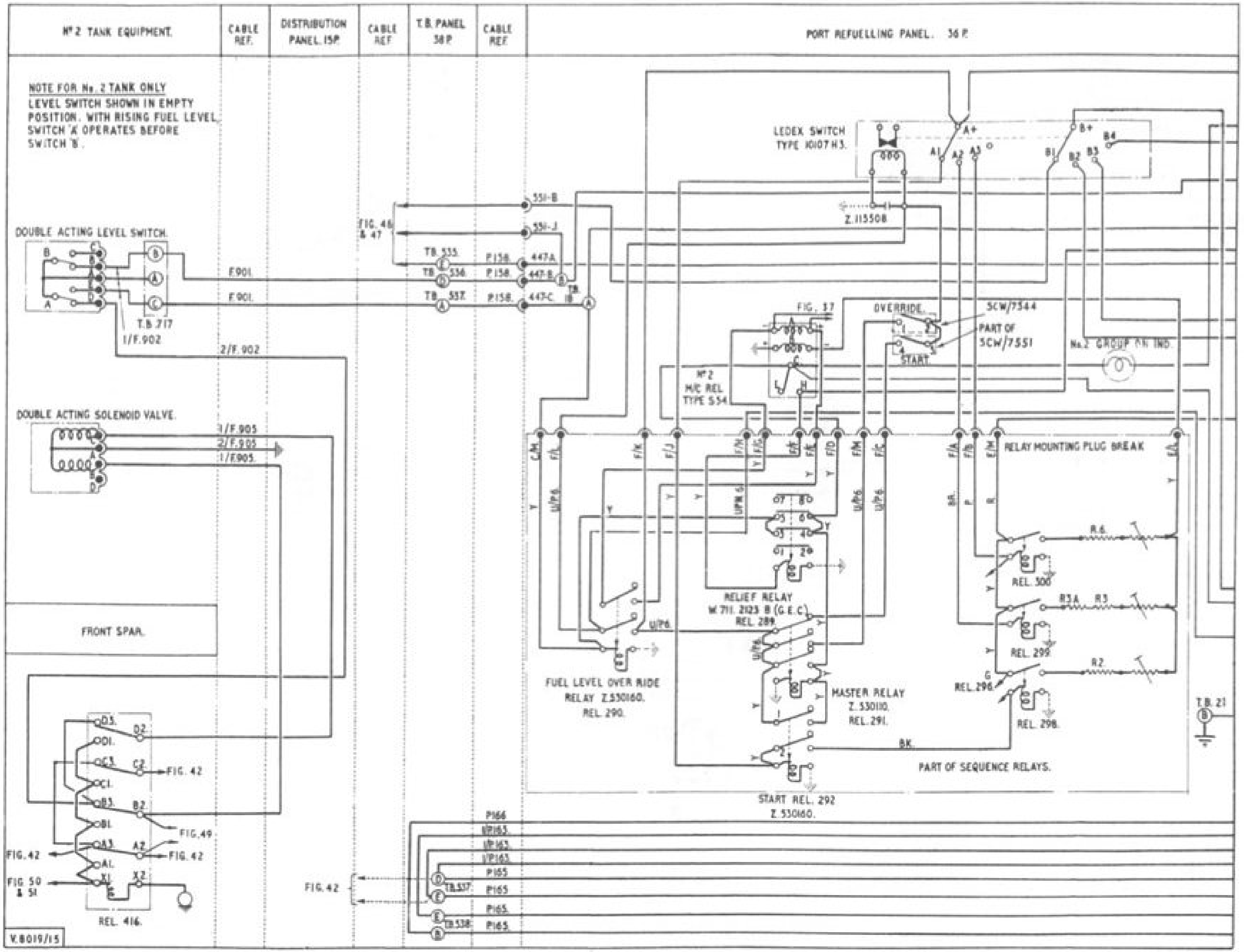


Fig. 41 (1) Refuelling, Group 2

◂ Cross references changed ▸

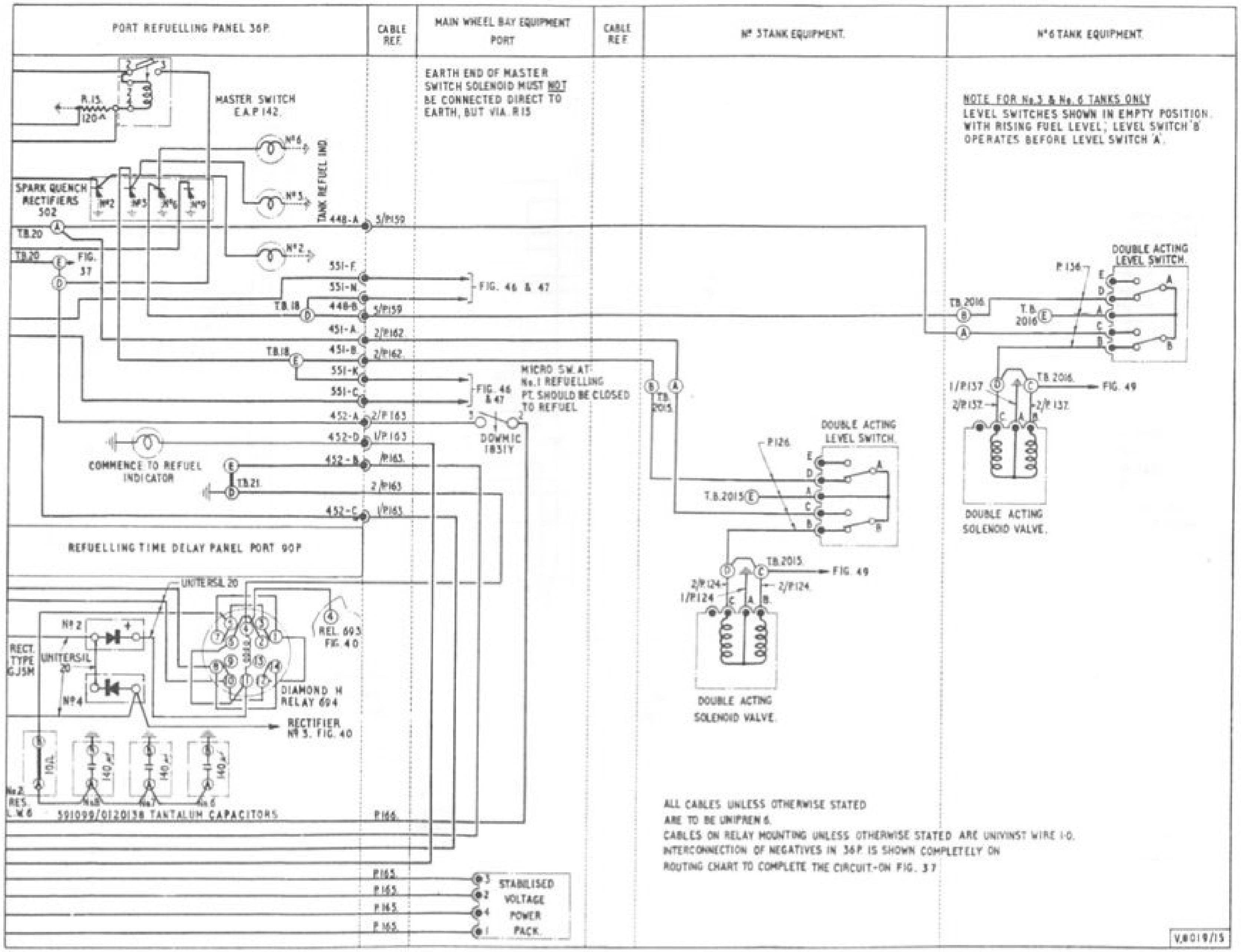


Fig. 41 (2) Refuelling, Group 2

◄ Cross references changed ►

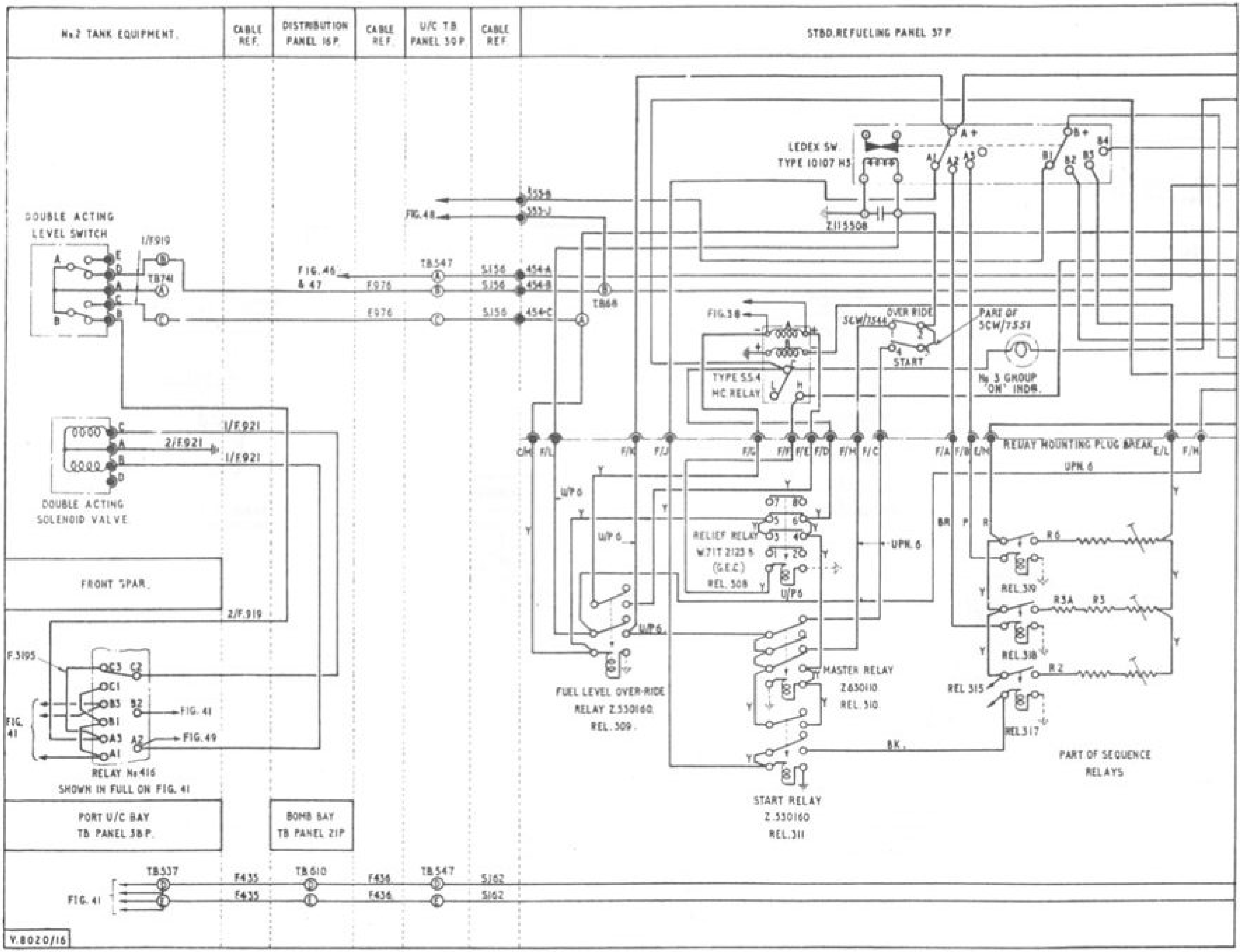


Fig. 42 (1) Refuelling Group 3

«Cross references changed »

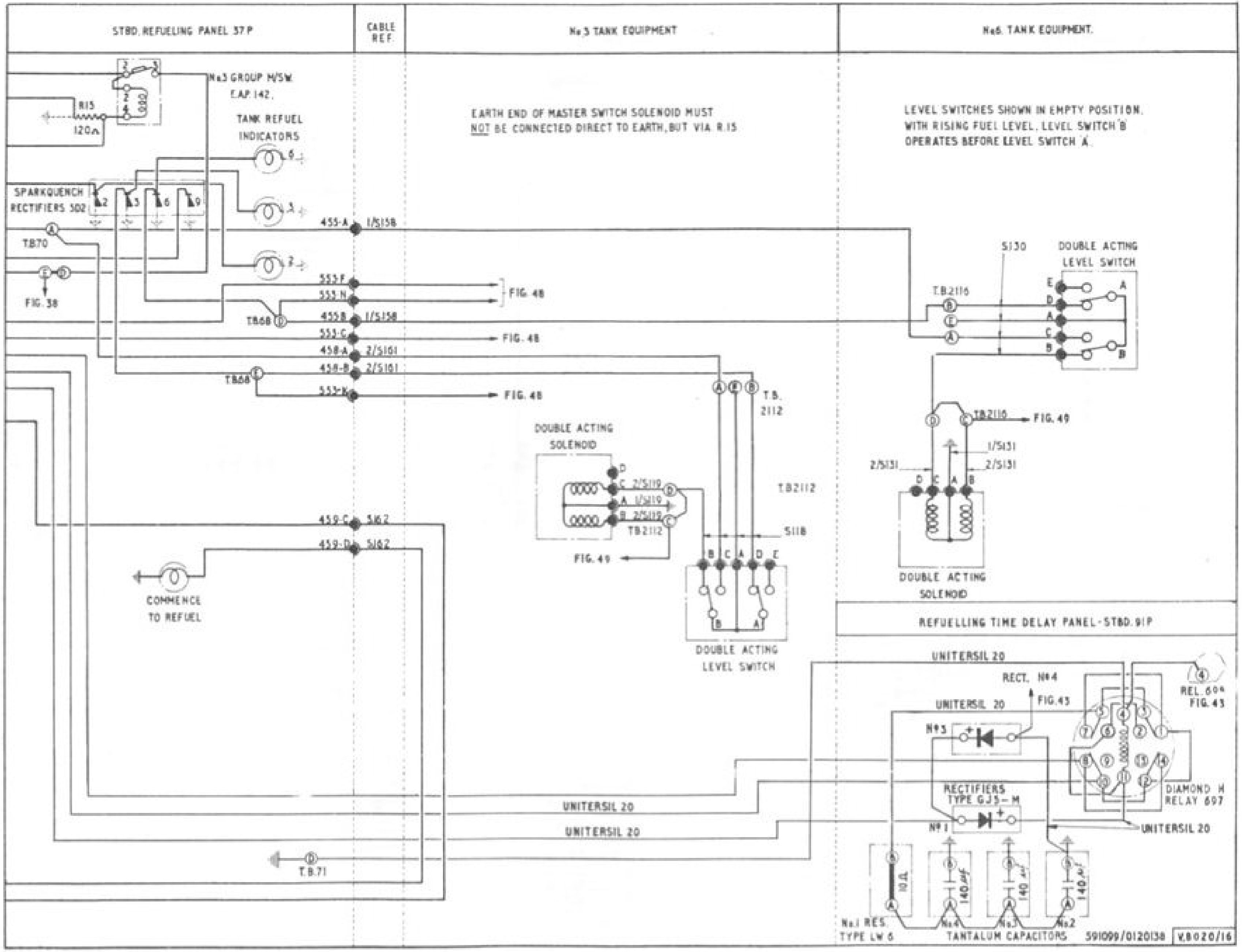


Fig.42 (2) Refuelling, Group 3

◂ Cross references changed ▸

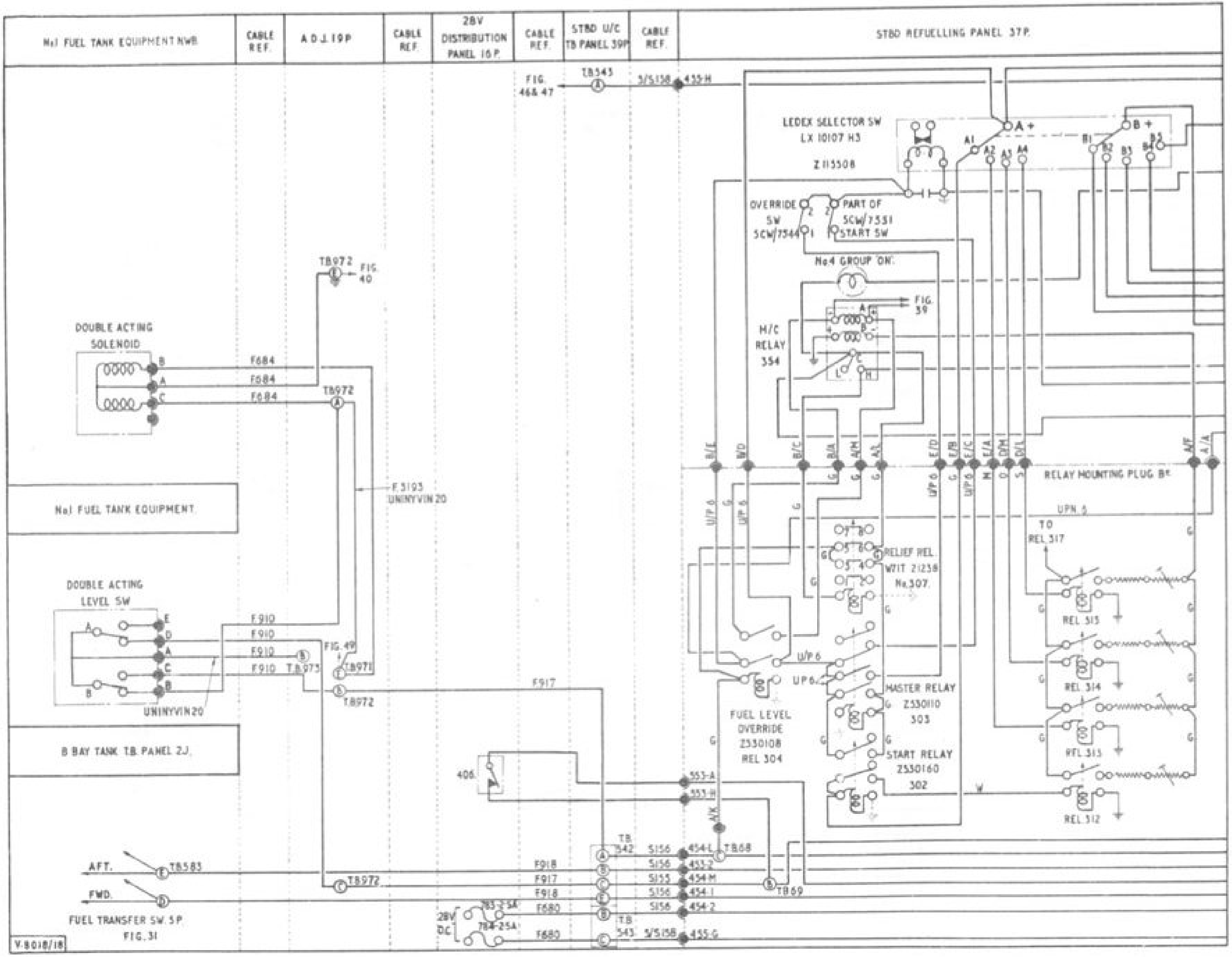


Fig. 43 (1) Refuelling, Group 4

◄Cross references changed►

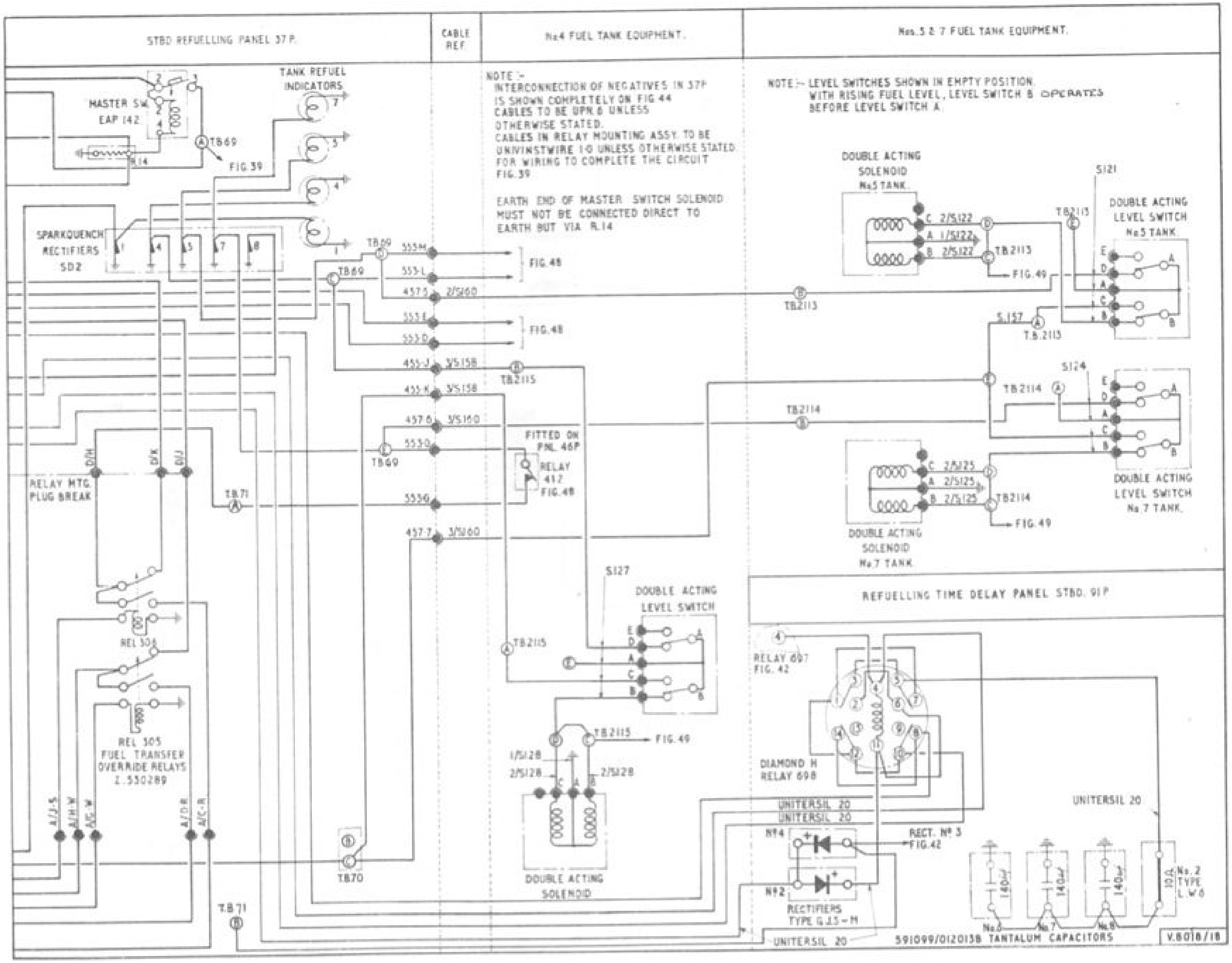


Fig. 43 (2) Refuelling. Group 4

◄ Cross references changed ►

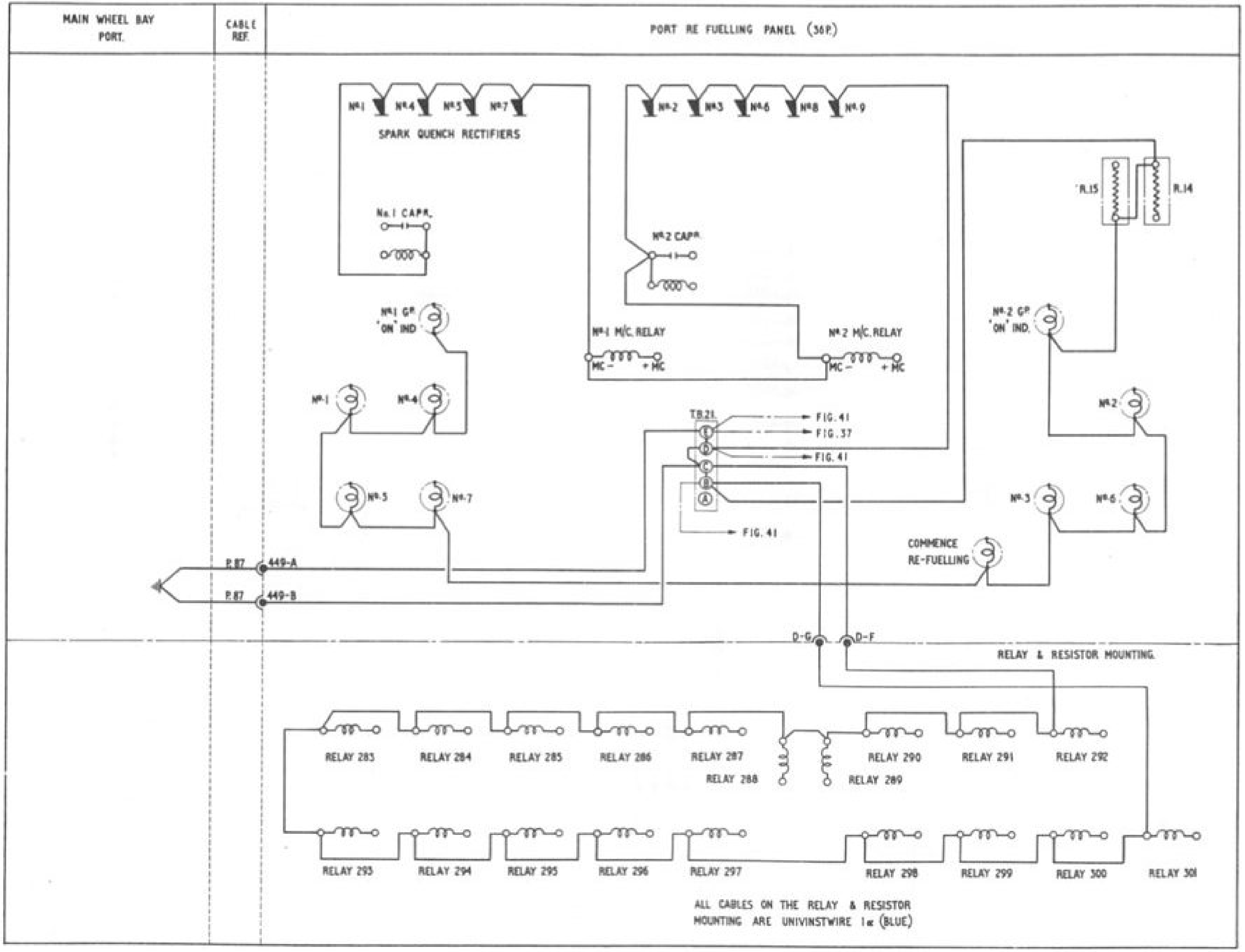


Fig. 44 (1) Negative distribution 36P and 37P

• Cross references changed •

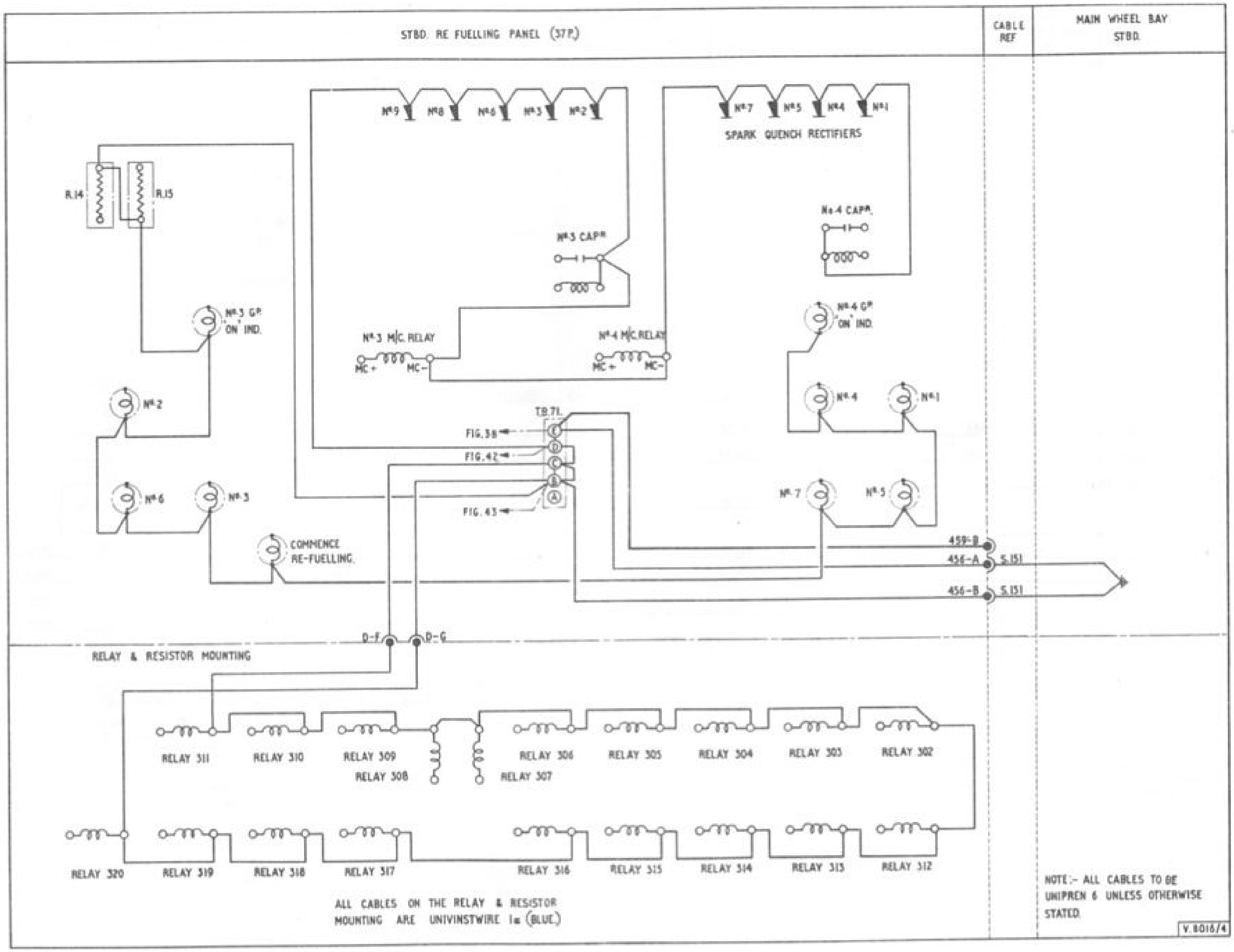


Fig. 44 (2) Negative distribution 36P and 37P

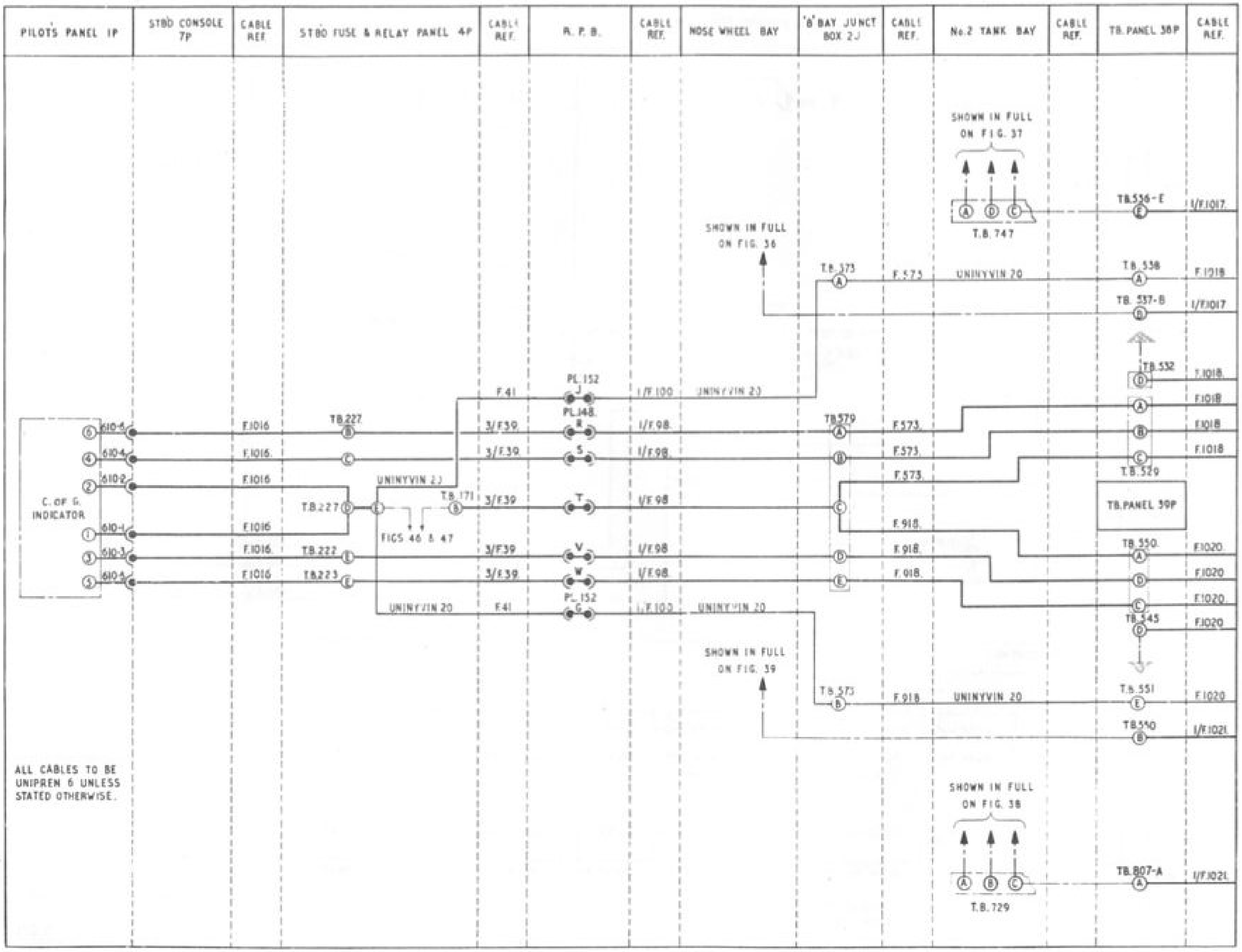


Fig. 45 (I) Fuel centre of gravity indicator

◄ Amplifiers removed ►

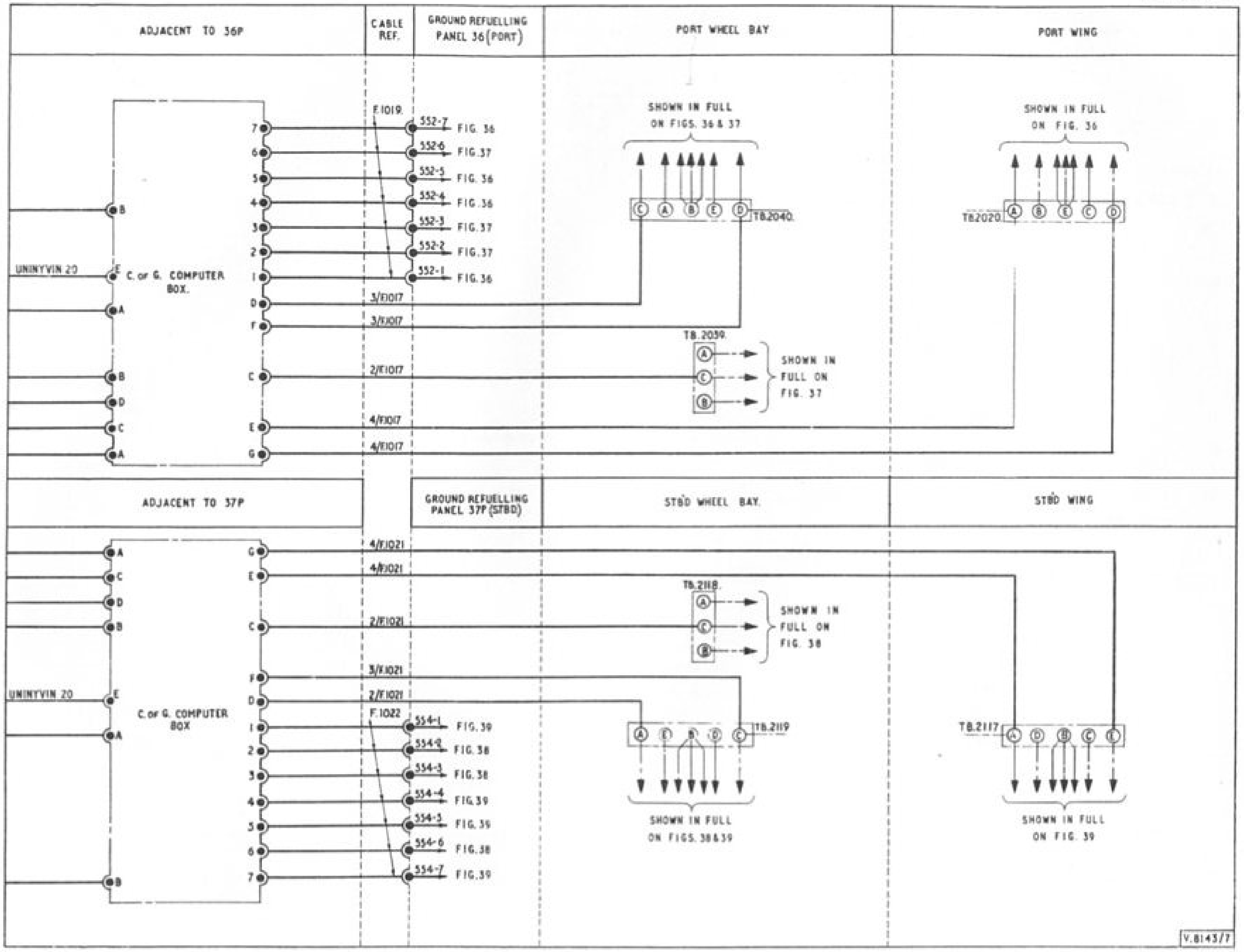


Fig. 45 (2) Fuel centre of gravity indicator

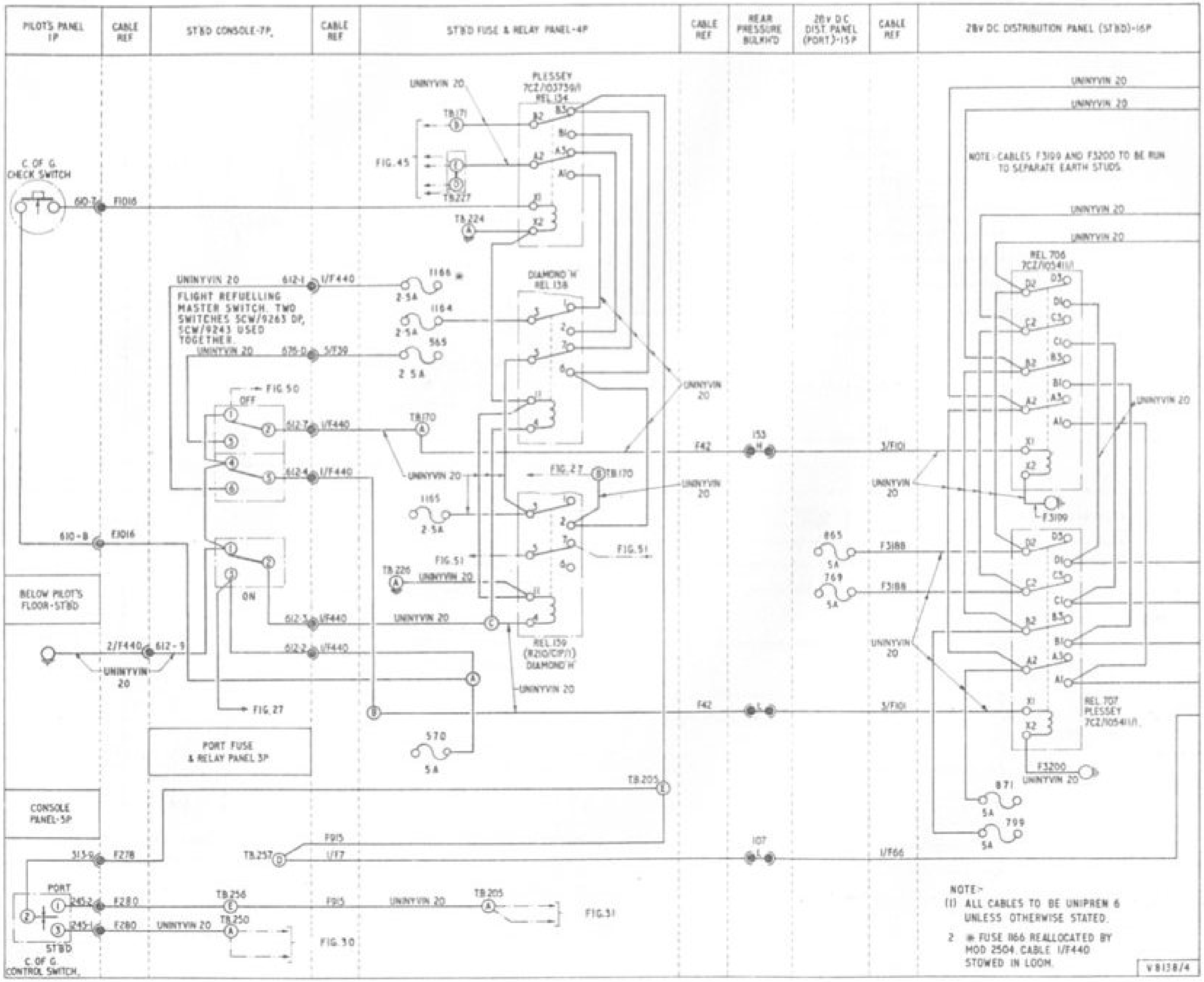


Fig. 47 (1) Flight refuelling (port)

▶Title change and note added◀

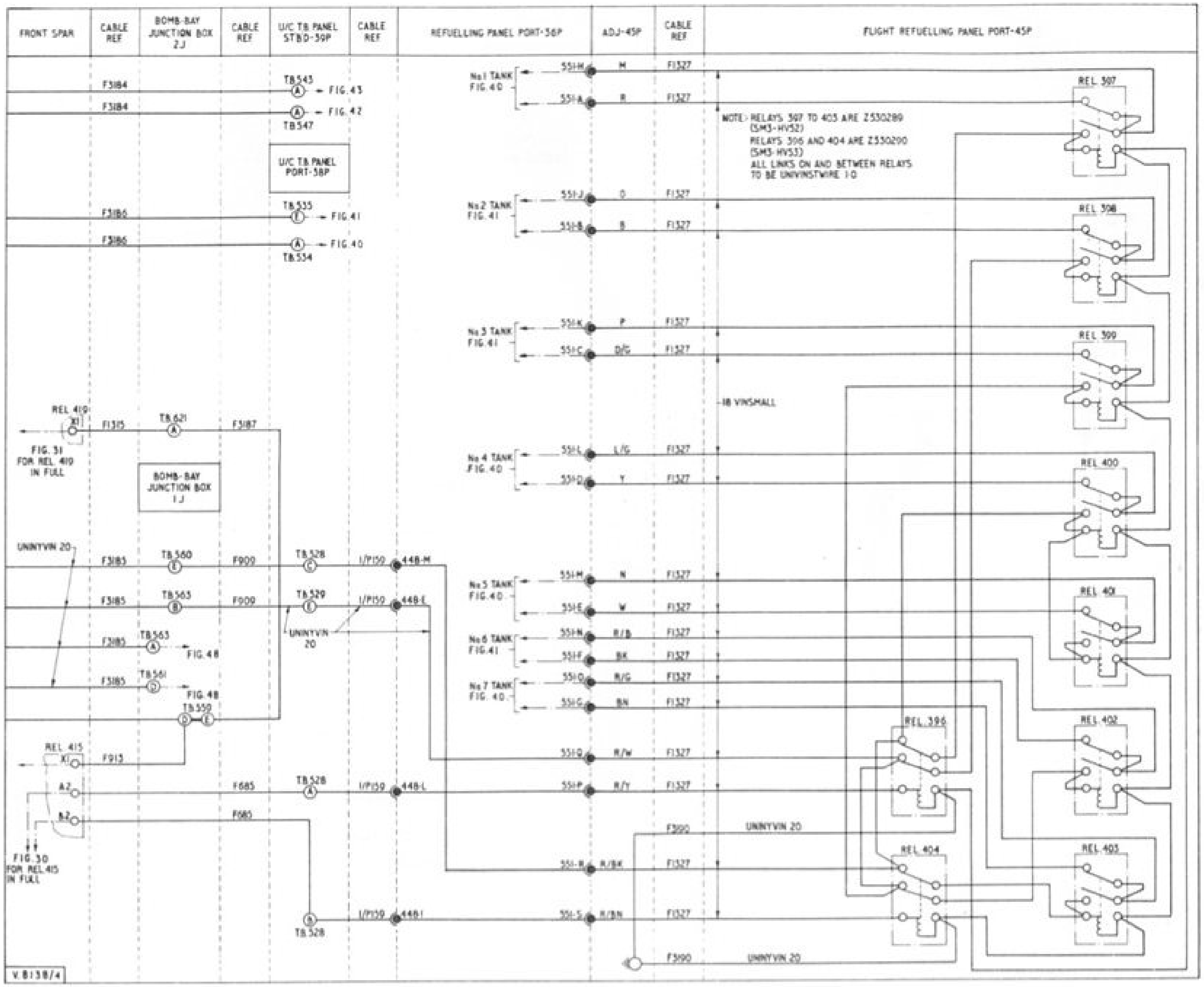


Fig. 47 (2) Flight refuelling (port)

►Title change◄

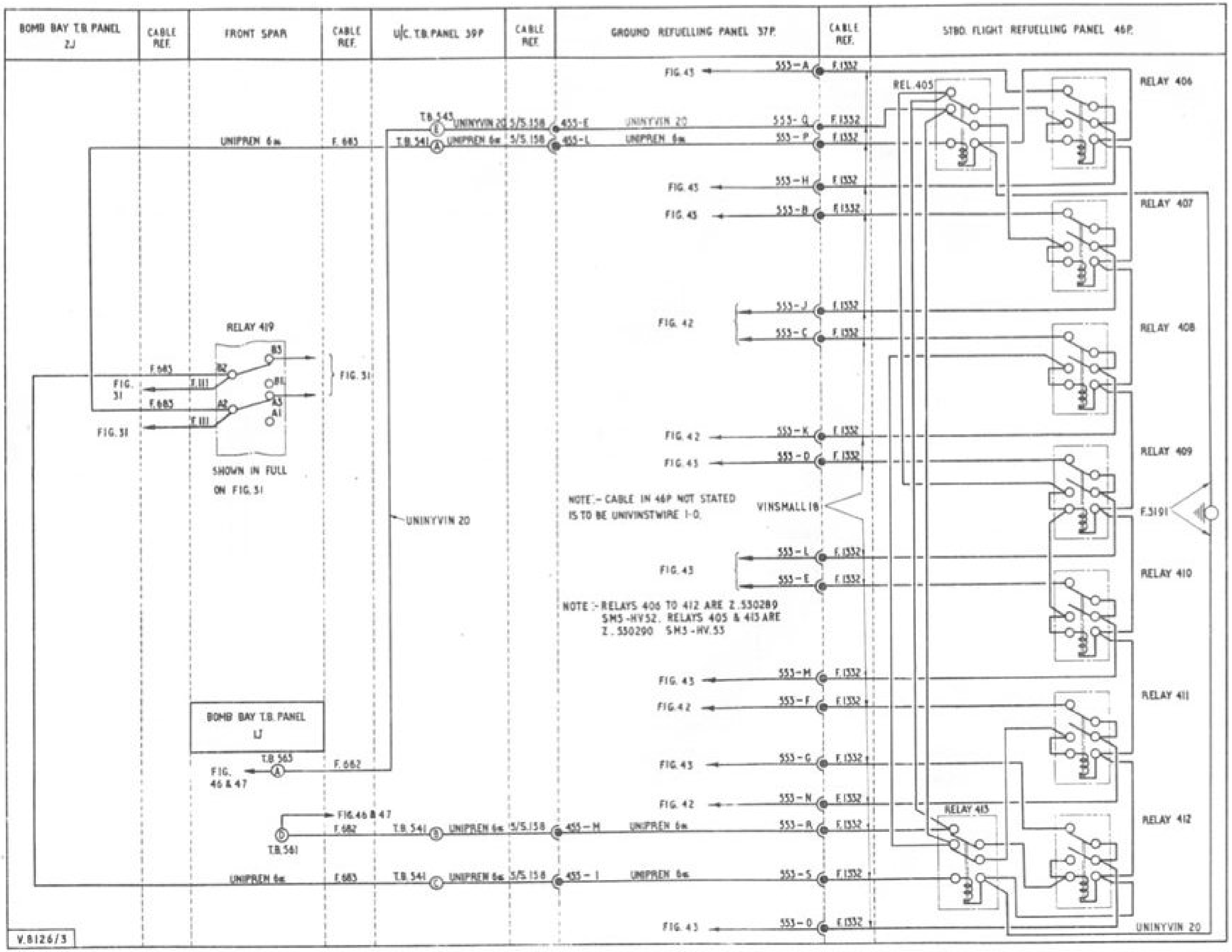


Fig. 48 Flight refuelling (stbd.)

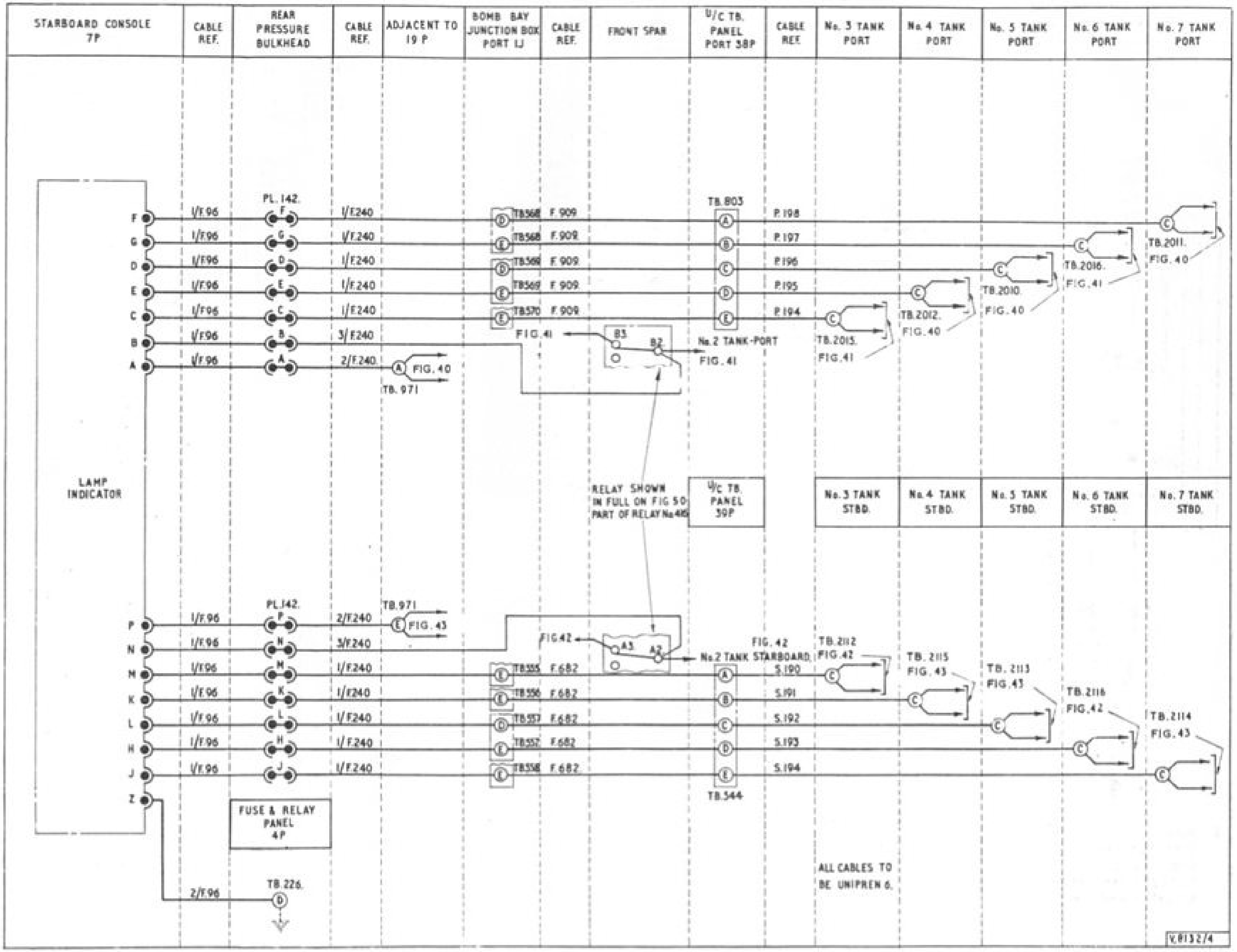


Fig. 49 Flight refuelling indicator

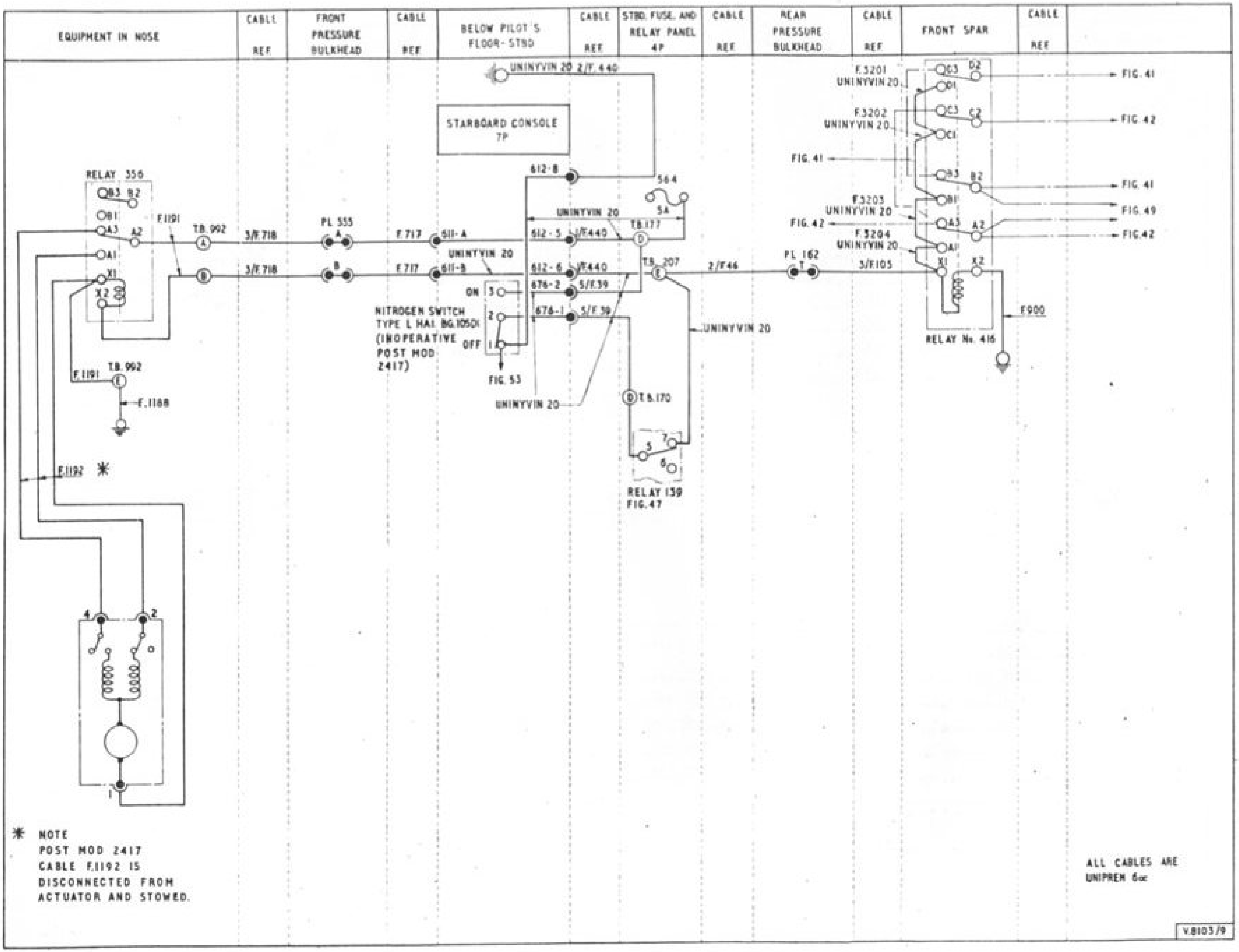


Fig 51 Nitrogen purge
► Title changed ◄

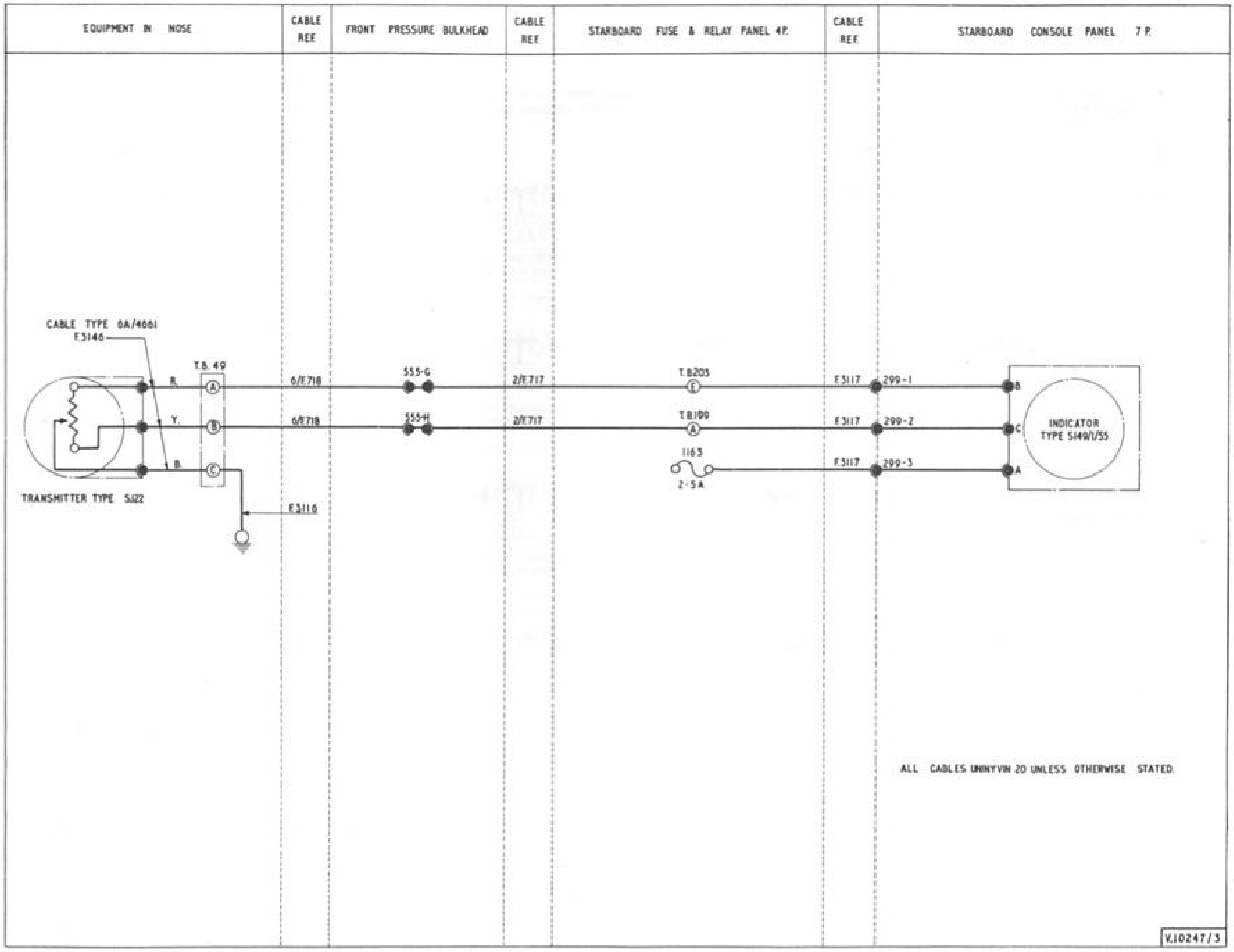


Fig. 52 Probe fuel pressure
◂ *Minor alterations* ▸

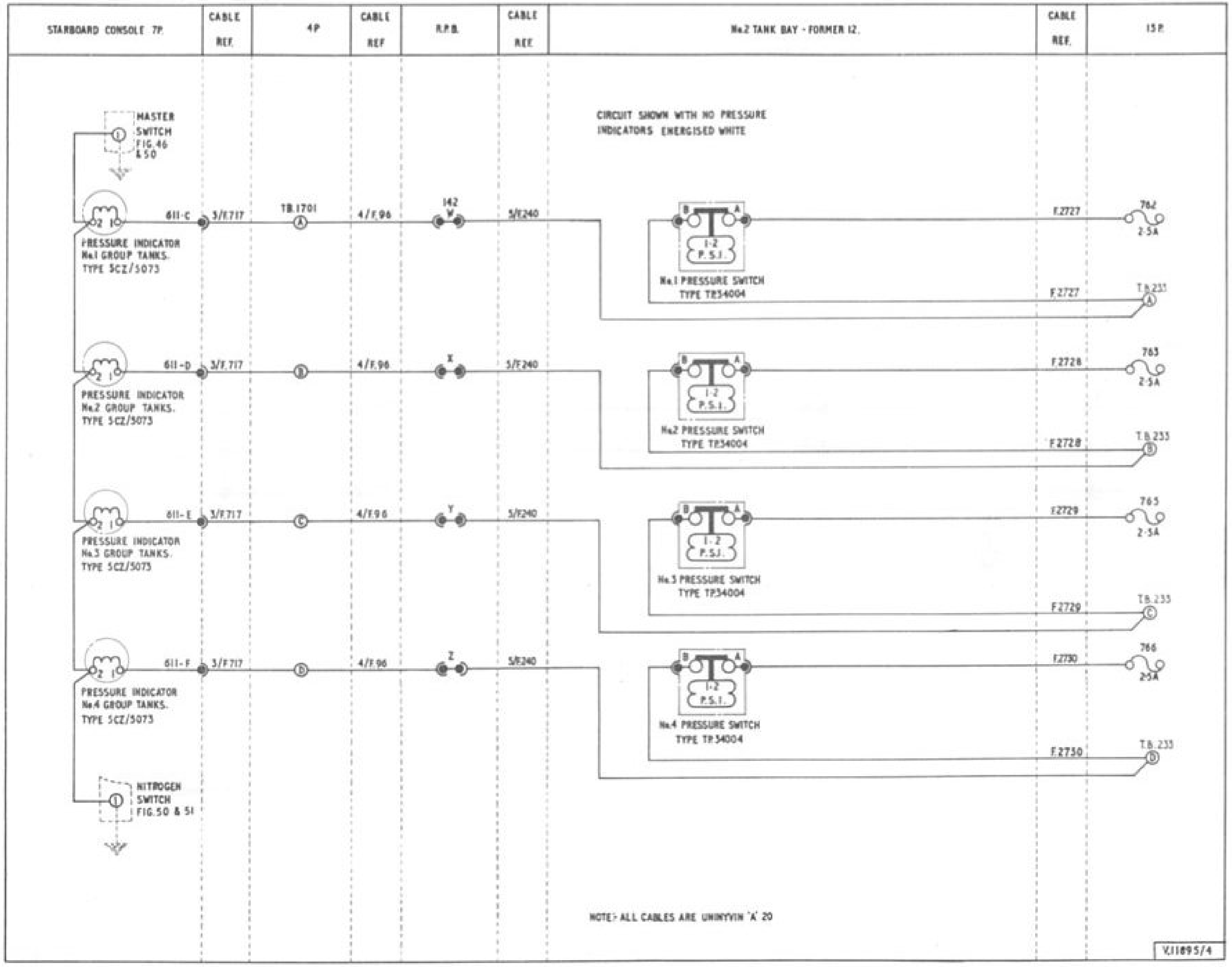


Fig. 53 Fuel tank pressure indication

◄ Cross references changed ►

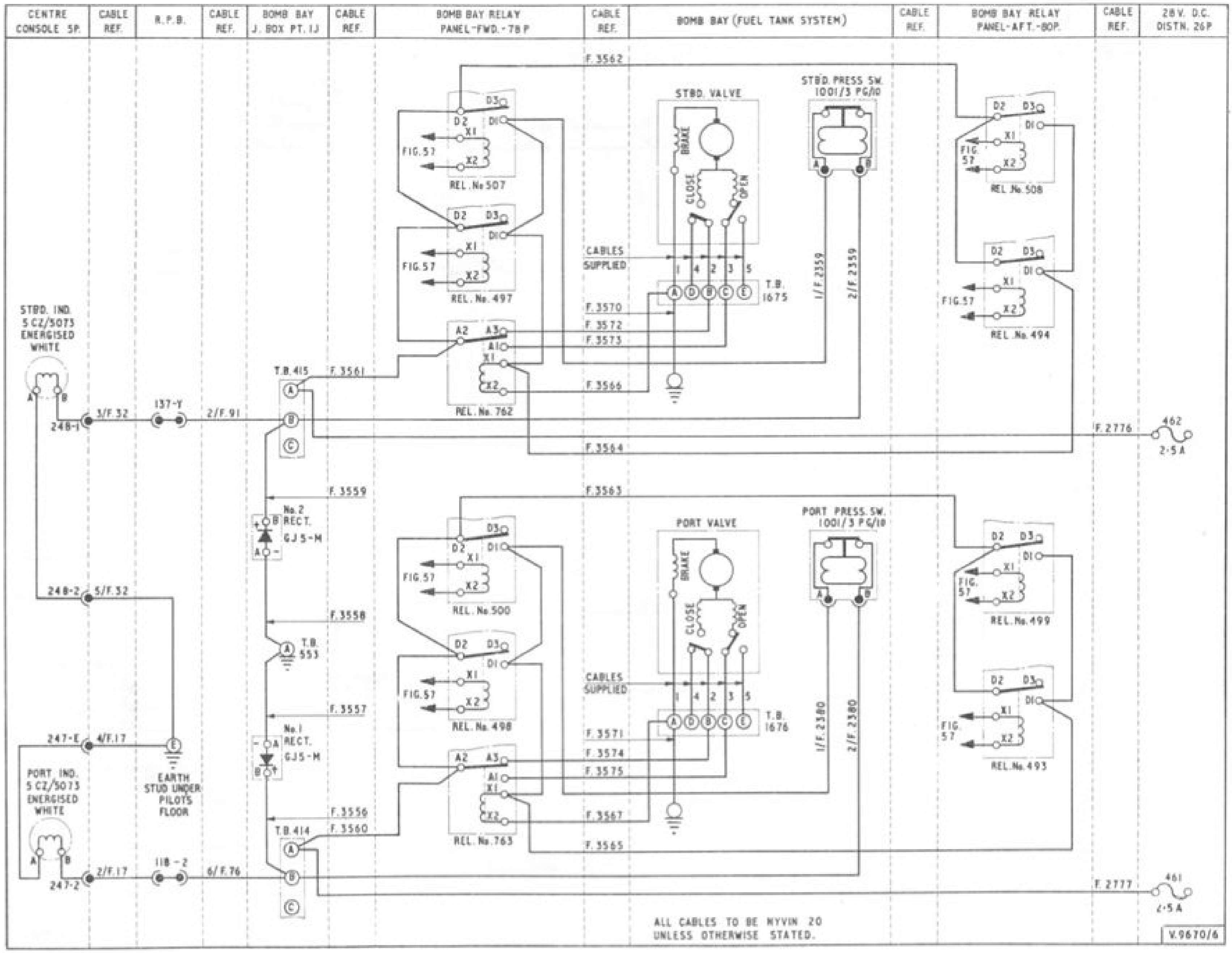


Fig. 54 Bomb bay fuel cocks and low pressure warning

◄Fuses now 2·5 A►

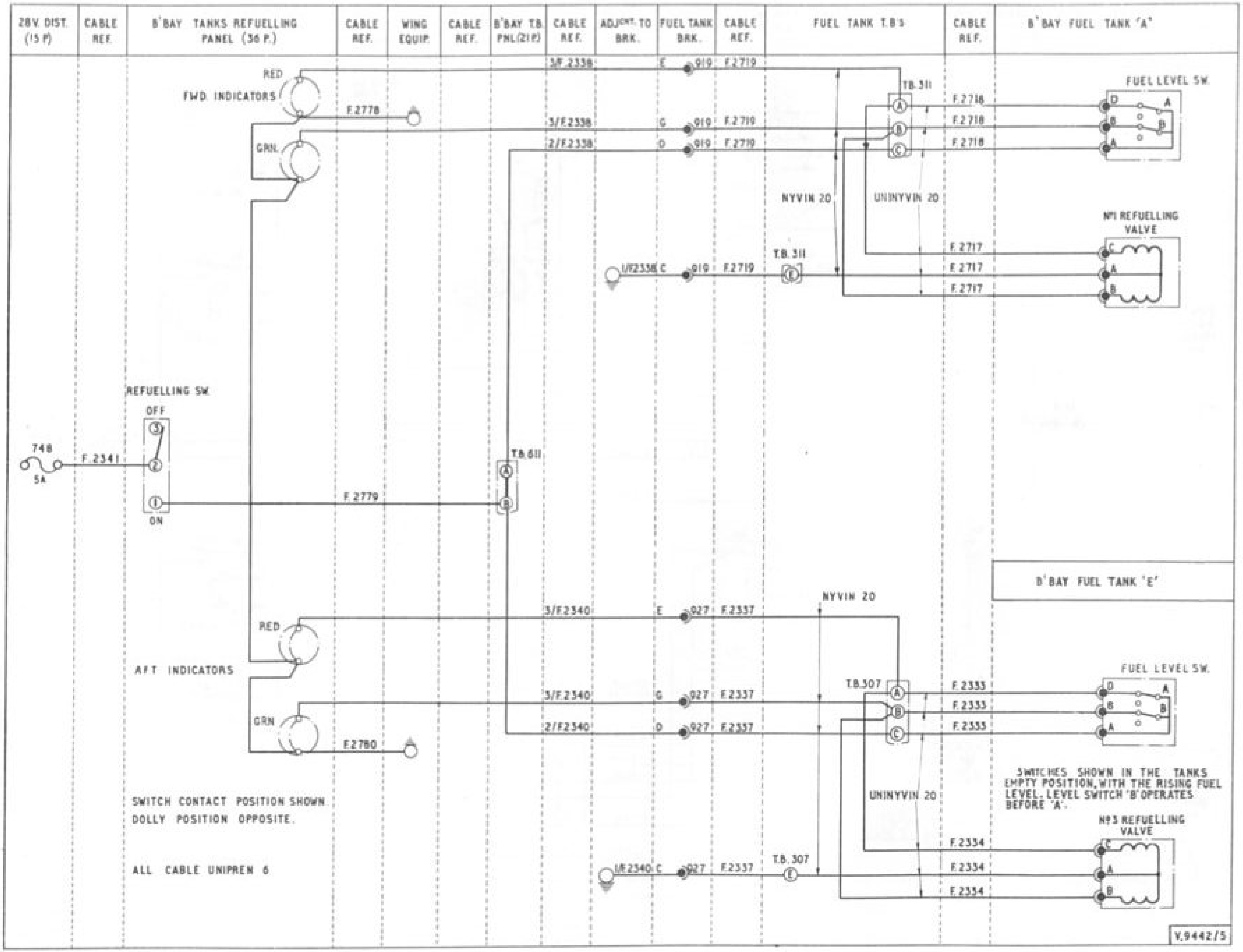


Fig. 55 Bomb bay tanks refuelling

◂ Minor alterations ▸

176089 570 8,75 H.S.A.1354

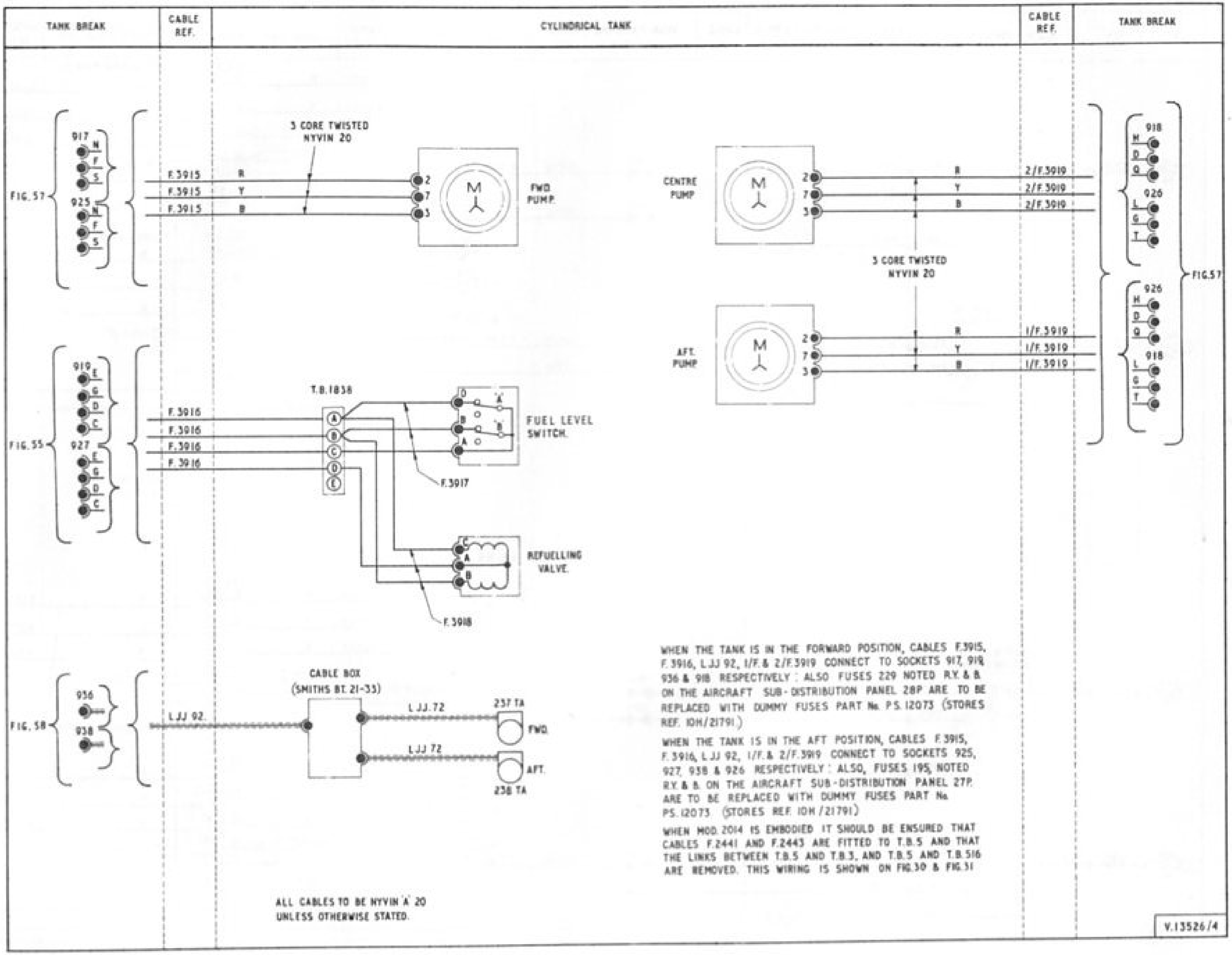
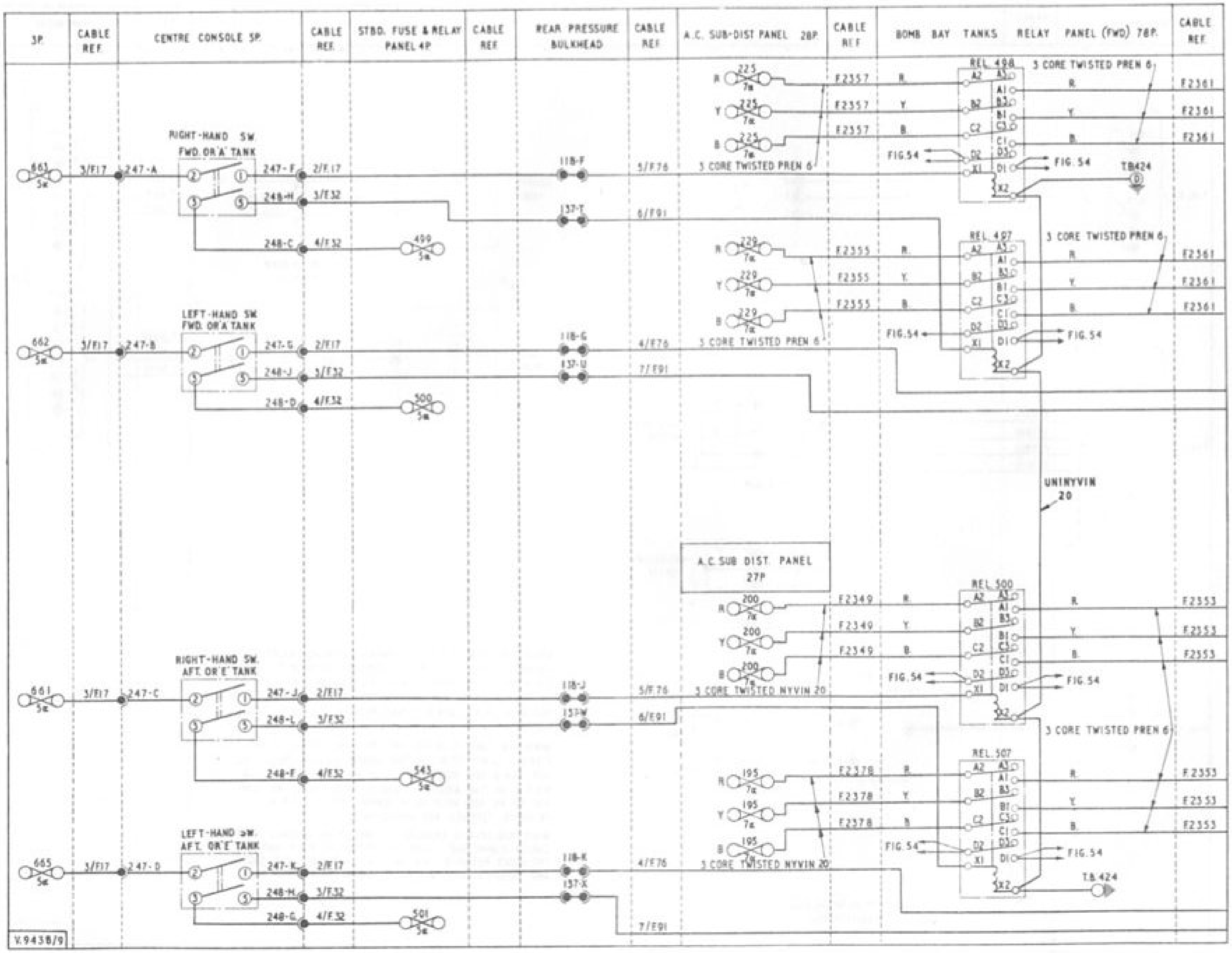


Fig. 56 Cylindrical tank equipment



186971 453 6,77 H.S.A. 1354

Fig. 57 (1) Bomb bay fuel pumps ('A' and 'E' tanks)

◄ Fuse 195 correctly located in 27P ►

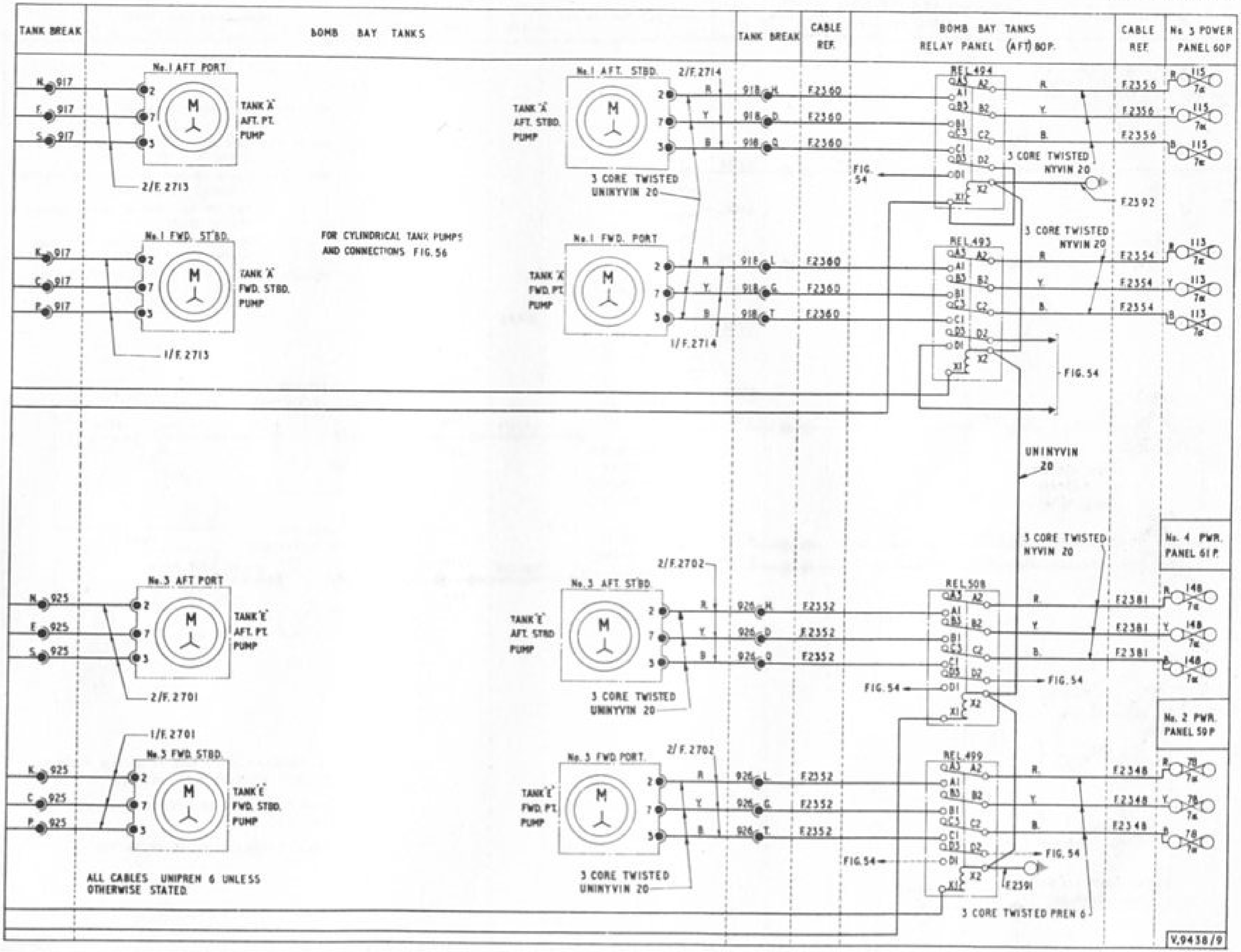
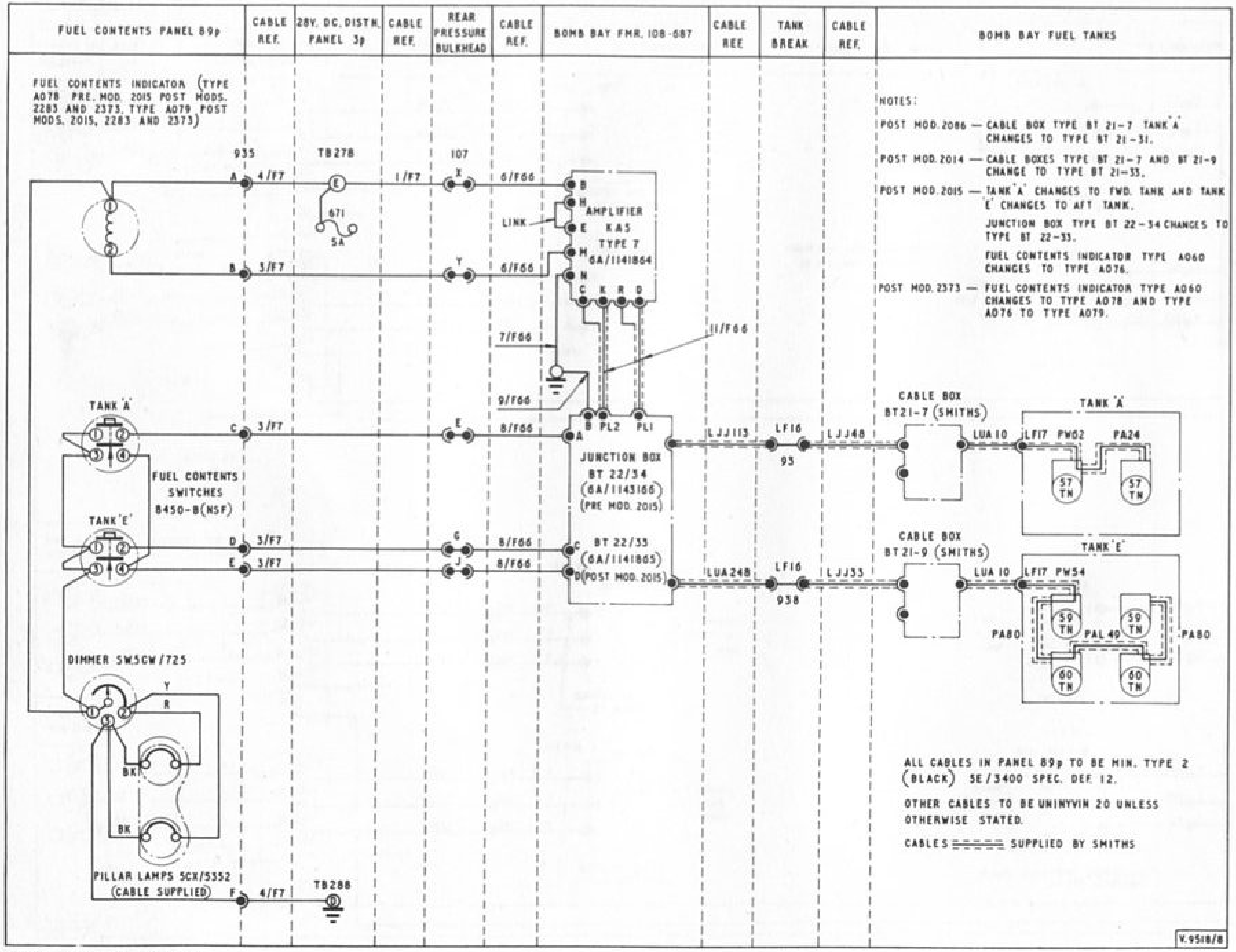


Fig. 57 (2) Bomb bay fuel pumps ('A' and 'E' tanks)



176675 570 11.74 H.S.A.1354.

Fig. 58 Bomb bay fuel contents.

◄Mod. 2373 incorporated►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