SECTION 11

FUEL SYSTEM

1. Introduction

This section is concerned with the description and circuit of the fuel system and components. Fourteen fuel tanks are provided to hold the engine fuel. The tanks are mounted on each side of the aircraft and are suitably numbered to assist in identification. For the purpose of normal fuel demands the fourteen tanks are divided and suitably inter-connected to form four distinct groups. Each of these four groups is then associated with a particular engine as shown in the following table.

Engine	Group No	Tanks forming the group
No 1	1	Port tanks Nos 1, 4, 5 and 7.
No 2	2	Port tanks Nos 2, 3 and 6.
No 3	3	Starboard tanks Nos 2, 3 and 6.
No 4	4	Starboard tanks Nos 1, 4, 5 and 7.

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.

Each tank is fitted with a main fuel pump for pumping fuel to the engines. In addition to the main pump each wing tank is provided with a secondary pump. The purpose of the secondary pump is to feed the main pump with fuel so that continuity of fuel flow is maintained irrespective of the aircraft's attitude. An electrically operated low pressure cock is fitted in each engine supply line.

2. Aircraft Centre of Gravity

Owing to the large quantity of fuel carried and the dis-position of the fuel tanks, the aircraft's centre of gravity is largely dependent upon the distribution of fuel. Certain controls are necessary to maintain the centre of gravity when fuel is being comsumed 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 4¾ minute cycle is proportional to the capacity of the tank.

A visual indication of the aircraft's centre of gravity is provided by a centre of gravity indicator at the pilots' station. The indicator is operated by a centre of gravity computor which is embodied in the fuel system. If a nose or tail heavy indication is given, a correction can be made by transferring fuel from No 1 tank to No 7 tank, or vice versa. The transfer operation is achieved by transfer pumps fitted one in each No 1 and No 7 tanks.

During flight refuelling, when the tanks are automatically replenished to maximum capacity, the stability of the centre of gravity in both fore and aft and lateral can be maintained within reasonable limits.

/Controls and Indicators.

3. Controls and Indicators

Most of the fuel system control switches are on the retractable console, 5P. Painted on the panel surface is a plan view of the fourteen tanks as they are situated in the aircraft. The area representing any one particular tank contains the fuel pump toggle switch and tank contents push button. Interconnecting pipe lines between tank groups are also shown on the plan. The cross feed cocks are represented by magnetic indicators which break the continuity of the lines when the cross feed cocks are shut.

The lower or aft portion of the panel carries the control switches and indicators for the bomb bay fuel system.

The low pressure fuel cocks are controlled by four switches at the top of 1P.

The four fuel contents gauges at the pilot's station are mounted side by side on panel 2P. The navigators' fuel gauges are fitted on a small panel above the navigators' instrument panel.

The flight refuelling control switches and indicators are arranged on the starboard console 7P.

The ground refuelling control switches and indicators are located in the main undercarriage bays at 34P and 37P.

4. Fuel Booster Pumps

The fuel pumps are controlled by the fourteen fuel pumps toggle switches on 5P. When the switches are selected to "PUMP" both the main and secondary booster pumps will commence to run. 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.

Speed variation on the main pumps is achieved by equipping each pump motor with two field windings, one six pole winding and the other four pole. The six pole when connected to the 400 cycles a.c. supply gives a synchronous speed of 8,000 rpm. The four pole winding gives a synchronous speed of 12,000 rpm when connected to the same supply.

5. Main Pump Speed Change Control

The selection of the 4 pole or 6 pole windings for speed changing is by means of change-over relays connected into the supply lines of the pumps. The 4 pole windings are connected through the normally closed contacts and the 6 pole windings are through the normally open contacts. This means that the pumps run at maximum speed with the change-over relay de-energised and reduced speed with the relay energised.

The relay will be de-energised and the pump motors will run at maximum speed whenever the AUTO-MANUAL switches on 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 DC supplies to the relays so that they are energised and de-energised in sequence.

6. Sequence Timer Units

Two sequence timer units, Rotax Type D10765, are fitted in the power compartment one on panel 40P, the other on 41P. Each sequence timer controls the seven main fuel pumps on its respective side of the aircraft.

By alternatively energising and de-energising the speed control 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 4¾ 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.

The cam operated contacts controlling the speed change relays are supplied with 28 volt DC via the AUTO-MANUAL switches. The sequence timer motors are fed with a 200 volt 3 phase 400 cycles AC supply via a control relay.

7. Transfer Pumps

Two three-position switches, labelled CG TRANSFER - FWD/AFT, control the fuel transfer pumps,

When either switch is moved to the FWD position, the asscciated fuel transfer pump in the No 7 tank will be switches on, and at the same time, the No 1 tank refuelling valve will be energised to open. The transfer pump will now deliver fuel into the refuelling line, through the refuelling valve and into No 1 tank. Overfilling of the tank is prevented by a fuel level float switch within the tank which de-energises the refuelling valves when the tank is full. It should be noted that during flight refuelling the CG transfer switches perform a slightly different function.

8. Fuel Cock Control

Three cross feed cocks and four low pressure cocks are employed in the fuel system. Each cock is electrically actuated. An indication that the cross feed cocks are switched on is provided by three magnetic indicators. Dowty Type C5175Y mk 7 fitted on 5P. Each actuator circuit is fed from a seperate fuse ie.

No 1 cerss feed actuator - fuse 622 - panel 3P
No 2 cross feed actuator - fuse 623 - panel 3P
No 3 cross feed actuator - fuse 520 - panel 4P

The four LP cock switches are fitted on the pilots coaming and are fused as follows:-

No 1 engine LP cock actuator - fuse 591 - panel 3P
No 2 engine LP cock actuator - fuse 592 - panel 3P
No 3 engine LP cock actuator - fuse 495 - panel 4P
No 4 engine LP cock actuator - fuse 496 - panel 4P

Four fuel low pressure warning indicators are fitted on the pilots centre instrument panel. Each indicator is operated by one of four low pressure switches, mounted one on each engine. The switch operates whenever fuel pressure to the engine falls below 5 psi.

9. Ground Refuelling

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

No 1 group - first to be filled = No 1 port tank
No 2 group - first to be filled = No 2 port tank
No 3 group - first to be filled = No 2 starboard tank
No 4 group - first to be filled = No 1 starboard tank

Only one tank in a group is filled at one time, automatic changeover to the next tank being made by a moving coil relay.

There are four M/C relays fitted to the aircraft fuel system, two located in 36P for the port tank groups and two in 37P for the starboard tank groups. One coil of each relay is connected to the fuel contents gauging system in the tanks and the other coil is connected to a resistance network which receives a supply from a stabilized voltage power unit.

10.

/Stabilized voltage power unit

10. Stabilized voltage power unit

This unit provides a stabilized voltage output to the selected M/C relay "B" coil the value of which can be set to any value between 0-50V by means of a selector potentiometer. The unit is installed in the port main wheel bay just forward of 36P.

The large selector dial on the face of the unit is marked to indicate selected or desired tank percentage whilst the rectangular window shows actual percentage (related to power unit output) obtained. The maximum discrepency between dial setting and window reading is ± 2%. The output voltage is only stable to this tolerance with an input to the unit of between 22 and 29 volts DC. The unit is switched on by operation of the refuelling lever in the port main wheel bay which actuates a micro switch which in turn conveys 28V DC via fuse 769 (15P). The unit when ready for operation illuminates two lamps, one on 36P and the other on 37P.

11. Refuelling selector controls

A double bank Ledex stepping switch controls the refuelling valves and tank selector relays in each group of tanks. The Ledex relay coil is operated by a relay which in turn is controlled by the M/C relay contacts. A solenoid operated master switch connects a 28 volt DC supply to each group refuelling circuit and a start switch is used to operate the Ledex switch to a correct starting position. When the last tank in the group is refuelled the Ledex switch automatically steps around to trip out the master switch solenoid, thus switching off the supply to the group.

Fuel level switches in the tanks in series with the refuelling valves prevent accidental overfilling. As an additional safety factor the fuel level switches and refuelling valves are of the double acting pattern, ie. Both fuel level switches must be closed and both solenoids energised before the valve will open.

All the ground control switches, resistance networks and M/C relays are housed in two refuelling panels 36P and 37P in the main wheel bays 36P port, 37P starboard. Each panel contains the following switches and indicators:-

1. Master switch (2 off - 1 per group).
2. Start switch (double pole - 1 pole per group).
3. Group ON indicators (2 off).
4. Tank indicators (7 off).
5. Commence refuelling indicator.
6. Overide switches (2 off - 1 per group).

12. Ground Refuelling Operation

With the stabilized voltage power unit switched on, indication is given on 36P and 37P. Refuelling sequence can now commence.

Operate the master switch which is held "ON" by a solenoid through its own contacts. This supplies 28V to the start switch which when operated "steps" the Ledex switch. This operation is repeated until the Ledex switch reaches the No 1 position. On reaching this position the Start relay (283) is energised which in turn energises the Master relay (284). The supply to the start switch is broken thus preventing further "stepping" of the Ledex switch past the No 1 position. Normally open contacts of the Master relay close to provide a hold in circuit for the Master relay, illuminate the Group commence indicator and also feed through the other bank of contacts of the Ledex switch to energise the No 1 tank

/refuelling

refuelling valve. Fuel will now enter No 1 tank.

As the Start relay energised 28V supply is fed to energise the Selector relay (293) which in turn energises the Shunt relay (297). The operation of these two relays connect the output from the power pack through the resistance network to the "B" coil of the Moving Coil Relay; they also connect the output of No 1 tank amplifier through the pilots fuel gauge via the "A" coil of the Moving coil relay.

As the fuel in No 1 tank increases so the current in the "A" coil increases. When the current flowing in the "A" coil is 2 milliamps above that in the "B" coil the contacts will close. Closing of the contacts energise the Relief relay (288) which in turn energises the change over relay (285). Operation of the Change over relay feeds a supply to the Ledex switch which will "step" to the next contacts. As the Ledex switch "steps" the refuelling valve of No 1 tank closes and that of No 4 tank opens. Also the Start relay and No 1 Selector relay de-energises and energised the No 4 Selector relay. Further contacts of the Change over relay short out the "A" coil to ensure that the contacts in the Moving coil relay open. On opening they de-energise the Relief relay and Change over relay. The system is now in a position to fill No 4 tank. The same procedure being employed to switch off No 4 tank as No 1 tank.

The sequence then carries on to Nos 5 and 7 tanks. As the Ledex switch "steps" after filling No 7 tank a "Blocking Positive" is fed to the Master switch coil, thus opening the Master switch shutting the system off.

An override switch is provided to "miss" a tank required when operated a supply through the Master relay contacts "steps" the Ledex switch.

13. Individual Contents Pushes

Although the four pilots fuel gauges normally read the group contents provision is made to read the individual tank contents. A push switch on 5P fitted beside each pump switch, when pressed energises the relevant Selector relay and Shunt relay which alters the reading of the pilots gauges from group to individual readings. IMPORTANT Do not push more than one push in any one group at a time or damage will result of the pilots gauge.

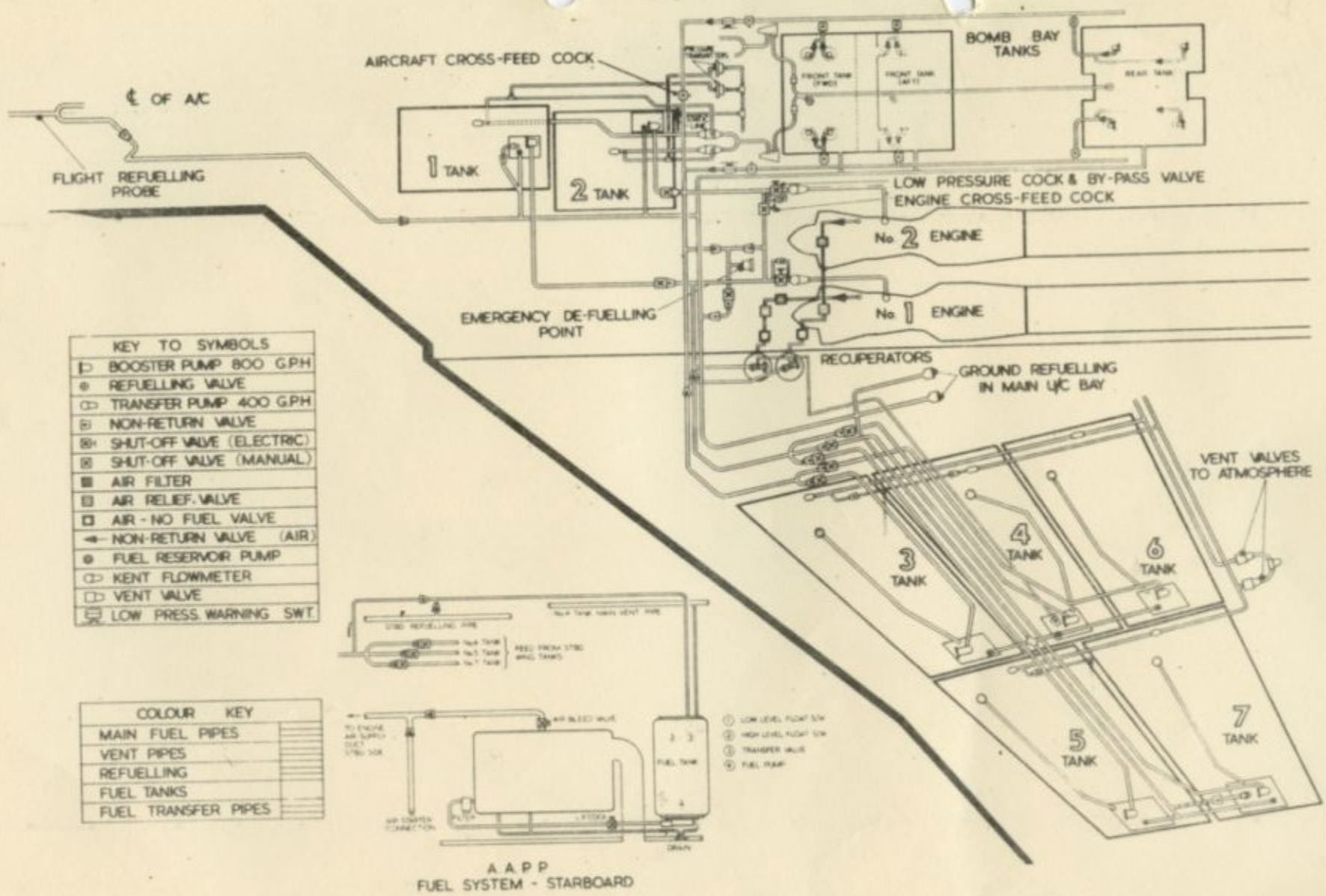
14. Flight Refuelling

Flight refuelling is carried out by probe and drogue method. The controls for flight refuelling are located on 7P Operation of the Master switch opens all 4 refuelling valves, which are cut off by the float switches when the tanks are full.

FWD and AFT C of G control is maintained during flight refuelling by the operation of the Transfer switches on 5P which isolates Nos 6 and 7, or Nos 1 and 2 tanks respectively. Lateral C of G control is maintained by a Lateral C og G switch. This switch isolates Nos 6 and 7 tanks on either the Port or Stbd. Thus C og G is maintained.

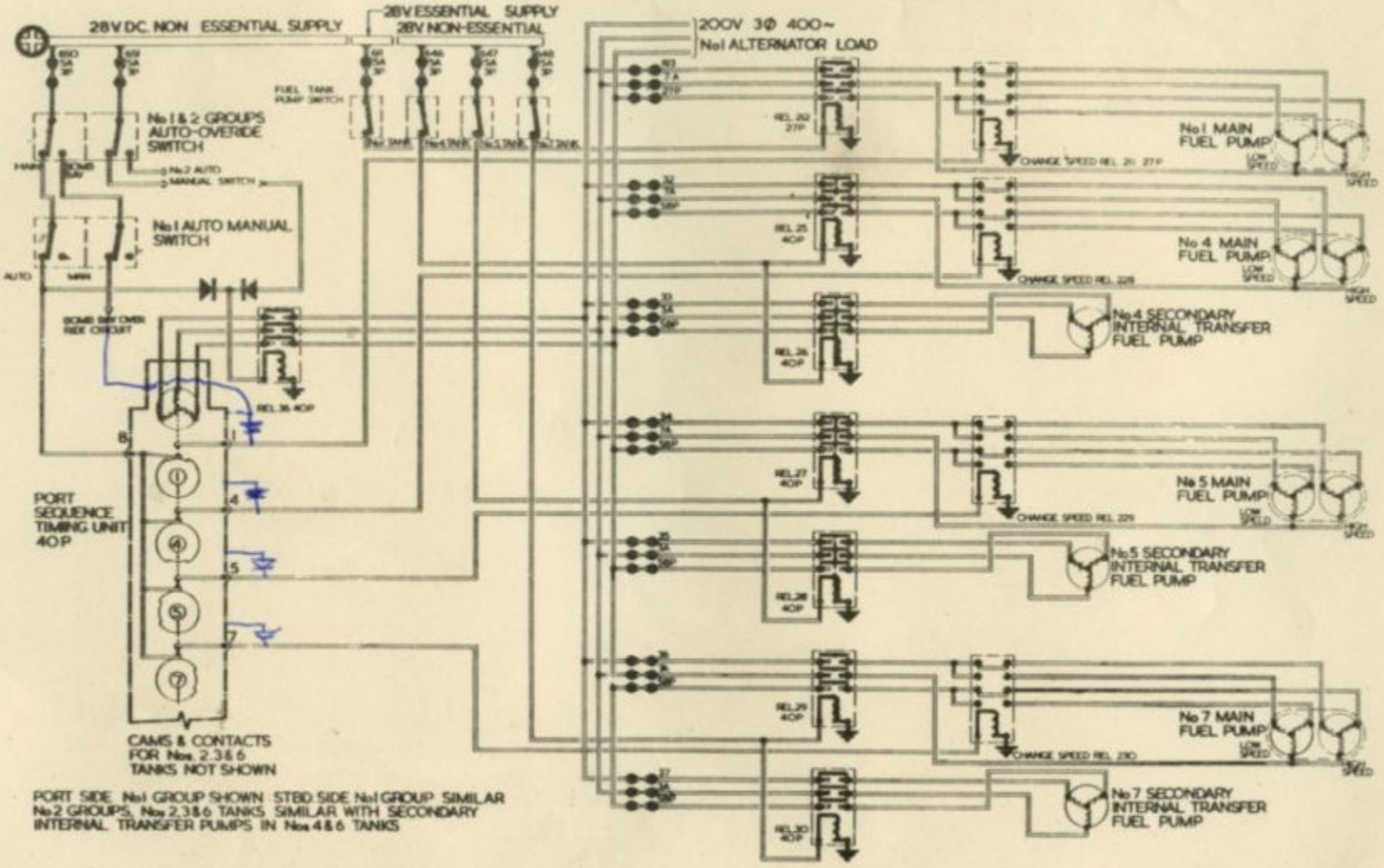
15. CG Indicator

ACG indicator is fitted on the pilot's centre instrument panel (1P). The indicator has two movements, one for each side of the fuel system. The instrument will indicate changes of trim and restoration of trim when the CG control switches are operated.



A.A.P.P.
FUEL SYSTEM - STARBOARD

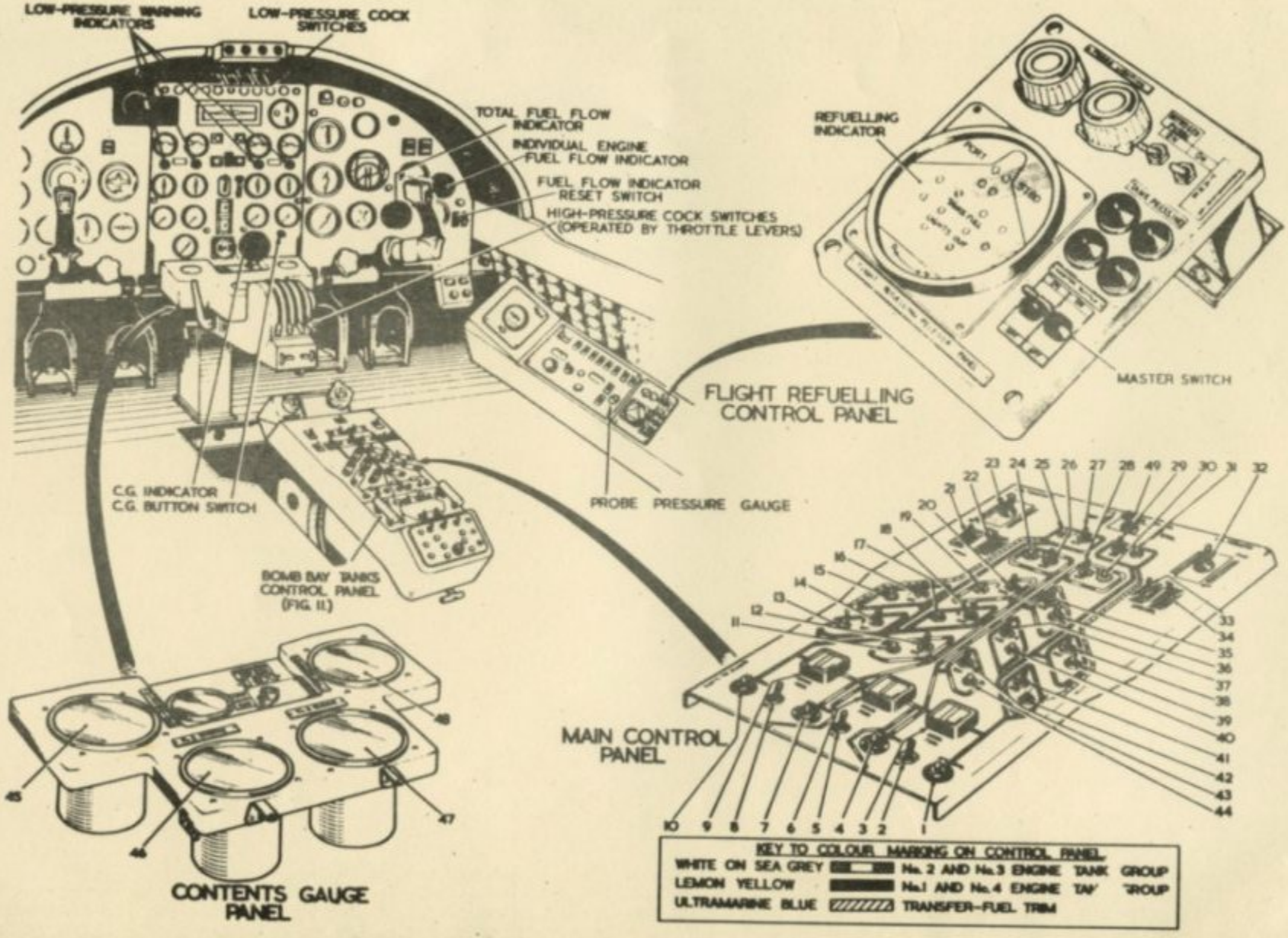
FUEL TANK LAYOUT



PORT SIDE No1 GROUP SHOWN STBD SIDE No1 GROUP SIMILAR
No2 GROUPS, Nos 2,3 & 6 TANKS SIMILAR WITH SECONDARY
INTERNAL TRANSFER PUMPS IN Nos 4 & 6 TANKS

DIAGRAM 14:1

FUEL SYSTEM CONTROLS.



KEY TO FUEL SYSTEM CONTROLS

Push-switches, rate-of-flow

When pressed, the rate of flow is given on the flow indicator on the second pilot's panel.

1 NO.4 ENGINE
4 NO.3 ENGINE
7 NO.2 ENGINE
10 NO.1 ENGINE

Cross-feed cock switches

Forward - SHUT
Rearward - OPEN

2 NOS.3 and 4 ENGINES
5 PORT and STARBOARD SIDES OF AIRCRAFT
8 NOS.1 and 2 ENGINES

Cross-feed cock position indicators

3 NOS.3 and 4 ENGINES
6 PORT and STARBOARD SIDES OF AIRCRAFT
9 NOS.1 and 2 ENGINES

Auto/manual switches

Forward - AUTO - energises sequence timer
Rearward - MANUAL - stops sequence timer

21 NO.1 TANKS GROUP
22 NO.2 TANKS GROUP
33 NO.3 TANKS GROUP
34 NO.4 TANKS GROUP

Tank pump switches

Forward - ON
Rearward - OFF

PORT
14 NO.7 TANK
12 NO.6 TANK
16 NO.5 TANK
18 NO.4 TANK
20 NO.3 TANK
26 NO.2 TANK
27 NO.1 TANK

STARBOARD
29 NO.1 TANK
28 NO.2 TANK
35 NO.3 TANK
37 NO.4 TANK
38 NO.5 TANK
43 NO.6 TANK
41 NO.7 TANK

Tank contents push-switches

When pressed indicate individual tank contents on outer ring of contents gauges. (items 45, 46, 47 and 48).

PORT
13 NO.7 TANK
11 NO.6 TANK
15 NO.5 TANK
17 NO.4 TANK
19 NO.3 TANK
24 NO.2 TANK
25 NO.1 TANK

STARBOARD
30 NO.2 TANK
31 NO.1 TANK
36 NO.3 TANK
40 NO.4 TANK
39 NO.5 TANK
44 NO.6 TANK
42 NO.7 TANK

C. of G. transfer pump switches

FWD. - starts No.7 tank transfer pump and opens No.1 tank refuelling valve. (During flight refuelling closes refuelling valves of 6 and 7 tanks).

Centre - OFF

AFT. - starts No.1 tank transfer pump and opens No.7 tank refuelling valve. (During flight refuelling closes refuelling valves of 1 and 2 tanks).

23 - Port side
32 - Starboard side

Flight refuelling C. of G. switch

49 Stops refuelling of two tanks on side opposite to that selected PORT - closes refuelling valves of Nos. 6 and 7 tanks on starboard side. STBD. - closes refuelling valves of No. 6 and 7 tanks on port side. Centre - OFF.

Contents gauge panel

Outer ring - individual tank contents
Inner ring - tank group contents

45 Contents gauge - No.1 engine group
46 Contents gauge - No.2 engine group
Contents gauge - No.3 engine group
Contents gauge - No.4 engine group

VULCAN B. MK. 2

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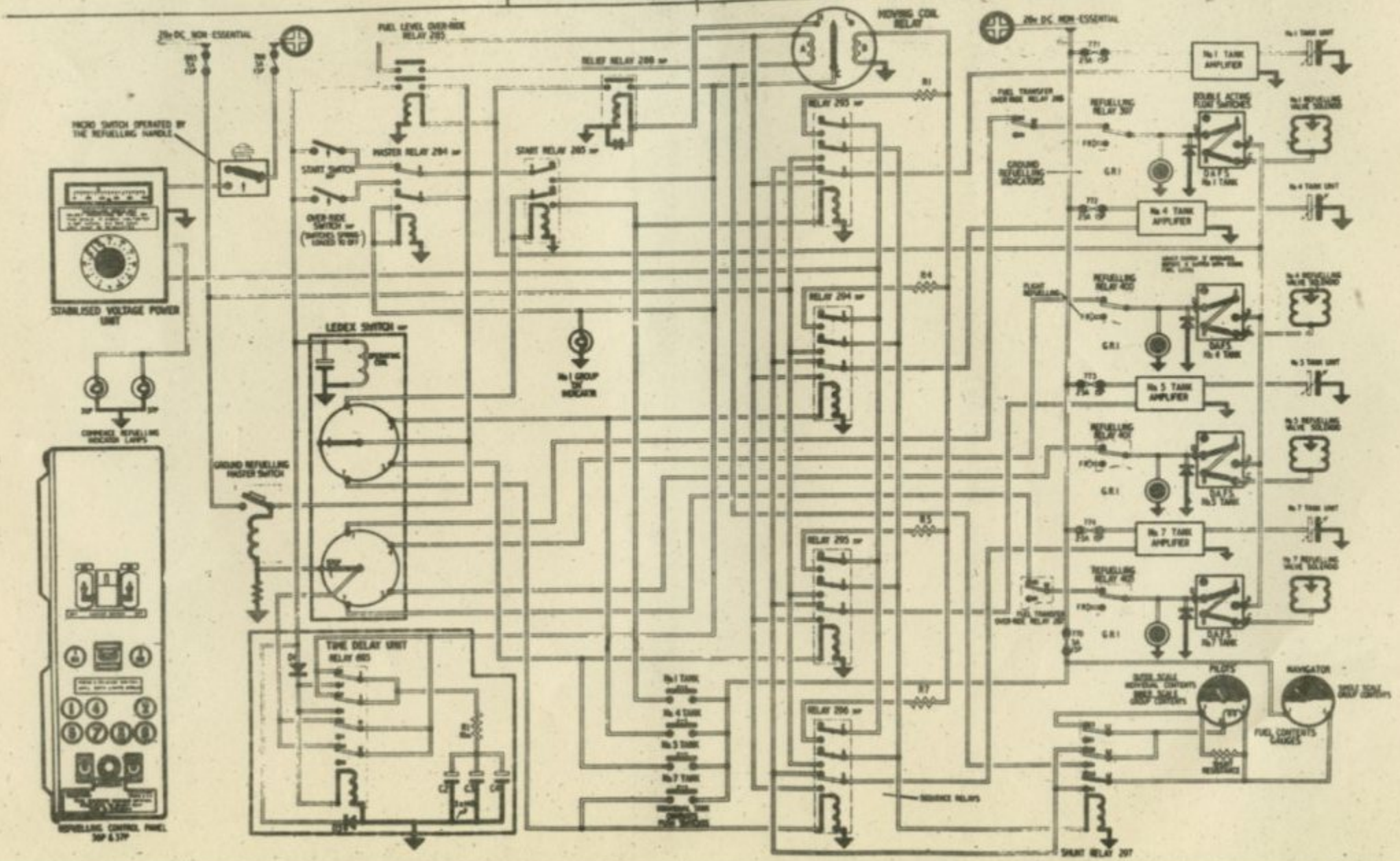
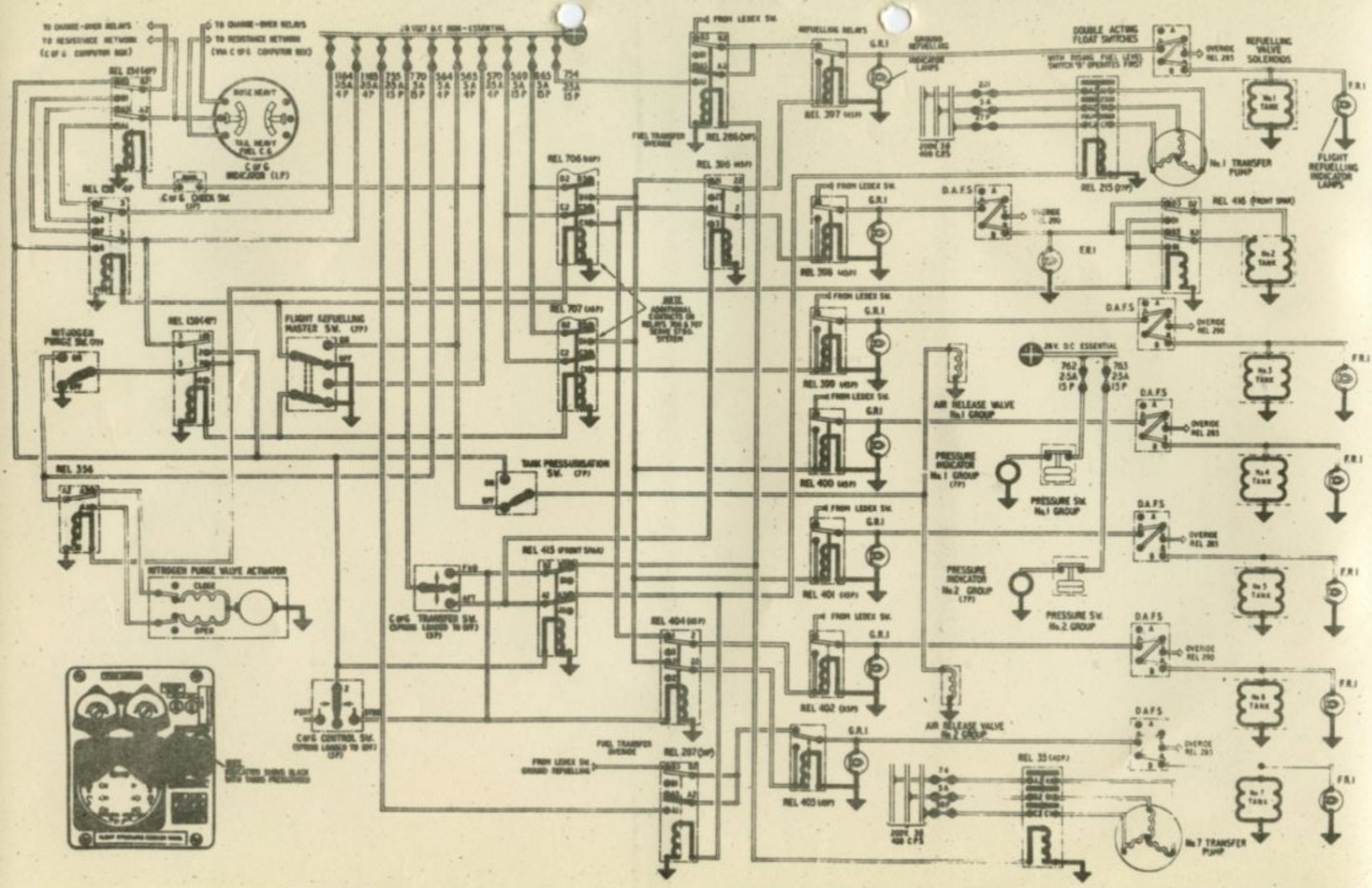
13

ELECTRICAL SYSTEM

GROUND REFUELLING




TO CHANGE-OVER RELAYS
TO RESISTANCE NETWORK
(C of G COMPUTOR BOX)
TO CHANGE-OVER RELAYS
TO RESISTANCE NETWORK
(VIA C of G COMPUTOR BOX)
28 VOLT A.C. NON-ESSENTIAL
REL 354 (4P)
NOSE HEART
TAIL HEAVY
FUEL C of G
INDICATOR (LP)
C of G CHECK SW. (SP)
REL 356 (4P)
NITROGEN PURGE SW. (SP)
REL 356 (4P)
FLIGHT REFUELLING MASTER SW. (7P)
REL 356
TANK PRESSURIZATION SW. (7P)
NITROGEN PURGE VALVE ACTUATOR
CLOSE
OPEN
C of G TRANSFER SW. (SP)
C of G CONTROL SW. (SP)
REL 706 (6P)
REL 707 (6P)
REL 415 (FRONT SPAR)
REL 404 (6P)
REL 207 (3P)
FUEL TRANSFER OVERIDE
FROM LEDEX SW. GROUND REFUELLING
REL 206 (3P)
REL 396 (6P)
ADD ADDITIONAL CONTACTS ON RELAYS 706 & 707 SERIAL 37 & SUBSEQUENT
REFUELLING RELAYS
G.R.I.
GROUND REFUELLING INDICATOR LAMPS
REL 397 (6P)
FROM 26V 400 C.P.S.
DOUBLE ACTING FLOAT SWITCHES
WITH RISING FUEL LEVEL SWITCH 'B' OPERATES FIRST
REFUELLING VALVE SOLENOIDS
No.1 TANK
F.R.I.
FLIGHT REFUELLING INDICATOR LAMPS
No.1 TRANSFER PUMP
REL 215 (3P)
D.A.F.S.
OVERIDE REL 290
REL 398 (6P)
REL 416 (FRONT SPAR)
No.2 TANK
REL 399 (6P)
No.3 TANK
AIR RELEASE VALVE No.1 GROUP
PRESSURE INDICATOR No.1 GROUP (7P)
PRESSURE SW. No.1 GROUP
OVERIDE REL 285
REL 400 (6P)
No.4 TANK
PRESSURE INDICATOR No.2 GROUP (7P)
PRESSURE SW. No.2 GROUP
REL 401 (6P)
REL 402 (6P)
AIR RELEASE VALVE No.2 GROUP
REL 403 (6P)
REL 35 (4P)
No.7 TRANSFER PUMP
No.5 TANK
No.6 TANK
No.7 TANK
762 2.5A 15P
763 2.5A 15P
26V. D.C. ESSENTIAL
1064 3.5A 4P
1188 3.5A 4P
735 3.5A 15P
770 3A 6P
564 3A 4P
565 3A 4P
570 2.5A 4P
569 3A 15P
663 3A 6P
754 3.5A 15P

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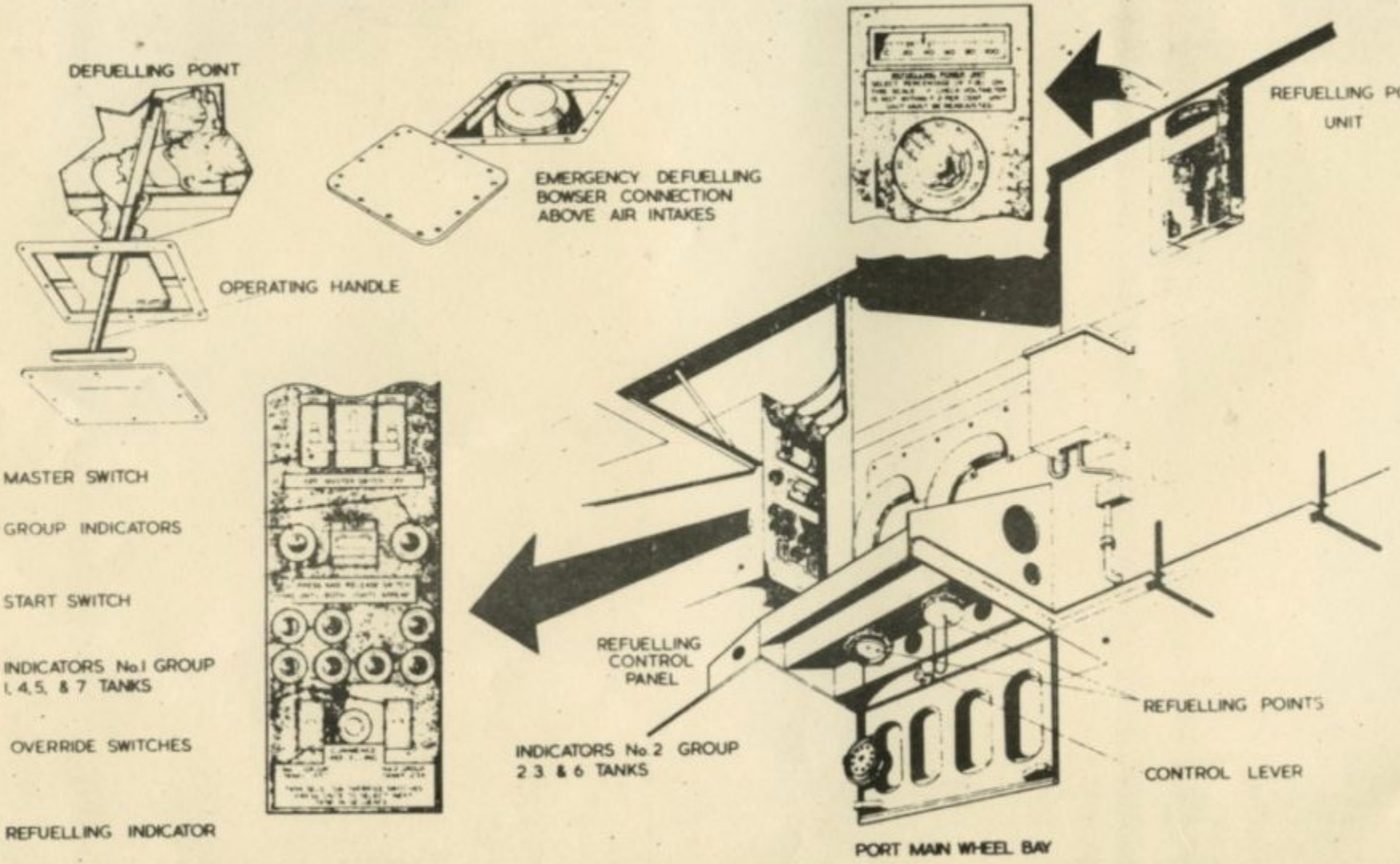
FUEL SYSTEM
GROUND REFUELLING

MOD. NO.
ISSUE NO.



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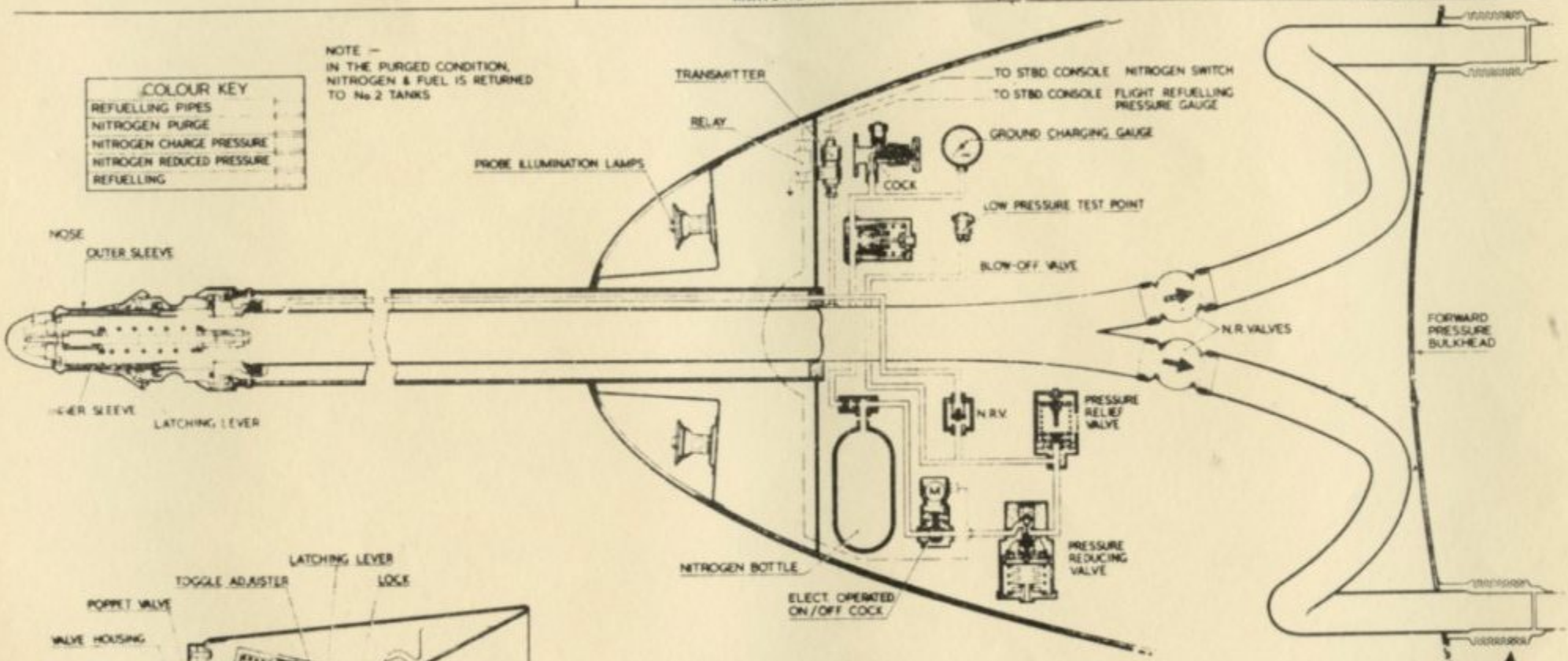
FUEL SYSTEM

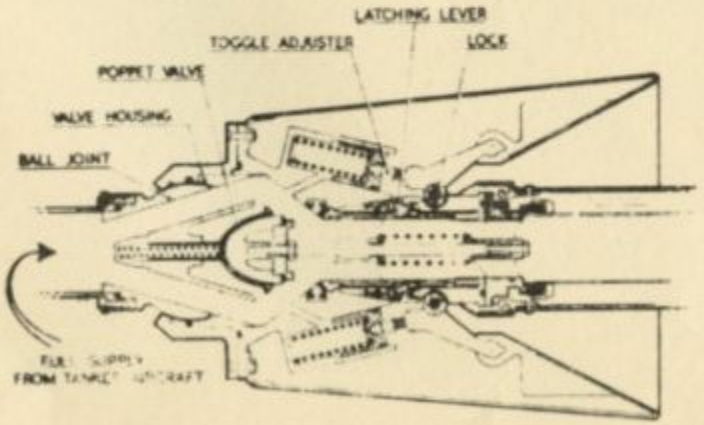
FLIGHT REFUELLING

MOD NO	
2	ISSUE NO

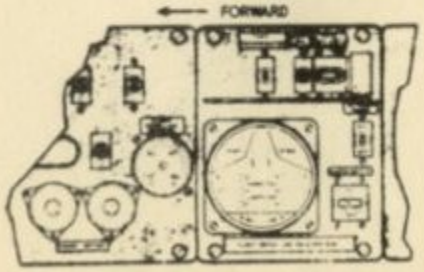
COLOUR KEY
REFUELLING PIPES
NITROGEN PURGE
NITROGEN CHARGE PRESSURE
NITROGEN REDUCED PRESSURE
REFUELLING

NOTE –
IN THE PURGED CONDITION, NITROGEN & FUEL IS RETURNED TO No.2 TANKS

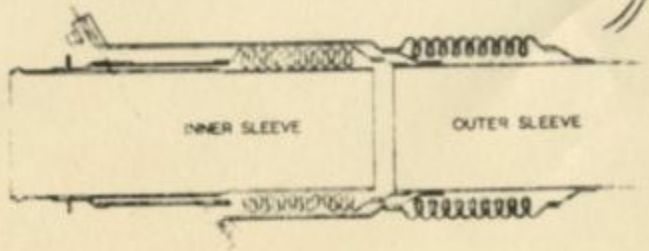




DETAIL OF DROGUE TO PROBE COUPLING



FLIGHT REFUELLING PANEL
(STARBOARD CONSOLE)



FUEL PIPE COMPENSATING BELLOWS