PART 2

CHAPTER 10 — FUEL SYSTEM

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Contents

Illustrations

General

1. A total of 19,355 Imp. gallons is stored in eight tanks, three in each wing, one in the centre section and one in the fin. The left wing tanks are numbered, from the wing tip, 1A, 1 and 2 and the right wing tanks 4A, 4 and 3 from the wing tip.

2. The wing tanks are integral with the wing torque box, rib diaphragms forming the tanks. The centre tank is integral with the centre section torque box and the fin tank is integral with the fin torque box.

3. At each wing tip, a vent surge tank collects fuel that is spilt into the vent system during manoeuvres; this fuel is automatically transferred back to either No. 1 or No. 4 tank.

4. All tanks are pressurized during flight, the wing and centre section tanks through ram air intakes flush with the under-surface of each wing tip and the fin tank through a ram air intake in the left upper surface of the fin.

5. The vent system for the wing tanks is also used to dump excess fuel during excessive pressure refuelling. The fin tank vent system is independent of the wing system.

6. Fuel can only be supplied to the engines from any of Nos. 1, 2, 3 and 4 tanks; fuel is transferred from the fin tank to the centre tank and from there to the wing tanks. Fuel from Nos. 1A and 4A tanks can only be transferred to No. 1 and No. 4 tanks.

7. In normal flight, fuel is supplied to each engine from the appropriate tank but in the event of abnormal conditions or in an emergency, fuel can be supplied to any other engine by use of the inter-engine and cross-feed valves.

8. The aircraft is refuelled or defuelled through a connection at the rear inboard edge of each wing. Either of these operations can be controlled manually or automatically through an electronic control box at the right wing connection. The two-point refuelling rate is 1,152 gall./min.

9. Provision is made for air-to-air refuelling through the refuelling probe in the nose of the aircraft. The operation is controlled from the fuel control panel at the engineer's station.

10. Fuel can be transferred from the centre tank to the fin tank for aircraft trim purposes.

11. Only a proportion of fuel in each of Nos. 1, 2, 3 and 4 tanks can be jettisoned but all the fuel in the centre tank, fin tank and Nos. 1A and 4A tanks can be jettisoned. Retention of the essential quantities of fuel in Nos. 1, 2, 3 and 4 tanks is by means of low level switches in each tank.

12. An electronic gauging system indicates the contents of the tanks on gauges at the Flight Engineer's station and on the refuel/defuel control box. Manually-operated underwing fuel level indicators are fitted in the wing and centre tanks. A second check on the contents of the fin tank can be made by reading the gauge operated by hydrostatic pressure, at the refuel/defuel control panel.

13. The fuel system is controlled from the Engineer's station.

Usable Fuel

14. The tank contents are as follows:

Tank Nos.	*Imp. Gall.*	*Lb. (Sp. gr. 0·8)*
1A	1,430	11,440
1	1,905	15,240
2	3,380	27,040
3	3,375	27,000
4	1,900	15,200
4A	1,430	11,440
Centre	4,565	36,520
Fin	1,370	10,960
	19,355	154,840

15 and 16. *Controls and Indicators — Fuel System* (*See Table* 1)

Fuel Feed—Description

17. Two electrically-driven booster-pumps operate in each of the four wing tanks. Each pump is contained within an isolating chamber to facilitate its removal without draining the contents of the tank.

18. Each pump delivers fuel via a non-return valve into a single delivery pipe from each tank. The non-return valve is incorporated to prevent the fuel delivery from one pump returning to the tank via the second pump when one pump only is in operation.

19. A flap-type suction valve at the extremity of a pipe branched into each of the front pump delivery pipes allows the engine-driven LP pumps to draw fuel from the tank, without undue resistance, in the case of failure of both booster-pumps in a particular tank.

20. The electrically-operated LP cocks in the four main delivery pipes allow the isolation of any one or more fuel feeds in case of engine fire.

Table 1. Controls and Indicators — Fuel System

The following fuel controls and indicators are on the engineer's fuel panel:

Item	*Marking/Indication*
Wing tank jettison valve switches (5)	JETTISON VALVES — No. 1/No. 2/CENTRE/No. 3/ No. 4 — NORM/OPEN
Jettison and transfer valve switches (6)	JETTISON VALVES — NEG. LINE LEFT — NORM/JETTN. TRANS No. 1A/1 — NORM/JETTN. MAIN LEFT — NORM/JETTN. MAIN RIGHT — NORM/JETTN. TRANS No. 4A/4 — NORM/JETTN. NEG. LINE RIGHT — NORM/JETTN.
Fin tank jettison valve switch	FIN — NORM/JETTN.
Gangbar	JETTN.
Jettison master valve indicators (3)	JETTN. MASTER VALVES — LEFT/FIN/RIGHT: OPEN; Cross-hatch; SHUT
Fin tank contents gauge and test button	FIN. LB × 1,000 PRESS TO TEST. Fuel quantity pre-set load selector
◀Fin trim alert and failure warning light	TRIM ALERT (Amber, press-to-test)▶
Fin tank fuel low level light	FIN LOW LEVEL (Amber, press-to-test)
Fin tank isolate valve switch	FIN ISOLATE — OPEN/SHUT
Fin tank isolate valve indicator	In-line; cross-line; cross-hatch
Fin tank transfer valves switches (3)	(1) FIN TRANSFER SLOW — OPEN/SHUT (2) FIN TRANSFER FAST — OPEN/SHUT (3) FIN TRANSFER FAST — OPEN/SHUT
Fin tank transfer valve indicators (3)	In-line; cross-line; cross-hatch
Centre tank contents gauge and test button ...	CENTRE. LB × 1,000 PRESS TO TEST. Fuel quantity pre-set load selector
Fuel system temperature gauge	MIN SYSTEM TEMP. °C
Contents gauges and test buttons for Nos. 1A and 4A tanks	1A/4A LB × 1,000. PRESS TO TEST
Probe drain pump and valve switch	PROBE DRAIN — OPEN/SHUT
Probe drain indicator	In-line; cross-line; cross-hatch
Fin tank flight refuelling valve switch	FL.R. VALVE — OPEN/SHUT
Fin tank flight refuelling valve indicator	In-line; cross-line
Centre tank flight refuelling valves switches (2)	FL.R. VALVES 1, 2 — OPEN/SHUT
Centre tank transfer pumps switches (2)	RH TRANS. PUMP ON: LH TRANS. PUMP ON
Centre tank flight refuelling valves indicator ...	In-line; cross-line; cross-hatch
No. 1A tank flight refuelling valve switch ...	FL.R. VALVE — OPEN/SHUT
No. 1A tank flight refuelling valve indicator ...	In-line; cross-line
No. 1A/1 tanks slow transfer valve switch ...	SLOW TRANS VALVE — OPEN/SHUT
No. 1A/1 tanks slow transfer valve indicator ...	In-line; cross-line; cross-hatch
No. 1A/1 tanks fast transfer valve switch ...	FAST TRANS VALVE — OPEN/SHUT
No. 1A/1 tanks fast transfer valve indicator ...	Cross-line; in-line; cross-hatch
Transfer low-pressure indicators (2)	TRANS. LOW PRESS.: LP or in-line
Transfer cross-feed valve switch	TRANS. CROSS-FEED — OPEN/SHUT
Transfer cross-feed valve indicator	Cross-line; in-line; cross-hatch
No. 4A tank flight refuelling valve switch	FL.R. VALVE — OPEN/SHUT
No. 4A tank flight refuelling valve indicator ...	In-line; cross-line
No. 4A/4 tanks slow transfer valve switch ...	SLOW TRANS. VALVE — OPEN/SHUT
No. 4A/4 tanks slow transfer valve indicator ...	In-line; cross-line; cross-hatch
No. 4A/4 tanks fast transfer valve switch ...	FAST TRANS VALVE — OPEN/SHUT
No. 4A/4 tanks fast transfer valve indicator ...	Cross-line; in-line; cross-hatch

— Continued on next page

Table 1. Controls and Indicators—Fuel System—*continued*

Item	*Marking/Indication*
Flight refuelling and transfer valve switches (4) ...	TRANS. AND F.R. VALVE—OPEN/SHUT
Flight refuelling and transfer valve indicators (4)	In-line; cross-line; cross-hatch
Contents gauges and test buttons (4)	1, 2, 3, 4. LB x 1,000: PRESS TO TEST
Booster-pump switches (8)	BOOSTER PUMPS—ON. FWD (4), AFT (4)
Low pressure cock switches (4)	L.P. COCK—OPEN/SHUT
Low pressure cock indicators (4)	Cross-line; in-line; cross-hatch
Fuel feed low pressure warning lights (4)	LOW PRESS. (Red)
Inter-engine valve switches (2)	INTER ENGINE—OPEN/SHUT
Inter-engine valve indicators (2)	Cross-line; in-line; cross-hatch
Cross-feed valve switch	CROSS FEED—OPEN/SHUT
Cross-feed valve indicator	Cross-line; in-line; cross-hatch
Temperature gauges (4)	°C.
Fuel flowmeters (4)	LB/MIN. x 10 FUEL FLOW
Fuel pressure gauges (4)	FUEL PSI
The following indicator is on the rear roof panel:	
Fuel probe vent valve indicator	FUEL PROBE LINE VENT VALVE OPEN; cross-hatch; SHUT
The following indicator is on the APU panel:	
Fin tank ground isolation valve indicator	FIN TANK GRD. ISOL: OPEN/SHUT

21. From the rear of the main wheel bays, the two fuel feed pipes enter ducts extending rearward along the fuselage. The forward ends of these ducts are open to atmosphere in the wheel bays. This ensures that if a leakage occurs neither the fuel nor its vapour can penetrate into the pressurised portion of the fuselage. The rear end of the duct is closed to prevent air current passing from the wheel bay to the engine nacelles.

22. Toward the rear of the fuselage the feed pipes turn outward and terminate at one half of self-sealing couplings which are located in the respective engine nacelles. The mating halves of the couplings form part of the engine fuel system.

23. A low-pressure switch is included in each engine feed system and is located in the associated engine nacelle stub. The switch gives an indication of fuel pressure failure on the fuel panel on the flight deck (see para. 35 below).

24. The following components, on each engine, are downstream of the self-sealing couplings:

(1) Engine-driven LP pump, together with the bypass and non-return valve.

(2) Low-pressure fuel-cooled oil cooler.

(3) Fuel heater.

(4) Filter.

(5) Temperature transmitter for temperature gauge.

(6) Flowmeter.

(7) LP pump pressure transmitter for the fuel pressure gauge.

(8) High-pressure pump.

(9) Fuel control unit (incorporating the high-pressure cock).

25. Immediately to the rear of the centre tank and upstream of the low-pressure cocks an inter-engine cross-feed pipe interconnects all four main feed pipes. Electrically-operated inter-engine valves are interposed between the feed pipes of No. 1 and No. 2 engines and No. 3 and No. 4 engines, whilst a fuel feed cross-feed valve is centrally disposed in the pipe joining the left and the right systems.

Booster-pump Control

26. When the BOOSTER PUMP switches are switched to ON, fuel from tanks Nos. 1, 2, 3 and 4 is delivered to the engines, via the non-return valves, low-pressure cocks and self-sealing couplings.

27. Each booster-pump output is sufficient to maintain the fuel flow at the required pressure to its appropriate power plant. Failure of both booster-pumps in a tank, resulting in a complete loss of pressure causes the associated low-pressure red warning light to come on (see para. 35 below).

28. In this case the fuel supply to the power plant can be adequately maintained by the engine-driven pumps, drawing fuel from the tanks via the suction valves, although altitude limitations may be imposed under certain conditions.

Low-pressure Cock Control

29. Each low-pressure cock circuit consists of a two-position switch, two micro-switches, an electrically-actuated cock and a magnetic indicator. When an LP cock switch on the fuel system panel is selected to OPEN, with that engine high-pressure cock lever in the START or RUN position and the fire control handle in its normal position, a 28-volt DC supply is taken from an essential bus-bar via a circuit-breaker and the normally closed micro-switches on the high-pressure cock to the actuator on the cock.

30. When the LP cock starts to open, its magnetic indicator is de-energised (black and white cross hatching). When the cock reaches the fully open position the magnetic indicator changes to show a vertical white line and completes the "fuel path" engraving on the panel. When the cock is fully closed the magnetic indicator shows a horizontal white line which breaks the "fuel path" engraving.

31. Operation of the appropriate high-pressure cock lever on the centre console to the SHUT position operates a micro-switch to break the supply line to the cock open circuit. If the appropriate fire control handle on the glare shield is pulled another micro-switch is operated. This completes a circuit through the high-pressure cock micro-switch to the low-pressure cock shut circuit. This arrangement automatically ensures that the low-pressure cock shuts whenever the fire drill is carried out for that engine.

Inter-engine and Fuel Feed Cross-feed Valve Control

32. Each valve circuit consists of a two-position switch, an electrically actuated valve and a magnetic indicator. Selecting an INTER-ENGINE valve switch to OPEN allows the booster-pumps in one tank to supply fuel to both power plants on that side of the aircraft provided that the booster-pumps of the other tank on the same side are switched off.

33. When the valve starts to open, its magnetic indicator is de-energised (black and white cross-hatching). When the valve is fully open the magnetic indicator changes to show a white horizontal line and completes the "fuel path" engraving on the panel.

34. Selecting the CROSS FEED valve switch to OPEN with the inter-engine valves already open will allow all power plants to be fed from a particular tank, or any combination of tanks, dependent on the booster-pump switches that are selected to ON.

Engine Fuel Feed Low Pressure Warning

35. Four pressure switches set to operate at 2 PSI are fitted, one in each engine fuel supply line, upstream of the self-sealing couplings. If the fuel pressure to an engine low pressure pump falls to 2 PSI, operation of the associated pressure switch causes the appropriate LOW PRESS red warning light on the fuel panel to come on. A rise in pressure above 2 PSI causes a light to go out.

Fuel Transfer—General

36. a. *Fuel Drills*

For transferring fuel in flight there are three drills:

No. 1 Fuel Drill (standard usage)

No. 2 Fuel Drill (maximum economy usage, see para. 39).

In-flight Refuelling Drill.

All control switches, indicators and tank contents gauges are on the fuel system panel at the engineer's station.

b. *Fuel Transfer Routes*

(1) *Centre tank to wing tanks.* Two transfer pumps in the centre tank transfer fuel from the centre tank to the wing tanks via the refuel/defuel gallery. Fuel from the centre tank enters each wing tank via a refuel/defuel valve, a non-return valve and a diffuser under the control of the associated TRANS. & FL.R VALVE switches (4, one for each tank) on the fuel panel. These switches also control fuel flow into the wing tanks during in-flight refuelling.

(2) *Tanks 1A to 1 and 4A to 4.* Fuel is transferred by gravity flow from tank 1A to tank 1 and from tank 4A to tank 4 via a fast or a slow transfer valve between the associated tanks on each side, each valve being in a separate pipeline. The valves are controlled by a FAST TRANS. VALVE switch and a SLOW TRANS. VALVE switch for each side, on the fuel panel. The refuel/defuel valves for tanks 1A and 4A are controlled by the associated FL.R. VALVE switches on the fuel panel.

(3) *Fin tank to centre tank.* Fuel is transferred from the fin tank to the centre tank by gravity flow via a transfer pipe which contains three transfer valves (1, 2 and 3) mounted in parallel. With the fin tank isolation valve OPEN fuel is transferred via one or more of the transfer valves, when selected by the associated FIN TRANSFER — No. 1 SLOW, No. 2 FAST and No. 3 FAST switches (3) on the fuel panel.

(4) When No. 1 Fuel Drill is used, fuel is normally transferred from the fin tank to the centre tank through No. 1 fin transfer valve. When No 2 Fuel Drill is used, fuel is transferred from the

fin tank to the centre tank via No. 1 fin tank transfer valve only, under the control of the PRE-SET LOAD knob on the fin tank contents gauge (see para. 81).
Transfer rate is:

No. 1 transfer valve ...	77 to 88 lb./min.
No. 2 or No. 3 transfer valve	286 to 308 lb./min.

NOTE: In certain circumstances however, fuel may be transferred via No. 2 fin tank transfer valve when No. 2 Fuel Drill is used, i.e. prior to landing when a rapid transfer is necessary in order to empty the fin tank for landing.

(5) *Centre tank to fin tank.* Fuel is transferred from the centre tank to the fin tank by the transfer pumps in the centre tank via the fin tank refuel/defuel pipe-line. Fuel enters the tank via a refuel/defuel valve, a tank isolation valve and a diffuser. With the fin tank isolation valve OPEN, fuel enters the tank under the control of the associated FL.R.VALVE switch on the fuel panel.

(6) When No. 1 Fuel Drill is used, fuel is not transferred to the fin tank. When No. 2 Fuel Drill is used, fuel for trim purposes is transferred to the fin tank via its refuel/defuel valve, under the control of the PRE-SET LOAD knobs on both the fin and centre tanks contents gauges (see para. 81). Transfer rate, with both centre tank transfer pumps ON is 286 to 308 lb./min.

c. The transfer cross-feed valve, which is normally open during flight, must be shut for normal refuelling/defuelling operations by setting the TRANS. CROSS FEED switch to SHUT, thus isolating each refuelling/defuelling source. If only one refuelling point is being used, the TRANS. CROSS FEED switch must be set to OPEN.

37. *Crew Controlled Transfer Systems* (See Table 2).

38. *Automatic Transfer System.* Fuel spilled into the left and right vent/surge tanks is transferred automatically into the No. 1 and No. 4 tanks, respectively.

Trim Fuel Transfer (No. 2 Fuel Drill)

39. a. In-flight trimming of fuel between the centre tank and the fin tank is carried out, to pre-determined levels (in accordance with the Trim Fuel Table in Pt. 2 Chap. 10 (Table 1) of Pilot's Notes (Flying)), when using the No. 2 Fuel Drill.

b. The quantity of fuel to be transferred between these two tanks is manually selected by adjustment of the PRE-SET LOAD knobs on their fuel contents gauges (see para. 81). In use, transfer of fuel ceases automatically and the TRIM ALERT light (adjacent to the fin tank contents gauge) flashes, when the pre-selected fuel load has been transferred.

c. The PRE-SET LOAD knob on the centre tank contents gauge pre-selects the amount of fuel to be transferred *to the fin tank from the centre tank*. It does not control the amount of fuel which may be transferred to the centre tank from the fin tank or any other source.

d. The PRE-SET LOAD knob on the fin tank contents gauge pre-selects the amount of fuel required to be transferred *into or out of the fin tank*: it may also be used to control the amount of fuel supplied to the fin tank during air-to-air refuelling.

Transfer from the Centre Tank to the Wing Tanks

40. *Description*

a. Two transfer pumps (of the same type as the booster-pumps), each located in its own isolating chamber, pump fuel from the centre tank through

Table 2. Crew Controlled Transfer Systems

a. Centre tank to wing tanks	Selective transfer of the contents of the centre tank, to any or all of the Nos. 1, 2, 3 and 4 wing tanks.
b. No. 1A and No. 4A tanks to No. 1 and No. 4 tanks respectively	Selective slow *or* fast transfer of the contents of No. 1A and No. 4A tanks into No. 1 and No. 4 tanks respectively.
c. Fin tank to centre tank	Selective slow transfer of the contents of the fin tank via No. 1 transfer valve to the centre tank, or transfer of fuel surplus to trim fuel required: selective fast transfer of the fin tank contents via No. 2 *or* No. 3 transfer valve to the centre tank.
d. Centre tank to fin	Selective transfer of fuel from the centre tank to the fin tank.

NOTE: Transfer of fuel from the fin tank to the centre tank may be combined with the transfer of fuel from the centre tank to the wing tank.

◀ a rate control valve into the refuel/defuel gallery. ▶ Fuel then passes into tanks Nos. 1, 2, 3 and 4, according to which transfer valve switches have been selected, via the normal refuel/defuel valve, non-return valve and diffuser.

b. A transfer cross-feed valve is incorporated in the main refuel/defuel gallery between the two junctions where the pipes from the centre tank pumps join the gallery. It is normally OPEN during flight and must be SHUT during refuelling/ ◀ defuelling operations when using both refuelling points. ▶

c. Two transfer low pressure warning switches, one on each side of the transfer cross-feed valve, operate low pressure warning magnetic indicators (TRANS—LOW PRESS (2)) on the fuel panel. The indicators normally show in-line but show LP when transfer pressure falls to 2 PSI. The appearance of LP indicates that transfer has terminated or that the transfer pump/s has/have ceased to operate.

41. *Operation*

a. To transfer fuel from the centre tank to any of the wing tanks the following switches must be selected:

(1) Either of the TRANSFER PUMP switches on the fuel system panel to ON. (Transfer cross-feed valve OPEN).

(2) Tank Nos. 1, 2, 3 and 4 TRANS. & FL.R. VALVE switches, or if necessary, any combination of these switches, on the fuel system panel, to OPEN.

b. The selection of a TRANS. & FL.R. VALVE switch from SHUT to OPEN completes a 28-volt DC supply, via the appropriate tank top-level float switch, to energise the refuelling solenoid on the refuel/defuel valve.

c. When the piston in the refuel/defuel valve begins to move under fuel pressure, an internally-mounted micro-switch operates to energise the magnetic indicator, adjacent to the switch on the fuel panel, to show in-line.

d. Fuel from the centre tank is then transferred to the selected wing tanks. When the centre tank is empty the drop in fuel pressure causes the pressure warning switches to interrupt the DC circuit and de-energise the magnetic indicators which will show LP. The drop in fuel pressure also allows the refuel/defuel valve to close and its indicator to show cross-line.

e. The TRANSFER PUMP switch is then switched off and the TRANS. & FL.R. VALVE switches are set to SHUT.

f. If the TRANS. LOW PRESS. indicators show LP before the tank is empty, as ascertained by the tank contents gauge, the second pump must be switched on.

g. When a tank becomes full during the transfer operation, the appropriate float switch de-energises the refuelling solenoid in the refuel/defuel valve, thereby shutting the valve and cutting off the supply of fuel to the tank; the TRANS. & FL.R. VALVE magnetic indicator is then de-energised and shows cross-line; the refuel/defuel valve automatically re-opens when the fuel level falls, the indicator then showing in-line.

h. The non-return valve placed across the jettison valves on the centre tank, ensures that fuel is not fed into the centre tank through a stationary pump during a transfer operation; it also ensures that during refuelling all fuel enters the centre tank via the refuel/defuel valves. The non-return valve is strongly spring-loaded to prevent defuelling through the transfer pumps, and it also controls the transfer flow rate.

Transfer from No. 1A and No. 4A Tanks to No. 1 and No. 4 Tanks

42. *Slow Transfer*

a. A slow gravity transfer system is provided between tanks 1A/1 and tanks 4A/4. The slow transfer valves are operated by their appropriate switches on the fuel system panel. The slow transfer valves and associated transfer pipes are located on a rear spar at the junction of tanks 1A/1 and 4A/4. ▶◀

b. As the fuel transfer between tanks Nos. 1A and 4A to tanks Nos. 1 and 4 can affect the aircraft CG, transfer must only be carried out as and when required by the flight plan. To transfer, the SLOW TRANSFER VALVE switches for tanks Nos. 1A and 4A, on the fuel control panel, must be set to OPEN. A 28-volt DC supply is then fed from an essential bus-bar to operate the slow transfer valves. The built-in limit switches of the actuators will, in turn, operate the magnetic indicators adjacent to the switches.

43. *Fast Transfer*

a. A fast transfer valve is mounted at the bottom rear of each of the diaphragms between tanks Nos. 1A/1 and tanks Nos. 4A/4. The fast transfer valves are operated by their appropriate switches on the fuel system panel. When the valves are open they permit a gravity flow from tanks Nos. 1A and 4A to tanks Nos. 1 and 4 respectively; they also act as non-return valves to prevent any fuel surge towards the wing tips that may be caused by abnormal manoeuvres.

b. As the fuel transfer between tanks Nos. 1A and 4A to tanks Nos. 1 and 4 can affect the aircraft CG, transfer must only be carried out as and when required by the flight plan. To transfer, the FAST TRANSFER VALVE switches for tanks Nos. 1A and 4A, on the fuel control panel, must be set to OPEN. A 28-volt DC supply is then fed from an essential bus-bar to operate the fast transfer valves. The built-in limit switches of the actuators will, in turn, operate the magnetic indicators adjacent to the switches. The circuit from the bus-bar passes through the transfer valve switches on the jettison panel to ensure that the transfer valve is open when the jettison gang bar is set to JETTISON. When the valve is open, fuel flows by gravity from tanks 1A and 4A to tanks 1 and 4 respectively.

Transfer from the Fin Tank to the Centre Tank (Nos. 1 and 2 Fuel Drills)

44. *Description*

a. The fin tank transfer system utilises the refuel/defuel pipe to where it forks to form a transfer pipe and a continuation of the refuel/defuel pipe. The transfer pipe branches into three pipes and an electrically-operated transfer valve is fitted in each branch pipe. After each transfer valve the pipes join to form a single transfer pipe which is connected, through an anti-surge valve, to the centre tank. Fuel is transferred by gravity.

NOTE: Before fuel transfer to or from the fin tank can take place, the fin tank isolate valve switch must be set to OPEN.

b. The left branch with No. 1 transfer valve is the No. 1 or normal (SLOW) system by which fuel is transferred, early in flight, to the centre tank. A restrictor is fitted just downstream of the valve.

c. The right branch with No. 2 transfer valve is the No. 2 or normal (FAST) system with no restriction, and is used in the latter stages of flight for fast transfer to the centre tank.

d. The centre branch with the No. 3 transfer valve is the No. 3 or alternative (FAST) system with no restriction. This is fitted as a standby system which may be used should No. 2 system fail.

e. Nos. 1 and 2 transfer valves are controlled by high level float switches in the centre tank but, when No. 2 Fuel Drill is used, No. 1 transfer valve is also controlled by the PRE-SET LOAD knob on the fin tank contents gauge. This causes the transfer valve to automatically shut and the TRIM ALERT light to flash when transfer is completed. Setting the FIN TRANSFER No. 1 switch to SHUT then causes the light to go out.

f. A FIN LOW LEVEL amber light on the fuel panel comes on when the tank is empty; the light is cancelled by setting the FIN ISOLATE valve switch to shut.

45. *Operation*

NOTE: The fin tank low level light comes on when the fin tank is empty but a check should also be made on the fin tank contents gauge. After a period of one minute, the switch(es) of the FIN TRANSFER valve(s) in use and the FIN ISOLATE valve switch should be set to SHUT. This action causes the low-level light to go out.

a. *Normal (Slow) Transfer via No. 1 Transfer Valve (No. 1 Fuel Drill).* To transfer fuel from the fin tank via the No. 1 fuel transfer valve (SLOW), the FIN ISOLATE switch must be set OPEN and the FIN TRANSFER 1 SLOW switch set to OPEN. If the centre tank is full, fuel will not flow from the fin tank because the centre tank float switch keeps the transfer valve closed. When the fuel level in the centre tank falls, the float switch operates to open the transfer valve to allow fuel flow to the centre tank under gravity.

b. *Transfer (Slow) via No. 1 Transfer Valve (No. 2 Fuel Drill).* When the fin tank contents are more than the trim fuel required, fuel may be transferred from the fin tank to the centre tank under the control of the PRE-SET LOAD knob on the fin tank contents gauge. To transfer fuel from the fin tank, the FIN ISOLATE switch must be OPEN and normal wing transfer should be in operation. After setting the required trim fuel load, by use of the PRE-SET LOAD knob on the fin tank contents gauge, setting the FIN TRANSFER No. 1 switch OPEN starts the transfer. At the required pre-set trim fuel load (indicated by the fin tank contents gauge pointers becoming coincident) the No. 1 transfer valve shuts automatically (magnetic indicator cross-line) and the TRIM ALERT light starts to flash. Setting the FIN TRANSFER No. 1 switch to SHUT causes the light to go out.

NOTE 1: If the transfer valve does not shut automatically when the TRIM ALERT light starts to flash, and the FIN TRANSFER No. 1 switch is not set to SHUT, fuel will continue to flow into the centre tank until the fin tank is empty or until the centre tank is full. When the centre tank is full, the top level float switch operates to shut the transfer valve and set its magnetic indicator cross-line. The trim alert light will continue to flash.

NOTE 2: If the No. 2 transfer valve is used, the load transfer must be monitored and, on completion of transfer of the necessary quantity, the FIN TRANSFER No. 2 switch must be set to SHUT.

c. *Fast Transfer via No. 2 Transfer Valve.* Operation is the same as for the slow transfer (No. 1 Fuel Drill) with the exception that the FIN TRANSFER 2 FAST switch is set to OPEN.

d. *Fast Transfer via No. 3 Transfer Valve.* Operation is the same as for slow transfer (No. 1 Fuel Drill) with the exception that the FIN TRANSFER 3 FAST switch is set to OPEN.

NOTE: No. 3 transfer valve is not controlled by a float switch in the centre tank.

Transfer from the Centre Tank to the Fin Tank (No. 2 Fuel Drill)

46. *Description.* The centre tank to fin tank transfer system utilises the refuel/defuel gallery. The wing tank transfer valves are closed during transfer of fuel from the centre tank to the fin tank and the fin tank refuel and isolation valves are open. Fuel is transferred by both transfer pumps in the centre tank to the refuel/defuel gallery and thence via the fin flight refuel valve to the fin tank. The fin tank isolation valve and transfer cross-feed valve are open during transfer. The amount of fuel to be transferred is selected and controlled by the PRE-SET LOAD knobs on both the centre and fin tank contents gauges (see para. 81) which, in operation, causes the refuel/defuel valve to automatically shut and the TRIM ALERT light to flash when transfer is completed.

47. *Operation*

a. When fuel is carried in the centre and/or fin tanks, the trim fuel table must be used to determine the trim fuel required for flight. Before or after take-off this quantity should be set on the fin tank fuel contents gauge by means of the PRE-SET LOAD selector knob.

b. When the fin tank contents are less than the trim fuel required, this difference must be subtracted from the initial quantity of fuel in the centre tank. The trim fuel quantity for the fin tank having been selected (sub-para. a. above), the pre-set load pointer on the centre tank contents gauge should be set to the quantity calculated above (centre tank contents minus the amount to be transferred).

c. To transfer fuel from the centre tank to the fin tank, the fin tank isolate valve switch must be set OPEN and all wing tank transfer and flight refuel valve switches must be set to SHUT. Then set the fin tank FL.R.VALVE switch to OPEN and the centre tank LH and RH TRANS. PUMP switches to ON.

d. At the required trim load (indicated by the contents pointers of either fin or centre contents gauges coinciding with their PRE-SET LOAD pointers) the fin flight refuelling valve shuts automatically (magnetic indicator cross-line) and the TRIM ALERT light starts to flash, indicating that transfer is complete. The fin tank FL. R. VALVE switch should then be set to SHUT, thus automatically cancelling the TRIM ALERT light.

e. Trim fuel is retained in the fin tank until 45 minutes prior to landing, when it is transferred via a fast transfer valve to the centre tank for distribution.

NOTE: If the fin tank refuel/defuel valve does not shut automatically when the TRIM ALERT light starts to flash, and the fin FL. R. VALVE switch is not set to SHUT, fuel will continue to flow into the fin tank until it is full. When the fin tank is full the top level float switch operates to shut the refuel/defuel valve and set its magnetic indicator cross-line. The trim alert light will continue to flash.

Venting

48. *Wing Tanks*

a. Venting is achieved through a main vent pipe, with branches from each tank leading into a vent/surge tank at each wing tip, which is open to atmosphere through a flush ram-air intake on the under-surface of the wing. Fuel accumulating in the vent/surge tanks is automatically pumped back into Nos. 1 and 4 tanks by a vent/surge pump.

b. During flight the fuel tanks are pressurised through the ram-air intakes, vent/surge tanks and vent pipes.

c. The three left-wing tanks are vented to the left-wing vent/surge tank, and the centre tank and the three right-wing tanks are vented to the right-wing vent/surge tank.

d. Vent pipes are fitted within the tanks to ensure adequate venting at all fuel levels and at all aircraft attitudes. Float-operated vent valves are fitted where necessary to ensure that fuel is not transferred from tank to tank or transferred in excessive quantities to the vent/surge tanks.

e. The venting system also protects the structure in the event of overfilling during pressure refuelling, by allowing the excess fuel to be dumped without building up dangerous pressures within the tanks.

49. *Vent/Surge Tanks.* A vent/surge tank in each wing acts as a collector for fuel spilled into the venting system.

50. *Fin Tank*

a. Ram-air venting is achieved through an intake flush with the left top side of the fin.

b. If over-fuelling occurs through the malfunctioning of a float switch, a float-operated valve over the aperture of the fuel over-flow pipe opens and fuel flows down the pipe into the jettison pipe in the tail cone. Downstream of where the

overflow pipe joins the jettison pipe there is a fin tank ground isolation valve which is normally open but if the APU start master switch is set ON, or if the APU fire warning light comes on, the valve is automatically closed. An associated magnetic indicator (FIN TANK GRD ISOL) on the APU panel shows OPEN or SHUT according to the setting of this valve.

c. During a steep climb away with a full fin tank, the float-operated valve operates in a similar manner.

d. Venting/purging of the combined over-fuel and jettison pipe is achieved by ram-air which is piped from an intake, in the lower left side of the fin, to the shut-off valve.

Fuel Drain Valves

51. Tank and pipe valves are installed in the lowest points of the fuel and vent system to enable tests to be made for the presence of water. They also permit complete draining of the fuel system when necessary.

Fuel Jettison

52. Fuel can be jettisoned down to 5,200 lb. (650 gallons) in each of Nos. 1, 2, 3 and 4 tanks, and all the fuel from the centre tank, Nos. 1A and 4A tanks and the fin tank. Retention of the essential quantities of fuel in the wing tanks is controlled by the operation of low-level float switches located in each tank.

53. Fuel is jettisoned from the centre tank by both transfer pumps and from the wing tanks by the rear booster-pump in each of the wing tanks. Fuel is jettisoned from the fin tank by gravity.

NOTE: The contents of Nos. 1A and 4A tanks are jettisoned by the booster-pumps in Nos. 1 and 4 tanks respectively.

54. A jettison master valve, located in a branch pipe from the refuel/defuel gallery of each wing, controls the jettisoning of fuel through an outlet at the trailing edge of each wing. A jettison valve, located in a pipe that is connected to the bottom of the fin tank and is joined to the vent pipe, controls the jettisoning of fuel from the fin tank through an outlet at the rear of the tail cone.

55. The jettisoning of fuel is controlled from a covered panel at the top of the fuel panel at the engineer's station and the control is so arranged that fuel can be jettisoned from any tank or combination of tanks and can be stopped at any level.

56. Both transfer pumps in the centre tank are used for jettisoning fuel from this tank. The delivery from each pump by-passes the spring-loaded non-return valve used during normal fuel transfer and passes through an electrically-controlled jettison valve before entering the main refuel/defuel gallery pipe running along the aft face of the trailing-edge member of the torque box.

57. The rear booster-pumps only in each of tanks Nos. 1, 2, 3 and 4 are used for jettisoning fuel. The fuel delivery from the forward pumps in each tank, used to maintain engine power during jettisoning, is prevented from entering the jettison system by non-return valves located in the normal delivery line from the rear pumps.

58. The fuel delivered by each of the four rear pumps passes through an electrically-operated jettison valve before entering the main refuel/defuel gallery.

59. Low-level float switches connected in series with the control switches of each of the jettison valves ensure that they will close to leave a quantity of at least 5,200 lb. (650 gallons) of fuel in each of tanks Nos. 1, 2, 3 and 4, in a normal cruise attitude.

60. Selection of both MAIN and NEGATIVE LINE switches either LEFT or RIGHT, causes the associated JETT. MASTER VALVES indicator to show cross-hatched and completes the circuit of the actuator causing the valve to open. When the valve reaches the fully open position the magnetic indicator shows OPEN.

61. The fin tank jettison valve is controlled by a single NORM/JETTN. switch (which is in the same row of switches as the wing tank master valves) and operation of the gang bar will also move the fin tank switch to the jettison position. The FIN tank jettison master valve indicator operates in a similar manner to the wing tank jettison master valves indicators.

62. *Fuel Jettisoning — Fin Tank Full.* When fuel is to be jettisoned and the fin tank is full the undermentioned procedure must be followed in the correct sequence:

a. Set the fin tank transfer valve switches to SHUT.

b. Ensure that all normal TRANSFER VALVES switches are selected to SHUT.

c. Select all eight BOOSTER-PUMP switches and the two TRANSFER PUMP switches to ON.

d. Open the lid covering the jettison panel above the fuel system panel.

e. Select all TANK JETTISON VALVE switches in the upper row of switches on the jettison panel to OPEN. This energises the solenoids of the jettison valves and allows the aft fuel pump pressure to open the valves.

f. Pull the JETTN. (Jettison) gang bar down. This operation sets all seven switches encompassed by the bar to JETTN.

63. The JETT. MASTER VALVES magnetic indicators will immediately change from SHUT to a cross-hatch indication and the jettison master valves

start to open. When fully open the JETT. MASTER VALVES indicators change from cross-hatch indication to OPEN.

64. The FAST TRANS. VALVE transfer valves in each wing then open to allow the fuel in tanks No. 1A and 4A to flow by gravity into tanks No. 1 and 4 respectively. The open state is shown by the respective magnetic indicators.

65. Fuel is then jettisoned to atmosphere through the discharge pipe at the trailing edge of each wing and, if there is fuel in the fin tank, through the discharge pipe in the tail cone.

66. When the quantity of fuel in any one of No. 1, 2, 3 and 4 tanks is down to 5,200 lb. (650 gallons) the respective low-level float switch interrupts the supply to its jettison valve thus de-energising the solenoid and closing the valve; jettisoning from that tank then ceases. When the fuel contents of tanks No. 1 and No. 4 reach 5,200 lb. (650 gallons), tanks No. 1A and 4A will be empty.

67. *Cancelling Fuel Jettison.* When the required quantity of fuel has been jettisoned the following procedure must be followed in the correct sequence:

a. Set all tank JETTISON VALVE switches to NORM.

◀ b. Set the FIN jettison switch to NORM. This operation closes the fin jettison master valve and the FIN JETT MASTER VALVE indicator shows SHUT.

c. Set the JETTISON VALVES MAIN LEFT and MAIN RIGHT switches to NORM. This operation closes the left and right jettison master valves and their indicators should indicate SHUT.▶

d. Select transfer valve switches TRANS. No. 1A/1 and TRANS. No. 4A/4 to NORM.

e. Check that the JETT. MASTER VALVES — LEFT/FIN/RIGHT indicators ▶◀ show SHUT.

f. Select the NEGATIVE LINE LEFT and NEGATIVE LINE RIGHT switches to NORM.

NOTE: *On no account must this latter operation be carried out before the jettison master valve indicators show shut.*

g. Close jettison panel lid.

h. Set the booster-pumps as required.

i. If the fin tank is empty, set the FIN ISOLATE switch to SHUT.

68. It may be necessary to jettison fuel from the fin tank only if the aircraft is landing with more than 100 lb. of fuel in the tank. In this case, set the fin tank isolate valve and transfer valve switches to SHUT and the fin tank jettison switch to JETTN. When the switch is set to JETTN. the jettison valve actuator is energised and the valve opens. When fully open the FIN TANK JETT. magnetic indicator shows OPEN. Selection of the FIN jettison valve switch to NORM, closes the jettison valve. When the valve is fully closed the magnetic indicator should show SHUT. When the fin tank is empty, set the FIN ISOLATE switch to SHUT.

Refuelling and Defuelling

69. *General.* An interconnection with the aircraft tank contents gauging system provides automatic control of both refuelling and defuelling. The maximum rate of refuelling is 500 gall./min. at 50 PSI at each refuel/defuel point. The maximum rate of ◀defuelling is 150 gall./min. at 11 PSI at each refuel/▶ defuel point. Provision is made for overwing refuelling and power draining through the refuel/defuel connections utilising the aircraft booster-pumps. Automatic control of refuelling/defuelling cannot be carried out unless the GROUND/FLIGHT switch is at GROUND — indicated by the POWER SUPPLY light on the refuel/defuel control panel coming on.

69A. Manual control of refuelling/defuelling can be carried out when a ground power supply is not available by using the aircraft batteries. Both battery POWER switches must be ON — magnetic indicators in line. The contents gauging system will be inoperative, since no AC supply is available. Tanks contents must be measured by use of the underwing drip sticks. If the APU is used to supply AC power, and the APU shuts down, there is a risk of overfuelling.

70. A refuel/defuel connection is in each wing, toward the inboard end of the trailing-edge member of the torque box. A refuel/defuel control panel, on which are mounted eight fuel contents gauges (each having its own pre-selector mechanism) and switches and indicators for automatic load-control, is located adjacent to the right-hand refuel/defuel connection.

71. The refuel/defuel connection is coupled into the refuel/defuel gallery pipe which extends along the trailing-edge of the torque box from tank No. 1A, on the left side of the aircraft to tank No. 4A on the right side.

72. An electrically-operated cross-feed valve in the refuel/defuel gallery pipe is used to isolate the left from the right system during refuelling/defuelling but is normally OPEN in flight.

73. *Wing Tanks.* From the refuel/defuel gallery pipe a branch pipe leads into each of the three left and three right tanks; the centre tank has two branch pipes leading into it, one located on each side of the transfer cross-feed valve. These dual branch pipes

allow the centre tank to be refuelled or defuelled by both refuel/defuel connections.

74. Each of the eight branch pipes passes through a refuel/defuel valve, which controls the flow of fuel to and from the tanks. After each refuel/defuel valve the pipe divides into a refuel and a defuel line. The refuel line has a non-return valve and terminates in a diffuser element and permits fuel to flow into the tank, whilst the defuel line has a non-return valve and terminates in an open-ended stand pipe and permits fuel to be drawn from the tank.

75. The diffuser elements are fitted to the refuel lines to distribute the incoming fuel over a wide area, so as to minimise the impact wear and static hazard at high refuelling pressures and rates. Splash guards are fitted to the diffuser element to further reduce any static hazard.

76. A float switch in each wing tank and two float switches in the centre tank are mounted on the leading edge members. Each float switch is coupled into the refuelling solenoid circuit of its associated defuel/refuel valve. The operation of the float switch, when the tank is full, causes the refuel/defuel valve to close.

77. *Fin Tank.* A branch pipe, in which a refuel/defuel valve is fitted, is taken from the gallery in the centre section to join the pipe that transfers fuel from the fin tank to the centre tank. During refuelling operations, fuel is transferred via this branch pipe, through the fin tank isolation valve, and a diffuser, into the tank.

78. A float switch at the top of the fin tank is coupled to the refuelling solenoid of the fin refuel/defuel valve and operation of this switch closes this valve. The valve also closes when the APU START MASTER switch is set ON.

79. A pressure-sensing line from the fin tank refuel/defuel valve to the centre tank relieves the differential fuel pressure on the face of the valve piston so that it can move the valve to open for the refuelling operation.

79A. A ground isolation valve, in the fin tank overfuel pipe, is interconnected with the fin tank refuel/defuel valve and is controlled by the APU starter master switch and APU fire-warning circuits. The valve is normally open but is automatically closed, together with the fin tank refuel/defuel valve, when the APU starter master switch is set ON, or if the APU fire-warning system operates. The fin tank ground isolation valve magnetic indicator and the fin tank refuel/defuel valve magnetic indicator then operate to show SHUT and cross-line respectively. (See Pt. 2, Chap. 7, Para. 104A).

Fuel Instruments

80. *Contents Gauges*

a. Each tank contains a number of tank units. In tanks 1A and 4A there are ten units in each tank; in tanks 1 and 4 there are seven units in each tank; in tanks 2 and 3 there are five units in each tank; in the centre tank there are six units and in the fin tank one unit. Tank units consist basically of two concentric metal tubes, and all the units in each tank are connected in parallel. In the wing tanks a number of the tank units are characterised. This is effected by altering the centre electrode diameter to suit the tank contour, and results in capacitance changes proportional to fuel quantity rather than fuel level. Four of the tank units are characterised in each of tanks 1A, 1, 4 and 4A and three in tanks 2 and 3. In each of the six wing tanks one tank unit incorporates a reference unit. This is another capacitor mounted at the lower end of the outer tube. It is completely immersed down to very low fuel levels and provides corrections for differing fuel grades. In the centre tank the reference unit is a separate item.

b. A relay is also fitted in the amplifier unit for necessary switching when the refuel/defuel panel is in use.

c. Eight fuel contents gauges are on the engineer's fuel system panel on the flight deck.

d. A PRESS-TO-TEST button adjacent to each gauge provides a functional test facility.

81. *Trim Fuel Transfer System*

a. The contents gauges for the fin and the centre tank each have two pointers which indicate on a common calibrated scale. On each gauge, the white pointer indicates the associated tank contents and the yellow pointer (which can be manually adjusted by the PRE-SET LOAD knob on the gauge) permits pre-selection of the amount of the fuel to be transferred.

b. Both the fin and centre tank contents gauges have internal switching mechanisms (adjustable by means of the associated PRE-SET LOAD knobs on the gauges), which allow for pre-selection of fuel loads for transfer between the two tanks. When transfer is made from the centre tank to the fin tank, the mechanisms in both gauges are used (failure of one mechanism does not prejudice satisfactory operation) but when transfer is made from the fin tank to the centre tank the mechanism in the fin tank contents gauge only is used.

c. The pre-selector mechanism in the centre tank contents gauge comprises a micro-switch which, when the white pointer moves down the scale (as fuel leaves the centre tank) and aligns with the yellow pointer, operates to shut the fin tank refuel/defuel valve.

d. The pre-selector mechanism in the fin tank contents gauge comprises two micro-switches.

When the white pointer *moves down* the scale (as fuel leaves the fin tank), and aligns with the yellow pointer, one microswitch operates to shut the *No 1 fin transfer valve*. When the white pointer *moves up* the scale (as fuel enters the fin tank), and aligns with the yellow pointer, the other microswitch operates to shut the *fin tank refuel/defuel valve*.

82. *Fuel Flowmeters*. Four fuel flowmeters, one for each engine, are provided on the fuel panel. They indicate, for the associated engine, the rate of fuel flow in lb/min x 10 and have a veeder counter on the face of the instrument to indicate the total fuel consumed in pounds. A resetting knob on each flowmeter, when pressed and turned, permits the veeder counter to be reset to zero.

83. *Fuel Temperature Gauges*

a. *Engine Fuel System Temperature*. Four fuel temperature gauges (one for each engine), are provided on the fuel panel. They are each connected to a temperature bulb fitted between the fuel filter and the flowmeter on the associated engine. The gauges are calibrated from minus 40°C to +120°C.

b. *Fuel System Minimum Temperature Gauge*. A MIN SYSTEM TEMP gauge on the fuel panel indicates the minimum fuel system temperature, as measured at the inboard rear corner of No 4 fuel tank. The gauge is calibrated from minus 60°C to +60°C.

84. *Fuel Pressure Gauges*. Four fuel system pressure gauges, one for each engine, are provided on the fuel panel. They operate from pressure transmitters downstream of the flowmeters and indicate the supply pressure to the HP pump from the low pressure pump and booster-pumps. The gauge is calibrated from 0 to 75 PSI. Average cruising power pressure is 35 PSI.

Refuel/Defuel Control Panel

85. The refuel/defuel control panel in the right wing incorporates the following components:

a. A fuel contents gauge for each of the seven fuel tanks. A gauge for the fin tank with a hydrostatic gauge (in place of a magnetic level indicator) is on a separate panel below the refuel/defuel control panel. The gauges are operative when the GROUND/FLIGHT switch on panel C is set to GROUND.

b. The gauges are calibrated in lb and have two pointers, one for indicating the tank contents and the other for pre-selecting a given quantity when refuelling or defuelling. The pre-selector pointer is operated from a knob adjacent to the gauges.

c. A GAUGE TEST switch for each of the eight gauges and a READ switch for the hydrostatic gauge.

d. A REFUEL/OFF LOAD—MASTER switch for selecting the appropriate solenoid on the refuel/defuel valve.

e. A MANUAL/AUTO—FUEL LOADING switch to enable the automatic load control to be used or isolated.

f. A POWER SUPPLY indicating lamp.

g. A tank TRIP/SELECT switch for each of the seven tanks.

h. A FUEL VALVE indicator for each of the tank refuel/defuel valves.

i. A nuisance bar controlling the main supply switch ensures that the supply switch and the tank TRIP/SELECT switches are off when the cover panel is closed.

Refuel/Defuel Gallery Drain Valve

86. A pipe from the refuel/defuel gallery leads into No 3 tank via a refuel/defuel gallery drain valve. A low-level float switch is mounted on the trailing-edge member at the inboard end of No 3 tank.

87. When the fuel level in No 3 tank reaches a low level, operation of the float switch completes a circuit from the No 1 28-volt DC Essential busbar to open the gallery drain valve allowing the contents of the refuel/defuel gallery pipe to gravity-drain into No 3 tank.

88. The refuel/defuel gallery drain valve closes when the gang bar on the refuel/defuel control panel is pulled down.

Refuelling and Defuelling — Operation

89. The refuel/defuel valves each incorporate two solenoids, one to control the valve in the refuel condition and the other in the defuel condition. When the appropriate solenoid is energised the valve only passes fuel in the selected direction and, when both solenoids are de-energised, the valve closes and prevents fuel flow in either direction.

90. When the refuel/defuel control panel is in use, with the MANUAL/AUTO switch at AUTO, the selected valve solenoids remain energised until the pre-selected load is attained. At the pre-selected load, for each tank, a contact is opened in the refuel contents gauge and the refuel solenoid in the associated valve is de-energised.

91. When a maximum fuel load is pre-selected the fuel cut-off is governed by either the float switch or the refuel/defuel control panel, depending on the

specific gravity of the fuel; the float switch, refuel/defuel control panel and the refuel solenoid of the refuel/defuel valve are electrically connected in series.

92. When MANUAL control is selected on the refuel/defuel control panel any refuel/defuel valve solenoid can be de-energised by setting the TRIP/SELECT switch for the selected tank to TRIP at the desired fuel level; the float switch in each tank automatically de-energises the associated refuel/defuel valve when the tank is full.

Fuel Heater System

93. Fuel heating is supplied from two sources:

a. Continuous heating supplied by the engine oil cooler.

b. Automatic heating from a hot air fuel heater unit.

94. Protection against fuel filter icing is provided by a hot air fuel heater just upstream of the main LP filters on each engine. The system is fully automatic, and is operated by a wax capsule unit which is sensitive to fuel temperature. The unit expands or contracts to vary the position of a valve controlling the supply of heated air from the compressors. Fuel temperature is thus maintained above +5°C — indicated on four gauges, one for each engine, on the engineer's panel.

Air-to-air Refuelling System

95. a. *Description.* A probe and drogue air-to-air refuelling (AAR) system is provided. The refuelling pipe from the probe in the nose of the aircraft divides into two pipes at the refuel/defuel gallery; both pipes incorporate a non-return valve and they join the gallery one on either side of the transfer cross-feed valve.

b. Between the probe and the refuel/defuel gallery, a vent pipe connects the air-to-air refuelling pipe to the air space above the contents of the centre tank. An electrically-operated vent valve in this pipe is controlled by the ground/flight switch and is always open in flight. A non-return valve is fitted between the vent valve and the centre tank.

c. A probe drain valve and an associated probe drain pump is provided between the probe line and the centre tank/fin tank transfer line. When air-to-air refuelling is completed the fuel remaining in the probe pipe-line is automatically pumped into the centre tank when the probe drain valve is opened. As the fuel is pumped out, air from the top of the centre tank is drawn into the refuelling pipe through the non-return valve and the vent valve.

d. Probe illumination is provided. (See Chapter 14.)

Air-to-air Refuelling — Operation

96. a. *Centre and Wing Tanks.* The centre and wing tanks are refuelled by setting the appropriate TRANS & FL R. VALVE or FL R. VALVE switches to OPEN (magnetic indicator in-line). When the requisite load (see **Table 4**) has been transferred to a tank, the appropriate switch must be set SHUT (magnetic indicator cross-line). If a tank is fully filled the associated refuelling valve is closed by operation of a float switch in the tank. The associated TRANS & FL R. VALVE or FL R. VALVE switch should be set SHUT, when convenient.

b. *Fin Tank.* When the fin tank is being refuelled, it is essential that the preset load pointer of the centre tank contents gauge is set at zero and the fin tank contents gauge preset load pointer is set to the quantity required. If the preset load pointer of the centre tank is set to show a greater quantity than its contents, the fin tank refuel/defuel valve is automatically closed thus preventing refuelling of the fin tank. With the FIN ISOLATE valve switch OPEN (magnetic indicator in-line) the fin tank is refuelled by setting the fin FL R. VALVE switch to OPEN (magnetic indicator in-line). If the fin tank preset load selector is used the fin tank refuel/defuel valve is closed by the action ot the preset load switching mechanism when the requisite load has been transferred to the fin tank. If a full fin tank is required, the top level float switch shuts the refuel/defuel valve when the tank is full. In either case, the FL R. VALVE switch should be set to SHUT when convenient.

c. *Probe Drain.* After completion of air-to-air refuelling, the fuel remaining in the probe pipe line is transferred to the centre tank by setting the PROBE DRAIN valve switch to OPEN. This operation opens the probe drain valve (magnetic indicator in-line) and starts the probe drain pump. A period of 5 minutes will drain the probe, when the PROBE DRAIN valve switch should be set to SHUT (magnetic indicator cross-line).

Table 3 — *see next page*

Table 3 — Fuel Distribution

Total Fuel Load (lb)	*Tank Numbers* 1A	1	2	*Centre*	*Fin*	3	4	4A
22000	Nil	5500	5500	Nil	Nil	5500	5500	Nil
24000	Nil	6000	6000	Nil	Nil	6000	6000	Nil
28000	Nil	7000	7000	Nil	Nil	7000	7000	Nil
32000	Nil	8000	8000	Nil	Nil	8000	8000	Nil
36000	Nil	9000	9000	Nil	Nil	9000	9000	Nil
39000	Nil	9750	9750	Nil	Nil	9750	9750	Nil
40000	5000	5000	10000	Nil	Nil	10000	5000	5000
44000	5000	5000	10000	4000	Nil	10000	5000	5000
48000	5000	5000	10000	8000	Nil	10000	5000	5000
51000	5000	5000	10000	11000	Nil	10000	5000	5000
52000	5125	5125	10250	11000	Nil	10250	5125	5125
56000	5625	5625	11250	11000	Nil	11250	5625	5625
60000	6125	6125	12250	11000	Nil	12250	6125	6125
62000	6375	6375	12750	11000	Nil	12750	6375	6375
64000	6625	6625	13250	11000	Nil	13250	6625	6625
66000	6875	6875	13750	11000	Nil	13750	6875	6875
68000	7125	7125	14250	11000	Nil	14250	7125	7125
70000	7375	7375	14750	11000	Nil	14750	7375	7375
72000	7625	7625	15250	11000	Nil	15250	7625	7625
74000	7875	7875	15750	11000	Nil	15750	7875	7875
76000	8125	8125	16250	11000	Nil	16250	8125	8125
78000	8375	8375	16750	11000	Nil	16750	8375	8375
80000	8625	8625	17250	11000	Nil	17250	8625	8625
82000	8875	8875	17750	11000	Nil	17750	8875	8875
84000	9125	9125	18250	11000	Nil	18250	9125	9125
86000	9375	9375	18750	11000	Nil	18750	9375	9375
88000	9625	9625	19250	11000	Nil	19250	9625	9625
90000	9875	9875	19750	11000	Nil	19750	9875	9875
92000	10125	10125	20250	11000	Nil	20250	10125	10125
94000	10375	10375	20750	11000	Nil	20750	10375	10375
96000	10500	10750	21250	11000	Nil	21250	10750	10500
98000	10500	11250	21750	11000	Nil	21750	11250	10500
100000	10500	11750	22250	11000	Nil	22250	11750	10500
102000	10500	12250	22750	11000	Nil	22750	12250	10500
104000	10500	12750	23250	11000	Nil	23250	12750	10500
106000	10500	13250	23750	11000	Nil	23750	13250	10500
108000	10500	13750	24250	11000	Nil	24250	13750	10500
110000	10500	14000	25000	11000	Nil	25000	14000	10500
112000	10500	14000	25000	12400	600	25000	14000	10500
114000	10500	14000	25000	13800	1200	25000	14000	10500
116000	10500	14000	25000	15200	1800	25000	14000	10500
118000	10500	14000	25000	16600	2400	25000	14000	10500
120000	10500	14000	25000	18000	3000	25000	14000	10500
122000	10500	14000	25000	19400	3600	25000	14000	10500
124000	10500	14000	25000	20800	4200	25000	14000	10500
126000	10500	14000	25000	22200	4800	25000	14000	10500
128000	10500	14000	25000	23600	5400	25000	14000	10500
130000	10500	14000	25000	25000	6000	25000	14000	10500
132000	10500	14000	25000	26400	6600	25000	14000	10500
134000	10500	14000	25000	27800	7200	25000	14000	10500
136000	10500	14000	25000	29200	7800	25000	14000	10500
138000	10500	14000	25000	30600	8400	25000	14000	10500

continued

Table 3 — Fuel Distribution — *continued*

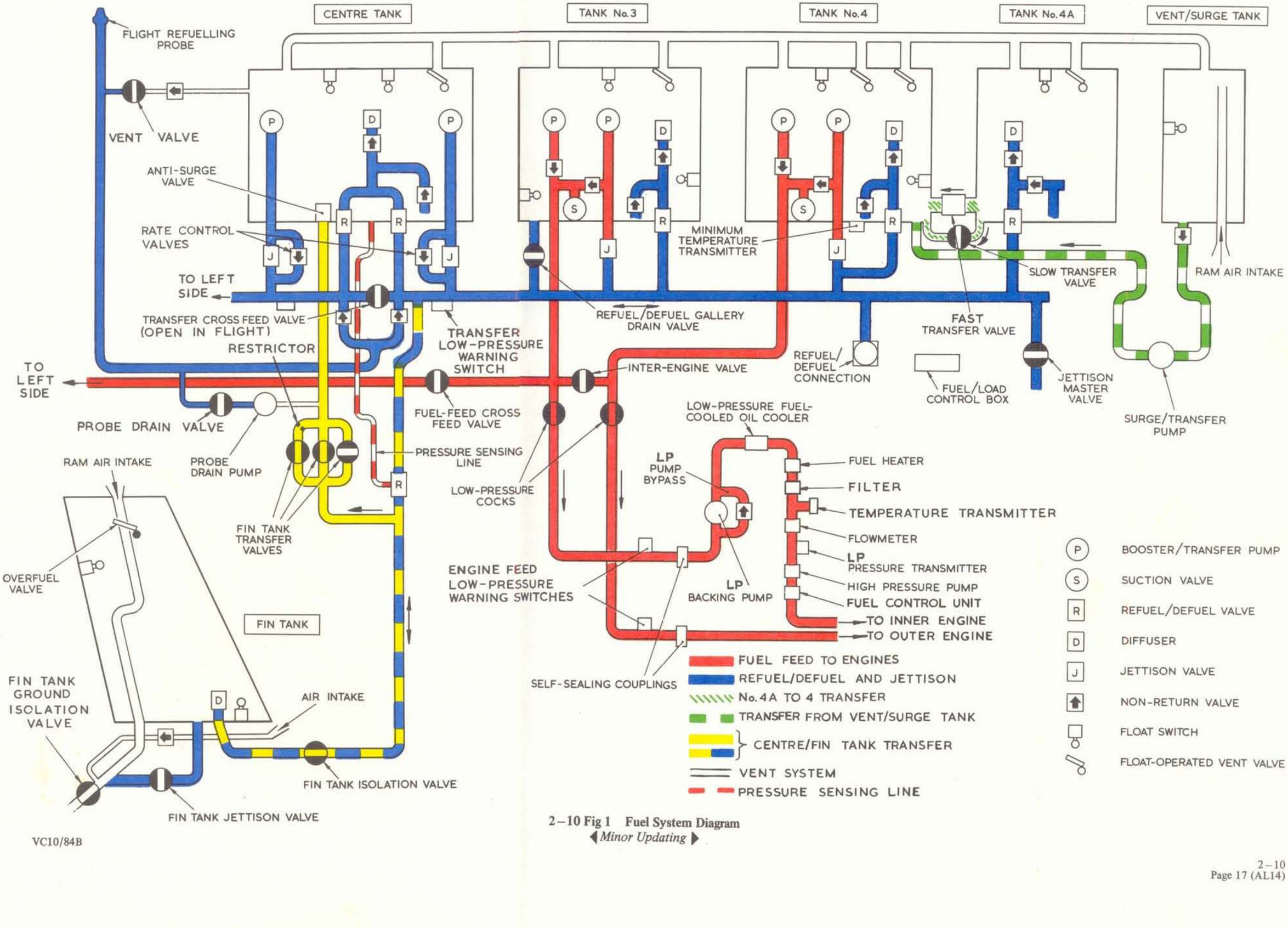
Total Fuel Load (lb)	*Tank Numbers* 1A	1	2	*Centre*	*Fin*	3	4	4A
140000	10500	14000	25000	32000	9000	25000	14000	10500
142000	10500	14000	25000	33400	9600	25000	14000	10500
144000	10700	14300	25350	33600	9700	25350	14300	10700
146000	10850	14450	25700	34100	9900	25700	14450	10850
148000	11000	14650	26000	34600	10100	26000	14650	11000
150000	11150	14850	26400	35000	10200	26400	14850	11150
152000	11300	15000	26700	35500	10500	26700	15000	11300
154000	11375	15125	26900	36340	10860	26900	15125	11375
154840	11440	15240	27040	36520	10960	27000	15200	11440

Table 4 — Fuel Distribution

Example of adjustment to the fuel distribution when the before-contact fin tank contents is greater than the quantity given in **Table 3 — Fuel Distribution**.

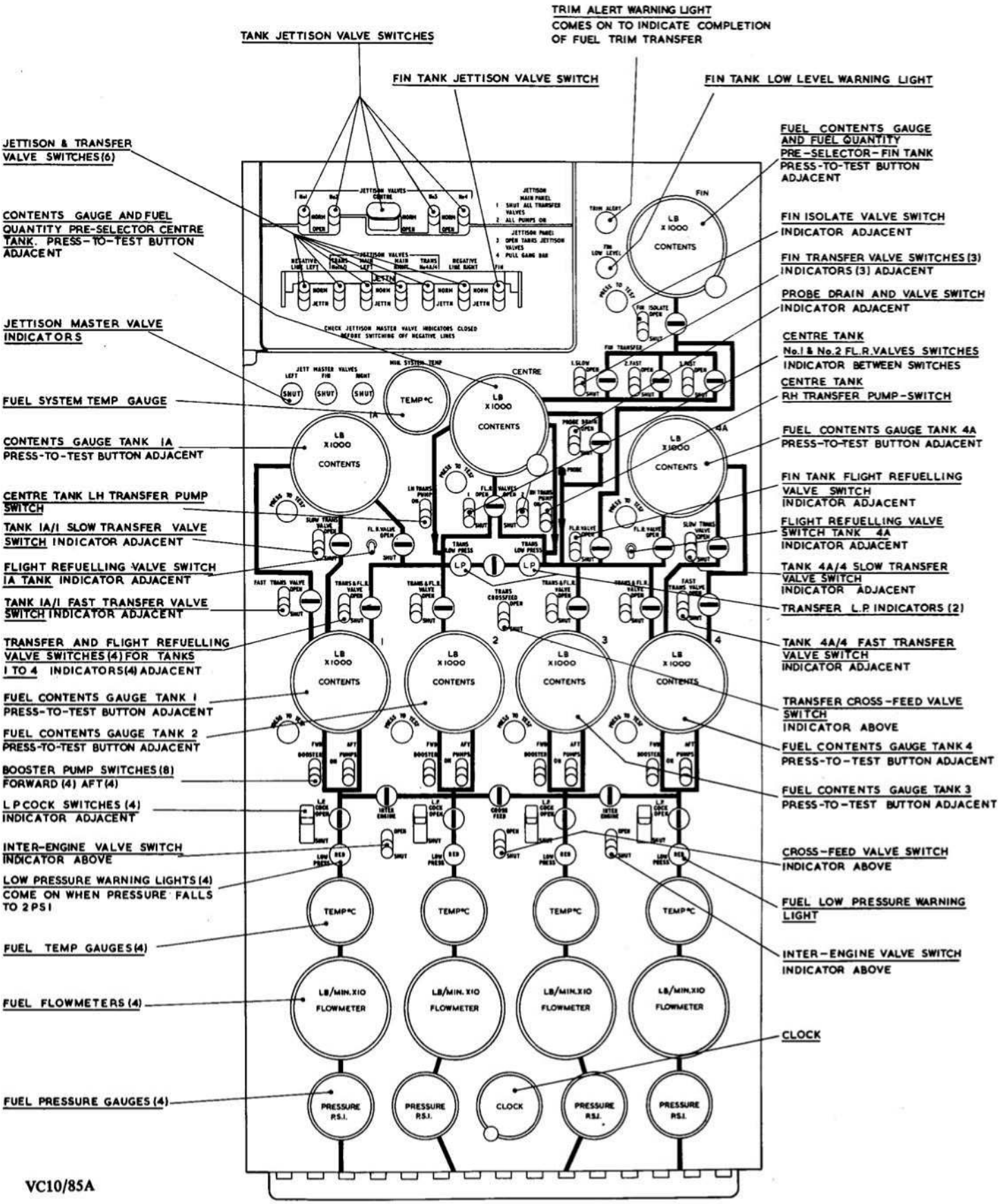
Fuel distribution before-contact — 40,000 lb
Fuel load to be received — 60,000 lb
Therefore total after transfer — 100,000 lb (ignoring fuel burnt off during refuelling operation)

Air-to-air refuelling	*Total fuel load lb*	*Tank Number* 1A	1	2	*Centre*	*Fin*	3	4	4A
Before-contact distribution (lb)	40000	4400	4600	9500	Nil	3000	9500	4600	4400
Fuel distribution (lb) from **Table 3**	100000	10500	11750	22250	11000	Nil	22250	11750	10500
		Note fin contents exceed value in **Table 3** by 3000 lb Therefore deduct from centre			- 3000				
Corrected after breaking contact distribution (lb)	100000	10500	11750	22250	8000	3000	22250	11750	10500

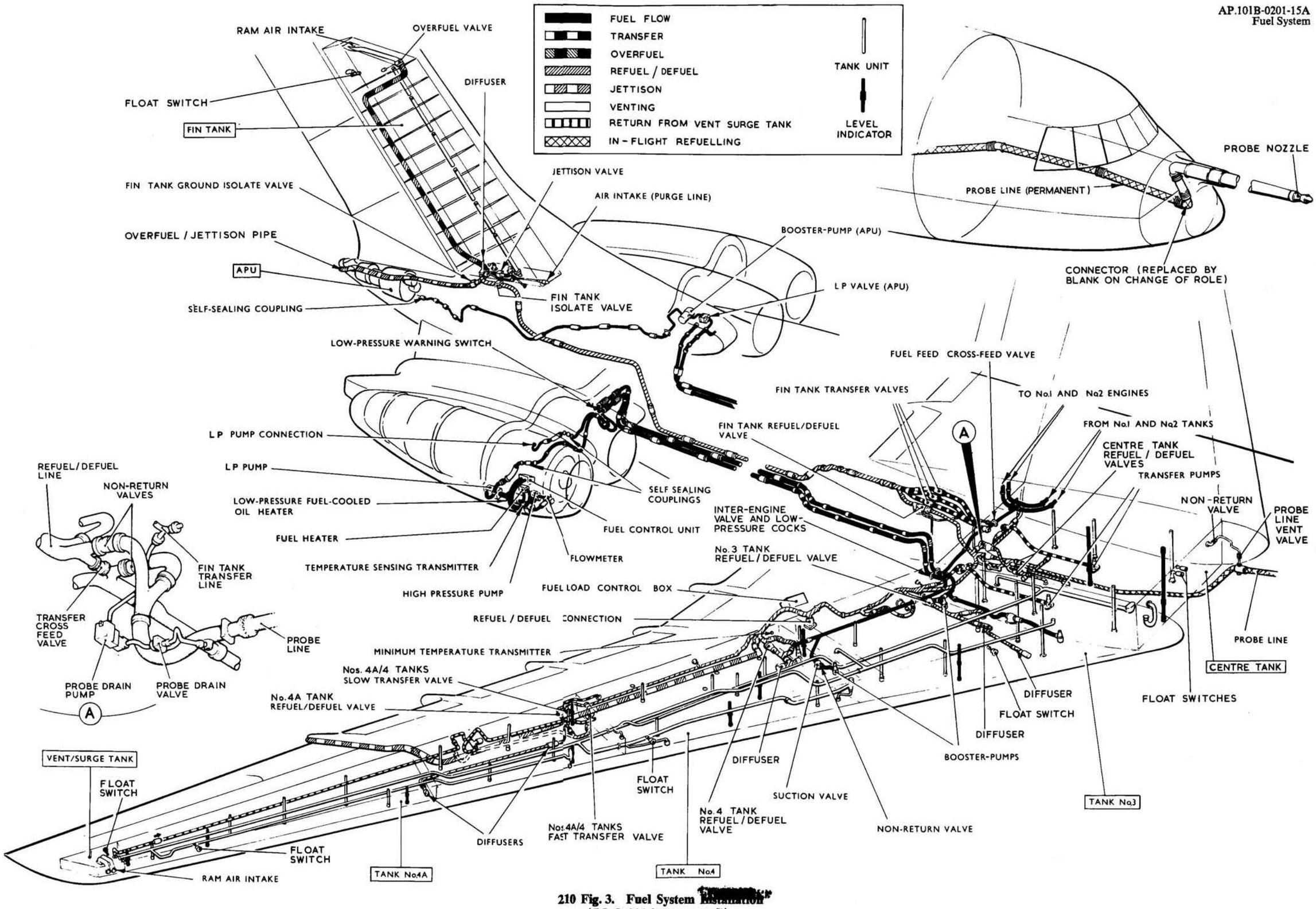


VC10/84B

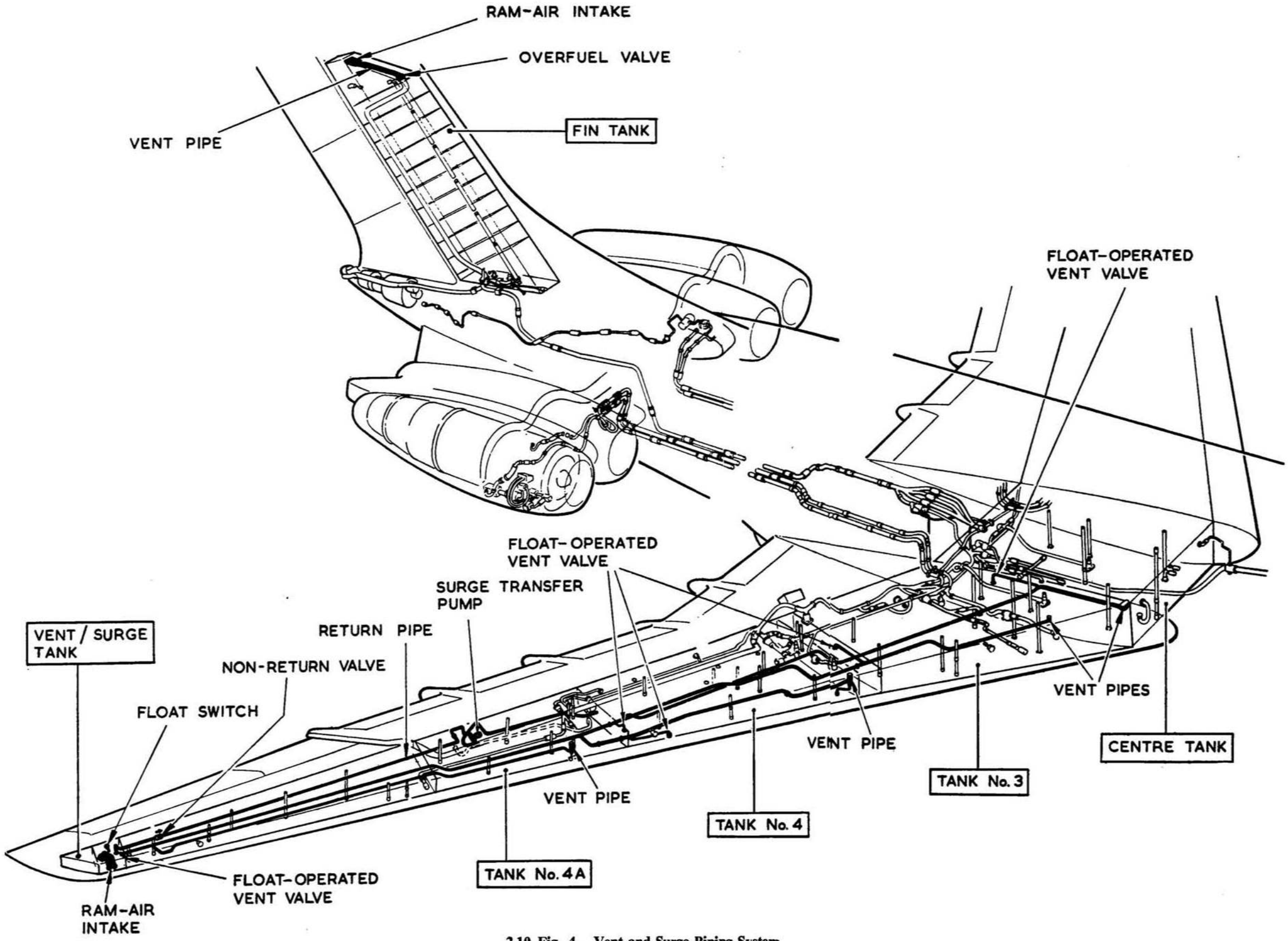
2–10 Fig 1 Fuel System Diagram
Minor Updating



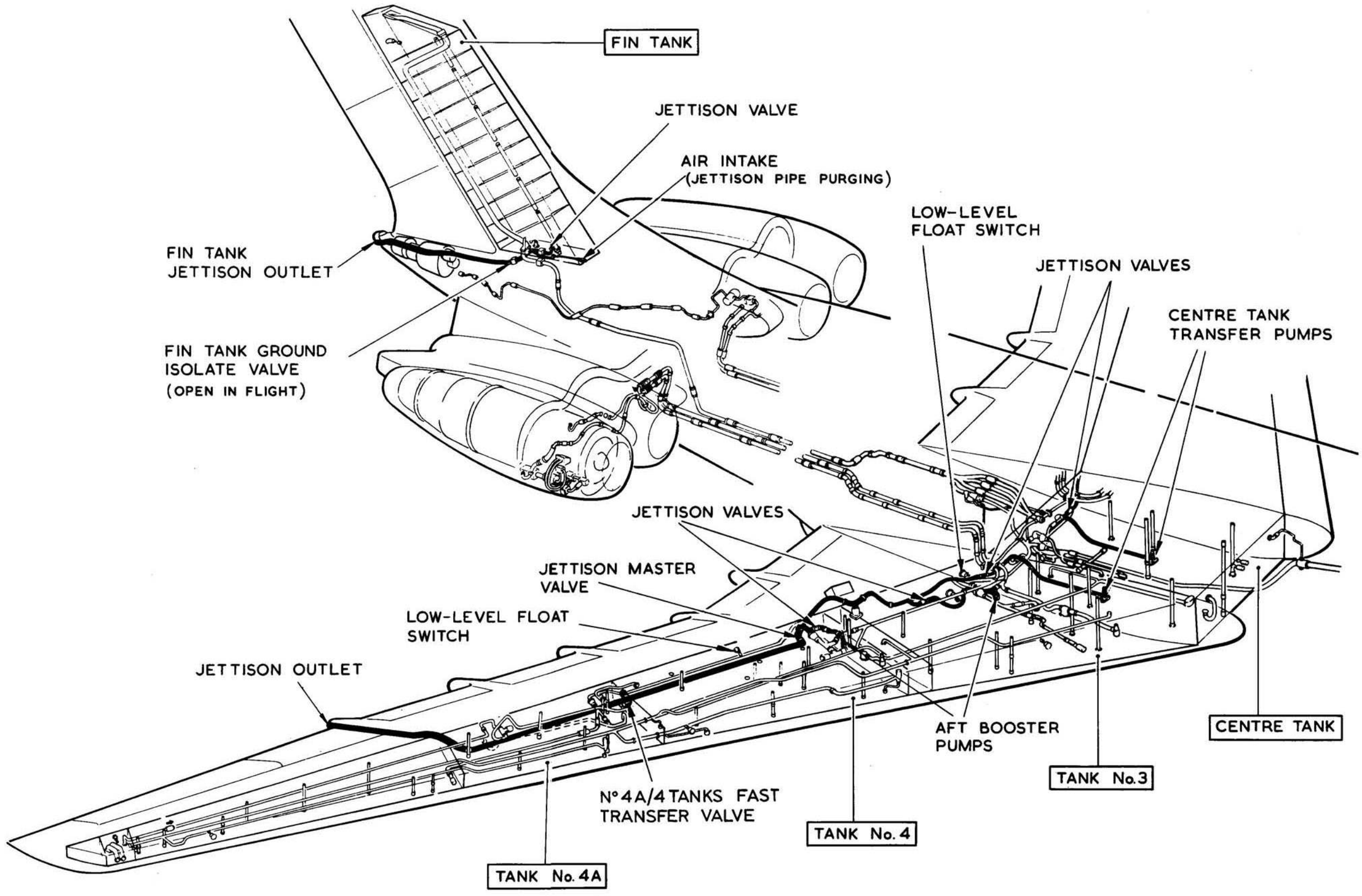
2–10 Fig 2 Fuel Control Panel



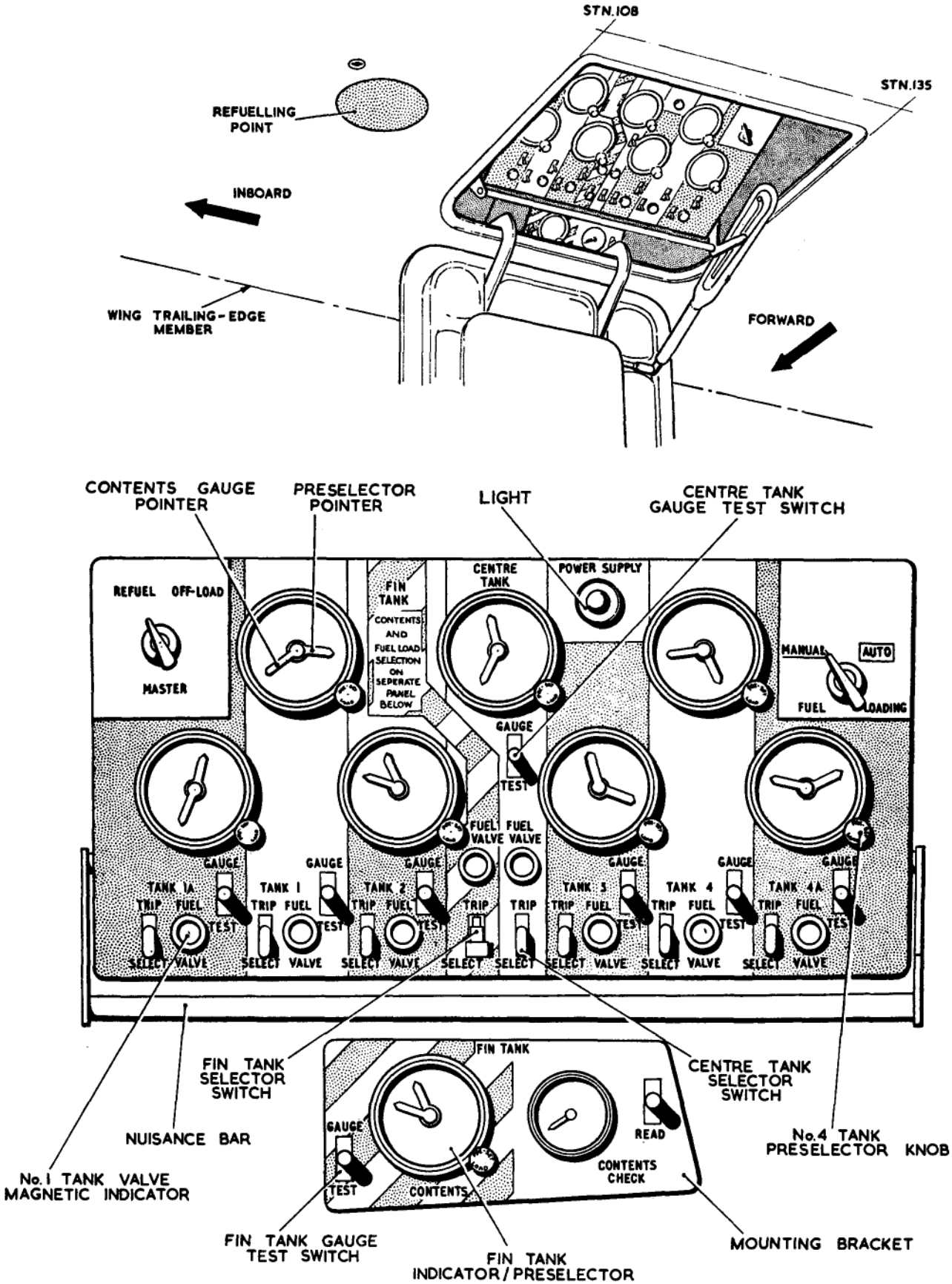
210 Fig. 3. Fuel System [illegible]
(Mod. 114 incorporated)



2.10 Fig. 4. Vent and Surge Piping System



2.10 Fig. 5. Jettison System



2.10 Fig. 6. Refuel/Defuel Control Panel