Part I

Chapter 2—Fuel System

List of Contents

Description

1 Introduction

(*a*) Fuel is stored in a series of flexible bag-type tanks, in three groups, one group in the fuselage and one in each wing. The basic fuel system tankage can be increased by the carriage of a drop tank under each wing and two tanks in the bomb-bay.

(*b*) The tanks of each fuel tank group are pressurised by a group pressurisation system all three of which operate from a common air supply system tapped from the bypass ducts of all four engines.

(*c*) All the fuel system controls are in the cockpit. The controls for fuel system usage are on a sliding panel AT between the two pilots and which slides forward under the centre instrument panel when not in use. On the second pilot's console AF are the individual tank control switches and on side panel AAJ are the individual tank indicators for refuelling and defuelling.

2 Tank capacities

The following table shows the approximate usable fuel capacities, in pounds and calculated at 8lb/gallon.

Group	*Tank and Location*	*No. off*	*Galls per tank*	*Pounds total usable fuel*	*Booster pumps per tank*
Wing, port & stbd.	No. 1, centre section	2	608	9,728	2
	No. 3, inner plane	2	261·5	4,184	1
	No. 4, inner plane	2	321	5,136	1
	No. 5, inner plane	2	338	5,408	2
	No. 6, outer plane	2	472	7,552	2
Fuselage	No. 7 centre section	2	746·5	11,944	2
	No. 8A, centre section	1	621	4,968	2
	No. 8B, bomb-bay roof	1			
	No. 10A & B, bomb-bay roof	1	388	3,104	1*
	No. 11, bomb-bay roof	1	754	6,032	2
	No. 12, rear fuselage	2	621	9,936	2
	TOTAL INTERNAL TANKS			67,992	
Long range	Drop tanks	2	1,655	26,480	2
	Aft, bomb-bay	1	988	7,904	2
	Forward, bomb-bay	1	988	7,904	2
	TOTAL WITH LONG-RANGE TANKS			110,280	

* A second pump is provided exclusively for AAPP supply

NOTE: There are no tanks numbered 2 or 9.

3 Fuel proportioners

(*a*) Three air-driven fuel proportioners are provided, one for each wing and fuselage group. Fuel from the drop tanks, bomb bay tanks and No. 10 fuselage tank is not proportioned. The air for driving the proportioners motors is tapped from the high pressure stage of the engines.

(*b*) The proportioners provide the desired ratio of fuel flow from individual tanks.

(*c*) Each proportioner consists of a number of cells each connected to a particular tank. Each cell contains a pair of rotors, a combined NRV and surge valve, a pressure regulating valve and a bypass valve controlled by a electric actuator.

(*d*) Each proportioner motor is controlled by an air throttling valve and a centrifugal governor which prevents overspeeding by controlling the air supply.

(*e*) Additionally a mass valve is incorporated to shut off the proportioner motor under negative G conditions, in which case the engines are kept running by the recuperators.

4 Fuel recuperators

Four fuel recuperators are provided and are piped in pairs, each pair feeding two engines. Each recuperator is of 5-gallon capacity and ensures that the engines are supplied with fuel under negative G conditions. The recuperators are re-charged from the main fuel feed system when negative G conditions no longer exist.

5 Fuel feed to the engines

(*a*) *Fuselage group*

From the fuselage proportioner fuel is fed to the engine gallery line, between two electrically operated NRV's, to each pair of engines via the LP cocks. The fuel from No. 10 fuselage tank is fed direct into the output line of the proportioner.

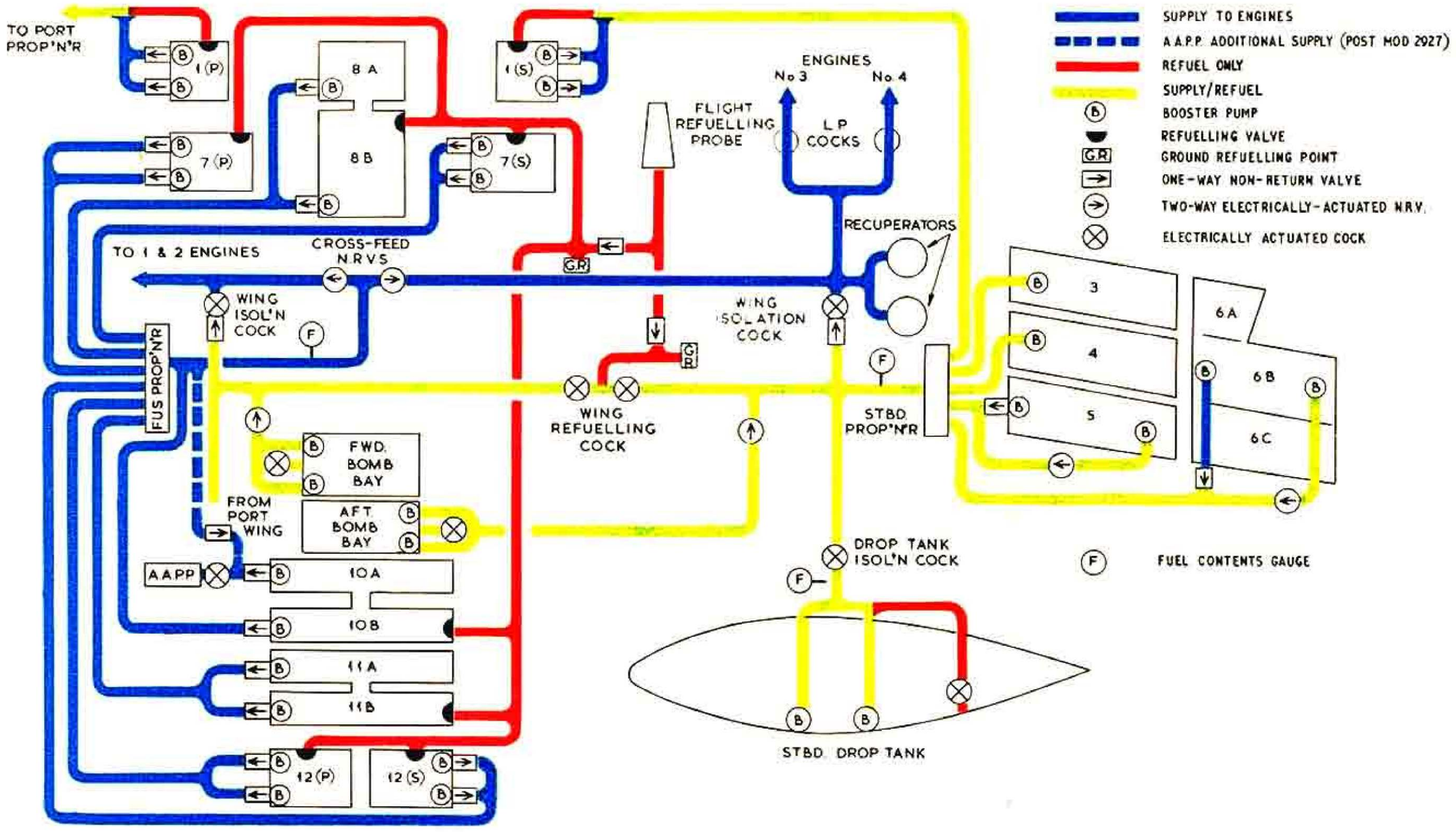
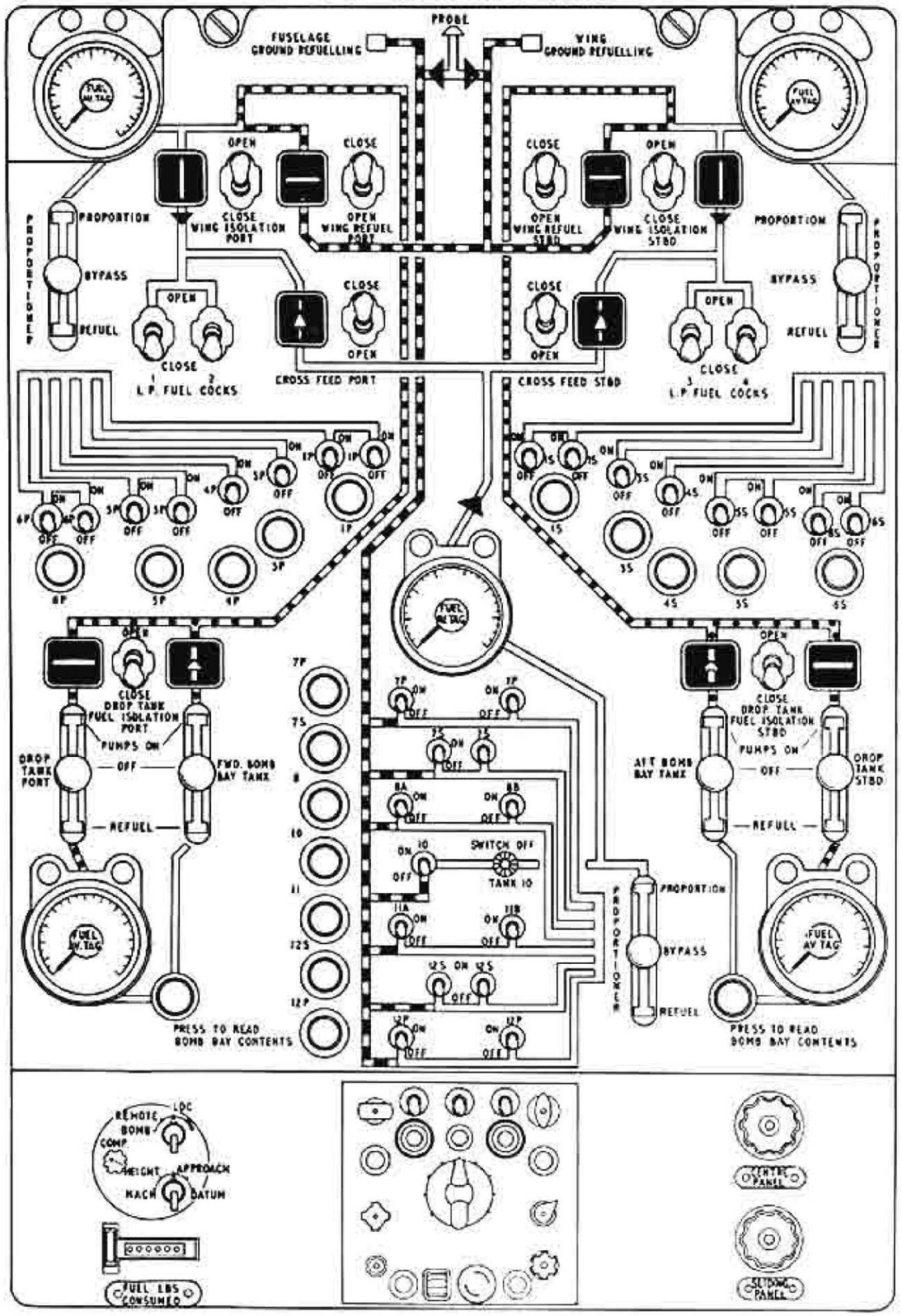
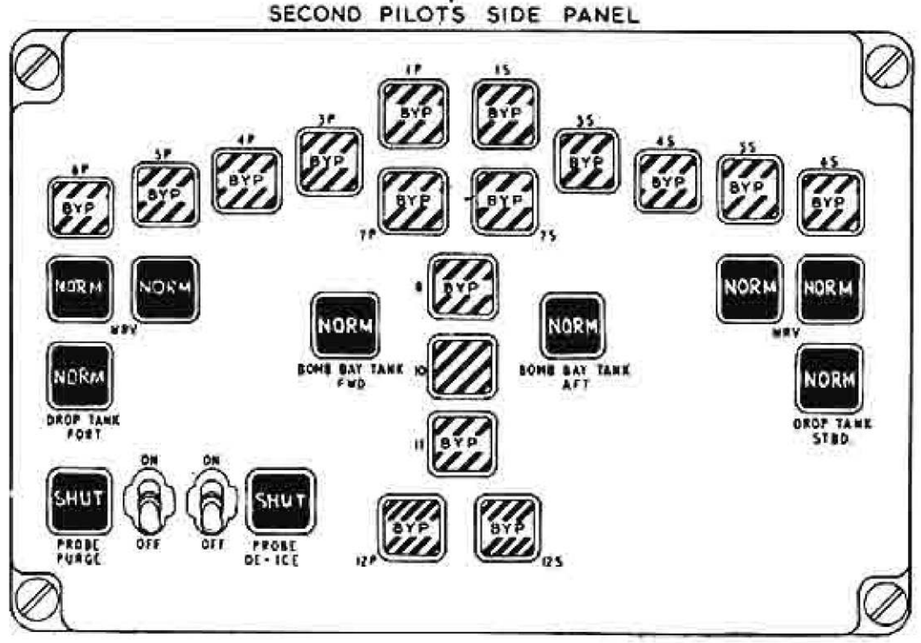
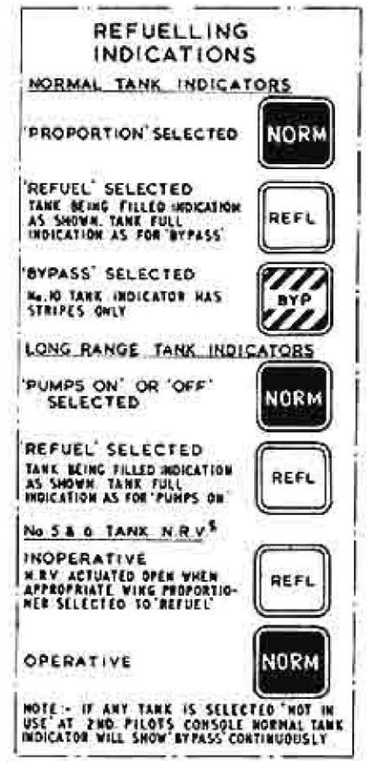
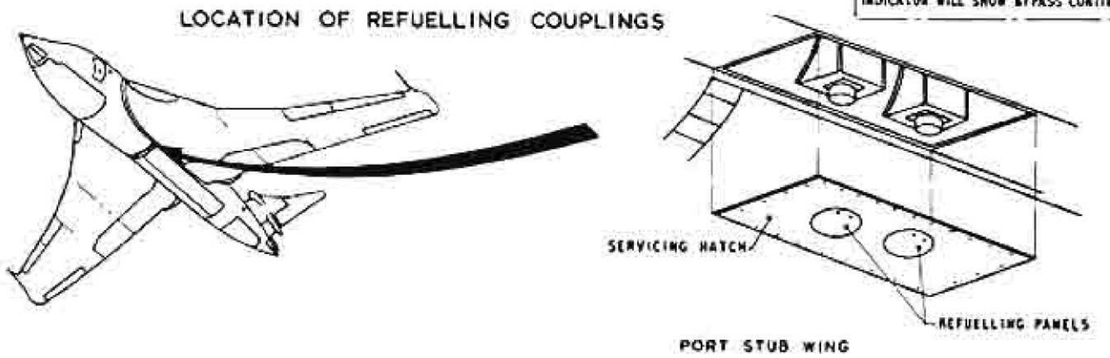


Fig. 1 Fuel system diagram









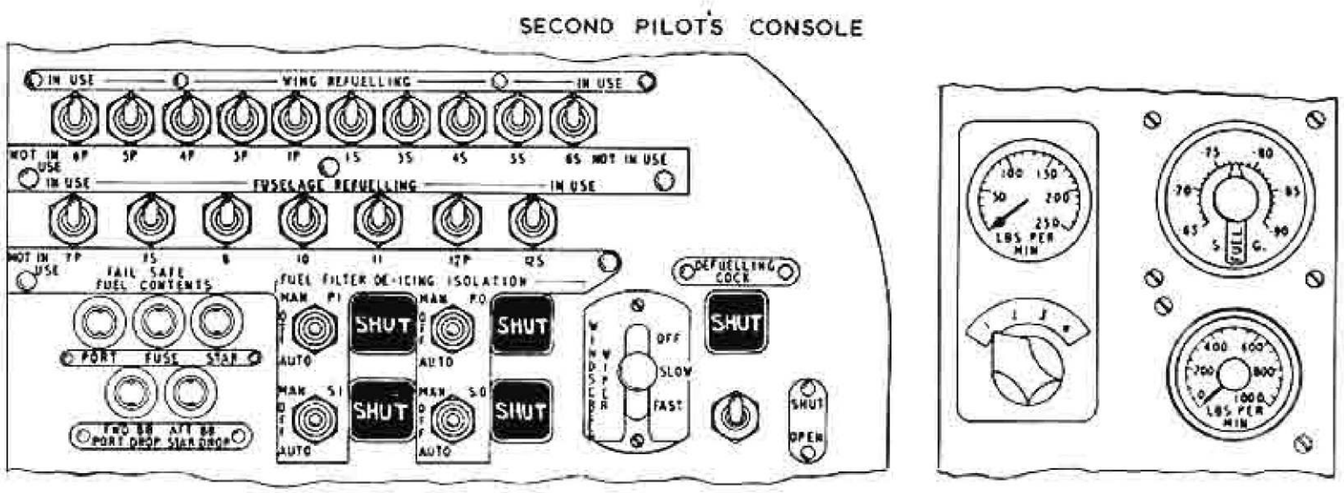


Fig. 2 Fuel system controls and indicators

(*b*) *Wing groups*

(i) From each wing group proportioner fuel is fed to the wing gallery line and then through wing isolation cocks to the engine gallery line on the associated side. The forward bomb bay tank feeds into the port wing gallery line via an electrically-operated NRV and the aft bomb-bay tank into the starboard gallery line. Cross feeding from the wing groups is prevented by wing refuelling cocks in the wing gallery line and by the previously mentioned electrically-operated NRV'S in the engine gallery line. These NRV's may be actuated should cross-feeding become necessary.

(ii) Fuel from each drop tank is fed through a drop tank isolation cock into the associated wing gallery line.

6 Fuel feed to the AAPP

(*a*) The normal fuel supply to the AAPP is tapped from the fuselage gallery line.

(*b*) When the fuselage booster pumps are OFF, or without MV power, a standby AAPP fuel supply is drawn from No. 10A tank by a 28v, 5 PSI booster-pump which operates automatically whenever the AAPP is in use.

(*c*) When using standard fuel handling procedures and the fuselage group becomes empty, i.e. total fuel state 6,000 lb., a reserve of 20 gallons is retained in No. 10 tank for AAPP supply. This is delivered by the 28v booster-pump and is sufficient for approximately 30 minutes running.

(*d*) If it is necessary to run the AAPP for a long period when the fuselage booster-pumps are normally off, see para. 28.

7 Tank pressurisation system

(*a*) The internal fuel tank pressurisation system automatically maintains a 2·5 to 4 PSI differential pressure between the fuel tanks and atmosphere for all conditions of flight. The system is divided into three groups with a common air supply tapped from the bypass ducts of all four engines. One or more engines or the AAPP can pressurise all three groups. A vent valve gives both inward and outward venting should the normal control system malfunction, outward venting ocurring when the differential pressure exceeds $3\frac{1}{2}$ PSI and inward venting when differential falls below 0 PSI.

(*b*) *Drop tanks*

No drop tank pressurisation is provided.

(*c*) *Bomb-bay tanks*

When a forward bomb-bay tank only is fitted, it is vented via the fuselage system and is pressurised via the vent line to the same value as the fuselage system. When both bomb-bay tanks are fitted, only the forward tank is pressurised, provided that it is vented into the fuselage system, but not if it is vented into the aft tank. The aft tank is never pressurised. When Mod. 2526 is embodied the bomb-bay tank pressurisation system is deleted.

8 Ground refuelling system

(*a*) Two pressure refuelling connections are in the port wing root, one for refuelling both wing groups, bomb-bay tanks and the drop tanks and the other for refuelling the fuselage tanks.

(*b*) The wing groups are refuelled via the normal gallery lines and proportioners, but the fueselage group is provided with separate refuelling lines.

(*c*) All tanks are fitted with high level float switches which control either the proportioner cells (wing groups) or the refuelling valves (fuselage group) to cut off the supply to the affected tank.

◂9 Fuel jettison system

(*a*) When Mods. 4131, 4132 and 4133 are all incorporated a facility is provided whereby fuel may be jettisoned from the wing groups, the drop tanks and the fuselage group tanks simultaneously at a combined rate of approximately 4,500 lb/min.

(*b*) With the jettison facility selected fuel is jettisoned from:
(i) Both drop tanks (and wing groups) by a combination of gravity and ram air intake pressure through a jettison cock at a total rate of approximately 2,500 lb/min.
(ii) The fuselage group by booster pump pressure, through the fuselage proportioner into the refuelling line via the defuelling cock and overboard through a jettison cock and pipe at a rate of approximately 2,000 lb/min.

Controls and Indicators

10 Sliding panel AT

(*a*) This is the main fuel control panel and slides in runners below the centre instrument panel. The panel is in the form of a mimic diagram of the fuel system and is transilluminated.

(*b*) On the panel are the following controls:
Three proportioner controls
Two wing isolation switches and indicators
Two wing refuel switches and indicators
Four LP cock control switches
Two crossfeed NRV switches and indicators
Twenty-nine booster pump switches
Two drop tank isolation switches and indicators
Two drop tank booster pump controls
Two controls, one for fwd and one for aft bomb-bay tank booster pumps, and NRV indicators
Five fuel contents gauges
Two drop tank/bomb-bay tank fuel gauge selector push switches
Seventeen individual tank contents push switches
Fuel consumed counter.

11 Internal tanks booster pumps controls

(*a*) Twenty-nine single-pole ON—OFF switches control the aircraft booster pumps. Eight are provided for each wing group and thirteen for the fuselage group.

(*b*) The switch toggle arms are coloured either red or green. This denotes that a pump is either supplied by the port (red) generating system or by the starboard (green) system. The breakdown of the various pumps supplied by individual busbars is as follows. (Where two pumps are installed in a tank these are referred to as A and B pumps.)

Bus-bar	*Pump*
No. 1 .	1(P)A, 6(P)B, 1(S)A, 6(S)A, 7(S)A, 8A, 10, 12(S)A
No. 2 .	3(P), 5(P)B, 4(S), 5(S)A, 7(P)A, 11(B), 12(P)A
No. 3 .	4(P), 5(P)A, 3(S), 5(S)B, 7(P)B, 11(A), 12(P)B
No. 4 .	1(P)B, 6(P)A, 1(S)B, 6(S)B, 7(S)B, 8B, 12(S)B

NOTE: The above table is consequent to the embodiment of Mod. 3904, which reversed the supplies for pumps 11(A) and 11(B), 5(P)A and 5(P)B, and 6(P)A and 6(P)B.

12 Bomb-bay tanks booster pumps controls

(*a*) The FWD BOMB-BAY and AFT BOMB-BAY TANK gated control switches, PUMPS ON—OFF—REFUEL, are on the port and starboard side of the fuselage tank booster pump switches.

(*b*) A locking sleeve below each switch toggle must be raised before the switch can be moved from one of the gates to either of the other two gates.

(*c*) Forward of each switch is a magnetic indicator which shows the direction of flow through the electrically-operated NRV. Indications are as follows:

PUMPS ON . .	An arrow points away from the switch
OFF . . .	As above
REFUEL . .	In-line indication

(*d*) The refuelling cock indicators on panel AAJ show NORM with PUMPS ON or OFF selected and REFL with REFUEL selected until operation of the high level float switch, when the refuelling cock will close and the indicator return to NORM.

13 Drop tanks booster pumps controls

(*a*) Outboard of the two bomb bay tank switches are two similar DROP TANK, PUMPS ON—OFF—REFUEL switches which operate as described in para. 12(*b*) and (*d*).

(*b*) Forward of each DROP TANK switch is a DROP TANK FUEL ISOLATION, OPEN-CLOSE switch which must be set to OPEN before fuel will flow to the wing gallery lines. A magnetic indicator adjacent to each switch gives " flow line " indication of the position of the cock, or striped indication if electrical supply is lacking or the cock is in an intermediate position.

14 Drop tanks jettison control

The DROP TANK RELEASE, SAFE-JETTISON switch is on 1st pilot's panel AC and is held up to jettison both drop tanks. Mod. 3949 introduces a guard over the switch. Post-Mod. 4130 the switch is operated in a fore and aft direction, moving it forward jettisons the drop tanks.

15 Fuel proportioner controls

(*a*) Three PROPORTIONER, PROPORTION — BYPASS — REFUEL control gated switches are situated, one at each forward corner of the panel and one at the aft end of the panel. Each one has a locking sleeve which must be raised before the control switch can be moved to one of the three positions.

(*b*) The settings of the switch are:

PROPORTION . Proportioned fuel from all tanks containing fuel in the respective group is fed to the engines, provided that the individual tank control switches are selected to " in-use "

BYPASS . . All cells in the particular proportioner are set to bypass and the air motor is closed down

REFUEL . . The cells of the wing proportioners are set to the refuel position, but the cells of the fuselage proportioner are set to the by-pass condition. The solenoid operated refuelling valves are energised. The air motors are closed down

NOTE: Operation of a high level float switch during refuelling causes a wing tank proportioner cell to go to bypass or, in the case of the fuselage, a refuelling valve to close. In both cases the appropriate indicator on panel AAJ changes from REFL to BYP.

(*c*) Individual cell bypass selection switches, IN USE—NOT IN USE are on the second pilot's console AF and are set to NOT IN USE for any tank not required to be refuelled. Selections on these switches override any selection on the proportioner switches.

(*d*) Proportioner magnetic indicators which give NORM (proportion) REFL (refuel) BYP (by-pass) indications are on 2nd pilot's panel AAJ.

16 Fuel contents gauges

(*a*) Five fuel contents gauges are provided which give total contents indications of the three internal and the two long range groups. The gauges are fuel density compensated.

(*b*) A series of spring-loaded push buttons, one for each internal tank are adjacent to the booster pumps switches. When any one button is pressed the associated group contents gauge will indicate the contents of the selected tank. Two buttons in any one group must never be pressed simultaneously.

(*c*) Adjacent to each drop tank/bomb-bay tank contents gauge is a PRESS TO READ BOMB-BAY TANK CONTENTS button, since these gauges normally read drop tank contents.

(*d*) On the second pilots' console AF are five buttons, one of each fuel gauge, marked FAIL SAFE, FUEL CONTENTS. If a gauge reading is suspect pressing the relevant pushbutton will cause the gauge reading to decrease; releasing the button will cause the needle to return to the correct reading only if the gauge is serviceable.

17 Wing isolation cocks switches and indicators

(*a*) An isolation cock in each wing-to-engine gallery line is controlled by a WING ISOLATION, OPEN-CLOSE switch. The cocks must always be open unless flight refuelling is taking place when it is essential that they be closed to prevent the possibility of air-contaminated fuel from the probe to pass into the engine gallery lines.

(*b*) A magnetic indicator outboard of each switch gives flow line indication of the position of the cock, or a striped indication if electrical supply is lacking.

18 Wing refuelling cocks and indicators

(*a*) Two isolation cocks are provided in the wing fuel gallery lines one either side of the refuelling connection. They are controlled by two WING REFUEL, OPEN-CLOSE switches inboard of the wing isolation cocks switches. The refuelling cocks are normally kept closed except during wing groups refuelling.

(*b*) A flow line magnetic indicator is adjacent to each switch. A striped indication is given when electrical supplies are lacking.

19 Cross-feed non-return valves and indicators

(*a*) The two cross-feed NRV's in the engine fuel gallery line are controlled by two CROSSFEED, OPEN-CLOSE switches. Normally the switches are left in the CLOSE position but should the port switch be set to OPEN the port wing groups will feed the starboard engines. Similarly setting the STBD switch to OPEN, with the PORT switch at CLOSE, will enable the port engines to be fed by the starboard wing groups.

(*b*) Two magnetic indicators show the direction of the setting of the NRV's by flow line indication. A striped indication is given when electrical supply is lacking.

20 LP cock controls

LP FUEL COCKS, OPEN-CLOSE control switches enable the LP fuel cocks of Nos. 1, 2, 3 and 4 engines to be actuated as desired.

21 Fuel flowmeter

(*a*) Each engine is fitted with a flowmeter transmitter and electronic computer. On the second pilot's console AF is a density corrector selector switch by which the signals from the computer may be corrected for various fuel specific gravities.

(*b*) An indicator which shows instantaneous fuel flow in lb/min. (250 lb/min. maximum) of any one selected engine is also on panel AF. A four-position engine selector switch is adjacent.

(*c*) A total flow indicator gives the total instantaneous flow of all four engines. This indicator is also on console AF.

(*d*) A FUEL-LB consumed counter type indicator at the aft end of panel AT records the total fuel consumed by all four engines up to a reading of 999,999. A zeroing wheel is incorporated in the unit.

22 Fuel tanks pressurisation controls

(*a*) The controls are mounted on 1st pilot's panel AAF and comprise of three FUEL VENT PRESSURE ISOLATION, NORMAL—ISOLATE switches, three pressure gauges and a temperature gauge.

(*b*) With the switches set to NORMAL all tank groups are pressurised when the engines are running. Setting any switch to ISOLATE causes that group to be depressurised.

(*c*) The pressure gauges read 0 to 10 PSI and are marked in red at 5 PSI, which pressure must not be exceeded.

(*d*) The temperature gauge reads the temperature in the fuselage system gallery line and this must not be allowed to exceed 100°C.

(*e*) A red warning light is on the pilots' coaming panel and comes on if the pressure differential in any group falls below 0·14 PSI.

◂ 23 Fuel jettison controls

(*a*) At the bottom left-hand corner of panel AAF is a wire-locked FUEL JETTISON, OPEN/SHUT switch which operates all three jettison cocks, one in each drop tank and one in the fuselage group. ▸

Adjacent to the switch are three FUEL JETTISON COCKS, PORT/FUSELAGE/STARBOARD magnetic indicators which display OPEN and SHUT indications according to the positions of their associated cocks.

(*b*) At the rear end of 1st pilot's panel AE is a new panel AEA which contains three FUEL JETTISON COCKS, PORT/FUSELAGE/STARBOARD circuit breakers. These control the electrical supplies to the individual jettison cocks.

(*c*) The ram air intakes of the drop tanks are provided with electric heater mats. The electrical supplies to these mats are controlled by the AUXILIARY HEATERS ON/OFF switch on panel AD. (See chap. 10 para. 3).

Normal Management of the System

24 General

The main aims of fuel system management are to ensure an adequate and reliable supply of fuel to all engines under all operating conditions and, at the same time to maintain a similar proportion of fuel in each tank so that the aircraft CG position remains reasonably constant within the laid down limits. With all the fuel booster pumps in operation, and all the fuel proportioner switches selected to PROPORTION, balancing should be achieved automatically. (Fuel from No. 10 tank does not feed through a proportioner, but as these tanks are situated close to the desired aircraft CG position, the use of fuel from them is governed by considerations other than the maintenance of CG position). It is also desirable to reduce the stresses on the airframe, and therefore selective use of the wing and fuselage fuel tank groups must be made to control the ratios of wing/fuselage loads.

25 Selection between fuel tank groups

(*a*) When changing from one source of fuel supply to another (i.e. making selections between fuel tank groups) it is essential to ensure that the new source of supply is available to the engines before switching off the original supply. If a tank group proportioner is selected to PROPORTION and the booster pumps in that tank group are not operating, fuel supply from that group may be inadequate to supply the engine requirements. In order to avoid engine malfunction due to fuel starvation, when making selections between fuel tank groups the proportioner and booster pump switches must be selected in the correct sequence as follows:

(*b*) *Changing to Wing groups from Fuselage group*

Wing tank booster pump switches . .	ON
Wing groups proportioner switches . .	PROPORTION
Fuselage group proportioner switch . .	BYPASS
Fuselage tank booster pump switches .	OFF

(*c*) *Changing to Fuselage groups from Wing groups*

Fuselage tank booster pump switches . .	ON
Fuselage group proportioner switch . .	PROPORTION
Wing groups proportioner switches . .	BYPASS
Wing tank booster pump switches . .	OFF

(*d*) *Selecting bomb-bay tanks*

Both Tanks ;	
FORWARD AND AFT BOMB-BAY TANK switches	Both PUMPS ON
One Tank only ;	
CROSSFEED PORT AND STARBOARD switches	Both OPEN
Appropriate BOMB-BAY TANK switch .	PUMPS ON

The reverse switching order should be used to select bomb-bay tank(s) off.

(*e*) *Selecting Wing Drop Tanks*

PORT and STARBOARD DROP TANK ISOLATION switches	Both OPEN
PORT AND STARBOARD DROP TANK switches	Both PUMPS ON

26 Fuel system control before flight

(*a*) 2,000 lb of fuel must always be loaded into the bomb-bay tank irrespective of the total fuel load. It can be used at the end of the sortie as detailed in para. 27.

(*b*) It is not considered advisable to start a flight with an unserviceable tank unless its fuel line is blanked off and its proportioner cell is set to NOT IN USE.

(*c*) If it is intended to fly with an unserviceable booster pump in any tank containing only one pump, the tank must be filled to a minimum of 50% of its capacity and its proportioner cell set to NOT IN USE. Amend the fuel drill to maintain the CG within limits. An unserviceable pump in a tank containing two pumps does not affect the fuel drill.

(*d*) Before starting the engines carry out the checks of fuel control indications in accordance with the aircraft check list. If, for any reason, any tanks do not contain fuel, or are not intended to be used during flight, the appropriate IN USE/NOT IN USE switches should be selected to NOT IN USE. All other tank switches should be selected to IN USE.

NOTE: Although No. 10 tank may not be used to supply the main engines, its switch should be selected to IN USE.

(*e*) The booster pump which supplies fuel from No. 10 tank to the AAPP will operate when the AAPP START SELECTOR switch is moved from the OFF position, and no selection by the pilots is required to supply fuel to the AAPP for starting.

(*f*) Start the main engines with the fuselage group booster pumps ON, and all proportioners selected to BYPASS (until a main engine is started there will be no air supply to drive the proportioner motors). When all engines have been started, select the fuselage proportioner to PROPORTION.

(*g*) Before taxying select wing group booster pumps ON and wing proportioner to PROPORTION. Select the fuselage proportioner to BYPASS and the fuselage booster pumps OFF.

27 Fuel system control in flight

(*a*) Take-off with all proportioners selected to PROPORTION and booster-pumps for all tanks containing fuel ON.

(*b*) When the contents of No. 10 tank reach 500 lb switch its booster-pumps OFF.

(*c*) When a bomb-bay tank contents falls to 2,000 lb., switch the tank off.

(*d*) When the drop tanks are empty, select their isolation cocks CLOSED and switch their booster-pumps OFF.

(*e*) When the fuselage group contents fall to 6,000 lb, select the fuselage proportioner to BYPASS and switch the fuselage booster-pumps OFF.

(*f*) When the wing group contents fall to 3,000 lb per group switch on pumps for all tanks containing fuel, except No. 10 tank, and select all proportioners to PROPORTION.

(*g*) When the bomb-bay tanks are empty, i.e. total fuel state 12,000 lb, proceed as follows:

(1) All wing and fuselage booster-pumps ON

(2) Fuselage proportioner selected to BYPASS

(3) Wing proportioners selected to PROPORTION

(4) Start the Artouste and run at ELECT for the remainder of the sortie. If unable to start the Artouste, land as soon as practicable.

(*h*) If it becomes necessary to operate below the normal minimum fuel reserve of 8,000 lb proceed as follows:

(1) Select both crossfeed NRV's OPEN

(2) Restrict engine RPM to 90% maximum

(3) Use only shallow angles of climb or descent.

◀(*j*) *Inadvertent emptying of a fuselage tank*

(i) If a fuselage tank is inadvertently emptied there is a risk of engine flame-out due to air ingress. To prevent flame-out, handle the fuel in the normal way until the fuselage group contents fall to 6,000 lb. Then select both wing proportioners to BYPASS,▶

pumps ON. Carry out a manual fuel drill on the wing groups ensuring that not more than three pumps in each group are switched off at one time.

(ii) If the fuselage proportioner is serviceable it should be left in PROPORTION with the pumps ON. If unserviceable, it should be put to BYPASS with the pumps OFF.

(iii) When the wing group contents are down to 3,000 lb each, revert to the normal fuel drill.

NOTE: When at high level select the fuselage group to BYPASS and fuselage pumps OFF for 30 seconds in every 30 minutes until the fuselage group total falls to 6,000 lb. This is to exercise and warm up the wing proportioners.

28 Fuel system control during emergency use of the AAPP

Should it be necessary to use the AAPP after the fuselage group contents have fallen to 6,000 lb:

(i) Select wing proportioners to BYPASS and check all wing booster-pumps ON.

(ii) Switch all fuselage booster-pumps ON (except No. 10 tank) and select fuselage proportioner to PROPORTION.

(iii) When the total fuel state reaches 12,000 lb revert to normal fuel handling procedure.

29 Use of No. 10 tank

NOTE: The contents of No. 10 tank must be reduced early in the flight to eliminate bleed from the recuperators overfilling the tank and entering the vent trunk.

The fuel from No. 10 tank does not pass through the proportioner and it therefore overfeeds the remainder of the fuselage group. No. 10 booster-pump should be used as in para. 27, the contents being carefully monitored while the pump is ON.

30 Contents checks

Systematic checks should be made of all tank contents every thirty minutes when cruising at 40,000 ft. or above, and more frequently when operating at lower levels. Check the individual tank contents for a given group and ensure that their total equals the amount indicated on the group contents scale. The individual tank contents of a group not in use should be checked in case a booster pump has failed to switch off. The various fuel tank readings should also be checked against the fuel calculator chart to ensure that the fuel is proportioning correctly. If the fuel is not proportioning correctly an attempt should be made to balance the fuel in a group of tanks by manual manipulation of the NOT IN USE switches. If a fuel tank gauge reading fault is suspected the appropriate FAIL SAFE switch on the 2nd pilot's starboard console should be pressed. The gauge reading should decrease by approximately 1,000 lb on the total contents scale, and return to its correct reading when the push-button is released. Failure of the needle to move indicates a faulty gauging system.

31 Management of the fuel tanks pressurisation system

Before starting the engines, and in accordance with the aircraft check list, check that the three tank pressure gauges indicate zero and that the temperature gauge reading is normal. Select the FUEL VENT PRESSURE ISOLATION switches to NORMAL. Under certain conditions the red FUEL TANK LOW PRESSURE warning light on the pilot's coaming panel may be illuminated when the engines are stationary. After starting the engines check that this light is out, and that the tank pressures and temperatures are normal. In flight the three tank pressure gauges and the temperature gauge must be checked periodically. If the reading of any pressure gauge exceeds 5 PSI, the appropriate isolation switch should be switched to ISOLATE, until the pressure reduces to below this figure. If the vent temperature exceeds 100°C the fuselage isolation switch must be set to ISOLATE until the temperature reduces below this figure.

32 Fuel jettisoning

(*a*) *Before jettisoning*

(i) As some fuel contamination of the rear fuselage may occur, all electrical equipment in the tail cone must be switched off. The airbrakes may be used; contamination is slightly reduced if the airbrakes are out when fuel is being jettisoned.

(ii) To ensure that an adequate fuel supply is available to the engines, the wing groups must be on with their proportioners at BY-PASS.

(iii) The pumps of all fuselage tanks containing fuel must be on and the proportioner should be set to BYPASS for maximum fuel discharge or to PROPORTION for slightly reduced proportional discharge. The fuel tank pressurisation system should be on, otherwise the jettison rate is reduced.

(iv) The fuselage defuelling cock must be selected shut so that it closes automatically when the jettison switch is selected off or when the fuselage jettison circuit breaker is tripped, otherwise fuel is jettisoned if the fuselage jettison cock fails to shut.

(v) Check that the three fuel jettison circuit breakers are made; normally, they should be made before take-off. The fuselage circuit breaker should not be opened in flight but the drop tank circuit breakers should be opened when the tanks are empty to remove a standing positive in each tank circuit.

(vi) The drop tank isolation cocks must be closed to prevent wing fuel flowing to the drop tanks.

(*b*) *Jettisoning*

(i) Set the jettison switch to open and check that the fuselage defuelling cock indicates open.

(ii) Carefully monitor individual tank contents while fuel is being jettisoned to ensure that the CG remains within limits and to avoid excessive wing asymmetry.

(iii) Check that the jettison rate from the drop tanks is approximately equal and switch off the drop tank pumps.

(iv) Stop jettisoning when the fuselage group contents reach 6,000 lb; check that the fuselage defuelling cock indicates shut.

(*c*) *After jettisoning*

(i) Reset the fuel system as required and revert to the normal fuel handling procedure, switching off the bomb-bay tank pumps when they are empty. It may be necessary to proportion the fuel in all groups manually.

(ii) Electrical circuits in the drop tanks must not be used after fuel has been jettisoned.

(iii) To prevent a fire hazard, jettisoning must be stopped before landing. At all times, care is required to avoid striking the fuselage jettison pipe on the ground.

(iv) After landing the aircraft must be cleared of fuel contamination of the rear fuselage.

Malfunctioning of the System

33 Asymmetric wing contents

(*a*) Although it is possible to fly the aircraft with maximum fuel asymmetry (i.e. one wing group full and the other empty) the maximum permissible difference for landing is 8,000 lb and this should be regarded as the maximum acceptable asymmetry in flight. If this state is approached manual fuel balancing will be necessary. To balance the fuel:

(*b*) (i) Set both crossfeed control switches on the fuel control panel to OPEN.

(ii) Select the proportioner switch for the heavy wing to BY-PASS.

(iii) Monitor the contents gauges and when fuel balance is achieved select the proportioner to PROPORTION, select both cross-feed control switches to CLOSE.

(iv) Do not cross-feed if either wing group contents is less than 3,000 lb.

34 Booster pump failure

(*a*) Tanks 1P, 1S, 5P, 5S, 6P and 6S in the wing groups, and tanks 7P, 7S, 8, 11, 12P and 12S in the fuselage group have duplicated fuel booster pumps. Both bomb-bay tanks and both wing drop tanks also have duplicated booster pumps. Thus single pump failure in any of these tanks will not affect fuel proportioning.

(*b*) (i) Tanks 3P, 3S, 4P and 4S in the wing groups have only one pump per tank. A failure of any one of these booster pumps will be revealed by a constant tank contents reading on a series of tank contents checks. There is no safe method available for extracting fuel from these tanks following booster pump failure, and fuel remaining in the tank at the time of the failure must be considered unusable.

(ii) Owing to their position, this will have little effect on movement of the aircraft CG, but may cause unbalance between the wing groups total contents. Balance may be achieved by switching OFF the booster pump in the appropriate tank in the opposite wing, or by the method described at 33 above.

(*c*) No. 10B tank in the fuselage tank group also has a single booster pump for delivering fuel for use by the main engines. Failure of this booster pump will mean that fuel remaining in the tank at the time of pump failure will not be available to supply the main engines, but this fuel will still be available to supply the AAPP.

(*d*) If it is necessary to fly with an unserviceable booster pump in any tank containing only one booster pump, the tank must be filled to at least 50% of its capacity and its proportioner cell switched to NOT IN USE. Adjust the fuel drill to maintain the CG within limits. One unserviceable booster pump in a tank containing two pumps will not affect the fuel drill.

35 Proportioner failure

(*a*) Complete failure of a proportioner whilst its control switch is selected to PROPORTION and associated booster pumps are ON will result in a total failure of the fuel supply from all tanks in its associated tank group to the engines. Indications of failure and actions to be taken are as follows:

(*b*) *Failure of fuselage group proportioner when fuselage group only is supplying the engines*

(i) *Indication*

Illumination of low pressure fuel warning lights for all four engines.

(ii) *Immediate action*

Select all wing pumps ON.

(iii) *Subsequent action*

Select the fuselage proportioner switch to BYPASS, and the wing proportioners to PROPORTION. Check that the fuselage group is feeding, select the wing groups to BYPASS, pumps OFF and carry out manual balancing of fuselage fuel.

(*c*) *Failure of a wing group proportioner whilst wing groups only are supplying their respective engines*

(i) *Indication*

Illumination of the fuel low-pressure warning lights for the two engines supplied by the affected wing group.

(ii) *Immediate action*

Select all fuselage pumps ON.

(iii) *Subsequent action*

Select the failed proportioner switch to BYPASS. Check fuel control panel selections, e.g. for the accidental closing of a wing isolation cock. Select the fuselage group to PROPORTION, check that the affected wing group is feeding, select the fuselage group to BYPASS, pumps OFF and carry out manual balancing of wing fuel.

(*d*) *Failure of any one proportioner when there is an alternate supply of fuel to the engines (e.g. both wing groups and fuselage group in use)*

Failure will be revealed during routine tank contents checks by complete lack of flow from the tanks in the affected group. Select the failed proportioner to BYPASS and by selective use of the booster pumps maintain the individual tank contents in approximate proportion.

36 Proportioner air motor blanked off

When an air motor has been blanked off an appropriate *red* ink entry is to be made in F.700. In these circumstances operate the fuel system as per para. 27 except that the sortie is to be planned

and conducted so as to preclude any possibility of landing with less than 8,000 lb of fuel.

37 Seized wing proportioner rotor

If an aircraft has to be operated with a seized proportioner rotor, make an appropriate entry in F.700 and operate the fuel system as follows:

(*a*) *Pre-flight*

Select the unserviceable proportioner to BYPASS and the associated IN USE/NOT IN USE switches to NOT IN USE. (Do not alter these selections during the sortie).

(*b*) *Pre Take-off*

Select both wing groups to BYPASS.

(*c*) *After Take-off*

On completion of the after take-off checks, switch OFF the booster-pumps of the wing group with the unserviceable proportioner and select the serviceable proportioner to PROPORTION.

(*d*) *Proportioning wing fuel*

If unequal feeding has occurred during take off,

(i) Operate the booster-pumps of the group with the U/S proportioner as necessary to achieve correct proportioning.

(ii) Correct proportioning for the group with the serviceable proportioner can be achieved by operation of the IN USE/NOT IN USE switches.

(*e*) *When fuselage group contents falls to* 6,000 *lb*

(i) Switch on all wing booster-pumps

(ii) Select fuselage group to BYPASS and switch off the fuselage booster-pumps.

(*f*) *When wing group contents fall to* 3,000 *lb each*

(i) Select all proportioners to BYPASS

(ii) Switch on all booster-pumps.

NOTE: If it is necessary to use the 2,000 lb. of fuel previously left in the bomb-bay tanks, serviceable proportioners must be set to PROPORTION and the booster-pumps of a wing group with a U/S proportioner must be switched off. When the bomb-bay tanks are empty, revert to (*f*) above.

(*g*) *Planning*

The sortie is to be planned and conducted so as to preclude any possibility of landing with a fuel state below 8,000 lb.

38 Backing pump failure

Failure of a backing pump will be indicated by illumination of the fuel low pressure warning light of the affected engine. It may also be accompanied by fluctuating or reducing RPM. Throttle back the affected engine, reducing RPM until the warning light goes out. (If the light fails to go out before throttle is fully closed, check for accidental closing of LP cock switch.)

39 Engine failure

Following engine failure, if wing tank groups are in use, select both crossfeed control switches to OPEN and allow the remaining engines to feed from both sides. Make periodic checks of balance of wing contents and adjust if necessary.

40 Leaking tanks

(*a*) A leaking fuel tank will be indicated by a continous and disproportionate decrease in its fuel level relative to other tanks in the same group. It may be confirmed by switching OFF the booster pumps in that tank, with the proportioner selected to PROPORTION, and noting whether its fuel contents continue to decrease.

(*b*) To minimise fuel loss and reduce the amount of fuel available to leak into the airframe, the leaking tank should be used exclusively to feed two engines until it is almost empty.

(*c*) Select the appropriate group switch to PROPORTION, switch ON all fuel pumps and select the IN USE/NOT IN USE switch of the leaking tank to NOT IN USE, thus ensuring that this tank will feed more quickly than the other tanks in the group.

(*d*) When the leaking tank is empty switch OFF the booster pump and leave the IN USE/NOT IN USE switch at NOT IN USE.

(*e*) If it is necessary to fly with a fuel tank that is known to be unserviceable, the fuel line from that tank must be blanked off and its proportioner cell selected to NOT IN USE.