Part I—Description and Management of Systems

Chapter 2—In-Flight Refuelling System

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1 General

(*a*) (i) A probe and drogue flight refuelling system is provided. Basically the system is an extension of the ground refuelling system, pipes from the probe in the nose running aft either side of the cabin to join the normal refuelling lines via a non-return valve. All tanks are refuelling at the same time, the rate of flow being approximately 4,000 lb/min. When Mod. 823 is embodied a probe-shut-off valve is provided. Further details will be issued by amendment.

(ii) A total approximately 45,000 lb of fuel is available for transfer from the Valiant tanker.

(*b*) (i) The Mk. 6 probe head, in addition to the fuelling pipe carries a nitrogen purge line, a de-icing line and valve (inoperative) and an inward vent which relieves the air pressure created by the compression between the probe nozzle and drogue coupling on engagement.

(ii) The Mk. 8 probe head has a nitrogen purge line but no de-icing line. The system is so arranged that an inward vent valve is not necessary.

(*c*) The nitrogen is used to purge the fuel lines passing through the cabin after refuelling has been completed, thus reducing the fire hazard following damage to the pipes. A nitrogen bottle, charged to 1,800 PSI, is in the nose of the aircraft and is recharged from a point behind the FLIGHT REFUELLING CHARGING panel at the forward end of nose on the starboard side. There is only sufficient nitrogen for one purge, and if more than one refuelling is to be made it should be retained until after the last transfer. Threat of enemy action may, however, necessitate purging earlier.

(*d*) The probe is illuminated by two lamps in the nose of the aircraft ; these lamps have independent supplies, each being controlled by a separate dimmer switch on the starboard console.

2 Flight refuelling controls and indicators and their use

(*a*) *Starboard console*

(i) The flight refuelling controls and indicators are grouped on the starboard console. They consist of the following:

NITROGEN PURGE. ON-OFF switch (E/23)
A split double-pole ON-OFF MASTER SWITCH (E/24)
A refuelling indicator (E/29)

A FLT. REFUELLING PRESSURE gauge (E/13)
Two PROBE LIGHTING dimmer switches (E/35)
Four TANK PRES INDicators.

(ii) The TANKS FULL indicator consist of an outline of the aircraft, with numbered lights in the approximate position of each tank. The lights in the indicator can be adjusted for day or night use by turning the rim around the indicator. The lights come on when the tank refuelling valves open and go out individually when the tanks fill.

(iii) The MASTER SWITCH must be set ON before drogue engagement and must remain on until after disengagement. When both halves of the switch are ON, the refuelling valves (in all tanks which are not full) are opened, tank pressurisation is switched off, the fuel contents gauges are isolated and will read zero, all lights on the refuelling indicator come on (except for full tanks) and the C of G indicator registers automatically. As each tank is filled a double float switch closes the refuelling valve and the appropriate light on the indicator goes out. Prior to embodiment of Mod. 1143, when any three lights are out on one side, indicating that three tanks are full, contact must be broken. When Mod. 1143 is embodied, however, 100% refuelling may be carried out, provided that the aircraft fuel system is depressurised. If pressure remains in the tanks, refuelling must be carried out with the tanker's main pump switched off and contact must be broken immediately if the fuel gallery pressure rises above 10 PSI. The MASTER switch must not be set OFF until the contact is broken. The NITROGEN PURGE switch should then be set ON (unless it is being retained for use after a further transfer) ; this action opens the nitrogen cock and the No. 2 tanks refuelling valves, and nitrogen pressure at 20 PSI forces fuel from the probe lines into the No. 2 tanks. During purging an irregular muffled thumping may be heard ; the pressure gauge will indicate 2-4 PSI. Contents gauging is regained when the MASTER SWITCH is set OFF.

NOTE : Notwithstanding the fact that setting the MASTER SWITCH ON depressurises the fuel tanks, the tank pressurisation system must be manually selected off before making contact.

(b) Fuel control panel

(i) The aircraft C of G can be controlled during in-flight refuelling by three switches on the fuel control panel. The two FWD-AFT switches (D/13), (D/20), which normally control the transfer pumps for fore-and-aft control, and the FR RECEIVER C of G CONTROL PORT—STARBOARD switch (D/16) (which is spring-loaded to the centre off position) at the front of the panel, for lateral control.

(ii) When the in-flight refuelling MASTER SWITCH is ON, the transfer pump switches are disconnected from the transfer pumps ; setting them to FWD closes the refuelling valves in tanks 6 and 7, while setting them to AFT closes the refuelling valve in tanks 1 and 2. In each case, the refuelling valves remain open in the remainder of the tanks. If the lateral control switch is moved to PORT or STARBOARD, the refuelling valves in the No. 6 and 7 tanks on the *opposite* side are closed.

(c) Electrical supplies

The in-flight refuelling system operates from 28-volt DC.

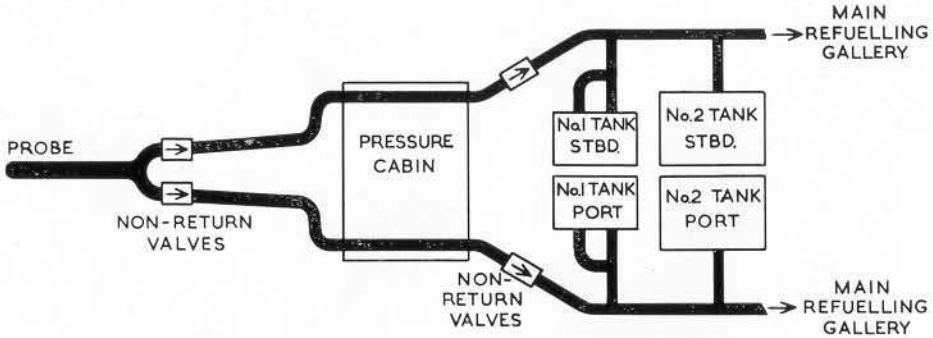
3 Pre-flight check of tank pressurisation system

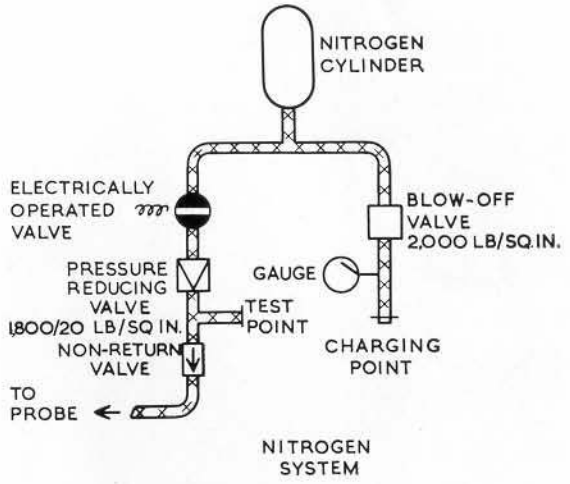
On aircraft with Mod. 1143 embodied in order to check the fuel tank pressurisation system, the following pre-flight check can be carried out.

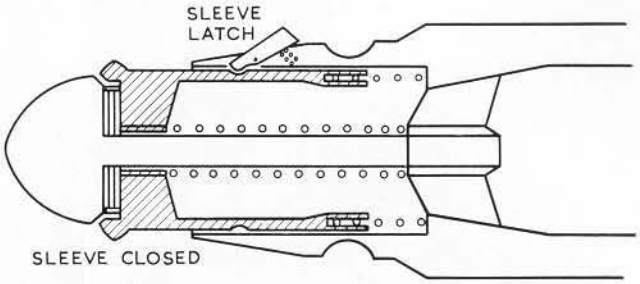
Testing each engine separately:

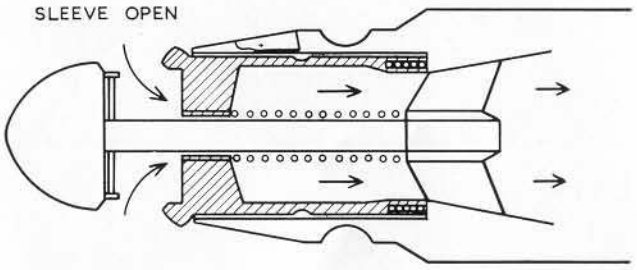
(*a*) With the tank pressurisation ON and the in-flight refuelling MASTER SWITCH OFF, run the engine at 80% RPM for 30 seconds to initiate tank pressurisation. Check indicator black.

(*b*) Reduce RPM to 43% and set the in-flight refuelling MASTER SWITCH ON. Tank pressurisation should then be lost. Check indicator white. The outward venting of the air can be heard outside the aircraft as the vent valves open.

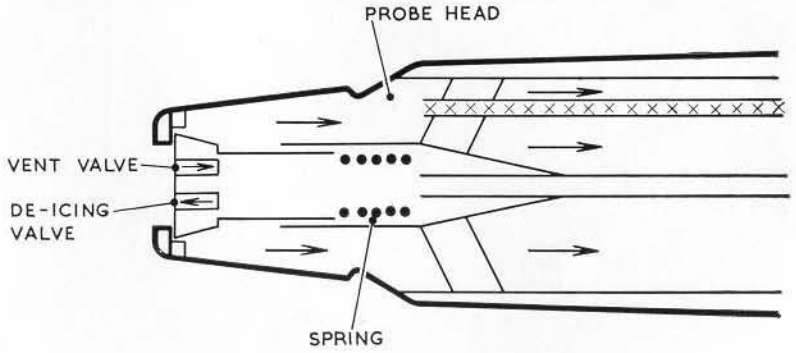








DETAIL OF MK.8 PROBE HEAD



DETAIL OF MK.6 PROBE HEAD

Fig 1 In-Flight Refuelling System

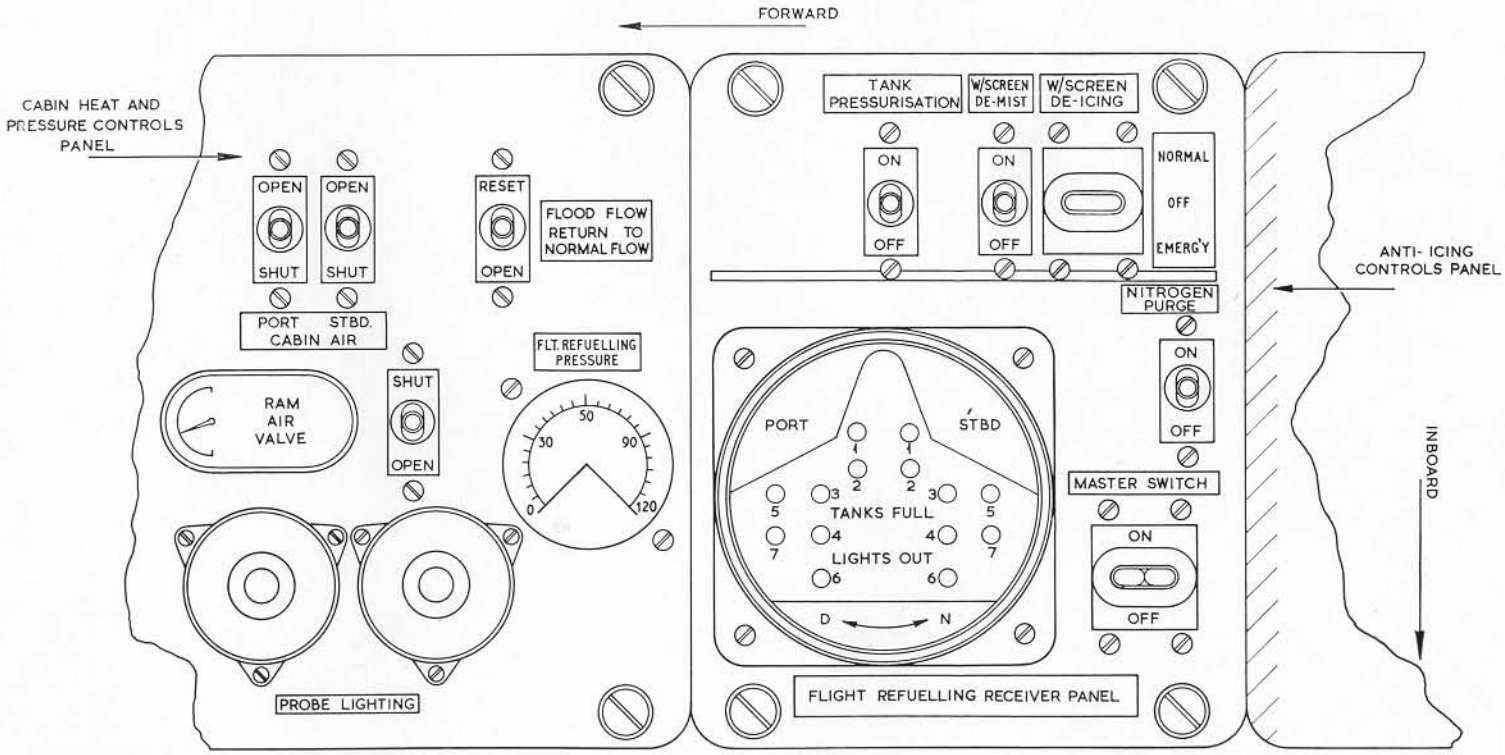


Fig 2 In-Flight Refuelling Panel

4 Refuelling indication

(*a*) If a tank light fails to come on, it may be for the following reasons:

(i) Tank full.

(ii) Float switches have failed to operate.

(iii) Light filament failure. The face of the indicator may be removed and the defective bulb replaced with one of the spares supplied with the instrument.

(*b*) Refuelling valve failure is not shown on the indicator. Failure of a tank to fill can be checked on the C of G indicator or, after breaking contact, by checking the fuel contents. Alternatively, pressing the C of G indicator button will cause the gauges to indicate.

5 C of G control

(*a*) The fuel C of G indicator must be monitored throughout the refuelling sequence, especially in the initial stages. If a tank valve fails to open, especially in a tank with a large moment arm, the appropriate needle will move quite rapidly forward or aft; this is the only indication of a valve failing to open. As the needle approaches the limit of the green sector, the appropriate FWD-AFT switch on the fuel control panel should be moved in the opposite direction to needle movement. Refuelling may be continued for as long as it is possible to keep the needles in the green sector ; if it becomes impossible, *contact must be broken immediately.*

(*b*) Normally, if all tanks are accepting fuel, the needles will move to and fro within the green sector and no action need be taken apart from monitoring. If contact is broken before all tanks are full the subsequent tank contents check with the MASTER SWITCH OFF may show considerable variations in tank percentages ; MANUAL use of the fuel system will be necessary to balance the tanks.

(*c*) Even if it is known that the tanks are only partially to be filled, monitoring of the refuelling indicator is still necessary ; in practice Nos. 7, 5 and 1 tanks are the first to fill, in that order, and the other tanks may lag behind by as much as 25%. Any method of adjusting the fuel in individual tanks, in an attempt to make all tanks fill simultaneously, reduces the safety margin provided by this lag and increases the possibility of rupturing a tank, if its valve remains open when all the others have closed. Such a failure could be catastrophic. Until embodiment of Mod. 1143, which restricts the rate of flow into all tanks which are filled to 80% or more, contact must be broken immediately when three tank indicator lights on one side go out (this includes tanks shut off by use of the C of G control switches). This provides a protection against the possible rupturing of a tank whose valve remains open when all the others have closed. If the tanks fail to depressurise, refuelling must be carried out with the tanker's main pump switched off and contact must be broken immediately if the probe pressure rises above 10 PSI.

6 Flight refuelling limitations

(*a*) The aircraft is cleared for flight refuelling contacts, by day or night, with Valiant B(K) Mk. 1 tankers, subject to the following conditions:

(i) Speed of the tanker at and during contact should be 220 to 240 knots. It is recommended that contacts be made and held at 230 knots.

(ii) Airbrakes may be used if required.

(iii) In other respects normal flying limitations apply.

(iv) That Mk. 8 refuelling equipment is modified up to Mod. FR 1010 before night contacts are attempted, and that at night sufficient reserve fuel is maintained in the receiver aircraft to allow for the possibility that the first contact is unsuccessful.

(v) Pilots must receive proper and adequate training in flight refuelling.

(*b*) Speed is referred to in terms of the tankers instruments; there is evidence that there may be a discrepancy between the two aircraft during contact. There is no height limitation.

(*c*) Before night flights the probe lighting should be adjusted so that the outer third of the probe is illuminated.

(*d*) Until Mod. 1143 is embodied, contact must be broken immediately three tank indicator lights on one side go out (this includes tanks shut off by use of the C of G control switches). This is necessary because ground tests have shown that under certain conditions, a fuel tank may become over-pressurised if both halves of the double level float switch fail to close. In these circumstances the vent system is not capable of passing fuel at the rate required to avoid a pressure build-up in the tank.

(*e*) When Mod. 1143 is embodied 100% refuelling may be carried out provided that the aircraft fuel system is depressurised. ▶◀

(*f*) Fuel C of G control switches may be used within the limits mentioned in (*d*) above, but contact must be broken if either needle of the C of G indicator goes into the red sector.