

## Chapter 9

## DE-ICING SYSTEMS AND BOMB BAY HEATING

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## DESCRIPTION

1. Two methods of de-icing are employed, thermal and fluid. A thermal system serves the airframe only, whilst three fluid systems serve the pilots' windscreen, the bomb-aimer's window and in pre-Mod. 2994 B/K and B/K/PR aircraft only, the refuelling probe. Each engine has a self-contained thermal system.

2. The airframe thermal system uses hot air tapped from the starboard side of each engine compressor, and ducted to the main plane, engine air-intake, tail plane and fin leading edges. This source of supply is also used for cabin pressurization. The hot air is exhausted to atmosphere through gauze-covered vents in the component skin.

3. The air temperature is controlled by in-

roducing into the system cold air ducted from flush-fitting intakes in each main plane undersurface and an intake in the dorsal fin leading edge. The cold air supplies are controlled by electrically-operated butterfly valves, the valve actuators being operated by thermostatically controlled inching devices. The hot and cold air supplies are mixed before entering the leading edges.

4. The system is switched on by moving the AIRFRAME AND ENGINE DE-ICING MASTER SWITCH to ON, the four ENGINE GATE VALVE switches to NORMAL and the four AIRFRAME DE-ICING SUPPLY ISOLATING switches to ON (pre-Mod. 701) or NORMAL (post-Mod. 701). If at any time it is necessary to shut off the air supply from any engine, move the

appropriate ENGINE GATE VALVE switch to EMERGENCY CLOSE. There are three red warning lamps, which indicate a condition of overheat, on the starboard console. Also on this console are (1) an ICING DETECTOR lamp (post-Mod. 2599) controlled by its own test switch and connected to a detector head and thermo bulb fitted forward of the bomb aimer's fairing, and (2) a temperature indicator (post-Mod. 2708) which, on selection through a switch, indicates the temperature at any one of three resistance bulbs fitted in the main plane and tail diffusers.

5. The bomb bay is heated by hot air, ducted from the tail unit de-icing supply to diffusers in the bomb bay. This supply is controlled by switches, on the starboard con-

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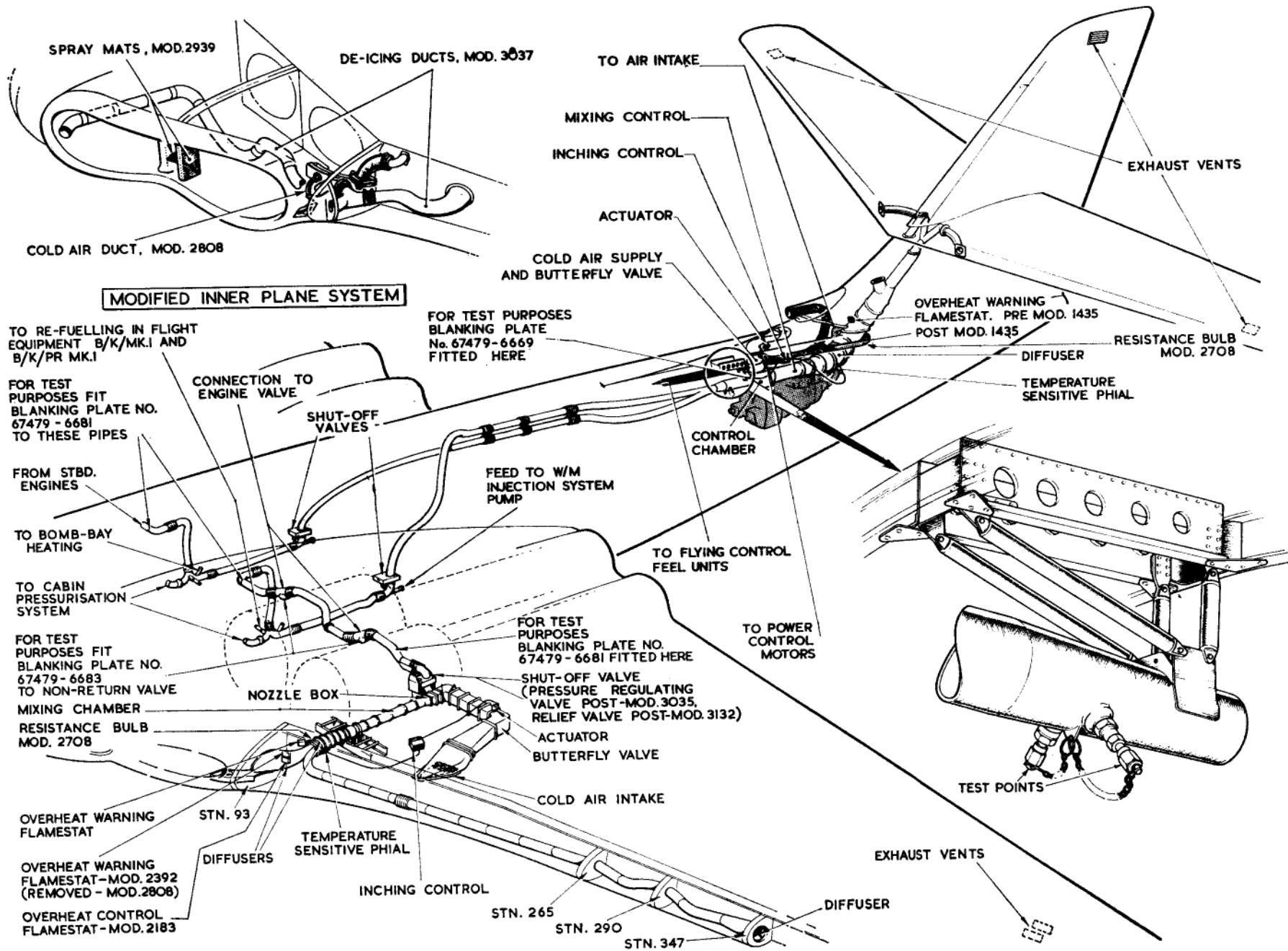


Fig. 1. Thermal de-icing system

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sole, which operate electrically-actuated valves in the supply ducting.

6. The fluid de-icing systems are supplied from separate tanks, independently operated by switches on the starboard console (pilots' windscreen), bomb-aimer's panel and starboard coaming panel (refuelling probe). The fluid flow over the pilot's windscreen can be varied by operating the switches to give any one of three different rates; the flow over the bomb-aimer's windows is variable by the operation of a rheostat whilst the flow to the probe is constant.

7. Each pilot's windscreen is fitted with a wiper unit, each comprising a wiper head (on the windscreen), rheostat control (port and starboard console respectively) and an electrically-driven hydraulic pump. Each pump has an integral reservoir and is directly coupled by pipes to its respective wiper head, through a closed hydraulic circuit.

#### THERMAL DE-ICING (fig. 1)

##### Airframe

8. The hot air supply for the main plane and engine air intake leading edges is derived from an outboard extension of the outboard engine supply point to the cabin pressurization system. The supply for the tail unit is also taken from the cabin pressurization system at each side of the fuselage Stn. 570 approx., where the supply ducts from the engines emerge from the main plane root; also at this point are the connections for the tanker role turbine-driven fuel pumps.

##### Main plane and engine air intake

9. The hot air supply to the main plane passes through an electrically-actuated gate type shut-off valve and into a nozzle box before entering the main ducting. Post-Mod. 3035, a pressure regulating valve replaces the shut off valve and controls the supply of hot air to the main plane. ◀ Post-Mod. 3132, a pressure relief valve is embodied in the pressure regulating valve to prevent excess pressure being built up in the

engine air-intake. ▶ The nozzle is fitted within part of the ducting leading from the cold air-intake in the main plane underside, this intake being fitted with an electrically-operated butterfly valve. Post-Mod. 2807, the flow of hot air entering the system is increased by substituting nozzles of larger diameter. Cold air flows around the outside of the nozzle and passes with the hot air, into the next portion of ducting, referred to as the mixing chamber. Hence the mixed air passes through a diffuser into a bifurcated duct (pre-Mod. 3037) in the inner-plane leading edge.

10. The air temperature in this diffuser controls the operation of the butterfly valve in the cold air duct through a temperature-sensitive phial, and a thermostatic inching control in the valve actuator circuit. When the temperature in the diffuser reaches a condition of overheat, a flamestat in the diffuser lights a red warning lamp on the starboard console.

11. One branch of the bifurcated duct turns inboard to supply a portion of the inner plane and engine air-intake leading edges, the other branch turning outboard to supply the outer plane leading edge; both branches terminate in diffusers. The duct outboard branch, formed in sections with integral flanges riveted together, incorporates an expansion bellows at its appropriate mid-length. Both diffusers are attached to the main plane structure, the inboard by rivets and the outboard by countersunk-head bolts in anchor nuts. The ducting is supported by spring-loaded plungers attached to the nose rib webs, reinforcing strips being welded to the ducts at the plunger contact points.

12. Air flowing outboard is discharged through the diffuser into the leading edge structure at Stn. 347 whence it flows between the inner and outer skin of the leading edge. Some of the air flowing inboard passes straight into the engine air-intake leading edge, the remaining air being deflected by a plate, which reverses the direction of air

flow, outboard into the leading edge de-icing channel to Stn. 347. The air exhausts to atmosphere through gauze-covered vents in the main plane bottom skin.

12A. On aircraft post-Mod. 3037, the bifurcated duct is replaced by a short duct connected to one arm of a T-piece, the other arm of which is secured (outboard of Stn. 93) to a bored attachment plate through which the heated air passes into the engine air-intake leading edges. The T-piece stem is connected to a duct which guides the heated air through a cut-out in the rib at Stn. 45 to the air-intake leading edges at the inboard end. The duct leading to the outer plane is disconnected and, post-Mod. 3034, the warm air supply to the inner plane is reduced by the fitting of a smaller diameter mixing chamber. To permit a more even flow of warm air in the air-intake lips the glass cloth de-icing plating is cropped, post-Mod. 2889; in the inner planes the airflow is improved post-Mod. 2808 by ram air which enters a flush air-intake in the inner plane under-surface (forward of the front spar and inboard of Stn. 93) and is ducted to the cable duct.

##### Tail unit

13. The port and starboard supply branches from the cabin pressurization system connect to the tail unit de-icing ducts which turn aft, close to the fuselage sides, to Stn. 653 where electrically-actuated, gate-type, shut-off valves are fitted, one on each side. From these valves, operated by switches on the starboard console, the ducts continue aft and upward toward the roof centre and merge into a single duct at Stn. 953. The air supply then flows into a control chamber, connected to the cold air supply from the dorsal fin, and out into the mixing chamber.

14. The cold air duct to the control chamber has a butterfly valve which is electrically actuated in a manner similar to the cold air supply valve in the main plane system. The control chamber contains a nozzle,

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cooled by the cold air, through which the hot air emerges before the two flows combine and enter the mixing chamber. (Post-Mod. 2807, the hot air supply is increased by the fitting of a larger diameter nozzle). The combined flow then enters a diffuser, fitted with strengthened guide vanes post-Mod. 3073, in which are located the temperature-sensitive phial of the inching control and a flamestat which operates an overheat warning lamp. A resistance bulb, post-Mod. 2708, is connected through a switch to a temperature indicator (*para.* 4). The duct turns upward and a branch is taken to the bottom fin leading edge, above which the duct bifurcates to port and starboard in the tail plane fixed structure where short ducts divert the airflow to the tail plane leading edges.

15. From the duct connected to the diffuser a branch leads forward and upwards to the dorsal fin air-intake, which serves two systems viz., the cold air supply to the tail unit de-icing system (*para.* 14) and the air supply to the flying control feel unit cylinders. This branch pipe is replaced, post-Mod.

2940, by a pipe of larger diameter fitted, post-Mod. 3075, with a break joint to facilitate repair work within the fin. From the cold air supply duct to the de-icing system a branch conducts cooling air to the power control motors.

16. The tail plane and fin leading edge structures serve as ducts for the hot air which, during its passage, heats the skin sufficiently to prevent adhesion of ice to the outer surface. The air is exhausted through gauze-covered vents in the tail plane bottom surface and on both sides of the fin.

17. Expansion joints, interposed in the ducting, are constructed from nickel plated bronze corrugated tubing, silver soldered to short joggled end ducts; the ends have machined flanges to take bolted half couplings, for ease of dismantling and reassembly. An asbestos impregnated silicone rubber seal ring, housed in a machined groove, ensures an airtight joint. The fuselage ducts are secured to one another and to the expansion joints by half-clamp type connections, the gate type valve being attached by bolts through its flanged ends.

18. Heat losses are prevented by lagging each fuselage duct with  $\frac{1}{2}$  in. thick fibreglass, this being covered with lightweight glass cloth on the exposed side of which is a coating of P.V.C. This serves as a protection against fire and fuel contamination of the fibreglass in the event of leakage from the fuselage fuel tanks.

#### Engines

19. Each engine has an independent thermal de-icing system for which the hot air is taken from the engine compressor, through electrically-operated gate type valves on the port side. The four valves are controlled by the AIRFRAME AND ENGINE DE-ICING MASTER switch on the starboard console. Post-Mod. 2939, electrically-heated spraymats are bonded to the vertical and horizontal guide vanes in the outboard air-intakes.

#### WARNING . . .

*Spraymat heaters must not be operated whilst the aircraft is on the ground except as stated in Book 2, Sect. 5, Chap. 5, Grp. 1, App. 1.*

#### Windscreen and bomb-aimer's window

20. The pilots' windscreen and bomb-aimer's window have de-misting diffusers that are operated from the air conditioning system (*Chap.* 8).

#### BOMB BAY HEATING

21. At each side of the fuselage, branches from the ducts supplying the tail unit de-icing system are led directly downward to electrically-actuated gate-type valves, controlled by switches on the starboard console.

22. The air supply passes through the valves and then through restrictors before reaching the main distributing ducts. The restrictors reduce the flow of hot air, thus preventing extremes of temperature in the bomb bay, with consequent adverse effects on batteries, electrical equipment and stores. The main distributing ducts are supported on brackets in the space between the fuselage skin and the bomb-bay walls. The supply ducts join the distributing ducts at their approximate mid-length, the end of the distributing ducts protruding inwards through holes in the bomb-bay walls; the duct open ends terminate in diffusers. Two intermediate

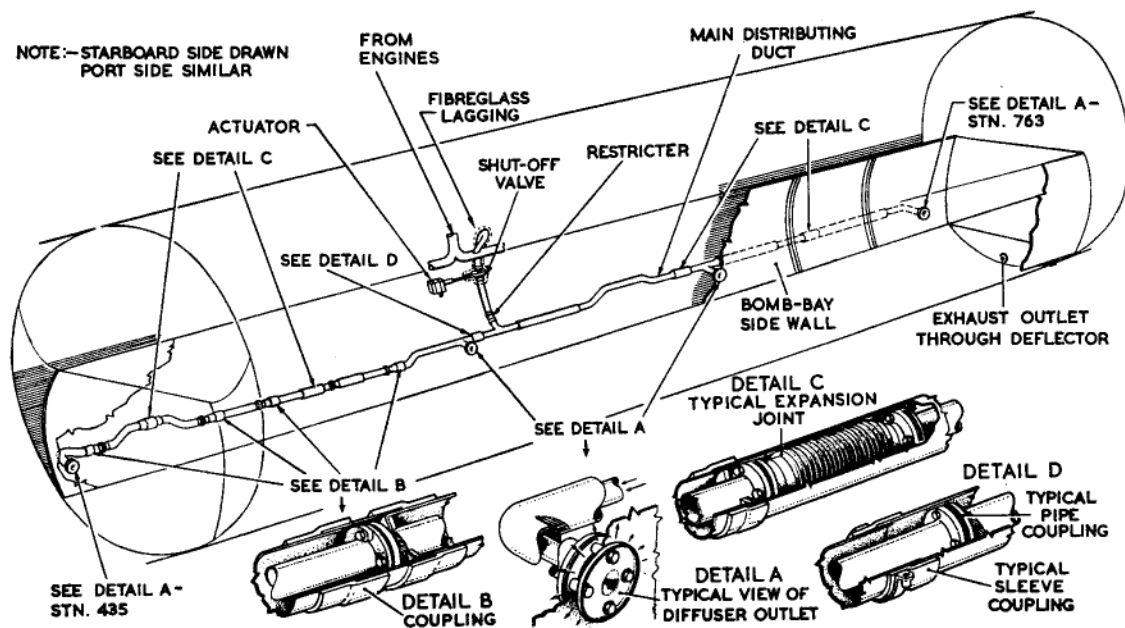


Fig. 2. Bomb bay heating

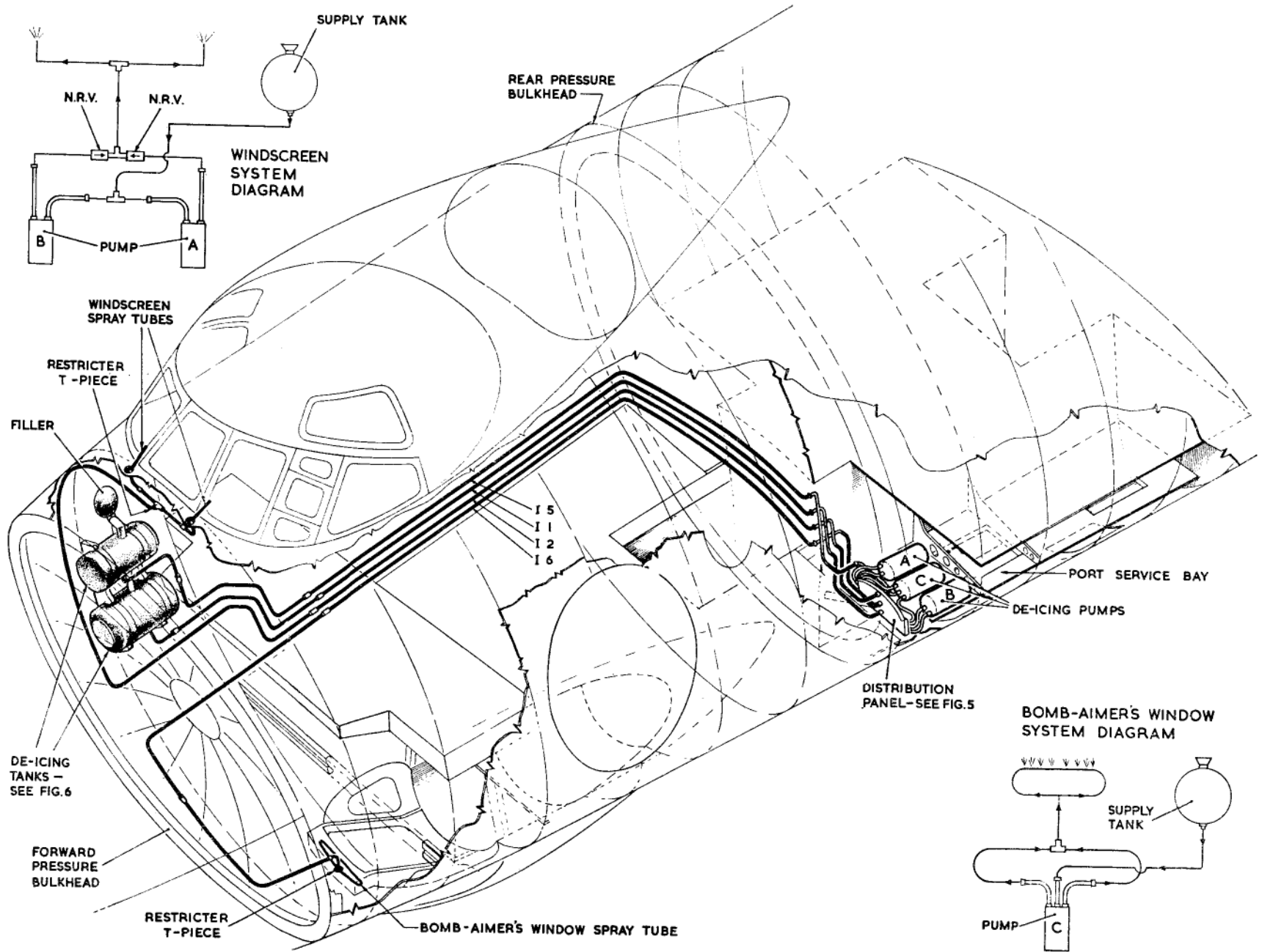


Fig. 3. Pilot's windscreen and bomb-aimer's window de-icing system

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branches from each distributing duct also protrude through the bomb-bay walls, each terminating in a diffuser. For the P.R. role these pipe ends should be blanked off (*Sect. 2, Chap. 5*).

23. The supply ducting is lagged with fibreglass and P.V.C. coated glass cloth from the branch pipes to the gate type valves, but hence its construction varies. Basically, the supply duct is supported in aluminium tubing with approximately  $\frac{3}{8}$  in. air space between the duct and tube. The supply ducts have flanged ends for bolting one to another and in some cases the outer tubing is welded to the inner duct, leaving the flanged ends exposed for easy coupling. These couplings are covered by an aluminium tube secured by Neoprene sleeves stretched over each end. Some ducts are encased in tubing of two different sizes, having one end flanged for bolt connection, while the other ends are free to telescope, when access to duct couplings is required. Two expansion joints are fitted in each distributing duct.

24. The aluminium tubing covering the heating ducts reduces fire risk in the event of fuel leakage from the fuselage tanks. Air temperature in the bomb bay is indicated on a gauge on the starboard console. Post-Mod. 2486 the bomb bay may be heated, whilst the aircraft is on the ground, from a heater trolley through a connection on the bomb-bay forward bulkhead.

## FLUID DE-ICING

### Windscreen and bomb-aimer's window

(*fig. 3*)

25. Two separate fluid systems are employed for de-icing the pilots' windscreen and the bomb-aimer's window, using the fluid quoted in Leading Particulars. Each system is supplied with fluid from a separate tank, the tanks being mounted one above the other on wall brackets, secured to the fuselage starboard side immediately behind the front pressure bulkhead. Three pumps, mounted at the base of the port servicing bay at Stn. 290, are accessible through the bay hatch.

26. The pilots' windscreen system employs two pumps (*Leading Particulars*) of single delivery type (*A.P.1803S, Vol. 1*). The pumps are independently operated by switches on the starboard console and the fluid is delivered, through non-return valves and a restrictor T-piece, to sprays at the windscreen. The pump, operated by the outboard (No. 2) switch, incorporates in its wiring circuit a fixed resistance which reduces the voltage and delivery by approximately one half. Three rates of delivery are therefore available by operating the two switches separately or together.

27. The bomb-aimer's window spray is served by a twin-delivery type pump, the outlets from which are connected, at a restrictor T-piece, into a single pipe that delivers the fluid to the window spray. The pump is con-

trolled by a rheostat switch on the bomb-aimer's panel, the rate of fluid flow being governed by the rheostat.

28. The tanks are interconnected by a stand pipe passing through the bottom of the upper tank and connected by a rubber hose, to a pipe projecting upwards from the top of the bottom tank. A filler neck on the upper tank protrudes into a recess in the fuselage skin. When the upper tank is filled above the level of the stand pipe the replenishing fluid flows down this pipe and fills the lower tank, this being considered full when fluid can be seen in the filler neck. The filler cap has a small vent hole which must be kept clear.

### Refuelling probe—B/K Mk. 1 and B/K/PR Mk. 1 ◀pre-Mod. 2994 only▶

29. This de-icing system consists of a one-gallon capacity tank, a single-delivery type pump, an electrically-actuated three-way cock and suitable pipelines terminating in a jet in the probe nozzle valve assembly. The tank, pump and cock are mounted on the starboard shelf in the radome nose. An access panel to the tank filler cap is in the probe fairing; the cap has a vent hole which must be kept clear. ◀It should be noted that in aircraft post-Mod. 2994, the Mk. 6 is replaced by a Mk. 8 probe nozzle which has no de-icing facility.▶

30. Moving the control switch (starboard coaming panel) to ON, starts the pump motor and operates the three-way cock actuator so that fluid passes to the probe nozzle. With the switch moved to OFF, the pump motor stops and the three-way cock opens to vent the system to atmosphere.

### WINDSCREEN WIPERS

31. Each windscreen has an independently controlled wiper, operated by a closed hydraulic circuit actuated by an electric pump. The pumps are located below the de-icing fluid tanks (*fig. 7*). The four-position type switches controlling the speed of the pumps, are mounted one on each console. The wiper heads are fitted at the bottom inner corner of each windscreen, whilst the

TABLE 1. Piping code

Code	Description
I 1	Tank to pumps A and B
I 2	Pumps A and B to restrictor T piece
I 3	Restrictor T piece to pilots' windscreen (starboard)
I 4	Restrictor T piece to pilots' windscreen (port)
I 5	Tank to pump C
I 6	Pump C to restrictor T piece

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parking levers are attached to the inboard frames. Each lever is connected to its appropriate wiper head and, when moved to PARK trips a microswitch in the circuit to the electric motor. The wipers are started by turning the switches to SLOW and unparking the wipers. To stop the wipers, turn the switches to OFF and move the parking levers to PARK.

## SERVICING THERMAL DE-ICING

### Electrically-operated components

32. Servicing of all electrically-operated mechanisms is detailed in Book 2, Sect. 5, Chap. 5.

### Ducts

33. All ducts should be examined at periods specified in A.P.4377A, Vol. 4, and no further servicing is required. When the fuselage ducts are dismantled and reassembled for any reason, the affected part of the system should be tested as follows:—

(1) *Front fuselage*—Blank off the ducting at these positions:—

- (a) Between the top expansion joint and engine supply inlet (Stn. 0).
- (b) Constant flow valve—inlet side.
- (c) Fuel heating valve—inlet side.
- (d) Flood flow valves—inlet side.
- (e) Tail unit shut-off valves—inlet side.
- (f) Pressure ratio pipes and water-methanol tapplings—inlets.
- (g) Bomb cell heating valve—inlet side. ▶

Introduce an air supply and pressurize to 60 lb/in<sup>2</sup>; the pressure must not fall below 40 lb/in<sup>2</sup> in less than 15 min. ◀Post-Mod. 925, pressurize to 120 lb/in<sup>2</sup>; the pressure must not fall below 40 lb/in<sup>2</sup> in less than 15 min. ▶ Remove the blank from the flood flow valve inlet, ensure that the valve is closed, and re-test to the same requirements.

(2) *Rear fuselage*—Blank off the ducting at these positions:—

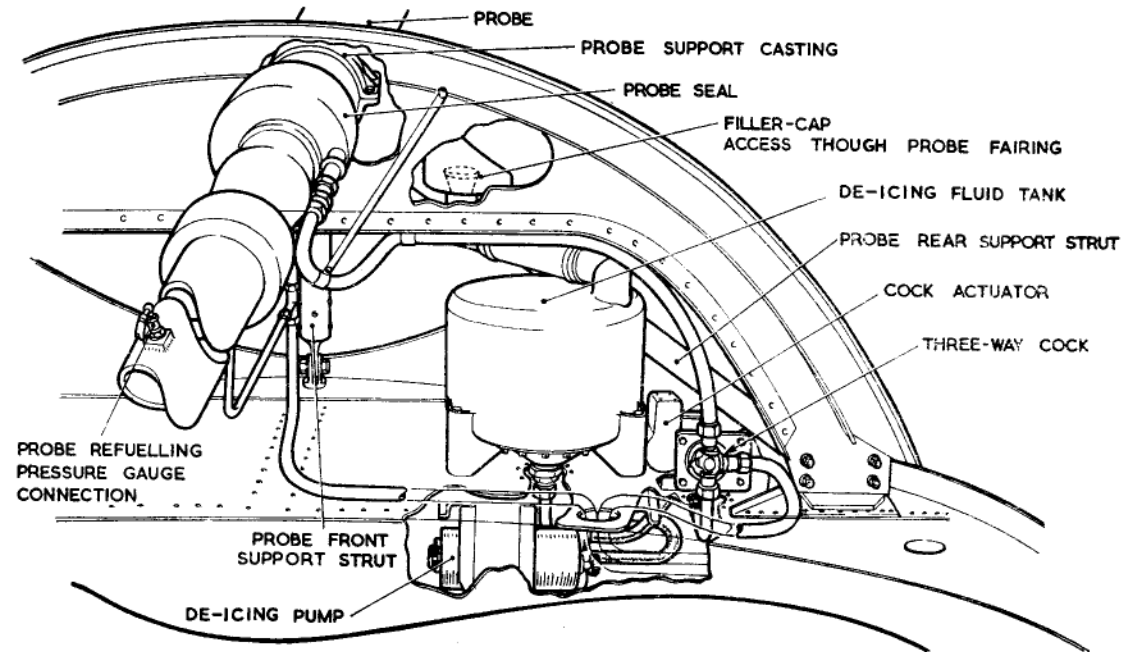


Fig. 4. Refuelling probe de-icing system

- (a) Forward connection to control chamber (Stn. 973).
- (b) Tail unit shut-off valves—outlet side.

Using test points at rear of ducting, pressurize to 60 lb/in<sup>2</sup>; the pressure must not fall below 40 lb/in<sup>2</sup> in less than 15 min. ◀Post-Mod. 925, pressurize to 120 lb/in<sup>2</sup>; the pressure must not fall below 40 lb/in<sup>2</sup> in less than 15 min. ▶

(3) *Bomb bay*—Blank off the ducting at these positions:—

- (a) All diffusers.
- (b) Shut-off valves—◀inlet▶ side.

Pressurize to 30 lb/in<sup>2</sup>; the pressure must not fall to zero in less than one minute.

33A. When assembling the bifurcated duct (Pt. No. 70682-79) connecting the supply duct from the starboard engines to the ducts running forward for cabin pressurization and

aft for tail unit de-icing, special care must be taken to prevent a foul with the elevator control rod. The duct joint clamps must be so positioned that the projecting bolt ends are not directly under the elevator control rod or likely to foul other items in the area. When fitting a new duct, if the holes in the duct attachment brackets are not in alignment with the existing holes in the support channels at Stn. 557-38 and 575-88, new support channels (Pt. No. 67427-3701 and 3703 respectively) must be fitted.

## FLUID DE-ICING

### Probe de-icing system flow test

34. If for any reason the system is dismantled, the following flow test must be made after reassembly:—

- (1) Fill the system tank with de-icing fluid, disconnect the pipe at the probe seal and lead into a graduated receptacle

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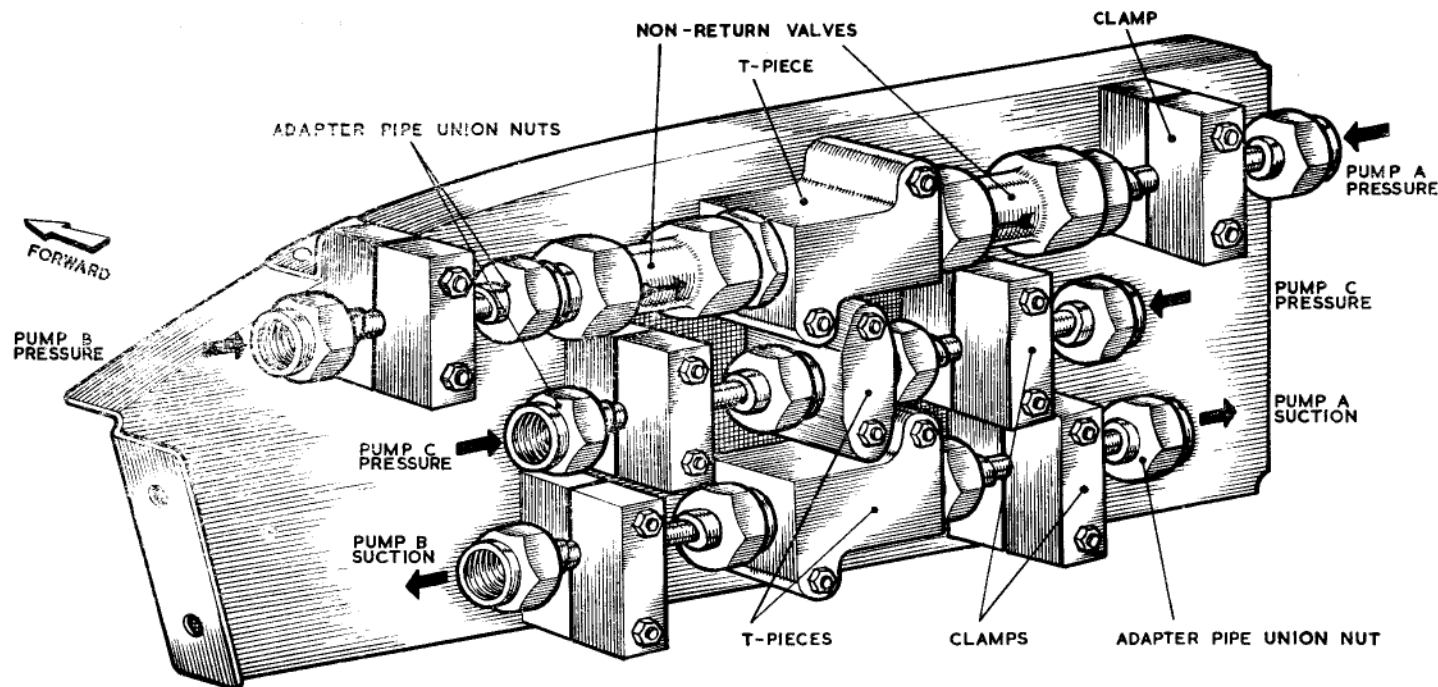


Fig. 5. Windscreen and bomb-aimer's window de-icing distribution panel

(2) Switch on the pump and measure the fluid flow from the disconnected pipe; the requirements are:—

- (a) 15 pints per hour at 26 volts.
- (b) 7 pints per hour at 14 volts.

(3) To test the operation of the three-way cock, switch off the pump and check that fluid from the probe vents to atmosphere through the starboard louvre in the scanner bonnet (pre-Mod. 2705) or from the fuselage starboard vent at Stn. 106 (post-Mod. 2705).

(4) Reconnect the pipe to the probe seal.

#### Windscreen and bomb-aimer's window de-icing

35. Servicing and testing the pumps used in the windscreen and bomb-aimer's window are described in A.P.1803S, Vol. 1, Book. 1, Sect. 2. The pipes in the system are coded as shown in Table 1.

#### WINDSCREEN WIPERS

36. The contents of the hydraulic reservoir should be checked periodically (A.P.4377A, Vol. 4); the reservoir is contained in the pump casing. Pressure of the wiper blades, when vertical on the windscreen, should be 8 lb.

37. If a system has been drained for any reason, it should be filled as follows:—

- (1) Remove the wiper arm or copiously wet the windscreen and ensure that it remains wet throughout subsequent operations.
- (2) Remove the filler cap and fill the reservoir with hydraulic fluid.
- (3) Start the wiper pump motor as described in para. 31.
- (4) Turn the switch to FAST and add hydraulic fluid to the reservoir as the level begins to fall. Continue until the fluid level remains constant.

(5) Top up the reservoir and replace the filler cap.

(6) Switch off the motor and replace the wiper arm (if removed).

**Note . . .**

*Absolute cleanliness of hydraulic fluid and utensils is essential when refilling or topping up the wiper hydraulic systems.*

#### REMOVAL AND REFITTING THERMAL DE-ICING COMPONENTS

##### Main plane components

38. The components in the main plane between Stn. 115 and 145 are accessible through the undercarriage rib. They are coupled by bolts through the flanges, seals or gaskets being interposed between the flanged ends where necessary. In each case removal is a matter of disconnecting electrical and mechanical actuator connections, removing bolts where necessary and withdrawing the

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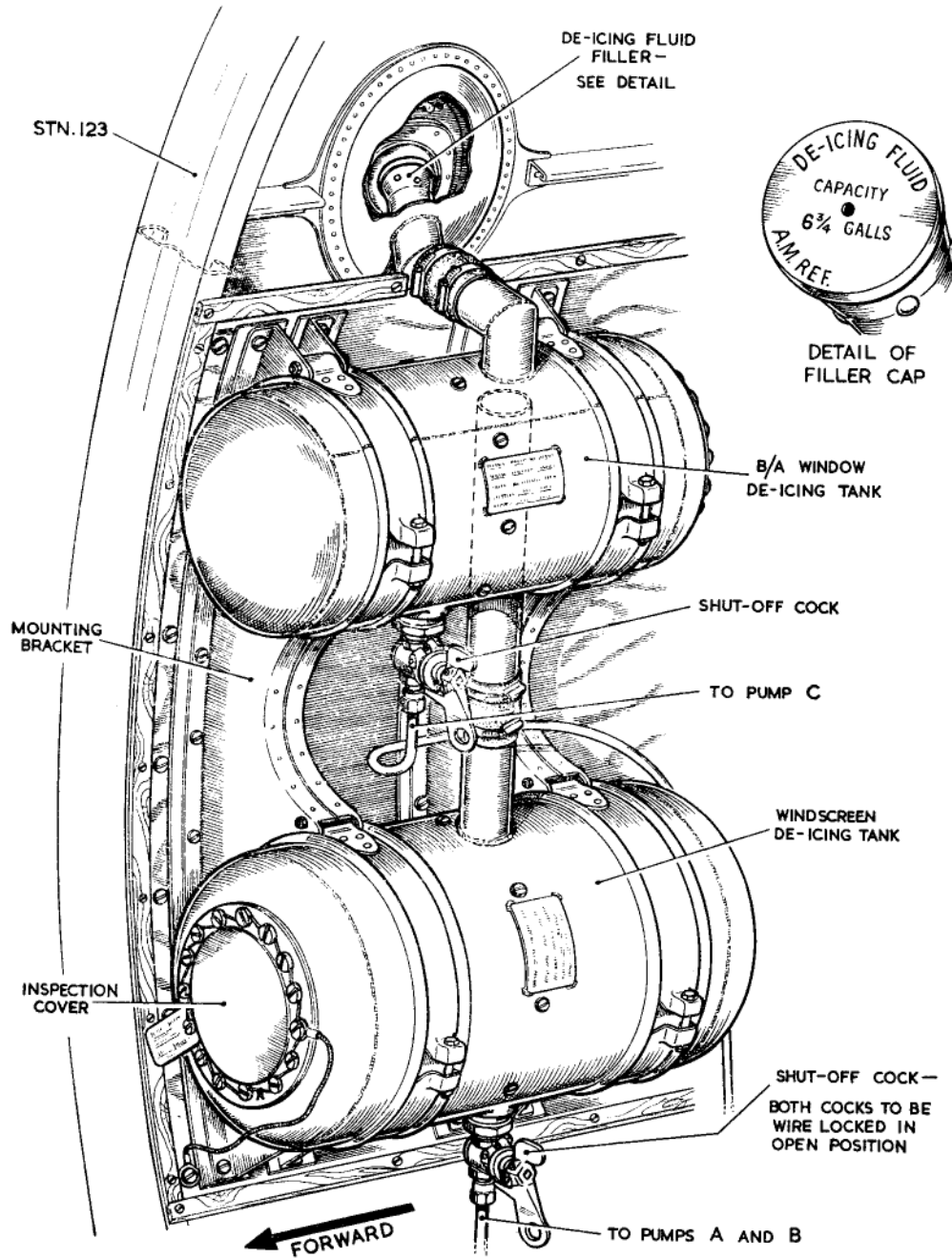


Fig. 6. De-icing tanks

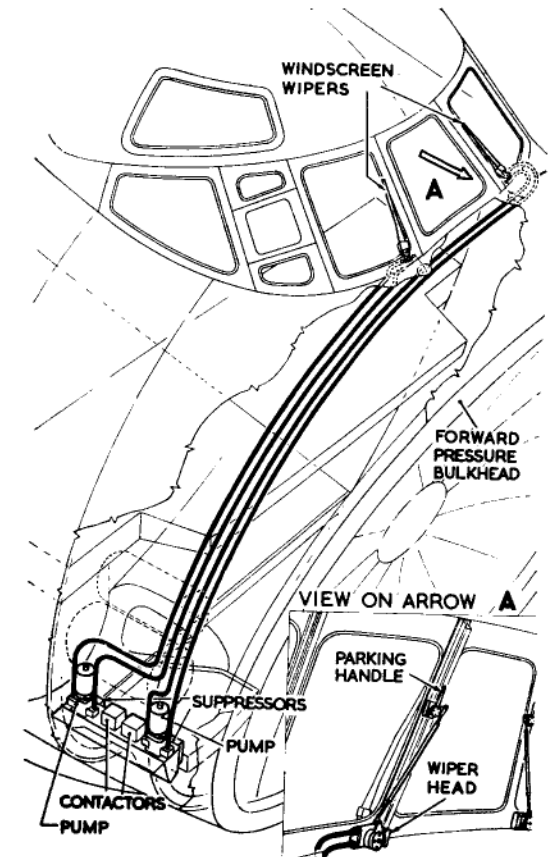


Fig. 7. Windscreen wiper system

components. To refit, reverse the removal sequence.

39. Attachment of the mixing chamber to the diffuser in the main plane is slightly more involved. The chamber forward end fits over the diffuser rear end and is attached to it by four equally-spaced bolts. The bolt holes in the mixing chamber are slotted to cater for expansion, the bolts screwing into tapped holes in a reinforcing ring within the diffuser. The joint is covered with asbestos tape

(lightly wrapped around the mixing chamber and diffuser ends) between two asbestos rings cemented, one to the mixing chamber and one to the diffuser, with sodium silicate. The whole joint is then covered with a neoprene sleeve secured with hose clips. Access to the securing bolts is gained by removing the hose clips, neoprene sleeve and asbestos tape.

40. The nozzle (*para. 9*) is fitted inside the nozzle box within the duct. To gain access to the nozzle it is necessary to remove the duct and the nozzle box.

#### **Fuselage components**

41. These components are all accessible from within the fuselage, the method of removal and refitting being obvious when the components are viewed on the aircraft.

### **FLUID DE-ICING COMPONENTS**

#### **Fluid tanks**

42. The windscreen and bomb-aimer's window de-icing fluid tanks are mounted in brackets and secured by straps. Fluid, remaining in a tank which is to be removed, must first be drained by closing the shut-off cock at the base of the tank, disconnecting the suction hose from the tank to the pump and opening the cock to drain the fluid into a

suitable receptacle. Disconnect the sleeve between the tanks and (top tank only) disconnect the filler neck, unbolt the securing straps and remove the tank. To refit, reverse the removal sequence and ensure that the shut-off cock is wire-locked OPEN.

43. The refuelling probe de-icing fluid tank, mounted on the shelf in the radome nose, is secured by bolting the three legs (welded to the bottom of the tank) to the shelf. Fluid remaining in the tank must first be drained by disconnecting the suction hose from the tank to the pump and collecting the fluid in a suitable receptacle. Remove the hose clips securing the tank to the filler neck, remove the bolts securing the tank to the shelf and withdraw the tank. To refit, reverse the removal sequence.

#### **Pumps**

44. The de-icing pumps for the pilots' windscreen and bomb-aimer's window are mounted in brackets in the port servicing bay and secured by straps. Fluid in the suction line must first be drained off by closing the shut-off cock at the base of the tank and disconnecting the suction line at the pump. Disconnect the delivery hose (windscreen pumps) or hoses (bomb aimer's window pump) at the pump, disconnect the electrical supply to the pump, move the bolt securing straps, and withdraw the pump. To refit reverse the removal sequence and ensure that

the shut-off cock on the tank is wire-locked OPEN.

45. The probe de-icing pump is mounted in a bracket under the shelf in the radome nose and secured by bolts. Fluid remaining in the tank and suction line must first be drained by disconnecting the suction line at the pump. Disconnect the supply hose from the pump to the three-way cock, disconnect the electrical supplies to the pump, remove the securing bolts and withdraw the pump. To refit, reverse the removal procedure.

46. Pumps for the windscreen wipers are bolted to a mounting bracket, below the de-icing fluid tanks in the cabin starboard side. To remove a pump, disconnect the pipe unions, collect the fluid from the pipes, remove the securing bolts and withdraw the pump. To refit, reverse the removal sequence.

#### **Probe de-icing three-way cock**

47. The three-way cock is bolted to a bracket adjacent to the probe de-icing fluid tank. Fluid remaining in the pipe between the pump and the cock must first be drained by disconnecting the pipe from the cock body. Disconnect the other two pipes from the cock, disconnect the cock actuator, remove the bolts securing the cock to the bracket and withdraw the cock. To refit reverse the removal sequence.

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