Chapter 9

DE-ICING SYSTEMS

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DESCRIPTION

THERMAL SYSTEM

Introduction

1. The thermal de-icing installation provides a means of keeping the temperature of the air in the region of the inner surfaces of the wing and fin leading edges within predetermined limits. The required heat is provided by air tapped from the main engine compressors; this hot air is mixed with a suitable proportion of cold air to control its temperature, and is then passed along the inside of the leading edges of the wing and fin. The hot and cold air valves are operated by motor driven actuators and can be controlled manually or automatically. Normally automatic control is employed, but manual control can be used in an emergency such as failure of the automatic controls.

2. The aircraft installation is divided into three separate systems, one for the port and one for the starboard wing leading edge and the third for the fin leading edge, each having its own injector and hot and cold air valves. The three systems are controlled electrically from the starboard console in the cockpit, three distinct circuits being employed. For electrical description and operation, reference should be made to Book 2, Sect.6 of this publication.

3. The engine anti-icing system installation is integral with the engine, delivery air from the h.p. compressor being used to protect the oil tank nose bullet fairing, the intake guide vanes and the entry guide blades against ice formation. Hot air is tapped from the delivery casing on the port side of the engine and led forward, through an external pipe, to a hot air valve mounted on the L.P. compressor casing. This valve is operated by an electrical actuator controlled from a switch on the de-icing systems panel in the cockpit (fig.1). The electrical system is fully described in Book 2, Sect.6 of this publication. For information on the engine system, reference must be made to A.P. 4712A, Vol.1, Sect.1, Chap.5.

CONTROLS AND INDICATORS

4. A panel on the starboard console houses the control switches and indicators, which are as follows:-

(1) Main control switches, one for each system, labelled AUTO OFF-MANUAL.

(2) MANUAL HEAT CONTROL switches - one for each system. They have three positions - INC - central off - DEC (Spring loaded to the central off position).

(3) PORT and STBD. ENGINE anti-icing system switches, one for each side. Each switch is guarded and labelled ON - OFF.

(4) Temperature indicators - one for each system, calibrated 0-200 deg.C, register the temperature of the air at the injector outlet.

NOTE . . .
Before the de-icing systems can function, the ENGINE AIR switches on the pressurisation panel must be ON.

In addition to the foregoing, three setting potentiometers, one for each circuit, are mounted at the rear of the pilots' floor on the starboard side. These are installed for calibration purposes as required.

HOT AIR SUPPLY

5. Hot air at a temperature and pressure of up to 350 deg.C and 200 p.s.i. is tapped off the main engine compressors through engine isolation valves. Outlets from the port and starboard pairs of engines feed their respective port and starboard wing systems, and provide a common feed through non-return valves to the fin de-icing and bomb bay heating systems. The same engine tapping connection is used for both cabin and de-icing air; the ducting for the wing de-icing air and for cabin air is common to a point just forward of the front spar. The flow of hot air into each leading edge system is controlled by electrically-operated valves.

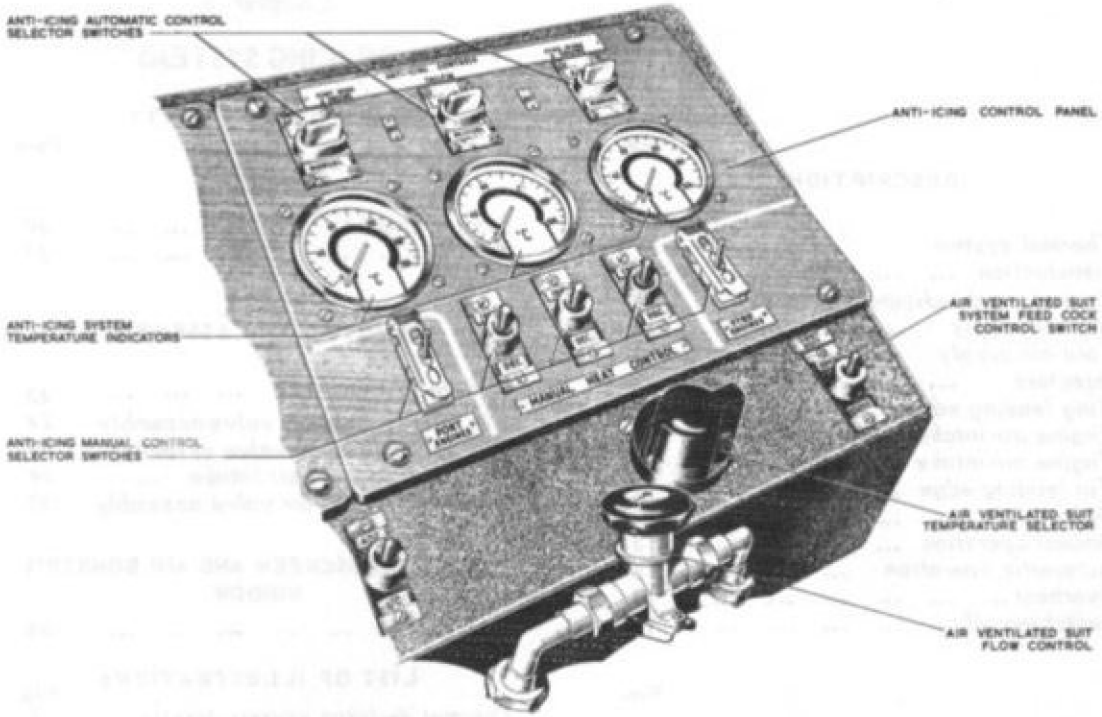

Fig. 1. De-icing system control panel

COLD AIR SUPPLY

6. Cold air is supplied to each injector from a separate flush air-intake. The wing system air-intakes also act as cold air valves, the intake area being varied by an electrically-operated flap. The fin supply enters by twin fixed flush air-intakes, back to back in the dorsal fin; the cold air flow being controlled by an electrically-operated valve between the intakes and the injector. The fin intakes also supply air to the bomb bay heating system.

INJECTORS

7. The operation of one injector is described, the other two being similar. Hot air from the engine passes through the hot air control valve to the nozzle of the injector. It then leaves the nozzle at considerable velocity and passes down a mixing tube, mixing with and imparting some of its velocity to the cold air which enters the mixing tube around the hot air nozzle. At the far end of the mixing tube, complete mixing has taken place and the final temperature of the warm air depends on the proportion of cold air allowed to mix with the engine air. The warm air is circulated to the wing and fin leading edge as described in the following paragraphs.

WING LEADING EDGE

8. Warm air from the injector in the

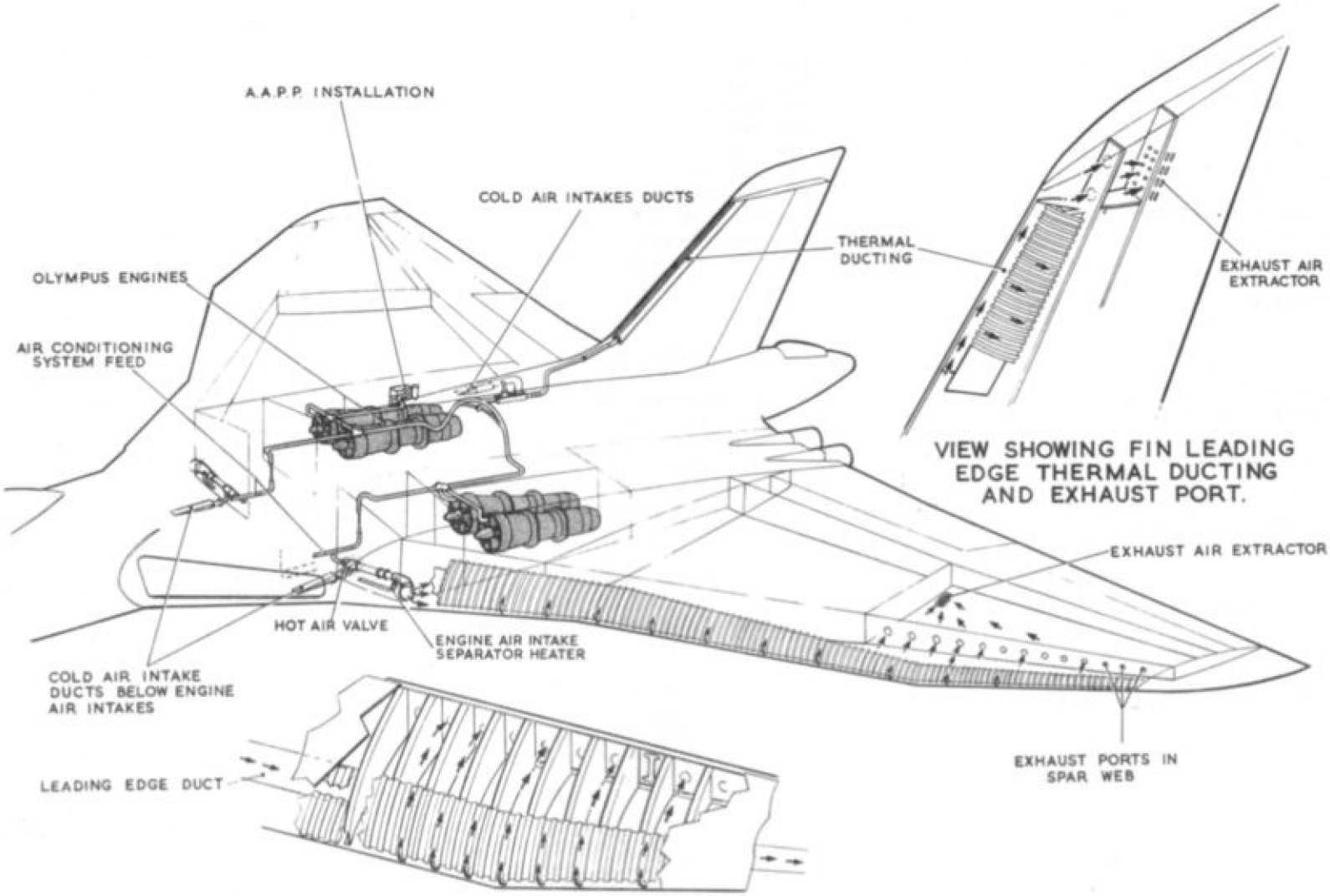

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Fig.2. Thermal de-icing system installation

port and starboard leading edge, enters a wedge section duct which runs the whole length of the outer wing leading edge. The forward side of the duct is open, and warm air flows to the inside of the leading edge skin and then rearwards between the outer skin and a corrugated inner skin. The warm air heats the leading edge skin and exhausts to the space between the wedge-shaped duct and the front spar. Outboard of the tank bays, a series of holes in the front spar web allows the exhaust air to flow rearwards to an exit louvre immediately forward of the rear spar.

ENGINE AIR-INTAKE LEADING EDGE

9. Warm air from the wing duct passes through the transport rib, to the upper and lower tips of the engine air intake, through ducts passing along the leading edge of each tip, and then rearward between the tip skin and a corrugated inner skin as in the wing. The air exhausts into the space around the air-intake tunnels and out through an electrically-operated extractor flap on the lower skin of the engine air-intake.

ENGINE AIR-INTAKE SEPARATOR

10. A branch pipe, from the main air duct, feeds warm air to a small duct along the leading edge of the engine air-intake separator. The warm air then passes rearwards between the separator skin and the inner skin and finally exhausts into the space around the air-intake tunnels.

FIN LEADING EDGE

11. Warm air from the fin injector enters a box section duct which runs the length of the fin leading edge. The forward side of the duct is open and warm air flows to the inside of the leading edge, then rearwards between the skin and a corrugated inner skin and exhausts to the space between the duct and the front fin post. A series of holes in the front and rear fin post allows the exhaust air to flow rearward to an exit louvre near the top of the fin balance chamber.

NOTE . . .
When Mod.1144 is embodied, main plane and fin leading edge de-icing systems are rendered inoperative by the introduction of a blanking plate in the duct joint at the inlet side of each of the three hot air valves. Embodiment of Mod.1704 authorizes the removal of the blanking plates from the main plane systems and restoration of the systems to normal, the fin system remains inoperative. STI/VULCAN/417 blanks off the redundant fin de-icing system.

OPERATION

12. The following paragraphs describe briefly the operation of one of the wing systems, the fin system is similar except that it has no extractor valve. Complete details of the electrical operations involved are contained in Book 2, Sect.6, Chap.1 of this publication.

MANUAL OPERATION

13. For manual operations proceed as follows:-

(1) Check that the ENGINE AIR switches are ON (pressurisation panel). This ensures that hot air from the engine compressors is applied to the hot air control valve.

(2) Place the main control switch to MANUAL. This operation opens the variable cold air intake and extractor valve to their full extent, and applies a positive supply to the MANUAL HEAT CONTROL switch.

(3) Hold the MANUAL HEAT CONTROL switch to the INC. (increase) position until the temperature indicator registers a temperature of 150 ± 5 deg. C. This operation opens the hot air control valve until the above heating air temperature is obtained. Opening and closing of the hot air valve can now be controlled by operating the MANUAL HEAT CONTROL switch to INC. or DEC. (decrease) as required. The cold air valve and extractor valve actuators will remain in the open position while the AUTO-MANUAL switch is at MANUAL.

AUTOMATIC OPERATION

14. To operate the system under automatic control proceed as follows:-

(1) Check that the ENGINE AIR switches are ON (pressurisation panel). This ensures that hot air from the engines is applied to the hot air control valve.

(2) Place the main control switch to AUTO.

15. Movement of the control switch to AUTO results in the following operations:-

(1) The variable cold air intake and the extractor valve open to their full extent.

(2) After (1) is completed, the hot air control valve is placed under the control of a temperature controller. The sensing element of the controller is attached to the leading edge skin, and the controller opens or closes the hot air valve to maintain a skin temperature of approximately 10 deg. C.

(3) At the same time that (2) occurs, the variable cold air intake is placed under the control of the inching control unit. The sensing element of the inching control unit is positioned in the heating air duct near the outlet of the injector. The unit opens or closes the

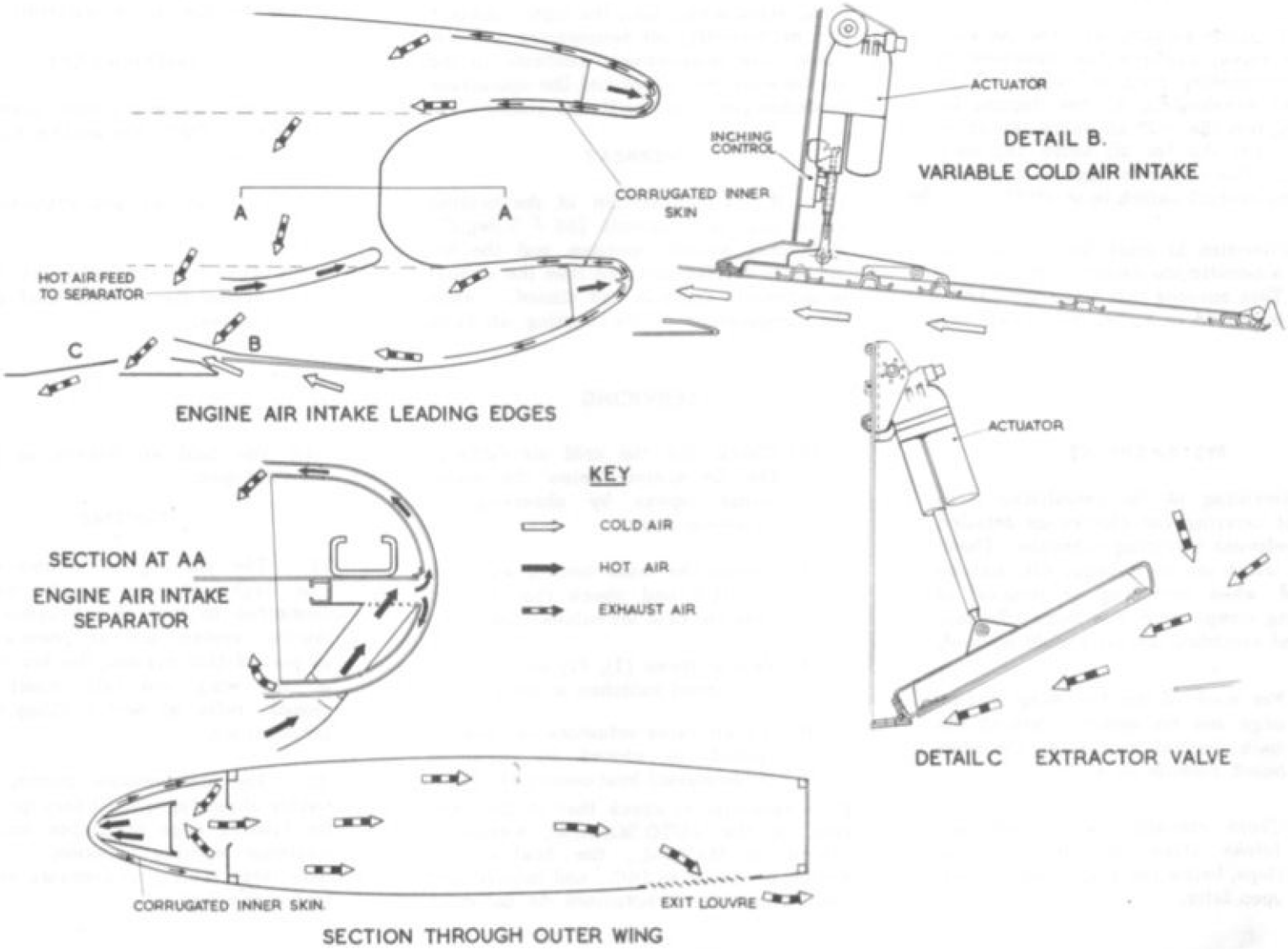

Fig. 3. Thermal de-icing system details
(◄Mod 862►)

variable cold air-intake to maintain the skin temperature.

16. A micro switch, mounted on each hot air valve, controls the movement of its corresponding cold air valve. This prevents overheating in the ducting by ensuring that the cold air valve cannot be closed until the hot air valve has been closed. The extractor flaps remain open while the control switch is at AUTO.

17. Provision is made for the installation of automatic ice detectors in each circuit. This ensures that when the control switch is placed to AUTO, the system will be placed under the control of its ice detector and when conditions are such that icing might occur, i.e., the right combination of humidity, air temperature and airframe skin temperature, contacts in the ice detector will close and the operations described previously will take place.

OVERHEAT

18. If the temperature of the heating air at any time exceeds 165 ± 5 deg.C., a thermal switch operates and the hot air valve is disconnected from the manual or automatic controls and closed. When the temperature of the heating air falls well below 160 deg.C., the thermal switch returns to normal and the hot air valve returns to manual or automatic control.

SWITCHING OFF

19. When the main control panel switch is placed to OFF, the system shuts down as follows:-

(1) The hot air and extractor valves close.

(2) When the hot air valve has fully closed the variable cold air-intake closes.

SERVICING

SYSTEM CHECKS

20. Servicing of the installation consists of carrying out checks as detailed in the relevant Servicing Schedule. These checks which are as follows, will also be required when servicing or renewal of operating components has been effected. A ground electrical supply should be used.

(1) For each of the two wing leading edge and fin systems, switch the main control switch on the starboard console to AUTO.

(2) Check visually that the cold air-intake flaps and the extractor flaps, below the engine air-intakes, open fully.

(3) Check that the cold air valve in the fin system below the dorsal intake opens by observing its follow-up lever.

(4) Switch the main control switches to OFF and check that in each case the cold air valves close.

(5) Repeat items (1), (2) and (3) with the control switches at MANUAL.

(6) Hot air valve actuators can now be opened or closed by operation of the manual heat control switches.

It is essential to check that at the same time as the AUTO/MANUAL switch is placed to MANUAL, the heat control switch is placed to INC., and to note that the hot air valve actuators do not open until the cold air valves or flaps are one-third open.

DUCTING

21. The ducting is in two sections. The high pressure supply ducting is connected to that of the cabin pressurisation system and is pressure tested as part of that system, the hot air valves at the wing and tail injectors being closed (refer to Sect.3, Chap.8 of this publication).

22. The low pressure ducting consists mainly of passages built into the wing and fin leading edge structures and, as the maximum working pressure is not more than three p.s.i., no pressure or leakage test is required.

REMOVAL AND ASSEMBLY

General

23. The following paragraphs give instructions for the setting of the hot and cold air valve assemblies, when they are re-installed after removal. This work should be done in conjunction with an electrical tradesman. Reference should be made to fig.4 when reading these instructions.

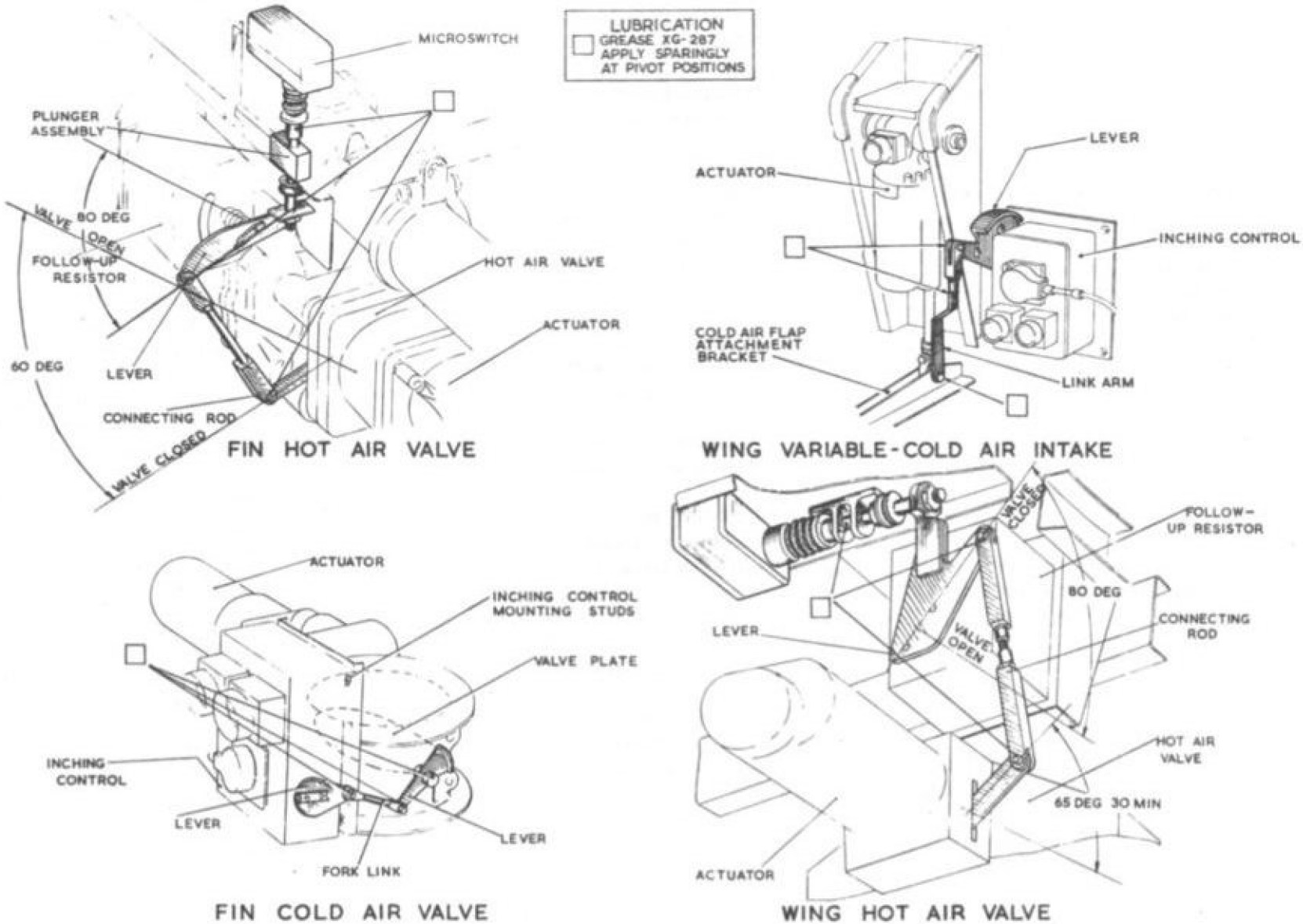

Fig. 4 De-icing system – microswitches and operating levers

FIN SYSTEM COLD AIR VALVE ASSEMBLY

24. Setting instructions are as follows:-

(1) Ensure that the inching control is set in the closed position, i.e., with the lever at 90 deg.

(2) With the cold air valve plate in the closed position, adjust the position of the inching control on its mounting studs to suit the length of the fork linkage at the setting described in item (1). Lock studs.

(3) Turn the valve plate through 6 deg 30 min.

(4) Ensure directional rotation of the Rotax actuator matches the rotation of the valve plate.

(5) Fit the actuator and adjust to suit the position of the valve plate, by rotating the eccentric washer at the top of the actuator mounting.

(6) Tighten and lock the mounting bolts and check the position of the valve plate.

(7) Lubricate all pin joints with anti-freeze grease XG-287.

FIN SYSTEM HOT AIR VALVE ASSEMBLY

25. After re-installation of any part of the hot air valve and follow-up resistor assembly, set the operating levers as follows:-

(1) Place the hot air valve lever and the follow-up lever in the 'valve closed' position.

(2) Maintaining position (1), adjust the connecting rod and fit to the levers.

(3) With the valve in the closed position, adjust the special bolt on the follow-up resistor lever so that the microswitch is tripped. Lock after setting.

(4) Check the lever for correct operation and working range. Working ranges are:-

Valve lever	60 deg
Resistor lever	80 deg

(5) Lubricate the pin joints and microswitch plunger stem with anti-freeze grease XG-287.

WING SYSTEM COLD AIR INTAKE

26. After re-installation of any part of the variable cold air-intake assembly, the following conditions must be observed:-

(1) In the down position the hinged ramp is to be flush with the outer skin.

(2) In the up position the hinged ramp is to be flush with the top of the cover.

(3) Any adjustment necessary to obtain conditions (1) and (2) is to be carried out on the screwed end of the actuator only.

(4) Lubricate all pin joints with anti-freeze grease, XG-287.

WING SYSTEM HOT AIR VALVE ASSEMBLY

27. After re-installation of any part of the hot air valve and follow-up resistor assembly, set the operating lever as follows:-

(1) Place the hot air valve and the follow-up resistor levers in the 'valve closed' position.

(2) Maintaining position (1) adjust the connecting rod and fit to the levers.

(3) With the valve in the closed position, adjust the special bolt on the follow-up resistor lever so that the microswitch is tripped. Lock after setting.

(4) Check the levers for correct operation and working range. Working ranges are:-

Valve lever	65 deg 30 min
Resistor lever	80 deg

(5) Lubricate all pin joints and the microswitch plunger stem with anti-freeze grease, XG-287.

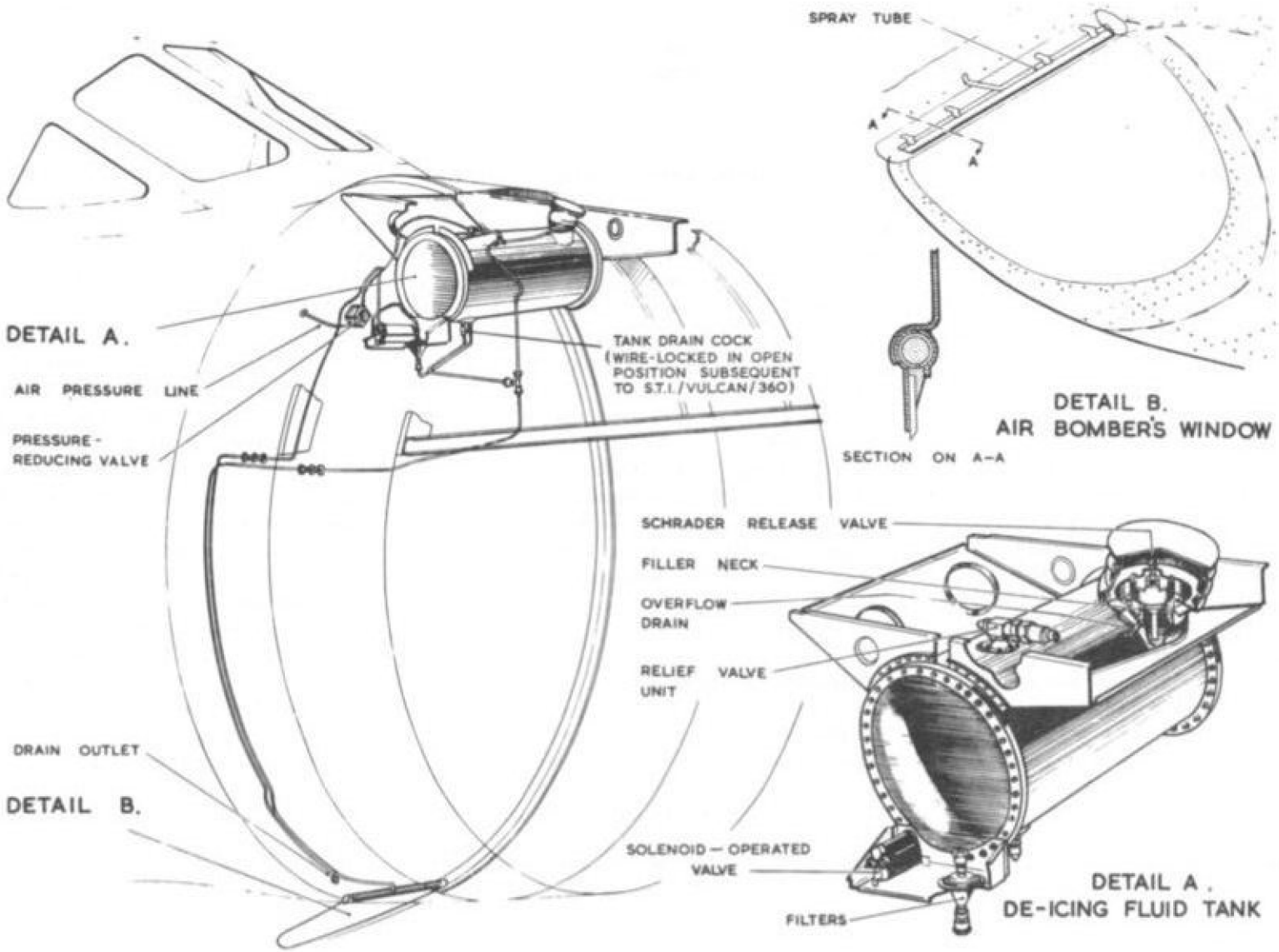

Fig. 5 De-icing installation - air bomber's window
◄ S.T.I./Vulcan/360 ►

PILOTS' WINDSCREEN AND AIR BOMBER'S WINDOW

Introduction

28. In addition to the thermal systems already described, a fluid de-icing system is installed, prior to S.T.I./Vulcan/360, for the air bomber's window and, prior to Mod.969, for the pilots' windscreen. Subsequent to Mod.969, the windscreen fluid de-icing system is removed, as de-icing of the windscreen is achieved by raising the temperature of the windscreen panels by electrical means. Brief information only is given of the heated panel windscreen de-icing system in the following text, therefore reference must be made to Sect.6 of this Publication for a description of control, function, etc.

Pilots' windscreen

29. De-icing of the pilots' windscreen is achieved by raising the temperature of the three centre panels electrically. Three different heat ranges are available, two of which are obtained automatically in conjunction with the function of other service circuits. 'Low heat', i.e., initial heating of the windscreen panels, is achieved, via microswitch operation, - when the main entrance door is closed and locked. This temperature is raised to 'medium heat' when the pitot tube heater switch is selected ON. When required, 'high heat' is obtained by operating the switch, labelled WINDSCREEN DE-ICE, on the second pilot's panel. This switch was used, prior to Mod.969, for windscreen fluid de-icing.

AIR BOMBER'S WINDOW

NOTE . . .
Subsequent to S.T.I./Vulcan/360 the air bomber's window de-icing system is rendered inoperable by blanking off the air supply to the supply tank (Sect.3, Chap.7), draining the tank and locking the tank drain cock in the open position.

Supply tank

30. De-icing fluid (refer to leading particulars) is supplied on demand from a tank mounted in the upper nose structure just below the metal nose fairing. The tank has a capacity of 12 gallons fluid and 0.5 gallon air space.

Pressurising the supply tank

31. The de-icing tank is pressurised at 14 to 16 lb/in^2 by air from the pneumatic system as described in Sect.3, Chap.7 of this book. To guard against excessive internal pressure, a relief valve, set to operate at 17 lb/in^2 is fitted to the top of the tank - just to the rear of the filler neck. A Schrader relief valve is incorporated in the filler cap assembly.

Air bomber's window supply

32. The supply of fluid to the air bomber's window is controlled from a three position switch, labelled DE-ICE NORMAL – OFF – EMERGENCY, which is mounted, together with the oxygen regulator, on a panel on the starboard side of the air bomber's station. When either NORMAL or EMERGENCY is selected, a solenoid-operated valve is opened allowing fluid to leave the tank under the influence of the 14 or 15 lb/in^2 air pressure in the tank air space. From the tank, fluid is piped through a filter and then down the starboard side of the nose section just forward of the front pressure bulkhead, to an external spray pipe situated immediately forward of the air bomber's window. When the control switch is set to NORMAL, fluid is sprayed over the external surface of the air bomber's window at a rate of 4 ± 0.5 pints per hour. This spray rate is increased to 16 ± 1.5 pints per hour when EMERGENCY is selected.

SERVICING

REPLENISHING THE TANK

33. Access to the tank for replenishing purposes is through a hinged door in the top surface of the metal nose of the aircraft. Instructions for replenishing are given in Sect.2, Chap.2 of this book, and are also stencilled on the inside face of the hinged access door.

DRAINING THE TANK

34. From a simple lever cock in the base of the tank, a pipe connection is made to the common drain system which is open to atmosphere. Before the tank is drained, the ground isolation cock (refer to Sect.3, Chap.7 of this book) must be turned off, and the pressure in the tank released by use of the Schrader valve in the filler cap.

REMOVAL AND ASSEMBLY

General

35. The door in the front pressure bulkhead provides access to the system, which is also readily accessible when the radome is removed. No special instructions are considered necessary concerning the method of removal or installation of components. Before breaking any connection or removing any component, the pressure supply must be isolated by turning off the ground isolation cock, and the pressure remaining in the tank released through the Schrader valve.

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