Chapter 9
DE-ICING SYSTEMS
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LIST OF ILLUSTRATIONS

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, by the combined action of hot and cold air valves. The required heat is provided by air tapped from the main engine compressors; this hot air, mixed with a suitable proportion of cold air to control its temperature, 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

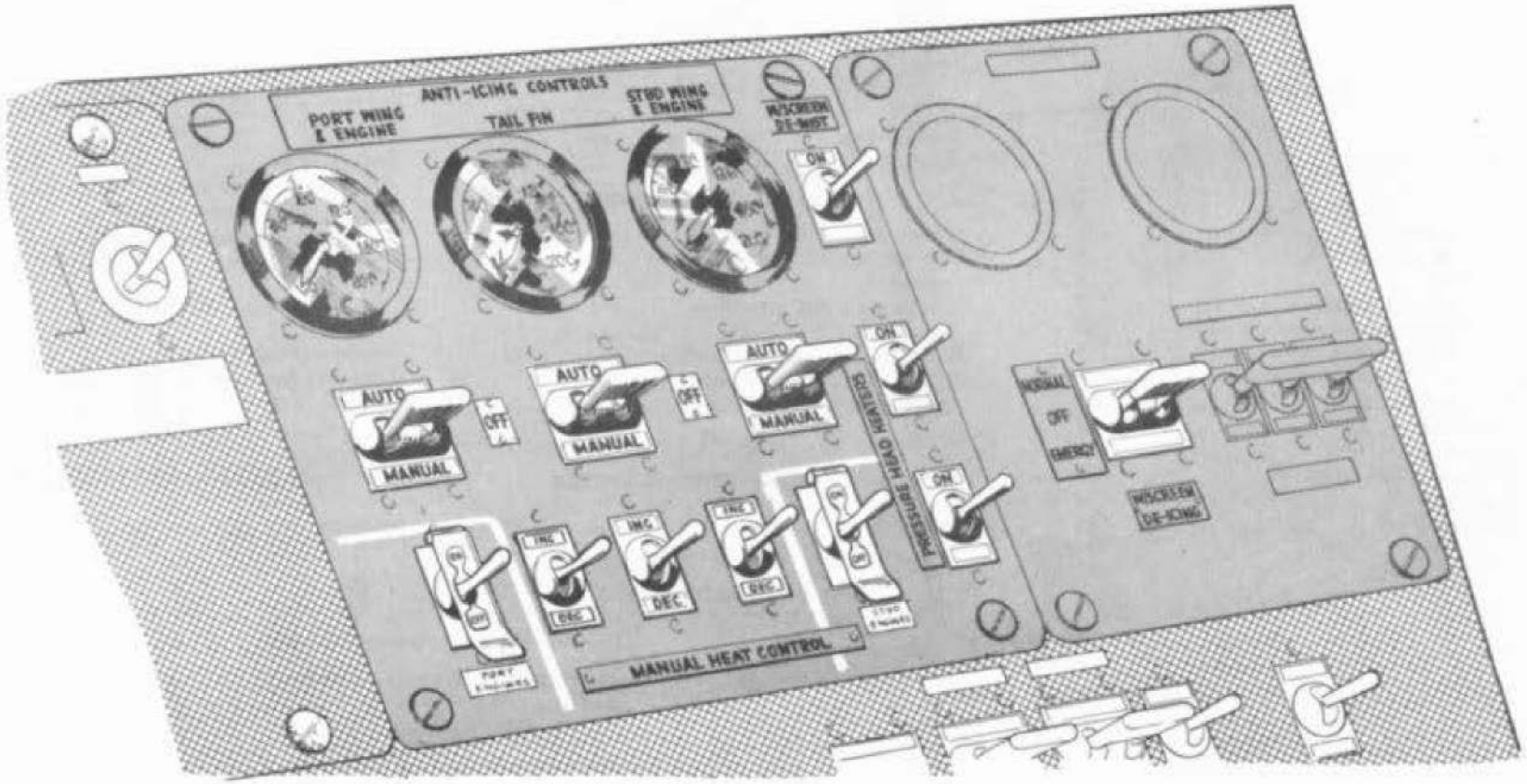

Fig.1. De-icing system control panel (pre Mod.38)

the starboard cockpit console, three distinct circuits being employed. For electrical description and operation, reference should be made to Book 2, Sect. 5, Chap.1 of this publication.

CONTROLS AND INDICATORS

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

◀ (4) PORT ENGINES and STBD. ENGINES switches (guarded) control the engine air intake casing ▶

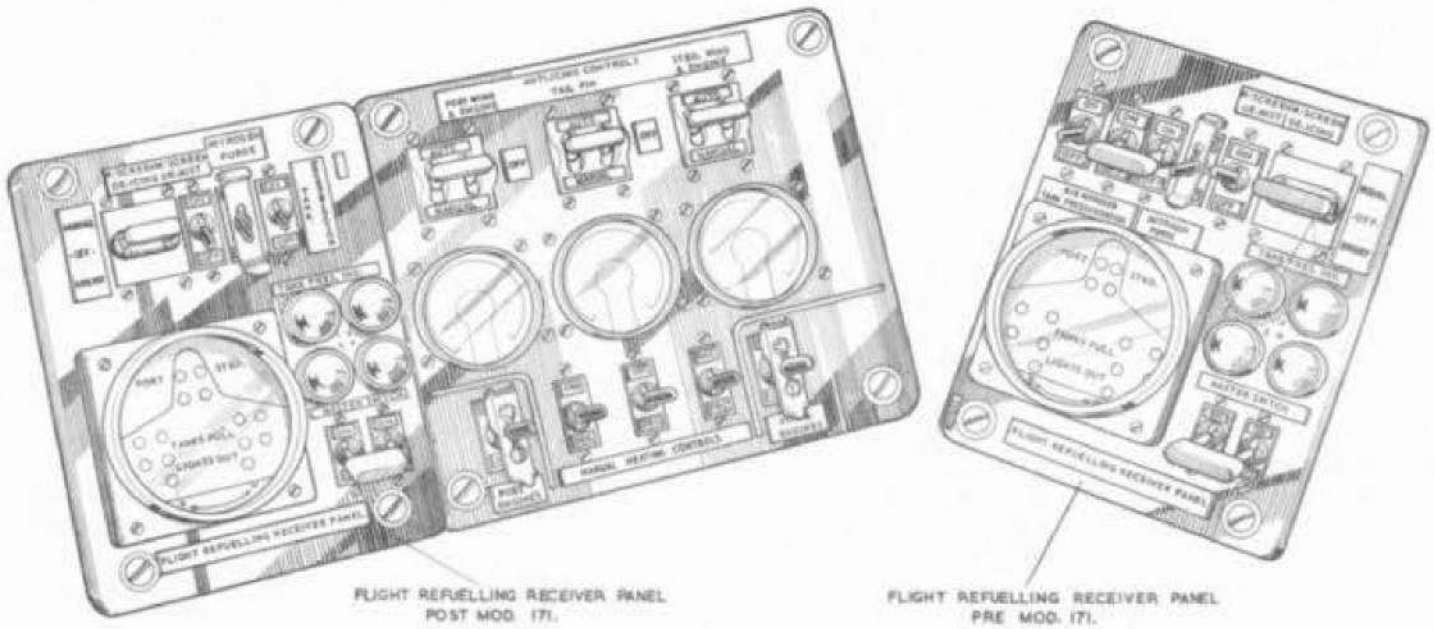

Fig.2 De-icing system control panel (post Mod.38)

anti-icing systems independently of the switches in (1) and (2) above.

NOTE:

Before the airframe 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

4. Hot air, at a temperature of up to 320 deg.C. and pressure of 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 air 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 hot air valves.

COLD AIR SUPPLY

5. 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 injectors. The fin intakes also supply air to the bomb bay heating system.

INJECTORS

6. The operation of one injector is described, the other two being similar. Hot air from the engines passes through the hot air control valve to the nozzle of the injector. It then leaves the nozzle at a 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

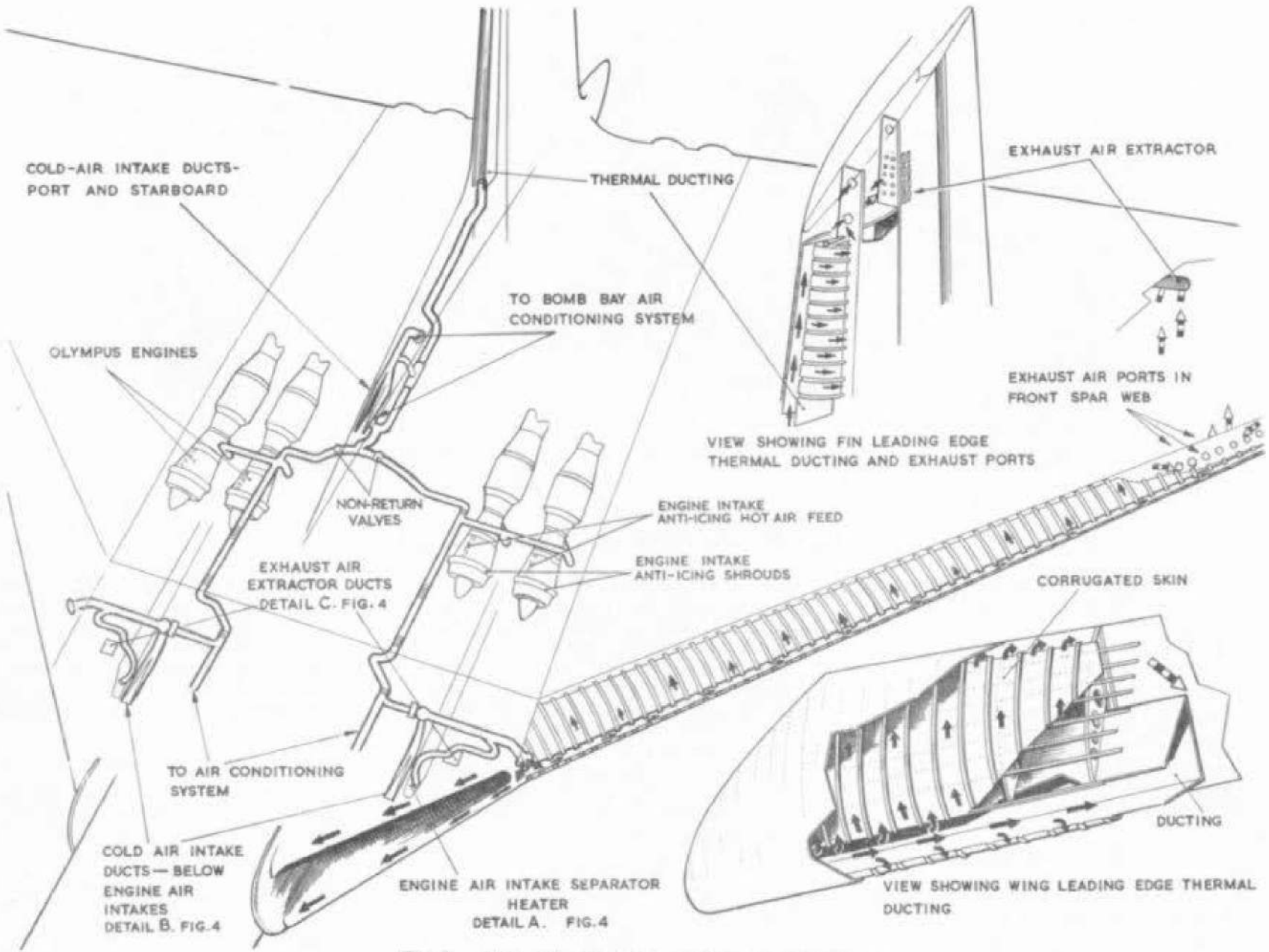

Fig. 3. Thermal de-icing system installation

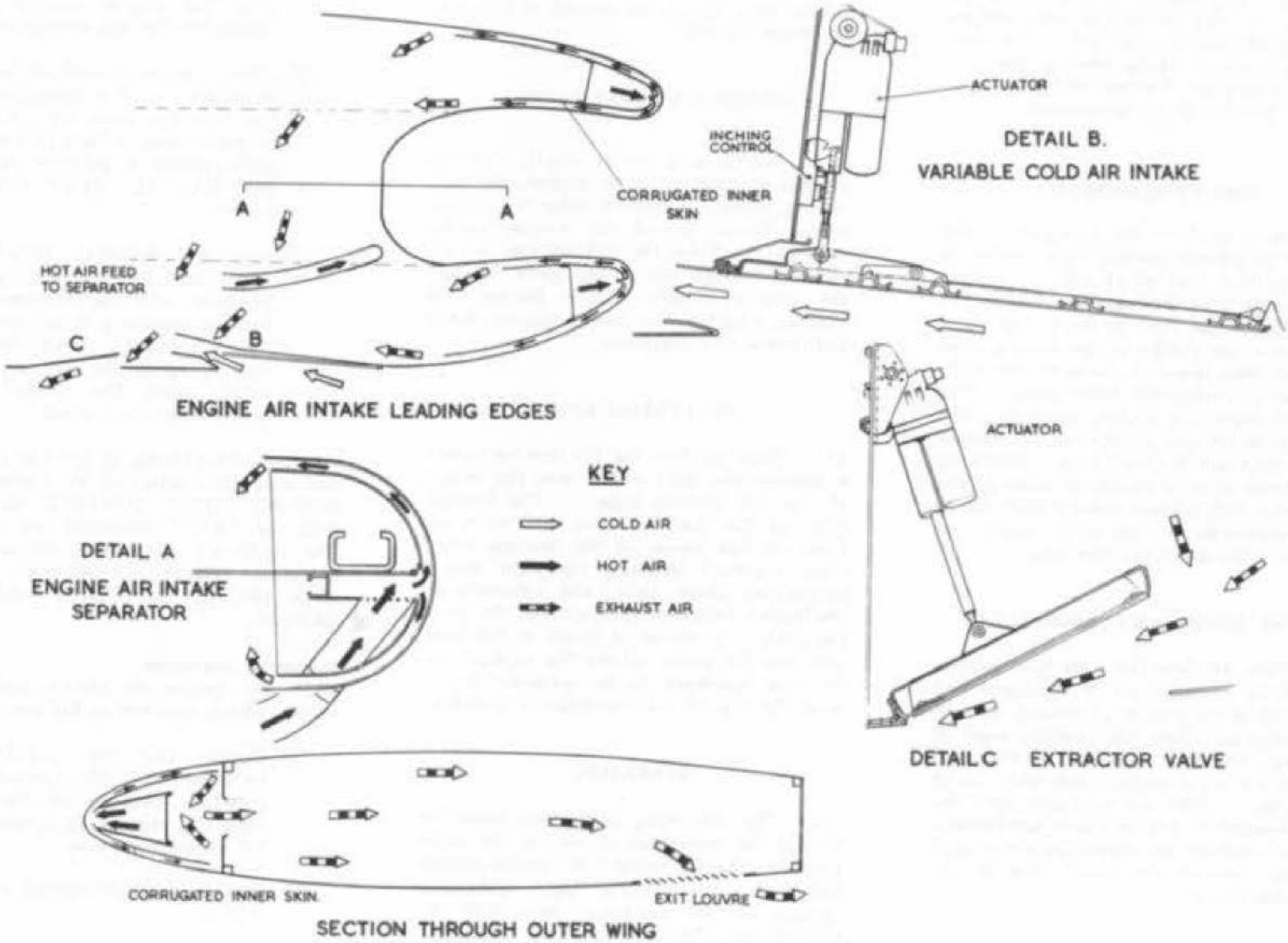

Fig.4. Thermal de-icing system details
(4 Micro switches deleted)

RESTRICTED

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 proportions and temperatures of the hot and cold air. The warm air is circulated along heating ducts in the wing and fin leading edges as described in the following paragraphs.

WING LEADING EDGES

7. Warm air from the injectors in the port and starboard leading edge, enters a wedge section duct which runs the 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 rearward 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 EDGES

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

ENGINE AIR-INTAKE SEPARATOR

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

ENGINE AIR-INTAKE CASINGS

10. Hot air is piped externally from the starboard side of each engine delivery casing, through a hot-air valve to an anti-icing shroud around the engine intake casings. From the shroud the hot air passes through the entry guide blades, the engine intake centre fairing, the leading edge of the intake casing vanes and thence to atmosphere.

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 rearward 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 posts allows the exhaust air to flow rearward to an exhaust louvre near the top of the fin balance chamber.

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 flap. Complete details of the electrical operations involved are contained in Book 2, Sect.5, Chap.1, of this Volume.

Manual operation

13. For manual operation 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 flap to their fullest 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 $\pm$ 5 deg.C. Operation of the switch opens the hot air control valve until the above heating 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 flap actuators 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, the

extractor flap and the hot air valve open to their full extent.

(2) After a time delay of 10 sec. control of the hot and cold air valves is taken over by an amplifier control unit and inching control respectively. The actuators will operate to positions determined by the reaction of sensing elements to maintain a skin temperature of approximately 10 deg.C.

16. A micro switch installed in the hot air valve actuator circuit is operated when the hot air valve is closing. The electrical circuit is such that the cold air valve cannot close until the hot air valve is closed and the micro switch operated.

17. Provision is made for the installation of automatic ice detectors in each circuit, when they are available. This would mean that when the control switch is selected to AUTO the system would be placed under the control of its detector. When conditions were such that icing might occur, i.e., the right combination of humidity, air temperature, and airframe skin temperature, contacts in the ice detector would close and the operations previously described would 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. With the main control panel switch 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 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 must be used.

(1) For each of the two wing leading edge and the 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 the movement of its follow-up lever.

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

(5) Repeat op.(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 must be closed during this test (Sect.3, Chap.8 and 8A).

22. The low pressure ducting consists mainly of passages built into the wing and fin leading edge structure. 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 installed after removal. This work must be done in conjunction with an electrical tradesman. Reference must be made to fig.4 when reading these instructions.

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 links maintaining the position in op.(1). Lock the studs.

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

▶ ◀

(4) Fnsure directional rotation of the actuator matches 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 and check the position of the valve plate.

(7) Lubricate all pin joints with grease XG-295.

FIN SYSTEM HOT AIR VALVE ASSEMBLY

25. After 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 follow-up resistor levers in the valve closed position.

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

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

(4) Check the lever for correct operation and working range.

Valve lever 60 deg.
Resistor lever 80 deg.

(5) Lubricate the pin joints and the micro switch plunger stem with grease XG-295.

WING SYSTEM COLD AIR INTAKE

26. After 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 must be flush with the outer skin.

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

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

▶ ◀

(4) Lubricate the pin joints with grease XG-295.

WING HOT AIR VALVE ASSEMBLY

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

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

(2) Maintain the position (op.1), adjust the connecting rod and fit it to the levers.

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

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

Valve lever	60 deg. 30 min.
Resistor lever	80 deg.

(5) Lubricate all pin joints and the micro switch plunger stem with grease XG-295.

WINDSCREEN DE-ICING SYSTEM

Introduction

28. In addition to the thermal system already described, a fluid system is installed for de-icing the pilots' windscreen and the air bomber's window, and is illustrated on fig.6.

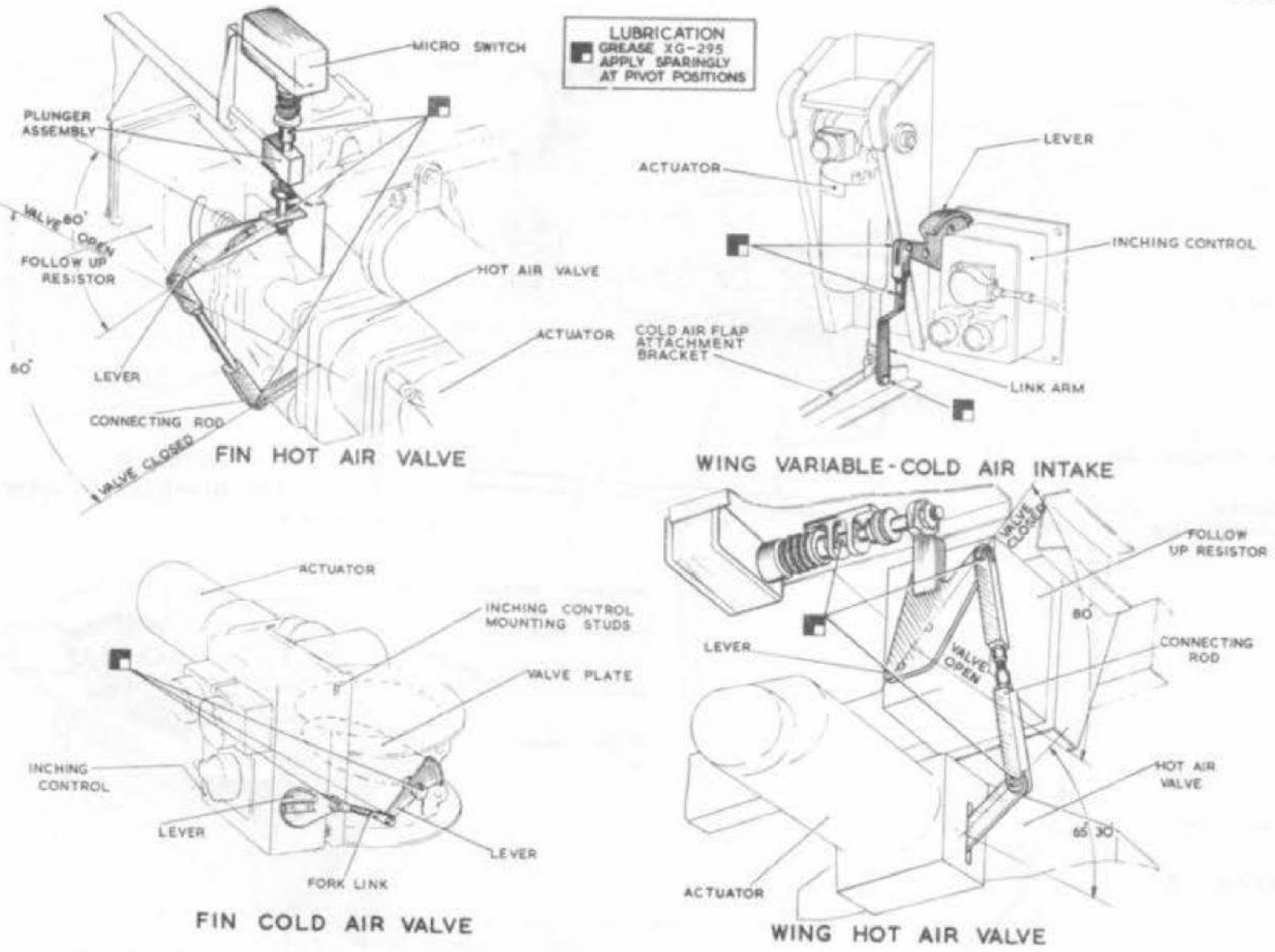

Fig. 5. De-icing system – micro switches and operating levers
(* Cold air valve micro switches deleted)

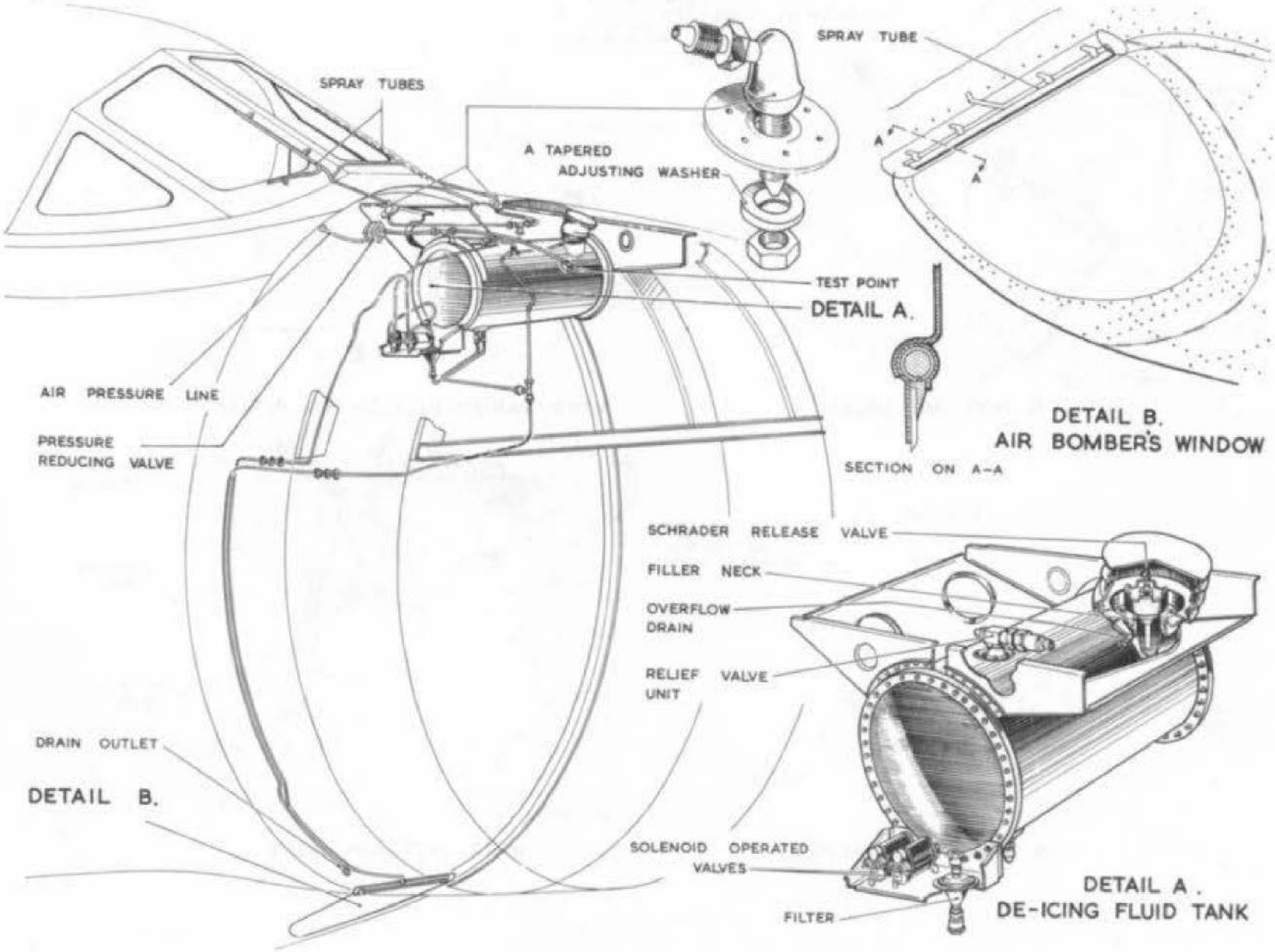

Fig. 6. Windscreen de-icing installation

DESCRIPTION

SUPPLY TANK

29. De-icing fluid (see Leading Particulars) is supplied on demand from a tank mounted across the longitudinal centre line of the nose metal section, below and slightly forward of former 386F. The tank, which is bolted to a supporting structure secured to the nose metal skin and formers 372, 386 and 400F has a capacity of 12 gallons of fluid with 0.5 gallon air space and provides a common supply for the pilots' and air bomber's positions. The solenoid-operated valves which control the pilots' and air bomber's fluid supplies, and a filter, are mounted on a platform at the starboard end of the tank. The fluid supply passes through the filter before branching to the pilots' and air bomber's solenoid-operated valves.

PRESSURISING THE SUPPLY TANK

30. The de-icing tank is pressurised to $15 \begin{smallmatrix}+0\\-1\end{smallmatrix}$ p.s.i. from the pneumatic system as described in Sect.3, Chap.7 of this publication. Any excessive rise of internal pressure is prevented by a relief valve, in the top of the tank, set to relieve at 17 p.s.i. Excessive pressure is released into the fluid drain system to which the valve is connected. Pressure in the tank can be released, when required, by a Schrader release valve fitted in the filler cap.

PILOTS' WINDSCREEN SUPPLY

31. A switch, situated on the nitrogen control panel (pre-Mod.38) or the flight refuelling panel (post Mod.38), on the starboard console for the control of the windscreen fluid supply, has three positions, NORMAL - OFF - EMERGENCY. Operation of the switch to either the NORMAL or EMERGENCY positions energises the solenoid-operated valve for the windscreen supply, and fluid at a pressure of 15 p.s.i., after passing through the filter, is directed through the solenoid-operated valve to spray pipes mounted on the windscreen framework. Adjustable adapters mounted in the nose metal skin, just forward of the front pressure bulkhead, ensure easy assembly of the spray pipes to the system.

32. Fluid is sprayed at a rate of 44 pints per hour when the switch is selected NORMAL and 73 pints per hour when selected EMERGENCY.

AIR BOMBER'S WINDOW SUPPLY

33. The control switch for operation of this supply is situated on the air bomber's oxygen and switching panel below the second pilot's floor. This switch is the same type as that supplied for use by the pilot, but gives a flow rate of 4 ± ½ pints per hour on NORMAL and 16 ± 1½ pints per hour on EMERGENCY. When either of the positions is selected, the solenoid-operated valve for the air-bomber's supply is energised, and fluid at 15 p.s.i., after passing tnrough the filter, is directed, through the solenoid-operated valve to a faired spray tube situated immediately forward of the air bomber's window.

SERVICING

REPLENISHING THE TANK

34. Access to the tank for replenishing is through a hinged door in the top of the nose metal section just forward of former 386 in.F. 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

35. A drain cock is fitted in the lower side of the tank. 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 the Schrader valve in the filler cap.

SYSTEM TEST

36. The sequence of operations for testing the system is as follows:-

(1) Connect an air supply and pressure gauge to the system test point.

(2) Ensure that the system operating switches on the second pilot's console are OFF.

(3) Apply air pressure at the charging valve, check that the relief valve operates at 17 p.s.i.

(4) Disconnect pilots' windscreen system at the adapters on the metal nose fairing and blank off the adapters.

(5) Disconnect bomb-aimer's system at the spray tube and blank off pipeline.

(6) With an electrical supply to the aircraft, move the systems operating switches on the second pilots' console to the NORMAL position.

(7) Apply a pressure of 15 p.s.i. at the charging valve and maintain for

30 minutes. Check system for leaks.

(8) Place operating switches to OFF, disconnect air pressure and gauge from charging valve, and reconnect all pipelines.

(9) With an adequate supply of air in the aircraft pneumatic system operate the systems, by means of the pilot's control switches on NORMAL and EMERGENCY. Check for a full and free flow of fluid from the spray tubes.

REMOVAL AND ASSEMBLY

General

37. 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 components the pressure supply must be isolated by turning off the ground isolation cock. The pressure remaining in the tank is released through the Schrader valve.