

**PART 2**

**CHAPTER 12 — ICE AND RAIN PROTECTION SYSTEMS**

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## DESCRIPTION

### General

1. The formation of ice is prevented or dispersed by heating those surfaces where ice accretion would be detrimental to the performance of the aircraft. The slats, leading edges of the wings, fin and tailplane are heated by hot air bled from the final stages of the LP and HP compressors of the engines and pressure and temperature is automatically controlled. The supply from all four engines is fed into a common duct for distribution to the services requiring ice protection. LP air is always available and provides adequate ice protection at high engine power. The flight deck windscreens are electrically heated for ice protection and hot air demisted; the sidescreens are electrically demisted. Windscreen wipers are provided for the three front windscreens.
2. Ice formation is indicated by an automatic ice detector controlling two warning lights: a red light on the engineer's panel B and a blue light on the pilot's centre panel A.
3. Indication of icing conditions may be seen by visual inspection of a hot-rod type ice detector. At night, floodlights directed at vulnerable areas provide for visual inspection and a rear-mounted periscope may be used to view some of these areas.
4. Pressure head and stall protection probes are electrically-heated for protection against icing, the heater elements being controlled from the flight deck.
5. Desiccator demisting systems are used for flight deck canopy and cabin windows.
6. HP air from a hot air collector manifold around the HP compressor outlet casing on each engine is passed to the engine anti-icing manifold on the upper right-hand side of the engine for anti-icing purposes.
7. *Summary of De-icing and Detection Systems. (See Table 1).*

## AIRFRAME ICE DETECTION

### Ice Detectors

8. a. Whenever No 3 Ground Cut-off busbar is energised a single-phase supply is fed to an AC motor causing it to rotate continuously, driving a small cylinder mounted externally on the left-hand underside of the aircraft nose. A stationary knife-edge cutter, mounted 0.002 inches from the cylinder, shaves off any ice which forms on the cylinder. This shaving action produces a torque reaction which rotates the motor housing slightly, causing microswitch contacts to complete an electrical circuit from No 2 Essential busbar to warning lights on the flight deck.
  - b. When no further accretion occurs, torque reaction ceases and the lights go out, provided that the No 2 wing actuator switch has been set to OPEN.
9. A hot-rod type ice detector, mounted just below the 1st pilot's side-window, in the normal field of vision, comprises an 8-inch tubular mast of aerofoil shape having a 380-watt heating element, the mast being mounted on a base containing a light for illumination of the mast at night. The assembly is supplied with power from No 1 Non-essential busbar and controlled by a HOT ROD-LIGHT/OFF/HEAT switch on the 1st pilot's instrument panel. When the switch is set to LIGHT the mast is illuminated. When held to HEAT the heating element operates and the ice is cleared; at the same time the mast is illuminated.

### Visual Indication

10. a. An inspection lamp is in a fixed fairing on the wing trailing edge at the outboard end of the inboard flap section on each side of the aircraft. The two lamps are each directed to illuminate the air intakes of the engines.

- b. Lamps in the aft main door and the top of the fin illuminate the leading edges of the left wing and the left tailplane respectively.
- c. The lamp in the aft main door is controlled by a switch on panel C at the engineer's station. The lamp in the fin and the lamps in the inboard flap sections are controlled by switches on the ALM aft panel.

11. Two mountings in the rear of the passenger cabin roof are provided to enable a periscope to be used for inspection of the tail unit and engine nacelles.

12. *Controls and Indicators—Ice Detection.* (See **Table 2**).

**Table 1—Summary of De-icing and Detection Systems**

<i>System</i>	<i>Method</i>	<i>Control</i>	<i>Flight Deck Indication</i>
Ice detection	Electro-mechanical	GROUND/FLIGHT switch set at FLIGHT	ICE DETECTOR lights (two) one red and one blue
	Hot rod	HOT ROD—LIGHT/OFF/HEAT switch	Visual inspection of hot rod
Engine ice inspection lamps (two)	Two lamps, the beams being directed to illuminate the engine air intakes	Manual RIGHT/OFF/LEFT switch	Nil
Wing/tailplane ice inspection lamps (two)	Two lamps directed to illuminate the leading edges of left wing and left tailplane	Manual ON/OFF switches for each lamp	Nil
Wings, slats and tailplane	Hot air from engine compressors	Manual ON/OFF switches, with automatic pressure and temperature control	Pressure and temperature gauges, magnetic indicators and warning lights
Engine	Hot air from engine compressors	Manual ON/OFF switches (four)	ENGINE ANTI-ICE AIR pressure gauges
<i>Windscreens—front (three)</i> Wipers	Electro-hydraulic	Manual FAST/SLOW/PARK switches (three)	Nil
Heating	Gold film heating element (700W/sq ft)	Thermostatic manual HIGH/LOW switches (three)	WINDSCREEN OVER-HEAT lights (amber) (three) Ammeters (three)
Demisting	Fan blown air	Manual ON/OFF switch	Nil
Flight deck side windows (demisting)	Gold film heating element (120W/sq ft)	None	Nil
<i>Demisting general—</i> Cabin	Air filter desiccator	None	Nil
Eyebrow window	Air filter desiccator	None	Nil
Pitot-static system	Electrical heating of pressure heads and masts	Manual switches (four) ON	Ammeters (four) and mast warning lights (two) (amber)
Stall protection	Electrical heating of probes	Two manual switches (1) CAPTAIN—ON (2) AUTOPILOT 2 ART FEEL 2—ON	Ammeters (four) at engineer's station

**Table 2—Controls and Indicators—Ice Detection**

<i>Item</i>	<i>Location</i>	<i>Marking/Indication</i>
◀ Ice detector warning light	Top left corner of pilots' centre panel	ICE DETECTOR (blue, press-to-test) ▶
Ice detector warning light	Bottom of engineer's engine anti-icing panel	ICE DETECTOR (red, press-to-test)
Switch for hot-rod type ice detector	Bottom left corner of 1st pilot's instrument panel	HOT ROD—LIGHT/OFF/HEAT, spring-loaded from HEAT to OFF
Switch for wing ice inspection light	Engineer's bulkhead panel	WING ICE INSP LTS—ON
Switch for engine ice inspection lights	ALM aft panel	ENGINE INTAKES—LEFT/OFF/RIGHT
Switch for tail inspection lights	ALM aft panel	TAIL-ON

**COMPONENTS OF THE AIRFRAME  
ICE PROTECTION SYSTEM**

**Compressors**

13. Both the LP and HP compressors of each engine are tapped. The supply from each pair of engines is similar and joins into a common duct for distribution through to the wing slats, fin and tailplane.

**Non-Return Valves**

14. A non-return valve is fitted in each of the LP and HP ducts from each engine. Another non-return valve is fitted in the common LP supply duct from each pair of engines.

**HP Stop Valves**

15. Situated downstream of the NRV in the HP outlet of each engine is an electrically-controlled pneumatically-operated HP stop valve, the function of which is to close the HP compressor outlet when necessary.

16. Switches marked NORMAL/SHUT on the engineer's anti-ice panel control the HP valves; magnetic indicators adjacent to the switches show the settings of the valves. Setting a switch to SHUT breaks the power supply to the HP stop valve and, provided that air pressure is available, the valve closes.

17. Closure of the two HP stop valves on either side of the aircraft occurs when either of the fire control handles for that side is pulled, or if the associated 68 PSI pressure switch operates (para 25).

18. The HP stop valves, when closed either by operation of a fire handle or a 68 PSI pressure switch, remain closed by the action of a latched relay and can only be released by use of the appropriate GROUND RESET NORMAL switch on the roof panel EA.

**Temperature Control Valves**

19. On each side, both HP supply ducts join together to form a common HP duct. Located in the duct is a pneumatically-controlled temperature control valve (TCV) which admits HP air to the system when the LP air is of insufficient temperature.

**Temperature Sensing Elements**

20. A temperature sensing element in the common duct pneumatically controls the operation of the temperature control valve. This sensing element has a solenoid which overrides the temperature control function of the TCV and opens it for engine starting. The temperature sensing element controls at approximately 230°C.

**Pressure Reducing Valves**

21. A pressure reducing valve (PRV) is fitted in the supply duct on each side to safeguard downstream ducting against excessive pressure. Pressure is controlled at 40 PSI.

22. The PRV can also be used as a stop valve by biasing its normal pneumatic control by a solenoid-controlled servo system to shut the main butterfly valve.

23. Each solenoid is controlled by a 2-position NORMAL/SHUT switch on the engineer's anti-icing panel; a second solenoid in each reducing valve enables the valve to be overridden to the open position for engine starting.

24. A magnetic indicator adjacent to each switch shows cross-line when the associated PRV is shut and in-line when it is controlling.

### Pressure Switches

25. Incorporated in each PRV is a pressure switch which is sensitive to downstream pressure. The switch is electrically connected to close the two HP stop valves on the associated side in the event of PRV malfunction and also operates at a pressure of 68 PSI.

### Duct Relief Valves

26. In the supply duct on each side downstream of the PRV are two safeguards in the form of a 55 PSI duct relief valve (one in each duct) and a 120 PSI rupture disc (RH duct only). The duct relief valve relieves excess pressure which may leak past the PRV when its butterfly valve is closed and no demand is made on the system, rising to a pressure which will operate the pressure switches to close the HP stop valves. In order to cater for a multiple failure condition whereby the supply duct pressure rises to a serious level, the rupture disc allows the excess pressure to blow-off via an overspill duct to atmosphere at the inboard side of the right inner nacelle stub.

27. The supply ducts from each side join together to form a common duct, which runs below the cabin floor forward and rearward to the wings and the tail unit.

Note: Air pressure for operating the refrigerators and humidifiers is tapped from the airframe anti-icing system and the anti-icing ducting is also utilised for engine starting.

### Wing and Tailplane Stop Valves

28. Two stop valves in the wing ducting in each leading edge, just inboard of the slats, control the supply of air to the wings. The valve plates move in two halves, one half of each being connected to one electric actuator and the other half to a second actuator. The two actuators are centrally positioned under the cabin floor and are connected by rods to the valve plate halves. This split valve arrangement prevents a complete loss of protection to one wing supply in the event of a single actuator failure. The actuators are controlled by two WING ACTUATORS-1/2-OPEN/SHUT switches on the engineer's anti-icing panel; two magnetic indicators adjacent to the switches show the position of the actuators.

29. The tailplane stop valve, which controls the flow of air to the tail unit, is in the ducting at the root of the fin and has two solenoids. A No 1 OPEN/SHUT/No 2 OPEN switch on the engineer's panel selects one or the other solenoid to open the valve, the remaining solenoid serving as a standby. The valve is solenoid-selected and air-pressure operated.

A magnetic indicator adjacent to the switch shows the position of the valve.

### Ducting and Distribution

30. The hot air passes through ducting fitted with components previously described, to various parts of the aircraft. Surfaces to be de-iced are double-skinned, a small space being formed between the two skins in which the hot air flows.

31. The air after heating the surfaces is exhausted to the atmosphere through outlets.

### Temperature and Pressure Indication

32. Indication of temperatures and pressures is provided on the flight deck by warning lights and gauges.

33. Two amber STUB O/HEAT warning lights on the engineer's anti-icing panel, one for each system, operated by means of a flamestat adjacent to the main delivery ducting in each engine stub, provide warning of overheating if leakage into the stub causes a temperature of 115°C.

34. A red DUCT OVERHEAT warning light on the engineer's anti-icing panel provides warning of overheating by means of a flamestat in the main delivery ducting. The warning light operates at a duct temperature of 245°C and requires a 15° temperature drop before the light automatically goes out.

35. The ducting in the fuselage is of the double-type, having a space between the inner and outer ducting. An amber DUCT FAIL warning light on the engineer's anti-icing panel comes on to indicate failure of the inner ducting. The light is controlled by two airspeed switches in the ducting. These switches are sensitive to the pressure in the space between the inner and outer ducting and operate at an airspeed of 90 knots; one switch is in the right main wheel bay and the other is in the aft freight hold. The warning light has a press-to-cancel facility to cater for a spurious warning.

36. A temperature gauge is on the engineer's anti-icing panel to indicate the temperature prevailing in the ducting. The temperature bulbs are located, one in the fuselage ducting at Station 1059 and one in the supply duct of each inner nacelle. A three-position DUCT TEMP-LEFT/MAIN/RIGHT switch adjacent to the temperature gauge connects the three temperature bulbs, in turn, to the gauge.

37. The pressure in the supply ducting in each nacelle is indicated on two pressure gauges on the engineer's bulkhead panel. A pressure transmitter in the fuselage is located in each supply ducting, downstream of the pressure reducing valves.

**Table 3 — Controls and Indicators — Airframe Ice Protection**

<i>Item</i>	<i>Location</i>	<i>Marking/Indication</i>	
Left duct pressure gauge	Engineer's bulkhead panel	AIRFRAME ANTI-ICE DUCT PRESSURE—LEFT PSI; RIGHT PSI	
Right duct pressure gauge			
HP stop valve switches (four)		HP STOP VALVE 1, 2, 3, 4 — NORMAL/SHUT	
HP stop valve indicators (four)		Magnetic indicator: 1, 2, 3, 4: In-line; cross-line	
Pressure reducing valve switches (two)		NORMAL/SHUT	
Pressure reducing valve indicators (two)		Magnetic indicator: REDUCE VALVE — In-line; cross-line	
Duct temperature change-over selector switch		DUCT TEMP — LEFT/MAIN/RIGHT	
Duct temperature gauge		Degrees C.	
Stub overheat warning lights (two)		STUB O/HT (amber, press-to-test)	
Duct overheat warning light		DUCT O/HT (red, press-to-test)	
Duct failure warning light		DUCT FAIL (amber, press-to-test)	
Left and right wing actuator switches (two)		Engineer's anti-icing panel	WING ACTUATORS 1, 2 — OPEN/SHUT
Left and right wing actuator indicators (two)			Magnetic indicators 1, 2: In-line; cross-hatch; cross-line
Wing temperature selector switch			WING — LEFT TEMP/RT TEMP
Wing temperature gauge	Degrees C.		
Tailplane stop valve selector switch	No 1 OPEN/SHUT/No 2 OPEN		
Tailplane stop valve indicator	Magnetic indicator: In-line; cross-line		
Left and right tailplane temperature selector switch	TAIL — LEFT TEMP/RT TEMP		
Tailplane temperature gauge	Degrees C.		
HP stop valves ground reset switches	Rear roof panel		HP STOP VALVES 1/2 and 3/4 — GROUND RESET/NORMAL

38. a. The temperature in the unslatted leading edge of each wing is sensed by a temperature bulb. A WING-LEFT TEMP/RIGHT TEMP switch on the engineer's anti-icing panel connects each bulb, in turn, to the adjacent WING gauge.

b. The TAIL temperature gauge on the engineer's anti-icing panel is similarly associated with a TAIL-LEFT TEMP/RIGHT TEMP switch and a temperature bulb in the ducting in the left and right tailplane.

39. *Controls and Indicators—Airframe Ice Protection.* (See Table 3)

**OPERATION**

**General**

40. While the engines are running a supply of hot air is available.

41. Two tappings are taken from each engine, one LP and one HP supply.

42. Each engine delivers LP air via a NRV into a common LP duct on each side. The flow passes through another NRV to the junction of the LP and HP ducting. Both NRV prevent air from passing from one engine to the other and also prevent HP air passing into the LP duct.

43. From each HP compressor air passes through an HP NRV and HP stop valve to join the common duct.

44. The HP stop valves can be closed by flight deck switching or automatically in the event of excessive pressure. They are also closed on either side of the aircraft by pulling either fire control handle on the associated side.

45. With the HP stop valves open, HP air is metered into the duct by the temperature control valve under the control of the temperature sensing element.

46. The sensing element is downstream of the junction of LP and HP airflows, and through its pneumatic sensing line adjusts the position of the temperature control valve to admit only enough HP air to maintain the working temperature. Under conditions of high engine RPM the LP air may be sufficient and the temperature control valve will be closed.

47. The temperature-controlled air is ducted to the pressure reducing valve.

48. Under normal conditions neither solenoid in the reducing valve is energised and the valve position is controlled pneumatically to give an acceptable downstream pressure.

49. Whilst anti-icing is in operation the supply pressure may be such that the reducing valve is not required to reduce the pressure, however, when anti-icing is not required the pressure reducing valve limits the pressure in the ducting to an acceptable pressure. The pressure reducing valve can be used as a stop valve by selecting SHUT on the control switch, this action energises the shut solenoid to bias the servo valve closed.

50. The pressure switch in the pressure reducing valve electrically shuts the HP stop valves in the event of failure of the reducing valve to control the pressure.

51. When neither anti-icing nor the refrigeration system are in operation the reducing valve moves to the closed position. If leakage occurs the duct relief valve operates if excessive pressure build-up results.

52. The rupture disc valve operates if a serious build-up of duct pressure occurs arising out of multiple failure of the previous safeguards.

53. The rupture disc valve is not resetting and must be replaced if ruptured.

54. The forward flow of air in the fuselage duct passes to the 2 wing stop valves, operated by push rods from 2 actuators. Each actuator is connected to one half of both valves, so that when the control

switches are selected to OPEN both actuators operate to fully open both valves. Failure of one actuator results in one half of both valves being operative.

55. The tail stop valve is open when either of its 2 solenoids is energised by selection of the control switch. Failure of one solenoid may be overcome by selecting the other.

### Electrical Control of the System

56. Each HP stop valve is opened by a solenoid within the valve and is closed when the solenoid is de-energised. With the control switch at NORMAL, the solenoid is energised by a circuit which passes across one contact of a magnetically latched relay. The corresponding circuit for the HP stop valve on the adjacent engine utilises another contact of the same relay.

57. The pressure switch within the pressure reducing valve will, when closed by high pressure, complete a circuit to the trip coil of the latched relay, thereby breaking the control circuits of both HP stop valve solenoids to close the valves.

Note: Both HP stop valves are similarly closed by pulling either fire control handle on one side of the aircraft.

58. The reset coil of the latched relay is energised and normal switch control of the HP stop valves is restored by momentary operation of the reset switch on panel EA to GROUND RESET.

59. Power for the HP stop valves and their magnetic indicators is taken from the 28-volt DC Essential busbars.

60. A pressure reducing valve can be closed to stop the flow in the supply duct by selecting the associated REDUCE VALVE switch to SHUT. This action energises the shut solenoid in the valve.

Note: The DC supply to the switch is controlled by the engine start master switch. During starting operations the open solenoid in the pressure reducing valve is energised directly from the start master switch.

61. The wing stop valves actuators are each controlled by a single pole switch. The DC supply to the switches is controlled by the start master switch so that, during starting operations, the valves are shut irrespective of the control switch position.

62. The tail stop valve has two solenoids, either of which will open the valve when energised. The 3-position switch can be set either way to operate one of the solenoids. The DC supply to the switch is

controlled by the same poles of the start master switch as the wing stop valves, thus the valve will be closed during engine start.

Note: Although the temperature control valve has no control from the flight deck for normal operation, a solenoid in the temperature sensing element is controlled by the engine start master switch, causing the temperature control valve to open fully during engine start.

### PITOT AND STATIC SYSTEM ICE PROTECTION

#### Pressure Heads

63. Four pressure head units are mounted on the exterior of the forward fuselage, two with a single probe and two with twin probes. Heater elements in the probes and around the pipes in each mast prevent the formation of ice.

64. Four single-pole manually-operated switches (on the forward roof panel) control the electrical supply to the heater elements and the current consumption of each pressure head is shown on an ammeter. The nominal current consumption is 18 amperes at 28-volts.

65. The extensions to the masts on which the twin probe units are fitted are also electrically heated but the current consumption is not indicated on the associated ammeters. Indication of an electrical supply to the mast heaters is given by two amber MAST lights which go out when the adjacent AUTOPILOT ART FEEL 1 AND 2 switches are set to ON. The lights come on to indicate system failure and when the switches are off.

66. a. The 28-volt DC power supplies for the single probe pressure head unit on the right side of the fuselage and the twin probe unit on the left side of the fuselage are taken from Non-essential busbars.

b. The 28-volt DC power supplies for the single probe pressure head unit on the left side of the fuselage and the twin probe unit on the right side are taken from the Essential busbars, thus ensuring maintenance of supplies at all times and also when the Elrat is operating.

67. *Controls and Indicators—Pressure Heads.* (See Table 4).

### WINDSCREENS AND SIDE WINDOWS ICE PROTECTION

#### Windscreen Anti-icing

68. The windscreen and side windows on the flight deck are designated numerically. The centre panel is No 1 and, to each side, No 2, 3, 4 and 5 in rearward sequence. No 1, and No 2 (on each side), are windscreen panels the remainder being window panels.

69. The three windscreen panels incorporate a gold-film heating element on the surface of the outer screen in contact with the vinyl interlayer. The panels are similar in construction and the heating elements have a power rating of 700W per sq ft at 200 volts. Each heating element is connected between busbars at the top and bottom of the panel and three temperature sensing elements are incorporated within the panel. The sensing elements are identical, one being used for normal control, one for overheat control and one serving as a spare. Terminal connections for the heating and sensing elements are exposed at the corners of the panel.

70. The three windscreen circuits are identical but independent of one another.

71. Three HIGH/LOW switches on the forward roof panel permit the individual windscreens to be operated from 200-volt AC or 115-volt AC respectively. Above the switches are three WINDSCREEN OVERHEAT warning lights. Below the switches are three ammeters marked CAPTAIN, CENTRE and CO-PILOT, which indicate the load in amperes for the associated windscreens.

72. The controller is powered by a single-phase AC supply from a generator cut-off busbar and, under normal temperature conditions at the windscreen, the controller makes a circuit to energise the normal temperature control relay. The contacts of this relay carry the power circuit from phase C of a generator busbar to one side of the gold-film heating element. With the selector switch on the flight deck set to LOW, the other side of the heating element is connected through the contacts of both the overheat control relay and the high heat control relay to earth. Both of these relays are de-energised. Thus a single-phase of 115-volts AC is applied to the heating element.

Table 4—Controls and Indicators—Pressure Heads

<i>Item</i>	<i>Location</i>	<i>Marking/Indication</i>
Pressure head heater switches (four)	Forward roof panel	PITOT HEATERS. CAPTAIN — ON AUTOPILOT 1 ART FEEL 1 — ON AUTOPILOT 2 ART FEEL 2 — ON CO-PILOT-ON
Pressure head ammeters (four)	Forward roof panel	PITOT HEAD HEATERS
Warning lights (two)	Forward roof panel	MAST (amber, press-to-test)

73. When the heating element attains a temperature of 35°C the resultant increase in resistance of the normal sensing element causes the controller to de-energise the normal temperature control relay, thereby interrupting the power supply to the heating element. Natural cooling of the windscreen reduces the resistance of the sensing element and at 25°C the normal temperature control relay again becomes energised.

74. If the normal temperature control system fails and a windscreen temperature rises to 45°C, the overheat sensing element in the windscreen causes the controller to switch on the overheat warning light and energise the overheat control relay. This relay then open-circuits the power supply to the heating element. Power is re-applied to the heating element and the warning light goes out when natural cooling has lowered the windscreen temperature by approximately 15°C.

75. With the selector switch set to HIGH, the high heat control relays are both energised. In this condition the relay contacts disconnect the heating element from earth and connects it across phases B and C of the generator busbar.

76. When a windscreen temperature reaches 35°C, the controller de-energises the normal temperature control relay, so interrupting the phase C supply to the heating element. The relay then connects that side of the heating element to earth, thus completing a single-phase circuit for the element from phase B. This 115-volt AC supply is maintained to the heating element until such time as the windscreen temperature has fallen to 25°C whereupon high voltage operation is restored.

77. Overheat control under HIGH selection is identical with that under LOW selection. The associated ammeter indicates the load in amperes for a windscreen when the heating selector switch is set to HIGH or LOW.

78. The controllers, normal temperature relays and high heat control relays are powered from generator cut-off busbars; the heating circuits are therefore operative only when FLIGHT is selected on the GROUND/FLIGHT switch.

79. The overheat relays which operate the warning lights are powered from the 28-volt DC Essential busbars.

#### **Side Window Demisting**

80. The three side windows to the left and right of the flight deck have heating elements similar to those of the windscreens except that the conducting film has a power rating of 120 W per sq ft and is on the innermost panel in contact with the vinyl interlayer.

81. In each No 3 (direct vision — DV) circuit the AC supply from the busbar to the window is controlled by a relay. The relay coil is controlled by one or two thermostats which are in series and sense the temperature of the window.

82. When the window temperature is below 40°C the thermostat contacts remain closed and the relay is energised to supply the heating element. The AC circuit is interrupted by the relay when one or other of the thermostats open at 40°C and is re-applied when the temperature falls to 32°C. Although both thermostats fitted to the DV window break at 40°C, they do not operate together because of their relative position to the window, thus they give normal and overheat protection. The overheat thermostat is mounted at the lower position.

83. A microswitch, operated by a striker on the DV window breaks the DC supply to that window relay when the window is not in the closed position; the AC supply to the window is thus interrupted.

84. A thermostat on each No 4 window, connected in series, control two relays so that when either window temperature reaches 40°C both relays are de-energised. The relay contacts then interrupt the AC circuit to both windows.

85. A thermostat on each No 5 window, connected in series, control one relay so that when either window temperature reaches 40°C the relay is de-energised. The relay contacts then interrupt the AC circuit to both windows.

86. In each of the DC control circuits the power is taken from one of the cut-off busbars. Thus operation of the heating circuits is dependent on the position of the GROUND/FLIGHT switch and is available only when the switch is at FLIGHT.

#### **Windscreen Demisting**

87. An electrically-driven fan delivers air to two nozzles at the base of each windscreen producing a flow of air to assist in preventing mist forming on the inside of the windscreens.

88. The fan, which is controlled by a switch on the auxiliary roof panel (right side), is below the floor of the flight deck and a single duct passes upward from the fan through the floor. Above floor level the duct connects with a distribution manifold supplying the six nozzles.

89. With the control switch on, three poles on the switch connect the 3-phase supply from No 1 generator busbar to the fan motor. Rotation of the fan causes an air flow over the windscreen for demisting purposes. When set to off the switch interrupts the 3-phase supply to the motor.

### Windscreen Wipers

90. Three windscreen wipers are provided, one for each front windscreen. Each wiper is hydraulically-operated through an independent system from a self-contained electro-hydraulic unit. The three electro-hydraulic units, which are on the front pressure bulkhead, are connected to the servo-reservoir which is also used for the main wheel brakes servo hydraulic system.

91. The control and operation of each wiper is identical, each wiper being separately controlled. The wiper parking system is operated by main hydraulic pressure from System A.

92. The three WINDSCREEN WIPER — FAST/SLOW/PARK switches are on the forward roof panel.

93. Power supplies for windscreen wiper operation are 28-volt DC and three-phase 200-volt AC for control/parking and operation of the wiper motors respectively.

Note: The wipers must not be operated when the windscreens are dry.

### Cabin and Eyebrow Window Demisting

#### 94. Cabin

a. The cabin windows consist of an inner and an outer panel separated by an air-space which is vented to atmosphere through a desiccator. All cabin windows except those in the freight door and the emergency exits are served by the one desiccator, which is situated in the keel beam.

b. The freight door, which contains six cabin windows, has a separate self-contained system, the

air space of which is vented to atmosphere through a desiccator fitted in the door.

c. The emergency exits, two on each side above the wing, each have an integral desiccator connected by flexible pipe, between the air inlet in the lower face of the exit and the window panel.

95. *Eyebrow Windows.* The eyebrow windows on the flight deck have their own desiccator system which also serves the turn-off light on each side of the fuselage nose. The desiccator is situated under-floor in the nose and is provided with an inspection window.

96. *Controls and Indicators—Windscreen Ice Protection.* (See Table 5).

### STALL WARNING ICE PROTECTION

#### Stall Probes

97. Each stall probe has a 28-volt DC supply for heating, which is controlled by the CAPTAIN'S PITOT HEAD heater switch for No 1 stall warning system and the PITOT HEAD heater switch for AUTOPILOT 2: ART FEEL 2 for No 2 stall warning system; both switches are on the forward roof panel. There are two heaters in the probe, one for the probe bearing and one for the inside of the probe; the heaters are connected in parallel; heater current is measured by four ammeters, one for each probe.

98. On the ground, the current to each probe is limited by the operation of oleo switches to approximately 2 amperes. In flight, approximately 4 amperes is indicated on each ammeter.

99. *Controls and Indicators — Stall Probes Ice Protection.* (See Table 6).

Table 5 — Controls and Indicators — Windscreen Ice Protection

Item	Location	Marking/Indication
Centre windscreen wiper switch	Forward roof panel	CENTRE WINDSCREEN WIPER-FAST/SLOW/PARK
1st pilot's windscreen wiper switch		CAPTAIN'S WINDSCREEN WIPER-FAST/SLOW/PARK
Co-pilot's windscreen wiper switch		CO-PILOT'S WINDSCREEN WIPER-FAST/SLOW/PARK
Windscreen demisting fan switch		WINDSCREEN FAN-ON
Windscreen heating switches (three)		WINDSCREEN HEATING CAPTAIN—HIGH/LOW CENTRE—HIGH/LOW CO-PILOT—HIGH/LOW
Windscreen heating ammeters (three)		CAPT/CENTRE/CO-PILOT
Windscreen overheat lights (three)		WINDSCREEN OVERHEAT— CAPTAIN/CENTRE/CO-PILOT Amber (press-to-test)

**ENGINE AND POWER PLANT  
ICE PROTECTION**

**General**

100. An integral ice protection system on each engine comprises an anti-icing manifold supplied with hot air from the engine HP compressor.

101. Parts of the engines and nacelles that can be supplied with hot air for anti-icing purposes are:

a. *Power Unit*

- (1) Intake casing
- (2) Inlet guide vanes
- (3) P<sub>1</sub> probe
- (4) Nose fairing

b. *Nacelles*

- (1) Nose cap
- (2) Intake fairing
- (3) Nacelle strut leading edge
- (4) Cabin compressor intake

102. In all cases a common source of high pressure air (P<sub>3</sub>) is used. This is tapped from the upper right-hand side of the compressor intermediate casing.

103. The nacelle struts leading edges receive a supply of air from their associated inboard nacelle nose cap, but the cabin compressor intake can be supplied from either nacelle nose cap.

104. One switch for each engine, at the engineer's station, controls the complete engine and nacelle anti-icing. Four pressure gauges, above the switches indicate the pressure in each system.

**Flow From Compressors**

105. When anti-icing is selected, a hot air valve is operated on the upper right-hand side of the compressor intermediate casing. This allows a controlled air pressure at 45 PSI from P<sub>3</sub> source to flow through a straight duct to the intake casing. At the front end of this duct a small pipe tapping is taken down the right-hand side of the engine to a pressure transmitter mounted on the bottom of the LP compressor casing.

**Power Unit**

106. a. *Intake Casing.* A manifold around the engine intake casing carries piping into which the hot air is fed.

b. *Inlet Guide Vanes.* Air ducted from the internal piping in the intake manifold passes down the centre of each inlet guide vane, back along the leading edge and trailing edge of each blade, back into the manifold surrounding the intake casing, and out through two ports, one on each lower side of the intake case manifold. This then forms the supply for anti-icing the nacelles and struts.

c. *P<sub>1</sub> Probe.* From the internal piping in the air intake casing manifold a small pipe takes air to the base of the probe. Hot air then flows over the probe and discharges into the engine intake.

d. *Nose Fairing.* Five of the inlet guide vanes have at their inner ends small tubes to take some of the hot air to the front of the nose fairing. The

**Table 6 — Controls and Indicators — Stall Probes Ice Protection**

<i>Item</i>	<i>Location</i>	<i>Marking/Indication</i>
Stall identification probe heater ammeters (two)	Engineer's engine panel	STALL IDENT PROBE HEATER No 1/No 2 (0 to 6 amperes)
Stall warning probe heater ammeters (two)	Engineer's engine panel	STALL WARNING PROBE HEATER-No 1/No 2 (0 to 6 amperes)
Pressure head heater and No 1 stall identification probe heater switch	Forward roof panel	CAPTAIN-ON
Pressure head heater and No 2 stall identification probe heater switch	Forward roof panel	AUTO-PILOT 2: ART FEEL 2—ON

**Table 7 — Controls and Indicators — Engine and Power Plant Ice Protection**

<i>Item</i>	<i>Location</i>	<i>Marking/Indication</i>
Engine anti-icing switches (four)	Engineer's anti-icing panel	ENGINE ANTI-ICE-ON/OFF switches 1, 2, 3 and 4
Engine anti-icing air pressure gauges (four)	Engineer's anti-icing panel	AIR PSI

air then flows rearwards between the outer two skins of the fairing, through exhaust vents in the outer skin into the engine intake.

### Nacelles

107. a. *Nose Cap.* Short flexible pipes connect the air outlet ports from the intake casing to the nacelle. Internal tubes in the nacelle direct the hot air to the front of the nacelle where it circulates around the nose cap.

b. *Intake Fairing.* The intake fairing forms a continuation rearwards of the nose cap. Air circulating around the nose cap also flows rearwards to circulate around the intake fairing. The air is finally exhausted overboard through grilles at the top and bottom, on the outer side of the outboard engine intake and on the inboard side of the inboard intake.

c. *Nacelle Strut Leading Edges.* The nacelle strut leading edges receive a hot air supply from the inner nacelles. It flows along the leading edge between skins and exhausts overboard through two grilles in the upper surface of each leading edge.

d. *Cabin Compressor Intake.* This receives a hot air supply from both nacelles which flows around the intake and is ducted overboard through the outboard nacelle grilles.

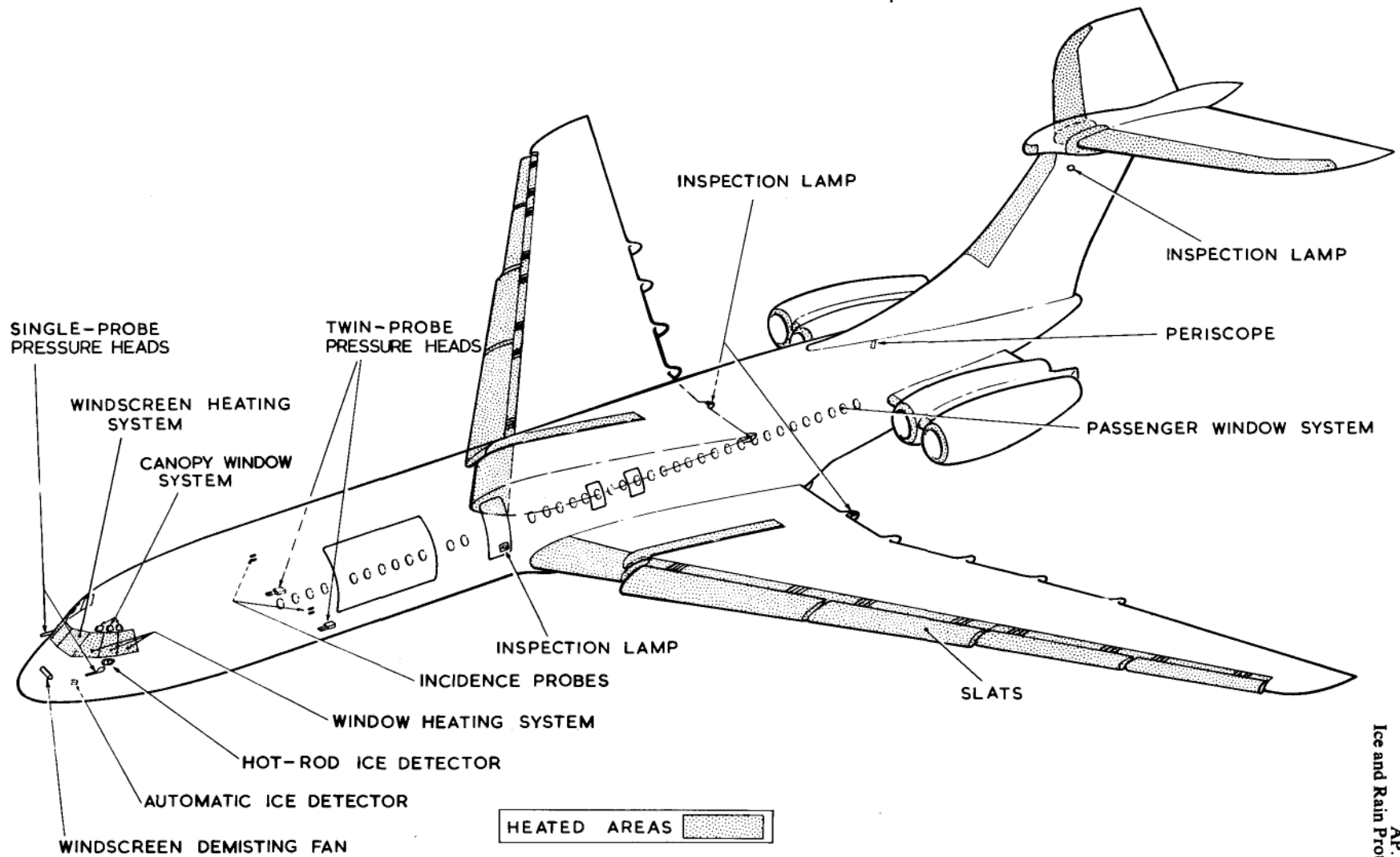
108. *Controls and Indicators — Engine and Power Plant Ice Protection.* (See **Table 7**).

### Ice Protection Systems Data

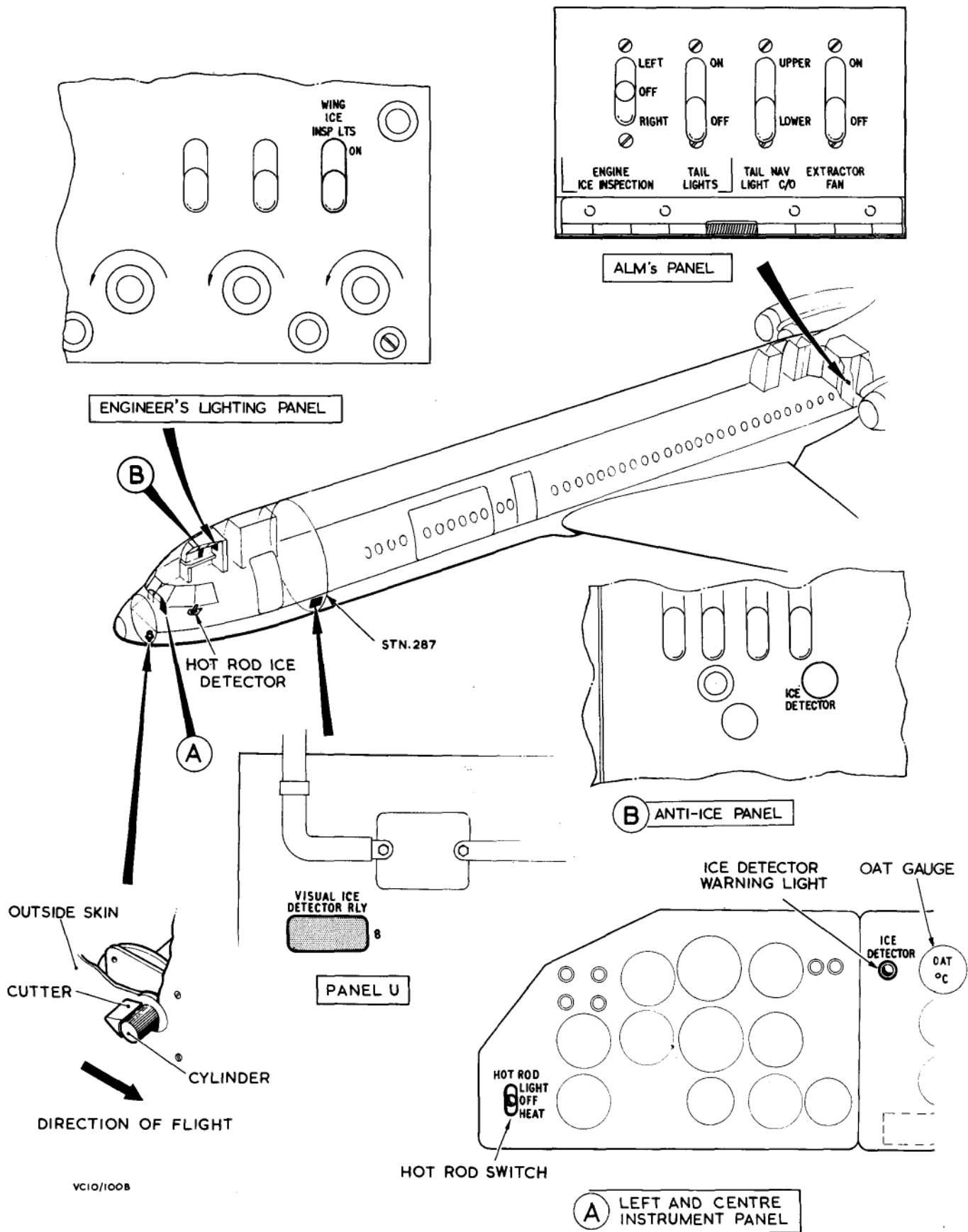
109. Engine LP tapping — design maximum working pressure ...	75 PSIG
Engine HP tapping — design maximum working pressure ...	212 PSIG
Engine HP tapping — associated maximum temperature ...	450°C
Temperature control sensing element controls at ...	230°C approx
Pressure reducing valve controls at	45 PSIG approx
Duct relief valve opens at 55 PSI, full open at ...	60 PSIG
Pressure switch closes at ...	68 PSIG
Rupture disc valve bursts at ...	120 PSIG
Flamestat (overheat warning) at ...	245°C
Duct failure warning light pressure switch operates at ...	0-15 PSI
Nacelle stub overheat warning light comes on at ...	115°C

When the aircraft is on the ground, neither the wing nor the tail checks must take more than 30 seconds.

2.12 Fig. 1. GA of Ice and Rain Protection System

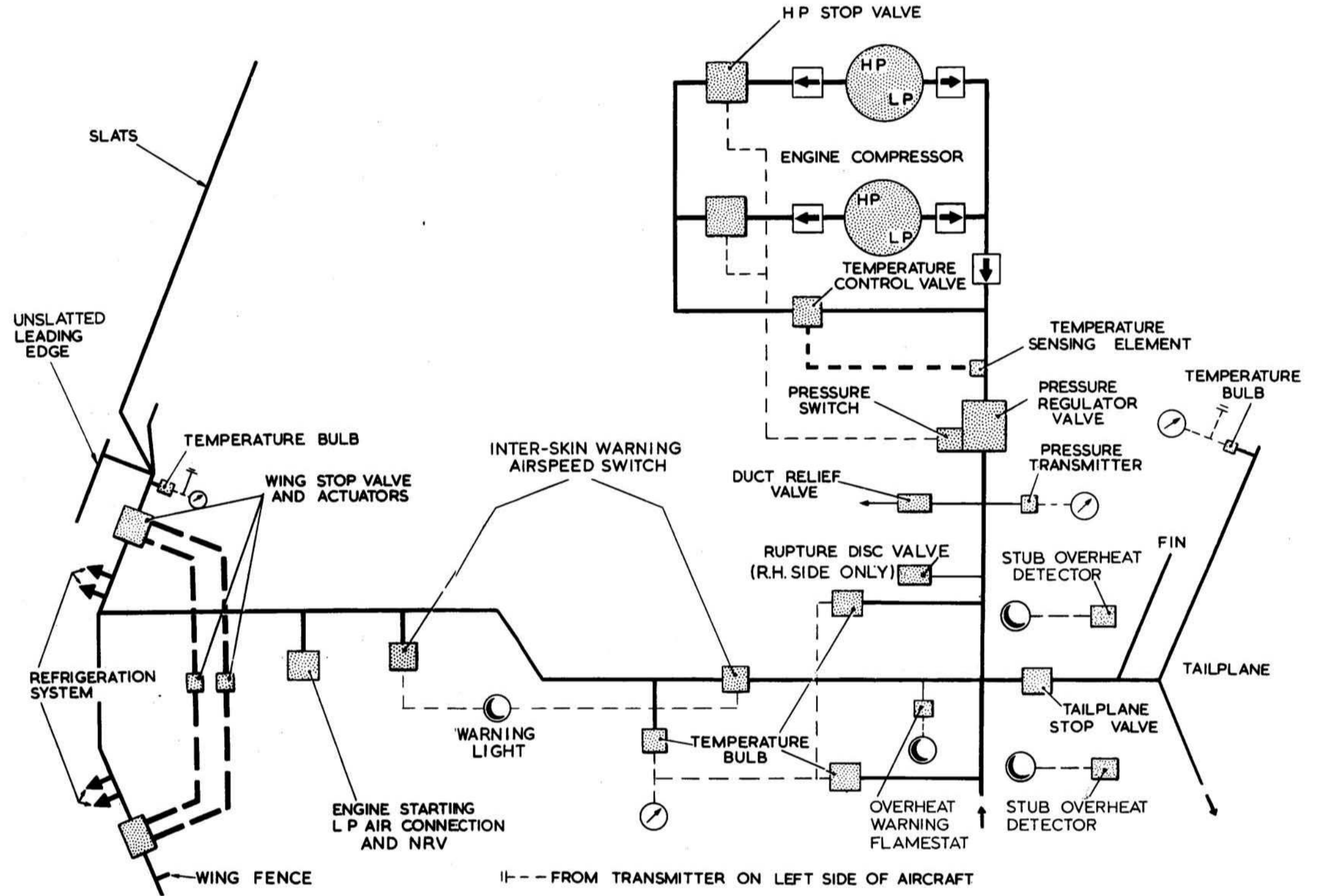


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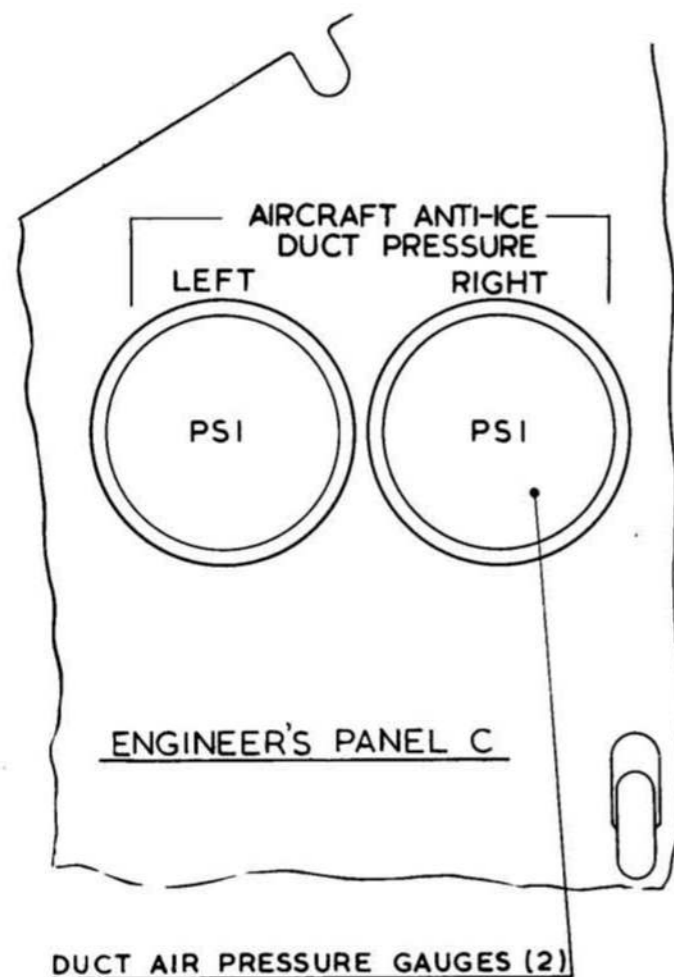
2.12 Fig. 2. Ice Detection Components

◀ ALM's Panel Identified ▶



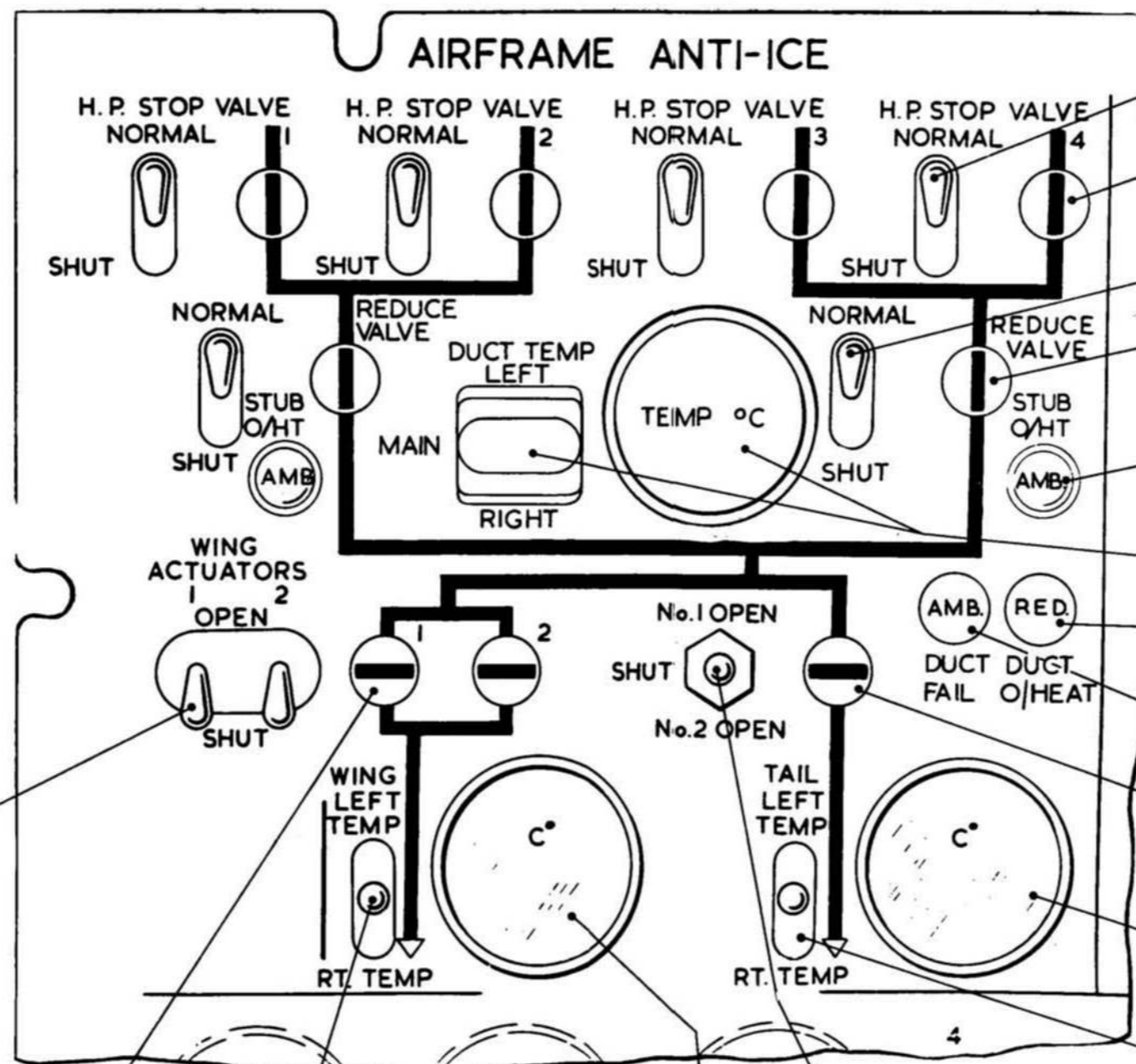
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2-12 Fig 3 Anti-Icing Schematic  
◀ (Minor Amendment) ▶



DUCT AIR PRESSURE GAUGES (2)

WING ACTUATOR SWITCHES (2)  
CONTROL SUPPLY OF AIR TO WINGS  
VIA WING STOP VALVES, LEFT AND RIGHT.



ENGINEER'S PANEL B

WING TEMPERATURE  
SELECTOR SWITCH

WING ACTUATOR INDICATORS (2)  
SHOW SETTING OF ACTUATORS;  
IN-LINE DUCT OPEN; CROSS-LINE  
DUCT SHUT.

WING TEMPERATURE GAUGE  
INDICATES WING TEMPERATURE,  
LEFT OR RIGHT, ACCORDING  
TO SELECTION.

H.P. STOP VALVE SWITCHES (4)  
CONTROLS SUPPLY OF AIR AT  
COMPRESSOR H.P. OUTLET.

H.P. STOP VALVE INDICATORS (4)  
IN-LINE WHEN H.P. STOP VALVE IS OPEN;  
CROSS-LINE WHEN SHUT.

REDUCE VALVE SWITCHES (2)

REDUCE VALVE INDICATORS (2)  
SHOWS CROSS-LINE WHEN ASSOCIATED  
VALVE IS SHUT; IN-LINE WHEN OPEN

STUB OVERHEAT LIGHTS (2)  
ON TO INDICATE OVERHEATING  
IN EITHER STUB WING

DUCT TEMPERATURE SELECTOR C/O  
SWITCH & TEMPERATURE GAUGE

DUCT OVERHEAT LIGHT  
ON TO INDICATE OVERHEATING  
IN MAIN DELIVERY DUCTING

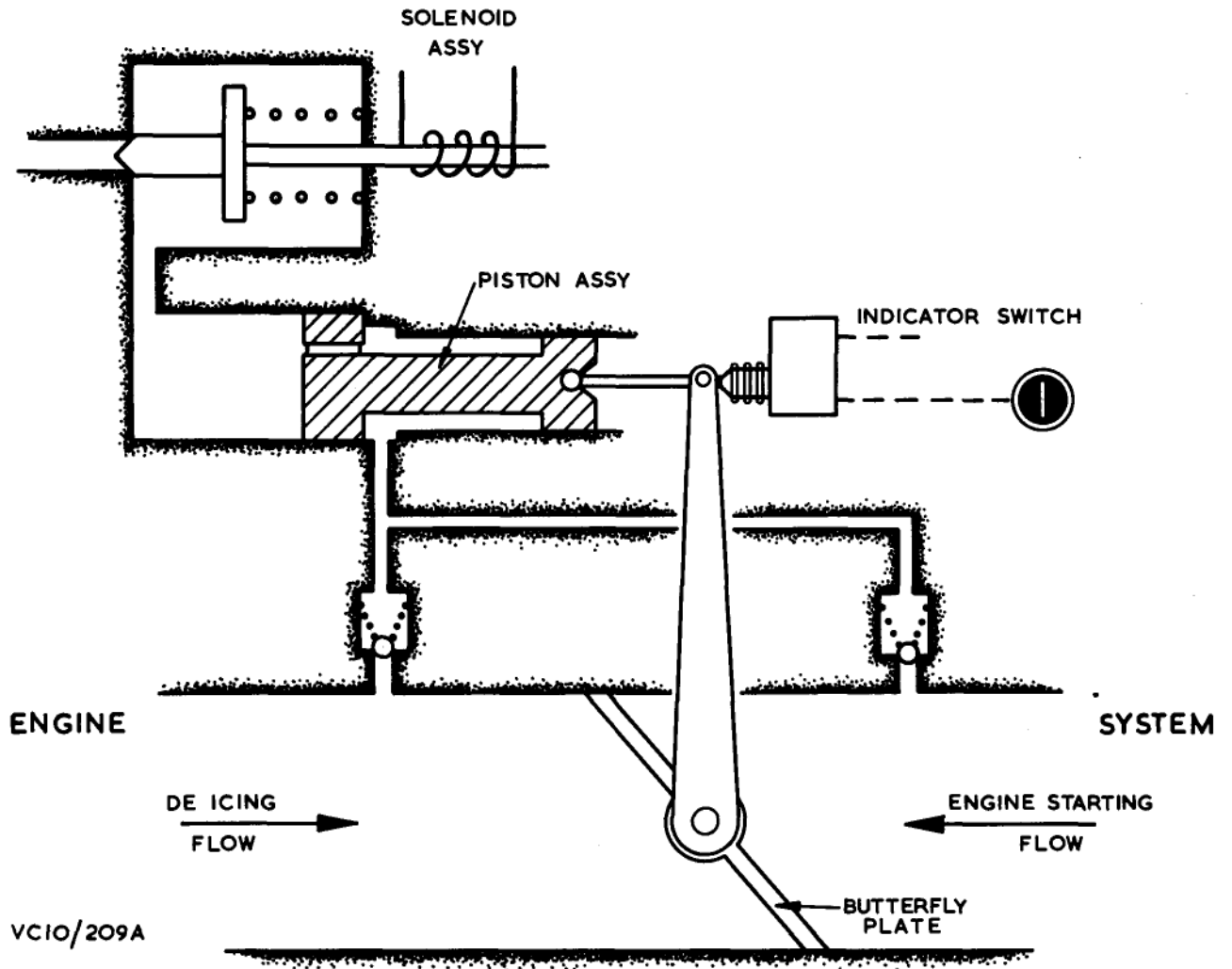
DUCT FAIL LIGHT  
ON TO INDICATE FAILURE OF INNER  
DUCTING IN THE FUSELAGE

TAIL STOP VALVE INDICATOR  
SHOW SETTING OF ACTUATOR; IN-  
LINE DUCT OPEN, CROSS-LINE  
DUCT SHUT.

TAIL TEMPERATURE GAUGE  
INDICATES TAIL TEMPERATURE,  
LEFT OR RIGHT, ACCORDING  
TO SELECTION.

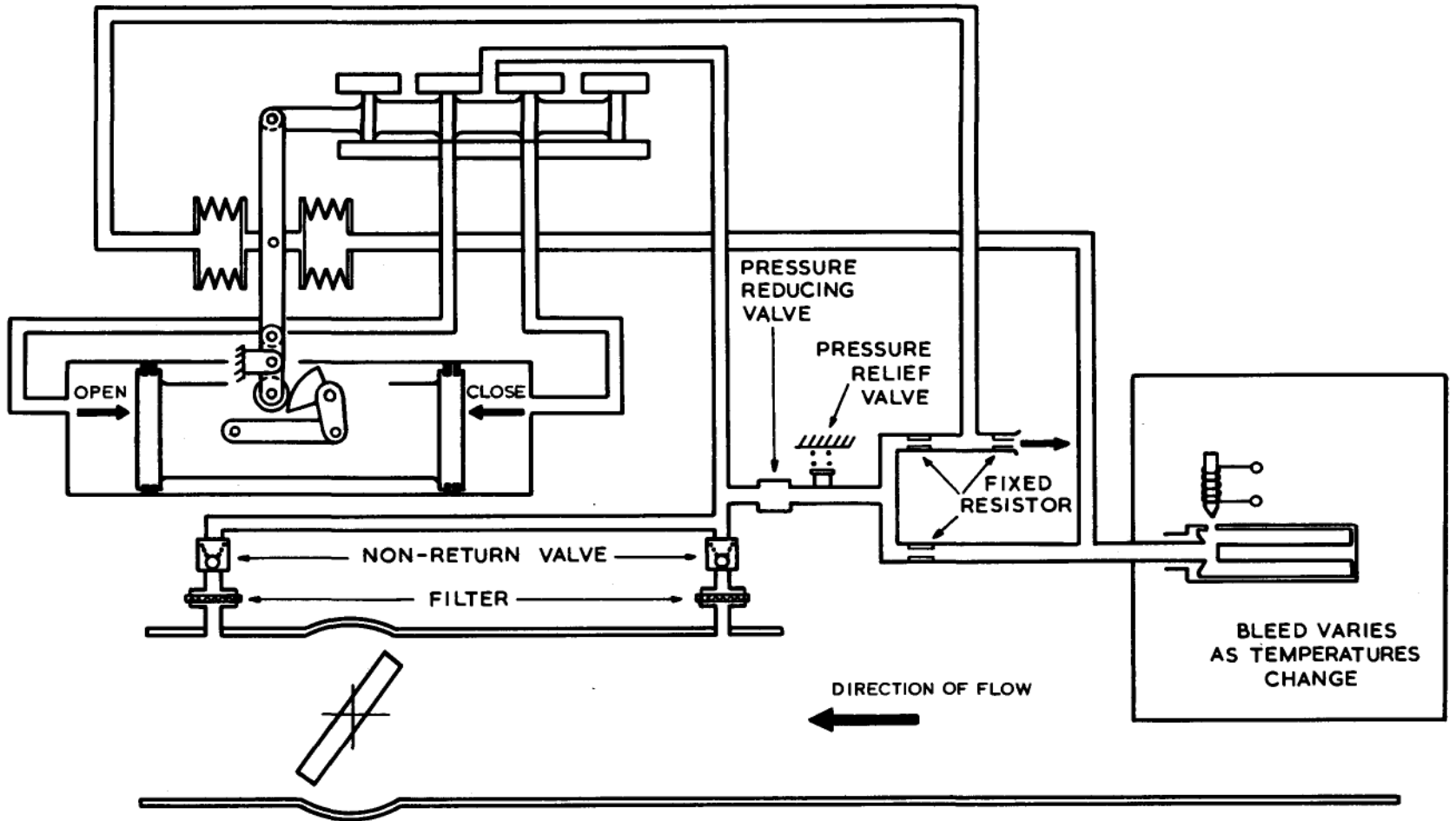
TEMPERATURE SELECTOR C/O SWITCH.

TAIL STOP VALVE SWITCH  
CONTROLS SUPPLY OF AIR TO THE  
TAIL UNIT VIA TAIL STOP VALVE



2-12 Fig 4A Diagrammatic Operation of HP Stop Valve

2-12 Fig 4B Temperature Control Valve — Diagrammatic

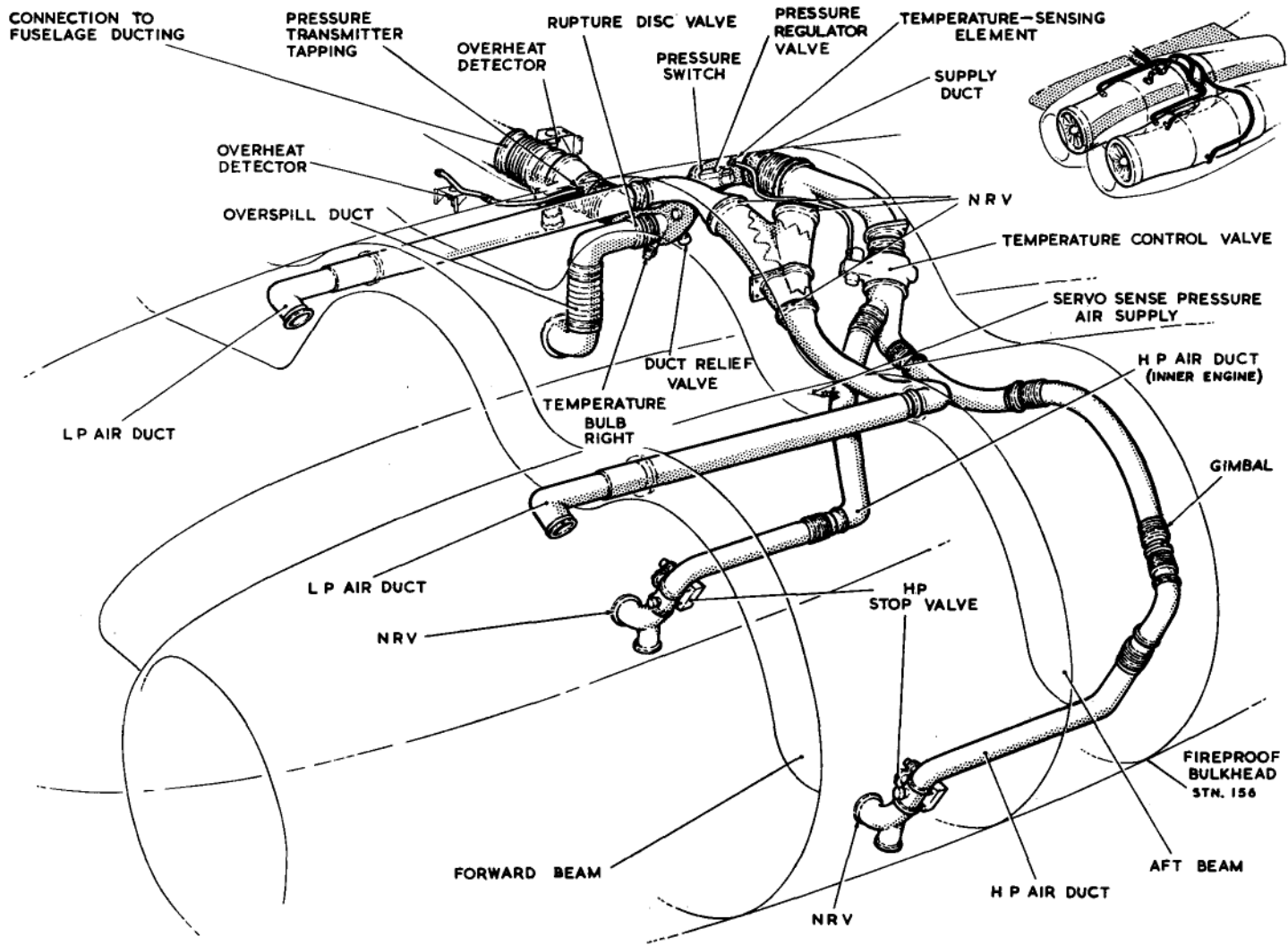


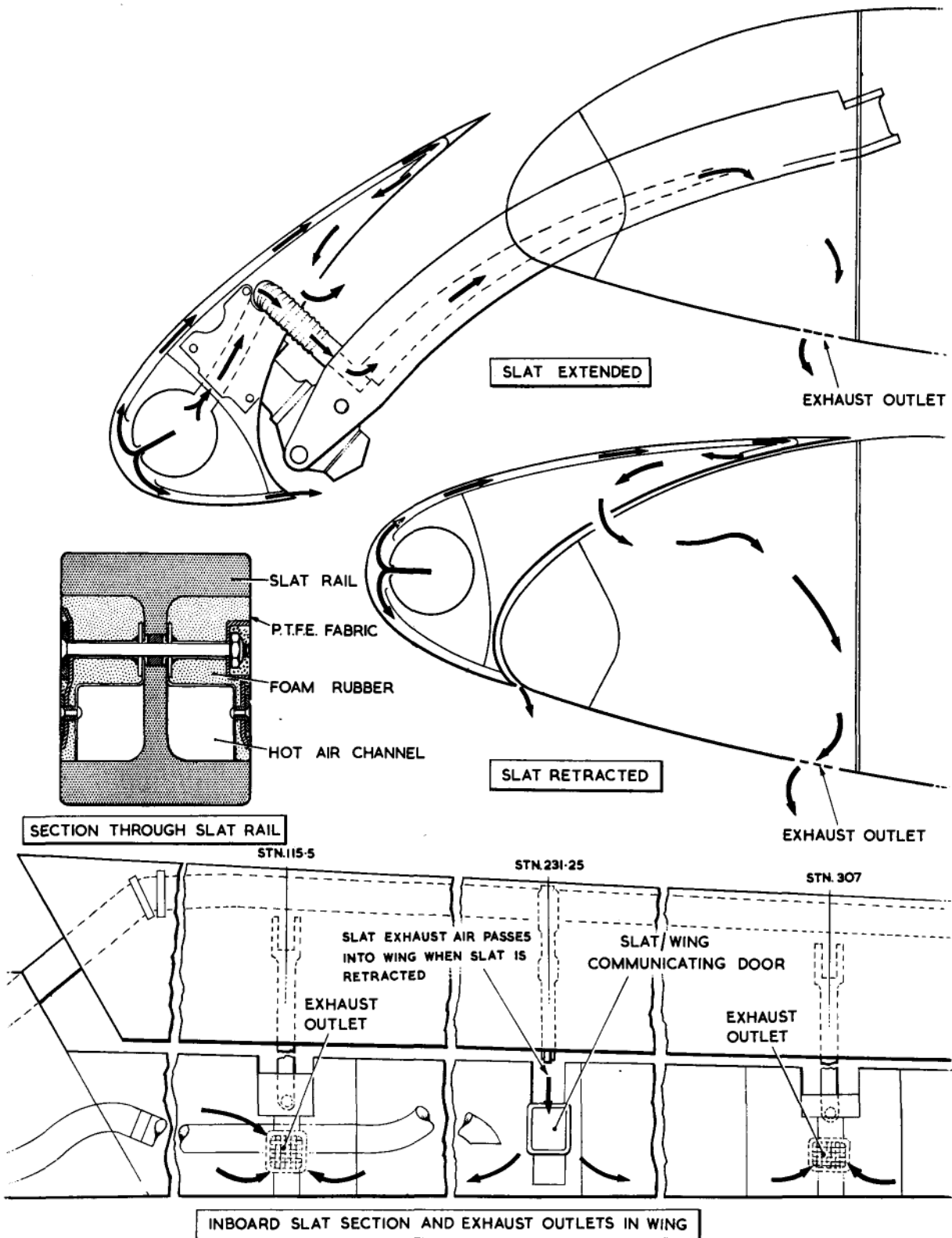
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2-12 Fig 4C Anticing Pressure Regulating Valve

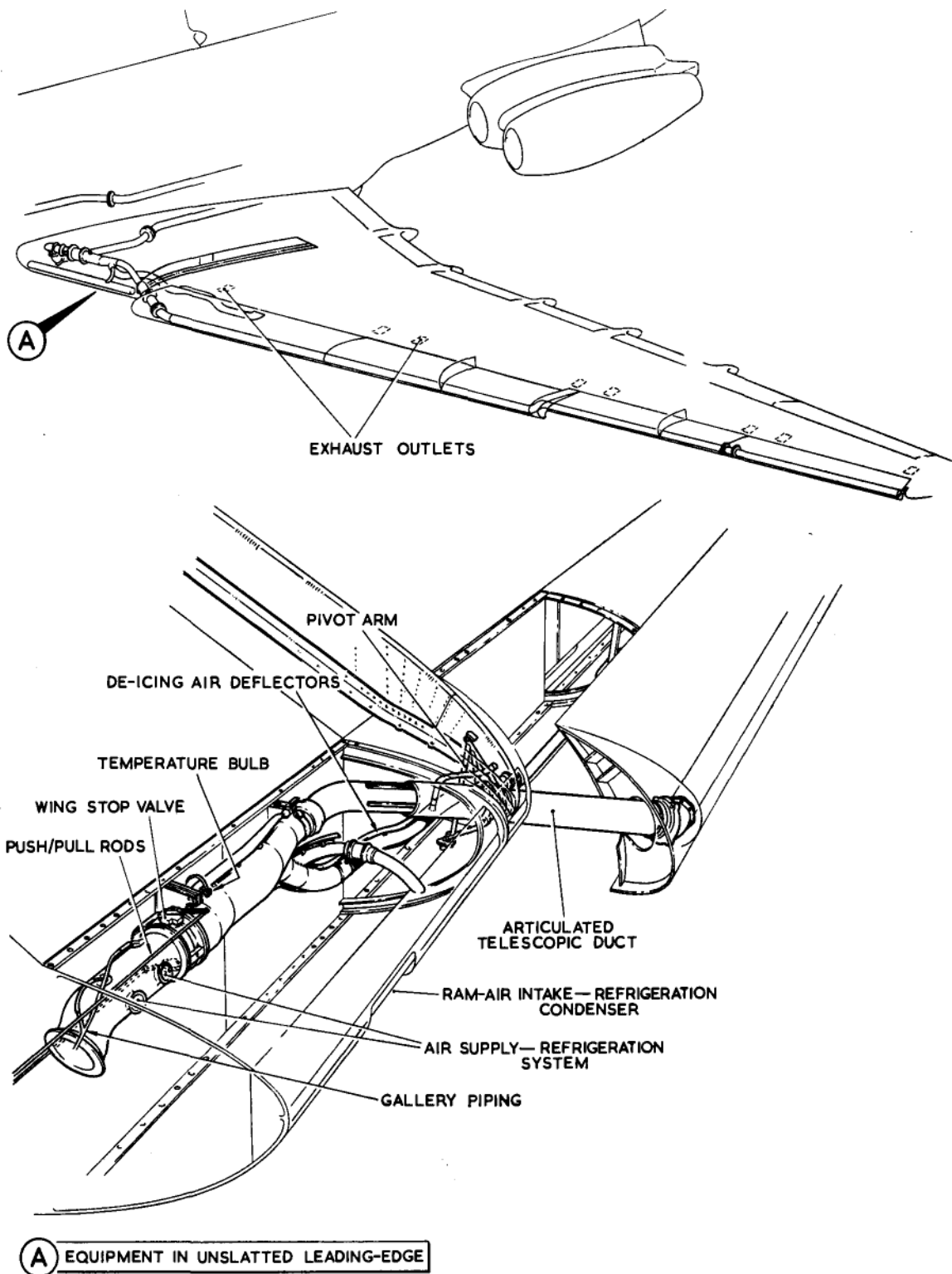


2.12 Fig. 5. Anti-icing Equipment in Nacelles

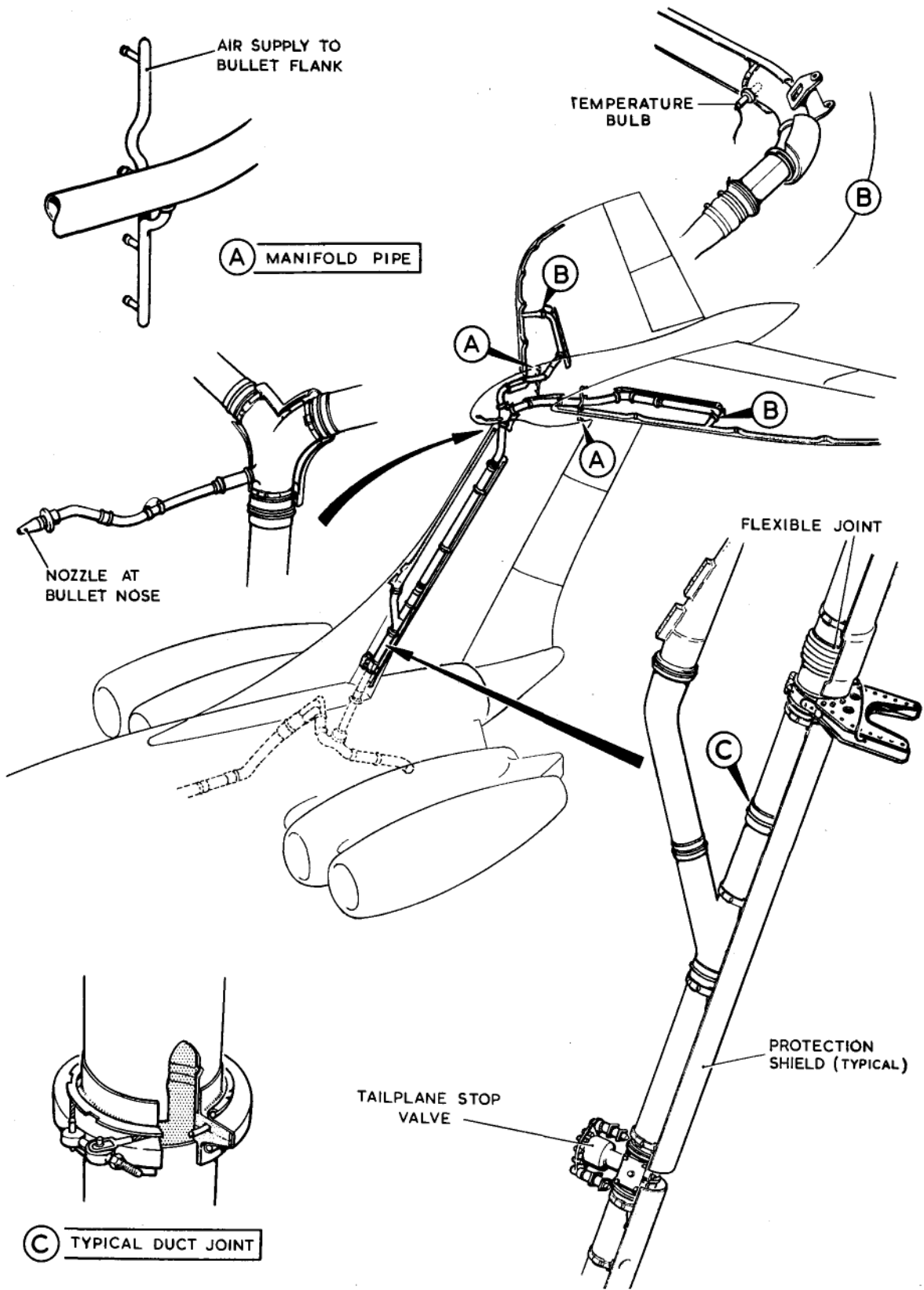




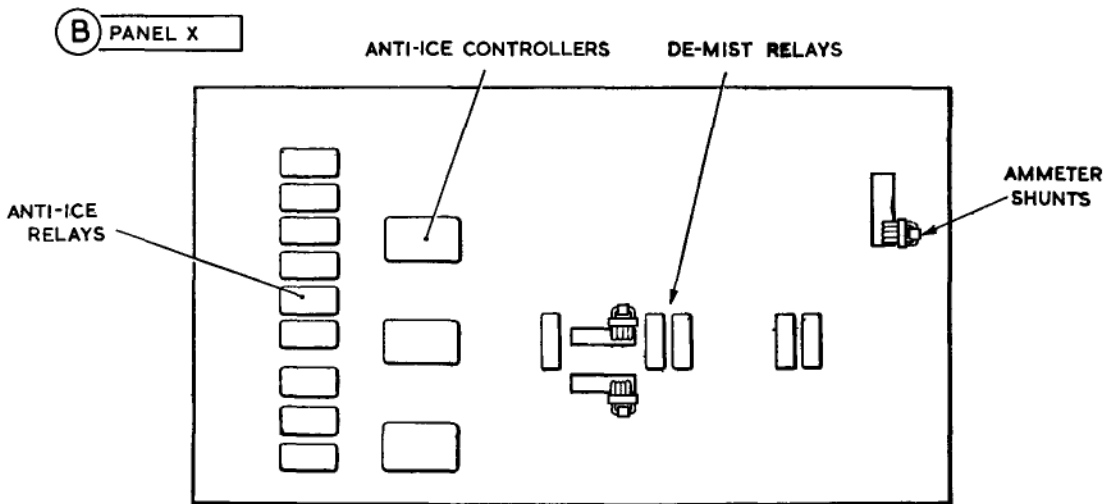
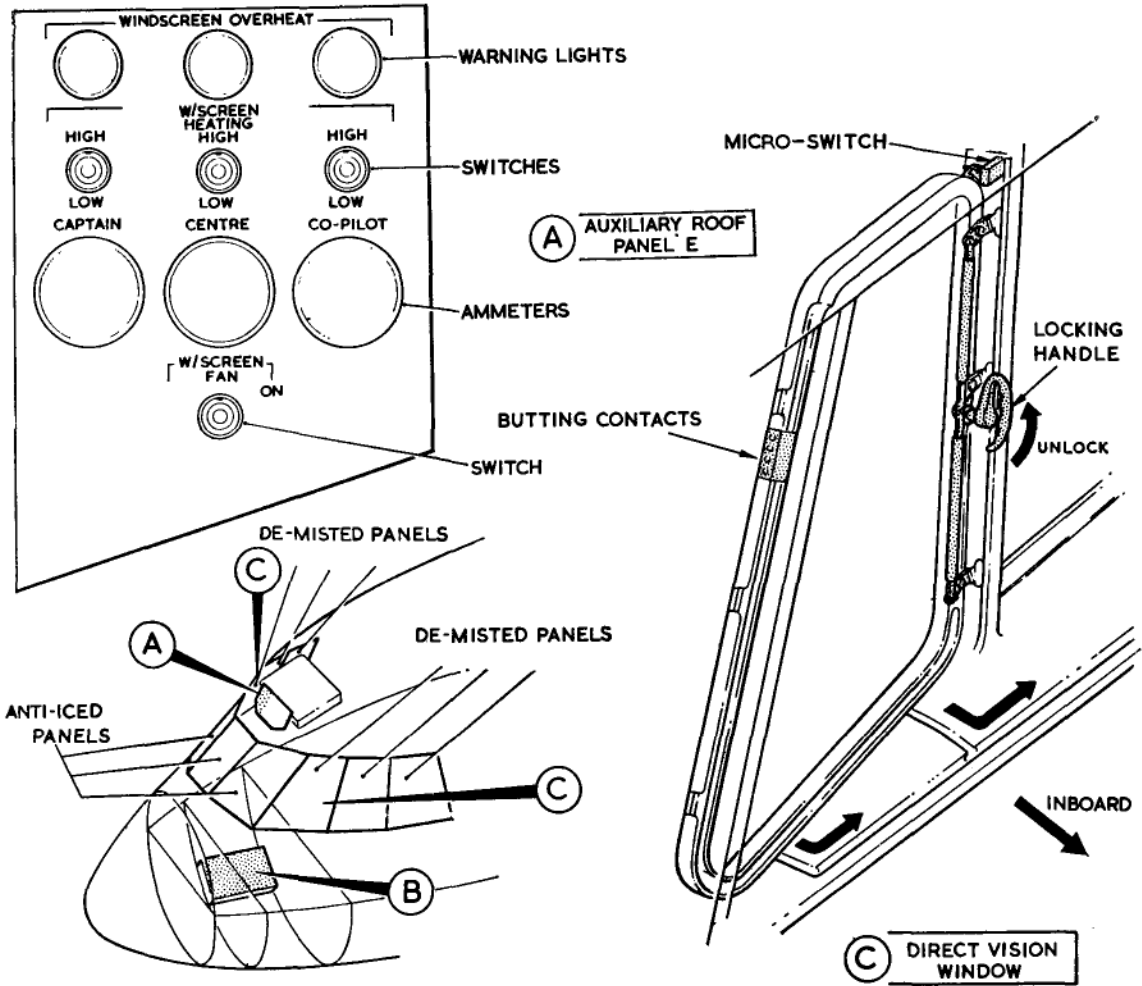
2.12 Fig. 6. Slat Anti-icing



2.12 Fig. 7. Wing Ducting



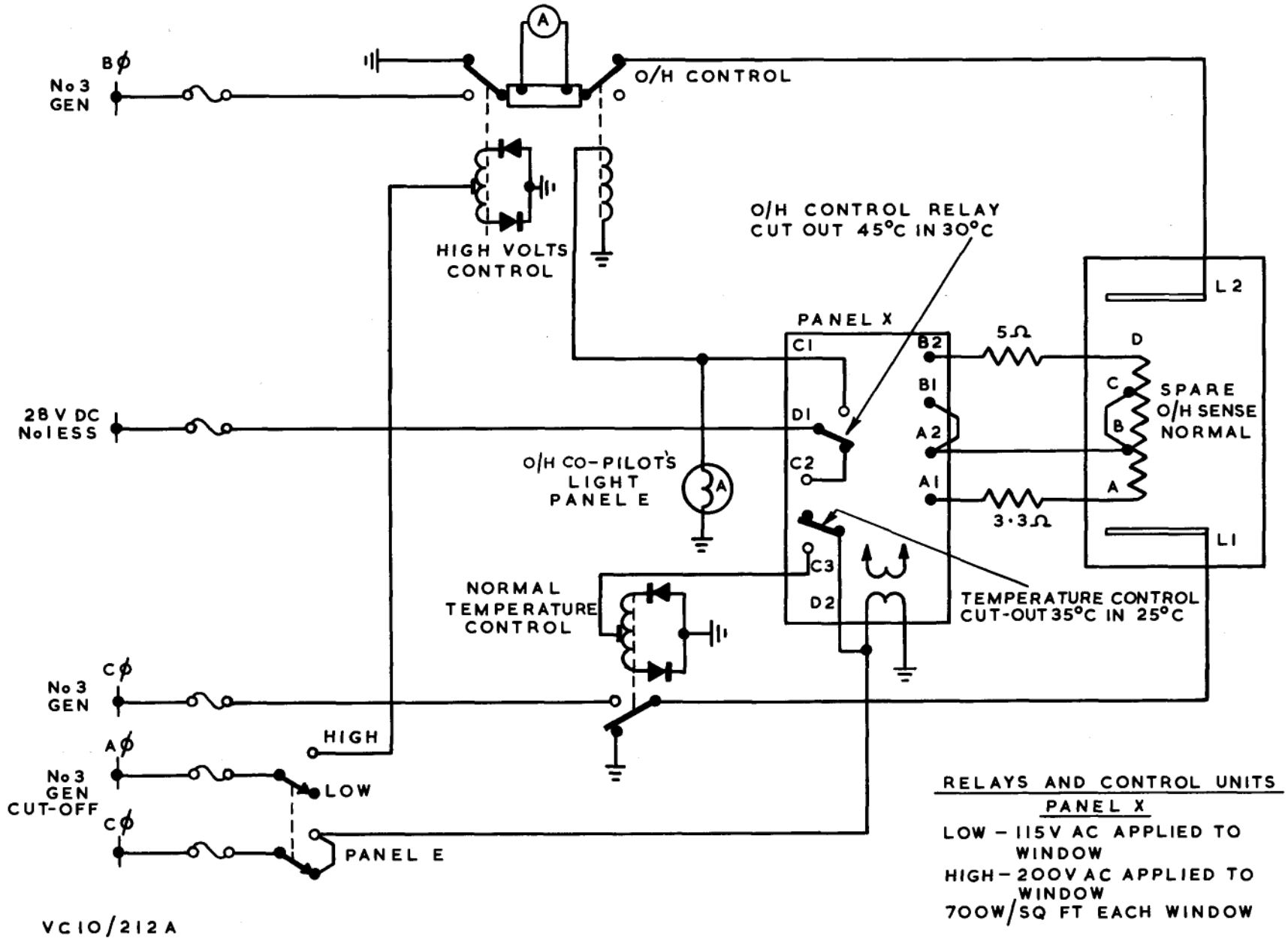
2.12 Fig. 8. Tail Ducting



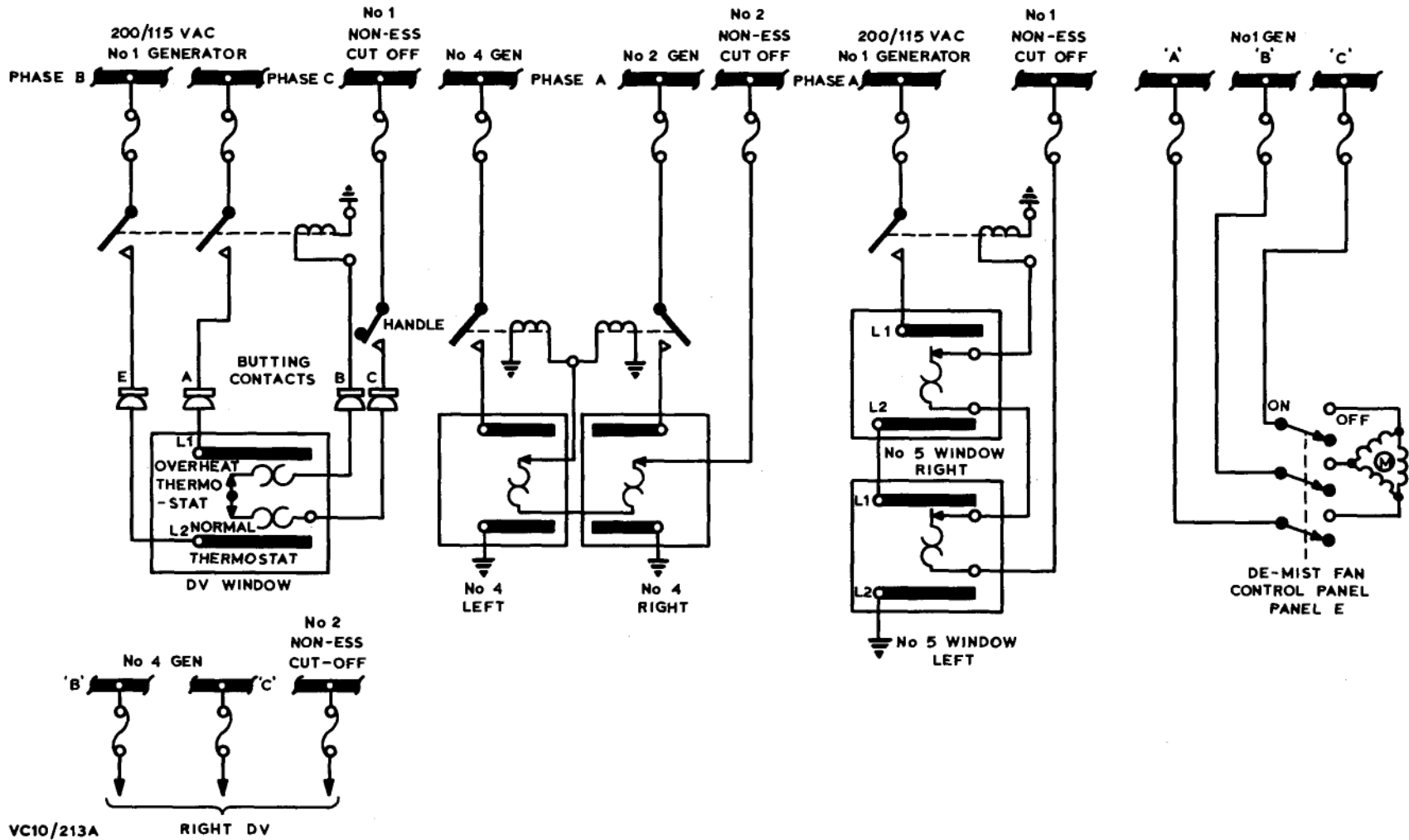
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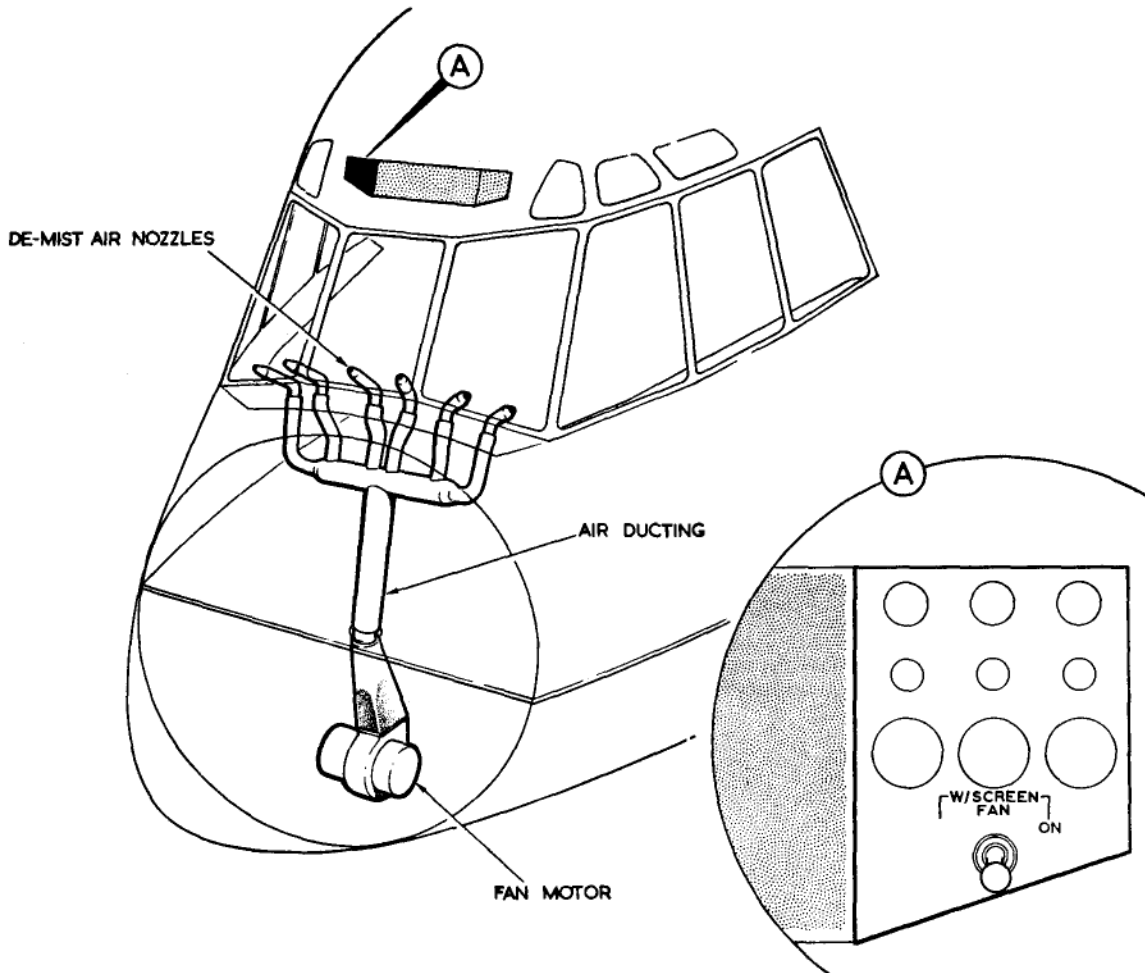
2-12 Fig 9 Windscreen Heating

2-12 Fig 9A Windscreen Antificing — Front Panels



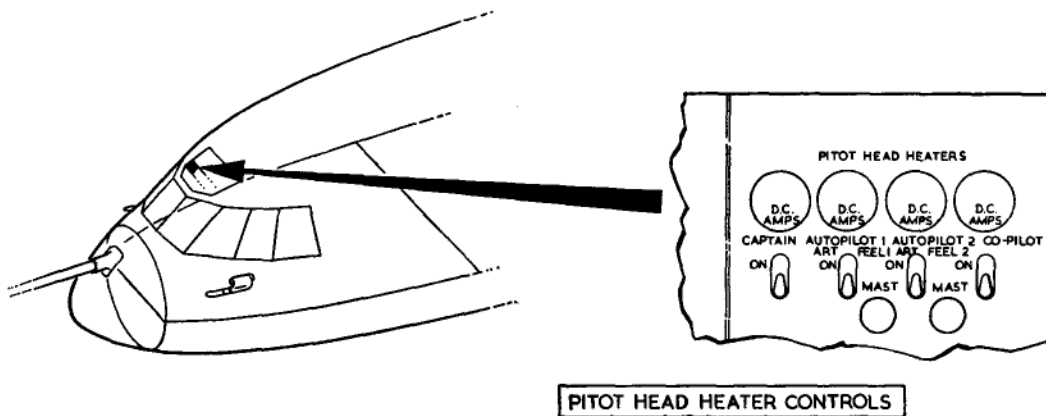
2-12 Fig 9B Windscreen Anti-icing—Side Windows





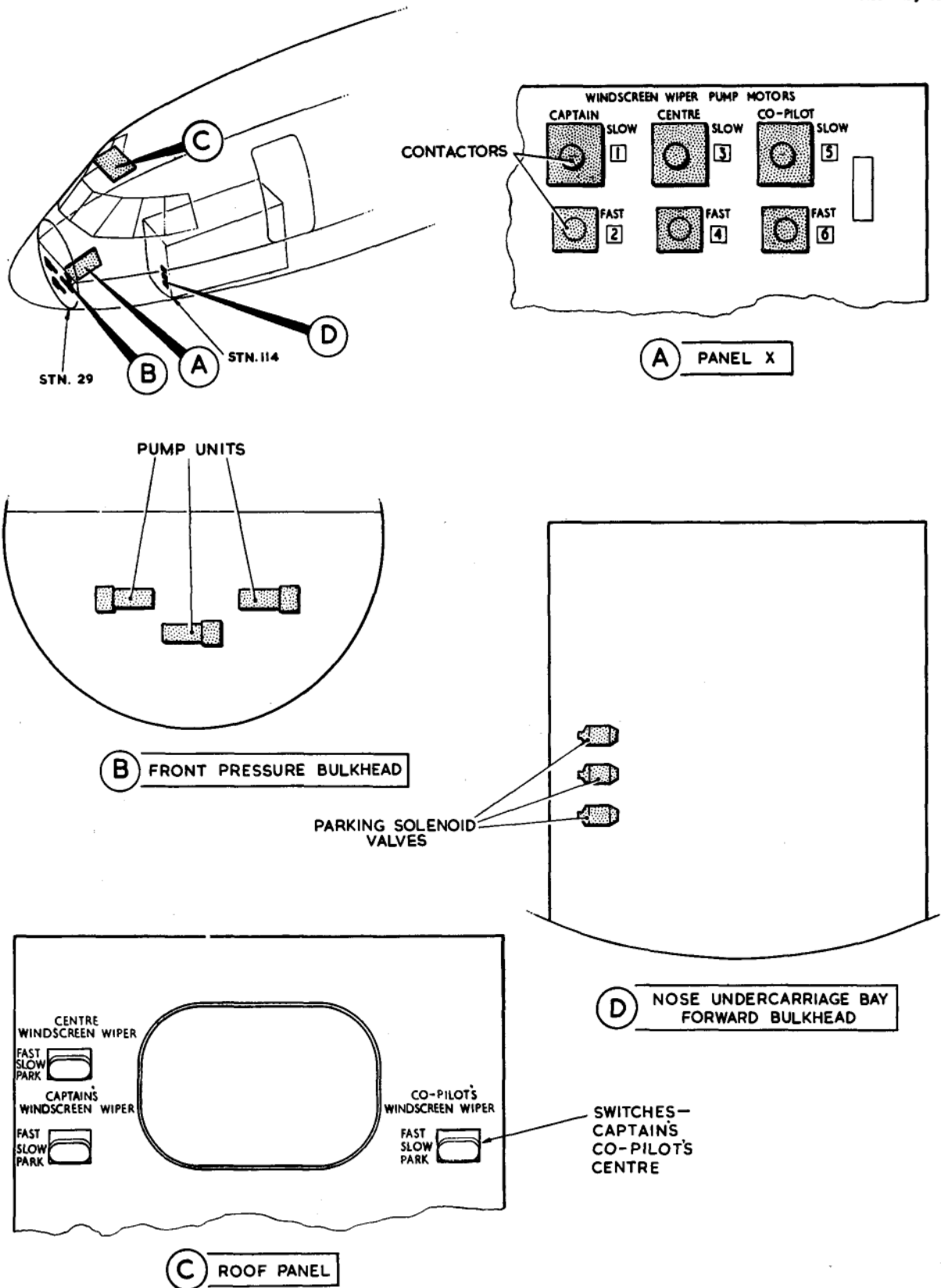
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2-12 Fig 10 Windscreen De-misting

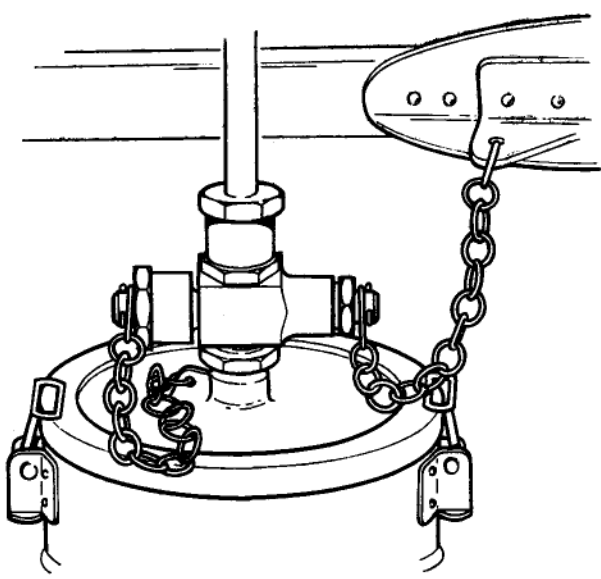
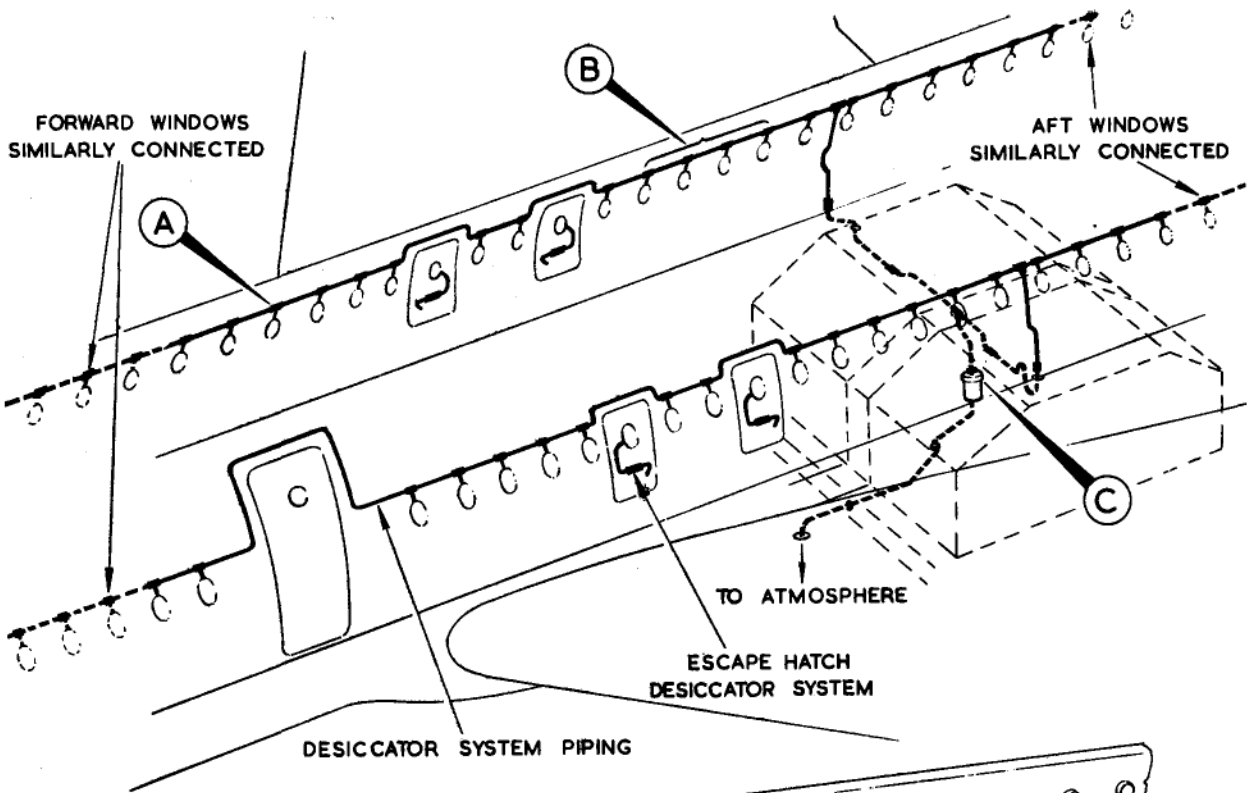


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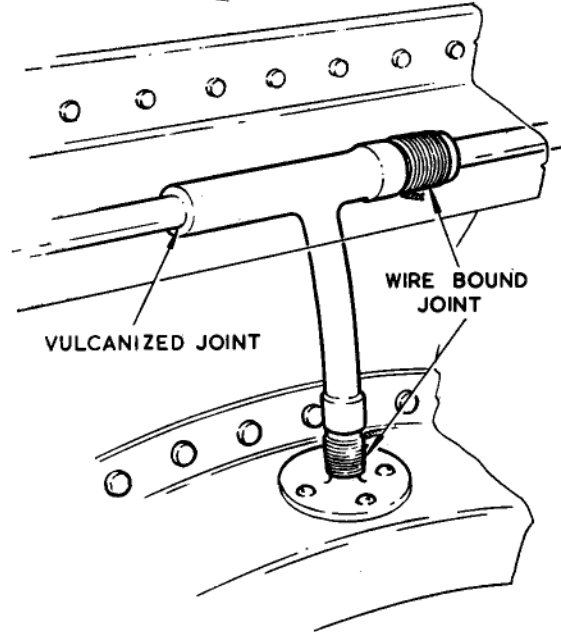
2-12 Fig 11 Pressure Head Heater Controls



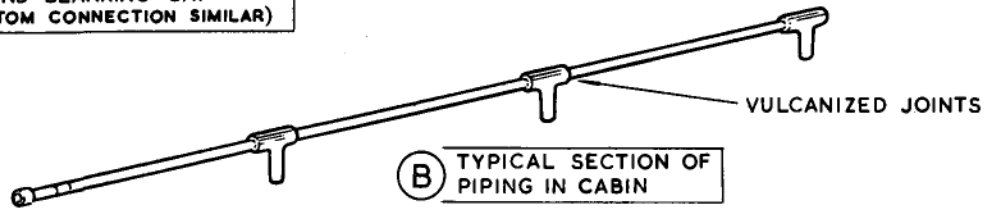
2.12 Fig.12. Windscreen Wiper System



**C** TOP DESICCATOR CONNECTION AND BLANKING CAP (BOTTOM CONNECTION SIMILAR)

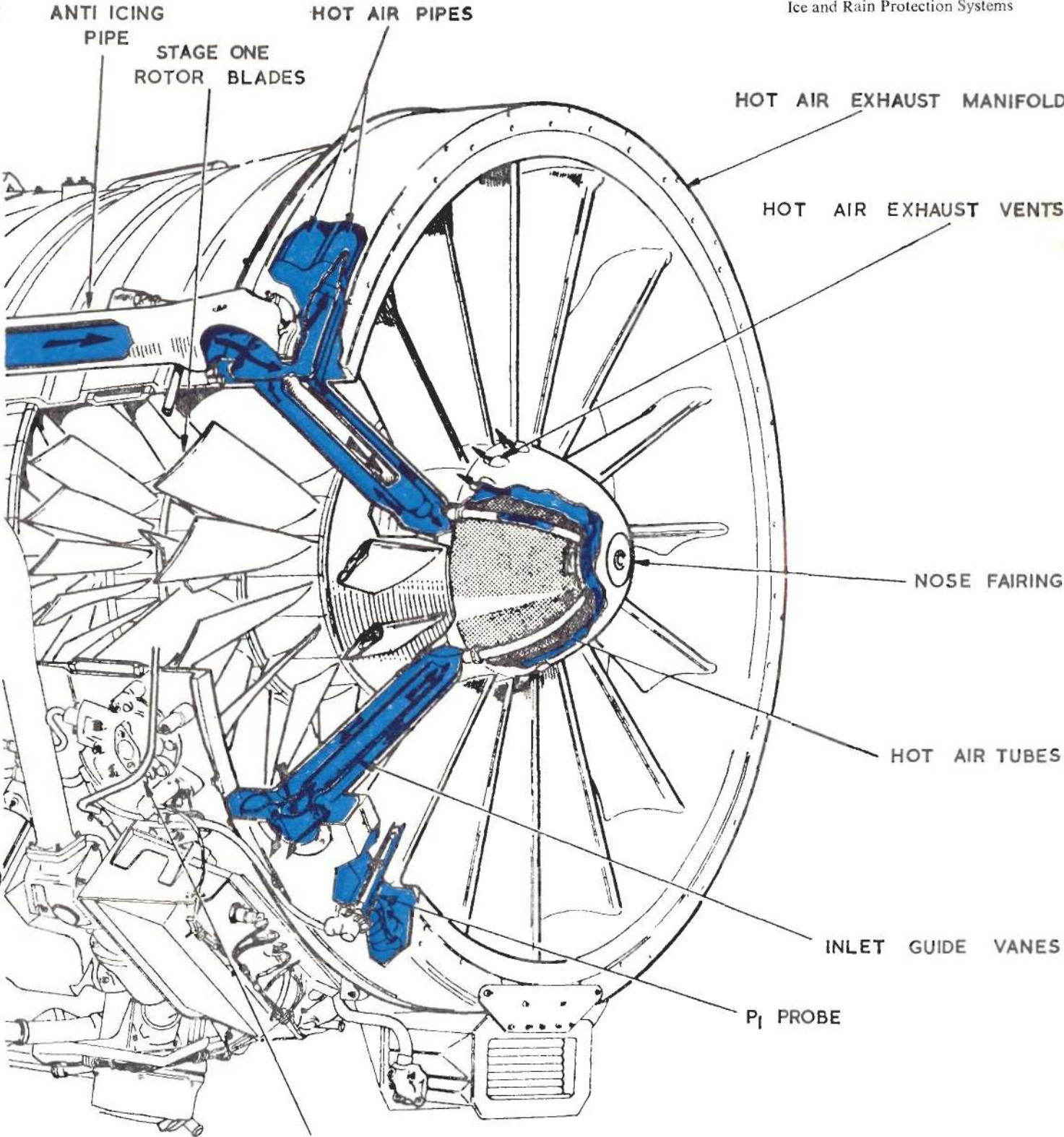


**A** NORMAL WIRE BOUND CONNECTION TO WINDOW AND CABIN PIPING



**B** TYPICAL SECTION OF PIPING IN CABIN

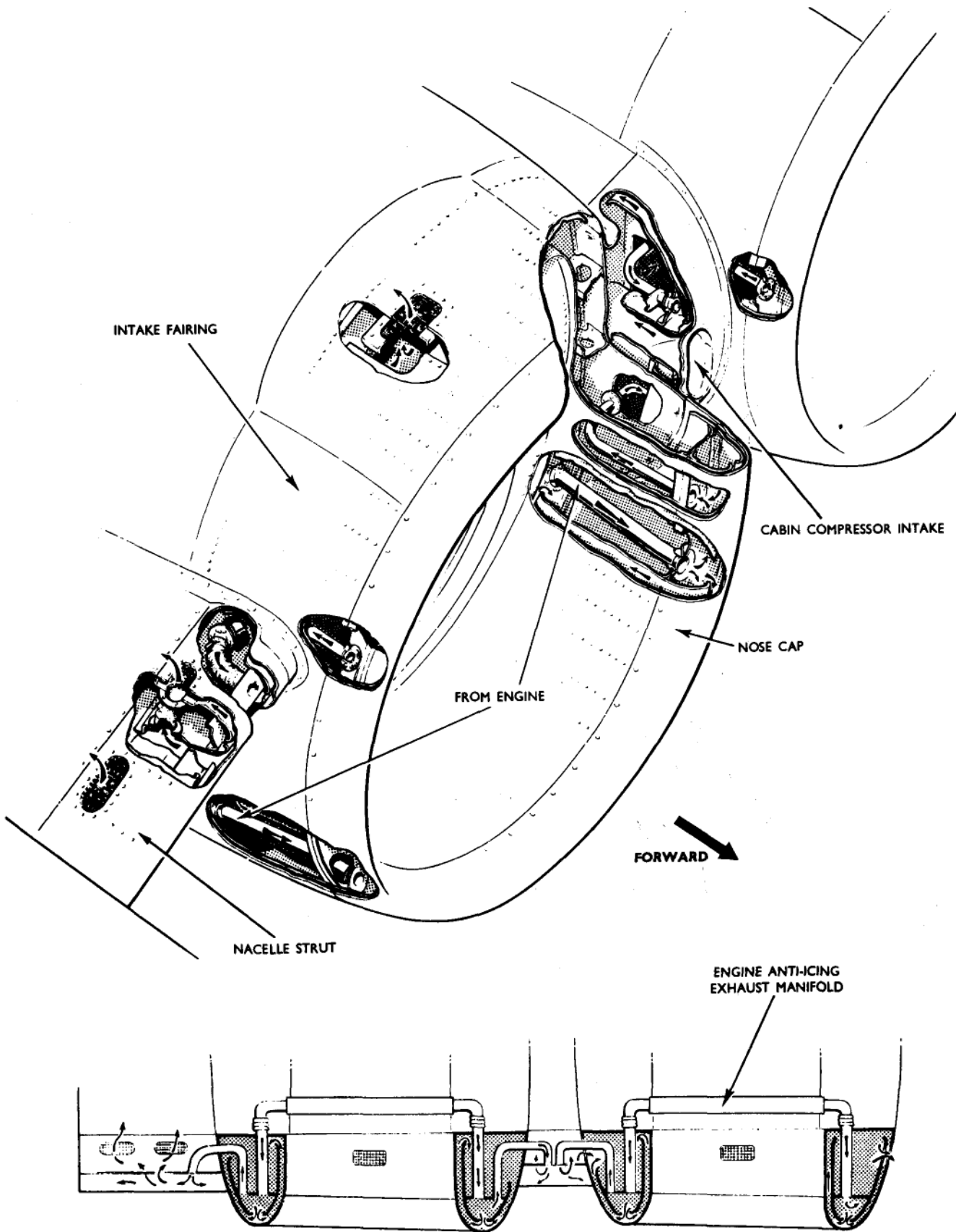
2.12 Fig. 13. Cabin Window Desiccator System



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PIPE TO  
ANTI-ICING  
PRESSURE  
TRANSMITTER

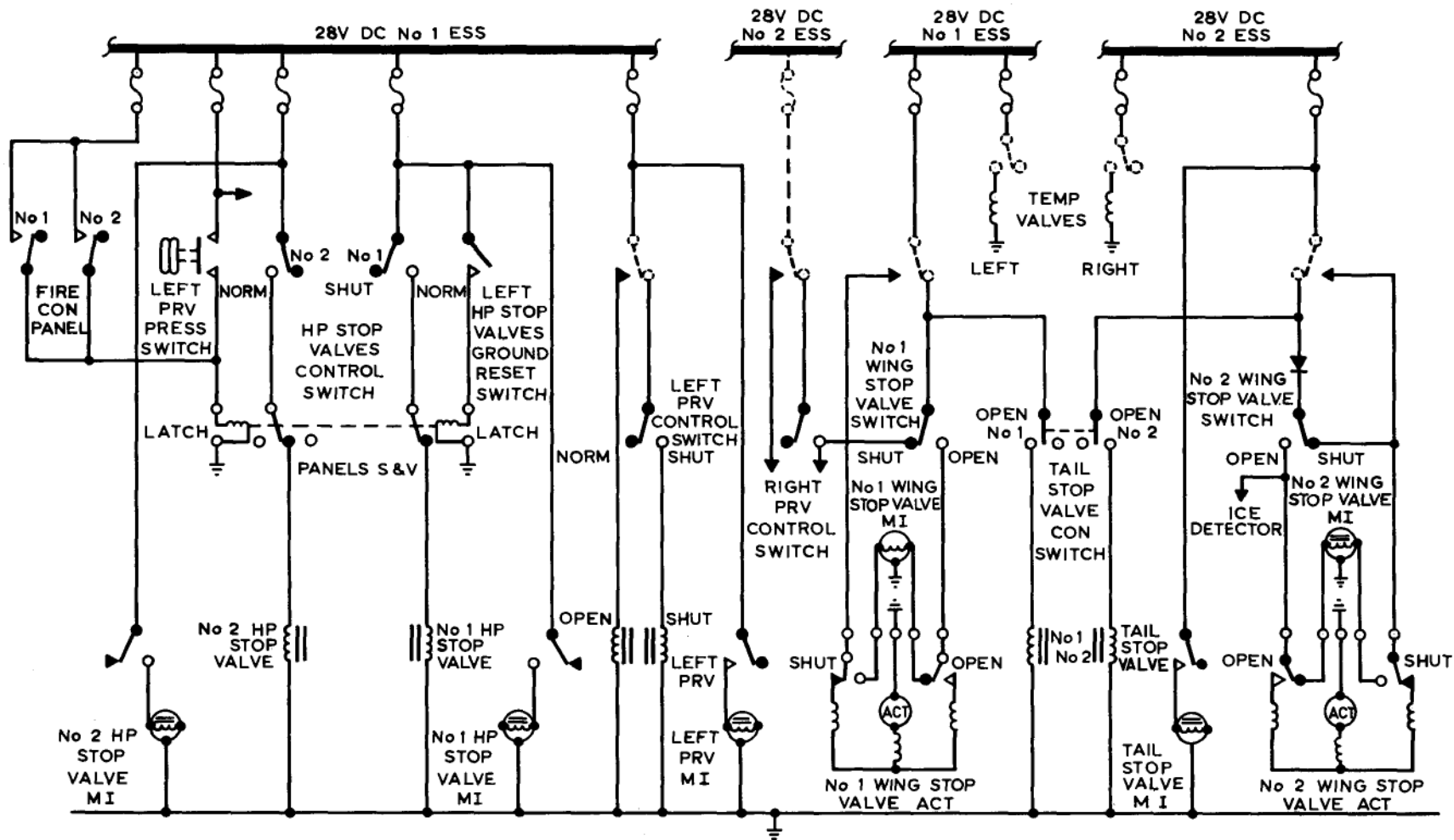
2-12 Fig 14 Engine Anti-icing System



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2-12 Fig 15 Engine Intake and Nose Cap Hot Air Flow

2-12 Fig 16 Airframe Anti-icing System — Electrical Circuit



DOTTED CONTACTS — ENGINE STARTING

VC10/214A



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