Section - III
SYSTEMS DESCRIPTION

Sub-section 11
ICE PROTECTION SYSTEM

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GENERAL

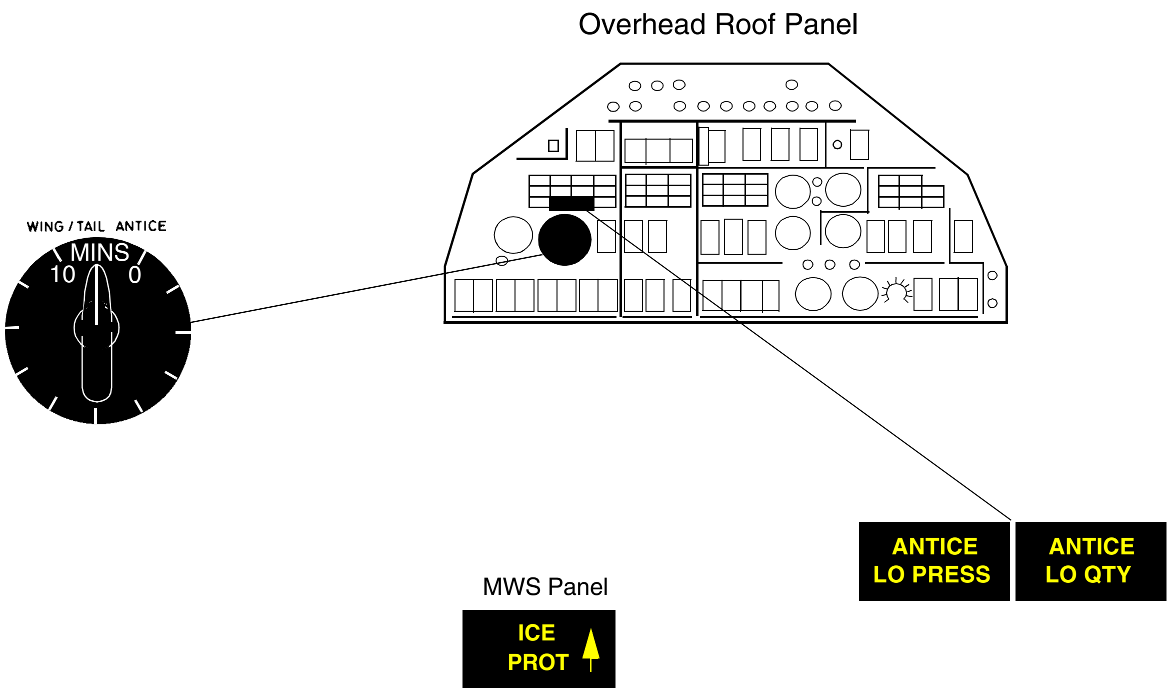
An airframe fluid ice protection system is provided for the leading edges of the wings and the horizontal stabilizers. The system is controlled by a single timer switch. An audio warning is given when the system switches off. Location of components in the vestibule area is shown in Figure 2.

Hot air is used to keep the main engine air intake and starter/generator cooling air intake free of ice with electric heating provided for windscreens, pitot heads, forward static plates and stall vanes, rudder bias struts and engine inlet temperature and pressure sensors Pt_2 and Tt_2.

SYSTEM OPERATION

A WING/TAIL ANTICE timer switch controls an electrically-operated pump for up to 10 minutes. When initially selected, the first minute of operation is at a high flow rate, after which, the system reverts to normal flow. If icing conditions still prevail or are expected, and therefore a further period of operation is required, this should be selected before the timer switch reaches zero.

Using this procedure the system will remain on the normal flow rate, without first delivering a high rate flow and therefore fluid will be conserved. When the timer switch returns to zero, the pump is de-energized and a warning chime sounds via the airplane audio system.



NOTE: At very low temperatures (-28° C or less) ice crystals can exist in the atmosphere, but do not present a hazard. If the airframe ice protection system is used at these low temperatures, the water/alcohol content of the fluid will evaporate, leaving solidified glycol which together with the impinging ice crystals can give the appearance of ice. Use of the airframe ice protection system, under these conditions, is not advisable.

Therefore, operation of the WING/TAIL ANTICE timer switch should be limited to the priming procedures, and additional use in flight only when weather conditions warrant.

De-icing fluid is drawn from the tank through a suction filter to the pump, and then via a pressure filter and check valve to the head compensating valve. The head compensating valve ensures equal fluid pressure at the wings and horizontal stabilizers proportioning units.

Fluid is fed from the head compensating valve to the three proportioning units, one located in each wing, the other between the horizontal stabilizers. A check valve is incorporated in each proportioning unit outlet to prevent back-flow when the system is inoperative. Each proportioning unit splits the main flow down to the requirements of the individual distributor panels. This arrangement makes sure the fluid supply is maintained to the remaining outlets should a pipe become disconnected.

At each distributor panel, fluid is fed through a metering tube into a cavity. From the cavity the fluid passes through a micro-porous plastic sheet and through a titanium outer skin of greater porosity to escape into the atmosphere. Airflow then causes the fluid to spread rearward over the wings and horizontal stabilizer surfaces.

ROTARY-CUTTER ICE DETECTOR (Figure 1)

Formation of ice is detected automatically after takeoff and manual selection of the detector is available for operation on the ground.

Power supplies to the ice detector are fed through the weight-on-wheels switch relay system and controlled by an ICE DET AUTO-OVRD switch. With the switch selected to AUTO, the detector operates when the airplane becomes airborne. Selecting the switch to OVRD by-passes the weight switch relay so that the detector runs on the ground and in flight.

NOTE: The ICE DET switch should be selected to OVRD before taxiing in icing conditions.

The ice detector unit consists of an AC powered motor driving a serrated rotor which rotates in close proximity to a fixed knife-edge cutter.

When ice forms on the rotor, the gap between the rotor and adjacent cutter is filled. The skimming action of the cutter against the ice causes a rise in motor torque which rotates the motor slightly within its mounting. Rotation of the motor actuates a microswitch which connects a DC power supply, via a time delay relay, to illuminate an ICE DETECTED annunciator located on the overhead roof panel. The ice warning is also indicated on the MWS by the illumination of the ICE PROT repeater annunciator.

Pushing an ICE DET TEST button illuminates both annunciators.

The time delay relay maintains the ice warning signal during intermittent rises in motor torque. When ice ceases to form, a spring returns the motor to the normal position, the microswitch opens and after a delay (60 seconds) the warning is cancelled.

WING SPOTLIGHTS (Figure 1)

Two spotlights, one on each wing fairing and controlled by a ICE ON-OFF switch, illuminates the left and right wing leading edges for night visual inspection.

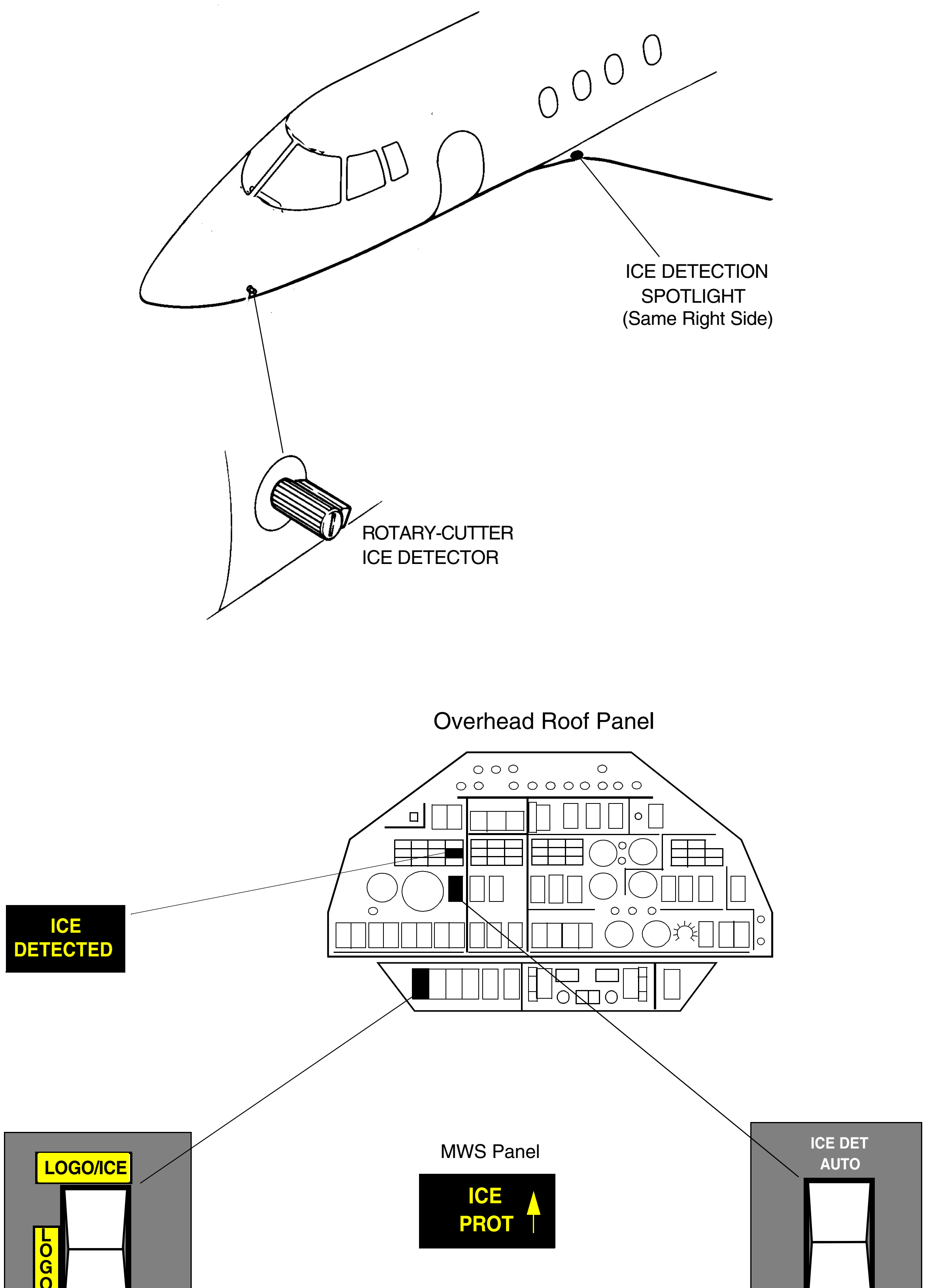


Figure 1
Ice Detection Components

FLUID STORAGE

De-icing fluid for the system is stored in a tank with an approximate capacity of 10.04 gallons (38 liters). For a tank indicating full, priming and protection for at least 85 minutes is provided. The fluid contents indicator on the right side console reads FULL above 8.19 gallons (31 liters), and reads EMPTY when there are approximately 12 minutes protection still available.

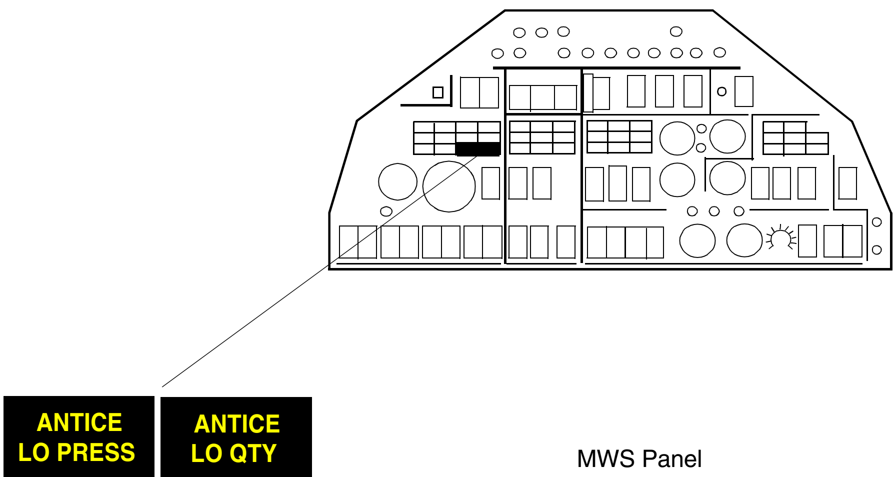
A tank filler cap is accessible from inside the airplane forward of the main entry door. After filling a completely empty system, the vent valve, located below the tank filler, should be pushed for 10 seconds to bleed the pump.

NOTE: The vent valve must not be operated while the pump is running.

Warning Annunciators

With the pump running, system low pressure is indicated by the illumination of an amber ANTICE LO PRESS annunciator on the overhead roof panel and the MWS ICE PROT flashing repeater annunciator.

Overhead Roof Panel



MWS Panel

Fluid low quantity is indicated by the illumination of an amber ANTICE LO QTY annunciator on the overhead roof panel and the MWS ICE PROT repeater annunciator flashing. When these warnings occur, 30 minutes of fluid usage remains.

POWER SUPPLIES

Electrical power distribution to the equipment is as follows:

Rotary-Ice Detector ....Busbar XS 2

Ice Warning Annunciators ....Busbar PS2

Left Wing Inspection Spotlight........................Busbar PS1

Right Wing Inspection Spotlight ....Busbar PS2

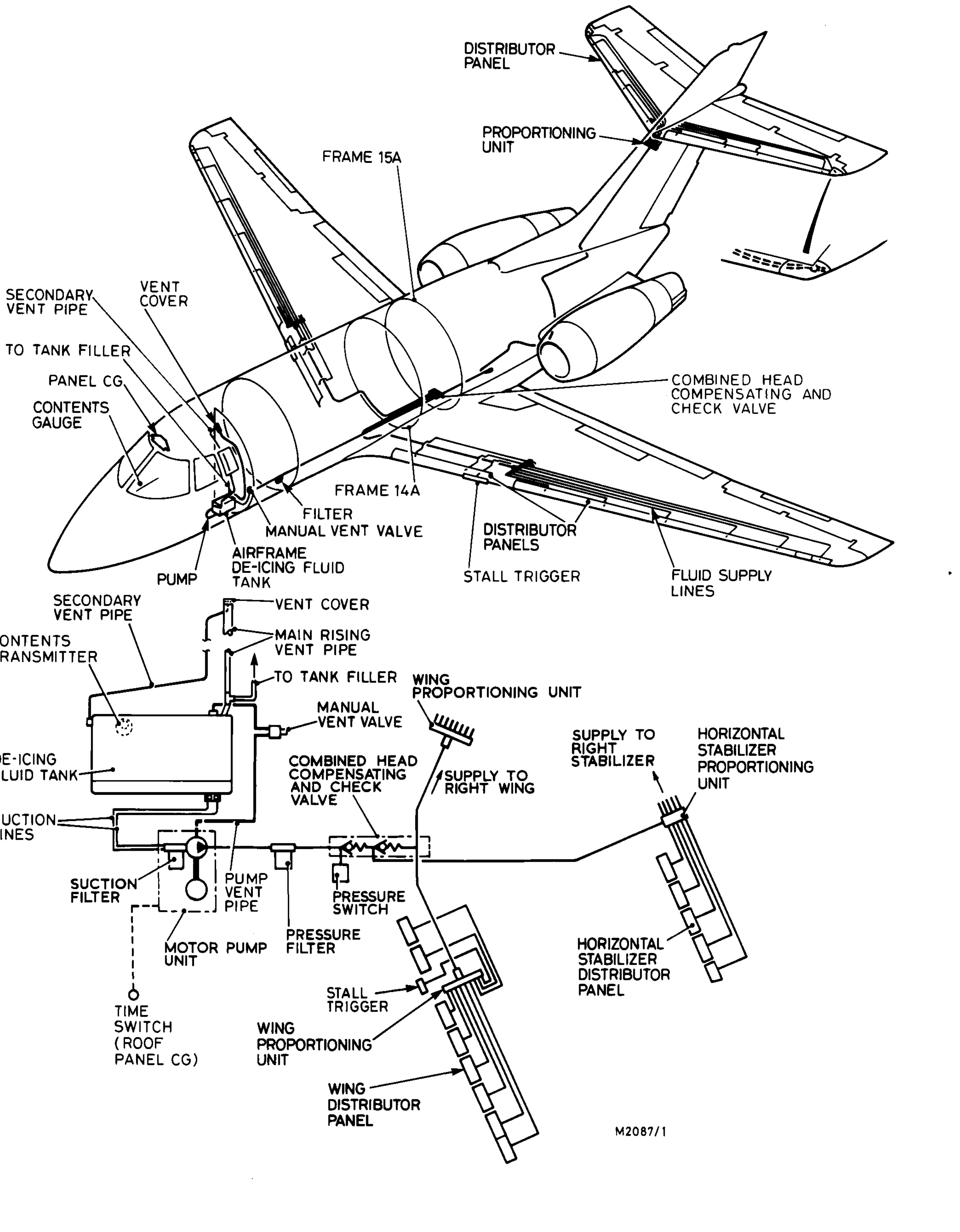


Figure 2
Airframe Ice Protection System

ENGINE BLEED AIR ANTI-ICING

Air is bled from two stages of the engine compressor to provide supplies for:

- Nacelle inlet cowl anti-icing
- Airplane services

An ENG ANTICE ON-OFF switch, located on the roof panel ice protection section, is provided for each engine. With either or both switches selected to ON, an ICE PROT SELECTED annunciator on the MWS panel is illuminated.

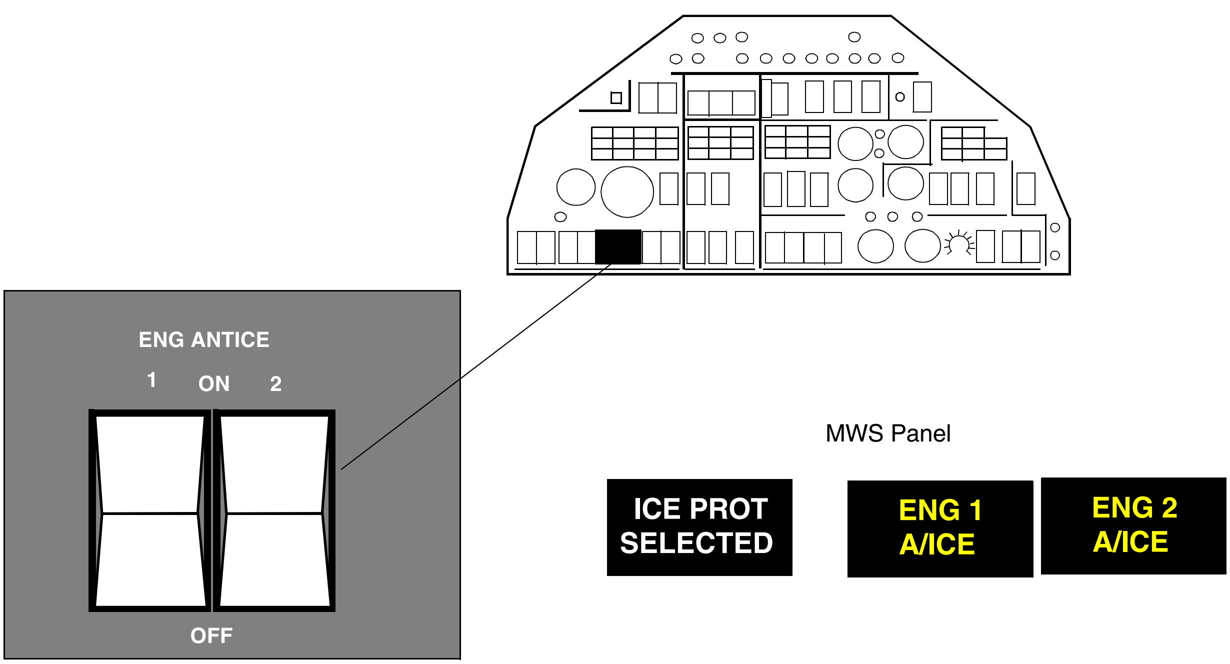
Each switch controls a servo-operated anti-icing on-off valve. When ON is selected, the following events occur:

- The anti-icing valve opens and high pressure air is bled from the HP compressor and ducted forward to anti-ice the nacelle inlet cowl.
- Electrical power is supplied, via the fuel computer switch when set to AUTO, to the Pt_2 and Tt_2 sensor probe heaters located in the inlet.
- In flight, the engine digital computers are reset to a schedule that incorporates a raised idle rpm to compensate for the effect on thrust.
- The temperature provided by the A panel windscreen heating film is raised from the normal setting to ensure adequate anti-icing performance.

Warning Annunciators

With the ENG ANTICE switched ON, low pressure flow into the inlet cowl is detected by a pressure switch set at 6 psi and indicated by the illumination of the MWS annunciators ENG A/ICE and ICE PROT repeater. Full details of the bleed air anti-icing system are contained in Sub-section 2 ENGINES.

Overhead Roof Panel



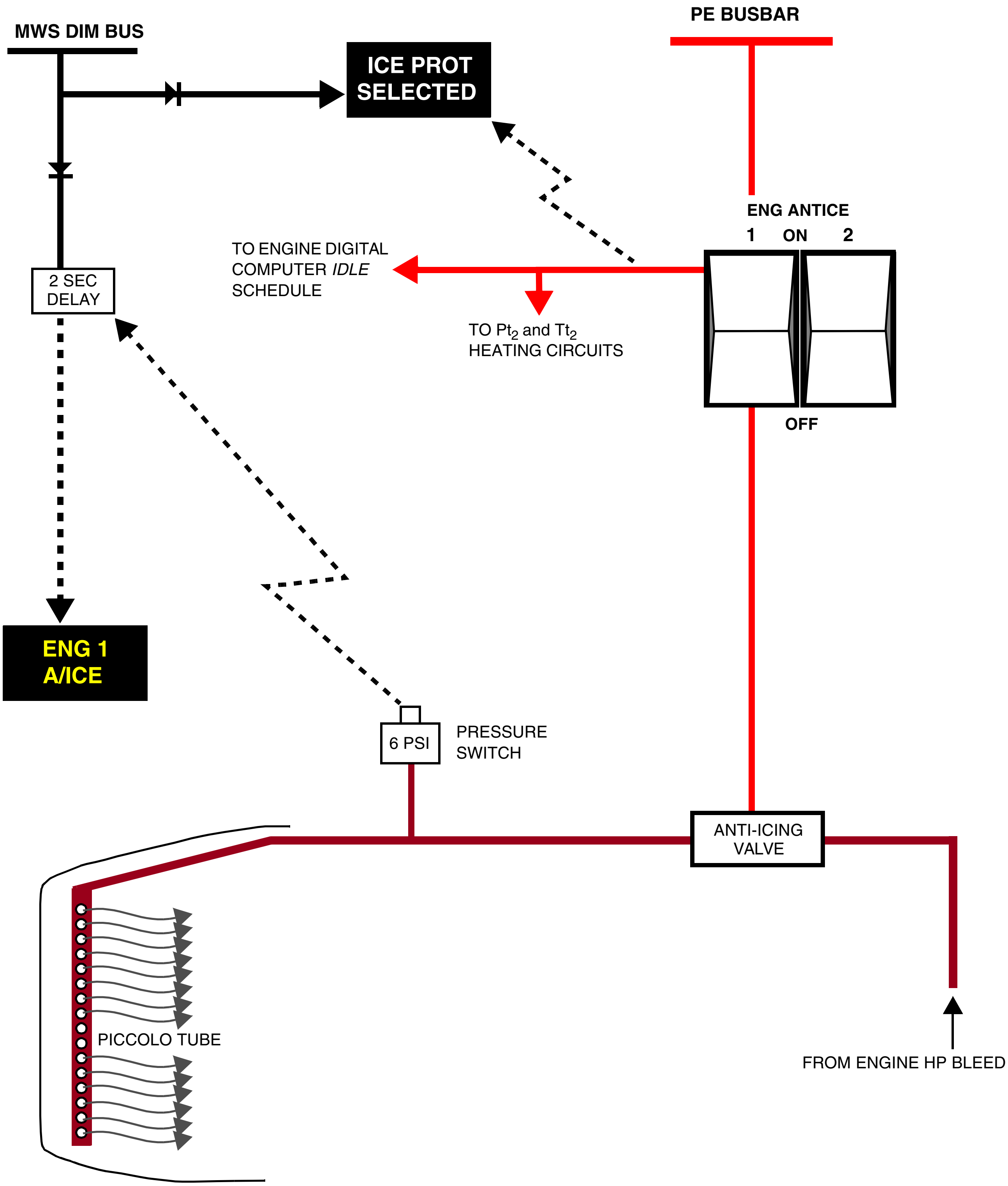


Figure 3
Engine Anti-icing System

ICE PROTECTION - WINDSCREENS

The two forward facing curved windscreens ('A' screens) and the left and right forward sidescreens ('B' screens) are anti-iced and anti-misted by electrical heating.

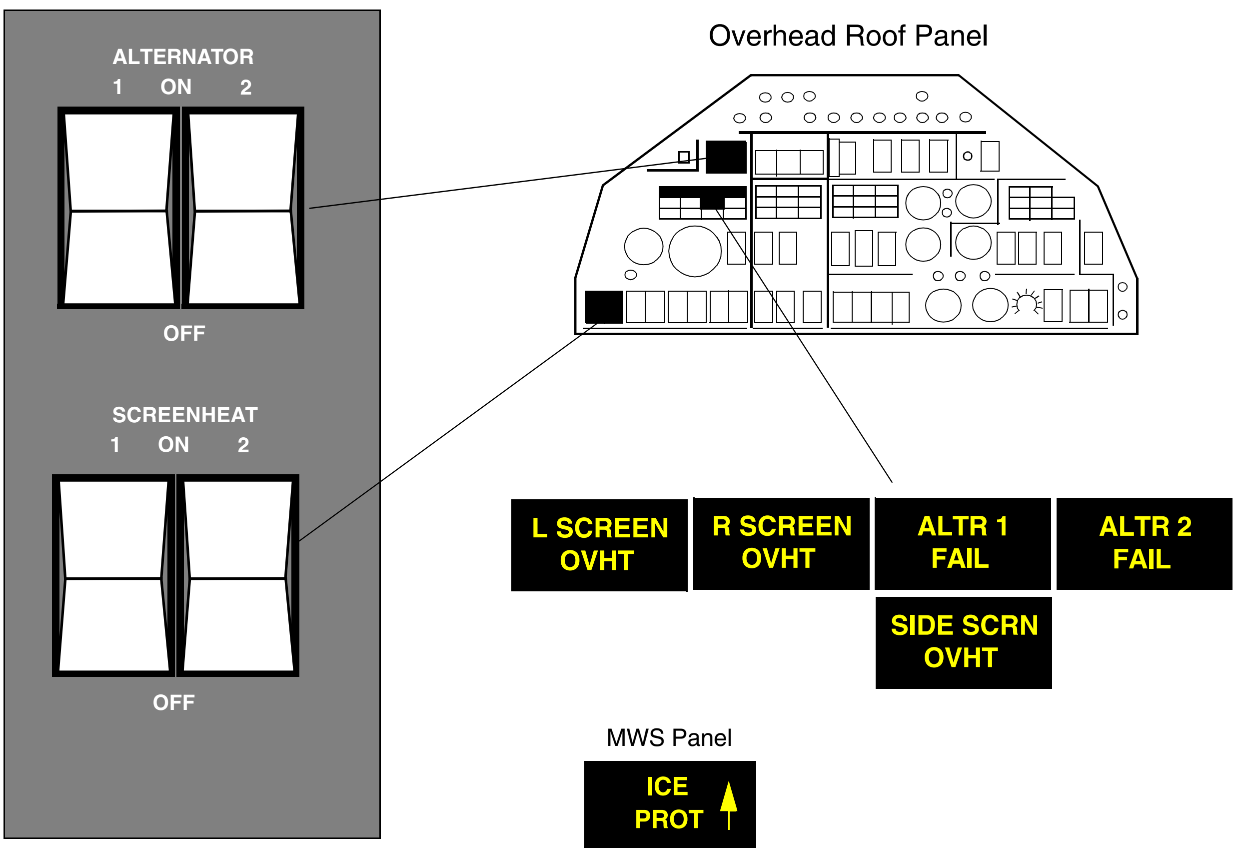
ELECTRICAL HEATING SYSTEM

Power for windscreen and sidescreen heating is supplied from two 208V, frequency wild, three phase alternators, one driven from each main engine. Each alternator is controlled by an associated ALTERNATOR 1 (2) ON/OFF switch. The alternator driven from No. 1 engine normally powers the left windscreen and the right sidescreen; the one driven from No. 2 engine, the right windscreen and the left sidescreen. If an alternator fails, the other automatically supplies both windscreens, but both sidescreens are disconnected. Alternator failure is indicated by the illumination of an associated ALTR FAIL 1 (2) annunciator and the MWS ICE PROT repeater annunciator.

The two forward facing panels of the windshield each incorporate a gold film heating element. Power supplies, from the alternator to the elements, are controlled by SCREEN HEAT ON-OFF switches (L or R). With SCREEN HEAT ON, the panel temperature, detected by integral sensing elements, is regulated by thermal controllers, one for each windscreen.

In the event of overheat occurring in a panel, a related SCREEN OVHT annunciator and the MWS ICE PROT repeater annunciator will illuminate. At the same time, a relay operates to disconnect the power supply to the overheating element.

When the airplane is on the ground or in flight without ENG ANTICE selected, the windshields are heated to a lower temperature setting. In flight, with ENG ANTICE selected, the temperature is controlled at a higher value.



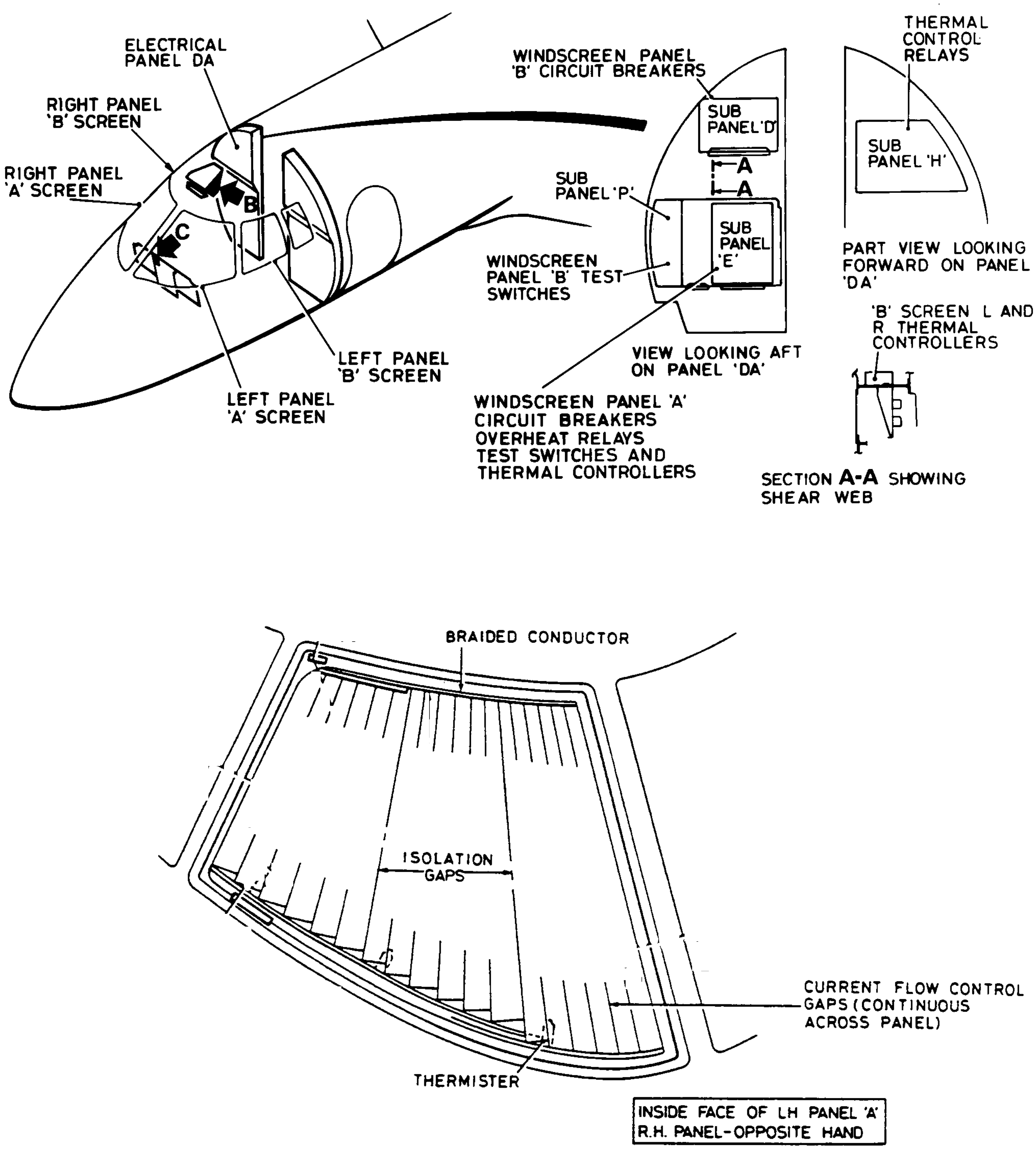


Figure 4
Windscreen Electrical Heating

POWER SUPPLIES

Power distribution to the equipment is as follows:

PE busbar supplies:

- ALTR 1 (2) FAIL annunciators.
- L (R) SCREEN OVHT annunciators.
- SIDE SCRN OVHT annunciator MWS ICE PROT repeater annunciator SCREEN HEAT L ON/OFF control PS2 busbar supplies.
- SCREEN HEAT R ON/OFF control.

No. 1 engine alternator supplies:

- Left windscreen panel heat normal power supply.
- Right sidescreen panel heat supply.

No. 2 engine alternator supplies:

- Right windscreen panel heat normal power supply.
- Left sidescreen panel heat supply.

PITOT, STATIC, RUDDER BIAS STRUT and AIRFLOW ANGLE SENSOR HEATING

Ice protection in the form of electrical heating is provided for the following:

- Two pitot heads, one located each side of the forward fuselage.
- Two forward static plates, one located each side of the nose section.
- Two rudder bias struts, connected to the rudder quadrant.
- Two airflow angle sensors, one located each side of the forward fuselage.

OPERATION

Each pitot head contains an electrical heating element controlled by a PITOT/VANE HEAT L or R ON-OFF switch. Each switch also controls one element of a double element heating muff installed on each of the two rudder bias struts.

L & R PITOT HTR FAIL annunciators illuminate with the MWS ICE PROT repeater annunciator flashing whenever a PITOT/VANE HEAT L or R switch is OFF, or when both switches are ON and the current draw by either pitot head element is insufficient.

Annunciator dimming is via the MWS dimmer.

A single ammeter and a L-R selector switch are provided. Selecting L or R connects the ammeter to the associated pitot head heater circuit. With PITOT/VANE HEAT switched ON for at least 1 minute, readings of between 5 and 10 amps indicate satisfactory operation of the pitot heaters only. Actual power consumption depends on the ambient temperature. The rudder bias heaters are not connected to the ammeter.

The left and right forward static plates are electrically heated. The electrical power supply to the heating element of each static plate is via a relay controlled by the PITOT/VANE HEAT R switch, and the weight switch relay system. Heating is only available when the airplane is in flight.

Ice protection for each airflow angle sensor is provided by a vane heater element, and a case heater element. The case heater element is thermostatically controlled.

The power supply to the heater elements is 115 VAC, and is derived as follows:

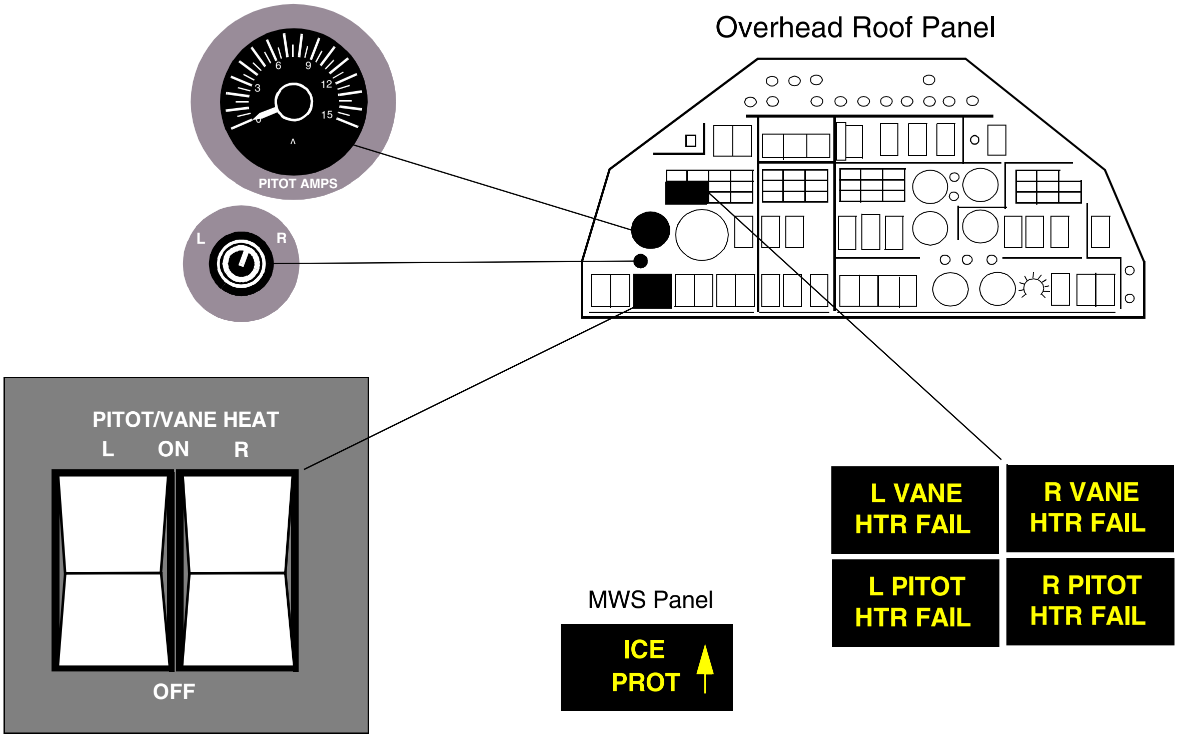
(1) Two windscreen alternators on line: left sensor elements from No. 1 alternator - right sensor elements from No. 2 alternator.

(2) One windscreen alternator off line and No. 1 and No. 2 inverters on line: elements of both sensors from No. 2 inverter.

(3) One windscreen alternator off line, and either No. 1 or No. 2 inverter off line: elements of both sensors disconnected.

The heating elements of each airflow angle sensor are controlled by an associated PITOT/VANE HEAT L or R switch.

A vane heater failure is indicated by the lighting of an associated L or R VANE HTR FAIL annunciator, and the MWS ICE PROT repeater annunciator.



POWER SUPPLIES

DC power supplies to the pump and chime unit are taken from busbar PS2. Supplies to the ANTICE LO PRESS, ANTICE LO QTY annunciators and the MWS ICE PROT repeater annunciator is taken from busbar PE.

The fluid contents indicator is supplied from busbar PE when the airplane is on the ground, and busbar PS2 when in flight. Switching of power supplies is controlled by a weight-on-wheels microswitch.