CHAPTER 10

ICE AND RAIN PROTECTION

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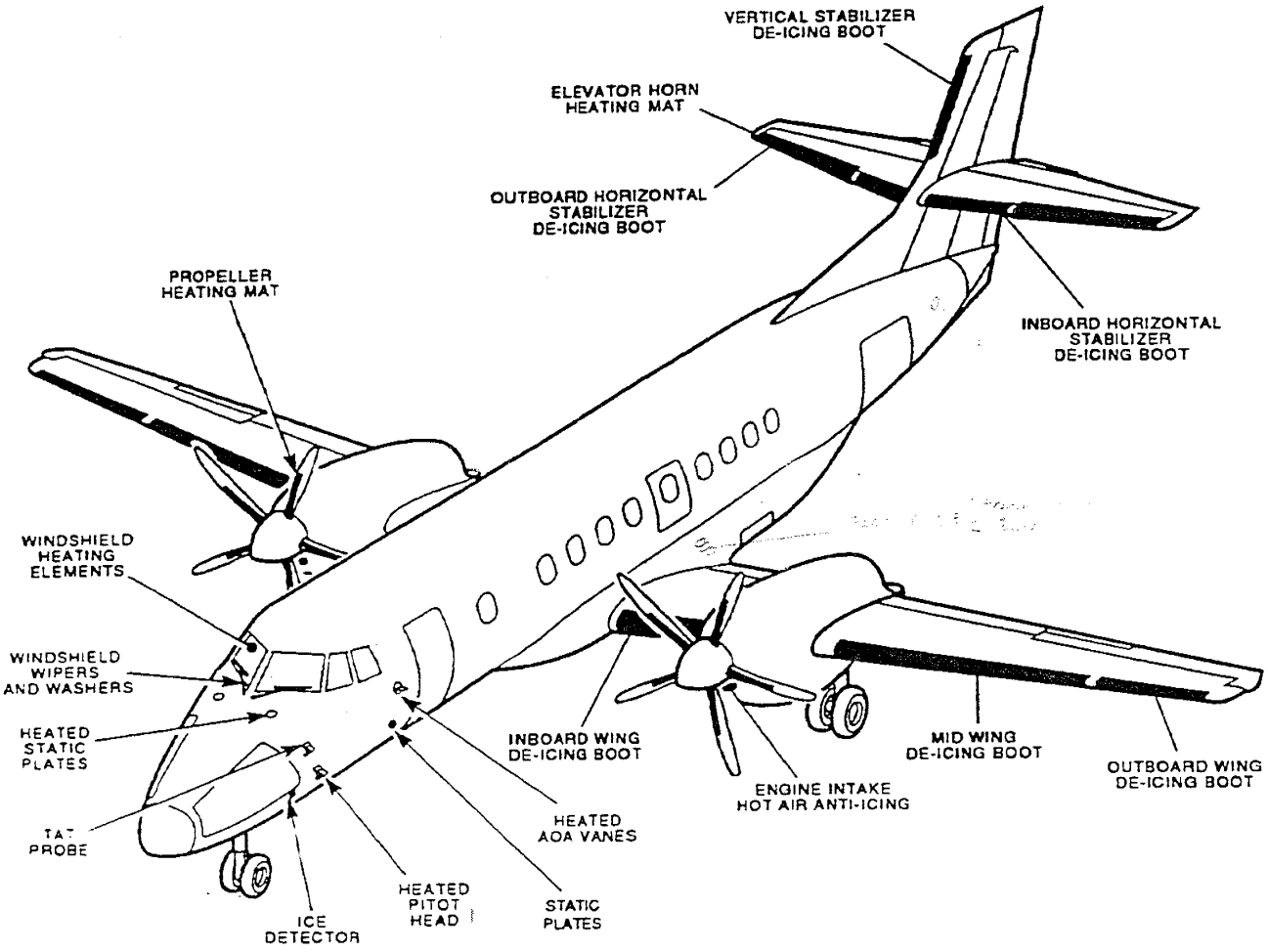

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CHAPTER 10

ICE AND RAIN PROTECTION

General Description

The aircraft is protected against ice and rain by the following systems:

Airframe de-icing	Pneumatic rubber boots on the leading edges of the wings horizontal and vertical stabilisers
Engine anti-icing	Engine bleed-air
Propeller de-icing	Electrically operated heater mats
Elevator horn anti-icing	Electrically operated heater mats
Air data system anti-icing	Electrically heated sensors
Windshield anti-icing	Electrically energized elements of indium trioxide
Windshield	Wipers
Windshield	Washers.

An ice detector is installed to the lower, left side of the forward fuselage to allow monitoring of ice build-up during the operation of the aircraft.

The ice detector incorporates a vibrating element which operates continuously when the right essential busbar of the aircraft is energized, and no-ice conditions prevail. The formation of ice on the vibrating element causes the movement of the element to stop. This causes the CAP [ICE DETECT] (amber) caption to come on.

The ice warning signal is energised for a minimum duration of 60 seconds. Simultaneously with the initiation of the ice warning signal, the ice detector de-ices itself by means of internal heaters, and is reset to sense ice formation again within approximately 7 seconds. If ice accretion is detected before the 60 second timed cycle has elapsed the ice warning signal will remain energised and the ice detector will begin a new 60 second timed cycle of de-icing/sensing.

The ice warning output will only be de-energised when the ice detection system has completed a 60 second timed cycle without detecting further ice accretion

A fail relay in the ice detector system also causes the CAP [ICE DETECT] (amber) caption to come on if a failure of the ice detector occurs

An ice observation light is installed in the outboard side of each engine nacelle cowling to allow in-flight observation of ice build-up. The lights are controlled by a switch on the roof panel labelled ICE OBS ON/OFF.

1. Airframe De-icing System

The airframe de-icing system consists of pneumatic rubber boots on the leading edges of the wings, horizontal and vertical stabilisers. Ice accretion on the leading edges is removed by inflating the rubber boots with pressure regulated engine bleed-air.

A. System Description

The airframe de-icing system is supplied with High Pressure (HP) and high temperature air from the HP bleed-air system of both engines.

The HP bleed-air output is regulated to 21.5 psi (±1) by pressure regulating valves installed in each engine nacelle. A pressure relief valve, installed in the Low Pressure (LP) manifold, will maintain the system pressure below 27 psi in the event of a pressure regulator failing in the fully open position.

Regulated bleed-air from each engine is connected to the LP manifold. The bleed-air supplied from a single engine is sufficient to satisfactorily operate the airframe de-icing system. Non-return Valves (NRV) ensure the bleed-air from a single engine is not lost through an unserviceable system or one that is not in operation.

Air from the LP manifold is also used for the passenger door seal, cabin pressurisation system jet-pump and hydraulic-reservoir pressurisation system.

Three solenoid operated Ejector Flow Control Valves (EFCV) are supplied with air from the LP manifold. When the airframe de-icing system is OFF, each EFCV solenoid is de-energised. In this condition the EFCVs provide the necessary vacuum to keep the de-icing boots in the deflated condition. The outlet pipe of each EFCV is exhausted to atmosphere through the fuselage ventral pod.

When an EFCV solenoid is energised, pressure regulated air is passed through pipes to the related de-icer boot. The air inflates tubes in the de-icer boot which causes the boot to expand.

De-icer boots are located:

- Outboard wing* (left and right)
- Mid wing* (left and right)
- Inboard wing (left and right)
- Outboard horizontal stabilizer* (left and right)
- Inboard horizontal stabilizer* (left and right)
- Vertical stabiliser.

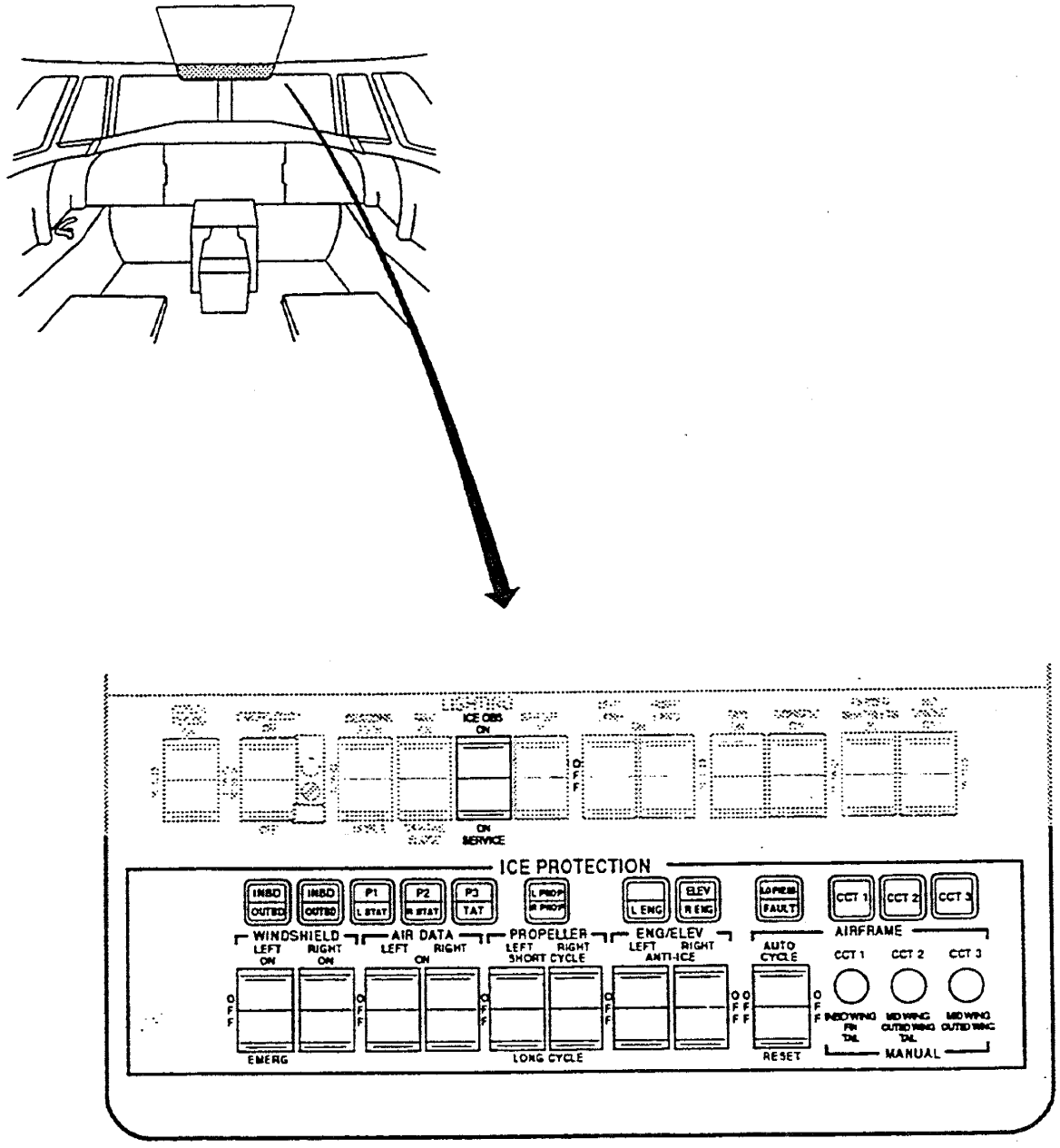
*The horizontal stabilizer, outboard wing and mid wing boots are of the clamshell type; having separate inflatable upper and lower clamshell surfaces.

The boots are connected to the EFCVs as follows:

EFCV 1 Inboard wing RH and LH
Fin
Outboard tail plane de-icer boot upper surface RH and LH
Inboard tail plane de-icer boot lower surface RH and LH.

- EFCV 2 Outboard wing RH and LH upper surfaces
Outboard tail plane de-icer boot lower surface RH and LH
Inboard tail plane de-icer boot upper surface RH and LH
Mid wing RH and LH lower surfaces.
- EFCV 3 Outboard wing RH and LH lower surface
Mid-wing RH and LH upper surfaces.

A pressure switch downstream of each EFCV operates at a pressure of 17 psi (± 1). When a pressure switch operates, a green caption in the roof panel comes on. This is to show the pressure supplied to the related boot is sufficient for correct operation. The captions CCT 1 CCT 2 and CCT 3 relate to the boots of the similarly numbered EFCV. A low pressure switch in the LP manifold operates when a decrease in pressure occurs. The switch operates at 15 psi (± 1) and causes a LOPRES (amber) caption in the roof panel to come on.



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Ice and Rain Protection-Roof Panel

B. Control and Indication

The airframe de-icing system is controlled manually from the flight deck by switches in the roof panel.

Switches in the roof panel control the operation of the de-icing boots. The AIRFRAME switches are labelled AUTO CYCLE/OFF/RESET, CCT 1, CCT 2 and CCT 3. The AUTO CYCLE/ RESET switch is a rocker switch spring loaded to the centre OFF position. The CCT switches are push button. Listed below each CCT switch is the section of the airframe de-icing system operated by the switch.

When the AUTO CYCLE/RESET switch is set to AUTO CYCLE, two full cycles of the de-icing boots occur. A timer switch controls the AUTO CYCLE operation and the order in which the boots operate is as follows:

- CCT 1 - 6 seconds
- CCT 2 - 6 seconds
- CCT 3 - 6 seconds.

A second cycle occurs immediately and then OFF.

During the cycle of operation green captions above the CCT switches come on. 17 psi pressure switches in each of the three circuits control the operation of these captions. The captions read [CCT 1] [CCT 2] [CCT 3] as the pressure switches operate.

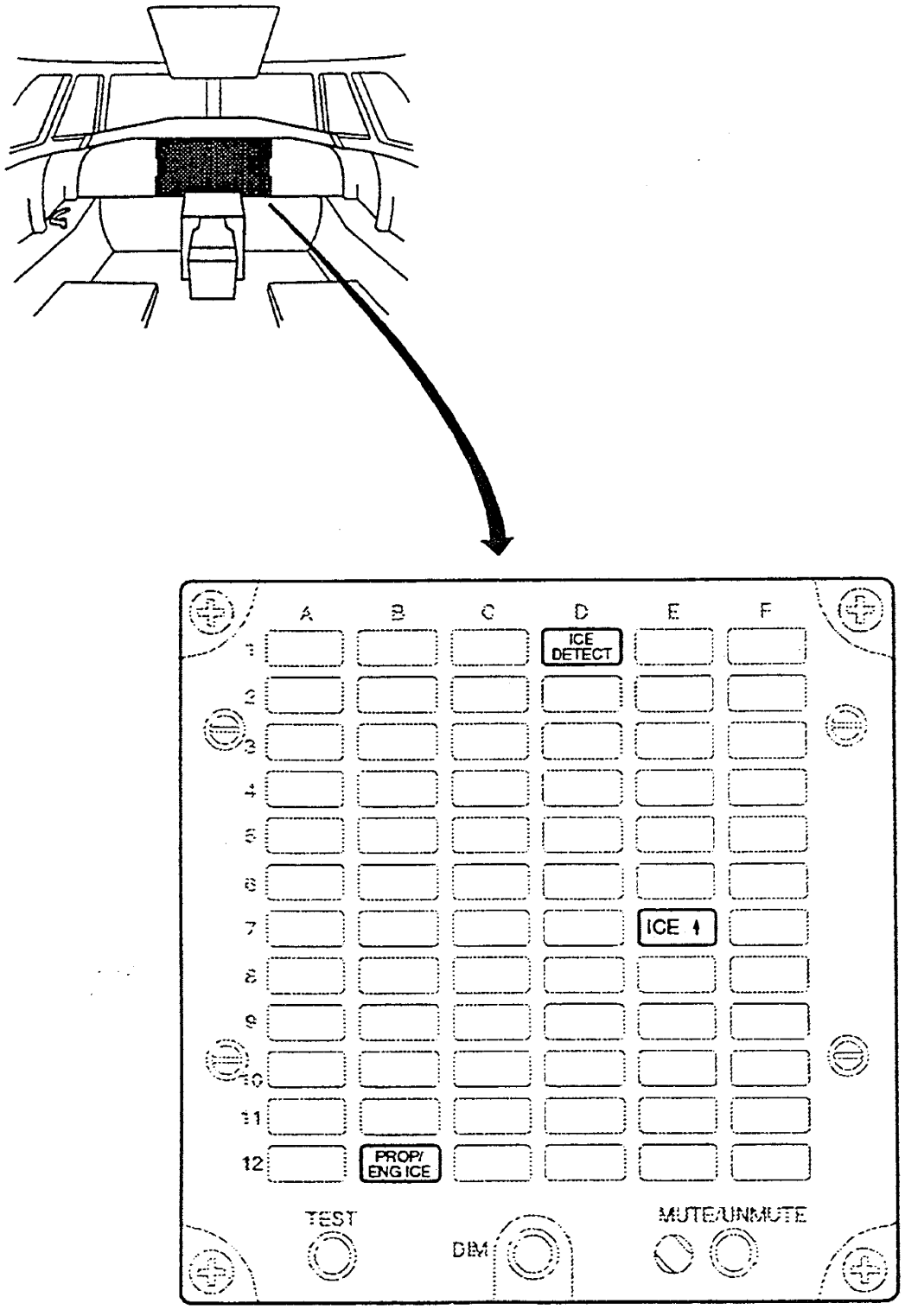
The AIRFRAME, CCT 1, CCT 2 and CCT 3 switches permit each group of de-icing boots to be independently operated. When a CCT switch is operated regulated bleed-air flows through the related EFCV to the boots. This bleed-air will operate the applicable 17 psi pressure switch and cause the related caption to come on.

The boots remain inflated while the CCT switch is in the on position. They deflate when the switch is released to the off position.

C. Warning Indications

If the bleed-air pressure in the LP manifold is less than 15 psi a pressure switch operates. This causes the [LO PRES] (amber) caption in the roof panel and the CAP [ICE ↑] (amber) caption to come on.

A fault in the AUTO CYCLE timer or the failure of an EFCV to open/close within 4 seconds of selection will cause a [FAULT] (amber) caption in the roof panel to come on. The fault caption is latched but can be reset by the AUTO CYCLE/RESET switch in the roof panel.



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Ice and Rain Protection-CAP

2. Engine Anti-icing

Anti-ice protection is provided for the engine intake cowl, compressor intake and P2 probe. The system uses engine HP bleed-air which is sent continuously to the inlet anti-ice shield. The HP bleed-air is also supplied to an anti-ice valve.

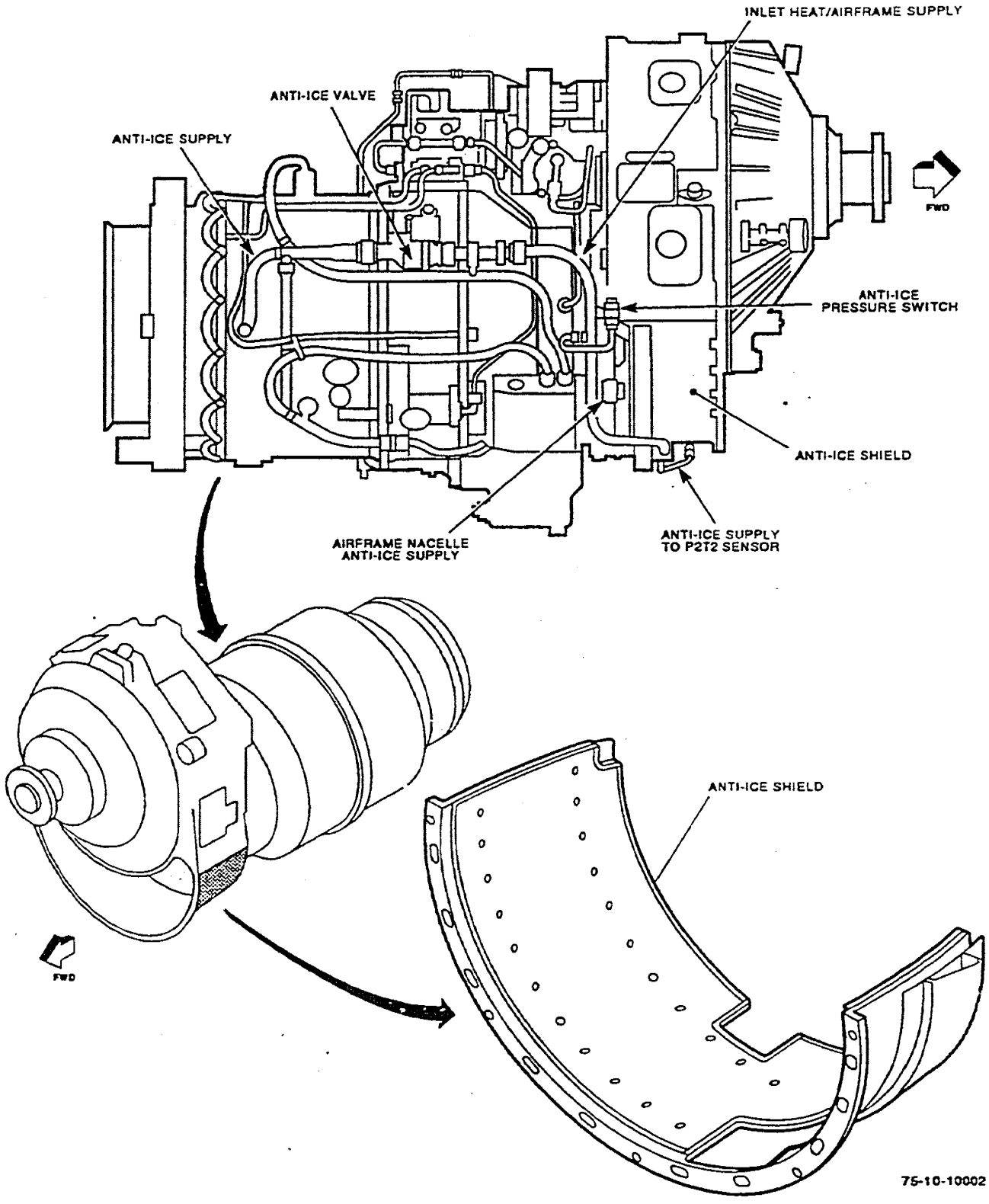
A. Control and Indication

Two switches in the roof panel labelled ENG/ELEV, LEFT/RIGHT, ANTI-ICE/OFF control the anti-ice valve. When the switches are set to ANTI-ICE the valves are opened and hot air circulates through the engine intake cowling-ducts. Warm air is also circulated round the P2 intake probes. The system is designed to ensure that the heat is sufficient to prevent ice forming on the probe but does not affect the air-pressure measured and transmitted by the probe. The switches also control the electrical power supply to the ELEVator horn heater mats through the weight-on-wheels switch.

Selection of ENG/ELEV ANTI-ICE will cause a CAP [PROP/ENG ICE] (green) caption to come on. If an ENG/ELEV switch is set to ANTI-ICE and the anti-ice valve fails to open a CAP [ICE] (amber) caption comes on. A [L ENG] or [R ENG] (amber) caption in the roof panel will indicate which engine anti-ice valve has failed.

B. Engine Continuous Ignition and Auto Relight

The engine continuous ignition and auto relight systems are described in Chapter 6-Engines.



Engine Anti-Ice System

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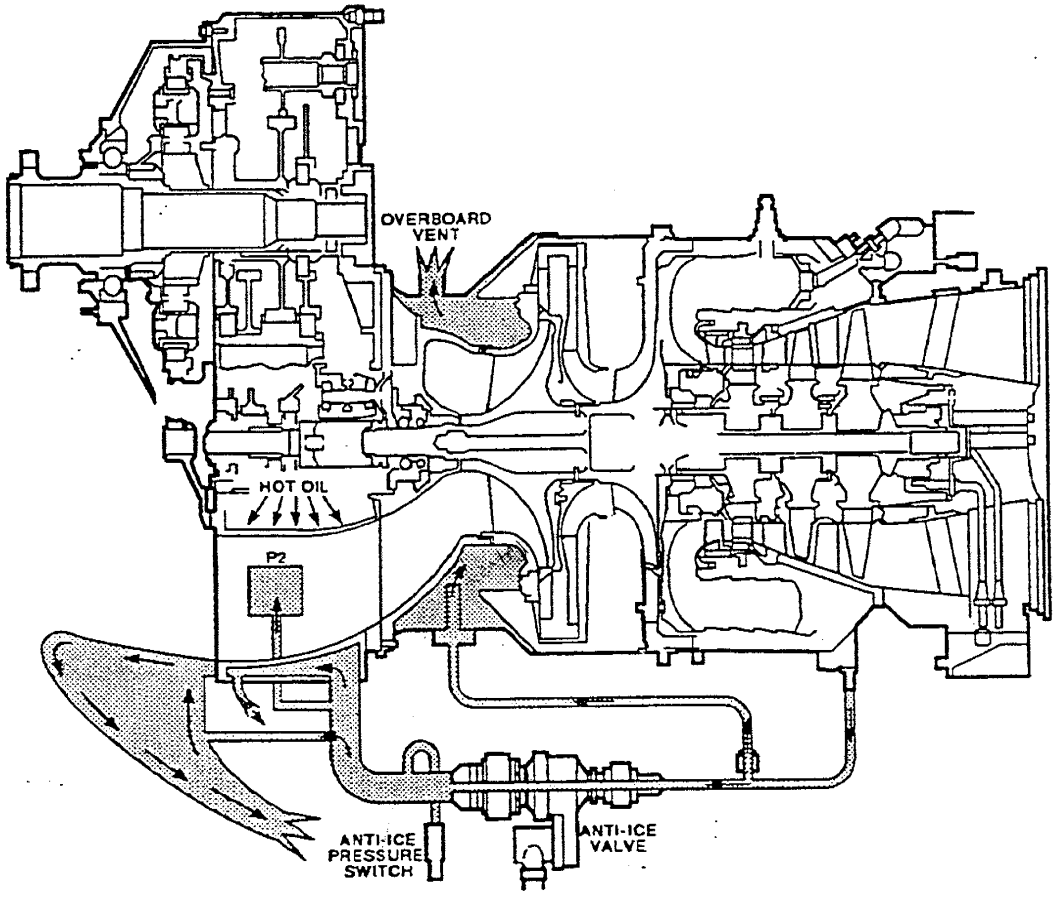

Heated

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Engine Anti-Ice

3. Propeller De-icing

Each propeller blade incorporates a two-element electrically powered de-ice mat.

DC electrical power is supplied to the mats through a brush block and slip ring assembly on the propeller back plate. The dc supply is controlled by electronic timers, and switches on the roof panel.

A. Control and Indication

The control switches are labelled PROPELLER LEFT/RIGHT, SHORT CYCLE/OFF/LONG CYCLE and are located on the roof panel.

The inner and outer propeller blade mats are energised alternately for 35 seconds (SHORT CYCLE) or 70 seconds (LONG CYCLE). The short cycle is used in icing conditions when the Total Air Temperature (TAT) is -5° C or warmer. The LONG CYCLE is used in icing conditions colder than -5° C TAT.

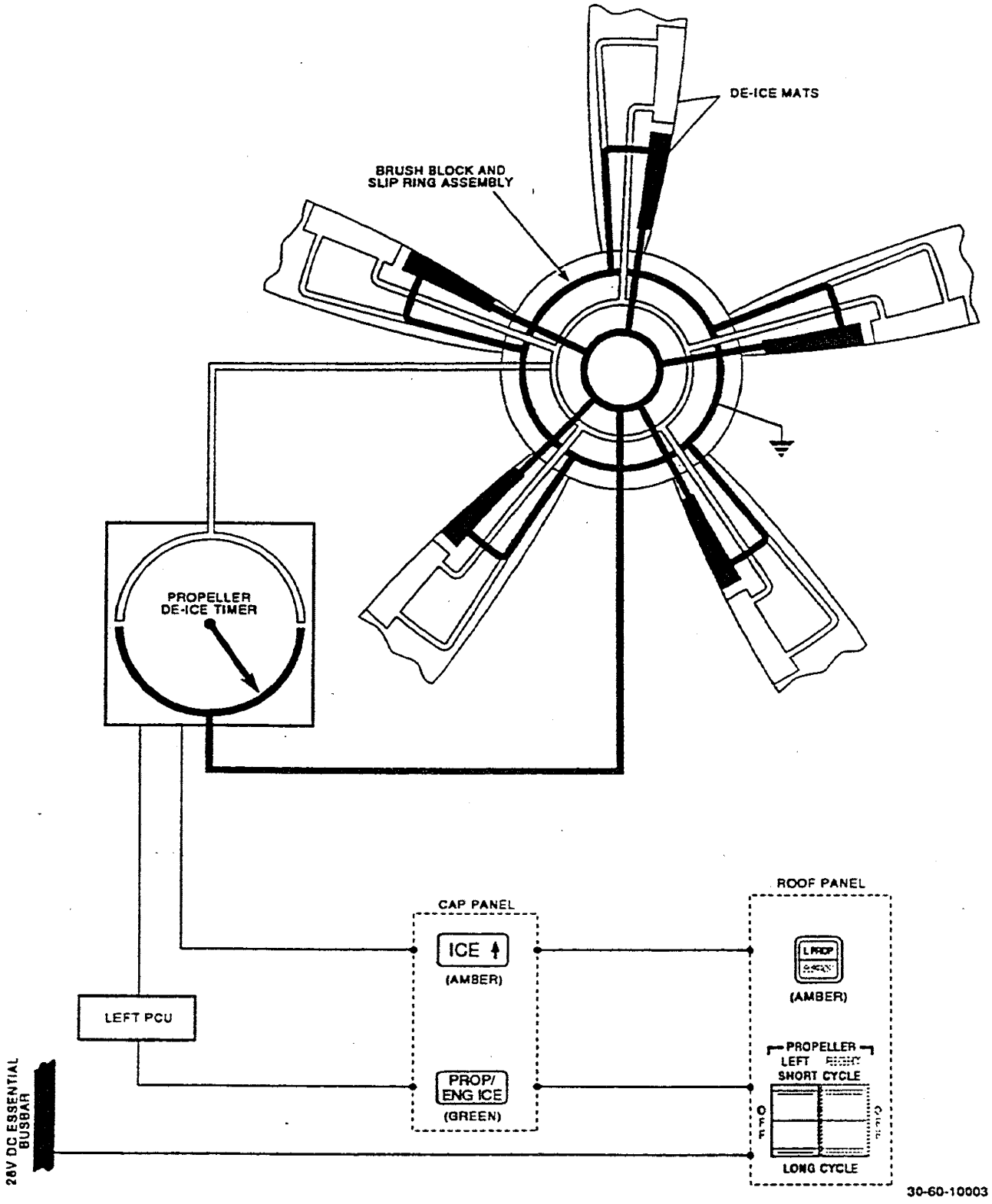
Selection of the LEFT or RIGHT PROPELLER ice protection system to on causes the CAP [PROP/ ENG ICE] (green) caption to come on.

Current sensors in the electronic timer of each propeller sense supply current failures in the system. If a current failure occurs the CAP [ICE] (amber) caption and the related [L PROP] or [R PROP] (amber) caption in the roof panel will come on.

A failure within the electronic timer itself will cause the same captions to come on as the current sensors.

B. Airframe Protection

The area of the fuselage in line with the propeller is strengthened to avoid damage to the fuselage caused by ice being shed from the propellers.



Propeller De-Ice Schematic

4. Elevator Horn Anti-icing

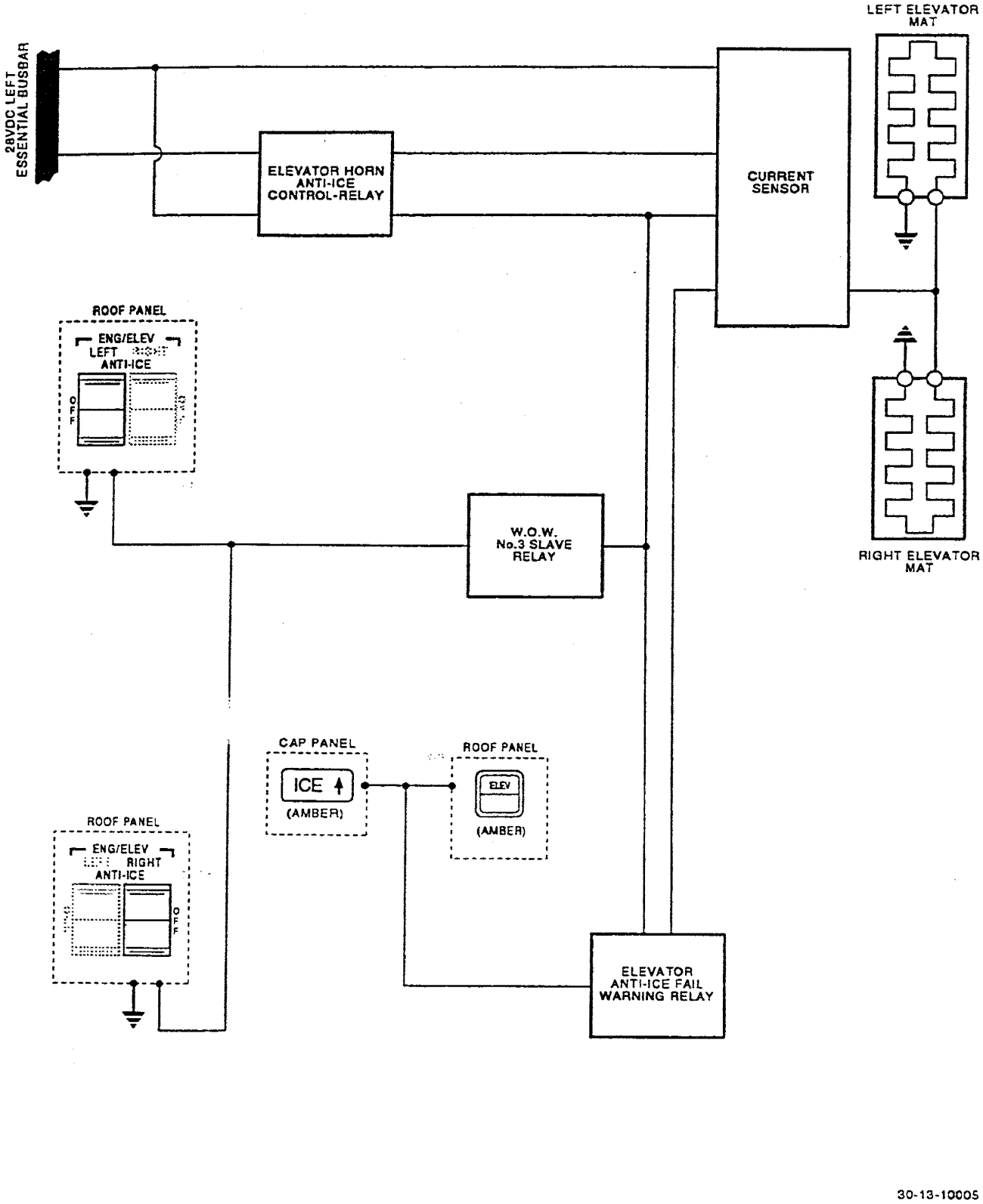
Protection against the formation of ice on the elevator horns is provided by electrically powered anti-ice heating mats.

A. Control and Indication

The two ENG/ELEV switches in the roof panel control the supply of power to the elevator horn heating mats. The power supply is also controlled through the main landing gear weight-on-wheels switches. This is to prevent heat damage to the mats while the aircraft is on the ground.

NOTE: When either ENG/ELEV switch is set to ANTI-ICE the CAP [PROP/ ENG ICE] (green) caption comes on.

The supply current to the heaters is monitored continuously. Failure of one or both elements causes the CAP [ICE] (amber) caption and the [ELEV] (amber) caption in the roof panel to come on.



Elevator Horn-Schematic

5. Air Data System Anti-icing

Protection against icing of the pitot heads, stall vanes, TAT probe and static vents (S1, S2, ~~S3~~) is provided by dc electrical heaters.

A. Control and Indication

Two switches installed in the roof panel and labelled AIR DATA, LEFT, RIGHT, ON/OFF, control the supply of power to the heaters.

NOTE: TAT probe heating also requires the L/H oleo weight on wheels switch to be in the flight position.

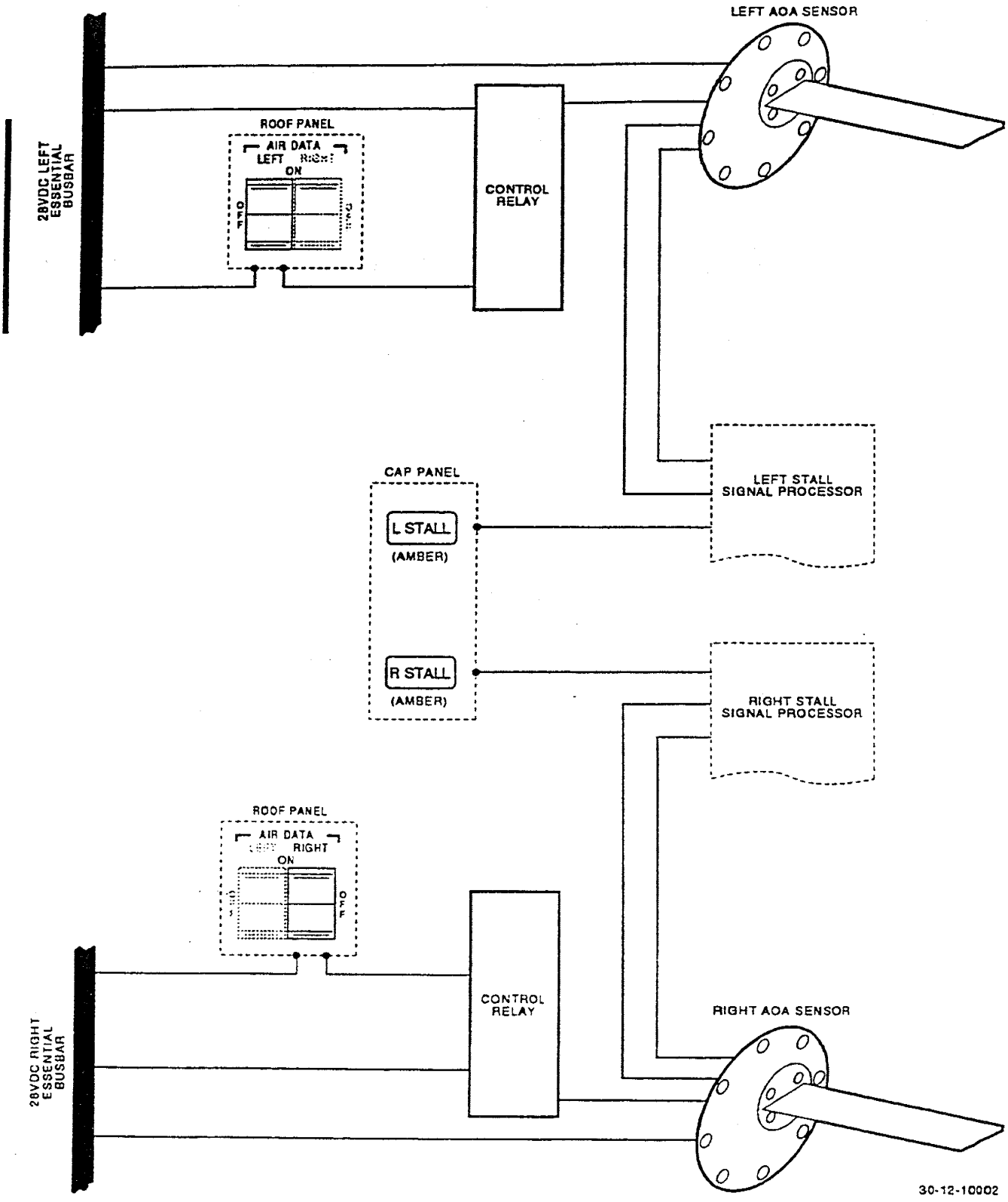
Current sensors are installed in the TAT probe, pitot heads and static vents.

These sensors cause the related P1 L STAT, P2 R STAT or P3 TAT (amber) caption in the roof panel to come on if a heater failure occurs.

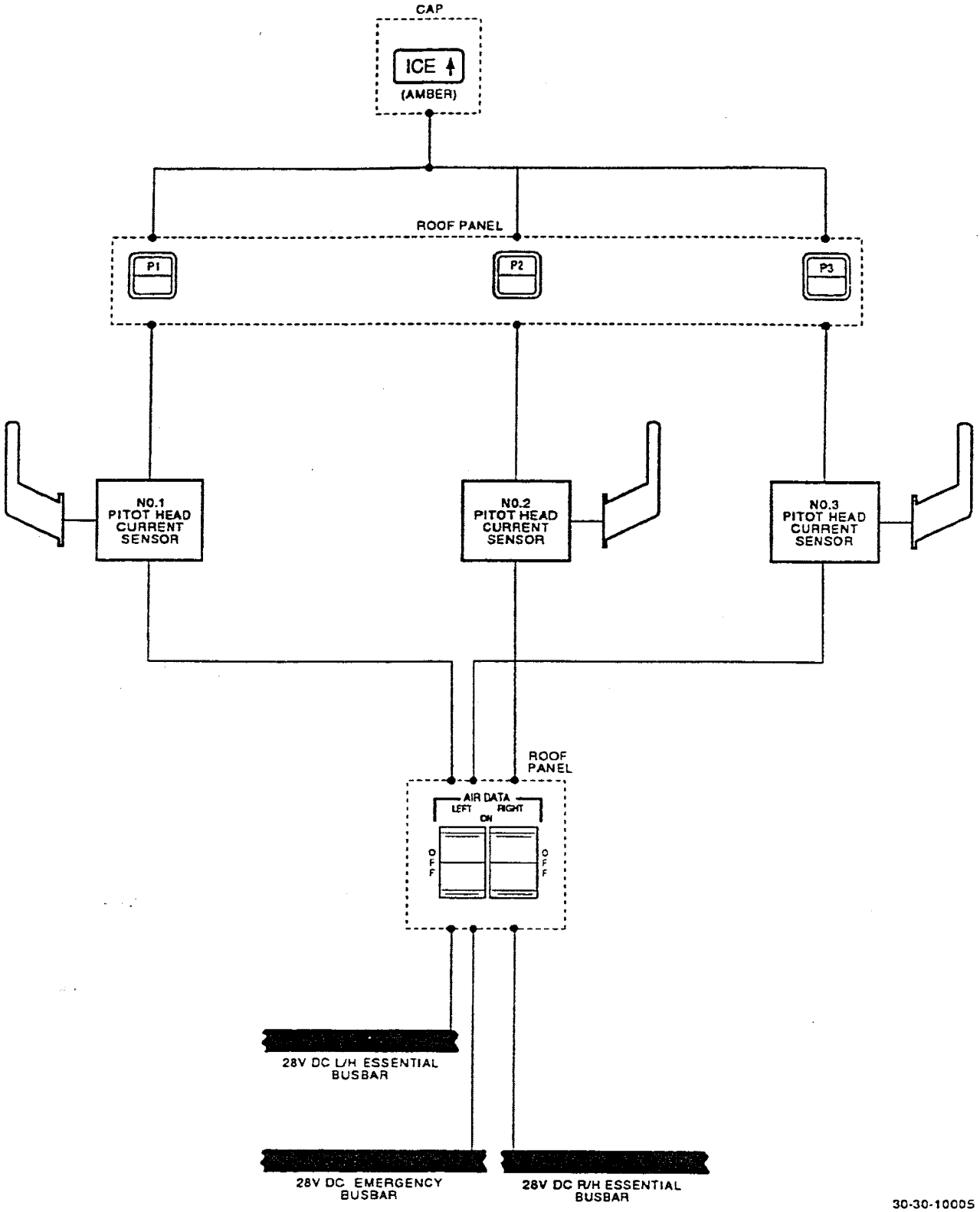
The captions, except TAT, will also come on if the AIR DATA switches are set to OFF. The TAT caption will only come on in flight.

A failure of a stall vane heater causes a CAP L STALL or R STALL (amber) caption to come on.

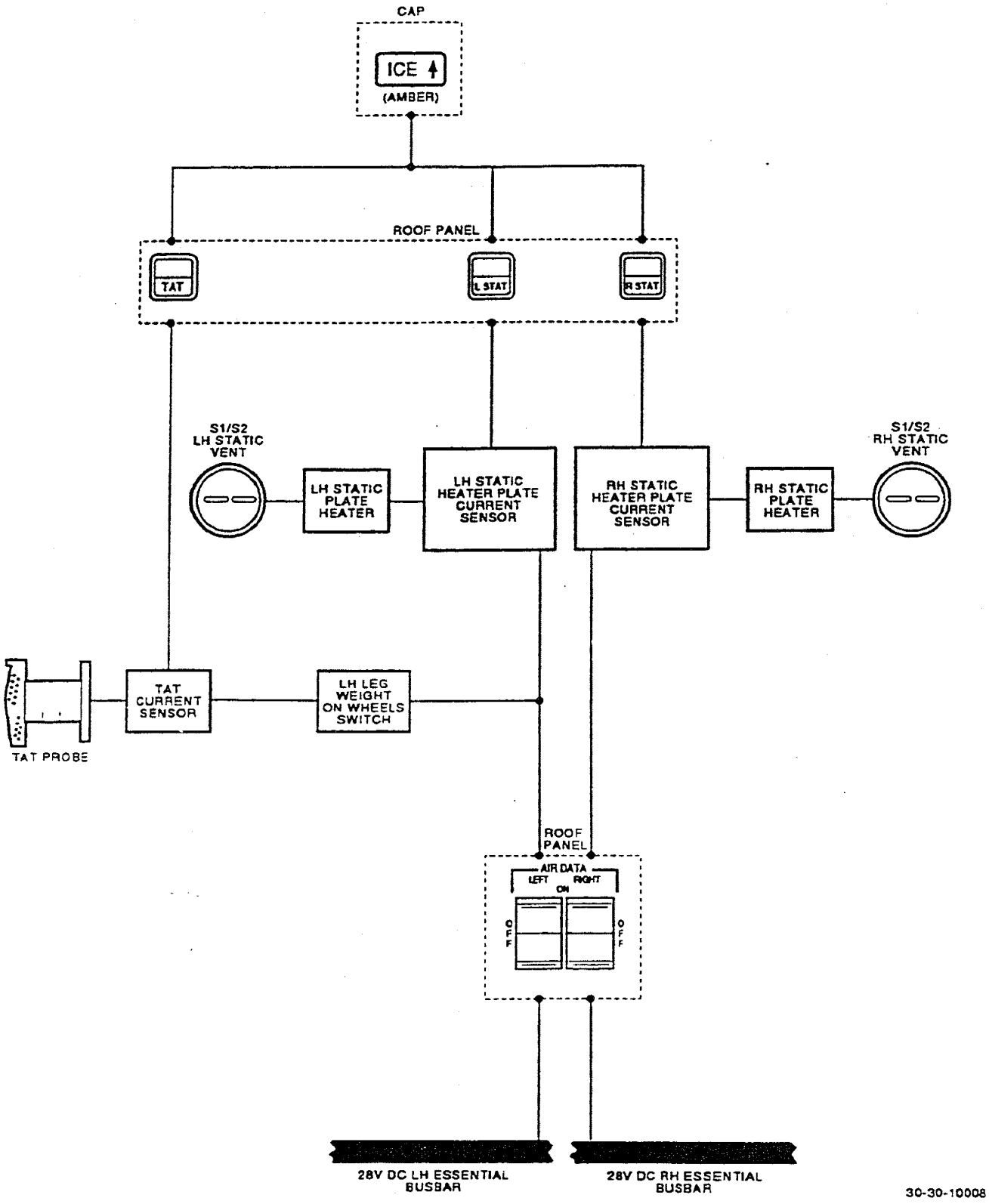
The CAP ICE (amber) caption will come on with an Air Data System Anti-icing heater failure or if the AIR DATA switches are set to OFF.



ADS Anti-Ice Schematic



Pitot Anti-ice



Static Anti-ice

6. Windshield Anti-icing

Protection against formation of ice on the windshield is provided by two independent anti-icing elements of indium trioxide film in each windshield main panel. The four elements each have an Inverter Unit and a Control Unit to supply their electrical power.

A. Control and Indication

Two modes of operation are available, normal and emergency. Control of the system is through two WINDSHIELD switches on the roof panel. These switches are labelled RIGHT ON/OFF and LEFT ON/OFF/EMERGency.

The system has three modes of temperature control, warm up, normal and overheat.

B. Normal Operation

When the WINDSHIELD heat is set to ON each inverter and controller supplies a slow and continuous increase in power to the windshield heater elements. Automatic power control ensures that a linear increase from zero to full power occurs in not more than 5 minutes. This slow and continuous warm-up period prevents adverse thermal stress on the windshield which could cause a failure of the windshield itself.

The windshield temperature in normal control will cycle at 43°C (± 4). A failure of the normal temperature control function causes the system to change to an overheat temperature control cycle of 55°C (± 4.5).

C. Emergency Operation

The windshield heat system will not operate in the normal mode if a failure of all the aircraft generated power occurs. This is because the essential and non-essential busbars which supply the inverters and controllers are shed.

The emergency mode permits operation of the left outboard element of the windshield. In this mode the left windshield outboard heat inverter and controller is supplied from the dc emergency busbar. There is no warm-up period in this mode of operation. As the emergency busbar is supplied only from the batteries (at this time) it must not be used for more than 5 minutes. This is sufficient to allow a landing to be safely carried out.

To operate the left outboard windshield element from the emergency busbar, set the WINDSHIELD LEFT switch to EMERGency. This switch is only to be set to EMERGency 5 minutes before landing. Do not operate the system for more than 5 minutes in the emergency mode.

D. Normal Indication

When the windshield heat system is set to OFF the left and right [INBD] (amber) and [OUTBD] (amber) captions in the roof panel come on. The CAP [ICE] (amber) caption also comes on.

When the windshield heat is set to ON, if the system is serviceable, all the caution captions will go off.

The CAP [ICE] (amber) caption and the applicable roof panel captions come on to show a system failure. Each system failure given below will cause the captions to come on:

- Power failure
- Warm-up time failure (not complete in 5 minutes)
- Overheat sensor failure.

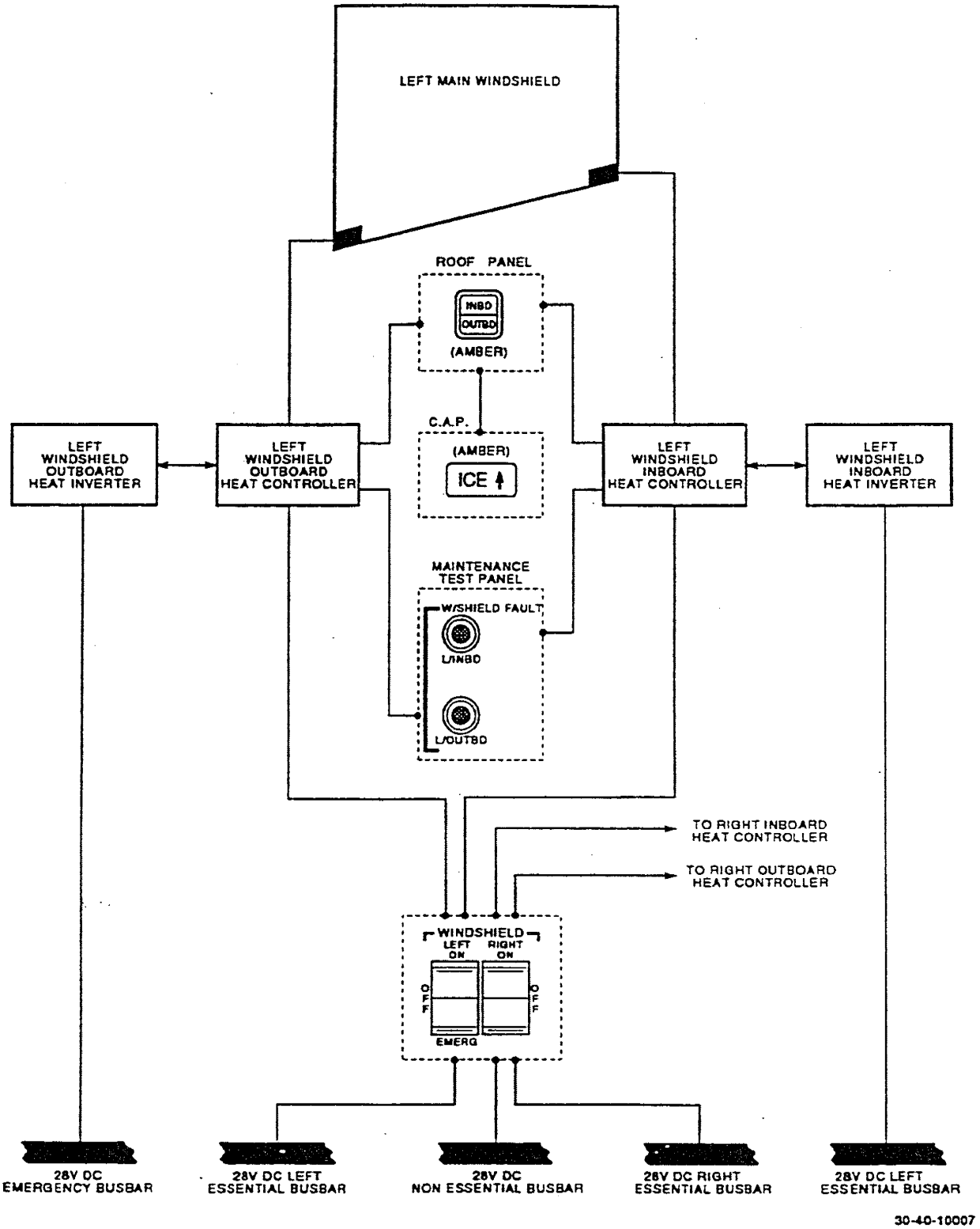
A failure of the normal heat sensor will energize the windshield-fault magnetic indicators on the maintenance test panel.

If a failure of the normal heat sensor occurs the overheat sensor will then control the applicable element. The related roof panel caption comes on during the cooling phase and goes off during the heating phase. This occurs as the windshield temperature cycles at 55°C (± 4.5°).

E. Power Supplies

The power supplies to the individual inverters and controllers are:

LEFT	
OUTBOARD HEAT INVERTER	28V dc Emergency Busbar
OUTBOARD HEAT CONTROLLER	28V dc Left Essential Busbar
	28V dc Emergency Busbar (when left windshield anti-ice control switch set to EMERG)
INBOARD HEAT INVERTER	28V dc Left Essential Busbar
INBOARD HEAT CONTROLLER	28V dc Left Essential Busbar
RIGHT	
OUTBOARD HEAT INVERTER	28V dc Right Essential Busbar
OUTBOARD HEAT CONTROLLER	28V dc Right Essential Busbar
INBOARD HEAT INVERTER	28V dc Non-Essential Busbar
INBOARD HEAT CONTROLLER	28V dc Non-Essential Busbar



Windshield Heat-Schematic

7. Windshield Wipers and Washers

A. Windshield Wipers

A two-speed electrical windshield wiper is provided for each windshield main panel.

(1) Wiper Control

The windshield wipers are controlled by switches on the left and right sides of the coaming panel. The switch panels are labelled W/SHIELD WASH/WIPE and the wiper control switches labelled Left and Right OFF/SLOW/FAST. When the wiper switches are set to OFF the wipers automatically go to the parked position.

CAUTION: DO NOT OPERATE THE WIPERS ON A DRY WINDSHIELD AS THIS CAN CAUSE SCRATCH DAMAGE TO THE WINDSHIELD.

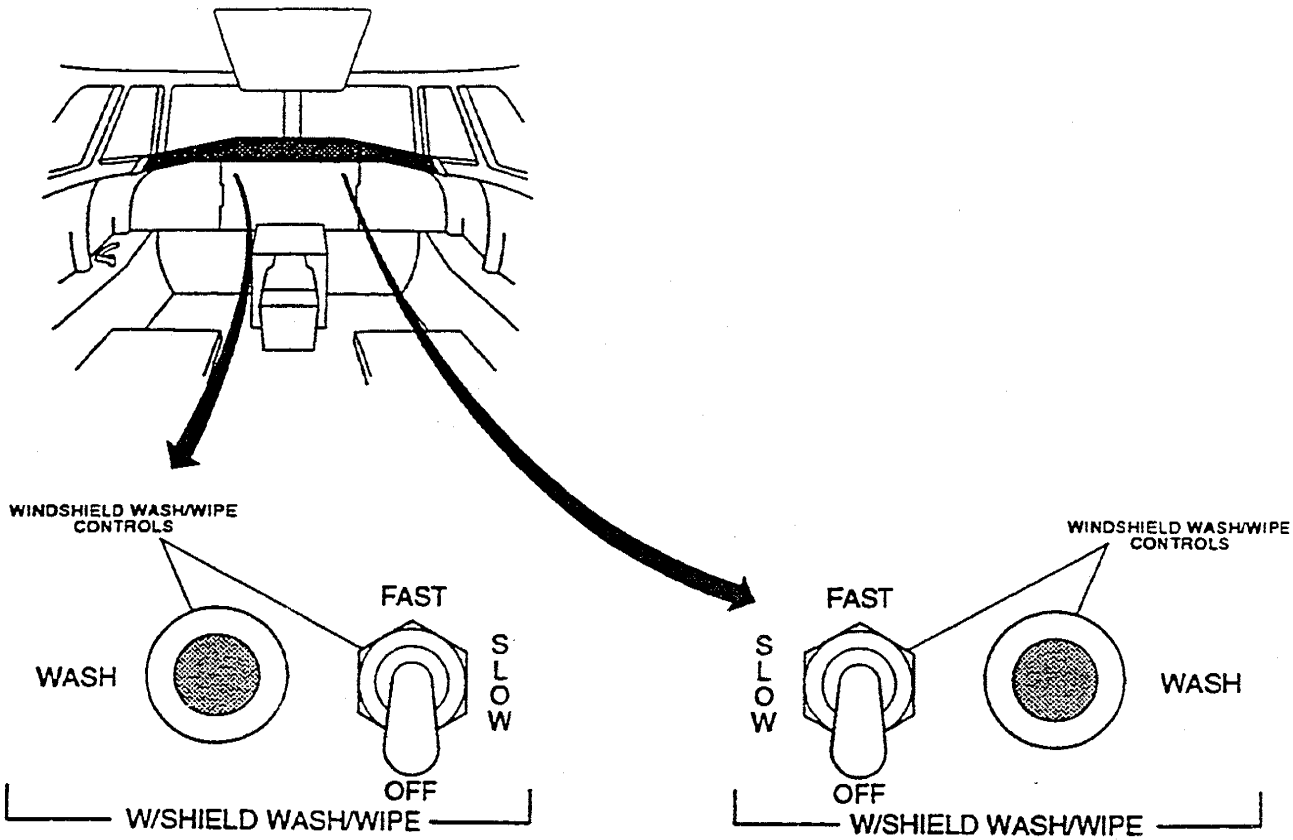
If a wiper motor overheats a protection device switches off the wiper until the motor temperature decreases.

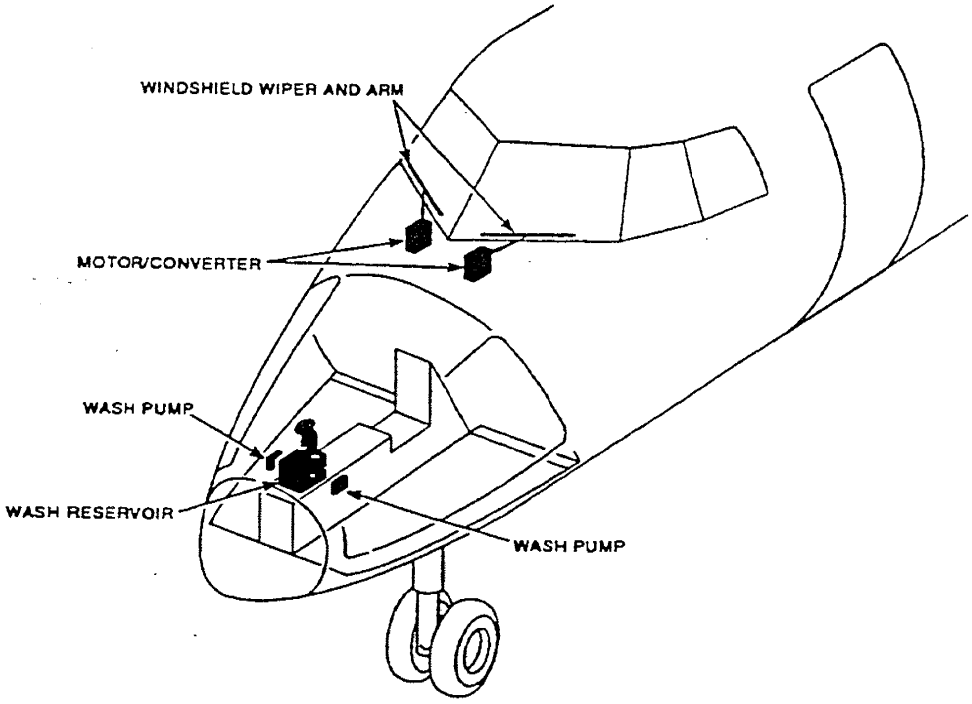
B. Windshield Washers

The washer bottle/pump unit is installed in the nose equipment bay. The washer outlet nozzles are integral parts of the wipers.

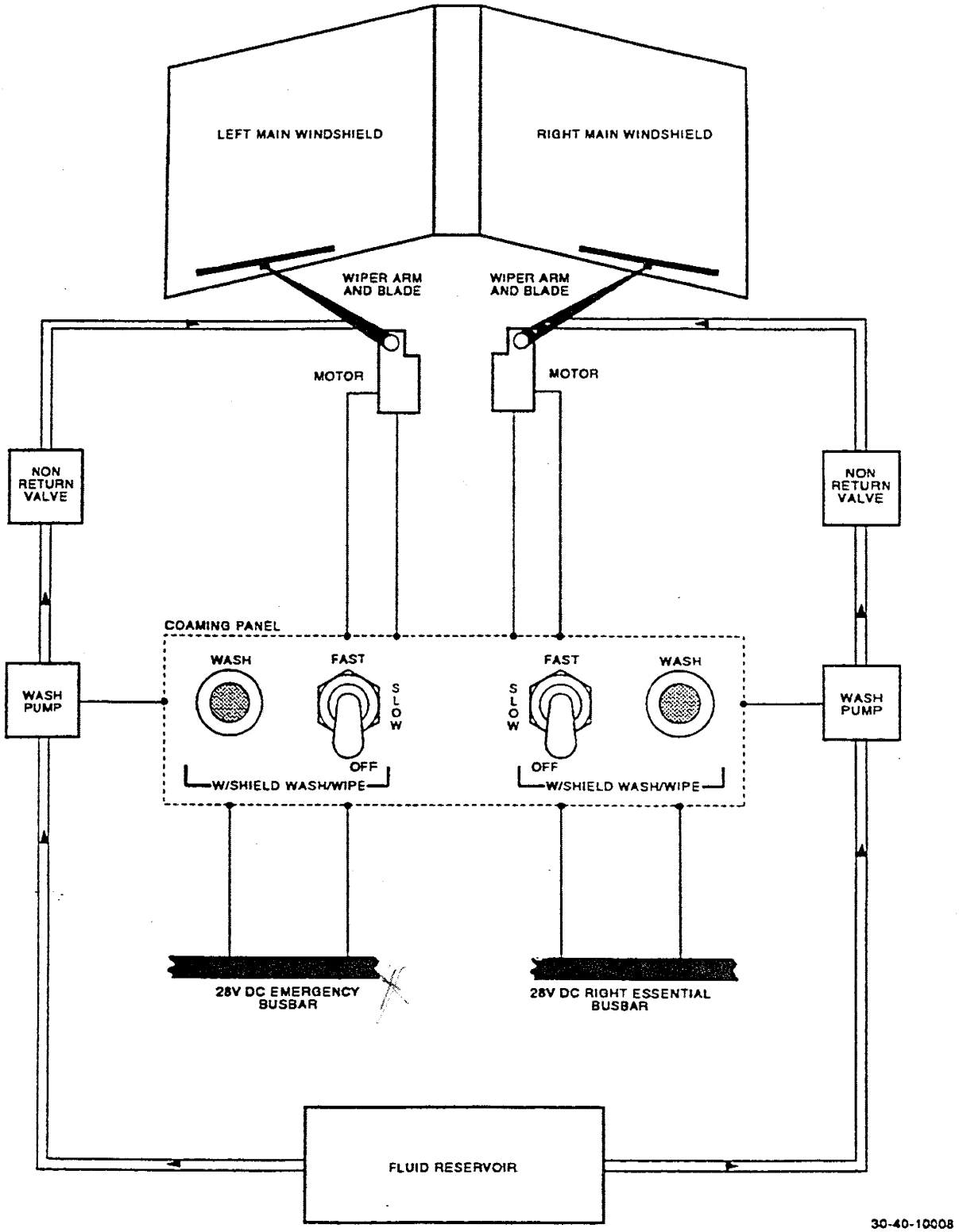
(1) Washer Control

The washers are controlled by wash push buttons installed on the W/SHIELD WASH/WIPE panels on the coaming.

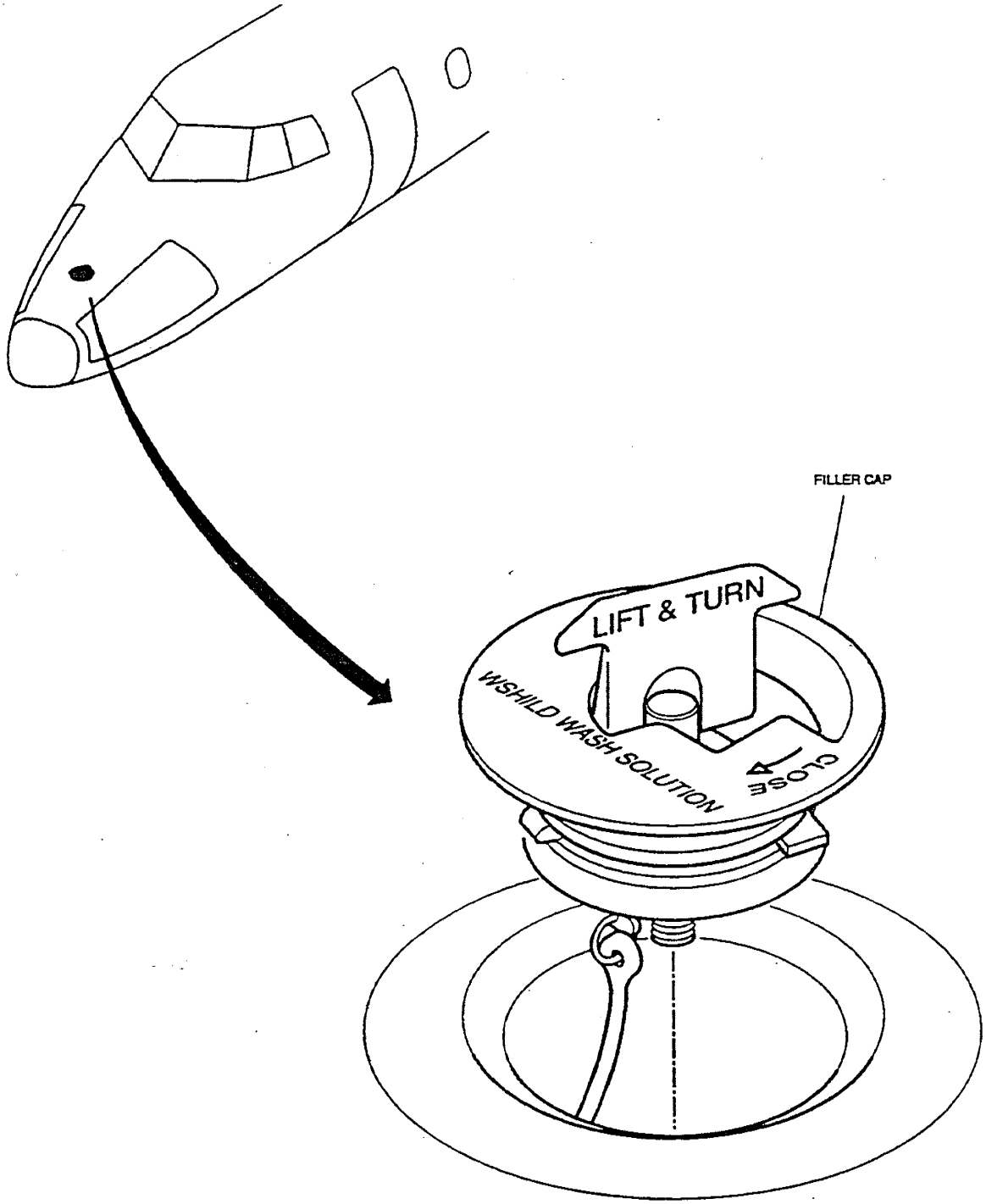




Windshield Wash/Wipe System



Windshield Wash/Wipe Schematic



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Windshield Washer Contents

8. Summary of Operation

A. Icing conditions start when the Indicated Outside Air Temperature (IOAT) on the ground or in-flight is 5° C or less, with visible moisture in the atmosphere (e.g. cloud, fog, rain, sleet or ice crystals) or as (surface snow, ice, standing water or slush) on ramps, taxiways or runways.

Icing conditions end when the above conditions no longer prevail and the ~~IOAT~~ TAT is 10° C or more.

B. Do not operate the airframe ice protection until approximately a ~~quarter to~~ a half inch of ice collects on the wing or tail boots. This is to prevent bridging of ice over the airframe de-icing system boots while they are in operation.

C. The ENG ANTI-ICE protection must be set to ON before icing conditions are entered.

During ground testing, with the engines not running, the propellers ice protection system is not to be operated for more than ~~ten seconds~~ 6 seconds. If icing conditions exist on the ground, propeller anti-icing should be set to on when the engine is running.

When engine anti-icing is required during take-off, refer to the Aircraft Performance Data for corrections necessary to take account of loss of engine power.

During ground testing, ENG/ELEV anti-icing must not be set to ON for more than ten seconds when the IOAT is more than 5° C.

The propeller anti-icing should be set to SHORT CYCLE when the TAT ~~IOAT~~ is -5° C or above and to LONG CYCLE when the IOAT is -5° C or below.

D. When flying in icing conditions it is recommended that regular gentle movements of the flying controls are made. This is to prevent ice bridging between the fixed and moveable surfaces.

If ice is suspected or is known to have formed on the wings or the tail plane refer to the Abnormal Handling Section of the Flight Guide for handling limitations.

All ice and snow should be removed, by approved means, from the aircraft on the ground before flight.