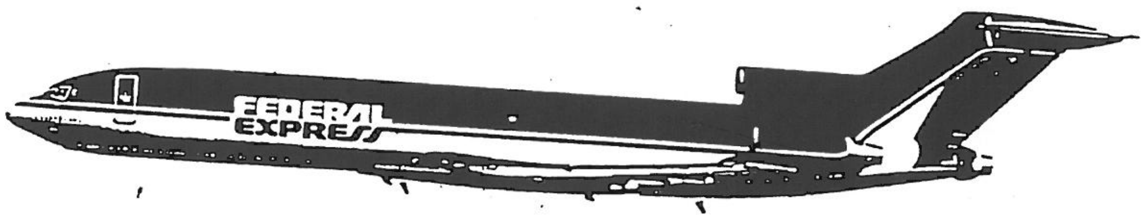
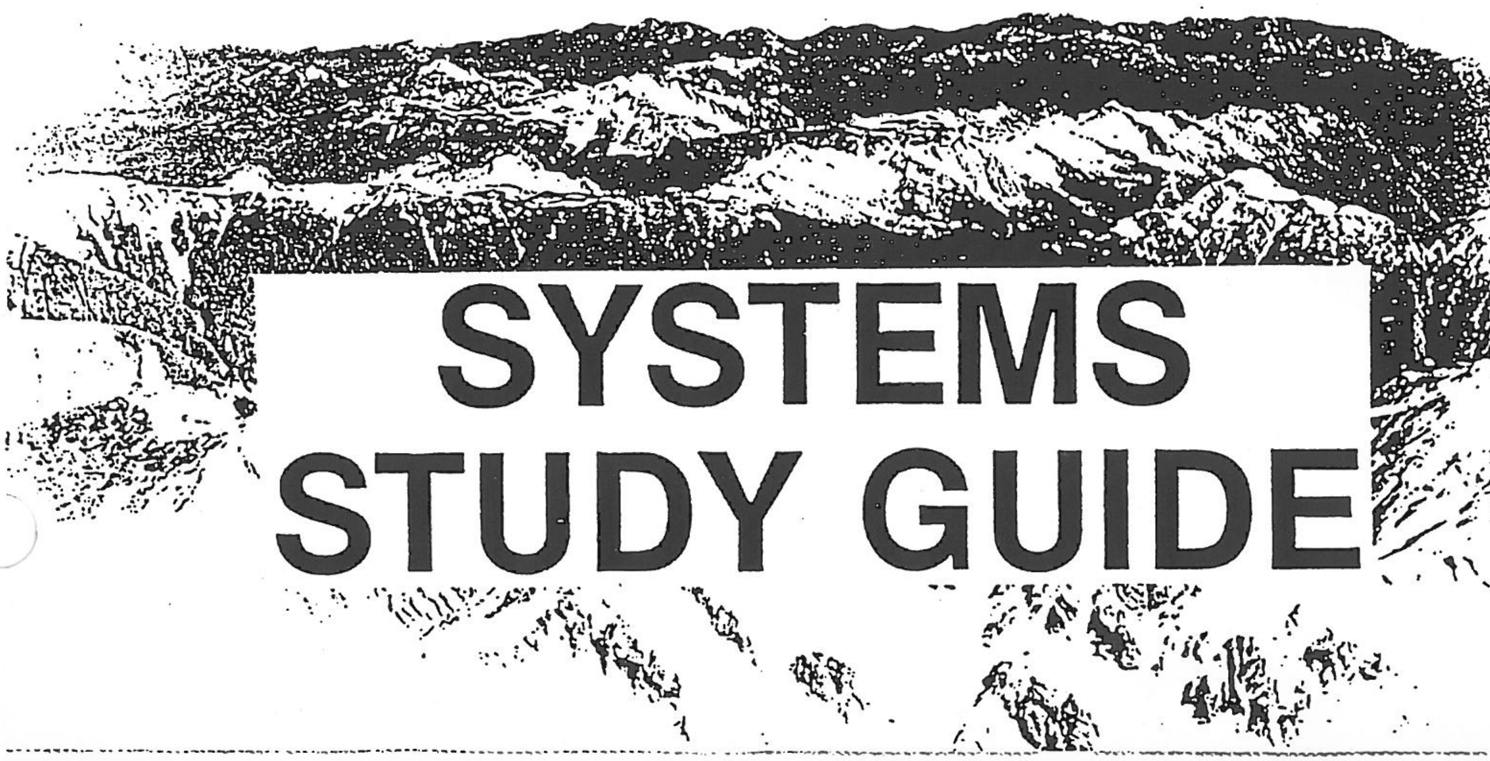
TECHNICAL TRAINING

FOR REFERENCE ONLY

ATA 30
ICE and RAIN
727-100C/200F





SYSTEMS STUDY GUIDE

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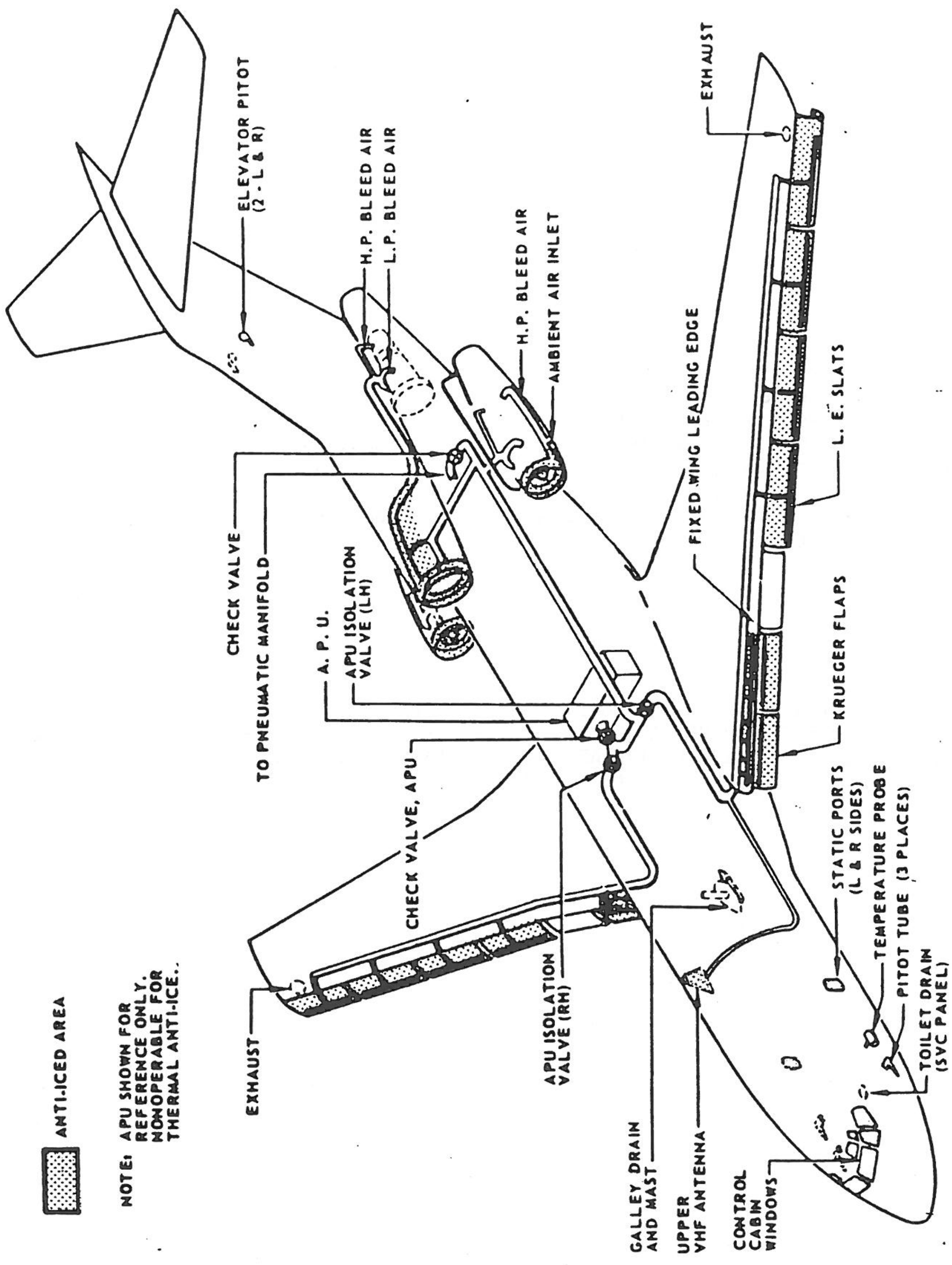
ICE AND RAIN PROTECTION
ATA 30

FORWARD

The material furnished here is to be used as a training aid only. Details, values and lengthy discussion of aircraft systems and equipment have been purposely avoided. It is suggested that in order to achieve maximum training value from this material, that it be considered a supplement to classroom lecture and a general study guide for a student during formal maintenance training.

NOTE

NOTHING IN THIS STUDY GUIDE SHALL BE CONSTRUED AS AUTHORITY FOR DEVIATION FROM FEDERAL AVIATION REGULATIONS OR APPROVED AIRCRAFT OR COMPONENT MAINTENANCE AND OVERHAUL MANUAL INSTRUCTIONS.



ICE PROTECTION SYSTEMS

I. GENERAL DESCRIPTION

The following systems are used to protect the airplane and aid the pilot when operating under ice and rain conditions.

Thermal anti-icing (TAI) systems using engine bleed air are provided for the wing, engine, engine cowls and center engine inlet duct, and the upper VHF antenna mast.

Electrical anti-icing systems are provided for the control cabin windows, pitot-static and temperature probe sensors, stall warning sensor, and the water and toilet drains.

Rain removal is provided for the No. 1 control cabin windows by a windshield wiper system. A rain repellent system is also provided to be used in conjunction with the wiper system.

A. Thermal Anti-Icing Systems

The wing anti-icing system de-ices the No. 2 through No. 5 Krueger flaps, the fixed inboard leading edge above the flaps and the leading edge slats. The TAI air for the system is supplied from the engine Nos. 1 and 3.

The engine anti-ice system de-ices the engine nose dome and inlet guide vanes.

The engine cowls and center engine inlet duct anti-icing systems de-ice the engine inlets and constant speed drive oil cooler scoops. Each engine supplies its own TAI air and is separate and independent of the other two.

B. Electrical Anti-Icing Systems

The control cabin window anti-icing system deices and provides bird proofing of the No. 1, 2, 4 and 5 control cabin windows on each side of the control cabin. The windows are heated by the use of a transparent electrical resistance coating incorporated as an integral part of the windows.

The pitot-static and temperature probe anti-icing system deices the left, right and auxiliary pitot tubes, the corresponding six static ports, the elevator left and right pitot tubes and the temperature probe. The sensors are heated by electrical resistance elements installed within the sensing had of the units.

The stall warning sensor is deiced by electrical resistance elements installed within the attitude sensor weathervane. The heater is controlled by the stall warning system and is heated whenever that system is in operation.

The water and toilet drain anti-icing system deices the forward water drain mast, and the toilet drain connectors. The drain masts are heated by electrical resistance elements wound around the tube within the mast. The toilet drain connectors are heated by electrical resistance elements installed as an integral part of the connector gasket. The heaters are controlled directly by their respective circuit breakers and are heated whenever the airplane has electrical power.

C. Rain Removal Systems

The windshield wiper system maintains clear areas on the No. 1 control cabin windows during takeoff, approach, and landing in rain or snow. The wipers are driven independently by electric motors which are controlled by a common switch.

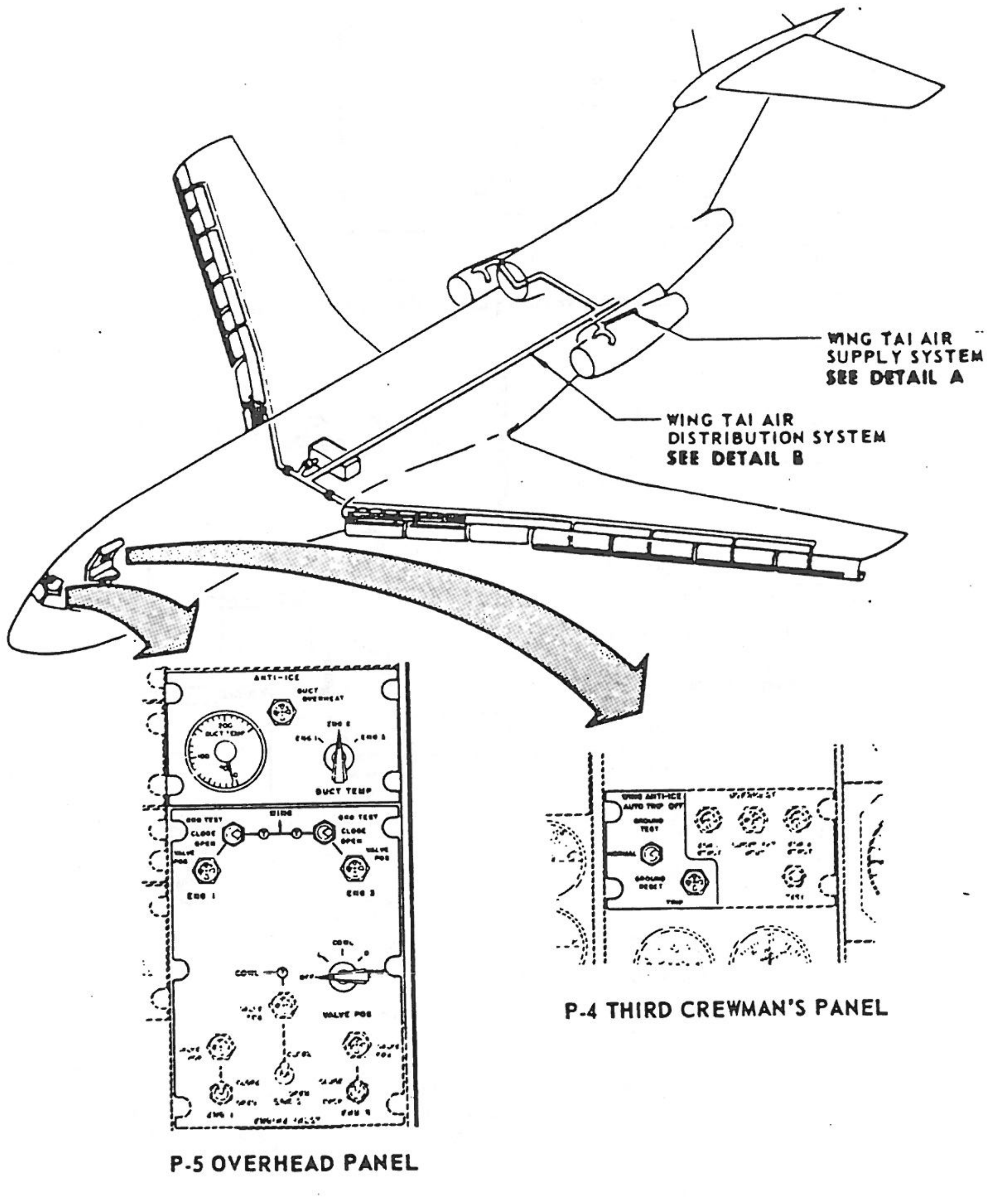
The rain repellent system sprays a rain repellent solution on the No. 1 control cabin windows and is used in conjunction with the windshield wiper system to improve visibility during heavy rain. The repellent solution for both windows is supplied from a common pressurized container, but is controlled independently by separate control switches for each window.

II. WING THERMAL ANTI-ICING SYSTEM

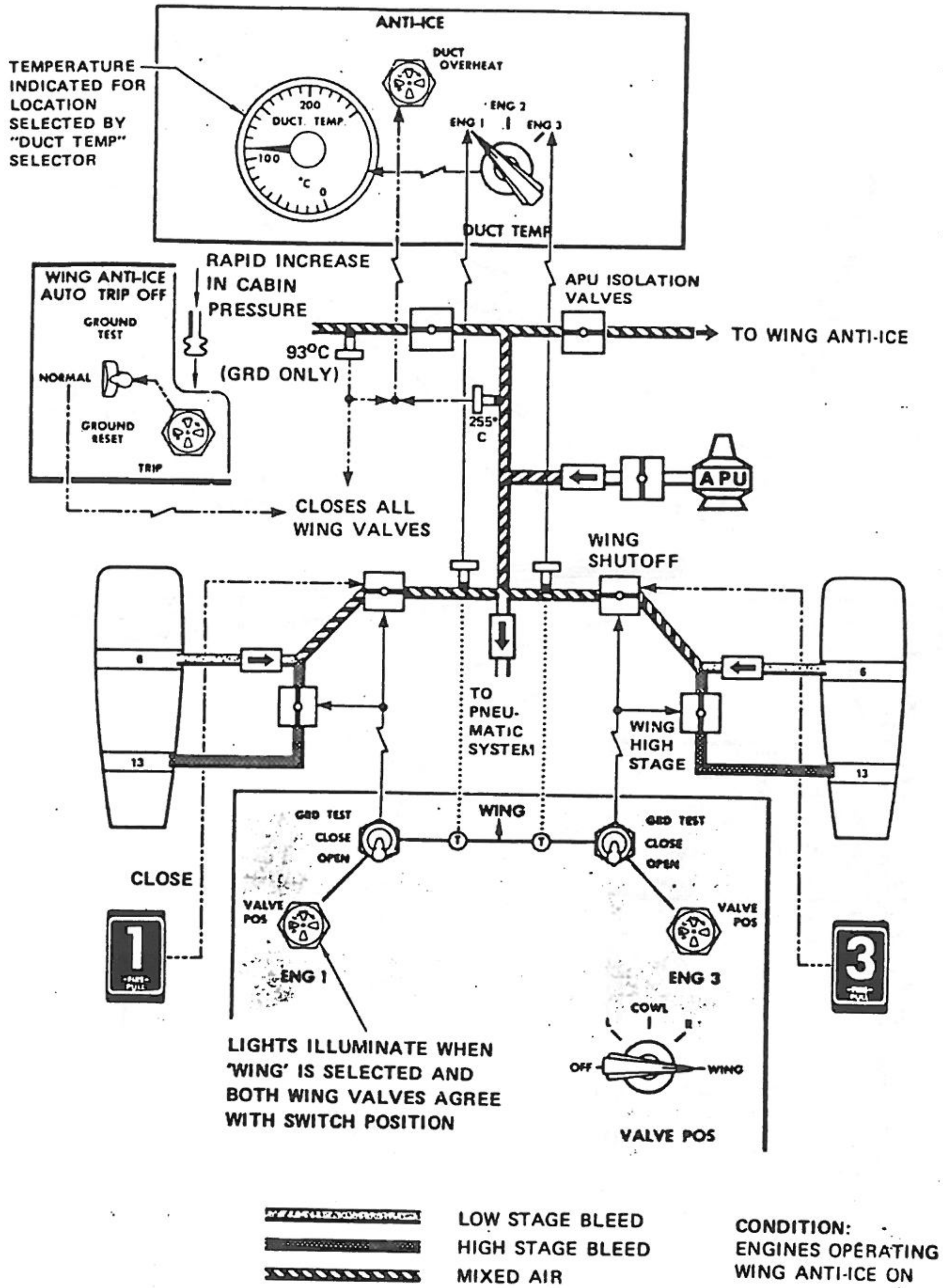
A. General Description

A thermal anti-icing (TAI) system using engine bleed air is provided to prevent the formation of ice on the Nos. 2, 3, 4 and 5 Krueger flaps, the fixed inboard leading edge above these flaps and the wing leading edge slats. The system uses a combination of hot 6th and 13th stage engine bleed air from engines No. 1 and No. 3. The bulk of the air is supplied from the 6th stage engine bleed manifold which is connected to the TAI supply duct. This air is boosted in temperature by 13th stage engine bleed air fed into the TAI supply duct by use of an ejector. The system consists of supply and distribution ducting, control valves, electrical control components and indicating components.

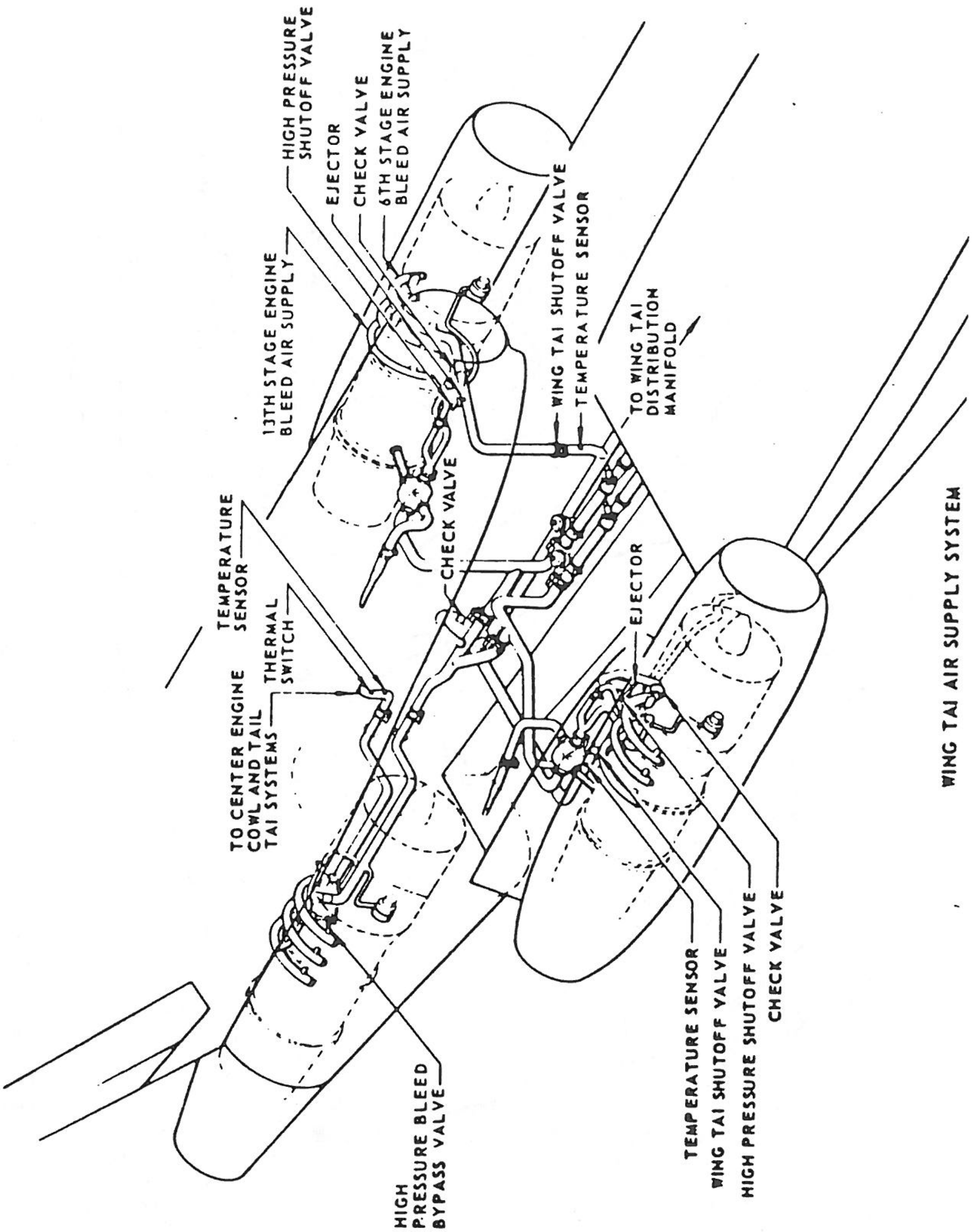
On all aircraft, a section of the wing TAI air distribution system is used in common with the auxiliary power unit (APU) air supply system during ground operations. The common manifold is connected to the APU at the forward end at the right hand wheel well and to the pneumatic system by a crossover duct located at the aft end. A check valve in the connection to the APU prevents air from flowing from the wing TAI system to the APU, and a check valve in the crossover duct prevents air from flowing from the pneumatic system into the wing TAI system. When the APU is in use for ground air supply, the common manifold is isolated from the wing TAI system by a left and right APU isolation valve in the ducting leading to each wing TAI distribution manifold and the engine No. 1 and No. 3 wing TAI shutoff valves. The left and right APU isolation valves are controlled by operation of the APU. Electrical interlocks in the control circuitry of both systems prevent the use of APU air and the wing TAI system at the same time.



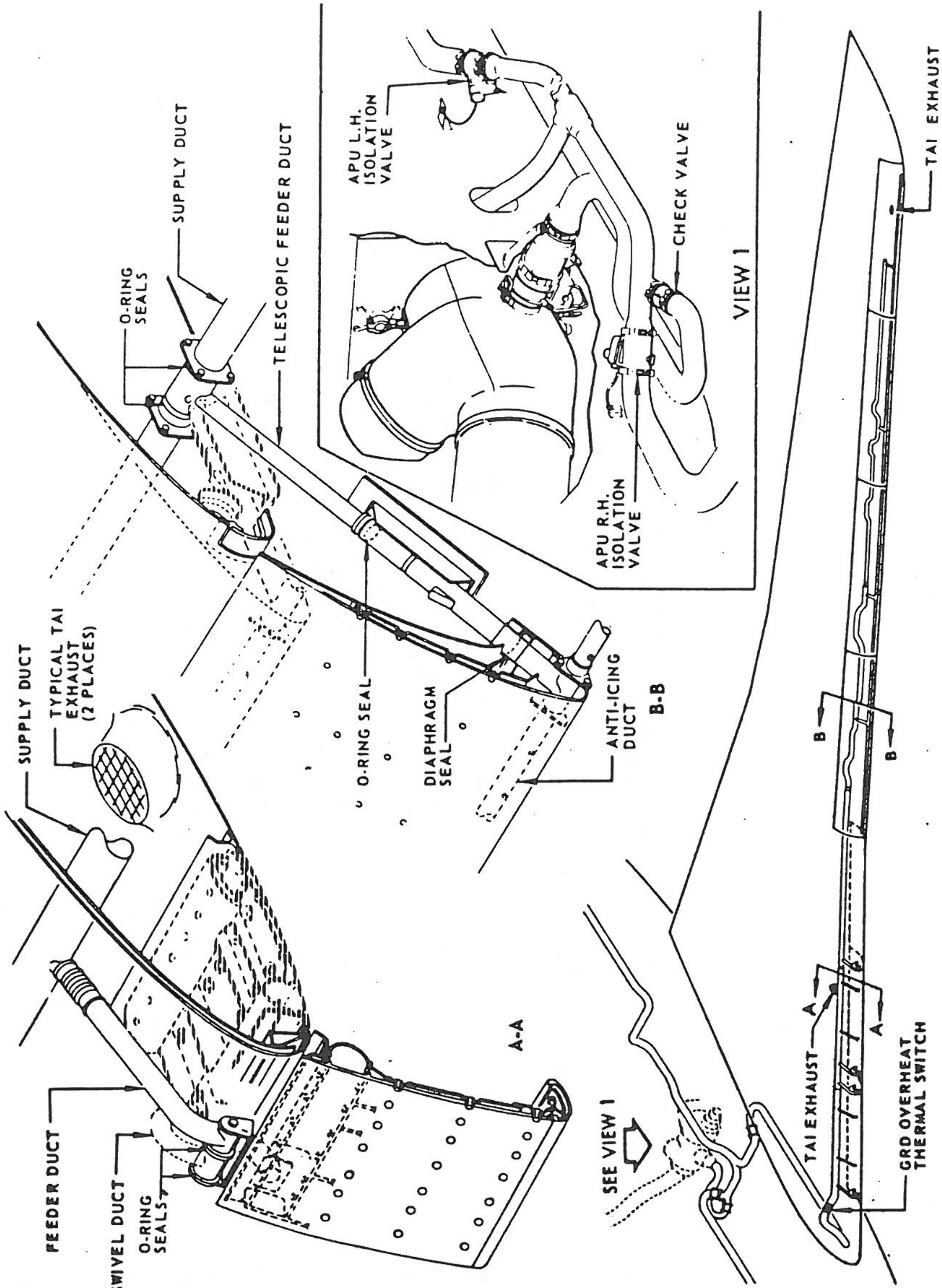
WING THERMAL ANTI-ICING CONTROLS



WING ANTI-ICE



Wing Anti-Icing System Equipment Location



Wing Anti-Icing System Equipment Location

1. Wing Anti-Ice Ducting

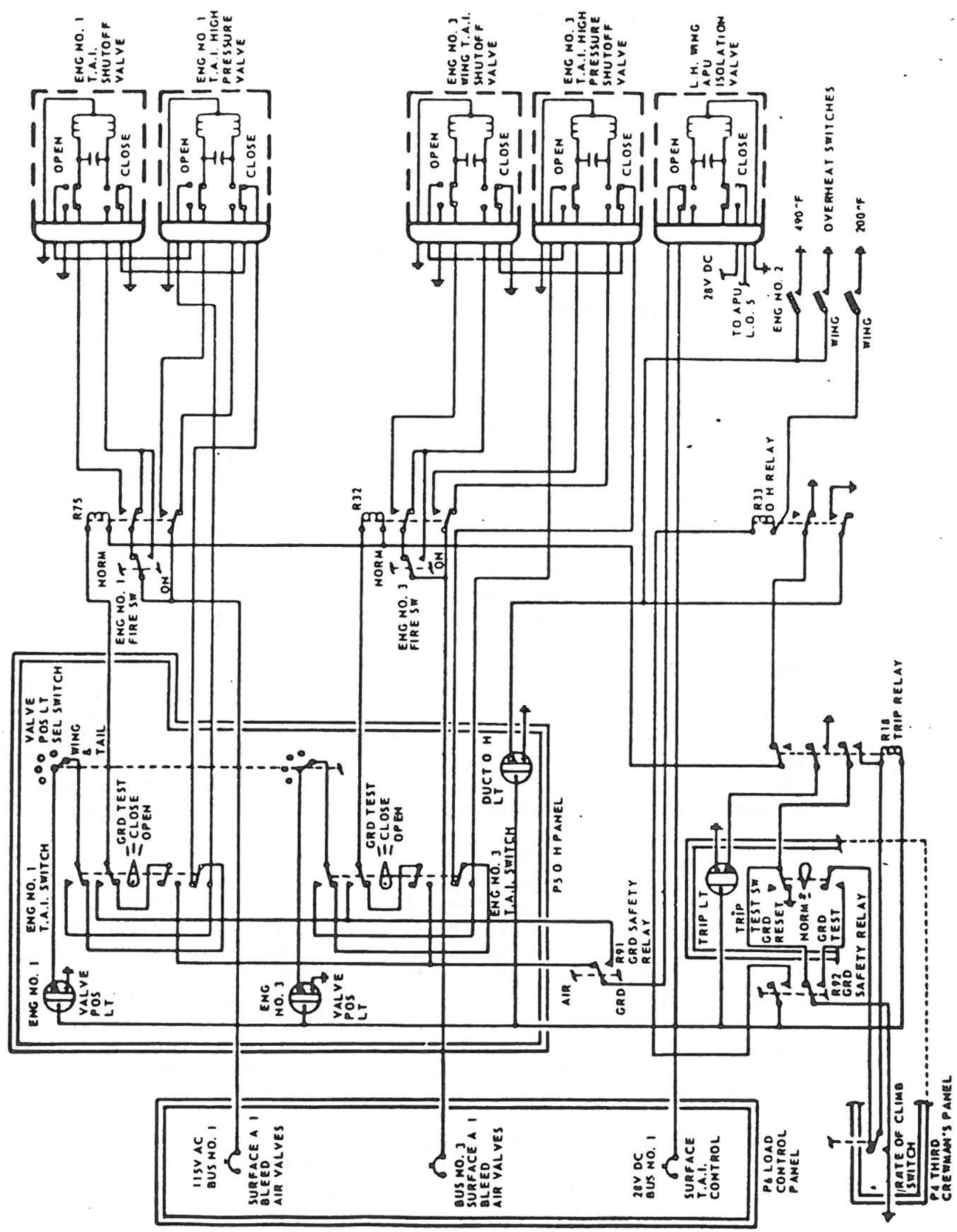
The supply ducts from each of the pod mounted engines are connected to the common manifold on the left hand side of the airplane. The common manifold extends from the aft end forward to the wing where it then is divided by a Y duct and routed to a wing manifold along each wing leading edge. From the wing leading edge manifold, feeder ducts are connected to each of the deiced Krueger flaps, the fixed inboard leading edge above these flaps, and the wing leading edge slats.

Each of the deiced Krueger flaps is connected to the wing leading edge supply manifold by two feeder ducts, one at each end. The flap feeder ducts are connected to the supply manifold by a flexible convoluted duct for ease of alignment and to the flap leading edge manifold by a swivel duct connection. The swivel duct is free to rotate around the feeder duct support arm as the flaps are extended. The swivel duct is sealed by two O-rings to prevent air leakage. The flap distribution duct runs the full length of the flap and has perforations to allow the air to flow towards the flap leading and trailing edge between the outer flap skin and a dimpled inner skin. The air is then vented out of the flap along the flap leading and trailing edges into the wing leading edge cavity and exhausted overboard through vents on the lower fixed wing leading edge.

One feeder duct is connected to the fixed leading edge inboard of the Krueger flaps and two feeder ducts are connected to the fixed leading edge above each Krueger flap. The feeder ducts are each connected at one end to the supply manifold by a flexible convoluted duct for each of alignment and rigidly fixed to a wing leading edge distribution duct at the other end. The leading edge distribution duct has perforations along the forward edge to allow air to flow between the fixed leading edge skin and a dimpled inner skin. The air is then vented from the aft end of the inner skin into the leading edge cavity and exhausted overboard through the vents on the lower fixed wing leading edge.

Each of the wing leading edge slats is connected to the wing leading edge manifold by a telescoping feeder duct. The telescoping ducts consist of two tubes, one of which slides within the other as the slats are extended. They are sealed by an O-ring between them. The inner feeder duct is connected to the wing manifold by a swivel T-connection to allow rotational movement of the feeder duct around the wing distribution duct. The T-connection is sealed by an O-ring between each end of the T and the distribution duct. The outer feeder duct is connected to the slat distribution duct by a swivel T-connection to allow rotational movement of the feeder duct about the slat distribution duct.

A sealing diaphragm is installed between the feeder duct and slat structure to prevent air leakage where the feeder duct enters the slat. The slat distribution duct runs the full length of the slat and has perforations to allow the air to flow towards the slat leading edge and between the outer slat skin and a dimpled inner skin. The air is then vented to the inner slat cavity and exhausted overboard through the slat track openings and drain holes.



Wing Thermal Anti-Icing System Circuit

The wing TAI ducting is fabricated from "Hastalloy" high temperature steel between the engine bleed ports and the wing TAI shutoff valves, and the remainder of the ducting is fabricated from titanium. The wing leading edge manifold has five slip type expansion joints plus the swivel joints at each telescoping slat connection to compensate for wing flexing, duct misalignment and thermal expansion. Duct movement throughout the rest of the system is accomplished by expansion bends in the duct routing.

2. Control Valves

The flow of air in the wing TAI system is controlled by a high pressure shutoff valve and a wing TAI shutoff valve for each pod mounted engine. The shutoff valves are electric motor driven butterfly valves which operate on 115-volt, 400-Hz current. The valves are equipped with limit switches to prevent overrunning of the motor, and valve position indicator switches which are used in valve position indicator circuits. Each valve is also equipped with an external valve position indicator to verify valve position. The high pressure wing TAI shutoff valves are controlled by a common switch for each engine. The switches are located on the P5 pilot's overhead panel.

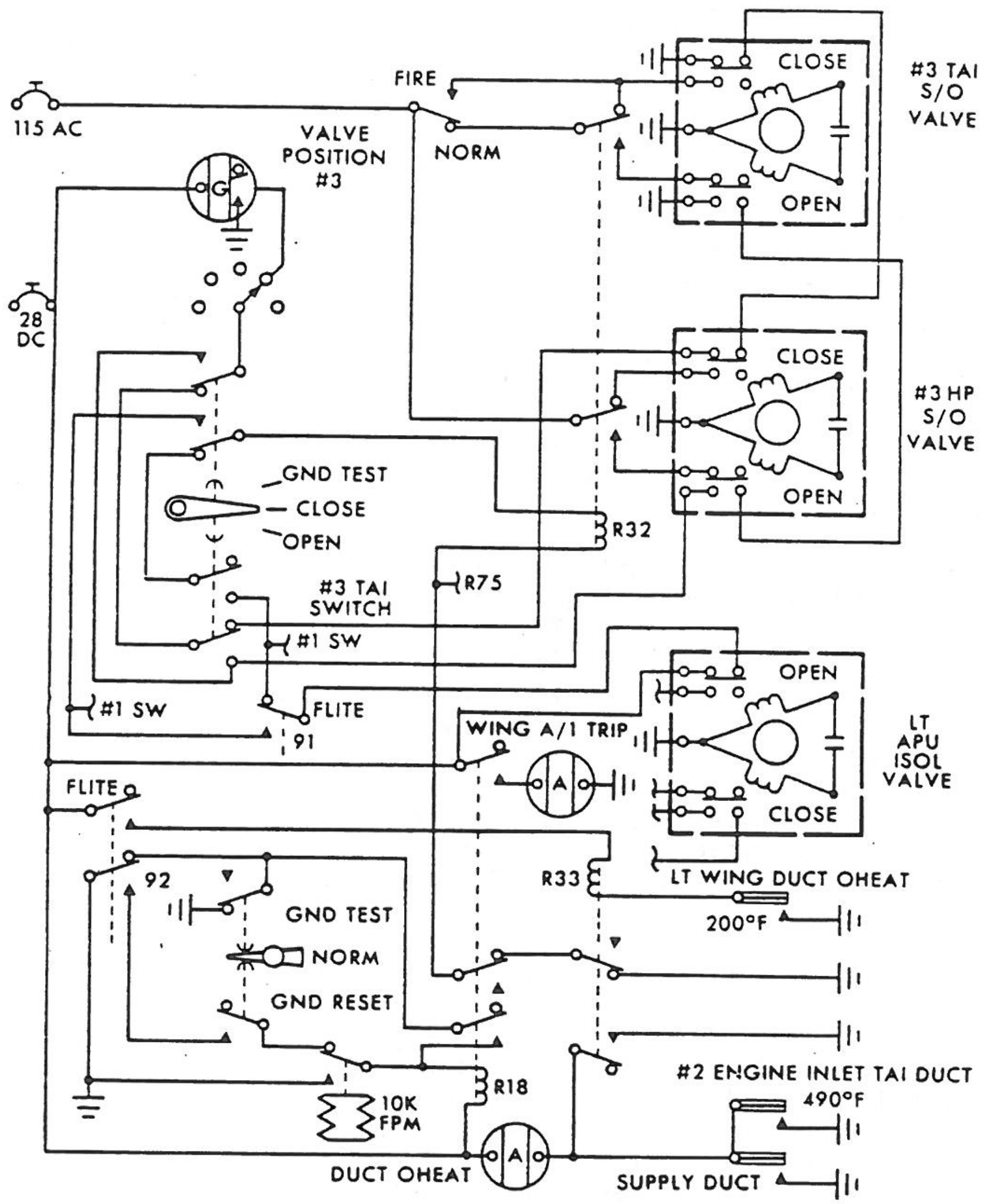
The high pressure shutoff valve is a 2-1/8" diameter valve located on a supply line connecting the 13th stage engine bleed air to the wing TAI supply manifold. The supply manifold is connected to the 6th stage engine bleed manifold and provides 6th stage air to be mixed with 13th stage air by the use of an ejector. A check valve in the supply manifold prevents any reverse air flow to the 6th stage engine bleed manifold.

The wing TAI valves are 4-1/2" diameter valves located on the wing TAI supply manifolds leading to the common distribution manifold. The valves control the flow of TAI air supply to the distribution manifolds.

3. Wing Anti-Ice Electrical Control Components

The wing anti-ice control valves are governed by the following electrical control components; a left and right anti-ice valve control switch, two valve control relays, a rate-of-climb switch, a wing anti-ice trip relay, a wing anti-ice trip test switch, one or two safety relays, a ground overheat thermal switch, a duct overheat relay, two engine fire switches, and a left isolation valve position.

The left and right anti-ice valve control switches are located on the P-5 overheat panel. The switches are three position four pole toggle switches. Two poles are used in the valve control circuits and the other two poles are used in the valve position indicating circuits. They have an "OPEN" position, a "CLOSED" position and a momentary "GRD-TEST" position. Operation of either valve control switch to the "OPEN" or "GRD-TEST" position will supply power from the 28-void dc bus No. 1 thru the ground safety relay contacts to energize its respective valve control relay.



THERMAL ANTI-ICING CIRCUIT

The anti-ice valve control relays are located behind the P-5 overhead panel. The engine No. 1 valve control relay controls the power from 115 volt ac bus No. 1 to open the engine No. 1 high pressure and wing TAI shutoff valves when energized to close the valves when the relay is de-energized. Similarly, the engine No. 3 valve control rèlay controls the power from 115 volt ac bus No. 3 to the engine No. 3 high pressure and wing TAI shutoff valves.

The rate of climb switch is located behind the third crewman's panel. It is a pressure sensitive aneroid type switch. The switch will actuate when a rate of increase of pressure in excess of 10,000 ft/min is detected over a maximum period of two seconds. The greater the rate of increase, the less time is required to actuate the switch. Actuation of the switch completes an electrical circuit to energize the trip relay.

The wing anti-ice trip relay is located behind the third crewman's panel. When energized, the trip relay breaks the circuit for the valve control relays, de-energizing the relays and closing all TAI shutoff valves. Once energized, the trip relay has a holding circuit through a pair of its normally open contracts and a pair of normally closed safety contacts to keep the relay energized as long as the airplane is in the air.

The wing anti-ice trip test switch is located on the P-4 flight engineer's panel. The switch is a three position toggle switch. It has a momentary "GRD-TEST" position, a "NORMAL" relaxed position and a momentary "GRD-RESET" position. Operation of the switch to the "GRD-TEST" position provides a ground for the anti-ice trip relay thru a pair of normally open safety relay contacts, to energize the trip relay for test purposes. Once energized, the trip relay maintains a holding circuit thru a pair of its normally open contacts and the ground reset contacts of the trip test switch. Operation of the switch to the ground reset position breaks the holding circuit and de-energizes the trip relay. The safety relay prevents control of the wing anti-ice trip relay by the trip test switch while the airplane is in the air.

The valve position indicator switch, installed on all except 727-200 series, in the left APU isolation valve controls the supply of current from the 28 volt dc bus No. 1 to the ground safety contacts in the engine No. 1 and No. 3 TAI valve control circuit. When the APU isolation valve is closed, the switch is open, breaking the circuit to the valve control relays. This ensures that the wing TAI control valves are closed while the common manifold is being utilized by the APU air supply system.

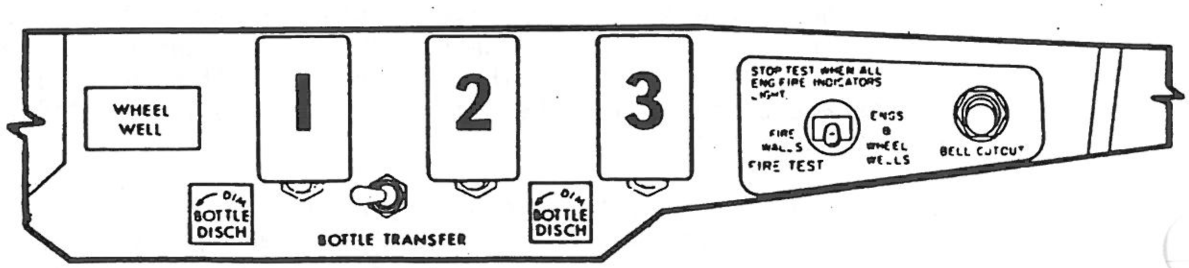
a. On all aircraft, the two safety relays are located behind the P5 pilot's overhead panel and are energized by a safety switch on the main gear torsion links. One pair of contacts on one of the relays is used to control power to the engine No. 1 and engine No. 3 valve control switches. On the other relay, two pairs of contacts are utilized. One pair of contacts is used to control power to the overhead relay, and the other pair is used in the trip circuit.

When the relays are energized (airplane on the ground) power is supplied to the GRD-TEST side of the valve control switches and to the overheat relay. The pair of contacts in the trip circuit completes the circuit to ground through the GRD-TEST side of the trip test switch. When the relays are de-energized, power is supplied only to the OPEN side of the valve control switches, and the pair of contacts in the trip circuit completes a holding circuit to ground a pair of holding contacts on the trip relay when the relay is energized.

The ground overheat thermal switch is located on the root end of the wing leading edge TAI distribution manifold. The switch is a temperature sensitive bimetallic type switch with normally open contact points which close at 200 ($\pm$ 10)°F. Actuation of the switch while the airplane is on the ground completes a circuit from the 28 volt dc bus No. 1 through the duct overheat control relay to ground, energizing the overheat relay.

The duct overheat relay is located behind the P-5 pilot's overhead panel. One pair of normally closed contacts on the overheat relay is used to control the TAI valve control relays, and one pair of normally open contacts is used in the duct overheat indicating circuit, When energized, the relay breaks the circuit for the valve control relays, de-energizing the relays and closing all wing TAI shutoff valves.

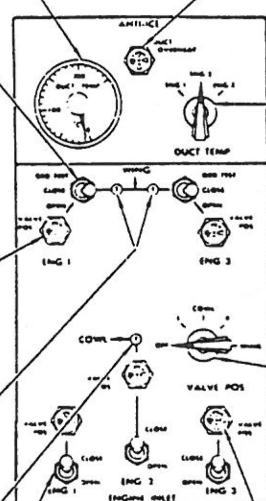
The engine fire switches are located on the P7 pilot's fire switch panel. The switches are two position toggle switches. They have a NORMAL position and a FIRE position. There is one switch to control the TAI mixed air shutoff valve circuits for each engine. When the engine No. 1 and engine No. 3 switches are in the NORMAL position, power is direct to the valve control relay pair of contacts which control the wing TAI shutoff valve for its respective engine. When the switches are in the FIRE position, power is routed to bypass the valve control relay contact points directly to the valve close circuit and shutting the wing TAI shutoff valves.



4. Wing Anti-Ice Indicating Components

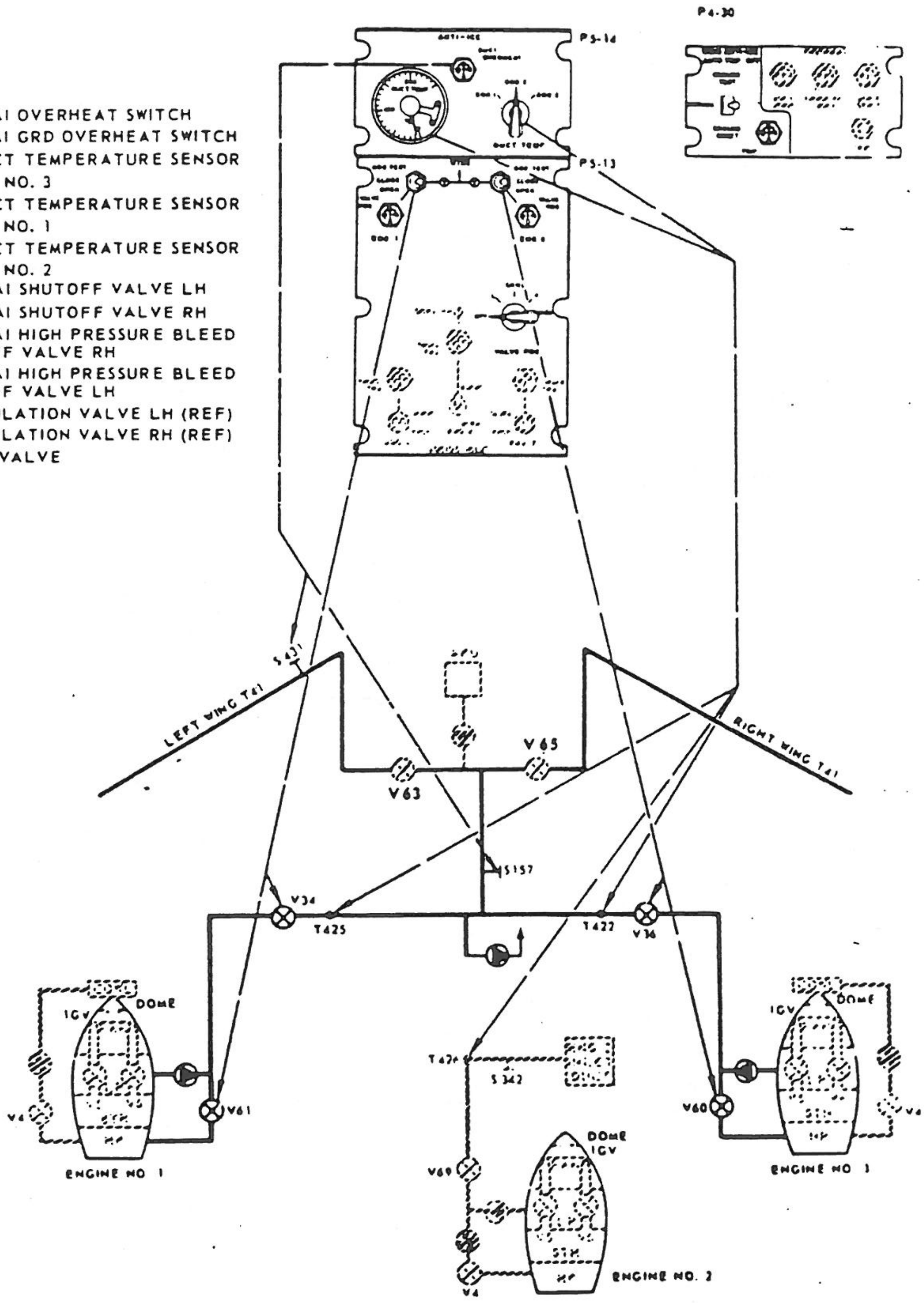
The wing anti-ice system is provided with the following indicating components: a valve position switch, two valve position indicator lights, a duct temperature selector switch, a temperature indicator, three temperature sensors, a duct overheat light, two thermal switches and a wing anti-ice trip light.

The valve position switch is located on the P-5 pilot's overhead panel. It is a six pole-five position switch, "OFF-LEFT-COWL-RIGHT-WING," and is used in common with the cowl and engine anti-icing systems. When the switch is moved to the "WING" position, it completes a circuit from the 28 volt dc bus No. 1 thru the valve position indicator lights for both engine No. 1 and No. 3 valve position switch, to the indicating pole of the valve control switch for the respective engine. If both valve positions agree with the valve control switch position for the respective engine, the circuit to ground for the respective indicating light will be completed thru the valve position indicator switches. There is no indication during valve travel as both valve position indicator switches are open in each valve during valve travel.



OVERHEAD PANEL

S157 WING TAI OVERHEAT SWITCH
S431 WING TAI GRD OVERHEAT SWITCH
T422 TAI DUCT TEMPERATURE SENSOR ENGINE NO. 3
T425 TAI DUCT TEMPERATURE SENSOR ENGINE NO. 1
T426 TAI DUCT TEMPERATURE SENSOR ENGINE NO. 2
V34 WING TAI SHUTOFF VALVE LH
V36 WING TAI SHUTOFF VALVE RH
V60 WING TAI HIGH PRESSURE BLEED SHUTOFF VALVE RH
V61 WING TAI HIGH PRESSURE BLEED SHUTOFF VALVE LH
V63 APU ISOLATION VALVE LH (REF)
V65 APU ISOLATION VALVE RH (REF)
CHECK VALVE



Thermal Anti-Ice Control Schematic

The valve position indicating lights are located close to the valve control switches on the P-5 pilot's overhead panel. They are 28 volt, green, press-to-test type lights.

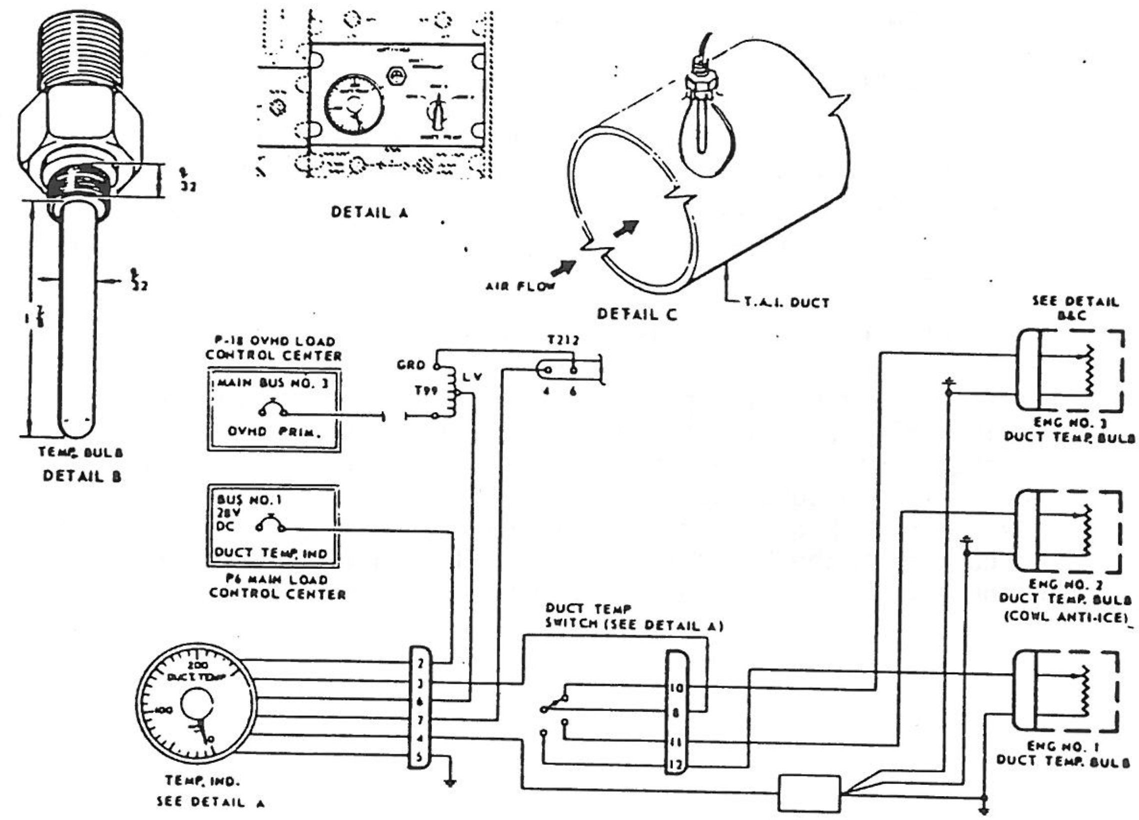
The duct temperature selector switch is located on the P-5 pilot's overhead panel, and is used in common with the cowl anti-icing system. It is a single pole, seven position rotary switch; however, only three positions are used. The positions are ENG No.1, ENG. No. 2 and ENG. No. 3. In either of the three positions, the switch completes a circuit to supply 28 volt dc current from the P6 load control center, thru the temperature indicator, selector switch, to the respective duct temperature sensor, to ground.

The duct temperature indicator is located on the P-5 pilot's overhead panel adjacent to the duct temperature selector switch. It is an integrally lighted resistance type indicator calibrated to read in degrees Centigrade.

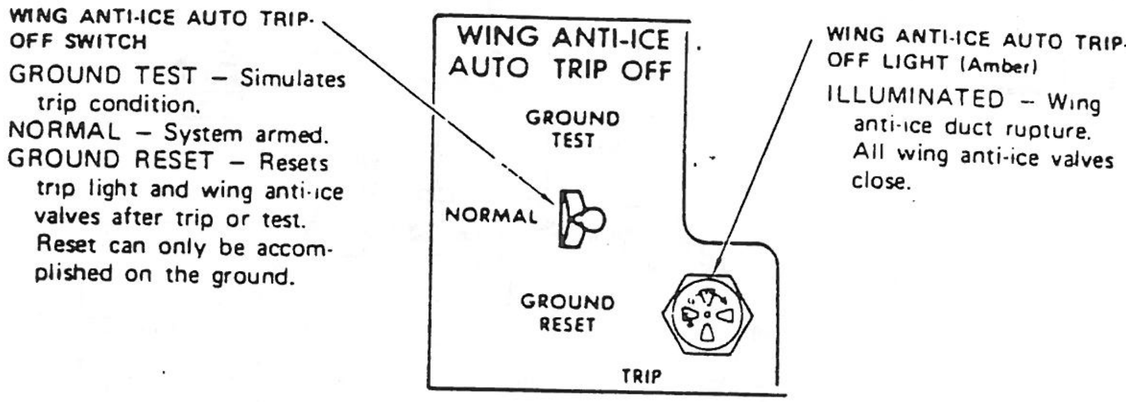
The duct temperature sensors are heat sensing, resistance type sensors. THere are three temperature sensors installed, one located in each TAI supply duct from the pod mounted engines just downstream from the mixed air shutoff valve and one in the TAI duct leading to the center engine inlet cowl.

The duct overheat light is located on the P5 pilot's overhead panel. The light is a 28 volt amber press-to-test type and when illuminated indicates a duct overheat condition in either the wing or center engine inlet cowl TAI systems. The light is controlled by a wing TAI overheat switch, an engine No. 2 TAI overheat switch, and a pair of normally open contacts on the overheat relay. Actuation of either thermal switch or energizing of the overheat relay will complete a circuit from the 28 volt dc bus No. 1 thru the light, thru the respective switch or relay contacts to ground.

The overheat thermal switches are temperature sensitive bimetallic type switches with normally open contact points. The switches close when the duct air temperature reaches 490 (± 10)°F on increasing temperature and open at 460°F minimum on decreasing temperature. One thermal switch is located in the wing TAI common manifold leading to the wind and the other is located in the TAI duct leading to the center engine inlet cowl.

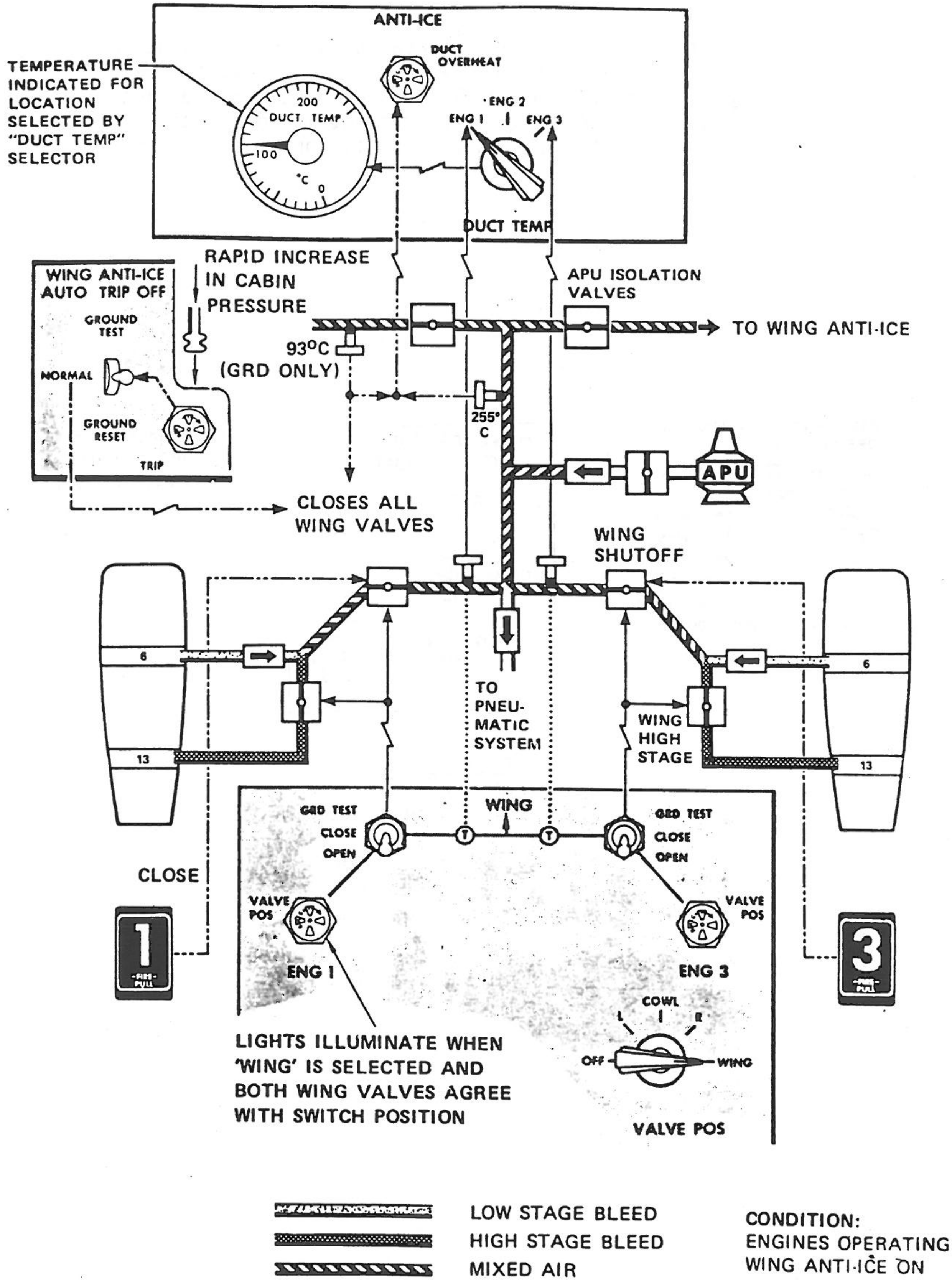


The wing anti-ice trip light is located on the P4 flight engineer's panel. The light is a 28 volt amber press-to-test type which is controlled by a pair of normally open contacts on the wing anti-ice trip relay. When the relay is energized, it completes a circuit from the 28 volt dc bus No.1, thru the light, thru the pair of contacts to ground



FLIGHT ENGINEER'S UPPER PANEL

WING ANTI-ICE AUTO TRIP OFF



WING ANTI-ICE

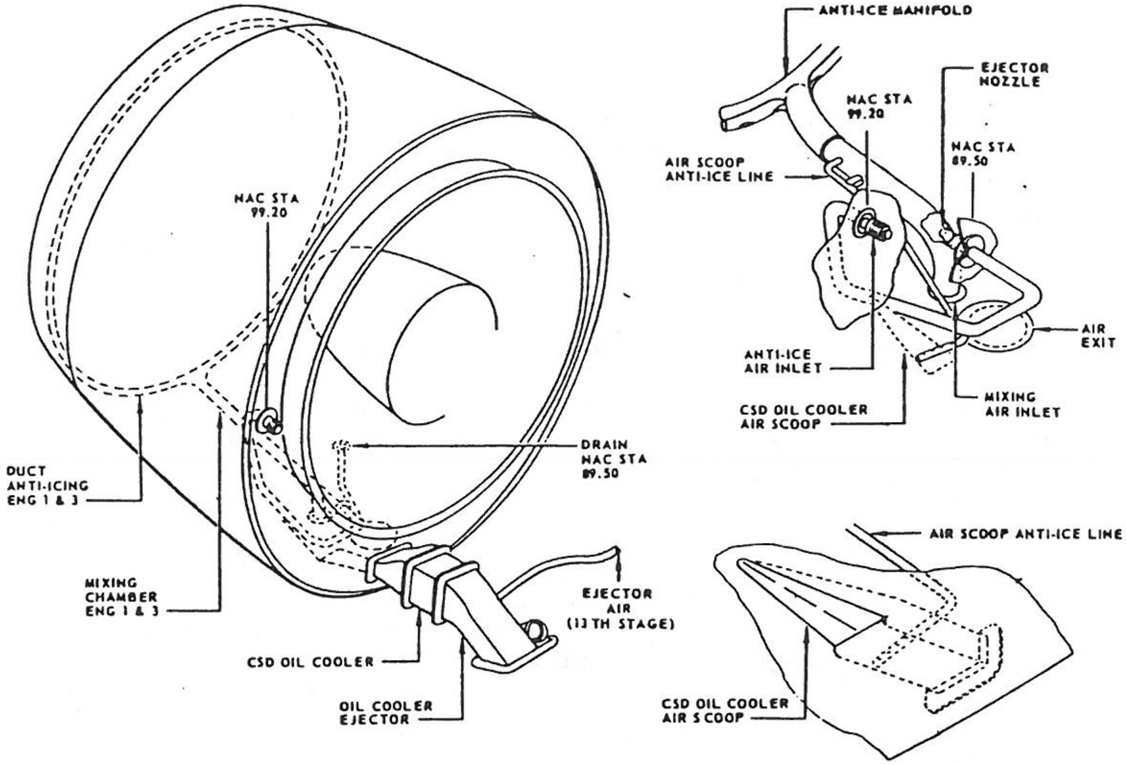
5 Wing Thermal Anti-Icing System Operation

The wing anti-ice system is controlled manually by the two wing anti-ice control switches on the overhead panel. Actuation of these switches to the ON or OPEN position while the airplane is in the air opens the wing TAI control valves for their respective engine and allows mixed 6th and 13th stage bleed air from the pod mounted engines to flow to the wing leading edge. The landing gear safety switch prevents wing anti-ice operation with the switch in the ON or OPEN position while the airplane is on the ground. The wing TAI control valves may be operated for testing on the ground by holding the switch in the GRD-TEST position. Overheating of the ducts by excessive ground testing is prevented by the wing TAI overheat switch which will automatically cycle the control valves to prevent the supply of air from exceeding 200°F.

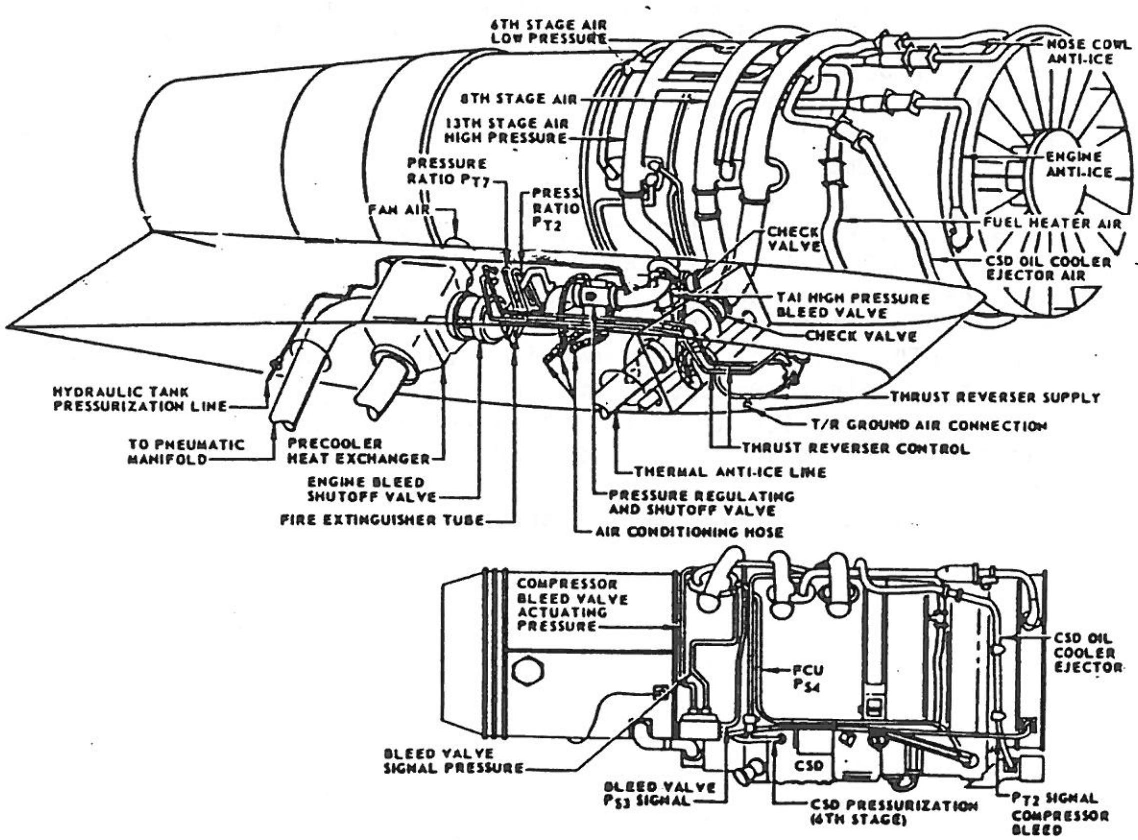
The valve position switch and the valve position indicator lights located under each control switch provide an indication of valve position. When the valve position switch is turned to the WING position, the lights will illuminate if the control valve positions agree with their respective control switch positions. The lights will go off when the valve position switch is returned to the OFF or Close position.

The duct temperature indicator and selector switch are provided to monitor TAI air supply temperature from each engine as selected. The duct overheat light illuminates when the TAI air supply duct temperature has exceeded 490°F when the airplane is in the air or when the overheat switch has overridden the "GRD-TEST" switch to prevent structural overheat when the airplane is on the ground. Continuous illumination on the ground or in flight may indicate a shutoff valve failure, and engine power should be reduced to prevent structural damage.

The wing anti-ice trip test switch is provided to check the operation of the wing anti-ice trip relay while the airplane is on the ground. When the switch is actuated to the "GRD-TEST" position, it energizes the wing anti-ice trip relay. When the switch is actuated to the "GRD-RESET" position, it de-energizes the wing anti-ice trip relay. The safety relay prevents control of the wing anti-ice trip relay by the trip test switch while the airplane is in the air. The wing anti-ice trip light illuminates when the wing anti-ice trip relay is energized to indicate that the wing TAI system has been tripped, and the control valves have been closed.



ENGINE NOSE COWL—1 AND 3 ENGINES



AIR DISTRIBUTION—ENGINES 1 AND 3

III. ENGINE COWL AND INLET DUCT ANTI-ICING SYSTEM

A. General Description

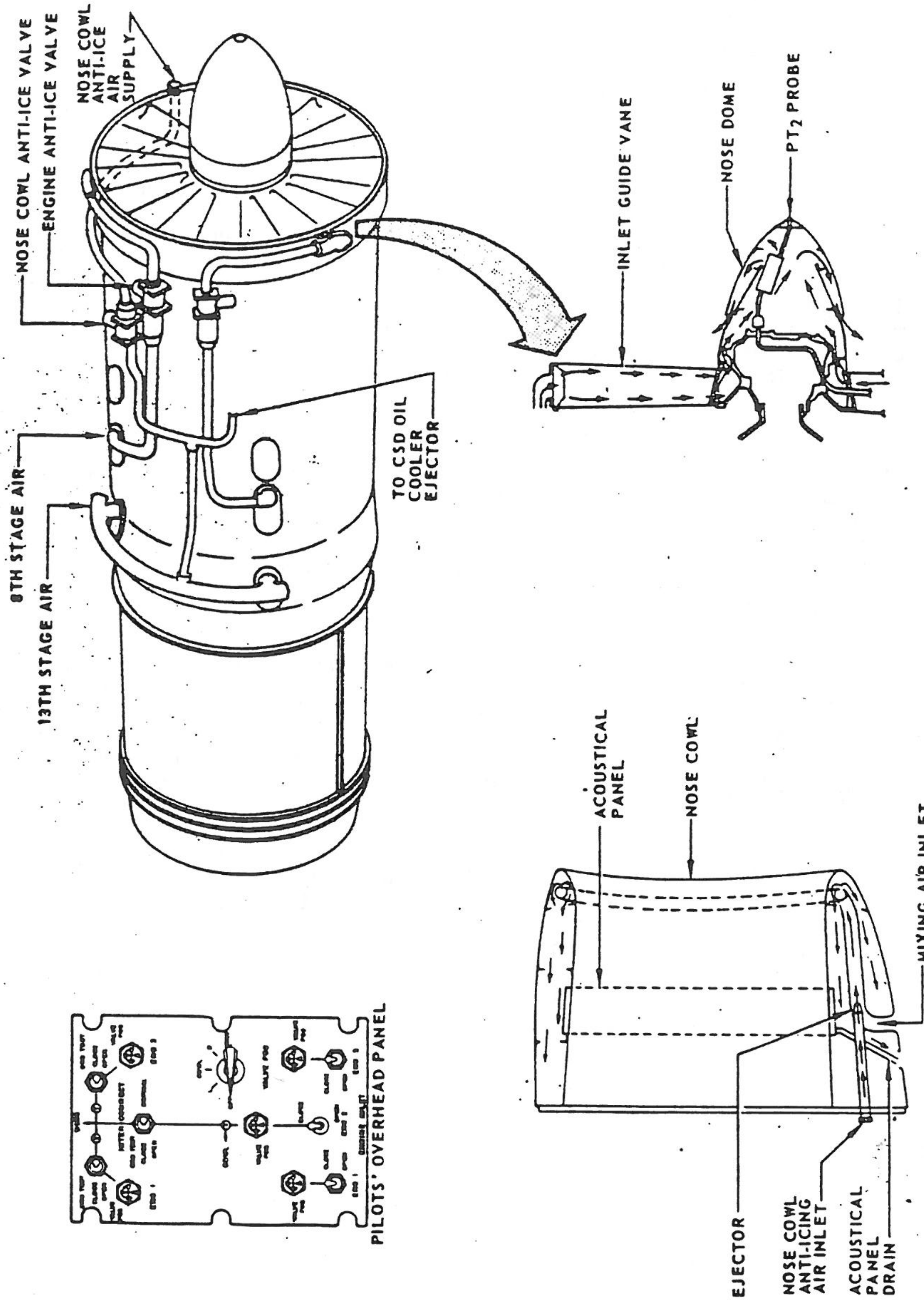
A thermal anti-icing (TAI) system using engine bleed air is provided to prevent the formation of ice in the engine air inlet and constant speed drive (CSD) oil cooler air scoop for each engine. The systems are separate and independently controlled for each engine. Each system consists of ducting, control valves, electrical control components and indicating components.

The engine inlet cowl leading edge and CSD oil cooler scoop for each pod mounted engine are anti-iced by 13th stage engine bleed air regulated by a thermostatic valve and tempered with ambient air by the use of an ejector. The pod engine cowl TAI systems are controlled by a single shutoff valve on the 13th stage engine bleed supply line for each engine.

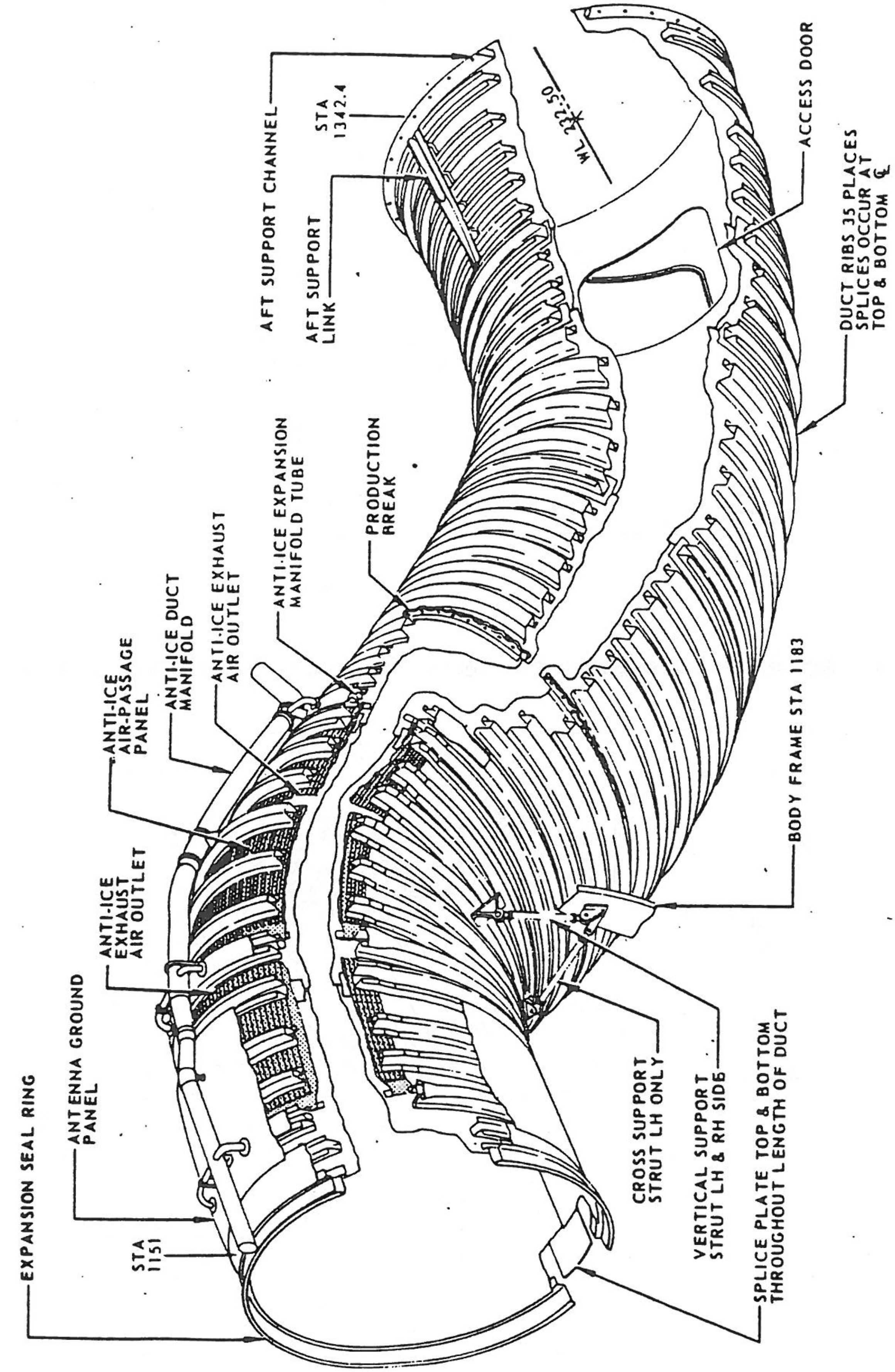
The center engine inlet cowl leading edge, inlet duct and CSD oil cooler air inlet are anti-iced by 13th stage engine bleed air regulated by a thermostatic valve and mixed with 6th stage engine bleed air by the use of an ejector. The center engine cowl TAI system is controlled by a shutoff valve on the 13th stage engine bleed air supply line and a shutoff valve on the mixed air flow distribution duct.

1. Cowl Anti-Ice Ducting

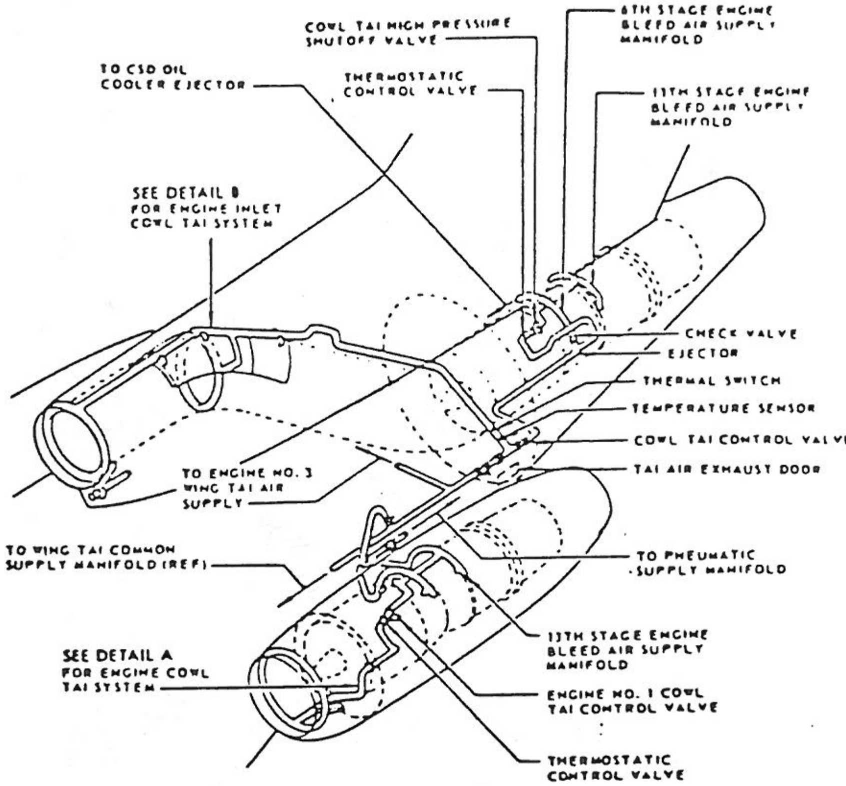
On the pod mounted engines, the 13th stage engine bleed air is supplied from the 13th stage engine bleed manifold to the shutoff and thermostatic control valves located on the left side of the engine. From the control valves the air is ducted directly to an ejector on a mixing chamber located in the bottom of the nose cowl. The ejector draws ambient air into the mixing chamber from an air inlet port on the bottom of the cowl. The mixed air is directed to a distribution manifold around the periphery of the cowl lip which has spray holes on the forward side to direct the air against the cowl leading edge. The air is then vented into the cavity between the cowl skins and exhausted overboard through an air outlet located on the bottom of the cowl. A tube connected to the forward end of the mixing chamber supplies TAI air to the lip of the CSD oil cooler air scoop where it is sprayed against the lip of the scoop and then exhausted overboard through the TAI air outlet.

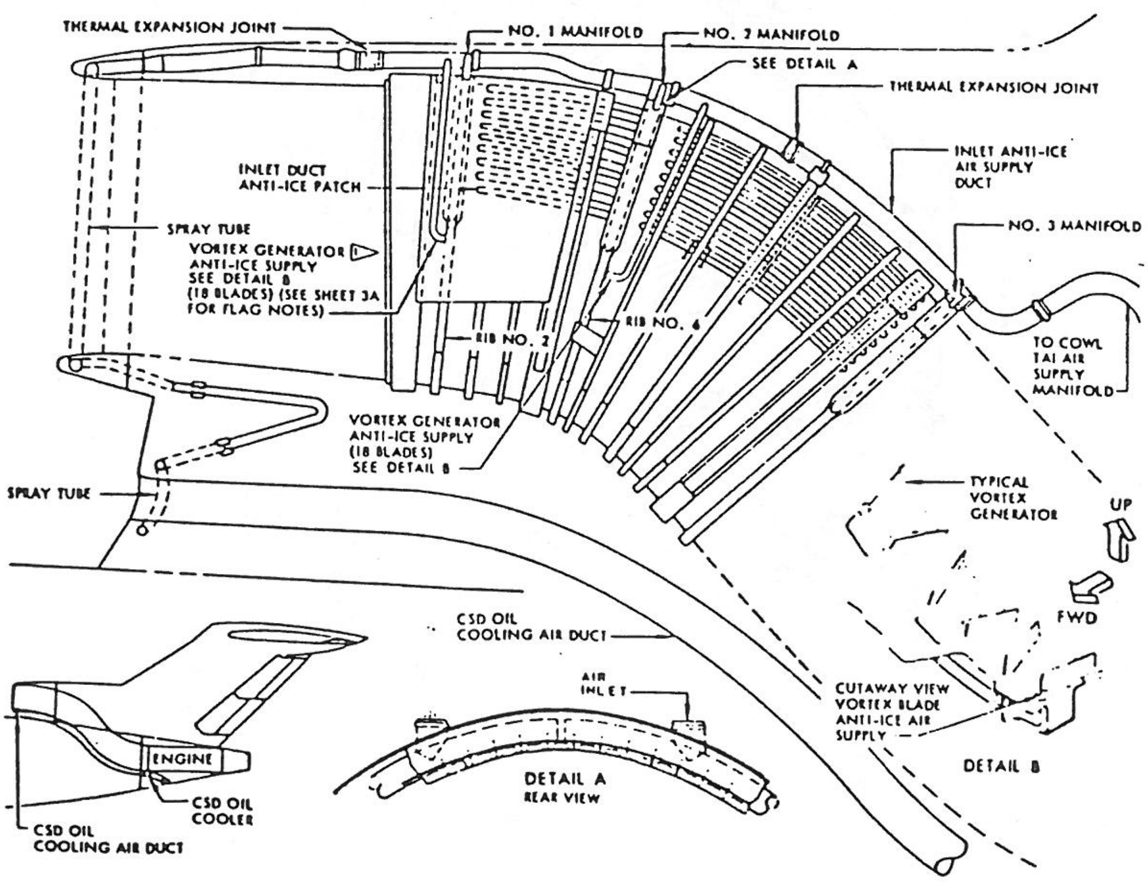


ENGINE AND NOSE COWL ANTI-ICE—1 AND 3



ENGINE NO. 2 DUCTING STRUCTURE


COWL TAI HIGH PRESSURE SHUTOFF VALVE
6TH STAGE ENGINE BLEED AIR SUPPLY MANIFOLD
TO CSD OIL COOLER EJECTOR
THERMOSTATIC CONTROL VALVE
13TH STAGE ENGINE BLEED AIR SUPPLY MANIFOLD
SEE DETAIL B FOR ENGINE INLET COWL TAI SYSTEM
CHECK VALVE
EJECTOR
THERMAL SWITCH
TEMPERATURE SENSOR
COWL TAI CONTROL VALVE
TAI AIR EXHAUST DOOR
TO ENGINE NO. 3 WING TAI AIR SUPPLY
TO WING TAI COMMON SUPPLY MANIFOLD (REF)
TO PNEUMATIC SUPPLY MANIFOLD
13TH STAGE ENGINE BLEED AIR SUPPLY MANIFOLD
SEE DETAIL A FOR ENGINE COWL TAI SYSTEM
ENGINE NO. 1 COWL TAI CONTROL VALVE
THERMOSTATIC CONTROL VALVE

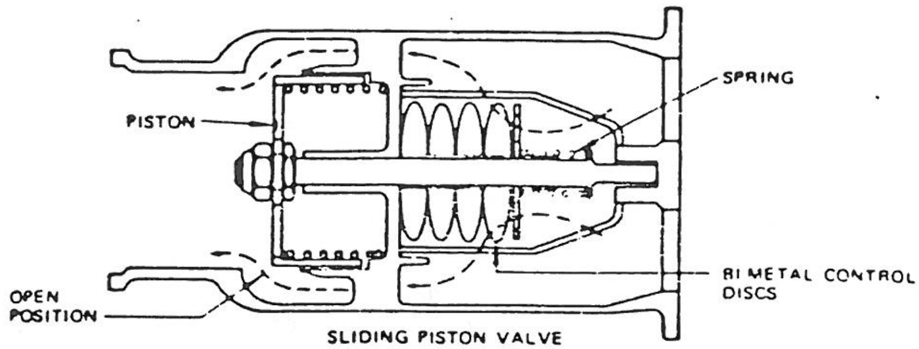

THERMAL EXPANSION JOINT
NO. 1 MANIFOLD
NO. 2 MANIFOLD
SEE DETAIL A
THERMAL EXPANSION JOINT
INLET DUCT ANTI-ICE PATCH
INLET ANTI-ICE AIR SUPPLY DUCT
SPRAY TUBE
VORTEX GENERATOR ANTI-ICE SUPPLY SEE DETAIL B (18 BLADES) (SEE SHEET 3A FOR FLAG NOTES)
NO. 3 MANIFOLD
RIB NO. 2
RIB NO. 6
TO COWL TAI AIR SUPPLY MANIFOLD
VORTEX GENERATOR ANTI-ICE SUPPLY (18 BLADES) SEE DETAIL B
SPRAY TUBE
TYPICAL VORTEX GENERATOR
UP
FWD
CSD OIL COOLING AIR DUCT
AIR INLET
ENGINE
CSD OIL COOLER
CSD OIL COOLING AIR DUCT
DETAIL A
REAR VIEW
CUTAWAY VIEW VORTEX BLADE ANTI-ICE AIR SUPPLY
DETAIL B

On the center engine, the 13th stage engine bleed air is supplied to a shutoff and thermostatic control valve on the left side of the engine, the same as on the pod engines. From the control valve the air is ducted to an ejector on the 6th stage engine bleed supply duct. A check valve located in the 6th stage supply duct prevents any reverse flow into the 6th stage engine bleed supply manifold. The mixed air is then ducted forward along the left side of the airplane to a mixed air shutoff valve which controls the flow of air into the cowl TAI distribution system. The distribution duct is connected to the cowl TAI system by a supply duct leading from the distribution duct up through the fin front spar, along the top of the engine air inlet duct and engine inlet cowl to a TAI distribution manifold around the periphery of the cowl lip. The cowl distribution manifold has spray holes on the forward side to direct air against the cowl leading edge. The air is then vented into the fuselage and is exhausted overboard through a spring loaded air vent door located on the left side of the fuselage. A tube connected to the bottom of the cowl distribution manifold supplies air to a TAI distribution manifold around the periphery of the CSD oil cooler air inlet where it is sprayed against the lip of the inlet. The air is then exhausted overboard the same as th cowl air.

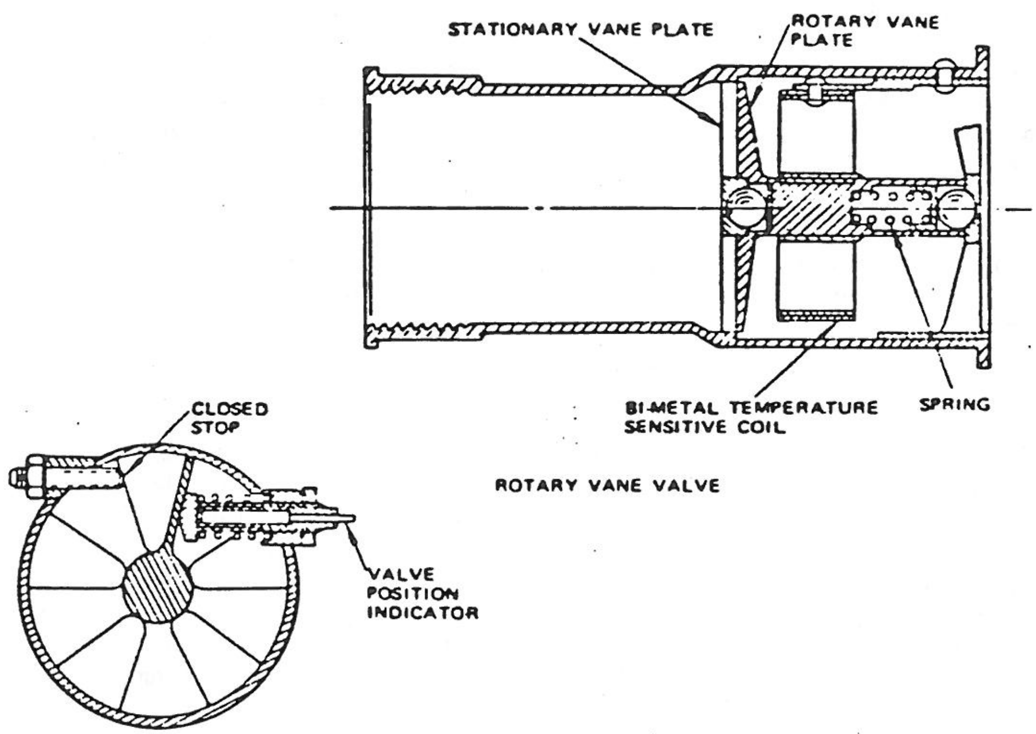
The outer half of the first bend of the center engine inlet duct is protected by three anti-icing patches. Three pairs of feeder ducts are connected from the TAI supply duct running along the top of the engine inlet duct to three distribution manifolds encircling the top half of the inlet duct. The air flows from the distribution manifolds into the TAI patches on the inlet duct, traveling between the inner duct skin and corrugated patches. The air is then exhausted overboard the same as the inlet cowl air.

A row of vortex generators located at rib No. 6 on the inner half of the first bend of the center engine inlet duct is anti-iced. A pair of feeder ducts is connected from the TAI supply duct running along the top of the engine inlet duct to a distribution manifold encircling the bottom half of the inlet duct. The air flows from the exhaust into the engine inlet airstream. On later airplanes an additional row of vortex generators is installed at rib No. 2 The additional row is anti-iced by a separate pair of feeder ducts connected to the TAI supply duct similar to the row at rib No. 6.

The TAI ducting on the pod engines, from the high pressure bleed manifold through to the ejector, is made of corrosion resistant steel. The mixing chamber and downstream duct are made of aluminum alloy. The TAI ducting on the center engine inlet, from the high pressure bleed manifold through to the center engine inlet TAI control valve, is made of Hastalloy. All ducting downstream of the control valve is titanium.

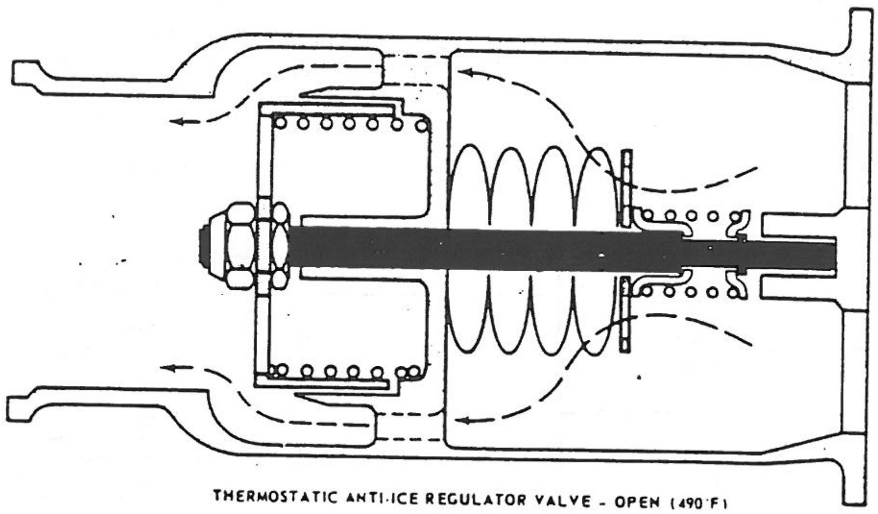


SLIDING PISTON VALVE

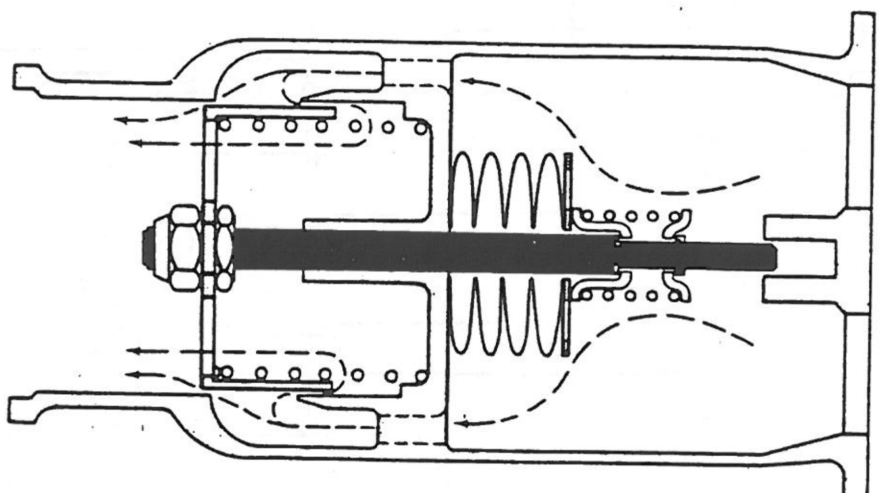


ROTARY VANE VALVE

Anti-Ice Regulator Valve

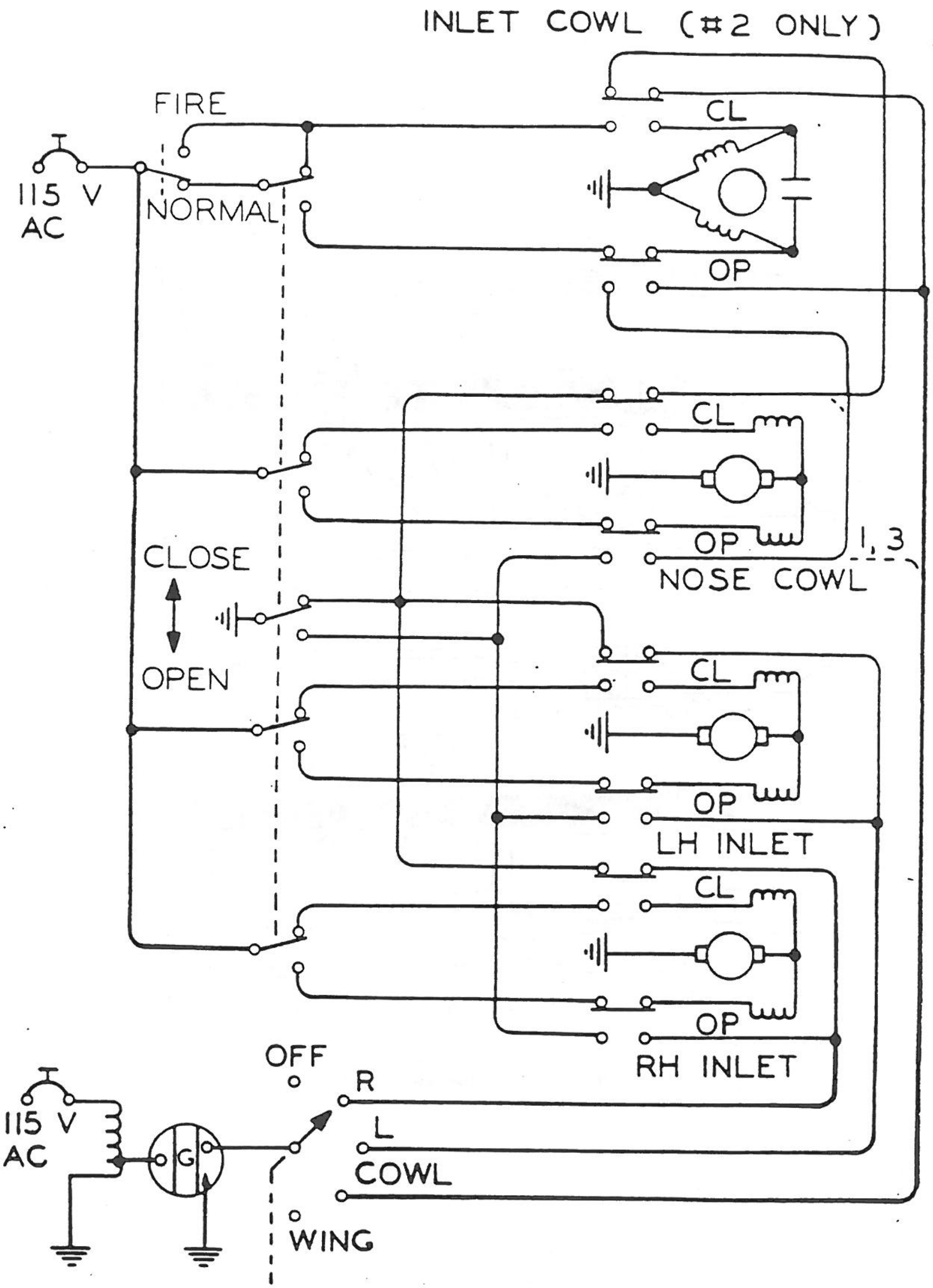


THERMOSTATIC ANTI-ICE REGULATOR VALVE - OPEN (490°F)



THERMOSTATIC ANTI-ICE REGULATOR VALVE - CLOSED (680 F)

ANTI-ICE REGULATOR VALVE



ENGINE COWL ANTI-ICE CONTROL CIRCUIT

2. Cowl Anti-Ice Control Valves

The flow of air in the cowl TAI systems is controlled by a 2-1/8" diameter high pressure shutoff valve and a 2-1/8" diameter thermostatic control valve for each engine, and a 4-1/2" diameter mixed air shutoff valve on the mixed air flow from the center engine.

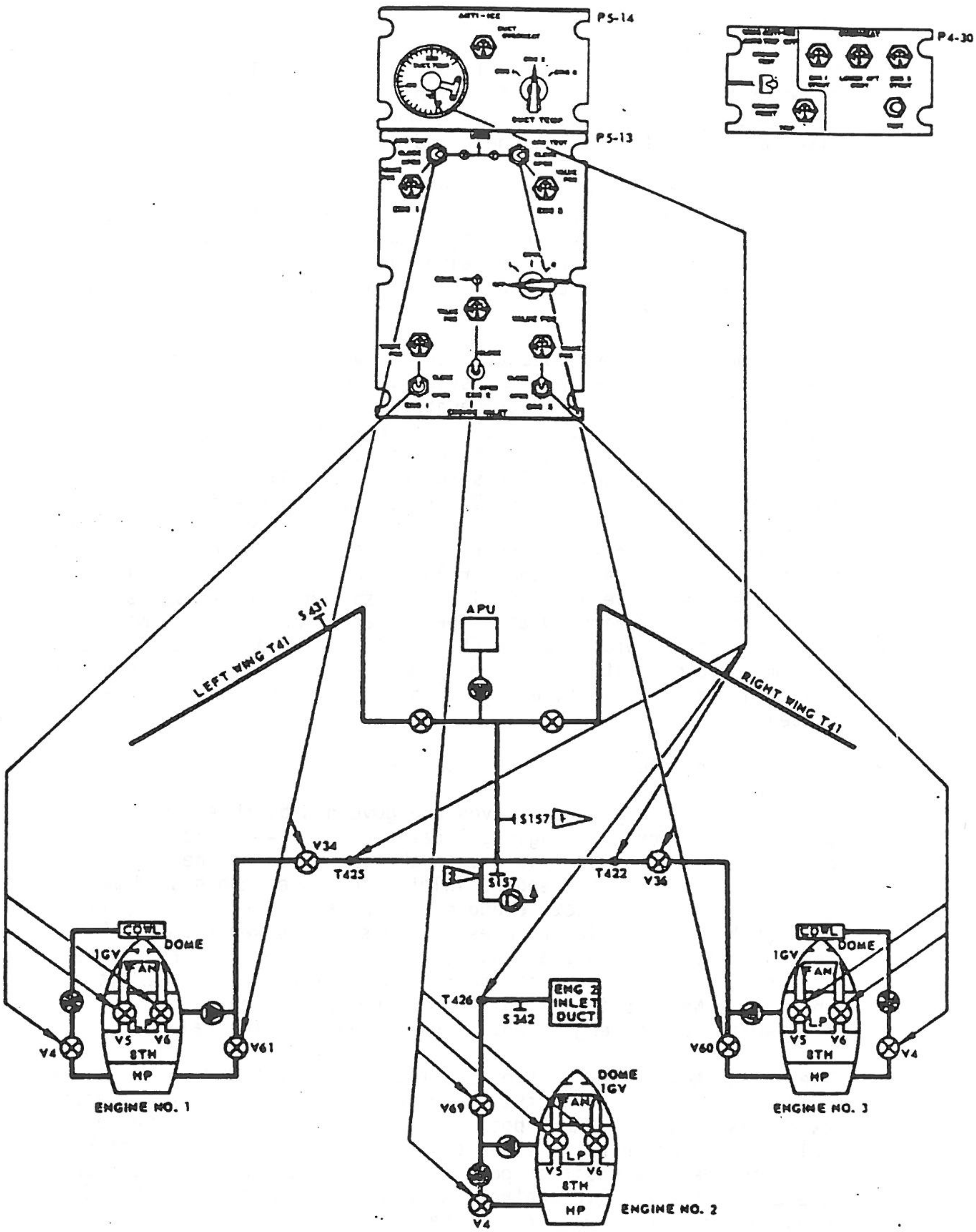
All four shutoff valves are electric motor driven butterfly valves which operate on 115 volt ac. The valves are equipped with limit switches, to prevent over-running of the motors, and valve position indicator switches for use in valve position indicator circuits. They are also equipped with external valve position indicators to verify valve position.

The thermostatic valve modulates the flow of air from the high pressure bleed to the cowl TAI system. The valve controls the volume of flow in relation to the temperature of the air. On some airplanes, the valve is a piston type regulated by a series of concave discs. As the temperature increases, the disc flattens, moving the piston, which closes the opening. On other airplanes, the valve is a rotary vane type. The rotary vane plate is rotated by a bi-metal temperature sensitive coil. As the temperature increases, the bi-metal coil rotates the rotary vane plate, which closes the opening, thus decreasing the airflow. An external plunger indicator shows when the valve is in full open position. The valve is designed to permit maximum airflow at temperatures below 490°F and minimum airflow at temperatures above 680°F. The cowl TAI system is designed to limit the quantity of air to no more than is necessary to prevent icing in order to minimize engine thrust loss as engine intake air is heated.

3. Cowl Anti-Ice Electric Control Components

The cowl anti-ice control valves are governed by three control switches, one for each engine, located on the P-5 pilot's overhead panel. These switches also govern the operation of the engine anti-ice valves for the engine inlet guide vanes and nose dome TAI system for their respective engines. The switches are two position "OPEN," "CLOSE" toggle switches. They supply power from the P-6 load control center 115 volt ac bus No. 1, No. 2 or No. 3 directly to the nose cowl anti-ice valve of their respective engine. In addition, the engine No. 2 switch also supplies power through the engine No. 2 fire switch to the engine No. 2 inlet cowl anti-ice valve.

The engine No. 2 fire switch is a two position, "NORMAL" and "FIRE" toggle switch located on the P-7 pilot's fire switch panel. When the switch is in the "NORMAL" position power is directed to the common pole of the engine No. 2 valve control switch. When the switch is moved to the fire position power is directed to the close contact of the engine No. 2 valve control switch, bypassing the switch and closing the inlet cowl anti-ice valve.

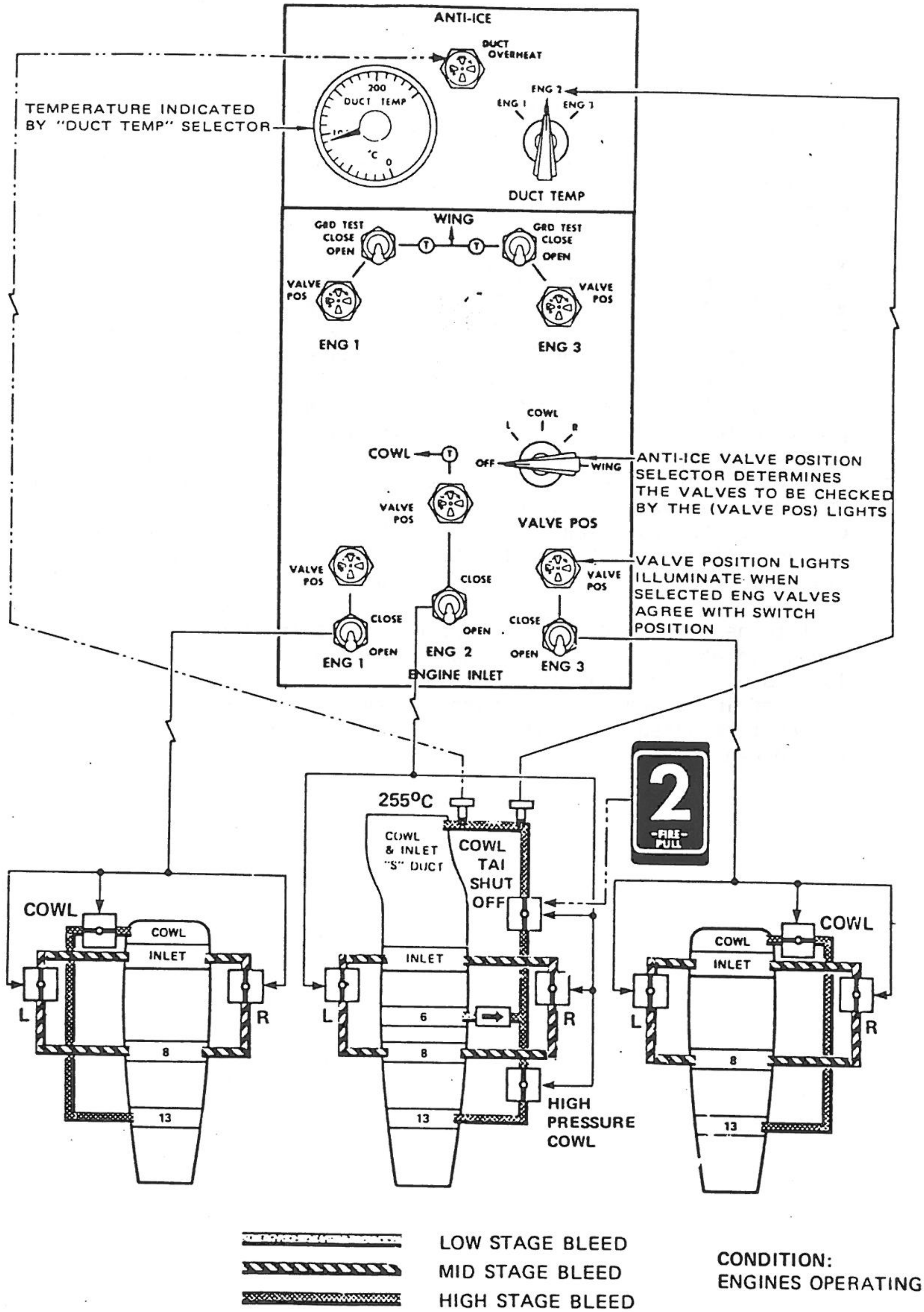


THERMAL ANTI-ICE CONTROL

4. Cowl Anti-Ice Indicating Components

The cowl anti-ice system is provided with a valve position indicator light for each engine and a valve position switch. The indicator lights and switch are located on the P-5 pilot's overhead panel adjacent to the valve control switches. The lights are 28 volt, green press-to-test type lights. The valve position switch is a six pole, five position switch, OFF-L (engine TAI left valves) - COWL (cowl TAI valves) - R (engine TAI right valves) - WING (wing TAI valves). When the switch is moved to the COWL position, it completes a circuit through the engine inlet valve indicator lights and valve position switch to each cowl TAI control valve, through whichever valve position indicator switch in the valve that is closed, to the respective contact of the indicating pole on the valve control switches. If the valve position agrees with the valve control switch position for the respective engine, the circuit will be completed through the indicating pole of the valve control switch to ground. In the case of the No. 2 engine both the high pressure and the inlet cowl anti-ice control valves must be in agreement with the valve control switch position to complete the circuit to ground. There is no indication during valve travel as both valve position indicator switches are open in each valve during valve travel.

Duct temperature and overheat protection is provided for the No. 2 engine inlet by a duct temperature indicator and duct overheat light located on the P5 pilot's overhead panel. The indicator and light are used in common with the wing TAI system and are controlled by a temperature sensor an thermal switch located in the TAI duct leading to the center engine inlet.



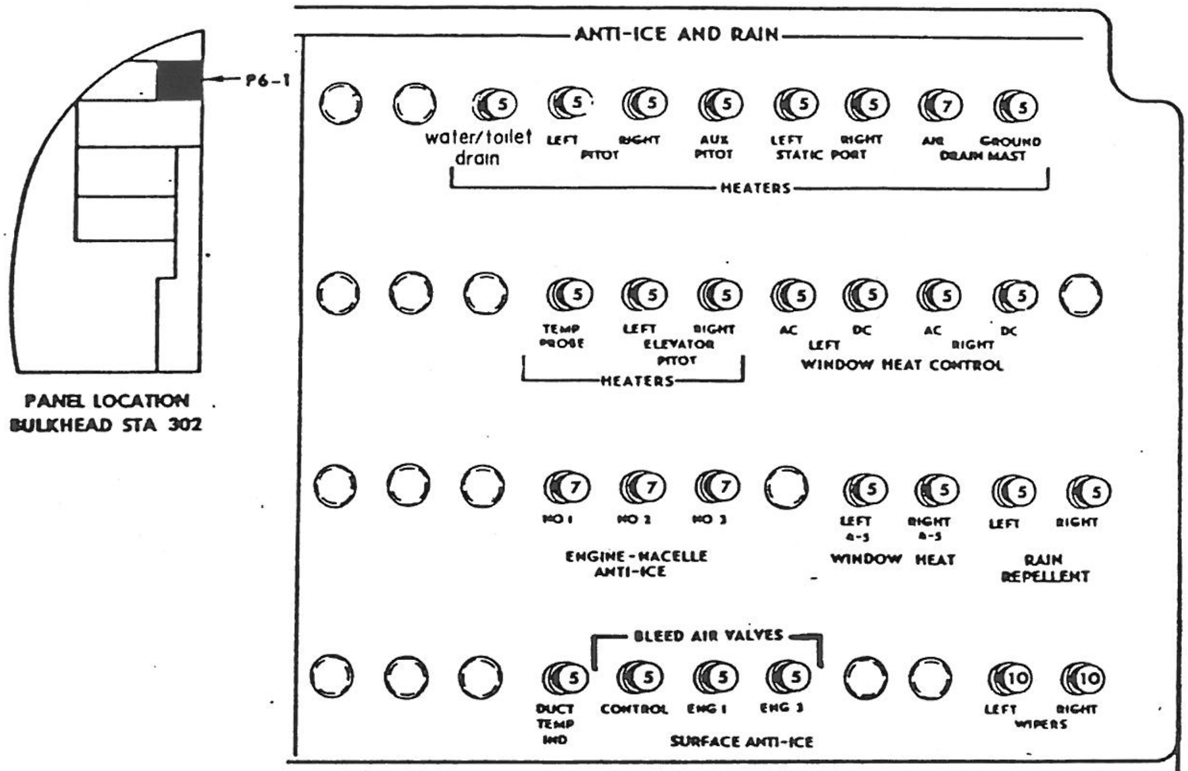
ENGINE ANTI-ICE

5. Cowl Anti-Icing System Operation

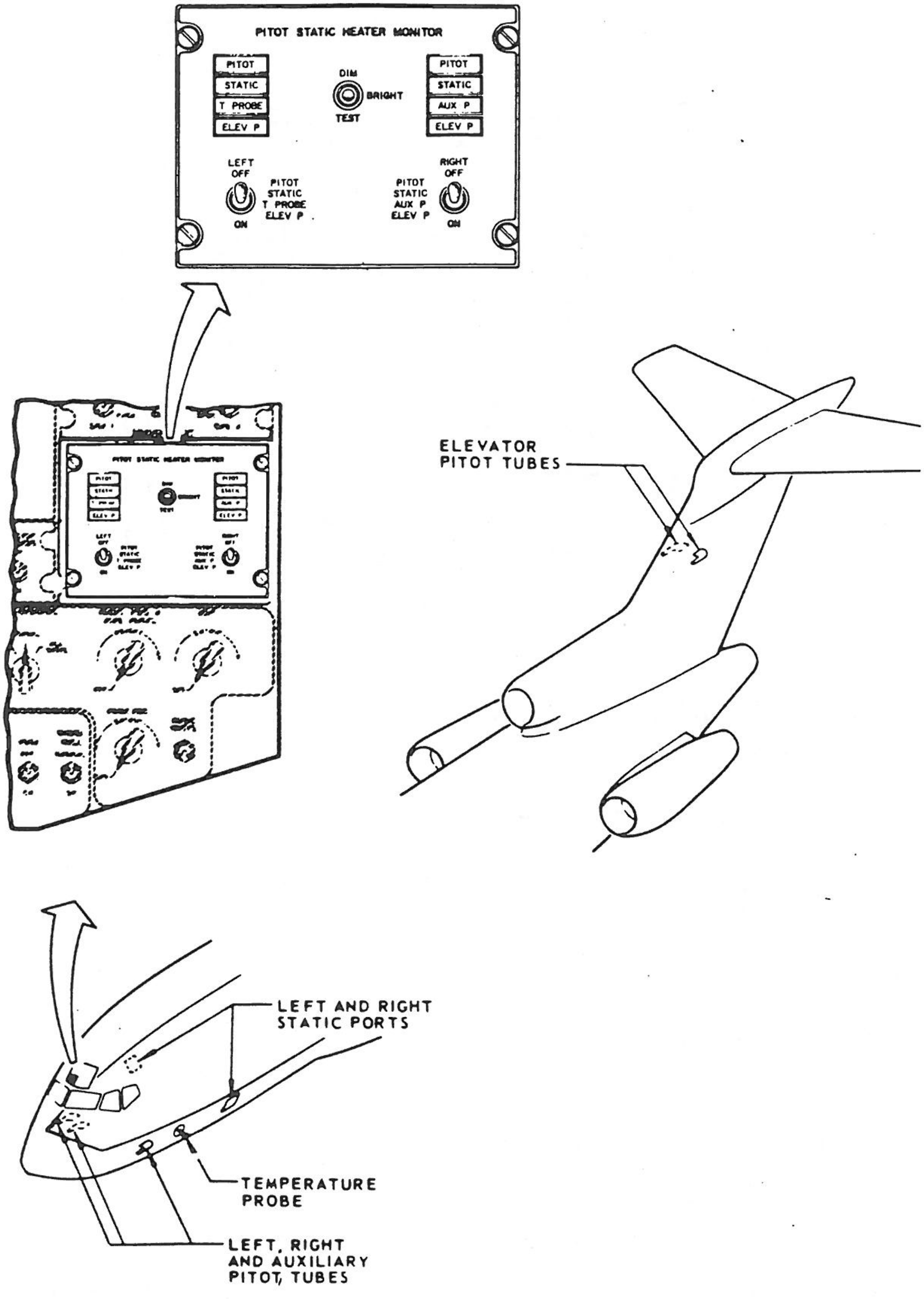
The cowl anti-icing system is controlled by the three cowl anti-ice switches on the overhead panel. Actuation of these switches to the ON or OPEN position opens the cowl TAI control valves for their respective engine and allows TAI air to flow into the respective cowl TAI distribution system.

CAUTION: DO NOT OPERATE THE COWL ANTI-ICING SYSTEMS AT HIGH ENGINE POWER SETTING WITH THE INDICATED OUTSIDE AMBIENT TEMPERATURES OVER 50°F (10°C). PROLONGED OPERATION UNDER THESE CONDITIONS WILL REDUCE THE HAIL RESISTANCE OF THE COWL LEADING EDGE SKIN.

The duct temperature indicator will monitor the TAI air supply temperature to the center engine cowl system when the duct temperature selector switch is turned to the engine No. 2 position. The duct overheat light will illuminate when either the center engine inlet or wing TAI air supply has exceeded 490°F or when the overheat relay has overridden the wing TAI control switch in the GRD-TEST position. Continuous illumination on the ground or in flight may indicate a control valve failure, and engine power should be reduced to prevent structural damage.

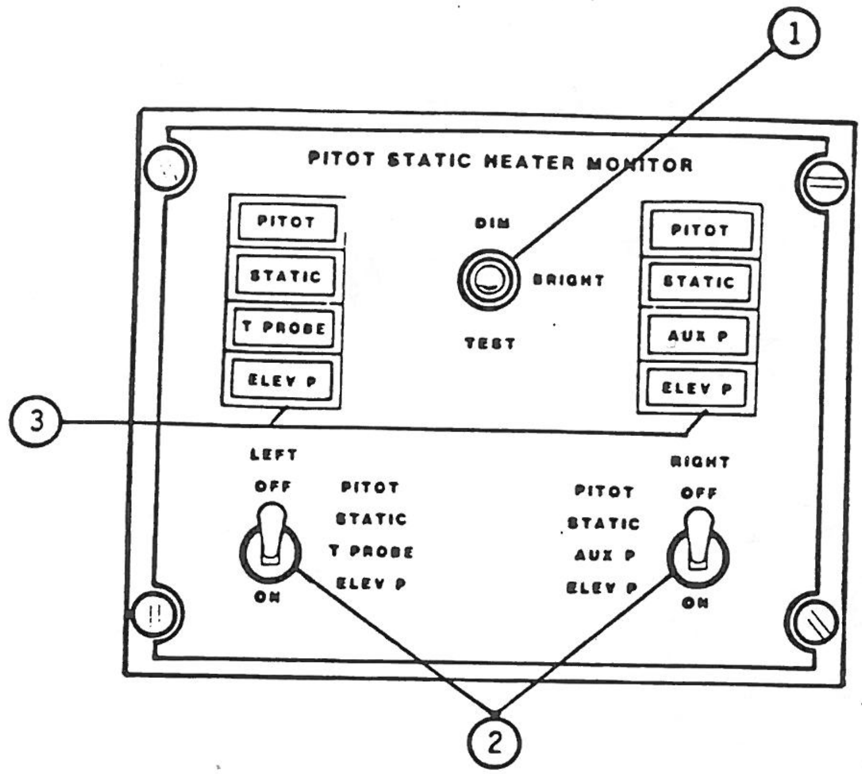


LOAD CONTROL CENTER CIRCUIT BREAKER PANEL (P6-1)



Pitot Static and Temperature Probe Anti-Icing
System Equipment Location

PITOT STATIC HEAT AND MONITOR (ALL AIRCRAFT)



1 DIM-BRIGHT-TEST SWITCH

2 PITOT-STATIC HEAT CONTROL SWITCHES

3 ANNUNCIATOR LIGHTS

NOTE: To provide 28 VDC power to PITOT-STATIC HEAT annunciator lights the following circuit breakers must be on:

N101FE - 136FE

CB-RADIO BUS (P6-2)
CB-AIR DATA HEAT MON (P18-1)

TESTING

With power on aircraft and PITOT-STATIC HEAT switches OFF.

- Annunciator lights should be illuminated.

- Select PITOT-STATIC HEAT switches ON. Annunciator lights should extinguish.

- Select PITOT-STATIC HEAT switches OFF. Annunciator lights should illuminate.

NOTE: The DIM-BRIGHT-TEST switch will only control the annunciator lights dim/bright feature. The TEST position is inactive on all aircraft.

IV. PITOT AND STATIC 727-100C

A. Pitot Static and Temperature Probe Anti-Icing System

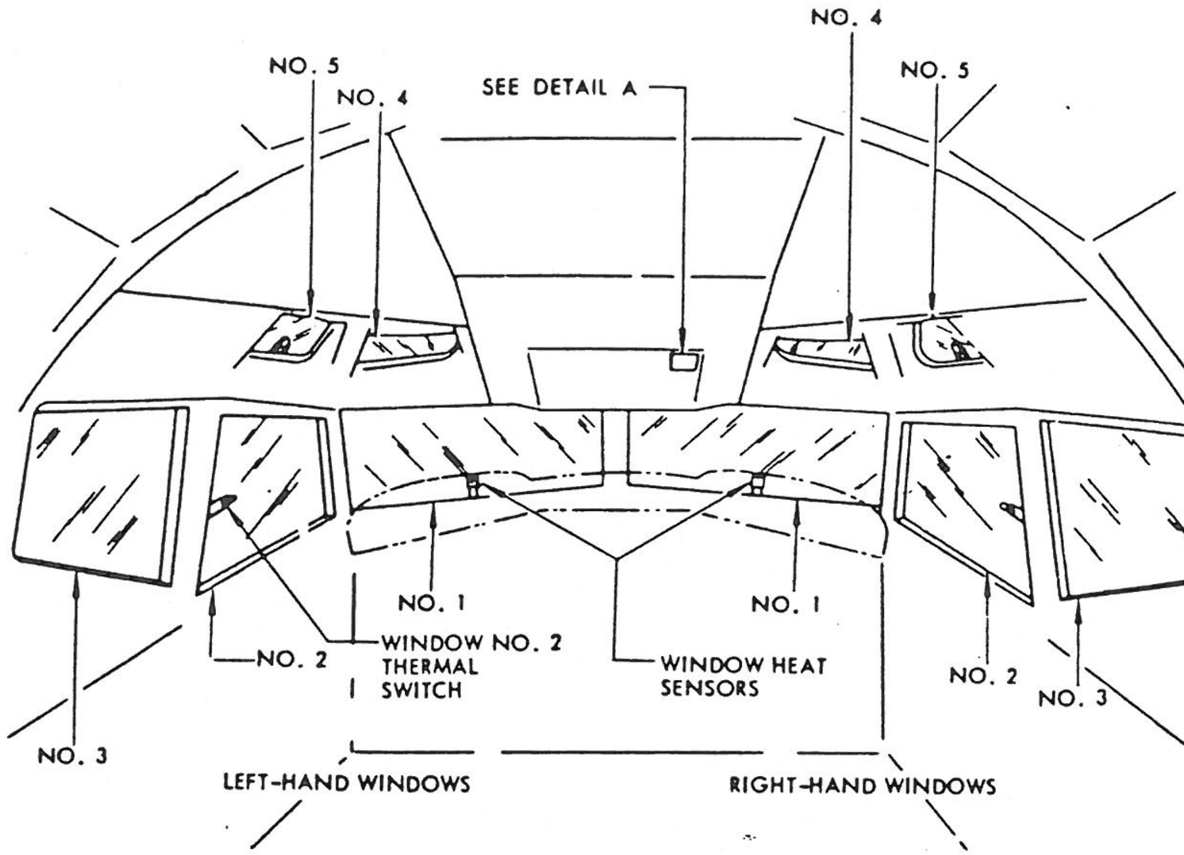
1. Description and Operation

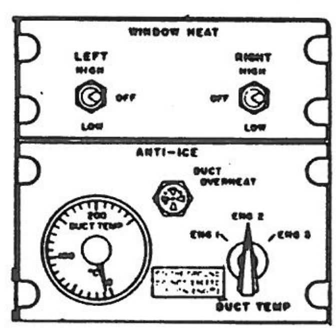
The left, right and auxiliary pitot tubes, six static ports, both left and right elevator pitot tubes and the temperature probe are heated to prevent the formation of ice on the sensor which could affect sensing accuracy. The heating is accomplished by electrical heaters installed as an integral part of the units. The heaters consist of resistance elements which operate on 115 volt single phase current.

The current of the heaters is supplied from six circuit breakers on the P6-1 panel, and is controlled by two switches on the Pitot Static Heat and Monitor panel on the overhead P5 panel. The left switch controls the heating of the left pitot, temperature probe (Rosemont), left static ports and left elevator pitot. The right switch controls the heating of the right pitot, auxiliary pitot, right static ports and right elevator pitot. Current for the left system is supplied from the 115 ac Essential bus. Current for the right system is supplied from the 115 ac Bus No. 2.

The monitor panel incorporates eight annunciator lights, four for left and four for right system for their respective heaters. With power applied to the busses and the control switches OFF the lights will be illuminated. When the control switches are ON and the heaters are operational the annunciator lights will be extinguished. Should an electrical failure occur in the heating system the respective light will illuminate to indicate the failure. Electrical 28 VDC power for the annunciator lights is supplied by the radio essential bus circuit breaker on the P6-2 panel.

Each electrical circuit to each heater has a line current transformer to sense the operation of each heater and the monitor panel incorporates the failure warning monitor circuit which will cause the annunciator lights to illuminate when a failure occurs.





DETAIL A

Control Cabin Window Anti-Icing System Equipment Location

V. WINDOWS AND WINDSHIELD 727-100C

A. Control Cabin Window Anti-Icing System

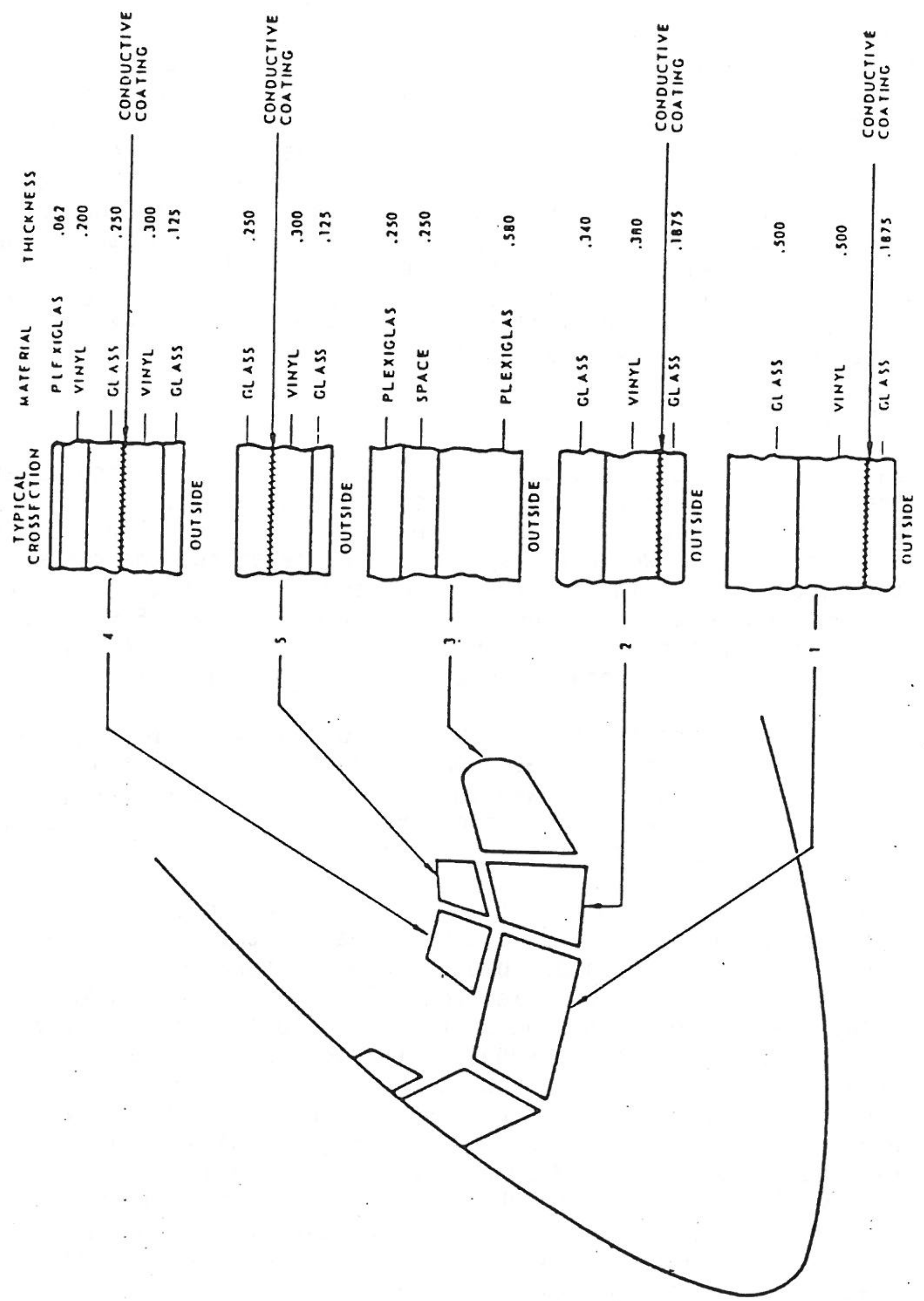
Windows No. 1, 2, 4 and 5 on each side of the control cabin are provided with electrical heating for window anti-icing and defogging. Heating of the control cabin windows also improves the impact strength of the windows and window heat is used for birdproofing the windows when flying at altitudes where bird strikes are possible. The windows are divided into two groups, each consisting of windows No. 1, 4 and 5 on one side of the cabin and window No. 2 on the other side. Each group of windows is controlled by a separate and independent system which maintains the windows at the required temperatures by the use of automatic controls while the system is in operation. In the event of a power failure to one system, the No. 2 windows of that side will still be operated by the other system, thus ensuring that reasonable forward vision from each side will be maintained.

1. Control System

Each system is controlled by a window heat control switch located on the pilot's overhead panel. The switches have a HIGH and LOW position which provide a choice of the rate at which the No. 1 and 2 windows will be heated. While the system is in operation, the temperature of the window is regulated between 100° and 114°F for the No. 1 and 2 windows and between 80° and 120°F for the No. 4 and 5 windows. An overheat detection system turns off the power to the No. 1 and 2 windows when an overheat condition of 135±20°F is detected.

Each system consists of the four heated windows, a window heat sensor, a combined heat and overheat control unit, a control switch, an overheat relay, a dual power control relay, a transformer, a window overheat indicating light, an overheat test switch, two thermal switches and a system testing circuit.

When the system is in operation, the temperature of the No. 1 and 2 windows is controlled by the window heat control unit. The window heat sensor in the No. 1 window provides the temperatures signal for the control unit. The dual power control relay and the window overheat relay are controlled by the control unit to accomplish power switching. The power is supplied through the overheat relay, and dual power control relay in series to the high or low voltage taps in the window heat transformer, depending on the control switch position. The window heat transformer supplies the higher voltages required for heating the windows. If an overheat condition is detected, the control unit will drop out the overheat relay cutting off power to the windows, and turning on the overheat indicating light. An overheat condition can be simulated by pressing the overheat test switch with the window heat control switch in either "HIGH" or "LOW" position. The system is returned to normal by momentarily turning the control switch to the OFF position. A thermal switch on the No. 2 window prevents overheating of that window in the open position. The temperature of the No. 4 and 5 windows is controlled by a window thermal switch on the No. 5 window.



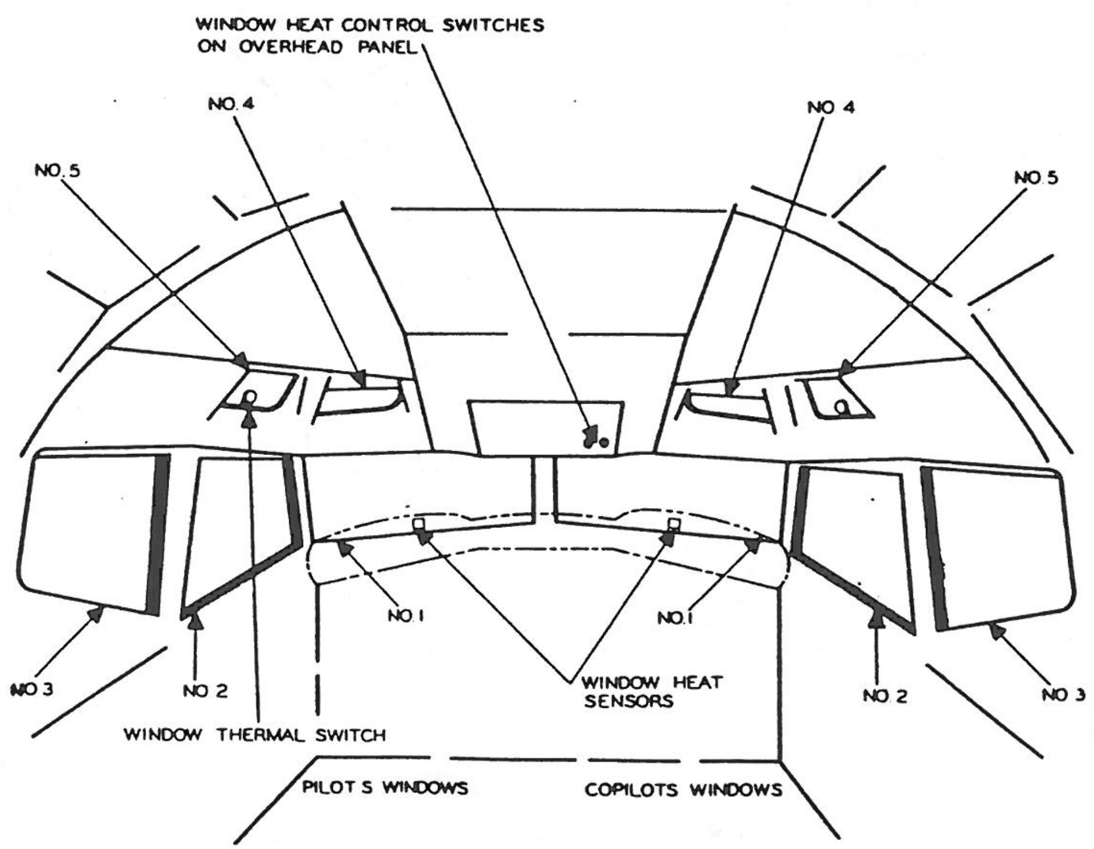
CONTROL CABIN WINDOWS

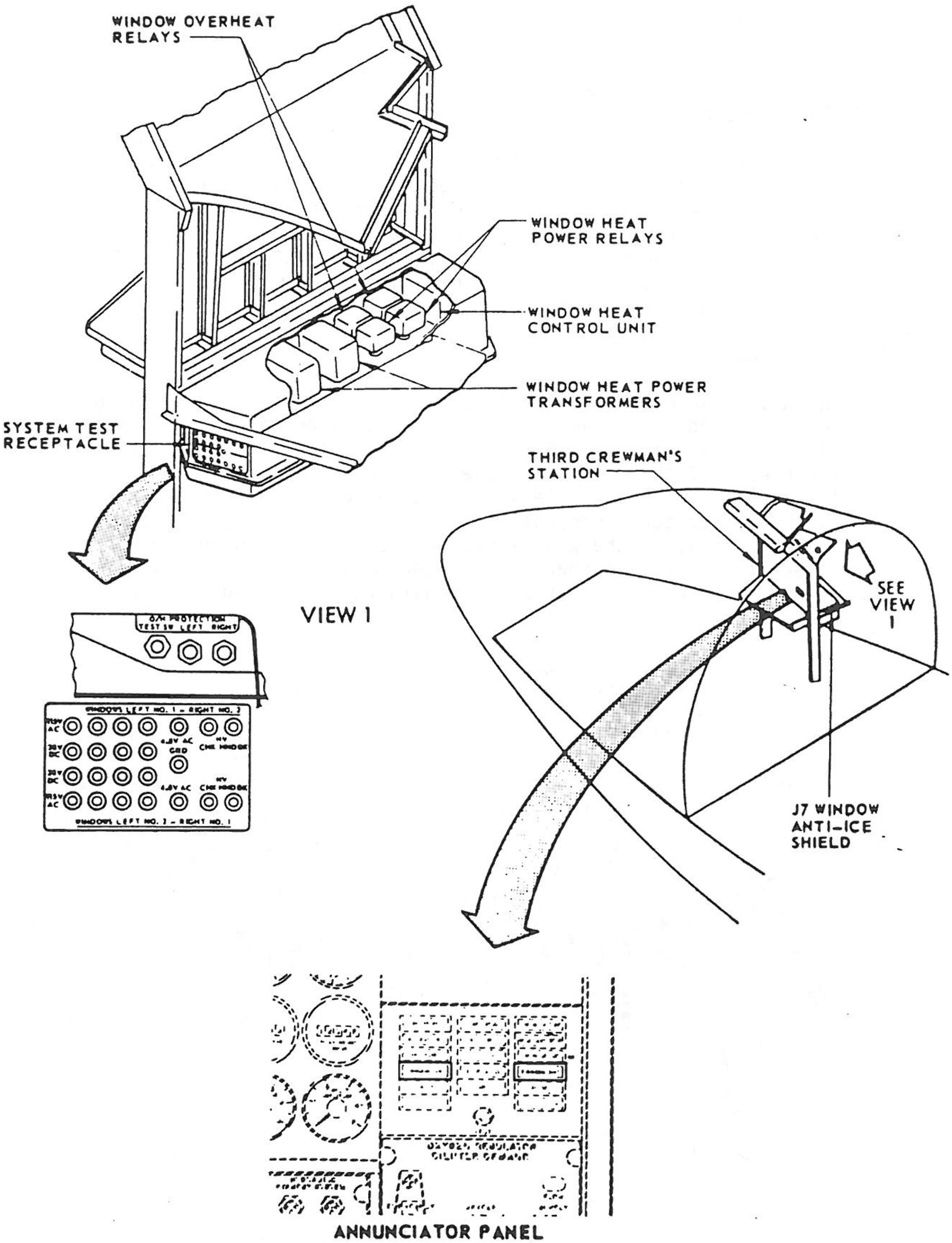
2. Window Conducting Coating

The control cabin windows are of laminated glass-vinyl construction. The No. 1 and 2 windows have a conductive coating between the outer glass pane and vinyl core where it is most effective for window anti-icing, whereas the Nos. 4 and 5 windows have their conductive coating between the inner glass pane and the vinyl core where it will be most effective for window defogging. All four windows have electrical terminals connected to bus bars which are molded into the upper and lower edges of the window in contact with the conductive coating. The windows are heated by allowing current to flow through the conductive coating between the upper and lower bus bars to maintain equivalent heat output.

3. Window Heat Sensor

The No. 1 windows have a heat sensor consisting of a filament of non-insulated resistance wire. The wire is arranged in a single plane coil and imbedded in a thin plastic wafer installed near the lower edge of the window, between the outer pane and plastic core. The resistance of the wire is sensitive to temperature and increases as the temperature increases. The heat sensor is used as a part of a bridge circuit in the window heat controller. A change in window temperature causes a change in sensor resistance, disturbing the voltage balance of the bridge circuits and providing a signal for the controller.





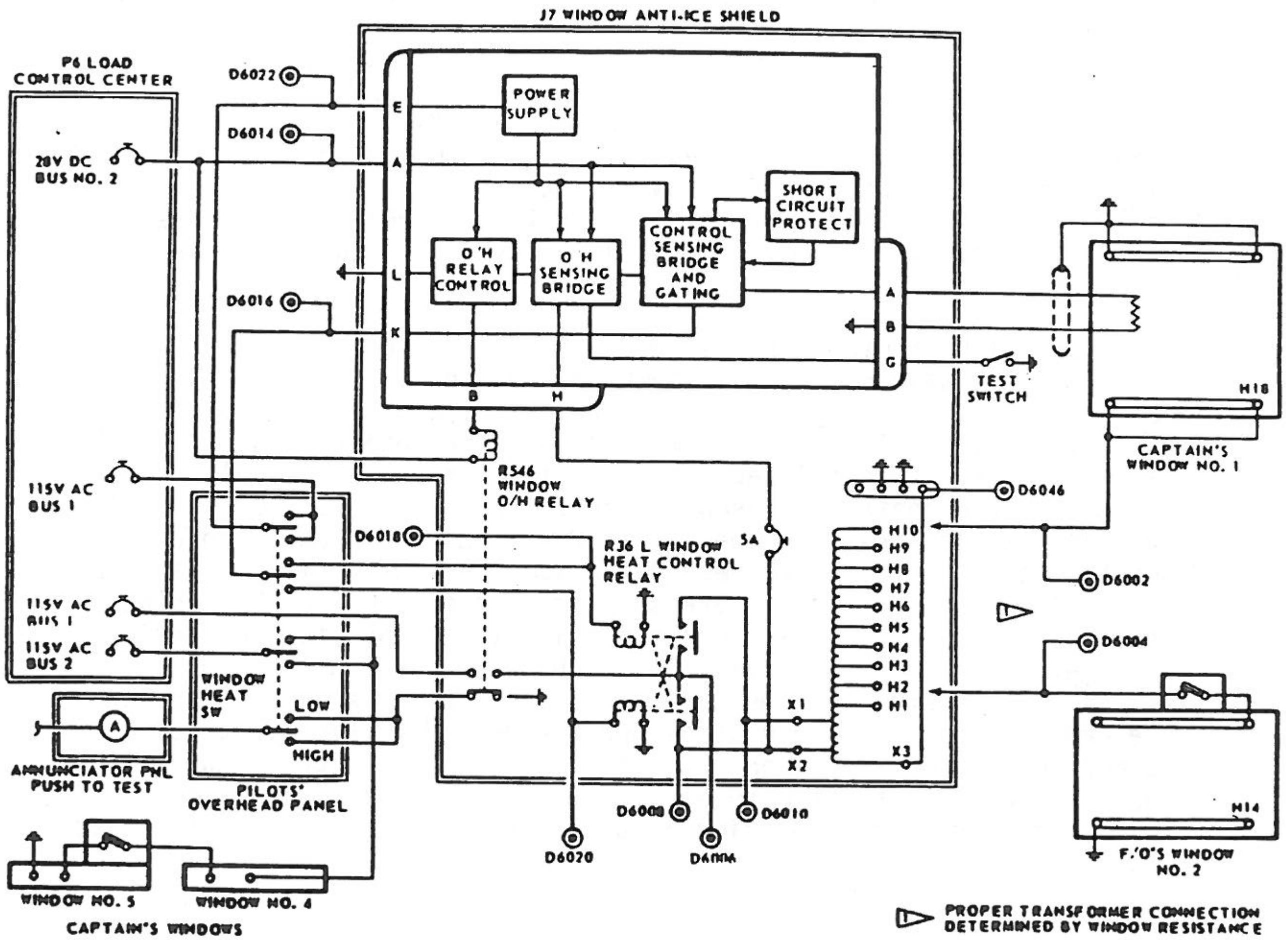
Control Cabin Window Anti-Icing System Equipment Location

4. Window Heat Control Unit

The window heat control unit is a solid sate controller. The units for both systems are mounted in a common housing located in the J7 window anti-ice shield. Each unit is controlled by its respective window heat control switch and in turn controls the operation of the window overheat and power relays.

While the system is in operation, the controller monitors the resistance of the window heat sensor for temperature control, shorted sensor and window overheat. When a sensor resistance of less than 333 (±3) ohms, but more than 100 ohms, is detected the unit supplies full wave rectified power to energize the window power relay. The unit cuts off power to the relay when a resistance of more than 339 (±3) ohms is detected. If the sensor resistance drops to 100 ohms or less (shorted sensor) the unit will not supply power to the power relay. If the sensor resistance rises to 352 (±6) ohms or more the unit will drop out the overheat relay preventing power from being supplied to the windows.

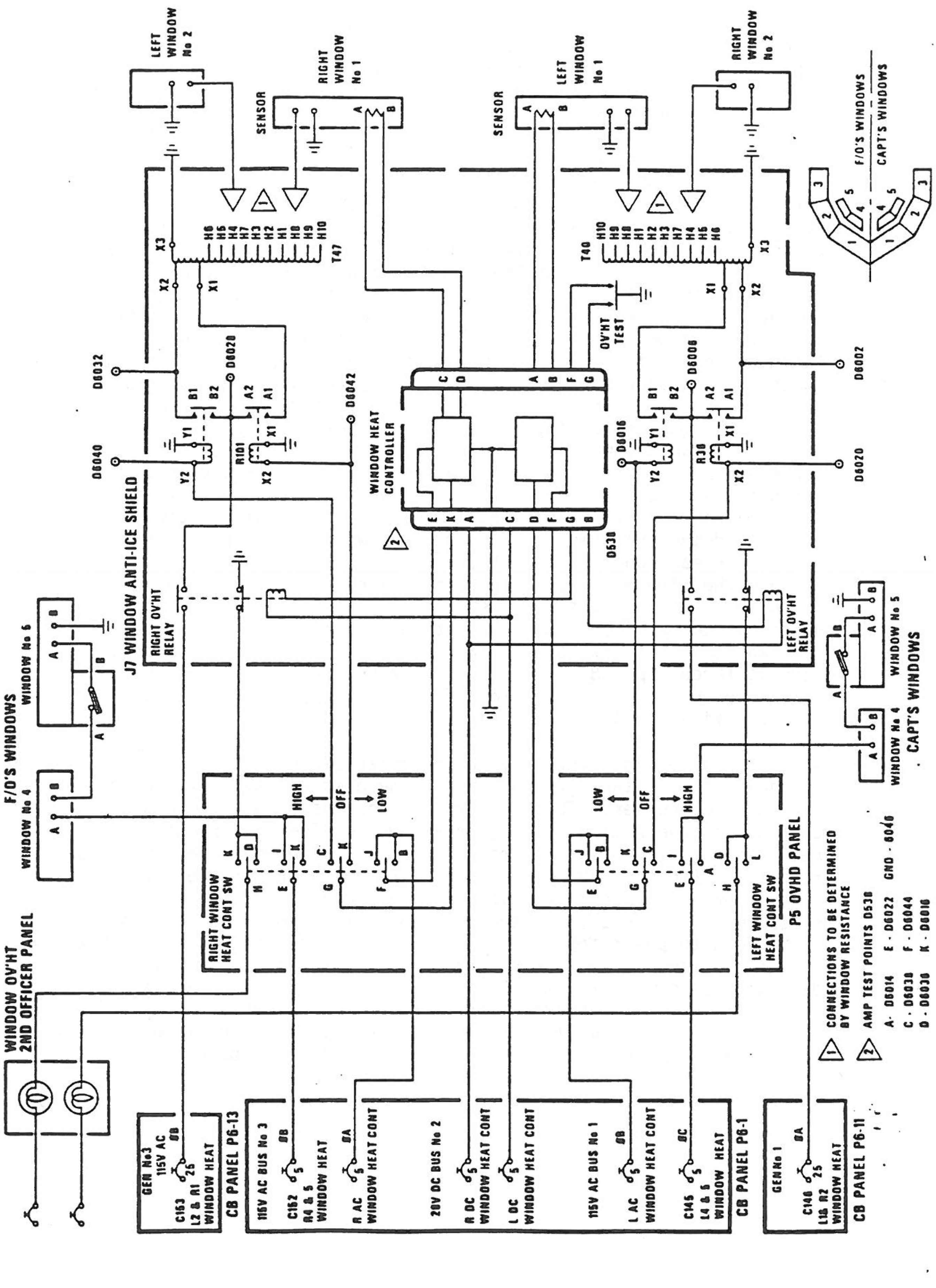
The control unit circuitry is separated into three functional sections, voltage regulation, temperature control, and overheat detection. The voltage regulator protects the other two sections from transient voltages which may upset their detection networks. The temperature control section consists of a pulse control circuit, a temperature control and shorted sensor bridge network of which the window heat sensor forms one leg, a detent circuit, and a power control circuit. The overheat detection section consists of a pulse control circuit, a temperature sensing bridge of which the window heat sensor forms one leg in common with the temperature control bridge, a time delay circuit, a switch, and a switch latching circuit. A system of time sharing is used to prevent interference between the temperature control and overheat detection functions, since the sensor is common to both systems. The bridge network of each system is activated to sample the sensor resistance by their respective pulse control circuit at different phase angles of the ac cycle.



WINDSHIELD ANTI-ICE CONTROL

With the window anti-ice circuit breakers closed, 28 volts dc will be applied directly to pin A of the unit and indirectly through the window overheat relay to pin B. When the pilot's window heat control switch is placed in either the "HIGH" or "LOW" position, 115 volts ac will be applied directly to pin E. The 115 volt ac supply will operate the switch in the detector circuit to close providing a ground for the overheat relay through pin B. As the voltage approaches zero from the negative side of the ac cycle, the temperature control pulse circuit will activate the temperature control sensing bridge to sample the window sensor resistance, which, if required, will activate the controller power relays providing full wave rectified power to pin K. With power at pin K a feedback voltage will activate the detent circuit which will upset the bridge balance to effectively lower the sensor resistance by 6 ohms, locking the power on until the sensor resistance increases sufficiently to restore the bridge balance. If the sensor resistance is below 100 ohms, the shorted sensor bridge circuit will override the temperature control bridge, preventing the controller power relays from being energized. When power is being applied to the windows, 115 volt ac power will be directed through pin H to the overheat detection circuit and as the voltage approaches zero from the negative side of the ac cycle the overheat detection pulse circuit will activate the overheat detection bridge, to sample the window sensor resistance. If an overheat condition exists, the bridge will provide a signal through the time delay circuit to the overheat switch latching circuit. If the condition persists for 2/3 ($\pm$1/3) seconds, the switch latching circuit will be activated, which will hold the overheat switch in the open condition. This will break the ground circuit through pin B, dropping out the overheat relay and preventing power from being applied to the window. The latching circuit will remain active until power to pin E of the controller is interrupted.

With the system in operation, the overheat circuit may be tested by providing a momentary ground through the overheat test switch to pin G of the controller. This disturbs the bridge balance of both the control and overheat circuits, lowering the effective sensor resistance for the control bridge and increasing the effective sensor resistance for the overheat bridge. The imbalance in the control bridge corresponding to a cold window is required to actually apply power to the windows since the overheat detection system is only operable with power applied to pin E. The imbalance in the overheat bridge corresponds to an overheated window, and the overheat detection system, after the 2/3 second delay, latched the overheat switch in the open condition and drops out the overheat relay. The system can be returned to normal operation by momentarily turning the window heat control switch to OFF, interrupting the power to pin E.



WINDSHIELD ANTI-ICE ELECTRICAL DIAGRAM

5. Window Heat Control Switches

The window heat control switches are four pole three position (LOW-OFF-HIGH) toggle switches. The switches are located on the P5 pilot's overheat panel. When the switch is in either the "HIGH" or "LOW" position, power is directed from the 115 volt ac window No. 4 and 5 circuit breaker to the No. 4 and 5 windows, from the 115 volt ac window control circuit breaker to pin E of the control unit, and from the 28 volt dc warning lights circuit breaker to the normally closed contacts of the overheat relay. Fully wave rectified power is directed from pin K of the control unit to the high or low power coils of the power control relay depending on the control switch position.

6. Window Overheat Relay

The window overheat relay is a double poled sealed relay, with a pair of normally closed and a pair of normally open contacts. The relay directs 28 volt dc power from the control switch to the window overheat light when de-energized, and 115 volt ac power from the windows No. 1 and 2 circuit breaker to the power control relay when energized. The relay is energized whenever the system is in operation in the absence of the overheat detection. The relay is located in the J7 relay shield.

7. Window Heat Power Control Relay

The window heat power control relay is a single pole, double throw, dual coil, nonpolarized relay. A common armature provides a mechanical interlock which prevents closing both pair of contacts at the same time. The relay directs 115 volt ac power to either the high or low voltage taps on the window heat transformer, depending on which coil is energized. The relay is located in the J7 relay shield.

8. Window Heat Transformer

The window heat transformer is an autotransformer providing high voltage for heating the No. 1 and 2 windows. It has two 115 input taps and 10 output taps. The voltage of the output taps range from 162 volts to 250 volts when using the low voltage input and 224 volts to 348 volts when using the high voltage input. The 10 taps provide a selection of voltages to suit the resistance of the conductive coating on the windows. The transformer supplies the selected voltages directly to window No. 1 and to window No. 2 through the window No. 2 thermal switch. The transformer is located on the J7 relay shield.

9. Window Overheat Indicating Light

The window overheat indicating light is an amber warning light located on the warning annunciator panel on the flight engineer's lower panel. The warning light consists of a single translucent lens illuminated by a pair of bulbs connected in a parallel circuit. The light is illuminated by 28 volts dc from the door warning lights circuit breaker whenever the control switch is in the "HIGH" or "LOW" position and the overheat relay is de-energized, indicating an overheat condition has occurred. The light may be tested by pressing a test switch on the annunciator panel which provides a common ground for all the lights on the panel.

10. Window Overheat Test Switch

The overheat test switch is located on the aft side of the J7 window anti-ice shield. The switch completes a circuit from pin G of the control unit to ground when pressed.

11. Window No. 2 Thermal Switch

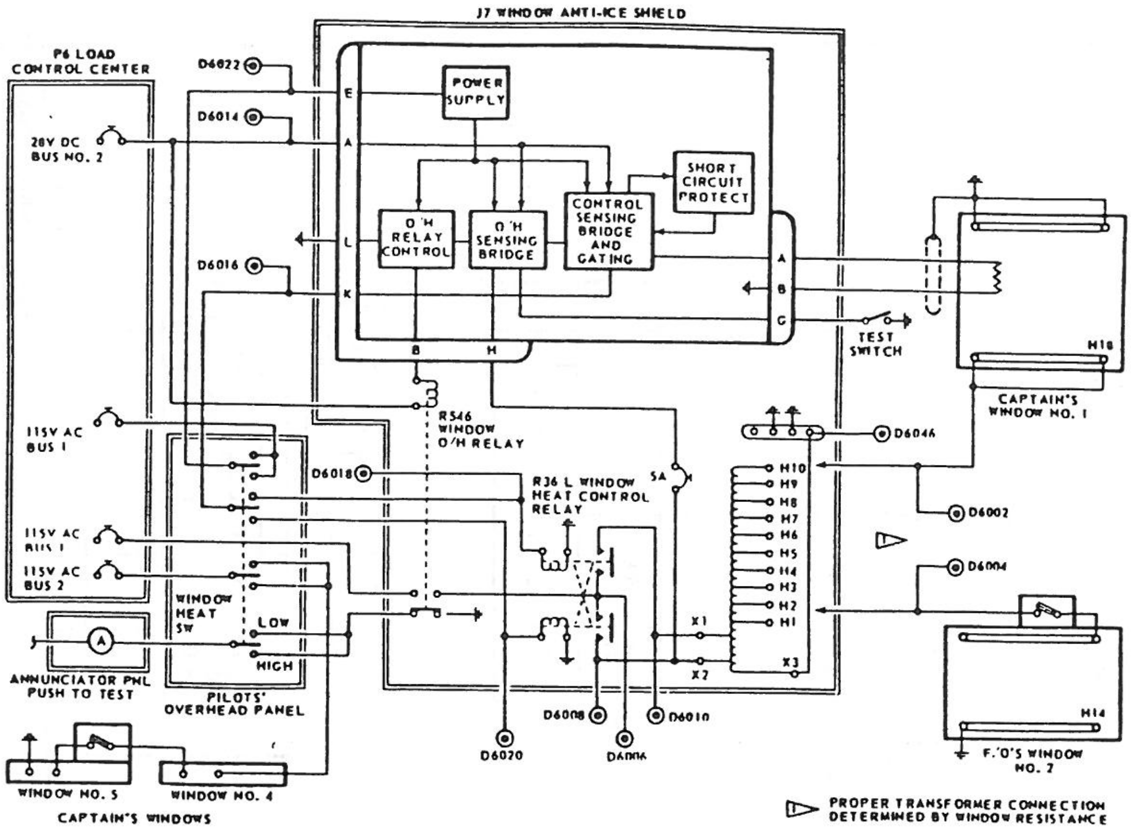
The window No. 2 thermal switch is a temperature sensitive, bimetallic single pole, snap action switch with normally closed contact points which open at 130° (±5°)F and close above 105°F. The switch is spring mounted near the center of the aft edge of the No. 2 window and prevents overheating of the window.

12. Window No. 5 Thermal Switch

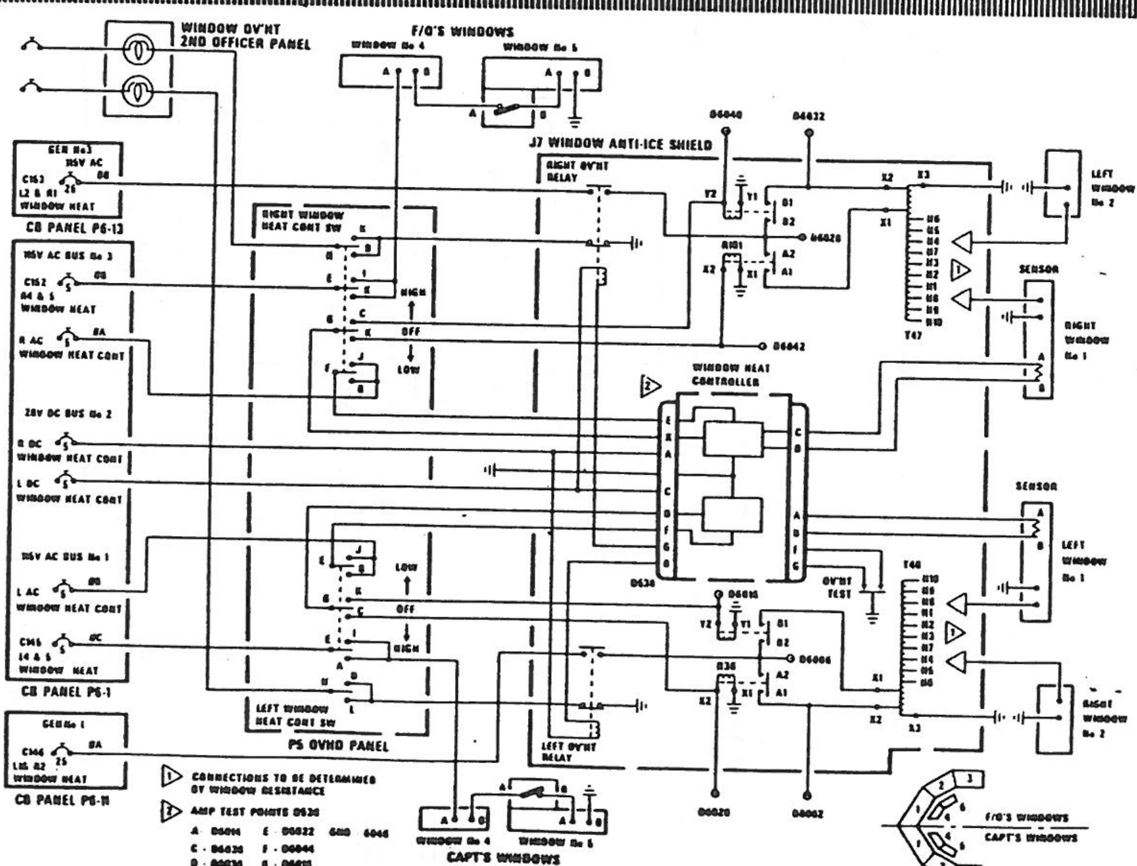
The window No. 5 thermal switch is a temperature sensitive, bimetallic single pole, snap action switch with normally closed contact points which open at 110° (±10°)F and close at 90° (±10°)F. The switch is spring mounted near the lower edge of the No. 5 window and controls the application of power to the No. 4 and 5 windows.

13. Testing Circuit

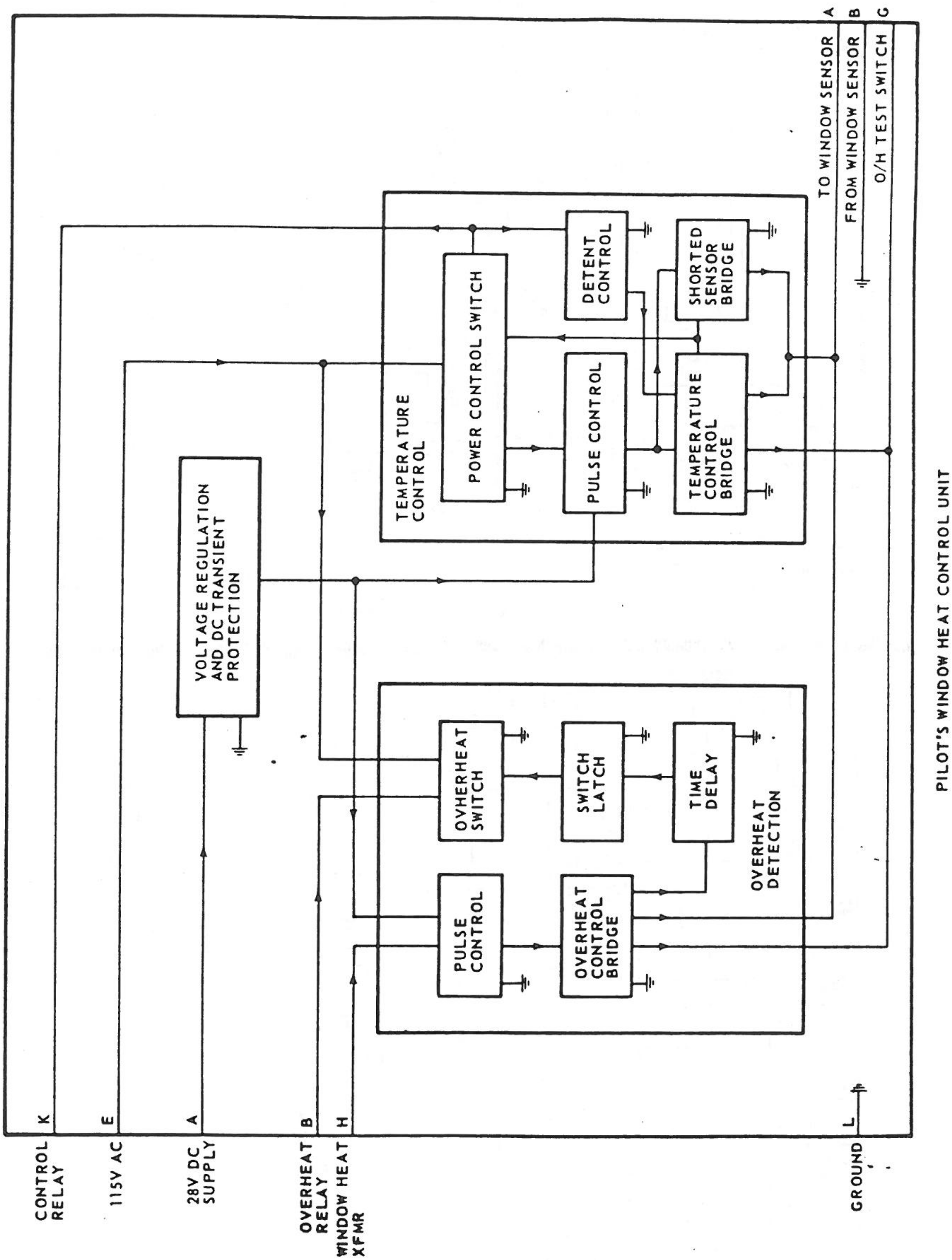
The system testing circuit is provided to facilitate checking of the system components located within the J7 relay shield, without gaining access to the components. Wires from a test receptacle located on the aft side of the J7 relay shield lead to the control terminals of each component of the window anti-ice system located within the shield.



WINDSHIELD ANTI-ICE CONTROL



WINDSHIELD ANTI-ICE ELECTRICAL DIAGRAM



Window Heat Control Unit

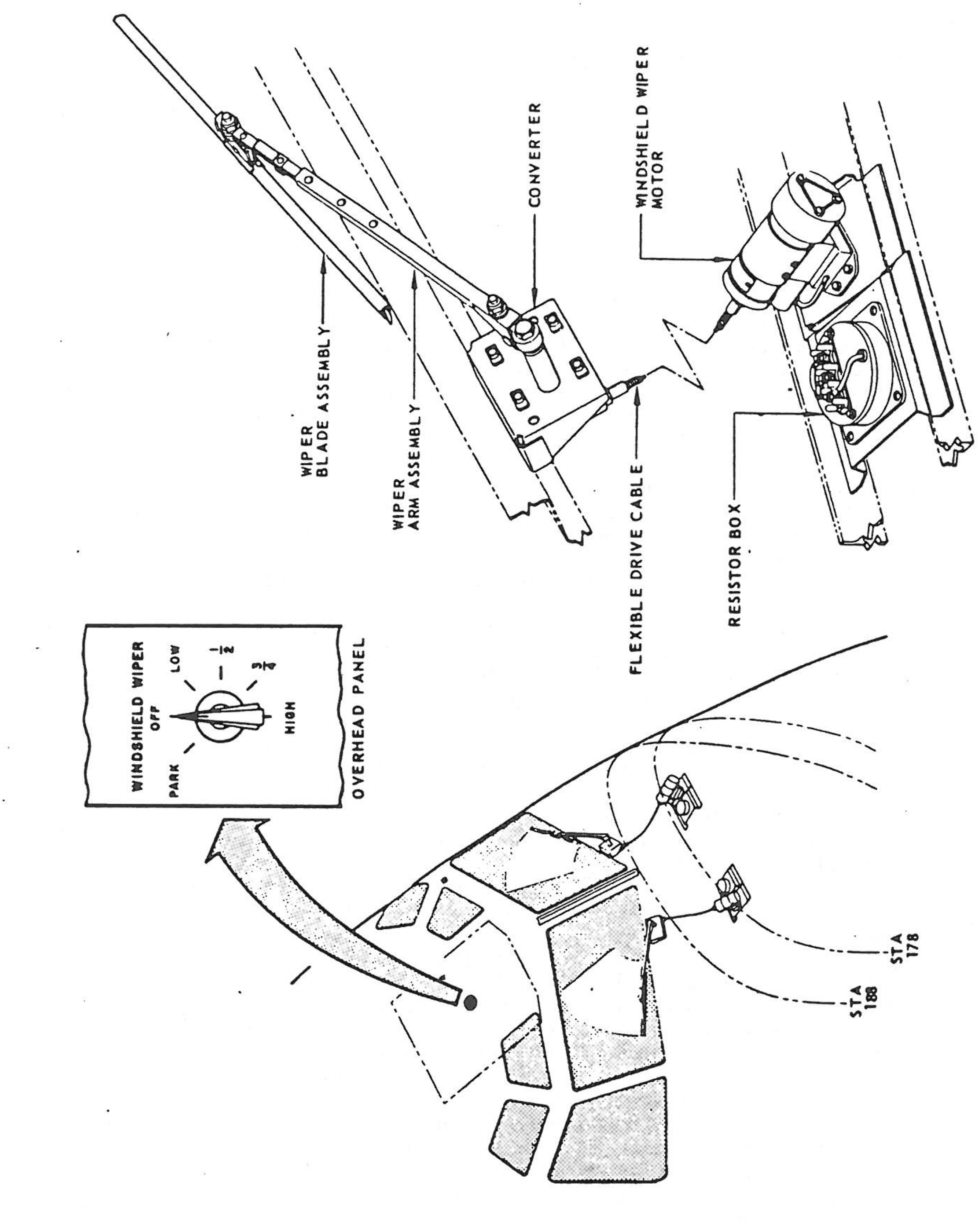
14. Window Anti-Icing System Operation

The window anti-ice systems are operated by the actuation of their respective control switch to either the HIGH or LOW position. With the switch in either position, 115 volt ac power will be directed from the P6 load control center to window No. 4 and 5, and to the window heat control unit for window Nos. 1 and 2. The No. 4 and 5 windows will be regulated between 80°F and 120°F by the window thermal switch on window No. 5, and the No. 1 and 2 windows will be regulated between 100°F and 114°F by the window heat control unit.

With 115 volts supplied to the control unit in the absence of an overheat condition, the control unit will provide a ground for the overheat relay circuit energizing the overheat relay. If the No. 1 windows are below 100°F, the window heat sensor will signal the window heat control unit to actuate either the high or low power coil of the control relay, depending on the control switch position. Energizing of either coil of the power control relay will supply 115 volt ac power from the P6 load control center to either the high or low voltage input tap of the window heat transformer, depending on which coil of the relay was energized. Th^ window heat transformer in turn will apply the preselected voltage from the transformer output taps directly to the No. 1 window, and to the No. 2 sliding window as long as the window No. 2 thermal switch is closed. The rate at which the windows are heated is dependent on the control switch position.

The windows will continue to heat until the window heat sensor on the No. 1 window detects a temperature of 110°F, at which time the resistance of the sensor will cause the window heat control unit to de-energize the power control relay which in turn cuts off power to the window heat transformer. When the window cools to 100°F, the control unit will again allow power to be supplied to the windows. This cycle will be repeated as long as the system is in operation.

In the open position, the No. 2 window is shielded by the No. 3 window which retards heat dissipation from the No. 2 window. The window No. 2 thermal switch will percent the No. 2 window from exceeding 130°F (±5°)F, with possible window damage from overheating, while in the open position or from a fault in the heat control system. If the window heat sensor detects a No. 1 window temperature above 135 (±20)°F while power is being applied, the overheat detection section of the window heat control unit will de-energize the overheat relay, turning on the overheat light and removing power from the No. 1 and 2 windows. Having the overheat detection section of the controller operate only while power is actually being applied to the windows allows a lower overheat trip setting without nuisance system trip and lockout under hot summer day conditions. While the system is in operation, the overheat detection section may be tested by pressing on the overheat test switch. This will cause the controller to apply power to the windows and then simulate an overheat condition after approximately 2/3 of a second turning on the light and removing power from the windows. The system may be reset by momentarily turning the control switch to OFF.



Windshield Wiper System Equipment Location

B. Windshield Wiper System (FEC N101FE to N109FE and N116FE to N124FE)

1. Description

A windshield wiper is provided to maintain a clear area of the pilot's and co-pilot's No. 1 windows during takeoff, approach, and landing, in rain or snow. Each wiper is operated by a separate system to ensure that clear vision through one of the windows will be maintained in the event of a system failure.

Both wiper systems are electrically operated and controlled by a common gang switch located on the pilot's overhead panel. The switch provides a selection of four wiper action speeds ranging from 190 to 275 strokes per minute and controls the stowing of the wiper blades in a PARK position when the system is not in use. A stroke is one sweep of the blade in one direction.

Each windshield wiper system consists of a drive motor, a control switch, a resistor box, a flexible drive shaft, a torque converter, and a windshield wiper assembly.

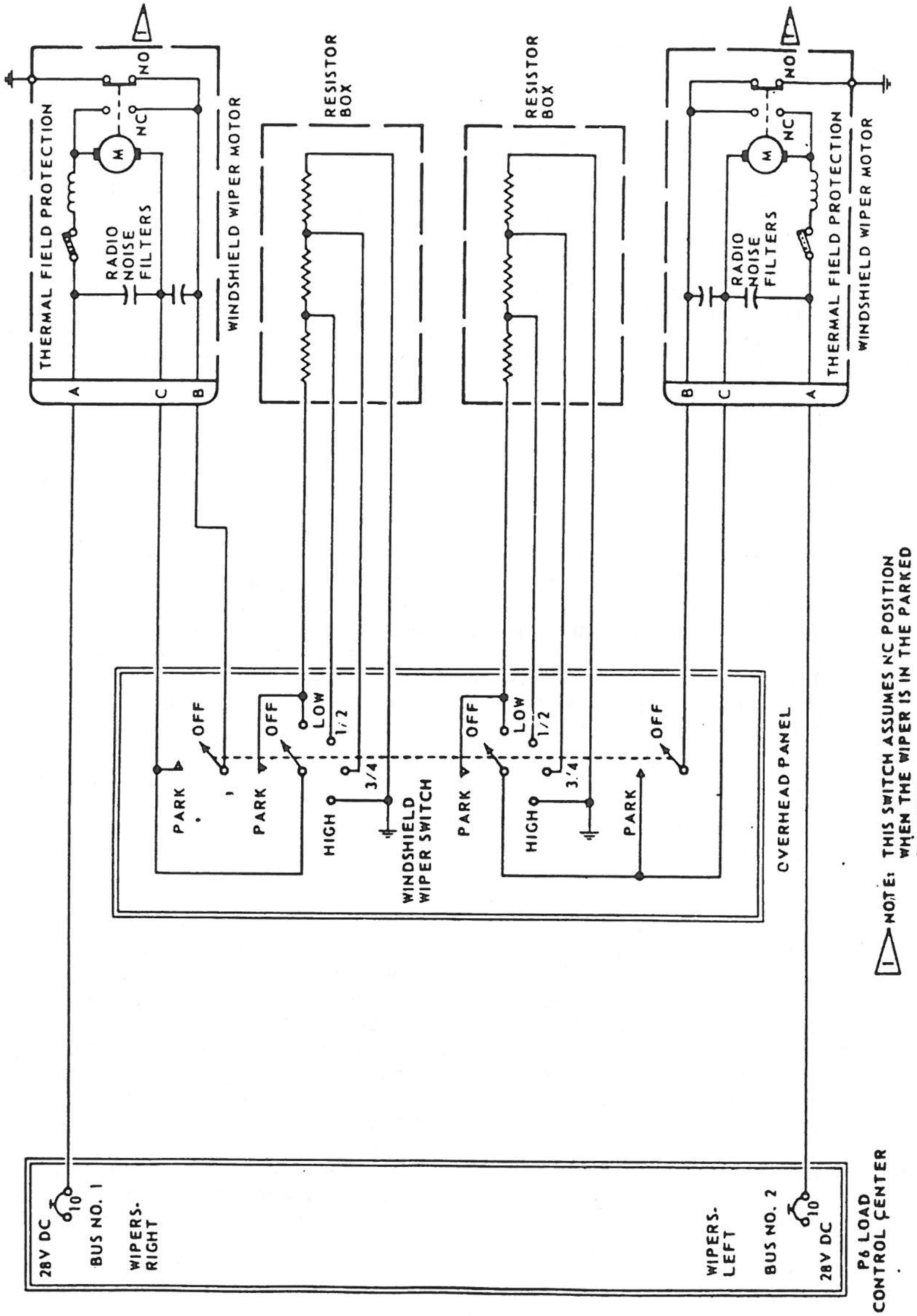
Speed control is accomplished by changing the voltage applied to the windshield wiper motor by means of resistances arranged in the resistor box. The required resistance is connected into the motor circuit by turning the windshield wiper switch to a selected speed. The rotary motion of the windshield wiper motor is transmitted by the flexible shaft to the converter. The converter reduces the shaft speed and changes rotary motion of an oscillating motion of the windshield wiper arm.

CAUTION: DO NOT OPERATE WINDSHIELD WIPERS ON DRY WINDSHIELDS.

A second method for maintaining clear windows in heavy rain is by the use of rain repellent.

2. Drive Motor

Each system is driven by a 28 volt dc, variable speed electrical motor mounted on brackets forward of the main instrument panel. Each motor is equipped with two radio noise filters, an automatically resetting thermal overload switch, and a cam actuated switch. The resetting thermal switch temporarily opens the motor field circuit when the motor temperature exceeds 300°F, or when the field current exceeds 8 to 10 amps. The cam actuated switch is a two pole two position micro switch. The operating cam is driven by reduction gearing in the motor to coincide with the wiper cycle. One pole of the switch is closed when the motor is in any part of the wiper cycle other than "PARK". The other pole of the switch is closed only when the motor is in the "PARK" position of the cycle. The switch is used in conjunction with the system control switch to stop the motor with the wipers in the "PARK" position when the system is not in use.



Windshield Wipers - Electrical Schematic

3. Control Switch

   The windshield wiper control switch is a six position double wafer-rotary gang switch. The switch is located on the pilot's overhead panel and is used to control the action of both windshield wiper motors by changing the motor circuitry. The switch has a momentary "PARK" position and five detent positions, OFF-LOW-1/2-3/4 and HIGH.

4. Resistor Box

   The resistor box for each system is mounted on a bracket close to its respective motor. The box contains three resistors which may be selected by the control switch to be added in series with the motor circuit to control the motor speed.

5. Drive Shaft

   The flexible drive shafts are closely coiled steel wire cables enclosed in a flexible galvanized steel casing. The shafts connect the windshield wiper motors to their respective converter.

6. Torque Converter

   The converter for each system is mounted on a bracket on its respective window sill close to the inner surface of the skin. The converter has a serrated drive shaft which protrudes through the skin just forward of the windshield for attachment of the wiper assembly. The converters change the high speed low torque rotary motion of the motor transmitted by the flexible drive shaft, to a low speed high torque circular oscillating motion for the wiper arm, by the use of a worm gear and eccentric drive mechanism. The motor and converter are synchronized with respect to the wiper cycle before the units are coupled by the flexible drive shaft.

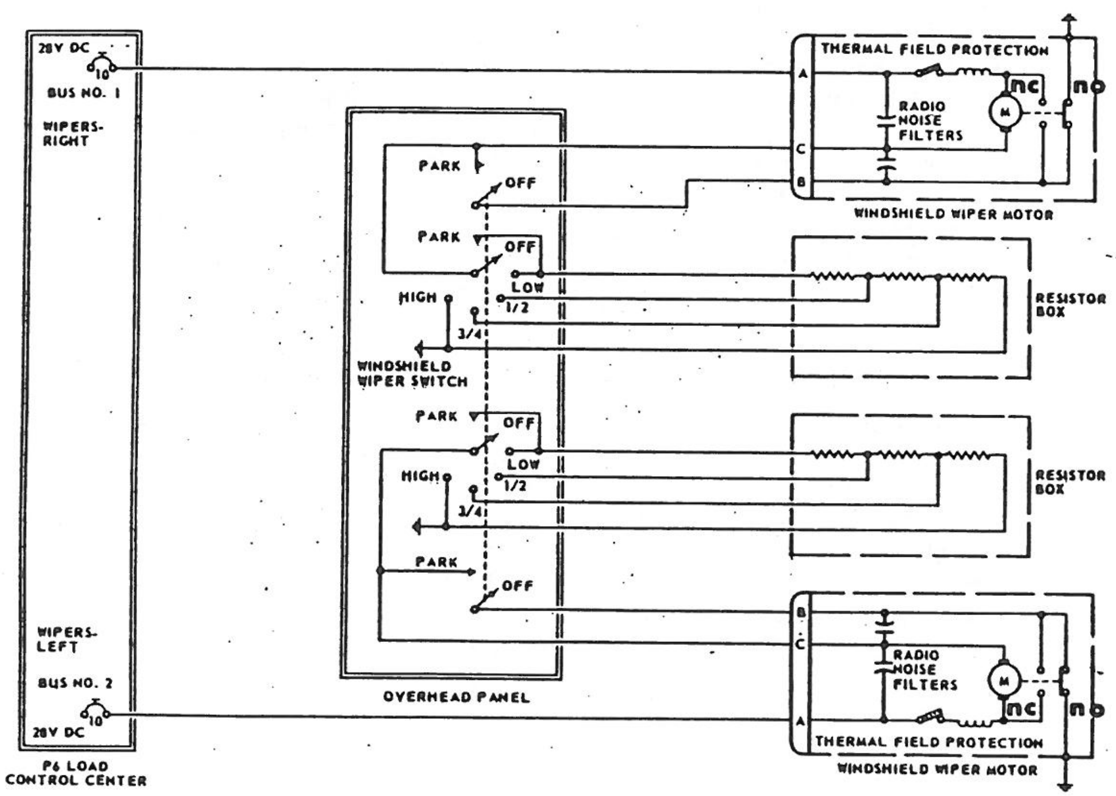
7. Wiper Assembly

   The windshield wiper assembly consists of a wiper blade and wiper arm. The wiper arm has a serrated sleeve at its hub to provide angular adjustment between the arm and the converter drive shaft, and is attached to the shaft by a bolt through the hub. The wiper tension of the arm can be adjusted by tension adjusting nut near the hub of the arm. The wiper blade is bolted to the end of the wiper arm and the angle between the blade and the arm can be adjusted by means of a serrated disc attached to each part.

8. Operation

The operation of both windshield wiper systems is controlled by turning the windshield wiper control switch located on the pilot's overhead panel to the rate of wiper action desired. When any switch position "LOW" through "HIGH" is selected, power will be directed from the respective system bus through the motor, control switch, and selected resistances to ground. The amount of resistance selected determines the motor speed and therefore the rate of wiper action.

When the control switch is turned to the "PARK" position and the wiper is in any position other than "PARK" the switch completes a circuit from the respective system bus through the motor, "PARK" contacts of the control switch, and through the "N O" contacts of the cam operated switch in the motor to ground. This will shut the resistor box out of the control circuit and drive the motor at high speed until the motor reaches the "PARK" position of the wiper cycle and the switch cam moves the switch to close the "N C" contacts of the cam operated switch and the circuit is completed to ground through the "PARK" contact of the control switch and the full resistor load. With the motor field coil still energized and the motor armature shorted by the cam operated switch, dynamic braking is provided to stop the motor from coasting. This stops the motor with the wiper blades in the "PARK" position.



WINDSHIELD WIPERS—ELECTRICAL

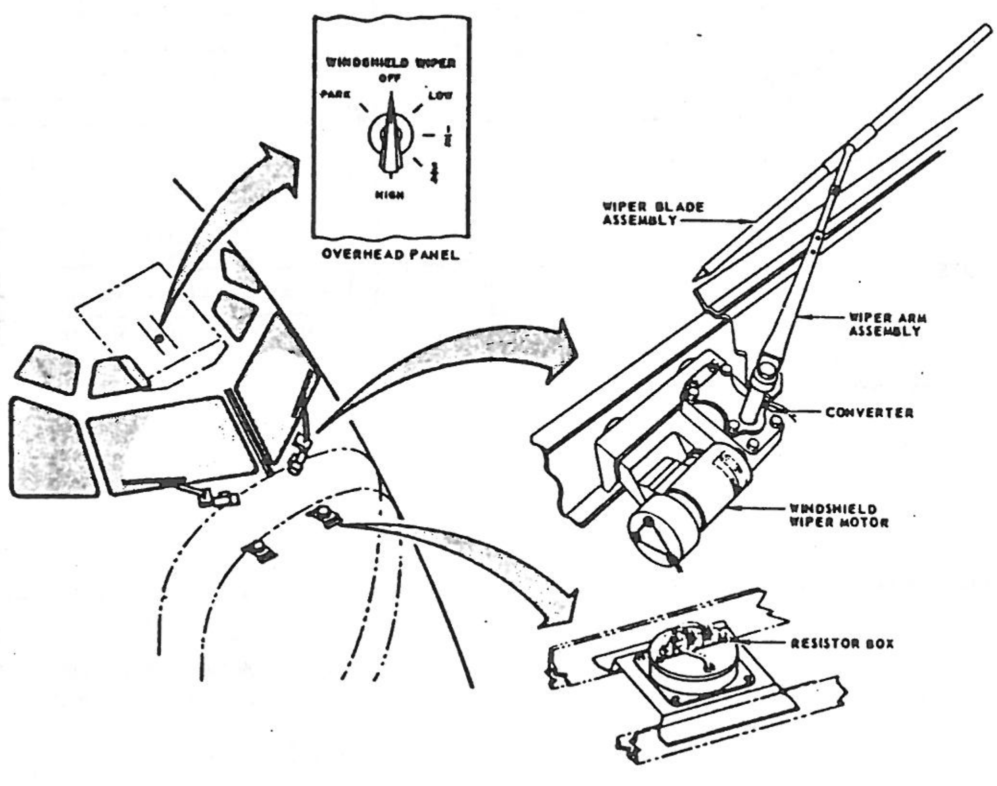
C. Windshield Wiper System (FEC N110FE to N113FE and N125FE to N136FE)

1. Description

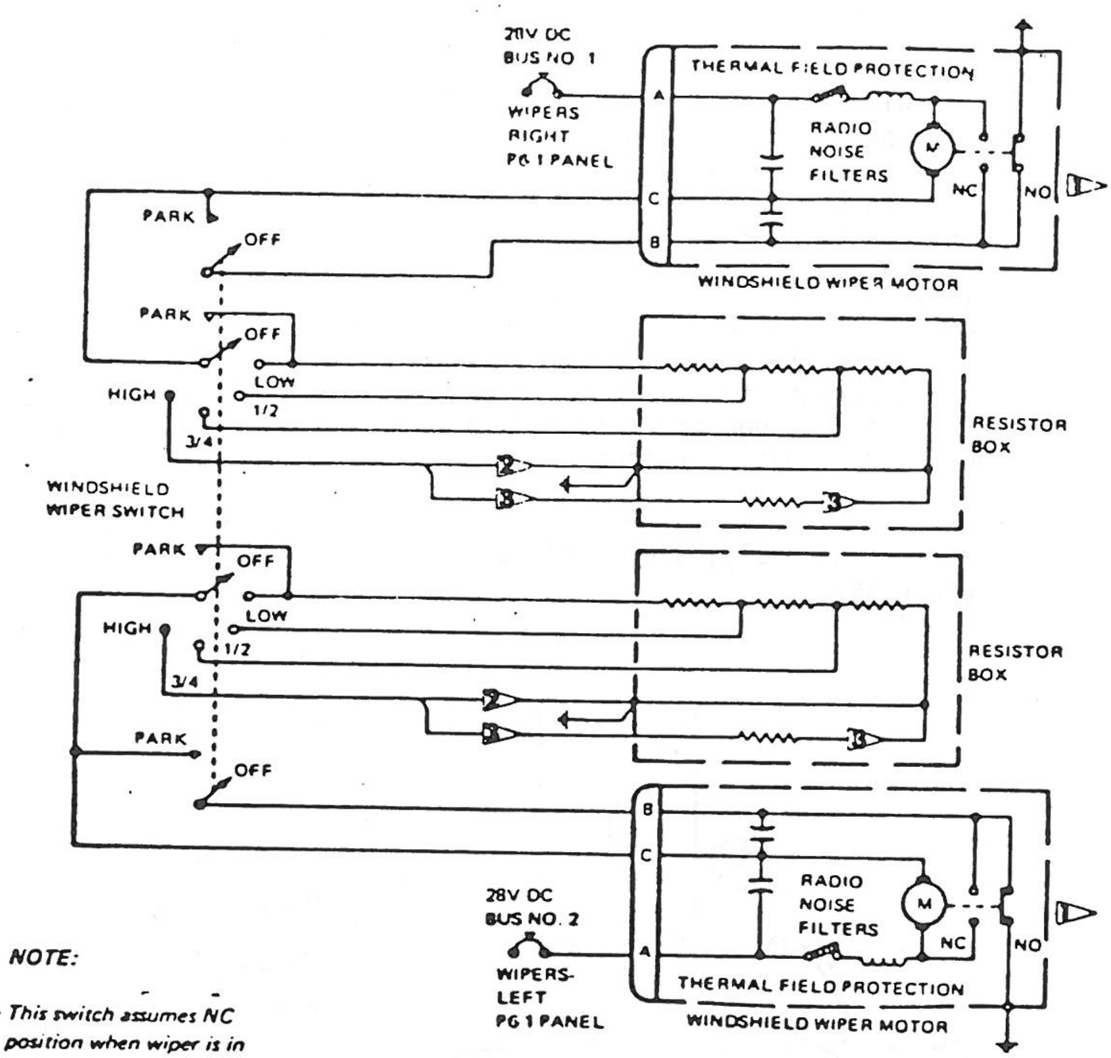
A windshield wiper is provided to maintain a clear area on the pilot's No. 1 windows during takeoff, approach, and landing, in rain or snow. Each wiper is operated by a separate system to ensure that clear vision through one of the windows will be maintained in the event of a system failure. The wiper blades clear a path approximately 13-1/2" wide through an arc of 84°.

Both wiper systems are electrically operated and controlled by a common gang switch located on the overhead panel. The switch provides a selection of four wiper action speeds ranging from 190 to 275 strokes per minute and controls the stowing of the wiper blades in a PARK position when the system is not in use. A stroke is one sweep of the blade in one direction.

Each windshield wiper system consists of a drive motor and torque converter assembly, a control switch, a resistor box, and a windshield wiper assembly.



WINDSHIELD WIPER EQUIPMENT LOCATION



NOTE:

1 *This switch assumes NC position when wiper is in parked position*

2 *UAL N7080U thru N7090U*

3 *UAL N7431, N7432, and N7620U thru N7630U*

EFFECTIVITY

UAL N7080U thru N7090U, N7431, N7432, and N7620U thru N7630U

NOTE: THIS SCHEMATIC IS ONLY APPLICABLE TO AIRCRAFT N110FE AND N111FE

Speed control is accomplished by changing the voltage applied to the windshield wiper motor by means of resistances arranged in the resistor box. The required resistance is connected into the motor circuit by turning the windshield wiper switch to a selected speed. The rotary motion of the drive motor is transmitted to the converter which reduces the shaft speed and changes rotary motion to an oscillating motion of the windshield wiper arm.

CAUTION: DO NOT OPERATE WINDSHIELD WIPERS ON DRY WINDSHIELDS.

2. Motor-Converter Assembly

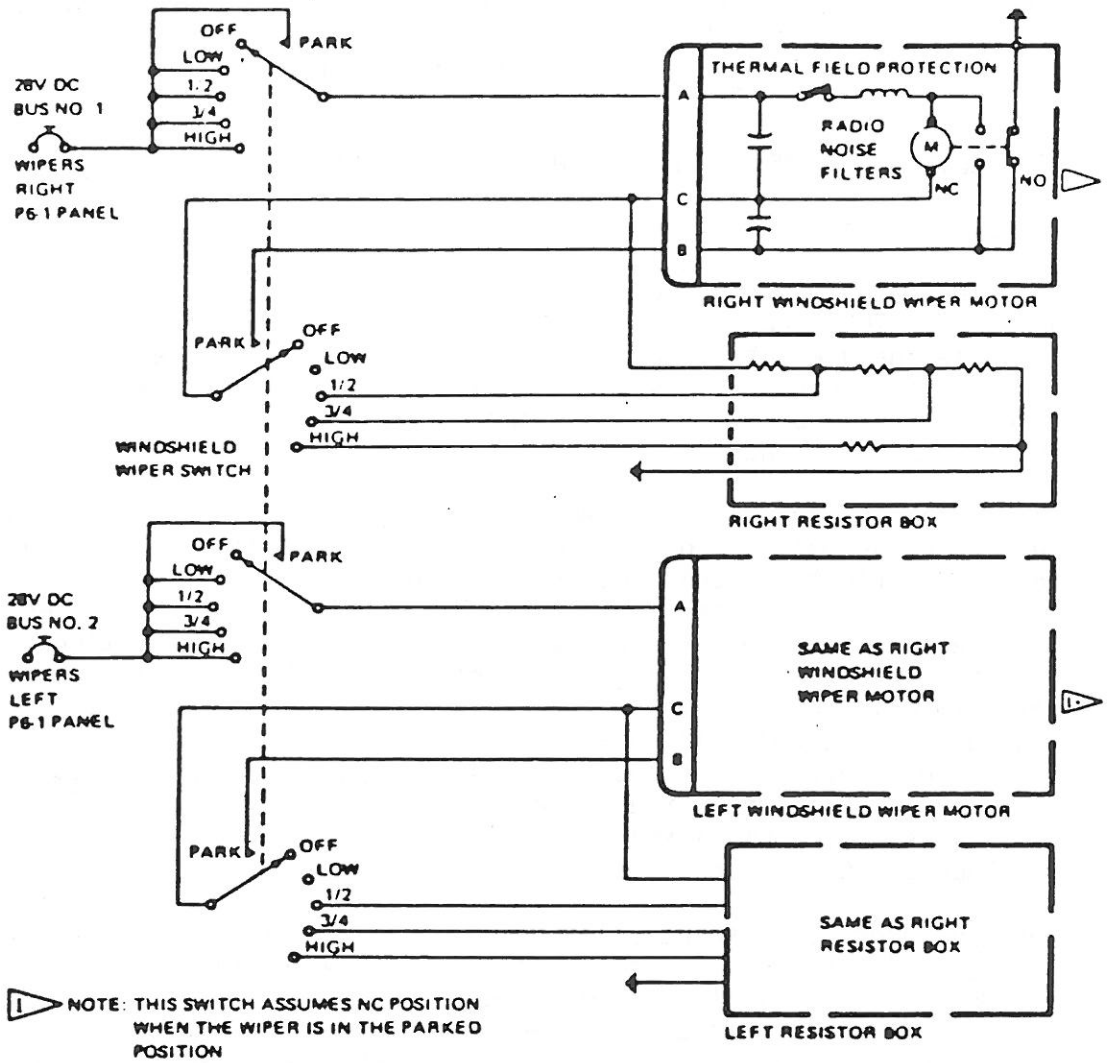
The wiper assembly for each system is driven by a motor-converter assembly. The motor-converter assembly consists of a 28 volt dc variable speed electric motor and torque converter coupled together by a connector sleeve and assembled on a support fitting. Each assembly is mounted on a bracket on its respective window sill close to the inner surface of the skin.

Each motor is equipped with two radio noise filters, an automatically resetting thermal overload switch, and a cam actuated switch. The thermal switch temporarily opens the motor field circuit when the motor temperature exceeds 300°F, or when the field current exceeds 8 to 10 amps. The cam actuated switch is a two pole two position microswitch. The operating cam is driven by reduction gearing in the motor to coincide with the wiper cycle. One pole of the switch is closed when the motor is in any part of the wiper cycle other than PARK. The other pole of the switch is closed only when the motor is in the PARK position of the cycle. The switch is used in conjunction with the system control switch to stop the motor with the wipers in the PARK position when the system is not in use.

The converter has a serrated drive shaft which protrudes through the skin just forward of the windshield for attachment of the wiper assembly. The converters change the high speed low torque rotary motion of the motor to a low speed high torque circular oscillating motion for the wiper arm, by the use of a worm gear and eccentric drive mechanism. The motor and converter are synchronized with respect to the wiper cycle before the units are coupled together.

3. Control Switch

The windshield wiper control switch is a six-position double-wafer-rotary gang switch. The switch is located on the overhead panel and is used to control the action of both windshield wiper motors by changing the motor circuitry. The switch has a momentary PARK position and five detent positions, OFF-LOW-1/2-3/4 and HIGH.



EFFECTIVITY

All except:

UAL N7080U thru N7090U, N7431, N7432, and N7620U thru N7630U

NOTE: THIS SCHEMATIC IS ONLY APPLICABLE TO AIRCRAFT N112FE AND N113FE

4. Resistor Box

The resistor box for each system is mounted on a bracket close to its respective motor. The box contains resistors which may be selected by the control switch to be added in series with the motor circuit to control the motor speed.

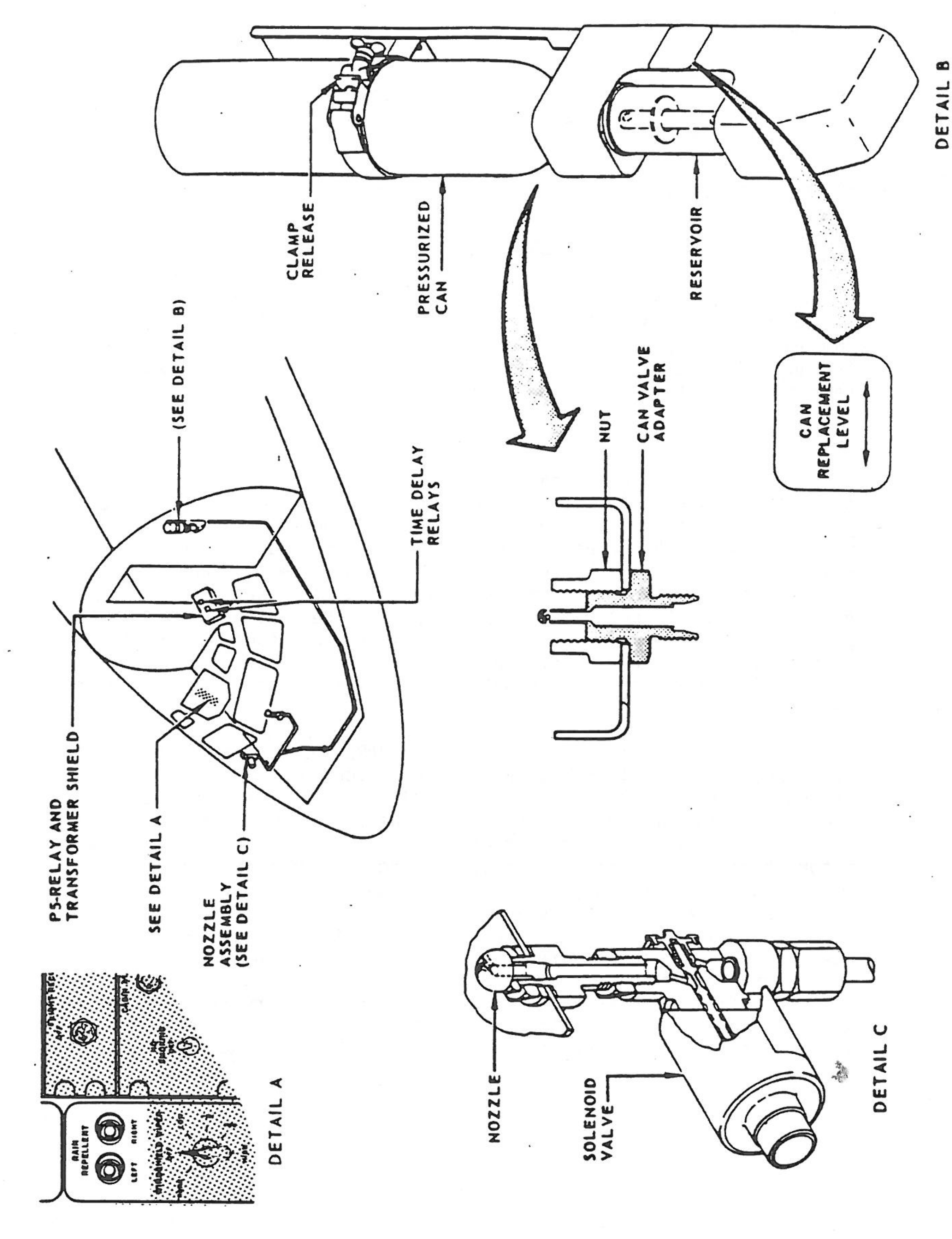
5. Wiper Assembly

The windshield wiper assembly consists of a wiper blade and wiper arm. The wiper arm has a serrated sleeve at its hub to provide angular adjustment between the arm and the converter drive shaft, and is attached to the shaft by a bolt through the hub. The wiper tension of the arm can be adjusted by a tension adjusting nut near the hub of the arm. The wiper blade is bolted to the end of the wiper arm and the angle between the blade and the arm can be adjusted by means of a serrated disc attached to each part.

6. Operation

The operation of both windshield wiper systems is controlled by turning the windshield wiper control switch located on the overhead panel to the rate of wiper action desired. When any switch position LOW through HIGH is selected, power will be directed from the respective system bus through the motor, control switch, and selected resistances to ground on airplanes with the control switch on the ground side of the motor. On airplanes with the control switch on the power side of the motor, power from the system bus goes through the control switch, then the motor and selected resistance to ground. The amount of resistance selected determines the motor speed and therefore the rate of wiper action.

When the control switch is turned to the PARK position and the wiper is in any position other than PARK, the switch completes a circuit through the PARK contacts of the control switch and through N O contacts of the cam operated switch in the motor to the ground. This will shunt the resistor box out of the control circuit and drive the motor at high speed until the motor reaches the PARK position of the wiper cycle and the switch cam moves the switch to close the N O contacts of the cam operated switch. With the cam operated switch in the N O position, the motor armature is shunted out by the cam operated switch and the circuit is completed to ground through the PARK contact of the control switch and the full resistor load. With the motor field coil still energized and the motor armature shorted by the cam operated switch, dynamic braking is provided to stop the motor from coasting. This stops the motor with the wiper blades in the PARK position.



RAIN REPELLENT SYSTEM

D. Rain Repellent System

1. Description

A rain repellent system is provided to be used in conjunction with the windshield wiper system to improve windshield visibility through the pilot's and co-pilot's No. 1 windshield during heavy rain. The system is controlled independently for each window by separate control switches located on the pilot's overhead panel and when actuated, the system sprays a rain repellent solution on the respective window as selected. The maximum quantity of solution sprayed per system actuation (approx 6cc) is predetermined by the setting on a time delay relay and cannot be exceeded by extended duration of switch actuation. The solution is spread over almost all of the window by the rain and airstream, however, spreading is enhanced within the wiped are of the windows by the action of the wiper blades. The length of time that an application remains effective varies inversely with the rain intensity and will last longer in the wiped area than in the unwiped area. Reapplication is repeated as required to maintain repellent effectiveness.

The rain repellent system should not be operated on dry windows, as heavy undiluted solution will restrict window visibility. In the event of inadvertent dry window application, do not operate the windshield wipers as this tends to increase smearing. Also the rain repellent residues caused by applications in dry weather or very light rain may cause staining or minor corrosion of the airplane skin. To prevent this, any concentrated repellent or residue should be removed by a thorough fresh water rinse at the earliest opportunity, preferably within a few hours after exposure. Repellent residues allowed to dry or "cure" on the surface will require polishing with an approved aluminum polish to remove the stain.

The rain repellent system consists of a pressurized container of rain repellent fluid, a container receptacle, a visual reservoir, two solenoid valves, two nozzles, associated plumbing, and two electrical control circuits.

2. Container and Receptacle

The rain repellent fluid is packaged in a pressurized disposable type container which is replaced when empty. Each container has a self sealing valve with a threaded boss for attaching the container to the system receptacle.

There are two types of fluid presently in use, type I and type III, which are packaged in different size containers. The two types of fluid are miscible; however, when mixed, the resultant solution tends to reflect the properties of the type I fluid. Therefore, when converting from type I fluid to type III fluid, it is recommended that the system be emptied of all type I fluid before introducing type III fluid.

NOTE: The useful service life of type I rain repellent fluid is dependent upon the temperature to which it is exposed. Stored at room temperature, 65-75°F, a service life of about 1 year may be expected. Exposure to high temperatures shortens the service life. The time rain repellent cans are installed on airplanes must be accredited to the 1 year useful service life storage period. Type III rain repellent fluid is not service life limited.

The fluid is essentially nontoxic and exposure to personnel during system maintenance is minimized by the use of the disposable container. Contact with significant amounts of the fluid can be irritating to skin or eyes (similar to household detergents) and normal precautions should be taken to prevent this. If skin or eyes are accidentally exposed to the fluid, the affected area should be thoroughly flushed with water.

The system receptacle has a valve actuating pin which opens the container valve as the container is attached to the receptacle. As the pin enters the valve assembly, it is sealed by an O-ring in the valve prior to unseating of the valve to prevent fluid leakage. The pin is hollow and has inlet ports near the tip of the pin to allow fluid to enter the system from the container. The container and receptacle are mounted on the left-hand upper forward side of the station 302 bulkhead.

FLUID TYPE	CONTAINER VOLUME	FLUID CHARGED	CONTENT DISCHARGED	CONTAINER CHARGED	WEIGHT DISCH.	CHARGING PRES. at 70°F
I	793CC (26.8 fl oz)	425CC (14.4 fl oz)	30CC (1.0 fl oz)	795 gms (1 lb 12 oz)	237 gms (8.4 oz)	85 psia
III	936CC (32.00 fl oz)	505CC (17.0 fl oz)	30CC (1.0 fl oz)	955 gms (2 lb 2 oz)	240 gms (8.5 oz)	85 psia

3. Visual Reservoir and Plumbing

A container receptacle is connected by an adapter to a translucent fiberglass fluid reservoir mounted below the receptacle. The container, receptacle and reservoir are all supported by a bracket on the forward side of the station 302 bulkhead. The bracket and exposed plumbing are enclosed in a plastic cover with cutouts for viewing the reservoir. The reservoir contains a red float level indicator which is visible through the side of the reservoir. A decal on the cover indicates the fluid level at which the container should be replaced. When the level of the fluid is at the container replacement level approximately ten individual repellent applications of fluid are left in the reservoir and plumbing leading to the spray nozzles.

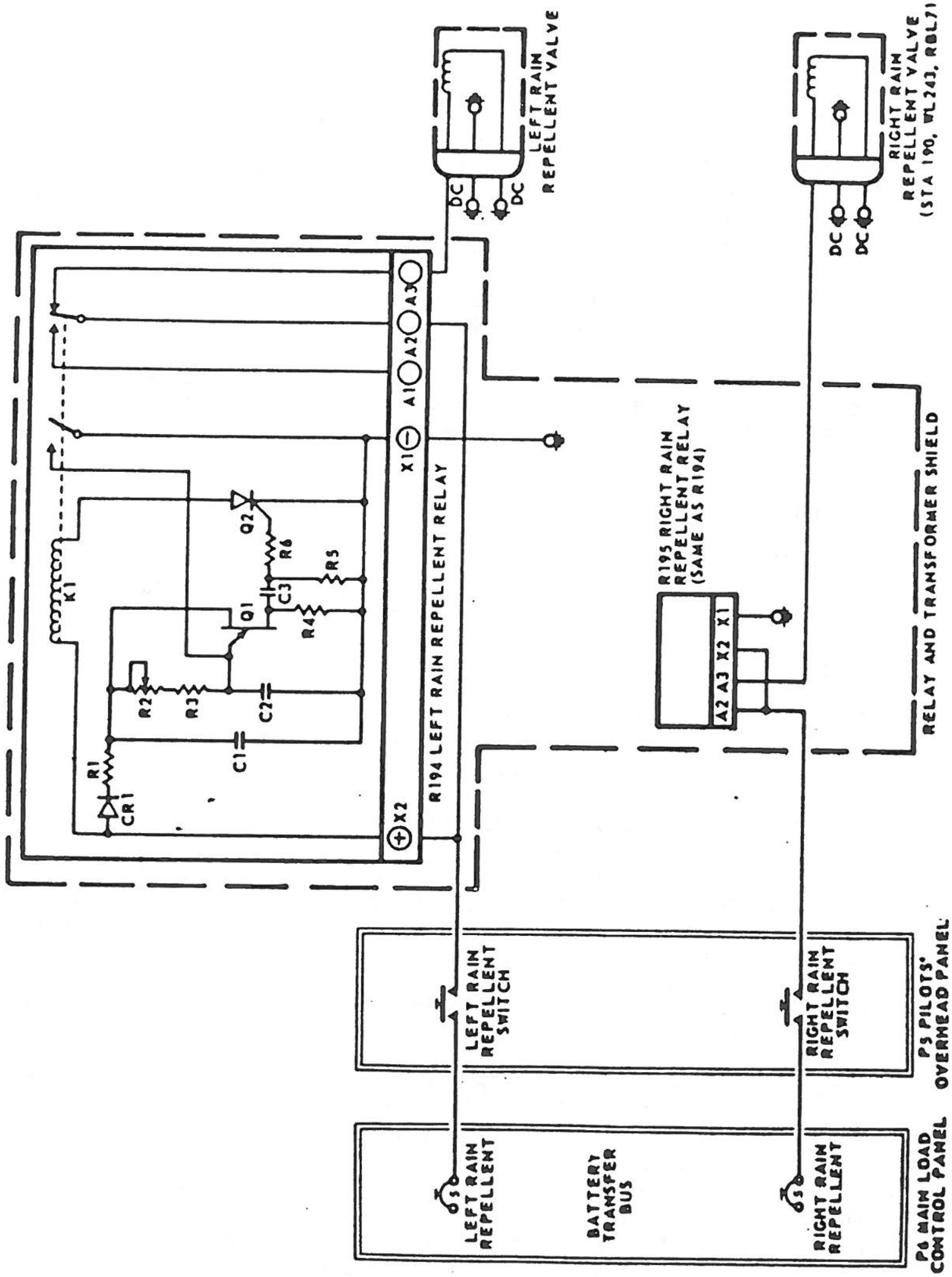
The reservoir is connected by a teflon supply line routed below the control cabin floor to a stainless steel "T" connection mounted aft of station 178. The "T" is connected by stainless steel tubing to a solenoid control valve for each window.

4. Solenoid and Spray Nozzles

The solenoid valves are normally closed electrically operated 28 volt dc valves. The valves control the flow of repellent fluid released to the spray nozzles and are coupled directly to the nozzles.

5. Time Delay Relay

Each solenoid valve is controlled by an independent electrical control circuit. The electrical control components of each circuit consists of a system control switch and a time delay relay. The control switches are push button type monetary switches and are located on the P5 pilot's overhead panel. The time delay relay consists of a relay and an adjustable time delay circuit. When power is supplied to the unit, a circuit is completed through the normally closed contacts of the relay to the solenoid valve. At the same time current is allowed to flow through the resistors R1, R2 and R3, charging condensers C1 and C2. When the voltage across the condensers builds up sufficiently to trigger the unijunction transistor Q1, it will conduct and apply voltage across condenser C3, opening the gate on the silicon control rectifier Q2, and energizing the relay K1. Q2 will continue to conduct and the relay K1 will remain energized as long as power is supplied. With the relay energized, the normally closed contacts will break the circuit to the solenoid valve and the normally open contacts will short out the condensers C1 and C2, and drop out Q1 preparing the unit for the next operation. Resistor R2 is variable and may be adjusted to change the time required to charge condenser C2 and thus the time delay action. The delay is adjusted to open the relay contacts after the required amount of repellent has been sprayed on the window. The relay is located behind the pilot's overhead panel in the relay and transformer shield.



Rain Repellent Schematic - Typical

6. Operation

With the pressurized fluid container installed in the system receptacle, and 28 volt dc power available on the battery transfer bus, the system is ready for use. The operation of the rain repellent system for each window is individually controlled by pushing the respective control switch. Pushing the control switch completes a circuit from the RAIN REPELLENT circuit breaker on the P6 load control center, through the switch and time delay relay, to energize the respective control valve solenoid. Actuation of the solenoid valve allows the pressurized reservoir to supply rain repellent through the tubing to the spray nozzles and onto the window. When the required amount of repellent has been sprayed on the window, the time delay will operate to break the circuit, de-energizing the solenoid valve and preventing further flow of repellent solution. Releasing the control switch breaks the circuit to the relay coil, de-energizing the relay and closing the relay points for the next operation. The pressurized fluid container will replenish the fluid in the reservoir as the fluid drops and the pressure is decreased.

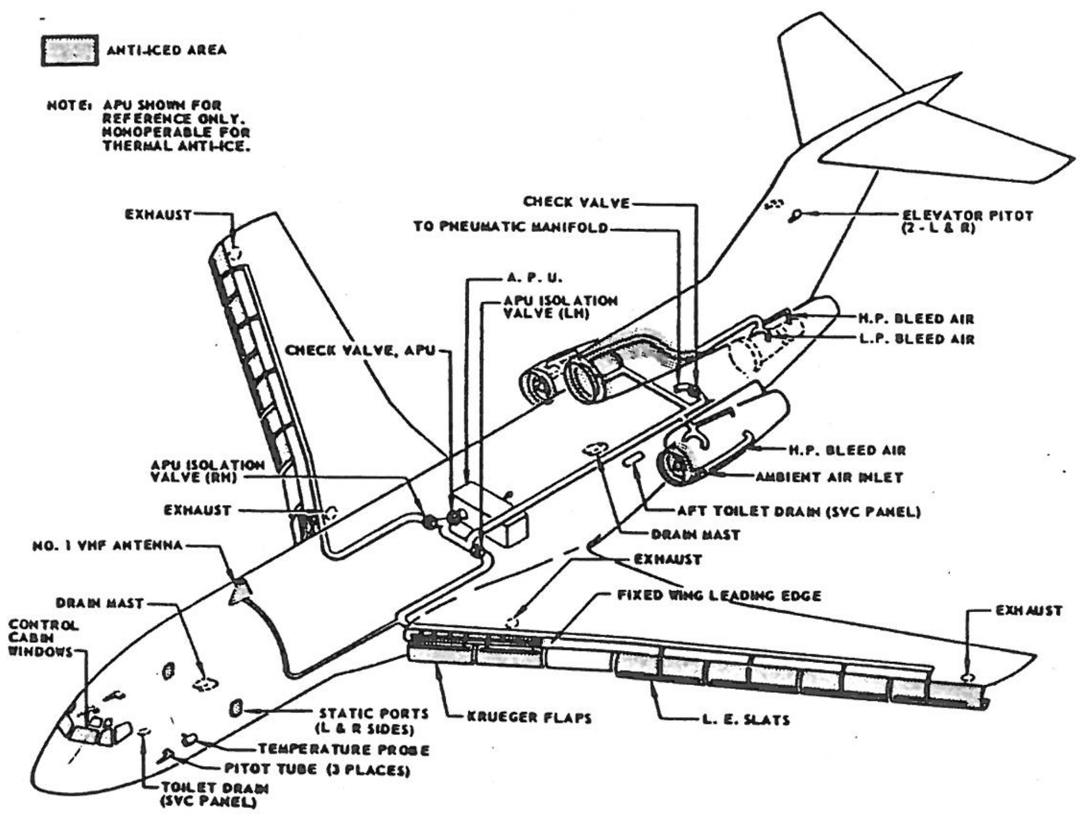
When actuating the control switch, hold switch depressed until fluid stops flowing from the nozzle. Rapid actuations of the control switch (less than 0.2 seconds) may de-energize the solenoid valve before the time delay relay operates, releasing less than the normal amount of fluid.

VI. ANTENNAS AND RADOMES

A. VHF Antenna Thermal Anti-Icing System

1. Description

The upper VHF antenna is thermal anti-iced to prevent ice from shedding into No. 2 engine inlet. The antenna mast has an air passage from the base to the top to allow TAI air to be vented through the mast and overboard. Tubing leading from the base of the mast to the left wing TAI air distribution manifold supplies TAI air to the mast whenever the wing TAI system is in operation. When leakage testing the wing TAI common manifold, the antenna vent must be blocked.



ICE PROTECTION SYSTEMS

VII. WATER LINES 727-100C

A. Water and Toilet Drain Anti-Icing System

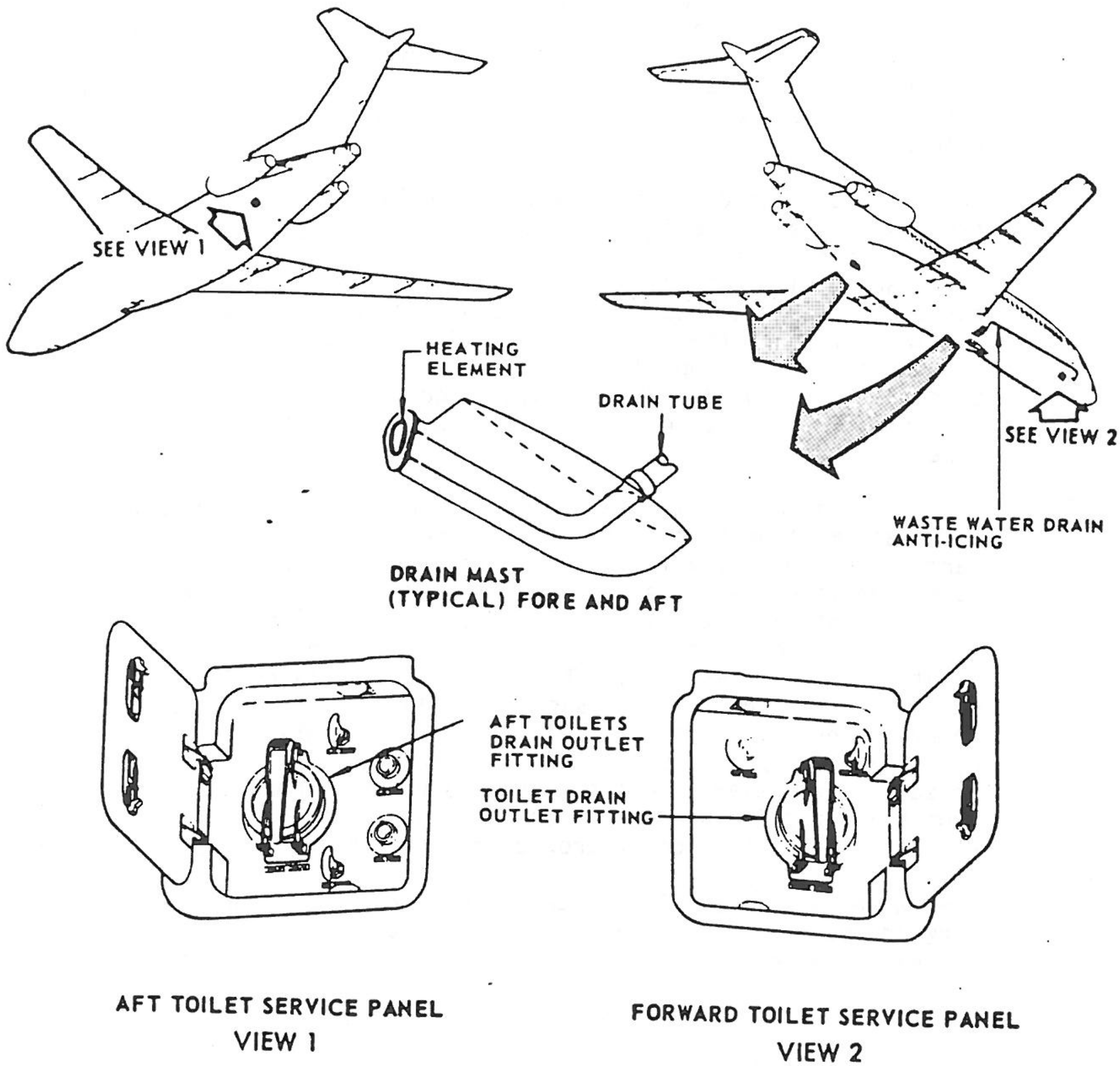
1. Description and Operation

The forward toilet drain is electrically heated to stop ice from forming in the drain connection and preventing removal of the draincap or obstructing the toilet drain. The heating element is an integral part of the drain connector fitting gasket, and operates on 115 volt ac current. The heater is controlled directly by the WATER DRAIN HEATER circuit breaker on the P6-1 miscellaneous ac, anti-ice, and rain panel.

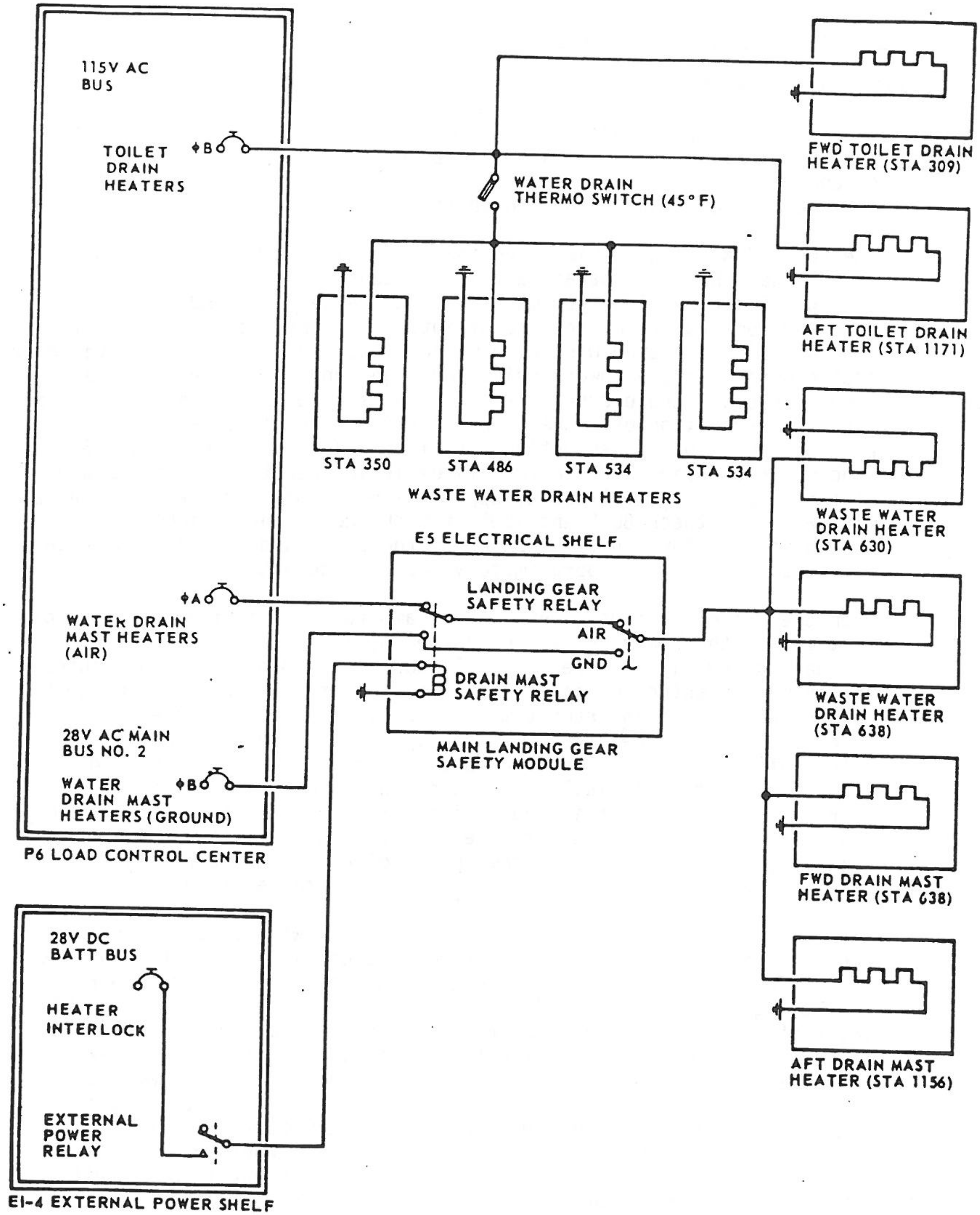
The forward water drain mast is electrically heated to prevent ice from forming and blocking the drain. The heating element is wound around the drain tube inside the drain mast and operate on either 28 volts ac for low hat ground operation of 115 volts ac for high heat air operation. Low heat power is supplied from the 28 volt ac main bus No. 2 through the DRAIN MAST HEATERS GROUND circuit breaker, and high heat power is supplied from the 115 volt ac main bus No. 1 through the DRAIN MAST HEATERS AIR circuit breaker. Both circuit breakers are located on the P6 miscellaneous ac, anti-ice, and rain panel.

Th- appropriate air (115 volts ac) or ground (28 volts ac) power to the drain mast heaters is selected by relays in the landing gear warning module. 28 volts ac power is used for low heat ground operation to prevent the heater from overheating and possibly burning out the heating element. On all aircraft, 28 volts ac is selected when either the drain mast safety relay is energized for the R10 safety relay is energized. The drain mast safety relay is energized by the external dc power sensing relay and either the tail skid down relay or the anti-skid test relay. The R10 safety relay is energized by the landing gear lever, latch, and safety relay circuit. Through these various relays and circuits, 115 volts ac power is prevented from being applied while the airplane is on the ground, irregardless of the type maintenance or ground operation being performed.

The waste water drain line between the forward lavatory and the forward drain mast is anti-iced to prevent ice from forming and blocking the drain.



Water and Toilet Drain Anti-Icing System Equipment Location



Water and Toilet Drain Anti-Icing Electrical Circuit

VIII. WINDOW HEAT ANTI-ICE SYSTEM 727-200

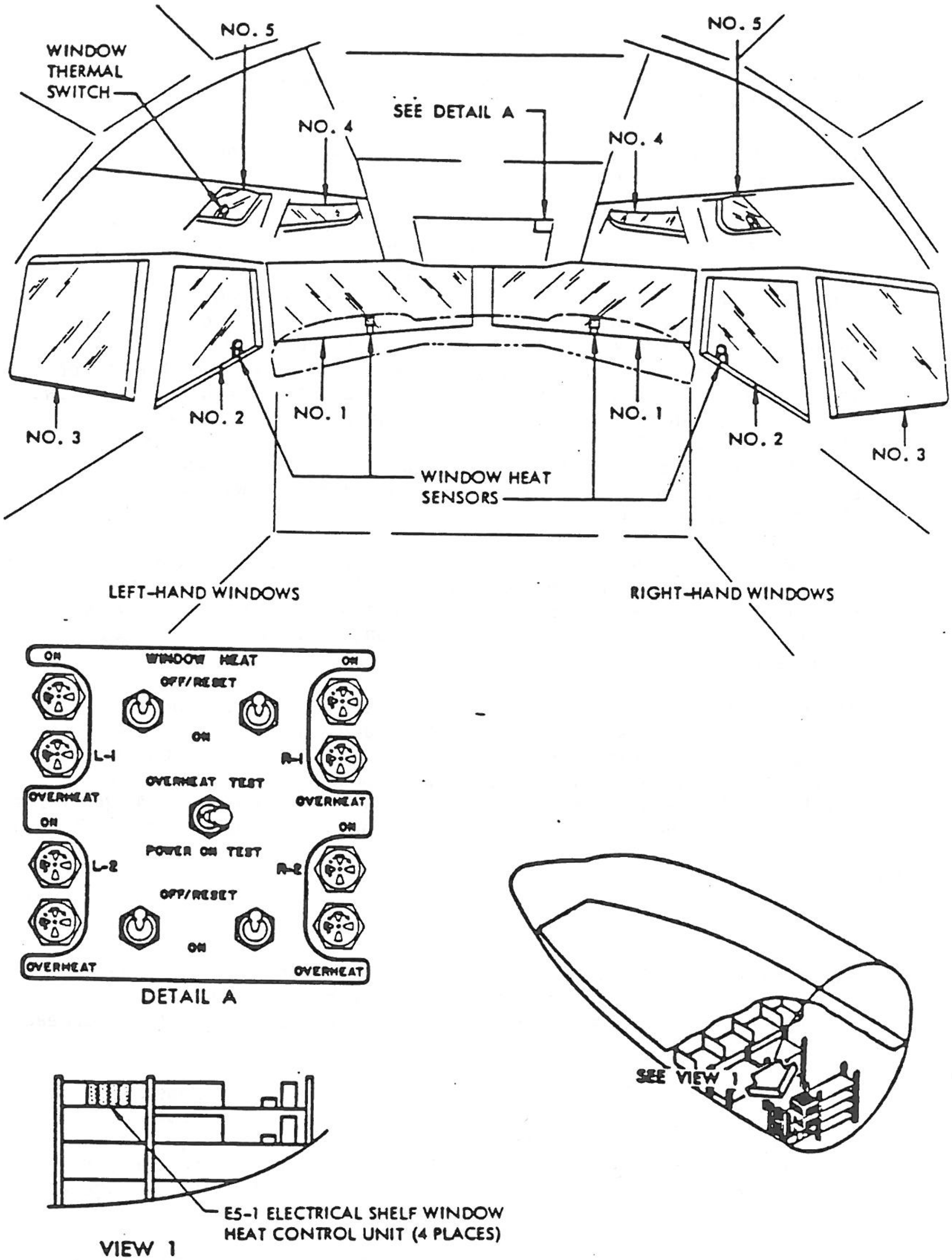
A. General Description

1. The purpose of the window heat system is to prevent ice and fog build-up on the control cabin windows No. 1, 2, 4 and 5 and to improve the impact strength of the windows in case of bird strikes. The window heat system is required to be operational dispatch.

2. The forward No. 1 windshield and the No. 2 sliding window on each side of the cabin have a separate and independent control system for each window. The control system maintains its respective window at the required temperature by the use of automatic controls. Each system consists of the heated window, a window heat sensor, a control switch, a heat control unit, a power indicating light and an overheat indicating light. A power and overheat test switch is used in common with all four systems. Actuation of either control switch for either side will provide power to its respective system and also to the No. 4 and 5 windows on the side. While the system is in operation the temperature of the windows is regulated at approximately 110°F for the No. 1 and 2 windows and between 80°F and 120°F for the No. 4 and 5 windows. The control system turns off the power to the No. 1 and 2 windows when the overheat condition of approximately 145°F is detected.

3. When the system is first energized a ramp function in the heat control unit causes the power delivered to the No. 1 and No. 2 windows to increase gradually from zero to full power in approximately 3 minutes, unless it is controlled at a lesser level by the window reaching control temperature before the ramp time runs out. This reduces the thermal shock to the pane when the power is applied to a cold window. A power interruption of five seconds or more will cause the ramp function to start over from zero, while for lesser interruptions the ramp will start over at a fraction that is proportional to the time off. The window heat sensor provides a temperature control signal to the heat control unit which in turn modulates the amount of power to the window to maintain the window at the required operating temperature.

4. The power indicating light will be illuminated when power is being supplied to the window. If an overheat condition is detected the heat control unit will cutoff power to the windows, turn off the power indicating light, and illuminate the overheat indicating light. While the system is in operation the heat control unit may be functionally tested by the use of the system test switch. Holding the test switch in the POWER position will force the control unit to supply power to the window and illuminate the power indicating light. If the operational confidence check is performed under conditions where the window temperature is within the overheat cutoff range, whether by outside environment or by excessively long testing, an overheat cutoff will occur. An overheat condition can be simulated by holding the test switch in the OVERHEAT position. The system is returned to normal by momentarily placing the control switch in the OFF position. The temperature of the No. 4 and 5 windows is controlled by the thermal switch on the No. 5 window.



Control Cabin Window Anti-Icing System Equipment Location

B. General Function

1. 115 VAC electrical power is passed through a conductive coating between the window layers in the pane and heat the window.

2. Wi dows No. 1, 2 4 and 5 on both left and right are heated. Windows No. 3 both left and right are not heated.

3. Windows No. 1 and 2, left and right, are controlled to a temperature of 110°F by a heat control unit for each of the windows. Each window has a temperature sensor embedded in it, sending a signal to the heat control unit. The control unit allows only enough power to the window to keep the temperature at approximately 110°F. Should control fail, and an overtemperature occur in which the temperature reaches 145°F, the heat control unit will cut off power to the window and an amber light on the overhead panel will illuminate. No. 1 and No. 2 windows have a spare sensor embedded in them, and will be connected and used, in the event the other unit fails. Two additional terminals are provided near the existing terminals along the lower edge for the spare sensor. This is to eliminate removal of the window in the event the first sensor fails.

4. Windows No. 4 and 5 on each side are heated together in a series circuit. A thermal switch mounted on window No. 5 controls the current so that the temperature stays between 90 and 110°F. When either window No. 1 or No. 2 is turned on, current will flow to windows No. 4 and 5 on that side.

5. Control panel consists of: (1) ON-OFF switch for each window No. 1 and No. 2. (2) POWER ON light (green) for each window No. 1 and 2. (3) OVERHEAT light (amber) for each window No. 1 and 2. (4) One test switch which has 3 positions, one for a power test, one for an overheat test, and a center off position. (5) Windows No. 4 and 5 are controlled by the ON-OFF switches used for windows No. 1 and/or 2.

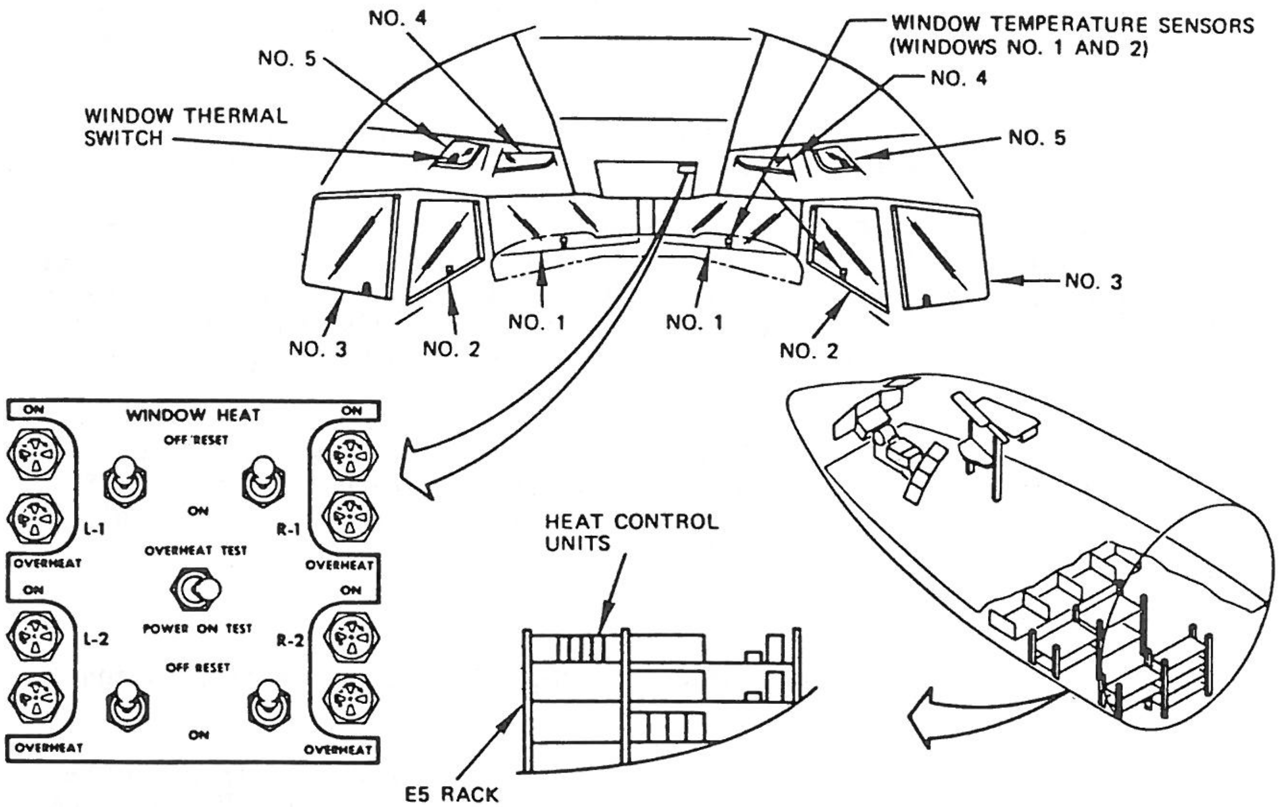
C. Functional Description - System

1. Windows No. 1 and 2

a. 115V AC, single phase power is supplied directly to the heat control unit but no power is available to the window until the control circuit is activated by the ON-OFF switch on the overhead panel.

b. When the control circuit is activated, electrical power is supplied to the window but only on a gradual power buildup. This gradual buildup is to prevent a shock to the window, causing a window failure. The gradual buildup is accomplished through a ramp circuit in the heat control unit. Voltage buildup time will be from 2 to 4 minutes.

c. Power from the heat control unit to the window is from an auto transformer through one of 6 taps. Each tap has a different voltage output. Choice of tap is based on the electrical resistance of the conductive coating in the window.



CONTROL CABIN WINDOW ANTI-ICE SYSTEM

CONTROL CABIN WINDOW ANTI-ICING

d. Power is not available inside the heat control unit to the auto transformer until an overheat relay, K1, is energized by the control switch.

2. Indicating Circuits

a. Power ON light will illuminate when power is flowing through the auto transformer, and the window is drawing 5 watts of power or more.

b. Overheat light will illuminate if an overheat condition exists, i.e., window temperature in excess of 145°F.

c. When the ON-OFF switch is first placed to ON position, overheat relay, K1, is energized if no overheat condition exists. Relay K1 will allow power to flow to the auto transformer and from there to the window. If an overheat condition does exist on start up, relay K1 will not energize and the amber overheat light will be illuminated.

d. Power ON light will illuminate when more than 5 watts of power is being drawn by the window. If window temperature is above 110°F the power ON light will not illuminate even though the control switch is placed in "ON" position.

3. Test Circuits

a. Test switch is a 3-position switch, detented in center position, momentary in other positions.

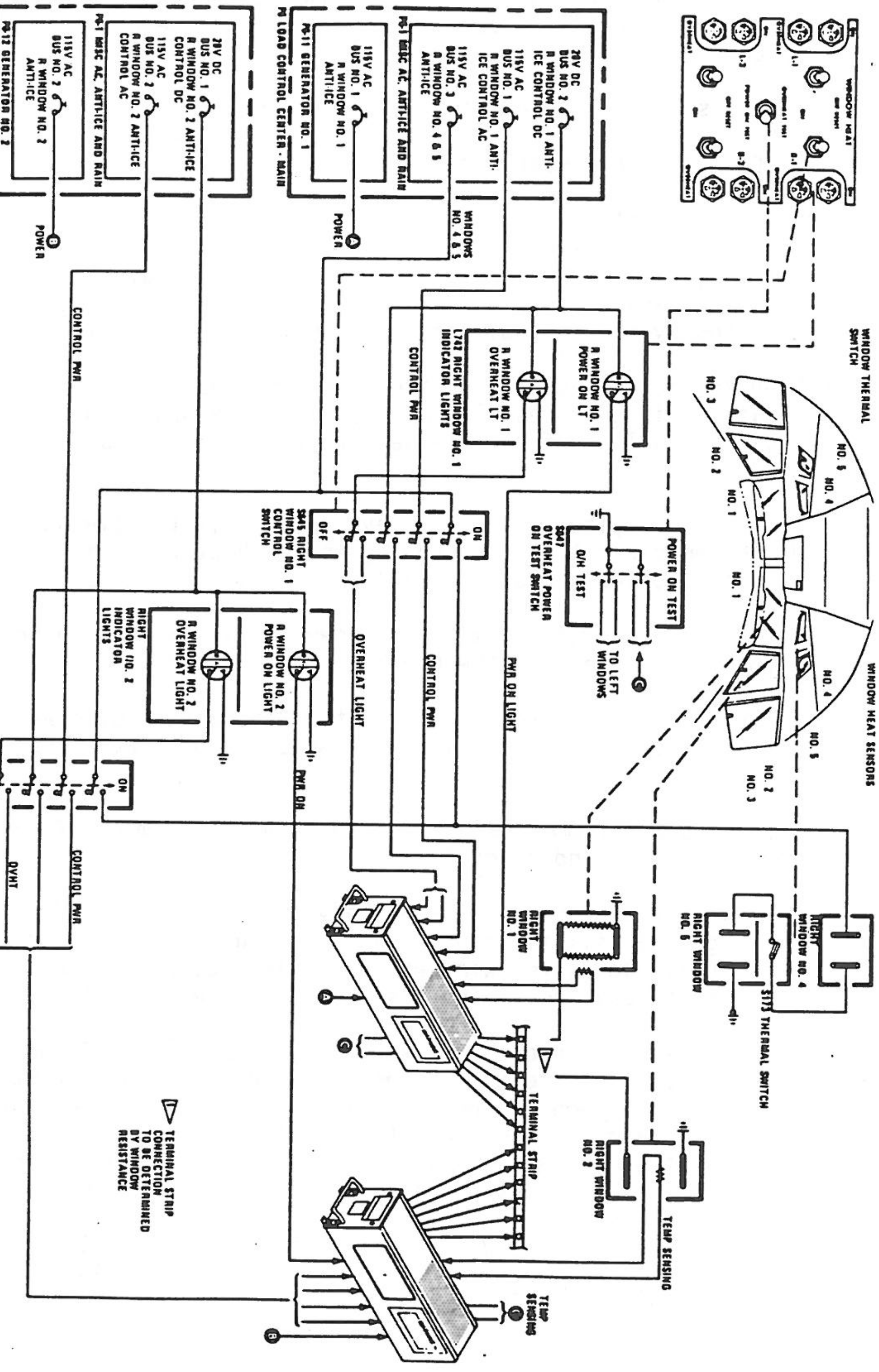
b. In the POWER ON TEST position, test switch provides power to the windows whose control switch is in the ON position. The POWER ON light (green) will illuminate even if the window temperature is above the control level of 110°F.

<u>CAUTION:</u> **DUE TO THE POSSIBILITY OF FORCING THE WINDOW INTO OVERHEAT CONDITION, THE POWER ON TEST SHOULD NOT BE HELD ON TOO LONG.**

c. In the OVERHEAT TEST position, test switch simulates an overheat condition in all heat control units that are operating (i.e., window heat control switch in ON position). Power ON light (green) will go out and OVERHEAT light (amber) will illuminate. After overheat test, heat control unit must be reset by positioning control switch to OFF and then back to ON position.

4. Windows No. 4 and 5

a. 115V AC, single phase power is supplied directly to window No. 4 and then to No. 5 in series when either the windows No. 1 or 2 for that side is placed in the operating condition.



CONTROL CABIN WINDOW ANTI-ICING SCHEMATIC

b. A thermal switch in the circuit between the No. 4 and 5 window will open when the window No. 5 temperature reaches 110±10°F. The thermal switch will close when the window temperature drops to 90 ± 10°F.

c. There is no indicating light in this circuit.

D. Functional Description - Heat Control Unit

1. Electrical Circuit

a. 115V AC, single phase power is available to relay K1. This power will not pass on to the window until the control circuits are actuated by the control switch on the overhead panel.

b. When the control switch on the overhead panel is placed in the ON position, it provides 115V AC, single phase power to transformer T2. This will activate the heat control unit and provide power to the window.

c. Power to energize relay K1 is available. If the overheat detection circuit is not sensing an overheat condition, it will provide provide a ground signal and K1 will energize.

d. With the K1 energized, 115 V AC power will now pass to primary of transformer T1 and to the power switch circuit.

e. The power switch circuit will control the amount of power to flow to the windows by controlling the AC power passing through the primary of T1.

f. 115V AC power from K1 will pass through the primary of T5 and then through the secondary of T1.

(1) In passing through the primary of T5, the power ON light (green) will illuminate when more than 5 watts of power is available to the windows. This is accomplished by a "power on" circuit receiving a signal from the secondary of T5.

(2) In passing through the secondary of T1, the voltage is boosted. There are 6 taps which provide 6 different voltages for the window. The selection of tap is based on the resistance of the conductive coating in the window. The maintenance manual has a chart which tells which tap is to be used for the varying window resistances. The voltages are:

Pin 1	272	Pin 14	135
Pin 7	285	Pin 20	331
Pin 8	299	Pin 21	347

g. Until a ground signal is supplied in the power switch circuit, no booster power will be available in the secondary of T1 and to the windows. The power switch is controlled by a pulse-width circuit which is in turn controlled by the error circuit.

h. The error circuit determines the amount of heat required to maintain a window temperature of 110°F.

(1) Window temperature is sensed in resistance value and sent to the error circuit by the temperature sensor.

(2) Power to the error circuit is provided by T2.

(3) Error circuit is basically a Wheatstone bridge circuit which sends its signal to an integrated circuit amplifier.

(4) The output of this amplifier also passes to a ramp circuit.

i. The ramp circuit is active only at the start of the heating cycle. Its purpose is to prevent a rapid power (or heat) buildup in the window.

(1) At start up, the ramp circuit will control the amount of error signal for about 3 minutes.

(2) The resulting power buildup in the window will start from zero watts and take at least 3 minutes to reach full wattage available.

j. The pulse width provides a control signal for the power switch circuit.

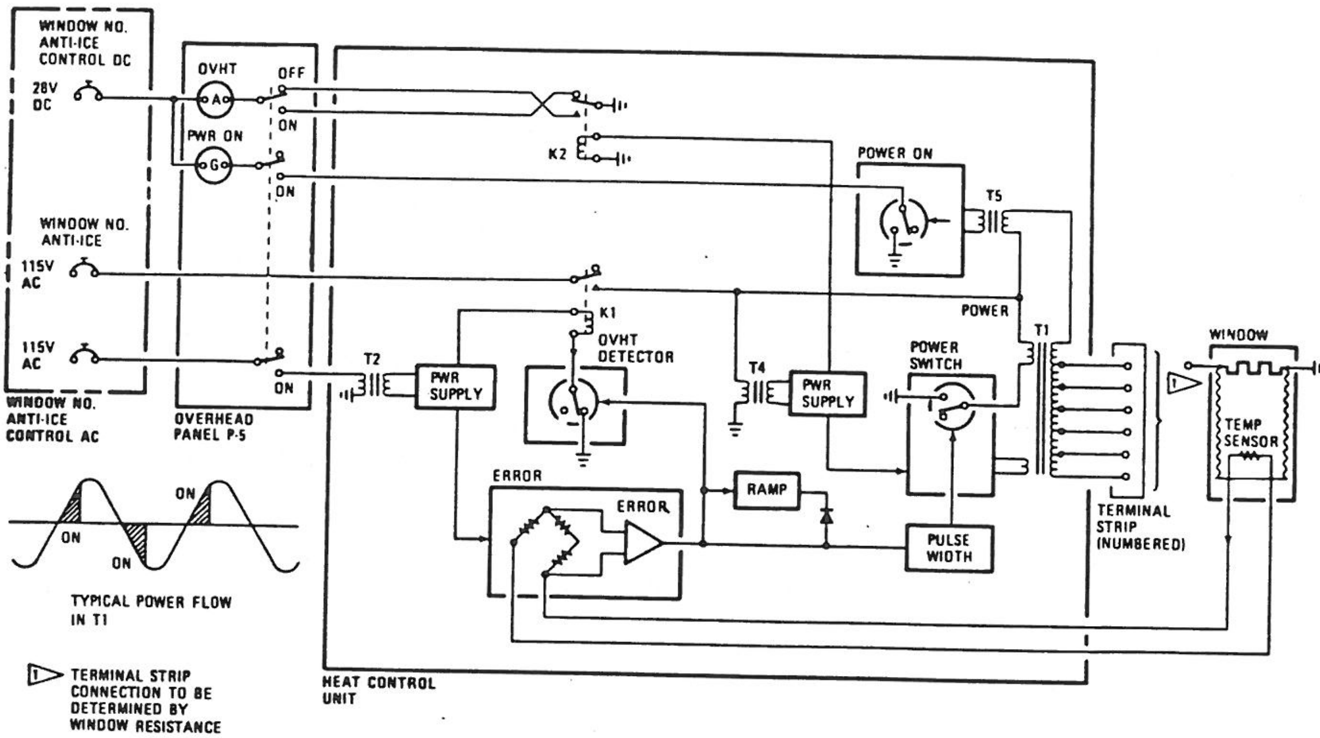
(1) The power switch circuit will provide the ground for primary power through T1.

(2) When the ground signal is provided, the transformer T1 is activated. The sine wave pattern on the diagram indicates when the ground signal is provided by noting the ON condition. Shaded area indicates when power activates T1.

k. The error circuit output is also provided to the overheat circuit. If the window temperature reaches 145°F, this circuit will cause the relay K1 to de-energize. This will cut-off power to:

(1) T1 and the windows.

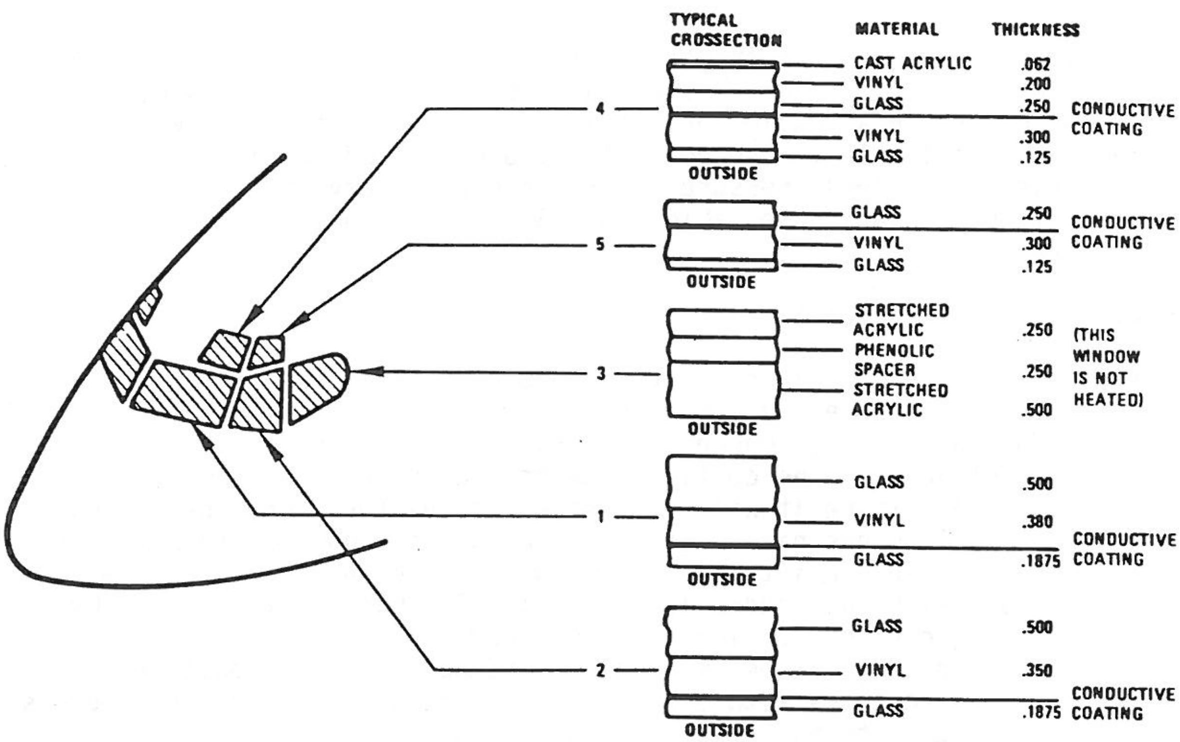
(2) T5, deactivating the ground signal for the power ON light.



HEAT CONTROL UNIT - FUNCTIONAL DIAGRAM

(3) T4, deactivating the power for the power switch circuit and for the K2 which has been controlling the overheat light circuit. With no power supply, K2 will be de-energized and the amber overheat light will come on.

1. If an overheat condition occurs, the ON-OFF switch on the overhead panel must be cycled to OFF to reset the various circuits inside the heat control unit.



CONTROL CABIN WINDOWS

E. Window Construction

1. Windows No. 1, 2, 4 and 5

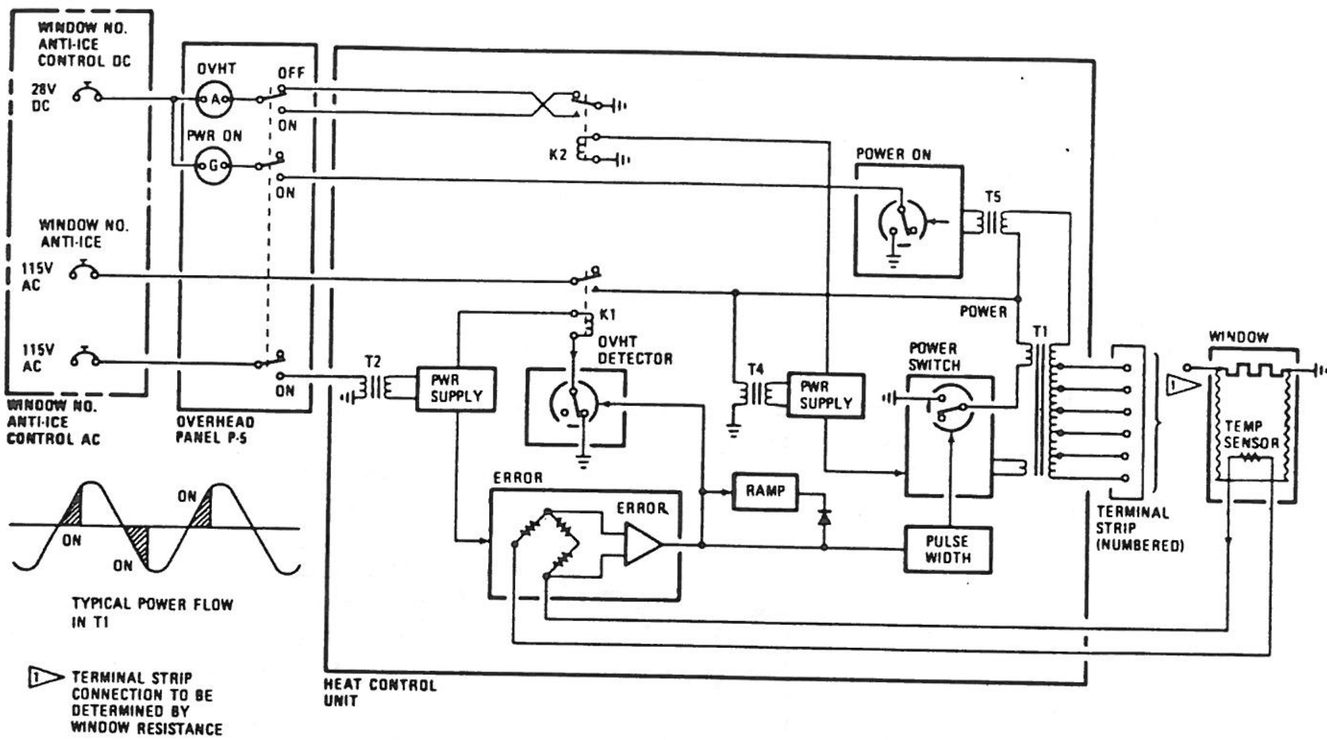
a. Windows No. 1, 2, 4 and 5 construction consists of laminated glass (tempered), vinyl and acrylic with a transparent conductor sandwiched next to the outer pane on anti-iced windows and close to the inner pane on defogged windows. The conductor is "STANUOUS OXIDE".

2. Window No. 3

a. The construction of the No. 3 window consists of two acrylic panes separated by a spacer. The spacer creates an insulation cavity which prevents fogging on the inner surface of the windows. There is a small hole in the upper forward corner of the inner pane. This hole allows pressure in the insulation cavity to equalize with pressure in the cabin. No. 3 window is not electrically heated.

3. Window Conductive Coating

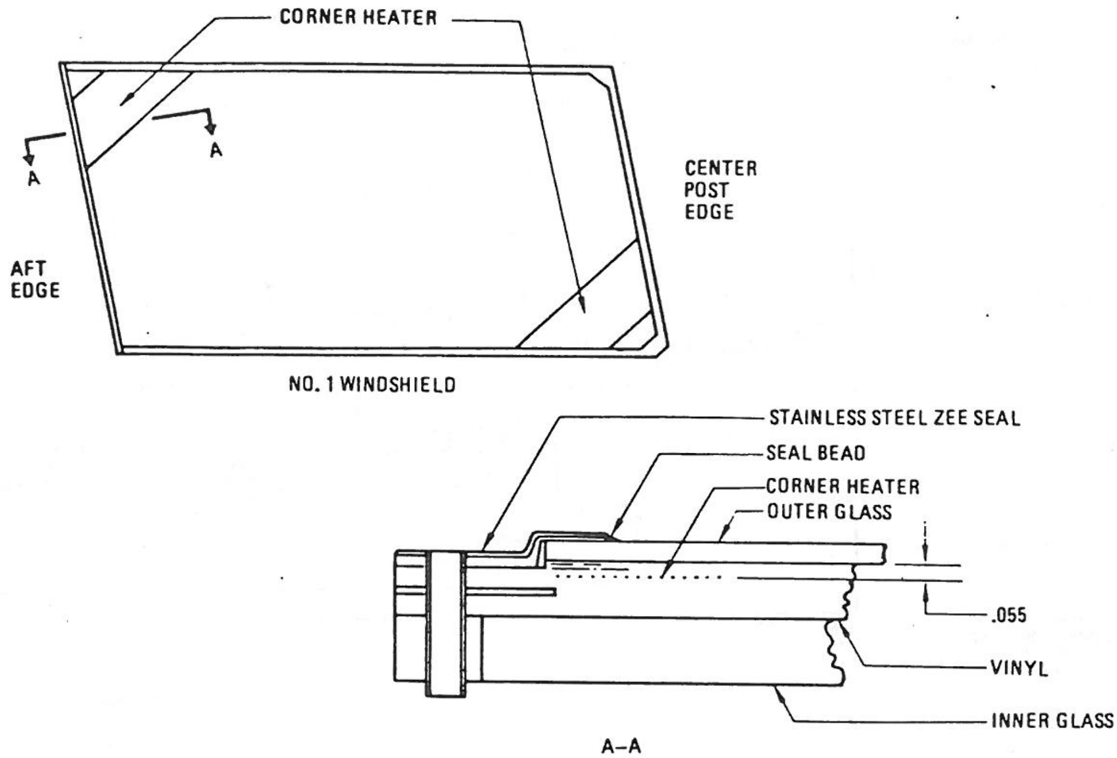
a. The No. 1 and 2 windows have a conductive coating between the outer glass pane and vinyl core where it is most effective for window anti-icing, whereas the No. 4 and 5 windows have their conductive training coating between the inner glass pane and the vinyl core where it will be most effective for window defogging. All four windows have electrical terminals connected to bus bars which are molded into the upper and lower edges of the window in contact with the conductive coating. The windows are heated by allowing current to flow thru the conductive coating between the upper and lower bus bars. The resistance of the conductive coating increases with age and higher voltages are required across the bus bars to maintain equivalent heat output.



HEAT CONTROL UNIT - FUNCTIONAL DIAGRAM

4. Window Heat Sensor

   a. The No. 1 and 2 windows each have a heat sensor consisting of a filament of noninsulated resistance wire. The wire is arranged in a single plane coil and inbedded in a thin plastic wafer installed near the lower edge of the window, between the outer pane and plastic temperature and increases as the temperature increases. A change in window temperature causes a change in sensor resistance, providing a signal for the heat control unit. Some No. 1 and 2 windows have a spare sensor located next to the primary heat sensor.

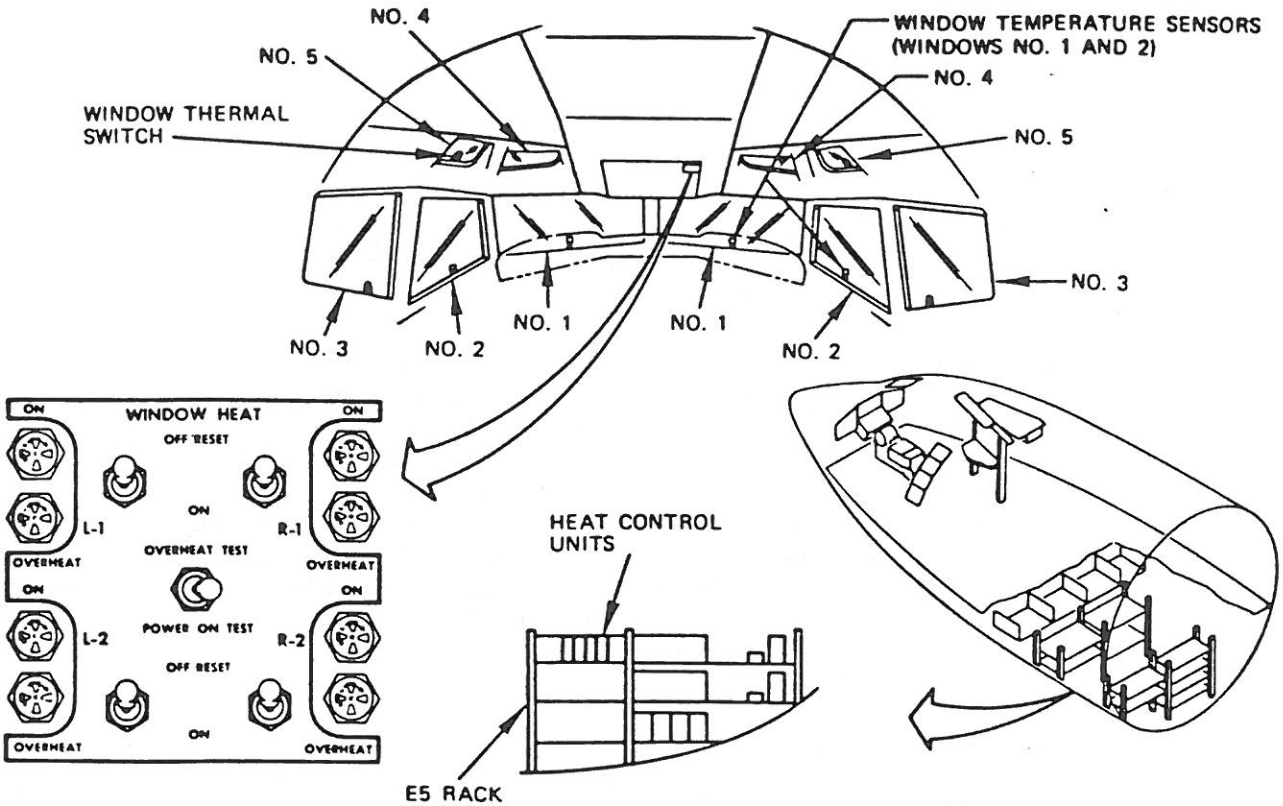


NO. 1 WINDSHIELD CORNER HEATERS

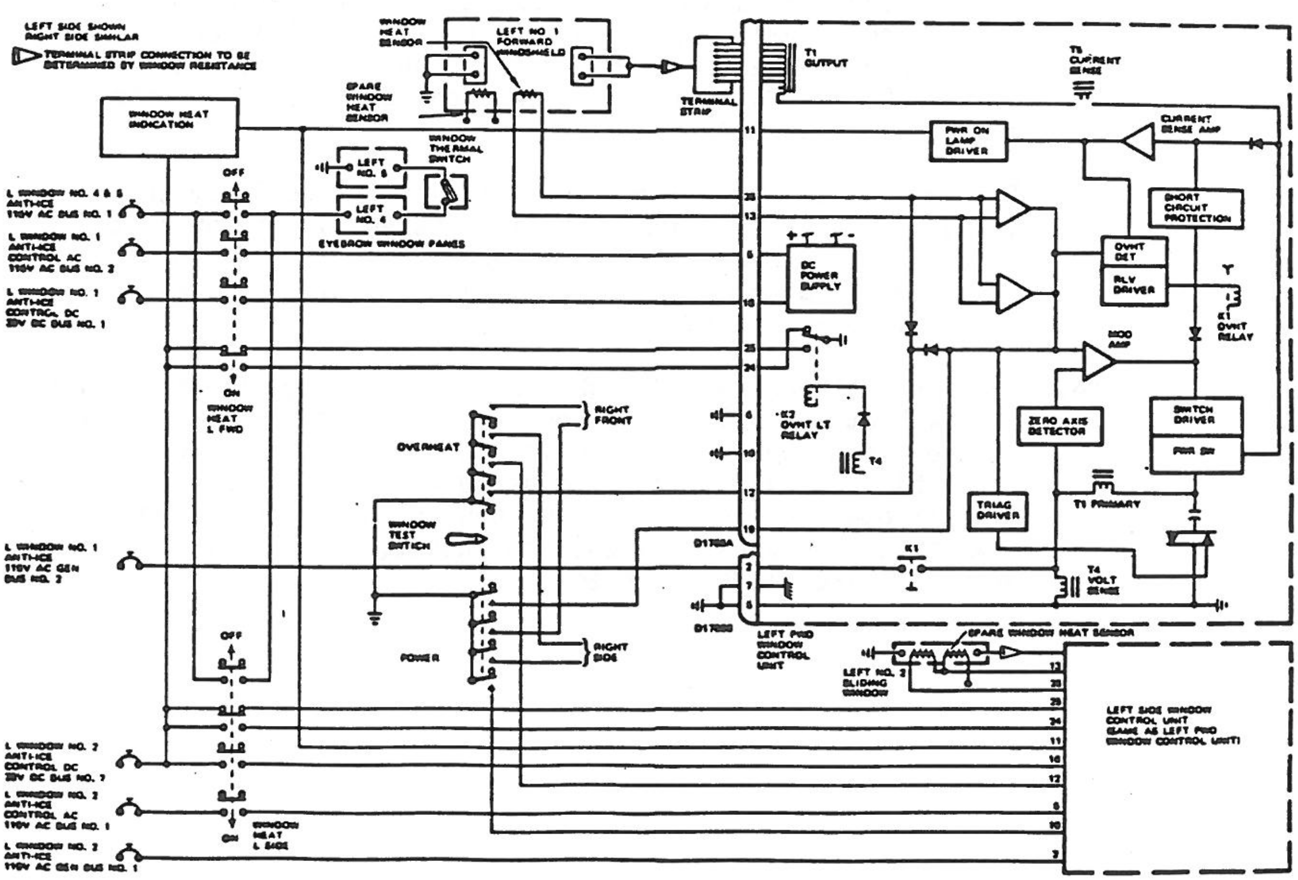
5. Window No. 1 Auxiliary Heat

   a. In addition to AC electrical power passed through a conductive coating located coating located between the two outer pane laminations, additional power is supplied to corner resistance units to adequately heat window No. 1 (left and right). Power input to the corner heaters is controlled via the window heat control unit and switches in the same way as that provided to the conductive coating.

      The corner heaters, made up of wire coils, are embedded in the vinyl layer a distance of about .05" from the outer glass layer of the window. These heaters are located at the lower forward and upper aft corners of the window. Each heater shall be divided into two zones connected in parallel and heater wires shall be in a sine wave pattern.



CONTROL CABIN WINDOW ANTI-ICE SYSTEM



Control Cabin Window Anti-Icing System Circuit

F. Components

1. Control Module P5-16

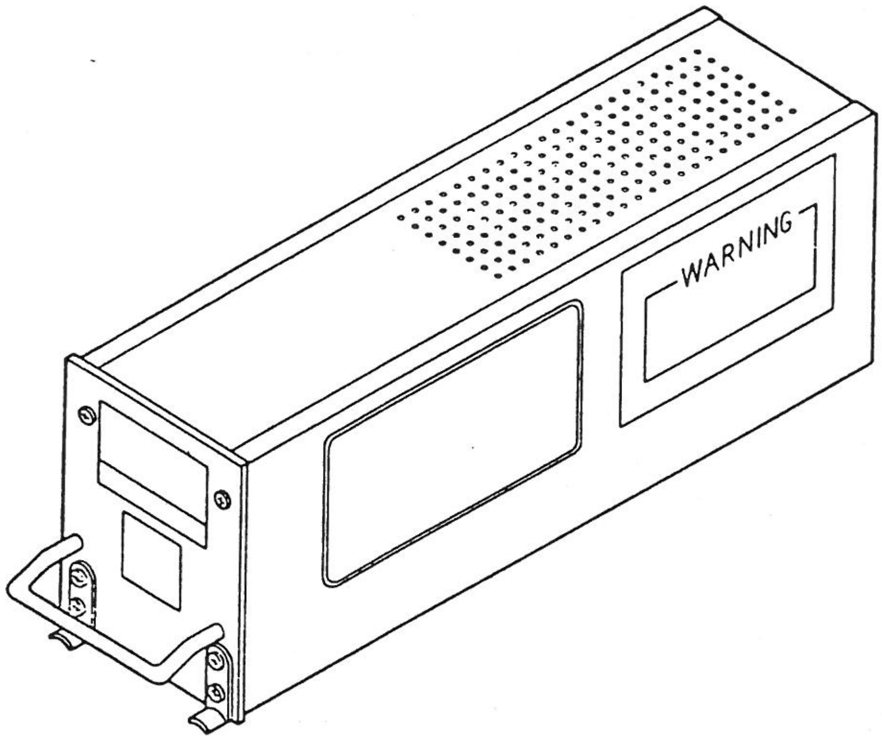
a. The P5-16 module in the Captain's overhead P5 panel contains switches for the control cabin window anti-icing systems and combination overheat indicating lights and test switches for windows No. 1 and 2 on each side of the control cabin.

(1) There are four window heat control switches, one for each of the No. 1 and 2 windows on each side of the cabin. The switches are four-poles, two-position ON-OFF/RESET toggle switches. When either switch for either side is placed in the ON position, power is directed from the 28-volt DC and 115-volt AC control circuit breakers for its respective window heat system to pins 18 and 5 of the corresponding heat control unit. When th No. 1 or 2 window switch is in the ON position, power is directed from the 115-volt AC window circuit breaker for the corresponding side directly to the No. 4 and 5 windows.

(2) There are two indicating lights for each of the No. 1 and 2 window heating systems, power indication and overheat indication. Both lights are mounted in a common base with separate light caps for each function and are located adjacent to their respective control switch on the overhead panel. The lights are of the press-to-test type and may be tested individually by pressing each of the light caps separately. Power to both lights is supplied from the 28-volt DC WINDOW ANTI-ICE CONTROL circuit breaker of their respective system.

(3) The power indicating light is controlled directly by the temperature control circuit in its respective window heat control unit. When 28-volt DC power is available, the light is illuminated whenever the control unit output exceeds approximately 5 watts of power.

(4) The overheat indicating light is controlled by its respective window heat control switch and the and the overheat circuit in the window heat control unit. When 28-volt DC power is available, the light is illuminated whenever the overheat circuit does not agree with the control switch position (switch on - overheat circuit energized, switch off - overheat circuit de-energized)



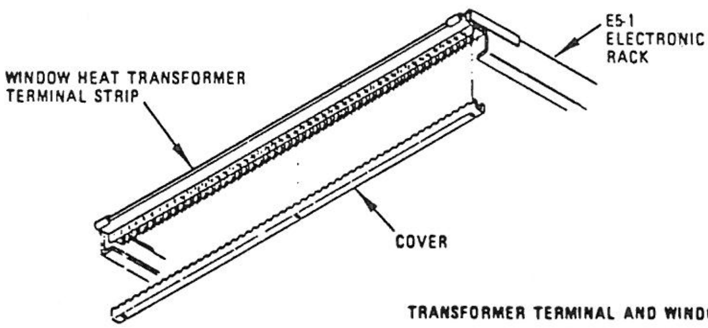
WINDSHIELD TEMPERATURE CONTROLLER

2. Heat Control Unit

a. There are four window heat control units, one for each of the window No. 1 and 2 heating systems. Each unit consists of a temperature controller, an overheat relay, and a transformer. The units are located in the E5-1 electrical rack.

b. The heat control unit is a solid state device that regulates the amount of electrical power supplied to the window conductive coating. Amount of electrical power is based on window temperature as detected by resistive element embedded in the window and feeding a signal to overheat protection system that isolates power from the window when overheating is sensed.

	WINDOW CODE WHEN NEW	BUS TO BUS WINDOW RESISTANCE (OHMS)		CONNECT TO TERMINAL STRIP TERMINAL NO.	
		MIN	MAX	LEFT SIDE	RIGHT SIDE
WINDOW NO. 1	H13 H12 H11	31.4 35.1 38.8 42.6 47.3 52.0	35.1 38.8 42.6 47.3 52.0 57.7	10 11 12 13 14 15	26 27 28 29 30 31
WINDOW NO. 2	H16 H15 H14	55.7 62.3 69.0 75.5 81.6 90.3	62.3 69.0 75.5 81.6 90.3 100.0	17 18 19 20 21 22	1 2 3 4 5 7



TRANSFORMER TERMINAL AND WINDOW RESISTANCE TABLE

3. Window Heat Transformer Terminal Strip

a. Windows No. 1 and 2 have a code number etched on the inner pane adjacent to one of the bus terminals which designates the window resistance when new. The resistance of the conductive coating increases slightly with age. If the resistance differs widely enough from that indicated by the window marking, the window power lead should be connected to a different control unit output terminal as required to maintain the correct heating current.

(1) Provides connections for the window leads to the heat control until T1 transformer taps.

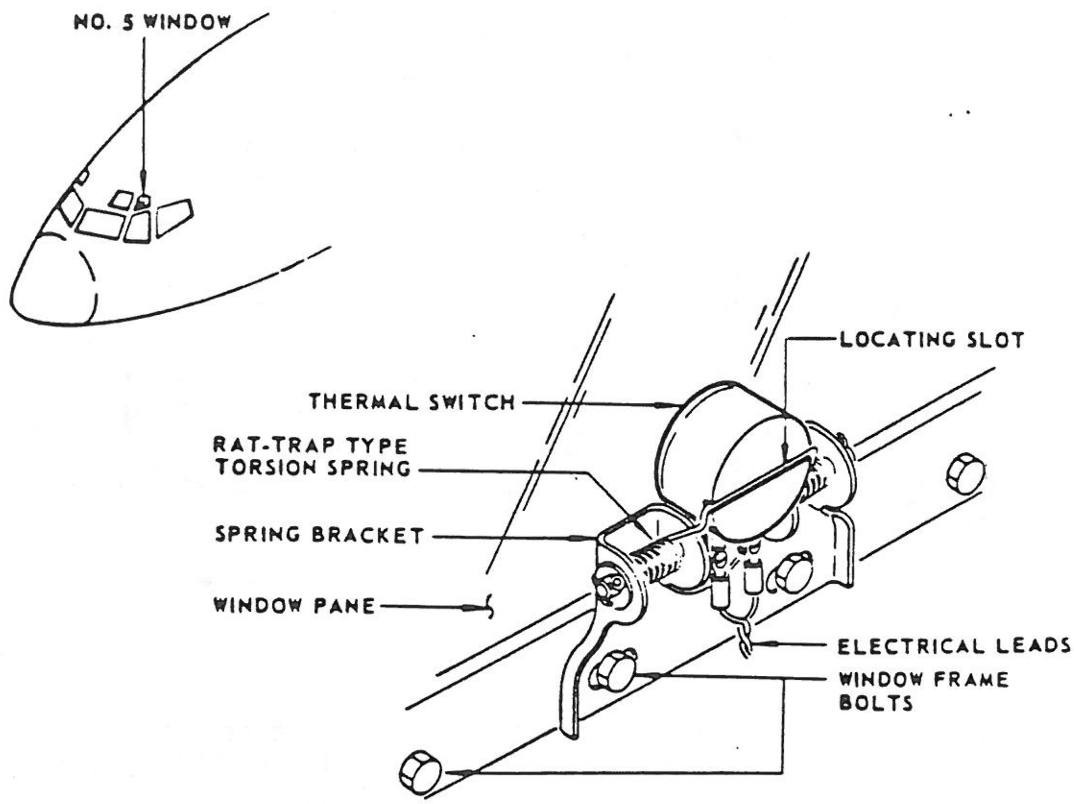
(2) Connections consists of studs on a long terminal strip.

(3) Terminal strip is mounted outboard and above the heat control units.

(4) Access to the terminal strip is through the heat control unit area.

(5) Studs are numbered and each window heat control unit has certain studs for its use as noted in the chart

(6) The maintenance manual identifies which studs to use for the window resistance involved.



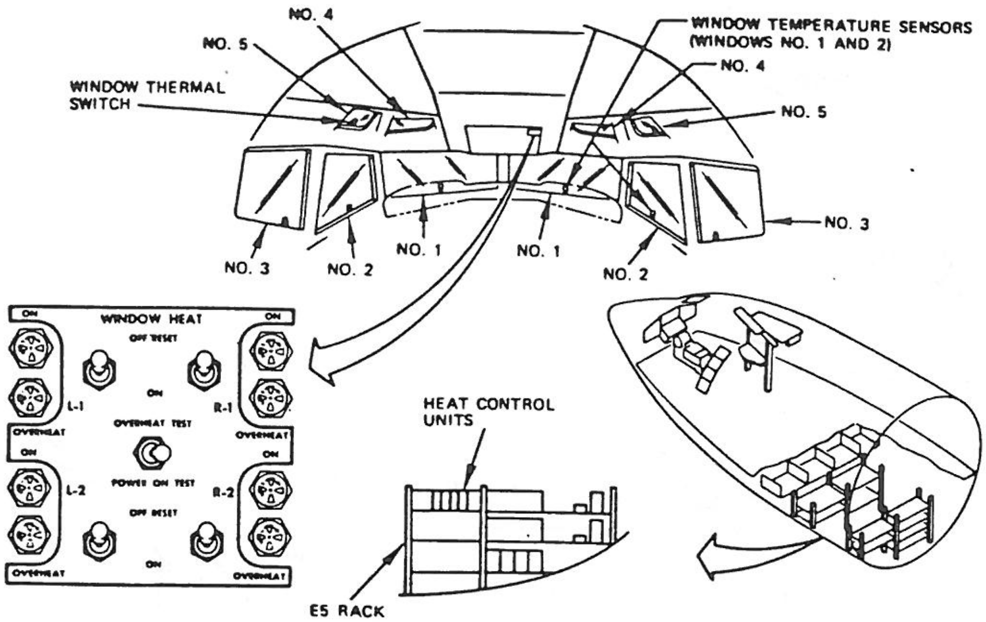
Window No. 5 Thermal Switch Installation

4. Window No. 5 Thermal Switch

   The window No. 5 thermal switch is a temperature sensitive, bimetallic, single pole, snap action switch with normally closed contact points which open at 110 (±10)°F. The switches are spring mounted near the lower edge of each of the No. 5 windows and regulates the application of power to the No. 4 and 5 windows of its respective side.

5. Test Switch

   The window heat test switch is a four-pole, double-throw, with center OFF position and momentarily on a both extremes, toggle actuated switch. The switch has momentary POWER and OVERHEAT position and is located between the window heat control switches on the overhead panel. The switch provides a ground for the power test input on each of the four window heat control units (pin 19) when placed in a POWER position, and similarly provides a ground for each of the overheat test inputs (pin 12) when placed in the OVERHEAT position.



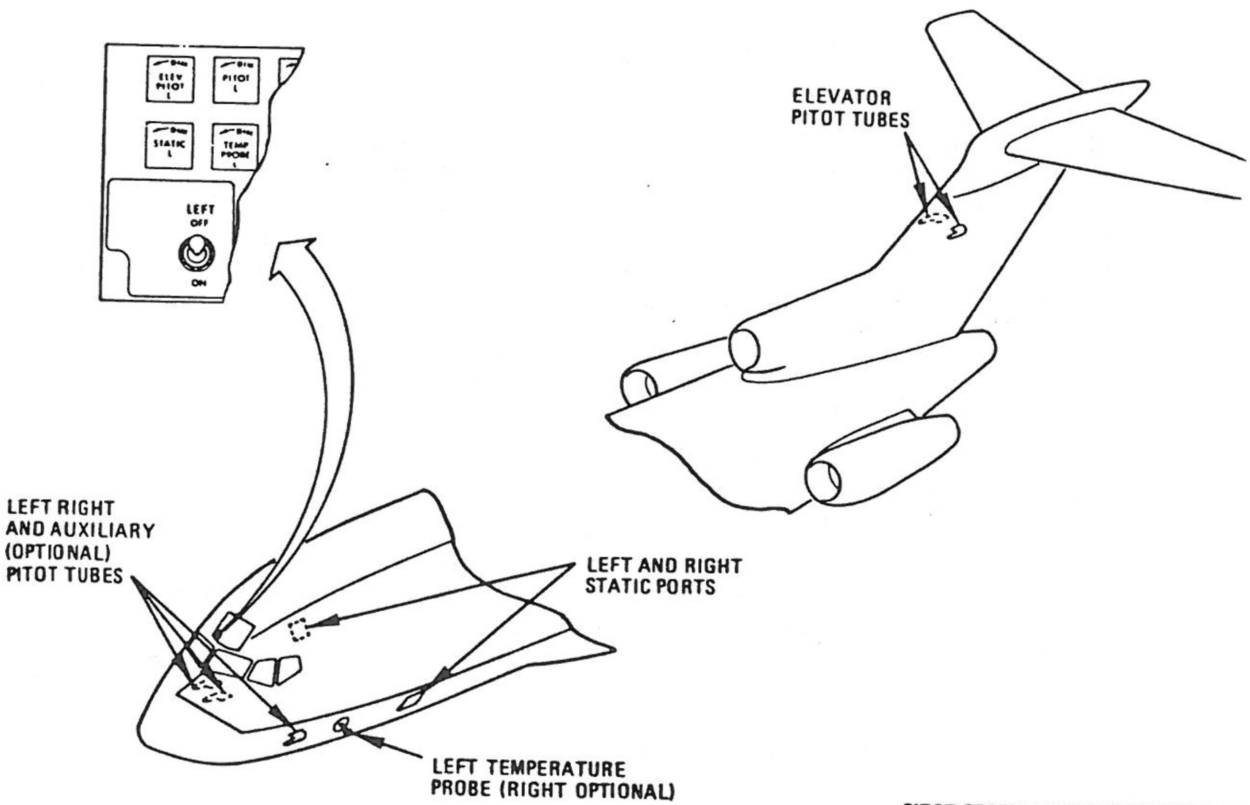
CONTROL CABIN WINDOW ANTI-ICE SYSTEM

G. Operation

1. Each of the No. 1 and 2 window heat systems are operated by the actuation of the respective control switch to the ON position. With either switch for either side in the ON position, 28-volt DC and 115-volt AC control power will be directed from the load control center to the window heat control unit for its respective window, and 115-volt AC heating power will be directed to windows No. 4 and 5 of the respective side. The No. 1 and 2 windows are maintained at approximately 110°F by the window heat control unit and the No. 4 and 5 windows are regulated between 80 and 120°F by the window thermal switch on the No. 5 window.

2. With control power supplied to the heat control unit in the absence of an overheat condition the temperature control circuit will energize the overheat circuit. With the overheat circuit energized, the 115-volt AC heating power is directed from the load control center to the control unit for modulation to the heat transformer. The temperature control circuit monitors the resistance of the window heat sensor and produces a signal to the modulation control circuit to maintain the window at the required temperature.

3. If the window heat sensor detects a window temperature above the 145°F while power is being applied to the window, the temperature control circuit will de-energize the overheat circuit. Whenever the overheat circuit is de-energized, with the control switch in the ON position, the overheat circuit will illuminate the overheat indication light. The overheat indication light will remain illuminated until the system is reset by momentarily turning the control switch to the OFF then ON position. While the system is in operation, the overheat detection system may be confidence tested through the use of the system OVERHEAT TEST switch.



PITOT STATIC COMPONENT LOCATION

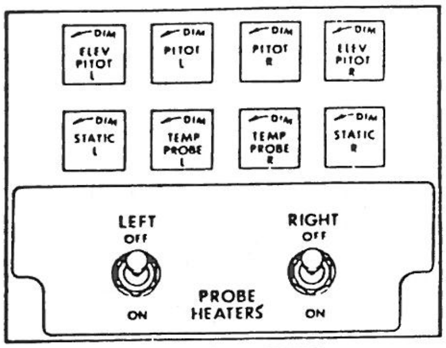
IX. PITOT STATIC AND TEMPERATURE PROBE ANTI-ICING SYSTEM 727-200

A. General Description

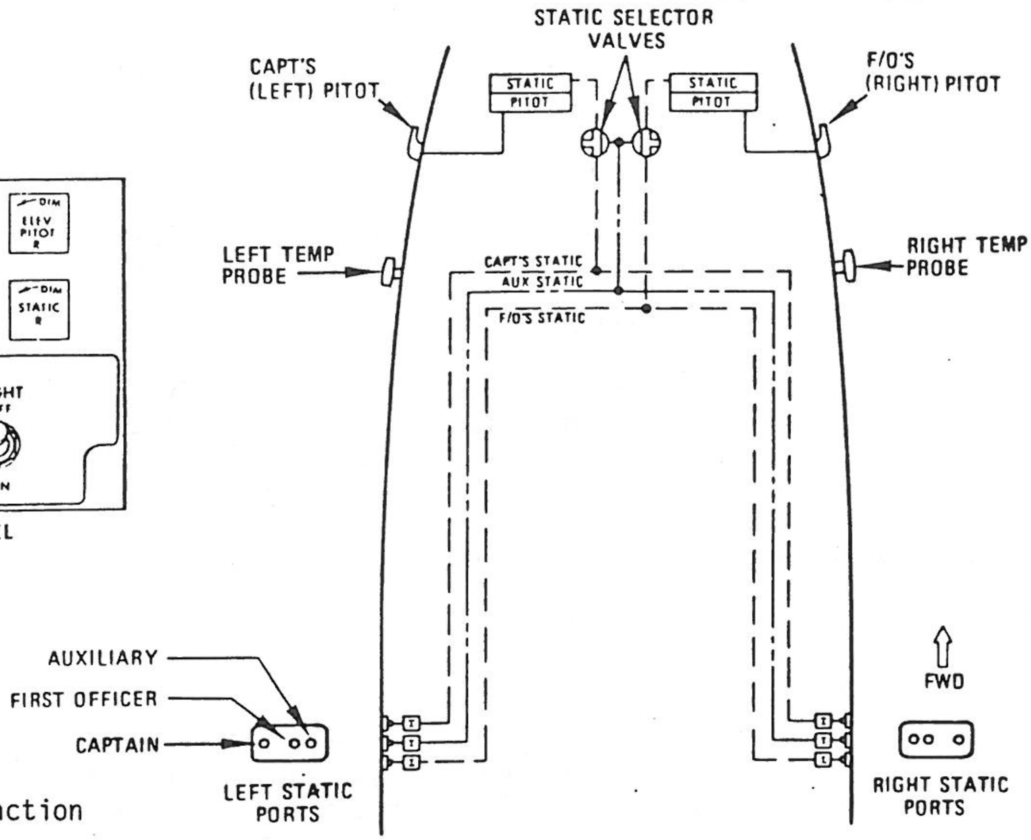
1. The left and right pitot tubes, the corresponding six static ports, the elevator left and right pitot tubes and the left and right temperature probes are heated to prevent the formation of ice on the sensor which could affect sensing accuracy. The heating is accomplished by electrical heaters installed s an integral part of the units. The heaters consist of resistance elements which operate on 115-volt single phase current.

2. The current to the heaters is supplied from the circuit breakers on circuit breaker panel P6-1, and is controlled by two switches on the pilot's overhead panel. The control switches are four-pole, two-position (ON-OFF) toggle switches. The left switch controls the heating of the right static ports, right pitot, right temperature probe and right elevator pitot. Current for the left pitot heater and the three left static port heaters is supplied from the essential AC bus to ensure that power is available from any generator. Current is supplied to the left elevator pitot heater and right temperature probe from AC bus No. 1. The remaining right pitot, right elevator pitot, right static ports and left temperature probe heaters are supplied from AC bus No. 2.

3. The system has an indicating circuit consisting of three current transformers and an indicator light for each control switch. The transformers are installed in the line from each pole of each control switch and connected to their respective amber indicator light which will indicate when current is not flowing to the respective heater elements. The indicator lights are located above the heater control switches on the pilot's overhead panel. The current transformers are located behind the overhead panel close to the control switches. The indicator system operates on 28 volts DC taken from the essential DC bus for the left heaters and bus No. 2 for the right heaters.



P5 CONTROL PANEL



TYPICAL PITOT STATIC SYSTEM

B. General Function

1. Pitot System

a. One pitot tube on the left forward side of the fuselage supplies dynamic pressure to the Captain's pitot static operated instruments.

b. The pitot tube on the right forward side of the fuselage supplies dynamic pressure to air data computer number 2.

c. A separate pitot system consisting of two pitot tubes are installed on the vertical stabilizer and connected to the elevator power drive unit to provide "feel" to the elevator control operation.

2. Static System

a. Static (for ambient) pressure is sensed through 6 ports. There are 3 ports on each side of the fuselage and they are paired so that one port on the left is connected to a port on the right side.

b. One of the pairs is connected to the Captain's pitot static manifold.

c. Another pair is connected to the air data computer number 2.

d. The third pair connects and auxiliary static system to the cabin pressure controller and third crewmans panel.

e. A two-way selector valve in the control cabin connects the Captain's static ports to the Captain's instruments when it is in normal position. When the selector valve is in alternate position, it connects the auxiliary static ports to the Captain's instruments. A similar selector valve is provided for the First Officer

C. Pitot Static Anti-Icing System

1. Functional Description

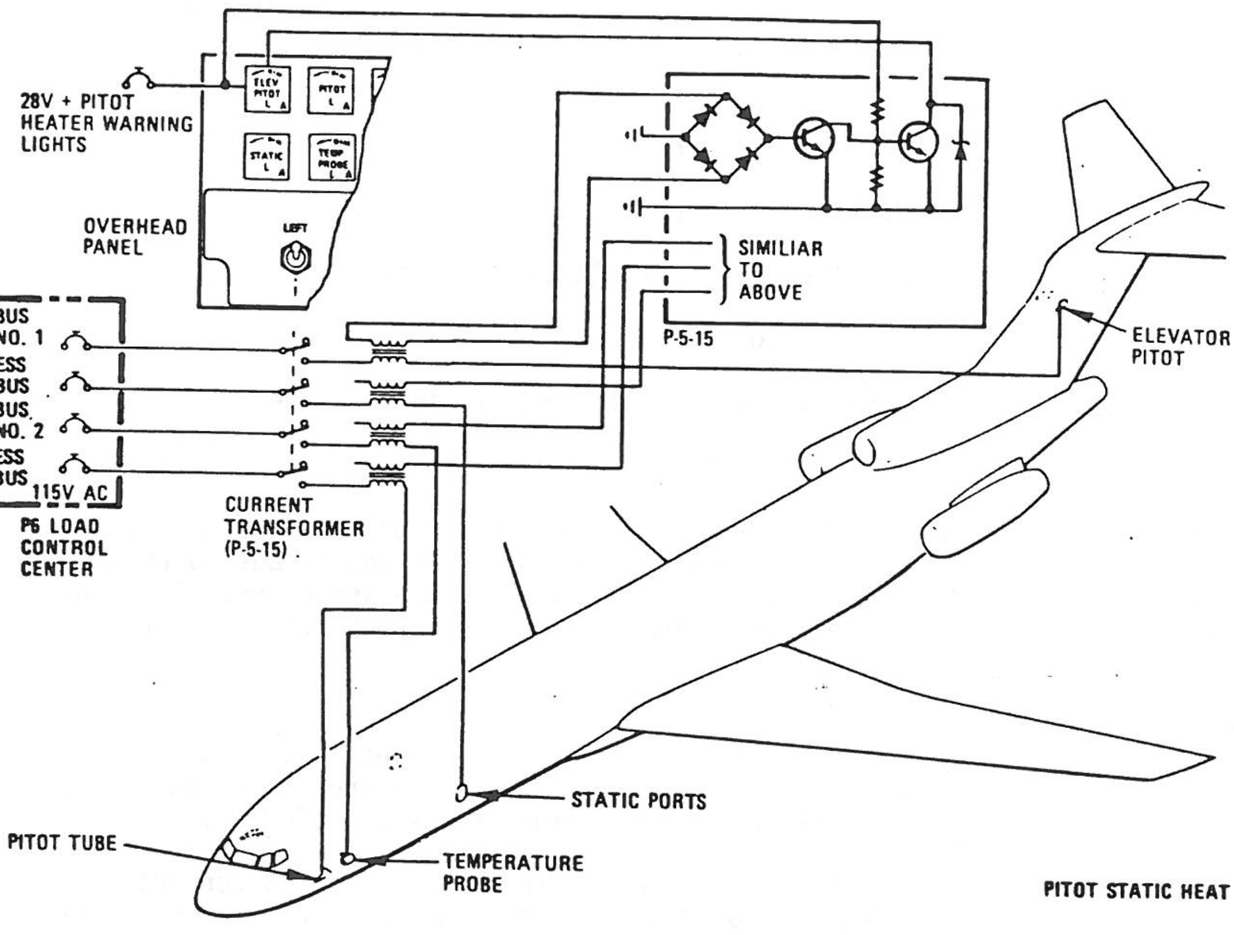
a. General

(1) All pitot tubes are electrically heated. Control of the heating is through 2 switches on the overhead panel, P5. One switch controls the pitot tubes on the left side of the aircraft and the other switch controls the pitot tubes on the right side of the aircraft.

(2) All static ports are electrically heated. Heating control is through the 2 switches which control the pitot tube heating. One switch for the static ports on the left side and the other switch for control of the static ports on the right side.

(3) The air temperature probes are electrically heated. Control is through the same switch which controls the left side pitot tube and static port heaters.

(4) Monitoring of the heating elements is accomplished by amber lights on the overhead panel, P5. Each pitot element has a light, which illuminates when power is not being drawn by that element.



PITOT STATIC HEAT

b. Heater Circuits

(1) All heaters consist of resistance elements which operate on 115V AC, single phase current.

(2) Current is controlled by 2 switches, which have ON-OFF positions.

(a) Left switch controls current to:

left pitot tube
left static ports
air temperature probe (LH)
left elevator pitot tube

(b) Right switch controls current to:

right pitot tube
right static ports
auxiliary pitot tube and air temperature probe (RH)
right elevator pitot tube

(3) Current for left instrument pitot tube and static ports heaters is supplied from the essential bus to ensure that power is available from any generator. The other heaters are supplied from either AC bus No. 1 or 2.

c. Indicating Circuits

(1) A current transformer is installed in each heater circuit supply line. Current to the heater passes through the primary side of the transformer.

(2) The secondary side of the transformer is connected to electric solid state switches, which will turn on the indicator light any time the heater is not drawing current.

(3) Current transformers are located in the pitot static heat module assembly. This module contains the control switches and indicator lights.

D. Components

1. Pitot Tube and Heater

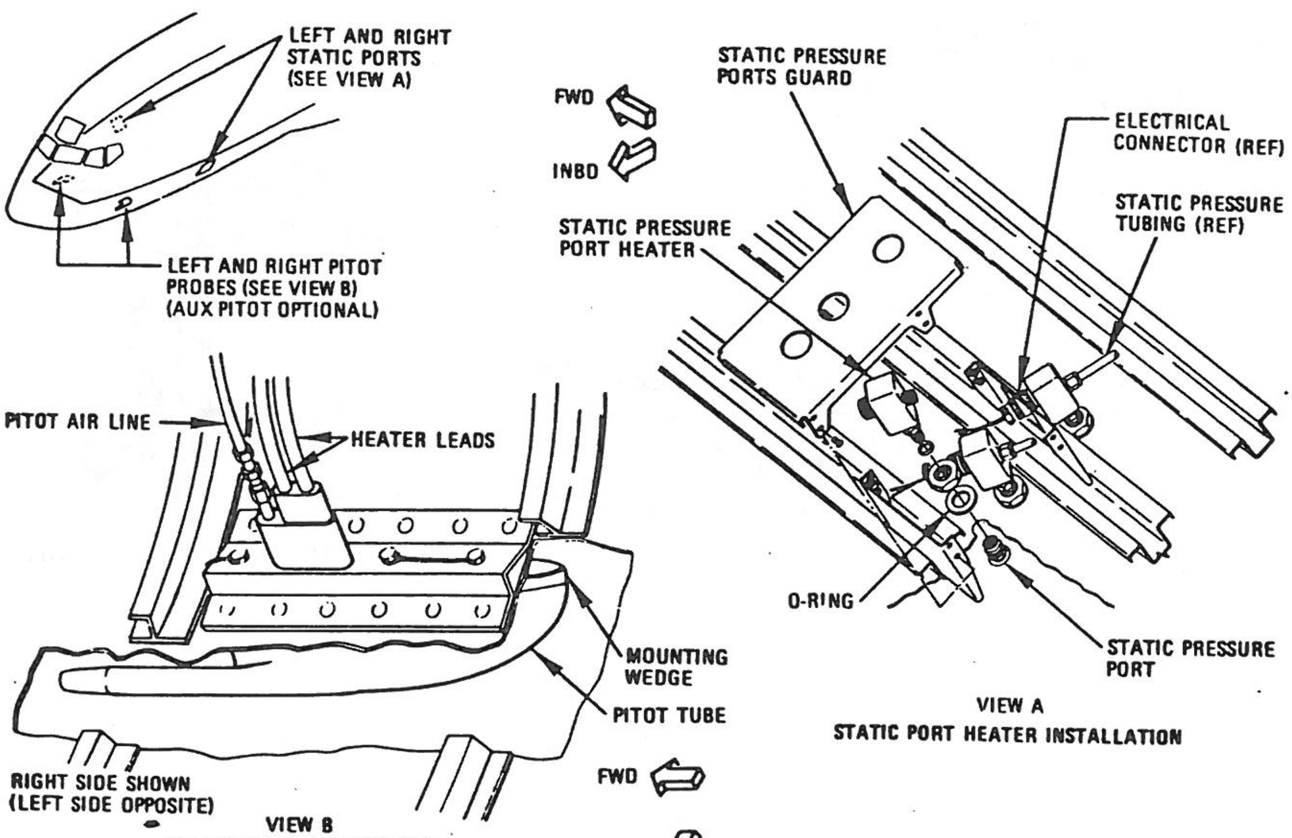
   a. Heater element built into the pitot tube. Replacement of the heater requires replacement of the tube assembly.

   b. Access to the tube mounting bolts is from inside the aircraft, lower 41 section.

2. Static Port and Heater

   a. Heater is a separate unit mounted at the port opening.

   b. Access to the heater is from the inside of the forward cargo compartment. The compartment lining and a sheet metal guard must be removed to get to the assembly.



VIEW B
PITOT PROBE INSTALLATION

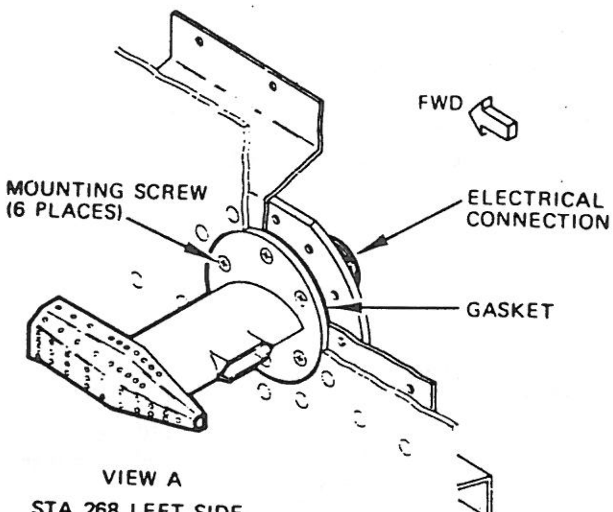
VIEW A
STATIC PORT HEATER INSTALLATION

PITOT STATIC HEATER INSTALLATION

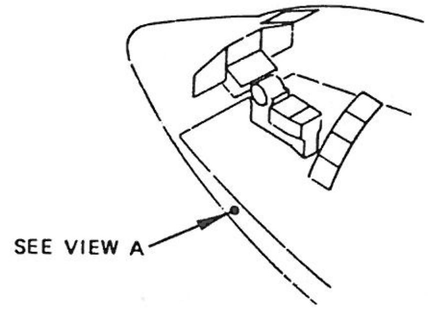
3. Air Temperature Probe

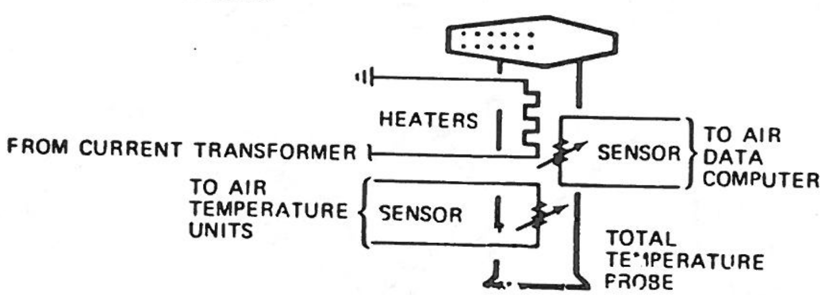
   a. Heater is built into the probe. Replacement of heater requires replacement of the probe.

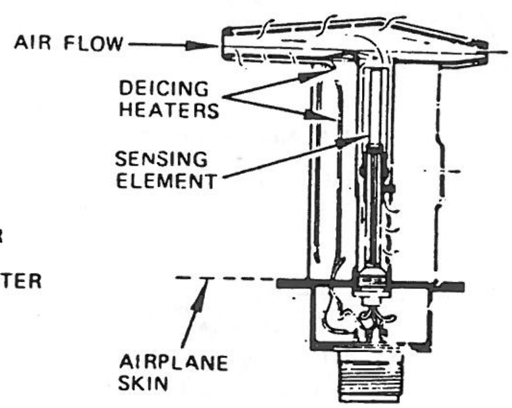
   b. Access to the probe is from the outside. Mount screws are on the outside of the aircraft.



VIEW A
STA 268 LEFT SIDE
BELOW CAPT WINDOW







AIR TEMPERATURE PROBE & HEATER