SECTION VI

ENVIRONMENTAL

Section VI ENVIRONMENTAL SYSTEMS

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Chapter 1

BLEED AIR SYSTEM

The environmental system is one of the most diversified systems on the C-141. Yet when divided into its components, it becomes relatively simple to understand. We will study the systems in this order:

1. Bleed Air Manifold
2. Cargo Floor Heat
3. Air Conditioning
4. Pressurization
5. Adverse Weather

<u>Bleed Air Manifold System</u> (Figure 6-3)

The purpose of the bleed air manifold system is to control the flow of bleed air in the environmental and adverse weather subsystems. There are three sources of bleed air: (1) The APU, (2) External ground cart, and (3) 16th stage ID engine air. The APU or ground cart supplies an airflow of approximately 133 pounds per minute at 40 psi and 230°C for ground operation of the air conditioning system, floor heat system, or engine starting. Approximately 4.6% of the 16th stage ID air is tapped off each engine for use in air conditioning, pressurization, floor heat, windshield rain removal and wing anti-icing.

<u>Bleed Air Manifold System Components</u> (Figure 6-4)

The system consists of a 4-inch stainless steel, cross-wing manifold, twelve check valves, four engine bleed valves, one wing isolation valve, two system shutoff valves, two pressure relief valves and three pressure transmitters.

The cross-wing manifold is mounted in the leading edge of the wing and extends from outboard of No. 1 engine pylon to outboard of No. 4 engine pylon. It is insulated with a fiberglass blanket and wrapped with a fiberglass and resin cover. To compensate for thermal expansion and wing flexing, the manifold is coupled with slip joints and compensators.

Engine Bleed Valves

One engine bleed valve is located in each engine pylon, for the purpose of isolating the engine from the manifold. It is a 28-volt DC motor-actuated butterfly valve powered by the isolated DC bus. The circuit breakers are located on the flight engineer's No. 3 circuit breaker panel. All four valves close when the air conditioning master switch is in the APU position. With the air conditioning master switch in any position other than APU, they may be opened or closed as selected by the engine bleed air switches located on the engineer's environmental panel. The valves also close whenever the respective fire control handle is "Pulled" or if a Bleed Duct Overheat occurs. Located above each switch is a CLOSED indicator light for each valve.

Wing Isolation Valve

The wing isolation valve is located in the center fuselage air conditioning compartment. Its purpose is to isolate the left and right wing. It, too, is a 28-volt DC motor-driven butterfly valve and receives power from the isolated DC bus. The circuit breaker is located on the flight engineer's No. 3 circuit breaker panel. The valve is normally controlled by the wing isolation switch on the environmental control panel. The valve is in the normal position when closed. The normal position is overridden, and the valve will open when the air conditioning master switch is positioned to "APU" or "ENG START." Should the valve be open during a Bleed Duct Overheat, it will close until the bleed duct overheat system is reset.

If the valve fails to operate electrically, provisions are provided for manual actuation. To manually operate the valve, gain access by removing the exterior fillet panel. Remove the dust cover on the valve and, using a socket, position the valve to the desired setting.

Venturi

A venturi is installed in the APU and ground high-pressure supply duct. This venturi will limit the maximum air loss, in the event of a duct rupture, to about 300 pounds per minute.

Similar flow limiting venturies are also installed in the bleed air ducts immediately upstream of the bleed air system pressure regulator valves. In addition to limiting the air loss in the event of a ruptured duct, they also limit the amount of air that would have to be dumped overboard by the relief valves if a regulator valve fails.

Floor Heat Shutoff Valve

The floor heat shutoff valve is normally controlled by the Floor Heat switch, but during certain ground operations, this valve is overridden open by the air conditioning master switch in the "APU" or "Eng Start" position. The floor heat shutoff valve is located in the floor heat manifold where this duct joins the bleed air manifold in the center fuselage air conditioning compartment. The floor heat shutoff valve is the same as and interchangable with the wing isolation valve. It is a motor-driven butterfly-type shutoff valve and receives power from the Isolated DC Bus No. 3 circuit breaker panel. With the valve in the "open" position, actuation of the Cargo Floor Ovht system will drive the valve closed.

System Air Pressure Regulating and Shutoff Valves (Figure 6-9)

There are two system air pressure regulating and shutoff valves - one for each air conditioning pack. They are located in the wing leading edge at the wing root and serve two purposes: (1) To isolate their particular air conditioning pack from the bleed manifold; and (2) To regulate bleed air pressure going to the air conditioning packs to a maximum of 70 psi. The system shutoff valves are solenoid-controlled and pneumatically actuated. The left valve receives power from the isolated DC bus and is protected by a circuit breaker on the flight engineer's No. 3 circuit breaker panel. The right valve receives power from the main DC Bus No. 2 and its circuit breaker is on the engineer's No. 4 circuit breaker panel. Both valves are overridden closed when the air conditioning master switch is in the OFF or the ENG START position and are opened or closed individually by the system shutoff switches in all other positions of the air conditioning master switch. Both valves are spring-loaded to the closed position. Should an overheat of the primary heat exchanger occur, these valves will automatically close. Emergency pressurization switches, located on the emergency circuit breaker panel, will transfer power for the system shutoff valves to the emergency DC bus, causing them to remain open during a loss of normal DC power. Overheat protection for the primary heat exchanger is overridden in the EMER position.

System Pressure Relief Valves (Figure 6-10)

The left and right system pressure relief valves are located in the wing leading edge adjacent to their respective system shutoff valves. They are pneumatically actuated. Their purpose is to regulate system pressure to a maximum of 90-115 psi in the event the system shutoff valves should fail. It does this by dumping excess air overboard through a port on the underside of the wing leading edge section.

Pressure Transmitters

A pressure transmitter is installed on the center wing section and is connected through check valves to the bleed air manifold on both sides of the wing isolation valve. With the wing isolation valve closed, the highest pressure sensed is transmitted to a single manifold bleed pressure gage on the engineer's panel.

Another pressure transmitter is located in each inboard wing leading edge section, downstream from the relief valves. The pressures indicated from these transmitters are read on the dual needle regulated air pressure indicator on the engineer's panel. Power for these transmitters is 26-volt AC from the flight engineer's No. 2 circuit breaker panel.

Bleed Manifold Overheat Warning (Figures 6-11, 6-12)

The overheat warning system consists of two identical Inconel loops. One loop is installed parallel to the bleed manifold ducting in the leading edge of the left wing, and along the ducting in the No. 1 and No. 2 engine pylon, and then along the left air conditioning compartment. The second loop protects the right wing, No. 3 and No. 4 engine pylons, and right air conditioning compartment.
GOES AS FAR AS THE BLEED AIR SHUTOFF VALVE ON EACH PYLON.

The purpose of the overheat warning system is to protect the leading edge of the wing, pylons, and wing fillet from structural damage in the event the bleed air manifold should rupture.

Actuation of the overheat system will occur whenever the temperature in the wing leading edge exceeds 310°F, or when tested by the wing, pylon and air conditioning compartment overheat switches.

When actuated, the overheat warning system will illuminate the left or right BLEED DUCT OVHT light on the engineer's panel, an annunciator light, the master CAUTION warning lights, close the two bleed air valves on the affected wing and the wing isolation valve, if open. A depressed starter button will override the automatic shutdown feature; however, overheat indications will still be displayed. Circuit protection and power for this system, comes from the flight engineer's No. 3 circuit breaker panel (isolated AC and DC).

Leading Edge Blowout Doors

There are 40 external and 8 internal blowout doors in the leading edge of the wing to protect the wing leading edge from structural damage due to a ruptured bleed air duct. The external doors open at 4 to 6 psid, depending on the door size. The internal doors are located inboard and outboard of each pylon and will allow air to escape in the event of a leak in the pylon-manifold connection area.

The pressure differential on the doors reacts through a lever, which shears a safety rivet, allowing the door to open.

The eight internal doors are spring-loaded, closed, and will open when the differential pressure reaches 4 psi.

Chapter 2

CARGO FLOOR HEAT SYSTEM

(Figure 6-13)

The cargo floor heat system warms the cargo floor by circulating a mixture of bleed air and ambient air underneath the cargo floor. The system consists of an ejector assembly, supply and distribution ducting, a motor-driven shutoff valve, a pneumatic modulating valve, a pneumatic temperature control thermostat, an anticipator and an overheat warning system.

For ground operation, air may be supplied by the APU, ground source, or by engine bleed air through the bleed air manifold. For flight operation, only engine bleed air is used.

Cargo Floor Heat

Hot air from the bleed air manifold is supplied through the APU and ground high-pressure supply duct to the APU compartment, and then through a floor heat supply duct to an ejector assembly under the center of the cargo floor. The ejector assembly discharges the hot air into fore and aft distribution ducts which extend nearly the entire length of the floor. Jet pump action of the ejector assembly causes ambient underfloor air to be drawn in and mixed with the bleed air. This air mixture discharges through holes in the distribution ducts. Some of the air is recirculated by the ejector assembly. The excess air flows up into the cargo compartment through holes along the sides of the cargo floor.

Floor Heat Shutoff Valve

As previously discussed, the cargo floor heat shutoff valve is located in the left wing root. Its purpose is to isolate the floor heat system and the APU from the bleed manifold. It is a motor-operated valve powered by the isolated DC bus. It may be opened or closed by the floor heat switch, located on the engineer's environmental panel, when the air conditioning master switch is in any position other than APU or ENG START. With the air conditioning master switch in APU or ENG START position, the floor heat shutoff valve is overridden open, supplying air to the cross wing manifold. .

Floor Heat Modulating Valve (Figure 6-14)

This valve is solenoid-controlled and pneumatically operated. The valve is located in the APU compartment and serves two purposes: (1) It serves as a shutoff valve, by isolating the floor heat system from all three air sources. (2) It regulates bleed air flow to the ejectors in response to the pneumatic thermostat. Electrical power is supplied by the main DC Bus No. 1 through a circuit breaker on the flight engineer's No. 4 circuit breaker panel. The valve is CLOSED when the air conditioning master switch is in ENG START. In all other positions, the floor heat Mod valve is controlled by the floor heat switch, located on the engineer's panel. The pneumatic thermostats will close the floor heat mod valve any time the floor temperature is above 65°F. The floor heat mod valve will also be closed by actuating the EMER DEPRESSURIZATION switch, or during a floor overheat.

Pneumatic Temperature Control Thermostat (Figure 6-15)

The temperature control thermostat is located in the distribution duct cavity. Its purpose is to sense recirculating air temperature and send a pneumatic signal to the floor heat Mod valve, causing it to regulate the bleed air flow and maintain a 65°F recirculating air temperature.

Pneumatic Anticipator

The anticipator is installed in the supply duct adjacent to the aft ejector. The purpose of the anticipator is to send pneumatic signals to the floor heat Mod valve in response to rapid temperature fluctuations. It works in conjunction with the control thermostat to maintain 65°F recirculated air temperature.

Cargo Floor Overheat Warning

Overheat warning is provided by two separate sensor systems. One sensor system is a continuous Inconel loop sensor, installed along the supply ducting from the floor heat shutoff valve to the ejector assembly. This system will detect a rupture of the supply ducting. It will actuate the FLOOR OVERHEAT WARNING light at 310°F. The second sensor is a thermal switch located in the distribution ducting. This sensor, set at 220°F, will detect overheat temperatures of the recirculated air caused by a failure of the cargo floor heat modulating valve. Should either sensor actuate the overheat system, the Floor Heat Shutoff Valve and Floor Heat Modulating Valve will close and the FLOOR HEAT OVERHEAT light on the engineer's panel will illuminate. A depressed starter button will override the automatic shutdown feature; however, the overheat indication will still be displayed.

Chapter 3

AIR CONDITIONING SYSTEMS

(Figure 6-1)

The air used for air conditioning is supplied by the bleed air manifold, regulated to a maximum pressure of 70 psi by the system air pressure regulating and shutoff valves. It is routed through two air conditioning packs, to the flight station and cargo compartments. Airflow from the left air conditioning pack normally supplies 1/3 of its flow to the flight station and the remainder to the cargo compartment. Airflow from the right pack is normally routed to the cargo compartment.

Air conditioning is accomplished by cooling bleed manifold air to 230°C through a primary heat exchanger, then to 65°C through a secondary heat exchanger, and routing a portion of it through a turbine refrigeration unit which super cools the air. To prevent ice formation, a certain amount of 65°C air is remixed with super cooled air to maintain a temperature of 2°C downstream of the water separator. The 2°C air can then be mixed with an appropriate amount of 230°C air to obtain the desired cabin temperature.

The two identical air conditioning packs are located in the center wing section and are made up of the following subunits: Primary heat exchanger, secondary heat exchanger, refrigeration unit, distribution ducting, temperature control system, and flow control and shutoff valve.

Primary Heat Exchanger

The purpose of the primary heat exchanger is to provide the initial cooling of the bleed air from the cross wing manifold. The components making up the primary heat exchanger are the heat exchanger core, cooling air control valve, ejector shutoff valve and temperature control system.

Heat Exchanger Core

The heat exchanger core is a single-pass air radiator mounted in the wing leading edge scoop. The bleed air passing through the unit is cooled by a controlled flow of ram air passing over the radiator.

Cooling Air Control Valves

The cooling air control valves are motor-driven, butterfly valves, located in the ram air duct, downsteam of the primary heat exchangers. The right cooling air control valve receives power from the essential AC Bus No. 2. The circuit breaker is located on the flight engineer's No. 2 circuit breaker panel. Electric power for the left valve is supplied by the isolated AC bus. The circuit breaker is located on the flight engineer's No. 3 circuit breaker panel. The purpose of the cooling air control valves is to control ram airflow over the primary heat exchangers. The valves are automatically controlled by the temperature control system. In the event of a primary heat exchanger overheat, the cooling air control valve will be driven to the full open position.

Ejector Shutoff Valves

The purpose of the ejector shutoff valves is to induce a cooling airflow over the primary heat exchangers during ground operation and at air speeds below .3 Mach. They are 28-volt, DC motor-driven, butterfly valves and are normally controlled by the CADC system during inflight and ground operation. The air conditioning master switch, when in the APU position, will override the CADC and close the ejector valves. Two EJECTOR ON lights on the environmental control panel indicate the position of the ejector valves.

Temperature Control System (Primary Heat Exchanger)

The purpose of the temperature control system is to provide a modulated AC control signal to position the cooling air control valve for an appropriate cooling air flow. The system consists of a temperature control box, temperature sensor (230°C), and a combination anticipator and high limit sensor. The sensors are located in the ducting downstream of the heat exchanger. The 230°C sensor provides the normal operating signal to the temperature control box for the positioning of the cooling air valve. The anticipator portion of the anticipator and high-limit sensor detects rapid temperature changes but is inoperative during normal operation. Should the temperature reach 280°C, the high-limit portion will open the cooling air control valve and close the system air pressure regulating and shutoff valve.

Flow Control and Shutoff Valve (Figure 6-17)

The flow control valve is an airflow regulator with a shutoff feature. Although its main purpose is to provide a constant flow of air through the air conditioning system, it also serves as an air conditioning system shutoff valve. The valve is an automatic modulating butterfly which regulates the airflow to a maximum of 100 pounds per minute (ppm). It is solenoid-controlled, pneumatically actuated, spring-loaded closed, and deenergized open. Both flow control valves are normally controlled by the Air Cond Master switch and are normally open during flight. Either valve, however, can be overridden closed by a secondary heat exchanger overheat condition. A thermal switch at the inlet of each cooling turbine automatically closes its respective flow control valve if the inlet temperature exceeds 100°C. Both valves are overridden closed by the Emer Depress switches. Power requirements are 28-volts DC which is received from the flight engineer's No. 4 circuit breaker panel.

Refrigeration System

There are two identical refrigeration systems located in the center wing section. Each system consists of a secondary heat exchanger, cooling turbine, turbine inlet temperature sensor, turbine bypass valve, water separator, low limit temperature control sensor, temperature control valve and compartment temperature control system.

Secondary Heat Exchangers

The secondary heat exchangers are located adjacent to the primary heat exchangers and receive cooling air from the same wing air scoop. The secondary heat exchangers differ from the primary heat exchangers in that the bleed air makes two passes through the radiator. Their purpose is to further lower the bleed air temperature to approximately 65°C for use in the cooling turbines.

Cooling Turbines (Figure 6-16)

The cooling turbines are radial flow design and are located downstream of the secondary heat exchangers. They operate by bleed air from the secondary heat exchanger. The work expended in turning the turbine causes a rapid expansion of the air and a large drop in temperature. The cold air is then routed through a water separator to a mixing chamber in the ducting. The turbine also drives a compressor fastened to the opposite end of the same shaft. The compressor discharges air through a slot-type ejector which induces an airflow over the secondary heat exchanger, causing an ejector action similar to that of the primary heat exchanger ejector. In flight, the compressor serves as an air preload on the turbine to prevent turbine overspeed.

Turbine Inlet Temperature Sensor

This sensor is a thermal switch in the bleed air duct between the secondary heat exchanger and the turbine inlet. Its purpose is to protect the secondary heat exchanger and turbine from excessive bleed air temperatures. If for any reason the turbine inlet temperature exceeds 100°C, the thermal switch will close the flow control and shutoff valve, thus shutting off bleed air to the refrigeration system. When the temperature drops below 100°C, the valve will open to resume normal operation.

Water Separator (Figure 6-18)

As air flows through the turbine, the rapid expansion and cooling effect causes the water vapor in the air to condense and become "free" moisture (fog). To remove some of this moisture and provide humidity control, a cyclonic-type water separator is installed. About 55 percent of the free moisture is removed by the separator. As the moisture-laden air flows through the separator, the unit extracts the water and discharges it overboard through a drain opening in the side of the fuselage. A relief valve in the unit will offset at approximately 8 psid to prevent a pressure build-up if the separator becomes clogged.

Low Limit Temperature Sensor and Turbine Bypass Valve (Figure 6-19)

The purpose of the low limit temperature sensor and turbine bypass valve is to prevent the turbine air temperature from dropping below 2°C at the water separator outlet. It is located in the ducting immediately downstream of the water separator. Should the air temperature at this point drop below 2°C, the sensor will send a signal to the turbine bypass valve, causing it to allow some of the secondary heat exchanger bleed air (65°C) to bypass the turbine and mix with the cold turbine air prior to entering the water separator.

Temperature Control Valve

The purpose of the temperature control valve is to bypass 230°C temperature air from the primary heat exchanger around the refrigeration unit, to be mixed with the 2°C refrigerated air downstream from the water separator. The temperature control valve is a DC motor-driven butterfly valve, actuated by a signal from the compartment temperature control system.

Compartment Temperature Control System (Figure 6-20)

Flight station and cargo compartment temperatures are controlled by similar but separate control systems. The components of each system are the same except for their internal calibration to accommodate the temperature of each compartment.

Compartment temperatures may be controlled manually or automatically by the temperature control switches and temperature selectors on the engineer's environmental panel. The flight station temperature control switches control the left air conditioning pack, and the cargo compartment temperature control switch controls the right air conditioning pack.

The temperature control switch is a four-position toggle switch. The four positions are AUTO, HOLD, COOL and HOT. The switch is spring-loaded from the COOL or HOT position to the HOLD position. When the switch is held in the COOL position, the temperature control valve is driven toward the closed position. In the HOT position, the temperature control valve moves toward the OPEN position. In HOLD, the valve remains in the previously assumed position.

During operation, duct temperature is limited by a high-limit temperature sensor switch located in the distribution ducting. The sensor will automatically drive the temp control valve closed when duct temp reaches 150°C and will reset when the temperature drops below 150°C.

When the temperature control switch is in the AUTO position, compartment temperature is controlled by positioning the temperature selector to the desired setting. The temperature selector is a potentiometer having a range of 40°F to 110°F, and makes up one leg of a bridge circuit. The compartment temperature sensor and a duct anticipator and high-limit sensor make up the other two legs.

The cargo compartment temperature sensor is located in the aft cargo compartment near the cabin pressurization outflow valves. The flight station temperature sensor is located on the right side of the flight engineer's panel. Both sensors are thermistors and have a small fan which circulates compartment air over them in order to give a more accurate temperature indication. A temperature bulb in the cargo compartment and a temperature gage on the environmental panel indicate cargo compartment temperature. There is no temperature indicator for the flight station.

Distribution Ducting (Figure 6-21)

There are two ducting systems for the flight station and one ducting system for the cargo compartment. The flight station has "gasper" air outlets and normal flight station outlets.

Gasper air comes directly from the left air conditioning pack downstream from the cooling turbine but prior to the temperature control valve duct junction. This supplies air to the gasper outlets at 2°C. A gasper outlet, which can be opened or closed manually, is located at each crew position except the jump seat.

Cargo Compartment Recirculation Fan

A recirculation fan is installed overhead in the forward cargo compartment to increase airflow in the cargo compartment. The fan runs any time that the air conditioning master switch is in APU, BOTH, LEFT or RIGHT. The recirculation fan will be shut off when the emergency depressurization switch is used.

Flight Station Diverter Valve (Figure 6-22)

The diverter valve is located in the left air conditioning pack distribution ducting. It is controlled by the flight station air flow switch, located on the environmental panel. The switch is a rotary switch with four positions: MIN, NORM, INCR and MAX. With the switch in NORM, (38%) approx 1/3 of the left pack airflow is directed to the flight station. The INCR position directs (68%) approx 2/3 to the flight station; MAX, 100% to the flight station; and the MIN position shuts off the airflow to the flight station and directs all the air from the left pack to the cargo compartment, with the exception of gasper air. In all positions other than MIN, the air not going to the flight station is directed to the cargo compartment. Circuit protection and power come from the flight engineer's No. 3 circuit breaker panel.

Alternate Air Shutoff Valve

The alternate air shutoff valve is located in the right air conditioning pack distribution ducting and normally directs all the airflow from the right pack to the cargo compartment. In the event the left air conditioning pack should become inoperative, 38% of the right pack air may be directed to the flight station through the alternate air shutoff valve, by positioning the air conditioning master switch to RIGHT. Circuit protection and power come from the flight engineer's No. 4 circuit breaker panel.

Ram Air Ventilating System

During nonpressurized flight, ram air may be used to ventilate the aircraft. The ram air intake is located in the right wing air scoop, adjacent to the right primary heat exchanger. The ram air ducting connects to the left air conditioning distribution ducting upstream from the diverter valve. This allows the airflow to be directed to the flight station and the cargo compartment, as desired, by positioning the diverter valve. The airflow will also back-flow through the distribution ducting to the gasper outlets.

Chapter 4

PRESSURIZATION SYSTEM

The flight station, cargo compartment, and underdeck area are pressurized.

Pressurization is maintained by controlling the outflow of air from the cabin. A maximum pressure differential of 8.3 psid is maintained by the automatic controller. This will maintain a sea-level cabin altitude up to an aircraft altitude of 21,000 feet, or an 8,000 cabin altitude up to an aircraft altitude of 41,000 feet.

The pressurization system consists of:

- Two outflow safety valves
- A manual controller
- Automatic controller
- Control venturi
- Two solenoid shutoff valves
- Jet pump regulator valve
- A control fan and venturi
- Two negative pressure relief valves
- A manual and electrical depressurization system
- Cabin pressurization instruments
- Two indicator lights

Outflow Safety Valves (Figure 6-23)

The two outflow safety valves are located on the aft pressure bulkhead. Their purpose is to regulate the amount of cabin air outflow. The valve assembly consists of a pneumatic relay, differential control, air jet pump, a cabin limit control, cabin limit override and negative pressure control.

In response to a pneumatic signal from the automatic or manual controller, the pneumatic relay controls the normal positioning of the outflow valve. The differential control prevents the cabin from exceeding a maximum differential pressure of 8.3 psid normally. A maximum differential pressure of 8.6 psid can be maintained with one valve inoperative. The air jet pump provides a reduced pressure to assist in positioning the outflow valve. The cabin limit control automatically limits cabin altitude to a maximum of 13,000 ± 1,500 feet, but may be overridden by the cabin altitude limit override switch.

Negative Pressure Relief Valves

The fuselage is built to withstand high inside pressure pushing out - not high outside pressure pushing in. Since it is possible to obtain a negative differential pressure under certain conditions, two separate valves are installed to limit this differential to a maximum of 0.4 psid.

Manual Controller (Figure 6-26)

The manual controller, located on the flight engineer's panel, provides a manual means of sending a pneumatic increase or decrease signal to the pneumatic relay. The control knob has three positions: DECREASE PRESS, AUTO and INCREASE PRESS.

Automatic Controller (Figure 6-25)

The automatic controller is located on the flight engineer's panel adjacent to the manual controller. It provides a means of selecting cabin altitude from -1,000 feet to 10,000 feet and controlling the rate of cabin altitude change from 200 to 2,000 FPM. The automatic controller also contains a differential pressure control set at 8.3 psid.

Cabin Pressure Control Venturi

A venturi is used to supply the negative pressure necessary for controlling the pneumatic relays of the outflow valves. It is located behind the flight engineer's station and is attached to the aircraft skin. With the air conditioning systems operating, cabin air flows overboard through the venturi. This airflow creates a slight negative pressure at the throat. The negative pressure is supplied to both pressure controllers and to the emergency depressurization solenoid.

Jet Pump Regulator Valve (Figure 6-26)

The high pressure air, used by the jet pumps and cabin altitude limit control override diaphragms in the outflow valves, is supplied from the bleed air manifold. A pressure regulator is installed in the supply line to provide a source of constant pressure for the jet and pumps, and to protect the altitude limit override diaphragms. The regulator is located on the aft right-hand side of the rear wing box in the cargo compartment. It regulates at 15 psid above cabin pressure and includes a 26 psid relief valve.

Solenoid Shutoff Valves

A cabin altitude limit override solenoid is located on the aft pressure bulkhead. When energized by the cabin limit override switch on the flight engineer's panel, it allows bleed air pressure from the jet pump regulator valve to enter the cabin limit override chamber of each outflow valve, and close off the cabin air passage into the head chamber. This will allow the cabin altitude to climb above 13,000 ± 1,500 feet.

The emergency depressurization solenoid is located behind the flight engineer's panel. When energized by either the pilot's or flight engineer's emergency depressurization switch, it evacuates the control chamber of the automatic and manual controllers overboard through the control venturi, causing the outflow valves to open and depressurize the aircraft. The cabin altitude limit override solenoid is also energized by the emergency depressurization switches.

Control Fan and Venturi

The control fan and venturi assembly is located on the aft pressure bulkhead, adjacent to the right outflow valve. Its purpose is to prevent pressurization on the ground. The control fan is actuated by a touchdown relay and pulls cabin air through the venturi, creating a vacuum sufficient to hold both outflow valves open. Also, if the Air Cond Master switch is positioned to ENG START, OFF, or RAM, both low-limit relays are deenergized, which applies power to the fan, causing both outflow valves to open.

Emergency Depressurization

Emergency depressurization may be accomplished electrically by the emergency depressurization switch or manually by the emergency depressurization "T" handle located on the pilot's overhead panel. The emergency depressurization "T" handle opens the number two hatch located overhead and just aft of the crew entrance door. Emergency depressurization may be accomplished in 90 seconds electrically and in 15 seconds manually. The emergency depressurization switches will also close both air conditioning flow control and shutoff valves and the floor heat mod valve.

Instruments

Two gages are located on the flight engineer's panel - a cabin rate of climb and a cabin altitude and differential pressure gage. The first indicates cabin rate of climb or descent from 0 to 6,000 fpm. The second is a dual indicator. The outer scale indicates differential pressure and the inside scale reads cabin altitude. An identical cabin altitude and differential pressure gage is located on the copilot's panel.

Cabin Altitude Warning Lights

Two cabin altitude warning lights illuminate when the cabin altitude exceeds 10,000 ± 1,000 feet. One light is located directly below the cabin altitude and differential pressure gage, at the flight engineer's panel, and the other is on the annunciator panel. The annunciator panel light reads CABIN PRESS LOW. Both lights are activated by a pressure switch located in the right-hand underdeck area, near the electrical cooling fans. Power for this system comes from the Isolated DC Bus.

Chapter 5

ADVERSE WEATHER SYSTEMS

Wing Anti-Ice System (Figures 6-27 thru 6-31)

The wing anti-ice system uses a mixture of bleed air and ambient air to heat the leading edge of the wing. The sections of the leading edge which are anti-iced are the "mid," "inner-outboard" and "outboard." The mid section is between the engine pylons; the inner-outboard is a section immediately outboard of the No. 1 and No. 4 pylons; the outboard section extends from the inner-outboard section to the wing tip.

Air from the bleed air manifold is routed through a wing anti-ice "mod" valve to the "piccolo" tube, where it is injected into a small transfer chamber between the double skin area, inside the leading edge of the wing. As the bleed air is injected into the transfer chamber, it induces leading edge ambient air to mix with the bleed air, then flows through the double skin transfer passages to heat the wing leading edge. Ambient air is drawn into the leading edge through quarter-sized ports in the lower portion of the leading edge. The air is exhausted overboard at the louvers in the wing tip for the outboard section and at slots in the upper trailing edge of the pylons for the inner-outboard and mid-sections.

Wing Anti-Ice "Mod" Valves

Three wing anti-ice "modulating" valves are in each wing, one for each section. The purpose of the "mod" valves is to regulate the temperature and volume of air flowing to the piccolo tubes. The valves are solenoid-controlled and pneumatically actuated. The "mod" valves receive power from the main DC buses. The circuit breakers are all located on the flight engineer's No. 4 circuit breaker panel.

Three (ON-OFF) wing anti-ice switches are on the pilots' overhead panel, marked: OUT-BOARD, INNER-OUTBD and MID. Each switch will control the corresponding section on both wings simultaneously. Four indicator lights are over each switch to indicate the left and right ON, and left and right OVERHEAT. The "mod" valves are controlled by a signal from pneumatic thermostats in the leading edge of the wing. The thermostats for the outboard, inner-outboard, and mid "mod" valves are set at different temperatures to compensate for the wing area they heat and to conserve the heated air.

Located near each pneumatic thermostat is an overheat sensor. Should the temperature reach 105°C in the outboard and inner outboard, or 90°C in the mid, the wing overheat, annunciator, and master CAUTION warning lights will come ON. The system will not shut down automatically.

Empennage De-icing (Figures 6-32 thru 6-34)

Empennage de-icing is provided by electrical heating elements embedded in the fiberglass leading edge sections of the horizontal stabilizer. No provision is made for de-icing the vertical stabilizer.

The leading edge of the horizontal stabilizer is divided into eight sections. Each section has two shedding areas containing heating elements and three parting strips, for a total of 16 shedding areas and 24 parting strip heaters. De-icing is accomplished by intermittently applying power to the shedding area heaters, individually, in sequence, and continuously applying power to the parting strip heaters. The deicing cycle always begins with the far left shedding area, which is number one, then alternates to the opposite far right side, which is number two, gradually working into the center, to provide symetric de-icing.

The principal components of the system include the leading edge heaters, an automatic controller (located in the vertical stabilizer) and a three-position ON - OFF - TEST control switch.

Placing the switch in the ON position energizes the controller, which automatically monitors the system. The controller closes the circuit to the continuously heated parting strips and switches power in sequence to each of the 16 shedding areas. The length of the heating time for each shedding area is determined by a skin temperature sensor or by a maximum heating time built into the controller. The controller will allow a maximum time of 15 seconds in each shedding area. In high temperature icing conditions, the skin temperature sensor causes the controller to switch power to the next shedding area when skin temperature reaches 32°C.

If an entire de-icing cycle is completed in less than 3 minutes, a built-in delay prevents the next cycle from starting until the 3-minute interval has elapsed. If the controller fails during normal operation, power to the shedding areas and the parting strips is disconnected, and the SYS OFF light on the overhead panel illuminates. Any shorted or open shedding area heater causes the ELEM FAULT light on the overhead panel to illuminate, when the controller connects power to that element. In case of a parting strip overheat, power to all parting strips will be disconnected, and the STRIP OFF light on the overhead panel will illuminate.

Operation of the system may be checked on the ground by placing the control switch in the TEST position. The controller will operate through a cycle, but a switch controlled by the landing gear prevents application of power to the heater elements. During ground test, the STRIP OFF light should illuminate. The SYS OFF light should cycle ON and OFF, and the ELEM FAULT light should remain OFF.

<u>Windshield Anti-Icing</u> (Figures 6-35, 6-36)

The windshield anti-icing system consists of seven electrically heated windshields. There are three front windshields and two side-panel windshields on each side. The heat used is commonly referred to as NESA heat.

The windshield anti-icing system consists of three separate systems, individually controlled by windshield heat control switches on the pilot's overhead panel, marked pilot's, center and copilot's. The system is further divided into windshield heat and side panel defogging. The pilot's and copilot's side panel defogging systems are controlled by the respective windshield heat switches.

If severe icing conditions are encountered, the switches can be placed to HIGH, which will increase the amount of voltage to the windshields. The HIGH position is intended to be used only in flight when the NORMAL position will not provide enough heat.

The voltage to the side panel windows will not increase with a change in switch position. Opening a clear vision windshield will cut power to both windshields on that side.

The cold start switches, on the overhead panel, provide manual heat control to the front windshields when the temperature is below -43°C. The manual cycling should be 5 seconds ON and 10 seconds OFF until the windshield temperature reaches -43°C, when automatic operation will commence. The windshield heat control switches should be placed in NORMAL, when using the cold start switches. The side windshield heat will start at temperatures as low as -54°C.

The pilot's and copilot's windshield heat is wired through the rain removal switch. Whenever the rain removal system is being used, the respective windshield heat is disconnected.

Windshield Rain Removal (Figures 6-37 thru 6-39)

The pilot's and copilot's windshields are cleared by a continuous blast of high temperature, high velocity air, discharged through nozzles at the base of the windshields. Air is normally supplied by both air conditioning packs but will function satisfactorily from either pack. Whenever the windshield rain removal system is used, it will automatically turn the NESA heat system off for the affected windshield.

The bleed air used in the windshield rain removal system is tapped from the downstream side of each primary heat exchanger. The system consists of a pilot's and copilot's rain removal shutoff valve, left and right pressure regulator shutoff valves, venturis, check valves and discharge nozzles. The rotary control switch and overheat lights circuit breakers are located on the flight engineer's No. 3 circuit breaker panel (Isolated DC Bus).

Rain Removal Shutoff Valves

There are two rain removal shutoff valves, one for the pilot's windshield and one for the copilot's. They are motor-driven butterfly valves and are controlled by the rotary rain removal switch marked OFF - PILOT - BOTH - COPILOT. Power and circuit protection come from the flight engineer's No. 3 circuit breaker panel.

Pressure Regulator Shutoff Valves

There are two pressure regulator shutoff valves, one controlling airflow from the left primary heat exchanger, and one controlling airflow from the right heat exchanger. They are solenoid-controlled and pneumatically actuated. They serve a dual function as a system shutoff valve and pressure regulator. Both valves are armed electrically when the rain removal switch is in any position other than OFF and are opened pneumatically by airflow from their respective primary heat exchanger. These valves regulate pressure to approximately 20 ± 2 psig for use in the rain removal system. Circuit protection and power for the left valve is Isolated DC and for the right valve, Main DC.

Check Valves

Check valves are located downstream of each venturi. Their purpose is to prevent a backflow of pressure from one air conditioning pack to the other when operating on only one air conditioning pack.

Rain Removal Overheat Warning

Overheat sensors are embedded in the vinyl layer of the pilot's and copilot's windshield's lower center. Should either windshield temperature reach 71°C, the RAIN REMOVAL OVHT light on the annunciator panel and the appropriate rain removal OVHT light on the pilots' overheat panel will come ON. The lights will go OUT when the temperature drops to 64°C. The system will not shut down automatically.

ENVIRONMENTAL CONTROL PANEL

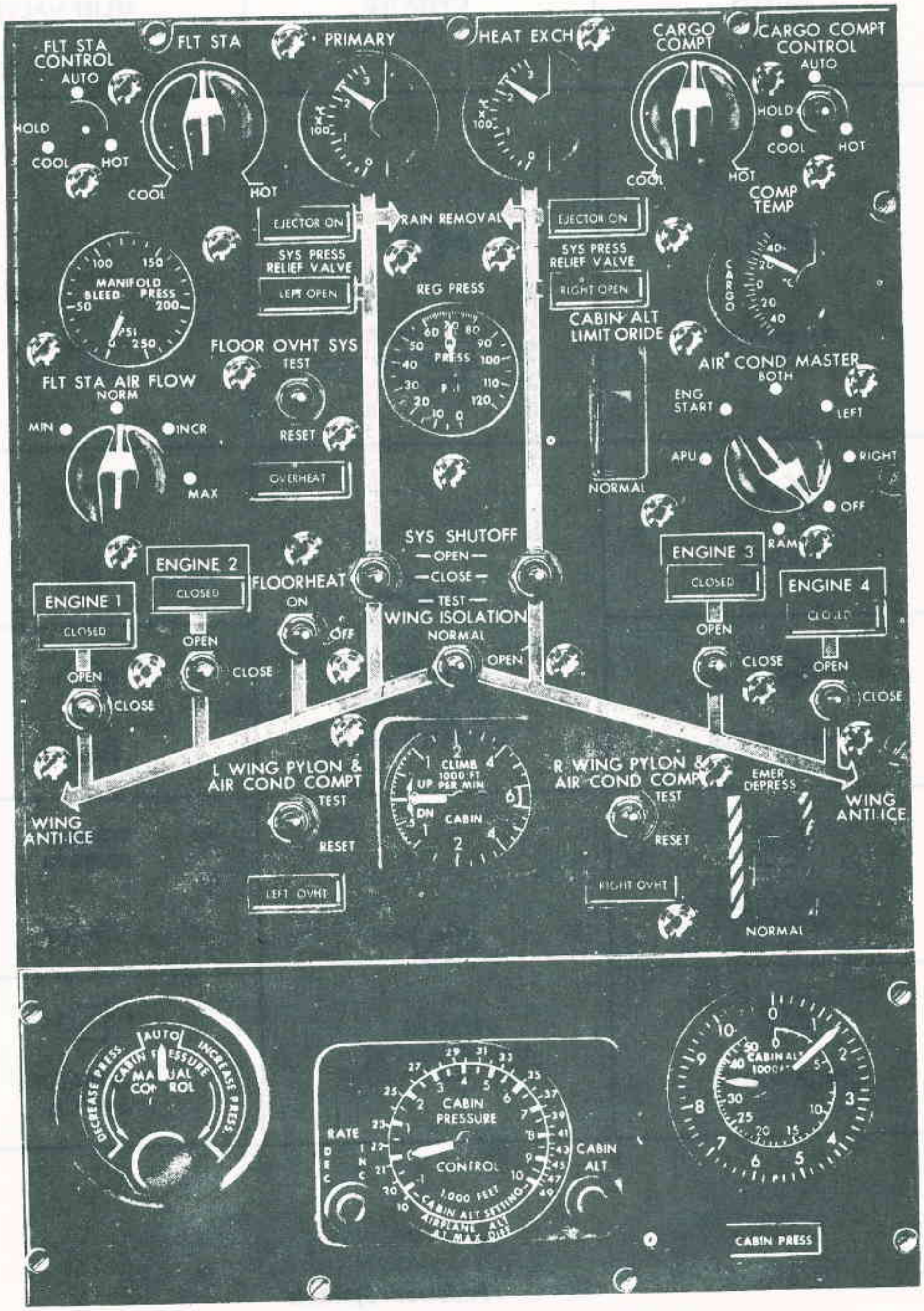
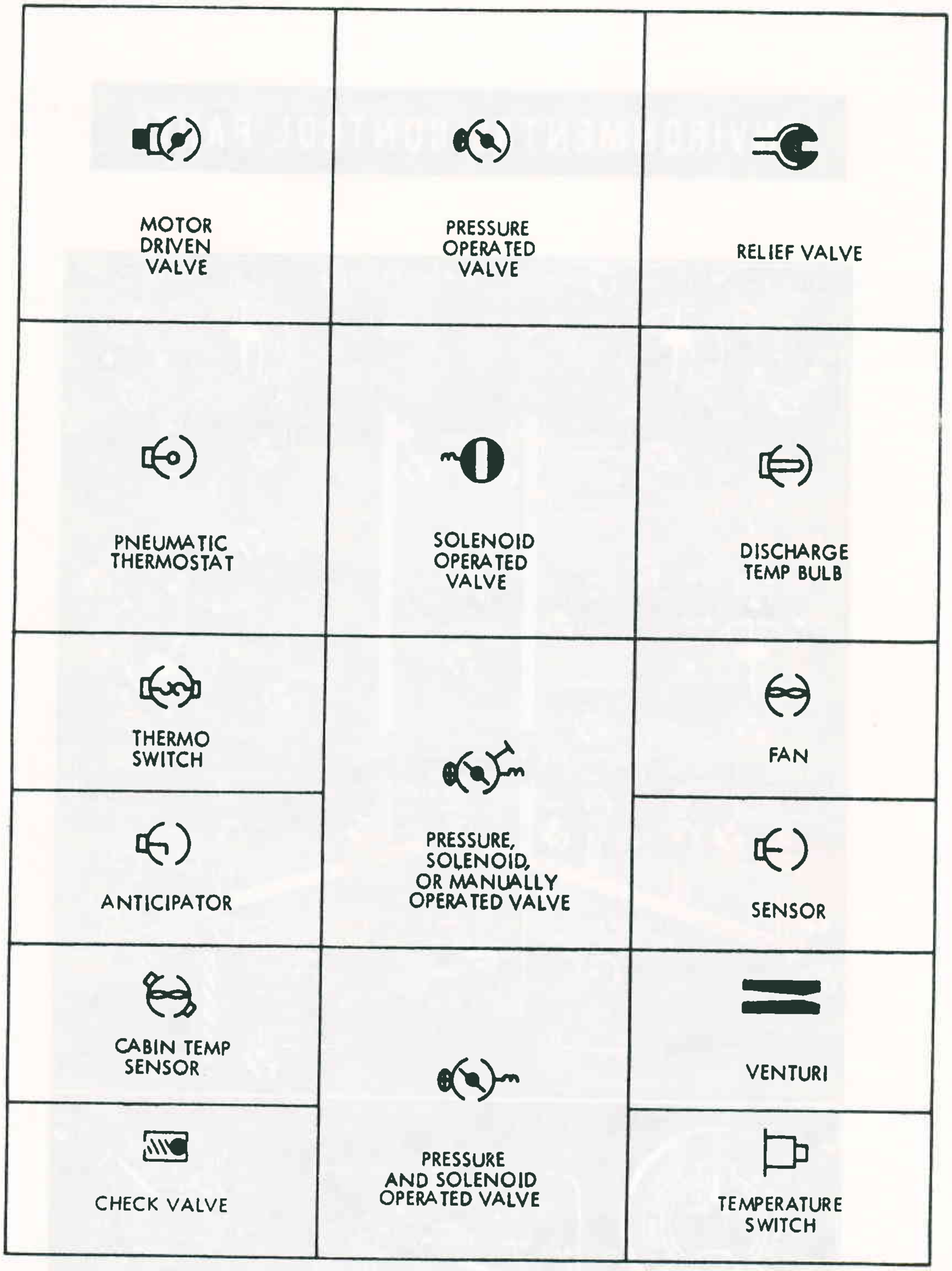
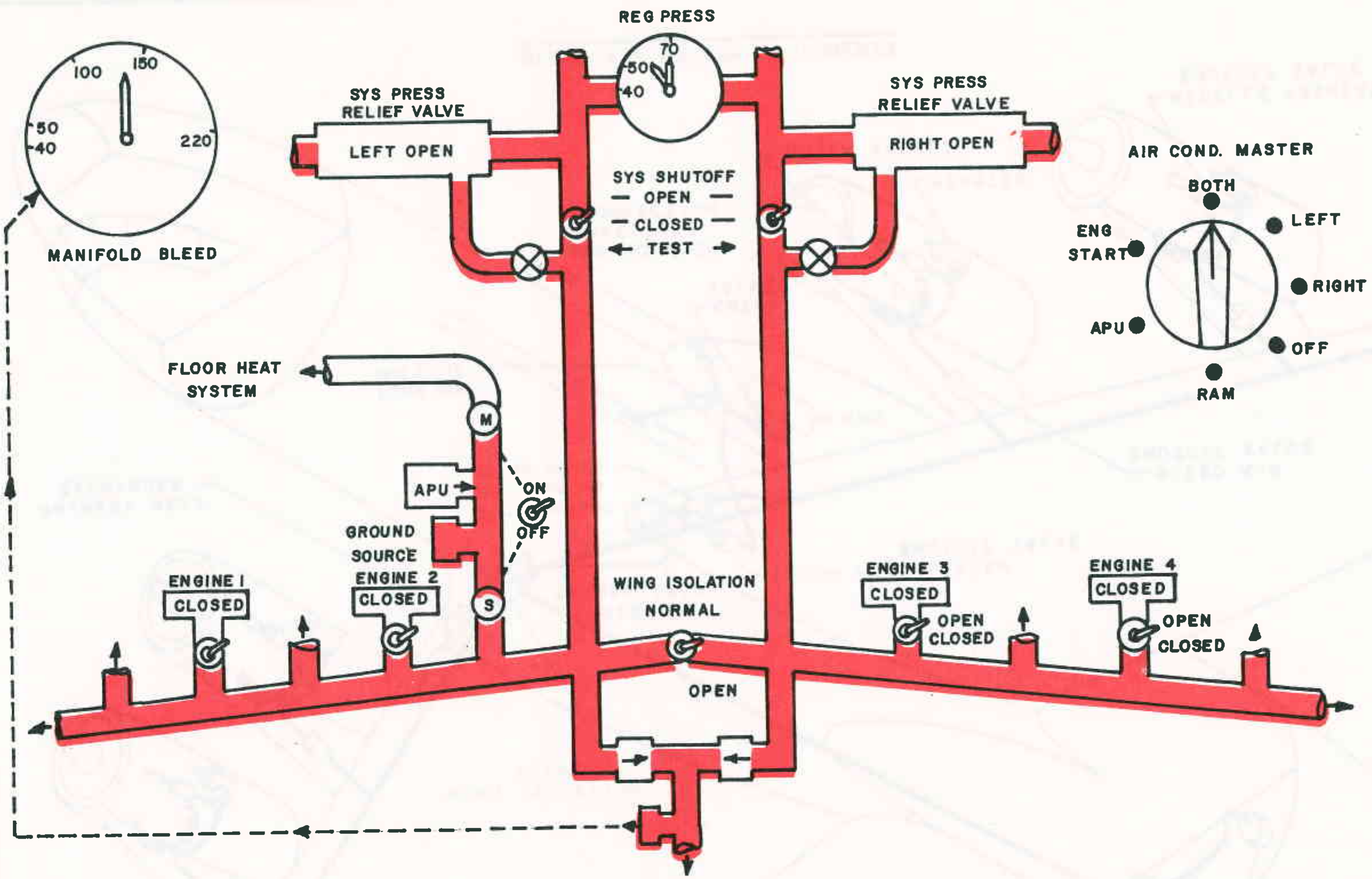


Figure 6-1



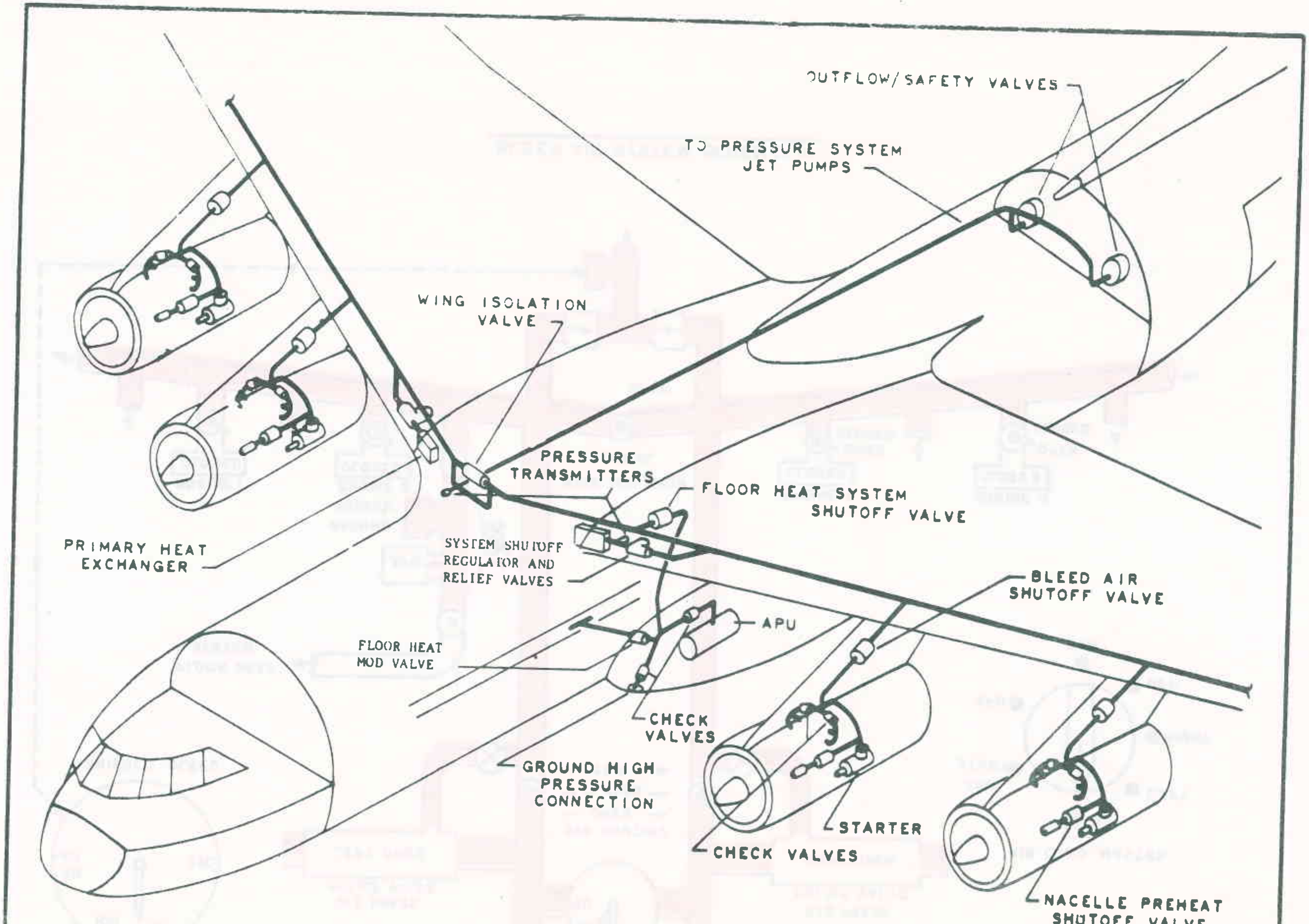
Pneumatic Symbols

Figure 6-2



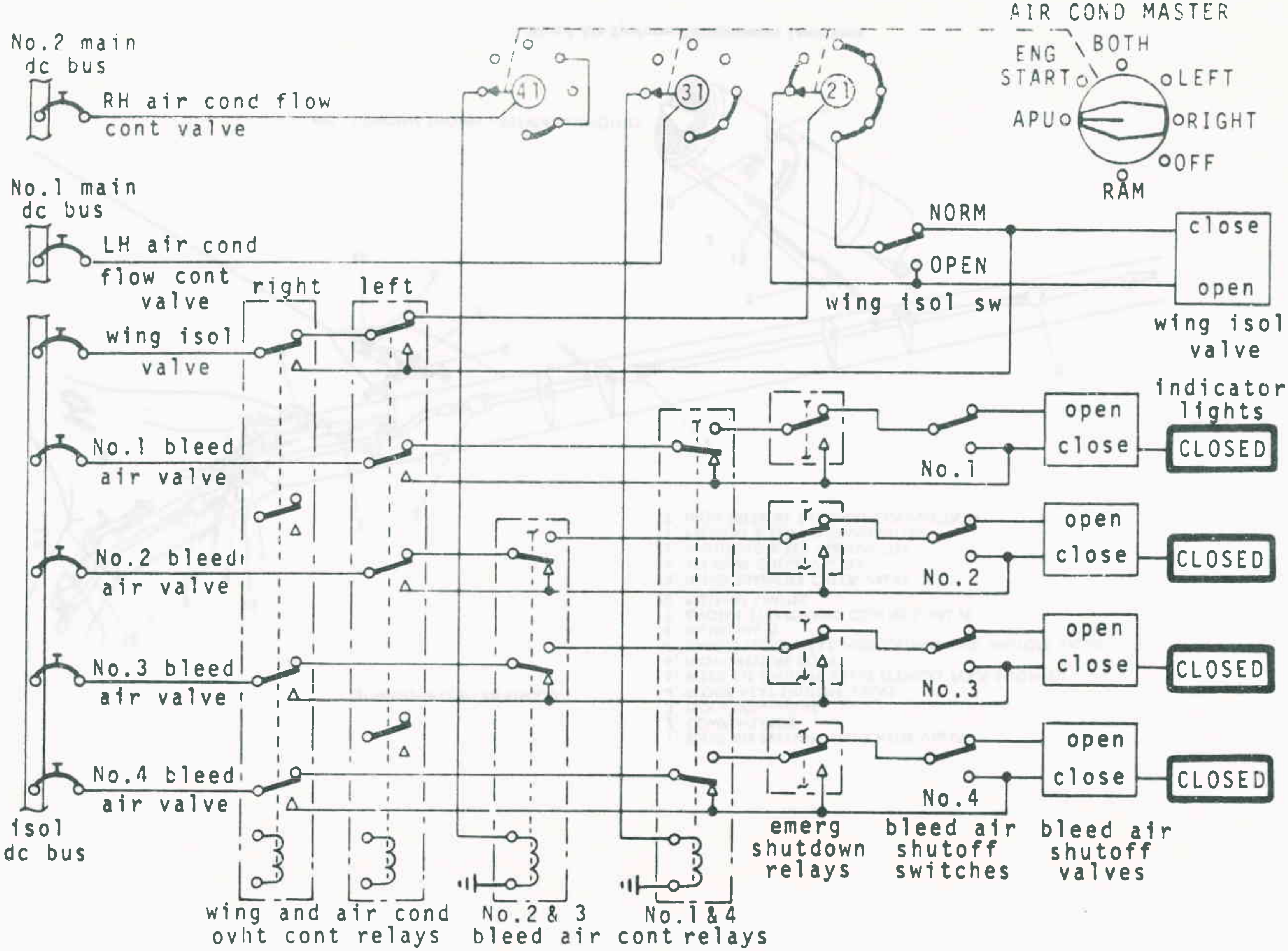
BLEED AIR SYSTEM SCHEMATIC

Figure 6-3



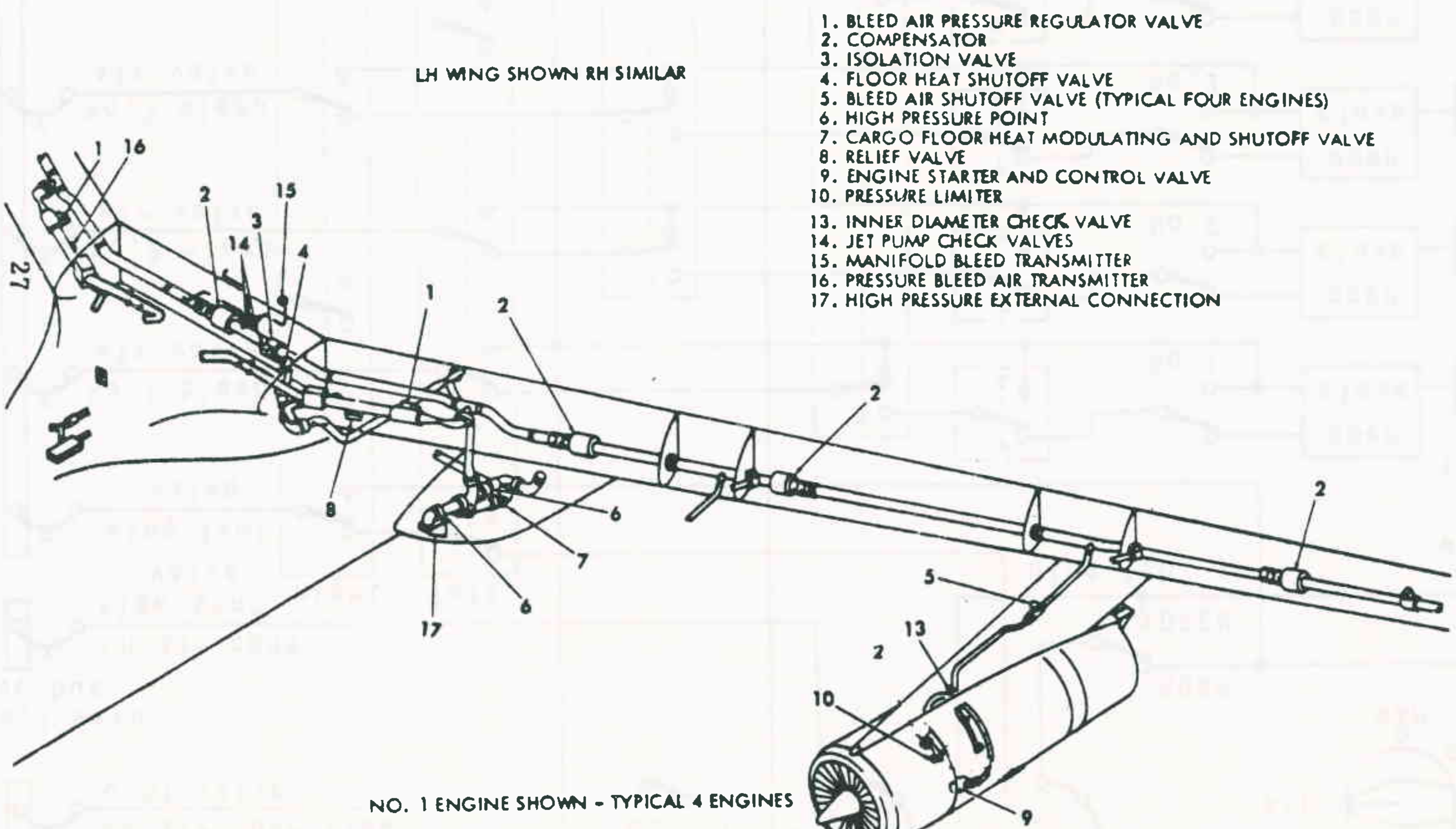
BLEED AIR SYSTEM COMPONENTS

Figure 6-4



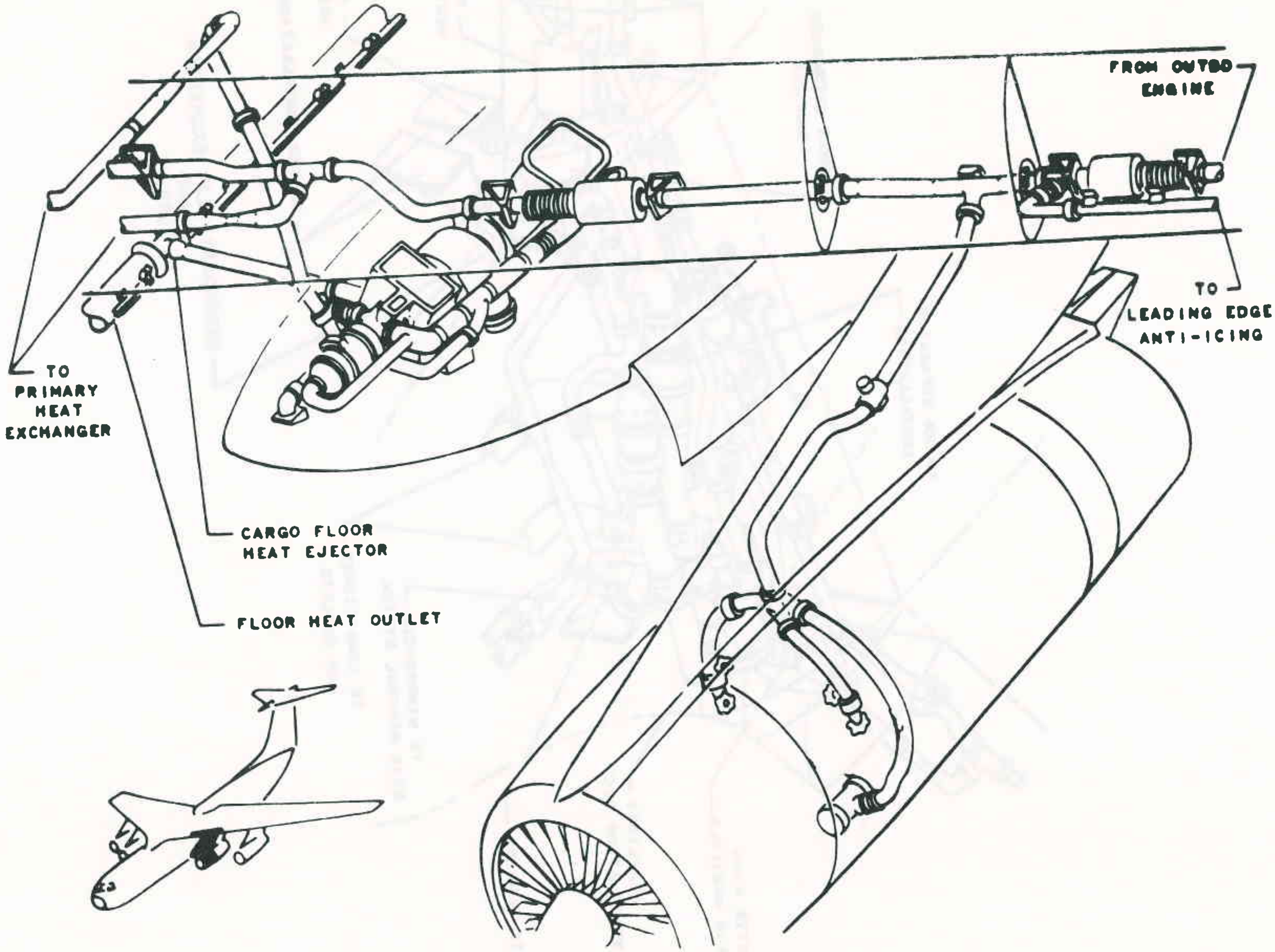
BLEED AIR VALVE CONTROL SCHEMATIC

Figure 6-5



Bleed Air Systems Components Locations

Figure 6-6



ENGINE BLEED AIR COMPONENT LOCATIONS

Figure 6-7

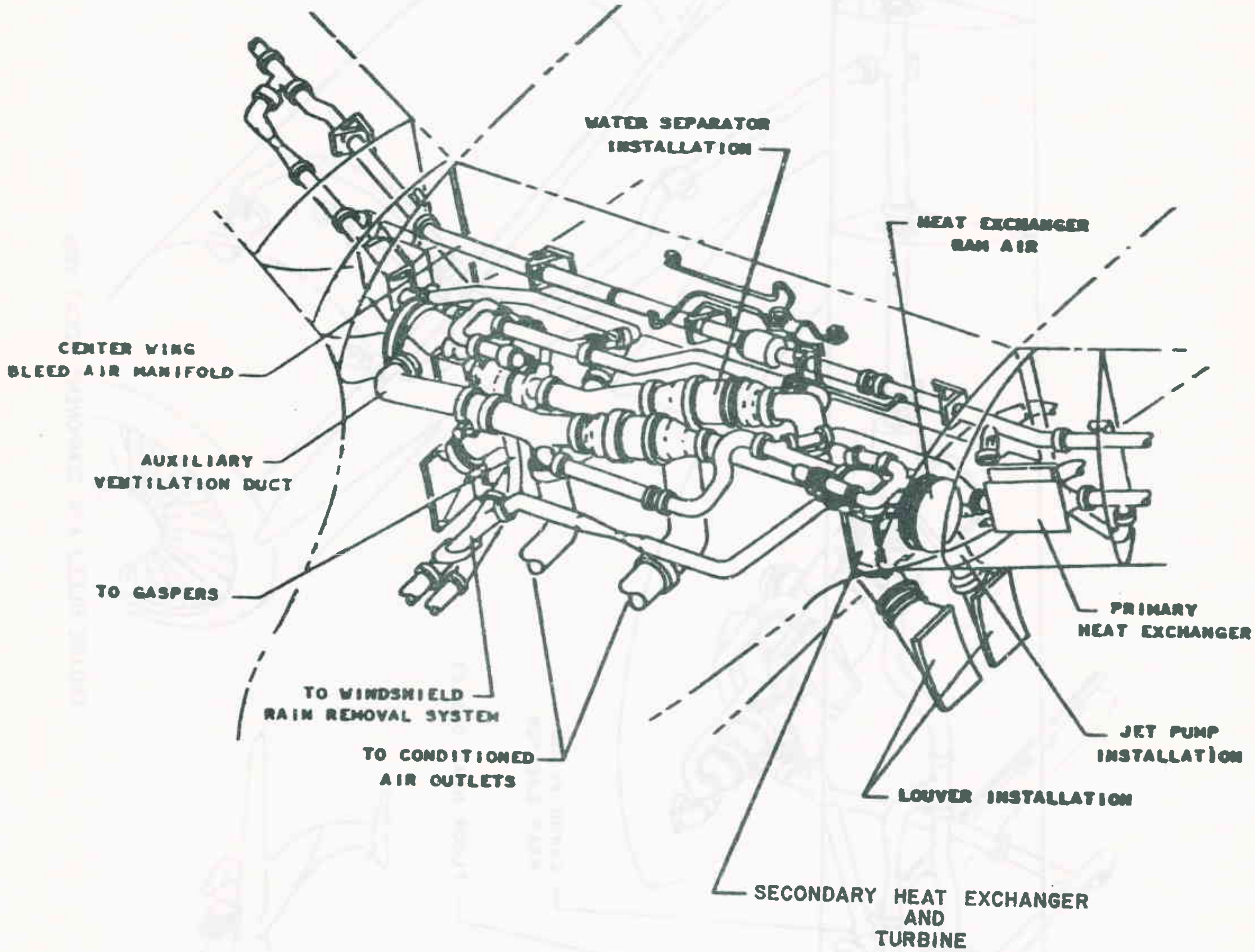
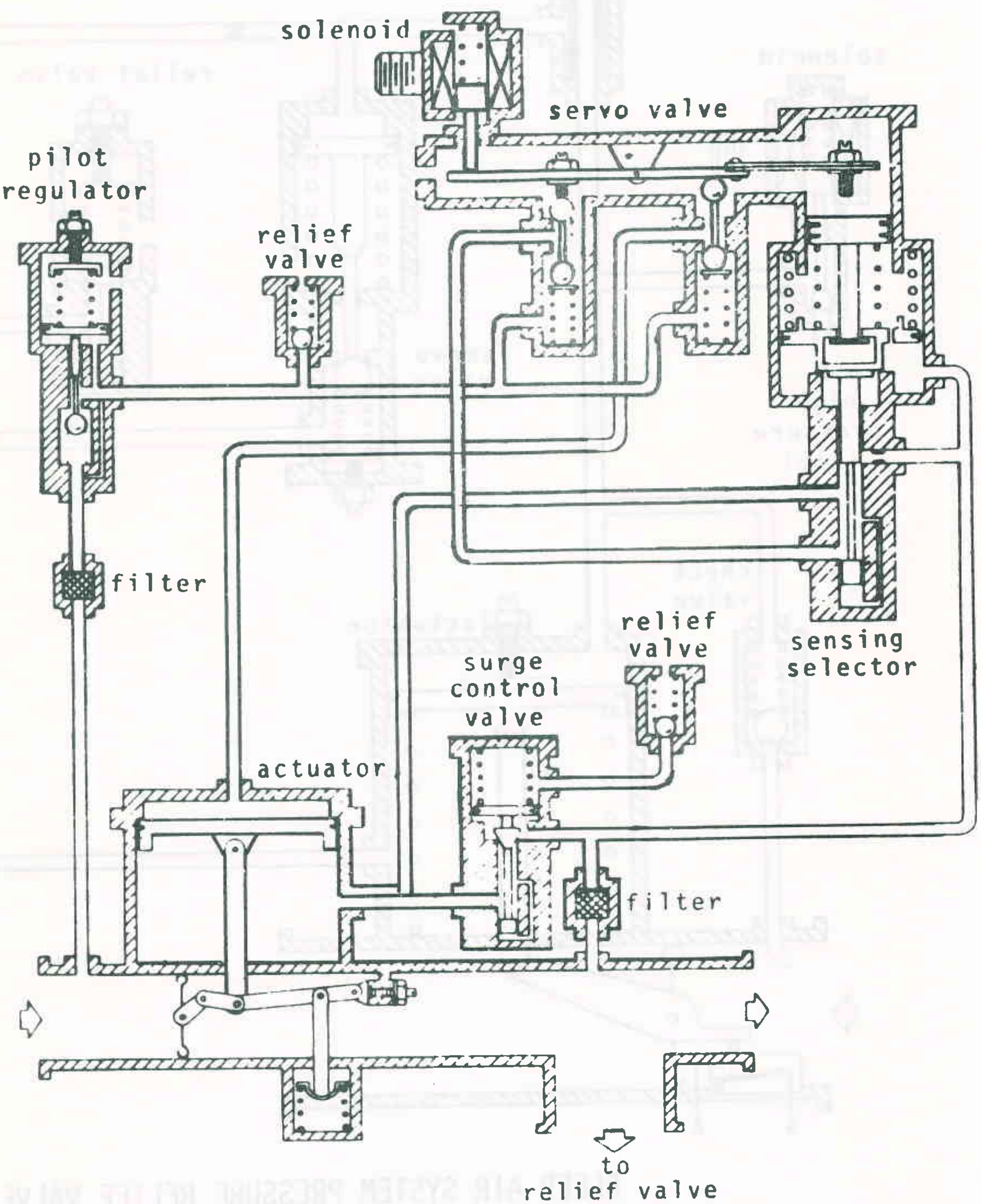
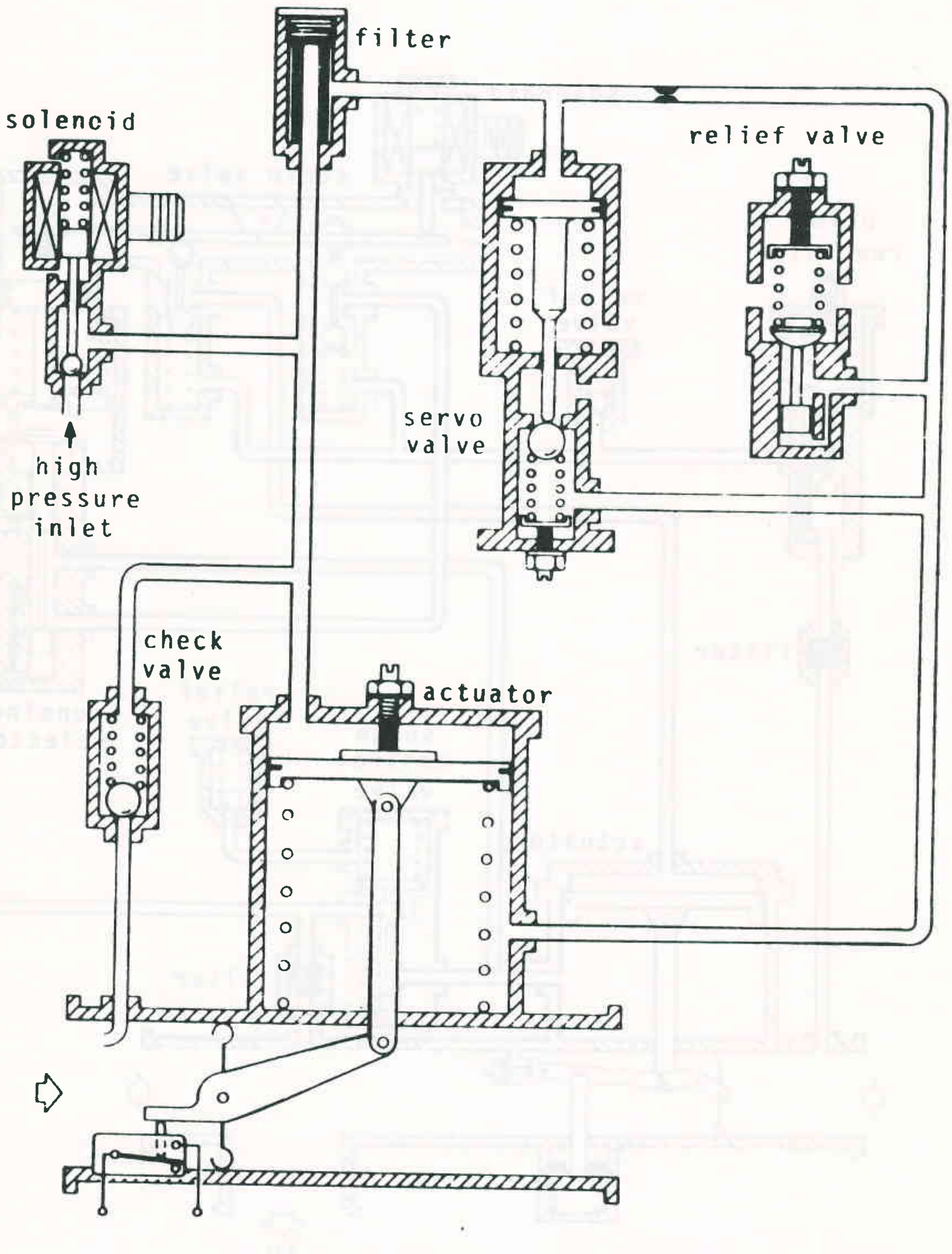

WATER SEPARATOR
INSTALLATION
HEAT EXCHANGER
RAM AIR
CENTER WING
BLEED AIR MANIFOLD
AUXILIARY
VENTILATION DUCT
TO GASPERS
TO WINDSHIELD
RAIN REMOVAL SYSTEM
TO CONDITIONED
AIR OUTLETS
PRIMARY
HEAT EXCHANGER
JET PUMP
INSTALLATION
LOUVER INSTALLATION
SECONDARY HEAT EXCHANGER
AND
TURBINE

Figure 6-8



BLEED AIR SYSTEM PRESSURE REGULATOR VALVE

Figure 6-9



BLEED AIR SYSTEM PRESSURE RELIEF VALVE

Figure 6-10

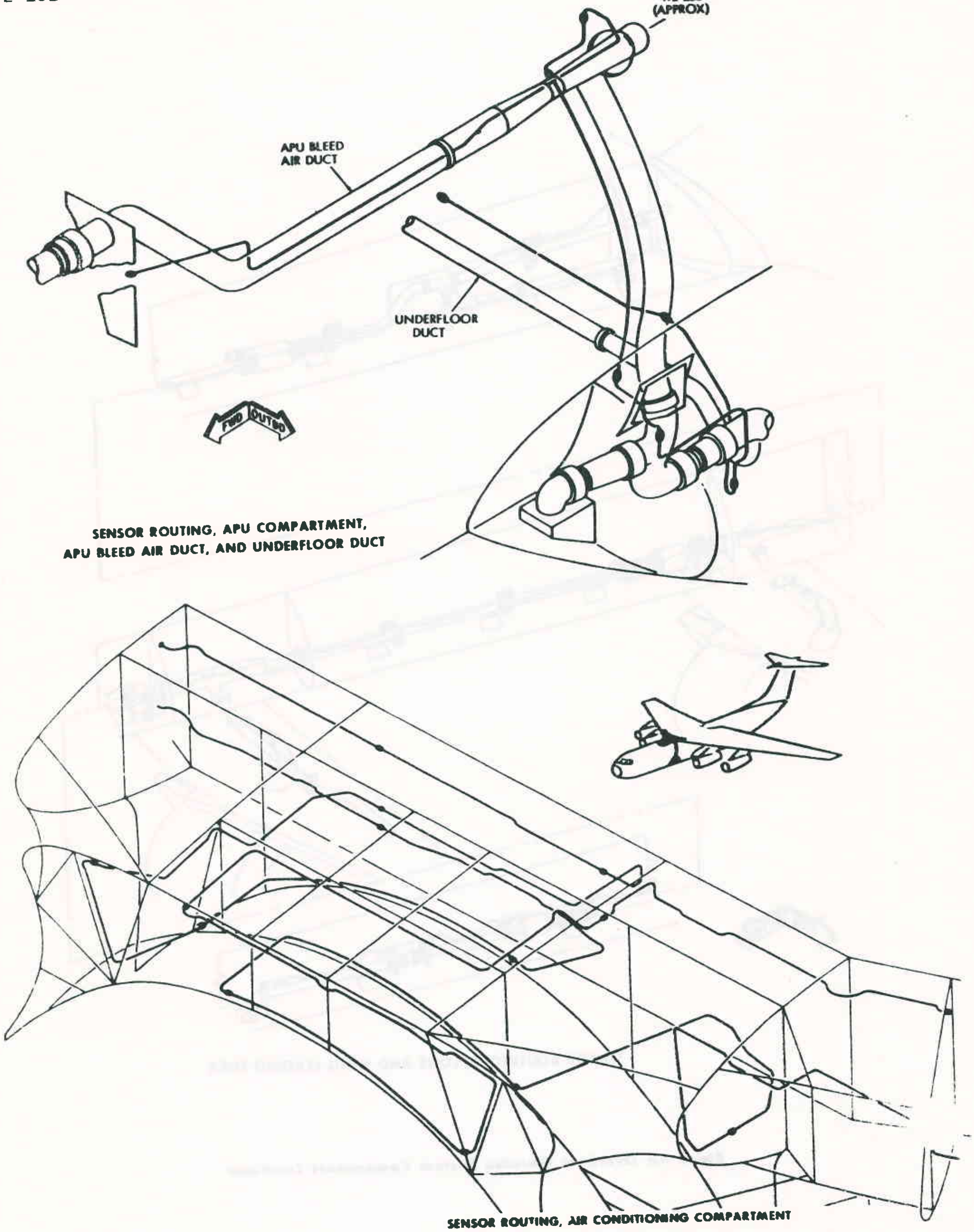
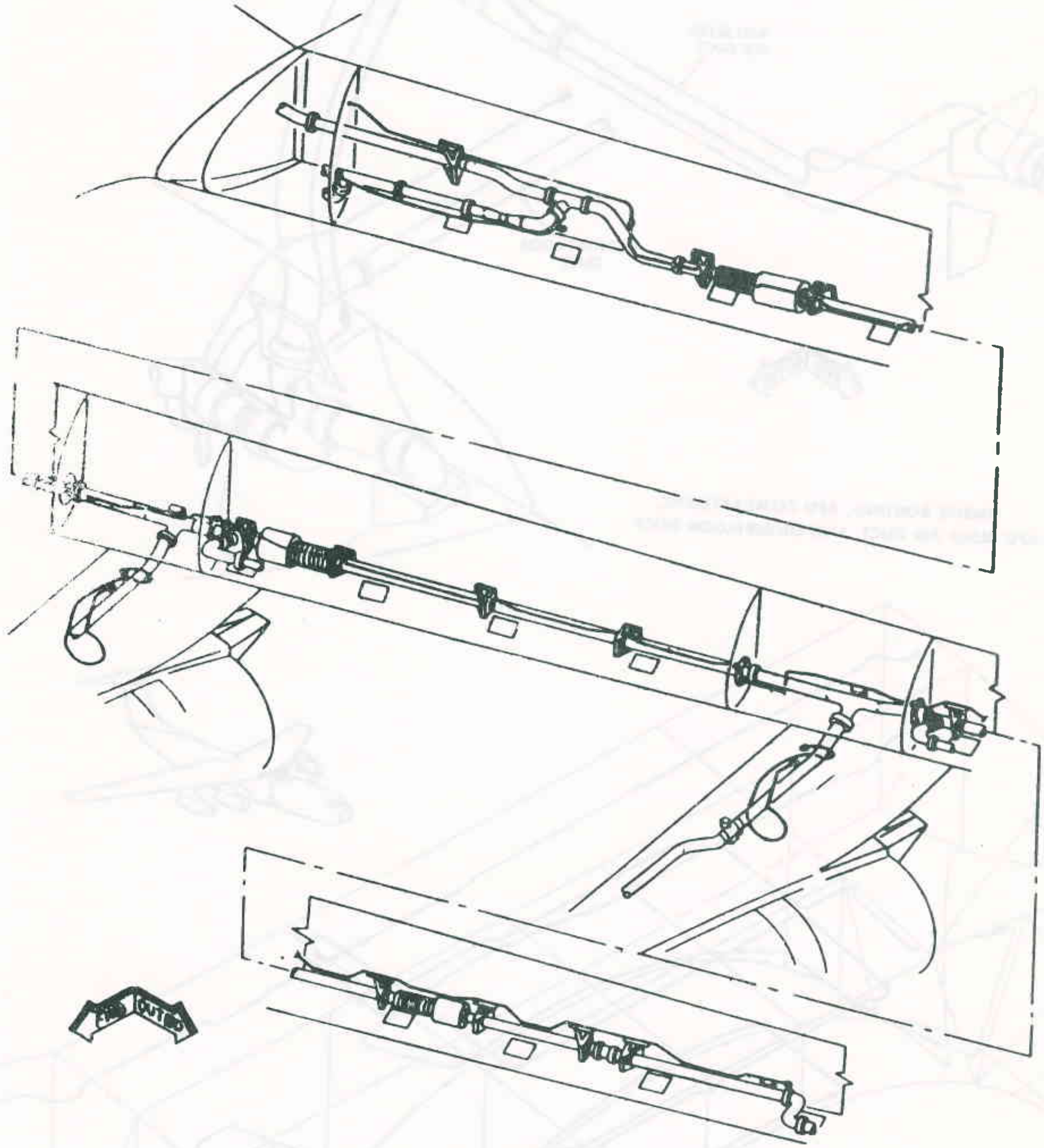

WL 255
(APPROX)
APU BLEED
AIR DUCT
UNDERFLOOR
DUCT
FWD
OUTBD
SENSOR ROUTING, APU COMPARTMENT,
APU BLEED AIR DUCT, AND UNDERFLOOR DUCT
SENSOR ROUTING, AIR CONDITIONING COMPARTMENT

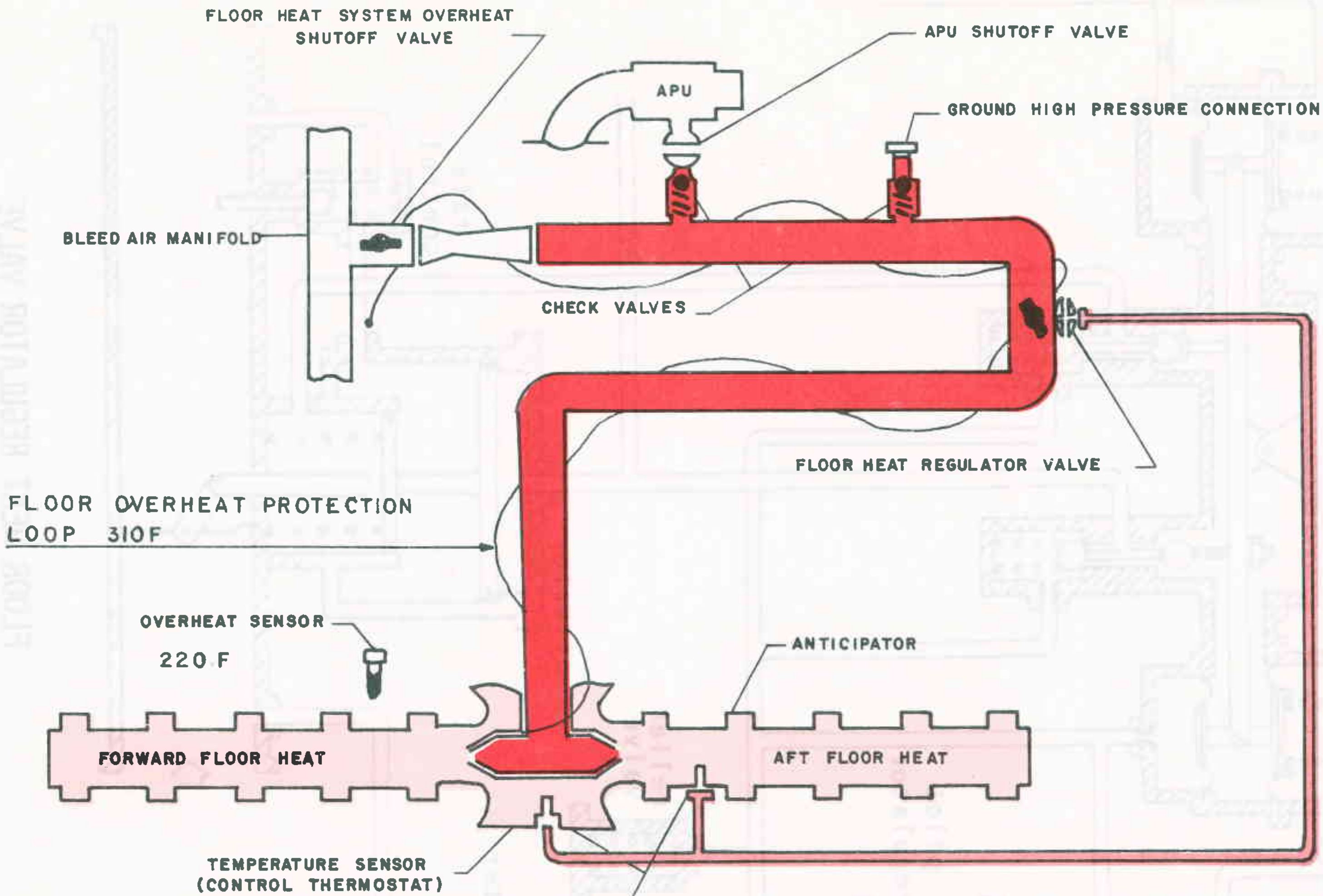
Figure 6-11



SENSOR ROUTING, PYLONS AND WING LEADING EDGE

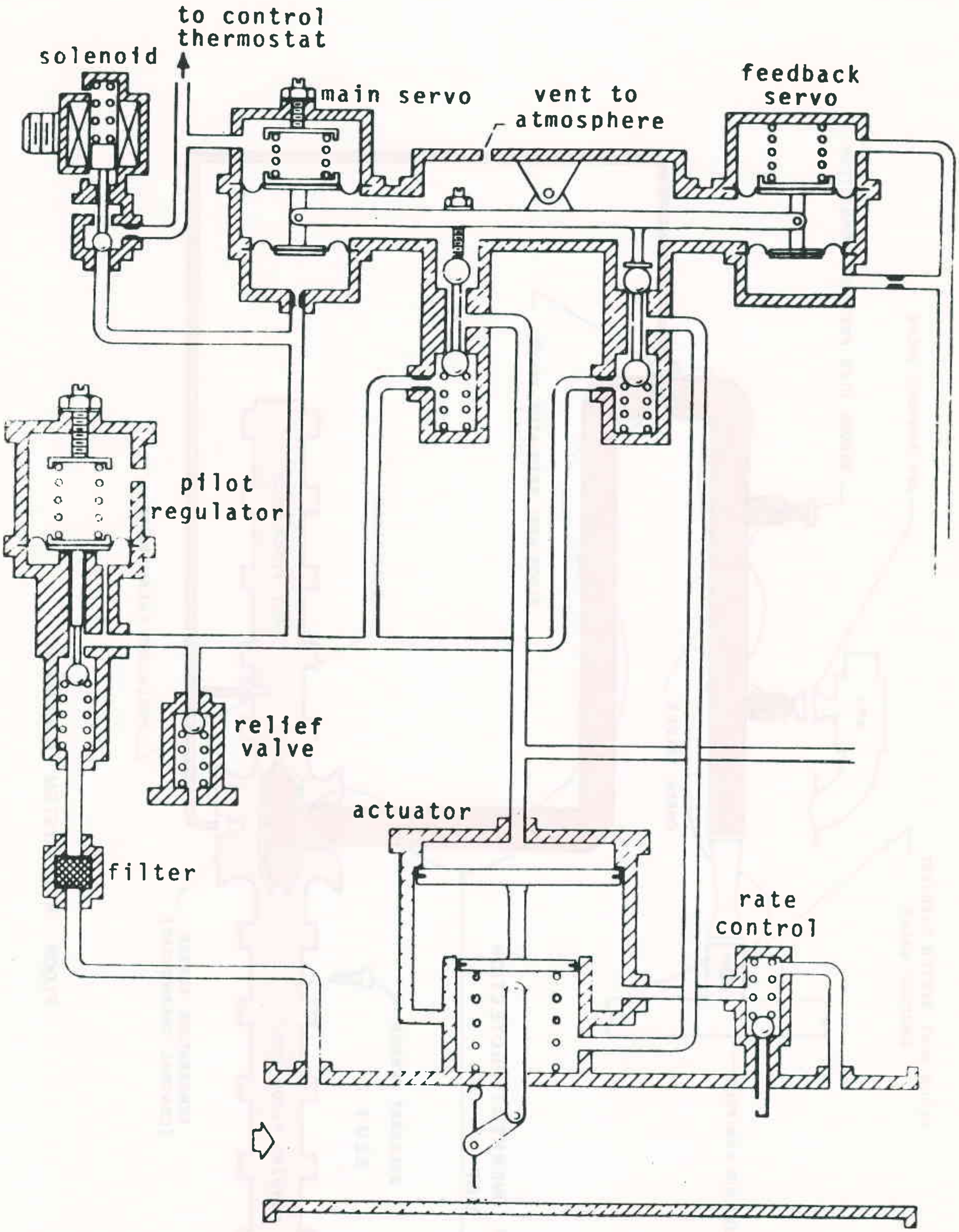
Bleed Air Overheat Warning System Components Locations

Figure 6-12



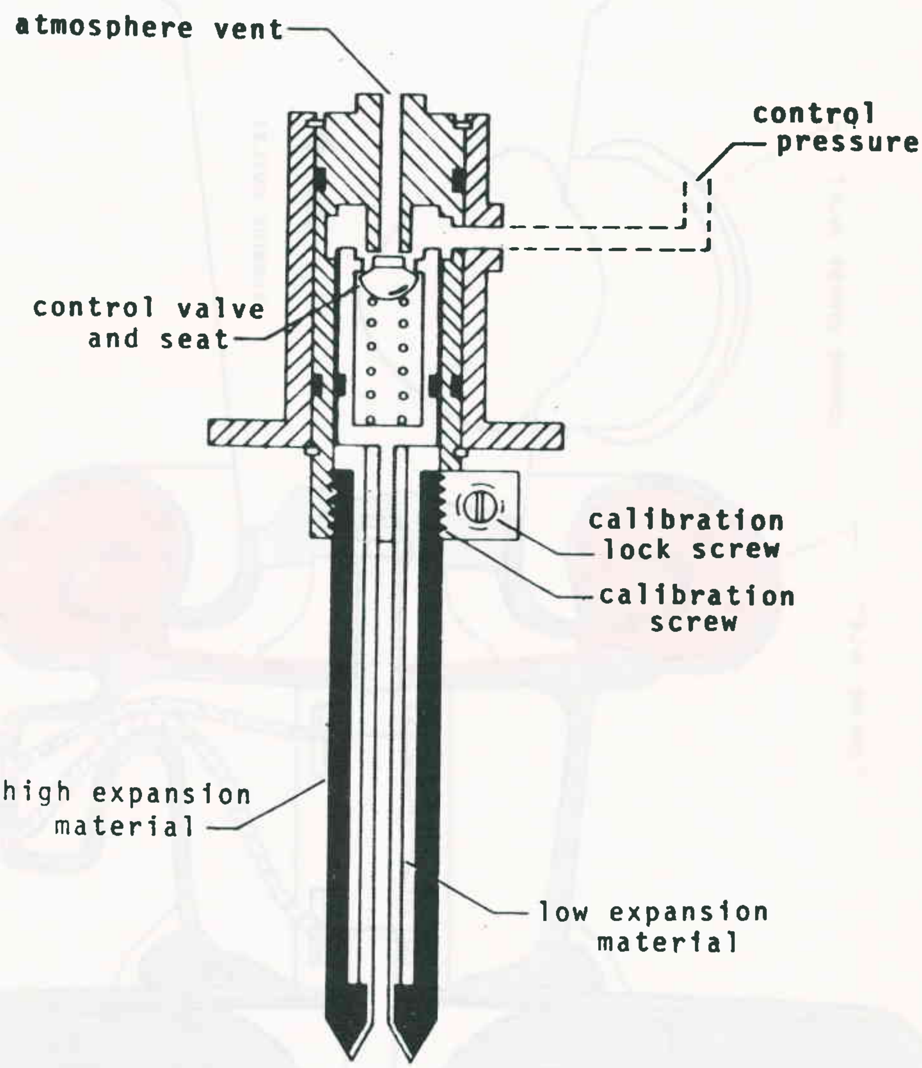
FLOOR HEAT SYSTEM SCHEMATIC

Figure 6-13



FLOOR HEAT REGULATOR VALVE

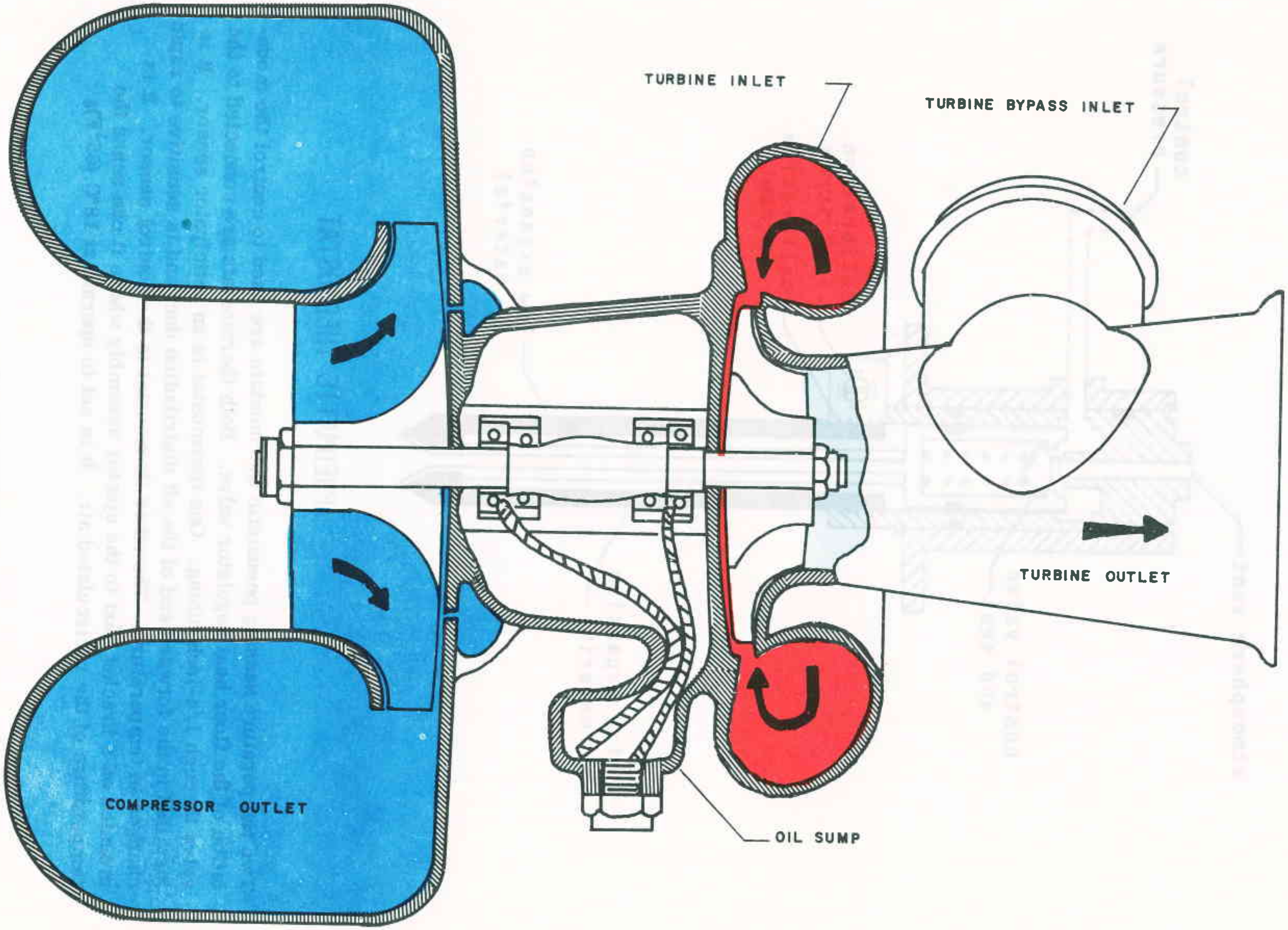
Figure 6-14



PNEUMATIC THERMOSTAT

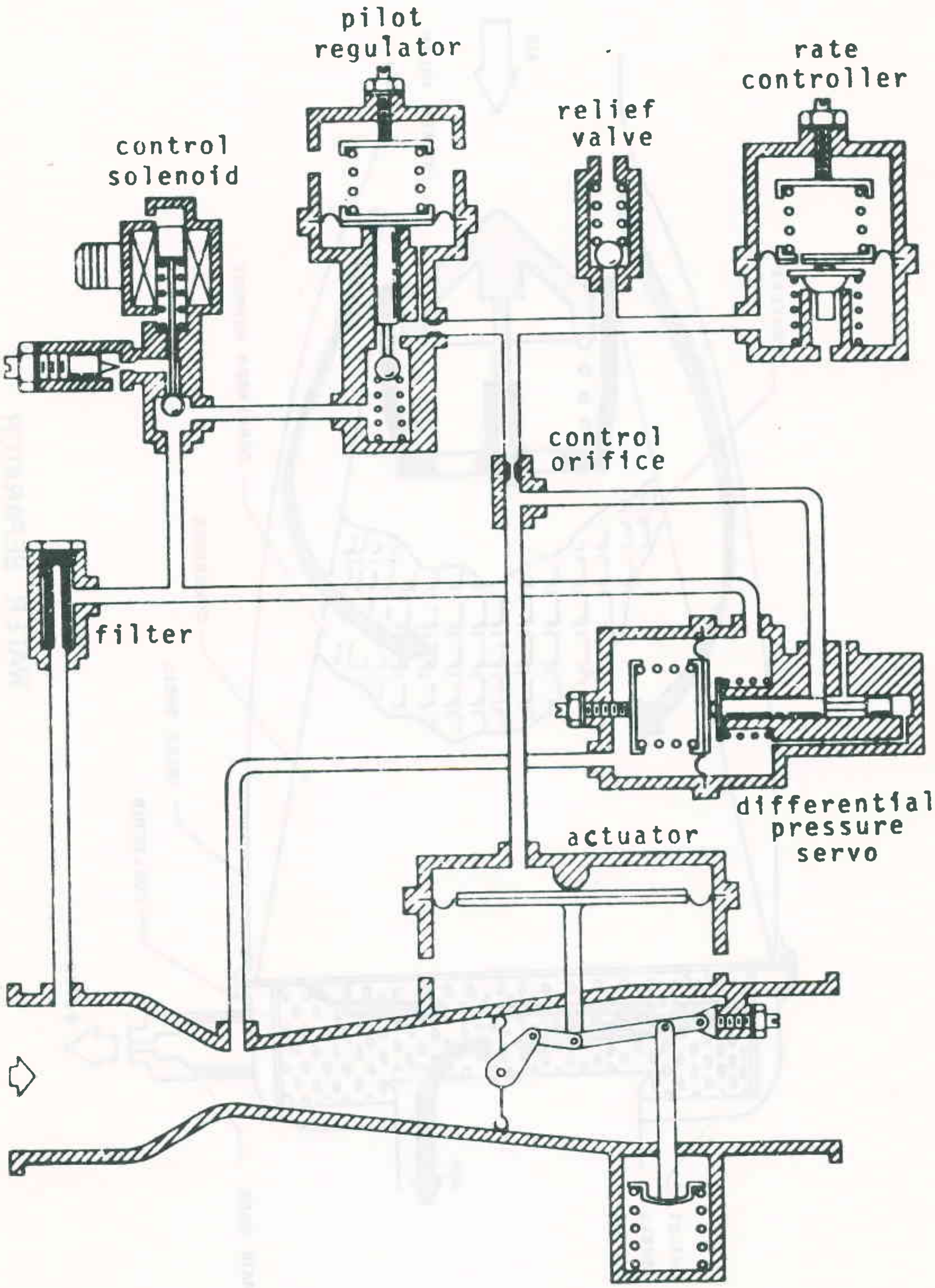
Two temperature sensing pneumatic thermostats are used to control the modulation of the floor heat regulator valve. Both thermostats are connected to the valve through 1/4-inch tubing. One thermostat is an anticipator sensor. It is installed in the forward end of the aft distribution duct and is sensitive to rapid changes in temperature. The other thermostat is the control sensor. It is mounted on a bracket next to the ejector assembly where it can sense the temperature of the recirculated air. It is set to operate at 18°C (65°F).

Figure 6-15



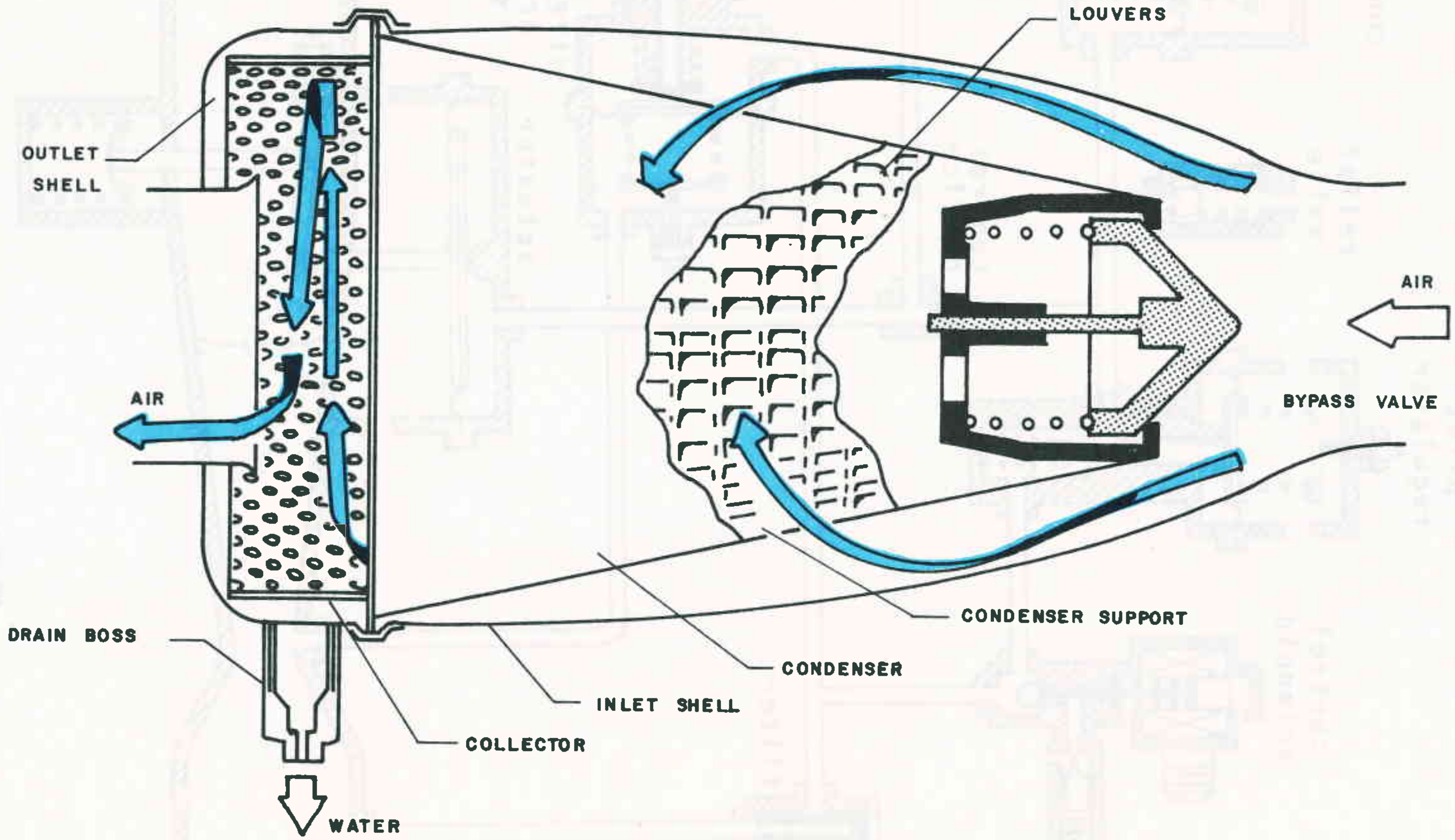
AIR CONDITIONING SYSTEM TURBINE AND FAN ASSEMBLY

Figure 6-16



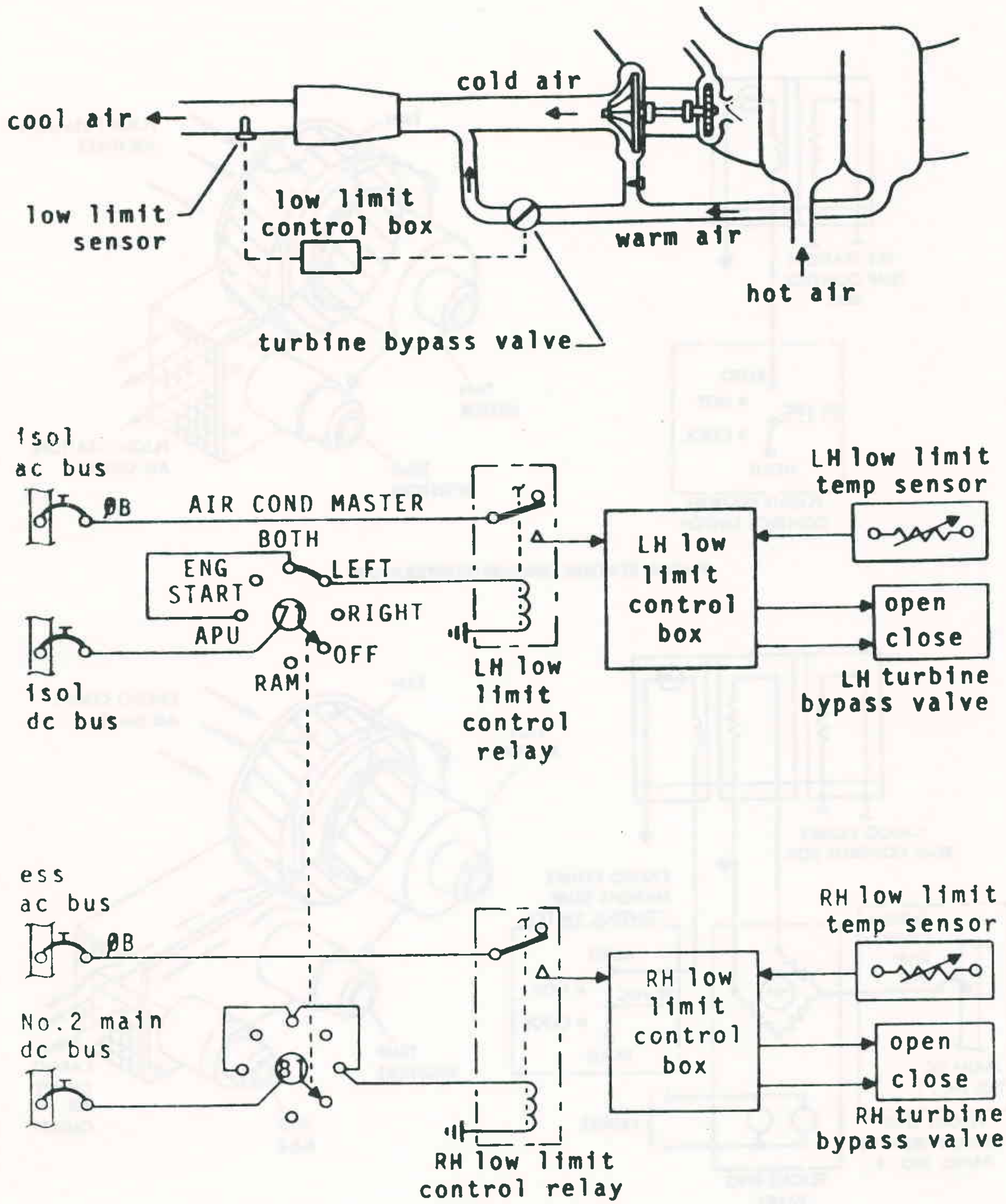
FLOW CONTROL AND SHUTOFF VALVE

Figure 6-17



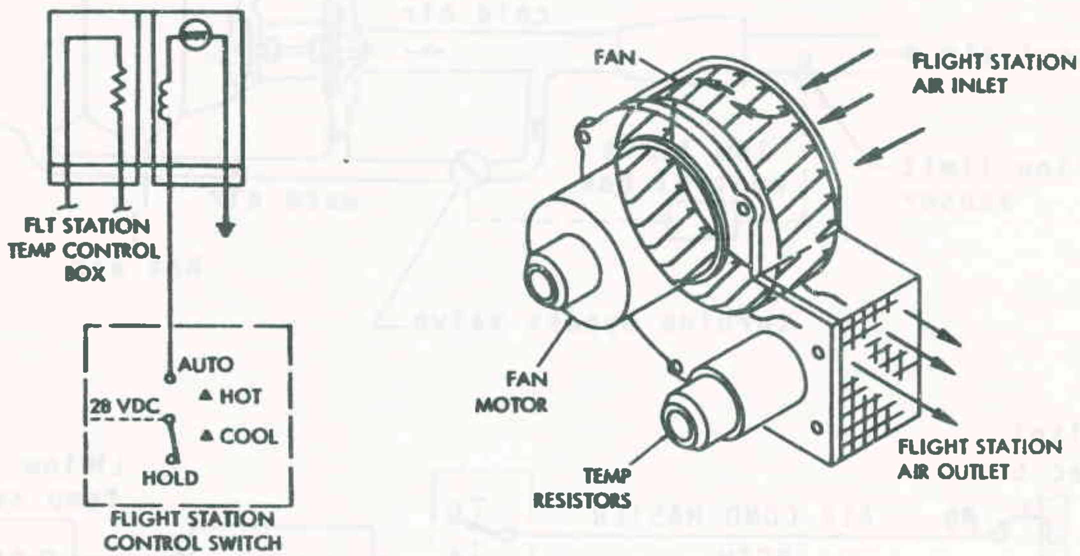
WATER SEPARATOR

Figure 6-18

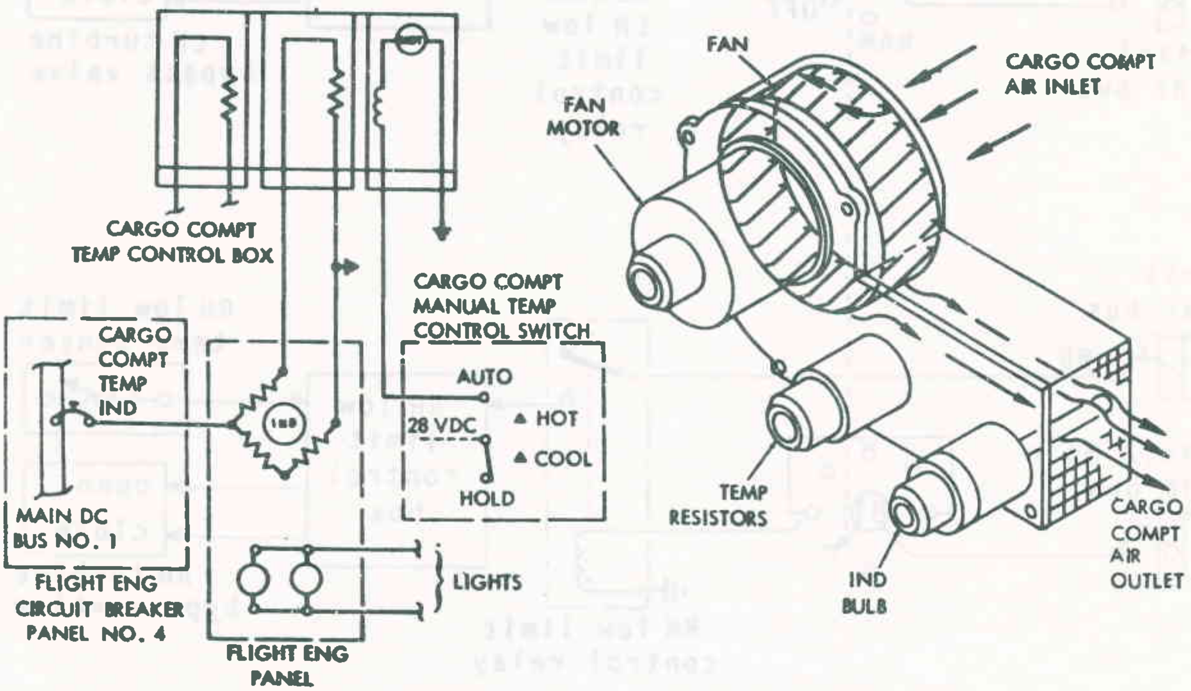


LOW-LIMIT TEMPERATURE CONTROL SYSTEM

Figure 6-19

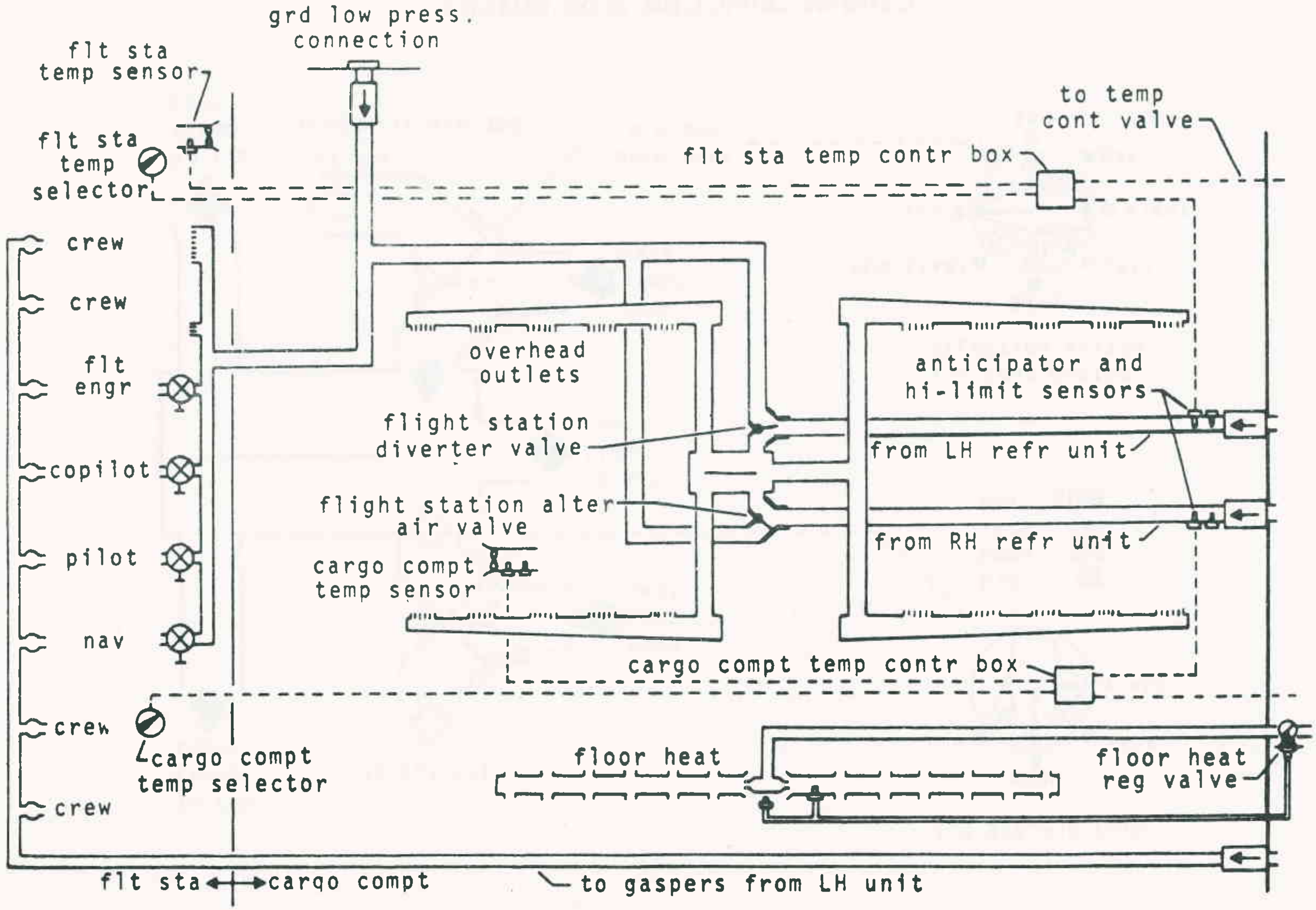


FLIGHT STATION SENSOR-TEMPERATURE



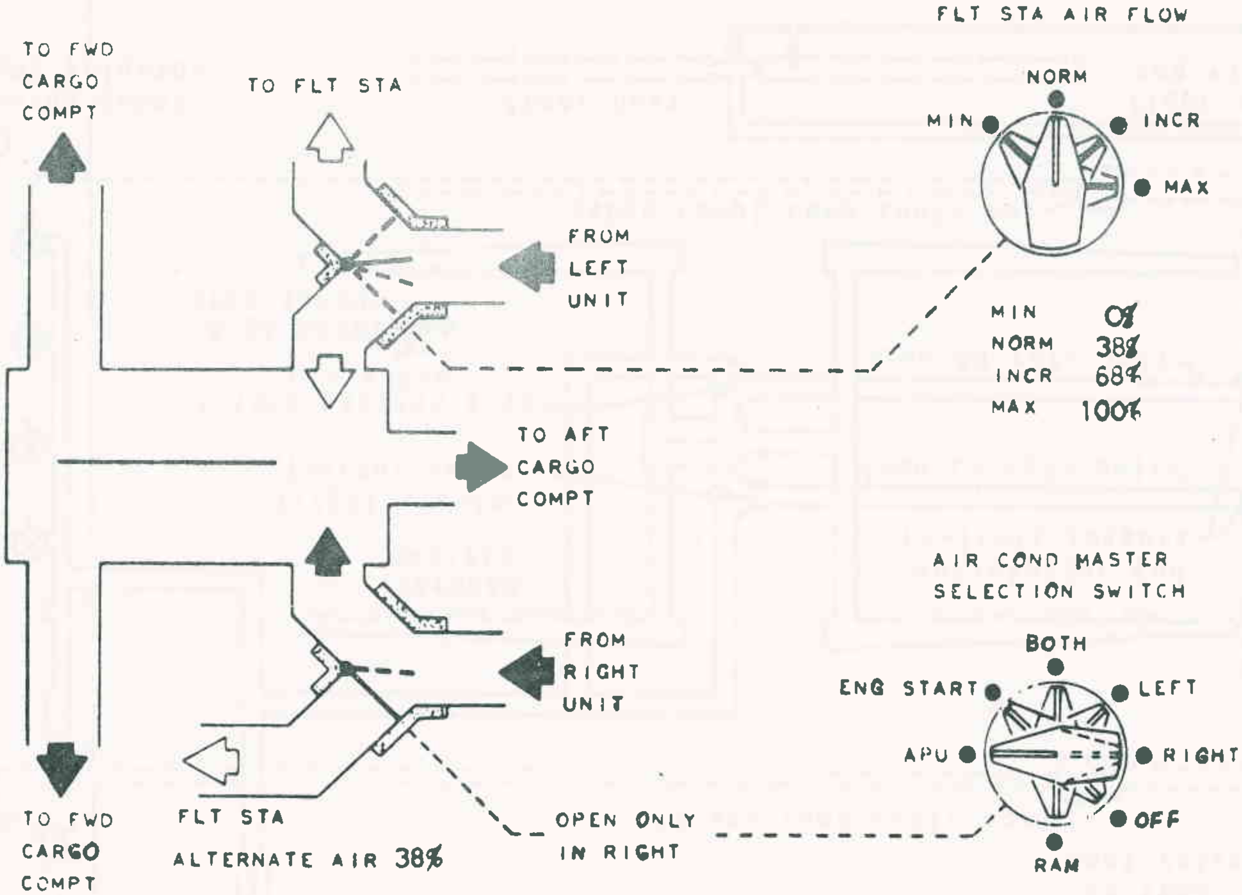
CARGO COMPARTMENT SENSOR-TEMPERATURE

Figure 6-20



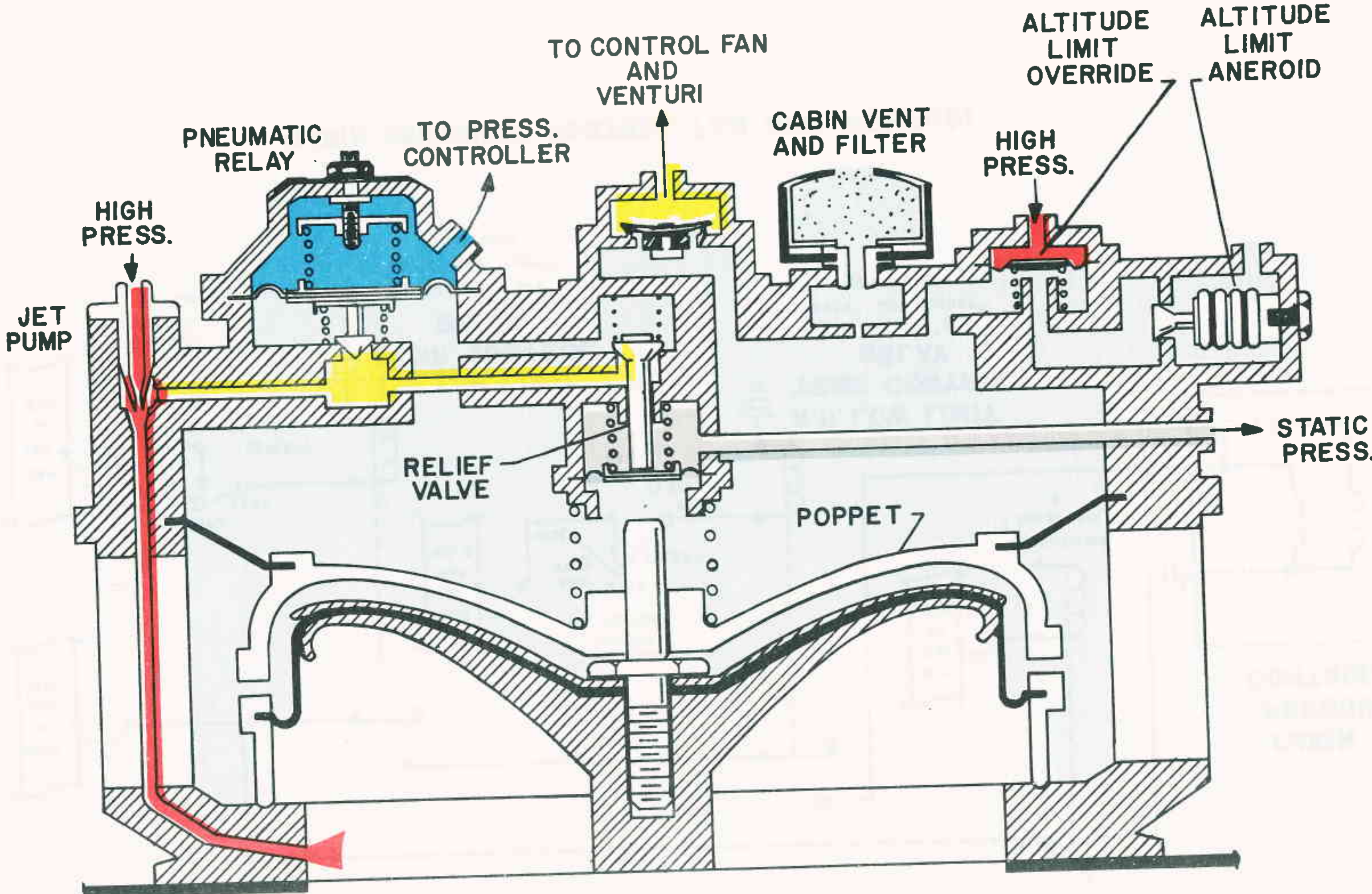
CONDITIONED AIR DISTRIBUTION SYSTEM

Figure 6-21



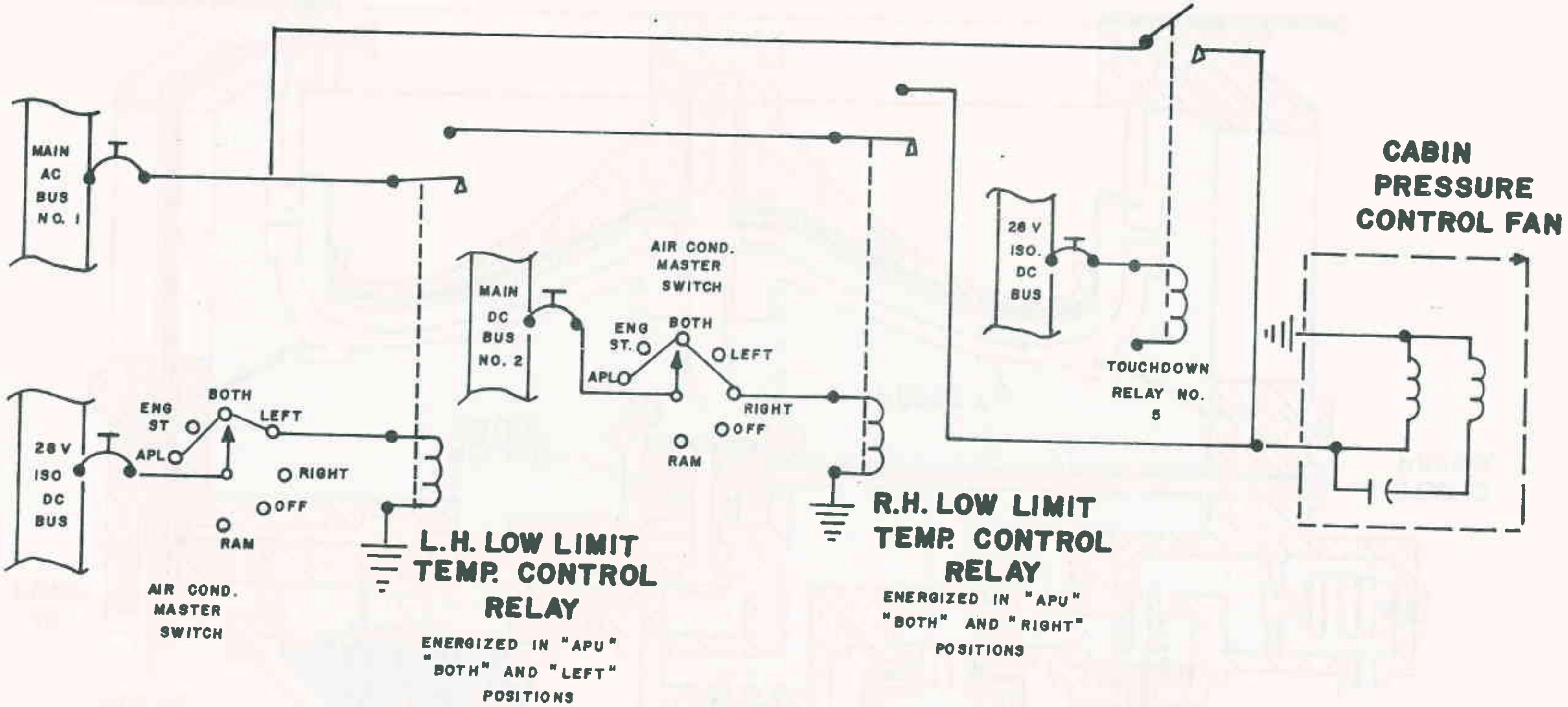
DIVERTER VALVE POSITIONING SCHEMATIC

Figure 6-22



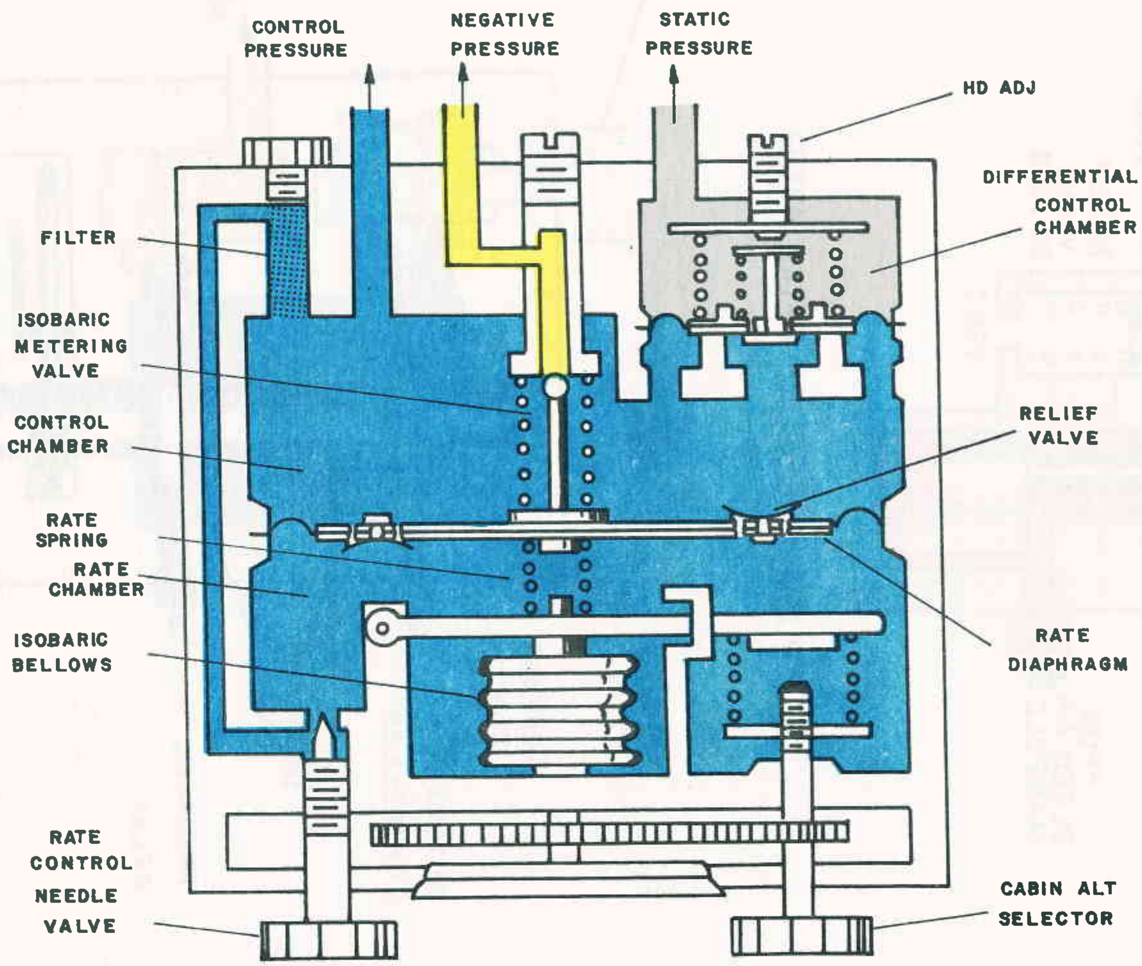
OUTFLOW/SAFETY VALVE

Figure 6-23



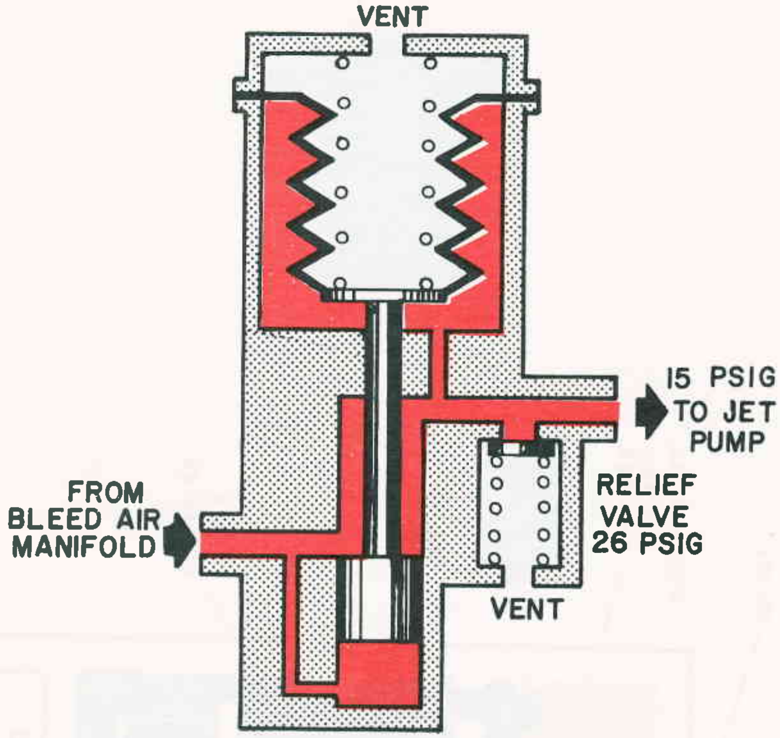
CABIN PRESSURE CONTROL FAN AND VENTURI

Figure 6-24

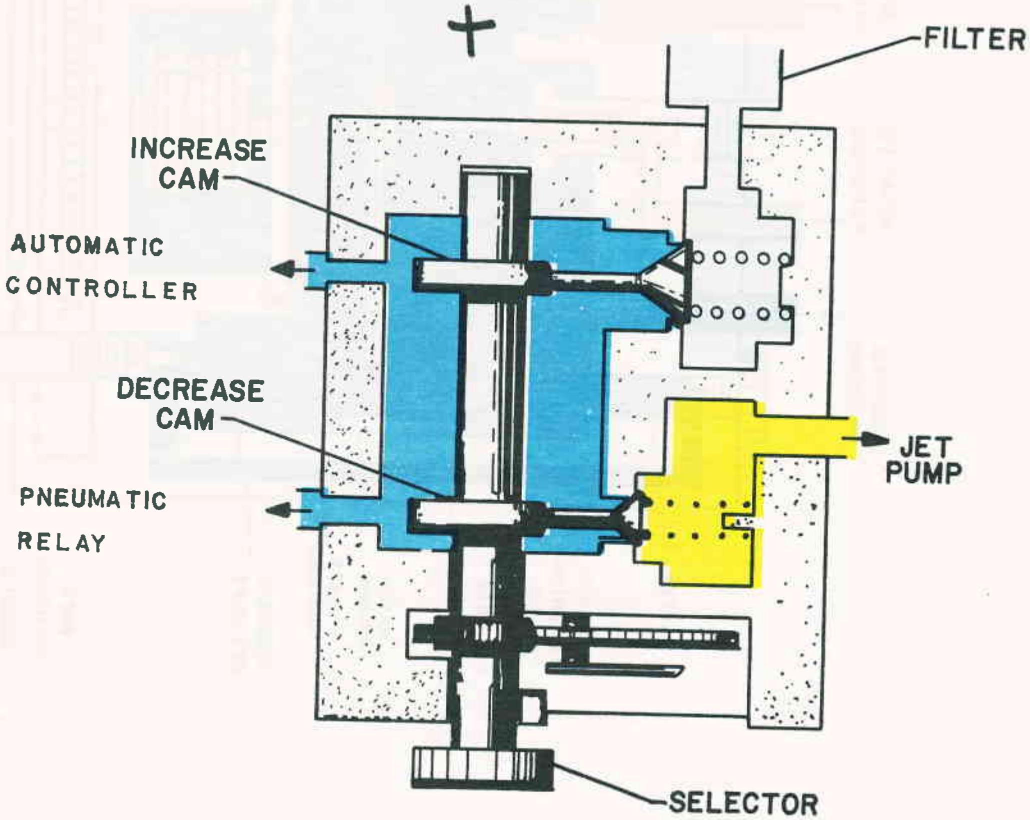


AUTOMATIC PRESSURE CONTROLLER

Figure 6-25

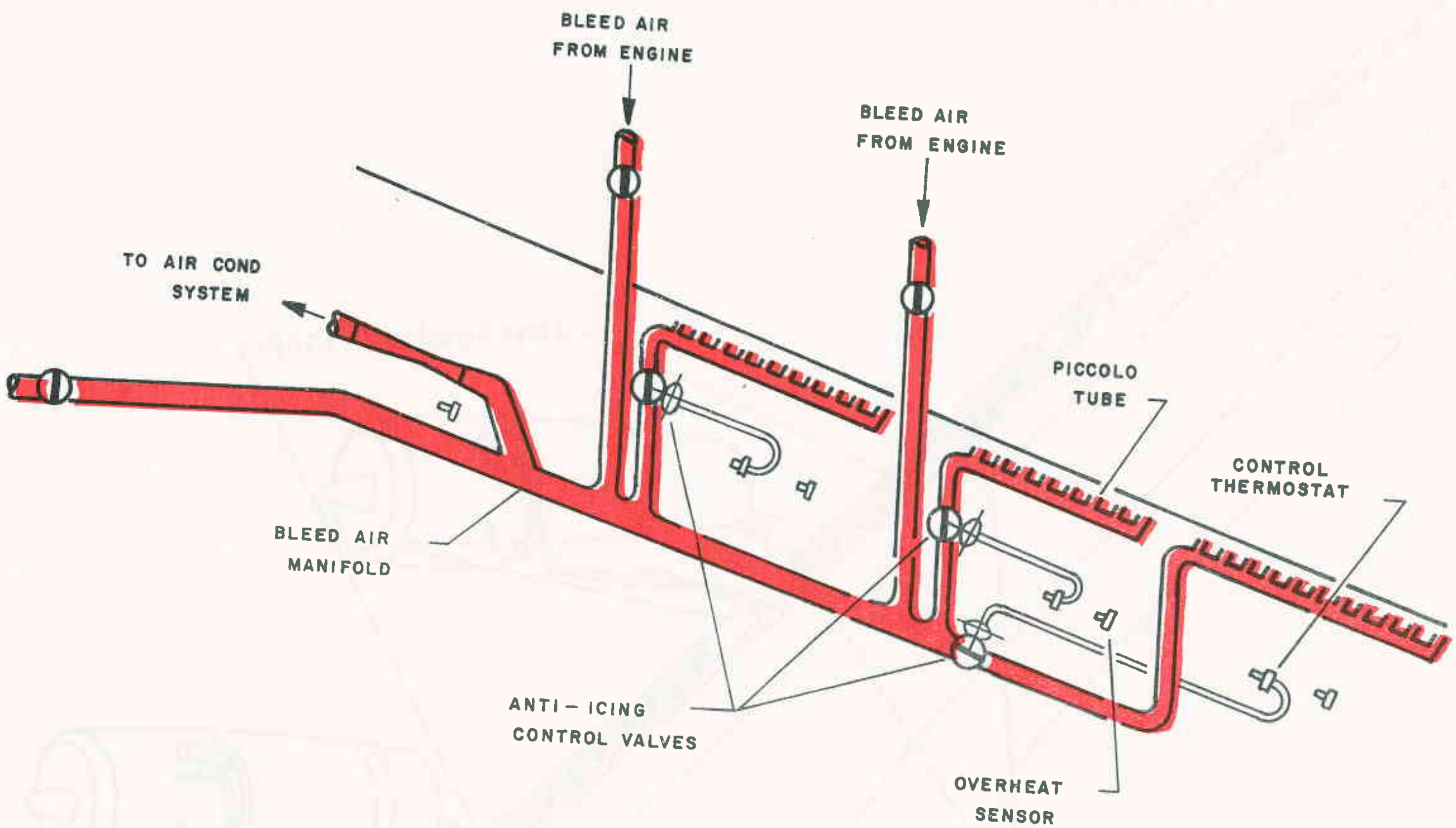


JET PUMP PRESSURE REGULATOR



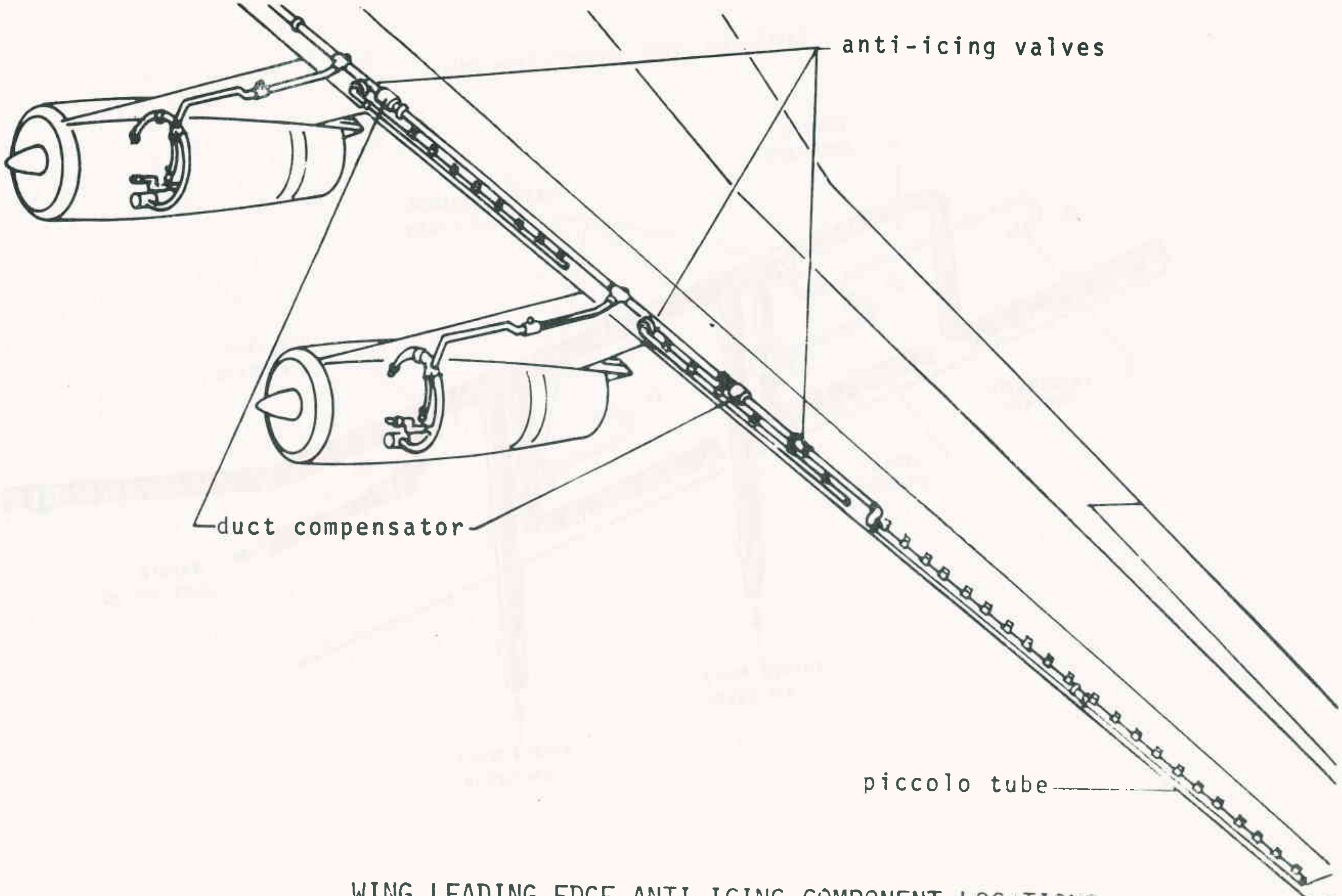
MANUAL PRESSURE CONTROLLER

Figure 6-26

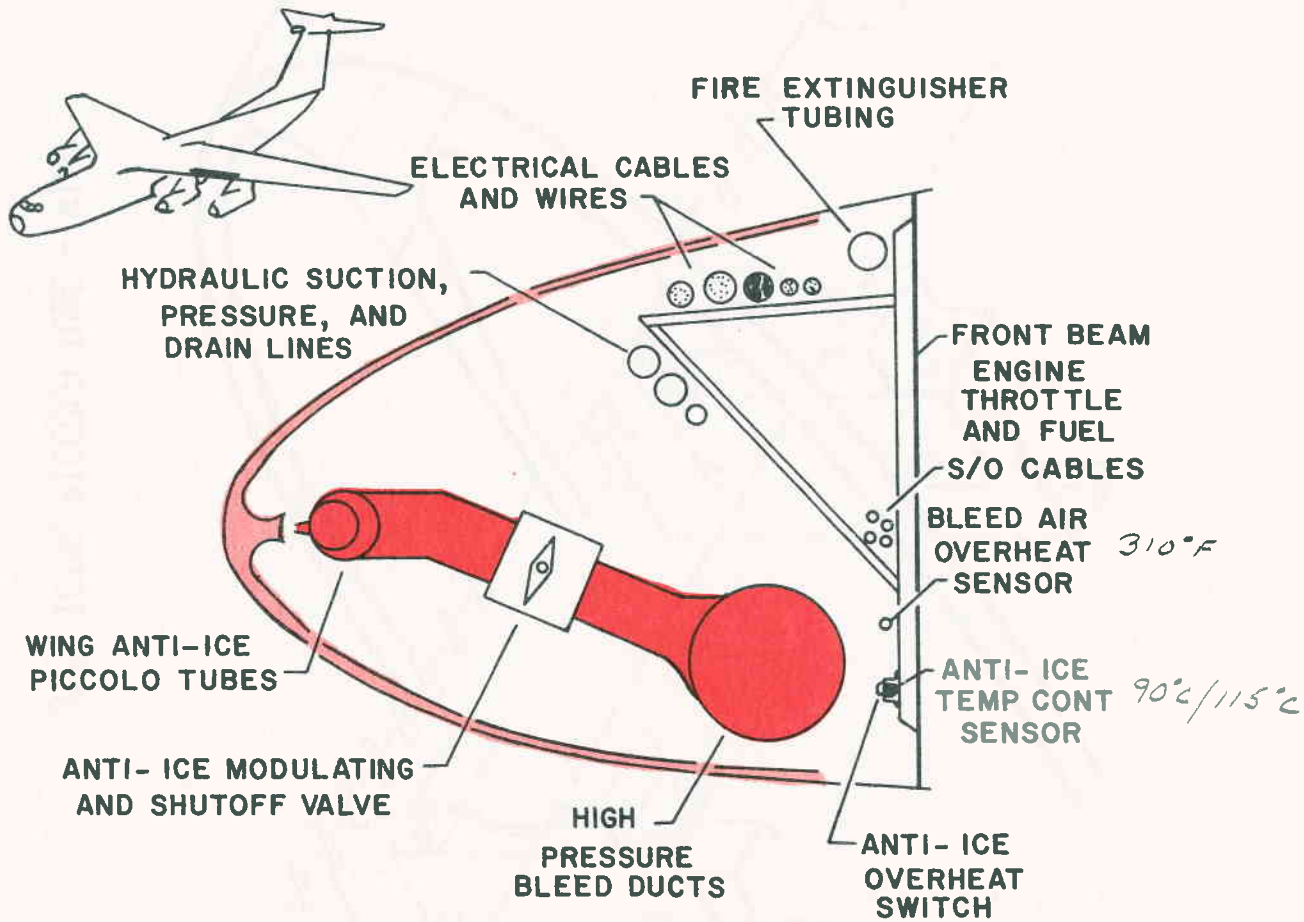


RIGHT WING LEADING EDGE ANTI-ICING

Figure 6-27

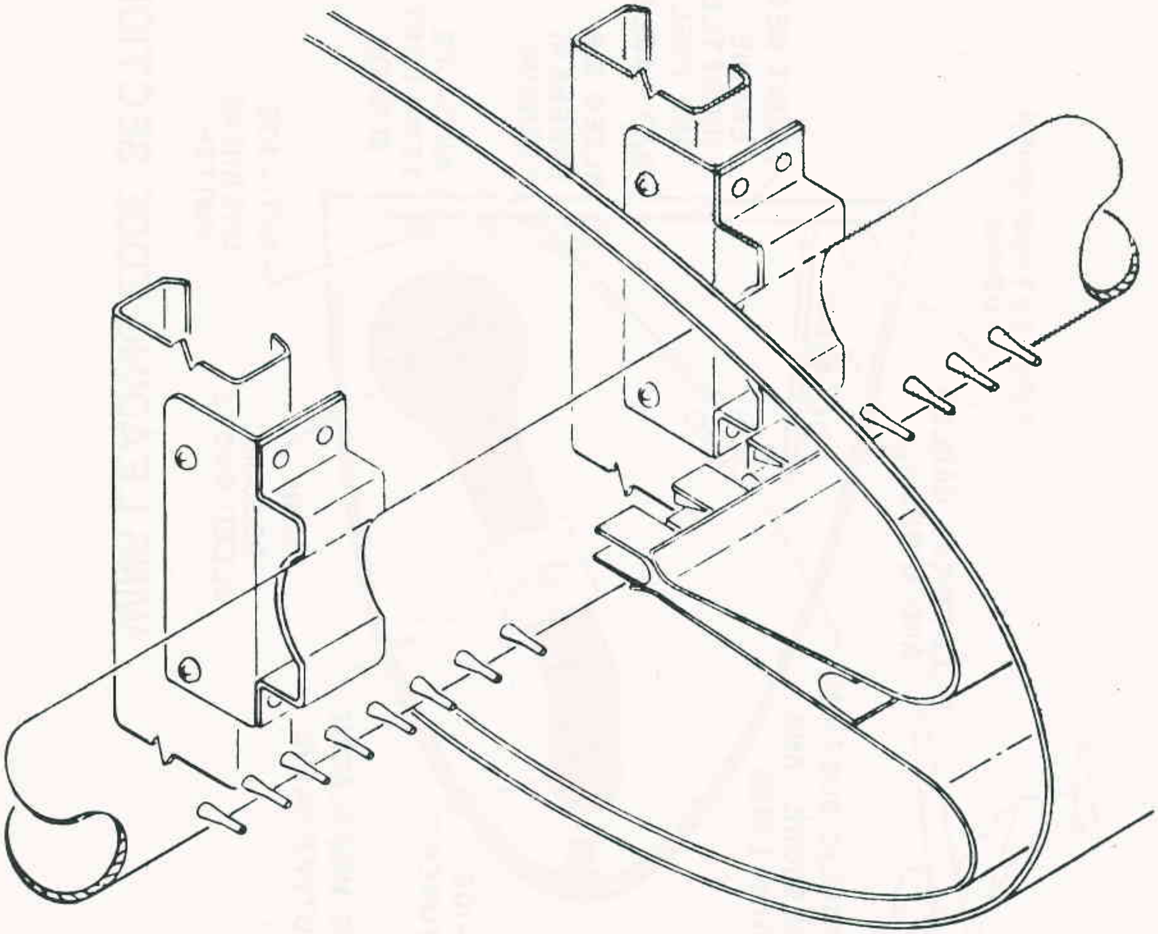


WING LEADING EDGE ANTI-ICING COMPONENT LOCATIONS



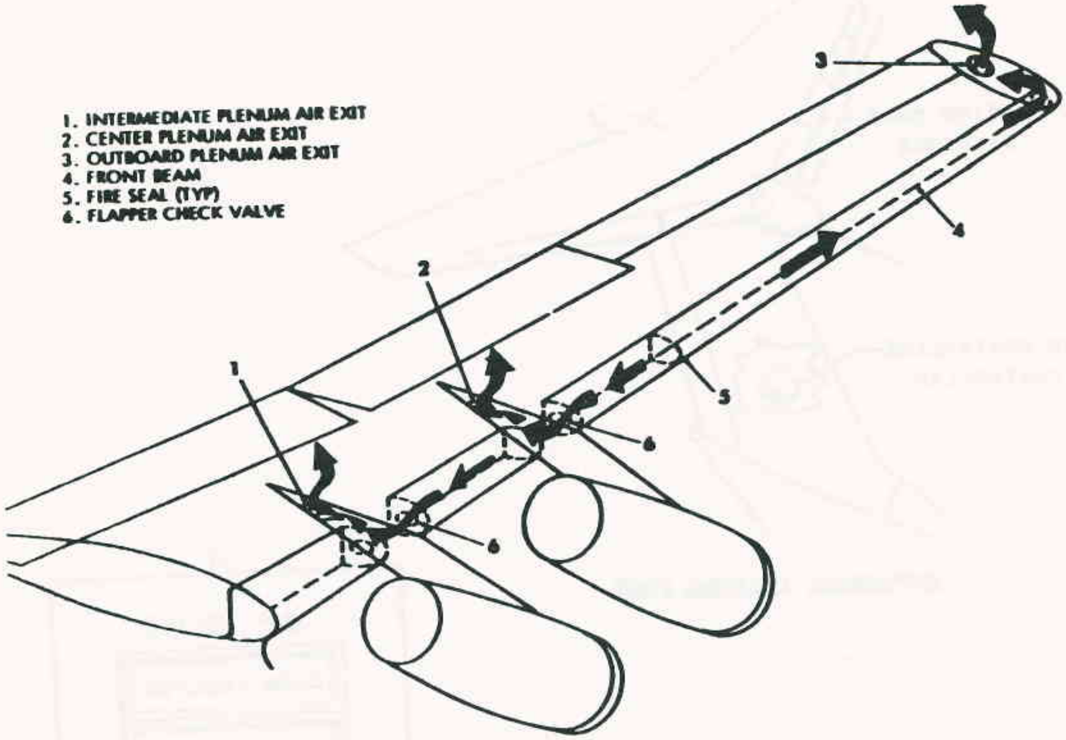
WING LEADING EDGE SECTION

Figure 6-29

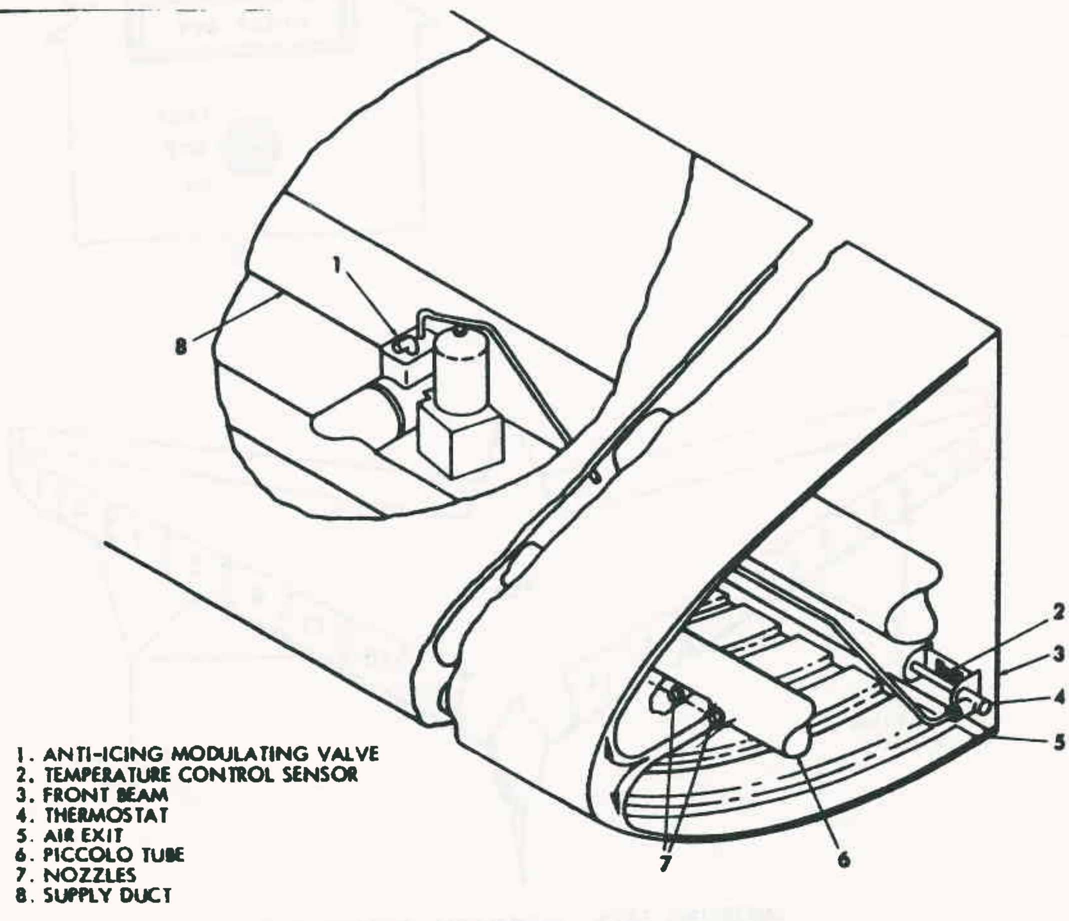


ANTI-ICING PICCOLO TUBE - WING

Figure 6-30

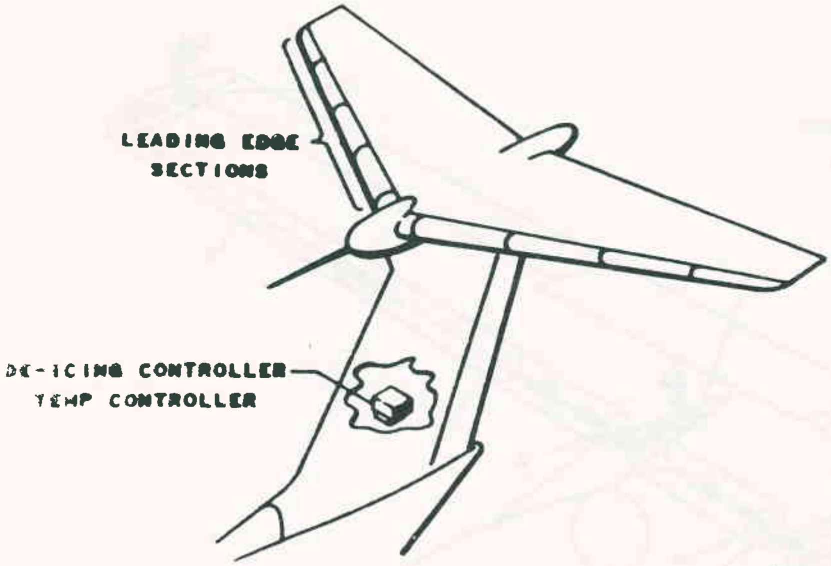


Wing Anti-icing Dump Provisions

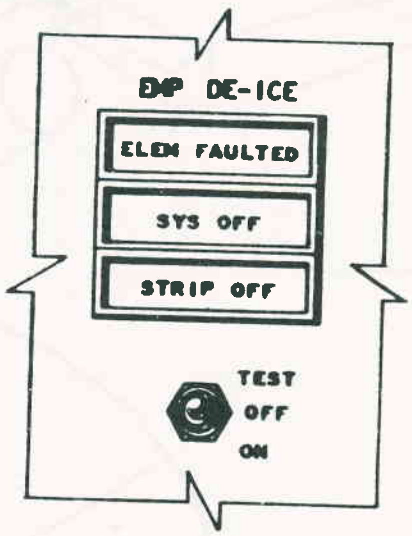


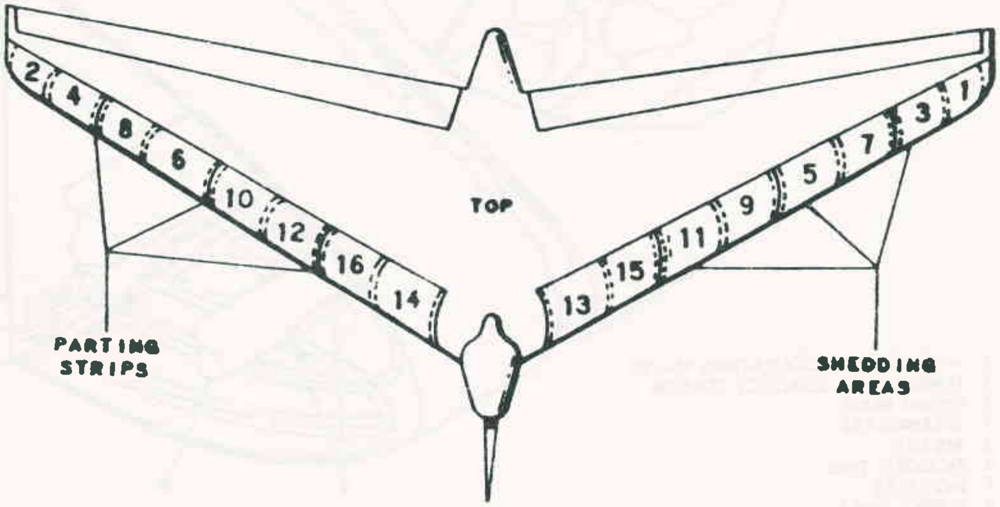
Wing Leading Edge Anti-icing

Figure 6-31



EMPENNAGE LEADING EDGE





SHEDDING AREA NUMERICAL DESIGNATION

Figure 6-32

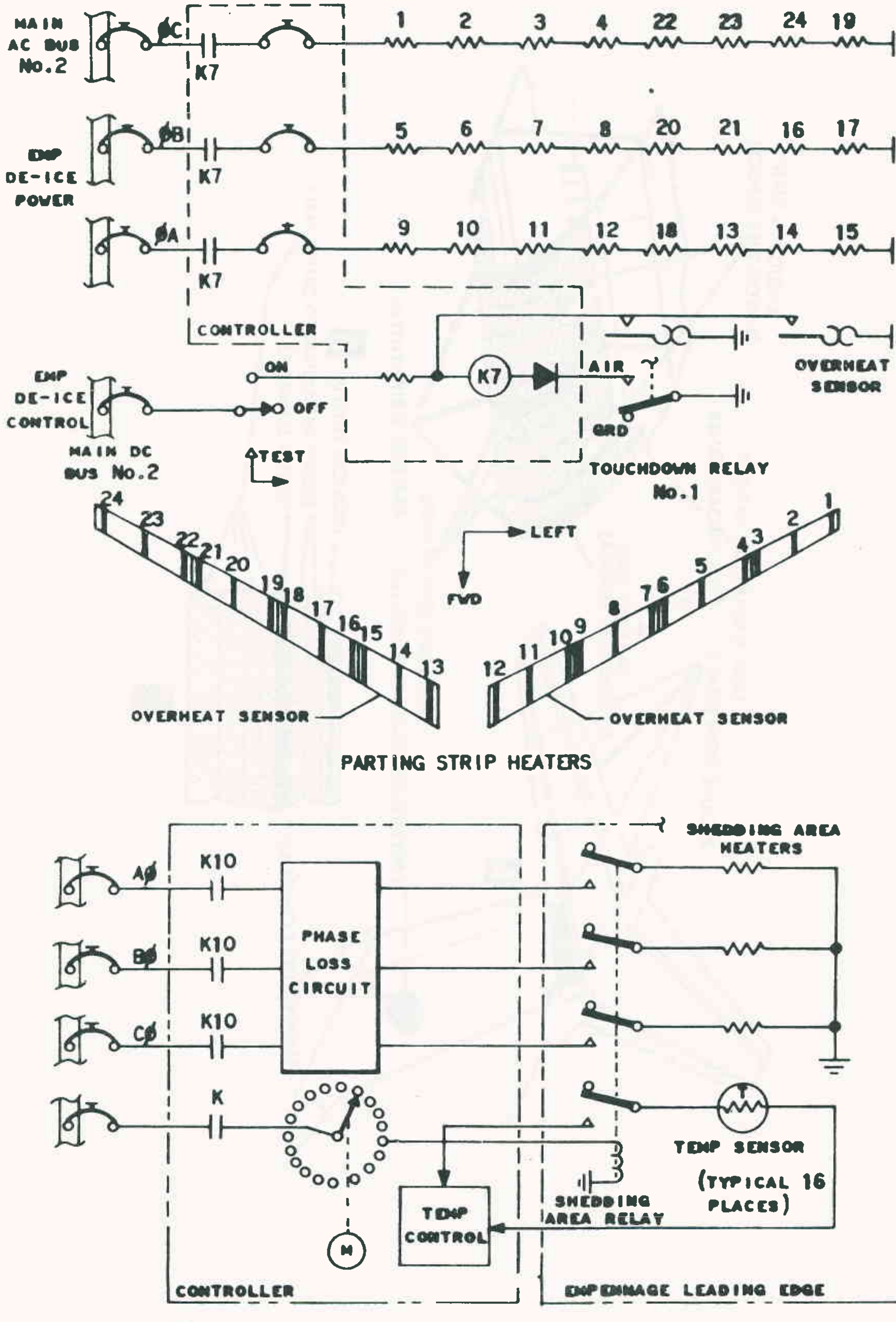

MAIN
AC BUS
No.2
ØC
ØB
ØA
K7
EMP
DE-ICE
POWER
CONTROLLER
1 2 3 4 22 23 24 19
5 6 7 8 20 21 16 17
9 10 11 12 18 13 14 15
ON
OFF
TEST
EMP
DE-ICE
CONTROL
MAIN DC
BUS No.2
AIR
GRD
TOUCHDOWN RELAY
No.1
OVERHEAT
SENSOR
LEFT
FWD
OVERHEAT SENSOR
OVERHEAT SENSOR
PARTING STRIP HEATERS
AØ
BØ
CØ
K10
K
PHASE
LOSS
CIRCUIT
SHEDDING AREA
HEATERS
TEMP SENSOR
(TYPICAL 16
PLACES)
SHEDDING
AREA RELAY
TEMP
CONTROL
M
CONTROLLER
EMPENNAGE LEADING EDGE

Figure 6-33

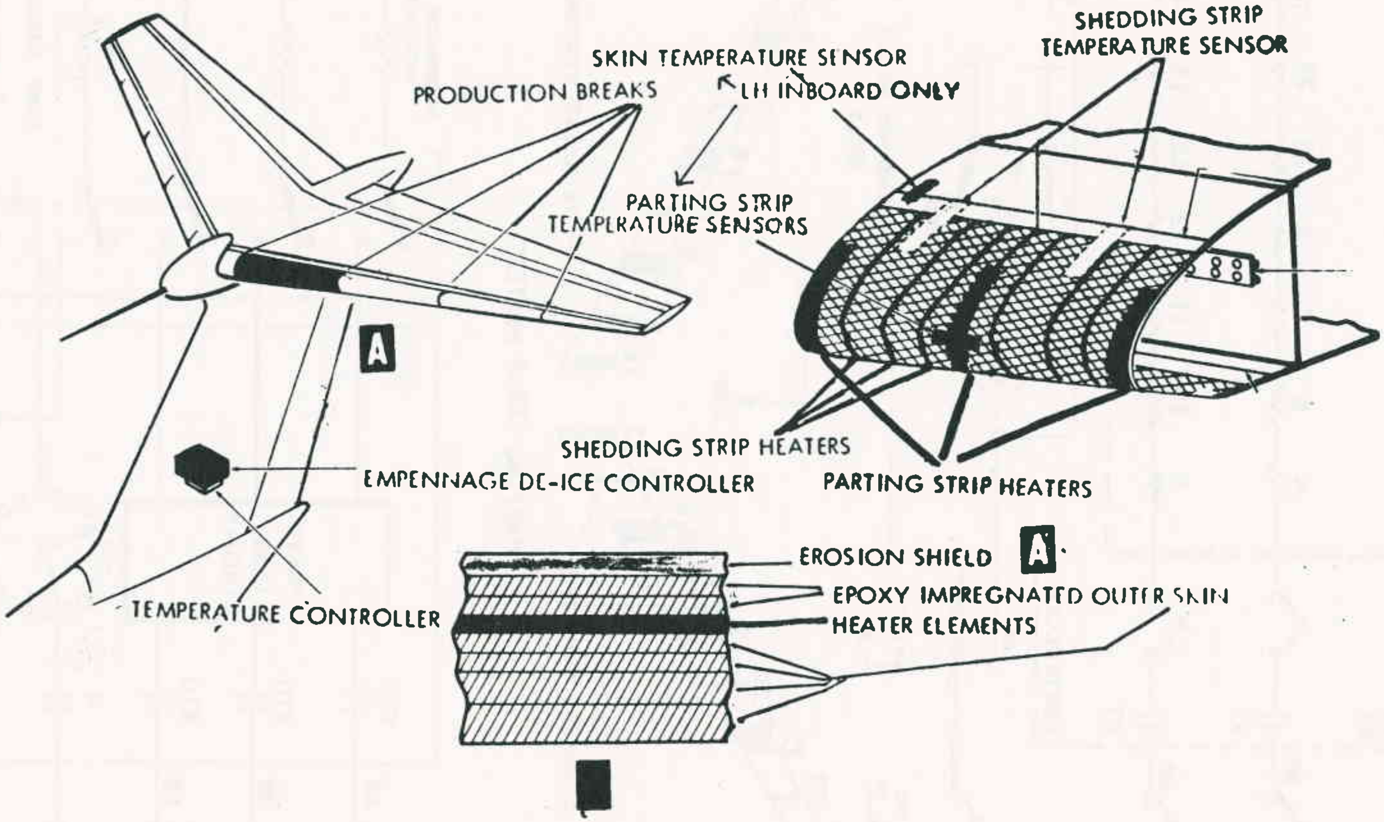
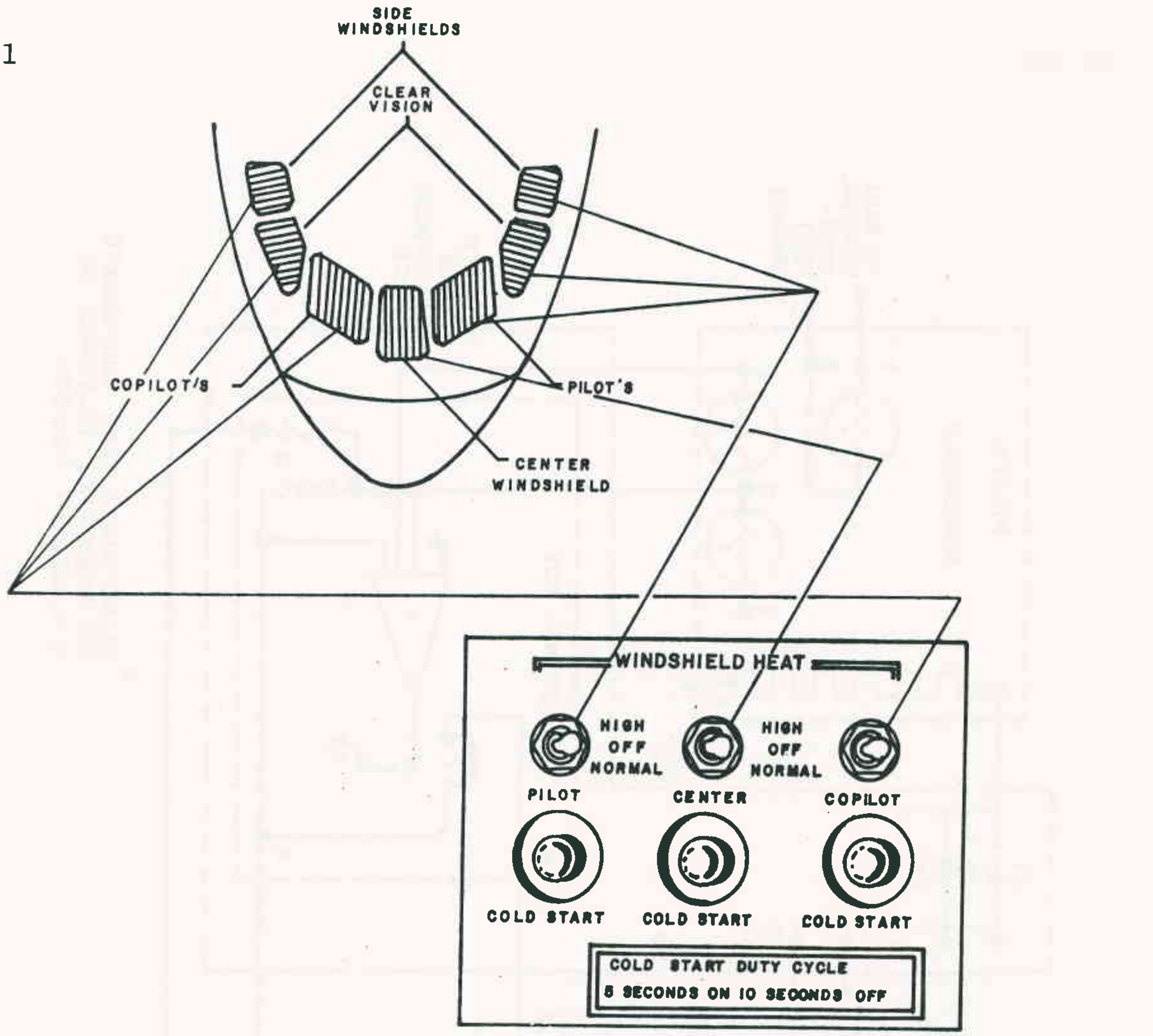
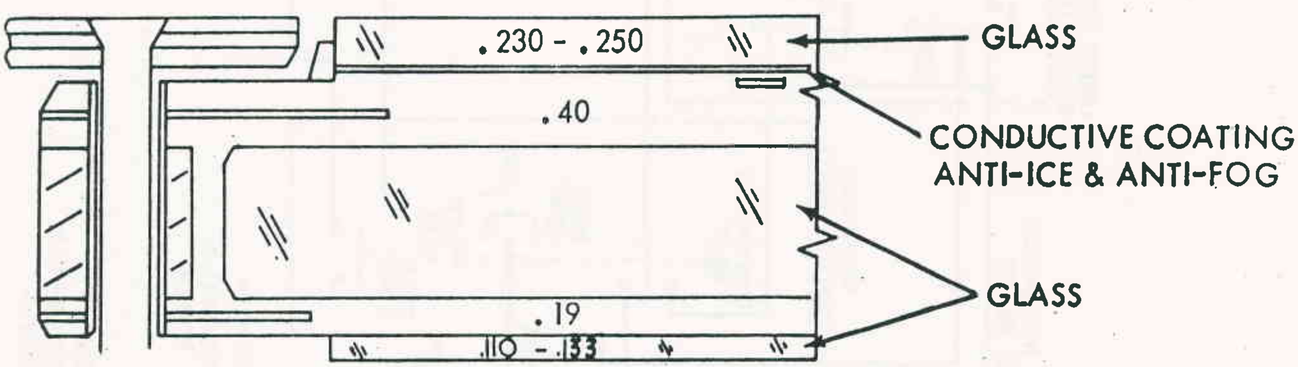
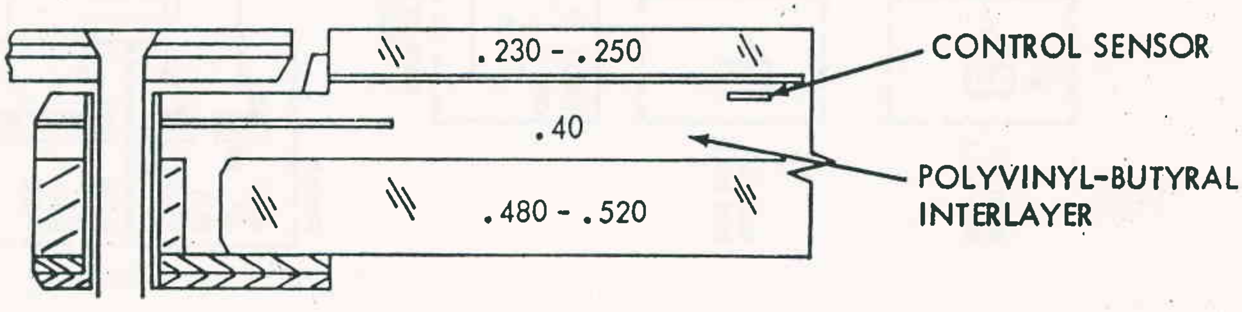

SHEDDING STRIP
TEMPERATURE SENSOR
SKIN TEMPERATURE SENSOR
LH INBOARD ONLY
PRODUCTION BREAKS
PARTING STRIP
TEMPERATURE SENSORS
A
SHEDDING STRIP HEATERS
EMPENNAGE DE-ICE CONTROLLER
PARTING STRIP HEATERS
EROSION SHIELD
A
EPOXY IMPREGNATED OUTER SKIN
HEATER ELEMENTS
TEMPERATURE CONTROLLER

Figure 6-34



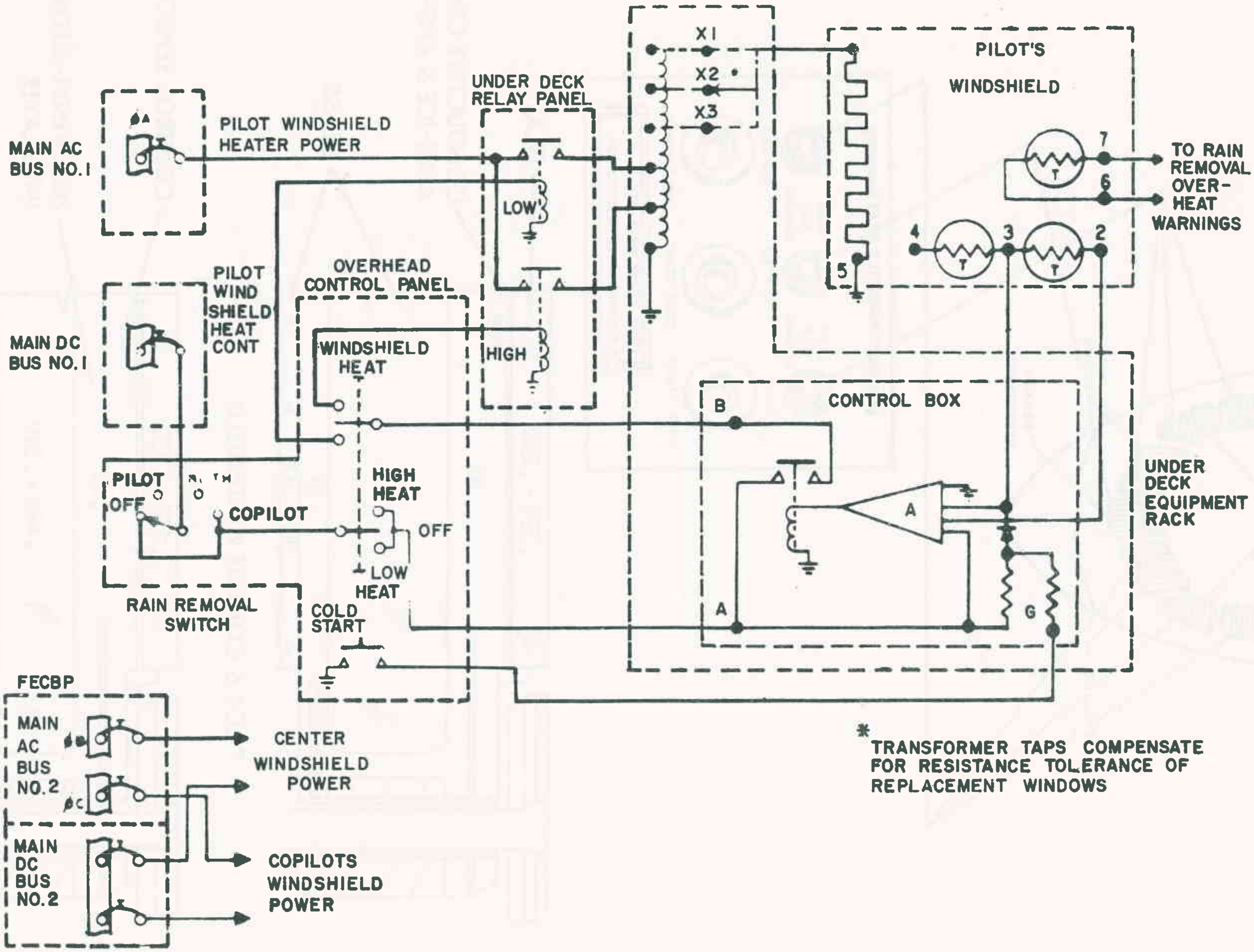


PILOT & COPILOT WINDSHIELD



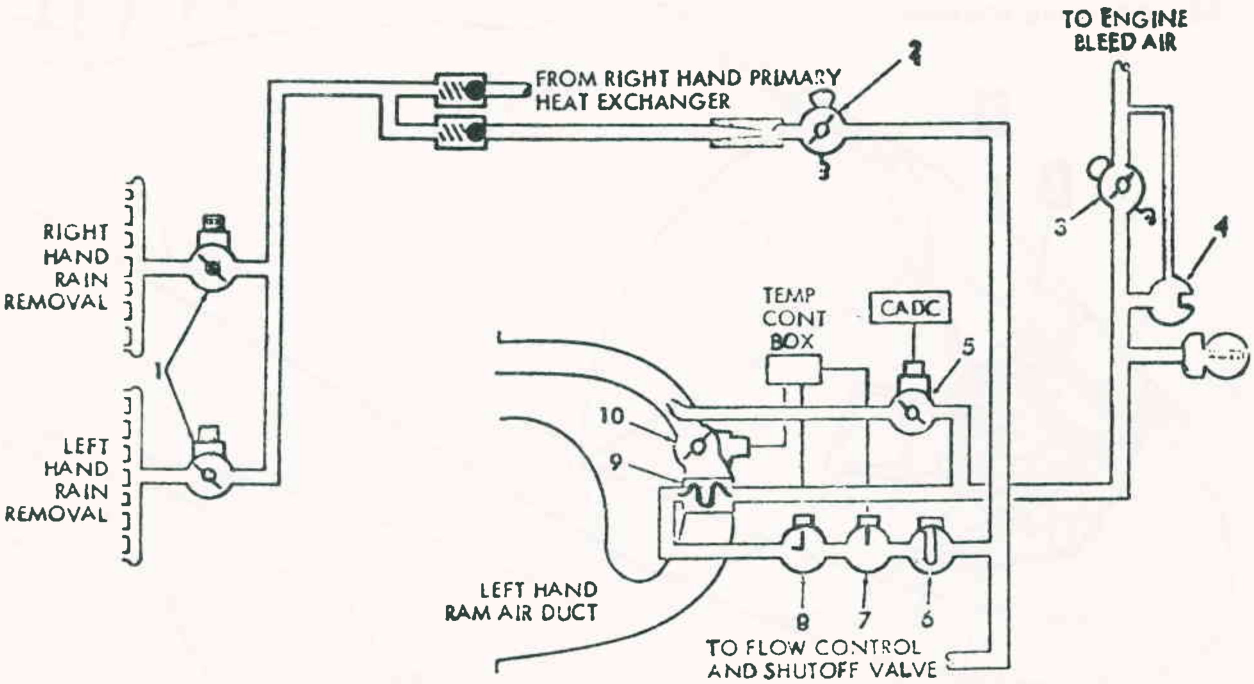
CENTER WINDSHIELD

Figure 6-35



WINDSHIELD HEAT CIRCUIT

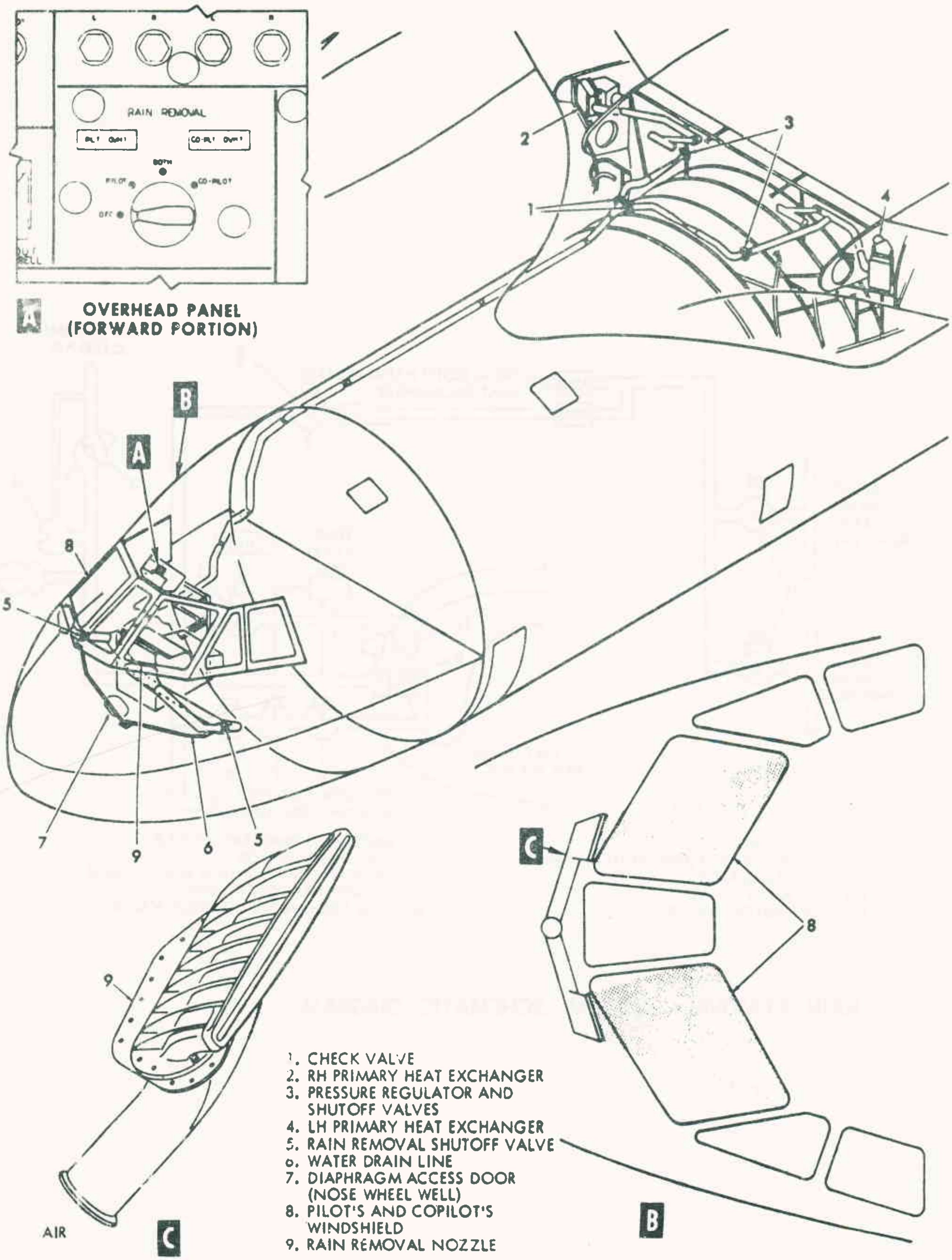
Figure 6-36



1. SHUTOFF VALVE
2. PRESSURE REGULATOR AND SHUTOFF VALVE
3. PRESSURE REGULATOR
4. PRESSURE RELIEF VALVE
5. EJECTOR SHUTOFF VALVE
6. DISCHARGE TEMPERATURE BULB
7. DISCHARGE SENSOR
8. ANTICIPATOR AND HIGH LIMIT SENSOR
9. PRIMARY HEAT EXCHANGE
10. HEAT EXCHANGER CONTROL VALVE

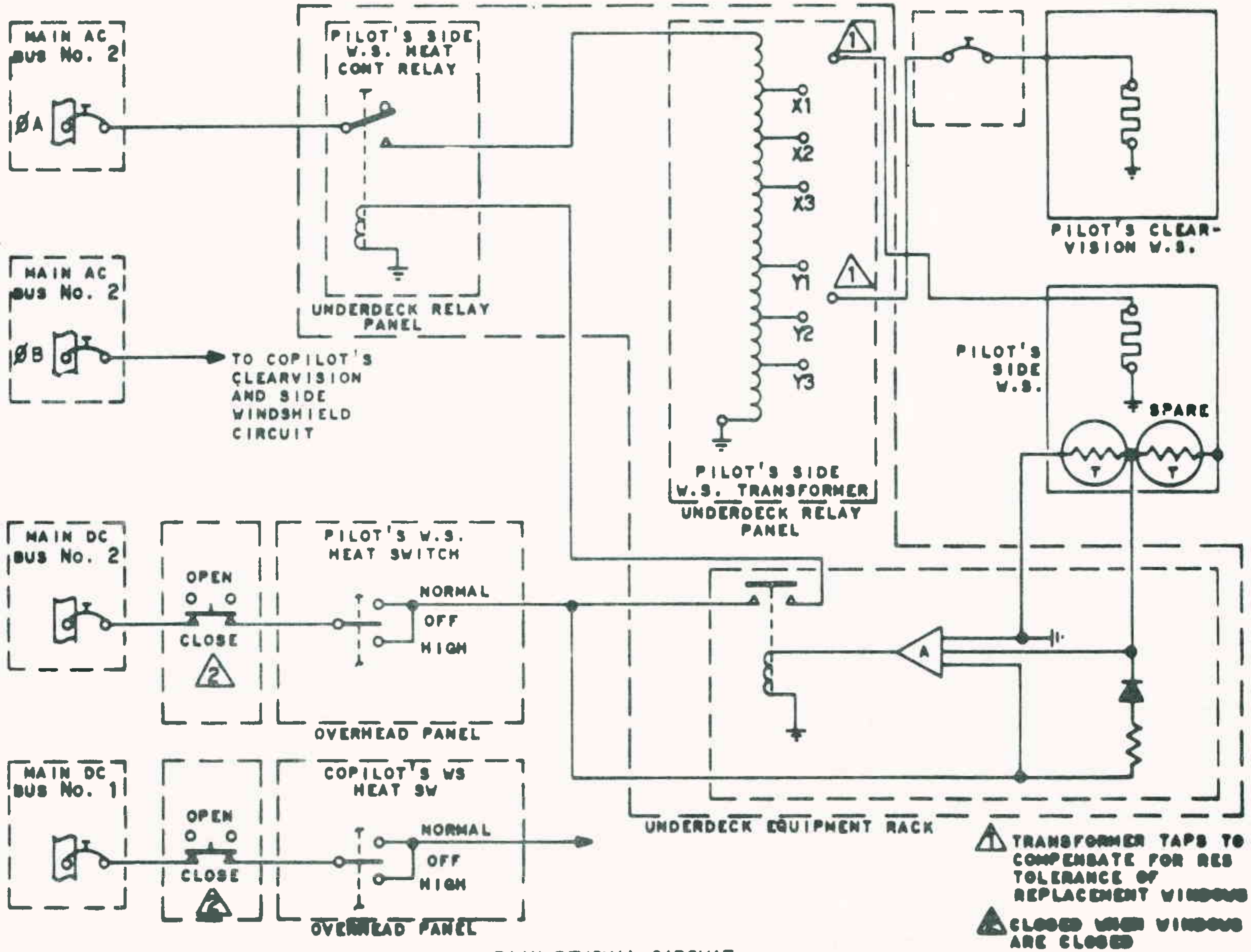
RAIN REMOVAL SYSTEM SCHEMATIC DIAGRAM

Figure 6-37



Windshield Rain Removal System Component Locations

Figure 6-38



RAIN REMOVAL CIRCUIT

Figure 6-39