CHAPTER 11
AIR CONDITIONING

INTRODUCTION

This chapter describes the Citation Mustang air-conditioning systems. Information is provided on temperature-controlled pressurized air, vapor-cycle air conditioning, and fresh air supply. Additionally, air distribution and temperature controls are discussed.

GENERAL

The Mustang uses modified engine bleed air to heat, cool, and pressurize the cockpit and cabin (pressure vessel). Bleed-air inflow also defogs cabin and cockpit windows. The hot engine bleed air is cooled by heat exchangers, regulated by valves, and enters the cabin through separate ducts on the left and right sides.

Outflow valves regulate the outflow of this cabin-air supply to control the air pressure (and resulting pressure altitude) of the cabin (refer to Chapter 12—"Pressurization").

The cabin-air supply is normally provided by bleed air from both engines; however, either engine can supply enough air to the cabin. The system can operate with complete or partial loss of DC power; however, temperatures will be within 30° above ambient.

A conventional vapor-cycle air-conditioning system provides further cooling and defogging, especially on the ground or at low altitudes on hot days. It moves refrigerant fluid through heat exchangers to extract heat from the cabin, then routes the fluid to another heat exchanger to vent the heat overboard. If either generator fails in flight, the vapor-cycle system is load-shed (powered off to conserve DC power).

A separate fresh-air vent system allows direct cockpit and cabin ventilation when unpressurized (at low altitudes or on the ground). It requires DC power.

These three air-conditioning subsystems (bleed air, vapor cycle, and fresh-air supply) are regulated by air-distribution and temperature-control systems. Engine indicating and crew alerting system (EICAS) indications advise the crew of system status.

TEMPERATURE-CONTROLLED BLEED-AIR INFLOW

In flight, cabin temperature is provided by hot bleed air from the engines, which is conditioned to appropriate warm temperatures by heat exchangers before entering the cabin.

DESCRIPTION

Bleed-Air Supply

The left engine supplies air to the cockpit (Figure 11-1). The right engine supplies air for the cabin area. Each system is separate and independent, so that a failure of either system does not prevent the other from operating.

All bleed-air inflow to both zones flows aft through the cabin and exits through the outflow valves in the aft pressure bulkhead (refer to Chapter 12—"Pressurization").

Bleed-Air Temperature Control

Before entering the cabin, hot, high-pressure bleed air from each engine passes through an air-to-air heat exchanger in the engine pylon. Outside (ambient) ram-air enters the pylon ram air inlet, passes through the heat exchanger, flows over the bleed-air ducts, and exits overboard through a temperature control valve, carrying away most of the heat from the engine bleed air. (The bleed air and ambient ram air do not mix.)

A temperature control valve limits the ambient ram-air flow through each ram-air duct (and through the heat exchanger) to limit how much the heat exchanger can cool the engine bleed air. This indirectly controls the temperature of the bleed air entering the cabin.

For each system (cockpit/left engine and cabin/right engine) the temperature control valve is positioned by a thermal actuator, controlled by a corresponding (cockpit or cabin) environmental printed circuit board (PCB) (Figure 11-1). The environmental PCB responds to crew commands and temperature sensors in the aircraft.

Bleed-Air Flow to Cabin Air Supply

On each side, the cooled high-pressure bleed air continues into the cockpit or cabin air supply duct through a series of valves.

Mechanical check valves prevent reverse flow of the bleed air into the engines.

An electrically controlled solenoid-driven pressure regulating shutoff valve (PRSOV) opens or closes completely to allow or to shut off the flow of bleed air on that side. Normally both shutoff valves are open.

An electrically controlled solenoid-driven flow control valve (FCV) controls the volume of air flowing in each duct, allowing either 4- or 8-ppm flow. Crew commands and electrical conditions position these valves.

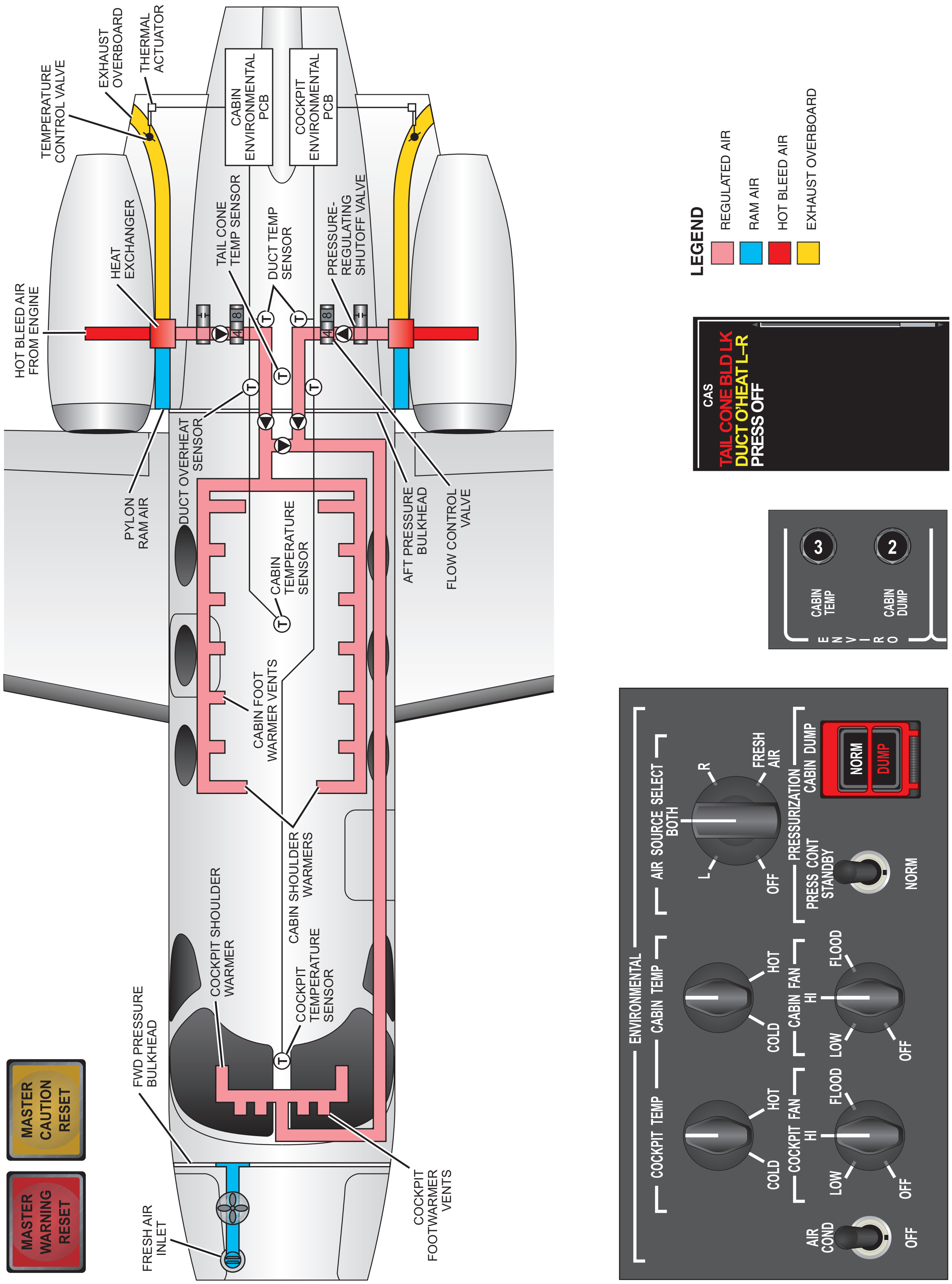

Figure 11-1. Cabin Bleed-Air Systems

Bleed-Air Distribution

Separate ducts route warm bleed air into the cockpit (from the left engine) and into the cabin (from the right engine).

The cockpit (left engine) bleed-air system routes warm bleed air to the foot warmer outlets above the pilot and copilot rudder pedals. It also provides warm bleed air to defog the side windows.

The cabin (right engine) bleed-air system routes warm bleed air to the cabin shoulder and foot warmer outlets.

Air from both bleed-air systems moves aft through the cabin and exits through the outflow valves (refer to Chapter 12—"Pressurization").

A check valve permits flow from the right engine (cabin) bleed-air system into the cockpit bleed-air system if the left engine fails. This keeps air flowing through the entire length of the aircraft interior.

COMPONENTS

Heat Exchangers and Ram-Air Ducts

Engine bleed air is cooled by a heat exchanger in each engine pylon. Engine bleed air enters and exits the precooler through bleed-air ducts. Outside (ambient) ram air enters through the pylon ram-air inlet on the leading edge of the pylon and flows into the ram-air duct. It then passes through the heat exchanger and flows over the bleed-air ducts (the bleed air and ambient ram air do not mix). Heat passes from the bleed air to the ram air through the metal walls of the separate ducts, cooling the bleed-air inside the bleed air ducts.

The heated ram air exits overboard through a temperature control valve in the ram-air duct, carrying away most of the heat from the engine bleed air. The ram air exits through the aft pylon, into the engine exhaust stream. Forward of the pylon ram air exhaust port, an eductor projects into the engine exhaust stream, creating a vacuum behind it to pull the ram air from the pylon exhaust port.

During preflight, check that the pylon ram air duct inlet and exhaust ports are clear (Figures 11-2 and 11-3).

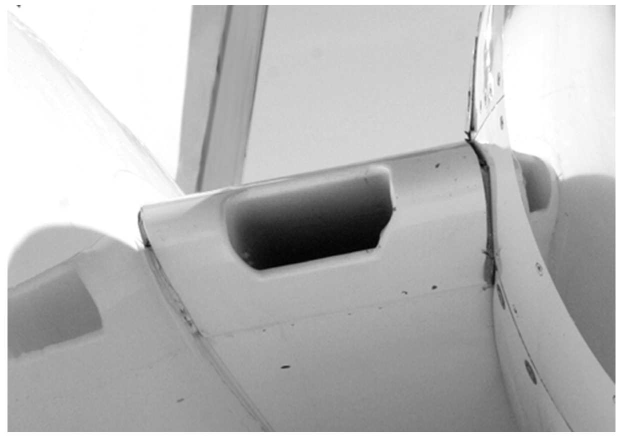

Figure 11-2. Pylon Ram-Air Duct Inlet

Figure 11-3. Exhaust Ports

Temperature Control Valves

Aft of the heat exchanger in each ram air duct, a thermally actuated temperature control valve limits the ambient ram-air flow through the duct to limit how much cooling ram air flows through the heat exchanger. This determines how much the heat exchanger cools the engine bleed air and directly controls the temperature of the bleed air before it enters the cabin.

Thermal Actuator

A thermal actuator adjusts the position of the temperature control valve. The actuator responds to the temperature of a gas inside the actuator, which is heated by an electrical heating element. The electrical heating element is powered and controlled by an environmental temperature controller.

If DC power is removed from the thermal actuator, it cools and retracts, opening its temperature control valve to maximum cooling. If the actuator fails by leaking, a spring retracts it to set the temperature control valve to maximum cooling.

Cockpit and Cabin Environmental PCBs

Each environmental PCB compares the temperature in its respective zone (cockpit or cabin) to the temperature setting selected by the crew for that zone. It then compares this to the temperature of the bleed-air supply in the ducts and powers the thermal actuator that adjusts the temperature control valve to allow more or less cooling air through the heat exchanger. The resulting heat exchanger temperature provides cooler or warmer bleed air to that zone.

Each environmental PCB (cockpit/left and cabin/right) is powered from the respective electrical feed bus. If DC power for either cockpit or cabin environmental PCB fails, the temperature control system for that zone fails to the full-cooling mode (30°F above ambient temperature).

Pressure Regulating Shutoff Valves

Each pressure regulating shutoff valve (PRSOV) is a normally open electrically actuated solenoid valve. Selecting either L or R with the AIR SOURCE SELECT knob (Figure 11- 4) energizes the opposite (left or right) PRSOV closed, limiting bleed-air inflow to the cabin from only the selected side. The left PRSOV is powered from the right feed bus No. 2. If either PRSOV loses power, the valve is spring-loaded to the open position.

Figure 11-4. AIR SOURCE SELECT Knob

Flow Control Valves

Each FCV has two openings: one allowing 4 ppm of bleed air to pass through the system from the corresponding engine, and the other allowing 8-ppm flow. Normally, both valves are deenergized to 4 ppm, for a total flow to the cabin of 8 ppm.

If either engine fails, or the crew manually selects cabin air supply from one engine only, the FCV of the supplying engine opens to the 8-ppm setting.

If power to either FCV is lost, the valve is spring-loaded to the 4-ppm position.

Duct Overheat Temperature Sensors

The duct overheat temperature sensors are downstream of the duct temperature sensors. The sensor opens or closes in response to the temperature of the bleed air in the duct. When closed, it sends a signal to the crew alerting system (CAS), which displays the AIR DUCT O'HEAT L (or R) message.

Duct Temperature Sensors

The duct temperature sensors are immediately downstream of the FCV and upstream of the overheat sensors. These duct temperature sensors signal the temperature of the bleed air to the zone PCB for that side.

Zone Temperature Sensors

The cockpit and cabin compartments each have a zone temperature sensor that detects the air temperature in that zone. The cockpit zone temperature sensor is behind the pilot instrument panel, below the cooling fan. The cabin zone temperature sensor is in the aft evaporator inlet (behind the aft cabin seats near the floor of the cabin).

The environmental PCB compares this zone temperature with bleed-air temperature reported by the duct temperature sensors and crew settings of the temperature control knobs to determine necessary automatic changes to bleed-air temperature.

Do not block the airflow at either of the zone temperature sensors. Obstructions to airflow causes errors in a sensor signal to its environmental temperature controller, resulting in incorrect temperature control for that zone.

CONTROLS AND INDICATIONS

Controls specifically for the cabin bleed-air systems are on the ENVIRONMENTAL control panel below the copilot primary flight display (PFD) (Figure 11-5).

AIR SOURCE SELECT Knob

The AIR SOURCE SELECT knob is a rotary electrical switch that selects the source(s) of air entering the cabin. To do this, it controls the PRSOVs and FCVs for the bleed-air ducts. It also controls the fresh-air fan when the aircraft is unpressurized.

OFF

The OFF position energizes both PRSOVs closed. This stops all bleed-air inflow and fresh-air inflow to the cockpit and cabin.

BOTH (Both Engines)

The BOTH position deenergizes both bleed-air PRSOVs open, allowing temperature-controlled,

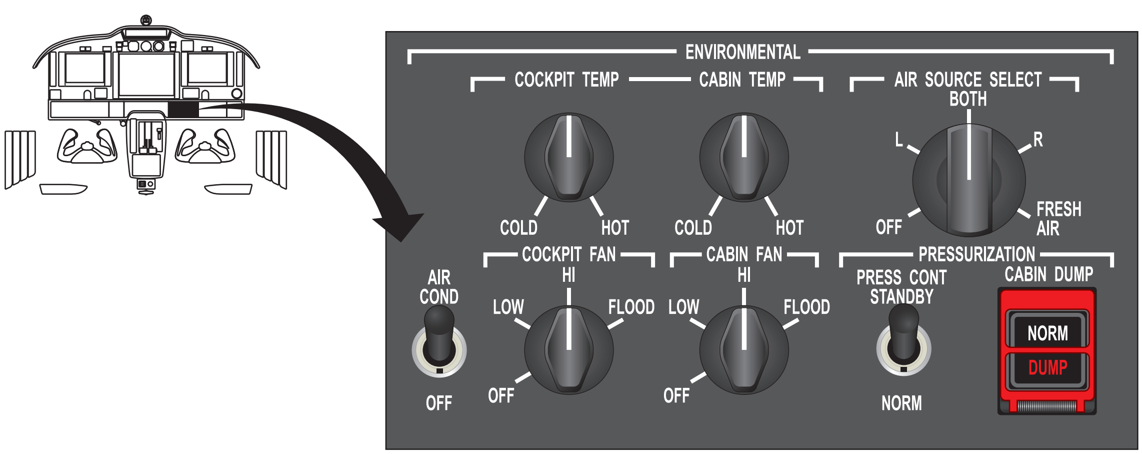

Figure 11-5. Environmental Control Panel

pressurized bleed air to both cockpit and cabin zones from their respective engines (left for cockpit, right for cabin). This also deenergizes both FCVs to 4 ppm, for a total flow of 8 ppm to the pressure vessel.

NOTE

On the ground, when the AIR SOURCE SELECT knob is set to BOTH, if cabin temperature is greater than 65°F and throttle position is less than cruise detent, the environmental PCBs automatically energize the PSROVs closed. This prevents hot air from entering a warm cabin.

L (Left Engine)

The L position energizes the opposite (right) PRSOV closed. This limits bleed-air flow to the pressure vessel from only the selected (left) engine. The right (cabin) system PRSOV closes, and bleed air flows to only the cockpit. Because all bleed air flows aft through the cabin to the outflow valves, cockpit air also supplies the cabin. This also positions the left FCV to 8 ppm for a total flow of 8 ppm to the pressure vessel.

R (Right Engine)

The R position energizes the opposite (left) PRSOV closed. This limits bleed-air flow to the pressure vessel from only the selected (right) engine. The left (cockpit) system PRSOV closes and bleed air flows only from the right engine. This supplies the cabin, but also supplies the cockpit through a check valve. This also positions the right FCV to 8 ppm for a total flow of 8 ppm to the pressure vessel.

FRESH AIR

The FRESH AIR position energizes both bleed-air PRSOVs closed. Pressurized bleed-air inflow to the cabin stops then slowly depressurizes (refer to Chapter 12— “Pressurization”). If the cabin is depressurized, fresh air is blown into the cockpit.

COCKPIT TEMP and CABIN TEMP Knobs

The crew uses the COCKPIT TEMP and CABIN TEMP knobs to set the desired temperature in the cockpit and cabin zones. Rotating the knob counterclockwise to COLD selects the coldest possible temperature and rotating the knob clockwise to HOT selects the hottest possible temperature. The normal range of both knobs is 65–85°F.

COCKPIT TEMP Knob

The crew uses the COCKPIT TEMP knob to set desired cockpit zone temperature. The left (cockpit) PCB compares the COCKPIT TEMP setting with the temperatures sensed by the cockpit zone temperature sensor and the left (cockpit) bleed-air duct temperature sensor to regulate bleed-air temperature cooling as necessary to create the desired cockpit temperature.

CABIN TEMP Knob

The crew uses the CABIN TEMP knob to set desired passenger cabin zone temperature. The right (cabin) PCB compares this setting with the temperatures sensed by the cabin zone temperature sensor and the right (cockpit) bleed-air duct temperature sensor to regulate bleed-air temperature cooling as necessary to create the desired cabin temperature.

Throttles

Throttles regulate engine power (and hence bleed-air temperature and pressure). Bleed-air temperature and pressure can be increased by increasing throttles. Throttles also determine availability of bleed air to the cabin.

On the ground, each throttle shuts off its respective PRSOV when it is retarded below approximately 85% N_2 and if the cabin temperature is above 65°F.

In flight, if a throttle is brought to cutoff, its corresponding PRSOV is shut off and the opposite FCV is switched to 8 ppm if the AIR SOURCE SELECT knob is in the BOTH position.

PRESS OFF Message

The white PRESS OFF message appears on the CAS when the crew selects the AIR SOURCE SELECT knob to either OFF or FRESH AIR. This alerts the crew there is no bleed-air inflow to pressurize the cockpit or cabin. All pressurization leaks out of the pressure vessel, which causes it to depressurize (refer to Chapter 12—“Pressurization”).

DUCT O’HEAT L (or R) Message

If either the cabin or cockpit air supply duct temperature exceeds approximately 300°F (149°C), an amber DUCT O’HEAT L (or R) message appears. A bleed-air overheat could cause damage to the nonmetal air-distribution system components within the pressure vessel. Crew action is required (refer to Emergency/Abnormal Operations). The message disappears if the temperature falls below approximately 285°F (141°C).

OPERATION

Normally, set the AIR SOURCE SELECT knob to BOTH to ensure proper pressurization inflow and adequate warm air, especially when in flight. Set the COCKPIT TEMP and CABIN TEMP knobs to the desired temperatures.

On the ground as determined by either squat switch, with the AIR SOURCE SELECT knob set to BOTH, bleed-air heat is available only if cabin temperature is below 65°F or throttles are above approximately 85% N_2.

If the AIR SOURCE SELECT knob is set to L or R, bleed-air inflow is supplied regardless of temperature, N_2 rpm, or squat switch position.

In flight, bleed-air inflow is always available.

VAPOR-CYCLE AIR CONDITIONING

DESCRIPTION

The conventional vapor-cycle system provides cool, dry air for the cockpit and passenger cabin. When the system is selected by the crew, the vapor-cycle evaporators in the cabin extract moisture and cool the air that is already in the cockpit and passenger cabin. The vapor-cycle system functions in conjunction with the temperature controlled bleed air.

A pressurized refrigerant gas circulates through the system to absorb heat from the cabin and dissipate it into the atmosphere. A DC-powered compressor compresses the refrigerant gas, heating it, then pumps it into a condenser, which transfers heat from the refrigerant to cooler ambient air passing over the condenser coils (see Figure 11-5). The cooled refrigerant condenses into a pressurized liquid.

Evaporator units depressurize the liquid refrigerant into a spray, cooling the liquid during the process. The cold spray circulates inside the evaporator coils. A fan in each evaporator unit blows interior air (cockpit or cabin air) across the cold coils, cooling and dehumidifying the air (Figure 11-6).

As the interior air transfers its heat through the heat exchanger, the refrigerant in the coils absorbs the heat, warms and vaporizes, then returns it to the compressor, carrying heat away from the aircraft interior. The refrigerant circulates continuously throughout the system, transferring heat from the interior air to the ambient air.

The forward evaporator is adjacent to the copilot seat. It provides conditioned air to the crew through two vents outboard of the instrument panel. The aft evaporator is on the aft bulkhead and provides cooling air to the passengers through individual overheat vents.

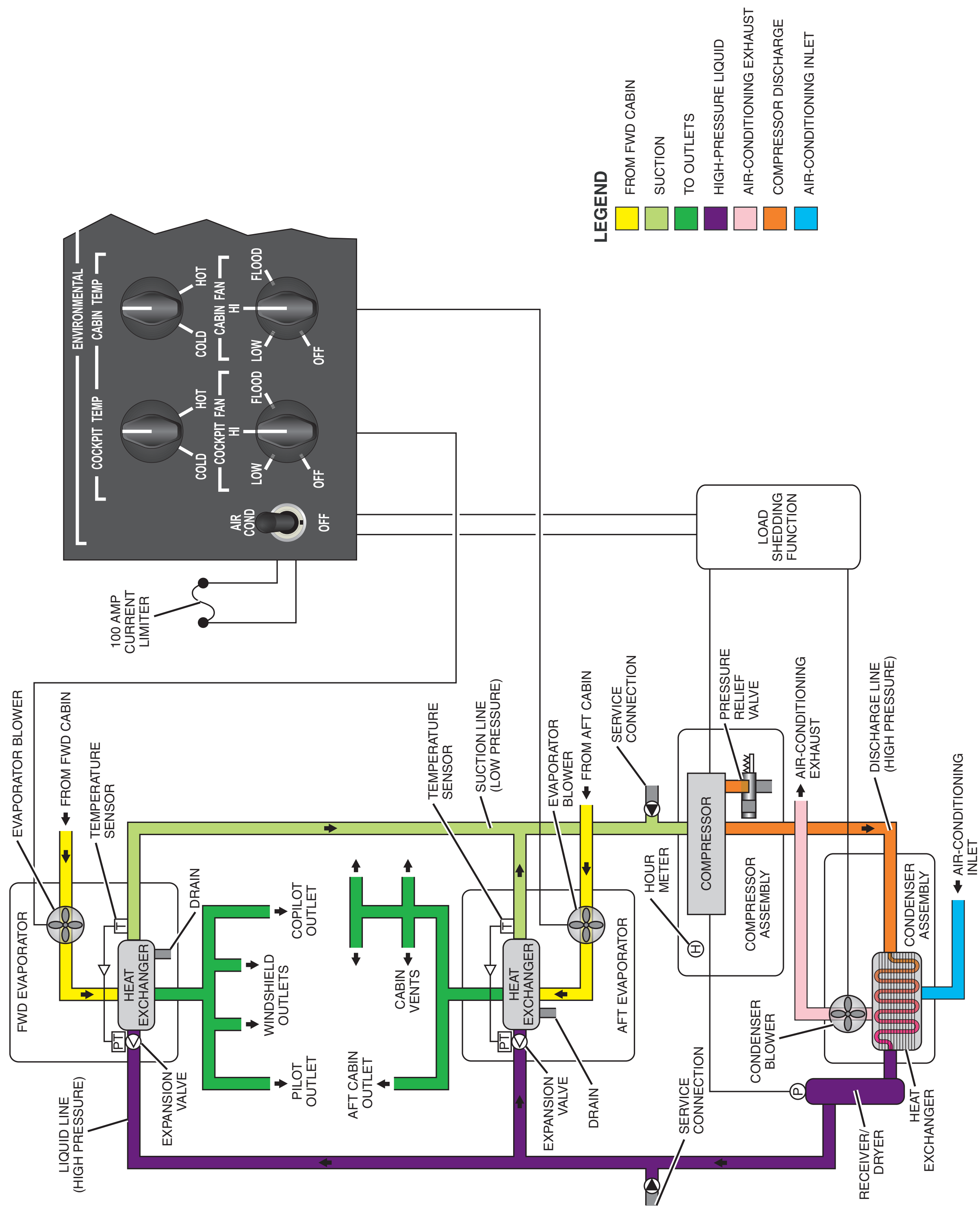

Figure 11-6. Vapor-Cycle Schematic

COMPONENTS

Refrigerant

The Citation Mustang uses R-134a-type refrigerant.

Compressor

The DC-powered compressor in the tail cone area compresses warm, low-pressure refrigerant vapor from the evaporators into a hot, high-pressure gas, then pumps it through the condenser.

On the ground as determined by either squat switch, the compressor can operate from the right generator or an external power unit (EPU). When airborne, it only operates when BOTH generators are operating. If a generator fails while airborne, the compressor is automatically load-shed (disconnected from DC power to reduce electrical loads).

The compressor operation hours are not the same as aircraft hours. A separate hourmeter for the compressor is on the compressor assembly, above the battery in the tail cone. To read the hourmeter, access it through a panel directly opposite the baggage door on the right forward side of the baggage compartment.

Condenser

The condenser is in the tail cone and cools the hot, high-pressure refrigerant gas flowing from the compressor prior to entry into the cabin pressure vessel. It utilizes finned coils through which the refrigerant gases flow to derive a cooling benefit from transient, ambient air, thereby acting as a heat exchanger.

This ambient, atmospheric air is ducted through the condenser by an inlet on the right side of the aft tail cone. The cooling air is then routed over the condenser coils, allowing for the transfer of heat, and then is ducted overboard through a duct on the upper right side of the tail cone.

Evaporators

There are two evaporators in the vapor-cycle system. Cold refrigerant chills the evaporator coils. Electrically powered blowers push cabin air over the cold evaporator coils and then force the cold air into the cabin air distribution system.

Water vapor from the cabin air condenses on the evaporator coils and the liquid water is routed overboard through two heated vents under the fuselage (one near each evaporator) (Figure 11-7). This dehumidifies cabin air.

Figure 11-7. Evaporator Drains

CONTROLS AND INDICATIONS

Controls specifically for the vapor-cycle air conditioning are on the ENVIRONMENTAL control panel.

AIR COND Switch

The AIR COND switch activates the vapor cycle system when selected on, provided either or both fan switches are also selected to an operationally energized position (i.e., LOW, HI, or FLOOD).

COCKPIT FAN and CABIN FAN Switches

Switches electrically energize the fans at the forward (cockpit) and aft (cabin) evaporators, to push interior air over the cold evaporator coils and into the interior through ducts:

- The LOW, HIGH, and FLOOD positions direct air through individually adjustable cockpit and cabin outlets.
- The OFF position deenergizes the fan.

OPERATION

To operate the vapor-cycle air conditioning system, select the AIR COND switch to AIR COND and select either (or both) fan switches to any position other than OFF.

FRESH AIR AND FANS

DESCRIPTION

A separate fresh-air system is in the cockpit between the copilot rudder pedals. If FRESH AIR is selected with the AIR SOURCE select knob, the duct (Figure 11-8) routes fresh air to the cockpit and an electric fan blows the air through the duct into the cockpit, between the copilot rudder pedals.

When the aircraft is pressurized, a check valve in the fresh-air duct closes and fresh air does not enter the cabin. This prevents cabin pressure from leaking out through the fresh-air duct.

Figure 11-8. Fresh Air Inlet

Additional circulation of air in the cabin is provided by the evaporator fans. They route cabin air through the evaporators and then through ducts to cabin outlets. The fans can be directly commanded by the crew when the vapor-cycle system is not operating.

CAUTION

The FRESH AIR position on the AIR SOURCE SELECT knob shuts off pressurized bleed-air inflow. The cabin will depressurize at nominal leak rate.

CONTROLS AND INDICATIONS

AIR SOURCE SELECT Knob

The AIR SOURCE SELECT knob, when set to FRESH AIR, energizes the fresh-air fan. If the AIR SOURCE SELECT knob is at any other position, the fresh-air fan is deenergized (refer to Temperature-Controlled Bleed-Air Inflow earlier in this chapter).

OPERATION

When on the ground or in unpressurized flight, if fresh-air ventilation is desired, set the AIR SOURCE SELECT knob to FRESH AIR.

At any time that increased circulation of air in the cabin is desired, set either the COCKPIT FAN or CABIN FAN fan switch (or both switches) to any setting other than OFF.

EMERGENCY/ABNORMAL

For specific information on emergency/abnormal procedures, refer to the appropriate abbreviated checklists or the FAA-approved *Airplane Flight Manual (AFM)*.