CHAPTER

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CHAPTER 75

AIR

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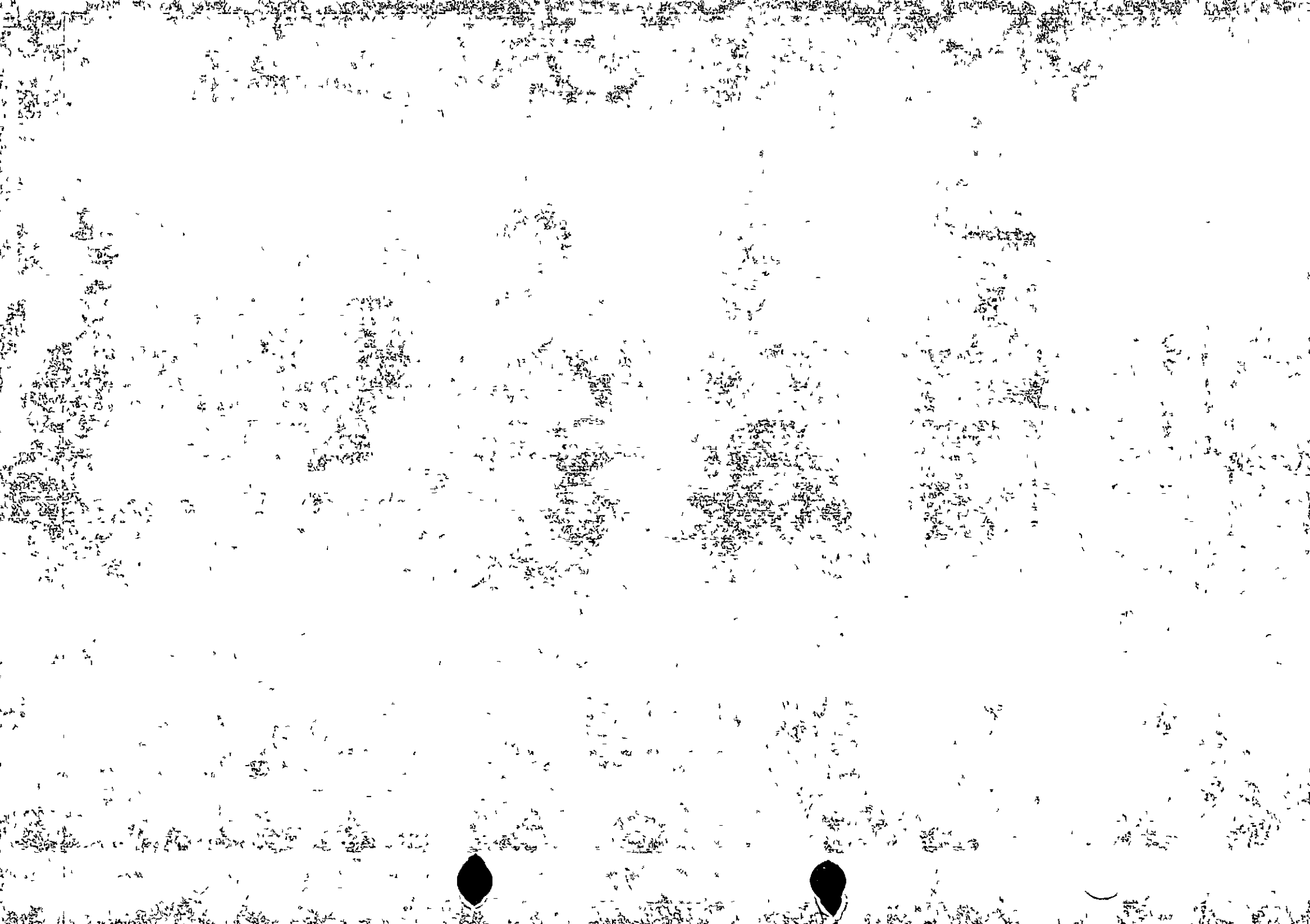


AIR SYSTEMS - DESCRIPTION AND OPERATION

1. General

A. A supply of both high and low pressure air is obtained from bleed ports located on the engine intermediate and diffuser casings. The bleed port on the intermediate compressor case furnishes the low pressure, medium temperature air for the airplane thermal anti-icing system. Similar bleed ports located in the diffuser case provide high pressure, high temperature air to drive the turbocompressor, to pressurize the hydraulic reservoir, to supply air to the oil cooler ground air ejector on turbojet engines, to anti-ice the engine air inlet section and nose cowl, and to actuate the thrust reverser. (See 75-6-0.)

B. On turbofan engines, a compressor bleed system is incorporated to relieve pressure from the front compressor through a large diameter overboard discharge bleed valve, controlled by a pressure sensitive pneumatic actuator.

C. For further information on systems utilizing engine high and low pressure compressor bleed air refer to the following

HIGH PRESSURE BLEED AIR		LOW PRESSURE BLEED AIR	
System	Chapter	System	Chapter
Engine Fuel Deicing System	28	A-C Generator Drive System	24
Hydraulic System	29	Ice and Rain Protection Systems	30
Pneumatic System	21, 36		
Thrust Reverser Control System	78		

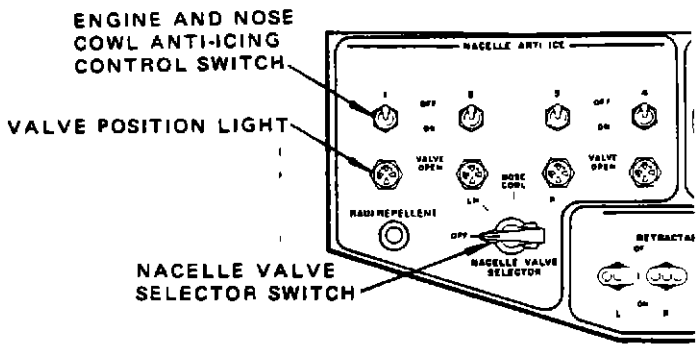
ENGINE AND NOSE COWL ANTI-ICING SYSTEM - DESCRIPTION AND OPERATION

1 General

A. The engine and nose cowl anti-icing systems provide thermal ice protection for the engine compressor inlet guide vane and shroud assembly, the engine nose dome, and the nose cowl. (See figure 1.) This protection also extends to the turbocompressor air inlet and air scoop, and the inlet pressure probe of pressure ratio system in the engine strut. The system utilizes hot, high pressure air from the engine diffuser case and directs it to the inside surfaces requiring anti-icing. Part of the air is then exhausted into the engine compressor while the remainder is exhausted overboard through an opening in the bottom of the nose cowl.

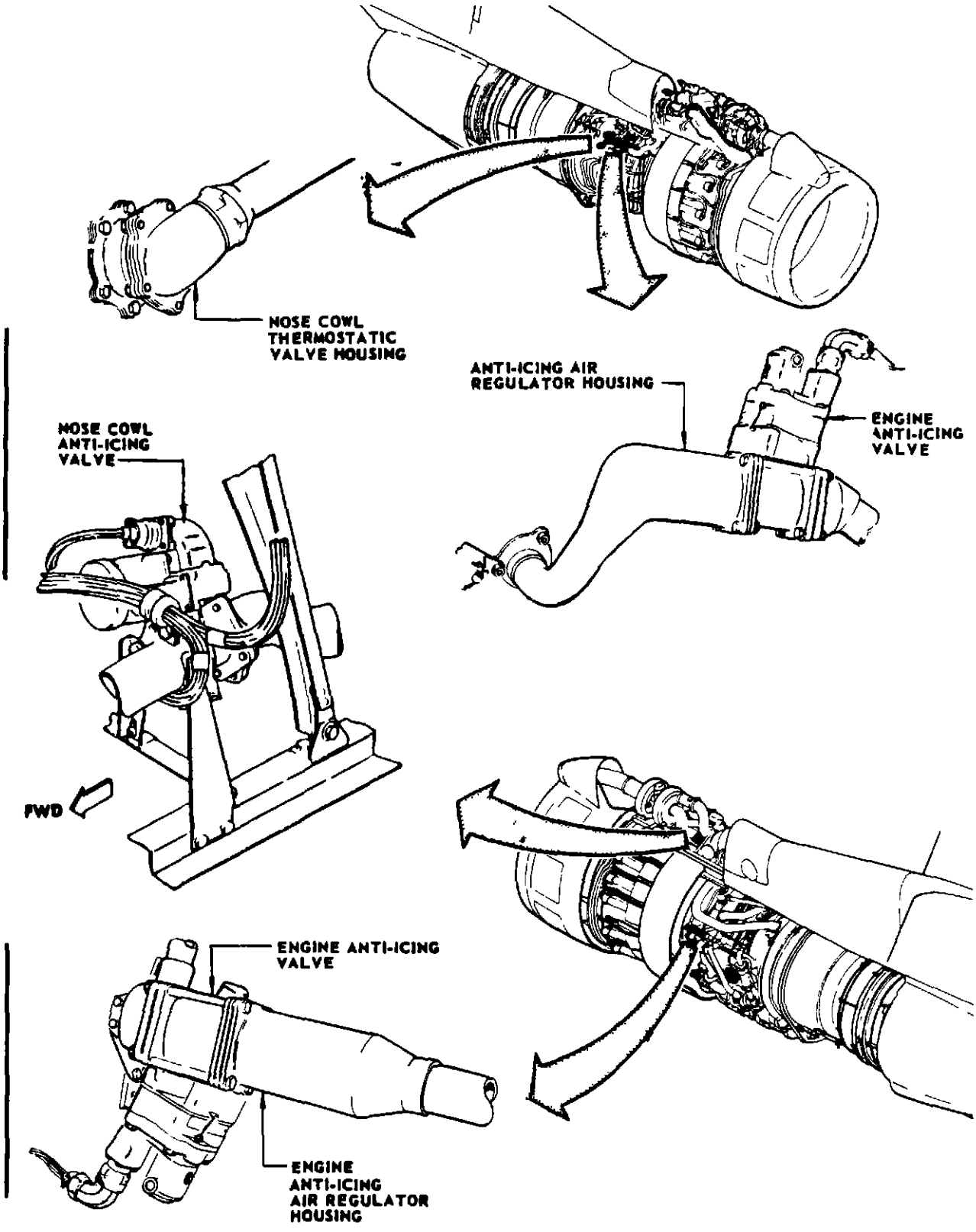
B. Engine and nose dome anti-icing air is drawn from the left and right side of each engine. An anti-icing valve and an air regulator are included in each line to control the flow.

C. Nose cowl anti-icing air is supplied from the right side of each engine. An anti-icing valve, thermostatic valve and an air ejector are installed in the line. The air ejector restricts the flow of air and controls the temperature by drawing ambient air into the nose cowl to mix the hot air from the engine.



OVERHEAD PANEL

Engine and Nose Cowl Anti-Icing System Equipment Location
Figure 1 (Sheet 1)



Engine and Nose Cowl Anti-Icing System Equipment Location
Figure 1 (Sheet 2 of 2)

D. The engine and nose cowl anti-icing valves are controlled by the nacelle anti-ice switches in the control cabin (See figure 1) A valve position light for each engine and a nacelle valve selector switch make it possible to determine from the control cabin if the valves have opened after the nacelle anti-ice switch for any engine has been positioned to "ON" ("OPEN"). The valve position light will illuminate when the nacelle valve selector switch is positioned to either 'LH,' "NOSE COWL" or "RH." Failure of the light to illuminate at any selector switch position indicates failure of that particular valve to have opened. On AF, TWA and USAF airplanes, it is also possible to determine if the valves have closed after the nacelle anti-ice switch for any engine has been positioned to "OFF" ("CLOSE"). Illumination of the valve position light on these airplanes indicates that each valve is in the same position as the nacelle anti-ice switch

2. Engine Anti-Icing Valve

A. The engine anti-icing valves are motor operated, butterfly type valves which are either fully open or closed according to switch position Two valve configurations are used on JT3D engines One type has a circular mounting flange with six bolt holes equally spaced around each flange. The other has square mounting flanges with four bolt holes in each flange, one at each corner.

B. The engine anti-icing valves are installed between the forward and rear anti-icing tubes on each side of the engine (See figure 1)

3. Engine Anti-Icing Air Regulator

A. Identical engine anti-icing air regulators are located on the left and right side of each engine (See figure 1.) The regulator valves are controlled by bimetallic coils connected to a moving sleeve The sleeve covers or uncovers holes in the regulator housing thus forming a variable orifice controlling the flow of air The setting of the regulators is such that they are fully open with 70°F (21°C) at the bimetallic coils and nearly closed (end of travel) with a 620°F (327°C) air temperature. If inlet air to the engine is heated, there will be a thrust loss; thus, the engine anti-icing system is designed to limit the quantity of air to no more than is necessary to control icing

4 Nose Cowl Anti-Icing Valve

A. The nose cowl anti-icing valve is a butterfly type valve Two types of valves are used: one type is operated by a reversible 28-volt d-c electric motor, the other type is operated by pneumatic pressure the direction of which is controlled by a solenoid. A position indicator, on each valve, enables the position of the valve butterfly to be verified

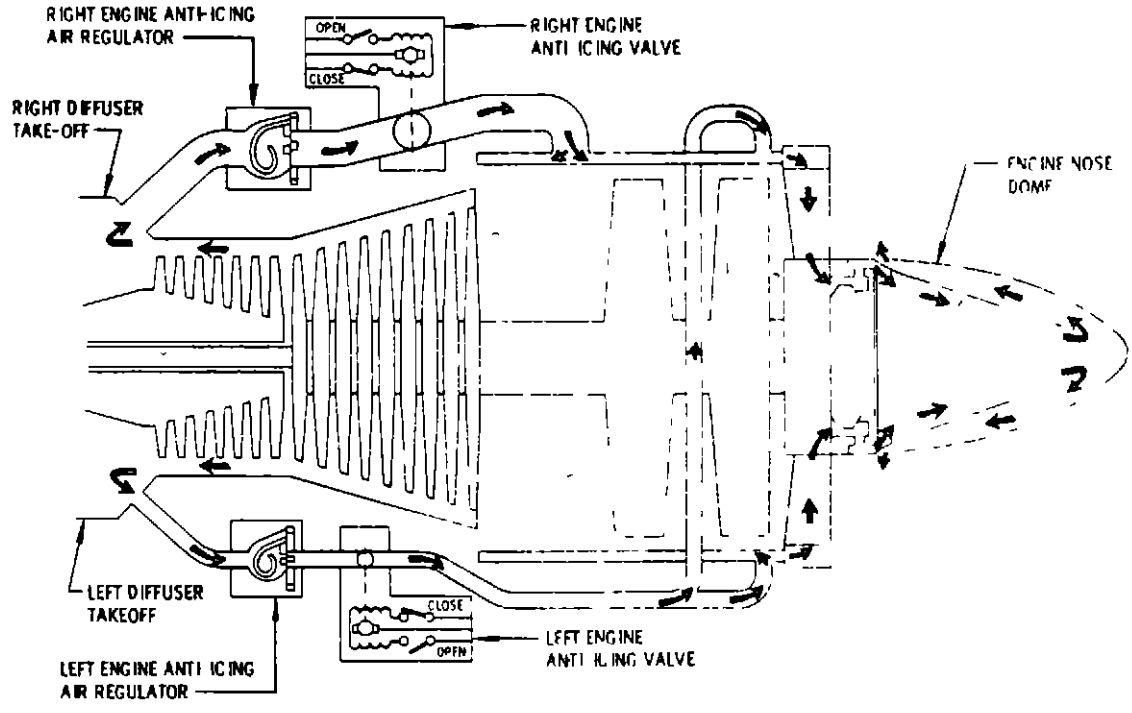
B. The nose cowl anti-icing valve is located on the left side of the engine above the forward reverser slot seal.

5 Nose Cowl Anti-Icing Thermostatic Valve

A. The nose cowl anti-icing thermostatic valve is bolted to the diffuser case on the right side of the engine. The purpose of the unit is to provide an orifice which varies with temperature to control the flow of air within the ducting. The valve is controlled by bimetallic coils connected to a moving sleeve. The extent and direction of movement is in accord with the expansion or contraction of the coils caused by variation in temperature. This rotation of the sleeve, covers or uncovers holes in the valve housing thus forming a variable orifice controlling the flow of air. The unit is capable of operating with a pressure of 250 psia on the upstream side of the unit, through the temperature range of -65°F to 790°F, and can operate at prolonged temperatures of 810°F The unit is made of corrosion resistant materials to resist the effects of compounds normally associated with high temperature jet engine pneumatic systems.

6. Operation

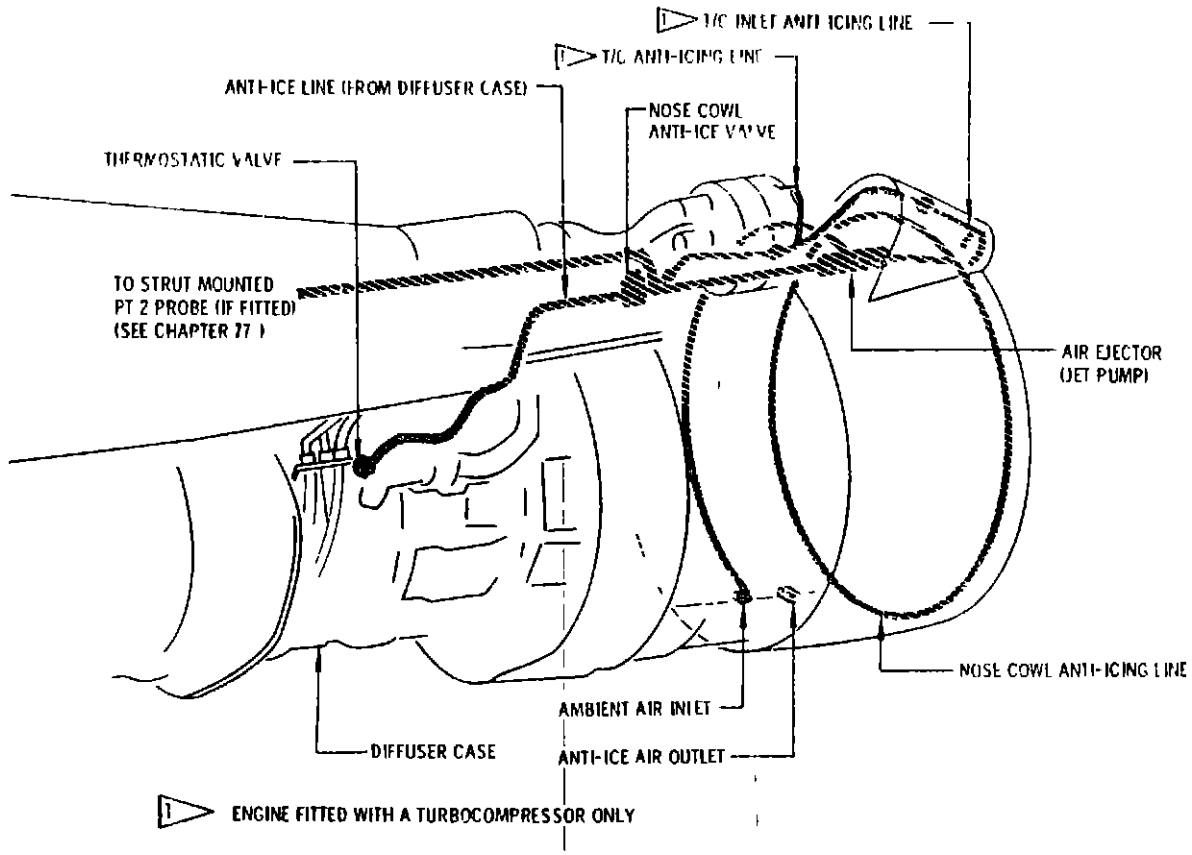
A. The engine anti-icing system picks up hot compressed air from the engine diffuser case. (See figure 2.) One external line on the left side of the engine, ducts the air forward to an engine anti-icing air regulator and engine anti-icing valve, and then into two smaller lines to the outer ring of the inlet guide vane and shroud weldment The right shroud fitting is at the four o'clock position and the left shroud



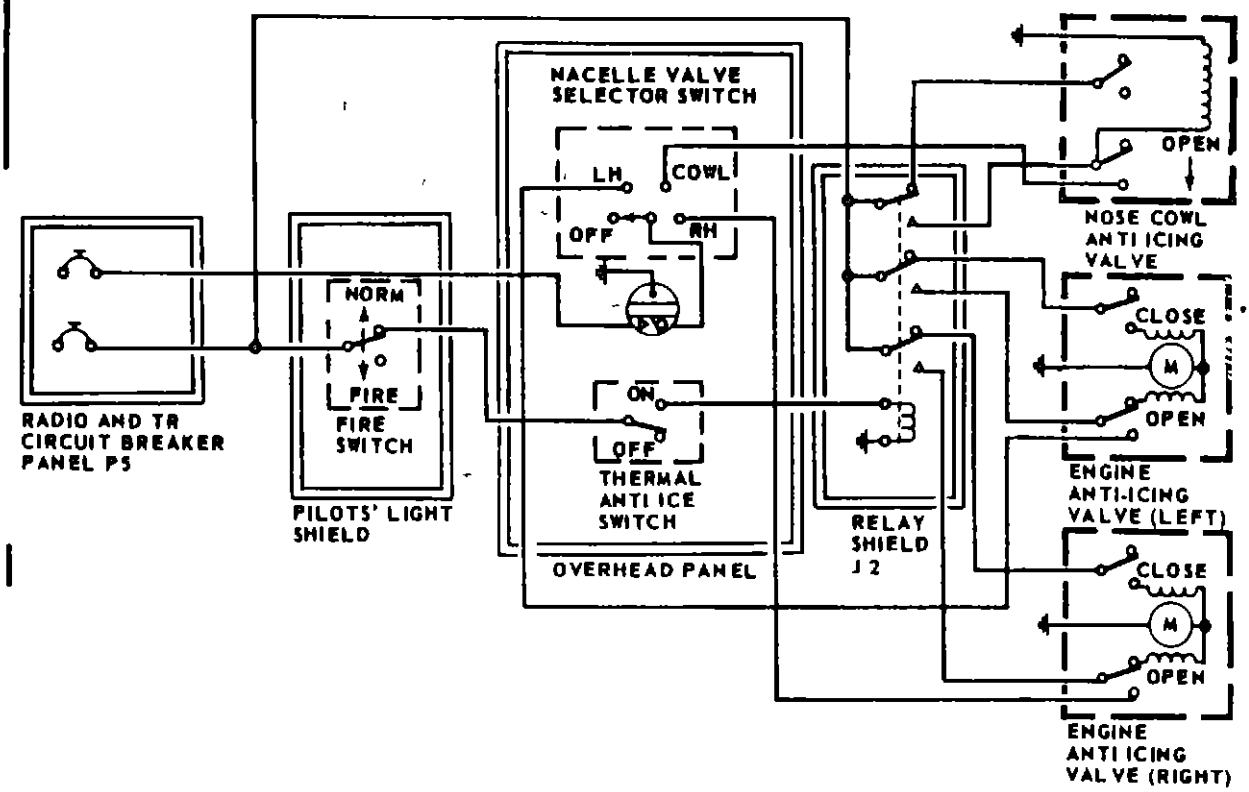
Engine and Nose Dome Anti-Icing Flow Diagram
Figure 2

fitting is at the eight o'clock position From the space between the outer shroud walls, the air travels inward through each inlet guide vane to the inner shroud ring The air then passes out the forward edge of the shroud ring to the engine nose dome and is exhausted into the engine compressor inlet through a louver at the lower rear of the nose dome At the two o'clock position on the right side of the engine a second anti-icing line ducts air through a regulator and an engine anti-icing valve to the fan section shroud. The air passes through the double wall shroud to the inlet guide vanes and nose dome

B The nose cowl anti-icing system picks up hot compressed air from the engine diffuser case (See figure 3) Air is ducted forward by an external line on the right side of the engine, through the thermostatic valve and the nose cowl anti-icing valve, to the nose cowl Ambient air is mixed with the high temperature air to prevent excessive heating of the nose cowl structure. The ambient air supply is drawn through an ambient air inlet (located at the bottom of the nose cowl) by means of a jet pump. The heated mixture is directed onto the interior surfaces of the nose cowl by means of a perforated distribution tube The air is then exhausted overboard through a port in the bottom of the nose cowl A smaller air duct directs anti icing air



Nose Cowl Anti-Icing Flow Diagram
Figure 3



TYPICAL ALL FOUR ENGINES

Engine and Nose Cowl Anti-Icing System Circuit
Figure 4

to the turbocompressor air inlet and air scoop. The nose cowl anti-icing valve on each engine is controlled by the same switch as the engine anti-icing valves for that engine.

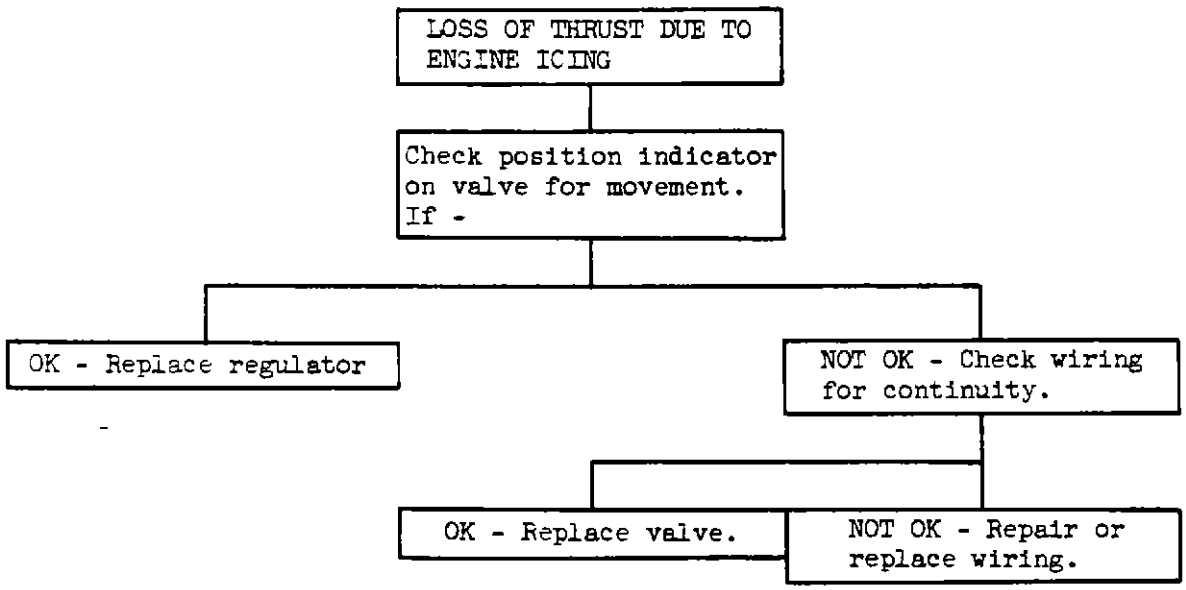
C. The three anti-icing valves on each engine are controlled by a single anti-icing control switch, located on the overhead panel together with four valve position lights and a single rotary selector switch. The selector switch has four positions, "OFF," "LH," "NOSE COWL" and "RH." The switch is rotated from the "OFF" position whenever confirmation of individual valve position is required. (See figure 4.) Simultaneous indication for all four engines is given at each selector switch position. Failure of an indicator light to illuminate upon selection indicates failure of the respective valve to have opened. Upon selection of the fire switches to the fire position, the anti-ice valves on the respective engines will close

ENGINE AND NOSE COWL ANTI-ICING SYSTEM - TROUBLE SHOOTING

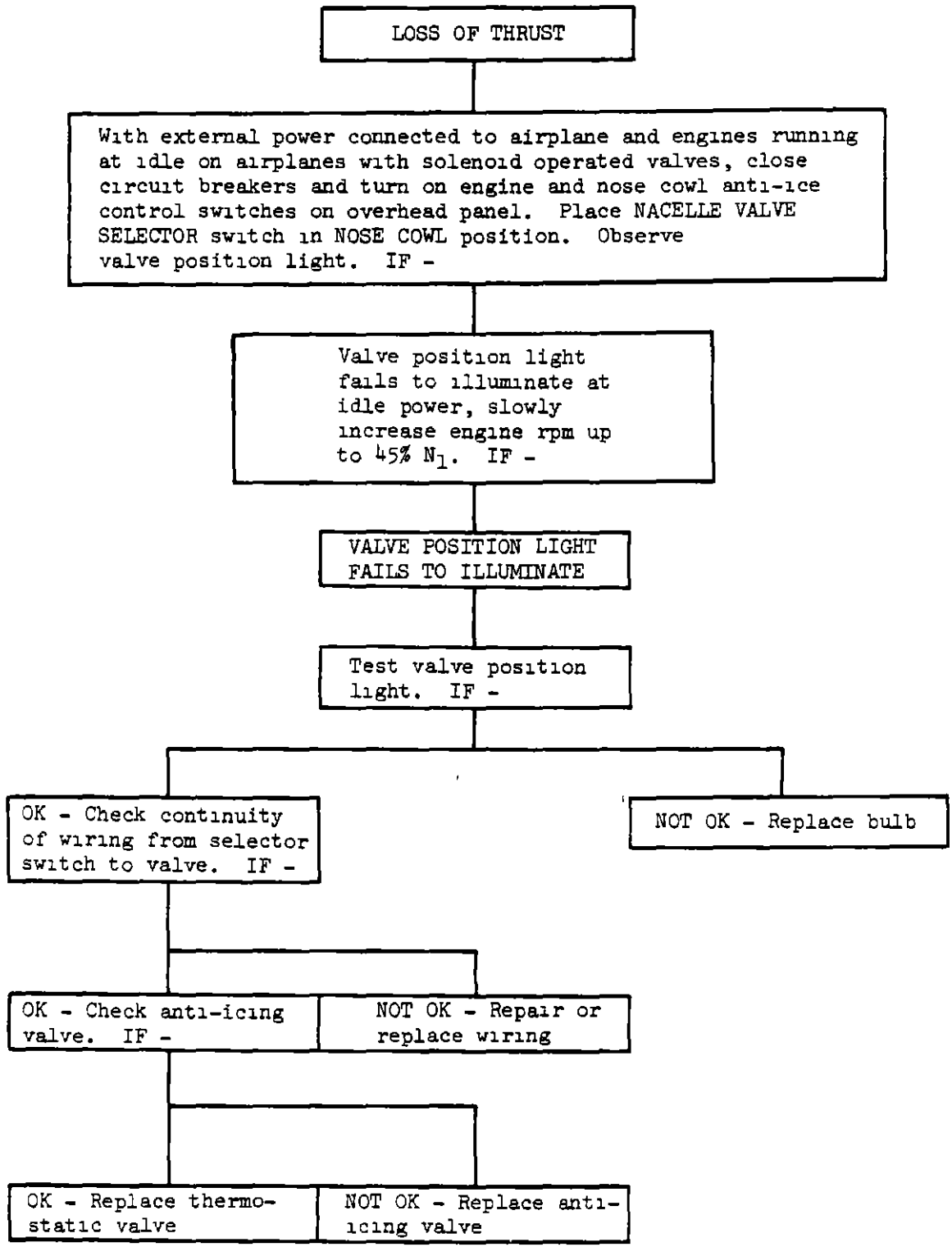
1 General

A. Trouble shooting for this system is accomplished through the use of two individual trouble shooting charts. One chart is used for the engine anti-icing system and the other chart for the nose cowl anti-icing system

2 Engine Anti-icing System Trouble Shooting Chart



3. Nose Cowl Anti-Icing System Trouble Shooting Chart



ENGINE ANTI-ICING AIR REGULATOR - MAINTENANCE PRACTICES

1. Removal/Installation Engine Anti-Icing Air Regulator

A. Remove Engine Anti-Icing Air Regulator (See figure 201.)

(1) Open four engine anti-icing system circuit breakers on circuit breaker panel P5.

(2) Open engine left or right side cowl panel as required.

(3) Disconnect electrical connector at valve assembly.

(4) Remove bolts securing rear anti-icing tube to engine diffuser case. Ensure that parts do not fall into engine diffuser case

CAUTION: IF PARTS FALL INTO ENGINE DIFFUSER CASE, THEY MUST BE RETRIEVED BEFORE ENGINE IS OPERATED OR INTERNAL ENGINE DAMAGE MAY RESULT.

(5) At left side of engine, remove clamps securing rear anti-icing tube to fuel heater deicing air supply tube and P&WA plumbing tube

(6) Remove bolts securing left anti-icing valve between anti-icing tube flanges, support valve and move rear anti-icing tube aft enough to remove air regulator from rear anti-icing tube.

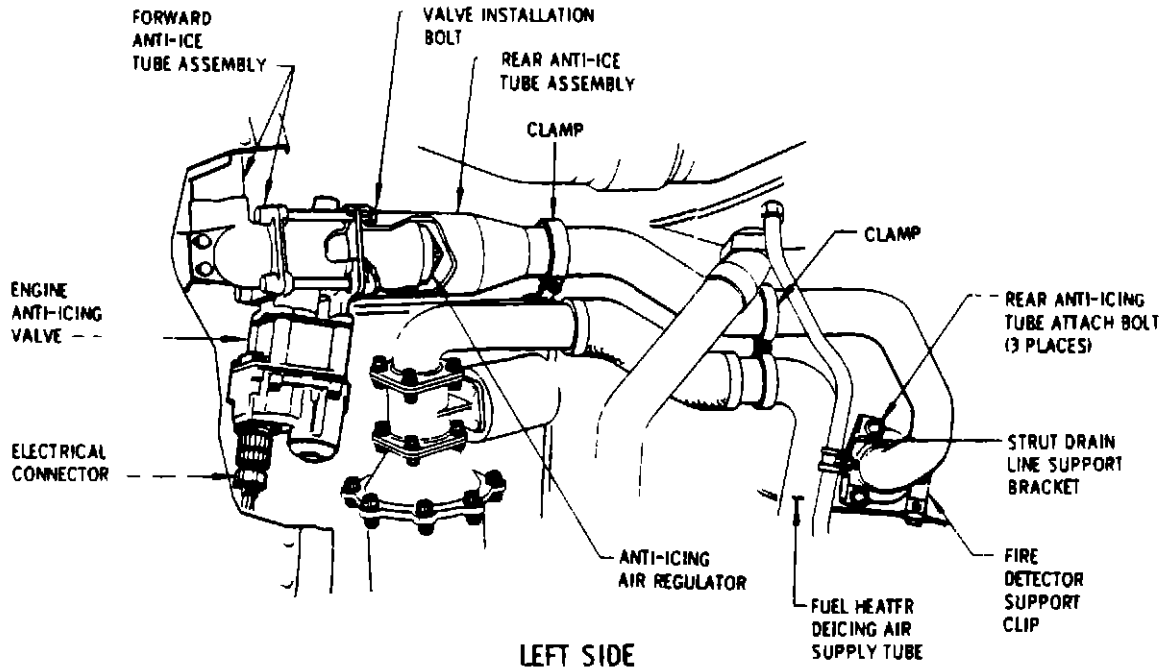
(7) At right side of engine, remove bolts securing aft flange of anti-icing valve to rear anti-icing tube, remove rear anti-icing tube.

(8) Remove anti-icing air regulator from rear anti-icing tube.

B. Install Engine Anti-Icing Air Regulator (See figure 201)

(1) Install anti-icing air regulator in rear anti-icing tube. If early style (six hole flange) air regulator is being installed, place new gasket between regulator and tube flanges

NOTE. New type (four hole flange) air regulator does not require a gasket.



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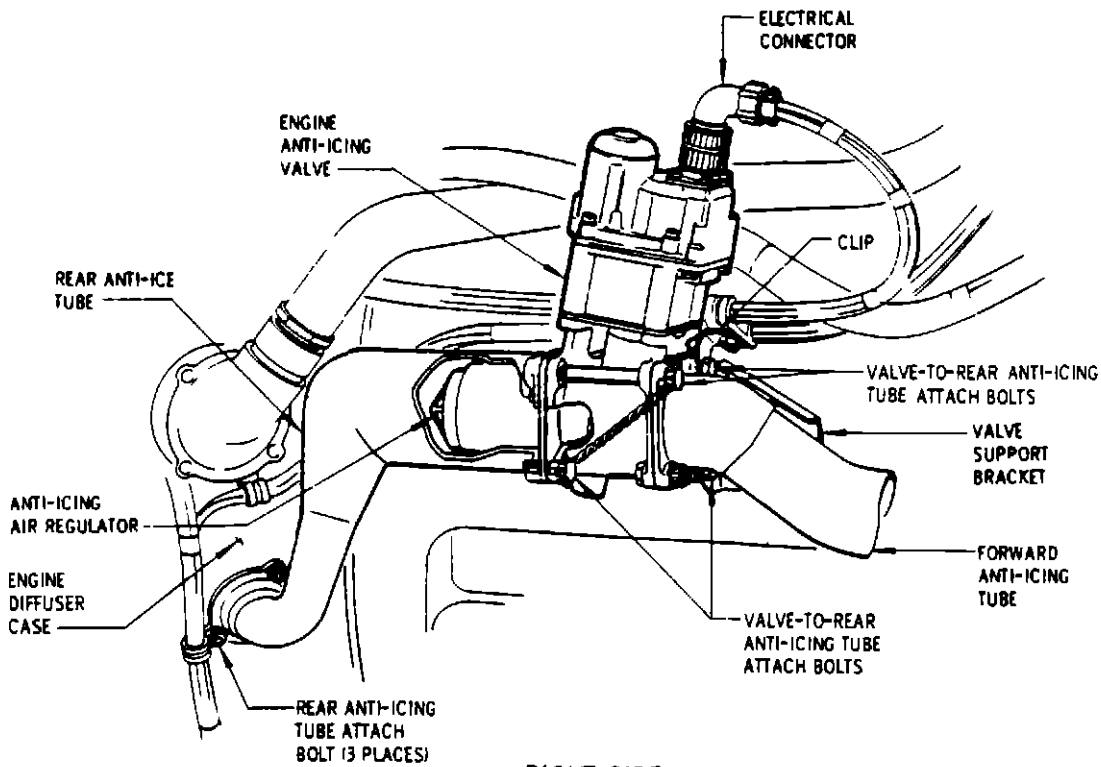


RIGHT SIDE

Engine Anti-Icing Air Regulator Installation
Figure 201

(2) Locate anti-icing valve in position between forward and rear anti-icing tubes. Place new gaskets at valve flanges if early style (six hole flange) valve is being installed. At right side valve, locate an electrical wiring support clip at upper inboard bolt hole location on forward anti-icing tube flange.

(3) Install bolts and nuts securing valve to tube flanges. Tighten bolts and install lockwire.

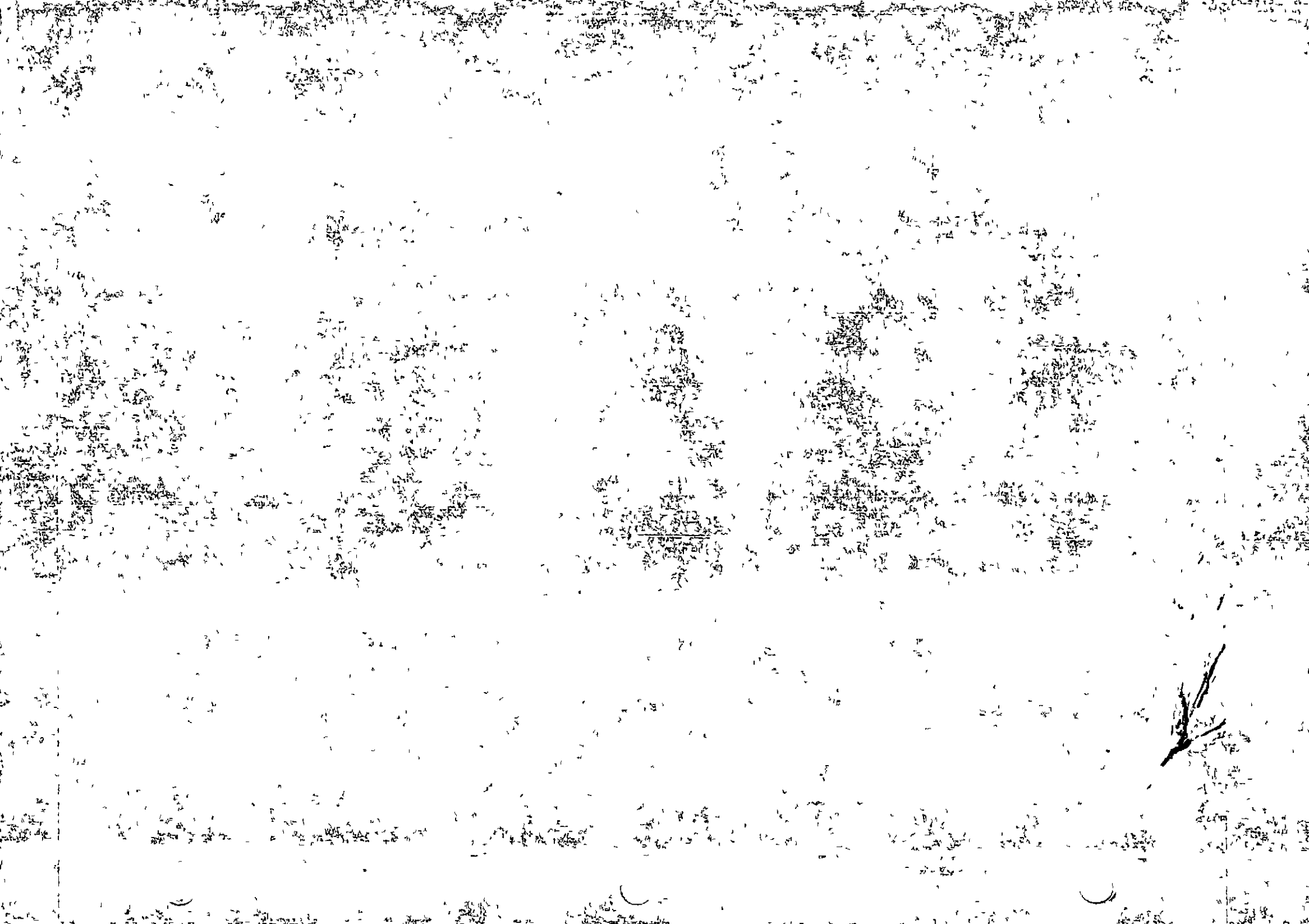
(4) Install three bolts securing rear anti-icing tube to engine diffuser case. At left side of engine, position strut drain line support bracket at forward bolt hole locations; if a continuous wire type fire detection system is installed, locate fire detector support clip at aft bolt hole location At right side of engine, locate an electrical wiring support clip at aft bolt hole location Tighten bolts and install lockwire.

(5) At left side of engine, install and tighten clamps between rear anti-icing tube, fuel heater deicing air supply tube and P&WA plumbing tube

(6) Connect electrical connector to valve

(7) Close engine anti-icing system circuit breakers.

(8) Close side cowl panels.



NOSE COWL ANTI-ICING VALVE - MAINTENANCE PRACTICES

1. Removal/Installation Nose Cowl Anti-Icing Valve

A Remove Nose Cowl Anti-Icing Valve

(1) Open four engine anti-icing system circuit breakers on circuit breaker panel P5

(2) Remove nacelle forward fairing. Refer to 71-5-11, "Nacelle Forward Fairing - Maintenance Practices "

(3) Disconnect electrical connector from valve assembly. (See figure 201.)

(4) Remove bolts connecting valve support brackets to valve forward flange

(5) Remove bolts connecting rear anti-icing tube to valve aft flange

(6) Remove bolts connecting froward anti-icing tube to valve forward flange

(7) Remove anti-icing valve assembly.

B. Install Nose Cowl Anti-Icing Valve

(1) With new gasket placed between mounting flanges, position electrical wiring clip as shown in figure 201 and bolt nose cowl anti-icing valve to forward anti-icing tube and valve support brackets Torque bolts within 70 to 80 pound-inches and install lockwire

NOTE When installing a solenoid controlled, pneumatically operated type valve, position valve with arrow on valve body pointing forward

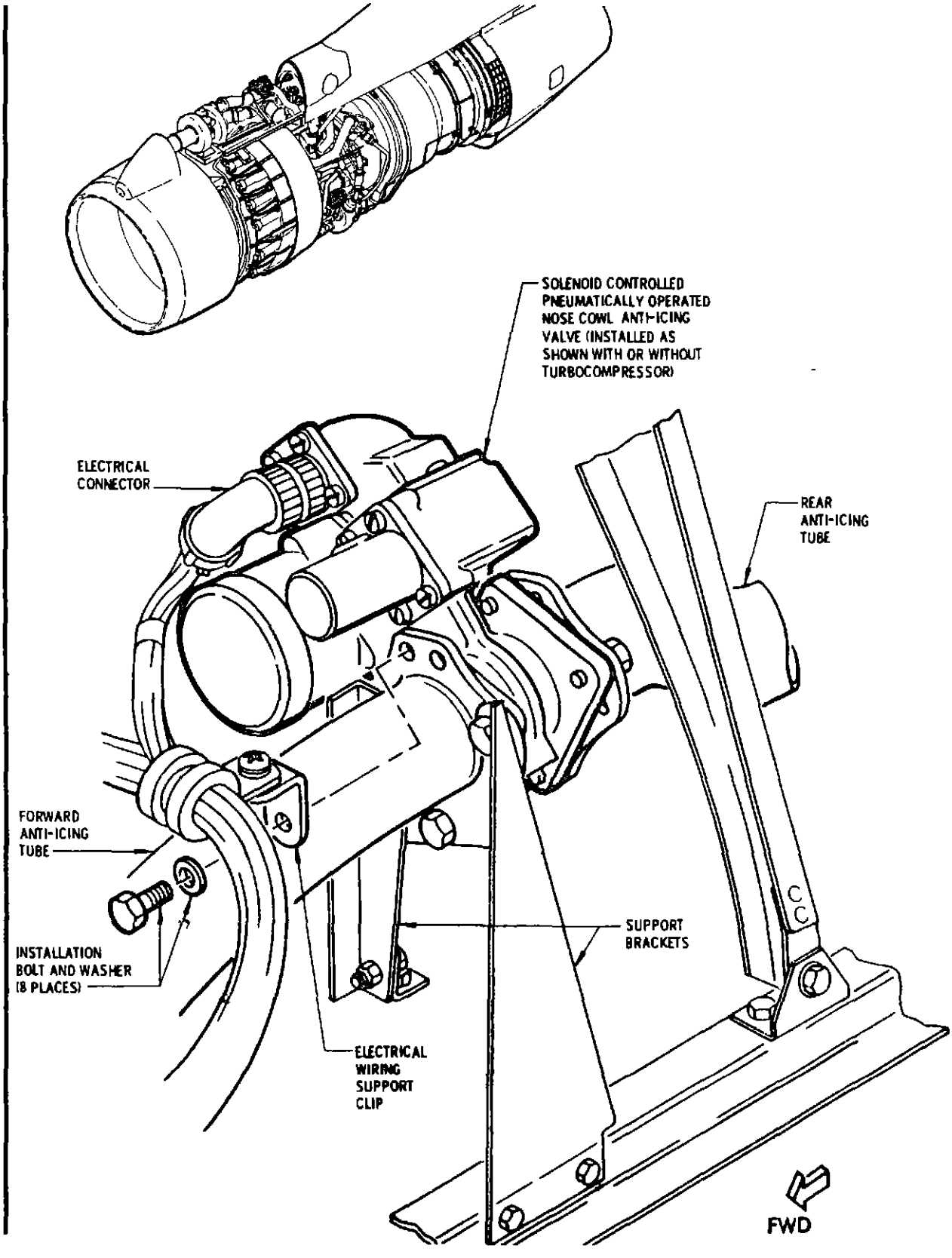
(2) With new gasket placed between mounting flanges, bolt rear anti-icing tube to nose cowl anti-icing valve assembly. Torque bolts within 70 to 80 pound-inches and install lockwire

(3) Deleted.

(4) Connect and lockwire electrical connector to valve assembly.

(5) Close engine anti-icing system circuit breakers.

(6) Reinstall nacelle forward fairing.



Nose Cowl Anti-Icing Valve Installation
Figure 201

NOSE COWL ANTI-ICING THERMOSTATIC VALVE - MAINTENANCE PRACTICES

1. Removal/Installation Nose Cowl Anti-Icing Thermostatic Valve

NOTE: Observe and mark locations of electrical wiring support clips before removing valve.

A. Remove Nose Cowl Anti-Icing Thermostatic Valve (See figure 201.)

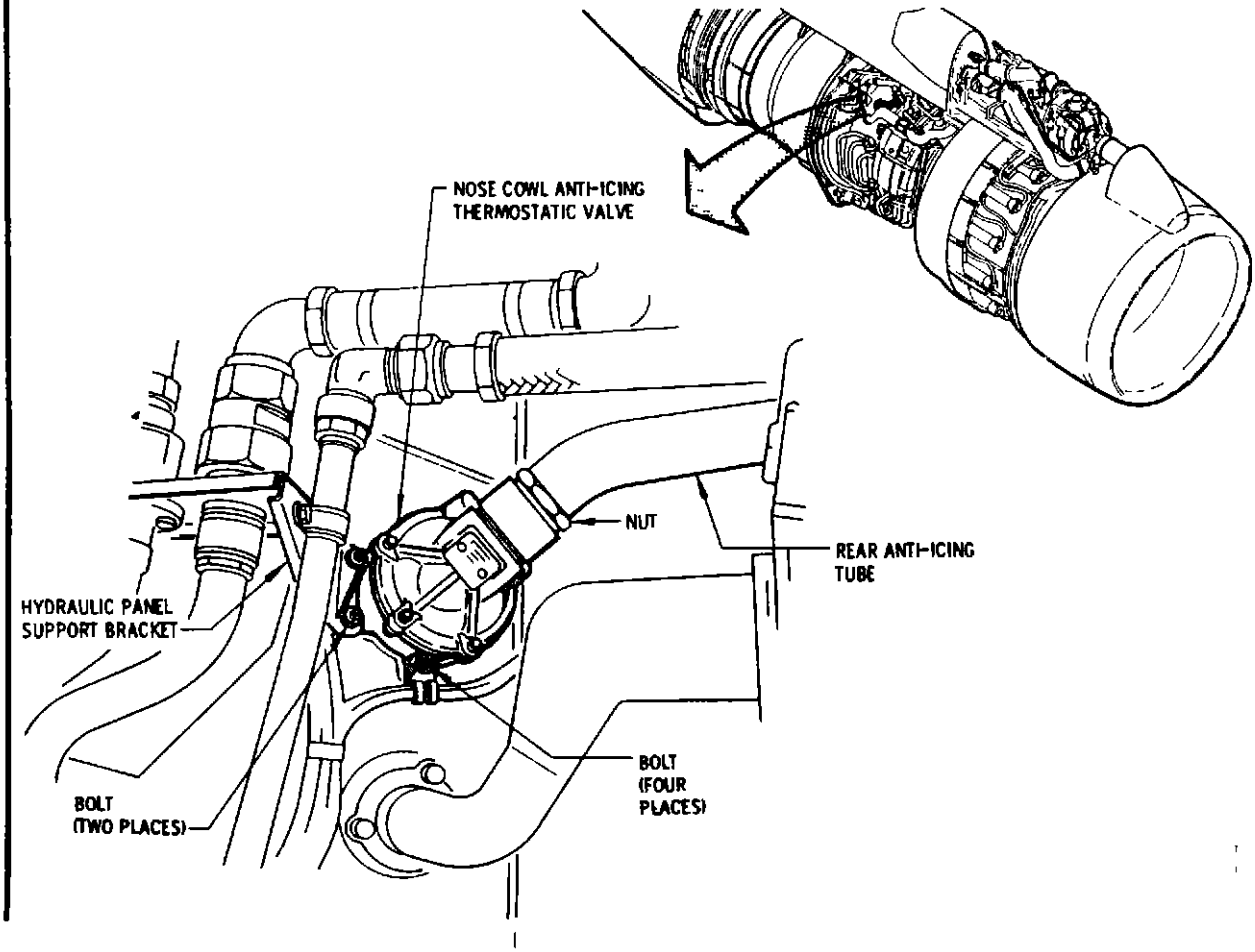
(1) Open four engine anti-icing system circuit breakers on circuit breaker panel P5.

(2) Open engine right side cowl panel.

(3) Remove two bolts connecting hydraulic panel support bracket and valve flange to engine bleed pad.

(4) Remove four valve mounting bolts.

(5) Uncouple nut and disconnect rear anti-icing tube from thermostatic valve. Remove valve assembly.



Nose Cowl Anti-Icing Thermostatic Valve Installation
Figure 201

B. Install Nose Cowl Anti-Icing Thermostatic Valve

(1) Using a new gasket, position thermostatic valve on engine bleed pad as shown in figure 201.

(2) Locate electrical wiring support clips on valve flange at locations noted during valve removal and secure valve to engine by installing four bolts. Do not tighten bolts.

(3) Install remaining two bolts through hydraulic panel support bracket at aft edge of valve flange. Do not tighten bolts.

(4) Connect rear anti-icing tube to valve and tighten nut. (If the nose cowl anti-icing shutoff valve or tube coupling have been loosened, install all tube connectors finger tight before final tightening of any fasteners. This will minimize preload stresses in the tubing.)

(5) Tighten all mounting bolts and install lockwire

(6) Close engine anti-icing system circuit breakers.

(7) Close right side cowl panel.

ENGINE ANTI-ICING VALVE - REMOVAL/INSTALLATION

1. Removal/Installation Engine Anti-Icing Valve (Left Side)

A. Prepare for Removal

(1) Open engine anti-icing system circuit breakers on circuit breaker panel P5.

(2) Open engine left side cowl panel.

B. Remove Engine Anti-Icing Valve (Left Side) (See figure 401.)

(1) Disconnect electrical connector from valve.

(2) Remove bolts attaching rear anti-icing tube to diffuser case.

CAUTION. ANY PARTS THAT MAY FALL INTO DIFFUSER CASE MUST BE REMOVED BEFORE ENGINE IS OPERATED OR INTERNAL ENGINE DAMAGE WILL RESULT.

(3) Remove clamps securing rear anti-icing tube to fuel heater deicing air supply tube and P&WA plumbing tube.

(4) Support valve and remove attaching bolts. Move rear anti-icing tube aft to free valve and remove valve.

C. Install Engine Anti-Icing Valve (Left Side)

(1) Position valve on forward anti-icing tube. If six hole flange valve is being installed, place new gasket on each flange.

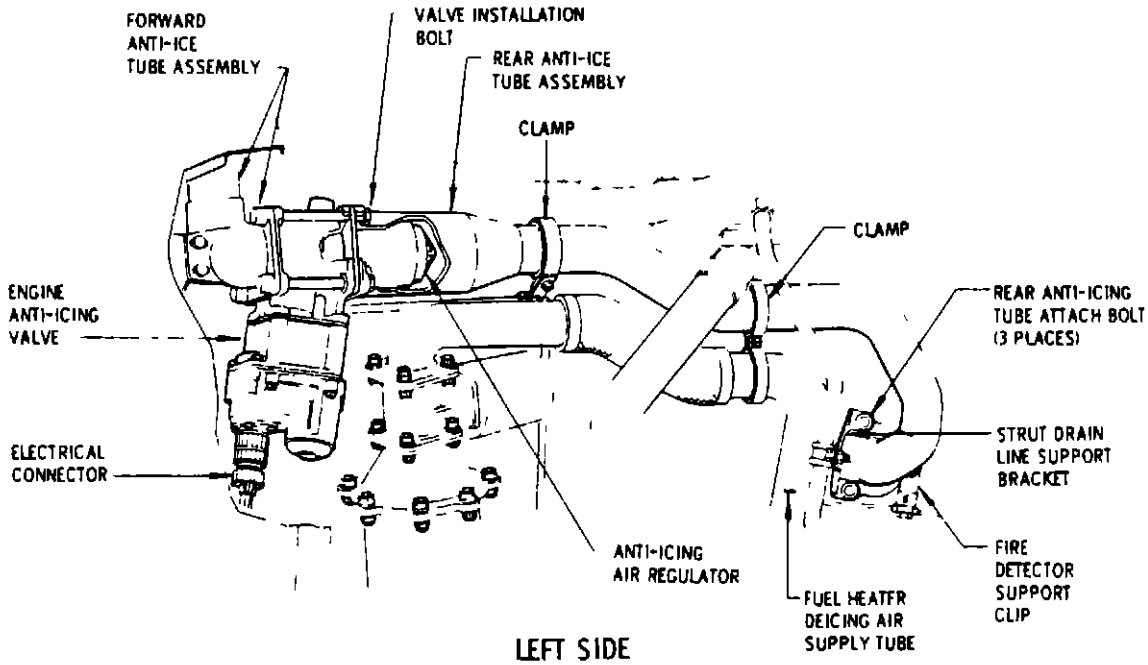
NOTE Four hole flange valves do not require gaskets.

(2) Move rear anti-icing tube forward against valve and install bolts. Tighten bolts and install lockwire.

(3) Install three bolts securing rear anti-icing tube to engine diffuser case. Position strut drain line support bracket at forward bolt hole locations. If a continuous wire type fire detection system is installed, locate fire detector support clip at aft bolt hole location. Tighten bolts and lockwire.

(4) Install clamps securing rear anti-icing tube to fuel heater deicing air supply tube and P&WA plumbing tube.

(5) Connect electrical connector to valve.



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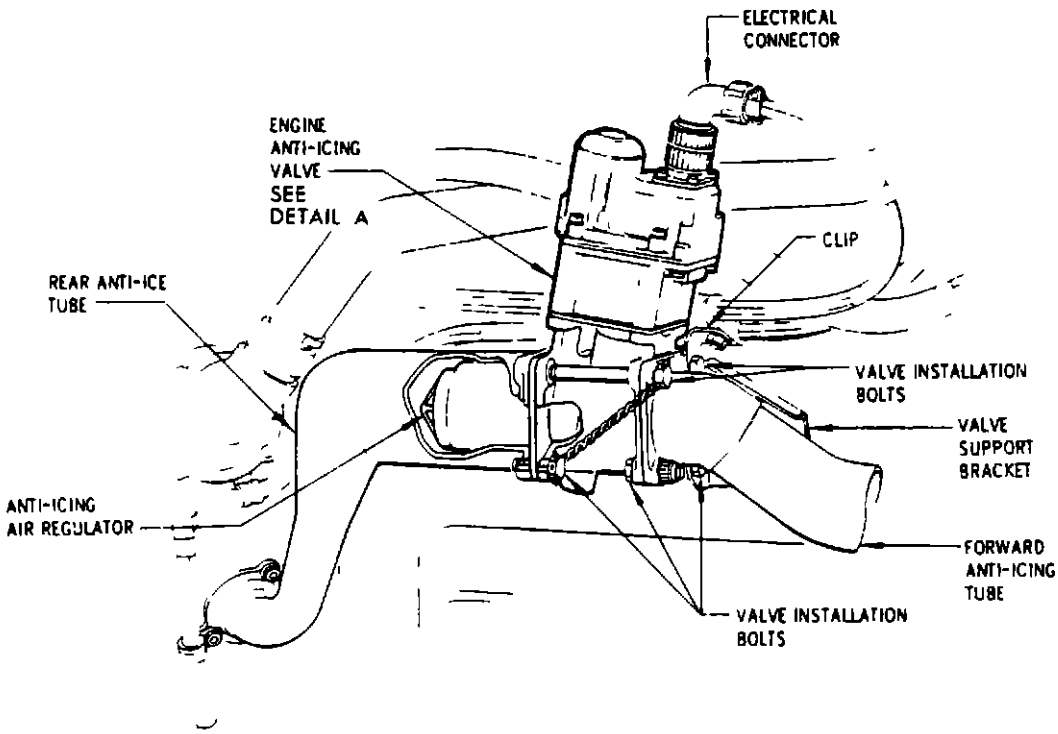
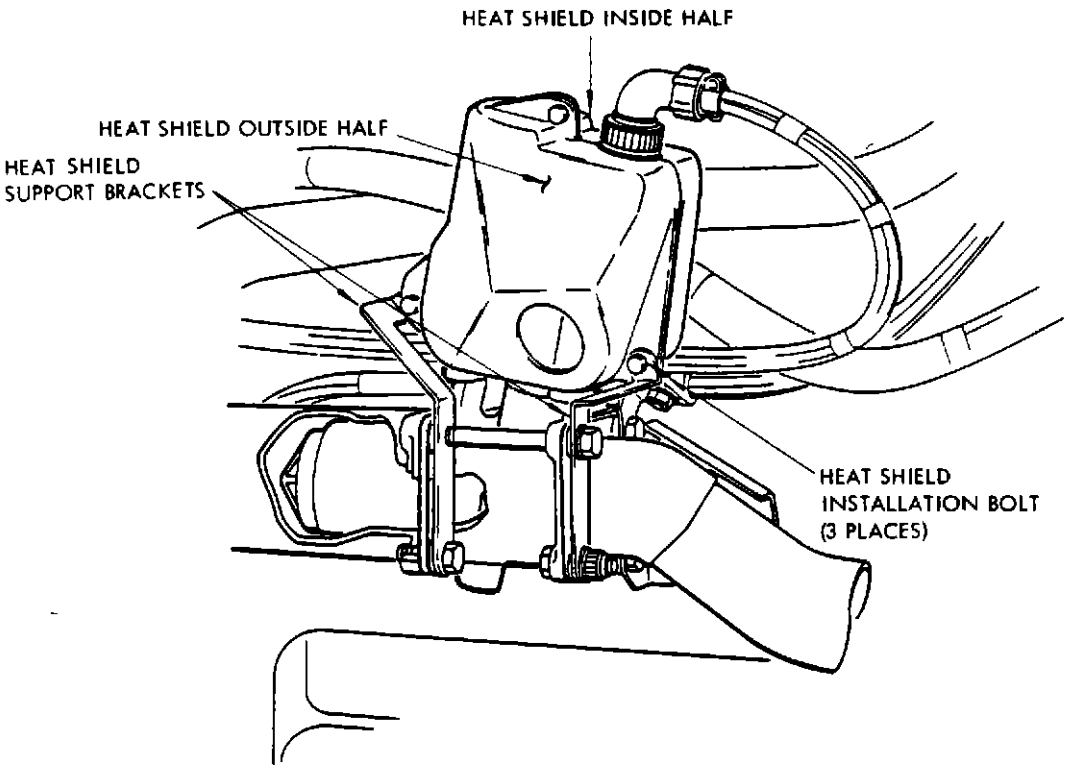


RIGHT SIDE



HEAT SHIELD INSTALLATION

DETAIL A

EFFECTIVITY

AI VT-DXT and on
SA ZS-EUW and on
SN OO-SJL and on
WD CF-FAN and on
AR All except LV-ISA thru LV-ISD

(6) Close engine anti-icing system circuit breakers.

(7) Close left side cowl panel.

2. Removal/Installation Engine Anti-Icing Valve (Right Side)

A. Prepare for Removal

(1) Open engine anti-icing system circuit breakers on circuit breaker panel P5.

(2) Open engine right side cowl panel.

B. Remove Engine Anti-Icing Valve (Right Side) (See figure 401.)

(1) Disconnect electrical connector from valve.

(2) Support valve and remove bolts and nuts securing valve (or heat shield if installed) to support bracket and anti-icing tube flanges. Remove valve.

NOTE: Valves with heat shield (see detail A for effectivity) may be removed with heat shield and heat shield support brackets installed on the valve.

C. Install Engine Anti-Icing Valve (Right Side)

(1) Position valve (or valve with heat shield) between flanges of anti-icing tubes. If six hole flange valve is being installed, place new gasket on each flange.

NOTE: Four hole flange valves do not require gaskets.

(2) Locate electrical wiring support clip at upper inboard bolt hole location on forward anti-icing tube flange; install bolts and nuts securing valve (or valve/heat shield assembly) to support bracket and to tube flanges. Tighten bolts and install lockwire.

(3) Connect electrical connector to valve.

(4) Close engine anti-icing system circuit breakers.

(5) Close right side cowl panel.

COMPRESSOR BLEED SYSTEM - DESCRIPTION AND OPERATION

1. General

A. The compressor bleed system is designed to relieve the engine of excess air when it is not needed. Except during normal operating thrust and higher, the engine does not need the full output of both compressors. When cranking first begins, air will flow inward through the open compressor bleed valve to the inlet of the rear compressor relieving part of the windmilling load of the front compressor. By the time the engine starts, the second, third and fourth stage turbines will be driving the front compressor. Air will be coming out of the compressor bleed valve from the front compressor.

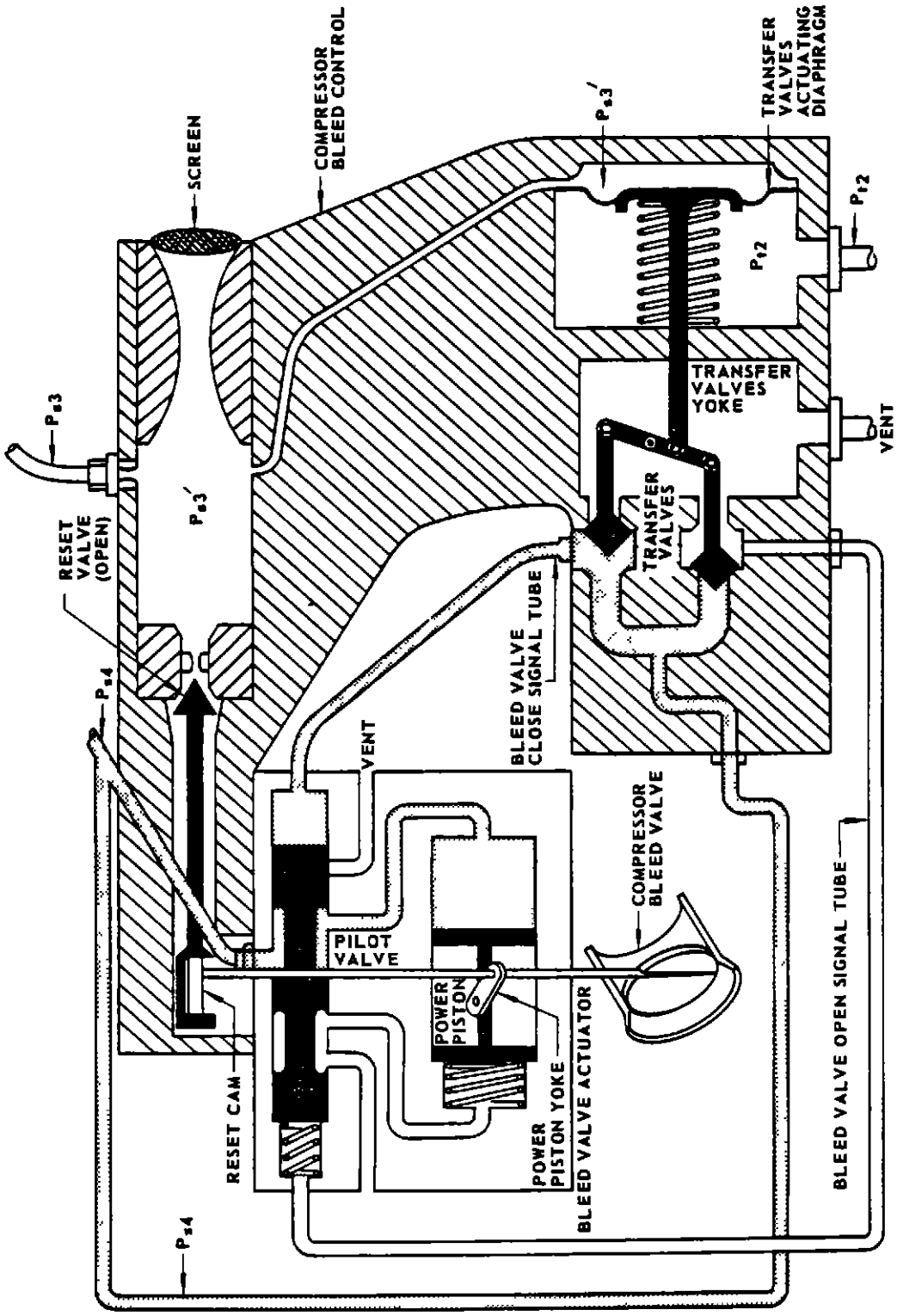
B. The air bleed system consists of a bleed valve, a compressor bleed valve actuator control and the necessary connecting tubing. This is a pressure ratio system since the actuator control schedules bleed valve operation to a varying front compressor ratio. High pressure air from the 16th stage compressor furnishes the actuating force to open or close the bleed valve. No intermediate position of the valve is used.

2 Compressor Bleed Valve

A. The compressor bleed valve is a butterfly type valve which is controlled by the compressor bleed valve control unit. The valve is located near the rear of the compressor intermediate case at the eight o'clock position. Air that passes through the valve travels from the front compressor inside the intermediate case but outside of the rear compressor case.

3 Compressor Bleed Valve Control Unit

A. The compressor bleed valve control unit is a self-contained unit consisting of a bleed valve actuator and an actuator control. This dual functioning unit is bolted to and supported by the compressor bleed valve body. Two studs are used at the valve shaft opening. The actuator section of the assembly contains a piston and pilot valve assembly. The piston operates the valve shaft by a slotted arm. Both pilot valve and piston are air operated. The control section contains a transfer valve assembly which is operated by a yoke from a diaphragm. The control section also contains a reset valve which is operated by a reset cam connected to the bleed valve shaft. (See figure 1.)



Compressor Bleed System Schematic
Figure 1

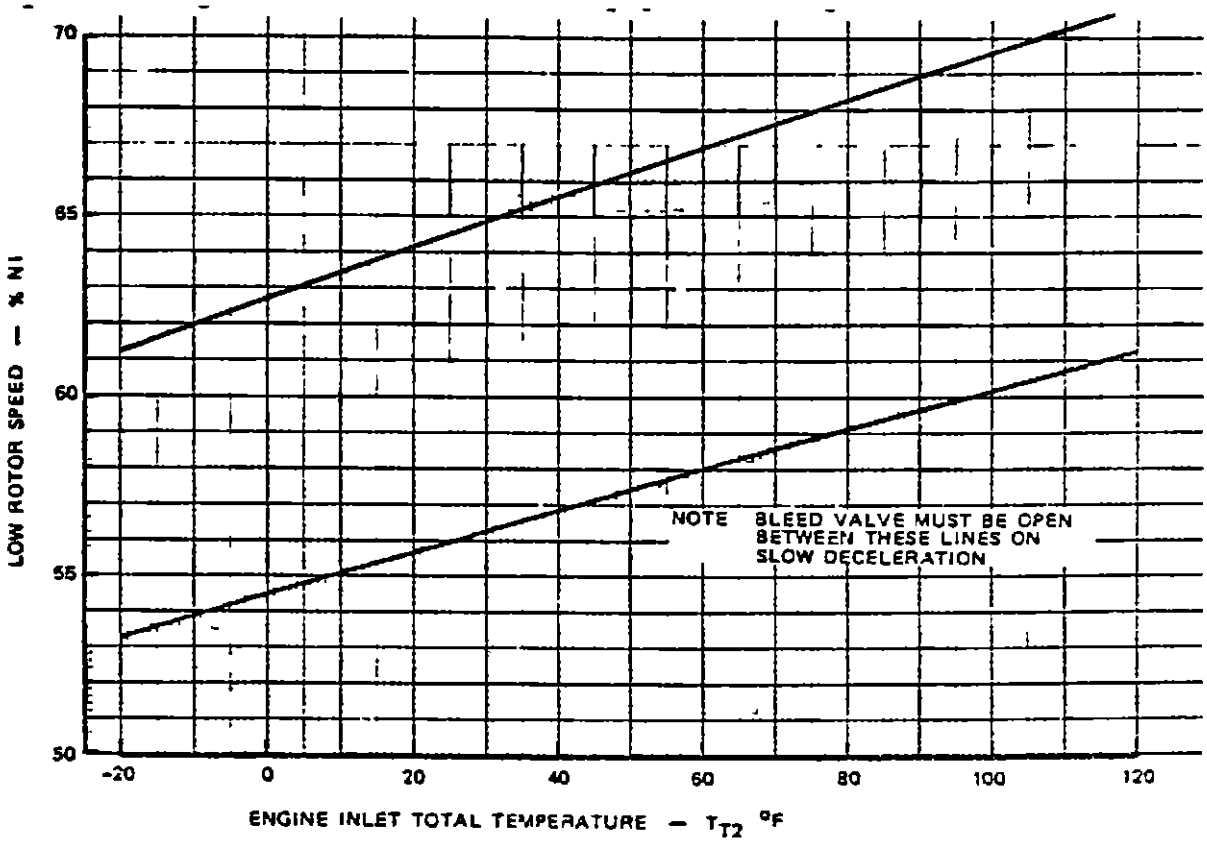
4. Operation

A. The pressure ratio bleed control schedules bleed valve operation to a varying N_1 compressor pressure ratio (P_{s3}/P_{t2}). Discharge pressure (P_{s3}) from N_1 compressor is used to achieve an intermediate high discharge pressure (P_{s3}') by means of a dual orifice system within the control. The pressure (P_{s3}') is applied to the high pressure side of the actuating diaphragm, and is a constant function relative to P_{s3} pressure. The low pressure (P_{t2}) is applied to the low pressure side of the diaphragm, plus a spring force. Any resulting deviation from the null or balanced position (P_{s3}' Area = P_{t2} Area + Spring) produces a corrective action by varying the low pressure bleed valve. Functionally, the displacement output resulting from a control deviation from null position is mechanically transmitted through a yoke assembly to a transfer valve assembly. The transfer valve assembly, consisting of two poppet type transfer valves, transmits the desired signal pressure to the bleed valve actuator assembly to schedule either open or closed bleed valve position. Sixteenth stage air (P_{s4}) is always supplied to one end of each poppet valve and ambient air pressure (P_{s2}) is supplied to the other end of each poppet valve. Therefore, depending upon direction of control signal error from null position, the transfer valve will be scheduled either in the bleed open or closed position and P_{s4} air pressure will be directed through the transfer valve to either open or closed signal line to the bleed valve and actuator.

B. A reset feature is designed into the control section to accomodate the step change in N_2 pressure between bleed closed and bleed open. The reset is necessary due to an appreciable change in N_1 discharge pressure between the bleed open and bleed close positions. If this variation was not compensated, excessive hysteresis in the control would occur. When the bleed valve is in the close position, the reset valve will be open and conversely when the bleed valve is in the open position, the reset valve will be in the close position.

C. The compressor surge bleed valve is left open after starting to give good acceleration characteristics to the engine by bleeding excess air overboard. At approximately N_1 speed in figure 2 the bleed valve closes and will remain closed until engine speed is reduced. Deceleration is also aided by compressor surge bleed valve operation.

NOTE: Present curve is compatible to engines having bleed valve with or without PWA SB 5209 incorporated.



APPLICABLE TO JT3D-1, JT3D-1 MC6 JT3D-1-MC7 JT3D-3 JT3D-3B AND JT3D-7 ENGINES

Compressor Surge Bleed Valve Schedule
Figure 2