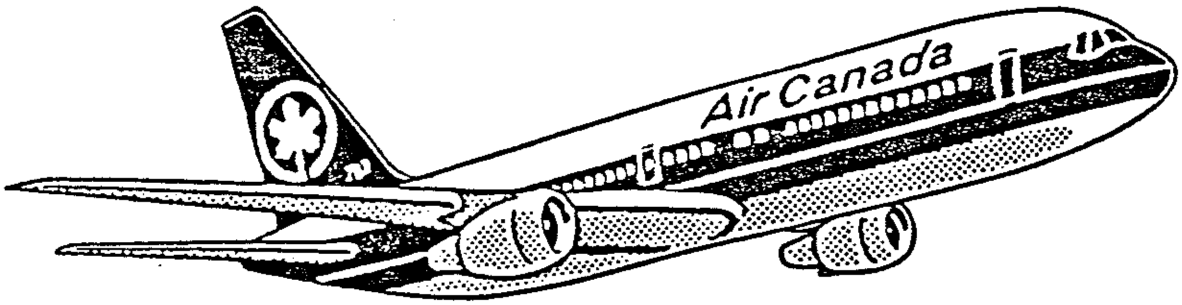
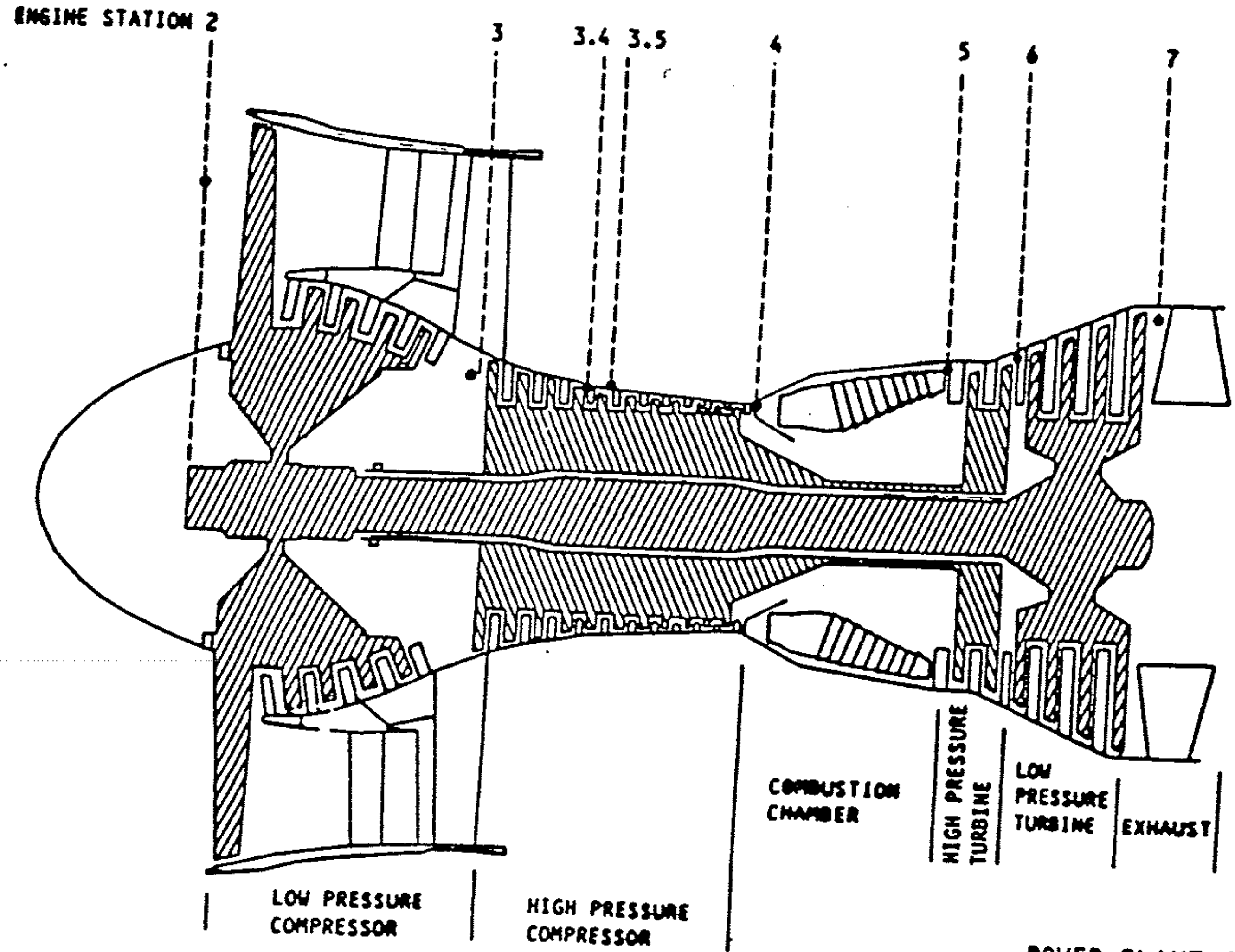
Air Canada

TECHNICAL TRAINING

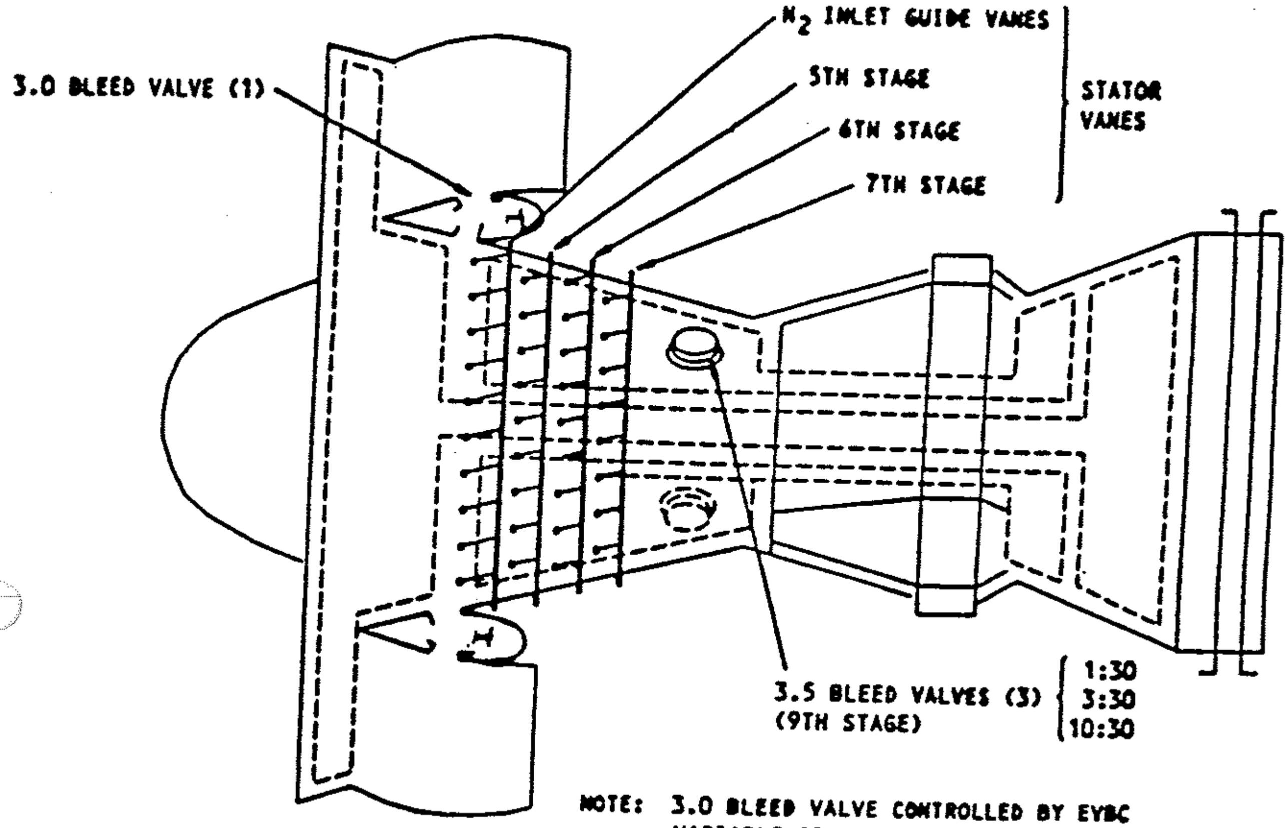


BOEING 767/JT9D-7R4
EVBC & FCU TRIM COURSE

THIS MATERIAL IS FOR TRAINING PURPOSES ONLY



POWER PLANT-GENERAL



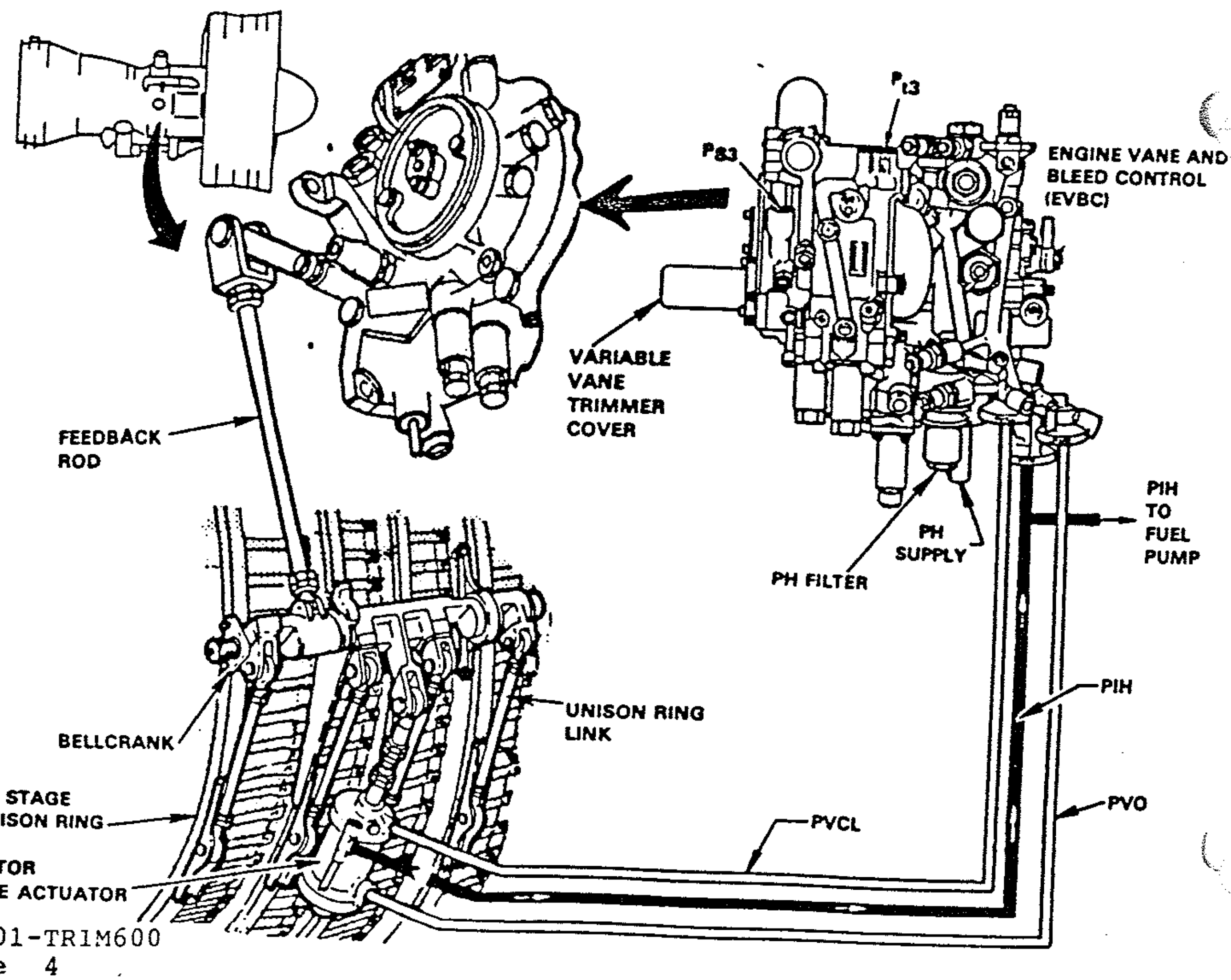
NOTE: 3.0 BLEED VALVE CONTROLLED BY EVBC
VARIABLE STATOR VANES CONTROLLED BY EVBC
3.5 BLEED VALVES CONTROLLED BY FCU

ENGINE AIR FLOW CONTROL

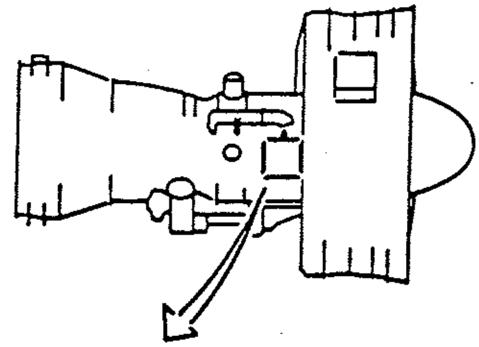
VARIABLE VANE SYSTEM

Purpose:

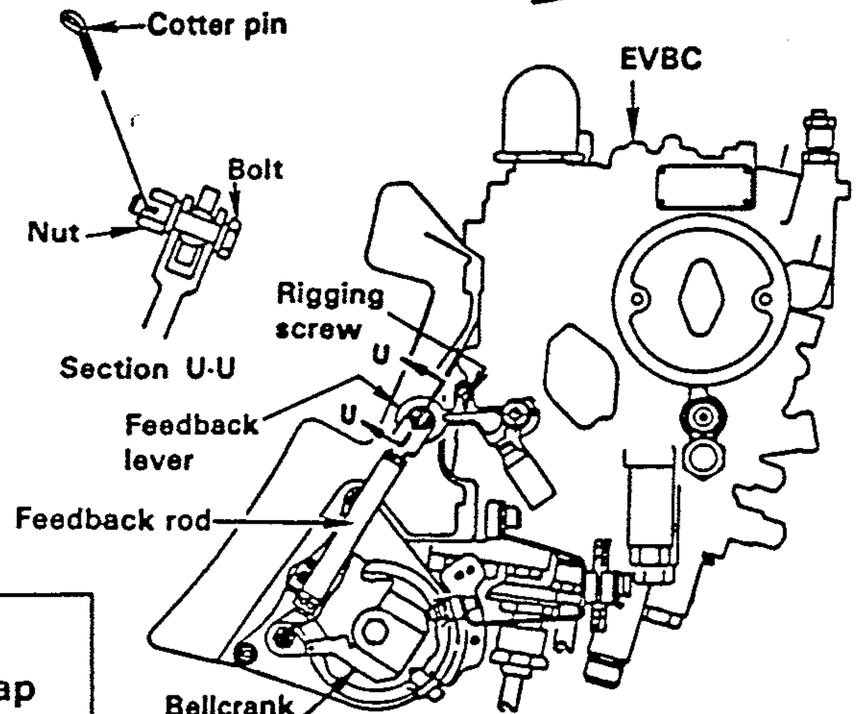
To provide optimum engine performance throughout the engine operating envelope by varying compressor airflow. At low engine RPM, the variable vanes are positioned in the closed direction allowing minimal airflow through the compressor. At high engine RPM, the variable vanes are open allowing maximum airflow through the compressor.



VISUAL CHECKS



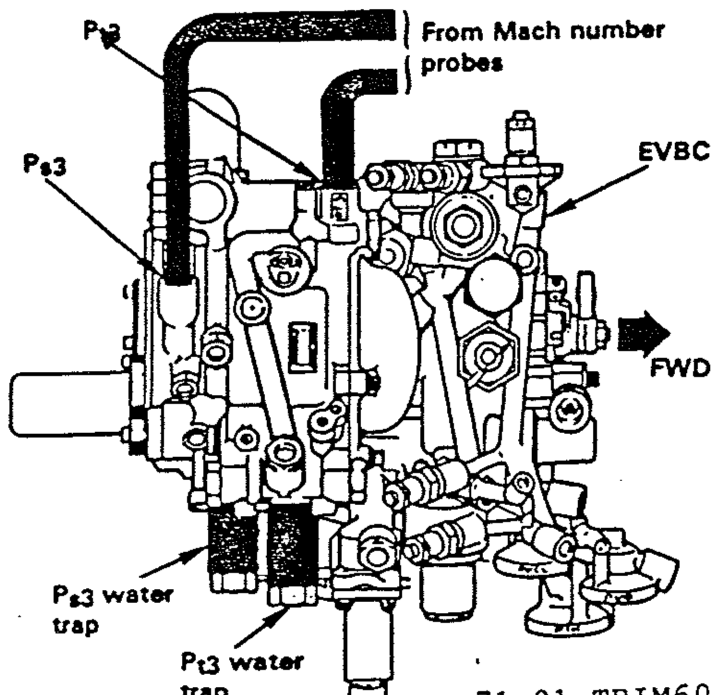
- Check that feedback lever rigging screw is retracted and secured
- Check security of feedback rod
- Insure that attaching bolt is installed with head towards front of engine



Operational discrepancy
Starting
Power and response
Surge

- Check EVBC P_{s3} water trap for leaks or for missing trap
- Check P_{s3} tubes and manifolds for leaks

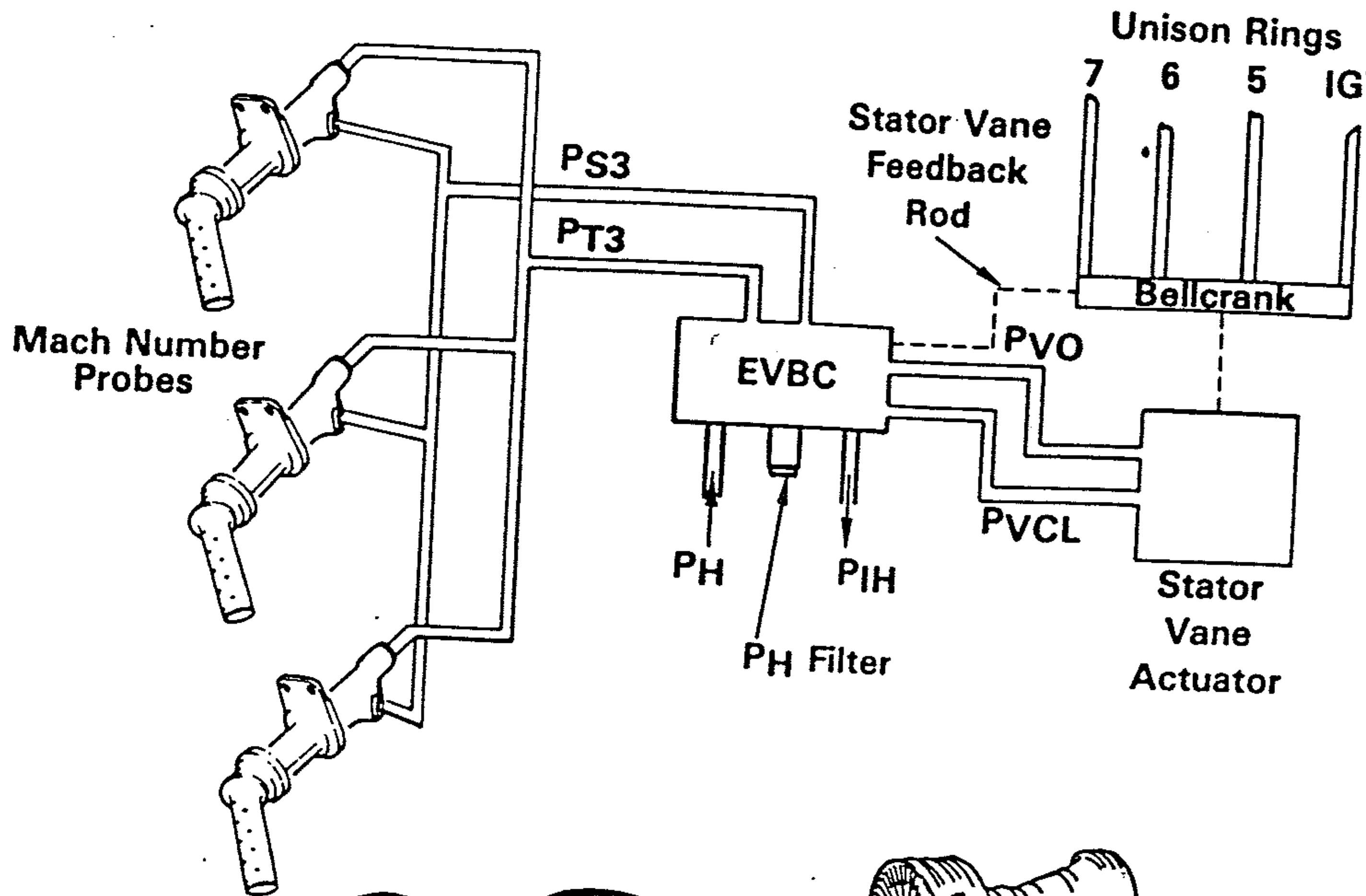
Operational discrepancy
Impending hot start
Surge

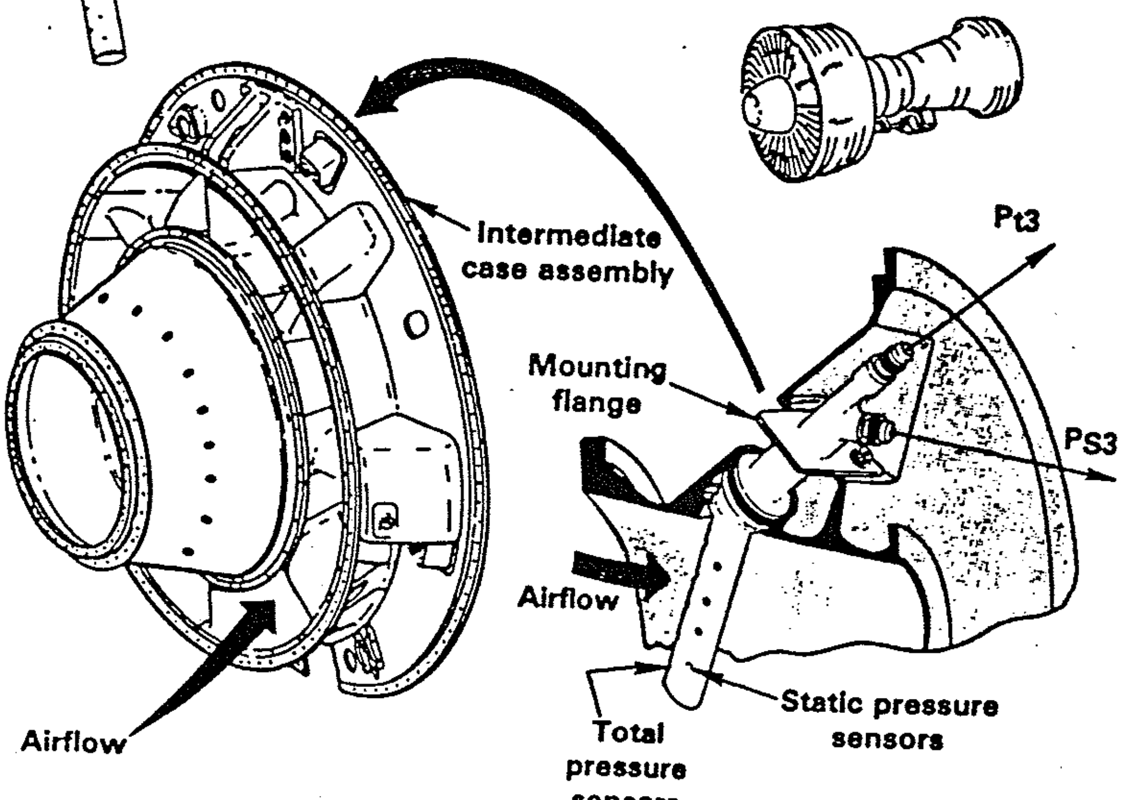


- Check EVBC P_{t3} water trap for leaks or for missing trap
- Check P_{t3} tubes and manifolds for leaks

Operational discrepancy
High oil consumption at idle
Power and response

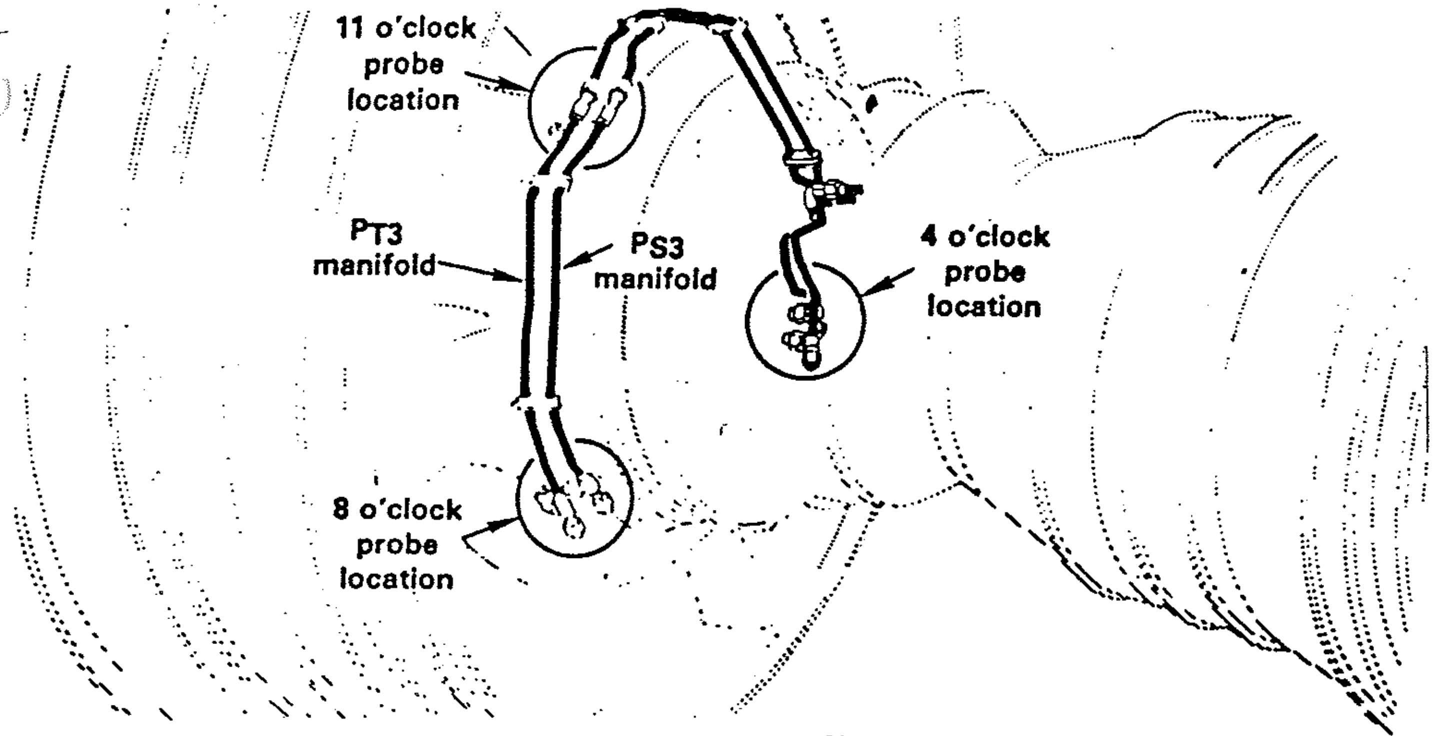
Schematic of Variable Vane System





(11 o'clock location shown)

VARIABLE VANE SYSTEM



Note: Probes located at the 8 and 11 o'clock locations are electrically heated for anti-ice protection. (B-767)

rmal operation:

PT3
PS3
FEEDBACK
Hyd sig

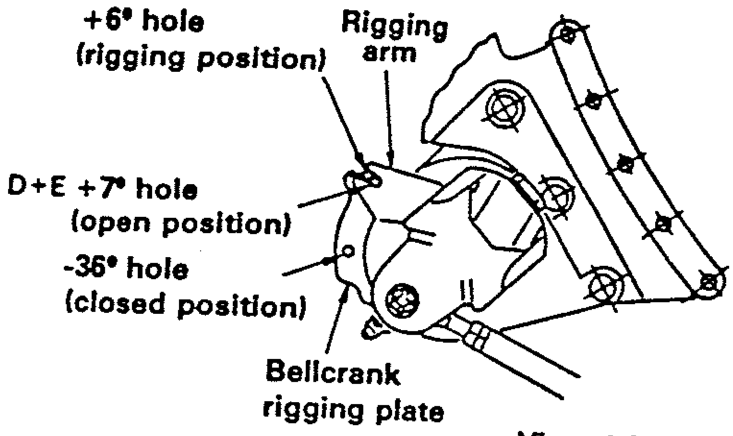
2. With engine starting and running, the engine vane and bleed control receives P_{t3} and P_{s3} signals from the Mach number probes. A ratio of these signals $[(P_T3-P_S3)/P_T3)]$ is used to schedule the vanes between full open and full closed. A third signal is provided to the engine vane and bleed control from the stator vane feedback rod providing information on the position of the vanes to complete the vane scheduling loop. Fuel pump hydraulic stage pressure (PH) is used as muscle and servo pressure within the engine vane and bleed control. The servo portion passes through the PH filter.

3. As the engine is started, the engine vane and bleed control sends a high pressure level vanes closed signal (PVCL) to the stator vane actuator until approximately 36% N_2 is reached. At this time, the vane closed signal is reduced and the vane open signal (PVO) is increased resulting in the vanes moving in the open direction. The vanes must start to schedule by 50% N_2 (actuator must be off the closed stop).

4. As the pressure ratio $[(P_T3-P_S3)/P_T3)]$ increases, the engine vane control regulates the level of vanes open and closed pressure signals to the stator vane actuator moving the bellcrank and the IGV and 5th through 7th stages of the high compressor in the open direction.

5. At approximately 96% N_2 (at sea level conditions), the vanes are in the full open position

VARIABLE VANE SYSTEM
BELLCRANK RIGGING PLATE

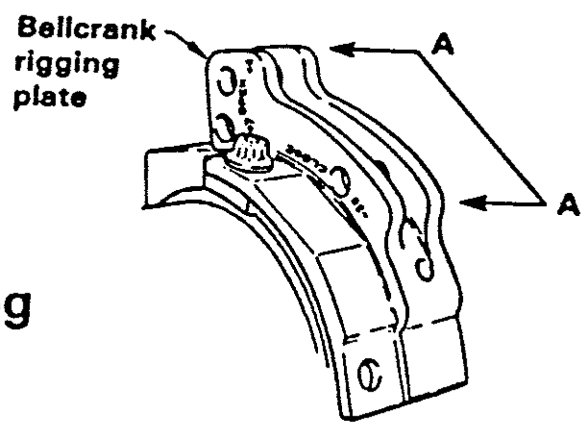


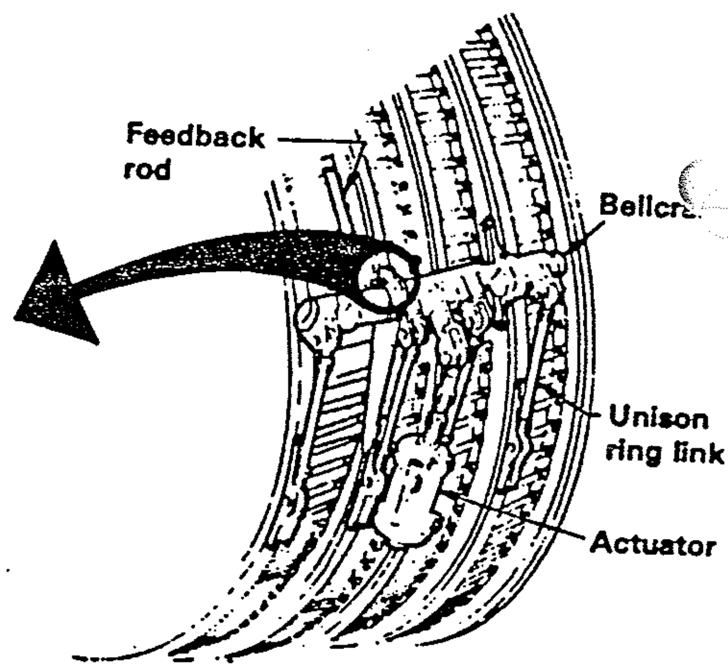
View AA

Function

+6° hole - use for feedback rod and unison ring rigging

D+E +7° open / −36° closed — use for stator vane actuator rigging

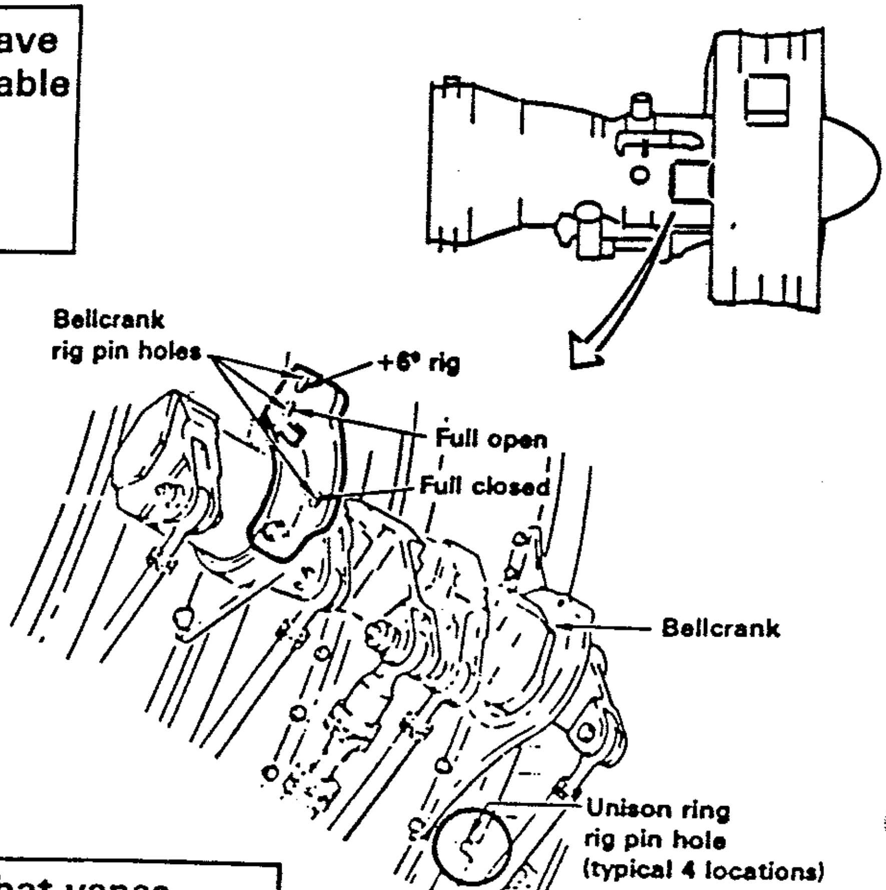




Boeing

VISUAL CHECKS

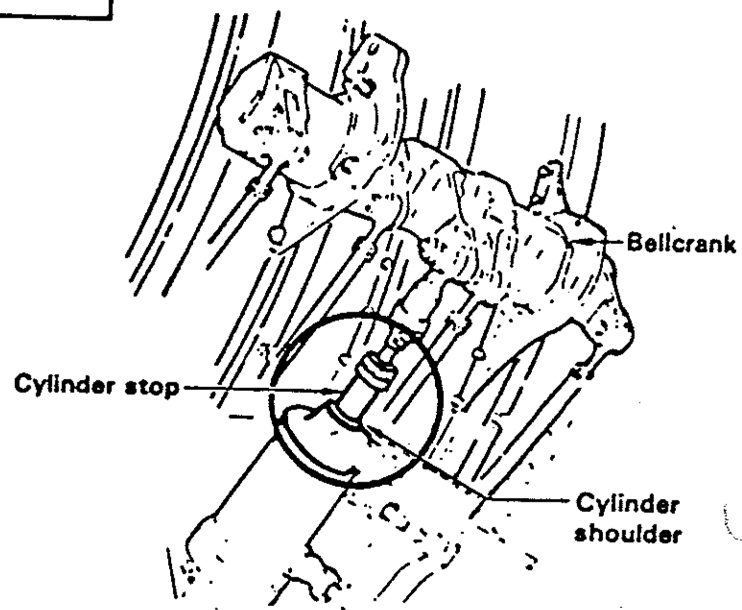
Check that all rig pins have been removed from variable vane system:
- Bellcrank
- Unison rings



Operational discrepancy
Starting problems
Power and response

Observe at vane actuator that vanes are on the closed stop:
- Statically
  - If not on closed stop, observe during motoring
- To approximately 36% N_2 during start

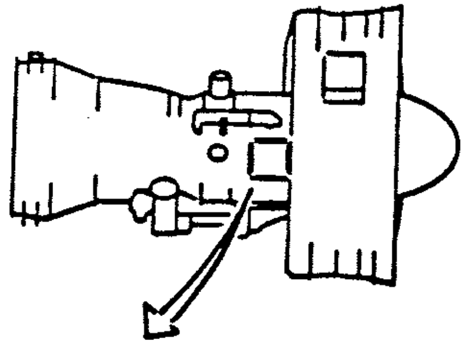
Note: Confirmation of vanes being on the closed stop - when cylinder stop is positioned against cylinder shoulder



Operational discrepancy
Hot start
Surge

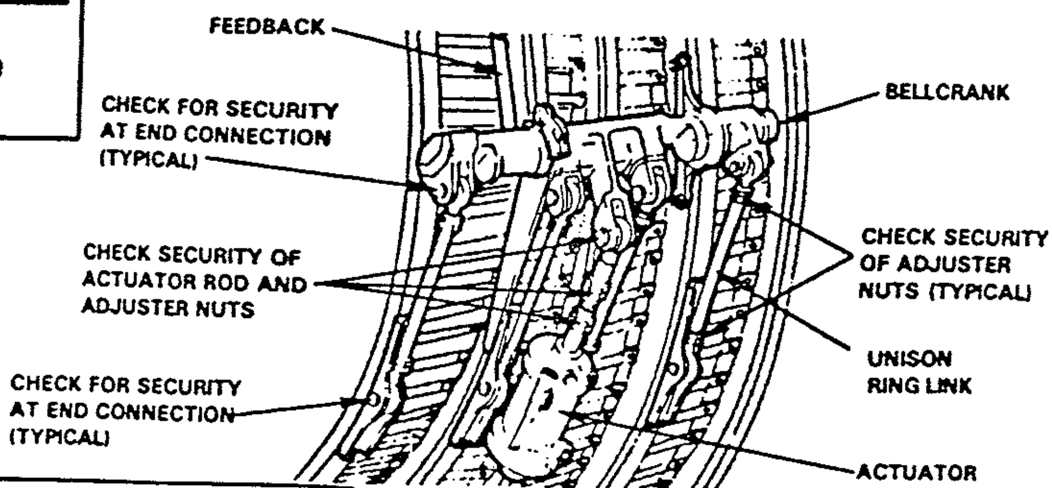
VISUAL CHECKS

Check unison ring linkages and actuator rod for security at rigging adjuster and end connections

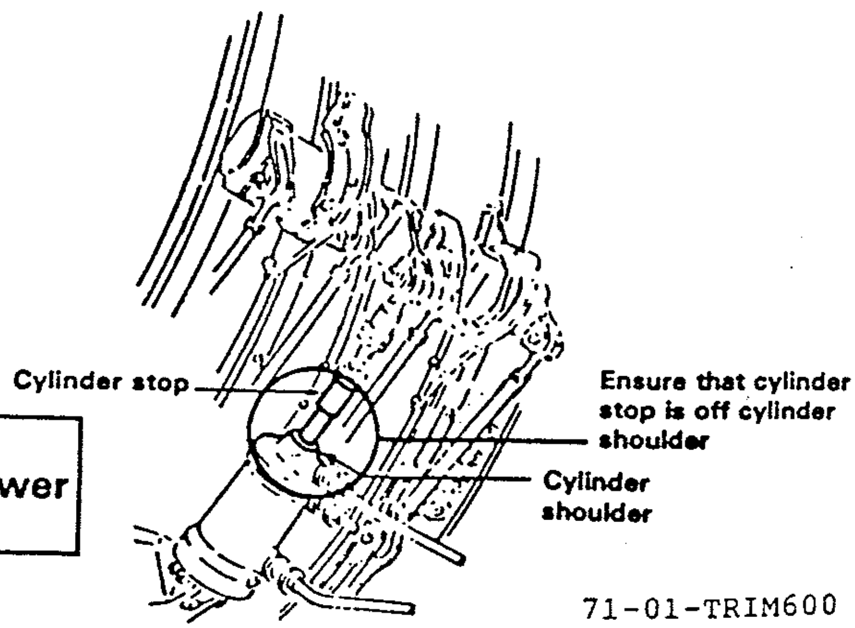


Operational discrepancy

Starting
Power and response
Surge



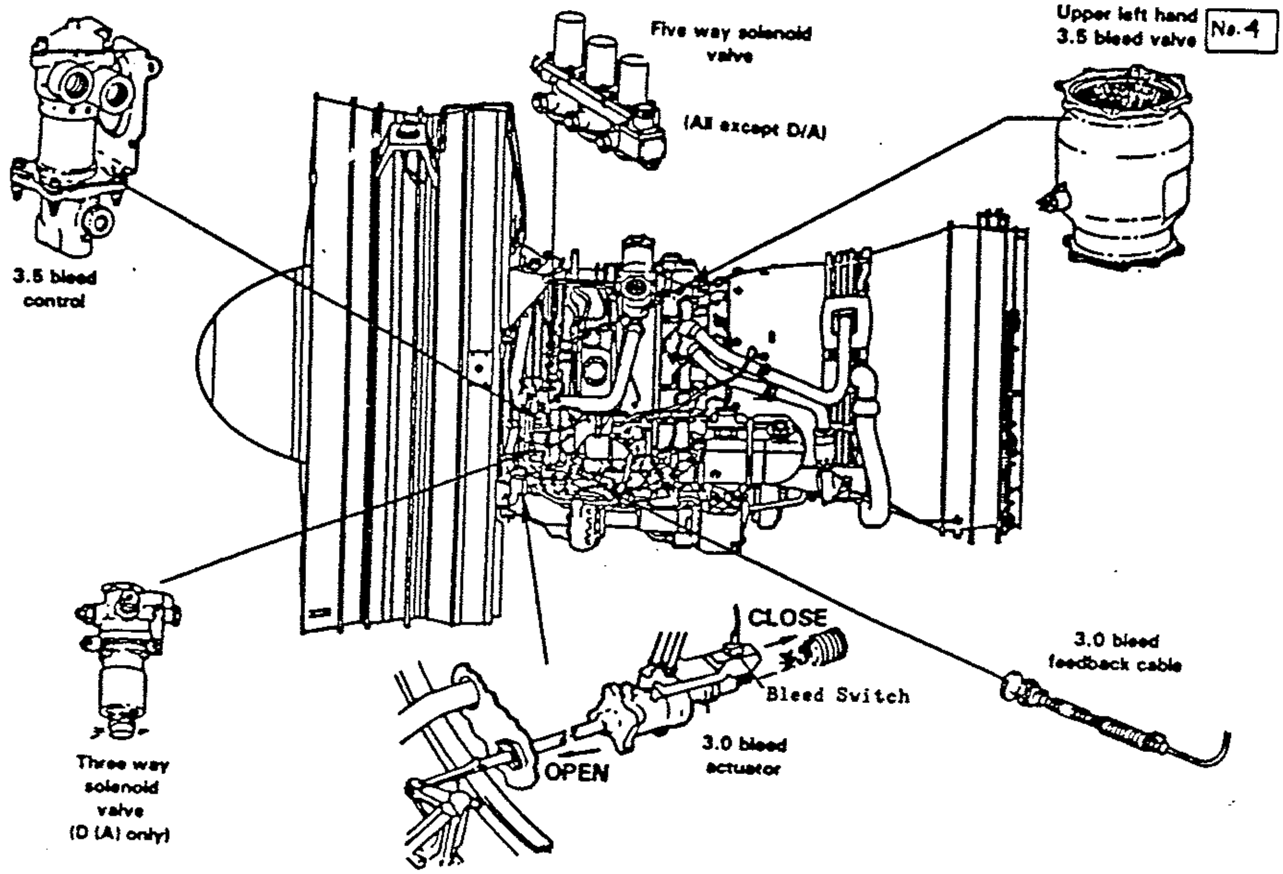
Observe at vane actuator that vanes are off the closed stop at idle

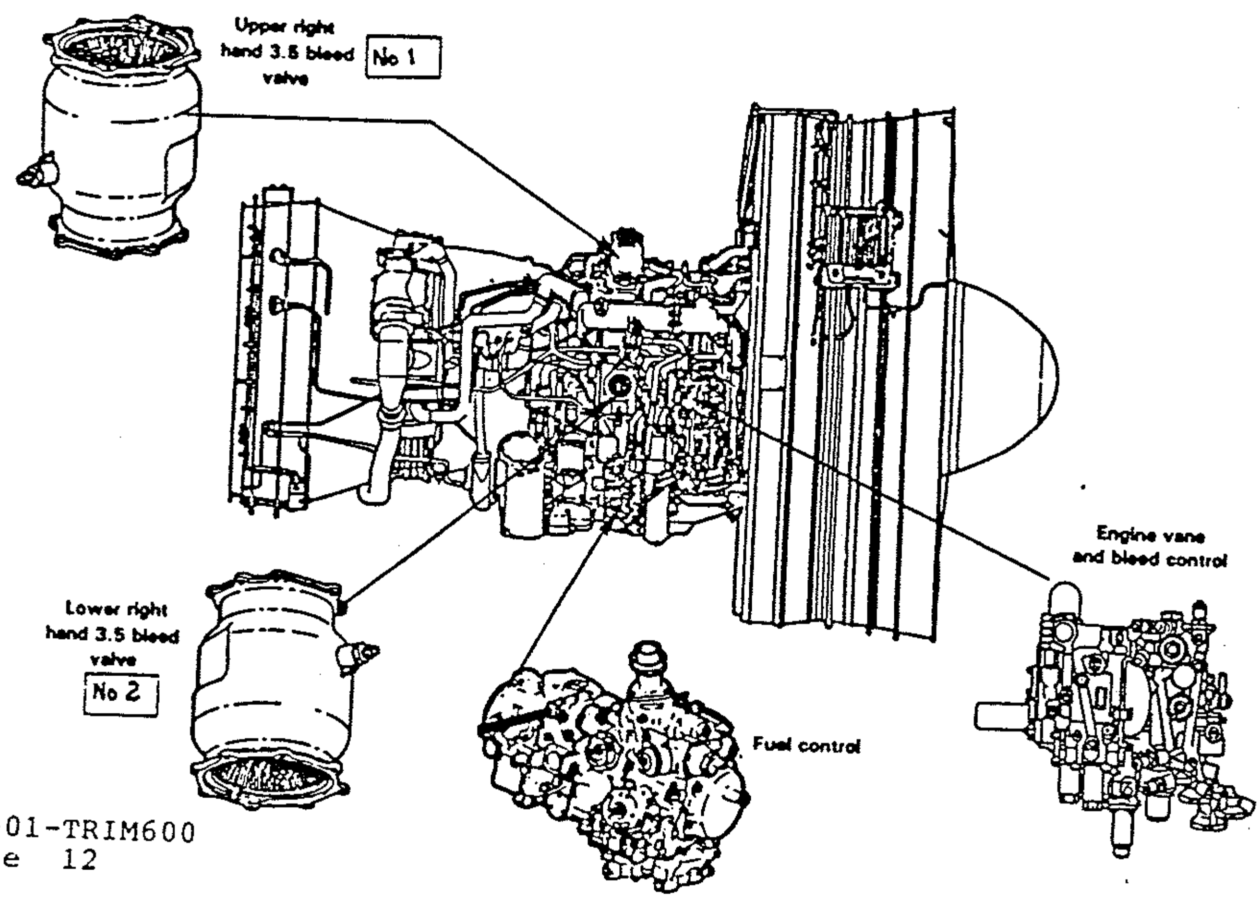


Operational discrepancy

High oil consumption at low power
ımes in cabin

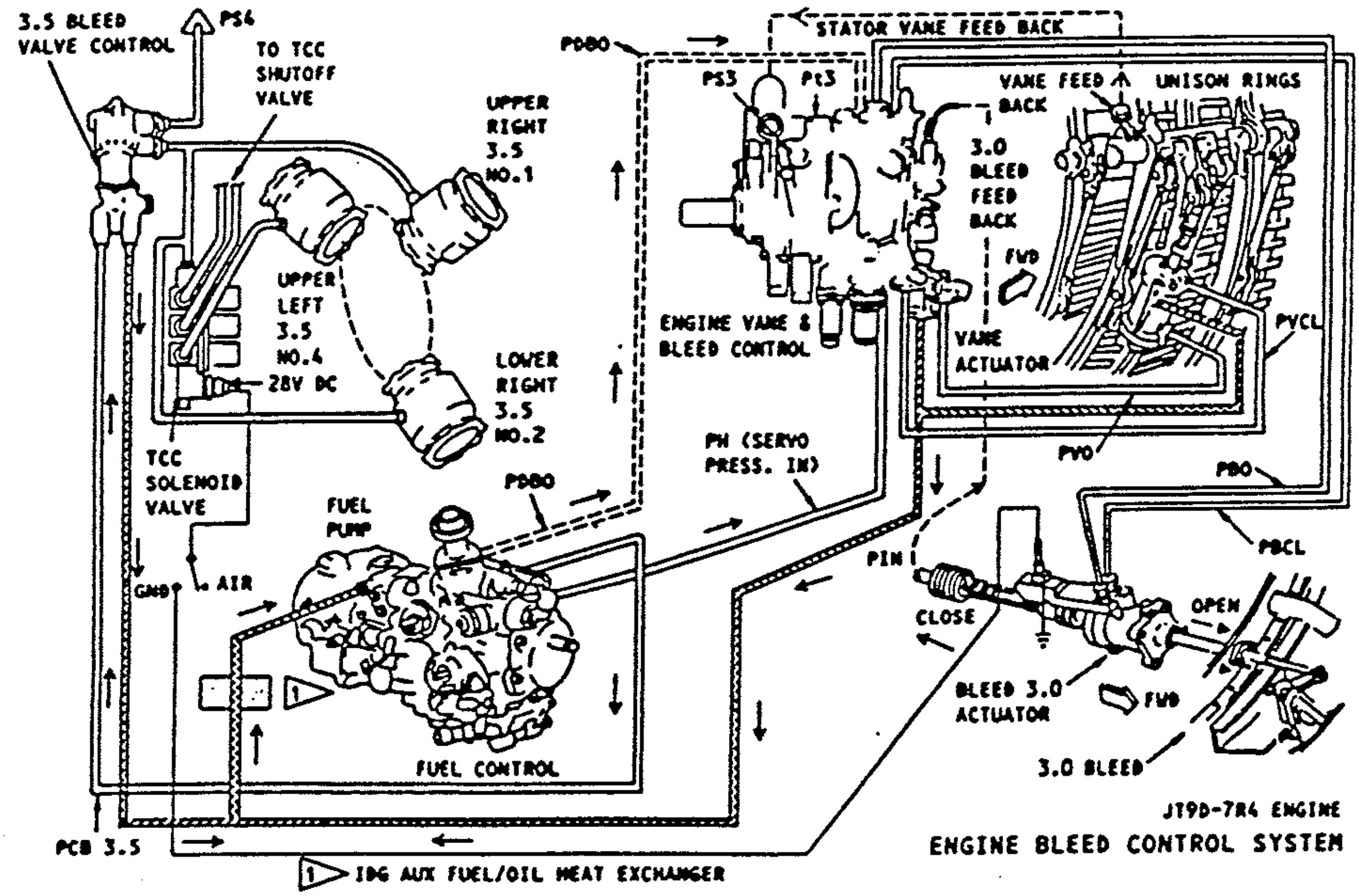
JT9D-7R4 BLEED SYSTEM





JT9D-7R4 BLEED SYSTEM

(Bleed system schematic)



ENGINE BLEED CONTROL SYSTEM

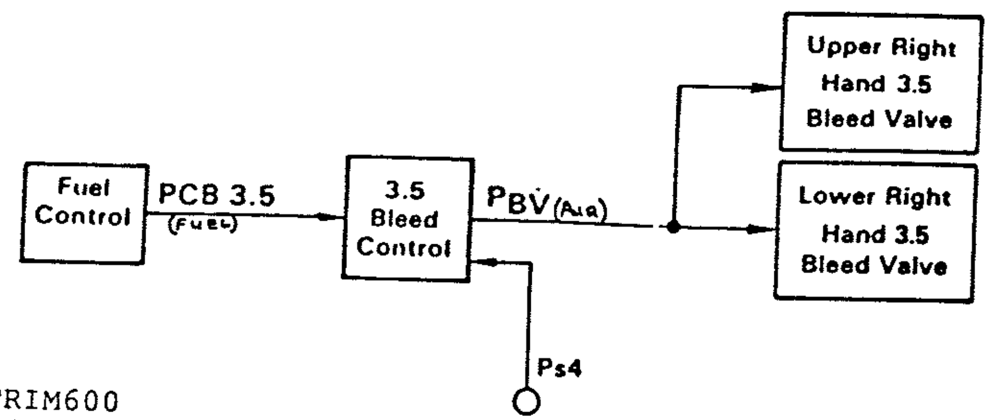
JT9D-7R4 BLEED SYSTEM

Consists of the following subsystems:

- Start bleed system — decreases drag on the compressor and provides increased starting surge margin
- Tandem bleed system — provides increased surge margin during low power operation
- Reverser actuated bleed system (RABS) — provides increased surge margin during reverser operation

START BLEED SYSTEM

- Components Involved: The Upper Right Hand and Lower Right Hand 3.5 Bleed Valves, Fuel Control, and 3.5 Bleed Control
- Normal Operation: 1. At Approximately 50% N2 Speed, Which is Below Idle, a Fuel Signal (PCB 3.5) is Directed from the Fuel Control to the 3.5 Bleed Control
  2. The 3.5 Bleed Control Converts the Fuel Signal (PCB 3.5 to a Pneumatic Muscle Pressure (PBV) for Valve Actuation
  3. PBV Muscle Pressure is Manifolded to the Individual 3.5 Bleed Valves Causing Them to Close. Valves Remain Closed as Long as Engine Remains Above 50% N2



TANDEM BLEED SYSTEM

- Components involved:
  Engine vane and bleed control, 3.0 bleed actuator, 3.0 bleed valve position switch, Mach number probes, 3.0 bleed valve and linkage, 3.0 bleed feedback push-pull cable, fuel control/fuel pump, three-way solenoid valve ("D (A)" only) or five-way solenoid valve All except D(A) , upper left hand 3.5 bleed valve and aircraft air/ground relay.

- Normal operation:
  1. Engine vane and bleed control (EVBC) receives four input signals: P_H and P_{DBO} fuel signals from the fuel control/fuel pump and P_{T3} and P_{S3} air signals from the Mach number probes.

  2. The EVBC schedules bleed open (P_{BO}) or bleed closed (P_{BCL}) fuel signals to the 3.0 bleed actuator as a function of P_{T3} and P_{S3} pressure levels.

  3. Upon receipt of the P_{BO} or P_{BCL} signal, the 3.0 bleed actuator modulates the 3.0 bleed valve to the required position through linkages.

     A. Aircraft on the ground: Aircraft air/ground relay is closed providing 28 VDC to the circuit controlling the three-way or five-way solenoid valve. This results in the upper left hand (ULH) 3.5 bleed valve working in tandem with the 3.0 bleed valve.

     When the 3.0 bleed valve is open, the 3.0 bleed valve position switch is closed which energizes the three-way solenoid valve ("D (A)" only) or five-way solenoid valve (All except D(A)). When energized, the solenoid valve terminates the PBV signal to the ULH 3.5 bleed valve and opens the valve.

     When the 3.0 bleed valve is closed, the 3.0 bleed position switch is open which de-energizes the solenoid valve. When de-energized, the solenoid valve allows P_{BV} signal to flow to the ULH 3.5 bleed valve and closes the valve.

     B. Aircraft in-flight: Aircraft air/ground relay is open terminating the 28 VDC to the circuit controlling the three-way or five-way solenoid valve. The de-energized solenoid valve allows P_{BV} signal to flow to the ULH 3.5 bleed valve and keeps the bleed closed regardless of the 3.0 bleed valve position.

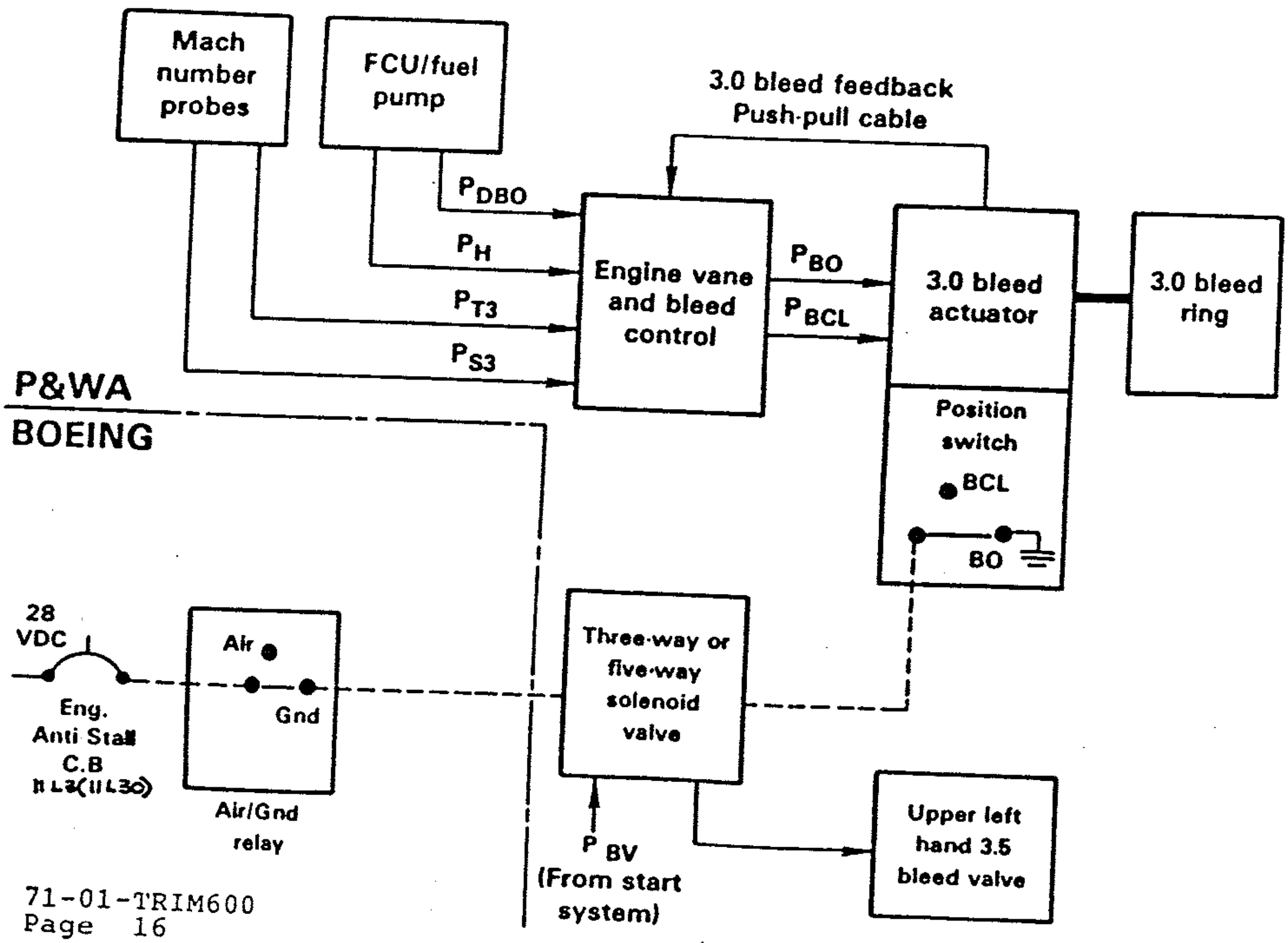
TANDEM BLEED SYSTEM

- **Normal operation (cont'd):**

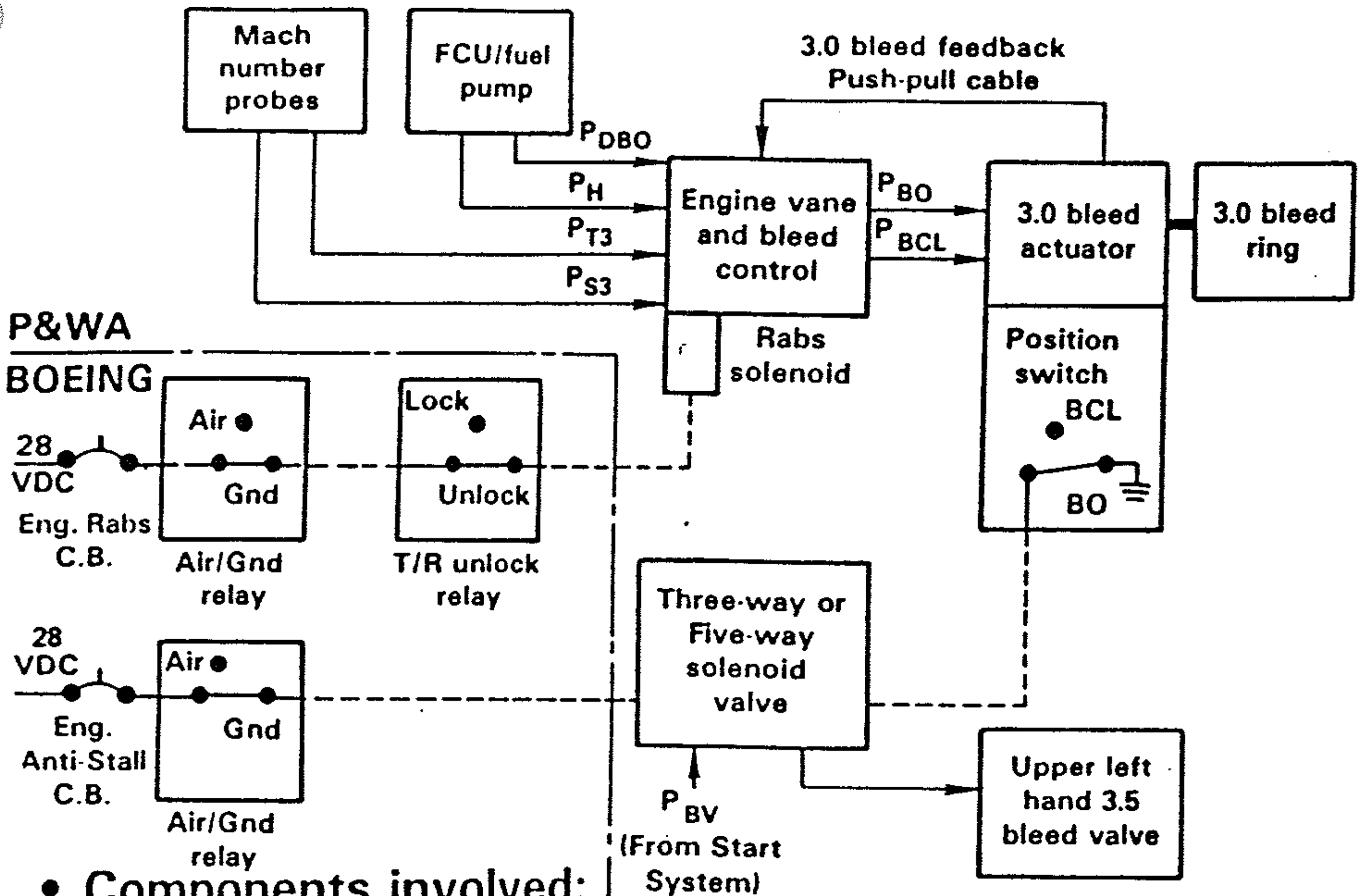
4. The 3.0 bleed feedback push-pull cable provides the 3.0 bleed valve position input to the EVBC to prevent over scheduling of the bleed

5. 3.0 bleed is modulated from full open below 1.09 EPR to full closed above APPROX. 1·32 EPR at sea level, static conditions

6. During rapid decelerations, the fuel control reduces the P_{DBO} signal level to the EVBC resulting in the EVBC scheduling the 3.0 bleed valve to the full open position. During ground operation, the ULH 3.5 bleed valve will open in tandem with the 3.0 bleed



REVERSER ACTUATED BLEED SYSTEM (RABS)



- **Components involved:**

  Engine vane and bleed control, 3.0 bleed valve and linkage, RABS solenoid (mounted on EVBC), 3.0 bleed actuator, 3.0 bleed valve position switch, three-way solenoid valve ("D (A)" only) or five way solenoid valve (All except D(A)) upper left hand 3.5 bleed valve, aircraft air/ground relays and aircraft thrust reverser (T/R) unlock relay.

- **Normal operation:**

  1. As the fan reverser sleeve starts to deploy, the switch in the T/R unlock position relay closes, resulting in 28 VDC being sent to the EVBC RABS solenoid. The air/ground relay inhibits power in flight.
  2. Upon receipt of the electrical signal at the RABS solenoid, the EVBC sends a bleed open signal (P_{BO}) to the 3.0 bleed actuator resulting in the 3.0 bleed valve fully opening.
  3. As the 3.0 bleed actuator translates to the open position, the 3.0 bleed valve position switch closes, energizing the three-way (or five-way) solenoid valve, terminating the P_{BV} signal to the upper left hand 3.5 bleed valve and opening the valve.

3.5 BLEED VALVE CHECK

(Engine Static)

Malfunction can cause:

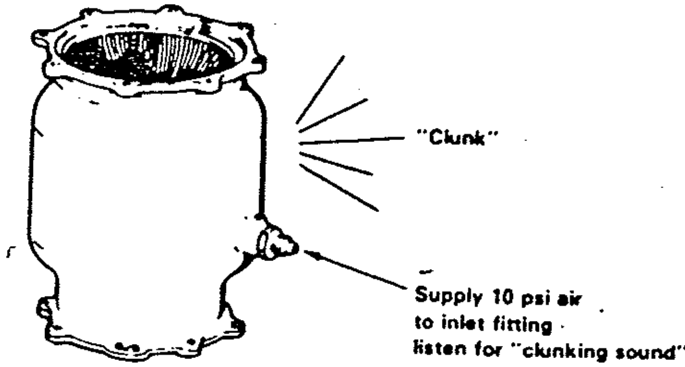
3.5 bleed valve to remain open, closed or partially open

Check determines:

If 3.5 bleed valve opens and closes properly

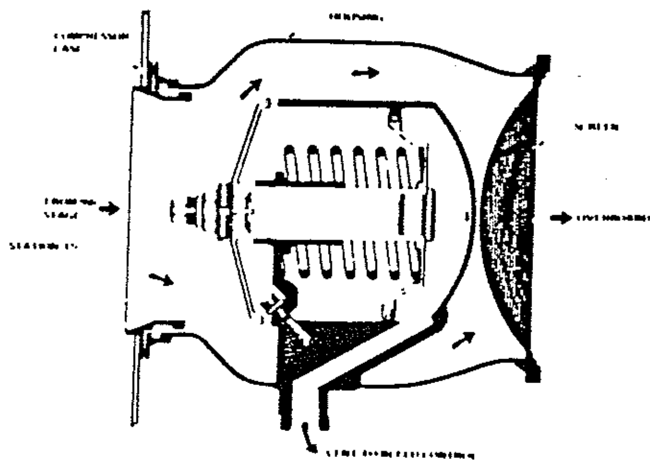
Instructions for check:

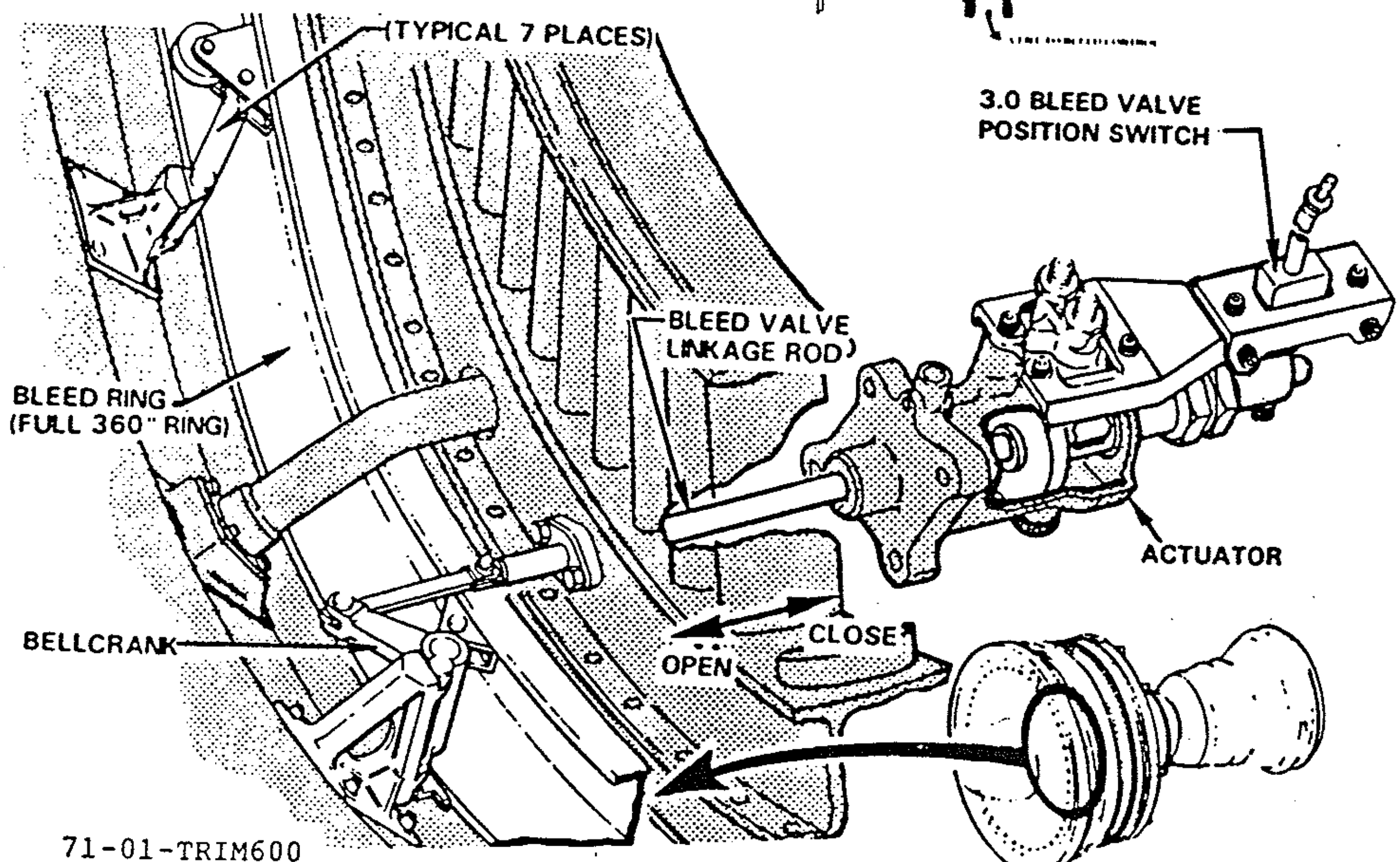
1. Supply 10 psi directly to valve
2. If valve makes a "clunking" sound it is opening and closing properly



Operational discrepancy:

- Impending hot start
- High EGT
- High N2
- Abnormal parameters
- Surge on ground

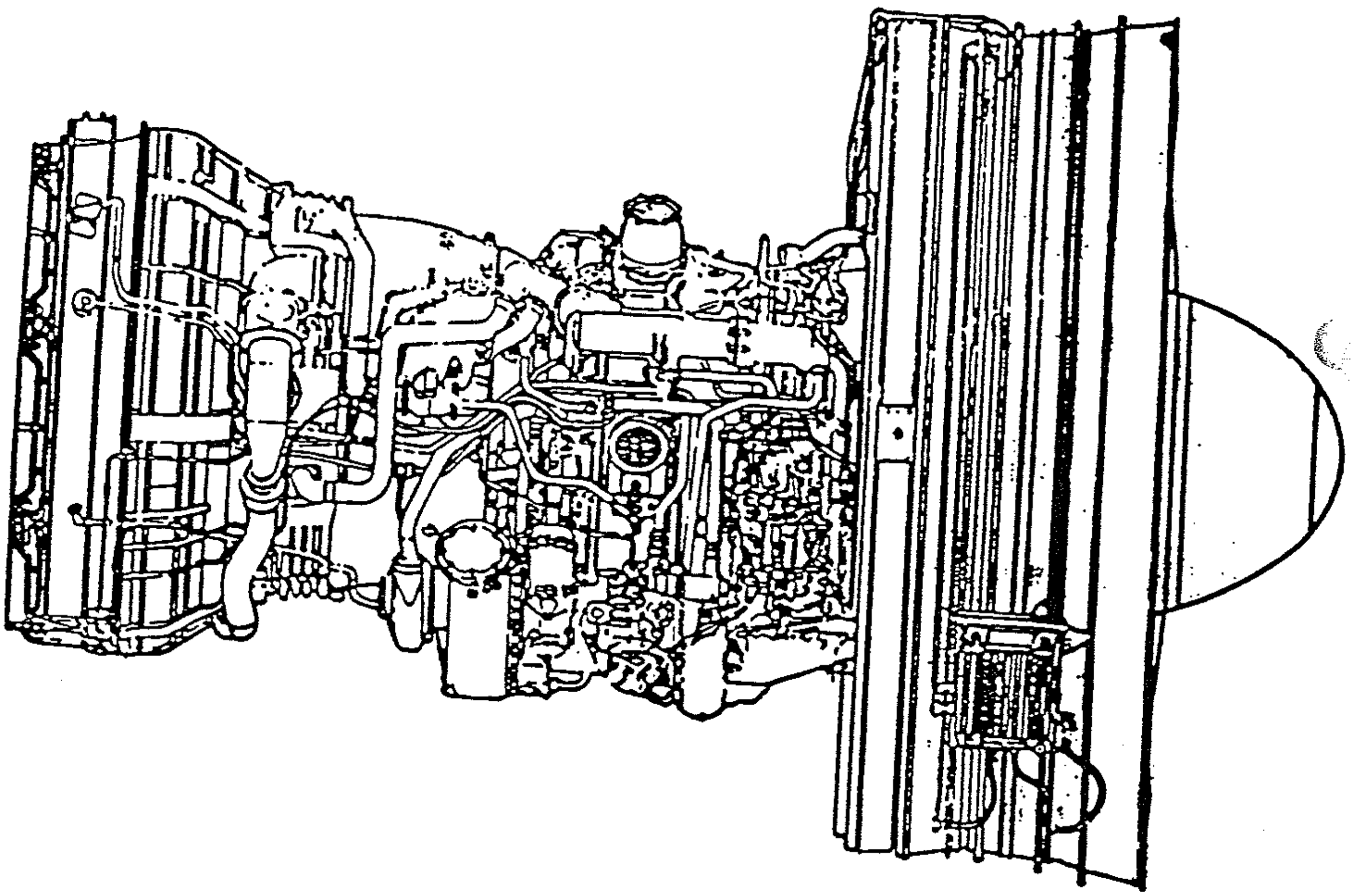




3.0 bleed ring and actuator

JT9D-7R4

PHASE II STABILITY IMPROVEMENTS

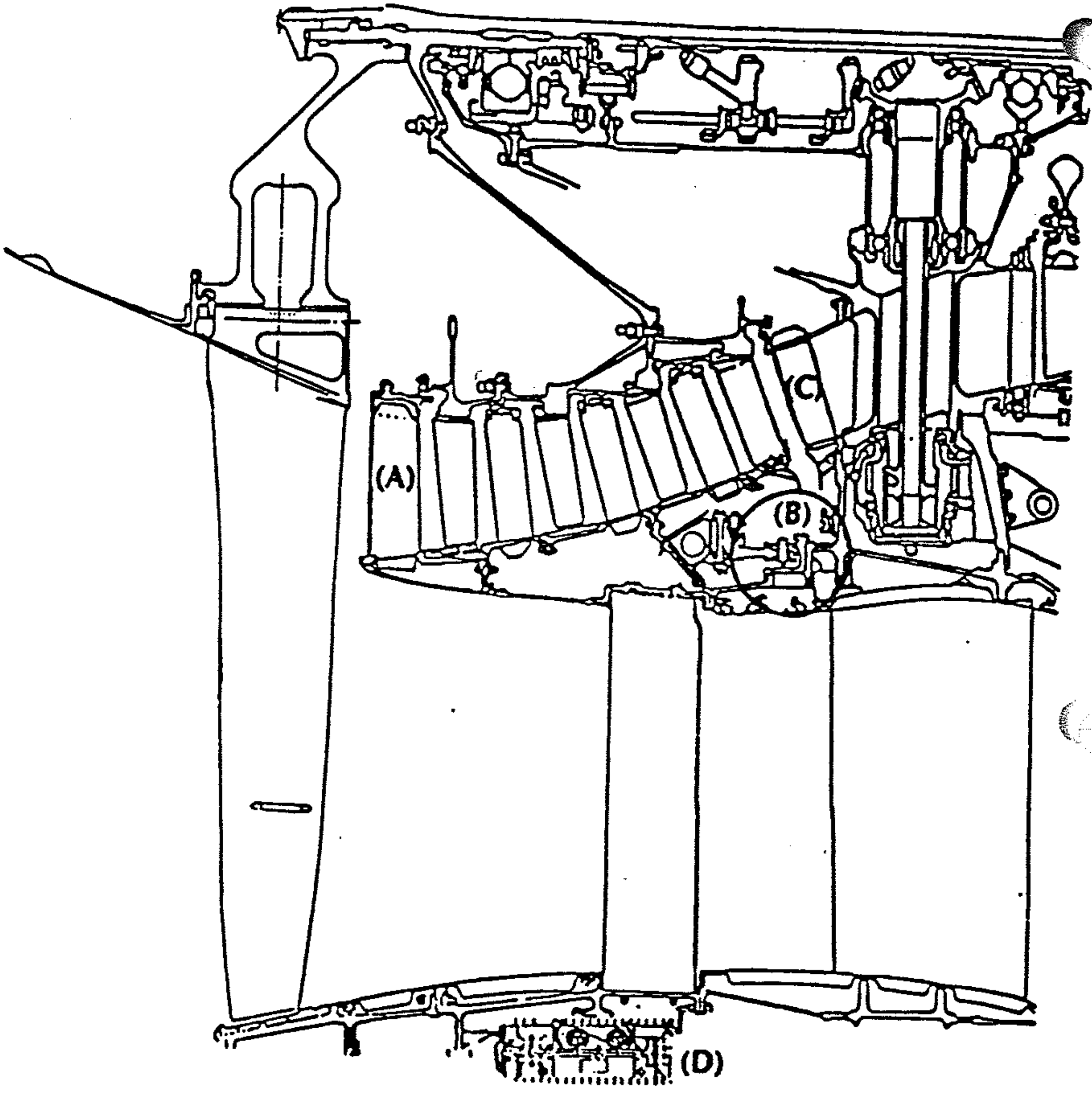


JT9D-7R4 Phase II Stability Improvements

Phase II Stability Improvements provide increased basic engine surge margin and improved surge recovery. Incorporation of Phase II in conjunction with Phase I improvements represents the optimum JT9D-7R4 engine stability configuration. Phase II improvements are as follows:

- Restaggered 5 degree closed first stator (A)
- Revised 3.0 bleed system hardware
  - 3.0 bleed valve (B)
  - LPC fourth stator and flow guides (C)
- Added EEC software functions (D)
  - Surge Recovery
  - Just-Turned-On

Note: Appropriate Phase II P&W Service Bulletins for the Boeing installation are given on page 13. Phase II Service Bulletins for the Airbus installation will be issued after certification.



JT9D-7R4 Phase II
Stability Improvements

A Phase I engine is used for comparison and incorporates the stability improvements listed in the tables on pages 14 & 15.

Phase II stability improvements and resulting benefits are described on the following pages. Engine performance curves show the benefits resulting from incorporation of each Phase II improvement relative to a Phase I engine.

All performance curves represent conditions at 43,000 feet/.80 Mach number. Unless otherwise noted, all curves represent a 2 degree Power Lever Angle (PLA) per second deceleration rate.

Restaggered 5 Degree Closed First Stator

Restaggering the first LPC stator closed by 5 degrees provides increased protection against deceleration and steady-state surges.

Deceleration Surge:

Engine testing shows that restaggering the first stator provides up to a 2.5% LPC surge margin improvement at altitude relative to a full Phase I engine. This improvement results from a 1.5% lower LPC operating line and a 1.0% higher LPC surge line.

Steady-State Surge:

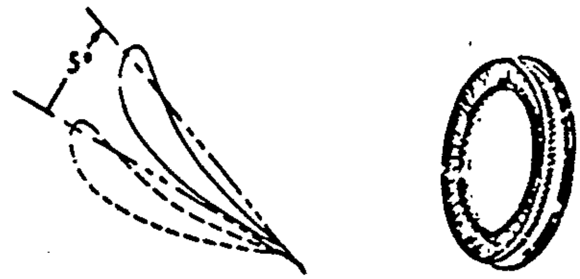
Relative to the pre-Phase II first stator, there is a 2.0% improvement in HPC surge margin.

Performance:

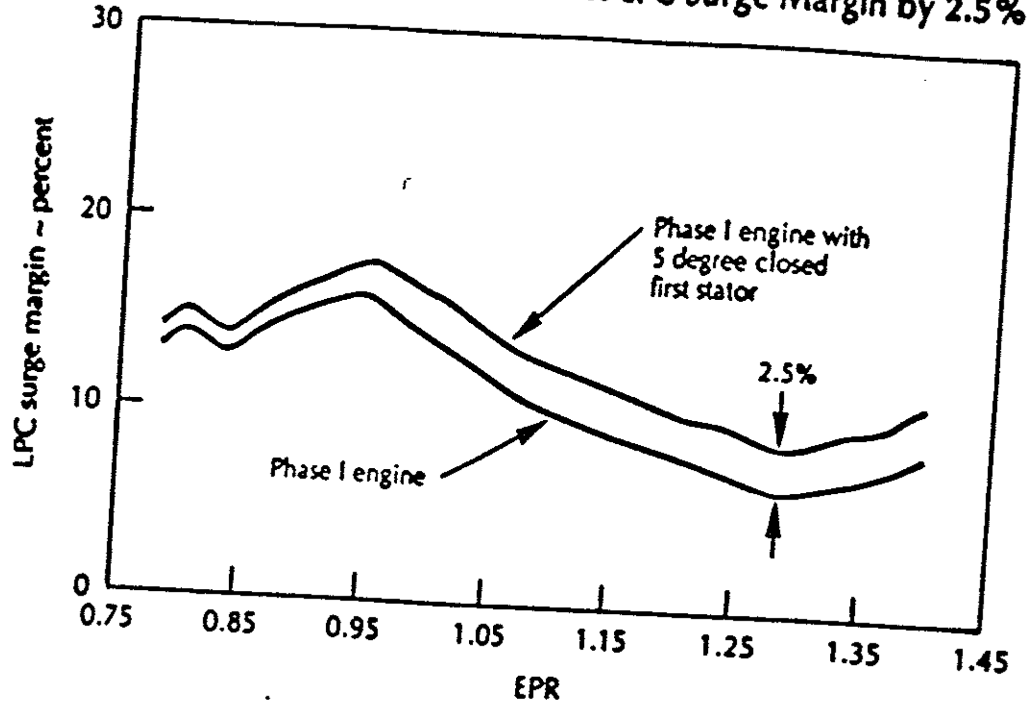
Engine test results show the following performance changes due to the 5 degree closed first stator:

TSFC	EGT	N1	N2
-0.1%	+3°C	+0.1%	-0.1%

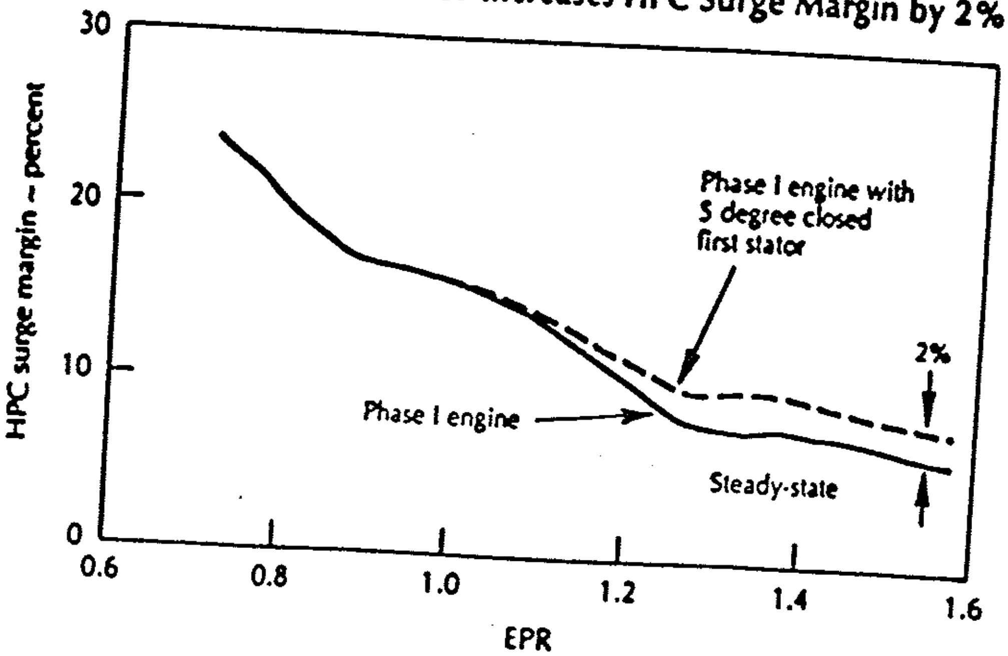
Restaggered
5 Degree Closed
First Stator



5 Degree Closed First Stator Increases LPC Surge Margin by 2.5%



5 Degree Closed First Stator Increases HPC Surge Margin by 2%



Revised 3.0 Bleed System Hardware

Revised 3.0 bleed system hardware provides additional protection against LPC surges when the 3.0 bleed valve is modulating below 1.30 EPR at altitude and when the bleed valve is fully open.

3.0 Bleed Valve:

To provide more surge margin when the bleed valve is modulating, 3.0 bleed flow has been increased by reducing the valve diameter to increase flow area.

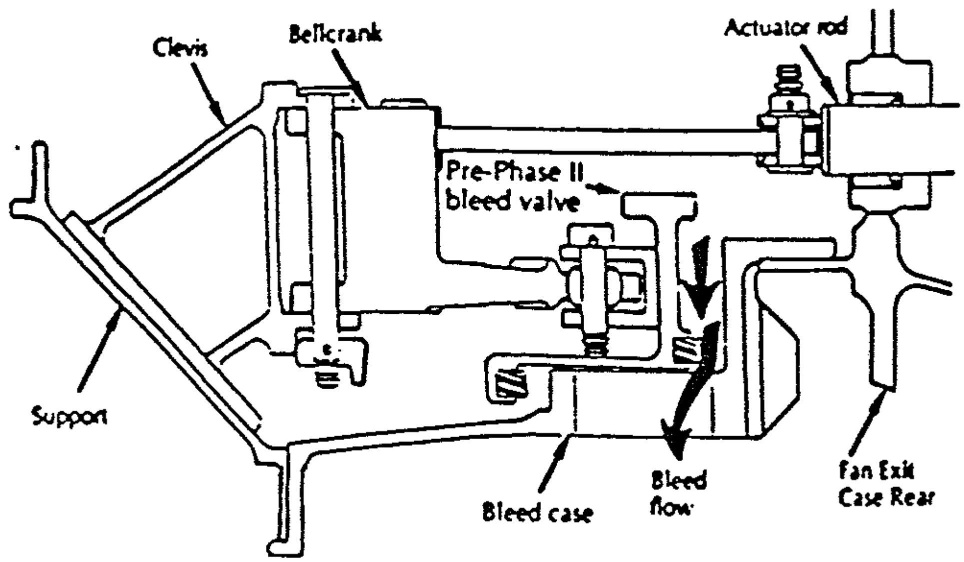
LPC Fourth Stator:

The revised LPC fourth stator increases the inlet area to the 3.0 bleed cavity to increase bleed flow. By shifting the fourth stator to the rear, the 3.0 bleed cavity inlet area has been increased.

Flow Guides:

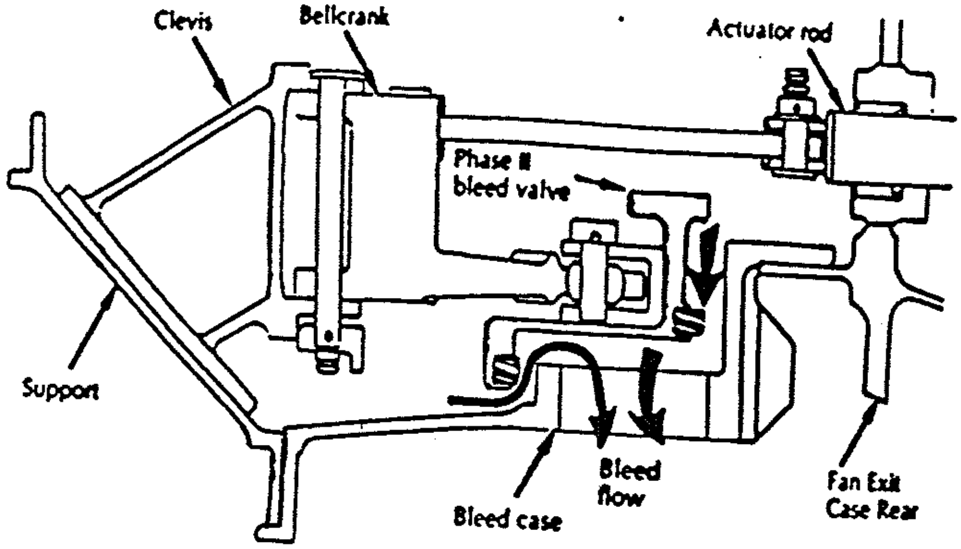
The flow guides have been revised to reduce the pressure loss from the LPC flow path to the 3.0 bleed cavity. This increases the pressure in the cavity and the pressure differential across the louvers to increase 3.0 bleed flow when the valve is fully open.

Pre-Phase II Configuration



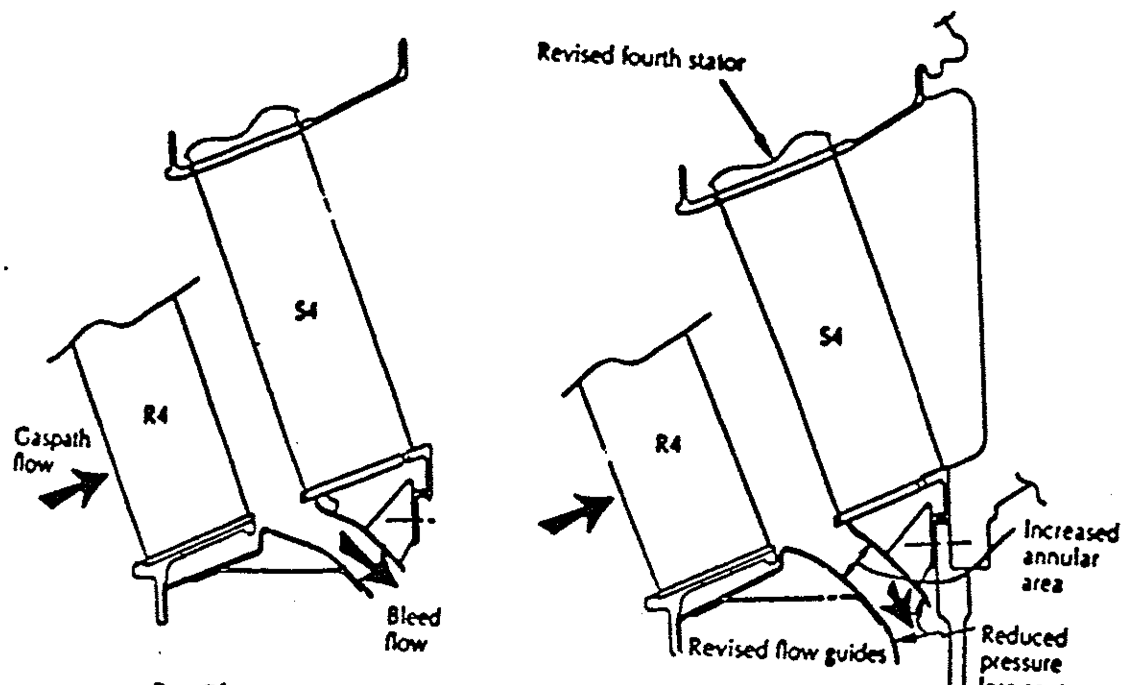
Partially Open

Phase II Configuration



Partially Open

Revised LPC Fourth Stator and Flow Guides



Pre-Phase II

Phase II

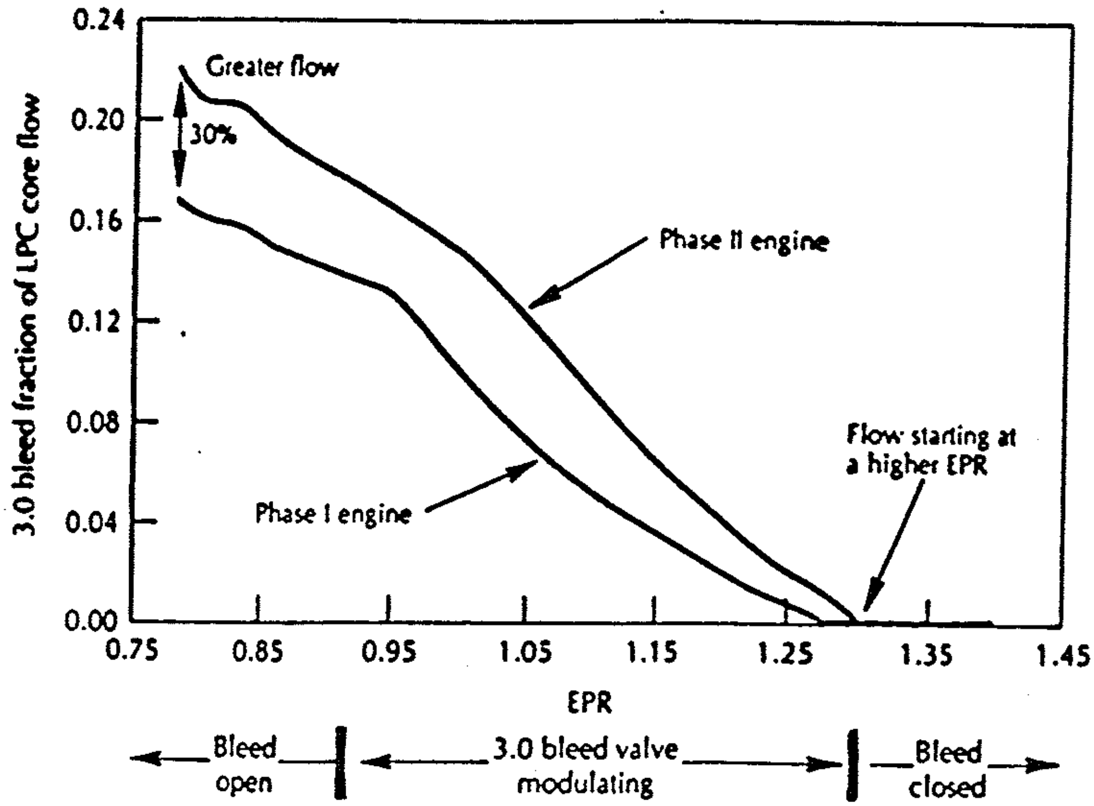
7

These 3.0 Bleed System Modifications Provide:

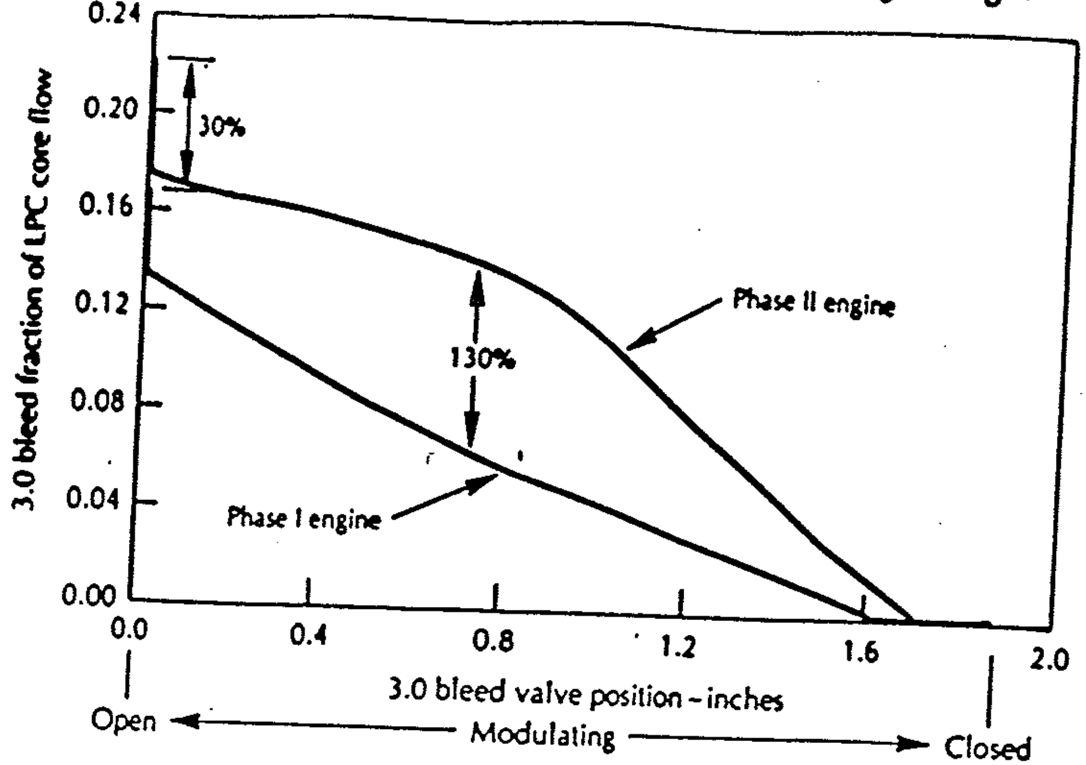
- Flow starting at a higher EPR to provide more surge margin during deceleration.
- As much as 130% increase in bleed flow while the valve is modulating.
- A maximum increase of 30% in bleed flow when the valve is fully open.

Because of the increased bleed flow, LPC surge margin in the 3.0 bleed modulation region is up to 10% more than a Phase I engine with the restaggered first LPC stator. With the valve fully open, LPC surge margin is increased by 7%. The Phase II bleed system modifications significantly increase LPC surge margin in the deceleration surge EPR range.

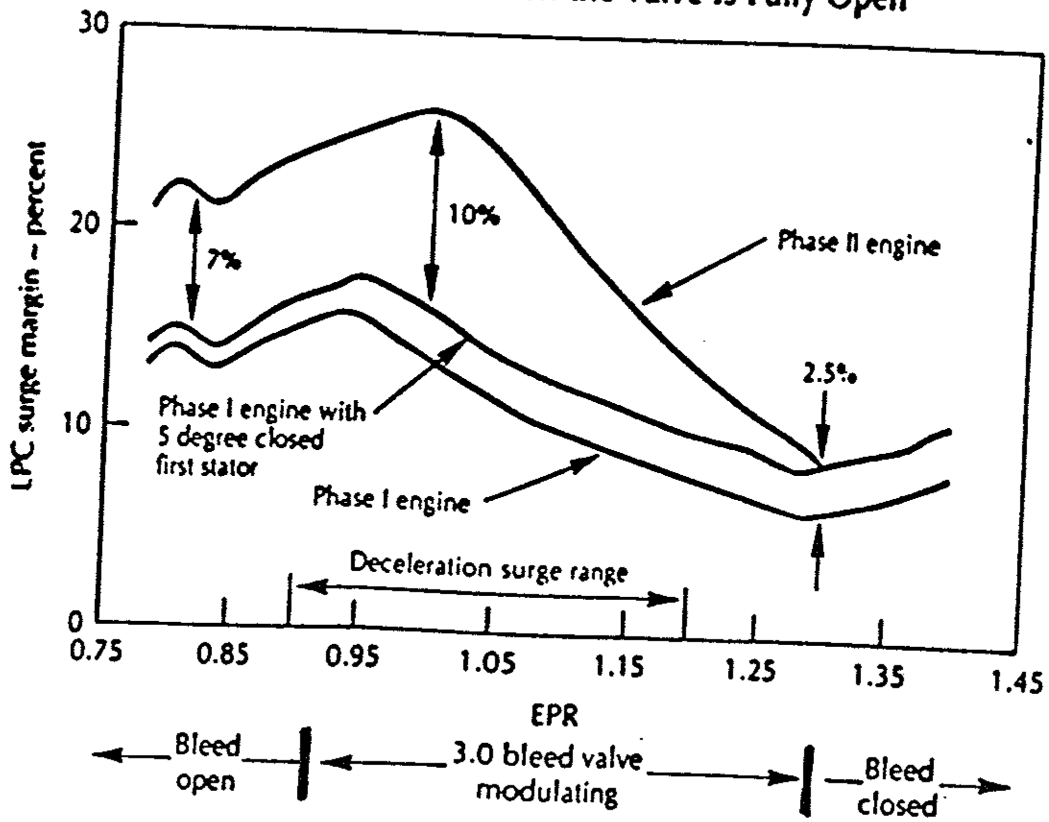
3.0 Bleed Flow Starts at a Higher EPR Providing Increased LPC Surge Margin during Deceleration



3.0 Bleed Flow Is Increased during Valve Modulation and When the Valve Is Fully Open, Providing Increased LPC Surge Margin

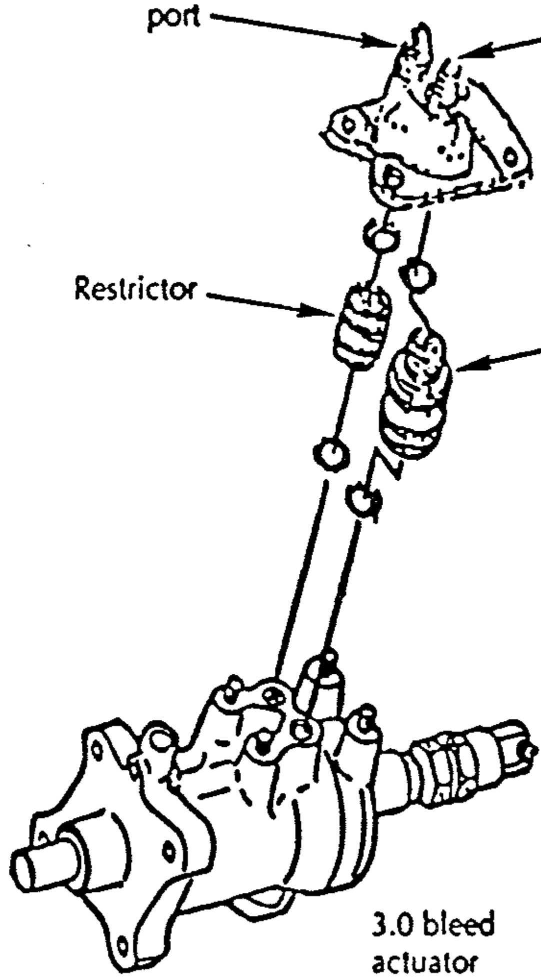


LPC Surge Margin Is Significantly Increased during Valve Modulation and When the Valve Is Fully Open



3.0 Bleed Valve Actuator Restrictor and Revised Fuel Check Valve

A 3.0 bleed valve actuator restrictor was incorporated and the fuel check valve revised to optimize the valve open and close rates with the 3.0 bleed system operating characteristics.

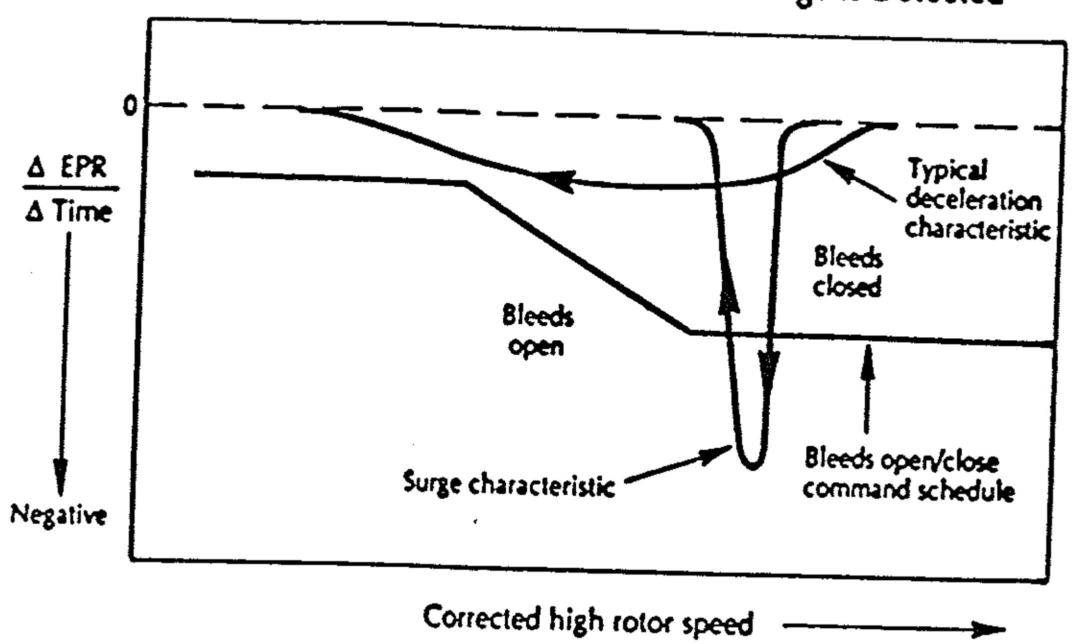


EEC Surge Recovery Functio

Surge recoverability is enhanced significantly when bleed flow is initiated immedia following a surge. The surge recovery function is a Phase II EEC software addition designed to open the 3.0 and the upper left hand 3.5 bleeds when a surge is detected. Surges are detected by EPR rate-of-change with time ($\frac{\Delta EPR}{\Delta Time}$) which is scheduled as a function of corrected high rotor speed. Both bleeds open when $\frac{\Delta EPR}{\Delta Time}$ crosses below the bleeds open/close schedule and remain open for 3 seconds after $\frac{\Delta EPR}{\Delta Time}$ crosses above the schedule.

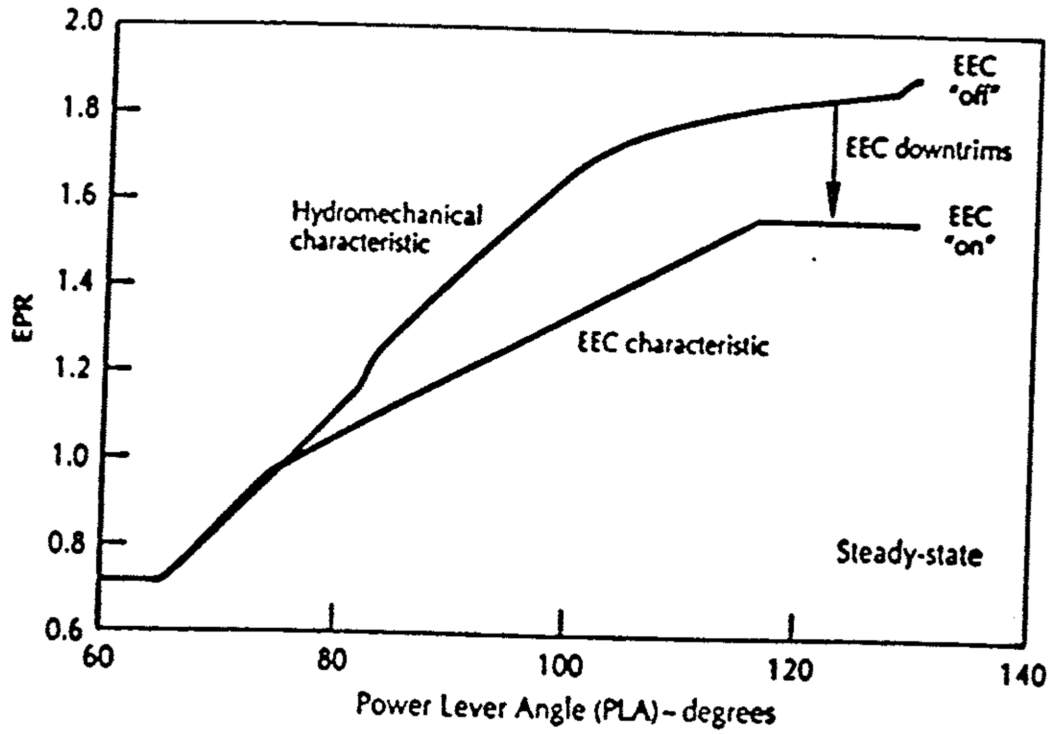
The surge recovery function is active whenever the EEC is "on".

Phase II EEC Surge Recovery Function Opens the 3.0 and Upper Left Hand 3.5 Bleeds When Surge Is Detected



The EEC Just-Turned-On function provides surge protection when the EEC is switched from "off" to "on" above 20,000 feet. With the EEC "off", the engine operates on the hydromechanical control EPR/PLA characteristic. When the EEC is turned "on", the EEC will downtrim from the hydromechanical to the EEC characteristic. This downtrimming results in an engine deceleration that can cause surge. The Phase II EEC function protects against deceleration surges when the EEC is switched from "off" to "on". When the EEC is switched "on", the function commands the 3.0 bleed open. It remains open for 5 seconds or until actual EPR is within 0.05 of the EEC target EPR.

When the EEC Is Switched from "Off" to "On" Engine Deceleration Surges Are Prevented by the EEC Just-Turned-On Function



WHY TRIM A JT9D ENGINE?

- Variable vane system —
  - Purpose: to provide optimum engine performance throughout the engine operating envelope by varying compressor airflow. At low engine RPM, the variable vanes are "closed" allowing minimal airflow through the compressor. At high engine RPM, the variable vanes are "open" allowing maximum airflow through the compressor.
  - Trimming the variable vanes ensures vane operation within a trim band in order to obtain the optimal engine performance while maintaining acceptable surge margin.
  - Vanes operating outside the trim band could result in any of the following engine discrepancies:
    - Impending hot start
    - Hung start
    - High EGT
    - High N_2
    - Abnormal parameters
    - Acceleration surge
    - Deceleration surge
    - Steady state surge
    - Reverse surge
    - High oil consumption
    - Oil fumes in cockpit

- Modulating 3.0 bleed system —
  - Purpose: provides surge margin during low power operation by the opening of the 3.0 bleed ring
  - Trimming the 3.0 bleed ensures that the 3.0 bleed ring opens and modulates closed within the correct EPR band
  - Off-schedule operation of the 3.0 bleed could result in any of the following engine discrepancies:
    - Impending hot start
    - High EGT
    - High N_2
    - Acceleration surge
    - Deceleration surge
    - Steady state surge
    - Reverse surge

WHY TRIM A JT9D ENGINE? (Cont'd)

- Fuel control —
  - Purpose: among other functions, the fuel control regulates the level of min idle and approach idle N_2 speeds and schedules fuel flow to produce the required EPR levels during high power running
  - Trimming the fuel control ensures proper N_2 speeds at min idle and approach idle conditions and the ability to obtain the proper EPR level at take-off power.
  - Fuel control operation off-schedule could result in any of the following engine discrepancies:
    - Low or high min idle speed
    - Low or high approach idle speed
    - Low take-off power
  - Airplane flight compartment N_2 and EPR indicators are used for engine trim
  - Prior to fuel control trimming the Engine Electronic Control (EEC) must be disengaged from the fuel control by means of the flight compartment switch

- Take off trim
  - The fuel control part power stop is remotely controlled from the flight compartment
  - With the thrust lever advanced to the part power stop the remote trimmer is actuated as required to attain target part power EPR

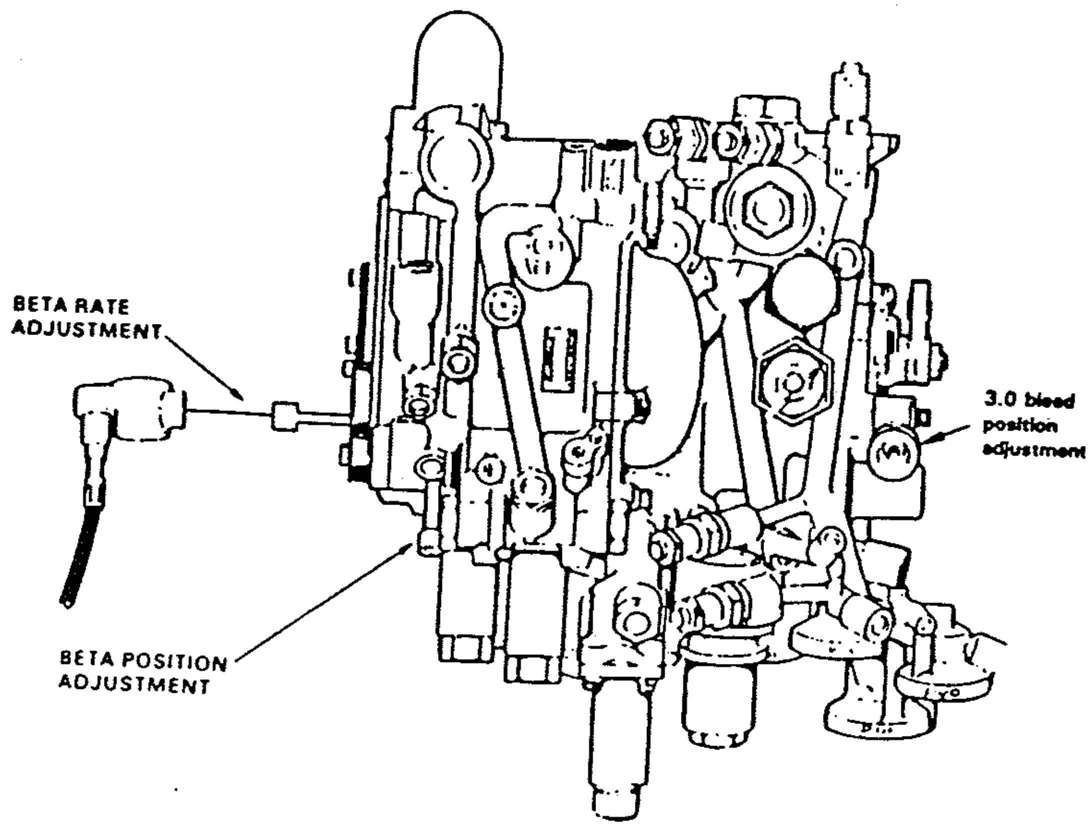
FUEL CONTROL TRIM (cont'd)

- Approach idle trim
  - Fuel control is placed in approach idle mode by pulling appropriat circuit breaker in flight compartment (fuel control solenoid is de-energized)
  - Remote trimmer is actuated as required to attain target approach idle N_2
- Min. idle trim
  - With fuel control in min. idle mode (solenoid energized) remote trimmer is actuated as required to attain target min. idle N_2

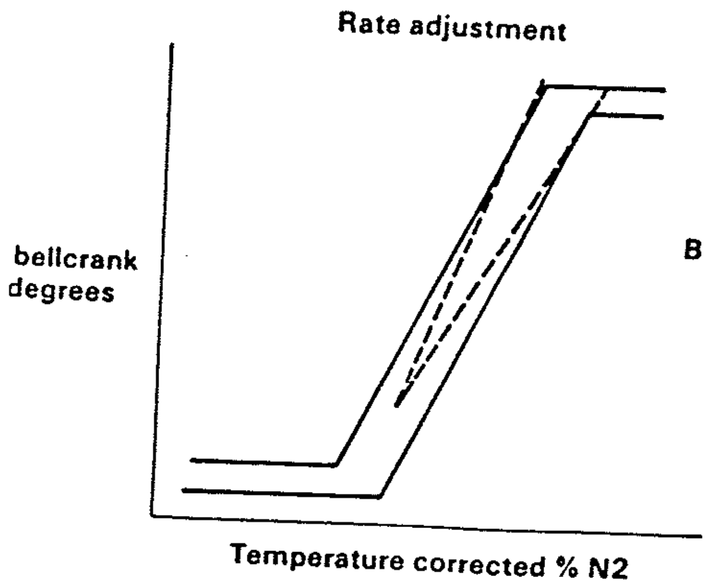
HOW IS ENGINE TRIM ACCOMPLISHED?

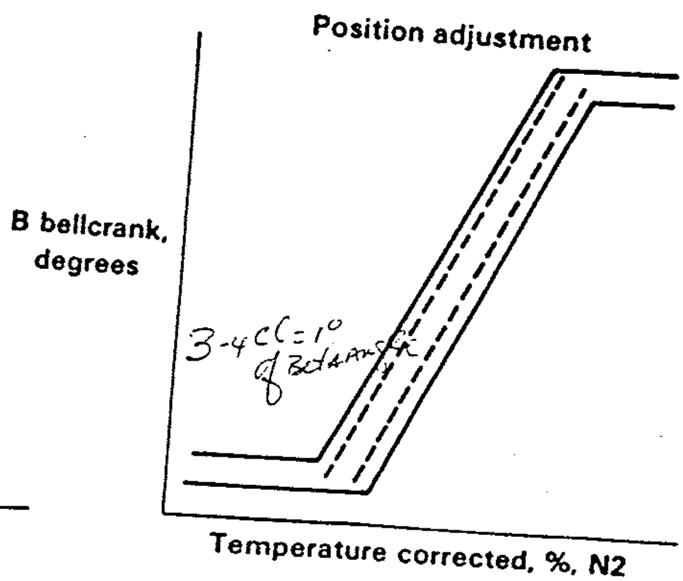
- Component trim sequence
  - Variable vane system (Beta vs. N2 corr)
  - 3.0 bleed
  - Fuel control
- Variable vane system trim
  - EVBC has two trimmers (rate and position adjustments)
    - "Rate adjustment" trimmer is activated from the flight deck via the trim equipment and "tilts" vane schedule

EVBC TRIMMER LOCATIONS

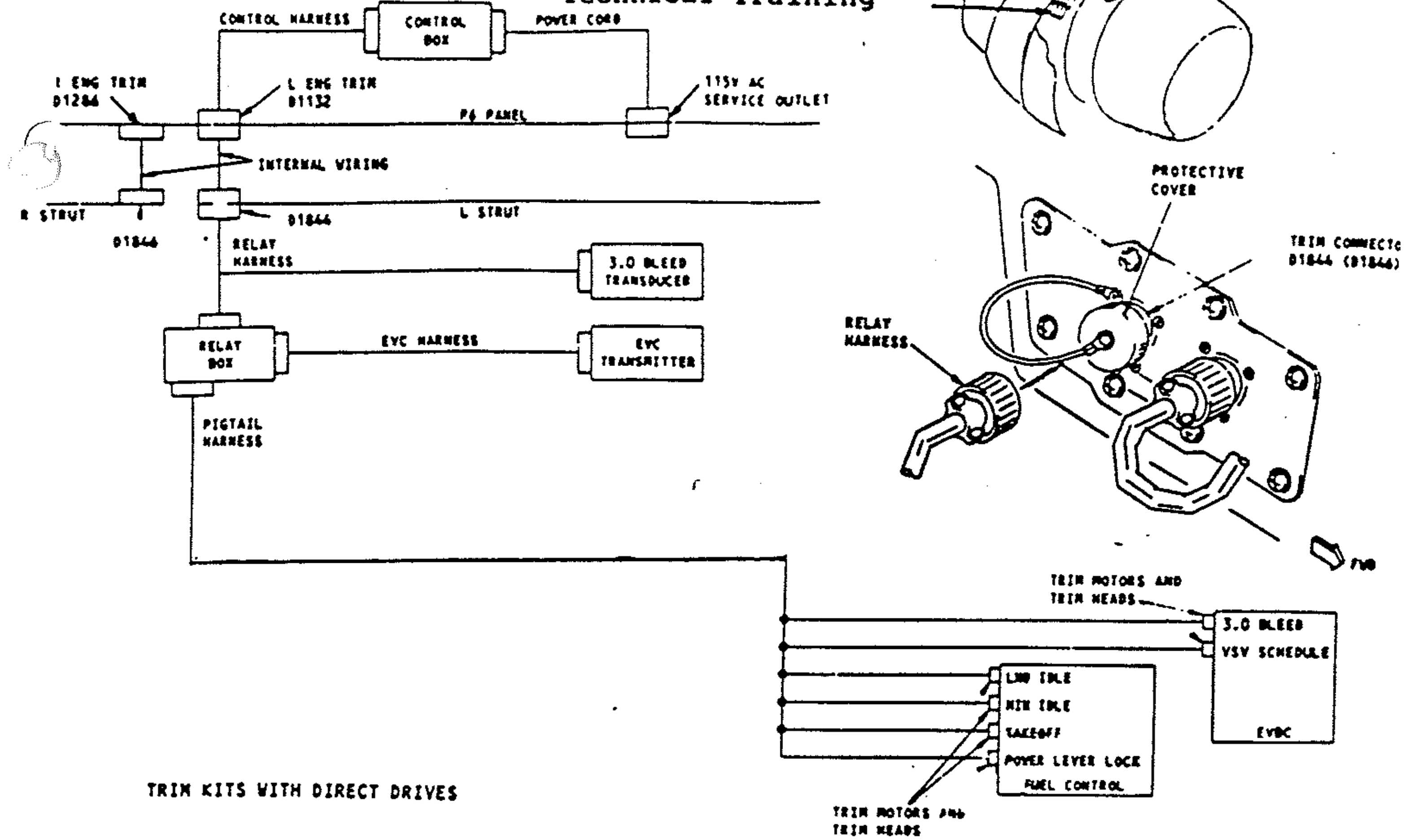


- "Position adjustment" trimmer is manually adjusted at the EVBC and "slides" vane schedule
- Use "position adjustment" to trim idle point into trim band and also to aid "rate adjustment" in positioning trim within band above idle





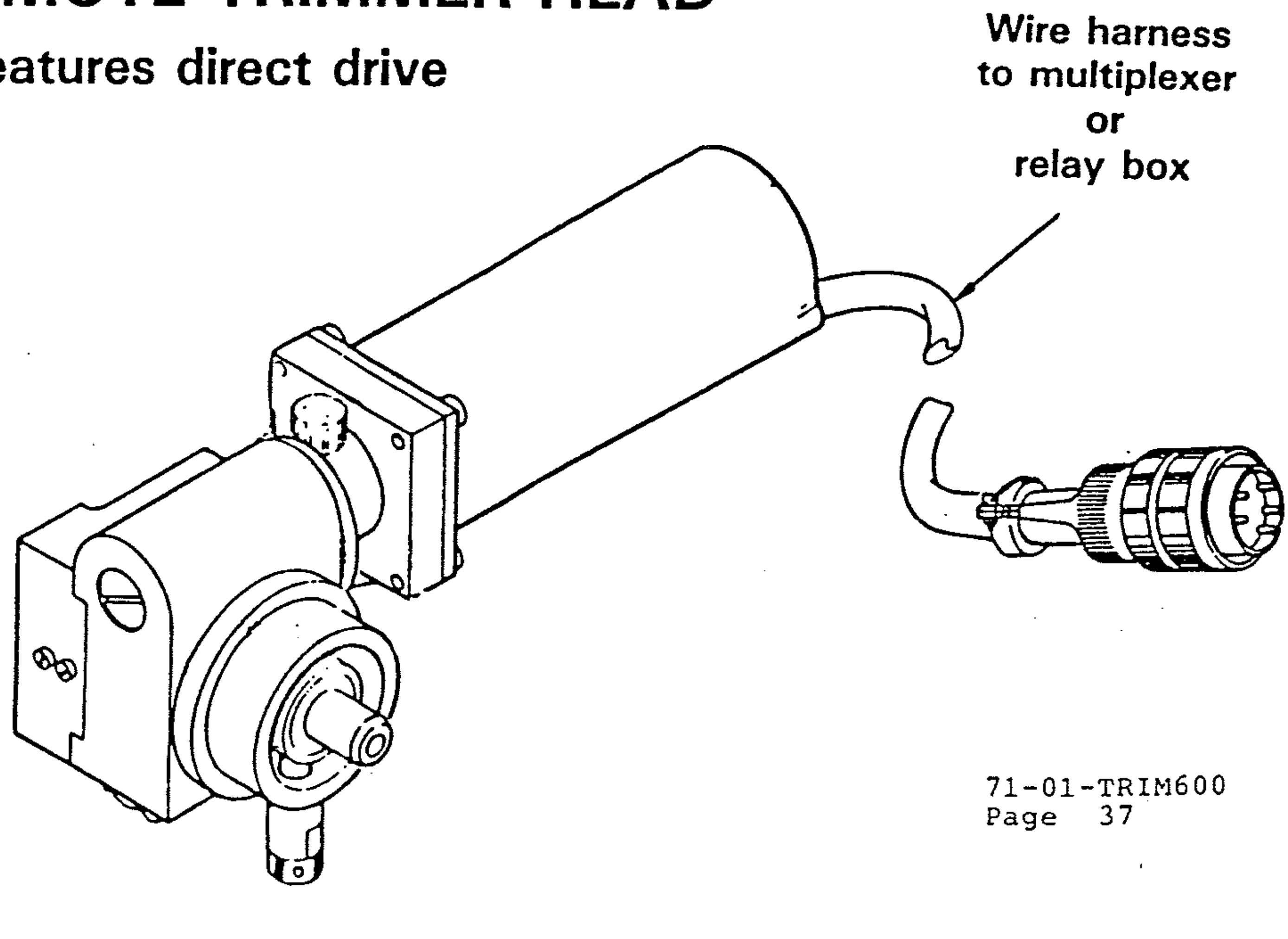
Use of remote EVBC rate adjustment will not change idle trim point

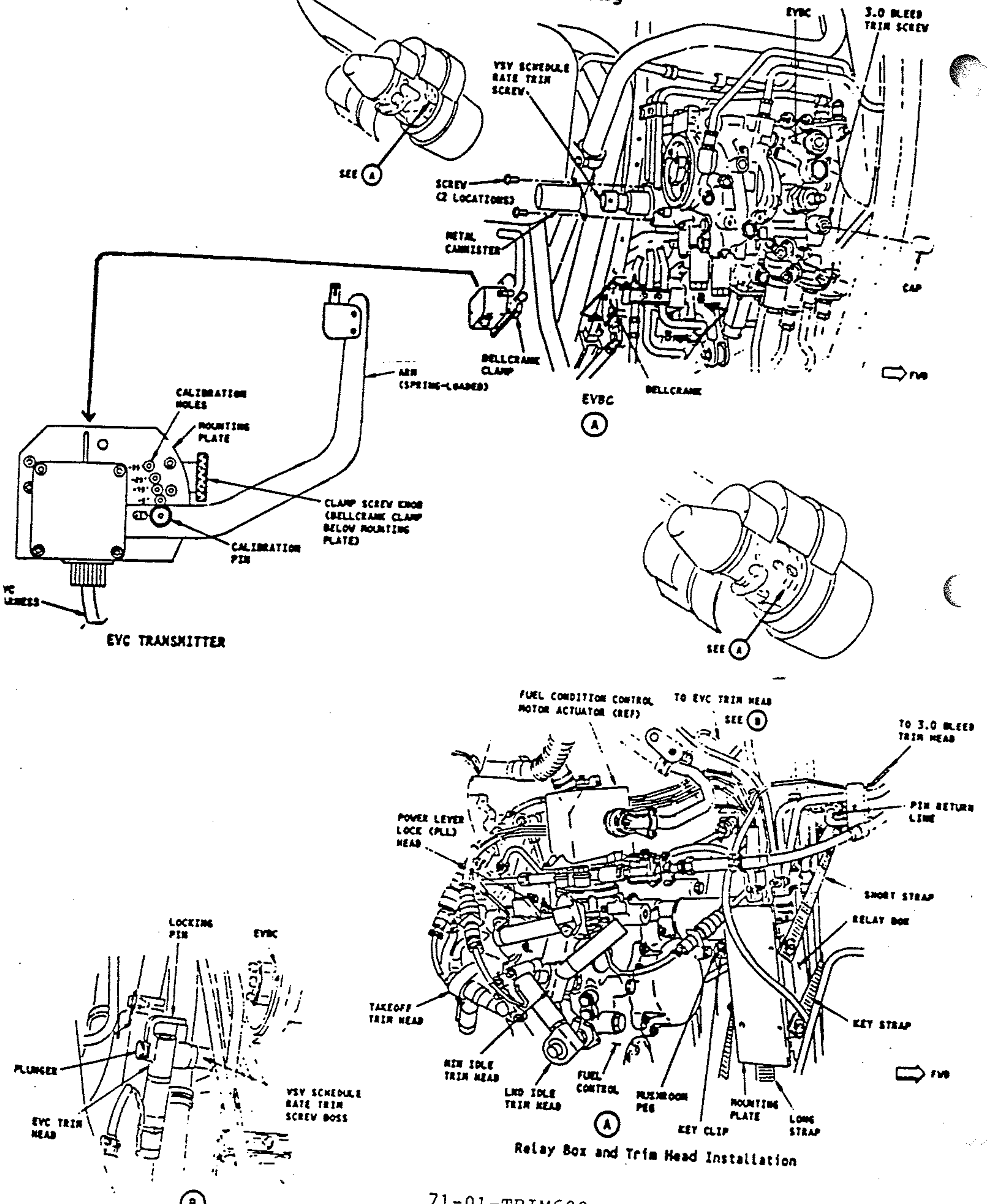


TRIM KITS WITH DIRECT DRIVES

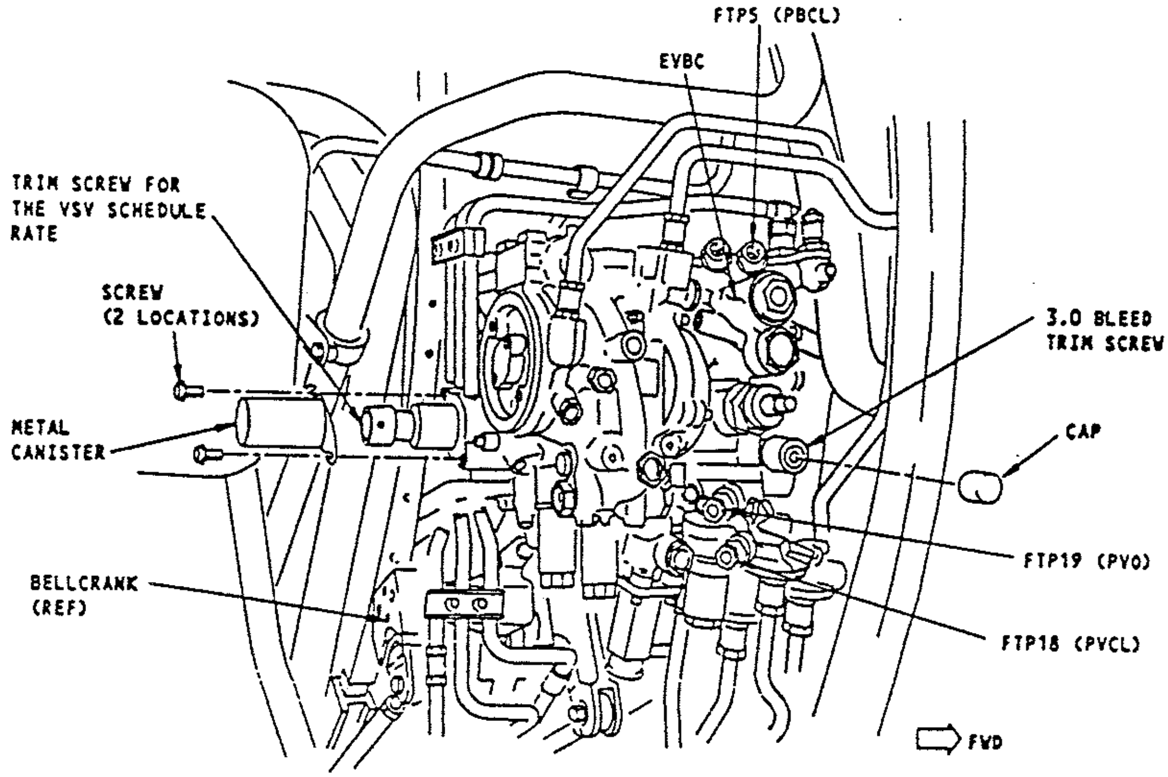
REMOTE TRIMMER HEAD

Features direct drive





Relay Box and Trim Head Installation



MANUAL ADJUSTMENTS TABLE		
TRIM SCREW	EFFECT OF CLOCKWISE ROTATION [1] [2]	MAXIMUM TORQUE
3.0 BLEED	1 TURN INCREASES EPR AT THE 3.0 BLEED VALVE CLOSURE BY 0.015	15 IN-LB
VSV SCHEDULE RATE	1/4 TURN (9 CLICKS) INCREASES N2 AT A GIVEN EPR BY 0.23% N2 WHEN YOU OPERATE ABOVE 1.30 EPR	25 IN-LB
VSV SCHEDULE POSITION	1/4 TURN (9 CLICKS) INCREASES N2 AT A GIVEN EPR BY 0.50% N2 WHEN YOU OPERATE ABOVE 1.30 EPR	25 IN-LB
	3 CLICKS INCREASES N2 AT VSV-BREAKAWAY BY 1% N2	
TAKEOFF [3]	7 CLICKS INCREASES EPR AT PART POWER BY 0.010	15 IN-LB
MIN IDLE [3]	1 CLICK INCREASES N2 AT MINIMUM IDLE BY 0.15% N2	25 IN-LB
LND IDLE [3]	1 CLICK INCREASES N2 AT APPROACH IDLE BY 0.1% N2	25 IN-LB

1/2

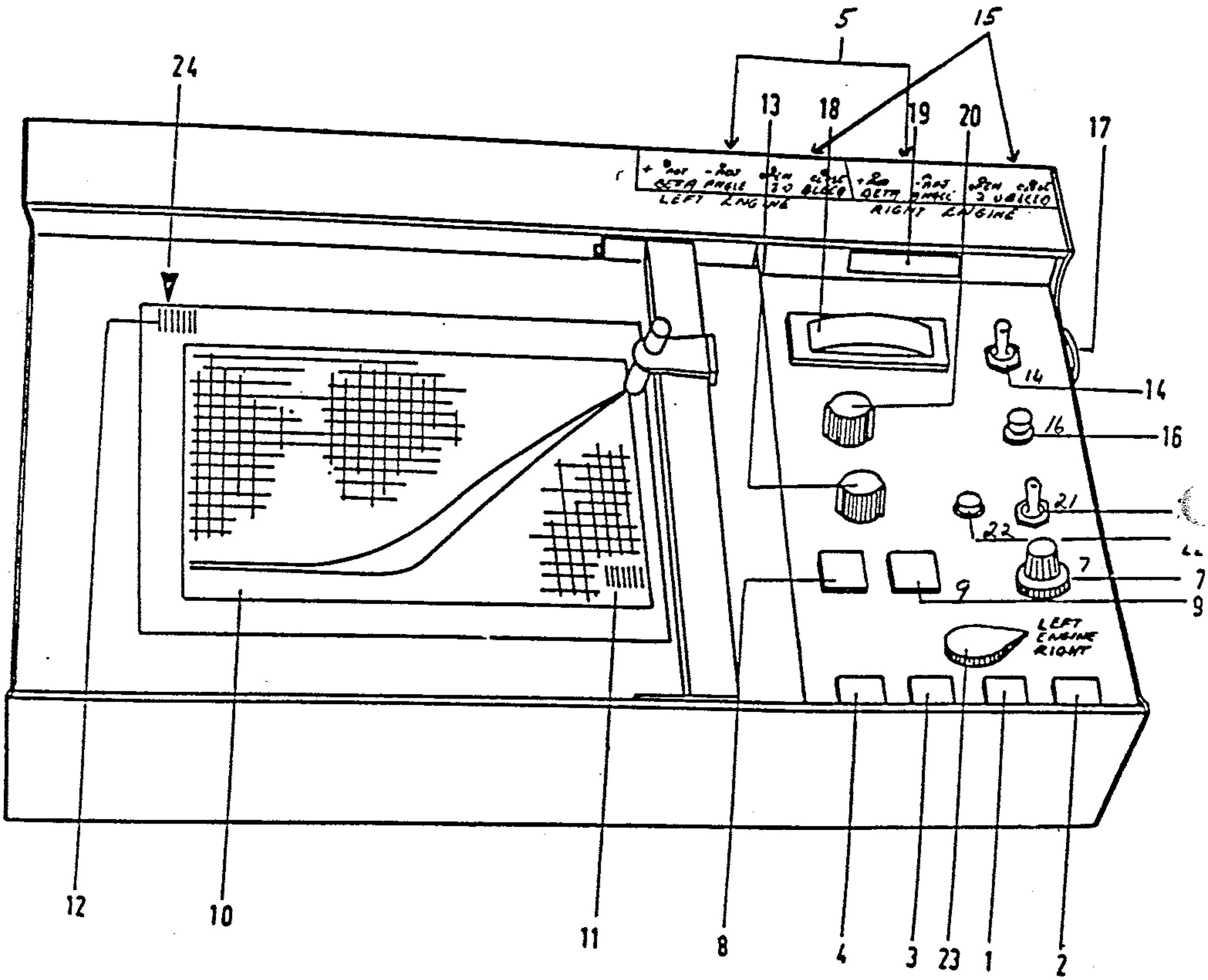
[1] ALL ADJUSTMENT EFFECTS ARE APPROXIMATE

[2] A COUNTERCLOCKWISE TURN HAS THE OPPOSITE EFFECT

[3] MAKE THE LAST ADJUSTMENT IN THE CLOCKWISE DIRECTION TO STOP THE INTERNAL LINKAGE BACKLASH

1.17
1.29

Alternate EVBC Trim Adjustments
Figure 508 (Sheet 2)


5
15
24
13
18
19
20
17
LEFT ENGINE
RIGHT ENGINE
14
16
21
22
7
9
LEFT
ENGINE
RIGHT
12
10
11
8
4
3
23
1
2

X-Y PLOTTER

(1) POWER SWITCH

A push button switch that controls the application of the ac line voltage to the recorder. When the ac line voltage is applied to the recorder, the switch indicator light will be illuminated.

(2) SERVO SWITCH

A push button switch that controls servo actuation for both axis. When the servos are energized the switch indicator light will be illuminated.

(3) CHART SWITCH

A push button switch that controls the application of power to the Autogrip. When the Autogrip is energized the switch indicator light will be illuminated.

(4) PEN SWITCH

A push button switch that controls the lowering and raising of the pen. When the pen is lowered, the switch indicator light will be illuminated.

(5) BETA ANGLE ADJ. (Calibrating Potentiometer) +ADJ.
Potentiometer for the adjustment of the positive angle to correspond with the vane angle directed by the rig pin. To be used at preadjustment as well as FOR CALIBRATION.
BETA ANGLE ADJ. (Preset Potentiometer) -ADJ
Potentiometer for the adjustment of the negative angle,

(7) RPM TEMP. ADJ.

To correct the 100%-RPM-position on the chart for OAT (Tt2).

A lock knob is provided on controls (5) and (7) to prevent the accidental alteration of the setting of the control.

(8) 100%-RPM

Push button switch must be operated during adjustment of control (7).

(9) SELF TEST

Push button switch must be operated during Self Test of XY-recorder.

(10) Beta trace chart for XY-plotter with PWA TRIM CURVE.

(11) Grid for temperature correction of the 100% RPM-position on the chart.

(12) O.A.T. TEMP. GRID

(13) Switch for choosing the parameter to be indicated on the digital display. (ITEM 19).

(14) TOGGLE SWITCH

Switch to operate the selected trim head in either "Decrease" or Increase" mode.

(15) Potentiometer closed/OPEN

Potentiometer to adjust the digital display of "closed 3.0 Bleed Valve Position" OR OPEN

(16) EVC HOLD TO TRIM

Switch must be operated at the same time as the toggle switch (13) in order to trim in the EVC-position of the switch (12).

(17) CONNECTOR

For connection to Junction Box cable

(18) MOTOR CURRENT

Instrument indicates the consumed power of the trim motor, however is out of function when Control Box TEE 38 is used with Junction Box TEE 38-500 and TEE 38-700.

(19) Digital Display to indicate the OAT OR 3.0 Bleed Valve position value.

(20) Switch for choosing the trimming point.
The relationship between the description on the Control Box and the Trim Heads applies as follows:

on the front panel of the Control Box		on the Motor Gear Box and Trim Heads
GRND IDLE	corresponds to	MIN. IDLE
FLT IDLE	"	LND IDLE
PART PWR	"	TAKE OFF
WATER	"	WATER
EVC	"	EVC
3.0 BLEED	"	3.0 BLEDD VALVE

(21) TOGGLE SWITCH

Switch to actuate the Power Lever Lock Pin (or Part Power Lock) in either "Engaged" or "Retracted" mode.

(22) PILOT LAMP

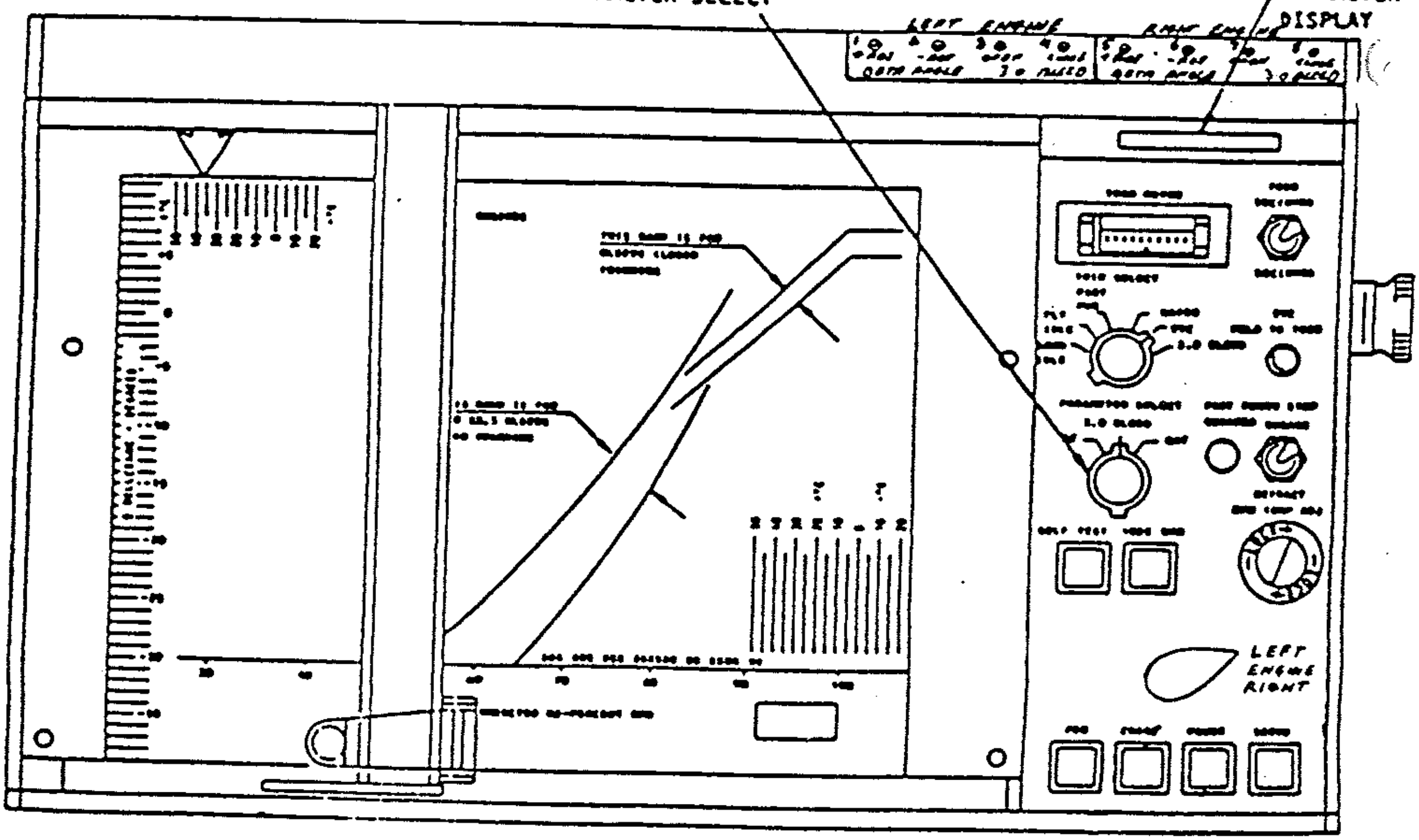
To indicate whether the Power Lever Lock is SELECTED TO "ENGAGED".

(23) ENGINE SELECT SWITCH

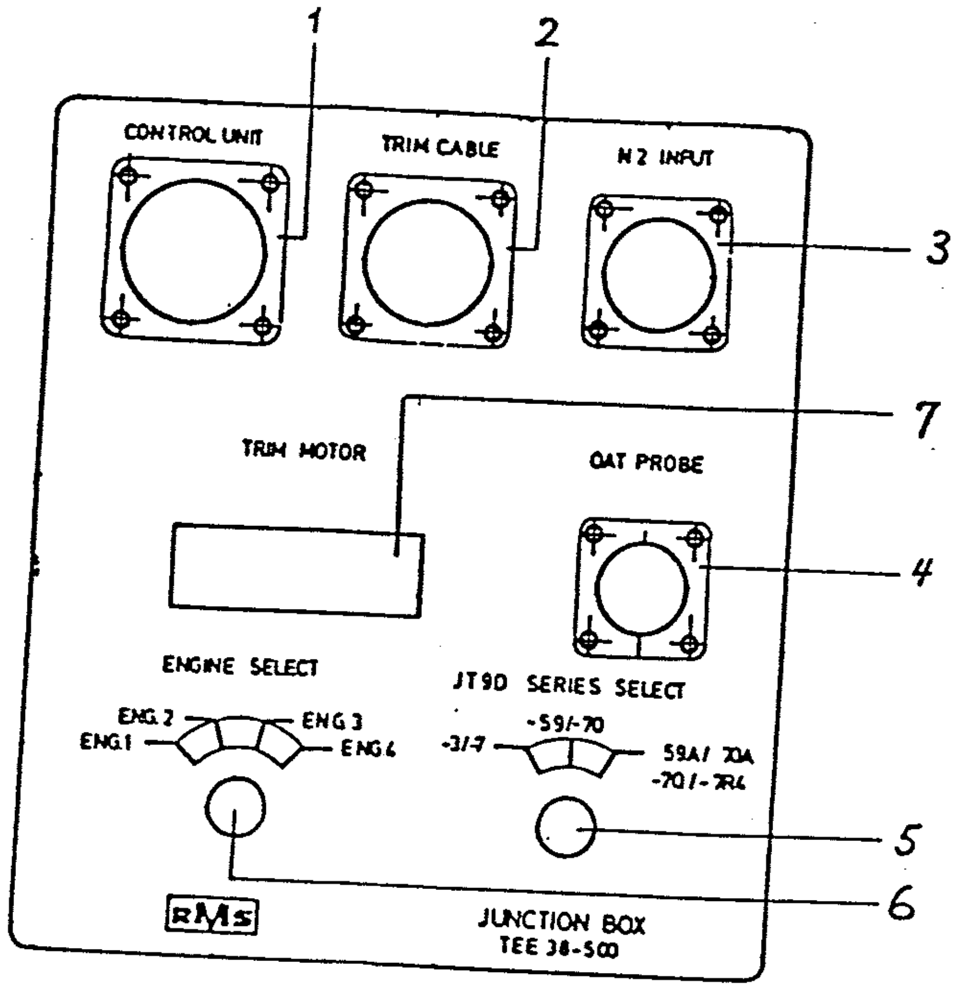
(24) Triangle Edge

Edge to adjust the chart according to the OAT (T_{t2}).

Control box



Junction Box's panel control



(1) Receptacle to connect the Control Box by means of the Junction Box Cable.

(2) Receptacle to connect the Flight Deck Cable to the according Trim Connector on aircraft.

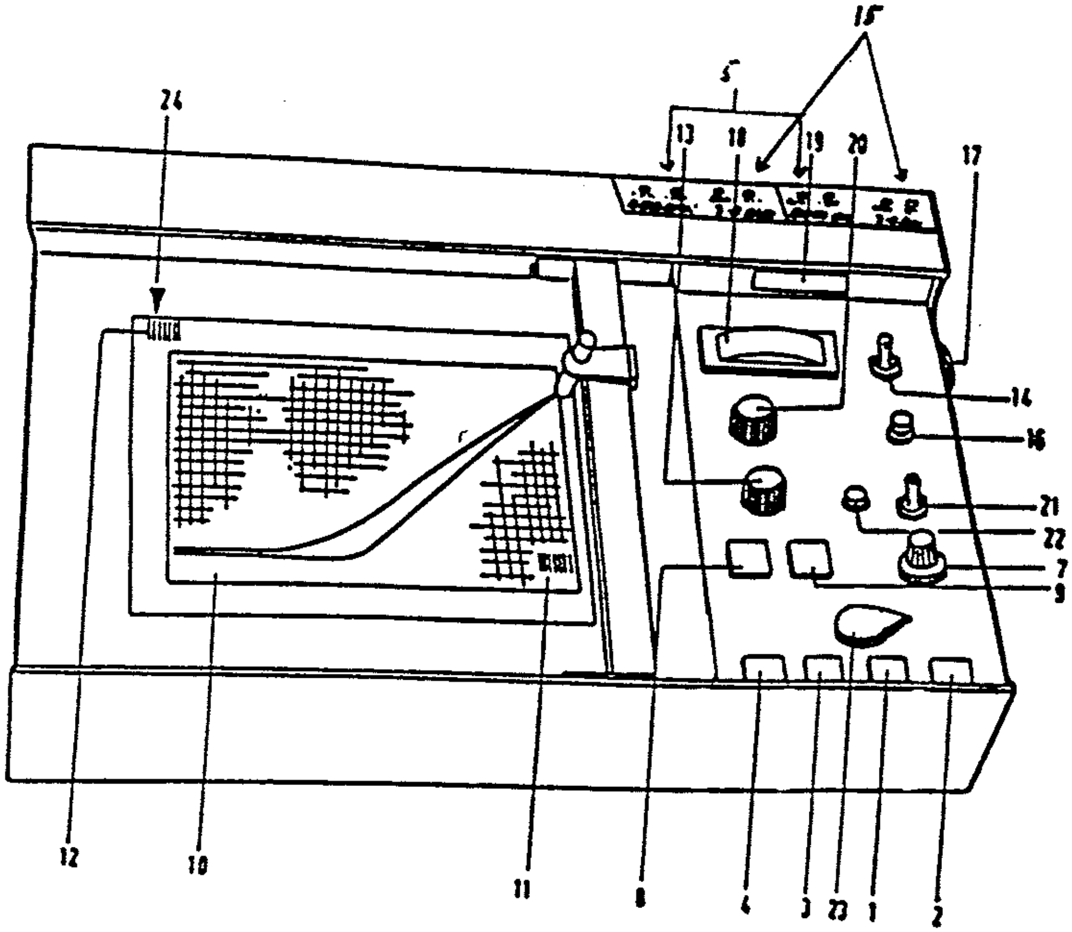
(3) Receptacle to connect the N2 Harness. Only applicable for B747 aircraft .

(4) Receptacle to connect the OAT-Probe

(5) Selector switch to chose applicable engine series.

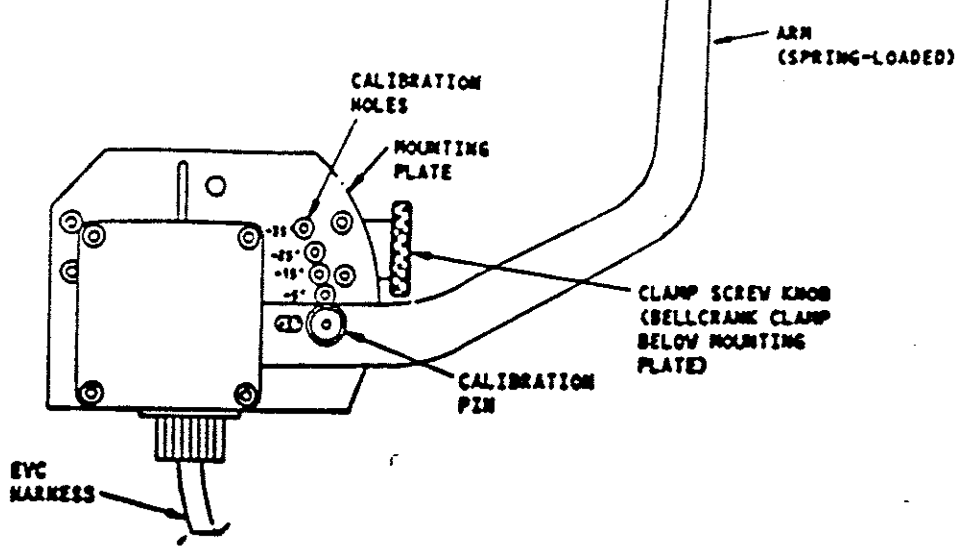
(6) Selector switch to adjust to the according engine position.

(7) Instrument indicates the consumed power of the trim motor.



1) POWER SWITCH
2) SERVO SWITCH
3) CHART SWITCH
4) PEN SWITCH
5) BETA ANGLE ADJUST (+AOJ, -AOJ)

7) RPM TEMP. ADJUST
8) 100% RPM TEST SWITCH
9) SELF TEST
10) CHART JT9D-7R4
11) 100% RPM TEMP. CORRECTION GRID
12) 25% RPM TEMP. CORRECTION GRID
13) DIGITAL DISPLAY SELECTOR SWITCH
14) TRIM TOGGLE SW. INCREASE/DECREASE
15) 3.0 BLEED CLOSED/OPEN POT.
16) EVC HOLD TO TRIM SWITCH
17) CONNECTOR TO JUNCTION BOX
18) MOTOR CURRENT METER
19) DIGITAL DISPLAY (3.0/OAT)
20) TRIMMING POINT SELECT SWITCH
21) POWER LEVER LOCK (PART POWER) INSTALL/RETRACT SWITCH
22) POWER LEVBR LOCK PILOT LAMP
23) ENGINE SELECT SWITCH
24) OAT CHART ADJUST POINT



EVC TRANSMITTER

Preadjust of Beta Angle Sensor

Check Beta Angle Sensor calibration using the built-in Test Fixture to prove sensor linearity and validate the system. Omission of this check prior to the linkage with the bell crank may result in erroneous beta angle indications.

Observe subsequent steps of operation as follows:

Connect equipment as per Page 8

Adjust Beta Angle Sensor to - 5° by means of the built-in Test Fixture. Place Beta Trace Chart onto the XY-Plotter surface plate and align the lower edge with the paper stop. Press buttons Power, Servo and Chart.

In order to check the Beta Angle Sensor adjust the angle indicated at the Control Unit to -5° by means of the potentiometers (TOP RIGHT HAND CORNER)

Proceed to the next test point (-15°) and check that the angle indicated at Control Unit shows the correct value.

Continue these checks up to -25° degrees.

Should any of the indicated angles deviate more than ± 0,3 degrees, the Beta Angle Sensor must be recalibrated in the workshop.

NOTE:- IF CALIBERATION IS GOOD, INSTALL BETA ANGLE SENSOR ON ENGINE

SELF TEST

Set up instrument and cable connection as described
Adjust Beta Angle Sensor to + 7° by means of the built-in Test Fixture. Place Beta Trace Chart onto the XY-Plotter surface plate. Press buttons Power, Servo, Chart and Pen.

Depress and hold Self Test button. The XY-Plotter will trace a straight line from the top left hand corner to the bottom right hand corner.
Press Pen button and release Self Test button when the pen is parked in the bottom right hand corner.
Remove the Trace Chart and check for linearity.
The same Chart can be used again for the Beta Angle Trace.

Adjustment of EVC and RPM-Indication

Place the Beta Trace Chart with the JT9D trim curve superimposed onto the recording platen and align the lower edge with the paper stop. Now align the mark on the recording platen with the mark of the temperature correction marker field , which is equal to the value of ambient temperature (Tt2).

Depress the button on the POWER SWITCH

Depress the button on the CHART SWITCH

When the button is released the switch light will come on indicating that the recording platen is energized. Smooth the paper as necessary.

Depress the button on the Servo-Switch

Depress the button on the 100 % N2 SIMULATION Switch (Fig. 4-8) and use potentiometer knob (Fig. 4-7) for RPM. Temp. Adjust and set plotter p n on that mark of the temperature correction grid (Fig. 4-11), which is equal to the value of the ambient temperature (Tt2). The XY-Plotter is NOW SET

Using A 1 3/4" WRENCH move the Stator Vanes to the full open position and insert the rig pin at the bell crank.

The Control Box has to indicate an angle of + degrees or a value which appropriate to the Rig Pin position.

If not turn the potentiometerS (TOP R/H CORNER) on the Control Unit until + 7 degrees is indicated.

CAUTION: For adjustment of the angle in the rig position, use only the potentiometer Do not adjust the pre-set potentiometer (Fig. 4-6). The + 7 (or according) and - 36 degrees position may be altered in the future by the engine manufacturer. Please Check with Maintenance Manual.

Adjustment of EVC and RPM Indication (Cont'd.)

Remove the rig pin, turn the Stator Vanes to the full closed position, insert rig pin and re-check that -36 degrees is indicated. Don't use potentiometer (Fig. 4-5) when re-checking.
If necessary, repeat the steps until the indicated deviation is less than ± 0,5 degrees.

IMPORTANT: THIS IS NOT THE USUAL PROCEDURE USE IN CASE OF FOLLOWING ONLY

Should a deviation of less than ± 0.5 degrees not be obtainable, check that there are no mechanical faults within the engine rigging and bell crank system. Re-rig if necessary. If the deviation of less than 0.5 degrees is still not reproduceable adjust as follows:

Use the ground hydraulic power supply to move the Stator Vanes to the full open position, insert the rig pin into the + 7 (or according) degrees hole.

The Control Box display has to indicate an angle of + 7 degrees. If not adjust the potentiometer (ITEM #5) on the Control Box until + 7 degrees is indicated. Move the Stator Vanes to the full closed position and insert rig pin.

The Control Box should indicate an angle of - 36 degrees. If not adjust the potentiometer on the Control Unit until - 36 degrees is indicated. (Small screwdriver required).
Remove rig pin, return the Stator Vanes to the full open position and re-check that + 7 degrees is obtained. Re-adjust if necessary, by repeating the steps described before until the indicated deviation is less than ± 0,5 degrees.

SUBTASK 482-075-P00

(7) If you do a Test 10 (Ref **71-01-00**), do the steps that follow (**Fig. 218**):

(a) Connect the 3.0 Bleed valve cable to the connector on the 3.0 Bleed valve transducer (uninstalled).

(b) Put the PARAMETER SELECT switch on the control box in the 3.0 BLEED position.

(c) Do the steps that follow to examine the adjustment of the rod end bearing:

<u>NOTE:</u> **Use this procedure to make sure that the middle of the transducer travel is equal to the middle of the travel of the 3.0 bleed actuator. Do this to make sure that the adjustment of the rod end bearing is correct.**

1) Move the transducer rod end to the fully retracted position.
2) Make a record of the 3.0 Bleed digital indication.
3) Move the transducer rod to the fully extended position.
4) Make a record of the 3.0 Bleed digital indication.
5) Add the indications together and divide them by 2 to find the Transducer Midpoint Target.

EXAMPLE: Fully retracted readout = -0.25

Fully extended readout = +2.05
-0.25 + +2.05 = +1.80
+1.80/2 = +0.90 = Transducer Midpoint Target

6) Install the transducer on the Calibration Fixture 76098.
7) Examine the 3.0 Bleed digital indication.
8) If the indication does not equal the Transducer Midpoint Target ± 0.020, do the steps that follow:
   a) Loosen the locknut on the rod end bearing.
   b) Turn the tansducer rod to move the rod in or out of the rod end bearing to get an indication for the Transducer Midpoint Target of ± 0.010.
   c) Tighten the locknut on the rod end bearing.
   d) Install a lockwire if it is necessary.
9) Remove the transducer from the calibration fixture.

(d) Do the steps that follow to calibrate the transducer:

1) Put the 3.0 Bleed transducer on the calibration fixture 76099 with the sleeve end bearing on the single post and the rod end bearing on the 0.50" STROKE post (**Fig. 218**, Detail B).
2) Adjust the 3.0 BLEED OPEN control on the control box to get a 0.50 inch indication on the digital display.
3) Move the rod end bearing to the 1.89" STROKE post.
4) Adjust the 3.0 BLEED CLOSED control to get a 1.89 inch indication on the digital display.
5) Do the adjustments again with the rod end bearing on the 0.50" and 1.89" STROKE posts until the digital indications show 0.50 ± 0.00 and 1.89 ± 0.00.
6) Move the rod end bearing to the 1.00" STROKE post and then to the 1.50" STROKE post.
7) Make sure that the digital indications show 1.00 ± 0.02 and 1.50 ± 0.02.
8) If one of the two indications is not in the tolerance, replace the transducer and do the adjustment procedure again.

(e) Do the steps that follow to install the 3.0 Bleed valve transducer (**Fig. 218**):

1) Install the 3.0 Bleed valve transducer with the extendable end aft.
2) Install the bolts that attach the transducer to the 3.0 Bleed actuator.

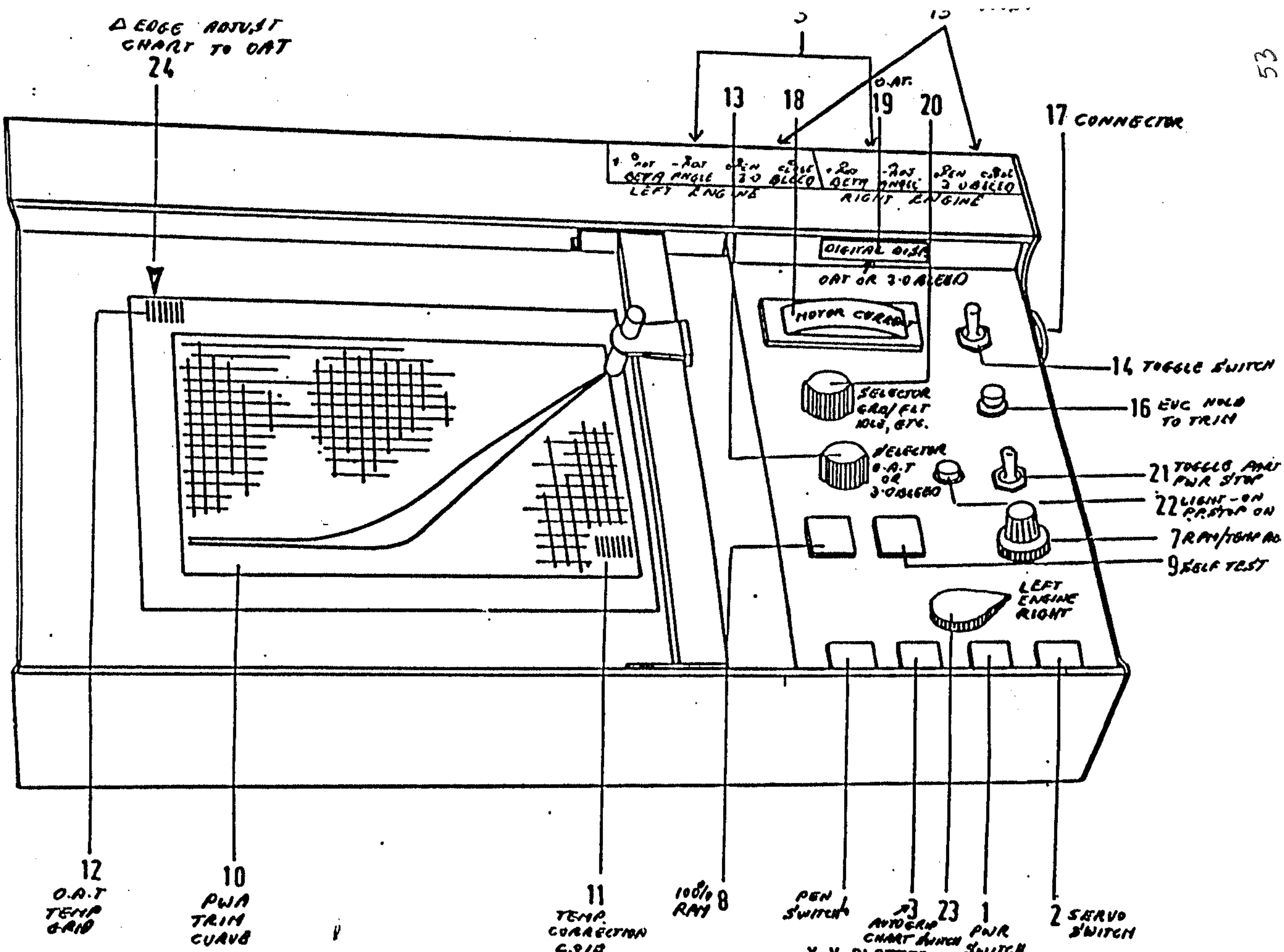
(f) Do the steps that follow to install the 3.0 Bleed trim head (**Fig. 217**):

50A·

Adjustments (Cont'd.)

Adjustment of 3.0 Bleed Valve Sensor

- Make sure that the 3.0 Bleed Valve is fully "Open" using a hydraulic hand pump.
- Adjust the digital display to read 0.00 ± 0.01 by means of potentiometer (ITEM #15).
- Move the 3.0 Bleed Valve to fully "Closed" by using a hydraulic hand pump.
- Adjust the digital display to read 1.89 ± 0.01 by means of potentiometer (ITEM # 15)


Δ EDGE ADJUST CHART TO OAT
24
13
18
19
20
17 CONNECTOR
LEFT ENGINE
RIGHT ENGINE
DIGITAL DISP
OAT OR 3-D BLEED
MOTOR CURRENT
14 TOGGLE SWITCH
SELECTOR GRD/FLT IDLE, ETC.
16 EVC HOLD TO TRIM
SELECTOR O.A.T OR 3-D BLEED
21 TOGGLE PART PWR STW
22 LIGHT-ON PRSTOP ON
7 RPM/TEMP AD
9 SELF TEST
LEFT ENGINE RIGHT
12 O.A.T TEMP GRID
10 PWA TRIM CURVE
11 TEMP. CORRECTION GRID
100% RPM 8
PEN SWITCH
3 AUTOGRID CHART SWITCH
23
1 PWR SWITCH
2 SERVO SWITCH
X-Y PLOTTER

B767 FCU TRIM WORKSHEET

TEST 9

REF J.T 6-214 MIM 71-01-00/500 TEST #9

ACFT ______ STN ______ DATE ______ TIME ______

ENG.POS ______ S/N ______

REASON ______

(1) Ensure proper p/power stop tab position prior to run (87deg. or 97 deg.) ______
(2) Record Mark 2 and 3 by advancing throttle to fwd. stop and allow to spring back.
(3) Obtain correct tables ref.71-01-02 fig 201 cofig 2.

Record OAT ______ Stn Baro Press. ______

Target min.idle ______ Target app. idle ______ Target P/P ______ Target T/Off ______
Unuased TLA ______ inches.

Start and allow eng to idle for 5 min in "no load" cond. with EEC SW OFF

CHECK AND ADJ. P/POWER TRIM:

(1) Advance lever to p/power stop and trim as required.
(2) Record:

EPR: ______ N1 ______ N2 ______ EGT ______ F/F ______ O/P ______ O/T ______

CHECK AND ADJ. APPROACH IDLE:

(1) Prior adj. approach idle,adj. Min. Idle to at least 3.5% N2 below app. idle target.
(2) Adjust approach idle to target

EPR: ______ N1 ______ N2 ______ EGT ______ F/F ______ O/P ______ O/T ______

CHECK AND ADJ. MINIMUM IDLE:

(1) Adjust min. idle to target.

EPR ______ N1 ______ N2 ______ EGT ______ F/F ______ O/P ______ O/T ______

Remove p/power stop,advance to t/off and record:

EPR: ______ N1: ______ N2: ______ EGT ______ F/F ______ O/P ______ O/T ______ VIB: ______

Reccord lever pos. as 'MARK 1'.
Return to idle,switch EEC ON and move throttle to T/OFF and record:
Measure and record diff. between MARK 3 AND 1. This is UNUASED TLA ______ inches.

EPR: ______ N1: ______ N2: ______ EGT: ______ F/F: ______ O/P ______ O/T ______ VIB: ______

COMPRESSOR AIRFLOW CONTROL SYSTEM

280-14-86

57

COMPRESSOR AIRFLOW CONTROL SYSTEM
OVERALL SYSTEM DATA

GENERAL

Purpose:

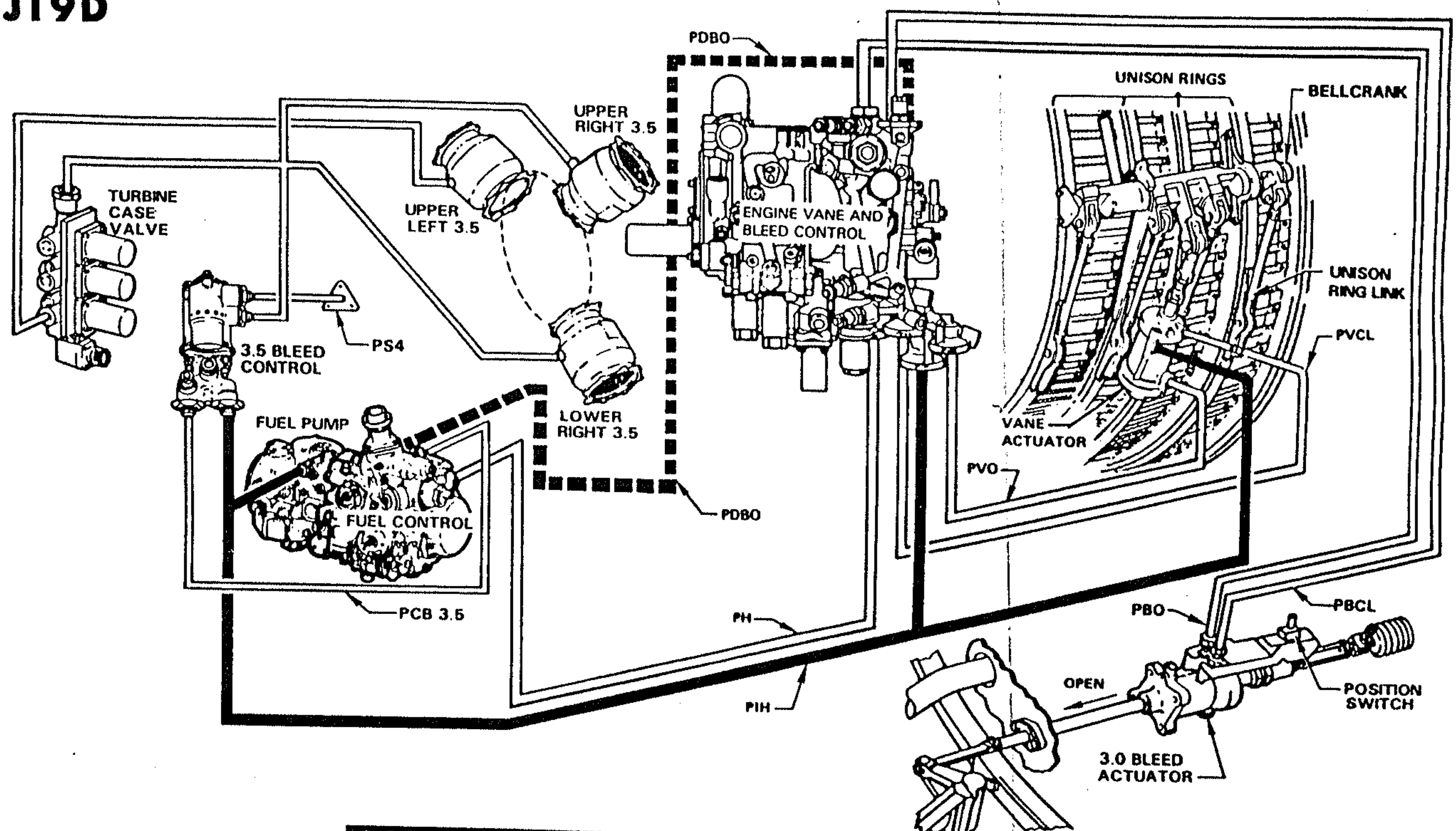
- Ensures compressor stability during starting, off design operating conditions and reverse thrust operation

Subsystems:

- Bleed systems
  - Start bleeds
  - Tandem bleed system
  - Reverser actuated bleed system
- Variable vanes system

Components:

- Fuel pump
- Hydromechanical fuel control
- Engine vane and bleed control
- Vane actuator
- Bellcrank
- Mach probes
- 3.5 bleed valves
- 3.5 bleed control valve
- 3.0 bleed actuator and feedback cable
- Turbine case valve



COMPRESSOR AIRFLOW CONTROL SYSTEM

COMPRESSOR AIRFLOW CONTROL SYSTEM
OVERALL SYSTEM DATA—COMPONENT LOCATION

ENGINE—RIGHT SIDE

MACH Probe:

- Mounted on intermediate case rear face at 4:00 position (not electrically anti-iced)

Engine Vane and Bleed Control:

- Mounted on high pressure compressor case at 3:00 position

Bellcrank:

- Mounted just above variable vane actuator

Vane Actuator:

- Mounted on high pressure compressor case at 4:00 position

Fuel Control:

- Mounted on fuel pump

Fuel Pump:

- Mounted on main gearbox forward right hand side

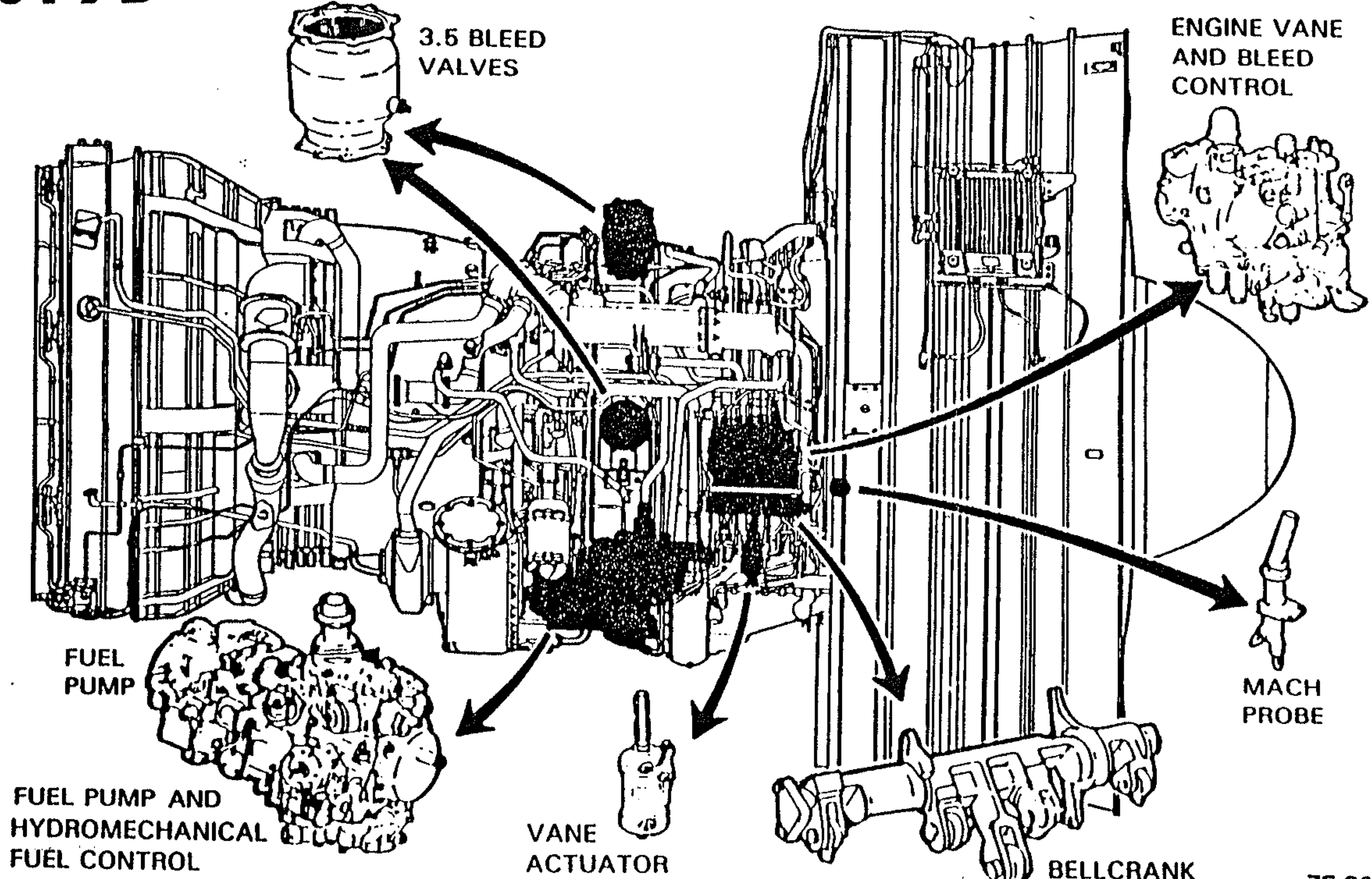
3.5 Bleed Valves:

#1

- Mounted on high pressure compressor at 1:00 and 3:00 positions

#2

JT9D



AIRFLOW CONTROL SYSTEM - RIGHT SIDE

75-30
CT 4328
2-85

5

CA(

COMPRESSOR AIRFLOW CONTROL SYSTEM
OVERALL SYSTEM DATA—COMPONENT LOCATION

ENGINE—LEFT SIDE

3.0 Bleed Actuator and Feedback Cable:

- Mounted on intermediate case rear flange at 7:00 position
- Cable connects to EVBC on right side of engine

3.0 Bleed Actuator Position Switch:

- Mounted on aft end of 3.0 bleed actuator

3.5 Bleed Control Valve:

- Mounted on high pressure compressor at 8:00 position

MACH Probes:

- Mounted on intermediate case rear flange at 8:00 and 11:00 positions (electrically anti-iced these positions)

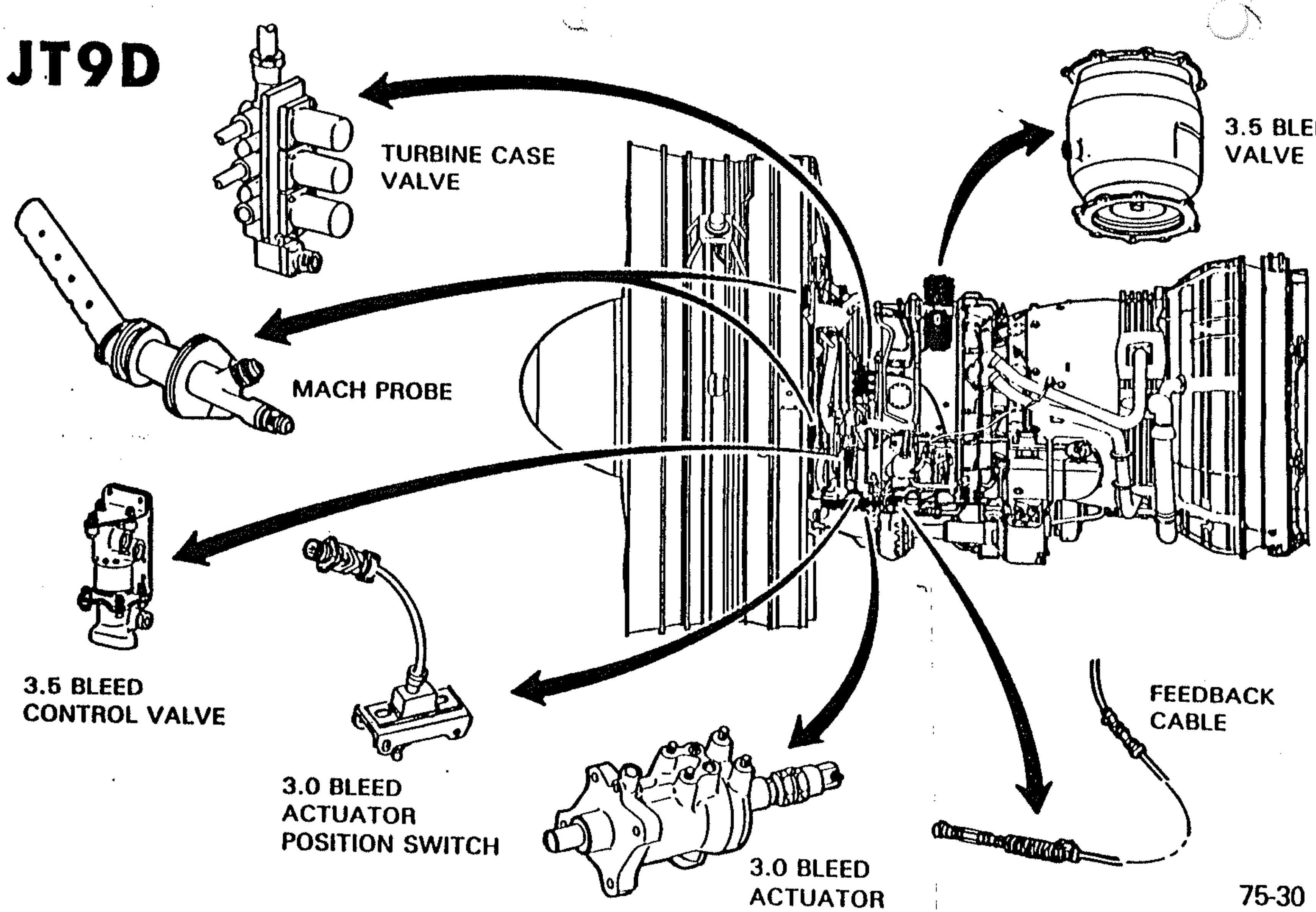
Turbine Case Valve:

- Mounted on high pressure compressor case at 9:00 position

3.5 Bleed Valve:

- Mounted on high pressure compressor case at 11:00 position

JT9D



AIRFLOW CONTROL COMPONENTS (LEFT SIDE)

75-30
CT 3640
2-85

7

CACS

63

64

COMPRESSOR AIRFLOW CONTROL SYSTEM
3.5 START BLEEDS SUBSYSTEM

GENERAL

Purpose:

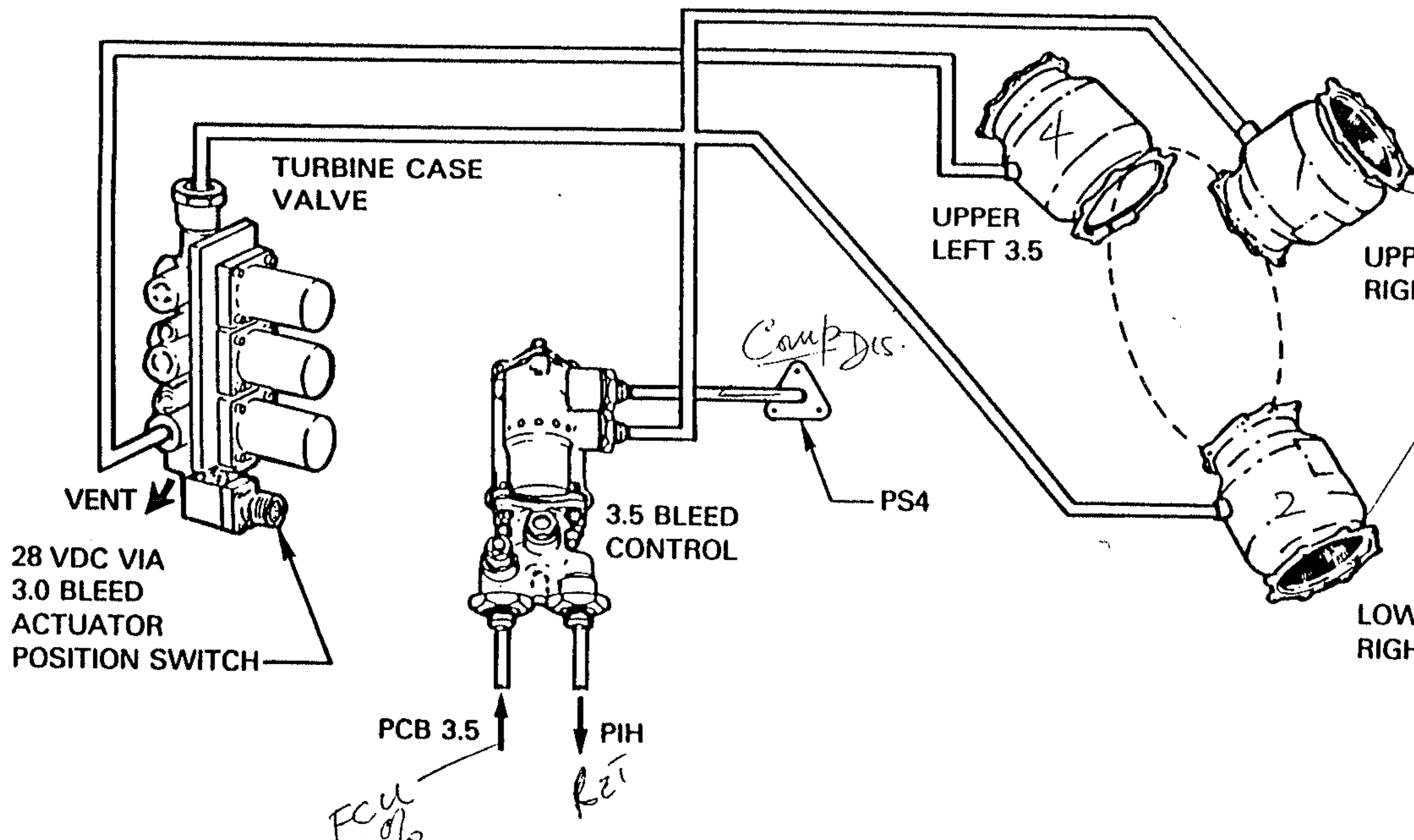
- Improves engine start characteristics and prevents compressor surge

Components:

- 3.5 Bleed control valve
- Turbine case valve
- 3.0 Bleed actuator position switch
- 3.5 Bleed valves (2)

Description and Operation:

- The 3.5 start bleed valves are spring loaded open at engine shutdown and up to 50% N2 during start
- At 50% N2, the PCB3.5 hydraulic signal from fuel control unit opens 3.5 bleed control valve allowing PS4 to pneumatically close upper right and lower right 3.5 bleed valves. (On ground)
- The upper left 3.5 bleed valve stays open since the 3.0 bleed actuator position switch energizes the bottom turbine case valve solenoid, venting the upper left 3.5 bleed valve to open
- The 3.0 bleed valve is full open during start



3.5 START BLEEDS

CT 4343
2-85

COMPRESSOR AIRFLOW CONTROL SYSTEM
TANDEM BLEED SUBSYSTEM

GENERAL

Purpose:

- Prevent compressor surge

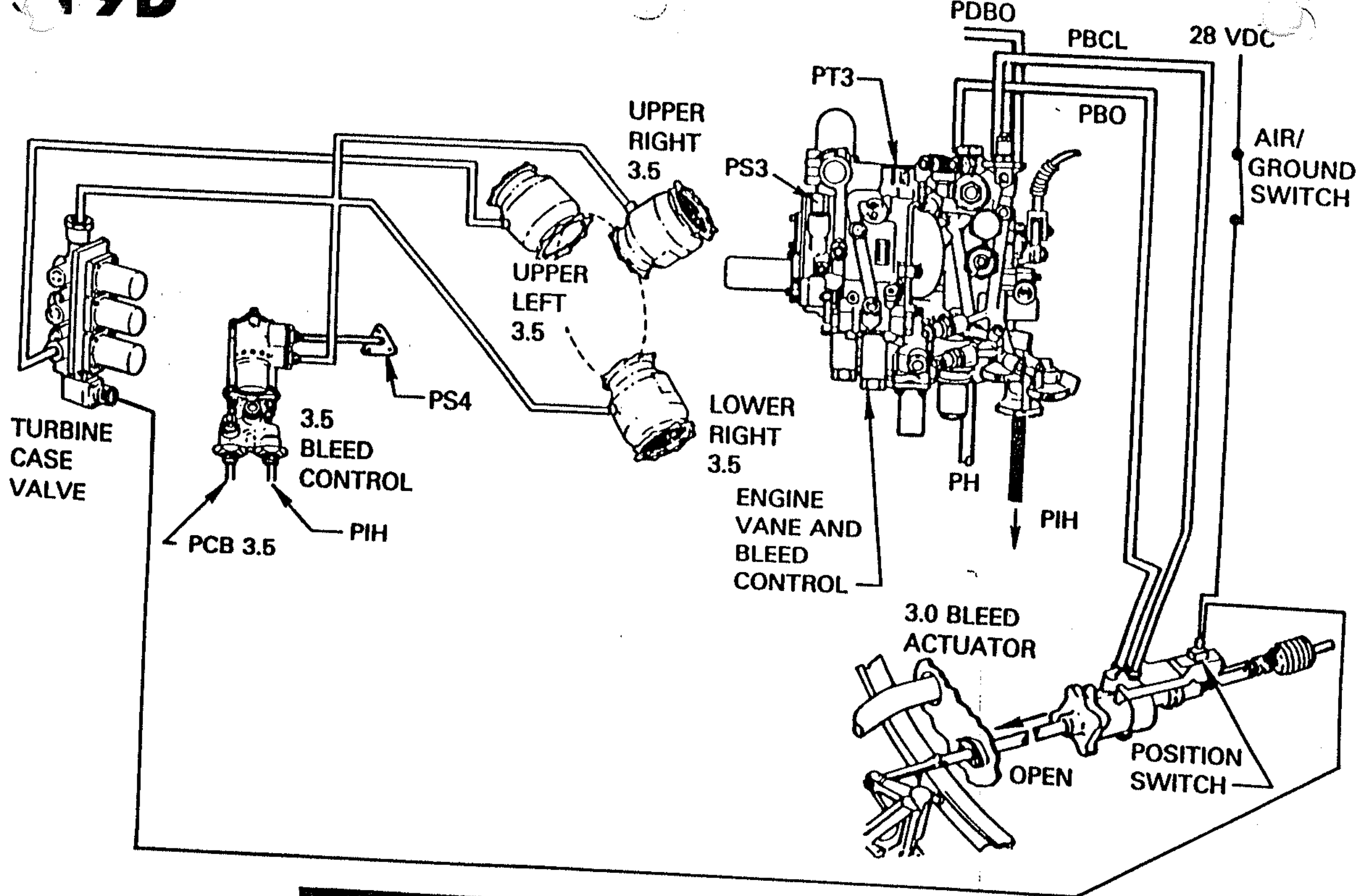
Components:

- 3.0 Bleed valve and actuator
- 3.0 Bleed actuator position switch and tripper
- EVBC
- ULH 3.5 bleed valve
- 3.5 bleed control valve
- Turbine case valve

Description and Operation:

- Upon acceleration from idle remaining open ULH 3.5 bleed valve and modulating 3.0 bleed valve both close; valves open again upon deceleration
- Tandem feature is removed at liftoff, thus all (3) 3.5 bleed valves remain closed in flight

- Incorporation of Phase II allows EEC to open both the 3.0 bleed valve and the #4 3.5 valve in flight to improve surge recovery



TANDEM BLEED SYSTEM

75-32
CT 4368
2-85

COMPRESSOR AIRFLOW CONTROL SYSTEM
TANDEM BLEED SUBSYSTEM

3.0 MODULATING BLEED

Purpose:

- Ensures compressor stability during start, low thrust operation, deceleration, and reverse thrust operation

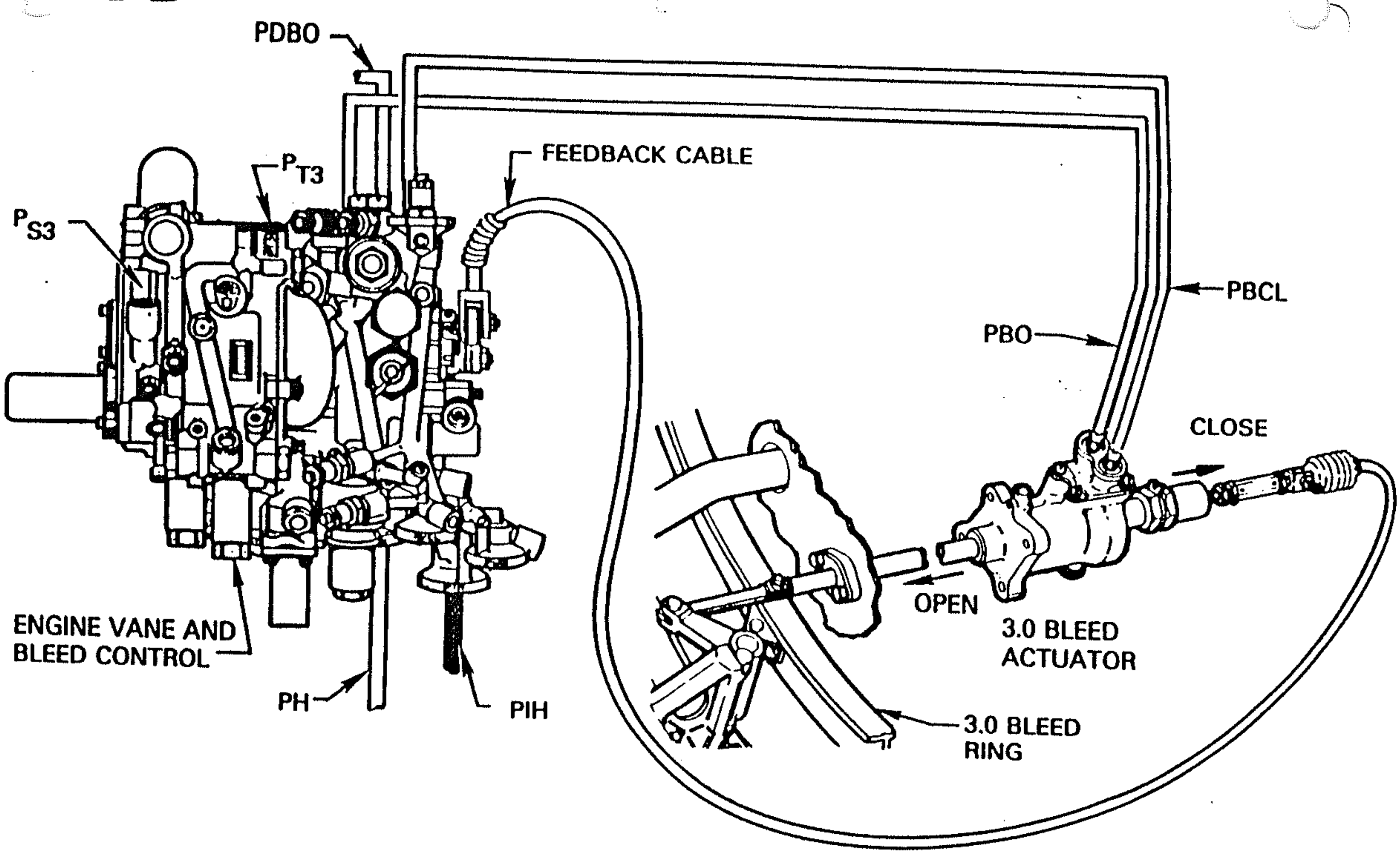
Components:

- Engine vane and bleed control (EVBC)
- 3.0 bleed actuator
- 3.0 bleed ring
- 3.0 bleed actuator feedback cable

Description and Operation:

- Proper 3.0 bleed ring position is determined by the engine vane bleed control as a function of low pressure compressor discharge total and static pressure. As a result of the total and static pressure relationship, the EVBC will provide high pressure fuel to a double acting 3.0 bleed ring actuator causing the 3.0 bleed ring to close, open, or modulate. The feedback cable closes the EVBC request/response loop.

- 3.0 bleed actuator position is sensed by 3.0 bleed actuator position switch



3.0 MODULATING BLEED

CT 4339
2-85

13

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ENGINE VANE AND BLEED CONTROL

Purpose:

- Controls the modulating 3.0 bleed actuator and variable vanes system actuator

Location:

- High pressure compressor case—3:00 position

Description and Operation:

- Inputs
  - Pneumatic
    - PT3 and PS3 converted to Station 3 Mach number as a function of the ratio: $\frac{PT3 - PS3}{PT3}$
  - Hydraulic
    - PH—servo and muscle pressure
    - PDBO—rapid deceleration logic
  - Electrical
    - 28 VDC
    - EVBC solenoid valve
      - Energized on ground during reverse thrust operation
      - De-energized in flight
  - Mechanical
    - 3.0 bleed actuator feedback cable
    - Variable vanes bellcrank feedback rod
- Outputs
  - Hydraulic
    - PBO—bleed open pressure
    - PBCL—bleed close pressure
    - PVO—vanes open pressure
    - PVCL—vanes close pressure
    - PIH—interstage hydraulic pressure
- Filter
  - Filters PH fuel
  - Disposable
  - Paper
  - 40 micron

MACH PROBES

Purpose:

- Sense PT3 and PS3

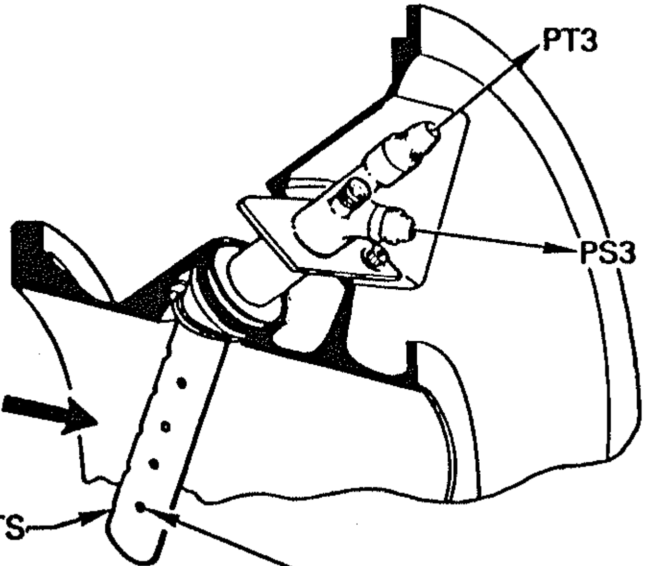
Location:

- Intermediate case—4:00, 8:00 and 11:00 positions

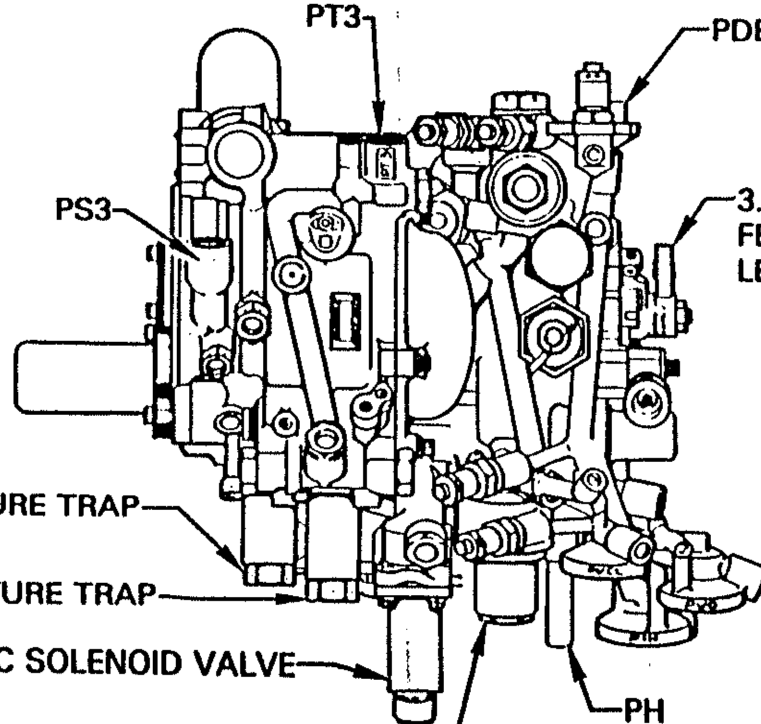
Description and Operation:

- Sense radial and circumferential pressure profile
- 8:00 and 11:00 probes—electrically anti-iced whenever engine is running
  - 115V/400Hz, 100 watts
- Two-section manifolds with moisture traps
- "ENG MACH PROBE" amber light on overhead panel if both heaters not operating

280-14-1066



MACH PROBE



ENGINE VANE AND BLEED CONTROL

3.0 BLEED SUBSYSTEM COMPONENTS

CT 4008
8-84

COMPRESSOR AIRFLOW CONTROL SYSTEM
TANDEM BLEED SUBSYSTEM—COMPONENTS

3.0 BLEED ACTUATOR

Purpose:

- Hydromechanically positions the 3.0 bleed ring

Location:

- Intermediate case at 7:00 position

Description and Operation:

- Double acting hydraulic actuator
- 0 to 1.89 inches displacement
- Displaced by fuel from EVBC
- Open port incorporates a restrictor
- Close port incorporates a restrictor-check valve and filter

3.0 BLEED ACTUATOR POSITION SWITCH AND SWITCH TRIPPER

Purpose:

- Signals upper left hand bleed valve operation in relation to 3.0 bleed actuator position

Location:

- Aft end of 3.0 bleed actuator

Description and Operation:

- Switch tripper cam translates with 3.0 bleed actuator rod
- Switch signals ULH 3.5 bleed valve to close on acceleration and re-open on deceleration (on ground) IN FCT PHASE II
- Switch actuation point adjustable
- Air/ground logic ensures ULH 3.5 bleed valve remains closed in flight
- Transducer brackets provide for 3.0 bleed position transducer mounting

3.0 BLEED RING

Purpose:

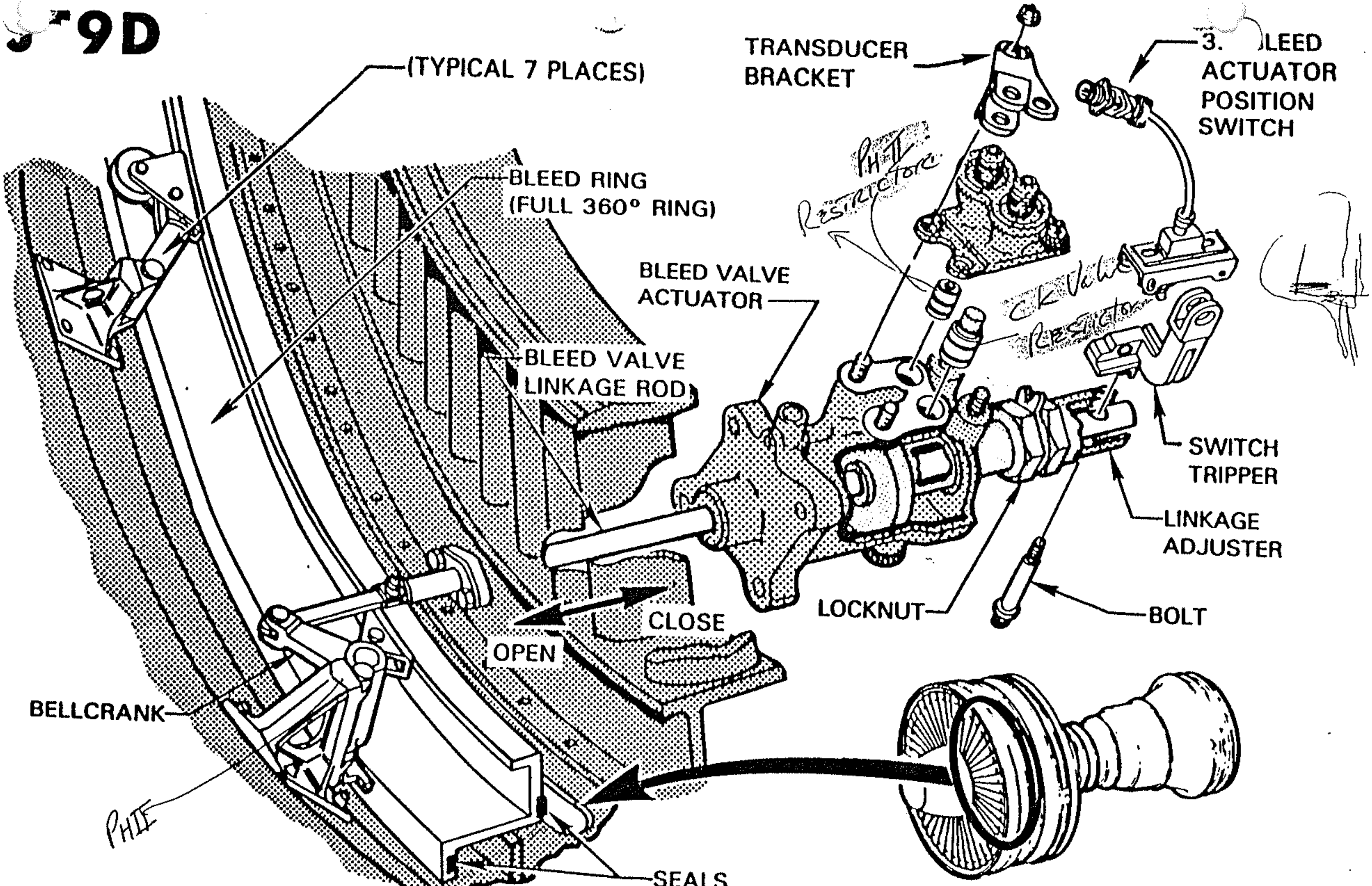
- Uncovers or covers bleed slots in the fan exit case to control the bleed of 3.0 air into the fan duct

Location:

- Fan exit case

Description and Operation:

- Modulating 360° ring
- Rubber seals—front and rear faces
- Rotates and translates
- Guided by bellcranks



3.0 BLEED RING AND ACTUATOR

CT 4344
2-85

24

3.0 BLEED ACTUATOR FEEDBACK CABLE

Purpose:

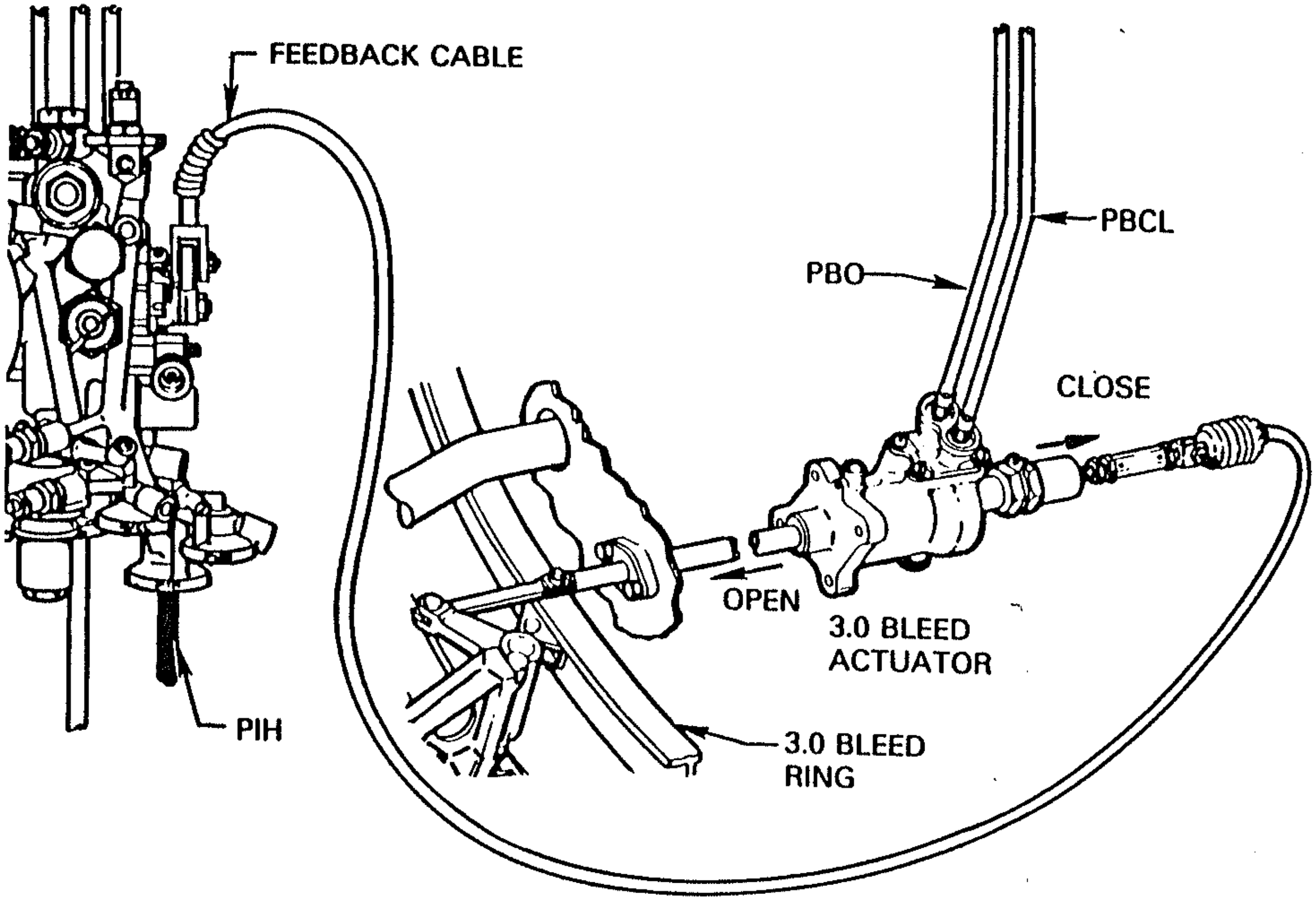
- Provides 3.0 bleed actuator position data to the EVBC
- Closes EVBC request/response loop

Location

- Attached to 3.0 bleed valve actuator and EVBC feedback arm

Description and Operation

- Two-piece cable assembly (upper and lower)
- Cable assembly transfers linear motion from 3.0 bleed actuator to EVBC
- Cable length adjustable for rigging



3.0 MODULATING BLEED FEEDBACK CABLE

CT 4098
8-84

OPERATING SEQUENCE

A - 3.0 bleed hydraulically opened during engine shutdown
  - 3.5 bleed valves spring loaded open during engine shutdown

B - 3.0 bleed remains fully open during start and at minimum idle
  - URH and LRH 3.5 bleed valves close during start at 50% N2

C - As engine power increases ULH 3.5 bleed valves closes

D - 3.0 bleed fully closed at __Hi__ EPR

E - Tandem feature removed in flight
  - 3.0 bleed only opens on deceleration (opens early on rapid deceleration)
  - 3.5 bleed valves close at 50% N2 during altitude relight

280-14-118A

TANDEM BLEED OPERATION

ENGINE OPERATING CONDITION	3.0 BLEED RING (4TH STAGE AIR)	3.5 BLEED VALVES (9TH STAGE AIR) URH	LRH	ULH
(A) ENGINE SHUTDOWN	Open	Open	Open	Open
(B) GROUND OPERATION – 50% N2 AND IDLE – RAPID DECELERATION	Open	Closed	Closed	Open
(C) INCREASE POWER ____ EPR	Open	Closed	Closed	Closed
(D) HIGH POWER ____ EPR	Closed	Closed	Closed	Closed
(E) FLIGHT OPERATION – 50% N2 AND IDLE – RAPID DECELERATION	Open	Closed	Closed	Closed

CLOSED ●
OPEN ○

CT 4341
2-85

21

77

COMPRESSOR AIRFLOW CONTROL SYSTEM
OVERALL SYSTEM DATA—REVERSER ACTUATED BLEED SYSTEM

GENERAL

Purpose:

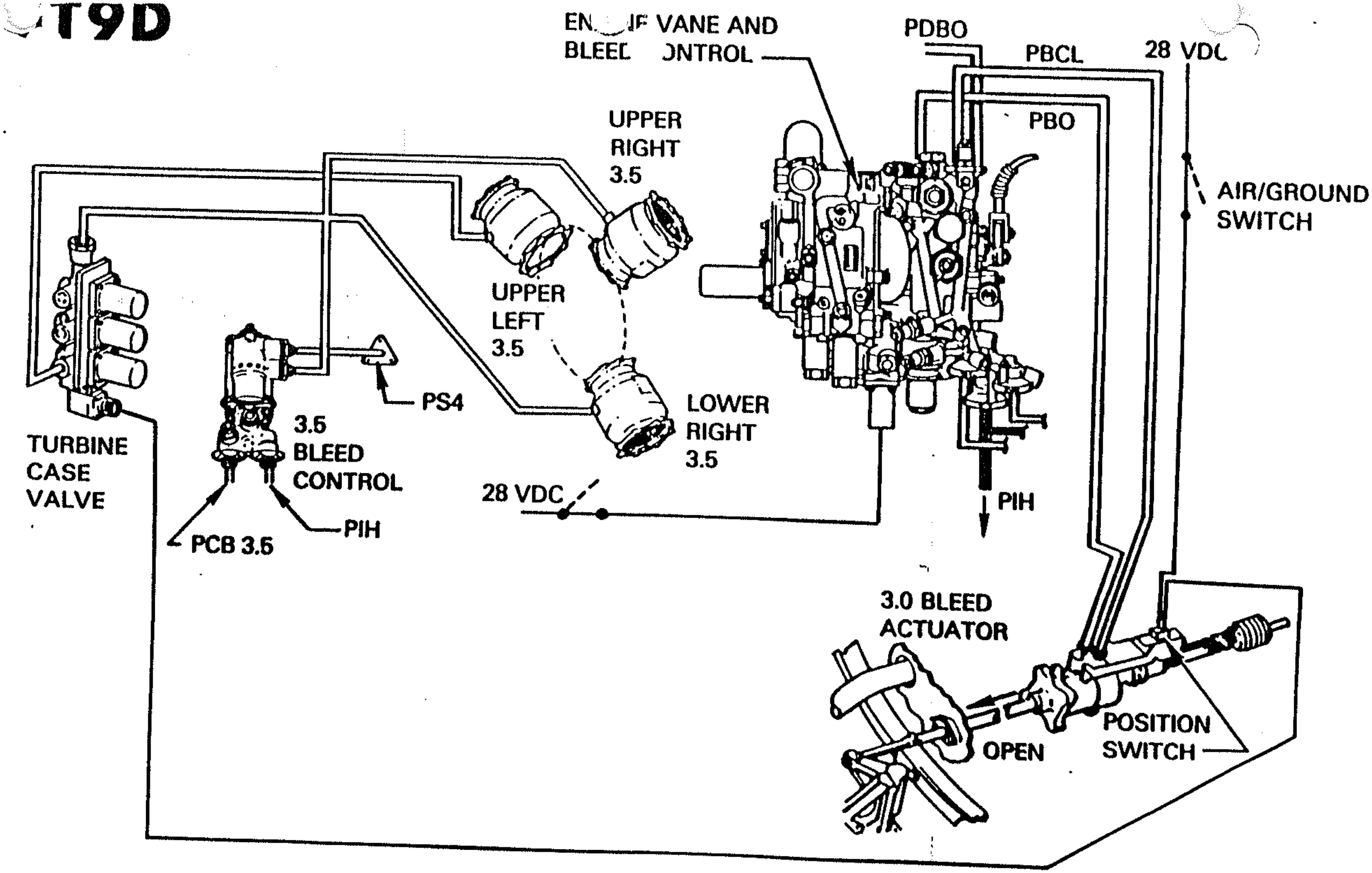
- Ensures compressor stability during reverse thrust operation by bleeding 3.0 and 3.5 air

Components:

- EVBC
  - Controls modulating 3.0 bleed actuator and 3.0 bleed ring position
- 3.0 bleed actuator
  - Hydromechanically positions 3.0 bleed ring
- 3.0 bleed ring
  - Uncovers or covers bleed slots in fan exit case
  - Full open during reverse thrust operation
- 3.0 bleed actuator feedback cable
  - Provides 3.0 bleed actuator position data to EVBC
- Upper left 3.5 bleed valve
  - Open during reverse thrust operation
  - Bleeds 9th stage air
- 3.5 bleed control valve
  - Controls flow of PS4 to the turbine case valve and upper and lower right hand 3.5 bleed valves
- Turbine case solenoid valve
  - Lower solenoid energized by 3.0 bleed position switch
  - Vents PS4 from ULH 3.5 bleed valve causing it to open
- EVBC solenoid valve
  - Electromechanically configures EVBC for reverse thrust bleed configuration
  - Energized in reverse thrust operation
  - 28 VDC from thrust reverser system
  - 3.0 bleed ring is prevented from closing during acceleration in reverse thrust

280-14-1186

T9D



REVERSER ACTUATED BLEED SYSTEM

CT 4340
2-85

80

COMPRESSOR AIRFLOW CONTROL SYSTEM
VARIABLE STATOR VANE SUBSYSTEM

GENERAL

Purpose:

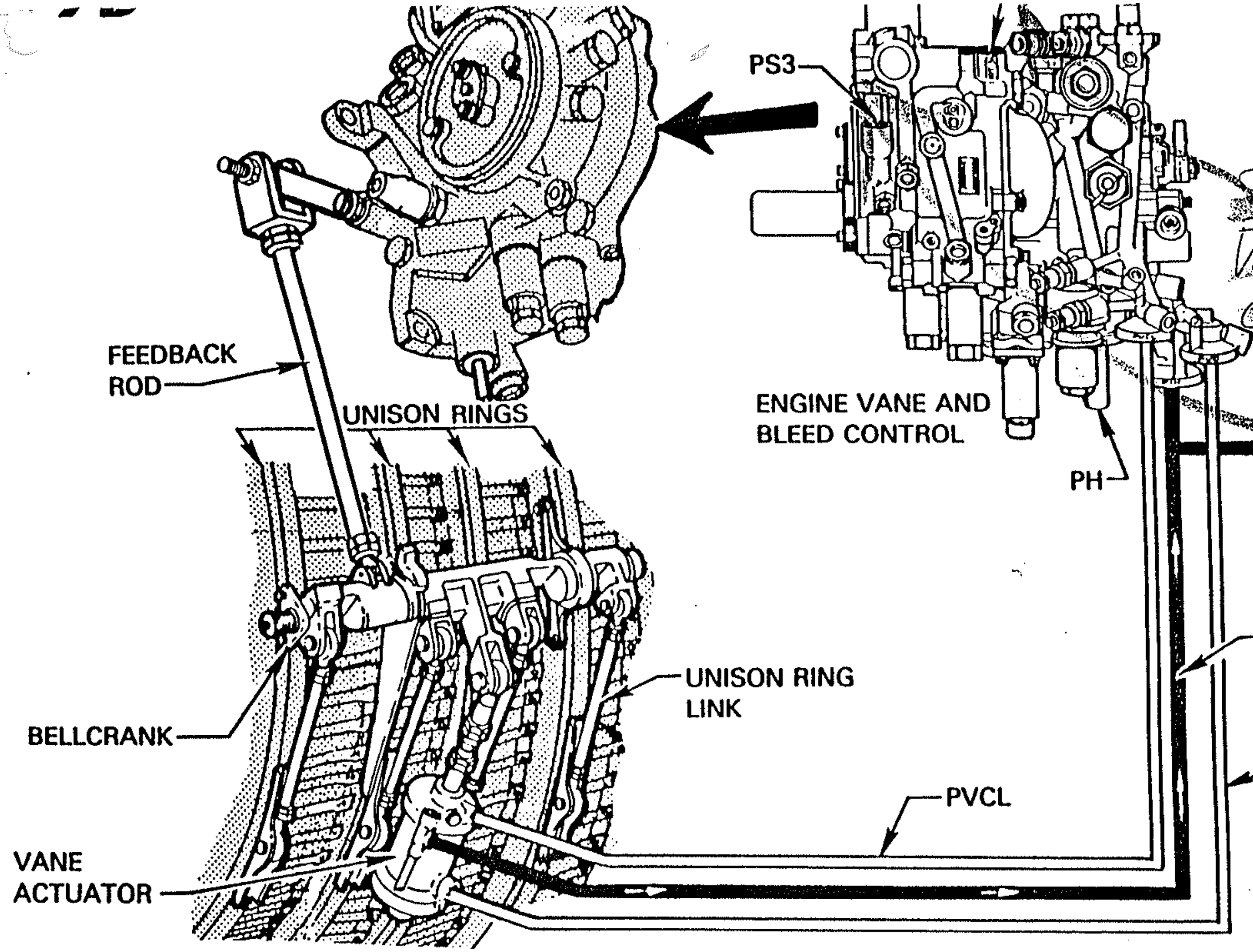
- Optimize compressor performance while providing design surge margin

Components:

- PT3/PS3 input to EVBC
- Engine vane and bleed control
- Vane actuator
- Bellcrank
- Unison ring links
- Unison rings
- Feedback rod

Description and Operation:

- Vane angle is controlled by EVBC
- Scheduled position is based on PT3 and PS3 senses
- N2 IGV and 5th, 6th and 7th stage stators are variable
- Vanes in each individual stage are linked by unison ring
- Unison ring links connect unison rings to bellcrank
- Bellcrank positioned by hydraulic actuator
- Vane open and close signals from EVBC hydraulically position the actuator
  - PVCL—Vanes close pressure
  - PVO—Vanes open pressure



PT3 Leak = Vane lag to Close = Hi EG Hi N_2

PS3 Leak = Vane open too early = Stall

VARIABLE STATOR VANE SYSTEM

75-31
CT 2882
10-83

25

CACS

COMPRESSOR AIRFLOW CONTROL SYSTEM
VARIABLE STATOR VANE SUBSYSTEM—COMPONENTS

ENGINE VANE AND BLEED CONTROL (EVBC)

Purpose:

- Control variable vanes actuator and vane position

Location:

- HPC CASE at 3:00 position

Description and Operation:

- Inputs:
  - Pneumatic
    PT3 and PS3
  - Hydraulic
    PH—servo and muscle pressure
  - Mechanical
    Variable vanes bellcrank feedback rod
- Outputs:
  - Hydraulic
    PVO—vanes open pressure
    PVCL—vanes close pressure
    PIH—interstage hydraulic pressure (RETURN)

VARIABLE VANE BELLCRANK FEEDBACK ROD

Purpose:

- Provide bellcrank angular position to EVBC
- Close EVBC request/response loop

Location:

- Interconnects EVBC and bellcrank

Description and Operation:

- Translates bellcrank and vane movement to EVBC

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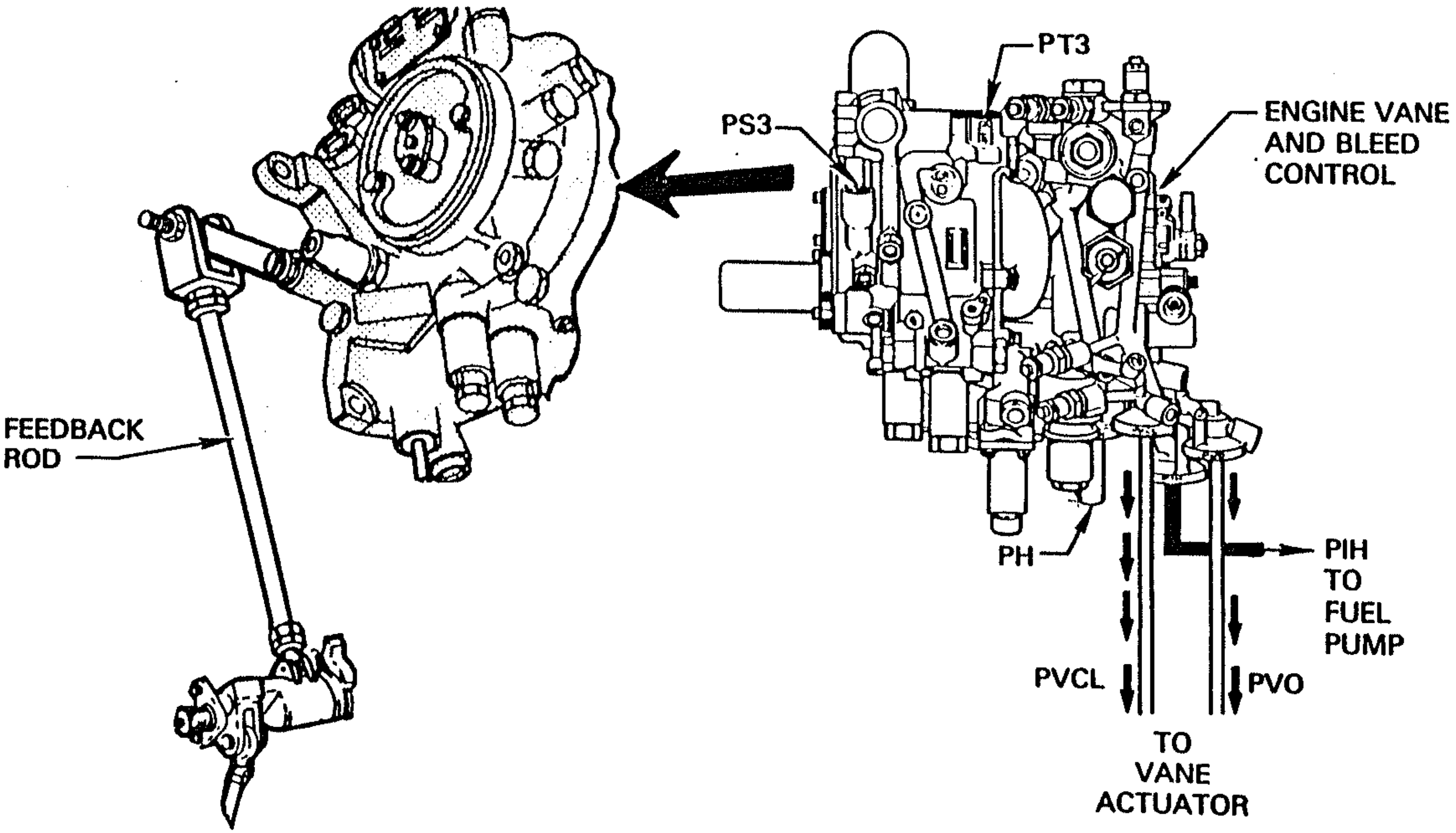


CT 4102
8-84

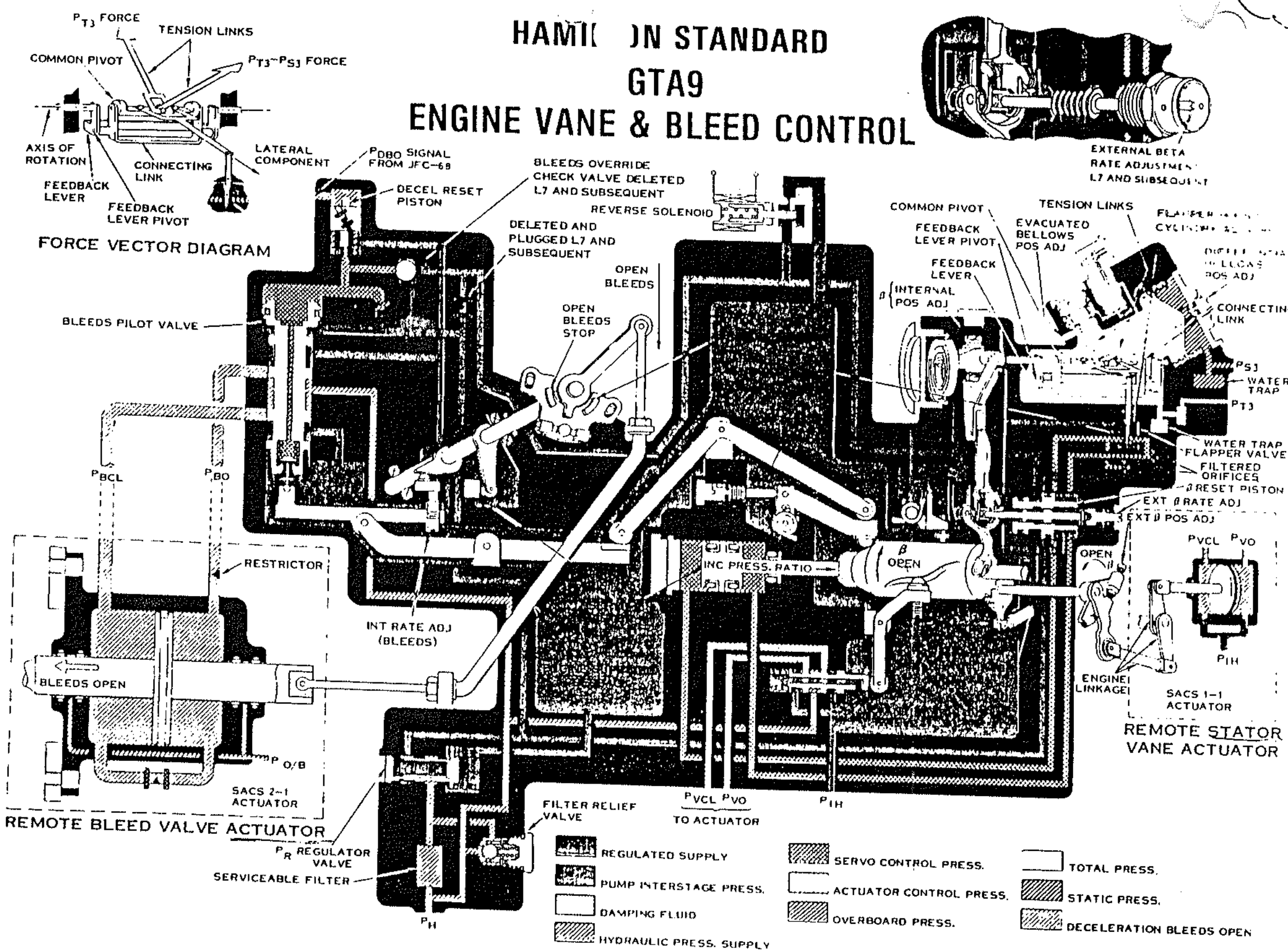
ENGINE VANE AND BLEED CONTROL/FEEDBACK ROD

27

CACS

83

HAMI[ ]N STANDARD GTA9 ENGINE VANE & BLEED CONTROL



SEPTEMBER 1984

22-5256

WHY TRIM A JT9D ENGINE?

- Variable vane system —
  - Purpose: to provide optimum engine performance throughout the engine operating envelope by varying compressor airflow. At low engine RPM, the variable vanes are "closed" allowing minimal airflow through the compressor. At high engine RPM, the variable vanes are "open" allowing maximum airflow through the compressor.
  - Trimming the variable vanes ensures vane operation within a trim band in order to obtain the optimal engine performance while maintaining acceptable surge margin.
  - Vanes operating outside the trim band could result in any of the following engine discrepancies:

Too closed	Too open
• Hung start	• Impending hot start
• High EGT	• Acceleration surge
• High N_2	• Deceleration surge
• High oil consumption	• Reverse surge
• Oil fumes in cockpit	
• STREB 5th Stg Blades	

J38016-5
R880906 a1

29

WHY TRIM A JT9D ENGINE? (Cont'd)

- Modulating 3.0 bleed system —
  - Purpose: provides surge margin during low power operation by the opening of the 3.0 bleed ring
  - Trimming the 3.0 bleed ensures that the 3.0 bleed ring opens and modulates closed within the correct EPR band
  - Off-schedule operation of the 3.0 bleed could result in any of the following engine discrepancies:

Open	Closed
• High EGT	• Impending hot start
• High N_2	• Acceleration surge
	• Deceleration surge
	• Reverse surge

J38018-6
R680906

WHY TRIM A JT9D ENGINE? (Cont'd)

- Fuel control —
  - Purpose: among other functions, the fuel control regulates the level of min idle and approach idle N_2 speeds and schedules fuel flow to produce the required EPR levels during high power running
  - Trimming the fuel control ensures proper N_2 speeds at min idle and approach idle conditions and the ability to obtain the proper EPR level at take-off power.
  - Fuel control operation off-schedule could result in any of the following engine discrepancies:
    - Low or high min idle speed
    - Low or high approach idle speed
    - Low take-off power
    - High oil consumption (low min idle)

31

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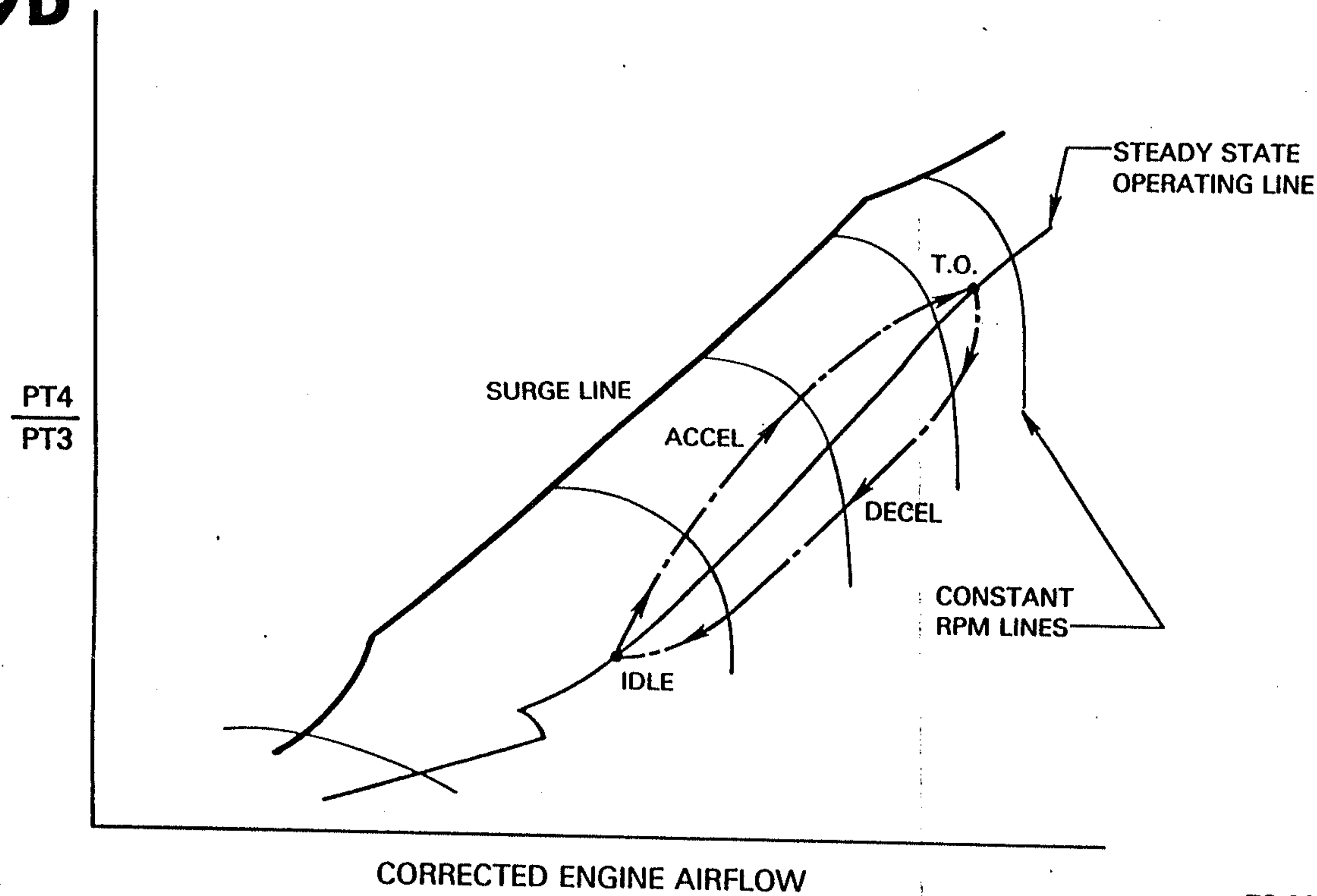
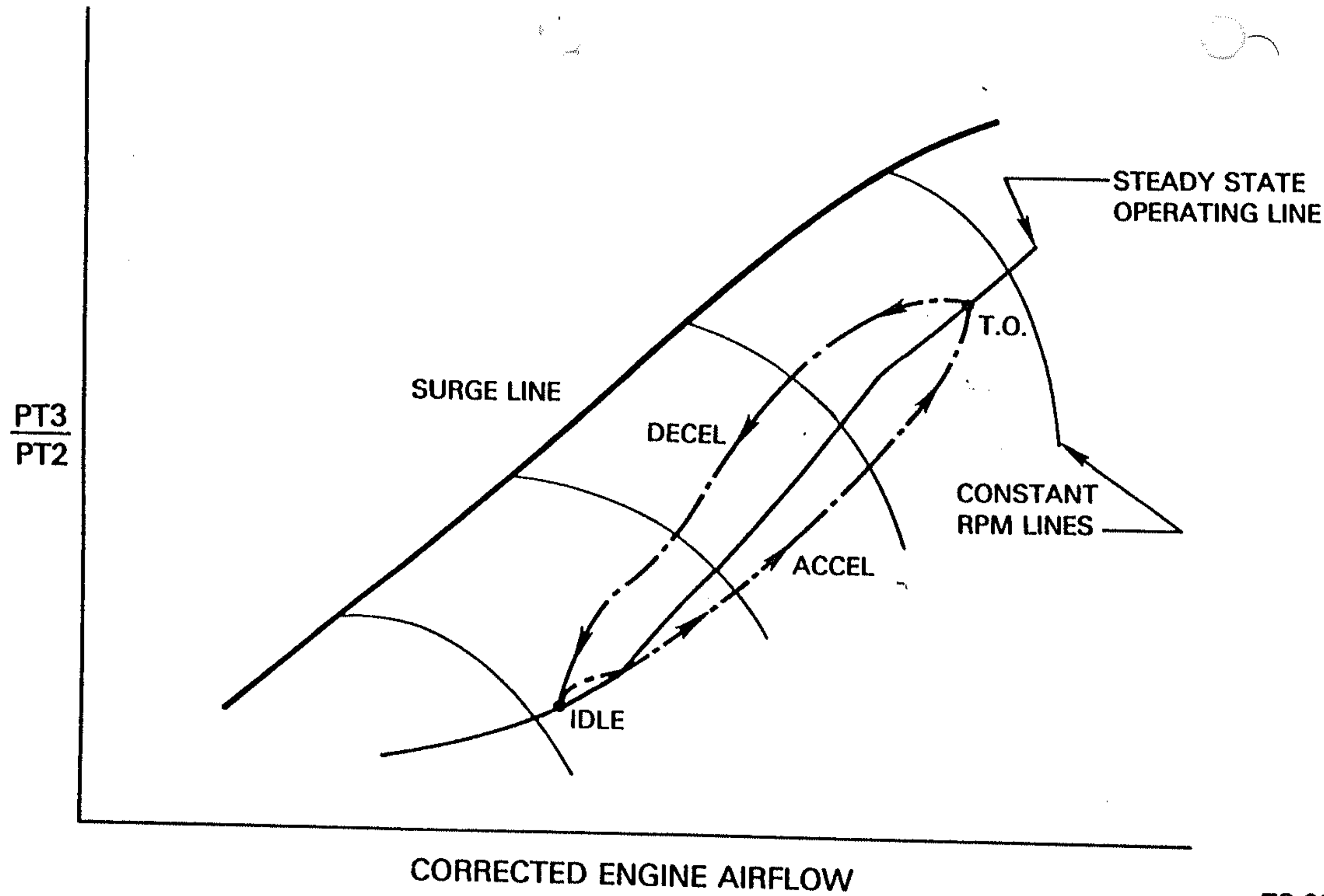


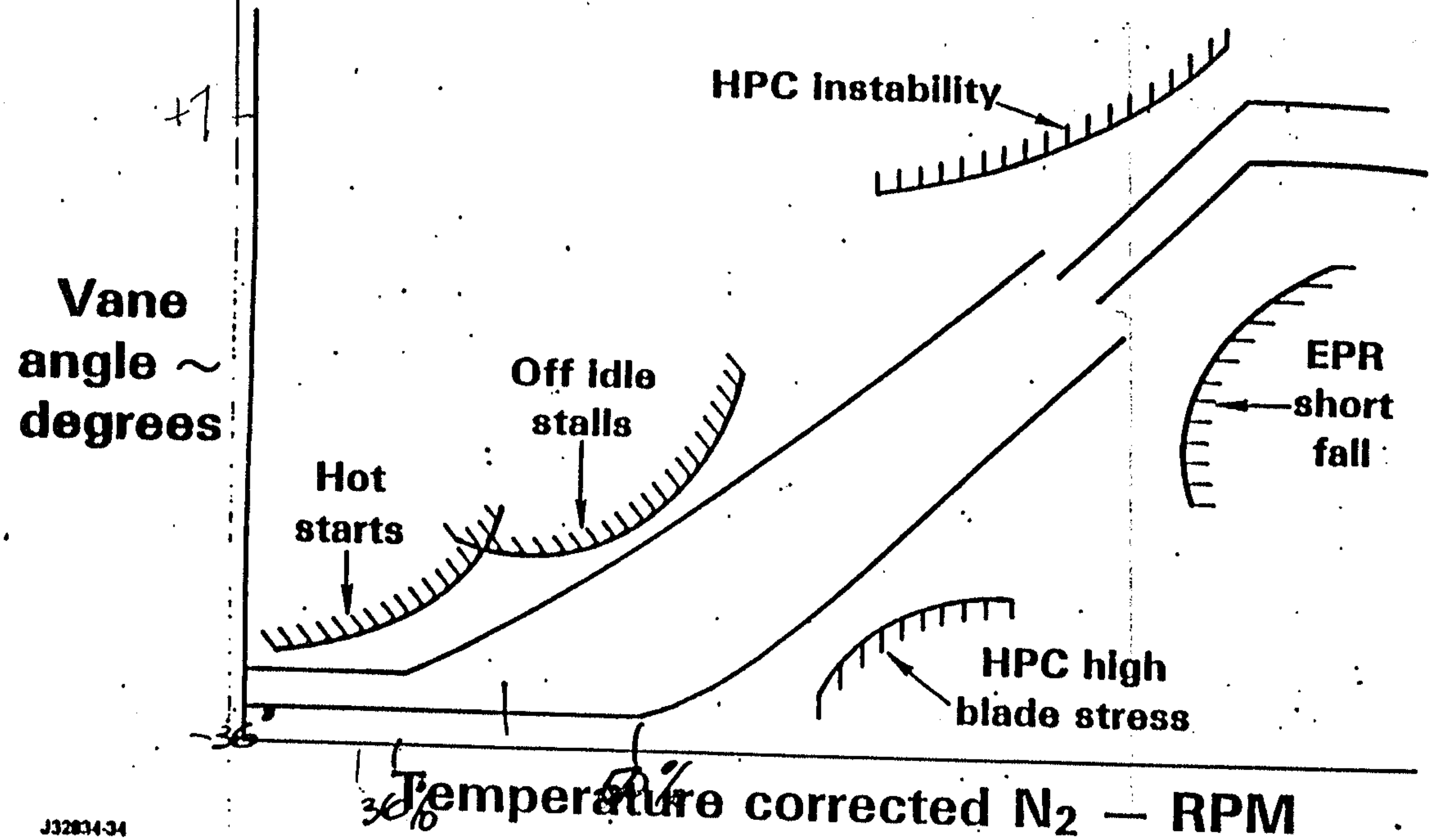
REAR COMPRESSOR MAP



FRONT COMPRESSOR MAP

ENGINE VANE AND BLEED CONTROL FUNCTION

HPC variable stator vane off schedule operational problems



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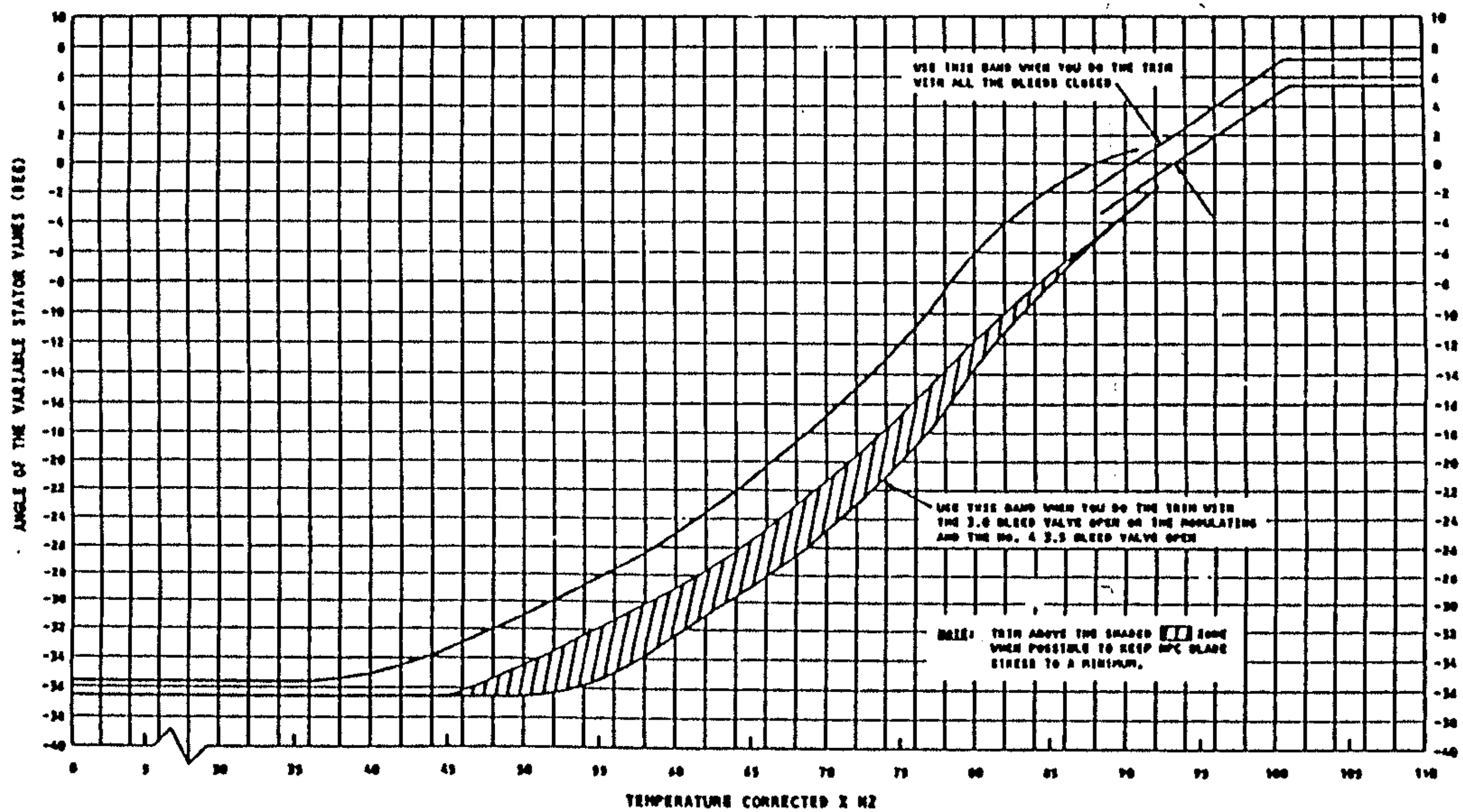
851007

CORRECTED N2						
VSV ANGLE						

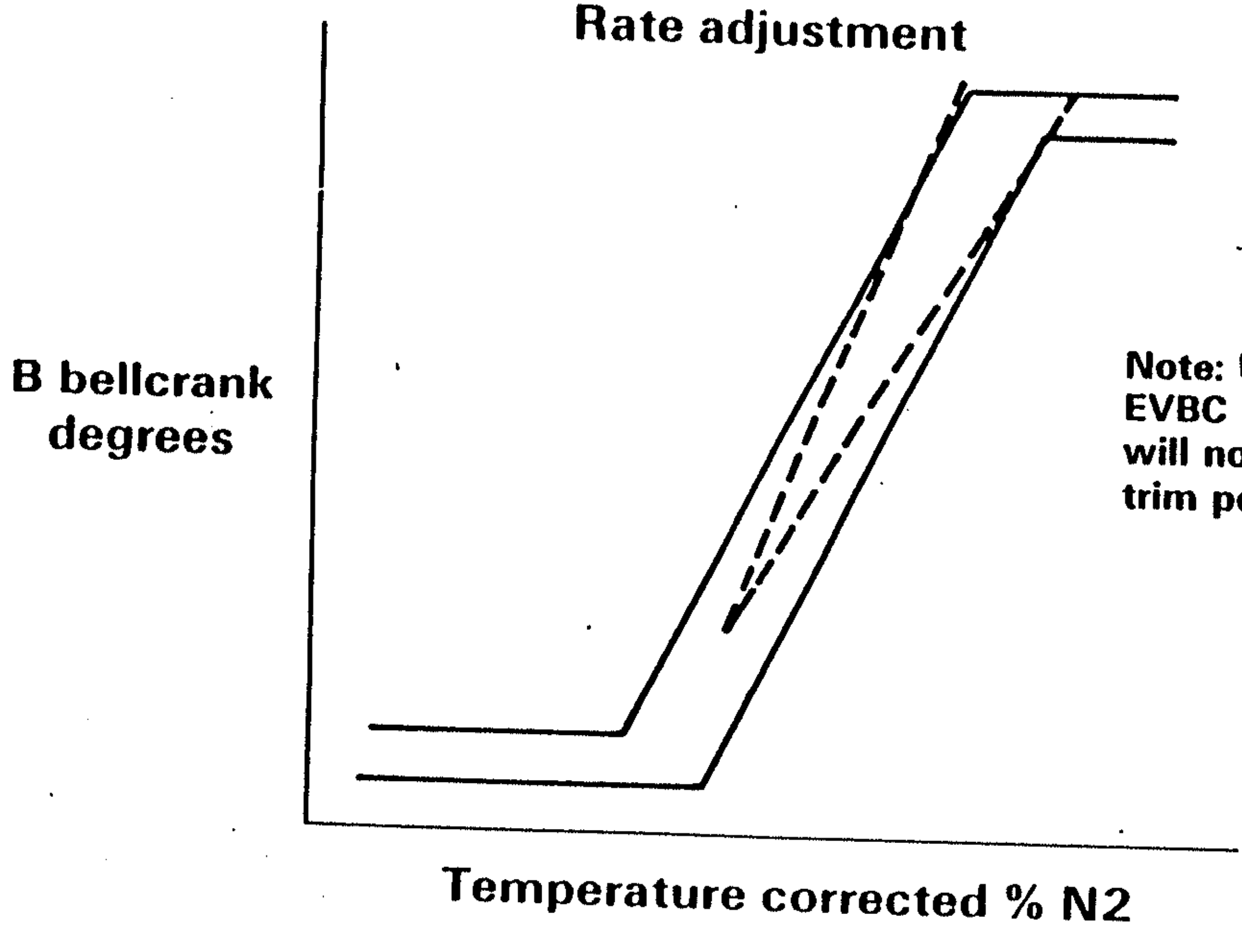


Variable Stator Vane Trim Curve
Figure 502

EFFECTIVITY—
ALL

VARIABLE VANE SYSTEM TRIM

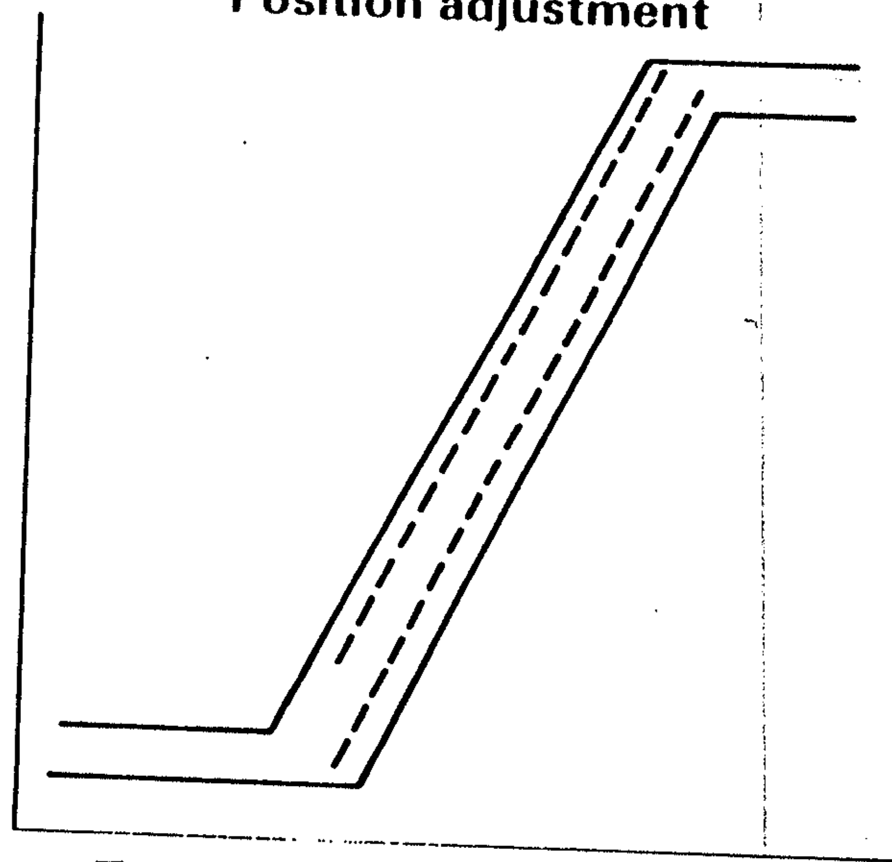
- EVBC has two trimmers (rate and position adjustments)
  - "Rate adjustment" trimmer is activated from the flight deck via the trim equipment and "tilts" vane schedule



Note: Use of remote EVBC rate adjustment will not change idle trim point

J38018-20
R880908 s1

- "Position adjustment" trimmer is manually adjusted at the EVBC and "slides" vane schedule vertically
- Use "position adjustment" to trim idle point into trim band and also to aid "rate adjustment" in positioning trim within band above idle

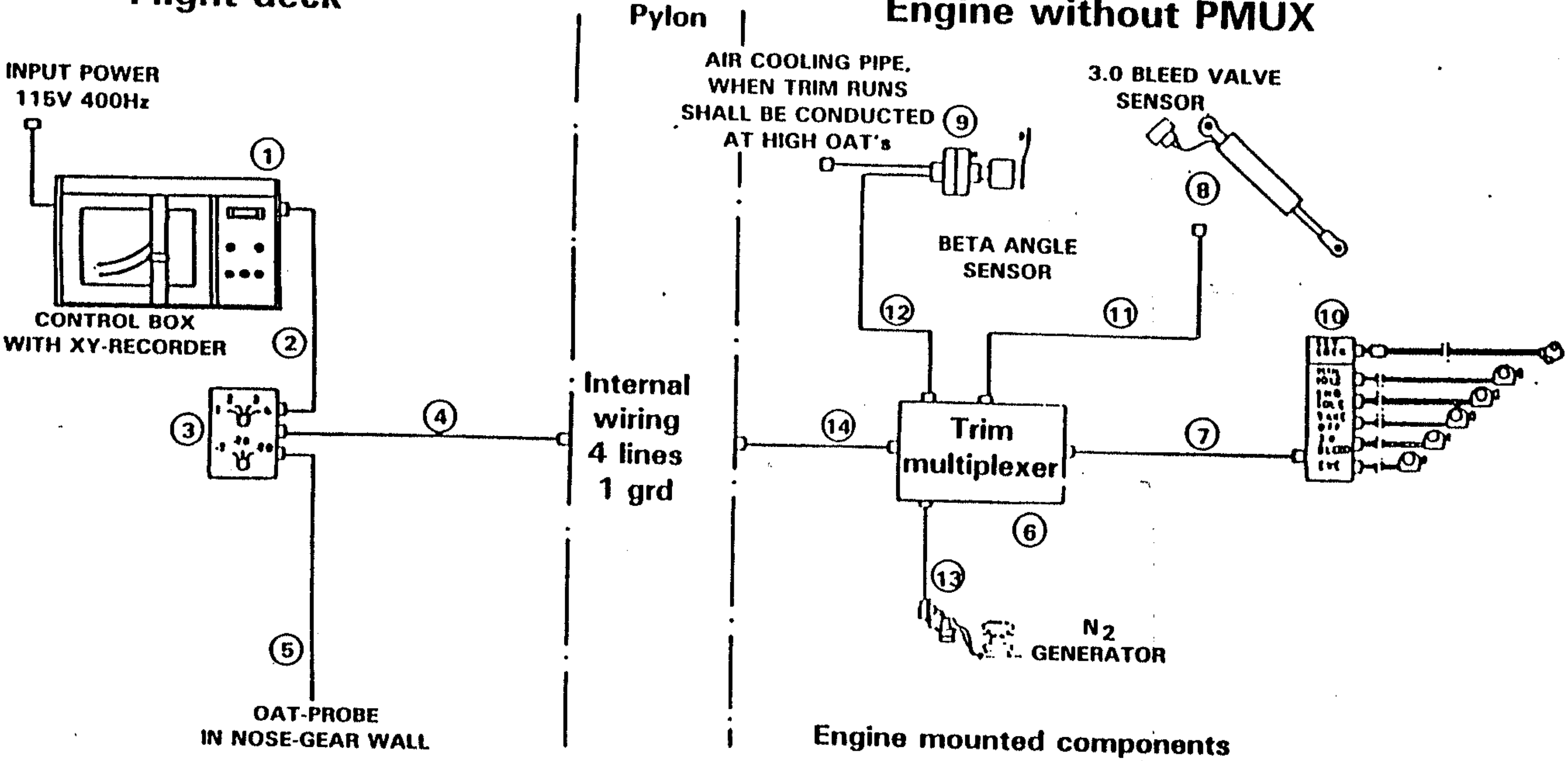


1/4 ccw = 2° ↑

J38018-21
R880504 m1

37

RMS



Flight deck components

1. Control box with XY-plotter
2. Junction box cable
3. Junction box
4. Cabin cable to 160VC
5. OAT probe

Engine mounted components

6. Multiplexer
7. Gear box cable
8. 3.0 bleed valve sensor
9. EVC sensor
10. Gearbox
11. 3.0 bleed valve cable
12. EVC sensor cable
13. N2 generator cable
14. Multiplexer cable

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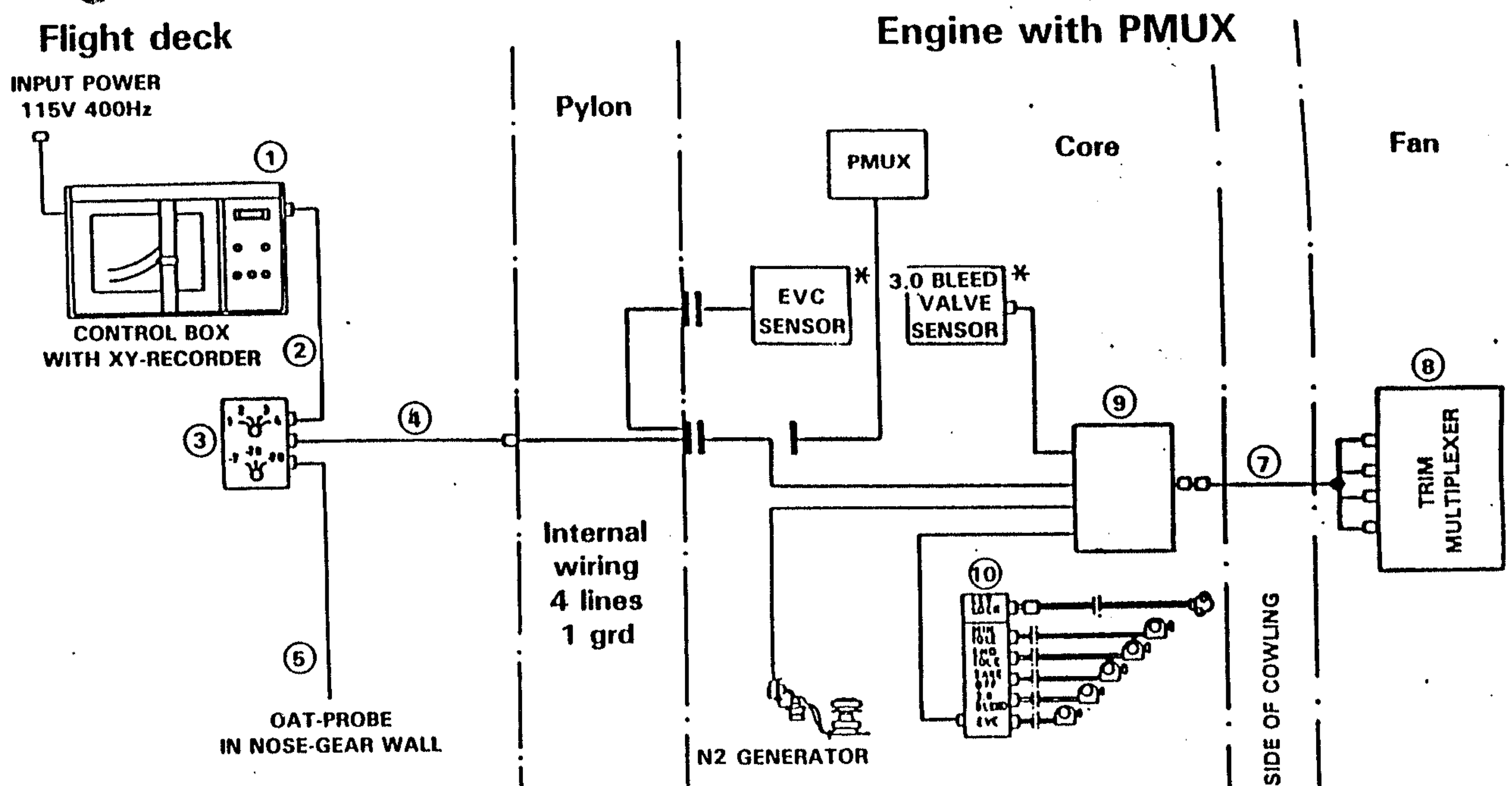
R880504 ml



Flight deck components

1. Control box with XY-plotter
2. Junction box cable
3. Junction box
4. Cabin cable to 160VC
5. OAT probe

Engine mounted components

7. Multiplexer cable
8. Multiplexer
9. Y-cable
10. Gearbox

Note: Both the 3.0 bleed valve sensor and the stator vane resolver are permanently mounted to the engine

J38018-13
R880305 mt

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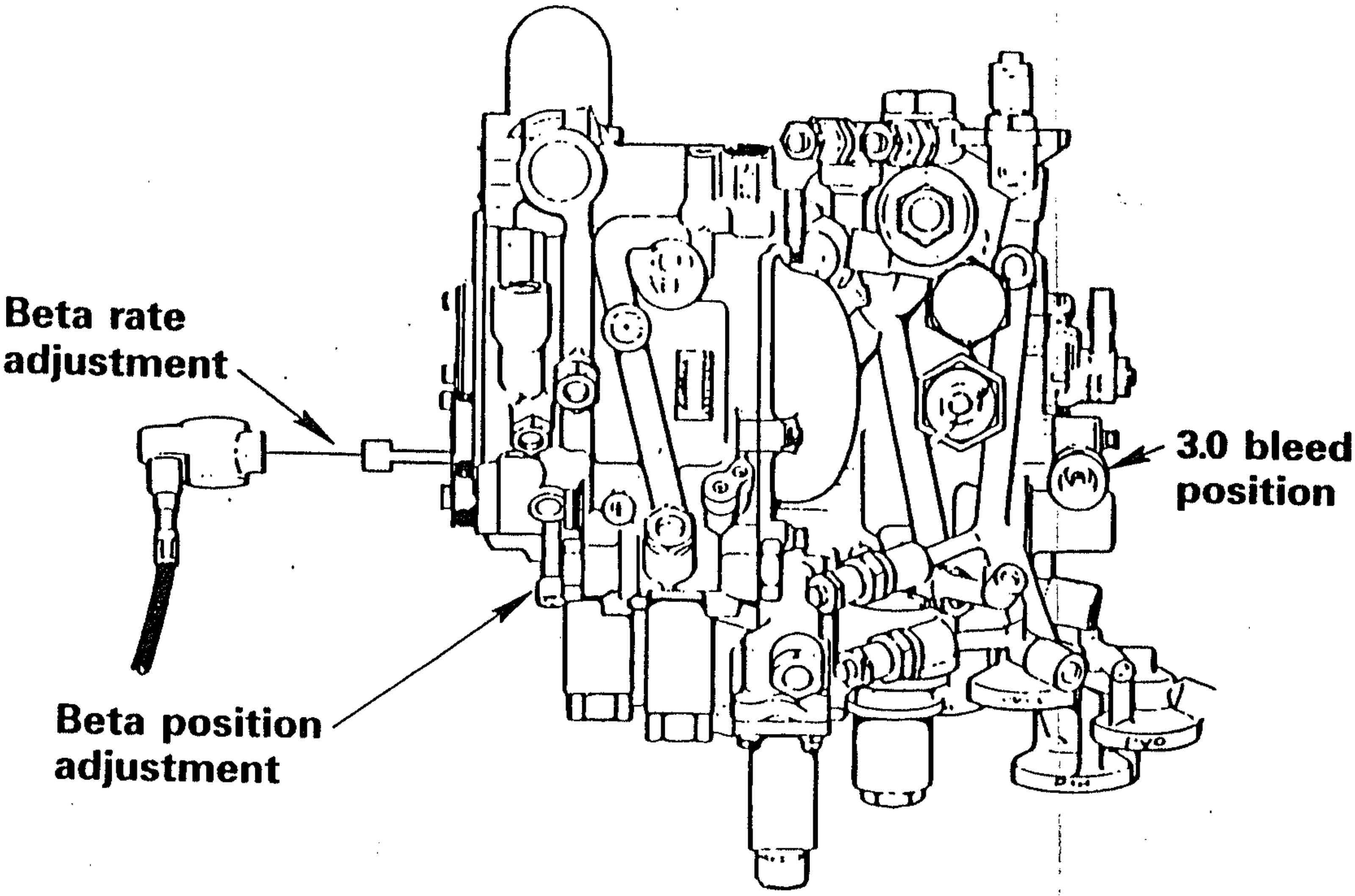
98

EVBC TRIMMER LOCATIONS



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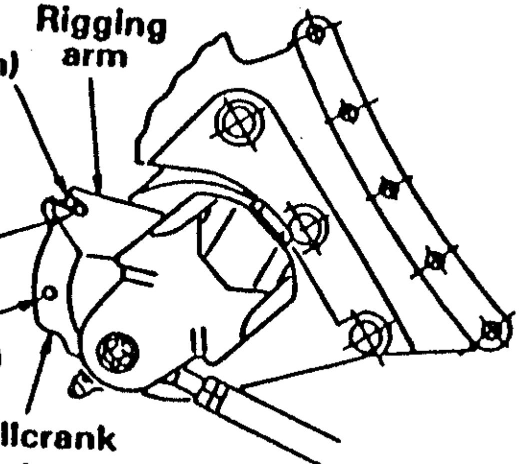
R880906

40

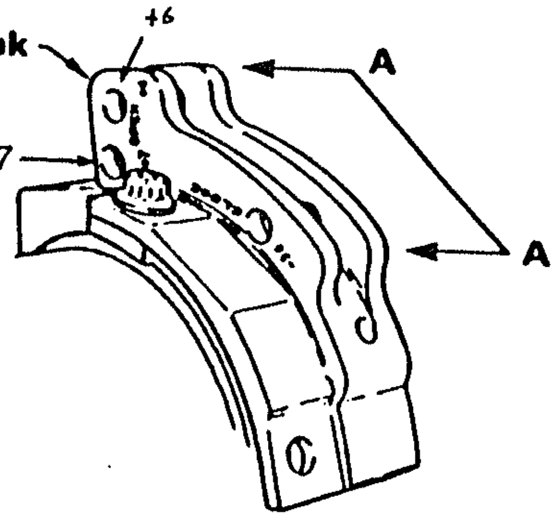
VARIABLE VANE SYSTEM
BELLCRANK RIGGING PLATE

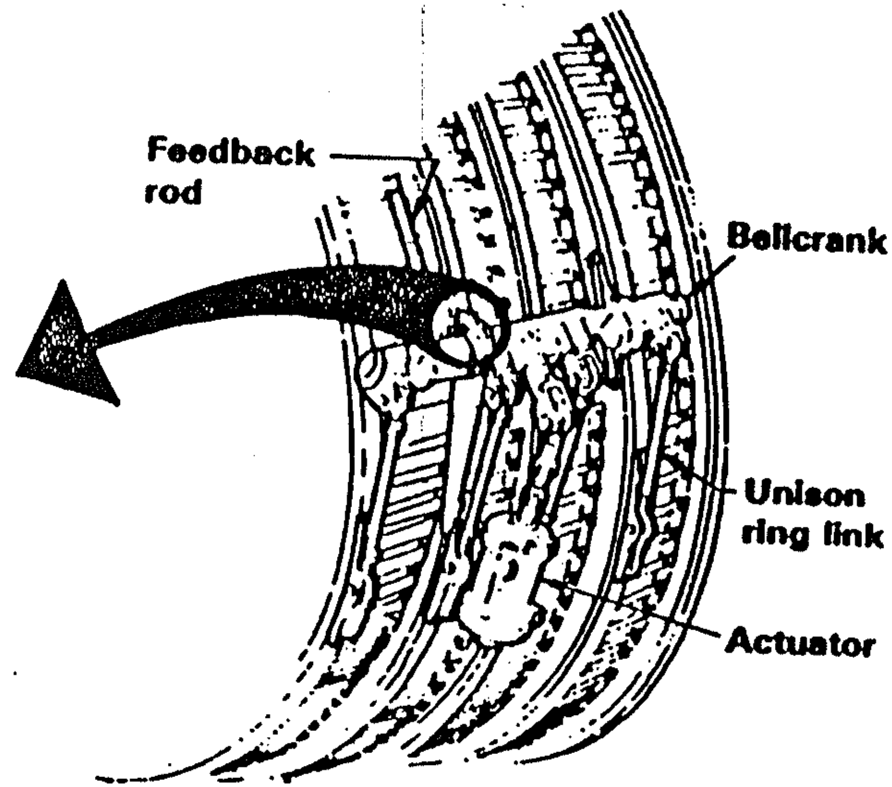


Function

+6° hole - use for feedback rod and unison ring rigging

D+E +7° open / −36° closed — use for stator vane actuator rigging

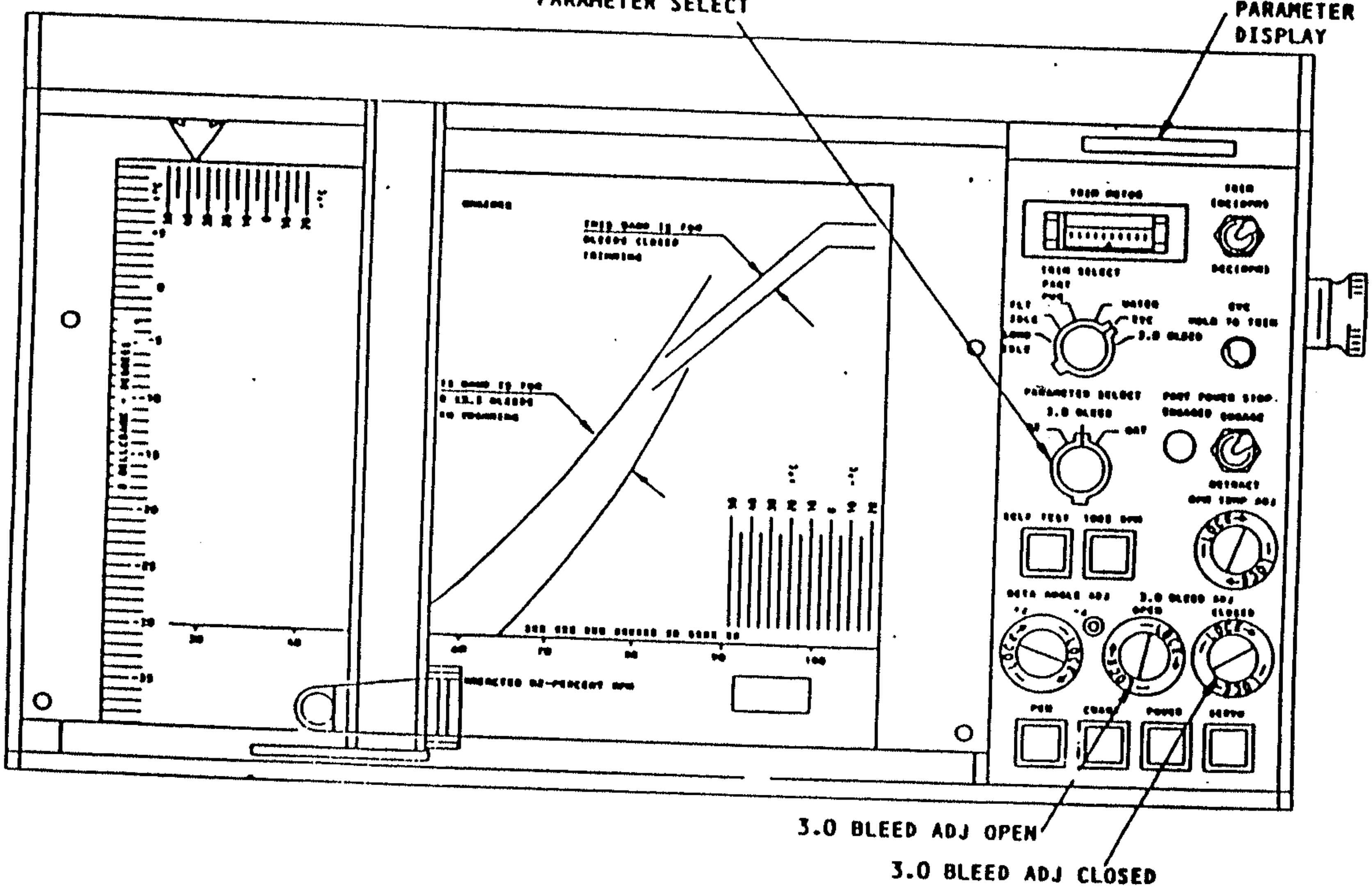




Boeing

RMS

Control box

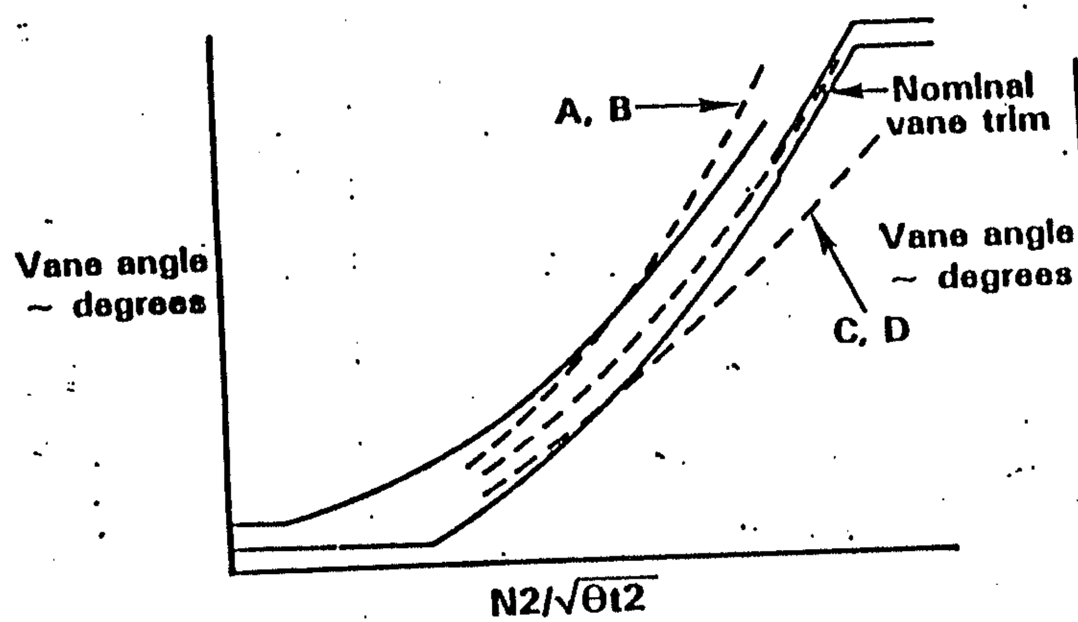


J38018-14
880202 sMs343

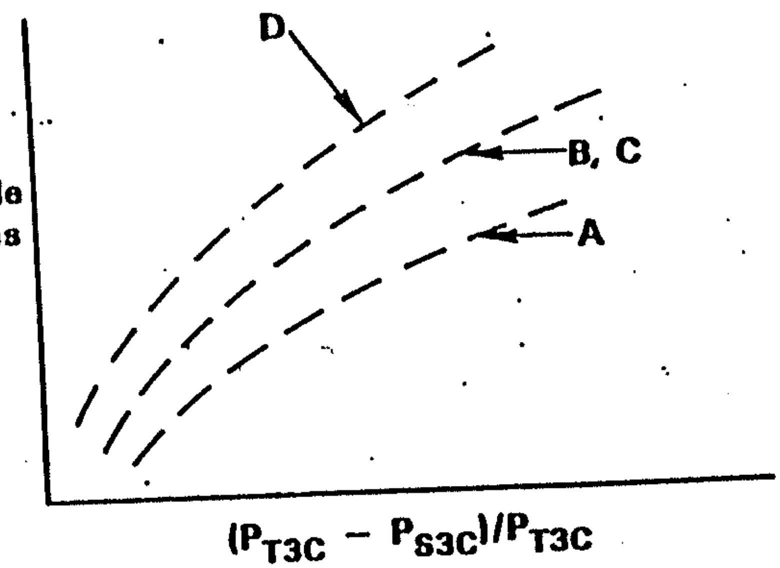
TROUBLESHOOTING

Effect of PT3C and PS3C leaks on vane trim
PT3C and PS3C measured at EVC water traps

Engine variable stator vane trim problem



Observed EVBC scheduling



A PS3C leak at instrumentation
B PS3C leak at manifold
C PT3C leak at manifold, PT3C probe internal leak
D PT3C leak at instrumentation

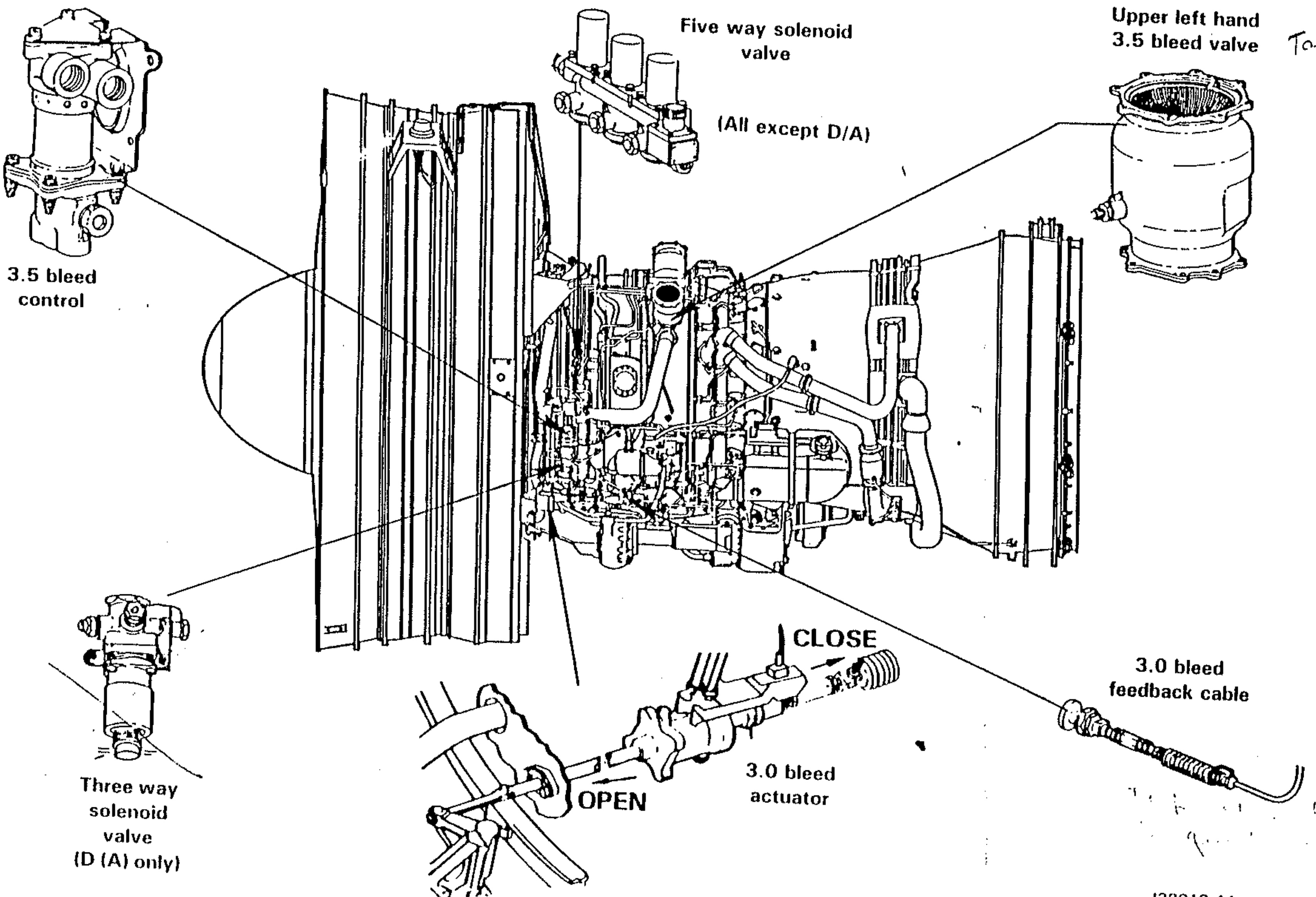
J37123-62
870607 mcs47

JT9D-7R4 BLEED SYSTEM

Consists of the following subsystems:

- Start bleed system — decreases drag on the compressor and provides increased starting surge margin
- Tandem bleed system — provides increased surge margin during low power operation
- Reverser actuated bleed system (RABS) — provides increased surge margin during reverser operation

JT9D-7R4 BLEED SYSTEM



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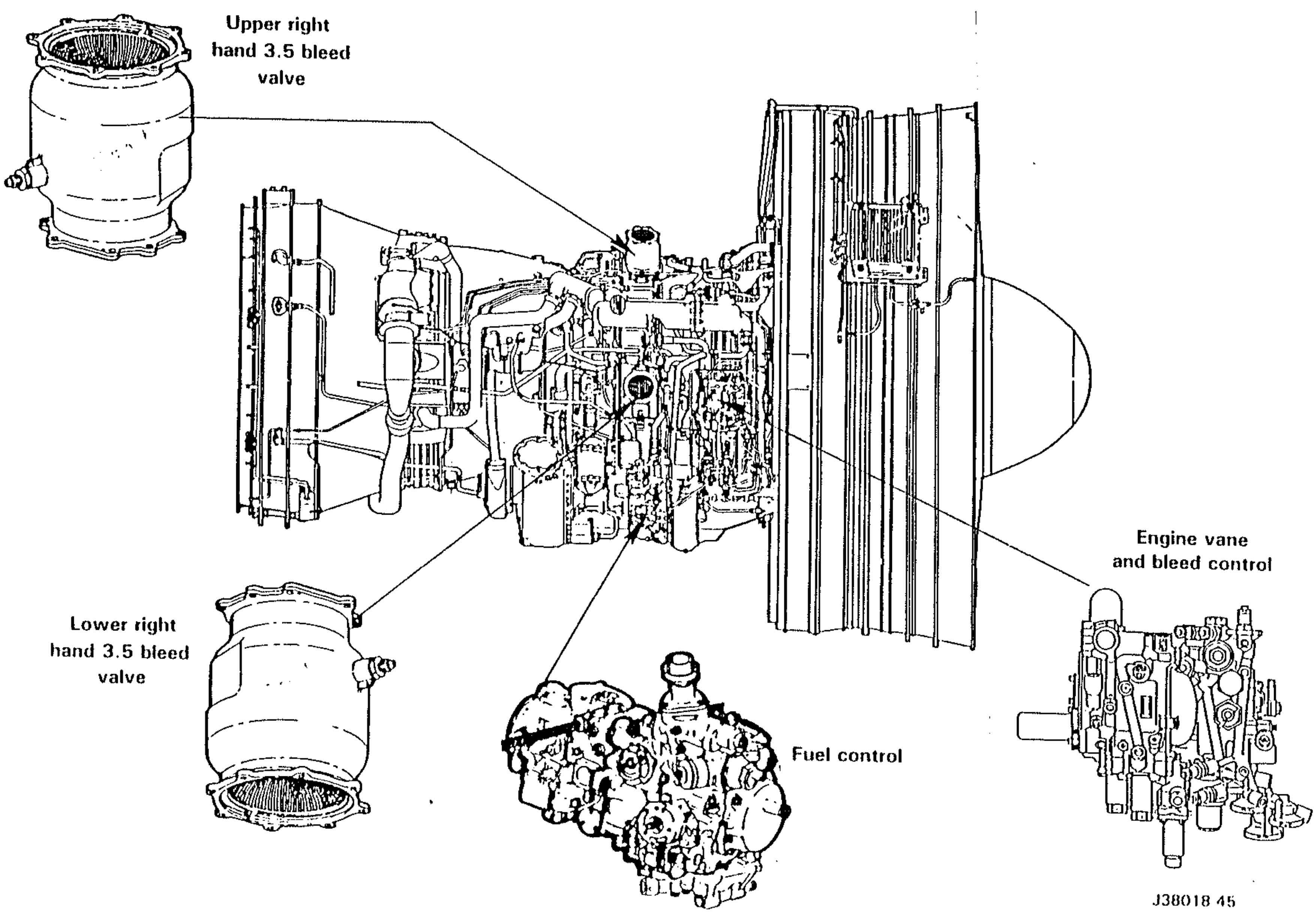
880302

JT9D-7R4 BLEED SYSTEM



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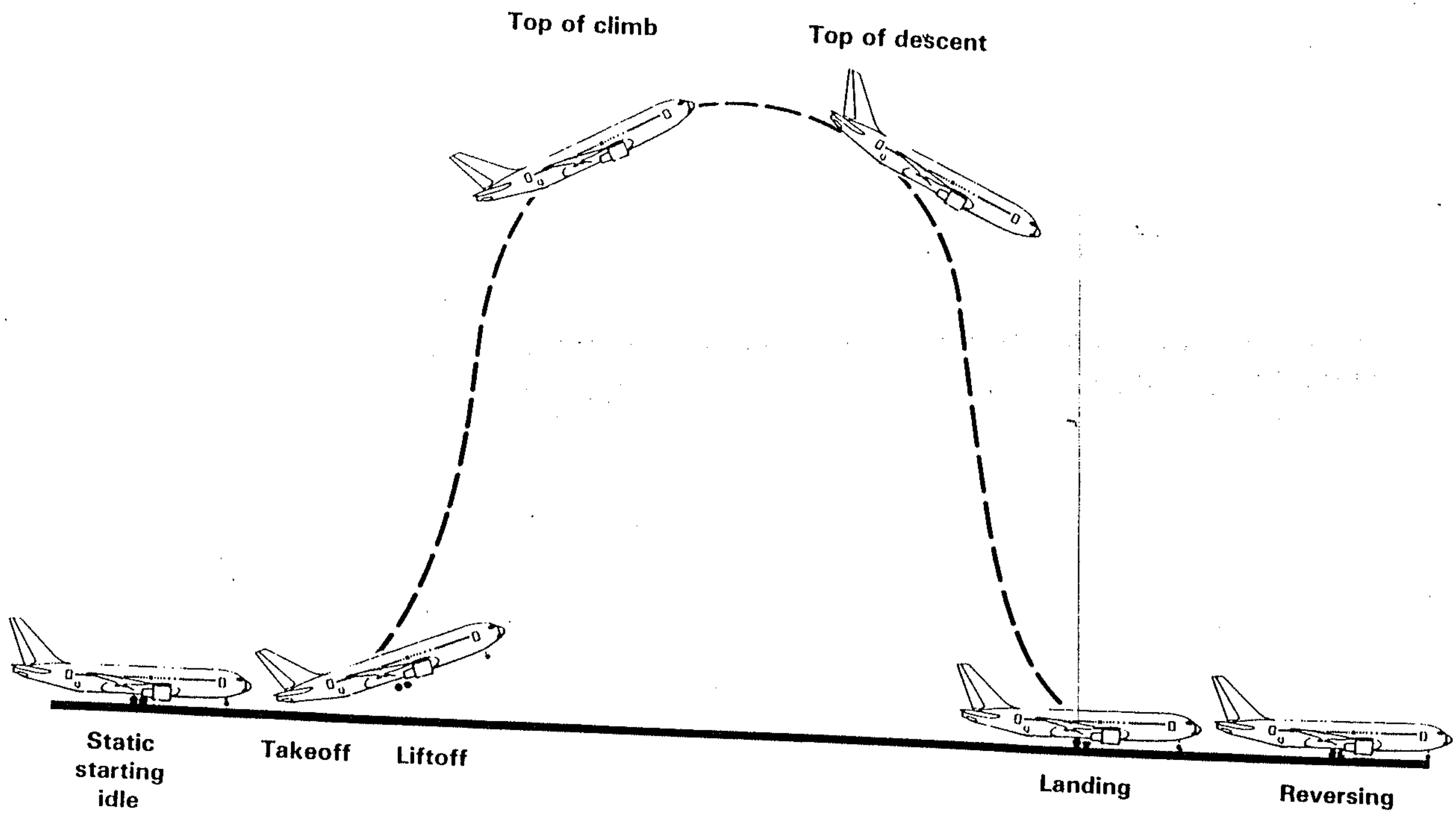
880302

105

BLEED SYSTEM OPERATION SEQUENCE



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BLEED OPERATION

Engine operating condition	Bleed valve position
Static	3.0 and three 3.5 bleed valves open
Starting	Start bleed system — Two 3.5 bleed valves close
Idle	Two 3.5 bleed valves are closed
Takeoff	Tandem bleed system — 3.0 and Upper Left Hand (ULH) 3.5 bleed valves close at approximately 1.24 or 1.27 EPR
Liftoff	ULH 3.5 bleed switches to start system
Top of climb	3.0 and three 3.5 bleeds closed
Top of descent	3.0 bleed opens
Landing	ULH 3.5 bleed switches to tandem system
Reversing	RABS — 3.0 and ULH 3.5 bleeds open

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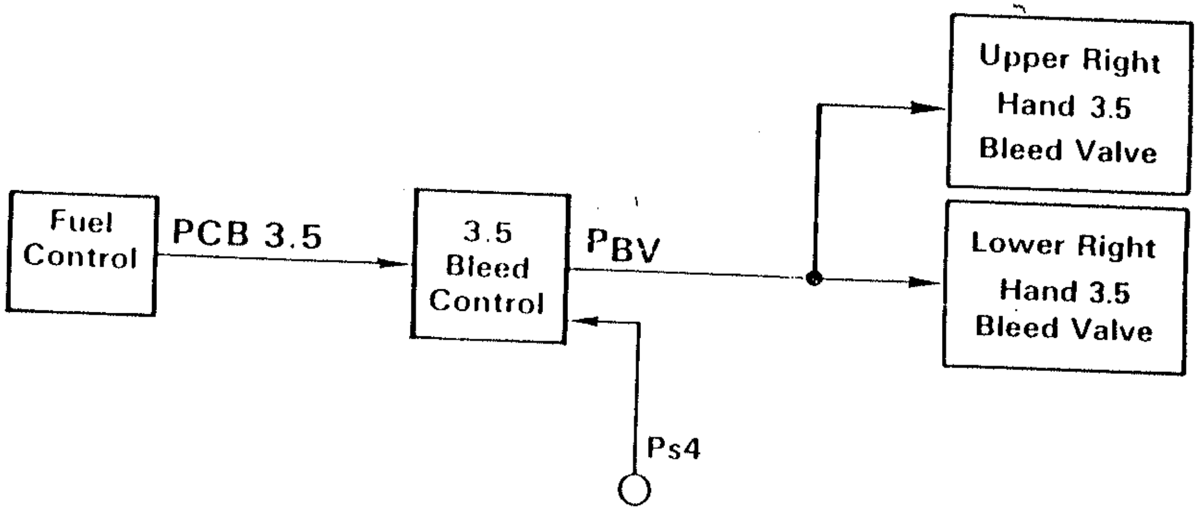
START BLEED SYSTEM

- Components Involved: The Upper Right Hand and Lower Right Hand 3.5 Bleed Valves, Fuel Control, and 3.5 Bleed Control
- Normal Operation: 1. At Approximately 50% N2 Speed, Which is Below Idle, a Fuel Signal (PCB 3.5) is Directed from the Fuel Control to the 3.5 Bleed Control
  2. The 3.5 Bleed Control Converts the Fuel Signal (PCB 3.5 to a Pneumatic Muscle Pressure (PBV) for Valve Actuation
  3. PBV Muscle Pressure is Manifolded to the Individual 3.5 Bleed Valves Causing Them to Close. Valves Remain Closed as Long as Engine Remains Above 50% N2



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TANDEM BLEED SYSTEM

- Components involved:
  Engine vane and bleed control, 3.0 bleed actuator, 3.0 bleed valve position switch, Mach number probes, 3.0 bleed valve and linkage, 3.0 bleed feedback push-pull cable, fuel control/fuel pump, three-way solenoid valve (''D (A)'' only) or five-way solenoid valve All except D(A) , upper left hand 3.5 bleed valve and aircraft air/ground relay.

- Normal operation:
  1. Engine vane and bleed control (EVBC) receives four input signals: P_H and P_{DBO} fuel signals from the fuel control/fuel pump and P_{T3} and P_{S3} air signals from the Mach number probes.
  2. The EVBC schedules bleed open (P_{BO}) or bleed closed (P_{BCL}) fuel signals to the 3.0 bleed actuator as a function of P_{T3} and P_{S3} pressure levels.

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TANDEM BLEED SYSTEM

- Normal operation (cont'd):

3. Upon receipt of the P_{BO} or P_{BCL} signal, the 3.0 bleed actuator modulates the 3.0 bleed valve to the required position through linkages.

   A. Aircraft on the ground: Aircraft air/ground relay is closed providing 28 VDC to the circuit controlling the three-way or five-way solenoid valve. This results in the upper left hand (ULH) 3.5 bleed valve working in tandem with the 3.0 bleed valve.

   When the 3.0 bleed valve is open, the 3.0 bleed valve position switch is closed which energizes the three-way solenoid valve (''D (A)'' only) or five-way solenoid valve (All except D(A)). When energized, the solenoid valve terminates the PBV signal to the ULH 3.5 bleed valve and opens the valve.

   When the 3.0 bleed valve is closed, the 3.0 bleed position switch is open which de-energizes the solenoid valve. When de-energized, the solenoid valve allows P_{BV} signal to flow to the ULH 3.5 bleed valve and closes the valve.

   B. Aircraft in-flight: Aircraft air/ground relay is open terminating the 28 VDC to the circuit controlling the three-way or five-way solenoid valve. The de-energized solenoid valve allows P_{BV} signal to flow to the ULH 3.5 bleed valve and keeps the bleed closed regardless of the 3.0 bleed valve position.

TANDEM BLEED SYSTEM

- Normal operation (cont'd):

4. The 3.0 bleed feedback push-pull cable provides the 3.0 bleed valve position input to the EVBC to prevent over scheduling of the bleed

5. 3.0 bleed is modulated from full open below 1.09 EPR to full closed above 1.24 or 1.27 EPR at sea level, static conditions

6. During rapid decelerations, the fuel control reduces the P_{DBO} signal level to the EVBC resulting in the EVBC scheduling the 3.0 bleed valve to the full open position. During ground operation, the ULH 3.5 bleed valve will open in tandem with the 3.0 bleed IN FLT ALSO PHASE II

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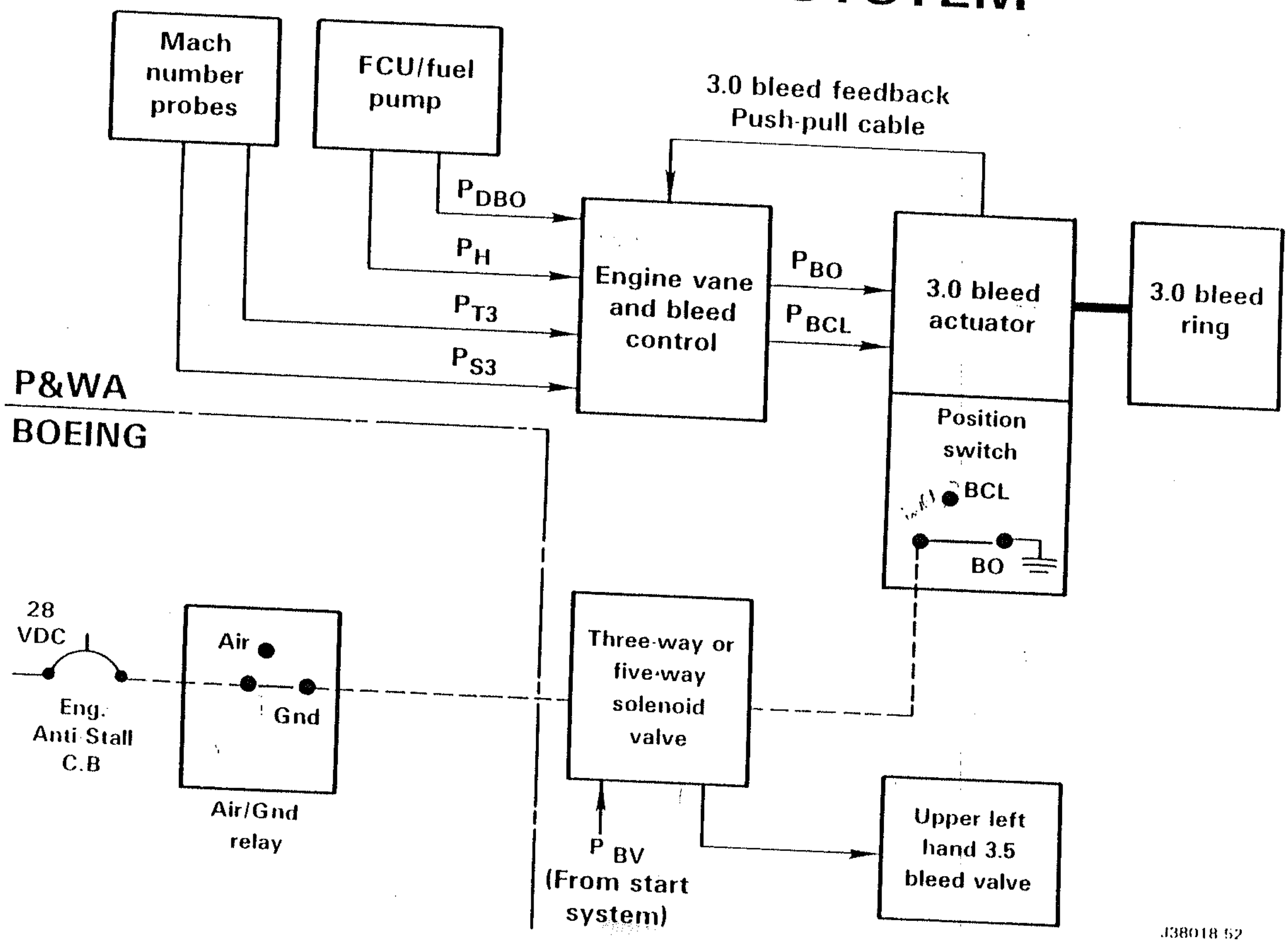
TANDEM BLEED SYSTEM



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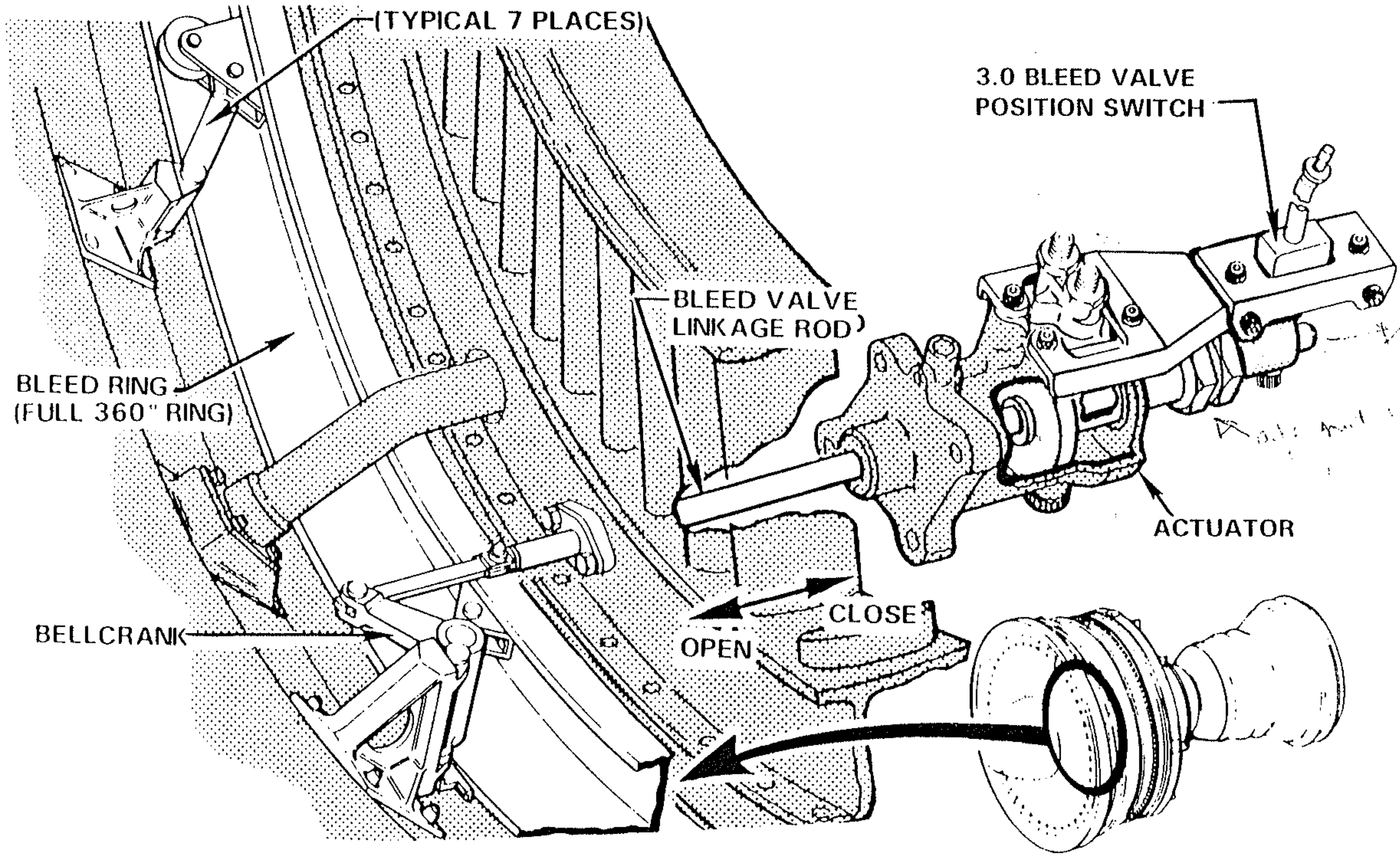

3.0 bleed ring and actuator

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REVERSER ACTUATED BLEED SYSTEM (RABS)

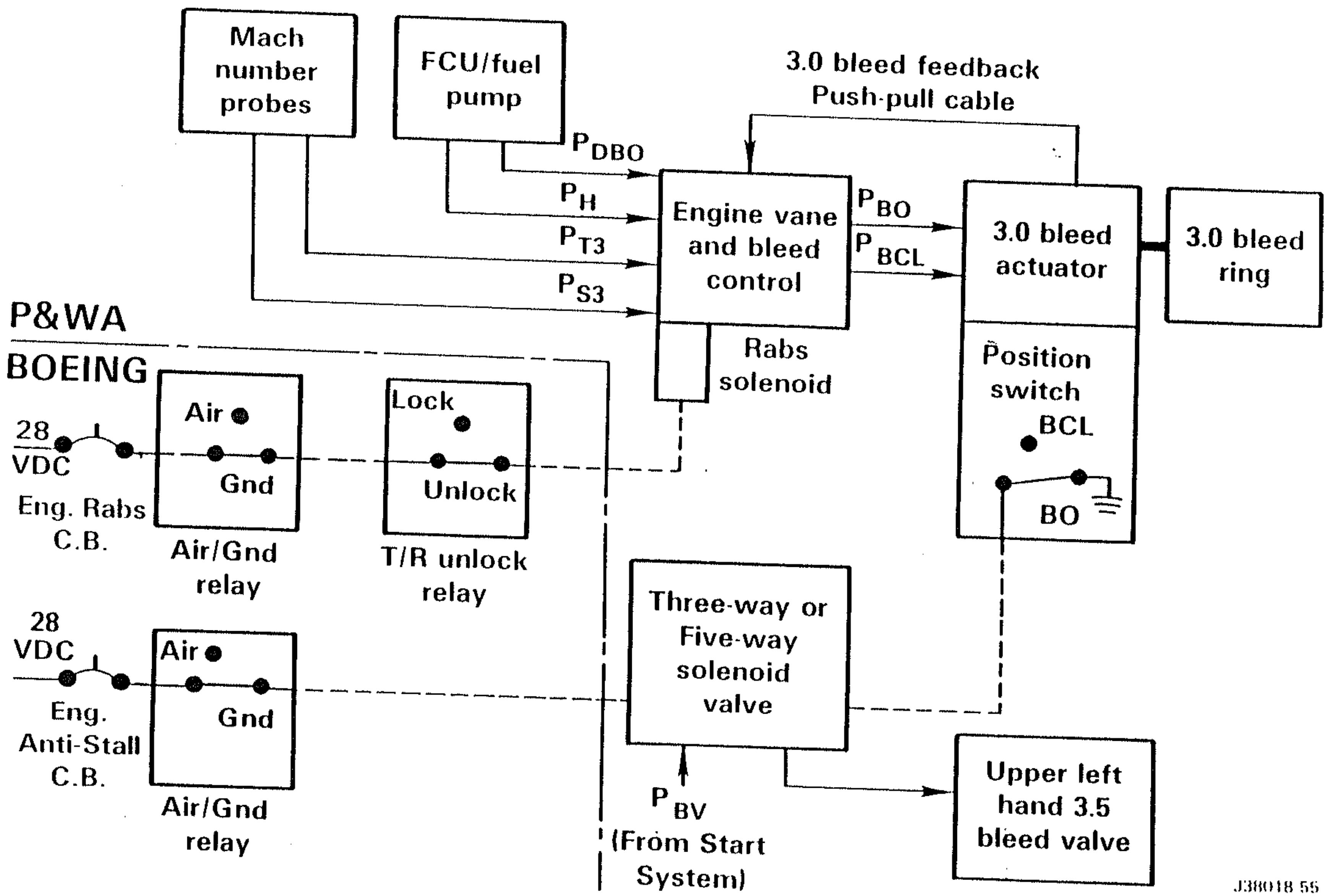
- **Components involved:**

  Engine vane and bleed control, 3.0 bleed valve and linkage, RABS solenoid (mounted on EVBC), 3.0 bleed actuator, 3.0 bleed valve position switch, three-way solenoid valve (''D (A)'' only) or five way solenoid valve (All except D(A)) upper left hand 3.5 bleed valve, aircraft air/ground relays and aircraft thrust reverser (T/R) unlock relay

- **Normal operation:**

  1. As the fan reverser sleeve starts to deploy, the switch in the T/R unlock position relay closes, resulting in 28 VDC being sent to the EVBC RABS solenoid. The air/ground relay inhibits power in flight
  2. Upon receipt of the electrical signal at the RABS solenoid, the EVBC sends a bleed open signal (P_{BO}) to the 3.0 bleed actuator resulting in the 3.0 bleed valve fully opening
  3. As the 3.0 bleed actuator translates to the open position, the 3.0 bleed valve position switch closes, energizing the three-way (or five-way) solenoid valve, terminating the P_{BV} signal to the upper left hand 3.5 bleed valve and opening the valve

REVERSER ACTUATED BLEED SYSTEM (RABS)



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JT9D-7R4 BLEED OPERATION

ENGINE OPERATING CONDITION	4TH STAGE AIR 3.0 BLEED RING	9TH STAGE AIR 3.5 BLEED VALVES URH	LRH	ULH
ENGINE SHUT DOWN	○	○	○	○
50% N2 AND IDLE (GROUND OPERATION)	○	●	●	○
50% N2 AND IDLE (FLIGHT OPERATION)	○	●	●	●
HIGH POWER ABOVE 1.24 or 1.27 EPR	●	●	●	●
REVERSE THRUST	○	●	●	○

CLOSED ● OPEN ○

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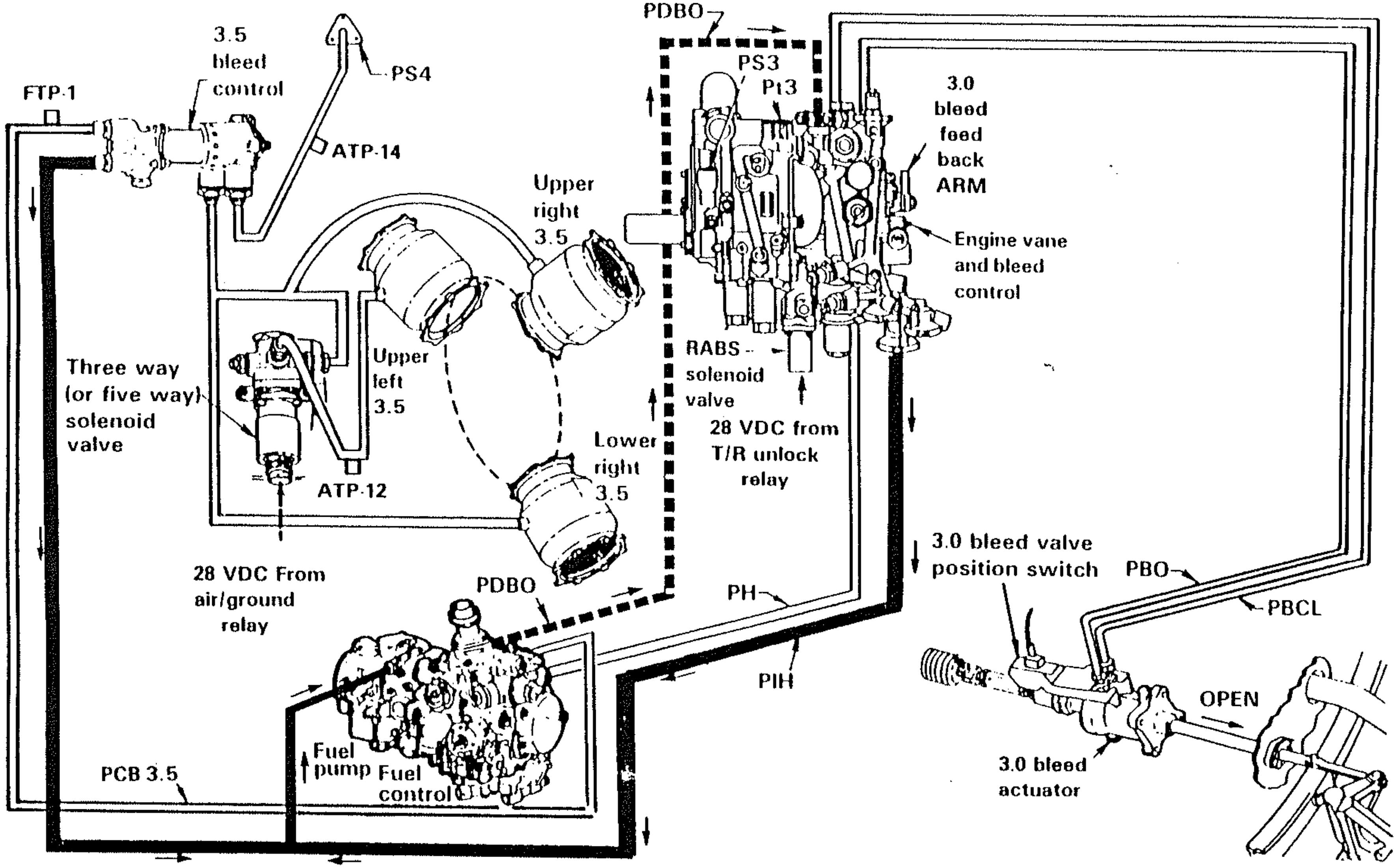
JT9D-7R4 BLEED SYSTEM

(Bleed system schematic)



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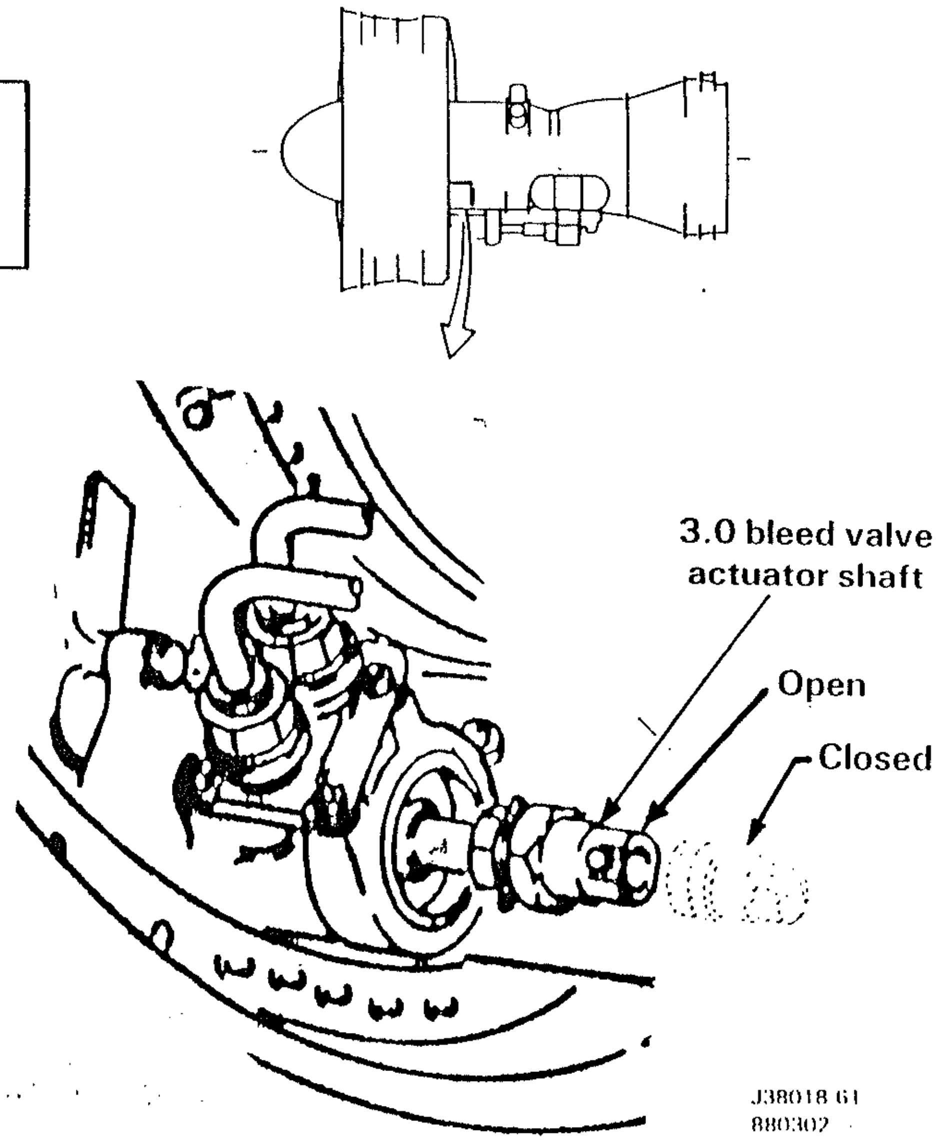
BLEED SYSTEM VISUAL CHECKS

VISUAL CHECKS

Check 3.0 bleed valve actuator shaft is in open position statically or after motoring

<u>Operational discrepancy</u>
Surge
Impending hot start



VISUAL CHECKS

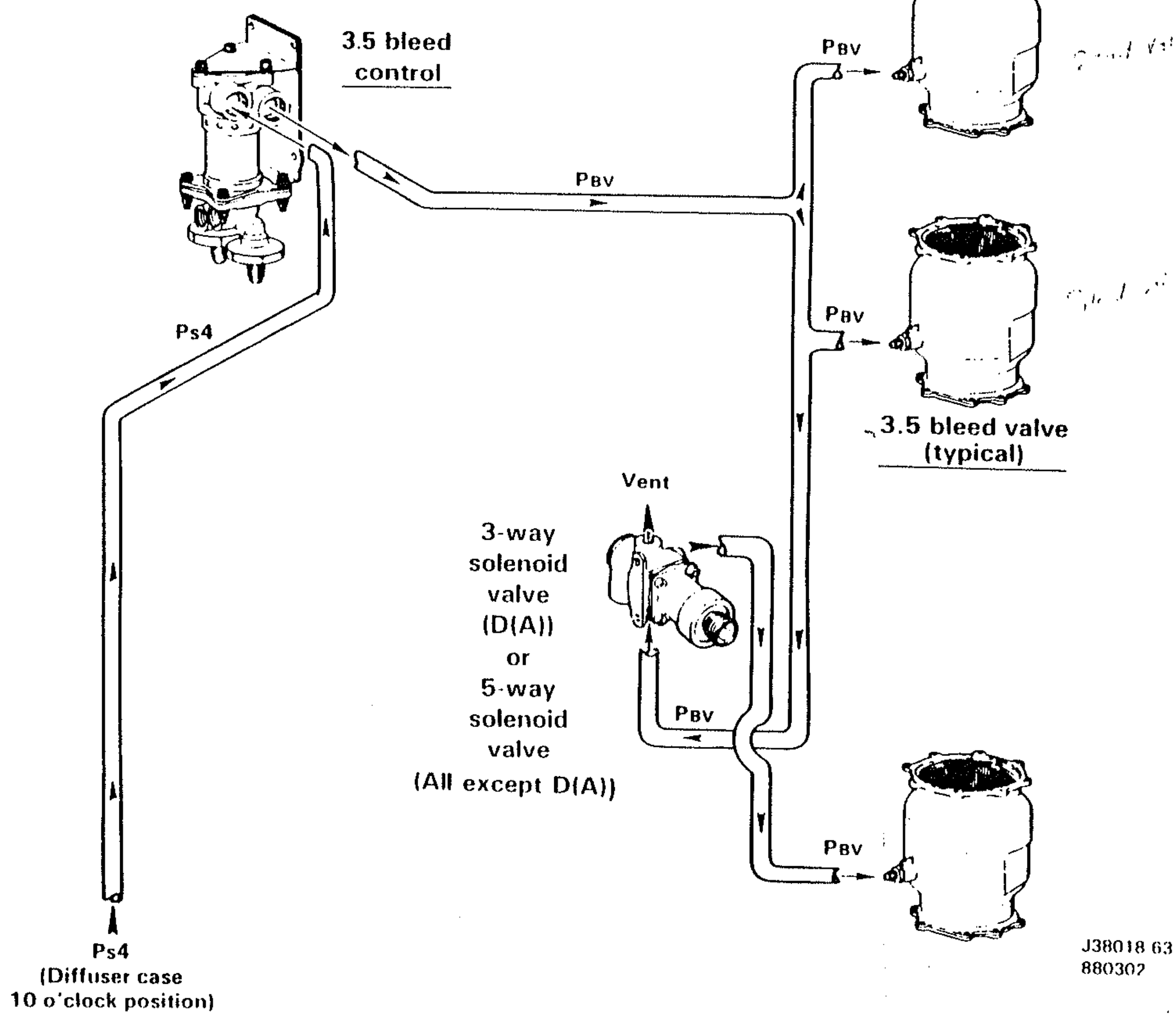
Check bleed system air lines for leakage

- Check bleed system air lines by locating the applicable component ports using the following illustrations and tracing the lines to the component upstream and/or downstream

Operational discrepancy:
- Unable to make take-off power
- High EGT
- High N2

BLEED SYSTEM

Plumbing Checks



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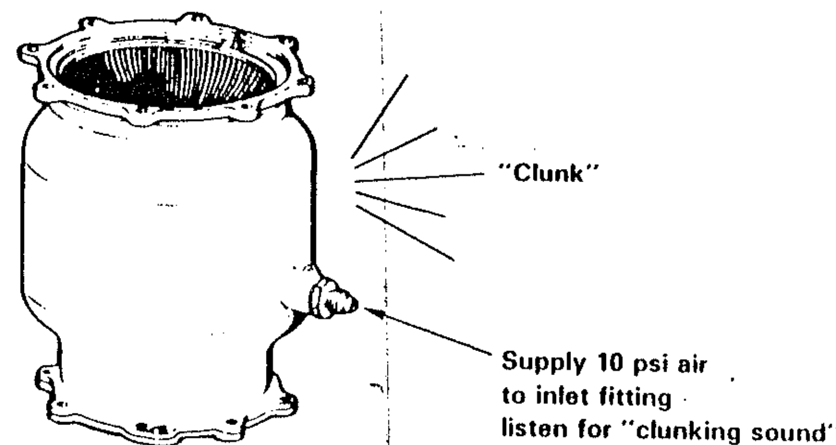
3.5 BLEED VALVE CHECK
(Engine Static)

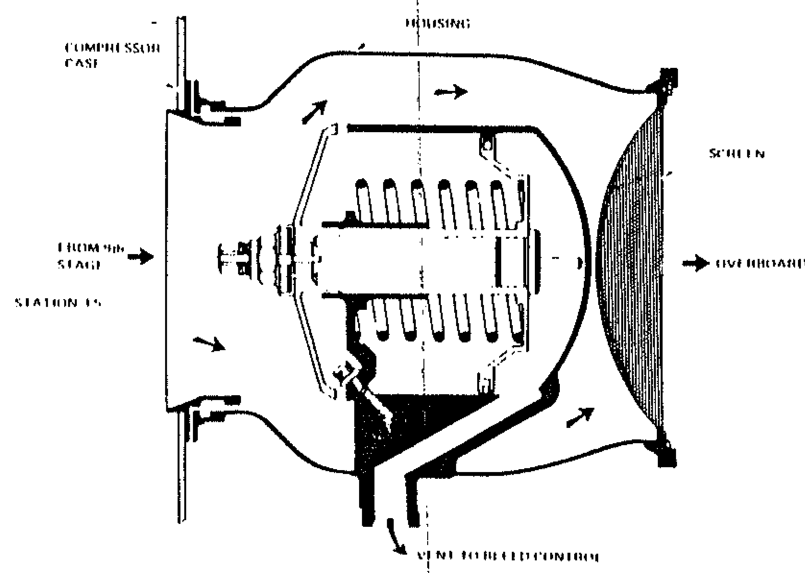
Malfunction can cause:
3.5 bleed valve to remain open, closed or partially open

Check determines:
If 3.5 bleed valve opens and closes properly

Instructions for check:
1. Supply 10 psi directly to valve
2. If valve makes a "clunking" sound it is opening and closing properly

Operational discrepancy:
- Impending hot start
- High EGT
- High N2
- Abnormal parameters
- Surge on ground





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3.0 BLEED VALVE CHECK

(Engine static)

Malfunction can cause:

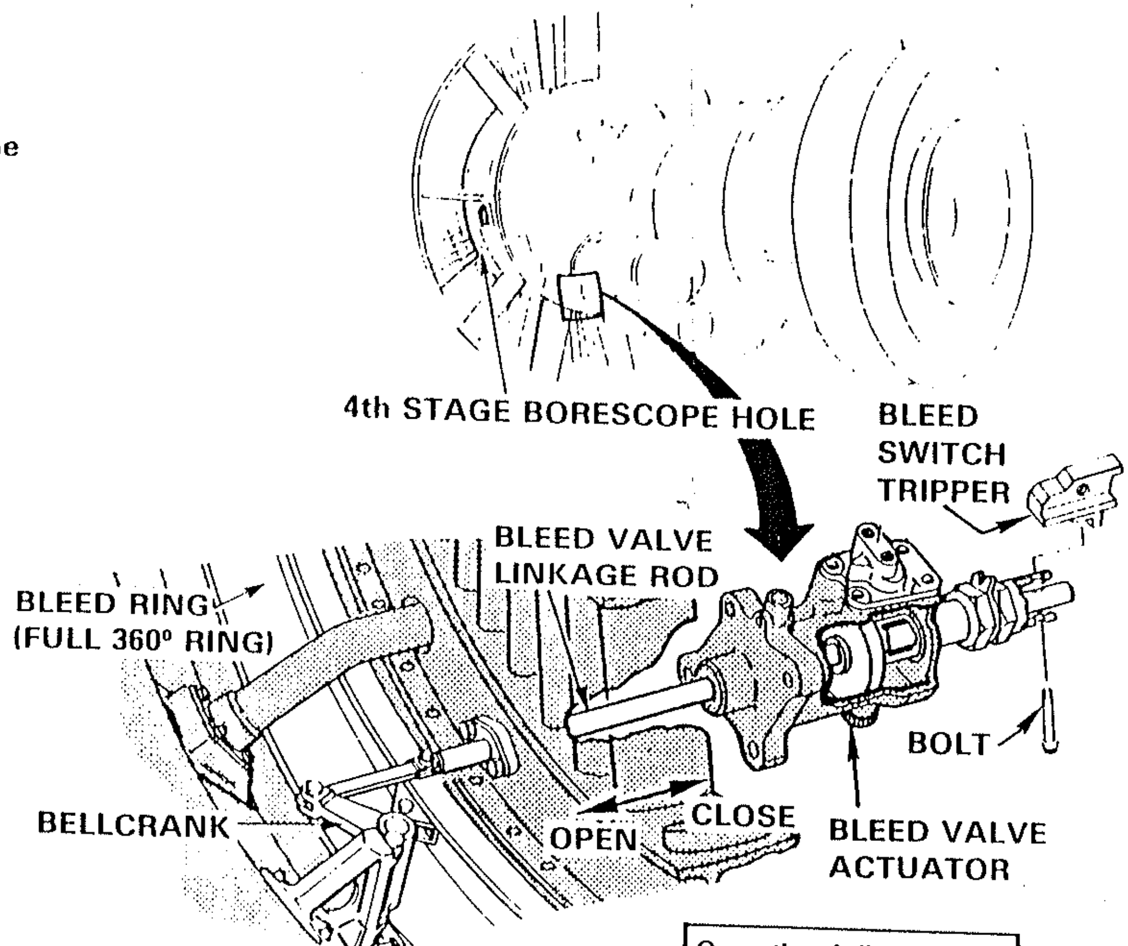
3.0 bleed valve to open and close randomly

Check determines:

If 3.0 bleed valve ring is attached to the 3.0 bleed valve actuator

Instructions for check:

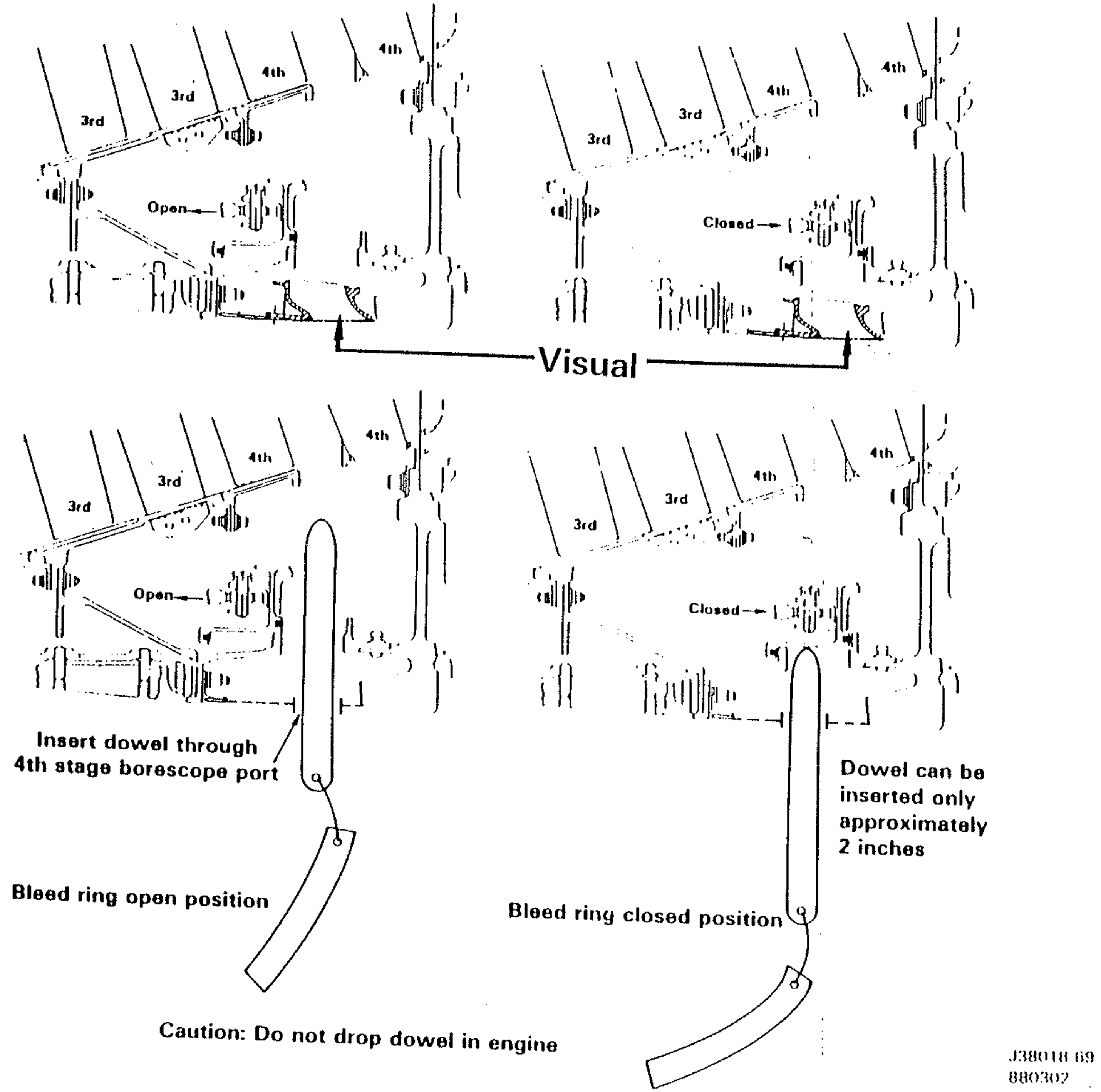
1. Ensure 3.0 bleed actuator is in full forward position. Disconnect bleed valve linkage rod from bleed valve actuator shaft by removing:
   - Bolt from linkage adjuster
   - Bleed switch tripper
2. Open and close 3.0 bleed valve ring by pulling and pushing on bleed valve linkage rod
3. Check bleed valve position relative to linkage rod position as follows:
   a) Visually through 3.0 bleed exhaust ports on engines with flow guides
   b) Insert dowel in 4th stage borescope hole on engines without flow guides



Note:

1. It is not necessary to disconnect 3.0 bleed push-pull feedback cable from 3.0 bleed rod

Operational discrepancy:
• Fluctuating parameters
• High EGT
• Surge



3rd
3rd
4th
4th
Open
Closed
Visual
Insert dowel through
4th stage borescope port
Dowel can be
inserted only
approximately
2 inches
Bleed ring open position
Bleed ring closed position
Caution: Do not drop dowel in engine
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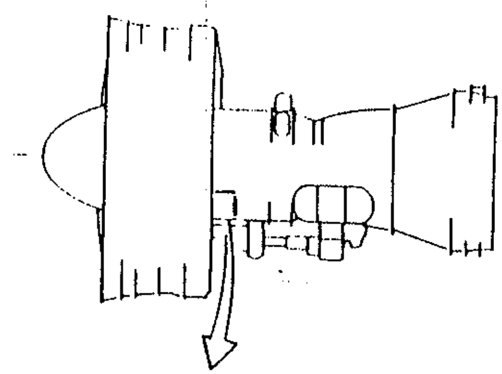
3.0 BLEED SYSTEM CHECK
(Engine Running)

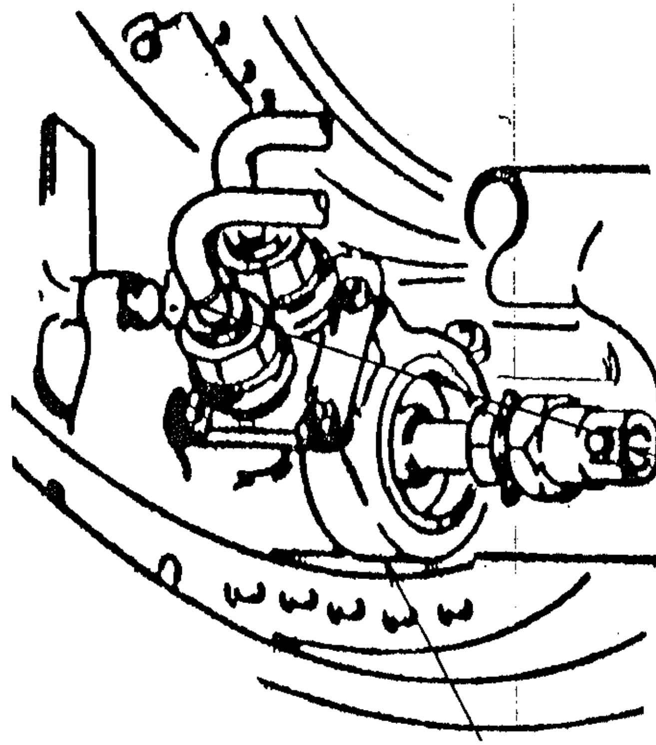
Malfunction can cause:
3.0 bleed valve to remain open.

Check determines:
If 3.0 bleed valve system up to and including 3.0 bleed valve actuator is operating (opening) properly

Instructions for check
1. Secure a very light gage wire to 3.0 bleed valve actuator shaft and to hardware forward of shaft
2. Run engine to power level sufficient to close 3.0 bleed valve
3. After shutdown observe that wire is broken indicating that actuator moved rearward. Note: physical connection between 3.0 bleed valve and actuator has not been verified

Operational discrepancy:
• Unable to make take-off power
• High EGT
• High N2
• Abnormal or sudden parameter shifts





SOLENOID VALVE CHECK
(Engine Static)

Malfunction can cause:

Tandem 3.5 bleed valve to remain open (common malfunction) or for it to close during engine starting (operates in start bleed system)

Check determines:

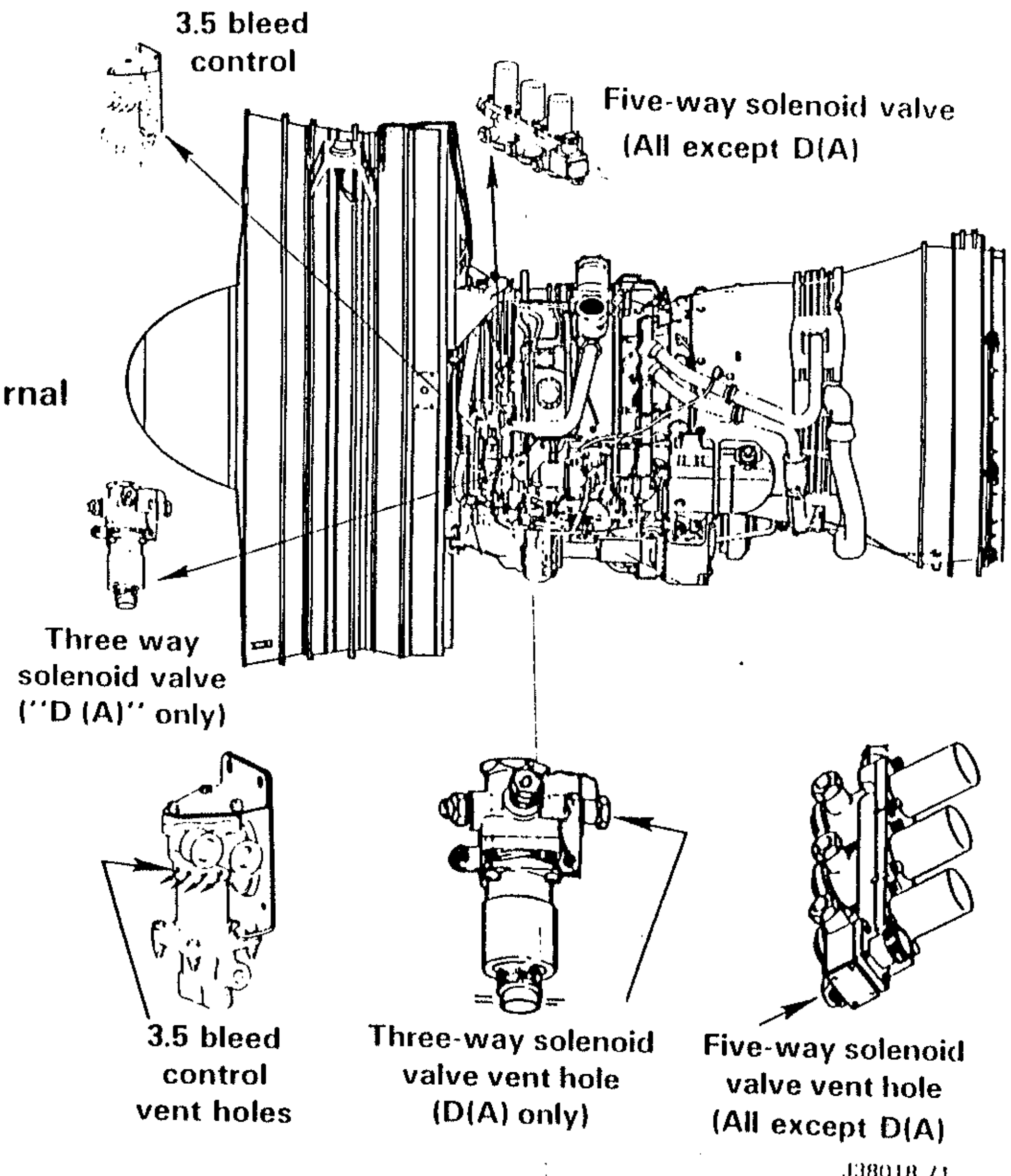
If three-way (or five-way) solenoid's internal valve is correctly positioned

Instructions for check:

1. Apply 100 PSIG air to ATP-12
2. With the solenoid valve de-energized air should vent from the 3.5 bleed control vent holes
3. Replace solenoid if evidence of air out three-way or five-way solenoid valve vent hole

Operational discrepancy:

- High EGT
- High N_2
- Abnormal parameters



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3.5 BLEED VALVE CHECK

(Engine motoring/running)

Malfunction can cause:

3.5 bleed valve(s) to remain open, closed or partially open

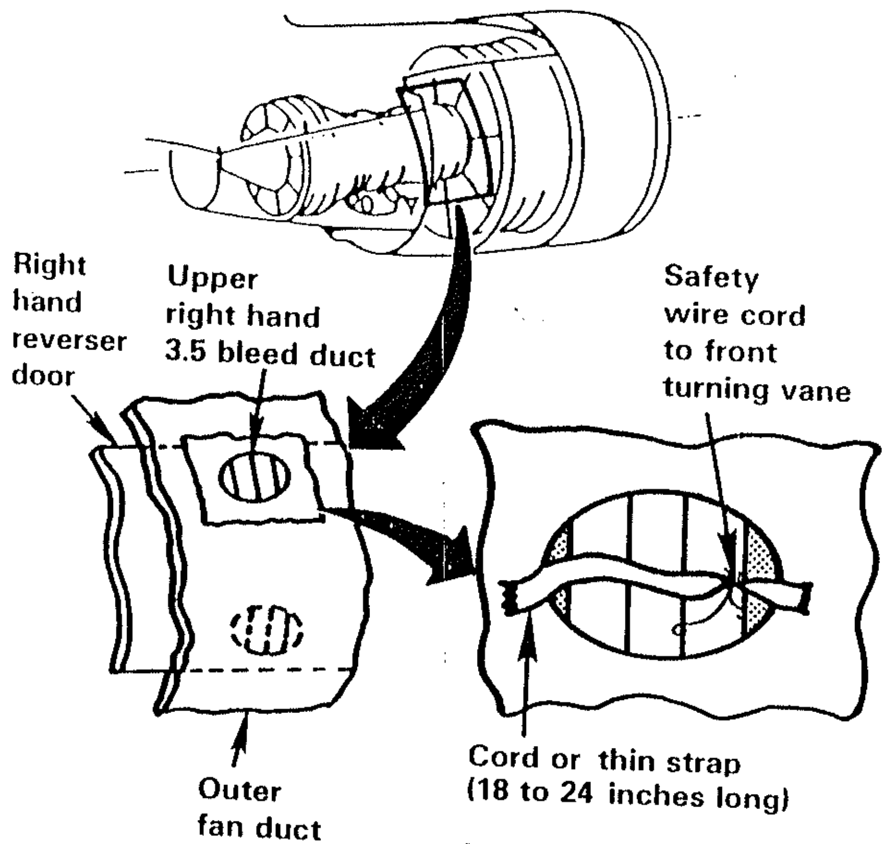
Check determines:

If 3.5 bleed valve(s) are open or closed

Instructions for check:

1. Secure an 18 to 24 inch piece of thin strap or cord to 3.5 bleed valve discharge turning vane
2. Observe strap or cord while motoring or running engine. If bleed is open, strap or cord will blow around vigorously. If bleed is closed, cord will lie along fan discharge duct

Note: Difference between cord movement with bleed open and closed, although noticeable, may be subtle. It is recommended that maintenance personnel familiarize themselves with a normally operating system prior to using this method for troubleshooting.



Operational discrepancy:

- Impending hot start
- High EGT
- High N_2
- Abnormal parameters
- Surge on ground

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TANDEM BLEED SYSTEM CHECK

(Engine Motoring)

Malfunction can cause:

Tandem bleed system to remain open or closed

Check determines:

If tandem bleed system is operating properly

Instructions for check: (See notes)

1. Connect test line assembly between FTP-1 tap and FP-12 port on fuel pump. Secure test line to prevent whipping
2. Loosen three bolts securing triangular pad of P_S4 line to diffuser case (10:00 o'clock position) so that pad can be lifted away from case enough to slip blank-off plate between pad and case. Tighten bolts to reduce false P_S4 leakage into case
3. Connect a false P_S4 supply of 50 psig to ATP-14
4. Secure an 18 to 24 inch piece of thin strap or cord to tandem (ULH) 3.5 bleed valve discharge turning vane
5. Connect a 0-10 psig air pressure source to P_T3 port, on EVBC
6. With zero air pressure on P_T3 port, motor engine to maximum motoring speed
7. Observe that strap or cord blows around vigorously indicating that tandem 3.5 bleed is open
8. Slowly increase P_T3 air pressure to 7-10 psig maximum. Observe that 3.0 bleed closes. Simultaneously, observe that tandem 3.5 bleed valve also closes by noting that strap or cord will lie along fan discharge duct

   Caution: Do not exceed 10 psig at P_T3 port or damage to EVBC will occur

Notes:

1. Ensure that fuel tank pressure of 10-20 psig is being supplied to fuel pump
2. Adequate fuel pump hydraulic stage pressure is required to perform this check. Verify that FP-12 pressure is above 570 PSIG at maximum motoring speed either prior to or during this check.

Operational discrepancy:
- Impending hot start
- High EGT
- High N2
- Abnormal parameters
- Surge

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RABS BLEED SYSTEM CHECK

(Engine running)

Malfunction can cause:

RABS bleed system to remain open or closed

Check determines:

If RABS bleed system is operating properly

Operational discrepancy:

- Impending hot start
- High EGT
- High N2
- Abnormal parameters
- Surge

Instructions for check:

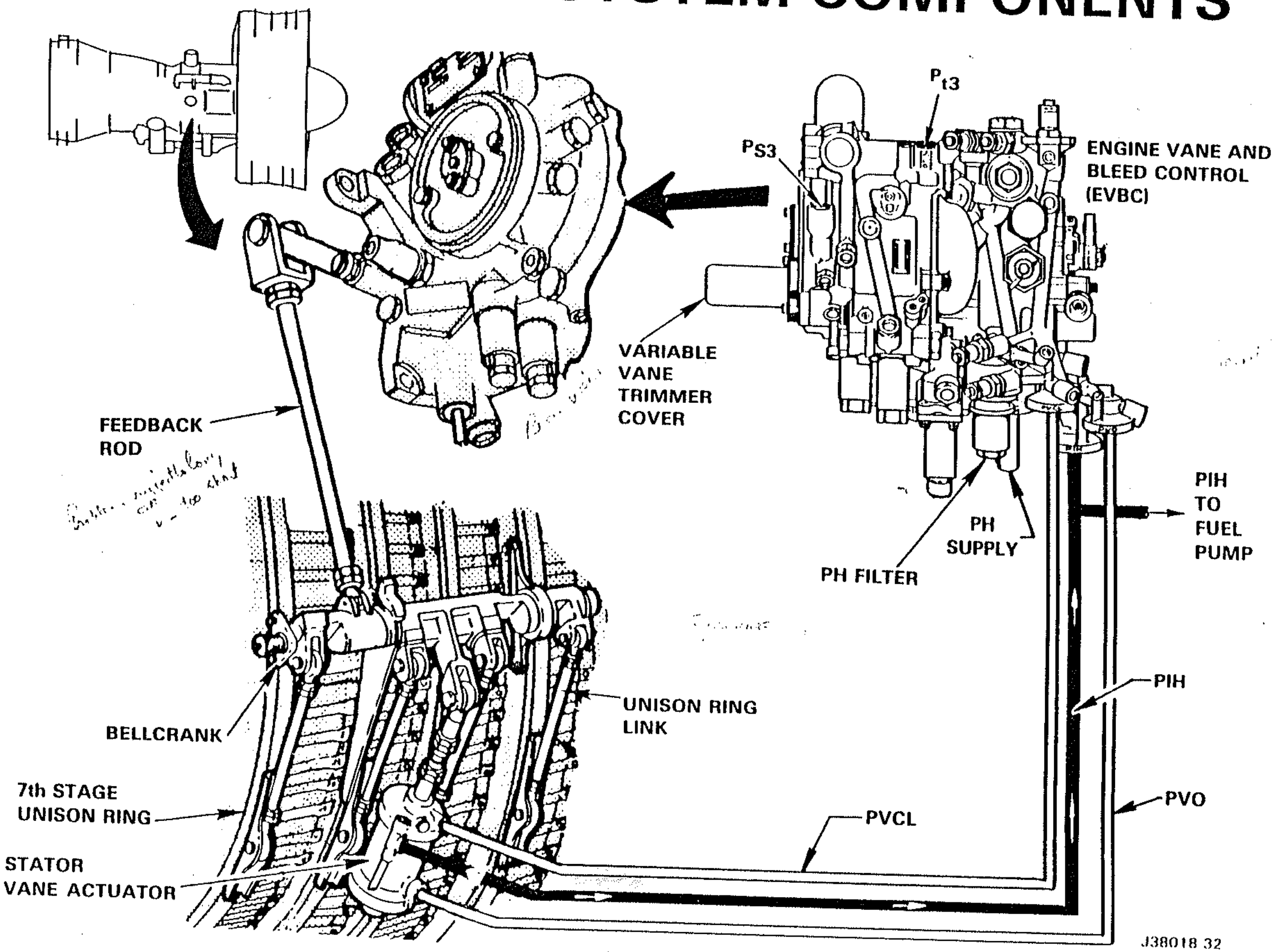
1. Start engine and advance thrust lever to 1.35 EPR
2. Mark position of thrust lever on control stand
3. Shutdown engine and install sensor deactuator between T/R unlock sensor and target on either LH or RH T/R hydraulic locking actuator. Refer to BMM 71-01-00
4. Restart engine. "AMBER REV" light must be illuminated. If not illuminated – shut down engine and troubleshoot A/C system
6. Note EPR indication after advancing thrust lever to control stand mark
   a. If EPR 0.05-0.06 EPR below – RABS operating properly
   b. If EPR 1.35 – RABS failed closed
   c. If EPR 0.02-0.03 EPR below 1.35 – either 3.0 or 3.5 bleed is failed close

VARIABLE VANE SYSTEM

Purpose:

To provide optimum engine performance throughout the engine operating envelope by varying compressor airflow. At low engine RPM, the variable vanes are positioned in the closed direction allowing minimal airflow through the compressor. At high engine RPM, the variable vanes are open allowing maximum airflow through the compressor.

VARIABLE VANE SYSTEM COMPONENTS



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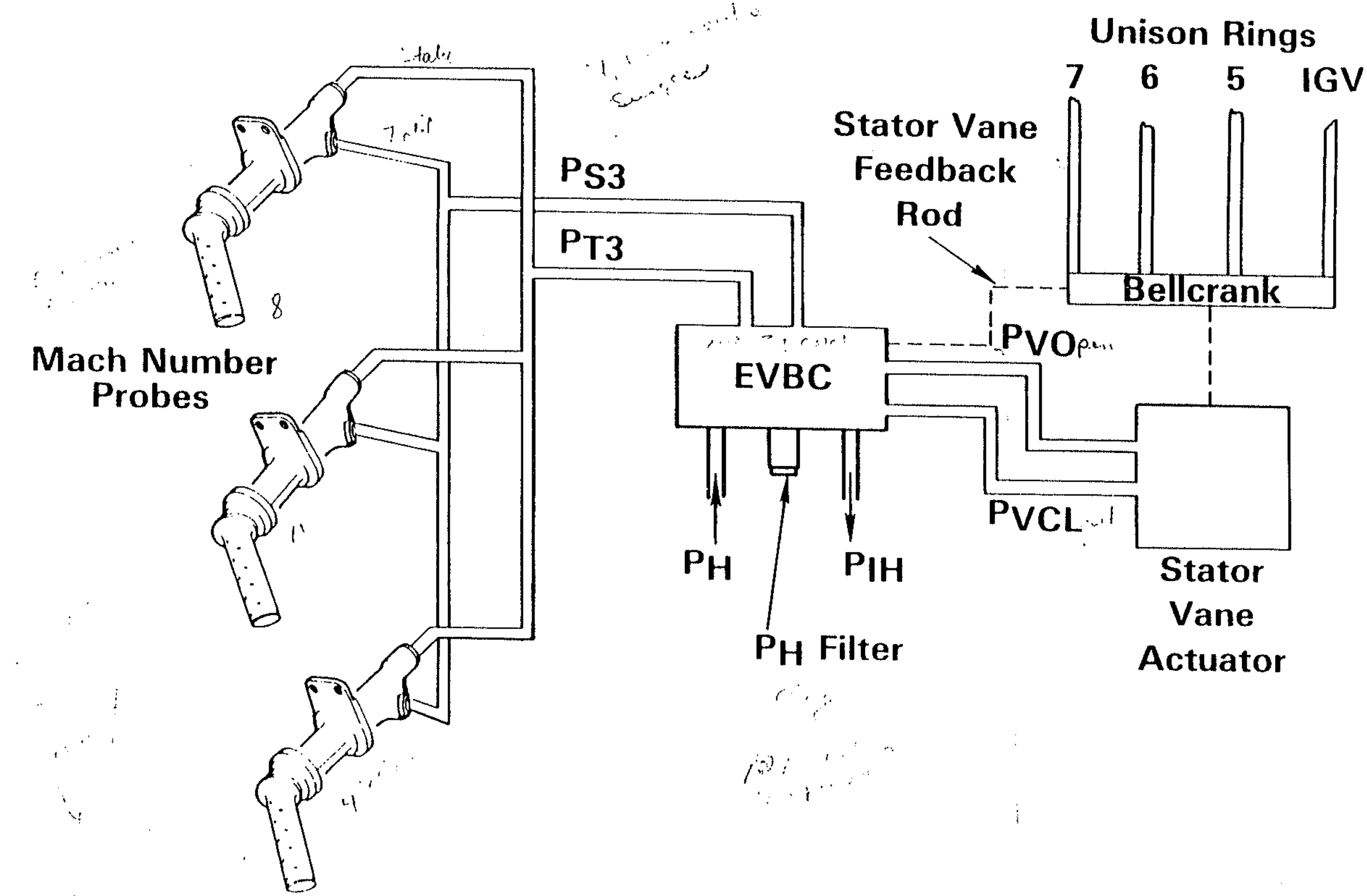
Schematic of Variable Vane System



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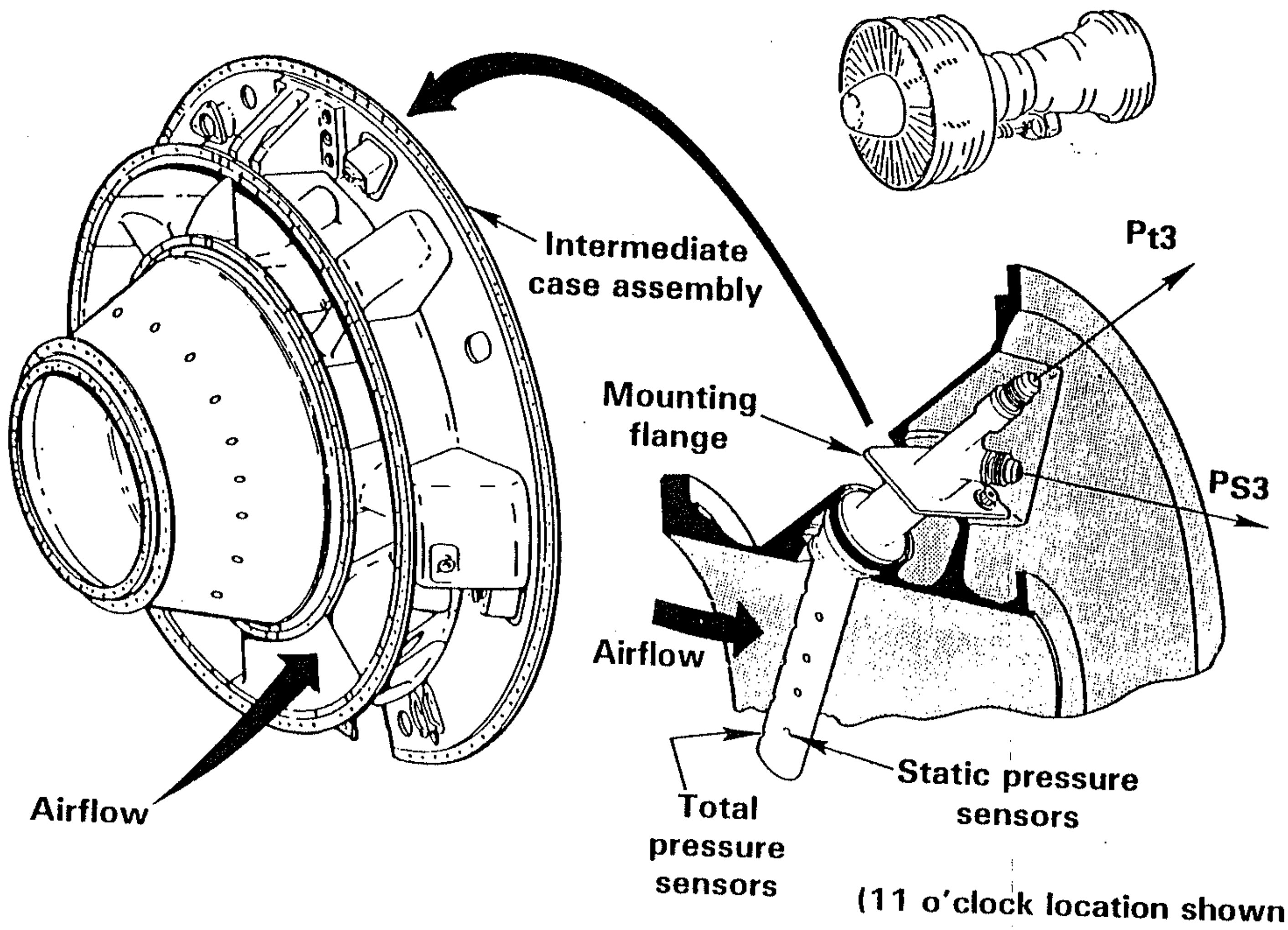
VARIABLE VANE SYSTEM MACH NUMBER PROBES



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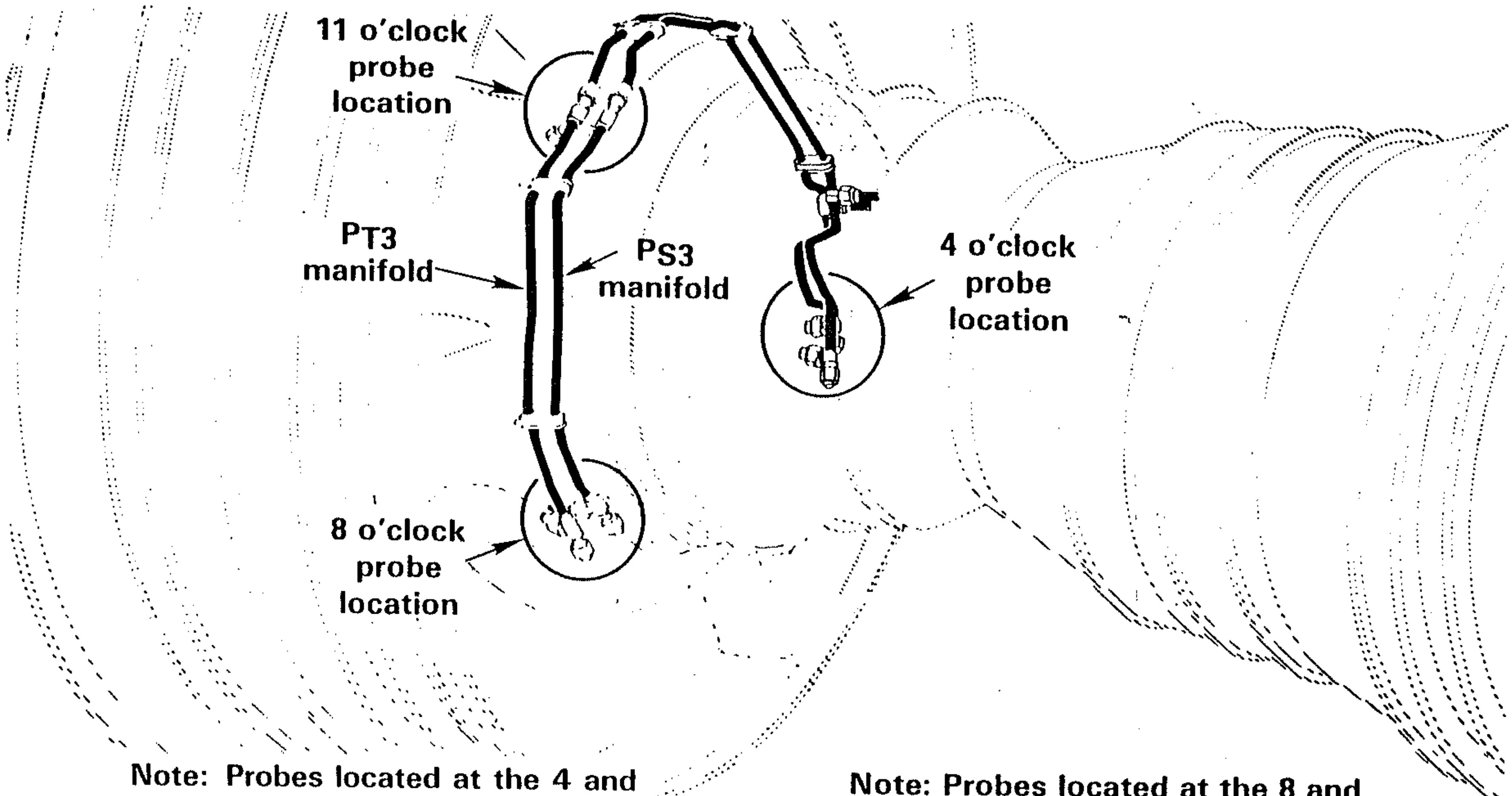
VARIABLE VANE SYSTEM PT3 AND PS3 MANIFOLDS AND MACH NUMBER PROBE LOCATIONS



Note: Probes located at the 4 and 11 o'clock locations are electrically heated for anti-ice protection. (A-300 & A-310)

Note: Probes located at the 8 and 11 o'clock locations are electrically heated for anti-ice protection. (B-767)

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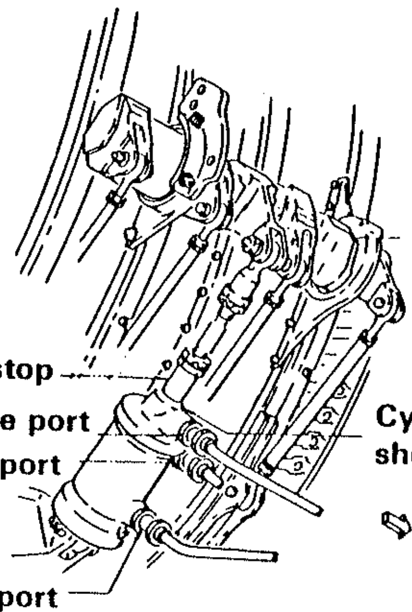
VARIABLE VANE SYSTEM

Components involved: Engine vane and bleed control (EVBC), feedback rod, bellcrank, stator vane actuator, Mach number probes and manifolds, unison rings (IGV and Stages 5,6,7), associated linkages

Normal operation: 1. With engine shut down, stator vane actuator is on the closed stop which indicates that the vanes are in the closed position which allows minimal airflow through compressor.



Note: Confirmation of vanes being on the closed stop — when cylinder stop is positioned against cylinder shoulder

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VARIABLE VANE SYSTEM (Cont'd)

Normal operation:

2. With engine starting and running, the engine vane and bleed control receives P_{t3} and P_{s3} signals from the Mach number probes. A ratio of these signals $[(P_T3-P_S3)/P_T3)]$ is used to schedule the vanes between full open and full closed. A third signal is provided to the engine vane and bleed control from the stator vane feedback rod providing information on the position of the vanes to complete the vane scheduling loop. Fuel pump hydraulic stage pressure (PH) is used as muscle and servo pressure within the engine vane and bleed control. The servo portion passes through the PH filter.

3. As the engine is started, the engine vane and bleed control sends a high pressure level vanes closed signal (PVCL) to the stator vane actuator until approximately 36% N_2 is reached. At this time, the vane closed signal is reduced and the vane open signal (PVO) is increased resulting in the vanes moving in the open direction. The vanes must start to schedule by 50% N_2 (actuator must be off the closed stop).

4. As the pressure ratio $[(P_T3-P_S3)/P_T3)]$ increases, the engine vane control regulates the level of vanes open and closed pressure signals to the stator vane actuator moving the bellcrank and the IGV and 5th through 7th stages of the high compressor in the open direction.

5. At approximately 96% N2 (at sea level conditions), the vanes are in the full open position

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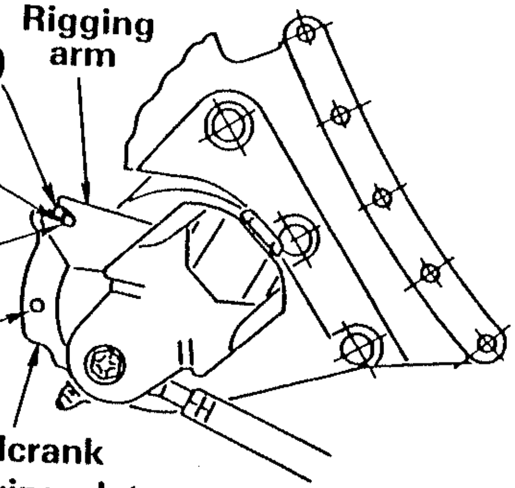
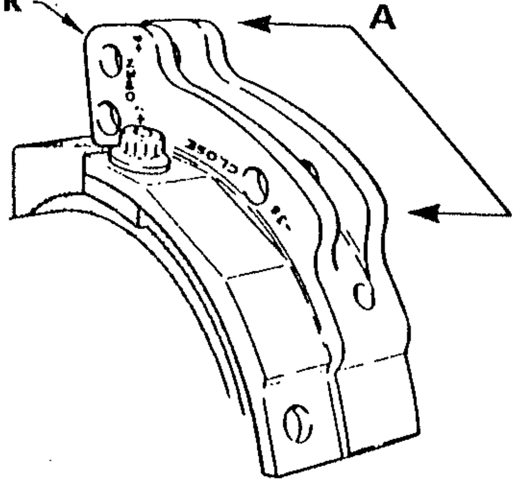
VARIABLE VANE SYSTEM BELLCRANK RIGGING PLATE

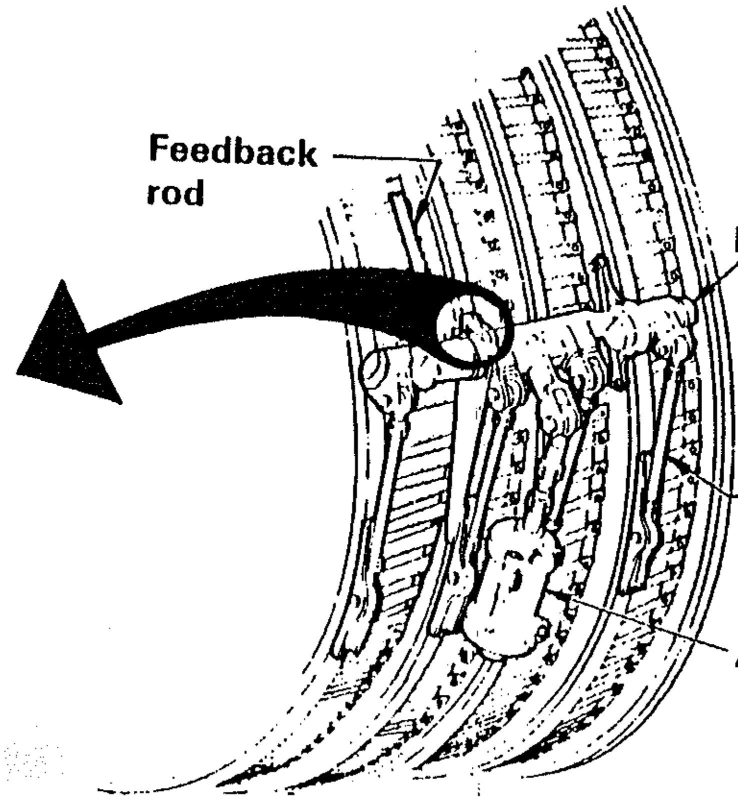


Function

+6º hole - use for feedback rod and unison ring rigging

E4	+3º open	use for stator vane actuator rigging
D + E	+7º open	
	−36º closed	





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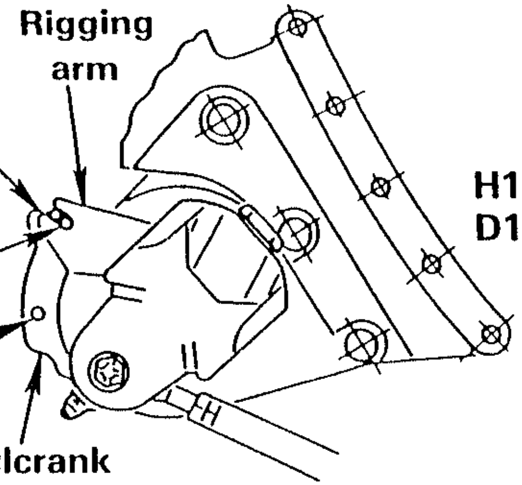
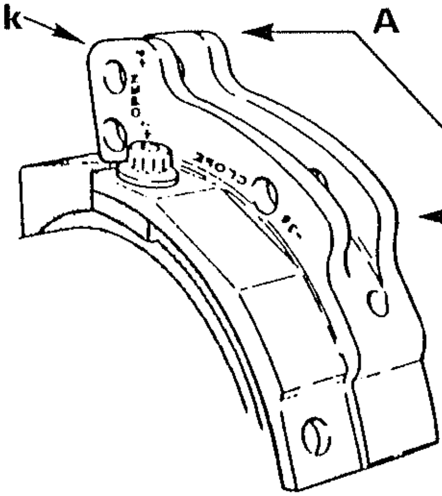
VARIABLE VANE SYSTEM BELLCRANK RIGGING PLATE

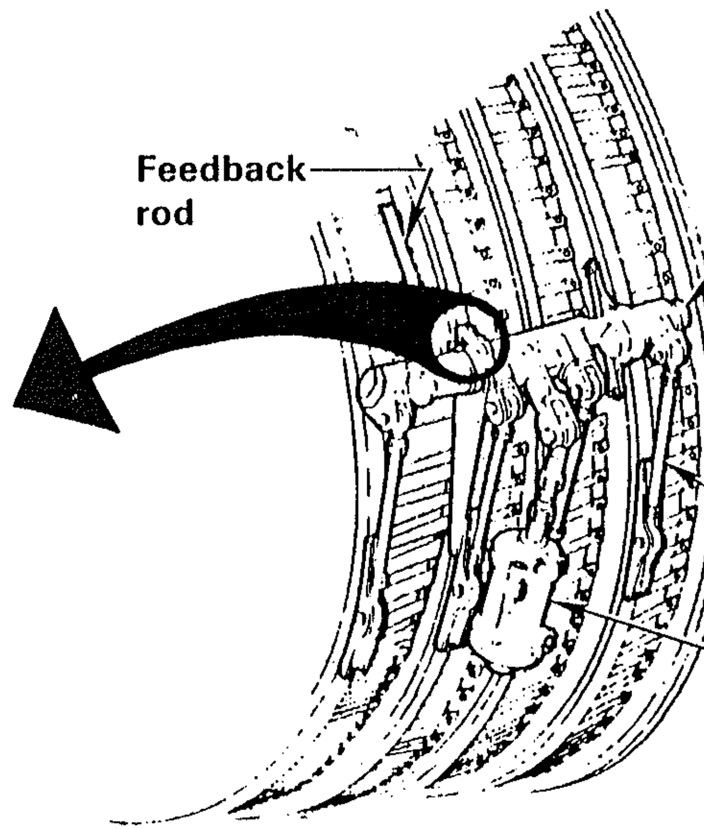


Function

+6° hole - use for feedback rod and unison ring rigging

H1 & E1(H)	+ 3° open	use for stator vane actuator rigging
D1 & E1	+ 7° open	
	−36° closed	





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VARIABLE VANE SYSTEM VISUAL CHECKS

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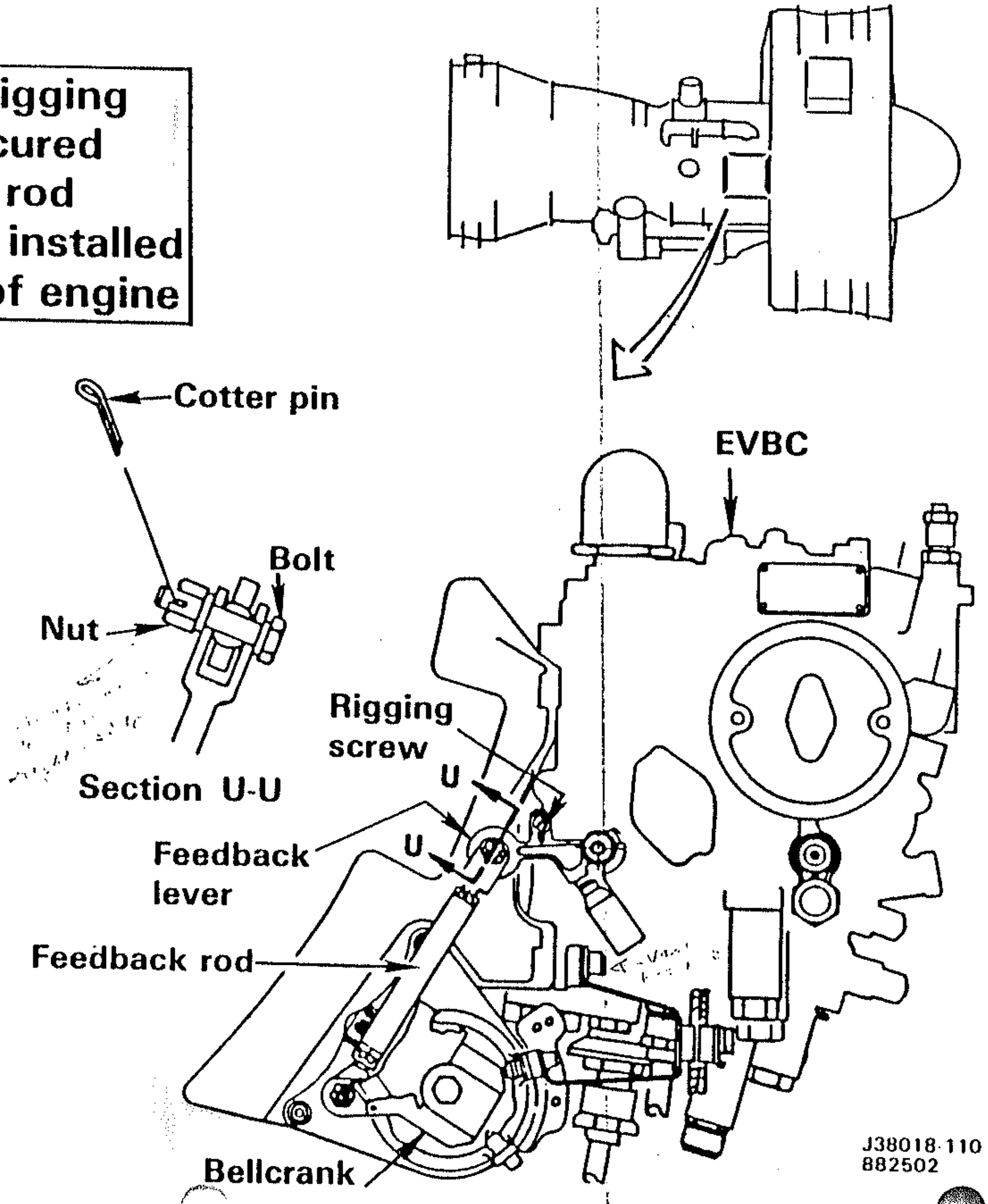
VISUAL CHECKS

- Check that feedback lever rigging screw is retracted and secured
- Check security of feedback rod
- Insure that attaching bolt is installed with head towards front of engine

Operational discrepancy

Starting
Power and response
Surge



VISUAL CHECKS

- Check EVBC P_{s3} water trap for leaks or for missing trap
- Check P_{s3} tubes and manifolds for leaks

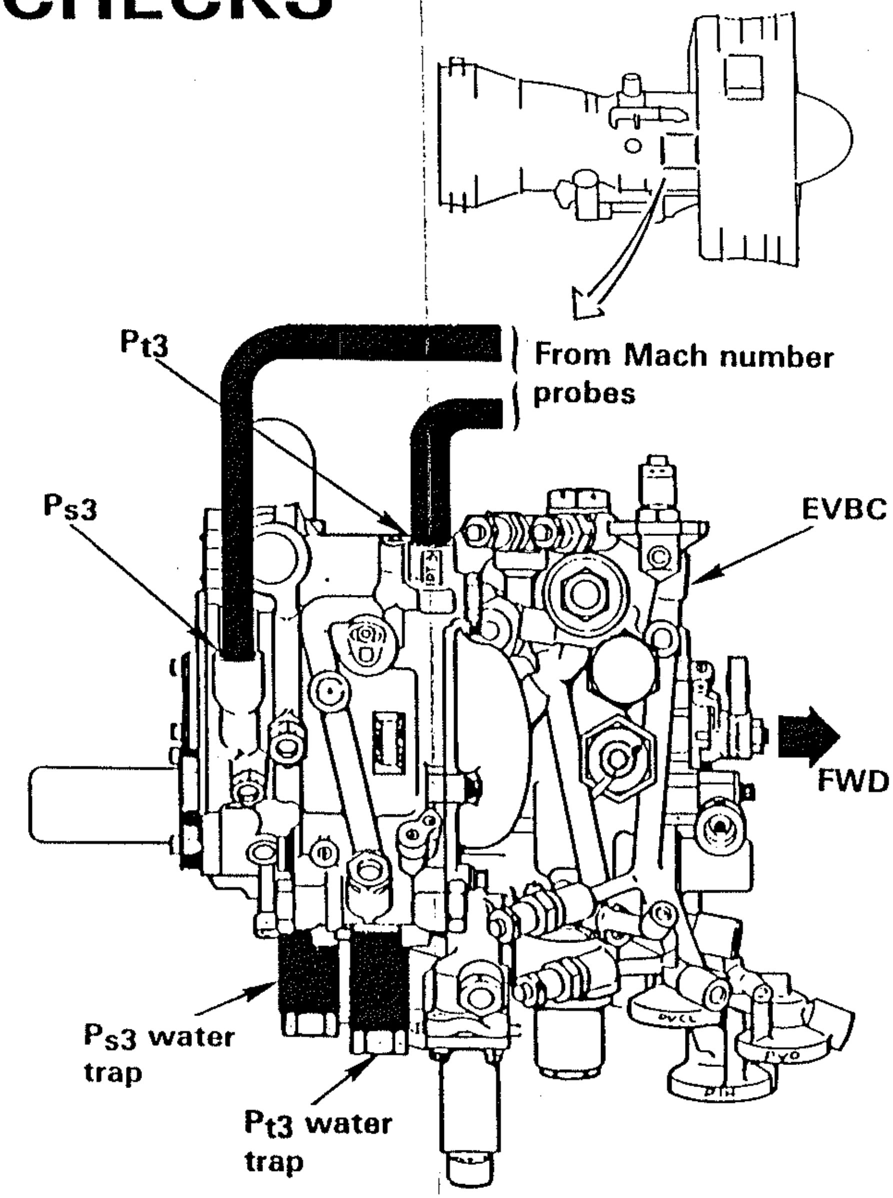
Operational discrepancy

Impending hot start
Surge

- Check EVBC P_{t3} water trap for leaks or for missing trap
- Check P_{t3} tubes and manifolds for leaks

Operational discrepancy

High oil consumption at idle
Power and response



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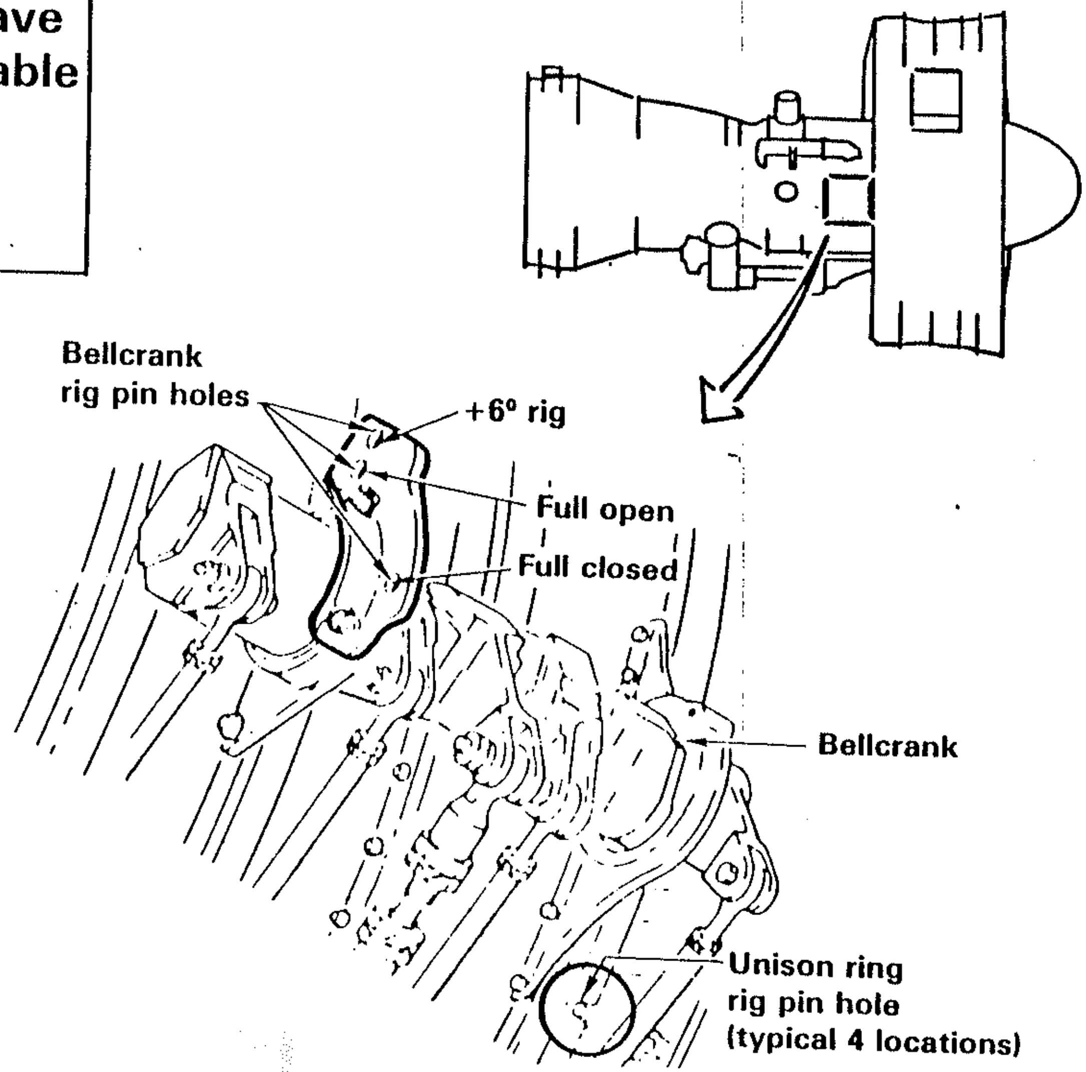
VISUAL CHECKS

Check that all rig pins have been removed from variable vane system:

- Bellcrank
- Unison rings



Operational discrepancy

Starting problems

Power and response

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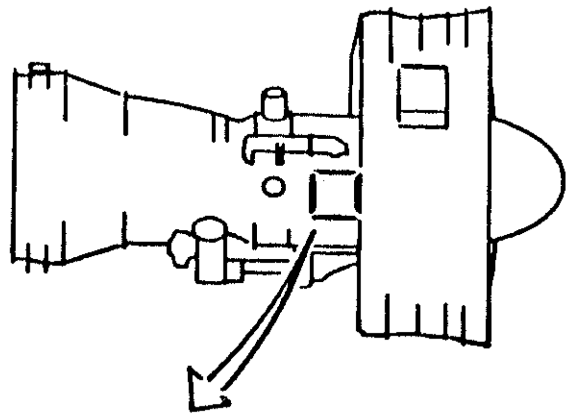
VISUAL CHECKS

Check unison ring linkages and actuator rod for security at rigging adjuster and end connections

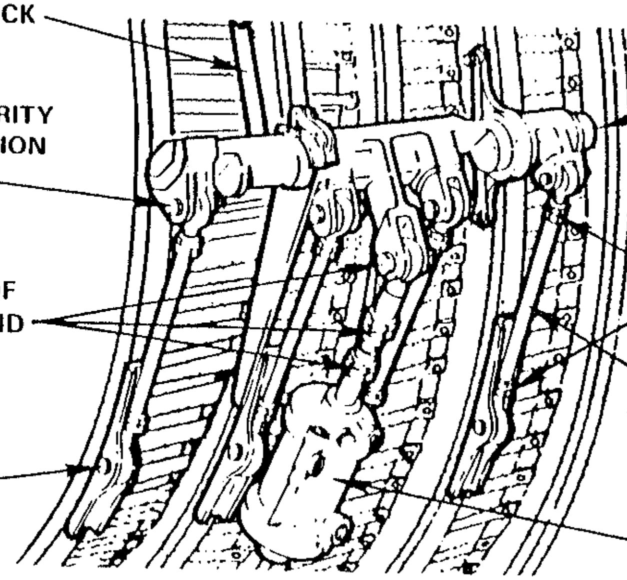


Operational discrepancy

Starting

Power and response

Surge



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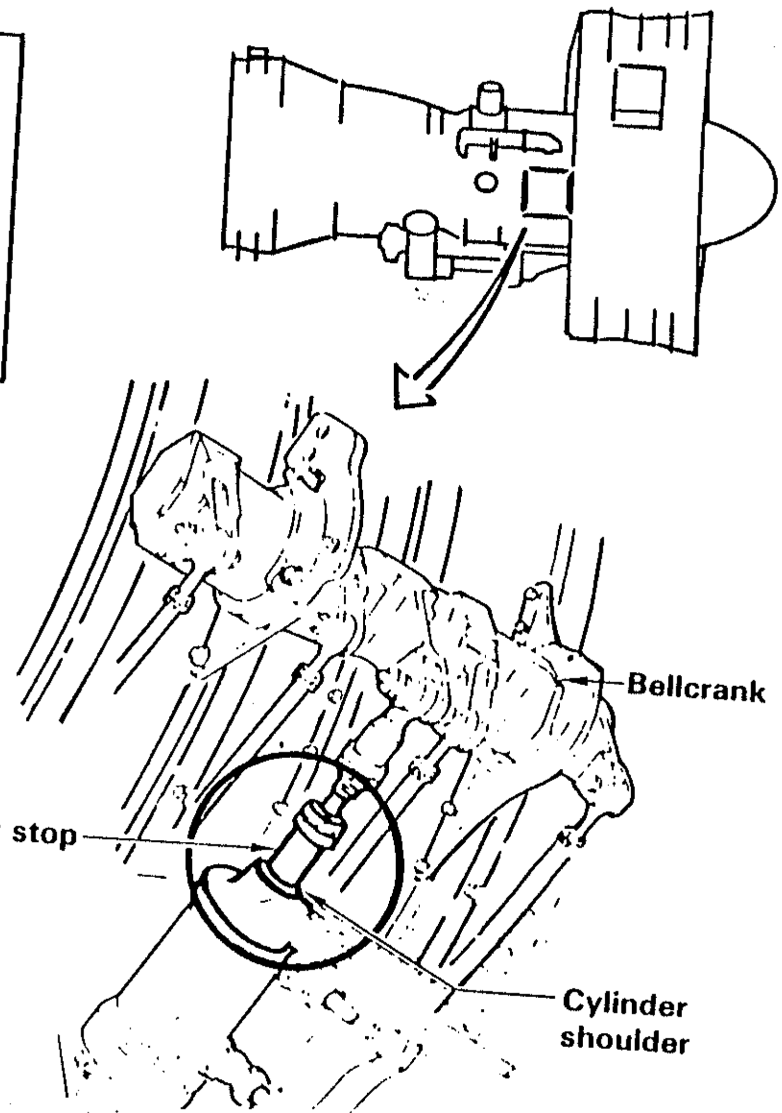
VISUAL CHECKS

Observe at vane actuator that vanes are on the closed stop:

- Statically
  - If not on closed stop, observe during motoring
- To approximately 36% N2 during start

Note: Confirmation of vanes being on the closed stop - when cylinder stop is positioned against cylinder shoulder

Operational discrepancy
Hot start
Surge



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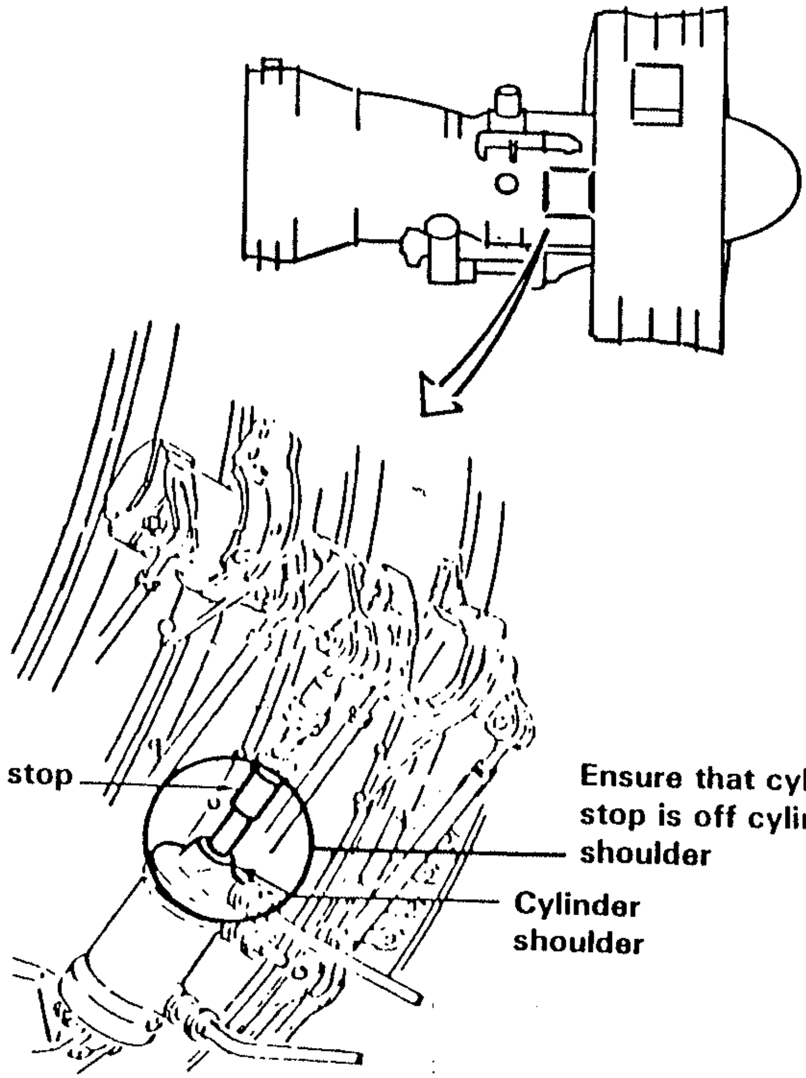
VISUAL CHECKS

Observe at vane actuator that vanes are off the closed stop at idle



Operational discrepancy
High oil consumption at low power
Fumes in cabin

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BLEED SYSTEM TROUBLESHOOTING PROCEDURES

START BLEED SYSTEM SIGNAL CHECK
(Engine running)

Malfunction can cause:

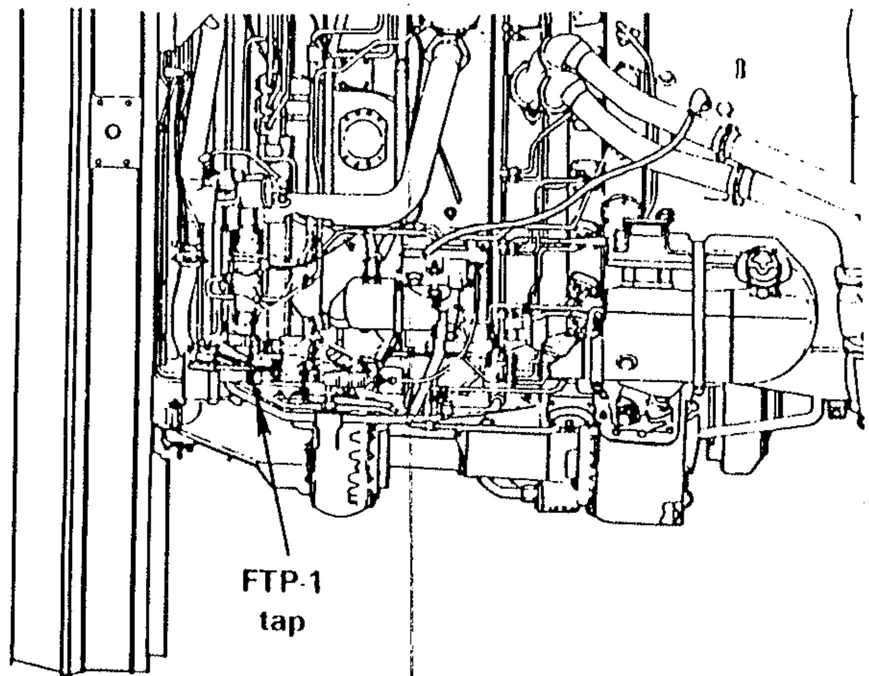
3.5 bleed valves to remain open or to close early

Check determines:

If the bleeds close signal ($P_{CB\ 3.5}$) occurs at the proper engine N2 speed and if its pressure level is correct

Instructions for check:

1. Connect a 1000 psi gage and line with a #4 female fitting to FTP-1 tap
2. Start engine and observe if pressure level increases to 600 psig or greater at approximately 50% N_2. Also observe if the 3.5 bleeds are closed at idle
3. These observations will pinpoint the fuel control or 3.5 bleed control as cause of malfunction. See maintenance manual for details.



Operational discrepancy:
• Impending hot start
• Unable to make take-off power
• High EGT
• High N2
• Abnormal parameters

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SURGE TROUBLESHOOTING

OTHER CAUSES

Accel	Decel	Reverse	Steady state
Gaspath damage	Gaspath damage	Gaspath damage	Gaspath damage
Oil system distress	Oil system distress	Oil system distress	Oil system distress
Fuel system contamination	Fuel system contamination	Fuel system contamination	Fuel system contamination
Leaking Ps3 sense line to EVBC	Leaking Ps3 sense line to EVBC	Leaking Ps3 sense line to EVBC	Leaking Ps3 sense line to EVBC
Stator vane system hardware integrity	Stator vane system hardware integrity	Stator vane system hardware integrity	Stator vane system hardware integrity
Failed fuel pump hyd. stage	Failed fuel pump hyd. stage	Failed fuel pump hyd. stage	Failed fuel pump hyd. stage
3.0 bleed system hardware integrity	3.0 bleed system hardware integrity	3.0 bleed system hardware integrity	3.0 bleed system hardware integrity
	3.0 bleed linkage wear	Fan blade tip rub	Fan blade tip rub
		RABS system	

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