

For Training Purposes Only
Maintenance Manual

CHAPTER

77

ENGINE

INDICATING

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PAGE	DATE		DATE	CODE
CHAPTER 77 TAB			77- 16- 0 (CONTINUED)	77- 18- 0
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EFFECTIVE PAGES SEE LAST PAGE OF LIST FOR NUMBER OF PAGES			77- 16- 0	2 MAY 15/75 29
		101 NOV 15/61 2		3 DEC 15/63 28
		102 BLANK		4 MAY 15/75 29
CONTENTS 77				5 MAY 15/75 30
				6 BLANK
1	MAY 15/75	63	77- 16- 0	77- 18- 0
2	JAN 15/68	2	201 FEB 15/74 2	101 MAY 15/75 29
			202 FEB 15/74 9	102 MAY 15/75 63
			203 JUN 15/63 9	
			204 FEB 15/74 9	77- 18- 0
			205 FEB 15/74 5	201 MAY 15/75 63
			206 FEB 15/74 5	202 MAY 15/75 63
77- 15- 0			77- 16- 1	77- 18- 0
1	MAY 15/75	63	201 MAY 15/75 63	501 MAY 15/75 29
2	AUG 20/77	SV	202 FEB 15/65 2	502 OCT 15/65 3
3	MAY 15/75	63	77- 16- 11	77- 18- 1
4	MAY 15/75	63	201 AUG 15/66 2	201 DEC 15/63 28
5	MAY 15/75	63	202 JUN 15/65 11	202 BLANK
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77- 15- 0			201 MAY 15/75 63	
101	MAR 15/63	2	202 JUN 15/64 9	
102	BLANK		203 JUN 15/63 9	
77- 15- 0			204 JUN 15/64 9	
201	AUG 20/76	63	205 JAN 15/70 9	
202	JAN 15/63	2	206 JUN 15/64 9	
* 203	NOV 05/86	2	207 JUN 15/64 9	
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204B	INT BLANK		201 MAY 15/75 63	
205	AUG 20/76	2	202 MAY 15/75 63	
206	AUG 20/76	2	203 MAY 15/75 63	
77- 15- 1			204 MAY 15/75 63	
201	MAY 15/75	63	77- 16- 31	
202	MAY 15/75	63	401 JAN 15/68 2	
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77- 15- 11			1 MAY 15/75 29	
201	NOV 15/61	2	2 MAY 15/75 29	
202	JUN 15/65	11	3 MAY 15/75 63	
77- 15- 21			4 MAY 15/75 29	
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403	JAN 15/72	3	202 BLANK	
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77- 16- 0			201 MAY 15/75 63	
1	NOV 15/61	2	202 NOV 15/62 2	
2	MAY 15/75	63		
3	JUL 15/62	3		
4	MAY 15/63	2		
5	MAY 15/63	3		

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63
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CHAPTER 77 EFFECTIVE PAGES
PAGE 1
LAST PAGE

For Training Purposes Only Maintenance Manual

CHAPTER 77

ENGINE INDICATING

TABLE OF CONTENTS

<u>Subject</u>	<u>Subject No.</u>
<u>ENGINE PRESSURE RATIO INDICATING SYSTEM</u>	77-15-0
Description and Operation	
Exhaust Pressure Sensing Probes	
Inlet Pressure Sensing Probe	
Exhaust Pressure Sensing Manifold	
Engine Pressure Ratio Transmitter	
Engine Pressure Ratio Indicator	
Trouble Shooting	
Adjustment/Test	
Engine Pressure Ratio Transmitter	77-15-1
Removal/Installation	
Exhaust Pressure Sensing Probes and Manifold*[1]	77-15-11
Removal/Installation	*[2] 77-15-21
Inlet Pressure (Pt2) Sensing Probe	77-15-22
Removal/Installation	
<u>EXHAUST GAS TEMPERATURE INDICATING SYSTEM</u>	77-16-0
Description and Operation	
Exhaust Gas Temperature Thermocouples	
Exhaust Gas Temperature Thermocouple Resistor	
Exhaust Gas Temperature Indicator	
Exhaust Gas Temperature Thermocouple Harness and Lead	
Trouble Shooting	
Adjustment/Test	
Exhaust Gas Temperature Thermocouple Resistor	77-16-1
Adjustment/Test	
Exhaust Gas Temperature Thermocouples	77-16-11
Removal/Installation	
Adjustment/Test	
Exhaust Gas Temperature Thermocouple Harness and Lead*[1]	77-16-21
Removal/Installation	*[2] 77-16-22
Adjustment/Test	
Exhaust Gas Temperature Indicator	77-16-31
Removal/Installation	

*[1] ALL EXCEPT HZ-ACA and HZ-ACB

*[2] HZ-ACA and HZ-ACB

For Training Purposes Only
Maintenance Manual

<u>Subject</u>	<u>Subject No.</u>
<u>ENGINE TACHOMETER SYSTEM.</u>	77-17-0
Description and Operation	
Engine Tachometer Generator	
Engine Tachometer Indicator	
Trouble Shooting	
Adjustment/Test	
Engine Tachometer Generator	77-17-1
Removal/Installation	
<u>ENGINE VIBRATION INDICATING SYSTEM.</u>	77-18-0
Description and Operation	
Engine Vibration Pickup	
Engine Vibration Amplifier	
Engine Vibration Indicator	
Trouble Shooting	
Adjustment/Test	
Engine Vibration Pickup	77-18-1
Removal/Installation	

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Maintenance Manual

ENGINE PRESSURE RATIO INDICATING SYSTEM - DESCRIPTION AND OPERATION

1. General

- A. The pressure ratio indicating system provides engine pressure ratio (Pt7/Pt2) readings in the control cabin. This information aids the pilot when selecting engine thrust.
- B. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, the system for each engine consists of six exhaust pressure (Pt7) sensing probes around the periphery of the engine exhaust housing, one inlet pressure (Pt2) probe on the right-hand side of the nacelle strut, a pressure ratio transmitter mounting in the nacelle strut and an indicator on the engine instrument panel (Fig. 1).

On airplanes HZ-ACA and HZ-ACB, the system for each engine consists of six exhaust pressure (Pt7) sensing probes around the periphery of the engine exhaust housing, one inlet pressure (Pt2) probe in the engine nose dome, a pressure ratio transmitter mounted in the nacelle strut and an indicator on the engine instrument panel (Fig. 1).

2. Exhaust Pressure Sensing Probes

- A. Engine exhaust pressure (Pt7) is detected by six probes extending into the engine exhaust chamber. These probes are connected to a common manifold.

3. Inlet Pressure Sensing Probe

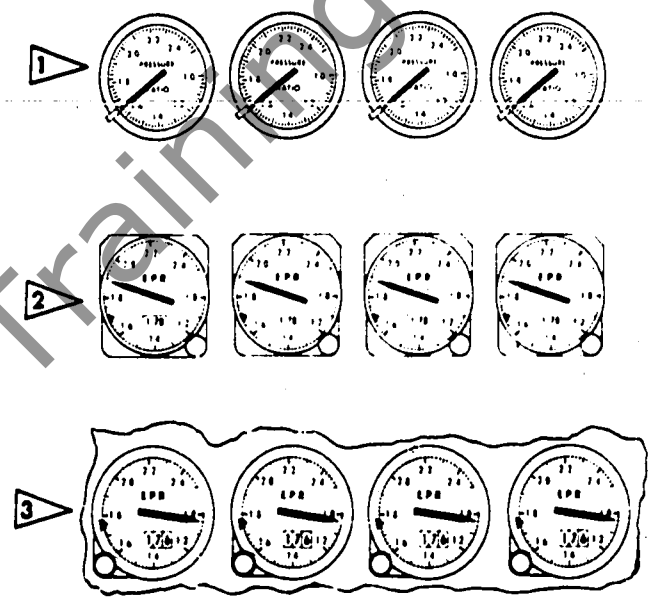
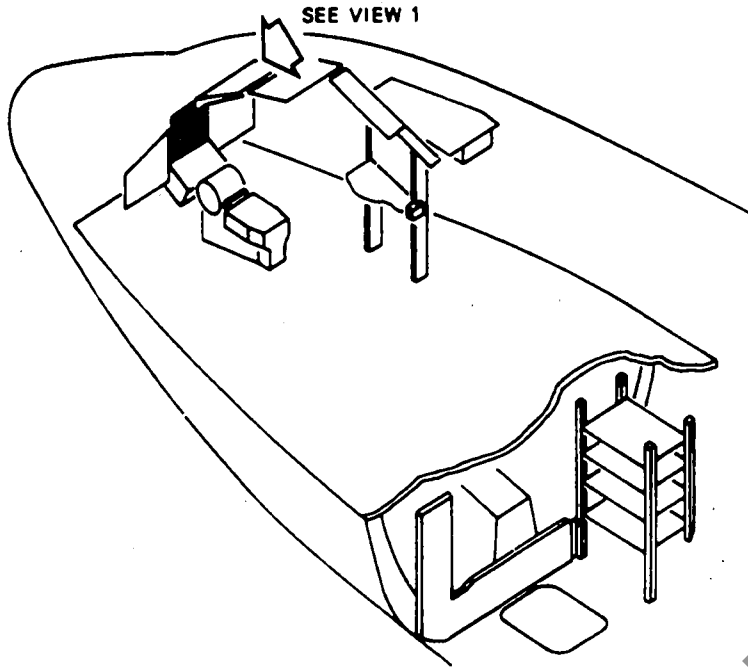
- A. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, engine inlet (Pt2) is sensed by a probe similar to a pitot tube. This probe is mounted on the right-hand side of the nacelle strut so that the open end of the tube faces the air stream. The probe is heated by nose cowl anti-icing air when the engine anti-icing system is in operation.

On airplanes HZ-ACA and HZ-ACB, engine inlet (Pt2) is sensed by a probe similar to a pitot tube. This probe is mounted through the center of the nose dome so that the open end of the tube faces the air stream. The probe is heated by nose dome anti-icing air when the engine anti-icing system is in operation.

4. Exhaust Pressure Sensing Manifold

- A. The exhaust pressure sensing manifold is made up of two segments of tubing mounted around the periphery of the exhaust casing. Three exhaust pressure sensing probes are connected to each manifold section. The manifold assembly averages the pressures sensed by the probes.

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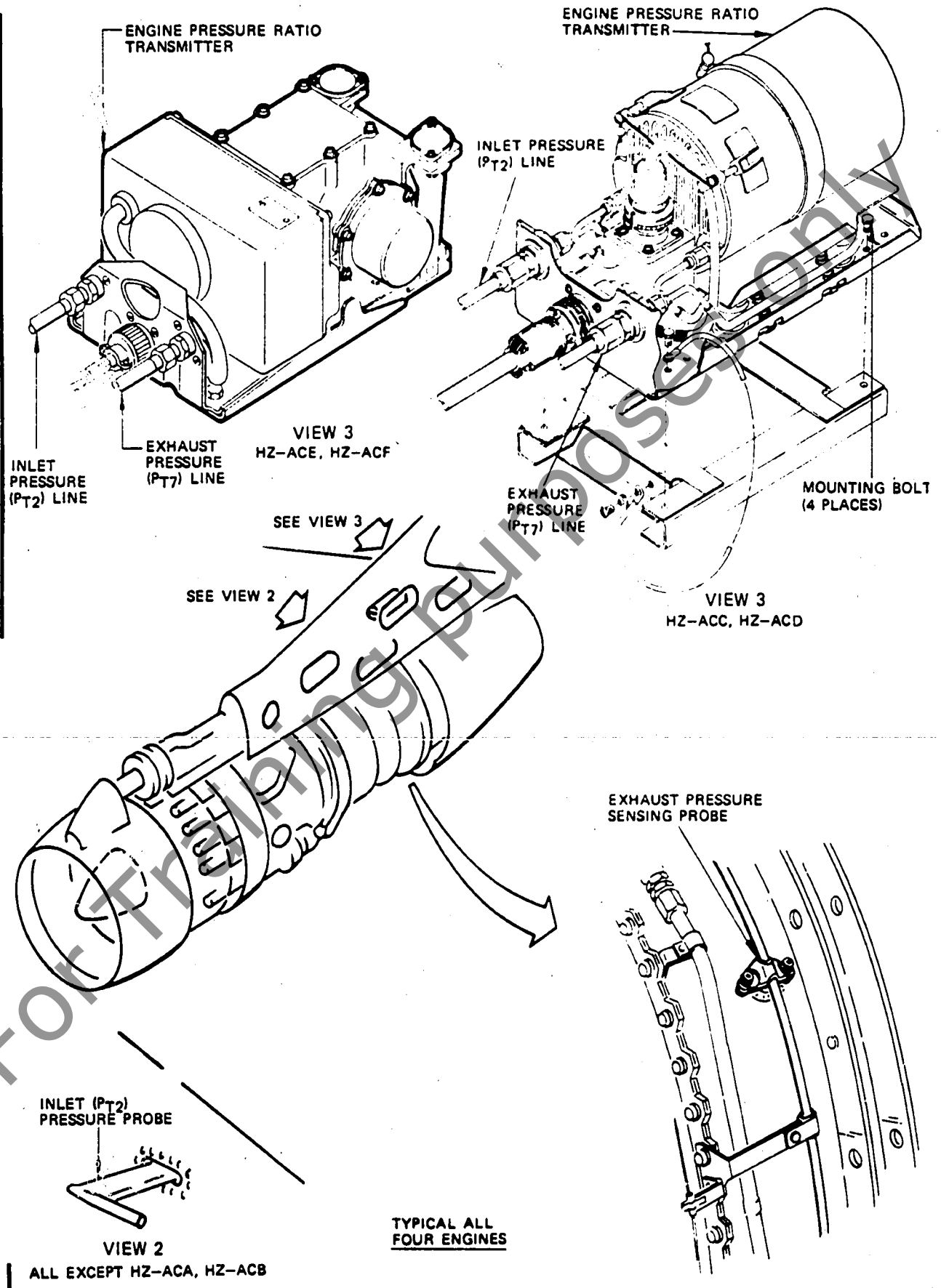
- 1 ▽ HZ-ACA, HZ-ACB
- 2 ▽ HZ-ACC, HZ-ACD
- 3 ▽ HZ-ACE, HZ-ACF

Engine Pressure Ratio Indicating System Component Location
Figure 1 (Sheet 1)

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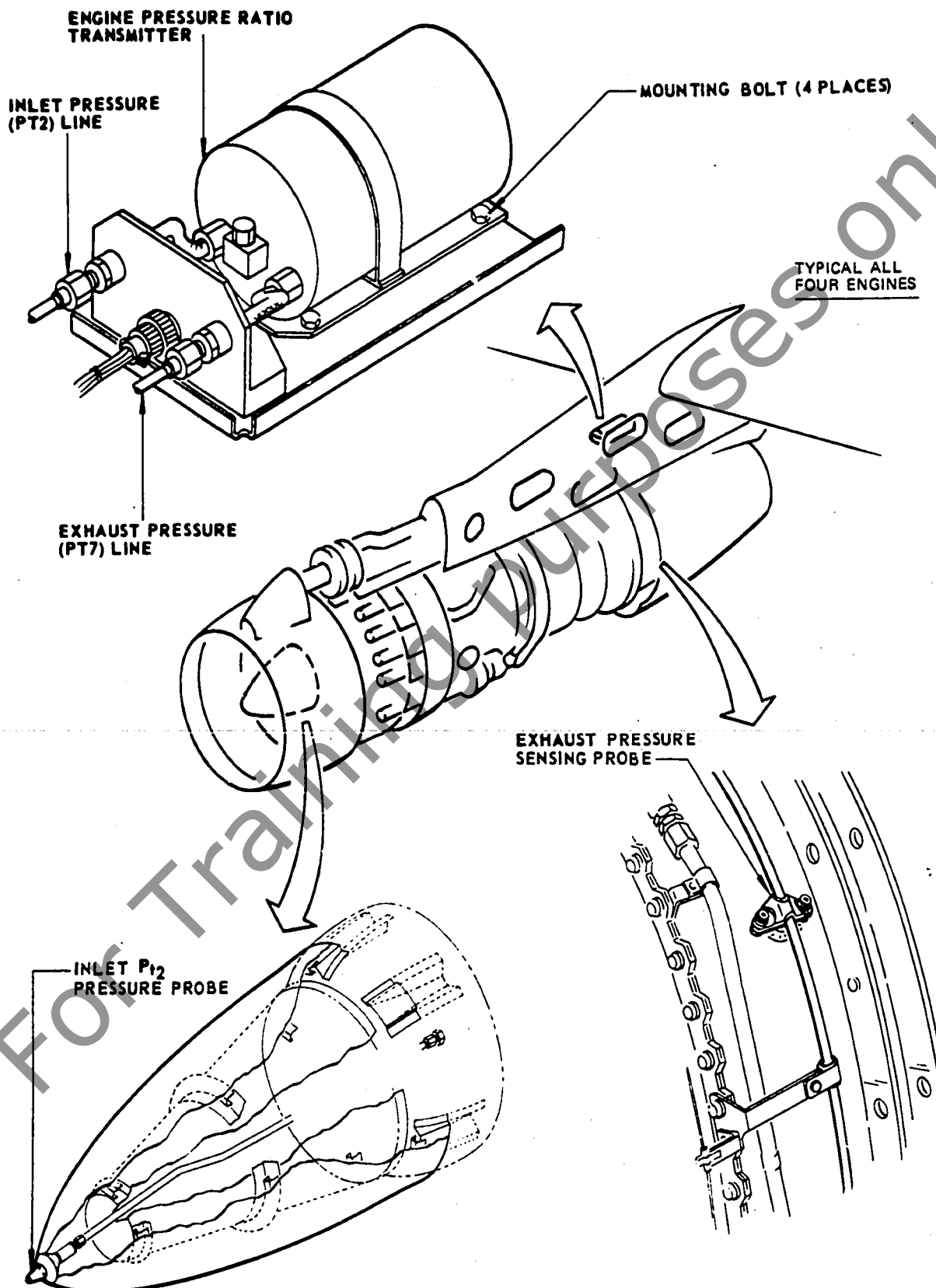
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Engine Pressure Ratio Indicating System Component Location
Figure 1 (Sheet 3)

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Maintenance Manual

5. Engine Pressure Ratio Transmitter

- A. The engine pressure ratio transmitter converts the exhaust pressure (Pt7) and the inlet pressure (Pt2) into a ratio, and generates three-phase electrical signals corresponding to pressure changes in the engine. It consists of two bellows (multicell diaphragms), a sensing mechanism, an amplifier, a motor-gear train, and a synchronous generator. The engine pressure ratio transmitter is mounted in the center section of the nacelle strut.
- B. The engine exhaust and inlet pressures are applied to the bellows assembly of the transmitter. A change in either of these pressures cause differential bellows movement. The bellows movement effects the sensing mechanism which, with the aid of the amplifier and the motor-gear train, causes the generator rotor to rotate and generate three-phase electrical signals.

6. Engine Pressure Ratio Indicator

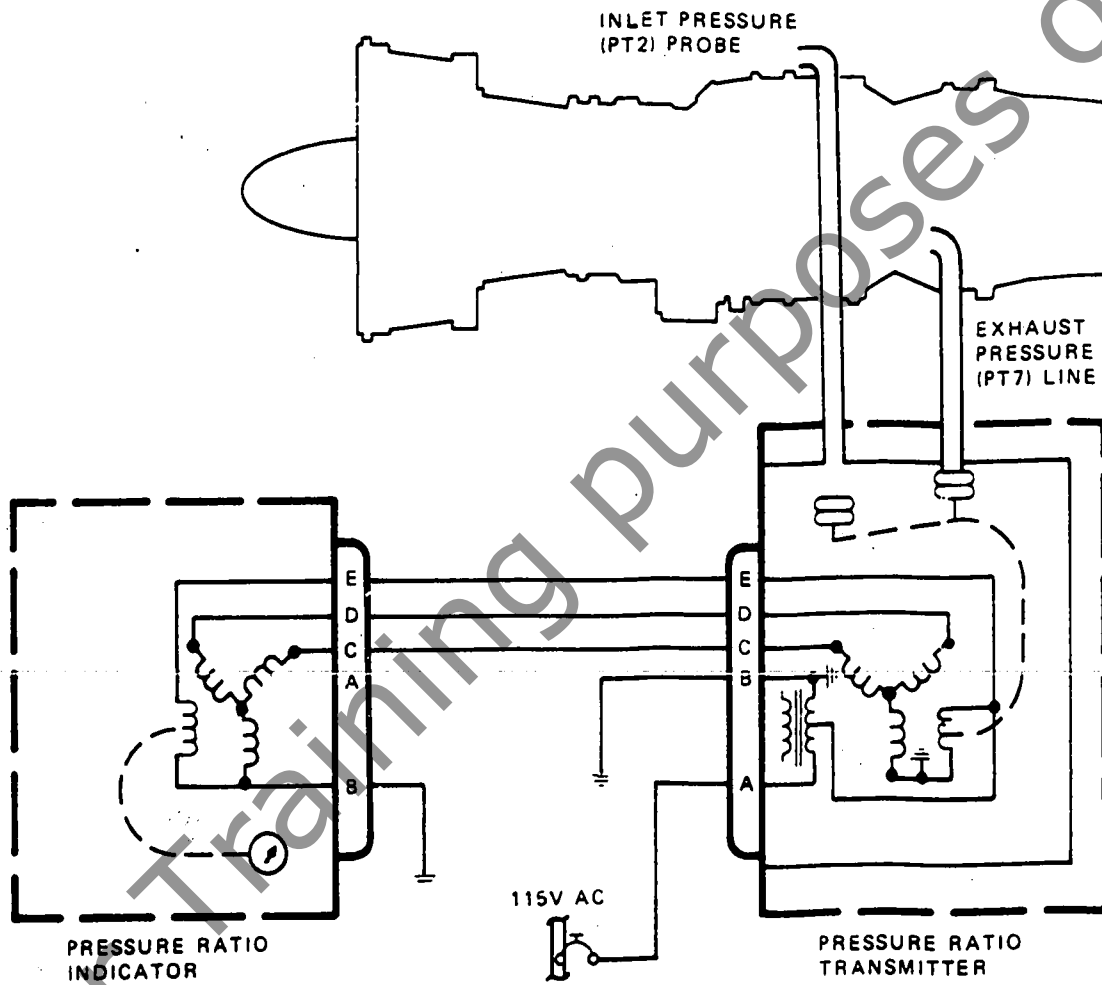
- A. The engine pressure ratio indicator is located on the engine instrument panel. It contains a synchronous receiver which is actuated by the electrical signals received from the engine pressure ratio transmitter. The indicator shows the ratio between the exhaust and inlet pressures (Pt7/Pt2) (Fig. 1).

7. Operation

- A. The system receives power from 115-volt ac circuit breaker panels P1, P2, P3, P4, through the OIL QTY & PRESS RATIO circuit breakers.
- B. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, the engine exhaust (Pt7) and inlet (Pt2) pressures are sensed by the pressure sensing probes. These pressures act on the bellows assembly of the pressure ratio transmitter, causing differential bellows movement whenever either of the pressures change. The relative bellows movement effects the sensing mechanism of the transmitter which, with the aid of the amplifier and motor-gear train, cause the generator rotor to rotate and generate three-phase electrical signals. The generated electrical signals are transmitted to a respective pressure ratio indicator over a three-wire system. The indicator converts the electrical signals into the pointer shaft rotation or indicator pointer movement corresponding to the pressure change in the engine (Fig. 2).

On airplanes HZ-ACA and HZ-ACB, the pressure ratio between inlet pressure (Pt2) and exhaust pressure (Pt7) is converted into an electrical signal by the engine pressure ratio transmitter. The chamber of the transmitter is sealed and pressure from the inlet probe (Pt2) is led into the chamber. The exhaust pressure (Pt7) acts inside a metal bellows contained in the chamber. The resultant movement of the bellows works a synchro transmitter through a linkage mechanism. The signals from this synchro transmitter provide an electrical output to operate a synchro motor in the exhaust pressure ratio indicator.

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Maintenance Manual

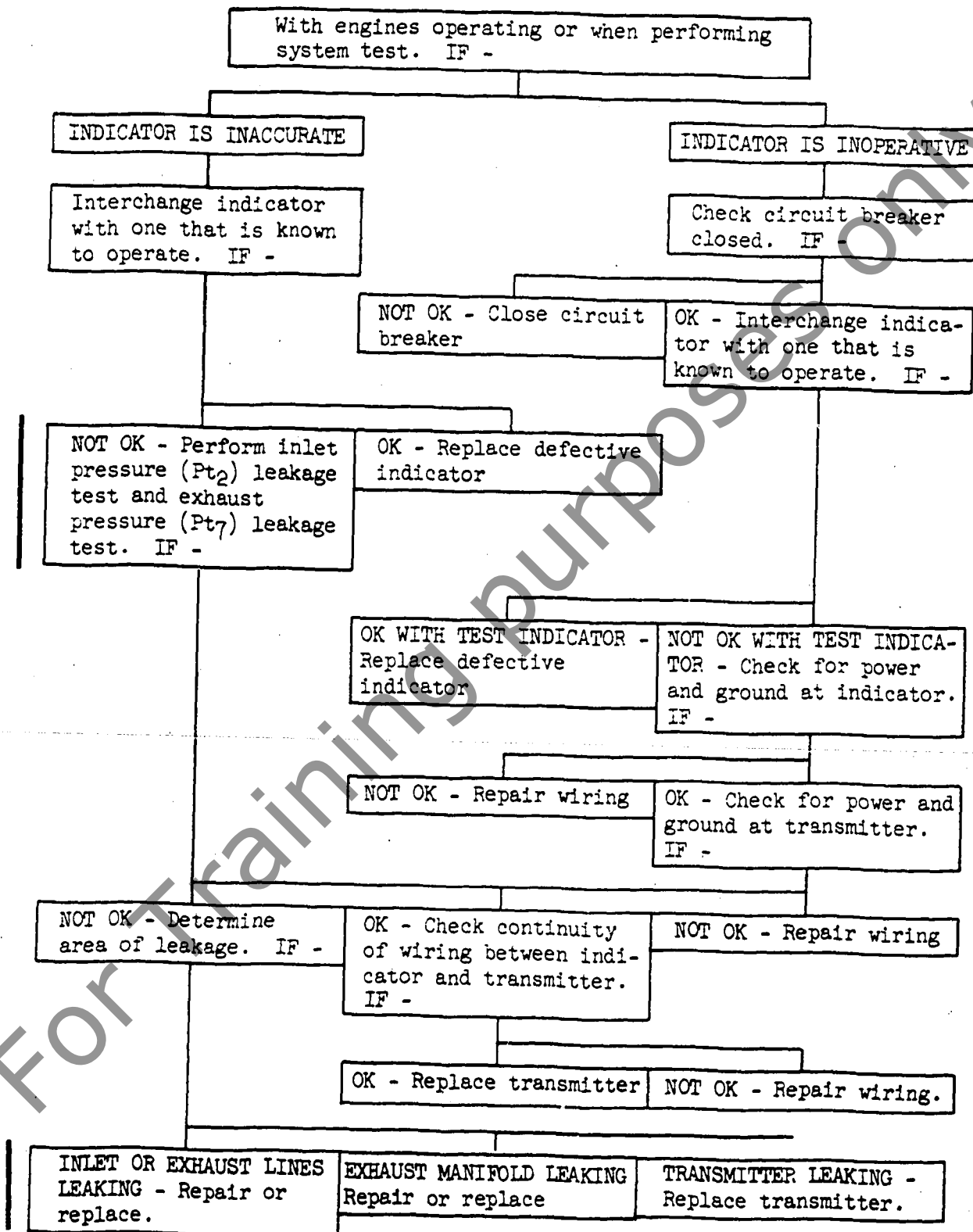


Engine Pressure Ratio Indication System Schematic
Figure 2

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ENGINE PRESSURE RATIO INDICATING SYSTEM - TROUBLE SHOOTING



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ENGINE PRESSURE RATIO INDICATING SYSTEM - MAINTENANCE PRACTICES

1. Adjustment/Test Engine Pressure Ratio Indicating System (Preferred Procedure)

A. General

- (1) This system test will include the transmitter, indicator, inlet and exhaust pressure tubing and exhaust pressure manifold.
- (2) The engine pressure ratio indicating system should be tested for leaks before performing operation and accuracy tests. Electrical power at 115 volts, 400 Hz must be applied to the system for 2 minutes for warmup to prevent damage to the transmitter.

NOTE: An engine pressure ratio indicator reading which is slightly above 1.00 with the engine shut down does not necessarily mean the system is inaccurate or that a component needs changing. Frictional losses may cause sticking of the pointer, and a calibration check should be made before changing items in the system.

- (3) Refer to step 2 for an alternate EPR test procedure.

B. Equipment and Materials

- (1) An air pressure source must be provided with two individually regulated outlets, the pressure of which can be accurately set at pressures between 25.00 and 130.00 inches of mercury absolute. All pressures are to be monitored by pressure gages (with accuracy of $\pm 0.05\%$). Shutoff valves are to be installed on the pressure source side of the gages (Fig 201)

C. Test Engine Pressure Ratio Indicating System (Fig. 201)

CAUTION: DO NOT EXCEED 42 INCHES OF MERCURY ABSOLUTE ON THE INLET PRESSURE LINE, OR 70 INCHES OF MERCURY ABSOLUTE ON THE EXHAUST PRESSURE LINE WHILE THE LINES ARE CONNECTED TO THE TRANSMITTER. MAXIMUM PRESSURE DIFFERENTIAL SHALL NOT EXCEED 45 INCHES OF MERCURY ABSOLUTE AT ANY TIME DURING THESE TESTS AS PERMANENT DAMAGE TO THE TRANSMITTER MAY RESULT.

- (1) Test Engine Inlet Pressure (Pt2) Line Leakage
 - (a) Remove engine right side cowl panel to obtain access to exhaust pressure tubing connection of engine pressure ratio system.
 - (b) On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, connect pressure hose from test apparatus to inlet pressure (Pt2) probe inlet port.

On airplanes HZ-ACA and HZ-ACB, connect pressure tubing from test apparatus to inlet probe on front of nose dome.

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- (c) On airplanes with P_{t2} probe mounted on engine strut, cap off vent hole at aft end of P_{t2} probe.

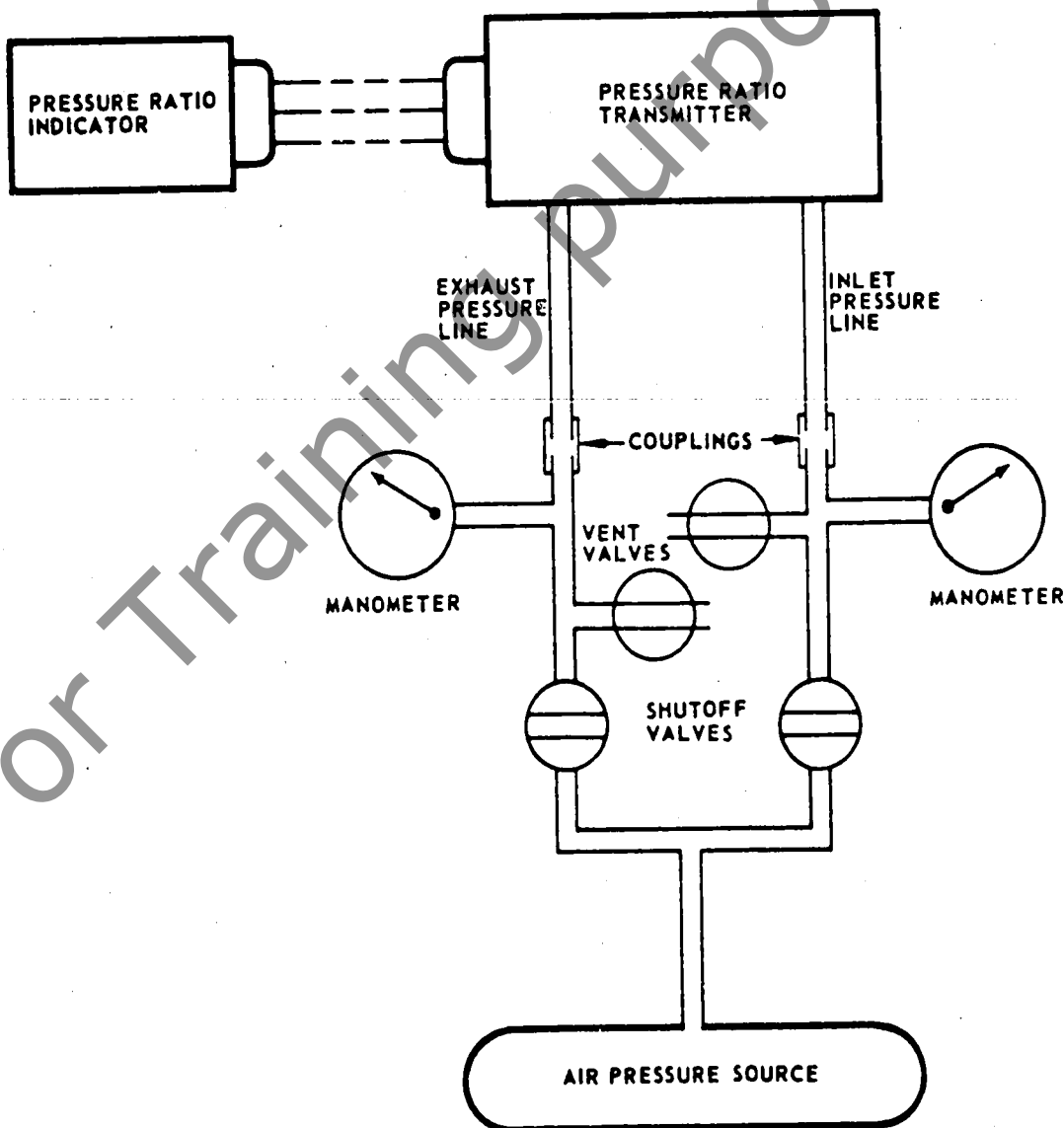
NOTE: The engine exhaust pressure plumbing should be left open to atmosphere during this test.

- (d) Slowly apply pressure of 42 inches of mercury absolute then shut off valve to pressure source.

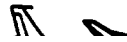
NOTE: Absolute pressure is the sum of gauge pressure and barometric pressure. For example, if barometric pressure is 30.1 inches of mercury, the gauge pressure required is 42 minus 30.1 or 11.9 inches.

- (e) Check that pressure leakage does not exceed 0.25 inch of mercury during five minute period.

- (f) Relieve pressure slowly through test set vent valve.



Engine Pressure Ratio Indicating System Test Connections
Figure 201



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(2)

- (a) Disconnect exhaust pressure tubing from exhaust pressure sensing manifold and attach test pressure hose to exhaust pressure tubing.
- (b) Slowly apply pressure of 35 inches of mercury absolute to inlet pressure probe with vent capped.
- (c) Slowly apply pressure of 70 inches of mercury absolute to exhaust pressure tubing, then close shutoff valve to pressure source.
- (d) Check that pressure leakage does not exceed 0.25 inch of mercury during five minute period. (Volume of entrapped air in test system should not exceed 45 cu inches).
- (e) Reduce exhaust pressure tubing pressure below 50 inches of mercury before reducing the inlet pressure.

(3) Test Engine Exhaust Pressure (P_{t7}) Manifold Leakage

- (a) Disconnect test pressure hose from exhaust pressure tubing and connect to the exhaust pressure manifold.

CAUTION: MAKE SURE THERE IS NO POSSIBILITY OF BLOWING AIR INTO EPR TRANSMITTER.

- (b) Apply pressure approximately of 130 inches of mercury absolute (65 psia) to exhaust pressure manifold.
- (c) Check exhaust pressure manifold, especially where connections made to individual probes, by applying soap and water solution.

NOTE: Air will be flowing through the P_{t7} probe continuously during this test, however pressure differential will be sufficient to detect leaks in the manifold.

- (d) If leaks are present, refer to 77-15-11 MP.
- (e) Relieve test pressure and remove test pressure hoses.

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(4) Test Operation and Accuracy

- (a) Connect external electrical power to airplane and close OIL QTY & PRESS RATIO circuit breakers.
- (b) Apply pressure to inlet and exhaust pressure tube per the chart to obtain 1.50 on the pressure ratio indicator.

ENGINE INLET PRESSURE		ENGINE EXHAUST PRESSURE		PRESSURE RATIO INDICATIONS
In. Hg Abs	PSIA	In. Hg Abs	PSIA	Pt7/Pt2
31.00**	15.23	65.10*	31.97	2.10 ±0.010**
31.00**	15.23	46.5*	22.84	1.5 ±0.010**

* Correct for barometric pressure
 ** The tolerances exclude test equipment accuracy. Test equipment tolerance should be determined and considered cumulative to the test tolerance.

TABLE I

- (c) Open applicable OIL QTY & PRESS RATIO circuit breaker. Engine pressure ratio indicator reading should not change.
- (d) With circuit breaker open, increase exhaust line pressure to 65.10 inches of mercury absolute. Engine pressure ratio indicator reading should not change.
- (e) Close applicable OIL QTY & PRESS RATIO circuit breaker. Pressure ratio indicator should read 2.10.
- (f) Engine pressure ratio indicator should read both values within tolerances shown in the chart after tapping lightly.

NOTE: An engine pressure ratio indicator above 1.00 with the engines shut down or no pressure applied to system is due to the lower mechanical stops in the transmitter which prevent the unit from going below 1.00. In some units due to tolerances in the gear train and location of the mechanical stop, the transmitter is incapable of transmitting a signal of 1.0 to the indicator.

For Training Purposes Only Maintenance Manual

- (g) Relieve test pressure and remove test pressure hoses.

CAUTION: REDUCE EXHAUST PRESSURE BELOW 50 INCHES OF MERCURY BEFORE REDUCING INLET PRESSURE TO PREVENT TRANSMITTER DAMAGE.

- (h) Connect exhaust pressure tubing to manifold fitting connection.
- (i) On airplanes with Pt2 probe mounted on engine strut, remove cap from aft end of Pt2 probe.
- (j) Install right side cowl panel.

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Maintenance Manual

2. Engine Pressure Ratio Indicating System Test (Alternate Procedure)

A. General

- (1) The following test procedure will apply during an Engine Pressure Ratio Indicating system accuracy check for turbine failure.

B. Equipment and Materials

- (1) A regulated air pressure source
- (2) Absolute pressure gage
- (3) Test hose
- (4) Shutoff valve

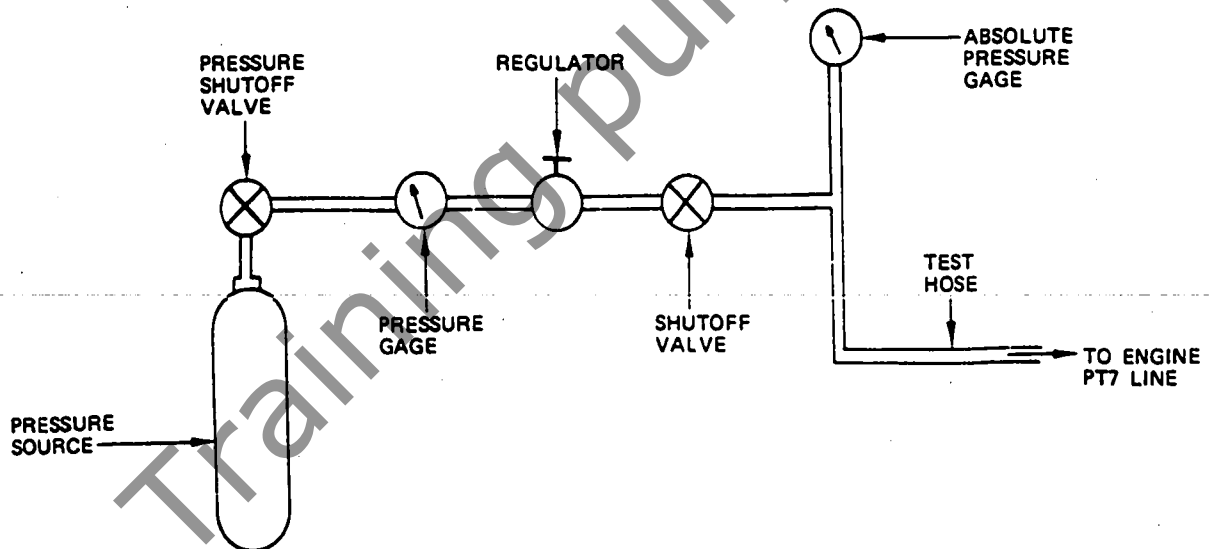
C. Test Engine Pressure Ratio Indicating System (Fig. 201)

- (1) Open bottom cowl of affected engine.
- (2) Disconnect PT7 line at the turbine exhaust case.
- (3) Attach test line to engine PT7 line.
- (4) Obtain barometric pressure from absolute pressure gage and note.
- (5) Check that regulator valve is backed off and the valve to test line is open.
- (6) Open shutoff valve on air source.
- (7) Gradually increase regulator setting until absolute pressure gage reads 1.5 times barometric pressure.
- (8) Close the air source valve. (This action will trap pressure in the entire PT7 plumbing.)
- (9) Note pressure reading on absolute gage. A drop in pressure indicates line leakage. Correct as necessary to obtain zero leakage.
- (10) With 1.5 times barometric pressure trapped in system, the EPR indicator must read 1.50 ± 0.01 .
- (11) Increase pressure with regulator until 2.2 times barometric is registered on absolute gage. Check that EPR indicator now reads 2.20 ± 0.01 .

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Maintenance Manual

- (12) If either check point is out of limits, install a serviceable indicator to determine whether transmitter or indicator is at fault.
- (13) Replace the faulty unit and recheck as per steps (10) and (11).
- (14) Disconnect engine PT7 line from test unit and reconnect line to turbine exhaust case.
- (15) Close engine cowling.



Engine Pressure Ratio Indicating System Test Connections
Figure 202

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ENGINE PRESSURE RATIO TRANSMITTER - MAINTENANCE PRACTICES

EFFECTIVITY

ALL EXCEPT HZ-ACA, HZ-ACB

1. Removal/Installation Engine Pressure Ratio Transmitter

A. Remove Engine Pressure Ratio Transmitter (Fig. 201)

- (1) Open applicable engine pressure ratio circuit breaker.
- (2) Remove access panels on nacelle strut as indicated below.

Engine Nacelle Strut No.	*[1] Access Panels No. (Ref Chapt 12)	*[2] Access Panels No. (Ref Chapt 12)
1 and 4	742	1742
2 and 3	708	1708

- (3) Disconnect electrical plug on pressure ratio transmitter.
- (4) Disconnect inlet (Pt2) and exhaust (Pt7) pressure lines at pressure connection on transmitter.
- (5) Remove four mounting bolts and lift transmitter free of strut.

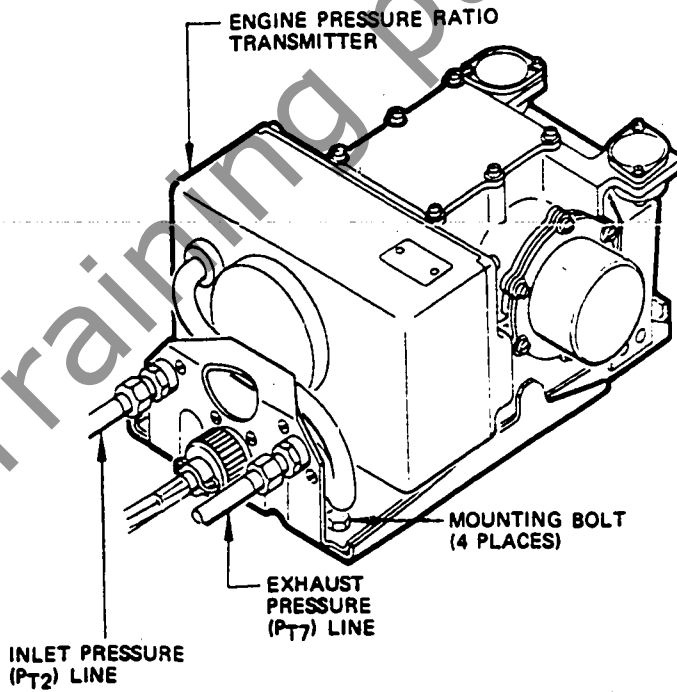
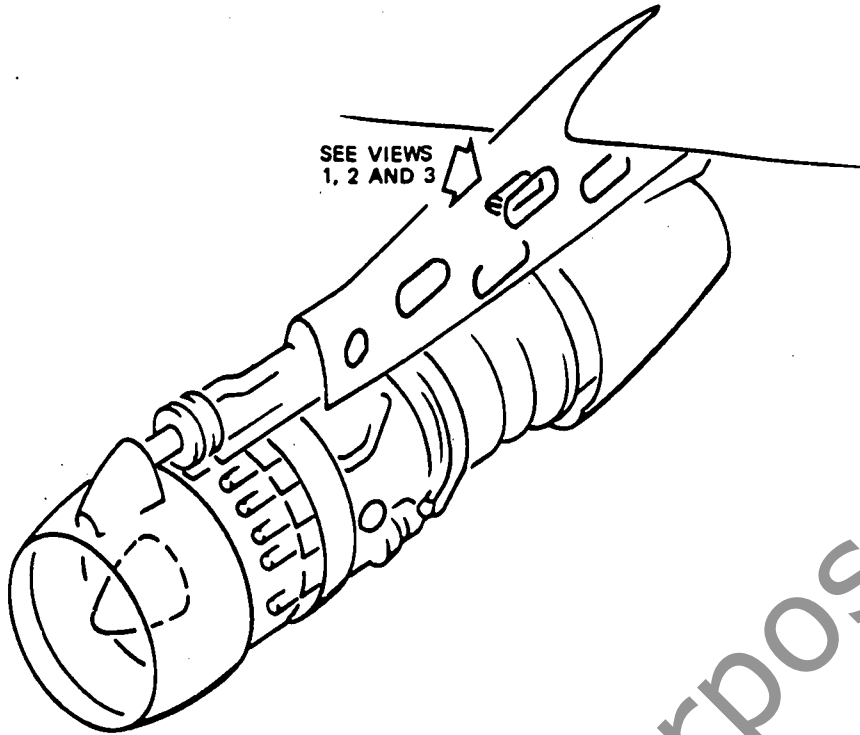
B. Install Engine Pressure Ratio Transmitter (Fig. 201)

- (1) Lift engine pressure ratio transmitter into position.
- (2) Install four mounting bolts holding transmitter assembly to bracket.
- (3) Connect inlet (Pt2) and exhaust (Pt7) pressure lines to pressure connections on transmitter. Connect electrical plug to transmitter.
- (4) Install access panels. Refer to Chapter 12 and Table above.
- (5) Close applicable engine pressure ratio circuit breaker.

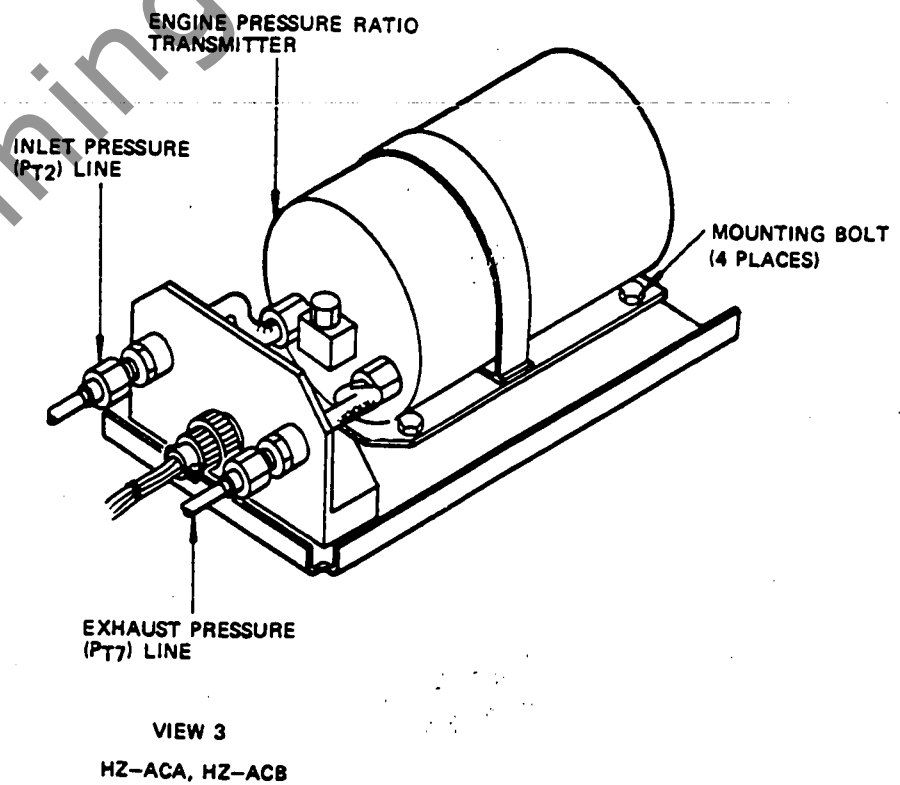
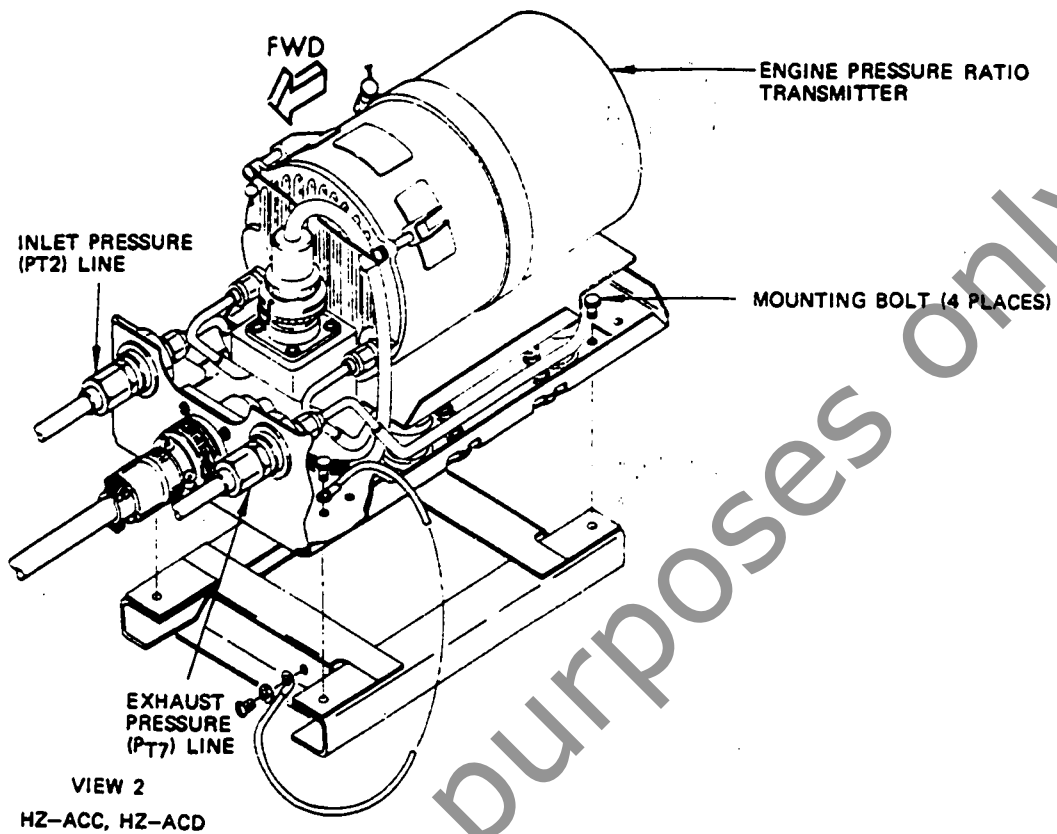
*[1] HZ-ACA, HZ-ACB

*[2] ALL EXCEPT HZ-ACA, HZ-ACB

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Maintenance Manual



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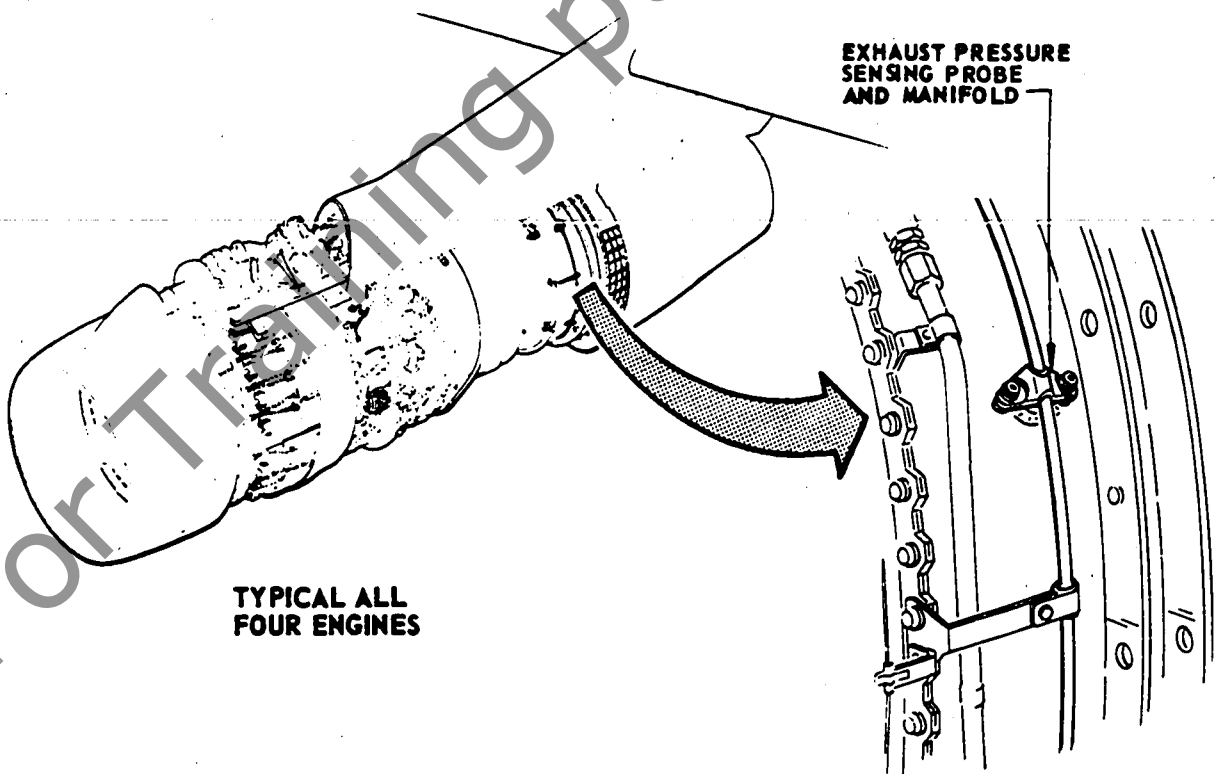
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EXHAUST PRESSURE SENSING PROBES AND MANIFOLD - MAINTENANCE PRACTICES

1. Removal/Installation Exhaust Pressure Sensing Probes and Manifold

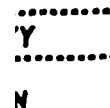
A. Remove Exhaust Pressure Sensing Probes and Manifold (See figure 201.)

- (1) Remove side cowl panels. Refer to "Cowl Panels," Chapter 71.
- (2) Disconnect clamps securing manifold to turbine case flange.
- (3) Disconnect manifold union nuts at 6 o'clock and 12 o'clock.
- (4) Disconnect branch line union nut at approximately 5 o'clock.
- (5) Remove probe mounting bolts and pull either left or right manifold section free of engine.
- (6) Repeat with other section of manifold.
- (7) Remove probes from housings in exhaust casing.



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Maintenance Manual



- B. Install Exhaust Pressure Sensing Probes and Manifold (See figure 201.)
- (1) Insert probes into housings around exhaust casing.
 - (2) Position one section of exhaust pressure sensing manifold around periphery of engine turbine chamber.
 - (3) Install probe mounting bolts and secure with locknuts.
 - (4) Repeat procedure for opposite manifold section.
 - (5) Tighten union nuts joining both halves of sensing manifold together.
 - (6) Connect clamps securing manifold to turbine case flange.
 - (7) Tighten union nut joining branch line to manifold assembly.
 - (8) Install side cowl panels. Refer to "Cowl Panels," Chapter 71.

For Training Purposes Only

Maintenance Manual

INLET PRESSURE SENSING PROBE - MAINTENANCE PRACTICES

EFFECTIVITY

HZ-ACA, HZ-ACB

1. Removal/Installation Inlet Pressure Sensing Probe

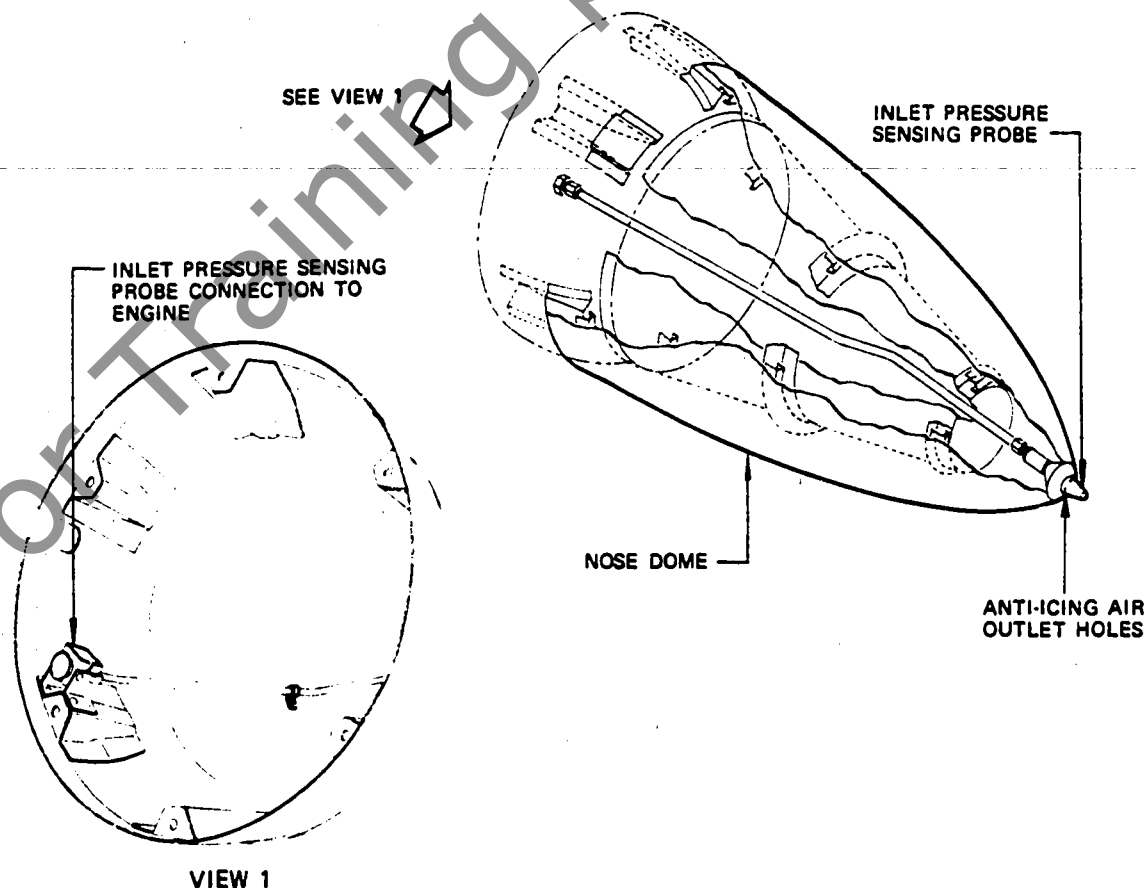
A. General

- (1) The inlet pressure (Pt2) sensing probe (Fig. 201) is assembled to the engine nose dome and is removed and installed with the nose dome (Ref Chapter 71, Engine Nose Dome).

2. Inspection/Check Inlet Pressure Sensing Probe

A. Check Inlet Pressure Sensing Probe

- (1) Examine the (Pt2) inlet air hole located at the front of the nose dome for damage (Fig. 201). Check the probe to engine connection, located aft end of nose dome, for damage to connection thimble and ingress of foreign material into sensing tube.



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Maintenance Manual

INLET PRESSURE (PT2) SENSING PROBE - REMOVAL/INSTALLATION

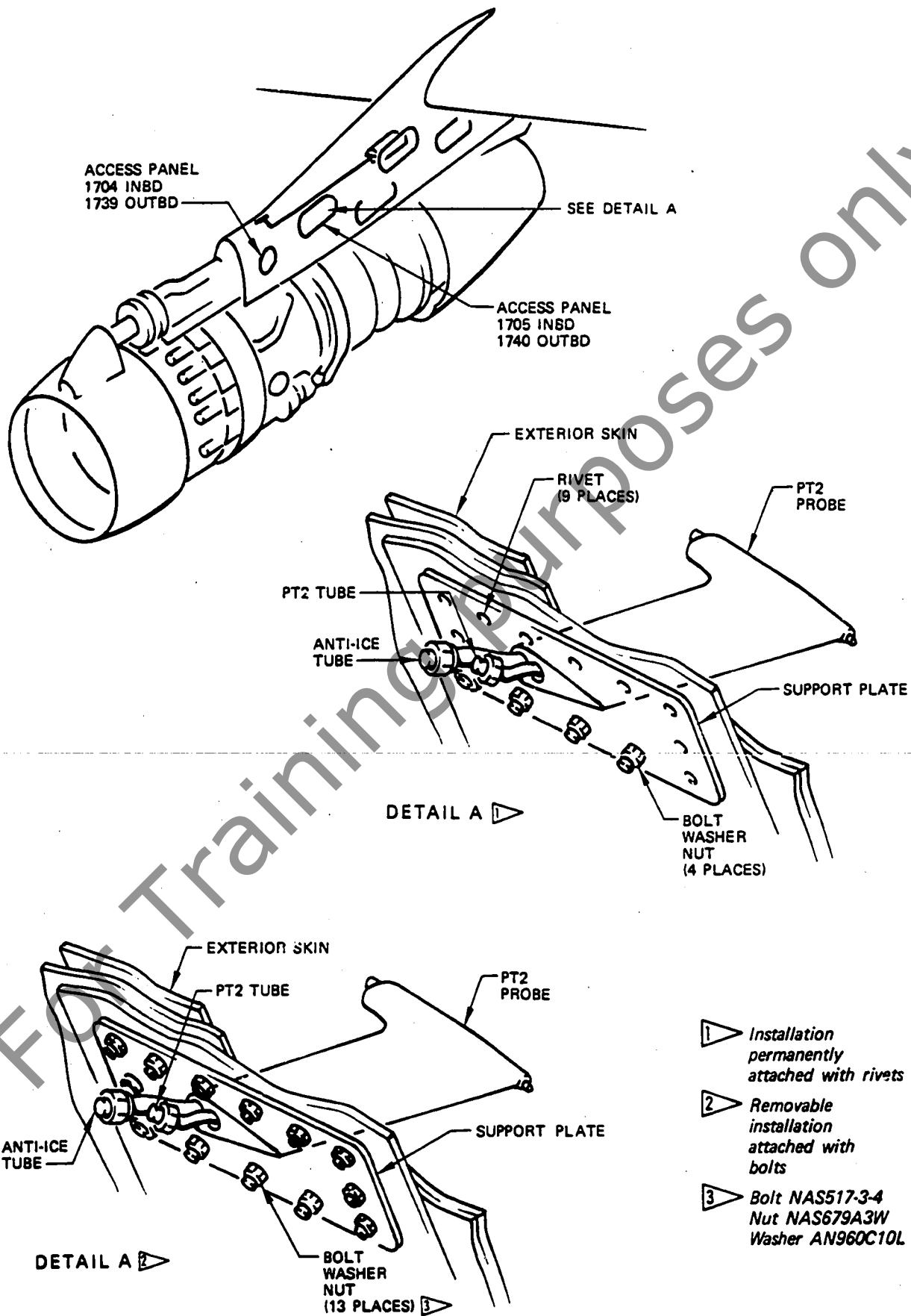
1. General

- A. The inlet pressure (Pt2) sensing probes are mounted on the right side of the nacelle strut.
- B. There are two types of Pt2 probe installations.
 - (1) Pt2 probe permanently attached to strut with rivets and lockbolts.
 - (2) Pt2 probe attached to strut with bolts.
- C. Removal of Pt2 probe which is permanently attached to the strut will require drilling out existing rivets and replacement of rivets with countersunk bolts.
- D. Removal of the probe is accomplished from the interior of the strut. Access is gained by removing two access panels on the left of the strut.

2. Remove Inlet (Pt2) Sensing Probe (See figure 401.)

- A. For airplanes with Pt2 probe permanently fastened to strut:
 - (1) From exterior of strut, drill out rivets holding Pt2 support plate to strut.
 - (2) Gain access to interior of strut by removing access panels shown in figure 401.
 - (3) From interior of strut, remove remaining four locknuts and bolts holding Pt2 support plate to strut.
 - (4) Remove all metal chips from interior of strut.

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Inlet Pressure (Pt2) Sensing Probe Installation
Figure 401

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Maintenance Manual

- B. For airplanes with Pt2 probe attached to strut with bolts:
- (1) Gain access to interior of strut by removing access panels shown in figure 401.
 - (2) Remove nuts and bolts holding Pt2 probe support plate to strut.
- C. From interior of strut, disconnect Pt2 tube and anti-ice tube from Pt2 probe connections.
- D. From interior of strut, remove Pt2 probe.
3. Install Inlet (Pt2) Sensing Probe (See figure 401.)
- A. For airplanes which had Pt2 probe permanently attached to strut:
- (1) Using new Pt2 probe as a pattern, make a steel template to match bolt pattern in Pt2 probe support plate.
 - (2) Bolt template to exterior of strut using four lower bolt holes.
 - (3) Drill all holes to 0.190-0.195 diameter.
 - (4) Remove template.
 - (5) Countersink exterior surface fastener holes 100 degrees.
 - (6) Remove chips from strut interior.
- B. From interior of strut, insert Pt2 probe and position probe assembly in place. Line up holes.
- C. Install bolts, washers, and nuts. Tighten nuts.
- D. Connect inlet Pt2 tube and anti-ice tube to Pt2 connections.
- E. Install access panels.



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EXHAUST GAS TEMPERATURE INDICATING SYSTEM - DESCRIPTION AND OPERATION

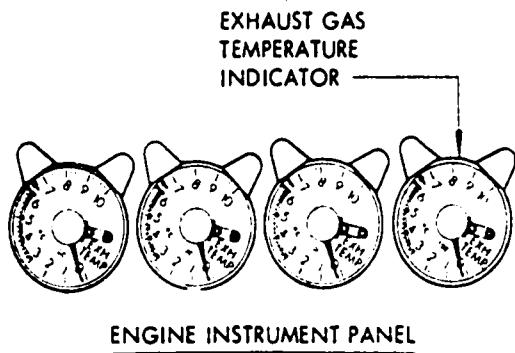
1. General

- A. The engine exhaust gas temperature (EGT) indicating system measures and shows a reading of engine exhaust gas temperature on indicators located in the control cabin.
- B. The engine exhaust gas temperature indicating system consists of twelve thermocouple elements grouped in pairs and enclosed in six probes arranged around the engine exhaust housing, one variable thermocouple resistor for each engine and four temperature indicators on the engine instrument panel.
- C. Engine exhaust gas temperature is sensed by the thermocouple elements. The heat of the exhaust gases causes the thermocouples to generate a d-c electrical signal which actuates the meter movement of the exhaust temperature indicator. Copper and constantan wires are used in the low temperature zone of the engine and chromel and alumel wires are used where higher temperatures are encountered. The variable resistance is included in the circuit to allow adjustment of the system.

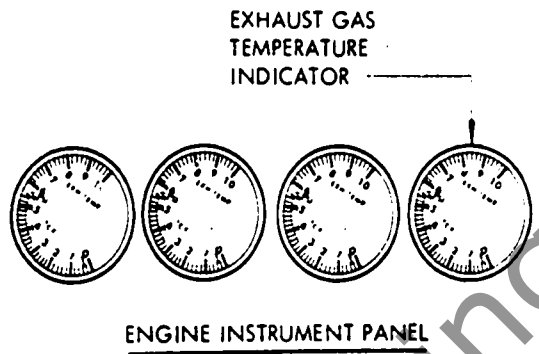
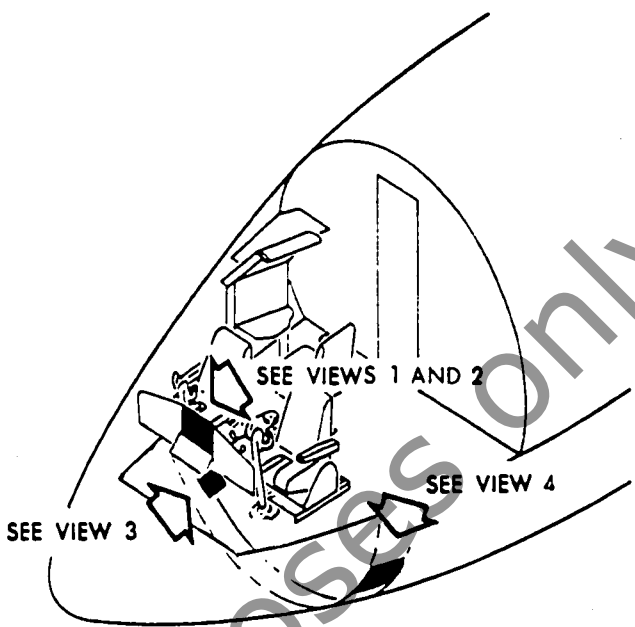
2. Exhaust Gas Temperature Thermocouples

- A. The exhaust gas temperature thermocouple is a thermo-electrical device which produces a d-c electrical signal for operation of the system. (See figure 2.)
- B. Two thermocouples are enclosed in each sampling probe mounted on the engine exhaust housing with the probes projecting into the exhaust stream. Six thermocouples, one from each pair, are connected in parallel so that two wires carry the average of the exhaust gas temperature signals. The remaining one from each pair has separate wires in the thermocouple harness to allow selection of a signal from any one probe. The thermocouple junction and studs are made of chromel and alumel material. The alumel stud terminal (-) is larger than the chromel stud terminal (+). The polarity of the thermocouples is also indicated by a green paint spot near the negative terminal. Each probe is provided with four gas inlet holes and one gas discharge hole.

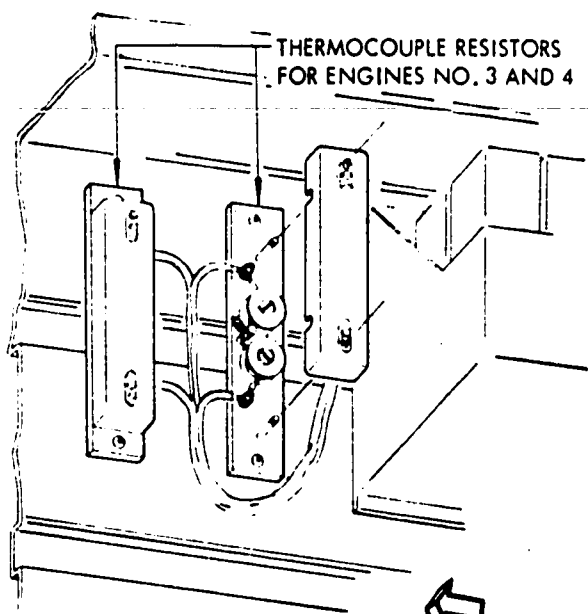
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VIEW 1



VIEW 2



J23 RELAY PANEL

VIEW 3

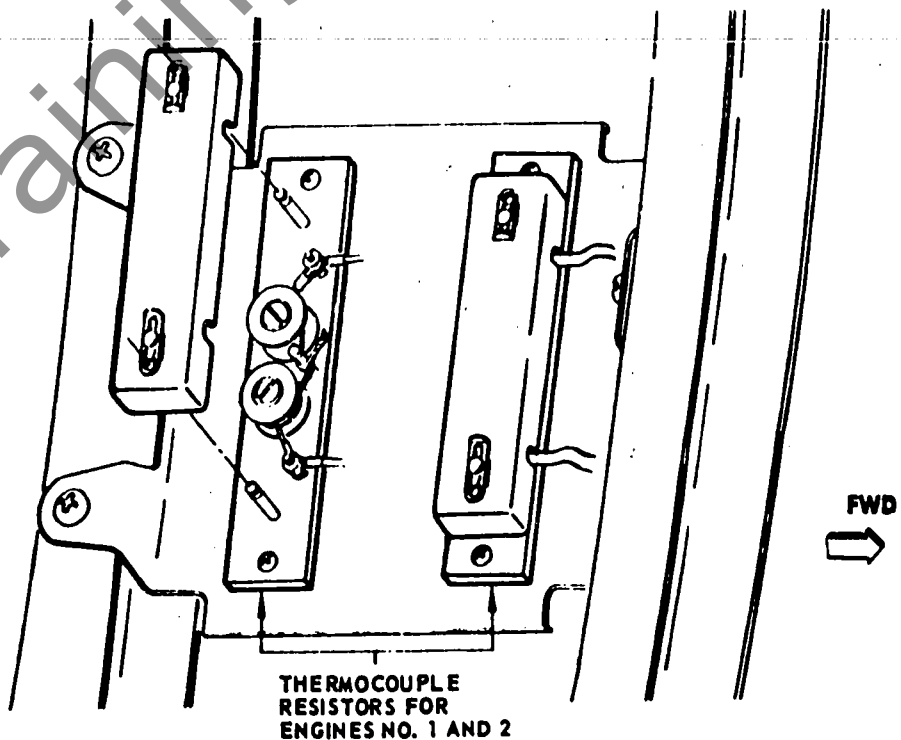
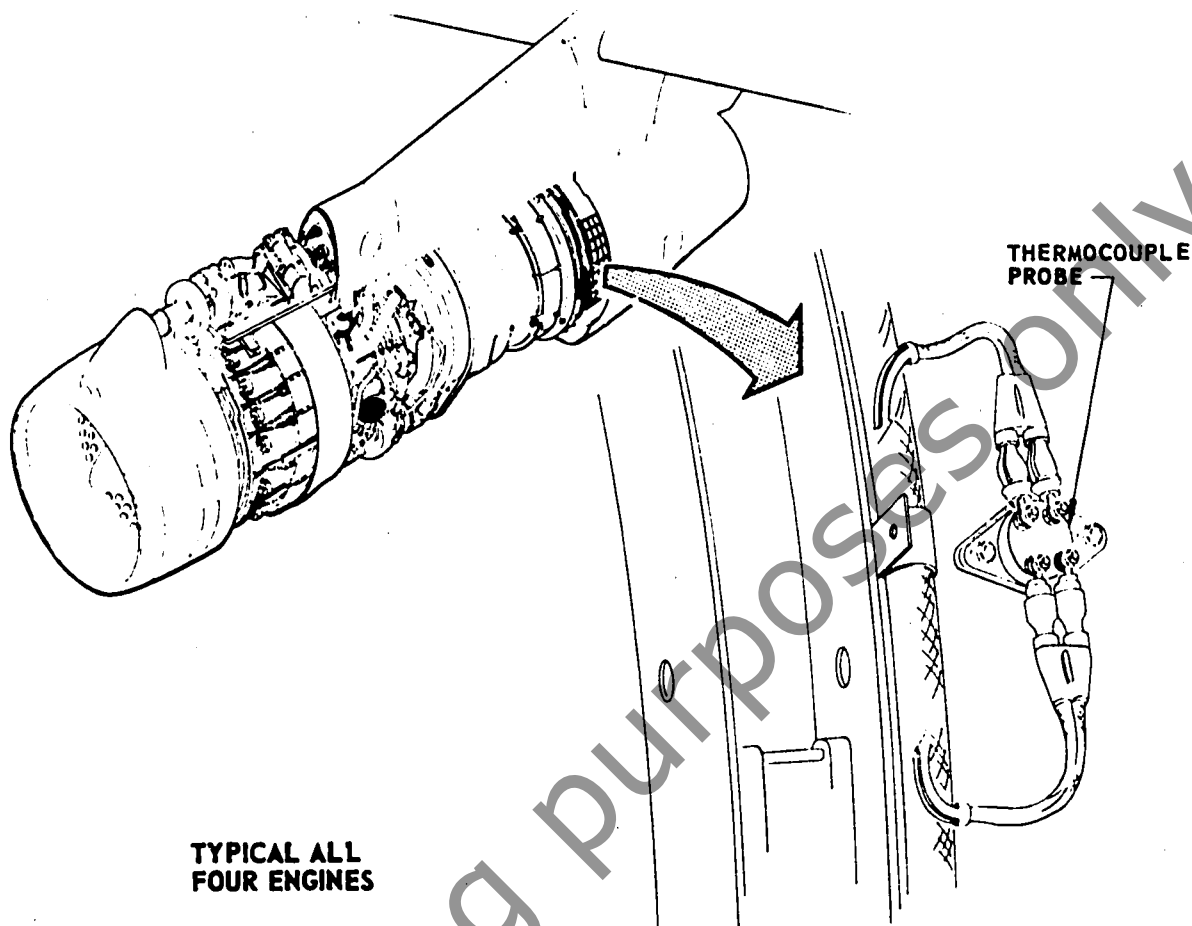


- 1 ALL AIRPLANES EXCEPT HZ-ACC AND HZ-ACD
- 2 AIRPLANES HZ-ACC AND HZ-ACD

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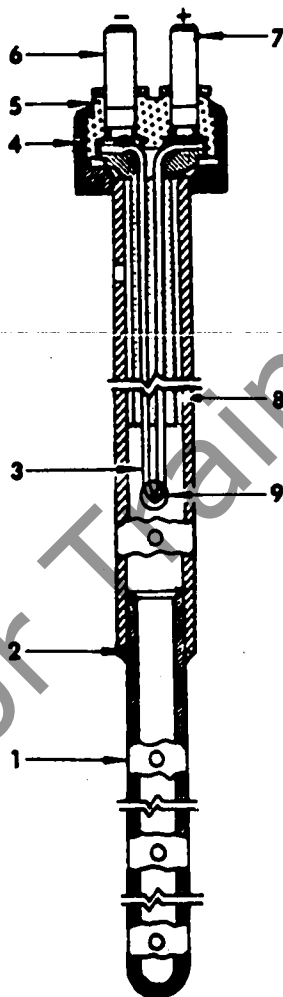
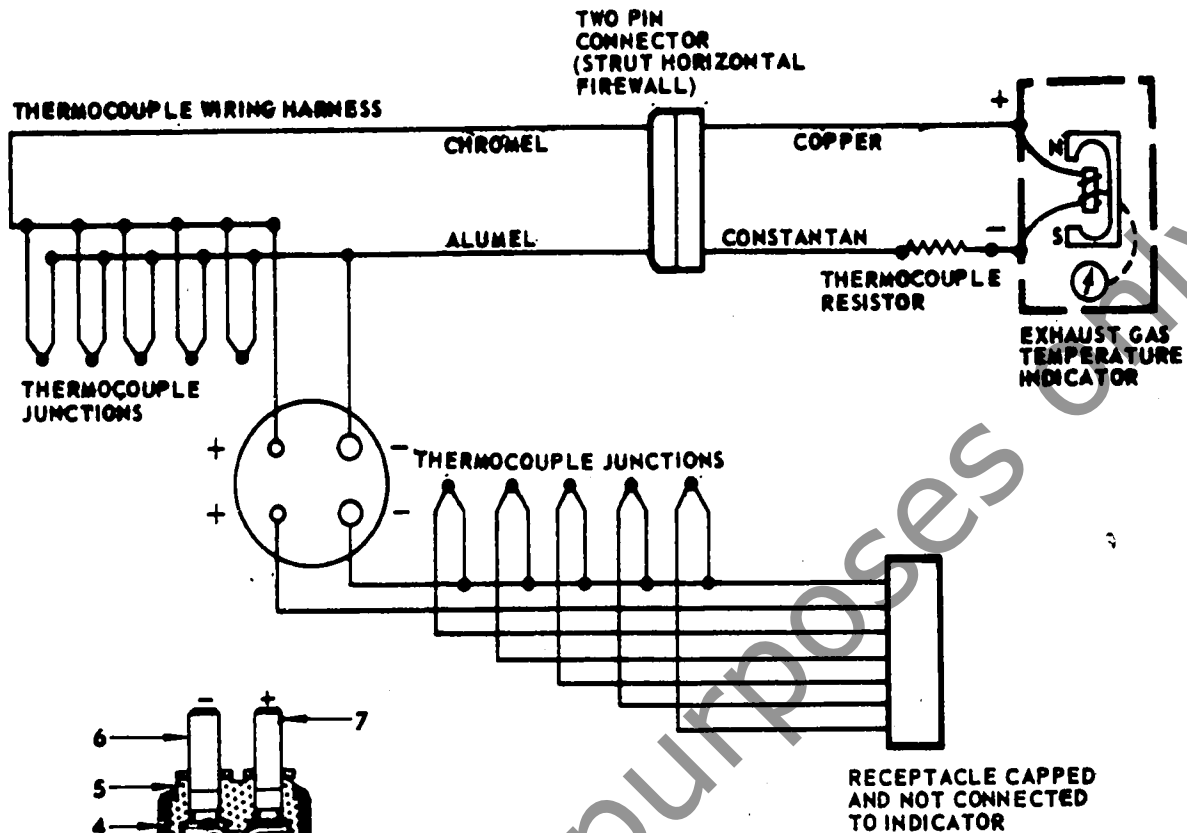
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**THERMOCOUPLE PROBE ASSEMBLY
(SHOWING ONE THERMOCOUPLE)**

- 1 SHIELDING ASSEMBLY
- 2 TUBE-EXTENSION
- 3 CONDUCTOR
- 4 SHELL
- 5 BLOCK-TERMINAL
- 6 NEGATIVE STUD
- 7 POSITIVE STUD
- 8 INSULATION
- 9 JUNCTION

**Exhaust Gas Temperature Indicating System Circuit
Figure 2**

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3. Exhaust Gas Temperature Thermocouple Resistor

- A. The exhaust gas temperature thermocouple resistor is provided to adjust circuit resistance of the exhaust gas temperature indicating system. The elements of the resistor are two spools of No. 24 constantan wire with a resistance of 8.0 (+10%/-0%) ohms for each spool before adjustment. The thermocouple resistors for engines No. 1 and 2 are mounted on the lower nose compartment fusealge walls. The resistors for engines No. 3 and 4 are mounted on the J23 relay shield located on the right side of the lower nose compartment.

4. Exhaust Gas Temperature Indicator

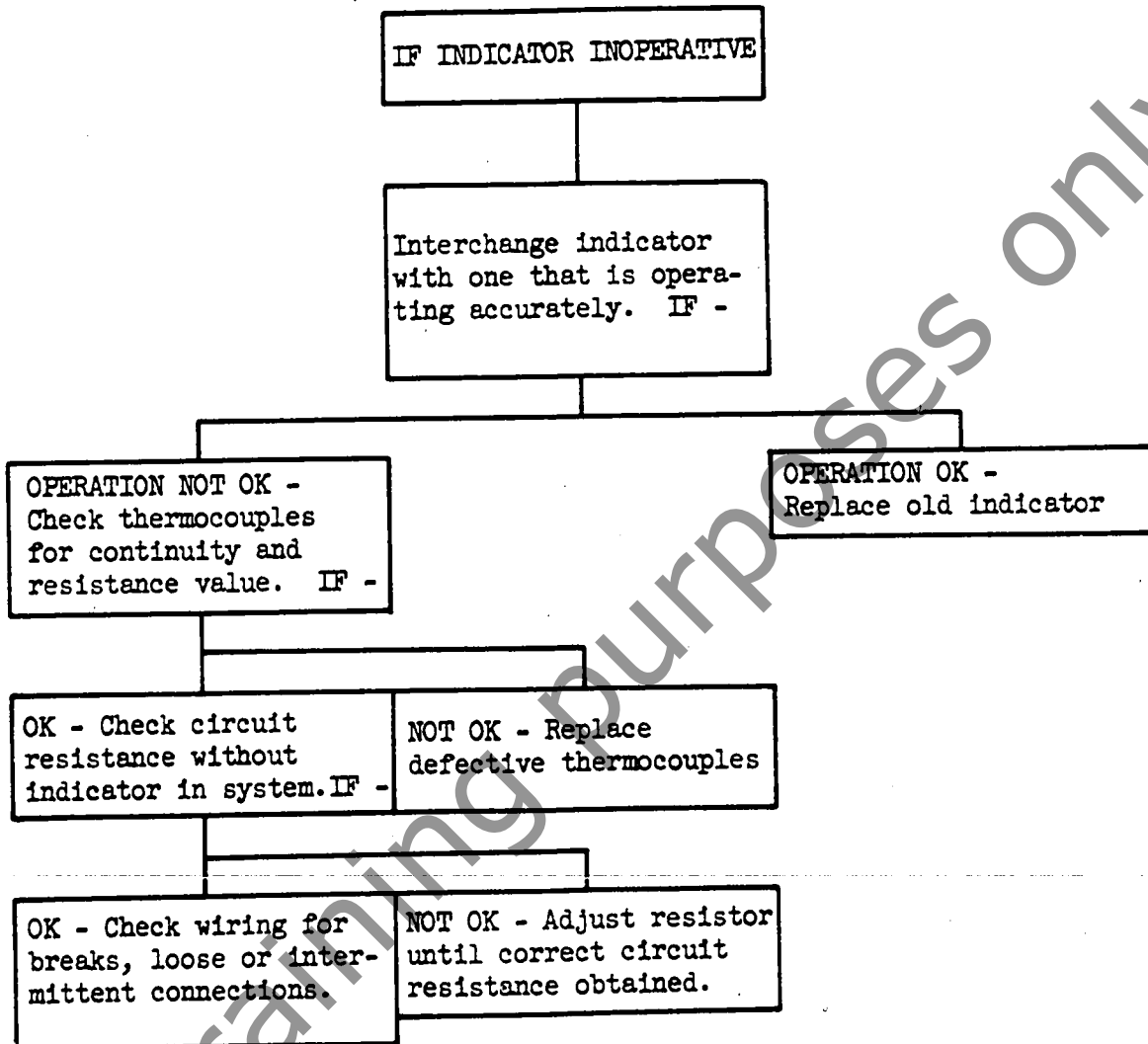
- A. The exhaust gas temperature indicator is a moving coil sensitive voltmeter. Four indicators, one for each engine, are mounted on the engine instrument panel. The instruments have two terminals in the back of the case marked plus (+) and minus (-). These two terminals connect the meter coils inside the unit to the thermocouple circuit. A screwdriver operated pointer adjustment on the back of the indicator allows approximately a 55° adjustment range at 700°C. The instrument dial indicates a temperature range from 0° to 1000°C, with normal and dangerous operating temperatures marked.

5. Exhaust Gas Temperature Thermocouple Harness and Lead

- A. One part of the exhaust gas temperature thermocouple harness averages the electrical output from six thermocouples by combining the individual signals in a parallel circuit which supplies the exhaust gas temperature indicator. The remaining wires in the harness take signals from the six other thermocouples to a test receptacle on the fireseal at the right side of the engine. This receptacle is capped off and the circuit is used for test purposes only.
- B. The thermocouple harness consists of a flexible electrical conduit mounted on the outer circumference of the engine exhaust housing. The harness has a two-wire averaging circuit lead fastened to the engine with clips and routed forward through the engine fireseal to an electrical disconnect plug located at the engine strut firewall. A second outlet from the thermocouple harness terminates at the electrical test receptacle located at 5 o'clock on the engine fireseal.

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EXHAUST GAS TEMPERATURE INDICATING SYSTEM - TROUBLE SHOOTING



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EXHAUST GAS TEMPERATURE INDICATING SYSTEM - MAINTENANCE PRACTICES

1. Adjustment Test Exhaust Gas Temperature Indicating System

A. General

- (1) The exhaust gas temperature (EGT) indicating system is tested using a wheatstone bridge and an ohmmeter. Tests include measurements of circuit resistance and insulation resistance.
- (2) Two operational tests are provided which may be used optionally to establish confidence of exhaust gas temperature indicating system. Neither test provides sufficient accuracy for system calibration, and is to be used only to indicate whether system operation is or is not satisfactory. Operational test No. 1 is preferred if conditions allow.

B. Equipment and Materials

- (1) Wheatstone resistance bridge capable of measuring resistance to + 0.1 ohm at 22 ohms.
- (2) Low voltage ohmmeter capable of measuring resistance of 100,000 ohms. Meter should utilize less than 40 volts (dc) and should have an accuracy of five percent.
- (3) Low value load resistance variable to within ± 0.05 ohms
- (4) DC power source variable from 0 to 50 millivolts
- (5) DC millivolt meter capable of measuring to ± 0.01 millivolt
- (6) Portable container of ice or accurate thermometer

C. Test Exhaust Gas Temperature Indicating System Resistance

- (1) Disconnect averaging circuit leads from exhaust gas temperature indicator on engine instrument panel.
- (2) Attach disconnected leads to Wheatstone Bridge and measure circuit resistance of system. Resistance reading should be as shown.

SYSTEM RESISTANCE (OHMS)	AMBIENT TEMPERATURE °C
22.00 (± 0.1)	20° \pm 5°
21.95 (± 0.1)	10° \pm 5°
21.90 (± 0.1)	0° \pm 5°

NOTE: If resistance is not within tolerance, check circuit for loose, corroded or shorted connections and defective thermocouple probes.

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- (3) Adjust resistor spool to bring circuit resistance within specified tolerance, if required.
- (4) Remove Wheatstone Bridge from averaging circuit leads, and reconnect leads to indicator.

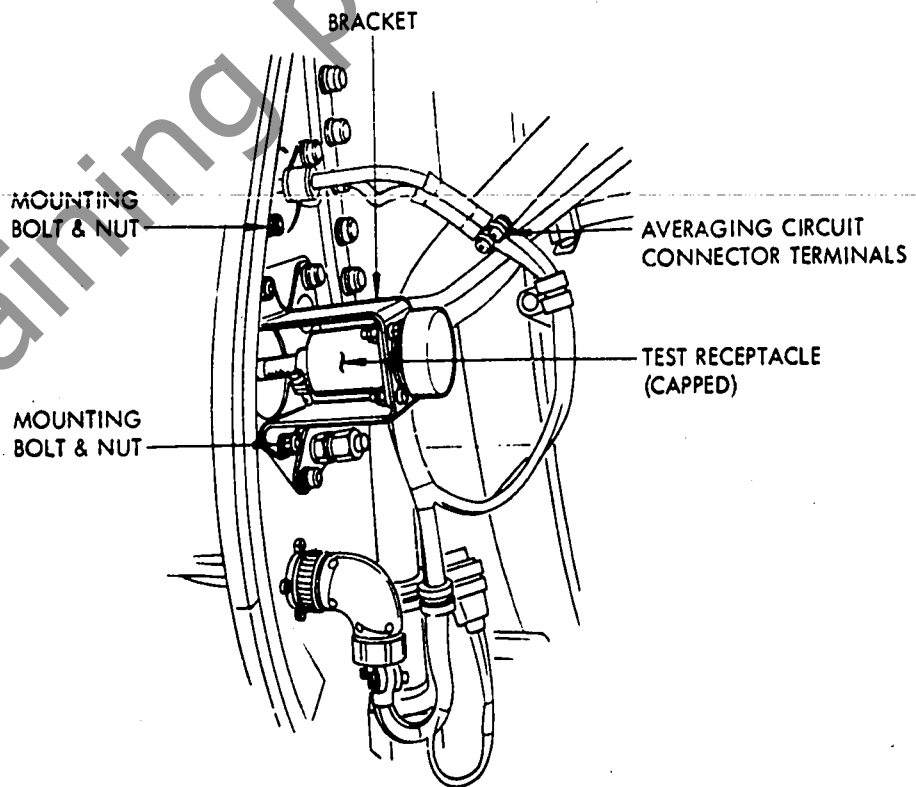
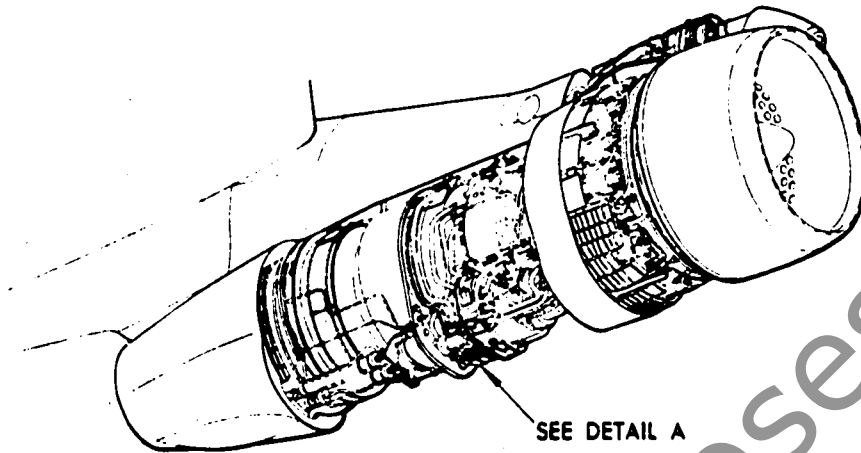
D. Test Insulation Resistance

- (1) Check averaging circuit leads from indicator to engine fireseal for shorts to ground.
 - (a) Disconnect averaging circuit leads from exhaust gas temperature indicator on engine instrument panel.
 - (b) Open left cowl panel on engine.
 - (c) Remove teflon tape from thermocouple averaging circuit connector, located forward of engine fireseal, and disconnect terminals (Fig. 201).
 - (d) Place one ohmmeter terminal in contact with fireseal connector alumel terminal, and ground other ohmmeter terminal.
 - (e) Check averaging circuit lead from engine fireseal to indicator for shorts to ground. Resistance shall not be less than 100,000 ohms.
 - (f) Repeat steps (d) and (e) using fireseal connector chromel terminal.
 - (g) Connect thermocouple averaging circuit leads to indicator.
- (2) Check exhaust gas temperature thermocouple harness and leads for shorts to ground.
 - (a) Place one ohmmeter terminal in contact with one averaging circuit fireseal connector terminal, and ground other ohmmeter terminal.
 - (b) Measure resistance. Resistance shall not be less than 10,000 ohms.
 - (c) If measured resistance is not at least 10,000 ohms, for further action refer to section 77-16-21, Exhaust Gas Temperature Thermocouple Harness and Lead - Maintenance Practices.
 - (d) Connect averaging circuit connector terminals and wrap connection with teflon tape.

CAUTION: BE SURE THERE IS ENOUGH INSULATING MATERIAL BETWEEN THE TWO SETS OF CONNECTED TERMINALS TO PREVENT SHORTING OUT THE SYSTEM.

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DETAIL A

Exhaust Gas Temperature Thermocouple
Harness Engine Fireseal Connectors
Figure 201

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E. Operational Test No. 1 (Preferred)

- (1) Open left cowl panel on engine.
- (2) Remove teflon tape from thermocouple averaging circuit connector, located forward of engine fireseal, and disconnect terminals (Fig. 201).
- (3) Connect Wheatstone Bridge to harness leads and measure circuit resistance (Fig. 202).
- (4) Take second reading with test leads reversed and obtain average resistance of opposite polarity readings.
- (5) Adjust load resistance to calculated resistance.
- (6) Make test connections to indicator leads (Fig. 202). Immerse test connections in ice bath.
- (7) Apply voltages and observe indicator readings. Lightly tap front of indicator before taking reading.

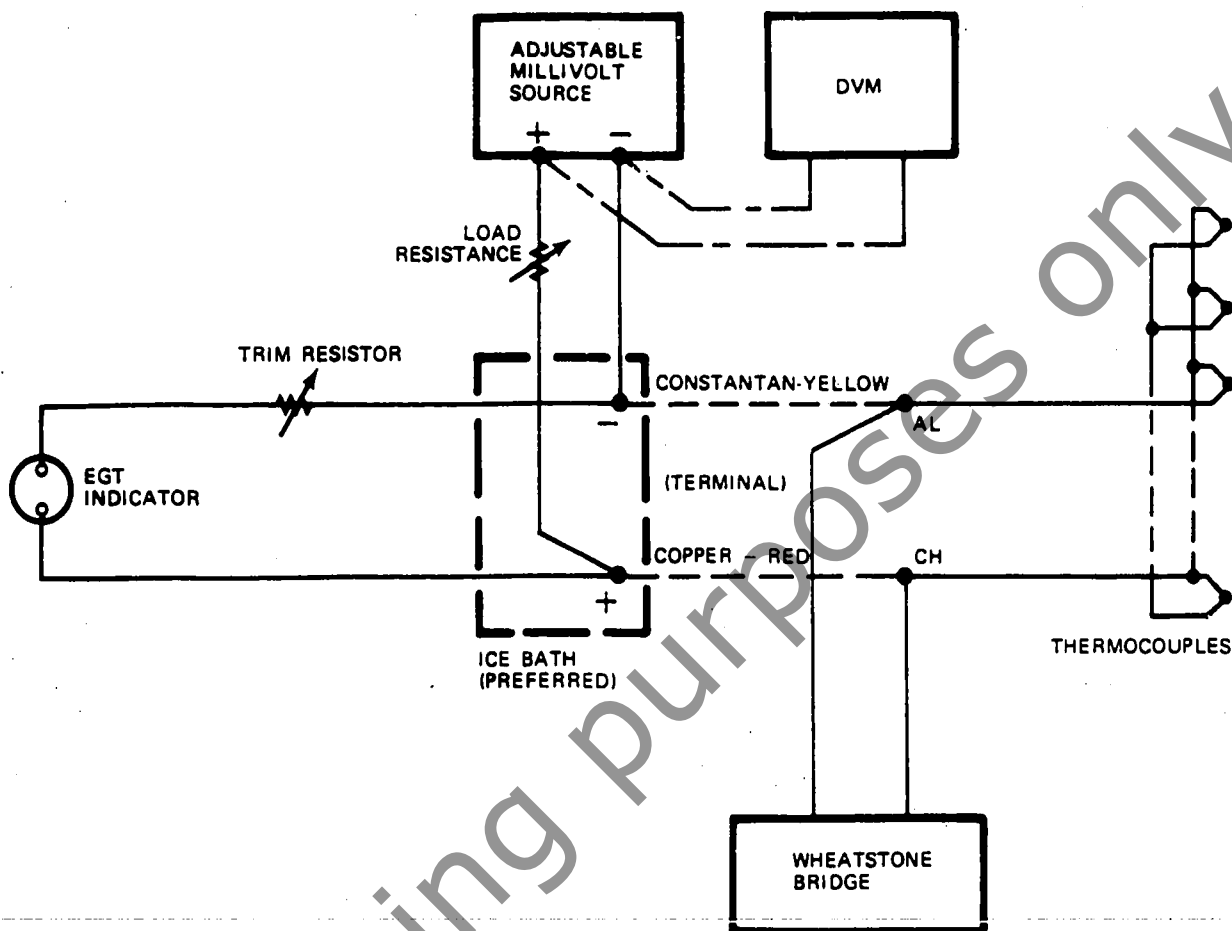
NOTE: A pointer movement greater than 25°C when tapping would be caused by defective indicator.

F. Operational Test No. 2 (Optional)

- (1) Perform steps E.(1) thru E.(5).
- (2) Make test connections to indicator leads (Fig. 202).
- (3) Monitor ambient temperature at test connections.
- (4) Apply voltages and observe indicator reading in Fig. 202 as adjusted for ambient temperature in Fig. 203.
- (5) Lightly tap front of indicator before taking reading.

NOTE: A pointer movement greater than 25°C when tapping would be caused by defective indicator.

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MILLIVOLTS-TO-INDICATED TEMPERATURE COMPARISONS

MILLIVOLT INPUT ($\pm 0.02\text{mv}$)	8.13	16.39	20.64	24.90	29.14	33.31	37.36	41.31
INDICATOR READING $^{\circ}\text{C}$	200	400	500	600	700	800	900	1000
INDICATOR READING TOLERANCE ($\pm ^{\circ}\text{C}$)	30	15	10	5	10	20	25	35

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AMBIENT REFERENCE TEMP °C	INDICATOR TEMPERATURE °C								
	000 ±40	200 ±30	400 ±15	500 ±10	600 ±5	700 ±10	800 ±20	900 ±25	1000 ±35
15	-0.60	7.53	15.79	20.04	24.30	28.54	32.71	36.76	40.71
16	-0.64	7.49	15.75	20.00	24.26	28.50	32.67	36.72	40.67
17	-0.68	7.45	15.71	19.96	24.22	28.46	32.63	36.68	40.63
18	-0.72	7.41	15.67	19.92	24.18	28.42	32.59	36.64	40.59
19	-0.76	7.37	15.63	19.88	24.14	28.38	32.55	36.60	40.55
20	-0.80	7.33	15.59	19.84	24.10	28.34	32.51	36.56	40.51
21	-0.84	7.29	15.55	19.80	24.06	28.30	32.47	36.52	40.47
22	-0.88	7.25	15.51	19.76	24.02	28.26	32.43	36.48	40.43
23	-0.92	7.21	15.47	19.72	23.98	28.22	32.39	36.44	40.39
24	-0.96	7.17	15.43	19.68	23.94	28.18	32.35	36.40	40.35
25	-1.00	7.13	15.39	19.64	23.90	28.14	32.31	36.36	40.31
26	-1.04	7.09	15.35	19.60	23.86	28.10	32.27	36.32	40.27
27	-1.08	7.05	15.31	19.56	23.82	28.06	32.23	36.28	40.23
28	-1.12	7.01	15.27	19.54	23.78	28.02	32.19	36.24	40.19
29	-1.16	6.97	15.23	19.48	23.74	27.98	32.15	36.20	40.15
30	-1.20	6.93	15.19	19.44	23.70	27.94	32.11	36.16	40.11
31	-1.24	6.89	15.15	19.40	23.66	27.90	32.07	36.12	40.07
32	-1.28	6.85	15.11	19.36	23.62	27.86	32.03	36.08	40.03
33	-1.32	6.81	15.07	19.34	23.58	27.82	31.99	36.04	39.99
34	-1.36	6.77	15.03	19.28	23.54	27.78	31.95	36.00	39.95
35	-1.40	6.72	14.98	19.24	23.50	27.74	31.90	35.96	39.90
36	-1.45	6.68	14.92	19.19	23.45	27.69	31.86	35.91	39.86
37	-1.49	6.64	14.88	19.15	23.41	27.65	31.82	35.87	39.82
38	-1.53	6.60	14.84	19.11	23.37	27.61	31.78	35.83	39.78
39	-1.57	6.56	14.80	19.07	23.33	27.57	31.74	35.79	39.74
40	-1.61	6.52	14.78	19.03	23.29	27.53	31.70	35.75	39.70

NOTE: Millivolt required for various ambient reference.

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EXHAUST GAS TEMPERATURE THERMOCOUPLE RESISTOR - MAINTENANCE PRACTICES

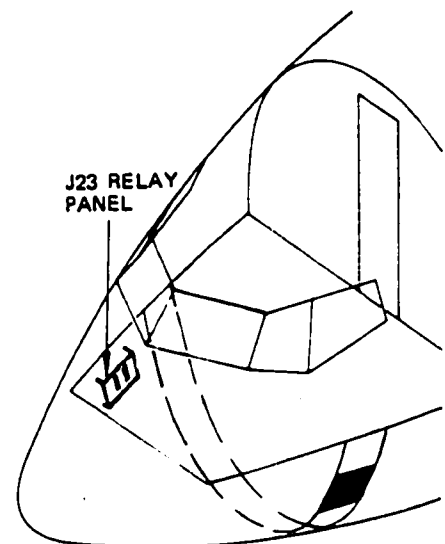
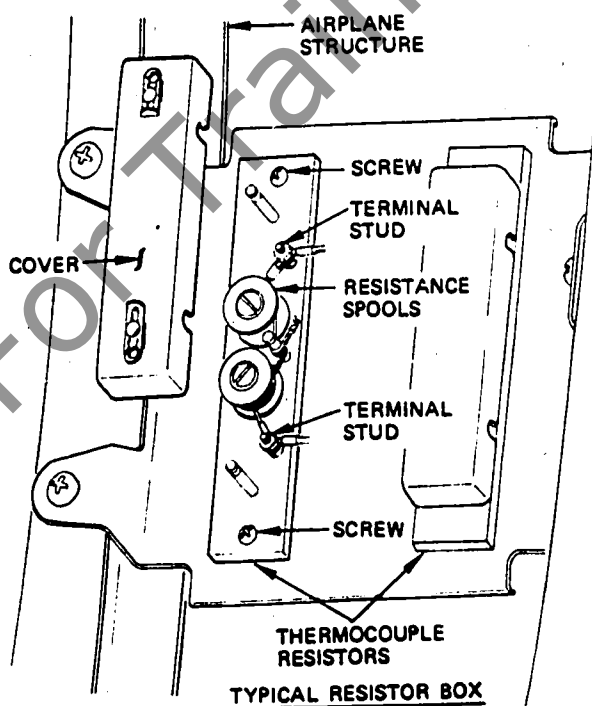
1. Adjustment/Test Exhaust Gas Temperature Thermocouple Resistor

A. General

- (1) The exhaust gas temperature thermocouple resistor is adjusted by shortening the resistance wire on the spools. Circuit resistance, excluding indicator, must be 22.00 ± 0.1 ohms. Total resistance of circuit including indicator is approximately 55 ohms. If it is necessary to increase circuit resistance, a new resistor must be installed and correctly adjusted (Fig. 201).

B. Adjust Exhaust Gas Temperature Thermocouple Resistor

- (1) Remove exhaust gas temperature indicator from instrument panel.
- (2) Remove wiring from indicator. Make good electrical connection between the two conductors on airplane wiring side of disconnect by bolting terminals together.
- (3) Obtain access to applicable thermocouple resistor; engine No. 1 and 2 resistors are mounted on left side of lower nose compartment. On airplanes HZ-ACA and HZ-ACB, resistors for engine No. 3 and 4 are located on right side of lower nose compartment. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, resistors for engine No. 3 and 4 are located on J23 relay panel. Remove resistor cover (Fig. 201).



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Maintenance Manual



- (4) Adjust resistor by unwinding resistor wire and measuring circuit resistance with Wheatstone Bridge as turns of wire are removed. Wire resistance is approximately 0.73 ohm per foot.
- (5) When correct circuit resistance of 22.00 (\pm 0.10) ohms is obtained, silver-solder resistance wire ends together.
- (6) Wind excess wire around post between resistor spools.
- (7) Replace resistor cover.
- (8) Remove connecting bolt from airplane wiring terminals and connect terminals to exhaust gas temperature indicator.
- (9) Install indicator on engine instrument panel.

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EXHAUST GAS TEMPERATURE THERMOCOUPLES - MAINTENANCE PRACTICES

1. Removal/Installation Exhaust Gas Temperature Thermocouple

A. Remove Exhaust Gas Temperature Thermocouple (See figure 201.)

- (1) Obtain access to thermocouples by opening side cowl panels.
- (2) Remove thermocouple harness leads from thermocouples.
- (3) Remove two bolts which fasten thermocouple to exhaust chamber.
- (4) Remove thermocouple from engine.

B. Install Exhaust Gas Temperature Thermocouple (See figure 201.)

- (1) Place thermocouple on mounting pad so that four gas holes in sampling probe face upstream.
- (2) Install and tighten two mounting bolts 65 to 85 pound-inches.
- (3) Connect thermocouple harness leads to studs on thermocouples and torque nuts to approximately 20 pound-inches.
- (4) Close side cowl panels.

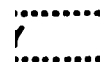
2. Adjustment/Test Exhaust Gas Temperature Thermocouple

A. Test Exhaust Gas Temperature Thermocouple

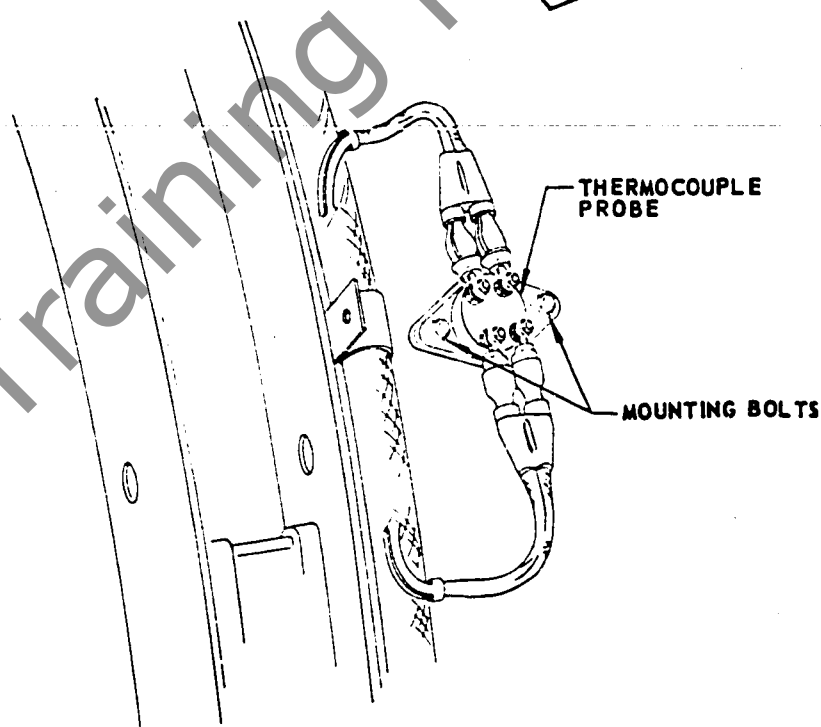
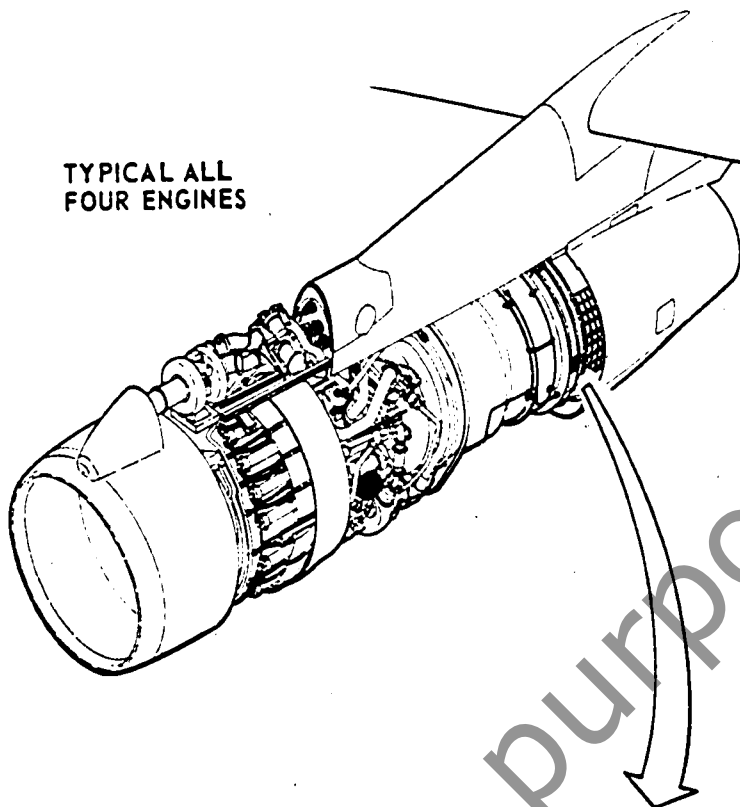
- (1) Place a soldering iron of at least 500 watts capacity against a thermocouple probe. Observe exhaust gas temperature indicator on engine instrument panel which should show a small reading. Allow time for indicator to return to zero then repeat procedure for each thermocouple probe.

NOTE: This is not a calibration check.

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EXHAUST GAS TEMPERATURE THERMOCOUPLE HARNESS AND LEAD - MAINTENANCE PRACTICES

EFFECTIVITY

ALL EXCEPT HZ-ACA and HZ-ACB

1. Removal/Installation Exhaust Gas Temperature Thermocouple Harness and Lead

A. Remove Thermocouple Harness and Lead

- (1) Remove teflon tape from thermocouple averaging circuit connector, located forward of engine fireseal, and disconnect terminals. (See figure 201, view 1).
- (2) Remove locknuts and bolts securing averaging circuit connector terminal support fitting to engine fireseal.
- (3) Pulling aft on averaging circuit lead, remove terminal support fitting from engine fireseal.
- (4) Remove locknuts and bolts securing test receptacle mounting bracket to engine fireseal.
- (5) Remove test receptacle from mounting bracket.
- (6) Pulling aft on test circuit lead, remove receptacle from engine fireseal.
- (7) Disconnect thermocouple leads from probe terminals.
- (8) Remove nuts and screws securing thermocouple harness and lead supporting clips.

NOTE: Tag harness and lead supporting clips being removed to assure their reinstallation in same location.

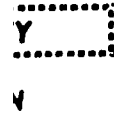
- (9) Remove harness and leads.

CAUTION: IN ALL HANDLING AND STORAGE, THE HARNESS AND LEADS SHOULD BE HUNG ON A RACK OR LAID ON A CLEAN TABLE FREE OF OIL AND MATERIAL WITH WHICH IT MAY BECOME ENTANGLED. SEVERE REPEATED FLEXING AND BENDING OR TWISTING WILL BREAK OR FRAY THE EXPOSED INSULATION. IF HUNG ON A RACK, CARE MUST BE TAKEN NOT TO INTRODUCE ANY SMALL RADIUS BENDS IN ANY PART OF THE ASSEMBLY.

- (10) Remove nuts and screws securing averaging circuit lead (from engine fireseal to strut firewall) supporting clips.
- (11) Disconnect averaging circuit lead connector at strut firewall (See figure 201, detail A), and remove lead.

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Maintenance Manual



B. Install Thermocouple Harness and Lead.

- (1) Position averaging circuit lead (from engine fireseal to strut firewall) on engine, and install supporting clips using screws and nuts.
- (2) Connect averaging circuit connector at strut firewall.
- (3) Position harness and leads on engine, and install supporting clips using screws and nuts.
- (4) Connect thermocouple leads to probe terminals.
- (5) Pull test receptacle forward through engine fireseal. (See figure 201, view 1.)
- (6) Secure test receptacle to mounting bracket.
- (7) Secure test receptacle mounting bracket to engine fireseal using bolts and locknuts.
- (8) Pull averaging circuit connector terminal support fitting forward through engine fireseal. (See figure 201, view 1.)
- (9) Secure averaging circuit connector terminal support fitting to engine fireseal using bolts and locknuts.
- (10) Connect averaging circuit connector terminals and wrap connection with teflon tape.

CAUTION: BE SURE THERE IS ENOUGH INSULATING MATERIAL BETWEEN THE TWO SETS OF CONNECTED TERMINALS TO PREVENT SHORTING OUT THE SYSTEM.

2. Adjustment/Test Exhaust Gas Temperature Thermocouple Harness and Lead

A. Equipment and Materials

- (1) Sensitive resistance measuring device - ohmmeter with a center scale value of approximately 10 ohms.
- (2) Low voltage ohmmeter capable of measuring resistance of 50,000 ohms. Meter should utilize less than 40 volts (dc) and should have an accuracy of five percent.

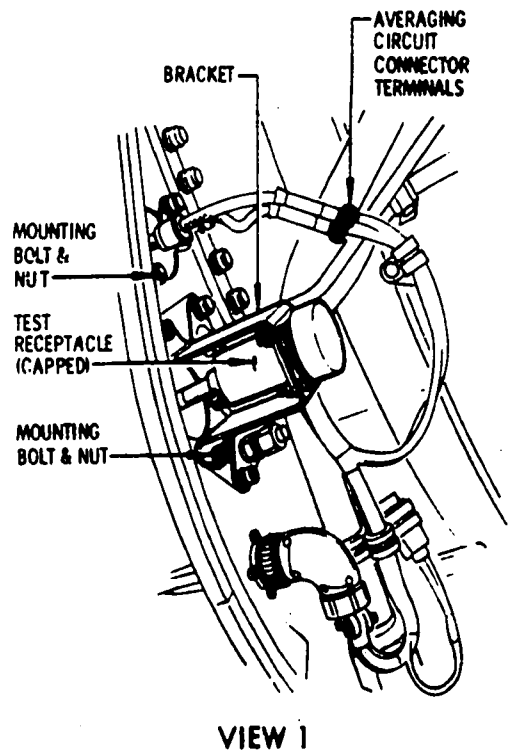
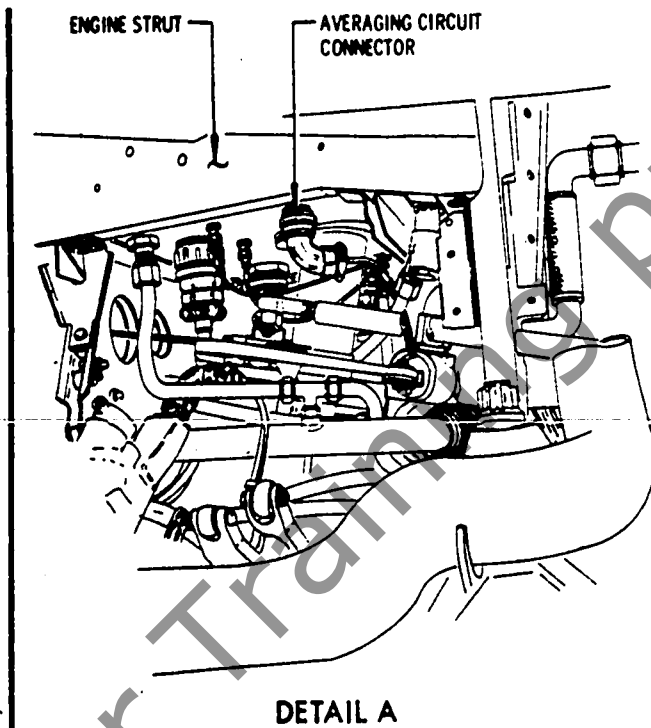
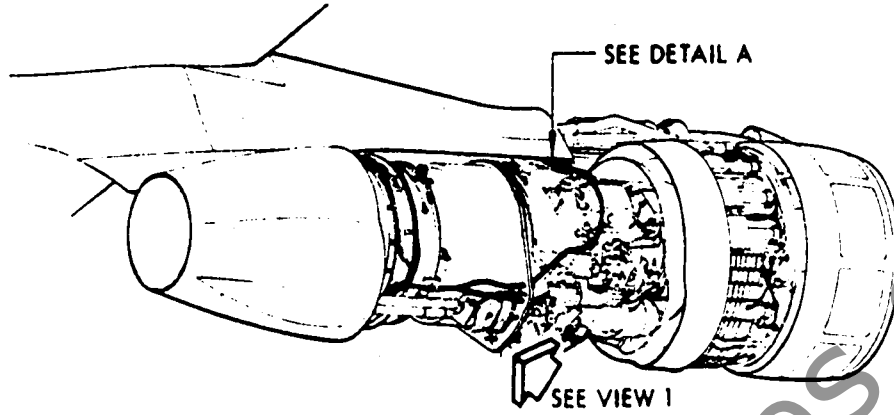
B. Test Thermocouple Harness and Lead Resistance.

- (1) Open both cowl panels on engine.
- (2) Remove teflon tape from thermocouple averaging circuit connector, located forward of engine fireseal, and disconnect terminals. (See figure 201, view 1).

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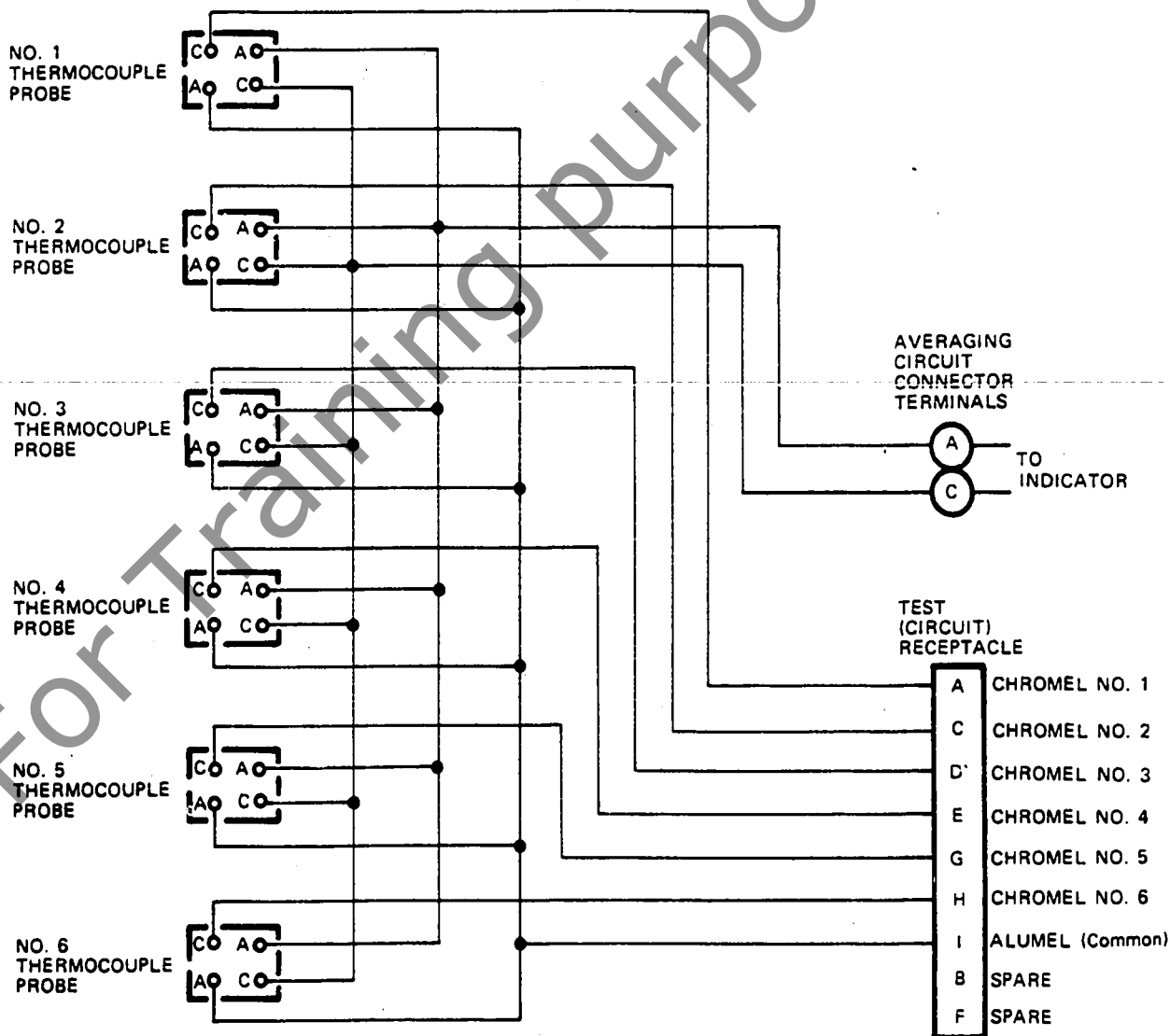
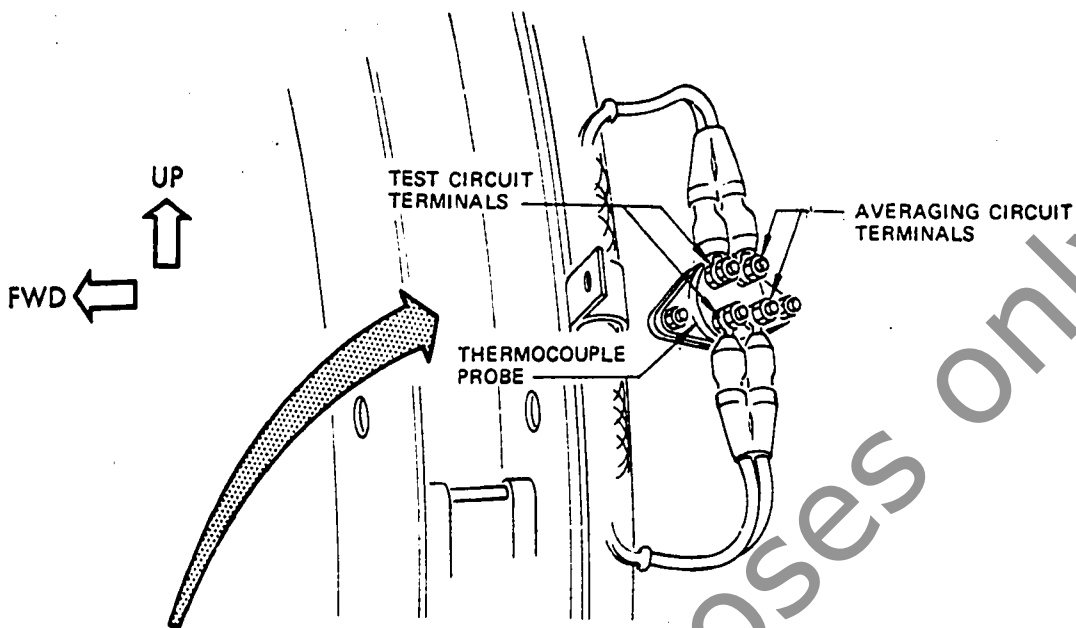
- (3) Place ohmmeter (sensitive) terminals in contact with averaging circuit fireseal connector alumel and chromel terminals (see figure 202), and measure resistance. Maximum allowable resistance is 2.05 ohms at 68°F (20°C).
- (4) Remove protective cap from test receptacle.
- (5) Place one ohmmeter terminal on test receptacle pin "I," other terminal on pin "A," and measure resistance. Maximum allowable resistance is 2.5 ohms at 68°F (20°C).
- (6) Repeat step (5) always leaving one ohmmeter terminal on pin "I," or common pin, and placing other terminal on each chromel pin successively ("C," "D," "E," "G," "H").
- (7) If resistance is not within limits, disconnect both sets of leads from thermocouple probes, and measure resistance of each thermocouple. (Resistance across thermocouple alumel and chromel terminals). Resistance of each thermocouple shall not exceed 0.250 ohms.
- (8) If resistance of each thermocouple is within limits, harness and leads are faulty, and should be replaced.

C. Test Thermocouple Harness and Lead Continuity

- (1) Install jumper across averaging circuit connector alumel and chromel terminals.
- (2) Disconnect both averaging circuit leads from thermocouple probe terminal studs on each probe if not already disconnected. Refer to figure 201.
- (3) Place or clamp ohmmeter (sensitive) terminals in contact with one set of disconnected thermocouple probe lead terminals. Refer to figure 202.
- (4) Flex harness and leads gently and observe instrument needle. If continuity does not exist, replace harness and leads.

NOTE: Broken wires which come in contact intermittently due to flexing will cause needle to fluctuate. False intermittent indications will result if ohmmeter terminals are not in firm contact with clean terminals, or if ohmmeter terminals or leads are defective.

For Training Purposes Only Maintenance Manual



For Training Purposes Only

Maintenance Manual

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- (5) Repeat steps (3) and (4) for other thermocouple probes.
- (6) Remove jumper from connector alumel and chromel terminals.
- (7) Place one ohmmeter terminal in contact with test receptacle pin "I" and other ohmmeter terminal in contact with test receptacle pin "A."
- (8) Flex harness and leads gently and observe instrument needle. If continuity does not exist, replace harness and leads. Refer to note in step (4).
- (9) Repeat steps (7) and (8) always leaving one ohmmeter terminal in contact with pin "I," or common pin, and placing other ohmmeter terminal in contact with each chromel pin successively ("C," "D," "E," "G," "H").

D. Test Thermocouple Harness and Lead Insulation Resistance.

WARNING: TO REDUCE POSSIBILITY OF IGNITING FUEL, DO NOT USE A MEGGER OR OTHER HIGH VOLTAGE OHMMETER.

- (1) Check averaging circuit insulation resistance between conductors by placing one ohmmeter (low voltage, high resistance) terminal in contact with connector alumel terminal, and other ohmmeter terminal in contact with chromel terminal, and measure resistance. Resistance shall not be less than 50,000 ohms.
- (2) Check averaging circuit insulation resistance between conductor and ground by placing one ohmmeter terminal in contact with connector alumel terminal and other ohmmeter terminal in contact with stainless steel wire braid and measure resistance. Resistance shall not be less than 50,000 ohms.
- (3) Repeat step (2) using averaging circuit chromel terminal.
- (4) Disconnect both test circuit leads from thermocouple probe studs on each probe. Refer to figure 202.
- (5) Check test circuit insulation resistance between conductors by placing one ohmmeter terminal in contact with receptacle pin "I" and other ohmmeter terminal in contact with each chromel pin successively and measure resistance. Resistance shall not be less than 50,000 ohms.
- (6) Check test circuit insulation resistance between conductor and ground by placing one ohmmeter terminal in contact with receptacle pin "I" and other ohmmeter terminal in contact with stainless steel wire braid and measure resistance. Resistance shall not be less than 50,000 ohms.

For Training Purposes Only

Maintenance Manual

- (7) Repeat step (6) using every chromel pin in place of alumel pin "I."
- (8) If resistance in any previous step was measured less than 50,000 ohms, proceed as follows: If full-scale deflection (zero ohms) was recorded, reject parts; if large (but not full-scale) deflection was recorded, presence of carbon or excessive moisture was indicated. Carbon yields a fairly steady reading. Moisture tends to produce readings which waver or drift after 5 to 30 seconds.
- (9) If presence of moisture was indicated, remove harness and leads and bake at 200° to 250°F (93° to 121°C) for one hour and recheck resistance. A substantial increase in readings indicates that moisture was cause of original low values.
- (10) Install harness and leads.
- (11) Connect leads to thermocouple probe studs.
- (12) Replace protective cap on test receptacle.
- (13) Connect averaging circuit connector terminals, and wrap connection with teflon tape.

CAUTION: BE SURE THERE IS ENOUGH INSULATING MATERIAL BETWEEN THE TWO SETS OF CONNECTED TERMINALS TO PREVENT SHORTING OUT THE SYSTEM.

- (14) Close engine cowl panels.

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Maintenance Manual

EXHAUST GAS TEMPERATURE THERMOCOUPLE HARNESS AND LEAD - MAINTENANCE PRACTICES

EFFECTIVITY

HZ-ACA, HZ-ACB

1. Removal/Installation Exhaust Gas Temperature Thermocouple Harness and Lead

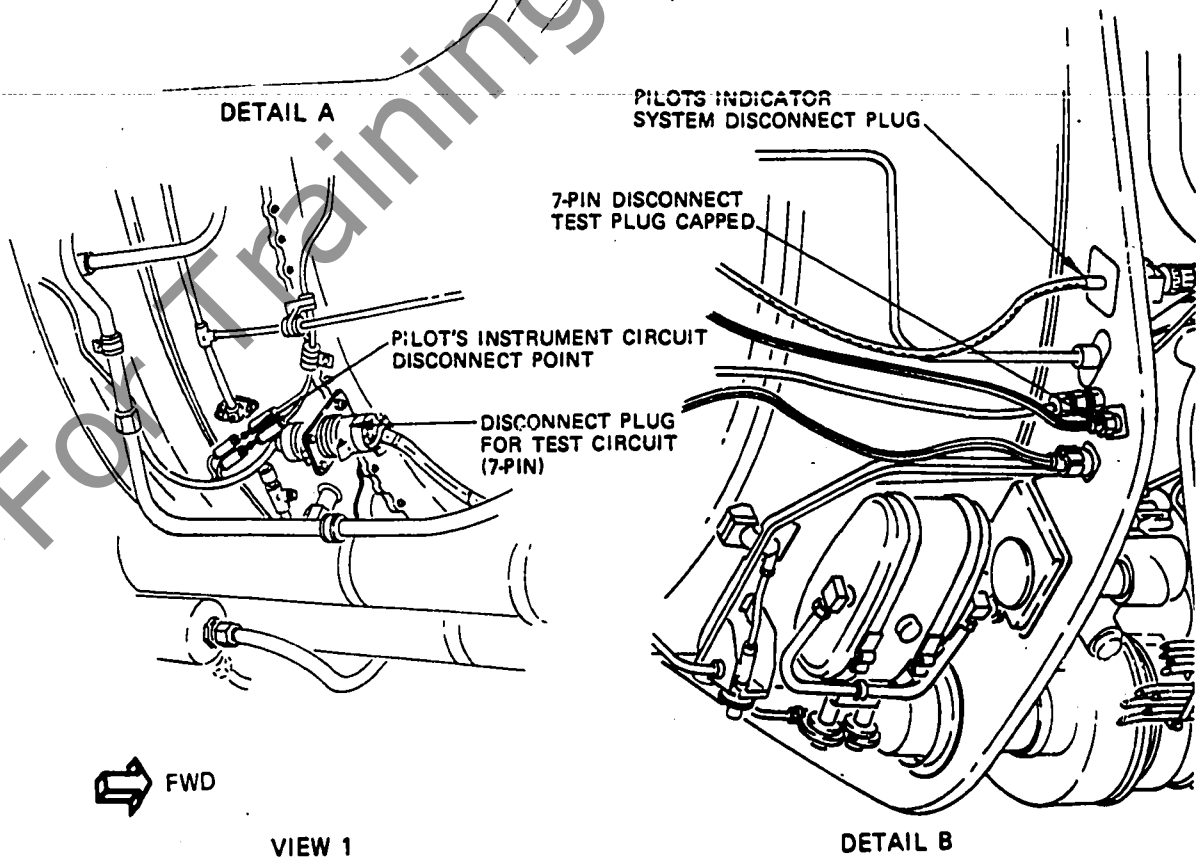
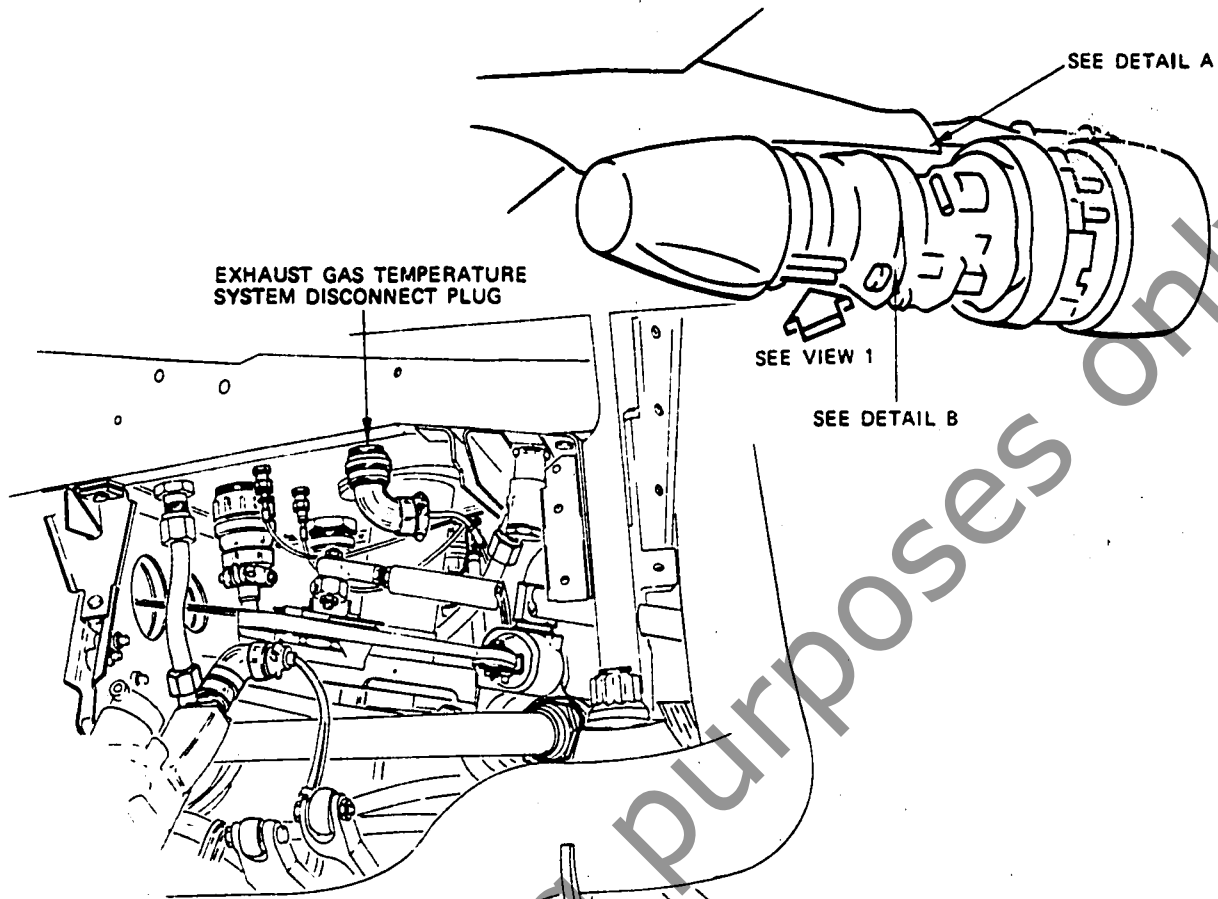
A. Remove Exhaust Gas Temperature Thermocouple Harness and Lead (See figure 201.)

- (1) Disconnect pilot's instrument thermocouple leads from thermocouple harness.
- (2) Remove seven-pin thermocouple harness receptacle from bracket located above thrust reverser actuators. See view 1. Remove seven-pin receptacle from engine firewall. Remove pilot's indicator system two-pin receptacle and bracket from engine firewall, (detail B.)
- (3) Disconnect thermocouple harness leads from respective thermocouples around periphery of engine exhaust housing. Tag thermocouple harness leads.
- (4) Loosen harness supporting clips and remove harness.
- (5) Disconnect support clips from thermocouple lead, uncouple EGT lead two-pin receptacle right side front of strut horizontal firewall, (detail A).
- (6) Remove thermocouple lead.

B. Install Exhaust Gas Temperature Thermocouple Harness and Lead (See figure 201.)

- (1) Position thermocouple harness around engine exhaust housing and bolt the thermocouple harness seven-pin receptacle to bracket located above thrust reverser actuators. (See view 1). Connect thermocouple harness leads to thermocouple studs.
- (2) Insert pilot's instrument connector of thermocouple lead through firewall and bolt in position. Connect other end to thermocouple harness. See view 1.
- (3) Bolt seven-pin receptacle with short lead to engine firewall and connect other end to thermocouple harness. Install cap on seven-pin receptacle. (Detail B.)
- (4) Route pilot's instrument lead forward to EGT disconnect plug on strut firewall. (See detail A.) Install clips holding lead to engine casing.

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Exhaust Gas Temperature Thermocouple Lead Installation
Figure 201

For Training Purposes Only

Maintenance Manual

2. Adjustment/Test Exhaust Gas Temperature Thermocouple Harness and Lead

A. Equipment and Materials

- (1) Sensitive resistance measuring device.
- (2) 500-volt megohmmeter.

B. Test Exhaust Gas Temperature Thermocouple Harness Leads Continuity

- (1) Disconnect the four thermocouple leads from any thermocouple.
- (2) Connect megohmmeter across one pair of leads. Check for continuity. Repeat for other pair of leads.

NOTE: One pair of leads from each probe form part of an incomplete circuit and will give a "no continuity" result when tested. Remaining pair should show continuity when tested.

- (3) Repeat steps (1) and (2) for all thermocouples.

C. Test Exhaust Gas Temperature Thermocouple Harness and Thermocouple Resistance

- (1) Disconnect the pilot's instrument lead at the thermocouple harness. (See view 1, figure 201.)
- (2) Using resistance measuring instrument check resistance between harness connections. Maximum reading should not exceed 2.05 ohms at 68°F (20°C).
- (3) If resistance is not within limits, disconnect harness from thermocouples and check that resistance of individual thermocouples does not exceed 0.25 ohms. If resistance of thermocouples is within limits then harness or leads are defective and should be replaced.
- (4) Repeat test between pins of seven-pin test plug.
- (5) With harness disconnected check the insulation resistance between each terminal and the thermocouple probe body. If resistance is between 10,000 and 2500 ohms the probe should be noted for replacement at the earliest opportunity.

D. Test Exhaust Gas Temperature System Thermocouple Harness and Lead Insulation

- (1) Disconnect thermocouple lead at two-pin receptacle on strut horizontal firewall. (detail A.)

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- (2) Place 500 volt megohmmeter test clip in one thermocouple lead connection pin and the other test clip on thermocouple lead outer wire braid. Flex harness and lead gently while observing instrument. A fluctuating resistance of less than 25,000 ohms may indicate moisture. Repeat for other pins.

CAUTION: REPEATED SEVERE FLEXING OR BENDING MAY BREAK OR FRAY THE INSULATION OF THE HARNESS OR LEAD. DO NOT ATTEMPT TO BEND HARNESS OR LEAD AROUND A SMALL RADIUS.

- (3) If a low or fluctuating resistance is indicated remove harness and lead; measure and record insulation resistance of each assembly.
- (4) Bake harness and lead at 200° to 250°F for one hour. Recheck insulation resistance values. A substantial increase in resistance indicates that moisture was the cause of original low readings.
- (5) Install and connect the harness and lead: connect harness leads to thermocouples. Repeat step (2). Again measure the resistance which must show a steady reading of at least 25,000 ohms at 68°F (20°C).

For Training Purposes Only Maintenance Manual

EXHAUST GAS TEMPERATURE INDICATOR - REMOVAL/INSTALLATION

NOTE: For general removal/installation of indicators, refer to Instrument Indicators, Chapter 31.

1. Remove Exhaust Gas Temperature Indicator

- A. Open applicable circuit breakers pertaining to indicator being removed.

WARNING: TAG AND SAFETY THE CIRCUIT BREAKERS.

- B. Record position of indicator (such as 9 o'clock position) with respect to rest of panel to facilitate installation.
- C. Loosen indicator mounting clamp adjustment screw.
- D. Remove indicator by pulling straight out of panel clamp.
- E. Disconnect terminals or electrical connector from indicator.

NOTE: Tag wires to identify if terminals are used.

2. Prepare for Installation

NOTE: If indicator is being replaced with a new indicator it will be necessary to prepare for installation in accordance with steps A. and B.

- A. Remove shorting strap from new indicator.
- B. Install shorting strap between alumel and chromel terminals on old removed indicator.
- C. Make certain applicable circuit breakers pertaining to indicator to be removed are open and tagged.

3. Install Exhaust Gas Temperature Indicator

- A. Connect terminals or electrical connector to indicator.
- B. Insert indicator into panel.
- C. Align indicator so that 9 o'clock position is as recorded in paragraph 1.B.
- D. Tighten mounting clamp adjustment screw.
- E. Close circuit breakers and remove safety tags.

For Training Purposes Only

Maintenance Manual

ENGINE TACHOMETER SYSTEM - DESCRIPTION AND OPERATION

1. General

- A. The engine tachometer system (Fig. 1) allows the rotary speed of an engine low pressure or high pressure compressor rotor to be read on indicators located in the control cabin. Each engine compressor drives a generator which supplies a three-phase electrical signal to operate the appropriate indicator.
- B. The engine tachometer system has two generator units (N1 and N2) on each engine and corresponding tachometer indicators. Tachometer system N1 indicates the speed of rotation of the low pressure compressor. Tachometer system N2 registers the speed of rotation of the high pressure compressor.

2. Engine Tachometer Generator

- A. The engine tachometer generators (N1 and N2) supply ac power for the operation of the indicators. Each tachometer generator consists of a stator and a permanent magnet rotor. The generator drive shaft turns the rotor inside the stator coils which produce an electrical signal whose frequency is a function of the engine compressor rpm. This signal is transmitted to the corresponding tachometer indicator by a two-wire system; the third phase is completed by ground (Fig. 2).
- B. The N1 tachometer generator (Detail A, Fig. 1) is located on the front accessory drive and the N2 tachometer generator (View 2, Fig. 1) is located on the aft right side of the main accessory drive gearbox. Each generator is driven by its respective compressor rotor through reduction gearing.

3. Engine Tachometer Indicator

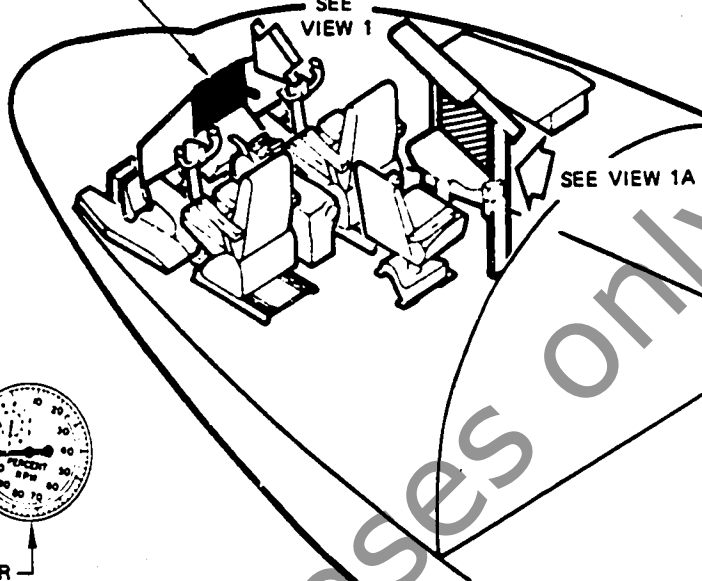
- A. Each engine tachometer indicator shows its respective engine rotor speed as a percentage of permissible maximum engine speed.
- B. Each tachometer indicator is hermetically sealed. On ALL EXCEPT airplanes HZ-ACC and HZ-ACD, the N1 and N2 indicators are located on the pilot's engine instrument panel. On airplanes HZ-ACC and HZ-ACD, the N1 indicators are located on the pilot's instrument panel and the N2 indicators are located on the flight engineer's panel (Fig. 1). The indicator contains a three-phase synchro-motor driving an induction drag cup mechanism. The synchro motor rotates at the same speed as the tachometer generator. The indicator dial is calibrated for reading between zero and 110% rpm.

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ENGINE INSTRUMENT PANEL

SEE VIEW 1

SEE VIEW 1A



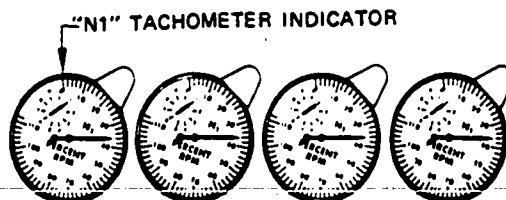
"N1" TACHOMETER INDICATOR



"N2" TACHOMETER INDICATOR

ENGINE INSTRUMENT PANEL

VIEW 1
HZ-ACE AND HZ-ACF



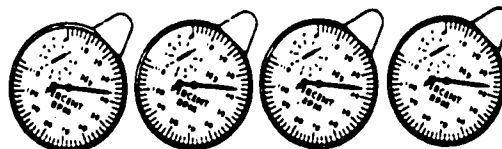
"N1" TACHOMETER INDICATOR

ENGINE INSTRUMENT PANEL

VIEW 1
HZ-ACC AND HZ-ACD



"N1" TACHOMETER INDICATOR



"N2" TACHOMETER INDICATOR

VIEW 1
HZ-ACA AND HZ-ACB

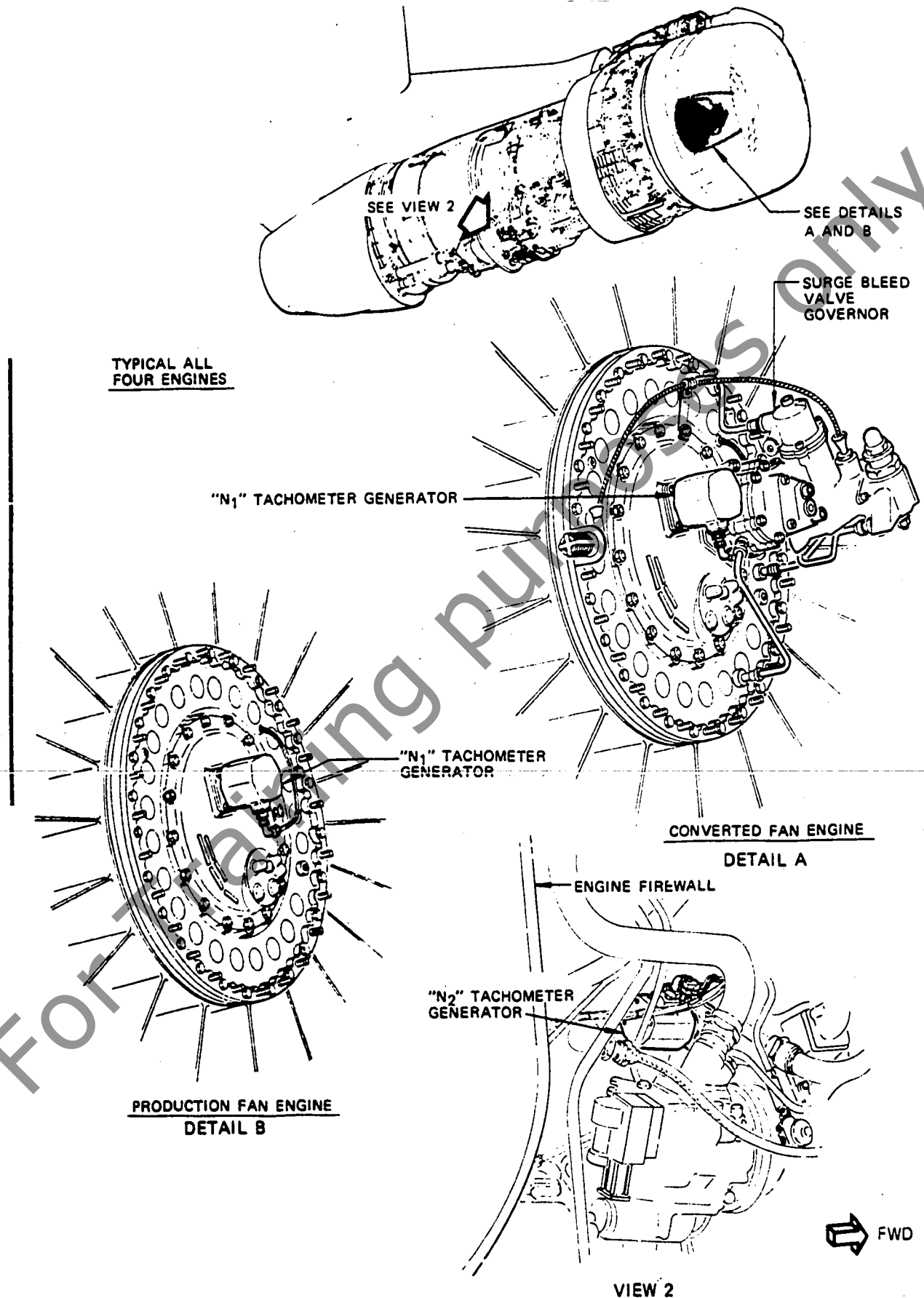


"N2" TACHOMETER INDICATOR

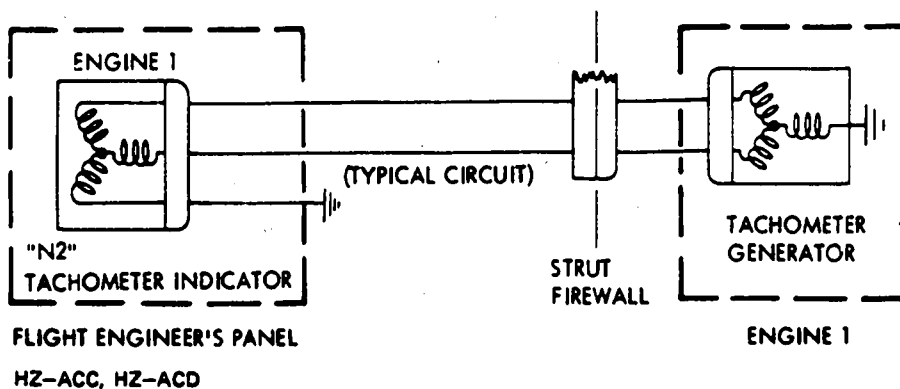
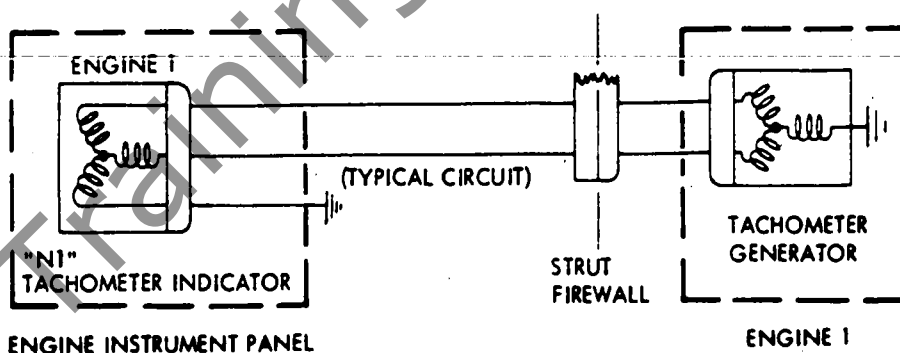
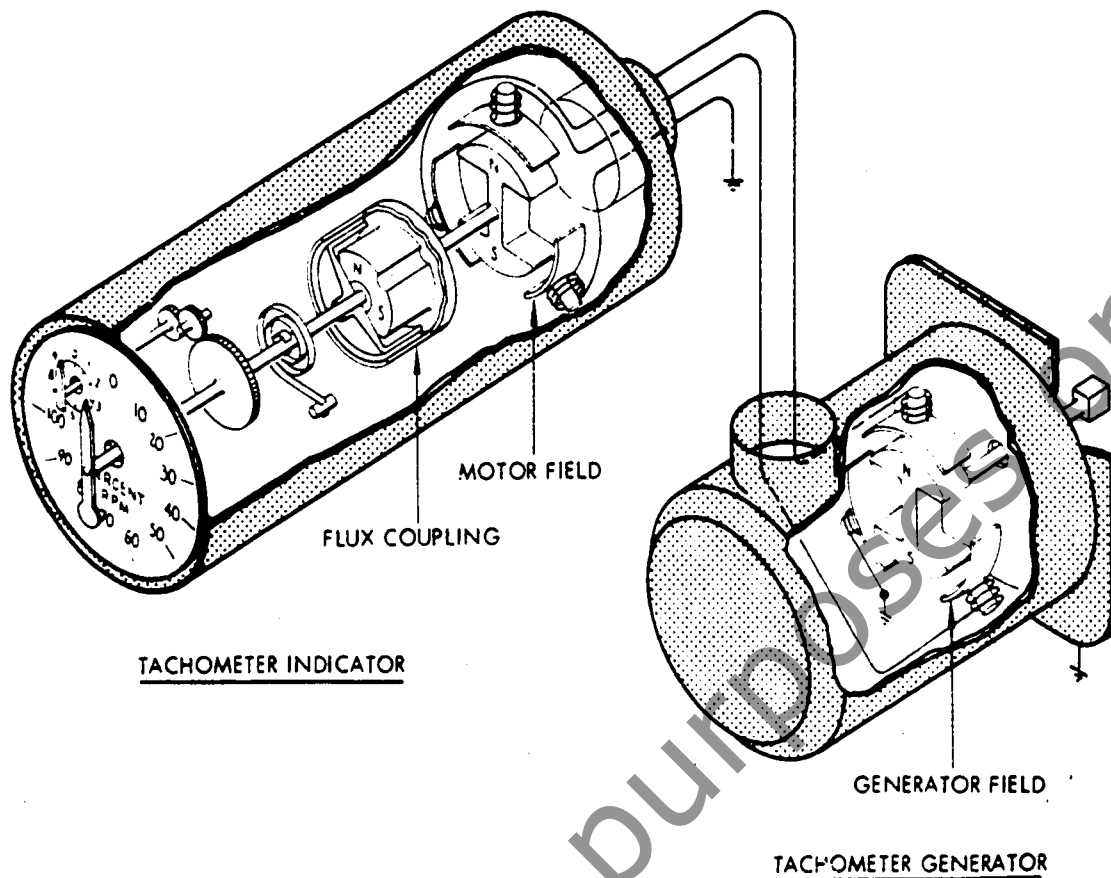
FLIGHT ENGINEER'S PANEL

VIEW 1A
HZ-ACC AND HZ-ACD

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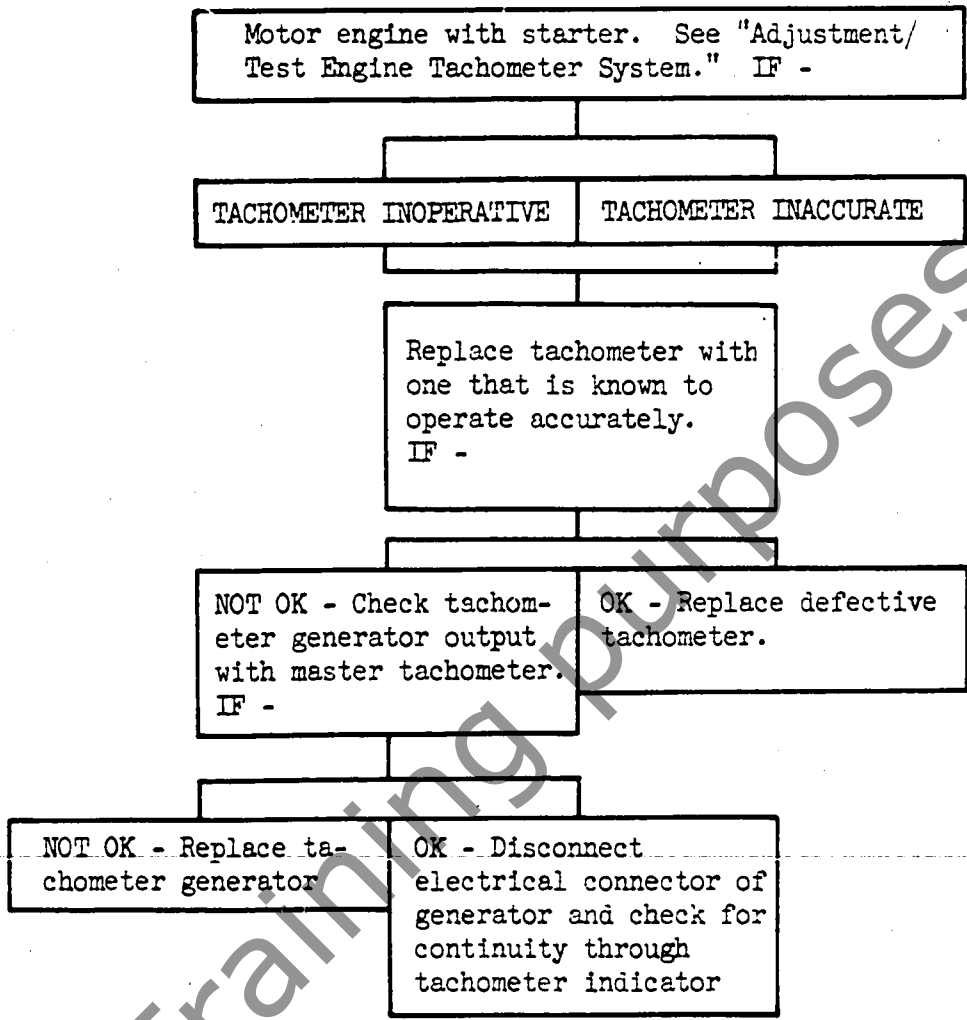
Engine Tachometer Schematic
Figure 2

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ENGINE TACHOMETER SYSTEM - TROUBLE SHOOTING



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ENGINE TACHOMETER SYSTEM - MAINTENANCE PRACTICES

1. Adjustment/Test Engine Tachometer System

A. General

- (1) The engine tachometer system can be tested only during engine run-up.

B. Equipment and Materials

- (1) Master Tachometer (with calibration correction chart)
- (2) Adapter harness for master tachometer.

C. Test Engine Tachometer System

- (1) Remove tachometer indicator from instrument panel.
- (2) Using adapter harness, connect master tachometer into system in parallel with engine tachometer indicator.

NOTE: Compare reading of the engine tachometer indicator with that of the master instrument at all speeds. At speeds below 95% rpm both instruments must agree within 2% rpm. At engine rpm between 95 and 102% both instruments must agree within 1%.

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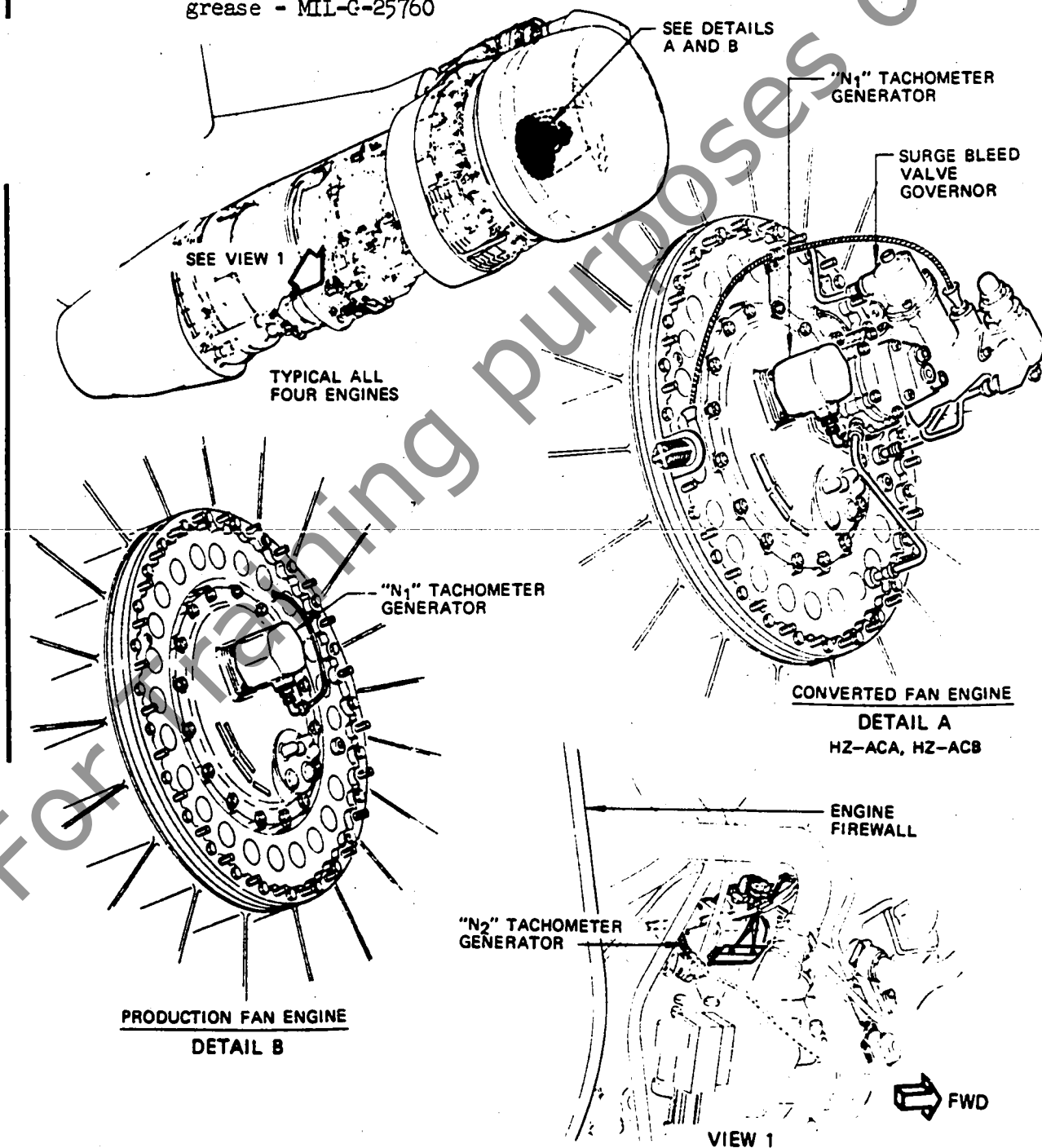
ENGINE TACHOMETER GENERATOR - MAINTENANCE PRACTICES

1. Removal/Installation Engine Tachometer Generator

A. Equipment and Materials

- (1) On airplanes HZ-ACA and HZ-ACB,
grease - MIL-L-3545

On ALL EXCEPT airplanes HZ-ACA and HZ-ACB,
grease - MIL-G-25760



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Maintenance Manual

B. Remove Engine Tachometer Generator (See figure 201.)

- (1) Disconnect electrical connector from applicable engine tachometer generator.
- (2) On N₂ tachometer generator, remove insulation type heat shield (if fitted).
- (3) Remove attaching nuts and washers which fasten tachometer generator to drive.
- (4) Remove generator and discard old gasket.

NOTE: Removal of N₂ generator is made easier if ignition harness is disconnected from ignitor and moved to one side. Refer to Chapter 7⁴.

CAUTION: CHECK CONDITION OF N₂ TACHOMETER GENERATOR HEAT SHIELD (IF FITTED) BEFORE INSTALLATION. IF TORN OR DAMAGED DISCARD AND REPLACE WITH NEW ONE.

C. Install Engine Tachometer Generator (See figure 201.)

- (1) Lightly coat splines of tachometer generator drive shaft with grease.
- (2) Place new gasket on mounting pad.
- (3) Place engine tachometer generator on mounting pad and carefully align drive shaft of tachometer generator.
- (4) Install washers and nuts attaching generator to engine.
- (5) Install insulation type heat shield (if fitted) around sides nearest to engine of N₂ tachometer generator.
- (6) Attach electrical connector to generator.

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Maintenance Manual

ENGINE VIBRATION INDICATING SYSTEM - DESCRIPTION AND OPERATION

1. General

- A. The engine vibration indicating system detects excessive engine vibration and provides indication of possible engine malfunction. Vibration measurements are registered on engine vibration indicators at the flight engineer's station.
- B. Each engine system consists of two vibration pickups, one vibration indicator and a pickup selector switch. One amplifier is provided for all four subsystems (Fig. 1). Electrical signals are generated by the vibration pickups, amplified by a four channel amplifier and rectified to a pulsating dc current which is fed to the appropriate indicator. One push-to-test switch is provided which permits a check of the four indicator channels.

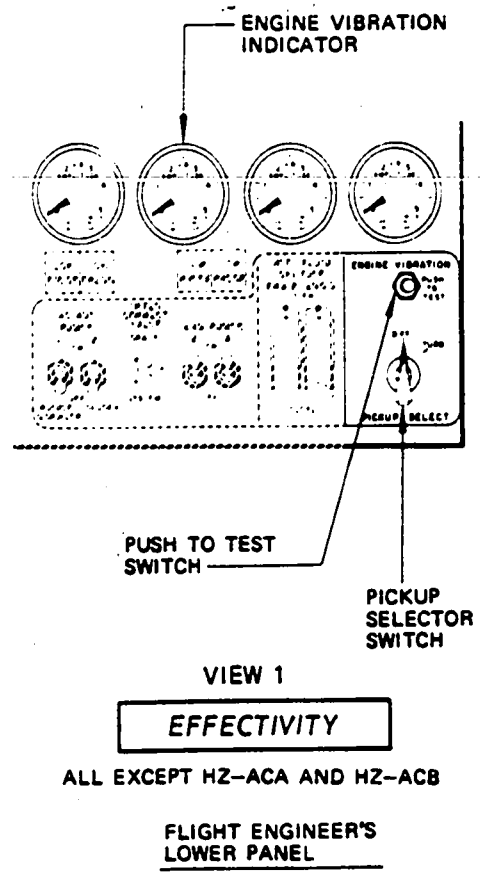
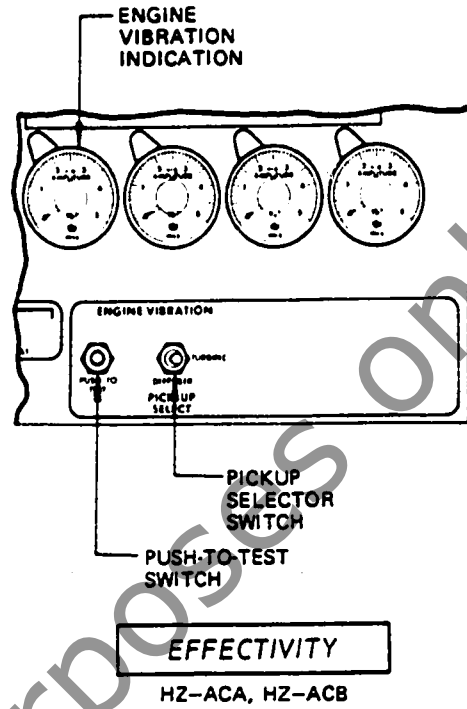
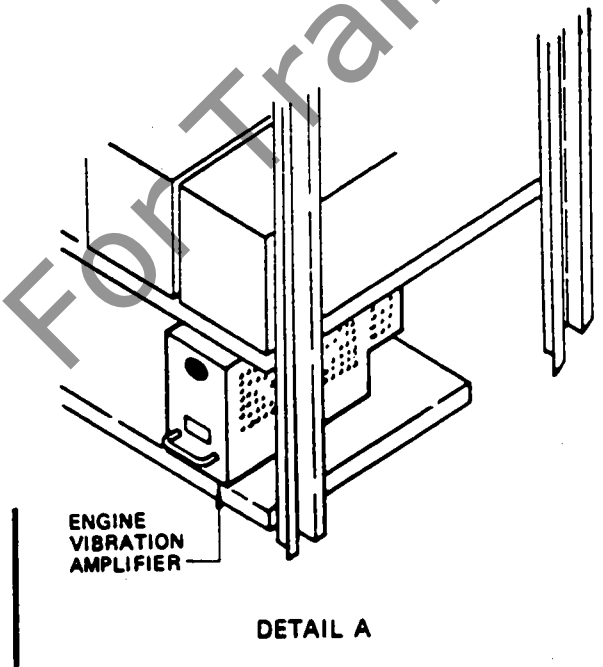
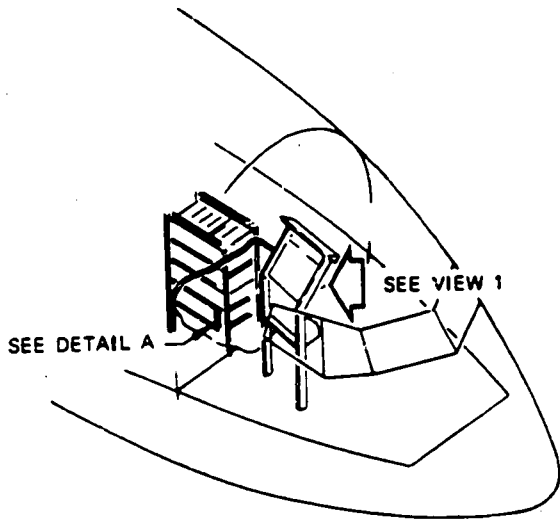
2. Engine Vibration Pickup

- A. The engine vibration pickup unit detects and transforms engine vibrations into electrical signals. This unit has a heavy stainless steel case containing a coil arranged around a spring-suspended magnet. One vibration pickup is attached to a bracket located at 9 o'clock on the front flange of the diffuser case. The other is on a bracket at 7 o'clock on the turbine case forward flange (Fig. 1).
- B. Engine vibration causes movement of the pickup housing and coil while the magnet tends to remain at rest. A voltage is generated proportional to the relative movement between the magnet and the coil. On airplanes HZ-ACA and HZ-ACB, the maximum peak-to-peak displacement between the magnet and the pickup case is approximately 0.50 inch. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, the peak-to-peak displacement between the magnet and the pickup case is 0.15 inch.

3. Engine Vibration Amplifier

- A. The engine vibration amplifier unit amplifies and rectifies the pickup signals before feeding them to the appropriate indicator. The amplifier assembly is made up of four amplifier modules each with a rectifier section to change output to pulsating dc.
- B. The amplifier assembly is mounted on a chassis together with its power supply unit and is located on the electronic equipment rack (Detail A, Fig. 1).

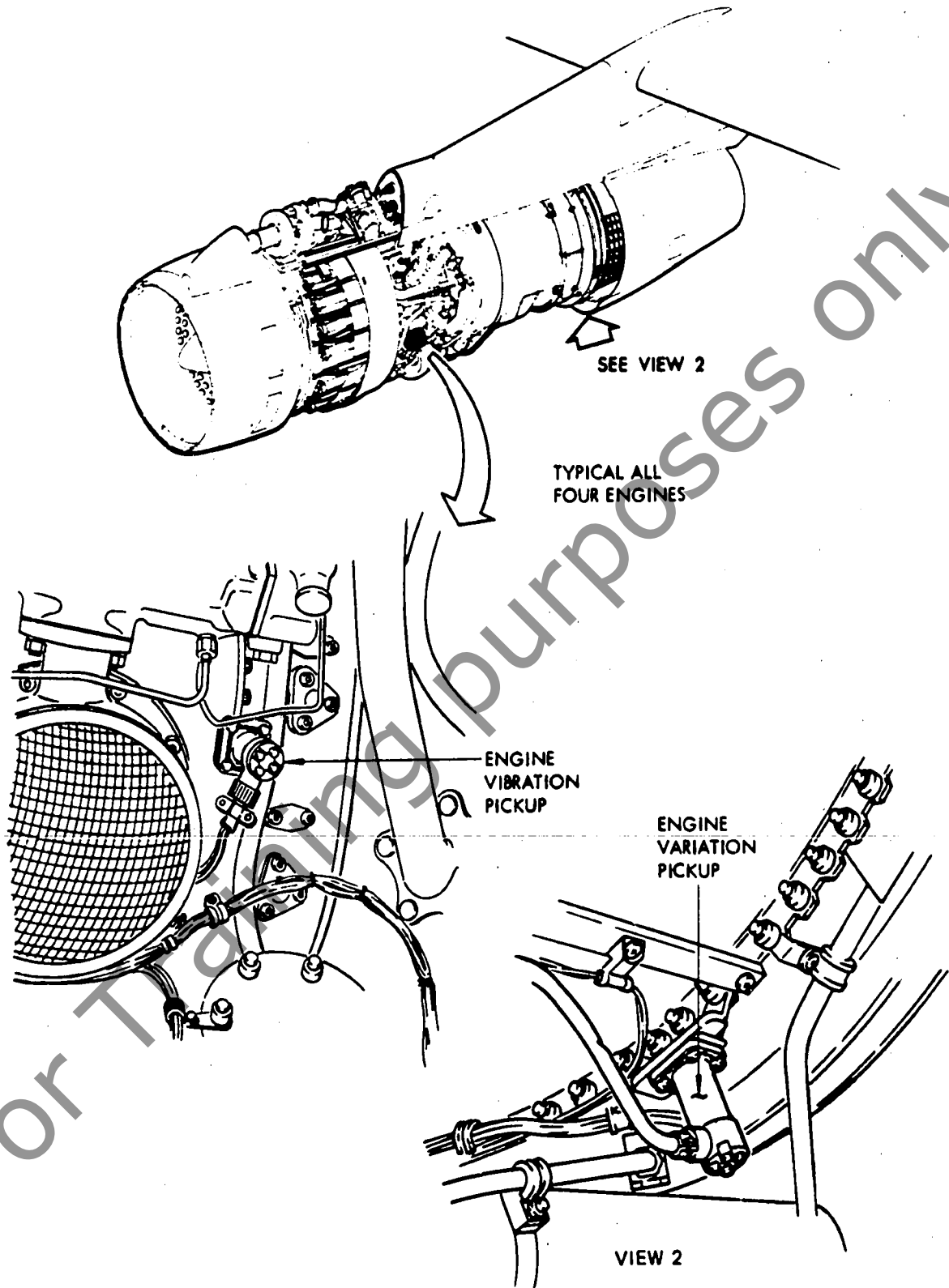
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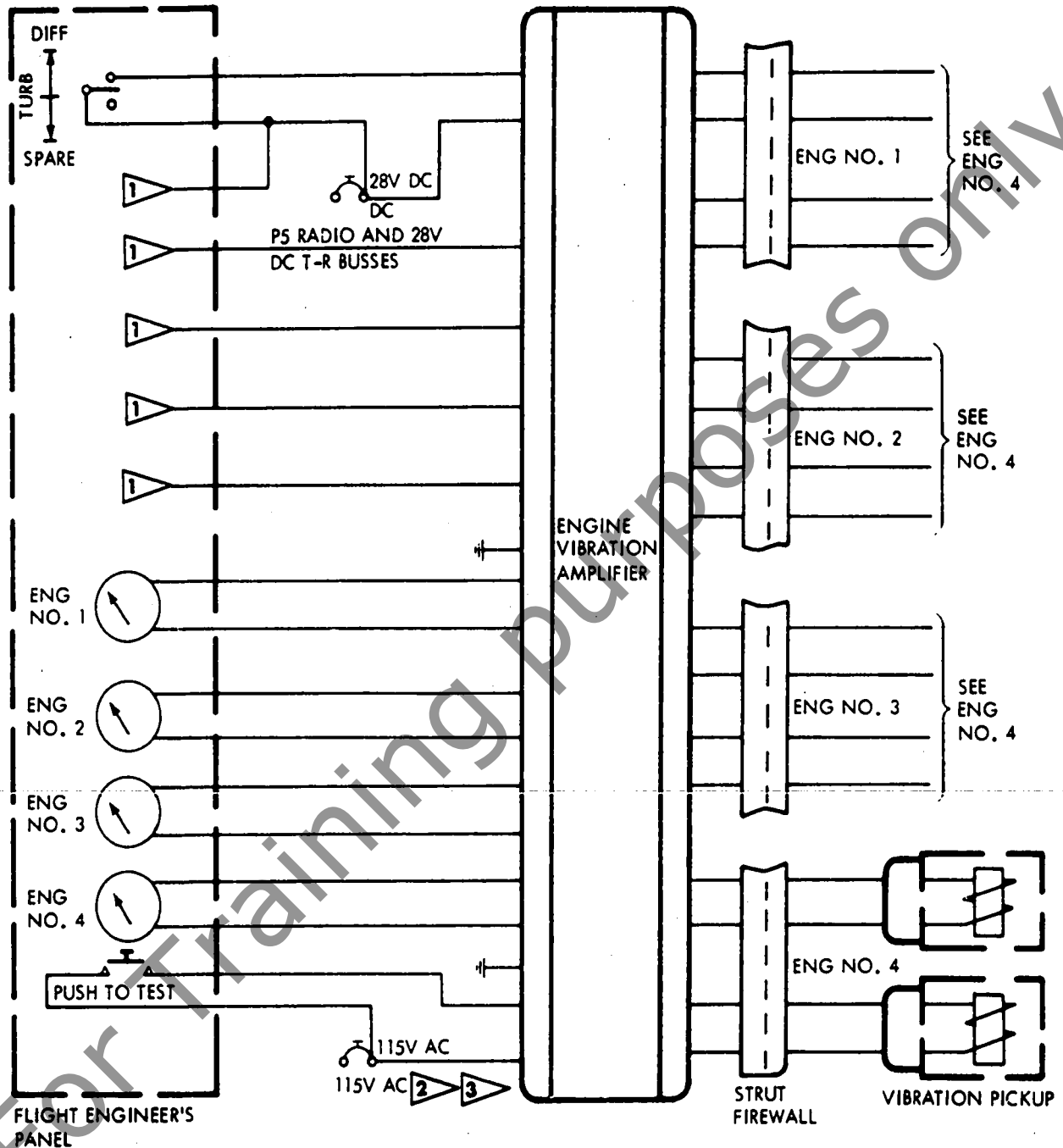
Engine Vibration Indicating System Equipment Location
Figure 1 (Sheet 1)

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- 1 THESE WIRES CAPPED
- 2 P2 115V AC, HZ-ACA, HZ-ACB
- 3 P4 115V AC, ALL EXCEPT HZ-ACA AND HZ-ACB

Engine Vibration System Circuit
Figure 2

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Maintenance Manual

4. Engine Vibration Indicator

- A. Each engine vibration indicator (View 1, Fig. 1) shows the amount of engine vibration. The indicator has a scale with five major graduations numbered 0 thru 5 VIB AMPLITUDE MILS. The engine vibration indicators are mounted in the lower right corner of the flight engineer's lower panel.

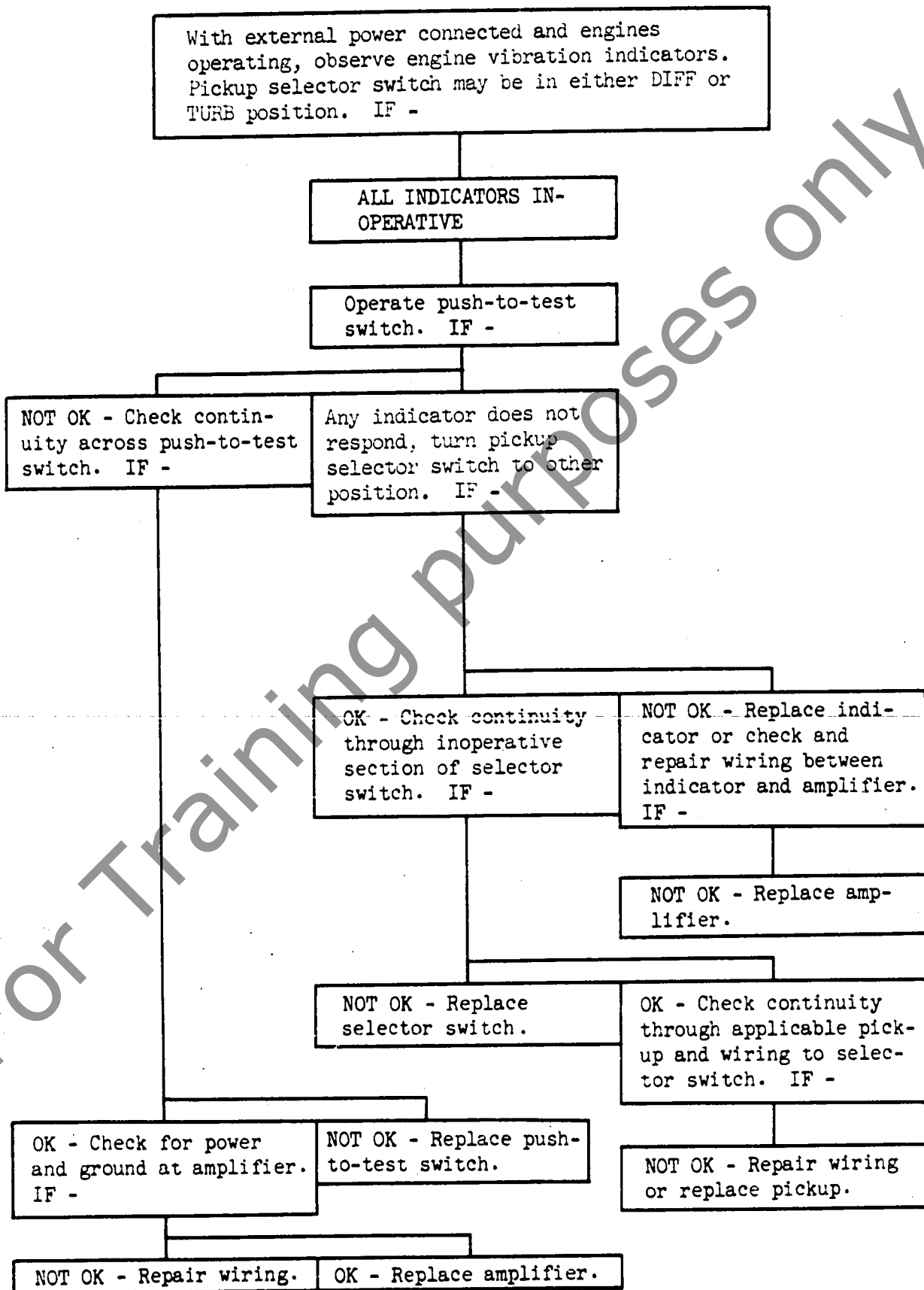
5. Operation

- A. The controls for the engine vibration indicating system are located on the flight engineer's lower panel. The pickup selector switch permits choice of signals from a pickup located on the diffuser case or a pickup attached to the engine turbine case. On airplanes HZ-ACA and HZ-ACB, electrical power is 115 volt ac obtained through a circuit breaker on ac bus No. 2 circuit breaker panel (P2) (Fig. 2).
- B. With engines operating a zero indication is not abnormal. If an unusually high signal is registered, the amplifier and indicator may be tested by actuating the push-to-test switch. This switch energizes a relay which removes engine vibration signals from the input circuit and substitutes a signal of predetermined value. When the test switch is operated the indicator should read 4.0 ± 0.5 on the scale. On ALL EXCEPT airplanes HZ-ACA and HZ-ACB, electrical power is 115 volt ac obtained through a circuit breaker on ac bus No. 4 circuit breaker panel (P4) (Fig. 2).

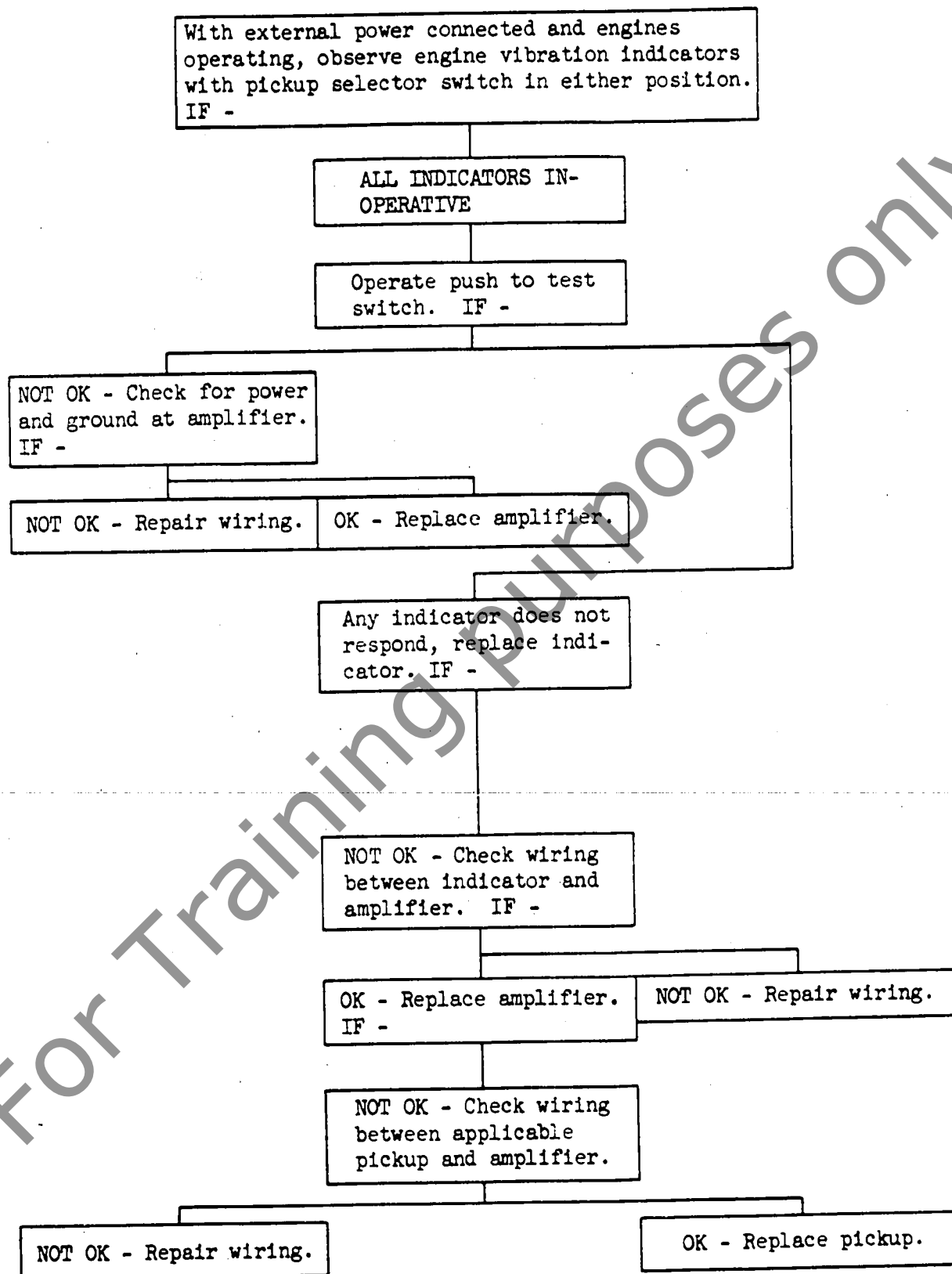
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Maintenance Manual

ENGINE VIBRATION INDICATING SYSTEM - TROUBLE SHOOTING



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For Training Purposes Only

Maintenance Manual

ENGINE VIBRATION INDICATING SYSTEM - MAINTENANCE PRACTICES

EFFECTIVITY

HZ-ACA and HZ-ACB

1. Adjustment/Test Engine Vibration Indicating System

A. Equipment and Materials

- (1) Signal generator capable of signal at 100 cps and 240 millivolts

B. Check System Operation (engines shut down)

- (1) With 115V AC and 28V DC system circuit breakers closed and pickup selector switch in the "DIFFUSER" position, operate the "PUSH-TO-TEST" switch. Indicator reading should be 4 (± 0.5).
- (2) Repeat with pickup selector switch in "TURBINE" position. Indicator reading should be 4 (± 0.5).

NOTE: If filter selector switch is fitted repeat (1) and (2) in both "HIGH" and "LOW" switch position.

- (3) Open any engine left side cowl panel.
- (4) With pickup selector switch on flight engineer's panel, set to "DIFFUSER" position, disconnect electrical plug from diffuser case pickup and connect in signal generator. With a 100 cps, 240 millivolt signal fed into the system the applicable flight engineer's indicator should read between 3.8 and 4.2.
- (5) If turbine pickup is fitted to engine, set pickup selector switch to "TURBINE" and repeat test procedure as in step (3). Reading at applicable flight engineer's indicator should be between 3.8 and 4.2.
- (6) Repeat (3), (4) and (5) for other engines.
- (7) Reconnect all pickup electrical plugs and close engine side cowl panels.

C. Check System Operation (engines operating)

- (1) With engine running at idle and power applied to vibration indicating system, set applicable engine pickup selector switch to "DIFFUSER" position.

For Training Purposes Only Maintenance Manual

- (2) Slowly advance engine power lever to maximum thrust position while observing applicable vibration indicator. Indicator pointer should move a minimum of half a pointer width at some moment during this engine operation.

NOTE: Movement of throttles should take at least 60 seconds.

- (3) Return power lever to "IDLE" and record maximum observed vibration reading and corresponding engine % N₂ rpm.
- (4) If turbine pickup is installed repeat (2) and (3) with selector switch in "TURBINE" position.
- (5) Shut down engine and repeat test on other engines.

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Maintenance Manual

ENGINE VIBRATION INDICATING SYSTEM - ADJUSTMENT/TEST

EFFECTIVITY

ALL EXCEPT HZ-ACA and HZ-ACB

1. Test System Operation (Engines Shut Down)
 - A. Connect external electrical power to airplane.
 - B. Pull 115 volts ac and 28 volts dc engine vibration indicating system circuit breakers on circuit breaker panel P4 and P5 respectively.
 - C. Open applicable engine left cowl panel.
 - D. Disconnect turbine section vibration pickup electrical plug. (Pickup located at approximately 7 o'clock position.)
 - E. Close 115 volts ac and 28 volts dc engine vibration indicating system circuit breakers.
 - F. With pickup selector switch in TURB position, push test switch.
 - G. Observe that applicable engine indicator scale reading is zero; then release test switch.
 - H. Pull 115 volts ac and 28 volts dc engine vibration indicating system circuit breakers.
 - I. Connect electrical plug to pickup.
 - J. Disconnect diffuser section vibration pickup electrical plug. (Pickup located at approximately 9 o'clock position.)
 - K. Close 115 volt ac and 28 volts dc engine vibration indicating system circuit breakers.
 - L. With pickup selector switch in DIFF position, push test switch.
 - M. Observe that applicable engine indicator scale reading is zero; then release test switch.
 - N. Pull 115 volts ac and 28 volts dc engine vibration indicating system circuit breakers.
 - O. Connect electrical plug to pickup.
 - P. Close engine cowl panel.

For Training Purposes Only

Maintenance Manual



- Q. Repeat steps C. through P. for other engines.
- R. Close 115V a-c and 28V d-c engine vibration indicating system circuit breakers.
- S. With pickup selector switch in "TURB" position, push test switch.
- T. Observe that all indicator scale readings are between 3.5 and 4.5.
- U. Repeat steps S. and T. with pickup selector switch in "DIFF" position.
- V. Determine whether there is any further need for electrical power on airplane, if not, remove external power.

2. Test System Operation (engines running)

- A. With engine running at "IDLE," check that 115V a-c and 28V d-c engine vibration indicating system circuit breakers are closed.
- B. Set pickup selector switch to "TURB" position.
- C. Slowly advance engine thrust lever to maximum thrust position, while observing indicator corresponding scale reading. Pointer shall move a minimum of half a pointer width at some instant during engine operation.

NOTE: Movement of thrust lever should take at least 60 seconds.

- D. Return thrust lever to "IDLE" position and record maximum observed vibration reading and corresponding engine N2 per cent rpm in log book.

NOTE: This test is not intended for establishing warning limits, but only to test functioning of system, and therefore obtained data can be used only as guide when warning limits are established for particular engine during first few flights after engine change.

- E. Repeat steps B. through D. with pickup selector switch in "DIFF" position.
- F. Shut down engine.
- G. Repeat steps A. through F. on other engines.

For Training Purposes Only

Maintenance Manual

ENGINE VIBRATION PICKUP - MAINTENANCE PRACTICES

1. Removal/Installation Engine Vibration Pickup

A. Remove Engine Vibration Pickup

- (1) Open left side cowl panel to gain access to vibration pickups.
- (2) Cut lockwire and disconnect electrical plug from vibration pickup. (See figure 201.)
- (3) Cut and remove lockwire from mounting screws.
- (4) Remove mounting screws and lift vibration pickup free of bracket.

B. Install Engine Vibration Pickup

- (1) Place vibration pickup on bracket and align holes. (See figure 201.)
- (2) Install and lockwire mounting screws.
- (3) Connect electrical plug to vibration pickup and lockwire.
- (4) Close left side cowl panel.

TYPICAL ALL
FOUR ENGINES

