PRELIMINARY

TECHNICAL MANUAL

INTERMEDIATE MAINTENANCE

TURBOFAN ENGINE

MODEL, YTF34-GE-2

GENERAL ELECTRIC
NAVY N00019-69-C-0424

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SAFETY SUMMARY

The following are general safety precautions that are not related to any specific procedures and therefore do not appear elsewhere in this publication. These are recommended precautions that personnel must understand and apply during many phases of operation and maintenance.

DO NOT STAND OR SIT UNDER A HOIST, OR CHAIN-FALL WHEN IN USE.

Under no circumstances should personnel stand or sit under a hoist, or chain-fall, when lifting engines or subassemblies.

DO NOT REMOVE, OR INSTALL ENGINES ALONE.

Under no circumstances should any person attempt to remove, or install an engine in the maintenance stand, or rail system alone; always obtain assistance from capable personnel.

THE FOLLOWING WARNINGS APPEAR IN THE TEXT, AND ARE REPEATED HERE FOR EMPHASIS.

WARNING

Menthanol
Fed Spec O-M-232

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Vapors are harmful. Avoid prolonged or repeated breathing of vapors. Do not use when ambient temperature is above 40°F unless adequate ventilation is provided according to local statuatory codes and regulations.
- May be fatal or cause blindness if swallowed. Cannot be made nonpoisonous.
- Keep container closed.
- Store in approved metal safety containers. (Paragraph 3-15.)

WARNING

Corrosion Preventive Compound
(Grade III)
MIL-C-16173

- Flammable - do not use near welding areas, near welding areas, near open flames and sparks, or on very hot surfaces.
- Use only with adequate ventilation.
- Avoid prolonged or repeated contact with skin.
- Avoid prolonged or repeated breathing of vapors.
- Store in approved metal safety containers. (Paragraph 3-21.)

WARNING

Trichloroethylene
Fed Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is

Trichloroethylene (Cont)

injurious to the lungs.
- Use only with adequate ventilation.
- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers. (Paragraph 4-67, 5-45, 5-86.)

WARNING

When ultrasonically cleaning parts, personnel shall be equipped with rubber gloves, an apron, and a face shield. The area should be well ventilated. (Paragraph 5-41.)

WARNING

Wear rubber gloves, an apron, and face shield while steam cleaning. (Paragraph 5-43.)

WARNING

Dry Cleaning Solvent
Fed Spec P-D-680

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Use only with adequate ventilation.
- Do not smoke when using it.
- Avoid prolonged or repeated breathing of vapors.
- Use protective creams and wear aprons, chemical goggles or face shield to protect the skin.
- Store in approved metal safety containers. (Paragraph 5-39, 5-49.)

WARNING

Phosphoric Acid
Fed Spec O-O-670

- Causes skin irritation.
- Avoid contact with skin and eyes.
- Wear approved gloves and goggles (or face shield) when handling, and wash hands thoroughly after handling. (Paragraph 5-54.)

WARNING

Properly positioned black light is harmless to the skin and eyes. Developing powder is not harmful to inhale, but may be annoying in heavy concentration. Irritation is apt to result if the penetrating oil remains on the skin for several days. To avoid this, use brackets to hold parts, and wear neoprene gloves when necessary. The presence of penetrating oil on the skin can be detected under black light. (Paragraph 5-70.)

WARNING

- Do not inhale vapors from solvents.
- Do not use solvents near flame or open sparks. (Paragraph 5-80.)

WARNING

Avoid contact with electrical output when operating any ignition component. Be sure the ignition unit and plugs are grounded before energizing the circuit. Never hold or contact the igniter plug when energizing the ignition circuit. (Paragraph 11-5.)

WARNING

Do not come closer than 160 feet of the rear of the engine with the engine running at max power. Do not come any closer than 25 feet of fan intake. (Paragraph 1-9.)

WARNING

Remove rings and watches before performing maintenance tasks.

LIST OF APPLICABLE TECHNICAL DIRECTIVES (FIELD SERVICE INSTRUCTIONS)

TECHNICAL DIRECTIVE NO. (FIELD SERVICE INSTRUCTION)	DATE	TITLE (ECP NO.)	DATE OF INCORP
1	23 June 71	Compressor Rotor Locking Lugs, Number 3 Bearing Shim Thickness and Power Takeoff Assembly Duplex Bearing Locknut - Inspection of	N/A
2	June 71	Main Electrical Harness - Relocation of (ECP 34E-32)	1 Oct 71
2 Amend 1	30 July 71	Same as above	1 Oct 71
3	30 July 71	C-Sump Oil Supply and Seal Pressurizing Tubes - Reclamping of	1 Oct 71
4	15 Sep 71	First-Stage Turbine Aft Cooling Plate - Replacement of (ECP 34H-1)	1 Oct 71
5	1 Oct 71	Starting Primer Nozzle System - Installation of (ECP 34L-1)	1 Oct 71
6	27 Sep 71	Engine Shipping Container - Rework of (ECP 34E-33)	N/A
7	5 Oct 71	Exhaust Frame Scavenge Tube at 6 O'clock Position - Rework of	N/A
8	5 Nov 71	Fan Housing, Replacement of (ECP 34V-1)	15 March 72
9	10 Dec 71	Front Frame Flight Cover Bolts, Replacement of	15 March 72
10	21 Jan 72	Fan Vanes, Feedback Cable, Hoses, and Anti-ice Ducting, Inspection of	N/A
11	21 Jan 72	Fuel Pump, Replacement of (ECP 62983-8089)	N/A
11 Amend 1	24 Feb 72	Same as above	N/A
12	27 Jan 72	Periodic Inspection of Feedback Cable, Fan Vanes, and Combustion Liner Fuel Scrolls	N/A
13	21 Jan 72	Thermocouple Harness and Control Amplifier, Replacement of (ECP 34N-1)	15 March 72

INTRODUCTION

This handbook, prepared by General Electric Company, Lynn, Massachusetts, under contract N00019-69-C-0424, contains all essential information required by maintenance personnel to perform intermediate maintenance on the YTF34-GE-2 turbofan engine.

Safety: This publication is intended to provide safe procedures and processes for accomplishing the maintenance herein described. It is, therefore, important that the Warnings of possible personnel injury be thoroughly understood and observed by the users of this manual. Changes or additions deemed necessary for safety improvements should be submitted through channels in accordance with OPNAV INST. 4790. 2.

The users of this manual should also be knowledgeable of the safety requirements outlined in Navy publication, Safety Precautions for Shore Activities, NAVSO-P-2455, especially as it applies to safe maintenance practices.

Table A lists the maintenance work which can be performed on these engines during intermediate maintenance. Allowable maintenance is consistent with spare parts provisioning, tooling and maintenance site capability.

These engines are designed and manufactured by the Aircraft Engine Group, General Electric Company, Turbotown, Lynn, Massachusetts 01910.

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES.

Note

The listing below defines maintenance levels and classifies specific maintenance functions for which tools and parts have been provisioned. Each maintenance level is responsible for the functions of all lower maintenance as specified.

Maintenance allocation for intermediate maintenance activities (IMA's) is divided into three maintenance levels as follows:

First Degree:

This maintenance level includes disassembly and repair to a depth which includes and goes beyond maintenance functions authorized for Second and Third Degree IMA's but not to the extent required to perform Depot Overhaul. First Degree Maintenance is Complete Engine Repair (CER) which includes capability of compressor rotor replacement or disassembly to a degree that the compressor rotor assembly could be removed. Activities designated as First Degree Maintenance will be equipped to accomplish CER as well as lesser degrees of maintenance including incorporation of all technical directives (PPC's and PPB's) below depot level of maintenance.

Second Degree:

This maintenance level includes the restoration of a damaged or non-operating engine, its accessories or components to an acceptable operating condition, including repair or replacement of turbine rotors and combustion sections. Also authorized is replacement of externally damaged, deteriorated or time limited components, gearboxes, or accessories and conducting engine calendar (or equivalent) inspections. In addition, minor repair to the compressor section is authorized (replacement of compressor rotor blades with rotor installed and dressing nicks in compressor vanes and blades within limits specified in the manual).

Third Degree:

This maintenance level includes restoration of a damaged or non-operating engine, its accessories or components to an acceptable condition as in Second Degree maintenance level. However, certain functions that require high manhour expenditures and are of a low incident rate will be deleted from Third Degree maintenance capability.

Some spare/replacement parts (and related special tools) will not be available at all levels of maintenance; therefore, the Maintenance Allocation Table may list procedures for both "Remove/Install" or "Replacement" for some components. In the event that tooling, parts support, personnel, or other factors preclude the functions as outlined, the affected activities shall ship the engine to a higher level maintenance for repair.

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES.

Level of Maintenance					
	Intermediate				
Organizational	Third Degree	Second Degree	First Degree	Procedure	Functions
X*			X	Test.	Functional test and adjustment of power plant and power plant system using engine test stand.
X	X	X	X	Service.	Clean, preserve and replenish oil and hydraulic systems.
X	X	X	X	Preservation/Depreservation	Preservation/Depreservation of engine.
X			X	Cleaning	Cleaning engine compressor for performance recovery.
X	X	X	X	Replacement.	1. All hoses, lines, harnesses and QEC.
X					2. Removal and Installation of engine.
X	X	X	X	Inspection and replacement.	All filters and magnetic plugs.
	X	X	X	Clean.	
X	X	X	X	Troubleshoot.	Determine engine malfunctions using GSE
X				Inspection.	1. Preflight.
X					2. Daily/Special.
X					3. Postflight/Conditional.
X	X	X	X		4. Calendar/Installed or Removed.
X				Repair.	1. Minor (installed).
X	X	X	X		2. Replace parts.
		X	X		3. Major.
			X		4. Complete.
				ACCESSORIES:	
X	X	X	X	Replacement.	Fuel pump.
X	X	X	X	Replacement.	Fuel heater.
X	X	X	X	Replacement.	Fuel filter.
X	X	X	X	Inspection/replacement.	Fuel filter element.
	X	X	X	Clean.	
X			X	Adjustment.	Fuel control.
X	X	X	X	Replacement.	
X	X	X	X	Replacement.	Compressor Inlet Temperature (T2) sensor.
X	X	X	X	Replacement.	Fuel distributor.

* On-wing

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organi-zational	Third Degree	Second Degree	First Degree	Procedure	Functions
		X	X	Removal/Installation.	Fuel manifold assembly.
X	X	X	X	Replacement.	Fuel manifold block.
X	X	X	X	Replacement.	Fuel manifold hoses.
X	X	X	X	Replacement.	Fuel tubes.
X	X	X	X	Replacement.	VG actuators.
X	X	X	X	Replacement.	Feedback cable.
X	X	X	X	Replacement.	Lube and scavenge pump.
X	X	X	X	Replacement.	A-sump scavenge pump.
X	X	X	X	Replacement.	Oil cooler.
X	X	X	X	Replacement.	Oil tubes/hoses (external).
X	X	X	X	Replacement.	Oil pressure transmitter.
X	X	X	X	Replacement.	Oil tank.
X	X	X	X	Replacement.	Oil tank drain valve.
X	X	X	X	Replacement.	Oil tank relief valve.
X	X	X	X	Inspection/replacement.	Oil filter element.
X	X	X	X	Inspect, clean, replacement	Chip detectors.
X			X	Adjustment.	Control amplifier.
X	X	X	X	Replacement.	
X	X	X	X	Replacement.	Electrical cable assemblies.
X	X	X	X	Replacement.	Thermocouple harness and leads.
X	X	X	X	Replacement.	Fan speed sensor.
X	X	X	X	Replacement.	Alternator stator.
X	X	X	X	Replacement.	Exciter.
X	X	X	X	Replacement.	Igniter leads.
X	X	X	X	Replacement.	Igniter plugs.
X	X	X	X	Replacement.	Anti-icing valve.
X	X	X	X	Replacement.	Pressure valve.
X	X	X	X	Replacement.	P5 pressure probe.
		X	X	Replacement.	Accessory gearbox.
X	X	X	X	Replacement.	Accessory gearbox seals.

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organizational	Third Degree	Second Degree	First Degree	Procedure	Functions
				FAN SECTION:	
		X	X	Replacement.	Fan rotor assembly.
X	X	X	X	Minor repair.	
X	X	X	X	Replacement.	Fan front and rear spinners.
	X	X	X	Repair.	
X	X	X	X	Minor repair.	Fan blade.
X	X	X	X	Replacement.	
X	X	X	X	Replacement.	Blade retaining pin.
		X	X	Replacement.	Fan stator tierod.
X	X	X	X	Minor repair.	
		X	X	Replacement.	Fan housing assembly.
X	X	X	X	Minor repair.	
X	X	X	X	Replacement.	Blade removal port cover.
		X	X	Replacement.	Fan outer cowl upper segment.
X	X	X	X	Minor repair.	
		X	X	Replacement.	Fan outer cowl lower segment.
X	X	X	X	Removal/Installation.	
X	X	X	X	Minor repair.	
X	X	X	X	Replacement.	Fan inner cowl segment.
X	X	X	X	Minor repair.	
		X	X	Major repair.	
		X	X	Replacement/minor repair.	Fan casing.
		X	X	Replacement.	Fan pylon fairing.
		X	X	Replacement.	1. Side panels.
		X	X		2. Stiffener plate.
X	X	X	X	Minor repair.	
		X	X	Major repair.	
		X	X	Replacement.	Fan nozzle inner frame.
		X	X	Repair.	

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organi-zational	Third Degree	Second Degree	First Degree	Procedure	Functions
X	X	X	X	Replacement.	Fan vane.
X	X	X	X	Repair.	
X	X	X	X	Replacement.	Forward anti-icing tube.
	X	X	X	Repair.	
		X	X	Replacement.	Splitter nose.
		X	X	Minor repair.	
		X	X	Replacement.	Splitter cone panel.
		X	X	Repair.	
		X	X	Replacement.	Pylon nose.
		X	X	Repair.	
		X	X	Replacement.	No. 1 and 2 bearings, support plate, housing and seal.
		X	X	Repair.	No. 1 and 2 bearing housing and support plate.
	X	X	X	Replacement.	6 o'clock position drain strut.
	X	X	X	Repair.	
		X	X	Replacement.	Fan lower outer cowl adapter flange.
		X	X	Repair.	
				COMPRESSOR SECTION:	
			X	Replacement/minor repair.	Compressor front frame.
			X	Replacement.	No. 3 bearing, oil seal, and housing.
			X	Repair.	No. 3 bearing housing.
		X	X	Replacement.	Power takeoff assembly and radial drive shaft.
			X	Replacement.	Compressor rotor assembly.
		X	X	Minor repair.	
		X	X	Replacement/repair.	Compressor blades.
		X	X	Removal/installation.	Compressor stator assembly (stages IGV to 10).

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organi-zational	Third Degree	Second Degree	First Degree	Procedure	Functions
		X	X	Replacement.	Compressor casing.
		X	X	Replacement/repair.	Compressor vanes (all stages).
		X	X	Replacement/repair.	Vane shroud rings.
		X	X	Replacement/repair.	Vane actuating rings.
		X	X	Replacement.	Vane actuating levers.
		X	X	Removal/installation.	Compressor stator assembly (stages 11 - 13).
		X	X	Replacement.	Compressor rear casing.
		X	X	Replacement.	Actuation system linkage.
	X	X	X	Minor repair.	
				COMBUSTION SECTION:	
			X	Replacement/repair.	Combustion chamber frame.
		X	X	Replacement/repair.	Outlet guide vane.
	X	X	X	Replacement.	Combustion liner.
		X	X	Repair.	
			X	Replacement/repair.	B-sump housing.
			X	Replacement.	No. 4 bearing.
			X	Replacement.	No. 4 bearing oil seal.
			X	Replacement	Compressor discharge stationary air seal.
		X	X	Replacement.	No. 5 bearing.
		X	X	Replacement.	No. 5 bearing oil seal.
	X	X	X	Replacement.	Inner and outer stationary balance piston seals.
	X	X	X	Replacement.	Stage 1 turbine nozzle segments.
	X	X	X	Removal/installation.	Combustion chamber rear inner duct.
		X	X	Replacement.	
		X	X	Repair.	
	X	X	X	Removal/installation.	Stage 1 turbine nozzle inner support.

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organizational	Third Degree	Second Degree	First Degree	Procedure	Functions
		X	X	Replacement.	
		X	X	Repair.	
			X	Replacement/repair.	Rear engine mount.
			X	Replacement/repair.	Thrust mount link assembly.
				HIGH-PRESSURE TURBINE SECTION:	
	X	X	X	Removal/installation.	Rotor assembly.
		X	X	Replacement/minor repair.	
		X	X	Removal/installation.	Stage 1 front cooling plate.
		X	X	Replacement/repair.	Stages 1 and 2 blades.
		X	X	Removal/installation.	Stage 2 rear cooling plate.
		X	X	Replacement.	Outer turbine casing.
		X	X	Repair.	
	X	X	X	Removal/installation.	Inner turbine casing.
		X	X	Replacement.	
		X	X	Repair.	
	X	X	X	Replacement.	Stage 2 stationary interstage seal.
	X	X	X	Replacement.	Stage 2 nozzle segments.
	X	X	X	Replacement.	Shroud sectors.
	X	X	X	Removal/installation.	
		X	X	Replacement.	Transition casing.
		X	X	Minor repair.	
		X	X	Replacement.	Transition outer liner.
		X	X	Minor repair.	
		X	X	Replacement.	Transition inner liner.
		X	X	Minor repair.	
				LOW-PRESSURE TURBINE SECTION:	
		X	X	Replacement.	Stages 3-6 nozzle segments.
		X	X	Replacement/minor repair.	Rotor assembly.

TABLE A. BREAKDOWN OF ENGINE MAINTENANCE FOR INTERMEDIATE LEVEL ACTIVITIES. (Cont)

Level of Maintenance					
	Intermediate				
Organi-zational	Third Degree	Second Degree	First Degree	Procedure	Functions
		X	X	Replacement.	Stage 3 blades.
		X	X	Replacement/repair.	Stages 4 - 6 blades.
		X	X	Removal/installation.	Stator assembly.
		X	X	Replacement.	Turbine casing.
		X	X	Repair.	
		X	X	Replacement.	Stationary interstage seals.
		X	X	Replacement.	Shroud sectors.
		X	X	Removal/installation.	
	X	X	X	Removal/installation.	Turbine module.
		X	X	Replacement.	
		X	X	Repair.	
		X	X	Replacement.	Fan drive shaft assembly.
		X	X	Repair.	
				<u>EXHAUST SECTION:</u>	
		X	X	Replacement/minor repair.	Exhaust frame.
		X	X	Replacement.	No. 6 bearing, oil seal, and housing.
		X	X	Repair.	No. 6 bearing housing.
		X	X	Replacement.	No. 7 bearing and housing.
		X	X	Repair.	No. 7 bearing housing.
	X	X	X	Replacement.	No. 7 bearing oil seal.
	X	X	X	Replacement.	Air Vent collector.
		X	X	Minor repair.	
	X	X	X	Replacement.	C-sump rear cover.
		X	X	Repair.	
	X	X	X	Replacement/minor repair.	Exhaust centerbody.
		X	X	Major repair.	
	X	X	X	Replacement.	Anti-icing air seal (internal).
	X	X	X	Replacement.	Rear anti-icing tube.

SECTION I
GENERAL INFORMATION

1-1. GENERAL.

1-2. The instructions and information in this manual apply to the YTF34-GE-2 turbofan engine. (See figures 1-1 and 1-2.) This section provides general information to be used by maintenance personnel to further their understanding of the engine. It includes:

1. A description of the engine and its related systems.

2. Principles of operation.

3. Listing of consumable materials (table 1-4) and expendable materials (table 1-5) at the end of this section.

1-3. BASIC DESCRIPTION, PERFORMANCE RATINGS AND LEADING PARTICULARS.

1-4. BASIC DESCRIPTION.

1-5. GENERAL. The YTF34-GE-2 turbofan engine a dual-rotor front-fan configuration with a bypass ratio of 6.23. It has a single-stage fan with pressure-ratio of 1.51 to 1, and a 14-stage axial-flow compressor with variable stators and nominal pressure-ratio of 14.5 to 1. The combustor is an annular type. The gas generator (core engine) high pressure turbine has 2 axial-flow stages, both air-cooled. The fan low-pressure turbine has 4 axial-flow stages and drives the fan through a concentric shaft passing forward inside the core engine rotor. The engine mounted accessory gearbox, driven through the six o'clock front frame strut off the gas generator rotor, provides a maximum combined hydraulic and electrical power extraction capability of 285 shaft horsepower. The lube system including engine oil tank is completely self-contained. The fan nozzle is an engine component. The engine provides bolted flanges for connection of the aircraft primary exhaust nozzle and attachment of aircraft cowling.

1-6. Basic engine components and mechanical operation are described in paragraphs 1-11 through 1-42. Engine systems and their components are described briefly in paragraphs 1-43 and 1-55. A more complex description of the engine systems is included in Section IX.

1-7. LEADING PARTICULARS. Basic engine data is listed in table 1-1.

1-8. PERFORMANCE RATINGS. The YTF34-GE-2 engine is capable of producing 9,275 pounds of thrust at a fan speed of 7,365 RPM at standard sea level static conditions. Performance ratings for the YTF34-GE-2 engine are shown in table 1-2.

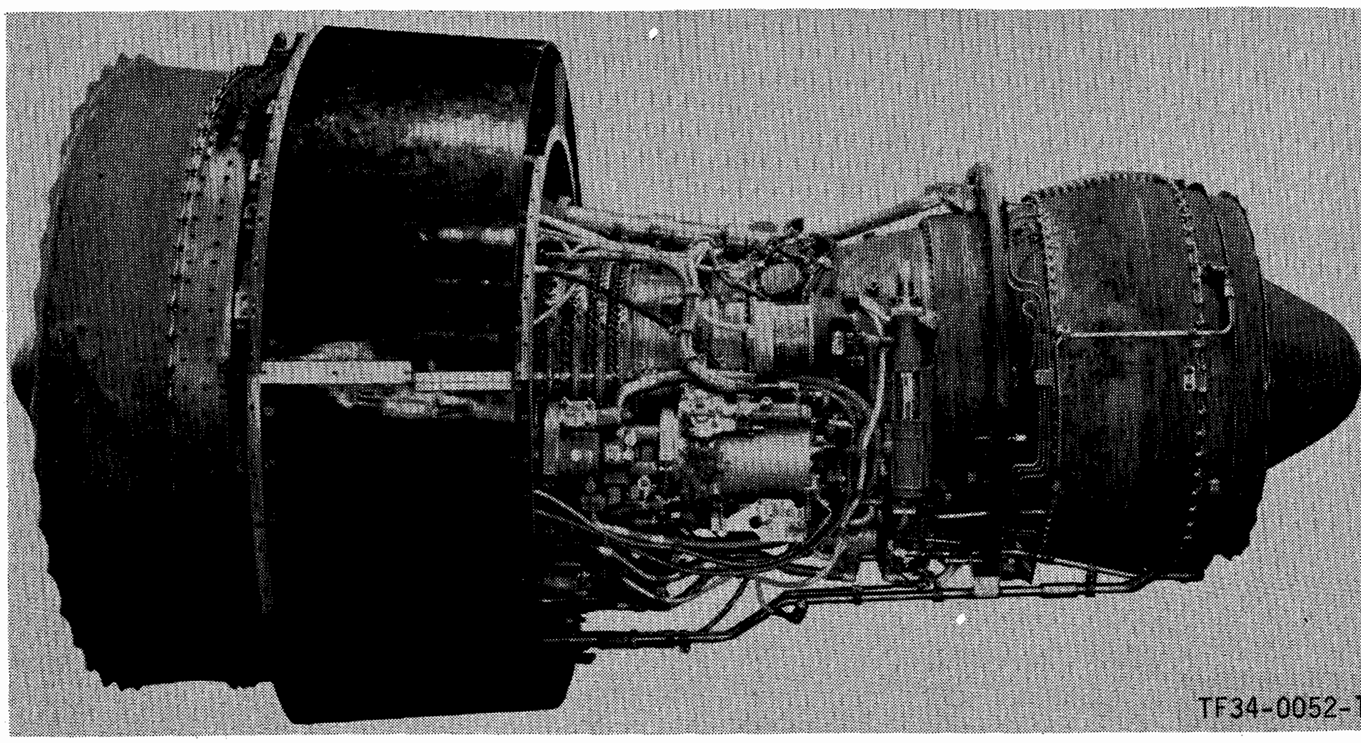


Figure 1-1. YTF34-GE-2 Turbofan Engine - Left Side

TABLE 1-1

BASIC ENGINE DATA

GENERAL

Model	YTF34-GE-2
Type of Engine	Turbofan
Type of Compressor	Axial Flow
Minimum Thrust at Max Power (Sea Level Conditions)	9275 lbs
Number of Compressor Rotor Stages	14
Variable Geometry	Inlet guide vanes, stator vane stages 1 through 5
Type of Combustion Chamber	Single, annular, through-flow
High Pressure Turbine Stages	2
High Pressure Turbine (Compressor) Rotor Speed	17,800 rpm (100%), 18,150 rpm (max transient)
Low Pressure Turbine Stages	4
Low Pressure Turbine (Fan) Rotor Speed	7,825 rpm (max), 7850 rpm (max transient)
Direction of Engine Rotation	Clockwise (aft looking forward) (both turbines)
Engine Length	99.956 inches
Fan Cowl Diameter (vertical centerline)	50 inches
Engine Weight (dry)	1421 lbs
Center of Gravity	0.7 in. below engine horizontal centerline; 0.6 in. left of vertical centerline (aft looking forward), 5.66 inches forward of combustion chamber forward flange.
Engine Mounting	Aft mount ring, thrust mount, and fan stator case.

FUEL SYSTEM

Fuel Specification	MIL-T-5624G, Grade JP-4 or Grade JP-5
Pump Inlet Pressure Range	0 psig to 50 psig
Pump Inlet Temperature Range	
Using JP-4	-54°C (-65°F) to 57°C (135°F)
Using JP-5	-29°C (-20°F) to 57°C (135°F)
Pump Rated Speed (max rated engine speed 17,900 rpm)	7340 rpm
Pump Pressure Relief Valve, Cracking Pressure	1075 psi max at 50 psi inlet pressure
Pressure at Vane Actuators	150-650 psi
Distributor Check Valve, Cracking Pressure	45-55 psi
Flow Range	185-4130 phr

IGNITION SYSTEM

Ignition Exiter Input	
Voltage (alternating current)	15-60 volts (variable with Ng)
Amperage	3.8 max
Power	36 watts
Rating	Intermittent (60 seconds between starts)
Duty Cycle	For use other than engine starting (2 minutes on 3 minutes off, 2 minutes on 23 minutes off)

ENGINE LUBE SYSTEM

Lube Specification	MIL-L-23699
Temperature Range	-40°C (-40°F) to 149°C (300°F)
Pressure Range, Normal Operation (approximate)	50-72 psig
Flow (approximate for normal operation)	8 gpm
Filter Efficiency	100% for all particles greater than 46 microns
Filter Bypass Valve Cracking Pressure	20 ±2 psi
Pump Relief Valve (differential pressure)	120 psi

Note

The information in tables 1-2 and 1-3 is not to be used as limits for operating the engine. This information has only been included to show the rated thrust the engine will produce at given rotor speeds and at given operating temperatures. Only the information in table 10-1 can be used for operating limits.

TABLE 1-2

ENGINE THRUST RATINGS AT STANDARD SEA LEVEL STATIC CONDITIONS

Rating	Net Thrust Minimum LB	Core Engine Rotor Speed (Ng) Maximum RPM	Fan Rotor Speed (Nf) Maximum RPM	Specific Fuel Consumption Maximum LB/Hr/LB	Measured Core Engine Discharge Temp. (T5) Maximum °F	°C	Engine Airflow Total (Wat) ±3% LB/SEC
Maximum	9275	17,900	7,365	0.363	1495	813	338.3
Intermediate	8159	17,340	6,930	0.349	1405	763	318.8
Max. Continuous	7513	17,130	6,690	0.343	1350	733	306.7
90% Max. Continuous	6760	16,890	6,405	0.337	1295	702	291.6
75% Max. Continuous	5632	16,480	5,935	0.328	1205	652	267.2
Idle	575	11,400	2,085	390 (max fuel flow lb/hr)	1100	593	86.7

Note: 100% Ng = 17,800 RPM.

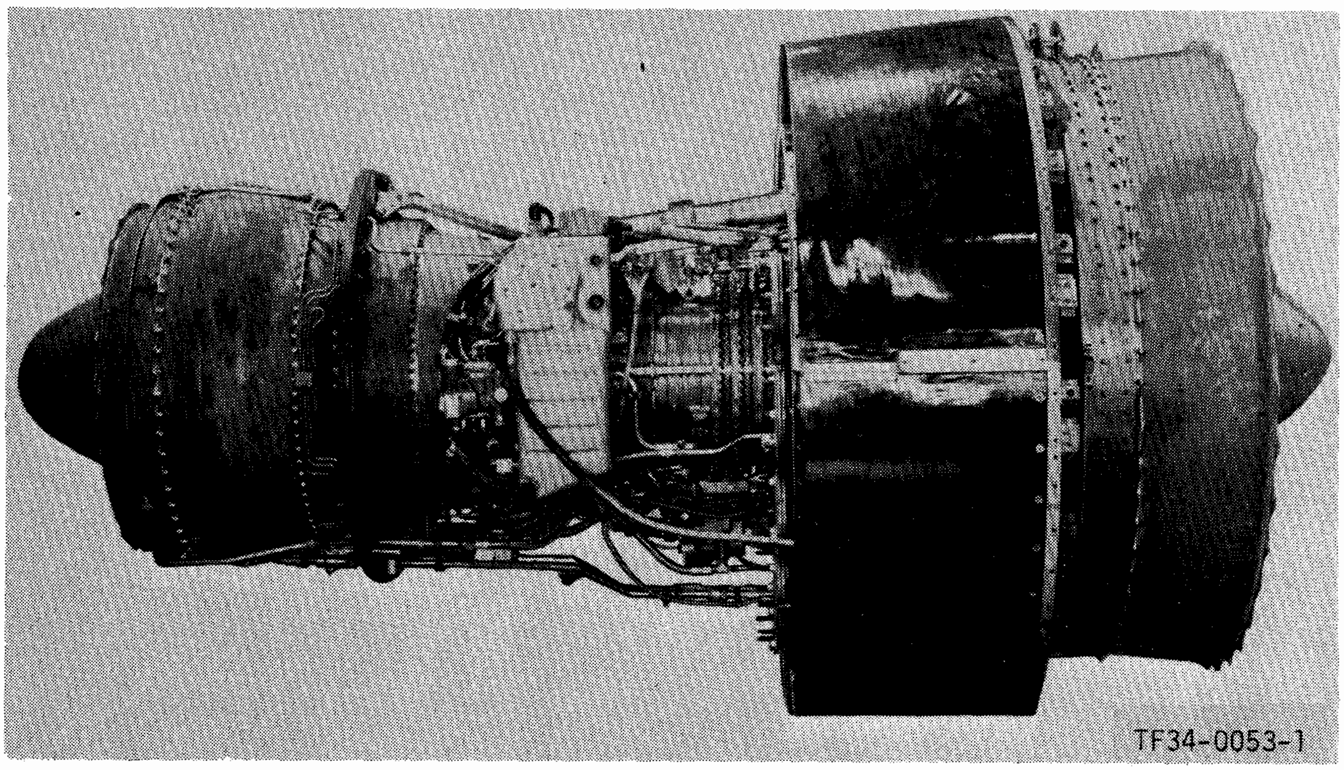


Figure 1-2. YTF34-GE-2 Turbofan Engine - Right Side

TABLE 1-3.

ENGINE THRUST RATINGS AT 15,000 FT. ALTITUDE CONDITION

Rating	Flight Speed Mach NO.	Net Thrust Minimum LB	Core Engine Rotor Speed (Ng) Maximum RPM	Fan Rotor Speed (Nf) Maximum RPM	Specific Fuel Consumption Maximum LB/Hr/LB	Measured Core Engine Discharge Temp. (T5) Maximum °F	°C	Engine Airflow Total (Wat) ±3% LB/SEC
Max. Continuous	0.6	3314	17,030	7,175	0.608	1350	733	248.8
80% Max. Continuous	0.6	2656	16,635	6,730	0.617	1265	685	235.5

1-9. FAN INTAKE AND JET WAKE DANGER AREA.

WARNING

Do not come any closer to the rear of the engine than 160 feet with the engine running at max power. Do not come any closer to fan intake than 25 feet.

1. Figure 1-3 shows the danger area of the fan intake and jet wake with the engine running at max power. This is based on a velocity of more than 20 mph. At 100 feet aft of the fan cowl, the path of air flow is 40 feet wide, or 20 feet either side of engine centerline. This width increases proportionately out to a distance of 160 feet. Beyond 160 feet, the velocity is less than 20 mph. The danger area of the fan intake extends 25 feet forward and to the sides of the intake.

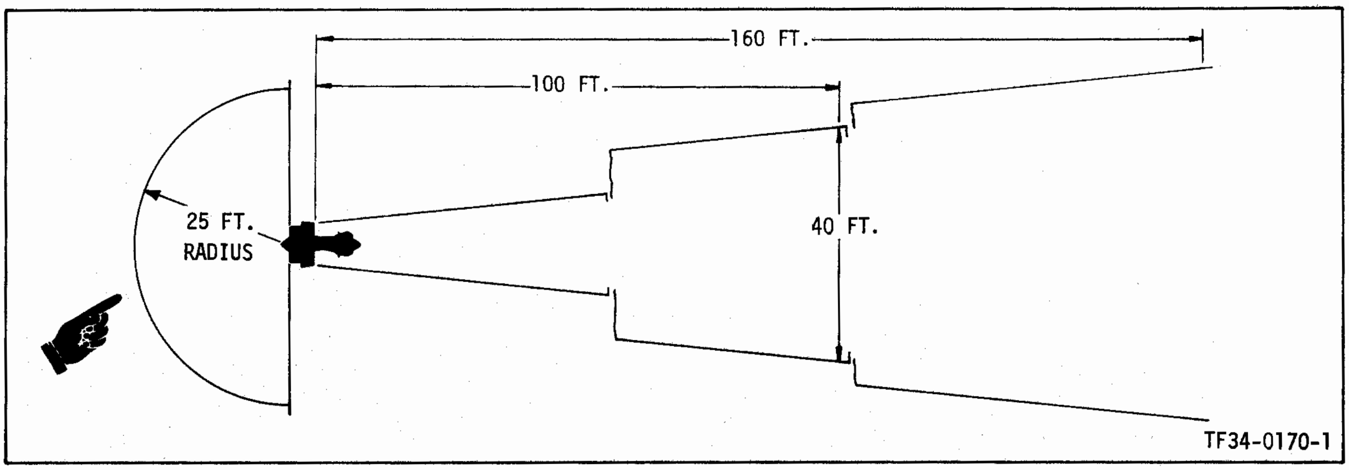


Figure 1-3. YTF34 Fan Jet Wake Danger Area

1-10. MAINTAINABILITY. Maintainability has been designed into the YTF34 engine since design inception. Figure 1-4 illustrates the resulting modular design which permits quick access to various components of the engine. The following summarizes some of the maintainability features of the engine:

1. Borescope ports in compressor and combustor section permit compressor FOD and hot section inspections to be performed with the engine installed.

2. Fan rotor blades and fan stator vanes individually replaceable.

3. Split fan outer cowl and segmented inner cowl provides ease of access to accessory gearbox and forward mounted accessories.

4. Compressor casing split on horizontal line for easy access.

5. All compressor blades, vane sectors, and vanes are individually replaceable.

6. Fuel lines and tubes individually removable.

7. Combustion liner removable without removing fuel tubes.

8. Electrical harnesses individually replaceable.

9. Individually replaceable nozzle segments.

10. Rotor blades replaceable without balancing.

11. Fan turbine blades individually replaceable.

12. Fan turbine replaceable as a module.

13. Color coded electrical harnesses facilitate servicing and replacement.

14. Deleted.

15. Compressor water wash capability is incorporated in front frame.

16. Engine condition monitoring is provided.

1-11. DETAILED ENGINE DESCRIPTION.

1-12. GENERAL. The engine consists basically of the sections shown in figure 1-4. Each of these components (or modules) is described separately in the following paragraphs. See figure 1-5 for engine orientation.

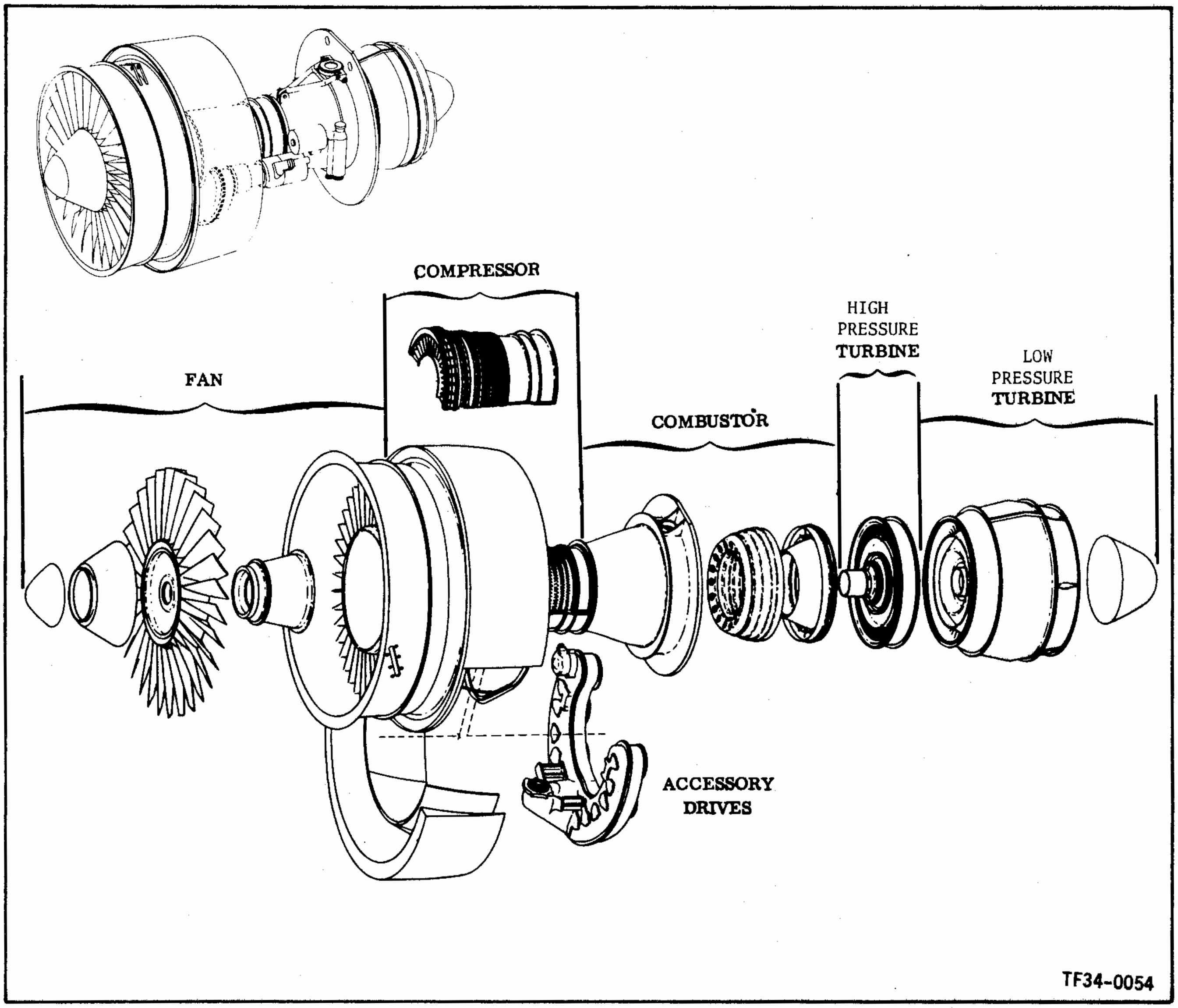


Figure 1-4. Major Sections of Engine

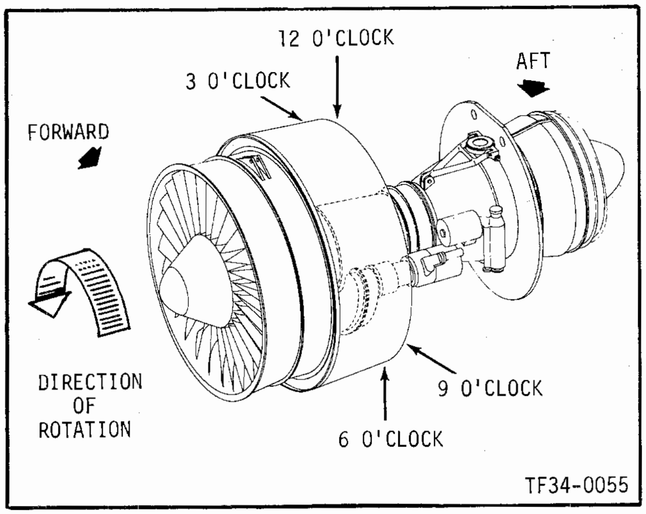


Figure 1-5. Engine Orientation

1-13. FAN SECTION.

1-14. FAN STATOR. The fan stator (figure 1-6) shrouds the fan rotor and directs the thrust air coming from the fan rotor out the aft end of the fan duct. It consists of 44 stator vanes, the stator casing, inner frames, and 4 pairs of A-frame struts located at 12:00, 3:00, 6:00 and 9:00 o'clock position. The A-frame struts attach the stator casing to the core engine front frame. The engine forward mount is located on the outer surface of the fan aft stator casing at the apex of the 12:00 o'clock A-struts. Externally this structure supports the engine forward cowl and fan nozzle.

1-15. FAN ROTOR. The single-stage fan rotor (figure 1-7) located at the forward end of the engine, provides the main thrust (driving force) of the engine. It also provides ram air into the compressor section. The rotor consists of 28 titanium alloy blades that are pin-connected to the double disk. The titanium double disk gives great strength to the fan rotor and provides rigid support for the fan blades. A four-pieced spinner, attached to the rotor disk, is anti-iced with air piped through the center of the engine. The fan stub shaft, bolted to the aft end of the disk, is supported by the No. 1 thrust bearing and the No. 2 roller bearing. The fan stub shaft is coupled to the main fan shaft, which transmits the driving power from the low pressure turbine rotor.

1-16. FRONT FRAME.

1-17. The front frame (figure 1-8) is used to channel the air into the compressor rotor. It supports the fan vane support on the forward flange of the front frame, the fan exit duct on the mid flange, and the compressor stator on the aft flange. The compressor rotor is supported on its forward shaft by the No. 3 thrust bearing housed in the front frame. The power takeoff is mounted in the front frame. The accessory drive gearbox is also supported by the front frame. The front frame is anti-iced at the air splitter and transfers anti-icing air to the fan vanes. Also, the front frame provides water wash capability.

1-18. COMPRESSOR SECTION.

1-19. COMPRESSOR STATOR. The compressor stator casing (figure 1-9) is split on a horizontal plane for easy access to the compressor rotor. The outer portion of the casing is titanium alloy and the inner rear high-temperature casing is nickel base alloy. The casing contains two integral air manifolds, stage 7 for sump pressurization and stage 10 for customer bleed air. The inlet guide vanes are a fabricated nickel base alloy and are anti-iced. They, as well as titanium alloy stator vanes, stages 1 through 5, are variable angle vanes. The inlet guide vanes and vanes in stages 1 and 2 are shrouded at the ID. The shrouds are split circumferentially to match the casing splitline. An extension of this half-ring acts as the interstage labyrinth seal seat on stages 1 and 2; the sealing surface is pre-grooved to improve its capability to withstand seal rubs. Vanes in stages 1 through 8 are individually replaceable. Vanes in stages 9 through exit guide vanes are replaceable as sectors. The fixed vanes are titanium alloy up to stage 8, and nickel base alloy, stage 9 to the exit guide vanes. Stages 9 through 13 are inserted into the rear casing by means of circumferential grooves. The exit guide vanes are supported by the combustion chamber frame.

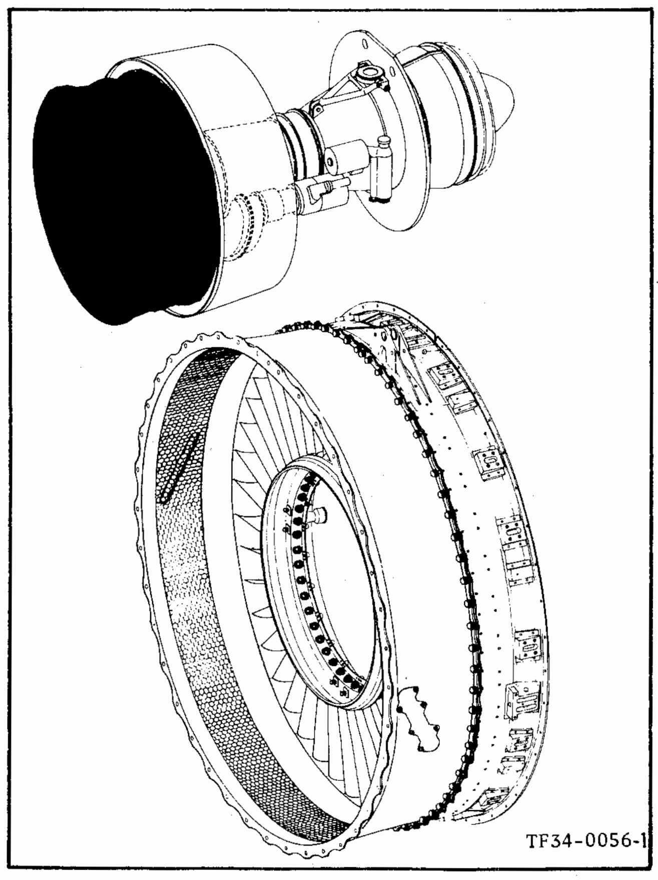


Figure 1-6. Fan Stator

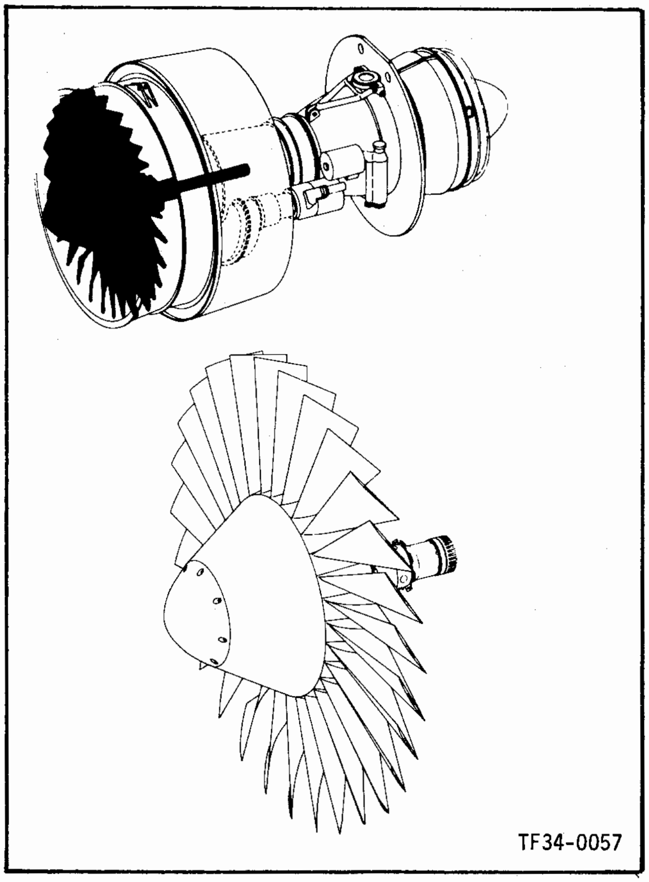


Figure 1-7. Fan Rotor

1-20. COMPRESSOR ROTOR. The 14-stage axial flow compressor has a pressure ratio of 14.5 to 1. The rotor (figure 1-10) is designed as a rigid drum, consisting of titanium alloy first-stage disk and second-stage disk, a nickel alloy ninth-stage disk and titanium alloy forward and nickel alloy rear spools. These are supported by means of tight tolerance bolt circles on steel forward and nickel alloy rear shafts, resulting in a rugged drum containing only two flange joints. The first two stages have axially oriented blade retention slots. The compressor spools contain circumferential grooves for blade retention. This feature allows blades to be removed easily. Blades are titanium alloy through the ninth-stage. Tenth-stage to fourteenth-stage blades are of nickel base alloy. A stepped seal is mounted on the rear shaft which mates with the static seal in the combustion section.

1-21. COMBUSTION SECTION.

1-22. The combustor (figure 1-11) utilizes an annular configuration with a carbureting scroll fuel injection system. The system provides high reliability, long combustor and turbine life, low smoke emission, and operation with contaminated fuels. The frame and inner casing support the B-sump and the No. 4 and No. 5 roller bearings. The outer casing of the frame carries pads for 18 removable fuel feed tubes, P3 and T3 taps, dual igniters, 2 primer fuel nozzles, and 7 borescope inspection ports. The annular combustion liner is fabricated from rings machined of Hastelloy X alloy. The compressor discharge seal stator is made of Inco 600 with brazed-on Hastelloy X honeycomb for sealing. The seal stator is centered on and bolted to the same frame flange that supports the forward end of the B-sump. The dome, which joins the inner and outer shells to form the liner assembly, has 18 scroll type fuel injection devices.

1-23. Air leaving the compressor is diffused to approximately 60% of compressor discharge velocity in the prediffuser, and divides into three, approximately equal, streams at the dome entrance. Inner and outer cowls, supported from the dome, capture compressor discharge total pressure for metering air flow to the dome. Most of the dome flow passes through the scrolls into the reaction zone to serve as primary combustion air. The remainder of the dome flow is used for dome cooling. Air passing into the inner and outer passages formed between the combustion chamber shells and the casings serves as primary air (to complete combustion), dilution air (to reduce the hot products to required turbine inlet temperature levels) and cooling air for combustor shells and other engine hot parts. Primary and dilution air are injected through the shells via radial and axial holes designed to meter the proper quantities and achieve the required depth of penetration. Shell

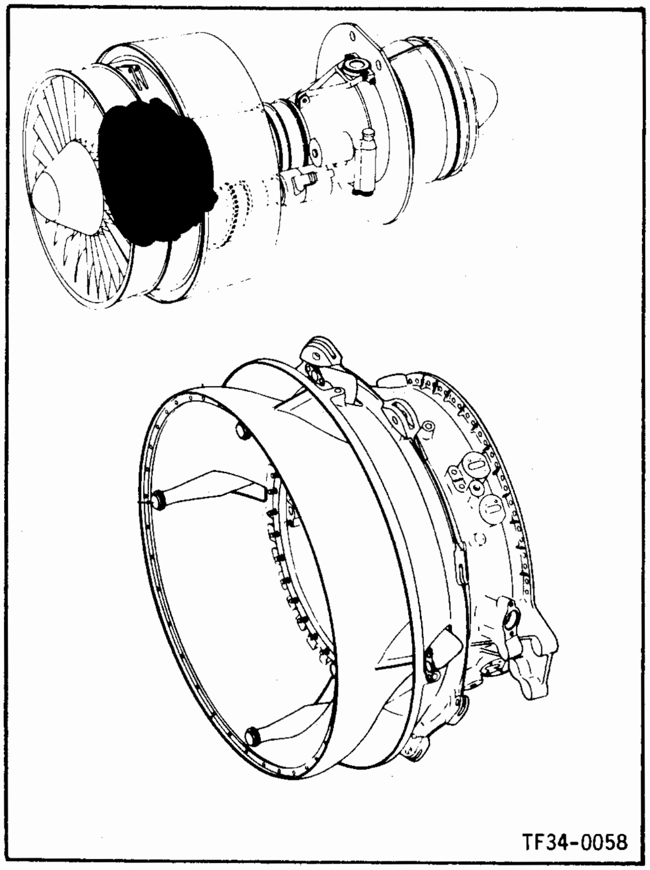


Figure 1-8. Front Frame

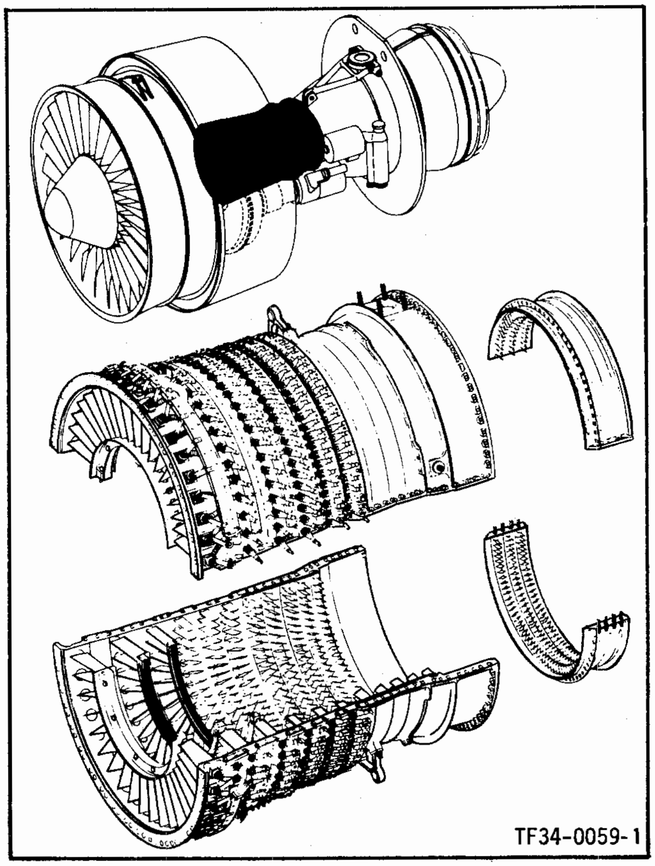


Figure 1-9. Compressor Stator

cooling air is metered through rows of small circular holes and injected along the inner surface of the shells through annular slots staged strategically along the combustor length.

1-24. Fuel is metered, distributed and introduced through 18 fuel tubes which project into the mouths of the scrolls. The fuel tubes are relatively large bore (0.08 inch ID), and therefore not susceptible to blockage by contaminated fuel. The fuel manifold consists of individual flexible lines between the fuel distribution valve and the fuel tubes. Equal amounts of fuel are metered into each line by the distribution valve. Each line contains an orifice which compensates for varying line length and provides each line with an equal pressure loss. The hot combustion products leaving the primary zone are reduced to the required turbine inlet temperature level by means of two rows of diluent air jets in both the outer and inner shells.

1-25. The carbureting scroll is a fuel/air mixing device in which fuel atomization and aeration is accomplished by high energy air. The premixing of fuel and air in the highly turbulent flow fields results in finely sized fuel droplets (and partial vaporization). This mixture flows through a cascade of tangential swirl vanes and is introduced into the combustor reaction zone in a wide cone angle thus avoiding over rich (high fuel/air ratio) combustion and provides low smoke and the capability of operation with contaminated fuels. Ignition is accomplished by means of two igniter plugs. At ignition, starting fuel is injected into the scrolls and the igniters are activated. After ignition the igniter is deactivated at a preset speed below idle.

1-26. CORE ENGINE HIGH PRESSURE TURBINE SECTION.

1-27. HIGH PRESSURE TURBINE STATOR. The turbine stator (figure 1-12) consists of two separate subassemblies; the first-stage nozzle assembly (supported by the combustor frame inner duct and located forward of the rotor assembly) and the turbine stator assembly (supported by the aft flange of the high pressure turbine outer casing and located aft of the first-stage rotor wheel and shaft assembly).

1-28. The first-stage nozzle assembly (figure 1-11) consists of the first-stage nozzle inner support, the stationary balance piston seal elements, the first-stage nozzle, the air guide and the combustor outer seal. The first-stage nozzle is cast in 22 segments with 2 vanes on each segment. It mounts on the circular outer flange of the first-stage nozzle support structure. The nozzle support locates the segments and prevents bypass leakage. The nozzle vanes are cooled by compressor discharge air by means of a film for the leading edge portions and convection and film cooling for the trailing edge portions. Inner and outer bands are cooled by convection and film cooling. Nozzle segments are made of cobalt alloy, coated with Codep.

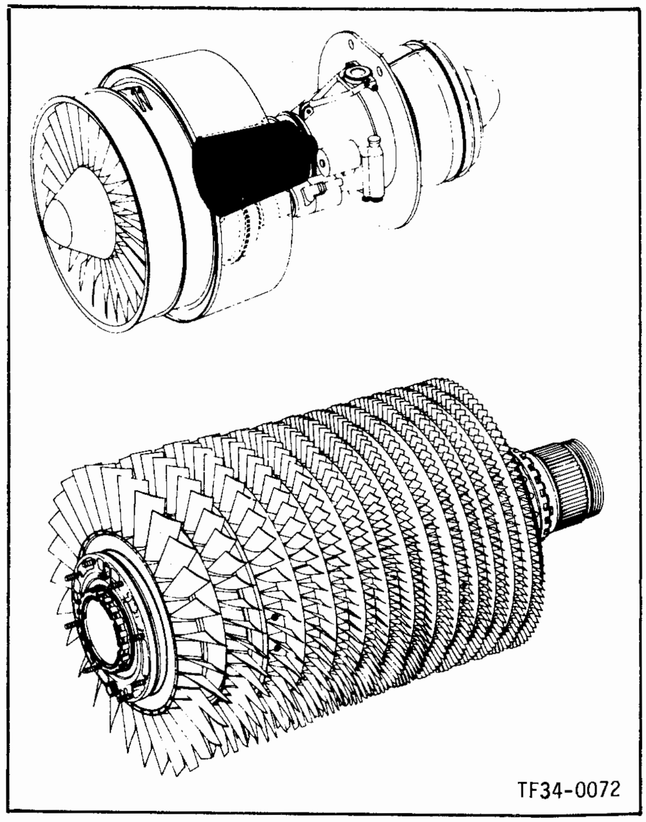


Figure 1-10. Compressor Rotor

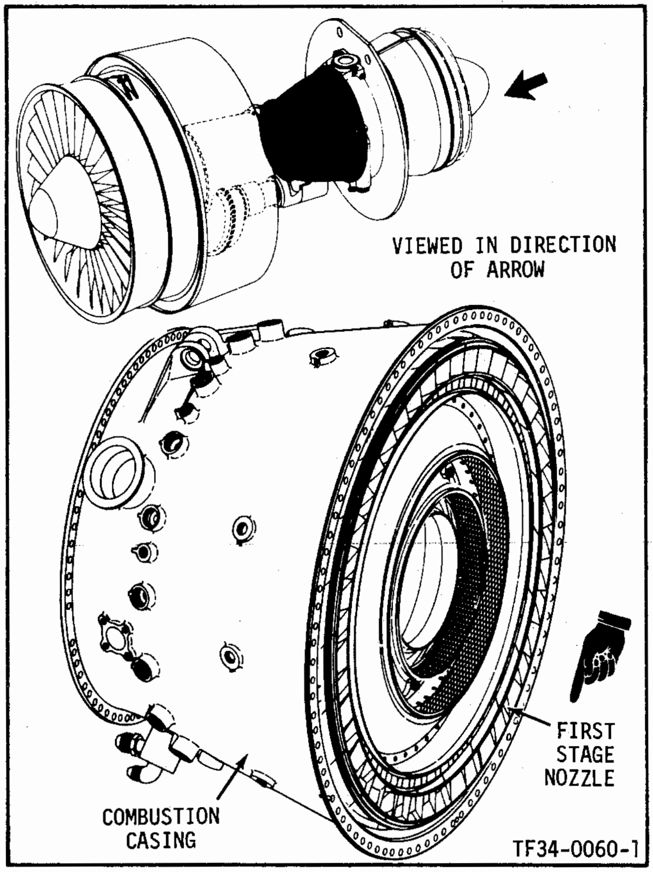


Figure 1-11. Combustion Section

1-29. The turbine stator assembly consists of the first stage shrouds, the second-stage nozzle vanes, the second-stage shrouds and shroud support, and the cooling baffle, all mounted inside a cylindrical air-cooled inner support case which is bolted through a flange to the cylindrical turbine casing. The first-stage shrouds consist of 10 individually replaceable segments containing Bradalloy filled honeycomb inserted in cylindrical grooves machined in the inner casing and are supported by 10 shroud supports. The 27 second-stage nozzle segments (cast nickel alloy and coated to prevent corrosion) also fit in similar inner casing grooves. The second-stage shrouds, also cut in 10 segments, are mounted in the shroud support ring. The interstage seal consists of 9 segments containing open faced honeycomb. These segments are pinned to the inner radius of the second-stage nozzle segments.

1-30. HIGH PRESSURE TURBINE ROTOR. The 2-stage turbine rotor (figure 1-13) consists of two disks bolted together by a torque coupling and contains internally cooled first-stage and second-stage blades. Both stages have individual Codep coated nickel cast alloy air cooled blades which are retained to the wheels by fir tree dovetails. The blades are held in position axially on each wheel by a pair of cooling plates, which in turn are held by axial bolts through the wheels. These plates also serve to seal against leakage of blade cooling air. The cooling plates also provide support for the outer torque coupling seal and seal the rotor cooling air. The plates contain projections which act as baffles to reduce hot gas in-flow into the rotor-to-stator cavities. The blades are cooled by air which flows through holes in the dovetails and out the tip and trailing edge. The torque coupling also carries the rotating interstage seal teeth.

1-31. A single conical shaft is bolted on the forward side of the first-stage disk with the same body-bound type bolts that hold the torque coupling to the aft side of the first-stage disk. The shaft drives the compressor by means of a piloted spline coupling. The second-stage disk is coupled to the aft side of the torque coupling with the same type body-bound bolts. The conical shaft also carries balance piston seal teeth which seal the rotor cooling air against leakage.

1-32. FAN LOW PRESSURE TURBINE SECTION.

1-33. LOW PRESSURE TURBINE TRANSITION ASSEMBLY. The transition assembly (figure 1-14) is the duct for the hot gases leaving the high pressure turbine rotor. It funnels the hot gases into the larger diameter fan low pressure turbine rotor. Inside the transition casing is the third-stage nozzle, and the transition inner and outer liners. The third-stage nozzle is in 11 sectors and is interlocked to the inner and outer liners. A honeycomb air seal is built onto the inner liner to prevent hot gases from entering the low pressure turbine rotor disks.

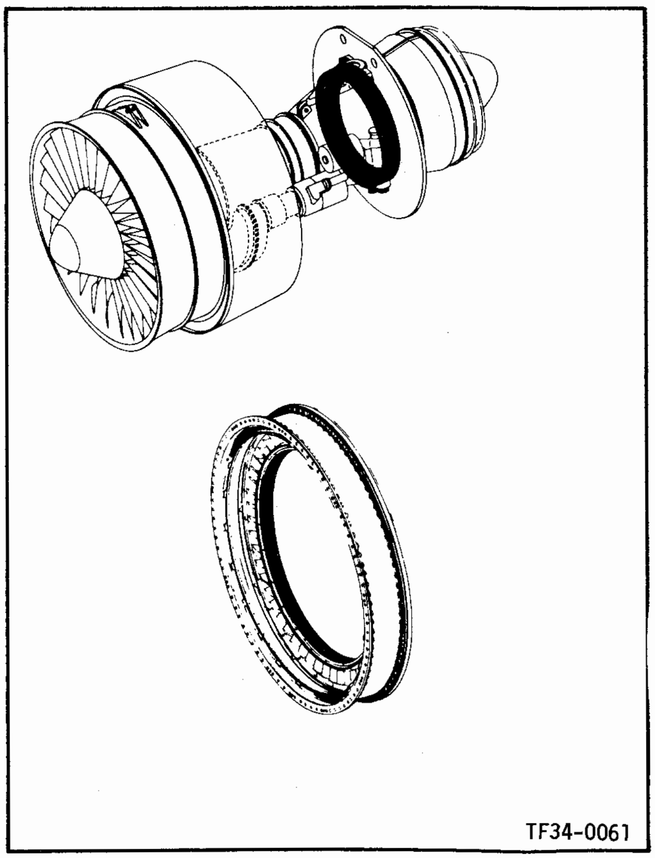


Figure 1-12. High Pressure Turbine Stator

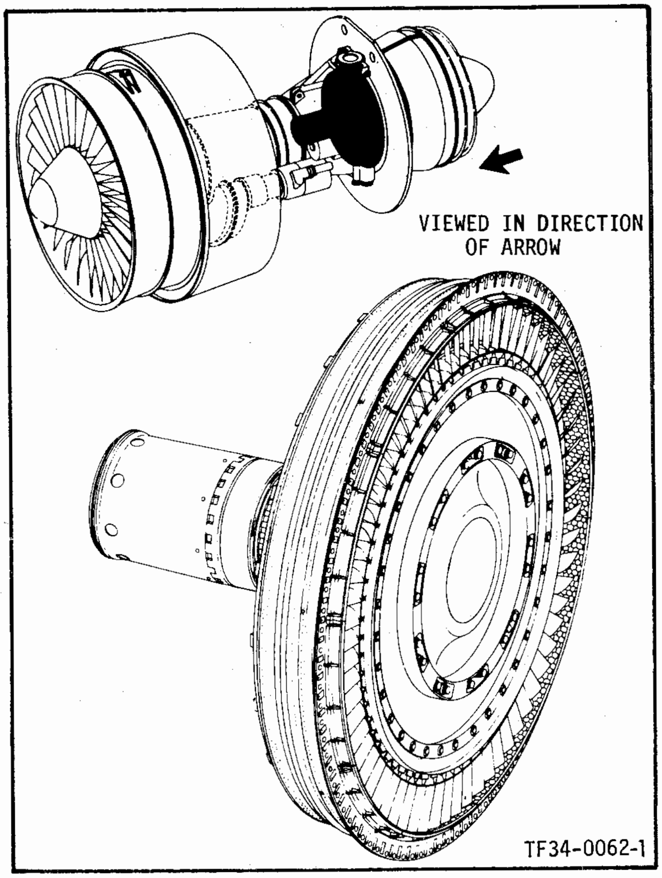


Figure 1-13. High Pressure Turbine Rotor

1-34. LOW PRESSURE TURBINE STATOR. The turbine stator casings (figure 1-15), split horizontally at the 6 and 12 o'clock position, can be removed without disassembling the engine. The casings contain sectored turbine nozzle vanes of nickel base alloy for stages 4, 5, and 6 and turbine shrouds for stages 3 through 6. The shrouds and seals are made in 4 segments per stage and have open face honeycomb wear surfaces.

1-35. LOW PRESSURE TURBINE ROTOR. The low pressure turbine has a 4 stage, tip-shrouded rotor (figure 1-16). The 4 disks, along with interstage seals, are bolted together with close fitting bolts. Blades are held in the disks by blade keys and the blades can be replaced without disassembling the rotor. The shrouded blade tips have an interlock that keeps them rigid. The rotor shaft is bolted between the fourth- and fifth stages and is splined to the fan drive shaft. Roller bearings, No. 6 and No. 7, support the rotor.

1-36. EXHAUST FRAME.

1-37. The exhaust frame (figure 1-17) supports the C-sump, which houses the No. 6 and No. 7 bearing outer races. It also serves as the main structual support for the low pressure turbine section. The outer casing and inner casing are joined together by 6 struts. The struts support the inner hub, which supports the C-sump and the bearings. The C-sump service lines, and the spinner anti-icing lines are routed through the 6 struts.

1-38. ACCESSORY DRIVE SECTION.

1-39. GENERAL. The accessory drive section consists of an internal power takeoff (PTO) assembly, a radial drive shaft, and an externally mounted accessory gearbox (AGB).

1-40. POWER TAKEOFF ASSEMBLY. The PTO assembly, (figure 1-18) located in the front frame A-sump, consists of a bevel drive gear coupled to the compressor forward stub shaft, a right angle bevel pinion (bearing-mounted to the PTO housing), and a lube distribution manifold containing the oil nozzle that lubricates the No. 2 bearing. Power is transmitted by the radial drive shaft through the 6:00 o'clock strut in the front frame to the transfer bevel gear train, located in the AGB, which transfers direction of drive from radial to axial. Loaded gear meshes are jet nozzle lubricated. Oil lubricated spline engagements at both ends of the drive shaft provide maintenance free operation. Gears are made of consumable electrode vacuum melted 9310 steel, with teeth case carburized and ground for long life.

1-41. ACCESSORY DRIVE GEARBOX. The AGB (figure 1-19), located in the engine bay area between the compressor casing and the fan nozzle inner wall,

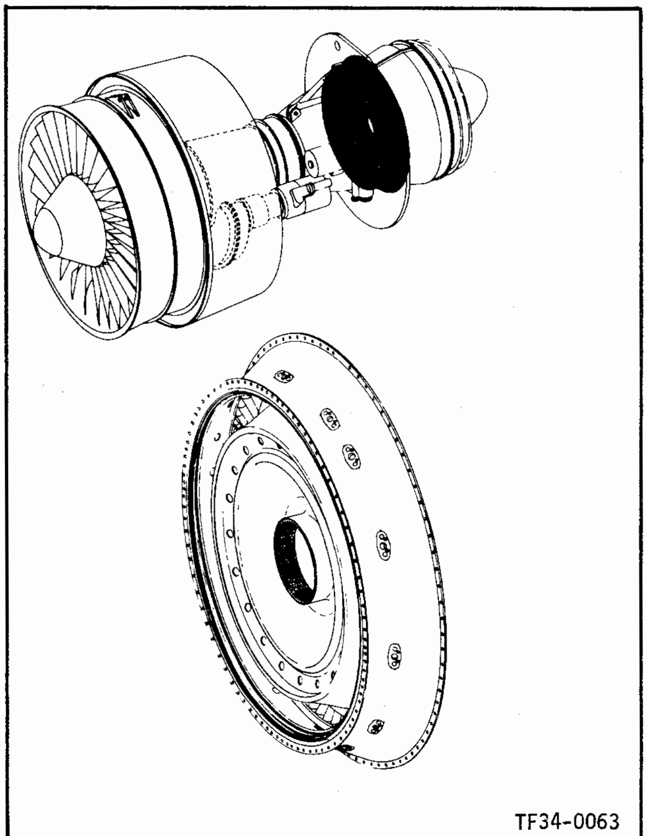


Figure 1-14. Transition Assembly

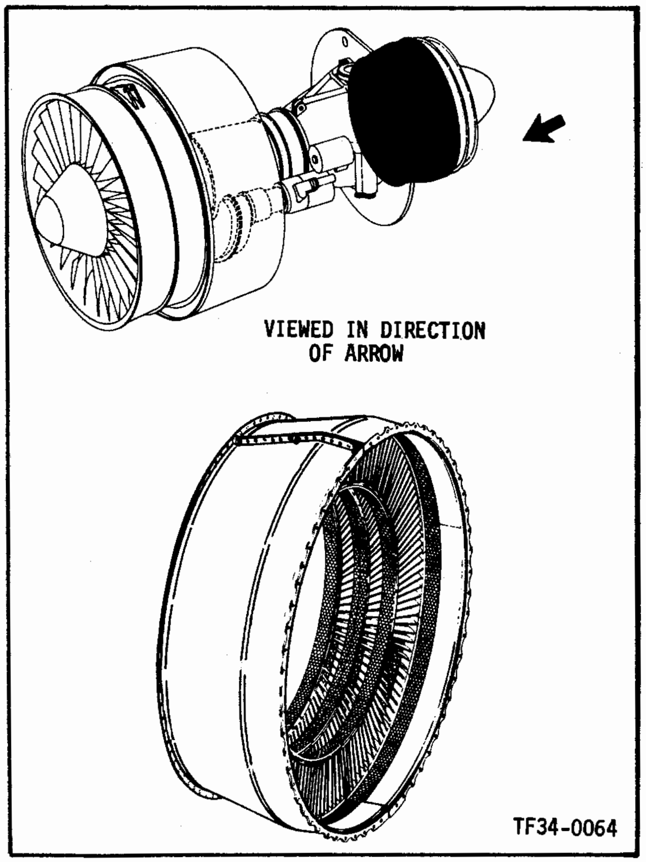


Figure 1-15. Low Pressure Turbine Stator

is rigidly supported by the front frame at the 3, 5, and 8 o'clock position through mount assemblies incorporating freedom for thermal expansion. Alignment, within the tolerance acceptable to the shaft spline engagements, is easily achieved by laminated shims located on the two lower mount pads. Once installed, the AGB may be removed and reassembled to the engine without realignment.

1-42. The AGB is composed of a train of spur gears which provide the mechanical drives for the engine and aircraft accessories. The AGB also provides the mounting support for these accessories. Pads for the ignition generator and the A-sump lube scavenge pump face forward. Pads for the aircraft hydraulic No. 1 and No. 2 pumps, starter, generator, lube and scavenge pump, fuel pump and main fuel control face aft.

1-43. ENGINE SYSTEMS.

1-44. GENERAL. The engine systems include the lubrication, fuel, electrical, and air systems. Each of these systems is described briefly. A detailed description of these systems is included in Section IX.

1-45. LUBRICATION SYSTEM. The lube system provides oil for all the bearings and gears during engine operation. System pressure is provided by a positive displacement supply-scavenge pump. Components include the pump, oil cooler, lube tank, filter, valves, nozzles, and the various lubrication lines that carry the oil throughout the engine. The system uses oil conforming to Specification MIL-L-23699. The supply and scavenge systems are supplemented by a third system - the vent system.

1-46. FUEL SYSTEM. The fuel system pressurizes and schedules fuel to the combustor and provides pressurized fuel for operation of the variable stator vane actuators, and fuel to the compressor inlet temperature sensor as a transmitting medium. The fuel system components include the fuel control, fuel heater, fuel pump, filter, a flow distributor, 2 stator vane actuators, fuel manifolds and tubes, and associated check valves, filters, relief valves and bypass valves.

1-47. ELECTRICAL SYSTEM. The electrical system provides power for ignition and for operating solenoids in the other engine systems. This system consists of an ignition exciter, 2 igniter plugs, a temperature-sensing thermocouple harness, anti-icing valve, control overspeed limiter solenoid, control amplifier, alternator, and the various cables and harnesses necessary to provide electrical power to the components. The system requires 28 volts dc (nominal) for operation.

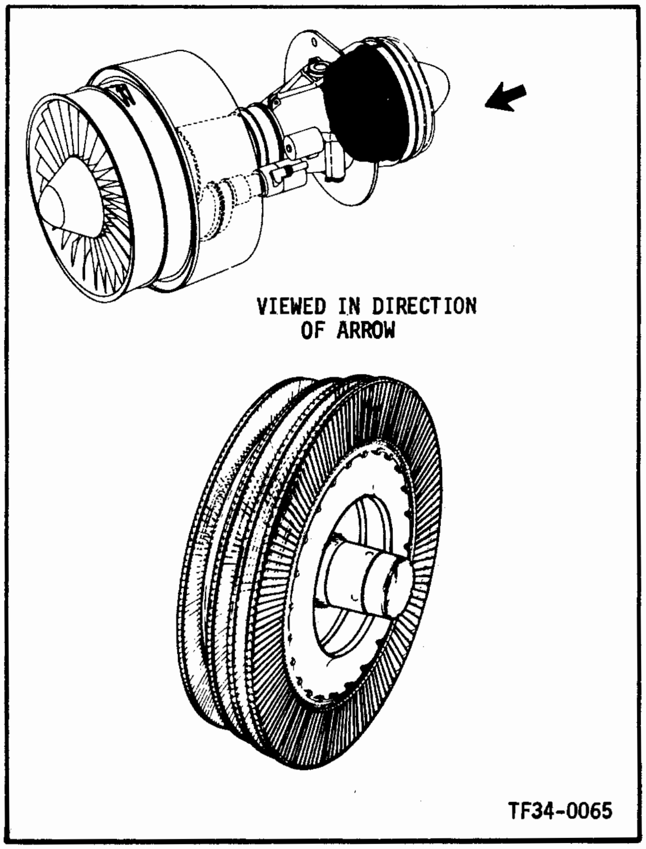


Figure 1-16. Low Pressure Turbine Rotor

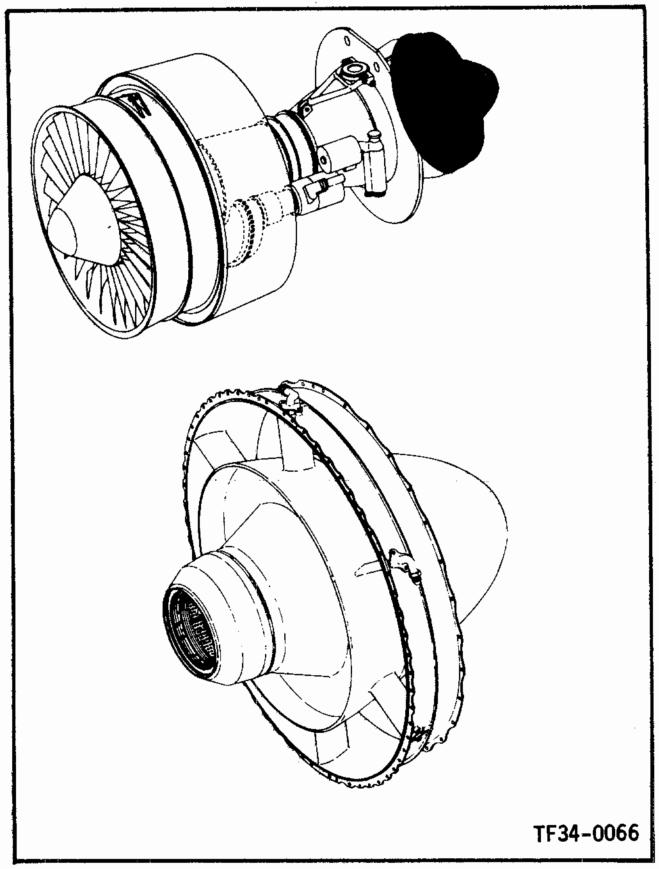


Figure 1-17. Exhaust Frame

1-48. AIR SYSTEM. Air which enters the engine through the fan passes through the front frame into the compressor where it is compressed at a ratio of 14.5 to 1. About one-fourth of the compressor discharge air is used for combustion. The remaining air is used for diluting combustion gases to ensure safe operating turbine inlet temperatures, for anti-icing, hot section cooling, seal pressurizing, rotor thrust balance, customer bleed, T2 operating and P3 signal to the fuel control.

1-49. <u>PRINCIPLES OF OPERATION.</u>

1-50. BASIC ENGINE OPERATION. The YTF34 engine is a gas turbofan engine which uses the free turbine principle of operation. The engine is started by external power (i.e., hydraulic or electric starter). Once combustion starts, the engine is self-sustaining. All that is required is a supply of air and fuel.

1-51. The combustion gases drive the high pressure turbine which is splined back to the compressor. The compressor draws in the air necessary for combustion. At the same time the compressor drives the accessories, including the fuel control, to schedule fuel to the combustion chamber.

1-52. About two-thirds of the power derived from combustion gases is required to sustain combustion. The remaining power is used to drive the fan low-pressure turbine rotor. The low pressure rotor is connected to the fan rotor.

1-53. ENGINE CONTROL SYSTEM. The YTF34 engine uses a hydro-mechanical fuel control assembly. Input signals to the fuel control are listed below. Operating with these signals, the control regulates fuel flow and provides regulated fuel pressure for positioning the stator vane actuators.

1. High pressure turbine speed (Ng)
2. Compressor discharge pressure (P3)
3. Compressor inlet air temperature (T2)
4. Fuel temperature
5. Variable stator position
6. Overspeed electrical signal
7. Power control shaft angle (PLA)

1-54. Engine output power (thrust) is regulated by the position of the power control shaft on the fuel control. The shaft is linked to the aircraft control lever for engine starting, acceleration and shutdown.

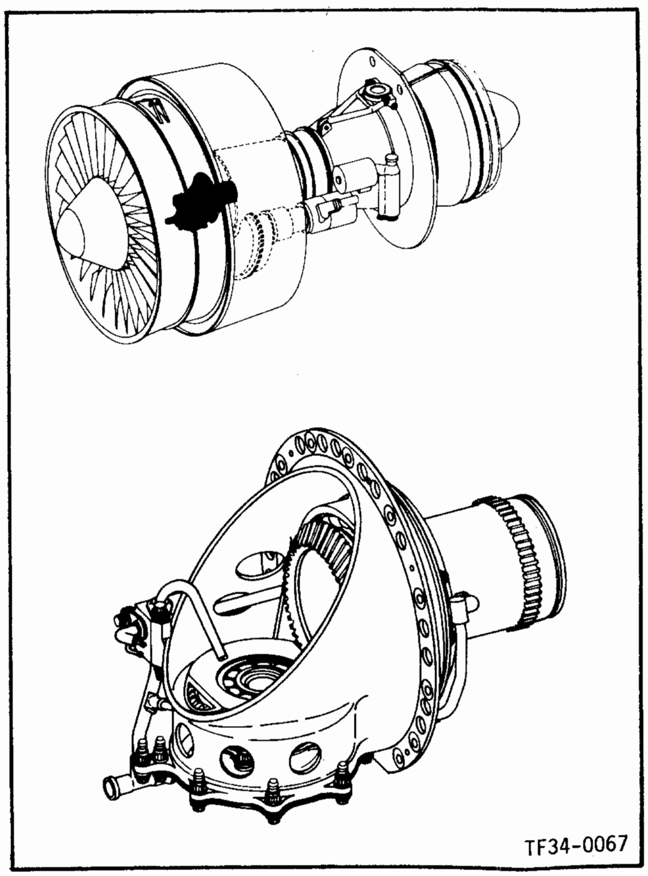


Figure 1-18. Power Takeoff Assembly

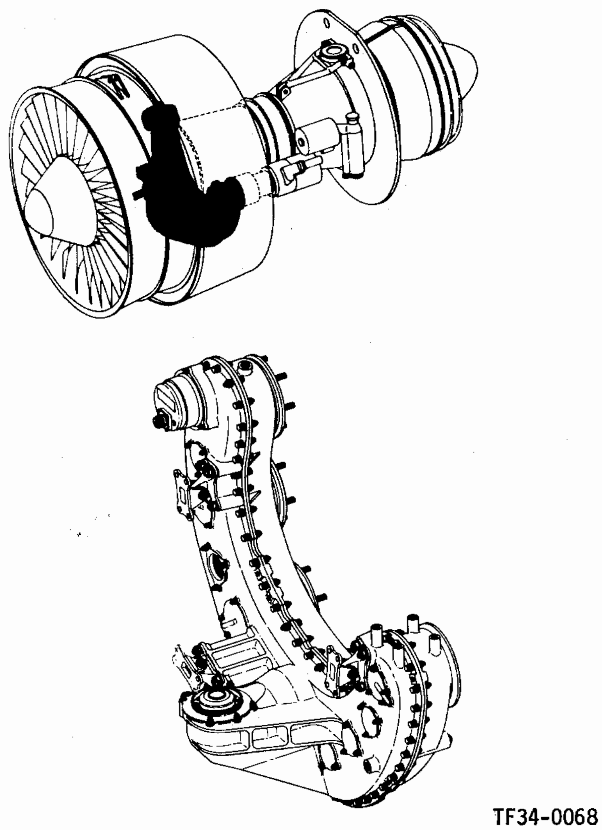


Figure 1-19. Accessory Drive Gearbox

Nominal travel of the shaft is 120 degrees, with position located as shown below. Shaft angles are nominal clockwise. (As power control shaft angle PLA is increased, more fuel is scheduled into the engine.)

PLA DEGREES	FUNCTION
0-3	OFF
6-10	Ignition
15-18	Idle
65	Maximum Continuous Speed
75-78	Intermediate Speed
97-100	Maximum Speed

1-55. Fuel is scheduled as a function of core engine speed, except that the speed setting schedule at high speed is modified by a signal from the electrical control amplifier to obtain desired core engine turbine discharge temperature. Thus, at idle and low power conditions power is established by speed control. At high power conditions, power is established by temperature control.

1-56. CONSUMABLE/EXPENDABLE MATERIALS.

1-57. CONSUMABLE MATERIALS. An item that is not listed in the engine Illustrated Parts Breakdown or cannot be reused, such as lockwire, grease, solvents, etc., is considered a consumable material and is listed in table 1-4.

1-58. EXPENDABLE MATERIALS. Certain items that are listed in the engine Illustrated Parts Breakdown are not reused, such as tab washers, cotterpins, etc. These are considered as expendable materials and are listed in table 1-5.

TABLE 1-4. CONSUMABLE MATERIALS.

Nomenclature	Manufacturer (Code)	Specification No.	FSN	Amount
		ASSEMBLY MATERIALS		
Dry Ice				
Dykem	Dykem Co., (98148)			
Kimwipes, Type 900-S (lintless paper wipers)	Kimberly Clark Corp. (33591)		7920-682-6710	Case/200
Masking Tape	GSA (81348)	UU-T-106, Type I	9Q7510-266-6710	
Marks-a-Lot	GSA (81348)	GG-M-00114B	7250-973-1059 7250-079-0288	(Black) (Yellow)
Plastic Strips	Artus Corporation (96013)	MIL-P-5425		
RTV 103	General Electric Co. (01139)			3 oz 12 oz
Silicone Tape (3003M20P01)	General Electric Co. (01139)			1 roll
Plastiseal F	Johns Manville Products Corp., Inc. (92764)	-	NZ8030-597-1413	
Versilube Plus	General Electric Co. (01139)	SE 1147		
		CLEANING MATERIALS		
Fingerprint Neutralizer		MIL-C-15074	8030-281-2338	Gal
Deoxidine, No. 624	Amchem Product, Inc. (84063)		5350-174-6460	Gal
Lubricating Oil		MIL-L-6082	9150-231-6669	
Oakite				
Solvent, Dry Cleaning (Stoddard)	General Services Administration (81348)	P-D-680-T2	6850-274-5421 6850-285-8012	5 Gal 55 Gal
Solvent, Cleaning		MIL-C-15074 or MIL-C-25107 or MIL-C-5346 or MIL-H-6998	6850-576-9842	5 Gal
Methanol		O-M-232		
Steam Cleaning Compound		P-S-751	MIL-C-22542	
Trichlorethylene (Triad)		O-T-634	6810-223-2734	55 Gal
Formula 409				
Hockwald No. 840				

TABLE 1-4. CONSUMABLE MATERIALS. (Cont)

Nomenclature	Manufacturer (Code)	Specification No.	FSN	Amount
		CORROSION PREVENTIVES, PRESERVATIVES		
Corrosion Preventive (Rust-Lick No. 606)	Rust-Lick, Inc. (14098)		6850-066-2333 6850-066-2334	5 Gal 55 Gal
Corrosion Preventive Compound		MIL-C-16173 Grade 1 Grade 2 Grade 3	 8030-231-2354 8030-244-1297 8030-244-1296	 Gal Gal Gal
Desiccant		MIL-D-3464	6850-057-6856	50 bags (8 units/ bag)
Lubrication Oil, Jet Engine Grade 1010		MIL-L-6081	9150-273-8807	Gal
B and B Cleaner Compound, Cleaning, Gas Path No. 3100	B and B Chemical Co. (21361)		9G6850-181-7594 9G6850-181-7597	5 Gal 55 Gal
		FUELS		
Jet Engine Fuel		MIL-T-5624G JP-4, JP-5	9130-265-8613	
		INSPECTION MATERIALS		
Film, Kodak Tri-X-Pan TX-135-20	Eastman Kodak Co. (19139)		6750-986-0468	
Kit, Oil Sampling	-	-	RM4920-938-3731-S150	72 bottles and 72 forms/kit
Envelopes, Mailing (Pensacola)	-	-	RM4920-938-3732-S150	72 envel-opes/kit
Envelopes, Mailing (North Island)	-	-	RM4920-938-3730-S150	72 envel-opes/kit
Ammonium Nitrate A676 Sodium Sulfide S425	Fisher Scientific Co. 828 Mitten Rd. Burlingame, Calif.		——	——
Ground Chalk	— —		——	——
		LUBRICANTS		
Grease, Silicone		MIL-G-25013		
Lubricating Oil, Aircraft Turbine Engine, Synthetic		MIL-L-23699	9150-985-7099 9150-985-5999	Qt 55 Gal
Molykote, X-15	Dow Corning Corp. (94499)			
Molykote, M-77	Dow Corning Corp. (94499)			
Grease, Versi-lube G392	General Electric Co. (01139)		9150-735-1800	5 lbs.

TABLE 1-4. CONSUMABLE MATERIALS. (Cont)

Nomenclature	Manufacturer (Code)	Specification No.	FSN	Amount
	PROTECTIVE COATINGS AND FINISHES			
Alodine, No. 1200		MIL-A-8625A	8030-613-3131	Lb
Heresite Finish	Heresite and Chemical Co. (73159)			
Silicone Aluminum Paint	General Electric Co. (01139)	MIL-P-14276	8010-655-8458 8010-857-1938	Gal 5 Gal
	REPAIR MATERIALS			
Epoxy System, Tra-Con No. 2116	Tra-Con Inc. (22835)			Bi-pax Pkg
Filler Rod, Hastelloy W (AMS 5786)		MIL-R-5031A Class 12		
Filler Rod, Hastelloy X (AMS 5798)			3439-882-7351	10 lb
Gas, Argon				
Gas, Helium				
Epoxy, Eccobond No. 286, with Plastic Syringe 6cc	Emerson and Cummings Corp., Canton, Mass. (04552)			
Epoxy, EA-934	Hysol, Div. of Dexter Corp., Pittsburg, California (04347)			
Fiberglass cloth 5.9 oz per ft.				
Antiseize Compound (milk of magnesia unflavored)	U.S. Pharmacy		6505-243-4954	1 Gal

TABLE 1-5. EXPENDABLE MATERIALS

PT NO.	Nomenclature	PT NO.	Nomenclature
AN123165	Rivet	R1312P210	Packing
AN123336	Rivet	R1313P10 and P12	Packing
AN123480	Rivet	R1313P14	Packing
AN123620	Rivet	U-158-S666	Packing
AN124993	Rivet	U-216-S666	Packing
AN381-2-6	Cotter Pin	3003M28P02	Shield, Chafing
AN381-2-8	Cotter Pin	3003M70P01	Tape, Silicone
J549P01	Packing	3017T48P01	Shim, Laminated
MS2046AD3-4 and -5	Rivet	3020T43P01 and P02	Vane Bushing
MS20470AD4-4	Rivet	3020T45P01	Vane Bushing
MS20600ML4W1	Rivet	3020T46G01	Lockwasher
		3020T56P01	Keywasher
MS24665-155	Cotter Pin	3020T67G01	Keywasher
MS24665-366	Cotter Pin	3020T82P01	Locking Clip
MS9245-45	Cotter Pin	3021T30P01	Gasket
MS9387-03 thru -08	Packing	3021T31G01	Gasket
MS9387-10	Packing	3021T32G01	Gasket
MS9387-12 and -16	Packing	3021T40G01	Gasket
MS9388-008 thru -013	Packing	3021T41P01	Gasket
MS9388-015	Packing	3021T46P02	Gasket
MS9388-016 thru -018	Packing	3021T94P01	Packing
MS9388-020 and -024	Packing	3022T18G01	Keywasher
MS9388-029	Packing	3023T05P01	Shim, Laminated
MS9388-031 thru -033	Packing	3023T72P01	Gasket
MS9388-035 thru -037	Packing	327B486P003 thru P006	Backup Washer
MS9388-039 and -042	Packing	327B486P008	Backup Washer
MS9388-044 and -045	Packing	4012T16P01	Filter Element
MS9388-049	Packing	4018T81P03	Keywasher
MS9388-111 and -112	Packing	4018T81P05 thru P07	Keywasher
MS9388-114 and -115	Packing	4020T40P01	Tabwasher
MS9388-120 and -131	Packing	4020T67P01	Gasket
MS9388-136 and -139	Packing	4020T89P01	Gasket
MS9388-153 thru -155	Packing	4028T27P01	Shield, Chafing (White)
R1307P014 and P020	Packing		
R1307P141	Packing	4028T27P04	Shield, Chafing (Blue)
R1309P016 and P023	Packing		
R1309P115 and P116	Packing	4028T27P05	Shield, Chafing (Yellow)
R1310P031 thru P033	Packing		
R1310P036 and P037	Packing	4028T27P06	Shield, Chafing (Green)

SECTION II

GROUND SUPPORT EQUIPMENT (GSE)

2-1. GENERAL.

2-2. This section lists by functional grouping (table 2-1) and by numerical listing (table 2-2) the GSE (special tools) required to maintain the YTF34-GE-2 engine. Figures 2-1 through 2-10 illustrate the GSE.

2-3. FUNCTIONAL GROUP.

2-4. Table 2-1 lists the GSE by functional groups based either on engine parts to which the GSE are applicable or on specific activities associated with the engine. Nomenclature for each group is determined by the part nomenclature or the work to be accomplished with the GSE. The groups are arranged in alphabetical order. The tools within each group are arranged in the order used.

2-5. NUMERICAL LISTING.

2-6. Table 2-2 lists the GSE numerically by tool number. Functional group numbers are also given.

TABLE 2-1. GSE

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
1. COMBUSTION CHAMBER AND FRAME, ASSEMBLY OF				
	2, 2-3	21C5055G01	Pusher, No. 4 Bearing Outer Race	6-6
		21C5229G01	Fixture, Alignment, Fuel Tubes	7-35
	2-6	21C5125G01	Guide, Combustion Liner	7-35
		21C5142G01	Fixture, Concentricity, No. 5 Bearing	
		21C5116G02	Stand, Buildup Combustor Module	6-6
2. COMBUSTION CHAMBER AND FRAME, DISASSEMBLY				
		21C5116G02	Stand, Buildup Combustor Module	5-30
3. COMBUSTION CHAMBER AND FRAME, INSTALLATION OF				
		21C5045G01	Plug, Alignment	7-19
		21C5169G01	Guide, Chamber-to-Compressor Rear Shaft	7-19
		21C5198G01	Adapter, Hoisting, Combustion Chamber Module	7-19
	2-10	21C5210G01	Adapter, Hoisting, Multi-purpose	7-19
		21C5220G01	Support, Combustion Chamber	7-19
		21C5219G01	Support, Front Frame	7-18
4. COMBUSTION CHAMBER AND FRAME, REMOVAL OF				
		21C5169G01	Guide	5-21
		21C5198G01	Adapter, Hoisting, Combustion Chamber Module	5-21
	2-10	21C5210G01	Adapter, Hoisting, Multi-purpose	5-21
		21C5220G01	Support, Combustion Chamber	5-21
		21C5116G02	Stand, Buildup Combustor Module	5-21

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
4.	COMBUSTION CHAMBER AND FRAME, REMOVAL OF (Cont)			
		21C5219G01	Support, Front Frame	5-16
		21C5174G01	Support, Compressor Rotor	5-21
5.	COMPRESSOR ROTOR BLADES, REPLACEMENT OF			
	2, 2-5	21C5132G01	Casing, Dummy	5-153
	-	21C485	Scale, Shadowgraph, Compressor Rotor Blades	5-153
	3, 2-4	21C5126G01	Kit, Assembly, Locking Lugs, Compressor Rotor	5-154
6.	COMPRESSOR ROTOR, ASSEMBLY OF			
	3, 2-2	21C5048G01	Pusher, No. 3 Bearing Inner Race	6-5
	5, 2-2	21C5050P01	Pusher, No. 3 Bearing Outer Race	
		21C5089G02	Fixture, Support	6-5
		21C5193G01	Wrench, Spanner, No. 3 Bearing Locknut	6-5
		21C5194G01	Wrench, Spanner, No. 4 Bearing Locknut	6-5
7.	COMPRESSOR ROTOR, DISASSEMBLY OF			
		21C5194G01	Wrench, Spanner, No. 4 Bearing Locknut	5-31
		21C5193G01	Wrench, Spanner, No. 3 Bearing Locknut	5-31
	-	21C5030G01	Pusher, No. 3 Bearing Housing Removal	
	4, 2-2	21C5049G01	Puller, No. 3 Bearing Outer Race	5-31
	-	21C5051G01	Puller, No. 3 Bearing Inner Race	5-31
		21C5081G01	Puller, No. 3 Carbon Oil Seal	5-31
		21C5089G02	Fixture, Support	5-31
8.	COMPRESSOR ROTOR, INSTALLATION OF			
	6, 2-5	21C5174G01	Support, Compressor Rotor	7-18
		21C5219G01	Support, Front Frame	7-18
		21C5220G01	Support, Combustion Chamber Module	7-18
		21C5210G01	Adapter, Housing, Multi-purpose	7-18
9.	COMPRESSOR ROTOR, REMOVAL OF			
	6, 2-5	21C5174G01	Support, Compressor Rotor	5-22
		21C5219G01	Support, Front Frame	5-16
		21C5220G01	Support, Combustion Chamber Module	5-20
		21C5210G01	Adapter, Hoisting, Multi-purpose	5-22

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
10.	COMPRESSOR STATOR, INSTALLATION/REMOVAL OF			
		21C5220G01	Support	5-20
	2, 2-5	21C5132G01	Casing, Dummy	5-20
	2-10	21C5190G01	Support	5-20
	-	21C5159G01	Kit, Guide Pins, Compressor Casing	5-20
	3, 2-3	21C5067G01	Handle, Compressor Casing	5-20
	-	21C5178G01	Retainer, Rear, Compressor Casing	5-20
		21C5219G01	Support	5-20
11.	COMPRESSOR STATOR VANES, REPLACEMENT OF			
	4, 2-3	21C5068G01	Spreader, Variable Vane Clip	5-143
		21C5397P01	Pusher, Bushing, Variable Vane	5-143, 5-146
		21C5398P01	Pusher, Vane Actuating Arms	5-143, 5-146
		21C5038G01	Kit, Vane Remover	5-146
	-	21C5032P02	Gage, Variable Vane Angle	5-143
		21C5033G01	Holder	5-146
	4, 2-4	21C5084G01	Holder	5-146
12.	ENGINE AND COMPONENT TESTING AND ADJUSTMENT EQUIPMENT			
		AN/PSM6	Multimeter	4-47E
		AR4300	Meggarmeter	4-47E
		1862B	Meggarmeter	4-47E
		619AS100	Trimmer Tracker	10-4A
		21C5506G01	Pylon Test	
		21C5507G01	Inlet Assembly	
		21C5511G01	Cowl Set	
		21C5512G01	Adapter, Transfer, Nozzle and Pylon	
		21C5513G01	Probe, Temperature, Engine Inlet	
		21C5514G01	Probe Temperature	
		21C5516G01	Trailer	
		21C5517G01	Probe	
		21C5518G01	Support, Vib Transducer, Engine	
		21C5519G01	Support, Vib Transducer, Fan Casing	
		21C5520G01	Support, Vib Transducer, Exhaust Frame	
		21C5521G01	Probe	
		64A128J1 (NFT-2)	Tester	11-22
		21C5503G01	Indicator, VG Remote	10-4A
		21C5032P02	Gage, Variable Vane Angle	4-132
		21C5086G01	Gage, Extension, Actuator	4-132
		21C5005G01	Pin, Rigging, Power Control Shaft	10-3
		21C5501G01	Kit, Adapter, Jet-Cal	4-47F

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
12.	ENGINE AND COMPONENT TESTING AND ADJUSTMENT EQUIPMENT (Cont)			
		21C9800G01	Kit, Borescope	11-20
		21C5010G01	Adapter, Cranking, Engine	11-22
		21C5501P04	Probe, Jet-Cal	4-47F
		21C5501P05	Probe, Jet-Cal	4-47F
		21C5505G01	Kit, Undercowl	
13.	ENGINE HANDLING EQUIPMENT			
	-	21C5189G02	Support, Forward, Aircraft Engine	3-3
	2-10	21C5190G01	Support, Aft, Aircraft Engine	3-3
	2-6	21C5200G03	Adapter, Hoisting, Engine	3-3
	-	3000	Trailer, Transportation	
	-	3100A	Stand, Assembly, Maintenance	
	-	4000A	Positioner	
14.	ENGINE PROTECTORS			
	-	21C5110P01	Cover, Fan Inlet	11-22
	5, 2-4	21C5130P01	Cover, Multi-purpose	3-3
	-	21C5209P01	Cover, Compressor Inlet	
	-	21C5011P01	Protector, IDG Drive Pad	
	-	21C5087P01	Protector, Fan Blade Tip	
15.	FAN DRIVESHAFT, INSTALLATION AND REMOVAL			
	-	21C5106G01	Guide, Fan Driveshaft	5-11 ,7-34
16.	FAN ROTOR, ASSEMBLY OF			
		21C5001G01	Fixture, Locking	5-10
	2, 2-2	21C5037G01	Holder, Fan Front Shaft	6-3
	1, 2-1	21C5018G01	Pusher, No. 1 Bearing Inner Races and Seal Runner	6-3
		21C5187G02	Stand, Buildup	5-10
		21C5042G01	Wrench, Spanner, No. 1 Bearing Locknut	6-3
		2501	Multiplier, Torque	6-3
	-	SWE102	Multiplier, Torque	6-3
	2, 2-1	21C5022P01	Pusher, No. 2 Bearing Inner Race	6-3
	-	21C5192G01	Wrench, Spanner, No. 2 Bearing Locknut	6-3
	1, 2-4	21C5117P01	Retainer, Pins, Fan Rotor	6-3

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
17.	FAN ROTOR, DISASSEMBLY OF			
		21C5001G01	Fixture, Locking	5-28
	2, 2-2	21C5037G01	Holder, Fan Front Shaft	5-28
	-	21C5192G01	Wrench, Spanner, No. 2 Bearing Locknut	5-28
		21C5187G02	Stand, Buildup	5-10
	-	SWE102	Multiplier, Torque	5-28
		2501	Multiplier, Torque	
	-	21C5021G01	Puller, No. 2 Bearing Inner Race	5-28
		21C5042G01	Wrench, Spanner, No. 1 Bearing Locknut	5-28
	-	SWE8100	Multiplier, Torque	5-28
	-	21C5090G01	Puller, No. 1 Bearing and Seal Runner	5-28
18.	FAN ROTOR ASSEMBLY, INSTALLATION OF			
	2-9	21C5066G01	Pusher, Fan Front Shaft	7-32
	2-9	21C5043G01	Wrench, Spanner, Fan Forward Locknut	7-32, 7-34
	-	SWE8100	Multiplier, Torque	7-32
		2501	Multiplier, Torque	
	1, 2-4	21C5117P01	Retainer, Pins, Fan Rotor	7-43
	-	21C5101G01	Adapter, Hoisting, Fan Rotor Disk	7-43
	-	21C5083G01	Retainer, Fan Rotor Disk	
	-	21C5088G02	Kit, Wrenches, Fan Disk	7-43
19.	FAN ROTOR ASSEMBLY, REMOVAL OF			
	-	21C5088G02	Kit, Wrenches, Fan Disk	5-10
	-	21C5083G01	Retainer, Fan Rotor Disk	
	2-9	21C5024G01	Puller, Fan Rotor Disk	5-10
	-	21C5101G01	Adapter, Hoisting, Fan Rotor Disk	5-10
	1, 2-4	21C5117P01	Retainer, Pins, Fan Rotor	5-10
	2-9	21C5043G01	Wrench, Spanner, Fan Locknut	5-12
		2501	Multiplier, Torque	
		SWE8100	Multiplier, Torque	5-12
	2-9	21C5065G01	Puller, Front Shaft, Fan Rotor	5-12
	2-9	21C5016G01	Adapter, Puller, No. 1 and No. 2 Bearing Housing	5-12
		21C5020G01	Puller, No. 2 Bearing Outer Race	5-12

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
20.	FAN STATOR, ASSEMBLY AND DISASSEMBLY OF			
		21C5072G01	Stand, Support	5-29, 6-4
21.	FAN STATOR, INSTALLATION AND REMOVAL OF			
	-	21C5219G01	Support, Front Frame	5-16, 7-29
	-	21C5177G01	Ring, Adapter, Front Frame	5-16, 7-29
	-	21C5189G02	Support, Forward, Engine	5-16, 7-30
	-	21C5215G01	Fixture, Inspection, Inner Frames	7-41
	-	21C5212G01	Fixture, Concentricity	7-38
	-	21C5202G01	Fixture, Locating Pylon Nose	7-41
22.	GEARBOX, ACCESSORY, INSTALLATION AND REMOVAL OF			
	-	21C5064G01	Fixture, Positioning, Accessory Gearbox	5-17, 7-28
	-	21C5080G01	Stand, Support, Positioning	
	-	21C5234G01	Puller, Packing Retainer	5-17
	-	21C5180G01	Pin, Alignment, Accessory Gearbox	7-28
	-	21C5231G01	Puller, AGB Seal Runners	5-93
23.	HIGH PRESSURE TURBINE ROTOR, ASSEMBLY OF			
		21C5039G01	Stand, Buildup, HPT Rotor	6-7
	-	21C5057G01	Pusher, No. 5 Bearing Inner Race	6-7
	-	21C5195G01	Wrench, Spanner, No. 5 Bearing Locknut	6-7
	2-7	21C5203P01	Fixture, Seating Check Stage 2 Disk	7-36
24.	HIGH PRESSURE TURBINE ROTOR, DISASSEMBLY OF			
		21C5039G01	Stand, Buildup, HPT Rotor	5-27
	-	21C5056G01	Puller, No. 5 Bearing (Inner Race) and Oil/Air Separator	5-27
	-	21C5195G01	Wrench, Spanner, No. 5 Bearing Locknut	5-27
25.	HIGH PRESSURE TURBINE ROTOR, INSTALLATION OF			
	2-8	21C5181G01	Support, Auxiliary, Fan Shaft	7-36
	2-8	21C5095G01	Bar, Aft Extension	7-36
	-	21C5211G01	Adapter, Hoisting, HPT Rotor	7-36
	2-10	21C5210G01	Adapter, Hoisting	7-36
		21C5039G01	Stand, Buildup, HPT Rotor	7-36
	2-7	21C5191G01	Pusher, HPT Rotor	7-36
	2-8	21C5182G01	Support, Shaft	7-36

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
25.	HIGH PRESSURE TURBINE ROTOR, INSTALLATION OF (Cont)			
		21C5232P01	Fixture, Checking HPT Locknut	7-36
	2-6	21C5079G01 or 21C5237G01	Wrench, Spanner, HPT Rotor Locknut	7-36
		2501	Multiplier, Torque	7-36
	-	SWE8100	Multipler, Torque	7-36
	2-7	21C5186P02	Fixture, Seating Check, HPT Rotor	7-36
		21C5088G02	Kit, Wrench, HPT Rotor	7-36
26.	HIGH PRESSURE TURBINE ROTOR, REMOVAL OF			
	-	21C5088G02	Kit, Wrench, HPT Rotor	5-7
	2-6	21C5079G01 or 21C5237G01	Wrench, Spanner, HPT Rotor Locknut	5-7
		2501	Multiplier, Torque	5-7
	-	SWE8100	Multiplier, Torque	5-7
	-	21C5204G01	Puller, Stage 2 HPT Disk	5-7
	2-6	21C5060G02	Puller, HPT Rotor	5-7
	-	21C5211G01	Adapter, Hoisting, HPT Rotor	5-7
	2-10	21C5210G01	Adapter, Hoisting	5-7
	2-8	21C5095G01	Bar, Aft Extension	5-7
	2-8	21C5182G01	Support, Shaft	5-7
	2-8	21C5181G01	Support, Auxiliary, Fan Shaft	5-7
		21C5039G01	Stand, Buildup	5-7
27.	LOW PRESSURE TURBINE MODULE (SECTION), ASSEMBLY OF			
		21C5085G01	Stand, Buildup, LPT Module	6-12
	1, 2-5	21C5131G01	Dummy Casing Bars (3)	6-12
	1, 2-3	21C5053G01	Pusher, No. 7 Bearing Inner Race	6-12
	2-10	21C5197G01	Wrench, Spanner, No. 7 Bearing Locknut	6-12
	2-6	21C5041G01	Retainer, LPT Rotor	6-12
28.	LOW PRESSURE TURBINE MODULE (SECTION), DISASSEMBLY OF			
		21C5085G01	Stand, Buildup, Low Pressure Turbine Module	5-6
	2-6	21C5041G01	Retainer, Low Pressure Turbine Rotor	5-23
	2-10	21C5197G01	Wrench, Spanner, No. 7 Bearing Locknut	5-23

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
28.	LOW PRESSURE TURBINE MODULE (SECTION), DISASSEMBLY OF (Cont)			
	6, 2-2	21C5052G01	Puller, No. 7 Bearing Inner Race	5-23
	1, 2-5	21C5131G01	Dummy Casing Bars (3)	5-23
29.	LOW PRESSURE MODULE (SECTION), INSTALLATION OF			
		21C5085G01	Stand, Buildup, LPT Module	6-12
	2-6	21C5041G01	Retainer, LPT Rotor	7-37
	2-8	21C5031G01	Fixture, Alignment, LPT Assembly	7-37
	2-10	21C5210G01	Adapter, Hoisting, LPT Module	7-37
	2-7	21C5160G01	Pusher, LPT Rotor	7-37
		21C5122P01	Fixture, Seating Check	7-37
	-	SWE8100	Multiplier, Torque	7-37
	-	2501	Multiplier, Torque	7-37
	2-8	21C5044G02	Wrench, Spanner, LPT Rotor Locknut	7-37
	1, 2-5	21C5131G01	Dummy Casing Bars (3)	7-37
	-	21C5133G01	Handle, LPT Casing	7-37
	2, 2-4	21C5123G01	Pusher, No. 7 Seal Runner	7-37
	-	21C5188G01	Wrench, Anti-ice Seal	7-37
30.	LOW PRESSURE TURBINE MODULE (SECTION), REMOVAL OF			
	2-7	21C5184G01	Puller, No. 7 Seal Runner	5-6
	2-6	21C5041G01	Retainer, LPT Rotor	5-6
	2-8	21C5031G01	Fixture, Alignment, LPT Assembly	5-6
	2-8	21C5044G02	Wrench, Spanner, LPT Rotor Locknut	5-6
		2501	Multiplier, Torque	5-6
	-	SWE8100	Multiplier, Torque	5-6
	2-7	21C5061G02	Puller, LPT Rotor	5-6
	2-10	21C5210G01	Adapter, Hoisting, LPT Module	5-6
		21C5085G01	Stand, Buildup, LPT Module	5-6
	-	21C5188G01	Wrench, Anti-ice Seal	5-6

TABLE 2-1. GSE (Cont)

Group Number	Figure and Index Number	Part Number	Nomenclature	Text (Para)
31.	LOW PRESSURE TURBINE ROTOR, ASSEMBLY OF			
	4, 2-1	21C5085G01	Stand, Buildup, LPT Module	6-10
	4, 2-5	21C5139G01	Pusher, No. 6 Bearing Inner Race	6-10
	2-10	21C5196G01	Wrench, Spanner, No. 6 Bearing Locknut	6-10
		2501	Multiplier, Torque	
	-	SWE102	Multiplier, Torque	6-10
32.	LOW PRESSURE TURBINE ROTOR, DISASSEMBLY OF			
	-	21C5085G01	Stand, Buildup, LPT Module	5-24
	2-10	21C5196G01	Wrench, Spanner, No. 6 Bearing Inner Race	5-24
	3, 2-5	21C5138G01	Puller, No. 6 Bearing Inner Race	5-24
	-	21C5175G01	Puller, LPT Air Seal	5-24
33.	LOW PRESSURE TURBINE STATOR, ASSEMBLY OF			
	-	21C5034G01	Holder, Low Pressure Turbine Stator	6-11
34.	LOW PRESSURE TURBINE STATOR, DISASSEMBLY OF			
	-	21C5034G01	Holder, Low Pressure Turbine Stator	5-25
34A.	NOZZLE, TURBINE, STAGE 1, ASSEMBLY AND DISASSEMBLY OF			
	-	21C5205G01	Stand, Buildup, Stage 1 Nozzle	5-181A
	-	21C5385P01	Wrench, Adapter	5-181A
35.	TURBINE ROTOR BLADES, REPLACEMENT OF			
	-	21C485	Scale, Shadowgraph	5-169
	-	21C5154G01	Kit, Tab Bending, LPT Rotor	5-173
36.	WASH EQUIPMENT			
		65A102J1	Cart, Corrosion Control	3-15, 11-3
		21C5183G01	Adapter, Waterwash/Rust-Lick Engine	3-15, 11-3

TABLE 2-2. NUMERICAL INDEX OF GROUND SUPPORT EQUIPMENT

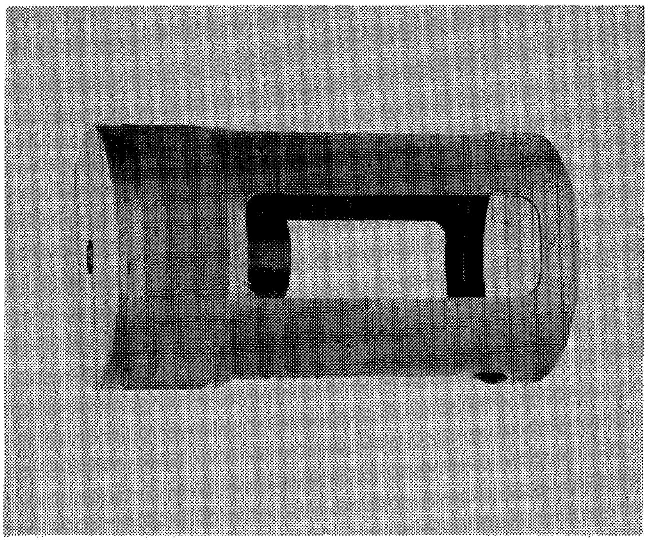
Tool Number	Functional Group No.
AN/PSM6	12
AR4300	12
SWE102	16, 17, 31
SWE8100	17, 18, 19, 25, 26, 29, 30
1862B	12
21C485	5, 35
21C5001G01	16, 17
21C5004P01 (Superseded by 21C5110P01	
21C5005G01	12
21C5010G01	12
21C5011P01	14
21C5016G01	19
21C5018G01	16
21C5020G01	19
21C5021G01	17
21C5022P01	16
21C5024G01	19
21C5027G01 (Superseded by 21C5042G01)	
21C5028G02 (Superseded by 21C5193G01)	
21C5029G01 (Superseded by 21C5043G01)	
21C5030G01	7
21C5031G01	29. 30
21C5032P02	11, 12
21C5033G01	11
21C5034G01	33, 34
21C5035G01 (Superseded by 21C5085G01)	
21C5036G02 (Superseded by 21C5039G01)	
21C5037G01	16, 17
21C5038G01	11
21C5039G01	23, 24, 25, 26
21C5041G01	27, 28, 29, 30
21C5042G01	16, 17
21C5043G01	18, 19
21C5044G01 (Superseded by 21C5044G02)	
21C5044G02	29, 30
21C5045G01	3
21C5048G01	6
21C5049G01	7
21C5050P01	6
21C5051G01	7
21C5052G01	28
21C5053G01	27
21C5055G01	1
21C5056G01	24
21C5057G01	23
21C5060G01 (Superseded by 21C5060G02)	
21C5060G02	26
21C5061G02	30
21C5064G01	22
21C5065G01	19
21C5066G01	18
21C5067G01	10
21C5068G01	11
21C5071G01 (Superseded by 21C5210G01)	
21C5072G01	20
21C5078G01 (Superseded by 21C5044G01)	
21C5079G01 (Superseded by 21C5237G01)	25, 26
21C5080G01	22
21C5081G01	7
21C5083G01	18, 19
21C5084G01	11
21C5085G01	27, 28, 29, 30, 31, 32
21C5086G01	12
21C5087P01	14
21C5088G02	18, 19
21C5089G01 (Superseded by 21C5089G02)	
21C5089G02	6, 7

TABLE 2-2. NUMERICAL INDEX OF GROUND SUPPORT EQUIPMENT (Cont)

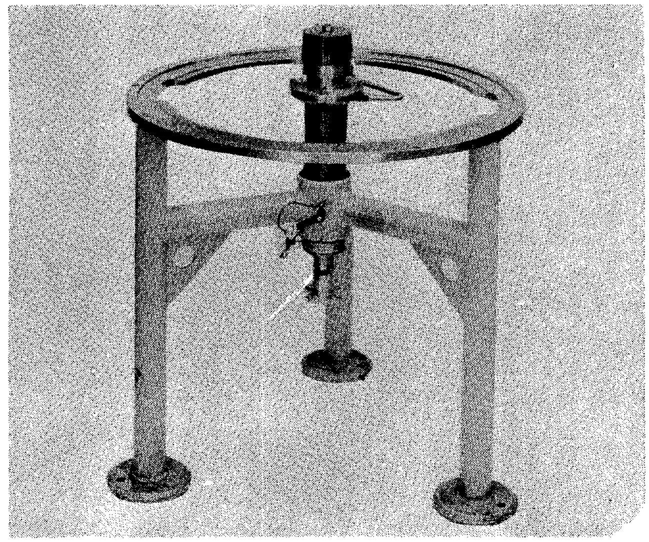
Tool Number	Functional Group No.
21C5090G01	17
21C5095G01	25, 26
21C5097G02 (Superseded by 21C5211G01)	
21C5101G01	18, 19
21C5106G01	15
21C5110P01	14
21C5114G01 (Superseded by 21C5210G01)	
21C5116G01 (Superseded by 21C5116G02)	
21C5116G02	1, 2, 4
21C5117P01	16, 18, 19
21C5122P01	29
21C5123G01	29
21C5125G01	1
21C5126G01	5
21C5127G01 (Superseded by 21C5084G01)	
21C5130P01	14
21C5131G01	27, 28, 29
21C5132G01	5, 10
21C5133G01	29
21C5138G01	32
21C5139G01	31
21C5142G01	1
21C5154G01	35
21C5159G01	10
21C5160G01	29
21C5166G01 (Superseded by 21C5219G01)	
21C5169G01	3, 4
21C5174G01	4, 8, 9
21C5175G01	32
21C5177G01	21
21C5178G01	10
21C5180G01	22
21C5181G01	25, 26
21C5182G01	25, 26
21C5183G01	36
21C5184G01	30
21C5186P02	25
21C5187G02	16, 17
21C5188G01	29, 30
21C5189G01 (Superseded by 21C5189G02)	
21C5189G02	13, 21
21C5190G01	10, 13
21C5191G01 (Superseded by 21C5191G02)	
21C5191G02	25
21C5192G01	16, 17
21C5193G01	6, 7
21C5194G01	6, 7
21C5195G01	23, 24
21C5196G01	31, 32
21C5197G01	27, 28
21C5198G01	3, 4
21C5199P01 (Superseded by 21C5130P01)	
21C5200G03	13
21C5202G01	21
21C5203P01	23
21C5204G01	26
21C5205G01	23, 24, 34A
21C5209P01	14
21C5210G01	3, 4, 8, 9, 25, 26, 29, 30
21C5211G01	25, 26
21C5212G01	21
21C5215G01	21
21C5219G01	3, 4, 8, 9, 10, 21

TABLE 2-2. NUMERICAL INDEX OF GROUND SUPPORT EQUIPMENT (Cont)

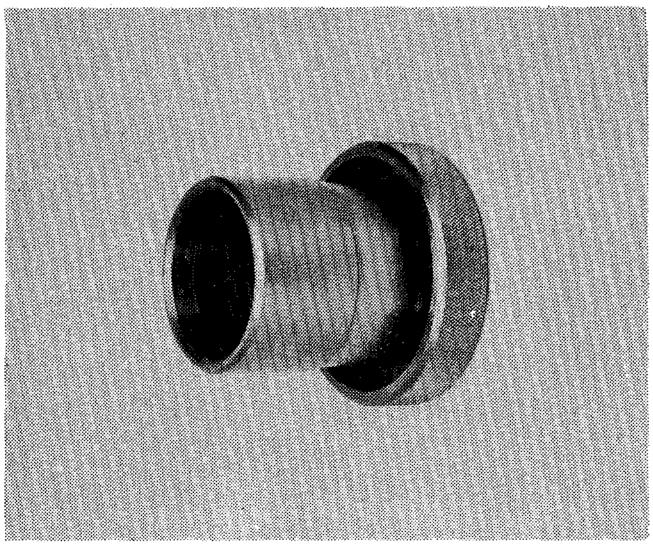
Tool Number	Functional Group No.	Tool Number	Functional Group No.
21C5220G01	3,4,8,9,10	21C5512G01	12
21C5229G01	1	21C5513G01	12
21C5231G01	22	21C5514G01	12
21C5232P01	25	21C5516G01	12
21C5234G01	22	21C5517G01	12
21C5237G01	25, 26	21C5518G01	12
21C5385P01	34A	21C5519G01	12
21C5397P01	11	21C5520G01	12
21C5398P01	11	21C5521G01	12
21C5501G01	12	21C5527G01	12
21C5501P01	12	21C9800G01	12
21C5501P04	12	2501	16,17,18,19,25,26, 29,30,31
21C5501P05	12	3000	13
21C5503G01	12	3100A	13
21C5505G01	12	4000A	13
21C5506G01	12	619AS100	12
21C5507G01	12	64A128J1 (NFT-2)	12
21C5511G01	12	65A102J1	36



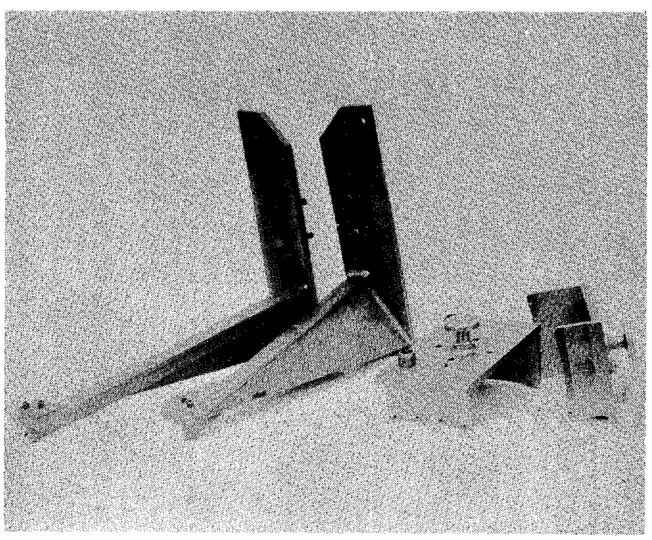
1 21C5018G01



4 21C5035G01



2 21C5022P01



3 21C5031G01

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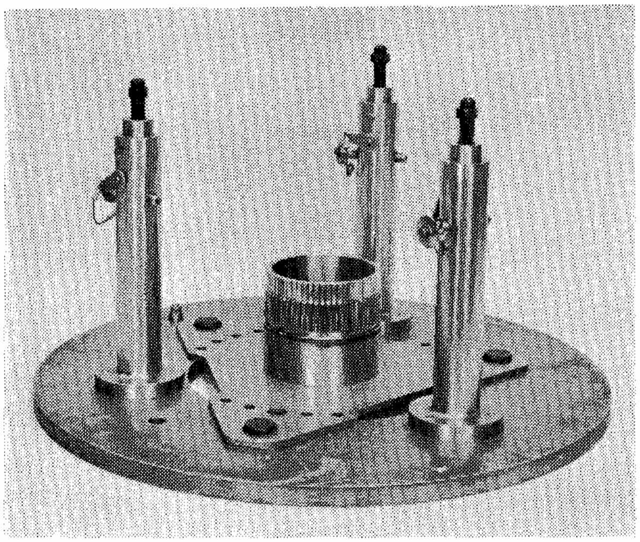
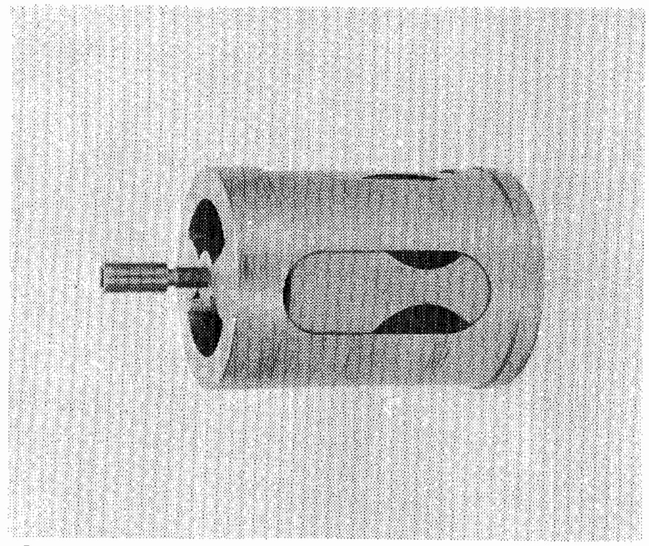
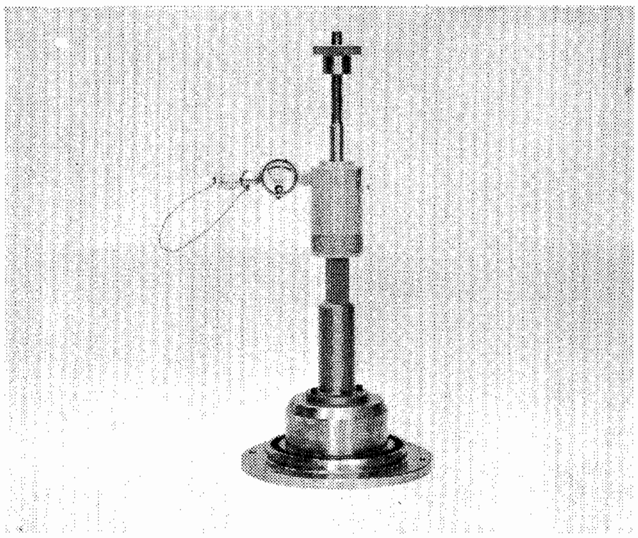
Figure 2-1. Ground Support Equipment



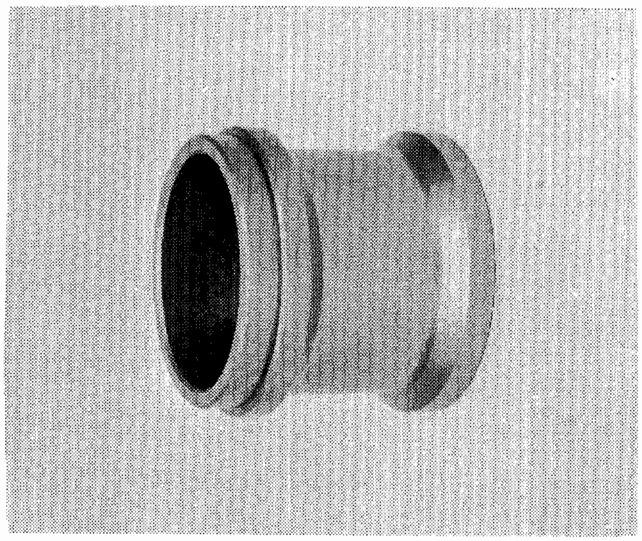
1 21C5036G02



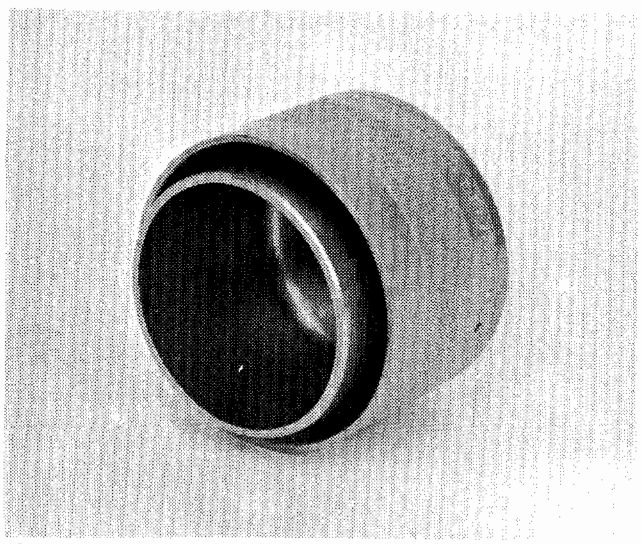
4 21C5049G01



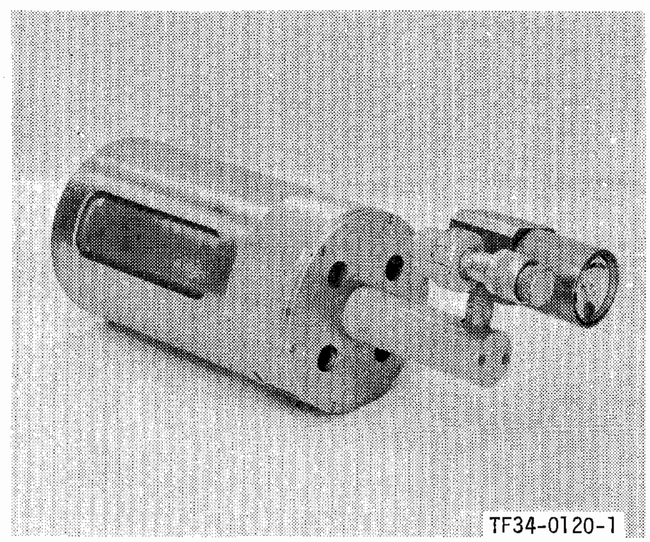
2 21C5037G01



5 21C5050P01

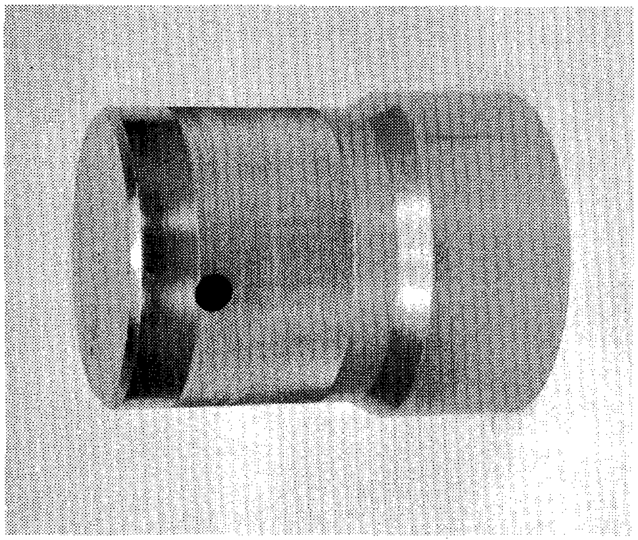


3 21C5048G01

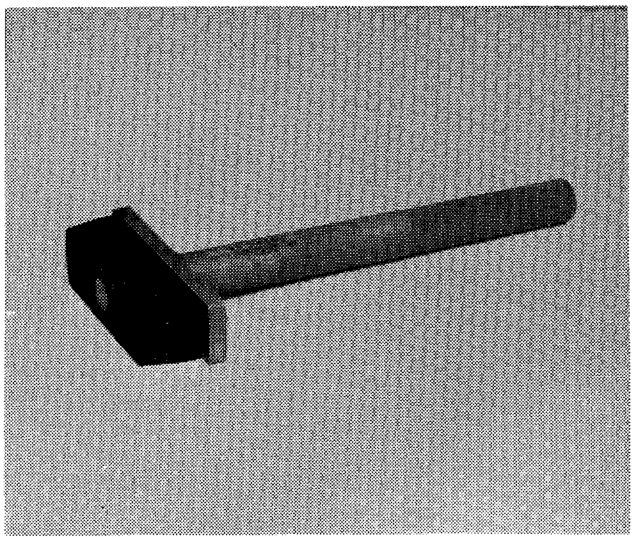


6 21C5052G01

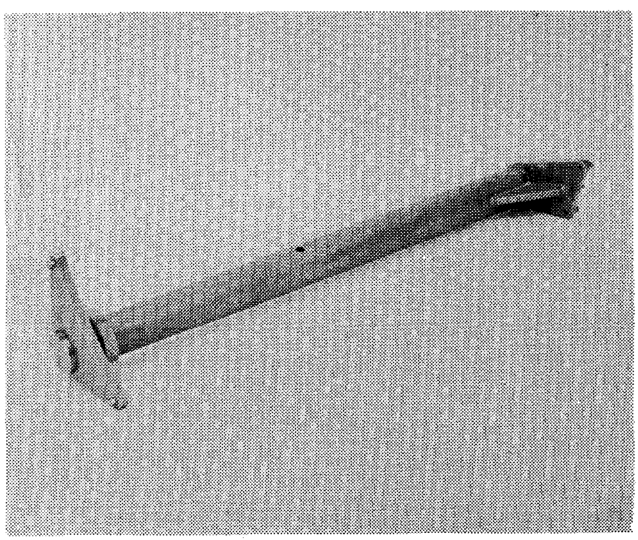
Figure 2-2. Ground Support Equipment



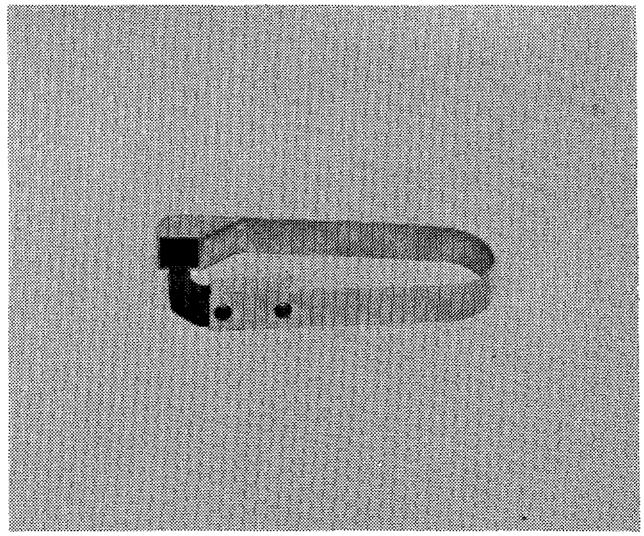
1 21C5053G01



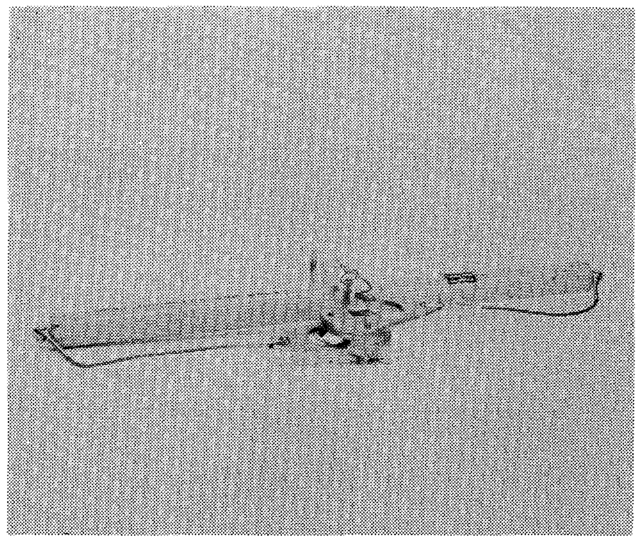
2 21C5055G01



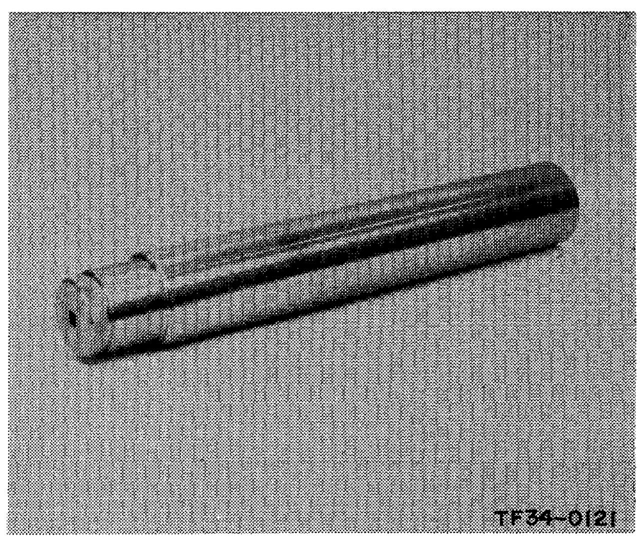
3 21C5067G01



4 21C5068G01

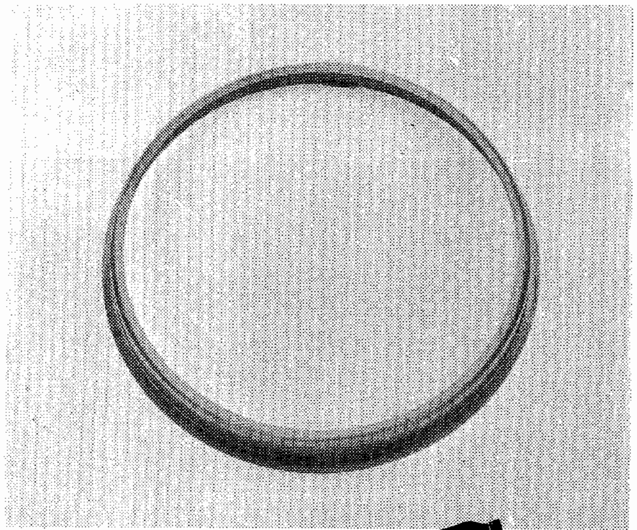


5 21C5071G01

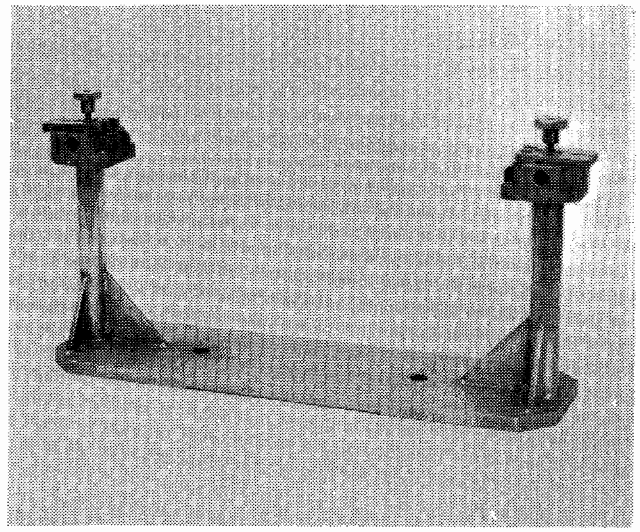


6 21C5095G01

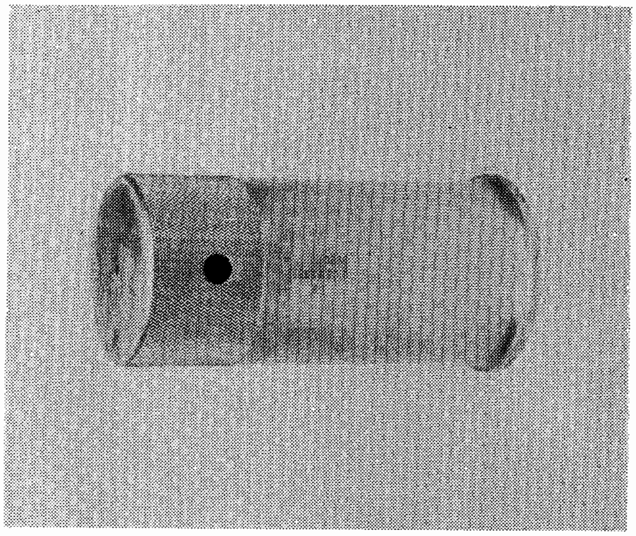
Figure 2-3. Ground Support Equipment



1 21C5117P01

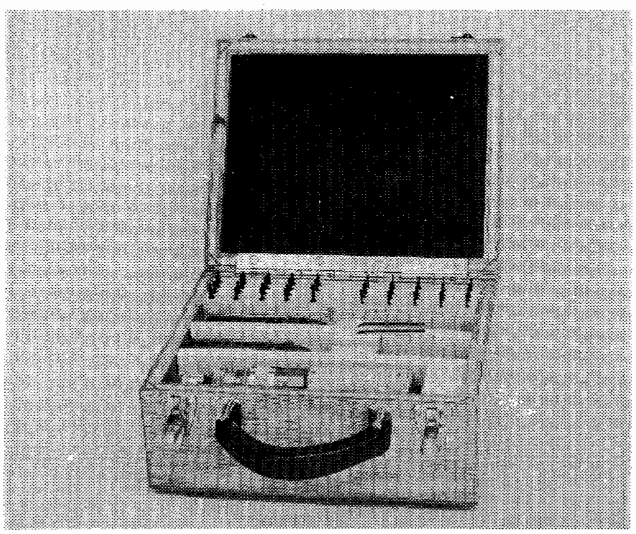


4 21C5127G01



2 21C5123G01

5 21C5130P01



3 21C5126G01

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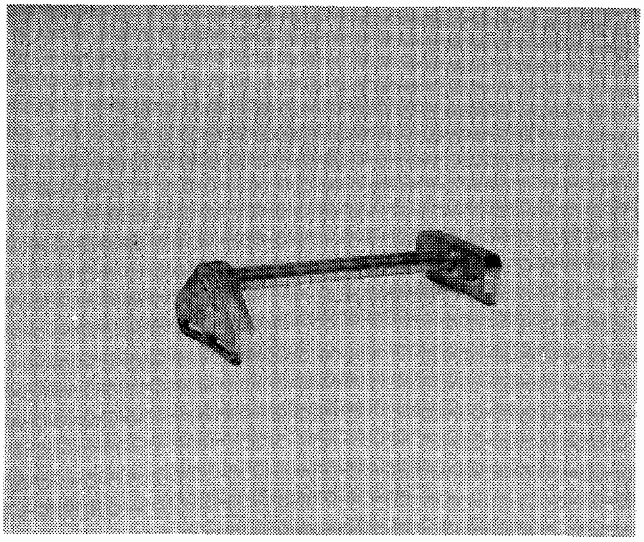
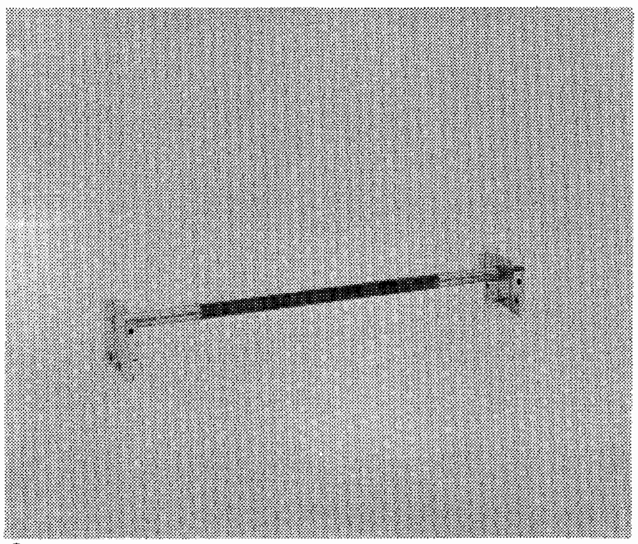
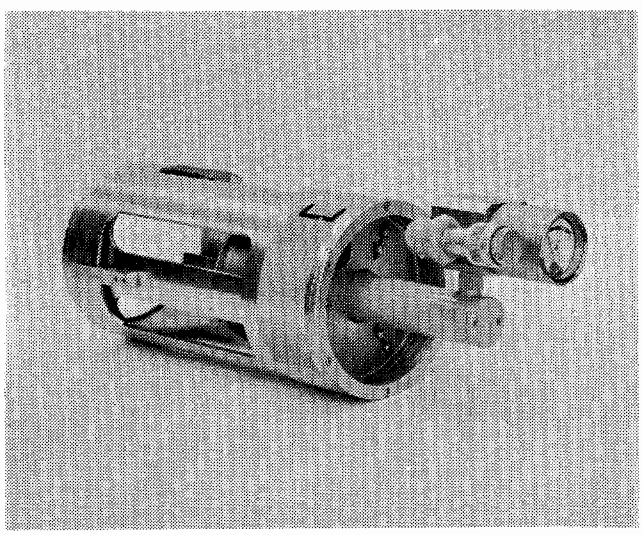
Figure 2-4. Ground Support Equipment



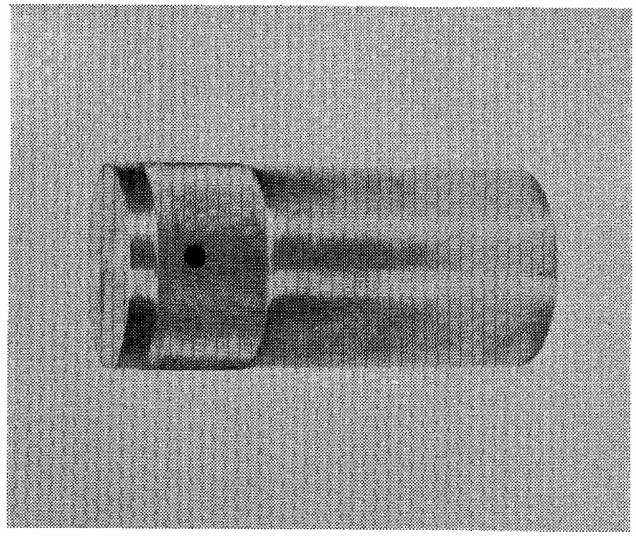
1 21C5131G01



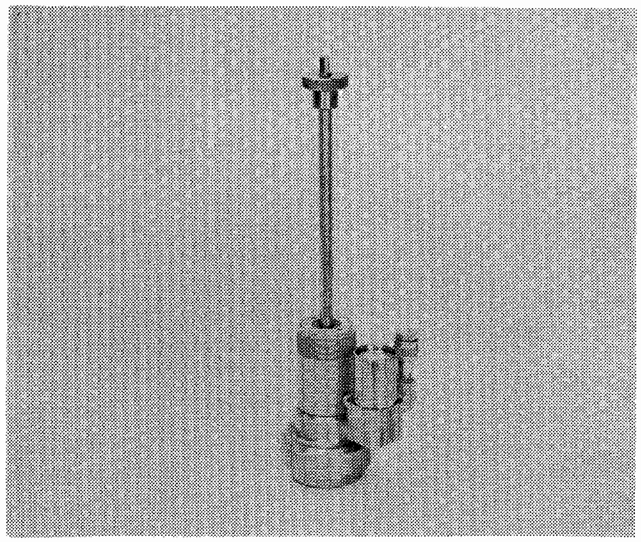
2 21C5132G01



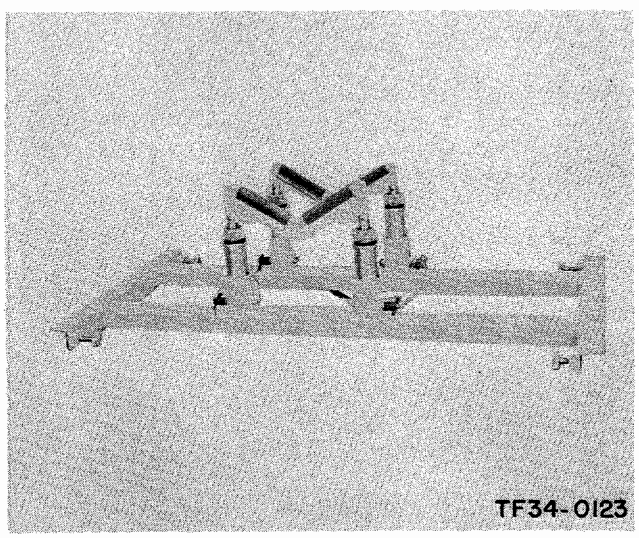
3 21C5138G01



4 21C5139G01

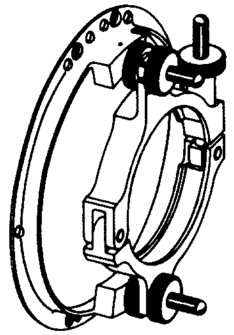


5 21C5160G01



6 21C5174G01

Figure 2-5. Ground Support Equipment



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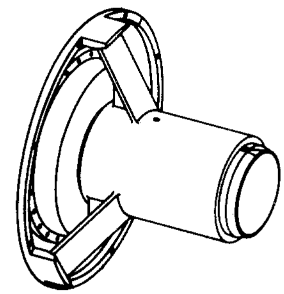

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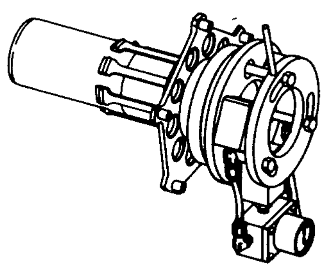

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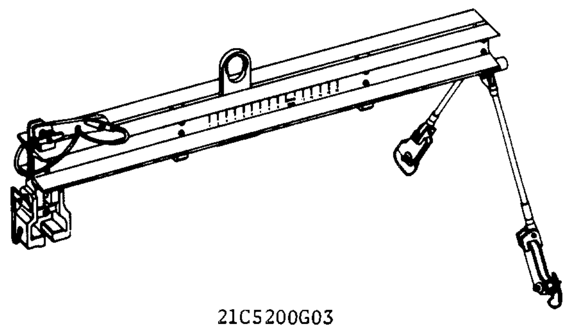

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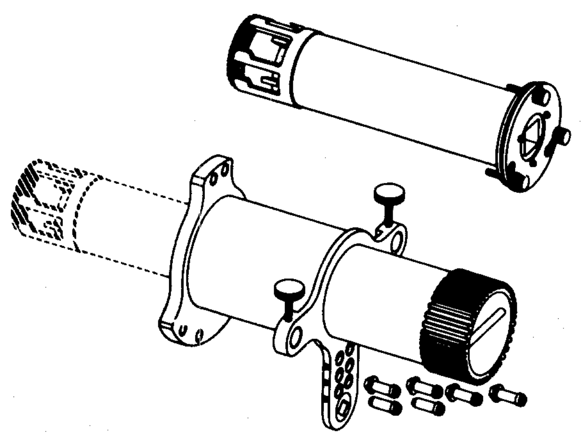

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Figure 2-6. Ground Support Equipment

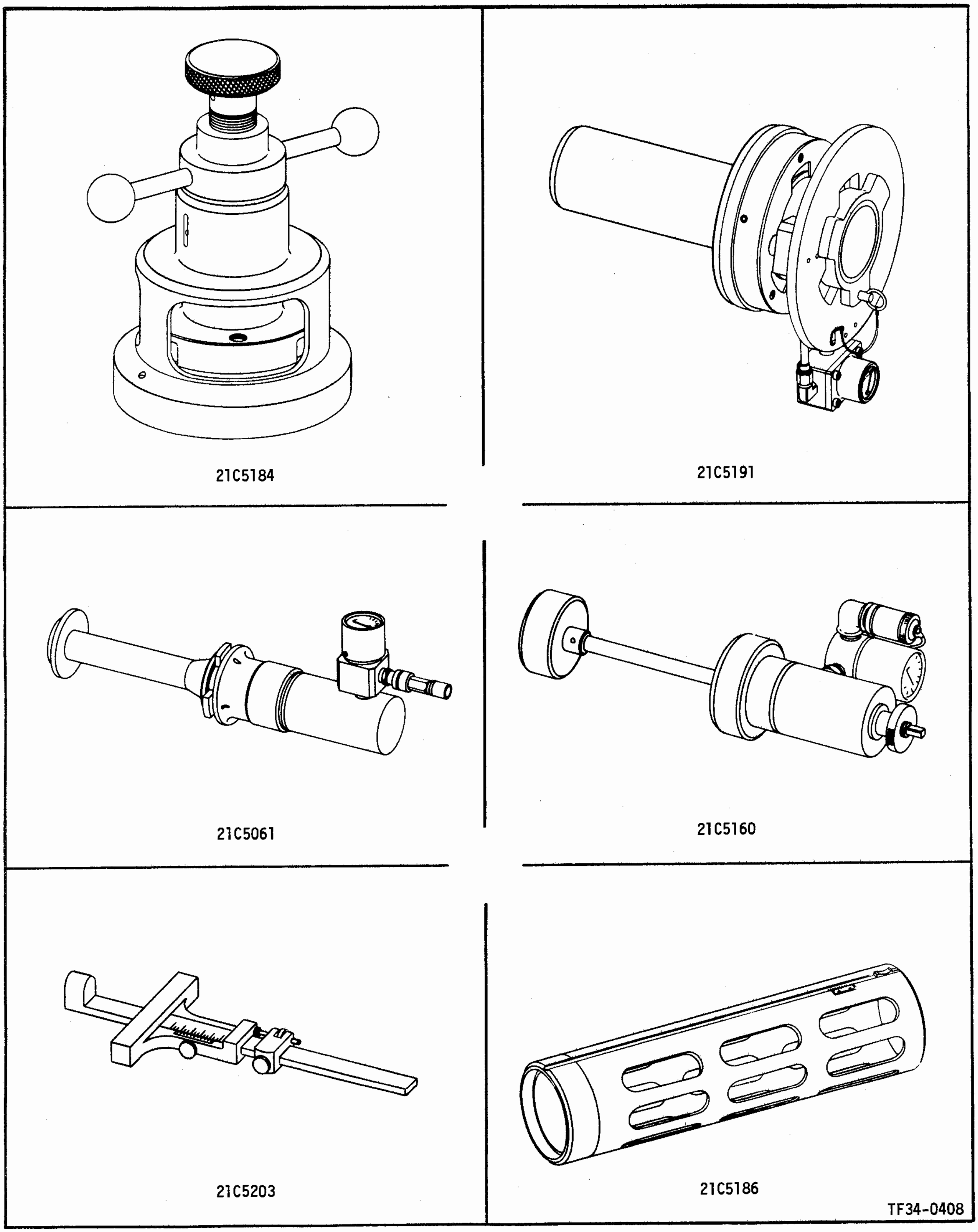


Figure 2-7. Ground Support Equipment

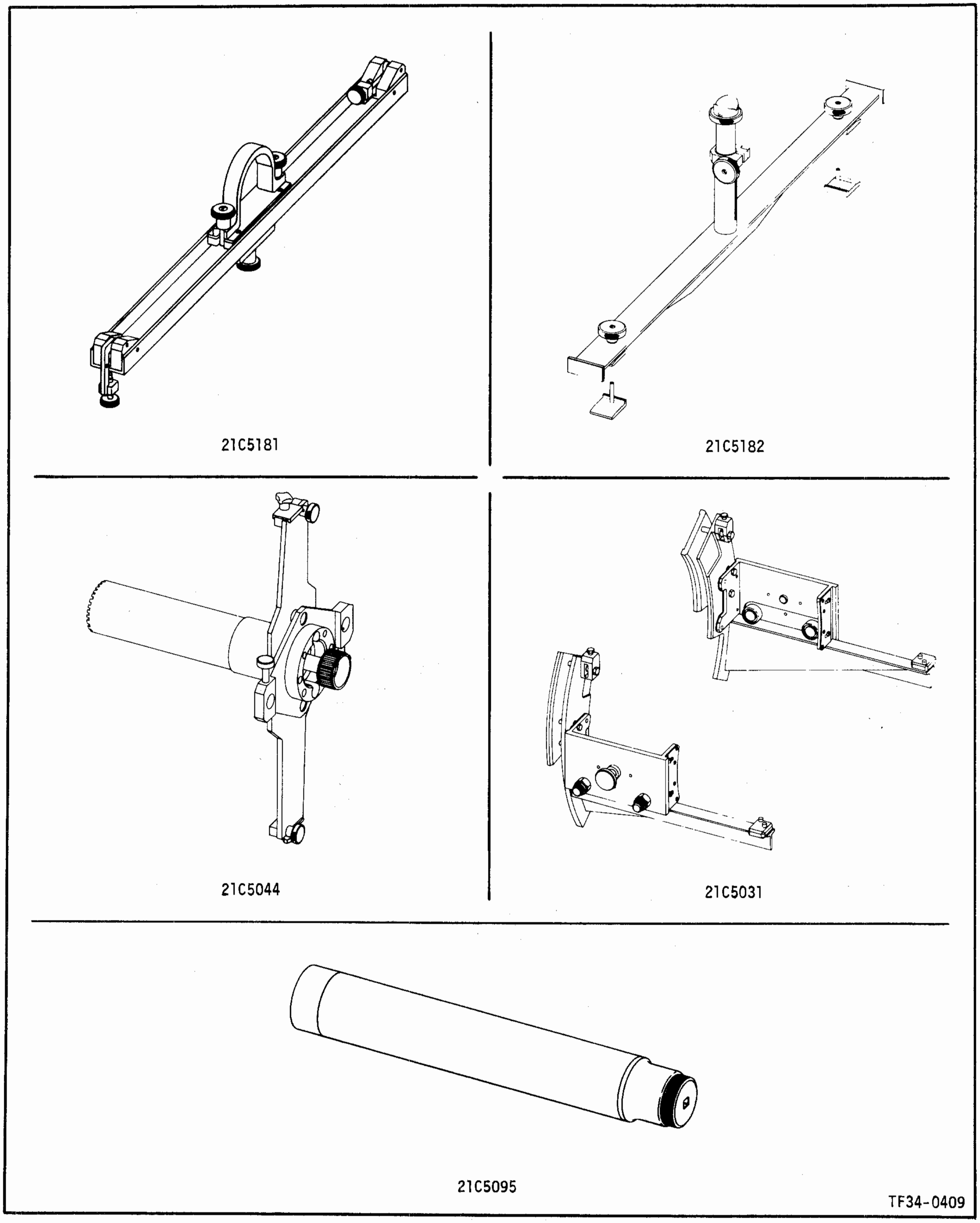


Figure 2-8. Ground Support Equipment

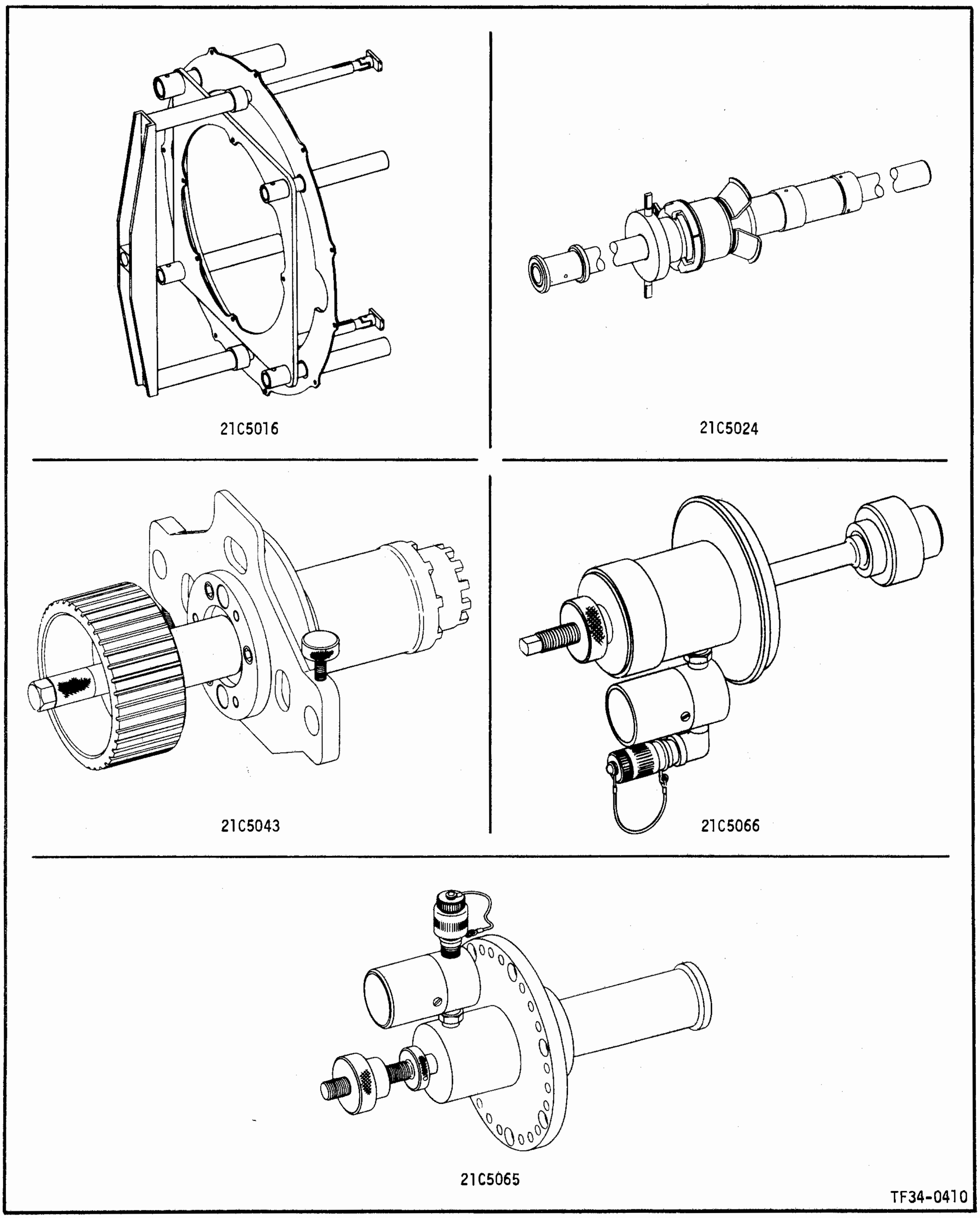


Figure 2-9. Ground Support Equipment

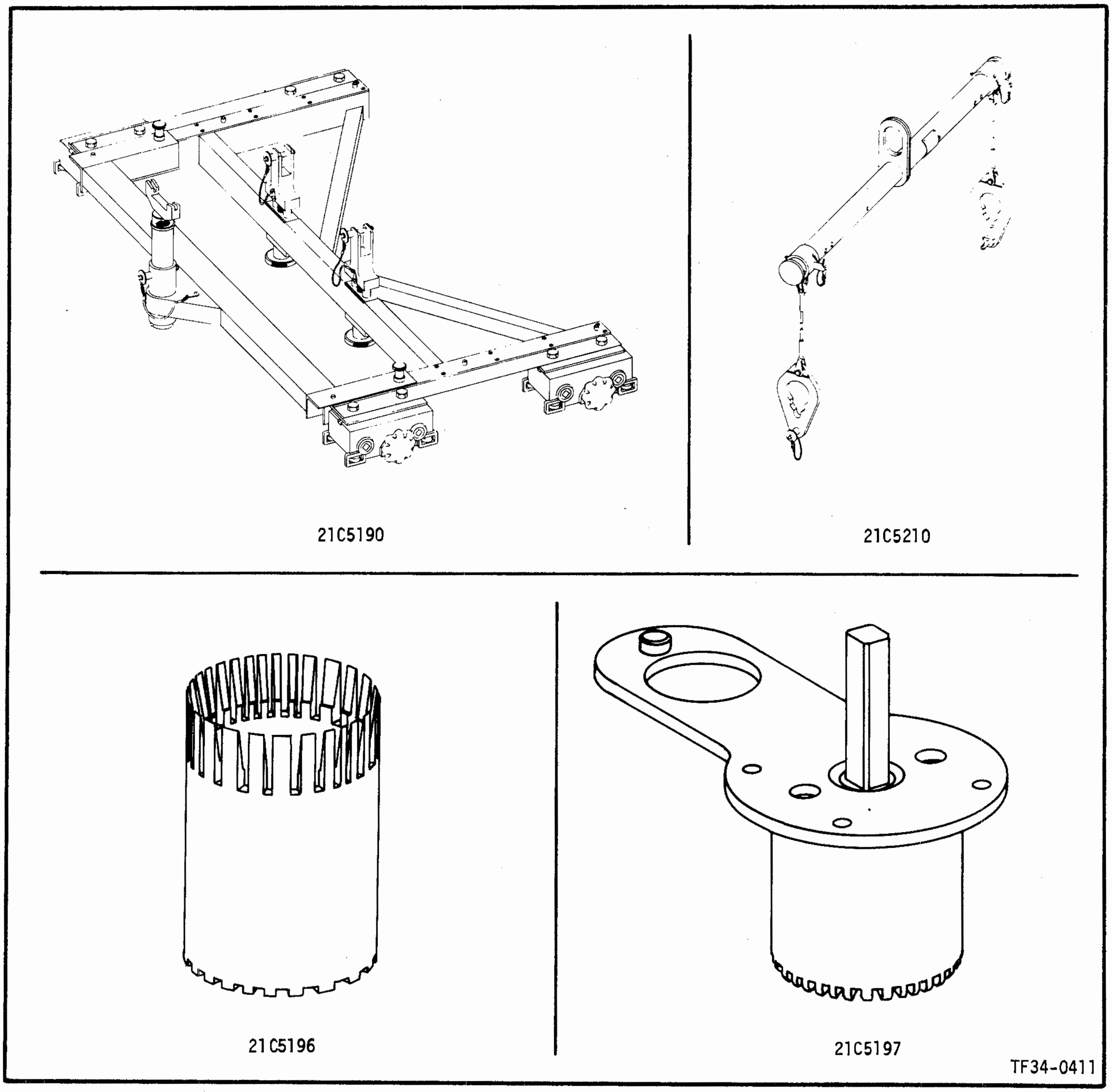


Figure 2-10. Ground Support Equipment

SECTION III
PREPARATION FOR SERVICE AND STORAGE

3-1. GENERAL.

3-2. This section contains instructions for preparation of the engine for service and storage. The preparation for service instructions describes removal of engine from shipping container and installation onto the standard 48-inch rail system, and depreservation and corrosion control. Instructions for storage include procedures for preservation of engine, removal of engine from rail system and installation in shipping container. Table 3-1 lists shipping container specifications.

TABLE 3-1.
SHIPPING CONTAINER SPECIFICATIONS

Length	139 in. max
Width	77 in. max
Height	66 in. max
Empty Weight	2800 lbs
Weight of Container and Engine (with QEC components)	4550 lbs

3-3. REMOVAL OF ENGINE FROM SHIPPING CONTAINER AND INSTALLATION ON RAIL SYSTEM. See Figure 3-1.

NOTE

If lifting container with engine inside, crane must have a 2-1/2 ton capacity. Lifting engine alone, crane must have 1 ton capacity.

1. Release any pressure buildup in container by breaking seal wire on left-hand vacuum relief valve and turning manual relief knob.

2. Loosen nuts (15, figure 3-1). Turn closure flange T-bolts (3) 90° counterclockwise.

CAUTION

Lift cover straight up to avoid damaging engine.

3. Remove cover assembly (1) from base assembly (2).

4. Remove 8 hex head cap screws (4), 8 self-locking nuts (5), and 16 flat washers (6) from forward and aft ring assemblies (7 and 8).

5. Position engine forward and aft supports (21C5189 and 21C5190) respectively, on rail system.

6. Attach hoisting adapter (21C5200) (21) to suitable hoist, then connect hoisting adapter to the forward and aft ring assemblies.

CAUTION

When lifting engine, be sure to lift it straight up to avoid damaging engine.

7. Lift engine from container and position over forward and aft supports.

8. Connect forward support to the lugs at the 3 and 9 o'clock positions on the fan casing with the quick-release pins provided.

9. Connect rear support to the holes at the 5 and 7 o'clock positions in the engine aft mount ring with the quick-release pins provided. Center the engine on rail system.

10. Remove forward and aft ring assemblies (7, 8) by removing engine mounting hardware.

10A. Install thrust mount cover plate (24) with bolts (23). Torque bolts to 38-42 lb in. and lockwire, double-strand method, using 0.032 inch lockwire.

10B. Install aft mount ring bearings and covers (26) with bolts (25). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

11. Fasten engine mounting hardware to forward and aft ring assemblies (7, 8).

12. Secure forward and aft ring assemblies to base assembly (2) using cap screws (4), washers (6), and nuts (5).

13. Lower the cover assembly (1) onto base assembly (2), using dowel pins for proper alignment. Make certain that the closure flange gasket (14), is properly seated prior to lowering of cover assembly onto base assembly.

14. Rotate closure flange T-bolts (3) 90° clockwise. Progressively tighten nuts on T-bolts making certain that T-bolt stays perpendicular to closure flange slot.

15. Install the following engine protectors (covers):

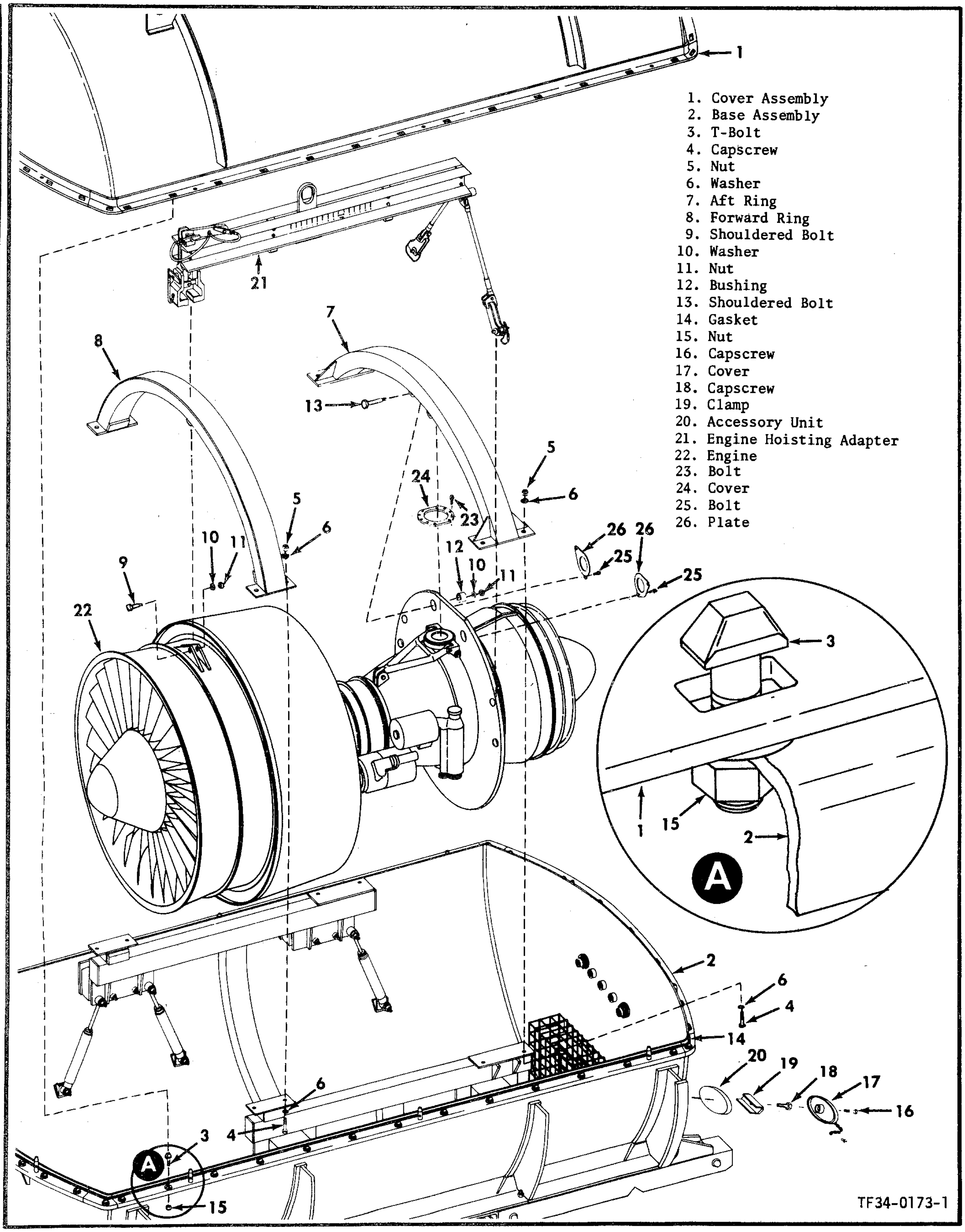


Figure 3-1. Shipping Container - Engine Removal/Installation

a. Multipurpose cover (21C5130).

b. Engine exhaust cover (21C5199).

3-4. ACTIVATING ENGINE AFTER STORAGE (DEPRESERVATION).

3-5. GENERAL.

After an engine, removed from storage, has been installed in test stand or aircraft, the lube system must be serviced and the fuel system purged of preservative oil before the engine can be operated.

3-6. These instructions do not in any way supersede the requirements of Specification MIL-E-5595 as amended. Examine the preservation record tags and the historical records of the engine.

3-7. SERVICING ENGINE OIL TANK.

CAUTION

- Be sure that filler cap is secure after adding oil.
- Under certain conditions, it is possible for the lubrication system to be overserviced. If the anti-leak check valve in the filter element is faulty, oil will start to drain from the tank when the engine is shut down. Oil will seep from the tank, into the pump, through the faulty check valve and into the engine sumps, including the one in the gearbox. If the engine is shut down for an extended period, usually several days, the oil will be completely drained from the tank. Consequently, if the tank is serviced to full, the amount of oil in the system could be twice the amount needed. This could cause the oil tank to deform or burst during startup.
- If the addition of 2 quarts of oil does not bring the level up to the tank opening (sight gage is full), do not add more oil until engine has been run at idle for one to two minutes and then shut down. If level is above tank opening, check if the valve is defective, in which case the filter element assembly must be replaced.
- There are 2 methods of filling the oil tank. Step 1 covers gravity filling and step 2 covers pressure filling.

1. Fill the oil tank by gravity as follows:

a. Remove filler cap.

b. Fill tank with engine oil (MIL-L-23699) until oil starts to overflow tank into scupper drain. Sight gage will be full.

c. Wipe off excess oil.

d. Install filler cap and secure.

2. Fill the tank using pressure cart as follows:

a. Connect the fill and drain hoses to tank.

b. Fill tank with engine oil (MIL-L-23699) until sight gage on tank is full.

c. Allow excess oil (if any) to drain from tank; disconnect the fill and drain hoses.

3. Drain the oil tank as follows:

WARNING

Be sure oil is cool before draining.

CAUTION

To get maximum service life out of engine and to minimize maintenance work, the period between oil changes shall not exceed 200 hours. Do not reuse oil.

a. Place a 5 gallon pail under the magnetic plug. Remove the plug assembly per paragraph 4-50.

b. Drain oil into pail.

c. Install plug per paragraph 4-51.

3-8. ACTIVATING NEW ENGINE, ENGINE RECEIVED FROM OVERHAUL, OR ENGINE STORED FOR MORE THAN 45 DAYS.

3-9. These engines are preserved per Specification MIL-E-5607. With the engine installed in the aircraft, or in test stand, and with proper fuel supplied, proceed as follows:

1. Service the oil tank per step 1 or 2, paragraph 3-7.

2. Purge the fuel system of preservation oil as follows:

CAUTION

To prevent shearing the oil pump shaft or damage to pump, make sure that lube lines are clear of plugs. Be sure an adequate supply of engine oil is provided to the engine lube system during depreservation.

a. Cap the primer system per paragraph 10-4, step 3.b.

b. Place ignition switch in OFF position.

c. Disconnect the fuel control discharge hose (10, figure 4-16) from the fuel distributor. Attach an extension line to the discharge hose and direct the extension line to an empty container.

d. Place throttle in the FULL OPEN position. Open the fuel system shut off valve.

e. If the engine is in the test stand, turn on the fuel boost pump.

CAUTION

Observe starter operating limits.

f. Place the start switch in the ON position. Motor the engine on the starter for 2 minutes.

NOTE

This procedure will also prime the fuel system.

g. De-energize the starter system and the fuel boost pump. Place the throttle in the closed position. Close the fuel system shutoff valve.

h. Remove the extension line installed in step b, this paragraph. Lubricate the threads of the discharge hose with engine oil. Reinstall the discharge line (10, figure 4-16) to the fuel distributor. Torque the discharge line to 38-45 lb ft.

i. Reconnect the primer system per paragraph 4-100E.

CAUTION

Observe starter operating limits.

3. The engine lube system is fully primed when the oil-pressure gage shows a steady, positive indication. Wait 3 minutes and, if necessary, motor engine on starter to get a positive indication.

4. Visually inspect for and correct any fuel or oil leaks.

5. Upon starting engine after depreservation, run engine at idle for 4-5 minutes before accelerating to full power.

3-10. ACTIVATING ENGINE STORED FROM 1 TO 45 DAYS.

1. If the oil level in the lube oil tank is low, motor the engine for about 1 minute before servicing the tank per paragraph 3-7. Motoring the engine will pump any oil in the sumps back into the tank.

2. Visually inspect for and correct any leaks.

3-11. DELETED.

3-12. DELETED.

3-13. CORROSION CONTROL.

3-14. GENERAL.

The following procedures give protection from corrosive elements to engines in active service as opposed to the preservation procedures in paragraph 3-17 which apply to engines being prepared for storage or shipment.

3-15. FAN AND COMPRESSOR SALT DEPOSIT REMOVAL.

1. Perform the salt deposit removal procedure if any of the following conditions exist:

a. When salt deposits are noted on engine intake areas, or other external surfaces of the aircraft that would indicate possible buildup on fan and compressor airfoils.

b. After operation when engines are operated near salt water and a performance loss is noted.

c. As often as required to keep fan and compressor clean and prevent performance loss.

d. Once a week on a carrier.

2. Wipe any salt deposits from the fan vanes, blades, inlet and exterior, using clean water and cloth.

CAUTION

Allow engine to cool after shutdown for at least 45 minutes or T5 to drop below 320°F (160°C) before using wash procedure.

3. Check the ambient temperature; then, depending upon its value, use the procedure in step a or b.

CAUTION

Do not exceed starter limitations or turn on ignition during this procedure.

a. At ambient temperatures above 40°F (4°C) proceed as follows:

(1) Connect the wash water supply on cart (65A102J1) to the inlet fitting on drain strut using adapter (21C5183); do not turn on washing solution.

(2) Set the air pressure for the water at 80 PSIG. This pressure setting results in 60 PSIG at the engine fitting.

(3) Spray water into engine for 1 minute while motoring the engine on the starter at 5000 RPM (28%) Ng. off starter.

(4) Allow starter to rest for 90 seconds.

(5) Repeat steps (3) and (4) once. Then procede to step 4.

WARNING

Methanol
Fed Spec O-M-232

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Vapors are harmful. Avoid prolonged or repeated breathing of vapors. Do not use when ambient temperature is above 40°F unless adequate ventilation is provided according to local statutory codes and regulations.
- May be fatal or cause blindness if swallowed. Cannot be made nonpoisonous.
- Keep container closed.
- Store in approved metal safety containers.

NOTE

At ambient temperatures between 40°F (4°C) and -15°F (-25°C), add Methanol (Specification O-M-232, Grade A or B) to the water at a ratio of 4 parts Methanol to 6 parts water. Do not clean the engine if the ambient temperature is below -15°F (-25°C).

b. At ambient temperatures of 40°F (4°C) or below, proceed per step a. except by spraying a 40 percent methanol, 60 percent water mixture in place of fresh water. For maximum solubility of the salt, the wash cycle should be repeated and the temperatures of the wash solution should not be below 40°F (4°C); ideally it should be between 70-80°F (21-26°C) and should be used as soon as possible after the 45-minute engine cooling period.

4. Disconnect waterwash supply and adapter (21C5183).

5. Perform Dry Cycle, as follows:

a. Start engine and run at 14,200 RPM Ng. for 5 minutes with anti-icing on to dry the compressor.

b. Shut engine down.

6. Install engine inlet and exhaust duct covers, and keep them in place during periods of engine inactivity.

3-16. COMPRESSOR CLEANING AFTER ACCIDENTAL INGESTION OF FIRE EXTINGUISHING MATERIAL.

1. Do not use this procedure if the following conditions exist:

a. Engine is suspected of malfunction.

b. Engine rotors do not turn freely (indication of internal damage).

c. Engines have ingested a dry-chemical firefighting agent and must be sent to the proper maintenance level for disposition.

2. If the engine has been subjected to organic fire extinguishing material, such as foam, due to accidental ingestion, the following procedure shall be adhered to within 48 hours of ingestion

3. Apply fresh water to the engine per paragraph 3-15, steps 3 through 6.

4. Perform a calendar inspection on the engine.

5. For engine cleaning and preservation after extinguishing fire using foam or other chemical solutions, refer to paragraph 3-20 and NAVAIR 15-02-500.

3-17. PREPARATION OF ENGINE FOR STORAGE (PRESERVATION).

3-18. PRESERVATION OF ENGINE TO BE INACTIVE FOR 1 TO 45 DAYS.

NOTE

Engines remaining in an inactive status beyond 45 days shall be preserved per entire paragraph 3-19.

NOTE

Compressor preservation is not required.

1. If the engine has been operated in a salt laden air environment, then comply with water wash requirements of paragraph 3-15.

2. Check level and fill engine oil system with engine oil (MIL-L-23699) per paragraph 3-7.

3. Remove and clean fuel filter per paragraph 4-108A and 4-109.

4. Reinstall fuel filter assembly per paragraph 4-109A.

5. Operate engine for at least 10 minutes at IDLE speed to make sure internal parts are coated with oil. Shut down engine.

6. Thirty minutes after shutdown, seal all engine openings to keep out moisture, dirt, and foreign objects.

7. Remove, inspect and reinstall the engine oil filter per paragraph 4-64, and chip detectors per paragraph 11-15.

8. Install the engine in the container per paragraph 3-27.

3-19. PRESERVATION OF ENGINE TO BE INACTIVE FOR 45 TO 180 DAYS.

NOTE

- Comply with requirements of paragraph 3-15 (Water Wash).
- Compressor preservation is not required.
- The 45 to 180 day preservation treatment may be renewed once. Engines inactive at the end of the second preservation period shall be preserved in accordance with MIL-E-5607. Engines in sealed containers will require no renewal of preservation, provided inspections performed per paragraph 3-23 indicate such action is unnecessary.

1. If the compressor is dirty or if the engine has been operated in a salt laden air environment, then comply with water wash requirements of paragraph 3-15.

2. Check level and fill engine oil system with engine oil(MIL-L-23699).

3. Remove and clean fuel filter.

4. Reinstall fuel filter per paragraph 4-109A.

5. Operate engine for at least 10 minutes at IDLE speed to make sure internal parts are coated with oil. Shut down engine.

6. Disable ignition system by disconnecting the electrical connection at the test stand connection.

7. Cap the primer system per paragraph 10-4, step 3, b.

NOTE

Use only fresh oil and a clean container.

8. Disconnect the fuel inlet line and replace with a line from a gravity-feed container of oil, specification MIL-L-6081, grade 1010 (approximately 2 gallon capacity). Filter the oil with a 10 micron filter.

9. Place the power lever in the FULL OPEN position and motor the engine with the starter for 2 minutes. One gallon of oil will be used in this period.

10. Disengage the starter and place the power lever in the CLOSED position. Disconnect the oil supply line and install the shipping cover if the engine is to be shipped or reconnect the fuel inlet line if the engine is to remain installed.

11. Thirty minutes after shutdown, seal all engine openings to keep out moisture, dirt, and foreign objects.

12. Remove, inspect and reinstall the engine oil filter per paragraph 4-64, and chip plugs per paragraph 11-15.

WARNING

Be sure oil is cool before draining.

13. Drain oil from tank per paragraph 3-7.

14. Install engine in container per paragraph 3-27.

3-20. PRESERVATION OF ENGINE IMMERSED IN SALT WATER OR EXPOSED TO FIRE EXTINGUISHING MATERIAL.

3-21. This procedure prescribes the minimum emergency preservation which shall be applied to engines after immersion in salt water and after involvement in crashes or fires where fire-fighting agents, other than CO_2 have been used. If CO_2 has been used exclusively, no corrective action is required.

1. This preservation shall be performed as soon as possible after recovery of the engine from the water or following the extinguishing of the fire. No preservation shall be accomplished prior to obtaining the release of the engine from any board of inquiry involved with the accident. However, it is extremely important that this emergency treatment be applied as soon as practicable to reduce the greatly accelerated corrosive attack induced by water and the presence of fire-fighting agents. The emergency preservation consists of removal of all salt deposits and fire-fighting agent residues, using fresh water, steam, or both, followed by prompt application of water-displacing preservatives such as MIL-C-16173 and thorough drying of parts and assemblies using heaters, ovens, or any other available means where temperature can be controlled.

2. When engines are involved in salt water crashes, it is assumed that all internal areas are contaminated, and disassembly shall progress (as far as available facilities permit) to the point where it can be definitely established that all contaminants

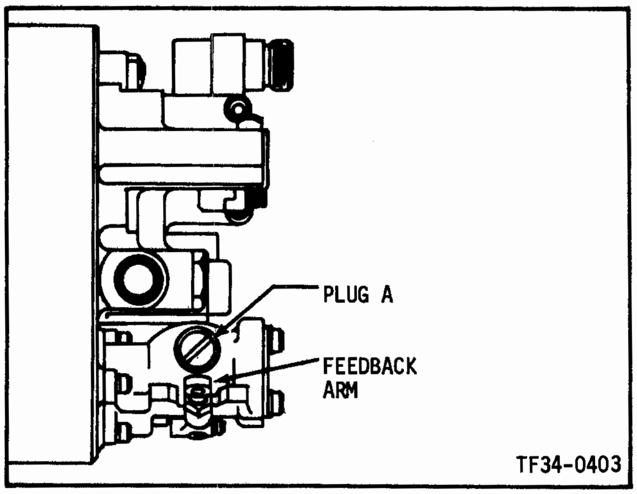


Figure 3-2. Fuel Control Preservation Port - Plug A.

have been removed and all surfaces have been effectively cleaned and inhibited against further corrosive attack.

NOTE

If engine has been subjected to internal or external fires extinguished by the use of a dry chemical fire extinguisher containing sodium bicarbonate or potassium bicarbonate (PKP), it shall be tagged with an appropriate water-crash-fire damage tag and sent to specified depot for further disposition.

3. Tag all parts removed from engines with an appropriate salt water-crash-fire damage tag. This tag shall remain with the part until disposal action is complete or overhaul of the part or assembly involved is accomplished. The tag shall specify:

WATER-CRASH-FIRE DAMAGE PART

Part No. ________________
Nomenclature ________________
Serial No. ________________
Preserved Method ________________
Date ________________
Name of Activity ________________
EXPEDITE HANDLING

4. Surfaces cleaned during emergency preservation shall not remain uncoated due to the lack of any specified preservatives. In an emergency, use any preservative oil available. If no preservative oil is at hand, any clean unused light oil may be substituted. The application of a non-preservative light oil will be better than allowing part to remain uncoated because of lack of a specified preservative.

5. To protect the salvageable components of an engine during emergency preservation, observe the following procedures:

a. Disassemble engine, as far as is possible with the available facilities, to expose all possible contaminated surfaces. Be careful during disassembly to prevent additional engine damage.

b. Thoroughly clean all removed components; use steam or hot, fresh water or cold, fresh water, in this order of preference. Continue steam-cleaning or flushing until all visible salt or other chemical deposits have been removed.

NOTE

If heating facilities are not available, dry all components with a suitable wiping cloth and coat all parts with water-displacing corrosion preventive compound, Specification MIL-C-16173, grade III.

c. Use drying ovens or portable heaters, if available, to dry the cleaned components.

WARNING

Corrosion Preventive Compound
(Grade III)
MIL-C-16173

- Flammable - do not use near welding areas, near open flames and sparks, or on very hot surfaces.
- Use only with adequate ventilation.
- Avoid prolonged or repeated contact with skin.
- Avoid prolonged or repeated breathing of vapors.
- Store in approved metal safety containers.

d. Coat heat-dried parts with soft film corrosion preventive compound, Specification MIL-C-16173, grade III.

e. After or during treatment of removed components, immerse the balance of the engine in fresh hot water agitated sufficiently to flush all components. If complete immersion cannot be accomplished, flood the engine with large quantities of fresh hot water, playing the stream of water back and forth across compressor vanes, blades, turbine blades, etc.

f. On portions of enclosed sections which cannot be reached by direct flushing, purge with fresh water by applying a stream of water to an appropriate opening and allowing the water to flow through all internal passages.

WARNING

Observe the warning for compound MIL-C-16173, Grade III used in step d.

g. After the engine has been thoroughly flushed and purged of all chemical and salt deposits, drain and dry all parts thoroughly; then, apply water-displacing corrosive preventive compound, Specification MIL-C-16173, grade III, to all surfaces.

h. Reassemble the engine in such manner that it may be installed in the engine container.

i. Attach a salt water-crash-fire tag, described in step 3, to the engine.

j. If the engine is shipped to another activity or is not immediately inducted for overhaul, install engine in shipping container. Double the amount of desiccant normally used.

6. Engines preserved after salt water immersion or fire-fighting damage shall have the outside of the shipping container plainly marked in at least two locations with an appropriate salt water-crash-fire damage tag requesting Expedite Handling.

3-22. PRESERVATION OF SERVICEABLE ENGINE OUTSIDE OF SHIPPING CONTAINER OR INSTALLED IN THE AIRCRAFT.

NOTE

No preservation is required if engine is going to be inactive for less than 14 days. Engines shall be limited to 180 days in this condition. One renewal of preservation is allowed.

1. Preservation shall be in accordance with paragraph 3-19. Check log book to see if this has already been done.

2. Every 60 days do the following:

a. Rotate the compressor a minimum of 4 turns using adapter (21C5010) or standard 1/4 inch ratchet with a 1/4 to 3/8 inch adapter.

b. Rotate the fan by hand, a minimum of 4 turns.

3-23. MONITORING PRESERVATION OF ENGINE INSTALLED IN SHIPPING CONTAINER.

NOTE

Two types of indicators are used to indicate the relative humidity within the container. This is done by indicator color changes from blue in dry atmospheres to pink at higher relative humidities. To differentiate between the types of indicators, check the surface markings. Printed on the visible surface of the first type is REPRESERVE WHEN PINK. This particular type has only one color change (blue to pink) at approximately 30-40 percent relative humidities. The second type changes color at different relative humidities. Printed on the visible surface of this indicator is the color indications at 20, 30, and 40 percent relative humidities. Both of these indicators may be reused without special processing. Storage in a sealed container with a dehydrating agent will restore blue color.

1. Inspect and record humidity in the shipping container at least once every 90 days.

a. If inspection reveals that internal relative humidity is less than 40 percent, no action is required.

b. If inspection reveals that internal relative humidity is 40 percent or above, an unsafe or corrosive condition exists. The cover shall be removed from the container, and the engine inspected per NAVAIR 15-02-500 to determine its serviceability. If the engine is found to be in a serviceable condition, rotate the compressor a minimum of 4 turns using adapter (21C5010) or standard ratchet with a 1/4 to 3/8 inch adapter, rotate the fan by hand a minimum of 4 turns and close the container and add new desicant per paragraph 3-26. If inspection shows evidence of rust or corrosion, replace the desicant, reinstall the shipping cover, and return the engine to a complete repair activity for detail inspection and repair.

3-24. PRESERVATION OF INOPERABLE (DAMAGED) ENGINE.

1. When the rotor can be rotated but no facilities are available for operation, proceed as follows:

a. Place the engine in the horizontal position.

b. Fill the engine oil system with engine oil (MIL-L-23699) per paragraph 3-7.

c. Preserve the fuel control, pump, and strainer element as follows:

(1) Attach a drain line from the fuel inlet port on the pump to a container.

(2) Move the power control shaft to the open position.

(3) Remove the plug from the fuel pressure readout port and provide a supply of oil, Specification MIL-L-6081 to the port. Pressurize the oil line to 45-50 psig.

(4) Watch the fuel and oil mixture coming from the drain line until fuel-free oil is noted. Continue purging for several additional minutes to remove any air trapped within the fuel control.

(5) Remove the fuel inlet drain line and cap off the fuel inlet.

(6) Remove the oil supply line from pressure readout port and replace the plug.

d. Remove salt deposits, if necessary, per paragraph 3-15 subject to the inoperative condition of this paragraph, prior to preservation treatment.

CAUTION

If engine starter is used for motoring, do not exceed starter limits.

e. Install the engine in the shipping container per paragraph 3-26.

f. Inspect and record humidity in the shipping container per paragraph 3-26.

2. When the rotor is incapable of rotation:

a. Place the engine in a horizontal position.

b. Remove salt deposits from affected areas, if required, by hand, prior to preservation treatment.

c. Preserve the fuel control, pump, and filter per step 1.c., this paragraph. Disconnect oil lines and force quantities of oil into the bearings.

d. Install the engine into the shipping container in accordance with paragraph 3-26.

e. Observe and record humidity in the shipping container per paragraph 3-23.

3-25. PRESERVATION OF ENGINE ACCESSORIES.

NOTE

If an accessory is removed from the engine for repair or is to be placed in spare parts stock, it must be properly prepared for storage. By observing normal practices of proper packaging, and by using the following preservation procedures, all engine accessories can be stored without detrimental effects.

1. Fuel System Components.

a. To store components (except fuel control), or if components are to be returned for overhaul or repair, flush them with oil, Specification MIL-L-6081, Grade 1010. Drain excess oil, install protective covers over drive shafts and control shafts, and cap all openings.

b. To store fuel control, or if fuel control is to be returned for overhaul or repair, flush with oil, Specification MIL-L-6081, Grade 1010 as follows:

(1) Remove permanent plug A (see figure 3-2) and other plastic caps from control, except the 2 CDP port plugs.

CAUTION

CDP ports must be plugged during the preserving procedure.

(2) With control in an upright position, partially fill with one quart of oil, MIL-L-6081, Grade 1010 filtered to 10 micron through Port A. Also pour a small amount of oil in head and rod, ports marked PB and P6 in top of control and Wf ports in base of control.

(3) Pour a small amount of oil on the drive spline and bearing.

(4) Lay control on its side and slowly rotate it to coat all internal parts. Use care not to damage the Linear Velocity transducer when rotating.

(5) Allow oil to drain from control then plug all ports with plastic caps. Place control in a plastic oil proof bag; then into a suitable shipping container.

2. Lubrication System Components.

NOTE

If engine oil has been used in the component, as in engine operation or testing, the internal mechanisms are adequately coated.

a. Pour enough engine oil into the component to coat the internal parts. Rotate the drive shaft of engine-driven components to ensure a thorough coating of oil.

b. Drain excess fluid.

c. Cap all openings.

d. Install protective covers over drive shafts.

3. Electrical Components. To store electrical components, install protective covers on electrical connectors.

4. Air System Components. To store air system components, install caps on all openings.

3-26. <u>REMOVAL OF ENGINE FROM RAIL SYSTEM AND INSTALLATION IN SHIPPING CONTAINER.</u>

3-27. PREPARATION OF CONTAINER FOR INSTALLATION OF ENGINE.

1. Release any pressure in container by breaking seal wire on left-hand vacuum relief valve and turning manual relief knob.

2. Loosen nuts (15, figure 3-1) and turn closure flange T-bolts 90° counterclockwise.

3. Remove cover assembly (1).

4. Remove 8 hex head capscrews (4), 8 self-locking nuts (5) and 16 flat washers (6) from forward and aft ring assemblies (8, 7).

5. Remove forward and aft ring assemblies (8, 7) from container.

6. Remove desiccant hand hole cover as follows:

a. Remove 1 hex head capscrew (16).

b. Remove cover (17).

c. Remove capscrew (18) from container.

d. Remove clamp assembly (19) from container.

e. Remove accessory unit (20) from container.

3-28. INSTALLATION OF ENGINE.

1. Remove all hardware from container forward ring (8, figure 3-1) and aft ring (7).

CAUTION

Do not let forward ring hit side of engine.

2. Lower forward ring (8) onto engine mounting lugs at 12 o'clock position on fan casing. Make certain 1/2 inch thick plate on ring fits between the 2 lugs.

3. Secure ring to lugs with bolt (9), 1 washer (10), and 1 self-locking nut (11).

4. Insert 2 bushings (12) onto the holes at the 1 and 11 o'clock positions in the engine aft mount ring.

5. Lower aft ring assembly (7) onto engine at forward side of aft mount ring. Make certain that the solid bronze bushing attached to the aft ring assembly is inserted into the aft engine thrust mount.

CAUTION

Do not overtorque nuts on shoulder bolts. Bolts should move axially.

6. Insert 2 shoulder bolts (13) through holes in aft ring assembly and into engine at aft mount ring. Secure with 2 washers (6) and 2 nuts (5).

7. Attach hoisting adapter (21C5200) to suitable hoist, then attach hoisting adapter to the forward and aft ring assemblies.

8. Take up on hoist and remove quick-release pins which attach engine to the engine forward and aft supports (21C5189 and 21C5190) respectively.

CAUTION

Carefully lower engine to avoid damaging it.

9. Lift and place engine in container. Position so that aft end of engine is at the receptacle end of the container.

10. Attach 8 hex head capscrews (4), 16 flat washers (6) and 8 self-locking nuts (5) to forward ring assembly and frame (8) and aft ring assembly and frame (7). The washers go under the bolt heads and the nuts.

CAUTION

Lower cover carefully to avoid damaging engine.

11. Lower the cover assembly (1) onto base assembly (2), using dowel pins for proper alignment. Make certain that the closure flange gasket (14) is properly seated prior to lowering of cover assembly onto base assembly.

12. Rotate closure flange T-bolts (3) 90° clockwise. Progressively tighten nuts on T-bolts, making certain that T-bolt stays perpendicular to closure flange slot.

13. Using the service receptacle hand opening, insert desiccant in the desiccant retainer. Do not pressurize the container.

SECTION IV
ACCESSORY SERVICING

4-1. GENERAL.

4-2. This section provides instructions for the removal and installation of externally mounted engine components. Refer to Section V for general maintenance procedures.

CAUTION

- Use care in assembling and disassembling any parts containing electrical connectors. Do not use tools to install or remove the electrical connectors. If difficulty is encountered in connecting electrical connectors, check cables and connectors for crossed threads, bent pins, and damaged keys or slots.
- Do not use pens, pencils, or other marking devices containing carbon when marking parts.
- There are 2 types of hoses and tubes used on the YTF34 engine; medium-pressure (with counter-torque wrenching flats) and light-weight (without counter-torque wrenching flats). Caution should be exercised in torquing light-weight hoses and tubes, or they may twist and kink if over torqued. Lubricate flares inside of coupling nuts on hoses and tubes with engine oil MIL-L-23699. Stop tightening immediately if hose/tube starts to twist. Disconnect hose/tube, relubricate and tighten again. Always use a torque wrench; do not overtorque. Always use 2 wrenches when torquing hoses and tubes, 1 to prevent turning the fitting, the other to torque coupling.

4-3. ORGANIZATION. This section provides instructions for removal and installation of external components. The installation paragraph for a special part is located immediately following the removal paragraph.

4-4. This section is arranged by systems. For example, removal and installation paragraphs of all air system parts are located in the same general area of the section. The order of systems in this section is as follows:

1. Air System.
2. Electrical System.
3. Lubrication System.
4. Fuel System.
5. Drain System.

4-5. If the engine is to be disassembled, do all the removal paragraphs in the order necessary to allow disassembly of the engine, and after reassembly, install the external components using only the installation paragraphs.

4-6. REMOVAL AND INSTALLATION OF AIR SYSTEM COMPONENTS.

4-7. REMOVAL AND INSTALLATION OF ANTI-ICING SYSTEM COMPONENTS.

4-8. REMOVAL OF ANTI-ICING VALVE.

CAUTION

Do not use pliers or other tools on electrical connectors.

1. Disconnect electrical cable from anti-icing valve (6, figure 4-1).

2. Disconnect pressure-sensing tube (1) from anti-icing valve (6).

3. Remove 2 bolts (2) and nuts (3) from bracket (30).

4. Push bracket (4) on oil tank vent tube (34) away from valve (6).

5. Remove 4 bolts (14), aft V-band coupling (5), duct (15), restrictor (17), and gasket (16).

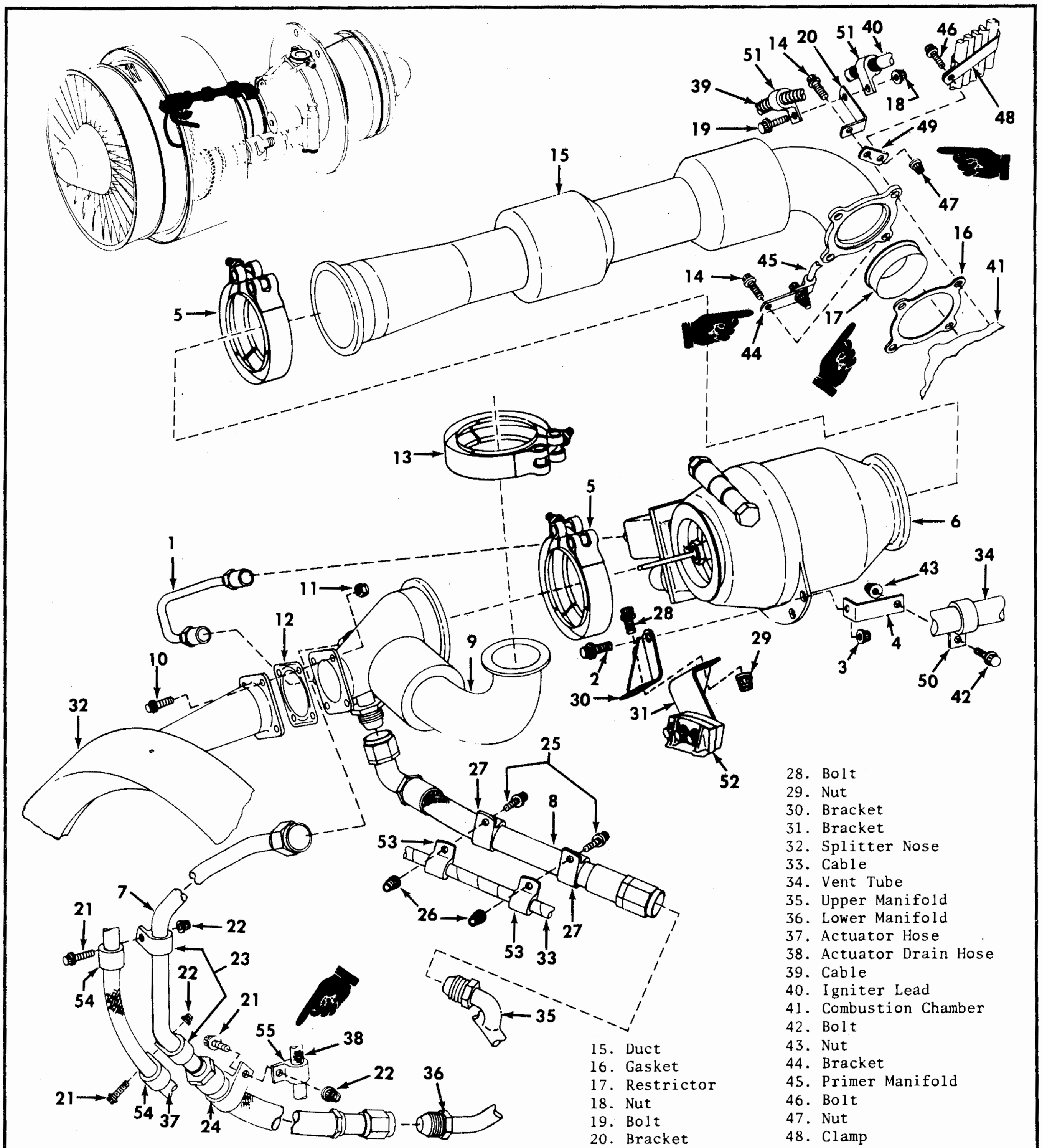
6. Remove V-band coupling (5), on forward end of valve (6), and remove the valve.

4-9. INSTALLATION OF ANTI-ICING VALVE.

CAUTION

Assemble gasket (16) before installing restrictor (17).

1. Assemble anti-icing valve (6, figure 4-1) between the anti-icing duct (15) and the discharge manifold (9), with 2 V-band couplings (5). Assemble 4 bolts (14), gasket (16), restrictor (17), and brackets (20, 44, 49) to combustion chamber. Torque bolts to 105-115 lb in. Do not torque couplings at this time.



1. Pressure Sensing Tube
2. Bolt
3. Nut
4. Bracket
5. V-Band Coupling
6. Anti-icing Valve
7. Right-hand Hose
8. Left-hand Hose
9. Discharge Manifold
10. Bolt
11. Nut
12. Gasket
13. V-Band Coupling
14. Bolt
15. Duct
16. Gasket
17. Restrictor
18. Nut
19. Bolt
20. Bracket
21. Bolt
22. Nut
23. Clamp
24. Clamp
25. Bolt
26. Nut
27. Clamp
28. Bolt
29. Nut
30. Bracket
31. Bracket
32. Splitter Nose
33. Cable
34. Vent Tube
35. Upper Manifold
36. Lower Manifold
37. Actuator Hose
38. Actuator Drain Hose
39. Cable
40. Igniter Lead
41. Combustion Chamber
42. Bolt
43. Nut
44. Bracket
45. Primer Manifold
46. Bolt
47. Nut
48. Clamp
49. Bracket
50. Clamp
51. Clamp
52. Front Frame Flange
53. Clamp
54. Clamp
55. Clamp

Figure 4-1. Anti-icing System Components

2. Line up holes in valve (6) with holes in bracket (30). Install bracket (4) and install 2 bolts (2) and 2 nuts (3). Torque bolts to 105-115 lb inch.

3. Torque V-band coupling (5) nuts to 40-50 lb inch.

4. Assemble pressure-sensing tube (1) to fitting on valve (6) and torque to 90-100 lb inch.

CAUTION

- Check connectors for bent or broken pins.
- Do not use tools on electrical connectors.

5. Assemble electrical cable to connector on valve and hand-tighten. Lock-wire connector using 0.020 inch wire, double-strand method.

4-10. REMOVAL OF ANTI-ICING DUCT AND DISCHARGE MANIFOLD.

1. Disconnect IGV anti-icing hoses (7, 8, figure 4-1) from discharge manifold (9).

2. Remove pressure-sensing tube (1) from discharge manifold (9).

3. Remove 4 bolts (10), 4 nuts (11) and gasket (12) from the discharge manifold (9) flange.

4. Remove V-band coupling (5) from anti-icing valve (6), remove V-band coupling (13) from customer bleed port. Remove discharge manifold (9).

5. Remove V-band coupling (5) from aft end of anti-icing valve (6).

6. Remove lockwire and remove 4 bolts (14), brackets (20, 44, 49), anti-icing duct (15), restrictor (17), and gasket (16).

4-11. INSTALLATION OF ANTI-ICING DUCT AND DISCHARGE MANIFOLD.

1. Assemble discharge manifold (9, figure 4-1) to tube on splitter nose (32) with gasket (12), 4 bolts (10) and 4 nuts (11). Torque bolts to 38-42 lb in.

2. Connect discharge manifold (9) to anti-icing valve (6) with V-band coupling (5). Torque coupling nut to 40-50 lb in.

CAUTION

Assemble gasket (16) to combustion chamber before installing restrictor (17).

3. Assemble anti-icing duct (15) to combustion chamber (41) with gasket (16), restrictor (17), brackets (20, 44, 49) and 4 bolts (14). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lock-wire.

4. Connect anti-icing duct (15) to anti-icing valve (6) with V-band coupling (5). Torque coupling nut to 40-50 lb in.

5. Connect pressure-sensing tube (1) to discharge manifold (9) and to anti-icing valve (6). Torque fittings to 90-100 lb in.

6. Connect left- and right-hand IGV anti-icing hoses (7, 8) to discharge manifold (9) and torque fittings to 38-45 lb ft.

4-12. REMOVAL OF IGV ANTI-ICING HOSES.

1. Disconnect hoses (7, 8, figure 4-1) from discharge manifold (9).

2. Remove 2 clamps (23) from right-hand hose (7) at about the 2 and 3 o'clock positions by removing 2 bolts (21) and nuts (22).

3. Disconnect clamp (24) by removing bolt (21) and nut (22).

4. Disconnect and remove hose (7) from IGV lower manifold (36).

5. Remove 2 clamps (27) from left-hand hose (8) at about the 12 o'clock position by removing 2 bolts (25) and nuts (26).

6. Disconnect and remove hose (8) from IGV upper manifold (35).

4-13. INSTALLATION OF IGV ANTI-ICING HOSES.

1. Connect left-hand anti-icing hose (8, figure 4-1) to upper IGV manifold (35) and to anti-icing discharge manifold (9). Make fittings handtight.

2. At 12 and 12:30 o'clock positions, assemble 2 clamps (27) to hose (8). Connect clamps to 2 clamps (53) on cable (33) with 2 bolts (25) and 2 nuts (26). Torque bolts to 38-42 lb in.

3. Torque hose fittings to 38-45 lb ft.

4. Connect right-hand anti-icing hose (7) to lower IGV manifold (36) and to anti-icing discharge manifold (9). Make fittings handtight.

5. At 2:30 and 3:30 o'clock positions, assemble 2 clamps (23) to hose (7). Connect clamps to 2 clamps (54) on actuator hose (37) with 2 bolts (21) and 2 nuts (22). Torque bolts to 38-42 lb in.

6. Assemble clamp (24) to hose (7). Connect clamp (24) to clamp (55) on drain hose (38) with bolt (21) and nut (22). Torque bolt to 38-42 lb in.

7. Torque hose fittings to 38-45 lb ft.

4-14. REMOVAL OF SPINNER ANTI-ICING TUBES (EXTERNAL)

1. Remove bolt (1, figure 4-2) and nut (2) holding clamp (4) on exhaust frame flange bracket (24).

2. Remove bolt (5) and nut (6) holding clamp (4) to the clamp (26) on C-sump scavenge tube (23).

3. Remove lockwire and upper bolt (8) from strut (at 8 o'clock position) on exhaust frame (25). Loosen lower bolt (8). Remove aft tube (7) by sliding it aft, away from tube (10).

4. Remove 4 clamps (4) from mid-tube (10) by removing 4 bolts (1, 11) and nuts (2, 12). Disconnect tubes (10, 16) and remove the mid-tube (10).

5. Remove piston rings (9) from mid-tube (10).

6. Remove clamp (4) from forward-tube (16) by removing bolt (1), nut (2) and washer (3).

7. Remove lockwire and bolts (17) holding forward tube (16) to splitter (18) and remove tube.

4-15. INSTALLATION OF SPINNER ANTI-ICING TUBES (EXTERNAL).

1. Using bolts (17, figure 4-2), bolt forward tube (16) to splitter (18) at the 7 o'clock position. Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

2. Assemble clamp (4) to forward tube (16) and connect it to bracket (20) on accessory gearbox with drain tube (21) using bolt (1), washer (3), and nut (2). Torque bolt to 38-42 lb in.

3. Assemble mid-tube (10) to forward tube (16). Do not torque fitting at this time.

4. Assemble 4 clamps (4) to mid-tube (10). Connect forward clamp to clamp (27) on fuel heater drain tube (21) with bolt (11) and nut (12). Torque bolts to 38-42 lb in.

5. Assemble second clamp (4) to clamp (28) on drain hose (22) using bolt (11) and nut (12). Torque bolt to 38-42 lb in.

6. Assemble third clamp (4) to clamp (27) on drain tube (21), using bolt (11) and nut (12).

7. Assemble aft clamp (4) to bracket (15) on scavenge tube (23) with bolt (1) and nut (2). Torque bolts (1, 11) to 38-42 lb in.

8. Install piston rings (9) onto aft end of mid-tube (10).

9. Compress piston rings (9) with your fingers and slide aft tube (7) over mid-tube (10). Bolt aft tube to exhaust frame (25) with 2 bolts (8). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

10. Assemble 2 clamps (4) to aft tube (7), one to bracket (24) on exhaust frame flange, the other to clamp on C-sump scavenge tube (23) with 2 bolts (1, 5) and nuts (2, 6). Torque bolts to 38-42 lb in.

11. Torque fitting on tube (10), to 75-91 lb ft.

4-16. REMOVAL OF P5 PRESSURE SENSING TUBING AND PROBE.

1. Remove thermocouple assemblies.

2. Remove C-sump forward oil supply tube per paragraph 4-77.

3. Disconnect clamps (11, figure 4-3) on tube (8) from brackets (13, 35) by removing bolts (9) and nuts (10).

4. Loosen fittings on tube (8) from nipple (14) on trim panel (37) and from tube (1) and remove the tube (8).

5. Remove 3 bolts (6) and nuts (7) holding manifold brackets to transition casing-low pressure turbine casing flange.

6. Loosen fittings on manifold (1) at the P5 probe (4) and remove the manifold. Discard gasket (5).

7. Remove 2 nuts (2) holding the P5 pressure probe (4). Remove bracket (3) from stud on transition casing (38). Remove probe.

4-17. INSTALLATION OF P5 PRESSURE PROBE AND TUBING.

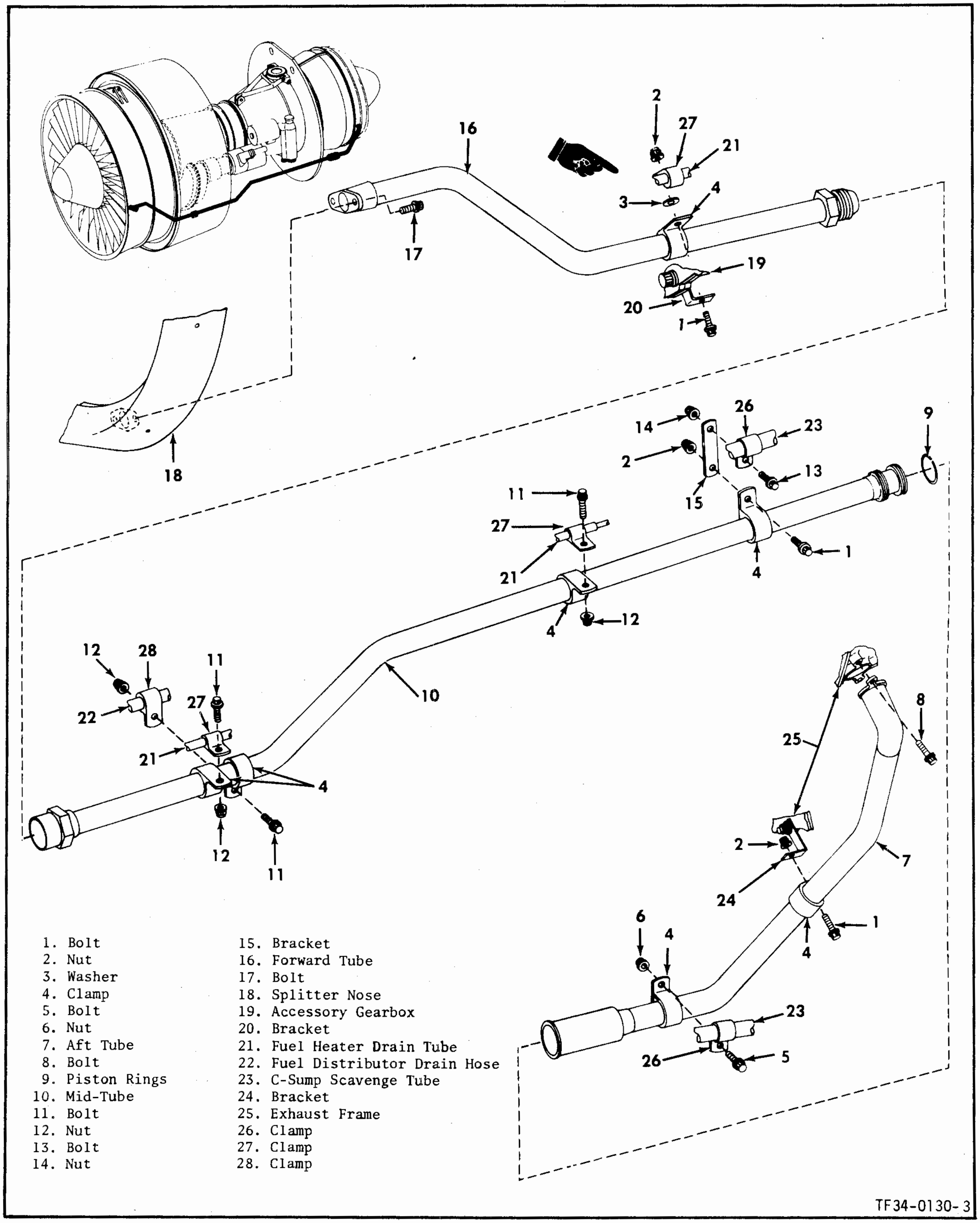
1. Assemble P5 pressure probe (4, figure 4-3) and gasket (5) to transition casing (38). Assemble bracket (3) to stud with nuts (2). Leave nuts loose until manifold (1) is installed.

2. Assemble manifold (1) to probe (4) leaving fitting handtight.

3. Using 3 bolts (6) and nuts (7), bolt manifold brackets to transition casing-low pressure turbine casing flange. Leave bolts loose.

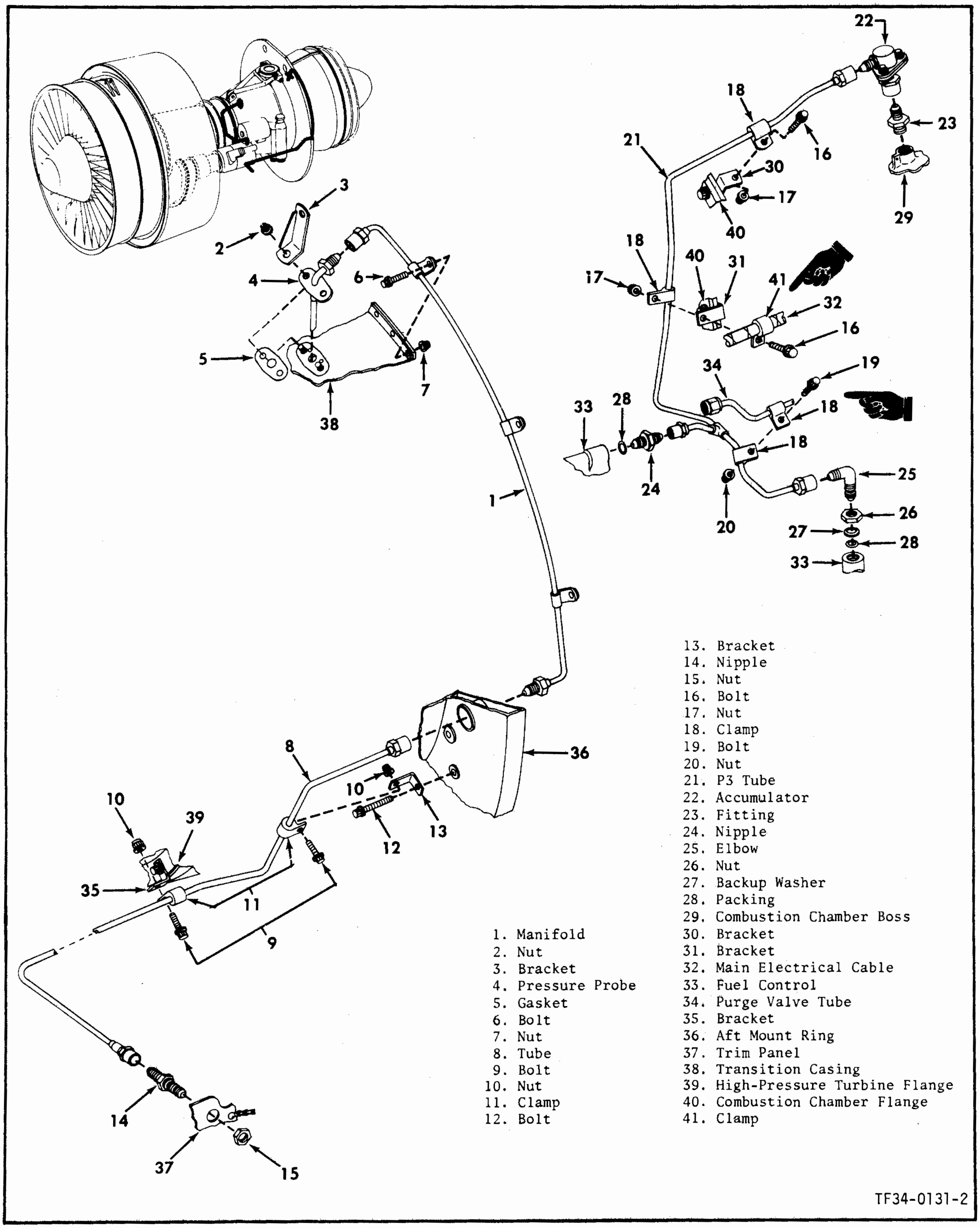
4. Torque fittings at probe (4) to 90-100 lb in. Torque probe nuts (2) to 105-115 lb in. Torque 3 flange bolts (6) to 85-95 lb in.

5. Assemble tube (8) to manifold (1) and to nipple (14) on trim panel (37), leaving fittings handtight.



1. Bolt
2. Nut
3. Washer
4. Clamp
5. Bolt
6. Nut
7. Aft Tube
8. Bolt
9. Piston Rings
10. Mid-Tube
11. Bolt
12. Nut
13. Bolt
14. Nut
15. Bracket
16. Forward Tube
17. Bolt
18. Splitter Nose
19. Accessory Gearbox
20. Bracket
21. Fuel Heater Drain Tube
22. Fuel Distributor Drain Hose
23. C-Sump Scavenge Tube
24. Bracket
25. Exhaust Frame
26. Clamp
27. Clamp
28. Clamp

Figure 4-2. Spinner Anti-icing Tubes (External)



1. Manifold
2. Nut
3. Bracket
4. Pressure Probe
5. Gasket
6. Bolt
7. Nut
8. Tube
9. Bolt
10. Nut
11. Clamp
12. Bolt
13. Bracket
14. Nipple
15. Nut
16. Bolt
17. Nut
18. Clamp
19. Bolt
20. Nut
21. P3 Tube
22. Accumulator
23. Fitting
24. Nipple
25. Elbow
26. Nut
27. Backup Washer
28. Packing
29. Combustion Chamber Boss
30. Bracket
31. Bracket
32. Main Electrical Cable
33. Fuel Control
34. Purge Valve Tube
35. Bracket
36. Aft Mount Ring
37. Trim Panel
38. Transition Casing
39. High-Pressure Turbine Flange
40. Combustion Chamber Flange
41. Clamp

Figure 4-3. P3 and PT5 Sensing System Tubing

6. Torque fittings on tube (8) to 90-100 lb in.

7. Torque fitting of tube (8) at trim panel (37) to 135-150 lb in.

8. Assemble 2 clamps (11) on tube (8) to brackets (13, 35) with bolts (9) and nuts (10). Torque bolts to 38-42 lb in.

4-18. REMOVAL OF P3 TUBING AND WATER ACCUMULATOR.

1. Remove bolts (16, figure 4-3) and nuts (17) holding clamps (18) to brackets (30, 31) on combustion chamber flange (40).

2. Remove bolt (19) and nut (20) holding clamps (18) on fuel control to purge valve tube (34).

3. Disconnect fittings of tube (21) at the fuel control (33) and at the water accumulator (22) and remove tube.

4. Disconnect fitting of water accumulator (22) from fitting (23) and remove accumulator.

4-19. INSTALLATION OF P3 TUBING AND WATER ACCUMULATOR.

1. Assemble water accumulator (22, figure 4-3) to fitting (23) on the boss at the 11 o'clock position on combustion chamber (29). Do not torque fitting at this time.

2. Assemble tube (21) to water accumulator (22) and to elbow (25) and nipple (24) on main fuel control (33).

3. Torque 3 fittings on tube (21) and fitting on water accumulator (22) to 90-100 lb in.

4. Assemble 3 clamps (18) to tube (21). Assemble 1 clamp to bracket (30) and 1 clamp to bracket (31) with clamp (41) on cable (32) with bolts (16) and nuts (17). Torque bolts to 38-42 lb in.

5. Assemble clamp (18) to clamp (18) on fuel control-to-purge valve tube (34) with bolt (19) and nut (20). Torque bolt to 38-42 lb in.

4-20. REMOVAL AND INSTALLATION OF SEAL PRESSURIZING TUBING.

4-21. REMOVAL OF SEAL PRESSURIZING TUBING AND PRESSURE VALVE.

1. Remove oil tank per paragraph 4-50.

2. Remove C-sump pressurizing tubes (1, 2, figure 4-4) as follows:

a. Remove bolts (3), nuts (4), and clamps (9) from brackets (52, 53).

b. Disconnect fittings on tube (1) and remove the tube.

c. Disconnect clamps (9) from thermocouple harness (50), bracket (49), and from fuel manifold hose (48).

d. Disconnect fittings on tube (2) and remove tube.

3. Remove A-sump pressurizing tube (19) as follows:

a. Remove clamps (18) from:

(1) Igniter lead (63).

(2) Oil tank vent tube (47).

(3) Electrical cable (46).

(4) Bracket (45) on accessory gearbox.

b. Disconnect fittings on tube (19) from tube (27) and from elbow (20) on the front frame. Remove tube.

4. Remove tubes (27, 33) and valve (29) as follows:

a. Disconnect ignitor lead (63) from bracket (56).

b. Remove clamp (26) from tube (27).

c. Remove bolts (31), nuts (32), gasket (30), and valve (29) from B-sump tube (33).

d. Remove clamps (36) from tube (33) at electrical cable (59) and from A-sump-to-tank hose (60).

e. Remove lockwire, 4 bolts (42) and gasket (43) from B-sump inlet on combustion chamber.

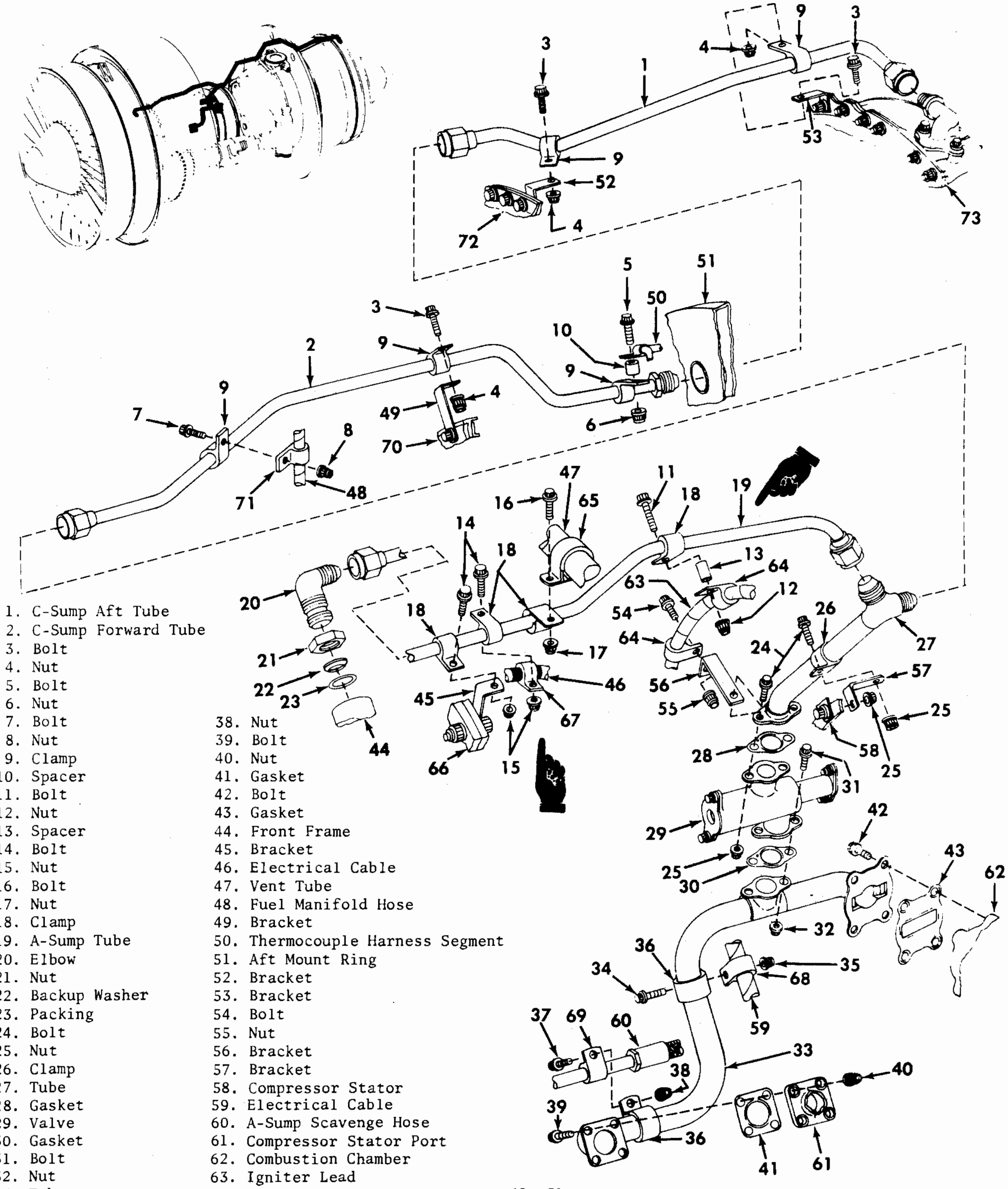
f. Remove 4 bolts (39), nuts (40), gasket (41), and tube (33) from seventh-stage bleed port on compressor casing.

g. Remove 2 bolts (24), nuts (25), bracket (56) and gasket (28) and separate the valve (29) from tube (27).

4-22. INSTALLATION OF SEAL PRESSURIZING TUBING AND PRESSURE VALVE.

1. Assemble one end of tube (33, figure 4-4) to B-sump inlet on combustion chamber (62) with gasket (43) and 4 bolts (42). Hand-tighten bolts.

2. Assemble other end of tube (33) to seventh-stage bleed port on compressor casing (61) with gasket (41), 4 bolts (39) and 4 nuts (40). Hand-tighten bolts.



1. C-Sump Aft Tube
2. C-Sump Forward Tube
3. Bolt
4. Nut
5. Bolt
6. Nut
7. Bolt
8. Nut
9. Clamp
10. Spacer
11. Bolt
12. Nut
13. Spacer
14. Bolt
15. Nut
16. Bolt
17. Nut
18. Clamp
19. A-Sump Tube
20. Elbow
21. Nut
22. Backup Washer
23. Packing
24. Bolt
25. Nut
26. Clamp
27. Tube
28. Gasket
29. Valve
30. Gasket
31. Bolt
32. Nut
33. Tube
34. Bolt
35. Nut
36. Clamp
37. Bolt
38. Nut
39. Bolt
40. Nut
41. Gasket
42. Bolt
43. Gasket
44. Front Frame
45. Bracket
46. Electrical Cable
47. Vent Tube
48. Fuel Manifold Hose
49. Bracket
50. Thermocouple Harness Segment
51. Aft Mount Ring
52. Bracket
53. Bracket
54. Bolt
55. Nut
56. Bracket
57. Bracket
58. Compressor Stator
59. Electrical Cable
60. A-Sump Scavenge Hose
61. Compressor Stator Port
62. Combustion Chamber
63. Igniter Lead
64. Clamp
65. Clamp
66. Accessory Gearbox
67. Clamp
68. Clamp
69. Clamp
70. High-Pressure Turbine Flange
71. Clamp
72. Low-Pressure Turbine Flange
73. Exhaust Frame

TF34-0132-2

Figure 4-4. Seal Pressurizing System Components

3. Assemble valve (29) to tube (33) so that largest port is facing forward, with gasket (30), 2 bolts (31), and nuts (32). Hand-tighten bolts.

4. Assemble tube (27) to valve (29) so that small fitting is facing aft. Use gasket (28), bracket (56), 2 bolts (24), and nuts (25). Hand-tighten bolts.

5. Assemble the forward C-sump tube (2) through aft engine mount ring (51) and connect front fitting to tube (27), handtight.

6. Assemble aft C-sump tube (1) to forward tube (2) and to fitting at 12 o'clock position on exhaust frame.

7. Assemble A-sump tube (19) to elbow (20) on front frame and to tube (27) handtight.

8. Torque bolts (24, 39) to 38-42 lb in.

9. Torque bolts (31) to 38-42 lb in.

10. Torque bolts (42) to 105-115 lb in. Lockwire bolts double-twist method, using 0.032 inch lockwire.

11. Torque 3 fittings on C-sump tubes (1, 2) to 270-300 lb in.

12. Torque fittings on tube (19) to 37-41 lb ft.

CAUTION

Connect clamps on tube (1) as shown.

13. Assemble 2 clamps (9) onto tube (1) and connect clamps to brackets (52, 53) one at turbine casing-exhaust frame flange, one at turbine casing-transition casing flange, using bolts (3) and nuts (4). Torque bolts to 38-42 lb in.

14. Assemble 3 clamps (9) to forward C-sump tube (2), 1 clamp to thermocouple harness (50) with spacer (10), bolt (5), and nut (6), 1 clamp to bracket (49) on combustion chamber-high pressure turbine casing flange, and 1 clamp to clamp (71) on fuel manifold hose (48), using bolts (3, 7) and nuts (4, 8). Torque bolts (3, 5, 7) to 38-42 lb in.

15. Assemble 1 clamp (26) to tube (27). Connect clamp to bracket (57) with bolt (24) and nut (25). Torque bolt to 38-42 lb in.

16. Assemble 4 clamps (18) to A-sump tube (19); connect 1 clamp to clamp (64) on igniter lead (63) with spacer (13); connect 1 clamp to clamp (65) on oil tank vent tube (47), 1 clamp to clamp (67) on electrical cable (46), and connect 1 clamp to bracket (45) on accessory gearbox (66) with 4 bolts (14, 16, 11) and nuts (12, 15, 17). Torque bolts to 38-42 lb in.

17. Assemble 2 clamps (36) to tube (33); connect 1 clamp to clamp (68) on electrical cable (59) and connect 1 clamp to clamp (69) on A-sump oil return hose (60), using 2 bolts (34, 37) and nuts (35, 38). Torque bolts to 38-42 lb in.

4-23. REMOVAL AND INSTALLATION OF FUEL HEATER AIR INLET AND DISCHARGE TUBES.

4-24. REMOVAL OF FUEL HEATER AIR INLET AND DISCHARGE TUBES.

1. Remove drain tube (20, figure 4-5) per paragraph 4-127.

2. Remove lockwire, 4 bolts (5) and 4 nuts (6) from flange of air inlet tube (2) at bottom end of fuel heater (17).

3. Remove lockwire and 4 bolts (1) from flange of tube (2) at 9 o'clock combustion chamber port (19).

4. Remove tube (2) restrictor (21) and gaskets (4, 3).

5. Remove 4 bolts (5) and 4 nuts (6) from flange of air discharge tube (7) at top end of fuel heater (17).

6. Disconnect clamp (10) from clamp (22) and remove tube (7).

4-25. INSTALLATION OF FUEL HEATER AIR INLET AND DISCHARGE TUBES.

1. Assemble heater discharge tube (7, figure 4-5) to top flange of fuel heater (17) with brackets (15, 16) using 4 bolts (5) and nuts (6). Torque bolts to 105-115 lb in.

2. Assemble clamp (10) to tube (7). Using bolt (8) and nut (9), bolt clamp to clamp (22) on oil supply line (18). Torque bolt to 38-42 lb in.

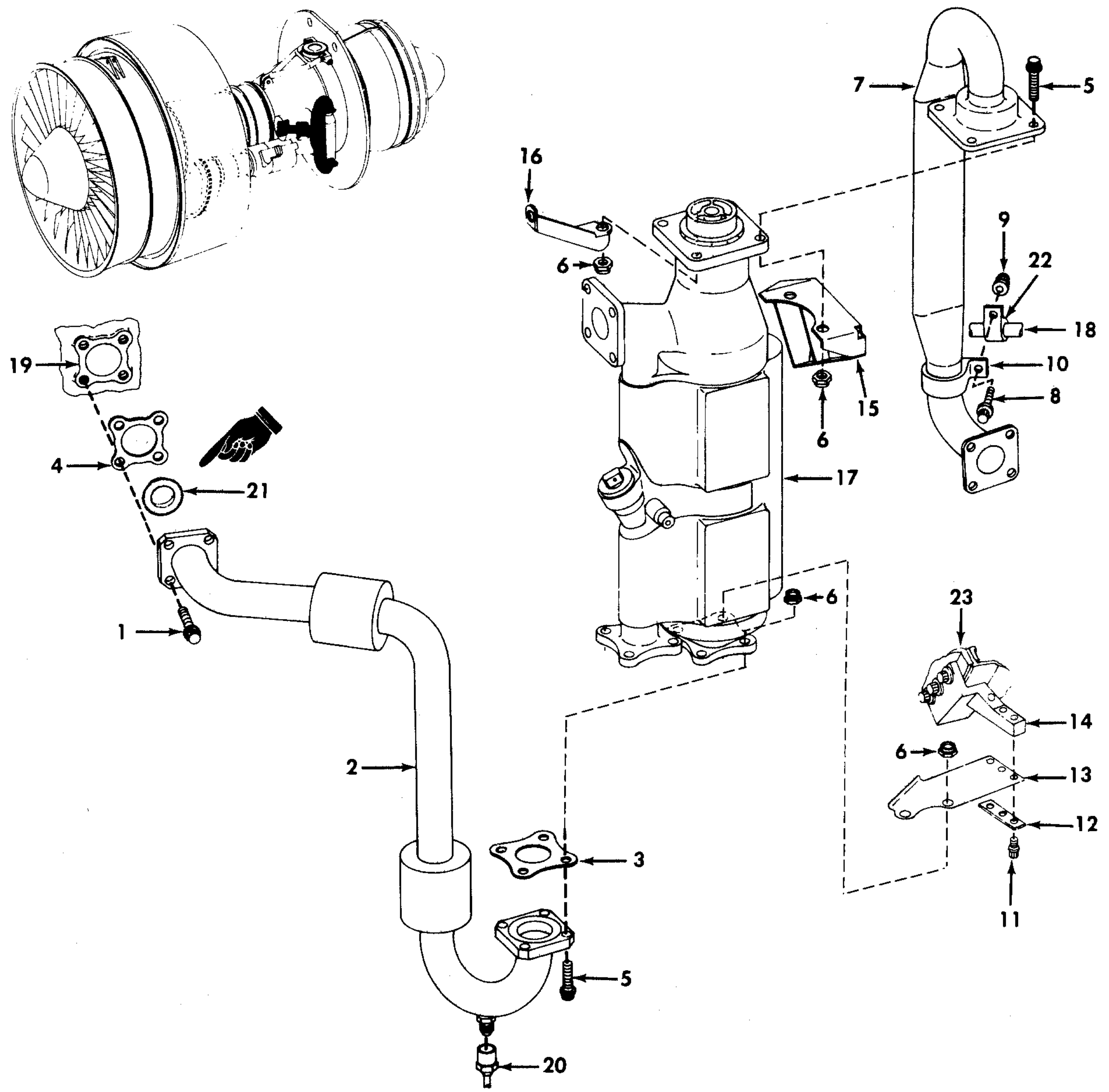
3. Assemble heater air inlet tube (2) to bottom end of heater (17) as follows:

a. Assemble gasket (3) and tube to fuel heater inlet flange with 4 bolts (5) and nuts (6). Do not torque bolts at this time.

b. Assemble other end of tube (2) to combustion chamber port (19) with gasket (4) restrictor (21), smaller ID in the chamber and 4 bolts (1). Torque bolts (1) to 105-115 lb in. and lockwire, double-strand method, using 0.032 inch lockwire. Torque bolts (5) to 105-115 lb in.

4-26. <u>REMOVAL AND INSTALLATION OF ELECTRICAL SYSTEM COMPONENTS.</u> (See figure 4-5A.)

4-27. REMOVAL AND INSTALLATION OF IGNITION EXCITER.



1. Bolt
2. Inlet Tube
3. Gasket
4. Gasket
5. Bolt
6. Nut
7. Discharge Tube
8. Bolt
9. Nut
10. Clamp
11. Bolt
12. Retainer Plate
13. Flex Bracket
14. Lower Bracket
15. Upper Bracket
16. Bracket
17. Fuel Heater
18. Oil Supply Line
19. Combustion Chamber Port
20. Drain Tube
21. Restrictor
22. Clamp
23. High-Pressure Turbine Flange

TF34-0133-3

Figure 4-5. Fuel Heater Tubes

4-28. REMOVAL OF IGNITION EXCITER.

CAUTION

Do not use tools to remove electrical connectors.

1. Disconnect the electrical cable connector (1, figure 4-8).

2. Disconnect the 2 igniter leads (2, 3, figure 4-6) at the exciter.

CAUTION

Isolators and ferrules are free to fall when bolts are removed.

3. Remove 2 bolts (2, figure 4-5B), 4 ferrules (5), and 4 vibration isolators (6) that secure exciter to aft support bracket (8).

4. Remove bolt (3) that secures exciter to forward support bracket (7) and remove exciter.

4-29. INSTALLATION OF IGNITION EXCITER.

CAUTION

- Check connectors for broken or bent pins. Do not use tools to install electrical connectors.
- Be sure bolts (4, 13, figure 4-5B) are lockwired.

1. Position exciter (1, figure 4-5B) on brackets on front frame.

2. Secure exciter to aft support bracket (8) with 4 vibration isolators (6), 4 ferrules (5), and 2 bolts (2). Do not torque bolts.

3. Secure exciter to forward support bracket (7) with bolt (3). Torque the bolt to 38-42 lb in.

4. Torque bolts on aft support bracket to 38-42 lb in.

5. Connect electrical connector (1, figure 4-8) to exciter. Make handtight. Lock-wire connector with 0.020 inch lockwire, using double-strand method.

6. Connect igniter leads (2, 3, figure 4-6) to exciter. Torque connectors on leads to 75-125 lb in. Lock-wire the leads with 0.032 inch lockwire, using double-strand method.

4-30. REMOVAL AND INSTALLATION OF IGNITER LEADS AND PLUGS.

4-31. REMOVAL OF IGNITER LEADS AND PLUGS.

1. Disconnect igniter leads (2, 3, figure 4-6) from the exciter (1) and from the igniter plug adapters (21) (at 2 and 4 o'clock positions) on combustion chamber (18).

2. Remove adapters (21) from igniter plugs (23).

3. Using a deep hex socket, remove bushings (22) and igniter plugs (23).

4-32. INSTALLATION OF IGNITER LEADS AND PLUGS.

1. Install igniter plugs (23, figure 4-6) in combustion chamber bosses (at 2 and 4 o'clock positions). Install bushings (22) and torque to 200-220 lb in. and lock-wire with 0.032 inch lockwire, using double-strand method.

2. Install igniter plug adapters (21) on igniter plugs (23). Torque adapters to 75-125 lb in.

3. Connect igniter leads (2, 3) to ignition exciter (1). Torque to 75-125 lb in.

4. Route both igniter leads through the cable clamp (4).

5. Route igniter lead (3) through cable clamp (5).

6. Clamp igniter lead (3) as follows:

a. Put 5 clamps (8) on igniter lead.

b. Secure clamp (8) with clamp on oil level sensor cable (24) to bracket (25) on compressor-to-combustion casing flange (26) with bolt (6) and nut (7).

c. Secure igniter lead (3) and cable (24) with clamp (9). Assemble bolt (2, figure 4-9) and nut (3). Torque bolt to 38-42 lb in.

d. Secure 2 clamps (8) to:

(1) Clamp on primer manifold tube (18) to bracket (17) with bolt (6) and nut (7).

(2) Clamp on fuel manifold hose (19) with bolt (6) and nut (7).

e. Assemble 2 clamps (10) to igniter lead (3) and cable (24). Secure 1 clamp with clamp on primer manifold (18) to bracket (16) with bolt (6) and nut (7). Secure other clamp (10) to clamp on fuel manifold hoses (19, 30).

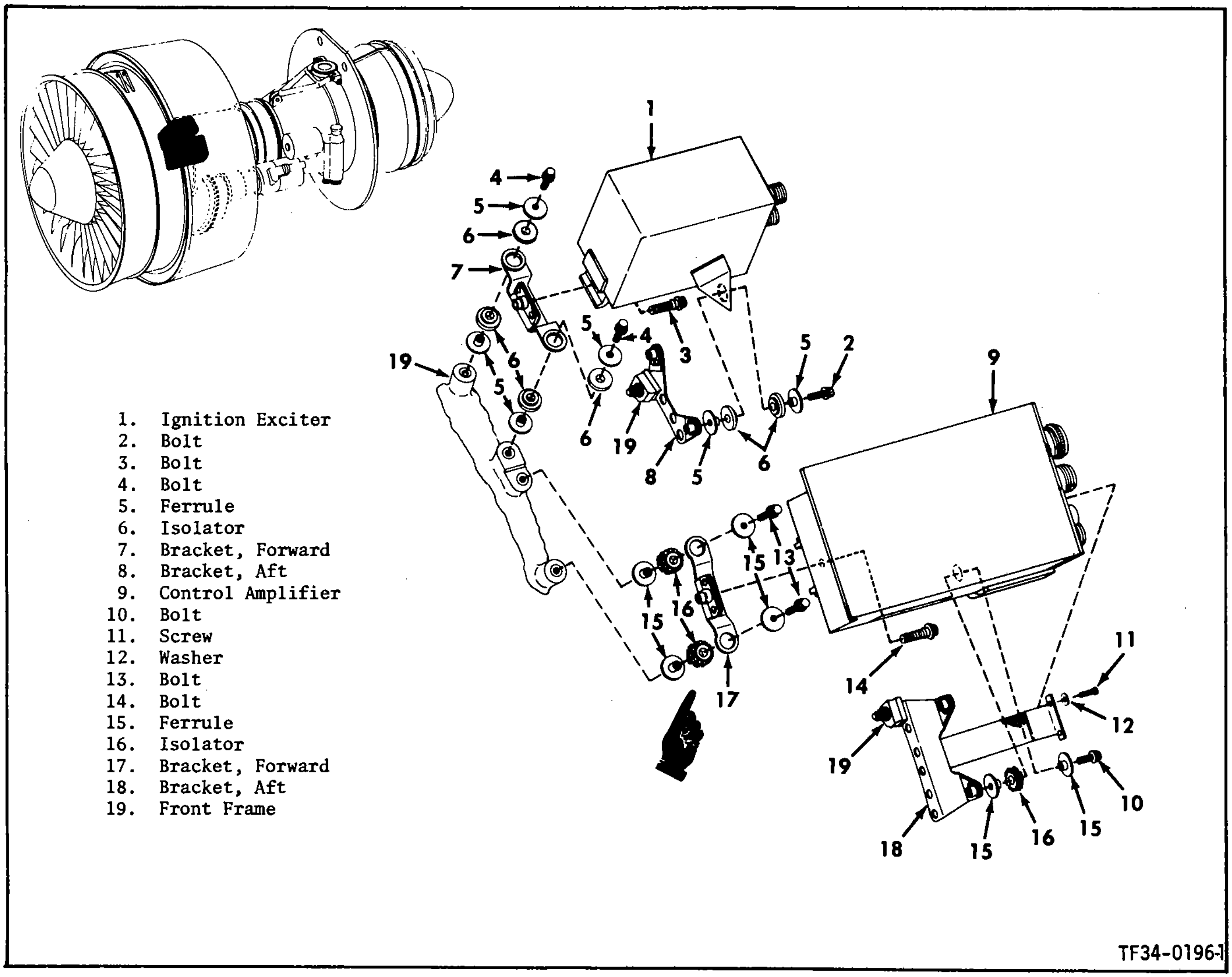


Figure 4-5B. Ignition Exciter and T5 Control Amplifier

f. Secure 2 clamps (8) to 2 clamps on cable (24) with bolts (6) and nuts (7).

7. Clamp igniter lead (2) as follows:

a. Put 4 clamps (8) on igniter lead.

b. Secure the clamps to:

(1) Clamp on A-sump seal pressurizing tube (15) with bolt (28), spacer (29) and nut (7).

(2) Bracket (13) on pressure valve (14), with bolt (6) and nut (7).

(3) Clamp on 7th-stage air bleed tube (12), with bolt (6) and nut (7).

(4) Bracket (11) on compressor-to-combustion chamber flange, with bolt (6) and nut (7).

8. Connect igniter leads (2, 3) to adapters (21) on igniter plugs. Torque to 75-125 lb in.

9. Torque all nuts securing clamps to 38-42 lb in.

4-33. REMOVAL AND INSTALLATION OF T5 CONTROL AMPLIFIER.

4-34. REMOVAL OF T5 CONTROL AMPLIFIER.

CAUTION

Do not use tools to remove electrical connectors.

1. Disconnect the 4 electrical connectors at amplifier (9, figure 4-5B).

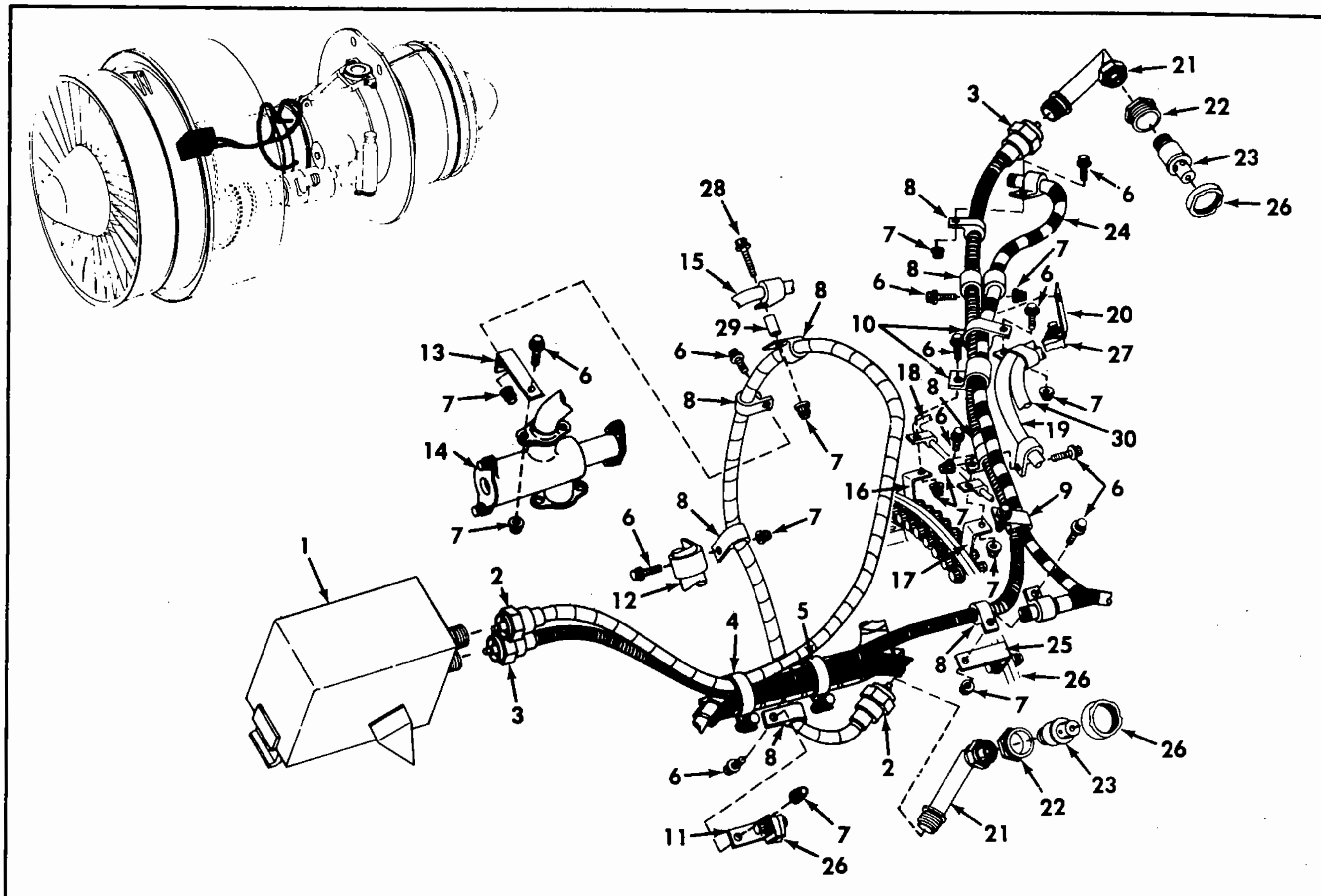


Figure 4-6. Ignition System Components

2. Disconnect flex shaft (9, figure 4-7) at the amplifier.

3. Remove 2 screws (11, figure 4-5B) and 2 washers (12) that secure grounding strap (part of amplifier bracket (18)) to amplifier.

4. Remove 2 bolts (10), 2 isolators (16) and 4 ferrules (15) that secure amplifier to aft support bracket (18).

5. Remove bolt (14) that secures amplifier to forward support bracket (17) and remove amplifier.

4-35. INSTALLATION OF T5 CONTROL AMPLIFIER.

CAUTION

Do not use tools to install electrical connectors. Check for damaged pins.

Note

Check IPB for proper matching of amplifier and thermocouple segments.

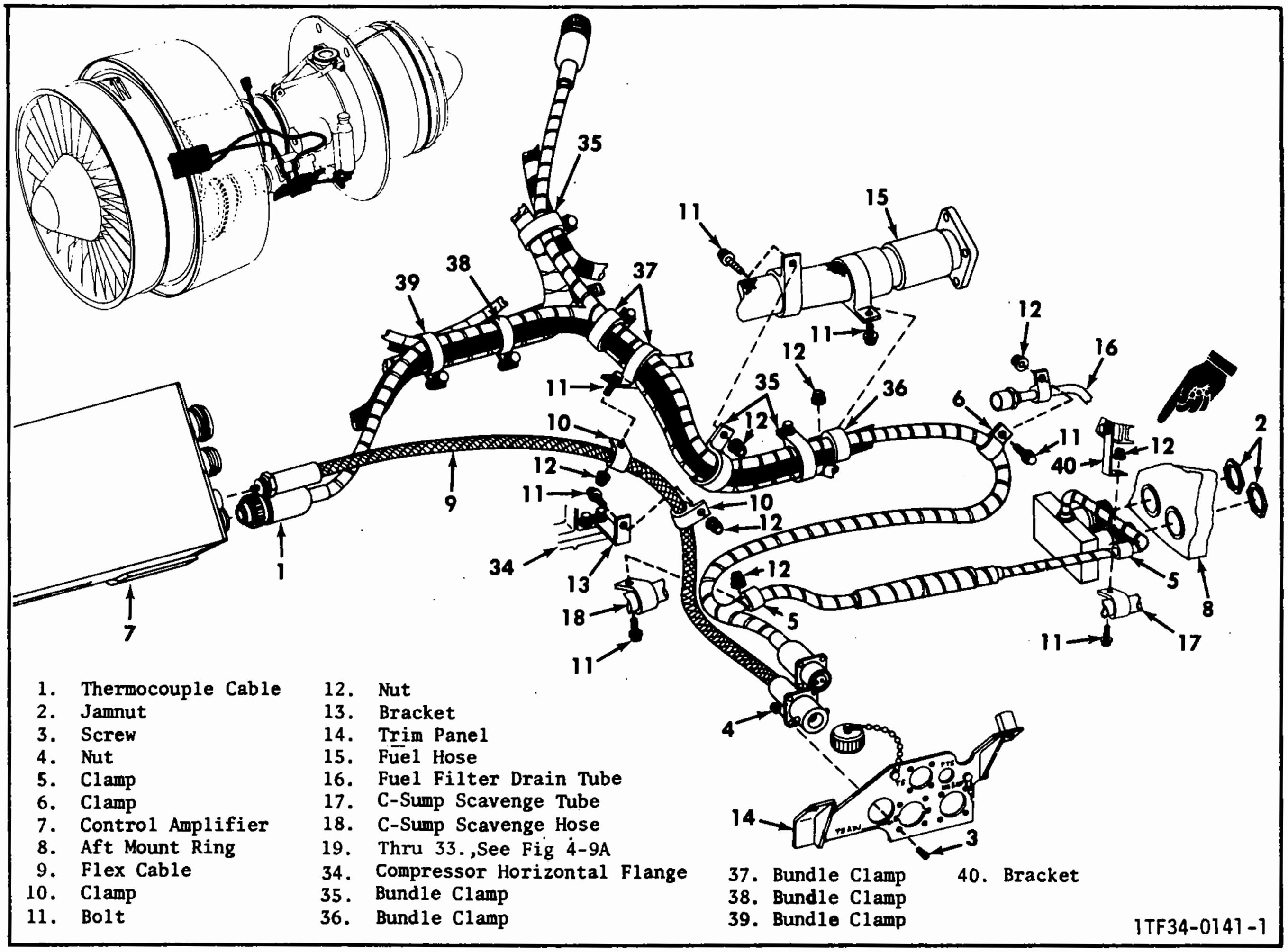


Figure 4-7. Thermocouple Cable and Amplifier Adjustment Cable

1. Position amplifier (9, figure 4-5B) on brackets (17, 18) on front frame.

2. Secure amplifier to forward support bracket (17) with bolt (14). Torque bolt to 38-42 lb in.

3. Secure amplifier to aft support bracket (18) with 4 ferrules (15), 2 isolators (16), and 2 bolts (10). Do not torque bolts.

4. Torque bolts on aft support bracket to 38-42 lb in.

5. Secure grounding strap to amplifier with 2 screws (11) and 2 washers (12). Torque the screws to 38-42 lb in. and lock-wire them with 0.032 inch lockwire, using the double-strand method.

6. Connect the 4 electrical connectors to amplifier. Make them handtight. Lock-wire connectors with 0.020 inch lockwire, using double-strand method.

7. Connect flex shaft (9, figure 4-7) to amplifier. Torque coupling nut on flex shaft to 20-30 lb in.

4-36. REMOVAL AND INSTALLATION OF THERMOCOUPLE CABLE.

4-37. REMOVAL OF THERMOCOUPLE CABLE.

1. Remove HPT drain tube (see paragraph 4-127).

2. Disconnect the left- and right-hand thermocouple harness segments at cable junction box connector on engine mount ring (8, figure 4-7).

3. Remove 2 jamnuts (2) that secure cable (1) junction box to engine mount ring (8).

4. Remove 4 screws (3) and nuts (4) that secure cable connector to trim panel (14).

5. Disconnect cable from control amplifier (7).

6. Disconnect all clamps securing cable (1).

7. Remove cable.

4-38. INSTALLATION OF THERMOCOUPLE CABLE.

CAUTION

- Do not lubricate electrical connectors. Check for damaged pins.
- Do not use tools to tighten electrical connectors.

1. Position cable (1, figure 4-7) on engine.

2. Secure cable junction box to engine mount ring (8) with 2 jamnuts (2). Torque jamnuts to 50-75 lb in. Lock-wire the 2 jamnuts together with 0.020 inch lockwire.

3. Connect HPT drain tube (see paragraph 4-128).

4. Secure cable connector to trim panel with 4 screws (3) and nuts (4). Torque screws to 5-7 lb in.

5. Connect cable to control amplifier (7) hand-tight. Lock-wire connector, double-strand method, using 0.020 lockwire.

6. Clamp cable as follows:

a. On cable, put 3 clamps (5) between engine mount ring and trim panel.

b. Secure the clamps to:

(1) Two clamps on C-sump aft scavenge tube (17) with 2 bolts (11) and nuts (12).

(2) Clamp on C-sump aft scavenge hose (18) with bolt (11) and nut (12).

c. Put clamp (6) on cable and secure it to clamp on fuel filter drain tube (16), with bolt (11) and nut (12).

d. Route remainder of cable through the 8 electrical cable bundle clamps (35, 36, 37, 38, 39).

7. Connect thermocouple segment assemblies to cable at engine mount ring (8). Torque coupling nuts to 105-115 lb in. Lock-wire coupling nuts, double strand method, using 0.020 inch lockwire.

8. Torque all nuts securing clamps to 38-42 lb in.

4-39. REMOVAL AND INSTALLATION OF MAIN ELECTRICAL CABLE.

4-40. REMOVAL OF MAIN ELECTRICAL CABLE.

CAUTION

Do not use tools to loosen electrical connectors. Discard all packings.

1. Disconnect electrical cable (1, figure 4-8) at the following components:

a. Alternator (16) on forward side of gearbox.

b. Exciter (18).

c. Both leads on amplifier (19).

d. Fan speed pickup (45) on front frame.

e. Fuel control (33).

f. Tach generator.

g. Oil pressure transmitter (44).

h. Trim panel (37) by removing 4 screws (35) and nuts (36).

2. Disconnect all clamps securing cable.

3. Remove cable.

4-41. INSTALLATION OF MAIN ELECTRICAL CABLE.

CAUTION

- Do not use tools to tighten electrical connectors. Check for damaged pins.
- Do not lubricate electrical connectors.
- Do not reuse packings.

1. Lay the cable (1, figure 4-8) in position on the engine.

2. Install packing (4) on alternator lead.

3. Install packing (3) on N. G. tach lead.

4. Install packing (2) on oil pressure transmitter lead.

5. Install clamps (6, 9, 10, 11, 12, 13) on cable (1).

6. Connect all leads to accessories as shown. Make handtight and lock-wire with 0.020 inch lockwire, double-strand method.

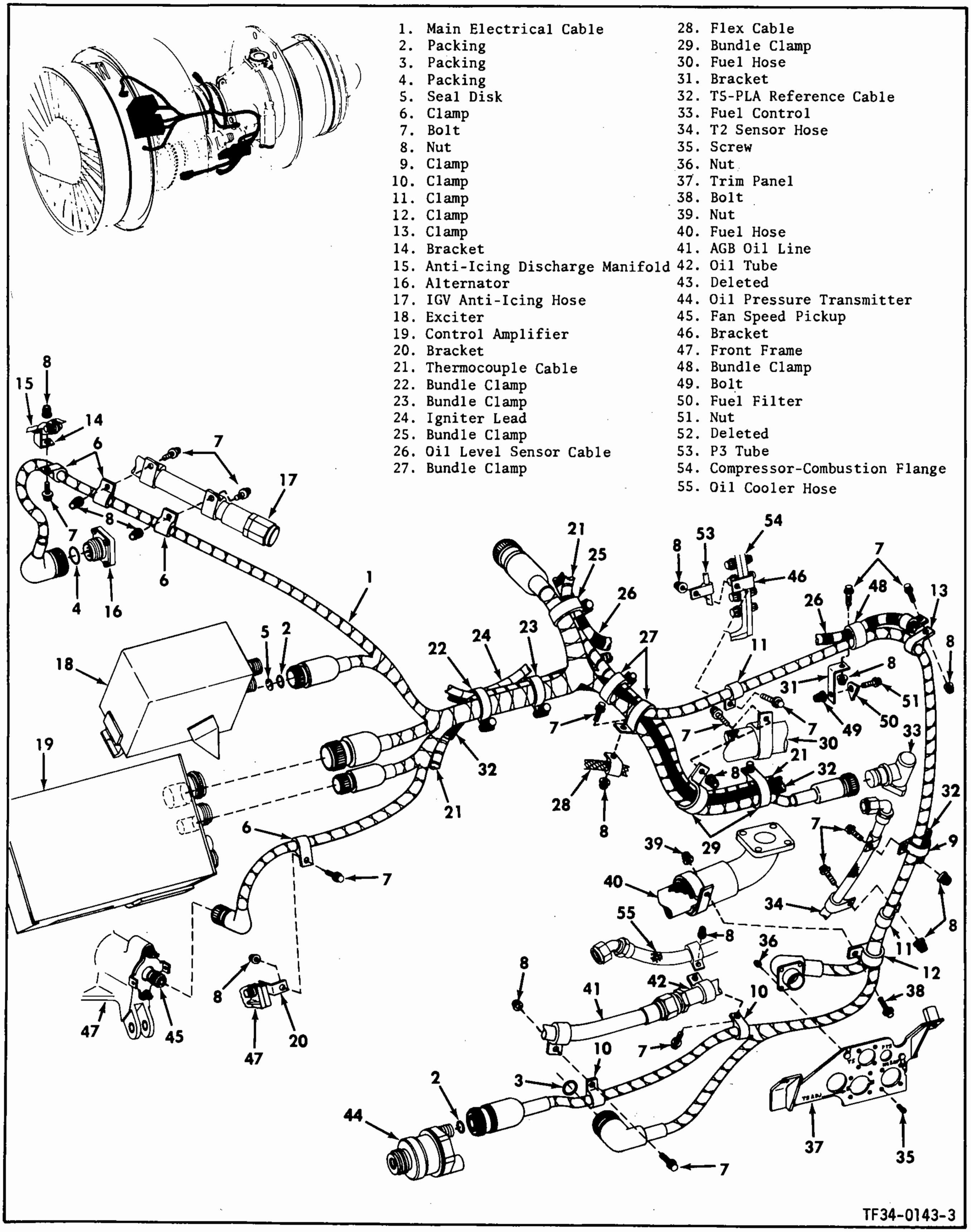


Figure 4-8. Main Electrical Cable

7. Secure 1 clamp (10) and clamp on AGB oil line (41) to bracket (43) on lube pump (52), with bolt (7) and nut (8).

8. Secure 1 clamp (10) to clamp on oil tube (42) with bolt (7) and nut (8).

9. Secure clamp (12) to clamp on fuel hose (40) with bolt (38) and nut (39).

10. Secure clamp (11) to clamp on T2 sensor hose (34) with bolt (7) and nut (8).

11. Secure clamp (9) on cable (32) and cable (1) to clamp on T2 sensor hose (34) with bolt (7) and nut (8).

12. Secure clamp (13) to clamp on electrical cable (26) with bolt (7) and nut (8).

13. Assemble clamp (48) around cables (1, 26) and secure it to bracket (31) on fuel filter (50) with bolt (7) and nut (8).

14. Secure clamp (11) to bracket (46) along with clamp on P3 tube (53) with bolt (7) and nut (8).

15. Assemble bundle clamps (22, 23, 25, 27, 29) as shown.

16. Secure clamp (6) to bracket (20) on front frame flange (47) with bolt (7) and nut (8).

17. Connect 3 clamps (6) on alternator lead of cable as follows:

a. Connect 2 clamps (6) to clamps on IGV anti-icing hose (17) with bolts (7) and nuts (8).

b. Secure clamp (6) to bracket (14) on anti-icing discharge manifold (15) with bolt (7) and nut (8).

18. Torque all nuts securing clamps to 38-42 lb in.

19. Secure lead to trim panel (37) with 4 screws (35) and nuts (36). Torque the screws to 5-7 lb in.

4-42. REMOVAL AND INSTALLATION OF ANTI-ICING VALVE, OIL LEVEL SENSOR, AND FUEL FILTER ELECTRICAL CABLE.

4-43. REMOVAL OF ANTI-ICING VALVE, OIL LEVEL SENSOR, AND FUEL FILTER ELECTRICAL CABLE.

CAUTION

Do not use tools to loosen electrical connectors.

1. Disconnect cable (1, figure 4-9) at anti-icing valve (23), fuel filter (22), and oil tank (13).

2. Disconnect all clamps securing cable.

3. Remove cable.

4-44. INSTALLATION OF ANTI-ICING VALVE, OIL LEVEL SENSOR, AND FUEL FILTER ELECTRICAL CABLE.

CAUTION

Do not use tools to tighten electrical connectors. Check for damaged pins.

1. Connect cable (1, figure 4-9) to anti-icing valve (23). Make handtight and lock-wire with 0.020 inch lockwire, using double-strand method.

2. Put 3 clamps (4) on anti-icing branch of cable and secure them to 2 clamps on oil tank vent hose (12) with 2 bolts (2) and nuts (3). Secure clamp (4) to clamp on seal pressurizing tube (11) with bolt (2) and nut (3).

3. Connect cable to oil level sensor on oil tank (13). Make handtight and lock-wire with 0.020 inch lockwire, using double-strand method.

4. On oil level sensor branch of harness, put 2 clamps (5), 2 clamps (6), and 1 clamp (7). Starting at oil tank and working away from it, secure clamps as follows:

a. One clamp (5) to 1 clamp on igniter lead (14) with bolt (2) and nut (3).

b. Clamp (5) and clamp on igniter lead (14) to bracket (15) on anti-icing duct (28) with bolt (2) and nut (3).

c. Clamp (6) to clamp on 2 fuel manifold hoses (16) with bolt (2) and nut (3).

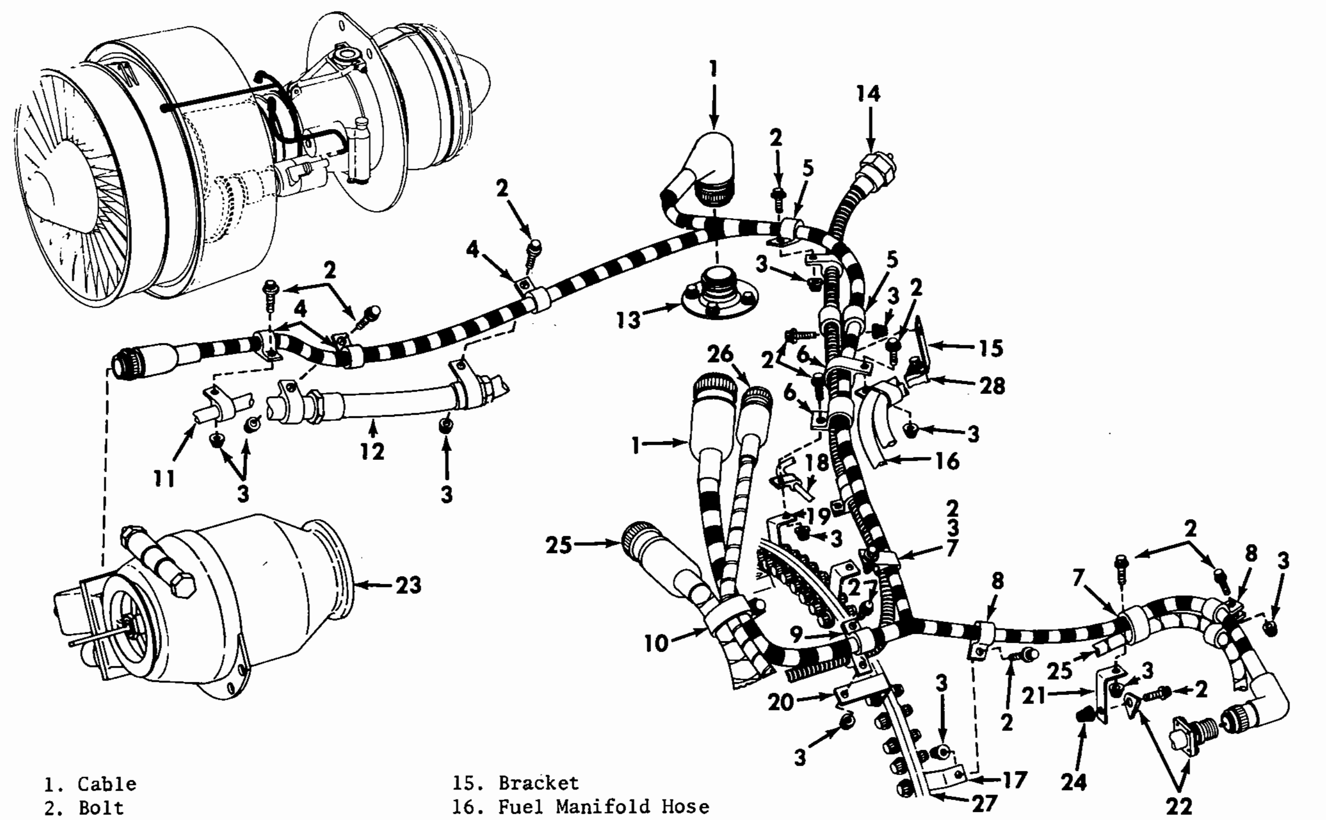
d. Clamp (6) with primer manifold (18) clamp to bracket (19) on compressor-to-combustion chamber flange, with bolt (2) and nut (3).

5. On fuel filter branch of cable, put 2 clamps (8) and 1 clamp (7) and secure them as follows:

a. One clamp (7) on electrical cable to bracket (21) on fuel filter (22) with bolt (2) and nut (3).

b. One clamp (8) to clamp on adjacent electrical cable (25) with bolt (2) and nuts (3).

c. One clamp (8) to bracket (17) on combustion chamber flange with bolt (2) and nut (3).



1. Cable
2. Bolt
3. Nut
4. Clamp
5. Clamp
6. Bundle Clamp
7. Bundle Clamp
8. Clamp
9. Clamp
10. Bundle Clamp
11. Seal Pressurizing Tube, A-Sump
12. Oil Tank Vent Hose
13. Oil Tank
14. Igniter Lead
15. Bracket
16. Fuel Manifold Hose
17. Bracket
18. Primer Nozzle Manifold Tube
19. Bracket
20. Bracket
21. Bracket
22. Fuel Filter
23. Anti-icing Valve
24. Nut
25. Main Electrical Cable
26. Thermocouple Cable
27. Combustion Chamber
28. Anti-Icing Duct

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Figure 4-9. Anti-icing Valve, Oil Level Sensor and Fuel Filter Cable

6. Assemble clamp (9) to cable and secure it to bracket (20) with clamp on igniter lead (14) using bolt (2) and nut (3).

7. Route remainder of cable through clamp (10).

8. Torque all bolts securing clamps to 38-42 lb in.

4-45. REMOVAL AND INSTALLATION OF T5-PLA REFERENCE CABLE.

4-46. REMOVAL OF T5-PLA REFERENCE CABLE.

CAUTION

Do not use tools to remove electrical connectors.

1. Disconnect cable (1, figure 4-10) at amplifier (9) and at 2 receptacles on fuel control (14).

2. Disconnect all clamps securing cable.

3. Remove cable.

4-47. INSTALLATION OF T5-PLA REFERENCE CABLE.

CAUTION

- Do not lubricate electrical connectors.
- Do not use tools to tighten electrical connectors. Check for damaged pins.

1. Position cable (1, figure 4-10) on engine.

2. Connect cable to amplifier (9). Make handtight and lock-wire with 0.020 inch lockwire, using double-strand method.

3. Connect cable to fuel control (14) (2 places). Make handtight and lock-wire with 0.020 inch lockwire, using double-strand method.

4. Clamp cable as follows:

a. Route cable through cable bundle clamps (2, 3, 4, 5, 6).

b. On cable (1), put 2 clamps (7, 8) near fuel heater (10).

c. Connect one clamp (7) to clamp on fuel filter drain tube (13) and to bracket (12) on fuel heater (10), with bolt (18) and nut (19).

d. Connect one clamp (8) to clamp on T2 sensor hose (15) with bolt (18) and nut (19).

5. Torque all nuts securing clamps to 38-42 lb inch.

4-47A. REMOVAL AND INSTALLATION OF THERMOCOUPLE HARNESS SEGMENTS.

4-47B. REMOVAL OF THERMOCOUPLE HARNESS SEGMENTS.

1. Remove 8 bolts (20, figure 4-9A) and nuts (21) holding segments (23, 24) to brackets (29) on aft mount ring (11).

2. Remove 17 bolts (20) and nuts holding segments (23, 24) to brackets (27, 28) on transition casing-low pressure turbine casing flange (32) and to P5 pressure probe stud. Remove clamp at seal pressure tube (30) and flange bolts from jumction boxes.

3. Remove high-pressure turbine drain tube (see paragraph 4-127).

4. Loosen coupling nuts of segments (23, 24) at cable (1). Loosen jamnuts (2) on end of cable and push cable forward to allow disconnection of segments.

5. Remove 20 nuts (19) holding T5 probes to transition casing (33).

CAUTION

Use care when removing probes from transition casing. Segments are easily damaged.

6. Carefully remove segments (23, 24) from engine.

7. Remove and discard packings (25) and gaskets (26).

4-47C. INSTALLATION OF THERMOCOUPLE HARNESS SEGMENTS.

Note

Check IPB for proper matching of amplifier and segments.

1. Install new packings (25, figure 4-9A) in coupling nuts of segments.

CAUTION

Use extreme care when installing thermocouple probes into transition casing. Probes are easily damaged.

2. Carefully install thermocouple segments (23, 24, figure 4-9A) and gaskets (26) into bosses on transition casing. Assemble 20 nuts (19) and torque them to 105-115 lb in.

3. Install 9 bolts (20) through clamps on segments and connect segments to brackets (27, 28) on transition casing-low pressure turbine casing flange and P5 pressure probe stud with 9 nuts (21). Torque bolts to 38-42 lb in.

4. Install 8 bolts (20) through clamps on segments and connect segments to brackets (29) on aft mount ring (8) with nuts (21). Torque bolts to 38-42 lb in.

5. Slide cable (1) aft through mount ring (8) and connect jam nuts of segments to cable, handtight. Torque jamnuts (2) on harness to 50-75 lb in. and lock-wire jamnuts together, double twist method, using 0.020 inch lockwire.

6. Torque coupling nuts of segments to 105-115 lb in. and lockwire, double twist method, using 0.032 inch lockwire.

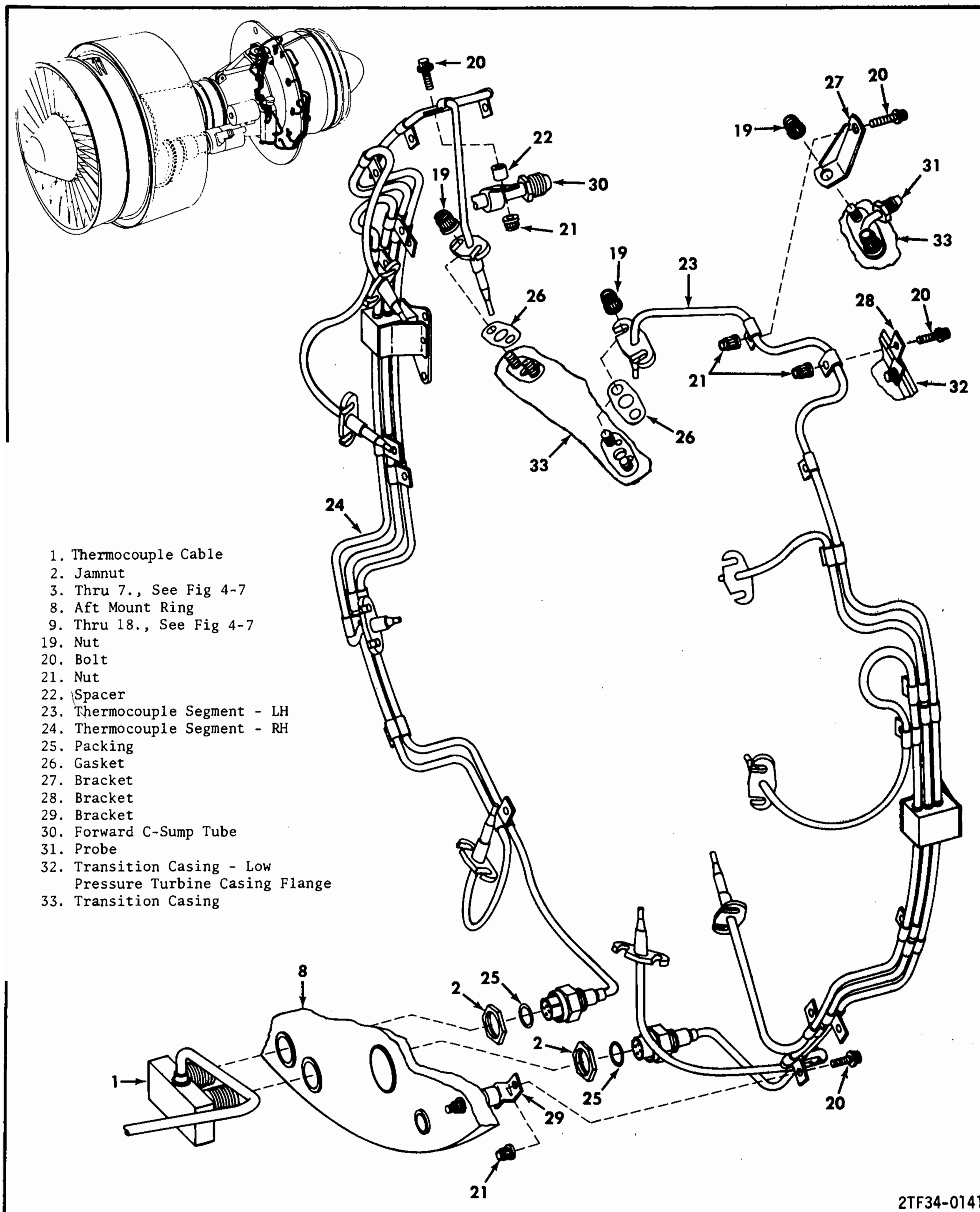
4-47D. JETCAL ANALYZER HOOKUP.

1. Place selector switch SW-1 in OFF position.

2. Place selector switch SW-7 in OFF position.

3. Turn temperature regulator to the ZERO position.

4. Attach power inlet cable (BH499) to Jetcal receptacle P1. Electrically ground the cable, and connect it to a 95-135 volt, 50-400 cycle AC power source.



1. Thermocouple Cable
2. Jamnut
3. Thru 7., See Fig 4-7
8. Aft Mount Ring
9. Thru 18., See Fig 4-7
19. Nut
20. Bolt
21. Nut
22. Spacer
23. Thermocouple Segment - LH
24. Thermocouple Segment - RH
25. Packing
26. Gasket
27. Bracket
28. Bracket
29. Bracket
30. Forward C-Sump Tube
31. Probe
32. Transition Casing - Low Pressure Turbine Casing Flange
33. Transition Casing

Figure 4-9A. Thermocouple Harness Segments

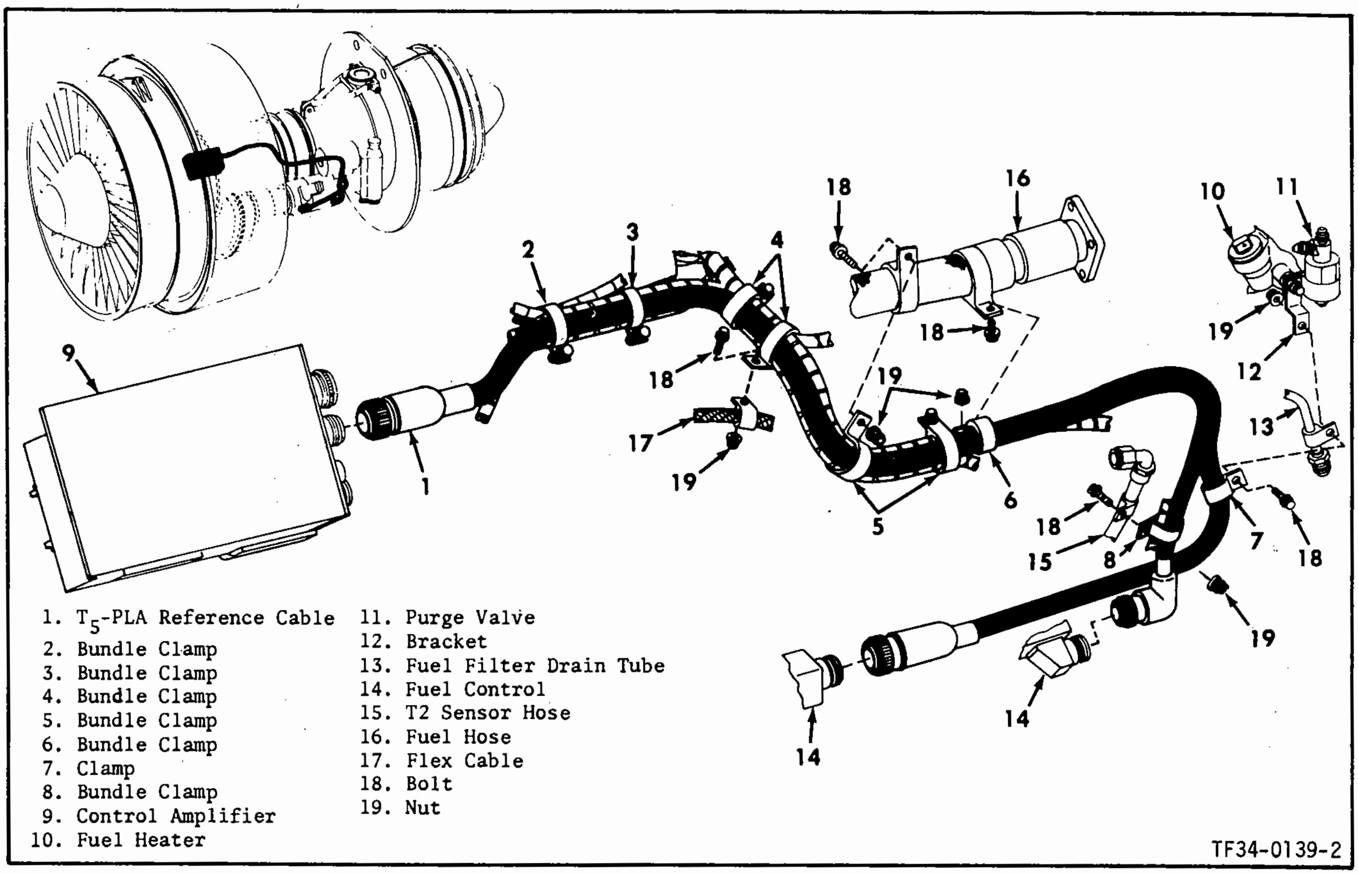


Figure 4-10. T5-PLA Reference Cable

CAUTION

Before removing cables from the JETCAL, place SW-1 in OFF position, place SW-6 in MECH ZERO position place SW-7 in OFF position, and place the temperature regulator in ZERO position, to avoid damage to the JETCAL.

4-47E. THERMOCOUPLE SEGMENT ASSEMBLY RESISTANCE CHECKS.

1. Remove thermocouple harness segments from the engine. See paragraph 4-47B.

Note

Resistance limits vary linearly by 1% for each 20°F change in temperature above or below 68°F. Checks should not be made with an input greater than 50 volts.

2. Check thermocouple segment resistance through the sockets of the segment connector. Resistance values, can be found stamped on the side of each segment junction box.

3. Using a resistance bridge, check thermocouple resistance as follows:

Note

The difference between the min and max value of the 2 branches of the cable assembly must not exceed 8% of minimum value.

a. Check circuit resistance by checking socket A to socket B and socket C to socket D on each individual segment connector. Resistance of individual circuits must be ±8% of ohms value stamped on junction box after correction to ambient temperature. See Note in step 1.

4. Check insulation resistance of segments as follows:

a. Using a 50V meggar meter (1862B), connect one alligator clip of the insulation meter to the T/C wire (sockets A, B, C and D) at the electrical disconnect; connect the other lead to segment connector shell.

b. The insulation check meter shall read more than 500 ohms. If resistance is less than 500 ohms, bake the segments at 110°-120°C (230°-250° F) for 8 hours. Allow the segments to cool and repeat steps a and b for each segment.

c. If insulation resistance is still below minimum limits, replace part.

4-47F. THERMOCOUPLE SEGMENT CORRELATION CHECK.

WARNING

For the operator's protection, the Jetcal analyzer should be grounded during the checks. Use the pigtail lead in the power inlet cable for grounding purposes.

1. Hook up Jetcal analyzer per paragraph 4-47D.

Note

Check one segment at a time.

2. Place one heater probe (21C5501) over each thermocouple on the segment. As each heater probe is placed over a thermocouple, the other end of the probe must be connected to junction box (BH361-12).

3. Connect heater cable (BH405) to Jetcal receptacle (S-1) and to junction box.

4. If check cable adapter (21C5501P01) is to be used, connect the following:

a. Connect thermocouple segment to thermocouple cable assembly.

b. Connect adapter to cable assembly connector and to Jetcal check cable (BH450). Complete steps 5, 6, and 7.

5. Connect Jetcal check cable (BH450) to receptacle (S-2) on Jetcal analyzer.

6. Set Jetcal switches and controls as follows:

a. Place selector switch (SW-2) in heater cable (S-1) position.

b. Place selector switch (SW-1) in T/C position.

c. Place selector switch (SW-6) in MECH ZERO position. Set GALVO-1 pointer to ZERO by turning MECH ZERO knob.

d. Hold selector switch (SW-6) in ELEC ZERO position and set GALVO-1 pointer to ZERO by turning ELEC ZERO knob (R3).

e. Place selector switch (SW-6) in RANGE position.

CAUTION

Adjust temperature regulator in the following steps, do not allow heater probes to go over 650° C. Never leave Jetcal Analyzer unattended unless temperature regulator is turned to zero.

Note

Be sure probes are locked firmly on thermocouples.

f. Turn temperature selector knob to set 600° C in the ° C window. Adjust temperature regulator until the heater probes are stabilized between 590° C and 610° C (indicated by GALVO-1 reading ZERO ±10). Allow 10 minutes for the temperature of the probes to stabilize. Record as temperature A.

g. Place selector switch (SW-2) in check cable (S-2) position.

h. Adjust temperature selector knob (located below ° C window) until GALVO-1 reads ZERO. Read temperature in ° C window and record as temperature B.

Note

If heater probe Jetcal reading is greater than thermocouple segment signal, a minus (-) error will be indicated.

i. Use the following example to find the difference between temperatures A and B.

Example:

	EX. 1	EX. 2
Thermocouple cable signal	602 degrees C.	596 degrees C.
Heater probe (Jetcal)	600 degrees C.	600 degrees C.
Thermocouple segment error	+2 degrees C.	-4 degrees C.

Note

- If after 10 minutes the system is not within limits, allow an additional 20 minutes soak time. Temperature reading must be within ±6° C of maximum engine operating temperature. If error exceeds ±6° C, examine the security of the heater probes and recheck. If error still exceeds ±6° C, replace the segment.

Note

- Because drafts tend to make the indication erratic, maintain some type of shielding for the system during windy conditions.

7. Place switch (SW-6) in MECH ZERO position. Place switch (SW-1) in OFF position and rotate temperature regulator to zero.

4-48. REMOVAL AND INSTALLATION OF LUBE SYSTEM COMPONENTS.

WARNING

Engine oil will be hot if engine has just been shut down. Be careful when disconnecting oil lines.

4-49. REMOVAL AND INSTALLATION OF OIL TANK.

4-50. REMOVAL OF OIL TANK.

1. Place a 5-gallon pail under the oil tank magnetic drain plug (10, figure 4-11).

2. Remove magnetic drain plug (10) and packing (11). Discard the packing.

3. Let all the oil drain from tank into pail.

Note

When disconnecting oil lines, let oil drain into pail.

4. Disconnect the following lines at the oil tank:

a. Pump-to-tank tube (40).

b. Tank-to-pump tube (46).

c. Oil tank scupper hose (69).

d. Green electrical cable (64) attaching to oil level sensor (16).

e. Tank vent-to-front frame line (29).

5. Loosen the 4 bolts (1) that secure tank (6) to the support brackets (65, 66, 67, 68).

6. Support oil tank by hand and remove the 4 bolts (1), 4 washers (2), and 8 isolators (3).

7. Lift oil tank clear of engine.

8. If oil tank is being replaced, remove the following from the tank:

Note

Discard all packings.

a. Reducer (38) and packing (39).

b. Nipple (44) and packing (45).

c. Nipple (19, figure 4-20) and packing (20).

d. Nipple (27, figure 4-11) and packing (28).

e. Pressure valve (24) from housing (77) and 2 packings (25, 26).

f. Drain valve (20), jamnut (21), packing (23), and backup washer (22).

g. Plug (18) and packing (19).

h. Oil sensor (dummy) (16), 4 screws (14), washers (15), and packing (17).

i. Sight gage (12) and packing (13).

9. If oil tank has been removed from an engine in which metal has contaminated the lube system, be sure it is flushed and clean before installing on a serviceable engine.

4-51. INSTALLATION OF OIL TANK.

1. If oil tank is being replaced, install the following on the tank:

a. Packing (39, figure 4-11) and reducer (38) for the pump-to-tank line (40). Torque reducer to 40-44 lb ft.

b. Packing (45) and nipple (44) for the tank-to-pump line (46). Torque nipple to 45-50 lb ft.

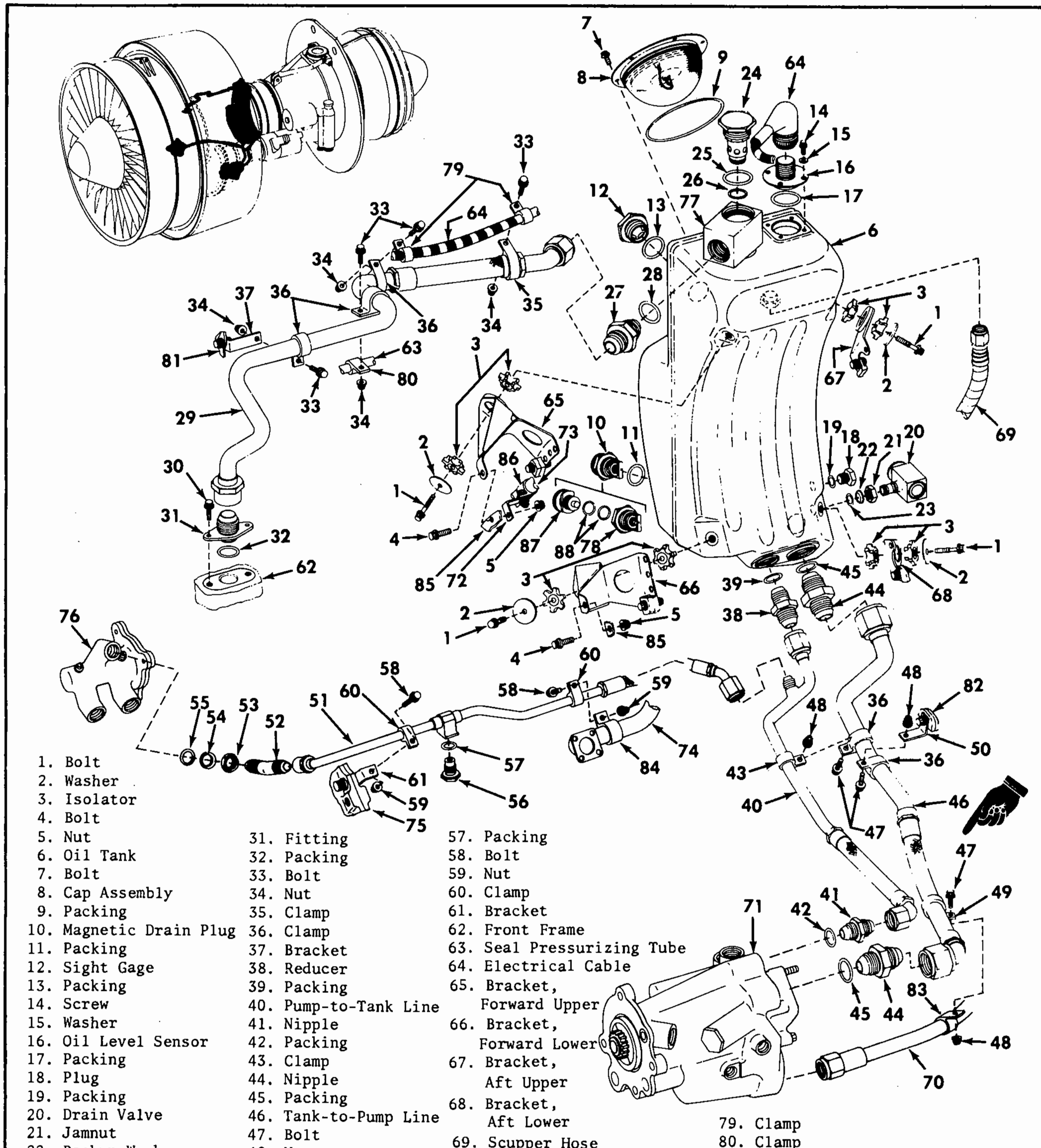
c. Packing (20, figure 4-20) and nipple (19) for the oil tank scupper line. Torque nipple to 180-200 lb in.

d. Packing (28, figure 4-11) and nipple (27) for the tank vent-to-front frame line. Torque nipple to 45-50 lb ft.

e. Packings (25, 26) and pressure valve (24). Torque valve to 25-35 lb ft.

f. Packing (17), oil sensor (16), 4 screws (14) and 4 washers (15). Torque screws to 8-10 lb in., and lock-wire, double-strand method, using 0.032 inch lockwire.

g. Packing (13) and sight gage (12). Torque gage to 25-35 lb ft.



1. Bolt
2. Washer
3. Isolator
4. Bolt
5. Nut
6. Oil Tank
7. Bolt
8. Cap Assembly
9. Packing
10. Magnetic Drain Plug
11. Packing
12. Sight Gage
13. Packing
14. Screw
15. Washer
16. Oil Level Sensor
17. Packing
18. Plug
19. Packing
20. Drain Valve
21. Jamnut
22. Backup Washer
23. Packing
24. Pressure Valve
25. Packing
26. Packing
27. Nipple
28. Packing
29. Tank Vent Line
30. Bolt
31. Fitting
32. Packing
33. Bolt
34. Nut
35. Clamp
36. Clamp
37. Bracket
38. Reducer
39. Packing
40. Pump-to-Tank Line
41. Nipple
42. Packing
43. Clamp
44. Nipple
45. Packing
46. Tank-to-Pump Line
47. Bolt
48. Nut
49. Clamp
50. Bracket
51. A-sump Line
52. Elbow
53. Jamnut
54. Backup Washer
55. Packing
56. Chip Detector
57. Packing
58. Bolt
59. Nut
60. Clamp
61. Bracket
62. Front Frame
63. Seal Pressurizing Tube
64. Electrical Cable
65. Bracket, Forward Upper
66. Bracket, Forward Lower
67. Bracket, Aft Upper
68. Bracket, Aft Lower
69. Scupper Hose
70. C-sump Scavenge Hose
71. Lube Pump
72. Bracket
73. Seal Pressurizing Tube
74. Air Tube
75. Accessory Gearbox
76. A-sump Scavenge Pump
77. Valve Housing
78. Drain Plug Body
79. Clamp
80. Clamp
81. Anti-icing Valve
82. Combustion Chamber Flange
83. Clamp
84. Clamp
85. Compressor Stator Rib
86. Clamp
87. Chip Detector
88. Packing

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Figure 4-11. Oil Tank and Tubing

h. Packing (19) and plug (18). Torque plug to 40-65 lb in.

i. Jamnut (21), backup washer (22), packing (23), and valve (20). Torque jamnut to 30-50 lb in.

j. Magnetic drain plug (10) and packing (11). Torque plug to 200-300 lb in.

2. Hold oil tank in position and secure to brackets (65, 66, 67, 68) with 8 isolators (3), 4 washers (2) and 4 bolts (1). Torque bolts to 38-42 lb in. and lock-wire to the brackets, with 0.032 inch lockwire, using double-strand method.

3. Connect the following at the tank:

a. Pump-to-tank line (40). Torque to 150-200 lb in.

b. Tank-to-pump line (46). Torque to 25-35 lb ft.

c. Oil tank scupper line (69). Torque to 75-125 lb in.

d. Tank vent-to-front frame line (29). Torque to 25-35 lb ft.

e. Electrical cable (64) to oil level sensor (16). Make handtight. Lock-wire connector with 0.020 inch lockwire, using double-strand method.

4. Fill tank to proper level with engine oil (MIL-L-23699). (See paragraph 3-7).

4-52. REMOVAL AND INSTALLATION OF OIL TANK LINES.

4-53. REMOVAL OF OIL TANK LINES.

Note

Use a pail to catch oil from disconnected lines.

1. Place a 5-gallon pail under the oil tank drain plug.

2. Remove magnetic drain plug (10, figure 4-11), and packing (11).

3. Let all the oil drain from tank into pail.

4. On oil tank lines, disconnect all clamps from brackets and from other clamps. Leave clamps on all lines that are not being replaced.

5. Disconnect oil tank scupper hose (69) at the oil tank and at the drain strut at 6 o'clock position.

6. Disconnect A-sump return line (51) at the tee in the pump-to-tank line (40) and at A-sump scavenge pump (76).

7. Disconnect tank-to-pump line (46) at nipple (44) on oil tank and at nipple (44) on lube pump (71).

8. Disconnect pump-to-tank line (40) at reducer (38) on oil tank and at nipple (41) on lube pump (71).

9. Disconnect tank vent line (29) at nipple (27) on pressure valve housing (77) and at vent fitting (31) (at 12 o'clock position) on front frame (62).

4-54. INSTALLATION OF OIL TANK LINES.

CAUTION

Always use 2 wrenches when disconnecting hoses and tubes, one to hold the fitting and the other to loosen the coupling nut.

1. Connect oil tank scupper hose (69, figure 4-11) to nipple on oil tank and to elbow on drain strut at the 6 o'clock position. Torque coupling nuts to 75-125 lb in.

2. Connect pump-to-tank line (40) to reducer (38) on oil tank (6) and to nipple (41) on lube pump. Torque coupling nuts to 150-200 lb in.

3. Connect tank-to-pump line (46) to nipple (44) on oil tank (6) and to nipple (44) on lube pump (71). Torque coupling nuts to 25-35 lb ft.

4. Connect A-sump return line (51) to tee in pump-to-tank line (40) and to A-sump scavenge pump (76). Torque coupling nut to 150-200 lb in.

5. Connect tank vent line (29) to nipple (27) on pressure valve housing (77) and to vent fitting (31) (at 12 o'clock position) on front frame (62).

6. Clamp the oil tank lines as follows:

a. Put 1 clamp (18, figure 4-20) on scupper hose (23). Secure clamp to bracket (32) on accessory gearbox flange with bolt (16) and nut (17). Torque nut to 38-42 lb in.

b. Put 4 clamps (35, 36, figure 4-11) on tank vent line (29).

c. Put 3 clamps (49, 36) on tank-to-pump line (46).

d. Put 1 clamp (43) on pump-to-tank line (40).

e. Put 2 clamps (60) on A-sump return line (51).

f. Secure the 4 clamps (35, 36) on tank vent line (29).

(1) To 2 clamps (79) on electrical cable (64) with 2 bolts (33) and 2 nuts (34).

(2) To clamp (80) on A-sump seal pressurizing line (63), with bolt (33) and nut (34).

(3) To bracket (37) on anti-icing valve (81), with bolt (33) and nut (34).

g. Secure the 3 clamps (49, 36) on tank-to-pump line (46):

(1) To bracket (50) on compressor-to-combustion casing flange (82) with bolt (47) and nut (48).

(2) To clamp (43) on pump-to-tank line (40), with bolt (47) and nut (48).

(3) To clamp (83) on C-sump aft scavenge hose (70), with bolt (47) and nut (48).

h. Secure 1 clamp (60) on A-sump return line (51), to clamp (84) on 7th-stage bleed line (74) with bolt (58) and nut (59) and 1 clamp (60) to bracket (61) on accessory gearbox (75) with bolt (58) and nut (59).

7. Torque all nuts securing clamps to 38-42 lb in.

8. Fill oil tank (6) to proper level with engine oil (MIL-L-23699). (See paragraph 3-7)

4-55. REMOVAL AND INSTALLATION OF LUBE SYSTEM B- AND C-SUMP SCAVENGE PIPING.

4-56. REMOVAL OF LUBE SYSTEM B- AND C-SUMP SCAVENGE PIPING.

CAUTION

Always use 2 wrenches when disconnecting hoses and tubes, one to hold the fitting and the other to loosen the coupling nut.

Note

Leave all clamps on the tube or hose being removed, and leave all brackets on the flange or component.

1. Remove the C-sump aft scavenge tube (46), figure 4-12) by disconnecting it at the fitting (89) on the exhaust frame strut (at the 6 o'clock position) and at the C-sump aft scavenge hose (37) below oil cooler.

2. Remove the C-sump aft scavenge hose (37) by disconnecting it at elbow (38) on the lube pump (74).

3. Remove the C-sump forward scavenge tube (36) by disconnecting it at the fitting (89) on the exhaust frame strut (at the 4 o'clock position) and at the C-sump forward scavenge hose (21).

4. Remove the C-sump forward scavenge hose (21) by disconnecting it at the nipple (22) on the lube pump.

5. Remove the B-sump aft scavenge hose (86) by disconnecting it at the adapter (at the 5 o'clock position) on the combustion chamber (95) and at tee (97) on the bottom of lube pump.

6. Remove the B-sump forward scavenge hose (53) by disconnecting it at the adapter (at the 7 o'clock position) on the combustion chamber (95) and at the nipple (54) on the lube pump.

4-57. INSTALLATION OF LUBE SYSTEM B- AND C-SUMP SCAVENGE PIPING.

CAUTION

Always use 2 wrenches when installing lines, one to hold the fitting, and the other to tighten the coupling nut.

1. Connect the C-sump aft scavenge hose (37, figure 4-12) to the elbow (38) on the lube pump (74). Torque the coupling nut to 150-200 lb in.

2. Connect the C-sump aft scavenge tube (46) to hose (37) and to the fitting (89) on the exhaust frame strut at 6 o'clock position. Torque the coupling nuts to 150-200 lb in.

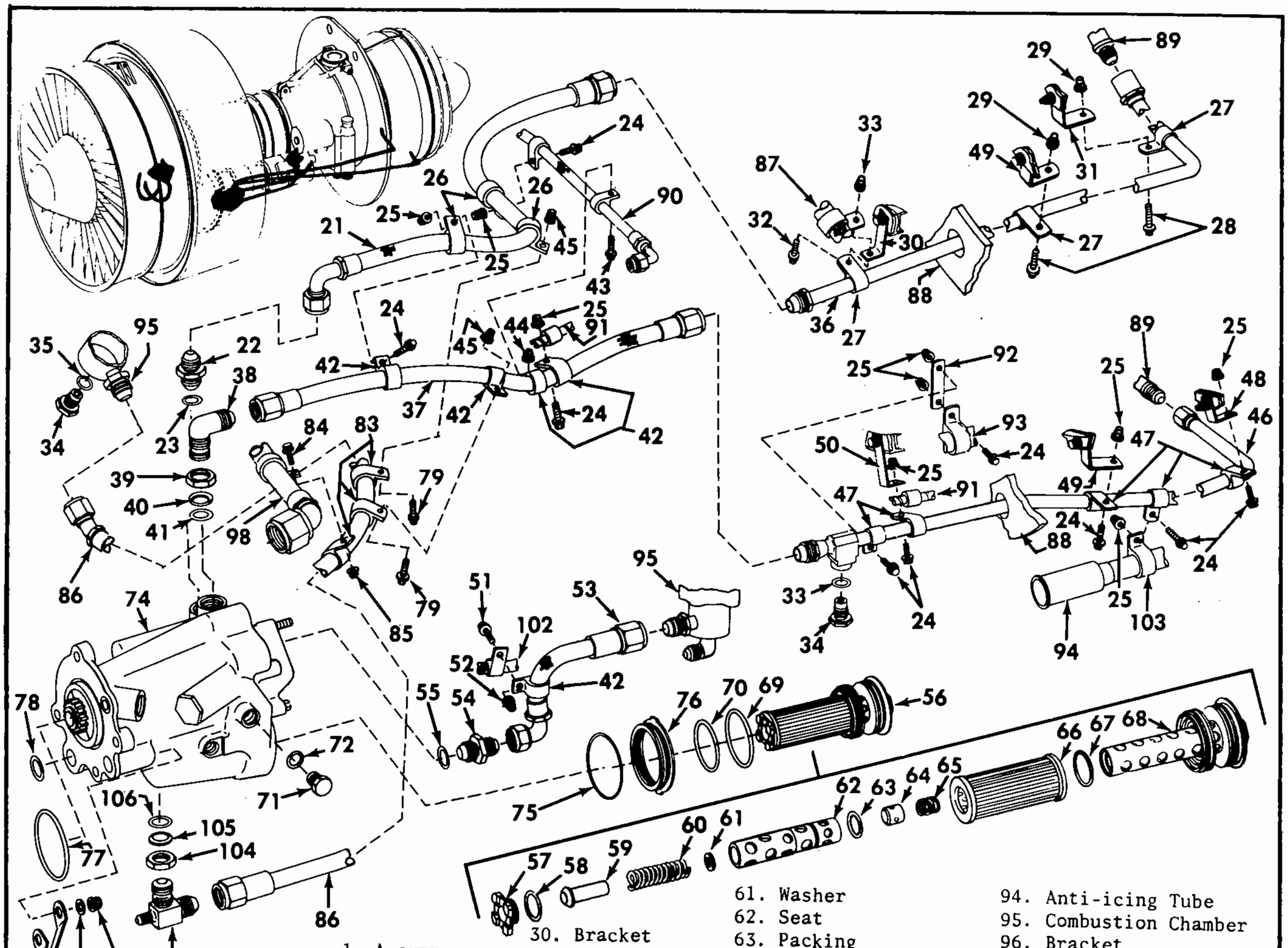
3. Connect the C-sump forward scavenge hose (21) to nipple (22) on lube pump (74). Torque coupling nut to 150-200 lb in.

4. Connect the C-sump forward scavenge tube (36) to hose (21) and to the fitting (89) on exhaust frame strut at 4 o'clock position. Torque the coupling nuts to 150-200 lb in.

5. Connect the B-sump aft scavenge hose (86) to adapter (at the 5 o'clock position) on combustion chamber (95) and to tee (97) located on bottom of lube pump. Torque coupling nuts to 150-200 lb in.

6. Connect the B-sump forward scavenge hose (53) to adapter (at the 7 o'clock position) on combustion chamber (95) and to nipple (54) on lube pump. Torque coupling nuts to 150-200 lb in.

7. Clamp the scavenge system piping as follows:



1. A-sump Scavenge Pump
2. Nut
3. Washer
4. Elbow
5. Jamnut
6. Backup Washer
7. Packing
8. Elbow
9. Jamnut
10. Backup Washer
11. Packing
12. Hose
13. Bolt
14. Packing
15. Hose
16. Bolt
17. Packing
18. Bolt
19. Clamp
20. Nut
21. Scavenge Hose
22. Nipple
23. Packing
24. Bolt
25. Nut
26. Clamp
27. Clamp
28. Bolt
29. Nut
30. Bracket
31. Bracket
32. Bolt
33. Nut
34. Chip Detector
35. Packing
36. Scavenge Tube
37. Scavenge Hose
38. Elbow
39. Jamnut
40. Backup Washer
41. Packing
42. Clamp
43. Bolt
44. Nut
45. Nut
46. Scavenge Tube
47. Clamp
48. Bracket
49. Bracket
50. Bracket
51. Bolt
52. Nut
53. Scavenge Hose
54. Nipple
55. Packing
56. Oil Filter
57. Valve Seat
58. Packing
59. Valve
60. Spring
61. Washer
62. Seat
63. Packing
64. Piston
65. Spring
66. Element
67. Packing
68. Body
69. Packing
70. Packing
71. Plug
72. Packing
73. Water-Wash Hose
74. Lube Pump
75. Packing
76. Sleeve
77. Packing
78. Packing
79. Bolt
80. Packing
81. Nut
82. Washer
83. Clamp
84. Bolt
85. Nut
86. Scavenge Hose
87. Fuel Distributor Hose
88. Aft Mount Ring
89. Exhaust Frame
90. Drain Hose
91. Thermocouple Cable
92. Bracket
93. Anti-icing Tube
94. Anti-icing Tube
95. Combustion Chamber
96. Bracket
97. Tee
98. Tank-to-Pump Hose
99. Actuator Drain Hose
100. Accessory Gearbox
101. Front Frame
102. Actuator Hose
103. Clamp
104. Jamnut
105. Backup Washer
106. Packing

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Figure 4-12. Lube Pump, Scavenge Pump and Scavenge Lines

Note

Clamps are installed by starting with the aft-most clamp and working in the forward direction.

a. Put 8 clamps (47) on C-sump aft scavenge tube (46).

b. Put 4 clamps (42) on C-sump aft scavenge hose (37).

c. Put 4 clamps (27) on C-sump forward scavenge tube (36).

d. Put 2 clamps (26) on C-sump forward scavenge hose (21).

e. Put 3 clamps (83) on B-sump aft scavenge hose (86).

f. Secure the 8 clamps (47) on C-sump aft scavenge tube (46) as follows:

(1) To bracket (48) on exhaust frame-to-turbine casing flange, with bolt (24) and nut (25).

(2) To clamp (103) on anti-icing tube (94) with bolt (24) and nut (25).

(3) To bracket (49) on turbine casing-to-transition casing flange, with bolt (24) and nut (25).

(4) To clamp on thermocouple cable (91) with bolt (24) and nut (25).

(5) To bracket (92) on anti-icing tube (93) with bolt (24) and nut (25).

(6) To bracket (50) on combustion casing rear flange, with bolt (24) and nut (25).

(7) Deleted.

(8) To clamp on electrical cable (91) with bolt (24) and nut (25).

g. Secure the 4 clamps (42) on C-sump aft scavenge hose (37):

(1) To clamp on electrical cable (91) with bolt (24) and nut (25).

(2) To clamp on fuel distributor drain hose (90) with bolt (43) and nut (44).

(3) To clamp (83) on B-sump aft scavenge hose (86) with bolt (79) and nut (45).

(4) To clamp (26) on C-sump forward scavenge hose (21), with bolt (24) and nut (25).

h. Secure the 4 clamps (27) on C-sump forward scavenge tube (36):

(1) To bracket (31) on exhaust frame-to-turbine casing flange, with bolt (28) and nut (29).

(2) To bracket (49) on turbine casing-to-transition casing flange, with bolt (28) and nut (29).

(3) To bracket (30) on combustion chamber rear flange, with bolt (28) and nut (29).

(4) To clamp on oil cooler-to-fuel distributor line (87), with bolt (32) and nut (33).

i. Secure clamp (26) on C-sump forward scavenge hose (21) to clamp (83) on B-sump aft scavenge hose (86), with bolt (79) and nut (45).

j. Secure clamp (83) on B-sump aft scavenge hose (86) to clamp on tank-to-pump hose (98), with bolt (84) and nut (85).

k. Secure clamp (42) on B-sump forward scavenge hose (53) to clamp on fuel control-to-actuator hose (102) with bolt (51) and nut (52).

8. Torque all nuts securing clamps to 38-42 lb in.

4-58. REMOVAL AND INSTALLATION OF A-SUMP SCAVENGE PUMP.

4-59. REMOVAL OF A-SUMP SCAVENGE PUMP AND SCAVENGE HOSES.

Note

Use a pail to catch oil from disconnected lines.

1. Disconnect the two A-sump scavenge lines (12, 15, figure 4-12) at the A-sump scavenge pump (1).

2. Remove lockwire and bolts (13, 16). Disconnect clamps and remove hoses (12, 15). Discard packings (14, 17).

3. Disconnect the A-sump scavenge pump-to-oil tank line (51, figure 4-11) at elbow (52) on the pump.

4. Remove 3 nuts (2, figure 4-12), washers (3) and A-sump scavenge pump. Discard packing (80).

5. If scavenge pump is being replaced, remove the following parts:

Note

Discard all packings and backup washers.

a. Two elbows (4, 8), packings (7, 11), jamnuts (5, 9), and backup washers (6, 10).

b. Elbow (52, figure 4-11), packing (55), jamnut (53), and backup washer (54).

6. If scavenge pump has been removed from an engine in which metal has contaminated the lube system, be sure it is flushed and clean before installing on a serviceable engine.

4-60. INSTALLATION OF A-SUMP SCAVENGE PUMP AND SCAVENGE HOSES.

1. If scavenge pump (1, figure 4-12) is being replaced, install the following parts on pump:

a. Jamnut (9), backup washer (10), packing (11), and elbow (8). Do not torque jamnut (9).

b. Jamnut (5), backup washer (6), packing (7), and elbow (4). Do not torque jamnut (5).

c. Backup washer (54, figure 4-11), packing (55), and elbow (52). Do not torque jamnut (53).

2. Install packing (80, figure 4-12) and position A-sump scavenge pump on gearbox and secure with 3 washers (3) and nuts (2). Torque to 105-115 lb in.

3. Connect the following lines to the fittings on the A-sump scavenge pump:

a. Two hoses (12, 15) connecting A-sump to scavenge pump. Torque to 150-200 lb in.

b. Scavenge pump-to-tank line (51, figure 4-11). Torque to 150-200 lb in.

4. Torque jamnuts on the elbows to 270-300 lb in.

5. Assemble 2 packings (14, 17, figure 4-12) to hoses (12, 15). Install hoses into ports in front frame (101) with bolts (13, 16). Torque bolts to 38-42 lb in. and lock-wire bolts together; double-strand method, using 0.032 inch lockwire.

6. Connect clamp (19) on hose (15) to clamp on actuator drain hose (99) with bolt (18) and nut (20). Torque bolt to 38-42 lb in.

7. Connect clamp on hose (73) to clamp on hose (12) with bolt (32) and nut (33). Torque bolt to 38-42 lb in.

4-61. REMOVAL AND INSTALLATION OF LUBE AND SCAVENGE PUMP.

4-62. REMOVAL OF LUBE AND SCAVENGE PUMP.

Note

- Make sure oil tank is drained.
- Use a pail to catch fluid from disconnected lines.

1. Drain oil tank.

2. Remove the fuel pump-to-fuel heater hose. See paragraph 4-93.

3. Remove the 2 fuel control-to-T2 sensor hoses. See paragraph 4-107.

4. Disconnect the 9 hoses at the fittings on the lube and scavenge pump (74, figure 4-12).

5. Remove oil filter (56) and packings (69, 70). Clean filter as instructed in paragraph 4-67.

6. Remove 4 nuts (81), 4 washers (82), and bracket (96).

7. Remove pump (74) by sliding it aft until it is clear of studs on gearbox.

8. Remove packings (77, 78) from pump.

9. If the lube and scavenge pump is being replaced, remove the following from the pump:

Note

Discard all packings and backup washers.

a. Loosen jamnut (39). Remove elbow (38), packing (41) and backup washer (40).

b. Nipple (22) and packing (23).

c. Nipple (54) and packing (55).

d. Nipple (44, figure 4-11) and packing (45).

e. Loosen jamnut (104, figure 4-12). Remove tee (97), packing (106), and backup washer (105).

f. Loosen jamnut (43, figure 4-14). Remove elbow (42), packing (45), and backup washer (44).

g. Nipple (51) and packing (52).

h. Nipple (41, figure 4-11) and packing (42).

i. Loosen jamnut (16, figure 4-14). Remove elbow (15), packing (18), and backup washer (17).

10. If lube and scavenge pump has been removed from an engine in which metal has contaminated the lube system, be sure pump is flushed and clean before installing on a serviceable engine.

4-63. INSTALLATION OF LUBE AND SCAVENGE PUMP.

1. If the lube and scavenge pump (74, figure 4-12) is being replaced, install the following on the pump:

a. Jamnut (39), backup washer (40), packing (41), and 90° elbow (38). Do not torque jamnut (39).

b. Packing (23) and nipple (22). Torque nipple to 270-300 lb in.

c. Packing (55) and nipple (54). Torque nipple to 270-300 lb in.

d. Packing (45, figure 4-11) and nipple (44). Torque nipple to 45-50 lb ft.

e. Backup washer (105, figure 4-12), jamnut (39), packing (106) and tee (97). Do not torque jamnut.

f. Backup washer (44, figure 4-14), packing (45), and 90° elbow (42). Do not torque jamnut (43).

g. Packing (52) and nipple (51). Torque nipple to 270-300 lb in.

h. Packing (42, figure 4-11) and nipple (41). Torque nipple to 270-300 lb in.

i. Backup washer (17, figure 4-14), packing (18), and elbow (15). Do not torque jamnut (16).

2. Put 1 packing (77, figure 4-12) and 3 packings (78) on pump.

3. Position pump on gearbox and secure with 1 washer (82) and nut (81) on the top stud.

3A. Install bracket (5, figure 4-18) over inboard stud and secure with washer (82, figure 4-12) and nut (81).

4. Slide oil transmitter bracket (96) over remaining studs and secure with washers (82) and nuts (81). Torque the 4 nuts to 180-200 lb in.

5. Connect lines to fittings on pump as follows:

CAUTION

Always use 2 wrenches when installing hoses, one to prevent twisting and the other to tighten the coupling nut.

a. C-sump aft scavenge hose (37) to elbow (38). Torque jamnut on elbow to 270-300 lb in. Torque coupling nut to 150-200 lb in.

b. C-sump forward scavenge hose (21) to nipple (22). Torque to 150-200 lb in.

c. B-sump forward scavenge hose (53) to nipple (54). Torque to 150-200 lb in.

d. Tank-to-pump tube (46, figure 4-11) to nipple (44). Torque to 25-35 lb ft.

e. B-sump aft scavenge hose (86, figure 4-12) to tee (97). Torque jamnut on tee to 270-300 lb in. Torque coupling nut to 150-200 lb in.

f. Transmitter reference hose (46, figure 4-14) to tee (47). Torque to 40-65 lb in.

g. Transmitter hose (41) to 90° elbow (42) Torque jamnut (43) on elbow to 135-150 lb in. Torque coupling nut to 40-65 lb in.

h. Pump-to-cooler hose (25) to nipple (51). Torque to 150-200 lb in.

i. Pump-to-tank tube (40, figure 4-11) to nipple (41). Torque to 150-200 lb in.

j. Oil cooler-to-gearbox hose (13, figure 4-14) to elbow (15). Torque jamnut on elbow to 270-300 lb in. Torque coupling nut to 150-200 lb in.

6. Install packings (69, 70, figure 4-12) on filter (56). Screw filter into pump and torque to 150-200 lb in. Lock-wire filter with 0.032 inch lockwire, using double-strand method.

7. Refill oil tank per paragraph 3-7.

4-64. REMOVAL AND INSTALLATION OF OIL FILTER.

4-65. GENERAL. Comply with the following instructions when doing the work specified in the following paragraphs:

1. Cap or cover the opening in an accessory immediately after removing the filter element.

2. When installing a filter, use care to prevent damage to the packings.

4-66. REMOVAL OF OIL FILTER.

1. Remove lockwire from filter.

2. Unscrew filter and remove packing.

3. Clean filter parts per paragraph 4-67.

4-67. DISASSEMBLY AND CLEANING OF OIL FILTER.

Note

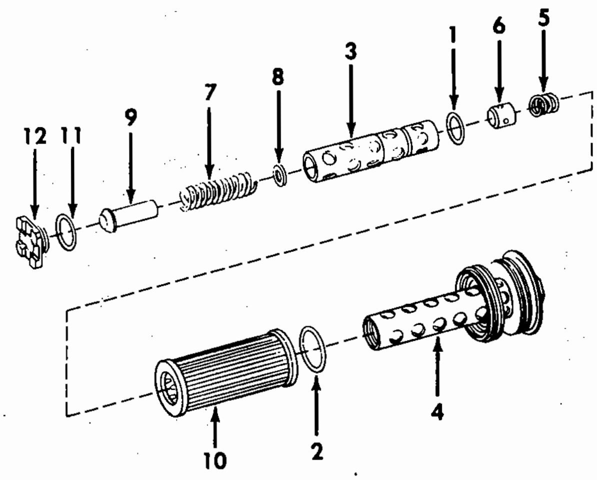
Read paragraph 4-65.

1. Disassemble the valve seat (12, figure 4-13), valve (9), spring (7), washer (8), seat (3), piston (6), spring (5), filter element (10), from body (4). Discard filter element (10) and the packings (1, 2, 11).

WARNING

Trichloroethylene
Fed Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is injurious to the lungs.
- Use only with adequate ventilation.



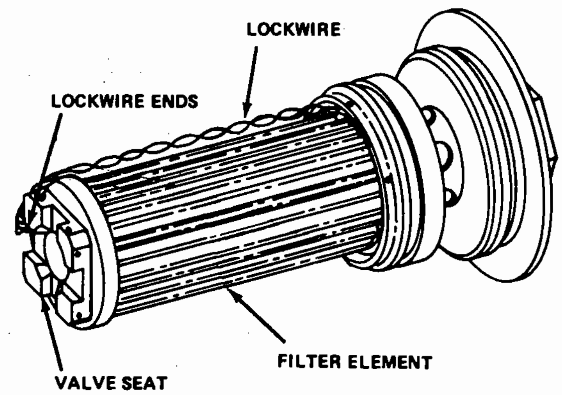


Figure 4-13. Oil Filter Components

WARNING

Trichloroethylene
Fed Spec O-T-634

- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers.

2. Clean all the filter components by washing them in a degreasing solvent such as stabilized trichloroethylene (O-T-634).

Note

The filter parts must be suspended in the cleaning tank without touching the bottom or sides of the tank.

3. Ultrasonically clean the filter parts while they are immersed in trichloroethylene (O-T-634) for 20 minutes minimum. Maintain the solvent temperature at 49° C (120° F) during the cleaning process.

4. Seal all parts in a clean plastic bag immediately after cleaning.

4-68. ASSEMBLY OF OIL FILTER.

Note

Read paragraph 4-65.

1. Apply a light coat of engine oil to packings (1, 2, figure 4-13). Assemble packing (1) to seat (3) and packing (2) to filter body (4).

CAUTION

Be sure to assemble piston (6), chamfered end first, into seat (3).

2. Install spring (5) into piston (6) and assemble piston into seat (3).

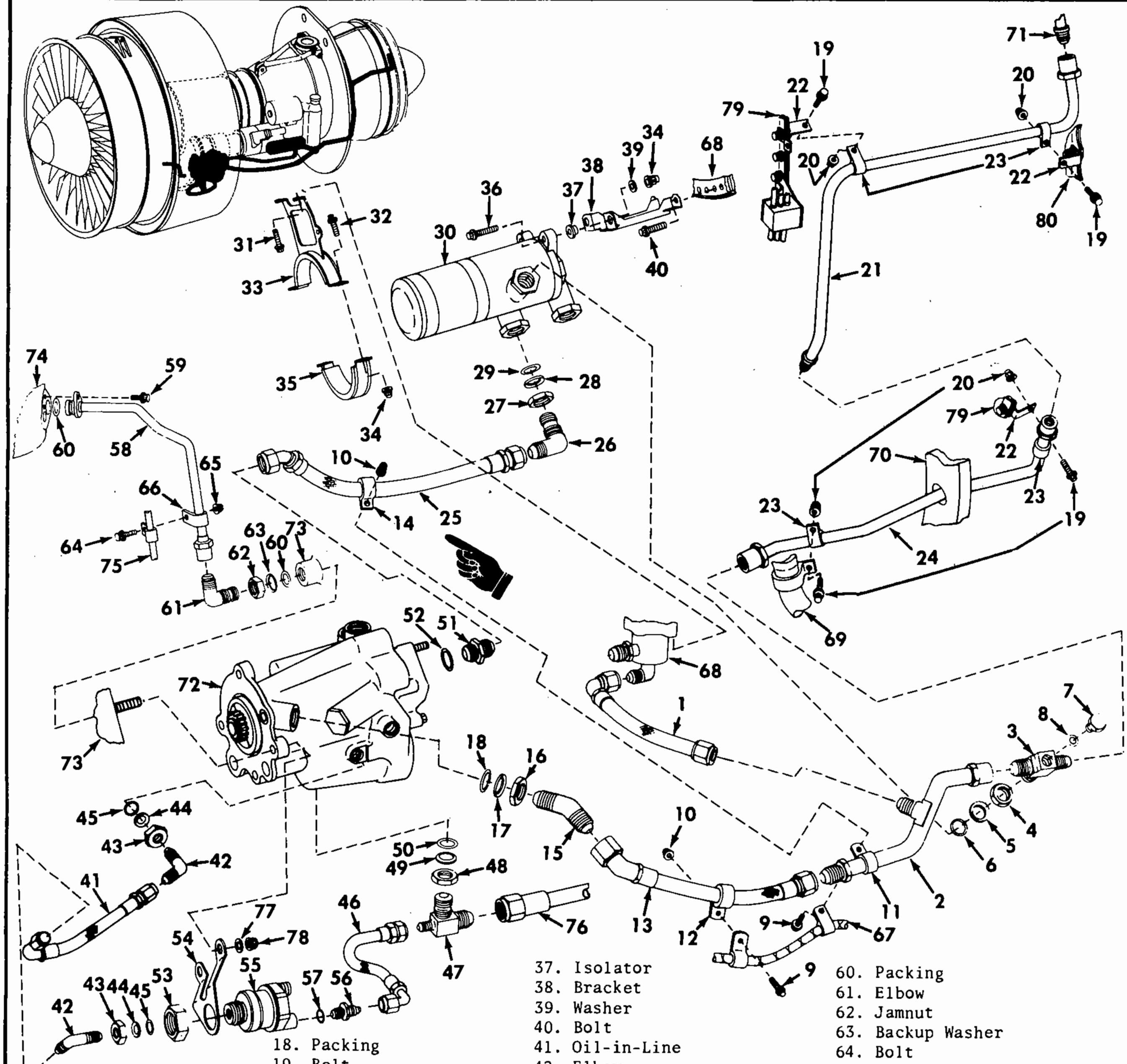
3. Assemble washer (8), spring (7), and valve (9) into seat (3).

4. Install seat subassembly into filter body (4).

5. Assemble new filter element (10) onto filter body subassembly.

6. Apply a light coat of engine oil to packing (11) and assemble it to seat (12).

7. Assemble seat (12) to filter body (4). Torque the seat to 20-25 lb in.



1. B-Sump Supply Hose
2. Oil Tube
3. Tee
4. Jamnut
5. Backup Washer
6. Packing
7. Plug
8. Packing
9. Bolt
10. Nut
11. Clamp
12. Clamp
13. A-Sump Supply Hose
14. Bracket
15. Elbow
16. Jamnut
17. Backup Washer
18. Packing
19. Bolt
20. Nut
21. C-Sump Supply Tube
22. Bracket
23. Clamp
24. C-Sump Supply Tube
25. Pump-to-Cooler Hose
26. Elbow
27. Jamnut
28. Backup Washer
29. Packing
30. Oil Cooler
31. Bolt
32. Bolt
33. Bracket
34. Nut
35. Strap Clamp
36. Bolt
37. Isolator
38. Bracket
39. Washer
40. Bolt
41. Oil-in-Line
42. Elbow
43. Jamnut
44. Backup Washer
45. Packing
46. Reference Hose
47. Tee
48. Jamnut
49. Backup Washer
50. Packing
51. Nipple
52. Packing
53. Nut
54. Bracket
55. Oil Pressure Transmitter
56. Nipple
57. Packing
58. A-Sump Supply Tube
59. Bolt
60. Packing
61. Elbow
62. Jamnut
63. Backup Washer
64. Bolt
65. Nut
66. Clamp
67. Electrical Cable
68. Combustion Chamber
69. Heater Discharge Tube
70. Aft Mount Ring
71. Exhaust Frame
72. Lube Pump
73. Accessory Gearbox
74. Front Frame
75. Front Frame Drain Hose
76. Scavenge Hose
77. Washer
78. Nut
79. Transition Casing
80. Turbine Casing

TF34-0157-2

Figure 4-14. Oil Cooler, Pressure Transmitter and Oil Supply Lines

8. To check valve (9) for proper operation, insert a blunt instrument through the hole in valve seat (12) and depress the valve. When the valve is released it should snap back to its original position against the valve seat. If it does not snap back, disassemble the filter and check for improper assembly or contamination. Reassemble the valve after correcting the problem and recheck the valve operation.

9. Lock-wire valve seat (12) to filter body (4) with 0.020 inch lockwire, using double-strand method.

4-69. INSTALLATION OF OIL FILTER.

Do not reuse packings.

Note

Read paragraph 4-65.

1. Apply a light coat of engine oil to packings (69, 70, figure 4-12) and assemble them to filter (56).

CAUTION

Use a light to make sure filter cavity in lube pump is free of foreign material. Use care in assembling filter to prevent damage to packings. Remove any burrs or pickups from pump bore and lead-in chamfer before installing filter.

2. Lubricate filter bore and lead-in chamfer with engine oil. Install filter in pump, torque it to 180-200 lb in; lock-wire, double-strand method, using 0.032 inch lockwire.

4-70. REMOVAL AND INSTALLATION OF OIL COOLER.

4-71. REMOVAL OF OIL COOLER.

1. Disconnect the fuel control-to-flow meter line (1, figure 4-16) at flowmeter.

2. Disconnect the following at the oil cooler (30, figure 4-14):

Note

When disconnecting lines, let fluid drain into pail.

a. Oil cooler-to-fuel distributor line (10, figure 4-16).

b. Oil pump-to-oil cooler line (25, figure 4-14).

3. Disconnect the C-sump supply line (24) and the B-sump supply tube (2) from the supply tee (3) on the oil cooler.

4. Loosen 2 bolts (32) and nuts (34) that hold the strap clamp (35) around the oil cooler.

5. Remove 2 bolts (36), nuts (34), isolators (37), and washers (39) that secure aft end of oil cooler to bracket (38).

6. Slide oil cooler up and aft until it is free from bracket (33).

7. Remove the fuel flowmeter from the oil cooler per paragraph 4-96.

8. If oil cooler is being replaced, remove the following parts:

Note

Discard all packings and backup washers.

a. Nipple (5, figure 4-16) and packing (6).

b. Elbow (26, figure 4-14), packing (29), and backup washer (28).

c. Elbow (11, figure 4-16), packing (14), and backup washer (13).

d. Tee (3, figure 4-14), packing (6), and backup washer (5).

9. If oil cooler has been removed from an engine in which metal has contaminated the lube system, be sure it is flushed and clean before installing on a serviceable engine.

4-72. INSTALLATION OF OIL COOLER.

1. If oil cooler is being replaced, install the following parts on cooler:

a. Packing (6, figure 4-16) and nipple (5) for fuel meter-to-cooler tube. Torque nipple to 270-300 lb in.

b. Backup washer (28, figure 4-14), packing (29), and elbow (26) for oil pump-to-oil cooler line. Do not tighten jamnut (27).

c. Backup washer (13, figure 4-16), packing (14) and elbow (11) for oil cooler-to-fuel distributor line. Do not tighten jamnut (12).

d. Backup washer (5, figure 4-14), packing (6), and tee (3). Do not tighten jamnut (8).

2. Slide oil cooler (30) down and forward until the leg of bracket (33) slides between oil cooler and oil cooler strap clamp (35).

3. Rotate oil cooler until the 2 isolators (37), washers (39), bolts (36), and nuts (34) can be installed securing oil cooler to bracket (38). Torque the nuts to 38-42 lb in.

4. Torque nuts (34) on strap clamp (35) to 38-42 lb in.

5. Connect the fuel control-to-flowmeter line (1, figure 4-16) at the flowmeter (27). Torque to 38-42 lb ft.

6. Connect the following lines to the fittings on oil cooler:

a. Oil pump-to-oil cooler line (25, figure 4-14). Torque to 150-200 lb in.

b. Oil cooler-to-fuel distributor line (10, figure 4-16). Torque to 38-42 lb ft.

c. B-sump supply tube (2, figure 4-14) on supply tee (3). Torque to 150-200 lb in.

d. C-sump supply tube (24) on supply tee (3). Torque to 75-125 lb in.

e. Torque oil cooler fitting jamnuts as follows:

(1) Oil-in elbow jamnut (27) to 270-300 lb in.

(2) Fuel-out elbow jamnut (25, figure 4-16) to 270-300 lb in.

(3) Supply tee jamnut (4, figure 4-14) to 270-300 lb in.

4-73. REMOVAL AND INSTALLATION OF OIL PRESSURE TRANSMITTER.

4-74. REMOVAL OF OIL PRESSURE TRANSMITTER.

Note

Use a pail to catch oil from disconnected lines.

1. Disconnect the oil-in line (41, figure 4-14) from elbow (42) on the forward end of transmitter (55).

2. Disconnect the transmitter reference line (46) from the nipple (56) on the aft end of transmitter.

3. Disconnect the electrical cable from the aft end of transmitter. Discard packing.

4. Remove nut (53) securing transmitter to bracket (54). Slide transmitter aft from bracket.

5. Loosen jamnut (43) on elbow (42).

6. Remove elbow. Discard packing (45) and backup washer (44).

7. Remove nipple (56) and packing (57) from aft end of transmitter.

4-75. INSTALLATION OF OIL PRESSURE TRANSMITTER.

1. Install backup washer (44, figure 4-14), packing (45), and elbow (42) on forward end of transmitter. Do not torque jamnut (43) at this time.

2. Install packing (57) and nipple (56) in aft end of transmitter. Torque nipple to 135-150 lb in.

3. Slide transmitter (55) forward through hole in bracket (54). Secure transmitter in position with nut (53), but do not torque.

4. Rotate transmitter in bracket until holes in transmitter are in position for connection of oil and electrical lines.

5. Torque nut (53) to 28-32 lb in. and lock-wire it to bracket (54) with 0.032 inch lockwire, using double-strand method.

6. Connect transmitter reference line (46) to nipple (56). Torque to 40-65 lb in.

7. Install electrical lead to aft end of transmitter. Make handtight. Lock-wire connector with 0.020 inch lockwire, using double-strand method.

8. Position elbow (42) on forward end of transmitter and connect oil-in line (41) to it. Torque to 40-65 lb in. Torque jamnut (43) on elbow to 135-150 lb in.

4-76. REMOVAL AND INSTALLATION OF OIL SUPPLY LINES.

4-77. REMOVAL OF OIL SUPPLY LINES.

Note

Use a pail to catch fluid from disconnected lines.

1. On oil supply lines, disconnect all clamps from brackets and other clamps. Leave clamps on all lines that are not being replaced.

2. Remove the C-sump oil supply aft tube (21, figure 4-14) by disconnecting it from the C-sump oil supply forward tube (24) and at the fitting on the exhaust frame (71) strut at 10 o'clock position.

3. Remove the C-sump oil supply forward tube (24) by disconnecting it at the tee (3) on the oil cooler (30).

4. Remove the B-sump oil supply hose (1) by disconnecting it at the adapter (at 7 o'clock position) on the combustion chamber, and from the tee on the oil supply tube (2).

5. Remove the accessory gearbox/A-sump oil supply hose (13) by disconnecting it at the 45° elbow (15) on pump and at the oil supply tube (2).

6. Remove the oil supply tube (2) by disconnecting it at the tee (3) on oil cooler.

7. Remove the A-sump oil supply tube (58) by disconnecting it at the elbow (61) on gearbox and removing bolt (59) and packing (60) on front frame end of tube.

4-78. INSTALLATION OF OIL SUPPLY LINES.

CAUTION

Always use 2 wrenches when installing lines, one to hold the fitting, and the other to tighten the coupling nut.

1. Connect the C-sump oil supply aft tube (21, figure 4-14) to the fitting on exhaust frame strut at the 10 o'clock position. Torque coupling nut to 75-125 lb in.

2. Connect the C-sump oil supply tube (24) to tee (3) on oil cooler and to C-sump oil supply aft tube (21). Torque coupling nuts to 75-125 lb in.

3. Connect the oil supply tube (2) to tee (3) on oil cooler. Torque coupling nut to 150-200 lb in.

4. Connect B-sump oil supply hose (1) to oil supply tube (2) and to adapter at 7 o'clock position on combustion chamber (68). Torque coupling nuts to 75-125 lb in.

5. Connect accessory gearbox/A-sump oil supply hose (13) to oil supply tube (2) and to 45° elbow (15) on pump. Torque coupling nuts to 150-200 lb in.

6. Put packing (60) onto A-sump supply tube (58). Push tube into front frame and secure with one bolt (59). Torque bolt to 38-42 lb in. and lock-wire with 0.032 inch lockwire, using double-strand method. Connect other end of supply tube to elbow (61) on gearbox. Torque coupling nut to 75-125 lb in.

7. Clamp the oil supply lines as follows:

Note

Clamps are installed by starting with the aft-most clamp and working in the forward direction.

a. Put 2 clamps (23) on C-sump oil supply aft tube (21).

b. Put 2 clamps (23) on C-sump oil supply forward tube (24).

c. Put 1 clamp (11) on oil supply tube (2).

d. Put 1 clamp (12) on accessory gearbox/A-sump oil supply hose (13).

e. Put 1 clamp (66) on A-sump oil supply tube (58).

f. Secure the 2 clamps on C-sump aft tube as follows:

Note

See figure 4-14 for clamp positions on brackets (22).

(1) To bracket (22) on exhaust frame-to-turbine casing flange, with bolt (19) and nut (20).

(2) To bracket (22) on turbine casing-to-transition casing flange, with bolt (19) and nut (20).

g. Secure clamp (23) on C-sump oil supply forward tube (24) to bracket (22) on turbine casing-to-transition casing flange, with bolt (19) and nut (20).

h. Secure clamp (23) on tube (24) to clamp on fuel heater discharge tube (69) with bolt (19) and nut (20).

i. Secure clamp (11) on oil supply tube (2) to clamp on electrical cable (67), with bolt (9) and nut (10).

j. Secure clamp (12) on accessory gearbox/A-sump oil supply hose (13) to clamp on electrical cable (67) and to bracket (14) on lube pump, with bolt (9) and nut (10).

k. Secure clamp (66) on A-sump oil supply tube (58) to clamp on front frame drain line (75), with bolt (64) and nut (65).

l. Torque all nuts securing clamps to 38-42 lb in.

4-79. <u>REMOVAL AND INSTALLATION OF FUEL SYSTEM COMPONENTS.</u>

4-80. REMOVAL AND INSTALLATION OF FUEL HEATER.

4-81. REMOVAL OF FUEL HEATER. Drain fuel into a suitable container.

1. Remove fuel filter (20, figure 4-15) from heater (29) per paragraph 4-84.

2. Remove bolts (57) and nuts (58) holding brackets (28, 17) to flanges of fuel heater (29).

3. Remove 4 bolts (9), nuts (10) and gasket (8) holding fuel line (11) to heater (29).

4. Disconnect drain tube (65) from heater inlet tube (66).

5. Remove lock-wire and 3 bolts (60) from brackets (62, 63). Remove retainer plate (61).

6. Support fuel heater (29) while removing remaining bolts (57), nuts (58), bracket (62), and gasket (67). Disconnect heater inlet tube (66) and discharge tube (56) and lift fuel heater away from engine.

4-82. INSTALLATION OF FUEL HEATER.

1. Insert fuel heater (29, figure 4-15) between air inlet tube (66) and discharge tube (56). Line up holes in tubes, and heater brackets (17, 28) with bolts (57) and nuts (58) to holes in flanges of heater.

2. Install gasket (8) and connect fuel inlet line (11) to fuel heater (29) with 4 bolts (9) and 4 nuts (10). Torque bolts to 105-115 lb in.

3. Insert gasket (67) between tube (66) and flange of heater and install 8 bolts (57), bracket (62), and 8 nuts (58). Torque bolts (57) to 105-115 lb in.

4. Adjust bracket (63) on flange until a gap of 0.030-0.040 inch exists between flex bracket (62) and bracket (63). Torque flange bolts to 160-170 lb in. Insert retainer plate (61) between brackets (62, 63). Install 3 bolts (60) and torque them to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

5. Connect drain tube (65) to heater inlet tube (66), and torque fitting to 90-100 lb in.

6. Assemble fuel filter (20) to fuel heater (29) per paragraph 4-85.

4-83. REMOVAL AND INSTALLATION OF FUEL FILTER ASSEMBLY.

4-84. REMOVAL OF FUEL FILTER ASSEMBLY. Drain fuel into a suitable container.

1. Remove lockwire, 4 bolts (4, figure 4-15), fuel hose (5), and gasket (6) from fuel filter assembly (20).

CAUTION

Do not use tools on electrical connectors.

2. Remove lockwire and disconnect electrical cable from fuel filter assembly (20).

3. Remove lockwire and 2 bolts (16) holding filter (20) to brackets (17).

4. Remove drain tube from fuel filter per paragraph 4-118.

5. Remove 4 bolts (18) holding filter (20) to fuel heater (29). Remove gasket (19) and filter assembly.

6. Disassemble filter per paragraph 4-108A.

4-85. INSTALLATION OF FUEL FILTER ASSEMBLY

1. Install gasket (19, figure 4-15) to top of filter assembly (20) and assemble filter to fuel heater (29) with 4 bolts (18). Leave bolts loose.

2. Connect 2 brackets (17) to filter with 2 bolts (16). Torque bolts (16, 18) to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

3. Install gasket (6) and assemble fuel line (5) to filter (20) with 4 bolts (4). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

CAUTION

Do not use tools on electrical connectors.

4. Assemble connector on cable to receptacle on filter (20) and hand-tighten. Lock-wire connector, double-strand method, using 0.020 inch lockwire.

5. Assemble drain tube to fuel filter per paragraph 4-119.

4-86. REMOVAL AND INSTALLATION OF FUEL CONTROL.

4-87. REMOVAL OF FUEL CONTROL.

Note

- Discard all packings and backup washers.
- Drain the fuel lines into a suitable container.

1. Remove P3 tube (21, figure 4-3) from main fuel control. Remove primer tube (2, figure 4-16A) from fuel control.

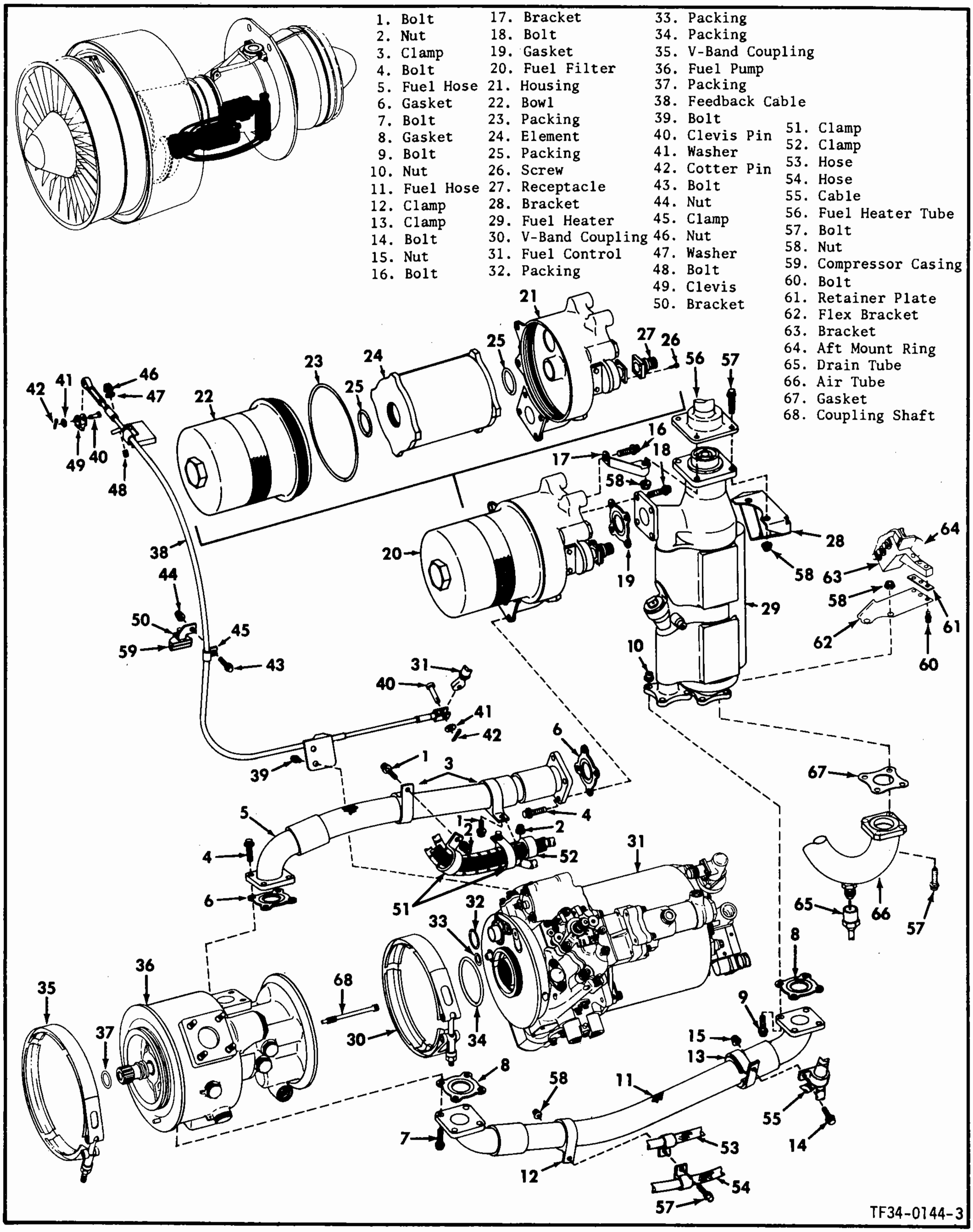


Figure 4-15. Fuel Control, Fuel Heater, Fuel Filter and Components

2. Remove T2 sensor hoses (53, 54, figure 4-15) from fuel control (31).

3. Remove cotter pin (42), washer (41) and clevis pin (40) from clevis (49) at right-hand linkage assembly. Remove nut (46) and washer (47). Remove bolt (43), and nut (44) holding feedback cable (38) to bracket (50) on compressor casing (59).

CAUTION

Do not use tools on electrical connectors.

4. Remove lockwire and accessible electrical connectors on electrical cables from fuel control.

5. Remove lockwire and bolts (28, 29, figure 4-5A) holding trim panel (36) to fuel control. Lower trim panel as far as possible without damaging lines.

6. Remove drain tube (43, figure 4-21) from fuel filter per paragraph 4-118.

7. Remove actuator hoses (3, 4, figure 4-18) from fuel control.

8. Remove the control-to-flowmeter hose (1, figure 4-16) and remove drain tube (17, figure 4-21) from fuel control.

CAUTION

When moving fuel control aft, be careful not to damage spline shaft (68). Shaft may stay in pump or come out with control.

Note

Steps 9 and 10 require 2 men, one to support the fuel control, the other to disconnect electrical cable and feedback cable.

9. Remove lockwire and V-band coupling (30, figure 4-15). Lift fuel control, guide it aft until it clears the fuel pump (36), and electrical cable and feedback cable are accessible.

10. Disconnect feedback cable (38, figure 4-15) from fuel control by removing clevis pin (40) and bolts (39). Disconnect blue electrical cable from fuel control.

11. Lift fuel control away from engine. Remove and discard packings (32, 33, 34) from fuel control.

12. If fuel control is being replaced, remove all nipples, elbows and fittings that have to be assembled to new fuel control. Leave shaft (68) with fuel pump.

4-88. INSTALLATION OF FUEL CONTROL.

Lubricate all packings on fuel control with fuel.

1. If main fuel control (3, figure 4-15) is being replaced, install the following parts on the control:

a. Assemble elbow (25, figure 4-3) with jamnut (26), backup washer (27) and packing (28) to P3 port on fuel control. Do not torque jamnut. Assemble packing (28) and nipple (24). Torque nipple to 90-100 lb in.

b. Assemble elbow (13, figure 4-19) with jamnut (14), backup washer (15) and packing (16) to T2 sensor port (upper) on fuel control. Do not torque jamnut.

c. Assemble elbow (9) with jamnut (10), backup washer (11), and packing (12) to T2 sensor port (lower) on fuel control. Do not torque jamnut.

d. Assemble packing (16, figure 4-21) to nipple (15). Assemble nipple to drain port on fuel control. Torque nipple to 135-150 lb in.

e. Assemble packing (3, figure 4-16) to reducer (2). Assemble reducer to fuel outlet port on fuel control. Torque reducer to 45-50 lb ft.

f. Assemble packing (9, figure 4-18) to nipple (25). Assemble nipple to actuator port on control marked Rod. Torque nipple to 155-175 lb in.

g. Assemble jamnut (11), backup washer (12), and packing (13) to elbow (26). Assemble elbow to actuator port on fuel control marked Head. Do not torque jamnut.

h. Assemble packing (4, figure 4-16A) to nipple (3). Assemble nipple to port closest to P3 fitting. Torque nipple to 90-100 lb in.

2. Install fuel control (31, figure 4-15) onto fuel pump as follows:

a. Assemble 3 packings (32, 33, 34) onto pump (36) and control (31).

b. Assemble feedback cable (38) to the control (31) with 2 bolts (39). Torque bolts to 28-32 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire. Install clevis pin (40), washer (41), and cotter pin (42), connecting feedback cable to feedback cable arm on control.

c. Assemble V-band coupling (30) onto flange of fuel pump (36).

CAUTION

Be sure splined coupling shaft (68) is installed in aft end of fuel pump.

Note

Steps d and e require 2 men, one to support the fuel control, the other to connect blue electrical cable to fuel control.

d. Hold fuel control in position and connect blue electrical cable to inboard connector on fuel control, hand-tight. Lock-wire connector, double-strand method, using 0.020 inch lockwire.

e. Install fuel control (31) onto fuel pump (36), engaging pin and spline shaft.

f. Move V-band coupling (30) into position on mating flanges of fuel control and pump. With nut on V-band coupling facing towards 6 o'clock (so coupling will not interfere with cowl frames), torque the nut to 50-55 lb in. Lock-wire the nut to the coupling stud, double-strand method, using 0.032 inch lockwire.

3. Assemble feedback cable bracket over bolt (48) on compressor casing with washer (47) and nut (46). Torque nut to 105-115 lb in. Check the cable for freedom of movement, by pulling on the VG end and allow it to return to its original position. If binding exists, or it requires more than 10 lb in. to pull cable, replace the cable. Connect feedback cable (38) to clevis (49) on right-hand linkage assembly with clevis pin (40), washer (41) and cotter pin (42).

4. Assemble control-to-flowmeter hose (1, figure 4-16) to reducer (2) on fuel control (22). Torque coupling nut on hose to 37-45 lb ft.

5. Assemble drain tube (17, figure 4-21) to nipple (15). Torque coupling nut on tube to 135-150 lb in.

6. Assemble T2 sensor hose (5, figure 4-19) to elbow (9) handtight. Hold elbow with wrench and torque jamnut (10) to 155-175 lb in. Torque coupling nut on hose to 180-200 lb in.

7. Assemble T2 sensor hose (6) to elbow (13) handtight. Hold elbow with wrench and torque jamnut (14) to 135-150 lb in. Torque coupling nut on hose to 135-150 lb in.

8. Assemble P3 tube (21, figure 4-3) to elbow (25), and nipple (24), handtight. Hold elbow with a wrench and torque jamnut (25) to 90-100 lb in. Torque coupling nuts on tube to 90-100 lb in.

CAUTION

Do not use tools on electrical connectors.

9. Assemble electrical connectors of cable (1, figure 4-8) to fuel control, handtight. Lock-wire connector, double-strand method, using 0.020 inch lockwire.

10. Assemble tube (2, figure 4-16A) to nipple (3) per paragraph 4-100D.

11. Reassemble drain tube (43, figure 4-21) onto fitting of fuel filter (68). Torque coupling nut to 135-150 lb in.

12. Assemble electrical connector of cable (1, figure 4-10) to fuel control, handtight. Lock-wire connector, double-strand method, using 0.020 inch lockwire.

13. Assemble trim panel (36, figure 4-5A) to fuel control. Assemble bolts (28, 29) and torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

14. Adjust feedback cable per paragraph 4-133.

15. Assemble actuator hose (3, figure 4-18) to elbow (26) handtight. Hold elbow with a wrench and torque jamnut (11) to 180-200 lb in. Torque coupling nut on hose (3) to 180-200 lb in.

16. Assemble actuator hose (4) to nipple (25). Torque coupling nut on hose to 270-300 lb in.

4-89. REMOVAL AND INSTALLATION OF FUEL PUMP.

4-90. REMOVAL OF FUEL PUMP.

Note

Drain fuel from lines into a suitable container.

1. Remove fuel control per paragraph 4-87.

2. Remove lockwire and 4 bolts (7, figure 4-15) holding the pump-to-heater hose (11) onto fuel pump (36). Remove gasket (8).

3. Remove lockwire and 4 bolts (4) holding the filter-to-pump hose (5) onto fuel pump (36). Remove gasket (6).

4. Remove lockwire and loosen V-band coupling (35) and remove fuel pump. Remove and discard packing (37).

4-91. INSTALLATION OF FUEL PUMP. Lubricate packing at pump to gearbox pad with engine oil.

1. Install packing (37, figure 4-15) onto fuel pump (36).

2. Install V-band coupling (35) to pad at the 9 o'clock position on gearbox.

3. Assemble the fuel pump to gearbox pad, engaging alignment pin in slot. Position V-band coupling (35) onto mating flanges of pump and gearbox with nut facing the 6 o'clock position. Torque nut on V-band coupling to 80-85 lb in. Lock-wire nut, double-strand method, using 0.032 inch lockwire.

4. Insert gasket (6) between flange of hose (5) and pump and insert 4 bolts (4). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

5. Insert gasket (8) between flange of hose (11) and pump and insert 4 bolts (7). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

6. Install the main fuel control (31) per paragraph 4-88.

4-92. REMOVAL AND INSTALLATION OF FUEL PUMP HOSES.

4-93. REMOVAL OF FUEL PUMP HOSES.

Note

Drain fuel lines into a suitable container.

1. Disconnect clamps (3, 12, figure 4-15) from hoses (5, 11).

2. Remove lockwire, 4 bolts (7), gasket (8) and disconnect one end of hose (11) from fuel pump (36).

3. Remove 4 bolts (9), 4 nuts (10) and gasket (8) from fuel heater (29). Remove hose (11).

4. Remove lockwire, 4 bolts (4), gasket (6) and one end of hose (5) from fuel pump (36).

5. Remove lockwire, 4 bolts (4) and gasket (6) from fuel filter (20). Remove hose (5).

4-94. INSTALLATION OF FUEL PUMP HOSES.

1. Insert gasket (6, figure 4-15) between discharge port on fuel filter (20) and hose (5) and install 4 bolts (4). Torque bolts to 105-115 lb in. and lockwire, double-strand method, using 0.032 inch lockwire.

2. Insert gasket (6) between port on fuel pump (36) and hose (5) and install 4 bolts (4). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

3. Insert gasket (8) between flange on fuel heater (29) and hose (11) and install 4 bolts (9), and 4 nuts (10). Torque bolts to 105-115 lb in.

4. Insert gasket (8) between port on fuel pump (36) and hose (11) and install 4 bolts (7). Torque bolts to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

5. Connect 2 clamps (3) to clamps (51, 52) on electrical cables with bolts (1) and nuts (2).

6. Connect clamp (12) to clamps on T2 sensor hoses (53, 54) with bolt (57) and nut (58). Torque bolts to 38-42 lb in.

4-95. REMOVAL AND INSTALLATION OF FLOWMETER.

4-96. REMOVAL OF FLOWMETER.

Note

Drain the fuel lines into a suitable container. Discard all packings and backup washers.

1. Disconnect and remove flowmeter-to-cooler tube (4, figure 4-16).

2. Disconnect fuel control-to-flowmeter hose (1) from the flowmeter (27). Remove flowmeter.

4-97. INSTALLATION OF FLOWMETER.

Lubricate all packings with fuel.

1. Assemble fuel control-to-flowmeter hose (1, figure 4-16) to flowmeter (27). Torque coupling nut of hose to 38-45 lb ft.

2. Assemble tube (4) to fittings on flowmeter and oil cooler (24) and torque coupling nuts to 38-45 lb ft.

4-98. REMOVAL AND INSTALLATION OF FUEL DISTRIBUTOR AND MANIFOLD.

4-99. REMOVAL OF FUEL DISTRIBUTOR.

Note

Drain the fuel lines into a suitable container.

1. Disconnect cooler-to-distributor hose (10, figure 4-16) from the fuel distributor (19).

2. Disconnect distributor drain hose (11, figure 4-21) from fuel distributor.

3. Remove lockwire, 3 bolts (17, figure 4-16), 1 bolt (16) and 4 washers (18). Push bracket (28) away from fuel distributor (19). Remove fuel distributor and gasket (13).

4. Reinstall 2 bolts (17), fingertight, to hold distributor block in place.

5. If fuel distributor is being replaced, remove:

a. Jamnut (12), elbow (15), backup washer (13), and packing (14). Discard packing and backup washer.

b. Nipple (9, figure 4-21) and packing (10). Discard packing.

4-100. INSTALLATION OF FUEL DISTRIBUTOR.

Lubricate packings with fuel.

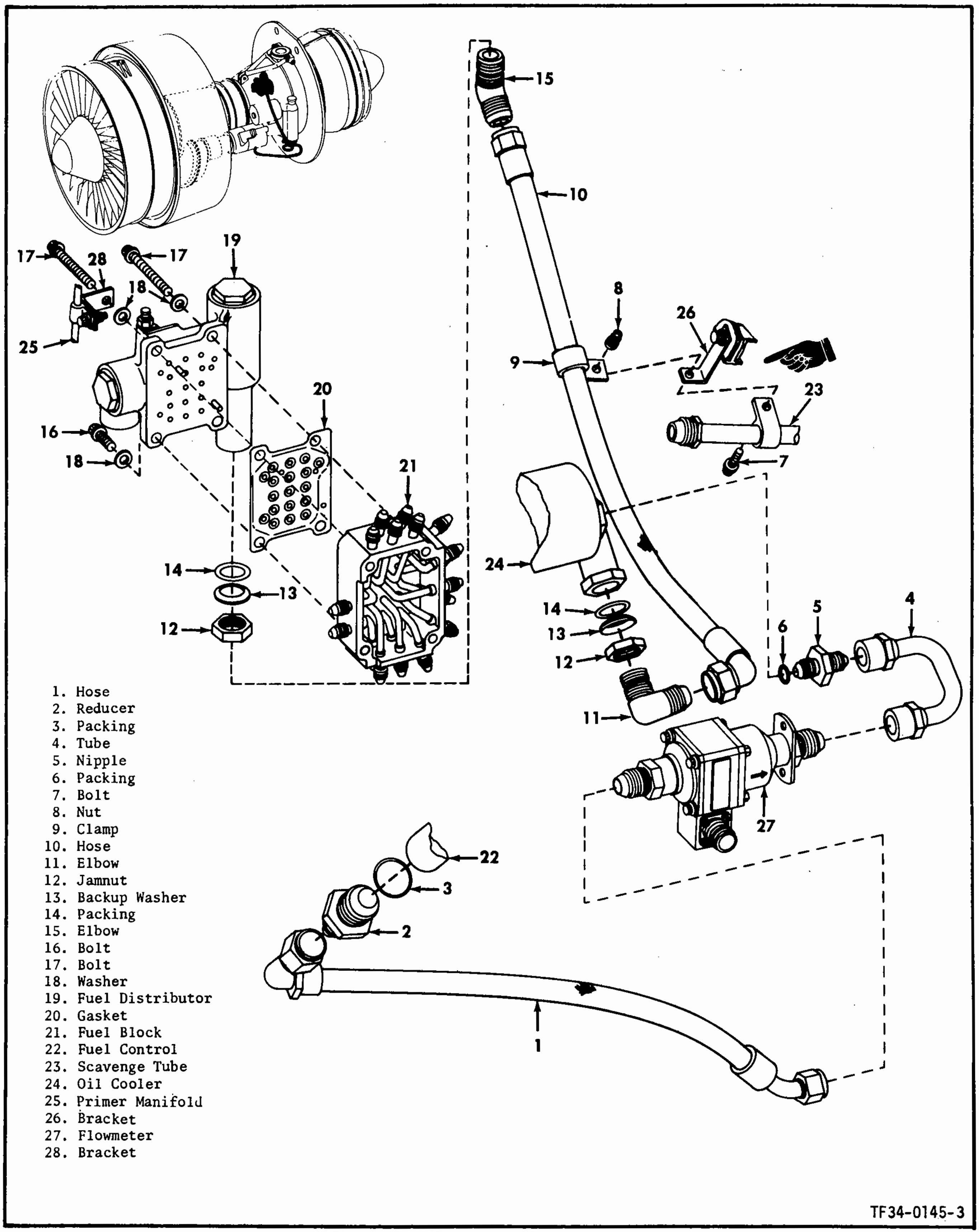


Figure 4-16. Flowmeter and Fuel Distributor Components

1. Assemble gasket (20, figure 4-16) over dowel pins in block (21) and assemble fuel distributor (19) to the block using 4 washers (18), 3 bolts (17), and 1 bolt (16). Place bracket (28) on primer manifold (26) under upper right-hand bolt (17). Torque bolts to 105-115 lb in. and lock-wire, double-twist method, using 0.032 inch lockwire.

2. If necessary, assemble the following items onto fuel distributor.

a. Assemble jamnut (12), backup washer (13), and packing (14) onto elbow (15).

b. Assemble elbow (15) to fuel distributor, leaving jamnut loose.

c. Assemble packing (10, figure 4-21) onto nipple (9) and assemble nipple to fuel distributor. Torque nipple to 135-150 lb in.

3. Connect cooler-to-distributor hose (10, figure 4-16) to elbow on fuel distributor (19). Hold elbow with a wrench and torque jamnut (12) to 270-300 lb in. Torque coupling nut of hose (10) to 38-45 lb ft.

4. Connect drain hose (11, figure 4-21) to nipple on fuel distributor. Torque coupling nut of hose to 40-65 lb in.

4-100A. REMOVAL AND INSTALLATION OF FUEL DISTRIBUTOR BLOCK.

4-100B. REMOVAL.

1. Remove fuel distributor per paragraph 4-99.

4-100C. INSTALLATION.

1. Temporarily mount block (21, figure 4-16) to combustion casing with 3 bolts (17).

2. Connect fuel manifold hoses to block per paragraph 4-102.

3. Install fuel distributor per paragraph 4-100.

4-100D. REMOVAL OF PRIMER NOZZLE SYSTEM COMPONENTS.

1. Remove bolt (49, figure 4-16A) and nut (50) connecting clamp (59) on fuel distributor drain hose (51) to clamp (23) on primer nozzle manifold (20) at the 4 o'clock position.

2. Remove bolt (21) and nut (22) connecting clamp (23) to bracket (26) at fuel distributor (48).

3. Remove bolt (21) and nut (22) connecting clamp (23) to bracket (25) at anti-icing duct (45).

4. Disconnect fitting at junction of primer manifolds (19, 20). Disconnect fittings of manifold (20) at 2 primer nozzles (27) and remove manifold.

5. Remove lockwire and bushings (28) and 2 primer nozzles (27).

6. At the 12 o'clock position, remove 2 bolts (39) and 2 nuts (40) on 2 brackets (41, 42). Pull manifold (19) and clamps (18) out from under clamps (56, 57) on igniter lead (43) and green electrical cable (44).

7. Remove bolt (35) and nut (36) connecting clamp (58) on fuel manifold hoses (37, 38) to clamp (18) on manifold (19). Disconnect fittings on manifold (19) and tube (17) and remove manifold (19).

8. Remove 2 bolts (14) and nuts (15) connecting clamps (16) on tube (11) to 2 clamps (18) on tube (17). Disconnect fittings of tube (11) at lower end of purge valve (10) and at elbow (13) on combustion chamber. Remove tube (11).

9. Remove bolt (14) and nut (15) connecting clamp (18) on tube (17) to bracket (34) under borescope plug (33). Disconnect fitting at purge valve (10) and remove tube (17).

10. Remove bolt (5) and nut (6) connecting clamp (7) on tube (2) to clamp (18) on P3 tube (29). Disconnect fittings of tube (2) at nipple (3) and at purge valve (10) and remove the tube.

11. Remove bolt (8) holding clamp (9) to fuel heater (30) and remove purge valve (10).

12. If necessary, loosen nut (12) and remove elbow (13) from combustion chamber at about the 9 o'clock position.

13. If necessary remove nipple (3) from fuel control (1). Discard packing (4).

4-100E. INSTALLATION OF PRIMER NOZZLE SYSTEM COMPONENTS.

CAUTION

Be sure the word AFT on primer nozzle wrenching flat, is facing aft and the wrenching flat is parallel to combustion chamber flange after torquing bushings.

1. Install primer nozzles (27, figure 4-16A) into lower openings at 2 and 4 o'clock positions on combustion chamber (32).

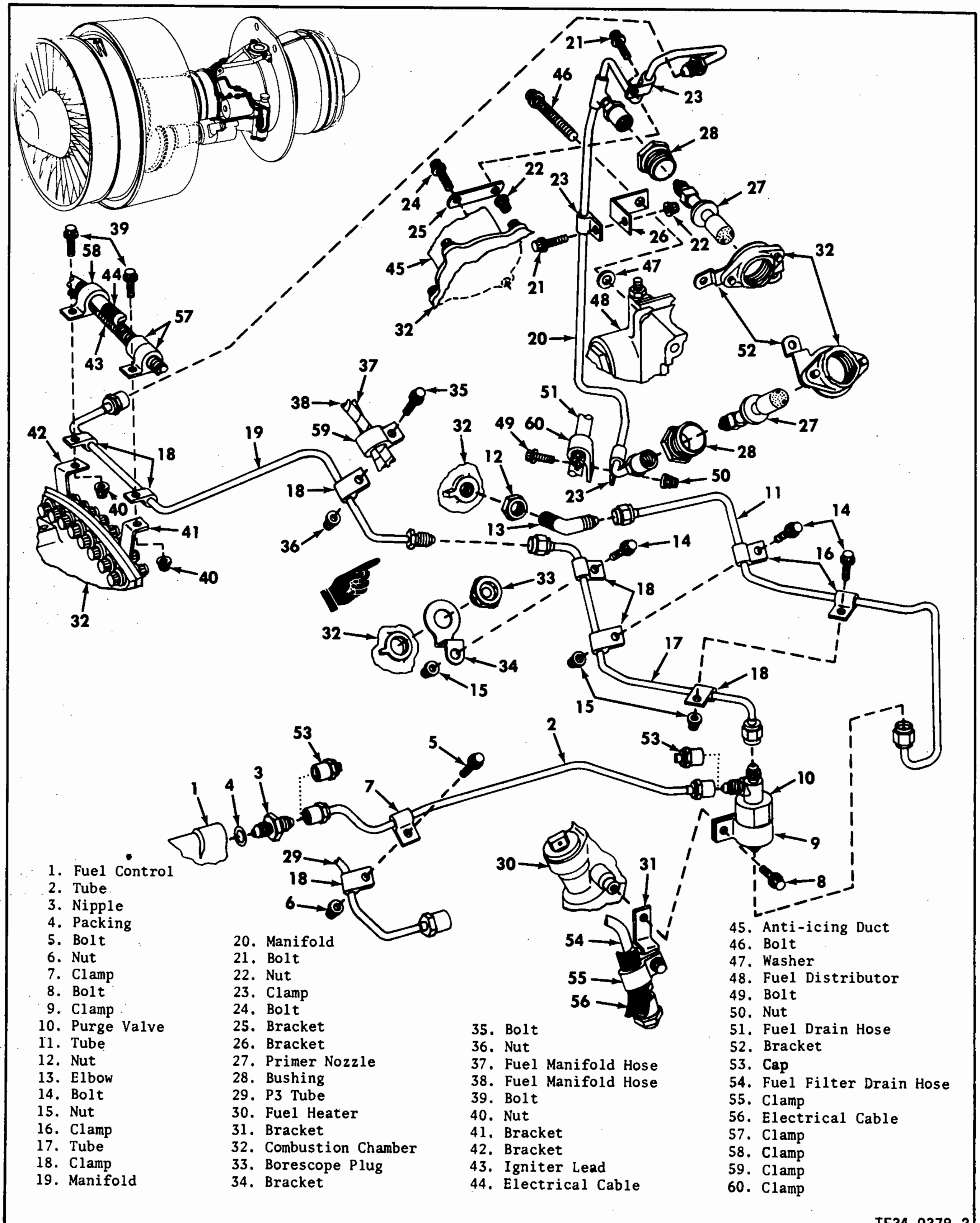


Figure 4-16A. Primer Nozzle System Components

2. Install 2 bushings (28) over primer nozzles and thread into combustion chamber. Hold primer nozzle with a wrench and torque bushings to 200-220 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

3. If removed, assemble packing (4) on nipple (3). Assemble nipple to fuel control (1) and torque it to 90-100 lb in.

4. Install nut (12) on elbow (13). Thread elbow into port in combustion chamber at the 9 o'clock position. Have elbow pointing aft, leave handtight.

5. Assemble clamp (9) onto purge valve (10). Install purge valve to boss on fuel heater (30) with bolt (8). Be sure to put bracket (31) on fuel filter drain tube (53), under clamp (9) on purge valve (10). Torque bolt (8) to 38-42 lb in., and lock-wire, double strand method using 0.032 inch lockwire.

6. Assemble tube (2) between fuel control (1) and purge valve (10) as follows:

a. Assemble clamp (7) to forward end of tube (2).

b. Assemble tube (end with sharp bend) to fuel control and other end to purge valve, handtight. The tube (2) will go behind fuel filter drain tube (53) and over top of P3 tube (29) to the left of the tee then under the tee portion of tube (29).

c. Attach clamp (7) to clamp (18) on P3 tube (29) with bolt (5) and nut (6). Torque bolt to 38-42 lb in.

d. Torque both fittings on tube (2) to 90-100 lb in.

7. Assemble tube (17) as follows:

a. Assemble 3 clamps (18) to tube.

b. Attach 1 end of tube to purge valve (10) at uppermost fitting, handtight.

c. Secure the clamp furthest away from valve to bracket (34) on borescope port (32) with bolt (14) and nut (15). Torque bolt to 38-42 lb in.

8. Assemble tube (11) between valve (10) and elbow (13) on combustion chamber as follows:

a. Assemble 2 clamps (16) to tube.

b. Connect hooked end of tube (11) to lower fitting on purge valve (10) and other end to elbow (13) on combustion chamber, handtight.

c. Connect 2 clamps (16) to 2 clamps (18) on tube (17) with bolts (14) and nuts (15). Torque bolts to 38-42 lb in.

d. Torque fittings on tube (11) and nut (12) on elbow (13) to 90-100 lb in.

9. Assemble manifold (19) as follows:

a. Assemble 3 clamps (18) to manifold (19).

b. Connect male end of tube (19) to tube (17), handtight.

c. Assemble 2 clamps (18) to brackets (41, 42) on forward combustion flange. Put clamps under clamps (56, 57) on igniter lead (43) and green electrical cable (44). Install bolts (39) and nuts (40) and torque them to 38-42 lb in.

d. Connect clamp (58) on 2 fuel manifold hoses (37, 38) to clamp (18) on manifold (19) with bolt (35) and nut (36). Torque bolt to 38-42 lb in.

10. Assemble manifold (20) as follows:

a. Assemble 3 clamps (23) to manifold (20), 1 in the middle and 1 at each end.

b. Assemble manifold (20) to 2 primer nozzles (27) and to manifold (19). Make fittings handtight.

c. At the 2 o' clock position, connect 1 clamp (23) to bracket (25) (on anti-icing discharge duct (45)) with bolt (21) and nut (22). Torque bolt to 38-42 lb in.

d. At the 3 o'clock position, connect 1 clamp (23) to bracket (26) on fuel distributor (48) with bolt (21) and nut (22). Torque bolt to 38-42 lb in.

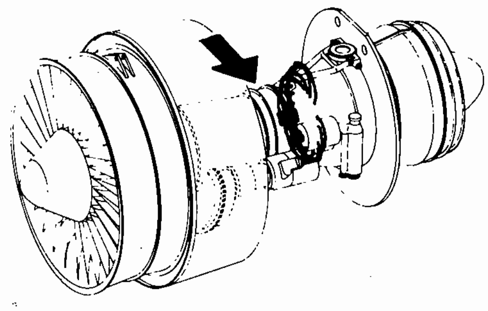
e. At the 4 o'clock position, connect clamp (23) to clamp (59) on fuel distributor drain hose (51) with bolt (49) and nut (50). Torque bolt to 38-42 lb in.

f. Torque fittings on manifold (20) at 2 primer nozzles (27) and at manifold (19) to 90-100 lb in. Torque fitting between manifold (19) and tube (17) to 90-100 lb in.

4-101. REMOVAL OF FUEL MANIFOLD.

1. Remove fuel manifold in reverse order of paragraph 4-102. Before removing hoses, identify each one by putting the number of the fuel tube to which hose connects, on a piece of masking tape and wrap it around the hose.

4-102. INSTALLATION OF FUEL MANIFOLD. Use figure 4-17 to install the fuel manifold.



READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE INSTALLING THE FUEL MANIFOLD:

1. INSTALL THE HOSES IN THE ORDER OF THE NUMBER SHOWN IN THE UPPER LEFT-HAND CORNER OF EACH BLOCK. CONNECT END OF HOSE WITH ARROW STAMPED ON IT TO DISTRIBUTOR BLOCK.
2. THE HOSE AND CLAMPS BEING INSTALLED IN EACH STEP ARE INDICATED BY AN ⬅
3. HOSES INSTALLED IN PREVIOUS STEPS, ARE SHADED WITH

CAUTION

USE 2 WRENCHES WHEN TIGHTENING EACH HOSE AT THE FUEL TUBE.

4. TORQUE BOTH ENDS OF EACH HOSE TO 90-100 LB. IN. AT TIME OF INSTALLATION. IF TIGHTENING IS LEFT UNTIL ALL HOSES ARE INSTALLED, IT IS DIFFICULT TO PUT THE WRENCH ON SOME FITTINGS.
5. LOCK-WIRE ALL MANIFOLD FITTINGS AT BOTH ENDS USING 0.032 INCH LOCKWIRE, DOUBLE-STRAND METHOD.

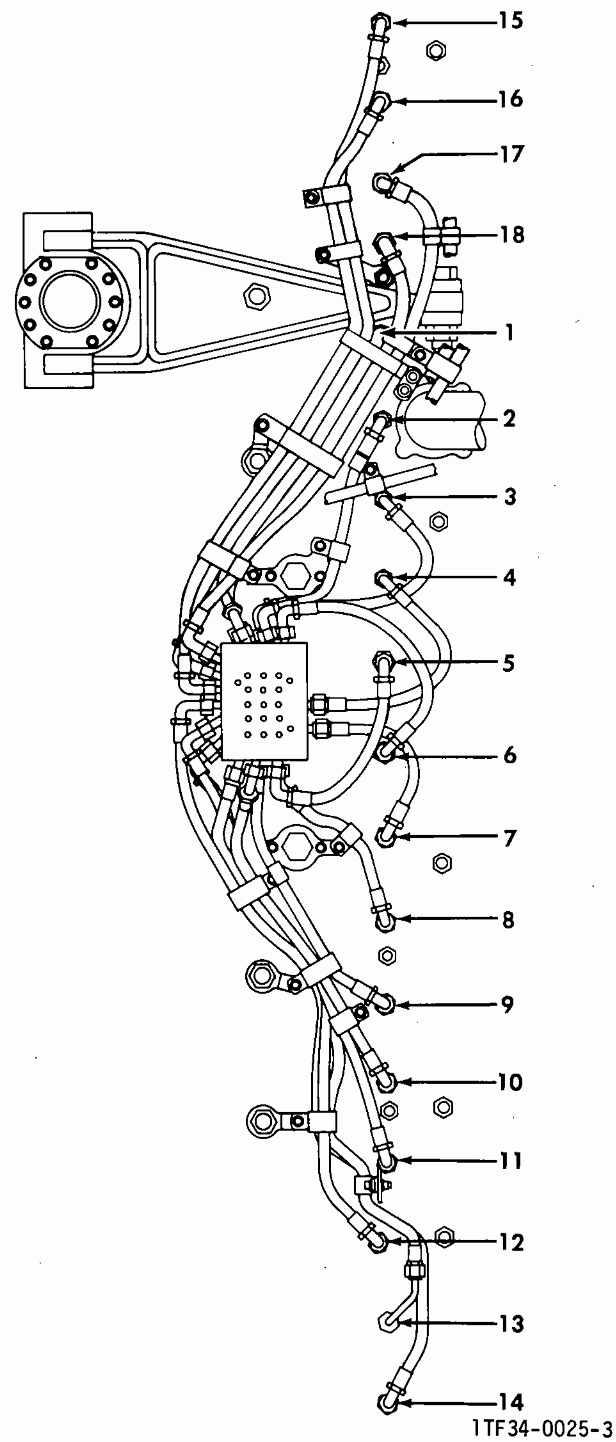


Figure 4-17. Fuel Manifold Installation (Sheet 1 of 6)

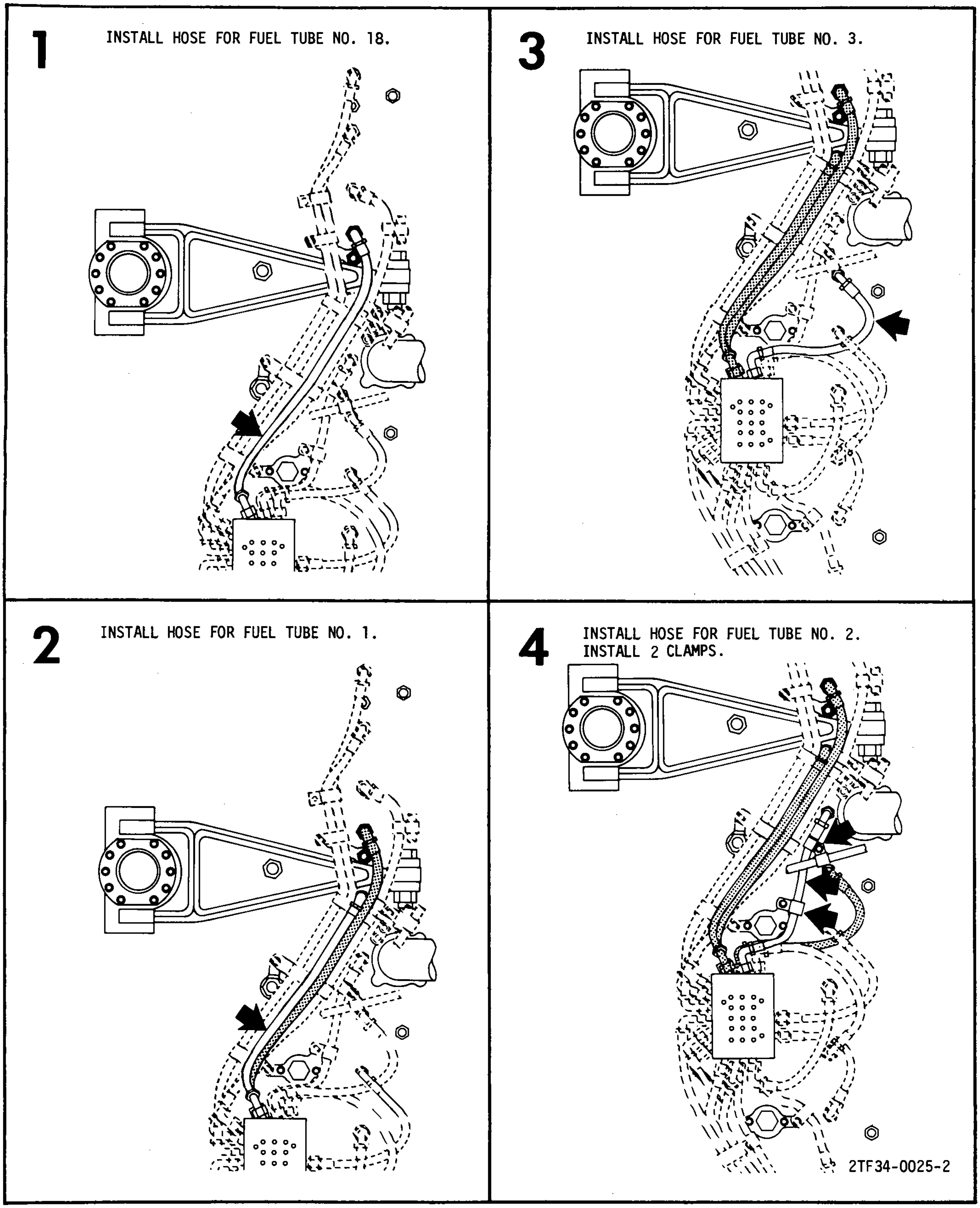


Figure 4-17. Fuel Manifold Installation (Sheet 2 of 6)

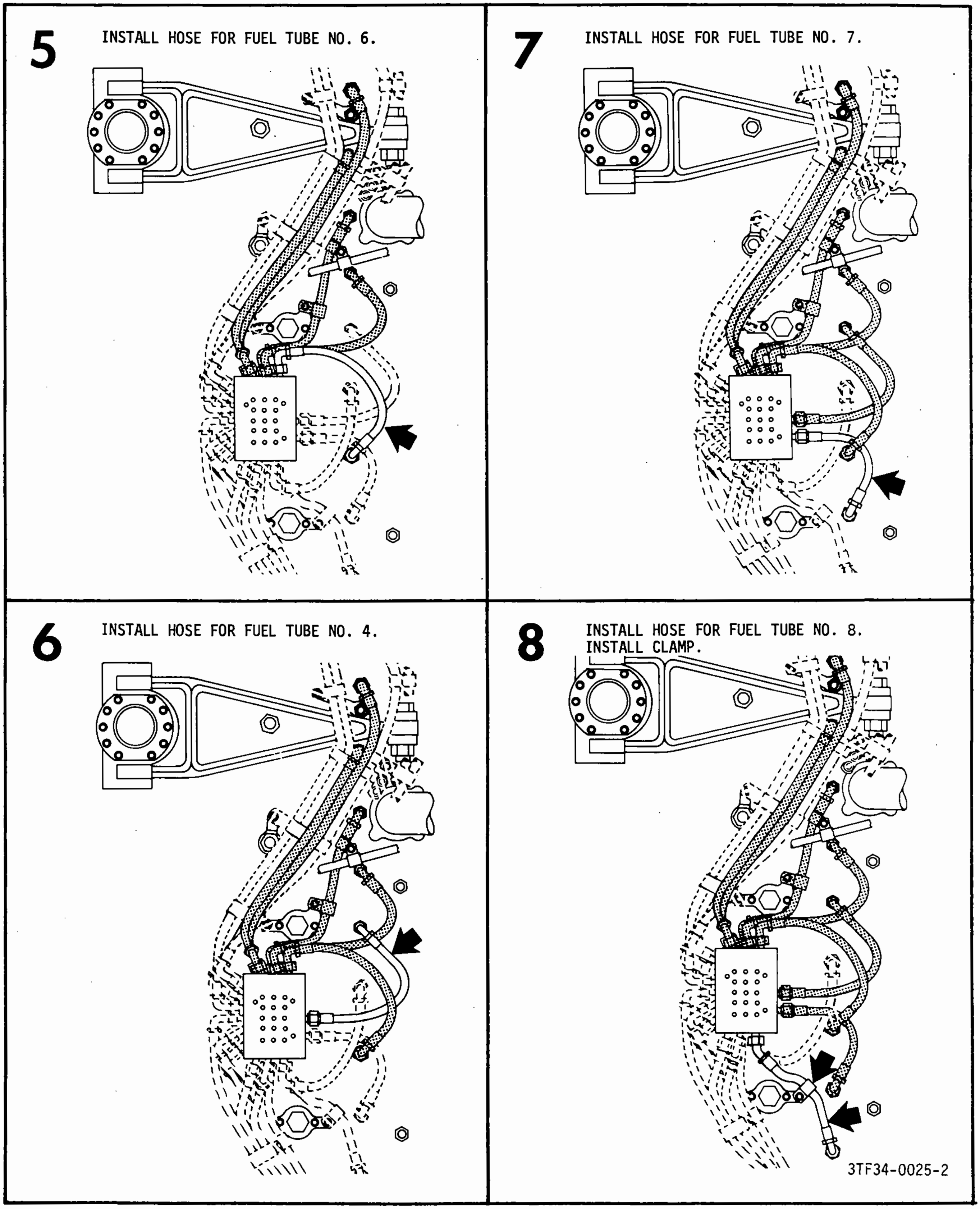


Figure 4-17. Fuel Manifold Installation (Sheet 3 of 6)

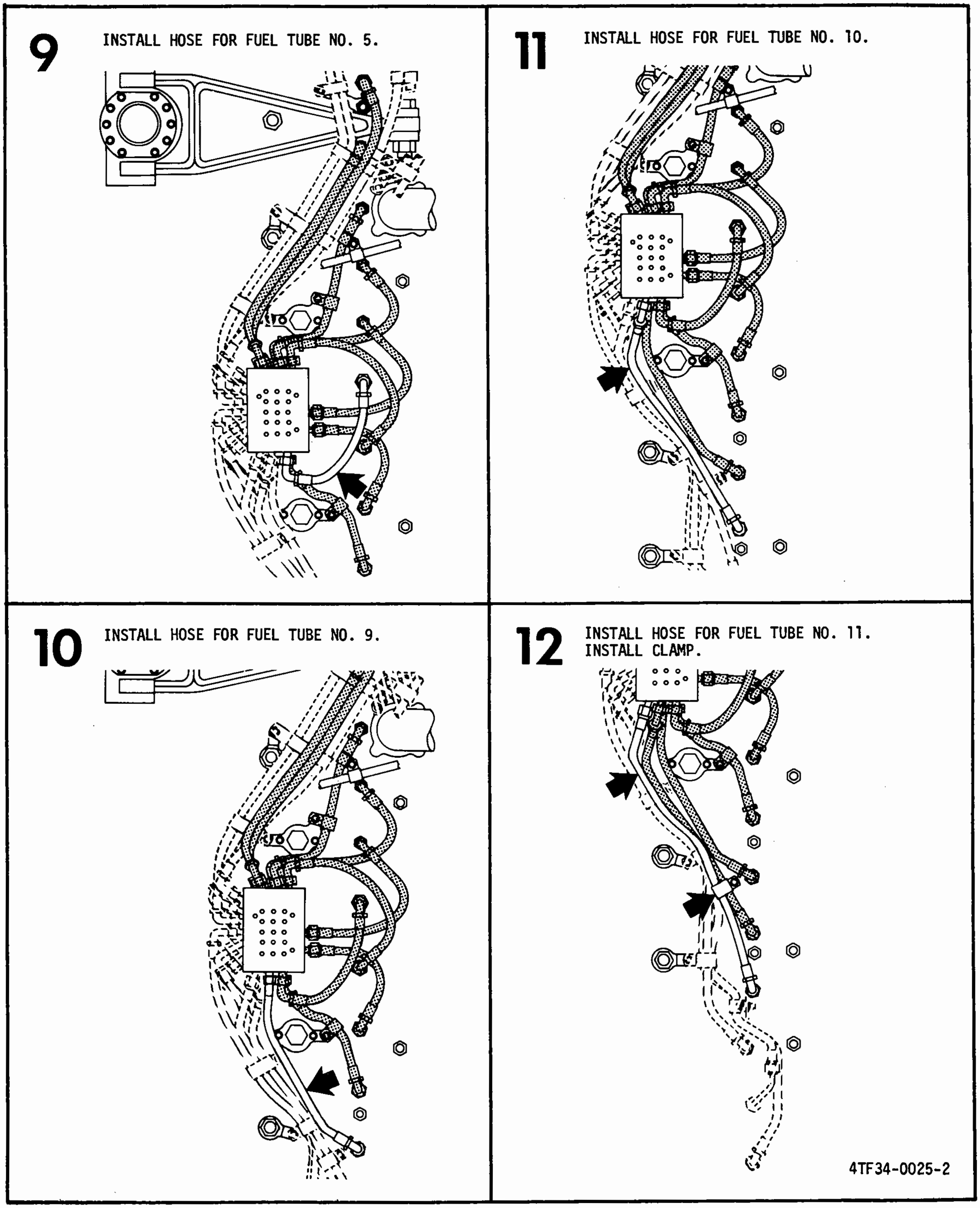


Figure 4-17. Fuel Manifold Installation (Sheet 4 of 6)

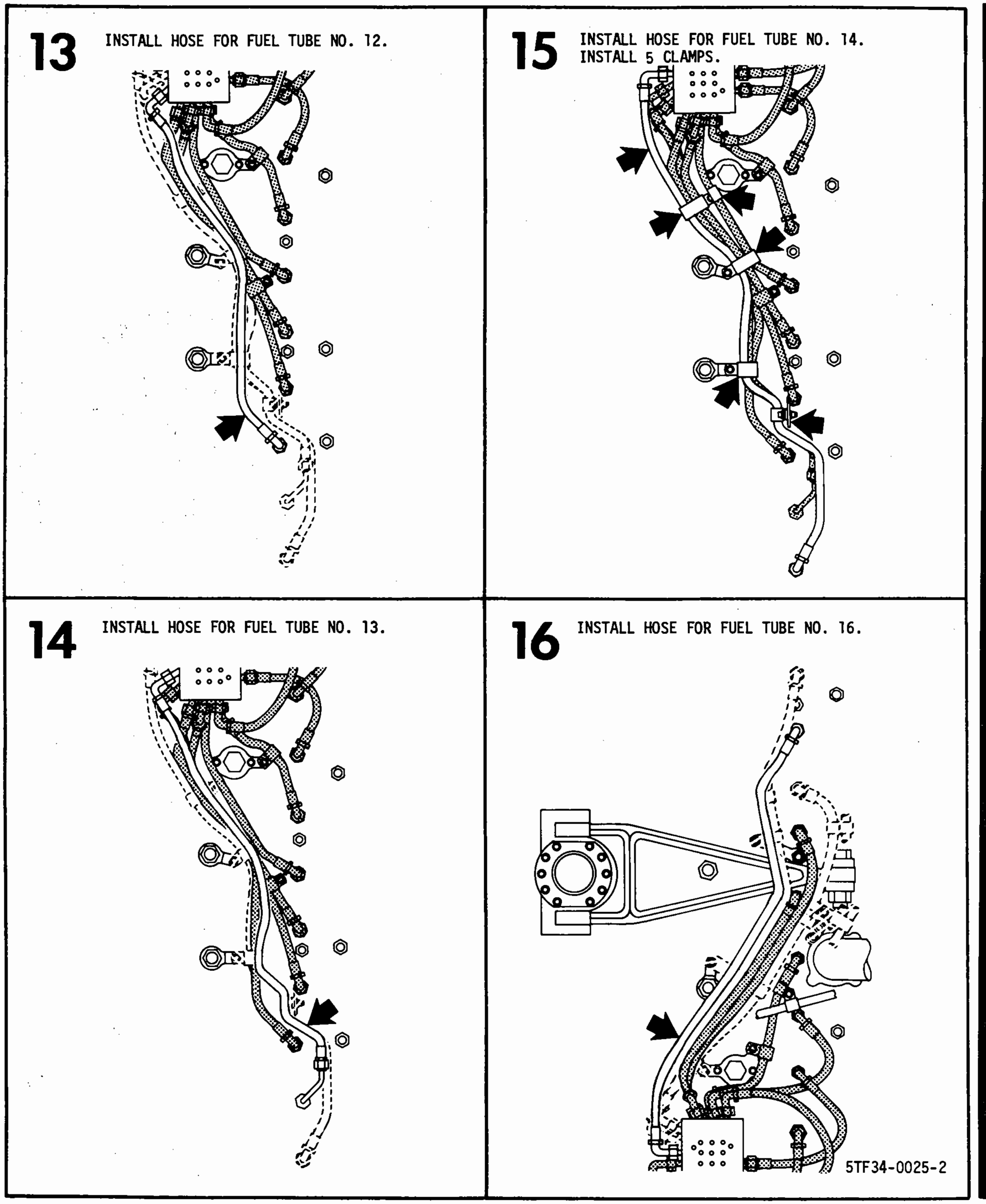


Figure 4-17. Fuel Manifold Installation (Sheet 5 of 6)

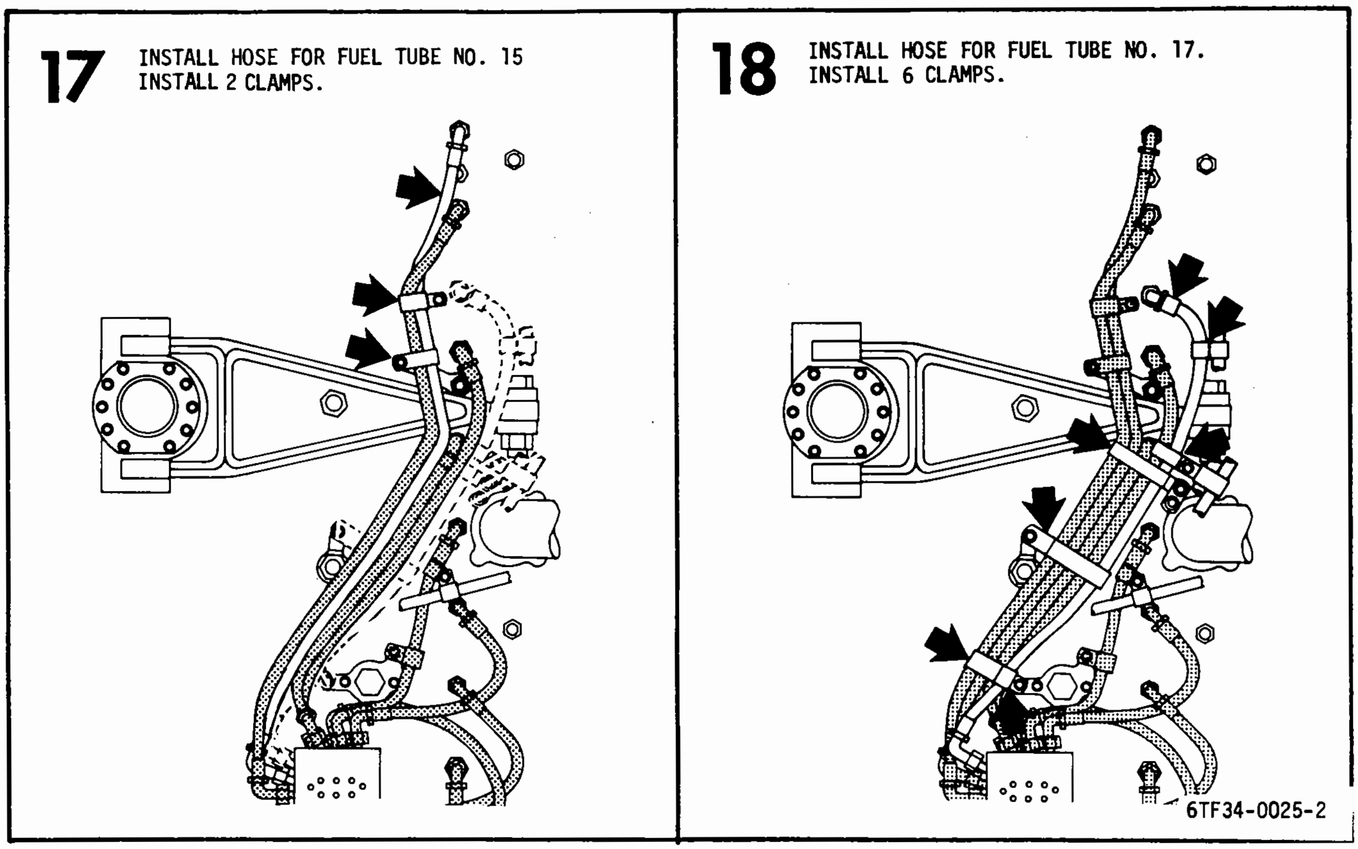


Figure 4-17. Fuel Manifold Installation (Sheet 6 of 6)

4-102A. REPLACEMENT OF FUEL TUBES. (See figure 4-17A.)

1. Remove lockwire from fuel manifold hose and from fuel tube bushing.

2. Remove fuel manifold hose from fuel tube.

3. Remove bushing holding fuel tube to combustion chamber, and remove fuel tube.

CAUTION

It is very important that these marks are exactly in-line with the key and keyway, to insure that the fuel tube is inside the opening of the swirl cup in the combustion liner.

4. Using Dykem or equivalent non-carbon, non-permanent marker, place a mark on the combustion chamber port in-line with keyway in the port. See figure 4-17A.

5. Place a mark on the new fuel tube, near the threaded end, in-line with key. See figure 4-17A.

6. Carefully insert the new fuel tube into port of combustion chamber. Slowly insert the fuel tube until the seating surfaces are touching and the key and keyway are engaged. If any resistance is encountered before seating surfaces are mated, do not force the tube any further. Back out and start again. When seating surfaces are touching, hold fuel tube in place and install bushing.

CAUTION

After torquing bushing, be sure that Dykem marks are still aligned. If not, remove fuel tube and reinstall.

7. Torque bushing to 160-180 lb in. Check Dykem marks for alignment. Remove and reinstall fuel tube, if required.

8. Lock-wire bushing, double-strand method, using 0.032 inch lockwire.

9. Assemble fuel manifold hose, and torque it to 90-100 lb in. Lock-wire manifold B-nuts to the bushing, using 0.032 inch lockwire, double-strand method.

4-103. REMOVAL AND INSTALLATION OF ACTUATOR SYSTEM FUEL LINES.

4-104. REMOVAL OF ACTUATOR SYSTEM FUEL LINES.

Note

- Drain the fuel lines into a suitable container.
- Discard all packings and backup washers.

1. Disconnect clamps (6, 7, figure 4-18) from clamp on scavenge hose (32) and from bracket (5).

2. Disconnect and remove hoses (3, 4) at fuel control (33) and at tubes (14, 15).

3. Disconnect clamps (7, 16) on tubes (14, 15) from brackets (17, 18) on accessory gearbox.

4. Disconnect and remove tubes (14, 15) from hoses (19, 20).

5. Disconnect 4 clamps (6) on hose (20) and 4 clamps (7) on hose (19).

6. Disconnect and remove hoses (19, 20) from actuators (24).

7. If necessary, remove the following parts from actuators (1):

   a. Left-hand actuator:

      (1) Jamnuts (11, 22).

      (2) Elbows (10, 21).

      (3) Packings (9, 13).

      (4) Backup washers (12, 23).

   b. Right-hand actuator:

      (1) Nipple (8).

      (2) Packing (9).

      (3) Jamnut (11).

      (4) Elbow (10).

      (5) Packing (13).

      (6) Backup washer (12).

8. If necessary, remove the following parts from fuel control (33):

   a. Nipple (25).

   b. Packing (9).

   c. Elbow (26).

   d. Jamnut (11).

   e. Packing (13).

   f. Backup washer (12).

9. Cap all ports in actuators with metal plugs.

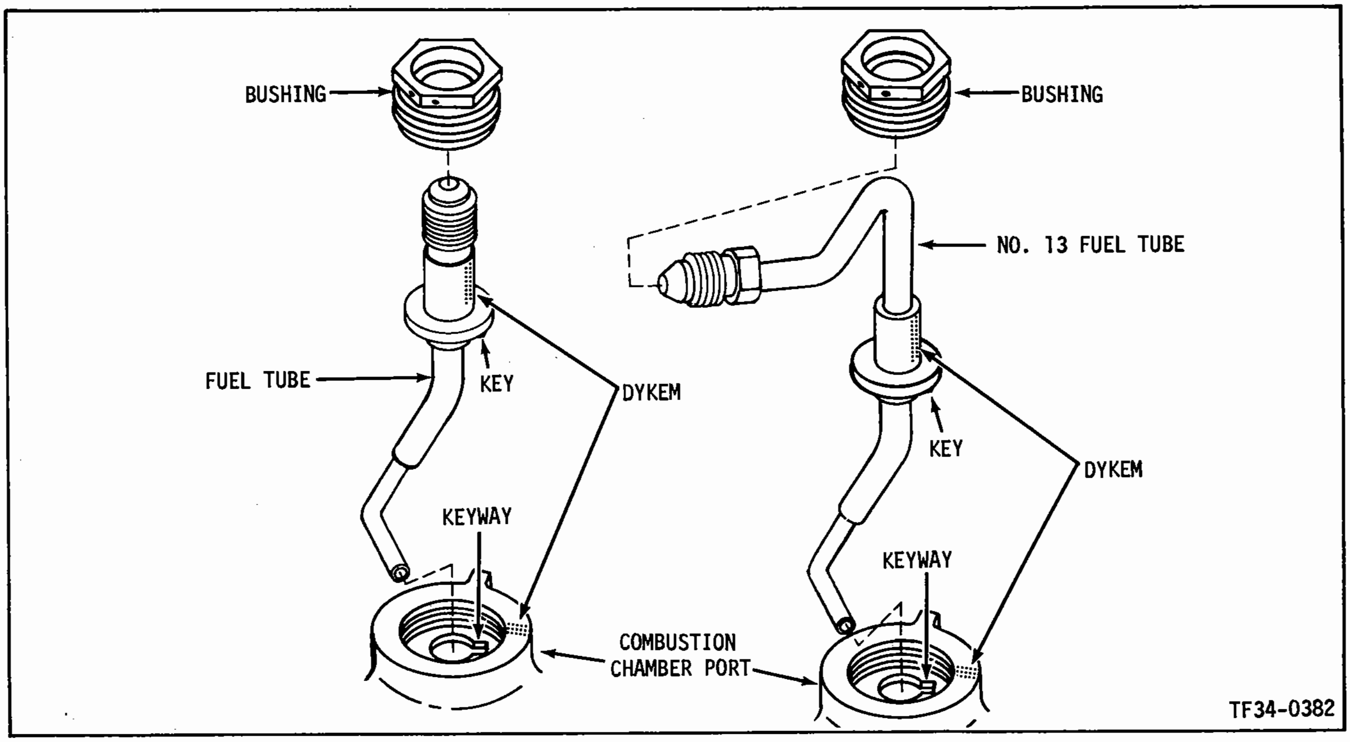


Figure 4-17A. Fuel Tube Installation

4-105. INSTALLATION OF ACTUATOR SYSTEM FUEL LINES.

Lubricate all packings with fuel.

1. If fittings on actuators (24, figure 4-18) were removed, install as follows:

a. Assemble jamnut (22), backup washer (23), and packing (9) onto elbow (21).

b. Thread elbow (21) into head port on left-hand actuator. Do not torque jamnut (22).

c. Assemble jamnuts (11), backup washers (12), and packings (13) to elbows (10).

d. Thread elbows (10) into rod ports on left-hand and right-hand actuators. Do not torque jamnuts.

e. Assemble packing (9) to nipple (8).

f. Thread nipple (8) into head port on right-hand actuator and torque to 155-175 lb in.

2. If fittings on fuel control were removed, install them per paragraph 4-88.

3. Assemble hose (19) to head port fittings on actuators, handtight.

4. Assemble hose (20) to rod port fittings on actuators, handtight.

5. Assemble tube (14) to tee on hose (19), handtight.

6. Assemble tube (15) to tee on hose (20), handtight.

7. Connect clamp (7) on tube (14) to bracket (17) on accessory gearbox (31), using bolt (1) and nut (2). Torque bolt to 38-42 lb in.

8. Connect clamp (16) on tube (15) to bracket (18) using bolt (1) and nut (2). Torque bolt to 38-42 lb in.

9. Hold elbow (21) on left-hand actuator (24) with a wrench and torque jamnut (22) to 155-175 lb in. Torque coupling nuts on hose (19) to 180-200 lb in.

10. Hold elbows (10) on both actuators with a wrench and torque jamnuts (11) to 180-200 lb in. Torque coupling nuts on hose (20) to 270-300 lb in.

11. Torque coupling nut of tube (14) to 180-200 lb in.

12. Torque coupling nut of tube (15) to 270-300 lb in.

13. Assemble hoses (3, 4) to tubes (14, 15) and to fittings on fuel control (33). Torque coupling nuts of hose (3) to 270-300 lb in.

14. Hold elbow (26) with a wrench and torque jamnut (11) to 155-175 lb in. Torque coupling nuts on hose (4) to 180-200 lb in.

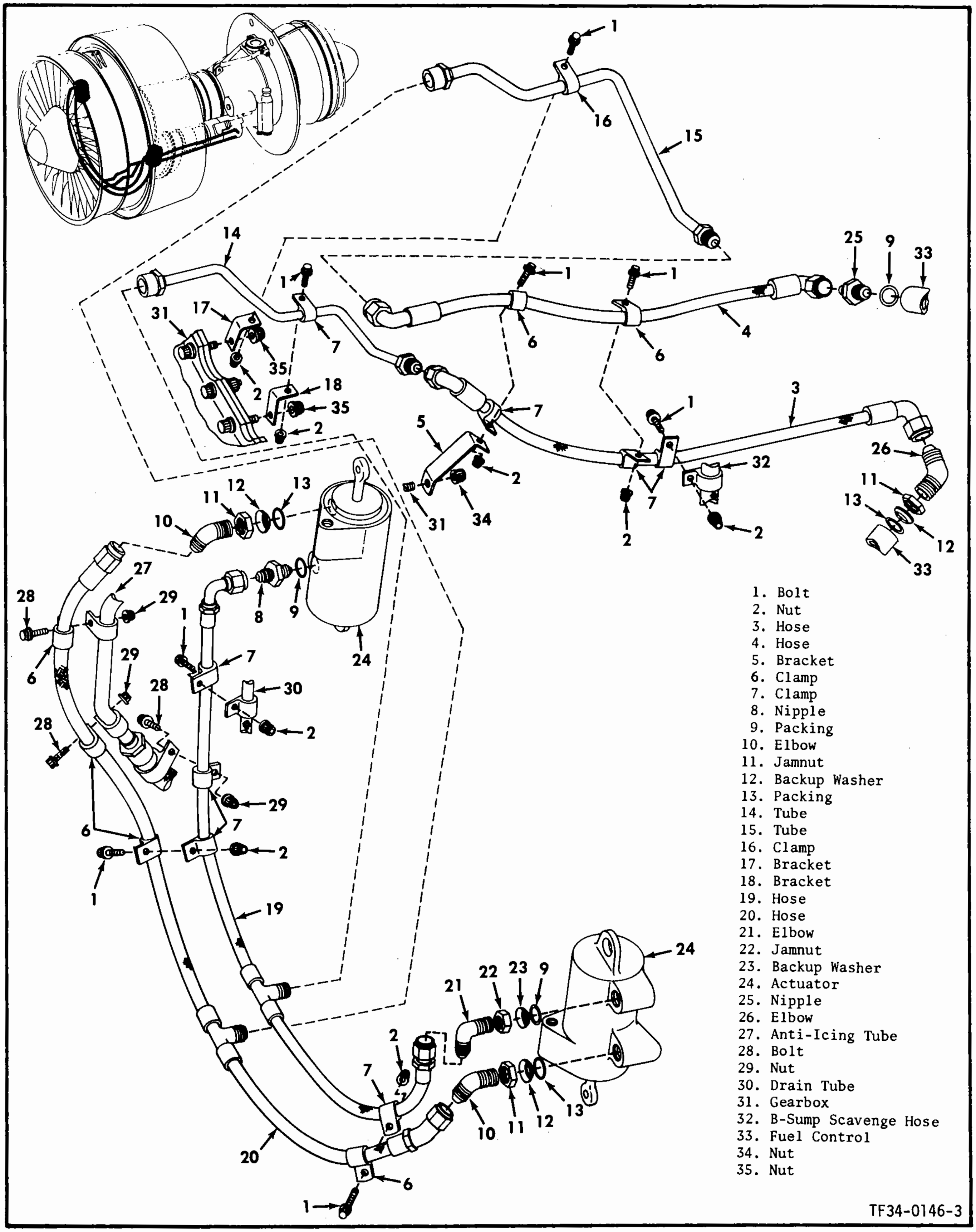


Figure 4-18. Actuating System Components

15. Assemble and connect the following clamps, using bolts (1) and nuts (2). Torque all bolts to 38-42 lb in.

a. Two clamps (6) on hose (20) to 2 clamps on anti-icing tube (27).

b. One clamp (7) on hose (19) to 1 clamp on actuator drain tube (30).

c. One clamp (7) on hose (19) to 1 clamp on anti-icing tube (27).

d. Two clamps (6) on hose (20) to 2 clamps (7) on hose (19).

e. One clamp (6) on hose (4) and 1 clamp (7) on hose (3) to bracket (5) on accessory gearbox.

f. One clamp (6) on hose (4) to 1 clamp (7) on hose (3).

g. One clamp (7) on hose (3) to 1 clamp on B-sump forward scavenge hose (32).

4-106. REMOVAL AND INSTALLATION OF T2 SENSOR.

4-107. REMOVAL OF T2 SENSOR, SENSOR HOSES, AND FITTINGS.

Note

Drain the fuel lines into a suitable container.

1. Remove fan panel (22, figure 4-19).

2. Disconnect clamps (3, 4) from T2 sensor hoses (5, 6).

3. Loosen fittings of hoses (5, 6) at fuel control (19) and at T2 sensor (7) and remove hoses.

4. Remove lockwire and 4 screws (8) holding T2 sensor (7) to No. 6 fan panel (22); remove sensor.

5. If necessary, remove the following parts from fuel control (19), as follows:

a. Loosen jamnut (10) and remove elbow (9). Discard packing (12) and backup washer (11).

b. Loosen jamnut (14) and remove elbow (13). Discard packing (16) and backup washer (15).

4-108. INSTALLATION OF T2 SENSOR, SENSOR HOSES, AND FITTINGS.

Note

Lubricate packings with fuel.

1. If the following fittings were removed, attach them to fuel control (19, figure 4-19):

a. Elbow (9) with jamnut (10), backup washer (11), and packing (12). Do not torque jamnut.

b. Elbow (13) with jamnut (14), backup washer (15), and packing (16). Do not torque jamnut.

2. Lubricate 4 screws (8) with Versilube Plus. Assemble T2 sensor (7) to No. 6 fan panel (22) at about the 7 o'clock position, using 4 screws (8). Torque screws to 20-25 lb in.

3. Assemble hoses (5, 6) to fittings on fuel control and on T2 sensor, handtight.

4. If jamnut (10) is loose, hold elbow (9) with a wrench and torque jamnut to 135-150 lb in. Torque coupling nuts on both ends of hose (5) to 135-150 lb in.

5. If jamnut (14) is loose, hold elbow (13) with a wrench and torque jamnut to 155-175 lb in. Torque coupling nuts on both ends of hose (6) to 180-200 lb in.

6. Assemble clamps as follows, using 6 bolts (1) and 6 nuts (2):

a. Assemble 6 clamps (3) to hose (5).

b. Assemble 4 clamps (4) to hose (6).

c. Connect 1 clamp (3) to clamp on electrical cables (20, 21).

d. Connect 1 clamp (3) to clamp on electrical cable (21).

e. Connect 2 clamps (3) to 2 clamps (4).

f. Connect 1 clamp (3) to clamp (4) and to clamp on fuel hose (18).

g. Connect 1 clamp (3) with 1 clamp (4) to bracket (17) on accessory gearbox.

h. Torque all clamp bolts to 38-42 lb in.

4-108A. REMOVAL OF FUEL FILTER.

1. Remove cap (42, figure 4-21) from end of fuel filter drain tube and drain residual fuel into a suitable container. Reinstall cap and torque it to 135-150 lb in. and lock-wire, double strand method, using 0.032 inch lockwire.

2. Remove lockwire and filter bowl (2, figure 4-18A). Remove filter and discard packings. Clean filter per paragraph 4-109.

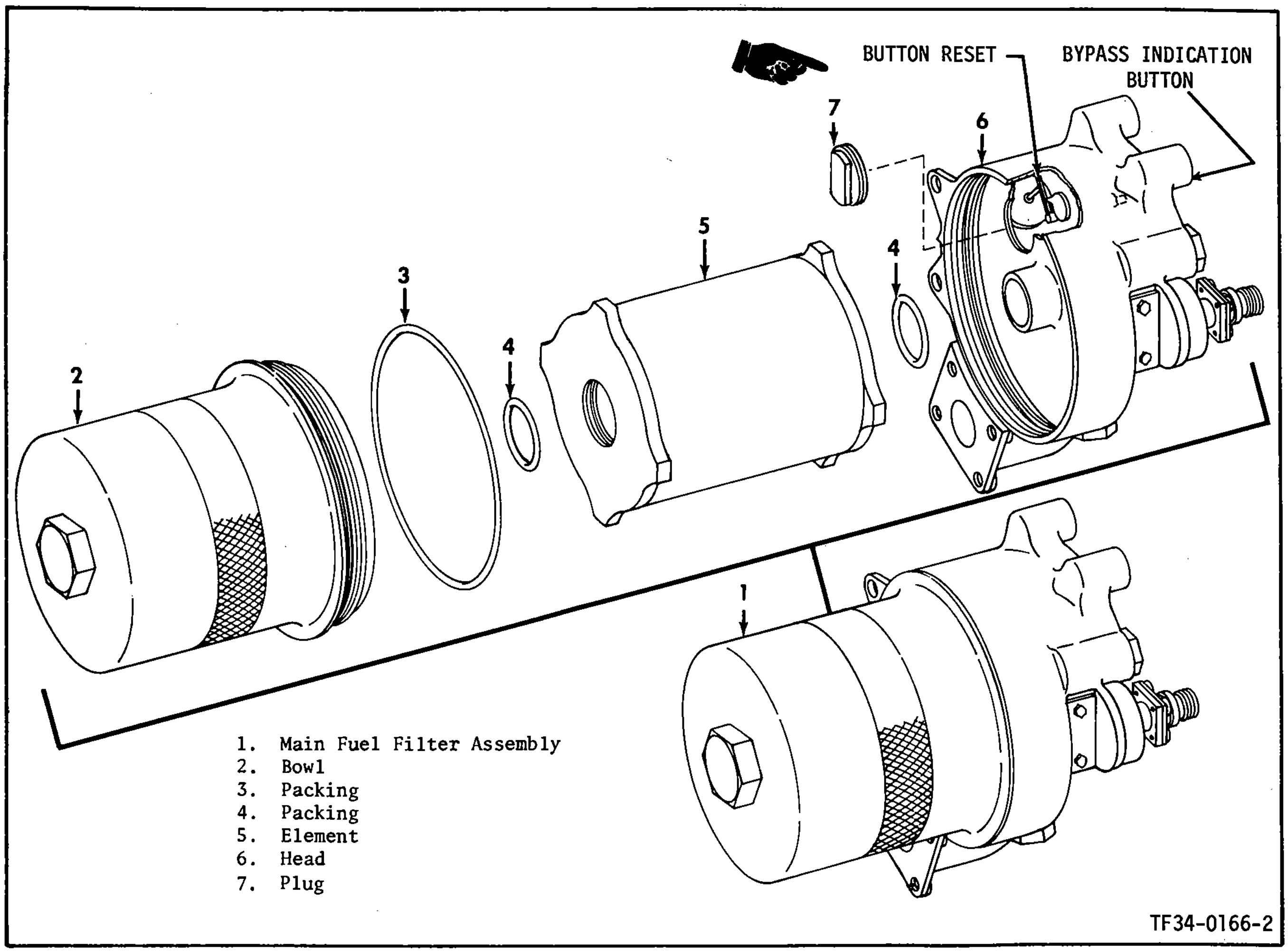


Figure 4-18A. Fuel Filter Components

4-109. CLEANING OF MAIN FUEL FILTER.

CAUTION

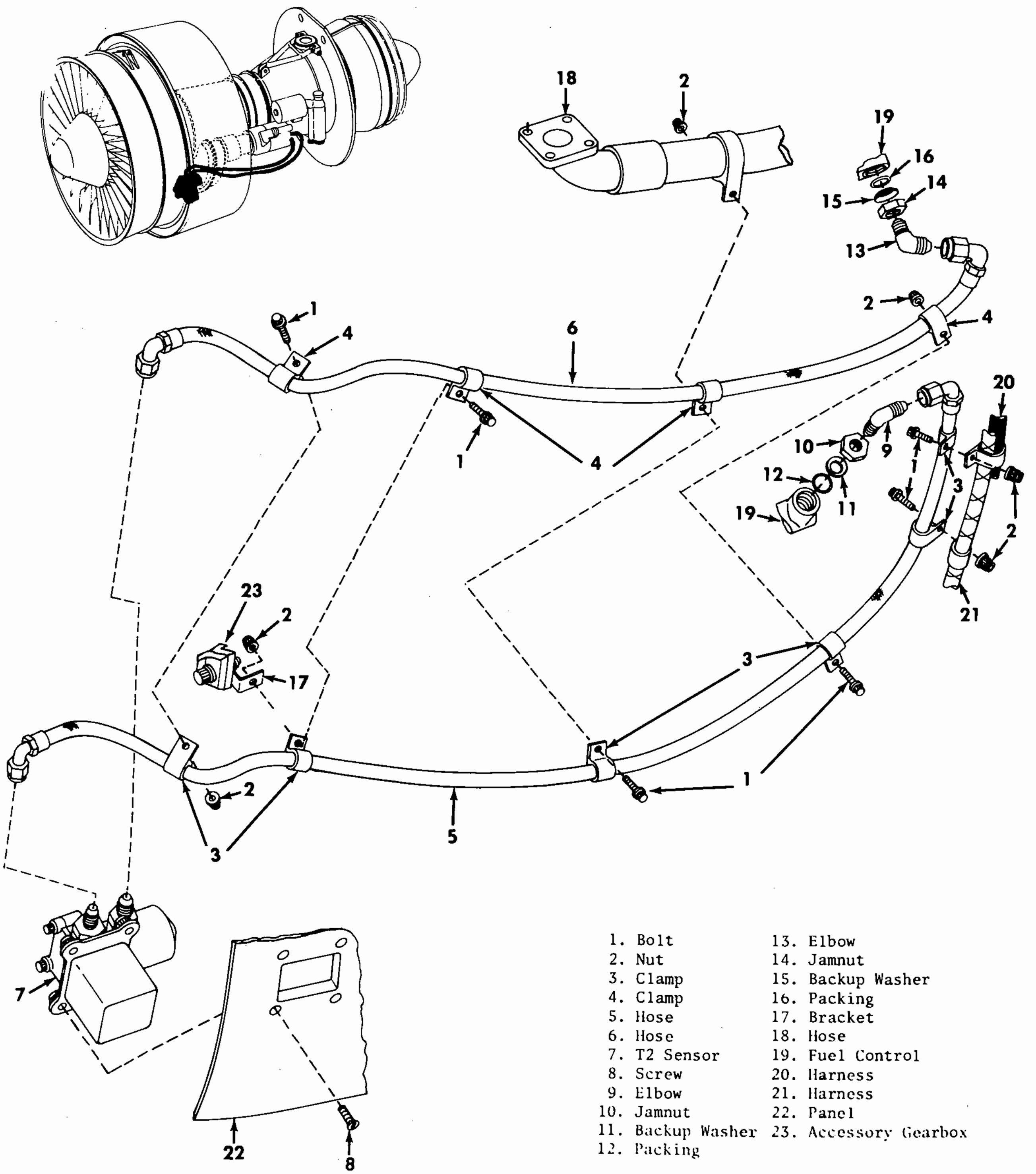
Do not use plastic plugs when cleaning the filter in trichloroethylene (O-T-634) or solvent (P-D-680). Do not use aluminum plugs when cleaning with Oakite. Plastic plugs can only be used when cleaning with Oakite.

1. Use No. 14 aluminum or plastic caps and cap off both ends of fuel filter.

WARNING

Trichloroethylene
Fed Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is injurious to the lungs.



1. Bolt	13. Elbow
2. Nut	14. Jamnut
3. Clamp	15. Backup Washer
4. Clamp	16. Packing
5. Hose	17. Bracket
6. Hose	18. Hose
7. T2 Sensor	19. Fuel Control
8. Screw	20. Harness
9. Elbow	21. Harness
10. Jamnut	22. Panel
11. Backup Washer	23. Accessory Gearbox
12. Packing	

Figure 4-19. T2 Sensing System Components

WARNING

Trichloroethylene
Fed Spec O-T-634

- Use only with adequate ventilation.
- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers.

Dry Cleaning Solvent
Fed Spec P-D-680

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Use only with adequate ventilation.
- Do not smoke when using it.
- Avoid prolonged or repeated breathing of vapors.
- Use protective creams and wear aprons, goggles or face shield to protect the skin.
- Store in approved metal safety containers.

2. Slosh the filter around for 3-5 minutes in one of the following solutions observing warnings and caution above:

a. Oakite - 6 ounces of Oakite to each gallon of water.

b. Trichloroethylene O-T-634.

c. Dry cleaning solvent P-D-680.

3. If filter element is heavily caked with contamination, use a tongue depressor (or equivalent) and run it down between pleats of element until heavy contamination is removed.

4. While sloshing the element in one of above solutions, brush the element with a stiff bristle brush (like a bottle brush). Repeat until element looks clean.

5. Remove one plug from element and drain solution. Dry filter by blowing filtered compressed air into the open end of filter. Remove second plug.

6. Insert a small bright light into the filter opening. Inspect for cleanliness by placing the light against the inside of pleats and looking from outside for contamination. Repeat steps 4 and 5, if necessary, until element is completely clean.

7. If salt crystals are present after drying the filter, brush filter in warm water and air dry as in step 5.

8. Before installing filter element, flush filter bowl with warm water to remove contamination.

4-109A. INSTALLATION OF FUEL FILTER. Lubricate packings with fuel.

1. Install 2 packings (4, figure 4-18A), into filter element (5).

2. If necessary, reset bypass indication button by removing cap (7) in filter head and pushing the lever towards engine centerline, push in red button at same time. Reinstall cap.

3. Install element into filter assembly head (6).

Note

Install lockwire in hole of filter bowl before it is threaded all the way into filter head.

4. Assemble packing (3) onto filter bowl (2) and assemble filter bowl to head of filter assembly.

5. Torque filter bowl to 200-250 lb in., and lockwire, double-strand method, using 0.032 inch lockwire.

4-110. REMOVAL AND INSTALLATION OF DRAIN SYSTEM HOSES AND TUBING.

4-111. REMOVAL AND INSTALLATION OF ACTUATOR DRAIN HOSES.

4-112. REMOVAL OF ACTUATOR DRAIN HOSES AND FITTINGS.

Note

- Drain the fuel lines into a suitable container.
- Discard all packings.

1. Disconnect hose (15, figure 4-20) from nipple (13) on drain strut and from tee (9).

2. Remove clamp (12) from hose (15) and remove hose.

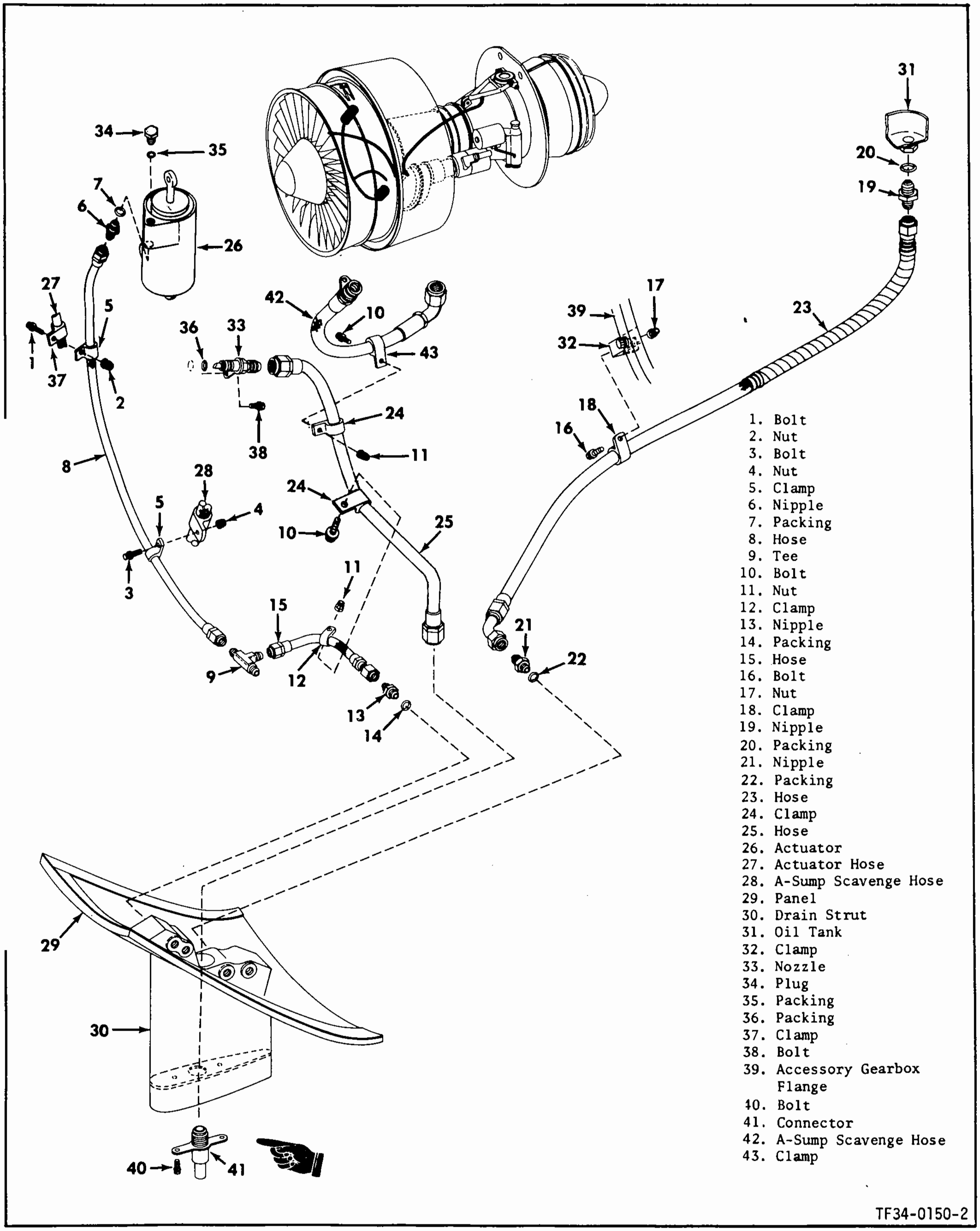


Figure 4-20. Drain System Components - Right Side

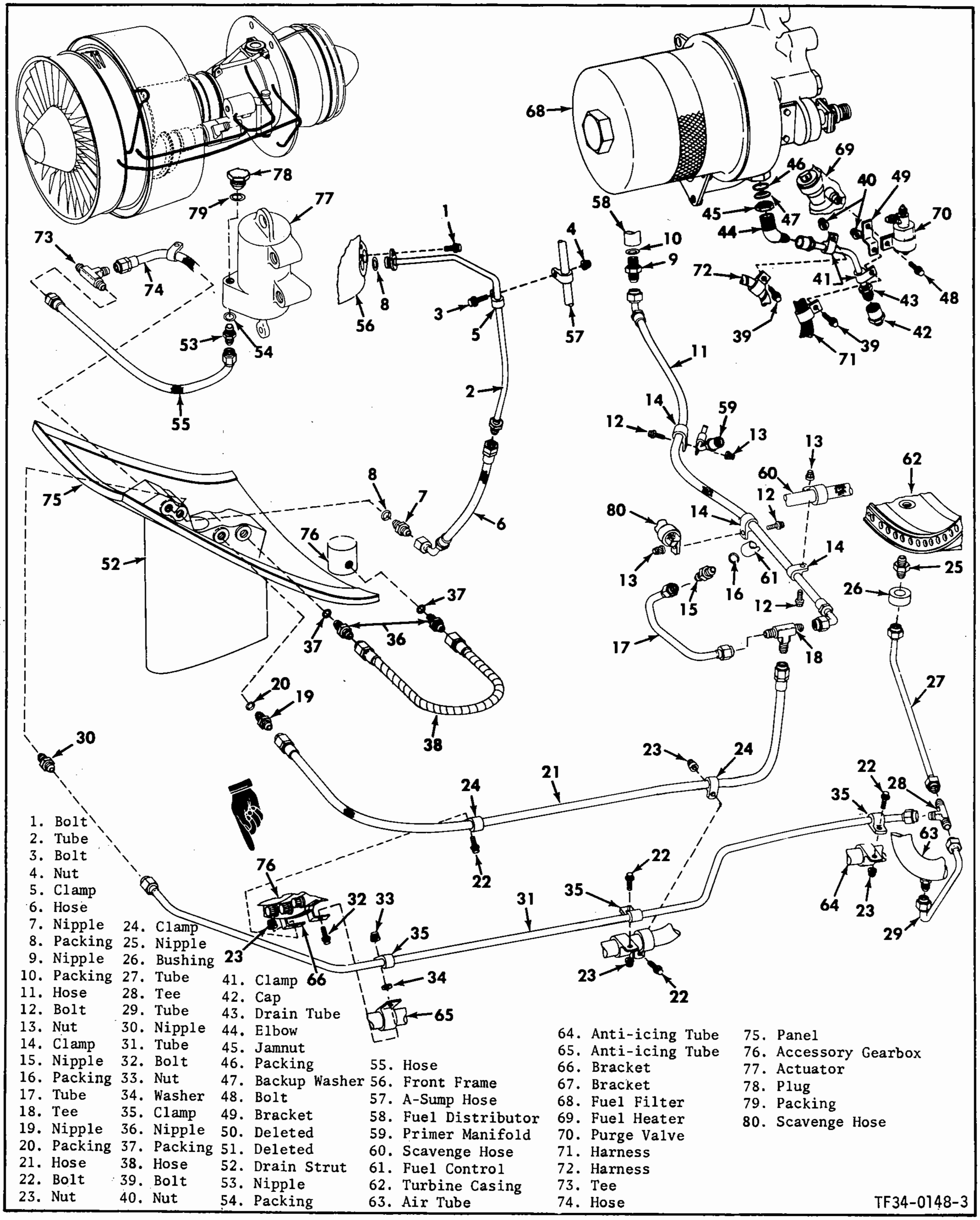


Figure 4-21. Drain System Components - Left Side

3. Disconnect hose (8) from right-hand actuator and from tee (9).

4. Remove 2 clamps (5) from hose (8) and remove hose.

5. Disconnect and remove hose (55, figure 4-21) from tee (73) and from actuator.

6. If necessary, remove nipples (6, figure 4-20) and packing (7) and nipple (53, figure 4-21) and packing (54) from actuators and nipple (13, figure 4-20) and packing (5) from strut.

4-113. INSTALLATION OF ACTUATOR DRAIN HOSES AND FITTINGS.

Lubricate packings with fuel.

1. If the following fittings were removed, attach them as follows:

a. Assemble 2 packings (7, figure 4-20) and (54, figure 4-21) to 2 nipples (53) and (6, figure 4-20) and assemble nipples to actuator. Torque nipples to 900-100 lb in.

b. Assemble packing (14) to nipple (13) and assemble it to strut (30). Torque nipple to 135-150 lb in.

2. Assemble hose (8) to drain fitting on right-hand actuator, and torque coupling nut to 40-65 lb in.

3. Assemble hose (55, figure 4-21) to drain fitting on left-hand actuator, and torque coupling nut to 40-65 lb in.

4. Assemble tee (73) between 2 hoses (55) and (8, figure 4-20) leaving coupling nuts handtight.

5. Assemble hose (15) to forwardmost fitting on right-hand side of strut (aft looking forward). Torque coupling nut to 40-65 lb in.

6. Assemble other end of hose (15) to tee (9). Hold tee with a wrench and torque coupling nuts of 3 hoses (8, 15) and (55, figure 4-21) to 40-65 lb in.

7. Attach clamps, torquing all bolts to 38-42 lb in. by assembling:

a. One clamp (12, figure 4-20) on hose (15) to 1 clamp (24) on water wash hose (25), using bolt (10) and nut (11).

b. One clamp (5) on hose (8) to 1 clamp on A-sump scavenge hose (28), using bolt (3) and nut (4).

c. One clamp (5) on hose (8) to 1 clamp (37) on actuator hose (27), using bolt (1) and nut (2).

4-114. REMOVAL AND INSTALLATION OF OIL TANK SCUPPER HOSE.

4-115. REMOVAL OF OIL TANK SCUPPER HOSE.

Discard all packings and backup washers.

1. Disconnect clamp (18, figure 4-20) from bracket (32) on accessory gearbox.

2. Disconnect coupling nuts of hose (23) from oil tank (31) and from nipple (21) and remove hose.

3. If necessary, remove nipple (21) and packing (22) from drain strut.

4. If necessary, remove nipple (19) and packing (20) from oil tank (31).

4-116. INSTALLATION OF OIL TANK SCUPPER HOSE.

Lubricate packings with engine oil.

1. If necessary, install fittings as follows:

a. Assemble packing (20, figure 4-20) onto nipple (19) and assemble nipple to oil tank (31). Torque nipple to 180-200 lb in.

b. Assemble packing (22) to nipple (21). Assemble nipple to drain strut, and torque it to 180-200 lb in.

2. Assemble hose (23) to fittings on oil tank (31) and drain strut. Torque coupling nuts of hose to 75-125 lb in.

3. Connect clamp (18) to bracket (32) on accessory gearbox (39), using bolt (16) and nut (17). Torque bolt to 38-42 lb in.

4-117. REMOVAL AND INSTALLATION OF FUEL FILTER DRAIN TUBE.

4-118. REMOVAL OF FUEL FILTER DRAIN TUBE.

Discard packing and backup washer.

1. Disconnect clamps (41, figure 4-21) from clamps on electrical cables (71, 72).

2. Remove tube (43) from elbow (44) on fuel filter (68).

3. If necessary, remove cap (42) from end of tube (43) and remove jamnut (45), elbow (44), packing (46) and backup washer (47) from fuel filter (68).

4-119. INSTALLATION OF FUEL FILTER DRAIN TUBE.

Lubricate packing with engine oil.

1. If fitting was removed, assemble it to fuel filter (68, figure 4-21) as follows:

a. Assemble jamnut (45), backup washer (47), and packing (46) to elbow (44).

b. Assemble elbow to fuel filter (68), leaving jamnut loose.

2. Assemble fuel filter drain tube (43) to elbow (44) on fuel filter.

3. Hold elbow (44) with a wrench and torque jamnut (45) to 135-150 lb in. Torque coupling nut of tube (43) to 135-150 lb in.

4. Assemble cap (42) to end of tube (43) and torque cap to 135-150 lb in.

5. Attach 2 clamps (41), 1 to clamp on electrical cable (72) and 1 to clamp on bracket (49), with electrical cable (71) using bolts (39) and nuts (40). Torque bolts to 38-42 lb in.

4-120. REMOVAL AND INSTALLATION OF FRONT FRAME DRAIN SYSTEM LINES.

4-121. REMOVAL OF FRONT FRAME DRAIN SYSTEM LINES.

Discard all packings.

1. Disconnect and remove hose (6, figure 4-21) from nipple (7) and from tube (2).

2. Remove lockwire and bolt (1) holding tube (2) to front frame; remove tube and discard packing (8).

3. If necessary, remove nipple (7) and packing (8) from drain strut.

4-122. INSTALLATION OF FRONT FRAME DRAIN LINES.

Lubricate packings with engine oil.

1. If nipple (7, figure 4-21) was removed from drain strut (52), install packing (8) onto nipple. Torque it to 135-150 lb in.

2. Assemble packing (8) to tube (2) and install tube into boss on front frame (56), using bolt (1). Torque bolt to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

3. Assemble hose (6) to nipple (7) on drain strut and to tube (2). Torque coupling nuts to 40-65 lb in.

4. Assemble clamp (5) to tube (2). Connect clamp to clamp on A-sump-to-gearbox hose (57), using bolt (3) and nut (4). Torque bolt to 38-42 lb in.

4-123. REMOVAL AND INSTALLATION OF ACCESSORY DRIVE GEARBOX DRAIN HOSE.

4-124. REMOVAL OF ACCESSORY DRIVE GEARBOX DRAIN HOSE.

Discard all packings.

1. Disconnect and remove hose (38, figure 4-21) from nipples (36) on accessory gearbox (76) and drain strut (52).

2. If necessary, remove 2 nipples (36) and 2 packings (37), 1 from accessory gearbox, and 1 from drain strut.

4-125. INSTALLATION OF ACCESSORY DRIVE GEARBOX DRAIN HOSE.

Lubricate packings with engine oil.

1. If removed, install 2 packings (37, figure 4-21) onto 2 nipples (36). Install 1 nipple into accessory gearbox (76) and 1 nipple into drain strut (52). Torque both nipples to 135-150 lb in.

2. Assemble hose (38) to nipples (36) and torque coupling nuts to 40-65 lb in.

4-126. REMOVAL AND INSTALLATION OF FUEL HEATER-HIGH-PRESSURE TURBINE DRAIN TUBES.

4-127. REMOVAL OF FUEL HEATER-HIGH-PRESSURE TURBINE DRAIN TUBES.

1. Disconnect 3 clamps (35, figure 4-21) on tube (31).

2. Disconnect tube (31) from tee (28) and from nipple (30) on drain strut (52); remove tube.

3. Disconnect and remove fuel heater drain tube (29) from tee (28) and from fuel heater air inlet tube (63).

4. Disconnect and remove high-pressure turbine drain tube (27) from turbine casing. Remove tee (28) from tube (27).

5. If necessary, remove the following fittings:

a. Remove nipple (30) from drain strut (52).

b. Remove nipple (25) from turbine casing (62).

4-128. INSTALLATION OF FUEL HEATER-HIGH-PRESSURE TURBINE DRAIN TUBES.

1. If fittings were removed, install them as follows:

a. Assemble nipple (30, figure 4-21) to drain strut (52). Torque it to 135-150 lb in.

b. Assemble nipple (25) to high-pressure turbine casing (62) and torque it to 90-100 lb in.

2. Assemble high-pressure turbine drain tube (27) to fitting on high-pressure turbine casing. Leave coupling nut loose.

3. Assemble tee (28) to other end of tube (27). Leave coupling nut loose.

4. Assemble fuel heater drain tube (29) to tee (28) and to fuel heater air inlet tube (63). Leave coupling nuts loose.

5. Assemble drain tube (31) to tee (28) and to nipple (30) on drain strut (52). Torque coupling nut at drain strut to 135-150 lb in.

6. Hold tee (28) with a wrench and torque all coupling nuts at tee to 90-100 lb in. Torque coupling nuts at turbine casing (62) and air inlet tube (63) to 90-100 lb in.

7. Attach clamps, using bolts (22) and nuts (23), as follows:

a. Attach 1 clamp (35) on tube (31), together with washer (34), 1 clamp on tube (65) to bracket (67) on accessory drive gearbox (76).

b. Attach 1 clamp (35) on tube (31) to 1 clamp (24) on hose (21).

c. Attach 1 clamp (35) on tube (31) to 1 clamp on anti-icing tube (64).

d. Torque all bolts to 38-42 lb in.

4-129. REMOVAL AND INSTALLATION OF FUEL CONTROL - FUEL DISTRIBUTOR DRAIN LINES.

4-130. REMOVAL OF FUEL CONTROL - FUEL DISTRIBUTOR DRAIN LINES.

Discard all packings.

1. Disconnect 3 clamps (24, figure 4-21) on drain hose (21).

2. Disconnect and remove hose (21) from tee (18) and from drain strut (52).

3. Disconnect tube (17) from tee (18) and from nipple (15) on fuel control (61).

4. Disconnect 2 clamps (14) on hose (11).

5. Disconnect hose (11) from nipple (9) on fuel distributor (58) and remove hose. Remove tee (18) from hose (11).

6. If necessary, remove fittings as follows:

a. Remove nipple (19) and packing (20) from drain strut (52).

b. Remove nipple (15) and packing (16) from fuel control (61).

c. Remove nipple (9) and packing (10) from fuel distributor (58).

4-131. INSTALLATION OF FUEL CONTROL - FUEL DISTRIBUTOR DRAIN LINES.

Lubricate packings with fuel.

1. If fittings were removed, install them as follows:

a. Assemble packing (10, figure 4-21) to nipple (9) and assemble nipple to fuel distributor (58). Torque nipple to 135-150 lb in.

b. Assemble packing (16) to nipple (15) and assemble nipple to fuel control (61). Torque nipple to 135-150 lb in.

c. Assemble packing (20) to nipple (19) and assemble nipple to drain strut (52). Torque nipple to 135-150 lb in.

2. Assemble hose (11) to fuel distributor nipple (9) and torque coupling nut to 40-65 lb in.

3. Assemble tee (18) to other end of hose (11). Leave coupling nut loose.

4. Assemble tube (17) to fuel control nipple (15) and to tee (18). Torque coupling nut at fuel control to 135-150 lb in. Leave coupling nut at tee loose.

5. Assemble hose (21) to tee (18) and to nipple (19). Hold tee with a wrench and torque 2 hoses to 40-65 lb in. Torque tube to 135-150 lb in. Torque hose at drain strut to 40-65 lb in.

6. Connect 2 clamps (14) on hose (11), 1 clamp to clamp on primer manifold (59) and 1 clamp to clamp on C-sump aft scavenge hose (60), using bolts (12) and nuts (13). Torque bolts to 38-42 lb in.

7. Connect 1 clamp (24) on hose (21) to 1 clamp (35) on tube (31), using bolt (22) and nut (23). Connect the forwardmost clamp to bracket (66) on accessory gearbox flange (38). Connect 1 clamp (24) to clamp on anti-icing tube (64) with bolt (22) and nut (23). Torque bolts to 38-42 lb in.

4-132. ADJUSTMENT OF ACTUATORS AND VARIABLE GEOMETRY VANE ANGLES. For special tools, see table 2-1, group 4.

1. Remove actuators from engine.

2. Using gage (21C5086), retract actuator rod ends to full-closed position. Measure dimension A as shown in figure 4-22. Dimension A must be 6.311 ±0.006 inches for each actuator. Adjust rod length if necessary. Torque jamnuts to 60-65 lb in. Lock-wire jamnuts using 0.032 inch lockwire.

3. Reassemble actuators to bellcranks.

4. Disconnect actuator hoses from fuel control. Use tester (64A128J1) and retract actuator pistons (vanes should be fully closed).

5. Use gage (21C5032) and measure closed vane angles for each stage, IGV through stage 5. See table 4-2 for angles and table 4-1 for vane angle measuring locations.

Note

When adjusting angles, always turn turnbuckles so that reading on gage (angle) is increasing (vane lever arms will be moving away from center position). If angles are beyond limits of table 4-2, return angles well inside limit and then turn turnbuckles to the desired settings. This reduces the backlash in the linkage. Also, adjust turnbuckles on both sides of engine, alternating from side to side, in small increments. If this is not done, and one side is adjusted to desired setting before the other side is touched, the adjustment of the second side will throw the first side out of limits. After angles are set to desired readings, open and close the vanes 3 to 5 times and recheck angles. Readjust if angles are out of limits.

6. Adjust angles as follows:

a. Remove lockwire from turnbuckles of each stage to be adjusted and loosen jamnuts.

b. Adjust closed position angles, as outlined in note above, one stage at a time, starting with IGV's, using gage (21C5032).

c. Tighten jamnuts on turnbuckles after each stage if set to desired closed-position angle.

d. Actuate the system from closed to open position, 3 to 5 times, using tester (64A128J1).

e. Recheck closed vane angle readings, using gage (21C5032). Reset if necessary.

f. Actuate the system to the open position (actuator piston rod fully extended), using tester (64A128J1).

g. Use gage (21C5032) and measure open-position angles of variable vanes. Angles must be within the limits of table 4-2. See table 4-1 for location of vanes to be measured. If all open-position readings are within limits, lock-wire jamnuts, double-strand method, using 0.020 inch lockwire.

TABLE 4-1.
VANE ANGLE MEASURING LOCATIONS.

No. 1 vane is at compressor splitline (9 o'clock position) top half. Vanes are numbered in a clockwise direction.

STAGE	VANE NUMBER			
IGV	5	12	21	31
1	3	14	26	37
2	7	17	31	45
3	8	20	37	54
4	8	22	41	60
5	9	23	42	62

TABLE 4-2.
VARIABLE VANE ANGLES.

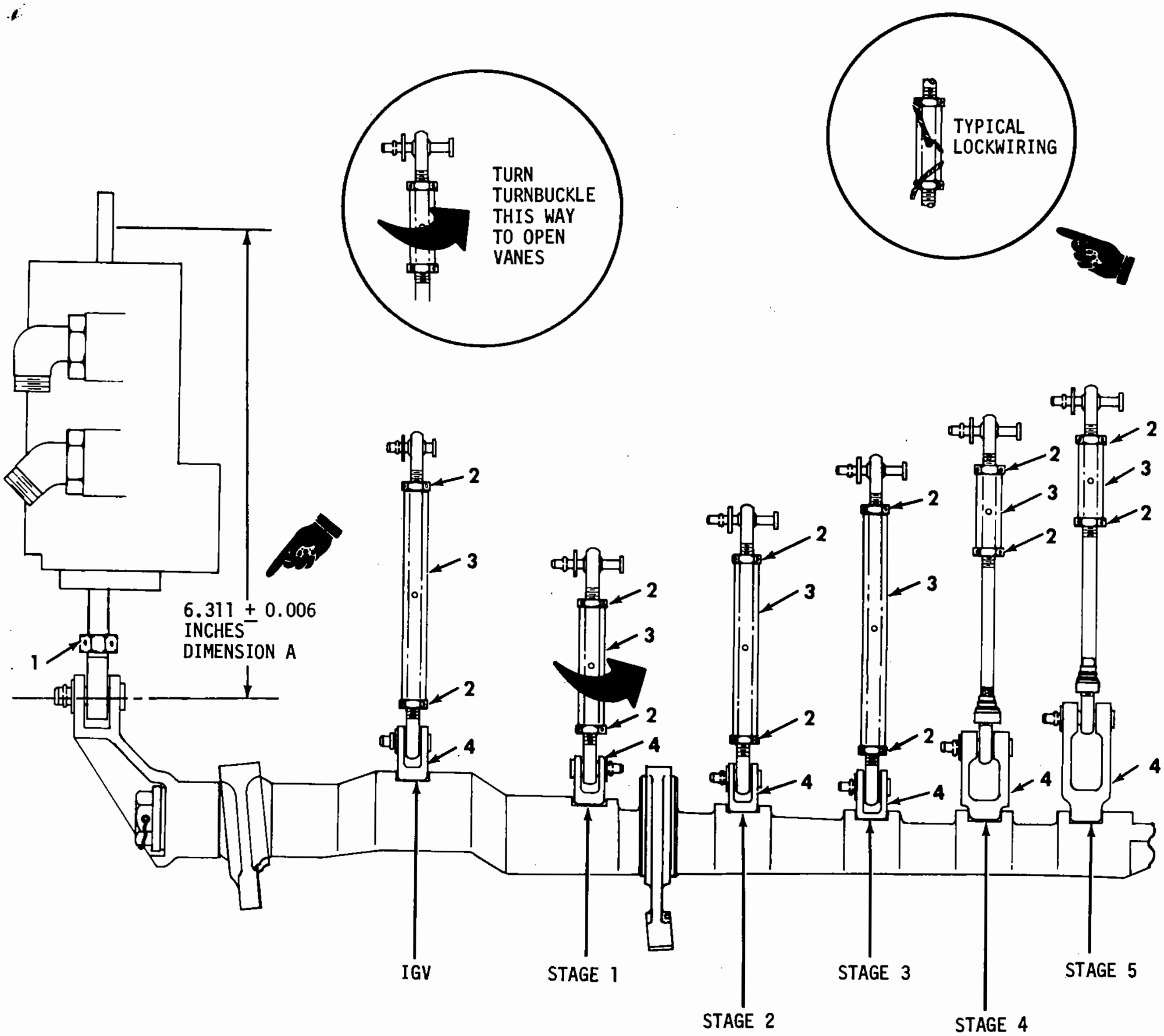
All readings for each position must be within 1° of each other.

STAGE NO.	CLOSED ANGLE	OPENED ANGLE
IGV	25° 49'±20'	34° 09'±1° 15'
1	18° 39'±20'	20° 37'±1° 15'
2	14° 52'±20'	18° 47'±1° 15'
3	19° 45'±20'	17° 18'±1° 15'
4	12° 55'±20'	15° 47'±2°
5	21° 51'±20'	10° 36'±2°

4-133. RIGGING OF VARIABLE GEOMETRY FEEDBACK CABLE.

1. Disconnect actuator lines at fuel control and connect tester (64A128J1) to lines.

2. Use tester (64A128J1) and retract actuator pistons to the fully closed position.



NOTE:
ACTUATOR PISTON
EXTENDED - VARIABLE
VANES OPEN

1. Actuator Rod Length Adjustment Stop Nut
2. Check Nut
3. Turnbuckle
4. Clevis

TF34-0118-1

Figure 4-22. Variable Geometry Linkage Adjustment

4. After completing all inspection and repair, pressure-flush the part with trichloroethylene solvent in both directions. Cap all inlets and outlets immediately after flushing.

5-87. REPAIR OF TUBING DEFECTS.

1. Blend minor indications as follows:

a. Use a fine abrasive stone, a small file, abrasive cloth, or a crocus cloth for blending.

b. Blend a cylindrically shaped part around its circumference. The finished blend shall be as close as is practical to the original finish of the part.

2. The correct blending of surface defects is necessary because it lessens the possibility of stress concentration at these points.

5-88. TORN LOCKWIRE HOLE REPAIR. (See figure 5-38.)

1. Choose same drill size for new lockwire holes.

2. Blind hole fittings (caps, plugs, etc.) shall be redrilled for lockwire not closer than 1/2 the drill diameter and parallel to the wrenching flat. Locate hole midway on flat thickness.

NOTE

Redrilled lockwire holes must not pass closer to any inner cavity than 1/2 the drill diameter.

3. Through-hole fittings (unions, connectors, etc.) shall be redrilled for lockwire across the hexagon corners. Locate hole to provide at least one drill diameter wall thickness to corner and positioned midway of flat thickness.

4. Deburr holes to remove sharp edges.

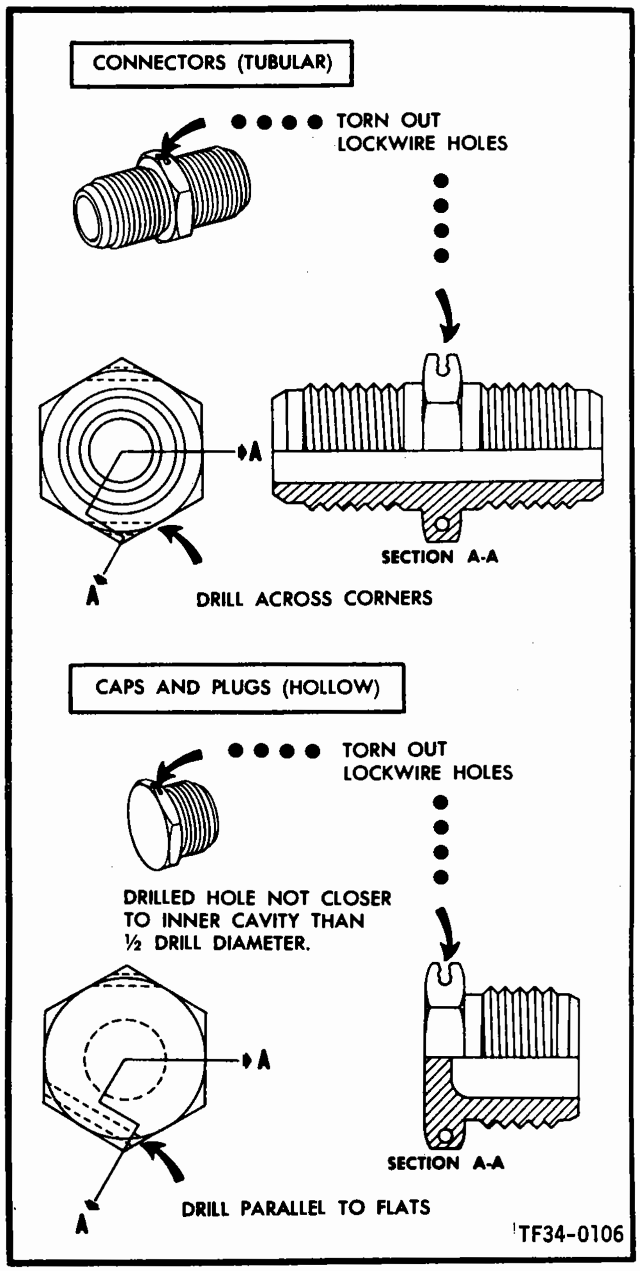


Figure 5-38. Repair of Torn Lockwire Holes

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS AND ELECTRICAL CABLE EXTERIOR.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	CAUTION Do not rebuild hoses.		
1. Teflon-lined flex hoses for:			
a. Kinks or buckling.	None allowed.	Not repairable.	Replace hose.

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS AND ELECTRICAL CABLE EXTERIOR. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Frayed or broken wire braid strands.	No more than 9 strands in a square area measuring 1 inch on a side. Bend back broken strands.	Not repairable.	Replace hose.
2. Tubing for:			
a. Splits or cracks.	None allowed.	Not repairable.	Replace tube.
b. Nicks, scratches, guoges, wear, chafing on:			
(1) Non fuel-carrying tubes.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal and blend to adjacent contour, using a fine abrasive stone. Replace tube if blending had been previously done in same area.
(2) Fuel-carrying tubes.	Not usable if depth of defect can be measured.	Not repairable.	Replace tube.
c. Dents.	Dented area not over 20% of tube diameter on straight or curved section having a radius over twice the tube diameter. On a sharply bent radius, not over 10% of tube diameter may be dented.	Not repairable.	Replace tube.
d. Flattened area.	OD not less than 3/4 of original OD.	Not repairable.	Replace tube.
e. Nicks and scratches on packing grooves.	Up to 0.003 inch deep on floor, 0.010 inch deep on wall of groove with no sharp edges. Tube must pass pressure test.	Not repairable.	Replace tube.
f. Flatness of bolt flange mating surface.	Flat within 0.005 inch (place on flat surface and insert 0.005 inch feeler gage).	Up to 25% of original flange thickness can be removed to meet usable limit.	Rework to usable limit by lapping, stoning or machining (if possible).
g. Cracks in bolt flange.	None allowed.	Not repairable.	Replace tube.
3. Hex coupling nuts for:			
a. Damaged corners.	Any amount as long as wrench can be used.	Not repairable.	Replace part.
b. Cracks.	None allowed.	Not repairable.	Replace part.
c. Nicks and burrs.	Any amount with no high metal.	Any amount with high metal.	Blend high metal (see paragraph 5-87).

SECTION V
ENGINE REPAIR

5-1. GENERAL.

1. This section contains instructions for replacing parts or components. This section provides instructions for making all repairs for which spare parts and tools have been provisioned. The Alphabetical Index at the end of this manual should be used for locating instructions for removal, inspection. repair and installation of specific parts.

5-2. EXTENT OF DISASSEMBLY.

1. Do not disassemble the engine any further than necessary to replace parts or related parts that may also be damaged even though complete disassembly instructions may be given.

2. Remove external components, as required, by following instructions of Section IV. When removing external components, disconnect as few brackets and clamps as possible. Remove components in as large a package as practical to reduce disassembly/assembly time.

5-3. ORGANIZATION.

This section is organized as follows:

1. Disassembly of the engine into major subassemblies. This is done in the order of normal disassembly beginning with removal of the low pressure turbine module and working forward into engine after removing external components. Table 5-1 gives order of disassembly for specific component replacement when it varies from normal disassembly sequence.

2. Disassemble the major subassemblies in the same order that they were removed from the engine.

3. General cleaning procedures.

4. General inspection procedures.

5. Specific inspection limits in the following general sequence.

a. External components.

b. Universal inspections such as Main Engine Bearings.

c. Component and parts inspection starting with fan and working aft to the exhaust frame in order.

NOTE

Limits for similar parts are located together, regardless of their location in the engine. For example, limits for stages 1, 2, 3, 4, 5, and 6 turbine nozzles are in paragraphs that follow one another.

5-4. GENERAL DISASSEMBLY PRACTICES AND PROCEDURES.

1. Use only prescribed tools. Improper tools cause damage to costly parts and may cause personal injury.

2. Keep parts and assemblies clean and free from corrosion, or foreign matter. All threaded parts, piping, mounting pads or faces, and splines should be capped, covered or sealed in a clean plastic bag immediately upon removal from the engine. Do not remove wrappings, protectors, or covers until the part is ready to be installed.

CAUTION

Efficient engine performance depends heavily on the cleanliness of engine components.

3. During disassembly, always hold bolt rigid and remove the nut from the bolt. During assembly, hold the bolt rigid and torque the nut.

4. Always drive body-bound bolts straight through, without turning, using a plastic drift. Turning enlarges the holes; the mating parts will not line up if the holes are oversize.

5. Do not use pens, pencils or other marking devices containing carbon when marking engine parts.

6. During disassembly, examine all subassemblies or parts for serviceability even though they are not the parts suspected of being unserviceable. Look for indications of work incorrectly performed during any previous repairs or overhauls. Report any such indications in accordance with current practices.

7. During disassembly, be extremely careful not to drop nuts, washers, pieces of lockwire, or other objects into a subassembly. If any object is dropped into a subassembly, do not proceed further

TABLE 5-1

REPLACEMENT OF
INDIVIDUAL ENGINE COMPONENTS

This table gives paragraph references and paragraph sequence for removing and installing those components that will most likely need replacing on an individual basis. After determining which component has to be replaced, follow the instructions of the applicable paragraphs in the numerical sequence shown.

PARAGRAPHS TO BE FOLLOWED TO REPLACE COMPONENT

COMPONENT TO BE REPLACED	5-10	5-9	5-12	5-13	5-14	5-15	5-16	5-17	5-18	5-19	5-20	5-28	5-108	5-6	6-3	7-25	7-26	7-27	7-28	7-30	7-31	7-32	7-40	7-41	7-42	7-37	7-43
Fan Housing	*1	2																			3						*4
Fan Blade	*1																										*2
No. 1 Bearing and Carbon Seal	1		2									3			4							5					6
Fan Stator Assembly	1	2		3	4	5	6													7	11		8	9	10		12
Fan Vane													1														
Power Takeoff	1		2	*3	*4			*5	6									7	*8			11		*9	*10		12
Compressor Blade/Vane				1	2	*3		4		*5	*6					*7	*8		9				10	11	12		
No. 7 Carbon Seal														*1												*2	

* = Partial Paragraph — Only do those steps required.

until the object is located and removed. Do not leave tools on any part of a unit during disassembly. Return each tool to its proper place as soon as it has served its immediate purpose.

8. Use care in disassembling any parts containing electrical connectors. Use only prescribed tools with protective inserts on electrical connectors.

9. Whenever a component in the fuel or lube system is removed, place a drip pan under that component to catch the drippings.

10. Whenever a measurement is required to be taken in the detailed disassembly instructions, use precision measuring instruments such as micrometers, depth gages, etc.

11. Extreme care must be exercised in restoring external tubing, lines, and harnesses to exact removal configuration. Improper routing causes stresses and subsequent failure. Do not force such items out of design contour and routing path. Do not relocate clamps, brackets, etc.

CAUTION

Do not use cadmium-plated tools on titanium parts. Doing so may cause parts to fail during subsequent use.

12. Titanium parts require special care. It has been found that when cadmium plated tools are used on titanium parts it is possible for particles of cadmium to become imbedded in the titanium. At temperatures above 600°F the cadmium can cause the titanium to become brittle, resulting in overstressed areas and possible cracking. Therefore, cadmium-plated tools shall not be used on titanium parts during assembly and disassembly.

13. It has also been found that silver and titanium react in the same way as cadmium and titanium. Be sure that silver-plated hardware is not used on titanium parts. Silver-plated nuts used in hot section assemblies, for example, shall not be substituted for nuts used on fan or compressor parts.

14. In the numerical tool list, none of the tools listed for use on titanium parts are cadmium plated. Cadmium-plated tools are not normally found in mechanic's tool kits.

5-5. SCHEDULED CALENDAR INSPECTION OF YTF34-GE-2 ENGINE.

Calendar inspection is a limited over-all inspection of the engine and is performed when the engine has reached the established date. The inspection consists of examining the engine using a borescope, through ports provided in the combustion chamber and compressor casings, and a visual inspection of external components, and inlet and exhaust areas.

5-6. REMOVAL OF LOW PRESSURE TURBINE MODULE.

For special tools, refer to table 2-1, group 30.

1. Remove 6 bolts (1, figure 5-1) that secure the exhaust centerbody to the exhaust frame. Remove exhaust centerbody (2).

2. Remove 2 bolts (3) that secure anti-icing tube (4) to strut (8 o'clock position) in exhaust frame. Remove the tube and piston rings (5).

3. Remove the 6 bolts (9) that secure the tubes to the struts at 4, 6, and 10 o'clock positions. Pull the tubes out of the exhaust frame struts until the tubes come out of the holes in the rear cover (13). Remove and discard packings (10, 11).

CAUTION

Use care in removing cover to prevent damage to carbon seal.

4. Remove 12 bolts (12) that secure rear cover (13) to bearing housing. Remove cover and packing (14) from bearing housing. Remove No. 7 carbon seal (27) by pushing it out aft end of cover (13). Discard packing.

5. If necessary, remove 3 nuts (6) that secure vent collector (7) to rear cover (13). Remove vent collector and discard packing (8).

CAUTION

Anti-icing seal has left-hand thread.

6. If necessary, use wrench (21C5188) and remove anti-icing seal from vent collector (7).

7. Remove retaining ring (1, figure 5-2) that secures seal runner (2) with snap ring pliers.

8. Use puller (21C5184) and remove seal runner (2).

9. Pull aft anti-icing tube (3) out by hand.

10. Remove retaining ring (4) and keywasher (5) that secure locknut (6).

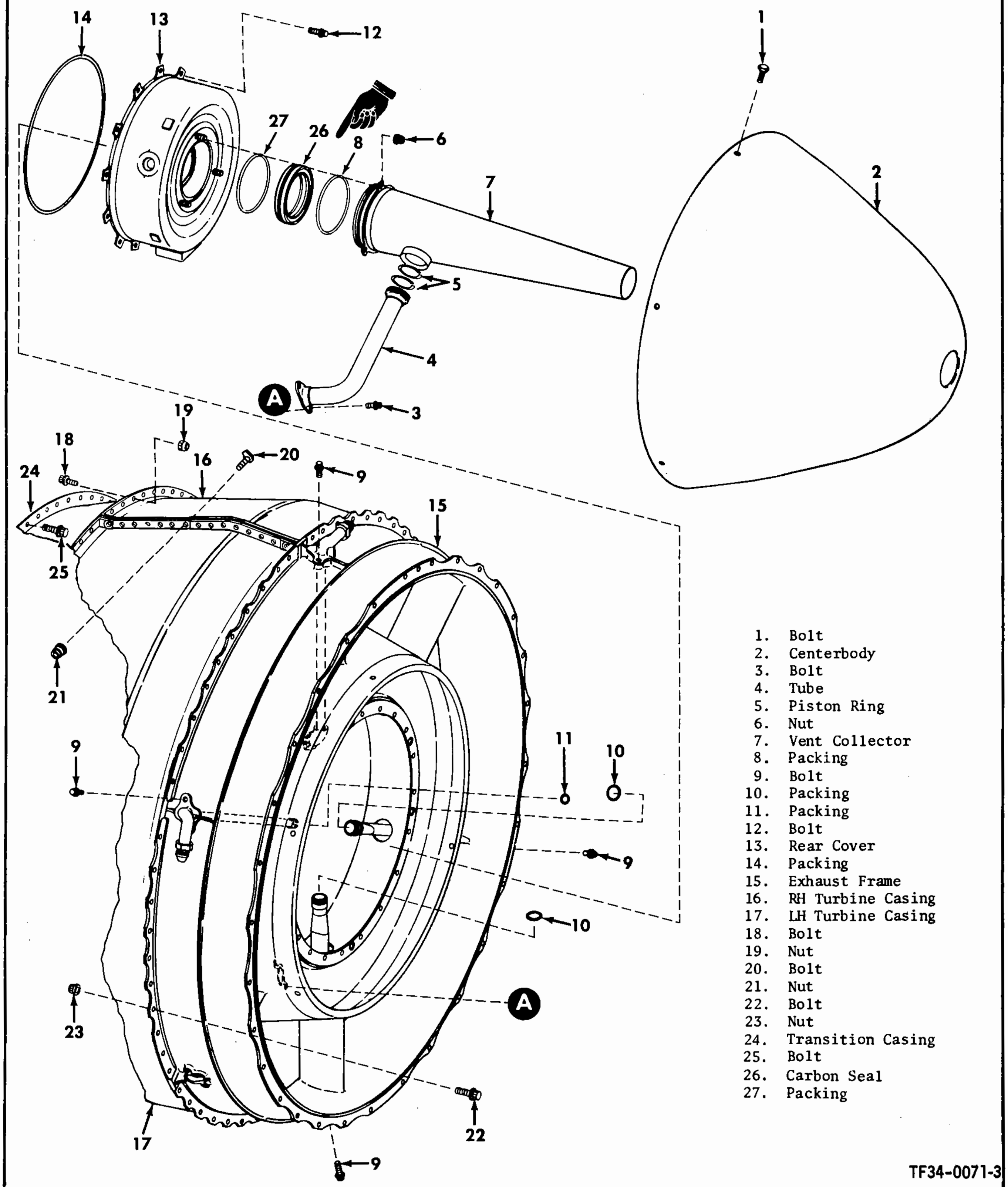
CAUTION

Make sure spacer is removed. Use 2 screwdrivers, if necessary, to remove it.

11. Use wrench (21C5044) and torque multiplier (SWE 8100) to loosen locknut (6). Remove locknut (6) and spacer (7) by hand.

11A. Using Dykem or equivalent noncarbon marker, match-mark the low-pressure turbine rotor and fan drive shaft by placing a mark on each part in line.

12. Remove 4 nuts and bolts (2, 1, figure 5-3) as shown from each side at 3 and 9 o'clock positions on mating flanges of low pressure turbine casing and exhaust frame. Remove 4 nuts and bolts (1, 2, figure



1. Bolt
2. Centerbody
3. Bolt
4. Tube
5. Piston Ring
6. Nut
7. Vent Collector
8. Packing
9. Bolt
10. Packing
11. Packing
12. Bolt
13. Rear Cover
14. Packing
15. Exhaust Frame
16. RH Turbine Casing
17. LH Turbine Casing
18. Bolt
19. Nut
20. Bolt
21. Nut
22. Bolt
23. Nut
24. Transition Casing
25. Bolt
26. Carbon Seal
27. Packing

Figure 5-1. Removal of Low-Pressure Turbine Module

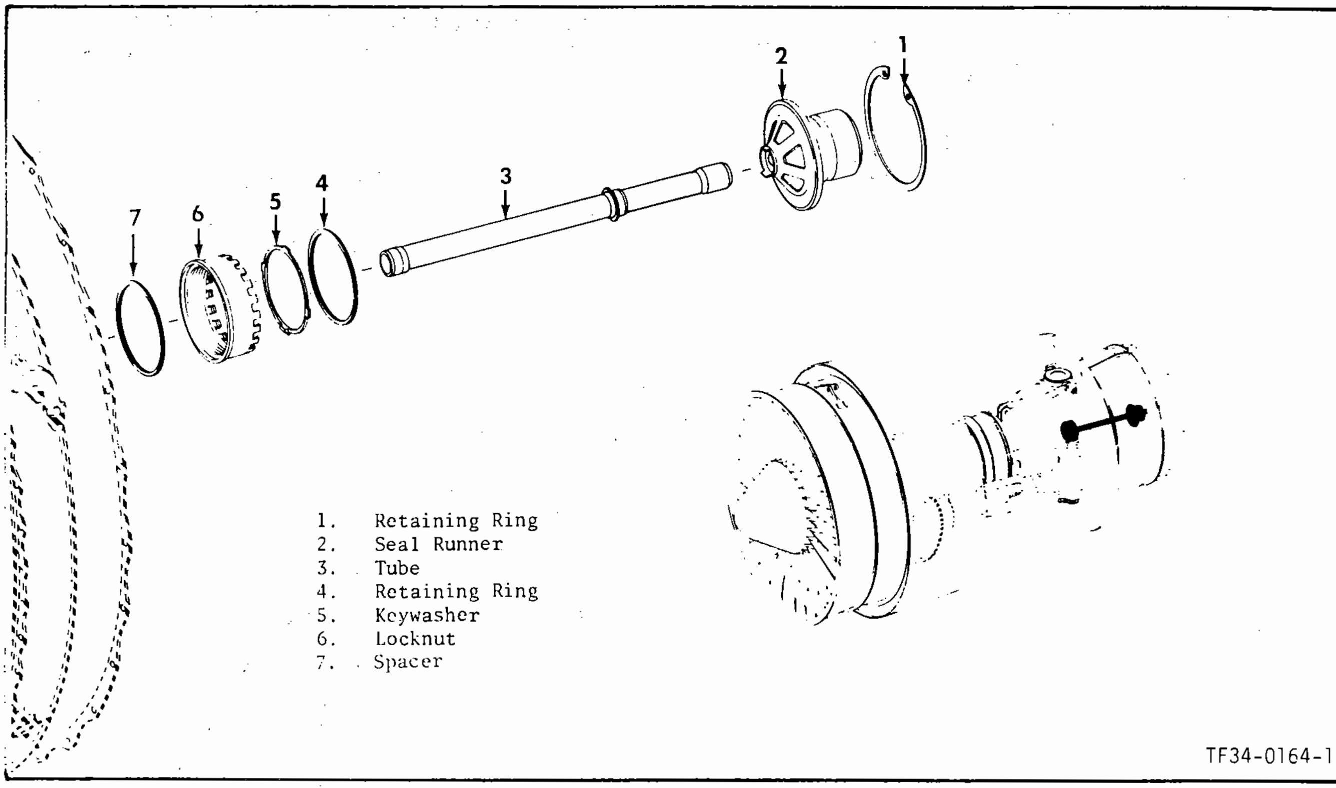


Figure 5-2. Low-Pressure Turbine Rotor Components

5-4) 2 on each side, from the third hole on either side of the 3 and 9 o'clock positions on mating flanges of the 3 and 9 o'clock positions on mating flanges of low pressure turbine casing and transition casing.

13. Remove all bolts that secure the transition casing to HPT casing except 6 bolts at 12 o'clock position.

14. Install 2 carriage assemblies (21C5031) on low pressure turbine module. Secure carriage assemblies to the module with bolts removed in step 12.

CAUTION

Be careful not to damage thermocouple assemblies when installing rear supports (21C5031).

15. Install 2 rear supports (21C5031) at 3 and 9 o'clock positions on engine rear mount.

16. Remove remaining 6 bolts (at 12 o'clock position) that secure transition casing to high pressure turbine casing.

CAUTION

Tap low pressure turbine module aft just enough to free it from high pressure turbine casing. If the module moves too far aft, the blades will hit the nozzles and cause damage.

17. Use a rawhide mallet and gently tap on the rear support carriage assemblies (21C5031), tapping in an aft direction, just enough to free the transition casing from the high pressure turbine casing.

18. Install rotor retainer (21C5041) on aft end of exhaust frame as follows:

a. Attach retainer to inner bolt circle of No. 7 bearing housing with 4 bolts (12, figure 5-1). Torque bolts to 38-42 lb in.

b. Clamp inner portion of retainer to No. 7 bearing locknut.

19. Install puller (21C5061) in aft end of low pressure turbine rotor.

20. Attach hydraulic handpump (ENERPAC No. P-39 or equivalent) to puller (21C5061).

CAUTION

Stop applying pressure if needle on gage approaches the red zone.

21. Use pump and pull rotor off fan shaft.

22. Disconnect hydraulic handpump. Remove puller (21C5061).

23. Slowly roll the low pressure turbine module back on the supports up to the stops.

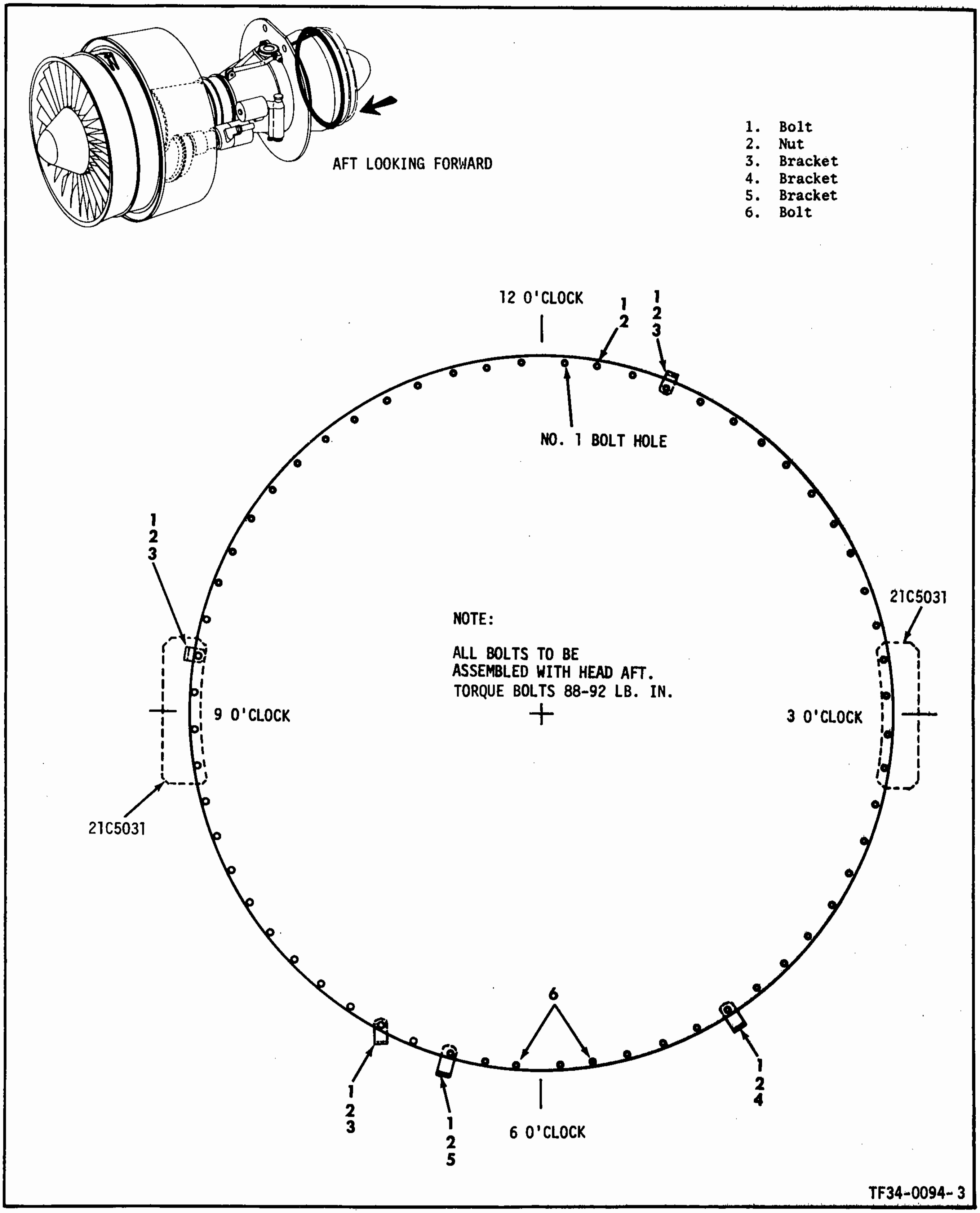


Figure 5-3. Bolting Diagram - Exhaust Frame-to-Low-Pressure Turbine Stator

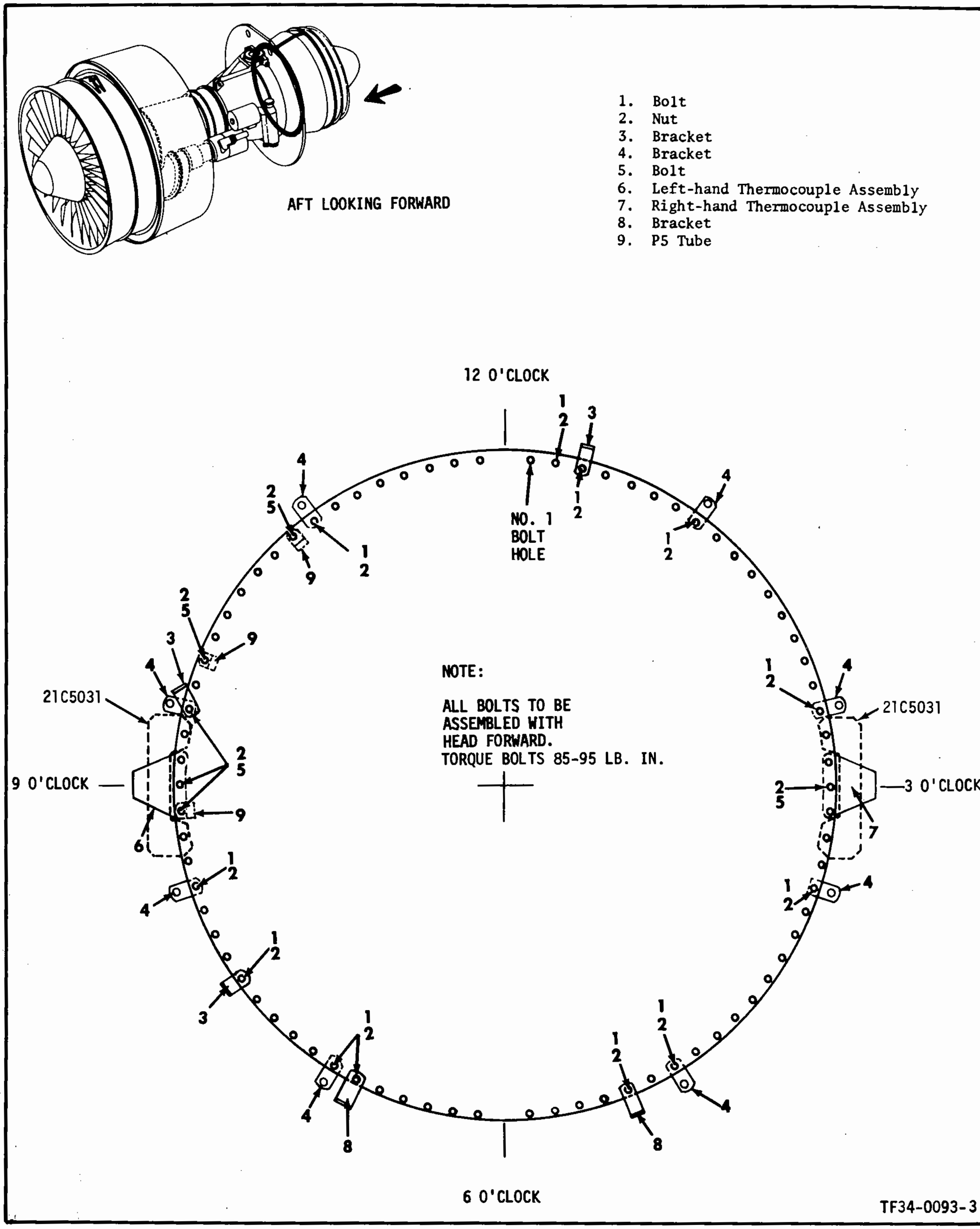


Figure 5-4. Bolting Diagram - Low-Pressure Turbine Stator-to-Transition Casing

24. Attach hoisting adapter (21C5071 or 21C5210). Use hoist and lift low pressure turbine module clear of supports.

25. Rotate module to vertical position, forward end down, and lower module into stand (21C5035 or 21C5085).

26. Remove hoisting adapter (21C5071 or 21C5210) and carriage assemblies (21C5031).

5-7. REMOVAL OF HIGH-PRESSURE TURBINE ROTOR. For special tools, see table 2-1, group 26.

1. Put masking tape around outside of shrouds to hold them in position on support ring.

CAUTION

Be sure to match-mark the stage 2 disk and the balance weights and the studs from which they are removed. This is done to make sure parts are properly reassembled.

2. Match-mark the stage 2 disk (5, figure 5-5) and a stud. Use Dykem or equivalent marker that will not rub off.

3. Insert fixture (21C5203, depth vernier) into bore of stage 2 disk. Measure the distance from aft face of stage 2 disk (5) to aft side of stage 1 disk (6). Record dimension for use at installation of high-pressure turbine rotor.

4. Number the nuts (2) and studs in sequence, and number any balance weights (3).

5. Use wrench (21C5088) and remove 6 nuts (2) to align wrench (21C5079) with studs.

6. Remove coupling nut (1) as follows:

a. Place a mark on aft side of stage 2 disk that is in line with one of the fingers of the locknut (1).

b. Place a mark on aft end of wrench (21C5079) that is in line with one of the tapered fingers on the wrench. Loosen 3 thumbscrews.

c. Install wrench, with marks in line, into bore of high-pressure turbine rotor. Engage splines and rotate outer portion of wrench clockwise. Tighten 3 thumbscrews.

d. Thread 2 guide pins (part of 21C5079) onto studs of HPT rotor so that pins will line up with holes in outer portion of (21C5079). Install outer portion onto disk and 4 retaining pins onto studs.

e. Install Powerdyne 2501 or adapter and SWE8100 torque multiplier. Loosen locknut (output drive counter-clockwise). Remove tools and locknut.

7. Remove nuts (2), balance weights (3), and bolt shield (4).

8. Attach aft extension bar (21C5095) to the fan shaft.

9. Install pullers (21C5204 and 21C5060). Install fan shaft extension support (21C5182) under the extension bar and raise the support just enough to take the weight off the shaft. Remove stage 2 disk (5).

10. Install the fan shaft support (21C5181) to hold stage 2 disk. Remove fan shaft extension support (21C5182) and disk.

11. Match-mark and remove the inner casing assembly (containing the stage 2 nozzle assembly and stage 1 turbine shrouds). Install spacer (part of 21C5060).

12. Insert puller (21C5060) into high pressure rotor. Connect hydraulic pump to puller (21C5060).

13. Attach aft extension bar (21C5095) to the fan shaft. Install fan shaft extension support (21C5182) under the extension bar and raise the support just enough to take the weight off the shaft.

CAUTION

Reduce hydraulic pressure to zero if needle on page goes into yellow zone. Do not build up pressure until you determine why rotor will not pull free.

14. Build up hydraulic pressure until high pressure rotor is free from compressor rotor.

15. Move the high pressure rotor over the fan shaft so that the high pressure rotor is close to the fan shaft support (21C5182).

16. Install support (21C5181) to hold high pressure turbine rotor. Remove fan shaft support (21C5182).

17. Attach hoisting adapter (21C5097) or (21C5210) and (21C5211) to high pressure rotor, and hook adapter to overhead crane. Remove support (21C5181).

18. Remove puller (21C5060) from rotor. Place rotor in buildup stand (21C5036) or (21C5039). Remove hoisting adapter (21C5097) or (21C5210) and (21C5211).

19. If necessary, disassemble stage 2 nozzle as follows:

a. Remove air baffle (4, figure 5-6) from inner casing (16).

b. Remove 54 bushings (5) from holes in inner casing (16).

c. Remove stage 2 nozzle assembly (6) from nozzle casing.

d. Remove 10 shroud retainers (13 and remove shrouds (14), and seal strips (15).

e. Replace stage 2 nozzle segments by following segment replacement instruction in this section.

5-8. REMOVAL OF STAGE 1 TURBINE NOZZLE, OUTER BALANCE PISTON SEAL (STATIONARY), AFT INNER DUCT AND COMBUSTION LINER.

1. Remove lockwire and 47 bolts (1, figure 5-7) securing stage 1 nozzle (3) outer bolt circle to combustion liner (6).

2. Use an Allen wrench to hold studs (12) and remove 3 nuts (10). Remove 9 bolts (2) from 6 bolt shields (11). Remove bolt shields.

3. Remove 12 bolts (2) securing inner bolt circle of stage 1 nozzle to air seal. Match-mark the stage 1 nozzle with Dykem or equivalent noncarbon marker and remove the nozzle.

4. Remove igniter plugs (8) and primer nozzles (13).

1. Locknut
2. Nut
3. Balance Weight
4. Bolt Shield
5. Stage 2 Disk
6. Stage 1 Shaft and Disk Assembly

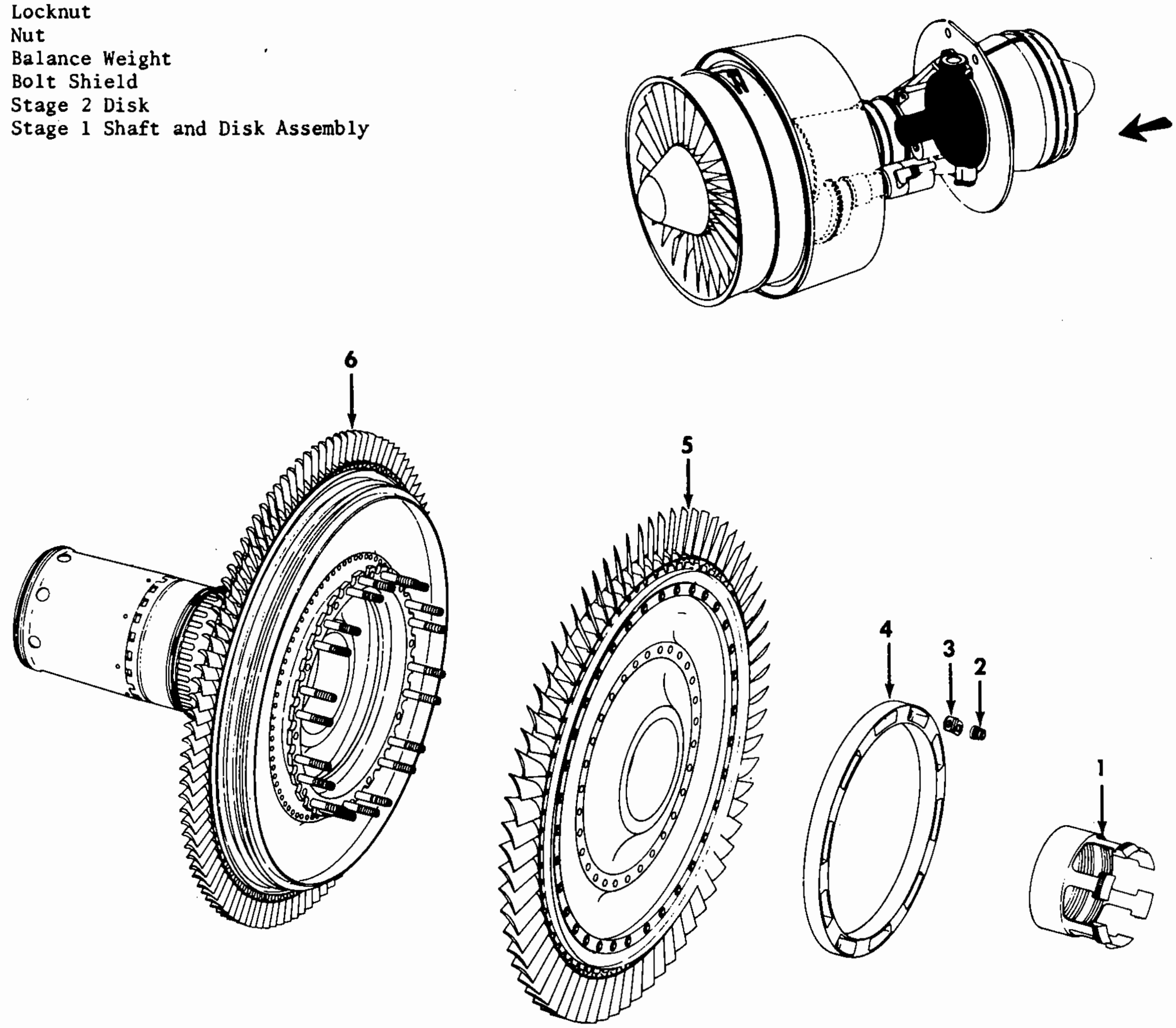


Figure 5-5. Removal of High Pressure Turbine Rotor

CAUTION

Leave 3 bolts (4) installed until the liner guide is installed to prevent liner from popping aft due to compression of B-sump housing.

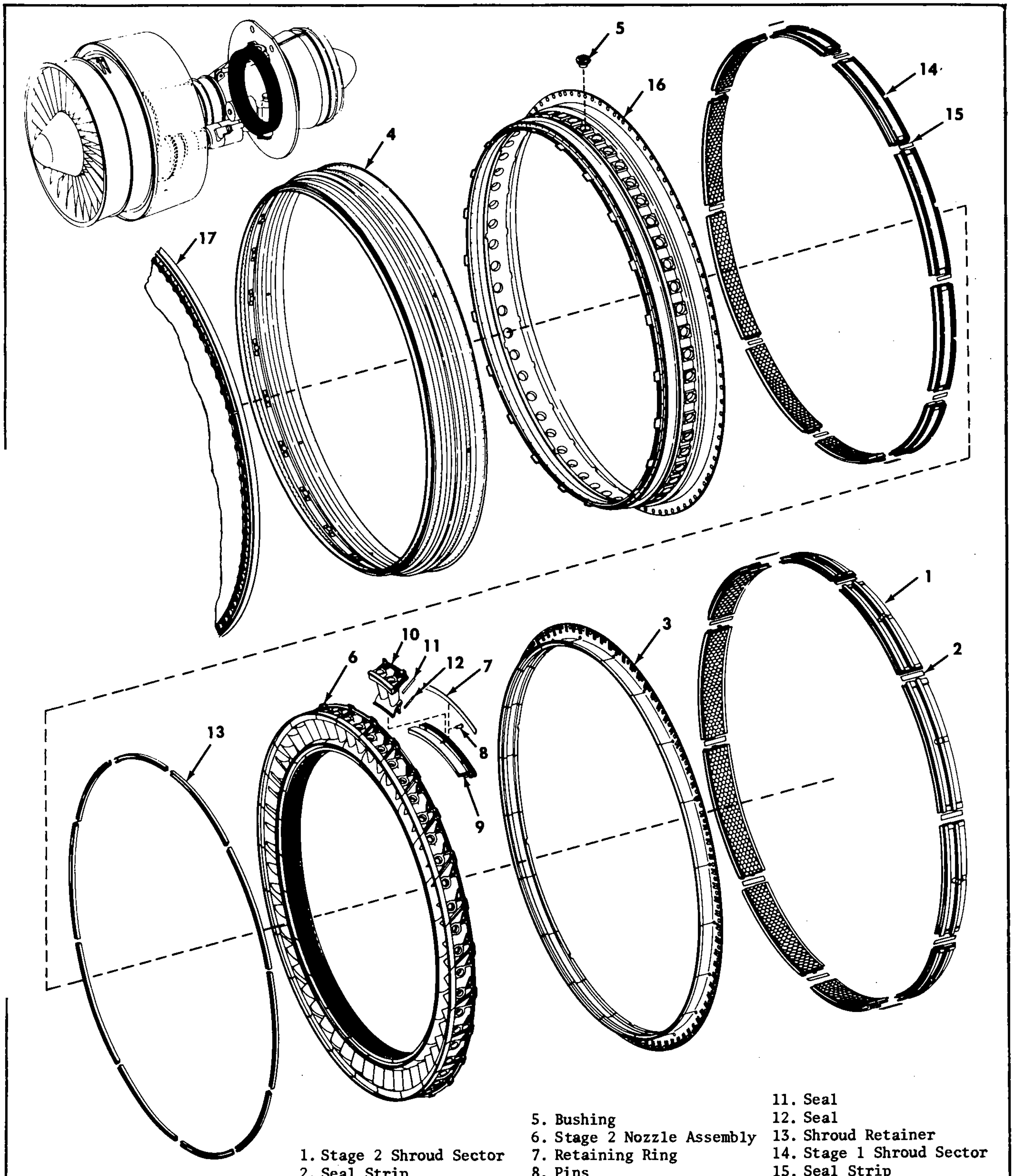
5. Remove 60 bolts (4) securing combustion liner (6) and aft inner duct (5) to combustion casing (7). Leave 3 bolts installed.

6. Assemble inner piece of liner guide (21C5125) to air seal with nuts (10), putting the keyway of guide at 12 o'clock position.

7. Assemble outer portion of liner guide (21C5125) over inner portion and on to aft inner duct (5) with bolts (2). Remove remaining 3 bolts (4).

8. Using the struts of guide (21C5125) as handles, lift the liner and inner duct from combustion casing. Remove both sections of guide (21C5125).

9. Remove 3 screws (9) securing inner duct to combustion liner.



5. Bushing
6. Stage 2 Nozzle Assembly
7. Retaining Ring
8. Pins
9. Seal
10. Stage 2 Nozzle Segment
11. Seal
12. Seal
13. Shroud Retainer
14. Stage 1 Shroud Sector
15. Seal Strip
16. Inner Casing
17. Outer Casing

1. Stage 2 Shroud Sector
2. Seal Strip
3. Stage 2 Shroud Support
4. Air Baffle

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Figure 5-6. Removal of High-Pressure Turbine Stator Components

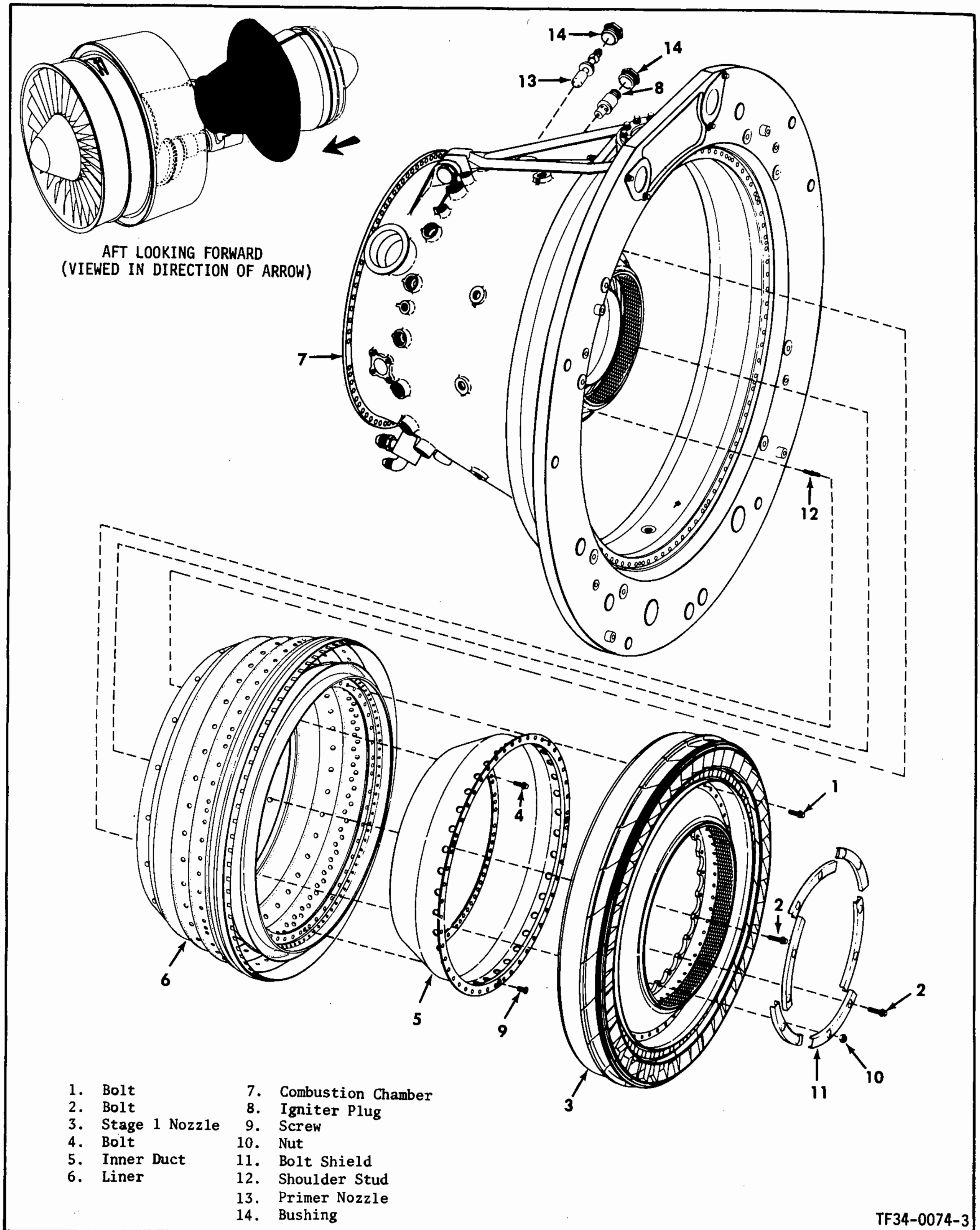


Figure 5-7. Removal of Stage 1 Nozzle, Aft Inner Duct, and Combustion Liner

5-9. REMOVAL OF FAN HOUSING ASSEMBLY.

NOTE

Use this procedure when fan housing is being removed for repair or replacement. If further disassembly of the engine is anticipated, the housing can be left assembled to the stator assembly.

1. Remove 15 fan blades (in a row) per paragraph 5-10, steps 1 through 6 and step 8.

2. Remove 73 bolts (1, figure 5-8), 73 washers (2), and 73 nuts (3) from aft flange of fan housing (4).

CAUTION

Be careful not to gouge fan housing on remaining blades.

3. Remove fan housing (4).

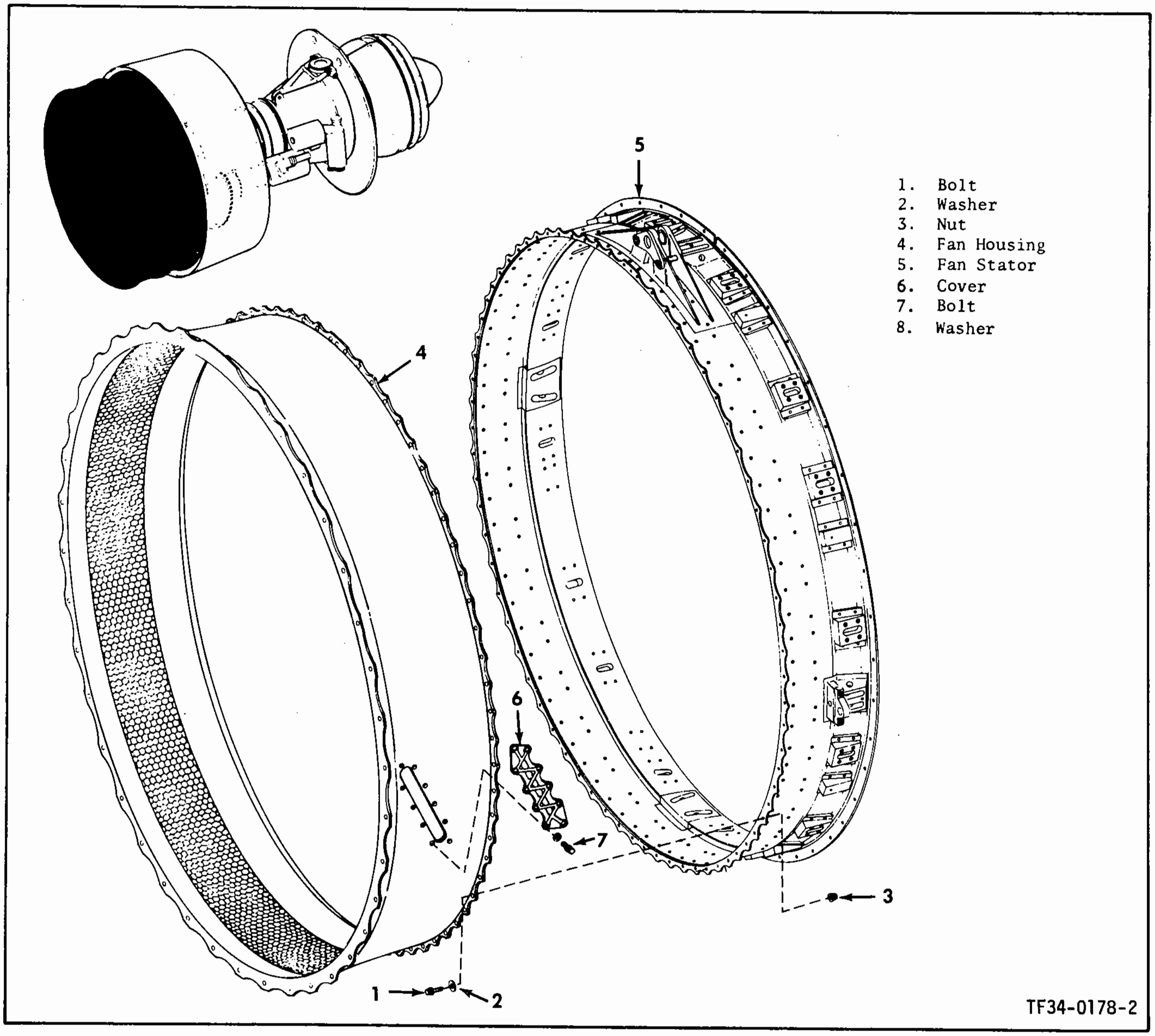


Figure 5-8. Removal of Fan Housing Assembly

5-10. REMOVAL OF FAN DISK ASSEMBLY. For special tools, see table 2-1, group 19.

NOTE

Match-marking of forward spinners is not required if the spinners are being replaced. It is done as a good assembly practice so that any unbalance is not introduced to the rotor.

1. Match-mark the forward and aft outer spinners (2, 4, figure 5-9) and a fan rotor blade with Dykem (Dykem Co., St. Louis, Mo.) or equivalent non-carbon markers.

NOTE

A wooden or plastic wedge may be needed to assist in removing spinners.

2. Remove 8 nuts (1) holding forward outer and inner spinners (2, 3) and the aft outer spinner (4) to the aft inner spinner (9).

3. Remove the forward outer spinner (2). Match-mark the forward inner spinner (3) and the aft outer spinner (4) with Dykem or equivalent. Remove the forward inner spinner and aft outer spinner (3, 4).

4. Pull out the anti-icing tube (5) and discard packing (6) and seal (7).

5. On the aft inner spinner (9) and disk (11), make a matchmark in line with matchmark made on the blade in step 1.

6. Remove 14 bolts (8) holding the aft inner spinner (9) to the disk (11), and remove spinner. Install pin retainer (21C5117).

NOTE

Fan blades (12) can be removed before removing the fan disk or the fan disk and blades can be removed as an assembly. Use step 7 to remove the disk and blades as an assembly or use step 8 to remove blades before removing the disk.

7. Remove fan disk and blades as an assembly as follows:

a. Install rotor locking fixture (21C5001).

b. Match-mark disk to fan front shaft.

c. Use wrench kit (21C5088) and remove 28 nuts (10) holding fan disk to the shaft.

d. Install puller (21C5024) into the fan disk (11) bore.

e. Install support (21C5182) under extension bar (part of 21C5024).

f. Rotate threaded ring on puller (21C5024) until disk (11) is loose on shaft studs. Carefully slide the disk straight out of fan housing being careful not to bump fan blades on inside of housing.

g. Remove retainer (21C5117) and remove 1 blade pin and 1 blade. Attach hoising adapter (21C5101) to disk (11) in the empty blade hole. Attach adapter to an overhead hoist.

h. Remove support (21C5182) and (21C5024) from fan disk (11). Place disk in stand (21C5187), aft side facing stand, and remove hoisting adapter (21C5101).

8. Remove fan blades (12) as follows:

a. Remove screws (7, figure 5-8) washers (8), and 1 blade removal port cover (6).

b. Number all blades (12, figure 5-9) and their respective retaining pins (13) and blade holes so all blades can be reassembled to the same position.

WARNING

Removal of 1 blade makes fan rotor out of balance. This will make rotor turn until the heaviest portion is on the bottom. Hold rotor to keep from injuring fingers.

c. Line up the blade (12) with blade removal port. Remove retainer (21C5117) and remove blade retaining pin (13).

d. Pull blade out of disk until blade tangs are clear of disk. Blade tip will stick out of removal port about 3 inches.

e. Tip blade towards you until it is forward of disk. Pull blade back towards engine centerline and remove blade.

f. Repeat steps c through e, alternating from 1 side of disk to the other to keep rotor somewhat in balance, until all blades are removed.

g. Remove disk by following step 7, this paragraph.

5-11. REMOVAL OF FAN DRIVE SHAFT. For special tools, see table 2-1, groups 15 and 19.

1. Remove the low pressure turbine module as described in paragraph 5-6.

2. Remove retaining ring (16, figure 5-10) and keywasher (15) from the front shaft locknut (14).

3. Attach the outer section of wrench (21C5043) to the fan disk mounting bolts on the front shaft with 4 nuts (10, figure 5-9).

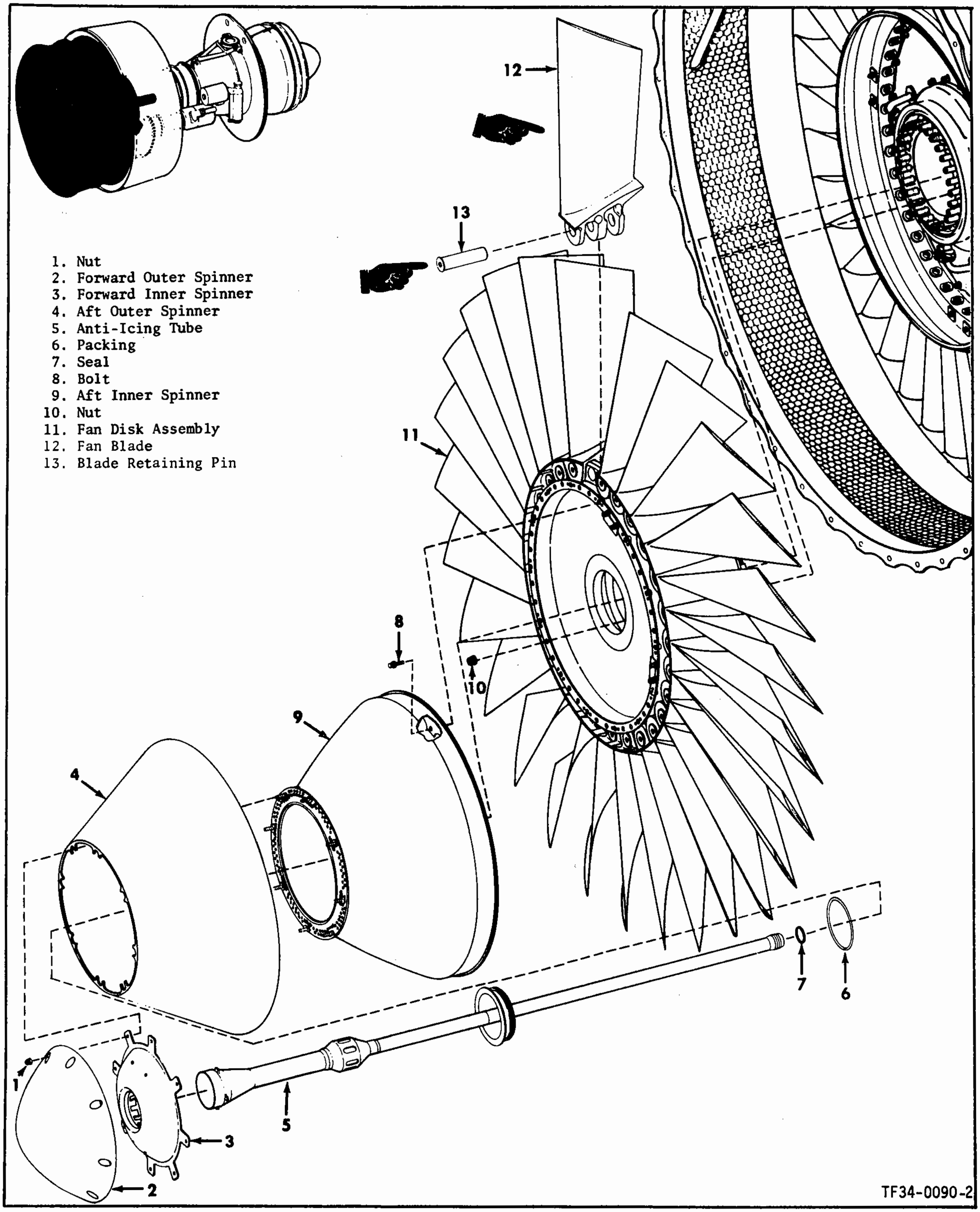
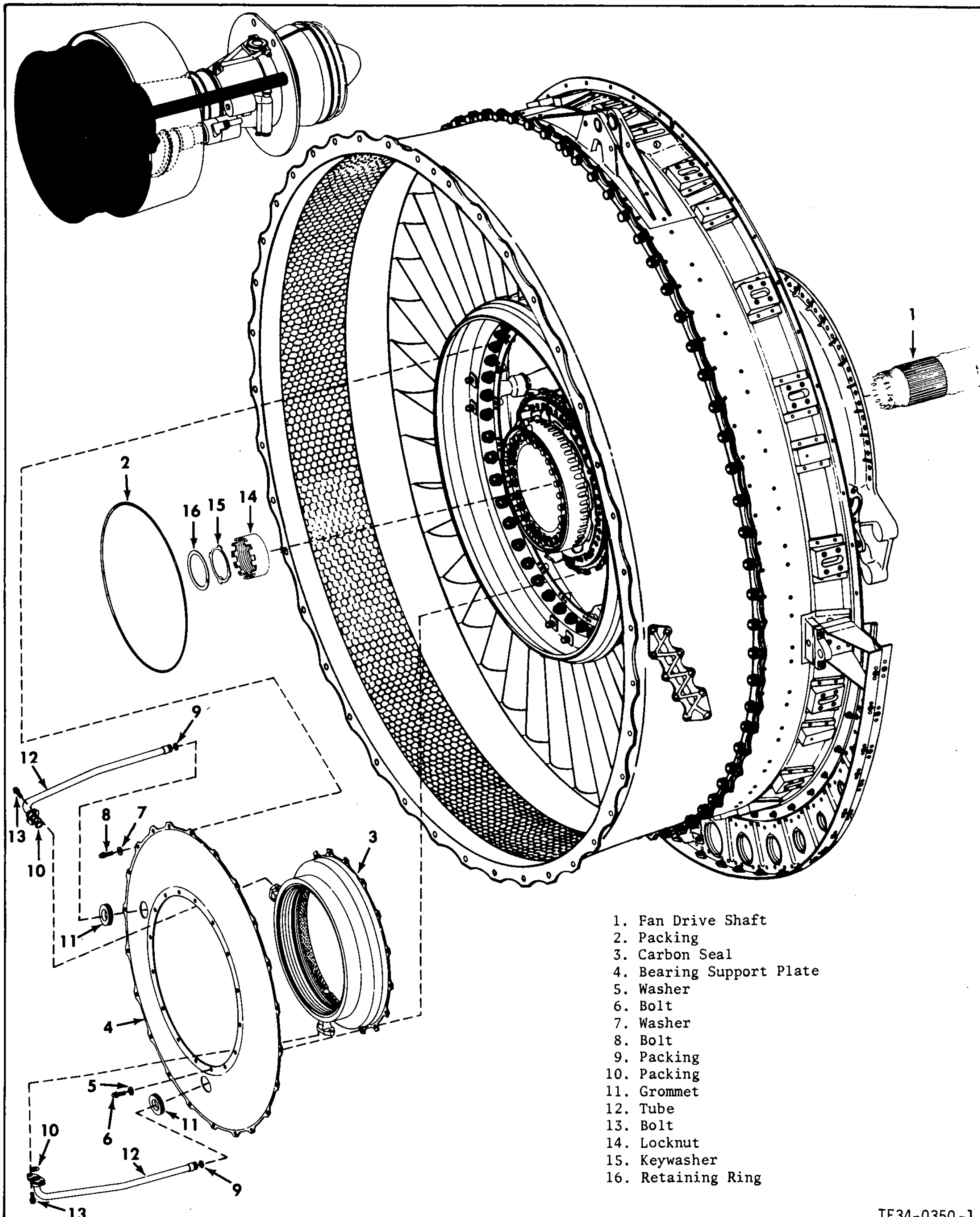


Figure 5-9. Removal of Fan Disk Assembly



1. Fan Drive Shaft
2. Packing
3. Carbon Seal
4. Bearing Support Plate
5. Washer
6. Bolt
7. Washer
8. Bolt
9. Packing
10. Packing
11. Grommet
12. Tube
13. Bolt
14. Locknut
15. Keywasher
16. Retaining Ring

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Figure 5-10. Removal of Fan Drive Shaft

4. Guide spanner wrench (21C5043) into front shaft and engage the locknut (14).

5. Put torque multiplier (SWE 8100) on the wrench (21C5043), output drive counterclockwise. Loosen locknut (14, figure 5-10) and remove wrench. Remove locknut.

5A. Use Dykem or equivalent marker and match-mark the front shaft to the drive shaft.

6. Remove lockwire and 4 bolts (13) holding the forward air tubes (12) to the carbon seal (3).

7. Remove tubes by pulling them through the bearing support plate (4). Discard packings (9,10).

8. Remove 22 bolts (8) and washers (7) from the outer boltholes of bearing support plate (4). Remove 16 bolts (6) and washers (5) from the inner boltholes. Remove the support plate.

9. Remove carbon seal (3). Discard packing (2).

10. Using puller (21C5065) remove fan drive shaft (1) as follows:

a. Match-mark the fan front shaft to fan drive using Dykem or equivalent marker.

b. Attach puller (21C5065) to fan front shaft using nuts (10, figure 5-9).

c. Connect hydraulic pump to puller (21C-5065).

CAUTION

Reduce hydraulic pressure to zero if needle on gage goes into yellow zone. Do not build up pressure again until you determine why drive shaft will not push free.

d. Activate pump until drive shaft is free of front shaft. Remove puller (21C5065).

11. Attach outer sleeve of the guide (21C5106) to fan disk bolts on the fan front shaft.

12. Install drive shaft guide (21C5106) through the fan front shaft and engage the 4 seal bolts into the slots in the guide.

13. Slowly push the fan drive shaft (1, figure 5-10) aft as far as the guide will allow.

14. Disengage the guide from the fan drive shaft. Remove guide and shaft.

5-12. REMOVAL OF FAN FRONT SHAFT. For special tools, see table 2-1, group 19.

1. If fan drive shaft has not been removed, do steps 2 through 9 of paragraph 5-11 before proceeding with step 2 of this paragraph.

2. Remove fan speed pickup (18, figure 5-11), if installed.

3. Remove nuts (10) holding bearing support (5) to front frame (11).

4. Using puller (21C5065) and adapter (21C5016), remove fan front shaft and No. 1 and 2 bearing housing module as follows:

a. Match-mark the fan front shaft to fan drive shaft using Dykem or equivalent marker.

b. Attach outer plate (21C5106P03) to fan vane support, with the steady legs at 6 and 12 o'clock positions, using support plate bolts.

c. Engage guide rods of inner plate (21C5016-P02) in guide tubes of outer plate; slide inner plate forward to rabbet on bearing housing assembly. Attach with bolts from support plate.

d. Attach puller (21C5065) to forward fan shaft using disk nuts.

e. Position truss (21C5016P01) over ram shaft of puller (21C5065) and engage the heads of the steady legs of outer plate (21C5016P03). Adjust steady legs until firm against front frame. Lock the assembly in position with the knurled nut (part of 21C5065).

f. Connect hydraulic pump to puller (21C5065).

CAUTION

Reduce hydraulic pressure to zero if needle on gage goes into yellow zone. Do not build up pressure again until you determine why shaft will not pull free.

g. Build up hydraulic pressure until bearing housing is free. Remove front shaft (12) and bearing support (5). Discard packing (6).

h. Disconnect hydraulic pump, remove adapter (21C5016) and puller (21C5065).

5. Disassemble front shaft (12) from bearing support assembly (5) as follows:

a. Remove 2 bolts (16), No. 1 bearing oil manifold (15), and oil tube (3). Discard packings (4).

b. Remove 8 bolts (16), 2 screws (14), and retainer plate (13).

c. Pull fan front shaft (12) out of bearing support (5).

d. Remove scavenge tube (2) from bearing support (5). Remove and discard packing (1).

e. Remove retaining ring (9) and antirotation key (8). Use pusher (21C5020) and remove No. 2 bearing outer race (7) from bearing support (5).

6. Disassemble fan front shaft by following instructions of paragraph 5-28.

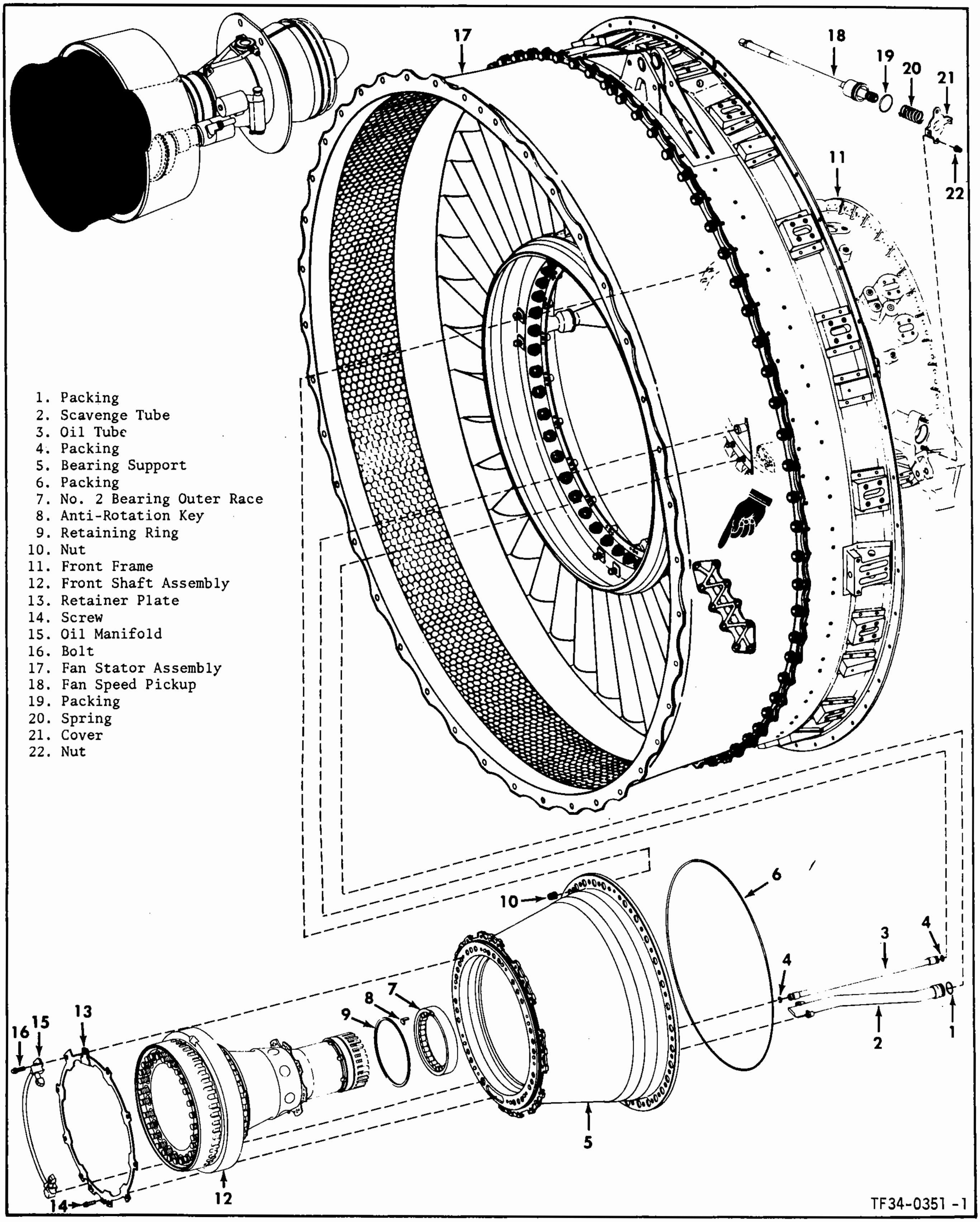


Figure 5-11. Removal of Fan Front Shaft

5-13. REMOVAL OF FAN OUTER COWL ASSEMBLY.

1. Remove 6 screws (1, figure 5-12) holding 2 covers (2) at the 3 and 9 o'clock positions on outer cowl assembly.

2. Remove 8 nuts (3) and washers (4) from the splitlines of outer cowl assembly.

3. Rotate 2 pins (5) outward and remove them from the 2 pinned interlocks (6).

CAUTION

- Do not remove upper cowl before removing lower cowl.
- Be careful not to damage upper cowl on pylon nose.

4. Remove outer cowl lower segment (10) as follows:

a. Remove 24 screws (11) holding lower segment to flange adapter (12).

b. Remove outer cowl lower segment (10).

5. Remove outer cowl upper segment (7) as follows:

a. Remove 24 bolts (8) holding outer cowl upper segment (7) to fan stator (9).

b. Remove outer cowl upper segment (7).

5-14. REMOVAL OF FAN INNER PANELS AND FRAMES.

1. Remove 105 screws (1, figure 5-13) holding the 6 inner fan panels to the frames. Remove panels (3,4,6) from the 4, 5, and 7 o'clock positions.

2. Remove V-band coupling (13, figure 4-1) connecting the anti-icing discharge manifold (9) to the pylon nose (8, figure 5-13).

3. Remove pylon nose (8) and pylon fairing (21, 22) from panel (2) as follows:

a. Remove 8 screws (24) holding left- and right-hand pylon fairing (21, 22) to the pylon nose (8), and to the pylon fairing stiffener (23). Remove 6 bolts (25) holding the pylon fairing and fairing stiffener to panel (2). Remove pylon fairing and fairing stiffener.

b. Remove 3 bolts (26) and 1 screw (27) holding pylon nose (8). Remove pylon nose and gasket (28).

4. Remove panel (2) (12 o'clock position).

5. At the 6 o'clock position, remove 4 screws (9) holding the panel (5) to the drain strut. Remove the panel. Remove drain connections from drain strut and remove strut. See section IV for drain locations.

6. At the 8 o'clock position, remove 4 screws (11) holding the panel (7) to the T2c sensor (12). Remove the panel.

7. Remove 14 bolts (13) and 14 nuts (14) connecting upper frame (15) to the lower frame (16).

NOTE

If there are washers (30) on studs of tie rods, make sure that washers stay with tie rods and that tie rods and washers are reinstalled to the same clock positions. The washers are used as shims to control the position of inner frames.

8. Remove 8 nuts (17) and any washers (30) holding upper and lower frames to fan stator tie rods (18).

9. Remove 24 bolts (19) holding upper and lower frames to splitter cone panels (20). Remove upper and lower frames.

5-15. REMOVAL OF SPLITTER CONE PANELS.

1. Identify each splitter panel (3, figure 5-14) by its clock position using Dykem or equivalent non-carbon marker.

2. Remove 28 bolts (1), 28 washers (2), and 8 splitter panels (3).

5-16. REMOVAL OF FAN STATOR ASSEMBLY. For special tools, see table 2-1, group 21.

NOTE

Do not remove fan stator assembly unless it is necessary. The fan stator and front frame can be removed from compressor rotor as an assembly.

1. Position engine support fixture (21C5219) onto fixture (21C5189) under front frame and install it as follows:

a. If accessory gearbox is installed, install support head (part of 21C5219) so that the tapered side is up.

b. Remove cover (3, figure 5-17) if installed.

c. Adjust head so that it enters gearbox access port.

d. Take the weight off the quick-release pins of the forward engine support (21C5189) by adjusting support fixture (21C5219).

e. If gearbox is not installed, install support head so the round side is up.

f. Adjust head so that it enters the 6 o'clock radial drive shaft port in the front frame.

g. Take the weight off the quick-release pins of the forward engine support (21C5189) by adjusting the support fixture (21C5219).

2. Remove 36 bolts (3, figure 5-5), and washers (4) holding fan vane inner support to front frame.

3. Remove 1 bolt (14) and tie rod cover (13) from the 12 o'clock position on the fan stator assembly.

4. Remove bolts (25, 28), washers (27), and nuts (26) holding 3 brackets (21, 22, 23) to flange adapter (24) and casing (7). Remove brackets.

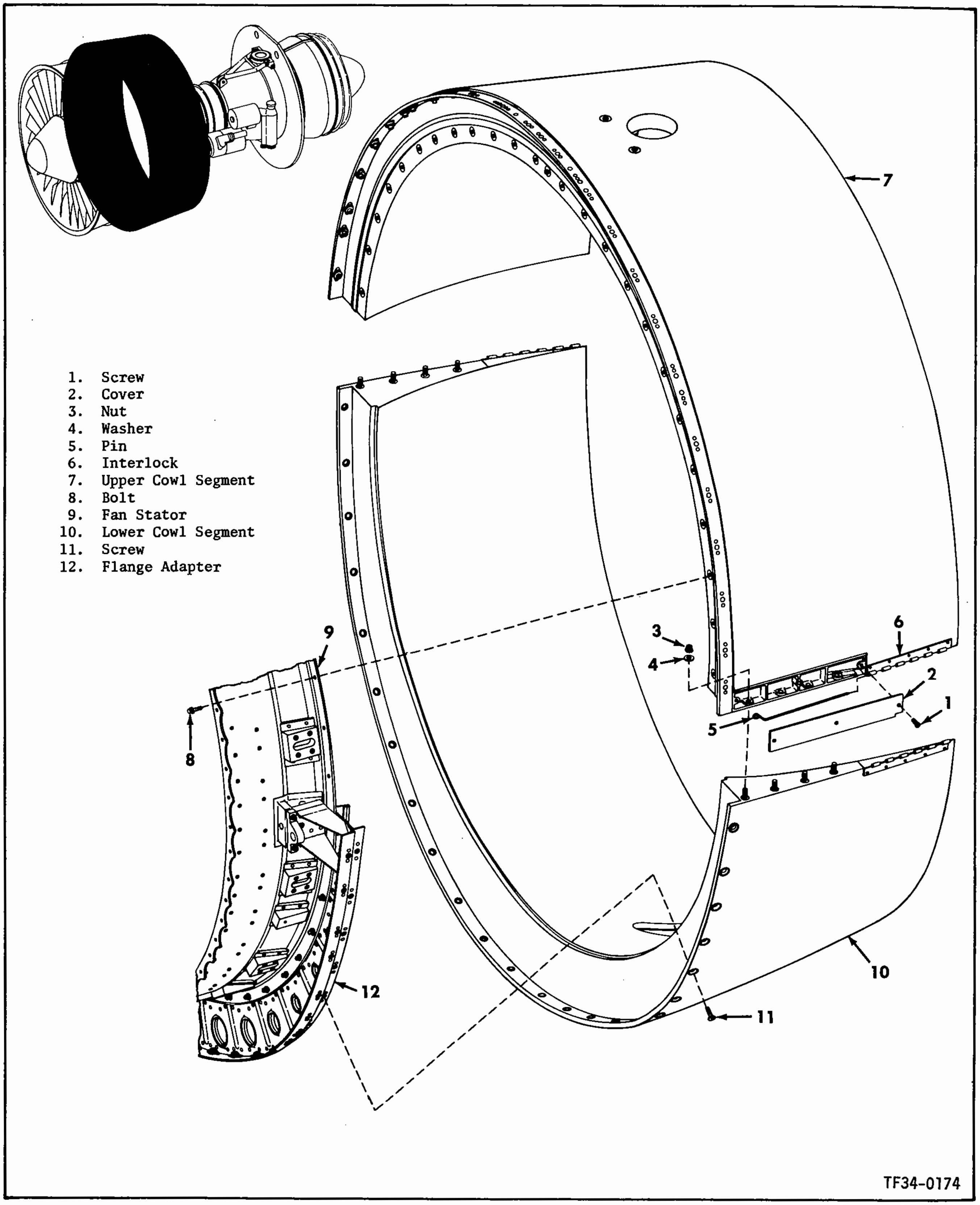


Figure 5-12. Removal of Fan Outer Cowl Assembly

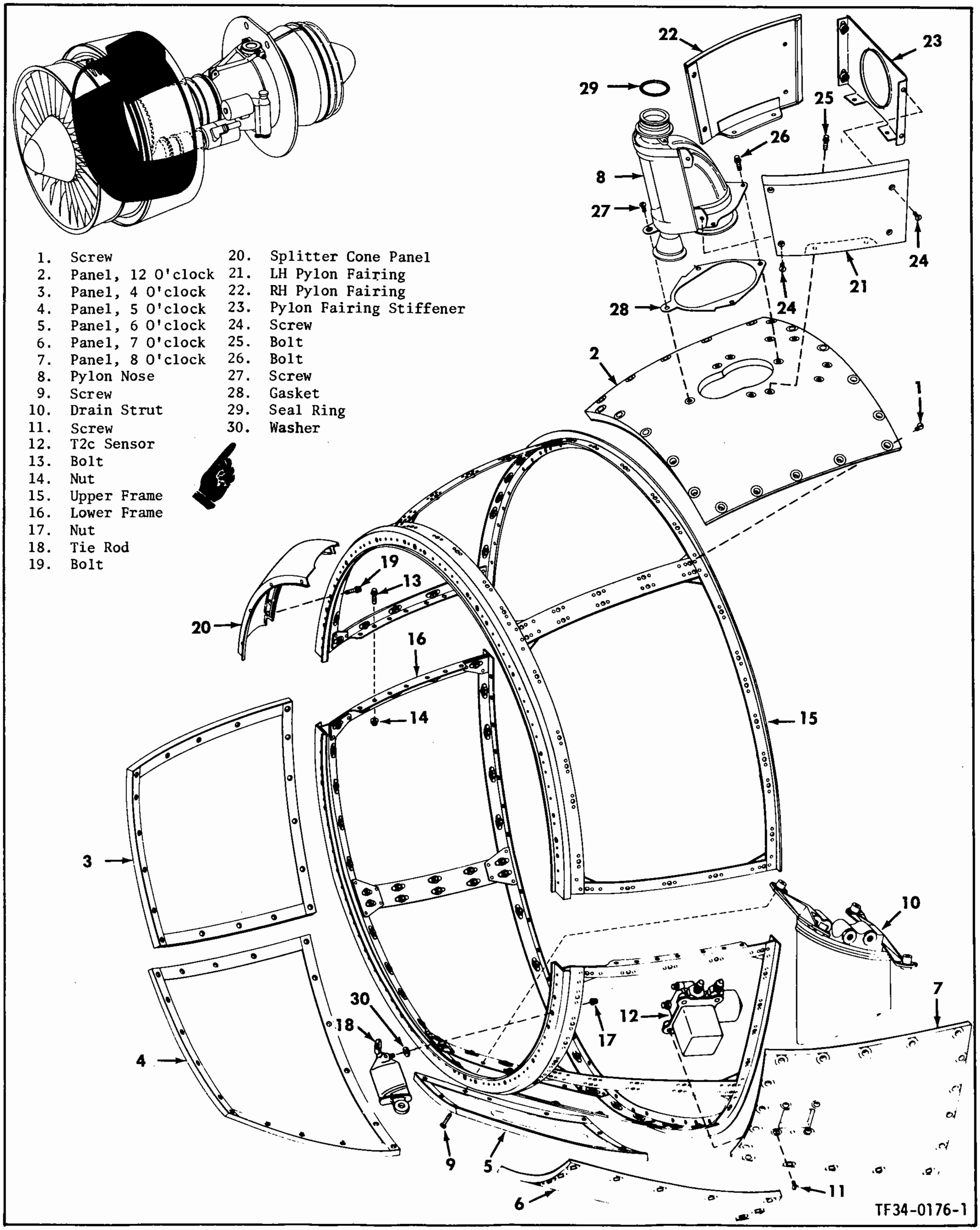


Figure 5-13. Removal of Fan Inner Panels and Frames

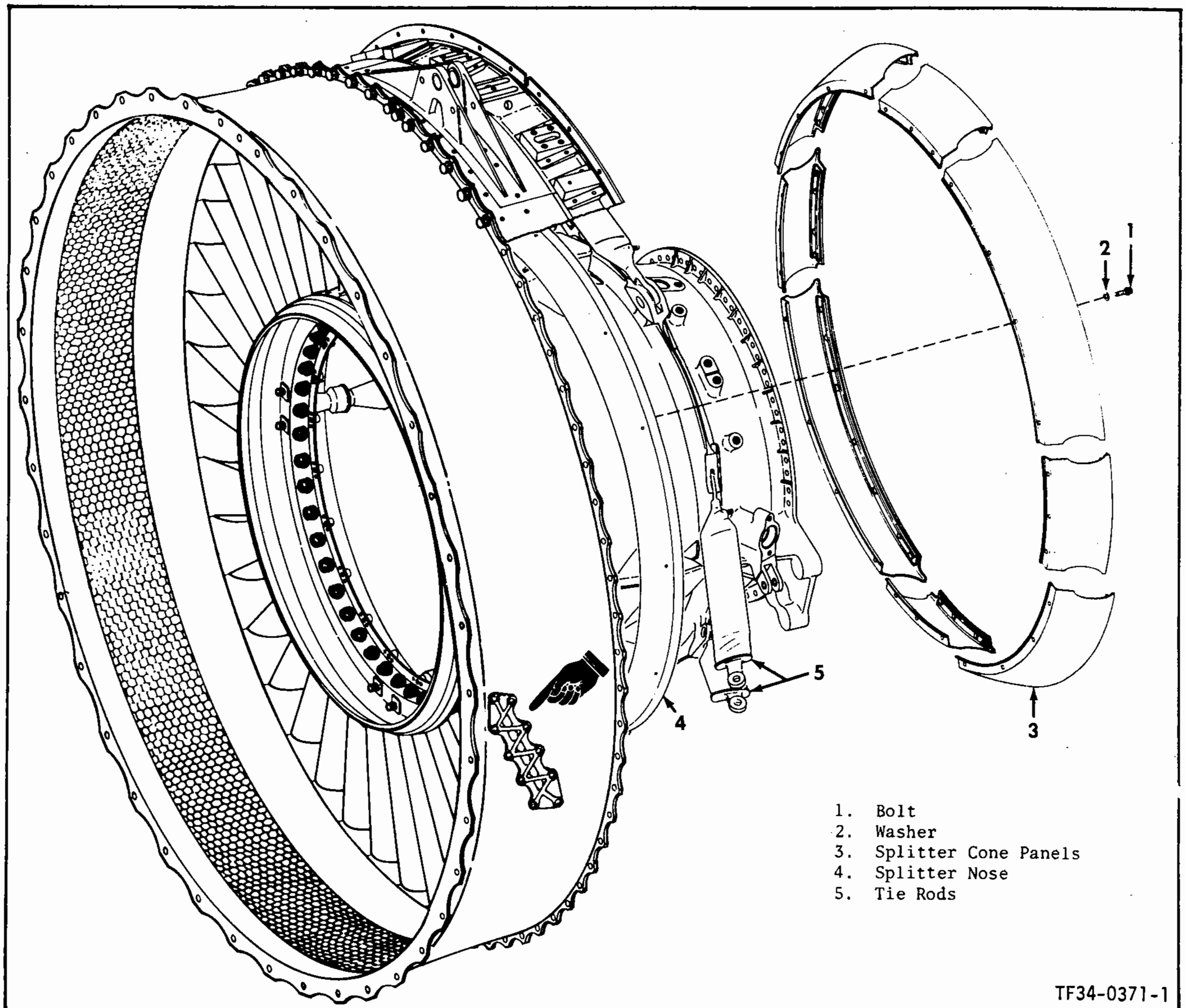


Figure 5-14. Removal of Splitter Cone Panels

5. Remove 8 tie rod pins (12) from the fan stator assembly.

6. Remove 2 nuts (11) from the 2 tie rod eccentric pins (8) at the 12 o'clock position on front frame. Match-mark the lockarms (9) to the pins (8) at the mating splines with Dykem or equivalent. This will make stator realignment easier at reassembly. Keep parts with tie rods when removed.

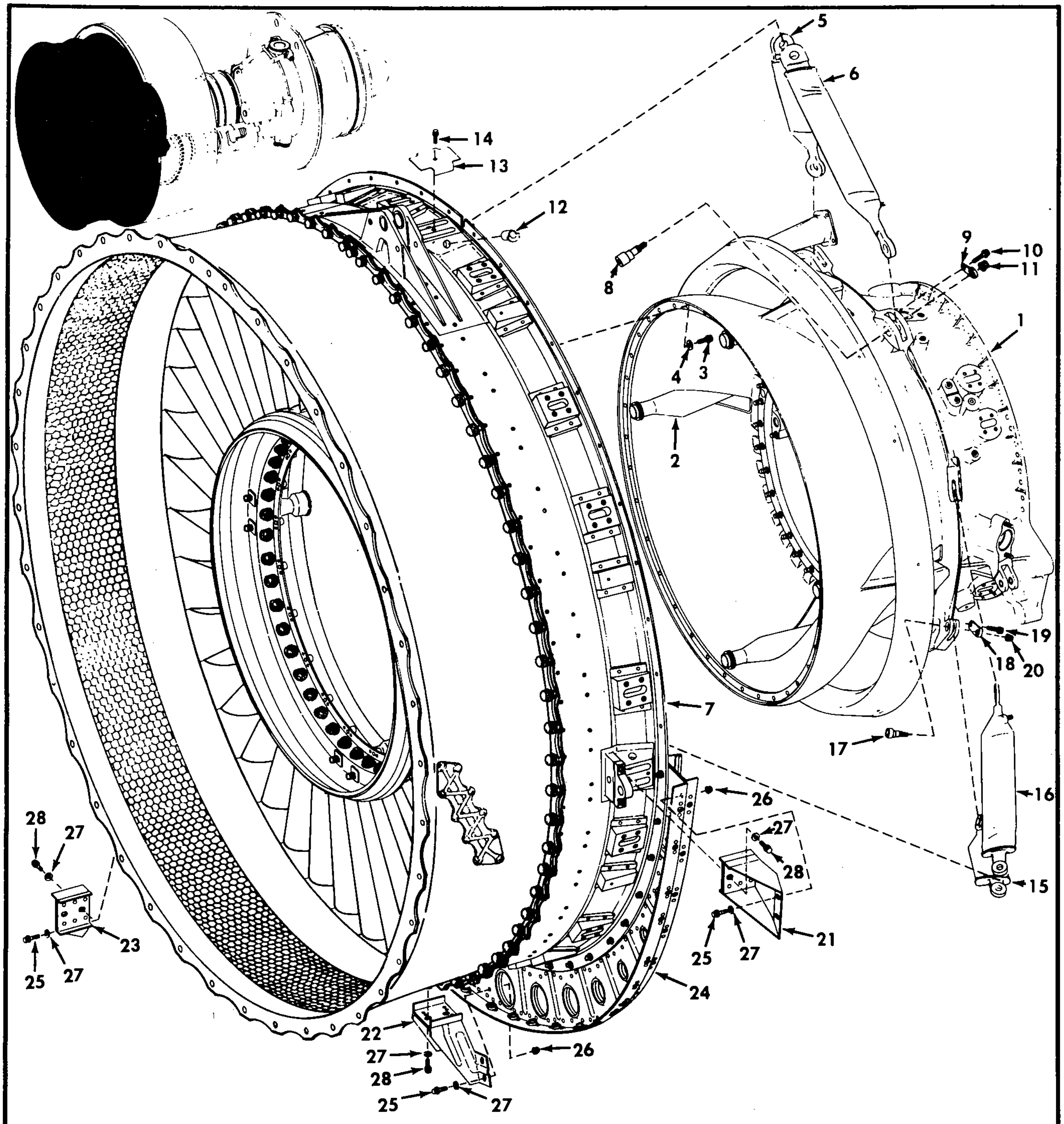
7. Remove 2 bolts (10), 2 lockarms (9), and 2 pins (8) from tie rods (5, 6) at the 12 o'clock position on the front frame. Remove tie rods.

8. Repeat steps 6 and 7 for 6 nuts (20), 6 bolts (19), 6 lockarms (18) and 6 eccentric pins (17). Remove tie rods (15, 16).

9. Attach hoisting adapter (21C5101) to forward engine mount. Remove quick-release pins and remove the fan stator assembly.

10. If necessary, remove lockwire and 8 bolts (4, figure 5-16) connecting 4 anti-icing tubes (5) to splitter nose (1). Pull tubes aft and remove splitter nose.

11. Install front frame adapter ring (21C5177) and connect it to forward engine mount (21C5189). Remove support (21C5219).



1. Front Frame
2. Anti-Icing Tube
3. Bolt
4. Washer
5. Tie Rod - 12 O'clock Position, Right-hand
6. Tie Rod - 12 O'clock Position, Left-hand
7. Fan Stator Casing
8. Eccentric Pin
9. Lockarm
10. Bolt
11. Nut
12. Pin
13. Cover
14. Bolt
15. Tie Rod - Left-hand
16. Tie Rod - Right-hand
17. Eccentric Pin
18. Lockarm
19. Bolt
20. Nut
21. Bracket - 9 O'clock Position
22. Bracket - 6 O'clock Position
23. Bracket - 3 O'clock Position
24. Flange Adapter
25. Bolt
26. Nut
27. Washer
28. Bolt

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Figure 5-15. Removal of Fan Stator Assembly

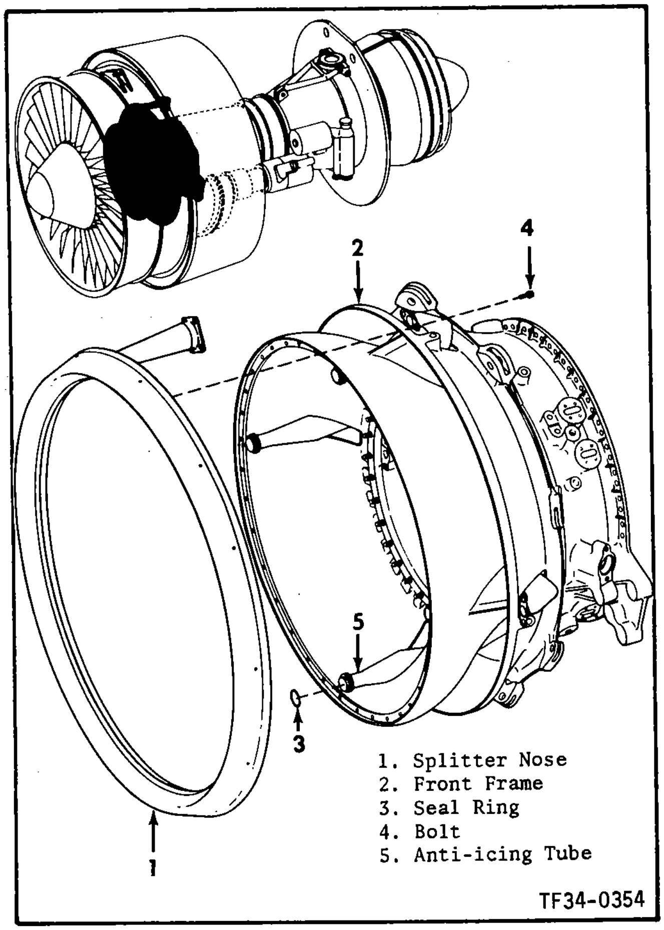


Figure 5-16. Removal of Splitter Nose

5-17. REMOVAL OF ACCESSORY DRIVE GEARBOX. For Special Tools, see table 2-1, group 22.

1. Disconnect harness and all hoses and tubes connected to accessory gearbox and accessories, if installed. Remove the fuel control, fuel pump and lube and scavenge pump per Section IV if gearbox is being replaced.

2. Remove 4 screws (2, figure 5-17) and cover (3) from bottom of accessory gearbox. Discard packing (4).

3. Remove retaining ring (5), drive shaft retainer (6), and radial drive shaft (7).

4. Install fixture (21C5064) onto accessory drive gearbox.

5. Remove lockwire, 10 bolts (8) and 2 bolts (9) connecting 3 gearbox brackets (14, 15) to compressor front frame. Remove laminated shim (13).

CAUTION

Be sure that gearbox does not get hung up in front frame and that all piping is disconnected.

6. Slowly lower accessory gearbox using fixture (21C5064).

7. Use puller (21C5234) and remove packing retainer (16) and packings (17, 18). Discard packings.

5-18. REMOVAL OF POWER TAKEOFF ASSEMBLY

1. Remove nut (12, figure 5-18) holding air tube (11) to front frame boss at 3 o'clock position. Remove air tube (11) and discard packings (9, 10).

2. Remove 11 nuts (5) securing the PTO assembly (4) to the front frame (13).

CAUTION

Be sure radial driveshaft has been removed before attempting to remove PTO.

3. Thread 4 bolts (10-32 thread), into jacking screw holes in PTO flange. Turn each bolt in a half turn at a time, alternating from side to side, until PTO assembly is free. Remove the 4 bolts from PTO flange and remove seal ring (3).

4. Remove oil tube (1) from front frame and discard packings (2).

5. If necessary, remove nut (8) holding vent tube (7) to boss in front frame at 6 o'clock position. Remove vent tube and discard packing (6).

5-19. REMOVAL OF VARIABLE GEOMETRY CONTROL LINKAGE.

1. Remove cotter pins (16, figure 5-19), clevis pins (14), and washers (15) from actuator bellcrank.

2. Remove cotter pins (12), clevis pins (9, 10) and washers (11) from rod end bearings, IGV through stage 5.

3. Remove bolts (7) and nuts (8) at forward bearing on the front frame to compressor flange.

4. Remove bolts (4), washers (5), and nuts (6) from middle bearing at the stage 2 vane rib.

5. Pull linkage assembly (1) out and forward; slide linkage out of aft bearing.

NOTE

In order for the middle bearing to clear the compressor casing, it may be necessary

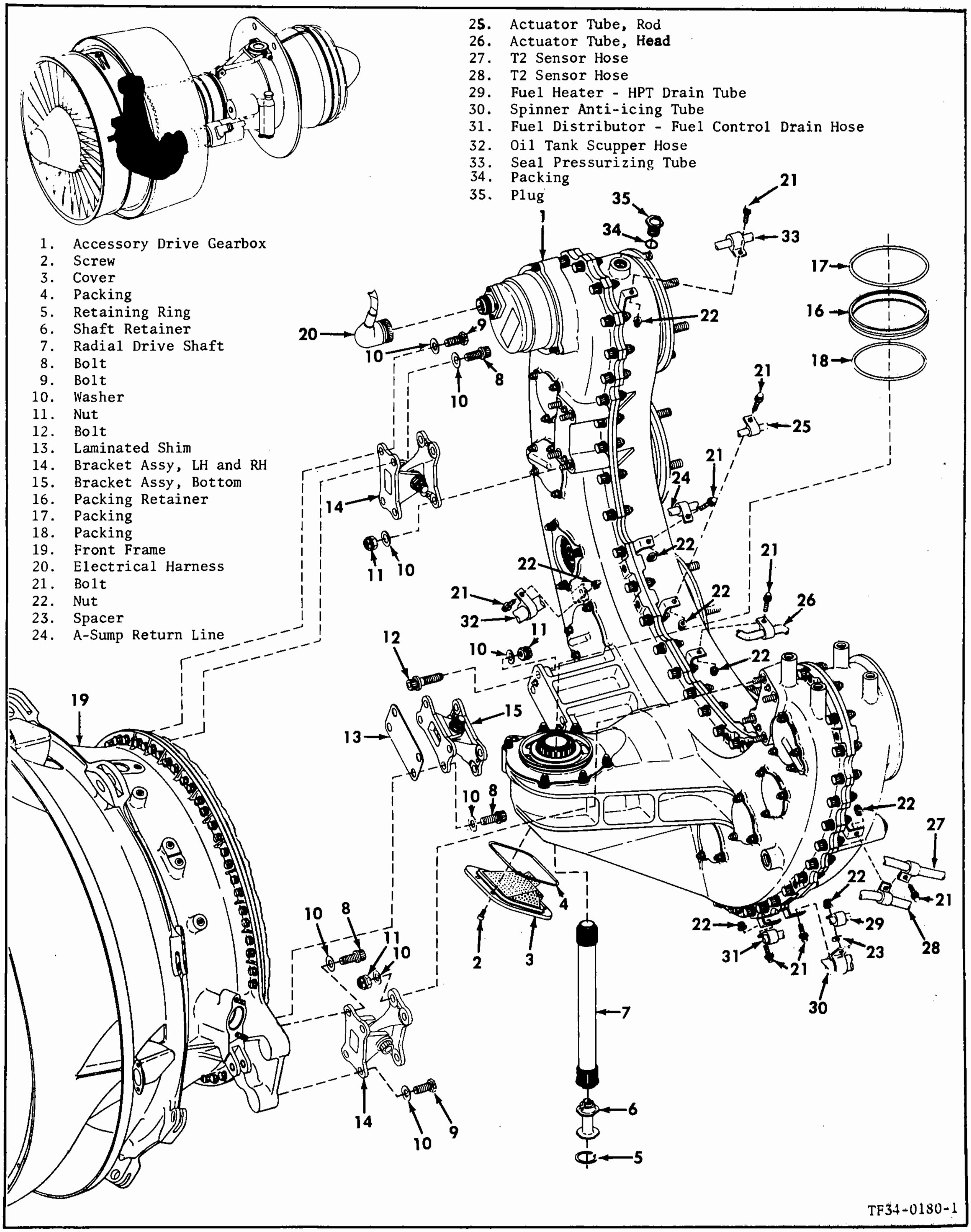


Figure 5-17. Removal of Accessory Drive Gearbox

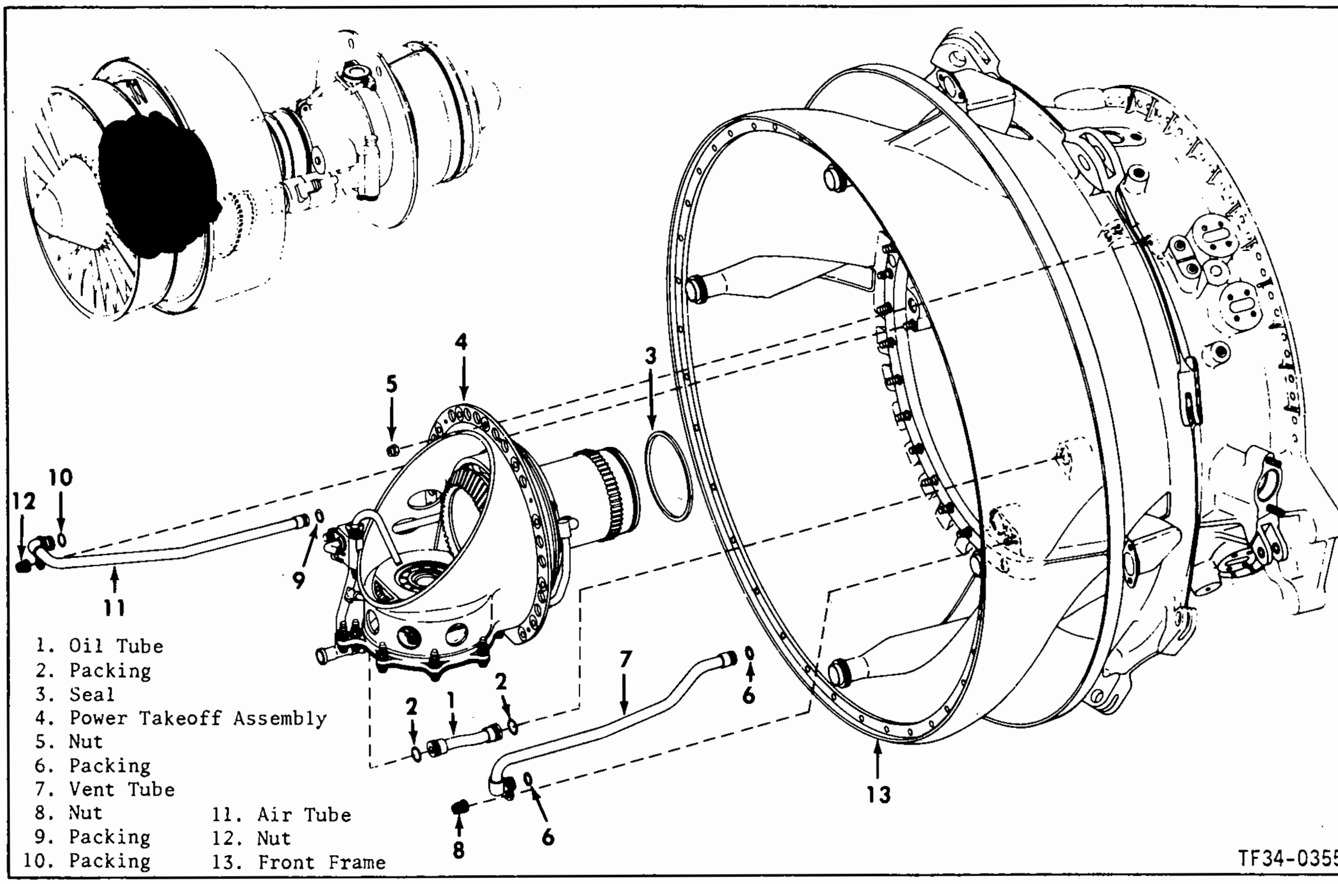


Figure 5-18. Removal of Power Takeoff Assembly

to loosen nuts holding aft bearing (3) to compressor casing.

5-20. REMOVAL OF COMPRESSOR STATOR ASSEMBLY. For special tools, see table 2-1, group 10.

1. Remove fan outer cowl, fan inner cowl, accessory gearbox, and variable geometry linkage as described in this section. Remove accessories as described in section IV.

2. Remove 8 nuts (1, figure 5-20) on IGV bridges (4). Remove 6 bolts (2) and 2 clevis arms (3).

3. Use spreader (21C5068) and remove 8 clips (5) from bridges. Remove 8 pins (6) and remove IGV bridges (4). Discard clips.

4. Remove 8 nuts (7) from stage 1 bridges (9). Slowly work the bridges outward from the casing until the pins in the bridges are free of actuator rings.

5. Repeat step 4 for bridges (10, 11, 12, 13) on stages 2 through 5.

6. Remove bolts and nuts from circumferential flanges on top casing half (14). See figures 5-21 and 5-22.

7. Remove split line bolts (16, 17, 18, figure 5-20) and nuts (19, 20).

8. Remove 5 bolts and nuts from each side of engine at compressor-combustion chamber flange, bottom casing half (see figure 5-22). Install guide pins (21C5159) through the bolt hole in compressor splitline and attach guide pin base to compressor-combustion chamber flange, using flange bolts (3, figure 5-22).

9. Install support (21C5219 or 21C5166) under front frame flange. Raise support just enough to take the weight off the compressor stator.

10. Install support (21C5220) onto support (21C-5190) under forward end of combustion chamber. Raise support just enough to take the weight off compressor stator.

11. Install handle (21C5067) to compressor casing top half at 12 o'clock position. Carefully

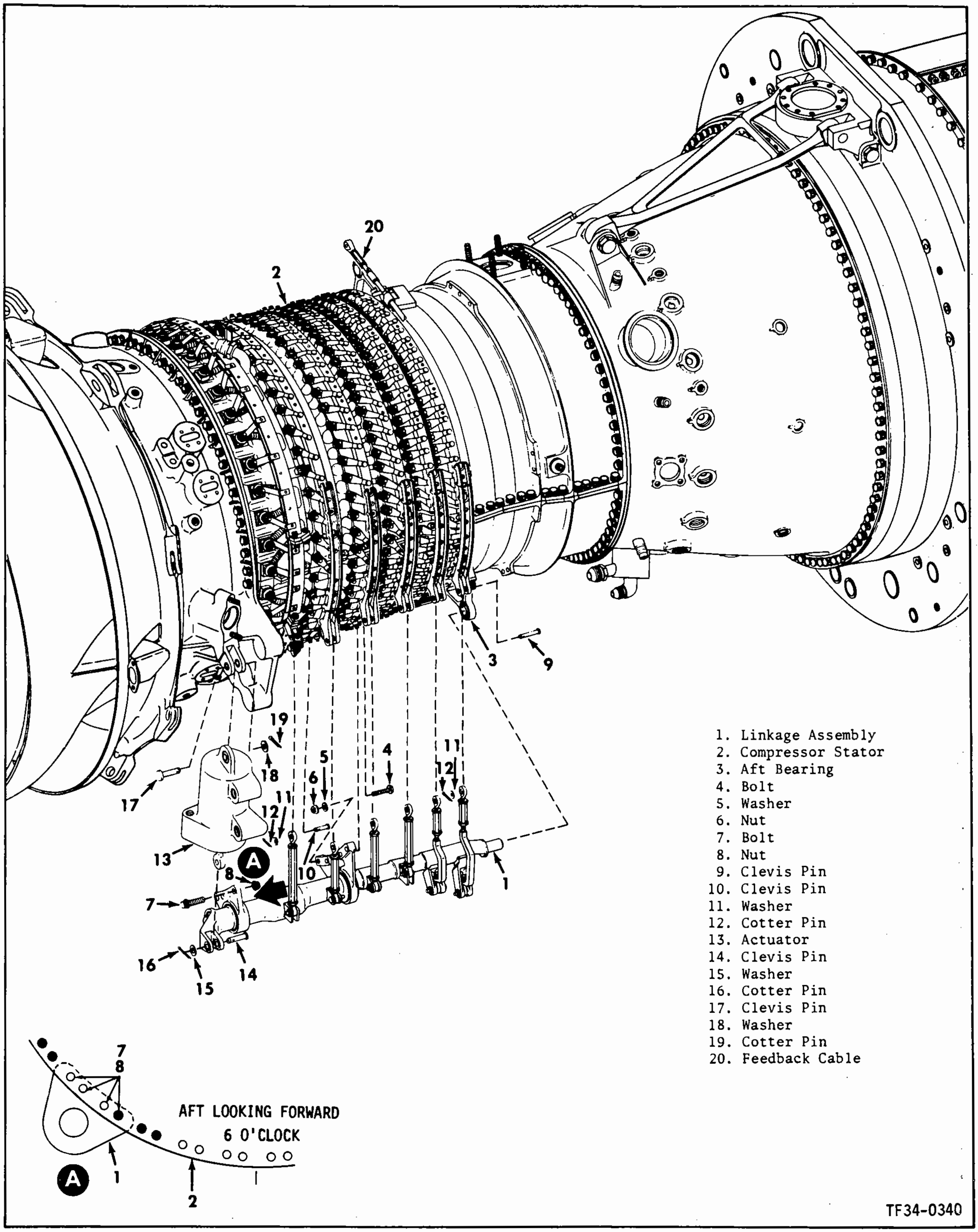
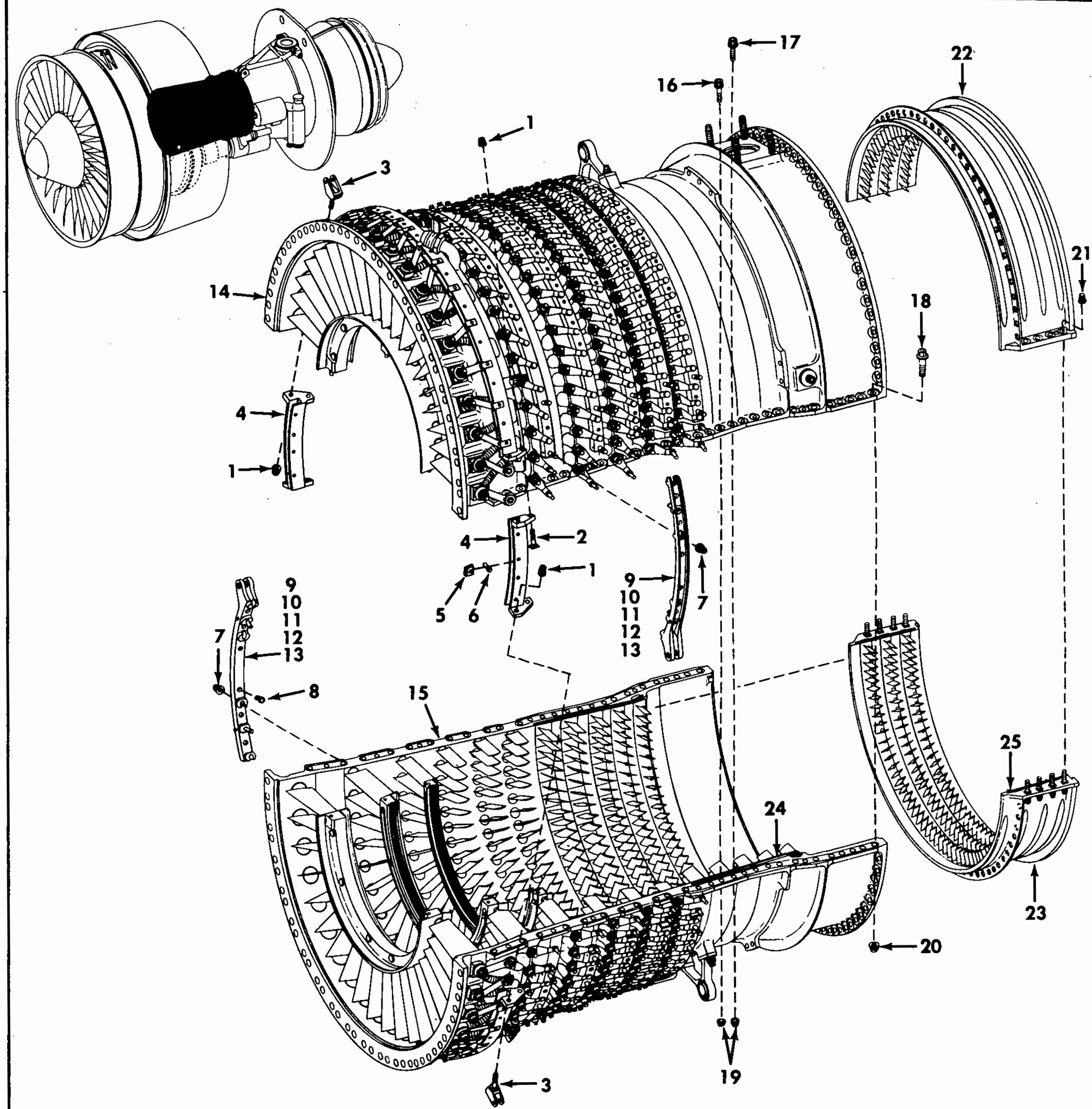


Figure 5-19. Removal of Variable Geometry Control Linkage



1. Nut
2. Bolt, Square Head
3. Clevis Arm
4. IGV Bridge
5. Clip
6. Pin
7. Nut
8. Vane Arm Bushing
9. Stage 1 Bridge
10. Stage 2 Bridge
11. Stage 3 Bridge
12. Stage 4 Bridge
13. Stage 5 Bridge
14. Compressor Casing - Top Half
15. Compressor Casing - Bottom Half
16. Body-Bound Bolt
17. Bolt
18. Body-Bound Bolt
19. Nut
20. Nut
21. Nut
22. Rear Casing - Top Half
23. Rear Casing - Bottom Half
24. Anti-Rotation Key
25. Anti-Rotation Key

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Figure 5-20. Removal of Compressor Stator Assembly

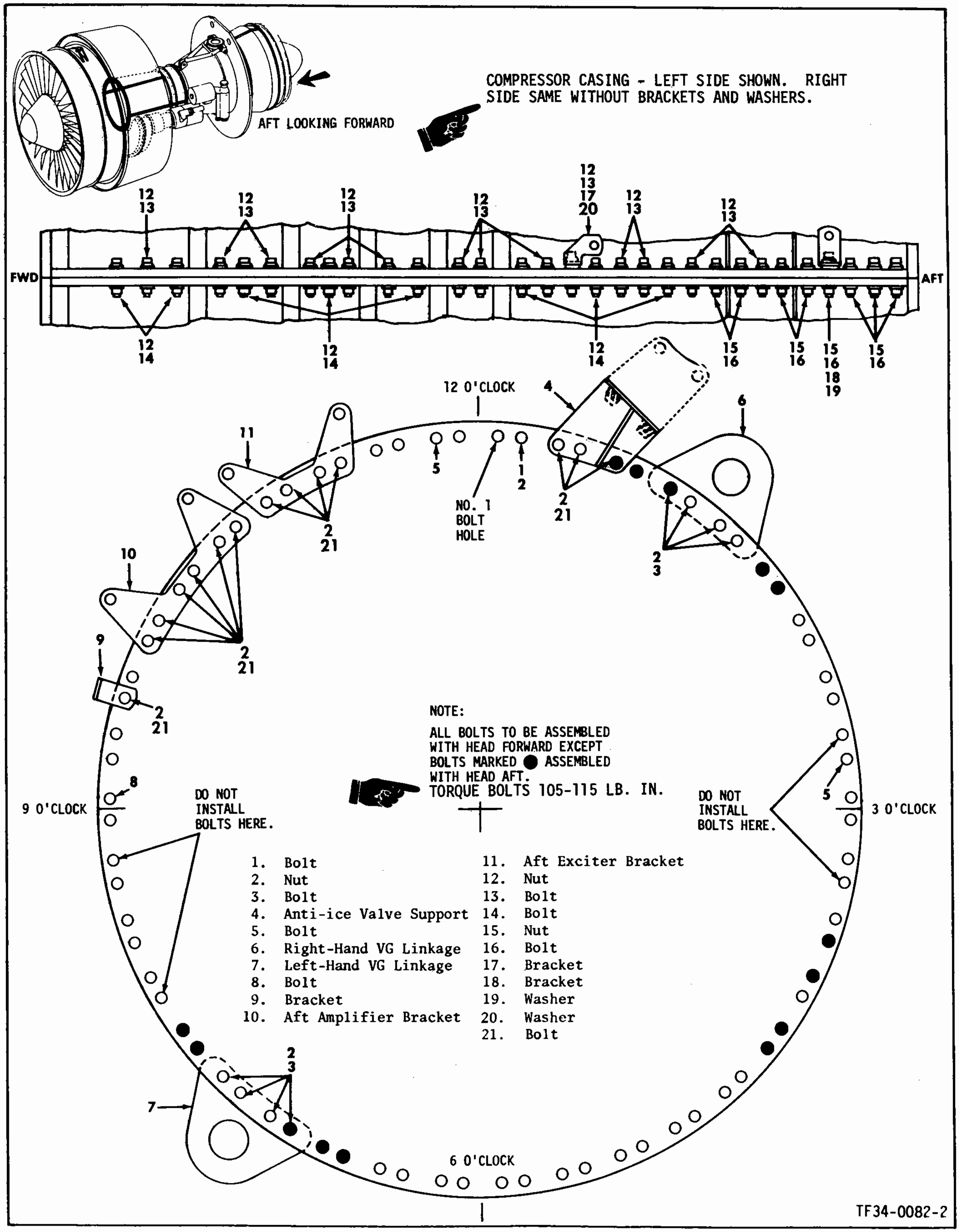


Figure 5-21. Bolting Diagram - Compressor Casing to Front Frame and Compressor Casing Split Line

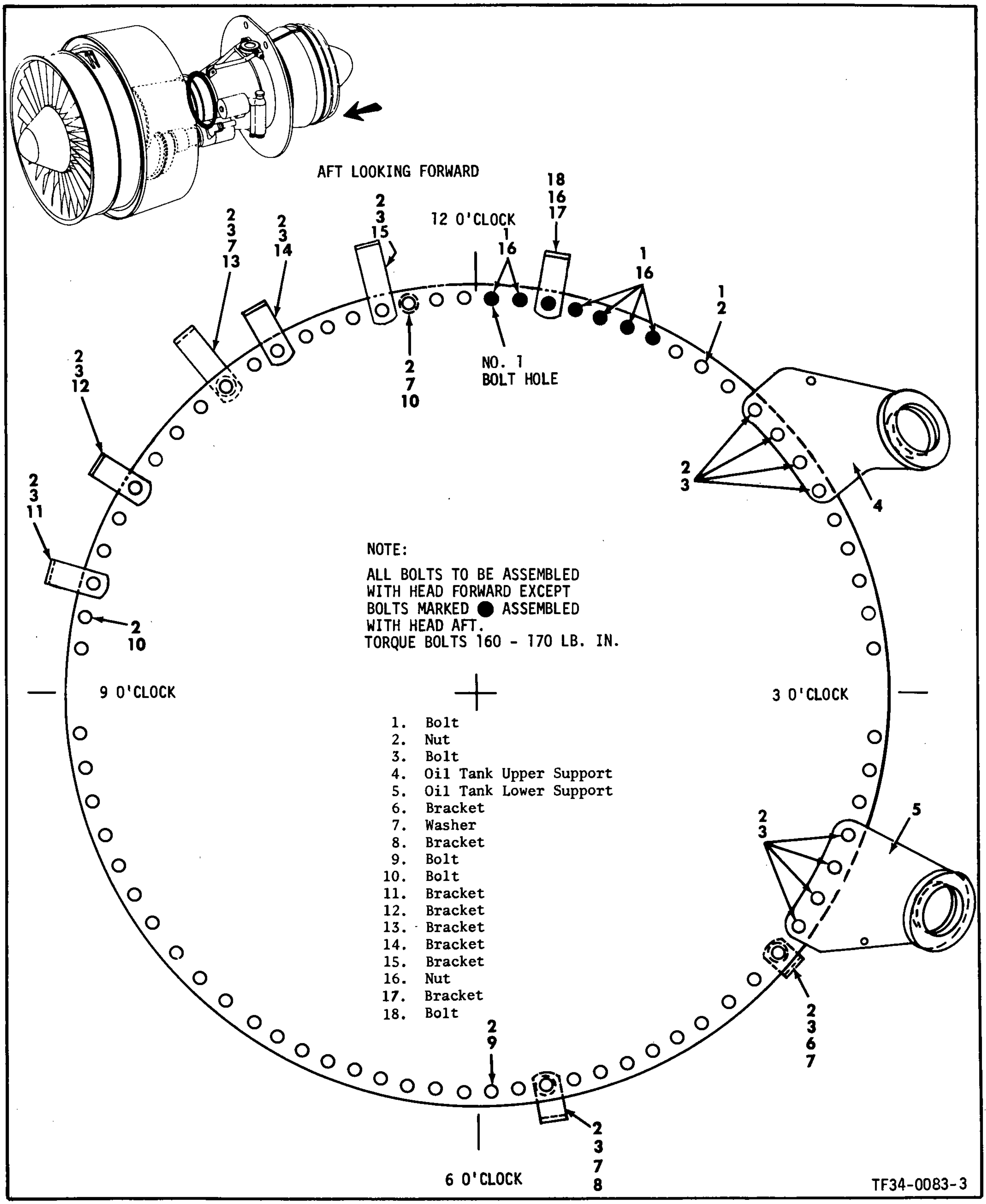


Figure 5-22. Bolting Diagram - Compressor Casing to Combustion Chamber

remove top casing half (14, figure 5-20) from engine. Remove guide pins (21C5159).

12. Remove 4 nuts (21) from rear casing splitline. Use two 1/4-28 bolts, 1 on each splitline, as jacking screws and separate the top half of rear casing (22) from bottom half (23). Carefully lift top half of rear casing from engine.

13. Assemble retainer (21C5178) to studs of bottom half of rear casing (23).

14. Assemble 3 dummy casing bars (21C5132) to engine, 1 at 12 o'clock position and 1 at 11 o'clock and 1 o'clock. Bolt dummy casing bars with engine hardware. Torque bolts to 105-115 lb in.

15. Assemble guide pins (21C5159) through holes in bottom half of compressor casing (15). Bolt guide pins to combustion chamber flange.

16. Remove all circumferential flange bolts from forward and aft end of compressor casing; remove bottom casing half.

17. Remove nuts (21) holding retainer (21C5178) to bottom half of rear casing (23). Remove retainer and rear casing. Remove guide pins (21C5159).

18. Install support (21C5174) under compressor rotor. Raise cradle arms so that the compressor rotor is supported by the support.

19. Remove dummy casing bars (21C5132).

5-21. REMOVAL OF COMBUSTION CHAMBER MODULE. For special tools, see table 2-1, group 4.

1. Adjust support (21C5220) so that the weight of compressor rotor is on compressor rotor support (21C5174), and not on the No. 4 bearing.

2. Install combustion module guide (21C5169) through the combustion chamber and hold outer portion while threading inner portion onto compressor rear shaft.

3. Loosen locks on rear engine support (21C-5190) and slowly roll combustion module (1, figure 5-23) away from compressor rotor until module hits the stop on guide (21C5169). Remove guide from compressor rotor rear shaft.

4. Bolt hoisting adapter (21C5198) to aft mount ring at 3 and 9 o'clock positions. Assemble lifting sling (21C5210) to trunnious of hoisting adapter (21C5198).

5. Remove quick-release pins (part of 21C5190) from mount ring and carefully lift combustion module away from rear engine support.

6. Place combustion chamber module in buildup stand (21C5116). Remove lifting (21C5210) and hoisting adapter (21C5198).

7. Disassemble combustion module per paragraph 5-30.

5-22. REMOVAL OF COMPRESSOR ROTOR. For special tools, see table 2-1, group 9.

1. Remove 8 nuts (3, figure 5-24) holding bearing retainer (2) to No. 3 bearing housing. Remove retainer (3) and shim (1).

2. Loosen locks on forward engine support (21C5189) and carefully roll the front frame forward until it is free of compressor rotor.

3. Assemble lifting adapters (part of 21C5089) to forward and aft ends of compressor rotor (8). Attach lifting sling (21C5210) to adapters and lift rotor from support (21C5174).

4. Install compressor rotor into buildup fixture (21C5089). Remove lifting sling (21C5210).

5. Remove and discard packings (4, 6, 7).

6. If necessary, remove the following parts from the front frame:

a. At 6 o'clock position, inside radial driveshaft hole, remove nut (12) and oil nozzle (11). Discard packing (10).

b. Remove 8 bolts (16), 7 spray nozzles (15), and 1 inlet nozzle (14). Remove and discard 8 packings (13).

c. Remove 24 bolts (19), 6 instrumentation covers (17), and shims (18).

d. Remove 3 plugs (20).

5-23. DISASSEMBLY OF LOW-PRESSURE TURBINE MODULE. For special tools, see table 2-1, group 28.

1. Place low-pressure turbine module in stand (21C5085). Raise jacking mechanism until it just supports the low-pressure rotor.

2. Remove retainer (21C5041) from exhaust frame.

3. Remove 20 bolts (4, figure 5-25) holding No. 7 bearing housing (5). Remove bearing housing and packing (18).

4. Remove retaining ring (1) and keywasher (2) securing No. 7 bearing locknut (3).

5. Use spanner wrench (21C5197) and remove locknut (3).

6. Use puller (21C5052) and remove the No. 7 bearing inner race (6) and the oil/air separator (7).

7. Remove oil tube (8) and discard packings (9).

8. Remove 2 bolts (10) and nuts (11) from tubes (12, 15). Remove 2 bolts (13) from exhaust frame

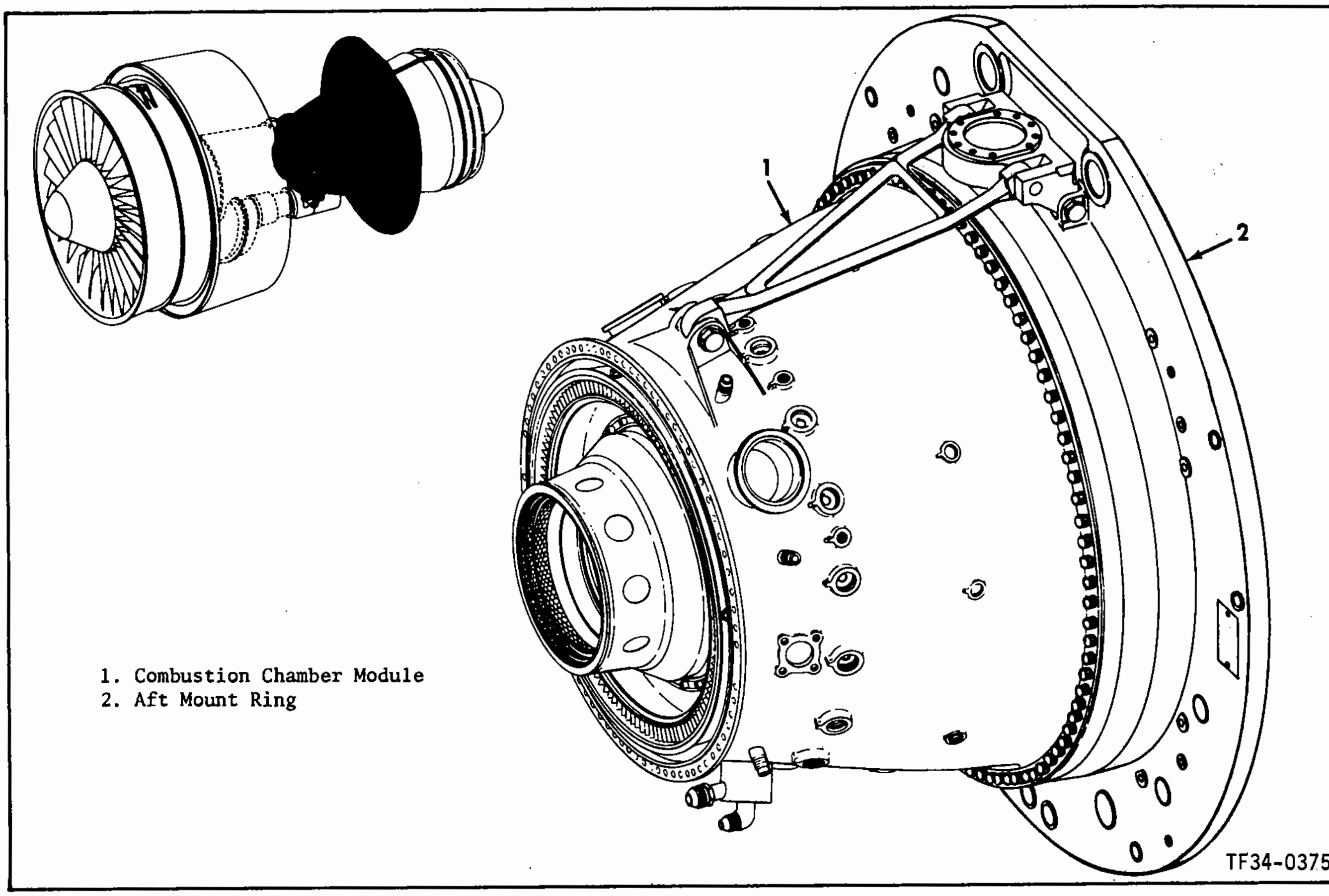


Figure 5-23. Removal of Combustion Chamber Module

outer casing at 12 o'clock position and pull back seal pressurizing tube (15).

9. Remove all flange and splitline bolts from the low pressure turbine casing. Use handle (21C5133) and remove 1 turbine casing half. Attach 2 dummy casing bars (21C5131). Remove second casing half and attach another dummy casing bar.

9A. Remove retaining ring (1, figure 5-26) from No. 6 bearing locknut.

10. Remove 20 bolts (16, figure 5-25) from No. 6 bearing housing (17). Remove the bearing housing and tube (12). Remove and discard packing (18).

11. Remove 2 bolts (19), 2 nuts (20) and scavenge tube (21). Discard packing (22).

12. Remove carbon seal (23).

13. Remove exhaust frame (14) and remove dummy casing bars (21C5131).

14. Remove 6 screws (26), 3 nut assemblies (27) and remove heat shield (24).

15. Lift low-pressure turbine rotor from transition assembly

16. Remove transition assembly from stand (21C5085) and reinstall low pressure rotor onto stand.

5-24. DISASSEMBLY OF LOW-PRESSURE TURBINE ROTOR. For special tools, see table 2-1, group 32.

1. Place low-pressure rotor (5, figure 5-26) in buildup stand (21C5085), forward end down.

2. Use spanner wrench (21C5196) and remove No. 6 bearing locknut.

3. Use puller (21C5138) and remove No. 6 bearing inner race (3) and seal runner (4).

4. Turn rotor so that forward end is up. Use a pin punch and carefully tap out the 3 pins (7) holding air seal (6) in place.

5. Use puller (21C5175) and remove air seal (6).

5-25. DISASSEMBLY OF LOW-PRESSURE TURBINE STATOR. For special tools, refer to table 2-1, group 34.

1. Install right half of turbine casing (1, figure 5-27) in holder (21C5034).

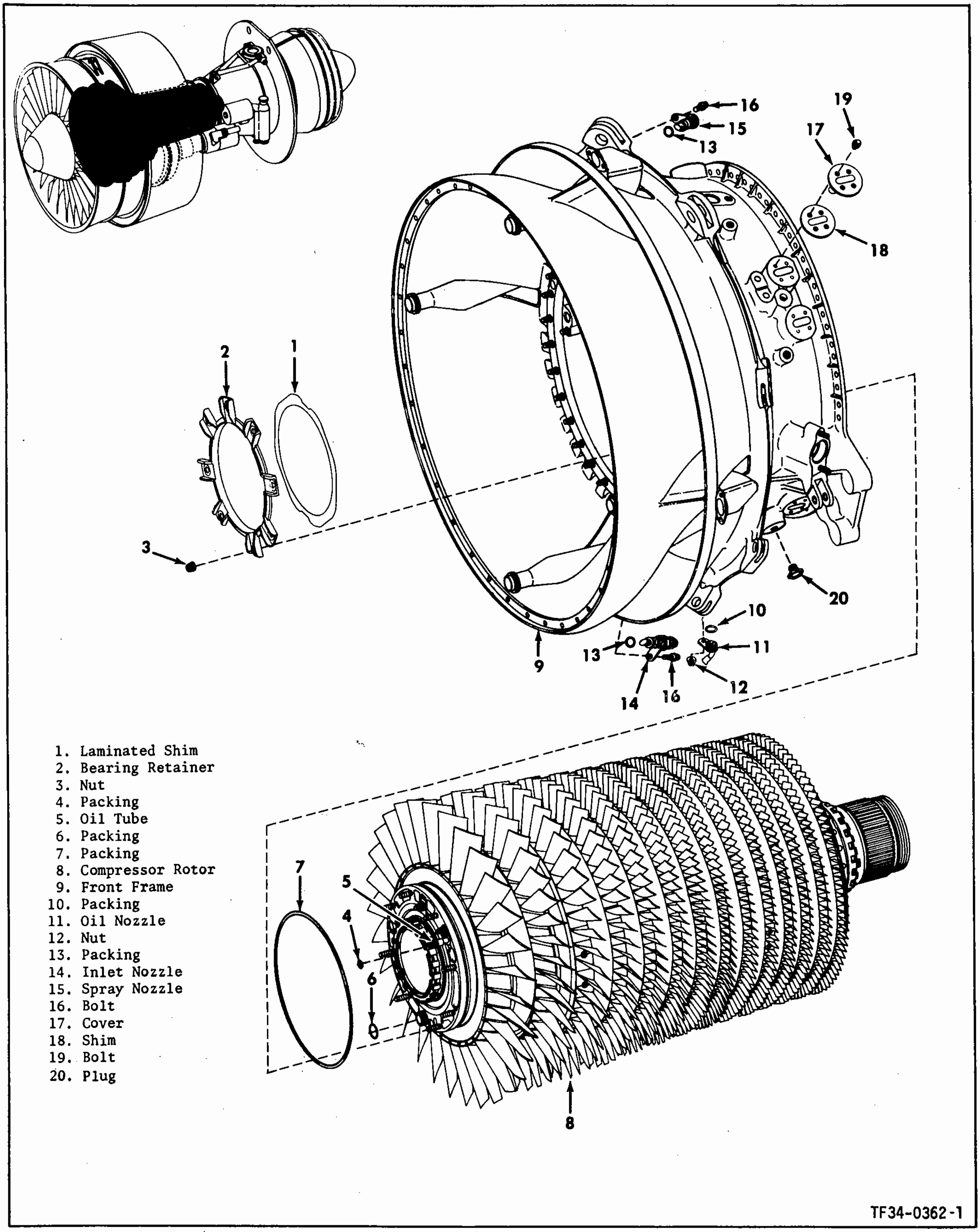
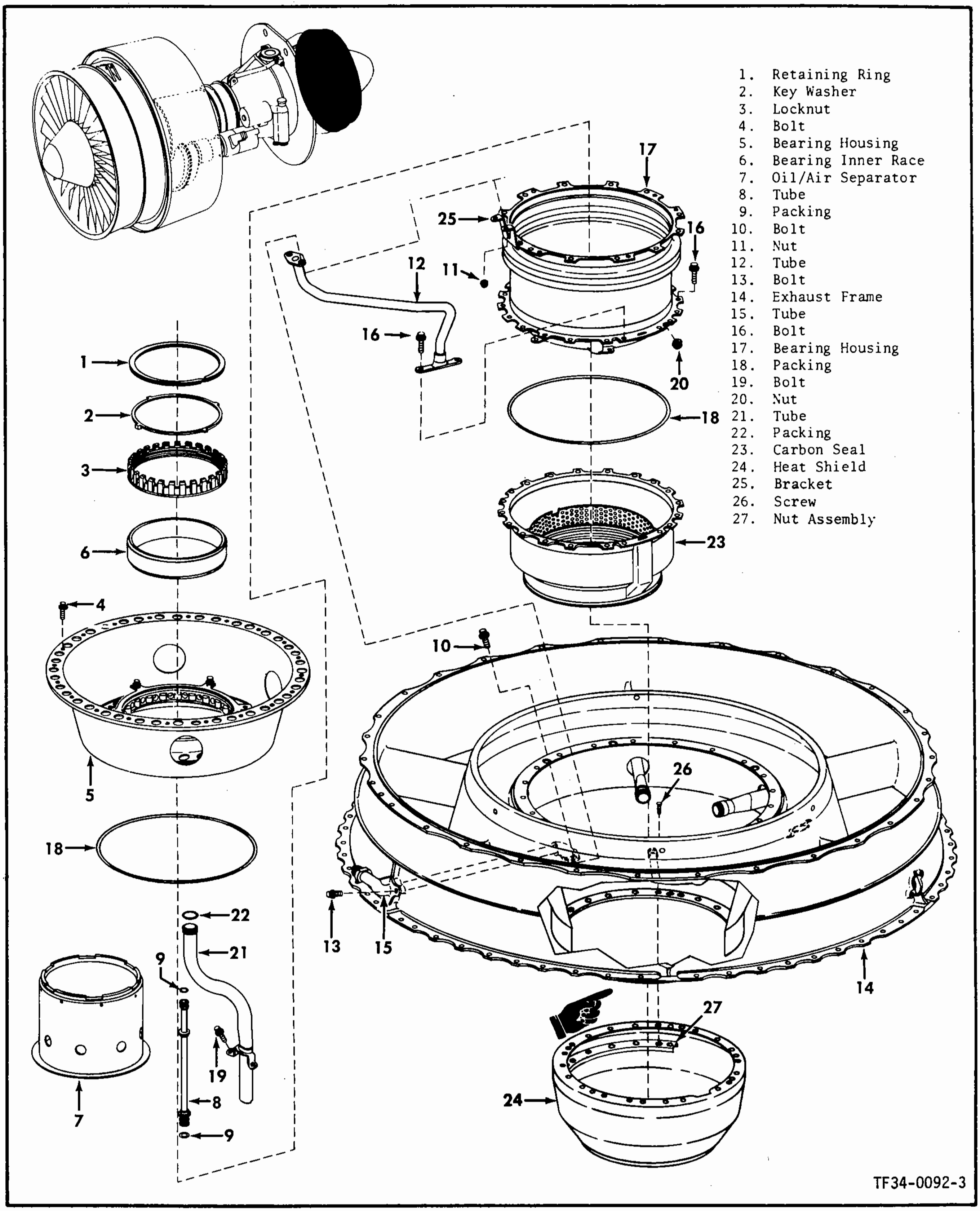


Figure 5-24. Removal of Compressor Rotor Assembly



1. Retaining Ring
2. Key Washer
3. Locknut
4. Bolt
5. Bearing Housing
6. Bearing Inner Race
7. Oil/Air Separator
8. Tube
9. Packing
10. Bolt
11. Nut
12. Tube
13. Bolt
14. Exhaust Frame
15. Tube
16. Bolt
17. Bearing Housing
18. Packing
19. Bolt
20. Nut
21. Tube
22. Packing
23. Carbon Seal
24. Heat Shield
25. Bracket
26. Screw
27. Nut Assembly

Figure 5-25. Disassembly of Low-Pressure Turbine Module

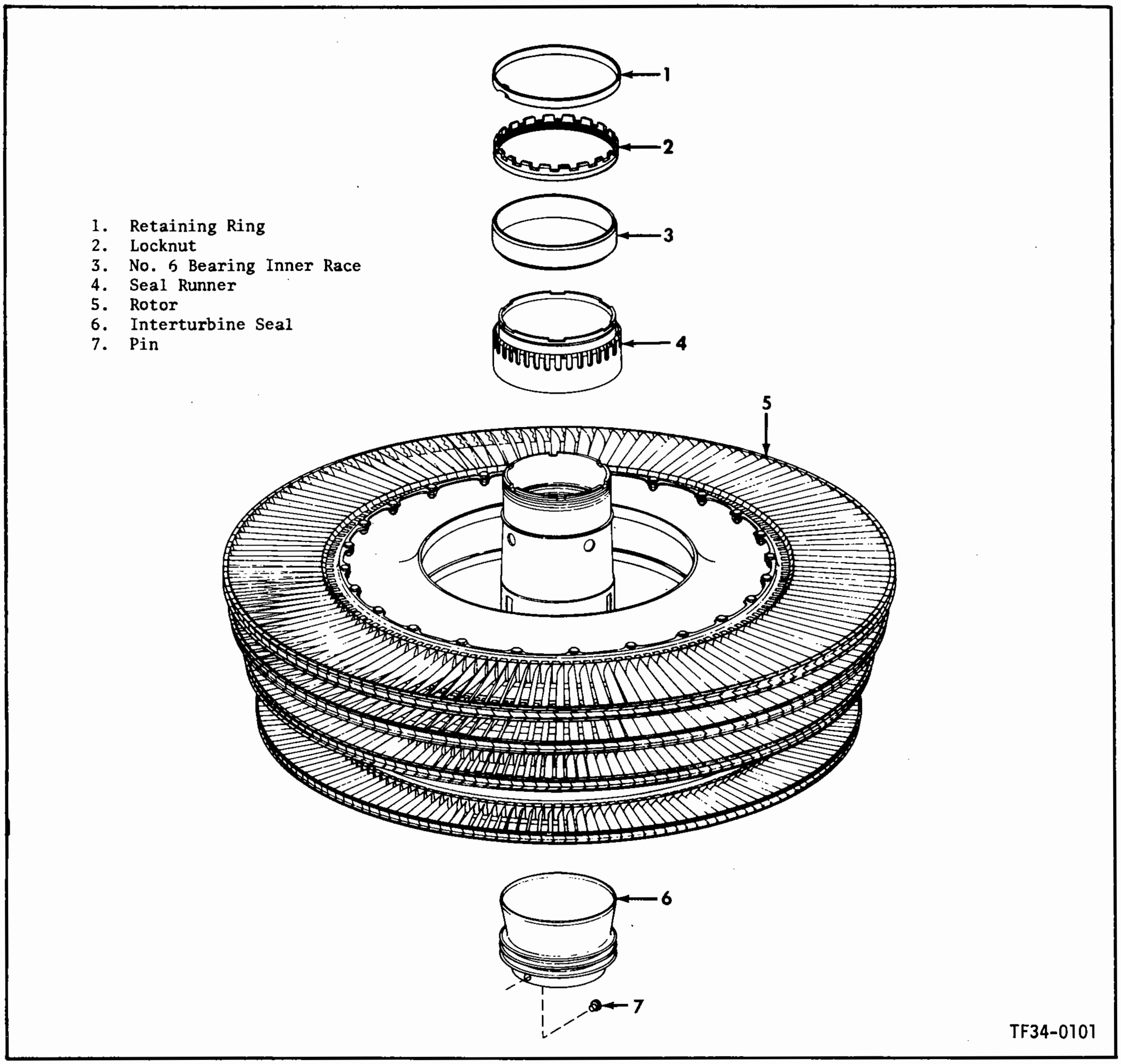


Figure 5-26. Disassembly of Low-Pressure Turbine Rotor

NOTE

Record part number, quantity, and positions of nozzle segments. The quantity and positions of nozzle segments must be the same after reassembly as before disassembly.

2. Unbend clips (11). Remove 11 pins (10) and 11 clips (11). Discard clips. Remove stage 6 seals (12, 13) and connector (14). Discard connector.

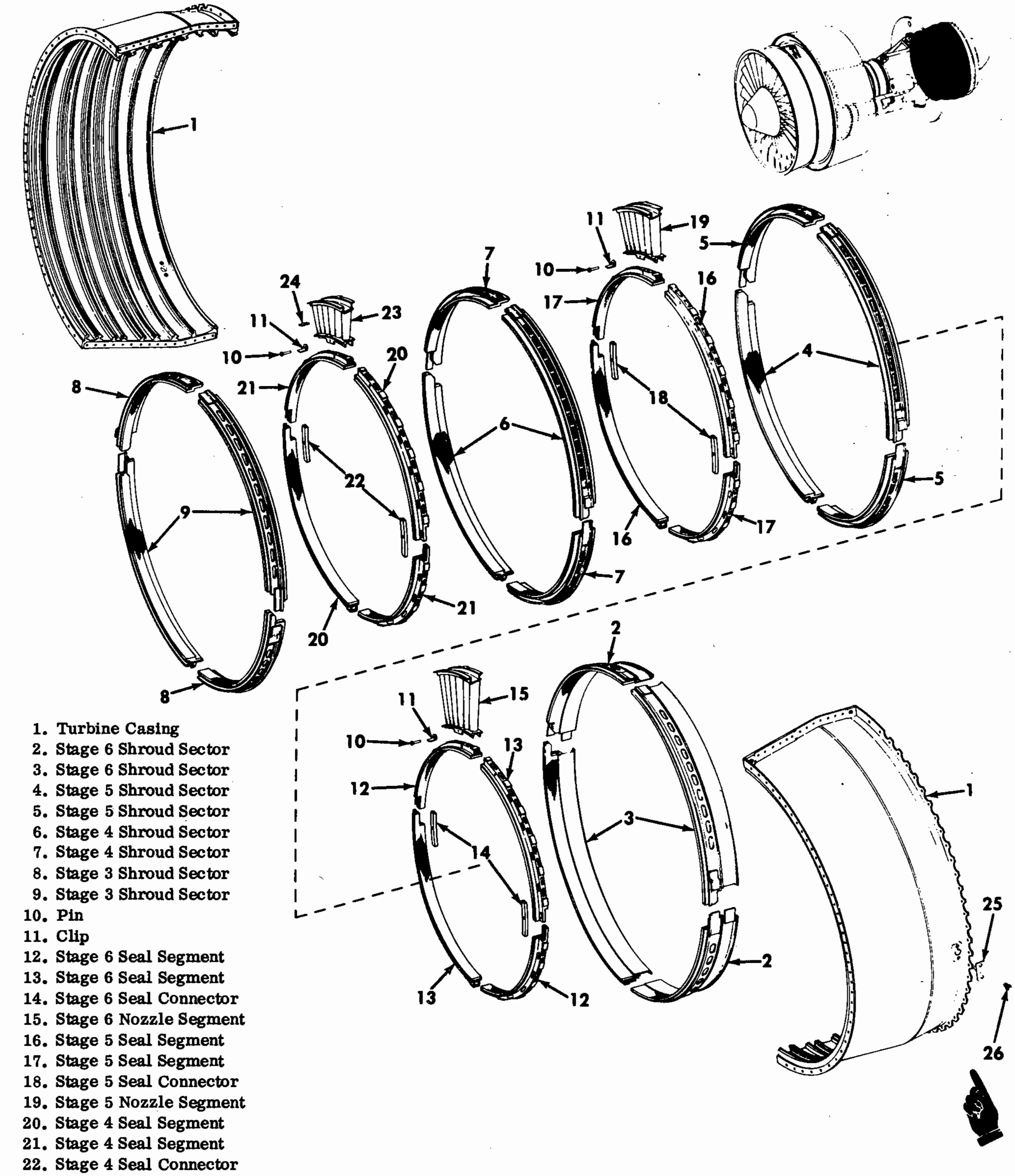
3. Remove stage 6 shrouds (2, 3).

4. Remove 11 stage 6 nozzle segments (15) from casing half.

5. Unbend clips (11). Remove 10 pins (10) and 10 clips (11). Discard clips. Remove stage 5 seals (16, 17) and connector (18). Discard connector.

6. Remove stage 5 shrouds (4, 5).

7. Remove 10 stage 5 nozzle segments (19) from casing half.



1. Turbine Casing
2. Stage 6 Shroud Sector
3. Stage 6 Shroud Sector
4. Stage 5 Shroud Sector
5. Stage 5 Shroud Sector
6. Stage 4 Shroud Sector
7. Stage 4 Shroud Sector
8. Stage 3 Shroud Sector
9. Stage 3 Shroud Sector
10. Pin
11. Clip
12. Stage 6 Seal Segment
13. Stage 6 Seal Segment
14. Stage 6 Seal Connector
15. Stage 6 Nozzle Segment
16. Stage 5 Seal Segment
17. Stage 5 Seal Segment
18. Stage 5 Seal Connector
19. Stage 5 Nozzle Segment
20. Stage 4 Seal Segment
21. Stage 4 Seal Segment
22. Stage 4 Seal Connector
23. Stage 4 Nozzle Segment
24. Seal Strip
25. Plug
26. Bolt

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Figure 5-27. Disassembly of Low-Pressure Turbine Stator

8. Unbend clips (11). Remove 11 pins (10) and 11 clips (11). Discard clips. Remove stage 4 seals (20, 21) and connector (22) from the ID of the stage 4 nozzle. Discard connector.

9. Remove the stage 4 shrouds (6, 7).

10. Remove the stage 3 shrouds (8, 9).

11. Remove stage 4 nozzle segments (23) and seals (24) between segments, from casing half (1).

12. Remove casing from holder (21C5034).

13. Install left half of casing in holder (21C-5034).

NOTE

Record part number, quantity, and position of nozzle segments. The quantity and position of nozzle segments must be the same after reassembly as before disassembly.

14. Disassemble left half of turbine casing by following steps 2 through 12.

5-26. DISASSEMBLY OF TURBINE TRANSITION ASSEMBLY.

1. Place transition casing (6, figure 5-28) on bench, forward side down.

2. Consecutively number the 11 nozzle segments (2) in a clockwise direction and match-mark segment number 1 to the inner liner (1).

3. Match-mark the inner liner (1) to the outer liner (5).

4. Match-mark outer liner (5) to casing (6).

5. Grasp inner liner (1) by interturbine seal and carefully remove inner liner-nozzle subassembly from transition casing.

6. Separate the nozzle segments (2) and seals (3, 4) from inner liner (1). Discard seals.

7. Remove liner (5) from casing (6).

5-27. DISASSEMBLY OF HIGH-PRESSURE TURBINE ROTOR. For special tools, see table 2-1, group 24.

1. Place the high-pressure turbine rotor (5, figure 5-29) in buildup stand (21C5036 or 21C5039), shaft end up.

2. Set up puller (21C5056) so the reaction element is at the bottom of the puller. Remove oil/air separator (1) from rotor shaft.

3. Remove No. 5 bearing locknut (2) using wrench (21C5195).

4. Set up puller (21C5056) so that the reaction element is near the top of the puller. Remove No. 5 bearing inner race (3) and seal runner (4).

5-28. DISASSEMBLY OF FAN ROTOR. For special tools, see table 2-1, group 17.

1. Place fan front shaft (11, figure 5-30) in holder (21C5037), forward end down.

2. Remove retaining ring (1) and keywasher (2).

3. Remove No. 2 bearing locknut (3), using spanner wrench (21C5192) and torque multiplier (SWE 102) (output drive turned clockwise).

4. Remove No. 2 bearing inner race (4), using puller (21C5021) as follows:

a. Slide outer sleeve of puller back so that jaws are expanded.

b. Guide puller over No. 2 bearing inner race.

c. Slide outer sleeve forward and compress the jaws, engaging the underside of inner race.

d. Attach a hydraulic pump to the puller.

CAUTION

Reduce hydraulic pressure to zero if needle on gage enters yellow zone. Do not build up pressure again until you determine why race will not pull free.

e. Build up hydraulic pressure and remove No. 2 bearing inner race (4).

f. Disconnect hydraulic pump; remove puller and inner race.

5. Remove retaining ring (5) and keywasher (6).

6. Remove No. 1 bearing locknut (7), using wrench (21C5042) and torque multiplier (SWE 8100) (output drive turned clockwise).

7. Remove No. 1 bearing (8) and seal runner (9), using puller (21C5090) as follows:

a. Remove legs from puller and install main section of puller onto front fan shaft.

b. Turn the swiveling jaws on the legs of puller so that the thick ends are down. Put jaws around bearing and connect legs to puller.

c. Attach hydraulic pump to puller.

CAUTION

Reduce hydraulic pressure to zero if needle on gage enters the yellow zone. Do not build up pressure again until you determine why bearing will not pull off.

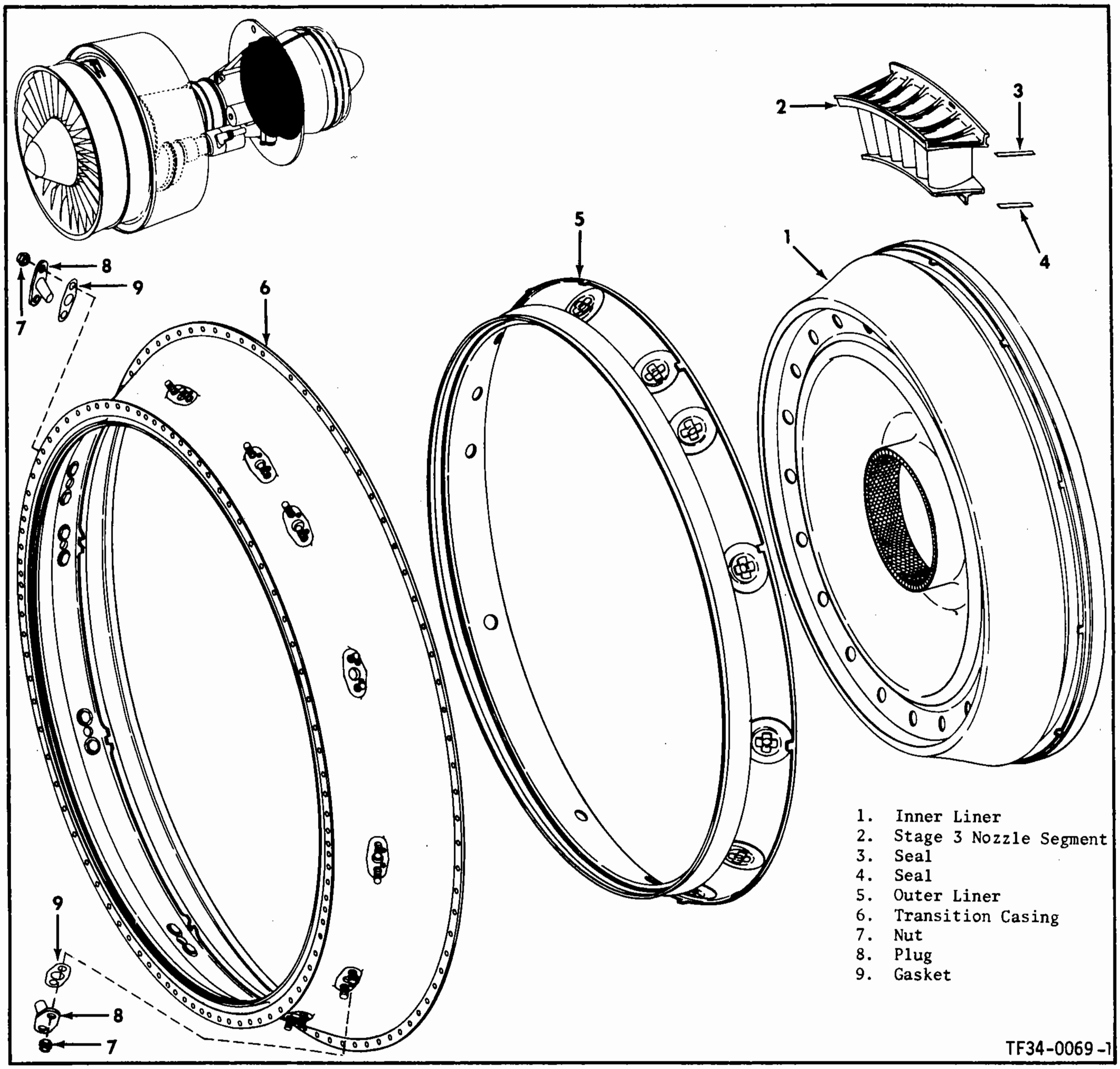


Figure 5-28. Disassembly of Turbine Transition Casing

d. Build up hydraulic pressure and pull No. 1 bearing.

e. Detach legs from puller, reverse jaws, and reassemble legs to puller. Engage jaw in groove of seal runner (9).

f. Build up hydraulic pressure and remove seal runner.

g. Disconnect hydraulic pump from puller.

8. Number fan blades and corresponding holes in disk (14) and pins (12) with Dykem or equivalent marker.

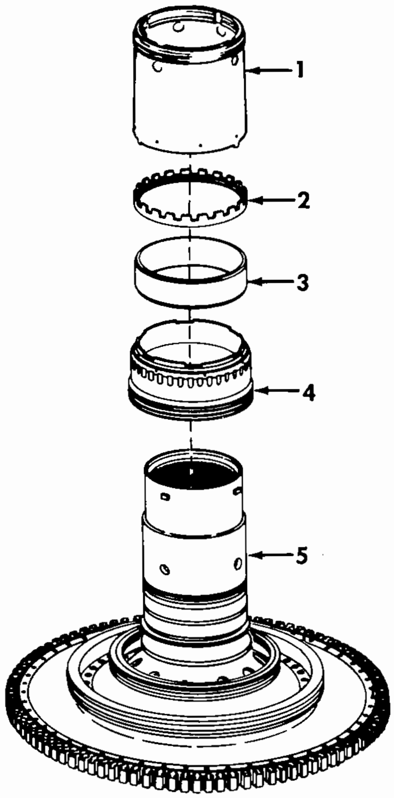
9. Remove pins (12) and fan blades (13) from disk (14).

5-29. DISASSEMBLY OF FAN STATOR ASSEMBLY. For special tools, see table 2-1, group 20.

1. Install assembly into fixture (21C5072) and remove 73 bolts (11, figure 5-31), 73 washers (12), and 73 nuts (13) from aft flange of fan housing (10).

2. Remove fan housing (10).

3. Remove 24 bolts (17), 24 nuts (19), and 24 washers (18) holding flange adapter (16) to fan stator (1). Remove flange adapter.



1. Oil/Air Separator
2. Locknut
3. No. 5 Bearing Inner Race
4. Seal Runner
5. Rotor

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Figure 5-29. Disassembly of High-Pressure Turbine Rotor

4. Remove 4 bolts (15) and 2 ground handling lugs (14).

5. Remove 88 nuts (8) holding 44 fan vane spacers (7). Remove fan vane spacers.

6. Remove 98 nuts (6) and 98 bolts (5) holding the 44 fan vanes (3, 4) to the fan stator (1).

7. Remove lockwire and 44 bolts (9). Remove 44 fan vanes (3, 4).

8. If necessary, remove 8 bolts (25) holding 4 anti-icing tubes (24) from fan vane inner support.

9. If necessary, remove 64 bolts (21) and 16 instrumentation covers (20) and shims (22).

5-30. DISASSEMBLY OF COMBUSTION CHAMBER MODULE. For special tools, see table 2-1, group 2.

1. Turn combustion chamber in buildup stand (21C5116) so that aft end is up.

2. Remove 90 bolts (1, 2, figure 5-32) from combustion chamber high-pressure turbine casing flange. Remove the high-pressure turbine outer casing (73, figure 5-33).

3. Remove cotter pin (71), nut (70) and bolt (69) from forward end of mount link. Remove aft engine mount (72).

4. Remove lockwire and 47 bolts (57) securing stage 1 nozzle (53) outer bolt circle to combustion liner (50).

5. Use an Allen wrench to hold studs (48) and remove 3 nuts (56). Remove 9 bolts (54) from 6 bolt shields (55). Remove bolt shields.

6. Remove 12 bolts (54) securing inner bolt circle of stage 1 nozzle (53) to air seal (47). Match-mark the stage 1 nozzle with Dykem or equivalent and remove the nozzle.

7. Remove igniter plugs (74) and primer nozzles (75) per section 4.

8. Remove 63 bolts (52) securing combustion liner (50) and aft inner duct (49) to combustion casing (1).

9. Assemble inner piece of liner guide (21C5125) to bearing support with nuts (56), putting the keyway of guide at 12 o'clock position.

10. Assemble outer portion of liner guide (21C-5125) over inner portion and onto aft inner duct (49) with bolts (57).

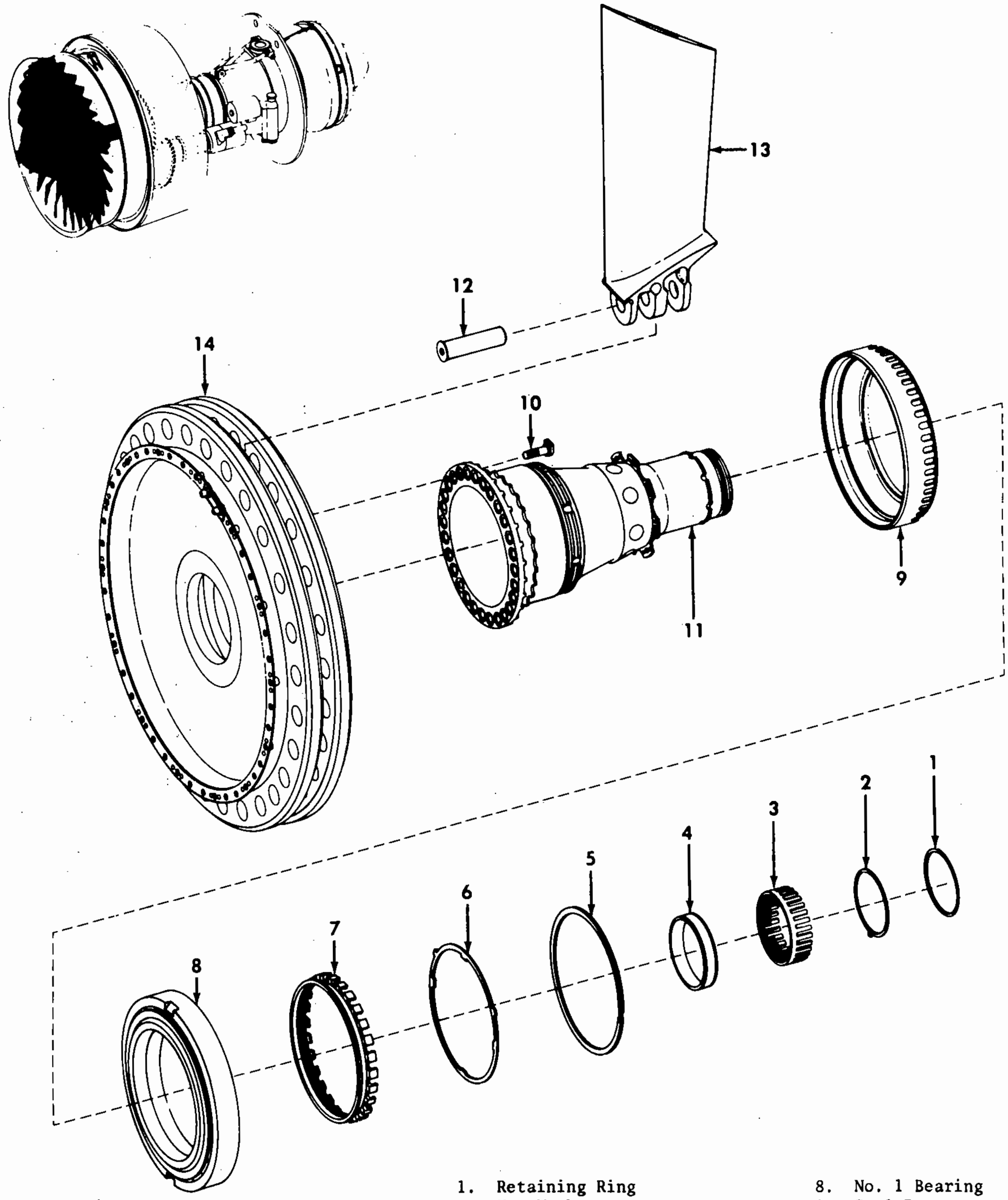
11. Using the struts of guide (21C5125) as handles, lift the liner (50) and inner duct (49) from combustion casing. Remove both sections of guide (21C5125)

12. Remove 3 screws (51) securing inner duct (49) to combustion liner (50).

13. Use an Allen wrench and remove 3 studs (48) securing balance piston seal (47) to air seal (45). Match-mark balance piston seal to air seal using Dykem or equivalent marker. Remove balance piston seal.

14. Remove 16 bolts (46) from inner flange of air seal (45). Match-mark air seal to B-sump housing (13) and remove air seal.

15. Remove lockwire and 8 bolts (6) from 5 and 7 o'clock lube and scavenge elbows on outside of



1. Retaining Ring
2. Key Washer
3. Locknut
4. No. 2 Bearing Inner Race
5. Retaining Ring
6. Key Washer
7. Locknut
8. No. 1 Bearing
9. Seal Runner
10. Bolt
11. Front Shaft
12. Pin
13. Blade
14. Disk

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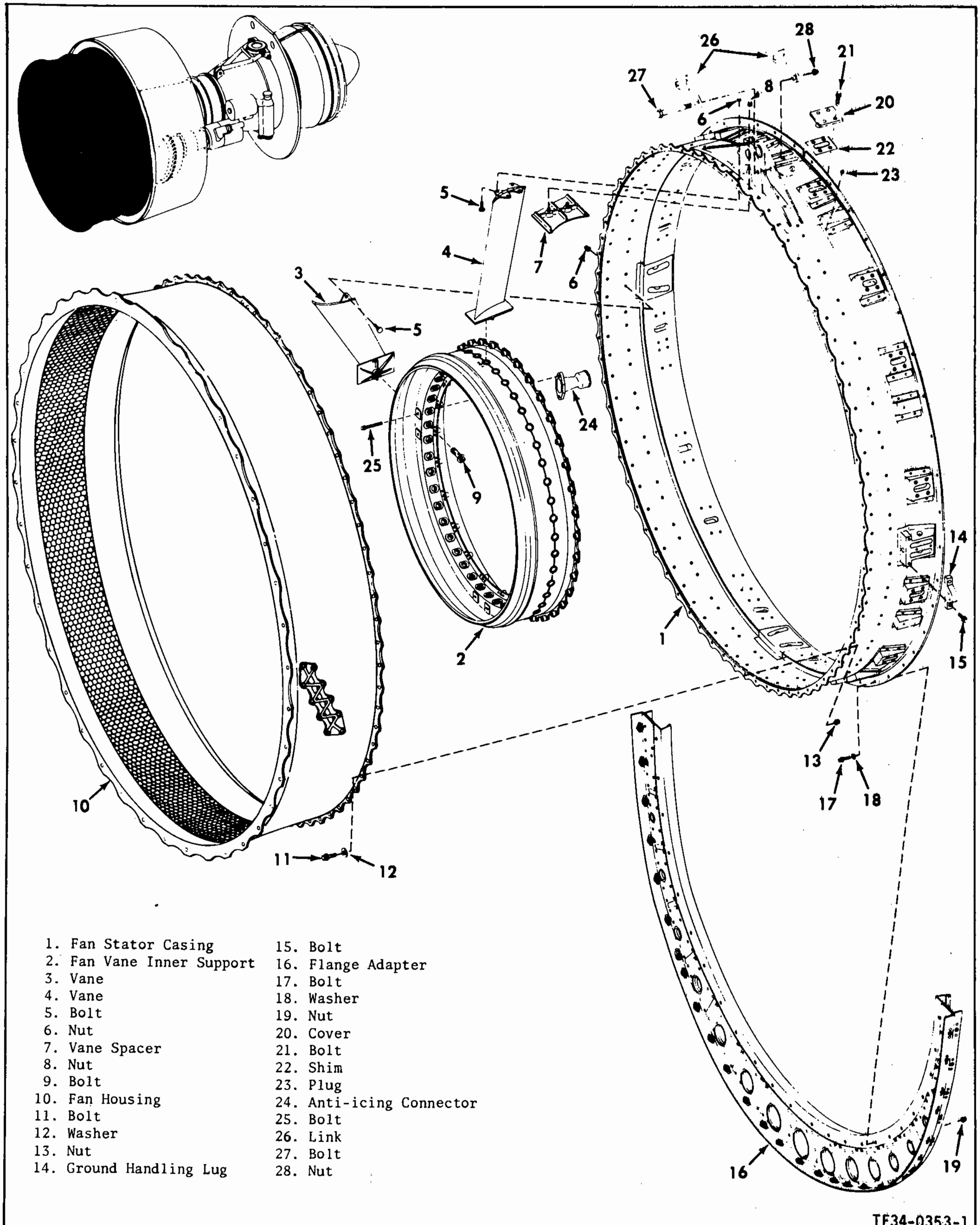
Figure 5-30. Disassembly of Fan Rotor



1. Fan Stator Casing
2. Fan Vane Inner Support
3. Vane
4. Vane
5. Bolt
6. Nut
7. Vane Spacer
8. Nut
9. Bolt
10. Fan Housing
11. Bolt
12. Washer
13. Nut
14. Ground Handling Lug
15. Bolt
16. Flange Adapter
17. Bolt
18. Washer
19. Nut
20. Cover
21. Bolt
22. Shim
23. Plug
24. Anti-icing Connector
25. Bolt
26. Link
27. Bolt
28. Nut

Figure 5-31. Disassembly of Fan Stator Assembly

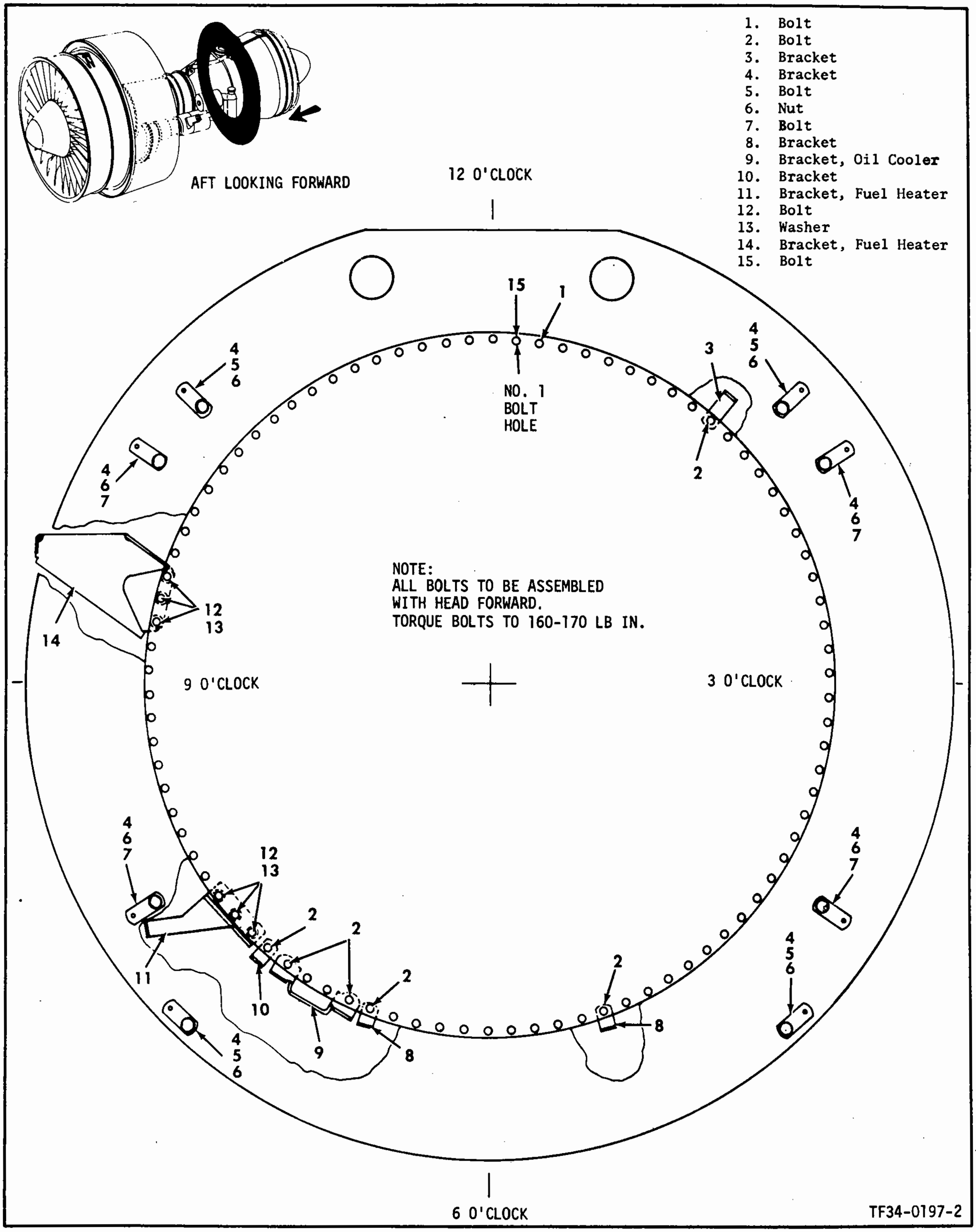


Figure 5-32. Bolting Diagram - High-Pressure Turbine Casing-to-Combustion Chamber

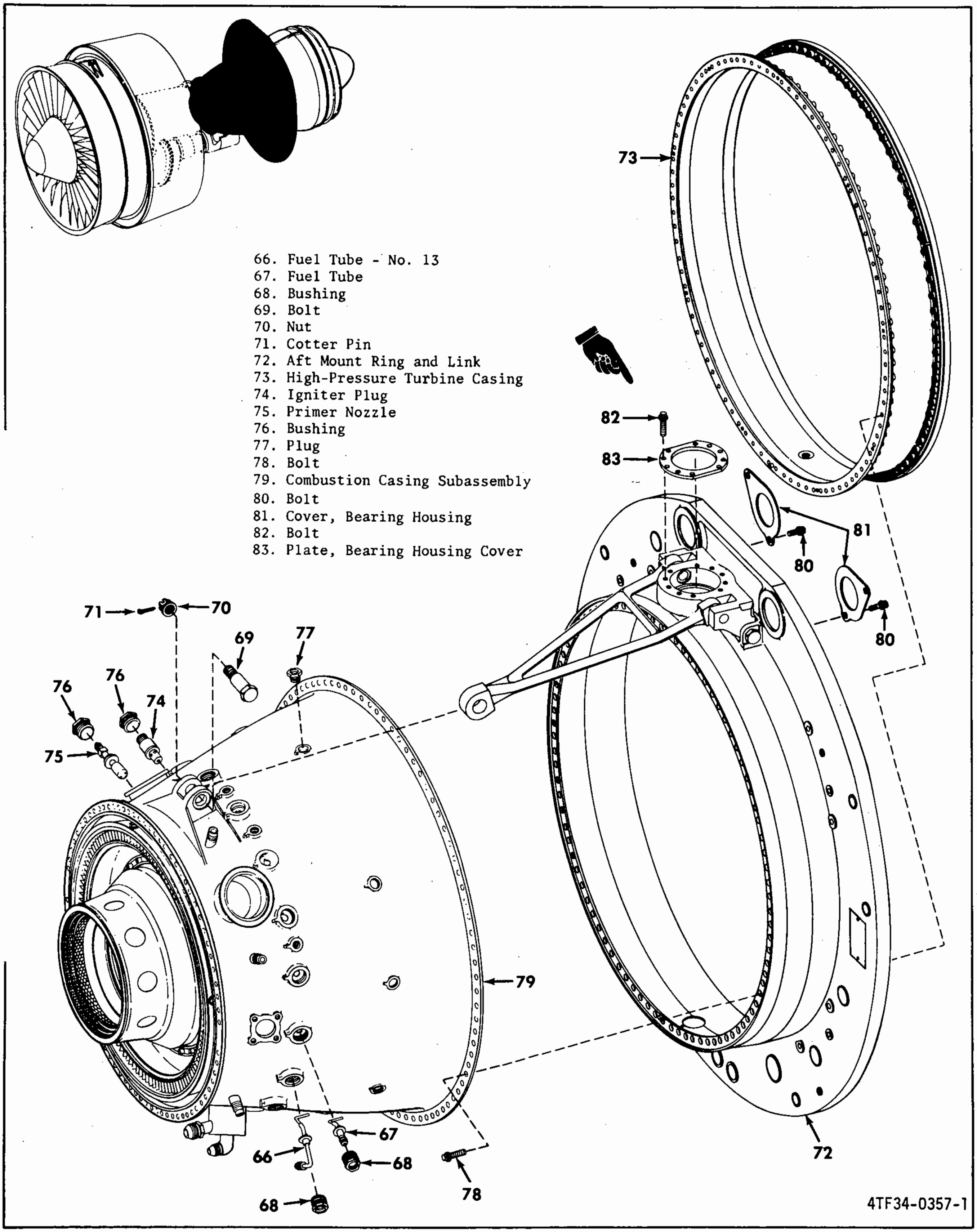
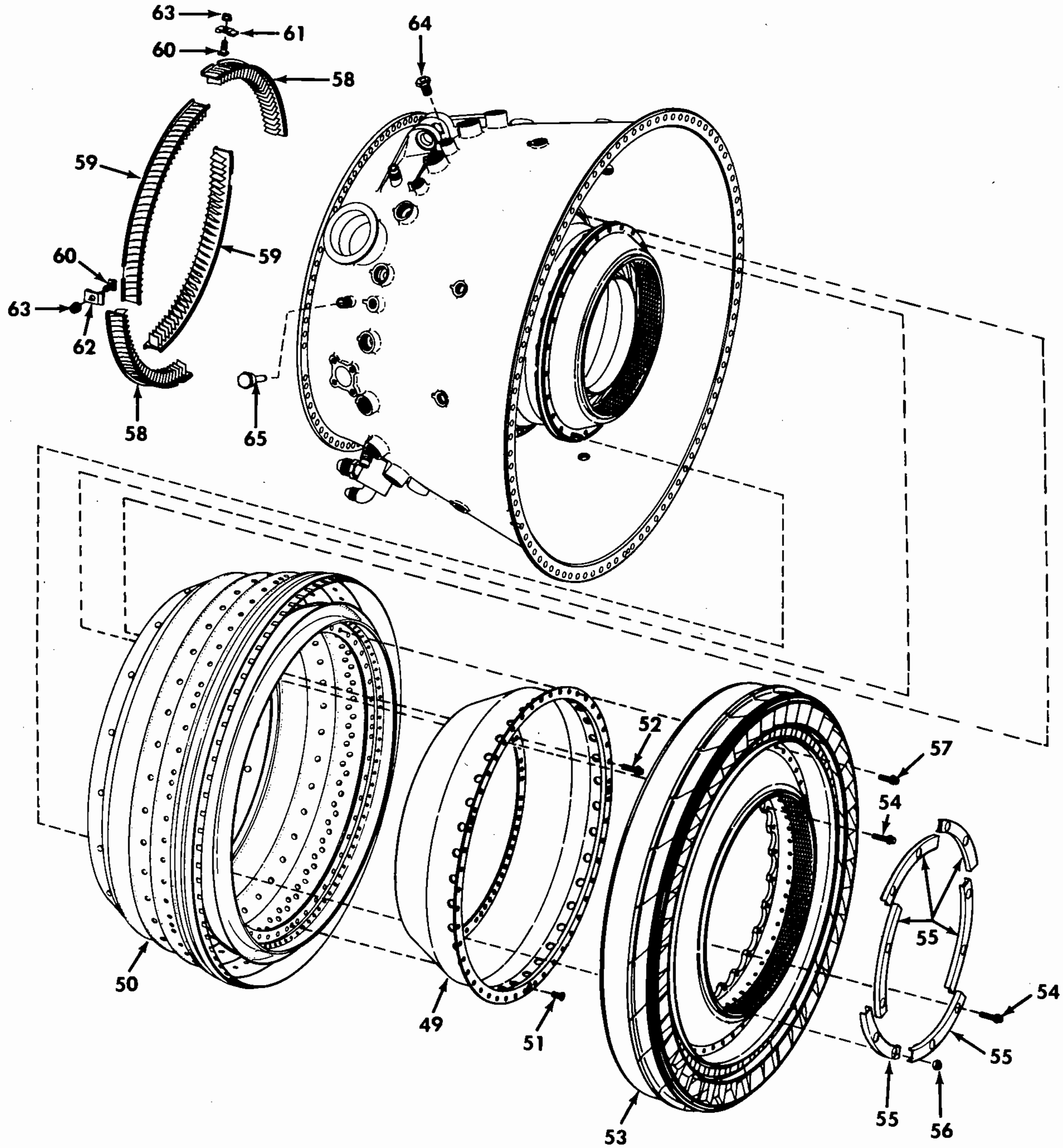


Figure 5-33. Disassembly of Combustion Chamber Module
(Sheet 1 of 4)



49. Inner Duct
50. Liner
51. Screw
52. Bolt
53. Stage 1 Nozzle
54. Bolt
55. Bolt Shield
56. Nut
57. Bolt
58. Exit Guide Vane Sector
59. Exit Guide Vane Sector
60. Key Bolt
61. Retainer Key
62. Retainer Key
63. Nut
64. Pressure Plug
65. Temperature Cap

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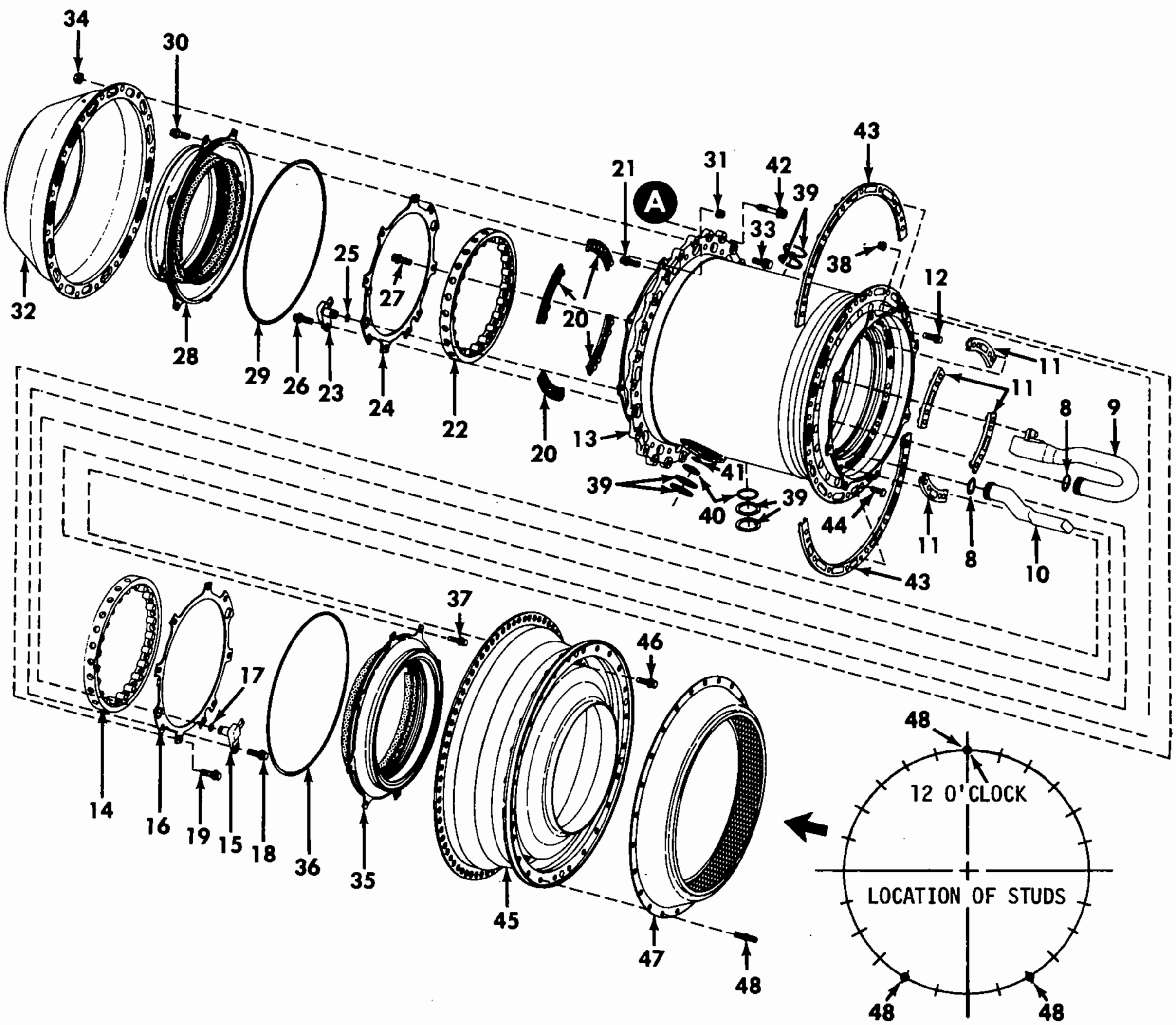
Figure 5-33. Disassembly of Combustion Chamber Module (Sheet 2 of 4)



8. Packing
9. Forward Scavenge Tube
10. Aft Scavenge Tube
11. Nut Assembly
12. Screw
13. B-sump Housing
14. No. 5 Bearing Outer Race
15. Oil Nozzle
16. Retainer
17. Packing
18. Bolt
19. Screw
20. Nut Assembly
21. Screw
22. No. 4 Bearing Outer Race
23. Oil Nozzle
24. Retainer
25. Packing
26. Bolt
27. Screw
28. No. 4 Carbon Seal
29. Packing
30. Bolt
31. Nut
32. Forward Seal
33. Bolt
34. Nut
35. No. 5 Carbon Seal
36. Packing
37. Bolt
38. Nut
39. Piston Ring
40. Packing
41. Packing
42. Bolt
43. Nut Assembly
44. Bolt
45. Air Seal
46. Bolt
47. Balance Piston Seal
48. Shouldered Stud

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Figure 5-33. Disassembly of Combustion Chamber Module
(Sheet 3 of 4)

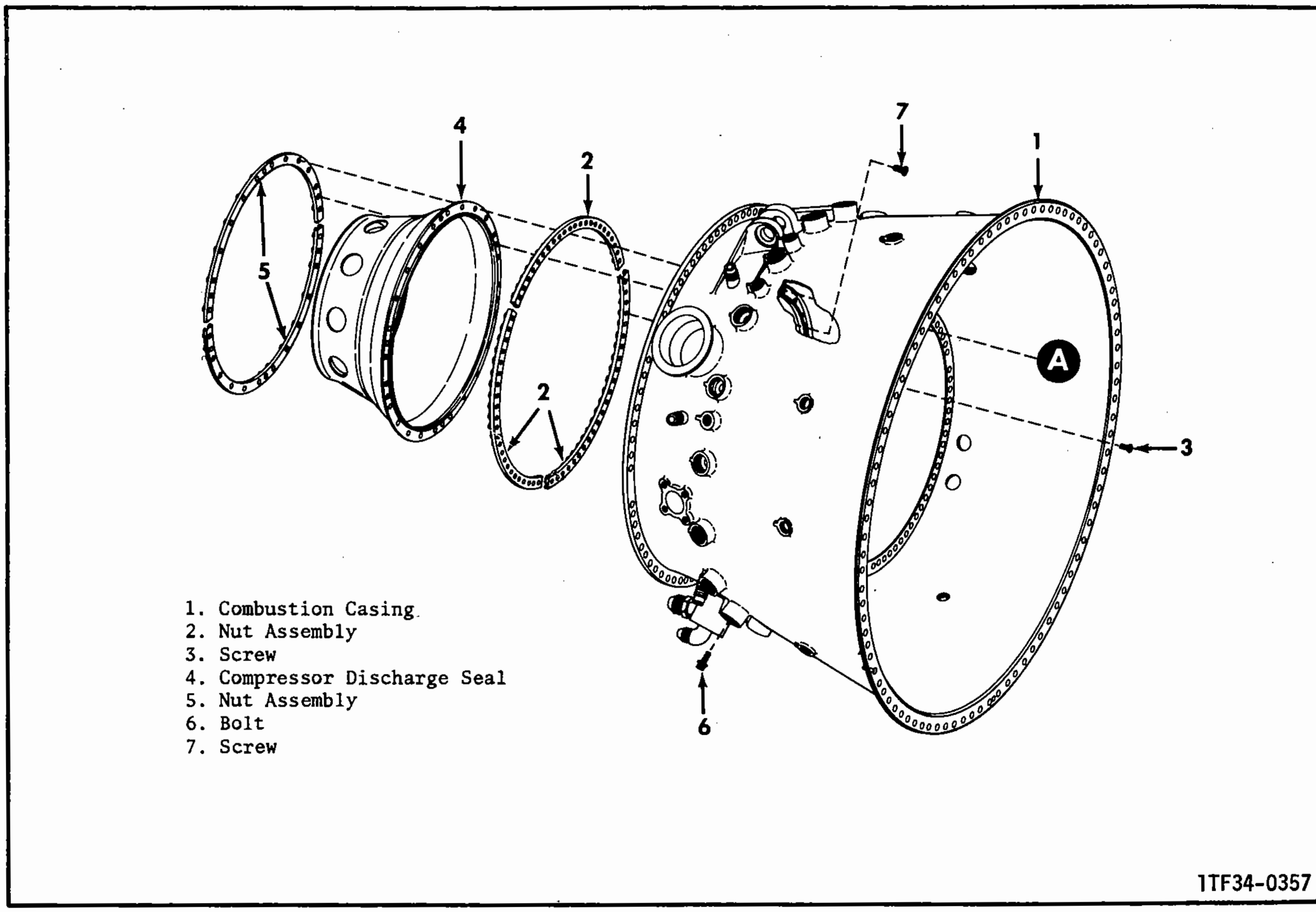


Figure 5-33. Disassembly of Combustion Chamber Module (Sheet 4 of 4)

combustion casing. Pull elbows outward at 3, 5 and 7 o'clock positions, disengaging 3 tubes from B-sump housing.

16. Loosen 24 bolts (42) at the forward end of B-sump housing (13), outermost bolt circle. Do not remove bolts entirely, just enough to be free of combustion casing. Carefully remove B-sump housing from combustion casing.

17. Match-mark compressor discharge seal (4) to combustion casing. Remove 6 screws (7), 2 nut assemblies (5) and compressor discharge seal (4).

18. Remove 8 bolts (37) and nuts (38) holding No. 5 carbon seal (35) to B-sump housing (13). Remove carbon seal and discard packing (36).

19. If necessary, remove 3 screws (44) and 2 nut assemblies (43).

20. Remove 8 bolts (18), 1 screw (19), 2 oil nozzles (15), bearing retainer (16) and No. 5 bearing outer race (14). Discard packings (17) from oil nozzle. Remove scavenge tube (10) and discard packing (8).

21. If necessary, remove 8 screws (12) and 4 nut assemblies (11).

22. Remove lockwire and 16 bolts (33) and nuts (34) holding the forward seal assembly (32) to the B-sump housing. Remove seal.

23. Remove 8 bolts (30) and nuts (31) holding No. 4 carbon seal (28) to B-sump housing. Remove seal and discard packing (29).

24. Remove 8 bolts (26), 1 screw (27), oil nozzles (23), bearing retainer (24), and No. 4 bearing outer race (22). Discard packings (25) from oil nozzles. Remove scavenge tube (9) and discard packing (8).

25. If necessary, remove seals (39) from the air tube at the 3 o'clock position inside combustion chamber.

26. Remove packing (40) and seals (39) from scavenge tube at 5 o'clock position inside combustion chamber.

27. Remove packings (40, 41) and seals (39) from oil and scavenge tube at 7 o'clock position inside combustion chamber.

28. If necessary, remove screws (21) and 4 nut assemblies (20) from B-sump housing (13).

5-31. DISASSEMBLY OF COMPRESSOR ROTOR. For special tools, see table 2-1, group 7.

1. Place compressor rotor in buildup stand (21C5089), forward end up.

2. Remove retaining ring (19, figure 5-34) and keywasher (18).

3. Use spanner wrench (21C5193) and torque multiplier (SWE 102 or Powerdyne 2501) and remove locknut (17).

4. Use puller (21C5051) with shortest puller ring (part of 21C5051) and a hydraulic pump and remove No. 3 bearing forward inner race (14). Remove puller components and hydraulic pump.

5. Remove No. 3 bearing outer race as follows:

a. Remove nut (16) and anti-rotation key (15).

b. Install outer portion of puller (21C5049) onto No. 3 bearing housing (5).

c. Use a soft faced mallet and tap on puller, pushing the bearing housing aft until puller groove in outer race is exposed. Remove outer portion of puller (21C5049).

d. Install inner portion of puller (21C5049) into groove of No. 3 bearing outer race (14).

e. Install outer portion of puller (21C5049) over inner portion. Pull arm on inner portion out as far as possible.

f. Use ratchet wrench and remove No. 3 bearing outer race.

6. Use puller (21C5051) with middle length puller ring (part of 21C5051) and a hydraulic pump, and remove aft half of No. 3 bearing inner race.

7. Remove oil slinger (4).

8. Remove housing (5) from compressor rotor.

9. Using puller (21C5081), engage outer set of fingers on lip of oil screen (13) and remove the screen.

10. Remove nut (12) holding oil tube (10) and oil nozzle (9) to bearing housing (5). Remove tube, nozzle, and packing (11).

11. Use snapring pliers and remove retaining ring (8).

12. Using puller (21C5081), engage inner set of fingers onto carbon seal assembly (7) and remove carbon seal. Discard packings (6).

13. Use puller (21C5051) with longest puller ring (part of 21C5051) and a hydraulic pump, and remove No. 3 carbon seal runner (3) from compressor rotor front shaft. Discard packing (2).

14. Turn compressor rotor so that the aft end is up.

15. Compress retaining ring (24) until it is out of slots in the locknut (22), then tap the tab washer (23) out of the locknut with a plastic drift. Remove retaining ring from tabwasher.

16. Use spanner wrench (21C5194) and torque multiplier (SWE 102 or Powerdyne) and remove locknut (22).

17. Install puller (21C5052) over compressor rear shaft and engage puller with No. 4 bearing carbon seal runner (20). Attach hydraulic pump to puller and remove No. 4 bearing inner race (21) and seal runner (20).

5-32. <u>CLEANING, INSPECTION AND REPAIR.</u>

5-33. GENERAL.

This portion of Section V contains the following:

1. General cleaning methods for both hot and cold section parts and special cleaning procedures for parts such as bearings. Table of cleaning methods.

2. General refinishing procedures.

3. General inspection procedures.

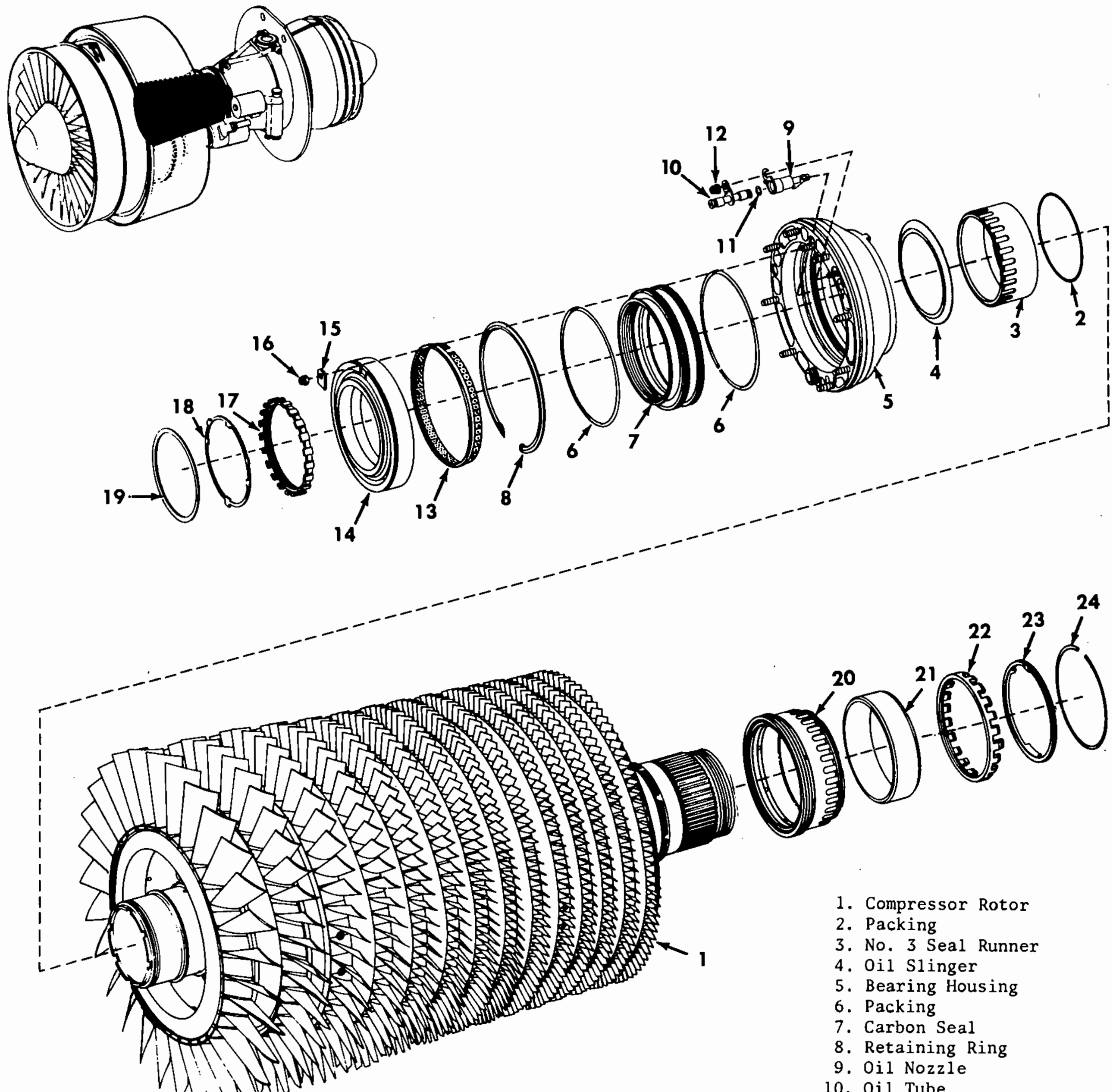
4. General blending instructions.

5. Specific inspection paragraphs, starting with external components and then progressing from the forward end of the engine to the rear.

NOTE

Limits for similar parts are located together, regardless of their location in the engine. For example, limits for stages 1, 2, 3, 4, 5 and 6 turbine nozzles are in paragraphs that follow one another.

6. Specific repair procedures follow the applicable inspection paragraph.



1. Compressor Rotor
2. Packing
3. No. 3 Seal Runner
4. Oil Slinger
5. Bearing Housing
6. Packing
7. Carbon Seal
8. Retaining Ring
9. Oil Nozzle
10. Oil Tube
11. Packing
12. Nut
13. Oil Screen
14. No. 3 Bearing
15. Anti-rotation Key
16. Nut
17. Locknut
18. Keywasher
19. Retaining Ring
20. No. 4 Seal Runner
21. No. 4 Bearing Inner Race
22. Locknut
23. Tabwasher
24. Retaining Ring

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Figure 5-34. Disassembly of Compressor Rotor Assembly

5-34. CLEANING.

5-35. PRELIMINARY INFORMATION.

CAUTION

Do not use any cleaner, lubricant or similar compound containing chlorine, bromine, fluorine or iodine or any of their compounds if they contain more than 50 parts per million of these halides (salt-producers).

5-36. CLEANING PROCESSES.

5-37. GENERAL.

1. The following alloys may be cleaned by following instructions of paragraph 5-39.

Inco 718	Inco W
Inco 600	R77
Astroloy	Hastelloy X
R80	X40
HS188	A286
R100	Hastelloy B
Hastelloy W	Inco 625

2. It is advisable to use P-D-680 when cleaning hot section parts which have internal passages with small openings such as nozzles, blades, etc. However, regardless of what procedures are used, extreme precautions must be taken to insure that all cleaning solutions are removed from internal passages. This can only be accomplished by pressure-rinsing all cavities. It is a time-consuming process but it must be followed. If precautions are not taken to remove all traces of alkali residue, hot corrosion failure will result during engine operation.

3. The cleaning-non-titanium instructions, paragraph 5-39, should be used on the following alloys except those associated with bearings.

M50	S Monel
AM355	52100
Bronze	

4. Titanium alloys 6-4, 6-2-2, 8-1-1, and A70 shall be cleaned per paragraph 5-40.

5. Parts made from the following materials/finishes should either be vapor-degreased in trichloroethylene or cleaned in P-D-680 only.

Aluminum
Magnesium
Cadmium
Dulited Parts
Painted Parts

5-38. CLEANING PROCESS SELECTION.

1. Refer to table 5-3. This is an index in which various engine parts are tabulated in alphabetical order, containing the applicable cleaning method for the part given.

2. If a particular part cannot be found in table 5-3, use the following as a guide in selecting a cleaning process.

a. Check the material and finish of the part to be cleaned to determine whether or not the cleaning solution will react harmfully with it. (See table 5-2.)

b. The type of contaminant to be removed such as oil, grease, rust, etc.

c. Availability of a specific cleaning solution and equipment. Potential hazards to personnel and the possibility of damage to parts make it mandatory to use the correct procedures and equipment for each cleaning process.

5-39. CLEANING-NON-TITANIUM PARTS.

The cold section of the engine consists of all parts forward of the combustion chamber, but not including the combustion chamber.

WARNING

Dry Cleaning Solvent
Fed Spec P-D-680

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Use only with adequate ventilation.
- Do not smoke when using it.
- Avoid prolonged or repeated breathing of vapors.
- Use protective creams and wear aprons, goggles or face shield to protect the skin.
- Store in approved metal safety containers.

1. Immerse the part in P-D-680 at room temperature, for 10-15 minutes.

2. Rinse the part by immersing it in clean, hot water at 65^{o} - $93^{o}C$ (150^{o} - $200^{o}F$).

NOTE

Vapor-degreasing may be substituted for steps 1 and 2.

3. After cleaning, dry the part with dry, clean, filtered compressed air or by heating in a forced convection oven for a time interval necessary to maintain the part at $121^{o}C$ ($250^{o}F$) for 1 hour.

NOTE

Do not perform step 4 if part is to be inspected immediately.

TABLE 5-2. MATERIALS LIST OF MAJOR ENGINE COMPONENTS

Part Name	Material AMS	Designation Commercial	Part Name	Material AMS	Designation Commercial
Front Frame	-	Aluminum	Turbine Shrouds:		
			Stage 1	-	HS188
Compressor Casing (Front)	-	Titanium 6.4	Stage 2 thru 6	-	Hastelloy X
Compressor Casing (Rear)	-	Inco 718	Exhaust Frame	-	Inconel W
IGV	-	Inco W	No. 6 Bearing Housing	-	Inco 600
Vanes, Stage 1 thru 8	-	Titanium 6.4	No. 7 Bearing Housing	-	Inco W
Vanes, Stage 9 thru EGV	-	Inco 718	Compressor Rotor Blades:		
			Stage 1 thru 9	-	Titanium
Combustion Chamber	-	Inco 718	Stage 10 thru 14	-	Inco 718
Combustion Liner	-	Hastelloy X	Turbine Rotor Disks:		
			Stage 1 thru 4	-	Astroloy
Turbine Casings	-	Inco 718	Stage 5 and 6	-	Inco 718
Stage 1 and 2 Turbine Nozzles:			Stage 1 and 2 Turbine Blades	-	R80
Partitions Stage 1	-	X40			
Partitions Stage 2	-	R80	Stage 3, 4, 5 and 6 Turbine Blades	-	R77
Stage 3, 4, 5 and 6 Turbine Nozzle Segments	-	R77	Fan Turbine Drive Shaft	-	Inco 718

4. After drying, immediately apply Rust-Lick 606 (Rust-Lick Inc., 755 Boylston St., Boston, Mass.) or a rust preventive such as General Electric No. D50R124 or equivalent.

NOTE

Clean parts are subject to rapid corrosion, especially in hot humid weather. Do not allow clean parts to remain unprotected in an inspection area longer than 8 hours. Also, personnel who handle clean parts should apply a generous application of hand cream (General Electric No. D23A2 or equivalent) every 2 to 3 hours to prevent corrosion from fingerprints.

5-40. CLEANING-TITANIUM PARTS.

NOTE

- Chemical or abrasive cleaning is not required before inspecting engine parts. Use white light method of inspection (paragraph 5-72).
- This cleaning procedure can also be used on steel components in the cold section.

NOTE

An alternate method of cleaning parts can be accomplished per paragraph 5-43. Compressor rotor blades and vanes, stages 1 through 10, and compressor casing can be cleaned using the following procedure:

1. Either Formula 409, used at full strength, or Hockwald No. 840, mixed 5 parts water to 1 part solvent, can be used.

2. Brush on solvent, using a small stiff brush (i.e., toothbrush). Let solvent soak in for about 30 minutes.

3. Lightly brush cleaned area to remove dirt and oil.

5-41. ULTRASONIC CLEANING.

WARNING

When doing this operation, personnel shall be equipped with rubber gloves, an apron and a face shield or goggles. The area should be well ventilated.

1. Parts cleaned in this manner must be suspended in the cleaning tank without touching the bottom or sides of the tank. Spread the parts so that they are not stacked on one another and submerge them in the cleaning solution for 4 to 6 minutes. To clean materials that are attacked by alkalines (such as aluminum or magnesium), use a solution of avia-

tion cleaner, 4 to 6 ounces per gallon water at 71°C (160°F) maximum.

5-42. DRY BLAST CLEANING.

CAUTION

Do not use dry blast on rotating parts other than blades. Painted or plated surfaces shall be shielded or masked.

Use this method to remove scale from hot-section parts of the engine, such as turbine blades and the exhaust casing. Perform the cleaning operation in a cabinet. Use an abrasive mixture with a pressure not greater than 60 psi from a nozzle that is held more than 3 inches from the part. The abrasive mixture shall be composed of 100 pounds of walnut shells, 100 pounds of abrasive rice hulls, and 20 pounds of 220-grit aluminum oxide.

5-43. STEAM-CLEANING. Use this method for parts that do not require chemical cleaning or removal of paint or surface finish.

WARNING

Wear rubber gloves, an apron and face shield while steam-cleaning.

1. Use 2 pounds of steam-cleaning compound to 55 gallons of water. Any of the following compounds may be used:

a. Steam-cleaning compound (P-S-751).

b. Sprex AC-3 (manufactured by Dubois Chemicals, Inc. or equivalent).

c. Solvent (Delchem 789, Penn Salt Chemical Co. or equivalent).

2. Hold the steam gun about 12 inches from the work and at about a 45-degree angle to the surface being cleaned.

5-44. CLEANING OF ANTIFRICTION BEARINGS.

NOTE

Refer to the handbook, "Maintenance of Aeronautical Anti-Friction Bearings", Specification No. NAVAIR 01-1A-503, for detail processing instructions.

1. Use the following procedure to remove carbon, grease or other contaminants before inspecting or storing bearings.

a. Bearing cleaning must be done in a clean area that is away from the general cleaning area.

b. Bearing cleaning solvents and equipment used for cleaning bearings must not be used for any other cleaning purpose.

c. De-magnetize bearings so that they are electrically "dead". Check with a magnetometer.

d. Cleaning solvents, preserving oils and filters shall be changed at the specified intervals given in the cleaning instructions.

e. The following materials and equipment are required:

3 stainless steel tanks (about 14 gallon capacity) with pumps, heaters and filters.

1 stainless steel tank (10 gallon capacity).

Solvent, P-D-680.

Fingerprint neutralizer (MIL-C-15074).

Stainless steel rack.

20-micron filter.

10-micron filter.

Lint-free gloves.

Polyethylene bags.

Wrapping paper.

Engine or instrument oil (MIL-L-23699).

2. Place bearings on a stainless steel rack and clean as follows:

a. Vapor-degrease using process No. 1 in NAVAIR 01-1A-503.

b. Soak in a tank containing 20-micron filtered solvent, P-D-680, at room temperature that is constantly agitated, for 5 to 10 minutes. Raise and lower rack several times to give a rinsing action during soaking. Change filter and solvent twice a month.

c. Remove rack from soaking tank and rinse in another tank containing 10-micron filtered solvent, P-D-680 at room temperature. Dip bearings (on rack) into solution at least 5 times and then let drain for 1 minute. Change filter and solvent each week.

d. Inspect bearing using a bright light. If still dirty, repeat steps b and c.

e. Dip clean bearings 4 times and soak in a tank of MIL-C-15074 at room temperature for 2 minutes. Remove bearings and drain over tank. Change solution once a month.

f. Repeat rinse in step c.

g. Dip bearings (on the rack) two or three times into a tank containing 20-micron filtered MIL-L-23699 at room temperature, to preserve the bearings. Change preserving oil and filter once each month.

h. Package bearings not to be used at once. Handle bearings with clean lint-free gloves and pack in clean polyethylene bags or wrapping paper and tie securely.

5-45. CLEANING CARBON SEALS.

WARNING

Trichloroethylene Fed
Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is injurious to the lungs.
- Use only with adequate ventilation.
- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers.

CAUTION

When handling carbon seals, avoid touching the carbon. Hold seals by seal housing only. Use extreme care in handling.

1. Carbon seals shall be ultrasonically cleaned in a trichloroethylene (Specification O-T-634) bath for 6 minutes and then dried with filtered shop air. If carbon seals are not fully cleaned, repeat this procedure for 30 minutes minimum.

2. If cleaning cannot be done ultrasonically, the seals may be cleaned as follows:

a. Swirl the seal around in a container of trichloroethylene until all traces of oil are removed.

b. Dry the seal with dry, filtered shop air.

5-46. CLEANING ENGINE PARTS AFTER FLUORESCENT-PENETRANT INSPECTION.

5-47. GENERAL.

Because of the possibility that residuals left on a part after a fluorescent-penetrant inspection has been performed, can cause corrosion, it is essential thay they be removed before the part is reassembled to the engine. See paragraph 5-48 for cleaning procedures for removing residual deposits.

5-48. CLEANING METHODS TO REMOVE FLUORESCENT-PENETRANT INSPECTION RESIDUAL DEPOSITS.

NOTE

Use table 5-3 as a guide to determine the applicable cleaning process for the part. All precautions given in previous paragraphs on handling dangerous chemicals still apply.

1. Method No. 1

a. Hand-brush part, with appropriate cleaner.

b. Air-dry part with clean filtered, dry air at about 40 psig.

2. Method No. 2.

a. Vapor-degrease.

TABLE 5-3. CLEANING PROCESS SELECTION AFTER FLUORESCENT-PENETRANT INSPECTION

PART DESCRIPTION	CLEANING METHOD NO.
Bearing Locknuts	1
Centerbody	2
Exhaust Frame	2
Front Frame	2
Radial Drive Shaft	1
Turbine Casing (Low Pressure)	2
Vent Collector	2

5-49. CLEANING OF OIL COOLER.

WARNING

Dry Cleaning Solvent
Fed Spec P-D-680

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Use only with adequate ventilation.
- Do not smoke when using it.
- Avoid prolonged or repeated breathing of vapors.
- Use protective creams and wear aprons, goggles or face shield to protect the skin.
- Store in approved metal safety containers.

1. Clean all metal parts in solvent (Federal Specification P-D-680, or equivalent). Dry thoroughly after cleaning.

2. Drain all residue from the weldment.

3. Flush the oil passages by circulating solvent (Federal Specification P-D-680, or equivalent) at room temperature for 15 minutes through the passages.

4. Immerse the cooler into the hot vapors of a degreasing tank. Direct a stream of the liquid trichloroethylene (Federal Specification O-T-634) on the part and into all the open ports. Drain the liquid from the ports while still in the tray in the tank.

5. Flush the fuel and oil ports of the cooler by circulating solvent (Federal Specification P-D-680, or equivalent) at room temperature for five minutes.

6. Blow filtered, dry air through the passages until all the liquid is removed.

5-50. PRESERVATION AFTER CLEANING.

After cleaning, coat all steel parts (except stainless steel) with Rust-Lick or a rust preventive such as General Electric No. D50R142, or equivalent.

NOTE

It is not necessary to do this step if parts are to be reassembled within 8 hours after cleaning.

5-51. GENERAL BLENDING PROCEDURE.

1. Blending is an operation used to remove stress concentration caused by nicks, scratches, etc. on critical parts. Removal of the material that surrounds the stress concentration (in a smooth contour) relieves this stress concentration and permits further use of the part by lessening the danger of cracking.

a. Blending may be done with an Arkansas stone, a fine file, or crocus cloth. If a large or deep blend is to be made, a medium file or heavy grade abrasive paper may be used to shorten the time required to remove the metal, but the finish must be smoothed out with an Arkansas stone.

b. When blending a cylindrically-shaped part, blend in a circumferential direction, not along the axis of the part.

c. The finish on the blended area must be as close as practical to the original finish of the part.

5-52. GENERAL REFINISHING PROCEDURES.

The following paragraphs contain instructions for refinishing (painting or coating) various engine parts and components that do not meet inspection requirements.

5-53. BAKED PHENOLIC OR POLYURETHANE FINISH

1. Use Heresite (Heresite and Chemical Company, Manitowac, Wisconsin) to refinish any engine parts or accessories with damaged paint, unless otherwise specified.

5-54. ALODINE NO. 1200 REFINISHING.

1. The Alodine No. 1200 process (similar to MIL-C-5541), is used to touch up and protect reworked and corroded aluminum surfaces. It can be used in place of anodizing and is either brushed or sprayed on the part. Proceed as follows:

CAUTION

Make sure the Alodine solution does not come in contact with steel parts.

NOTE

Alodine No. 1200 coating is thin, golden and iridescent. However, the color of the coating may vary with different aluminum alloys. The coating must be adherent and free from dust.

WARNING

Phosphoric Acid
Fed Spec O-O-670

- Causes skin irritation.
- Avoid contact with skin and eyes.
- Wear approved gloves and goggles (or face shield) when handling, and wash hands thoroughly after handling.

a. Clean the part in Deoxidine No. 624 (Amchem Products, Inc., Ambler, Pennsylvania), or suitable phosphoric acid. Keep the part wet with Deoxidine No. 624 for from 1 to 5 minutes.

b. Rinse thoroughly with clean water.

c. Brush or spray Alodine No. 1200 solution on the surface of the part and allow it to set from 3 to 5 minutes.

d. Remove the excess Alodine with a wet cloth or sponge and rinse the part thoroughly in water.

e. Allow the Alodine coating to air-dry.

5-55. INSPECTION.

1. The following paragraphs contain general inspection procedures and service and repair limits that are allowable for both normal and extended intermediate maintenance of engine parts and specific repair procedures. Limits are based on maximum defects which can be tolerated before the part must be repaired or replaced.

2. When an engine is disassembled for inspection or replacement of parts, inspect every part that is removed, including subassemblies not disassembled. For example, if the combustion liner is being replaced, clean and inspect the low pressure turbine module as a subassembly at the same time.

5-56. TERMS.

The terms listed in this paragraph are used throughout the inspection paragraphs. An explanation of the terms of phrases follows:

1. Inspect - Refers to visual or other inspection based upon availability of equipment. Unless otherwise specified, visual inspection is implied.

2. Usable Limits - That limit which is allowable without repairing or replacing the part.

a. The part can be maintained in service if this limit is not exceeded.

b. If this limit is exceeded, and the part cannot be repaired at this level of maintenance, replace the part. Return the defective part to overhaul for repair.

3. Max Repairable Limit - That limit (always greater than the usable limit) which is allowable if the defect is repaired according to the instructions in the "corrective action" column.

a. If the usable limits are exceeded, but the repairable limits have not been exceeded, the part can remain in service only if that repair which removes the defect is performed.

b. If the repairable limits are exceeded, the part must be scrapped or replaced (returned to overhaul for repair).

4. Corrective Action - Action to be followed if the maximum limits have been exceeded.

a. If the action requires that the defective part be replaced, return the defective part to overhaul.

b. If the action calls for blending or some other repair procedure, the part must be repaired; otherwise, it must be replaced.

c. In some instances the entire engine must be replaced due to balancing requirements or loss of performance, etc.

d. Cold-Work - Return material to original contour without applying heat to the material. After cold-work, reinspect the immediate area, for cracks, per applicable inspection paragraph.

e. Remove High Metal (or Pickup) - Use a fine stone to return material to the original contour.

f. TIR - Total Indicator Runout.

g. Blending - See paragraph 5-51.

h. Hand-Polish - Use a fine crocus cloth to remove scratches.

CAUTION

Do not use crocus cloth on carbon seals.

5-57. DEFINITION OF INSPECTION TERMS.

A definition of inspection terms is given in table 5-4. The first column lists terms generally used to describe deviations from normal conditions in engine parts. The second column defines the terms. The third column lists the cause or causes of the defined terms.

5-58. INSPECTION PROCEDURES.

1. If the engine is disassembled for any reason, all parts which are handled should be observed for apparent damage.

2. This section lists service and repair limits allowable for intermediate maintenance of the engine. Limits are based upon maximum defects or imperfections which can be tolerated before the part must be replaced. Repair of engine parts at this maintenance level is limited to blending, removal of high metal and other light repair.

3. Keep the inspection area, inspection benches, and tools thoroughly clean. Cover work benches with

TABLE 5-4. DEFINITIONS OF INSPECTION TERMS

Term	Definition	Causes
Abrasion	Roughened surface. May vary from light to severe.	Foreign material between moving parts.
Bend	Distortion in a part. Curvature out of proper contour.	Severe application of heat, or excessive force.
Blister	Raised portions of the surface, usually where the surface has separated from the base. Generally found on surface-treated parts (plated or painted surfaces).	Poor original bond with base. Possible aggravation by heat or pressure.
Break	Separation of part.	Severe force, pressure or overload.
Brinelling	Indentation of the surface, usually found on ball or roller bearings.	Incorrect assembly or disassembly procedure used on bearings, or application of excessive force on the bearing free race.
Brittleness	Loss of resiliency in the base material.	Severe application of heat or cold or possible chemical action.
Buckling	Large deformation of contour; a bulge in a surface.	Severe pressure, impact of a foreign object, or heat distortion.
Burnishing	Smoothing of a metal surface of mechanical action, but without a loss of material, generally found on plain bearing surfaces. Surface discoloration is sometimes present around the outer edges. Normal burnishing from operational service is not detrimental if the coverage approximates the carrying load and there is no evidence of burns.	Operation of mechanical parts.
Burr	Rough edge or sharp projection.	Excessive wear or poor machining.
Chatter Mark	Surface irregularity.	Machining process, minor defect.
Chipping	Breaking away of small metallic particles.	Heavy impact of foreign object.
Corrosion	Formation of many small pits which cumulatively create a wide cavity (usually shallow) in the surface of the part.	Oxidation of particles.
Coking	Buildup of carbon deposits.	Deterioration of lubricants or incomplete combustion.
Crack	Parting of the parent material or of the metal in a welded zone with or without deformation of the adjacent areas.	Severe stress from overloading or shock; possible extension of a scratch. Also caused by thermal expansion, vibration, and material fatigue.
Crazing	A mesh of minute hairlike cracks on glazed or baked-on surfaces which do not penetrate into parent metal.	Temperature changes or deformation of parent metal.
Dent	Smooth cavity in the surface. Material is displaced, not separated.	Careless handling or striking of the part; operational wear with foreign-object interference.

TABLE 5-4. DEFINITIONS OF INSPECTION TERMS (Cont.)

Term	Definition	Causes
Electrolytic Action	Surface breakdown.	Galvanic action between dissimilar metals.
Erosion	Metal carried away.	Sand or corroding gas or liquids.
Fatigue Failure	Progressive yielding to repeated stress of one or more local areas, caused by the cumulative effect of scratches, sharp indentations, cracks, tool marks and inclusions. As the stress is repeated, cracks develop, then spread, usually from the surface (or near the surface) of the particular section. Finally so little sound material remains that the normal stress on the part exceeds the strength of the remaining material. This results in separation. It is not caused by metal crystallization and can easily be determined by visual inspection of the part. There will be evidence of several more or less concentric lines. The center (or focus) of the lines indicates the origin of the failure.	Cracks, tool marks, sharp corners, nicks, galling, inclusions, corrosion, insufficient tightening of studs, or bolts.
Flaking	Pieces of a plated or painted surface breaking away.	Imperfect bond or severe load.
Fracture	Same as "Break".	
Fretting	Loss of fine particles of metal.	Rubbing action between parts.
Galling	Accumulation of foreign material deposited on the surfaces.	Movement of 2 surfaces in contact with one another under severe pressure.
Glazing	Covering of hard, glossy surface on plain bearing areas (sometimes a desirable condition).	Pressure, oil, and heat in combination.
Gouging	Wide, rough scratching or group of scratchings, usually accompanied by one or more sharply impressed corners, and sometimes by deformation or removal of material.	Presence of a rather large foreign body between parts in motion.
Grooving	Long, narrow, continuous channels having no sharp edges.	Concentrated wear due to abnormal-relative motion of parts.
High Metal	Displaced surface metal.	Nicks, scratches, gouges, or dents.
Hot Gas Corrosion	The corrosion of unprotected metal (with no coating) that has been exposed to hot gases. When first exposed, the surface becomes rough and appears to be pitted and pockmarked. Also, there is a noticeable difference in the colors of the exposed and unexposed surfaces. Further exposure of surface to hot gases causes it to blister and, in time, flake off in layers.	This kind of corrosion differs from that normally found on surfaces attacked only by salt in the atmosphere. In hot-gas corrosion, the hot gases convert sulphur to sulphide in the presence of salt. The metal is attacked by the resulting deposits.
Nick	Sharp indentation.	Negligent handling of parts or foreign-object damage during engine operation.
Peening	Surface deformation.	Foreign object damage.

TABLE 5-4. DEFINITIONS OF INSPECTION TERMS (Cont.)

Term	Definition	Causes
Pickup	A burr, subject to being transferred from one part to another.	Insufficient lubrication, unbroken edges of press-fitted parts. Seizure of rotating parts during operation. Improper manufacture.
Pitting	Minute depressions or cavities, without sharp, high-stress corners.	Chemical action: oxidation of surfact; electrolytic action. Mechanical action: chipping of loaded surfaces due to improper clearances and overloading; presence of foreign material.
Scoring	Deep scratches or elongated gouging.	Presence of chips between loaded surfaces that have relative motion.
Scratch	Long, narrow, sharp-cornered impression.	Movement of a sharp object across the surface.
Spalling	Sharply roughened area characteristic of progressive chipping or peeling of surface material.	Surface crack, inclusion, or similar surface injury that causes a progressive breaking away of the parent material.
Stress	A cause of any of several engine part failures, generally divided into 5 groups, according to cause: compression, shear, shock, tension, and torsion.	Compression: action of 2 directly opposed forces which tend to squeeze, bend, twist, stretch or otherwise apply abnormal pressures to a part. Shear: action of 2 opposed parallel forces. Shock: instantaneous application of stress. Tension: action of 2 directly opposed forces which act to pull apart. Torsion: action of 2 opposed forces around a common axis.
Wear	Relatively slow removal of parent material from any cause, frequently not visible to the naked eye.	Chafing, Chattering, Erosion, Oxidation, Rubbing, Scraping or Scuffing.

a clean, dry cover. Keep components free of dirt, dust and grease. Use polyethylene storage bags or similar containers. Cap openings in components with protective closures. Refer to table 2-1 for special protectors.

4. Inspect parts under adequate light; only the most thorough inspection can properly evaluate damage. Tag each component to indicate repair or replacement. Numerous parts can be visually examined for external defects but others require the use of micrometers, measuring instruments or gages. More than one method of inspection may be needed to determine the extent of damage.

5-59. MAGNETIC-PARTICLE INSPECTION.

5-60. GENERAL.

NOTE

Fluorescent-penetrant inspection shall always precede magnetic-particle inspection when both tests are required.

The magnetic-particle inspection method, Specification MIL-I-6866, is a nondestructive method of inspecting ferromagnetic steel parts for fatigue cracks and defects which may not be readily apparent by visual inspection methods. Reinspect all parts repared after the magnetic-particle inspection. Evaluate any flaw indication to determine the final disposition of the part. A qualified inspector shall make the evaluation.

5-61. DESCRIPTION OF INSPECTION METHOD.

Completely disassemble, clean, degrease and decarbonize all engine parts to be magnetically inspected. Stone and polish (with crocus cloth and oil) any scratches, scoring and galling. Plug, with heavy grease or wood plugs, passages which are too difficult to clean. Then magnetize the part to be inspected by passing a 1/4 to 1/2 second current flow through it. Longer flow periods waste power and can possible burn the part. To prevent further burning at the points of contact, be sure the machine contact plates are clean and the part is held tight. Do not release pressure on the part until the current flow indication on the ammeter needle returns to zero.

5-62. METHODS OF MAGNETIZATION.

Two methods of magnetization are used: circular and longitudinal; the choice depends on the shape of the part and the direction of the field required. If a crack is located perpendicular (or nearly perpendicular) to the magnetic field, set up opposite poles at each side of the crack so that the leakage field flows through the air between them. The inspection medium (applied to the part) bridges the gap between the opposite poles. When the defects are at a 90 degree angle to the magnetic field, the indications are the strongest. The indications gradually decrease in intensity as the angle is reduced toward zero. Inclusions and cracks under the surface form the same leakage field but do not produce similar strong indications.

5-63. TYPES OF MAGNETIZATION.

Two types of magnetic-particle inspection methods are used: The residual method and the continuous method. In the residual method apply either a dry medium (consisting of finely divided ferromagnetic particles) or a wet medium (consisting of magnetic iron oxide particles suspended in a petroleum distillate) to the magnetized part. In the continuous method, apply the dry medium or the wet medium while the part is being magnetized. Use the wet medium on finished parts.

5-64. DEMAGNETIZATION.

Following the magnetic-particle inspection, demagnetize the parts by passing them slowly through the entire length of the demagnetizer, holding the parts close to the top or bottom of the demagnetizer. Rotate circular parts as they are passed through. Before turning off the current, withdraw all parts from the demagnetizer with a straight-away motion for a distance of at least 3 feet.

5-65. DEMAGNETIZATION TEST.

To be sure the parts are completely demagnetized use a good quality compass with a 1-3/4 inch case and a free-acting needle not less than 1/4 inch long. The complete demagnetization of an engine part is not always obtained easily, however. If the compass needle does not turn 180 degrees during the test, consider the part acceptable.

1. When the parts are relatively small, place the compass on a wooden bench and pass the parts from left to right and back and forth across the compass. Keep the part in contact with the compass during the test.

2. When larger parts are to be tested, place the part on a wooden bench and move the compass over the part,

3. To test circular parts, move the compass around the circumference of the part for one complete revolution.

5-66. FLUORESCENT-PENETRANT METHOD OF INSPECTION.

5-67. GENERAL.

NOTE

Fluorescent-penetrant inspection shall always precede magnetic-particle inspection when both tests are required.

Inspection by the fluorescent-penetrant method, Specification MIL-I-6866, is a non-destructive means of testing parts for cracks and defects that have openings to the surface. Apply a highly fluorescent, water-emulsifying, low viscosity oil to a completely clean surface, and allow the oil to penetrate any flaws. Then remove surface oil. The residual oil, which has penetrated the flaws, glows when exposed to ultraviolet light, thus revealing the extent of the defect. The post-emulsion penetrant method of inspection is a more sensitive process used on critical parts.

NOTE

Phenolic coating surface finishes do not require stripping prior to fluorescent-penetrant inspection. If fluorescent indications are found, the part will then be stripped and reinspected.

5-68. CLEANING PRIOR TO APPLICATION OF FLUORESCENT-PENETRANT.

Be sure the surfaces to be inspected are free of foreign materials (such as heavy oil, grease, rust or scale) which would either prevent penetration of the oil, or indicate false flaws by absorbing the penetrant. Polishing causes false indications because displaced surface metal may cover defects and thereby close the surface openings of deeper flaws. Remove heavy oils by degreasing, and remove dirt and scale by the applicable cleaning method.

5-69. APPLICATION OF FLUORESCENT-PENETRANT OIL.

Apply the fluorescent-penetrant oil by immersing the part, or by flowing the oil over it. All surfaces to be examined must be completely covered. Allow sufficient time for penetration into all crevices. The sensitivity of this process is controlled largely by the length of time allowed for penetration. The total dip and drain time for forgings, castings and weldments is 15 minutes minimum and for forged turbine blades and cast blades with finished machine areas it is 30 minutes minimum. Immerse in emulsifier and drain for 2 minutes minimum, 3 minutes maximum. Apply a warm-water spray to remove excess oil from the part, so that only the oil remains which has penetrated deeply into the flaws. Dry the part in a soft flow of hot, dry air (150° - 200°F at 5 psig maximum).

5-70. APPLICATION OF DEVELOPER.

After all excess fluorescent oil has been removed, cover the part with developing powder. This powder draws to the surface the oil trapped in defects. When the part is examined in a darkened booth under ultraviolet (black) light, the developed oil from the defects is readily visible. The nature and extent of flaws can be determined by the extent of the development around the defects.

WARNING

Properly positioned black light is harmless to the skin and eyes. Developing powder is not harmful to inhale, but may be annoying in heavy concentration. Irritation is apt to result if the penetrating oil remains on the skin for several days. To avoid this, use brackets to hold parts and wear neoprene gloves when necessary. The presence of penetrating oil on the skin can be detected under black light.

5-71. POST-EMULSION PENETRANT METHOD OF INSPECTION.

Perform the post-emulsion penetrant method of inspection as follows:

1. Immerse the part in fluorescent-penetrant oil and allow it to penetrate for at least 30 minutes.

NOTE

Do not apply the emulsifier until the parts are ready for the washing operation.

CAUTION

The parts must be removed from the emulsifier immediately after dipping. If the parts are in contact with the emulsifier too long the effectiveness of the inspection is reduced.

2. Dip the part into emulsifier. Remove from the tank and wash it immediately.

3. Wash the parts individually and perform a "black light" inspection to be sure all excess penetrant oil has been removed.

a. If automatic washing units are used, place parts in the washer and wash them. Inspect each part under "black" light.

b. If manual wash stations are used, do not permit the parts to remain submerged in water for over 3 minutes.

c. If spray rinse is used, spray entire basket of parts immediately to prevent over-emulsification of penetrant oil. After entire basket has been sprayed, wash parts individually and inspect under "black" light for complete removal of penetrant oil.

d. Water temperature should be maintained at 32° - 43°C (90° - 110°F).

e. Air pressure, if used in conjunction with water spray, should be maintained at 40 to 60 psi.

f. Dip parts in developer and remove immediately. (Use dry developing powder on rotating parts. Cover parts with powder and let them stand for a minimum of 5 minutes. Shake off excess powder.) Allow to drain for one minute. Wet developer should be prepared by mixing 2-1/2 pounds of wet developer to each 5 gallons of clean tap water.

NOTE

Check the developer bath twice daily, using "black" light to determine contamination of solution by penetrant oil. If there is considerable fluorescence on the surface of the bath, or if parts show fluorescent streaks or spots on removal from the developer, the contaminated solution should be replaced.

4. Place parts in a circulating hot-air dryer for 10 minutes with dryer temperature maintained at 105°C (220°F).

NOTE

Excessive drying time will evaporate oil from defects.

5. Remove parts from the dryer and place in a suitably darkened inspection booth.

6. Inspect each part individually.

7. Clean parts per paragraph 5-46 after inspection.

5-72. WHITE LIGHT METHOD OF INSPECTION.

5-73. GENERAL.

The inspection limits in this manual are based on using the White Light method described in paragraph 5-74.

5-74. DESCRIPTION OF INSPECTION METHOD.

1. Inspect parts as follows:

NOTE

Use this inspection method on all engine parts and subassemblies removed from the engine. Do not chemically clean parts before visually inspecting them.

a. Inspect the part for defects under a bright white light (150-watt standard spot or 40-watt high intensity, or equivalent).

b. Inspect each suspect area using low power (5 to 10 power) magnification to verify the defect and to determine its size.

c. Mark the extent of each unusable defect directly on it, along its entire length using a vibro-peen pencil. Circle each defect using a Marks-A-Lot, Dykem, or chalk.

5-75. GENERAL WELDING INSTRUCTIONS.

5-76. OUTLINE OF PROCEDURE.

The following paragraphs are for repair-welding all parts listed in this manual, using tungsten, inert-gas-shielded arc welding (TIG). These instructions must be closely followed. If they are not, the weld may not be acceptable.

- PRELIMINARY INFORMATION.
- EQUIPMENT REQUIRED.
- INSPECTING BEFORE REPAIR-WELDING.
- PREPARING DEFECTS FOR REPAIR-WELDING.
- USING GAS-BACKING OR COPPER-BACKING.
- WELDING TECHNIQUES.
- INSPECTING AFTER REPAIR-WELDING.
- ADDITIONAL INSTRUCTIONS FOR WELDING INCONEL.

5-77. PRELIMINARY INFORMATION.

1. All welding must be done by welders certified per MIL-T-5021.

2. Additional weld data can be found in table 5-6.

3. Cumulative length of a repair, specified in the repairable limits column, includes the total length of all previous repairs in that section of the part. However, if cracks develop immediately after welding, repair them without adding their length to the total. Consider each section of an engine part separately when finding the cumulative length of cracks.

4. When welding parts made of Inconel, follow the GENERAL WELDING INSTRUCTIONS.

5-78. EQUIPMENT REQUIRED.

1. Safety equipment.

a. Welding helmet with No. 10 filter glass.

b. Safety glasses or face shield for grinding.

c. Gloves.

2. Welding machine and accessories.

a. An AC machine is required for welding aluminum. For welding steel, use a machine with a minimum 250-300 amp DC rectifier with high frequency capability and:

(1) A means of providing variable current from a remote position (usually foot operated).

(2) Welding torch with a power cable adapter.

b. Pointed electrode, 1/16 inch diameter, tungsten (1% thoriated).

c. An ammeter for checking machine output. If a meter is not installed, the machine must be periodically calibrated.

d. Two sources of argon gas (one for torch, the other for backup) including regulators and flowmeters.

e. Filler wire, Hastelloy W 1/32 inch and 1/16 inch diameter (3/64 inch diameter optional).

f. Spare ceramic cups for welding torch.

g. Spare torch collets and collet bodies.

3. Equipment and tools.

a. Good lighting, preferably an adjustable lamp.

b. Eight-power magnifying glass.

c. Metal workbench grounded to welding machine.

d. Hand grinder and an assortment of carbide rotary files and miniature grinding wheels.

e. Stainless steel wire brush.

f. Eight-ounce ball peen hammer.

g. Chisel.

h. Side-cutting pliers.

i. Assortment of C-clamps.

j. Vise grip pliers.

k. Trichloroethylene, acetone or similar solvent for cleaning defects.

5-79. INSPECTING BEFORE REPAIR-WELDING.

It is important that the ends of a crack be found so that the crack will be completely welded. If the crack is not completely welded, it may get longer after welding. Do the following:

1. Fluorescent-penetrant inspect defective area.

2. Run a line directly on each crack along its entire length, using a vibropeen pencil. Circle each defect, using chalk, so that the marking will not be removed by degreasing.

3. Vapor-degrease the part.

5-80. PREPARING DEFECTS FOR REPAIR-WELDING.

When preparing a part for repair-welding, it is extremely important that all contaminants be removed from the repair area. Contaminants not removed can cause a crack to form in the weld after part is returned to service. Prepare part as follows:

1. Vapor-degrease part per paragraph 5-41 and dry part, using filtered compressed air.

2. Remove protective coating within 1/2 inch of area to be welded.

3. Mark the ends of the crack, using a grease pencil or other marker such as Marks-A-Lot or chalk.

4. Using either dry-blast process or wet-blast process, clean the area to be repaired; clean both sides of part if possible. DO NOT use glass beads with the wet-blast process.

5. Using a bright light and an 8-power magnifying glass, find the exact end of the crack.

6. If necessary, re-mark the ends of the crack.

NOTE

Fillet welds do not require grinding unless otherwise specified.

7. Using an electric or air hand-grinder and a carbide rotary file (figure 5-35), completely grind out the crack as follows (figure 5-36).

NOTE

Keep groove as narrow as possible.

a. Select a rotary file based on the width of the crack to be ground out.

b. If crack is not through, grind it out completely.

c. If crack is through and material thickness is 1/8 inch or less, grind it out, removing about 80% of material thickness.

d. If crack is through and material is thicker than 1/8 inch, grind it out on one side, removing about 60% of material thickness. Weld this side; then grind out remainder of crack on other side of part.

e. If there is more than one layer of material, grind out crack completely, even if this requires grinding into the next layer.

8. If the part has not been blasted, remove the surface oxides, using fine abrasive cloth or soft abrasive wheel.

a. Do not reduce the material thickness.

b. Clean the surface within 1/4 to 1/2 inch of crack to remove oxides.

c. If you can get at the back side of the crack, clean it also.

9. Grind 1/8 inch beyond the end of all cracks, if possible.

10. Grind out all burned metal.

11. Grind out old filler material.

12. On anodized aluminum parts, remove all anodize within 1/2 inch of area to be welded.

WARNING

- Do not inhale vapors from solvents.

- Do not use solvents near flame or open sparks.

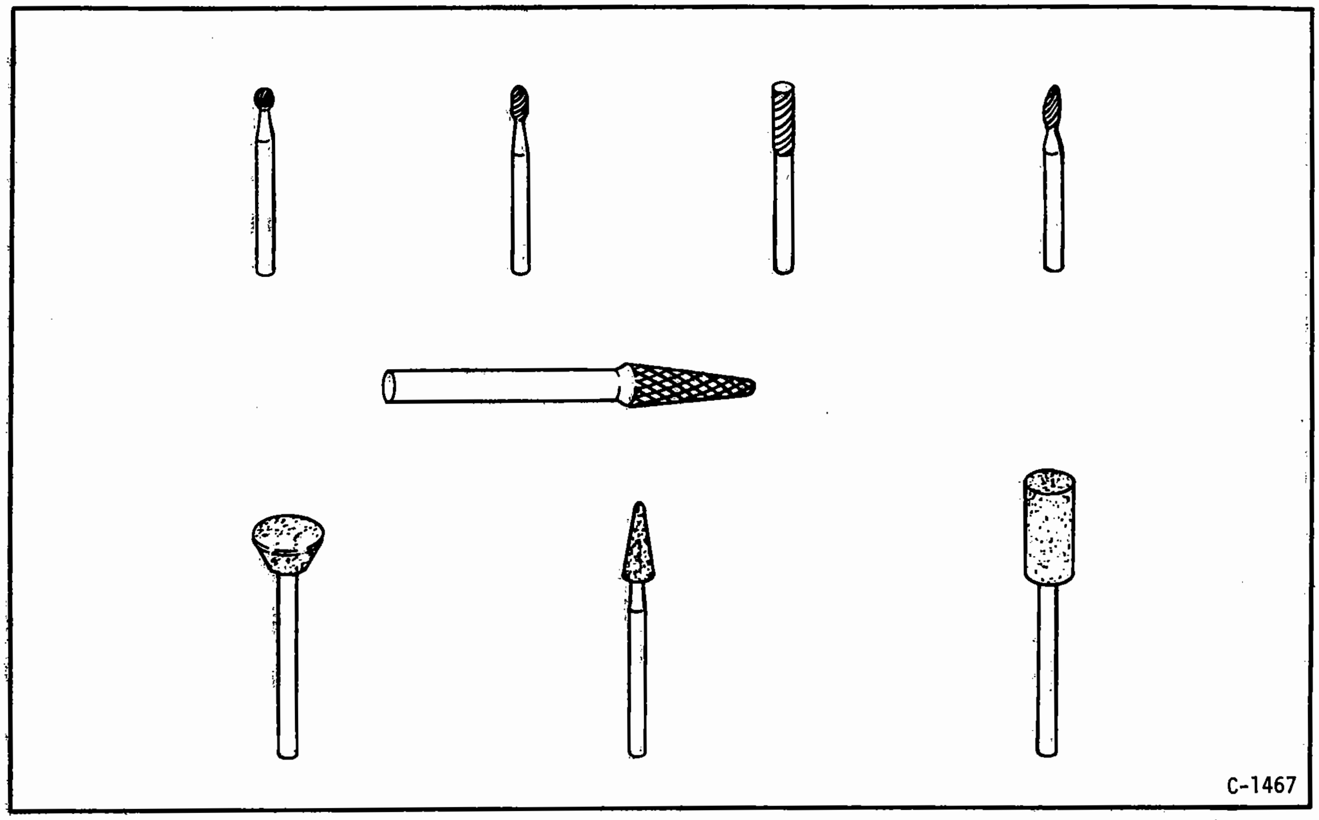


Figure 5-35. Rotary Grinding Bits and Stones

13. If the prepared area is oily or greasy, clean with solvent.

5-81. USING GAS-BACKING OR COPPER-BACKING.

TIG welding uses an inert-gas shield to protect the weld from air. This prevents oxides from forming on the side where the welding is being done. The backside of the weld must also be protected to prevent oxides from forming there. This is done by using either gas-backing or copper-backing. Copper-backing also takes away heat to reduce distortion.

1. Look in table 5-6 to find the recommended method of backing. If there is none listed, use gas-backing.

2. Gas-backing. The recommended methods of using backup gas are (Method A), applying gas directly from a hose and (Method B), flowing gas into a sealed space.

a. Method A. This is done by having someone else follow the weld, on the backside, with a continuous flow of gas (figure 5-37) as follows:

(1) Attach a short piece of copper tubing to gas hose.

(2) Attach a ceramic torch cup to tubing. Gas coverage can be increased by putting steel wool into the cup. Keep steel wool at least 1/8 inch below the end of cup.

(3) Gas flow should be as high as possible but not so high that it pushes molten metal out of the weld. The flow rate should be as shown in table 5-6. If defect is wide, keep rate low; if it is narrow, keep rate high.

(4) Hold cup 1/32 to 1/16 inch away from weld on the backside and directly under spot being welded.

(5) Keep gas flowing after arc has been broken until the red glow is gone.

b. Method B. This is done by sealing a space behind the weld to make a pocket for gas. The pocket can be formed by using aluminum foil or screening covered with masking tape; or gas may be sealed in the part itself, such as in struts or tubes.

(1) When pocket is formed, there must be at least 1 inch of space between weld and foil. Tape foil or screen to the part.

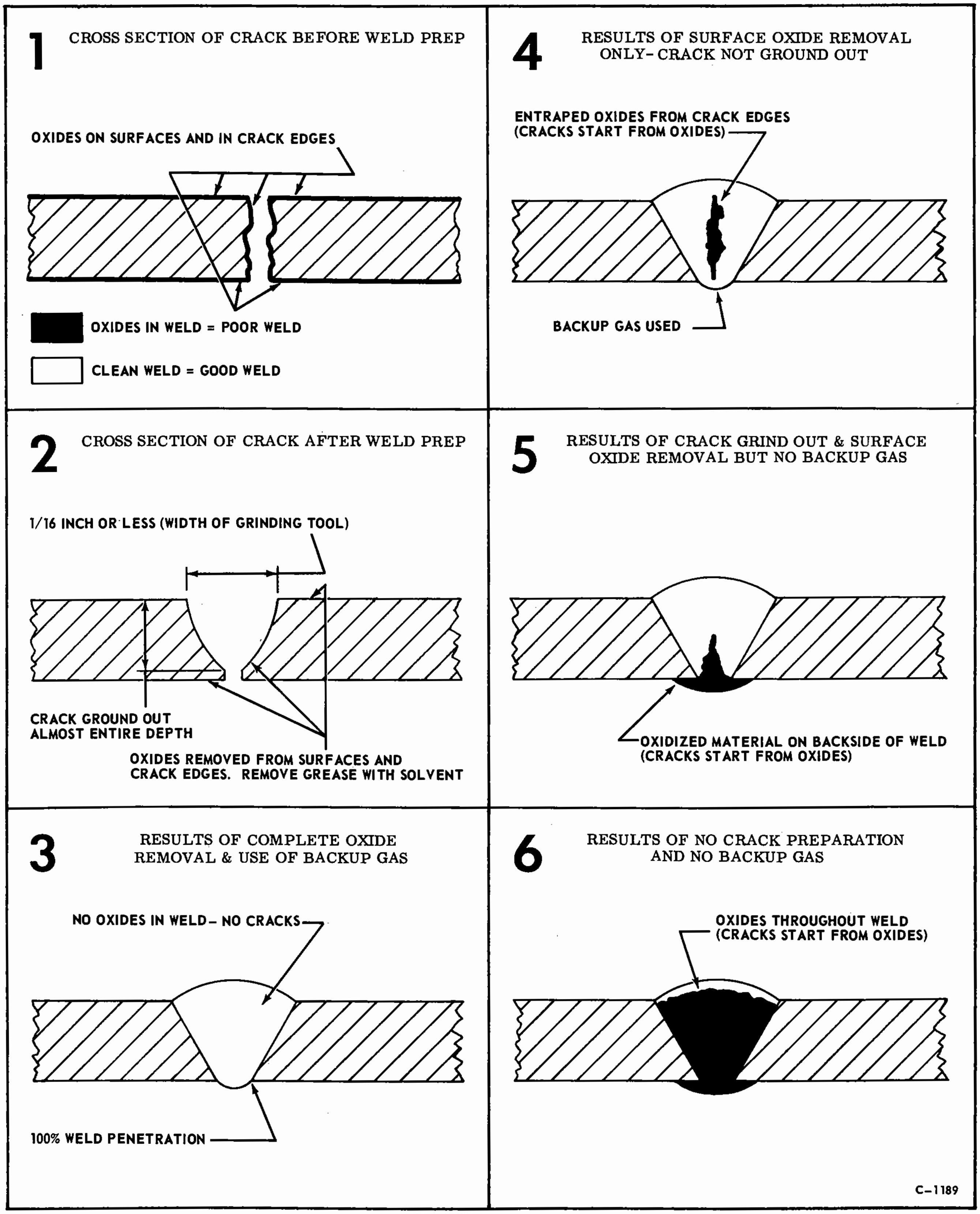
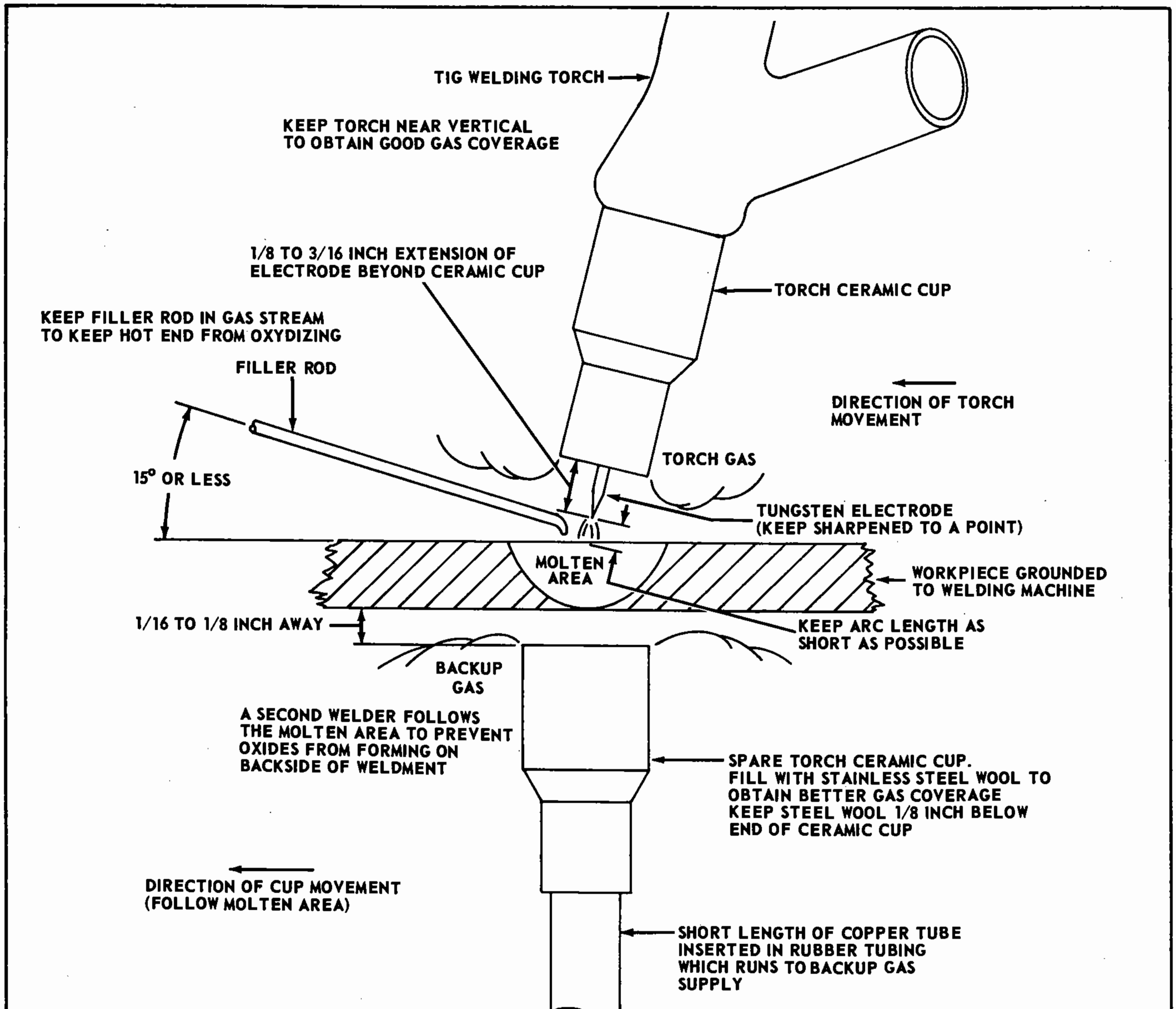


Figure 5-36. Crack Repair Weld Practices



NOTE: IF BACKSIDE OF REPAIR IS INACCESSIBLE, GAS BACKING CAN BE OBTAINED BY MAKING A POCKET BEHIND THE REPAIR AREA USING ALUMINIUM FOIL TAPED TO THE WORKPIECE, SCREENING COVERED WITH MASKING TAPE OR ANY METHOD WHICH WILL HOLD GAS AGAINST THE REPAIR AREA. INTRODUCE GAS AT ONE END OF THE POCKET AND PUT SEVERAL SMALL HOLES IN THE OPPOSITE END TO ALLOW GAS FLOW. ALLOW GAS TO FLOW 3 OR 4 MINUTES BEFORE STARTING TO WELD.

C-1190

Figure 5-37. Welding Torch Use

(2) Put gas hose into a hole at one end of the pocket. Seal with tape.

(3) Seal all other holes with tape. Punch a few small holes in foil or tape at the other end of pocket to let gas escape.

(4) Let gas flow for 3 to 4 minutes to drive out all air. The bigger the pocket, the longer the gas must flow. All air must be forced out before welding.

3. Copper-backing. This kind of backing draws heat from the area around the weld. Use it to prevent damage to nearby areas, such as melting a braze joint. Use it also to reduce distortion caused by welding heat.

a. Form a piece of copper to fit flush against the backside of area to be welded.

b. Undercut copper about 0.010 inch in the area that will be directly behind the weld. This makes room for molten metal to drop slightly below the part contour so that weld can penetrate 100%.

5-82. WELDING TECHNIQUES. (See figure 5-37.)

Table 5-6 gives the following information: material of part, filler material, current amperes, torch and backup gas flow, and type of weld contour. The inspection paragraph for the part being welded references the correct item number in table 5-6. For best results, use the following techniques.

CAUTION

Welding Inconel is difficult. Do not take any shortcuts. Shortcuts will result in a poor weld.

1. Use an 8-power magnifying glass, to see if the entire defect has been properly prepared.

2. Do not preheat parts unless specified.

3. Remove oxides from filler wire, using a fine emery cloth; then wipe just before using with a clean wiper dipped in solvent.

4. Ground the part either by contact with a bench grounded to the machine or by direct contact with ground cable of the machine.

5. If machine does not have a high frequency starting feature, start arc on a copper strip clamped next to the defect.

6. Use a ceramic torch cup that will give good coverage. Keep filler wire in the stream of gas.

7. Keep torch electrode sharp unless otherwise specified. A blunt electrode will make it difficult to direct the arc exactly where you want it to go.

NOTE

Periodically calibrate machine to assure accurate current settings.

8. Keep heat-affected zone to a minimum by keeping the arc short and welding at a reasonably fast speed. The higher the current, the faster the arc should be moved. Current ranges in the weld data table will allow the welder to select a setting to fit the speed at which he prefers to weld.

9. Make a short weld. Check the backside to be sure of getting 100% penetration. Too high a current and too slow a speed will cause too much buildup of bead on the backside.

10. If oxides or dirt get into the weld, stop welding immediately. Grind out the weld and clean the area with solvent. If there is oil on the part, heat will draw it into the weld. It may be necessary to repeat this procedure a few times before all the oil is removed.

11. Keep the torch in a near vertical position to get good gas coverage over and around the weld.

12. When reaching end of weld, rotate the torch so that arc goes back in bead; and with remote control, slowly decrease current until arc goes out. Doing this will prevent a pit at the end of the weld.

13. Hold torch over the bead with the gas flowing until the red glow is gone. This prevents formation of oxides at the end of the weld.

14. Never run a bead over or into another bead, without first thoroughly brushing it off with a stainless steel wire brush. This removes surface oxides which may have formed on the original weld. If they are not removed and a bead is run over them, the oxides become trapped, making a bad weld.

15. If a crack appears in a repair weld, stop welding. It is an indication that dirt is still in the crack or that heat is too high, causing too much shrinkage. Never run another bead over a weld crack without first grinding out the crack.

16. Clean all repairs with a stainless steel wire brush or with fine emery cloth.

17. The contour of the repair weld is specified in table 5-6. Reinforced welds must not be higher than 1/32 inch above parent metal contour. Flush welds must not extend above or below parent metal contour. Blend repair weld to the contour specified, if it is too high.

5-83. INSPECTING AFTER REPAIR-WELDING.

1. Fluorescent-penetrant inspect unless otherwise specified. Weld all cracks that are found, using procedures given above.

2. If repair is in a critical location, certain dimensions may have to be measured. Refer to inspection paragraph to see if an inspection is required. Dimensionally inspect as specified.

5-84. ADDITIONAL INSTRUCTIONS FOR WELDING INCONEL.

These materials are difficult to weld because they are more susceptible to weld shrinkage and cracking. It is important that all of the GENERAL WELDING INSTRUCTIONS be followed closely. If quality of weld is unsatisfactory, use table 5-5 to find reason.

5-85. INSPECTION OF TUBING.

5-86. PRELIMINARY INSTRUCTIONS.

1. Using pinpoint micrometers, determine the depth of defects in tubing by subtracting the tube OD in the defect from the tube OD immediately adjacent to the defect. The difference will be the defect depth. If there is a defect diametrically opposite to the one being checked (as is usually the case when a tube has been chafed by a clamp), divide the difference of the micrometer readings by 2 to obtain the average wear.

2. Determine if an area has been previously blended by comparing tube OD measured at the suspect area and at 2 different areas which do not appear to have been blended.

3. Finishes may be inspected by comparing the surface with a set of standard finish specimens. (General Electric surface roughness scale catalog No. 8665947G1 Apparatus Dept., Schenectady, N.Y. or equivalent.)

WARNING

Trichloroethylene
Fed Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is injurious to the lungs.
- Use only with adequate ventilation.
- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers.

TABLE 5-5. REASONS FOR UNSATISFACTORY WELDS IN INCONEL

Cause of Cracks	Explanation	Remedy	Remarks
1. Defect not cleaned properly.	Oxides trapped in weld.	Grind out oxides.	Cracks start from oxides trapped in weld.
2. Oil not removed from defect.	Heat draws oil into molten puddle.	Grind out and degrease.	This will occur at seam welds, small pockets, etc.
3. Current too high.	Puddle shrinks too much and causes cracks.	Reduce amperage.	Check machine setting and table 5-6 before starting.
4. Torch electrode touched puddle.	Tungsten acts like oxides in weld.	Grind weld where electrode touched and resharpen electrode.	
5. Blunt electrode.	Difficult to control arc.	Sharpen electrode.	Blunt electrode result in higher than necessary current.
6. Welding over uncleaned old weld.	Oxides trapped in weld.	Grind out oxides.	Do not weld over an uncleaned weld.
7. Oxides in backside of weld.	Backside not completely protected from air.	Protect backside from air.	Read paragraph on gas-backing and copper-backing.

TABLE 5-6. INERT ARC WELDING DATA

(Electrode: 0.062 Dia. 1% Thoriated Tungsten-Pointed Unless Otherwise Noted Under "Remarks".)
Use filler wire 1/32 inch to 1/16 inch diameter (1/32 inch is preferred) unless otherwise stated in remarks.

Item	Material to be Welded	Welding Rod Specification or Designation	Size (Dia.)	Torch Gas Flow-CFH	Backup Gas Flow-CFH	Current (Amperes)	Weld Contour	Clean before Welding per Paragraph	Inspection after Welding per Paragraph
1.	AMS 5735 B50T73	Hastelloy W	0.030-0.062	Argon 8-14	Argon or Helium as required.	25-30	Tack Weld	5-36	5-196
2.	B50T73	Hastelloy W	0.030-0.062	Argon 8-14	Argon 2-10	25-30	Reinforced	5-36	5-196
3.	AMS 5599 Inconel 625	Hastelloy W	0.030-0.062	Argon 8-14	Helium or Argon 2-10	25-35 D.C. Straight polarity	Butt	5-36	5-127
4.	Inconel 718	Hastelloy W	0.030-0.062	Argon 8-14	Helium or Argon	20-35 D.C. straight polarity	Butt	5-36	5-121
5.	B50TF14	Hastelloy W	0.030-0.062	Argon 8-14	Helium or Argon 2-10	25-35 D.C. straight polarity	Butt	5-36	5-111
6.	AMS 5604 17-4PH SST	Hastelloy W	0.030-0.062	Argon 8-14	Helium or Argon 2-10	25-35 D.C. Straight Polarity	Butt	5-36	5-124
7.	AMS 5754/5536 Hastelloy X	Hastelloy X	0.030-0.062	Argon 8-14	Argon 2-10	35-50 D.C. straight polarity	Reinforced (blend flush)	5-36	5-158
8.	AMS 5536	Hastelloy X	0.030-0.062	Argon 8-14	Argon 2-10	25-40 D.C. straight polarity	Reinforced (bench flush)	5-36	5-158
9.	Inconel 718	Hastelloy W	0.030-0.062	Argon 8-14	Argon 5-10	25-50 D.C. straight polarity	Reinforced	5-36	5-177
10.	AMS 5536	Hastelloy W	0.030-0.062	Argon 8-14	Argon 5-10	25-50 D.C. straight polarity	Reinforced	5-36	5-187
11.	AMS 5540	Hastelloy W	0.030-0.062	Argon 8-14	Helium or Argon 2-10	15-25 D.C. straight polarity	Reinforced	5-36	5-202

4. After completing all inspection and repair, pressure-flush the part with trichloroethylene solvent in both directions. Cap all inlets and outlets immediately after flushing.

5-87. REPAIR OF TUBING DEFECTS.

1. Blend minor indications as follows:

a. Use a fine abrasive stone, a small file, abrasive cloth, or a crocus cloth for blending.

b. Blend a cylindrically shaped part around its circumference. The finished blend shall be as close as is practical to the original finish of the part.

2. The correct blending of surface defects is necessary because it lessens the possibility of stress concentration at these points.

5-88. TORN LOCKWIRE HOLE REPAIR. (See figure 5-38.)

1. Choose same drill size for new lockwire holes.

2. Blind hole fittings (caps, plugs, etc.) shall be redrilled for lockwire not closer than 1/2 the drill diameter and parallel to the wrenching flat. Locate hole midway on flat thickness.

NOTE

Redrilled lockwire holes must not pass closer to any inner cavity than 1/2 the drill diameter.

3. Through-hole fittings (unions, connectors, etc.) shall be redrilled for lockwire across the hexagon corners. Locate hole to provide at least one drill diameter wall thickness to corner and positioned midway of flat thickness.

4. Deburr holes to remove sharp edges.

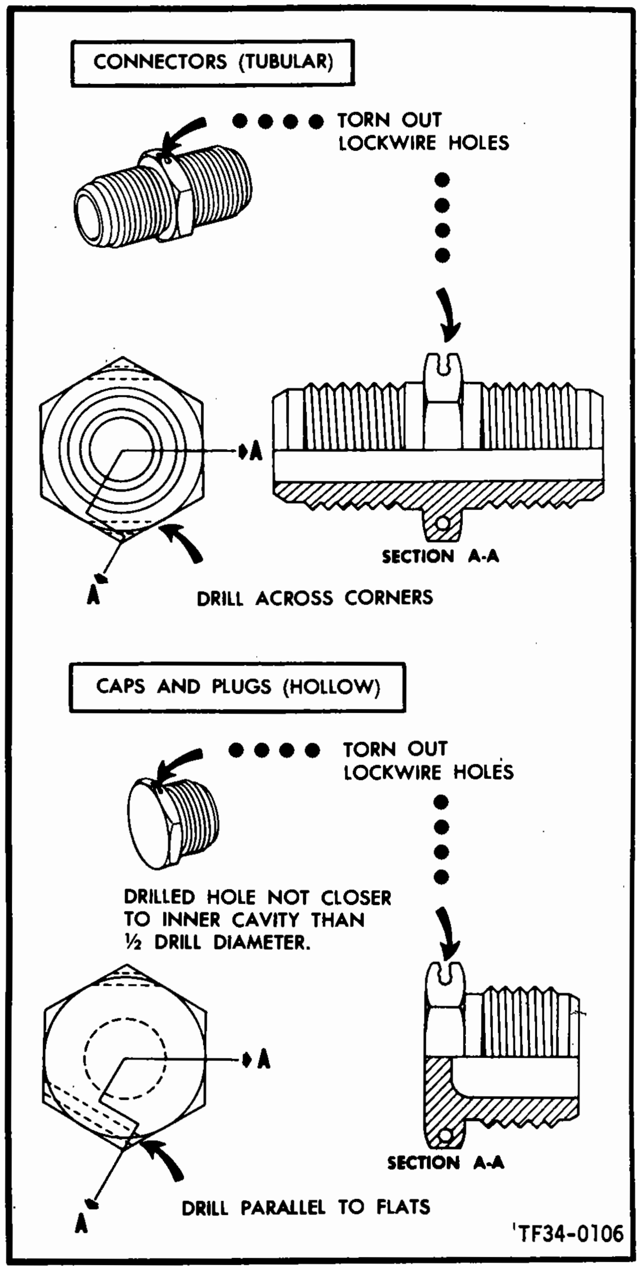


Figure 5-38. Repair of Torn Lockwire Holes

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS AND ELECTRICAL CABLE EXTERIOR.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	CAUTION Do not rebuild hoses.		
1. Teflon-lined flex hoses for:			
a. Kinks or buckling.	None allowed.	Not repairable.	Replace hose.

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS AND ELECTRICAL CABLE EXTERIOR. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Frayed or broken wire braid strands.	No more than 9 strands in a square area measuring 1 inch on a side. Bend back broken strands.	Not repairable.	Replace hose.
2. Tubing for:			
a. Splits or cracks.	None allowed.	Not repairable.	Replace tube.
b. Nicks, scratches, guoges, wear, chafing on:			
(1) Non fuel-carrying tubes.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal and blend to adjacent contour, using a fine abrasive stone. Replace tube if blending had been previously done in same area.
(2) Fuel-carrying tubes.	Not usable if depth of defect can be measured.	Not repairable.	Replace tube.
c. Dents.	Dented area not over 20% of tube diameter on straight or curved section having a radius over twice the tube diameter. On a sharply bent radius, not over 10% of tube diameter may be dented.	Not repairable.	Replace tube.
d. Flattened area.	OD not less than 3/4 of original OD.	Not repairable.	Replace tube.
e. Nicks and scratches on packing grooves.	Up to 0.003 inch deep on floor, 0.010 inch deep on wall of groove with no sharp edges. Tube must pass pressure test.	Not repairable.	Replace tube.
f. Flatness of bolt flange mating surface.	Flat within 0.005 inch (place on flat surface and insert 0.005 inch feeler gage).	Up to 25% of original flange thickness can be removed to meet usable limit.	Rework to usable limit by lapping, stoning or machining (if possible).
g. Cracks in bolt flange.	None allowed.	Not repairable.	Replace tube.
3. Hex coupling nuts for:			
a. Damaged corners.	Any amount as long as wrench can be used.	Not repairable.	Replace part.
b. Cracks.	None allowed.	Not repairable.	Replace part.
c. Nicks and burrs.	Any amount with no high metal.	Any amount with high metal.	Blend high metal (see paragraph 5-87).

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS AND ELECTRICAL CABLE EXTERIOR. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Damaged threads.	One-half of one thread (cumulative) with no high metal.	Same as usable limits, with high metal.	Chase threads using a bottoming tap.
e. Torn lockwire holes.	Not usable	Any number if one corner does not have a lockwire hole through it.	Drill a lockwire hole in an undrilled corner (see paragraph 5-88).
4. Male fittings for:			
a. Nicks, dents, scratches, ridges and pits on sealing surface.	Any number as long as defects do not extend across (axially) more than 1/2 the sealing surface. No high metal allowed.	Same as usable limits, with high metal.	Rework sealing surface, maintaining original contour using a fine abrasive stone.
b. Damaged threads.	One-half of one thread (cumulative) with no high metal.	Same as usable limits, with high metal.	Chase threads with a die or blend defects with a fine file or stone.
c. Nicks, dents, scratches, and gouges on all other fitting surfaces.	Any number, 0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour using a fine abrasive stone.
d. Cracks.	None allowed.	Not repairable.	Replace part.
e. Torn lockwire holes.	Not usable	Any number if one corner still does not have a lockwire hole.	Drill a lockwire hole in an undrilled corner (see paragraph 5-88).
5. Female fittings (including flares) for:			
a. Nicks, dents, scratches, ridges and pits on sealing surfaces.	Any number as long as defects do not extend across (axially) more than 1/2 the sealing surface. No high metal. Four superficial nicks, dents, or pits (with no high metal) on the leading half of the sealing surface if the fitting passes pressure check.	Same as usable limits, with high metal.	Blend high metal (see paragraph 5-87).
b. Nicks and gouges on tubing flare.	Any number, 1/32 inch deep, if there is no high metal and if fitting passes pressure check.	Same as usable limits, with high metal.	Blend high metal (see paragraph 5-87).
6. Tube flare ferrules for:			
a. Cracks.	None allowed.	Not repairable.	Replace part.

5-89. INSPECTION OF HOSES, TUBING, FUEL TUBES, FITTINGS, AND ELECTRICAL CABLE EXTERIOR. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Adhesion to flare nuts.	Any amount if nut turns smoothly on ferrule.	Any amount if nut can be made to turn smoothly on ferrule.	Apply penetrating oil to nut and try to work it free. Remove all traces of penetrating oil.
7. Electrical cable for:			
a. Broken braid strands.	Five strands in any 1-inch square.	Any amount as long as insulation is intact, and area can be covered by a 1 inch patch.	Carefully bend back each broken strand so that strands do not puncture insulation. Repair (see figure 5-39).
b. Worn or damaged Viton backshells at connectors.	Any amount provided wire braid is not exposed. Exposed solid metal, up to 50% of circumference, is acceptable.	Not repairable.	Replace cable.
8. Cable ring nuts for:			
a. Damaged threads and out-of-roundness.	Ring nuts must screw on mating parts without difficulty and attach securely.	Not repairable.	Replace cable.
b. Worn knurled area.	Any amount unless base ring has cuts deeper than 1/32 inch.	Not repairable.	Replace cable.
9. Teflon wrap for tightness.	Wrap should conform to harness with no projecting ends.	Any amount.	Remove damaged sections and rewrap with same color Teflon. Tape ends of wrap with silicone tape.

5-90. INSPECTION OF MAIN ENGINE BEARINGS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. All bearings for:			
a. Dirt and foreign material.	None allowed.	Any amount.	Clean bearings (see paragraph 5-44).
b. Cracked, flaked or broken parts.	None allowed.	Not repairable.	Replace bearing.

CAUTION

All bearings are matched assemblies. If any part of a bearing is rejected, the entire bearing assembly must be replaced.

5-90. INSPECTION OF MAIN ENGINE BEARINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
c. Distortion on cage.	No visual distortion allowed.	Not repairable.	Replace bearing.
d. Heat discoloration.	Straw or light brown color is acceptable.	Not repairable.	Replace bearing.
e. Stains on balls, rollers, raceways.	Any amount not interpreted as corrosion.	Any amount with no apparent depth after corrective action.	Remove stains using crocus cloth with light polishing action.

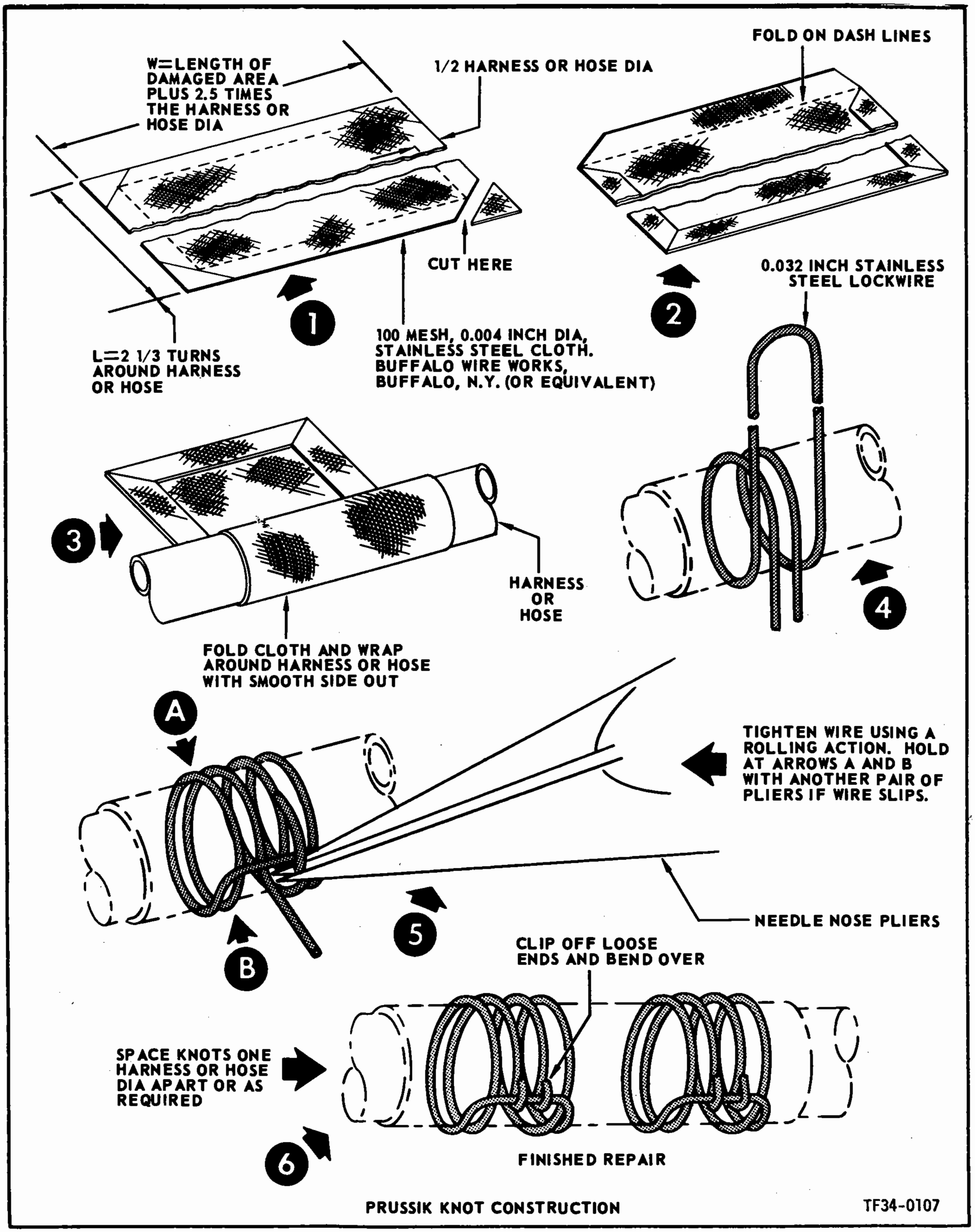


Figure 5-39. Wire Brand Repair

5-90. INSPECTION OF MAIN ENGINE BEARINGS. (CONT.)

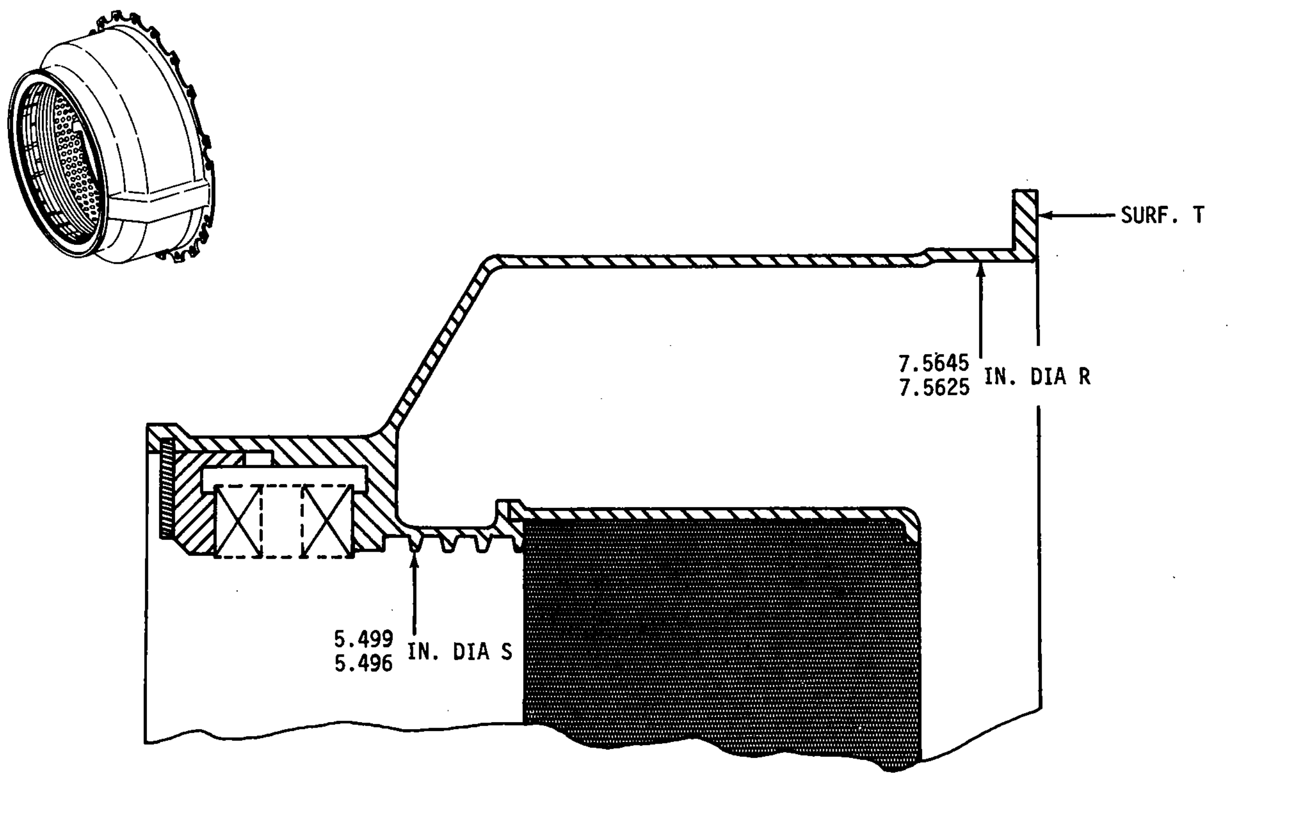
Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Roller bearings for:			
a. Circumferential grooves on rollers.	Using light pressure, slide a scriber with 0.03 inch radius transversely across the roller surface. Three grooves per surface on 50% of rollers allowed, provided no single groove exceeds 0.010 inch in width. Grooves can readily be felt and tend to hang up a scriber with a 0.03 inch radius. Those not hanging up on scriber are not considered grooves.	Not repairable.	Replace bearing.
b. Concentric wear on ends of rollers.	Any roller having end wear that can be readily felt with a 0.03 inch radius scriber is not usable.	Not repairable.	Replace bearing.
c. Eccentric wear on ends of rollers.	Not allowed.	Not repairable.	Replace bearing.
d. Scratches, pits, nicks and smooth dents.	Should not be readily felt with a scriber having a 0.03 inch radius.	Not repairable.	Replace bearing.
3. Roller bearing raceways for:			
a. Scratches, nicks and smooth dents on roller path.	Should not be readily felt with a scriber having a 0.03 inch radius.	Not repairable.	Replace bearing.
b. Skidding (dull areas in an otherwise shiny roller path) on roller path.	Not allowed.	Not repairable.	Replace bearing.
c. Axial scratches on OD of the outer race and ID of inner race.	Any amount of no apparent depth. Ten per race, 0.010 inch wide with no high metal.	Same as usable limits, with high metal.	Remove high metal with crocus cloth.
d. Corrosion stains on surfaces other than roller track.	Twenty-five percent of width, thickness or circumference with no measurable depth and free of corrosion stains.	Fifty percent of width, thickness or circumference with no measurable depth.	Remove stains with crocus cloth.
4. Ball bearings for:			
a. Scratches, nicks and smooth dents on balls and raceway path.	Should not be felt with a 0.03 inch scriber when moved across the defect.	Not repairable.	Replace bearing.

5-90. INSPECTION OF MAIN ENGINE BEARINGS. (CONT.)

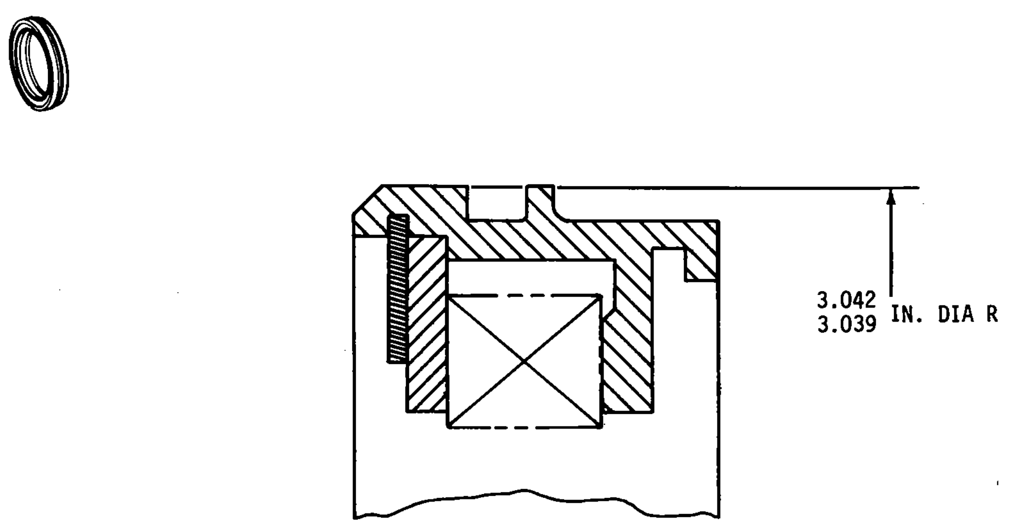
Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Axial scratches on OD of the outer race and ID of inner race.	Any amount of no apparent depth. Ten per race, 0.010 inch wide with no high metal.	Same as usable limits, with high metal.	Remove high metal with crocus paper.
c. Corrosion stains on surfaces other than balls and raceway path.	Twenty percent of width, thickness or circumference with no measurable depth and free of corrosion stains.	Fifty percent of width, thickness or circumference with no measurable depth.	Remove stains with crocus cloth.
	CAUTION Bearings must be cleaned per paragraph 5-44 after being inspected.		
5. Cage for:			
a. Scratches and nicks on non-functional surfaces.	Any amount.	Not repairable.	Not applicable.
b. Dents.	No visible dent allowed.	Not repairable.	Replace bearing.

5-91. INSPECTION OF RADIAL CARBON SEALS. (See figures 5-40 and 5-41)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	NOTE Seals are repaired at overhaul only, but are to be inspected per the following limits.		
	CAUTION The running surfaces of the carbon oil seals are extremely brittle and easily damaged. Be careful when handling them. Do not attempt to repair the carbon surfaces of the seal. Rework surface defects on the seal housing and retaining plate. Replace the oil seal assembly if there are cracks in the housing or plate.		
1. Carbon seals in the assembled condition for:			
a. Chipped sealing dam.	Any number across sealing dam, maximum individual length 1/8 inch, maximum total length 1 inch.	Not repairable.	Replace seal.
b. Cracks in carbon segments.	None allowed.	Not repairable.	Replace seal.
c. Foreign material imbedded in carbon.	None allowed.	Not repairable.	Replace seal.



NO. 6 BEARING CARBON SEAL



NO. 7 BEARING CARBON SEAL

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Figure 5-41. Radial Type Carbon Seals Inspection
(Sheet 2 of 2)

5-91. INSPECTION OF RADIAL CARBON SEALS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. For chips (other than on sealing dam or gaps).	Any number not over 1/4 inch long.	Not repairable.	Replace seal.
e. Ragged corners.	Any amount.	Not applicable.	Not applicable.
f. Excess surface wear of carbon segments	Allowed up to 75 percent of depth of grooves adjacent to gaps. (Measure by comparing to a new seal.)	Not repairable.	Replace seal.
g. Surface pitting (sand blasted appearance).	Any amount.	Not applicable.	Not applicable.
h. Scratches in carbon segments.	Any number not over 1/4 inch long.	Not repairable.	Replace seal.
i. Buildup of coked oil or hard material in axial grooves.	Allowed up to 75 percent of the original depth of the groove.	Not repairable.	Replace seal.
j. Buildup of coked oil or hard material in axial gap.	None allowed.	Not repairable.	Replace seal.
2. Carbon seal housings, cover plate and snap ring of seals that must be rebuilt for:			
a. Nicks, dents, burrs, carbon and varnish deposits (all surfaces).	Any number with no high metal	Same as usable limits, with high metal	Remove high metal using a fine file or stone. Wash part in solvent Federal Specification PD-680, or Trichloroethylene Federal Specification O-T-634.
b. Wear on radial seal face.	Step wear 0.002 inch maximum.	Not repairable.	Replace seal.
3. Carbon seal housings for (see figure 5-41):			
a. Dia. R for roundness.	Max. 0.006 inch TIR	Not repairable.	Replace seal.
b. Dia. S and windback seal for:			
(1) Cracks.	(a) 5 radial cracks 1/32 inch long. (b) No circumferential cracks allowed.	Not repairable.	Replace seal.
(2) Nicks and radial dents.	Any number, 0.005 inch deep; 4 per tooth not over 0.02 inch deep; 4 per seal not over 0.04 inch deep; cumulative length of all	Same as usable limits, with high metal or sharp edges.	Blend to a smooth contour.

5-91. INSPECTION OF RADIAL CARBON SEALS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	defects per tooth not over 30% of seal circumference. No high metal or sharp edges.		
(3) Axial dents.	Any number within a 0.10 inch deviation from original contour; cumulative length per tooth not over 30% of seal circumference. No high metal or sharp edges.	Same as usable limits, with high metal or sharp edges.	Blend to a smooth contour.
(4) Wear.	Not more than 0.010 inch on the diameter.	Not repairable.	Replace seal.

5-92. INSPECTION OF CARBON RUBBING SEAL RUNNERS

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	NOTE Sealing surface is OD of runner, extending to within 1/16 inch of edge of seal runner.		
1. Sealing surface for:			
a. Dents, scratches, nicks, pits.	Any number, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Chipping of chrome plating.	None allowed in seal rub pattern.	Not repairable.	Replace seal runner.
c. Crazing of chrome plating (superficial honeycomb cracks).	Any amount.	Not applicable.	Not applicable.
d. Chatter marks.	Any amount.	Not applicable.	Not applicable.
e. Circumferential grooves.	Any amount with no high metal.	Same as usable limits, with high metal.	Remove high metal.
f. Heat discoloration.	Discoloration or blueing with no apparent change in surface finish allowed. Obvious burns are not acceptable.	Not repairable.	Replace seal runner.
g. Foreign material deposits.	Any amount not higher than base surface. Carbon in fine pits and crazing is normal.	Any amount.	Clean runners (see paragraph 5-39).
	NOTE Carbon and varnish deposits that remain after cleaning may be removed by buffing the runner in a lathe using a		

5-92. INSPECTION OF CARBON RUBBING SEAL RUNNERS (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	soft, cotton buffing wheel. Use extreme care during buffing process to assure required finish.		
2. Other areas for:			
a. Cracks.	None allowed.	Not repairable.	Replace seal runners.
b. Dents, scratches, nicks other than on sealing surface.	Any amount, 0.030 inch deep, if less than 20% of the area is affected with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Braze separation of 2-piece runners.	None allowed.	Not repairable.	Replace seal runner.
3. Windback seal teeth for:			
a. Cracks.	None allowed.	Not repairable.	Replace seal runner.
b. Nicks and radial dents.	Any number, 0.005 inch deep; 4 per tooth not over 0.02 inch deep; 4 per seal not over 0.04 inch deep; cumulative length of all defects per tooth not over 30% of seal circumference. No high metal or sharp edges.	Same as usable limits, with high metal or sharp edges.	Blend to a smooth contour.
c. Axial dents.	Any number within a 0.10 inch deviation from original contour; cumulative length per tooth not over 30% of seal circumference. No high metal or sharp edges.	Same as usable limits, with high metal or sharp edges.	Blend to a smooth contour.
d. Wear.	Not more than 0.010 inch on the diameter.	Not repairable.	Replace seal.

5-93. INSPECTION OF ACCESSORY GEARBOX CARBON FACE SEALS AND MATING RINGS. (See figure 5-42)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action

NOTE

During inspection of carbon seals and mating rings, do not touch any portion of the sealing surfaces since finger prints can offset flatness checks. Carbon seals on axis D, F, H and L (see figure 5-42) must be disassembled for inspection. The lockring is first removed to release the carbon element. Handle the carbon with care since it is brittle. Carbon seal of axis BB (see figure 5-43) is an integral assembly and does not come apart.

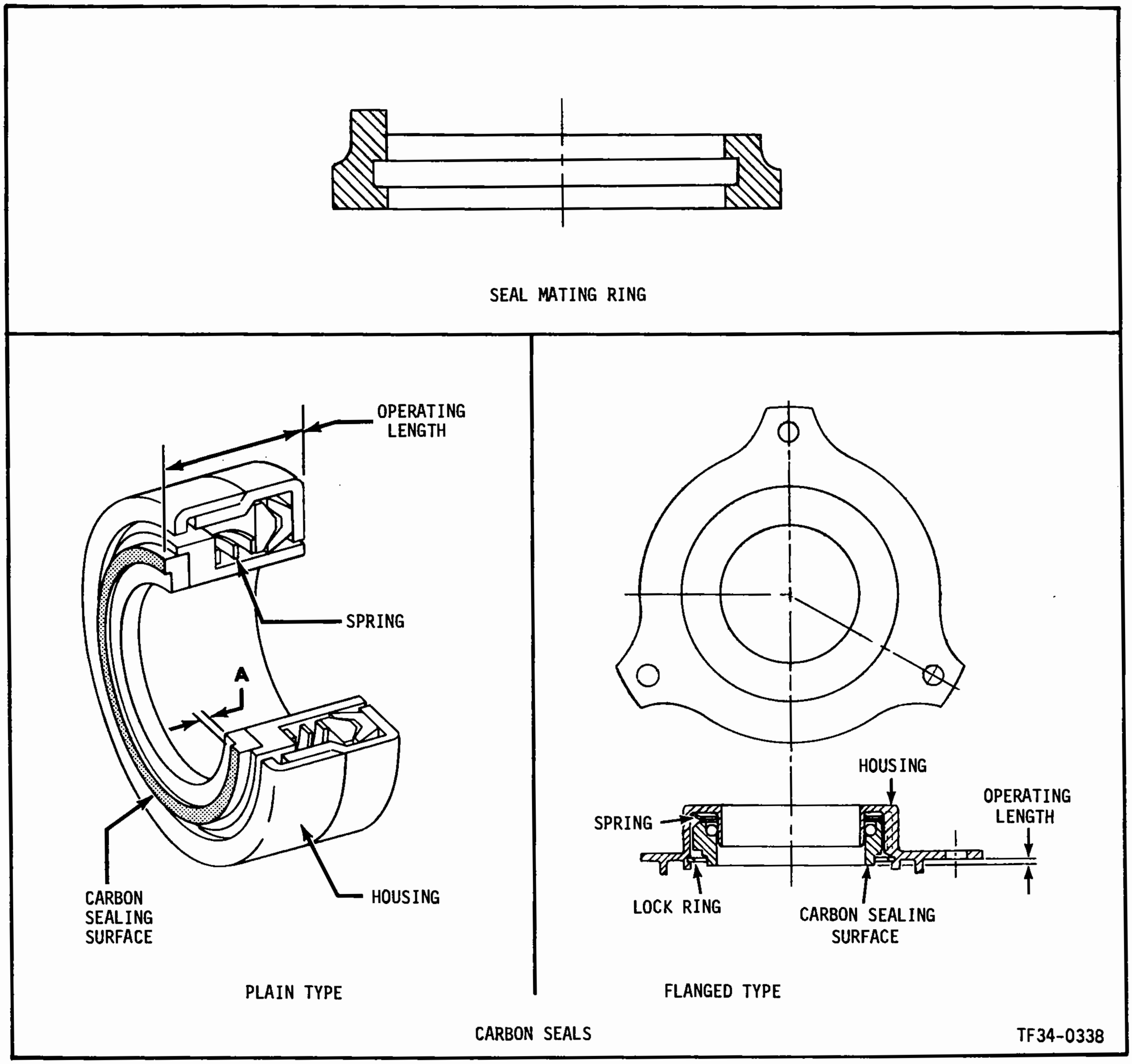


Figure 5-42. Gearbox Carbon Seal and Mating Ring Inspection

5-93. INSPECTION OF ACCESSORY GEARBOX CARBON FACE SEALS AND MATING RINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Housing for:			
a. Cracks.	None allowed.	Not repairable.	Replace seal.
b. Nicks and scratches.	Up to 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Dents and distortion.	No visible distortion allowed.	Not repairable.	Replace seal.

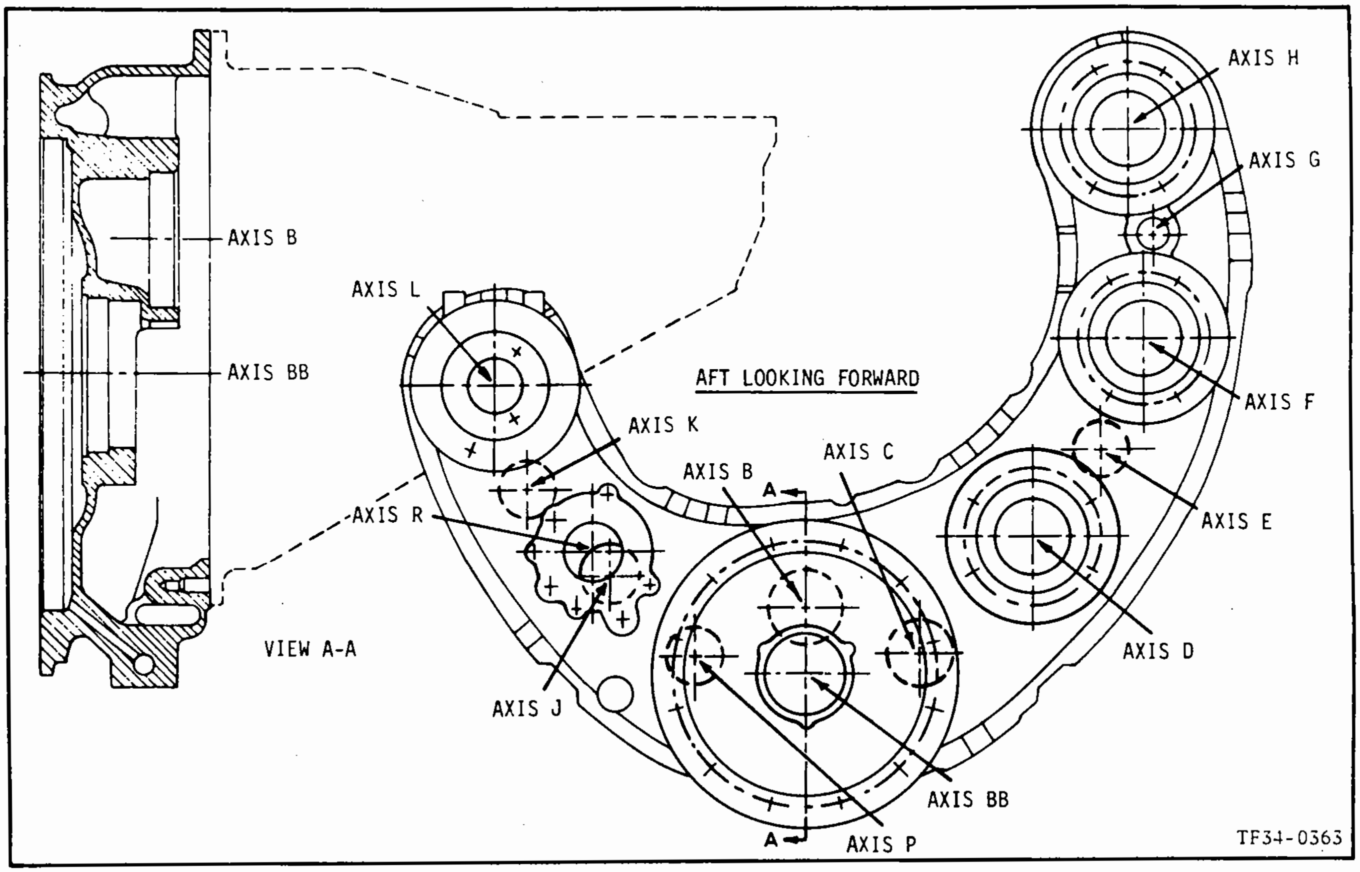


Figure 5-43. Gearbox Carbon Seal Location

5-93. INSPECTION OF ACCESSORY GEARBOX CARBON FACE SEALS AND MATING RINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Carbon element for:			
a. Cracks.	None allowed.	Not repairable.	Replace seal.
b. Scratches.	None allowed on sealing surface. Any amount elsewhere.	Not repairable.	Replace seal.
c. Coking at sealing surface.	None allowed.	Any amount.	Clean. (See paragraph 5-39).
d. Nicks and chips.	Up to 5 if not deeper than 1/64 inch, not to exceed 1/4 of the sealing surface width.	Not repairable.	Replace seal.
e. Anti-rotation key slot for wear.	Not more than 1/16 inch greater than key width.	Not repairable.	Replace seal.
3. Mating Seal ring for:			
a. Scratches or nicks.	Up to 1/64 inch deep with no high metal. None allowed on sealing surface.	Not repairable.	Replace seal.

5-93. INSPECTION OF ACCESSORY GEARBOX CARBON FACE SEALS AND MATING RINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Varnish deposits.	None allowed.	Any amount.	Clean seal. (See paragraph 5-39.)
	NOTE After assembly, check spring tension to assure element moves easily and that no binding exists. The seal must be coated with engine oil and kept in a dustfree bag until use.		

5-93A. INSPECTION OF OIL NOZZLES.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
Oil Nozzles for:			
1. Cracks.	None allowed.	Not repairable.	Replace nozzle.
2. Distortion.	No visible distortion allowed.	Any amount not causing tube collapse or cracks.	Cold work to proper alignment. No cracks allowed.
3. Clogged jet.	Not allowed.	Any amount.	Remove dirt with wire.
4. Nicks and scratches.	Any number up to 0.010 inch deep on tubing; elsewhere 1/64 inch deep. No high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Dents.	Up to 1/64 inch deep if not within 1/4 inch of oil nozzle hole.	Not repairable.	Replace nozzle.

5-93B. INSPECTION OF OIL TANK.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall tank for dents on:			
a. Corners.	Any number, 1/8 inch deep.	Not repairable.	Replace tank.
b. Flat or large concave surfaces.	Any number, 1/4 inch deep.	Not repairable.	Replace tank.
2. Overall tank for creases.	None allowed.	Not repairable.	Replace tank.
3. Nicks, scratches, and gouges.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.
4. Missing anodize finish.	Twenty percent missing.	Any amount.	Alodine· (see paragraph 5-54).
5. Bulging.	Any number, 3/16 inch above original surface except not allowed on middle third of tank.	Not repairable.	Replace tank.

5-93B. INSPECTION OF OIL TANK. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
6. Cracks	Not allowed.	Not repairable.	Replace tank.
7. Thread damage.	1 1/2 threads missing (cumulative) with no high metal.	Same as usable limits, with high metal.	Chase threads.

5-94. INSPECTION OF MAGNETIC CHIP DETECTORS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	CAUTION Flakes, chunks or metallic particles of over 1/16 inch in diameter indicate pending engine failure.		
1. Overall detector for:			
a. Fuzz-like magnetic particles or slivers.	None allowed.	Any amount.	Clean (see paragraph 5-95).
b. Flakes of magnetic particles.	None allowed.	Any amount.	Clean (see paragraph 5-95).
c. Chunks of metallic material.	None allowed.	Any amount.	Clean (see paragraph 5-95).

NOTE

- Place a straightedge across the detector outer shell adjacent to the center electrode. Insulation material shall not interfere with straightedge.

5-94. INSPECTION OF MAGNETIC CHIP DETECTORS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
•	Rejected chip detectors must be mutilated and disposed of.		
d. Insulation material interference.	None allowed.	Not repairable.	Replace detector.
	NOTE Connect center pin at external connection with center pin on magnetic end using a 6 volt supply and 6 volt bulb. Bulb must light.		
e. Direct short circuit.	None allowed.	Not repairable.	Replace detector.
2. Detector threads for:			
a. Crossed or damaged.	Not over the equivalent of one thread.	Not repairable.	Replace detector.
b. Nicks and burrs.	Any number with no high metal if threads can be used without danger of cross threading.	Same as usable limits, with high metal.	Blend to usable limits by removing high metal.

5-95. CLEANING OF MAGNETIC CHIP DETECTORS

1. Clean chip detectors as follows:

a. Use a clean container partially filled with clean engine oil.

b. Immerse detector and swish around several times to dislodge any material.

c. Wipe dry with clean lint-free cloth.

d. Lightly brush with soft brush or blow dry with 5 psi of filtered shop air.

e. Inspect. If not clean, repeat procedure.

5-95A. INSPECTION OF P3 WATER ACCUMULATOR.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
Accumulator assembly for bent tube at base.	Any amount of bend that does not result in difficult assembly or interference.	Any amount.	Repair (see paragraph 5-95B).

5-95B. REPAIR OF P3 WATER ACCUMULATOR BENT BASE.

1. Obtain an 1/8-inch aluminum straight connector PN J512P003 and a 1/8-inch fitting cap PN J521G01.

2. Assemble the fitting and the cap to the accumulator.

3. Clamp the straight connector in a bench vise.

4. Use a box wrench on the cap to apply a straightening force to the accumulator since the tube at the base is the weakest link of the accumulator, it should require a very small force to straighten.

5. Proof test at 700 PSIG for 2 minutes (leakage is allowed at flare fittings and flange).

6. Pressure test with air at 350 PSIG for two minutes. Max allowable leakage 0.02 SCFM.

5-96. INSPECTION OF FAN ROTOR ASSEMBLY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Spinner assemblies for:			
a. Nicks and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Cracks.	None allowed.	Not repairable.	Replace part of assembly that is cracked.
c. Dents.	Any number 0.020 inch deep.	Any number.	Cold-work dent to usable limits. Inspect for cracks; none allowed.
d. Bent bolt tabs.	0.010 inch from normal position.	Any amount.	Cold-work to usable limits. Inspect for cracks; none allowed.
e. Bolt flanges out of flat.	0.030 inch out of flat.	Any amount.	Cold-work to usable limits. Inspect for cracks; none allowed.
2. Forward outer spinner for worn rabbet diameter.	9.480 inches diameter maximum.	Not repairable.	Replace spinner.
3. Aft outer spinner for worn rabbet diameter.	17.386 inches diameter.	Not repairable.	Replace spinner.
4. Aft inner spinner for:			
a. Worn aft outer rabbet diameter.	17.378 inches diameter minimum.	Not repairable.	Replace spinner.
b. Worn aft inner rabbet diameter.	15.874 inches diameter maximum.	Not repairable.	Replace spinner.
c. Worn boltholes.	0.1950 inch diameter maximum.	Not repairable.	Replace spinner.
5. Spinner assembly stud for:			
a. Worn diameter.	0.189 inch diameter minimum.	Not repairable.	Replace studs.
b. Damaged threads.	1-1/2 thread damaged or missing with no high metal or burrs.	Any amount.	Remove high metal and damaged threads. Use a 10-32 UNJF-3A die.
6. Fan blade retaining pin for:			
a. Nicks and scratches.	None allowed.	Not repairable.	Replace pin.
b. Cracks.	None allowed.	Not repairable.	Replace pin.
c. Broken shoulder.	None allowed.	Not repairable.	Replace pin.

5-96. INSPECTION OF FAN ROTOR ASSEMBLY. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Damaged threads.	1-1/2 threads damaged or missing, with no high metal.	Same as usable limits, with high metal.	Remove high metal and damaged threads. Chase thread with a 1/4-28 UNJF-3B tap.
e. Worn OD.	0.7460 inch diameter minimum, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
7. Missing or loose plug.	None allowed.	Any amount.	Install new plug (PN 3020T20P01).
8. Fan disk for:			
a. Cracks.	None allowed.	Not repairable.	Replace fan rotor.
b. Nicks, dents and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal. Polish out defect smoothly.
9. Retaining pin bushing loose or missing.	Not allowed.	Not repairable.	Replace fan rotor.

5-96. INSPECTION OF FAN ROTOR ASSEMBLY. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
10. Retaining pin bushing ID for wear.	0.794 inch diameter maximum.	Not repairable.	Replace fan rotor.
11. Missing plating around fan blade retaining pin holes.	0.005 inch wear maximum	Not repairable.	Replace fan rotor.
12. Stripped threads in nut plates or loss of self-locking action.	None allowed.	Any amount.	Remove anchor nut per paragraph 5-163. Replace the nut plate with new nut plate (PN J146P03) and the rivets with new rivets (PN AN 123470).
13. Worn boltholes in shaft.	0.3180 inch diameter maximum. One hole may be 0.3190 inch diameter as long as the 2 holes on each side of the worn hole are 0.3180 inch diameter.	Not repairable.	Replace fan rotor.
14. No. 1 bearing seal runner for:			
a. Worn OD.	7.8580 inches diameter minimum.	Not repairable.	Replace seal runner.
b. Worn ID.	5.9133 inches diameter maximum.	Not repairable.	Replace seal runner.
c. Cracks.	None allowed.	Not repairable.	Replace seal runner.
d. Nicks, dents and scratches on any surface except inner OD.	Any number 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
e. Nicks, dents and scratches on seal OD.	None allowed.	Not repairable.	Replace seal runner.
15. Disk and shaft assembly bolts for:			
a. Worn diameter.	0.3165 inch diameter minimum.	Not repairable.	Replace bolt.
b. Nicks, dents and scratches on 0.3165 inch diameter.	0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Damaged or missing threads.	1-1/2 threads damaged or missing with no high metal or burrs.	Same as usable limits, with high metal or burrs.	Remove high metal and burrs and damaged threads by chasing with a die.
d. Nicks, dents and scratches on all other surfaces.	Any number 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-96. INSPECTION OF FAN ROTOR ASSEMBLY. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
16. Front fan shaft for:			
a. Cracks.	None allowed.	Not repairable.	Replace shaft.
b. Nicks and scratches.	Any number 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Damaged threads.	1/2 of 1 thread total cumulative length with no high metal or burrs.	Same as usable limits, with high metal or burrs.	Remove high metal and burrs.
17. Fan disk boltholes for wear.	0.3180 inch diameter maximum. One hole may be 0.3190 inch diameter as long as there are 2 good holes on both sides of the worn hole.	Not repairable.	Replace fan rotor.
18. Forward No. 1 seal runner rabbet diameter for wear.	7.2798 inches diameter minimum.	Not repairable.	Replace shaft.
19. Aft No. 1 seal runner rabbet diameter for wear.	5.9140 inches diameter minimum.	Not repairable.	Replace shaft.
20. No. 1 bearing journal for wear.	5.9070 inches diameter minimum.	Not repairable.	Replace shaft.
21. Inner air seal diameter for nicks and scratches.	Any number 0.005 inch deep with no high metal	Same as usable limits, with high metal.	Remove high metal.
22. Inner air seal diameter for wear.	3.205 inches diameter maximum.	Not repairable.	Replace shaft.
23. Forward inner shaft pilot diameter for wear.	2.2585 inches diameter maximum.	Not repairable.	Replace shaft.
24. Aft inner shaft pilot diameter for wear.	2.5770 inches diameter maximum.	Not repairable.	Replace shaft.
25. No. 2 bearing journal for wear.	2.9517 inches diameter minimum.	Not repairable.	Replace shaft.
26. Nut plates for stripped threads.	None allowed.	Any amount.	Remove anchor nut (see paragraph 5-163). Replace the nut plates with new nut plate (PN J148-P01) and the rivets with new rivets (PN AN 123-471).
27. Shaft spline for wear.	2.367 inches diameter maximum under 0.1080 inch pins. (0.006 inch wear at PD).	Not repairable.	Replace shaft.

5-97. INSPECTION OF FAN BLADES. (See figure 5-44)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall blade for cracks.	None allowed.	Not repairable.	Replace entire fan rotor assembly except if crack is clearly the result of FOD, then replace cracked blade only. If rotor is replaced, return it to overhaul marked as suspected fatigue failure.
2. Area A critical contour and blade fillet for nicks, dents, pits and scratches.	None allowed.	Any number which can be blended without exceeding a maximum blend of 0.010 inch deep.	Blend out defect. Remove as little material as possible to completely remove defect.
3. Area B critical contour and blade fillet for nicks, dents, pits and scratches.	Any number, 0.005 inch deep with no high metal.	Any number which can be removed without exceeding a maximum blend of 0.010 inch deep.	Blend out defects. Remove as little material as possible to completely remove defect.
4. Area C contour for nicks, dents, pits and scratches.	Any number, 0.010 inch deep with no high metal.	Any number which can be reworked without exceeding a maximum blend of 0.015 inch deep.	Blend out defect. Remove as little material as possible to completely remove defect.
5. Leading and trailing edges and blade tips for nicks, dents, tears and scratches.	Any number, 0.005 inch deep with no high metal.	Any number which can be blended out without exceeding the limits of figure 5-44.	Blend out defect. Remove as little material as possible.
6. Curled tip.	1/8 inch maximum from original contour on all blades. Up to 1/4 inch on 3 blades.	Any amount which can be re-formed or blended to usable limits.	Re-form or blend out defects. Inspect for cracks after re-forming.
7. Top surface of blade platform excluding blade fillet radius for nicks and scratches.	Any number 0.020 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
8. Blade retaining pin-holes for wear.	0.7510 inch diameter maximum.	Not repairable.	Replace blade.
9. Missing coating on blade lugs.	Ten percent of the coating may be missing.	Not repairable.	Replace blade.
10. Blade lugs for nicks and scratches.	Any number 0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
11. Blade platforms for wear.	0.030 inch with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-98. FAN BLADE BLENDING AND REPLACEMENT. See figure 5-44. See paragraph 5-150, airfoil blending.

NOTE

The minimum acceptable chord dimensions for the fan blade are shown in figure 5-44. The minimum chord for all points between the root and tip can be determined by drawing the maximum blending limit line and measuring the chord length.

1. Blade with minor leading and/or trailing edge damage shall be blended per the following procedure.

a. Determine the maximum amount of blending allowed at any point on the blade by drawing the

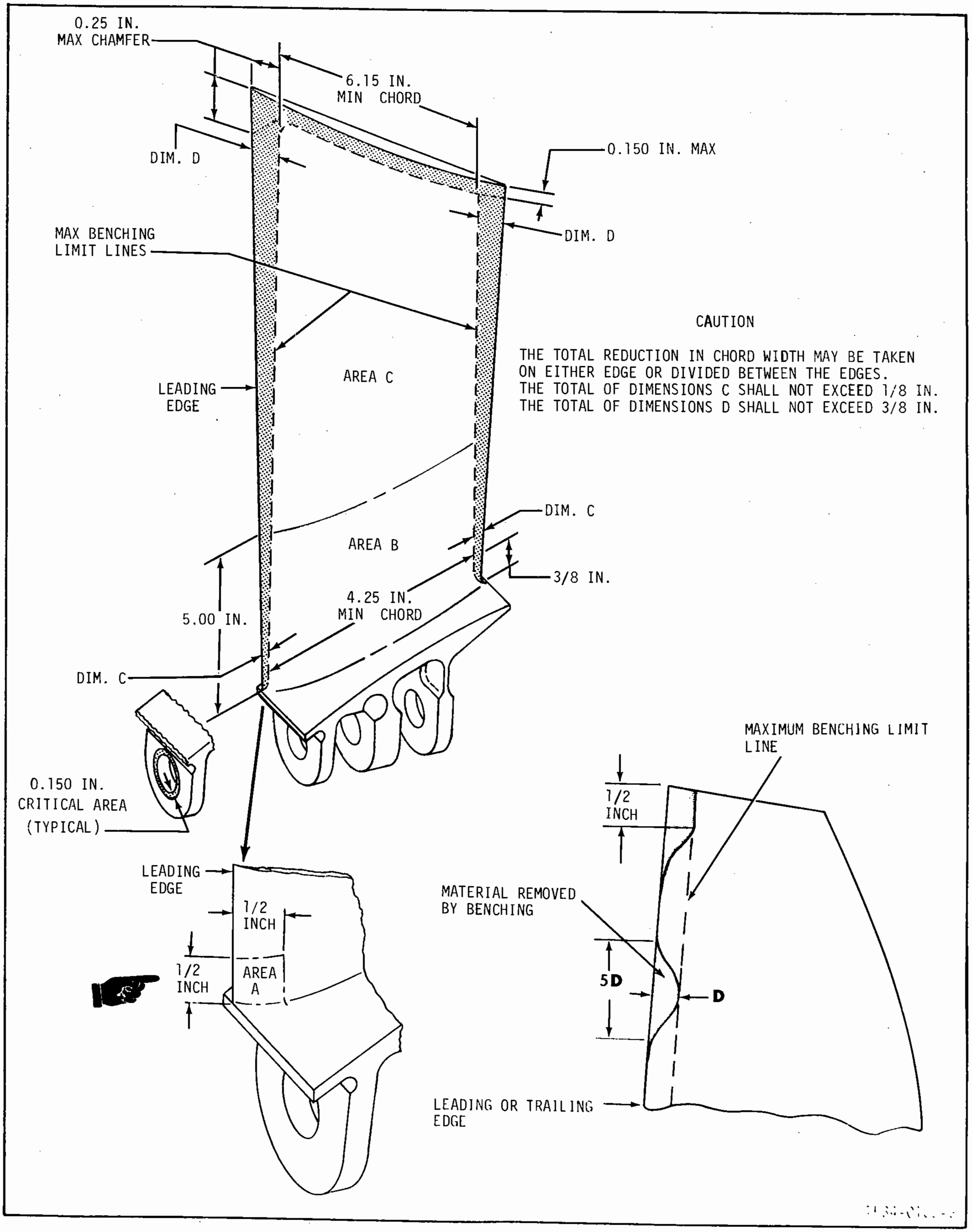


Figure 5-44. Inspection of Fan Blades

maximum blending limit line as shown in figure 5-44. Any number of blades may be blended to this limit.

b. Blend out the defect using the techniques described in paragraph 5-150. Pay particular attention to the leading and trailing edge radius.

c. Vacuum the titanium dust from the inlet after all blending is finished. Titanium dust is considered a fire hazard.

d. After all blending is completed, run the engine and check the vibration level.

2. Blades with major leading and trailing edge damage shall be replaced per the following procedure:

a. Remove damaged blade and record moment weight (located under blade platform).

b. If balance hardware is located at balance holes closest to blade pin remove hardware and determine moment weight per Table 5-6A.

c. If balance hardware is located at balance holes closest to blade 180° from removed blade, remove hardware and determine moment weight per Table 5-6A.

d. After all blades have been replaced, perform a clearance check per paragraph 7-43 and run the engine and determine the vibration level. If clearance limits are not met, remove material from blade tip, not exceeding limits of figure 5-44. If excess vibration is measured, reject the fan to overhaul.

3. Calculate effective moment weight by adding moment weight of blade, determined in step 2a, and balance hardware directly below, determined in step 2b, and subtracting moment weight of balance hardware at blades 180° opposite, determined in step 2c.

TABLE 5-6A. MOMENT WEIGHT OF BALANCED HARDWARE

EACH NUT/BOLT COMBINATION = 23 Gram inches
EACH BALANCE PLATE =

3021T21P01	15 Gram inches
3021T21P02	23 Gram inches
3021T21P03	31 Gram inches
3021T21P04	39 Gram inches

4. Select replacement blade with moment weight within 170 gram inches of effective moment weight of damage blade/balance hardware.

5. Using Table 5-6B, select required balance hardware to reduce moment weight difference to ± 10 gram inches. If replacement blade is lighter than effective moment weight, install balance hardware, as required, at balance location closest to blade pin holes. If replacement blade is heavier, install balance hardware 180° from blade being replaced.

TABLE 5-6B. SELECTION OF BALANCE WEIGHTS

Effective Moment Weight Difference (Gram inches)		Nut/Bolt	P01	P02	P03	P04
0-10	Install	-	-	-	-	-
11-34	Install	1	-	-	-	-
35-55	Install	2	-	-	-	-
56-65	Install	2	1	-	-	-
66-75	Install	2	-	1	-	-
76-82	Install	2	-	-	1	-
83-92	Install	2	-	-	-	1
93-105	Install	2	1	-	-	1
106-115	Install	2	-	1	-	1
116-123	Install	2	-	-	1	1
124-130	Install	2	-	-	-	2
131-140	Install	2	1	-	-	2
141-150	Install	2	-	1	-	2
151-160	Install	2	-	-	1	2
161-170	Install	2	-	-	-	3

Notes.

1. If the replacement blade is lighter than original blade and weights, install balance weight at balance location closest to replacement blade.

2. If the replacement blade is heavier than original blade and weights, install balance weight at balance location 180° from replacement blade.

3. Torque balance nuts to 25-30 in. lbs.

5-99. INSPECTION OF SPLITTER NOSE AND PANELS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Splitter nose for:			
a. Nicks and scratches.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Dents.	Any number, 1/16 inch deep with smooth deformation.	Not repairable.	Replace splitter nose.
c. Cracks.	None allowed.	Not repairable.	Replace splitter nose.
d. Damaged threads.	One-half of 1 full thread damaged or missing on all flange connections or 2 full threads on outside hole pattern with no high metal or burrs.	Same as usable limits, with high metal and burrs.	Chase threads with 10-32 tap to remove high metal and burrs.
e. Nicks, dents and scratches on air duct flanges.	Any number, 0.010 inch deep, that do not extend from outside of flange to inside of duct. No high metal allowed. Flange must be flat within 0.005 inch TIR and be within 0.010 inch of true position.	Same as usable limits, with high metal.	Remove high metal and check for flatness. Flange must be flat within 0.005 inch TIR.
2. Splitter vane panels for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Cracks.	Any number, up to 1/4 inch long, if not closer together than 2 inches.	Not repairable.	Replace splitter vane panel.
3. Channel nuts for stripped or worn threads.	None allowed.	Not repairable.	Replace channel nuts per paragraph 5-163. See NAVAIR 02B-105ALA-4 for part numbers.

5-100. INSPECTION OF FAN STATOR CASING.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall casing for cracks.	None allowed.	Not repairable.	Replace casing.
2. Nicks and scratches.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
3. Dents.	Any number, 1/32 inch deep.	Any number, 1/16 inch deep.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
4. Forward and aft flanges for bent areas.	Any number, 0.010 inch from original contour.	Any amount that can be reworked to usable limit.	Cold-work to usable limit. Inspect using white light; no cracks allowed.

5-100. INSPECTION OF FAN STATOR CASING. (CONT.)

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
5. Threads for damage.	One thread total (cumulative) with no high metal.	Same as usable limits, with high metal.	Chase threads with 10-32 UNJF-3B tap.
6. Mounting bushing for wear.	Maximum diameter 0.753 inch ID.	Not repairable.	Replace casing.

5-101. INSPECTION OF FAN HOUSING.

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
1. Overall housing for:			
a. Cracks.	None allowed.	Not repairable.	Replace front housing.
b. Dents.	Any number, 1/16 inch deep, with no peeling of the skin from the honeycomb or exposed edges and no delamination of skin plies.	Not repairable.	Replace front housing.
c. Nicks and scratches.	Any number, 0.010 inch deep, with no high material.	Same as usable limits, with high material.	Remove high material.
	NOTE Combined external and internal unbonded or missing material at the same location renders the casing unusable until either the inside or the outside or preferably both are repaired.		
2. External fiberglass skin for:			
a. Delamination and/or discoloration (brown spots). Detect per paragraph 5-104.	Four areas, 6 square inches maximum in each area, inside or outside. Areas not to be closer than 12 inches. Edges of delamination shall be free of crazing, cracks and exposed edges.	Any number of areas. Maximum size of any one area is 24 square inches.	Repair per paragraphs 5-103 and 5-105.
b. Missing skin area.	None allowed.	Any number of areas with maximum size of one area being 2 square inches.	Repair per paragraphs 5-103 and 5-105.
3. Forward and aft bolt flanges for bent areas.	Any amount within 0.010 inch of original shape.	Any amount that can be reworked to usable limit.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
4. Internal honeycomb core for:			

5-101. INSPECTION OF FAN HOUSING. (CONT.)

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
a. Cell damage-broken and delaminated. Detect per paragraph 5-104.	Four areas, 6 square inches max. in each area. Areas not to be closer than 12 inches.	Any number of areas. Max. size of any one area, 24 square inches.	Repair per paragraphs 5-103 and 5-104.
b. Missing cells.	None allowed.	Any number of areas. Max. size of missing honeycomb core cells any one area, 2 square inches.	Repair per paragraphs 5-103 and 5-105.
5. Fan blade access port for:			
a. Loose or missing threaded inserts	None allowed.	Not repairable.	Replace housing.
b. Damaged threads in inserts.	1 1/2 threads missing.	Any amount.	Chase damaged threads.
c. Cracked, loose or missing honeycomb plastic filler material at port edges.	Any number of fine cracks. No missing pieces, no open cracks or delamination.	Any amount.	Repair per paragraphs 5-103 and 5-106.
d. Delamination and/or discoloration of external fiberglass skin. No port edge damage. Detect per paragraph 5-104.	2 areas per port, 1 square inch maximum in each area.	Any number of areas. Max size of any one area, 2 square inches.	Repair per paragraphs 5-103 and 5-104.

NOTE

Combined external and internal unbonded or missing material at the same location renders the casing unusable until either the inside or the outside or preferably both are repaired. Experience has shown that if the aluminum membrane type skin separating the shroud material from the external honeycomb and fiberglass skin is not supported in any way it will fatigue rapidly and fail.

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
6. Fan Shroud Area for:			
a. Rubs.	Any amount 3/32 inch deep.	Not repairable.	Replace fan housing.
b. Missing abradable material (missing all the way to the aluminum inner skin).	Maximum amount missing in one area 6 square inches. Max total missing 12 square inches.	Not repairable.	Replace fan housing.
c. Unbonded areas (when tapped, a dead sound is heard instead of a ringing sound).	Maximum circumferential dimension of an area unbonded for the full axial length is 4 inches. Maximum total of all unbonded areas is 12 square inches.	Not repairable.	Replace fan housing.

5-101. INSPECTION OF FAN HOUSING. (CONT.)

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
7. Combined external and internal distress at same location per steps 3, 4, 5 and 6 above.	External: None allowed. Internal: Usable limits per step 6.	External: Repair per item 3, 4 or 5 above. Internal: Not repairable.	External: Repair per paragraphs 5-103, 5-104, 5-105 and 5-106. Internal: Replace housing.

5-102. REPAIR OF FAN HOUSING.

5-103. MATERIALS REQUIRED.

1. Epoxy - Eccobond 286
   Plastic syringe 6cc size

   Obtain from: Emerson and Cuming,
   Canton, Massachusetts

2. Alternate - Epoxy - EA-934

   Obtain from: Hysol Division, Dexter Corp.
   Pittsburg, California

5-104. REPAIR OF FAN HOUSING DELAMINATED AREA.

1. Determine the unbonded area by tapping the fiberglass skin with a quarter or a key or other light metallic object. A sharp ringing or metallic sound indicates a bonded area. A dull sound with no resonance indicates an area that is not bonded. Using a soft pencil or a "marks-a-lot", (Not a grease pencil) circle the unbonded area.

2. With a 3/16 inch drill, carefully drill through the fiberglass skin only, a series of holes on 3/4 inch centers through the whole area of unbond and for approximately 3/4 inch outside of the unbonded area.

CAUTION

Do not damage the aluminum skin.

3. Remove the 3/16 inch drill bit from the power or hand drill and using it as a reamer, remove the honeycomb down to the aluminum skin.

CAUTION

Insure correct mixture ratio between epoxy and reaction agent is used per manufacturer's instruction.

NOTE

Allow the air to escape around the needle and keep injecting the epoxy as the needle is withdrawn so as to leave as few air bubbles trapped as possible. Work from the outside holes in, hole by hole, until all holes are filled to overflowing. The plastic needle will have to be wiped clean each time or the air will not flow out of the hole easily.

4. Mix up the epoxy as directed and carefully load it into the plastic syringe. Insert the needle all the way into the hole and slowly fill the hole with epoxy from the bottom up.

5. Wait a few minutes and inspect the holes to see if any that had some air bubbles in them end up with epoxy sinking down. Fill any of this type of hole to overflowing again.

6. The epoxy that has flowed out on the fiberglass skin may now be smoothed over the surface of the repaired area. Follow the instructions for cure time of the epoxy used. As pointed out in these instructions, the use of a heat lamp will reduce the cure time.

5-105. REPAIR OF FIBERGLASS SKIN OR MISSING HONEYCOMB CORE (EXCLUDING FAN BLADE RUB SHROUD).

1. Inspect damaged area and carefully extract any loose honeycomb pieces from the hole. Trim jagged edges of honeycomb that do not provide any structural benefit (high spots). Inspect the honeycomb for bonding to the aluminum plate underneath. If bonding is satisfactory, allow honeycomb to remain. If honeycomb is loose, remove material to aluminum plate per paragraph 5-104.

2. Determine the extent of the delaminated fiberglass and/or missing honeycomb surrounding the actual hole (see paragraph 5-104 for method of determining unbonded area). Repair delaminated area surrounding hole per paragraph 5-104. Before applying epoxy, carefully clean all holes and damaged areas with high pressure air. After the delaminated area has been repaired, fill in hole using the identical procedure. Smooth the epoxy to match the surrounding contour immediately after the repair and after the epoxy has hardened.

5-106. REPAIR OF FAN BLADE ACCESS PORT EDGES.

1. Repair cracked or missing plastic filler material at blade removal port edges as follows:

a. Using an air driven high speed drill and a small carbide burr, remove all plastic filler material that is loose or unbonded from either the aluminum or fiberglass skin. Rout out all open cracks so that the crack is wider at the bottom than at the outside end of the crack. Using a 3/16-inch drill, drill a series of holes at 1/2-inch spacing about 1/2-inch from the edge of the blade removal port. Drill through the fiberglass skin only. Then remove the drill and using it as a hand reamer, remove retaining honeycomb and plastic filler material from the hole.

b. Mix up the epoxy as directed and carefully load it into the syringe. Insert the needle all the way into each hole and slowly fill the hole from the bottom up. Allow the air to escape around the needle and keep injecting the epoxy as the needle is withdrawn so as to leave as few air bubbles trapped as possible. Fill each hole to overflowing then wait a few minutes and add more epoxy to any hole that the epoxy sinks down in.

c. Fill all the voids in the edges of the removal port using the same plastic syringe, filling each void area from the bottom up using the technique described in step b,to avoid air bubbles. Small area may be shaped by eye. Larger repairs may require the use of cellophane as a parting agent and the port cover as a mold.

5-107. INSPECTION OF FAN VANES.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Nicks and scratches.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
2. Dents.	Any number, 1/16 inch deep, with a smooth contour.	Not repairable.	Replace vane.
3. Cracks or tears.	None allowed.	Not repairable.	Replace vane.

Figure 5-45. Deleted.

5-107. INSPECTION OF FAN VANES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
4. Missing or cracked bolt tabs.	Not allowed.	Not repairable.	Replace vane.
5. Stripped threads.	One thread (cumulative), with no high metal.	Same as usable limits, with high metal.	Chase threads.

5-108. REPLACEMENT OF INDIVIDUAL FAN VANES ON ASSEMBLED ENGINE.

1. Remove fan housing by following instructions of paragraph 5-9.

2. Determine which fan vanes must be replaced. Remove vane spacers (3, figure 5-46) on both sides of each vane to be replaced by removing nuts (4) on outside of fan stator casing.

3. Remove nuts from fan vane retaining bolts on outside of fan stator casing and remove bolts (5).

4. Remove lockwire from bolt (7) at the fan vane inner support. Back bolt out until threads are disengaged from vane, but do not remove bolt completely from inner support. Remove damaged vane.

NOTE

Five vanes, 1 at 12 o'clock position and 2 on either side have 4 bolt ears while remaining 39 vanes have 2 bolt ears.

5. Install new vane. Assemble bolts (5) through vane ears and fan stator casing. Install nuts (4) and torque them to 38-42 lb in.

6. Thread bolt (7) into base of vane. Torque bolt to 28-30 lb ft. and lockwire, double strand method using 0.032 inch lockwire.

7. Install vane spacers (3) between vanes with nuts (4). Torque nuts to 38-42 lb in.

8. Install fan housing as described in paragraph 7-31.

9. Reinstall fan blades into same disk location from which they were removed with retaining pins.

10. Reinstall spinners as described in paragraph 7-43.

11. Assemble blade removal port cover as follows:

a. Coat inner flange of cover with RTV-103.

b. Install cover with 10 bolts and washers. Torque bolts to 32-35 lb in.

c. Lockwire bolts, double-strand method using 0.032 inch lockwire. Lockwire 2 top bolts together, 2 middle bolts together, and 2 bottom bolts together.

d. Apply RTV-103 to entire length of lockwire.

5-109. INSPECTION OF FAN VANE SPACERS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall spacer for:			
a. Nicks and scratches.	Any number, 0.020 inch deep, with no high material.	Same as usable limits, with high material.	Remove high material.
b. Cracks.	None allowed.	Not repairable.	Replace spacer.
c. Missing paint.	Any amount.	Not required.	Not required.
2. Spacer studs for:			
a. Looseness.	Not allowed.	Not repairable.	Replace spacer.
b. Stripped threads.	One thread (cumulative) with no high metal.	Same as usable limits, with high metal.	Chase threads.

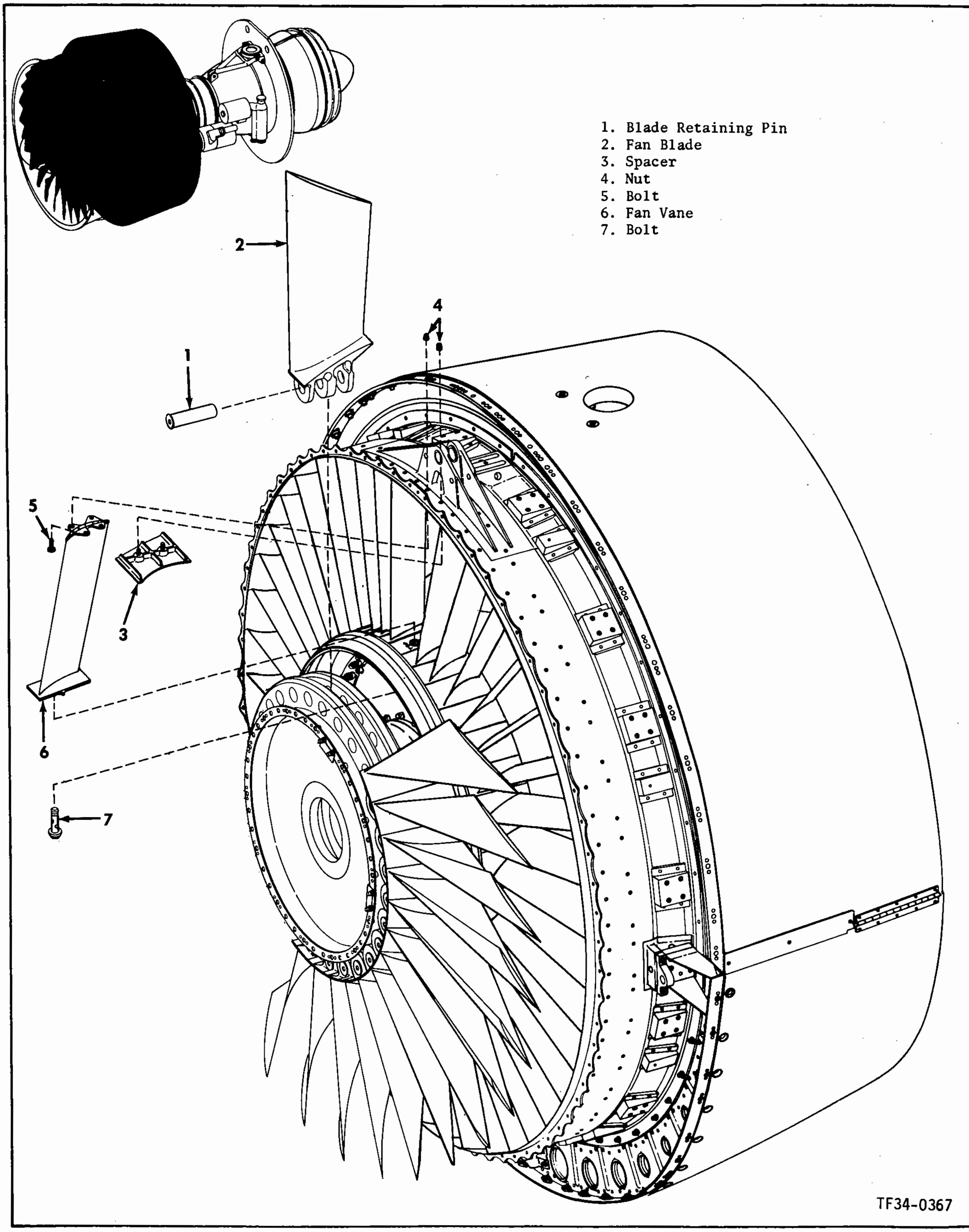


Figure 5-46. Replacement of Fan Vanes

5-110. INSPECTION OF FAN NOZZLE INNER FRAMES.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Upper and lower inner frames for:			
a. Cracks.	None allowed.	Not repairable.	Replace defective frame.
b. Dents (in frame members).	Any number, 0.010 inch from original contour.	Any amount that can be reworked to usable limit.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
c. Bends or kinks.	Any amount as long as parts can be properly assembled.	Any amount that can be reworked to usable limit.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
d. Nicks and scratches.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
2. Nut plates for stripped threads.	One thread total cumulative length, with no high metal.	Not repairable.	Replace damaged nut plate (see paragraph 5-163), gang channel replacement.

5-111. INSPECTION OF PYLON NOSE.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Pylon nose for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep with no high metal.	Not repairable.	Replace pylon nose.
b. Cracks.	None allowed.	Any number.	Repair-weld (see weld data table 5-6, item 5).
c. Stripped threads or loss of locking action on nut plates.	None allowed.	Not repairable.	Replace nut plate per paragraph 5-163 using J146P03 nut and MS-20426AD3-4
d. Bent bolthole tabs.	Not more than 1/64 inch from normal position.	Any amount.	Cold-work to usable limit. Inspect for cracks; none allowed.
e. Nicks, dents, and scratches on:			
(1) V-band coupling sealing surfaces.	Any number, 0.005 inch deep, with no high metal, and does not extend across face of sealing surface.	Same as usable limits, with high metal.	Remove high metal.
(2) Packing grooves.	Any number, 0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
(3) All other surfaces.	Any number 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
f. Missing gasket.	None allowed.	Any amount	Replace gasket.

5-111. INSPECTION OF PYLON NOSE. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Stiffener plate for:			
a. Nicks, dents, and scratches.	Any number, 1/32 inch deep.	Not repairable.	Replace plate.
b. Cracks.	None allowed.	Not repairable.	Replace plate.
c. Bent flanges.	Not more than 1/64 inch from original position.	Any amount.	Cold-work to usable limit. Inspect for cracks; none allowed.
d. Stripped threads or loss of locking action on nut plates.	None allowed.	Not repairable.	Replace nut plate per paragraph 5-163 using J146P03 nut plate and MS20426AD3-4 rivet.

5-112. INSPECTION OF FAN COWL ADAPTER FLANGE.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Adapter flange for:			
a. Nicks, dents, and scratches.	Any number, 1/32 inch deep.	Not repairable.	Replace adapter flange.
b. Cracks.	None allowed.	Not repairable.	Replace adapter flange.
c. Bent flanges.	Not more than 1/64 inch from original position.	Any amount.	Cold-work to usable limit. Inspect for cracks; none allowed.
d. Stripped threads or loss of locking action on nut plates.	None allowed.	Not repairable.	Replace nut plate per paragraph 5-163 using nut plates J146P03, J146P04 and 3023T10. Use rivets MS20426AD-3-4.
e. Missing gasket.	Not allowed.	Any amount.	Replace gasket.

5-113. INSPECTION OF FAN PYLON NOSE FAIRINGS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Fairings for:			
a. Nicks, dents, and scratches.	Any number, 1/64 inch deep, with no high material.	Same as usable limits, with high material.	Remove high material.
b. Missing paint.	Any amount.	Not applicable.	Not applicable.
c. Missing or loose rubber strips.	Any number.	Not applicable.	Not applicable.
d. Loose bushings.	None allowed.	Not repairable.	Replace fairing.
e. Missing gasket.	None allowed.	Any amount.	Replace gasket.
f. Cracked bolt flange.	None allowed.	Not repairable.	Replace fairing.

5-114. INSPECTION OF OUTER FAN COWL (UPPER).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Nicks, dents and scratches.	Any number 1/64 inch deep with no high material.	Same as usable limits, with high material.	Remove high material.
2. Missing paint.	Any amount.	Not applicable.	Not applicable.
3. Splitline flange for cracks.	None allowed.	Not repairable.	Replace cowl.
4. Splitline flange for stripped threads.	a. Any number with 1-1/2 threads damaged or missing.	Any amount which can be reworked to usable limits.	Chase threads with a 10-32 UNF tap.
	b. One insert with 1/2 of the total threads missing on each side of cowl.	Any amount which can be reworked to usable limits.	Chase threads with tap until it just engages the locking feature of the insert. Do not remove the locking feature.
5. Forward flange inserts for stripped threads.	a. Any number with 1-1/2 threads missing or damaged with no high metal.	a. Any number which can be reworked to usable limits.	Chase threads with a 10-32 UNF tap.
	b. One insert with 1/2 of the total threads missing or damaged provided that the adjacent insert on both sides meets the requirements of item a.	b. Same as item a.	Chase threads until tap just engages the locking feature of the insert. Do not remove the locking feature.
	c. One insert with all threads missing provided that the two adjacent inserts on each side meet the requirements of items a and b.	c. Not repairable.	Replace cowl.
	NOTE Loss of locking feature shall be treated the same as item C.		
6. Forward flange inserts missing or loose.	a. Any number of inserts may be loose provided they cannot be pulled out by hand.	Not repairable.	Replace cowl.
	b. One insert may be missing provided the two adjacent inserts on each side are serviceable per item a and b in step 5.	Not repairable.	Replace cowl.
7. Anti-icing air pad inserts for:			

5-114. INSPECTION OF OUTER FAN COWL (UPPER) (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Stripped threads.	Both with 1 1/2 threads missing or damaged.	Any amount which can be reworked to usable limits.	Chase threads with a 1/4-28 UNJF tap. Chase threads until tap just engages the locking feature of the insert. Do not remove the locking feature.
	NOTE Loss of locking feature shall be treated as a missing insert.		
b. Looseness or missing.	Any amount provided the insert cannot be pulled out by hand.	Not repairable.	Replace cowl.
8. Anchor nuts for stripped threads or loss of locking feature.	Not allowed.	Any number.	Replace anchor nuts (see paragraph 5-163). Remove the rivets which retain the damaged nut plate. Replace the rivets with P/N MS20426AD3-4 and the anchor nuts with J146P03 or 3023T10.
9. Broken skin and damaged honeycomb.	Not allowed.	Any number.	Repair (see paragraph 5-116).
10. Trailing edge for delamination.	Not allowed.	3 sq. inches.	Repair (see paragraph 5-116A).

5-115A. RELOCATION OF AIRFRAME CONNECTION HOLES IN UPPER COWL AND FLANGE ADAPTER.

1. Install the outer cowl flange adapter on the engine. Do not lockwire. See section VII of this manual.

2. Install the fan outer cowl assembly. Do not lockwire. See section VII of this manual.

3. Without forcing any of the hardware, install the airframe panels with as many of the attaching bolts as will fit. There is limited amount of float in the anchor nuts and a number may be installed even though they do not line up perfectely.

4. Mark using a grease pencil, the anchor nuts and holes on the fan outer cowl assembly and outer cowl flange adapter that are so misaligned that bolts may not be inserted or properly torqued.

5. Remove the panels, and the fan outer cowl assembly, and flange adapter.

NOTE

A good support would be a 1 inch square block of aluminum or plastic with a 1/4 inch clearance hole for the rivet head in it.

6. With a milling machine or file, carefully remove the heads of the rivets on the anchor nut side of the nuts marked in step 4 above, supporting the outer cowl or flange adapter in the rivet area. Punch out the rivets.

7. If the anchor nut lug is damaged in the removal process, or the rivet hole is enlarged more than a few thousandths, the anchor nut assembly should be scrapped. See Illustrated Parts Breakdown, NAVAIR 02B-105ALA-4, for nut assembly and rivet part numbers.

8. Reassemble all parts as in stens 1 and 2 above.

9. Using a hand drill and/or a rattail file, line up the bolt holes in all places where the anchor nuts have been removed. The panels may be used as templates or with care as drilling fixtures. After each hole is reworked, drop a bolt in the hole to insure an easy final assembly. The bolt should slip in easily with no binding.

10. Remove all panels, cowl assembly, and flange adapter.

11. Replace the anchor nuts in the new positions, placing the rivet lugs at an angle so that two new rivet holes may be drilled at least one rivet hole diameter away from the original holes.

NOTE

The new nut position may be determined in the following manner. If the anchor nut is located so that both original rivet holes line up, the nut is in its original position. If prior to any drilling the rivet holes do not line up, but the bolt hole does, then the anchor nut is in the correct new position and it may now be rotated slightly to position it for the drilling of the new rivet holes. Immediately after drilling the new rivet holes, mark them so that the nut will be riveted in the correct position later.

12. Rivet all the anchor nuts previously removed back into their new locations.

13. Reassemble all parts as called out in section VII, being careful to lockwire the assembly as the manual specifies.

5-115. INSPECTION OF OUTER FAN COWL (LOWER).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Nicks, dents, and scratches.	Any number, 1/64 inch deep, with no high material.	Same as usable limits, with high material.	Remove high material.
2. Broken skin and damaged honeycomb.	Not allowed.	Any amount.	Repair (see paragraph 5-116).
3. Missing paint.	Any amount.	Not applicable.	Not applicable.
4. Damaged threads on splitline bolts.	1. Any number with 1-1/2 threads damaged or missing.	1. Any amount which can be reworked to usable limits.	Chase threads, using a 10-32 UNF die.
	2. One bolt with 1/2 of total threads damaged on each side. Nut must be installed on bolt and properly torqued.	2. Any amount which can be reworked to usable limits.	
5. Loose or missing circumferential flange bushings.	Any number may be loose. One bushing may be missing provided there is one bushing on each side.	Not repairable.	Replace lower cowl.
6. Loose or missing gaskets.	Any number.	Not applicable.	Not applicable.
7. Trailing edge for delamination.	Not allowed.	3 sq. inches.	Repair (see paragraph 5-116A).

5-116. REPAIR OF DAMAGED HONEYCOMB.

1. Outline the damaged areas so that it includes all cracks.

2. Use a small hand-held grinder and grinding wheel to remove the damaged skin. The cut along the outline shall not exceed 1/16 inch in depth.

3. Remove all damaged honeycomb. The amount removed shall be held to a minimum yet sufficient to remove all damaged honeycomb.

4. Remove all loose material from the damaged area.

5. Cut a piece of 5.9 OZ/FT open-weave fiberglass cloth which will cover the open honeycomb in the damaged area.

6. Determine the amount of epoxy required to fill the damaged area, and select the proper package size. Use Tra-Con epoxy system #2116 in the bi-pax package or equivalent. (Tra-Con Inc., 55 North Street, Medford, Mass. 02155).

NOTE

The pre-measured by-pax system shall be placed in the foil barrier pouch for storage. This will increase the shelf life of the system.

7. Place the fiberglass cut in step 5 in the damaged area.

8. Mix the epoxy and place it in the damaged area. Smooth the epoxy to match the contour as closely as possible.

9. After the epoxy has set up, smooth and match the surrounding contours.

5-117. INSPECTION OF FAN COWL ASSEMBLY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Missing interlock connector.	Not allowed.	Not repairable.	Replace cowl assembly.
2. Loose or missing rivets.	Two rivets on each side of cowl assembly may be missing.	Not repairable.	Replace cowl assembly.
3. Bent interlock connector pin.	Any amount as long as interlock connector can be assembled.	Any amount that can be reworked to usable limits.	Bend pin until interlock connector can be assembled.
4. Bent splitline cover.	1/32 inch out of flat.	Any amount that can be reworked to usable limits.	Flatten cover to usable limit.
5. Missing splitline cover.	Not allowed.	Not applicable.	Replace cover.

5-118. INSPECTION OF 6 O'CLOCK FAN DRAIN STRUT. (See figures 5-47 and 5-48.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace strut assembly.
2. Loose, chipped or missing paint.	10 percent of coated surface missing.	Any amount.	Phenolic finish (see paragraphs 5-53 and 5-54).
3. Nicks, dents and scratches (all surfaces except machined areas).	Any number 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
4. Nicks, dents and scratches on the fluid bosses.	Any number, 0.005 inch deep with no high metal.	Same as usable limits with high metal.	Remove high metal.
5. Inserts for:			
a. Stripped threads.	1-1/2 threads may be damaged with no high metal or burrs.	Any number which can be reworked to usable limits.	Chase thread with a 10-32 tap. Do not cut into locking feature.
b. Loss of locking feature.	None allowed.	Not repairable.	Replace insert with PN R1270P05.
6. Nut plates for damaged thread or loss of locking feature.	None allowed.	Not repairable.	Replace nut plate per paragraph 5-163 with PN J146P03, J146P02 and MS20426AD3-5 rivet.
7. Missing or loose gasket.	None allowed.	Any amount.	Replace gasket (see paragraph 5-119).

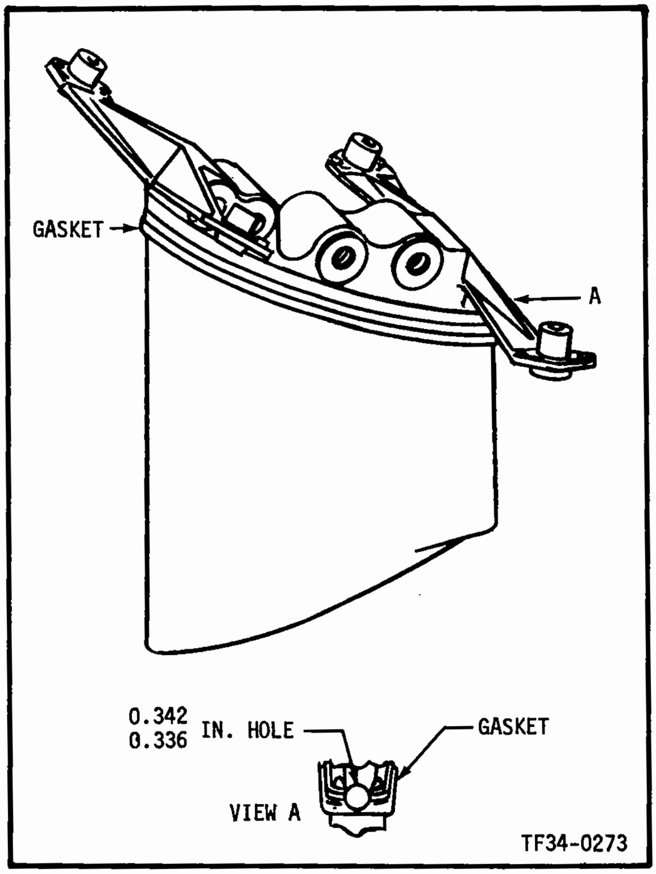


Figure 5-47. Fan Stator 6 O'Clock Drain Strut and Gasket Inspection

5-119. REPAIR OF 6 O'CLOCK FAN DRAIN STRUT GASKET.

1. Remove gasket from the part if any portion of bond has separated. Re-use gasket if it is free of all torn or missing material.

2. If a new gasket is required, cut gasket to proper length by using either the damaged gasket as a pattern or measuring the part.

3. Using a 220 or 120 grit sandpaper, remove any remaining epoxy from the part and/or the gasket. Sand only in the area where the gasket was removed from. Do not damage or remove the finish from the surrounding area. Roughen the flat side of the gasket with the sandpaper.

4. Trace the template from figure 5-48 onto a piece of heavy paper or manilla folder. Bend template along dotted lines.

5. Place template on the part so that the long fold line is on the leading edge and Tab A is under the bottom of the leading edge. Fold the template so that it conforms to the contour of the airfoil.

6. Wash any grease and oil from the surfaces to be bonded.

7. Using a pencil, draw a line which follows the edge of the template.

CAUTION

Do not use trichlorethylene on the rubber gasket.

8. Mix the epoxy per the Manufacturers instructions (Tra-Bond 2143D, Tra-Con Inc., 55 North St., Medford, Mass. 02155 or equivalent). Spread a thin layer of epoxy on the gasket.

9. Position the gasket on the part as shown in figure 5-47 and clamp in position using a large rubber band or C-clamps. Epoxy will cure overnight.

10. Remove any excess epoxy from around the edge of the gasket.

11. Cure the epoxy overnight at room temperature, or 4 hours at 70-80°F followed by 4 hours at 145-155°F.

5-120. INSPECTION OF FAN VANE INNER SUPPORT.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall support for:			
a. Cracks.	None allowed.	Not repairable.	Replace vane support.
b. Nicks and scratches.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Blend to adjacent contour.
c. Dents.	Any number 1/16 inch deep.	Any number 1/4 inch deep.	Cold-work to usable limit. Inspect using white light; no cracks allowed.

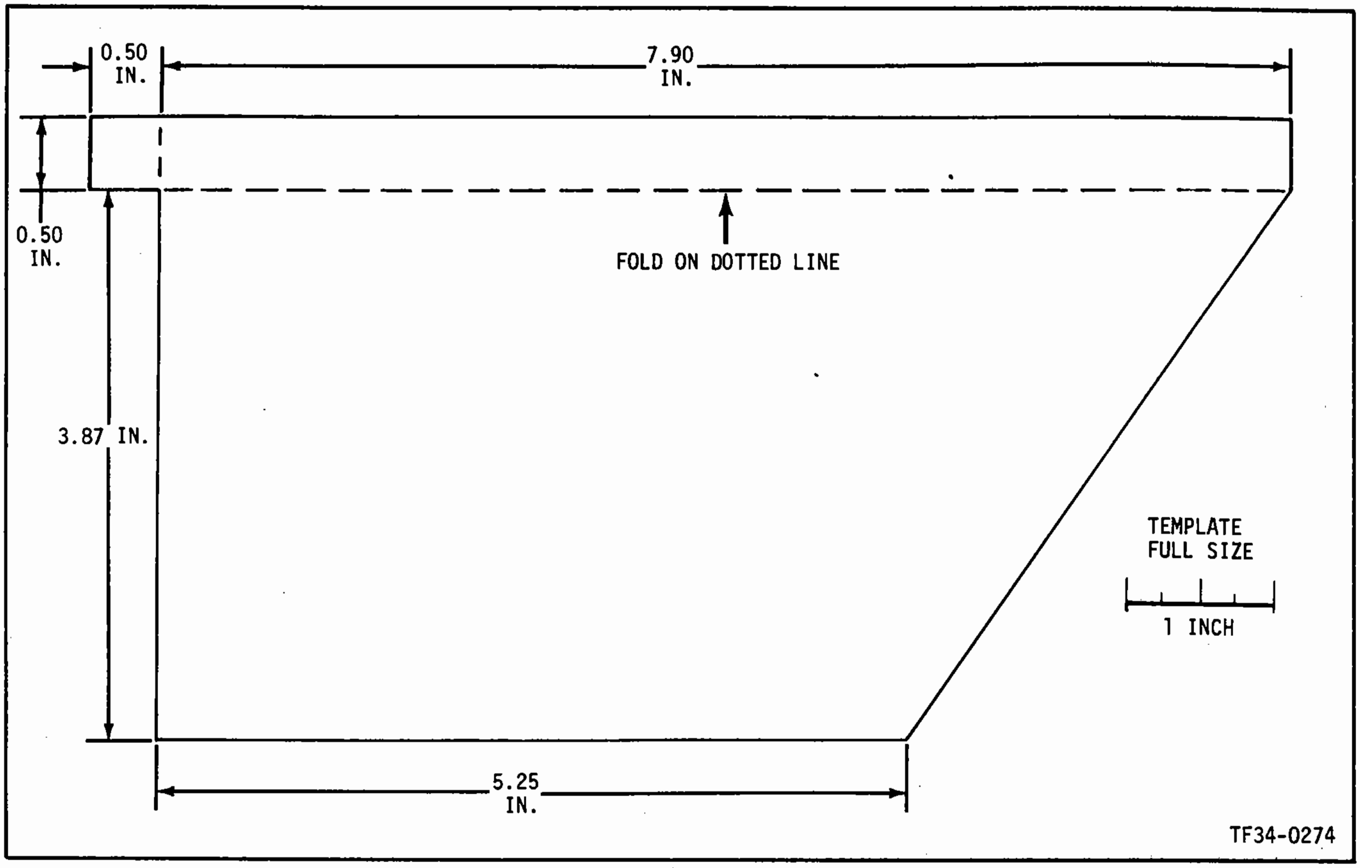


Figure 5-48. Gasket Positioning Template

5-120. INSPECTION OF FAN VANE INNER SUPPORT. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Fan runner abradable material for nicks and rub marks.	Any number, 1/16 inch deep, 3/8 inch wide, any length.	Not repairable.	Replace vane support.
3. Vane support bushing for:			
a. Nicks and scratches on shoulder.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits with high metal.	Blend to adjacent contour.
b. Wear on bushing ID.	0.460 inch diameter maximum.	Not repairable.	Replace vane support.
c. Damaged threads.	No more than 2 threads (cumulative) damaged, with no high metal and provided a bolt can be threaded into hole.	Same as usable limits, with high metal.	Chase threads with 7/16-20 UNFF-3P tap.
4. Inner bolt circle flange for:			

5-120. INSPECTION OF FAN VANE INNER SUPPORT. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Damaged threads on floating nuts.	One full thread (cumulative) on each floating nut.	Not repairable.	Replace floating nuts, using gang channel replacement procedure (see paragraph 5-163). Use replacement parts J146-P03 and 2 rivets MS204-26AD3-5.
b. Flange out-of-flat.	0.010 inch from normal position.	1/16 inch from normal position.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
5. Flange ID for:			
a. Wear.	18.402 inches diameter maximum (average of 4 diameters). 0.010 inch out-of-round.	Not repairable.	Replace vane support.
b. Nicks and dents.	Any number, 0.060 inch deep with no high metal, no closer than 1/2 inch apart.	Same as usable limits, with high metal.	Remove high metal from ID and forward side of flange.
6. Aft bolt flange for bent bolt tabs.	0.010 inch from normal position.	1/16 inch from normal position.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
7. Aft rabbet diameter for:			
a. Wear.	21.998 inches diameter minimum (average of 4 diameters). 0.100 inch out-of-round.	Not repairable.	Replace vane support.
b. Nicks and scratches.	Any number 1/16 inch deep with no high metal, at least 1/2 inch apart.	Same as usable limits, with high metal.	Remove high metal from ID and aft side of flange.

5-121. INSPECTION OF FAN TIE RODS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall tie rod for:			
a. Nicks, dents and scratches.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Cracks.	None allowed.	Any amount.	Repair-weld (see table 5-6, item 4).
2. Stud for stipped threads.	One thread (cumulative) with no high metal.	Any amount that can be reworked to usable limit.	Chase threads with 1/4-28 die or replace stud (see paragraph 5-122).
3. Tie rod end holes for wear.	Top end: 0.503 inch max diameter. Bottom end: 0.403 inch max diameter for short tie rods, 0.503 inch max both ends of long tie rods.	Not repairable.	Replace tie rod.

5-122. REPLACEMENT OF TIE ROD STUD.

CAUTION

Do not grind into tie rod parent metal.

1. Using a hand-held rotary grinder, grind off the weld holding the stud.

2. Remove damaged stud.

3. Chase threads in tie rod with a 1/4-28 UNJF-3B tap.

4. Install stud (PN 3022T51P01) and tack-weld in position, using weld data from table 5-6, item 4.

5-123. INSPECTION OF NO. 1 BEARING OIL SEAL AND OIL MANIFOLD AND NOZZLE.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Seal housing for:			
a. Nicks and scratches.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits with high metal.	Remove high metal.
b. Dents.	Any number, 1/32 inch deep.	Any amount that can be reworked to usable limits.	Cold-work to usable limit. White-light inspect for cracks; none allowed.
2. Packing sealing diameter for nicks and scratches.	None allowed.	Not repairable.	Replace seal.
3. Oil screen holes for plugging.	None allowed.	Any amount.	Remove contamination from holes.
4. Labyrinth oil seal for damage.	One tooth (cumulative) damaged, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Air inlet and vent bosses for:			
a. Nicks and scratches.	None allowed within 3/16 inch of edge of hole. All other areas, any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Stripped threads.	One thread (cumulative), with no high metal.	Same as usable limits, with high metal.	Chase threads with a 10-32 UNJF-3B tap.
6. Carbon seal elements for:			
a. Scratched or chipped sealing surfaces.	Any number, 0.010 inch deep, not more than 1/2 the width of the sealing surface, and no defects in line across 2 elements.	Not repairable.	Replace seal.
b. Cracks.	None allowed.	Not repairable.	Replace seal.
7. Oil manifold and nozzle for:			
a. Nicks, dents and scratches on:			

5-123. INSPECTION OF NO. 1 BEARING OIL SEAL AND MANIFOLD AND NOZZLE. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(1) Tube area.	Any number, 0.005 inch deep with no high metal	Same as usable limits, with high metal.	Remove high metal.
(2) All other areas except packing groove.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
(3) Packing groove.	None allowed.	Not repairable.	Replace nozzle.
b. Bent or kinked tube.	Not allowed.	Not repairable.	Replace nozzle.
c. Blocked oil passages.	None allowed.	Any amount.	Use 0.032 inch lockwire and loosen contamination. Back-flush nozzle with low pressure water or air. Apply pressure to oil inlet and check orifices for clear passage. Repeat process if necessary.
8. Seal housing and oil nozzle bolthole tangs for:			
a. Distortion.	No more than 0.010 inch from original position.	Any amount that can be reworked to usable limits.	Cold-work to usable limit. Inspect using white light; no cracks allowed.
b. Cracks or breaks.	None allowed.	Not repairable.	Replace part.

5-124. INSPECTION OF NO. 1 AND NO. 2 BEARING HOUSING.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall bearing housing for:			
a. Dents.	Any number 0.060 inch deep.	Not repairable.	Replace housing.
b. Nicks and scratches (except on packing groove).	Any number 0.010 inch deep, with no high metal.	Same as usable limits with high metal.	Remove high metal.
c. Cracks.	None allowed.	Not repairable.	Replace bearing housing.

5-124. INSPECTION OF NO. 1 AND NO. 2 BEARING HOUSING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Channel nuts for damaged threads or loss of locking feature.	None allowed.	Not repairable.	Replace channel nut (see paragraph 5-163). Inspect the channel nut and determine its part number. Replace with same part number. Use AN12336 rivets, channel nuts PN's 5023T13, 4019T46 and 4019T47.
3. Bearing housing packing grooves for nicks and scratches.	Any number 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
4. Snapring groove for nicks and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. No. 1 bearing bore for wear.	8.6630 inches diameter maximum average of 3 point check. 8.6619 inches diameter minimum at any point.	Not repairable.	Replace bearing housing.
6. No. 2 bearing bore for wear.	4.1356 inches diameter maximum average of 3 point check. 4.1344 inches diameter minimum at any point.	Not repairable.	Replace bearing housing.
7. Bearing antirotation slot for wear.	0.220 inch maximum.	Not repairable.	Replace bearing housing.
8. Fan speed pickup tab for:			
a. Cracks.	None allowed.	Not repairable.	Replace bearing housing.
b. Broken off.	None allowed.	Not repairable.	Replace bearing housing.
c. Bent.	None allowed.	Not repairable.	Replace bearing housing.
9. Bearing support plate for:			
a. Dents.	Any number 0.030 inch deep, with no sharp bends.	Not repairable.	Replace bearing support plate.
b. Nicks and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Cracks.	None allowed.	Not repairable.	Replace bearing support plate.

5-125. INSPECTION OF POWER TAKE-OFF ASSEMBLY AND RADIAL DRIVE SHAFT.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Housing for:			
a. Worn rabbet diameter.	7.478 inches diameter minimum, average of three readings.	Not repairable.	Replace assembly.
b. Cracks.	None allowed.	Not repairable.	Replace assembly.
c. Nicks, dents and scratches.	Any amount 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Stone off high metal.
d. Distortion.	No visual distortion allowed.	Not repairable.	Replace assembly.
e. Loose screws.	None allowed.	Any amount.	Tighten screw. If thread is stripped, replace assembly.
2. Oil jets for:			
a. Clogging.	None allowed.	Any amount.	Clear out jet and perform smoke check or squirt oil from plastic bottle.
b. Distortion.	No visual distortion allowed.	Not repairable.	Replace assembly.
3. Bevel gears for:			
a. Tooth face pitting.	None are to be over 0.010 inch diameter.	Not repairable.	Replace assembly.
b. External spline for wear.	3.422 inches minimum over 0.120 inch diameter balls.	Not repairable.	Replace assembly.
c. Worn silver plate.	Any amount.	Not applicable.	Not applicable.
4. Radial drive shaft for:			
a. Cracks.	None allowed.	Not repairable.	Replace shaft.
b. Bends.	No visual deformation is allowed.	Not repairable.	Replace shaft.
c. Spline wear.	1.078 inches minimum over 0.0960 inch diameter balls.	Not repairable.	Replace shaft.
d. Nicks and scratches.	Any amount 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Stone off high metal.

5-126. INSPECTION OF ACCESSORY DRIVE GEARBOX ASSEMBLY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Accessory drive gearbox housing for:			
a. Cracks.	None allowed.	Not repairable.	Replace assembly.

5-126. INSPECTION OF ACCESSORY DRIVE GEARBOX ASSEMBLY. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Missing paint.	Ten percent of coating missing.	Any amount.	Repair finish (see paragraph 5-53). Protect new finish (see paragraph 5-54).
c. Studs and inserts for:			
(1) Looseness.			
(a) Radial (wobble)	Any amount.	Not applicable.	Not applicable.
(b) Axial	None allowed.	Not repairable.	Replace studs or inserts. (see paragraph 5-128).
(2) Damaged threads.	Up to 2 damaged or missing threads with no crossed threads or loose material.	Same as usable limits, with crossed threads or loose material.	Remove loose material and chase threads.
d. Nicks and scratches on:			
(1) Machined surfaces.	Any amount, 0.020 inch deep if it does not exceed 10% of the area with no high metal.	Same as usable limits, with high metal.	Remove high metal with a fine file or stone.
(2) Cast surface.	Any amount 0.040 inch deep, with no high metal or sharp grooves.	Same as usable limits, with high metal or sharp	Remove high metal and blend out sharp grooves.
e. Dents.	Any amount 1/16 inch deep, with no high metal.	Same as usable limits with high metal.	Remove high metal.
f. Packing groove for damage.	No damage allowed on bottom surface of groove. Side walls may have scratches or nicks up to 0.020 inch wide if no more than 10% of the area is affected. The top edge may be nicked any amount but not deeper than 0.020 inch. No burrs, high metal or sharp edges are allowed.	Same as usable limits, with burrs, high metal or sharp edges.	Remove burrs and high metal with a fine stone and blend (see paragraph 5-51).

5-126A. REPLACEMENT OF ALTERNATOR STATOR.

NOTE

A very heavy magnetic field is present in the alternator. It is advisable to remove wristwatches before removing alternator stator.

1. Remove lockwire and disconnect electrical lead from alternator stator.

2. Remove 3 nuts and 3 washers from studs on accessory drive gearbox.

3. Remove stator from gearbox and discard packing from stator housing.

4. Install new packing on new stator.

5. Install new stator, with electrical connector pointing up and away from center of engine.

6. Install 3 washers and 3 nuts. Torque nuts to 45-55 lb in.

7. Connect electrical lead to alternator stator, hand-tight. Lockwire lead, double-strand method, using 0.020 inch lockwire.

5-127. INSPECTION OF COMPRESSOR FRONT FRAME (White light method).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall front frame for:			
a. Cracks.	None allowed.	Not repairable.	Replace front frame.
b. Loose, chipped or missing paint.	Ten percent of coating missing.	Any amount.	Repair finish (see paragraph 5-53). Protect new finish (see paragraph 5-54).
c. Corrosion pits.	None allowed.	Any number, 1/16 inch deep.	Blend out pit (see paragraph 5-51). Repair finish (see paragraph 5-53). Protect new finish (see paragraph 5-54).
d. Nicks, dents and scratches.	Any number, 1/16 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal (see paragraph 5-51). Repair finish (see paragraph 5-53). Protect new finish (see paragraph 5-54).
2. Internal passages for foreign material.	None allowed.	Any amount that can be removed.	Loosen foreign material with a brush. Wash passages with noncaustic solvent and blow out with compressed air.
3. Threaded holes without inserts for damaged threads.	Seventy percent of threads without nicks, dents, stripped threads or high metal.	Any amount that can be reworked to usable limits.	Remove damage by chasing threads. Repair finish (see paragraph 5-53).
4. Threaded holes with threaded inserts for:			
a. Damaged threaded insert.	Seventy percent of threads without nicks, dents, stripped threads or high metal.	Any amount that can be reworked to usable limit.	Remove damage by chasing threads or replace insert (see paragraph 5-128).
b. Stripped parent metal thread.	None allowed.	Not repairable.	Replace front frame.
5. Mounting pad studs for:			
a. Studs loose in:			
(1) Axial direction.	0.001 inch loose.	Not repairable.	Replace studs (see paragraph 5-129).
(2) Radial direction.	0.0025 inch loose, measured 1/2 inch above pad surface.	Not repairable.	Replace studs (see paragraph 5-129).
b. Loose stud lock ring.	None allowed.	Not repairable.	Replace studs and lockring (see paragraph 5-129).
6. Fan support lugs for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-127. INSPECTION OF COMPRESSOR FRONT FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Cracks.	None allowed.	Not repairable.	Replace front frame.
c. Loose bushing.	Not allowed.	Not repairable.	Replace front frame.
d. Worn bushing.	0.502 inch diameter maximum.	Not repairable.	Replace front frame.
7. Variable vane support lugs for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Cracks.	None allowed.	Not repairable.	Replace front frame.
c. Loose bushings.	None allowed.	Not repairable.	Replace front frame.
d. Worn bushings.	0.252 inch diameter maximum.	Not repairable.	Replace front frame.
8. Lube system packing grooves for:			
a. Nicks and scratches along bottom of groove.	None allowed.	Not repairable.	Replace front frame.
b. Scratches in groove wall.	0.003 inch deep where packing seats.	Not repairable.	Replace front frame.
9. Accessory drive gear-box mounting surfaces for nicks, dents, and scratches.	Any number, 1/16 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
10. Forward rabbet ID for:			
a. Nicks, dents and scratches.	Any number, 1/16 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Missing material.	Four areas, 1/4 inch in diameter no closer than 2 inches, with smooth contour and with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Wear (visual indication). Measure diameter if obviously worn.	22.018 inches maximum diameter.	Not repairable.	Replace front frame.
11. Aft rabbet OD for:			
a. Nicks, dents and scratches.	Any number, 1/16 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-127. INSPECTION OF COMPRESSOR FRONT FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Missing material.	Four areas, 1/4 inch in diameter, no closer than 2 inches and a smooth contour with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Wear (visual indication). Measure diameter if obviously worn.	16.186 inches minimum diameter.	Not repairable.	Replace front frame.
12. Forward hub ID, OD and face for:			
a. Nicks, dents and scratches on:			
(1) Hub OD and face.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
(2) Hub ID.	Any number 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Carefully remove high metal with fine polishing paper.
13. Forward hub OD for wear.	14.350 inches minimum diameter.	Not repairable.	Replace front frame.
14. Forward hub ID for wear.	13.073 inches maximum diameter.	Not repairable.	Replace front frame.
15. Mid hub diameter for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Wear.	7.485 inches maximum diameter.	Not repairable.	Replace front frame.
16. Aft hub diameter for:			
a. Nicks, dents and scratches.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Carefully remove high metal with fine polishing paper.
b. Wear.	7.445 inches maximum diameter.	Not repairable.	Replace front frame.
17. IGV support groove for:			
a. Nicks, dents and scratches.	Any number, 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Wear on diameter.	9.020 inches minimum diameter.	Not repairable.	Replace front frame.
c. Missing material on aft rim.	Eight segments, 1/4 inch maximum, not closer than 1/2 inch with a smooth contour, and no sharp edges or corners.	Same as usable limits, with sharp edges and corners.	Remove all sharp edges and corners.

5-127. INSPECTION OF COMPRESSOR FRONT FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Wear on aft rim.	0.110 inch minimum.	Not repairable.	Replace front frame.
18. Anti-icing sleeve for cracks.	None allowed.	Any number that can be reached with a welding torch, without heating the front frame.	Repair-weld (see table 5-6, item 3).
19. Forward packing groove for nicks, dents and scratches.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
20. Aft bolt plate for:			
a. Bent ears.	0.005 inch out of flat.	Any amount.	Bend ear back to original position and blend to within 0.005 inch flat.
b. Nicks, dents and scratches.	Any number, 0.010 inch deep, with no high metal. Defect should not extend from inside diameter to the outside of part.	Same as usable limits, with high metal.	Remove high metal.

5-128. REPLACEMENT OF ROSAN THREADED INSERTS AND STUDS.

1. For detailed information, refer to figures 5-49 and 5-50, and table 5-7 for part numbers and tooling.

TABLE 5-7. ROSAN THREADED INSERTS AND STUDS

INSERTS

		(G.E.Part No.)			(Rosan Part Nos.)		
Internal Thread	External Thread	Insert	Lockring	Removal Drill	Wrench	Drive Tool	Max Removal Depth
8-36	1/4-20	J478P002	R1381P003	19/64	R1104-W	R104-D	0.140
10-32	5/16-24	J478P003	R1381P005	F (0.257)	R1105-W	R205-D	0.120
1/4-28	3/8-24	J478P004	R1381P007	5/16	R1106-W	R106-D	0.125
3/8-24	1/2-20	J478P006	R1381P010	29/64	R1108-W	R108-D	0.200
1/4-28	3/8-16	J479P04	R1381P007	5/16	R1106-W	R206-D	0.156
---	5/16-18	3017T45P01	R1381P007	F (0.257)	R1105-W	R1105-D	0.141
---	3/8-16	3017T45P02	R1381P007	5/16	R1106-W	R1106-D	0.156
1/2-20	3/4-16	3018T86P01	R1382P002	23/32	R1111-W	R210-D	0.141

TABLE 5-7. ROSAN THREADED INSERTS AND STUDS (CONT.)

STUDS

		(G.E. Part No.)			(Rosan Part No.)		
Stud End Thread	Nut End Thread	Stud	Lockring	Max Removal Depth	Removal Tool	Wrench	Drive Tool
10-24	8-36	J482P06	R1381P002	0.109	SM81-16	R1103-W	S81D-10
1/4-20	10-32	J483P05, 10	R1381P003	0.109	SM91-16	R1104-W	S91D-10
5/16-18	1/4-28	J484P08	R1381P005	—	SM101-18	R1105-W	S1014-12
5/16-18	1/4-28	J504P08, 14	R1381P005	0.141	SM101-18	R1105-W	S101D-12
3/8-16	5/16-24	J505P17	R1381P007	0.156	SM111-20	R1106-W	S111D-12
7/16-14	3/8-24	J506P13, 16, 27	R1381P009	0.172	SM121-22	R1107X-W	S121D-12

5-129. REPLACEMENT OF KELOX THREADED INSERTS.

1. For detailed information, refer to figure 5-51 and table 5-8 for part numbers and tooling.

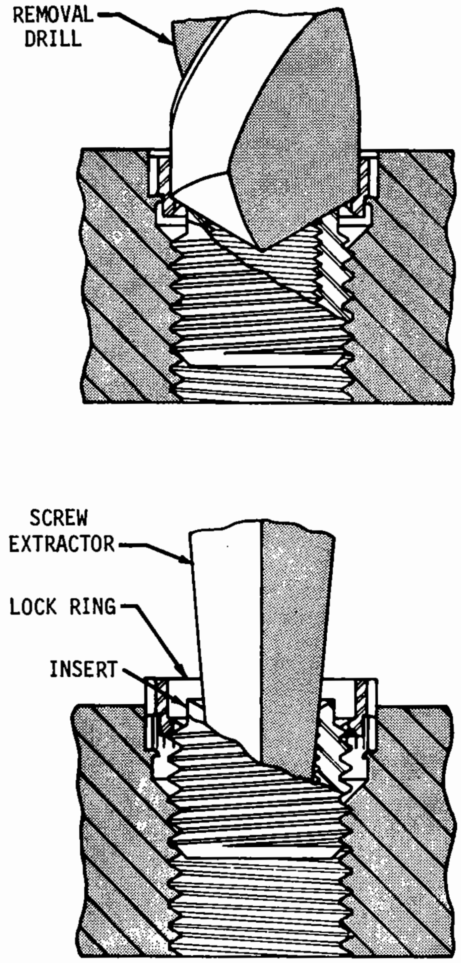
TABLE 5-8. KELOX THREADED INSERTS

		(G.E. Part No.)			(Kelox Part No.)	
Internal Thread	External Thread	Insert	Removal Drill	Max Removal Depth	Greenfield No. 8 Series Extractor	Drive Tool
8-36	1/4-20	3017T47P02	0.191	0.127	No. 3	T2-36-4

5-130. INSPECTION OF VARIABLE VANE ACTUATING COMPONENTS.

5-131. INSPECTION OF VARIABLE VANE ACTUATING ARMS. (See figure 5-52.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace arm.
2. Dents and bends.	None allowed.	Not repairable.	Replace arm.
3. Nicks and scratches.	Any number 0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
Stages 1 - 5			
4. Pin for looseness.	None allowed.	Not repairable.	Replace arm.
5. Pin for wear.	0.120 inch diameter minimum.	Not repairable.	Replace arm.
6. Slot width (if wear is noted visually).	0.1746 inch maximum	Not repairable.	Replace arm.
IGV			
7. Slot width (if wear is visible).	0.222 inch maximum.	Not repairable.	Replace arm.



REMOVAL

1. Clamp part from which insert is to be removed securely to drill press table. Align spindle with hole in part.

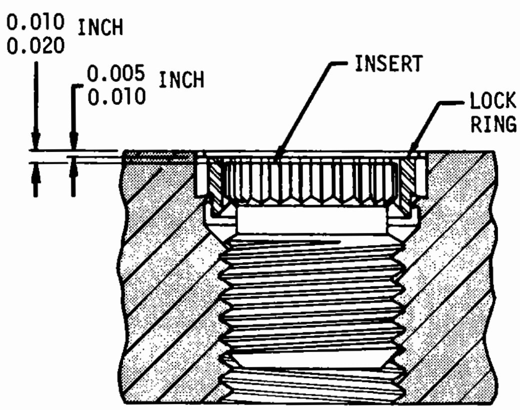
2. Secure removal drill in chuck and set spindle speed at 300 to 700 RPM.

3. Drill through lock ring and neck of insert to destroy serration interlock. Do not drill beyond the depth of the counterbore in the parent material.

4. When removing hydraulic ring locked inserts, drill only through serrated flange of insert. Do not drill through second flange. See Table for depth.

5. Drive square screw extractor into insert and apply removal torque. When insert thread flanks push against lower surface of lock ring, continued removal torque will remove the lock ring.

6. If lock ring has been drilled completely through and fails to lift out with insert, the remaining portion may be collapsed with a punch and removed.



INSTALLATION

1. Refinish threaded hole with Alodine.

2. Coat the external threads with zinc chromate primer, spec. MIL-P-6889A.

3. Install the insert using the wrench from Table and to depth shown.

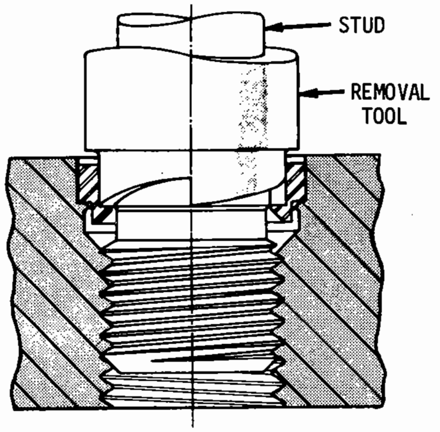
4. With applicable drive tool, install the lock ring to depth shown.

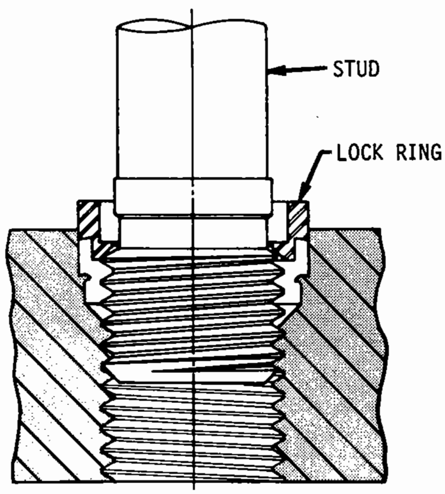
NOTE

Replacement of Rosan inserts and lock rings is make with same size parts as those removed and in same manner as originally installed, rotate new lock ring if necessary, before driving, to a position in which the external serrations are aligned with those in parent material.

TF34-0019

Figure 5-49. Replacement of Rosan Inserts





REMOVAL

1. Clamp part from which stud is to be removed securely to drill press table after carefully aligning axes of stud and drill press spindle. Set spindle speed at 300 to 700 RPM.

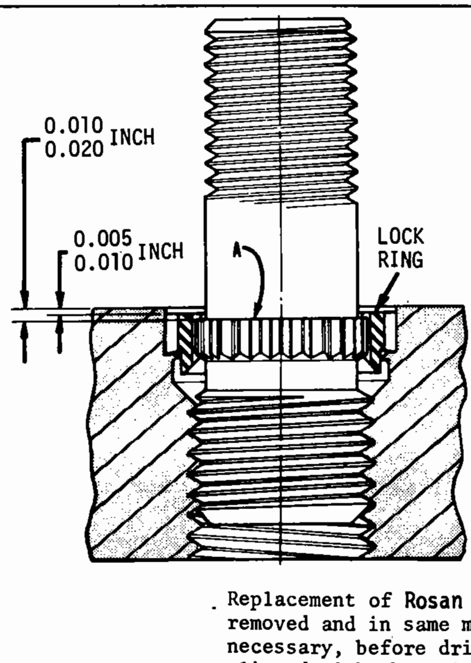
2. Secure removal tool in check and lower over stud shank before starting motor.

3. Without raising spindle, start motor. Mill through lock ring, raising tool every few seconds to allow chips to clear cutting teeth. Best results will be obtained by not milling completely through lock ring.

4. When removing hydraulic ring locked studs, mill only through serrated flange of insert. Do not mill through second flange. See Table for depth.

5. Apply removal torque to stud. When stud thread flanks push against lower surface of lock ring, continued removal torque will remove the lock ring to be jacked out. Stud removal may thus be completed.

6. If lock ring has been milled completely through and fails to lift out with stud, the portion remaining may be collapsed with a punch and removed.



INSTALLATION

1. Refinish threaded hole with Alodine.

2. Coat the stud threads with zinc chromate primer, Spec. MIL-P-6889A.

3. With applicable wrench, install stud to depth shown.

CAUTION

Location of flange is important so that the lock ring drive tool will not make contact with surface A . Any impact or pressure on this surface may cause damage to threads in parent material, resulting in a loose fit.

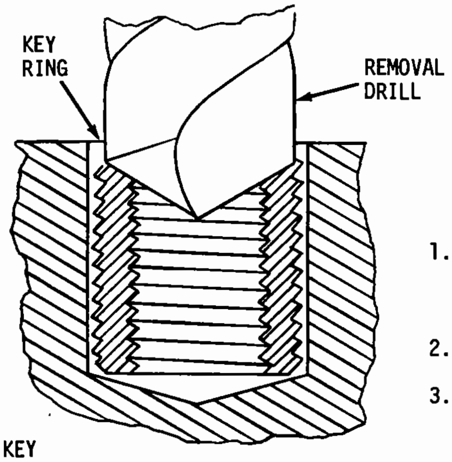
4. With applicable drive tool install lock ring to depth shown.

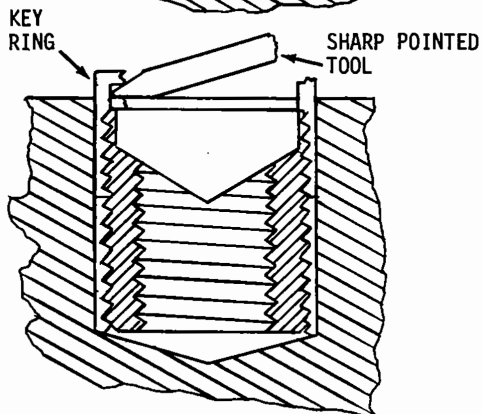
NOTE

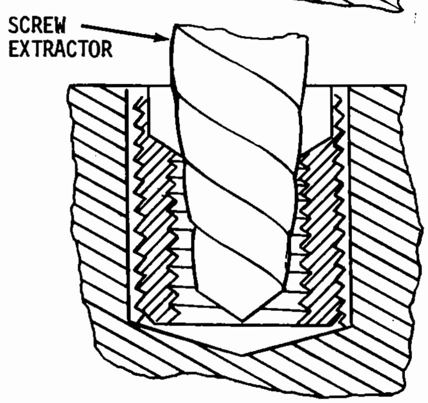
Replacement of Rosan studs and lock rings is made with same size parts as those removed and in same manner as originally installed. Rotate new lock ring if necessary, before driving, to a position in which the external serrations are aligned with those in the parent material.

TF34-0020

Figure 5-50. Replacement of Rosan Studs







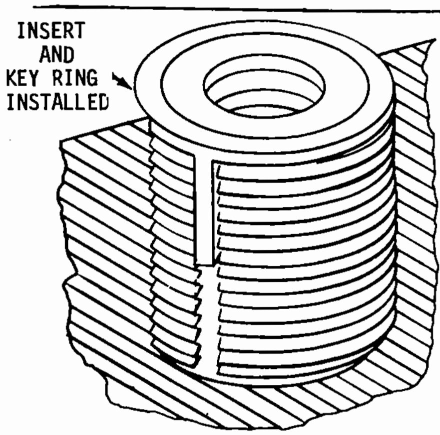
KELOX INSERT/STUD REMOVAL

1. Drill out top of insert (see Insert/Stud Replacement Data table for drill size and depth). The hardened key ring acts as a drill bushing.
2. Pick out key ring using pointed tool.
3. Remove insert using screw extractor specified in table.

NOTE

Studs are removed in the same manner except that they must first be cut off fairly flush with surface.

Replacement insert or stud of the same size may now be installed in the original hole.



KELOX INSERT/STUD INSTALLATION

1. Refinish threaded hole with Alodine.
2. Coat external threads with zinc chromate primer, spec. MIL-P-6889A.
3. Slide one-piece insert (or stud) and key ring assembly onto installation tool mandrel.
4. Screw assembly into tapped hole until keys make contact with first thread.
5. Drive key ring flush with or slightly below surface.

TF34-0202

Figure 5-51. Replacement of Kelox Inserts

5-131. INSPECTION OF VARIABLE VANE ACTUATING ARMS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
8. Uniball hole wear.	0.127 inch diameter maximum.	Not repairable.	Replace arm.
9. Pin for wear.	0.122 inch diameter minimum.	Not repairable.	Replace pin.
10. Uniball looseness in arm.	0.005 inch maximum radial looseness.	Not repairable.	Replace arm.

5-132. INSPECTION OF VARIABLE VANE ACTUATING RINGS. (See figure 5-53.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Actuation ring assembly for:			
a. Cracks.	None allowed.	Not repairable.	Replace ring.
b. Dents, nicks, scratches and wear grooves.	Any number 1/32 inch deep.	a. Same as usable limits, with high metal. b. Any amount.	a. Remove high metal. b. Cold work to usable limits; refinish (see paragraph 5-54).
c. Out of round or flat.	1/32 inch TIR in free state.	Any amount.	Reshape to usable limits.
d. Assembly pin holes for wear (if noted visually):			

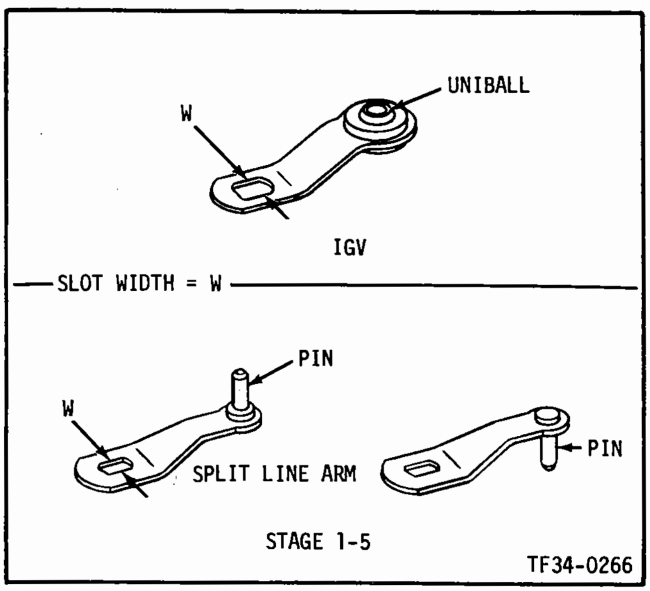


Figure 5-52. Variable Vane Actuating Arms Inspection

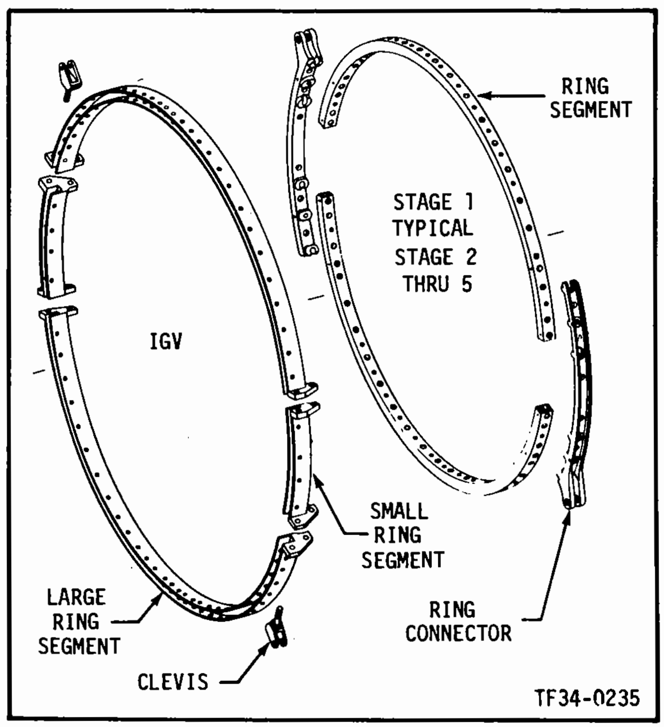


Figure 5-53. Variable Vane Actuating Rings Inspection

5-132. INSPECTION OF VARIABLE VAN ACTUATING RINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
(1) Stages 1, 2, 3, 4 and 5.	0.1415 inch diameter maximum.	Not repairable.	Replace actuator ring.
(2) IGV assembly.	0.1980 inch diameter maximum.	Not repairable.	Replace actuator ring.
2. Clevis pin holes for wear.	0.1270 inch diameter maximum.	Not repairable.	a. Replace actuator ring stage 1-5 b. Replace IGV Clevis
3. Vane spindle bushing.	No inspection required.		
4. Shroud bushings for wear.	IGV: I.D. 0.306 inch maximum diameter. Wall thickness 0.026 minimum.	Not repairable.	Replace bushing.
5. Actuating ring bushing for wear.	I.D. 0.126 inch maximum. O. D. 0. 207 inch minimum.	Not repairable.	Replace bushing.

5-133. INSPECTION OF VARIABLE VANE SHROUD SEALS (See figure 5-54).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace seal.
2. Nicks, dents and scratches on all surfaces except variable vane slots.	Any number 1/32 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
3. Variable vane slots for wear:			
a. IGV	0.400 inch maximum.	Not repairable.	Replace seal.
b. Stages 1 and 2.	0.261 inch maximum.	Not repairable.	Replace seal.

5-134. INSPECTION OF VARIABLE VANE SHROUD RINGS (See figure 5-55).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace ring.
2. Dents.	1/32 inch deep on non-mating surfaces.	Any amount.	Rework to usable limits. No cracks allowed.
3. Nicks and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal. Alodine refinish (see paragraph 5-54).

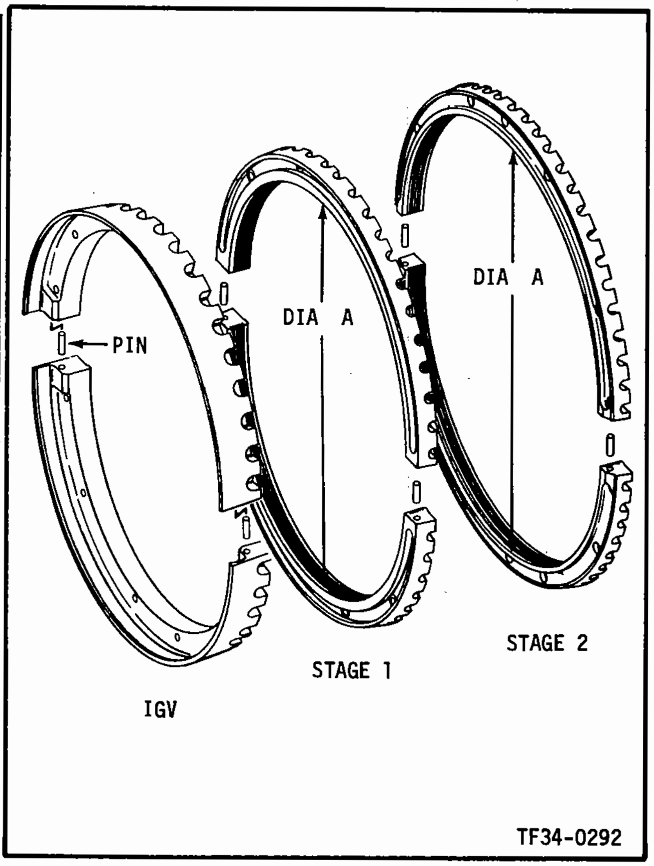


Figure 5-54. Variable Vane Shroud Seals Inspection

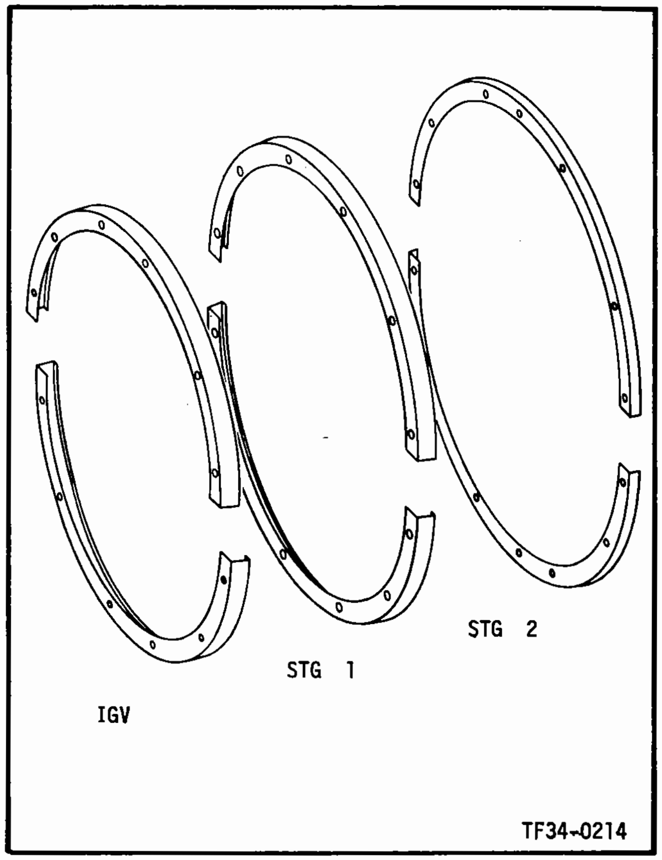


Figure 5-55. Variable Vane Shroud Rings Inspection

5-135. INSPECTION OF IGV ANTI-ICING MANIFOLD.

Fluorescent-penetrant inspect manifold, then proceed as follows:

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Manifold for cracks.	None allowed.	Not repairable.	Replace manifold.
2. Spherical fitting for nicks and scratches.	Up to 0.003 inch deep, with no high metal.	Same as usable limits, with high metal.	Carefully stone off high metal.
3. Bellows and tube for nicks and scratches.	Any number 1/64 inch deep, with no high metal. None on bellows.	Same as usable limits, with high metal.	Remove high metal.
4. Torn lockwire hole.	Any number provided one hole is not torn out and there is no high metal around this hole.	Five holes torn out.	Drill 1/16 inch dia. hole through a nut corner not previously drilled and 3/8 inch from center of nut.
5. Damaged threads.	Up to 1/2 thread missing with no crossed threads.	Same as usable limits, with crossed threads.	Chase thread.
6. Dents in tube.	Any number if diameter is not changed more than 1/16 inch with no sharp creases.	Not repairable.	Replace manifold.

5-135. INSPECTION OF IGV ANTI-ICING MANIFOLD. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
7. Flexible tube connection diameter for wear.	0.403 inch maximum.	Not repairable.	Replace manifold.

5-136. INSPECTION OF COMPRESSOR STATOR CASINGS. (See figure 5-56.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	NOTE Compressor casing halves are not interchangeable.		
1. Overall casing for:			
a. Cracks.	None allowed.	Not repairable.	Replace casings.
b. Nicks and scratches except on flanges.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Corrosion.	Any amount with no apparent buildup.	Any amount with slight buildup, and where pits are not 1/64 inch below original surface.	Remove corrosion with fine steel wool and wipe surface with clean towel and acetone.

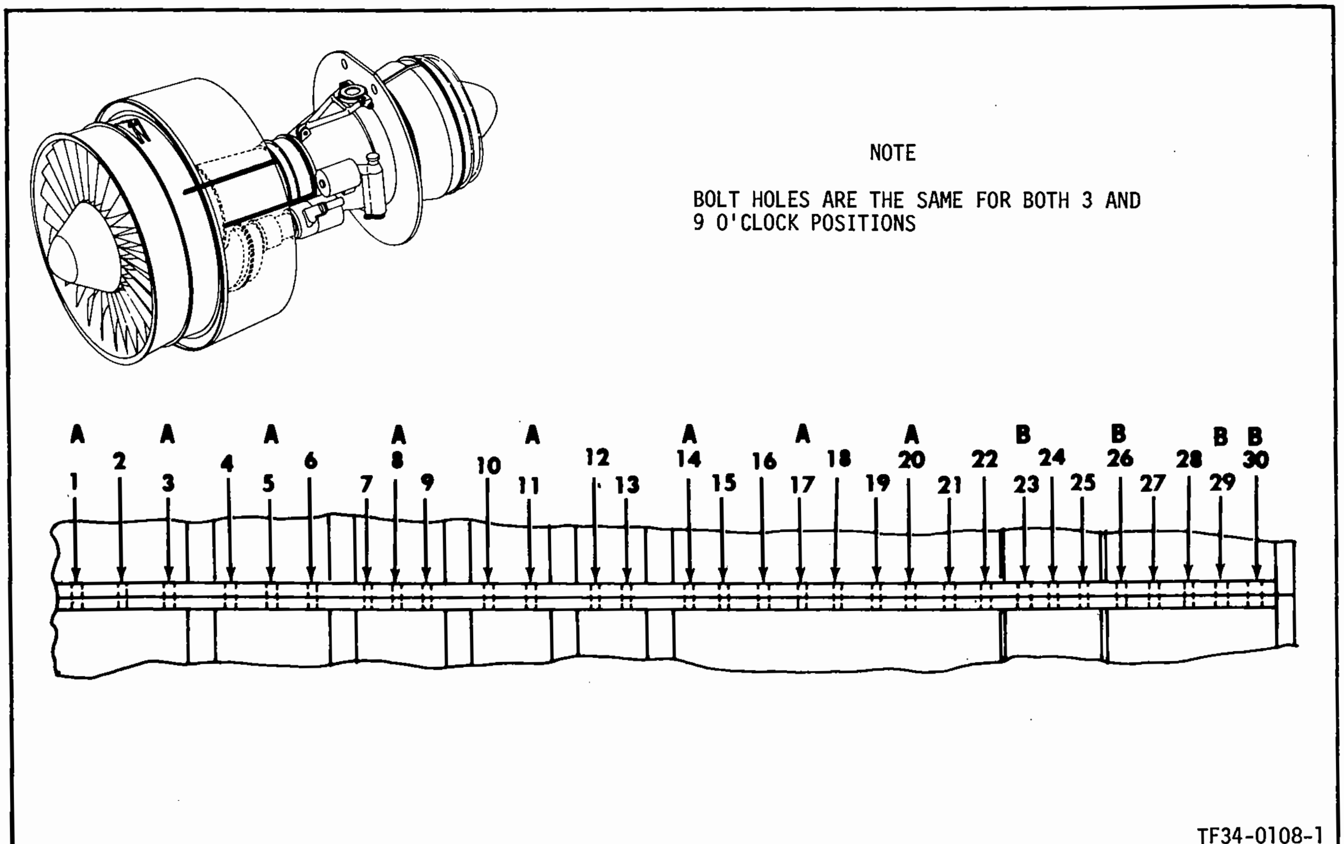


Figure 5-56. Compressor Splitline Body-Bound Boltholes

5-136. INSPECTION OF COMPRESSOR STATOR CASINGS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Dents except on flanges.	Not more than 1/32 inch deep, not to interfere with proper assembly and function of any mating part.	Not more than 1/32 inch deep with high metal that can be removed to prevent interference.	Remove high metal and polish to original finish.
2. The flanges for:			
a. Nicks and scratches on:			
(1) Non-mating surfaces.	Any number, 1/16 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
(2) Mating surfaces	Any number, 1/16 inch deep with no high metal. Not less than 25% of flange width undamaged.	Same as usable limits, with high metal.	Remove high metal.
b. Dents on:			
(1) Non-mating surfaces.	Any number, 1/16 inch deep.	Not repairable.	Replace casings.
(2) Mating surfaces.	Any number, 1/16 inch deep with no high metal. Not less than 25% of flange width undamaged.	Same as usable limits, with high metal.	Remove high metal.
3. Wear in body-bound boltholes. (See figure 5-56.)	Holes marked A: Any amount if hole marked A on each side is not larger than 0.1906 inch diameter.	Not repairable.	Replace casings.
	Holes marked B: At least one hole marked B on each side must not be larger than 0.2505 inch diameter.	Not repairable.	Replace casings.
4. Bushings for damaged threads.	Up to 1 full thread cumulative with no loose material or crossed threads.	Same as usable limits, with loose material or crossed threads.	Chase threads.

5-137. INSPECTION OF INLET GUIDE VANES. (See figure 5-57.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall vane for:			
a. Cracks in parent metal.	No crack is to exceed 3/8 inch in length. Total crack length (cumulative) is limited to 11/16 inch per vane.	Not repairable.	Replace vane.
b. Indications in brazed joints.	Any number of braze voids or depressions.	Not applicable.	Not applicable.

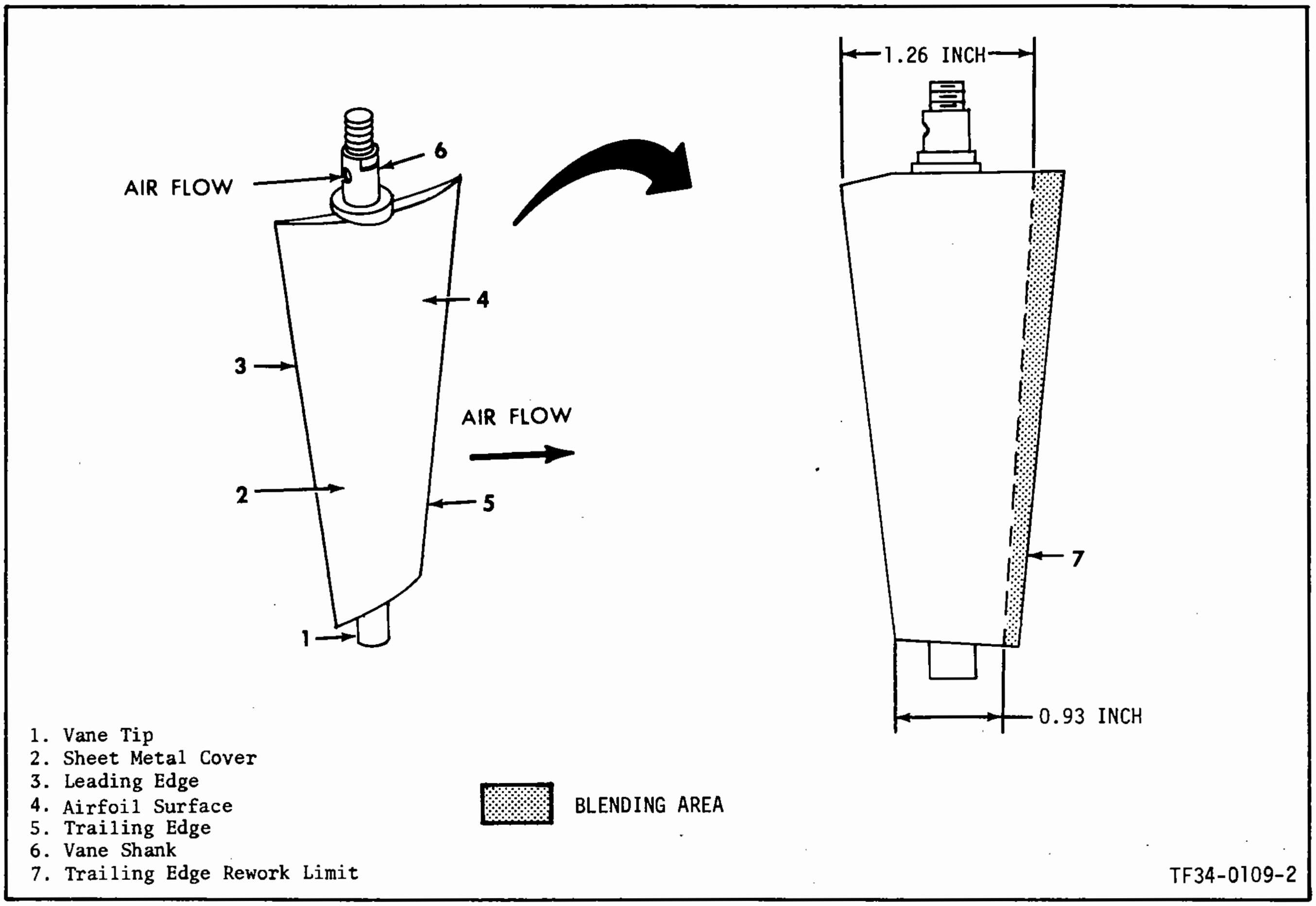


Figure 5-57. Inspection of Inlet Guide Vanes

5-137. INSPECTION OF INLET GUIDE VANES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Sheet metal cover for:			
a. Dents.	Any number 1/16 inch deep.	Not repairable.	Replace vane.
b. Nicks and scratches.	Any number 0.010 inch deep.	Not repairable.	Replace vane.
3. Vane shank (6) for:			
a. Wear (if noted visually).	Minimum diameter outer shank; 0.299 inch.	Not repairable.	Replace vane.
b. Nicks and scratches.	Any number 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Damaged threads.	None allowed.	Up to one full thread damaged.	Chase thread.
d. Actuating arm flats for scratches and gouges.	Any number, 0.005 inch deep, no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-137. INSPECTION OF INLET GUIDE VANES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
4. Vane tip (1) for nicks and scratches.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Trailing edge (5) for:			
a. Dents.	Any number, 1/16 inch deep.	Any amount that can be blended to usable limits.	Blend (see paragraph 5-150) but do not exceed limits of figure 5-57. Be sure bleed slots are clear.
b. Nicks and scratches.	Any number, 1/16 inch deep, with no high metal.	Any amount that can be blended to usable limits.	Blend (see paragraph 5-150) but do not exceed limits of figure 5-57.
	CAUTION In removing restriction, do not enlarge slot width to more than 1/64 inch.		
c. Restricted bleed slots.	Not more than 1/32 inch in length of any bleed slot to be restricted.	Any amount.	Remove restriction. Smoke-check or air flow vane; air flow should be about equal from each slot. No cracks allowed.
d. Closed bleed slots.	Not more than 1/32 inch in length of any bleed slot to be closed.	Any amount.	Repair (see paragraph 5-138).
6. Leading edge (3) for:			
a. Straightness.	Leading edge to be straight within 0.020 inch.	Not repairable.	Replace vane.
b. Dents.	Any number, 1/16 inch deep.	Not repairable.	Replace vane.
c. Nicks and scratches.	Any number, 1/64 inch deep.	Same as usable limits, with high metal.	Remove high metal.
7. Airfoil section (4) for surface roughness due to erosion.	Equivalent to roughness of fine sandpaper.	Any amount on convex side that can be polished to usable limits.	Polish with fine emery cloth to within usable limits.

5-138. REPAIR OF INLET GUIDE VANE TRAILING EDGE SLOTS.

1. Partially closed slot:

a. Insert the corner of a 0.010 inch steel feeler gage into slot and work gage into slot until it is completely open.

b. Lay the convex surface of the vane on a flat surface with the 0.010 shim still in the slot.

c. Lightly tap the concave side of trailing edge to bring the slot width to 0.007-0.012 inch.

d. Smooth edges.

e. No cracks allowed.

2. Completely closed slot:

a. Modify a pin punch by grinding the end to a 60° angle.

b. Set the leading edge of the vane on a solid surface with trailing edge up.

c. Insert the tip of the modified punch into any portion of the slot that is open (generally the ends).

d. Tap punch lightly until entire slot is open enough to insert shim into opened slot.

e. Proceed per steps 1.b through 1.e.

5-139. INSPECTION OF VARIABLE VANES. (See figure 5-58.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. All areas for cracks or torn metal.	None allowed.	Not repairable unless clearly the result of FOD.	Blend but do not exceed limits in figure 5-58. No cracks allowed.
2. Critical areas for nicks, dents, pits, and scratches.	Any number, 0.010 inch deep.	Any amount, on leading and trailing edges only, that can be blended to usable limits.	Blend (see paragraph 5-150). Do not exceed limits shown in figure 5-58.
3. Non-critical areas for:			
a. Nicks.	Any number, 1/32 inch deep, with no high metal.	Any amount that can be blended to usable limits.	Blend (see paragraph 5-150) but do not exceed limits shown in figure 5-58.
b. Dents and bends in leading and trailing edges.	Any number, 0.020 inch deep.	Any number.	Re-form to original contour. No cracks allowed. Do not exceed limits in figure 5-58.
4. Vane shank for:			
a. Wear.	Minimum inner shank: (stages 1 and 2) 0.149 inch. Minimum diameter outer shank: 0.247 inch.	Not repairable.	Replace vane.
b. Nicks and scratches.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Damaged threads.	None allowed.	One full thread damaged.	Chase thread.
d. Gouges on actuating arm flats.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Airfoil section for:			
a. Surface roughness due to erosion.	Equivalent to roughness of fine sandpaper.	Any amount that can be polished to maximum usable limits.	Polish with fine emery cloth to within usable limits.
b. Jagged trailing edges due to erosion. (See figure 5-58.)	Any amount with no curled material.	Any amount of curled material that can be removed to within usable limits.	Remove curled material but do not exceed minor rework minimum chord limits.
c. Chord reduction due to erosion only.	Any amount within minor rework minimum chord limits shown in figure 5-58.	Not repairable.	Replace vane.
6. Platform for undercut at leading edge due to erosion.	0.040 inch deep for stages 1 and 2; 0.020 inch deep for stages 3, 4 and 5. (See figure 5-58.)	Not repairable.	Replace vane.

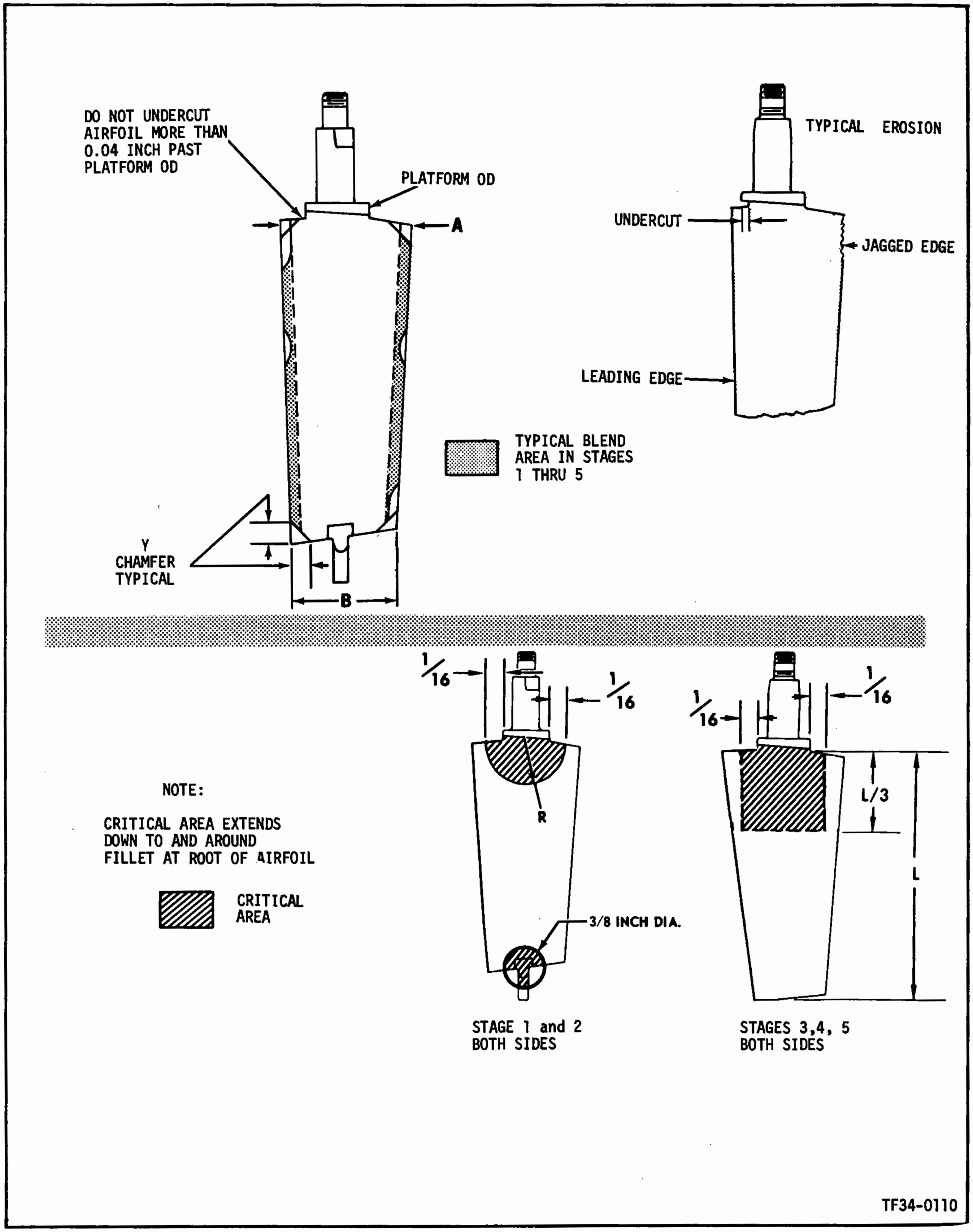


Figure 5-58. Inspection of Variable Vanes (Sheet 1 of 2)

STAGE VANE	MINOR REWORK				CHAMFER Y MAX.
	ROOT A		TIP B		
	MAX. DEPTH	MIN. CHORD	MAX. DEPTH	MIN. CHORD	
1	5/64	15/16	1/16	55/64	1/8
2	1/16	23/32	1/16	23/32	1/8
3	3/64	21/32	3/64	5/8	7/64
4	3/64	19/32	3/64	19/32	7/64
5	3/64	19/32	3/64	19/32	7/64

BLEND LIMITS

MATERIAL MAY BE REMOVED FROM EITHER OR BOTH EDGES UP TO THE MIN CHORD LIMIT. DISREGARD THE CHAMFER WHEN MEASURING CHORD.

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Figure 5-58. Inspection of Variable Vanes (Sheet 2 of 2)

5-140. INSPECTION OF FIXED VANES. (See figure 5-59.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall vane for cracks or torn metal.	None allowed.	Any amount.	Replace vane or segment.
2. Critical areas for nicks, pits, scratches, and dents.	Any number 0.005 inch deep.	Any number on leading or trailing edge that can be blended to usable limits.	Blend (see paragraph 5-150) but do not exceed limits of figure 5-59.
3. Non-critical areas for nicks, pits, scratches, and dents.	Any number, 0.020 inch deep, with no high metal.	Any number that can be blended or re-formed to usable limits.	Re-form or blend (see paragraph 5-150) but do not exceed limits of figure 5-59.
4. Vane platform for scratches, nicks, dents, and pits.	Any amount, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Vane tips for:			
a. Burrs due to rubs.	0.010 inch high.	Any number of burrs.	Blend off burrs.
b. Curling.	0.020 inch maximum from original contour on all vanes. Up to 0.050 inch from original contour on 10% of the vanes in a stage.	Any amount that can be blended or re-formed to usable limits.	Re-form or blend to usable limits. Inspect for cracks; none allowed.
6. Airfoil section for:			
a. Surface roughness due to erosion.	Equivalent to roughness of fine sandpaper.	Any amount that can be polished to usable limits.	Polish with fine emery cloth within usable limits.

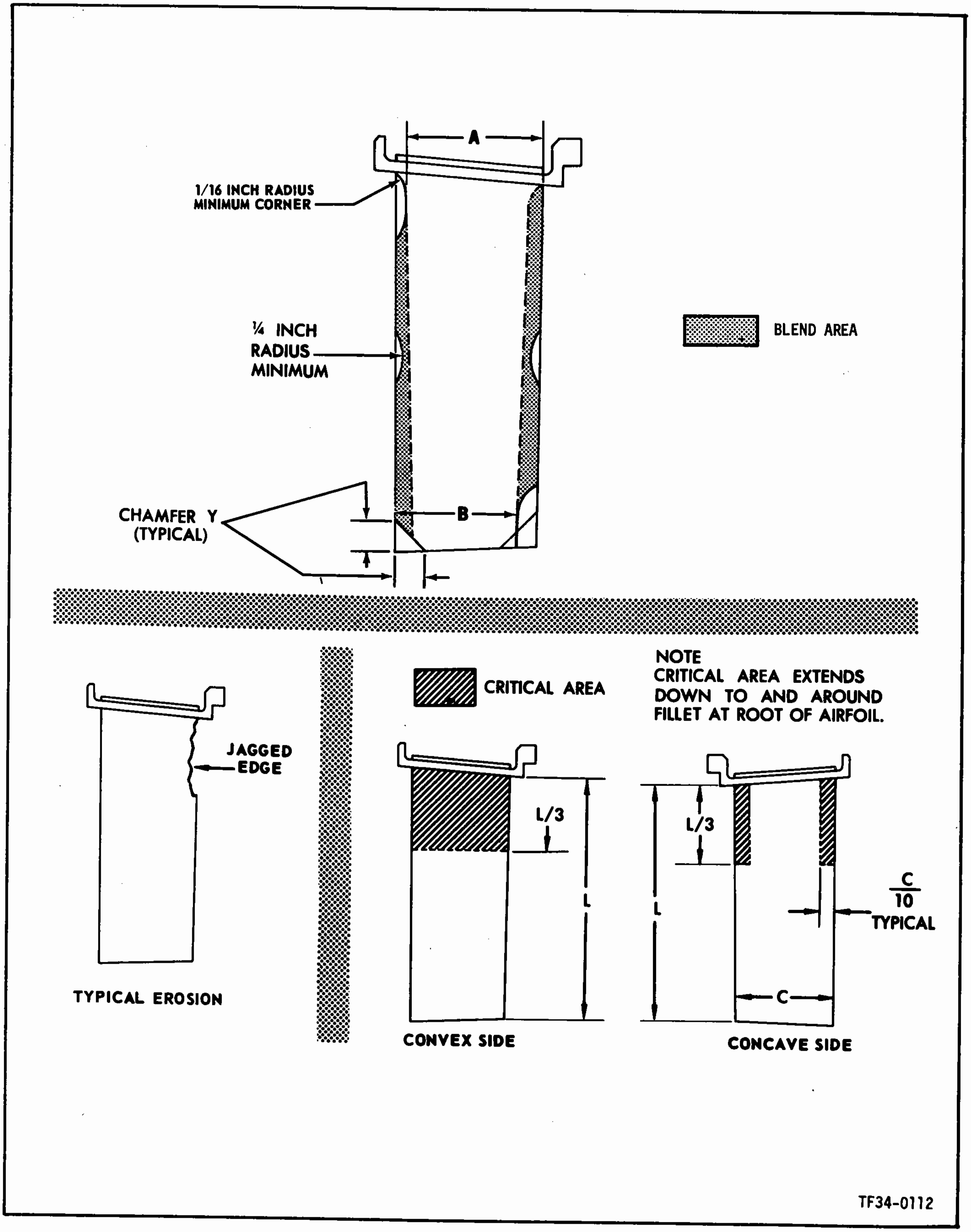


Figure 5-59. Inspection of Fixed Stator Vanes (Sheet 1 of 2)

STAGE	MAJOR REWORK				MINOR REWORK		CHAMFER
	ROOT A		TIP B		ROOT A & TIP B		
	DEPTH	MIN CHORD	DEPTH	MIN CHORD	DEPTH	MIN CHORD	
6	1/16	9/16	3/32	17/32	1/32	19/32	1/8
7	1/16	17/32	3/32	1/2	1/32	9/16	1/8
8	3/64	17/32	5/64	1/2	1/64	9/16	1/8
9	1/32	1/2	1/16	15/32	1/64	33/64	3/32
10	1/64	15/32	1/16	7/16	1/64	15/32	3/32
11,12,13	1/64	7/16	3/64	13/32	1/64	7/16	3/32
OGV	1/64	37/64	1/16	17/32	1/64	37/64	1/8

MATERIAL MAY BE REMOVED FROM EITHER OR BOTH EDGES UP TO THE MIN CHORD LIMIT. DISREGARD THE CHAMFER WHEN MEASURING CHORD.

Figure 5-59. Inspection of Fixed Stator Vanes (Sheet 2 of 2) TF34-0113

5-140. INSPECTION OF FIXED VANES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Jagged trailing edges due to erosion.	Any amount without curled material.	Any amount of curled material that can be removed within usable limits.	Remove curled material but do not exceed rework minimum chord limits.
c. Chord reduction due to erosion only.	Any amount within rework minimum chord limits. (See figure 5-59.)	Not repairable.	Replace vane or segment.
d. All vanes for visual evidence of erosion around root. (Reduction of chord or thinning of trailing or leading edge.	Any amount that will not yield under eraser test and still be within vane blending limits. (Eraser test, paragraph 5-141.)	Refer to vane blending limits.	Blend to within usable limits. If over limits, replace vane or segment.

5-141. TEST FOR ERODED COMPRESSOR ROTOR BLADES AND FIXED STATOR VANES.

1. Check eroded rotor blades and fixed stator vanes for usability as follows: (See figure 5-60.)

CAUTION

Back up the adjacent area at the point where force is applied to prevent excessive bending outside the area being checked. Do not apply excessive force.

a. Using a soft (Shore A Durometer 80) pencil eraser, apply pressure perpendicular to the eroded section.

b. Use an 8-power glass and check for any yield of vane or blade material.

c. If eroded area yields under eraser force, remove eroded area by blending to usable limits. Replace any blades that are outside usable limits after blending. Replace vanes or vane sectors that are outside usable limits after blending.

5-142. <u>REPLACEMENT OF COMPRESSOR STATOR VANES.</u>

Use the following instructions for replacing damaged stator vanes.

1. Lubricate all screw threads and fixed vane casing slots with engine oil.

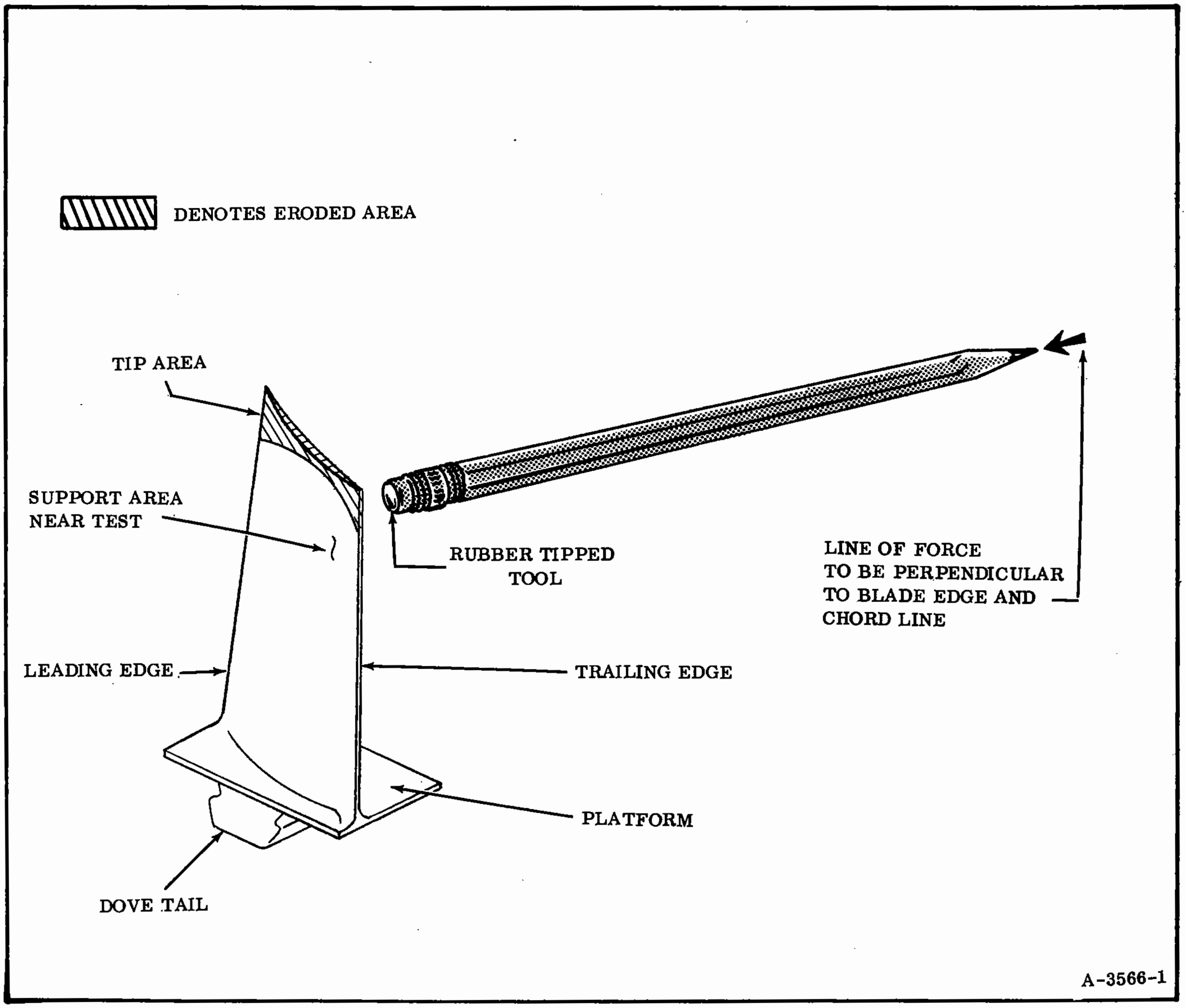


Figure 5-60. Erosion Test for Blades and Fixed Vanes

2. Do not reuse locking clips, deformed key washers, cotter pins, packings, or bushings.

CAUTION

Nuts for inlet guide vanes differ from the nuts used on vanes in stages 1 through 5. Do not mix nuts as disassembly.

3. If clip breaks during removal, press out the pin from below.

5-143. REPLACEMENT OF INLET GUIDE VANES.

1. Remove the bolts (1, figure 5-61), nuts (2) and the shroud rings (3) and seal (4) from the inlet guide vanes (5). Remove bushing (6).

CAUTION

Nuts (7) for inlet guide vanes differ from the nuts used on vanes in stages 1 through 5. Do not mix nuts at disassembly.

NOTE

Keep parts removed (sleeves, washers, etc.) together if possible. This will make reassembly stackup easier.

2. Remove the clips (8) using clip remover (21C5068), pins (9) and vane lever arms (10) from the actuating ring (11). Remove the nuts (7), lever arms (10), sleeves (12), manifold (13), washers (14) and spacing washers (15) from the damaged vanes as applicable.

3. Remove the bushings (16) from the vane shanks or casing holes.

CAUTION

Nuts for inlet guide vanes differ from the nuts used on vanes in stages 1 through 5. Be sure correct nuts are installed.

4. Place new bushings (16) into the compressor casing; then insert the vane shanks through the bushings. Twist the vane back and forth if necessary. Assemble the spacing washer (15), washer (14), manifold (13), sleeve (12), and lever arm (10) to the vane shanks. Secure the vanes to the stator with nuts (7).

5. Apply an increasing torque of 30-40 lb inch and tighten the nuts (7) until the bushings and lever arms are seated.

6. Use a feeler gage and measure gap between spacing washer (15) and washer (14). Gap should be 0.002-0.005 inch. See figure 5-61A. If not, remove parts and change spacing washer (15, figure 5-61) to different thickness. See NAVAIR 02B-105ALA-4 for part number of different thicknesses of spacing washers.

7. Assemble shroud rings (3) and seals (4). Secure the rings in position with bolts (1). Torque the bolts (1) to 16-19 lb inch.

NOTE

Be sure that the bolt heads are below the ring surface.

8. Attach a spring scale (graduated in ounces) to the lever arm (10) pinhole. While pulling the spring scale perpendicular to the actuating arm centerline, either loosen or tighten nuts (7) until a pull of 0-25 ounces is necessary to move the vanes. Secure the arms to the actuating ring with clips (8) and pins (9).

9. Use fixture (21C5032) and set the vane arms to the open and closed positions. (See figure 5-62.) At both the open and closed positions measure clearances A and B (figure 5-62). The clearance values are 0.002 inch minimum. Blend the vanes to meet this limit. Do not remove any more material than is necessary to meet the minimum clearnace value. Every effort should be made not to exceed a 0.005 inch gap after blending.

10. Measure clearances C and D (figure 5-62) using the same procedure and tolerances as outlined in step 9 for clearances A and B.

5-144. REPLACEMENT OF STAGE 1 THROUGH 5 VANES. For special tools, see table 2-1 group 11.

1. Remove screws (17, figure 5-61) and nuts (18) holding shroud seals (19, 20) and shrould rings (21, 22). Remove shroud seals (19, 20), shrould rings (21, 22) and vane bushings (23) as needed.

2. Remove actuating rings (24, 25, 26, 27, 28) by carefully pushing them towards center of casing until pins of lever arms (29) are free of rings. Lift rings up and out.

3. Unbend key washers (33). Remove nuts (34), keywashers (33), lever arms (29, 30, 31, 32), washers (35), vanes (36, 37, 38, 39, 40) and bushing (41) as required.

NOTE

Vane lever arms with pins pointing out, to be assembled to 2 vanes at each splitline.

4. Install new bushings (41), and vanes (36, 37, 38, 39, 40). Assemble washers (35) and vane lever arms (29, 30, 31, 32) as required.

5. Assemble keywashers (33) and nuts (34). Torque nuts to 20 lb inch maximum.

6. Assemble bushings (23) for stage 1 and stage 2 vanes, to the vane tips. Assemble shroud.

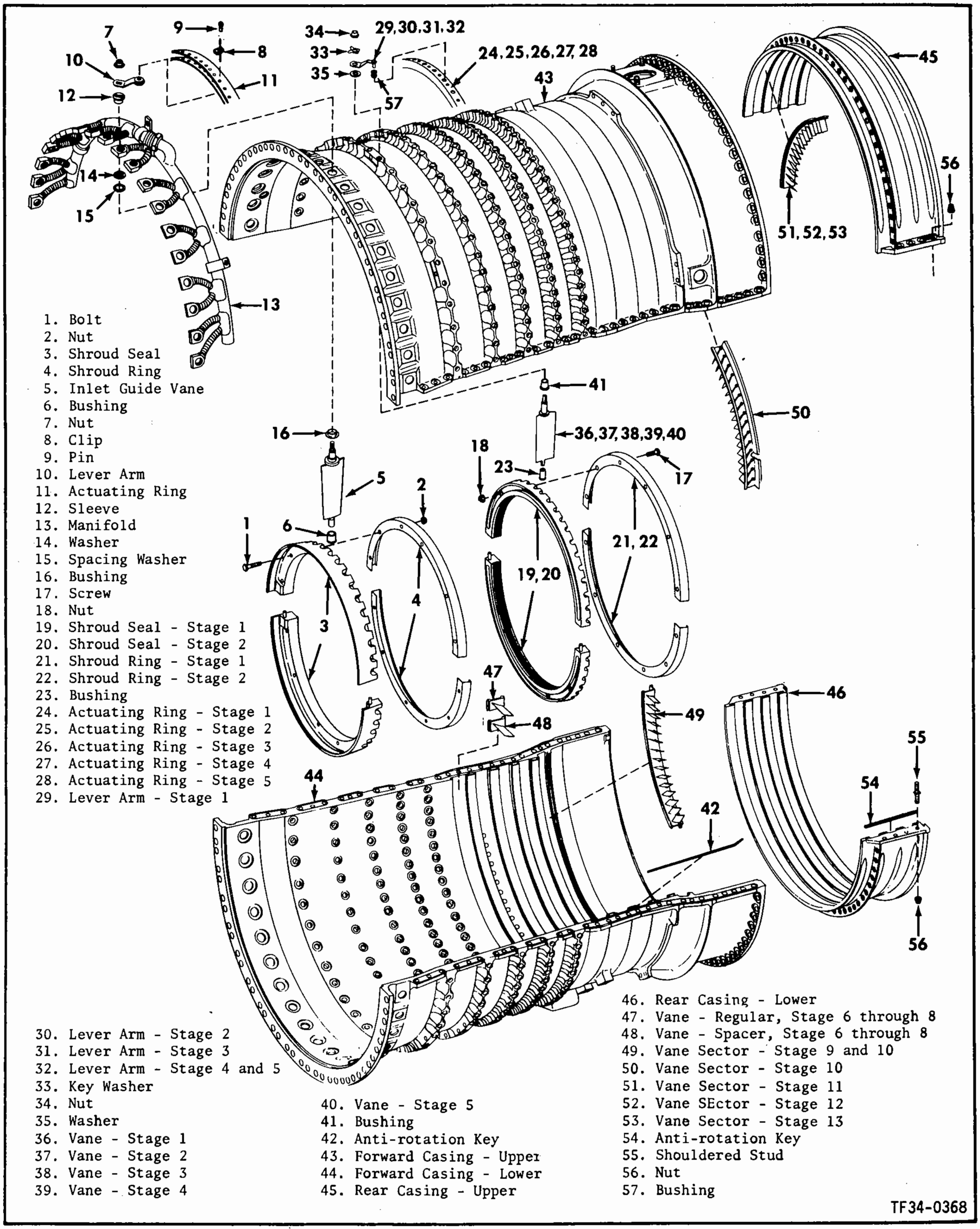


Figure 5-61. Replacement of Compressor Stator Vanes

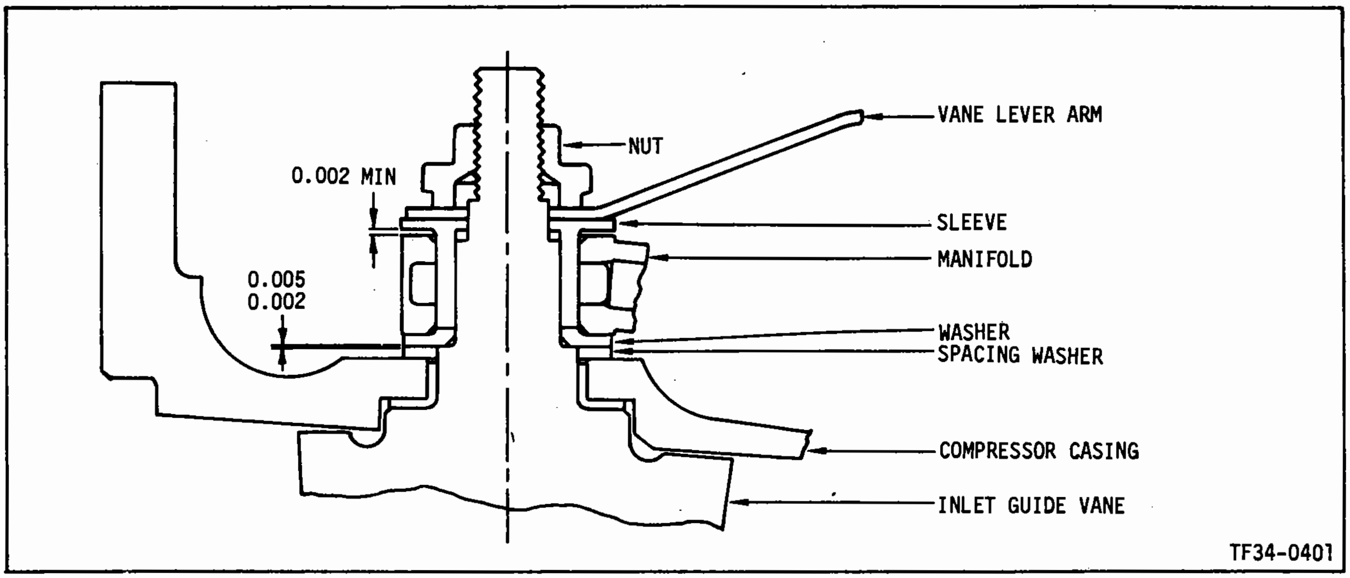
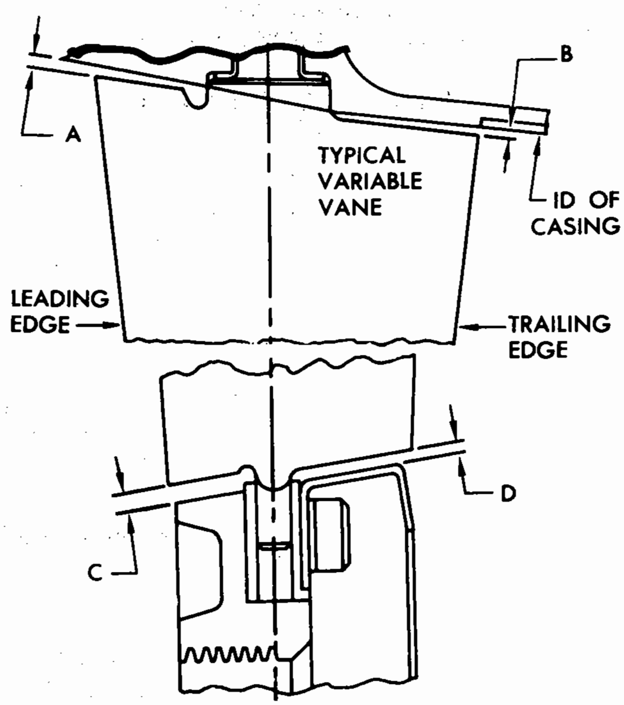


Figure 5-61A Inlet Guide Vane Stackup



STAGE	OPEN POSITION	CLOSED POSITION
IGV	41° CCW	41° CW
1	29° CCW	29° CW
2	24° CCW	24° CW
3	21° CCW	21° CW
4	20° CCW	20° CW
5	20° CCW	20° CW

NOTE: CLOCKWISE (CW) AND COUNTERCLOCKWISE (CCW) ANGLES MUST BE MEASURED LOOKING FORWARD.

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Figure 5-62. Variable Vane Clearance Check

seals (19) and shroud rings (21) to stage 1 vanes. Install screws (17) and nuts (18). Torque screws to 16-19 lb inch.

7. Repeat step 6 for stage 2 shroud seals (20) and shroud rings (22).

8. Attach a spring scale (graduated in ounces) to the actuating arm pinhole. While pulling the spring scale perpendicular to the actuating arm centerline, either loosen or tighten the nuts until a pull of 12-20 ounces is necessary to move the vanes. Assemble actuating rings (24, 25, 26, 27, 28) to lever arms.

9. Use fixture (21C5032) and set the vane actuating arms to the open and closed positions. (See figure 5-62.) At both the open and closed positions measure clearances A and B (figure 5-62). The clearance values are 0.002 inch minimum. Blend the vanes to meet this limit. Do not remove any more material than is necessary to meet the minimum clearance value. Every effort should be made not to exceed a 0.005 inch gap after blending. Bend up the tabs of the keywashers (33, figure 5-61) to secure the nuts in position.

10. Measure clearances C and D (figure 5-62) using the same procedure and tolerances as outlined in step 9 for clearances A and B.

11. Assemble casing halves (43, 44, figure 5-61) together and check gap between the shroud seals (3, 19, 20). Gap must be 0.002 - 0.010 inch. Blend excess material from shroud seal (without the pin) to get minimum clearance.

5-145. REPLACEMENT OF STAGES 6 THROUGH 8 STATOR VANES.

1. Place stator casing half in holder (21C5033).

2. Remove the required number of vanes to allow removal of damaged vanes.

CAUTION

On stages 6 through 8, be sure the correct stator vane is installed in its correct location by stage and by type of vane (regular, or spacer, refer to paragraph 5-147 for vane identification).

3. Assemble a regular vane (47, figure 5-61) with its platform next to horizontal splitline. Do not use stator vane keys (42) at this time.

4. Assemble the regular vanes (47) and spacer vanes (48) in the remainder of the stator half.

5. Measure and record the dimension from the horizontal splitline to the nearest vane platform. A clearance of 0.000-0.020 inch below the horizontal splitline is required.

a. An overstacked condition exists when the vane platform nearest to the horizontal splitline extends over the splitline surface. To correct an overstacked condition, replace spacer vanes with regular vanes having a narrow platform. Remove up to 0.005 inch from regular vanes (equal amounts from both sides of platform may be removed) as necessary if there are no spacer vanes in the stage.

b. An understacked condition exists when the vane platform nearest to the horizontal splitline exceeds the limits in step 4. To correct this condition, replace the required quantity of regular vanes with an equal amount of spacer vanes.

CAUTION

- When blending platforms, do not blend the radius at base of airfoil.
- Do not force stator keys into slots. They are machined parts and can only be installed in one position.

5. Assemble 2 stator keys (42).

5-146. REPLACEMENT OF STAGES 9 THROUGH 13 STATOR VANES.

1. Place compressor casing half (43, 44, 45, 46, figure 5-61) in holder (21C5033 for forward casing, 21C5127 for aft casing).

NOTE

Use vane removal kit if vanes cannot be removed by hand.

2. Use vane removal kit (21C5038) to remove vane sectors as follows:

a. Select the set of pushers for the stage of vane sectors being removed.

b. Remove stator keys.

c. Place the stepped end of pusher against vane sector. Tap other end of pusher with soft-faced mallet, using only enough force to move vane sectors in casing grooves.

d. As 1 pusher completely enters the casing, start another pusher. Repeat this process until all desired vane sectors are removed.

NOTE

One peculiar stage 10 sector (50) (with slot in ring) belongs in upper casing half, 9 o'clock position.

3. Apply grease, Versilube G392, to vane sector mating flanges. Assemble vane sectors using kit (21C5038) if necessary, to compressor casings. Check for overstack/understack condition in paragraph 5-145

4. Install stator keys.

5. Install compressor casings to engine by following instructions of paragraph 7-25.

5-147. COMPRESSOR FIXED STATOR VANE IDENTIFICATION.

1. Vanes for stages 6 through 8 can be identified by a code number marked on the bottom of the vane platform. This code number is made up of three (3) digits; the first two digits, which identify the stage number, are part of the manufacturer's part number; the last digit identifies whether it is a REGULAR or SPACER vane.

a. Stages 6 through 8 are made up of regular and two (2) types of spacer vanes. The first two digits identify the stage as shown in table 5-9.

b. The last digit of the code number marked on vanes in stages 6 through 8 identifies the type of vane as shown in table 5-10.

TABLE 5-9.
FIXED STATOR VANE STAGE IDENTIFICATION

Stage	Code Number
6	16
7	17
8	18

TABLE 5-10.
FIXED STATOR VANE TYPE IDENTIFICATION

Type	Code No. (last digit)
Regular	1
Spacer (wide platform)	2

5-148. INSPECTION OF COMPRESSOR ROTOR ASSEMBLY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Rear spool OD surface for:			
a. Nicks, dents and scratches.	Any number 0.003 inch deep with no high metal.	Any number 0.010 inch deep with high metal.	Blend to usable limits.

5-148. INSPECTION OF COMPRESSOR ROTOR ASSEMBLY. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Stator vane rubs.	Light buildup (black or gray streaks) which is smooth to the touch and not deeper than 0.010 inch with no blue discoloration (from heat). Straw color is acceptable.	Same as usable limits, with high metal.	Remove high metal and polish with fine emery cloth. Reject any spool with blue or black heat discoloration
2. Front spool OD surface for:			
a. Nicks, dents and scratches.	Any number 0.003 inch deep with no high metal.	Not repairable.	Replace rotor assembly.
b. Stator vane rubs.	Coating peaks knocked off with light titanium buildup (black or gray streaks) which is smooth to the touch and not deeper than 0.007 inch.	Not repairable.	Replace rotor assembly.
3. Overall seal except teeth for:			
a. Cracks.	None allowed.	Not repairable.	Replace rotor.
b. Nicks, gouges, scratches or dents.	Any number 1/64 inch deep. Cumulative length 3 inches. No high metal.	Same as usable limits, with high metal.	Remove high metal.
4. Seal teeth for:			
a. Nicks and radial dents.	Any number 0.005 inch deep, 8 per tooth 1/32 inch deep, and 8 per seal 1/16 inch deep with no high metal or sharp edges.	Same as usable limits, with high metal or sharp edges.	Remove high metal and sharp edges.
b. Axial dents (bent teeth).	Any number 1/16 inch out of line. Not over 30% of any one tooth effected.	Not repairable.	Replace rotor.
c. Cracks.	None allowed.	Not repairable.	Replace rotor.
d. Chipped or missing abrasive coating if originally applied.	Any amount.	Not applicable.	Not applicable.

5-149. INSPECTION OF COMPRESSOR ROTOR BLADES. (See figure 5-63)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	All blending is to be accomplished per paragraph 5-150. Do not exceed the limits of figure 5-63.		

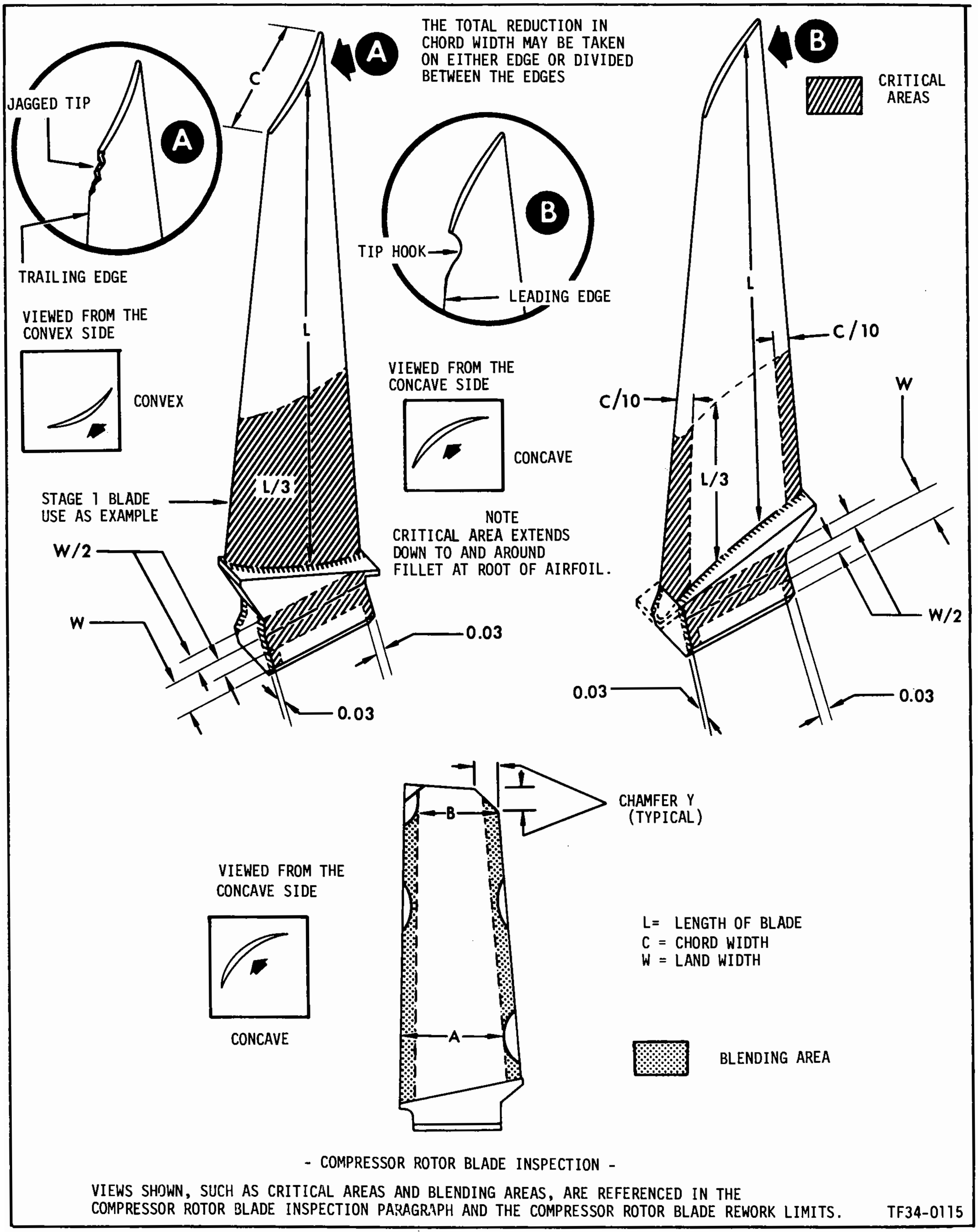


Figure 5-63. Inspection of Compressor Rotor Blades (Sheet 1 of 2)

STAGE	MAJOR REWORK				MINOR REWORK				MAX. TIP CHAMFER Y
	ROOT A		TIP B		ROOT A		TIP B		
	Max. Depth	Min Chord	Max. Depth	Min. Chord	Max. Depth	Min Chord	Max. Depth	Min. Chord	
1	1/32	1 21/64	3/16	1 3/8	1/32	1 21/64	1/16	1 1/2	1/4
2	1/32	1 3/32	5/32	1 1/32	1/32	1 3/32	3/64	1 9/64	1/4
3	1/32	1	9/64	55/64	1/32	1	3/64	61/64	1/8
4	1/32	55/64	1/8	23/32	1/32	55/64	1/32	25/32	1/8
5	1/64	3/4	3/32	43/64	1/64	3/4	1/32	47/64	1/8
6	1/64	21/32	3/32	37/64	1/64	21/32	1/32	41/64	1/8
7	1/64	19/32	5/64	33/64	1/64	19/32	1/32	37/64	3/32
8,9	1/64	33/64	1/16	15/32	1/64	33/64	1/64	33/64	3/32
10,11	0	15/32	1/16	13/32	0	15/32	1/64	15/32	1/16
12,13, 14	0	7/16	1/16	25/64	0	7/16	1/64	7/16	1/16

COMPRESSOR ROTOR BLADE REWORK LIMITS

NOTE

THIS TABLE GIVES THE MAX. DEPTH TO WHICH THE LEADING AND TRAILING EDGES OF THE BLADES CAN BE REPAIRED AND THE MIN. CHORD THAT MUST BE MAINTAINED. USE FIGURE OPPOSITE FOR THE LOCATION OF BLENDING AREAS AND FOR EXAMPLES OF ACCEPTABLE BLEND AND BLADE TIP REPAIRS.

MEASURE CHORD 0.050 INCH BELOW BLADE TIP

TF34-0114

Figure 5-63. Inspection of Compressor Rotor Blades (Sheet 2 of 2)

5-149. INSPECTION OF COMPRESSOR ROTOR BLADES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	NOTE Inspection of compressor rotor blades should be done in the following manner: 1. If the condition of the blade is questionable, inspect it further using the limits of this paragraph in conjunction with the sketches shown in figure 5-63. The sketches define critical and non-critical areas. 2. Minimum chord rework limits and maximum defect rework limits are shown in figure 5-63, depending on the stage being inspected. If the blade is usable, return it to service without reworking. If it is repairable, blend out the defects per paragraph 5-150 using the limits shown in figure 5-63 and the blending areas defined in the sketches of figure 5-63. If the blade is scrapped, replace it per paragraphs 5-151 through 5-156.		
1. All areas for cracks or torn metal.	None allowed.	Not repairable unless it is clearly the result of FOD.	Replace compressor rotor. Exception: If the crack is clearly the result of FOD, the blades may be replaced within the allowable limits of paragraphs 5-151 through 5-156, or the crack may be blended out if it is within blending limits. Reinspect any blended blade to be sure crack is completely removed.
2. Critical areas for nicks, pits, scratches and dents.	Any number, 0.005 inch deep.	Any amount on leading or trailing edge that can be blended to usable limits.	Blend, but do not exceed limits of figure 5-63.
3. Non-critical areas for nicks, pits, scratches, dents, and bends.	Any number 0.010 inch deep.	Any amount on leading or trailing edge that can be blended to usable limits.	Blend, but do not exceed limits of figure 5-63.
4. Platform for nicks, pits, and scratches.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
5. Corners of locking blades for damage.	None allowed.	Not repairable.	Replace blade.
6. Platform edges for nicks and dents.	Any number 1/16 inch deep if at least 75% of each edge is undamaged with no high metal.	Same as usable limits, with no high metal.	Remove high metal.
7. Dovetail and shank:			

5-149. INSPECTION OF COMPRESSOR ROTOR BLADES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Critical areas for scratches, nicks, dents and pits.	Defects of no apparent depth.	Repairable dovetail corners only, where defects may be removed within an 0.030 inch radius.	Repair corners to limits.
b. Non-critical areas for nicks, pits, and scratches.	Any number, 0.005 inch deep, with no high metal.	Repairable on corners only, where defects may be reworked to limits within 0.030 inch radius.	Repair on corners to limits.
8. Airfoil section for:			
a. Surface roughness due to erosion.	Equivalent to roughness of fine sandpaper.	Any amount that can be polished to usable limits.	Polish with fine emery cloth to within usable limits.
b. Burrs on leading edge due to erosion.	None allowed.	Any amount.	Remove burrs.
c. Tip hook due to erosion.	Any amount.	Not applicable.	Not applicable.
d. Erosion at leading and trailing edges and at tip.	Any amount that will not yield under eraser test and still be within blade blending limits. (Eraser test paragraph 5-141.)	Refer to blade blending limits.	Blend to within usable limits. If over usable limits, replace blade.
e. Jagged trailing edge tip due to erosion.	Any amount without curled material.	Any amount of curled material that can be removed to meet usable limits.	Remove curled material, but do not exceed rework minimum chord limits.
f. Chord reduction due to erosion only.	Any amount within rework minimum chord limits.	Not repairable.	Replace blade.
9. Blade tips for:			
a. Burrs due to rubs.	0.01 inch high.	Any amount.	Blend off burrs.
b. Curling.	0.02 inch from original contour. 1/16 inch from original contour on 10% of blades in stage.	Any amount that can be re-formed or blended to usable limits.	Re-form or blend but do not exceed the limits of figure 5-63. Inspect for cracks; none allowed.

5-150. AIRFOIL BLENDING PROCEDURES.

1. Definitions of types of damage to compressor airfoils:

a. NICK: A V-shaped depression in the airfoil made by a sharp-edged object pushing the metal inward. If it is more than twice as long as it is wide, treat it as a scratch. The surface of the nick should be clean and free of corrosion.

b. PIT: A round sharp-edged hole with a rounded bottom caused by corrosion.

c. SCRATCH: A V-shaped line or shallow groove made by a sharp object dragged across the surface.

d. DENT: A smooth, rounded depression made by impact with a rounded object. If the depression is not completely smooth, it should be considered as a nick. Any dent whose diameter or shortest distance across is less than four times its depth should be considered as a nick. Wavy leading or trailing edges shall be treated as a dent.

e. EROSION: A sand- or shot-blasting effect on the leading edges or on the leading portion of the concave side, caused by sand or dust going through the engine.

f. TORN METAL: A separation or pulling apart of material by force, leaving jagged edges.

2. Blending instructions:

a. Blending is done to remove stress caused by nicks, pits, and scratches. The removal of high metal and straightening of dents (where permitted) is done to restore, as close as possible, the finish and shape of the airfoil to that which it was originally.

b. Blending should be finished with fine stone or crocus cloth. Coarser tools may be used for initial removal of material. Finish blending must be done in a direction along the length of the blade or vane so as to remove all evidence of marks across the airfoil that may have been made during initial blending.

NOTE

To speed up the blending process, suitable power tools may be used. Refer to step 3 for instructions for using this equipment to rework rotor blades, variable vanes, and vane segments.

c. Defects more than 1/4 inch apart shall be blended separately; those less than 1/4 inch apart shall be blended together. All blends shall have a minimum radius of 1/4 inch. The total reduction in chord width may be taken on either side or divided between the sides. The amount of rework is controlled by the minimum chord width limit. The minimum allowable chord is given for root and tip of airfoil; the minimum chord at other points is proportional. To minimize the possibility of having the engine stall, keep the shape of the blended airfoil leading edge as close as possible to the original contour. See figure 5-64.

d. Blending limits are given as depth dimensions to make it easier to see how much can be repaired. Experience has shown that depth limits are used for doing most rework. However, the minimum chord limit is the most important dimension; it should be checked in borderline cases or where previous rework is evident in the same area. In borderline cases where depth limits and minimum chord limits conflict with one another, use the minimun chord dimension to decide whether the part is serviceable.

e. Defect limits are given as depth dimensions, since this is the dimension that affects strength. However, accurate depth measurements require special equipment not normally available at maintenance activities. Comparing the depth of a defect with the thickness of a thickness gage or with the thickness of a piece of lockwire is a reasonably accurate way of measuring depth (see figure 5-65).

f. If major rework is required for damage other than erosion, up to 10% of the airfoils in any stage may be reworked.

g. If major rework is required due to erosion, up to 100% of the airfoils in stages 11 through 14 may be reworked.

h. Any number of blades and vanes in any stage may be reworked to the minor rework limits given in figure 5-63.

i. Tip rubs may be repaired on any number of blades.

j. Apply fluorescent-penetrant oil and emulsifier with brush on IGV's to prevent plugging air passages.

3. Rework rotor blades, variable vanes, and vane segments using power tools as follows:

a. Separate repairable blades, variable vanes and vane segments by individual stages and identify rework areas per steps 2.f, 2.g, and 2.h.

CAUTION

To avoid damaging the airfoil, use masking tape on the airfoil next to the rework area.

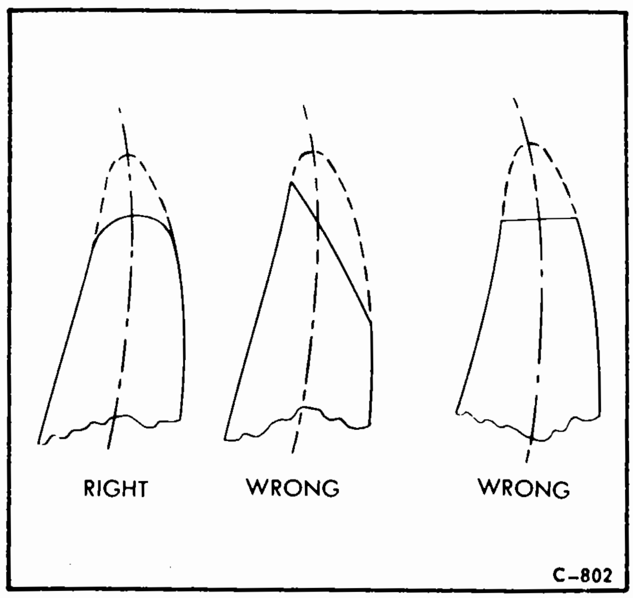


Figure 5-64. Airfoil Blending

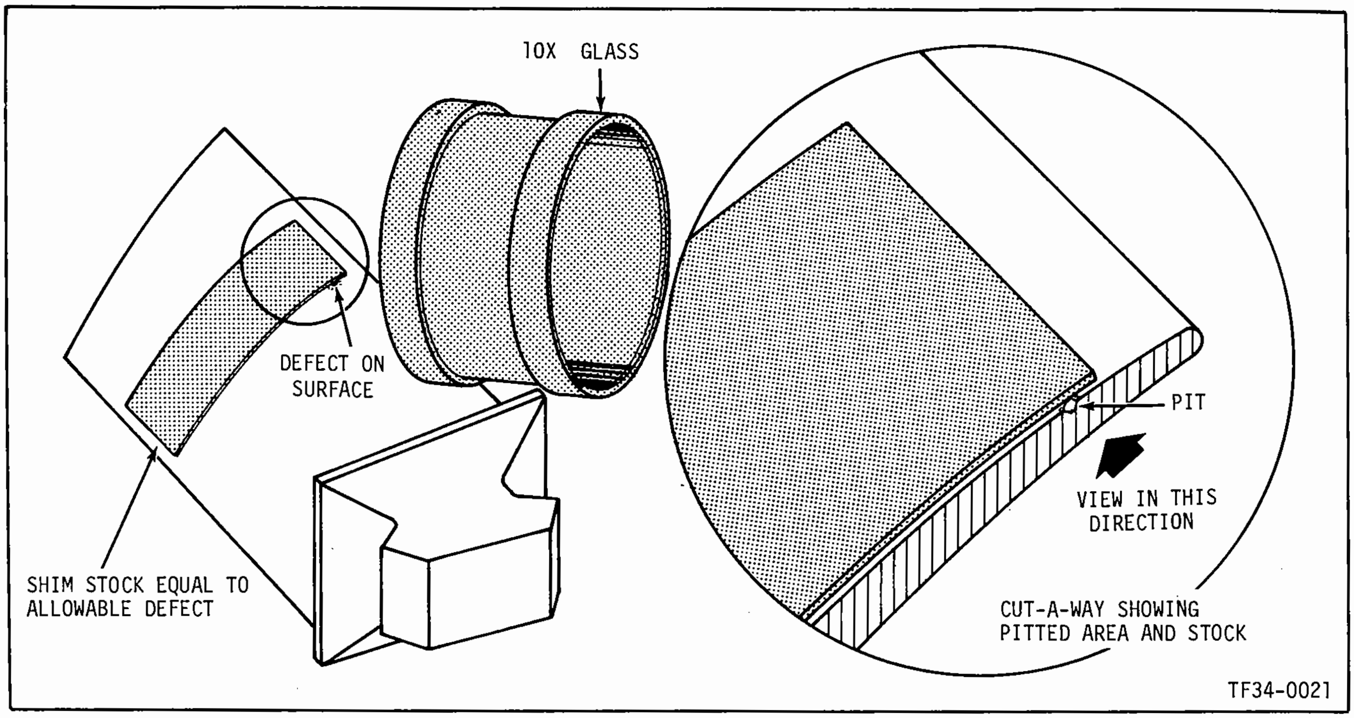


Figure 5-65. Measuring Compressor Blade Defects

b. Use coarse grade, silicon-carbide impregnated rubber wheels and points (Cratex Manufacturing Co., 1600 Rollins Road, Burlingame, California) for the initial blending of the blades and vanes.

NOTE

During finish-blending of the defects, make a radius on both the leading and trailing edges of the airfoil. To do this, apply light pressure with the rubberized abrasive wheel, and let the cushion action of the wheel do both the blending of the radius and the buffing of the defect.

c. Finish blending the defects, using the fine and extra-fine grade rubberized abrasive wheels. Remove only that material required to repair the defect.

d. Place the repaired blades and vanes in separate containers to prevent damage while they are being carried.

e. Carefully reinspect the blades and vanes per the applicable paragraph.

5-151. REPLACEMENT OF COMPRESSOR ROTOR BLADES. For special tools, refer to table 2-1, group 5.

CAUTION

Do not use hardware or tools containing cadmium or silver plate on titanium parts. Using hardware or tools of these materials can cause corrosion of the titanium at engine operating temperatures.

5-152. GENERAL.

Any number of damaged compressor rotor blades can be replaced. However, the method used to replace them depends on the number of damaged blades needing replacement. Use the information in table 5-11 for making this decision. Review this table each time blades have to be replaced.

Any time all the blades in a stage are replaced, be sure to take blade tip clearances during final engine assembly.

Any time blades are replaced, be sure to check engine vibration per paragraph 10-10.

TABLE 5-11. COMPRESSOR ROTOR BLADE REPLACEMENT LIMITS.

Stage	Number of Blades That Can be Replaced	Method of Replacement (Highlights)
1 2	1 - 4 1 - 4	Match pan weight of new blade to pan weight of damaged blade.
1 2	5 - 30 5 - 38	Remove all blades. Intermix new and usable blades. Map blades and install.
3	1 - 6	Match pan weight of new blade to pan weight of damaged blade.
3	7 - 44	Remove all blades and map position of balance weights. Intermix new and usable blades. Map and install blades. Weights must go in original position.
4-14	1 - All	Matching of blade weights is not required. Balance weight positions must be mapped and weights installed in original position. Randomly install blades without regard to blade weights.

5-153. REPLACEMENT OF STAGE 1 AND 2 COMPRESSOR ROTOR BLADES. For special tools, refer to table 2-1, group 5.

CAUTION

- Use table 5-11 to determine whether the blades have to be mapped or can be individually replaced by pan weighing.
- Do not release aft retaining rings on stages 1 and 2. Removal of forward ring on each stage will allow blade removal and installation.
- Do not use hardware or tools containing cadmium or silver plate on titanium parts. Using hardware or tools of these materials can cause corrosion of the titanium at engine operating temperature.

1. Install dummy casing bar (21C5132) between front frame and combustion chamber flanges.

2. Attach a dial indicator to the dummy casing bar.

3. Using a button tip on the indicator, center the indicator tip on a blade tip in the stage requiring blade replacement. Mark the blade as a starting reference.

4. Rotate compressor rotor slowly and watch indicator. Locate the longest blade and mark it. If longest blade has to be replaced, mark the next longest blade that is usable.

5. Stick masking tape (UU-T-106) on the forward side of all the blades in the stage being repaired. This keeps blades from falling out of slots when retaining ring is released. Release retaining ring (1 or 3, figure 5-66).

6. If only 1 to 4 blades are being replaced, proceed as follows: If more than 4 blades are being replaced, go to step 7.

NOTE

Remove only one damaged blade at a time.

a. Remove one damaged blade. If material is missing, replace blade as follows: Otherwise go to step b.

(1) Select a new blade, disregarding its weight.

(2) Install new blade in disk, using tape (UU-T-106) to hold it in place.

b. Place the damaged blade in front pan of scale (21C485).

c. Place new blade in back pan of scale.

d. If weight of new blade is within 0.2 gram of weight of damaged blade, proceed to step e. Otherwise, continue weighing new blades until one that is within 0.2 gram of the damaged blade is found.

e. Install the new blade in the disk. Use tape (UU-T-106) to hold it temporarily in position.

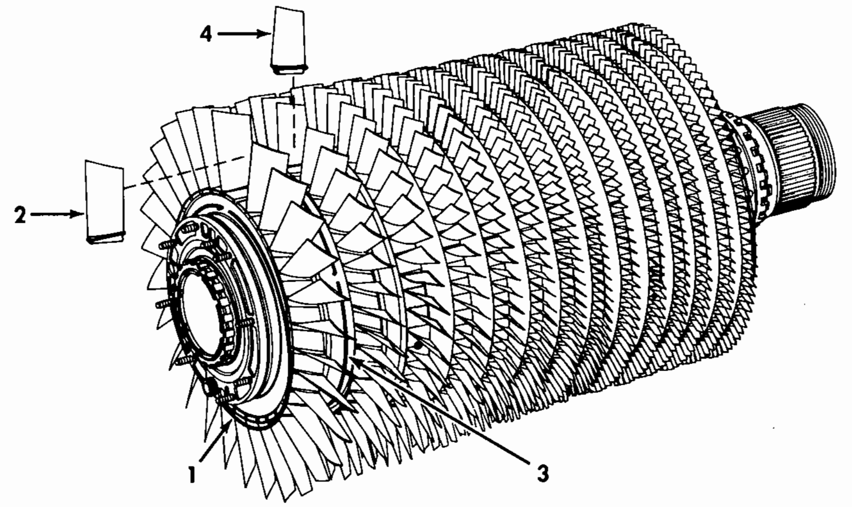


Figure 5-66. Replacing Stage 1 and 2 Compressor Blades

f. Replace the remaining damaged blades by following steps a through e.

g. Spring the retaining ring (1 or 3) into position on disk. Visually inspect ring to be sure it has seated. Ends of ring must not overlap.

h. Remove masking tape.

7. If more than 4 blades are being replaced, proceed as follows:

a. Remove all blades from stage being repaired. Discard all unusable blades.

b. Draw replacement blades from supply.

NOTE

All marking on blades must be done with grease pencil, Dykem or other suitable noncarbon marker.

c. Use scale (21C485) and weigh each blade (both new and usable) to the nearest 0.1 of a gram. Mark the weight on airfoil of each blade.

d. Lay the blades in a single line, starting with the heaviest at the left and ending with the lightest blade at the right.

e. Number the blades left to right, 1 through 30 for stage 1, or 1 through 38 for stage 2. See figure 5-67.

f. Form 2 rows of blades as shown in figure 5-68 for stage 1 or 5-69 for stage 2.

g. Starting with the left blade in the top row, install blades in the rotor as shown in figure 5-68 for stage 1 or in figure 5-69 for stage 2.

h. Spring the retaining ring (1 of 3, figure 5-66) into position on disk. Visually inspect ring to be sure it has seated. Ends of ring must not overlap.

8. Inspect all blades in stage to be sure leading edges are forward.

9. Attach a dial indicator to dummy casing bar.

10. Set indicator up on longest blade marked in step 4.

11. Take a reading on each new blade installed and compare it to the reading taken in step 10.

12. Blend all blades that are longer than the longest original blade, using instructions in paragraph 5-150.

13. After engine assembly, be sure to run a complete engine vibration check per paragraph 10-10.

5-154. LIMITED REPLACEMENT OF STAGE 3 COMPRESSOR ROTOR BLADES. For special tools, refer to table 2-1, group 5. This procedure must be used when replacing 6 or less blades.

CAUTION

Do not use hardware or tools containing cadmium or silver plate on titanium parts. Using hardware or tools of these materials can cause corrosion of the titanium at engine operating temperatures.

1. Install dummy casing bar (21C5132) between front frame and combustion chamber flanges.

2. Attach a dial indicator to the dummy casing bar.

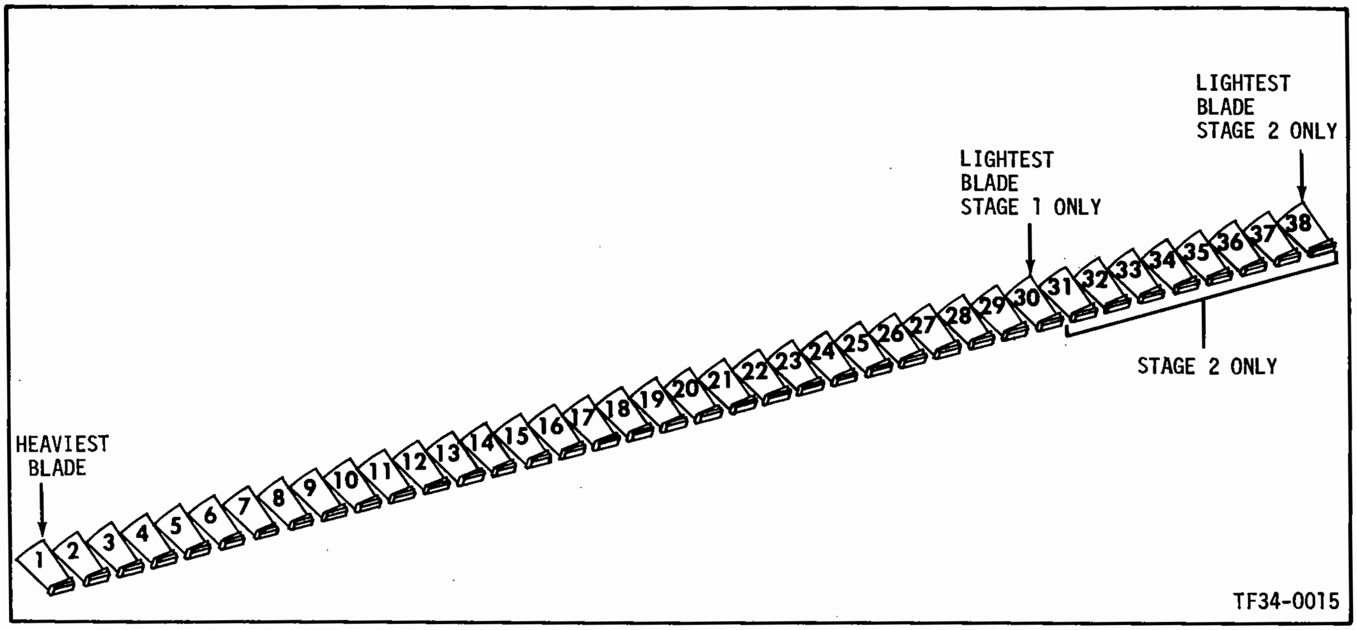


Figure 5-67. Weight Mapping - Stage 1 and 2 Compressor Blades

3. Using a button tip on the indicator, center the indicator tip on a blade tip. Mark the blade as a starting reference.

4. Rotate compressor rotor slowly and watch indicator. Locate the longest blade and mark it. If longest blade has to be replaced, mark the next longest blade that is usable.

5. Unlock locking lug assemblies (figure 5-70) as follows:

a. Turn the rotor until the locking lug assemblies are in the most accessible position. Access to locking lug assemblies is through the cutouts in the left- and right-hand locking blade platforms.

b. Put a small amount of engine oil or equivalent to both locking lug assemblies. Wait about 3 minutes and swab oil from screws.

c. Use grease pencil, Dykem, or other suitable noncarbon marker and number the blades in the counterclockwise direction, aft looking forward, numbering the first blade to the left (counterclockwise) of the locking blade as number 1. The 4 locking blades will be numbered 41, 42, 43, and 44.

NOTE

The tools used in the following procedure are all part of kit (21C5126). See figure 5-71.

d. Use screwdriver (4) with bit (9) and turn locking lug screw counterclockwise until locking lug tangs disengage from slots in rotor spool. If head on locking lug screw is damaged so that bit does not work, do the following:

(1) Modify a standard No. 1 Ezy-out screw extractor (or equivalent) by cutting off 11/16 inch (end should be 1/16 inch in diameter).

NOTE

Success in removing screw depends on following the removal procedure exactly.

(2) Tap the extractor firmly into hex socket of screw.

(3) Turn extractor slowly and evenly while pressing toward screw. Stop about every 1/4 turn and tap extractor to maintain grip in screw until locking lug assembly is loose.

e. Repeat step d to loosen other locking lug assembly.

6. Move all blades clockwise until locking blades and lugs can be removed. Discard locking lug assemblies.

CAUTION

Location of balancing slugs must be recorded. The slugs must go back in the same position to keep rotor in balance.

7. Remove only those blades needed to remove all damaged blades and lay them in order on a table.

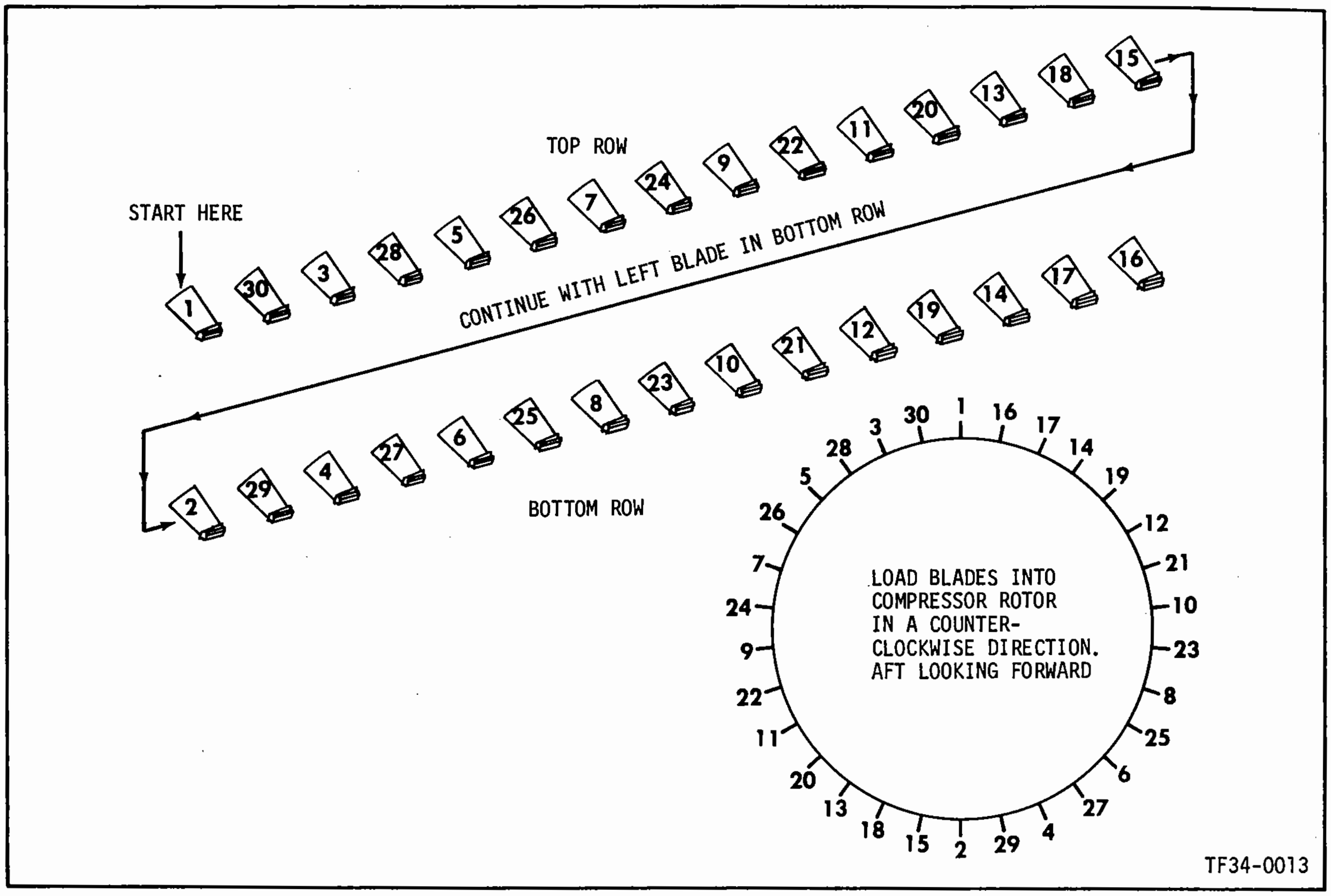


Figure 5-68. Installation Mapping - Stage 1 Compressor Blades

Record the location of balancing slugs, as they are removed, as shown on figure 5-72.

8. Each blade has a code marked on the dovetail. See table 5-12 for code explanation.

9. If material is missing, replace blades as follows: Otherwise, go to step 10.

TABLE 5-12. CODING OF COMPRESSOR ROTOR BLADES, STAGES 1 THROUGH 14.

NOTE

First 2 digits of code indicate stage number. Third digit indicates type of blade as follows:

THIRD DIGIT	TYPE OF BLADE
1	Regular
2	Spacer
3	Right-hand Locking
4	Left-hand Locking

Example: 092 marked on bottom of blade dovetail means it is a 9th stage spacer blade.

a. Select a blade that has the same code (marked on the bottom of dovetail) as the one on the blade being replaced, disregarding weight.

b. Use grease pencil, Dykem, or other suitable noncarbon marker and mark the blade position number on the new blade. Place the blade on the table in the proper position.

c. Repeat steps a and b for remaining damaged blades with missing material.

10. Replace damaged blades without missing material as follows:

a. Place the damaged blade in front pan of scale (21C485).

b. Place new blade, one with same code on dovetail as is marked on the damaged blade, in back pan of scale.

c. If weight of new blade is within 0.2 gram of weight of damaged blade, proceed to step d. Otherwise, continue weighing new blades (with same code) until one that is within 0.2 gram of the damaged blade is found.

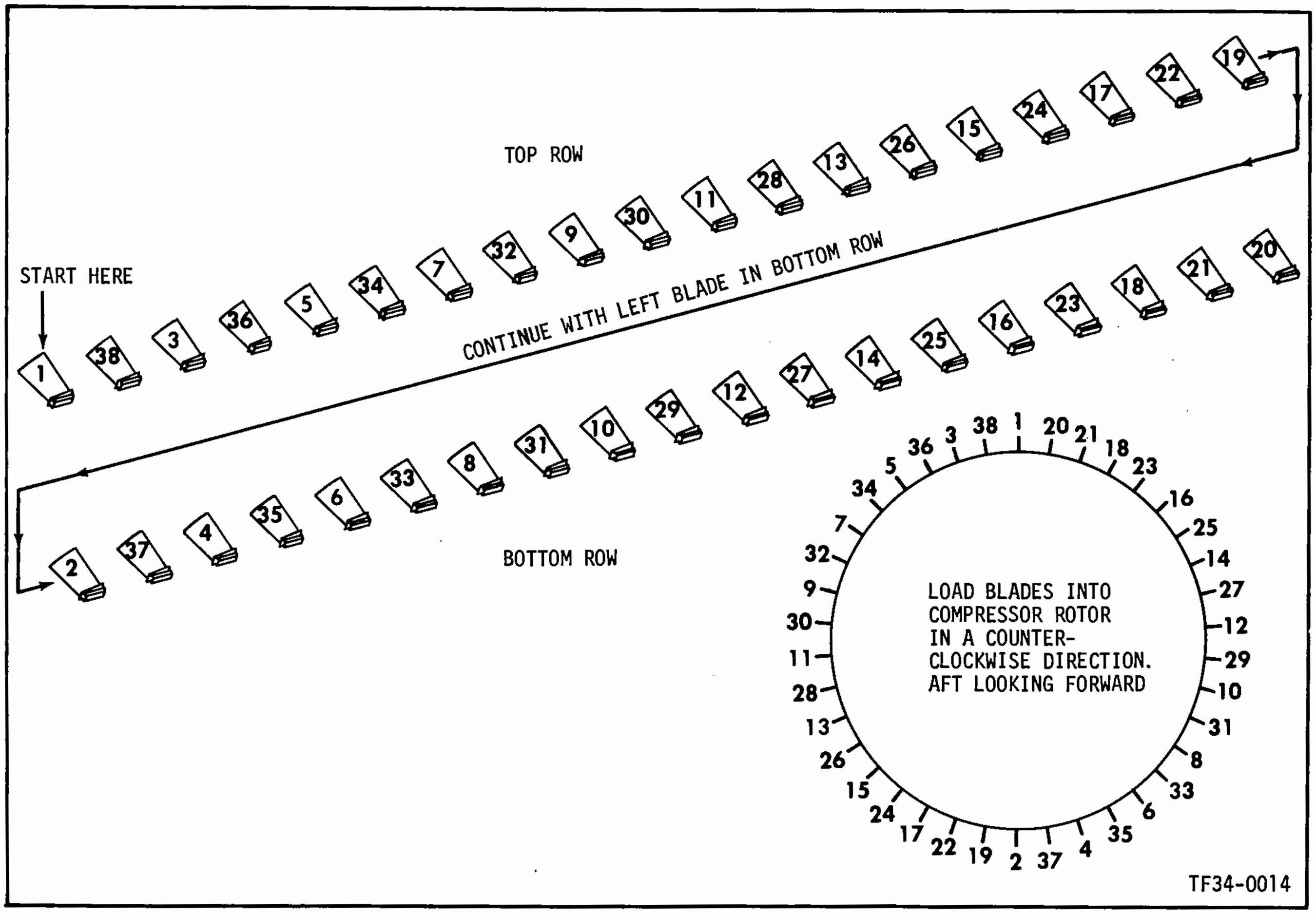


Figure 5-69. Installation Mapping - Stage 2 Compressor Blades

d. Use grease pencil, Dykem, or other suitable noncarbon marker and mark the blade position on the new blade. Place the blade on the table in the proper position.

e. Repeat steps a through d to replace remaining damaged blades without missing material, regular and spacer blades in original position.

11. Install blades (codes 031 and 032) in rotor. Be sure balancing slugs go into positions recorded in step 7.

12. Install a left-hand locking blade (code 034), a locking lug assembly, right-hand locking blade (code 033), another left-hand locking blade, a locking lug assembly and a right-hand locking blade. See figure 5-70. If the last locking blade will not fit, remove all locking blades and first regular blade. Remove same amount of material from each side of blade platform, up to 0.005 inch from each side, until the last locking blade can be installed.

13. Push all blades clockwise until the tangs on each locking lug assembly are aligned with tang slots in rotor spool.

NOTE

The tools used in the following procedure are part of kit (21C5126). See figure 5-71.

14. Use screwdriver (4) with bit (9) and turn locking lug screw clockwise until tangs on locking lug ride up into slots in rotor spool. In the same way, position other locking lug assembly.

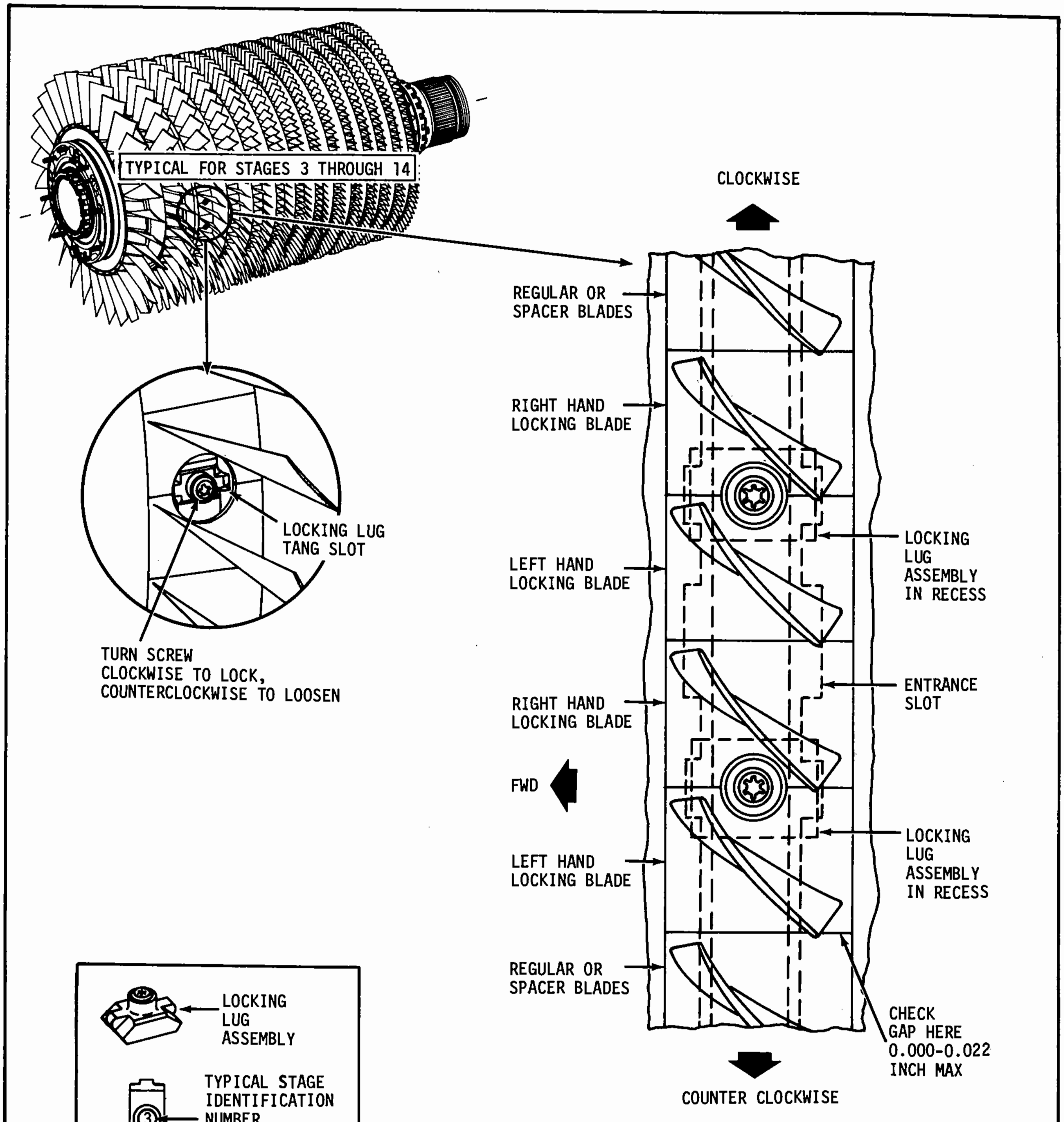
CAUTION

Be sure locking lug tangs are completely engaged in slots.

15. Use torque screwdriver (5), adapter (7), and bit (9) and tighten both locking lug screws to 19-21 lb inch. Visually inspect seating of locking lug assemblies. Both tangs on each lug must engage tang slots in rotor spool.

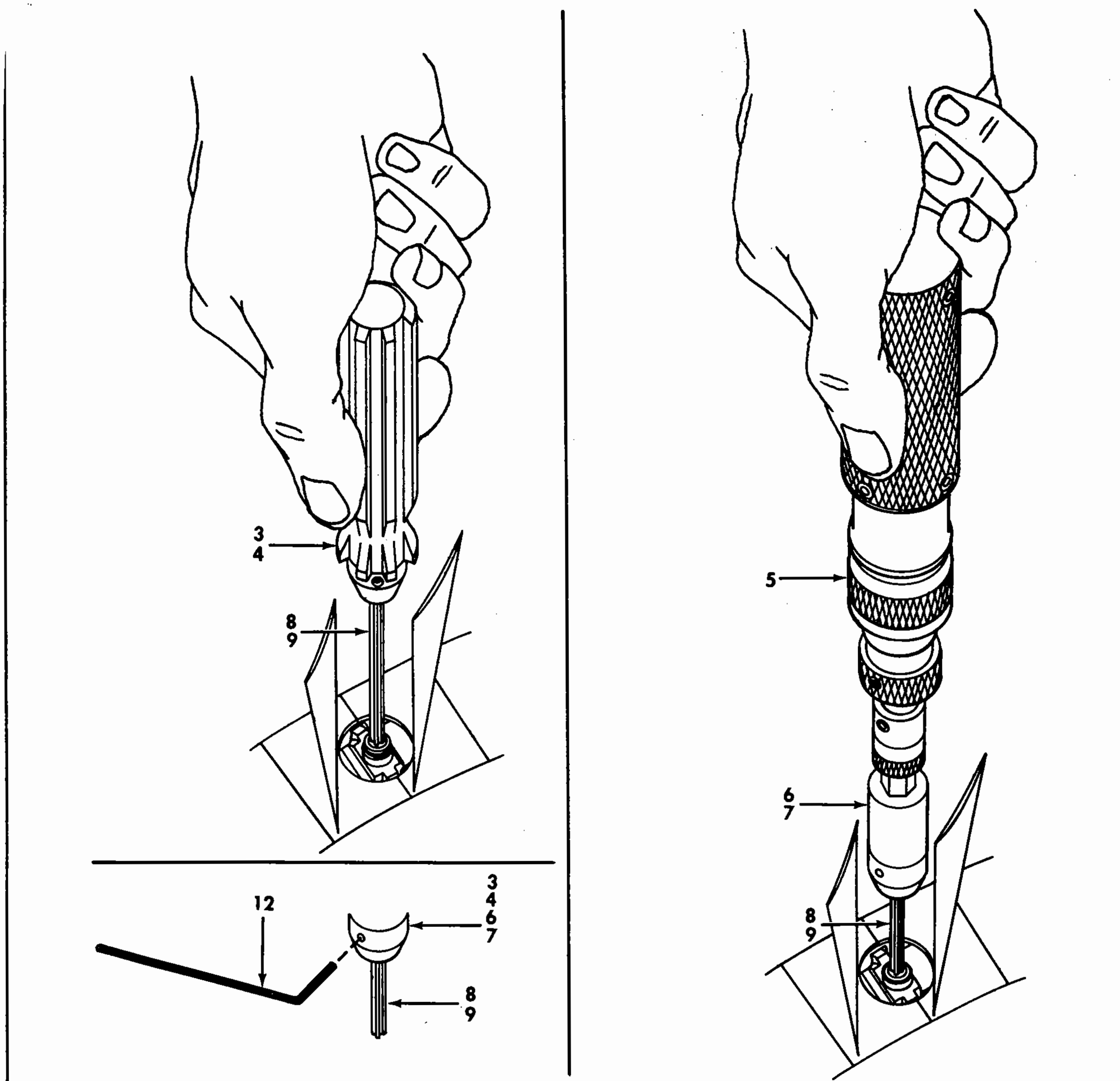
16. Measure blade looseness as follows:

a. Move all blades counterclockwise until the gap between blade No. 1 and blade No. 44 is as wide as possible.



STAGE	IDENTIFICATION NUMBER
3-4	3
5	5
6-7	6
8-14	8

Figure 5-70. Locking Lug - Removal and Installation



KIT 21C5126 ITEM NO.	NOMENCLATURE	WHERE USED (STAGES)	WHEN USED
4	Screwdriver DS-111	3 and 4	Disassembly and Assembly
3	Screwdriver DS-072	5 through 14	Disassembly and Assembly
5	Torque Screwdriver TS-30	3 through 14	Final Torquing
7	Adapter 21C5126P03	3 and 4	Used with kit Item No. 5
6	Adapter 21C5126P02	5 through 14	Used with kit Item No. 5
9	Bit B-111-3	3 and 4	Used with kit Item Nos. 4 and 7
8	Bit B-072-3	5 through 14	Used with kit Item Nos. 3 and 6
12	Key S-072	————	Replacement of Bits (kit Item Nos. 9 and 8)

TF34-0010

Figure 5-71. Kit, Locking Lug - 21C5126

ENGINE S/N XXXXXX COMPRESSOR ROTOR STAGE NO. 6

SAMPLE

BALANCE WEIGHT NO.	BETWEEN	BLADE NO.	AND	BLADE NO.
1		7		8
2		8		9
3		14		15
4		17		18
5		18		19
6		19		20
7		20		21
8		28		29
9				

NOTE

IT IS SUGGESTED THAT THE LOWER HALF OF THIS FORM BE REPRODUCED FOR USE DURING ACTUAL BALANCE WEIGHT MAPPING.

ENGINE S/N ________ COMPRESSOR ROTOR STAGE NO. ________

BALANCE WEIGHT NO.	BETWEEN	BLADE NO.	AND	BLADE NO.
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

TF34-0022

Figure 5-72. Sample Balance Weight Map

b. Use feeler gage and check gap in location shown in figure 5-70. Gap shall not exceed 0.024 inch or be less than 0.002 inch.

c. If gap is more than 0.024 inch, replace regular blades with spacer blades (spacer blade platforms are 0.020 inch wider than regular blade platforms). Be sure spacer blades are separated by at least 2 regular blades.

d. If gap is less than 0.002 inch, replace spacer blades with regular blades or remove material as described in step 12.

e. Be sure proper number of blades are installed per table 5-13.

17. Attach a dial indicator to dummy casing bar.

18. Set indicator up on longest blade marked in step 4.

19. Take a reading on each new blade installed and compare it to the reading taken in step 18.

20. Blend all blades that are longer than the longest original blade, using instructions in paragraph 5-150.

21. After engine assembly, be sure to run a complete engine vibration check per paragraph 10-10.

5-155. UNLIMITED REPLACEMENT OF STAGE 3 COMPRESSOR ROTOR BLADES. For special tools, refer to table 2-1, group 5. This procedure must be used when replacing more than 6 blades.

CAUTION

Do not use hardware or tools containing cadmium or silver plate on titanium parts. Using hardware or tools of these materials can cause corrosion of the titanium at engine operating temperatures.

1. Install dummy casing bar (21C5132) between front frame and combustion chamber flanges.

2. Attach a dial indicator to the dummy casing bar.

3. Using a button on the indicator, center the indicator tip on a blade tip. Mark the blade as a starting reference.

4. Rotate compressor rotor slowly and watch indicator. Locate the longest blade and mark it. If longest blade has to be replaced, mark the next longest blade that is usable.

5. Unlock locking lug assemblies (figure 5-70) as follows:

a. Turn the rotor until the locking lug assemblies are in the most accessible position. Access to locking lug assemblies is through the cutouts in the left- and right-hand locking blade platforms.

b. Put a small amount of engine oil or equivalent on both locking lug assemblies. Wait about 3 minutes and swab oil from screws.

c. Use grease pencil, Dykem, or other suitable noncarbon marker and number the blades in the counterclockwise direction, aft looking forward, numbering the first blade to the left (counterclockwise) of the locking blades as number one. The 4 locking blades will be numbered 41, 42, 43, and 44.

NOTE

The tools used in the following procedure are all part of kit (21C5126). See figure 5-71.

TABLE 5-13. COMPRESSOR ROTOR BLADE QUANTITIES.

Stage No.	Regular Blades Plus Spacer Blades	Locking Blades RH	Locking Blades LH	Total Blades per Stage
1	*30	-	-	30
2	*38	-	-	38
3	40	2	2	44
4	50	2	2	54
5	60	2	2	64
6	72	2	2	76
7	82	2	2	86
8	94	2	2	98
9	84	2	2	88
10	90	2	2	94
11	84	2	2	88
12	97	2	2	101
13	97	2	2	101
14	97	2	2	101

*Stages 1 and 2 have regular blades only.

d. Use screwdriver (4) with bit (9) and turn locking lug screw counterclockwise until locking lug tangs disengage from slots in rotor spool. If head on locking lug screw is damaged so that bit does not work, do the following:

(1) Modify a standard No. 1 Ezy-out screw extractor (or equivalent) by cutting off 11/16 inch (end should be 1/16 inch in diameter).

NOTE

Success in removing screw depends on following the removal procedure exactly.

(2) Tap the extractor firmly into hex socket of screw.

(3) Turn extractor slowly and evenly while pressing toward screw. Stop about every 1/4 turn and tap extractor to maintain grip in screw until locking lug assembly is loose.

e. Repeat step d to loosen other locking lug assembly.

6. Move all blades clockwise until blade No. 1 (marked in step c) can be removed. Discard locking lug assemblies.

CAUTION

Location of balancing slugs must be recorded. The slugs must go back in the same position to keep rotor in balance.

7. Remove all stage 3 blades, one at a time. Record the location of balancing slugs, as they are removed, as shown in figure 5-72.

8. Segregate all the blades into two piles - usable and scrap.

9. Count the number of scrapped regular blades (code 031 on the dovetail) and the number of scrapped spacer blades (code 032 on the dovetail). Draw the required number of each type of blade from supply.

NOTE

All marking on blades must be done with grease pencil, Dykem, or other suitable noncarbon marker.

10. Use scale (21C485) and weigh each regular blade and each spacer blade (both new and old) to the nearest 0.1 of a gram. Mark the weight on airfoil of each blade.

11. Lay the regular blades and spacer blades in a single line starting with the heaviest at the left and ending with the lightest blade at the right. If necessary, swap spacer blades and regular blades of close weights so that there are at least 2 regular blades between each spacer blade.

12. Number the blades as shown in the center of figure 5-73. It is extremely important to number the blades exactly as shown.

13. Form 2 rows of blades - 1 through 20 as the top row, 21 through 40 as the bottom row as shown.

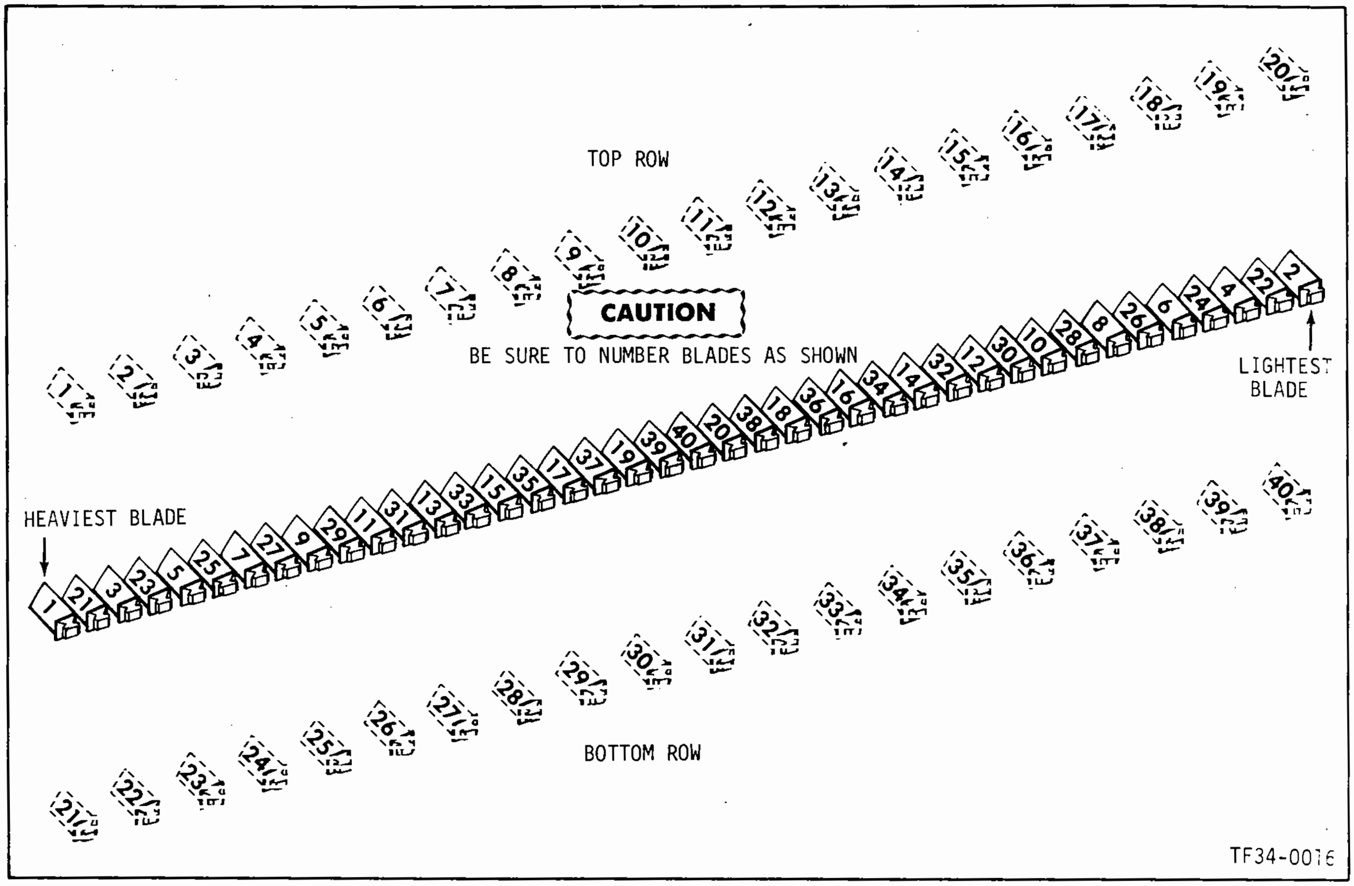


Figure 5-73. Weight Mapping - Stage 3 Compressor Blades

14. Using the balancing slug map made in step 7, place the balancing slugs between the proper blades.

15. Install regular and spacer blades (codes 031 and 032) in rotor as shown in figure 5-74. Be sure balancing slugs go into positions recorded in step 7.

16. Install a left-hand locking blade (code 034), a locking lug assembly, right-hand locking blade (code 033), another left-hand locking blade, a locking lug assembly, and a right-hand locking blade. See figure 5-70. If the last locking blade will not fit, remove all locking blades and first regular blade. Remove same amount of material from each side of blade platform, up to 0.005 inch from each side until the last locking blade can be installed.

17. Push all blades clockwise until the tangs on each locking lug assembly are aligned with tang slots in rotor spool.

NOTE

The tools used in the following procedure are part of kit (21C5126). See figure 5-71.

18. Use screwdriver (4) with bit (9) and turn locking lug screw clockwise until tangs on locking lug ride up into slots in rotor spool. In the same way, position for other locking lug assembly.

CAUTION

Be sure locking lug tangs are completely engaged in slots.

19. Use torque screwdriver (5), adapter (7), and bit (9) and tighten both locking lug screws to 19-21 lb inch. Visually inspect seating of locking lug assemblies. Both tangs on each lug must engage tang slots in rotor spool.

20. Measure blade looseness as follows:

a. Move all blades counterclockwise until the gap between blade No. 1 and blade No. 44 is as wide as possible.

b. Use thickness gage and check gap in location shown in figure 5-70. Gap must not exceed 0.024 inch or be less than 0.002 inch.

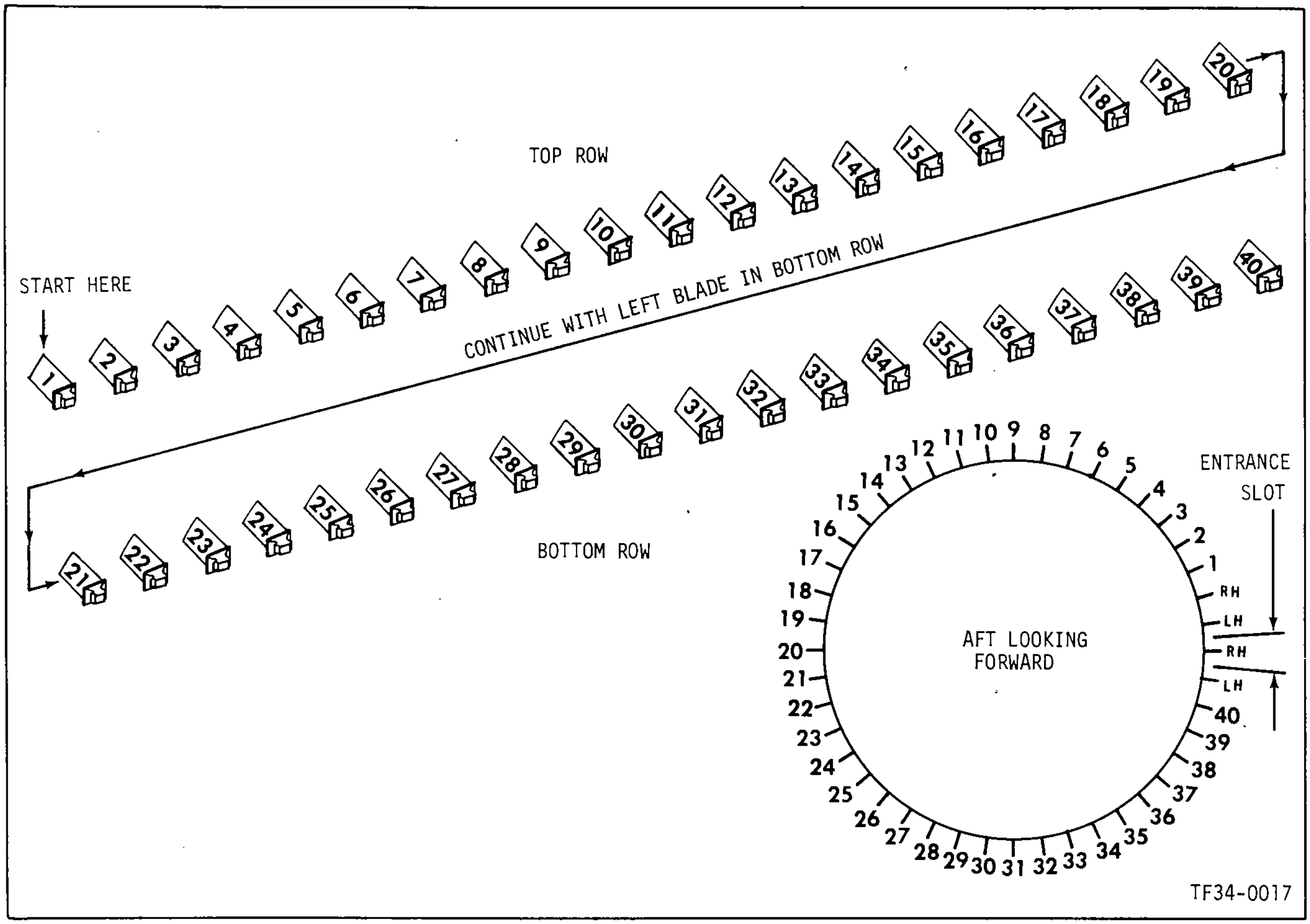


Figure 5-74. Installation Mapping - Stage 3 Compressor Blades

c. If gap is more than 0.024 inch, replace regular blades with spacer blades.

d. If gap is less than 0.002 inch, replace spacer blades with regular blades or remove material as described in step 16.

e. Be sure proper number of blades are installed per table 5-13 (spacer blade platforms are 0.020 inch wider than regular blade platforms). Be sure spacer blades are separated by at least 2 regular blades.

21. Attach a dial indicator to dummy casing bar.

22. Set indicator up on longest blade marked in step 4.

23. Take a reading on each new blade installed, and compare it with the reading taken in step 22.

24. Blend all blades that are longer than the longest original blade, using instructions in paragraph 5-150.

25. After engine is assembled, be sure to run a a complete engine vibration check per paragraph 10-10.

5-156. UNLIMITED REPLACEMENT OF STAGES 4 THROUGH 14 COMPRESSOR ROTOR BLADES. For special tools, refer to table 2-1, group 5. This procedure shall be used for replacing any number of blades in stages 4 through 14.

CAUTION

Do not use hardware or tools containing cadmium or silver plate on titanium parts. Using hardware or tools of these materials can cause corrosion of the titanium at engine operating temperatures.

1. Install dummy casing bar (21C5132) between front frame and combustion chamber flanges.

2. Attach a dial indicator to the dummy casing bar.

3. Using a button tip on the indicator, center the indicator tip on a blade tip in the stage requiring

blade replacement. Mark the blade as a starting reference.

4. Rotate compressor rotor slowly and watch indicator. Locate the longest blade and mark it. If longest blade has to be replaced, mark the next longest blade that is usable.

5. Unlock locking lug assemblies (figure 5-70) as follows:

a. Turn the rotor until the locking lug assemblies are in the most accessible position. Access to locking lug assemblies is through the cutouts in the left- and right-hand locking blade platforms.

b. Put a small amount of engine oil or equivalent on both locking lug assemblies. Wait about 3 minutes and swab oil from screws.

c. Use grease pencil, Dykem or other suitable noncarbon marker and number the blades in the counterclockwise direction, numbering the first blade to the left (counterclockwise, aft looking forward) of the locking blade as number one.

NOTE

The tools used in the following procedure are all part of kit (21C5126). See figure 5-71 to determine which combination of tools in kit must be used on stage being repaired.

d. Use screwdriver (3 or 4) with bit (8 or 9) and turn locking lug screw counterclockwise until locking lug tangs disengage from slots in rotor spool. If head on locking lug screw is damaged so that bit does not work, do the following:

(1) Modify a standard No. 1 Ezy-out screw extractor (or equivalent) by cutting off 11/16 inch for screws in stages 4 and 5 (end should be 1/16 inch in diameter) or by cutting off 1/16 inch for screws in stages 6 through 14 (end should be 3/64 inch in diameter).

NOTE

Success in removing screw depends on following the removal procedure exactly.

(2) Tap the extractor firmly into hex socket of screw.

(3) Turn extractor slowly and evenly while pressing toward screw. Stop about every 1/4 turn and tap extractor to maintain grip in screw until locking lug assembly is loose.

e. Repeat step d to loosen other locking lug assembly.

6. Move all blades clockwise until blade No. 1 (marked in step c) can be removed. Discard locking lug assemblies.

CAUTION

Location of balancing slugs must be recorded. The slugs must go back in the same position to keep rotor in balance.

7. Remove all blades from stage being repaired, one at a time. Record the location of balancing slugs, as they are removed, as shown in figure 5-72.

8. Segregate all the blades into two piles - usable and scrap.

9. Each blade has a code marked on the dovetail. See table 5-12 for explanation.

10. Count the number of scrap regular blades and the number of scrap spacer blades. Draw the required number of each type of blade from supply.

11. Lay all the new and usable blades in one line so that spacer blades are separated by at least 2 regular blades.

12. Number all the blades in the stage being repaired, starting with the left blade.

13. Using the balancing slug map made in step 7, place the balancing slugs on the table between the proper blades.

14. Install regular blades and spacer blades in rotor as shown in figure 5-75. Be sure balancing slugs go into original positions recorded in step 7.

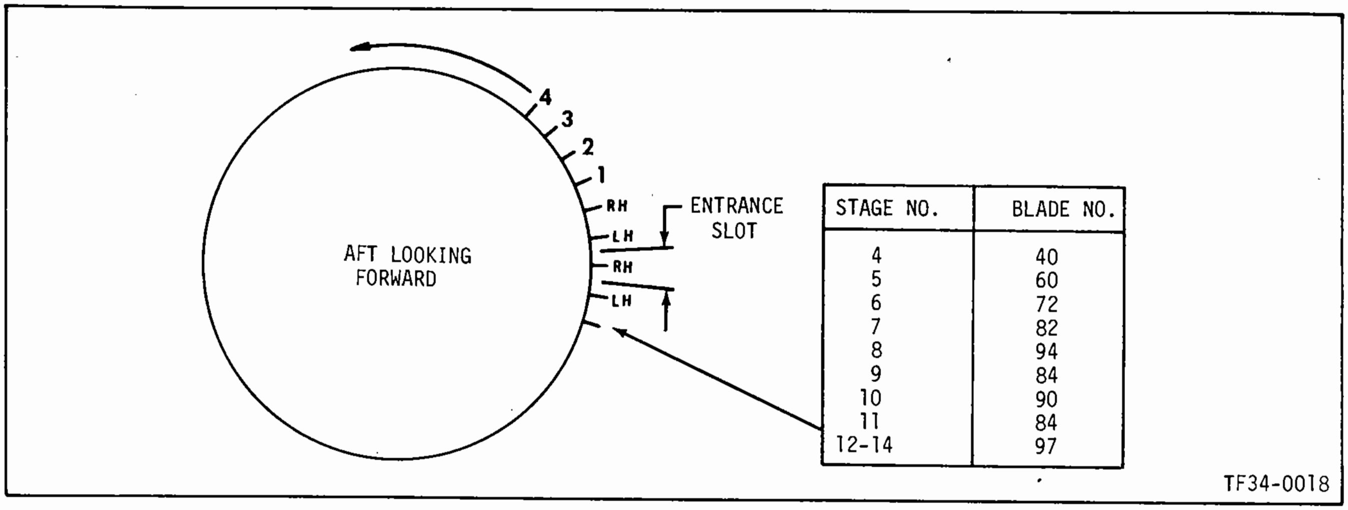
15. Install a left-hand locking blade (code 034), a locking lug assembly, right-hand locking blade (code 033), another left-hand locking blade, a locking lug assembly, and a right-hand locking blade. See figure 5-70. If the last locking blade will not fit, remove all locking blades and first regular blade. Remove same amount of material from each side of blade platform, up to 0.005 inch from each side, until the last locking blade can be installed.

16. Push all blades clockwise until the tangs on each locking lug assembly are aligned with tang slots in rotor spool.

NOTE

The tools used in the following procedure are part of kit (21C5126). See figure 5-71.

17. Use screwdriver (4) for stage 4 with bit (9). Use screwdriver (3) for stages 5 through 14 with bit (8). Turn locking lug screw clockwise until tangs on



STAGE NO.	BLADE NO.
4	40
5	60
6	72
7	82
8	94
9	84
10	90
11	84
12-14	97

Figure 5-75. Installation of Compressor Blades, Stage 4 through 14

locking lug ride up into slots in rotor spool. In the same way, position other locking lug.

18. Use torque screwdriver (5) with adapter (7) and bit (9) for stage 4, or adapter (6) with bit (8) for stages 5 through 14, and torque both locking lug screws as follows:

a. Stage 4: 19-21 lb inch.

b. Stages 5 through 14: 6-7 lb inch.

19. Visually inspect seating of locking lug assemblies. Both tangs on each lug must engage with tang slots in rotor spool.

20. Measure blade looseness as follows:

a. Move all blades counterclockwise until the gap between blade No. 1 and locking blade is as wide as possible.

b. Use thickness gage and check gap in location shown in figure 5-70. Gap must not exceed 0.024 inch or be less than 0.002 inch.

c. If gap is more than 0.024 inch, replace regular blades with spacer blades.

d. If gap is less than 0.002 inch, replace spacer blades with regular blades or remove material as described in step 15.

e. Be sure proper number of blades are installed per table 5-13 (spacer blade platforms are 0.020 inch wider than regular blade platforms). Be sure spacer blades are separated by at least 2 regular blades.

21. Attach a dial indicator to dummy casing bar.

22. Set indicator up on longest blade marked in step 4.

23. Take a reading on each new blade installed and compare the reading taken in step 22.

24. Blend all blades that are longer than the longest original blade, using instructions in paragraph 5-150.

25. After engine assembly, be sure to run a complete engine vibration check per paragraph 10-10.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. The outer and inner strut supports for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.005 inch deep.	Any number 0.015 inch deep, if there is no evi dence of previous blending in the area.	Blend sharp edges of defect into adjacent contour.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	NOTE When blending defects on the frame, use mounted aluminum oxide, rubber bonded wheels or points. Remove material locally around defect until sharp corners of the defect have been rounded out, but do not completely remove evidence of the defect.		
2. The outer and inner duct for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.005 inch deep.	Any number 0.015 inch deep, if there is no evidence of previous blending in the area.	Blend sharp edges of defect into adjacent contour.
c. Burn-through or bulges due to overtemperature.	None allowed.	Not repairable.	Replace frame.
3. The struts for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks or scratches.	Any number, 0.005 inch deep, with no high metal.	Any number, 0.010 inch deep, with high metal.	Blend sharp edges of defect into adjacent contour.
c. Dents.	None allowed.	Not repairable.	Replace frame.
4. The forward and aft inner and outer flanges for:			
a. Cracks extending from boltholes.	One per hole extending radially toward the OD of the outer flanges and toward the ID of the inner flanges, provided each cracked hole is separated by three uncracked holes and no more than 15% of the holes in any one flange are cracked.	Not repairable.	Replace frame.
b. Cracks in parent metal.	None allowed.	Not repairable.	Replace frame.
c. Nicks, scratches, and gouges.	Any number, 0.020 inch deep with no high metal. Defects on flange mating surfaces must not extend across more than 3/4 of the surface width.	Any number, 0.020 inch deep which can be reworked to usable limits.	Blend high metal to adjacent contour.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
5. The gang channel nut assemblies on the aft inner flange for stripped threads or loss of locking action.	Not allowed.	Any amount.	Remove gang channel assembly (see paragraph 5-163). Install new gang channel assembly with new screw (PN R1472P04).
6. The EGV guide ring for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.015 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Dents or visual distortion.	None allowed.	Not repairable.	Replace frame.
7. The fuel tube bosses for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Damaged or stripped threads.	Total cumulative length of one thread damaged or stripped per boss with no high metal provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads with a 0.750-16 UNJF-3B bottoming tap. Blow out all chips.
8. The strut pads at the 1,3,5,7, and 9 o'clock positions, and the scavenge tube housings at the 5 and 7 o'clock positions, for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.015 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Damaged or stripped pad threads.	Total cumulative length of 1/2 thread damaged or stripped per hole, with no high metal, provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads with a 0.250-28 UNJF-3B tap. Blow out all chips.
9. The bleed pads for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Nicks and scratches.	Any number, 0.020 inch deep with no high metal. Defects on flange mating surface must not extend across more than 3/4 of the surface width.	Any number, 0.020 inch deep which can be reworked to usable limits.	Blend high metal to adjacent contour.
10. The igniter and fuel primer bosses for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.020 inch deep, with no high metal. Defects on mating surfaces must not extend across more than 3/4 of the surface width.	Any number, 0.020 inch deep.	Blend high metal to adjacent contour.
c. Damaged or stripped threads in the flange of the bosses.	Total cumulative length of one full thread damaged or stripped per hole, with no high metal, provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads using a 0.190-32 UNJF-3B tap. Blow out all chips.
d. Damaged or stripped threads in the bosses.	Total cumulative length of 1/2 thread damaged or stripped per boss, with no high metal, provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads, using a 0.875-14 UNJF-3B bottoming tap. Blow out all chips.
11. The instrumentation bosses for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.020 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Damaged or stripped threads.	Total cumulative length of one thread damaged or stripped per boss, with no high metal, provided thread can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads using a 0.4375-20 UNJF-3B tap. Blow out all chips.
12. The fuel distributor assembly support bosses for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME. (CONT.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
c. Damaged or stripped threads.	Total cumulative length of five threads damaged or stripped, with no high metal, provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Chase threads with a 1/4-28 UNJF-3B tap. Blow out all chips.
13. The oil tank bracket mounting lugs for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
14. The engine mount bracket for:			
a. Cracks.	None allowed.	Not repairable.	Replace frame.
b. Nicks and scratches.	None allowed.	Any number, 0.020 inch deep.	Blend out defect to adjacent contour.
15. The strut service tubes (in the 3, 5 and 7 o'clock position struts) for:			
a. Damage to the end fitting. (See item 18.)			
b. Nicks and scratches on remaining surfaces.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
16. The scavenge connectors (located on the 5 and 7 o'clock position strut service tubes) for:			
a. Damage to the end fitting (see item 18).			
b. Cracks.	None allowed.	Not repairable.	Replace frame.
c. Nicks and scratches except on the end fitting.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
17. The oil tube (located on the 7 o'clock position strut service tube) for:			
a. Damage to the end fitting (see item 18).			
b. Cracks.	None allowed.	Not repairable.	Replace frame.

5-157. INSPECTION OF COMBUSTION CHAMBER FRAME. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
c. Nicks and scratches in packing grooves.	None allowed.	Not repairable.	Replace frame.
d. Nicks and scratches on remaining surfaces.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
18. The fittings for:			
a. Damaged or stripped threads.	Total cumulative length of one thread damaged or stripped, with no high metal, provided threads can be used in the normal manner.	Any amount that can be reworked to usable limits.	Blend high metal down to permit normal assembly.
b. The spherical seating surface for nicks, scratches, or dents.	None allowed. Burnishing is allowed if it has no measurable depth.	Not repairable.	Replace frame.
c. The remaining surfaces for nicks, scratches, or gouges.	Any number, 0.020 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.

5-158. INSPECTION OF COMBUSTION LINER. Inspect for cracks under bright white light using an 8 power glass.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. The inner and outer shells for:			
a. Cracks in shell bands:			
(1) Which run circumferentially around the shell.	Total length of a crack, including burn holes, not to exceed 3 inches provided ends in parent metal have been stop drilled and cumulative length of circumferential cracks in a band does not exceed 10 inches, or cracks have been welded.	a. Same as usable limit before stop-drilling. b. Any amount provided cooling air holes are not welded shut.	a. Stop-drill ends of cracks using a 3/64 inch diameter drill or: b. Repair-weld cracks (see table 5-6, item 7).
(2) Other than circumferential.	Any number, 1/16 inch long; 30 per shell band, 1/4 inch long; 10 per shell band, 1/2 inch long provided ends in parent metal have been stop drilled and no piece of	a. Same as usable limit before stop-drilling. b. Any amount provided cooling air holes are not welded shut.	a. Stop-drill ends of cracks using a 3/64 inch diameter drill or: b. Repair-weld cracks (see table 5-6, item 7).

5-158. INSPECTION OF COMBUSTION LINER. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	metal is in danger of falling out under any condition, or cracks have been welded.		
b. Cracks in fusion welds.	Any number, 1/32 inch long, no closer together than 1/2 inch.	Any amount that is accessible to a welding torch.	Repair-weld (see table 5-6, item 7).
c. Distortion of the cooling lips (annular slots aft of each band of aspirator holes on hot side of shell).	Distortion towards center of liner no more than 1/16 inch from adjacent undistorted contour. Gap between lip and shell to be no less than 1/16 inch.	Any amount that can be reworked to usable limits.	Cold-work lip contour until it visually matches adjacent undistorted contour. Inspect for cracks.

NOTE

The hot sides of the liner are the ID of the outer shell and the OD of the inner shell.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Dents, buckles or warps.	Contour of defective area distorted no more than 1/16 inch above or below adjacent undistorted section.	Any amount provided distortion is away from hot side of shell.	Cold-work to contour of adjacent undistorted section. Inspect for cracks; none allowed.
e. Burn holes in shell bands.	10 per shell band, provided hole diameter does not exceed 1/4 inch and cracks extending from the defect have been repair welded.	Not repairable.	Replace liner.
f. Nicks, scratches and gouges.	Any number 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.

NOTE

Cooling hole sizes range from 0.037 inch to 0.063 inch.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
g. Plugged or distorted cooling holes.	None allowed.	Any amount.	Hole size in each band is different. Determine size by trying various sizes of hand-held drill bits. Run proper size drill bit through defective hole. Be sure not to drill into shell section behind hole.
h. Cracks in cooling lips.	Any number of cracks extending full width of cooling lip, provided no piece is in danger of falling out and distortion is within limits.	Not repairable.	Replace liner.

5-158. INSPECTION OF COMBUSTION LINER. (CONT.)

Insert	Usable Limits	Max Repairable Limits	Corrective Action
i. Burnout of cooling lips. (Hot side is ID of outer shell and OD of inner shell.)	Ten per lip provided length of each side of defect does not exceed 3/16 inch, and there is no high metal along the edges of the defect which extends into the gas flow on the hot sides of the liner.	10 per lip provided maximum width of defect does not exceed 1/8 inch.	Blend and cold work defective area as necessary to eliminate high metal and sharp edges.
2. The outer ring for:			
a. Nicks, scratches and gouges.	Any number 0.020 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
b. Distortion (out of round).	No visual distortion allowed.	Any amount that can be reworked to usable limits.	Round out ring by applying force as necessary to obtain usable limit.
3. The outer seal and outer band for:			
a. Cracks in parent metal.	Any number, 1/4 inch long; 6 per item 3/8 inch long.	Any amount.	Repair-weld (see table 5-6, item 8).
b. Cracks in fusion welds.	Any number, 1/32 inch long, no closer together than 1/2 inch.	Any amount.	Repair-weld (see table 5-6, item 7).
c. Dents, buckles or warps.	No visual distortion of annular slot formed by band and seal.	Any amount.	Cold-work defective part to usable limit. Inspect for cracks; none allowed.
d. Areas of surface erosion due to overtemperature.	Any number provided thickness of defective area is not less than 1/2 the thickness of the adjacent non-defective area.	Any amount.	Patch repair (see paragraph 5-160).
e. Burnout of trailing edge.	Any amount provided defect does not extend forward more than 3/8 inch.	Any amount.	Patch repair (see paragraph 5-160).
4. The outer band for worn spacer pads.	Thickness of pad plus band shall be no less than 0.038 inch.	Not repairable.	Replace liner.
5. The inner flange for:			
a. Cracks in parent metal.	None allowed.	Any amount.	Repair-weld (see table 5-6, item 8).
b. Cracks in fusion welds.	Any number, 1/32 inch long, no closer together than 1/2 inch.	Any amount.	Repair-weld (see table 5-6, item 8).
c. Nicks, scratches or gouges.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.

5-158. INSPECTION OF COMBUSTION LINER. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Stripped threads or loss of locking action in gang channel assemblies.	None allowed.	Any amount.	Remove gang channel assembly (see paragraph 5-163). Secure new gang channel with new rivets (PN AN123636).
6. The dome for:			
a. Cracks.	None allowed.	Not repairable.	Replace liner.
b. Dents, buckles, or warps.	Contour of defective area no more than 1/16 inch above or below undistorted contour.	Not repairable.	Replace liner.
c. Nicks, scratches, or gouges.	Any number, 0.020 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
d. Plugged cooling holes.	None allowed.	Any amount.	Push foreign material out of hole using piece of wire. Steam clean (see paragraph 5-43).
7. The scroll assembly:			
a. Housings for:			
(1) Cracks.	None allowed.	Any amount provided defect is accessible and can be gas backed.	Repair-weld (see table 5-6, item 8).
(2) Nicks, scratches or gouges.	Any number, 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
(3) Dents.	No visual distortion allowed.	Not repairable.	Replace liner.
(4) Braze cracks.	None allowed.	Not repairable.	Replace liner.
b. Vanes for:	NOTE Inspect vanes using a flashlight and dental mirror, or a borescope.		
(1) Cracks.	None allowed.	Not repairable.	Replace liner.
(2) Burnout.	None allowed.	Not repairable.	Replace liner.
c. Covers and hubs for:			
(1) Cracks.	None allowed.	Not repairable.	Replace liner.
(2) Carbon buildup including plugged holes.	1/32 inch deep, provided holes are not plugged.	Any amount.	Steam clean (see paragraph 5-43).

5-158. INSPECTION OF COMBUSTION LINER. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
8. The baffles for:			
a. Cracks.	Any number, 1/16 inch long, four per baffle, 3/16 inch long.	Not repairable.	Replace liner.
b. Burnout.	Allowed at corners and along edges, provided cooling holes in dome are not exposed and burned edges are smooth.	Any amount that can be blended to usable limits.	Blend rough edges along defect to a smooth contour.
c. Buckling.	None allowed.	Not repairable.	Replace liner.
d. Carbon buildup.	1/32 inch deep.	Any amount.	Steam clean (see paragraph 5-43).
9. The ferrules for:			
a. Cracks.	None allowed.	Not repairable.	Replace liner.
b. Seizure.	Ferrule must slide freely.	Any amount.	Work ferrule free. As an aid, use penetrating oil to help free seized parts. When ferrule is free, degrease area.
c. Nicks, scratches, and gouges.	Any number, 0.01 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
10. The ferrules retainer for distortion.	Clearance between retainer and ferrule to be 0.005-0.015 inch.	Any amount.	Cold-work to usable limits and check ferrule for seizure. Inspect for cracks; none allowed.
11. The outer and inner cowl and the cowl adapter for:			
a. Cracks.	Any number, 1/16 inch long.	Any amount provided defect can be gas backed.	Repair-weld (see table 5-6, item 8).
b. Nicks, scratches, and gouges.	Any number, 0.010 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Dents.	No visible distortion allowed.	Any amount that is accessible for repair.	Cold-work defective area to usable limits. Inspect for cracks; none allowed.
12. The liner assembly for missing rivets.	None allowed.	Any number missing.	Insert a rivet (PN 123334) and a washer (PN 6019T61-P22) in same manner as adjacent rivet. Upset rivet and visually check installation to assure rivet completely fills holes and there is no gap between parts at the rivet. Weld washer to liner and rivet to washer

5-162. INSPECTION OF GANG CHANNEL ASSEMBLIES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
3. The channels for loose or missing rivets.	Not allowed.	Any amount.	Replace rivet per paragraph 5-163.

5-162A. REPLACEMENT OF INDIVIDUAL NUTS IN GANG CHANNEL ASSEMBLIES.

1. Insert a dowel into the defective nut on the nut side of the channel. Do not push the dowel in as far as the channel.

2. Push the nut, as far as possible, towards the ID or OD of the channel, and using the dowel as an aid, pry the nut out of the channel.

3. Note how the nut in the adjacent position is installed. Place the new nut into the channel in the same manner. If the channel lip was not bent out enough to allow the nut to drop into place, bend the channel lips back so that the new nut will drop in.

4. Work the channel lips back over the nut carefully using a steel rod and hammer, so the channel contour is back to its original position. Do not force the lip against the nut flange because this will restrict the movement of the nut.

5. Check the installation to be sure the nut floats freely and that the stops in the channel limit its movement in the normal manner.

6. Inspect the channel in the reworked area for cracks; none allowed.

5-163. REMOVAL OF ANCHOR AND CHANNEL NUTS.

NOTE

Rivets which hold the damaged nut shall be removed from the same side of the flange on which the nuts are located unless removal from that side is difficult and could result in damage to the part. Use table 5-14 to determine size drill required to remove rivet.

1. Remove rivets that are not recessed into a countersunk hole as follows:

a. Determine the diameter of the rivet to be removed and select the proper drill size.

b. Remove any raised burrs or identification bumps from the rivet heads. File a small flat on the head of round-head rivets.

c. Center-punch the rivet head as close to the center as practical.

d. Use a 1/4 inch drill motor and the drill selected in step a, and drill through the rivet head. Wiggle the drill around to open the drilled hole up. Do not drill any deeper than the height of the rivet head.

CAUTION

When popping the rivet head off, the chisel cutting edge must be pointed toward the part being removed. If this is not possible, a small piece of sheet rubber 1/16 inch thick must be used to protect the part in those areas where the chisel may cause damage.

e. Use a small cold chisel and pop the rivet head off.

f. Use a small pin punch and remove the remaining portion of the rivet. Remove the damaged nut.

2. Remove rivets that are recessed into a countersunk hole as follows:

a. Remove any raised burrs or identification marks from the rivet head.

b. Determine the size of the rivet to be removed and select the proper drill size.

c. Center-punch the rivet head as close to the center as practical.

d. Use a 1/4 inch drill motor and the drill selected in step b, and drill through the rivet.

CAUTION

When popping the rivet head off, the chisel cutting edge must be pointed toward the part being removed. If this is not possible, a small piece of sheet rubber 1/16 inch thick must be used to protect the part in those areas where the chisel may cause damage.

e. Use a small cold chisel and pop the protruding head of the rivet off.

f. Remove the anchor or channel nut.

g. Remove the remaining portion of the rivet.

3. Remove rivets with the protruding head inaccessible to a chisel as follows:

a. Remove any raised burrs or identification marks from the rivet head.

b. Determine the size of the rivet to be removed and select the proper drill size.

CAUTION

Extreme care must be used to insure that only the rivet head is being countersunk.

c. Drill a hole in the countersunk head through the rivet head. Use a 100° countersink and remove the rivet head.

d. Drive the remaining portion of the rivet out using a pin punch.

e. Remove the anchor or channel nut.

TABLE 5-14
DRILL SIZES FOR RIVET REMOVAL.

Rivet Diameter	Drilling in Protruding Head Side	Drilling in Countersunk Head Side
1/16	1/16	3/64
3/32	3/32	1/16
1/8	1/8	3/32
5/32	5/32	1/8

5-164. INSPECTION OF STAGE 1 NOZZLE OUTER SEAL.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Seal assembly for:			
a. Cracks in:			
(1) Seal parent metal coming from slots.	Not allowed if they are perpendicular to slot axis. Any number, 1/8 inch long if they are parallel to slot axis.	Not repairable.	Replace seal assembly.
(2) Seal parent metal not coming from slots.	Any number, 1/8 inch long.	Not repairable.	Replace seal assembly.
(3) Band and flange parent metal.	None allowed.	Not repairable.	Replace seal assembly.
b. Separation at seal and band joint.	Not allowed.	Not repairable.	Replace seal assembly.
c. Nicks and scratches in:			
(1) Band and seal.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
(2) Flange.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
d. Dents.	Any number, 1/16 inch from original contour.	Any amount that can be reworked to usable limits.	Cold-work to usable limits. Fluorescent-penetrant inspect. No cracks allowed.
e. Gap between aft end of seal segments and band ID.	Gap must be 1/16-1/8 inch.	Any amount that can be reworked to usable limit.	Cold-work to usable limit. Fluorescent-penetrant inspect. No cracks allowed.

5-165. INSPECTION OF COMBUSTION CHAMBER REAR INNER DUCT.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cone for:			
a. Cracks in parent metal and welds.	None allowed.	Not repairable.	Replace inner duct.
b. Nicks and scratches.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
	NOTE Measure depth of defect with a wire or shim stock of thickness equal to usable limit.		
c. Dents.	Any number 1/32 inch deep.	Any amount.	Cold-work to usable limit. Fluorescent-penetrant inspect for cracks. None allowed.
2. Forward and aft flanges for:			
a. Cracks extending from boltholes.	One per bolthole extending radially inward on forward flange or radially outward on aft flange. Each cracked hole must be separated by 3 uncracked holes. No more than 15% of holes cracked in a flange.	Not repairable.	Replace inner duct.
b. Cracks in remaining parent metal.	Any number, 1/64 inch deep with no high metal, provided defects on flange mating surfaces do not extend across more than 3/4 of the mating surface width.	Same as usable limits, with high metal.	Blend high metal to adjacent contour.
c. Nicks and scratches.	Any number 1/64 inch deep with no high metal. Defects on flange mating surfaces must not extend across more than 3/4 of surface width.	Any number, 1/64 inch deep, that can be reworked to usable limit.	Blend high metal to adjacent contour.
3. Combustion liner locating pin for nicks, scratches and burrs on corners.	Any amount with no high metal, provided the average width across the flats is no less than 0.246 inch.	Any amount that can be reworked to usable limit.	Blend high metal to adjacent contour.

5-166. INSPECTION OF ENGINE THRUST MOUNT ASSEMBLY AND AFT MOUNT. (White light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Mount assembly for cracks.	None allowed. (Disregard indications less than 1/16 inch)	Not repairable.	Replace defective part.
2. Broken or damaged cotter pins.	None allowed.	Any amount.	Replace cotter pin. (Recheck torque of nut.)
3. Broken or loose lockwire.	None allowed.	Any amount.	Replace lockwire. (Recheck torque value.)
4. Plate side for cracks.	Any number 1/4 inch long, separated by at least 2 inches. Cumulative length of cracks not to exceed 3.0 inches.	Not repairable.	Replace aft-mount.

5-167. REPLACEMENT OF HIGH AND LOW PRESSURE TURBINE ROTOR BLADES.

5-168. GENERAL.

This procedure only applies to turbines in which damaged blades have not caused so much unbalance as to produce excessive engine vibration, and the blade damage is clearly the result of FOD.

5-169. TURBINE BLADE REPLACEMENT PROCEDURE. High and low pressure turbine rotor blades damaged beyond the repairable inspection limits must be replaced. Blade replacement is permitted in any stage within the limits shown in table 5-15. Return the rotor to overhaul if the number of damaged blades in any stage exceeds the limit of table 5-15.

TABLE 5-15
ALLOWABLE TURBINE BLADE REPLACEMENT

Stage	No. of Blades that can be Replaced
1	20
2	14
3,4	16
5,6	14

1. Randomly select a starting point and consecutively number the blades, blade dovetail slots (and blade baffles in high-pressure turbine rotor only) in a clockwise direction using grease pencil, white ink, Dykem or other suitable non-carbon marker.

2. Remove all defective blades and correspondingly numbered blade baffles per paragraph 5-170.

3. Draw enough new blades from supply to equal the number of defective blades.

4. Lay all new blades on a sheet of paper on a table by weight from left to right with the lightest blades on the left. Mark the paper with the corresponding weights of blades.

CAUTION

Variation in pan weight between any one blade and the corresponding pan weight of the replacement blade cannot exceed 0.1 gram. This difference of 0.1 gram may not occur more than four times in any one stage.

5. Select new blades as follows:

NOTE

- Low pressure turbine blades must be replaced using the moment weight marked on blade tip. Moment weight of replacement blades must be within 1 gram inch of the blade being replaced.
- Weigh blades during replacement with pan weight scale 21C485.
- If a blade is damaged so that material is missing, and its original weight cannot be determined, use the weight of the blade located 2 positions on either side of the damaged blade.

a. A single blade may be replaced by another blade of identical pan weight, ±0.10 gram.

b. A pair of adjacent blades may be replaced by another pair of an equal combined pan weight, ±0.10 gram. (See (a), figure 5-76.)

c. Two blades identical in pan weight 180 degrees apart may be replaced by two others of identical pan weight within ±0.10 gram, but not necessarily equal to the original pan weight. (See (b), figure 5-76.)

d. Two pairs of blades equal in total pan weight per pair and 180 degrees apart may be replaced by two other pairs of equal pan weight within ±0.10 gram per pair. (See (c), figure 5-76.)

e. Two blades separated 180 degrees and of different pan weights may be replaced by two other blades of different pan weights if the difference in pan weights is the same within ±0.10 gram and the heaviest new blade replaces the heaviest old blade. (See (d), figure 5-76.)

f. Two pairs of blades 180 degrees apart and of different total pan weights may be replaced with two other pairs if the difference in total pan weights is the same within ±0.10 gram and heaviest new pair replaces the heaviest old pair. (See (e), figure 5-76.)

5-170. REMOVAL OF HIGH PRESSURE TURBINE ROTOR BLADES.

1. Match-mark the cooling plate to the disk, using Dykem or equivalent marker.

2. Remove nuts (34, stage 2, 50 stage 1) holding cooling plate to disk. Remove cooling plate and seal wire.

3. Number the damaged blades, the slots in the disk and the baffles on both sides of the damaged blades.

4. Start at a point 180° away from damaged blade and lift the blade up as far as it will go.

5. Move to the next blade in a counterclockwise direction (aft looking forward, stage 2) (forward looking aft, stage 1). Lift the next blade up as far as it will go. Continue lifting each successive blade (each one will lift a little higher than the previous one) until you reach the damaged blade. The damaged blade should lift high enough to be removed.

6. Allow other blades to return to their original positions in the blade slots.

7. Select replacement blades per paragraph 5-169.

5-171. INSTALLATION OF HIGH-PRESSURE TURBINE ROTOR BLADES.

CAUTION

Turbine blades can be installed backwards, Be sure blades are installed with leading edge forward. The leading edge is the rounded edge.

1. Start at a point 180° away from the blade slot where the new blade is to be installed. Lift each blade up as far as it will go, moving counterclockwise as in the removal procedure.

2. The blade next to the slot where the replacement blade will go will be high enough to allow the replacement blade to be installed.

NOTE

Always use new seal wire.

3. Install replacement blade, baffles, new seal wire and cooling plate.

4. Assemble nuts and torque them to 50-55 lb inch, distributing torque evenly around the disk.

5. Try to insert a 0.002 inch feeler gage between cooling plate and disk. Gage may enter but cannot pass circumferentially for more than 2 consecutive blades. Check seal wire if gage enters all around.

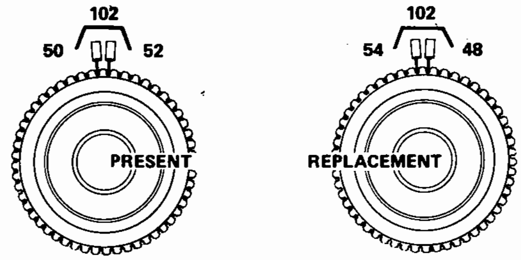
5-172. REMOVAL OF LOW-PRESSURE TURBINE ROTOR BLADES.

1. Use a Nylon drift and unbend the key holding in the damaged blade.

THIS ILLUSTRATION SHOWS BLADE COMBINATION REPLACEMENT

THIS INSTRUCTION IS NOT MEANT TO LIMIT THE NUMBER OF BLADES THAT CAN BE REPLACED. ALL BLADES WEIGHTS ARE SCALE WEIGHTS. THE REPLACEMENT BLADE OR TOTAL COMBINATION WEIGHT MUST BE WITHIN 0.1 GRAM OF BLADE REPLACED AS ILLUSTRATED.

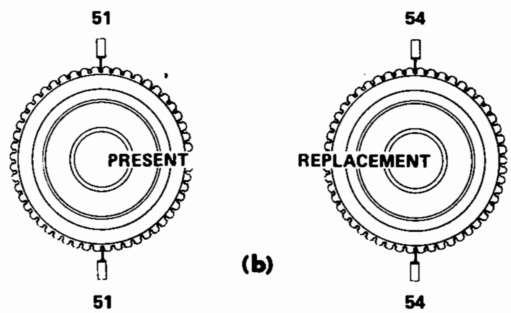
USABLE BLADES REMOVED DURING REPLACEMENT SHOULD BE RETAINED FOR REUSE. AFTER BLADE REPLACEMENT IS COMPLETE, TAKE CLEARANCE CHECKS PER TABLE 8-1 DURING ENGINE ASSEMBLY AND VIBRATION CHECK PER TEST SECTION DURING ENGINE TEST.



(a)

A PAIR OF ADJACENT BLADES MAY BE REPLACED BY ANOTHER PAIR OF BLADES HAVING THE SAME COMBINED TOTAL WEIGHT.

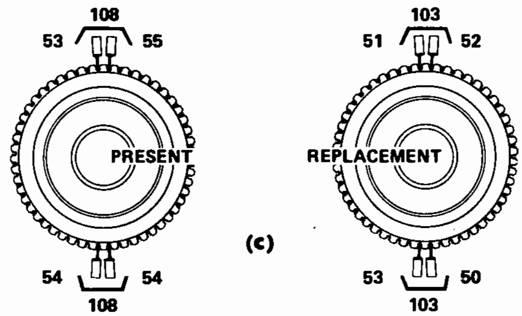
EXAMPLE (a) 102 TOTAL (OLD WEIGHT) — 101.9 or 102 or 102.1 TOTAL (NEW WEIGHT)



(b)

TWO BLADES IDENTICAL IN WEIGHT 180 DEGREES APART MAY BE REPLACED BY TWO OTHER BLADES IDENTICAL IN WEIGHT TO EACH OTHER BUT NOT NECESSARILY IDENTICAL IN WEIGHT TO THE ORIGINAL BLADES.

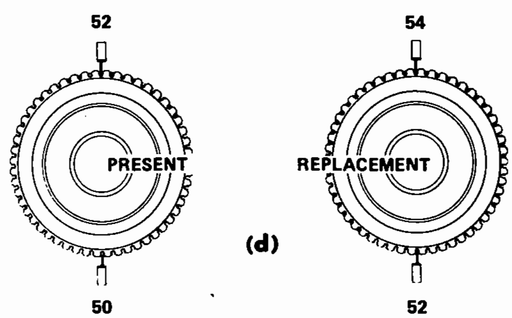
EXAMPLE (b) 51 / 51 (OLD WEIGHT) — 53.9 or 54 or 54.1 (NEW WEIGHT) / 54



(c)

TWO PAIRS OF BLADES IDENTICAL IN TOTAL WEIGHT PER PAIR 180 DEGREES APART MAY BE REPLACED BY TWO OTHER PAIRS OF BLADES HAVING THE SAME IDENTICAL COMBINED WEIGHT.

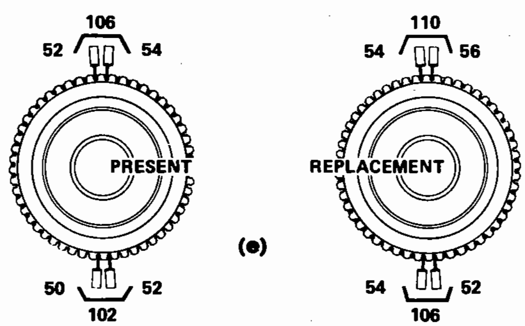
EXAMPLE (c) 108 TOTAL (OLD WEIGHT) 108 TOTAL — 102.9 or 103 or 103.1 TOTAL (NEW WEIGHT) 103 TOTAL



(d)

TWO BLADES 180 DEGREES APART AND OF DIFFERENT WEIGHTS MAY BE REPLACED BY TWO OTHER BLADES OF DIFFERENT WEIGHTS PROVIDED THE DIFFERENCE IN WEIGHTS OF BLADES IS THE SAME AND THE HEAVIER NEW BLADE REPLACES THE HEAVIER OLD BLADE.

EXAMPLE (d) 52 (OLD WEIGHT) 50 — 53.9 or 54 or 54.1 (NEW WEIGHT) 52



(e)

TWO PAIRS OF BLADES 180 DEGREES APART AND OF DIFFERENT TOTAL WEIGHTS MAY BE REPLACED BY TWO OTHER PAIRS OF BLADES OF DIFFERENT TOTAL WEIGHTS PROVIDED THE DIFFERENCE IN TOTAL WEIGHTS OF THE PAIRS OF BLADES IS THE SAME AND THE HEAVIER PAIR OF NEW BLADES REPLACES THE HEAVIER OLD PAIR OF BLADES.

EXAMPLE (e) 106 TOTAL (OLD WEIGHT) 102 TOTAL — 109.9 or 110 or 110.1 TOTAL (NEW WEIGHT) 106 TOTAL

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Figure 5-76. Turbine Blade Replacement Data

2. Starting at a point about 8 blades away from blade to be removed, push the end of each blade in the direction away from the damaged blade, moving progressively closer to the damaged blade. This takes up the slack in the blade inter-locks, allowing removal of damaged blade. Hold the 8 blades away from the damaged blade and repeat the process in the other direction from the damaged blade. Hold these blades in this position.

3. Now, the inter-locks on the damaged blade should be separated from the surrounding 2 blades enough to allow removal of damaged blade. Have someone tap the damaged blade out while you are holding the surrounding blades away from damaged blade. Remove used blade key.

4. If removing more than 1 blade, number the blades and their slots in the disk, using Dykem or equivalent noncarbon marker.

5. Select replacement blades per paragraph 5-169.

5-173. INSTALLATION OF LOW PRESSURE TURBINE BLADES. For special tools, see table 2-1, group 35.

1. Select replacement blades per paragraph 5-169.

2. Install new blade keys, pre-bent end forward.

3. Install new blades, one at a time, to the numbered slots in the disk. Spread the surrounding blades, as in removal procedure, to allow the new blade to seat on pre-bent end of blade key.

4. Use tab bending kit (21C5154) and bend the blade key. Check the gap between blade key and blade dovetail, using a 0.010 inch feeler gage. Gage must not enter. Bend key again or replace key if gage enters.

5-174. INSPECTION OF HIGH PRESSURE TURBINE BLADES.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall blade for cracks in coating or other damage that exposes parent metal.	None allowed except along leading edge if due to erosion.	Not repairable.	Replace blade.
2. Shank and dovetail for:			
a. Cracks.	None allowed.	Not repairable.	Replace blade.
b. Nicks, dents, scratches, pits, and wear on:			
(1) Pressure surfaces and concave radii of dovetail.	None allowed.	Not repairable.	Replace blade.
(2) Other areas.	Any amount, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
3. Blade tips for rub grooves.	Any number, any width if none exceed 1/32 inch depth, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
4. Plugged cooling holes.	None allowed.	Any number.	Remove foreign material using a suitable size wire or pin.
5. Curled blade tip.	1/16 inch long on leading and trailing edges.	1/8 inch long on leading and trailing edges.	Blend corner to 1/4 inch radius maximum.
6. Erosion of leading edge.	0.010 inch deep.	Not repairable.	Replace blade.
7. Missing tip plugs.	Not allowed.	Not repairable.	Replace blade.

5-174. INSPECTION OF HIGH PRESSURE TURBINE BLADES. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
7. Hot gas corrosion (sulfidation)	Any amount of discoloration or surface roughness, providing there is no blistering, splitting, or separation (delamination) of the airfoil surface.	Not repairable.	Replace blade.

5-175. INSPECTION OF COOLING PLATES, STAGE 1 FRONT AND STAGE 2 REAR.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. All areas for:			
a. Cracks.	None allowed.	Not repairable.	Replace rotor.
b. Nicks, scratches, and pits.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
2. Inner flange for dents.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
3. Warpage on:			
a. Stage 1, 0.101-0.103 inch dimension.	0.091-0.113 inch.	Not repairable.	Replace rotor.
b. Stage 2, 0.156-0.158 inch dimension.	0.146-0.168 inch.	Not repairable.	Replace rotor.

5-176. INSPECTION OF HIGH PRESSURE TURBINE OUTER CASING.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks in:			
a. Casing ring.	None allowed.	Not repairable.	Replace casing.
b. External flanges.	Six per flange if radial depth does not exceed 1/8 inch.	Not repairable.	Replace casing.
2. Hot spots.	Allowed if metal is not burned and there are no cracks.	Not repairable.	Replace casing.
3. Nicks and scratches in flange mating surfaces.	Any number 0.010 inch with no high metal provided 25% of width of sealing surface is not affected.	Same as usable limits, with high metal.	Blend high metal.
4. Dents in flange mating surface.	Any number 1/32 inch deep with no high metal, with no interference at assembly.	Same as usable limits, with high metal.	Blend high metal.

5-176. INSPECTION OF HIGH PRESSURE TURBINE OUTER CASING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
5. Nicks, scratches in casing.	Any number 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
6. Drain boss thread damage.	Two threads cumulative provided thread can be used without cross threading.	Total 2 threads, cumulative.	Chase threads.
7. Defective gang channel nut assemblies.	Inspect per paragraph 5-162.		
8. Forward flange locating pin for nicks, dents and gouges.	Any amount 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.

5-177. INSPECTION OF HIGH-PRESSURE TURBINE INNER CASING. (White Light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Entire casing for cracks in:			
a. Aft flange.	None allowed.	Not repairable.	Replace casing.
b. Internal flanges:			
(1) Radial.	Any amount 1/16 inch radial depth and at least 2 inches apart.	Any amount.	Repair weld (see table 5-6, item 9.) Hand blend to fit nozzle segments or shrouds.
(2) Circumferential.	No cracks to be over 1/4 inch long, cumulative length of all cracks not to exceed 1 inch with no distortion which would prevent assembly of nozzle segments or shrouds.	Any amount.	Repair weld (see table 5-6, item 9.) Hand blend to fit nozzle segments or shrouds.
c. Lugs.	None allowed.	Not repairable.	Replace casing.
2. Entire casing for:			
a. Nicks, scratches in flange mating surfaces.	Any number 1/32 inch deep with no high metal provided 25% of surface is intact radially.	Same as usable limits, with high metal.	Blend high metal.
b. Dents in flange mating surface.	Any amount 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
c. Nicks, scratches and wear marks.	Any number 1/32 inch deep with no high metal.	Same as usable limits,	Blend high metal.
3. Bleed holes for obstructions.	Not allowed.	Any number.	Clean out hole using suitable diameter wire.

5-177. INSPECTION OF HIGH-PRESSURE TURBINE INNER CASING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
4. Aft flange for fretting.	0.025 inch deep maximum.	Not repairable.	Replace casing.

5-178. INSPECTION OF HIGH PRESSURE TURBINE INNER CASING AIR BAFFLE.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace baffle.
2. Nicks, scratches, and pits.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
3. Dents (smooth deformation).	Any number, 1/16 inch deep, with no high metal.	Any number, 1/8 inch deep.	Cold-work to usable limit. Fluorescent-penetrant inspect. No cracks allowed.
4. Missing brackets.	None allowed.	Any number.	Repair (see paragraph 5-179.)
5. Forward mating flange surface for wear (2.785-2.781 inches).	2.776 inch minimum.	Not repairable.	Replace baffle.

5-179. REPLACEMENT OF BRACKETS ON HIGH PRESSURE TURBINE INNER CASING AIR BAFFLE.

1. Use a hand-held rotary file and clean the area to be welded.

2. Weld new bracket, PN 5022T02P02, in place, using AMS 5786 filler wire. See table 5-6 for weld data.

5-180. INSPECTION OF STAGE 2 SHROUD SUPPORT.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall support for:			
a. Cracks.	None allowed.	Not repairable.	Replace support.
b. Nicks, scratches, and pits.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
2. Support flange for:			
a. Dents (smooth deformation).	Any number, 1/16 inch deep, with no high metal, if there is no interference at assembly.	Any number, 1/8 inch deep.	Cold-work to usable limit. Remove any high metal White-light inspect; no cracks allowed.
b. Bending (0.661-0.659 inch).	0.639 inch minimum to 0.681 inch maximum.	Any amount	Cold work to usable limits. White light inspect; no cracks allowed.
c. Wear.	Any amount not to exceed 0.010 in. deep	Not repairable.	Replace support.

5-181. INSPECTION OF STAGE 1 TURBINE NOZZLE.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Partitions for:			
a. Cracks.	5 cracks, 1/4 inch long per partition.	Not repairable.	Replace segment.
b. Burns or erosion on:			
(1) Partition (except trailing edge).	1 inch x 1 inch - 2 places per partition.	Not repairable.	Replace segment.
(2) Trailing edge.	1/2 inch high x 1/4 inch back from edge of partition.	Not repairable.	Replace segment.
c. Nicks, pits and scratches.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
d. Dents (smooth deformation) in:			
(1) Trailing edge.	Any number, 1/64 inch deep within 1/4 inch of edge with smooth deformation and no high metal.	Same as usable limits, with high metal.	Remove high metal.
(2) All other areas.	Any number 1/32 inch deep with smooth deformation and no high metal.	Same as usable limits, with high metal.	Remove high metal.
e. Plugged cooling air holes.	None allowed.	Any amount.	Remove foreign material using a suitable size wire or pin.
f. Bent trailing edges.	Any amount as long as other inspection requirements are within usable limits and engine performance is satisfactory.	Not applicable.	Replace segment.
g. Hot gas corrosion (sulfidation).	Any amount of discoloration or surface roughness, providing there is no blistering, splitting or separation (delamination) of the airfoil surface.	Not repairable.	Replace partition.
2. Inner and outer bands for cracks.	5 cracks, 1/2 inch long. Any number 1/8 inch long.	Not repairable.	Replace segment.
3. Air guide for:			
a. Cracks.	Four cracks, total cumulative length not more than 1 inch. No one crack more than 1/2 inch.	Not repairable.	Replace guide.

5-181. INSPECTION OF STAGE 1 TURBINE NOZZLE. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
b. Bent flange (smooth deformation).	Any amount not to exceed 1/64 inch from original contour.	Not repairable.	Replace guide.
c. Nicks, pits and scratches.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal using a fine abrasive stone.
d. Dents (smooth deformation).	Any number, 1/32 inch deep.	Not repairable.	Replace guide.
4. Retaining ring for:			
a. Nicks, pits and scratches.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal using a fine abrasive stone.
b. Cracks.	Any number 1/64 inch deep.	Not repairable.	Replace retaining ring.
c. Dents.	None allowed.	Not repairable.	Replace retaining ring.

5-181A. REPLACEMENT OF STAGE 1 NOZZLE SEGMENTS. For special tools see table 2-1, group 34A.

1. Place stage 1 nozzle assembly into fixture (21C5205) aft end down.

2. Remove retaining ring (1, figure 5-76A) from outer band.

3. Use wrench (21C5385) and remove 44 nuts (3) from bolts (2).

4. Lift off air guide (9).

5. If more than 1 segment is being replaced, number the nozzle segments using Dykem or equivalent marker that cannot be rubbed off.

6. Remove bolts (2) and bolt shields (4) from segments being removed.

7. Remove nozzle segments being replaced. Discard seals (5, 6).

CAUTION

- Replacement nozzle segments must have same part number as segment being replaced and be installed in same position. Part numbers are located on outer band of segment, forward end.
- If all segments or most all segments are being replaced, replace seal wire (10).

8. Install new segments (same part number in same location) being careful not to damage seal wire. Insert seals (5, 6); long seal (5) at inner band, shorter seal (6) at outer band.

9. Line up holes in nozzle segments with holes in nozzle support (8). Install bolt shields (4) and bolts (2).

10. Install air guide (9) over bolts and assemble 44 nuts (3).

11. Use wrench (21C5385) torque 22 nuts (3) on bolts in small holes (hole on left side of each segment, forward looking aft) to 48-52 lb in. Torque 22 nuts (3) on bolts in large holes (hole on right) to 20-24 lb in.

12. Assemble retaining ring (1) to slot in outer band.

13. Remove nozzle assembly from fixture (21C5205).

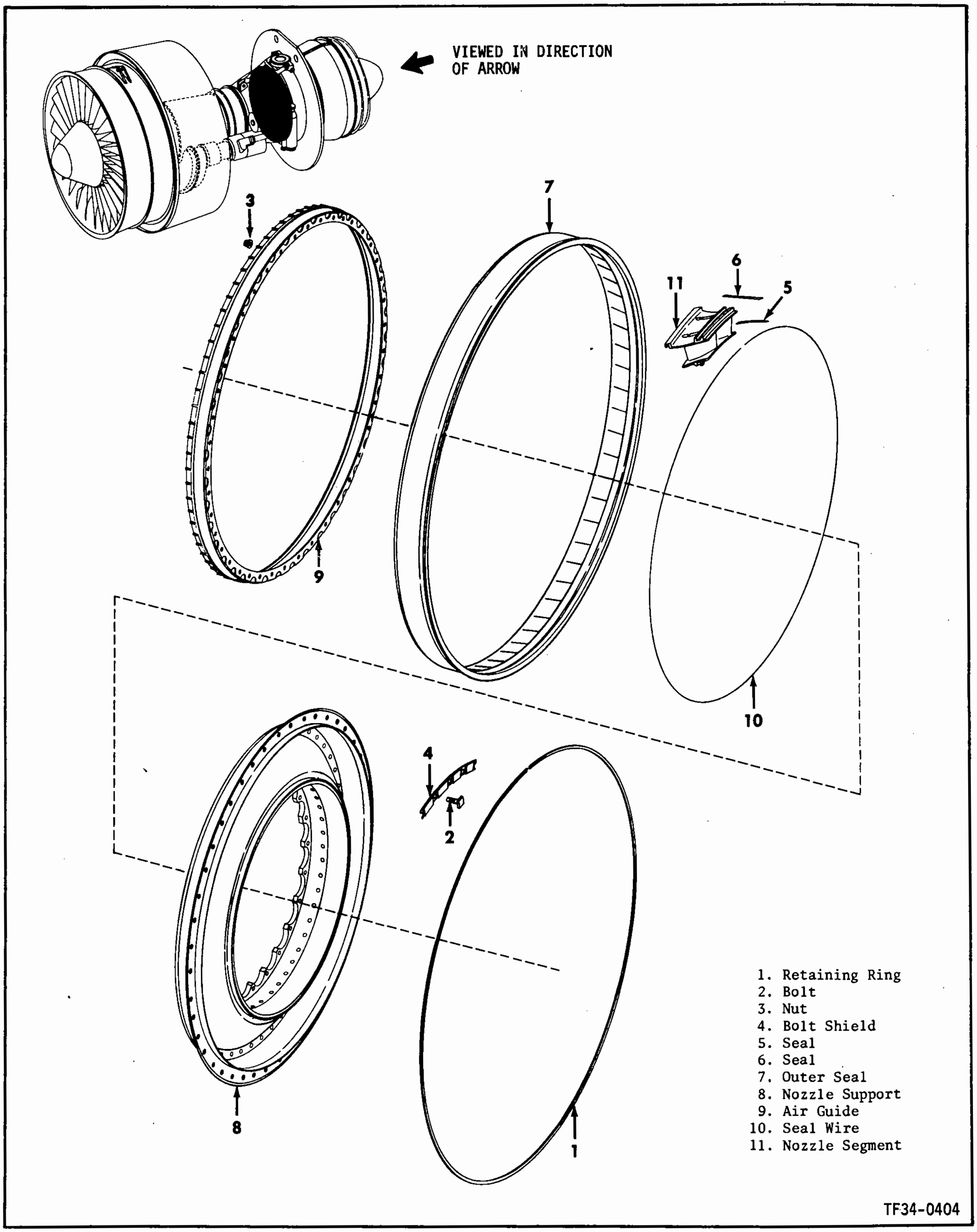


Figure 5-76A. Replacement of Stage 1 Nozzle Segments

5-182. INSPECTION OF STAGE 2 TURBINE NOZZLE ASSEMBLY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Segments for:			
a. Cracks in:			
(1) Partitions.	5 cracks, 1/4 inch long, per partition.	Not repairable.	Replace segment.
(2) Inner and outer bands.	5 cracks, 1 inch long.	Not repairable.	Replace segment.
b. Burns or erosion on:			
(1) Partition except trailing edge.	1 inch x 1 inch, 2 places per partition.	Not repairable.	Replace segment.
(2) Trailing edge.	1/2 inch high x 1/4 inch back from edge of partition.	Not repairable.	Replace segment.
c. Nicks, scratches, and pits.	Any number, 1/64 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
d. Dents (smooth deformation).	Any number, 1/32 inch deep.	Not repairable.	Replace segment.
e. Plugged cooling air slots.	Not allowed.	Any amount.	Remove foreign material using a wire or pin.
2. Air seal for:			
a. Cracks.	None allowed.	Not repairable.	Replace seal.
b. Nicks, scratches, and pits.	Any number, 0.01 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Dents (smooth deformation).	Any number, 1/16 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
d. Bent flanges.	Any number, 1/32 inch deep, with no high metal if there is no interference at assembly.	Any number, 1/16 inch deep.	Cold-work to usable limit. Fluorescent-penetrant inspect. No cracks allowed.
e. Honeycomb for:			
(1) Grooves in ID.	Any number any width, if there is an equal amount of original seal material remaining between the grooves, and the grooves are no more than half way, radially, through the seal.	Not repairable.	Replace seal.
(2) Unbrazed cells. Note: Use an 8 power glass.	Ten adjacent cells in any one direction. No more than 25 cells in one inch of casing circumference, at least 6 inches between groups.	Not repairable.	Replace seal.

5-182A. REPLACEMENT OF STAGE 2 NOZZLE SEGMENTS.

1. Place stage 2 nozzle assembly (6, figure 5-6) on bench, forward side down.

2. Remove retaining rings (7) and pins (8), as required to allow access to damaged segments (10).

3. Remove seals (9).

4. Remove segments (10) and seals (11, 12).

CAUTION

Be sure replacement segments have same part number as segments being removed and are assembled to same location in nozzle assembly.

5. Assemble stage 2 nozzle segments (10) to 9 seals (9), inserting seals (11, 12) between each segment.

6. Install pins (8), and retaining rings (7) to seals (9). Dimpled end of retaining ring must be on right-hand side of the assembly, aft looking forward, just to the right-hand side of pin (8).

5-183. INSPECTION OF STAGES 3 THROUGH 6 TURBINE NOZZLE SEGMENTS. White light inspect as follows:

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Partitions for:			
a. Axial cracks.	10 cracks 1/8 inch long in trailing edge.	Not repairable.	Replace segment.
b. Burnout.	1/8 inch from trailing edge over a distance of 1/2 inch.	Not repairable.	Replace segment.
c. Dents in trailing edge.	Any number, 0.04 inch deep.	Not repairable.	Replace segment.
d. Dents other than in trailing edge.	Any number, 1/64 inch deep.	Not repairable.	Replace segment.
e. Radial cracks.	Two per partition, 1/8 inch long.	Not repairable.	Replace segment.
f. Nicks and gouges.	Any number, 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
g. Hot gas corrosion (see glossary for definitions) on leading and trailing edges.	Any amount of discoloration or surface roughness, provided there is no splitting or cracking of the surface of leading edge.	Not repairable.	Replace segment or nozzle.

5-183. INSPECTION OF STAGES 3 THROUGH 6 TURBINE NOZZLE SEGMENTS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Inner and outer bands for:			
a. Buckling or distorting.	Any amount as long as parts can be reassembled without excessive force.	Not repairable.	Replace segment.
b. Cracks.	6 radial cracks 1/8 inch long. No circumferential cracks allowed.	Not repairable.	Replace segment.
c. Nicks, gouges, dents and pickups.	Any number, 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
d. Missing or cracked antirotation lug.	Not allowed.	Not repairable.	Replace segment.
e. Worn antirotation lug.	Remaining stock must be at least 0.450 inch wide with no high metal.	Same as usable limits, with high metal.	Remove high metal.
f. Cracks in seal retaining pinhole.	None allowed.	Not repairable.	Replace segment.
g. Worn seal retaining pinhole.	Diameter not more than 0.1285 inch.	Not repairable.	Replace segment.

5-184. INSPECTION OF STAGES 1 AND 2 TURBINE SHROUD SECTORS. (White light inspect only.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Shroud sector for cracks in:			
a. Honeycomb support.	Any number 1/4 inch long radially.	Not repairable.	Replace shroud.
b. Support rib braze.	Any number 1/8 inch long.	Not repairable.	Replace shroud.
c. Tracks.	Any number 1/8 inch long radially, provided they are separated by 1 inch.	Not repairable.	Replace shroud.
2. Tracks for:			
a. Nicks, scratches.	Any number 0.015 inch deep with no high metal provided part can be assembled.	Same as usable limits, with high metal.	Blend high metal.
b. Wear.	Any amount 0.005 inch with no high metal.	Same as usable limits, with high metal.	Blend high metal.
c. Bending.	Any amount which does not prevent shroud being assembled to casing without excessive force.	Not repairable.	Replace shroud.

5-184. INSPECTION OF STAGES 1 AND 2 TURBINE SHROUD SECTORS. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
3. Honeycomb for:			
a. Rubs.	Any amount 0.025 inch deep with no high metal (when compared with unrubbed section)	Not repairable.	Replace shroud.
b. Build-up/pickup of rubbed area.	Not allowed.	Any amount.	Blend smooth (compare with unrubbed section).
c. Missing or unfilled cells.	10% of abradable area.	Not repairable.	Replace shroud.
d. Cracks.	Any number provided no material is in danger of becoming loose.	Not repairable.	Replace shroud.
e. Separation of liner from shroud.	Not allowed.	Not repairable.	Replace shroud.

5-185. INSPECTION OF STAGES 3 THROUGH 6 TURBINE SHROUDS. (See figure 5-77.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall shroud for:			
a. Cracks.	Any number, 1/16 inch long.	Not repairable.	Replace shroud.
b. Nicks, dents and scratches.	Any number, 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Bends or distortion.	Any amount with no cracks or separation of material if shroud can be assembled to casing without excessive force.	Not repairable.	Replace shroud.
2. Honeycomb for:			
a. Grooves in ID.	Any number, any width, if there is an equal amount of original material remaining between grooves, and grooves are no more than halfway radially, through the honeycomb.	Not repairable.	Replace shroud.
b. Missing cells.	Ten percent of honeycomb missing.	Not repairable.	Replace shroud.
3. Tracks for bending:	Any amount which does not prevent shroud being assembled to casing without excessive force.	Not repairable.	Replace shroud.

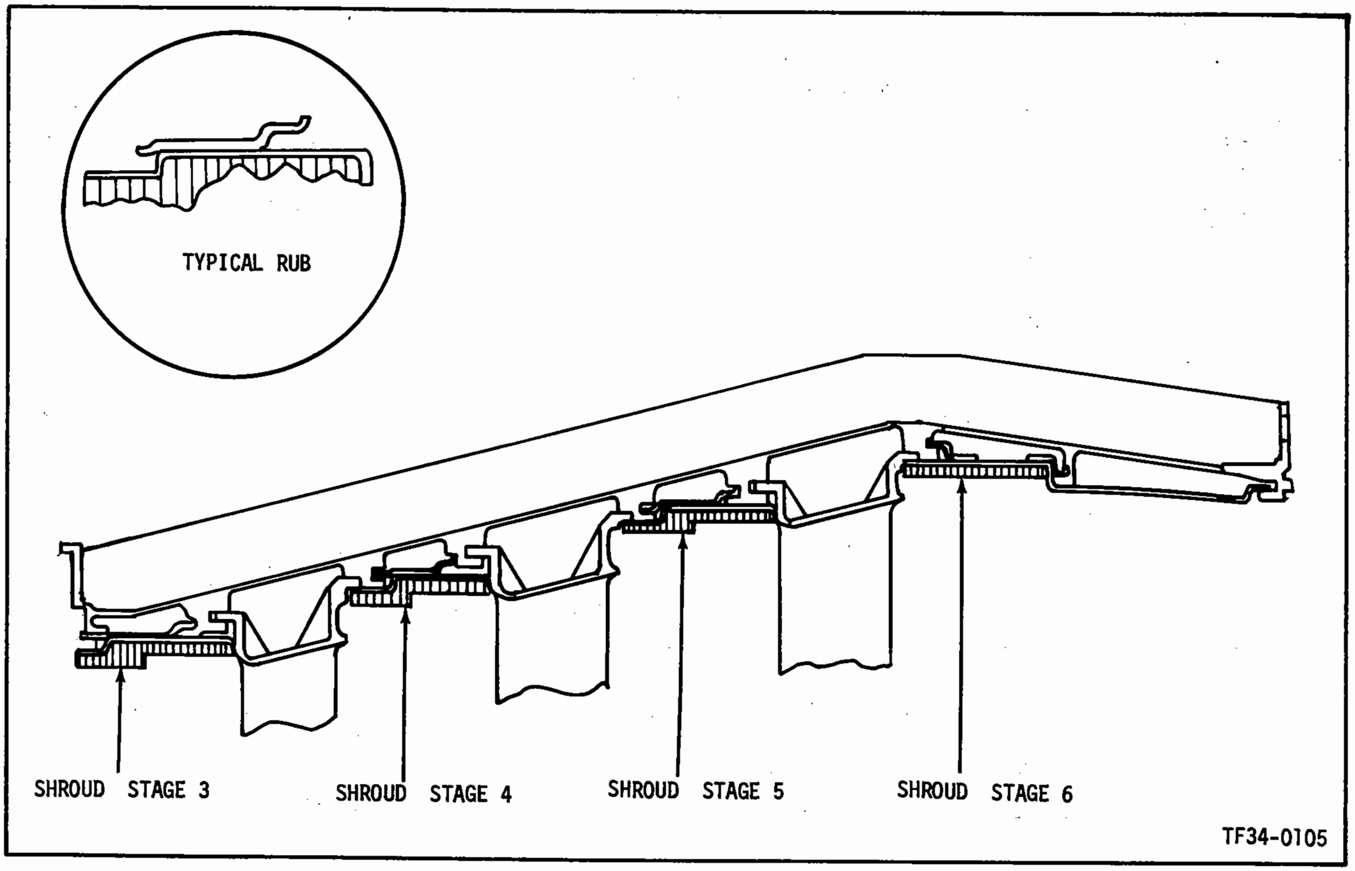


Figure 5-77. Low-Pressure Turbine (Stages 3 through 6) Shroud Inspection

5-186. INSPECTION OF TURBINE TRANSITION CASING. (White light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Casing for cracks in:			
a. Casing wall.	None allowed.	Not repairable.	Replace casing.
b. External flanges.	Any number - radial depth not over 1/16 inch deep.	Not repairable.	Replace casing.
c. Internal flanges:			
(1) Radial.	Any number 1/16 inch - radial depth and at least 2 inches apart.	Not repairable.	Replace casing.
(2) Circumferential.	No crack to be over 1/2 inch long, cumulative length of all cracks not to exceed 2 inches, with no distortion which would prevent assembly of liner or nozzle segment.	Not repairable.	Replace casing.
d. Welds.	None allowed. (Disregard indications less than 1/16 inch long.)	Not repairable.	Replace casing.

5-186. INSPECTION OF TURBINE TRANSITION CASING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
e. Lugs/slots.	None allowed.	Not repairable.	Replace casing.
2. Hot spots.	Allowed if metal is not burned and there are no cracks.	Not repairable.	Replace casing.
3. Nicks, scratches in flange mating surface.	Any number 1/32 inch deep with no high metal provided 25% of original sealing surface is intact.	Same as usable limits, with high metal.	Blend high metal.
4. Dents in flange mating surfaces.	Any amount 1/32 inch deep with no high metal, if there is no interference at assembly or visual leakage paths.	Same as usable limits, with high metal.	Blend high metal.
5. Nicks and scratches in shell.	Any number 0.005 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
6. Studs for damaged or stripped threads.	Total length of damage not over 1-1/2 threads with no high metal.	Same as usable limits, with high metal.	Chase threads.

5-187. INSPECTION OF TURBINE TRANSITION OUTER LINER. (White light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Aft flange for:			
a. Cracks.	None allowed.	Not repairable.	Replace liner.
b. Broken or damaged lugs.	Up to 3 lugs if separated by a good one.	Not repairable.	Replace liner.
c. Nicks, dents and scratches.	Any number 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
2. Forward flange for:			
a. Wear.	Any amount 0.020 inch deep, provided cumulative length does not exceed 2/3 length of any 90° section with no high metal.	Same as usable limits, with high metal.	Blend high metal/replace liner.
b. Nicks, dents and scratches.	Any amount 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
3. Liner for:			
a. Burn holes.	None allowed.	Not repairable.	Replace liner.
b. Buckles/warps.	Contour of deformed area not more than 3/16 inch above or below undeformed area.	Not repairable.	Replace liner.
c. Cracks.	Any number 1/4 inch long and at least 2 inches apart.	Any amount.	Repair weld (see table 5-6, item 10).

5-187. INSPECTION OF TURBINE TRANSITION OUTER LINER. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
4. Ferrules for:			
a. Looseness.	Clearance between ferrule and retainer not to exceed 0.015 inch and ferrule must move freely.	Any amount greater than usable limits.	Cold work to usable limits.
b. Cracks.	Any amount provided no tab is in danger of breaking off.	Not applicable.	Break off cracked tab and blend. (Two tabs max total.)

5-188. INSPECTION OF TURBINE TRANSITION INNER LINER AND SEAL. (White light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Flange for:			
a. Cracks.	None allowed.	Any number.	Repair weld (see table 5-6, item 10).
b. Bent lugs.	Any amount if liner will assemble freely and there are no cracks or high metal.	Same as usable limits, with high metal.	Blend high metal.
c. Cracked lugs.	None allowed.	Any amount.	Repair weld (see table 5-6, item 10). Hand blend.
d. Nicks, dents and scratches.	Any number 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Blend high metal.
2. Liner for:			
a. Burn holes.	None allowed.	Not repairable.	Replace liner.
b. Buckling/warps.	Contour of deformed area not more than 3/16 inch above or below undeformed area.	Not repairable.	Replace liner.
c. Cracks.	Any number 1/4 inch long, at least 2 inches apart.	Any amount.	Repair weld (see table 5-6, item 10).
3. Honeycomb for:			
a. Rubs.	Any amount 1/2 of honeycomb thickness provided cumulative width of groove or grooves at any location do not exceed 1/3 width of honeycomb.	Not repairable.	Replace liner.
b. Missing cells.	10% of honeycomb.	Not repairable.	Replace liner.

5-189. INSPECTION OF STAGES 4 THROUGH 6 TURBINE NOZZLE INTERSTAGE SEALS.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall seal for:			
a. Cracks.	Any number, 1/16 inch long.	Not repairable.	Replace seal.
b. Nicks, dents and scratches.	Any number, 0.025 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
c. Bends or distortion.	Any amount with no cracks or separation of material if seal can be assembled to nozzle sectors without excessive force.	Not repairable.	Replace seal.
2. Honeycomb for:			
a. Rubs.	Any amount as long as cumulative width of groove or grooves does not exceed 1/3 the width of honeycomb.	Not repairable.	Replace seal.
b. Missing cells.	Ten percent of honeycomb missing.	Not repairable.	Replace seal.
3. Brazed joints for cracks.	Any number, 1/8 inch long.	Not repairable.	Replace seal.
4. Retaining pinhole for:			
a. Wear.	Diameter not more than 0.130 inch wide.	Not repairable.	Replace seal.
b. Cracks.	None allowed.	Not repairable.	Replace seal.
c. Dents, raised metal on edges.	Any amount with no high metal.	Any amount with high metal.	Remove high metal.
5. Seal slots for:			
a. Wear.	Diameter not more than 0.130 inch wide and no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Cracks.	None allowed.	Not repairable.	Replace seal.
c. Dents, raised metal on edges.	Any amount with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-190. INSPECTION OF LOW-PRESSURE TURBINE CASING. (See figure 5-78.) White light inspect as follows:

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks in:			
a. Casing wall.	None allowed.	Not repairable.	Replace casing.
b. External flanges.	Any number, if radial depth is not over 1/8 inch.	Not repairable.	Replace casing.

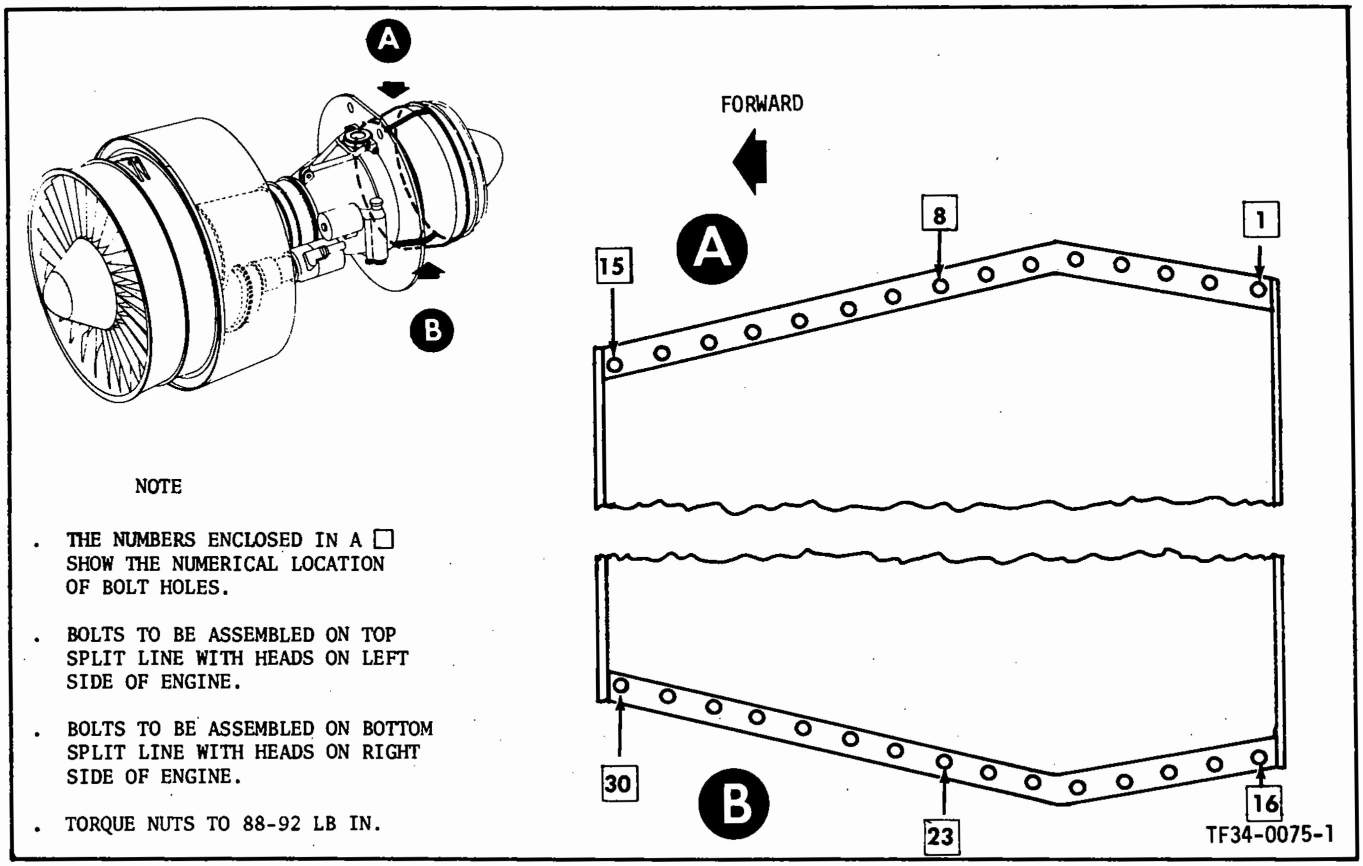


Figure 5-78. Low-Pressure Turbine Casing Inspection

5-190. INSPECTION OF LOW-PRESSURE TURBINE CASING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
c. Internal flanges.			
(1) Radial.	Any number, not within 1/8 inch of casing wall.	Not repairable.	Replace casing.
(2) Circumferential.	No cracks to be over 1/2 inch long, cumulative length of all cracks not to exceed 2 inches with no distortion that would prevent shroud or vane segment assembly.	Not repairable.	Replace casing.
d. Welds.	Any number, not over 1/8 inch long in any 1-inch area.	Not repairable.	Replace casing.
2. Casing for hot spots.	Any amount if metal is not burned or cracked.	Not repairable.	Replace casing.
3. Flange mating surfaces for:			

5-190. INSPECTION OF LOW-PRESSURE TURBINE CASING. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Nicks and scratches.	Any number, 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Dents.	Any number, 1/32 inch deep, as long as there is no interference at assembly or areas where leaks could occur. No high metal.	Same as usable limits, with high metal.	Remove high metal.
4. Shell for:			
a. Nicks and scratches.	Any number, 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Dents.	Any number, 1/16 inch deep.	Not repairable.	Replace casing.
5. Body-bound boltholes for wear.	Diameter on holes numbered 1, 8, 15, 16, 23, 30 not over 0.2205 inch. All other holes not over 0.221 inch. See figure 5-78 for hole location.	Not repairable.	Replace casing.
6. Internal flanges for:			
a. Bending.	Any amount which does not prevent assembly of nozzles or shrouds to the casing.	Not repairable.	Replace casing.
b. Nicks, dents, and scratches.	Any number 1/32 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-191. INSPECTION OF LOW-PRESSURE TURBINE ROTOR BLADES (ALL STAGES). (See figure 5-79.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
	CAUTION Do not use a grinding wheel. All blending must be done in the longitudinal (span wise) direction.		
1. The overall blade for:			
a. Cracks.	None allowed.	Not repairable.	Replace blade if cracks are caused by FOD. Otherwise, replace rotor.
b. Nicks, pits, scratches, and dents.	All stages: any number 1/64 inch deep with no high metal.	Stages 4, 5, 6: any number 1/64 inch deep with high metal.	Remove high metal.
		Stage 3: not repairable.	Replace blade.
c. Erosion of leading edge.	All stages: 0.005 inch.	Stages 4,5,6: 0.010 inch deep.	Remove sharp edges and blend leading edge to a smooth radius.
		Stage 3: not repairable.	Replace blade.

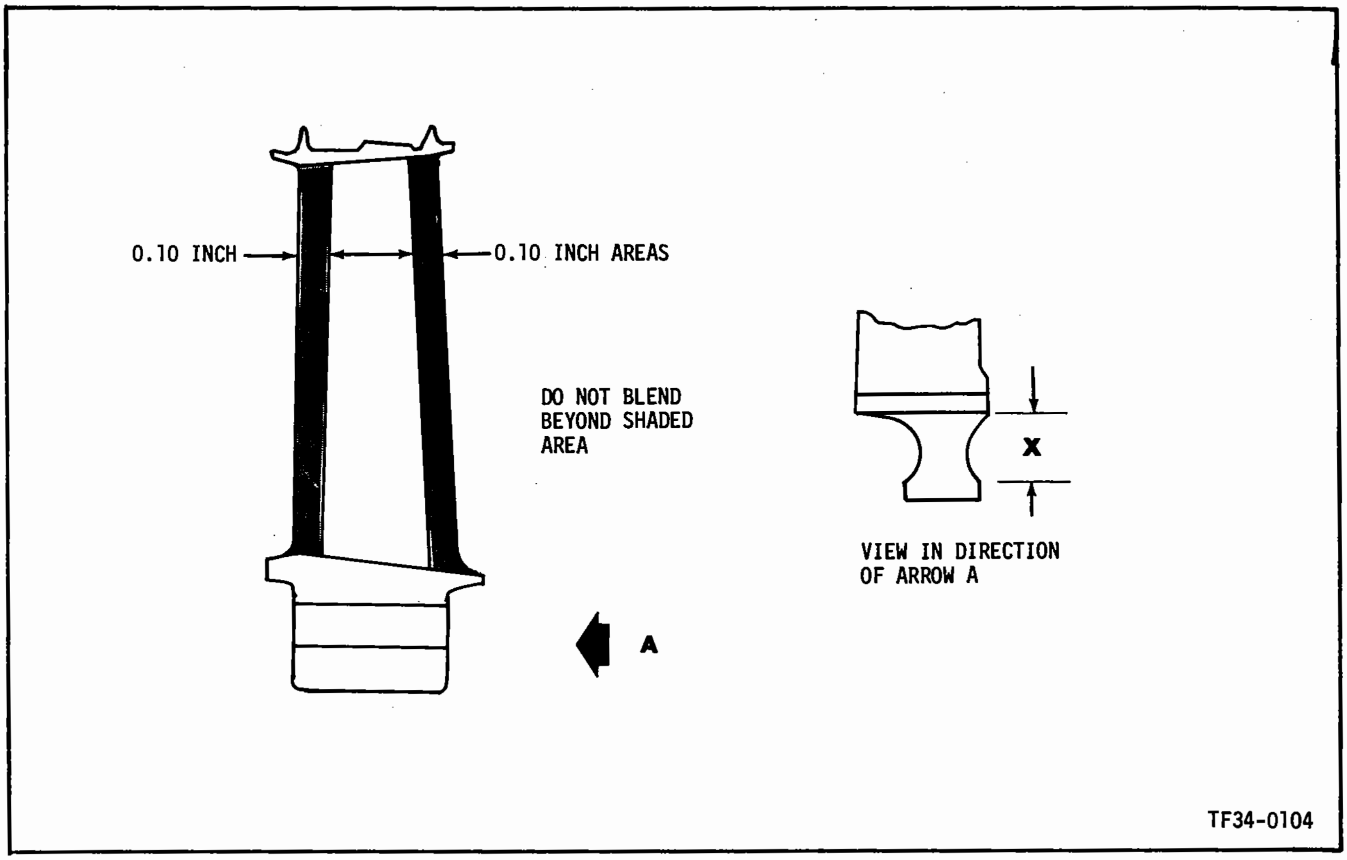


Figure 5-79. Low-Pressure Turbine Blade Inspection

5-191. INSPECTION OF LOW-PRESSURE TURBINE ROTOR BLADES (ALL STAGES). (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
d. Hot gas corrosion (sulfidation).	Any amount of discoloration or surface roughness, providing there is no blistering, splitting or separation (delamination) of the airfoil surface.	Not repairable.	Replace blade.
2. Dovetail area X (see figure 5-79) for:			
a. Nicks, pits, dents and scratches.	None allowed.	Not repairable.	Replace blade.
3. All other dovetail areas for:			
a. Nicks, pits, dents and scratches.	Any number 0.005 inch deep with no high metal.	Stage 3. Not repairable.	Replace blade.
		Stages 4, 5, 6. Any number 0.005 inch deep with high metal.	Remove high metal with a smooth blend.

5-192. INSPECTION OF LOW-PRESSURE TURBINE ROTOR DISKS (ALL STAGES).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks.	None allowed.	Not repairable.	Replace rotor.
2. Nicks, pits, and scratches.	Any number 0.020 inch deep with no high metal. None to break over corners or in the bore.	Any number 0.020 inch deep, 1/2 inch long with high metal.	Remove high metal. Blend smooth. Note Surface finish at bore must be maintained in an axial or radial direction.
3. Dents.	None allowed.	Not repairable.	Replace rotor.

5-193. INSPECTION OF HPT AND LPT ROTOR SEALS (ALL STAGES).

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Overall seal except teeth for:			
a. Cracks.	None allowed.	Not repairable.	Replace rotor.
b. Nicks, gouges, scratches or dents.	Any number 1/64 inch deep. Cumulative length 3 inches. No high metal. Exception: HPT balance piston seal. Any number 0.005 inch deep.	Same as usable limits, with high metal.	Remove high metal.
2. Seal teeth for:			
a. Nicks and radial dents.	Any number 0.005 inch deep, 8 per tooth 1/32 inch deep, and 8 per seal 1/16 inch deep with no high metal or sharp edges.	Same as usable limits, with high metal or sharp edges.	Remove high metal and sharp edges.
b. Axial dents (bent teeth).	Any number 1/16 inch out of line. Not over 30% of any one tooth affected.	Not repairable.	Replace rotor.
c. Cracks.	None allowed.	Not repairable.	Replace rotor.
d. Chipped or missing abrasive coating if originally applied.	Any amount.	Not applicable.	Not applicable.

5-194. INSPECTION OF LOW-PRESSURE TURBINE ROTOR LOCKNUT. (See figure 5-80.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Forward vertical face (surface C) for:			

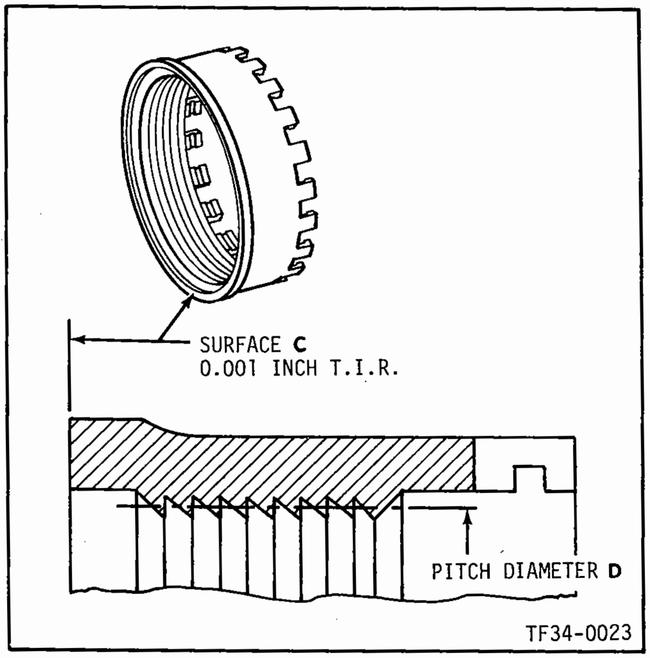


Figure 5-80. Low-Pressure Turbine Rotor Locknut Inspection

5-194. INSPECTION OF LOW-PRESSURE TURBINE ROTOR LOCKNUT. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
a. Galling.	Not more than 25% of each quadrant damaged with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Scratches and grooves.	Any amount with no high metal as long as a 63 microinch finish is maintained and face is square with pitch diameter within 0.001 inch TIR. (See figure 5-80.)	Same as usable limits with high metal.	Remove high metal.
c. Missing antiseize coating.	Not more than 25% missing.	Any amount.	Replace coating (see paragraph 5-195).
2. Threads for:			
a. Damage.	One quarter of one thread damaged or missing with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Missing antiseize compound.	Not more than 25% missing.	Any amount.	Replace coating (see paragraph 5-195).
3. Tangs for bending or other damage.	Any amount which does not prevent locknut from being assembled without excessive force.	Not repairable.	Replace locknut.

5-194. INSPECTION OF LOW-PRESSURE TURBINE ROTOR LOCKNUT. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
4. Remaining surfaces for:			
a. Scratches.	Any number, 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.
b. Dents.	Any number, 0.020 inch deep, with no high metal.	Same as usable limits, with high metal.	Remove high metal.

5-195. REPLACEMENT OF ANTISEIZE COMPOUND (MOLYKOTE X-15) ON LOW-PRESSURE TURBINE ROTOR LOCKNUT.

1. Place locknut in a solution of P-D-680 or equivalent cleaner, for 5 minutes.

2. Remove locknut from cleaner and wash it thoroughly in trichloroethylene (O-T-634).

3. Rinse locknut in warm water and air-dry.

4. Spray Molykote X-15, or equivalent, 0.0003-0.0007 inch thick on threads and surface C (figure 5-80).

5. Air-dry for 1/2 hour. Heat locknut for 2 hours at 180°F and for 2 hours at 300°F.

5-196. INSPECTION OF EXHAUST FRAME. (White light method.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Inner casing for:			
a. Cracks.	Any number, 1/4 inch long, at least 1 inch apart.	Any amount.	Weld (see table 5-6, item 2) or replace exhaust frame.
b. Dents.	Any number, 1/4 inch deep, at least 1 inch from flange.	Any number, any depth, at least 1 inch from flange.	Cold-work to usable limit. White-light inspect for cracks; see step 1.a. for limits.
2. Inner bolt flanges for nicks, dents, and scratches.	Any number, 1/32 inch deep with no high metal, provided 25% of original width of sealing surface is intact.	Same as usable limits, with high metal.	Remove high metal.
3. Centerbody nuts for:			
a. Poor locking action.	Usable if bolt cannot be turned through entire nut by hand.	Not repairable.	Replace nut (see paragraph 5-197).
b. Damaged or stripped threads.	Not more than 1 thread cumulative if bolt can be threaded into hole.	Not repairable.	Replace nut (see paragraph 5-197).
4. Outer casing for:			
a. Cracks in parent metal and welds.	None allowed.	One-half inch long (cumulative), not over 3 inches.	Weld (see table 5-6, item 2), or replace exhaust frame.
b. Dents/buckling.	Any number, 1/8 inch deep from original contour.	Any number, any depth.	Cold-work to usable limit. Inspect using white-light; no cracks allowed.

5-200. INSPECTION OF EXHAUST VENT COLLECTOR. (CONT.)

Inspect	Usable Limit	Max Repairable Limits	Corrective Action
b. Nicks, dents and scratches.	Any number 0.005 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.
2. Forward flange for:			
a. Broken or damaged lugs.	None allowed.	Not repairable.	Replace collector.
b. Damage or stripped thread. (Collector has left-hand threads.)	2 threads damaged with no high metal, provided threads can be utilized without cross threading.	2 threads, total cumulative length with high metal.	Remove high metal.
c. O ring sealing surface for nicks and scratches.	Any number 0.004 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.
d. Air seal seat for nicks and scratches.	Any number 0.004 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.
3. Aft flange O ring sealing surface for nicks and scratches.	Any number 0.004 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.

5-201. INSPECTION OF EXHAUST CENTER BODY.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. Cracks in:			
a. Shell/cone.	Any number 3/16 inch long.	Not repairable.	Replace centerbody.
b. Stiffener.	Any number 1/8 inch long.	Not repairable.	Replace centerbody.
2. Dents.	Any number 1/8 inch deep.	Any number.	Cold work to restore contour to usable limits. Inspect for cracks. None allowed.
3. Entire centerbody for nicks and scratches.	Any number 0.010 inch deep, with no high metal.	Same as usable limits, with high metal.	Blend high metal.

5-202. INSPECTION OF FORWARD C-SUMP HEAT SHIELD.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. All areas for:			
a. Cracks.	None allowed.	Any amount.	Repair weld per table 5-6, item 11.
b. Nicks and scratches.	Any amount up to full penetration.	Same as usable limits, with high metal.	Remove high metal.
c. Dents.	Any number 1/16 inch deep.	Any amount that can be reworked to usable limits.	Cold work to usable limits. No cracks allowed.

5-202. INSPECTION OF FORWARD C-SUMP HEAT SHIELD. (CONT.)

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
2. Worn bolt holes.	Any amount.	Not applicable.	Not applicable.
3. Aft face for flatness.	1/16 inch TIR out of flatness.	Any amount.	Cold work to usable limits. No cracks allowed.
4. Aft ID out of round.	Not to exceed 1/64 inch out of round in free state.	Any amount that can be reworked to usable limits.	Cold work to usable limits. No cracks allowed.

5-203. INSPECTION OF AIR OIL SEPARATOR.

Inspect	Usable Limits	Max Repairable Limits	Corrective Action
1. All areas for:			
a. Cracks.	None allowed.	Not repairable.	Replace separator.
b. Nicks, dents and scratches.	Any amount 1/64 inch deep with no high metal.	Same as usable limits, with high metal.	Remove high metal.
2. ID out of round.	Up to 0.005 inch out of round is allowed.	Not repairable.	Replace separator.

SECTION VI

ASSEMBLY OF SUBASSEMBLIES

6-1. GENERAL.

This section contains instructions for assembling engine component parts and subassemblies into major subassemblies.

6-2. ORGANIZATION.

1. All the information needed to completely assemble the following major subassemblies is included.

a. Fan Rotor

b. Fan Stator

c. Compressor Rotor

d. Combustion Chamber Module

e. High-Pressure Turbine Rotor

f. High-Pressure Turbine Stator

g. Transition Casing Assembly

h. Low-Pressure Turbine Rotor

i. Low-Pressure Turbine Stator

j. Low-Pressure Turbine Module

2. It should be kept in mind that installation procedures for subassemblies that were removed for maintenance work and not for routine inspection may be included in Section VII. If, for example, only the low-pressure turbine rotor was removed for maintenance reasons, assembly instructions for this part can be found in Section VI, and installation instructions can be found in Section VII. Complete as much subassembly work per Section VI as possible before proceeding to Section VII.

3. The order of assembly of subassemblies is from the forward end of the engine aft.

CAUTION

The cleanliness of engine parts has a direct effect on engine performance. Keep all parts and assemblies clean and free of corrosion and foreign matter. These instructions demand special handling of engine parts and subassemblies. Do not remove wrappings, protectors or covers until the part is to be installed.

4. During assembly do not drop anything into a subassembly. If anything is dropped, find and remove it before doing any more work. Do not leave tools or parts on any part of the unit at any time. Return each tool to its proper place as soon as it has served its purpose. Protective caps, plugs and covers used to cover openings in subassemblies, engine lines and accessories must be free of dirt and loose material to minimize contamination.

5. Do not reuse any of the following items:

a. Gaskets (paper).

b. Preformed Packings (O-rings).

c. Deformable Lockwashers.

d. Compressor Vane Spindle Keywashers.

e. Inlet Guide Vane Lever Arm Locking Clips.

f. Cotter Pins.

g. Lockwire.

h. Blade Locking Keys.

i. Turbine Nozzle Sealing Strips.

j. Self-locking Nuts (if run-on torque is low).

6. Do not use excessive force to assemble mating parts. If excessive force seems necessary, inspect mating surfaces for burrs or pickups and carefully remove any such defects.

7. When heating parts in an oil bath, suspend parts in oil so that they will not touch the oil container. Use asbestos gloves when handling heated parts.

8. General Assembly Practices and Procedures will be found at the beginning of Section VII.

9. All engine bearings and their respective seal runners, locknuts, lockwashers can be replaced without affecting balance of engine. Make sure that bearings are replaced as matched sets and that matchmarks are aligned as required. Also be sure that seating checks are done where required in assembly procedures. Blades can be replaced by following blade replacement procedures in Section V.

10. Heat resistant lockwire (MS20995N20 and MS20995N32) may be used in place of R297P02 and R297P04.

6-3. ASSEMBLY OF FAN ROTOR.

For special tools, see table 2-1, group 16.

1. Place shaft (11, figure 6-1) in holder (21C-5037), forward end down.

2. Measure and record dimensions A, B, and D per figure 6-2.

WARNING

Use asbestos gloves when handling heated parts.

CAUTION

The bearing is a matched set. Be sure bearing parts have same serial numbers.

3. Heat seal runner (9, figure 6-1) and No. 1 bearing inner races (8) for 20 minutes at 300°F.

4. While you are waiting for parts to heat, put 28 bolts (10) into holes in forward flange of shaft (11).

5. Install seal runner (9) using pusher (21C5018). Measure and record dimension C per figure 6-2. Dimension C plus dimension B shall be within 0.001 inch of dimension A. Reseat if necessary.

6. Install No. 1 bearing forward inner race (8) with pusher (21C5018). Check seating with a 0.001 inch feeler gage.

7. Install No. 1 bearing balls and outer race (8), keyway forward. Install No. 1 bearing aft inner race (8), using pusher (21C5018). Allow parts to cool to room temperature.

8. Measure and record dimension E per figure 6-2. Add dimensions D and E. Sum must be within 0.001 inch of dimension C.

9. Assemble locknut (7, figure 6-1) to shaft and torque it to 800-900 lb ft using wrench (21C5042) and torque multiplier (SWE-8100) or Powerdyne (2501.) Apply 71-80 lb ft input to SWE-8100 torque multiplier.

10. Assemble keywasher (6) and retaining ring (5).

CAUTION

The bearing is a matched set. Be sure bearing parts have same serial number.

11. Heat No. 2 bearing inner race (4) at 300°F for 20 minutes. Install inner race on shaft using pusher (21C5022). Check seating with a 0.001 inch feeler gage.

12. Install locknut (3) and torque to 200-240 lb ft using wrench (21C5192) and torque multiplier (SWE-102). Apply 26-31 lb ft input to torque multiplier.

13. Install lockwasher (2) and retaining ring (1) to locknut (3).

CAUTION

Be sure fan blade retaining pins are installed with head on forward side of disk.

14. Slide fan blades (13) into slots in disk (14) from which they were removed and assemble pins (12). Assemble pin retainer (21C5117).

15. Place disk and shaft aside for final installation to engine.

6-4. ASSEMBLY OF FAN STATOR.

Note

Fan stator vanes (4, figure 6-3) must be assembled to the 12 o'clock position and 2 positions on both sides of 12 o'clock. These vanes can be identified by 4 bolt-hole ears at the tip while the 39 vanes (3) have only 2 ears.

1. Assemble 44 fan vanes (3, 4) to fan vane inner support (2) with 44 bolts (9), fingertight. Assemble fan vanes (4) to hole marked TOP on inner support and 2 holes on both sides of TOP.

2. Assemble 98 bolts (5) and 98 nuts (6) to fan vanes and stator assembly, fingertight.

3. While torquing bolts (9) to 28-30 lb ft, restrain fan vanes so that the aft edge of vane platform is parallel to aft flange at inner support (2) within 0.010 inch.

4. Torque nuts (6) to 38-42 lb in.

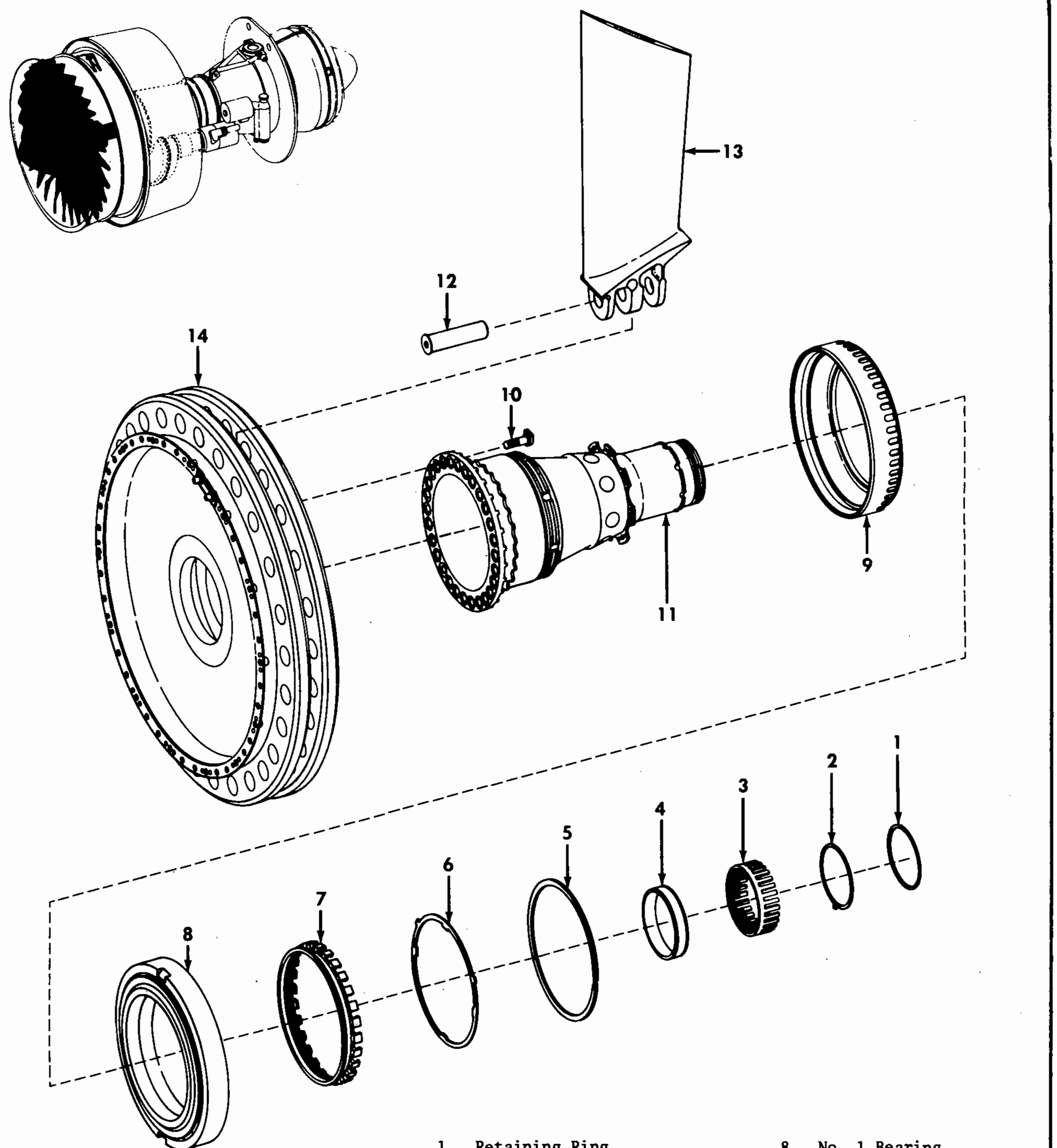
5. Assemble 44 fan vane spacers (7) with 88 nuts (8). Torque nuts to 38-42 lb in.

6. Lock-wire bolts (9), double-strand method, using 0.032 inch lockwire.

7. Install fan housing (10) with 73 bolts (11), 73 washers (12) and 73 nuts (13). Torque bolts to 38-42 lb in.

8. Install 2 ground handling lugs (14) using 4 bolts (15). Torque bolts to 38-42 lb in.

9. Assemble flange adapter (16) to fan stator assembly with 24 bolts (17), 24 washers (18), and 24 nuts (19). Torque bolts to 38-42 lb in.



1. Retaining Ring
2. Key Washer
3. Locknut
4. No. 2 Bearing Inner Race
5. Retaining Ring
6. Key Washer
7. Locknut
8. No. 1 Bearing
9. Seal Runner
10. Bolt
11. Front Shaft
12. Pin
13. Blade
14. Disk

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Figure 6-1. Assembly of Fan Rotor

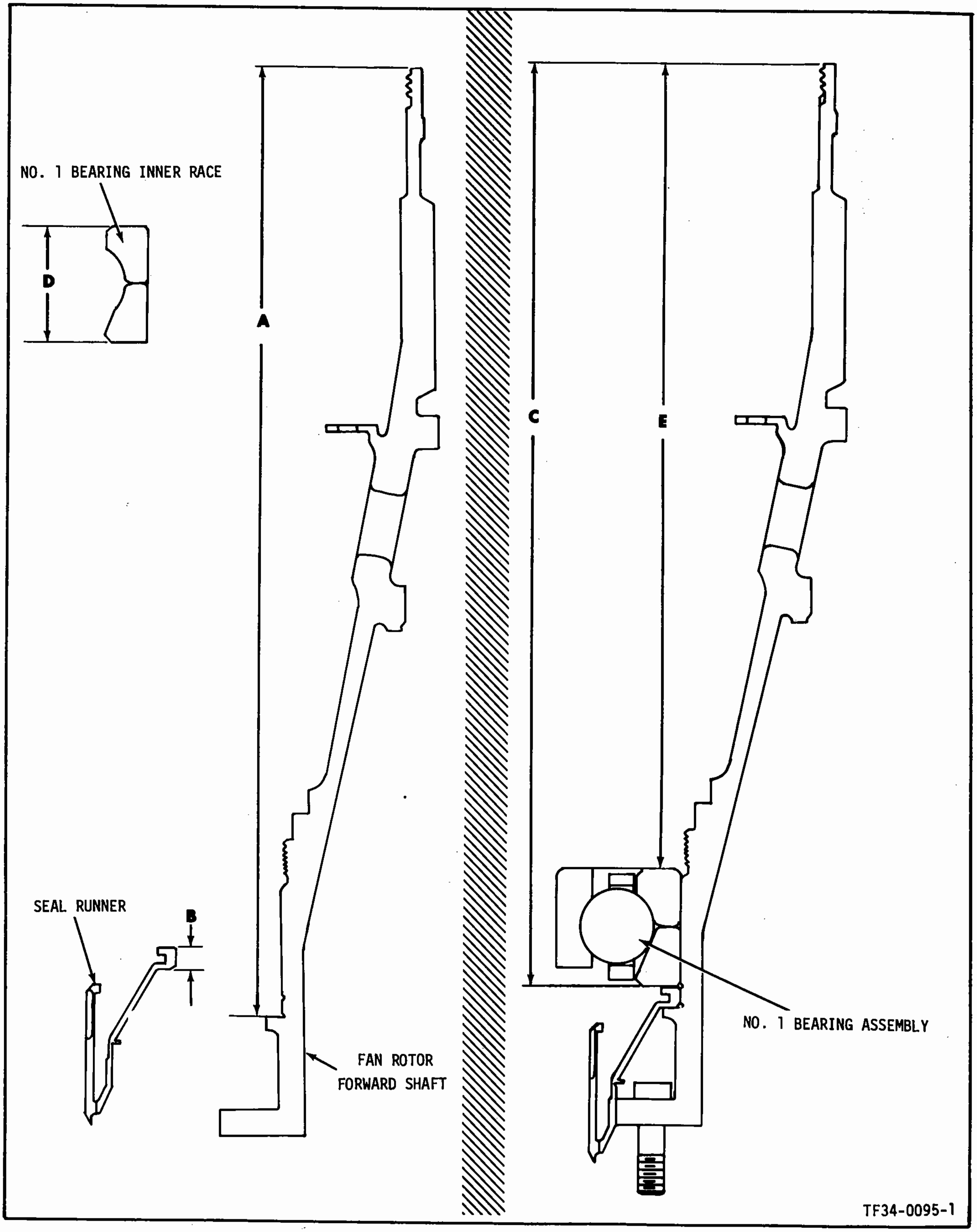
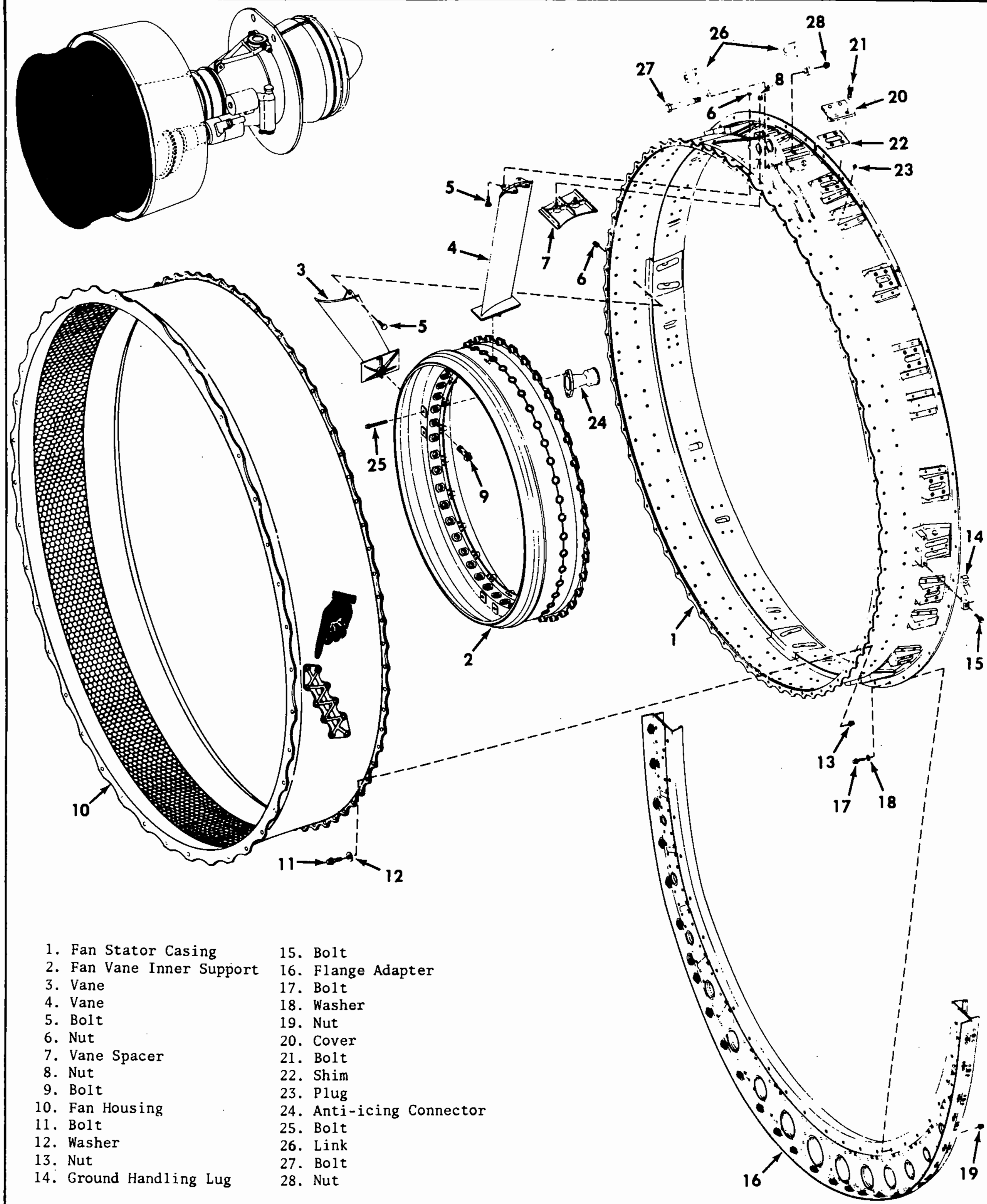


Figure 6-2. No. 1 Bearing and Seal Runner Seating Checks



1. Fan Stator Casing
2. Fan Vane Inner Support
3. Vane
4. Vane
5. Bolt
6. Nut
7. Vane Spacer
8. Nut
9. Bolt
10. Fan Housing
11. Bolt
12. Washer
13. Nut
14. Ground Handling Lug
15. Bolt
16. Flange Adapter
17. Bolt
18. Washer
19. Nut
20. Cover
21. Bolt
22. Shim
23. Plug
24. Anti-icing Connector
25. Bolt
26. Link
27. Bolt
28. Nut

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Figure 6-3. Assembly of Fan Stator

Note

Flange adapter brackets will be installed after the fan stator is assembled to engine.

10. If removed, assemble 16 instrument covers (20) and shims (22) (to bring cover ID flush with casing ID) to bosses on fan stator casing (1) with 64 bolts (21). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lock-wire.

11. Install 8 plugs (23) to fan stator casing (1). Torque plugs to 25-30 lb in. and lock-wire (to bolt (21) on adjacent cover) double-strand method, using 0.032 inch lockwire.

12. Assemble 4 anti-icing connectors (24) to fan vane inner support (2) with 8 bolts (25). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

13. If necessary, assemble 2 links (26) to fan stator casing (1) front mount with 2 bolts (27) and 2 nuts (28). Torque nuts until flush with links. Do not overtorque.

14. Place stator assembly into stand (21C5072) by connecting quick-release pins to ground handling lugs (14).

6-5. ASSEMBLY OF COMPRESSOR ROTOR. For special tools, see table 2-1, group 6. Lubricate packings with engine oil.

1. Place compressor rotor (1, figure 6-4) in buildup stand (21C5089), forward end up.

2. Measure and record dimension K (see figure 6-5), using a parallel bar and a 6-inch depth vernier.

3. Measure and record dimension J (seal runner flange thickness), using a 0-1 inch micrometer.

WARNING

Use asbestos gloves when handling heated parts.

4. Heat seal runner (3, figure 6-4) at 250-300°F for 20 minutes. Install packing (2) into groove of compressor front shaft.

5. Using pusher (21C5048), install seal runner onto shaft. Measure and record dimension F (see figure 6-5).

6. Add dimension F to dimension J. Result should equal dimension K within 0.001 inch. Reseat seal runner, if necessary.

7. Measure and record dimension G (see figure 6-5), the thickness of No. 3 bearing inner races (14, figure 6-4), using a 0-1 inch micrometer. Measure each race separately and add dimensions together.

8. Measure and record dimension H (see figure 6-5), the thickness of oil slinger (4, figure 6-4), using a 0-1 inch micrometer.

9. Add dimensions G and H. Subtract the result from dimension F. Record as dimension L. This result will be used to check seating of No. 3 bearing.

10. Heat both halves of No. 3 bearing (14, figure 6-4) inner races to 250-300°F for 20 minutes.

11. Measure and record the following dimensions for use in calculating shim thickness requirement at installation of compressor rotor.

a. Measure and record dimension A (see figure 6-5), the depth of No. 3 bearing housing (5, figure 6-4).

b. Measure and record dimension C (see figure 6-5), the thickness of No. 3 bearing outer race.

12. Assemble carbon seal (7, figure 6-4) to bearing Housing (5) as follows:

a. Assemble 2 packings (6) to carbon seal (7).

b. Install carbon seal into bearing housing (5), using pusher (21C5050), aligning the slot in seal with the pin in bearing housing.

c. Install retaining ring (8) using snapring pliers (Truarc No. 7), tapered side up.

13. Assemble oil tube (10) and oil nozzle (9) as follows:

a. Assemble packing (11) to one end of tube (10).

b. Insert end of tube with packing into oil nozzle (9). Engage pin of nozzle in the hole of tube flange.

c. Install nozzle and tube assembly into hole in bearing housing (5), placing stud on housing through the hole in the nozzle and tube assembly flange.

d. Assemble nut (12) to stud and torque it to 38-42 lb in.

14. Install oil screen (13) onto the carbon seal retaining ring (8), using pusher (21C5050) aligning the slot in the screen with the oil nozzle (9).

15. Assemble bearing housing (5) onto compressor rotor front shaft.

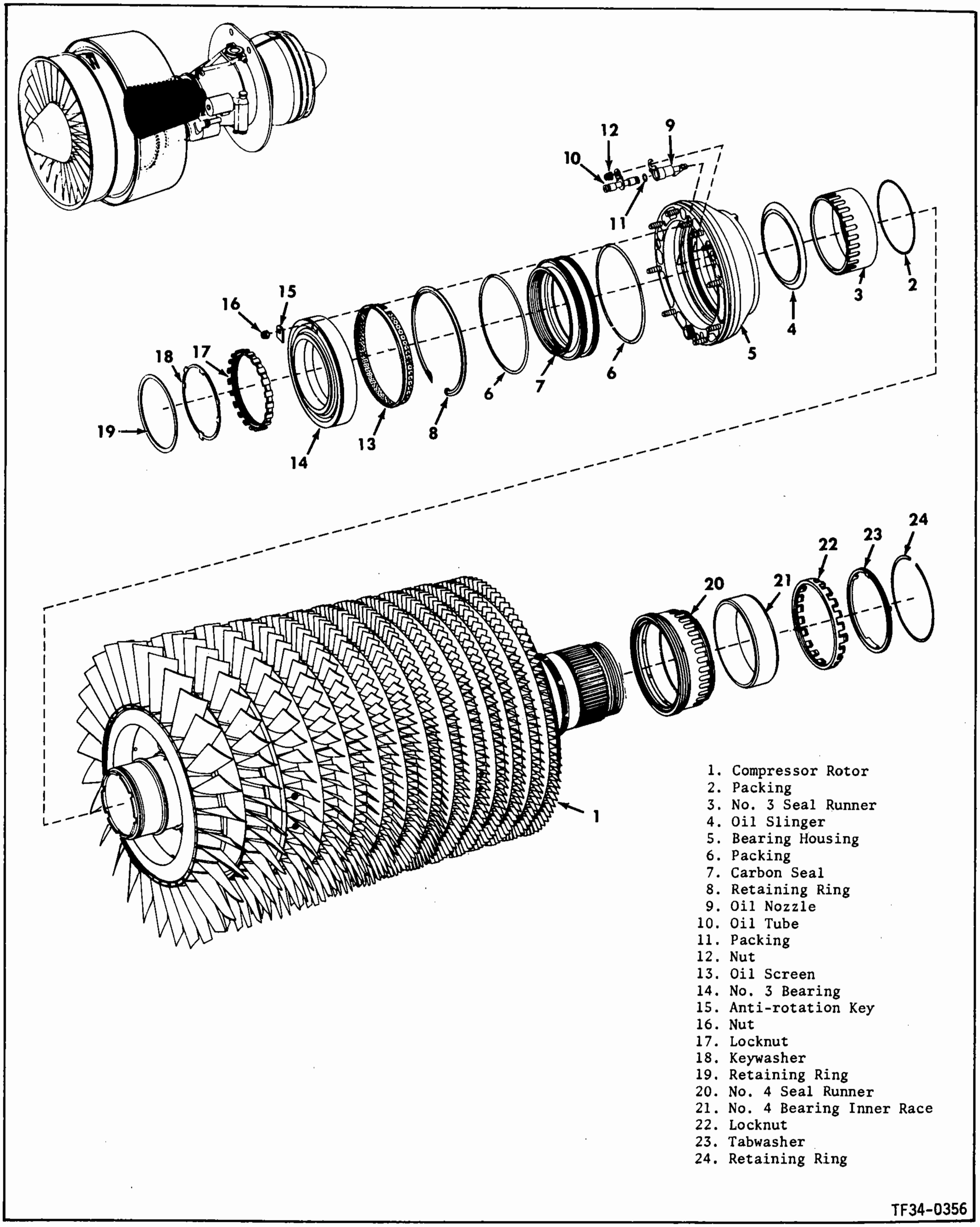


Figure 6-4. Assembly of Compressor Rotor

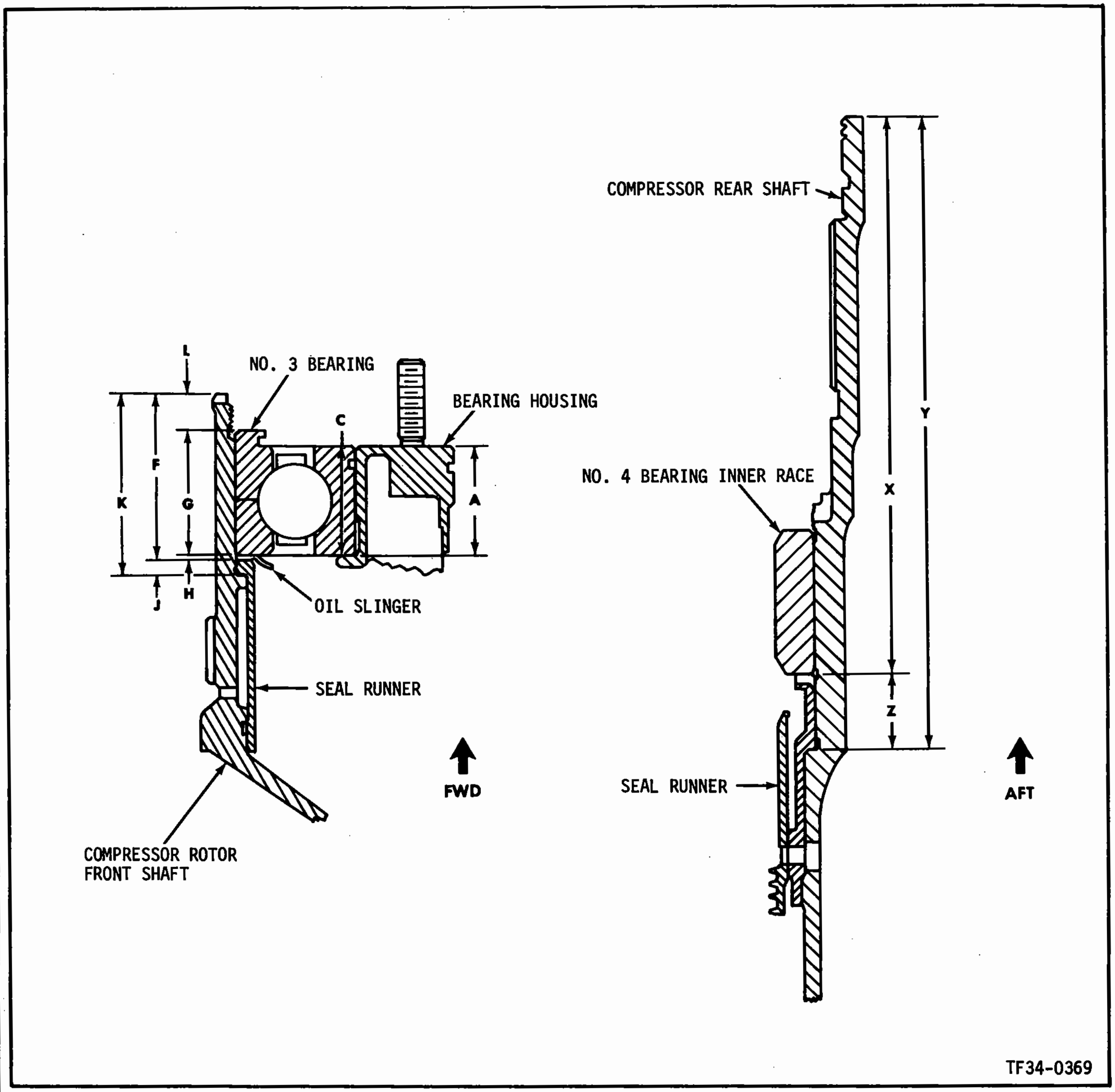


Figure 6-5. Seating Check of No. 3 Bearing and No. 4 Bearing

16. Assemble oil slinger (4), flare pointing aft, onto compressor rotor shaft and seat it on seal runner (3).

WARNING

Use asbestos gloves when handling heated parts.

17. Assemble aft half (no puller groove) of No. 3 bearing inner race (14) onto compressor front shaft using pusher (21C5048). Remove pusher.

18. Assemble No. 3 bearing balls and cage and outer race, anti-rotation slot facing forward and aligned with slot in housing (5).

19. Assemble anti-rotation key (15) and nut (16). Torque nut to 105-115 lb in.

WARNING

Use asbestos gloves when handling heated parts.

20. Assemble forward half of No. 3 bearing inner race (14) to compressor front shaft, puller groove forward, using pusher (21C5048).

21. Measure and record dimension L (see figure 6-5). Compare dimension L to the dimension L calculated in step 9. Dimensions must compare within 0.001 inch. Reseat bearing inner races if dimensions do not compare.

22. Assemble locknut (17, figure 6-4) to front shaft. Use spanner wrench (21C5193), torque multiplier (SWE-102 or Powerdyne 2501) and torque locknut to 300 lb ft. Input 38 lb ft to SWE-102. Check alignment of slot in compressor shaft with a slot in locknut. Torque locknut up to 350 lb ft to get alignment (46 lb ft input to SWE-102).

23. Install lockwasher (18) and retaining ring (19).

24. If parts affecting clearance 69 have been replaced (see table 8-2), check minimum clearance by inserting a feeler gage (set up to minimum limit for clearance 69 specified in table 8-1) between the No. 3 bearing housing and stage 1 disk ID. Feeler gage must enter.

25. Turn compressor rotor over in buildup stand (21C5089) so that aft end is up.

26. Using a 0-1 inch micrometer, measure and record dimension Z (see figure 6-5), thickness of No. 4 seal runner (20, figure 6-4). Heat seal runner and No. 4 bearing inner race (21) at 250-300°F for 20 minutes.

27. Using a 6 inch depth vernier, measure and record dimension Y (see figure 6-5), distance from end of compressor rotor rear shaft to seal runner seating surface.

WARNING

Use asbestos gloves when handling heated parts.

28. Align matchmarks and install No. 4 seal runner (20, figure 6-4) using pusher (21C5053). Using a 6 inch depth vernier, measure and record dimension X (see figure 6-5). Dimension X should equal the result of dimension Y minus dimension Z within 0.001 inch. Reseat seal runner if necessary.

29. Assembly No. 4 bearing inner race (21, figure 6-4) to compressor rear shaft, using pusher (21C5053). Tap pusher with soft-faced mallet until inner race cools sufficiently (about 1 minute). Check seating of inner race by trying to insert a 0.001 inch feeler gage between the inner race and seal runner. Gage must not enter.

30. Assemble locknut (22) to compressor rear shaft. Use spanner wrench (21C5194) and torque multiplier (SWE-102 or Powerdyne 2501) and torque locknut to 200-300 lb ft (26-40 lb ft input to SWE-102), aligning a slot in locknut with a slot in compressor rear shaft.

31. Assemble retaining ring (24) to groove in tabwasher (23). Assemble tabwasher to locknut, engaging the tab in slot of compressor rear shaft. Lightly tap tabwasher until retaining ring (24) is engaged in groove of locknut (22).

6-6. ASSEMBLY OF COMBUSTION MODULE.

1. Place combustion casing (1, figure 6-6) in buildup stand (21C5116), aft end up.

Note

All parts where Plastiseal F is applied must be assembled and torqued before 30 minutes has elapsed.

2. If removed, assemble 3 nut assemblies (2) to the forward side of the inner flange using 6 screws (3) through the 6 small holes. Torque screws to 28-32 lb in.

3. Check seating of the screws (3). Heads must be a minimum of 0.005 inch below surface of combustion casing. Turn combustion casing over.

4. Deleted.

5. Assemble compressor discharge seal (4) to the forward end of the combustion casing as follows:

a. Apply a thin coat of Plastiseal F to the mating flange of the seal (4).

b. Assemble seal to the forward end of the combustion casing using 2 nut assemblies (5) and 6 screws (7) through the 6 small holes.

c. Torque screws to 28-32 lb in.

d. Check seating of the screws. Heads must be a minimum of 0.005 inch below surface of combustion casing.

6. Assemble the forward and aft scavenge tubes to the B-sump housing as follows:

a. Assemble 2 packings (8), one each to the forward and aft scavenge tubes (9, 10) respectively.

b. Assemble forward scavenge tube (9) to the 7 o'clock strut inside B-sump housing.

c. Assemble aft scavenge tube (10) to the 5 o'clock strut inside B-sump housing.

7. If removed, assemble 4 nut assemblies (11) to the B-sump housing (13) at outer diameter of the No. 5 bearing bore using 8 screws (12). Torque screws to 28-32 lb in.

8. Assemble the No. 5 bearing outer race (14) and oil nozzles (15) to the aft end of the B-sump housing (13) as follows:

a. Assemble the No. 5 bearing outer race (14) to the bearing bore at the aft end of the B-sump housing (13) with the anti-rotation slot aft.

b. Place bearing retainer (14) over the No. 5 bearing aligning antirotation key and oil nozzle ports.

c. Assemble 2 packings (17), one each to 2 oil nozzles (15).

d. Insert nozzles through bearing retainer (16) into lube ports of the B-sump housing.

e. Secure retainer and nozzles with 8 bolts (18).

f. Secure aft scavenge tube with screw (19).

g. Torque bolts to 38-42 lb in. and screw to 28-32 lb in.

9. If removed, assemble 4 nut assemblies (20) to the B-sump housing at outer diameter of the

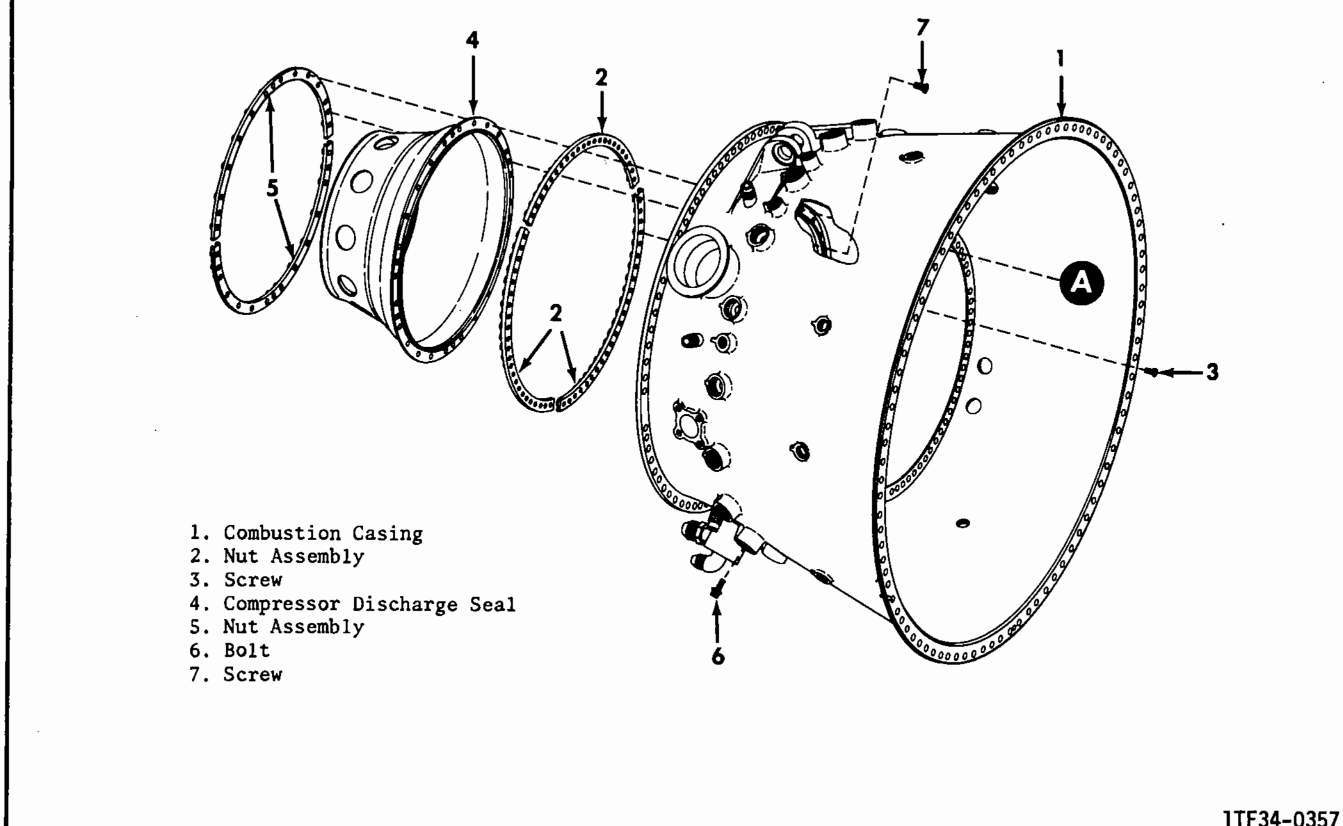
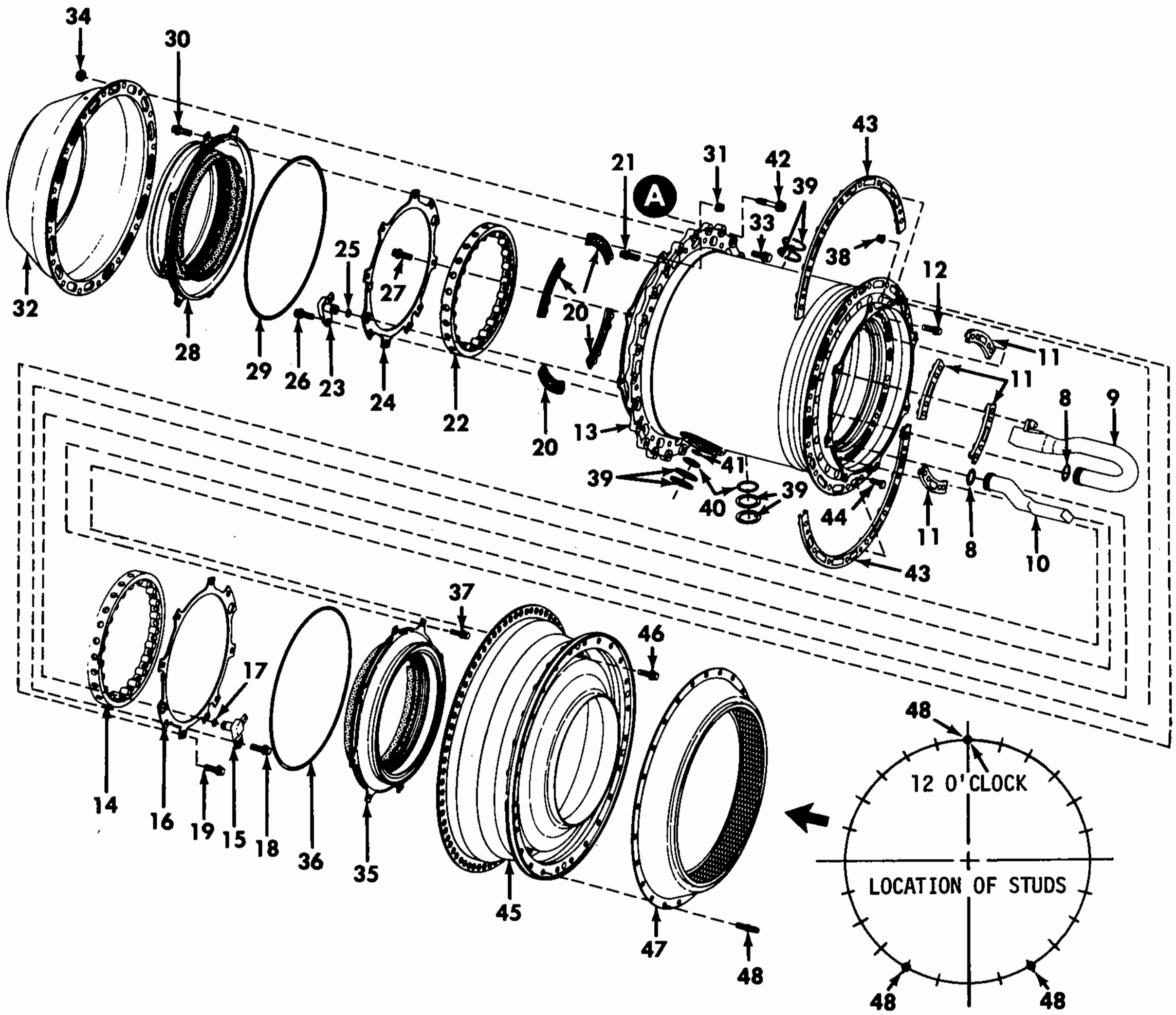


Figure 6-6. Assembly of Combustion Chamber Module (Sheet 1 of 4)



8. Packing
9. Forward Scavenge Tube
10. Aft Scavenge Tube
11. Nut Assembly
12. Screw
13. B-sump Housing
14. No. 5 Bearing Outer Race
15. Oil Nozzle
16. Retainer
17. Packing
18. Bolt
19. Screw
20. Nut Assembly
21. Screw
22. No. 4 Bearing Outer Race
23. Oil Nozzle
24. Retainer
25. Packing
26. Bolt
27. Screw
28. No. 4 Carbon Seal
29. Packing
30. Bolt
31. Nut
32. Forward Seal
33. Bolt
34. Nut
35. No. 5 Carbon Seal
36. Packing
37. Bolt
38. Nut
39. Piston Ring
40. Packing
41. Packing
42. Bolt
43. Nut Assembly
44. Bolt
45. Air Seal
46. Bolt
47. Balance Piston Seal
48. Shouldered Stud

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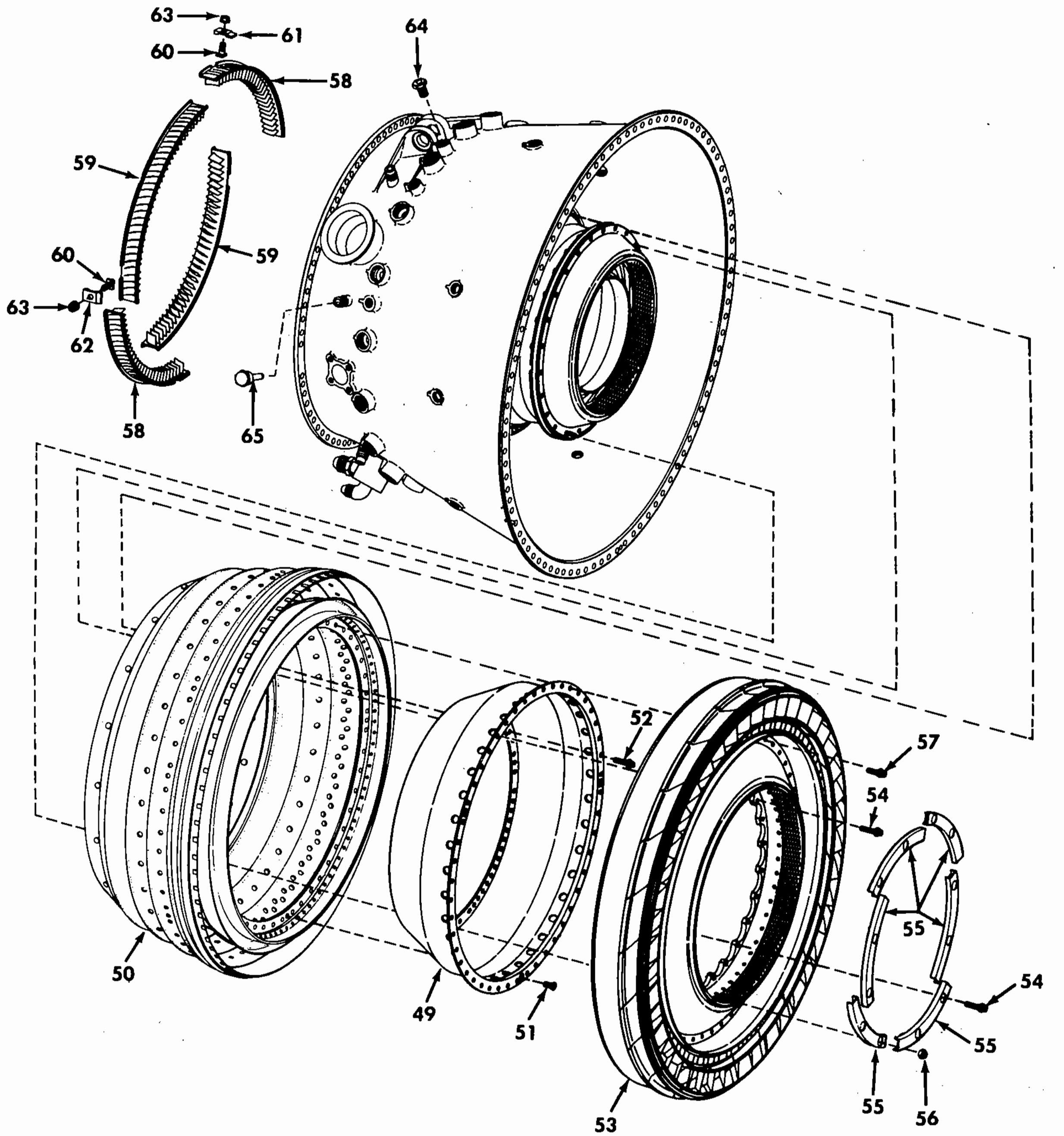
Figure 6-6. Assembly of Combustion Chamber Module (Sheet 2 of 4)



49. Inner Duct
50. Liner
51. Screw
52. Bolt
53. Stage 1 Nozzle
54. Bolt
55. Bolt Shield
56. Nut
57. Bolt
58. Exit Guide Vane Sector
59. Exit Guide Vane Sector
60. Key Bolt
61. Retainer Key
62. Retainer Key
63. Nut
64. Pressure Plug
65. Temperature Cap

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Figure 6-6. Assembly of Combustion Chamber Module (Sheet 3 of 4)

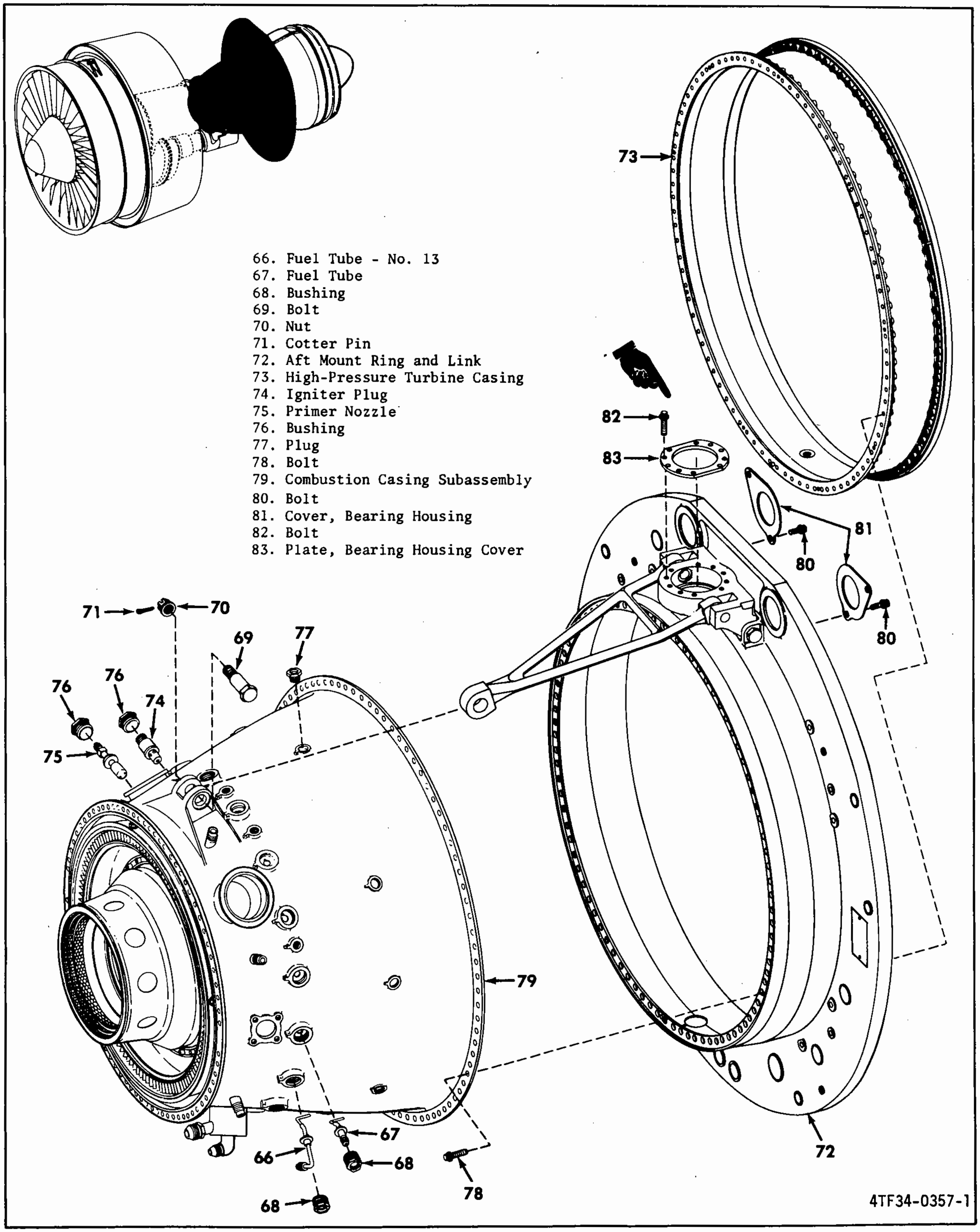


Figure 6-6. Assembly of Combustion Chamber Module (Sheet 4 of 4)

No. 4 bearing bore using 8 screws (21). Torque screws to 28-32 lb in.

10. Assemble the No. 4 bearing outer race (22) and oil nozzles (23) to the forward end of the B-sump housing (13) as follows:

a. Assemble the No. 4 bearing outer race (22) to the bearing bore at the forward end of the B-sump housing (13) with the antirotation slot forward.

b. Place bearing retainer (24) over the No. 4 bearing, aligning antirotation key and oil nozzle ports.

c. Assemble 2 packings (25), one each to 2 oil nozzles (23).

d. Insert nozzles through bearing retainer into lube ports of B-sump housing (13).

e. Secure retainer and nozzles with 8 bolts (26).

f. Secure forward scavenge tube with screw (27).

g. Torque bolts to 38-42 lb in. and screw to 28-32 lb in.

11. Assemble No. 4 carbon seal (28) to the forward end of the B-sump housing as follows:

a. Assemble packing (29) to carbon seal (28).

b. Assemble carbon seal to the forward end of the B-sump housing using 8 bolts (30) and nuts (31) with bolt heads forward.

c. Torque bolts to 28-32 lb in.

12. Assemble forward seal assembly (32) to the forward end of the B-sump housing (13) as follows:

a. Assemble forward seal assembly (32) to the forward end of the B-sump housing using 16 bolts (33) and nuts (34) with bolt heads aft.

b. Torque bolts to 38-42 lb in.

c. Lock-wire bolts, double-strand method, using 0.032 inch lockwire.

13. Assemble No. 5 carbon seal (35) to the aft end of the B-sump housing as follows:

a. Assemble packing (36) to carbon seal (35).

b. Assemble carbon seal to the aft end of the B-sump housing (13) using 8 bolts (37) and nuts (38) with boltheads aft.

c. Torque bolts to 28-32 lb in.

14. Assemble piston rings and packings to the 3, 5, and 7 o'clock struts as follows:

Note

Piston ring end gaps to be staggered approximately 180°. Do not lubricate.

a. Assemble 2 piston rings (39) to 3 o'clock strut inside combustion casing.

b. Assemble 2 piston rings (39) and packing (40) to 5 o'clock strut inside combustion casing.

c. Assemble 2 piston rings (39), packing (40) and packing (41) to 7 o'clock strut inside combustion casing.

15. Assemble B-sump housing to combustion casing as follows:

a. Assemble 24 bolts (42) to the forward flange of the B-sump housing (13) engaging approximately 6-8 threads.

b. If removed, assemble 2 nut assemblies (43) to the forward side of the outer flange on the aft end of the B-sump housing using 6 bolts (44) through the 6 small holes.

c. Position the 3, 5, and 7 o'clock struts in the combustion casing radially outboard.

d. Apply a thin coat of Plastiseal F to the forward mating flange of the B-sump housing.

CAUTION

Be sure B-sump housing is aligned exactly. One hole off will allow insertion of tubes but will cause leakage when engine is run.

e. Assemble B-sump housing to combustion casing, aligning lube and scavenge ports at 5 and 7 o'clock position, and air bleed tube at 3 o'clock position with those in combustion casing.

f. Secure B-sump housing (13) with 24 bolts (42).

g. Torque bolts to 38-42 lb in.

h. Apply a thin coat of Plastiseal F to the mating flange of the tubes at 5 and 7 o'clock.

i. Engage tubes at 5 and 7 o'clock into B-sump housing (13) and secure using 8 bolts (6) at each of the 5 and 7 o'clock positions.

j. Torque bolts to 105-115 lb in.

k. Lock-wire bolts on tube at 5 and 7 o'clock, double strand method, using 0.032 inch lockwire.

16. Assemble air seal to the B-sump housing as follows:

a. Apply a thin coat of Plastiseal F to the forward side of the forward mating flange of air seal (45).

b. Assemble air seal (45) to the aft end of the B-sump housing (13) aligning the match-marked arrow with the 3 o'clock strut.

c. Secure the inner flange of the seal to the housing (13) using 16 bolts (46). Torque bolts to 38-42 lb in.

17. Assemble balance piston seal (47) to the aft flange of the air seal (45) using 3 shouldered studs (48) spaced as shown, starting at 12 o'clock hole. Torque studs to 15-20 lb in.

18. Assemble aft inner duct (49) to combustion liner (50) as follows:

a. Apply a light coat of Magnesium Hydroxide compound (milk of magnesia - unflavored) to 3 screws (51) and mating flange holes. Allow to dry before assembly.

CAUTION

Be sure alignment pin engages slot in inner duct completely.

b. Assemble aft inner duct (49) to combustion liner (50) inserting alignment pin into locating hole of liner, using 3 screws (51).

c. Torque screws to 15-20 lb in.

d. Check seating of screws (51). Heads must be a minimum of 0.005 inch below surface of inner duct.

19. Assemble combustion liner (50) and aft inner duct (49) to combustion casing (1) as follows:

a. Assemble combustion liner and aft inner duct to the inner flange of the combustion casing using 63 bolts (52), aligning liner and duct locating pin at 12 o'clock.

b. Torque bolts to 88-92 lb in.

20. Assemble first-stage nozzle to the combustion casing as follows:

a. Lower the first-stage nozzle (53) onto combustor aligning the 12 o'clock matchmark and 3 holes of the inner flange with the studs (48) in the combustion casing.

b. Secure the inner flange using 12 bolts (54) in every other hole, starting with a hole next to any one of the 3 studs (48).

c. Torque bolts (54) on inner flange to 88-92 lb in.

d. Assemble 6 bolt shields (55) to the inner flange and secure with 9 bolts (54).

e. Assemble 3 nuts (56), one each to each of the 3 studs (48).

f. Torque bolts and nuts securing shields to 88-92 lb in.

g. Secure the outer flange using 47 bolts (57).

h. Torque bolts in outer flange to 88-92 lb in.

i. Lock-wire bolts (57), double-strand method, using 0.020 inch lockwire.

21. Assemble exit guide vane (EGV) sectors with the trailing edge (sharp edge) aft, as follows:

a. Assemble EGV sector (58) at 12-3 o'clock position, using key bolt (60), retainer key (61), and nut (63) with bolthead inboard.

b. Assemble EGV sector (59) at 3-6 o'clock position, using key bolt (60), retainer key (62), and nut (63) with bolthead inboard.

c. Repeat step a. for 6-9 o'clock position.

d. Repeat step b. for 9-12 o'clock position.

e. Torque nuts (63) to 105-115 lb in.

CAUTION

Retainer keys must not protrude beyond face of combustion casing and must be parallel to the face within 0.002 inch.

22. Use a feeler gage and measure clearance 36, the distance between EGV tips and combustion casing at 6 equally spaced positions. See table 8-1 for limits.

23. Assemble 18 fuel tubes as follows:

a. Assemble 17 fuel tubes (66), one to each boss, omitting the 13th boss, and secure with bushings (68).

b. Assemble fuel tube (67) to the 13th boss and secure with bushing (68).

c. Using Borescope (21C9800), visually check each nozzle for proper alignment with the scrolls on the combustion liner.

d. Torque bushings to 160-180 lb in.

e. Lock-wire bushings to their respective bosses, double-strand method, using 0.032 inch lockwire.

24. Apply Plastiseal F to threads and under head of static pressure plugs (64). Install plugs and torque to 90-100 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

25. Assemble temperature caps (65) into fittings on combustion chamber and torque them to 180-200 lb in.

26. Turn combustion chamber so that aft end is up. Apply a light coat of Plastiseal F to combustion chamber aft flange.

27. Assemble aft mount ring (72) and link to aft flange.

28. Install bolt (69) through forward end of mount link and connection on combustion chamber. Install nut (70) and torque it to 80-90 lb in., aligning a cotter pin hole with slot in nut. Install cotter pin (71).

28A. Install thrust mount cover plate (83) with bolts (82). Torque bolts to 38-42 lb in. and lockwire, double-strand method, using 0.032 inch lockwire.

28B. Install aft mount ring bearings and covers (81) with bolts (80). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

29. Apply a light coat of Plastiseal F to forward flange of high-pressure turbine outer casing. Install high-pressure turbine outer casing (73) to combustion chamber aft flange. Install flange bolts and brackets as shown in figure 6-7. Torque flange bolts to 160-170 lb in.

30. Apply Plastiseal F to the threads and under head of borescope plugs. Assemble 7 borescope plugs (77, figure 6-6) along with brackets to ports in combustion chamber. Torque plugs to 180-200 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

6-7. ASSEMBLY OF HIGH-PRESSURE TURBINE ROTOR.

For special tools, see table 2-1, group 23.

1. Place rotor on buildup stand (21C5036 or 21C5039), shaft end up.

2. Assemble seal runner (4, figure 6-8) as follows:

a. Measure and record dimension U shown in figure 6-9.

b. Heat seal runner (4, figure 6-8) at 300°F for 20 minutes.

c. Measure and record dimension M shown in figure 6-9.

d. Assemble seal runner (4, figure 6-8) onto shaft using pusher (21C5057). Remove pusher.

e. Measure and record dimension L shown in figure 6-9.

f. Dimension L plus dimension U must be within 0.001 inch of dimension M.

CAUTION

The bearing is a matched set. Be sure bearing parts have same serial number.

3. Heat No. 5 bearing inner race (3, figure 6-8) at 300°F for 20 minutes.

4. Install inner race using pusher (21C5057). Check seating with 0.001 inch feeler gage; gage must not enter.

5. Assemble locknut (2) to shaft. Use spanner wrench (21C5195), torque multiplier (SWE-102), and torque locknut to 200 lb ft (by applying 26 lb ft to torque multiplier).

6. Trial-assemble oil-air separator (1) to high-pressure turbine shaft. Check alignment with No. 5 bearing locknut (2), 4 positions, to get closest alignment. Torque locknut (per step 5) enough to allow engagement, but not exceeding 300 lb ft (39 lb ft input). Check alignment of oil-air separator and match-mark with Dykem (or equivalent).

7. Heat oil-air separator (1) at 300°F for 20 minutes. Align matchmarks and assemble separator to shaft.

8. Set high-pressure turbine rotor aside for final assembly to engine.

6-8. ASSEMBLY OF HIGH-PRESSURE TURBINE STATOR.

1. Assemble 10 stage 1 shroud sectors (14, figure 6-10) to inner casing (16). Insert hook of each sector into its mating groove and push aft end of sector towards casing.

2. Install 10 seal strips (15) between ends of shroud sectors (14). Seal strips must not extend beyond face of aft shroud hook.

3. Assemble 10 shroud retainers (13) over aft end of shroud (14) and casing (16).

4. Assemble 27 stage 2 nozzle segments (10) to 9 seals (9), inserting seals (11, 12) between each segment.

5. Install 27 pins (8), and retaining rings (7) to seals (9). Dimpled end of retaining ring must be on right-hand side of the assembly, aft looking forward, just to the right-hand side of pin (8).

6. Align matchmarks and install stage 2 nozzle (6) into casing (16), fitting slots in nozzle outer flange and tabs on casing.

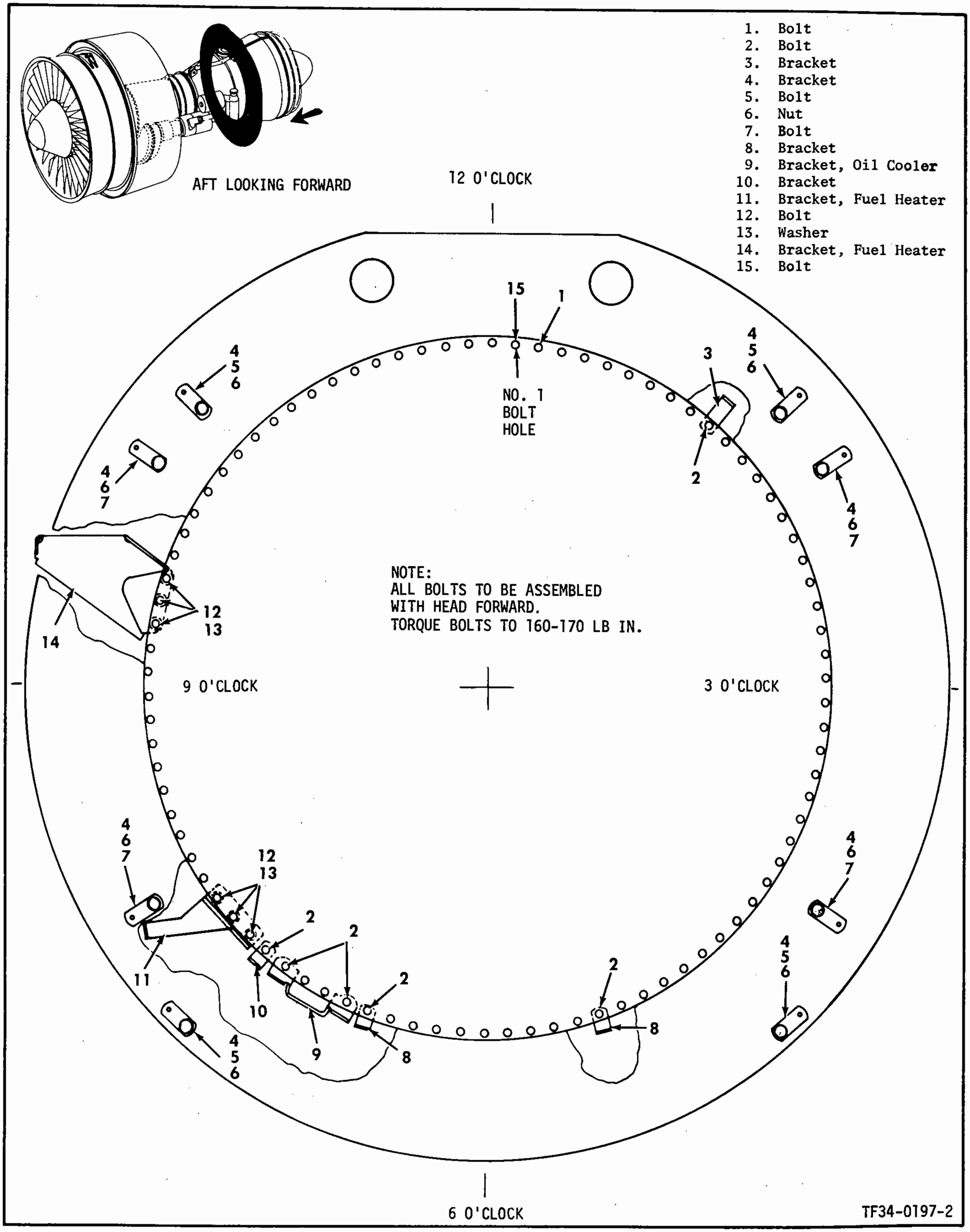
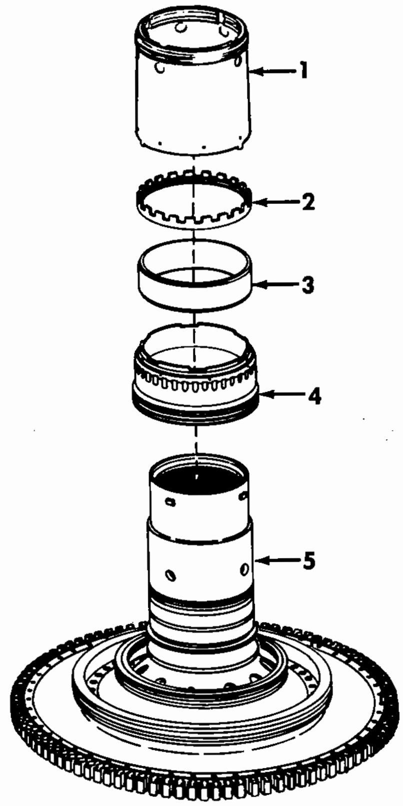


Figure 6-7. Bolting Diagram - Combustion Chamber-High-Pressure Turbine Casing



1. Oil/Air Separator
2. Locknut
3. No. 5 Bearing Inner Race
4. Seal Runner
5. Rotor

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Figure 6-8. Assembly of High-Pressure Turbine Rotor

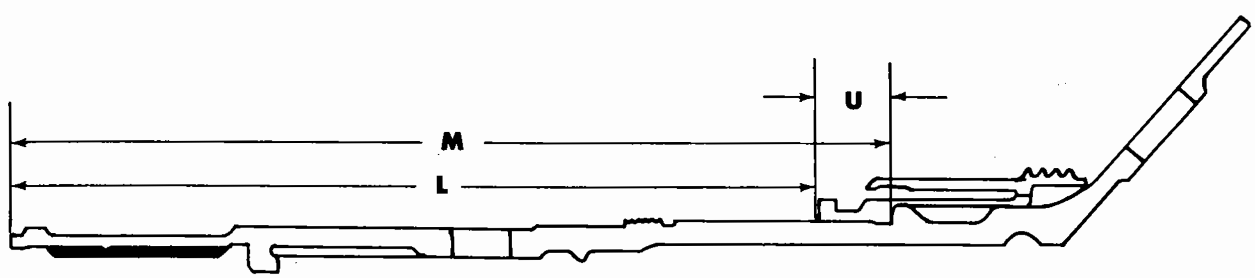


Figure 6-9. Seal Runner Seating Checks

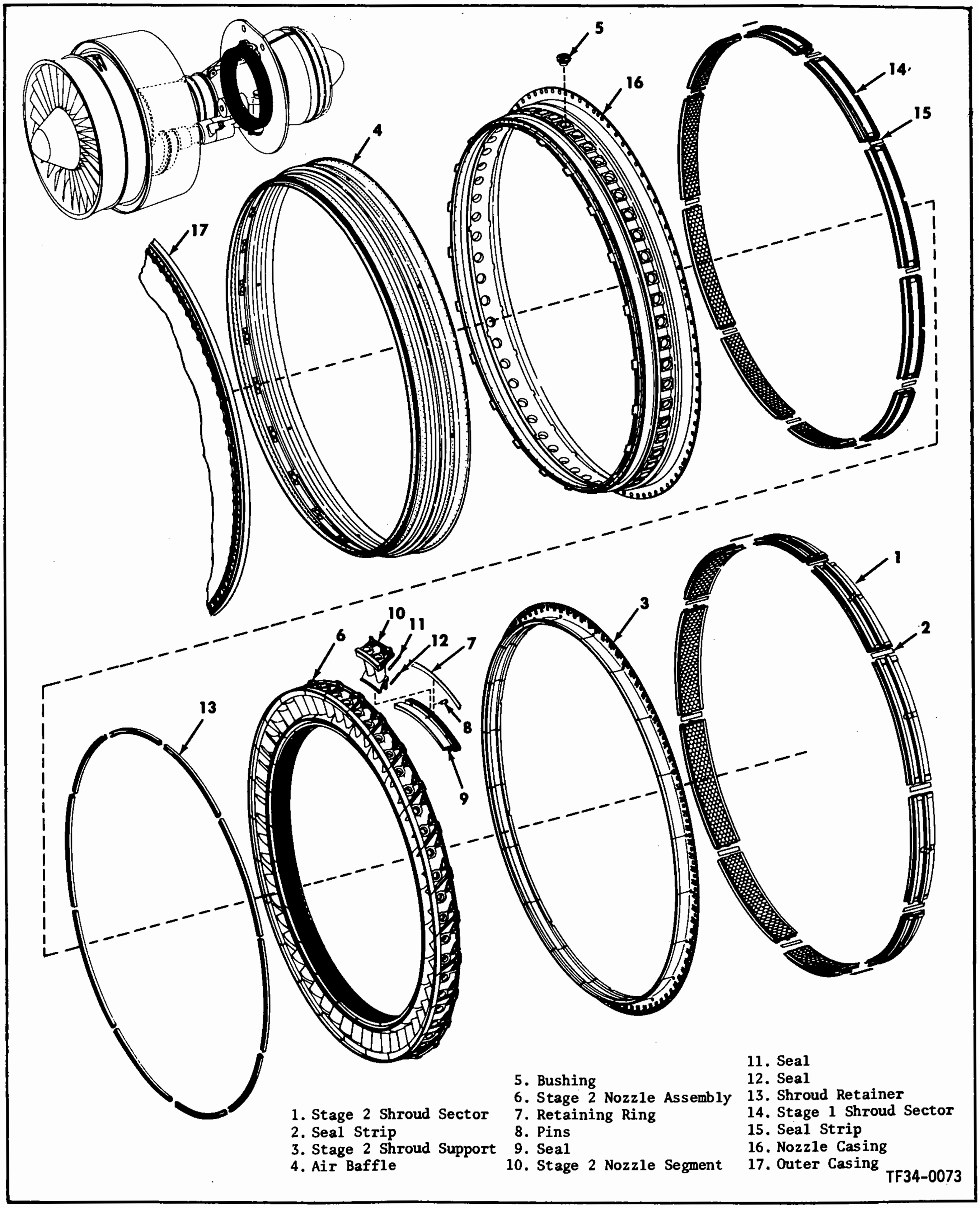


Figure 6-10. Assembly of High-Pressure Turbine Stator

7. Lubricate piston ring surface of each bushing assembly (5) with engine oil.

CAUTION

Be careful not to damage piston rings when installing bushings (5).

8. Install 54 bushings (5) through holes in casing (16), 1 to each nozzle partition.

9. Align matchmarks and slide air baffle (4) over OD of inner casing (16) until it seats on forward flange of inner casing.

10. Assemble stage 2 shroud support (3) into groove of inner casing (16). Align matchmarks and boltholes.

11. Assemble 10 stage 2 shroud sectors (1) to shroud support (3), inserting seal strips (2) between each shroud sector.

12. Set high-pressure turbine stator aside for final assembly to engine.

6-9. ASSEMBLY OF TURBINE TRANSITION ASSEMBLY.

1. Place transition casing (6, figure 6-11) on bench, forward side down.

2. Assemble liner (5) to casing (6).

Note

Install nozzle segments, one at a time, putting the short seal (4) in inner band slot and long seal (3) in outer band slot, left side of segment. After installing the first segment, slowly install the next segment into the liner, working the 2 segments together, making sure seals engage slots in second segment.

3. Align matchmarks and assemble 11 nozzle segments (2), seals (3, 4) into inner liner, one at a time, clockwise in numerical order.

4. Grasp inner liner (1) by interturbine seal and carefully install inner liner-nozzle subassembly into transition casing, aligning matchmarks and slots on nozzle segments. Tap segments with plastic mallet to seat them.

CAUTION

Keep forward side of casing down. Nozzle segments will fall out if casing is tipped.

5. Set transition assembly aside for final assembly to low-pressure turbine module.

6-10. ASSEMBLY OF LOW-PRESSURE TURBINE ROTOR.

For special tools, see table 2-1, group 31.

1. Place low-pressure turbine rotor in buildup stand (21C5035 or 21C5085), forward end down.

2. Measure and record dimension A on seal runner (4, figure 6-12) per figure 6-13.

3. Heat seal runner (4, figure 6-12) and No. 6 bearing inner race (3) at 300°F for 20 minutes minimum.

4. Measure and record dimension B on rear shaft as shown in figure 6-13.

5. Assemble seal runner (4, figure 6-12) to shaft using pusher (21C5139). Measure and record dimension C as shown in figure 6-13.

6. Add dimension C to dimension A taken in step 2 above. Result must equal dimension B, taken in step 4, within 0.001 inch. Reseat seal runner if necessary.

7. Assemble No. 6 bearing inner race (3, figure 6-12) to rear shaft, using pusher (21C5139). Check seating by trying to insert a 0.001 inch thickness gage between inner race and seal runner (4). Gage must not enter.

8. Assemble No. 6 bearing locknut (2) to rear shaft by hand. Use wrench (21C5196) and torque multiplier (SWE-102) and torque locknut to 200-300 lb ft (by applying 26-39 lb ft to torque multiplier). Align tab on locknut with slot in rear shaft.

9. Remove rotor from buildup stand (21C5035 or 21C5085) and place it on a bench so that forward end of rotor is up. Chill seal (6) and 3 pins (7) for 20 minutes.

10. Install seal (6) on forward end of rear shaft and align holes in seal with holes in shaft. Allow seal to warm to room temperature.

11. Insert pins (7), one at a time, into holes in shaft so that small end of pin is engaged with hole in seal. Hold each pin in place until it warms enough to stay in position. Make sure pins do not stick out beyond surface of ID of shaft.

12. Set low-pressure turbine rotor assembly aside for buildup of low-pressure turbine module.

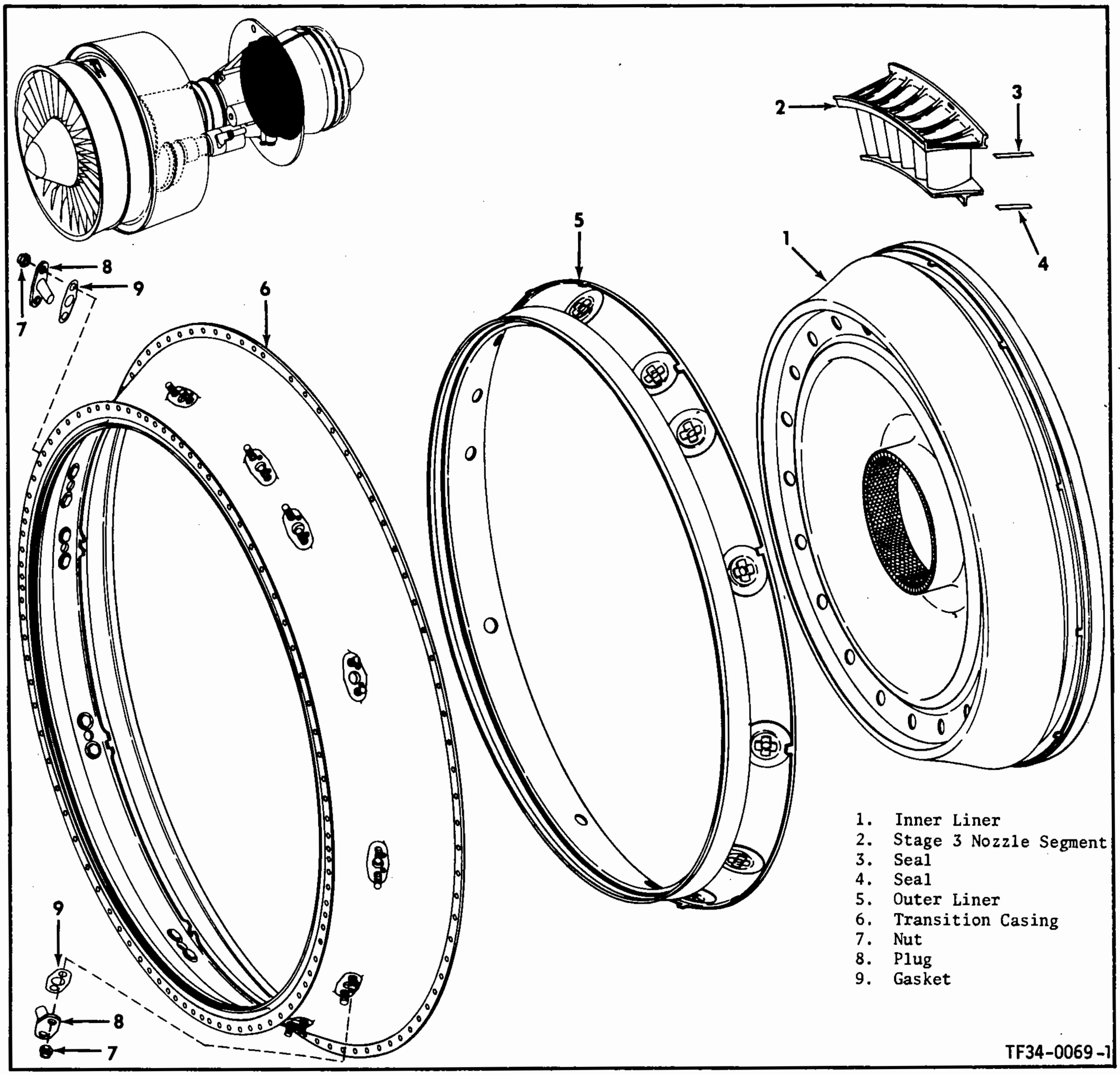


Figure 6-11. Assembly of Turbine Transition Assembly

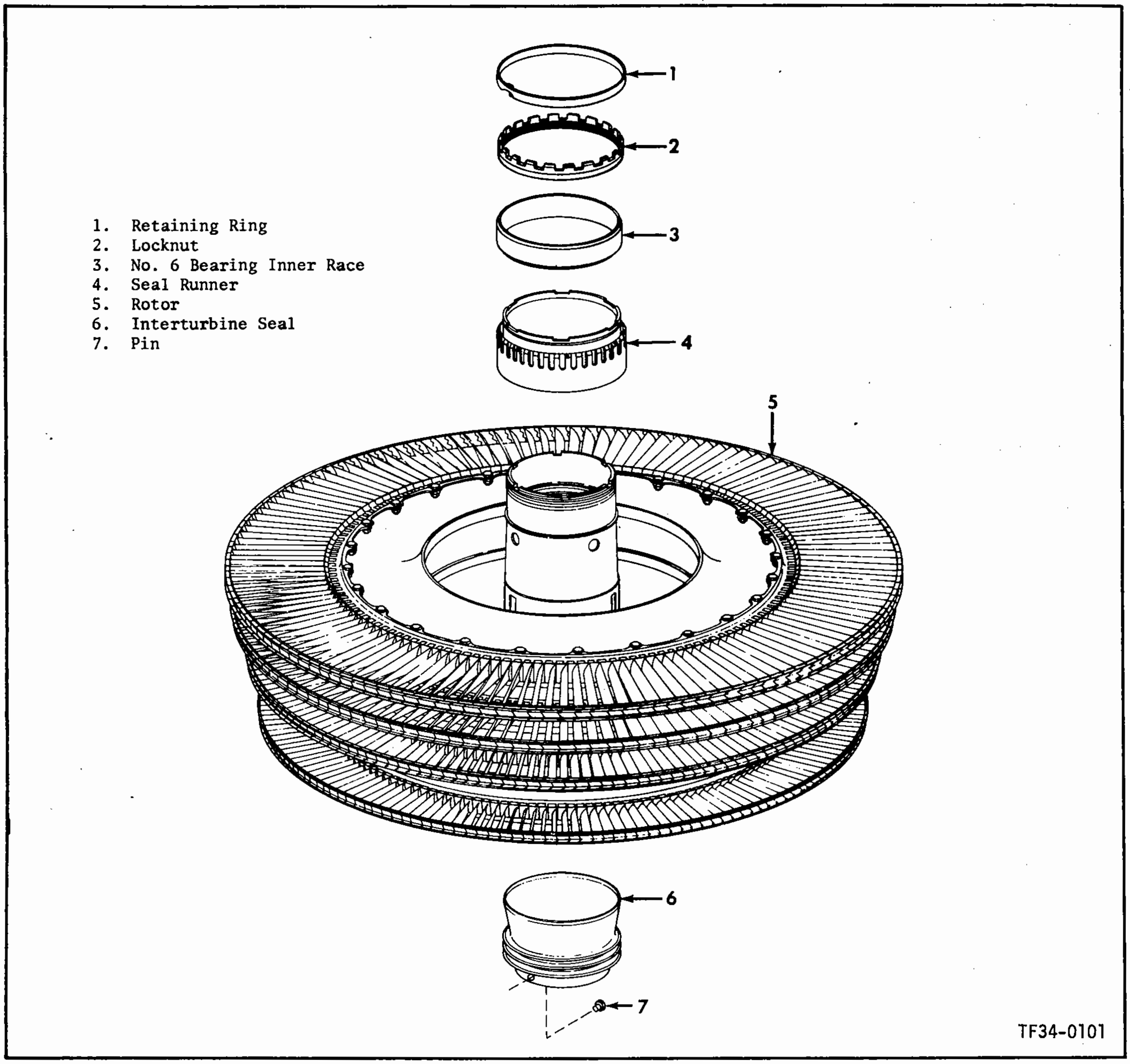


Figure 6-12. Assembly of Low-Pressure Turbine Rotor

6-11. ASSEMBLY OF LOW-PRESSURE TURBINE STATOR.

For special tools, refer to table 2-1, group 33.

1. Install right half of turbine casing (1, figure 6-14) in holder (21C5034).

Note

The quantity and positions of different part number nozzle segments must be the same after reassembly as before disassembly.

2. Install stage 4 nozzle segments (23), with seals (24) between segments, into casing half (1).

CAUTION

Do not use excessive force to drive in the turbine shrouds.

3. Apply Versilube grease G392 to all shroud lands on stator casing halves. Install the stage 3 shrouds (8, 9).

4. Install the stage 4 shrouds (6, 7).

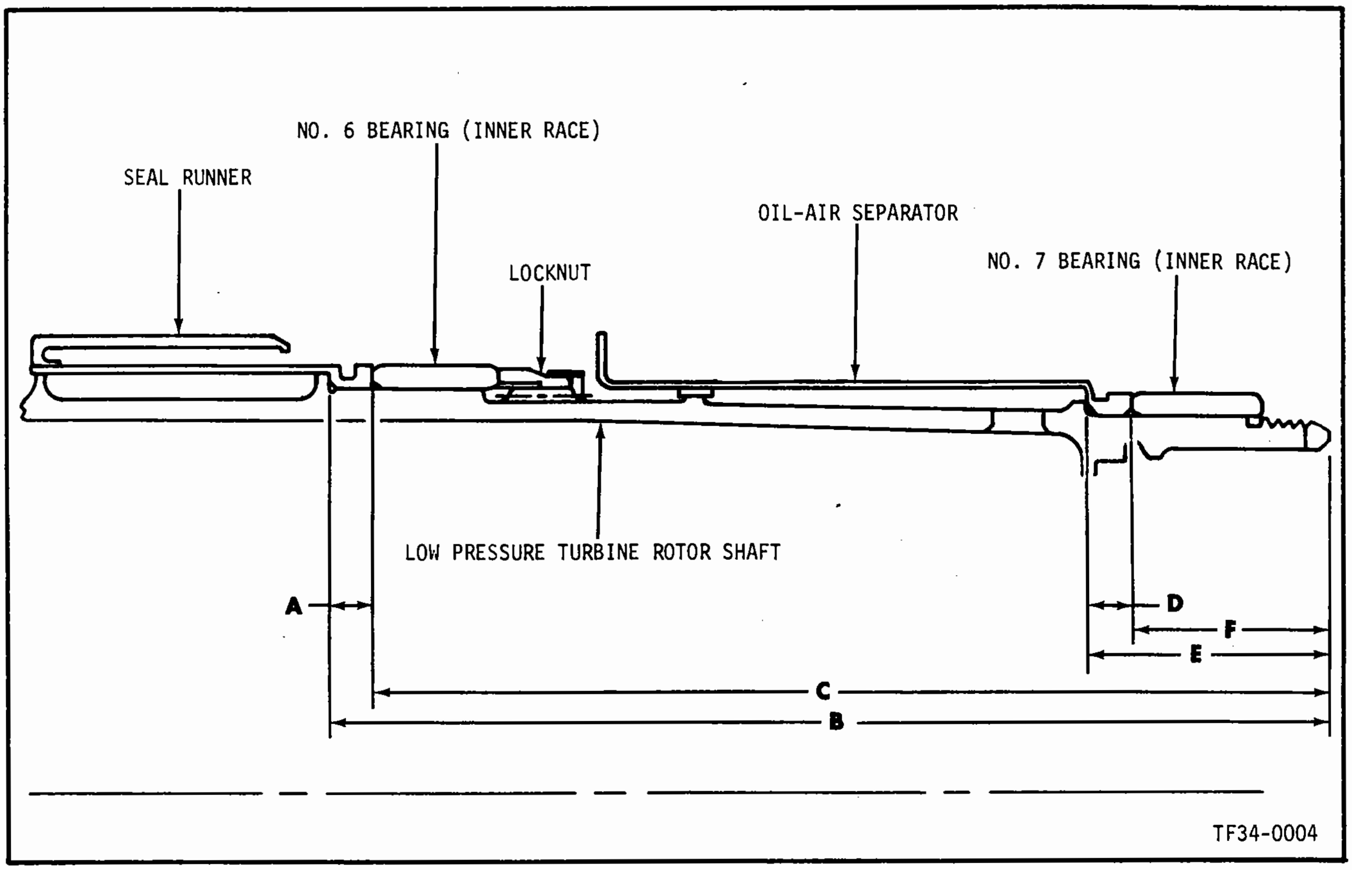


Figure 6-13. No. 6 Seal Runner and Oil/Air Separator Seating Checks

5. Install stage 4 seals (20, 21) and connector (22) in the ID of the stage 4 nozzle. Secure them with 11 pins (10) and 11 clips (11). Bend clips (11) over head of pin.

6. Install 10 stage 5 nozzle segments (19) in casing half.

7. Install stage 5 shrouds (4, 5).

8. Install stage 5 seals (16, 17) and connector (18). Secure them with 10 pins (10) and 10 clips (11). Bend clips (11) over head of pin.

9. Install 11 stage 6 nozzle segments (15) in casing half.

10. Install stage 6 shrouds (2, 3).

11. Install stage 6 seals (12, 13) and connector (14). Secure them with 11 pins (10) and 11 clips (11). Bend clips (11) over head of pin.

12. Remove casing from holder (21C5034).

13. Install left half of turbine casing in holder (21C5034).

Note

The quantity and positions of different part number nozzle segments must be the same after reassembly as before disassembly.

14. Assemble left half of turbine casing by following steps 2 through 12.

6-12. ASSEMBLY OF LOW-PRESSURE TURBINE MODULE.

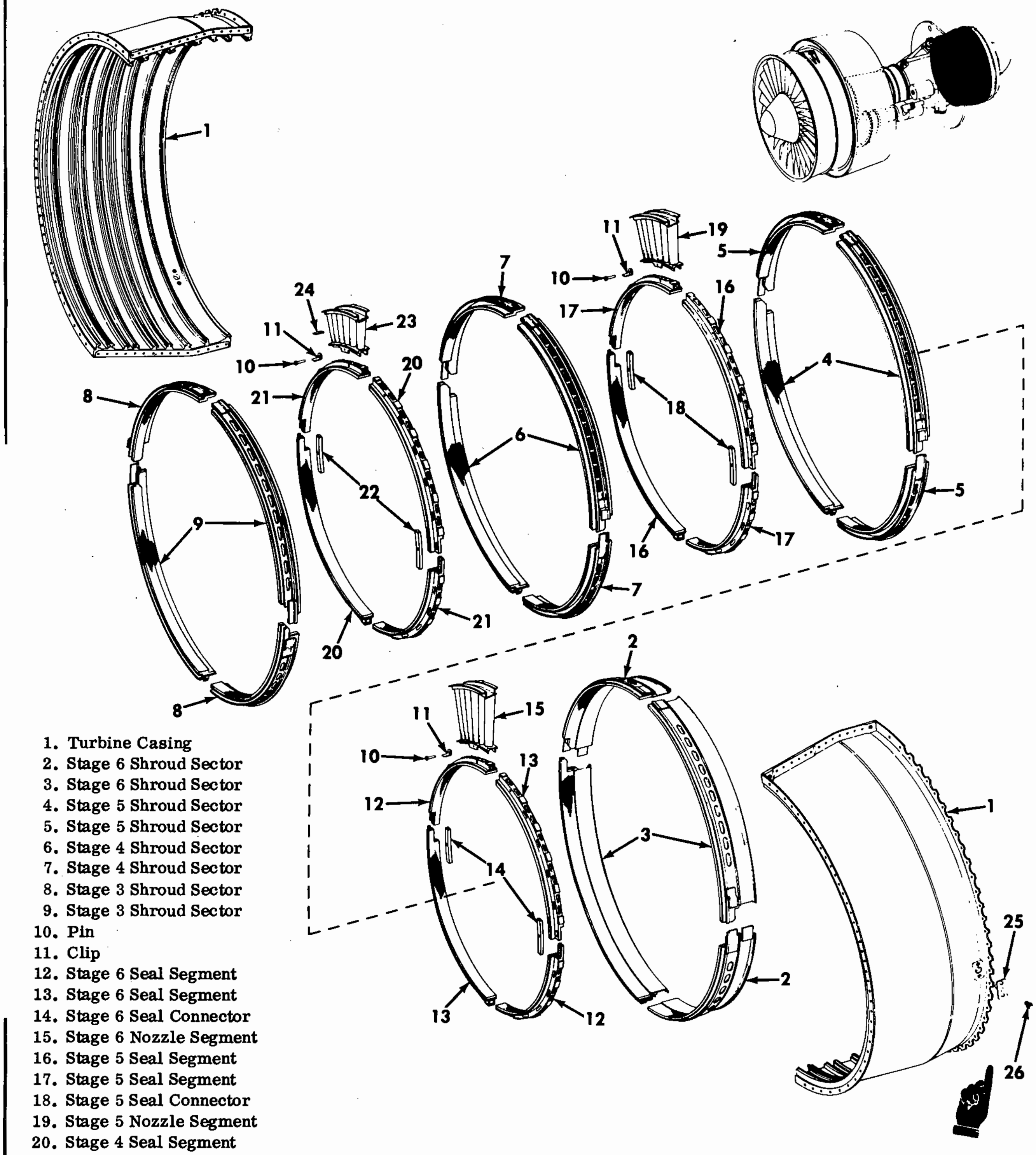
For special tools, refer to table 2-1, group 27.

1. Place transition casing on buildup stand (21C5035), forward side down.

CAUTION

Make sure jacking mechanism is up before installing low-pressure turbine rotor into buildup stand (21C5035).

2. Install low-pressure turbine rotor assembly through transition casing onto buildup stand (21C5035 or 21C5085).



1. Turbine Casing
2. Stage 6 Shroud Sector
3. Stage 6 Shroud Sector
4. Stage 5 Shroud Sector
5. Stage 5 Shroud Sector
6. Stage 4 Shroud Sector
7. Stage 4 Shroud Sector
8. Stage 3 Shroud Sector
9. Stage 3 Shroud Sector
10. Pin
11. Clip
12. Stage 6 Seal Segment
13. Stage 6 Seal Segment
14. Stage 6 Seal Connector
15. Stage 6 Nozzle Segment
16. Stage 5 Seal Segment
17. Stage 5 Seal Segment
18. Stage 5 Seal Connector
19. Stage 5 Nozzle Segment
20. Stage 4 Seal Segment
21. Stage 4 Seal Segment
22. Stage 4 Seal Connector
23. Stage 4 Nozzle Segment
24. Seal Strip
25. Plug
26. Bolt

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Figure 6-14. Assembly of Low-Pressure Turbine Stator

3. Assemble 3 dummy casing bars (21C5131) to transition casing aft flange at 9, 1, and 5 o'clock positions.

4. Assemble heat shield (24, figure 6-15) and 3 nut assemblies (27) to exhaust frame with 6 screws (26). Torque screws to 5-7 lb in.

5. Assemble exhaust frame (14) over low-pressure turbine rotor shaft onto dummy casing bars (21C5131).

CAUTION

Do not damage carbon elements.

6. Assemble carbon seal (23) over shaft, aligning boltholes with holes in exhaust frame (14).

7. Lubricate 2 packings (9) with engine oil and assemble packings to oil tube (8).

8. Assemble oil tube (8) through housing (17) and into oil nozzle.

9. Smoke-check oil nozzle for obstruction in passage.

10. Lubricate packing (22) with engine oil and assemble to scavenge tube (21). Assemble scavenge tube (21) to housing (17) with 2 bolts (19) and 2 nuts (20). Torque bolt to 28-32 lb in.

11. Lubricate packing (18) with engine oil and assemble it to housing (17).

12. Assemble housing (17) into exhaust frame, aligning slot in bolthole flange with slot in carbon seal (23).

13. Assemble retaining ring (1, figure 6-12) to No. 6 bearing locknut (2). Engage tab on retaining ring with a slot in rotor shaft.

14. Install all bolts (16, figure 6-15) except the 2 at 9 o'clock position. Torque bolts to 38-42 lb in.

15. Assemble tube (12) to housing (17) with 2 bolts (16). Torque bolts to 38-42 lb in.

16. Assemble bracket (25) to flange of housing (17).

17. Assemble tube (15) in exhaust frame to tube (12) and to bracket (25). Install 2 bolts (10) and nuts (11). Torque bolts to 38-42 lb in.

CAUTION

Check part number and serial number of bearing (6). The No. 4 bearing and No. 7 have same inner diameter.

18. Measure and record dimension D (see figure 6-13) on oil-air separator (7, figure 6-15). Heat separator (7) and No. 7 bearing inner race (6) at 300°F for 20 minutes minimum.

19. Measure and record dimension E per figure 6-13. Calculate dimension F by subtracting dimension D from dimension E.

20. Assemble oil-air separator (7, figure 6-15) to low-pressure turbine rotor with pusher (21C5053). Measure and record dimension F per figure 6-13. Measured dimension F must equal dimension calculated in step 19 above, within 0.001 inch.

21. Assemble No. 7 bearing inner race (6, figure 6-15) with pusher (21C5053). Check seating with 0.001 inch thickness gage.

22. Assemble locknut (3) to shaft; torque to 200-300 lb ft (by applying 26-39 lb ft) using spanner wrench (21C5197) and torque multiplier (SWE-102). Align slot in nut with slot in shaft.

23. Assemble keywasher (2) and retaining ring (1).

24. Lubricate packing groove on housing (5) and packing (18) with engine oil. Install packing on housing.

25. Assemble bearing housing (5) to flange of exhaust frame (14) with 20 bolts (4). Torque bolts to 38-42 lb in.

26. If parts have been replaced and clearances have to be taken, do not assemble the low-pressure turbine stators at this time. Assembly of stators and taking of clearance checks will be done at final assembly.

27. If no parts were replaced, assemble the low-pressure turbine stators as follows:

a. Remove dummy casing bar (21C5131) from the 9 o'clock position.

b. Apply a thin coat of Plastiseal F to forward, aft, and splitline flanges of left-hand low-pressure turbine casing (1, figure 6-16).

c. Lubricate flange bolts with engine oil. Assemble left casing (1) to transition casing flange with bolts and nuts per figure 6-17. Install bolts and nuts to exhaust frame flange per figure 6-18. Do not torque flange bolts at this time.

d. Apply a thin coat of Plastiseal F to forward and aft flanges of right-hand casing (2, figure 6-16). Remove dummy casing bars (21C5131) from 1 and 5 o'clock positions; install right-hand casing per figures 6-17 and 6-18. Do not torque bolts at this time.

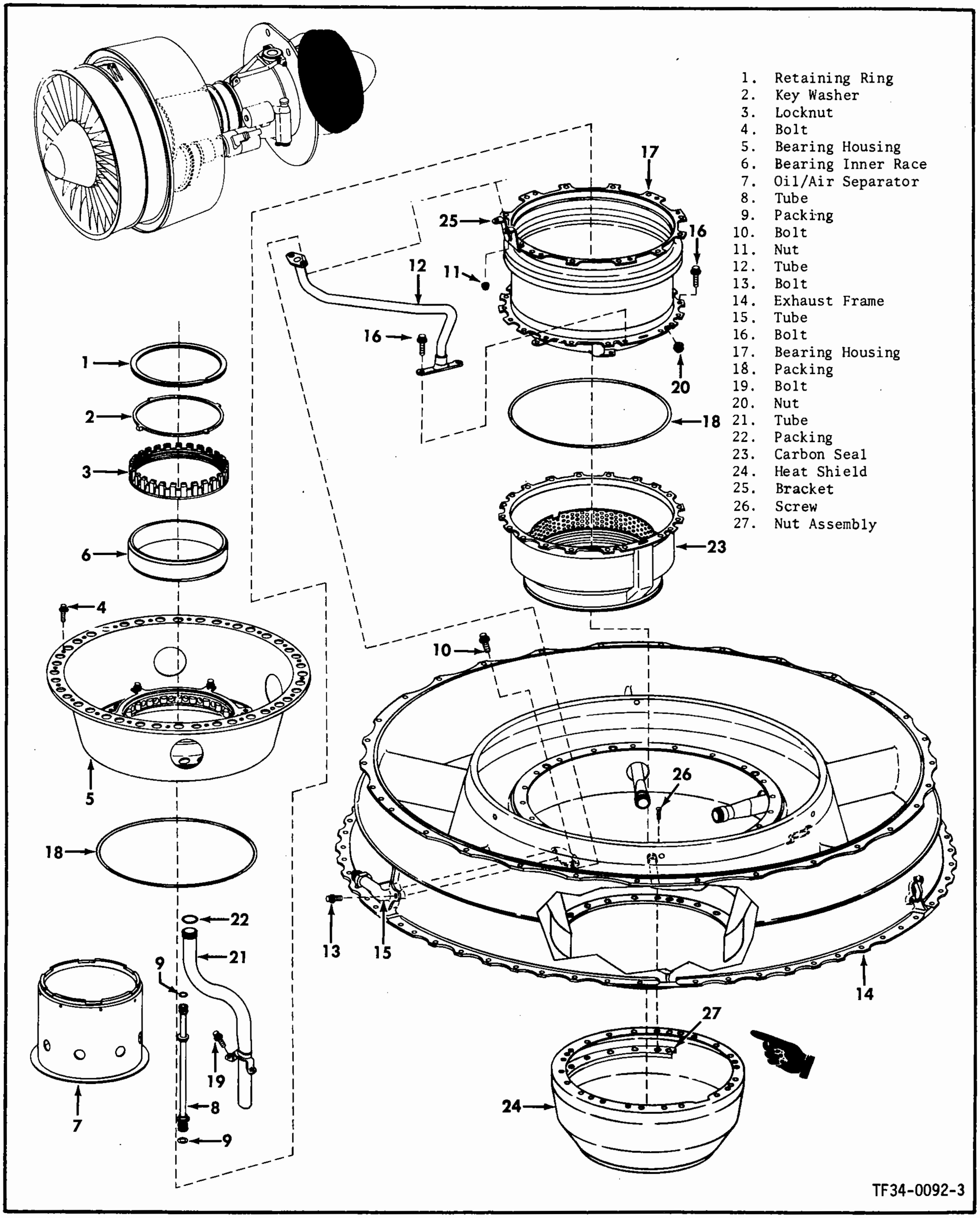
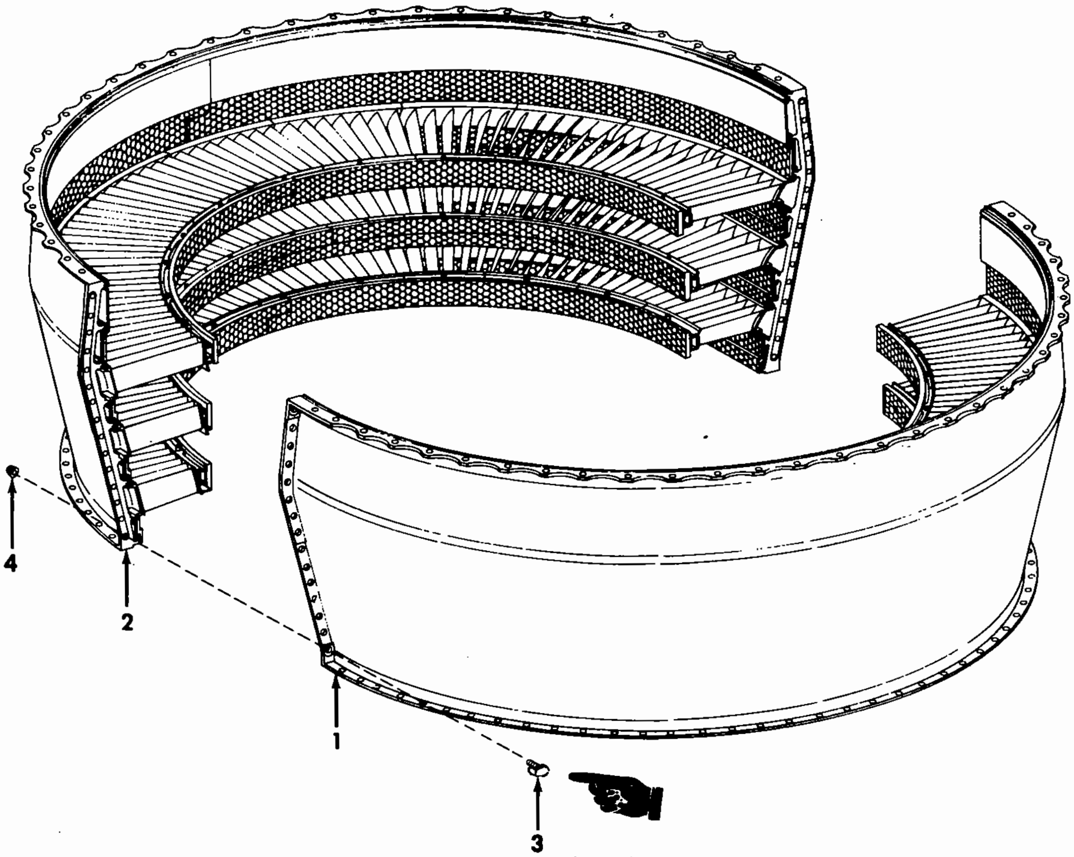


Figure 6-15. Assembly of Low-Pressure Turbine Module



1. Left Hand Casing
2. Right Hand Casing
3. Bolt
4. Nut

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Figure 6-16. Installation of Low-Pressure Turbine Stator

e. Install 30 bolts (3, figure 6-16) and nuts (4) to splitlines of low-pressure turbine stator. Torque nuts to 88-92 lb in. in the following sequence: (See figure 6-19.)

(1) 8, 23, 15, 30, 1, 16, 22, 21, 20, 19, 18, 17, 7, 6, 5, 4, 3, 2, 9, 10, 11, 12, 13, 14, 24, 25, 26, 27, 28, 29.

28. Install retainer (21C5041) to exhaust frame and stage 6 disk as follows:

a. Attach retainer to inner bolt circle of No. 7 bearing housing with bolts (4, figure 6-15). Torque bolts to 38-42 lb in.

b. Clamp inner portion of retainer to No. 7 bearing locknut.

29. Torque transition-to-turbine casing, and turbine casing-to-exhaust frame flange nuts to 88-92 lb in.

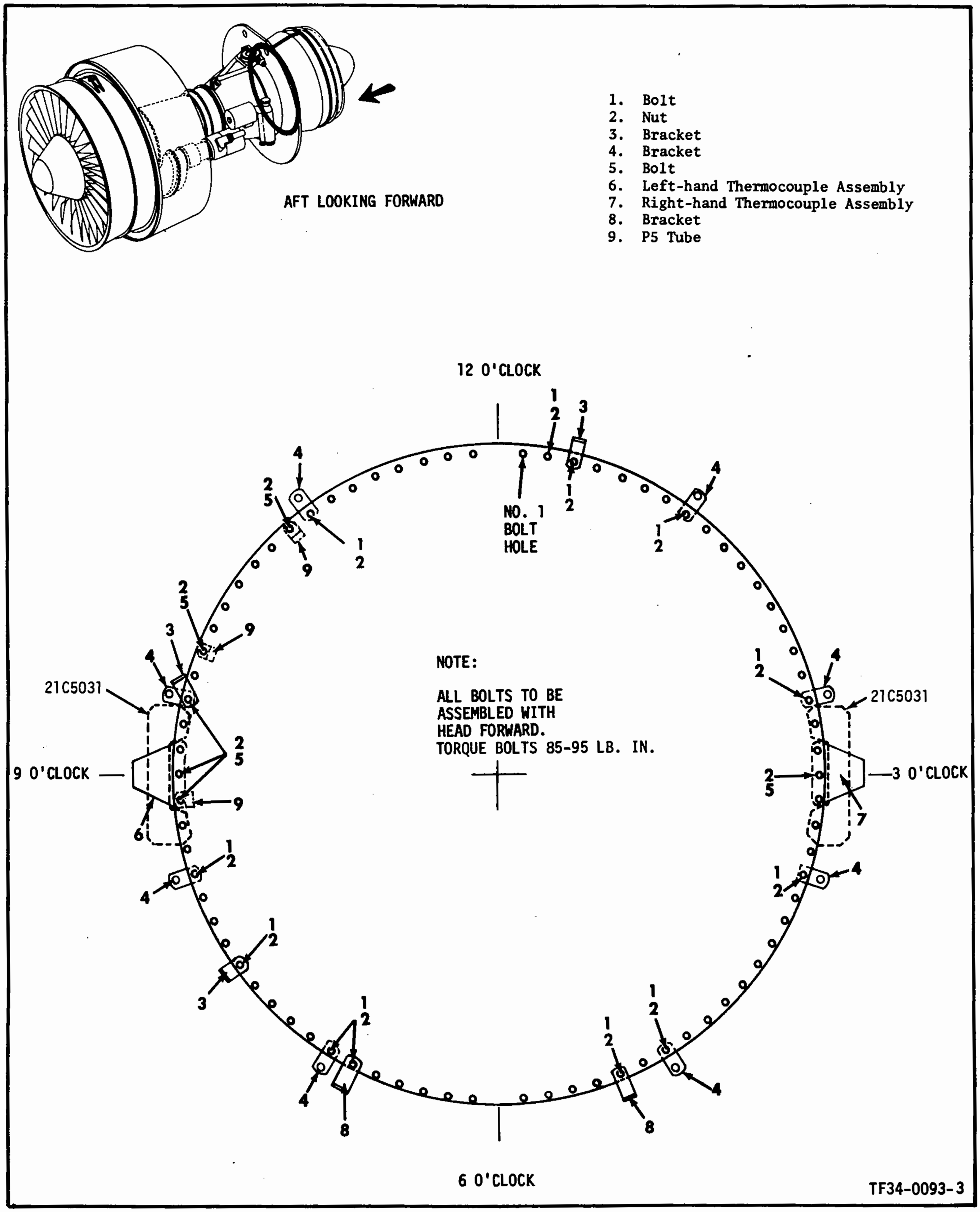


Figure 6-17. Bolting Diagram - Low-Pressure Turbine Casing-to-Transition Casing Flange

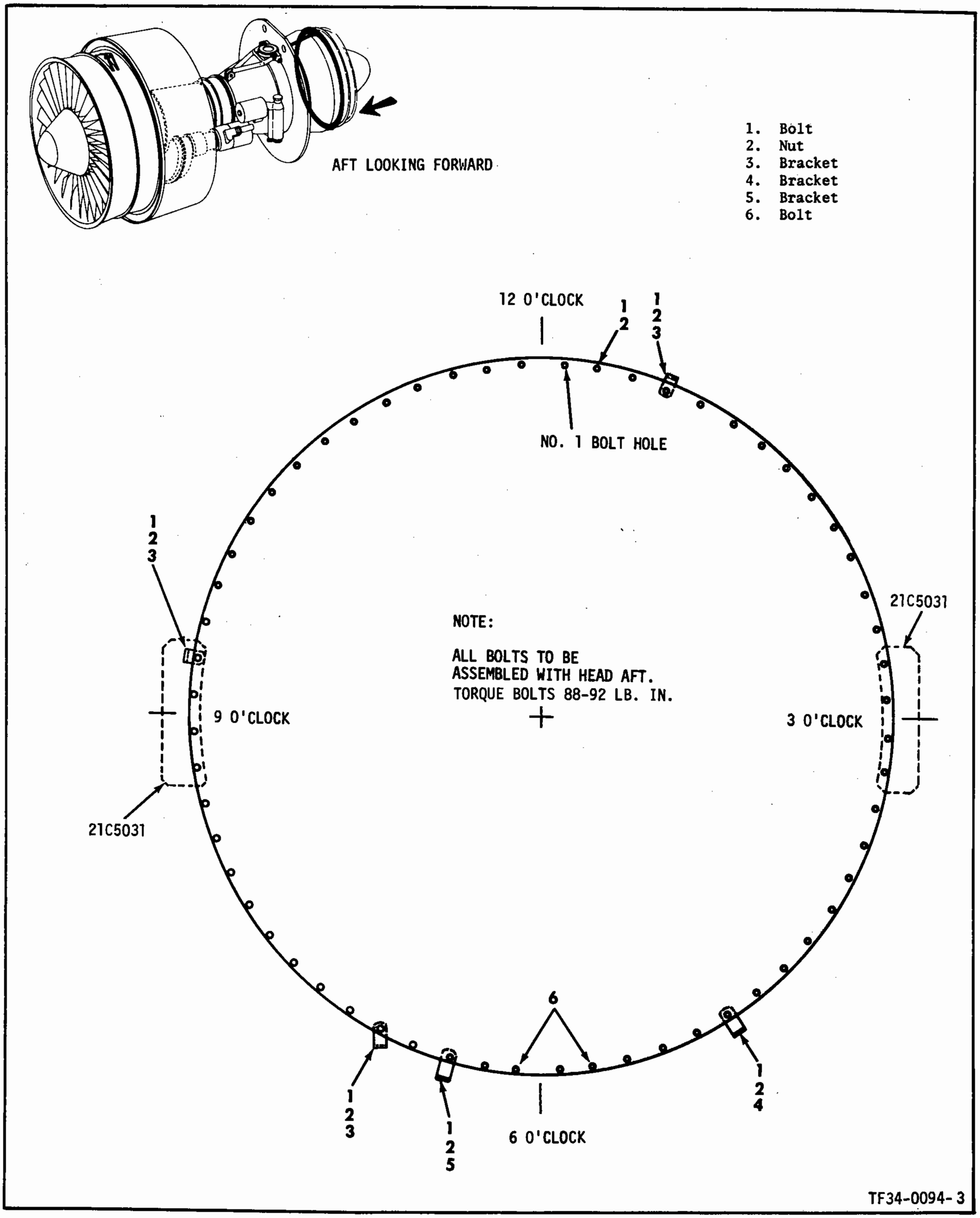
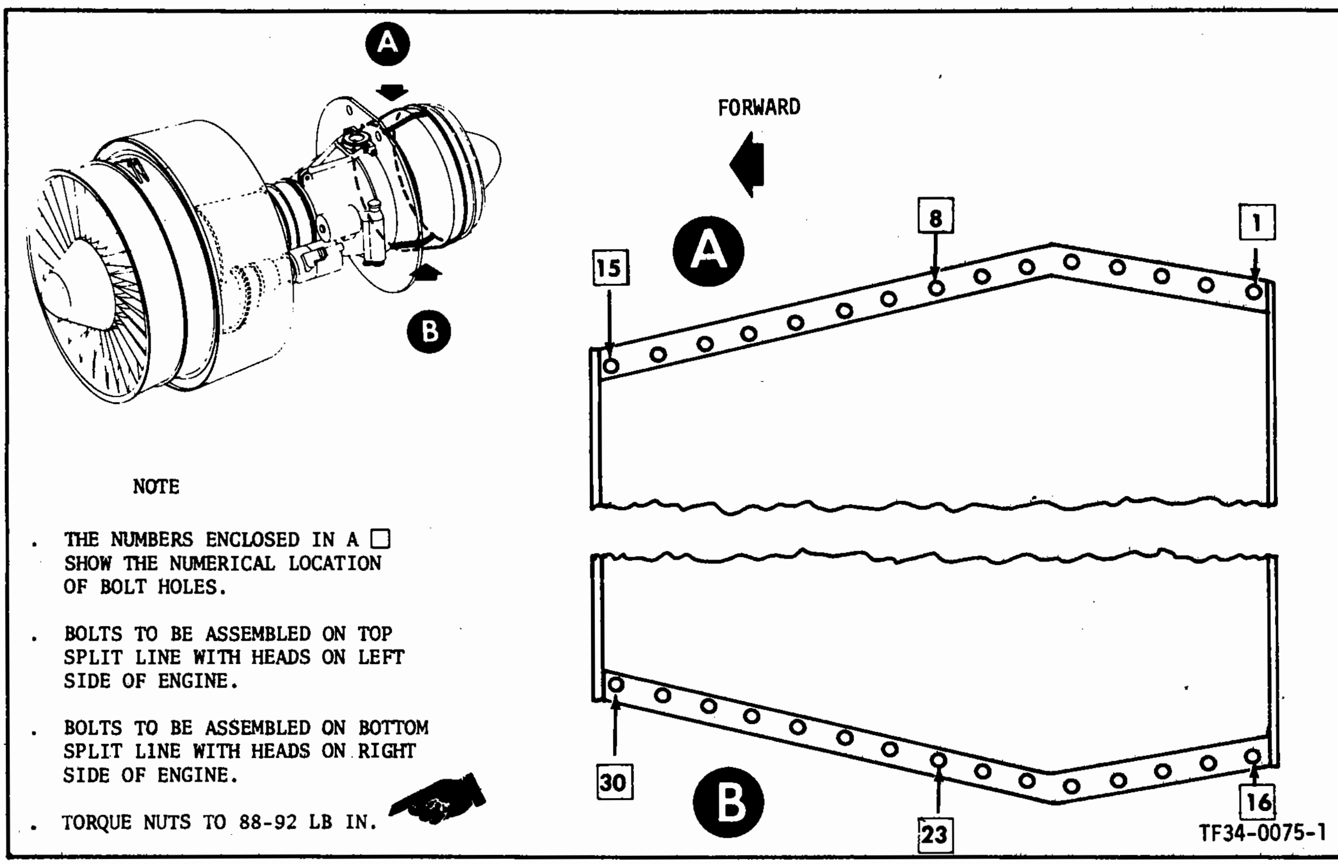


Figure 6-18. Bolting Diagram - Exhaust Frame-to-Low-Pressure Turbine Casing Flange



NOTE

- THE NUMBERS ENCLOSED IN A ☐ SHOW THE NUMERICAL LOCATION OF BOLT HOLES.
- BOLTS TO BE ASSEMBLED ON TOP SPLIT LINE WITH HEADS ON LEFT SIDE OF ENGINE.
- BOLTS TO BE ASSEMBLED ON BOTTOM SPLIT LINE WITH HEADS ON RIGHT SIDE OF ENGINE.
- TORQUE NUTS TO 88-92 LB IN.

Figure 6-19. Low-Pressure Turbine Casing Horizontal Flange Bolthole Locations

SECTION VII

FINAL ENGINE ASSEMBLY

7-1. GENERAL.

1. This section contains instructions for assembling parts and subassemblies together to make a complete engine.

2. Before installing any subassembly or part to the engine, be sure to read all the information at the beginning of each paragraph. In some cases, procedures covering work previously done per section VI can be disregarded.

7-2. ORGANIZATION.

1. The assembly paragraphs begin at the front of the engine and work aft.

2. Final assembly of the engine is completely done with the engine in the horizontal position. All GSE (tools) has been designed to do it this way.

7-3. BOLTING DIAGRAMS.

1. Bolting diagrams are provided to show the location of all bolts, nuts, and brackets used on the engine flanges and the compressor ribs. As the major sections of the engines are assembled, use the applicable illustration to determine the location of the parts.

7-4. GENERAL ASSEMBLY PRACTICES AND PROCEDURES.

CAUTION

- The cleanliness of engine component parts has a direct affect on the engine performance. Keep all parts and assemblies clean and free of corrosion and foreign matter. These instructions demand special handling of engine parts and subassemblies. Do not remove wrappings, protectors or covers until the part is going to be installed.
- Do not use pens, pencils or other marking devices containing carbon when marking engine parts. Carbon may cause stress cracks at high temperatures.

1. During assembly do not drop anything into the subassembly. If any object is dropped, do not proceed further until it is located and removed. Do not leave tools or parts on any part of the unit at any time. Return each tool to its proper place as soon as it has served its purpose. Protective caps, plugs and covers used to cover openings in subassemblies, engine lines and accessories must be free of dirt and loose material to minimize contamination.

2. When assembling body-bound bolts, drive them straight through using a plastic drift. Turning enlarges the holes; compressor or turbine casing halves will not line up if the holes are oversize.

3. Do not use excessive force to assemble mating parts. If excessive force appears necessary, inspect mating surfaces for burrs or pickups and remove any such defects.

4. Do not reuse the following parts after removing them from the engine:

a. Gaskets (Paper).

b. Preformed Packings (O-rings).

c. Deformable Lockwashers.

d. Compressor Vane Spindle Key Washers.

e. Inlet Guide Vane Lever Arm Locking Clips.

f. Cotter Pins.

g. Lockwire.

h. Blade Locking Keys.

i. Turbine Nozzle Sealing Strips.

j. Self-Locking Nuts (if run-on torque is low).

5. Lubricate all packing grooves, lead-in chamfers, bores and outside diameters over which packings pass, with engine oil prior to assembly of packings.

CAUTION

Do not lubricate electrical connectors or their packings.

6. Use care in assembling and disassembling any parts containing electrical connectors. Do not use tools to install or remove electrical connectors (except for ignition leads and thermocouple harness).

7. Whenever a component in the fuel or lube system is removed, place a drip pan under that component to catch the drippings.

8. Whenever a measurement is required to be taken in the detailed assembly instructions, use precision measuring instruments such as micrometers, depth gages, etc.

9. Do not interchange rollers, races or balls in bearings with components having the same or different part numbers as all bearings are matched assemblies.

10. Whenever an assembly lubricant such as Molykote is applied to a part, always wipe off the excess.

7-5. LOCKWIRING PROCEDURE.

1. Observe the following lockwire procedure unless otherwise specified in the detailed maintenance instructions.

7-6. BASIC RULES FOR THE INSTALLATION OF LOCKWIRE.

1. Lockwiring is the securing together of two or more parts with a wire which shall be installed in such a manner that any tendency for a part to loosen will be counteracted by an additional tightening of the wire.

2. The common method of installing lockwire shall consist of two strands of wire twisted together (so called "Double-Twist" or Double-Strand method), where one twist is defined as being produced by twisting the wires through an arc of 180 degrees and is equivalent to half of a complete turn. The single strand method of lockwiring may be used, when so specified, such as in a closely spaced, closed geometrical pattern (triangle, square, rectangle, circle, etc.), or parts in electrical systems, and in places that would make the single strand method more advisable. In such cases the single strand wire shall be limited to the pattern or group of similar parts.

3. The maximum span of lockwire between tension points shall be six inches unless otherwise specified.

4. Where multiple groups are lockwired by either the double-twist or the single strand method, the maximum number in a series shall be determined by the number of units that can be lockwired by a twenty-four inch length of wire.

5. Wire shall be pulled taut while being twisted.

6. Caution must be exercised during the twisting operation to keep the wire tight without overstressing, or allowing it to become nicked, kinked or otherwise mutilated, except that abrasions normally caused by wire twisting pliers shall be acceptable.

7. Lockwire shall not be installed in such a manner as to cause the wire to be subjected to chaffing, fatigue through vibration, or additional tension other than the tension imposed on the wire to prevent loosening.

8. In all cases wiring must be done through the holes provided. In the event that no wire hole is provided, wiring should be to a convenient neighboring part in a manner so as not to interfere with the function of the parts and in accordance with the basic principles described herein (see views, A, D, E, figure 7-2).

9. Lockwire shall be new upon each application.

10. Hose and electrical coupling nuts shall be wired in the same manner as tube coupling nuts.

11. Various examples of lockwiring are shown in figures 7-1 and 7-2. Although every possible combination is not shown, any combination used must adhere to the basic rules outlined in this procedure. View K, figure 7-1, shows the single-strand method, while the other figures show the two-strand or double-twist method.

12. The lockwire material for use up to 371°C (700°F) shall be a stainless steel such as AMS 5685. For use up to 981°C (1800°F), a corrosion and heat resistant alloy such as AMS 5687 (Inconel) shall be used.

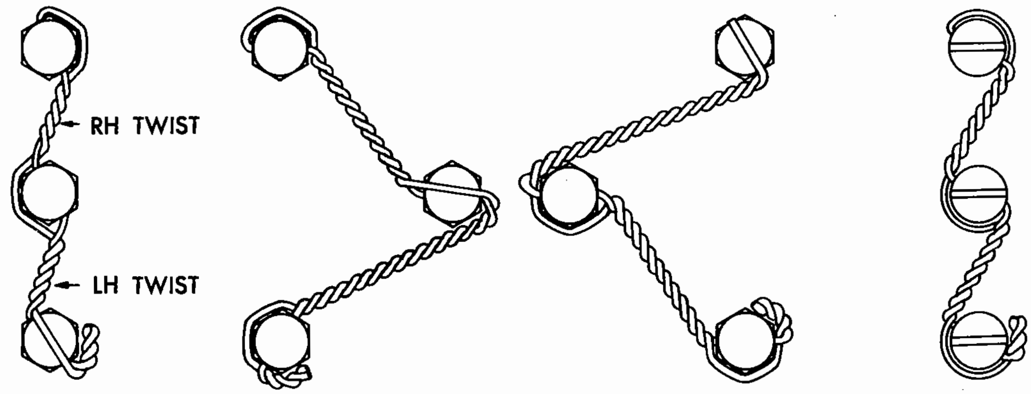
7-7. DETAILED INSTRUCTIONS FOR THE INSTALLATION OF LOCKWIRE. (See figures 7-1 and 7-2.)

1. Check the units to be lockwired to make sure that they have been correctly torqued. Under-torquing or over-torquing to obtain proper alignment of the holes is not permitted. If it is impossible to obtain a proper alignment within the specified torque limits, back off the unit and try it again or select another unit.

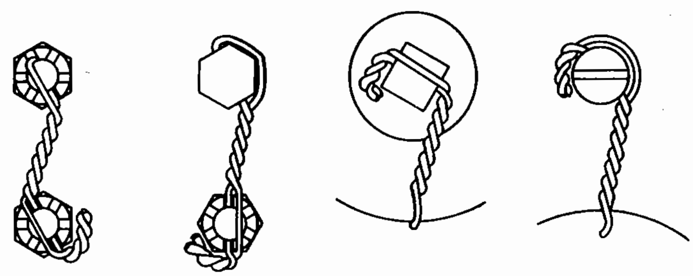
2. In adjacent units, it is desirable that the holes be in approximately the same relationship to each other as shown in views A, B, C, D, figure 7-1 for right-hand threads, and the lockwire shall be installed in such a manner that the strand through the hole will have a tendency to pull the unit clockwise. This should be reversed for left-hand threads.

3. Insert the lockwire through the first unit and bend the upper end either over the head of the unit or around it. If bent around it, the direction of wrap and twist of the strands shall be such that the loop around the unit comes under the strand protruding from the hole so that the loop will stay down and will not tend to slip up and leave a slack loop (see view A, figure 7-1).

4. Twist the strands while taut until the twisted part is just short of a hole in the next unit. The twisted portion should be within one-eighth inch from the hole in either unit.

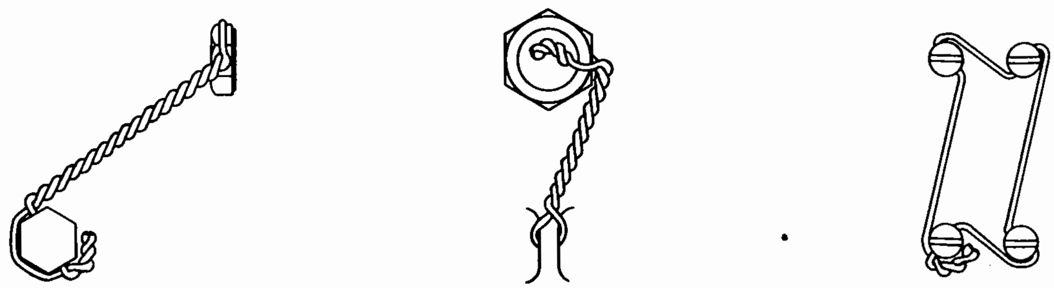


A B C D



E F G H

VIEWS A THROUGH H SHOW METHODS FOR WIRING VARIOUS STANDARD ITEMS. NOTE: WIRE MAY BE WRAPPED OVER THE UNIT RATHER THAN AROUND, AND SHOULD BE WRAPPED OVER THE UNIT ON TAPER HEAD BOLTS.



I

CORRECT METHOD FOR WIRING BOLTS IN DIFFERENT PLANES. NOTE THAT WIRE SHOULD ALWAYS BE APPLIED SO THAT TENSION IS IN THE TIGHTENING DIRECTION.

J

WHEN PRACTICABLE, HOLLOW HEAD PLUGS SHALL BE WIRED AS SHOWN WITH THE PIGTAIL BENT INSIDE THE HOLE TO AVOID SNAGS AND POSSIBLE INJURY TO PERSONNEL.

K

CORRECT APPLICATION OF SINGLE WIRE TO CLOSELY SPACED MULTIPLE GROUP.

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Figure 7-1. Lockwiring Details - 1

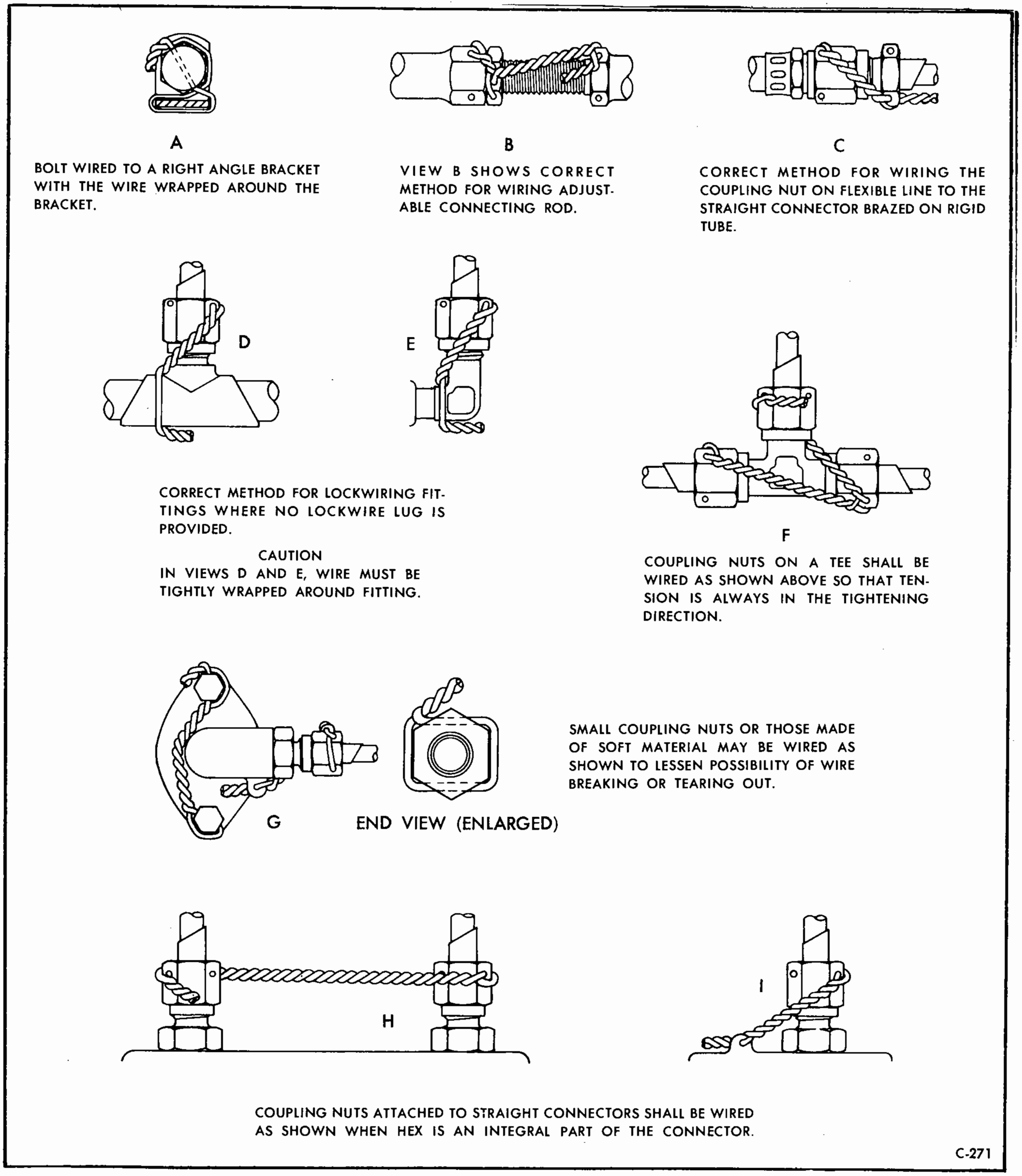


Figure 7-2. Lockwiring Details - 2

5. If the free strand is to be bent around the head of the second unit, insert the upper-most strand through the hole in this unit, and follow the rules in step c. (See center unit of view A, figure 7-1.) If the free strand is to be bent over the unit the direction of twist is unimportant. If there are more than two units in the series, repeat the above procedure.

6. After wiring the last unit, continue twisting the wires to form a pigtail of three to five twists and cut off the excess wire. Bend the pigtail in toward the part in such a manner as to prevent it from becoming a snag. Short pigtails are desirable because of vibration.

7. When lockwire holes are drilled across corners, use method illustrated in view G, figure 7-2, in preference to other methods.

7-8. LOCKING WITH COTTER PINS.

1. Cotter pins are used to restrain motion between two parts by inserting the cotter pin through a hole in the part and spreading the exposed ends.

2. Cotter pins are not reusable and must be replaced after removal.

7-9. INSTALLATION OF COTTER PINS.

1. See view A, figure 7-3 for the proper method of locking clevis pins with cotter pins.

2. See view B, (figure 7-3 for the preferred method of locking nuts using cotter pins). The alternative method view C, figure 7-3 should only be used to overcome a clearance problem.

7-10. INSTALLATION OF NONPOSITIONING TYPE FITTINGS. (See figure 7-4.)

NOTE

In figure 7-4, a nipple has been selected for illustrative purposes. Nonpositioning type fittings also includes plugs, reducers, bushings, etc.

7-11. INSTALLATION OF POSITIONING TYPE FITTINGS. (See figure 7-5.)

NOTE

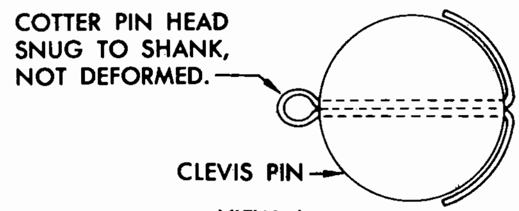
Positioning type fittings consist of bulkhead tees, bulkhead elbows, etc.

STEP 1

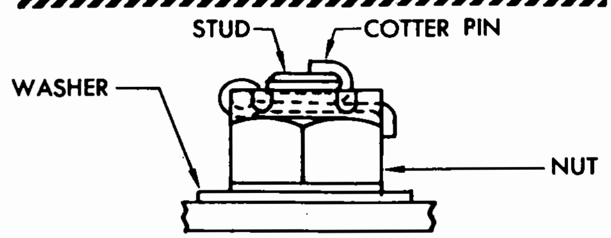
INSTALL THE COTTER PIN WITH THE AXIS OF THE EYE PARALLEL TO THE SHANK OF THE CLEVIS PIN.

STEP 2

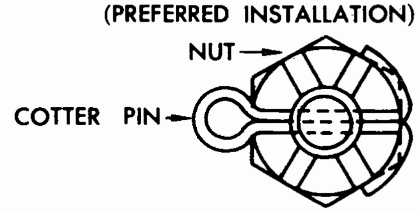
BEND THE PRONGS OF THE COTTER PIN AROUND THE SHANK OF THE PIN AS ILLUSTRATED.



VIEW A
LOCKING CLEVIS PINS



VIEW B
LOCKING NUTS
(PREFERRED INSTALLATION)



VIEW C
LOCKING NUTS
(ALTERNATIVE INSTALLATION)

STEP 1

INSTALL THE COTTER PIN WITH THE HEAD SEATED FIRMLY IN THE SLOT OF NUT WITH THE AXIS OF THE EYE AT RIGHT ANGLES TO THE STUD SHANK.

STEP 2

BEND PRONGS SO THAT THE HEAD AND UPPER PRONG ARE FIRMLY SEATED AGAINST THE STUD.

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Figure 7-3. Installation of Cotter Pins

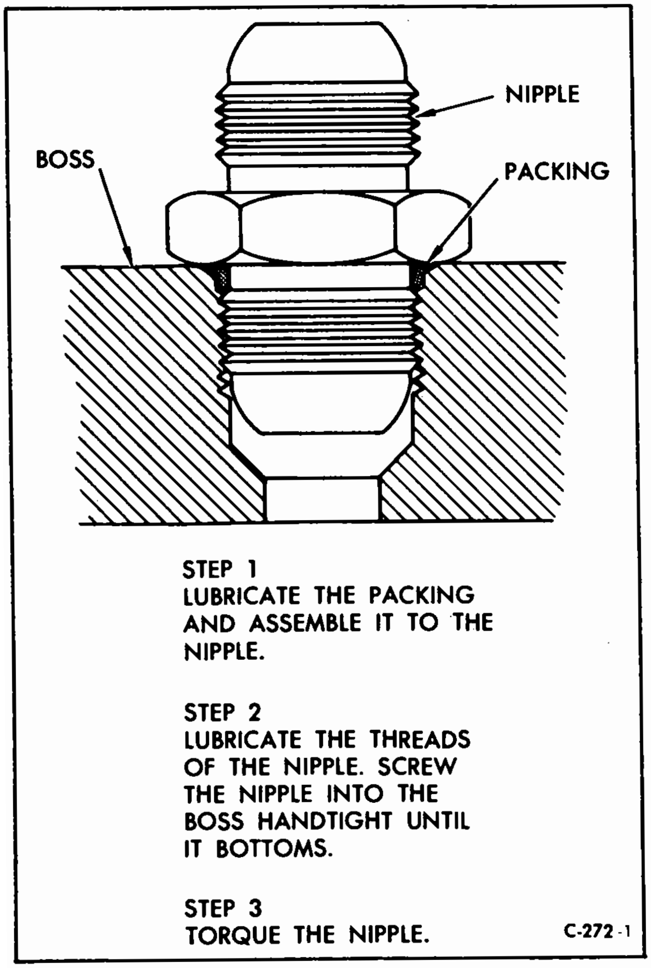


Figure 7-4. Installation of Nonpositioning Type Fittings

7-12. TORQUE-TIGHTENING PRACTICES.

1. Torque is expressed as lb in (pound-inches) or lb ft. (pound-feet). One pound-inch (or one pound-foot) is the twisting stress of one pound applied to a twist-type fastener (such as a bolt or nut) with one inch (or one foot) of leverage. This twisting stress is applied to the fastener to secure the components. Unless otherwise specified, all torque values prescribed within this manual shall be obtained with lubricated threads.

7-13. TORQUE-TIGHTENING PROCEDURES.

1. Tighten at a uniformly increasing rate until the desired torque is obtained. In some cases, where gaskets or other parts cause a slow permanent set, be sure to hold the torque at the desired value until the material is seated.

2. Apply a uniform average torque to a series of bolts of varying cross-sectional area on one flange or in one area. This prevents the tighter bolts from shearing or snapping loose because of force concentrations.

3. It is not desirable to tighten to the final torque value during the first drawdown; uneven tension can cause distortion or overstressing of parts. Seat and torque mating parts by drawing down the bolts or nuts gradually until the parts are firmly seated. Then loosen each one separately and apply final tightening. Tightening in a diametrically opposite (staggered) sequence is desirable in most cases. Do not exceed listed maximum torque values.

CAUTION

When chilling or heating engine parts during assembly, do not torque locknuts or retaining bolts until the part returns to room temperature. If the part has been heated, the fastener may loosen as the part cools.

If the part has been chilled, the fastener may be overstressed as the part expands.

4. When applying torque to a series of bolts, select a medium value. If some bolts in a series are torqued to a minimum value and others to a maximum, force is concentrated on the tighter bolts and is not distributed evenly. Such unequal distribution of force may cause bolt failure. Torque flange bolts as follows.

a. Torque 2 bolts (each mounting flange 180° apart).

b. Torque 2 bolts (each mounting flange) 90° from the first bolts that were torqued.

c. Torque the remaining bolts.

NOTE

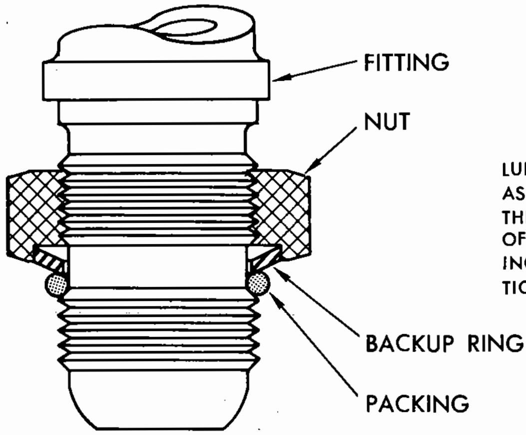
This procedure also applies to engine parts which are bolted similar to the circumferential flanges (for example, the exhaust frame centerbody).

7-14. SUGGESTED TORQUE WRENCH SIZES.

1. The torque wrenches listed in table 7-1 are recommended for use within the indicated ranges. Larger wrenches have too great a tolerance, and use of these wrenches can result in inaccuracies.

TABLE 7-1. TORQUE WRENCH SIZES

Torque Between	Torque Wrench	Tolerance
0 and 25 lb in.	30 lb in.	± 1 lb in.
25 and 140 lb in.	150 lb in.	± 5 lb in.
140 and 550 lb in.	600 lb in.	± 20 lb in.
30 and 140 lb ft	150 lb ft	± 5 lb ft
140 and 240 lb ft	250 lb ft	± 10 lb ft
240 and 1000 lb ft	1000 lb ft	± 20 lb ft

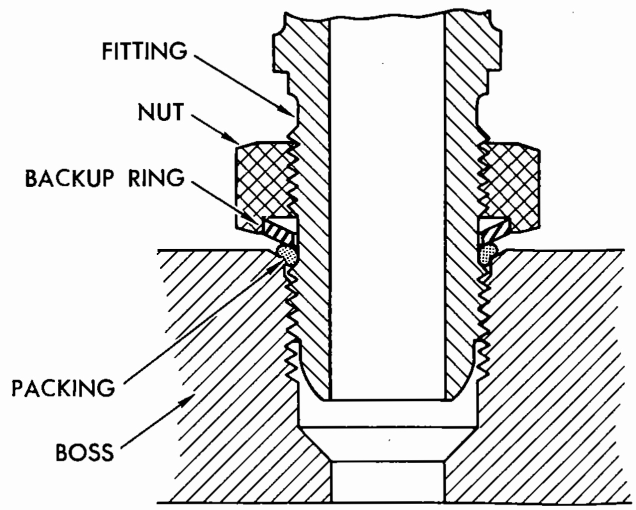


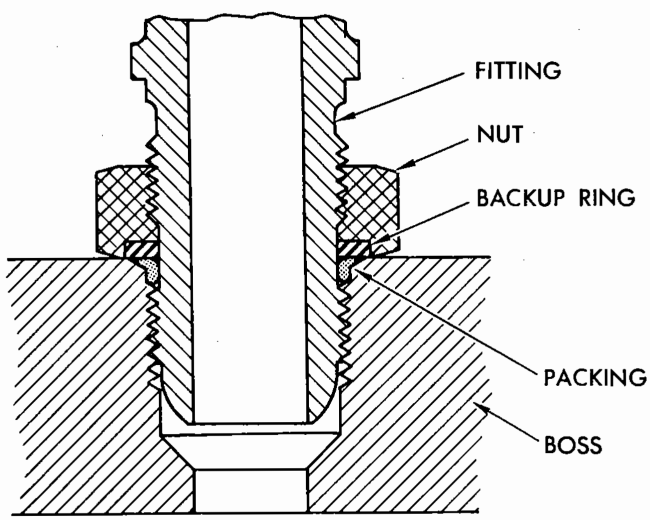
STEP 1

LUBRICATE THE FITTING, RING AND PACKING AND ASSEMBLE AS SHOWN. THE CONVEX SIDE OF THE RING SHOULD FACE THE FITTING END. WORK THE RING INTO THE COUNTERBORE OF THE NUT; THEN TURN THE NUT DOWN UNTIL THE PACKING IS PUSHED FIRMLY AGAINST THE LOWER THREADED SECTION OF THE FITTING.

STEP 2

INSTALL THE FITTING INTO THE BOSS AND, AT THE SAME TIME, KEEP THE NUT TURNING WITH THE FITTING UNTIL THE PACKING CONTACTS THE BOSS. THIS POINT CAN BE DETERMINED BY A SUDDEN INCREASE IN TORQUE. WITH THE FITTING IN THIS POSITION, PUT A WRENCH ON THE NUT TO PREVENT ITS TURNING AND, AT THE SAME TIME, TURN THE FITTING IN 1½ TURNS. POSITION FITTING BY TURNING IT NOT MORE THAN ONE ADDITIONAL TURN.





STEP 3

HOLD THE FITTING AND TORQUE THE NUT. SLIGHT EXTRUSION OF THE RING IS NOT DETRIMENTAL.

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Figure 7-5. Installation of Positioning Type Fittings

7-15. USE OF OFFSET EXTENSION WRENCH (CROWFOOT).

1. When a crowfoot extension wrench is used with a torque wrench, the effective length of the torque wrench is changed. The torque wrench is so calibrated that when an extension wrench is used, the indicated torque (torque which appears on a dial or gage of the torque wrench) may be different from the actual torque that is applied to the nut or bolt. Therefore, when a crowfoot extension is used, the torque wrench shall be preset to compensate for the increase or decrease in actual torque as compared to indicated torque.

7-16. MEASURING EFFECTIVE LENGTH OF OFFSET EXTENSION WRENCH (CROWFOOT). (See figure 7-6).

1. The addition or subtraction of the effective length of the crowfoot extension wrench (E) is determined by the position of the extension wrench on the torque wrench. When the extension wrench is pointed in the same direction as the torque wrench, add the effective length of the extension wrench to the effective length of the torque wrench (L + E). When the extension wrench is pointed back toward the handle of the torque wrench, subtract the effective length of the wrench from the effective length of the torque wrench (L - E). When the extension wrench is pointed at right angles to the torque wrench, the actual value does not change. It is not recommended that the extension wrench be set at angles other than the above. However, if it becomes necessary to do this, add or subtract the effective length (M) of the extension wrench to the effective length (L) of the torque wrench, as required, in the same manner as was done with (E). The effective length of the torque wrench is a variable, and a different figure will be used for each type of torque wrench. The effective length of the crowfoot extension wrench is determined by measuring from the center of the drive opening to the center of the extension wrench opening (E).

7-17. DETERMINATION OF GAGE READING WHEN USING OFFSET EXTENSION WRENCH (CROWFOOT). (See figure 7-6.)

NOTE

Effective length (M) may be substituted directly for (E) in the following calculations.

1. The object is to find the gage reading which indicates the required torque.

2. Determine the effective length of the torque wrench (which is designated as L in the following example) and the effective length of the crowfoot wrench (E).

3. Multiply the required torque by the effective length of the torque wrench (L).

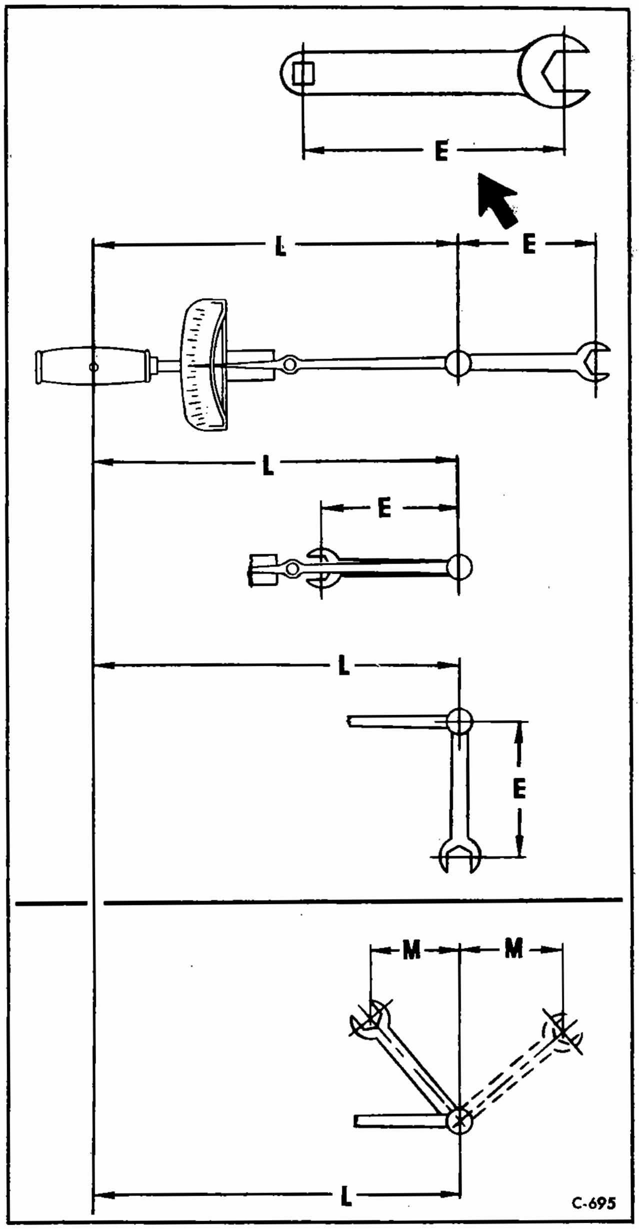


Figure 7-6. Computing Effective Length of Extension Wrench (Crowfoot)

4. Divide this result by (L + E), or (L - E), as determined from figure 7-6. This answer is the gage reading which indicates the required torque. For example: Required torque = 265 lb in. Effective length of torque wrench = 8.4 in. Effective length of crowfoot = 1.5 in. Therefore (L + E) = 9.9 in.

$$265 \times 8.4 = 2226.0$$

$$2226.0 \div 9.9 = 224.8 \text{ lb in.}$$

Thus, a gage reading of 225 lb in. indicates required torque of 265 lb in.

7-18. INSTALLATION OF COMPRESSOR ROTOR INTO FRONT FRAME. For special tools, see table 2-1, group 8.

1. Assemble adapter ring (21C5177) to front frame forward flange, using engine hardware.

2. Install front frame (9, figure 7-7) onto forward engine mount (21C5189). Support aft end of front frame with support (21C5166 or 21C5219).

3. Place cradle support (21C5174) on rails. Assemble lifting adapters (part of 21C5089) to forward and aft end of compressor rotor. Use lifting sling (21C5210) and lift rotor from buildup fixture (21C5089). Install compressor rotor in cradle support (21C5174). Remove lifting sling (21C5210) and lifting adapters.

NOTE

Steps 4, 5, and 6 are required only if new parts are being installed or laminated shim is being replaced.

4. Using a 0-1 inch micrometer, measure and record the thickness of front frame flange that mates with the No. 3 bearing housing. Record as dimension B. See figure 7-8.

5. Using a parallel bar and depth vernier, measure and record dimension D on bearing retainer (2, figure 7-7); distance from aft end of retainer inner ring to aft face of a tab.

6. Calculate dimension E, the gap between No. 3 bearing outer race and the bearing retainer, as follows:

a. Transfer dimensions A and C taken at compressor rotor subassembly, section VI.

b. Add dimensions A and B. Subtract dimension C from the total of A + B.

c. Subtract dimension D from the result of A + B -C. This result is dimension E, which should be between 0.017-0.036 inch.

d. Peel laminated shim (1, figure 7-7) to thickness of dimension E plus 0.001-0.003 inch.

7. Assemble packing (4) to oil tube (5) and packing (6) to scavenge port on No. 3 bearing housing.

8. Install packing (7) on outside of No. 3 bearing housing.

9. Align scavenge fitting on bearing housing so it will fit in port at 6 o'clock on front frame. Loosen locks on forward engine mount (21C5189) and roll front frame back, engaging the studs on bearing support with holes in front frame flange. Align scavenge tube and seat the front frame onto the No. 3 bearing. Adjust cradle support (21C5174), for proper alignment.

CAUTION

Be sure shim does not fall between housing and front frame flange.

10. Install laminated shim (1) and bearing retainer (2) with 8 nuts (3). Torque nuts to 105-115 lb in.

11. If the following parts were removed from front frame (9), install them as follows:

a. Assemble packing (10) to radial drive shaft oil nozzle (11). Install oil nozzle into port inside the 6 o'clock opening in front frame with nut (12). Torque nut to 38-42 lb in.

b. Assemble packings (13) to 8 waterwash nozzles (14, 15).

c. Assemble inlet nozzle (14) to front frame at the 5 o'clock position and secure with bolt (16). Torque bolt to 88-92 lb in.

d. Assemble 7 spray nozzles (15) to front frame and secure with bolts (16). Torque bolts to 88-92 lb in.

e. Assemble 6 instrumentation covers (17) with shims (18) to bosses in front frame and secure with bolts (19). Torque bolts to 38-43 lb in. and lockwire, double-strand method, using 0.032 inch lockwire.

f. Assemble 3 plugs (20) to front frame. Torque plugs to 25-30 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

7-19. INSTALLATION OF COMBUSTION CHAMBER MODULE. For special tools, see table 2-1, group 3.

1. Assemble hoisting adapter (21C5198) to aft mount ring (2, figure 7-9) at the 3 and 9 o'clock positions. Assemble lifting sling (21C5210) to trunnions of hoisting adapter (21C5198).

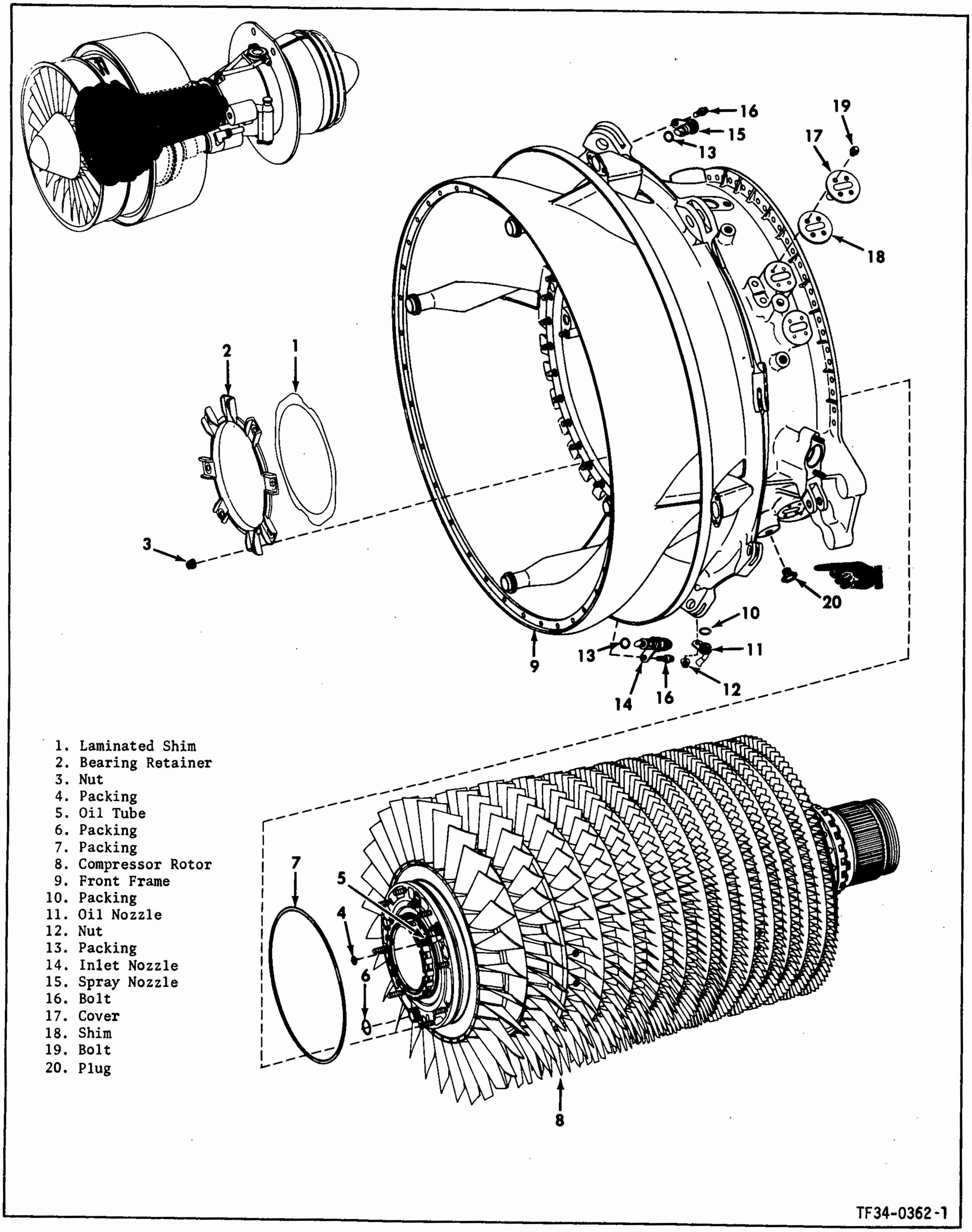
2. Attach overhead hoist and lift combustion chamber module (1) from buildup stand (21C5116).

3. Install module in rear engine mount (21C-5190) by putting the aft mount ring (2) into support portion of rear engine mount and connecting it with quick release pins. Adjust support (21C5220) to hold forward end of combustion chamber module.

4. Remove lifting sling (21C5210) and hoisting adapter (21C5198).

5. Install combustion module guide (21C5169) through combustion module and thread it onto compressor rotor rear shaft. Assemble dummy casing bar (21C5132) onto front frame flange.

6. Loosen locks on rear engine mount (21C-5190) and slowly roll it forward, aligning combustion chamber with module guide (21C5169). Carefully guide combustion module over guide (21C5169) until the No. 4 bearing inner and outer races are completely engaged. Lock rear engine mount in position and remove combustion module guide (21C5169).



1. Laminated Shim
2. Bearing Retainer
3. Nut
4. Packing
5. Oil Tube
6. Packing
7. Packing
8. Compressor Rotor
9. Front Frame
10. Packing
11. Oil Nozzle
12. Nut
13. Packing
14. Inlet Nozzle
15. Spray Nozzle
16. Bolt
17. Cover
18. Shim
19. Bolt
20. Plug

Figure 7-7. Installation of Compressor Rotor

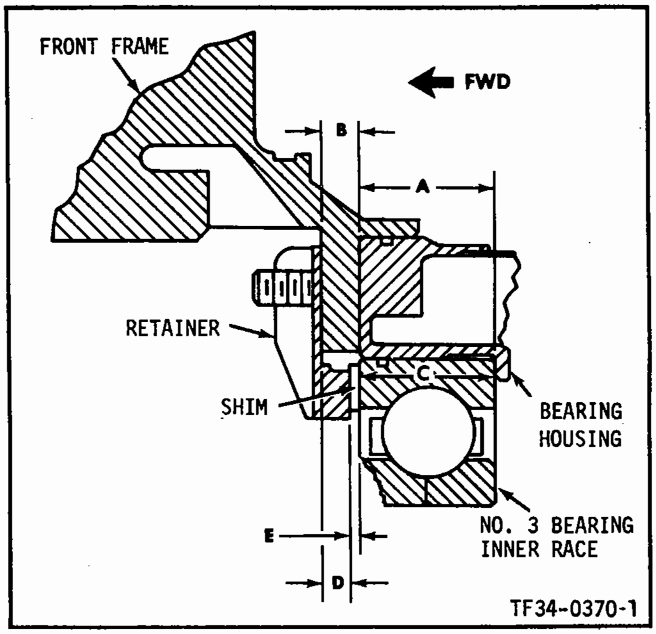


Figure 7-8. Calculation of Shim Thickness

7-20. INSTALLATION OF COMPRESSOR STATOR ASSEMBLY. For special tools, see table 2-1 group 10.

1. If blades, vanes or casings have been replaced, clearance checks are required on those stages affected. Follow the procedure in paragraph 7-21. If no parts were replaced, follow instructions for final assembly of compressor stators in paragraph 7-25.

7-21. COMPRESSOR BLADE AND VANE TIP CLEARANCE CHECKS.

1. Three methods are used for making compressor blade and vane tip checks. Method number 1 is used for taking all vane-to-rotor spool clearances. Method no. 2 is used for taking blade tip clearances if a complete stage of blades has been replaced. Method number 3 is used for taking compressor blade tip clearances and can only be used for taking partial stage or stages clearances. Clearances only have to be taken when parts have been replaced. Determine from assembly records which parts were replaced. If a stage or stages have been replaced, check only the clearances affected by that stage or

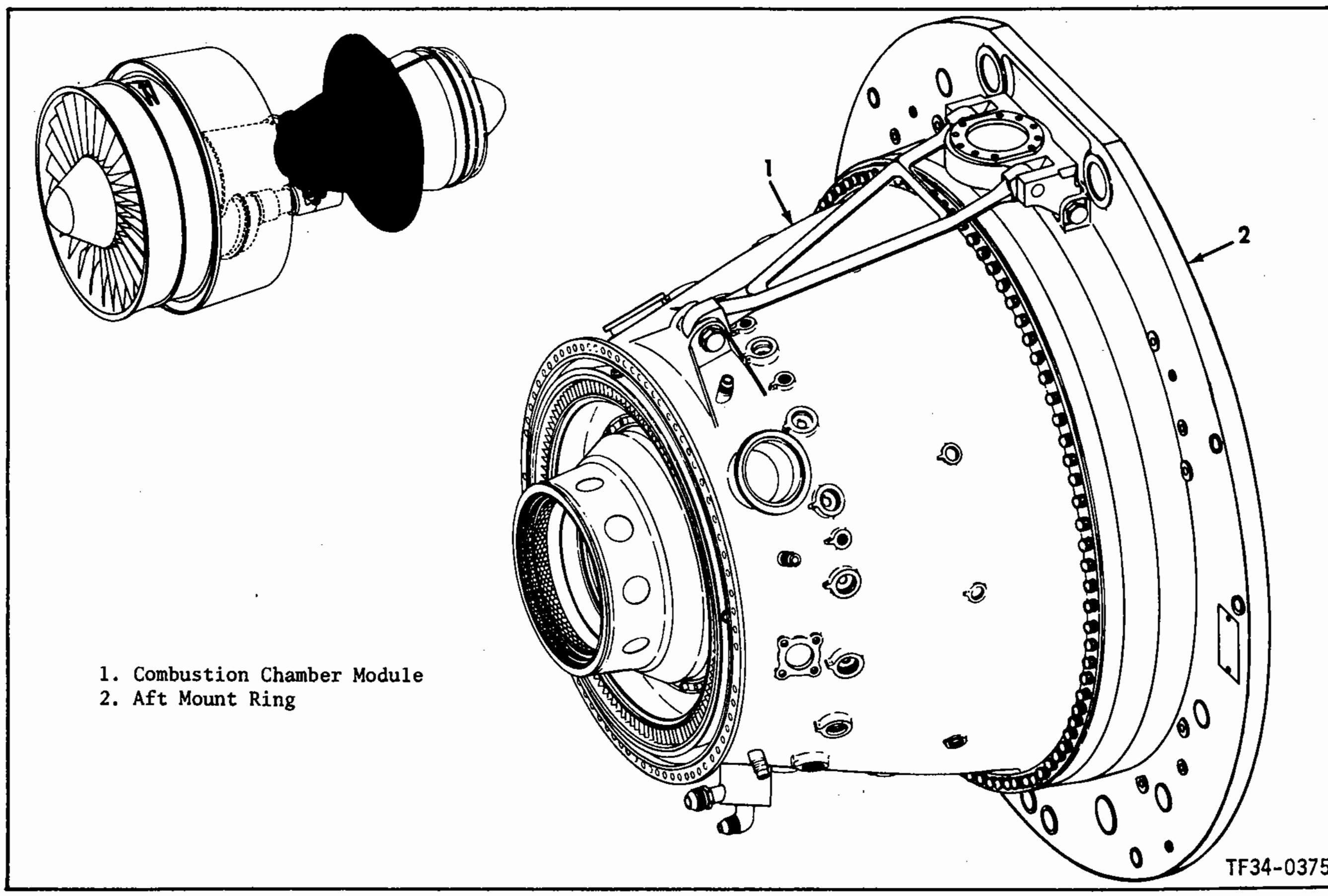


Figure 7-9. Installation of Combustion Chamber Module

stages. If a compressor casing (forward or rear) is replaced, all clearances pertaining to the casing would have to be taken (IGV through 10 or 11 through 13). See table 8-2 to determine which clearances must be taken. All three methods are done with one-half of compressor casings installed. Follow assembly instructions in paragraph 7-25, except do not apply silicone aluminum paint to the flanges. After all the casing halves are installed, remove one half, leaving the second half bolted at the front and rear flanges. For vane clearances, make sure the half that is assembled contains the new vanes. If both halves contain new parts, repeat the procedure with the other half installed. This applies to both forward and rear casings.

7-22. MEASURING VANE TIP CLEARANCES; (Method number 1).

1. Select a piece of plastic shim stock as thick as the minimum clearance limit given in table 8-1 for the stage being checked. It should be long enough to extend around the circumference of the rotor spool.

2. Taper one end of the shim stock and attach it to the rotor spool with a piece of cellophane tape so that the thickness of the tape and tapered end of the plastic shim is not more than the thickness of the shim stock.

3. Slowly rotate the rotor one full revolution clockwise. If rotor binds, immediately turn the rotor counterclockwise and install a thinner piece of shim stock. If necessary, do this until the shim stock passes completely around the casing half.

4. Based on the thickness of the shim stock that passed through the casing, determine whether any material has to be benched from the vane tips. For example, if the minimum clearance is 0.022 inch, and 0.017 inch shim stock was used to complete a full turn of the rotor, 0.005 inch must be removed from the long vane or vanes. If the shim stock equal to the minimum clearance passes through the casing, no benching is required. If benching is required, see air foil benching procedure in section 5; repeat preceding steps until all clearances are within the limits of table 8-1. If vanes were replaced in other casing half, install other casing half, remove first casing half and repeat this paragraph.

7-23. MEASURING BLADE TIP CLEARANCES, FULL STAGE REPLACEMENT; (Method number 2).

1. Select a piece of plastic shim stock as thick as the minimum clearance limit given in table 8-1 for the stage being checked. Its length should be at least the same as the circumference of the compressor rotor at the blade tip of the stage being checked.

2. Attach one end of the shim stock to a blade with cellophane tape. Slowly rotate the rotor clockwise, aft looking forward, one full revolution, feeding the shim stock into the casing. If binding results, immediately turn the rotor counterclockwise and remove the shim stock. Select a thinner piece of shim stock and repeat the process until the shim stock passes completely around the casing half.

CAUTION

Be careful not to let metal particles fall into engine parts when benching.

3. Follow the procedure in paragraph 7-24 to remove material from blade tips, if required. Repeat this step for all other stages that were completely replaced.

4. Install second casing half, remove first casing half, and repeat the procedure for the second casing half.

5. When all clearances are within the limits of table 8-1, install the compressor stator assembly per instructions in paragraph 7-25.

7-24. MEASURING BLADE TIP CLEARANCES, PARTIAL STAGE REPLACEMENT; (Method number 3).

1. Attach a dial indicator to a dummy casing bar (21C5132). Install a button tip on the indicator and adjust indicator so that the tip centers on a blade tip.

2. Using the indicator, locate the longest old blade in the stage.

CAUTION

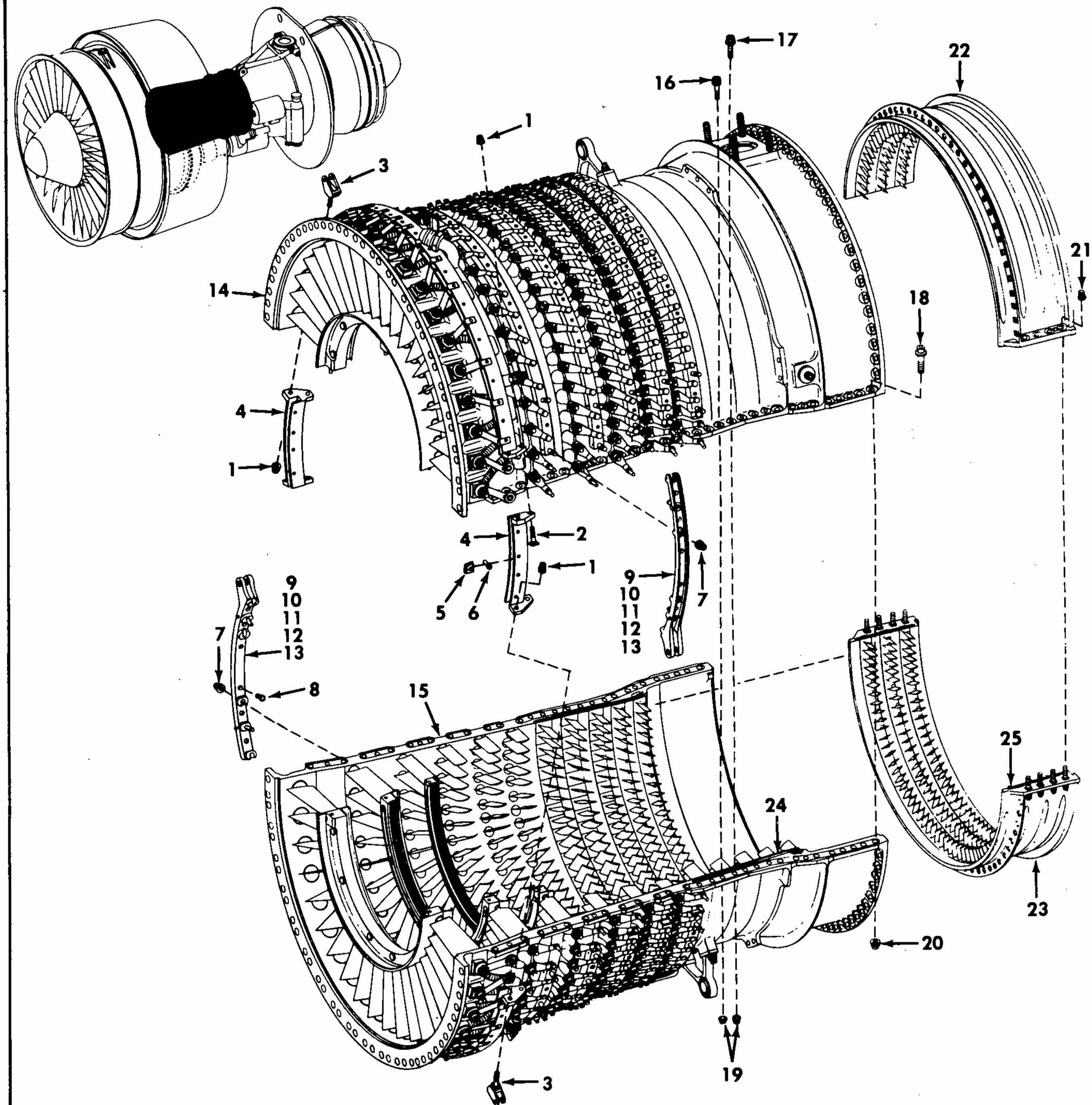
Be careful not to let metal particles fall into engine parts when blending.

3. Check all the new blades against the longest old blade to see that all the new blades are equal to or shorter than the longest old blade. Blend new blades that are longer than the longest old blade, until they are the same length as the longest old blade.

4. Repeat procedure for all other stages that have new blades. When all clearances are within the limits of table 8-1, install the compressor stator assembly per paragraph 7-25.

7-25. FINAL INSTALLATION OF COMPRESSOR STATOR ASSEMBLY. For special tools, see table 2-1, group 10.

1. Install bottom half of rear casing (23, figure 7-10) into position and assemble retainer (21C5178) to aft-most studs at each splitline using nuts (21).



1. Nut
2. Bolt, Square Head
3. Clevis Arm
4. IGV Bridge
5. Clip
6. Pin
7. Nut
8. Vane Arm Bushing
9. Stage 1 Bridge
10. Stage 2 Bridge
11. Stage 3 Bridge
12. Stage 4 Bridge
13. Stage 5 Bridge
14. Compressor Casing - Top Half
15. Compressor Casing - Bottom Half
16. Body-Bound Bolt
17. Bolt
18. Body-Bound Bolt
19. Nut
20. Nut
21. Nut
22. Rear Casing - Top Half
23. Rear Casing - Bottom Half
24. Anti-Rotation Key
25. Anti-Rotation Key

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Figure 7-10. Installation of Compressor Stator Assembly

NOTE

Application of silicone paint must be done within 4 hours of casing installation.

2. Apply a thin coat, 0.001 to 0.003 in. thick, of silicone paint (mfd, by General Electric Co., Waterford, N.Y.) to aft flange on bottom half of forward casing (15). Install bottom half of forward casing on engine with circumferential bolts and nuts. See bolting diagrams, figures 7-11 and 7-12 for location of bolts, clamps, and brackets. Leave bolts fingertight.

3. Adjust front frame support (21C5219) and combustion support (21C5220), so the dummy casing bars (21C5132) can be removed. Remove dummy casing bars.

4. Remove retainer (21C5178). Apply silicone paint, as in step 2 above, to both split line flanges of both rear casings (22, 23, figure 7-10) and both forward casings (14, 15). Assemble guide pins (21C5159).

CAUTION

Be sure anti-rotation keys (24, 25) are properly installed in compressor casing split lines.

5. Assemble top half of rear casing (22). Install nuts (21) to studs on bottom half of rear casing (23). Studs are numbered 1 through 4, forward to aft. Torque nuts to 45-55 lb in., in sequence of 4, 1, 3, 2, alternating split lines.

CAUTION

Drive the body-bound bolts straight through without turning, using a plastic drift. Turning enlarges the holes; the casings will not line up if the holes are oversize.

6. Apply a thin coat of silicone paint, as in step 2., to aft flange of top half of forward casing (14). Using lifting handle (21C5067), assemble casing to engine and install bolts (16, 17, 18) and nuts (19, 20). Torque nuts (19) to 40-45 lb in., and nuts (20) to 100-110 lb in. Remove guide pins (21C5159).

7. Install remaining circumferential flange bolts and nuts per figures 7-11 and 7-12. Torque forward flange bolts to 105-115 lb in. and aft flange bolts to 160-170 lb in.

CAUTION

Be sure to align matchmarks on actuator ring bridges. These are matched assemblies.

8. Install IGV actuating ring bridges (4, figure 7-10), with matchmarks aligned, to actuating rings with 6 bolts (2), 2 clevis rods (3) and 8 nuts (1). Assemble clevis rods to actuating rings as shown in figure 7-10. Both clevis rods go in forward holes. Do not torque nuts at this time.

9. Align vane lever arms and assemble 8 pins (6) and 8 clips (5). Torque nuts (1) to 40-45 lb in.

CAUTION

Do not force bridges onto the studs.

10. Assemble 4 bushings (8) to each stage 1 bridge (9) with heads of bushings on ID of bridge.

11. Assemble bridges (9) to actuating rings and to pins of vane lever arms, with matchmarks aligned (LT on left top, RB on right bottom). Assemble left-hand bridge so that clevis pin hole is closest to 6 o'clock position and right-hand bridge so that clevis pin hole is closest to 12 o'clock position.

CAUTION

After installing both bridges of each stage, make sure that all vane lever arm pins are engaged in the holes of actuating rings. When bridges are not installed, and one half of actuating ring is removed, lever arm pins have a tendency to become disengaged from actuating ring holes.

12. Assemble 8 nuts (7) and torque them to 40-45 lb in.

CAUTION

Be sure to align matchmarks.

13. Repeat steps 10 through 12 for stages 2 through 5, using bridges (10, 11, 12, 13).

7-26. INSTALLATION OF VARIABLE GEOMETRY CONTROL LINKAGE.

1. Assemble left-hand linkage assembly (1, figure 7-13) to compressor stator (2) by inserting the aft end of linkage assembly into aft bearing (3).

2. Align center bearing on linkage assembly with 4 holes in compressor casing at stage 2 vane rib.

3. Install 4 bolts (4), 4 washers (5) and 4 nuts (6) to center bearing and compressor casing stage 2 rib, fingertight.

CAUTION

After torquing bolts on center and forward bearings, make sure that linkage does not bind. Reposition bearings if binding exists.

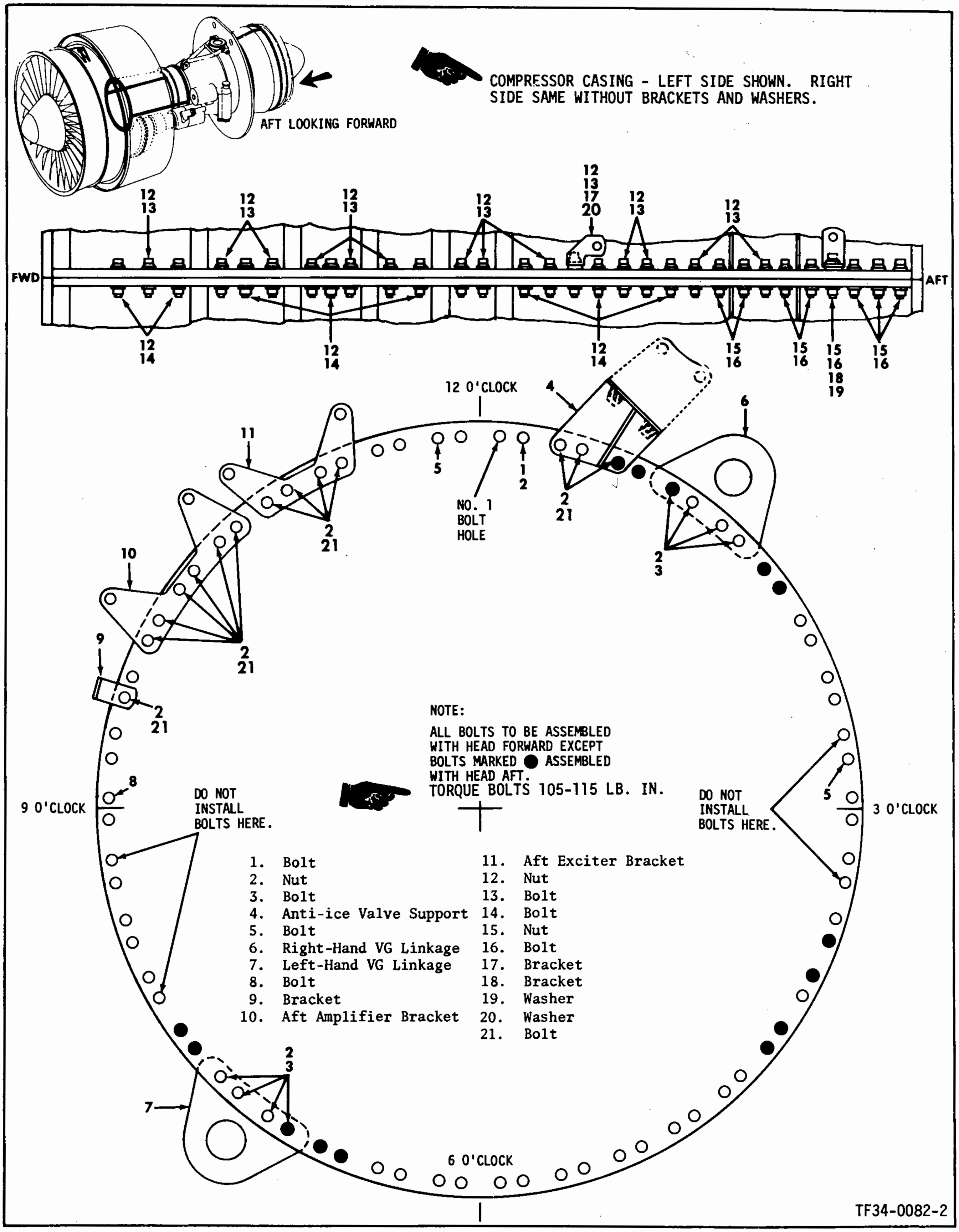


Figure 7-11. Bolting Diagram - Compressor Casing-To-Front Frame and Compressor Casing Splitline

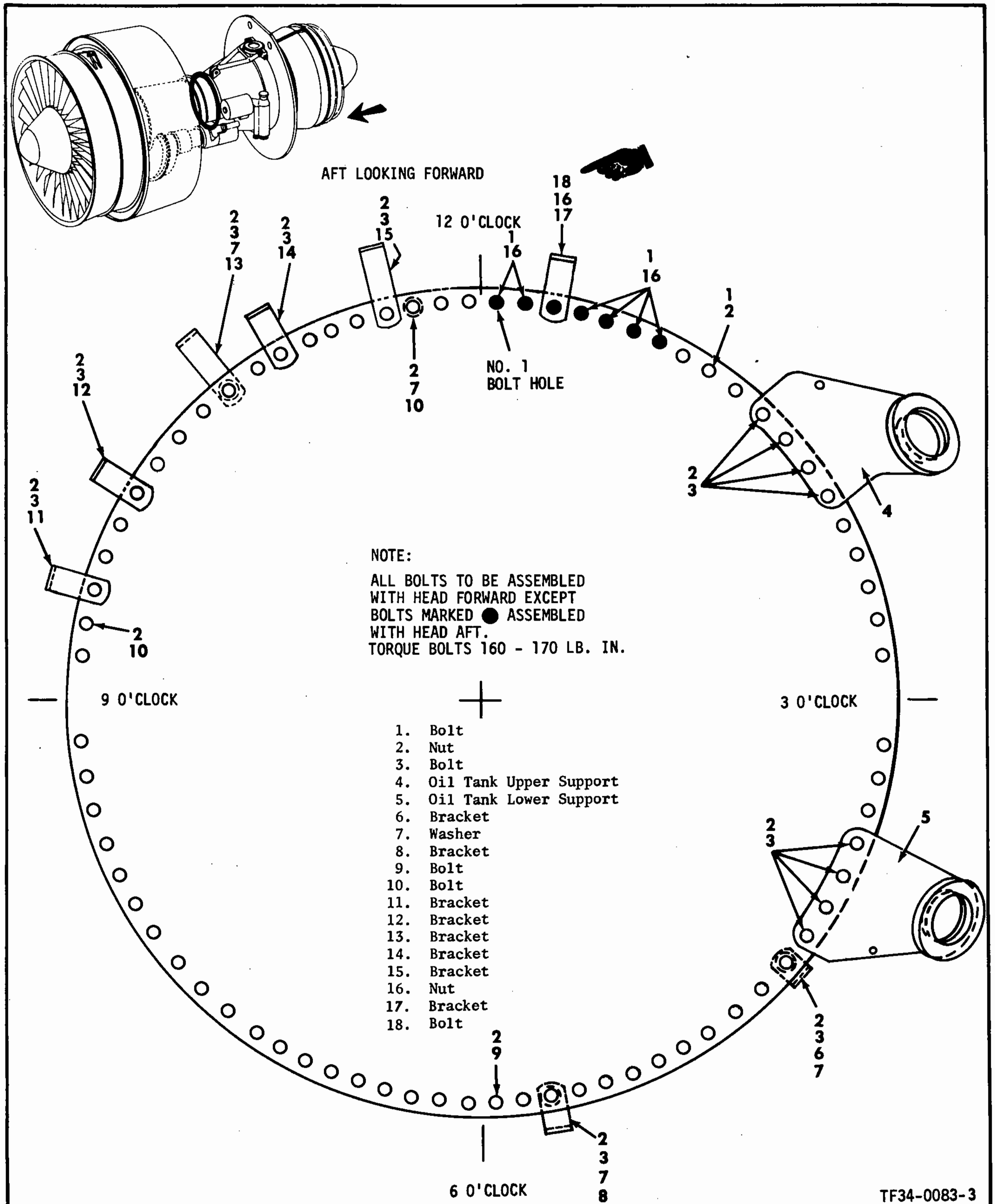
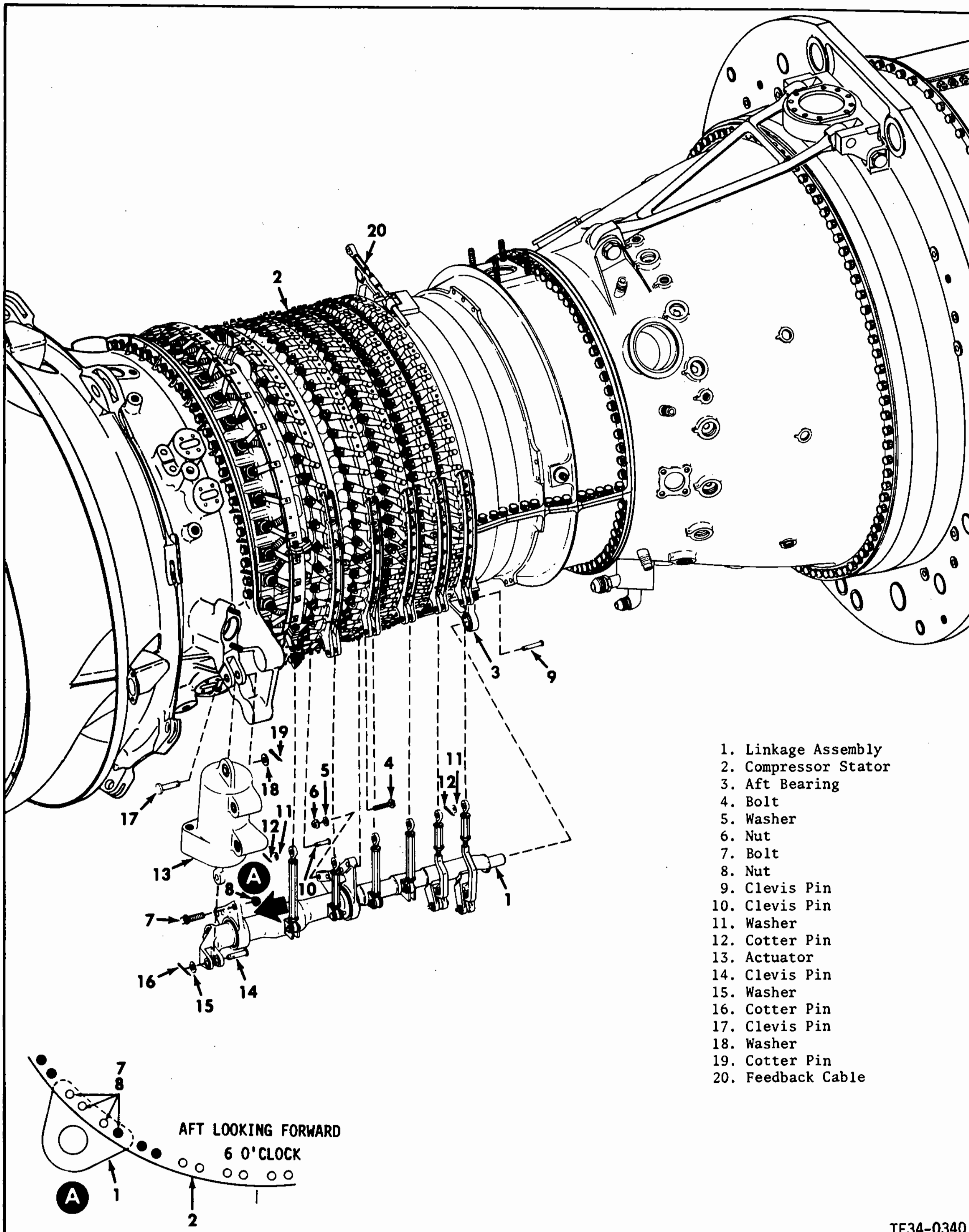


Figure 7-12. Bolting Diagram - Compressor Casing-to-Combustion Chamber



1. Linkage Assembly
2. Compressor Stator
3. Aft Bearing
4. Bolt
5. Washer
6. Nut
7. Bolt
8. Nut
9. Clevis Pin
10. Clevis Pin
11. Washer
12. Cotter Pin
13. Actuator
14. Clevis Pin
15. Washer
16. Cotter Pin
17. Clevis Pin
18. Washer
19. Cotter Pin
20. Feedback Cable

Figure 7-13. Installation of Variable Geometry Control Linkage

4. Install 4 bolts (7) through forward bearing at the front frame compressor circumferential flange and assemble 4 nuts (8). Torque bolts to 105-115 lb in.

5. Torque bolts (4) on center bearing to 40-45 lb in.

6. Before assembling rod end bearings to actuator rings, make sure there is an equal number of threads showing on each side of the turnbuckle checknuts.

7. Assemble rod end bearings to vane actuating rings, IGV through stage 5 with clevis pins (9,10) washers (11) and cotter pins (12). Assemble clevis pins with heads facing aft.

8. Assemble actuator (13) to bellcrank on linkage assembly (1) with clevis pin (14), washer (15), and cotter pin (16). Connect actuator (13) to front frame with clevis pin (17), washer (18), and cotter pin (19).

9. Assemble right-hand linkage assembly by following steps 1 through 8. Connect feed back cable (20) by following instructions in paragraph 4-88.

10. Adjust the variable geometry control linkage by following instructions in paragraph 4-132.

7-27. INSTALLATION OF POWER TAKEOFF ASSEMBLY. Lubricate all packings with engine oil.

1. Assemble 2 packings (2, figure 7-14) to oil tube (1). Install oil tube into front frame at about the 6:30 o'clock position. Install the tube so the forward end is at its upper most position.

2. Assemble seal (3) to groove at the end of bevel gear shaft on PTO assembly (4).

3. Install the PTO into front frame, aligning oil tube (1) with fitting in PTO housing. Use hand-pressure to seat the PTO assembly.

4. Assemble 11 nuts (5) and torque them to 105-115 lb in.

5. Assemble 2 packings (6) to vent tube (7). Insert vent tube into boss in front frame at 6 o'clock position. Secure forward end of tube to stud with nut (8). Torque nut to 105-115 lb in.

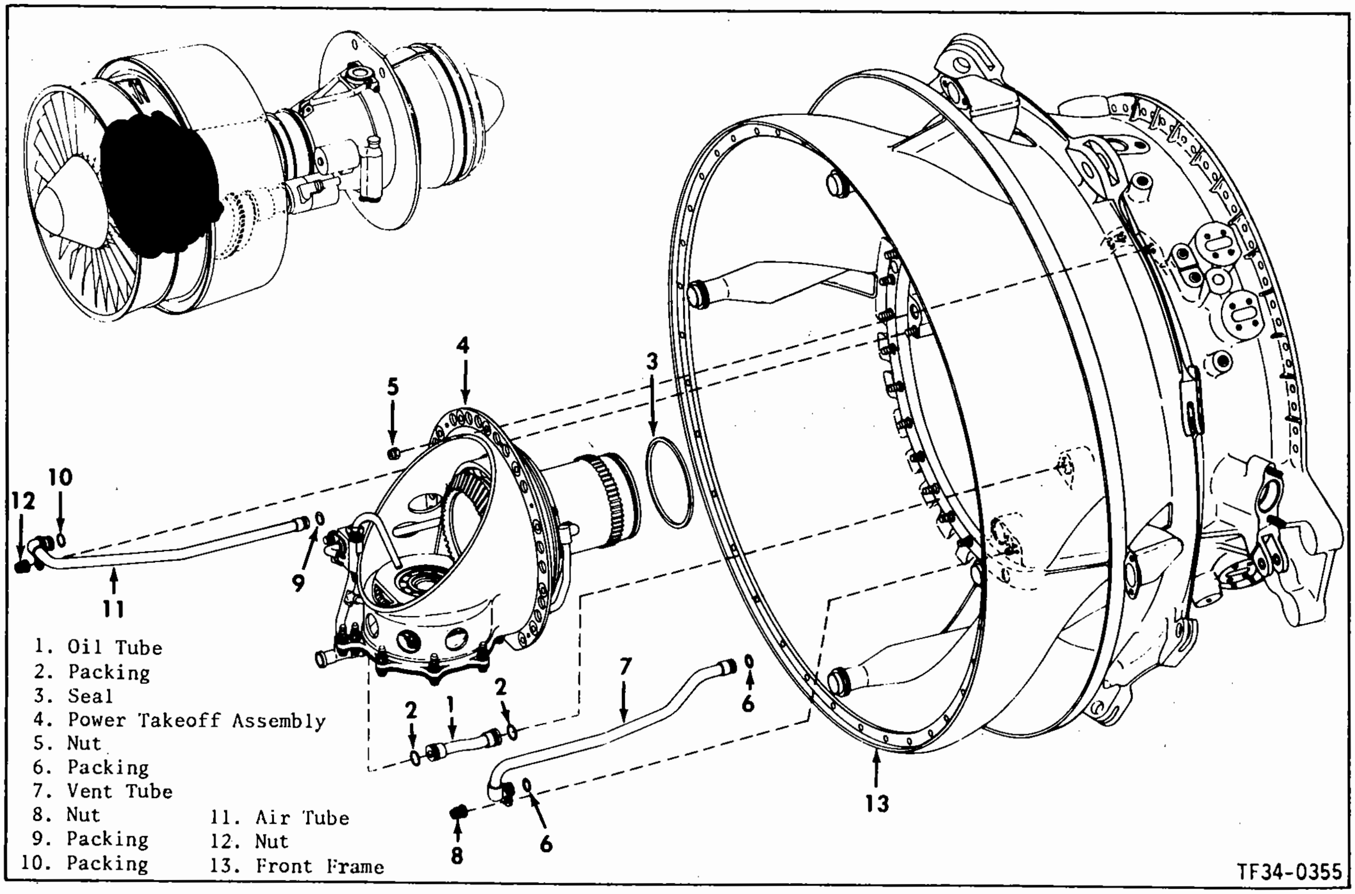


Figure 7-14. Installation of Power Takeoff Assembly

6. Assemble packing (9) to aft end of air tube (11) and packing (10) to forward end. Insert tube through the hole at 3 o'clock position in PTO, into fitting of No. 3 carbon seal. Secure forward end of the tube to stud on front frame with nut (12). Torque nut to 105-115 lb in.

7-28. INSTALLATION OF ACCESSORY DRIVE GEARBOX. For special tools, see table 2-1, group 22.

NOTE

Accessories may be installed before or after gearbox installation. See Section IV for accessories installation instructions.

1. Assemble tubing and brackets to flanges of gearbox as described in paragraphs 4-105 and 4-60. Torque splitline bolts to 70-80 lb in.

2. If bracket assemblies (14, 15) were removed from gearbox, assemble them to pads as follows:

a. Assemble 2 bracket assemblies (14) to the left- and right-hand pads on gearbox. Assemble the brackets so that the letter X on the front frame side of each bracket, is located at lower left corner (aft looking forward) on left-hand bracket and upper right corner on right-hand bracket. Assemble 8 washers (10) and 8 nuts (11) to studs on gearbox. Torque nuts to 25-30 lb ft.

b. Assemble bottom bracket (15) to bottom pad on accessory gearbox with 4 bolts (12), 4 washers (10), and 4 nuts (11). Torque bolts to 25-30 lb ft.

3. Lubricate packings (17, 18) with engine oil. Assemble packing (18) into groove on gearbox pad. Assemble packing (17) into groove of packing retainer (16).

4. Lubricate ID of packing retainer (16) with engine oil and install it over packing groove of gearbox pad. Lubricate mating bore on front frame with engine oil.

5. Install gearbox onto fixture (21C5064). Roll fixture and gearbox under engine.

6. Raise fixture so that brackets on accessory gearbox line up with pads on front frame.

7. Assemble 2 washers (10) and 2 bolts (9), one to each hole marked X in the left- and right-hand brackets. Make bolts fingertight.

8. Assemble 6 washers (10) and 6 bolts (8) to the remaining 3 holes in each bracket, fingertight. Remove fixture (21C5064).

9. Install alignment pin (21C5180P05) into hole in bottom of gearbox, shown in figure 7-16. Make sure the pin goes into mating hole in front frame.

10. Use a feeler gage and measure the gap between front frame pad and the bottom bracket.

11. Peel a laminated shim (13) to within 0.001 inch of gap determined in step 10. Remove alignment pin (21C5180P05).

12. Install shim (13), 4 bolts (8), and 4 washers (10). Torque bolts on all 3 brackets to 25-30 lb ft.

13. Install alignment pin (21C5180P04). Pin must enter the hole in front frame. If it does not, do the following:

a. Remove alignment pin.

b. Remove bolts from bottom bracket.

c. Vary shim thickness until alignment pin (21C5180P04) can be inserted into hole in front frame with bolts torqued to 25-30 lb ft.

14. Install radial drive shaft (7), drive shaft retainer (6) and retaining ring (5).

15. Assemble packing (4) to cover (3). Assemble cover to gearbox with 4 screws (2). Torque screws to 25-30 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

16. Lock-wire bolts on 3 gearbox brackets, using 0.032 inch lockwire double-strand method.

7-29. INSTALLATION OF SPLITTER NOSE. For special tools, see table 2-1, group 21.

1. If accessory drive gearbox is installed, position lifting head of fixture (21C5219) so that the tapered end is up.

2. If accessory gearbox is not installed, position head of fixture (21C5219) so that round end is up.

3. Install fixture (21C5219) onto aft side of forward engine support (21C5189) under the front frame.

4. Adjust head (part of 21C5219) so that weight of engine is on fixture (21C5219) and not on front frame support (21C5177). Remove front frame support (21C5177).

5. Assemble splitter nose (1, figure 7-17) over the front frame (2) and align it so that the anti-icing neck is at approximately the 1 o'clock position.

6. Assemble 4 seals (3) to 4 anti-icing tubes (5).

7. Align 4 holes in splitter nose (1) with 4 anti-icing tubes (5) trapped in front frame struts and assemble 8 bolts (4) through the anti-icing tubes into splitter nose. Torque bolts to 88-92 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

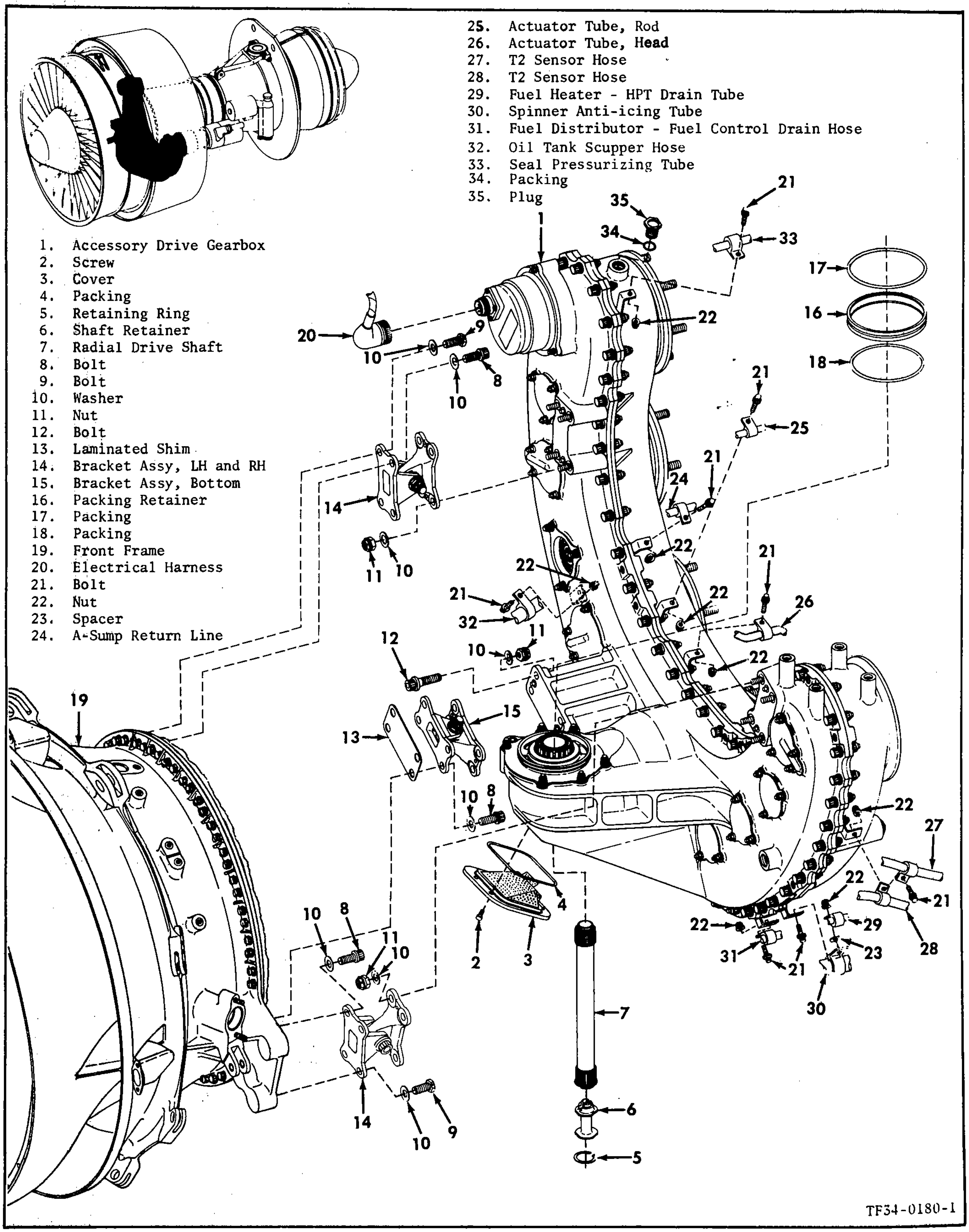


Figure 7-15. Installation of Accessory Drive Gearbox

7-30. INSTALLATION OF FAN STATOR ASSEMBLY. For special tools, see table 2-1, group 21.

1. Install fan stator assembly into forward engine support (21C5189), with quick release pin heads facing forward.

2. Roll support (21C5189) aft until fan vane inner support and front frame (1, figure 7-18) flange are aligned. Adjust position of support (21C5189) and/or (21C5166) if necessary, and insert 4 anti-icing tubes (2) into holes of inner support.

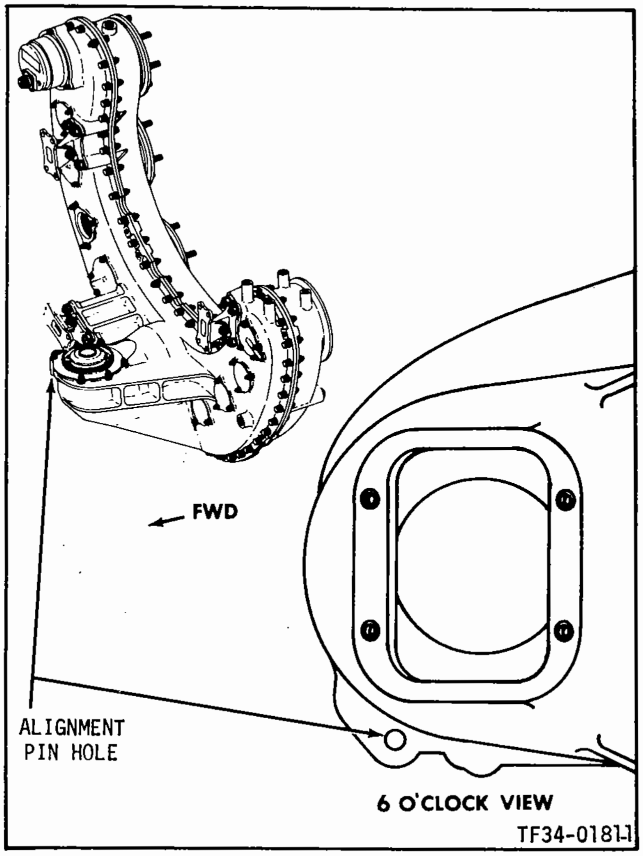


Figure 7-16. Alignment of Accessory Drive Gearbox

3. Install 36 bolts (3) and washers (4) through front frame flange into fan vane inner support. Torque bolts to 38-42 lb in.

NOTE

Tie rods (5, 6) must be assembled with the studs pointing aft.

4. Assemble 2 tie rods (5, 6) to front frame (1) and fan casing (7) at 12 o'clock position. Install 2 eccentric pins (8) and 2 lockarms (9), aligning the matchmarks. Install 2 bolts (10), and 2 nuts (11), fingertight. Install 2 tie rod pins (12). Fill the slots in the casing where tie rods are pinned, with RTV-103. Install cover (13), and bolt (14).

5. Repeat step 4 for tie rods (15, 16) at the 3, 6, and 9 o'clock positions, using pins (12), eccentric pins (17), lockarms (18), bolts (19), and nuts (20).

6. Install 3 brackets (21, 22, 23) onto flange adapter (24) and fan casing (7), with bolts (25, 28), washers (27), and nuts (26). Torque bolts to 38-42 lb in. Lock-wire bolts (28), double-strand method, using 0.032 inch lockwire.

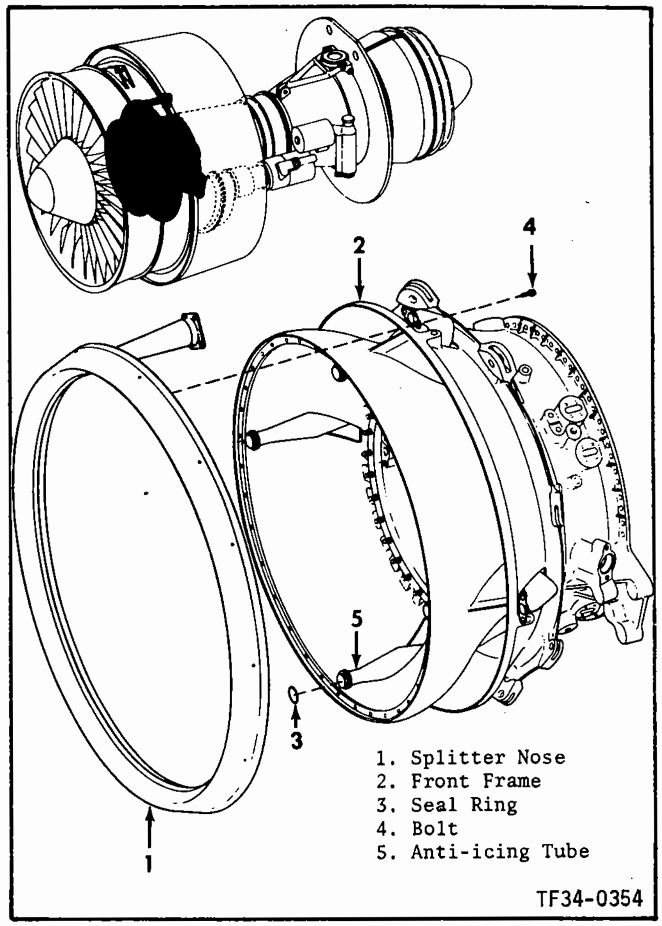


Figure 7-17. Installation of Splitter Nose

NOTE

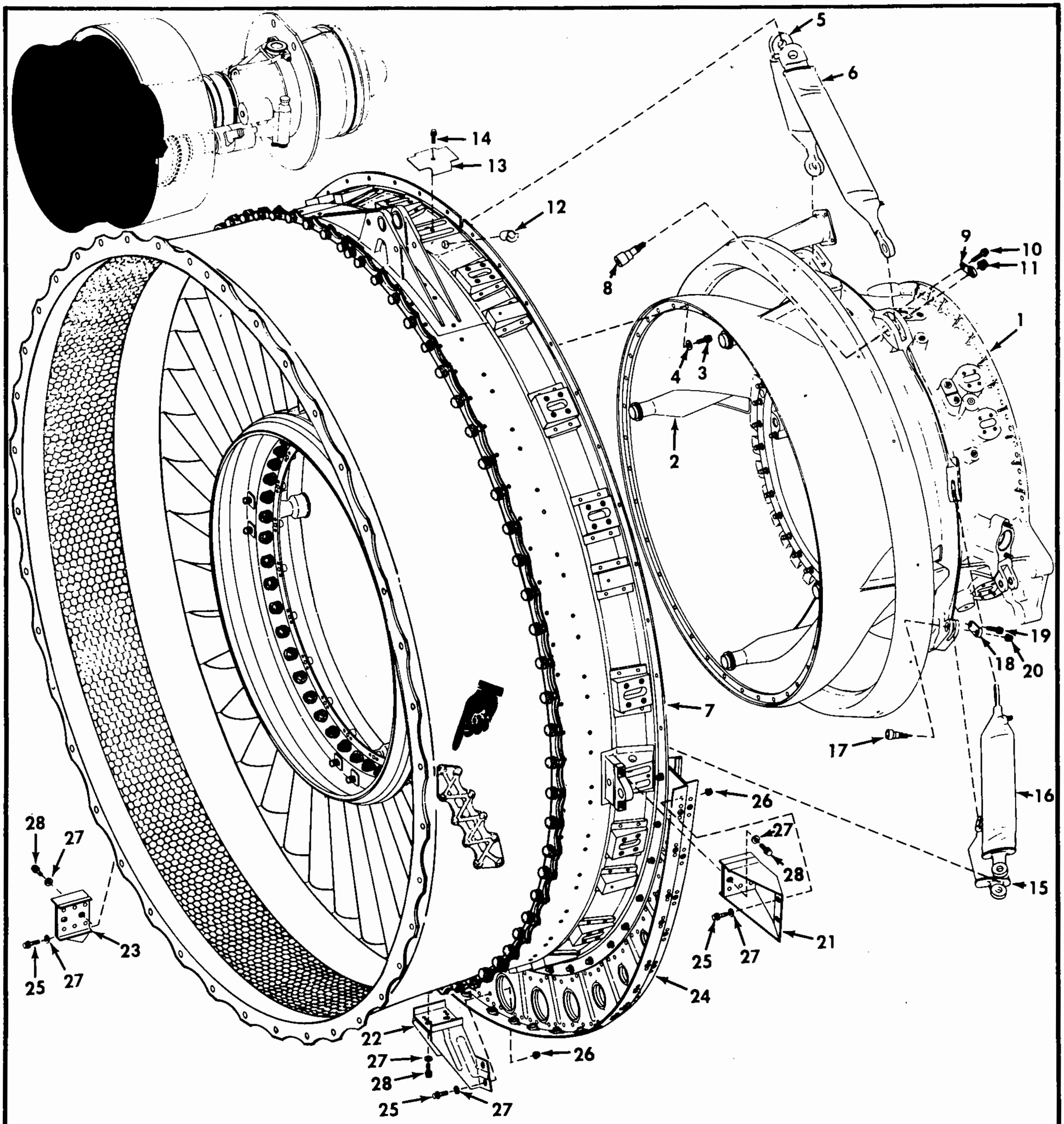
Do not torque nuts (11, 20) or bolts (10, 19) at this time. After installation of fan drive shaft, a runout is required which may require adjustment of eccentric pins (8, 17).

7-31. INSTALLATION OF FAN HOUSING.

1. Install fan housing (4, figure 7-19) with 73 bolts (1), washers (2) and nuts (3). Torque bolts to 38-42 lb in.

2. Apply RTV-103 around the mating surface of blade removal port cover (6).

3. Install cover with bolts (7). Torque bolts to 32-35 lb in. and lock-wire with 0.032 inch wire double-strand method. Lockwire 2 bolts together. Apply RTV-103 to entire length of lockwire.



1. Front Frame
2. Anti-Icing Tube
3. Bolt
4. Washer
5. Tie Rod - 12 O'clock Position, Right-hand
6. Tie Rod - 12 O'clock Position, Left-hand
7. Fan Stator Casing
8. Eccentric Pin
9. Lockarm
10. Bolt
11. Nut
12. Pin
13. Cover
14. Bolt
15. Tie Rod - Left-hand
16. Tie Rod - Right-hand
17. Eccentric Pin
18. Lockarm
19. Bolt
20. Nut
21. Bracket - 9 O'clock Position
22. Bracket - 6 O'clock Position
23. Bracket - 3 O'clock Position
24. Flange Adapter
25. Bolt
26. Nut
27. Washer
28. Bolt

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Figure 7-18. Installation of Fan Stator Assembly

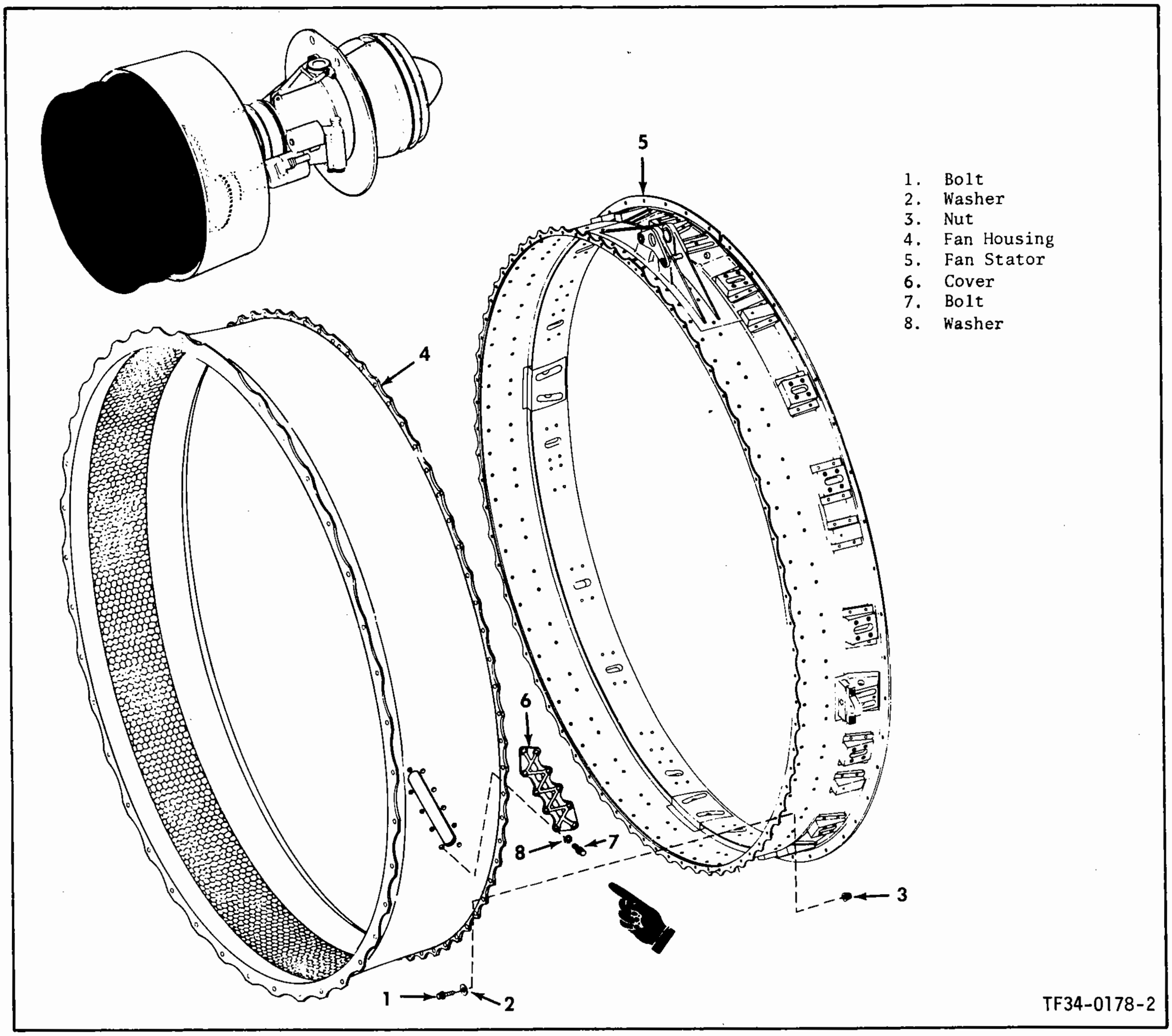


Figure 7-19. Installation of Fan Housing

7-32. INSTALLATION OF FAN FRONT SHAFT - FAN DRIVE SHAFT INSTALLED. For special tools, see table 2-1, group 18.

NOTE

- Follow instructions of this paragraph when the fan drive shaft is already installed in the engine. If fan drive shaft is not installed, follow instructions of paragraph 7-33.
- If a new fan front shaft or a new fan drive shaft is being installed, comply with step 14 of this paragraph. If original parts are being installed, disregard step 14.

1. Lubricate packing (1, figure 7-20) with engine oil and assemble it to tube (2).

2. Install scavenge tube (2) into bearing support (5) at 6 o'clock position.

3. Lubricate packing (6) and assemble it to bearing support (5).

4. Assemble No. 2 bearing outer race (7) to bearing support (5) using pusher (21C5020). Install anti-rotation key (8) and retaining ring (9).

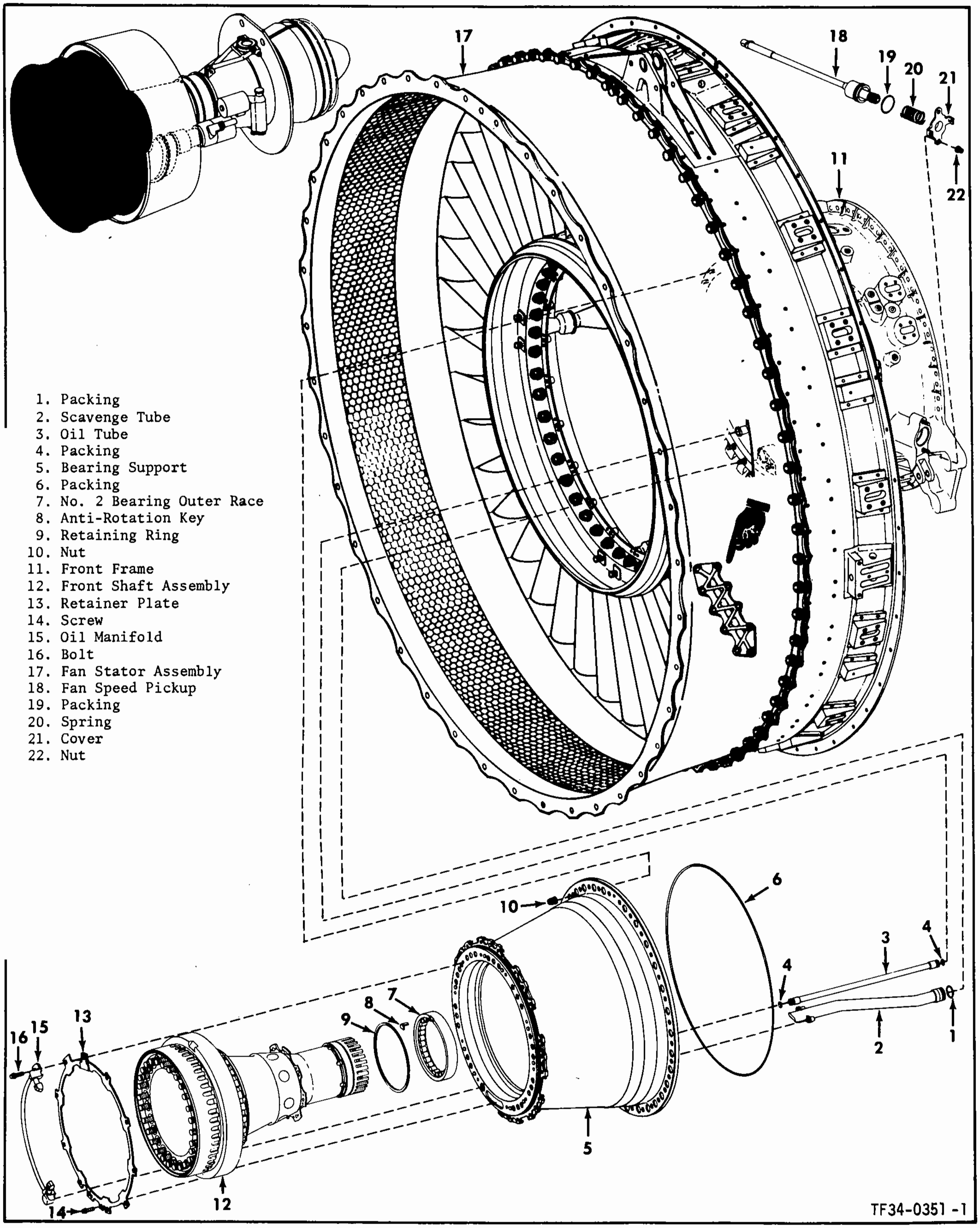


Figure 7-20. Installation of Fan Front Shaft

5. Assemble bearing support (5) to front frame (11), engaging alignment pin (at 12 o'clock position) in hole in bearing support.

6. Assemble 32 nuts (10) and torque nuts to 60-65 lb in. Seat scavenge tube (2) in port in front frame (11).

7. Lubricate 2 packings (4) with engine oil and assemble them to oil tube (3).

8. Install tube (3) through bearing support into front frame (11).

9. Measure and record dimension A on fan front shaft per figure 7-22, using a 0-1 inch micrometer.

10. Measure and record dimension B on fan drive shaft per figure 7-22, using a 6 inch depth vernier.

11. Lubricate mating surfaces of drive shaft and front shaft with engine oil and install front shaft (12, figure 7-20) to the drive shaft (1, figure 7-21) as follows:

a. Align matchmarks and install the front shaft (12, figure 7-20) onto the drive shaft.

b. Thread extension from pusher (21C5066) into fan drive shaft.

c. Install ram portion of pusher (21C5066) onto the extension, and attach knurled knob.

d. Connect hydraulic pump to pusher.

CAUTION

- Make sure No. 1 bearing moves freely into bearing support when seating the shaft.
- Reduce hydraulic pressure to zero if needle on gage enters yellow zone. Do not build up pressure again until you determine why front shaft will not seat.

e. Build up hydraulic pressure and seat front shaft.

f. Remove pusher (21C5066).

12. Measure and record dimension C per figure 7-23, using a parallel bar and 12 inch depth vernier. Calculate front shaft seating as follows:

a. Subtract dimension A from dimension B.

b. Result must be within 0.001 inch of dimension C. Reseat shaft if not within limit.

13. Assemble retainer plate (13, figure 7-20) and oil manifold (15) with 10 bolts (16). Torque bolts to 38-42 lb in.

14. If a new fan front shaft or fan drive shaft has been installed, proceed as follows:

a. Install LPT module as described in paragraph 7-37.

b. Remove fan front shaft, leaving the No. 1 and 2 bearing housing installed. Use puller (21C5065).

c. Remove number 1 bearing only, as described in paragraph 5-28. Reinstall seal runner as described in paragraph 6-3.

d. Install fan front shaft (without Number 1 bearing) as described in steps 9 through 12 of this paragraph.

e. Attach a dial indicator in a position so that the Number 1 bearing journal on fan front shaft can be runout.

f. Carefully rotate the fan front shaft 1 full turn. TIR should not exceed 0.0008 inch. If it does, remove fan front shaft, (see step b) rotate front shaft 180° from original position and reinstall it. Check runout again. Repeat procedure as necessary, until indicator runout is 0.0008 inch or less.

g. When runout is within limits, match-mark the fan front shaft to the fan drive shaft, using Dykem or equivalent. Remove fan front shaft.

h. Permanently place an X, using electro-etch method, on the drive shaft and the front shaft, at the locations marked with Dykem in step g.

i. Reassemble Number 1 bearing to fan front shaft as described in paragraph 6-2.

j. Reinstall fan front shaft as described in steps 9 through 13, this paragraph.

k. Continue with normal assembly procedure by following steps 15 through 26, this paragraph.

15. Assemble 2 screws (14) to scavenge tube (2) and torque to 28-32 lb in.

16. Lubricate packing (2, figure 7-21) with engine oil and install it on bearing support.

17. Assemble carbon seal (3) over seal runner and seat it against bearing support flange.

18. Assemble bearing support plate (4) to flange of bearing support with 16 washers (5) and bolts (6). Assemble 22 washers (7) and bolts (8) to outer holes in support plate. Torque bolts (6, 8) to 38-42 lb in.

19. Lubricate 2 tube packings (9) and 2 seal packings (10) with engine oil. Install packings and grommets (11) on tubes (12).

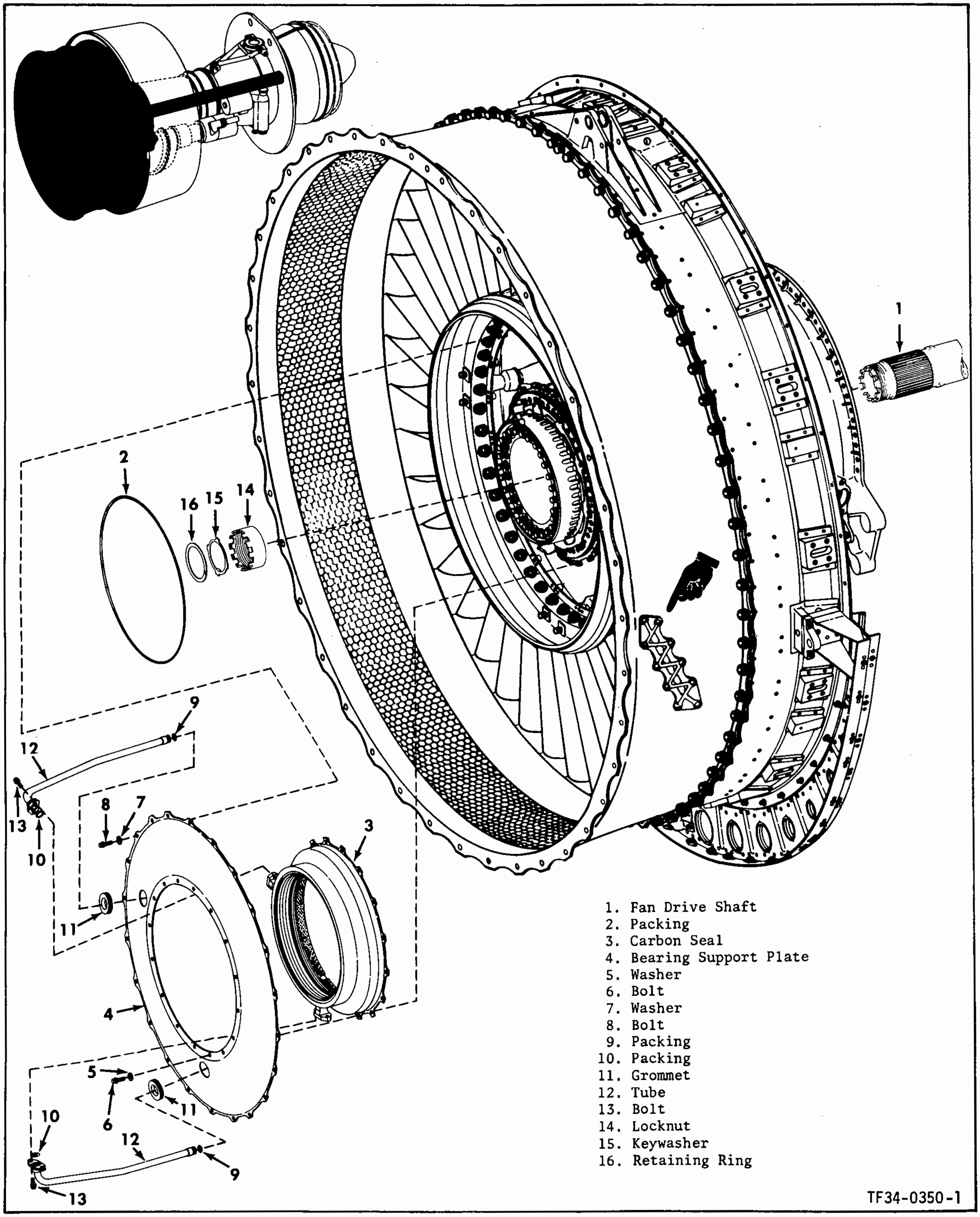


Figure 7-21. Installation of Fan Drive Shaft

20. Insert 2 tubes (12) through holes in support plate (4) and into the fittings on the front frame. Secure tubes (12) to carbon seal (3) with bolts (13). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire. Insert grommets (11) into holes in support plate.

21. Thread front shaft locknut (14) onto drive shaft (1).

22. Guide spanner wrench (21C5043) onto locknut (14). Attach outer section of wrench to disk bolts using 4 nuts (10, figure 7-39).

23. Put torque multiplier (SWE 8100) on wrench (21C5043), with multiplier output in a clockwise direction.

24. Torque locknut (14, figure 7-21) to 575-625 lb ft by applying 51-55 lb ft input to torque multiplier.

25. Assemble keywasher (15) and retaining ring (16) to locknut (14).

26. Assemble fan speed pickup (18, figure 7-20) with lug facing forward to front frame at the 9 o'clock position with packing (19) and spring (20). Install cover (21) over speed pickup with the tangs pointing up. Assemble 2 nuts (22) to studs and torque nuts to 38-42 lb in.

7-33. INSTALLATION OF FAN FRONT SHAFT - FAN DRIVE SHAFT REMOVED. For special tools, see table 2-1, group 18.

NOTE

If fan front shaft or fan drive shaft is being replaced, see paragraph 7-32.

1. Lubricate packing (1, figure 7-20) with engine oil and assemble it to scavenge tube (2).

2. Use pusher (21C5020) and assemble No. 2 bearing outer race (7) to bearing support (5). Install anti-rotation key (8) and retaining ring (9).

3. Lubricate packing (6) and assemble it to bearing support (5).

4. Install scavenge tube (2) into bearing support (5) at 6 o'clock position.

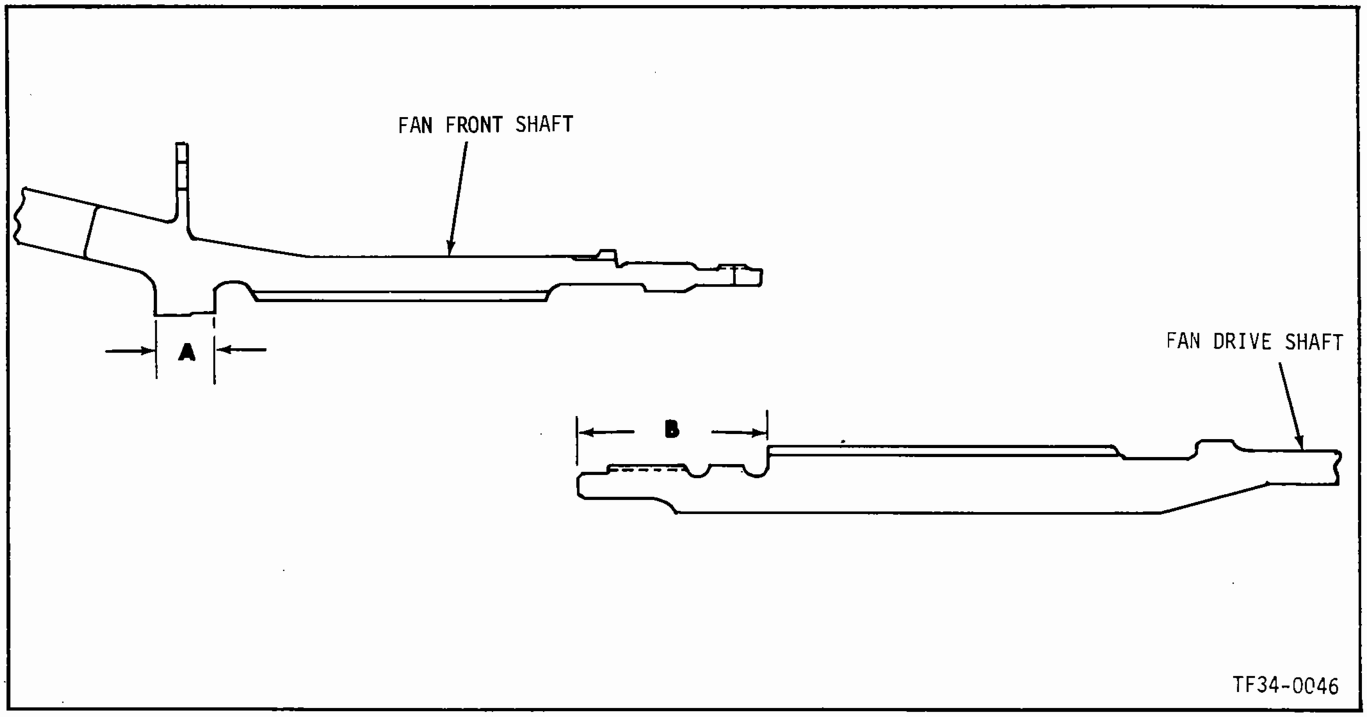


Figure 7-22. Fan Front Shaft Seating Dimensions - Before Installation

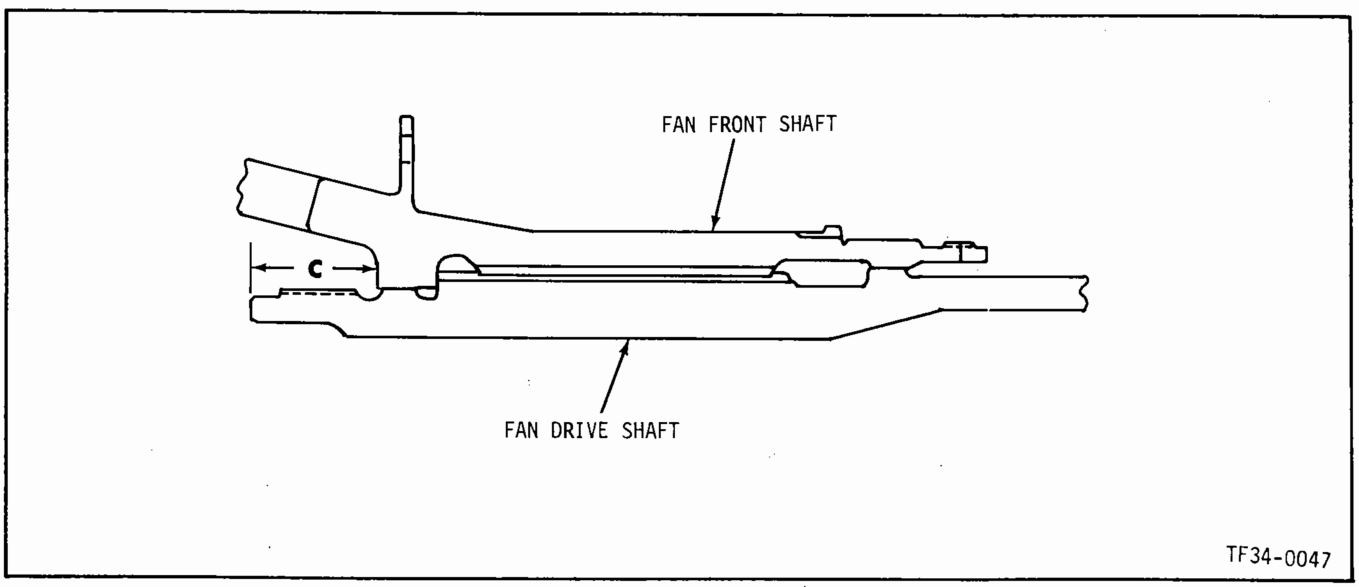


Figure 7-23. Fan Front Shaft Seating Dimensions - After Installation

5. Assemble bearing support (5) to front frame (11), engaging alignment pin (at 12 o'clock position) in hole in bearing support.

6. Assemble 32 nuts (10) and torque nuts to 60-65 lb in. Seat scavenge tube (2) in port in front frame (11).

7. Lubricate 2 packings (4) with engine oil and assemble them to oil tube (3).

8. Install tube (3) through bearing support into front frame (11).

9. Measure and record dimension A on fan front shaft per figure 7-22, using a 0-1 inch micrometer. Retain dimension A for use during fan drive shaft installation.

10. Align matchmarks and install fan front shaft (12, figure 7-20) into bearing support (5). Put keyway on No. 1 bearing at 1 o'clock position.

11. Assemble retainer plate (13) with locking key in slot of No. 1 bearing and oil manifold (15) with 10 bolts (16). Torque bolts to 38-42 lb in.

12. Assemble 2 screws (14) to scavenge tube (2) and torque to 28-32 lb in.

7-34. INSTALLATION OF FAN DRIVE SHAFT. For special tools see table 2-1, group 18.

CAUTION

The following procedure (to prevent fan driveshaft damage) is a two-man operation and should not be attempted along.

NOTE

If fan driveshaft is being replaced, see paragraph 7-32.

1. Install guide (21C5106) through fan front shaft. Attach outer plate of guide to fan disk bolts with fan disk nuts.

2. Push guide as far aft into engine as it will go. Lock in place with quick-release pin.

3. Using a 6 inch depth vernier, measure and record dimension B on fan drive shaft per figure 7-22.

4. Install fan drive shaft (1, figure 7-21) through aft end of engine, forward end (end with air seal) first.

5. Engage the drive shaft onto the guide by aligning the seal bolts with slots of guide. Turn drive shaft to lock it in place.

6. With one man supporting driveshaft, and the other man removing the quick-release pin, slowly guide fan driveshaft through the engine until mating splines are engaged.

7. Remove guide (21C5106).

8. Thread extension from pusher (21C5066) onto fan drive shaft.

9. Install ram portion of pusher (21C5066) onto the extension, and attach knurled knob.

10. Connect hydraulic pump to pusher.

CAUTION

Reduce hydraulic pressure to zero if needle on gage enters yellow zone. Do not build up pressure again until you determine why front shaft will not seat.

11. Build up hydraulic pressure and seat drive shaft. Remove pusher (21C5066).

12. Using a parallel bar and a 12 inch depth vernier, measure and record dimension C per figure 7-23. Calculate drive shaft seating as follows:

a. Subtract dimension A from dimension B.

b. Result must be within 0.001 inch of dimension C. Reseat shaft if not within limit.

13. Lubricate packing (2, figure 7-21) with engine oil and install it on bearing support.

14. Assemble carbon seal (3) over seal runner and seat it against bearing support flange.

15. Assemble bearing support plate (4) to flange of bearing support with 16 washers (5) and bolts (6). Assemble 22 washers (7) and bolts (8) to outer holes in support plate. Torque bolts (6, 8) to 38-42 lb in.

16. Lubricate 2 tube packings (9) and 2 seal packings (10) with engine oil. Install packings and grommets (11) on tubes (12).

17. Insert 2 tubes (12) through the holes in the support plate (4) into the fittings on the front frame. Secure tubes to carbon seal (3) with bolts (13). Torque bolts to 38-42 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire. Insert grommets into holes of support plate.

18. Thread front shaft locknut (14) onto drive shaft (1).

19. Guide spanner wrench (21C5043) onto locknut (14). Attach outer section of wrench to disk bolts using 4 nuts (10, figure 7-39).

20. Put torque multiplier (SWE 8100) on wrench (21C5043), with multiplier output in a clockwise direction.

21. Torque locknut to 575-625 lb ft by applying 51-55 lb ft to torque multiplier.

22. Assemble keywasher (15, figure 7-21) and retaining ring (16) to locknut (14).

23. If necessary, assemble fan speed pickup (18) with lug facing forward to front frame (11) at the 9 o'clock position with packing (19) and spring (20). Install cover (21) over speed pickup with tangs up. Assemble 2 nuts (22) to studs and torque to 38-42 lb in.

7-35. INSTALLATION OF AFT INNER DUCT, COMBUSTION LINER, STAGE 1 NOZZLE, AND OUTER BALANCE PISTON SEAL (STATIONARY).

1. Check fuel tube alignment, using fixture (21C5229) as follows:

a. Assemble fixture (21C5229) to inner flange of combustion chamber, making sure fuel tubes enter holes in fixture. Align the pin in the fixture with hole in flange at 12 o'clock position.

b. Assemble 4 bolts (4, figure 7-24) to hold fixture in place.

c. Check all 18 fuel tubes for centralization in the holes of the fixture. Replace bent fuel tubes or reposition misaligned fuel tubes. See section IV for instructions.

d. Remove 4 bolts (4) and fixture (21C5229).

2. Lubricate 3 screws (9) with milk of magnesia. Align matchmarks and assemble inner duct (5) to liner (6). Assemble 3 screws (9) and torque them to 14-20 lb in.

3. Assemble outer portion of liner guide (21C5125) to liner/duct assembly, aligning the pin at 12 o'clock position. Use bolts (4) to secure liner guide.

4. Assemble inner portion of (21C5125) over 3 studs on balance piston seal aligning slot with 12 o' clock position. Secure fixture with 3 nuts (10).

5. Assemble liner/duct assembly by sliding the outer portion of guide (21C5125) over inner portion, engaging pin in slot. Remove guide (21C5125).

6. Secure inner duct (5) to combustion chamber with 63 bolts (4). Torque bolts to 88-92 lb in.

7. Align matchmarks and install stage 1 nozzle assembly (3) in combustion chamber. Secure the nozzle assembly with bolts (1). Torque bolts to 88-92 lb in. and lock-wire double-strand method, using 0.020 inch lockwire.

8. Assemble 12 bolts (2) to every other hole starting on either side of any shouldered stud (12). Torque bolts to 88-92 lb in.

9. Assemble one bolt shield (11) so that a shouldered stud (12) is in one of the holes of the bolt shield. Assemble nut (10) and bolt (2). Install remaining bolt shields, nuts and bolts. Torque nuts and bolts to 88-92 lb in.

10. Install 2 igniter plugs (8) in combustion chamber. Torque bushing on plug to 200-220 lb in. and lock-wire, using 0.032 inch lockwire, double-strand method.

CAUTION

Be sure the word AFT, stamped on primer nozzle wrenching flat is facing aft and perpendicular with combustion chamber aft flange, after torquing bushings. This aligns nozzle jets for proper direction.

11. Install 2 primer nozzles (13) at the 2 and 4 o'clock positions, and 2 bushings (14). Align wrenching flat marked AFT and hold primer nozzle with a wrench while torquing bushing to 200-220 lb in. Recheck nozzle alignment.

12. Lock-wire bushings (14), double-strand method, using 0.032 inch lockwire.

7-36. INSTALLATION OF HIGH-PRESSURE TURBINE ROTOR. For special tools, see table 2-1, group 25.

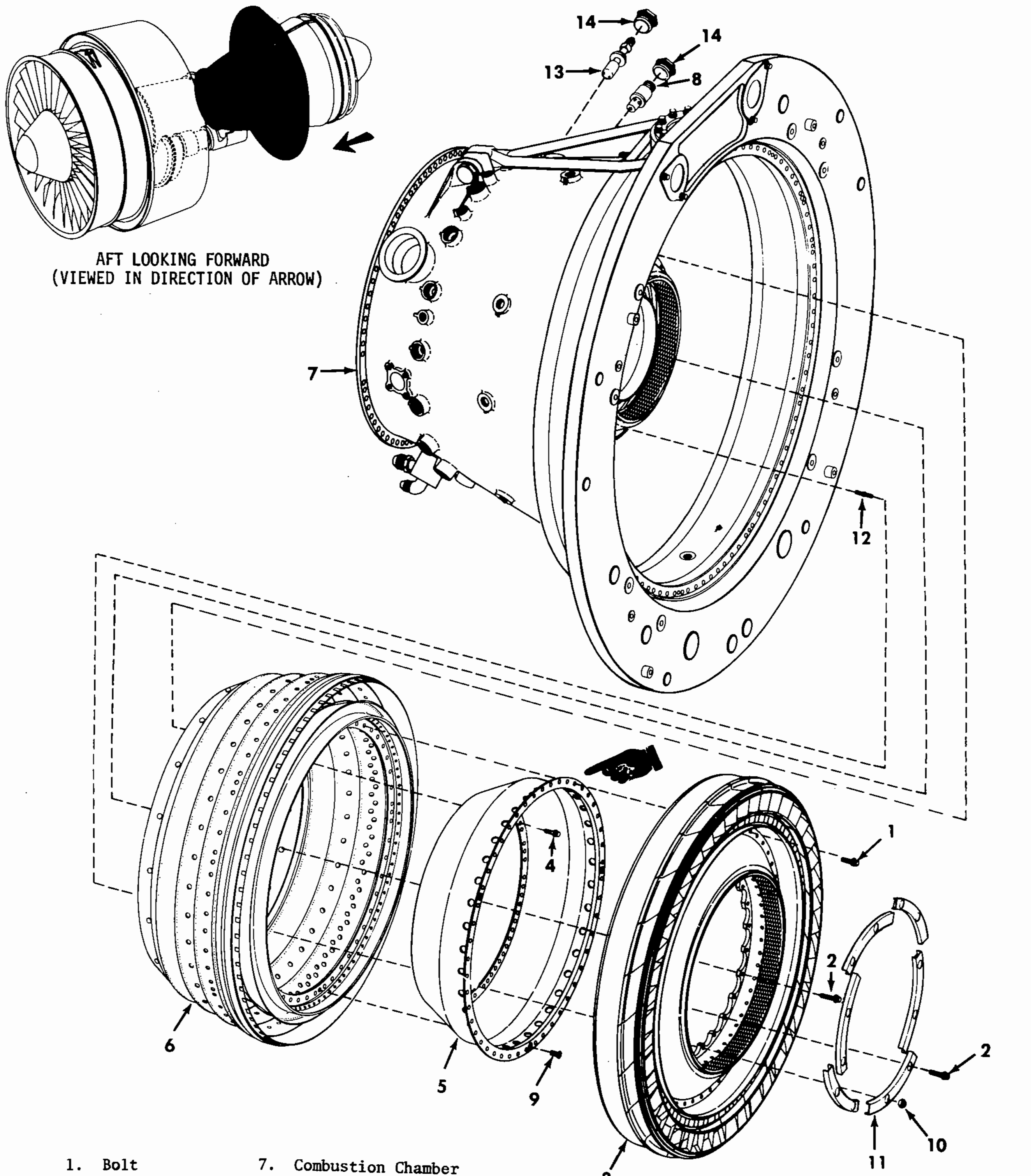
1. Record dimension A, stamped on high-pressure turbine rotor shaft (6, figure 7-25) or measure dimension A, using 0-1 inch micrometer.

2. Assemble fixture (21C5186) onto compressor rear shaft and measure and record dimension B. See figure 7-26.

2A. Add dimension A to dimension B.

3. Install aft extension bar (21C5095) onto fan drive shaft. Install rear supports (part of 21C5031) onto aft mount ring.

4. Install fan drive shaft support (21C5181) and centralize fan drive shaft within compressor rotor and combustion section.



1. Bolt
2. Bolt
3. Stage 1 Nozzle
4. Bolt
5. Inner Duct
6. Liner
7. Combustion Chamber
8. Igniter Plug
9. Screw
10. Nut
11. Bolt Shield
12. Shoulder Stud
13. Primer Nozzle
14. Bushing

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Figure 7-24. Installation of Combustion Chamber Components

5. Assemble hoisting adapter (21C5097 or 21C5210 and 21C5211) to rotor. Remove rotor from buildup stand (21C5036 or 21C5039), tip rotor to horizontal position, and install tube section of pusher (21C5191) into rotor shaft. Position rotor on extension bar (21C5095).

6. Install shaft support (21C5182) and raise it until it contacts aft extension bar (21C5095).

7. Remove hoisting adapter (21C5097 or 21C5210 and 21C5211) and remove support (21C5181).

8. Align matchmarks, and slide rotor and tube section of pusher (21C5191) forward until splines engage and rotor bottoms.

9. Thread tube section of pusher onto compressor rear shaft. Remove shaft support (21C5182) and aft extension bar (21C5095).

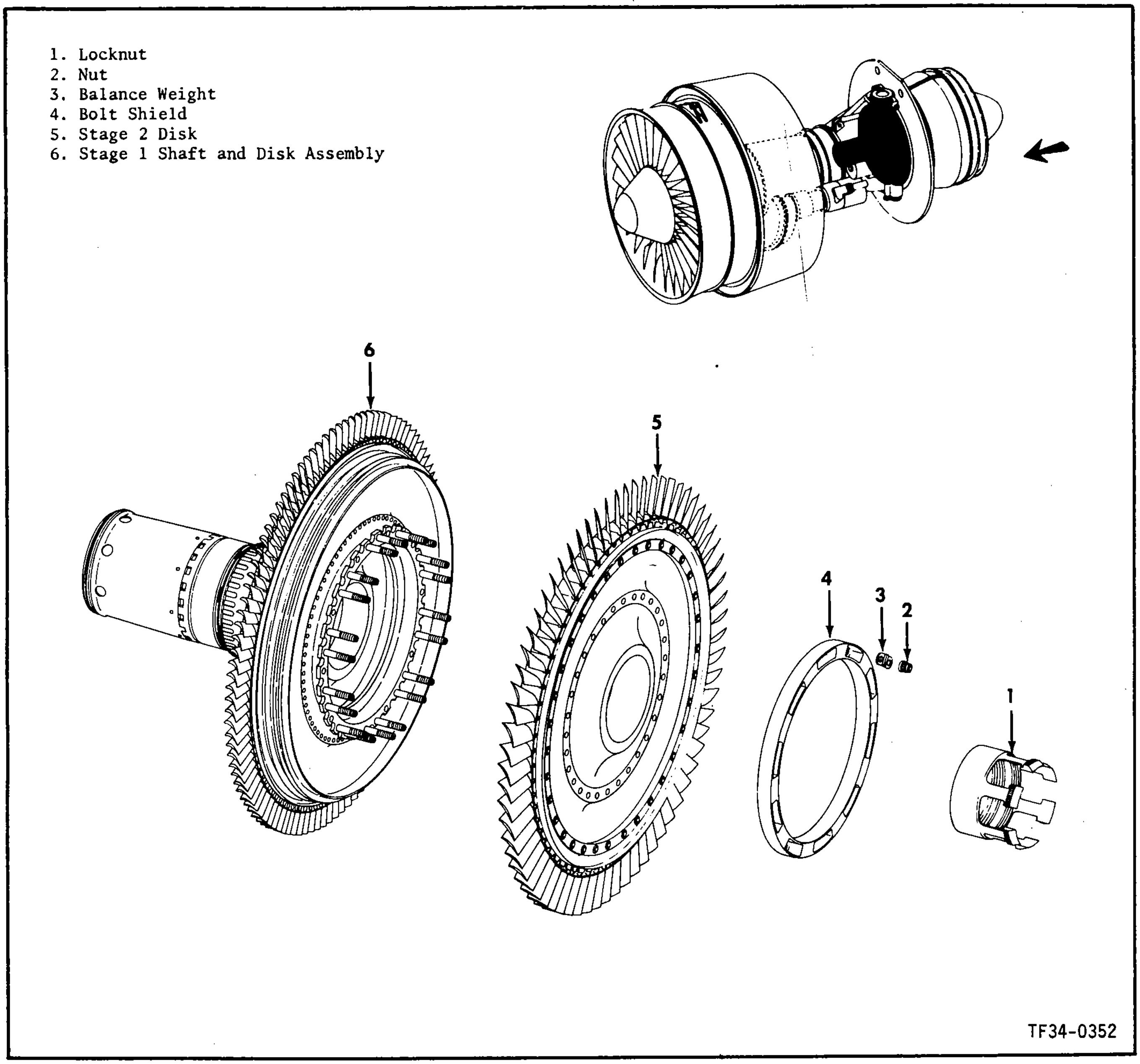


Figure 7-25. Installation of High-Pressure Turbine Rotor

CAUTION

Reduce hydraulic pressure to zero if needle on gage enters yellow zone. Do not build up pressure again until you determine why rotor will not seat.

10. Install ram section, collar, and lockring (part of 21C5191), over tube section. Attach hydraulic pump and seat the rotor.

11. Remove pusher components (21C5191).

11A. Check condition of locknut fingers by installing locknut into fixture (21C5232). Rotate locknut so that all fingers pass by reference arm with at least 0.002 inch clearance. Reject locknut if clearance is not met.

12. Install fixture (21C5186) in rotor and measure and record dimension C. Dimension C must equal the sum of dimensions A and B, calculated in

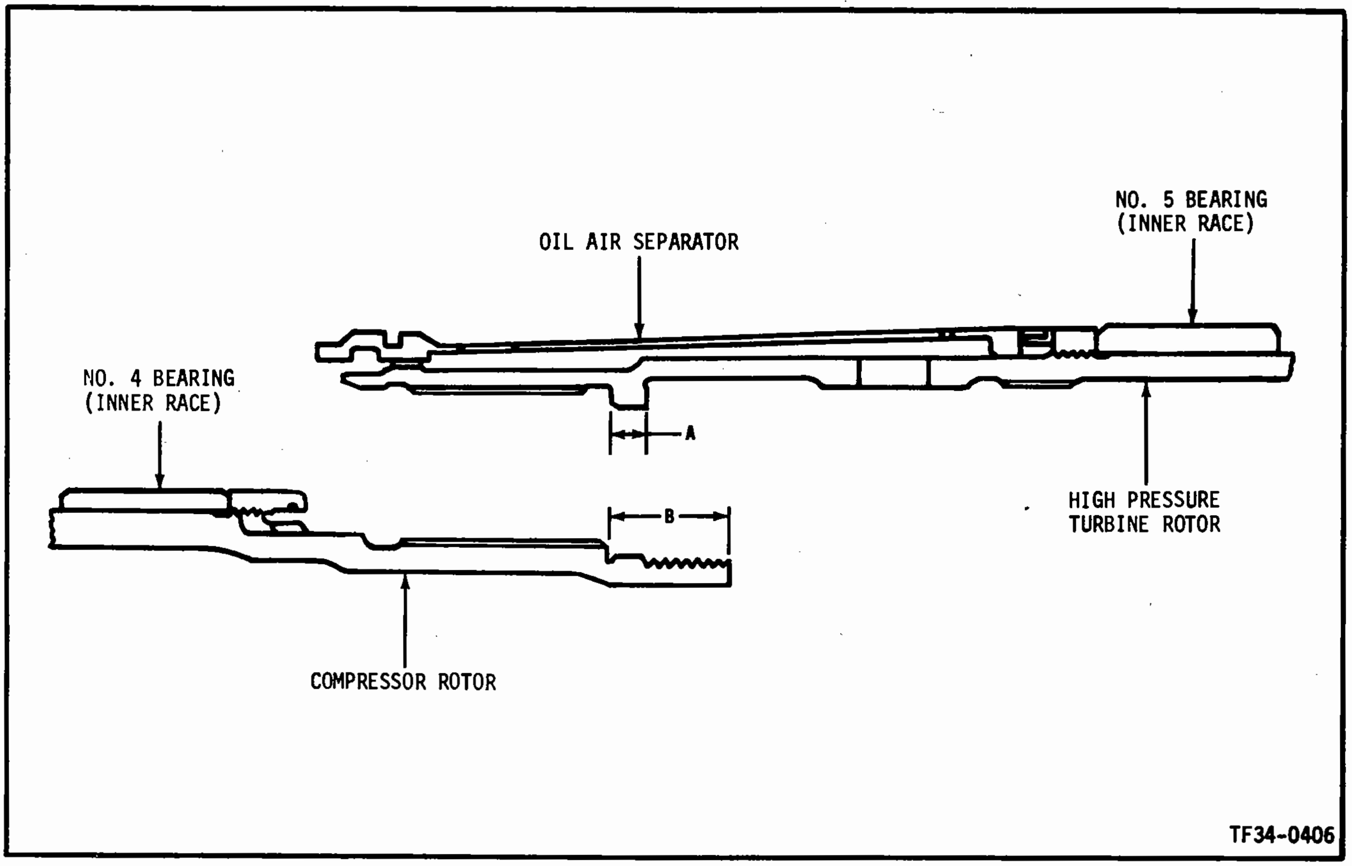


Figure 7-26. Seating Check - High-Pressure Turbine Rotor

step 2A within 0.002 inch. Reseat rotor, if not within limits.

13. Assemble stage 2 disk (5) and bolt shield (4) to stage 1 disk. Do not assemble nuts (2) at this time.

14. Install high-pressure turbine coupling nut as follows:

a. Lubricate threads and face of coupling nut (1) with Molykote M-77.

b. Assemble coupling nut to inner portion of wrench (21C5079).

c. Thread nut/wrench onto compressor rear shaft. Assemble outer portion of wrench, with alignment and retaining pins onto stage 2 disk studs. Make pins handtight.

d. Install Powerdyne 2501 or adapter and SWE 8100. Torque locknut to 900-950 lb ft. (Output drive of torque multiplier clockwise.) Apply 80-85 lb ft input for SWE 8100.

e. Remove tools from engine.

15. Remove stage 2 disk (5) and bolt shield (4).

16. If stage 1 blades or shrouds have been replaced, check minimum clearance 90 as follows:

a. Install high-pressure turbine inner casing (2, figure 7-27) and stage 2 nozzle support (5) without the stage 2 nozzle installed.

b. Set feeler gage to thickness of minimum clearance 90, table 8-1.

c. Insert feeler gages between blade tips and shrouds, at the middle and about 1/8 inch from each end of 10 shroud sectors. Rotate the rotor 1 full turn at each of 30 places. Rotor blades must not bind against feeler gages.

CAUTION

Use care to prevent metal particles from entering engine parts while blending blades.

d. If clearance is less than minimum limit of table 8-1, mark blades that are under limits, remove turbine inner casing, and blend them per instructions given in Section V. Recheck clearance when benching is complete.

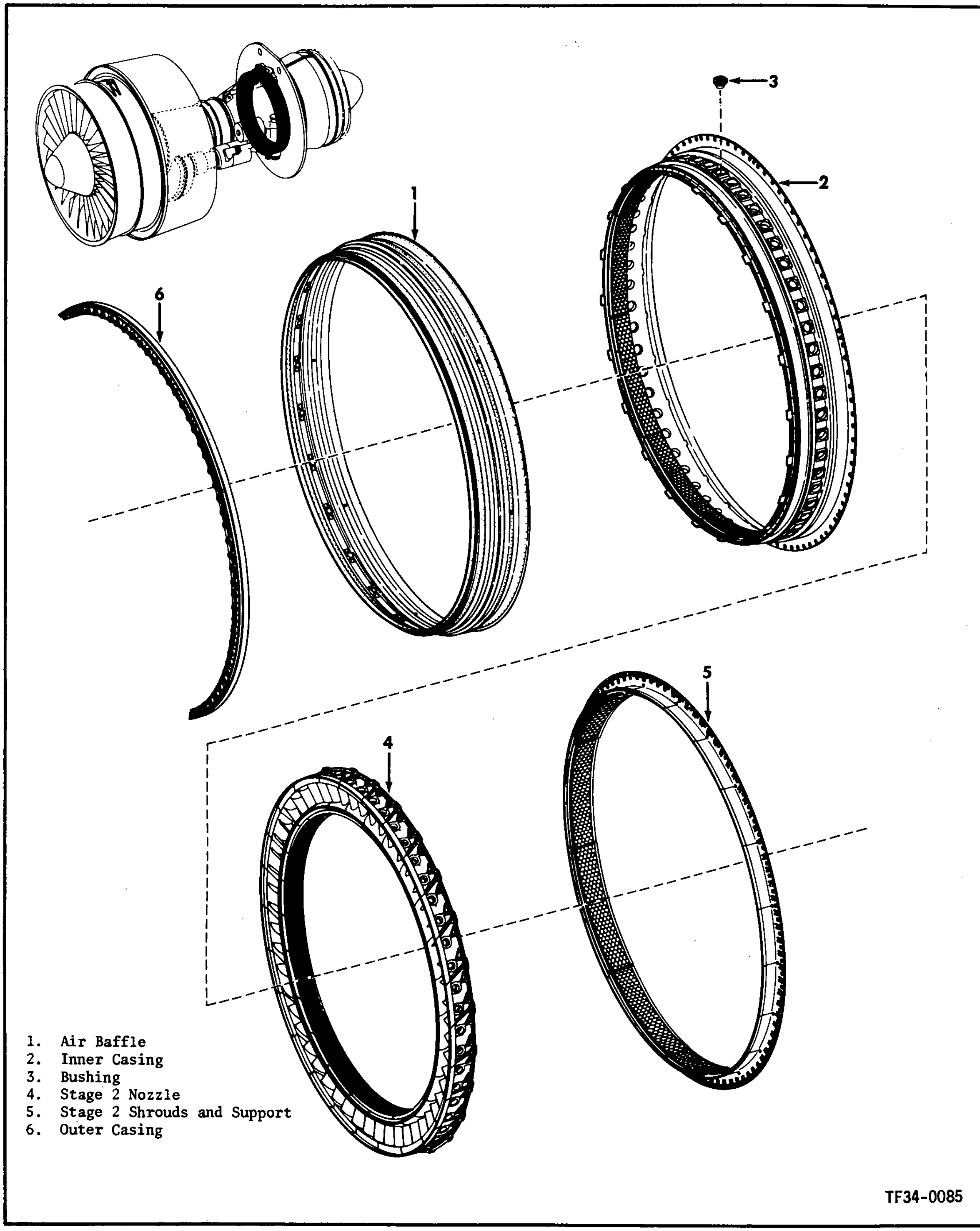


Figure 7-27. Installation of Stage 2 Nozzle Assembly

17. When clearances are within limits, reassemble stage 2 nozzle (4) to turbine inner casing (2). Be sure to align matchmarks.

18. Install high-pressure turbine inner casing assembly into high-pressure turbine outer casing.

CAUTION

- Be sure to align matchmarks on stage 2 disk and put balance washers back on their respective bolts.
- Be sure stage 2 disk is not installed in reverse.

19. Align matchmarks and assemble stage 2 disk (5, figure 7-25). Tap on center hub to seat disk, using a soft-faced mallet.

20. Check seating of stage 2 disk (5) using fixture (21C5203). Compare dimension with dimension recorded at rotor removal. Dimension taken must be within 0.001 inch of dimension taken in paragraph 5-7.

CAUTION

Be sure balance weights are assembled to same location identified at rotor removal, Section V.

NOTE

- Discard nuts that do not have a minimum run-on torque of 6 lb in.
- If blade tip clearances have to be taken, assemble nuts on every other bolt.

21. Install bolt shield (4, figure 7-25), balance weights (3) and nuts (2). Hold studs with hex (Allen) wrench while tightening nuts. Use wrench (21C5088) to torque nuts to 150-200 lb in., then to 320-340 lb in. in the following sequence:

1, 11, 6, 16, 2, 12, 7, 17, 3, 13, 8, 18, 4, 14, 9, 19, 5, 15, 10, 20

22. If stage 2 blades or shrouds have been replaced, measure clearance 91 as follows:

a. Set feeler gages to thickness of minimum clearance 91 per table 8-1.

b. Insert feeler gages between blade tips and shrouds, at the middle and about 1/8 inch from each end of 10 shroud sectors. Rotate the rotor 1 full turn at each of 30 places. Rotor blades must not bind against feeler gages.

c. If clearance 91 is under minimum limit of table 8-1, mark blades to be benched, and remove stage 2 disk. Blend blade tips per Section V. Reassemble stage 2 disk per steps 19, 20, and 21 of this paragraph. Recheck clearance 91 per step 22.

d. When clearance 91 is within limits of table 8-1, assemble remaining balance weights (34, 35) and nuts (36) to bolts on high-pressure turbine rotor. Torque nuts per step 21.

7-37. INSTALLATION OF LOW-PRESSURE TURBINE MODULE. For special tools, refer to table 2-1, group 29.

CAUTION

If low-pressure turbine casings are not installed, be sure that 3 dummy casings (21C5131) are tightly fastened to the exhaust frame and transition casing, with nuts and bolts.

1. With the low pressure turbine module in assembly stand (21C5035 or 21C5085), install rotor retainer (21C5041) on aft end of exhaust frame as follows:

a. Attach retainer to inner bolt circle of No. 7 bearing housing using bolts (12, figure 7-31). Torque bolts to 38-42 lb in.

b. Clamp inner portion of retainer to No. 7 bearing locknut.

2. Install 2 carriage assemblies (21C5031) on module at the 3 and 9 o'clock positions.

3. Install 2 rear supports (21C5031) at 3 and 9 o'clock positions on engine rear mount.

4. Install hoisting adapter (21C5071 or 21C5210). Use hoist and lift module from stand (21C5035). Rotate module to horizontal position.

5. Calculate dimension for checking seating of module as follows (see figure 7-28):

a. Use fixture (21C5122) and measure dimension A on fan shaft (from the aft end of the shaft to the shoulder on the shaft). Record this dimension to nearest 0.001 inch.

b. Measure dimension B in ID of low-pressure turbine rotor shaft (the length of the shoulder on shaft). Record this dimension to nearest 0.001 inch. Use a 0-1 inch micrometer.

c. Subtract dimension B from A and record this as calculated dimension C (A-B = C). Calculated dimension C will be compared with measured dimension C when the rotor is joined to the fan shaft.

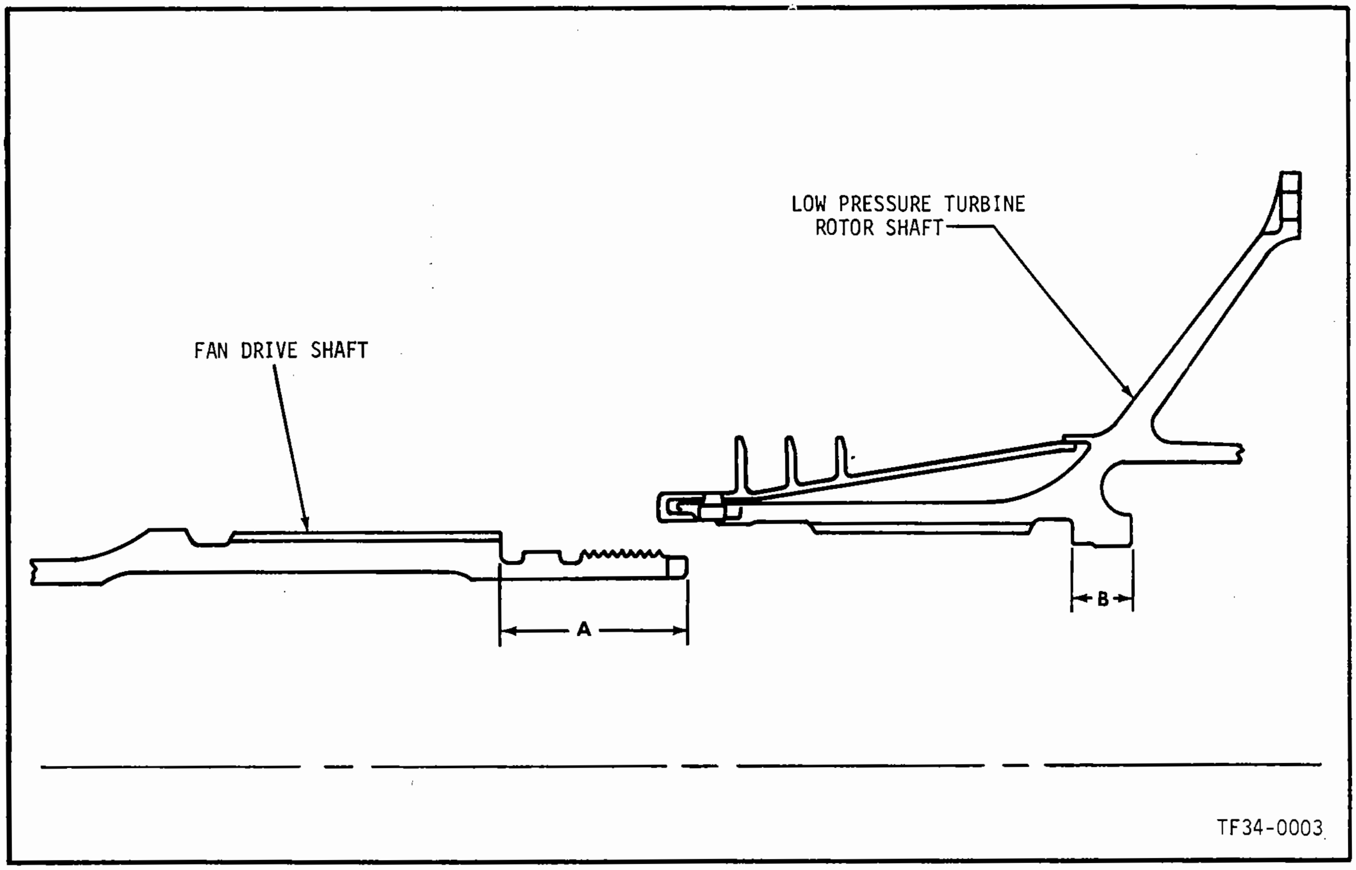


Figure 7-28. Low-Pressure Turbine Rotor Seating Dimensions - Before Installation

6. Position the module so that carriage assemblies (21C5031) are over the rear supports (21C5031).

7. Lower the module until rollers of carriage assemblies rest on rails of rear supports.

8. Lubricate spline on fan shaft and internal spline on low-pressure turbine rotor with engine oil.

9. Roll the module forward until it mates with the fan shaft.

10. Guide pusher (21C5160) in through exhaust frame and screw end cap of pusher onto aft end of the fan shaft.

11. Attach hydraulic hand pump (ENERPAC No. P-39 or equivalent) to pusher (21C5160).

CAUTION

Stop applying pressure if needle on gage approaches the red zone.

12. Use pump and press rotor on fan shaft.

13. Disconnect hydraulic pump. Unscrew end cap of pusher (21C5160) and remove pusher.

14. Remove retainer (21C5041).

15. Use fixture (21C5122) and check seating of rotor on fan shaft as follows (see figure 7-29):

a. Install fixture onto fan drive shaft. Measure and record distance from aft end of driveshaft to locknut seating surface.

b. The result is dimension C and must be within 0.002 inch of dimension C calculated in step 5.c.

CAUTION

- Be sure coating on rotor-to-fan shaft coupling nut is within the limits specified in Section V.
- Be sure spacer is completely flush with low pressure turbine rotor and not hung up in groove in fan drive shaft.

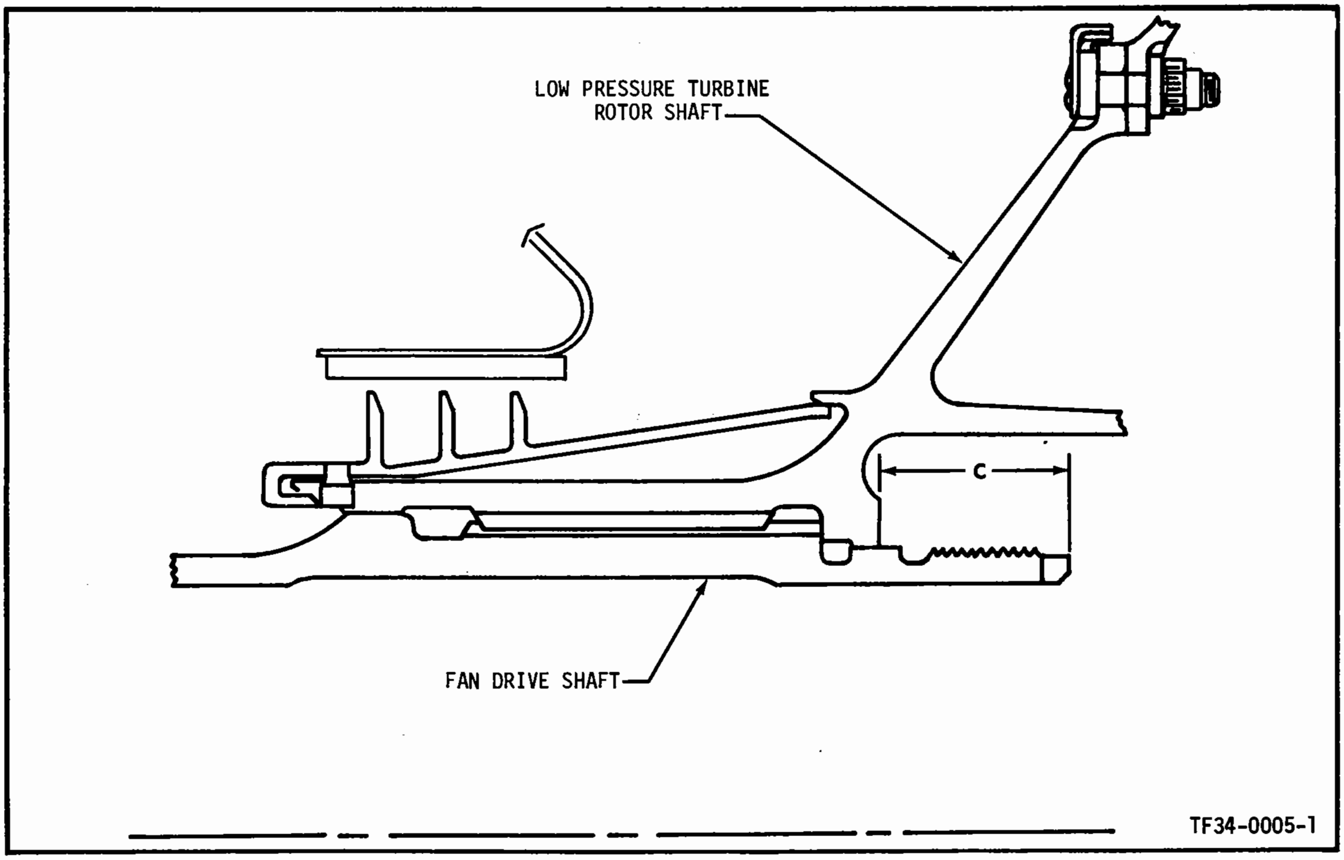


Figure 7-29. Low-Pressure Turbine Rotor Seating Dimensions - After Installation

16. Measure and record spacer (7, figure 7-30) thickness (dimension D, figure 7-30A), and locknut (6, figure 7-30) thickness (dimension E, figure 7-30A). Install spacer (use 2 screwdrivers if necessary) and install locknut hand-tight.

17. Use gage (21C5122) and measure dimension F. Add dimensions D and E. Subtract dimension F from the result of D plus E. Result should equal dimension C within 0.002 inch.

18. Assemble wrench (21C5044) to exhaust frame at 6 and 12 o'clock positions. Install torque multiplier SWE 8100 or Powerdyne 2501. Torque locknut to 600-650 lb ft (applying 54 to 58 lb ft to SWE 8100). Install keywasher (5, figure 7-30) and retaining ring (6).

19. Secure the transition casing to the high-pressure turbine casing with 90 bolts. Torque the bolts to 85-95 lb in. Remove alignment fixture (21C5031).

20. Put seal runner (2) in a solution of Dry Ice and alcohol for 20 minutes.

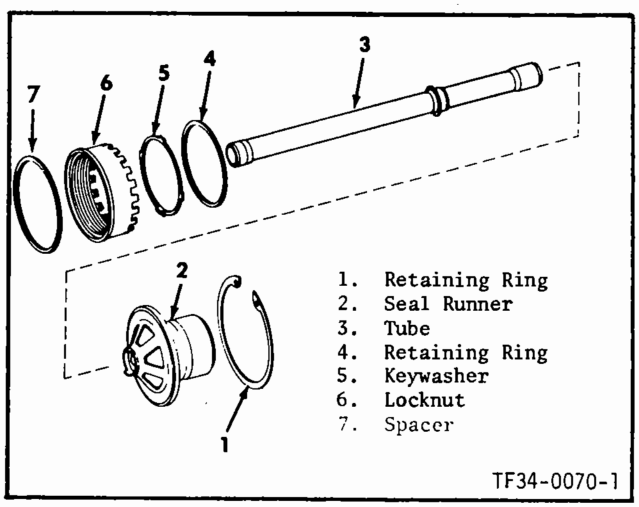


Figure 7-30. Installation of Low-Pressure Turbine Rotor Locknut

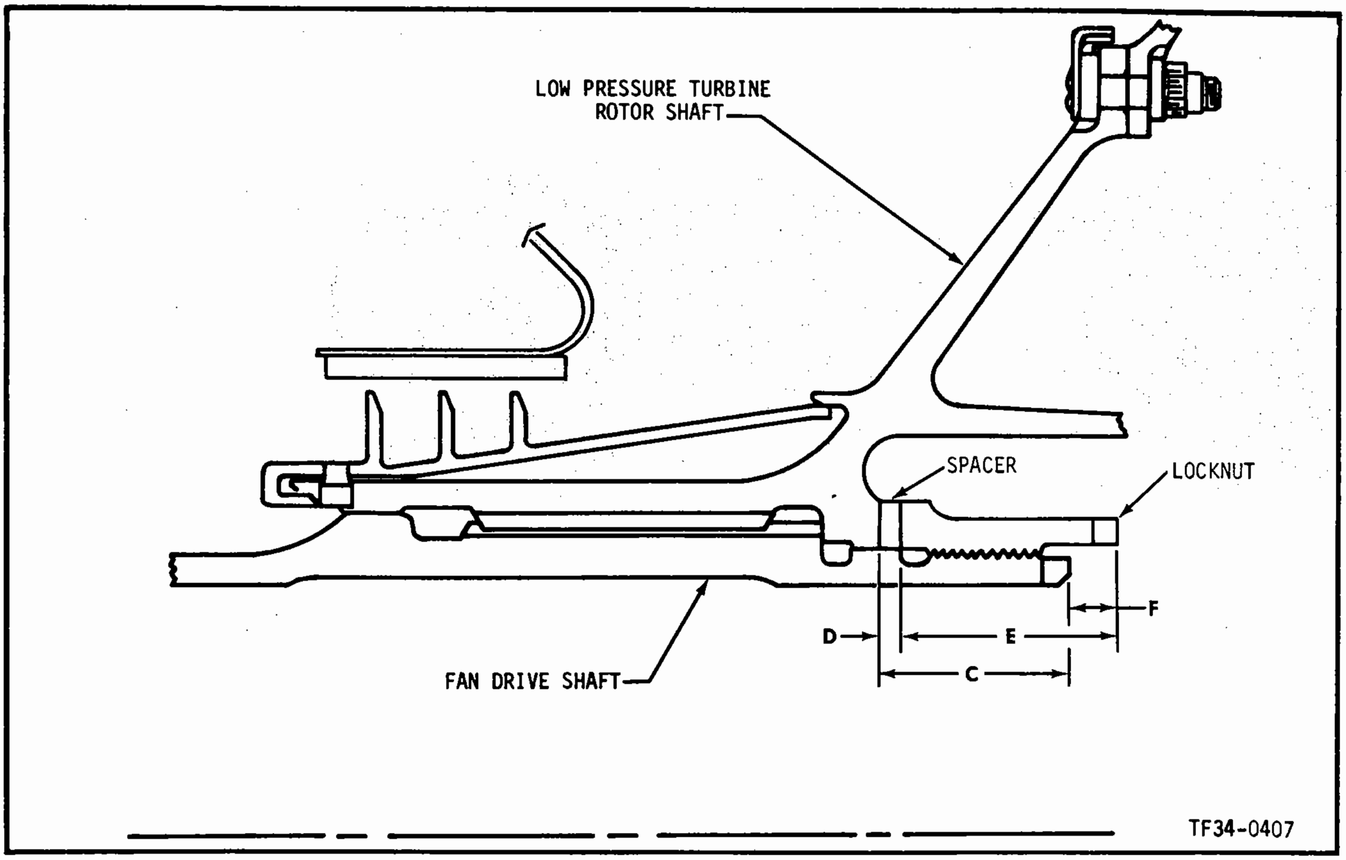


Figure 7-30A. LPT Spacer Seating Check

21. While chilling seal runner, push aft anti-ice tube (3) into mud anti-ice tube in the bore of fan shaft.

22. Slide seal runner (2) over aft anti-ice tube (3). Use pusher (21C5123) to seat seal runner in bore of low-pressure turbine rotor. Hold seal runner in position with pusher for about 1 minute.

23. Secure seal runner in position with retaining ring (1), bevel side aft, using Truarc No. 7 snap ring pliers or equivalent.

23A. Lubricate packing (26) with engine oil and install it on No. 7 carbon seal (27). Install carbon seal in cover (13).

24. Lightly lubricate packing (14, figure 7-31) with engine oil and put it in packing groove on bearing housing.

25. Install rear cover (13). Lightly lubricate 12 bolts (12) with engine oil and secure cover to bearing housing. Torque bolts (12) to 38-42 lb in.

CAUTION

Anti-icing seal is left-hand thread.

26. If necessary, install anti-icing seal in vent collector (7), using wrench (21C5188). Torque to 50-75 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

27. Lightly lubricate packing (8) with engine oil and position it in packing groove on vent collector (7).

28. Lightly lubricate 3 nuts (6) with engine oil. Slide collector into bore of rear cover (13) with the hole in the collector at the 8 o'clock position. Secure collector (7) to rear cover with the 3 nuts. Torque the nuts to 38-42 lb in.

29. Install rings (5) on anti-ice tube (4). Position them in ring groove on anti-ice tube (4), with openings 180° apart.

30. Push tube (4) into hole in vent collector (7). Lightly lubricate 2 bolts (3) with engine oil. Secure the tube (4) to the strut at 8 o'clock position on exhaust frame with the bolts. Torque the bolts to 38-42 lb in. Lock-wire bolts with 0.032 inch wire, using the double-strand method.

31. Lightly lubricate packing (11) with engine oil and position it on the oil-in tube located in the strut at the 10 o'clock position.

32. Push tube into hole in cover (13). Secure tube to exhaust frame with 2 bolts (9). Torque the bolts to 38-42 lb in. and lock-wire them with 0.032 inch wire, using the double-strand method.

33. Lightly lubricate 2 packings (10) with engine oil. Position 1 packing on forward scavenge tube (for C-sump) in strut at 4 o'clock position. Position 1 packing on aft scavenge tube (for C-sump) in strut at 6 o'clock position.

34. Push the 2 scavenge tubes into the holes in cover (13). Secure tubes to exhaust frame with 4 bolts (9). Torque the bolts to 38-42 lb in. and lock-wire them with 0.032 inch wire, using the double-strand method.

35. Install exhaust centerbody (2) on inner flange of exhaust frame.

36. Lightly lubricate 6 bolts (1) with engine oil. Secure exhaust centerbody to exhaust frame with 6 bolts (1). Torque bolts to 38-42 lb in.

37. Insert a 0.050 inch feeler gage between center body and vent collector. Gage must enter at any point of 360° circle. Loosen bolts (1) and reposition centerbody, if needed.

38. If parts have been replaced, take clearances as follows:

a. Remove dummy casing bar (21C5131).

b. Secure turbine casing handle (21C5133) to left-hand turbine casing.

c. Slide casing half between transition casing and exhaust frame. Secure the casing to exhaust frame with 4 bolts (22) and 4 nuts (23) evenly spaced. Secure the turbine casing to the transition casing with 8 bolts (18) and 8 nuts (19) evenly spaced. Do not torque nuts at this time.

d. Remove turbine casing handle (21C5133) and secure it to right-hand casing.

e. Slide casing half into place. Secure the casing halves together with 6 bolts (20) and 6 nuts (21) evenly spaced. Torque the nuts to 88-92 lb in. Leave casing handle in place.

f. Torque the forward and aft flange nuts to 88-92 lb in.

g. Remove 6 nuts and 6 bolts from casing splitlines and remove right-hand casing.

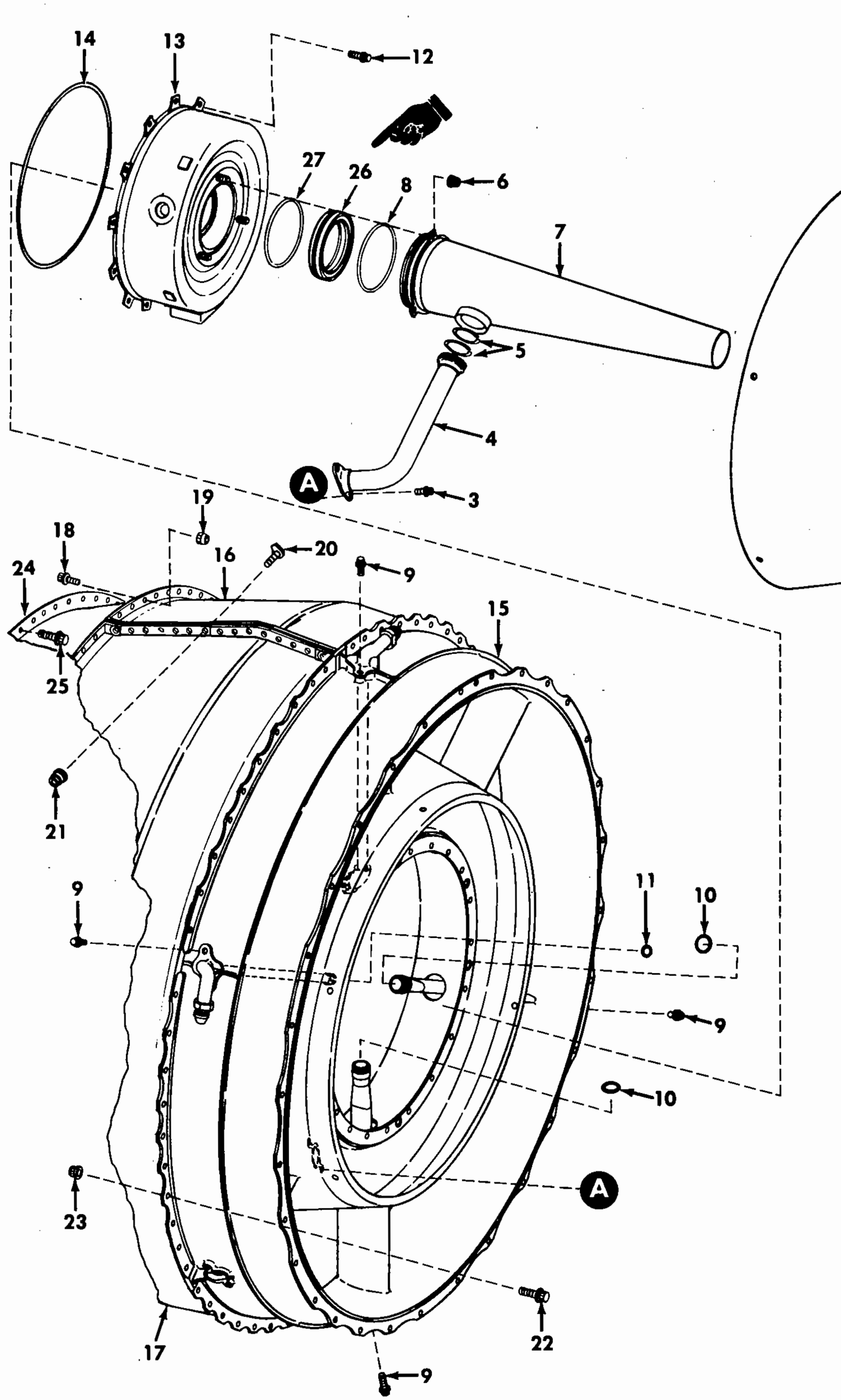
h. Review table 8-2 to determine which clearances must be taken.

i. Take clearances required by table 8-2 as follows:

NOTE

Amount of clearance required is given in table 8-1.

(1) Turbine blades replaced - Using a dial indicator, find the longest blade that has not been replaced. Indicate each new blade and compare the length to the longest old blade. New blades must not be longer than the longest old blade.



1. Bolt
2. Centerbody
3. Bolt
4. Tube
5. Piston Ring
6. Nut
7. Vent Collector
8. Packing
9. Bolt
10. Packing
11. Packing
12. Bolt
13. Rear Cover
14. Packing
15. Exhaust Frame
16. RH Turbine Casing
17. LH Turbine Casing
18. Bolt
19. Nut
20. Bolt
21. Nut
22. Bolt
23. Nut
24. Transition Casing
25. Bolt
26. Carbon Seal
27. Packing

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Figure 7-31. Installation of Low-Pressure Turbine Module

(2) Stage 3 nozzle segments on transition casing replaced - Take clearance 127 between transition liner and stage 3 turbine disk. Take clearance 144 between stage 3 nozzle inner band and stage 3 blade platform.

(3) Stage 4 nozzle segments replaced - Take clearance 128 using feeler gage, the same size as clearance required, between the nozzle tip shroud and the teeth on the rotating air seal between the stage 3 and stage 4 turbine disks.

(4) Stage 5 nozzle segments replaced - Take clearance 129 using feeler gage, the same size as clearance required, between the nozzle tip shroud and the teeth on the rotating air seal between the stage 4 and stage 5 turbine disks.

(5) Stage 6 nozzle segments replaced - Take clearance 131 using feeler gage, the same size as clearance required, between the nozzle tip shroud and the teeth on rotating air seal between stage 5 and stage 6 turbine disks.

(6) Low pressure turbine stator casings replaced - Take:

(a) Clearances required in steps (1), (3), (4), and (5).

(b) Clearance 143 using thickness gage, the same size as clearance required.

NOTE

See figures 7-32, 7-33, 7-34 and 7-35 for location of clamps and brackets on flanges.

39. Remove the left-hand casing.

40. Put Plastiseal F on flanges and install casing halves as follows:

a. Apply a thin coat of Plastiseal F to forward, aft, and splitline flanges of left-hand low-pressure turbine casing (17, figure 7-31).

b. Lubricate bolts (18, 22) with engine oil. Assemble left casing (17) to transition casing flange with bolts (18) and nuts (19). Install bolts (22) and nuts (23) to exhaust frame flange. Do not torque bolts at this time.

c. Apply a thin coat of Plastiseal F to forward and aft flanges of right-hand casing (16). Remove dummy casing bars (21C5131) from 1 and 5 o'clock positions; install right-hand casing with bolts (18, 22) and nuts (19, 23). Do not torque at this time.

d. Install 30 bolts (20) and nuts (21) to splitlines of low-pressure turbine stator. Torque nuts to 88-92 lb in. in the following sequence (see figure 7-34):

8, 23, 15, 30, 1, 16, 22, 21, 20, 19, 18, 17, 7, 6, 5, 4, 3, 2, 9, 10, 11, 12, 13, 14, 24, 25, 26, 27, 28, 29.

e. Torque transition-to-turbine casing, and turbine casing-to-exhaust frame flange nuts per figures 7-32 and 7-33.

7-38. RUNOUT OF FAN HOUSING AND ADJUSTMENT OF FAN STATOR TIE RODS. Use this procedure if fan tie rods, fan stator, or fan housing have been removed or replaced. For special tools, see table 2-1, group 21.

1. Attach concentricity fixture (21C5212) to fan front shaft or to fan disk if installed, using 2 blade slots. Adjust dial indicator so that it is about in the middle of the blade path.

2. Slowly rotate the fixture 1 full turn, observing the dial indicator. TIR should not exceed 0.025 inch.

3. If TIR exceeds 0.025 inch, proceed as follows:

a. Locate the clock position where maximum runout occurs.

b. Adjust tie rod eccentric pins on tie rods to reduce TIR.

4. Repeat steps 2 and 3 until TIR is less than 0.025 inch. Record position of minimum runout, used to calculate minimum blade tip clearance.

5. Torque bolts (10, 19, figure 7-18) to 105-115 lb in. and lock-wire, double-strand method, using 0.032 inch lockwire.

6. Torque nuts (11, 20) to 38-42 lb in.

7. Install any blades removed as follows:

a. Remove 10 bolts (7, figure 7-19) 10 washers (8) and blade removal port cover (6).

b. Insert tip of blade through the slot in housing until lugs on blade clear the disk.

c. Align lugs of blade with slots in disk. Bring blade inward and seat the blade in slots of disk. Install blade retaining pins.

d. Apply RTV-103 to mating surface of blade removal port cover.

e. Install cover (6) and secure with 10 washers (8) and 10 bolts (7). Torque bolts to 32-35 lb in. and lock-wire double-strand method using 0.032 inch lockwire.

f. Apply RTV-103 to entire length of lockwire. This reduces the possibility of lockwire breaking due to vibration when engine is running.

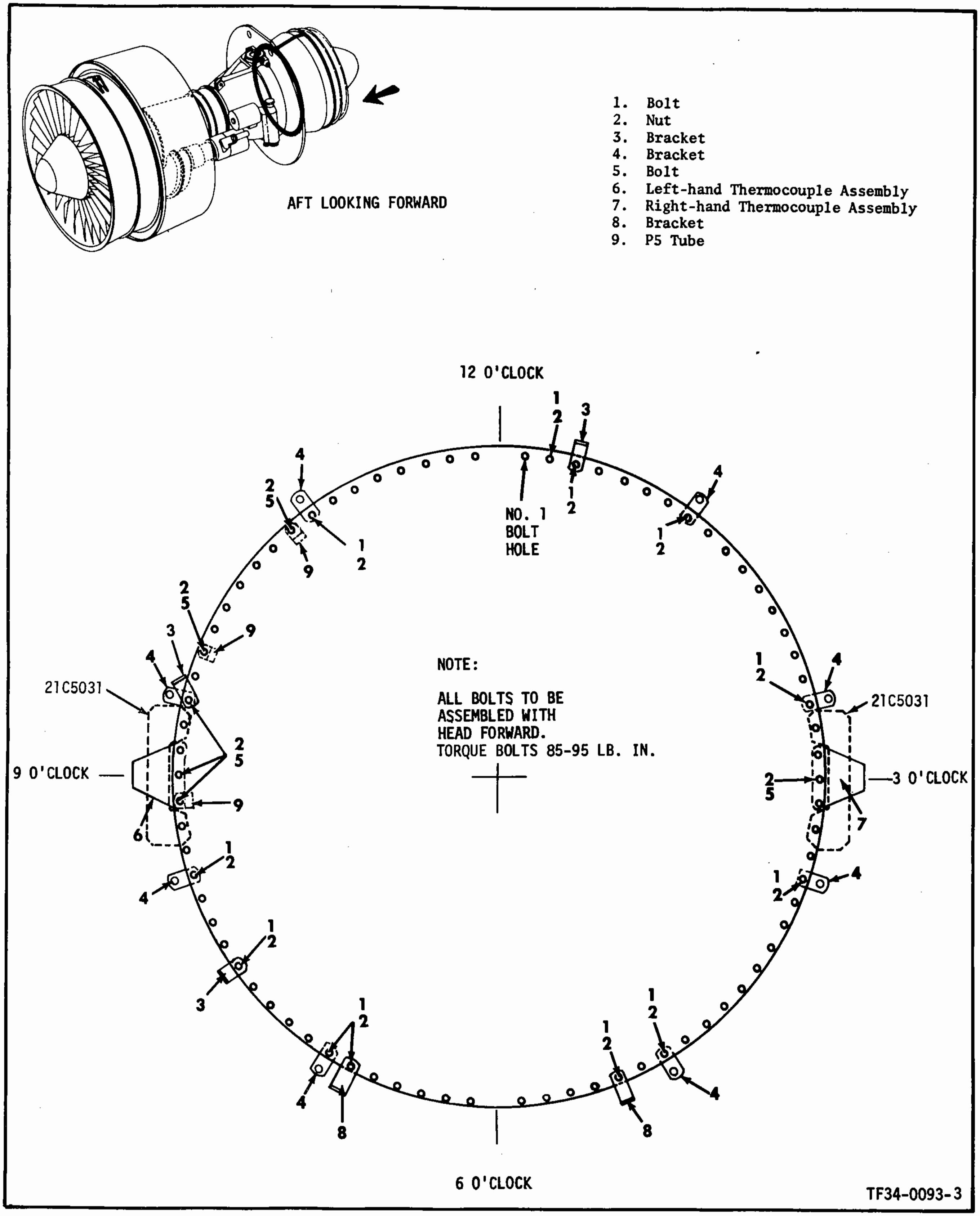


Figure 7-32. Bolting Diagram - Transition Casing to Low-Pressure Turbine Casing

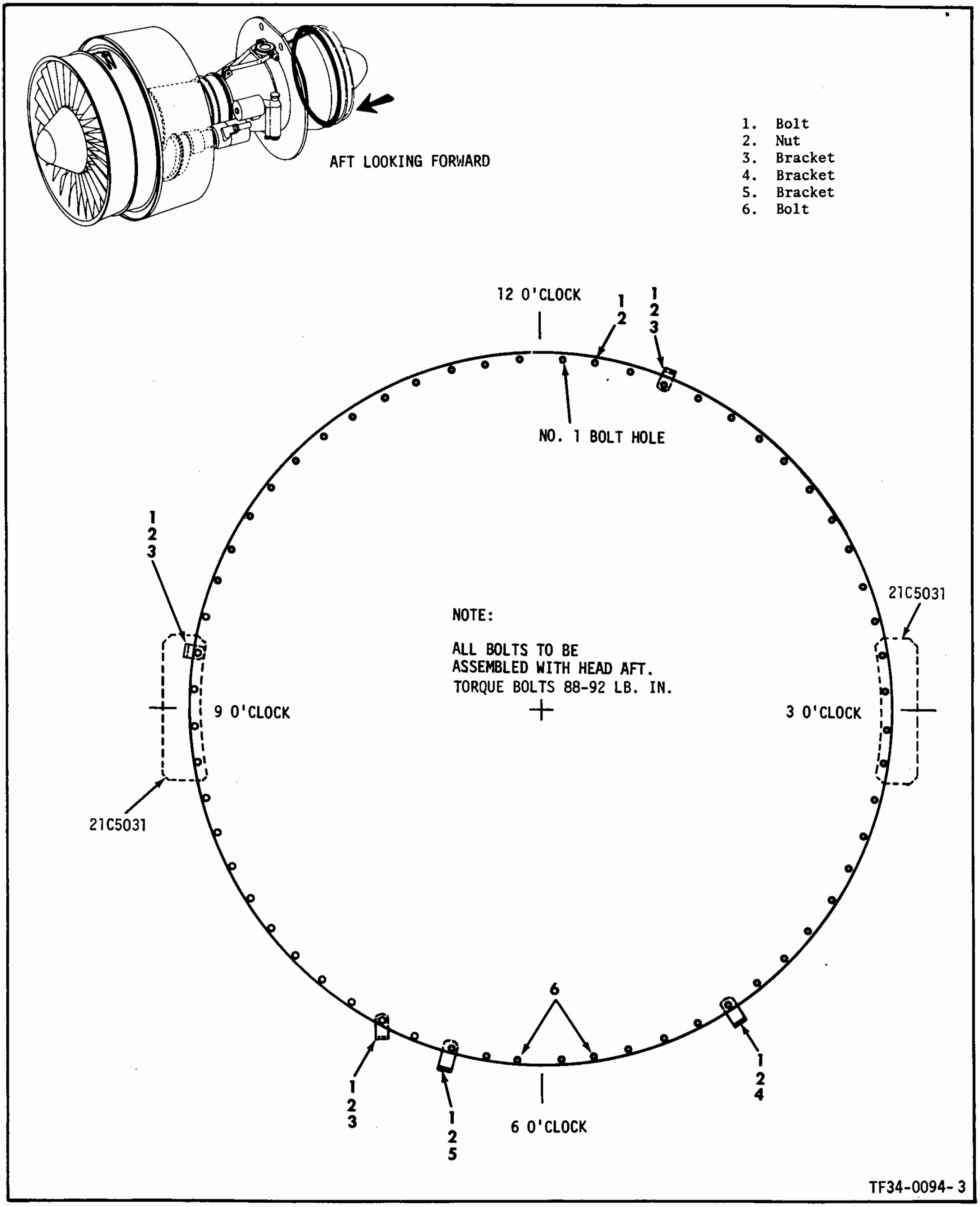


Figure 7-33. Bolting Diagram - Low-Pressure Turbine Casing-to-Exhaust Frame

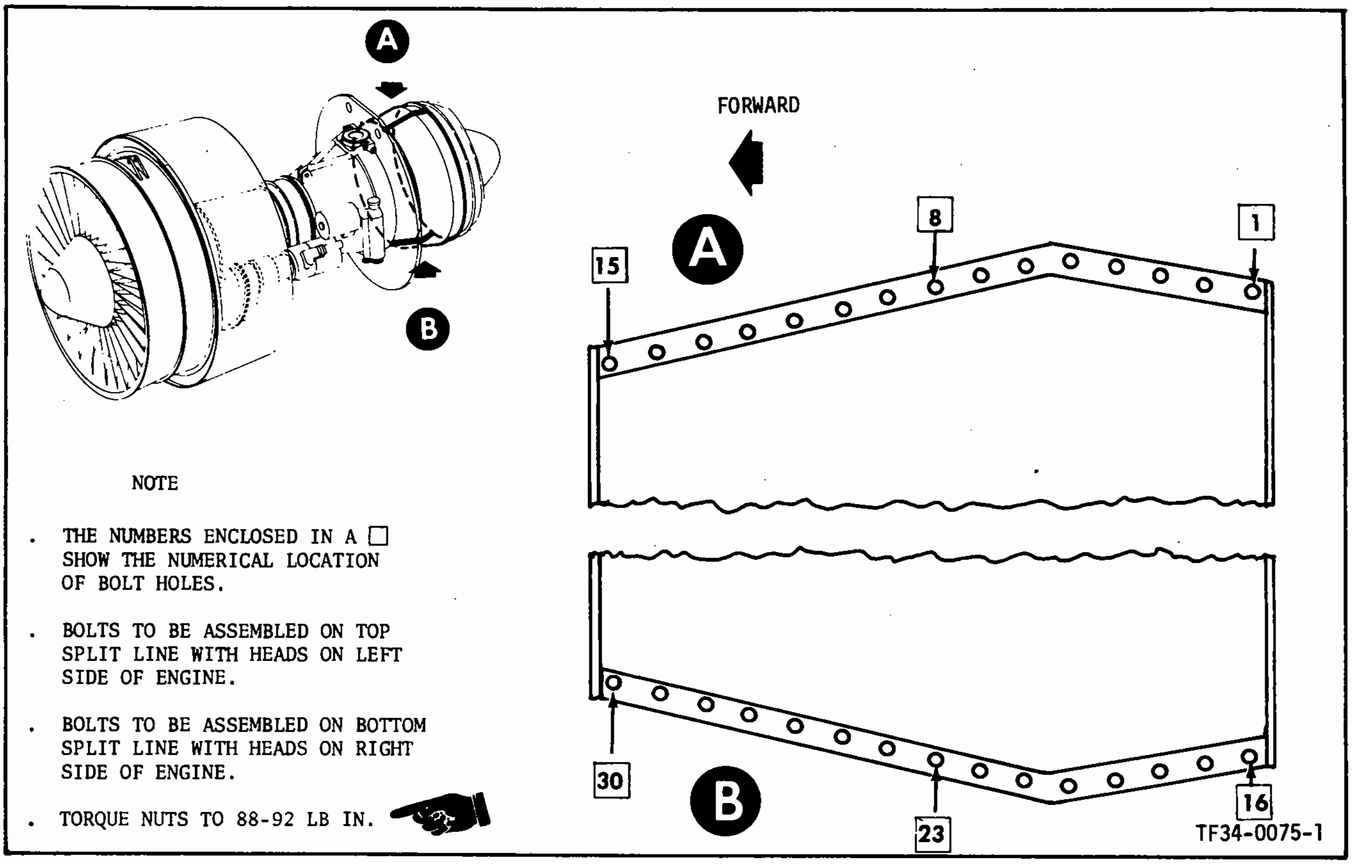


Figure 7-34. Bolting Diagram - Low-Pressure Turbine Casing Horizontal Flanges

7-39. INSTALLATION OF EXTERNAL COMPONENTS.

At this point of engine assembly, all external components (accessories, hoses, and tubes) can be installed. Using the installation instructions of section IV, install those components that were removed. Be sure that all connections are made securely before installing fan cowling.

7-40. INSTALLATION OF SPLITTER CONE PANELS.

1. Assemble 8 splitter cone panels (3, figure 7-36) to their respective clock positions as marked at disassembly.

2. Install 28 bolts (1) and 28 washers (2) to the forward flange of splitter cone panels. Torque bolts to 88-92 lb in.

3. Lock-wire bolts, double-strand method, using 0.032 inch wire.

4. Apply a thin coating of RTV-103 around each tie rod at the splitter cone panels. Seal splitter cone panels completely.

7-41. INSTALLATION OF FAN INNER FRAMES AND PANELS. Lubricate screws (1, 9, 11, figure 7-37) with Versilube Plus.

1. Assemble any washers (30, figure 7-37) to the same tie rod studs from which they were removed. Assemble lower frame (16) onto studs of 4 tie rods (18) and assemble nuts (17).

2. Assemble 12 bolts (19) through the frame and into splitter cone panels. Make bolts finger-tight.

3. Assemble upper frame (15) onto studs of 4 tie rods (18) and assemble 4 nuts (17).

4. Assemble 12 bolts (19) through the frame and into splitter cone panels (20). Make bolts finger-tight.

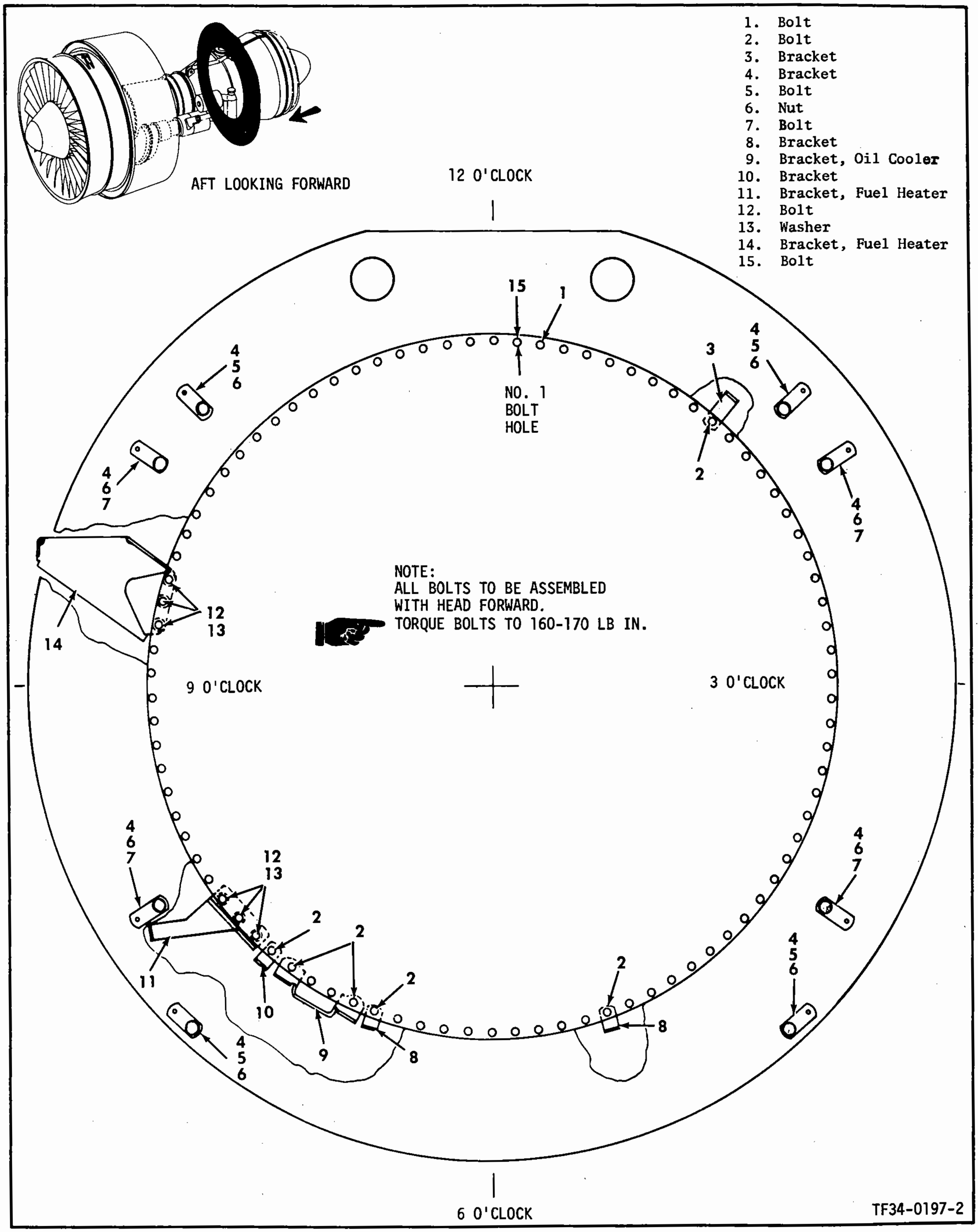


Figure 7-35. Bolting Diagram - High-Pressure Turbine Casing and Aft Mount Ring

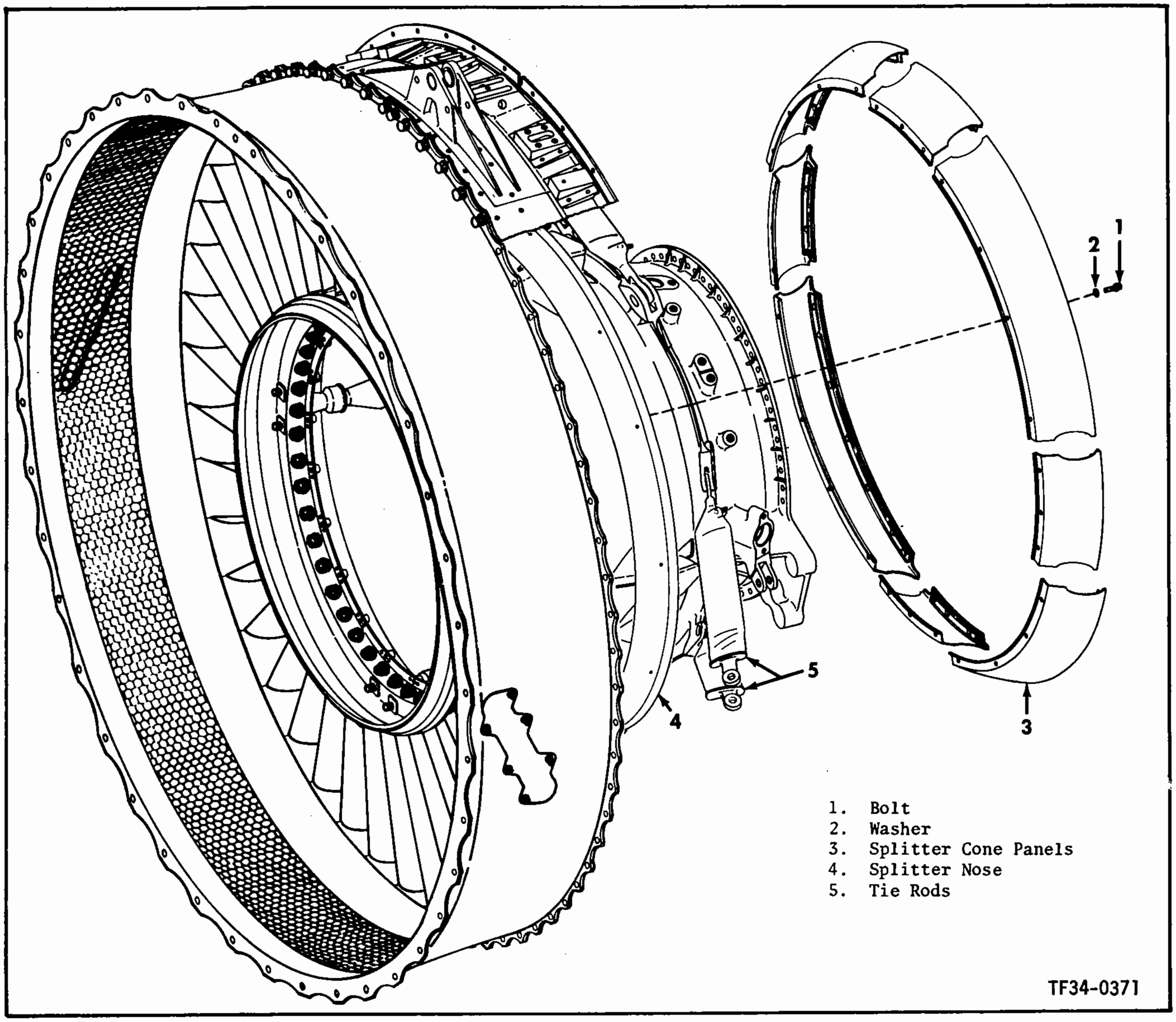


Figure 7-36. Installation of Splitter Cone Panels

5. Assemble 14 bolts (13) and 14 nuts (14) to mating flange of upper and lower frames. Torque bolts to 38-42 lb in.

6. Torque bolts (19) to 38-42 lb in. and nuts (17) to 105-115 lb in.

NOTE

The inspection check covered by the following step is required only when inner frames have been replaced, spacing washers lost or not mapped, or when any engine casing has been replaced except for fan housing.

7. Install inspection fixture (21C5215) onto aft end of exhaust frame and check inner frame positioning as follows:

a. Check overall dimension from exhaust frame aft flange to inner frame aft flange at 12 equally spaced locations. Dimension must be 49.100 inches ± 0.061 inch.

b. Check that the inner frame aft flange is parallel to exhaust frame aft flange within 0.050 inch.

c. Check that the vertical centerline of inner frame aft flange (established by four 0.250

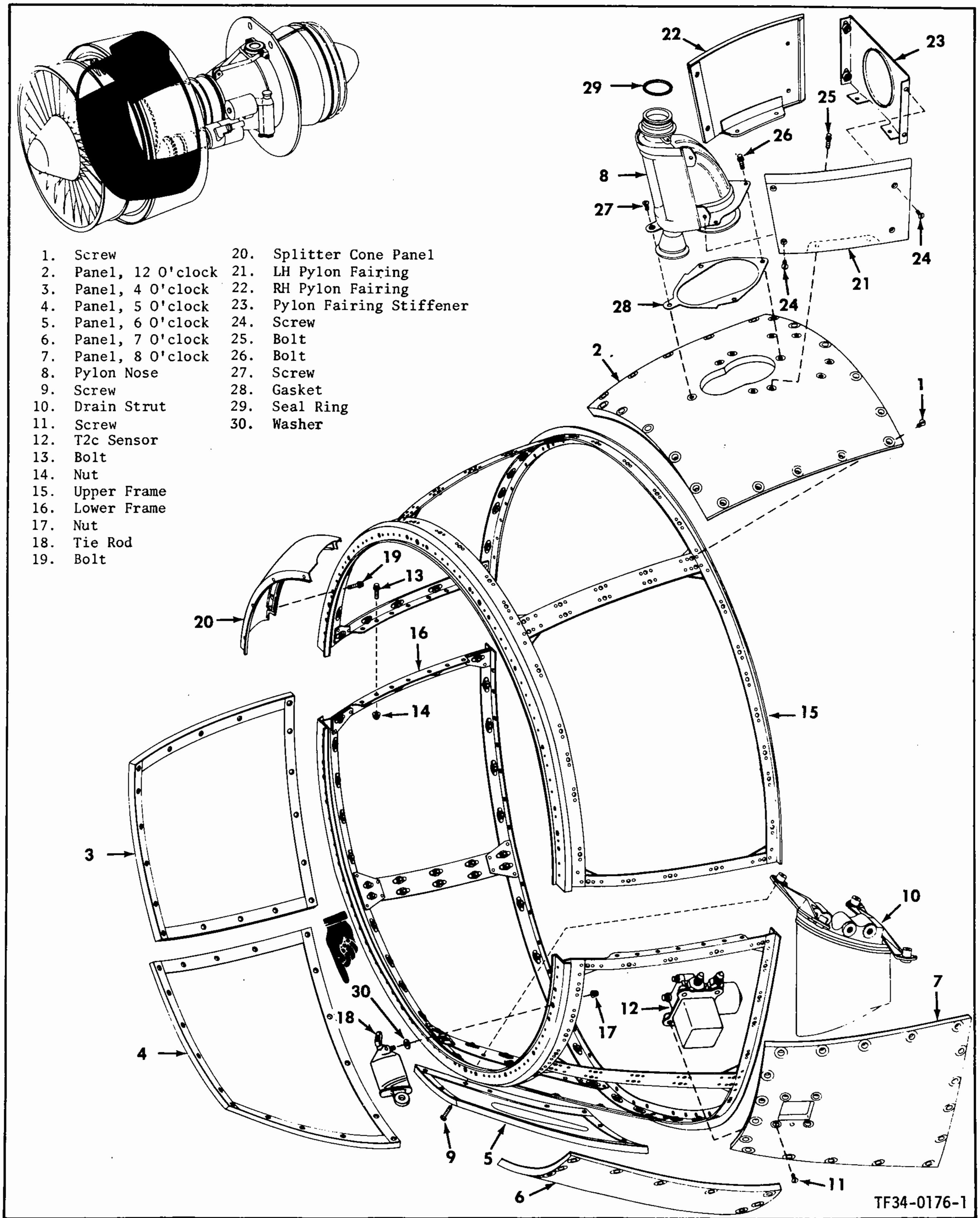


Figure 7-37. Installation of Fan Inner Frames and Panels

inch diameter holes) is within 0.100 inch of a line between the thrust mount and forward mount.

d. Check that the centerline of the inner frame (as established by four 0.250 inch holes in inner frame aft flange) falls within 0.060 inch of a line passing through the center of exhaust frame aft flange pilot diameter and perpendicular to exhaust frame aft flange.

NOTE

Before trying to adjust inner frame position, disconnect anti-icing duct at the combustion chamber and the valve from the bracket.

e. Adjust overall dimension and parallelism by losening bolts (19); removing nuts (17) and adding the minimum number of washers (30) required to bring distance and parallelism within limits.

8. Assemble the 12 o'clock position panel (2) to upper frame (15) with 20 screws (1). Torque screws to 20-25 lb in.

9. Assemble pylon nose (8) and fairing (21, 22) to the 12 o'clock panel (2) as follows:

a. Assemble gasket (28) and pylon nose (8) to panel (2) with 3 bolts (26) and 1 screw (27). Torque bolts and screw to 32-36 lb in.

b. Assemble fairing stiffener (23) to panel (2) with 2 bolts (25). Make bolts fingertight.

c. Assemble left-hand pylon fairing (21) and right-hand pylon fairing (22) to pylon nose (8) and fairing stiffener (23) with 8 screws (24). Torque screws to 32-36 lb in.

d. Assemble bolts (25) to both fairings and torque all bolts (25) to 32-36 lb in.

e. Assemble seal rings (29) to pylon nose (8).

f. Install pylon nose alignment fixture (21C5202) to the thrust mount at the combustion chamber and to forward mount on the fan stator.

g. Check the location of pylon nose. It should be within 0.050 inch of the line established by the forward and rear engine mounts. Loosen bolts (25, 26) and adjust pylon nose if necessary. Retorque bolts to 32-36 lb in.

10. Assemble the 4 o'clock position panel (3) and the 5 o'clock position panel (4) with 36 screws (1). Torque screws to 20-25 lb in.

11. Assemble the drain strut (10) and the 6 o'clock position panel with 13 screws (1) and 4 screws (9). Torque screws to 20-25 lb in.

12. Assemble the 7 o'clock position panel (6) to the lower frame (16) with 18 screws (1). Torque screws to 32-36 lb in. Assemble 4 screws (11) to the T2c sensor (12) and torque screws to 20-25 lb in.

7-42. INSTALLATION OF FAN OUTER COWL ASSEMBLY.

1. Assemble upper cowl segment (7, figure 7-38), engaging pylon nose in the hole at 12 o'clock to fan stator (9).

2. Install 24 bolts (8) through fan stator flange into outer cowl upper segment (7). Leave bolts loose.

3. Assemble the lower cowl segment (10) to flange adapter (12) with 24 screws (11). Torque screws to 32-36 lb in. Assemble 4 washers (4) and 4 nuts (3) to each splitline of cowl assembly. Torque nuts to 32-36 lb in. Torque bolts (8) to 32-36 lb in.

4. Insert 2 pins (5), bent end forward, into interlocks (6). Twist pins so that bent ends are recessed in splitline flange.

5. Install covers (2) with screws (1). Torque screws to 15-20 lb in.

6. Assemble seal ring (29, figure 7-37) to pylon nose (8).

7-43. INSTALLATION OF FAN ROTOR DISK ASSEMBLY. For special tools, see table 2-1, group 18.

CAUTION

Be sure fan blade retaining pins are installed with heads on forward side of disk.

1. Remove 1 fan blade (12, figure 7-39) and pin and assemble hoisting adapter (21C5101) to the disk (11) with pin. Attach hoisting adapter to overhead hoist. Remove disk assembly from stand (21C5187).

2. Install puller (21C5024) into bore of fan disk. Install extension bar (part of 21C5024) into ID of puller (21C5024).

3. Move disk into position and insert extension bar into fan front shaft until it seats on driveshaft. Install support (21C5182) onto rails and under extension bar. Remove adapter (21C5101) and reinstall blade and pin.

4. Guide fan disk assembly (11) into the fan casing. Align matchmarks and assemble disk to shaft studs. Length of studs exposed through the disk should be more than the length of nut. Remove support (21C5182) and puller (21C5024).

5. Assemble 28 nuts (10) and torque to 200-230 lb in., distributing torque evenly around the disk (11). Use wrench kit (21C5088) to torque the nuts.

6. Lubricate packing (6) with engine oil and assemble it on anti-icing tube (5). Install seal (7) on anti-icing tube.

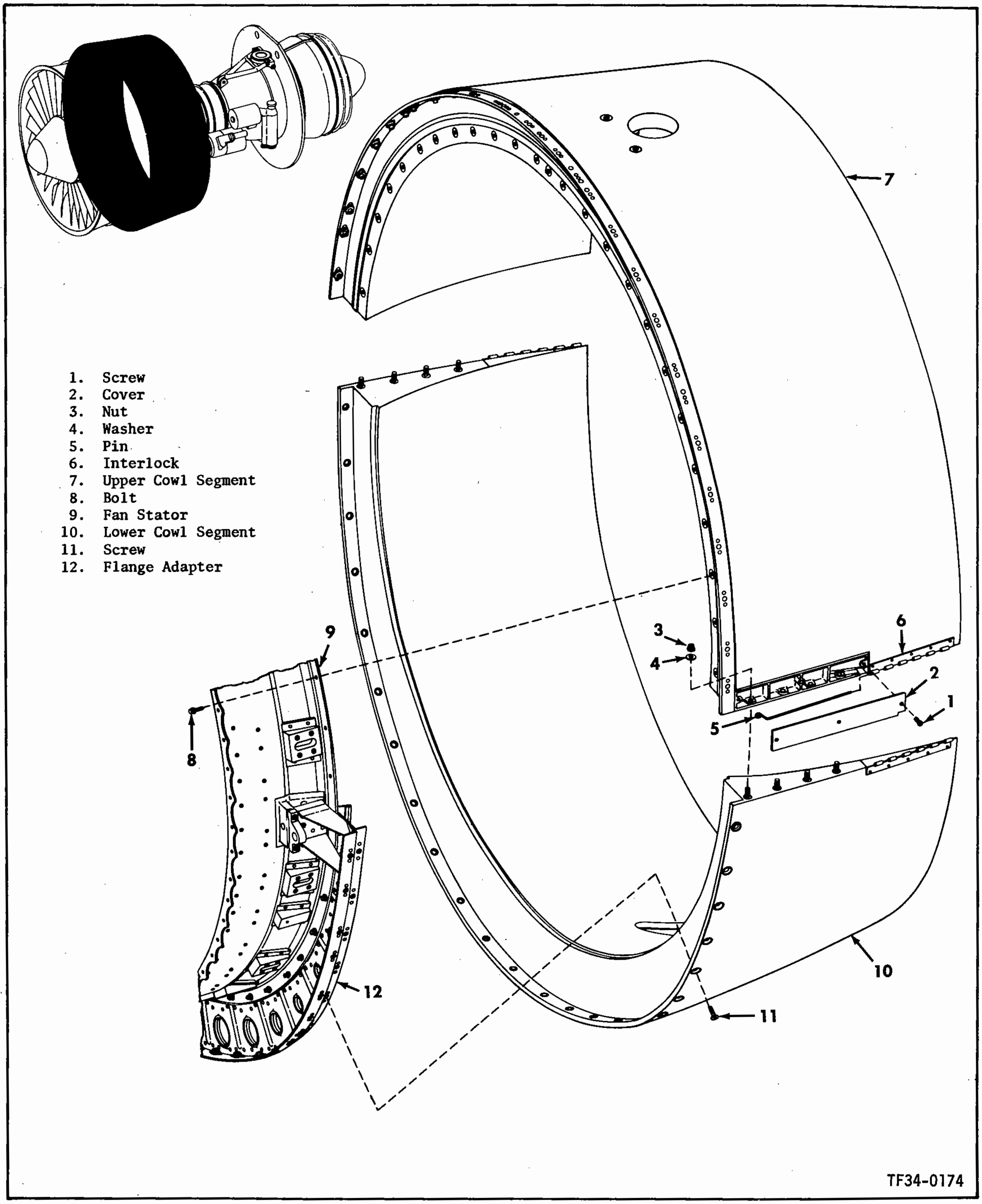


Figure 7-38. Installation of Fan Outer Cowl Assembly

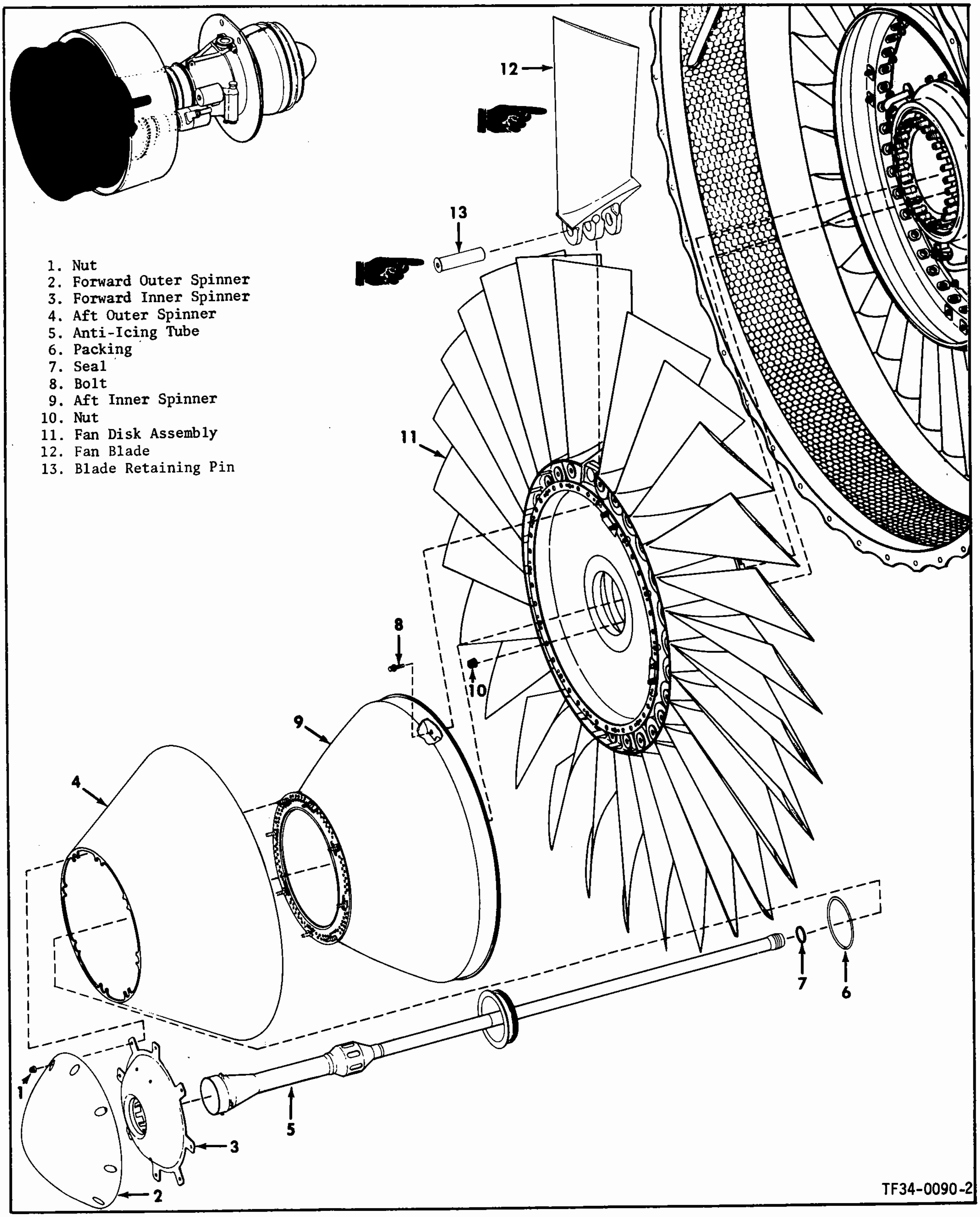


Figure 7-39. Installation of Fan Disk Assembly

7. Remove pin retainer (21C5117). Align matchmarks and bolt aft inner spinner (9) to the fan disk (11) with 14 bolts (8). Torque bolts to 25-30 lb in.

8. Insert anti-icing tube (5) through fan rotor into mating anti-ice tube. Seat the tube in the front shaft.

9. If parts have been replaced affecting clearances 1 and 2, proceed as follows (see table 8-2 to determine when clearances have to be taken):

a. Set up feeler gages to the thickness of the minimum clearance limit given in table 8-1.

b. Pull foward on fan disk until you hear the No. 1 bearing clunk. This is to insure that fan is in its most forward position.

c. Check clearance 1 by rotating the new blade to the point of minimum fan housing runout obtained in paragraph 7-38, and inserting the feeler gage at the front, middle and aft points of the blade tip, holding the fan blade in its most extended and forward position. Check each new blade, or every blade if the rotor has been replaced. The feeler gage must enter at every point checked.

d. Check clearance 2 by inserting a feeler gage, which is the same thickness as the minimum limit for clearance 2 given in table 8-1, between the underside of the fan blade platform and the fan vane support. Feeler gage must enter.

10. Assemble aft outer spinner (4), forward inner spinner (3), and forward outer spinner (2) to aft inner spinner (9) with 8 nuts (1). Check locking action of nuts by running them on until at least 2 threads of studs is showning. Measure breakaway torque. If it is less than 4 in. lb., replace the nuts. Torque nuts to 25-30 lb in. Install blade port cover per paragraph 7-38.

SECTION VIII

DIMENSIONAL LIMITS AND TORQUE VALUES

8-1. GENERAL.

This section lists engine clearances for use during engine assembly.

8-2. ENGINE CLEARANCES.

8-3. GENERAL.

It is not necessary to take all the clearances listed in table 8-1. Those which must be taken are designated in the disassembly-assembly instructions. All clearance limits are based on 360° consideration.

8-4. CLEARANCE REQUIREMENTS FOR REPLACING INDIVIDUAL ENGINE COMPONENTS OR PARTS.

Table 8-2 lists the minimum clearance and assembly checks required when replacing individual engine components or parts.

8-5. FLANGE CLEARANCES.

When axial and circumferential flanges are bolted together, the gap between mating surfaces of the flanges must not exceed 0.001 inch for a radial depth of 1/32 inch, as measured from the outside of the flanges.

8-6. DEFINITION OF CLEARANCE TERMS.

The following abbreviations appear in table 8-1:

A - Axial clearance, measured parallel to the rotor shaft. All axial clearances must be taken with the rotors in the most forward position to remove axial play in thrust bearings.

R - Radial clearance, measured perpendicular to the rotor shaft.

T - Interference or "tight" fit.

Min - Minimum clearance.

Max - Maximum clearance.

Max avg - Maximum allowable average clearance when measured clearances are calculated and averaged.

Ref - Reference - for information only.

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
1		Fan Blade Clearance	R	1	0.060	--
2		Fan Blade to Fan Vane Support	R	2	0.036	--
3 through 10		Not Applicable				
11		Stage 1 Compressor Blade Clearance	R	3 or 7	0.028	
12		Stage 2 Compressor Blade Clearance	R	3 or 7	0.023	--
13		Stage 3 Compressor Blade Clearance	R	3 or 7	0.033	--
14		Stage 4 Compressor Blade Clearance	R	3 or 7	0.030	--
15		Stage 5 Compressor Blade Clearance	R	3 or 7	0.028	--
16		Stage 6 Compressor Blade Clearance	R	3 or 7	0.028	--
17		Stage 7 Compressor Blade Clearance	R	3 or 7	0.029	--
18		Stage 8 Compressor Blade Clearance	R	3 or 7	0.026	--
19		Stage 9 Compressor Blade Clearance	R	3 or 7	0.024	--
20		Stage 10 Compressor Blade Clearance	R	3 or 7	0.040	--
21		Stage 11 Compressor Blade Clearance	R	3 or 7	0.027	--
22		Stage 12 Compressor Blade Clearance	R	3 or 7	0.026	--
23		Stage 13 Compressor Blade Clearance	R	3 or 7	0.025	--
24		Stage 14 Compressor Blade Clearance	R	3 or 7	0.024	--
25		Stage 3 Compressor Vane Clearance	R	4	0.035	--
26		Stage 4 Compressor Vane Clearance	R	4	0.032	--
27		Stage 5 Compressor Vane Clearance	R	4	0.030	--
28		Stage 6 Compressor Vane Clearance	R	4	0.031	--
29		Stage 7 Compressor Vane Clearance	R	4	0.031	--
30		Stage 8 Compressor Vane Clearance	R	4	0.028	--

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
31		Stage 9 Compressor Vane Clearance	R	4	0.043	--
32		Stage 10 Compressor Vane Clearance	R	4	0.044	--
33		Stage 11 Compressor Vane Clearance	R	4	0.029	--
34		Stage 12 Compressor Vane Clearance	R	4	0.028	--
35		Stage 13 Compressor Vane Clearance	R	4	0.028	--
36		Exit Guide Vane Clearance	R	5	0.004	--
37		Compressor Rear Spool Lip to ID of Combustion Chamber Forward Inner Flange	R	6	0.060	--
38 through 41		Not applicable.				
42		Stage 2 Blade Root to Stage 2 Vane Tip	A	7	0.068	--
43		Stage 2 Vane Tip to Stage 3 Blade Root	A	7	0.072	--
44		Stage 3 Blade Root to Stage 3 Vane Tip	A	7	0.124	--
45 through 56		Not applicable.				

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
57		Stage 9 Vane Tip to Stage 10 Blade Root	A	7	0.080	--
58		Stage 10 Blade Root to Stage 10 Vane Tip	A	7	0.058	--
59		Stage 11 Blade Root to Stage 11 Vane Tip	A	7	0.063	--
60 through 62		Not applicable.				
63		Stage 13 Blade Root to Stage 13 Vane Tip	A	7	0.058	--
64		Stage 13 Vane Tip to Stage 14 Blade Root	A	7	0.061	--
65		Stage 1 Vane Shroud Ring to Stage 2 Blade Platform	A	7	0.135	--
66		Compressor Rear Spool to Combustion Chamber Forward Inner Flange	A	7	0.080	--

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
67		IGV Shroud Ring to Stage 1 Blade Platform	A	7	0.070	--
68		Stage 2 Seal Bolt-head to Compressor Front Spool	A	7	0.112	--
69		Stage 1 Compressor Disk ID to No. 3 Bearing Housing OD	R	6	0.037	--
70		Stage 1 Compressor Seal Clearance	R	6	0.013	--
71		Stage 2 Compressor Seal Clearance	R	6	0.013	--
72		Compressor Discharge Seal Clearance (Forward Step)	R	6	0.001	0.007
73		Compressor Discharge Seal Clearance (Middle Step)	R	6	0.001	0.007
74		Compressor Discharge Seal Clearance (Aft Step)	R	6	0.001	0.007
75		Compressor Discharge Stationary Seal to Compressor Rear Shaft Bolt-head	A	8	0.085	--
76		Fan Shaft Air Seal to PTO Shaft ID	R	6	0.008	--
77		Aft side of first tooth on compressor discharge rotating seal to forward side of middle step on stationary seal	A		0.110	--
78		Aft side of second tooth on compressor discharge rotating seal to forward side of aft step on stationary seal.	A		0.110	--
79 through 89		Not Applicable				
90		Stage 1 Turbine Blade Clearance	R	9	0.040	0.046
91		Stage 2 Turbine Blade Clearance	R	9	0.036	0.042

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
92		Stage 1 Turbine Cooling Plate to Stage 2 Nozzle Inner Band	R	10	0.060	--
93		Stage 2 Turbine Cooling Plate to Transition Liner	R	10	0.060	--
94		OBP Seal Flange to Stage 1 Turbine Cooling Plate	R	10	0.040	--
95		Stage 2 Turbine Nozzle Seal Clearance (Forward step)	R	6	0.014	--
96		Stage 2 Turbine Nozzle Seal Clearance (Aft Step)	R	6	0.014	--
97		OBP Seal Clearance	R	6	0.014	0.017
98		IBP Seal Clearance	R	6	0.006	0.009
99		Stage 1 Blade Platform to Stage 1 Nozzle Inner Band	R	10	0.035	
100		Stage 1 Nozzle Retaining Ring to Inner Turbine Casing	A	8	0.026T	0.017
101		Not applicable				
102		Not applicable				
103		Not applicable				
104		Stage 2 Turbine Cooling Plate to Transition Liner	A	8	0.125	--
105		Not applicable				
106		Oil/Air Seal to High Pressure Turbine Shaft	A	8	0.150	--
107		Stage 2 Nozzle Inner Band to Stage 2 Turbine Blade Platform	R	10	0.060	--
108		Inner Turbine Casing ID to Stage 1 Nozzle OD	R	6	0.005	--
109 through 119		Not applicable				
120		Stage 3 Turbine Blade Clearance (Forward Step)	R	11	0.006	0.024

TABLE 8-1. ENGINE CLEARANCES

Clearance No.	Fig. No.	Description	Direction Measured	See Note No.	Min	Max
121		Stage 3 Turbine Blade Clearance (Aft Step)	R	11	0.006	0.024
122		Stage 4 Turbine Blade Clearance (Forward Step)	R	11	0.006	0.024
123		Stage 4 Turbine Blade Clearance (Aft Step)	R	11	0.006	0.024
124		Stage 5 Turbine Blade Clearance (Forward Step)	R	11	0.016	0.030
125		Stage 5 Turbine Blade Clearance (Aft Step)	R	11	0.016	0.030
126		Stage 6 Turbine Blade Clearance	R	11	0.020	0.037
127		Transition Liner to Stage 3 Disk	R	6	0.050	--
128		Stage 4 Seal to Stage 4 Nozzle	R	6	0.008	--
129		Stage 5 Seal to Stage 5 Nozzle	R	6	0.008	--
130		Not applicable				
131		Stage 6 Seal to Stage 6 Nozzle	R	6	0.008	--
132		Not applicable				
133		No. 7 Bearing Locknut retaining ring to rear cover	R	12	0.060	--
134		Transition Air Seal Clearance	R	6	0.034	--
135		Transition Liner to Stage 3 Nozzle Inner Band	A	8	0.007	--
136		Stage 3 Nozzle Outer Band to Stage 3 Blade Tip	A	7	0.281	--
137		Stage 3 Blade Tip to Stage 4 Nozzle	A	7	0.361	--
138		Stage 4 Nozzle Outer Band to Stage 4 Blade Tip	A	7	0.187	--
139		Stage 4 Blade Tip to Stage 5 Nozzle	A	7	0.324	--
140		Stage 5 Nozzle Outer Band to Stage 5 Blade Tip	A	7	0.206	--

TABLE 8-2. PART REPLACEMENT - MINIMUM CLEARANCE AND ASSEMBLY CHECKS

Section/Part	Clearance No.	Assembly Checks
Compressor Blades	11 through 24, as required.	Blade gap per para. 5-129
Compressor Vanes	25 through 36, as required.	Vane Stack up per section V.
Combustion Section:		
Compressor Discharge Air Seal	66, 72, 73, 74, 90, 91	HPT Rotor Seating Check LPT Rotor Seating Check
B-Sump	75, 90, 91, 106	Shim Check No. 4 & 5 Bearing Outer Races HPT Rotor Seating Check LPT Rotor Seating Check
Seal, Outer Balance Piston, Stationary	97, 90, 91	HPT Rotor Seating Check LPT Rotor Seating Check
Seal, Inner Balance Piston, Stationary	98, 90, 91	HPT Rotor Seating Check LPT Rotor Seating Check
Frame, Combustion Chamber	36, 37, 64, 65, 94, 66, 90, 91, 106	Shim Check, No. 4 & 5 Bearing Outer Races HPT Rotor Seating Check LPT Rotor Seating Check
Liner	94, 108	HPT Seating Check LPT Seating Check
No. 4 & 5 Bearings	90, 91	Shim Check, No. 4 & 5 Bearing Outer Races
Stage 1 Nozzle	90, 91, 94, 108	HPT Rotor Seating Check LPT Rotor Seating Check
High Pressure Turbine Section:		
Turbine Shrouds Stage 1	90	LPT Rotor Seating Check
Turbine Shrouds Stage 2	91	LPT Rotor Seating Check
Stage 2 Nozzle	92, 95, 96, 107	LPT Rotor Seating Check
Turbine Blades, Stage 1	90	HPT Rotor Seating Check LPT Rotor Seating Check
Turbine Blades, Stage 2	91, 104, 107	LPT Rotor Seating Check
High Pressure Turbine Rotor	90, 91, 92, 93, 94, 95, 96, 97, 98, 104, 106, 107	No. 5 Bearing Seating Check HPT Rotor Seating Check LPT Rotor Seating Check
High Pressure Turbine Casing	90, 91, 92, 96	LPT Rotor Seating Check
Low Pressure Turbine Section:		
Transition Casing	93, 104, 127, 134, 136, 144	LPT Rotor Seating Check

TABLE 8-2. PART REPLACEMENT - MINIMUM CLEARANCE AND ASSEMBLY CHECKS

Section/Part	Clearance No.	Assembly Checks
Stage 3 Nozzle Segments	93, 104, 127, 134, 135, 136 144	LPT Rotor Seating Check
Transition Liner (Outer)	--	LPT Rotor Seating Check
Transition Liner and Seal	93, 104, 134, 135	LPT Rotor Seating Check
Rotor, LPT	120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 131, 136, 137, 138, 139, 140, 141, 142, 143, 149, 150, 151, 155	No. 6 Bearing & Seal Runner Seating Check No. 7 Bearing & Oil/Air Separator Seating Check
Turbine Blades:		
Stage 3	120, 121	Blade Key Gap
Stage 4	122, 123	Blade Key Gap
Stage 5	124, 125	Blade Key Gap
Stage 6	126	Blade Key Gap
Stage 4 Turbine Nozzle Segments	128	--
Stage 5 Turbine Nozzle Segments	129	--
Stage 6 Turbine Nozzle Segments	131	--
Turbine Shrouds:		
Stage 3	120, 121	--
Stage 4	122, 123	--
Stage 5	124, 125	--
Stage 6	126	--
Stator Casing, LPT	120, 121, 122, 123, 124, 125, 126, 128, 129, 131, 143, 145, 151	--
Exhaust Frame	151, 155	--
No. 6 Bearing	--	Seal Runner Seating Check and Feeler Gage Check, Inner Race
No. 7 Bearing	--	Oil/Air Separator Seating Check and Feeler Gage Check, Inner Race

SECTION IX

SYSTEM OPERATION AND DESCRIPTION

9-1. GENERAL.

9-2. This section gives a detailed description and principles of operation of the various systems in the YTF34-2 engine. Included are the turbine cooling, anti-icing, lubrication control, fuel, and starting systems.

9-3. LUBRICATION SYSTEM.

9-4. GENERAL. The lubrication system, schematically illustrated in figure 9-1, is self-contained, having its own engine-mounted oil tank, main lube and scavenge pump, front (A-sump) scavenge pump, oil cooler, oil filter, oil pressure transmitter, oil filter bypass check valve, oil pressure relief valve, oil anti-leak check valve, magnetic drain plug, and related piping. The system consists of a pressurized full flow supply circuit and a return circuit which allows dry sump operation. Air entering the sumps is vented overboard through the engine exhaust. The sumps are vented through the center vent system and are independent of air leakage flow.

9-5. OIL SUPPLY CIRCUIT. Oil from the tank enters the supply element of the main lube and scavenge pump. From the pressure element the oil passes through a filter, an anti-drain check valve, and then to the oil-to-fuel heat exchanger (oil cooler). The oil pump is provided with a bypass valve that relieves the excess pressure during cold start conditions. The oil filter also has a bypass valve which allows oil flow to the engine if the filter becomes completely obstructed. Except during very cold starting conditions, all the oil supplied by the pressure element passes through the cooler to the engine, and all valves receive filtered oil to prevent malfunction due to contamination.

9-6. Oil is cooled by a tube and shell type of oil cooler with fuel flow inside the tubes. The oil and fuel passages are large and receive filtered fluid which eliminates the need for relief valves. The oil cooler is located on the oil supply side of the pressure element and cools hot deaerated high pressure oil. After leaving the oil cooler the oil flow divides into high and low pressure circuits. The low pressure circuit supplies oil forward to the A-sump and the accessory gearbox. The high pressure circuit services the B-sump in the center of the engine and the C-sump at the aft end of the engine.

9-7. Oil is returned to the oil tank by eight scavenge pumping elements. The scavenge pump for the A-sump has 2 elements for scavenging the A-sump at climb and dive attitudes. During straight and level flight, the A-sump oil drains into the accessory gear box where it is scavenged by two large scavenge elements, contained in the main lube and scavenge pump. Both B- and C-sumps each contain two independent scavenge return systems connected to scavenge elements in the main lube and scavenge pump. The scavenge discharge oil from all elements is routed back into the oil tank through a cyclone type deaerator. Vent air separated from the oil is routed to the center vent system and then into the engine exhaust.

9-8. An oil tank pressurizing valve is located in the tank vent line at the discharge of the deaerator, and provides positive pressure for the lube pump to prevent cavitation and low flow at high altitude. The pressurizing valve piston contains a small bleed hole to allow system pressure collapse upon engine shutdown. The deaerator is located above the oil level in the tank and is designed such that oil cannot drain back through the scavenge circuits into the engine after shutdown. Magnetic chip detectors are located in the scavenge lines from each sump, as well as in the oil tank and accessory gearbox.

9-9. MAIN SHAFT OIL SEALING SYSTEM. The A-sump is sealed by tandem carbon seals pressurized between elements by regulated seventh stage bleed air. The seals are drained overboard through external drain lines. The drain system is purged by seal pressurization air which prevents contaminants from accumulating and eventually obstructing the drains. The B-sump is sealed by single element bore carbon seals at the forward and aft ends of the sump. The seals are pressurized and cooled directly by seventh stage air. The C-sump has a tandem carbon seal provided at the forward end. It is also pressurized by regulated seventh stage bleed air between sealing elements. Oil seepage escaping from the seal is consumed in the exhaust and is, therefore, not drained. At the aft end of the C-sump a carbon seal prevents C-sump vent air from short circuiting the C-sump air-oil-separator, and also prevents oil loss from the center vent during steep climbs. All rotating seal runners are cooled directly or indirectly with jetted oil for long life.

9-10. MAIN SHAFT BEARING AND ROTOR SUPPORT.

9-11. All main shaft bearings have positive oil jet lubrication with two jets per bearing to provide uniform temperature distribution and a safety factor in the event of jet obstruction. The main shaft roller bearings feature M50 tool steel races and rollers and silver plated steel cages. Close operating clearances maintain the desired rotor centerline, assure adequate bearing loading and prevent roller and cage wear. Increased radial cross sections on inner races are provided to prevent secondary shaft damage in the event of bearing malfunction, as well as to maintain shaft fits to prevent fretting for long life. Anti-rotation locks are provided between the bearing outer races and bearing housings to prevent wear and debris generation. The core engine rotor and fan-rotor thrust bearings are located in the cool A-sump for maximum life and reliability. Positive anti-rotation locks are provided between these bearings and their housings to prevent wear.

9-12. FUEL SYSTEM.

9-13. GENERAL. The fuel system, schematically illustrated in figure 9-2 includes fuel control, fuel pump, fuel heater, fuel filter, fuel distributor, oil cooler, VG actuators and flowmeter. (The flowmeter is not furnished with engine.) The fuel system provides engine fuel required for combustion, control system actuation and oil cooling. In addition, the fuel system has provisions for supplying fuel to the airframe fuel tank for jet pump motive flow, if required. Fuel used must conform to MIL-T-5624, Grades JP-4 and JP-5.

9-14. FLOW. Fuel is supplied from the aircraft tank to the engine fuel pump. It passes through the boost element where a portion of the flow is diverted to the secondary positive displacement pump for jet pump motive flow, which returns fuel to the aircraft under all operating conditions at or above idle. If the motive fuel flow is not utilized in the aircraft fuel system, coolers must be provided to cool this bypass flow before it is returned to the engine pump inlet to assure that allowable engine fuel inlet temperature is not exeeded.

9-15. The undiverted engine fuel flow passes from the periphery of the boost impeller through the fuel heater, fuel filter, then back to the inlet of the primary positive displacement pump where the fuel pressure is raised to meet system demand. Fuel flow from the primary pump goes directly to the main fuel control where required flow for variable geometry control and engine operation is scheduled. Fuel in excess of engine flow is bypassed back to the inlet of the primary pump. Flow for engine operation passes from the main fuel control through the fuel flowmeter then through the oil cooler where heat is extracted from the oil by the fuel. Fuel then flows to the flow distributor where it is equally distributed to each of the 18 fuel tubes in the combustor frame. Positive shut-off fuel flow to the engine is provided in the fuel control by rotating the power lever to the OFF position.

9-16. A fuel heater is provided to prevent icing of fuel and control system components. It is an air-to-fuel heat exchanger which uses a fuel temperature sensing valve to control the flow of extracted compressor air through the heat exchanger, to maintain fuel temperature above 40° F.

9-17. CONTROL SYSTEM.

9-18. GENERAL. The engine control system, schematically illustrated in figure 9-3, is made up of the fuel control, amplifier, alternator, electrical harnesses and airframe interfaces. Functions include auto-ignition actuation and the armament firing reset system. These control units include all those needed for proper and complete control of the engine. The control is designed to allow ready attachment of remotely actuated devices for all adjustments which may re required in service. The fuel control mounting pad has provisions for use of a V-band clamp. The drive spline is lubricated by fuel. The control system is completely self-contained and requires no external power from the aircraft electrical system. The fuel control and control amplifier may be removed from the engine separately from any input system (such as the inlet temperature sensing system), and replaced without calibration or matching with such input systems. (The VG system has to be rigged to the fuel control.)

9-19. FUEL CONTROL. The fuel control is basically the core engine high pressure turbine speed control. However the speed-setting, scheduled by the power lever is overridden by an electrical signal from the control amplifier at high speeds to obtain the desired high pressure turbine-discharge temperature as scheduled by the power lever. This scheduling of speed and temperature is such that the power condition is established by the speed control at Idle and low power conditions, and established by the control amplifier at high power conditions, including Maximum Continuous, Intermediate, and Maximum power. Since the control system is designed for limited trim of the scheduled speed setting, power modulation is available from the power lever in the event of any temperature control system failure by disabling the temperature control. This should only be used during emergency conditions as it may result in an overtemperature condition, depending upon PLA, bleed and horsepower extraction. External access to the temperature control circuit is provided at connections 8 and 9 of connector E2, figure 9-4. For normal operation, an external circuit must be completed between these two connections. In the event of a temperature control system electrical failure in either the under or over-temperature direction, the normal current flow (signal) from the temperature amplifier to the torque motor within the fuel control may be interrupted by opening this external circuit. When this is done, the engine will be speed controlled unbiased by temperature. Normal operation is still available at

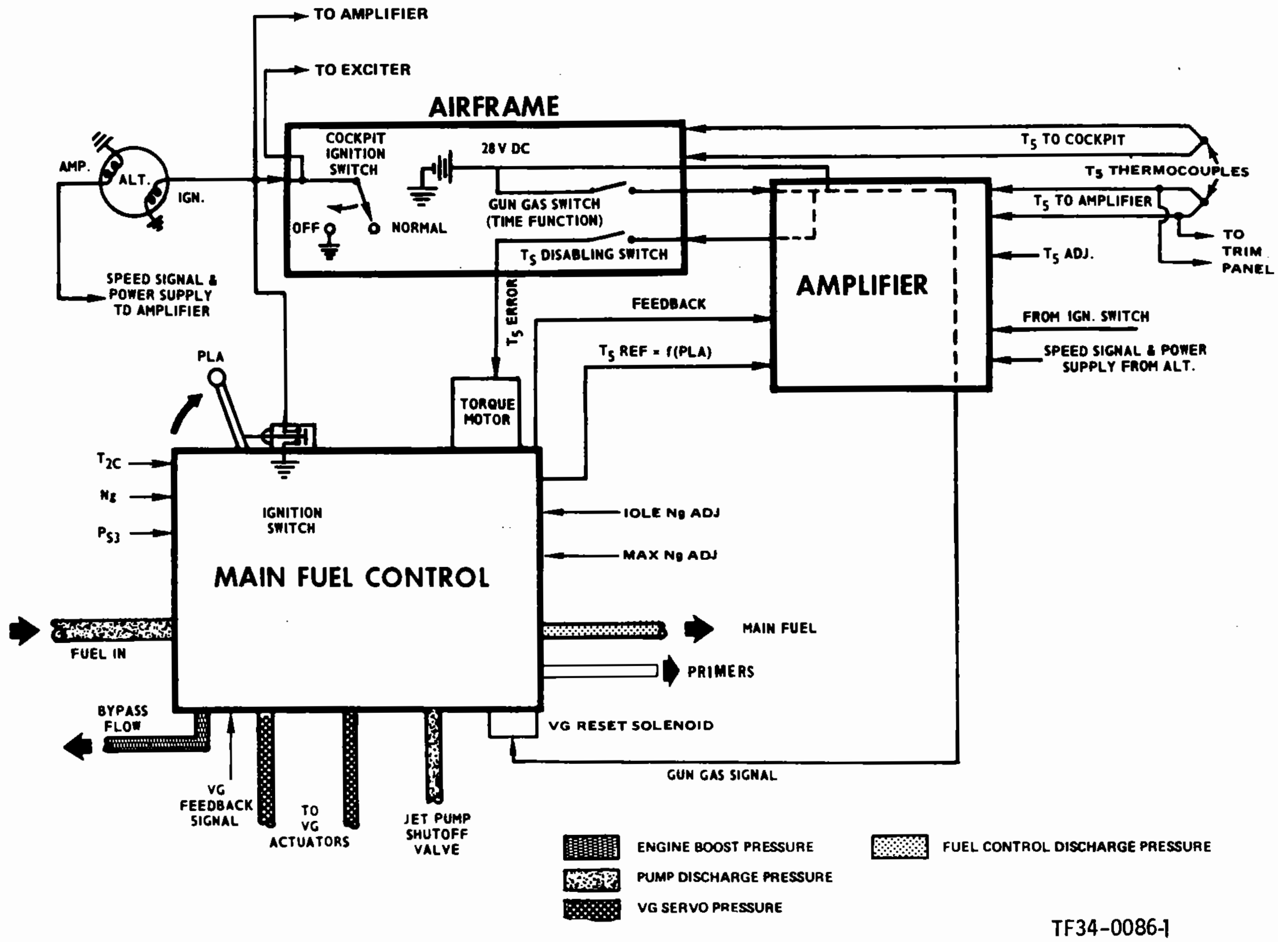


Figure 9-3. Fuel Control System Schematic Diagram

11. The fuel control schedules high pressure fuel as a function of NG and T2c to the external hydraulic actuators which reposition the variable geometry and provides position feedback to null out the schedule flow when the desired position is obtained.

12. The fuel control incorporates fuel temperature compensating features which correct the acceleration and VG schedules to maintain the required accuracies throughout the specified normal fuel temperature range.

13. A single-pole-single-throw ignition switch integral with the control is provided which breaks contact at power lever angles of 8 ±2 degrees and above to allow the ignition system to operate.

14. Fail safe schedules are provided in the event of CIT sensor failure.

15. Upon command from an electrical gun gas signal, the control shifts the variable geometry schedule a preset number of degrees and decreases fuel flow to a preset RPM and turns ignition on. This decreases Ng.

16. The fuel control provides separate and independent idle and maximum speed adjustments.

17. The fuel control provides an external pressure signal to the fuel pump as a function of NG, to provide jet pump motive flow to airframe when NG exceeds 52%.

9-21. VARIABLE-GEOMETRY CONTROL. The compressor variable-geometry control system consists of two fuel operated actuators and a mechanical feedback cable used in conjunction with the main fuel control to position the compressor variable-geometry as a function of corrected high pressure turbine speed. The variable-geometry pilot valve in the main fuel control directs fuel flow to the actuators, as required. The feedback cable connects the actuator system and the pilot valve to close this servo loop which assures proper variable-geometry positioning.

9-22. TEMPERATURE CONTROL. The high pressure turbine discharge temperature ITT (or inlet temperature to fan low pressure turbine) control, receives a T5 thermocouple signal (separate from that which activates the cockpit/test cell instrument) and compares it to a reference T5 signal from the fuel control PLA. The error signal is used to reset fuel flow until the engine temperature corresponds to the reference T5. Power lever position establishes the reference temperature level.

The temperature control receives its power supply from the engine-driven alternator.

9-23. AUTOMATIC CONTROL OF IGNITION AND ARMAMENT FIRING SYSTEMS. Automatic control of the ingition system is provided by the control amplifier upon receipt of control power lever, automatic ignition actuator, armament firing and high pressure turbine speed signals as described in paragraph 9-34.

9-24. CONTROL SYSTEM PERFORMANCE. The control system will control engine operation to obtain the steady-state and transient engine performance specified herein. The engine control system will automatically prevent the engine from exceeding any of its mechanical limits throughout the complete operating range of the engine. The design relationship between thrust and power lever position is of the fully modulated type, free of abrupt changes, and essentially linear.

9-25. ENGINE STARTING. The normal starting procedure is simple and does not require critical timing. After activation of the starter and Ng indication, the power lever is advanced to idle. Ignition and primer system fuel flow are automatically scheduled by the control system to provide for ground and air starting and satisfactory acceleration to stabilized idle operating conditions. The primer system is used strictly for engine starting. For the primer system to operate, the throttle must be open to idle position and Ng must be below 9250 RPM. The fuel control meters a small amount of fuel through 2 primer nozzles. When engine speed reaches 9250 RPM, fuel flow to the primer nozzles is shut off by the fuel control and P3 air is blown through the primer tubes and nozzles to purge the system of residual fuel. This system will only work properly using JP-5 grade of fuel. If JP-4 fuel is used, the primer system must be disconnected and capped off. If the system is not disconnected, ground and air starting stalls may result. During all starting, simultaneous operation or actuation of switches or levers or combinations thereof are not required. Steady-state operating times at thrust levels above ground idle are not required prior to operation at maximum thrust.

A readily visible indexing plate is provided at the engine power lever connection. A single power lever is provided and the dwell bands are as follows:

Condition	PLA Degrees
Maximum	97 - 100
Intermediate	75 - 78
Max Continuous	65
Idle	15 - 18
Ignition	6 - 10
Off	0 - 3

9-26. CONTROL SYSTEM ADJUSTMENT. External adjustments to the control system are limited to adjustments which can be made correctly with the engine assembled and with reference only to the operating characteristics of the engine on the ground. These adjustments are clearly marked and accessible. All other adjustments are protected to discourage tampering. The external adjustments include the following:

1. Measured Gas Temperature Adjustment. The maximum averaged measured gas temperature is adjustable within the range of ±75° F (23. 9° C).

2. Idle Speed and Adjustment. The compressor idle RPM is adjustable within a range of at least ±5% of the specified idle speed.

3. Adjustment for Fuel Grades. No adjustment is required for changes to the fuel grades within the range specified in table 1-1 except that primer nozzle system must be capped off when using JP-4.

9-27. <u>ELECTRICAL SYSTEM.</u>

9-28. GENERAL. The engine has a self-contained electrical power supply for the control system and ignition system. In the event of loss of external (aircraft) electrical power the engine will accomplish air starts and operate at all engine speeds at or above ground idle throughout the complete thrust range. With loss of external electrical power, the anti-icing system fails safe with the anti-icing valve spring loaded in the open position. The electrical system (see figure 9-4) includes an alternator, the ignition system exciter and plugs, the anti-icing system solenoid valve, the main fuel control T5-PLA linear differential transformer, torque motor and VG/armament firing solenoid, a control amplifier, thermocouples and wiring harness and the various engine condition sensing elements.

9-29. ALTERNATOR. The single phase 16 pole alternator, mounted on the forward side of the accessory gearbox has 3 sets of windings; one set drives the control amplifier and the other two sets, in parallel, drive the ignition exciter. The alternator speed varies from 1617 to 18, 277 rpm as a function of the gas generator, and produces a frequency ranging from 216 to 2454 Hz.

9-30. IGNITION SYSTEM. The ignition system, schematically illustrated in Figure 9-5, is a intermittent duty AC powered, capacitor discharge, low tension type. It is completely self-contained on the engine, requiring no power from the aircraft electrical system. The system consists of the engine-driven alternator rotor, an alternator stator, a dual circuit and dual-output exciter, two ignition leads and ignitor plugs, and an ignition de-activation relay and logic circuit in the control amplifier, a PLA igniter switch, and a cockpit disable switch. The stored energy level is three joules minimum per charge when the engine alternator is operating at 1600 pad rpm or higher.

9-35. When the engine is windmilling, the power lever should be stopcocked and the cockpit ignition circuit should be closed.

9-36. FUEL CONTROL ELECTRICAL ELEMENTS. The fuel control contains a fuel flow reset torque motor, a T5-PLA linear variable differential transformer, (LDVT), ignition cutout switch rate of feedback transducer and the armament firing VG solenoid. There are 3 electrical connectors on the control to provide connection of input-output signals from the control amplifier.

9-37. ARMAMENT FIRING FUEL FLOW RESET. The control amplifier provides an electrical signal to the input of the T5 torque motor which resets the fuel flow to the deceleration schedule only at speeds 14,000 rpm (NG) and above.

9-38. T5-PLA ELECTRICAL SCHEDULE. The fuel control power lever shaft actuates a linear displacement variable transformer (LDVT) which provides an electrical signal to the control amplifier. This is a T5 reference demand signal.

9-39. IGNITION SWITCH. A single-pole-single-throw ignition switch in the control breaks contact at power lever angles of 8 ±2 degrees and above.

9-40. ARMAMENT FIRING SOLENOID (VG RESET). During armament firing, (see paragraph 9-34) upon command from an electrical gun gas signal the VG resets in the closed direction by 45% of full stroke within 0.3 seconds. After termination of the gun gas signal the VG returns to its normal schedule after a 1 second delay.

9-41. CONTROL AMPLIFIER. The control amplifier is part of the integrated hydro-mechanical-electrical control system. It has the following functions:

1. Activate and deactivate the ignition exciter as a function of speed and a T5 error signal.

2. Accept an airframe dc voltage and energize the solenoid and VG resets the torque motor to reduce fuel flow as a function of an airframe armament signal, and concurrently provide for the activation of the ignition exciter.

3. Provide a temperature control where the T5 schedule as a function of fuel control power lever angle (PLA) position will be maintained.

9-42. IGNITION ACTIVATION AND DEACTIVATION FUNCTION. The amplifier contains an automatic ignition control relay which will turn ignition on when any of the following exist:

1. Ng is less than 8450 RPM (1140 Hz).

2. ITT (T5) lower then 800°F (444°C) below reference T5.

3. Armament trigger signal on.

9-43. FLAMEOUT FUNCTION. Provision is made for activating the ignition system when an engine flameout occurs. T5 is used as the flameout detection signal. The ignition system is activated when T5 reference minus T5 harness is equal to 800°F or more. A lead-lag circuit with T1 seconds lead and a lead to lag time constant ratio of 10 or greater is included to compensate for the thermocouple harness time constant and will affect only the T5 reference minus the T5 harness and not the flameout reference.

9-44. IGV SOLENOID AND FUEL FLOW RESET FUNCTION. The dc airframe voltage is applied to the IGV solenoid and the amplifier current output fully resets the torque motor to the minimum fuel flow position when the armament signal is applied. The time delays between removal of the armament firing signal and (1) removal of the dc signal from across the IGV solenoid, (2) removal of the signal to reset the torque motor, is 1.0 second. Two separate time delay circuits, one for each function, are incorporated in the amplifier. The maximum current required by the solenoid is 1.0 ampere at 77°F. In addition, the armament firing signal over-rides all other signals to require that ignition is "ON". Ignition remains on as long as dc power is applied to the solenoid. The fuel derichment function is operational to at least 10,000 RPM (1343 Hz) minimum speed. The reset current between the speed range 10,000 RPM (1343 Hz) and 13,250 RPM (1780 Hz) is 175 ma (positive) or greater.

9-45. T5 SCHEDULING FUNCTION. The amplifier supplies a T5 error signal to the fuel control torque motor to maintain T5 temperature in accordance with the prescribed PLA-T5 reference schedule by accepting a T5 thermocouple signal and comparing it with the PLA-T5 reference signal. Provision is made to supply an AC voltage to the primary of the PLA linear differential variable transformer (LDVT) and accept its output. The AC output of the PLA LDVT is proportional to PLA position. The PLA T5 REF is generated with this signal and an adjustable T5 REF is established. The LDVT electrical null corresponds to a T5 REF of 1462°F. The T5 reference field adjustment has an adjustment capability of ±75°F.

9-46. FEEDBACK TRANSDUCER. The amplifier has provisions for accepting a dc signal from a feedback transducer which is proportional to rate of change of the fuel metering valve position, with increasing fuel direction represented by a positive dc signal and a decreasing fuel direction represented by a negative dc signal. The dc output of the feedback transducer is proportional to rate of change of the fuel metering valve position. The amplifier output current is double ended, that is, both positive and negative as measured with respect to the torque motor, with a positive current (above null) resulting from an overtemperature error input and a negative current (or positive current less than null current) resulting from an undertemperature error.

9-47. ENGINE CONDITION ELECTRICAL SENSING SYSTEMS. The engine provides the high-pressure turbine discharge (fan low pressure turbine inlet) T5 thermocouple harness, a fuel filter impending bypass detector, an oil pressure transmitter, and oil pressure transmitter, and a fan rotor speed indicator. In addition, there is provision for installation (but not supplied with engine) of the high pressure turbine rotor speed tachometer generator and a fuel flow transmitter, and an oil tank level sensor.

9-48. T5 THERMOCOUPLE HARNESS. Ten chromel-alumel thermocouple probes, equally spaced and alternately immersed at two levels, are electrically paralleled to give an average output EMF proportional to measured high pressure turbine discharge gas temperature. Two independent thermocouple systems within each probe provide separate but identical temperature signals to the engine control amplifier and to the aircraft/test cell temperature indicator. The temperature range is between 900°F (482°C) to 1800°F (982°C) and the signal accuracy is ±15°F. Periodic ground checks of the functioning of the temperature sensing system while installed in the engine can be made at the connector sockets with a resistance bridge suitable for accurately measuring the circuit resistance across the sockets and comparing them to a calibration value stamped on the harness horizontal junction box. Insulation resistance between each connector socket and the connector shell (ground) can be checked and compared to 500 ohm minimum limit.

9-49. FUEL FILTER BY-PASS DETECTOR. The main fuel filter is provided with an integral by-pass and provides an electrical indication of impending by-pass, requiring input power of 1 amp at 28 volts dc. The filter also has a visual pop-out button on the head of the filter which indicates when the filter bypass valve has been actuated. This button cannot be reset until the filter bowl is removed.

9-50. OIL PRESSURE TRANSMITTER. A differential pressure transmitter, mounted on a bracket at the main lube and scavenge pump, senses differential pressure between B-sump scavenge and main lube pump discharge. An electrical signal, using 26 volts 400 Hz, is sent to the aircraft/test cell indicator which requires a range of 0-100 psi.

9-51. OIL TANK LEVEL TRANSMITTER. Provisions for an oil tank lever transmitter for aircraft/test cell indication have been made but only a dummy connection is provided.

9-52. FAN ROTOR SPEED INDICATOR (Nf SENSOR). The fan rotor speed indicator consists of a reluctance transmitter on the No. 2 bearing locknut and a probe mounted on the 9 o'clock side of the front frame. An electrical signal is thereby sent to the aircraft/test cell indicator, and to the trim panel.

9-53. AIR SYSTEM.

9-54. GENERAL. The engine air system includes the turbine cooling and anti-icing systems.

9-55. TURBINE COOLING SYSTEM. The high pressure turbine is cooled with compressor discharge air. The blades are cooled by cooling air flowing radially through the airfoils of both stages and discharging through the blade tips. First-stage blade trailing edges are cooled by air discharging directly through their trailing edges. The forward face of the first-stage wheel is cooled by outer turbine seal leakage air. The aft face of the second-stage wheel and the fan turbine first-stage wheel are both cooled by compressor seal leakage air.

9-56. The first-stage nozzle is cooled with compressor discharge air which enters through the OD of the nozzle assembly and exits through leading and trailing edge holes and slots located on the nozzle vane. The second-stage nozzle is cooled with compressor discharge air which enters at the OD and is discharged through trailing edge holes and radially into the interturbine wheel cavity, cooling the interstage seal.

9-57. ANTI-ICING SYSTEM. The engine anti-icing system, schematically illustrated in figure 9-6, is a noncontinuous system. On-off control is provided by a solenoid operated anti-icing valve actuated from externally supplied power. The valve opens when external power is removed. A pressure switch downstream of the valve completes a circuit between connections P and R of connector E3 shown in figure 9-4. The pressure switch circuit will be closed when the anti-icing system is "ON" and open when the system is "Off". When the system is "On", compressor discharge air is ducted to the fan splitter nose, front frame struts, fan stator vanes, compressor inlet guide vanes, fan spinner, fan pylon, bleed inlet, and airframe anti-icing.

9-58. The anti-icing valve, schematically illustrated in figure 9-7 regulates the output air pressure and incorporates a secondary pressure regulator in case of failure of the primary element. A pop-out button is provided on the body of the valve to indicate primary pressure regulating element malfunction. Failure of the externally supplied electrical power causes the valve to open to the fail safe anti-icing "On" condition. Continuous operation of the engine anti-icing system will not damage the engine and affects the engine performance and characteristics in a manner equivalent to the percent of compressor discharge bleed which flows through the engine anti-icing system.

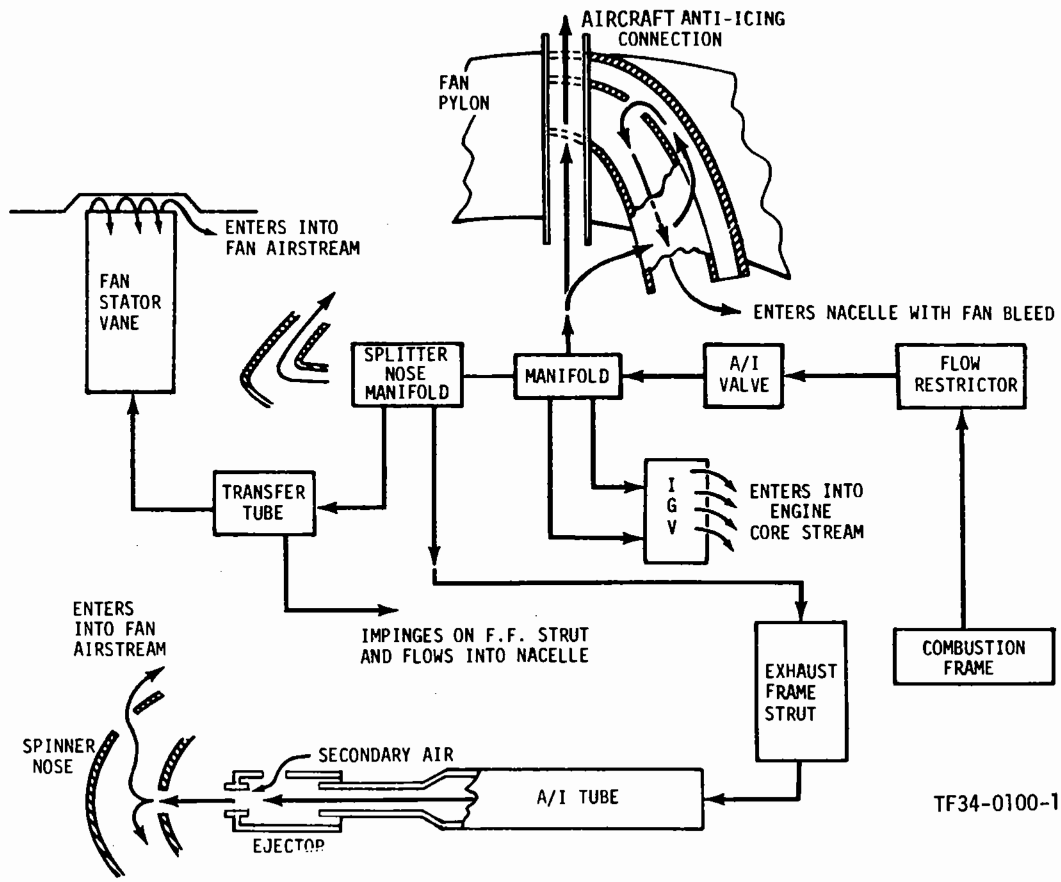


Figure 9-6. Anti-Icing System Schematic Diagram

9-59. Air downstream of the valve is piped into the fan splitter nose manifold (where a portion of it flows around the nose and into the fan airstream) and then to the fan stator vane inner support via four transfer ducts which pass through the front frame struts. Some anti-icing air is bled through holes in the transfer ducts for impingement anti-icing of the front frame struts. The inner support distributes air to the 44 vanes which then travels radially outward through the internal corrugations and exits at the vane tips into the fan air stream through holes sized to meter the air according to chordwise distribution needs.

9-60. Compressor inlet guide vanes are anti-iced by air which is piped from a separate line downstream of the anti-icing valve through a manifold which feeds anti-icing air radially inward through cored passages in the IGV's. This air flows through trailing edge holes in the IGV's and becomes part of the core engine air flow.

9-61. Fan spinner anti-icing air, obtained from the splitter nose manifold, is piped aft to the exhaust frame, radially inward through a strut, and then forward through the center of the fan drive shaft to the center of the ejector. Air extracted from the hub of the fan rotor is routed through holes in the conical fan rotor shaft to the ejector where it is mixed with the hot anti-icing air to provide the warm air used for anti-icing the entire exposed surface of the aluminum spinner. Spent air rejoins the main air stream just forward of the fan rotor blades.

9-62. The fan pylon anti-icing air is fed radially outward around the double walled surfaces of the fan pylon nose together with the aircraft anti-icing air. Part of this air is exhausted into the fan bleed duct, and enters the nacelle with the fan bleed air for bay cooling. Aircraft anti-icing air, the greater part of that entering the pylon, is ducted radially outward through the fan pylon and delivered to the customer bleed port at the surface of the outer fan cowl.

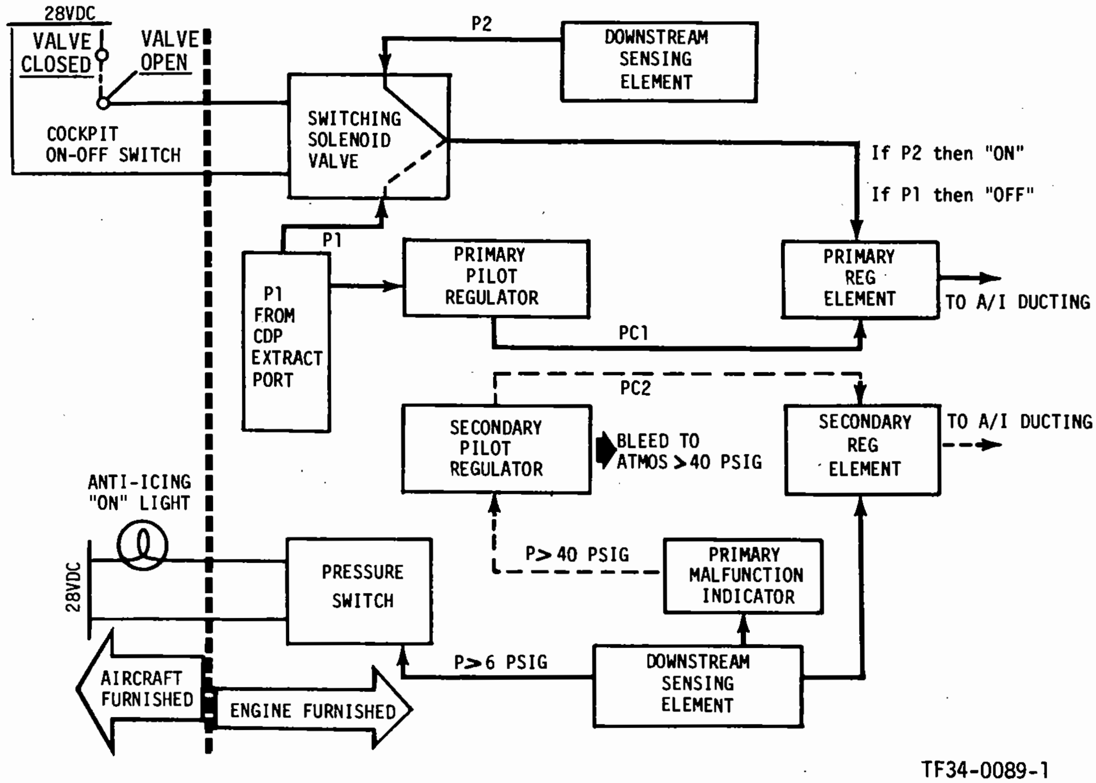


Figure 9-7. Anti-Icing Valve Schematic Diagram

SECTION X
FINAL TEST

10-1. GENERAL.

1. This section contains instructions for testing the YTF34 engine. Instructions for operating the engine under normal and abnormal conditions are included in this section. Engine operating limits are listed in table 10-1.

2. After maintenance has been completed, the engine must be tested to ensure that it will operate properly when installed in an aircraft. The test procedures, limits and all other information contained in this section are intended for use in testing engines installed only in a test stand at intermediate maintenance activities.

3. Comply with all engine operating limits (see table 10-1). Do not exceed any maximum limit when making power changes.

Note

Atmospheric conditions such as pressure, temperature, and water vapor content greatly affect turbofan engine performance. Since atmospheric conditions continuously change, graphs and tables are provided for correcting engine performance to standard atmospheric conditions.

4. Symbols and abbreviations used throughout the test section are:

Ng	High-pressure turbine rotor speed
Nf	Low-pressure turbine (fan turbine) rotor speed
PLA	Power-lever angle
T5 (T5.4)	Low-pressure turbine (fan turbine) inlet temperature
T2	Engine inlet temperature
T2c	Compressor inlet temperature
P3	Compressor discharge pressure
Wf	Fuel flow in phr
phr	Pounds per hour (fuel flow measurement)

10-2. STANDARD CHARTS AND CONVERSION TABLES.

1. Table 10-2 can be used to convert temperatures from Fahrenheit to centigrade, or from centigrade to Fahrenheit. Table 10-3 can be used to convert Ng speed from % to RPM.

10-2A. AMOUNT OF TESTING FOLLOWING SPECIFIC REPAIRS.

10-2B. GENERAL.

Table 10-4 shows what checks have to be made when parts are replaced. To use table 10-4, look in the left-hand column for the part being replaced and follow across the page; the required checks are denoted by an X. Proceed upward from each X to find out what checks should be made.

10-3. RIGGING OF POWER CONTROL SHAFT.

1. Position fuel control power control shaft so that the slot in the shaft is in line with the IDLE slot in the guide plate.

2. Insert rigging pin (21C5005) through the square hole in fuel control casting and into the IDLE position recess in the power control shaft.

3. With rigging pin installed, assemble power control shaft splined mechanism (part of test cell).

4. Adjust power lever to IDLE position (16.5 degrees PLA). Remove rigging pin (21C5005) from fuel control.

5. Move power lever from IDLE to OFF; from OFF to MAX POWER, making sure the fuel control stops are reached before power lever stops are reached. Adjust power lever stops, if necessary.

6. If power lever stops were adjusted, reset power lever to IDLE, repeat steps 2, 4, and 5.

10-4. SAFETY PRECAUTIONS AND PRESTART CHECKS.

1. Inspect ducts for foreign objects and inlet screen for cracks or damage.

2. Open nacelle doors and check the following:

TABLE 10-1. ENGINE OPERATING LIMITS

Item	Limits	Remarks
1. High-Pressure Turbine Rotor (Ng) Speed:		
	Maximum (97 - 100° PLA)	
	Up to 17,700 RPM (99.4%)	Operating limit.
	17,701 - 18,150 RPM (99.4% - 101.9%)	Troubleshoot per Section XI.
	18,151 - 18,200 RPM (101.9% - 102.3%)	Less than 3 seconds, troubleshoot per Section XI. More than 3 seconds, return engine for overspeed inspection.
	Above 18,200 RPM (102.3%)	Not allowed. Return engine for overspeed inspection.
	Intermediate (75 - 78° PLA for reference only)	
	Up to 17,200 RPM (96.6%)	Operating limit.
	Above 17,200 RPM (96.6%)	Troubleshoot per Section XI.
	Maximum Continuous (65° PLA for reference only)	
	Up to 16,900 (94.9%)	Operating Limit.
	Above 16,900 (94.9%)	Troubleshoot per Section XI.
2. Low-Pressure Turbine Rotor/ Fan Rotor (Nf) Speed:		
	Maximum (97 - 100° PLA)	
	Up to 7,400 RPM	Operating limit.
	7,401 - 7,825 RPM	Check Ng and T5.
	7,826 - 7,850 RPM	Less than 3 seconds, check Ng and T5. More than 3 seconds, return engine for overspeed inspection.
	Above 7,850 RPM	Not allowed. Return engine for overspeed inspection.
	Intermediate (75 - 78° PLA for reference only)	
	Up to 7,200 RPM	Operating limit.
	Above 7,200 RPM	Troubleshoot per Section XI.
	Maximum Continuous (65° PLA for reference only)	
	Up to 7,050 RPM	Operating limit.
	Above 7,050 RPM	Troubleshoot per Section XI.

TABLE 10-1. ENGINE OPERATING LIMITS (Cont)

Item	Limits	Remarks
3. Low-Pressure Turbine Inlet Temperature (T5):		
a. Steady State: See figure 10-6.		
(1) Maximum Continuous	1389°F (754°C)	Normal operating limit.
	1390°F (754°C) to 1395°F (757°C)	Troubleshoot per table 11-1.
(2) Intermediate (30 Minutes)	1443°F (784°C)	Normal operating limit for 30 minutes maximum.
	1447°F (786°C)	If less than 30 minutes, but more than 1443°F (784°C), troubleshoot per table 11-1 to return within operating limits. If more than 30 minutes, follow instructions for overtemperature inspection in note 1.
(3) Maximum (5 Minutes)	1532°F (833°C)	Normal operating limit for 5 minutes maximum.
	1536°F (836°C)	5 minutes maximum. If less than these time limits, but more than 1532°F (833°C), troubleshoot per table 11-1 to return within operating limits. If more than these operating limits, follow instructions for overtemperature inspection in note 1.
b. Transient (during starting or acceleration): See figure 10-6.		
	1575°F (857°C)	For no more than 10 seconds.
	1576° to 1639°F (857° to 893°C)	Troubleshoot per table 11-1. If time duration in this range exceeds 5 seconds, record time and temperature in engine log book. See note 3.
	1640° to 1700°F (893° to 927°C)	Momentary time period. See note 2 below.

NOTES:

1. Overtemperature inspection is required if the limits in figure 10-6 are exceeded.

   If overtemperature inspection is required, remove 3 consecutive blades from stages 1 and 3 turbine disks per paragraph 5-167. Record weight and position of each blade for use in the event that the engine is found to be not overtemperatured. Return these blades, along with any static parts that appear overtemperatured, to Depot Maintenance for analysis.

2. A momentary limit is a transient high-temperature condition of short duration where temperature peaks and falls off, either automatically or through corrective action. If corrective action is taken before T5 reaches 1700°F, no overtemperature inspection is required. Enter maximum temperature in engine log book and troubleshoot per table 11-1.

3. In the 1532-1640°F range, the engine could experience sustained T5 readings in a steady-state or near-steady-state condition. Therefore, measurement of time and temperature beyond 5 seconds is required. Refer to figure 10-6 for corrective action.

4. Below 1536°F, maintenance action limits differ from operating limits to allow for possible gage or reading errors. For overtemperature disposition, refer to figure 10-6.

TABLE 10-1. ENGINE OPERATING LIMITS (Cont)

Item	Limits	Remarks
4. Ambient Temperature Range.	-54°C (-65°F) to 71°C (160°F)	Do not operate the engine when outside this range.
5. Fuel System:		
a. Flow range (Wf).	185 to 4130 phr	If limits are exceeded, shut down engine and troubleshoot.
b. Temperature:	JP-4 fuel. -65°F (-54°C) to 135°F (57°C)	See paragraph 10-4, step 3.
	JP-5 fuel. -20°F (-29°C) to 135°F (57°C).	See paragraph 10-4, step 3.
c. Pressure (at inlet):	0 to 50 psig during starts. 5 to 50 psig during operation. 100 psig maximum when shut down.	
6. Lubrication System:		
a. Flow (at pump discharge).	0 to 8 GPM.	Proportional to Ng.
b. Temperature (at discharge of oil cooler).	250°F (121°C) Maximum.	
c. Pressure:		
(1) Starting.	Not over 200 psi at anytime. Must be below 100 psi after 2.5 minutes maximum.	If limits are exceeded shut down engine and troubleshoot. Measured as differential pressure between pump discharge and B-sump pressure.
(2) Maximum Continuous.	50 to 72 psi.	See figure 10-1 for oil pressure limits at any Ng.
d. Pressure fluctuations.	±5 psi.	
e. Oil consumption.	0.1 gallons/hour.	
f. Sump pressure:	A-sump - ambient.	
	B-sump - 55 psig maximum.	
	C-sump - ambient.	
g. Oil leakage.	3 cc/hour (1 drop per minute) from any gearbox pad.	
7. Variable Vane Angles:	63° (full closed) Nominal.	Measure at stage 1 vanes.
	22° (full open) Nominal.	See figure 10-4 for variable angle schedule during engine operation.
8. Acceleration Time (for 1 second power lever motion).	5 seconds.	From IDLE to 95% of maximum fan speed shown in figure 10-5.

TABLE 10-1. ENGINE OPERATING LIMITS (Cont)

Item	Limits	Remarks

9. Vibration:

Note

Vibration readings can be at the maximum limit in both frequency ranges at the same time and still be acceptable. For example, a fan casing vibration reading in the 25 to 130 cps range can be 8 mils and, at the same time can be 3 mils in the 130 to 310 cps range, giving a total reading of 11 mils.

		Read in MILS - Double Amplitude		
Pickup Location	Frequency CPS	Steady State	Transient	Direction and Clock Position
Fan casing bottom ground handling flat, left-hand bolt	25 to 130 130 to 310	8 3	10 4	1 Vertical 6 o'clock
Fan casing right-hand ground handling lug, bottom bolt	25 to 130 130 to 310	8 3	10 4	1 Horizontal 3 o'clock
Compressor to combustion casing flange, forward side	25 to 130 130 to 310	3 3	4 4	1 Vertical, third bolt ccw from 12 o'clock
Compressor to combustion casing flange, aft side	25 to 130 130 to 310	3 3	4 4	1 Horizontal, eighteenth bolt ccw from 12 o'clock
Exhaust frame flange	25 to 130 130 to 310	8 3	10 4	1 Vertical first bolt cw from 6 o'clock
Accessory gearbox top right-hand side	25 to 130 130 to 310	3 3	4 4	1 Horizontal, first bolt to left of top bolt, forward side

10. Starting: No bleed allowed, minimum power extraction.

Item	Limits	Remarks
a. Time between starts.	30 seconds minimum after high-pressure turbine rotor has stopped rotating.	Do not attempt restart until time has elapsed.
b. Time from start to idle.	See figure 10-2.	Idle = 15-18° PLA.
c. Time to lightoff after fuel flow is indicated.	20 seconds maximum.	

11. Fluid Leakage:

Item	Limits	Remarks
a. Total from engine during operation (total of fuel and oil).	5 cc per minute.	
b. Total oil leakage during operation.	15 cc per hour from gearbox. 5 cc per hour from A-sump.	
c. Oil leakage at each gearbox pad.	3 cc per hour (1 drop/minute).	
d. Fuel leakage from fuel distributor upon shutdown.	130 cc maximum.	

TABLE 10-2. TEMPERATURE CONVERSION CHART.

Look up reading in middle column, if in degrees Centigrade, read Fahrenheit equivalent in right-hand column, if in degrees Fahrenheit, read Centigrade equivalent in left-hand column.

-60 to 43			44 to 93			94 to 510			520 to 1010			1020 to 1510			1520 to 2010			2020 to 2510			2520 to 3000		
C		F	C		F	C		F	C		F	C		F	C		F	C		F	C		F
-51	-60	-76	6.7	44	111.2	34.4	94	201.2	271	520	968	549	1020	1868	827	1520	2768	1104	2020	3668	1382	2520	4568
-46	-50	-58	7.2	45	113.0	35.0	95	203.0	277	530	986	554	1030	1886	832	1530	2786	1110	2030	3686	1388	2530	4586
-40	-40	-40	7.8	46	114.3	35.6	96	204.8	282	540	1004	560	1040	1904	838	1540	2804	1116	2040	3704	1393	2540	4604
-34	-30	-22	8.3	47	116.6	36.1	97	206.6	288	550	1022	566	1050	1922	843	1550	2822	1121	2050	3722	1399	2550	4622
-29	-20	- 4	8.9	48	118.4	36.7	98	208.4	293	560	1040	571	1060	1940	849	1560	2840	1127	2060	3740	1404	2560	4640
-23	-10	14	9.4	49	120.2	~~37.2~~	~~99~~	~~210.2~~	299	570	1058	577	1070	1958	854	1570	2858	1132	2070	3758	1410	2570	4658
-17.8	0	32	10.0	50	122.0	37.8	100	212.0	304	580	1076	582	1080	1976	860	1580	2876	1138	2080	3776	1416	2580	4676
-17.2	1	33.8	10.6	51	123.8	38	~~100~~	~~212~~	310	590	1094	588	1090	1994	866	1590	2894	1143	2090	3794	1421	2590	4694
-16.7	2	35.6	11.1	52	125.6	43	110	230	316	600	1112	593	1100	2012	871	1600	2912	1149	2100	3812	1427	2600	4712
-16.1	3	37.4	11.7	53	127.4	49	120	248	321	610	1130	599	1110	2030	877	1610	2930	1154	2110	3830	1432	2610	4730
-15.6	4	39.2	12.2	54	129.2	54	130	266	327	620	1148	604	1120	2048	882	1620	2948	1160	2120	3848	1438	2620	4748
-15.0	5	41.0	12.8	55	131.0	60	140	284	332	630	1166	610	1130	2066	888	1630	2966	1166	2130	3866	1443	2630	4766
-14.4	6	42.8	13.3	56	132.8	66	150	302	338	640	1184	616	1140	2084	893	1640	2984	1171	2140	3884	1449	2640	4784
-13.9	7	44.6	13.9	57	134.6	71	160	320	343	650	1202	621	1150	2102	899	1650	3002	1177	2150	3902	1454	2650	4802
-13.3	8	46.4	14.4	58	136.4	77	170	338	349	660	1220	627	1160	2120	904	1660	3020	1182	2160	3920	1460	2660	4820
-12.8	9	48.2	15.0	59	138.2	82	180	356	354	670	1238	632	1170	2138	910	1670	3038	1188	2170	3938	1466	2670	4838
-12.2	10	50.0	15.6	60	140.0	88	190	374	360	680	1256	638	1180	2156	916	1680	3056	1193	2180	3956	1471	2680	4856
-11.7	11	51.8	16.1	61	141.8	93	200	392	366	690	1274	643	1190	2174	921	1690	3074	1199	2190	3974	1477	2690	4874
-11.1	12	53.6	16.7	62	143.6	99	210	410	371	700	1292	649	1200	2192	927	1700	3092	1204	2200	3992	1482	2700	4892
-10.6	13	55.4	17.2	63	145.4	100	212	413.6	377	710	1310	654	1210	2210	932	1710	3110	1210	2210	4010	1488	2710	4910
-10.0	14	57.2	17.8	64	147.2	104	220	428	382	720	1328	660	1220	2228	938	1720	3128	1216	2220	4028	1493	2720	4928
- 9.4	15	59.0	18.3	65	149.0	110	230	446	388	730	1346	666	1230	2246	943	1730	3146	1221	2230	4046	1499	2730	4946
- 8.9	16	60.8	18.9	66	150.8	116	240	464	393	740	1364	671	1240	2264	949	1740	3164	1227	2240	4064	1504	2740	4964
- 8.3	17	62.6	19.4	67	152.6	121	250	482	399	750	1382	677	1250	2282	954	1750	3182	1232	2250	4082	1510	2750	4982
- 7.8	18	64.4	20.0	68	154.4	127	260	500	404	760	1400	682	1260	2300	960	1760	3200	1238	2260	4100	1516	2760	5000
- 7.2	19	66.2	20.6	69	156.2	132	270	518	410	770	1418	688	1270	2318	966	1770	3218	1243	2270	4118	1521	2770	5018
- 6.7	20	68.0	21.1	70	158.0	138	280	536	416	780	1436	693	1280	2336	971	1780	3236	1249	2280	4136	1527	2780	5036
- 6.1	21	69.8	21.7	71	159.8	143	290	554	421	790	1454	699	1290	2354	977	1790	3254	1254	2290	4154	1532	2790	5054
- 5.6	22	71.6	22.2	72	161.6	149	300	572	427	800	1472	704	1300	2372	982	1800	3272	1260	2300	4172	1538	2800	5072
- 5.0	23	73.4	22.8	73	163.4	154	310	590	432	810	1490	710	1310	2390	988	1810	3290	1266	2310	4190	1543	2810	5090
- 4.4	24	75.2	23.3	74	165.2	160	320	608	438	820	1508	716	1320	2408	993	1820	3308	1271	2320	4208	1549	2820	5108
- 3.9	25	77.0	23.9	75	167.0	166	330	626	443	830	1526	721	1330	2426	999	1830	3326	1277	2330	4226	1554	2830	5126
- 3.3	26	78.8	24.4	76	168.8	171	340	644	449	840	1544	727	1340	2444	1004	1840	3344	1282	2340	4244	1560	2840	5144
- 2.8	27	80.6	25.0	77	170.6	177	350	662	454	850	1562	732	1350	2462	1010	1850	3362	1288	2350	4262	1566	2850	5162
- 2.3	28	82.4	25.6	78	172.4	182	360	680	460	860	1580	738	1360	2480	1016	1860	3380	1293	2360	4280	1571	2860	5180

TABLE 10-2. TEMPERATURE CONVERSION CHART. (cont)

-60 to 43			44 to 93			94 to 510			520 to 1010			1020 to 1510			1520 to 2010			2020 to 2510			2520 to 3000		
C		F	C		F	C		F	C		F	C		F	C		F	C		F	C		F
-1.7	29	84.2	26.1	79	174.3	188	370	698	466	870	1598	743	1370	2498	1021	1870	3398	1299	2370	4298	1577	2870	5198
-1.1	30	86.0	26.7	80	176.0	193	380	716	471	880	1616	749	1380	2516	1027	1880	3416	1304	2380	4316	1582	2880	5216
-0.6	31	87.8	27.2	81	177.8	199	390	734	477	890	1634	754	1390	2534	1032	1890	3434	1310	2390	4334	1588	2890	5234
0.0	32	89.6	27.8	82	179.6	204	400	752	482	900	1652	760	1400	2552	1038	1900	3452	1316	2400	4352	1593	2900	5252
0.6	33	91.4	28.3	83	181.4	210	410	770	488	910	1670	766	1410	2570	1043	1910	3470	1321	2410	4370	1599	2910	5270
1.1	34	93.2	28.9	84	183.2	216	420	788	493	920	1688	771	1420	2588	1049	1920	3488	1327	2420	4388	1604	2920	5288
1.7	35	95.0	28.9	85	185.0	221	430	806	499	930	1706	777	1430	2606	1054	1930	3506	1332	2430	4406	1610	2930	5306
2.2	36	96.8	30.0	86	186.8	227	440	824	504	940	1724	782	1440	2624	1060	1940	3524	1338	2440	4424	1616	2940	5324
2.8	37	98.6	30.6	87	188.6	232	450	842	510	950	1742	788	1450	2642	1066	1950	3542	1343	2450	4442	1621	2950	5342
3.3	38	100.4	31.1	88	190.4	238	460	860	516	960	1760	793	1460	2660	1071	1960	3560	1349	2460	4460	1627	2960	5360
3.9	39	102.2	31.7	89	192.2	243	470	878	521	970	1778	799	1470	2678	1077	1970	3578	1354	2470	4478	1632	2970	5378
4.4	40	104.0	32.2	90	194.0	242	480	896	527	980	1796	804	1480	2696	1082	1980	3596	1360	2480	4496	1638	2980	5396
5.0	41	105.8	32.8	91	195.8	254	490	914	532	990	1814	810	1490	2714	1088	1990	3614	1366	2490	4514	1643	2990	5414
5.6	42	107.6	33.3	92	197.6	260	500	932	538	1000	1832	816	1500	2732	1093	2000	3632	1371	2500	4532	1649	3000	5432
6.1	43	109.4	33.9	93	199.4	266	510	950	543	1010	1850	821	1510	2750	1099	2010	3650	1377	2510	4550			

TABLE 10-3. PERCENT SPEED TO RPM CONVERSION CHART - HIGH-PRESSURE TURBINE SPEED (Ng)

Percent RPM	RPM	Percent RPM	RPM	Percent RPM	RPM	Percent RPM	RPM	Percent RPM	RPM	Percent RPM	RPM
50	8900	60	10680	70	12460	80	14240	90	16020	100	17800
51	9078	61	10858	71	12638	81	14418	91	16198	101	17978
52	9256	62	11036	72	12816	82	14596	92	16376	102	18156
53	9434	63	11214	73	12994	83	14774	93	16554	103	18334
54	9612	64	11392	74	13172	84	14952	94	16732	104	18512
55	9790	65	11570	75	13350	85	15130	95	16910	105	18690
56	9968	66	11748	76	13528	86	15308	96	17088		
57	10146	67	11926	77	13706	87	15486	97	17266		
58	10324	68	12104	78	13884	88	15664	98	17444		
59	10502	69	12282	79	14062	89	15842	99	17622		

TABLE 10-4. CHECKS REQUIRED AFTER COMPONENT REPLACEMENT

To use table, look for part being replaced in left-hand column and follow across page. Where there is an X, do the work called for in the vertical column.

MAINTENANCE WORK DONE ON ENGINE / FUNCTIONAL CHECKS AND ADJUSTMENTS	Engine Starting Paragraph 10-6	Fuel and Oil System Leak Check Paragraph 10-7	Idle Check Paragraph 10-8	Engine Break-in Run Paragraph 10-9	Vibration Check Paragraph 10-10	Anti-Icing Check Paragraph 10-11	Control Amplifier Check Paragraph 10-12	Variable Vane Schedule Checkout Paragraph 10-13	Performance Checkout Paragraph 10-14	Armament Firing Check Paragraph 10-15	Engine Shutdown Paragraph 10-16
a. Fuel Pump, Heater, Filter	X	X	X								X
b. Fuel Control	X	X	X				X	X	X	X	X
c. T2 Sensor	X	X	X					X			X
d. Fuel Distributor, Manifold, Nozzles	X	X									X
e. Variable Geometry Actuators	X	X						X			X
f. Feedback Cable	X							X			X
g. Lube Pump, Scavenge Pump	X	X									X
h. Oil Cooler	X	X									X
i. Oil Tank Valves	X	X									X
j. Oil Filter	X	X									X
k. Amplifier	X								X	X	X
l. Electrical Cable Assemblies	X					X	X		X	X	X
m. Fan Speed Sensor	X								X		X
n. Alternator Stator	X	X					X				X
o. Exciter	X										X
p. Anti-Icing Valve	X					X			X		X
q. T5 Harness	X						X		X		X
r. Rotors/Blades	X	X	X	X	X			X	X		X

a. Engine mounts for security.

b. Variable geometry linkage for security and for foreign objects.

c. Fuel control, fuel pump, oil pump, and associated hoses, tubes, and accessories for security and leaks.

d. Fuel filter and anti-icing valve for exposed pop-out buttons.

e. Lines for chafing.

f. Engine exterior for cracks, burns, hot spots and buckling.

g. Power lever (linkages at the fuel control).

CAUTION

Be sure to place power lever in full-closed position at the end of this check to prevent premature fuel entry to the engine.

(1) Move power lever from the full-closed to the full-open position.

(2) Move power lever to the full-closed position. Check for proper operation and freedom from binding.

CAUTION

Be sure power lever is fully closed.

h. Oil level.

CAUTION

- Under certain conditions, it is possible for the lubrication system to be overserviced. If the anti-leak check valve in the filter element is faulty, oil will start to drain from the tank when the engine is shut down. Oil will seep from the tank, into the oil pump, through the faulty check valve and into the engine sumps, including the one in the gearbox. If the engine is shut down for an extended period, usually several days, the oil may be completely drained from the tank. Consequently, if the tank is serviced to full, the amount of oil in the system could be twice the amount needed. This could cause the oil tank to deform or burst during startup.

CAUTION

Compliance with the following instructions will prevent overservicing the lubrication system:

If the addition of 2 quarts of oil does not bring the level up to the tank opening (sight gage is full), do not add more oil until engine has been run for one to two minutes and then shut down. If level is above tank opening, check valve is defective, in which case the filter element assembly must be replaced. Remove excess oil.

3. Check the fuel grade (JP-4 or JP-5) to be used for the following reasons:

a. Operation of the engine using JP-5 fuel requires that the primer fuel (starting) system be connected and operating. If the system is disconnected, starts may be slower than normal.

b. Operation of the engine using JP-4 requires that the primer fuel (starting) system be disconnected. If the system is not disconnected, starting stalls may result. When using JP-4 fuel, disconnect primer system as follows:

(1) Remove tube connecting fuel control to purge valve.

(2) Install 2 caps PT NO. J521G01, one on the fuel control fitting and one on the purge valve fitting.

(3) Torque both caps to 90-100 lb in. and lockwire, double strand method, using 0.032 inch lockwire.

c. Operation of the engine using a mixture of JP-4/JP-5 requires that the primer system be disconnected if the mixture is over 10% JP-4. It is recommended that the engine not be run using a fuel grade mixture.

10-4A. INSTALLATION AND USE OF TRIM TESTER EQUIPMENT (619AS100).

1. Install VG position transmitter (21C5503) to accessory drive gearbox pad at 9 o'clock position. Torque mounting bolts to 60 lb in. and single-strand lock-wire, using 0.032 inch lockwire.

2. Adjust transmitter so that the shaft lines up with the No. 3 stage 1 vane (No. 1 vane is first vane up from 9 o'clock splitline) on top compressor casing half.

3. Thread transmitter shaft onto vane and torque it to 12-15 lb in.

4. Route the cable up to the trim panel.

5. Route cables from trimmer tracker 619AS100 through trim mast.

6. Connect cables as described in following steps, to trim panel and VG cable.

7. Connect trim mast to airframe cowling or to cowl set (21C5511) per airframe manufacturers instructions.

Note

Circuit breaker will trip if other than required voltage-cycles is connected.

8. Connect cables to trim tester 619AS100. Supply 115V, 400 Hz to connector J204. (On airframe, connect to J1 or J2 in ECS compartment through left-hand wheel well.)

9. The trim tester will monitor the following functions:

a. T5 temperature (in centigrade).

(1) Actual T5.

(2) Corrected T5 (corrected to square root of theta).

(3) Simulated T5 to check cockpit indicator.

(4) Allow cockpit gage to be read at trimmer tracker.

(5) Self check.

b. Pressure.

(1) Ambient.

(2) PT5.

(3) Pressure ratio (PT5 divided by ambient).

(4) Self check.

c. Speed

(1) Ng (actual) in percent.

(2) Ng (corrected) in percent.

(3) Nf (actual) in RPM.

(4) Nf (corrected) in RPM.

(5) Self check.

d. Variable geometry position (VG angle).

10. To read T5 ACTUAL, do the following:

a. Connect cable IHS-771991 to plug J201 on trim tester.

b. Connect cable IHS-771992 to cable IHS-771991.

c. Connect cable IHS-771992 to engine trim panel.

d. Place selector switch S201 in T5 ACTUAL position.

e. Read actual T5 on temperature display in degrees centigrade.

11. To read T5 Corrected, do the following:

a. Connect cables as described in steps 10 a, b, c.

b. Place selector switch S201 in T5 CORRECTED position.

c. Dial in ambient temperature (in fahrenheit).

d. Read corrected T5 on temperature display in degrees centigrade.

12. To read T5 COCKPIT, do the following:

a. Connect cable IHS-771991 to plug J201 on trim tester.

b. Connect cable IHS-771993 to cable IHS-771991.

c. Connect cable IHS-771993 between cockpit gage and T5 cable (E3).

d. Place selector switch S201 in T5 cockpit position.

Note

Aircraft operator cannot read cockpit gage if selector switch is not in T5 COCKPIT position.

e. Read T5 COCKPIT on temperature display in centigrade.

f. Place selector switch S201 in T5 ACTUAL position. Read actual T5. Compare T5 COCKPIT reading to T5 ACTUAL. Readings must compare within 8°C. Replace cockpit gage if difference exceeds 8°C.

13. To read pressure (ambient) proceed as follows:

a. Remove lower cap on trim tester.

b. Place selector valve to P AMB.

c. Place selector switch S202 to ABSOLUTE IN. HG position.

d. Read ambient pressure in inches Hg.

14. To read pressure (PT5) proceed as follows:

a. Connect pressure hose GB32F19-I-300 to engine trim panel and to PT5 fitting on trim tester.

b. Place selector valve to PT5 position.

c. Place selector switch S202 in ABSOLUTE IN HG. position.

d. Read interturbine total pressure (PT5) in inches Hg.

15. To read pressure ratio (PT5 divided by ambient), proceed as follows:

a. Connect pressure hose as in step 14.

b. Place selector valve in PT5 position.

c. Place selector switch S202 in PRESSURE RATIO position.

d. Dial in ambient pressure, recorded in step 13. on R202.

e. With engine running, read pressure ratio on pressure display.

16. To read engine speeds (Nf and Ng) proceed as follows:

a. Connect cable IHS-771994 to plug J202 on trim tester. Connect other end to engine trim panel.

b. To read actual speeds, place selector switch S203 in Ng % RPM position or Nf RPM position. Read actual speed on speed display.

c. To read corrected speeds, place selector switch S203 in Ng % RPM CORRECTED or Nf RPM CORRECTED position. Dial in ambient temperature in degrees fahrenheit on AMBIENT TEMP °F R203. Read corrected speeds on speed display.

17. To read variable geometry position, proceed as follows:

a. Connect cable IHS-771995 to plug J203 on trim tester. Connect other end to cable supplied with 21C5503.

b. With power lever closed, motor engine and adjust CDX201 until readout is 62.1 degrees.

c. Perform VG schedule checkout as described in paragraph 10-13.

18. To check trim tester indicators, depress IND TEST switch S204. Temperature display will read 1888, RPM display will read 18888, pressure display will read 188.8, and VG display will read 888.

10-5. PRESTART MOTORING (DRY).

CAUTION

- Never advance the throttle or otherwise allow fuel to enter the engine during motoring. If fuel is inadvertently allowed to flow into the engine, it must be purged by motoring the engine for at least 6 minutes with no fuel flow.
- Be sure ignition switch is in OFF position.
- Do not exceed starter operating limits.

1. Energize starter.

2. Check for:

a. Zero fuel flow.

b. Unusual rubbing or scraping noises.

c. Positive oil pressure indication within 30 seconds. Stop rollover if no pressure is indicated.

d. Ng speed - should be 5000 RPM minimum.

e. Nf speed - should be 300-700 RPM (for reference only).

f. Leaks.

3. De-energize starter.

4. If a fuel/oil system leak check (per paragraph 10-7) is to be done, do the following before starting the engine:

Note

Fan inner panels may be removed to look at the accessory gearbox area. Remove the 3 o'clock and 5 o'clock, 5 o'clock alone, or 5 o'clock and 7 o'clock panels. The engine can be run safely at idle with any one of these combinations of panels removed.

a. Make a solution of ground chalk and Methanol alcohol (1 to 1 ratio by volume). Put solution into a spray gun.

b. Clean suspect areas of the engine with Stoddard cleaning solution.

c. Dry the engine with filtered compressed air.

d. Spray the chalk and methanol alcohol solution around all fittings, flanges, hoses and tubes in the suspected area.

10-6. ENGINE STARTING.

CAUTION

- Do not try to start engine unless prestart inspection and motoring checks have been successfully completed.
- Before starting engine, motor engine on starter. Ng must be at least 28% and oil pressure gage must show a positive indication.
- If lightoff does not occur within 20 seconds after fuel flow begins to increase, close power lever, de-energize start and ignition switches.
- Shut down engine at first sign of fuel or oil leak or if there is no engine oil pressure.
- A false start is when fuel has been allowed to enter the combustion chamber but ignition was not activated.
- No bleed allowed and power extraction must be less than 17.5 lb ft.
- Purge engine between false starts; motor engine for 5 minutes (ignition OFF, power lever CLOSED).
- Immediately close power lever if ITT reaches 871°C (1600°F) before Ng reaches idle or ITT exceeds 835°C (1540°F) for 7 seconds.
- Do not operate above idle with engine cowl open.
- When restarting a hot engine, motor the engine until ITT is below 100°C.
- Read paragraph 10-4, step 3, before starting the engine.

1. A normal start is one in which the engine fires and accelerates, within time and temperature limits, to IDLE speed. See figure 10-2.

2. Place test stand ignition switch in ON position.

3. Energize starter and advance power lever to 16.5° as soon as you get an indicated Ng speed.

CAUTION

Carefully observe T5 and Ng for indication of a hangup or rollback. If either occurs, immediately pull power lever to 0°. Allow engine to coast to a complete stop. Motor engine on starter until cool.

4. Keep starter engaged until Ng is about 8500 RPM (normal starter cutout speed).

5. If a false start occurs or if for any reason fuel is allowed to enter the combustion chamber without ignition, purge the fuel by motoring the engine at 5000 RPM Ng in the following sequence until 6 minutes of motoring time is accumulated before attempting a start.

   a. 1 minute on starter.

   b. 1 1/2 minutes off starter.

   c. 1 minute on starter.

   d. 1 1/2 minutes off starter.

   e. 1 minute on starter.

   f. 15 minutes off starter.

6. Allow engine to stabilize for 2 minutes. Record the following at idle:

   a. Time from fuel flow indication to lightoff.

   b. Time to reach idle speed.

   c. Oil pressure at idle speed.

   d. Ng.

   e. Nf.

   f. Max T5 during start.

10-7. FUEL AND OIL SYSTEM LEAK CHECK.

Use this procedure when the source of a leak cannot be detected by a visual examination with the engine running at idle speed, and cowl doors open. See paragraph 10-5 for prestart procedures.

WARNING

Do not put head or hands in fan stream.

1. Run the engine at idle speed with the cowl doors open. Observe the path of the leak; it will turn the chalk solution gray at the source of the leak. Take necessary steps to correct the leak.

2. If, at idle speed, the leak source cannot be determined, shut engine down.

3. Reinstall fan inner panels, close cowl doors and run the engine at intermediate speed for 2 minutes. Shut engine down.

4. Open cowl doors and trace the gray area of the chalk and methanol alcohol solution, to its source. Take necessary steps to correct the leak.

5. Clean the chalk and methanol solution from the engine using Stoddard solution.

10-8. IDLE CHECK AND ADJUSTMENT.

1. Increase Ng speed approximately 4000 RPM above idle and return to idle.

2. Record Ng and T2 and check IDLE limits per figure 10-3. The point where the T2 line intersects the Ng line must be within the idle band.

3. If necessary, adjust IDLE speed as follows:

CAUTION

The idle adjustment and max Ng adjustment are very close together. The ground idle adjustment is marked MIN.

Note

One click of the IDLE trim alters speed setting 38 rpm. One full turn (36 clicks) alters speed setting 1370 rpm.

a. Determine from figure 10-3 whether the point of intersection of observed speed for existing T2 is above or below the band.

b. If the point is below the band, IDLE speed setting is too low; if the point is above the band, IDLE speed setting is too high. Proceed to step c.

c. Idle adjustment procedure. (See figure 10-3A.)

(1) If speed setting is too low, use a wrench and turn the idle trim clockwise the number of clicks required to set the speed within the limits shown in figure 10-3.

(2) If speed setting is too high, use a wrench and turn the trim counterclockwise until the speed is set at a point below minimum allowable setting, then turn the trim clockwise the number of clicks required to set the speed within the limits shown in figure 10-3.

(3) Check idle speed per step 1.

4. Record Ng, T5, T2, oil temperature, oil pressure and vibration readings.

10-9. CONTROL AMPLIFIER CHECK.

1. Check the operation of the control amplifier as follows:

a. Set power lever at idle speed position.

b. Set amplifier disable switch to DISABLE position.

CAUTION

Do not exceed T5 limit of 1532°F.

c. Slowly advance power until T5 reaches 1400°F. Allow T5 to stabilize for 2 minutes.

d. Set amplifier disable switch to NORMAL position. T5 should drop at least 25°F. If T5 does not drop off, check disable switch, amplifier and thermocouple segments.

e. Retard power lever to idle speed position.

10-10. ANTI-ICING CHECK.

1. Set Ng at 14,000 RPM and check the operation of the anti-icing valve as follows:

a. Turn on the anti-icing system. The fan rotor speed should decrease approximately 60 RPM.

b. Turn off the anti-icing system. The fan rotor speed should return to approximately the speed set in step 1.

c. If the anti-icing valve does not operate properly, shut the engine down and inspect the valve popout indicator for regulator failure.

10-11. ENGINE BREAK-IN RUN. Required only if turbine blades, turbine air seals, turbine shrouds, or compressor discharge seals have been replaced.

CAUTION

- Do not make any rapid changes in speed until the break-in run has been completed.
- Do not exceed engine operating limits.

1. With the engine stabilized at idle speed, check all instruments; be sure all readings are within limits of table 10-1. Accelerate and decelerate the engine for the break-in according to the schedule shown in table 10-5. Monitor variable vane schedule per figure 10-4 during the break-in run.

TABLE 10-5. BREAK-IN SCHEDULE

Step No.	Power Lever Setting	Hold Speed For:
	Note All power lever position changes must be completed in 4 to 6 seconds.	
1	Idle to 45° PLA	2 minutes
2	45° PLA to Idle	2 minutes
3	Idle to 55° PLA	2 minutes
4	55° PLA to Idle	5 minutes
5	Idle to 65° PLA	2 minutes
6	65° PLA to Idle	5 minutes
7	Idle to 75° PLA	5 minutes
8	75° PLA to Idle	5 minutes
	CAUTION Do not exceed T5 limit of 1532°F (833°C).	
9	Idle to 100° PLA	5 minutes
10	100° PLA to Idle	10 minutes

10-12. VIBRATION CHECKOUT.

Note

- This checkout may be made at the same time as other checkouts that are run at the same speeds.
- Vibration limits are given in table 10-1.

1. Set PLA to idle position (16.5°).

2. While monitoring vibration readings, slowly increase PLA to 100° and then decrease to idle speed.

3. If vibration limits in table 10-1 are exceeded, refer to table 11-1 under HIGH VIBRATIONS.

10-13. VARIABLE VANE SCHEDULE CHECKOUT.

Note

- This test shall be performed using transmitter assemble (21C5503) and trim tester (619AS100). See paragraph 10-4A.
- Always approach Ng points from a higher speed. When moving to a higher Ng point, go above the desired point, then move down to it.
- Do not check bands 2 and 3 of figure 10-4 when T2 is below 30°F.

1. Increase Ng until vane angle is within band 1 of figure 10-4.

2. Stabilize for 2 minutes; record Ng, T2, and vane angle

3. Find out whether vane angle is within limits as follows:

Note

See the example in figure 10-4 to understand how to determine whether vane angle is within limits.

a. Using figure 10-4, find point where T2 and Ng recorded in step 2 intersect.

b. Move directly to the right to intersect vane angle band. Vane angle recorded in step 2 must fall within shaded area of vane angle band.

Note

One full turn of the feedback cable adjustment nut, in the shortening direction, opens the 1st stage vanes 1.6°.

4. If the point falls outside the band, adjust feedback cable the number of turns required to bring vane angle within band 1 and check variable geometry system rigging.

5. Repeat steps 1, 2, and 3 to verify that bands 2, 3, and 4 of figure 10-4 are within limits.

6. Decel to idle. Replace the fuel control if this does not correct the problem.

10-14. PERFORMANCE CHECKOUT.

1. Turn off all equipment that reduces power (anti-icing).

CAUTION

- Do not allow T5 to exceed 833°C (1532°F).
- Check to see that idle speed does not exceed limits of figure 10-3.

Note

Use trim tester 619AS100 to check readings. See paragraph 10-4A.

2. Start engine, check idle speed, and accelerate up to max power. Allow 5 minutes for readings to stabilize; record T5, Nf, T2, Ng, and oil pressure on a log like the one shown. Repeat procedure at each of 4, T5 readings shown below. Return to IDLE.

SAMPLE LOG

Measure	Actual	Limit
T5 (at Max Power)		1532°F (833°C)
Nf (at Max Power)		7400 rpm Max (See figure 10-5)
Ng (at Max Power)		17, 700 rpm (99.4%)
Oil Pressure (at Max Power)		50-72 psi
Vane Angles (at Max Power)		See figure 10-4
Vibration (at Max Power)		See table 10-1
T2		-
Nf, Ng, Oil Pressure, Vane Angles, and Vibration at the following T5 settings:		
1405°F		
1350°F		
1295°F		
1205°F		

3. Using figure 10-5, check performance by drawing lines from the recorded Nf and T2. The point where the lines intersect should fall within the band (shaded area) of figure 10-5.

CAUTION

Do not attempt to adjust T5 if T2 is below 20°F. P3 limiter in fuel control will not allow T5 to increase. If adjustment is made, T5 will not increase until T2 is above 20°F, then an overtemperature may occur. See figure 10-5.

4. If the point of intersection is outside the band, proceed as follows:

a. Determine the difference between the recorded Nf and the Nf required to make the point of intersection fall in the middle of the band in figure 10-5.

b. Open cowling door that gives access to the trim panel.

Note

One click of T5 trim alters Nf speed 6 rpm. One full turn (6 clicks) alters Nf speed 36 rpm.

c. Use a 1/8-inch hex (Allen) wrench and turn T5 trim adjustment the number of clicks needed to change Nf the amount determined in step 4.a. (clockwise to increase T5, counterclockwise to decrease T5).

d. Close cowling.

6. Repeat steps 1 through 3 to check accuracy of adjustment. If the point of intersection still falls outside the band in figure 10-5, repeat step 4.

CAUTION

Do not allow Ng to exceed top line of band in figure 10-5.

7. If Nf fails to reach the band in figure 10-5 before a T5 of 1532°F (833°C) is reached, troubleshoot the engine for low power.

10-15. ARMAMENT FIRING CHECK.

1. Set power lever position so that T5 is 1395-1405°F (757-763°C). Record Ng.

2. Move the armament firing switch to the ENERGIZE position. The panel light should go on. Ng should decrease to approximately 14, 000 RPM and cycle slowly.

3. Move armament firing switch to the DE-ENERGIZE position. Ng and T5 should immediately return to approximately the same levels set in step 1.

10-15A. BODIE BURST STALL CHECK.

1. Run engine at IDLE speed and record stabilized Ng.

2. Advance power lever to INTERMEDIATE speed. Allow T5 to stabilize at 1400°F (760°C) ±5°F (2.7°C).

3. Chop power lever to IDLE position. When Ng reaches IDLE speed recorded in step 1., immediately burst to INTERMEDIATE speed (T5 at 1400°F as in step 2). Remain at INTERMEDIATE for at least 30 seconds.

4. If engine does not stall, repeat steps 1, 2, and 3, except do not allow engine to stay at intermediate longer than 30 seconds; as required by step 2.

5. If engine does stall, chop to IDLE. If engine is still in a stall condition at IDLE speed PLA, chop power lever to OFF.

CAUTION

Watch for indications of a post-shutdown fire (T5 above 1000°F). See paragraph 10-35.

10-16. ENGINE SHUTDOWN.

1. Place the power lever in the IDLE position.

2. Stabilize the speed at IDLE for 5 minutes to allow engine to cool. Check IDLE speed per figure 10-3. Readjust speed if necessary per paragraph 10-8.

3. Move power lever to 0° position.

Note

Clicking noise in alternator and AGB is caused by the magnetic field of alternator and resulting gear backlash. This noise is normal and acceptable.

4. During coastdown, listen for any unusual noises (scraping, rubbing) at low speed, especially during the final rotation.

5. Watch T5 for an indicator of post-shutdown fire.

6. Do not motor the engine after shutdown unless there is evidence of a post-shutdown fire.

7. After shutdown, check oil level within 10 minutes, and service oil tank, if necessary.

8. After engine cools (about 30 minutes), install engine inlet and exhaust covers.

10-17. EMERGENCY SHUTDOWN.

CAUTION

If possible, retard the power lever to idle and hold it there for 30 seconds to allow the engine to cool before shutting down.

1. Push the emergency stop button and simultaneously pull the power lever to the OFF position.

2. Allow the engine to cool for 20 minutes.

3. If the shutdown was made from a power setting above Idle, but the engine is considered operable, proceed as follows:

a. Motor the engine on the starter at maximum speed for 30 seconds (normal rotor speeds during motoring are 5000-6000 rpm Ng and 300-700 rpm Nf). Allow the engine to coast down. If the engine does not motor normally, wait 5 minutes and try to motor the engine.

b. After the engine motors normally, start the engine immediately after coastdown. Stabilize at ground idle speed for 10 minutes.

CAUTION

Do not accelerate to higher speeds for at least 10 minutes if low-pressure turbine rotor has seized.

c. If the low-pressure turbine rotor was seized, operate the engine at ground idle speed for at least 10 minutes after the low-pressure rotor starts turning.

10-18. OPERATION UNDER UNUSUAL CONDITION.

10-19. COLD WEATHER STARTING.

Engine starts made with low ambient temperatures will result in maximum gage oil pressure (100 psig). The time required for oil pressure to return to normal, depends on power lever settings; high power settings will bring oil pressure down in the least amount of time and lower power settings will take longer time periods to bring oil pressure down to normal. There are no restrictions on high power settings following low temperature starts. If pressure does not return to normal after 2.5 minutes maximum, refer to troubleshooting.

10-20. COLD WEATHER PROCEDURES.

10-21. BEFORE STARTING.

1. Use ground heater units to remove any ice from fan inlet.

2. Inspect drain strut to ensure normal drainage.

3. Repair fuel and oil leaks in a warm area whenever possible to ensure proper sealing of packings and tubing connectors.

10-22. GROUND OPERATION UNDER ICING CONDITIONS.

1. Turn engine anti-icing system to ON when ambient temperature is -40°F (-40°C) to 40°F (4°C) and the dew point is within 5°F (2.5°C) of ambient air temperature.

2. Use normal starting procedures.

3. Make throttle movements cautiously.

10-23. SPECIAL GROUND OPERATION UNDER ICING CONDITIONS WHEN DEW POINT IS KNOWN.

Note

Under these conditions, icing can occur without warning.

1. When operating with an inlet screen or when the anti-icing system is inoperative, avoid operations between -14°F (-26°C) to 40°F (4°C) if dew point is within 7°F (4°C) of ambient air temperature.

2. If a sudden unexplainable rise in T5 occurs, shut the engine down immediately.

10-24. GROUND OPERATION UNDER ICING CONDITIONS WHEN DEW POINT IS UNKNOWN.

1. Ground operation.

a. Turn anti-icing system ON when ambient air temperature is between -40°F (-40°C) and 40°F (4°C), and there is visible moisture in the air.

2. Ground operation when anti-icing system is inoperative.

a. Do not operate the engine when ambient air temperature is between -14°F (-26°C) and 40°F (4°C) and there is visible moisture in the air.

10-25. AFTER ENGINE SHUTDOWN.

1. Do not install engine inlet and exhaust covers until after engine has cooled.

2. If the engine is stored outdoors, make sure engine inlet and exhaust covers are installed to protect against rain, sleet, snow, or foreign matter.

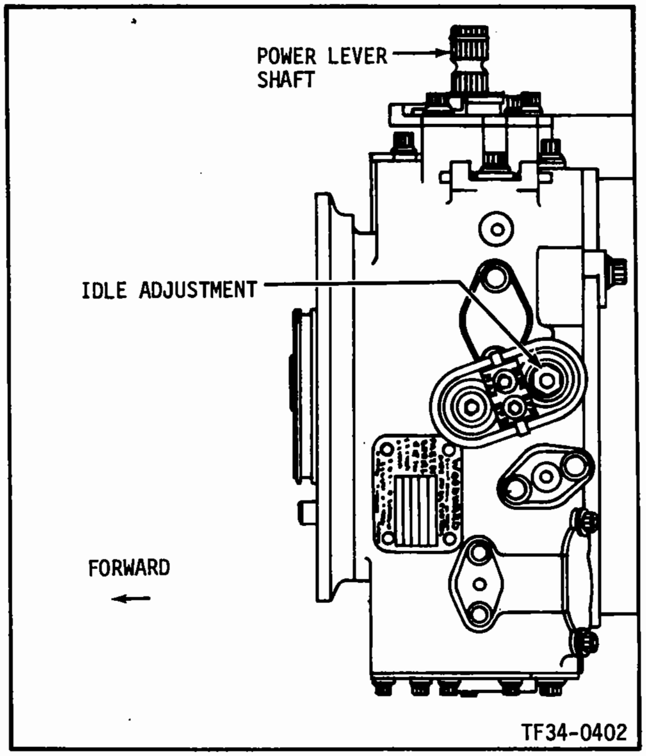


Figure 10-3A. Idle Speed Adjustment Socket

10-26. HOT WEATHER AND DESERT OPERATING PROCEDURES.

10-27. BEFORE STARTING.

1. Make sure the fan inlet is free of sand, heavy dust accumulation and other foreign matter.

2. Check all filters more frequently than during normal operation.

10-28. GROUND OPERATION.

1. Use normal starting procedures.

Note

During hot weather, oil temperature will probably be on the high side of the operating range.

10-29. AFTER ENGINE SHUTDOWN.

1. Install engine inlet and exhaust covers.

10-30. ABNORMAL CONDITIONS DURING OPERATION.

10-31. GENERAL.

If an abnormal engine condition occurs, such as compressor stall, flameout, or overtemperature, shut the engine down immediately. Record and report to maintenance personnel the duration and degree of any overtemperature or overspeed condition. Refer to table 10-1 for limits.

10-32. COLD HANGUP.

1. During a start attempt, the engine may fail to accelerate to proper IDLE speed. This is generally accompanied by a low T5. An attempt to accelerate the engine with the throttle will have no effect.

10-33. HOT START.

1. If during a start T5 increases abnormally, record highest T5 and shut the engine down immediately. Refer to table 10-1 to determine if operating limits have been exceeded.

2. Refer to Troubleshooting, under HOT STARTS, to determine cause.

10-34. COMPRESSOR STALL.

1. A compressor stall is caused by an aerodynamic disturbance of the smooth airflow pattern through the compressor. A rapid rise in T5 and usually a speed hangup (although some are accompanied by a rapid drop in speed) are indications of a stall. A change in the engine noise level may also be noted.

2. If a stall occurs, proceed as follows:

a. Shut the engine down immediately.

b. Listen for unusual noises and indications of mechanical failure during coastdown.

CAUTION

Do not engage the starter after a stall until unusual noises and mechanical failures (if they occur) have been investigated and corrected.

c. Refer to Troubleshooting, under COMPRESSOR STALLS.

10-35. POSTSHUTDOWN FIRE.

1. If a postshutdown fire occurs, as indicated by a constant T5 of 1000°F (538°C) or higher, proceed as follows:

a. Set all controls and switches in the shutdown position.

b. When high-pressure turbine stops, engage the starter (without ignition) and motor the engine until the fire is extinguished.

CAUTION

Use fire extinguisher as a last resort. Introduction of CO_2 into a hot engine can cause severe damage.

2. If all other means fail, apply a CO_2 fire extinguisher to the engine inlet.

10-36. ABNORMAL VIBRATIONS.

High vibrations can be caused by rotor unbalance, loose engine mounts or other external connections. If the cause cannot be determined, an internal inspection of the engine may be necessary.

10-37. ABNORMAL VIBRATIONS DURING A RESTART.

1. If during a normal restart (following engine operation of at least 5 minutes of running) engine vibrations exceed limits of table 10-1, proceed as follows:

CAUTION

Do not exceed transient vibration limits of table 10-1.

a. Set power lever to idle position (15-18° PLA).

b. Use a frequency meter and determine if the vibration levels indicated are the result of a response from another rotor operating at a higher frequency rate (example: a high fan indication could be the result of a response from the high-pressure turbine rotor).

c. If vibration readings are within the limits of table 10-1, continue to operate the engine.

d. If vibration limits are exceeded, refer to Troubleshooting, under HIGH VIBRATIONS.

10-38. ABNORMAL OIL PRESSURE.

Do not operate the engine if the stabilized oil pressure is outside the limits specified in table 10-1. If limits are exceeded, refer to Troubleshooting, under LUBRICATION SYSTEM PROBLEMS.

10-39. FLAMEOUT.

1. An engine that flames out will immediately show a decrease in T5, speed, and fuel flow. Automatic ignition should occur when a T5 differential of 830°F between actual T5 and requested T5 or when Ng drops below 8500 rpm. If Ng drops below 7120 rpm, and re-ignition has not occurred, shut the engine down and refer to Troubleshooting.

2. Refer to Troubleshooting, under FLAMEOUT, to determine cause of initial flameout.

10-40. ABNORMAL FUEL FLOW READINGS.

If flow is abnormal for the existing operating conditions (refer to table 10-1), investigate the fuel system for clogged filters or fuel lines, or faulty fuel system components.

10-41. OVERSPEED.

If high pressure turbine speed (Ng) exceeds the limits shown in table 10-1, take corrective action as indicated.

CAUTION

Do not operate engine until cause of overspeed has been determined and corrective action taken.

10-42. OVERTEMPERATURE.

1. If after starting, the limits given in table 10-1 for turbine inlet temperature are exceeded, refer to step 2. to determine if an overtemperature inspection is required.

CAUTION

Do not operate engine until cause of overtemperature has been determined. An overtemperature inspection may be necessary.

2. Overtemperature inspection is required if during starting:

a. T5 rises rapidly above 1700°F (930°C) immediately after lightoff.

b. After the engine reached an Ng speed of 8900 RPM, T5 exceeds the limits of table 10-1.

10-43. OVERTEMPERATURE INSPECTION PROCEDURE.

If overtemperature inspection is required, remove 3 consecutive blades from stages 1 and 3 turbine wheels as instructed in paragraph 5-137. Record the weight of each blade for future use in the event that the engine is found not to be overtemperatured. Return these blades (along with any static parts which exhibit overtemperature) to General Electric Co., West Lynn, Mass., 01910, Attention - Building 66C - Repairable Cage.

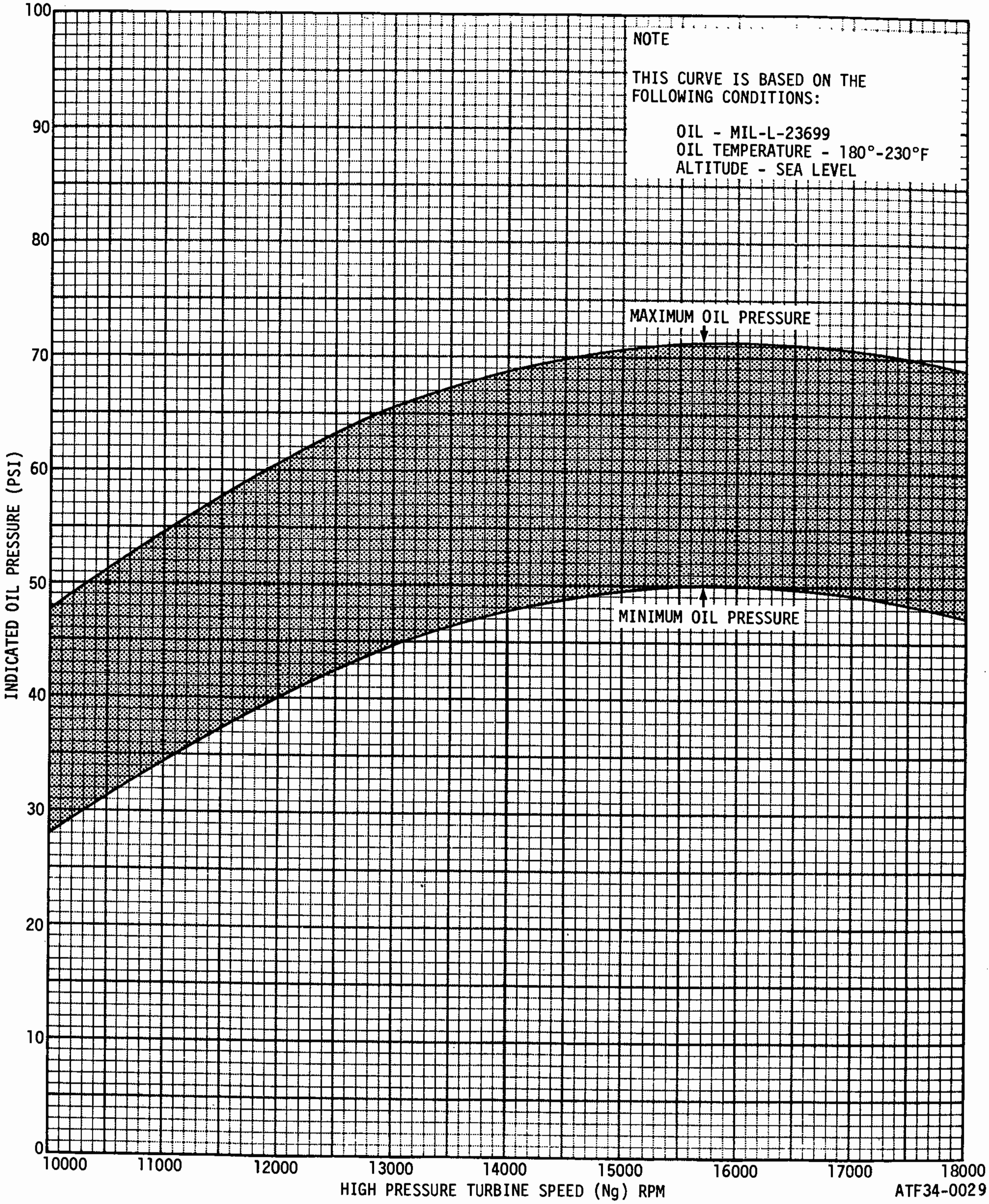


Figure 10-1. Oil Pressure Versus Ng Speed

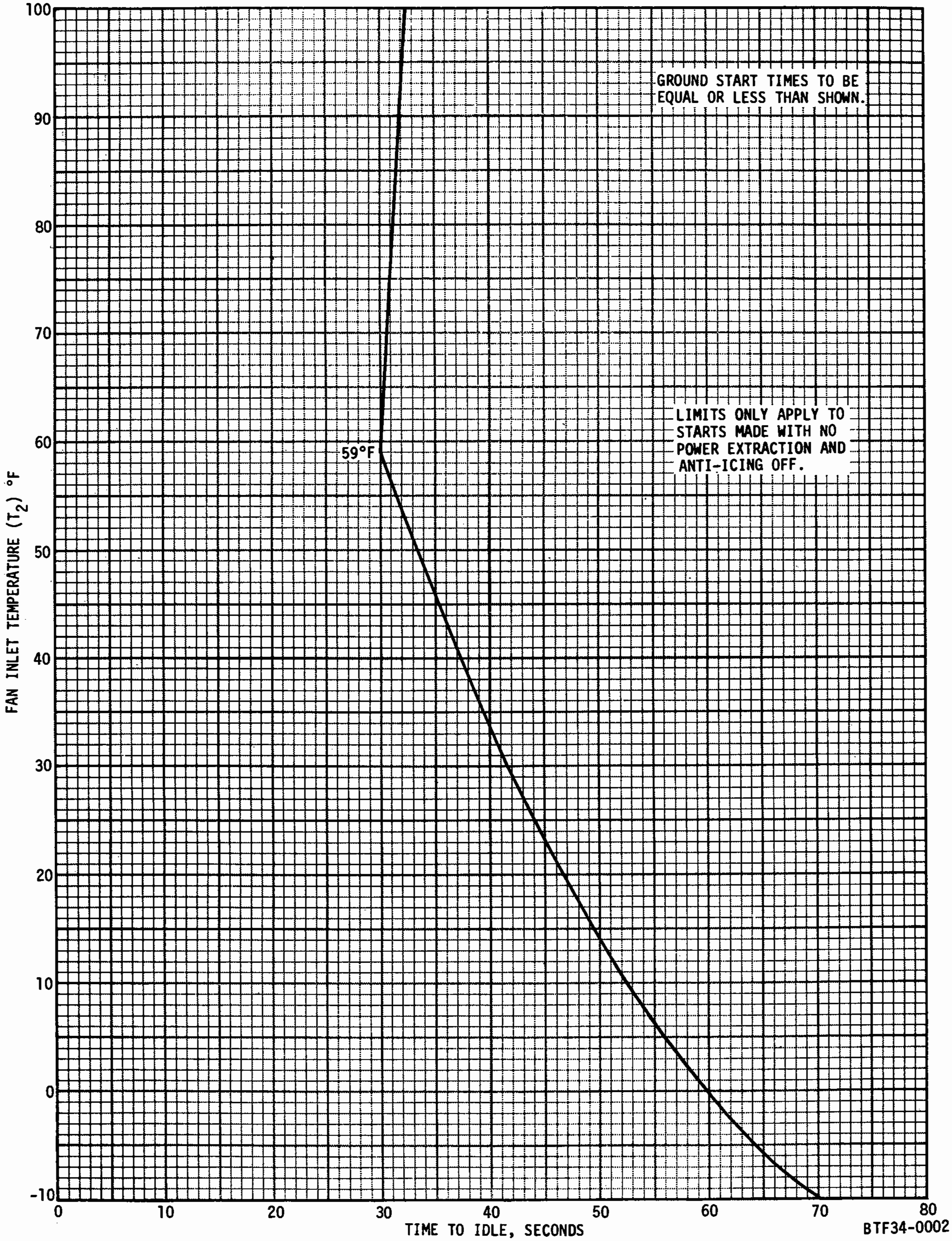


Figure 10-2. Time to Idle Speed Limits

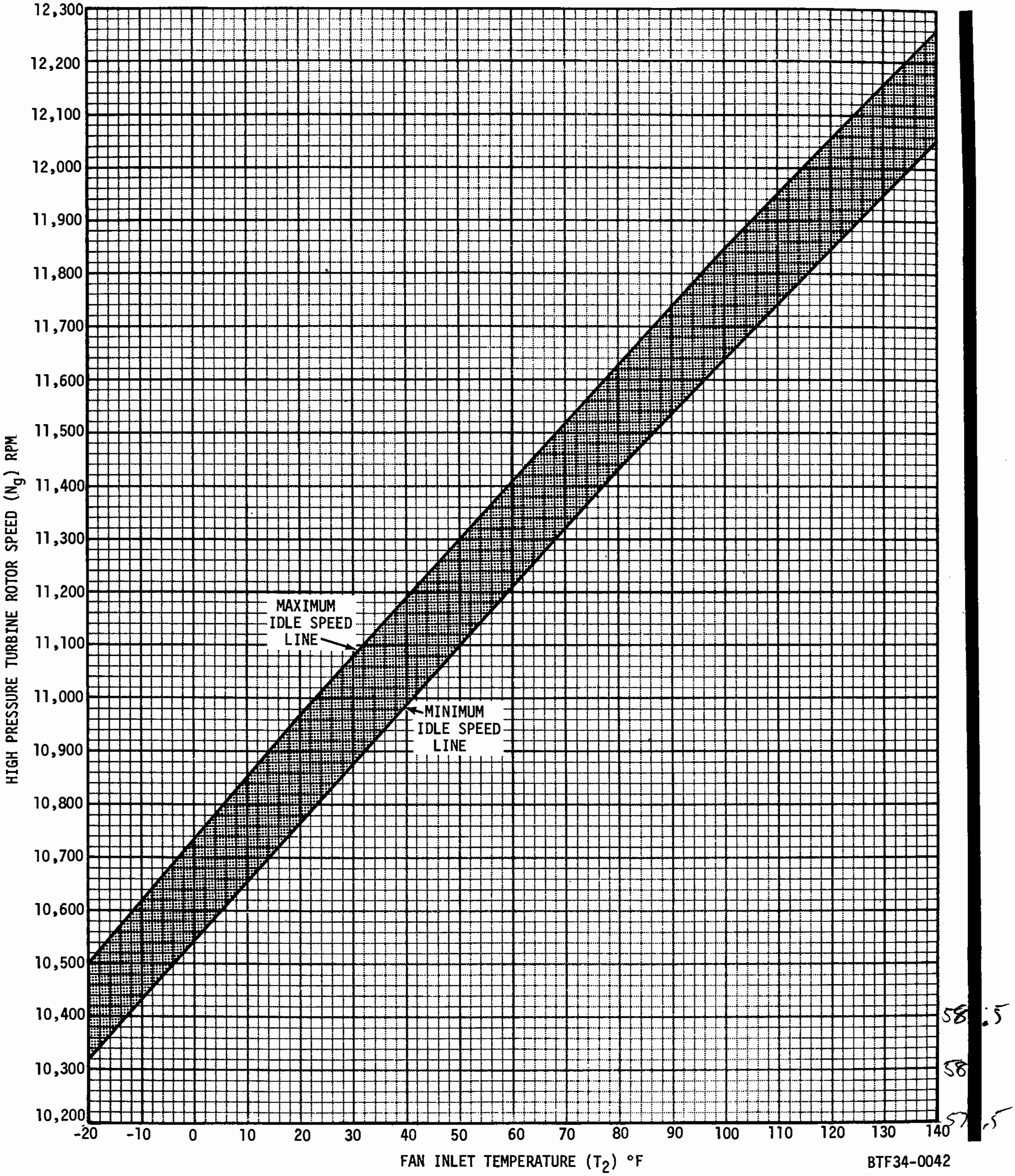


Figure 10-3. Idle Speed Limits

EXTRACTION	FAN SPEED DECREASE (RPM) SEA LEVEL	5000 FT
50 HORSEPOWER	17	20
0.2 PPS AIR BLEED FROM COMPRESSOR 10TH STAGE	17	20

NOTE:

1. THIS SPEED BAND REPRESENTS SEA LEVEL OPERATION. IT IS RAISED VERTICALLY 150 RPM PER 1000 FEET PRESSURE ALTITUDE.
2. THIS SPEED BAND APPLIES TO AN ENGINE RUNNING WITH NO COMPRESSOR BLEED OR POWER EXTRACTION. TO ACCOUNT FOR EXTRACTIONS, REDUCE SPEEDS BY THE RATES IN EXTRACTION TABLE ABOVE.
3. IF POINT PLOTS ABOVE THIS LINE, TROUBLESHOOT. INDICATES FUEL CONTROL MALFUNCTION.
4. CURVE ASSUMES 0.98 INLET RECOVERY FACTOR FOR S-3A AIRCRAFT. RAISE CURVE 35 RPM WHEN USING INLET 21C5507.

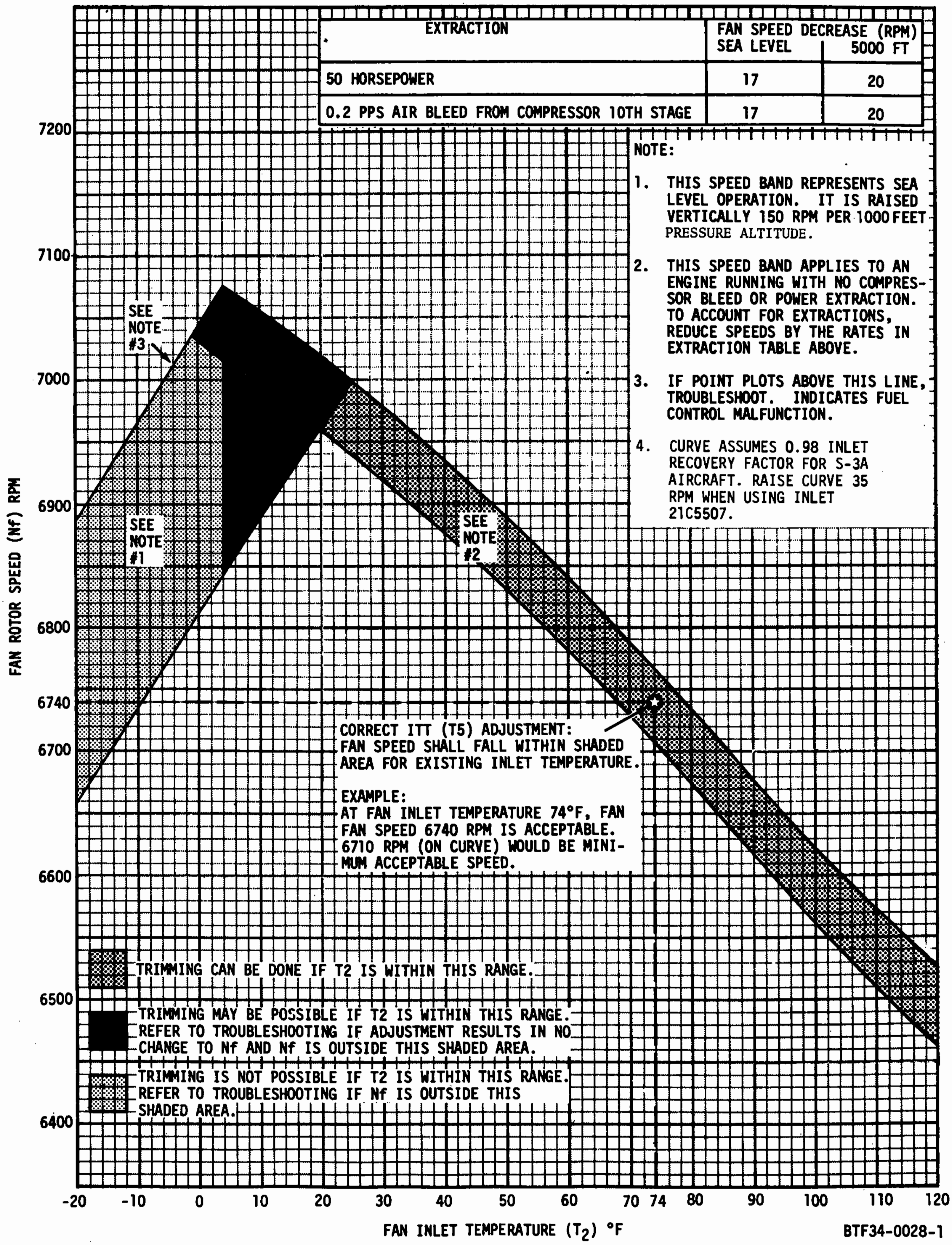


Figure 10-5. Engine Performance Curve

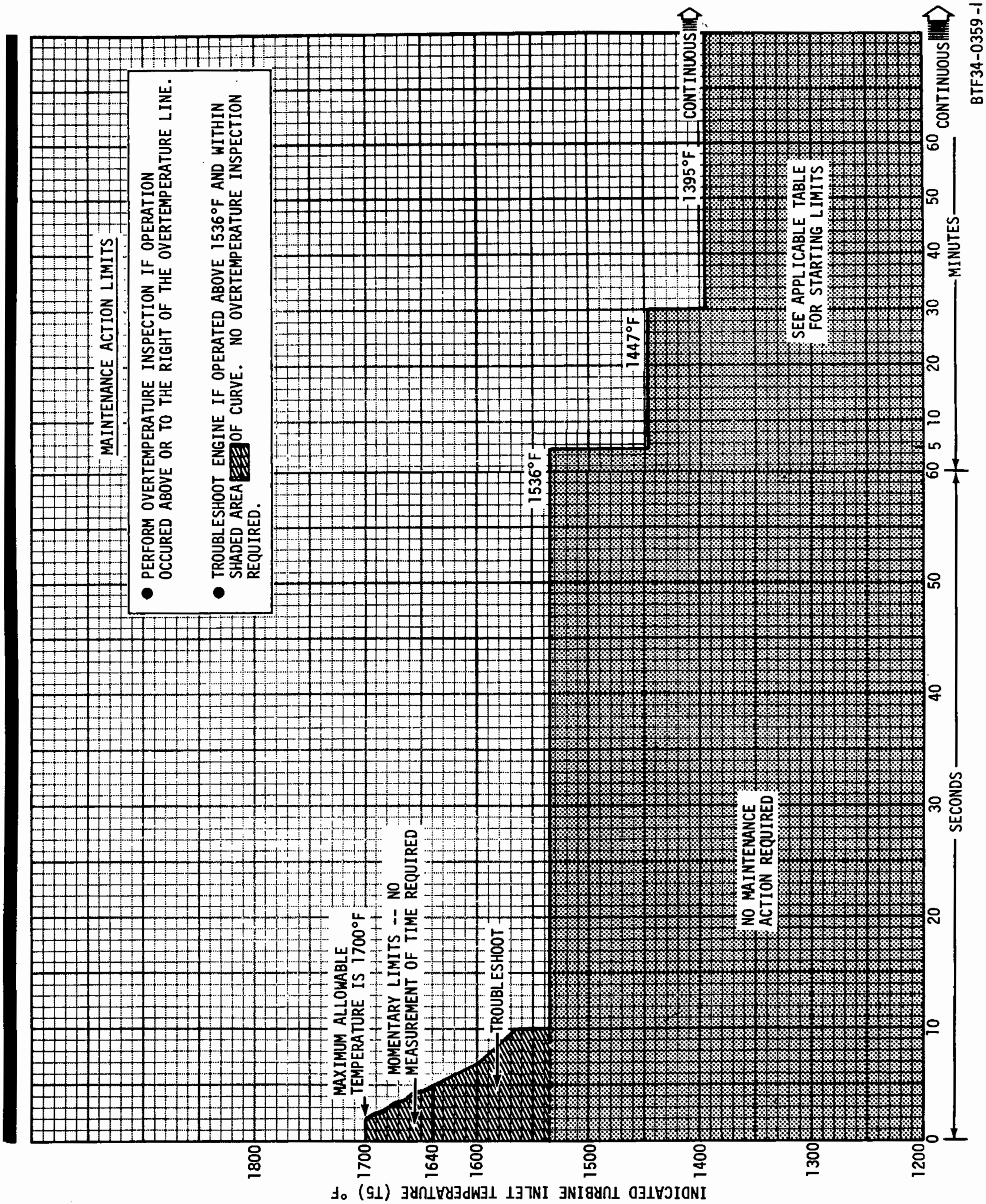


Figure 10-6. Overtemperature Limits

SECTION XI
TROUBLESHOOTING

11-1. GENERAL.

1. This troublshooting guide consists of three types of information:

a. Troubleshooting procedures with symptom, probable cause, troubleshooting, and corrective action, for each type of problem.

b. General engine operating limits with item, limits and remarks.

c. General accessory information with leading particulars which will aid general engine troubleshooting.

2. The following symbols are used throughout the troubleshooting guide:

Ng	-	High pressure turbine rotor speed.
Nf	-	Low pressure turbine rotor speed.
PLA	-	Power lever angle.
PTO	-	Power takeoff assembly.
T5(T5.4)	-	Fan turbine inlet temperature (Interturbine Temperature)
T2	-	Engine inlet temperature.
T2c	-	Compressor inlet temperature.
P3	-	Compressor discharge pressure.
Wf	-	Fuel flow in phr.

11-2. TROUBLESHOOTING INSTRUCTIONS.

1. If the engine does not operate properly, refer to table 11-1 and locate the category which applies to the phase of operation during which the trouble occurred (for example, NO START with Ng indication), or if the engine is operating outside its limits, refer to the appropriate category (for example, LUBRICATION SYSTEM PROBLEMS).

2. Follow the sequence of checks outlined in the referenced paragraph.

3. If the checks indicate that a component is defective, replace the component. Test the engine based on which component has been replaced.

11-3. ENGINE CLEANING FOR PERFORMANCE RECOVERY (USING B AND B 3100).

1. Perform the following operation when:

a. Engine performance has deteriorated.

b. Visual inspection of engine inlet shows that fan blades or fan vanes have a buildup of carbon, salt, dirt, or oil-based deposits.

2. If the engine is being operated in the test stand, disconnect engine bellmouth and roll it forward.

3. Scrub dirt off fan blades and exposed areas of fan vanes with B and B 3100 (4 parts water to 1 part B and B 3100) and a soft bristle brush.

CAUTION

Engine must be allowed to cool for 45 minutes minimum before spraying water into engine. T5 should be 320°F (160°C) or below before spraying water into engine. Anti-icing must be OFF.

4. Thoroughly rinse blades and vanes with fresh water.

5. If engine is being operated in the test stand, roll engine bellmouth aft and secure it.

WARNING

Methanol
Fed Spec O-M-232

- Flammable - do not use near welding areas, near open flames, or on very hot surfaces.
- Vapors are harmful. Avoid prolonged or repeated breathing of vapors. Do not use when ambient temperature is above 40°F unless adequate ventilation is provided according to local statuatory codes and regulations.
- May be fatal or cause blindness if swallowed. Cannot be made nonpoisonous.
- Keep container closed.
- Store in approved metal safety containers.

Note

At ambient temperatures between 40°F (4°C) and -15°F (-25°C), add Methanol (Specification M-232, Grade A or B) to the water at a ratio of 4 parts Methanol to 6 parts water. Do not clean the engine if ambient temperature is below -15°F(-25°C).

6. Mix 4 parts water or 4 parts water/methanol solution described above to 1 part B and B 3100 and add it to corrosion control cart 65A102J1.

7. Connect the hose from corrosion control cart 65A102J1 to the wash manifold fitting located at 6 o'clock position on fan outer cowl using adapter (21C5183).

8. Set the air pressure for the B and B 3100 to 80 PSIG. This pressure setting results in 60 PSIG at the engine fitting.

9. Motor the engine for 1 minute at 5000 RPM Ng while spraying B and B 3100 solution into the engine.

10. Stop motoring and spraying for 90 seconds.

11. Motor the engine for 1 minute at 5000 RPM Ng while spraying B and B 3100 solution into the engine.

12. Stop motoring and spraying. Allow starter to rest for 15 minutes.

13. Disconnect corrosion control hose from adapter (21C5183). Connect water hose to adapter (21C5183).

14. Motor the engine for 1 minute at 5000 RPM Ng while spraying water or water/methanol into the engine.

15. Stop motoring and spraying for 90 seconds. Shutoff water supply.

16. Air dry the compressor by motoring the engine at 5000 RPM Ng for 1 minute.

17. Stop motoring for 90 seconds.

18. Air dry the compressor by motoring the engine at 5000 RPM Ng for 1 minute.

19. Stop motoring and rest starter for 15 minutes.

20. Motor the engine for 1 minute at 5000 RPM Ng while spraying water or water/methanol into the engine.

21. Stop spraying and stop motoring for 90 seconds.

22. Air dry the compressor by motoring at 5000 RPM Ng for 1 minute.

23. Stop motoring for 90 seconds.

24. Air dry the compressor by motoring at 5000 RPM Ng for 1 minute.

25. Stop motoring and rest starter for 15 minutes.

26. Motor the engine for 1 minute at 5000 RPM Ng while spraying water or water/methanol into the engine.

27. Stop spraying and stop motoring for 90 seconds.

28. Air dry the compressor by motoring at 5000 RPM Ng for 1 minute.

29. Stop motoring for 90 seconds.

30. Disconnect water supply hose and adapter (21C5183) from engine.

CAUTION

Be sure cowl doors are closed.

31. Start engine and run at 14,200 RPM Ng for 5 minutes with anti-icing ON.

32. Shut engine down.

TABLE 11-1. TROUBLESHOOTING

Symptom	Paragraph No.
NO START (NO Ng INDICATION). A. No core engine rotation (with oil pressure indication). B. No core engine rotation (without oil pressure indication).	11-4
NO START (WITH Ng INDICATION). A. No lightoff (RPM and fuel flow OK). B. No lightoff (RPM and ignition system OK with no or low fuel flow).	11-5
HOT START (STARTING STALL). Engine stalls during start. Slow increase in T5 plug Ng speed hangup or drop off.	11-6
DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE. (COLD HANGUP) Engine does not reach idle speed or acceleration time exceeds limits.	11-7
IDLE SPEED PROBLEMS. A. No Ng indication. B. Idle speed low. C. Idle speed high. D. Idle instability. E. Fan rotating with no speed indication. F. No fan rotation.	11-8
ABNORMAL ACCELERATION TO TAKEOFF POWER. A. No acceleration. B. Slow acceleration with low T5. C. Slow acceleration with high T5. D. Stall. E. Speed hangup and slow oscillation at 14,000 to 14,200 RPM Ng. F. Ng RPM overshoot.	11-9

TABLE 11-1. TROUBLESHOOTING (Cont)

Symptom	Paragraph No.
LOW POWER AT MAX POWER SETTING.	11-10
A. Low fan speed (Nf) with T5 OK.	
B. Low engine speed with T5 below maximum.	
C. Speed fluctuation with power lever held in one position.	
D. Higher or lower T5 than previous reading at same PLA.	
E. T5 fluctuation.	
F. Steady state stall.	
FLAMEOUT	11-10A
Steady decrease in T5 and Ng.	
LUBRICATION SYSTEM PROBLEMS.	11-11
A. No oil pressure.	
B. Low oil pressure.	
C. High oil pressure.	
D. Fluctuating oil pressure (greater than 5 psi).	
E. Low oil temperature.	
F. High oil temperature (oil appears as though it has been overheated).	
G. Fluctuating oil temperature.	
H. Engine chip detector indication (continuity).	
I. High oil consumption.	
HIGH VIBRATIONS.	11-12
A. Core engine vibration.	
B. Fan rotor vibration.	
CRACKED BRACKETS, ENGINE CASINGS, OR BROKEN TUBING.	11-13
A. Cracked brackets.	
B. Broken tubing.	
C. Cracked casings.	
POST SHUTDOWN FIRE.	11-14
After shutdown, T5 indicates 540°C (1000°F) or higher.	
ANTI-ICING VALVE PROBLEMS.	11-14A
A. Valve pop-out button extended.	
B. Valve open, pressure light off.	
C. Valve closed, pressure light on.	
MAGNETIC CHIP DETECTOR INSPECTION AND DEBRIS ANALYSIS.	11-15
OIL FILTER INSPECTION AND DEBRIS ANALYSIS.	11-16
OIL ANALYSIS.	11-17
INSPECTING ENGINE PARTS WITH BORESCOPE.	11-18

11-4. NO START (NO Ng INDICATION).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No core engine rotation indication (with oil pressure indication).	Ng indication system failure.	Check tach generator indicator and leads.	Replace tach generator indicator or leads.
B. No core engine rotation indication (without oil pressure indication).	1. Starter air pressure below limits.	Check starter air pressure. It must be 35 psi minimum at this starter and engine must rotate 5000 to 6000 rpm.	Increase air pressure to proper limit.
	2. Faulty starter air shutoff valve.	a. Check start valve position with start switch in ON position.	a. Replace valve if it is stuck closed or does not fully open.
		b. Check starter air valve solenoid voltage. Voltage must be 18-30 volts dc.	b. Repair power supply.
		c. Check connector and lead to starter air valve solenoid.	c. Tighten connector or replace lead if faulty.
	3. Faulty start switch or open circuit breakers.	Check starter switch and circuit breakers.	Replace switch and reset circuit breakers.
	4. Starter inoperative.	Depress start switch to determine if starter is rotating.	Replace starter if it does not rotate or it cuts out early.
	5. Core engine seized.	a. Allow a hot engine to cool for 30 minutes, and check engine rotation with starter or with wrench on gearbox.	a. Attempt another start after cooling period and rotation check.
		b. Check cold engine rotation with wrench on gearbox pad.	b. Replace engine if wrench cannot rotate engine. Replace radial drive shaft or gearbox if wrench turns but engine does not rotate.
		c. Borescope engine at compressor inlet and tenth stage port for FOD.	c. Remove engine for repair if FOD is noted.
	6. Starter shaft sheared.	Remove starter and inspect for damage.	Replace starter.
	7. Accessory gearbox failure.	Remove gearbox per paragraph 5-17 and inspect for damage.	Replace gearbox and flush lube system to remove contaminants.

11-5. NO START (WITH Ng INDICATION).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No lightoff (rpm and fuel flow OK).	1. Fuel distributor drain valve stuck open.	Check for excessive draining during start attempt. **WARNING** Avoid contact with electrical output when operating any ignition component. Be sure the ignition unit and plugs are grounded before energizing the circuit. Never hold or contact the igniter plug when energizing the ignition circuit. **CAUTION** Turn ignition system off, place power lever in OFF position, and motor the engine at least 5 minutes to purge the engine of fuel.	Replace fuel distributor. See paragraph 4-98.
	2. Faulty electrical system.	a. Check all electrical connectors for looseness.	1. Tighten connectors. 2. Check yellow electrical harness, blue electrical harness, and test cell electrical harness for resistance and continuity. Replace fuel control, alternator, or control amplifier. 3. Check: a. Igniter leads and adapters for continuity. b. Igniter plugs for cracked insulator and heavy carbon buildup. c. If item a and b are ok, replace ignition exciter (see paragraph 4-27.)
B. No lightoff (rpm and ignition system OK with no or low fuel flow).	1. No fuel in tanks.	Check tanks for fuel quantity.	Refill tanks.
	2. Fuel inlet shutoff	Check switch position and panel light.	Open fuel inlet shutoff valve.

11-5. NO START (WITH Ng INDICATION) (Cont).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
B. No lightoff (RPM and ignition system OK with no or low fuel flow). (cont)	3. No fuel boost pump pressure.	Check fuel boost pump and boost pressure system.	Replace faulty component.
	4. Air in fuel supply lines.	Disconnect fuel supply lines, and check for presence of air.	Bleed air from fuel supply lines.
	5. Fuel control stopcock closed or pump unloading valve open.	Check PLA at fuel control. PLA must be 15-18° with throttle positioned at IDLE.	Re-rig fuel control per paragraph 10-3.
	6. Fuel pump-to-fuel control drive shaft sheared.	Remove fuel control and inspect drive shaft for damage.	Replace fuel control per paragraph 4-86 or replace drive shaft only.
	7. Fuel pump drive shaft sheared.	Remove fuel pump and inspect drive shaft for damage.	Replace fuel pump per paragraph 4-89.
	8. Sheared radial drive shaft or PTO shaft.	Engergize starter; Ng increases rapidly to cut out speed (8,000 to 8,500 RPM Ng).	Replace radial drive shaft or PTO.

11-6. HOT START (STARTING STALL).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
Engine stalls during start. Slow inerease in T5 plus Ng speed hangup or dropoff.	1. Starter air pressure below limits.	Check starter air pressure. It should be 35 PSI at the starter and engine rotates at 5,000 to 6,000 RPM Ng.	Increase air pressure to proper limit.
	2. Engine not properly purged of fuel from previous start attempt.	Move PLA to shutdown position. Motor engine on starter for 5 minutes to purge fuel.	Attempt another start. Observe correct starting procedures.
	3. High fuel flow.	a. Disconnect fuel hose at fuel distributor. b. Check fuel flow for positive indication at maximum motoring speed.	Replace fuel control per paragraph 4-86.

11-6. HOT START (STARTING STALL) (Cont).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
Engine stalls during start. Slow increase in T5 plus Ng speed hangup or dropoff. (cont)	4. Variable vane position.	Check variable vane position during motoring; should be 62-64°.	a. Re-rig feedback cable per paragraph 4-133. b. Adjust vane angles per paragraph 4-132.
	5. Compressor discharge pressure system leak or blockage.	Check for loose, damaged, or blocked lines.	Remove blockage; tighten or replace lines.
	6. Compressor inlet temperature sensor shift.	Check variable vane angles against RPM and compressor inlet temperature.	Replace faulty T2c sensor per paragraph 4-106.
	7. Foreign object damage.	Inspect engine with borescope.	Replace engine if FOD is out of limits.
	8. Low starter torque or starter cutout speed too low.	Check starter output and Ng RPM at which starter cuts out. It should cut out between 8,000 to 8,500 RPM Ng.	Replace faulty starter.
	9. Delayed ignition.	Check ignition system per "NO START" (Ng INDICATION), symptom A.	Replace faulty component.

11-7. DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE (COLD HANGUP).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
	1. Starter air pressure below limits.	Check starter air pressure. It should be 35 PSI (results in 5000-6000 RPM).	Increase pressure to proper limit.
	2. Starter cutout speed too low.	Check speed at which starter cuts out. It should cut out between 8000 and 8500 RPM.	Replace faulty starter.
	3. Faulty starter air shutoff valve.	a. Check start valve position with start switch in ON position. b. Check starter air valve solenoid voltage. Voltage must be 18-30 volts dc. c. Check connector and lead to starter air valve solenoid.	a. Replace valve if it is stuck closed or does not open fully. b. Repair power supply. c. Repair as necessary.

11-7. DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE. (Cont) (COLD HANGUP)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
	4. Leaking drain valve in fuel distributor.	Check fuel distributor for excessive overboard draining.	Replace fuel distributor per paragraph 4-98.
	5. Excessive bleed or AGB power extraction.	Check bleed and power extraction equipment controls.	Turn off unnecessary bleed and power extraction equipment.
	6. Anti-icing system operating.	a. Check switch. It must be in OFF position.	a. Move switch to OFF position.
		b. Check anti-ice valve position.	b. Replace faulty valve per paragraph 4-7.
	7. Compressor discharge pressure system is leaking or blocked.	Check for loose, damaged, or blocked lines.	Remove blockage; tighten or replace lines.
	8. Variable vane position.	Check variable vane position during motoring; should be 62-64°.	Re-rig feedback cable per paragraph 4-133.
	9. Fuel contamination.	a. Check for impending filter bypass indication.	Drain and refull fuel system. Clean or replace all fuel filters.
		b. Check fuel system sample.	Drain and refill fuel system. Clean or replace all fuel filters.
	10. Incorrect power lever rigging.	Check power lever rigging.	Correct power lever rigging per paragraph 10-3.
	11. Compressor/low pressure turbine rotor rubbing excessively or foreign object damage.	Inspect engine with borescope.	Replace engine.
	12. Defective fuel control (output low).	Check fuel flow indicator for proper phr.	Replace fuel control per paragraph 4-86.

11-7. DOES NOT REACH IDLE OR SLOW ACCELERATION TO IDLE. (Cont) (COLD HANGUP)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
	13. Defective fuel pump.	Check fuel flow indication for proper phr.	Replace fuel pump per paragraph 4-89.
	14. Compressor inlet temperature sensor.	Check Idle speed per figure 10-3. Adjust speed if possible.	Replace sensor per paragraph 4-106 if Idle speed is below 9800 RPM and cannot be adjusted.
	15. Incomplete fuel burning.	a. Check for fuel leakage at turbine flange and exhaust nozzle exit.	a. Inspect engine with borescope. Replace fuel control per paragraph 4-86 if engine OK.
		b. Check for proper fuel.	b. Drain and refill fuel system with proper fuel.

11-8. IDLE SPEED PROBLEMS.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No Ng indication.	1. Tach generator.	Check oil pressure for positive indication.	Replace faulty tach generator.
	2. Lube pump shaft sheared.	Check oil pressure for positive indication.	Immediately shut engine down and replace lube pump per paragraph 4-61.

11-8. IDLE SPEED PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
B. Idle speed low.	1. Power lever rigging.	Check power lever rigging at fuel control.	Rerig power lever per paragraph 10-3.
	2. Fuel control idle adjustment.	Check engine idle RPM per figure 10-3.	Adjust idle speed setting on fuel control per paragraph 10-8.
	3. Compressor discharge pressure system leaking or blocked.	Check for loose, damaged, or blocked lines.	Remove blockage, tighten or replace lines.
	4. Faulty Ng speed indication.	a. Check Ng indicator for accuracy.	a. Replace faulty Ng indicator.
		b. Check Ng tach generator.	b. Replace faulty Ng tach generator.
	5. Compressor inlet temperature sensor.	Check Idle RPM per figure 10-3.	Adjust idle speed per paragraph 10-8, replace sensor if idle speed is below 9800 RPM and cannot be adjusted.
	6. Fuel control, output flow low.	Check fuel flow indication for proper phr.	Replace faulty fuel control per paragraph 4-86.
C. Idle speed high.	1. Power lever rigging.	Check rigging at fuel control.	Re-rig power lever per paragraph 10-3.
	2. Fuel control idle adjustment.	Check Idle RPM per figure 10-3.	Adjust idle speed per paragraph 10-8.
	3. Faulty Ng speed indication.	Check Ng indicator for accuracy.	Replace faulty Ng indicator.
	4. Fuel control		Replace fuel control per paragraph 4-86.
D. Idle instability.	1. Lube pump driveshaft sheared.	Check oil pressure for positive indication.	Replace faulty lube pump per paragraph 4-61.
	2. Drain valve in fuel distributor.	Check fuel distributor for excessive overboard leakage.	Replace faulty fuel distributor per paragraph 4-98.
	3. Water in fuel.	Check filter for water.	Drain and refill fuel system. Clean all fuel filters.
	4. Air in fuel system.	Advance power lever above idle.	Return to idle. Check for stability.
	5. Faulty Ng/T5 Wf indicators.	a. Check indicators for accuracy.	a. Replace faulty indicator.
		b. Check tach generator and leads.	b. Replace faulty equipment.
	6. Compressor inlet temperature sensor.	Check Idle RPM per figure 10-3.	Adjust idle speed per paragraph 10-8. Replace sensor if idle speed is below 9800 RPM and cannot be adjusted.

11-8. IDLE PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
D. Idle instability. (cont)	7. Variable vanes off schedule.	a. Binding feedback cable.	Replace faulty feedback cable.
		b. Check variable vane schedule per paragraph 10-13.	Re-rig vanes per paragraph 10-13.
	8. Fuel control.	Try to adjust idle speed. If adjustment results in no change to Ng, check compressor discharge tubes for leaks.	If no tubes are leaking, replace fuel control.
	9. Fuel pump.		Replace fuel pump per paragraph 4-89.
E. Fan rotating with no speed indication.	1. Faulty Nf speed indication.	Check Nf indicator for accuracy.	Replace faulty Nf indicator.
	2. Faulty Nf sensor.	Check Nf sensor.	Replace Nf sensor.
		CAUTION Do not exceed idle power.	
F. No fan rotation.		Operate engine at idle power for 5 minutes. Shut engine down if fan does not rotate.	
	1. Fan locked by ice.	Visually inspect fan inlet for ice.	Remove ice with portable heaters.
	2. LP turbine blade/ shroud seizure.	Inspect for rubs.	Replace LP turbine shrouds.
	3. Foreign object damage on low pressure turbine rotor blades.	Inspect LP turbine blades looking up through exhaust frame.	Replace low pressure turbine module.

11-9. ABNORMAL ACCELERATION TO TAKEOFF POWER.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No acceleration.	1. Power lever linkage disconnected or broken.	Visually check movement of fuel control input shaft when power lever is moved.	Replace or repair power lever linkage.
	2. Compressor discharge pressure system leaking or blocked.	Check for loose, damaged, or blocked lines.	Remove blockage, tighten or replace lines.

11-9. ABNORMAL ACCELERATION TO TAKEOFF POWER. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No acceleration. (cont)	3. Excessive bleed or AGB power extraction.	Check bleed and power extraction equipment controls.	Turn off unnecessary bleed and power extraction equipment.
	4. Fuel control.	Check fuel flow during attempted acceleration.	Replace fuel control per paragraph 4-86.
	5. Fuel pump.	Check fuel flow during attempted acceleration.	Replace fuel pump per paragraph 4-89.
B. Slow acceleration with low T5.	1. Compressor discharge pressure system leaking or blocked.	Check for loose, damaged, or blocked lines.	Remove blockage, tighten or replace lines.
	2. Compressor inlet temperature sensor.	Check Idle RPM per figure 10-3.	Adjust idle speed per paragraph 10-8. Replace sensor per paragraph 4-106 if idle speed is below 9800 RPM and cannot be adjusted.
	3. Fuel control (low fuel flow).	Check fuel boost pressure, and fuel filter differential pressure.	If boost pressure and filter differential pressure are within limits, replace fuel control.
	4. Fuel pump (relief valve open).	Check fuel pump relief valve.	Replace fuel pump.
	5. Fuel filter blocked.	Check for fuel bypass indication.	Clean and replace fuel filter.
C. Slow acceleration	1. Foreign object damage.	Inspect engine with borescope.	Replace engine.
	2. Excessive bleed or horsepower extraction.	Check bleed and power extraction equipment controls.	Reduce bleed or horsepower extraction to within limits.
	3. Variable vanes off schedule.	Check variable vane schedule per paragraph 10-13.	Re-rig vanes per paragraph 10-13.
	4. Dirty compressor.	Inspect engine with borescope.	Water-wash compressor per paragraph 11-3.
D. Stall.	1. Binding feedback cable.	Disconnect feedback cable and check for free travel.	Replace feedback cable.
	2. Variable vanes off schedule.	Check variable vane schedule. See paragraph 10-13.	Re-rig vanes per paragraph 10-13.

11-9. ABNORMAL ACCELERATION TO TAKEOFF POWER. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
D. Stall (cont)	3. Disconnected vane lever arm.	Use borescope and check to see that all vane lever arms are engaged in holes of actuating rings. If a number of lever arms are disconnected, check for FOD.	Install vane lever arm in actuating ring.
	4. Compressor inlet temperature sensor.	Check Idle RPM. See figure 10-3.	Adjust idle speed per paragraph 10-8. Replace sensor per paragraph 4-106 if Idle speed is below 9800 RPM and cannot be adjusted.
	5. Foreign object damage.	Inspect engine with borescope. Check vane lever arms for disengagement from actuating ring.	Replace engine if damaged beyond limits.
	6. High fuel output from fuel control.	Check fuel flow.	Replace fuel control per paragraph 4-86.
E. Speed hangup and slow oscillation at 14,000 to 14,200 RPM Ng.	Armament firing solenoid activated.	Variable vanes are fully closed and ignition is on.	a. Check test cell wiring. b. Replace control amplifier per paragraph 4-33.
F. Ng RPM	1. Faulty Ng RPM indication.	Check Ng indicator for accuracy.	Replace faulty Ng indicator.
	2. Variable vanes off schedule (vanes closed).	Check variable vane schedule per paragraph 10-13.	Adjust feedback cable per paragraph 10-13.
	3. Amplifier not governing.	Check T5 and adjust amplifier if necessary.	Replace faulty amplifier per paragraph 4-33.
	4. Fuel control.	Fuel control not governing.	Replace faulty fuel control per paragraph 4-86.

11-10. LOW POWER AT MAX POWER SETTING.

SYMPTOM	P PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Low fan speed (Nf) with T5 OK.	1. Faulty Nf signal to gage.	Check fan speed pickup for high resistance.	Replace fan speed pickup.
	2. Anti-icing system operating.	a. Check switch. It must be in OFF position. b. Check anti-ice valve position.	a. Move switch to OFF position. b. Replace faulty valve.

11-10. LOW POWER AT MAX POWER SETTING. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Low fan speed (Nf) with T5 OK. (cont)	3. Bleed system ON or leaking.	a. Check switch. It must be in OFF position.	a. Move switch to OFF position.
		b. Check for loose or damaged bleed system components.	b. Tighten or replace bleed components.
	4. Faulty speed indication.	Check indicator for accuracy.	Replace indicator.
	5. Faulty T5 indication.	Check indicating system. (See paragraph 4-47E and figure 9-4.)	Replace gage or thermocouple harness.
	6. Variable vanes off schedule.	Check variable vane schedule. See paragraph 10-13.	Re-rig vanes per paragraph 10-13.
	7. Dirty compressor.	Inspect engine with borescope.	Clean compressor per paragraph 11-3.
	8. Foreign object damage.	Inspect engine with borescope.	Replace engine if damaged beyond limits.
	9. Low pressure turbine rotor clearance excessive.	Check LPT rotor clearance.	Replace LPT module.
B. Low fan speed (Nf) with T5 below maximum.	1. T5 amplifier control setting too low.	Turn on anti-icing:	
		a. T5 stays steady, Ng and Nf decrease.	a. Adjust control amplifier per paragraph 10-14.
		b. Ng stays steady, T5 increases.	b. Replace fuel control per paragraph 4-86.
		c. T5 and Ng increase.	c. Engine is P3 (pressure) limited by fuel control.
	2. Variable vane schedule.	Check variable vane schedule per paragraph 10-13.	Re-rig vanes per paragraph 10-13.
	3. Compressor inlet temperature sensor.	Check Idle RPM per figure 10-3.	Adjust idle speed per paragraph 10-8. Replace sensor per paragraph 4-106 if Idle speed is below 9800 RPM and cannot be adjusted.
	4. Power lever rigging.	Check power lever rigging at fuel control.	Re-rig power lever per paragraph 10-3.

11-10. LOW POWER AT MAX POWER SETTING. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
B. Low fan speed (Nf) with T5 below maximum. (cont)	5. Compressor discharge pressure system leaking or blocked.	Check for loose, damaged, or blocked lines.	Remove blockage, tighten or replace lines.
	Note: Fluctuation of a single instrument, without similar fluctuation of related instruments, indicates instrument malfunction.		
C. Speed fluctuation with power lever held in one position.	1. Faulty Ng/Wf indicators.	Check indicators for accuracy.	Replace faulty indicator.
	2. Binding feedback cable.	Disconnect feedback cable and check for free travel.	Replace faulty feedback cable.
	3. Fuel supply system.	a. Check pump inlet pressure. It must be 0-50 psig and steady.	a. Repair fuel system.
		b. Check emergency shutoff valve for full open position.	b. Replace faulty shutoff valve.
	4. Clogged fuel filter.	Check bypass indicator button.	Clean or replace fuel filter.
	5. Worn power lever linkage.	Check power lever linkage for worn parts and excessive total play.	Replace worn parts.
	6. Compressor discharge pressure system leaking or blocked.	Check for loose, damaged, or blocked lines.	Tighten or replace lines.
	7. Fuel pump.	Check fuel flow for stability.	Replace fuel pump per paragraph 4-89.
	8. Fuel control.	Check fuel flow for stability.	Replace fuel control per paragraph 4-86.
D. Higher or lower Ng than previous reading at 100° PLA under same operating conditions.	1. If all other readings are same as those previously taken at 100° PLA:		
	a. Faulty indicator.	Check indicator for accuracy.	Replace faulty indicator.

11-10. LOW POWER AT MAX POWER SETTING. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
D. Higher or lower Ng than previous reading at 100° PLA under same operating conditions. (cont)	2. If Ng and Nf are both lower:		
	a. Dirty fan and/or compressor rotor.	Visually check for dirt.	Clean per paragraph 11-3.
	b. Foreign object damage.	Borescope engine.	Replace engine.
	c. Excessive bleed (anti-ice).	Reduce bleed or check anti-icing valve.	Replace anti-icing valve.
	d. Excessive power extraction (AGB).	Reduce power extraction.	
	3. If Ng rises and Nf drops, variable vanes misrigged (closed).	Check variable vane schedule per paragraph 10-13.	Re-rig feedback cable per paragraph 10-13.
	4. If Ng and Nf rise:		
	a. Thermocouple harness.	Check thermocouple harness per paragraph 4-47E.	Replace thermocouple harness.
	b. T5 control amplifier.		Replace amplifier.
E. Higher or lower T5 than previous reading at 100° PLA under same operating conditions.	1. If all other readings are the same as those previously taken at same PLA:		
	a. Faulty indicator.	Check indicator for accuracy.	Replace faulty indicator.
	2. If all other readings changed with T5:		
	a. Variable vanes off schedule.	Check variable vane schedule per paragraph 10-13.	Adjust feedback cable per paragraph 10-13.
	b. Compressor inlet temperature sensor.	Check Idle RPM per figure 10-3. Adjust speed if possible per paragraph 10-8.	Replace sensor per paragraph 4-106 if Idle speed is below 9800 RPM and cannot be adjusted.

11-10. LOW POWER AT MAX POWER SETTING (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
F. T5 fluctuations.	Note: T5 fluctuations, without similar fluctuations of Ng, Nf, and Wf, indicate instrument or harness malfunction.		
	1. Faulty T5 indication:		
	a. Indicator.	a. Check indicator for accuracy.	a. Replace faulty indicator.
	b. Thermocouple harness.	b. Check thermocouple harness resistance pin to pin and pin to ground. See figure 9-4 and paragraph 4-47E.	b. Replace thermocouple harness.
	2. Control amplifier.		Replace control amplifier per paragraph 4-33.
	3. Fuel control.		Replace fuel control per paragraph 4-86.
G. Stall during steady-state operation.	1. Inlet restricted by:		
	a. Ice.	a. Melt ice with portable heater. Check anti-ice valve.	a. Replace valve.
	b. Foreign objects.	b. Remove objects restricting inlet. Borescope engine for FOD.	b. Replace engine if FOD exceeds limits.
	2. Improper variable vane position.	Check variable vane schedule per paragraph 10-13.	Re-rig feedback cable per paragraph 10-13.
	3. Foreign object damage.	Borescope engine.	Replace engine.

11-10A. FLAMEOUT.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
Steady decrease in T5 and Ng.	1. Fuel supply system.	a. Check fuel pump inlet pressure. It must be 0-50 PSIG and steady.	a. Repair fuel system.
		b. Check emergency shutoff valve for full open position.	b. Replace valve.
	2. Fuel contamination.	Check sample of fuel for contamination.	Drain and refill fuel system. Clean or replace all fuel filters.
	3. Improper variable vane position if flameout happened during compressor stall.	Check variable vane schedule per paragraph 10-13.	Re-rig feedback cable per paragraph 10-13.

11-10A. FLAMEOUT. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
Steady decrease in T5 and Ng. (cont)	4. Fuel control.	Check fuel system for correct flow and pressure.	Replace fuel control per paragraph 4-86.
	5. Fuel pump.	Check fuel system for correct pressure.	Replace fuel pump per paragraph 4-89.

11-11. LUBRICATION SYSTEM PROBLEMS.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION

CAUTION

- Under certain conditions, it is possible for the lubrication system to be overserviced. If the anti-leak check valve in the filter element is faulty, oil will start to drain from the tank when the engine is shutdown. Oil will seep from the tank, into the oil pump, through the faulty check valve and into the engine sumps, including the one in the gearbox. If the engine is shutdown for an extended period, usually several days, the oil may be completely drained from the tank. Consequently, if the tank is serviced to full, the amount of oil in the system would be twice the amount needed. This would cause the oil tank to deform or burst during startup.

- Comply with the following instructions to prevent overservicing the lubrication system:

  1. If the addition of 2 quarts of oil does not bring the level up to the full mark, do not add more oil until engine has been run for one to two minutes and then shut down. If level is above full mark, check valve is defective and must be replaced.

  2. To get maximum service life out of engine and to minimize maintenance work, the period between oil changes shall not exceed 200 hours.

Note

Many lubrication system problems are progressive. Check engine records before troubleshooting to aid in fault isolation.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. No oil pressure.	1. Low oil level in tank.	Check oil level. If tank is empty, inspect check valve in oil filter. **CAUTION** Use a suitable container to catch any oil whenever oil connections are loosened or removed.	Add 2 quarts of oil to tank. Run to idle for 1 minute, shutdown. Check oil level. If full, replace the anti-leak valve. If still low, fill tank and do not replace check valve in filter. Monitor oil level to establish consumption rate.
	2. Faulty oil pressure indication.	Check indicating system for faulty circuits.	Replace faulty component.
	3. Faulty transmitter or pressure line.	a. Check pins A to B of transmitter for short circuit in transmitter.	Replace faulty component.
		b. Check pin 5 of cable to pin 6 of cable at airframe connector for short circuit.	
		c. Check for a broken pressure line.	
	4. Obstruction in oil supply line to pump.	a. Disconnect supply line at pump and check for flow while motoring the engine.	Remove obstruction from supply line.
		b. Check oil-in line for deterioration (collapsed).	Replace oil-in line.
		c. Check for obstruction in pump inlet.	Remove obstruction from pump and clean oil tank.
		d. Check for crossed lines.	Reroute lines to eliminate crossing.
	5. Fitting on tank (for pump supply line) obstructed.	Remove tank-to-pump line and inspect fitting for obstruction.	Remove obstruction and clean oil tank.
	6. Sheared lube pump shaft.	Check for lack of Ng indication while motoring engine.	Replace lube pump per paragraph 4-61 if there is no oil pressure and no Ng indication.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
B. Low oil pressure.	Note A decrease of 10 PSI from that pressure considered normal is cause for investigation. Do not operate engine if pressure is more than 15 PSI below minimum.		
1. With fluctuation:	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. External oil leak.	Inspect all external lines and components for leaks. Check torque on all oil-in lines.	Replace leaking component.
	3. Faulty oil pressure indication.	Check indicating system for accuracy.	Replace faulty component.
	4. Fuel/water contamination.	Check oil sample for milky appearance or for dilution with fuel. Pressure leak-check oil cooler if fuel is found in oil.	Drain, flush, and refill oil system. Clean or replace oil filter. Replace oil cooler per paragraph 4-70 if it leaks.
	5. Oil pump relief valve.	Dirty or damaged oil pump relief valve seat.	Remove valve (not pump). Disassemble valve and inspect valve seat for dirt and damage. Clean or replace valve.
	6. Obstructed or collapsed oil supply line to pump.	a. Disconnect supply line at pump and check for flow while motoring the engine.	Replace supply line.
		b. Check oil-in line for deterioration.	Replace oil-in line.
		c. Check for obstruction in pump inlet.	Remove obstruction from pump.
2. Without fluctuation.	1. Internal engine oil leak. (Possible damaged oil seals.)	Check for high oil consumption.	Replace engine.
	2. Faulty pressure transmitter or cable.	a. Check pin B to pin C of transmitter for short circuit.	Replace transmitter or cable.
		b. Check pin 6 to pin 7 of cable at airframe connection for short circuit.	

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
C. High oil pressure.	**CAUTION** Do not operate engine if oil pressure exceeds 30 PSI over normal, after engine reaches stabilized temperatures. Note • An increase in oil pressure of 10 PSI, over that pressure considered normal for a particular engine, is cause for investigation. Do not change the oil pump because it cannot be the cause of high oil pressure. • Oil pressure during initial start (cold oil), should return to normal after 5 minutes at IDLE RPM. Higher power settings than IDLE are required for more rapid warm up.		
	1. Low oil temperature.	Operate engine to allow pressure to reduce after warmup.	None, if oil pressure is reduced.
	2. Faulty oil pressure indication.	a. Check pin A to pin C of transmitter for short circuit.	Replace faulty component.
		b. Check pin 5 to pin 7 of cable at airframe connection for short circuit.	
	3. Plugged filter.	Remove and inspect filter per paragraph 4-64.	If metal chips are found, check chip detectors; otherwise, clean or replace filter. Check for reversed anti-leak check valve.
	4. Blocked or kinked oil lines.	Check tubes and hoses for kinks or	Clean or replace faulty tube or hose.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
C. High oil pressure. (cont)	5. Clogged oil lines and oil jets. This is often indicated by pressure creeping up in a trend.	If filter was plugged but replacement did not reduce pressure to within limits, check all chip detectors and record location of chips and sludge before replacing engine.	Replace engine.
D. Fluctuating oil pressure (greater than 5 PSI).			
	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
	2. Fuel/water contamination.	Check oil sample for contamination. Pressure-check oil cooler if fuel is found in oil.	Drain, flush, and refill oil system. Clean or replace oil filter. Replace oil cooler per paragraph 4-70 if fuel is found in oil.
	3. Plugged filter.	Remove and inspect filter per paragraph 4-64.	If metal chips are found, check chip detectors; otherwise clean or replace filter.
	4. Faulty oil pressure transmitter.	Check transmitter for accuracy.	Replace transmitter.
	5. Blocked or defective pump inlet line.	Disconnect inlet line and check for blockage or damage. Inspect for tank fitting.	Clean or replace line. Clean tank.
	6. Oil pump relief valve.	Remove valve (not pump). Disassemble valve and inspect valve seat for dirt and damage and inspect valve spring for wear.	Clean or replace valve.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
D. Fluctuating oil pressure. (Cont)	7. Oil tank deaerator.	Remove pressure fill adapter and inspect deaerator for cracks with borescope.	Replace tank per paragraph 4-49 if deaerator is ruptured or if scavenge return tube is broken.
	8. B-sump pressure unstable.	Check B-sump pressure at B-sump scavenge chip detector boss.	Replace engine if pressure is unstable.
	9. Oil pump - tach pad seal.	Check for seal oil leakage or oil wetting.	Replace pump per paragraph 4-61 if seal leakage exceeds 2 cc per hour.
E. Low oil temperature.	1. Faulty oil temperature indication.	Check indicating system for accuracy.	Replace faulty component.
	2. Oil cooler.	Check oil sample for fuel.	Replace oil cooler per paragraph 4-70.
F. High oil temperature indicated by:	1. Low oil level in tank.	Check oil level.	Refill oil tank to correct level.
• Extremely dark oil in tank samples or pungent burnt odor. • Sludge and varnish on oil filter. • Sludge on chip detectors.	2. Low oil flow in B- and/or C-sump resulting in high scavenge temperature.	a. Replace B- and C-sump chip detectors with thermocouples. b. Operate engine and record B- and C-sump scavenge oil temperature and temperature at oil cooler output. c. Subtract the temperature at the oil cooler from each of the B- and C-sump scavenge temperatures. The resulting differential temperature should be below the following limits: B-sump, 160°F C-sump, 130°F d. Check for high or low oil pressure.	Record the sump area and temperature that is beyond limits and replace engine.
	3. Fuel heater air regulator valve open.	Fuel heater exhaust tube excessively hot.	Replace fuel heater per paragraph 4-80.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont).

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
G. Fluctuating oil temperature.	Faulty oil temperature indicating system.	Check indicating system for accuracy.	Replace faulty component.
H. Chip detector indication (continuity).	1. Chips on detector.	Troubleshoot as directed in figure 11-1.	As directed in figure 11-1.
	2. Faulty indication system.		
I. High oil consumption.	**CAUTION** Do not operate with fluctuating or below-limits oil pressure. A sudden increase in oil consumption or a gradual increase over a period of time indicates deterioration of the oil system and is cause for investigation.		
	1. Records in error.	Verify records.	Correct records as necessary.
	2. Oil leaks in:		
	a. External lines.	Check all line connections for leaks.	Torque line or replace line or fitting.
	b. No. 7 bearing carbon seal.	Borescope inspect inside vent exhaust for oil deposits in vent exhaust only.	Replace seal if damaged.
	c. Accessory gearbox.	(1) Check each gearbox pad for no more than 1 drop per minute leakage.	Replace defective parts.
		(2) Check packings and seals for damage.	Remove gearbox and replace defective parts.
	d. Oil pump.	Check oil pump seal drain slots at tachometer generator drive pad for no more than 1 drop per minute leakage.	Replace oil pump per paragraph 4-61.

11-11. LUBRICATION SYSTEM PROBLEMS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
I. High oil consumption. (cont)	e. Preformed packings on exhaust frame lube and scavenge lines.	Check inside exhaust frame for oil wetting. Remove tubes and inspect packings.	Replace packings (regardless of condition) and install tubes.
	3. Plugged seal pressure tube leading to C-sump.	Attach a line to C-sump air tube and blow through gently. Tube must have no restrictions.	Clean tube and orifice.
	4. Plugged A-sump seal drain tube if fan exit guide vanes or fan duct is oil wetted.	Attach a line to A-sump drain tube and blow through gently. Tube must have no restrictions.	Clean tube and orifice.
	5. Air pressure regulator valve.	Remove valve. Clean and pressure test valve.	Replace faulty valve.
	6. Internal engine damage.	a. Check oil filter and chip detectors for debris.	a. Replace engine.
		b. Check NOAP reports for signs of impending failure.	b. Replace engine.

11-12. HIGH VIBRATIONS.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Core engine vibration.	1. Faulty vibration indicating system.	Check all connections and pickups for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component.
	2. Loose engine mounts.	Check engine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Inspect engine with borescope.	Replace engine.

11-14B. REMOVAL AND INSTALLATION OF CHIP DETECTORS.

Only remove chip detectors (except on oil tank) when a continuity check indicates a chip is on the detector.

WARNING

Do not remove chip detectors until engine has cooled sufficiently to prevent personnel from getting burned by hot oil.

1. Remove lockwire and chip detector from the A-sump scavenge line, located at the 4 o'clock position, half way up the compressor casing. Discard packing.

2. Remove lockwire and chip detector from C-sump scavenge line, located at the 7 o'clock position, just forward of aft mount ring. Discard packing.

3. Remove lockwire and chip detector from the B-sump scavenge elbow, located at 5 o'clock position, on the combustion chamber. Discard packing.

4. Remove lockwire and chip detector from aft side of accessory drive gearbox, located at the 7 o'clock position. Discard packing.

5. Remove chip detector from oil tank, located at bottom left-hand corner, by grasping the outer knurled knob, push in, and turn it 1/4 turn to the left. Then pull it straight out. Discard packing.

6. Inspect each chip detector by following instructions of paragraph 11-15.

7. Install new packings on chip detectors.

8. Install chip detector into accessory drive gearbox. Torque it to 175-225 lb. in. and lockwire, double-strand method, using 0.032 inch lockwire.

9. Install chip detectors into A-, B-, and C-sump fittings. Torque them to 155-175 lb. in., and lock-wire, double-strand method, using 0.032 inch lockwire.

10. Install chip detector into oil tank by inserting it into the drain fitting and turning it 1/4 turn to the right. Detector should snap into position.

11-12. HIGH VIBRATIONS. (Cont)

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Core engine vibration. (cont)	4. Bearings.	a. Check oil pressure per paragraph 11-11 steps B and C.	Replace engine.
		b. Check oil filter and chip detectors for debris.	Replace engine.
		c. Check NOAP reports for signs of impending bearing failure.	Replace engine.
	5. Rotor shift.	Determine if vibration cycle is 1/rev of HPT rotor.	Replace engine.
B. Fan rotor vibration.	1. Faulty vibration indicating system.	Check all connections and pickups for looseness. Check leads for chafing. Check indicators for accuracy.	Replace faulty component.
	2. Loose engine mounts.	Check engine mounts for security and alignment.	Realign and tighten mounts.
	3. Foreign object damage.	Visually inspect fan and low pressure turbine rotor for damage.	Replace engine.
	4. Rotor shift.	Determine if vibration cycle is 1/rev of fan rotor.	Replace engine.

11-13. CRACKED BRACKETS, ENGINE CASINGS, OR BROKEN TUBING.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Cracked brackets.	1. Brackets are loose or not properly located.	Check for security of installation and correct location.	Replace faulty parts. Be sure to locate parts properly and securely.
	2. Incorrect brackets installed on engine.	Check part numbers to be sure correct brackets are installed.	Replace with correct parts.
	3. High vibration.	Do a vibration check.	Replace engine.
B. Broken tubing.	1. Tubing strained because of incorrect routing.	Inspect tubing for strains and proper routing.	Replace broken tube. Be sure no strains are induced because of routing.
	2. Improper support of tubing.	Check to see that tubing is correctly supported.	Replace broken tube. Clamp and support correctly.
	3. High vibration.	Do a vibration check.	Replace engine.
C. Cracked casings.	High vibration.	Do a vibration check.	Replace engine.

11-14. POST SHUTDOWN FIRE.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
After shutdown, T5 indicates 540 degrees C (1000 degrees F) or higher.	1. High ambient temperatures.	With ambient temperatures at 38 degrees C (100 degrees F) or above, a T5 temperature of 540 degrees C (1000 degrees F) or slightly above can be normal.	Motor engine with starter, ignition off, until T5 indicates 316 degrees C (600 degrees F) or less.
	2. Power lever rigging.	Check rigging at fuel control. Fuel control must be at stopcock position with power lever at 0 - 3° position.	Re-rig power lever per paragraph 10-3.
	3. Fuel distributor.	Check overboard drain immediately upon shutdown for overboard draining.	Replace fuel distributor per paragraph 4-98 if no overboard draining occurs.
	4. Fuel control.	Motor engine with power lever at 0° position. Check for fuel flow and for fuel vapors coming from tail pipe.	Replace fuel control per paragraph 4-86.

11-14A. ANTI-ICING VALVE PROBLEMS.

SYMPTOM	PROBABLE CAUSE	TROUBLESHOOTING	CORRECTIVE ACTION
A. Valve pop-out button extended.	1. Downstream flow blockage.	Inspect piping for restriction.	a. Remove restriction and replace valve.
	2. Faulty valve.	Note Pop-out button on anti-icing valve cannot be reset once it has popped. Valve must be replaced.	b. Replace valve per paragraph 4-7.
B. Valve open, pressure light off (valve solenoid de-energized, power off.	1. Light burned out.	Check cockpit light.	Replace light.
	2. DC power supply failure.	Check DC power supply.	Repair DC power supply.
	3. Faulty valve.	Check for extended pop-out button on valve.	Replace valve.
C. Valve closed, pressure light on (valve solenoid energized, power on).	1. Downstream flow blockage.	Inspect piping for restriction.	a. Remove restriction.
	2. Faulty valve.	Check for faulty valve.	b. Replace valve per paragraph 4-7.

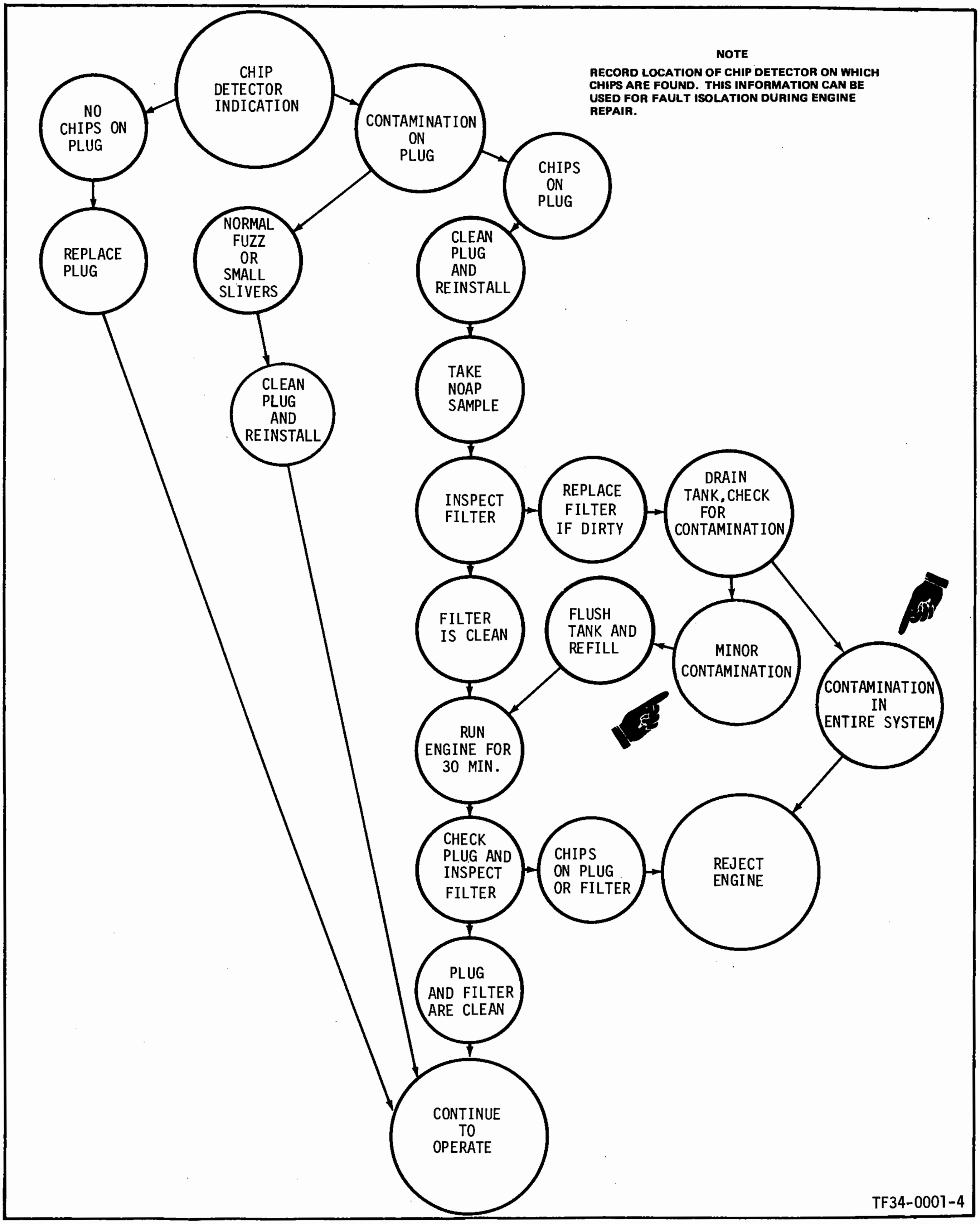


Figure 11-1. Magnetic Chip Detector Troubleshooting

11-15. MAGNETIC CHIP DETECTOR INSPECTION AND DEBRIS ANALYSIS.

1. During normal engine operation, some accumulation of fuzz-like magnetic particles will be found on the chip detector when it is removed and inspected (see figure 11-2). Other materials such as non-metallic sludge, small silver or non-magnetic flakes, bronze powder or machining chips of aluminum (the latter especially on new engines) will accumulate on the plug. The quantity will vary but should not be cause for engine removal.

2. Hair-like slivers of magnetic particles as long as 1 inch may be found on the chip detector and should not be cause for engine removal.

3. Flakes of magnetic material 1/64 inch diameter or more (see figure 11-2) indicate a pending failure. This condition is cause for engine removal.

4. Chunks of metallic material measuring 1/32 x 1/32 inch or more, other than fuzz or hair-like slivers, are cause for engine removal.

5. There are 5 chip detectors on the YTF34 engine. Four are checked by making a continuity check and the fifth (on oil tank) is checked by removing it and visually checking for particles. Check all five chip detectors as follows:

a. If threads are crossed or burred, chase threads or replace the chip detector.

b. If the condition of the chip detector is satisfactory, clean and reinstall.

6. When conditions of preceding steps 1. and 2. above are found, and a new or cleaned chip detector is installed, the engine shall be considered operational.

11-16. OIL FILTER INSPECTION AND DEBRIS ANALYSIS.

1. Inspect filter for debris (see figure 11-2) as follows:

WARNING

Trichloroethylene
Fed Spec O-T-634

- Vapors are harmful - do not use near open flames, or on very hot surfaces.
- Do not use near welding areas, a source of concentrated ultraviolet rays. Intense ultraviolet rays can cause the formation of phosgene gas, which is injurious to the lungs.
- Use only with adequate ventilation.

WARNING

Trichloroethylene
Fed Spec O-T-634

- Avoid prolonged or repeated breathing of vapors.
- Avoid prolonged or repeated contact with skin. Wear approved gloves and goggles (or face shield) when handling and wash hands thoroughly after handling.
- Do not take internally.
- Do not smoke when using it.
- Store in approved metal safety containers.

a. Immerse the filter in a clean non-magnetic container partially filled with clean trichloroethylene O-T-634 or equivalent solvent.

b. Slosh filter in solvent and brush between the pleats with a soft-bristle brush to remove metallic particles.

c. When filter has been thoroughly brushed and appears clean, remove it from the container. Take a clean magnet (magnetic chip detector) and move it through the solvent and into the debris removed from the filter.

d. Inspect the magnet (magnetic chip detector) for magnetic debris. See paragraph 11-15, steps 2. and 3.

e. Inspect the solvent and residue for non-magnetic debris. See paragraph 11-15, steps 1. and 4.

11-17. OIL ANALYSIS.

The Naval oil analysis program (NOAP) is in use as a maintenance tool in determining the internal condition of the engine's oil wetted components such as bearings, gears, lube pump and related parts. NOAP is used as a supplement to the normal maintenance procedures of chip detector and filter inspection, and does not replace these established safety checks. As the engine parts are operating, normal wear can be expected from gears, splines and bearings. This metallic wear is of microscopic size, measuring less than 1 micron, circulating freely with the lubrication oil and will stay in suspension with the oil. A micron is a measurement equal to one-thousandth of a millimeter. The lower limit of naked eye visibility is 40 microns. The oil filter on the YTF34 engine is rated at 25 microns nominal. Samples of oil taken from the engine after shutdown will contain varying amounts of wear-metal particles. The oil sample is analyzed by either a rotating-disk emission spectrometer or an atomic absorption instrument which translates the analytical information into parts per million (PPM) for the following elements:

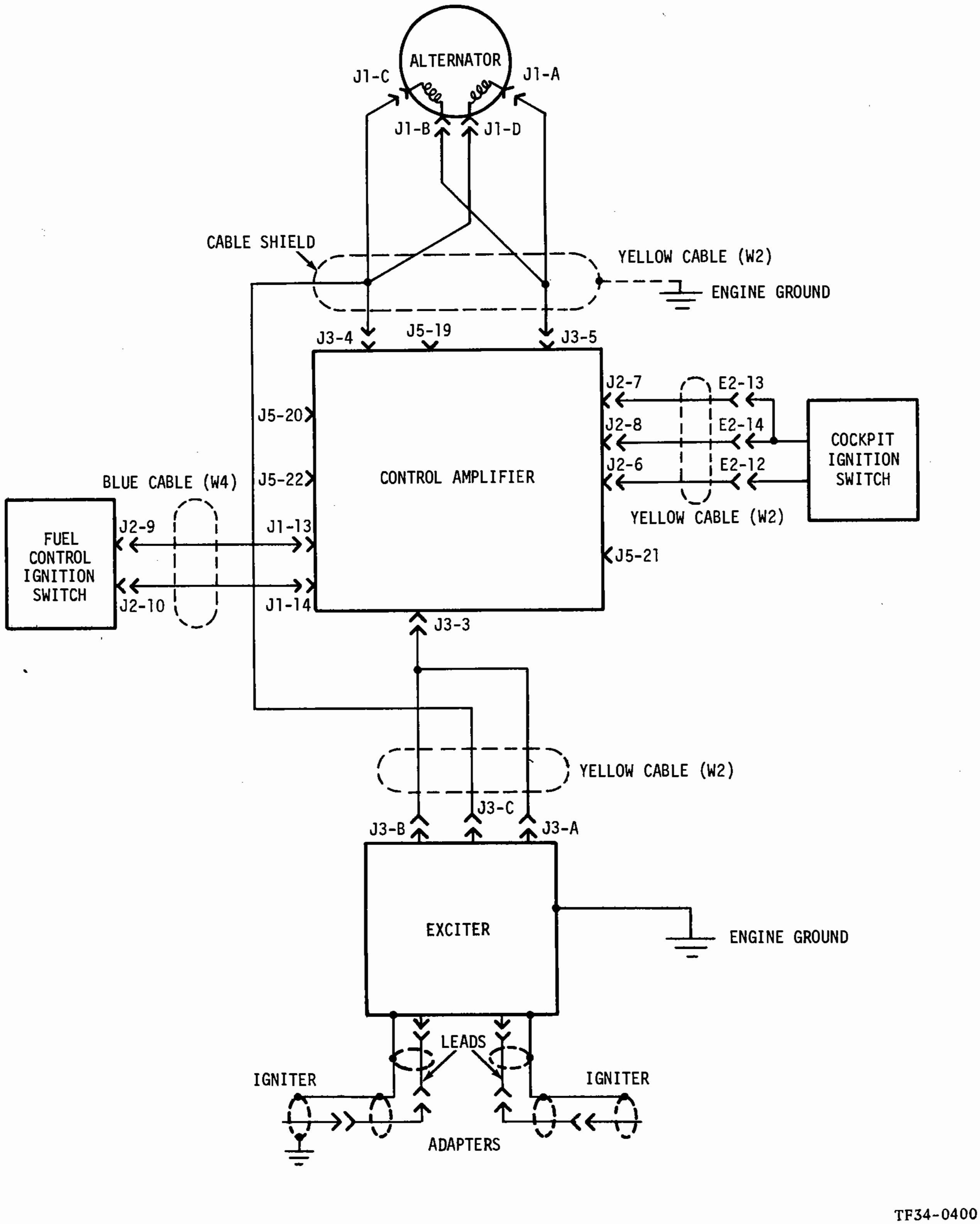


Figure 11-1A. Ignition System Schematic

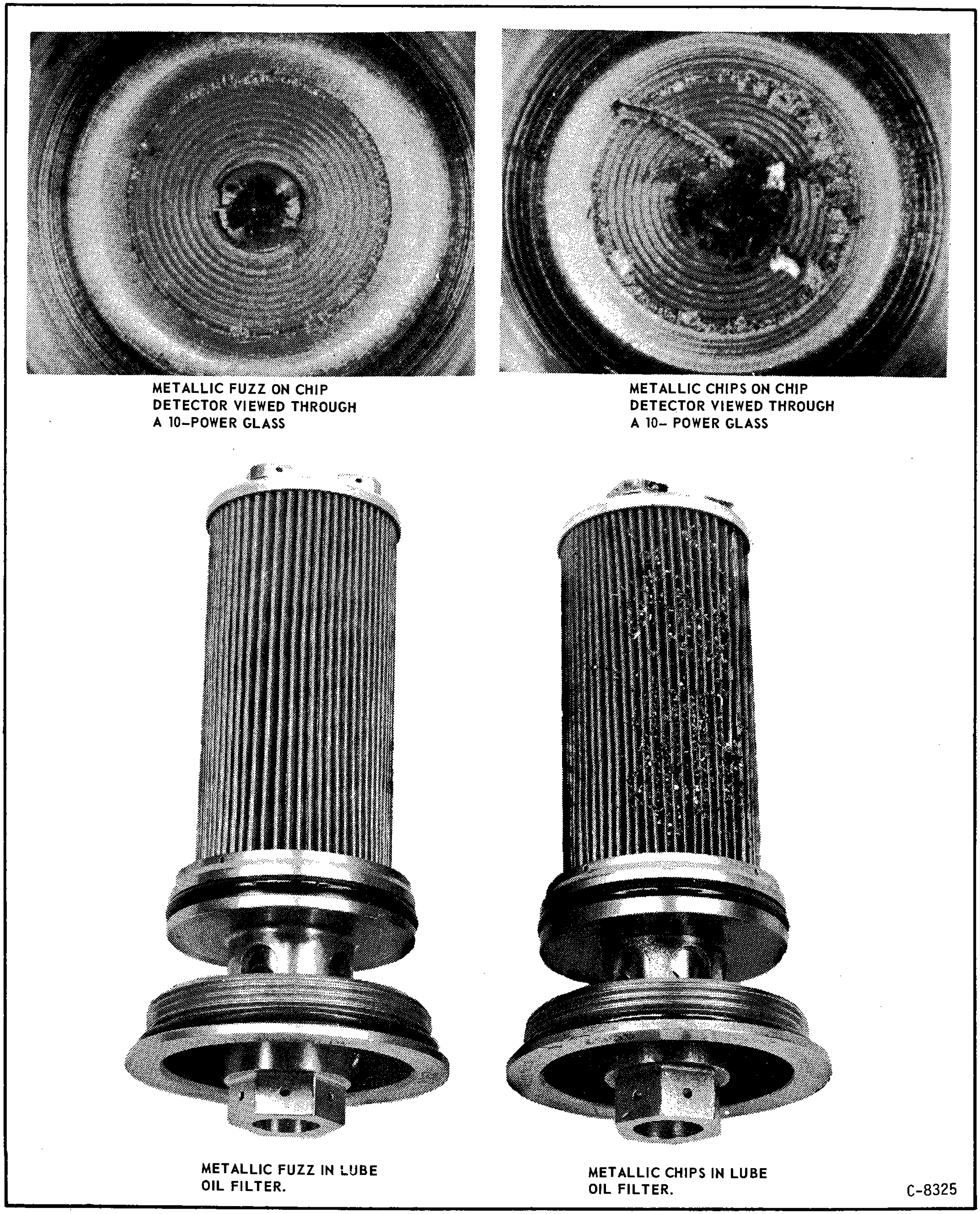


Figure 11-2. Magnetic Chip Detector and Oil Filter Inspection

Al - Aluminum	Ag - Silver	Mg - Magnesium
Fe - Iron	Cu - Copper	Pb - Lead
Cr - Chromium	Sn - Tin	Ni - Nickel

Wear-metal content is the most important data to evaluate. All jet or turboshaft engines of the same model produce approximately the same concentration of wear-metals when functioning properly. The wear-metals build up to the normal concentration during the first few hours of flight and then level off with no further increase throughout the life of the engine, unless a discrepancy develops. Minor fluctuations are probably due to contamination during sampling procedures or to addition of new oil. Normal wear-metal concentration for the YTF34 engine is usually less than 10 PPM for all elements. In engines where abnormal friction is developing, a pattern or trend of increasing wear-metal is observed. The rate of wear-metal increase is critical. A rapid buildup may indicate imminent component failure. If the rate of wear-metals is slow and steady, there is some point where friction responsible for wear-metal exceeds normal and becomes abnormal. This critical point is called the "threshold limit". The threshold limits or values have been established by concentration with Disassembly-Inspection Reports (DIR). Most threshold limits are tentative and should not be regarded as "Go-No-Go" values.

Not only must the quantity of wear-metal be evaluated but also the type of wear-metal present. The type and combination of metals may help to pinpoint what component is failing and to assess how serious it may be. For example, the presence of Fe and Ag may indicate bearing wear and gear wear. Fe alone may indicate gear wear. Differentiation of main shaft bearings and gears can only be positively detected by Spectro-Chemical analysis of chips because the percentage of Cr in bearings and Ni in gears is very small (less than 5%).

Oil sample is taken from a special drain valve on the side of the oil tank. Before taking a sample, drain off 1/4 cup oil. This will remove any sediment that might accumulate in the spout.

Oil samples must be taken at time intervals specified by COMNAVAIRLANT INSTRUCTION 4730.19 and care must be exercised while taking the sample. External contamination introduced to the oil sample will give a false indication of the exact internal condition of the engine. The oil sample should always be taken from the same location, and in the same way as directed, to assure that a representative sample of the engine lube oil will be analyzed. The oil sample should be properly identified and NAVWEPS Form 4730/7 must be completely filled out in order that proper records can be kept on the history of the engine.

Submit samples to the analysis laboratory, using oil sampling kit, Form NAVWEPS 4730/7 "Used Oil Analysis Request", and mailing envelope.

The following is a list of the various metals used in the engine that are oil wetted and may be subjected to wear and/or failure.

Component	Material
Main Shaft Bearings	B50TF34 (Fe, Cr, Mg)
AGB and PTO Bearings	AMS 6444 (Fe, Cr)
Bearing Cages:	
Nos. 1 and 3	S-Monel (Cu, Ni)
No. 2	AMS 4616 (Fe, Cu)
Nos. 4-7	AISI 4340 (Fe, Ag)
Lube and Scavenge Pump	AMS 4217 (Al)
AGB and PTO Gears	AMS 6265 (Fe, Ni)
PTO Shaft Spline, AGB Spur Gear	AISI 9310 (Fe)

High Al (more than 10 PPM) on a newly installed engine generally indicates contamination from the oil tank, oil cooler, oil pump, or front frame (A-sump).

Engine Removal Criteria

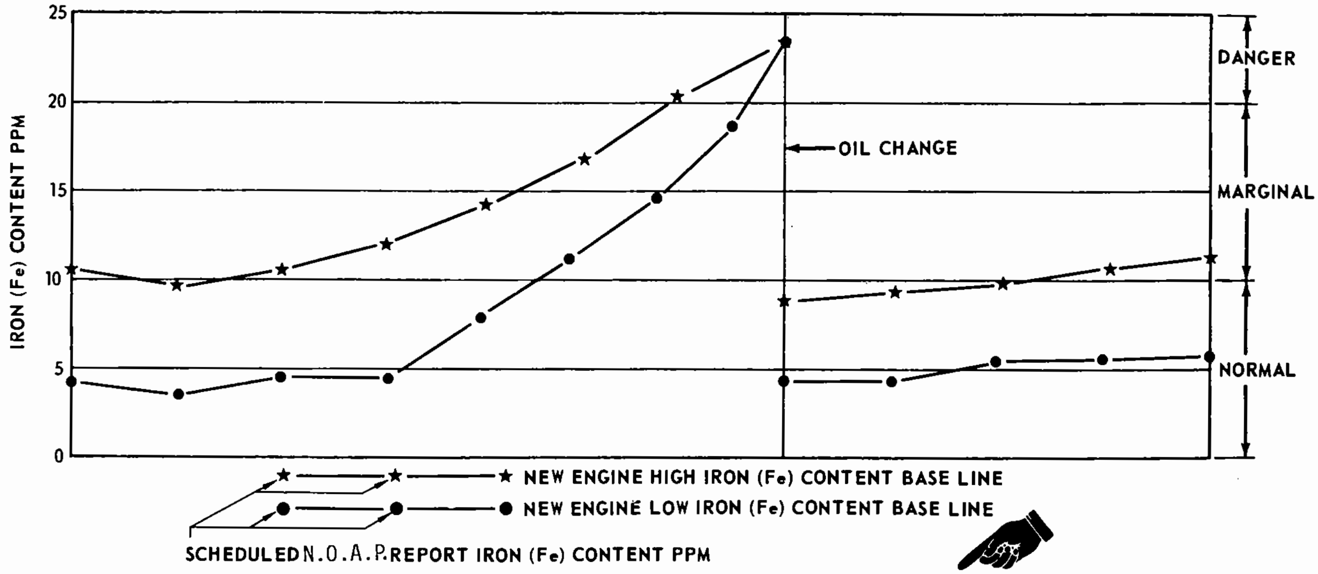
Following installation, the engine should have an oil sample taken immediately after the first shutdown following the first runup. This sample, when analyzed, will establish an Iron (Fe) content baseline.

Note

Some new cans of oil have been analyzed and found to contain as much as 16 PPM Fe.

The decision to remove an engine must be based on the rate of change in Fe that the oil contains with continued operating time in addition to engine filter and magnetic chip detector inspections. Spectrometric oil analysis will pick up wear-metals from any or all of the engine bearings, gears, lube pump and related parts. The chip detectors will pick up debris from all sumps and the tank.

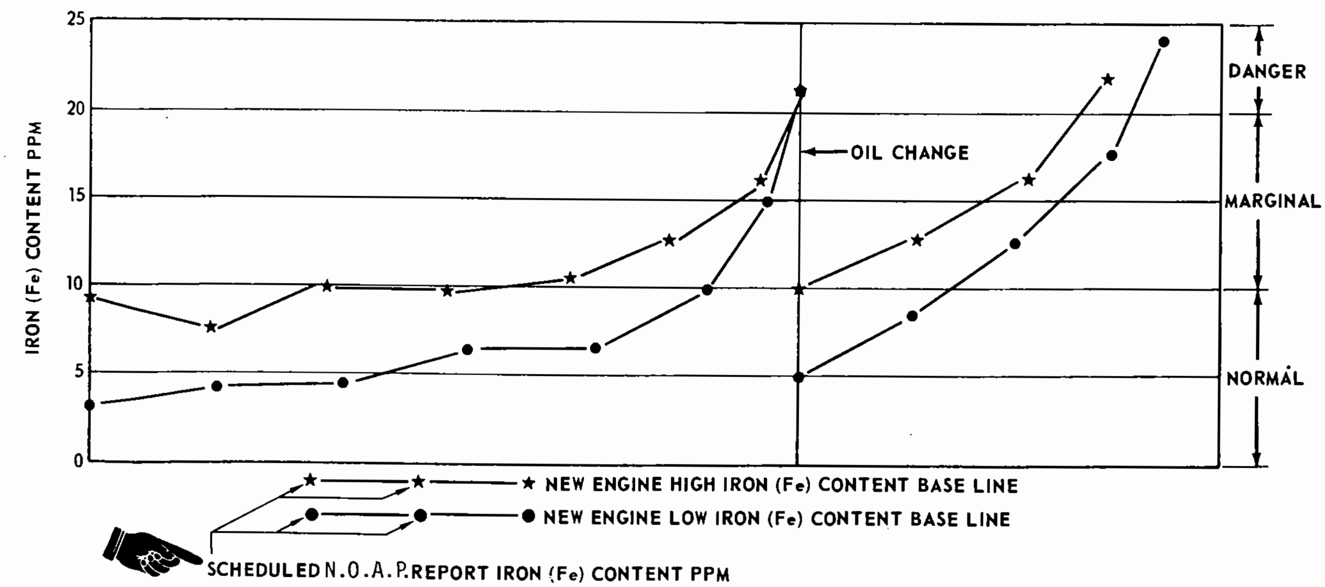
Engines with high iron content and clean engine filter and clean magnetic chip detector do not necessarily indicate imminent failures. The oil should be changed and a new sample of the oil analyzed for a new Fe content baseline. Engines approaching 20 PPM Fe at a slow progressive rate (less than 5 PPM between samples, see figure 11-3) should be monitored normally, as long as the engine filter and magnetic chip detectors remain clean. An oil change should be conducted as described when 21 PPM is reached. Engines approaching 21 PPM Fe at a fast rate (more than 5 PPM between samples, see figure 11-4) should have the lube system drained and filled with new oil. An oil sample should be taken and if the new sample shows relatively low rise in Fe content (less than 5 PPM), continue to operate the engine normally. However, if the iron content increases sharply 10 or 15 PPM between samples, the engine should be removed, disassembled, inspected and repaired as necessary.



Experience has shown that gradual increase in iron content (less than 5 PPM) in NOAP reports is normal. No bearing distress has been found on subsequent major inspection. Continue to operate engine with normal oil samples and routine chip detector and filter inspection.

TF34-0182

Figure 11-3. Normal Iron (Fe) Particle Increase



Experience has shown that sharp iron (Fe) content (more than 5 PPM) increases in oil, following an oil change for high iron (Fe) content, has disclosed distressed bearings on subsequent major inspections. Remove engine, disassemble, inspect and repair as necessary.

TF34-0183

Figure 11-4. Abnormal Iron (Fe) Particle Increase

11-18. INSPECTING ENGINE PARTS WITH BORESCOPE.

Paragraphs 11-19 through 11-25 contain instructions for viewing certain internal parts of an assembled engine with a borescope. The areas that can be viewed are described in paragraph 11-19. Be sure to read all the information in paragraph 11-19 before inspecting the engine.

11-19. PRELIMINARY INFORMATION.

1. Normal inspection with a borescope consists of inspecting the following parts: (See figure 11-5 for borescope port location and designation.)

a. Stage 11 compressor blades and visible portions of stage 10 vanes. View through the port at the 9 o'clock position on compressor casing (S15).

b. Combustion liner dome, inner shell, and outer shell. View through ports at the 1, 7, and 10 o'clock positions (S17, S21, S24) and through the igniter plug port at the 4 o'clock position (S19).

c. Stage 1 turbine nozzle partitions and stage 1 turbine rotor blades. View through the igniter port at the 4 o'clock position (S19).

2. Inspect the stage 1 compressor blades by viewing through the fan, if damage is suspected due to foreign object ingestion or if stage 11 blades are damaged.

3. During the normal hot-parts inspection, if you suspect that a portion of a part (not clearly visible) is damaged, use inspection ports located at the 2, 5, 8, 9:30 and 12 o'clock positions (S18 igniter, S20, S22, S23, and S16) on the combustion chamber to make a more thorough inspection of the part. These ports are partially obstructed by engine accessories and/or by QEC equipment. See table 11-2 for a list of components that have to be removed to inspect through these ports.

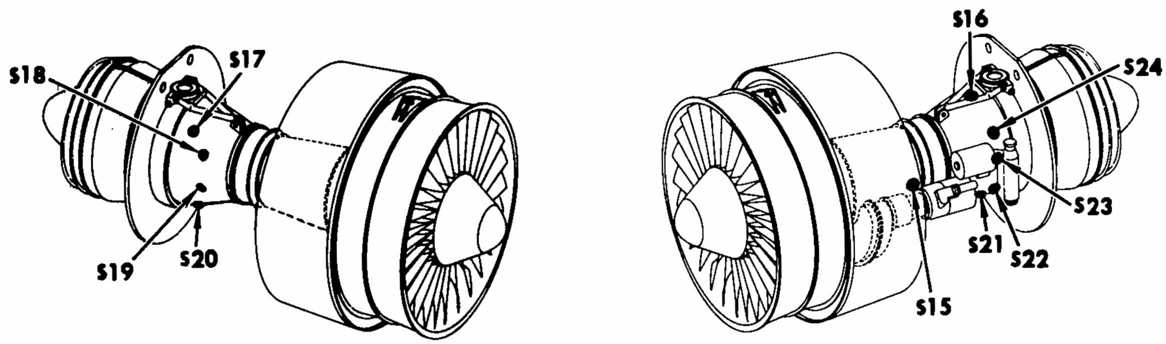
TABLE 11-2.

INSPECTION PORT ACCESSIBILITY

Note

Unless otherwise indicated, part is located on the combustion casing.

Port Designation (See figure 11-5)	Position (Aft Looking Forward)	Obstruction	Where To Find Procedure To Remove Obstruction
-	Fan entrance	None	---
S15	9 o'clock (compressor casing)	None	---
S16	12 o'clock	Cooling air duct	Airframe manufacturer's instructions
S17	1 o'clock	None	---
S18	2 o'clock (igniter)	Oil tank	Section IV of this manual
S19	4 o'clock (igniter)	None	---
S20	5 o'clock	None	---
S21	7 o'clock	None	---
S22	8 o'clock	Fuel heater	Section IV of this manual
S23	9:30 o'clock	Fuel heater	Section IV of this manual
S24	10 o'clock	14th stage bleed line	Airframe manufacturer's instructions



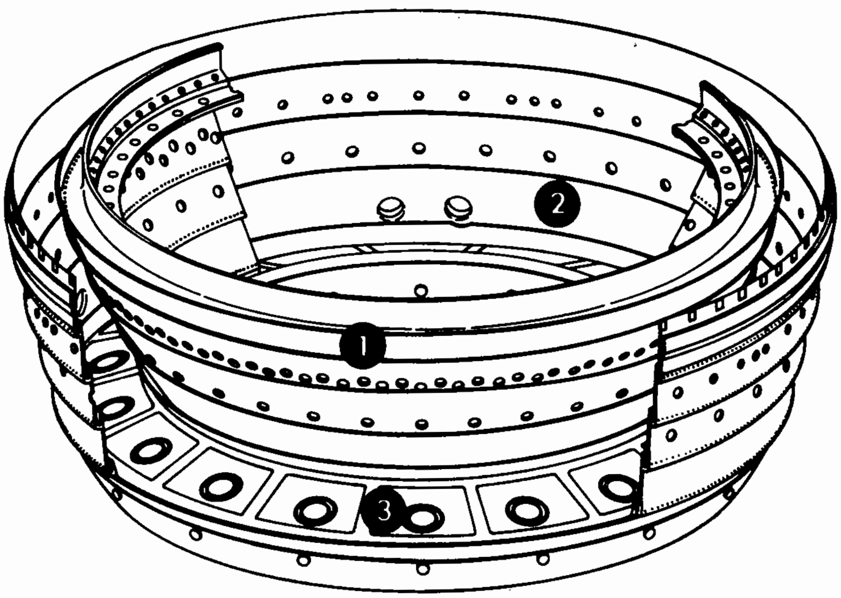


Figure 11-5. Borescope Port Locations

WARNING

Methanol
Fed Spec OM-232

- Flammable - do not use near welding areas, near open flames or sparks, or on very hot surfaces.
- Use only with adequate ventilation.
- Avoid prolonged or repeated breathing of vapors.
- Keep container closed.
- Store in approved metal safety containers.

4. Clean the eyepiece, tip (lens), and both ends of the light bundle with methanol alcohol (Fed Spec OM-232) if they appear dirty.

5. Inspection of the combustion section using the rigid probe is done in the same way at each port.

6. The flexible borescope can only be used through the igniter plug ports.

7. Borescopes are delicate instruments. Handle all pieces carefully, and return them to the case for protection when not in use.

8. It is possible to photograph defects through the borescope. See paragraph 11-26 for procedure.

9. To rotate the compressor and high-pressure turbine rotors one turn with the cranking adapter, turn the adapter one-half turn.

11-20. EQUIPMENT REQUIRED.

Note

See figure 11-6 for description of field of view for each borescope.

1. The following items are included in the borescope kit (21C9800G01).

a. Dual light source (PN ACMI FCB 1000).

b. Light bundle (PN ACMI 56211154).

c. Rigid borescope (PN ACMI BFO 3927C), 27 inches long, with right angle field of vision.

d. Rigid borescope (PN ACMI 9420M31G01), 12 inches long, with right angle field of vision.

e. Rigid borescope (PN ACMI BFO 2112R), 12 inches long, with field of vision coming back toward the user.

f. Flexible borescope (PN BFO 3827 DD), movable tip (which points in the direction of the field of vision).

g. Camera (ACMI 35 MM Olympus Pen Ft, 70 MM f2.0 Zuiko lens, lens case and adapter B5051).

h. Remote shutter release (PN 31728-C).

i. Lamps (tungsten PN DKR and Arc projector PN MARC-300/16).

j. Camera support fixture (PN 17A5511G01).

2. Additional equipment required (not included in the kit):

a. Compressor rotor cranking adapter (21C-5010G01).

b. Tester (64A128J1).

11-21. LIGHT SOURCE SETUP.

1. Remove cover from light source.

2. Place light switches (both Routine and Photo) in the OFF position and turn brightness dial all the way counterclockwise to L.

3. Connect the light source to 115 volt, 60 cycle power source.

4. Slide the plate on the front of the light source cabinet all the way to the left so that the hole in the plate is under the word ROUTINE.

5. Insert one end of light bundle into the ROUTINE hole on the light source.

11-22. INSPECTION OF STAGE 1 COMPRESSOR ROTOR BLADES.

1. Remove engine fan cover (21C5110P01).

2. Hold fan spinner so that fan will not rotate and install a suitable fan rotor locking fixture.

3. Open nacelle doors on both sides of engine.

4. Two methods of opening variable vanes for Borescoping are available. If engine is in test cell/airframe, steps 5 through 9 should be used. If engine is not in test cell/airframe follow step 10 through 28.

5. Remove clevis pin from VG feedback cable at right-hand VG linkage.

6. Pull feedback cable out until the feedback arm on fuel control hits the stop.

7. Lock-wire the feedback cable in this position to an accessible point like the A-sump seal pressurizing tube. Make sure feedback cable and lock-wire are clear of VG linkage, and the feedback arm is against the stop of fuel control.

CAUTION

Make sure power lever is OFF and there is no fuel flow into combustion chamber.

8. Motor the engine, power lever OFF, until variable vanes are open. Stop motoring.

9. After engine stops rotating, borescope compressor by following steps 15 through 25. Then restore feedback cable to original position with clevis pin, washer, and cotter pin. Motor engine, power lever off, until variable vanes are closed.

10. Disconnect the 2 variable vane actuator lines at the fuel control. Install aluminum caps on nipple and on elbow on fuel control to keep out dirt.

11. Connect tester (64A128J1) to actuator lines.

12. Move valve on tester to neutral position.

13. Use the hand pump on the tester and pressurize the tester to 100 psig.

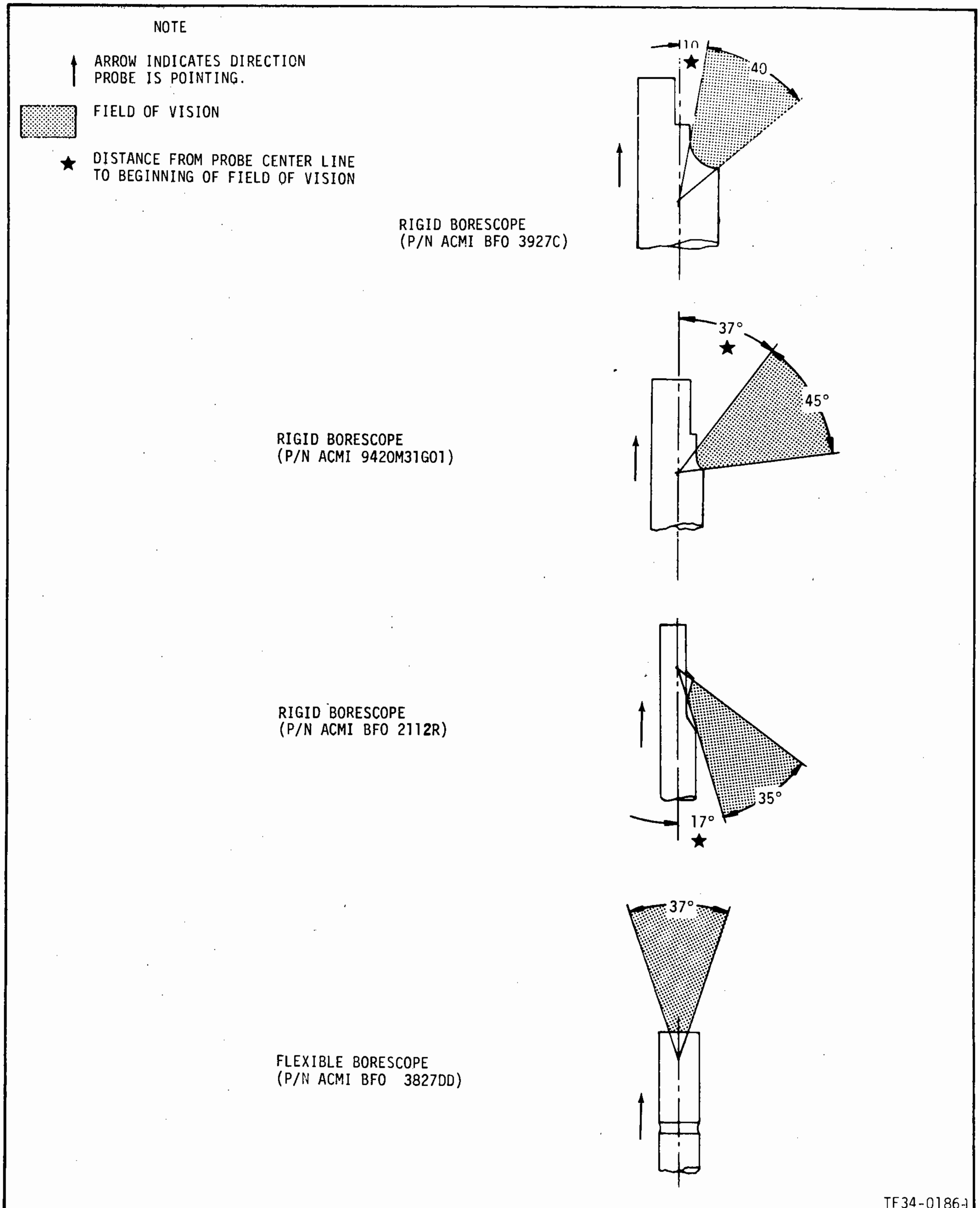


Figure 11-6. Field of Vision of Borescope Probes

14. Move valve to OPEN position (actuator rings on engine will move counterclockwise until actuator rods are fully extended.

CAUTION

- Be sure rubber stop on borescope is not more than 25 inches from borescope tip.
- Use extreme care when inserting borescope into engine.

15. Connect borescope (PN ACMI BFO 3927C) to light bundle. Turn on ROUTINE light and turn brightness dial clockwise from L to H.

16. Insert borescope through fan blades, vanes, and into compressor inlet on the front frame. If borescope will not enter, loosen fan rotor locking fixture and carefully move rotor just enough to allow easy penetration. Retighten fan rotor locking fixture.

17. Continue inserting borescope until rubber stop on probe lightly rests against the leading edge of a fan blade.

18. Remove retaining ring using right angle snap ring pliers, plug (1/4-20 thread), and packing from aft right side of gearbox. Install compressor rotor cranking adapter (21C5010) or standard 1/4 inch rachet wrench with a 1/4 to 3/8 inch adapter.

19. Rotate probe until tip of stage 1 blade comes into view. See figure 11-7.

20. Using cranking adapter, rotate rotor and inspect all compressor blades for nicks, pits, scratches, dents, erosion and wear. See paragraph 5-149 for usable limits.

21. Rotate probe until root of stage 1 blade comes into view. Using cranking adapter, rotate rotor and inspect all compressor blades for nicks, pits, scratches, dents, erosion, and wear. See paragraph 5-149 for usable limits.

Note

If the size of the defects cannot be determined using just the borescope, tape a long piece of 0.032 inch lockwire to the borescope probe and bend the end of the wire so that it can be seen through the borescope. Insert probe into engine and compare defects to the wire size.

22. Stop rotating rotor.

23. Turn brightness dial on light source from H to L and turn off ROUTINE light.

24. Carefully remove the borescope.

25. Disconnect borescope from light bundle and place it in case.

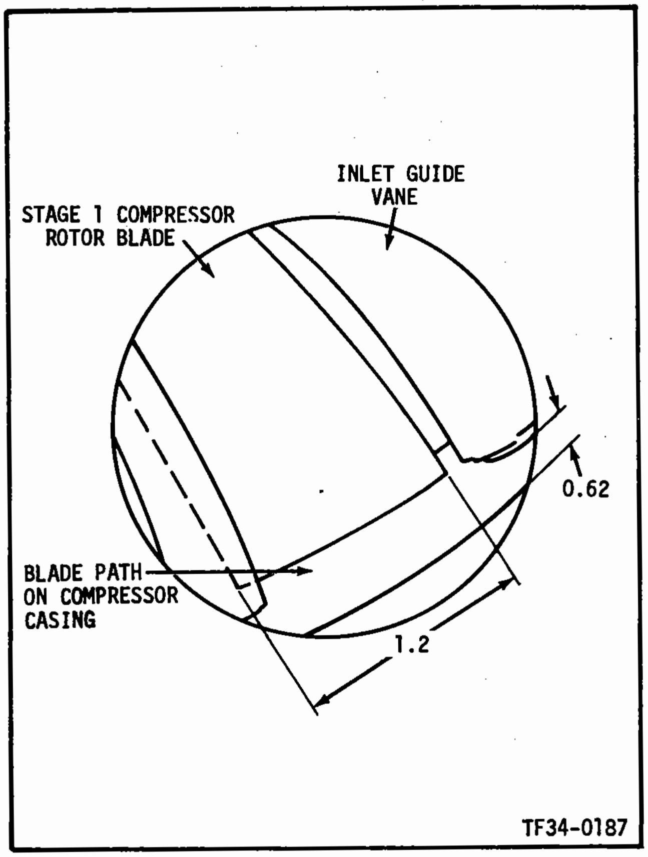


Figure 11-7. Typical View of Stage 1 Compressor Rotor Blades

26. Move valve on tester (64A128J1) to CLOSE position (actuator rings on engine will move clockwise) until actuator rods are fully retracted.

CAUTION

Be sure no contamination enters the fuel control or actuator lines.

27. Disconnect actuator lines from tester. Remove aluminum caps from elbow and nipple on fuel control. Reconnect actuator lines to the fuel control. Torque the larger line to 270-300 lb in. and the smaller line to 180-200 lb in.

28. Remove fan rotor locking fixture.

11-23. INSPECTION OF STAGE 11 COMPRESSOR ROTOR BLADES.

1. Remove borescope port plug just above the left-hand splitline on compressor casing (S15, figure 11-5).

2. Connect borescope (ACMI 9420M31G01) to light bundle. Turn on Routine light and turn brightness dial clockwise from L to H.

3. Insert borescope into port about 3/4 inch (11-1/4 inches of the probe should be outside the casing). Sight towards 6 o'clock position. Adjust depth and rotate probe until view looks like that shown in figure 11-8.

CAUTION

Be sure borescope tip does not contact blades or rotor.

4. Using cranking adapter (21C5010) or standard 1/4 inch ratchet wrench with a 1/4 to 3/8 inch adapter, rotate rotor and inspect all stage 11 blades for nicks, pits, scratches, dents, erosion, and wear. See paragraph 5-149 for usable limits.

Note

If the size of the defects cannot be determined using just the borescope, tape a long piece of 0.032 inch lockwire to the borescope probe and bend the end of the wire so that it can be seen through the borescope. Insert probe into engine and compare defects to the wire size.

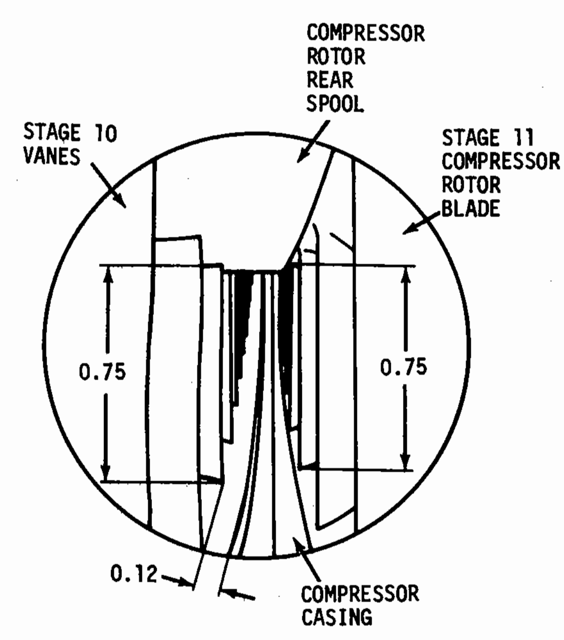


Figure 11-8. Typical View of Stage 11 Compressor Rotor Blades

5. Stop rotating rotor.

6. Turn brightness dial on light source from H to L, and turn off ROUTINE light.

7. Carefully remove the borescope.

8. Disconnect borescope from light bundle and place it in case.

9. Install borescope port plug. Torque plug to 100-110 lb in. and lock-wire.

11-24. INSPECTION OF COMBUSTION LINER DOME, INNER SHELL, OUTER SHELL, AND STAGE 1 TURBINE NOZZLE PARTITIONS. (See paragraph 5-158 for usable limits.)

Note

The same method is used to inspect part from any of the ports.

1. Open the left- and right-hand nacelle doors.

2. Remove the borescope port plugs located at 1, 7 and 10 o'clock positions (S17, S21, and S24, figure 11-5) on the combustion chamber.

3. Disconnect igniter lead from adapter on igniter plug at the 4 o'clock position on the combustion chamber.

4. Remove the igniter plug adapter, plug bushing, and plug (S19).

5. Connect borescope (ACMI 9420M31G01) to light bundle. Turn on ROUTINE light and turn brightness dial clcokwise from L to H.

6. Insert borescope about 2 inches into port at 10 o'clock position (S24). Rotate probe so that light bundle connection is pointing aft. Adjust depth and rotate probe until scroll assemblies are seen as shown in figure 11-9.

7. Rotate borescope clockwise and inspect all visible scrolls.

8. Return borescope to position described in step 6.

9. Rotate probe counterclockwise and inspect all visible scrolls.

10. Adjust depth and direction of borescope until outer shell is viewed as shown in figure 11-10.

11. Check all visible areas of the outer shell by starting at the scroll and rotating the borescope (inspecting the shell as you rotate) until the stage 1 turbine nozzle comes into view. Vary the depth of the insertion, at each pass, until all areas have been thoroughly inspected.

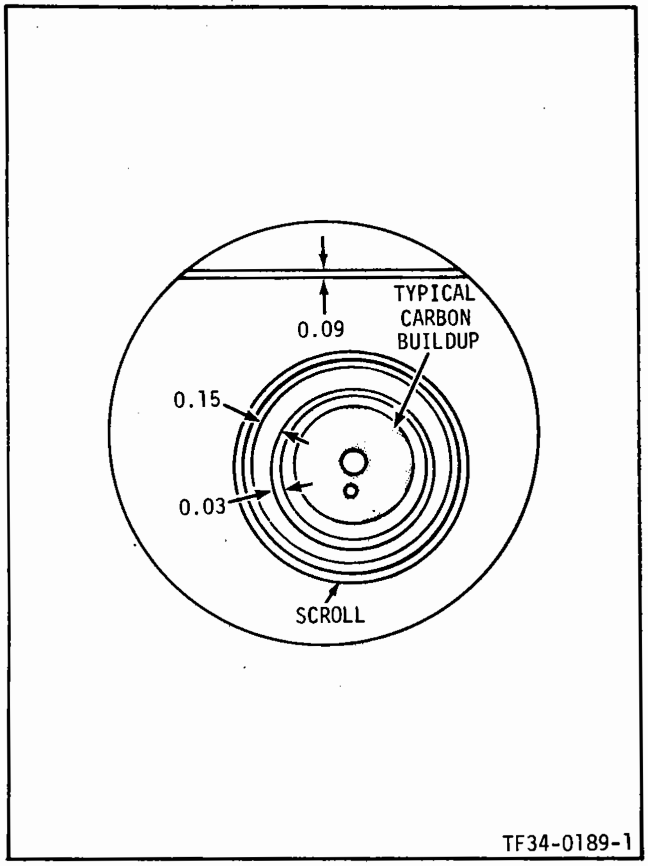


Figure 11-9. Typical View of Combustion Liner Scroll looking through Inspection Port at 10 O'clock Position

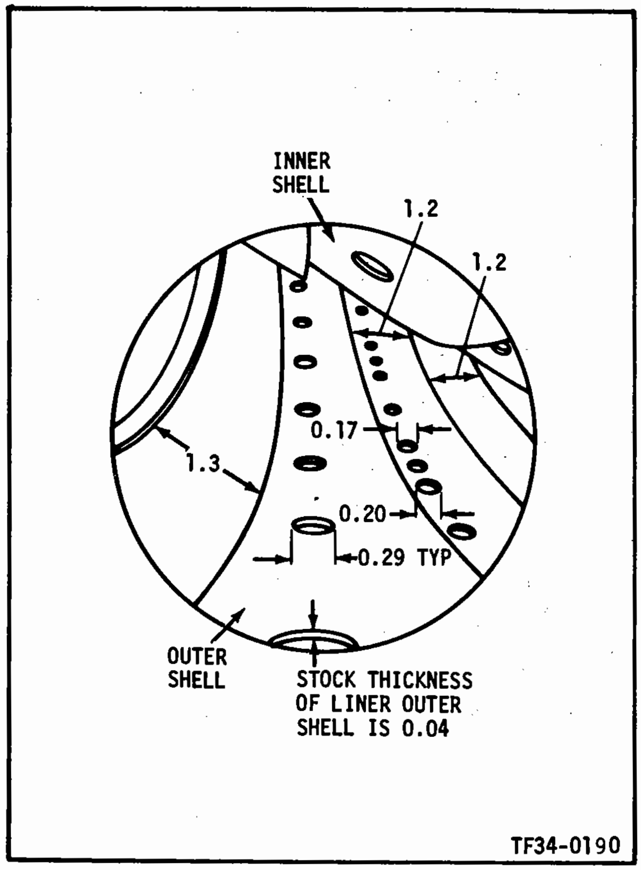


Figure 11-10. Typical View of Combustion Liner Outer Shell looking through Inspection Port at 10 O'clock Position

12. Return borescope to the position described in step 6.

13. Slowly rotate probe clockwise until the view of the inner shell is as shown in figure 11-11.

14. Check all visible areas of the inner shell by starting at the scroll and rotating the borescope (inspecting the shell as you rotate) until the stage 1 turbine nozzle comes into view. Vary the depth of insertion, at each pass, until all areas have been thoroughly inspected.

15. Slowly rotate probe until the view of the stage 1 turbine nozzle is as shown in figure 11-12. See paragraph 5-181 for usable limits. See figures 11-13 and 11-14 for other typical views.

16. Slowly rotate probe counterclockwise (inspecting nozzle partitions as you rotate) until the outer shell comes into view.

17. Return borescope to position described in step 15.

18. Slowly rotate probe clockwise (inspecting nozzle partitions as you rotate) until the outer shell comes into view.

19. Disconnect borescope from light bundle and connect borescope (ACMI-BFO 2112R) to light bundle.

20. Insert borescope into port about 2 inches.

Note

This borescope views back towards the user.

21. Slowly rotate borescope to inspect areas of outer shell not inspected in steps 13 and 14. Vary depth of insertion, at each pass, until all areas have been thoroughly inspected.

22. Repeat steps 6 through 22 through the ports at the 7 and 10 o'clock positions (S21 and S24) and at the igniter port at the 4 o'clock position (S19).

23. Turn brightness dial from H to L and turn off Routine light.

24. Carefully remove borescope.

25. Disconnect borescope from light bundle and place it in case.

26. Put a light coat of sealant (Plastiseal F or equivalent) on the port plugs. Install and torque the

plugs to 180-200 lb in. and lock-wire. Do not install igniter plug until the stage 1 turbine blades have been inspected as specified in paragraph 11-25.

11-25. INSPECTION OF STAGE 1 HIGH PRESSURE TURBINE ROTOR BLADES. (See paragraph 5-174.)

1. Connect flexible borescope (ACMI BFO 3827DD) to light bundle.

2. Turn on Routine light and turn brightness dial from L to H.

Note

There are 2 adjustments on the flexible borescope, one to focus and one to move the tip back and forth.

CAUTION

Forcing either adjustment on the borescope will damage tip or break control cables.

3. Insert tip of borescope into igniter port at 4 o'clock position (S19) and move tip with remote adjustment until the tip is pointing towards stage 1 nozzle.

4. Gently push probe in port until it binds slightly.

5. Relax pressure on remote tip adjustment so that probe can go farther into the liner.

6. Continue to insert probe (moving tip back and forth with remote adjustment) until tip goes between 2 nozzle partitions.

7. Move the probe tip until the stage 1 blade tip can be seen.

8. Using cranking adapter (21C5010) or standard 1/4 inch ratchet wrench with a 1/4 to 3/8 inch adapter, rotate rotor and inspect all blades for damage.

9. Stop turning rotor.

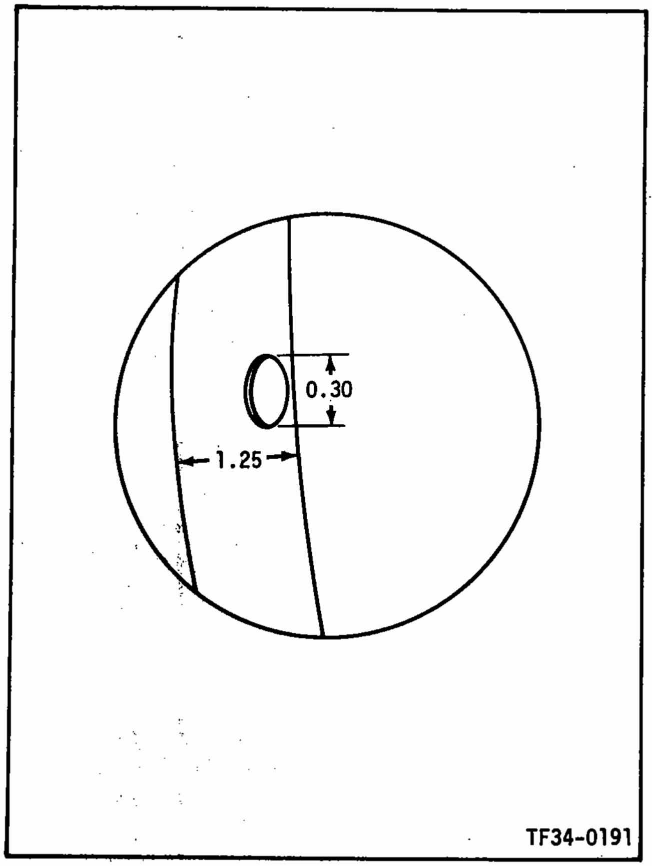


Figure 11-11. Typical View of Combustion Liner Inner Shell looking through Inspection Port at 10 O'clock Position

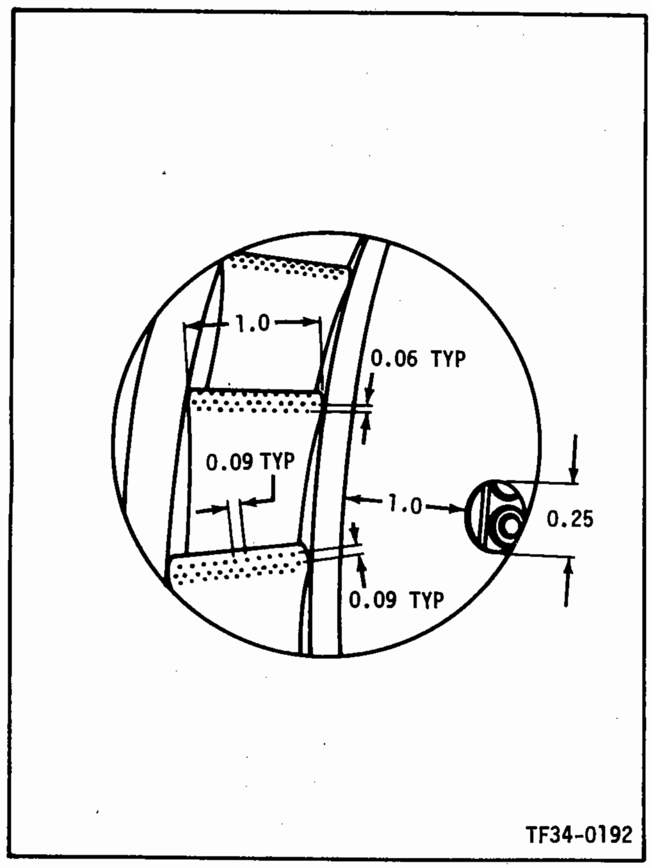


Figure 11-12. Typical View of Stage 1 Turbine Nozzle looking through Inspection Port at 10 O'clock Position

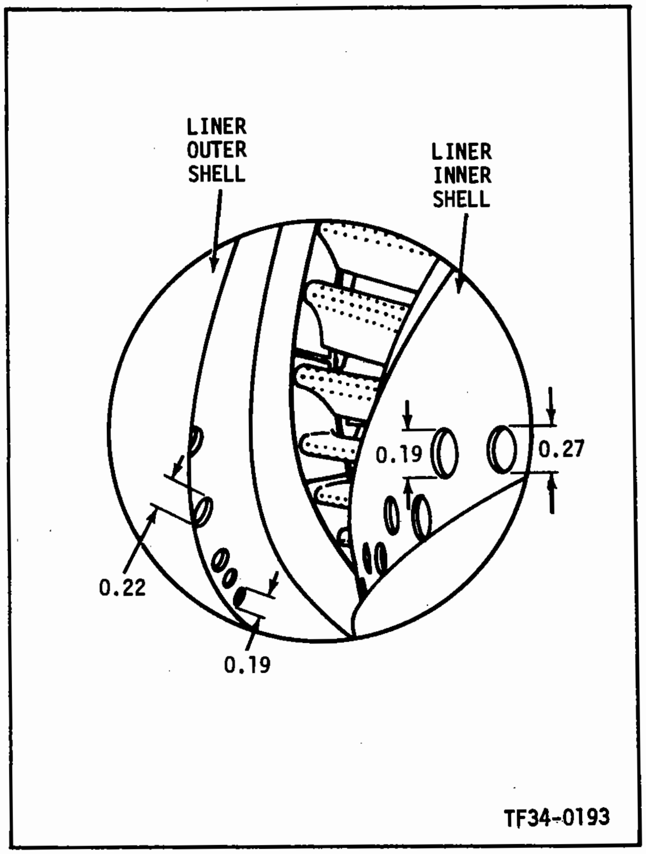


Figure 11-13. Typical Right Angle View of Stage 1 Turbine Nozzle

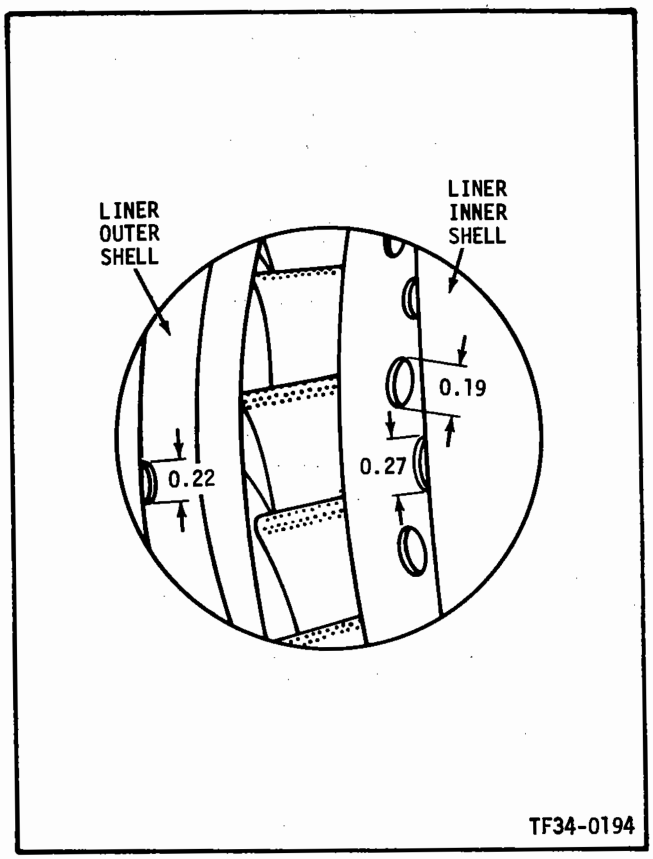


Figure 11-14. Typical Straight On View of Stage 1 Turbine Nozzle

Note

It may be necessary to move the tip slightly out from between the nozzle partitions to change viewing direction.

10. Move probe tip until the root of the stage 1 blade can be seen.

11. Using cranking adapter (21C5010), rotate rotor and inspect all blades for damage.

12. Stop turning rotor.

13. Gently withdraw the flexible borescope from the engine. If the probe binds, move tip back and forth until it moves freely.

14. Turn brightness dial from H to L and turn off "Routine" light.

15. Disconnect borescope from light bundle and place it in case.

16. Disconnect light bundle from light source and place it in case.

17. Place cover on light source.

CAUTION

Do not lubricate threads of igniter bushing.

18. Put a thin coat of sealant (Plastiseal F or equivalent) on threads and forward face of igniter plug bushing.

19. Install igniter plug in combustion chamber boss (at 4 o'clock position). Secure the plug with bushing. Torque bushing to 120 lb in. and lock-wire with 0.032 inch lockwire, using double-strand method.

20. Install igniter plug adapter on igniter plug. Torque adapter to 200-220 lb in.

21. Connect igniter lead to adapter and torque to 135-150 lb in.

22. Remove cranking adapter from gearbox. Install packing (MS9388-020), plug, and a new retaining ring.

23. Close and secure nacelle doors.

11-26. PHOTOGRAPHING DEFECTS USING BORESCOPE.

1. Attach camera support to mount ring.

2. Set camera film speed to 400 (this is the suggested speed for the film supplied in the kit).

3. Set camera lens to infinity.

4. Set the f stop wide open (f2).

5. Screw camera adapter (ACMI B5051) onto thread on camera lens.

6. Attach camera to borescope with adapter and tighten adapter ring screw. Be sure eyepiece on borescope bottoms in adapter.

7. Insert borescope into port on engine, secure camera to support, and attach remote shutter release.

8. Attach light bundle to borescope.

WARNING

Never look directly into light bundle with PHOTO LIGHT on.

Note

The PHOTO LIGHT takes about one minute to reach full intensity.

9. Slide plate on light source all the way to the right so that the light bundle is under the word PHOTO.

10. Turn on PHOTO LIGHT.

11. Look through view finder on camera. Adjust supporting fixtures if necessary to get desired picture. If picture is to be taken through flexible borescope, adjust focus for best clarity.

12. See table 11-3 for typical exposure times.

13. Use remote shutter release and take picture.

14. Record the following information for each photograph taken:

a. Date

b. Engine No.

c. Photo Sequence No.

d. Exposure Time

e. Engine Part

f. Engine Operating Hours

g. Defect Observed

h. Borescope immersion and direction of view with respect to port.

TABLE 11-3. BORESCOPE PHOTOGRAPH EXPOSURE TIMES

Borescope P/N	Port Location	Part	Direction of View	Exposure Time
9420M31G01	Compressor Casing	Stage 11 Blade		1 sec
9420M31G01	Combustion Chamber	Scroll	Directly forward	5 sec
9420M31G01	Combustion Chamber	Outer Shell		60 sec
9420M31G01	Combustion Chamber	HPT Nozzle	Directly aft	10 sec
9420M31G01	Combustion Chamber	HPT Nozzle	45° to engine axis	30 sec
9420M31G01	Igniter	Inner Shell		2 sec
9420M31G01	Igniter	HPT Nozzle	Directly aft	15 sec
BFOF-3827DD (Flexible)	Igniter	HPT Nozzle	(4 inches from nozzle)	1/15 sec
BFOF-3827DD (Flexible)	Igniter	HPT Nozzle	(1 inch from nozzle)	1/30 sec
BFOF-3827DD (Flexible)	Igniter	Stage 1 Turbine Blade	(Through nozzle partitions)	1/30 sec

SECTION XII
GROUND SUPPORT EQUIPMENT (GSE) MAINTENANCE

12-1. GENERAL.

12-2. This section includes procedures for the proper care and maintenance of GSE provisioned for intermediate maintenance of the YTF34 engine. GSE is listed in Section II.

12-3. CARE OF TOOLS WHILE IN USE.

1. Use plastic or rawhide (never metal) hammer heads when driving on any of the pushers. Apply force evenly to all bearing pushers or pullers.

2. Tighten jack screws, bolts, and nuts in small increments on opposite planes.

3. Wipe tools clean before using on the engine.

4. Always use the correct size wrench (or socket) to turn or tighten a tool, locknut, or bolt.

5. Never leave tools or gages on benches, airframes, etc., where they could fall and be damaged.

6. Lubricate tools in accordance with the requirements of paragraph 12-11.

12-4. CARE OF TOOLS IN STORAGE (PREVENTIVE MAINTENANCE).

1. Clean and lubricate all tools before returning them to the storage box or container.

2. Always store tools in their respective storage box or container (if provided); otherwise, store in a clean dry area.

12-5. CALIBRATION AND ADJUSTMENT OF TOOLS.

1. Use only calibrated tools.

2. Measuring type tools that have been dropped should be recalibrated before using.

12-6. SHIPMENT OF TOOLS.

1. Wipe tools with an oil-treated cloth before shipment.

2. Ship tools in their storage box or container (if provided). Package tools securely before shipment.

3. To prevent corrosion, include adequate bags of desiccant when shipping tools.

12-7. MAINTENANCE OF GROUND SUPPORT EQUIPMENT (GSE).

12-8. GENERAL.

This section contains instructions for servicing the tools. Because most of the tools are precision made, they must be periodically inspected, carefully handled, and properly maintained. Servicing is needed under the conditions described in paragraph 12-10.

12-9. SERVICING OF TOOLS.

12-10. WHEN TO SERVICE TOOLS. Knowing when to service tools is as important as knowing how to service them. It is important that these tools be removed from service when lubrication is required and when it is known, or there is reason to believe they:

- Are worn beyond usable limits.
- Were dropped or misused.
- Do not work properly.
- Were severely stressed during use.

12-11. LUBRICATION REQUIREMENTS. Tools requiring lubrication and the interval required are listed in table 12-1.

12-12. PROCEDURE.

1. Lightly lubricate all threads, splines, pivot points, external surfaces, bearings, and all wedging or pressure surfaces of tools, using oil, MIL-L-23699.

2. Wipe off excess oil.

12-13. INSPECTION REQUIREMENTS. Tools requiring periodic inspection to determine if they are in usable condition are listed in table 12-1.

12-14. PROCEDURE. Inspect tools for high metal, cracks, or other visible defects which might keep the tool from working properly. Tools having defects should either be replaced or repaired before using to avoid damage to engine parts.

12-15. PARTS REPLACEMENT. Tools that can be repaired by replacing certain parts are listed in tables 12-2 and 12-3. The replacement parts listed in these tables are not stocked but can be ordered from the vendors referenced by FSCM or FSN, if known.

12-16. REPLACEMENT OF QUICK-RELEASE PINS.

1. Center-punch head of holding-chain rivet.

2. Use a drill slightly smaller than rivet shank diameter, and drill down through rivet head. If rivet head did not break off after drilling, use a chisel and remove it.

3. Remove chain and quick-release pin.

4. Install a chain and rivet using a small hammer to lightly tap rivet into place.

5. Install new quick-release pin on chain. (Refer to table 12-1 for quick-release pin replacement data.)

12-17. REPAIR OF HYDRAULIC RAMS.

1. Disassemble the hydraulic ram following the sequence numbers of figure 12-1.

2. Refer to table 12-3 for repair kit data.

3. Reassemble ram in the reverse order of disassembly as shown in figure 12-1.

12-18. CADMIUM PLATE DETECTION TEST.

1. The following equipment is required to detect cadmium plated tools.

2. a. 2 medium dropper bottles.

b. Ammonium nitrate No. A676 (Fisher Scientific Co., Burlingame, Cal.)

c. Sodium Sulfide No. S425.

d. Filter paper.

2. Test for cadmium as follows:

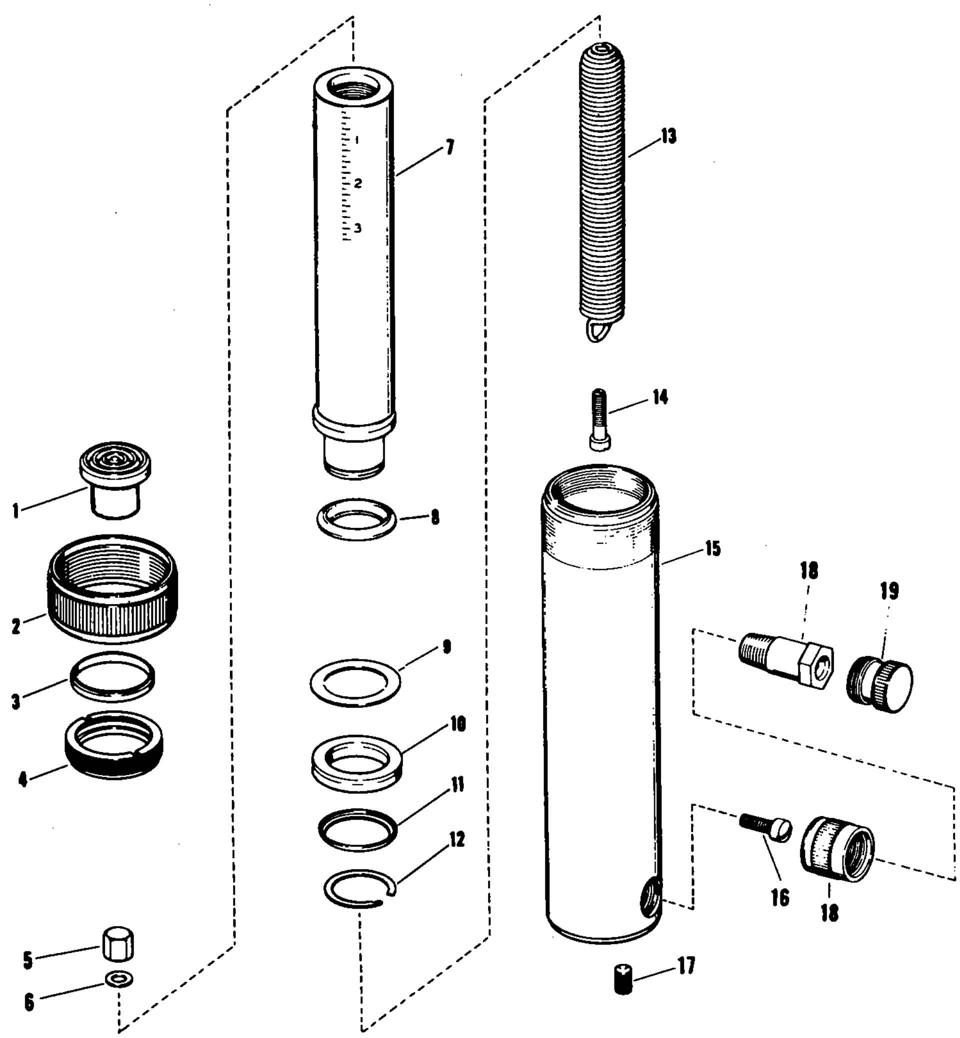
CAUTION

Do not allow ammonium nitrate (A676) to contact tools longer than 45 seconds.

a. Drop 1 or 2 drops of ammonium nitrate mixed with water onto tool being checked.

b. After 45 seconds, absorb the drops with the filter paper.

c. Drop 1 drop of 10% sodium sulfide (S425) onto the ammonium nitrate drops on the filter paper. If paper turns yellow, the tool is cadmium.



1. Saddle
2. Thread Protector
3. Wiper Ring
4. Stop Ring
5. Nut
6. Gasket
7. Plunger
8. Bearing
9. Backup Washer
10. U-Cup
11. Washer
12. Retaining Ring
13. Spring
14. Screw
15. Cylinder
16. Retaining Screw
17. Plug
18. Coupler Assembly
19. Dust Cap

TF34-0376

Figure 12-1. Typical Ground Support Equipment Hydraulic Ram - Exploded View

TABLE 12-1. TOOLS REQUIRING SERVICING

TOOL PART NUMBER	NOMENCLATURE	LUBRICATE PER PARAGRAPH 12-11 INTERVAL	INSPECTION (See Note)
21C5016	Adapter	30-days	3
21C5021	Puller	30-days	3
21C5024	Puller	Before use	3
21C5030	Pusher	30-days	3
21C5031	Fixture	30-days	3
21C5032	Gage	Before use	1,3
21C5033	Holder	30-days	3
21C5035	Stand	30-days	3
21C5037	Holder	30-days	3
21C5039	Stand	30-days	3
21C5041	Retainer	30-days	3
21C5042	Wrench	30-days	3
21C5043	Wrench	30-days	3
21C5044	Wrench	30-days	3
21C5049	Puller	30-days	3
21C5051	Kit	30-days	3
21C5052	Puller	30-days	3
21C5056	Puller	30-days	3
21C5060	Puller	Before use	3
21C5061	Puller	30-days	3
21C5064	Fixture	30-days	3
21C5065	Puller	30-days	3
21C5066	Pusher	30-days	3
21C5067	Casing	30-days	3
21C5079	Wrench	30-days	3
21C5081	Puller	30-days	3
21C5089	Fixture	30-days	3
21C5090	Puller	30-days	3
21C5095	Bar	Before use	3

TABLE 12-1. TOOLS REQUIRING SERVICING (Cont)

TOOL PART NUMBER	NOMENCLATURE	LUBRICATE PER PARAGRAPH 12-11 INTERVAL	INSPECTION (See Note)
21C5106	Guide	Before use	3
21C5125	Fixture	Before use	3
21C5133	Handle	30-days	3
21C5138	Puller	30-days	3
21C5142	Fixture	Before use	3
21C5159	Kit	30-days	3
21C5160	Pusher	30-days	3
21C5169	Guide	30-days	3
21C5174	Support	30-days	3
21C5175	Puller	30-days	3
21C5181	Support	30-days	3
21C5182	Support	30-days	3
21C5184	Puller	30-days	3
21C5187	Stand	30-days	3
21C5189	Support	30-days	3
21C5190	Support	See Note 2	3
21C5191	Pusher	Before use	3
21C5193	Wrench	30-days	3
21C5194	Wrench	30-days	3
21C5195	Wrench	30-days	3
21C5200	Adapter	30-days	3
21C5211	Adapter	30-days	3

Notes:

1. Maintain Gage Control.
2. Lubricate threads every 6 months with grease (MIL-G-25013).
3. Inspect tool per paragraph 12-13.

TABLE 12-2. QUICK-RELEASE PIN REPLACEMENT DATA

TOOL PART NO./ITEM	QUICK-RELEASE PIN NO.*	PIN-SIZE
21C5001G01	BLC3B08S	3/16 inch diameter x 0.8 inch long
21C5034G01	BLDC4R20	1/4 inch diameter x 2 inches long
21C5035G01	BLC6B07S	3/8 inch diameter x 0.7 inch long
	BLC4BA09S	1/4 inch diameter x 0.9 inch long
21C5039G01	BLC6B10S	3/8 inch diameter x 1 inch long
21C5043G01	BLC4B05S	1/4 inch diameter x 0.5 inch long
21C5089G02	BLC6B22S	3/8 inch diameter x 2 inches long
	BLC6B30S	3/8 inch diameter x 3.7 inches long
	BLC4B05S	1/4 inch diameter x 0.5 inch long
21C5101G01	BLC3B19S	3/16 inch diameter x 1.9 inches long
21C5106G01	BLC3B07S	3/16 inch diameter x 0.7 inch long
21C5125G01	BLC6B07S	3/8 inch diameter x 0.7 inch long
21C5174G01	BLC8B26S	1/2 inch diameter x 2.6 inches long
21C5187G01 and G02	BLC6B14S	3/8 inch diameter x 2.6 inches long
21C5188G01	BLC4BA10S	1/4 inch diameter x 1 inch long
21C5189G01	BLC7B16S	7/16 inch diameter x 1.6 inches long
21C5190G01	BLC7B16S	7/16 inch diameter x 1.6 inches long
21C5191G01	BLDC4R10	1/4 inch diameter x 1 inch long
21C5200G03	BLC12B25S	3/4 inch diameter x 2.5 inches long
	BLC12B27S	3/4 inch diameter x 2.7 inches long
	BLC8B63S	1/2 inch diameter x 6.3 inches long
	BLC8B20S	1/2 inch diameter x 2 inches long
21C5204G01	BLC3BA10S	3/16 inch diameter x 1 inch long
21C5210G01	BLC6B20S	3/8 inch diameter x 2 inches long
	BLC6B26S	3/8 inch diameter x 2.6 inches long
21C5220G01	BLC7B26S	7/16 inch diameter x 2.6 inches long

* Pins manufactured by AUDEL CORP., Burbank, California (FSCM 84256).

TABLE 12-3. GROUND SUPPORT EQUIPMENT HYDRAULIC RAM REPAIRABLE KIT DATA

TOOL NO.	HYDRAULIC RAM PART NO.*	REPAIR KIT PART NO.*	FSN
21C5021G01	RC53	RC53K	1 RM 4320-135-0800MN
21C5037G01	RC112	URC112	NSL
21C5051G01	RC53	RC53K	1 RM 4320-135-0800MN
21C5052G01	RC53	RC53K	1 RM 4320-135-0800MN
21C5056G01	RC53	RC53K	1 RM 4320-135-0800MN
21C5060G01	RC50	RC-4-K	NSL
21C5061G02	RC426	KRC426	NSL
21C5065G01	RWH-121	KRHS-121	NSL
21C5066G01	RWH-121	KRHS-121	NSL
21C5090G01	RC102	R-11-K-3	NSL
21C5138G01	RC53	RC53K	1 RM 4320-135-0800MN
21C5160G01	RWH-121	KRHS-121	NSL
21C5191G01	RC50	RC-4-K	NSL

* Manufactured by ENERPAC CORP., Butler, Wisconsin (FSCM 26952).

GLOSSARY

This glossary lists the first word of each term alphabetically, the way the term is used in the manual. Every effort has been made to include all the terms that might cause disagreement among those using this manual. However, certain terms may not be found if the instructions and procedures including those terms, were added too late to update the glossary.

Words in capital letters denote that it is a term described elsewhere in the glossary.

A

ABRASION -- A roughened surface.

ABRASIVE CLOTH -- A cloth coated with grit, used for abrading (cleaning, polishing, removing corrosion, and paint, etc) metal by hand.

ACCESSORY -- A self-contained unit, mounted on a higher assembly, designed to do a specific job. Fuel pumps, fuel controls, and like parts are typical accessories.

ADAPTER -- Any device that makes it possible to use parts or pieces of equipment that were not designed to be used together.

AEROSPACE GROUND EQUIPMENT (AGE) -- All nonairborne equipment such as that required to inspect, repair, assemble, and test parts to make them operational.

AIRFOIL -- In turboshaft engines, that part of a vane or blade that affects or is affected by the flow of air.

ASSEMBLY -- A unit normally removed and reassembled as a single item, consisting of accessories and components that operate together for a specific purpose. Typical assemblies are: engine, torque sensor shaft and sleeve assembly, power takeoff assembly.

AVERAGE DIAMETER -- A number found by adding several measurements, usually 3 or more, of the same diameter and dividing the sum by the number of measurements taken.

AXIAL -- Relating to the axis of a part.

AXIAL LOOSENESS -- The amount of looseness between parts that have a common center or whose axes are parallel.

AXIAL PLAY -- A term used mostly in bearing inspection to describe the total movement of the inner race relative to the outer race when a load is applied first in one direction and then in the other.

AXIAL MOVEMENT -- The distance that a part travels in an axial direction, relative to the axis of the part, when a load is applied first in one direction and then in the other.

AXIS -- An imaginary straight line through the center of a part, as in the case of a rotor, or through some feature of a part as in the case of a gearbox.

B

BACKLASH -- A term used to describe the distance that a working part has to move before it moves its mating part. The motion lost between two connected parts when the direction of motion is changed is also considered backlash. This loss of motion or looseness, is caused by design tolerances or by the wearing of working parts (such as clevis pin in rod-end bearing).

BENCH -- To do the work described in the term BENCHING.

BENCHING -- A general shop term that refers to a particular kind of work (stoning, grinding, filing, buffing, etc.) done by hand at a bench.

BENCH CHECK -- The action taken by maintenance for determining whether an accessory or component is working properly.

BEND -- Distortion in a part.

BLENDING -- An operation in which surfaces are worked by hand to produce a smooth surface without abruptly changing its contour.

BLISTER -- Raised portion of a surface separated from its base.

BLUEING -- A term that describes the bluish color on the surfaces of some metals exposed to high temperatures.

BODY-BOUND BOLT -- A bolt used to keep mating parts from moving sideways. The size of the body is held to a close tolerance so that it will fit tightly in the hole in the mating parts.

BORE -- A hole made by machining with a boring tool.

BOSS -- A raised portion of a casting or forging generally used as a seating surface to keep another part from the main body of the part.

BREAK -- Separation of part.

BRINELLING -- Surface indentations.

BRITTLENESS -- Loss of resiliency.

BUCKLING -- Large deformation of contour.

BULGE -- An area on a SHEET METAL part that has swelled outward.

BURNISHING -- Smoothing of a metal surface, but with no loss of material.

BURN-THROUGH -- A portion of PARENT METAL, usually sheet metal, that has burned through leaving a hole.

BURR -- A rough or sharp edge on a hole or corner, usually caused by machining, sometimes by wearing.

C

CALIBRATE -- The work done in testing and/or adjusting an instrument or accessory to known standards.

CAPTIVE NUT -- A nut permanently attached to a piece of equipment.

CHAFING -- A worn or rubbed area caused by friction; refers to the wear produced by parts such as fuel and air lines rubbing against other parts.

CHAMFER -- A beveled edge, usually made by machining, sometimes by forming.

CHASE THREADS -- To remove high spots, dirt, etc. from threads, using a hand tap or hand die.

CHATTER MARK -- Surface irregularity.

CHIPPING -- Breaking away of metallic particles.

CHORD -- A straight line drawn between the leading and trailing edges of an airfoil.

CHORDAL LENGTH -- The distance between the leading and trailing edges of an airfoil.

COCKED -- A term generally used to describe a condition in which close-fitting parts are not square with one another either before or after being assembled.

COKING -- Carbon-like deposits (caused by improperly burned fuel) left on parts in hot section of engine.

COLD-WORK -- To rework metal parts at normal room temperature, using hand tools. The removal of dents in sheet metal parts and the enlargement of louvers in liners are examples of COLD-WORKING.

COLD-WORKING -- The work done in re-forming or reshaping a part, using hand tools. See COLD-WORK.

CONFIGURATION -- A term referring to the form, shape, or contour of a part or parts.

CONCENTRIC -- Outside or inside diameters of different size but which have the same center or axis are called concentric.

CORROSION -- Formation of small pits.

COKING -- Carbon deposits.

CRACK -- Parting of parent metal.

CRAZING -- A mesh of very small hairlike cracks found in glazed or baked-on coated surfaces, generally caused by temperature changes or by deformation of PARENT METAL. Cracks do not penetrate into parent metal.

COMPONENT -- A unit somewhat similar to an accessory in that it is self-contained but differing in that it is designed to control operations. Valves, switches, solenoids, etc, are typical components.

CONCAVE -- A hollow surface curved like the inside of a bowl.

CONTAMINATION (FOREIGN MATERIAL) -- Any foreign substance such as metal chips, lint, rust, and water that would be harmful to the functioning of a part or system.

CONVEX -- A surface shaped like the outside of a sphere or a ball.

COPPER BACKUP -- A copper block, shaped to suit part being repaired, used during welding to take away some of the heat.

D

DENT -- Smooth surface cavity.

DESICCANT -- A drying agent, usually placed in containers along with parts being stored, to absorb moisture and prevent rusting.

DIAMETER -- The length of a chord passing through the center of a circle.

DIAMETRAL -- Referring to the DIAMETER.

DIAMETRAL RUNOUT -- The total indicator reading of an indicator in contact with a cylindrical or conical surface when the piece or indicator is rotated 360 degrees about an established axis. This includes both eccentricity and out-of-roundness.

DOWEL PIN -- A pin pressed or tapped into a reamed hole through two parts, so that about 1/2 of its length is in each part. Principally used to make it possible to accurately realign parts.

DROP -- The distance that one surface is below another parallel surface.

DISTORTION -- Twisting or bending out of a normal, natural,or original shape, usually caused from being exposed to excessive pressure or temperature either when restrained or unrestrained.

DEFORMATION -- A change in the natural form or shape of a part, usually of a permanent nature.

DRIFT -- A flat, tapered piece of steel used to remove tapered shank drills and other tools from their holder.

DEFECT -- A general term covering any flaw affecting the usefulness or serviceability of a part.

DISHING -- The CONCAVE shape taken by a normally flat surface, usually after being subjected to excessive pressures.

DYNAMIC-BALANCE -- To determine the area of unbalance of a rotating part so that material can be removed or added to make part run without vibration.

DEMINERALIZED WATER -- Water from which minerals such as salt, lime sulphur etc. have been removed, usually by distilling or boiling.

E

ELECTROLYTIC ACTION -- Surface breakdown.

ENTRANCE THREAD -- The first or lead thread in a tapped hole or in a nut.

EROSION -- Wearing away of material.

ETCHING -- The process of treating the surface of a part with acid to expose and exaggerate the surface conditions of the metal.

EXCESSIVE -- Too much, more than is allowable or necessary.

EXTERNAL COMPONENT -- A COMPONENT attached to the outside of the engine.

F

FACE RUNOUT -- The total reading on an indicator measuring the runout on the face of a part rotating about an established axis.

FATIGUE FAILURE -- Progressive yielding to repeated stress.

FILLET WELD -- A weld having a triangular cross-section, usually joining two surfaces at right angles to one another.

FILLER METAL -- The metal used, usually in rod form, in making a weld.

FIT -- The amount of tightness or looseness between mating parts when assembled together.

FLAKING -- Breaking away of paint or plate.

FLATNESS -- See OUT-OF-FLATNESS.

FLUSH -- A shop term used in describing two surfaces that are even with each other. The term is also used to describe the washing or cleaning of chips or dirt by pressure flushing. See PRESSURE - FLUSH.

FOREIGN MATERIAL -- See CONTAMINATION.

FOREIGN OBJECT -- Any object such as a tool, piece of equipment, engine part (nut, bolt, lockwire),that could in any way damage the engine.

FRACTURE -- See BREAK.

FREE STATE VARIATION-- The amount that a part (bolted or tightly held to another part) may distort after being removed or after being released from a fixture (as when machining).

FRET CORROSION -- Oxidation (rusting) of metal, usually bearings, that takes place at loaded surfaces subjected to relatively slight motion.

FRETTING -- Loss of metal.

FRAYING -- Wearing or rubbing of areas, generally used in reference to damage on wire-braid covering (of Teflon hose) or on thermocouple harnesses.

G

GALLING -- Accumulation of foreign material.

CAP -- An opening or space; a break in continuity.

GAS BACKING -- Gas, usually argon, used to back up a joint during welding to keep oxygen away from the weld and help get a sound weld at the root.

GLAZING -- A hard, glossy surface.

GOUGING -- Wide, rough scratches.

GROOVING -- Continuous channels having no sharp edges.

H

HANG UP -- Failure of an engine to accelerate to the speed at which the throttle has been set.

HARDWARE -- Miscellaneous nuts, bolts, studs, washers etc. used as fasteners.

HIGH METAL -- Displaced metal next to a defect such as a scratch, nick or a gouge.

HOT SPOT -- A condition caused by a defective fuel nozzle (poor spray patterns) causing fuel to burn unevenly in the combustion chamber, which caused metal on outside of combustion casing to turn blue.

I

INCLUSION -- Foreign material impressed into a surface.

INTERFERENCE -- Anything that prevents a part, component, etc. from being assembled or disassembled.

J

JACKING HOLES -- Threaded holes through which JACKING SCREWS are threaded to force off a tight-fitting part that would otherwise be difficult to remove. They serve no other purpose.

JACKING SCREW -- A screw used in JACKING HOLES to remove a tight-fitting part from another.

K

KINKS -- Short, tight twists or curls caused by a doubling or winding of a hose or line upon itself. Likely to cause difficulties in the operation of something.

KIT -- A group or set of parts or tools usually used for repair or replacement of worn or damaged assemblies.

L

LAMINATED -- Consisting of layers of material, each of identical thickness, such as certain kinds of shims.

LAPPING -- Smoothing or polishing two surfaces, with or without abrasives, to a high degree of accuracy, until a very close fit is produced.

M

MANUFACTURED HEAD -- On a rivet, the head formed by the manufacturer.

MAP -- Doing the work described in MAPPING.

MAPPING -- Layout out parts, usually blades, so that they are in the same relative position on a mapping sheet that they were in the engine.

MATCHMARK -- A mark made on the surfaces of two or more mating parts so that they can be re-aligned to these marks at reassembly.

MATCH-MARK -- Doing the work described in MATCHMARK.

MATCHED -- Fitted together or made suitable to be fitted together.

MATING SURFACES -- Two surfaces that join or fit together.

MICROINCH -- One millionth of an inch; largely used in measuring imperfections of surface finishes.

MICRON -- A unit of length in the metric system equal to 0.001 millimeter.

N

NICK -- Sharp indentations.

O

OF NO APPARENT DEPTH -- A term which means the depth of a defect (nick, dent, scratch, or pit) is, after visually inspecting, so slight that it would not be worth measuring.

ORIFICE -- A small-diameter hole, machined to close tolerances, used to accurately control the flow of fluid or air through accessories and components, especially in fuel and oil systems.

OUT-OF-FLATNESS -- The total amount that a surface deviates from a true, flat surface.

OUT-OF-ROUNDNESS -- Total variation, in a radial direction, from a true circle. When measured with an indicator, it is the total indicator reading when the part is rotated 360°; when measured with a micrometer, it is one-half the total difference between the maximum and minimum diameters.

P

PARENT METAL -- The basic metal of a part, sometimes referred to as base metal; the term is used particularly in connection with welding, where the parent metal is that being welded rather than that used in the welding rod.

PEENING -- Surface deformation.

PICKUP -- Transfer of one material onto another.

PITTING -- Very shallow depressions in a surface, usually caused by chemical reaction (rusting chemical corrosion).

PRESSURE-FLUSH -- To force a liquid (water, solvent) under pressure through all inside passages or over the outside of a part to wash it clean.

R

RADIAL CRACK -- A crack that runs perpendicular to the axial centerline of the engine.

ROUTE -- Doing what is described in ROUTING.

ROUTING - The path usually taken by lines, hoses, etc. on the outside of engine connecting the various fittings.

RUN-ON TORQUE -- The torque required to screw a self-locking nut onto a thread until threads are fully engaged.

RUNOUT -- See DIAMETRAL RUNOUT and FACE RUNOUT.

S

SCORING -- Deep scratches.

SCRATCH -- Long narrow impression.

SEAM -- A surface discontinuity.

SEIZURE -- A wedging or binding of two surfaces, which prevents further movement.

SETUP -- A general term used to describe the work done in setting up tools, fixtures, etc. to do a specific job.

SHEET METAL -- Rolled metal up to one-quarter inch thick; the type used in making fabricated parts such as nozzles, turbine casings, etc.

SOAK TIME -- The period of time in which parts are kept in a bath of liquid.

SPALLING -- Sharply roughened area.

STAKING -- An operation in which the metal around a pin or shaft or the end of pin (or shaft) itself is displaced to hold part firmly in place.

STATIC BALANCE -- An operation, usually done before dynamic balancing, in which blades are shifted or weight is added, depending on the assembly being balanced, to eliminate unbalance.

STOP-DRILL -- Drilling a small-diameter hole in the end of a crack, usually in sheet metal parts, to keep it from getting longer.

STRESS -- A cause of part failures.

SUBASSEMBLY -- A self-contained unit of an ASSEMBLY that can be removed, replaced and repaired separately. Turbine nozzles and combustion liners are typical subassemblies.

SURFACE FINISH -- A shop term that refers to surface roughness. Surface roughness, a standard term used in industry to accurately express the degree of roughness of a surface, is expressed in microinches. In the text, the allowable surface finish is given in microinches. But on an illustration, the symbol is used, as in the following example: 63 . The apex of the symbol is always shown touching the surface in question.

T

THROUGH-CRACK -- A crack, usually V-shaped and relatively narrow, deep enough to penetrate the total thickness of the parent metal.

TIP-SHAKE -- The amount that the tip of a blade can be moved (circumferentially) by hand.

TOLERANCE -- The range of variation allowed in maintaining a specified dimension in making a part.

TORQUE -- To tighten a nut, bolt, or fitting, using a torque wrench, to a specified torque value expressed as lb in. or as lb ft.

TOTAL INDICATOR READING (TIR) -- Is the total movement of the pointer of an indicator when measuring the amount of OUT-OF-ROUNDNESS, OUT -OF-FLATNESS or other deviations of a part.

TRUE CONTOUR -- The basic shape of a surface.

U

UNBALANCE -- Unequal distribution of weight about the axis of rotation; usually results in vibration.

UPSET HEAD -- On a rivet, the head formed after the body has been inserted through the holes of the pieces being held together.

W

WEAR -- Removal of parent material.

WARPED -- Not true to an established plane or line; out of true shape.

WELD -- Metal fused by heating, with or without pressure applied, with or without using filler material. See WELD BEAD.

WELD BEAD -- A deposit of weld made when the bare electrode melts during arc welding.

WELDMENT -- An assembly made up of parts joined by welding.

Alphabetical Index

HOW TO USE THIS INDEX

IMPORTANT: READ THE FOLLOWING INFORMATION BEFORE USING INDEX.

1. ENGINE COMPONENTS ARE LISTED IN ALPHABETICAL ORDER BY THEIR IDENTIFYING NOUN, FOLLOWED BY ITS MODIFIER.

Example:

THIS	NOT THIS
CASING-Compressor	COMPRESSOR-Casing
FILTER-Oil	OIL-Filter
LINER-Combustion	COMBUSTION-Liner
ROTOR-High-Pressure	HIGH-PRESSURE-Rotor
SEAL-Carbon	CARBON-Seal

Note

SOME CROSS REFERENCING IS GIVEN IN CASES WHERE THE SECONDARY WORD MIGHT BE THOUGHT OF FIRST, SUCH AS THERMOCOUPLE HARNESS INSTEAD OF HARNESS. UNDER THERMOCOUPLE HARNESS WILL BE LISTED THE CROSS REFERENCE TO HARNESS.

2. AFTER A COMPONENT HAS BEEN LOCATED, LOOK UP THE DESIRED MAINTENANCE FUNCTION AS LISTED BELOW EACH COMPONENT.
EXAMPLE: ASSEMBLY, DISASSEMBLY, INSTALLATION, ETC.

3. LOCATE EACH ITEM USING PARAGRAPH NUMBER LISTED NEXT TO EACH FUNCTION.

ALPHABETICAL INDEX (cont)

ALPHABETICAL INDEX (cont)

ALPHABETICAL INDEX (cont)

ALPHABETICAL INDEX (cont)

ALPHABETICAL INDEX (cont)

ALPHABETICAL INDEX (cont)

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ALPHABETICAL INDEX (cont)

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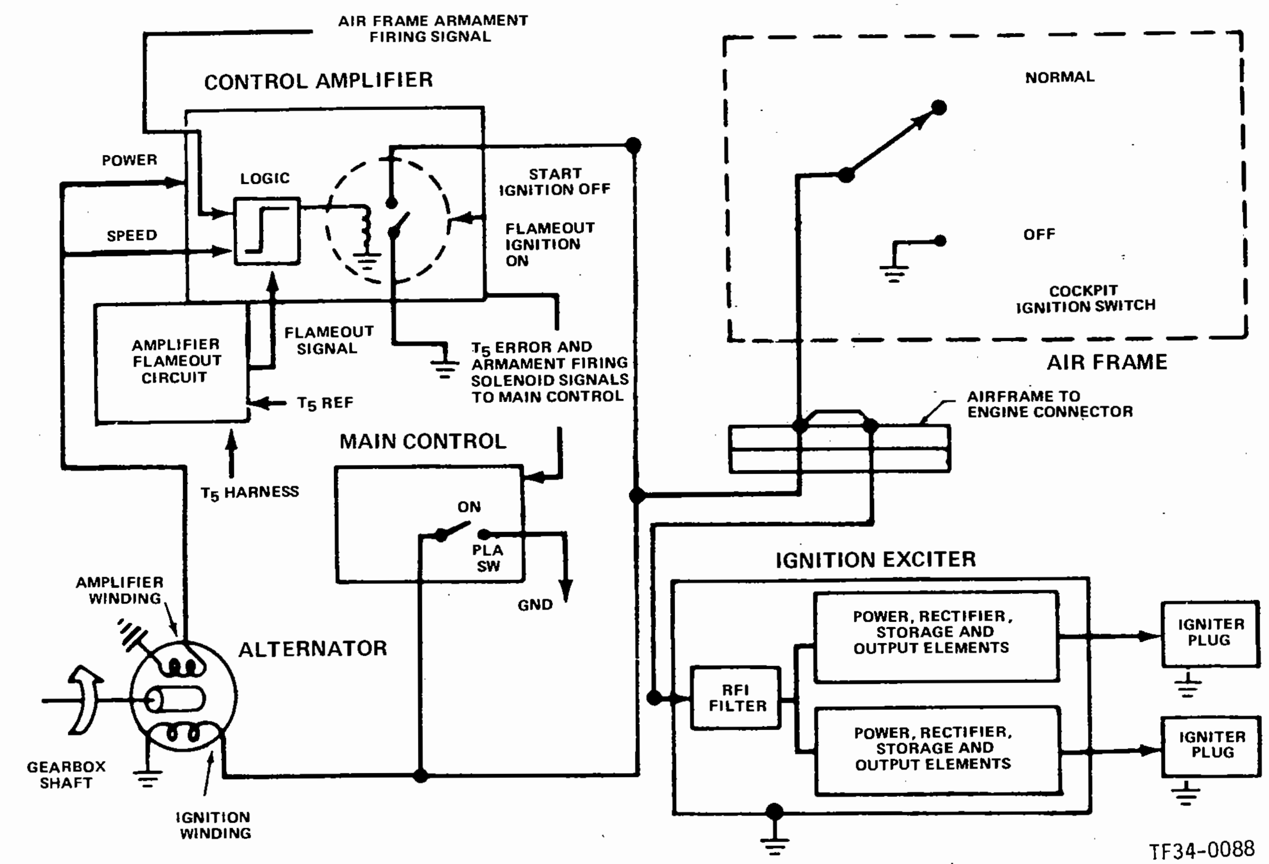


Figure 9-5. Ignition System Schematic Diagram

Ignition circuit connections are provided for wiring external to the engine as shown in figure 9-4.

9-31. The ignition exciter, mounted near the aft flange of the front frame, produces the electrical energy needed to create the spark required to start combustion. The fuel-air mixture in the combustion chamber is ignited by the spark produced at the igniter plugs which protrude into the combustion chamber. Sparking is required during the starting cycle armament firing and any time the engine flames out. The exciter requires a 15 volts RMS 400Hz ac input and has a maximum output of 2 Joule.

9-32. For normal (automatic) ignition system operation, the external (aircraft cockpit) circuit must be completed. Engine ignition will be provided during ground and air starts when the control power lever is advanced beyond 10 degrees and when speed has reached 1600 RPM. Ignition ceases automatically when gas generator speed exceeds 8500 RPM.

9-33. When external circuit as described in paragraph 9-32, ignition ceases automatically when the signal from the automatic ignition actuator ceases, or when gas generator speed exceeds 8500 RPM, whichever occurs later. Also, automatic ignition will occur when the control amplifier senses a T5 error exceeding 800°F from PLA requested T5. The ignition logic within the amplifier turns the ignition system "On" whenever speed is below the idle ignition cutout speed of 8500 RPM and ignition will continue until the T5 error signal is reduced to less than 800°F.

9-34. To accommodate rocket gas ingestion, the ignition system can be automatically activated during armament firing. Airframe supplied cockpit controls are required. When the pilot degresses the trigger, the variable compressor stators are reset to low speed condition, the fuel flow is decreased to low flow and ignition is automatically turned ON. When the pilot releases the trigger, there is one second time delay built into the control amplifier for variable stator reset and fuel flow reset. Ignition will go off simultaneously with release of the trigger unless the 800°F error signal exists.

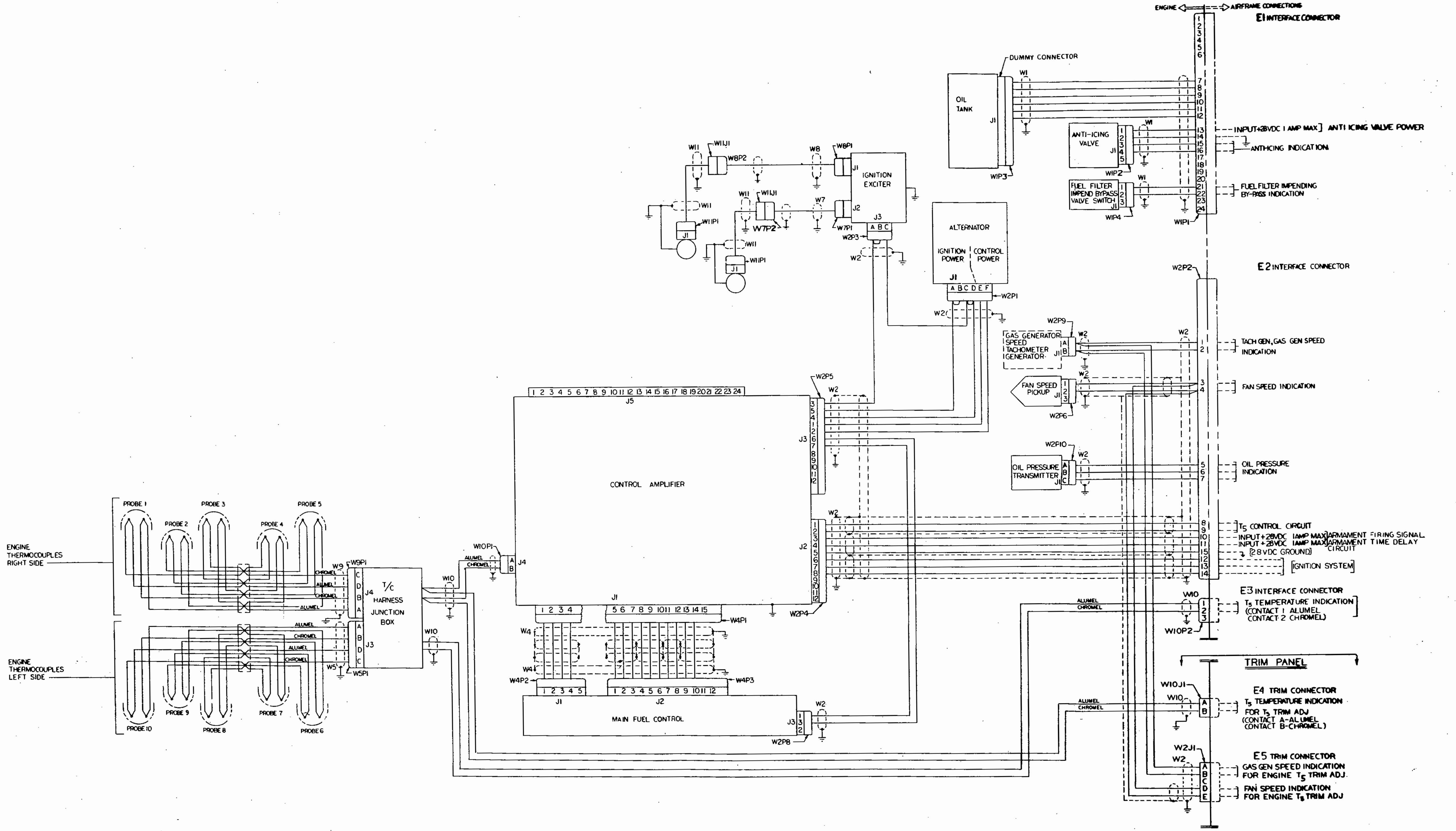


Figure 9-4. Electrical System Wiring Diagram

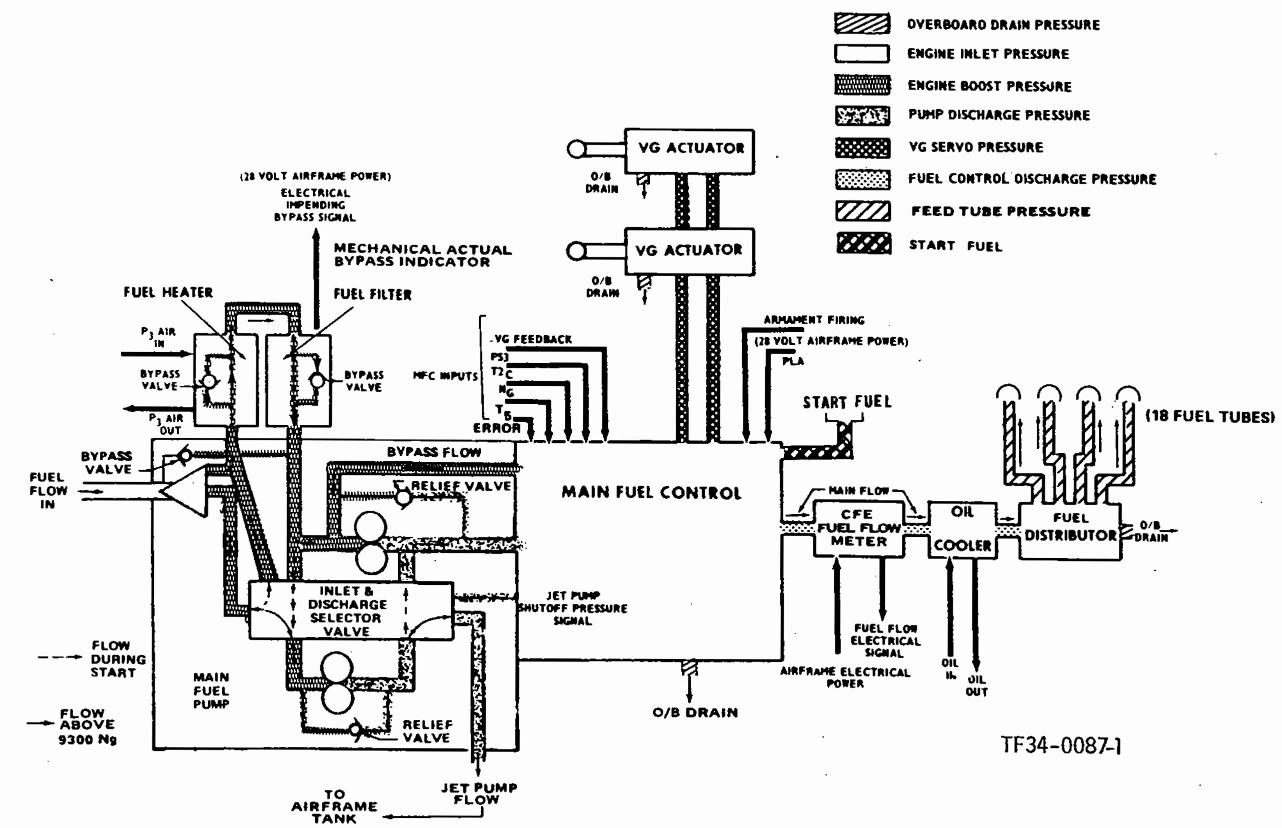


Figure 9-2. Fuel System Schematic Diagram

all power settings but T5 monitoring is required due to possible overtemperature depending on PLA, bleed, and horsepower extraction. No external electrical power requirements are associated with this system.

9-20. The fuel control contains two essentially independent means of protecting the high pressure turbine from possible overspeed. First, the normal speed intelligence to the computer section of the fuel control coupled with specially designed slopes in the overspeed region of the acceleration fuel schedules results in a high gain Wf/Ps3 governor which limits overspeed as a function T2c to a value less than maximum allowable transient speed. Thus, a failure in the Ng speed-governing mechanism will not cause excessive overspeed if the computer section is still functioning. The second feature in the control provides overspeed protection in the event of computer failures or metering valve servo failures which call for high fuel flow by opening the control bypass valve and reducing engine fuel flow. Maximum P3 will be limited by the control to prevent the engine compressor discharge pressure level from exceeding 335 psia at high ram conditions or low engine inlet temperatures by reducing fuel flow. In summary:

1. The control system sets the engine power by means of a single power control shaft.

2. The fuel control schedules acceleration fuel flow as a function of compressor inlet total temperature (T2c), compressor discharge pressure (Ps3), and compressor speed (NG).

3. The fuel control schedules deceleration fuel flow as a percentage of the acceleration schedule.

4. The fuel control provides minimum and maximum physical fuel flow limits.

5. The fuel control provides positive mechanical shutoff of fuel flow to the engine.

6. The fuel control provides high pressure turbine overspeed protection.

7. The fuel control provides a reset of the Idle speed schedule as a function of P3 and T2c.

8. A limiter in the control prevents the P3 signal from increasing above a set value.

9. The fuel control provides a windmill bypass valve to limit the control fuel discharge pressure during stopcocking.

10. In the high power range, an electrical signal to the control, which is a function of PLA scheduled fan turbine inlet temperature (ITT), resets the fuel flow setting in the fuel control to maintain the desired ITT.

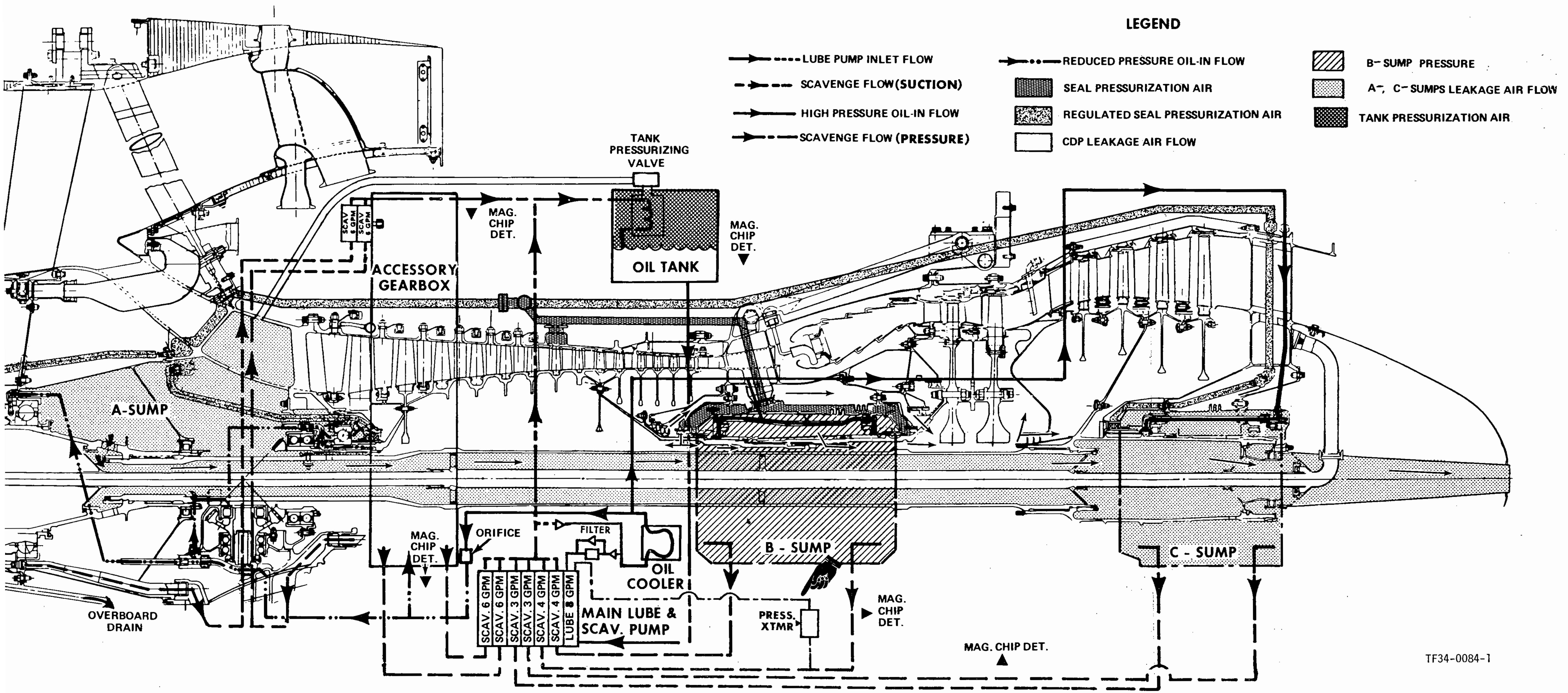


Figure 9-1. Lubrication System Schematic Diagram

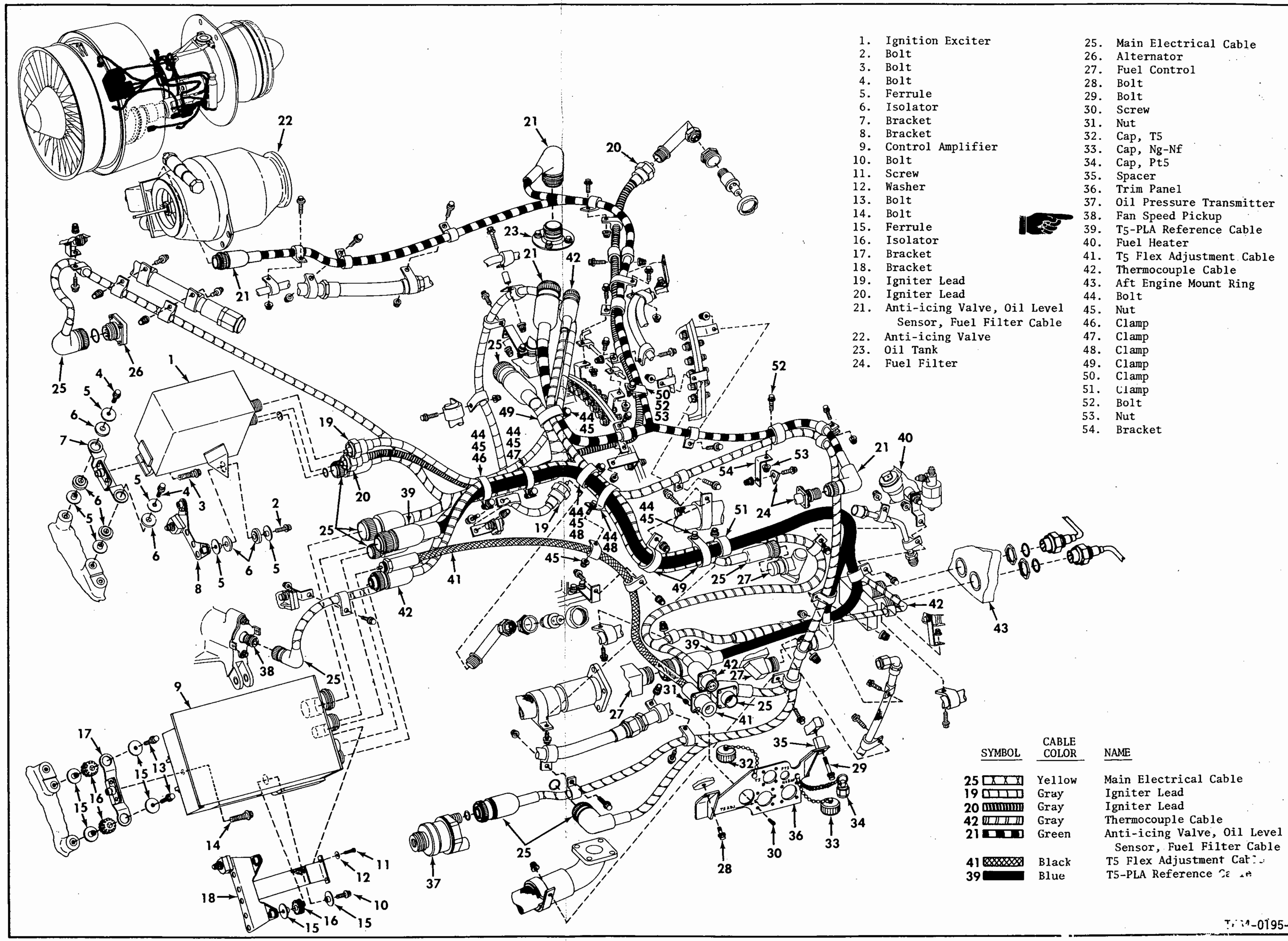


Figure 4-5A. Electrical System Orientation

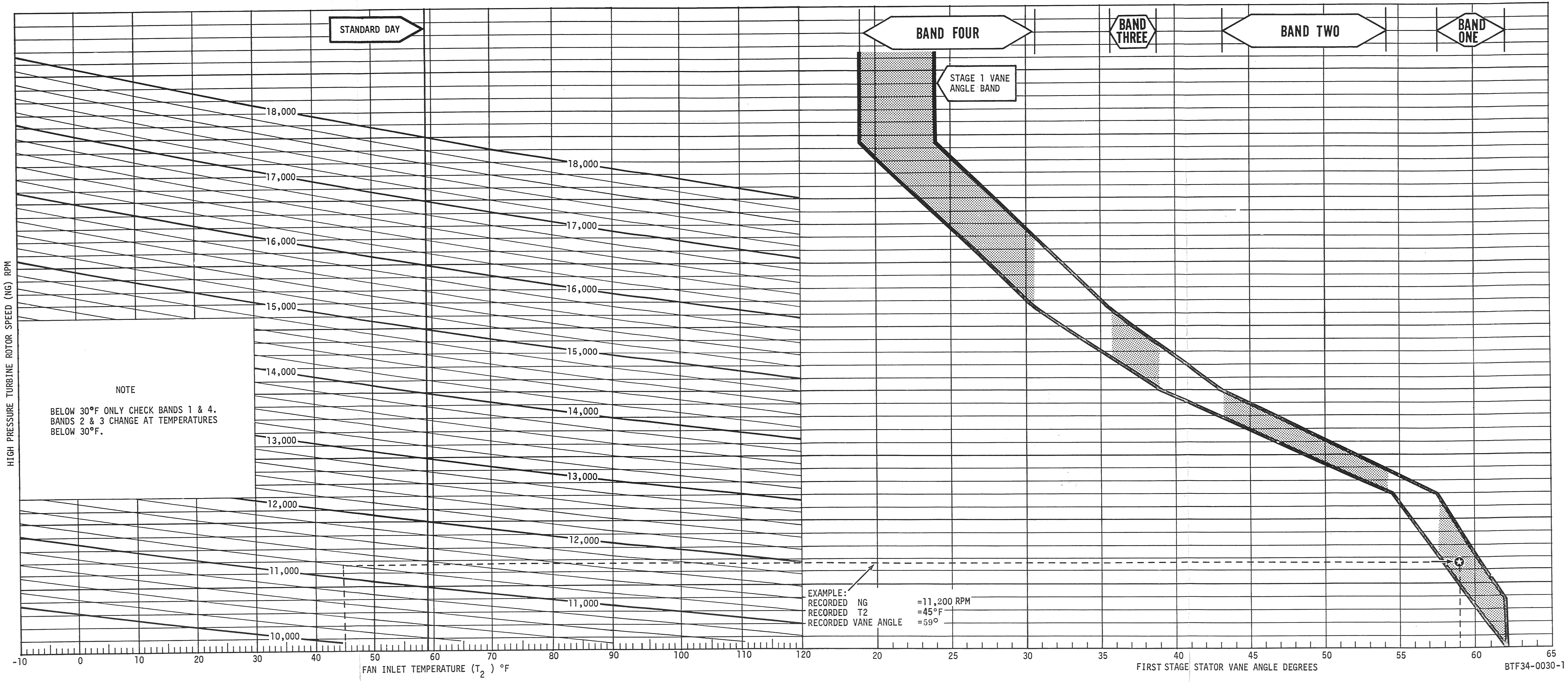
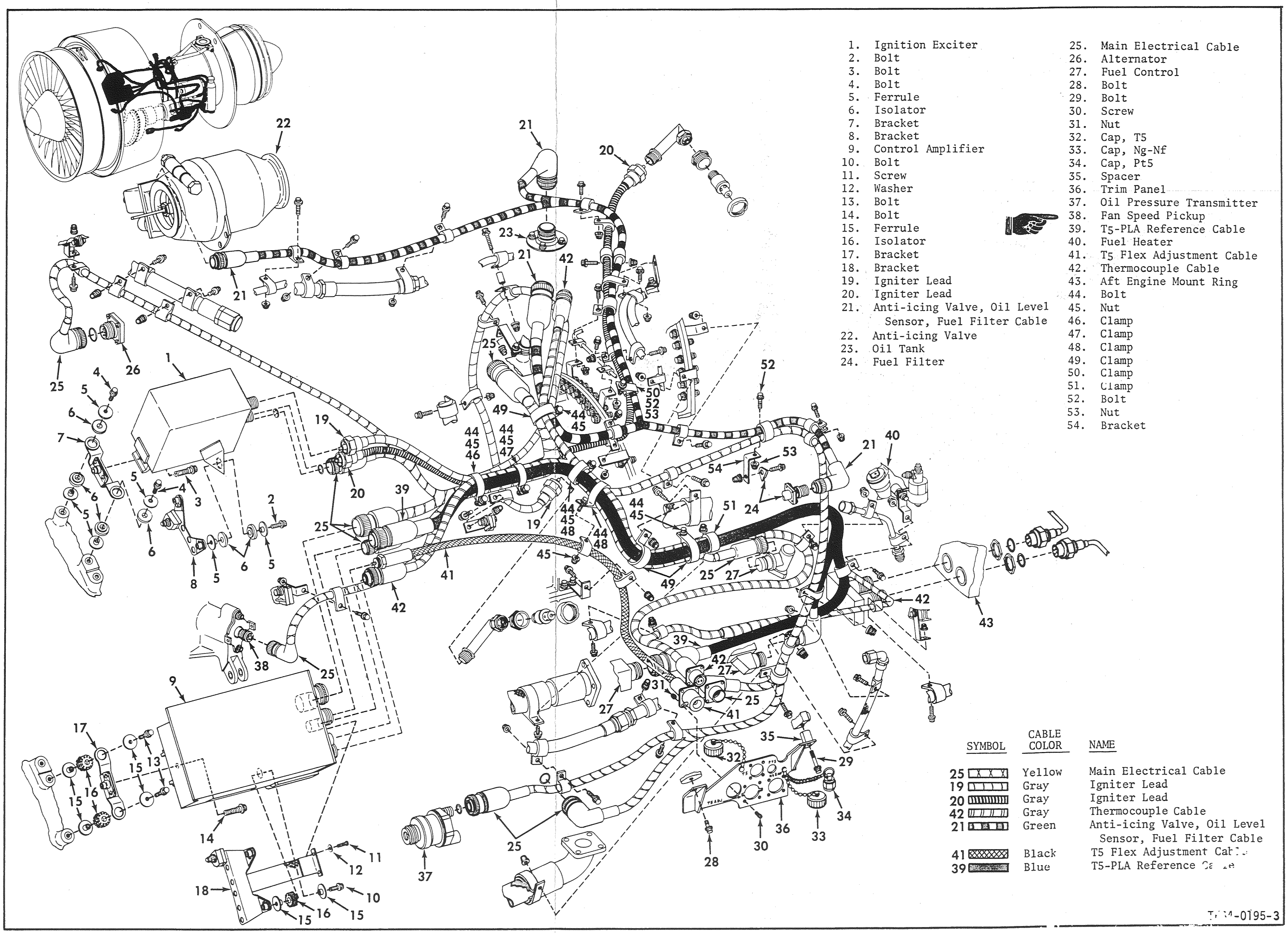


Figure 10-4. Vane Angle Tracking Curve



1. Ignition Exciter
2. Bolt
3. Bolt
4. Bolt
5. Ferrule
6. Isolator
7. Bracket
8. Bracket
9. Control Amplifier
10. Bolt
11. Screw
12. Washer
13. Bolt
14. Bolt
15. Ferrule
16. Isolator
17. Bracket
18. Bracket
19. Igniter Lead
20. Igniter Lead
21. Anti-icing Valve, Oil Level Sensor, Fuel Filter Cable
22. Anti-icing Valve
23. Oil Tank
24. Fuel Filter
25. Main Electrical Cable
26. Alternator
27. Fuel Control
28. Bolt
29. Bolt
30. Screw
31. Nut
32. Cap, T5
33. Cap, Ng-Nf
34. Cap, Pt5
35. Spacer
36. Trim Panel
37. Oil Pressure Transmitter
38. Fan Speed Pickup
39. T5-PLA Reference Cable
40. Fuel Heater
41. T5 Flex Adjustment Cable
42. Thermocouple Cable
43. Aft Engine Mount Ring
44. Bolt
45. Nut
46. Clamp
47. Clamp
48. Clamp
49. Clamp
50. Clamp
51. Clamp
52. Bolt
53. Nut
54. Bracket

SYMBOL	CABLE COLOR	NAME
25	Yellow	Main Electrical Cable
19	Gray	Igniter Lead
20	Gray	Igniter Lead
42	Gray	Thermocouple Cable
21	Green	Anti-icing Valve, Oil Level Sensor, Fuel Filter Cable
41	Black	T5 Flex Adjustment Cable
39	Blue	T5-PLA Reference Cable

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Figure 4-5A. Electrical System Orientation

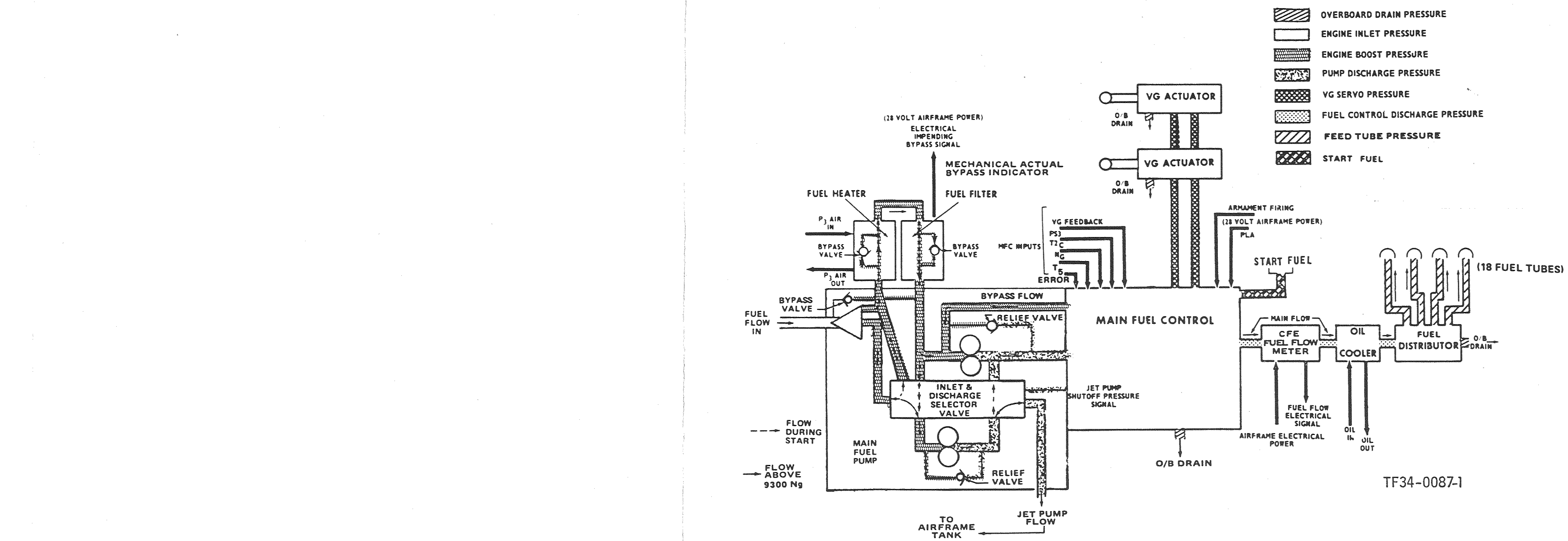

Figure 9-2. Fuel System Schematic Diagram

all power settings but T5 monitoring is required due to possible overtemperature depending on PLA, bleed, and horsepower extraction. No external electrical power requirements are associated with this system.

9-20. The fuel control contains two essentially independent means of protecting the high pressure turbine from possible overspeed. First, the normal speed intelligence to the computer section of the fuel control coupled with specially designed slopes in the overspeed region of the acceleration fuel schedules results in a high gain Wf/Ps3 governor which limits overspeed as a function T2c to a value less than maximum allowable transient speed. Thus, a failure in the Ng speed-governing mechanism will not cause excessive overspeed if the computer section is still functioning. The second featu: e in the control provides overspeed protection in the event of computer failures or metering valve servo failures which call for high fuel flow by opening the control bypass valve and reducing engine fuel flow. Maximum P3 will be limited by the control to prevent the engine compressor discharge pressure level from exceeding 335 psia at high ram conditions or low engine inlet temperatures by reducing fuel flow. In summary:

1. The control system sets the engine power by means of a single power control shaft.

2. The fuel control schedules acceleration fuel flow as a function of compressor inlet total temperature (T2c), compressor discharge pressure (Ps3), and compressor speed (NG).

3. The fuel control schedules deceleration fuel flow as a percentage of the acceleration schedule.

4. The fuel control provides minimum and maximum physical fuel flow limits.

5. The fuel control provides positive mechanical shutoff of fuel flow to the engine.

6. The fuel control provides high pressure turbine overspeed protection.

7. The fuel control provides a reset of the Idle speed schedule as a function of P3 and T2c.

8. A limiter in the control prevents the P3 signal from increasing above a set value.

9. The fuel control provides a windmill bypass valve to limit the control fuel discharge pressure during stopcocking.

10. In the high power range, an electrical signal to the control, which is a function of PLA scheduled fan turbine inlet temperature (ITT), resets the fuel flow setting in the fuel control to maintain the desired ITT.

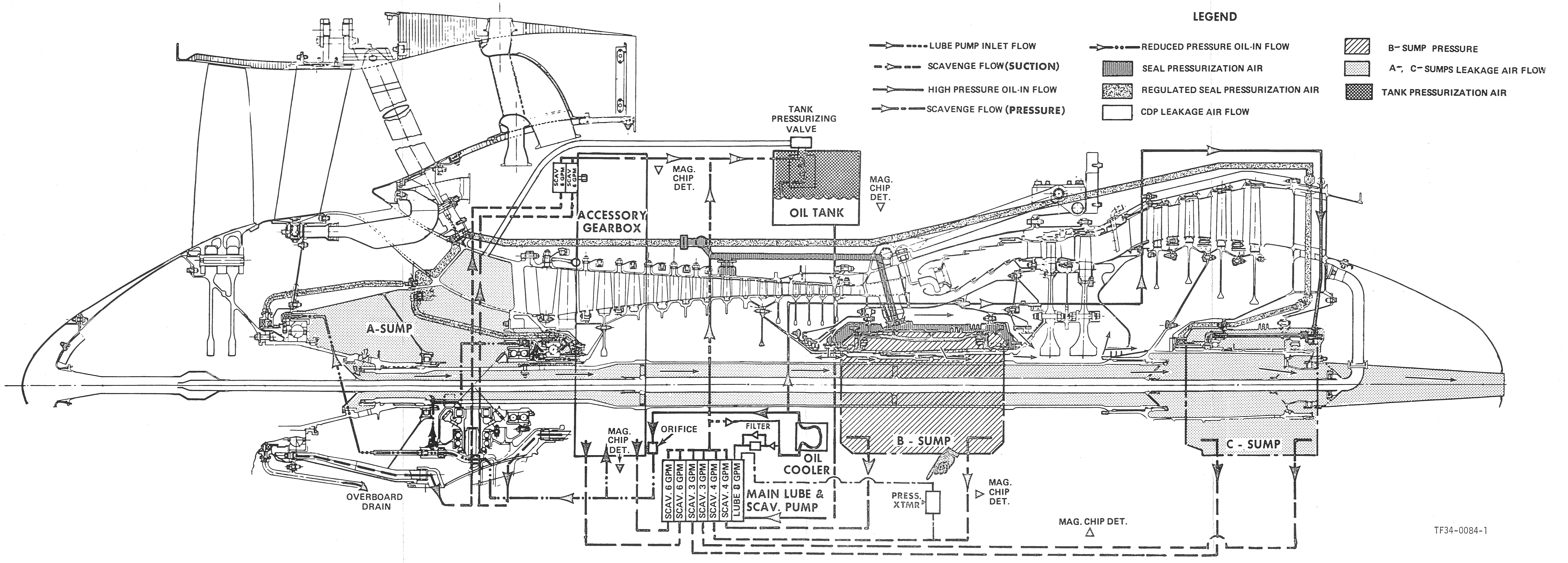

Figure 9-1. Lubrication System Schematic Diagram

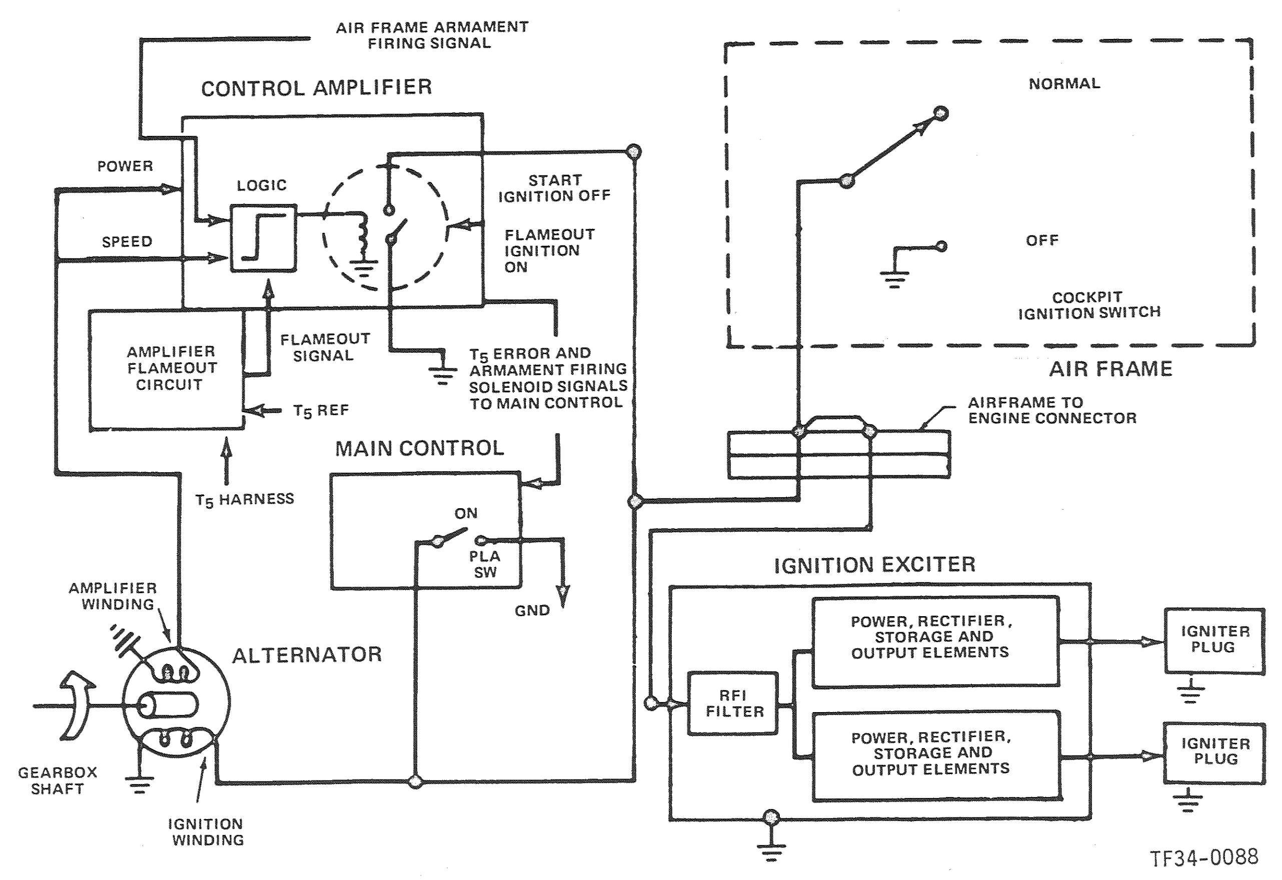

Figure 9-5. Ignition System Schematic Diagram

Ignition circuit connections are provided for wiring external to the engine as shown in figure 9-4.

9-31. The ignition exciter, mounted near the aft flange of the front frame, produces the electrical energy needed to create the spark required to start combustion. The fuel-air mixture in the combustion chamber is ignited by the spark produced at the igniter plugs which protrude into the combustion chamber. Sparking is required during the starting cycle armament firing and any time the engine flames out. The exciter requires a 15 volts RMS 400Hz ac input and has a maximum output of 2 Joule.

9-32. For normal (automatic) ignition system operation, the external (aircraft cockpit) circuit must be completed. Engine ignition will be provided during ground and air starts when the control power lever is advanced beyond 10 degrees and when speed has reached 1600 RPM. Ignition ceases automatically when gas generator speed exceeds 8500 RPM.

9-33. When external circuit as described in paragraph 9-32, ignition ceases automatically when the signal from the automatic ignition actuator ceases, or when gas generator speed exceeds 8500 RPM, whichever occurs later. Also, automatic ignition will occur when the control amplifier senses a T5 error exceeding 800°F from PLA requested T5. The ignition logic within the amplifier turns the ignition system "On" whenever speed is below the idle ignition cutout speed of 8500 RPM and ignition will continue until the T5 error signal is reduced to less than 800°F.

9-34. To accommodate rocket gas ingestion, the ignition system can be automatically activated during armament firing. Airframe supplied cockpit controls are required. When the pilot degresses the trigger, the variable compressor stators are reset to low speed condition, the fuel flow is decreased to low flow and ignition is automatically turned ON. When the pilot releases the trigger, there is one second time delay built into the control amplifier for variable stator reset and fuel flow reset. Ignition will go off simultaneously with release of the trigger unless the 800°F error signal exists.

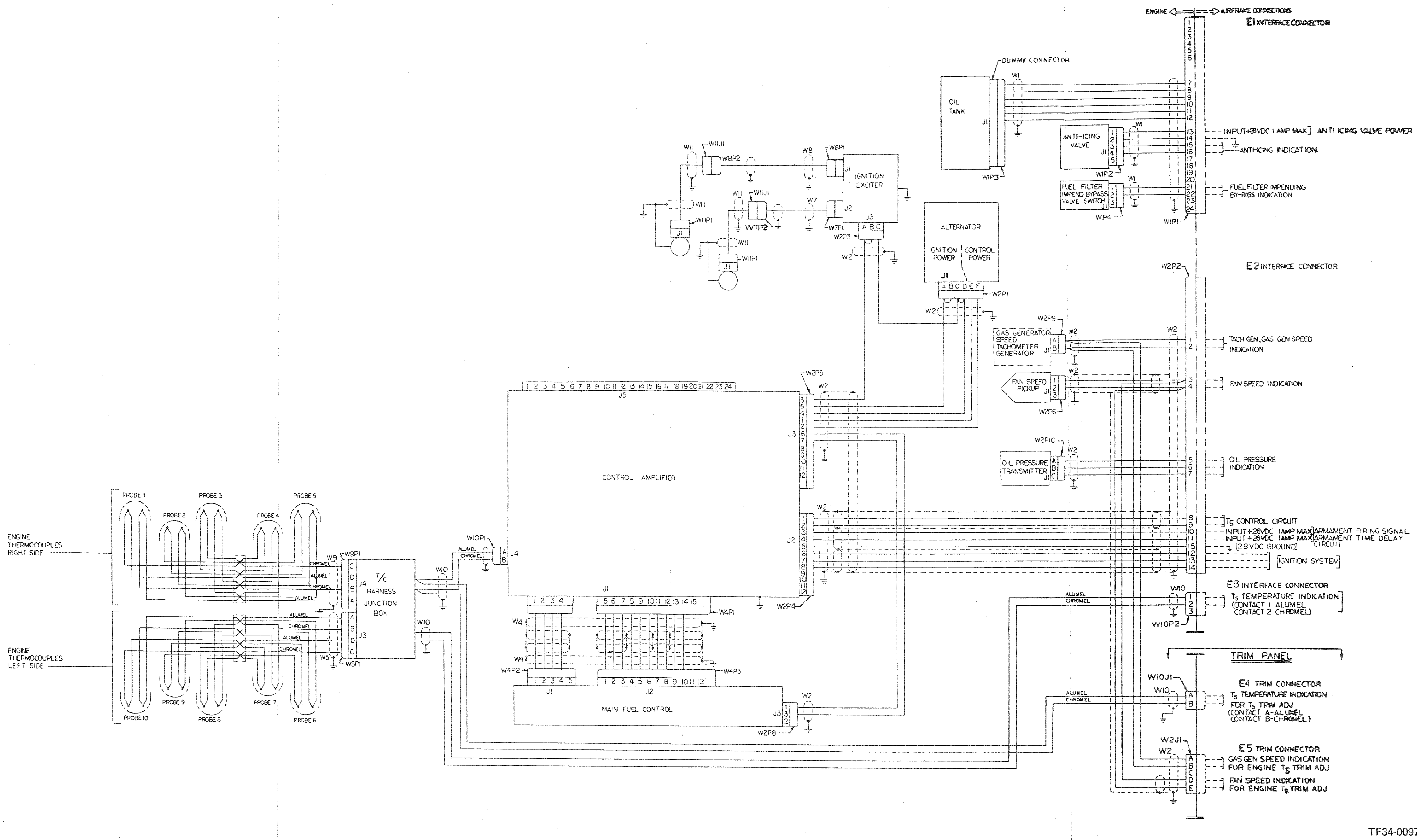

Figure 9-4. Electrical System Wiring Diagram