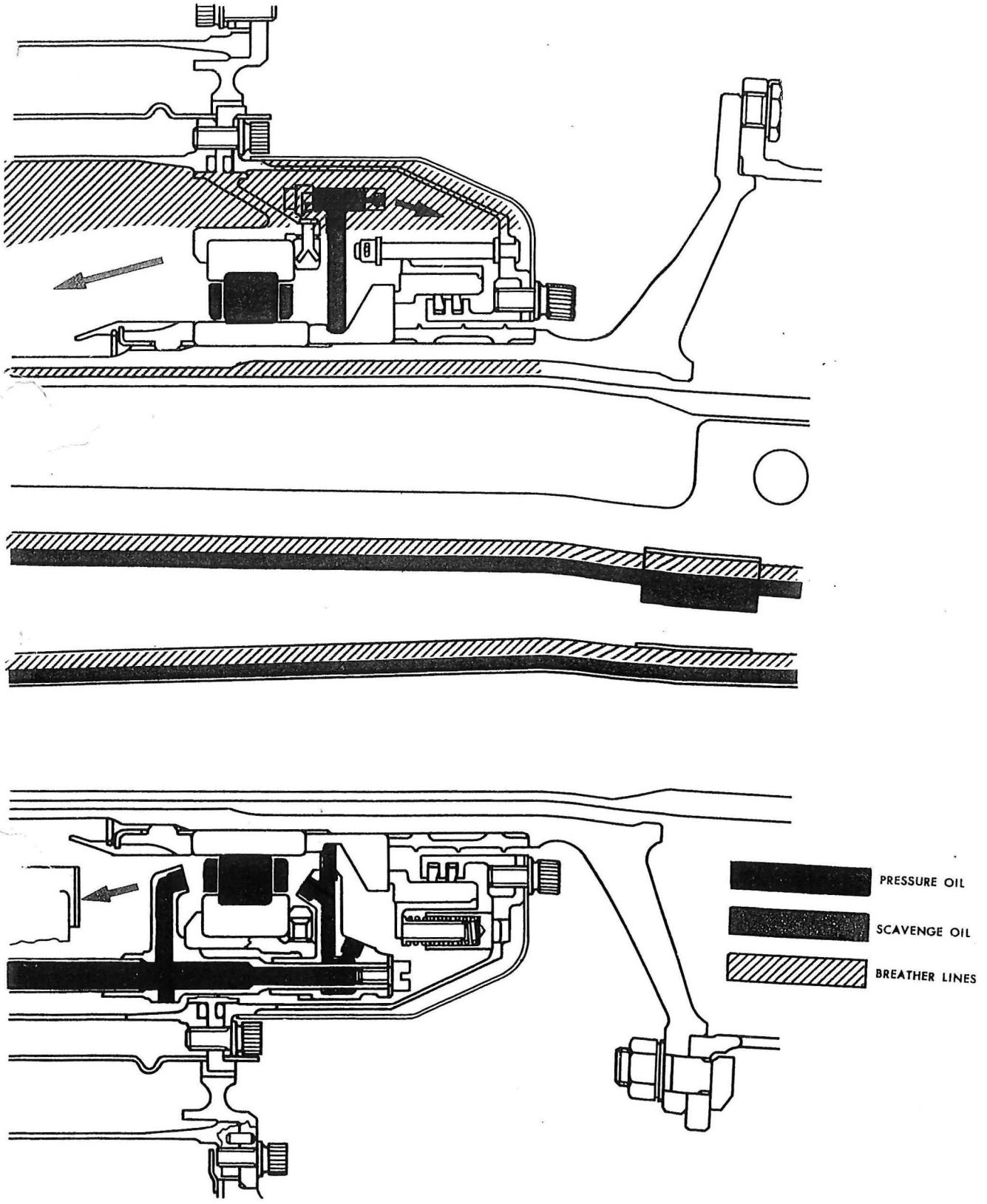


No. 5 Bearing Oil Schematic
Figure 51

ENGINE - DESCRIPTION AND OPERATION

No. 4 1/2 and No. 6 Bearings

See Figures 52 and 53.

Oil from rearmost external tube is brought through strainer into engine. Oil passes through center of rod in three o'clock strut of turbine exhaust case. Tube that carries oil is inside of No. 6 bearing support rod. Inner end of support rod is fastened to No. 6 bearing internal oil pressure tube by through bolt fitting. Other end of tube connects to No. 6 bearing oil sump assembly. Strainer is located at this point. Inside of sump assembly, oil flow is divided, part flowing to No. 6 bearing nozzle assembly, which is bolted to flange near inside upper rim of sump. No. 6 bearing gets its oil from this nozzle. Other flow inside of sump tubes is to outlet at sump center. From this point, oil is led forward into nozzle assembly. This nozzle assembly is threaded into center outlet of sump assembly, and carries metering jet inside nozzle tube. Nozzle assembly passes through center of No. 6 bearing oil suction pump pinion, and discharges oil into center of No. 6 bearing oil seal sleeve. No. 4 1/2 bearing shield assembly fits into forward end of sleeve using two bronze rings for seals. Four oil tubes in this assembly carry pressure oil forward from sleeve and discharge it to tapered space between front two of three seals. These seals fit tightly to internal taper of inside of front compressor turbine shaft. Drilled holes through shaft allow oil to run out into space just ahead of No. 4 1/2 bearing. This bearing forms rear wall of this space and in this way receives its lubrication.

Front Accessory Section

See Figure 48.

No. 1 bearing oil, previously discussed, provides lubrication for front accessory section gears and bearings. This is accomplished by splash and gravitation in annulus formed by front accessory support and No. 1 bearing support.

Accessory Component Drive Gearbox Assembly

See Figure 44.

Lubrication for front bearing of fuel pump and fuel control shaft bearings in gearbox assembly is delivered by passages in casting and jets. Splash and spray from above and from return oil of No. 4 and 5 bearing area provide remainder of lubrication in this section.

ENGINE - DESCRIPTION AND OPERATION

Angled Accessory Drive Shaftgear Bearings

See Figure 44.

Angled accessory drive shaftgear bearing oil tube carries oil to upper bearing, roller type, of accessory drive shaftgear. Discharged oil from this roller bearing that falls downward in bearing housing is used to lubricate lower shaftgear ball bearing.

Scavenge System

See Figure 44.

General

Engine uses dry sump system. Four scavenge pumps with five scavenge sections (one is dual sectioned) are capable of pumping about three times quantity of oil that pressure pump can handle. Each scavenge pump draws oil from sump. Oil is routed to cooler and tank through internal passages and external tubing.

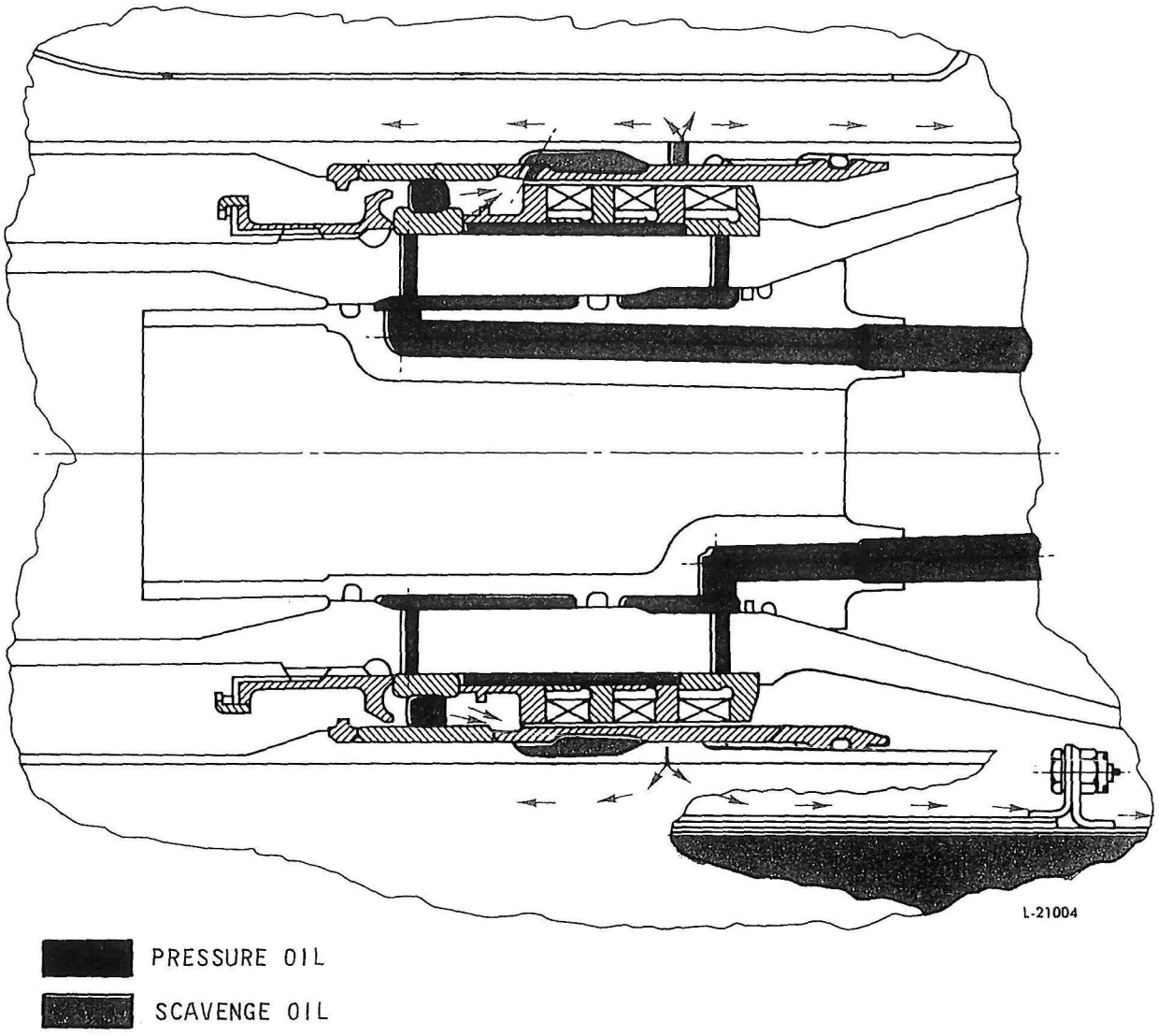
No. 1 Bearing and Front Accessory Section

See Figure 48.

Oil from No. 1 bearing drains to low point between No. 1 bearing front support and front accessory drives support which forms sump for this oil. Oil from all of front accessory gears and bearings drains down between these supports to same sump.

Conventional gear type pump is supported on boss on rear face of front accessory drive support. Pump is driven by front accessory drive gear. This pump is located in sump with strainer inlet in bottom of pump. Scavenge oil from pump travels through drilled passage in front accessory drive support to "O" ring sealed transfer tube; then to tube inside eight o'clock inlet vane. External tube connected to fitting on outside of outer shroud at eight o'clock position, carries oil to rear underneath engine to approximate front flange location of intermediate case where it connects to elbow on tube from No. 2, 2 1/2, and 3 bearing oil manifold.

ENGINE - DESCRIPTION AND OPERATION



No. 4 1/2 Bearing Oil Schematic
Figure 52

ENGINE - DESCRIPTION AND OPER TION

No. 2, 2 1/2, and 3 Bearings and Main Accessory System

See Figure 49.

Scavenge oil from No. 2, 2 1/2, and 3 bearings drains into No. 2 bearing support assembly. Oil first drains to rear of center support of this assembly. This oil passes through holes in bottom of center support to space formed by bearing assembly's front support, rear support, and inner shroud of compressor intermediate case assembly. Oil then runs down through lower vanes of intermediate case assembly to 6 o'clock vane. No. 2 bearing oil pressure tube does not fully fill this vane. There is room around it to allow drainage of scavenge oil. There are holes through support ring at lower end of tube. Scavenge oil drops through these holes and through No. 2 bearing oil drain adapter into pressure and scavenge oil adapter assembly. This adapter assembly is mounted under compressor intermediate case assembly. Sump at bottom center of gearbox assembly case collects oil. All scavenge oil from gearbox accessory gears and bearings also drains to this same sump. Scavenge section of duplex pump scavenges sump of oil.

No. 4 Bearing

See Figure 50.

Scavenge oil is discharged from front of forward bearing and rear of rear bearing. Space in seal housing allows oil from front to drain back to rear of No. 4 bearing support structure in diffuser case. Oil from rear bearing drains directly to same place. Splash from this rear bearing scavenge oil forms lubrication for gears and scavenge pump idler bearings in this area. All scavenge oil then drains to sump formed where No. 5 bearing support weldment joins No. 4 bearing support structure.

Lower section of dual scavenge pump, draws oil from sump. Oil scavenge tube for this pump is passage in pump housing casting. There is inlet strainer located in pump housing. Pump shafts are vertically mounted and driven by gear train from accessory drive gear ("bull gear"). Pump housing is bolted to bearing support structure in diffuser case. Pump outlet tube assembly is flange bolted to left side of strut. Tube through this strut carries oil to pad outside of diffuser case. Elbow, tube, and connector carry oil forward into right front face of gearbox assembly. Internal passages in gearbox assembly casting carry oil to outlet pad.

ENGINE - DESCRIPTION AND OPERATION

No. 4 1/2 and 5 Bearings

See Figures 51 and 52.

Scavenge oil from No. 4 1/2 bearing is discharged from rear side of rollers into space formed by No. 4 1/2 bearing spacer and No. 4 1/2 bearing seal liner.

Through slots in front of this liner and in rear compressor drive turbine shaft, oil drains into No. 5 bearing support weldment. Some of this oil may run forward to sump at No. 4 bearing. Remainder runs aft to sump formed by junction of No. 5 bearing support weldment and No. 5 bearing housing. Scavenge oil from No. 5 bearing drains into this same sump. No. 5 bearing oil scavenge tube dips its rear end into this sump. Tube is bolted into place in lower part of No. 5 bearing support weldment. Forward end of this tube fits into inlet of upper scavenge pump. Tube is sealed with "O" rings and strainer is held inside pump inlet with snapring. Scavenge pump is second section of dual unit discussed under No. 4 bearing scavenge system. Outlet of both sections is common and oil travel from this outlet was discussed under No. 4 bearing scavenge system.

No. 6 Bearing

See Figure 53.

Scavenge oil is discharged from both sides of No. 6 bearing. Oil that is discharged forward can run back through holes in rear of seal housing. Oil that is discharged rearward falls into sump, lubricating scavenge pump gears as it goes. Sump is horizontally mounted, cylindrical unit, with scavenge pump at its bottom. Gear-type pump is driven by gear which meshes with pinion. This pinion is at rear end of front compressor drive turbine. Pump inlet is at rear end of front compressor drive turbine. Pump inlet is at bottom of sump, and is covered by strainer. Pump outlet is at six o'clock position of sump assembly. Tube connects this point to tube assembly passing through six o'clock exit strut to rear of No. 6 bearing support rod. Tubes carry oil forward along left side of engine and discharge it into fitting at left rear of rear gearbox housing.

ENGINE - DESCRIPTION AND OPERATION

Angled Accessory Drive Shaftgear Bearings

Scavenge oil from accessory drive shaftgear bearings, inside of diffuser case, falls through tube to rear gearbox housing. This tube is located just forward of accessory drive shaft. Through internal passages in rear gearbox housing oil reaches sump. Oil from accessory drive gears and bearings also falls into this same sump.

Oil Cooling System

From oil outlet pad on gearbox housing assembly, oil is piped to fuel-oil cooler, then to air-oil cooler and from air-oil cooler to oil tank. These units are airframe supplied parts.

Fuel-Oil Cooler

R This is cylindrical unit mounted in front lower right quadrant of
R diffuser case. Fuel flows through tubes in core of cooler and
R oil circulates within housing and around the outside of core tubes.
R Engine oil which has not been heated sufficiently by engine
R operation to require cooling is prevented from entering cooler
R by thermostatic valve located in inlet connector of cooler. This
R unit is further discussed in Chapter 79.

Breather System

General

All breathing is done through gearbox assembly. Inside this assembly and attached to fuel pump drive shaft is impeller which serves as centrifugal device to remove oil from air. Internal passages and external tubing are used to connect all breathing points to gearbox assembly. Overboard breather tube furnished by airframe manufacturer is attached to adapter on upper left side of gearbox assembly.

ENGINE - DESCRIPTION AND OPERATION

No. 1 Bearing and Front Accessory Breathing

See Figure 48.

Space behind front accessory drive support and No. 1 bearing is vented by means of "O" ring seal transfer tube, to tube through 12:30 o'clock vane than to fitting on outside of outer shroud of compressor inlet guide vane and shroud assembly. Connector and flexible tube carry breathing air from outer shroud fitting to external breather tee. On outboard engines, this flexible tube is connected to oil tank. This tee is bolted to compressor intermediate case at two o'clock position between mounting rings. Tube from tee leads inward through vane to No. 2 bearing area.

No. 2, 2 1/2, and 3 Bearings Breather

See Figure 49.

This space is formed by No. 2 bearing front support and No. 2 bearing seal on forward side. No. 2 bearing rear support and No. 3 bearing seal form rear wall. Inner shroud of compressor intermediate case forms outside wall of space. This space breathes through six o'clock vane and No. 2 bearing oil drain adapter. No. 2 1/2 and 3 bearings use this same breathing space and passages.

No. 4, 4 1/2, and 5 Bearings Breathing

See Figures 50 through 52.

Forward wall of compressor-to-turbine space is formed by No. 5 bearing support structure in diffuser case and seal just ahead of No. 4 bearing. Rear wall is No. 5 bearing seal system. Inner wall is structure of No. 5 bearing support system. No. 4, 4 1/2, and 5 bearings, accessory drive gearing, accessory drive adapter (elbow) assembly and No. 4 and 5 bearings oil scavenge pump are all vented to this space. Accessory drive adapter vents through strut that carries accessory drive shaft. Twelve o'clock diffuser case strut is open from this space to pad on top of diffuser case. Elbow bolted to this pad connects to tube. Forward end of this tube is connected to tee that was mentioned in connection with No. 1 bearing and front accessory case breather.

ENGINE - DESCRIPTION AND OPERATION

No. 6 Bearing Sump

See Figure 53.

This area has two possible breathing passages. One is through its scavenge system. Other is through No. 4 1/2 bearing lubrication system. Tubes in No. 4 1/2 bearing oil tube shield assembly do not run full of oil. Jet tube that feeds oil into sleeve that is their common rear termination is not tight on this sleeve. Air from No. 6 bearing area can enter these tubes along with No. 4 1/2 bearing oil. Because tubes taper outward as they go forward, centrifugal force is used to make oil move forward to No. 4 1/2 bearing. These tubes, therefore, do not have to run full of oil under pressure. No. 6 bearing area breathing air follows same path as No. 4 1/2 bearing oil supply and eventually breathes through same passages used by No. 4 1/2 bearing oil supply. Air flow will always be in same direction as oil flow in these tubes. This is because of slight pressure that is created in No. 6 bearing area by leakage of 9th stage air through No. 6 bearing carbon seals.

Accessory Component Drive Gearbox Assembly

In foregoing it was shown how all breathing is to gearbox assembly. Also as has been mentioned, inside of this case and mounted on fuel pump drive shaft is centrifugal device to remove oil from air. It resembles pump impeller with its vanes enclosed on both sides. Inside diameter of breather assembly is vented to inside front end of fuel pump drive shaft. Forward end of this shaft is open to passage in cover of gearbox assembly. Internal passage in cover casting leads to outlet at top right hand corner of casting. Breather adapter is mounted on gearbox rear housing in this area.

Cooling Air System

Cooling air for third and fourth stage disk and seals is furnished by front compressor. Leakage at rear of ninth stage blade platform enters front compressor rotor assembly through holes in front compressor rear hub. Air then enters front end of front compressor drive turbine shaft and passes rearward through hollow shaft. Cooling air leaves shaft through holes in turbine disk spacer between third and fourth disk and in turbine rotor hub. It flows outward through hole in air seal and past knife-edge seal in hub to cool rear face of third stage turbine and rear face of fourth stage turbine. Leakage past triple seal between third and fourth stage turbine cools front face of fourth stage turbine. Hole in extruded flange of second stage turbine permits this cooling air to be static in area above seal between second and third stage turbine.

ENGINE - DESCRIPTION AND OPERATION

Rear compressor air from sixteenth stage leaks by air seal of rotor and enters diffuser case inner cavity forward of No. 4 bearing heat-sheild. It then passes through holes in inner periphery of case to chamber formed by diffuser case inner and outer walls. From here it passes through hoes in diffuser case rear flange to air space between No. 5 bearing support to enter area between turbine nozzle inner case and first stage turbine seal support. Air then leaks past air seals at front of first stage turbine disk to mix with exhaust gases cooling front of turbine as it goes or enters larger holes in extended inner flange of disk and then past knife-edge seals to cool rear face of first stage turbine and front face of second stage turbine.

ENGINE - TROUBLESHOOTING

1. General

A. Troubleshooting is a process of identifying engine problems through observation and evaluation of engine behavior. When an engine develops a problem, maintenance personnel must evaluate the symptoms and identify the cause of the problem, using evidence which supports a certain cause or disqualifies other causes. In order to save time, the most probable cause, as determined by maintenance experience and by the recommendations of this section, should be examined first.

B. Before attempting to work on an engine which has been reported as malfunctioning, it is important to know as much as possible about the engine. Not only is the engine's behavior at the time of its malfunctioning important, but also the recent history of the engine should be considered; time since overhaul or major component replacement, time since the last trim or ground check, or the relationship in service time between the engine and other engines in the aircraft should be taken into account. Consult the pilot's flight report, engine log books, and any other available sources.

C. These troubleshooting procedures are prepared with the assumption that maintenance personnel are familiar with the design and structure of the JT3D Turbofan engine. See the Description sections in the engine and accessory component chapters for details on the various areas of the engine.

D. Approved removal and installation procedures for various engine parts and components are described in their respective sections in this manual. Special assembly procedures, special torques, etc. are listed in "Fits and Clearances" portions of applicable Removal/Installation or Inspection/Check sections; all maintenance procedures not covered by special limits shall conform to the techniques and limits in the "General Maintenance Procedures" portion of Chapter/Section 72-00, Dismantling/Assembly.

ENGINE - TROUBLESHOOTING

R 2. Troubleshooting Section Structure

R A. The troubleshooting section is divided into general engine and power response problems and individual system problems and troubleshooting procedures. The "Power and Engine Response Problems" section provides a list of common engine problems and either indicates the most likely cause and appropriate troubleshooting procedures or makes reference to one or more system troubleshooting sections. When troubleshooting an engine malfunction, the "Power and Engine Response Problems" section should first be consulted to determine what systems may be responsible, reference is then made to the most likely component in that system responsible for the problem.

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R C. The scope of this section is to locate the cause of engine
R malfunction and to prescribe corrective action. Detailed
R inspection and check procedures on engine subassemblies and
R accessory components are found in the applicable engine or
R accessory component subsection of this manual; where detailed
R inspection of a subassembly or component would be helpful and
R practical in troubleshooting the engine, specific reference
R will be made to the section in which that procedure is found.

R D. For detailed treatment of engine-related systems not part of
R the basic JT3D engine, consult the applicable airframe
R maintenance manual.

R 3. Subsystem Troubleshooting Procedures

R A. Specific subsystem problems are listed in the following
R paragraphs, together with test procedures to help isolate the
R problem, and corrective action required. Possible causes are
R listed in order of probability, from highest to lowest.

R ENGINE - TROUBLESHOOTING

R 4. Power And Engine Response

R Possible Cause	Test Procedure	Corrective Action
R A. No (Or Limited) N1 or N2 During Starting		
R See Engine Indicating System.		
R B. No Light-Off During Starting		
R (1) Defective Ignition System	See Ignition System.	
R (2) No Fuel to Combustion Section	R (a) Check fuel shutoff lever rigging (see applicable airframe maintenance manual).	
	R (b) Check fuel pump discharge pressure (see Fuel System).	R Replace fuel pump.
		R If fuel pump output normal replace P&D valve (Section 73-12-1)
		R If problem is not corrected replace Fuel Control.
R (3) Defective Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
R C. Impending Hot Start		
R (1) Gaspath Damage	Check inlet and tailpipe area for damage.	Replace engine if damage is found.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
C. Impending Hot Start (Continued)		
(2) Defective Fuel System	(a) Check for fuel control schedule shift by comparing fuel flow of suspect engine with fuel flow of other engines in aircraft.	Replace defective fuel control unit. If fuel control replacement does not correct problem replace P&D valve (Section 73-12-1) NOTE: Perform "Clear Engine Procedure" in Adjustment/Test section before restarting engine.
	(b) Check for premature starter cutout (see applicable airframe maintenance manual).	
D. Hung Start (No Acceleration To Idle; N2 And EGT Stable)		
(1) Defective Fuel System	See Fuel System "Hung Start"	
(2) Defective Bleed System	Check bleed valves for proper closing schedule (see Adjustment/Test Section).	See Surge Bleed System "Surge Bleed not operable or off-schedule".
(3) Defective Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
(4) Premature Starter Cutout	See applicable airframe maintenance manual.	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedures	Corrective Action
E. No Or Abnormal Power Lever Response		
(1) Defective Fuel System	(a) Check fuel pump discharge pressure (see Fuel System).	
	(b) Check fuel control rigging (Section 73-21-2).	Re-rig as necessary.
	(c) Check for leaks in fuel control Ps4 sense line.	Retorque or replace line as necessary. If no leaks found, replace fuel control.
(2) Restricted Airframe/QEC Fuel System	See applicable airframe maintenance manual.	
F. Power Lever Misalignment		
(1) Surge Bleed System Defective or Off-Schedule	Check bleed valve operation (see Adjustment/Test).	See Surge Bleed System
(2) Gaspath Deterioration	Conduct ground performance or data plate speed check.	Wash engine gaspath and/or check turbine nozzle condition.
(3) Defective Fuel System	(a) Check for proper fuel control rigging.	Re-rig as necessary.
	(b) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
	(c) Check that the fuel pressurizing and dump valve is not in dump mode.	Replace defective P&D valve (Section 73-12-1).

R ENGINE - TROUBLESHOOTING

R	Possible Cause	Test Procedure	Corrective Action
	F. Power Lever Misalignment (Continued)		
R R		(d) Check fuel control for proper trim.	Retrim as necessary.
R R R R	(4) Airframe/QEC Fuel or Bleed Air Malfunction	See applicable airframe maintenance manual.	
R	G. Unable To Attain Takeoff EPR		
R R R	(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation (see Adjustment/Test).	See Surge Bleed System.
R R R R R R	(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Blend or replace fan blades as necessary. If FOD beyond repair, replace engine or module.
R R R R R R		(b) Conduct ground performance or data plate speed check.	If gaspath deterioration suspected, wash engine (Section 72-00 Engine - Cleaning).
R R R	(3) Leak or obstruction in Pt7 Line	See Indicating System under "Low EPR".	
R R R	(4) Defective Fuel System	See Fuel System "Unable to attain takeoff EPR".	
R R R R	(5) Airframe/QEC Fuel or Bleed Air Malfunction	See applicable airframe maintenance manual.	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. EGT Limited		
(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Blend or replace fan blades as necessary. If FOD beyond limits, replace engine.
	(b) Conduct ground performance monitoring or data plate speed check.	If gaspath contamination is suspected, wash engine. (Section 72-00 Engine Cleaning.
(3) Defective Indication System	See Indicating System, under "EGT Indication High".	
(4) Airframe/QEC Bleed Air Malfunction	See applicable airframe maintenance manual.	
I. N1 Limited		
(1) Defective N1 or EPR indicating System.	See indicating system "Leaking Pt7 System".	Disconnect Pt7 Line and free if obstructed. Torque loose fittings.
		If no discrepancies found, replace N1 tach generator or gage.
(2) Leaking thrust reverser seal	See applicable airframe maintenance manual.	Repair or replace thrust reverser.

R ENGINE - TROUBLESHOOTING

R	Possible Cause	Test Procedure	Corrective Action
R	I. N1 Limited (Continued)		
R R R R R	(3) Large Exhaust Nozzle Area	Measure Exhaust Nozzle Area. See applicable airframe maintenance manual.	Resize nozzle.
R R R	(4) Gaspath Damage or deterioration	Check Fan Blades for excessive blending or FOD.	Blend or replace fan blades as necessary.
R R R R	(5) Gaspath contamination	Conduct ground performance monitoring check.	Wash engine. (Section 72-00 Engine-Cleaning).
R	J. N2 Limited		
R R R	(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
R R R	(2) Gaspath Damage or Deterioration	(a) Check inlet and tailpipe area for FOD.	Replace engine if damage is found.
R R R R R R		(b) Conduct ground performance monitoring or data plate speed check.	If gaspath contamination is suspected, wash engine. (Section 72-00 Engine Cleaning.
R R R R R R R R R R	(3) Defective N2 or EPR Indicating Systems	See Indicating System Leaking Pt7 System.	Disconnect Pt7 Line and free if obstructed. Torque loose fittings. If no discrepancies found, replace N2 Tach generator or gage.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
K. Slow Acceleration		
(1) Defective Fuel Control Schedule	Check Ps4 sense line for leaks.	Retorque or replace line as necessary; if no leaks, replace fuel control.
(2) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
(3) Combustion Chambers Shifted Rearward	Conduct combustion chamber isotope inspection (Section 72-00 Inspection/Check).	Replace chambers as necessary.
L. Auto Acceleration (Power Increase Without Power Lever Movement)		
(1) Loss of N2 Sense at Fuel Control		Replace fuel control.
M. Fluctuating Power Level		
(1) Surge Bleed Valve Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
(2) Defective Fuel System	(a) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
	(b) Check fuel pump discharge pressure (see Fuel System).	Replace defective fuel pump; if pump not defective, replace fuel control.
	(c) Check for water in fuel.	

R ENGINE - TROUBLESHOOTING

R	Possible Cause	Test Procedure	Corrective Action
R	M. Fluctuating Power Level (Continued)		
R R R R	(3) Combustion Chambers Shifted Rearward	Conduct combustion chamber isotope inspection (Section 72-00 Inspection/Check)	Replace chambers as necessary.
R	N. Flame-Out		
R R R	(1) Defective Fuel System	(a) Check fuel control Ps4 sense line for leaks.	Retorque or replace line as necessary.
R R R R R R		(b) Check for failed fuel pump driveshaft by checking fuel discharge pressure (see Fuel System).	Replace defective fuel pump, or if fuel pump not defective, replace fuel control.
R R R R		(c) Check airframe fuel system (see applicable airframe maintenance manual).	
R R	P. Sudden Parameter Shift Or Fluctuation Relative To Other Engines In Aircraft		
R R R	(1) Surge Bleed Valve Malfunction	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
R R R R	(2) Indicating System Malfunction	See Indicating System for check of EPR, rpm, and EGT indication systems.	
R R R	(3) Gaspath Damage	Check inlet and tailpipe area for FOD.	Replace engine if damage is found.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
Q. Engine Pressure Ratio Varies With Increasing Altitude		
(1) Capped or Obstructed Pt7 Line.	Inspect Pt7 line for blockage.	Remove blockage.
(2) Leaking Pt2 Line	Check Pt2 line per Indication System or see applicable airframe maintenance manual.	
R. Fluctuating N1 Or N2 With Other Parameters Normal		
See Indication System, "N1 or N2 Indication Fluctuates".		
S. Off-Idle Surge		
(1) Surge Bleed Valve Defective or Off-Schedule	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System.
(2) Gaspath Damage or Deterioration	Check inlet and tailpipe area for FOD.	If no damage is found, wash gaspath and check turbine nozzle condition.
(3) Rich Fuel Control Acceleration Schedule		Replace fuel control.
(4) Defective Fuel Pressurizing and Dump Valve		Replace fuel P&D valve.
T. High Power Surge		
(1) Gaspath Damage or Deterioration	Check inlet and tailpipe area for FOD.	If no damage is found, wash gaspath and check condition of 1st stage turbine vanes and outer airseal.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
T. High Power Surge (Continued)		
(2) Surge Bleed System	Check bleed valve operation per Adjustment/Test.	See Surge Bleed System
(3) Fuel System		Replace Fuel Control.

R 5. Lubrication System

Possible Cause	Test Procedure	Corrective Action
A. No Oil Pressure Indication		
(1) Low Oil Quantity	Check oil level.	Add oil.
(2) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(3) Defective Main Oil Pump	(a) Open main oil pump discharge port.	
	CAUTION: STAND CLEAR OF PUMP DISCHARGE PORT WHILE MOTORING.	
	(b) Motor engine with starter.	If no oil is discharged, replace main oil pump (Section 72-00).
(4) Obstructed Oil Tank-Pump Inlet Passage	(a) Drain oil.	
	(b) Remove main oil pump Section 72-00 and oil tank (Section 79-11-1).	
	(c) Check oil tank-to-pump passage for obstructions.	Clear oil passages.

R ENGINE - TROUBLESHOOTING

R	Possible Cause	Test Procedure	Corrective Action
R	A. No Oil Pressure Indication (Continued)		
R		(d) Reinstall main oil pump (Section 72-00) and oil tank (Section 79-11-1)	
R		(e) Refill oil tank.	
R	B. Low Oil Pressure		
R	(1) Low Oil Quantity	Check oil level.	Add oil.
R	(2) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R	(3) Defective Oil Pressure Relief Valve	(a) Drain oil.	
R		(b) Remove oil pressure relief valve (Section 72-00).	
R		(c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding per General Maintenance Procedures (Section 72-00).	If packing is damaged, reinstall oil valve with new packing; if packing is not damaged install new valve (with new packing).
R		(d) Refill oil tank after valve is in place.	
R	(4) Defective Main Oil pump	(a) Drain oil.	
R		(b) Remove main oil pump (Section 72-00).	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R B. Low Oil Pressure (Continued)		
R	(c) Inspect pump packings for damage. NOTE: Check pump cavity in gearbox for scoring. (d) Refill oil tank after pump is in place.	If packings are damaged, reinstall old pump with new packings; if packings are not damaged install new pump (with new packings).
R C. High Oil Pressure		
R (1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual. NOTE: On airframe installations in which main oil pressure is read directly (cockpit gage vented to ambient rather than to engine gearbox), increase in breather pressure will result in equal increase in main oil pressure indication. See breather pressure check under "Excessive Oil Consumption".	
R (2) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Remove oil pressure relief valve (Section 72-00).	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedures	Corrective Action
C. High Oil Pressure (Continued)		
	(c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding per (Section 72-00) General Maintenance Procedures. (d) Refill oil tank after valve is in place.	If packing is damaged, reinstall old valve with new packing; if packing is not damaged, install new valve (with new packing).
D. Fluctuating Oil Pressure		
(1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
(2) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Remove oil pressure relief valve (Section 72-00). (c) Check preformed packing for damage. NOTE: If packing is undamaged and valve is suspect, inspect old valve for internal binding per (Section 72-00) General Maintenance Procedures. (d) Refill oil tank after valve is in place.	If packing is damaged, reinstall old valve with new packing; if packing is not damaged, install new valve (with new packing).

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R E. Oil Pressure Following Throttle		
R (1) Defective Oil Pressure Relief Valve	(a) Drain oil. (b) Replace oil pressure relief valve (Section 72-00). NOTE: Inspect removed oil pressure relief valve for internal binding per (Section 72-00). (c) Refill oil tank after valve is in place.	Replace oil pressure relief valve.
R F. Oil Filter Differential - Pressure Signal Does Not Go Out		
R (1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R (2) Clogged Main Oil Filter	NOTE: Disassemble and clean removed oil filter per (Section 72-00).	Replace main oil filter (Section 72-00).
R G. High Oil Temperature Indication		
R NOTE: If oil temperature exceeds maximum steady state temperature limit of 270°F (132°C) for more than 15 minutes, refer to "Oil Temperature Over Limit" chart in Oil Systems Section 79.		
R (1) Low Oil Quantity	Check oil level.	Add oil.
R (2) Defective Airframe/QEC Indicating System	See applicable airframe maintenance manual.	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R G. High Oil Temperature Indication (Continued)		
R (3) Fuel De-Icing Valve Stuck Open	(a) Start engine and stabilize at idle.	
R	(b) Advance power lever to 1.6 EPR.	
R	(c) Activate fuel de-icing valve and fuel temperature should increase 70°F to 110°F (39°C to 61°C) within one minute.	If no change, replace fuel de-icing valve (Section 73-14-3)
R	(d) Return engine to idle and shut down.	
R (4) Fuel/Oil Cooler Bypass Valve Open	Remove fuel/oil cooler (Section 79-22-1).	Clean oil cooler element or replace cooler (Section 79-22-1)
R (5) Bearing Failure	(a) Remove main oil strainer per (Section 72-00).	
R	(b) Disassemble main oil strainer and check for metal particles.	
R	(c) Check chip detectors (if engine is so equipped).	Replace engine if metal particles are found.
R	(d) Sample engine oil to determine whether or not oil is black.	Replace engine if oil is black.
R	(e) Perform breather pressure check (see "Excessive Oil Consumption" in this section.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. Excessive Oil Consumption		
(1) External Tubing Leakage	Inspect oil pressure, breather, and scavenge tubes for evidence of leakage.	Replace tube connector seals and torque connectors.
(2) Oil Discharge At Overboard Breather	NOTE: Check engine log for evidence of oil system oversericing (unnecessary oil addition).	
	(a) Install locally manufactured oil tank cap with 0 - 30 psig gage attached.	
	(b) Start engine and stabilize at idle. Accelerate to Take-off power.	
	CAUTION: OBSERVE PROPER SAFETY PRECAUTIONS AROUND RUNNING ENGINE. USE TELLTALE GAGE OR LARGE DIAL GAGE FOR EASY READING IF POSSIBLE. WIRE ALL TEST INSTRUMENTS SECURELY TO PREVENT DAMAGE BY VIBRATION.	
	(c) Observe and record breather pressure.	
	(d) Return engine to idle and shut down.	

ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
H. Excessive Oil Consumption (Continued)		
	NOTE: Although oil consumption is used as the basis for removing an engine from service, experience has shown that it is not economical to maintain an engine in service when steady state breather pressure exceeds 7 inches of Hg. NOTE: Some operators make use of a static airflow check to determine general condition of entire engine oil and breather system. This check is performed by pressurizing oil system at oil tank to 10 psig with gearbox breather vent capped. Leakage greater than 60 pph is considered excessive but has not been established as a limit. (e) Inspect inlet and exhaust areas of gaspath for oil wetting. (f) Check gearbox accessory component drive seals for leakage.	If oil wetting is found, remove engine. Replace seals as necessary.
R R (3) Static oil flooding of gearbox	See Paragraph 10.	

ENGINE - TROUBLESHOOTING

6. AIR BLEED SYSTEMS

Possible Cause	Test Procedure	Corrective Action
A. Surge Bleed Not-Operable Or Off Schedule		
	Perform Surge Bleed Valve Check (Section 72-00 Engine Adjustment/ Test).	If Surge Bleed inoperative or off schedule, perform steps 1 through 3 as necessary.
(1) PRBC Vent Screen Contamination	Inspect screens.	Clean as necessary.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R A. Surge Bleed Not-Operable or Off-Schedule (Continued)		
R R R R (2) Defective Pt2, Ps3, or Ps4 Tubes	Inspect PRBC tubes for connector tightness, freedom from cracks or obstruction.	Retorque or replace tubes as necessary.
R R R R R R R R R R (3) Defective Pressure Ratio Bleed Control	If bleed valve does not function or is off-schedule, and checks (1) and (2) show no defect, PRBC is faulty.	Replace PRBC (Section 75-31-1) NOTE: Ensure replacement PRBC is calibrated to current overhaul manual schedule (Section 75-6-1)
R B. Engine Anti-Icing Bleed System Inoperative		
R R R R R (1) Defective Electrical Circuit to Anti-Icing Valve	Check electrical circuit for power to valve.	Replace Defective switch or wiring to anti-icing valve.
R R R (2) Anti-icing Air Regulator Defective	Check valve position indicator for movement.	Replace regulator
R R (3) Anti-Icing Air Valve Defective	Check valve position indicator for movement.	Replace valve

R 7. Fuel System

Possible Cause	Test Procedure	Corrective Action
R A. No Fuel Flow With Fuel Shutoff Lever On		
R R R (1) Improper Fuel Shutoff Lever Rigging	Check for full travel at fuel control.	Re-rig as necessary.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R A. No Fuel Flow With Fuel Shutoff Lever On (Continued)		
R (2) Defective Fuel Pump	(a) Connect 0 - 300 psig gage to fuel pump discharge port.	
R	(b) With fuel shut-off lever in "On" position, motor engine with starter and observe fuel pressure.	If pressure is below 150 psig, replace fuel pump.
R (3) Defective Fuel Control	Perform fuel pump discharge pressure check in (2).	If fuel pump output is normal, replace fuel control.
R (4) No Fuel To Engine	See applicable airframe maintenance manual.	
R B. Fuel Flow Indication But No EGT Rise On Starting		
R (1) Defective Fuel Pressurizing and Dump Valve	(a) Motor engine with starter and check for fuel draining from P&D valve (for valves with open drain ports only).	If fuel drains, replace P&D valve (Section 73-12-1).
R	(b) Check P&D valve fuel strainer (Section 73-12-1).	Clean or replace strainer.
R (2) Defective Ignition System	See Ignition System.	
R C. Hung Start (No Acceleration To Idle)		
R (1) Defective Ps4 Sense Line	(a) Inspect Ps4 sense line for leaks or breaks.	Tighten or replace line as necessary.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R C. Hung Start (No Acceleration To Idle) (Continued)		
R	(b) If icing conditions are present check for internal icing by applying external heat (flameless hot air only).	If external heat solves problem by removing icing, drain water from Ps4 sense line and water trap. Blow line clear (from fuel control end) using dry compressed air. If icing is not problem, replace fuel control.
R D. Hot Start (EGT High On Starting)		
R (1) Defective Fuel Control	Check for excessive starting fuel flow.	Replace fuel control.
R (2) Defective Pressurizing and Dump Valve		Replace P&D Valve.
R E. Engine Unable To Attain Takeoff EPR		
R (1) Improper Fuel Shutoff Lever Rigging	Check for full travel at fuel control.	Re-rig as necessary.
R (2) Fuel Control Not Correctly Trimmed	Perform Part Power Trim Check. See applicable airframe maintenance manual.	Retrim fuel control
R (3) Defective Fuel Pump	(a) Connect 0 - 300 psig gage to fuel pump discharge port.	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R E. Engine Unable To Attain Takeoff EPR (Continued)		
R R R R R R	(b) With fuel shut-off lever in "On" position, motor engine with starter and observe fuel pressure.	If pressure is below 150 psig, replace fuel pump.
R R R (4) Insufficient Fuel Control Ps4 Sense	Check Ps4 line for leaks.	Retorque or replace line.
R R R R (5) Defective Fuel Control	Perform fuel pump discharge pressure check in (2).	If fuel pump output is normal. Replace fuel control.
R R R (6) Insufficient Fuel To Engine	See applicable airframe maintenance manual.	
R F. Throttles Out Of Alignment		
R R R (1) Improper Power Lever Rigging	See applicable airframe maintenance manual.	
R R R (2) Improper Trim	See applicable airframe maintenance manual.	
R R R (3) Fuel Restriction	See applicable airframe maintenance manual.	
R G. Fuel Temperature Low With Fuel Heat On		
R R R (1) Defective Indication System	See applicable airframe maintenance manual.	

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R G. Fuel Temperature Low With Fuel Heat On (Continued)		
R (2) Fuel De-icing Shutoff Valve Failed Closed	Check position of shut-off valve indicator if applicable.	Replace shutoff valve.
R (3) Defective Fuel De-icing Heater	Remove fuel de-icing heater and check for obstruction.	Replace fuel de-icing heater.
R (4) Failed Fuel Pump Impeller (Boost Stage)		Replace fuel pump.

R 8. Engine Indicating System

Possible Cause	Test Procedure	Corrective Action
R A. Engine Pressure Ratio System Inoperative		
R Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R B. Engine Pressure Ratio Indication Fluctuates		
R Loose Pt2 Line Connections	Check Pt2 connections, (see applicable airframe maintenance manual).	Retorque or replace tubes as necessary.
R C. Engine Pressure Ratio Indication Drops Excessively When Anti-Icing Air Is Used		
R Loose Pt2 Line Connections	Check Pt2 connections (see applicable airframe maintenance manual).	Retorque or replace lines as necessary.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R D. Low Engine Pressure Ratio		
R (1) Defective Airframe/QEC EPR Indication System	Check if other parameters are also low.	If other parameters normal, EPR indication system is defective. See applicable airframe maintenance manual.
R (2) Leaking Pt7 System	Check Pt7 fittings for looseness. Leak check Pt7 system per Section 77-10	Torque loose fittings.
R (3) Obstructed Airframe/QEC Pt7 Line	Disconnect line and check for obstructions (see applicable airframe maintenance manual).	
R (4) Obstructed Pt7 Probes or Manifold	(a) Disconnect Pt7 outer internal tube connector and connect a source of clean filtered air (or bottled nitrogen) into Pt7 manifold, regulated to 10 psig.	
	R (b) Pass hand in front of each Pt7 probe and check for even air discharge from probe holes.	R If blockage is found, clean or replace probes.
R E. No N1 Or N2 Indication		
R (1) Compressor or Turbine Rotors Seized or Jammed	(a) Check inlet and tailpipe areas for damage.	Replace engine if damage is found.

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R E. No N1 Or N2 Indication (Continued)		
R R R R	(b) Check N1 and N2 rotors for freedom of rotation. (Section 72-00)	If N1 or N2 rotor does not rotate, replace engine.
R R R R (2) Defective Indication System	Check connections to tach generator and cockpit gage.	If no discrepancies found, replace tach generator or gage.
R F. N1 Or N2 Indication Fluctuates		
R R R R Defective Indication System	Check connections to tach generator and cockpit gage.	If no discrepancies found, replace tach generator or gage.
R G. Exhaust Gas Temperature System Inoperative (No EGT Indication)		
R R R R (1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R R R R (2) High Resistance in EGT Averaging Leads	Perform continuity and resistance check. (Section 77-22-1)	Replace cable or leads as necessary.
R H. EGT Indication High Compared To EPR, N1, And N2		
R R R R (1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R R R (2) Defective EGT Probes	Perform continuity and resistance check. (Section 77-22-1)	Replace suspect probes or leads

R ENGINE - TROUBLESHOOTING

Possible Cause	Test Procedure	Corrective Action
R I. EGT Indication Low Compared To EPR, N1, And N2		
R (1) Defective Airframe/QEC Indication System	See applicable airframe maintenance manual.	
R (2) Defective EGT Probes	Perform continuity and resistance check. (Section 77-22-1)	Replace suspect probes or leads.

R 9. Ignition System

Possible Cause	Test Procedure	Corrective Action
R A. Ignition System Inoperative		
R (1) No Power Input to Ignition Exciter	See applicable airframe maintenance manual.	
R (2) Defective Igniter Plug	R WARNING: TAKE PRECAUTIONS TO AVOID PERSONAL INJURY WHILE CONDUCTING FUNCTIONAL CHECKS ON IGNITER PLUGS. MAKE SURE EXCITER ENERGY IS COMPLETELY DISCHARGED BEFORE HANDLING IGNITION LEADS, AND PERFORM "CLEAR ENGINE PROCEDURE" IN SECTION 72-00, ADJUSTMENT/TEST TO CLEAR FUEL VAPOR FROM ENGINE.	

R ENGINE - TROUBLESHOOTING

	Possible Cause	Test Procedure	Corrective Action
R	A. Ignition System Inoperative (Continued)		
R		WARNING: BECAUSE THE VOLTAGE AT THE IGNITER PLUGS IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN "OFF" POSITION, AND THE IGNITION SYSTEM INOPERATIVE FOR SIX MINUTES BEFORE THE REMOVAL OF IGNITION SYSTEM COMPONENTS. FOR ADDITIONAL PROTECTION AGAINST ELECTRICAL SHOCK HAZARD, AFTER DETACHING THE IGNITER PLUG COUPLING NUTS TOUCH THE CONNECTOR CONTACT TO THE IGNITER PLUG BODY SHIELD. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY.	
R		Remove igniter plugs and check igniter plug operation (Section 74-22-1).	Replace defective igniter plug (Section 74-22-1)
R	(3) Defective Igniter Plug Lead	WARNING: TAKE PRECAUTIONS TO AVOID PERSONAL INJURY WHILE CONDUCTING FUNCTIONAL CHECKS ON IGNITER PLUGS. MAKE SURE EXCITER ENERGY IS COMPLETELY DISCHARGED BEFORE HANDLING IGNITION LEADS, AND PERFORM "CLEAR ENGINE PROCEDURE" IN CHAPTER/SECTION 72-00, ADJUSTMENT/TEST TO CLEAR FUEL VAPOR FROM ENGINE.	

R ENGINE - TROUBLESHOOTING

	Possible Cause	Test Procedure	Corrective Action
R	A. Ignition System Inoperative (Continued)		
R		WARNING: BECAUSE THE VOLTAGE AT THE IGNITER PLUGS IS DANGEROUSLY HIGH, THE IGNITION SWITCH MUST BE IN "OFF" POSITION, AND THE IGNITION SYSTEM INOPERATIVE FOR SIX MINUTES BEFORE THE REMOVAL OF IGNITION SYSTEM COMPONENTS. FOR ADDITIONAL PROTECTION AGAINST ELECTRICAL SHOCK HAZARD, AFTER DETACHING THE IGNITER PLUG COUPLING NUTS TOUCH THE CONNECTOR CONTACT TO THE IGNITER PLUG BODY SHIELD. THIS IS TO ENSURE THE COMPLETE DISSIPATION OF ENERGY. (a) Remove igniter plugs. Ensure that igniter plugs are operating correctly. See Item (2).	
R		(b) Reconnect plugs to leads outside engine and activate ignition system from cockpit. Observe spark intensity and firing rate.	Replace defective plug leads.
R	(4) Defective Ignition Exciter	Perform items (1) through (3).	If items (1) through (3) fail to correct problem, replace ignition exciter and/or transformer. (Section 74-11-1).

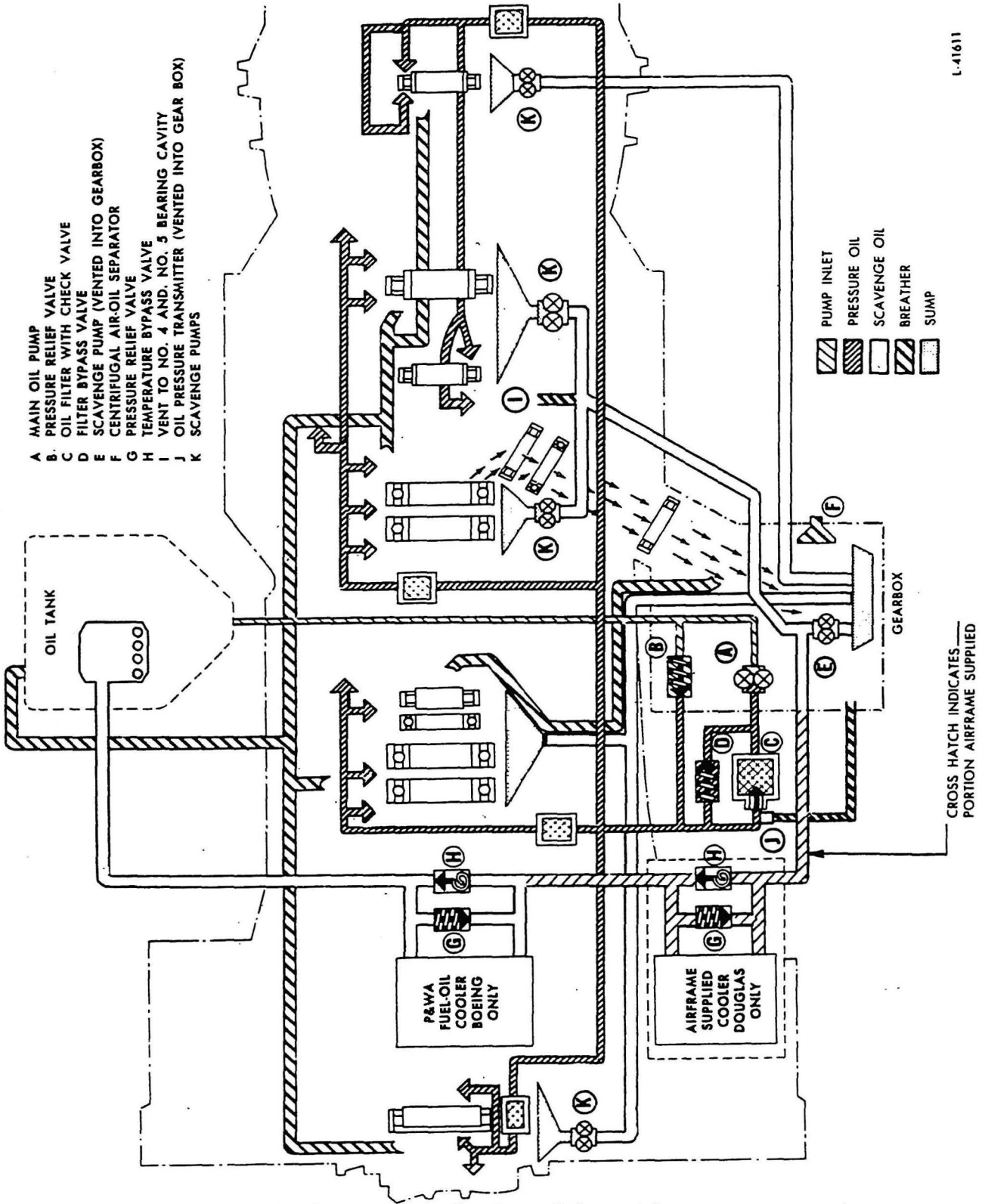
ENGINE - TROUBLESHOOTING

R 10. Static Oil Flooding of the Gearbox
R See Figure 101.
R
R A. Static leakage of oil from the tank to the gearbox can occur
R as a result of oil leaking past seals and valve seats
R located at the main strainer assembly, oil pressure relief
R valve, and main oil pump which are intended to retain oil
R against the pressure exerted by the head of oil in the oil
R tank. Normally, static leakage will not be a problem if it
R occurs at a slow rate. However, the rate of leakage can be
R rapid and as oil drains from the tank it floods the gearbox
R and drains overboard through the gearbox breather vent.
R This overflow provides an external indication of the
R problem. Overboard drainage which is detected only after
R extended periods of engine shutdown will, in most instances,
R not be a problem when the engine is operating.

R B. When the engine is not running, oil at the pump inlet and at
R the relief side of the oil pressure relief valve is under
R gravity pressure from the oil tank. This oil can flow
R through the pump gears and through the external tube to the
R main oil strainer assembly where it is blocked by the
R strainer bypass valve and by the check valve downstream of
R the strainer element. If leakage occurs at these locations
R or at the oil pressure relief valve area, oil will pass
R through the gearbox jets into the gearbox. If static
R leakage occurs at the main oil pump shaft lip seals or at
R the pump center and inboard O.D. "O" ring packings, oil will
R leak into the gearbox.

R C. The following troubleshooting procedure is suggested for
R engines having a static oil leakage problem detected by oil
R drainage from the gearbox overboard breather. For reference
R information, leakage of 946 cc per hour (16 cc/min.) amounts
R to approximately 3 gallons in 12 hours.
R
R (1) Drain the gearbox and after the initial drainage surge,
R determine the stabilized drainage rate from the gearbox
R drain. An oil supply must be maintained in the oil tank
R for this drainage check.

R (2) With the gearbox drain still open, remove the strainer
R element assembly from the strainer housing. Oil from the
R tank will leak from the strainer cavity as a result of oil
R flow through the pump gears. Recheck the drainage rate
R from the gearbox drain. If leakage from the drain
R continues at the previous rate, leakage is at the pressure
R relief valve or at the main oil pump. If leakage from the
R drain stops, the leakage area is in the strainer assembly.



Lubrication System Schematic
Figure 101

R The above check can also be accomplished by removing the
R gearbox oil out-to strainer tube assembly and installing
R a cover on the gearbox oil outlet port. This will
R prevent oil drainage resulting from leakage through the
R pump gears.

(3) If the problem is determined to be in the strainer assembly, See Figure 102 and proceed as follows:

(a) Remove the strainer check valve using PWA 30491 Puller. Check the following and correct discrepancies as necessary:

1 Condition of packings, Indexes 1 and 2.

2 Condition of lower disk and valve seat, Indexes 3 and 4.

3 Possible binding of valve rod in the seat sleeve, Indexes 5 and 4.

4 Possible weak spring, Index 6.

5 Condition of strainer housing cavity surface where valve assembly packing, Index 2, seats.

(b) Remove the bypass valve liner, springs, valve, and valve seat. Bypass valve and seat can be removed by pushing from inside the strainer housing. Check the following and correct discrepancies as necessary:

1 Condition of packing, Index 7.

2 Condition of the valve and mating seat, Indexes 8 and 9.

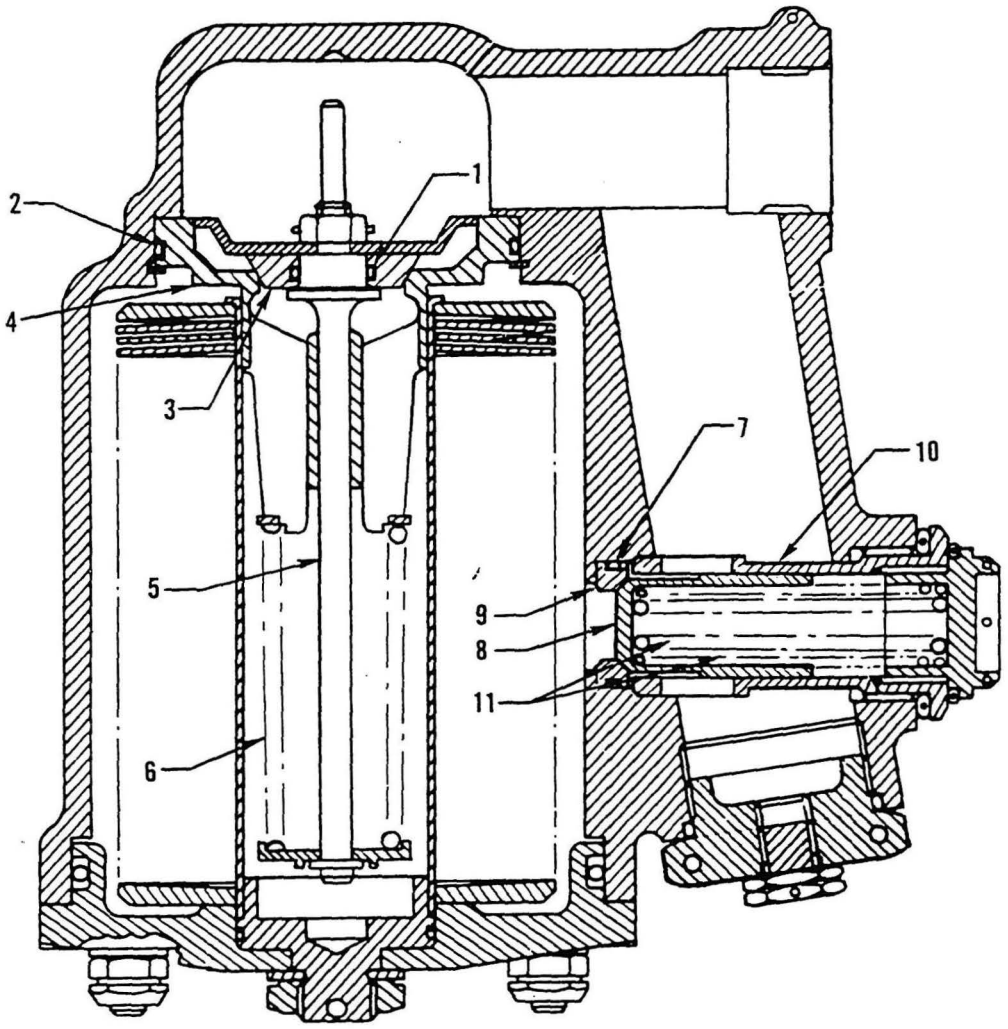
3 Possible binding of the the valve in the valve liner, Indexes 8 and 10.

4 Possible weak springs, Index 11.

5 Condition of inner surface where packing, Index 7, seats.

(4) If check per 2. above indicates that the problem is in the pressure relief valve or oil pump, proceed as follows:

(a) Oil Pressure Relief Valve. See Figure 103.



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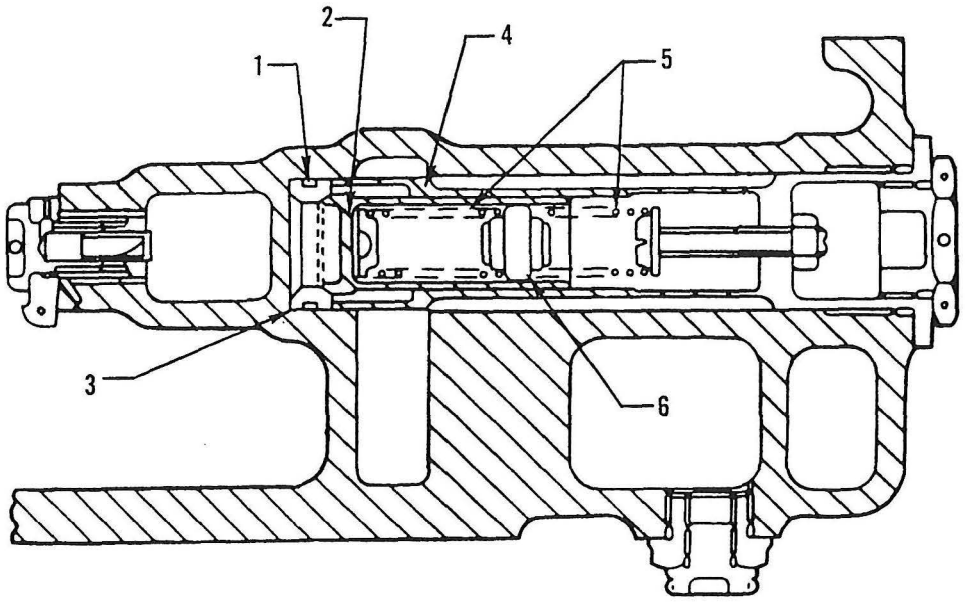
1. Packing
2. Packing
3. Lower Disk
4. Check Valve Seat
5. Valve Rod
6. Check Valve Spring
7. Packing
8. Bypass Valve
9. Bypass Valve Seat
10. Bypass Valve Liner
11. Bypass Valve Springs

Filter Housing Assembly
Figure 102



R
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1. Packing
2. Valve
3. Valve Seat
4. Valve Housing
5. Spring
6. Spring Seat

R
R
R

Cross Section of Main Oil Pressure Relief Valve As Installed in Engine
Figure 103

ENGINE - TROUBLESHOOTING

R 1 Drain the oil from the oil tank.

R 2 Remove valve parts and using PWA 16359 Puller remove the valve seat from the gearbox housing.

R 3 Check the following and correct discrepancies as necessary:

R a Condition of the packing, Index 1.

R b Condition of the valve sealing surface and mating seat surface, Indexes 2 and 3.

R c Possible binding of the valve in the valve housing, Indexes 2 and 4.

R d Possible weak springs or worn spring seat, Indexes 5 and 6.

R e Condition of internal gearbox surface where packing, Index 1, seats.

R (b) Oil Pressure Pump, See Figure 104.

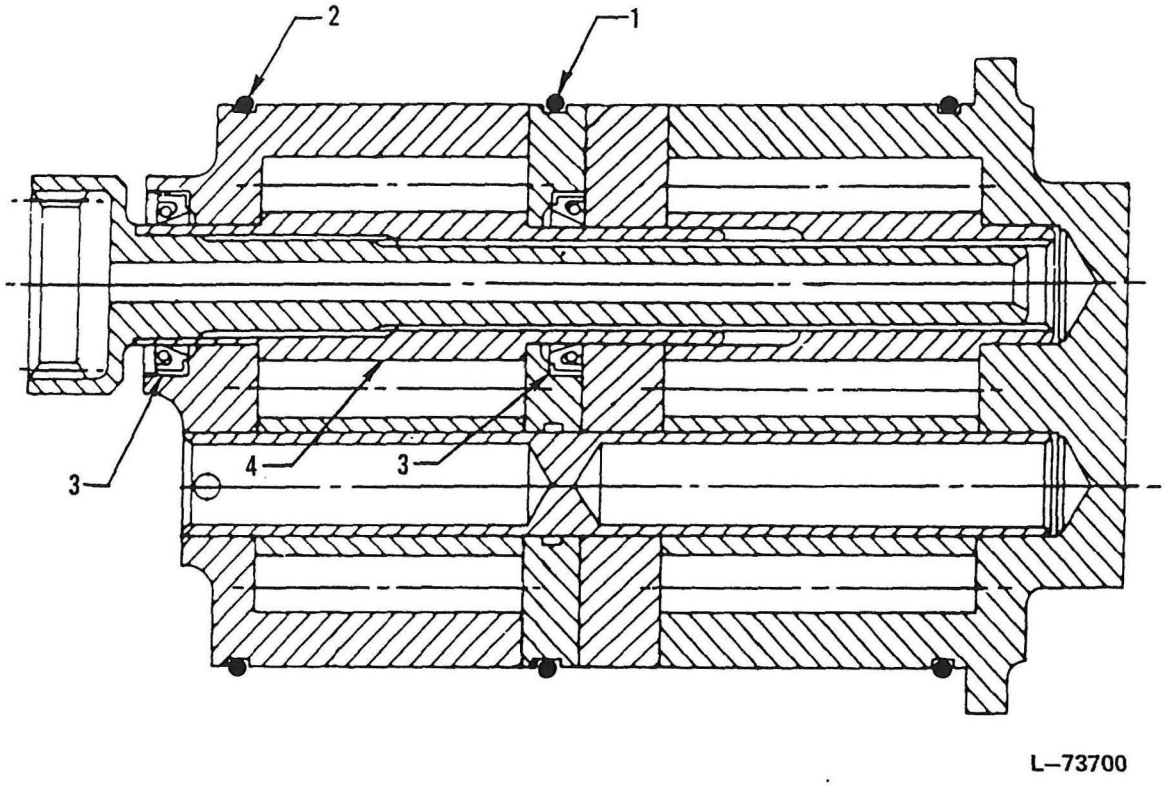
R 1 With the oil tank drained, remove the pump assembly using two PWA 2536 Pullers.

R 2 Check the following and correct discrepancies as necessary:

R a Condition of the center and inner O.D. packings, Indexes 1 and 2. A problem with the outer O.D. packing will result in external leakage.

R b Condition of the two lip seals and mating gearshaft journals, Indexes 3 and 4.

R c Condition of gearbox internal surfaces that mate with the center and inner packings.



R
R
R
R

1. Center O.D. "O" Ring Packing
2. Inner O.D. "O" Ring Packing
3. Shaft Lip Seal
4. Gearshaft

R
R

Oil Pump Assembly
Figure 104

ENGINE - SERVICING

1. Periodic Inspection
   A. General
      (1) Life of engine and its associated equipemnt is determined by operational conditions. Inspection system must anticipate these conditions. See Inspection/Check for periodic inspection procedures.
2. Repair
   A. General
      (1) Permisssible repair procedures for line maintenance are listed in Approved Repairs. These repairs can be made at any airport.
3. Fuel
   A. General
      (1) Fuel for engine shall conform to PWA 522 Specifications.
      (2) Fuel contamination may occur in shipment, during transfer from one container to another, or in aircraft fuel system from scale, lint from packings and seals, and deterioration of fuel lines and hoses. Serious malfunction of engine will occur, even to extent of engine stoppage, as result of contaminants in fuel reaching engine fuel system. It is important, that mesh screen in aircraft fuel system upstream of engine fuel pump be inspected periodically for removal of all foreign particles.
   B. Fuel Drainage
      See Section 72-00, Adjustment/Test.
4. Fuel Tanks
   See Airframe Service Instructions.
5. Lubricating Oil
   A. General
      (1) Synthetic oil for engine shall conform to PWA 521 Specifications.
      (2) Engine internal oil system is shown schematically in Figure 44.
   B. Oil Connections and Servicing Drains
      (1) Oil connections are separated into two groups; overboard drains and operational connections. Servicing drains are not aircraft oil connections but are used to drain oil from engine low points.
6. Storage of Shipping Container
   A. Remove humidity indicator from observation port and remove dehydrating agent from bottom of sealing cover. Place all internal components, bolts, nuts, side rails, and brackets in container. Secure these units and then secure container side sections and cover for storage.

ENGINE - SERVICING

CAUTION: ENGINES AWAITING REPAIR OR OVERHAUL SEALL HAVE ADEQUATE PRESERVATION MEASURES ACCOMPLISHED UPON REMOVAL FROM AIRCRAFT ENGINES SHUT DOWN OR NOT OPERATED IN FLIGHT SHALL BE DRIED ACCORDING TO PROCEDURES FOR SPARE ENGINE TRANSPORTATION AND STORAGE

7. Preservation/Depreservation of Engine

NOTE: Engine storage situations not specifically covered shall be preserved by practices and procedures compatible with preservation principles of this manual.

A. Procedure to be followed in preservation and depreservation (reactivation) of engines in service will vary depending upon length of inactivity. Type of preservative used, and whether or not engine may be rotated during inactive period. Therefore, before attempting work of this nature, refer to preservation records (tags) and engine service record (log book) and also establish length of inactivity or length of inactivity anticipated.

CAUTION: UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL BE SPRAYED INTO COMPRESSOR OR TURBINE END OF ENGINE DIRT PARTICLES DEPOSITING ON BLADES AND VANES DURING OPERATION WILL ALTER AIRFOIL SHAPE AND ADVERSELY AFFECT COMPRESSOR EFFICIENCY

B. Engine Preservation Schedule

(1) 0 to 7 days. Engines may be left in an inactive status with no preservation protective requirements provided:
   (a) Engine is sheltered.
   (b) Humidity is not excessively high.
   (c) Engine is not subjected to extreme temperature changes which would produce condensation.

(2) 7 to 28 days. Engines which are to be inactive up to 28 days may have no preservation providing all engine openings are sealed off and relative humidity in engine is maintained at less than 40 percent. This can be accomplished by placing approximately 26 pounds of dehydrating agent in engine inlet and tailpipe. Place dehydrating agent on racks to keep it off engine parts. Suitable windows shall be provided in inlet and exhaust closures to allow observation of humidity indicators.

(3) 28 to 90 days. Engines which are to be stored longer than 28 days but not to exceed 90 days need only fuel system preserved. Engine oil system shall be drained; however no oil system preservation is required. Desiccant agents, humidity indicators, engine coverings such as intake, exhaust breather discharge, etc. must be utilized.

(4) 90 plus days. Engine preservation must be complete. Preserve engine oil system and engine fuel system as described in following paragraphs.

C. Engine Oil System Preservation

(1) Following procedures shall be followed for preservation of engines which are to be inactive for periods exceeding 90 days.

(a) Rotate engine with starter or auxiliary power unit at starter pad until oil pressure and high compressor (N2) speed is indicated. Disengage starter.

(b) Open drain on bottom of oil tank and remove drain plug from bottom of N2 gearbox. Drain all oil into suitable containers.

(c) With drains open, motor engine over to 1200 plus or minus 100 rpm with starter, allowing scavenge pumps to clear engine, indicated by cessation of steady stream of oil from drains. To prevent excessive operation with limited lubrication, limit rotation to shortest possible time to fulfill above requirement. Starter operating time limits should not be exceeded.

(d) Remove main oil strainer and rinse assembly in petroleum solvent.

(e) Allow engine oil to drain to slow drip for approximately one-half hour.

(f) Install oil strainer and close previously opened drains.

(g) Fill oil tank with new engine oil.

(h) Motor engine over with starter until oil pressure indication is observed.

(i) Start and operate engine for five minutes at 75 percent normal rated and shut down engine. Specific engine operating instructions should be observed during preservation run.

(j) Drain oil tank and accessory case by opening oil tank drain and removing drain plug from bottom of N2 gearbox. Drain oil into suitable containers.

(k) Close oil tank drain and reinstall N2 gearbox drain plug.

(l) Remove cover plates from pads of accessory drives upon which accessories are not installed and spray exposed surfaces with engine oil. Reinstall cover plates.

(m) Plugs, caps, covers, or screens should be installed over all openings to prohibit entrance of foreign material and accumulation of moisture.

(n) If engine is to remain in aircraft, install 52 pounds of dehydrating agent, distributing 26 pounds in compartment. Balance should be distributed equally in aircraft inlet and exhaust section.

(o) Oil filler caps should be tagged as to preservative used and date of preservation. Using air tight moisture barrier or other suitable covers, cover air inlet and exhaust end of engine compartment, installing humidity indicator at each end. Inspection windows at each end should be provided through which indicators will be visible.

(p) Inspection of preserved unit should be made every two weeks if aircraft is stored outside or every 30 days if aircraft is stored inside. If relative humidity as indicated on humidity cards is 40 percent or less, no further action is required. If humidity indications are 40 percent or higher, unit should be depreserved, then represerved.

D. Fuel System Preservation

R NOTE: On engines modifed by SB 3721, dump valve overboard
R drain and signal lines have been removed and ports
R plugged: In order to perform fuel system preserva-
R tion on these engines, remove plugs from dump valve
R overboard drain and signal ports and disregard step
R (2).

(1) Place suitable container, having minimum capacity of five gallons, under pressurizing and dump valve overboard drain.

R (2) Disconnect dump signal line (line from pressurizing and dump valve to fuel control) at either end. Install pressure tight closure on passage leading to fuel control, leaving passage to dump valve open to atmosphere.

(3) Disconnect fuel-in supply at inlet pad of fuel pump and connect supply of filtered slushing oil at pressure of 5 - 25 psi and minimum temperature of 60°F (15°C). Extreme care should be taken to prevent foreign material from being drawn into engine fuel system. Equipment should be provided with suitable filters and/or strainers of no coarser mesh than used in engine. Ten micron filter is recommended for this purpose.

R (4) With ignition switch off and fuel control shut-off lever
R open, move fuel control power lever to full open position.
R Motor engine at a speed of 1700 ± 100 rpm with starter
R until at least two gallons of oil have discharged out over-
R board drain. During motoring period fuel control power
R lever should be moved from open to closed to open.

(5) Remove closure from dump signal passage leading to fuel control and reinstall line to pressurizing and dump valve fitting.

R NOTE: On engines modified by SB 3721, reinstall plugs in
R dump valve overboard drain and signal ports.

(6) Fuel control power lever should be tagged as to preservative used and date of preservations.

E. Preservation of Water Injection System

(1) Attach source of heated dehydrated air to water inlet pad. Actuate water shut-off valve to open position.

(2) Allow heated air at temperature not to exceed 250°F (121°C), to blow through system for minimum of ten minutes.

(3) On completion of procedure, return shut-off valve to closed position.

F. Engine Depreservation Schedule

(1) 0 to 28 days. No depreservation required.

(2) 28 to 90 days. Depreserve fuel system and service engine oil system with fresh oil.

(3) 90 plus days. Complete depreservation is required.

G. Engine Depreservation

R NOTE: On engines modified by SB 3721, dump valve overboard
R drain and signal lines have been removed and ports
R plugged. In order to perform fuel system depreserva-
R tion on these engines, remove plugs from dump valve
R overboard drain and signal ports and disregard step
R (5).

Check all oil passages for obstructions before installing accessories which are dependent on engine oil.

(1) Remove all moisture barriers, humidity indicators, and dehydrating agent.

(2) Fill oil tank with engine lubricating oil.

(3) Connect fuel supply line to fuel inlet pad.

(4) Place suitable container, having minimum capacity of five gallons, under pressurizing and dump valve overboard drain.

(5) Disconnect either end of dump signal line-to-fuel control tube. Leave dump valve connection open to atmosphere. Plug fuel control connection with suitable plugged fitting to prevent dumping of fuel.

R (6) With ignition off, fuel control shut-off lever open, and
R fuel control power lever in full open position, motor engine over with starter on external power source to high
R rotor (N2) speed of 1700 ± 100 rpm. During motoring period,
R fuel control power lever should be moved from open to closed to open.

CAUTION: ROTATION OF ENGINE SHOULD BE LIMITED TO SHORTEST POSSIBLE TIME IN ORDER NOT TO EXCEED STARTER OPERATING LIMIT.

(7) When at least two gallons of fluid have been obtained from overboard dump line, close fuel control levers and disengage starter.

(8) Remove plugged fitting from dump signal line and reconnect signal line to pressurizing and dump valve.

R NOTE: On engine modified by SB 3721, reinstall plugs in
R dump valve overboard drain and signal ports.

(9) Remove preservation tags and make proper entry in engine records.

8. Inspection of Engine During Storage

A. Maintenance

(1) Maintaining engine during storage period consists principally in maintaining air within container below 40 percent relative humidity. Although experience and test indicate that corrosion will not usually occur at relative humidities below 40 percent, corrosion is occasionally found even though record indicated that safe level has not been exceeded. For most part, such corrosion has been shown to result from renewal of dehydrating agent being delayed too long. Maintenance procedure for an engine in storage is as equally important as initial preservative treatment. Only when two are carried out in every detail can there be assurance of protection to engine during storage period.

B. High Relative Humidity Indication of Engines in Storage

(1) If humidity indicator shows relative humidity within container to exceed 40 percent, proceed as follows:

(a) Position container under suitable hoist. Free overhead space of approximately eight feet minimum, exclusive of distance from top of container to hoist hook, is required.

(b) After removing straps, install suitable sling to rings in top section of container.
(c) Unfasten four hooks securing side sections of container.
(d) Raise top section straight up until free and clear of engine and draw it to one side; then remove four side sections.
(e) Using knife, open covering and check it for tears or holes.
(f) Check engine for evidence of corrosion.
(g) Remove old humidity indicator from observation port and dehydrating containers from bottom of covering.

NOTE: Care must be exercised to assure that dehydrating agent and humidity indicator which have been removed are properly disposed of and cannot possibly be reinstalled in container.

(h) Check interior of container to be sure that it is free of all dirt, oil, water, or other foreign matter.
(i) Install new humidity indicator in place provided (observation port). Fasten indicator securely with tape as required so that transparent side is visible from exterior of container.
(j) Place dehydrating agent containers loosely in bottom of engine covering.
(k) Close covering and seal it with sealing iron or equivalent.
(l) Using guide pins, install four sides in their position on box and fasten four hooks. Lower top on container.

NOTE: If engine is to be shipped, install side straps.

9. Preservation of Non-Operable Engines
A. Procedure
(1) Engines which cannot be operated or cannot use methods described in Preservation/Depreservation shall be preserved by practices and procedures compatible with preservation principles of this manual.

10. Protection of Non-Running Engines
A. Procedure
(1) Engines in aircraft left standing outside or exposed to wind must have inlet and exhaust duct openings covered, to prevent dirt, dust, and foreign materials from entering engine, and to prevent reverse rotation of low rotor due to wind blowing through inlet or exhaust ducts.

ENGINE - SERVICING

11. Spare Engine Transportation and Storage
A. Procedure
(1) Spare engine may be transported in external pod or in cargo compartment of aircraft. In either case protect engine from corrosion, especially if humid conditions are expected to be encountered enroute to destination.
(2) Preserve engine, fuel and oil system, as directed in Preservation/Depreservation of Engine.

NOTE: In addition to following regular preservation procedures, following may be done for engines which are enroute to overhaul.

CAUTION: ENGINES WHICH HAVE BEEN SPRAYED WITH OIL INTERNALLY ARE NOT TO BE RUN UNTIL COMPLETELY DISASSEMBLED AND CLEANED

(a) While rotating both compressor and turbine rotors with starter, use fine spray to apply thin film of oil on internal parts of engine.
(b) Direct spray into inlet at start and spray exhaust area just before rotors stop.
(3) Install 52 pounds of desiccant or dehydrating agent, half in inlet and half in exhaust section of engine. Be sure desiccant is properly packaged and secured.
(4) Install and secure humidity indicator in inlet and exhaust ends of engine.
(5) Install appropriate external pod fairings and covers to act as moisture barriers and prevent air circulation through engine.
(6) Engines shipped in cargo compartments shall be wrapped in nearly air tight suitable plastic type envelope or sealed by covers at inlet and exhaust openings.
(7) Upon arrival at destination and removal of engine from aircraft, remove fairings, covers, humidity indicators, and dehydrating agent. Check humidity indicators before removal.
(8) Blow hot dry air through engine to remove moisture before continued storage. Hot air velocity shall not be great enough to cause engine rotations.

NOTE: If engine is to be installed in an aircraft and run immediately, drying process is not required.

(9) Continued storage shall follow established procedures.

12. Transporting Engine Using "Three-Engine Ferry" Method

A. Front and rear compressor sections of engines being transported by "three-engine ferry" must be immobilized to prevent rotation due to air passing through engine.

(1) Secure front compressor rotor using three PWA 30233 Locking
R Straps. See Figure 301.

(a) Feed one end of strap into engine inboard of mid-span shroud, around trailing edge of first stage fan blade and back outside of engine.

(b) Position strap so one end extends past leading edge of inlet guide vane approximately one inch (not including velero tape detail).

(c) Pass other (long) end of strap over leading edge of next inlet guide vane in direction of engine rotation and around trailing edge of closest first stage fan blade, causing strap to pull on blade in direction of rotation.

(d) Continue weaving strap alternately between blades and vanes keeping strap tight and always pulling compressor rotor in direction of engine rotation.

NOTE: Some blades will be skipped because there are more blades than vanes. Each strap should pass around approximately one third of vanes.

(e) When end of strap is reached, bring end out of engine, pull tight and overlap velero tape at each end of strap.

(f) Secure velero tape by tightly rolling overlap and whipping with nylon cord for 3 to 4 inches at each end. Wrap nylon cord and velero tape with adhesive tape and tape overlaid strap span to nearest inlet guide vanes.

(g) Continue to secure remaining portions of front compressor rotor by repeating above procedure with remaining two straps.

(2) Secure rear compressor rotor using PWA 30251 Holder.

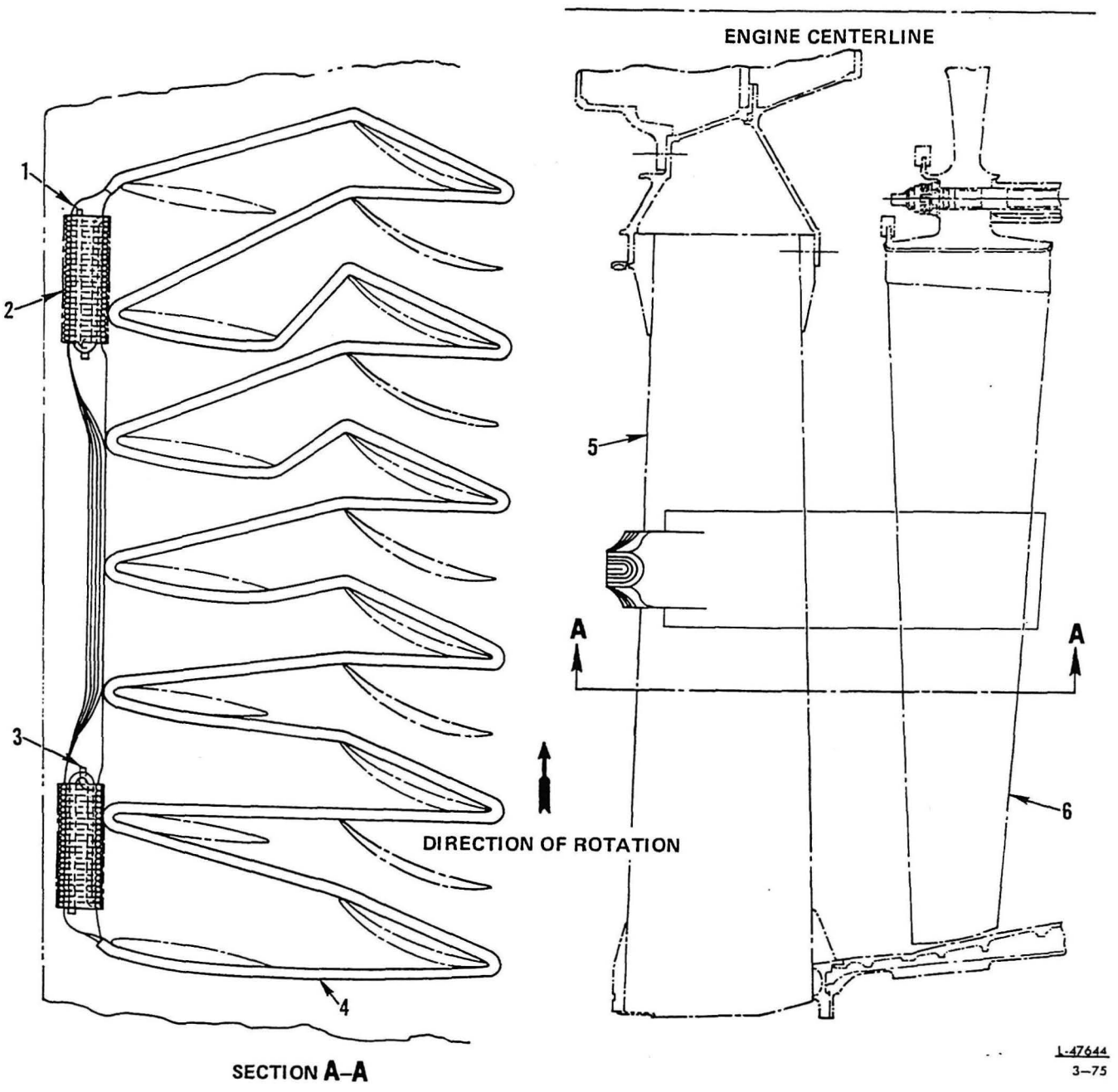
(a) Remove starter from engine (see appropriate section in airframe manual).

(b) Place PWA 30251 Lock over studs on starter drive pad engaging lock with starter drivegear splines.

(c) Secure lock to starter drive pad studs with nuts.

13. Identification of Metal Particles

A. When unidentified particles of metal are found, they may be either steel, tin, aluminum, magnesium, silver, bronze, or cadmium. In some cases type of metal may be determined by color and hardness of pieces. However, when particles cannot be positively identified by visual inspection and knowledge of exact character of metal is desired as an aid to trouble-shooting, few simple tests will determine kind of metal present.



R 1. Nylon Cord Wrap, Two Places. Reference Tool Detail-4.
R 2. Pressure Sensitive, Waterproof, Adhesive Tape Wrap, Two Places.
R 3. Pull Cord Tight
R 4. Strap Cover, Reference Tool Detail-5
R 5. Inlet Guide Vane, Reference
R 6. First Stage Compressor Blade, Reference.

Front Compressor Rotor
Locking Strap
Figure 301

B. Following equipment and chemicals are required to make these tests: Source of open flame, permanent magnet, two ounces of aqueous solution containing ten percent ammonium nitrate, an electric soldering iron, two ounces each of 50 percent by volume hydrochloric acid, and concentrated nitric acid, sodium hydroxide pellets, watch glass, white porcelain spot plate, ammonium bifluoride crystals, 5 to 10 percent hydrofluoric acid or concentrated sulfuric acid, 3 to 10 percent hydrogen peroxide, and concentrated phosphoric acid.

WARNING: USE EXTREME CARE IN HANDLING ACIDS

14. Test Procedure for Identification of Metal Particles

NOTE: Following test procedure is recommended for determining character of unknown metal particles. For best results, follow steps as outlined:

A. Steel - Particles can be isolated by means of permanent magnet. Steel or iron is attracted by magnet.

WARNING: NEVER ATTEMPT TO BURN MORE THAN FEW PARTICLES OF METAL SUSPECTED TO BE MAGNESIUM MAGNESIUM POWDER OR DUST IS EXPLOSIVE

B. Magnesium - Simple test for these particles is burning. Magnesium will burn with bright white flash.

C. Cadmium - Place remaining particles in aqueous (water) solution of ammonium nitrate. If all or any of particles dissolve in this solution, they are cadmium. After this test, rinse and dry any remaining particles.

D. Tin - Tin particles can be distinguished by their low melting point. With clean soldering iron, heated to 500°F (260°C) and tinned with 50-50 solder (50 percent tin - 50 percent lead), tin particle dropped on iron will melt and fuse with solder.

E. Aluminum - When particle of aluminum is placed in hydrochloric acid 50 percent by volume, it will fizz with rapid emission of gas bubbles and gradually disintegrate and form black residue (aluminum chloride). Silver and bronze do not noticeably react with hydrochloric acid.

WARNING: HYDROCHLORIC ACID IS DANGEROUS AND REQUIRES SPECIAL HANDLING.

F. Aluminum Paint - Use this procedure to determine whether or not material is aluminum silicone paint, aluminum chips, or silver particles.
   (1) Make sodium hydroxide solution by adding one pellet of sodium hydroxide to three cubic centimeters of water.
   (2) Place several drops of this solution in watch glass and drop in suspected particles.
      (a) If particles are aluminum silicone paint, there will be mild reaction in form of gas bubbles and some visible gas as particles change to sodium aluminate.
      (b) If particles are aluminum chips, reaction will be much more active with many more gas bubbles forming and more visible gas.
      (c) If particles are silver, there will be no reaction.

G. Silver - When silver particle is placed in nitric acid, it reacts rather slowly, producing whitish fog in acid.

H. Bronze - When bronze (or copper) particle is placed in nitric acid, bright green cloud is produced.

15. Test Procedure For Identification of Titanium Particles

A. Place piece or pieces of metal to be identified on white porcelain spot plate. Piece of titanium or titanium bearing metal should be placed on another spot plate to observe and verify results obtained.

B. Add several crystals of ammonium bifluoride and 5-10 drops of water to metal particles. (2-3 drops of a 5-10 percent hydrofluoric acid solution can be used instead.)

C. Let stand 20 to 30 minutes, or until solution becomes slightly discolored.

D. Add 2-3 drops of 1:1 sulfuric acid (1 part water to 1 part concentrated acid).

E. Let stand 20 to 30 minutes, or until solution becomes more discolored.

F. Add 3-4 drops of 3-10 percent hydrogen peroxide. Solution must not be too old.

G. If titanium is present, yellowish color will develop. This yellow color will become progressively darker with time, if allowed to set.

H. Add 2-3 drops of concentrated phosphoric acid, and stir to discharge any yellow color due to possible presence of iron.

I. Any light yellow to orange coloration indicates presence of titanium.

NOTE: Above chemicals are hazardous and require special handling. Solid ammonium bifluoride is crystalline and can be conveniently stored in dry place and used as needed.

16. Extreme Weather Maintenance

R A. Cold Weather Procedures

(1) General

(a) A discourse on the effects of cold weather upon turbofan engine operation is not the purpose of this publication; however it is felt that a summary of a few of the more prevalent effects will aid in troubleshooting some of the problems arising from cold weather operations.

(b) Aviation fuels will normally contain little of no water, but the percentage of water is governed to a great extent by storage and handling conditions of the fuel. Fuel exposed to dampness or ordinary atmospheric conditions naturally contain a larger percentage of water than those kept in tightly sealed containers. This water content, under poor conditions may average as high as several gallons in every thousand gallons of fuel.

(c) As temperatures are reduced, the solubility of water in the fuel is also markedly reduced, which results in the water separating from the fuel, seeking the lowest point in the tank, system, and/or accessory concerned and freezing there if the temperature goes low enough. Under these conditions it also will freeze in the fuel, forming tiny needle-shaped crystals which may be found impinged on the strainers, restricting fuel flow and in severe cases clogging the strainers entirely. Should this condition occur it will be evidenced by a drop in, or loss of fuel pressure to the engine. The only remedy is hot air applied to the engine and fuel system components. Refer to airframe manufacturer's recommendations for externally applied heat.

R (d) Under these conditions, it is most important that all sumps, strainers, traps (burner pressure sensing line moisture trap) and filters be thoroughly inspected on all preflight checks. As long as fuel will flow freely from the drain cocks in the tank sumps and strainers it can be surmised that the system is free of ice.

R (e) In the event that water has collected and frozen in the sumps and/or strainers (indicated by the lack of flow from the drain cock) heat should be applied in accordance with the airframe manufacturers recommendations.

CAUTION: DO NOT ASSUME THAT ALL THE ICE HAS MELTED IF IT IS POSSIBLE TO DRAIN FUEL FROM THE DRAIN COCK AFTER SEVERAL MINUTES OF HEATED AIR APPLIED TO THE EXTERIOR OF THE AFFECTED COMPONENT. THE ICE ADJACENT TO THE INTERIOR OF THE AFFECTED UNIT MAY MELT AND ALLOW SOME WATER AND FUEL TO FLOW FROM THE DRAIN, BUT A LUMP OF ICE MAY STILL REMAIN IN THE FUEL CREATING A SERIOUS HAZARD TO ANY FLIGHT OPERATION. THE FLOW OF FUEL TO THE OUTLET, ON ENGINE STARTING MAY CAUSE THIS BLOCK OF ICE TO SLIP OVER THE OUTLET AND RESTRICT OR PLUG THE OPENINGS CREATING A DANGEROUS SITUATION. IF FUEL DOES FLOW FROM THE DRAIN COCK, CONTINUE TO APPLY HEATED AIR FOR A SHORT TIME, CHECKING THE DRAIN COCK FLOW FREQUENTLY. THIS FUEL SHOULD BE CAUGHT IN A CONTAINER AND INSPECTED FOR GLOBULES OF WATER UNTIL IT IS EVIDENT THAT IT IS ALL REMOVED FROM THE AREA.

R (f) It is well to note that a similar situation may exist in the lubrication system, with the water coming from condensation of air in the tank or engine case area. When a hot engine is shut down under low temperature conditions and allowed to stand for a period of time or possibly overnight in the open, the possibility of ice in the fuel and lubrication system is much more prevalent. Extra precautions should be observed to prevent this condition and the system should be checked for the presence of ice on the preflight.

ENGINE - SERVICING

R CAUTION: WHEN STARTING AN ENGINE WHICH HAS BEEN EXPOSED
R TO LOW TEMPERATURES OVERNIGHT CAREFULLY OBSERVE
R THE FUEL AND OIL PRESSURES. THE LACK OF ANY
R INDICATION BELOW THE NORMAL OPERATING LIMITS IS
R CAUSE FOR IMMEDIATE ENGINE SHUTDOWN. INSPECT
R FOR ICE IN THE SYSTEM(S) OR MOVE THE PLANE
R INDOORS AND/OR APPLY HEATED AIR BEFORE
R ATTEMPTING ANOTHER START.
R
R (2) Additional Preflight Inspection
R
R (a) Examine the engine inlet and exhaust section for the
R collection of ice. Rotational freedom of the rear
R turbine should be verified.
R
R (3) Starting Engine
R
R (a) Start the engine using the normal starting procedure.
R
R CAUTION: IF THERE IS NO INDICATION OF OIL PRESSURE
R AFTER 30 SECONDS OF ENGINE OPERATION OR IF
R THE PRESURE DROPS TO ZERO AFTER A FEW MINUTES
R OF GROUND RUNNING, STOP THE ENGINE AND
R INVESTIGATE.
R
R (b) Although not absolutely necessary, it is desirable when
R a start is made during extreme cold weather with an
R engine which has cold soaked to a temperature of -30
R degrees F (-35 degrees C) or below to warm up the
R engine for two minutes before advancing the power lever
R above IDLE rpm.
R
R NOTE: It should be noted that engine thrust developed
R at low ambient temperatures is higher than that
R developed at standard day conditions at
R comparable power lever settings.
R
R (4) Engine Shutdown
R
R (a) Shutdown engine in the normal manner.

R B. Hot Weather Procedures

(1) Starting Engine

(a) Normal starting procedures are used in hot weather. Temperatures will probably be on the high side of operating ranges.

(2) Warm-up and Ground Test

(a) Ground testing should be complete but accomplished as rapidly as possible.

17. Numerical Tool List

PWA 30233 Locking Strap
PWA 30251 Lock.

ENGINE - DISMANTLING/ASSEMBLY

1. Air Frame Parts

   A. See Chapter 71, as required, for information concerning removal of airframe installed parts.

   B. Alternator Drive Adpater Pad

      CAUTION: THIS MOUNT PAD MAY INCORPORATE MID-GRIP TYPE HELICAL INSERTS IDENTIFIED BY HEXAGONAL APPEARANCE OF ONE THREAD AND BY RESISTANCE WHEN TURNING BOLT BY HAND WITH UNIFORM THREAD DRAG WHICH LOCKS BOLT IN PLACE WHEN TURNED WITH WRENCH. GASKET MUST BE INSTALLED SO AS NOT TO OBSTRUCT OIL PASSAGE HOLES. REMOVE TEST PLUGS FROM OIL PASSAGES IN ALTERNATOR DRIVE ADAPTER PAD BEFORE INSTALLING ALTERNATOR DRIVE ADAPTER.

   C. Accessory Housing Breather

      CAUTION: ON BOEING ENGINES ONLY, ROTARY BREATHER SEAL CARRIER MUST EXTEND TO FACE OF BREATHER MOUNT PAD OR INCLUDE SPACER P/N 446978.

2. General Maintenance Procedures

R NOTE: PWA-9156-51 Engine Air Inlet Cover and PWA-9156-52 Engine
R Turbine Exhaust Cover have been provided to prevent
R foreign objects from entering engine. Use these tools as
R required during engine maintenance.

   A. To ensure proper reinstallation, tag and mark all parts, clips, and brackets as to their location.

      CAUTION: IT IS POSSIBLE TO ASSEMBLE CERTAIN ENGINE PARTS IN A LOCATION OR IN OTHER MODELS OF ENGINES FOR WHICH THESE PARTS WERE NOT INTENDED. BECAUSE SUCH MISASSEMBLY CAN POSSIBLY RESULT IN A FAILURE, CHECK EACH PART TO BE SURE CORRECT PART IS USED.

   B. During removal of tubes or engine parts, look for indications of scoring, burning, or other undesirable conditions. To facilitate reinstallation, observe location of each part during removal. Tag unserviceable parts and units for investigation and possible repair.

ENGINE - DISMANTLING/ASSEMBLY

C. Extreme care shall be taken to prevent dust, dirt, lockwire, nuts, washers, or other foreign matter from entering engine. If at any time such items are dropped, assembly process must stop until dropped articles are located, even though this may require considerable amount of time and labor. Before assembling or installing any part, be sure it is thoroughly clean. Suitable plugs, caps, and other covering shall be used to protect all openings as they are exposed.

NOTE: Dust caps used to protect open lines against contamination shall always be installed over tube ends and not in tube ends. Flow through lines may be blocked off if lines are inadvertently installed with dust caps in tube ends.

D. Lockwire, lockwashers, tablocks, tabwashers, or cotterpins shall never be reused. All lockwire and cotterpins must fit snugly in their holes. Install cotterpin so that head fits into castellation of nut, and unless otherwise specified, bend one end of pin back over stud or bolt and other end down flat against nut. Only lockwire and cotterpins made of corrosion resistant steel shall be used. Bushing plugs shall be lockwired to assembly boss or case. Do not lockwire plug to bushing.

E. Replace all gaskets, packings, and rubber parts at every removal/installation. Make sure that new nonmetallic parts to be installed (such as an oil seal) show no sign of having deteriorated in storage. If necessary, coat gasket surfaces with Gredag Lubricant to reduce possibility of gasket adhering to surfaces of mating parts.

F. In order to protect critical areas of engine parts (such as compressor and turbine disks) against scratches and nicks, tool surfaces contacting these areas must be covered with protective material.

CAUTION: BEFORE USING TOOLS SO COVERED, MAKE CERTAIN THAT THERE IS SUFFICIENT PROTECTIVE MATERIAL PRESENT TO PRECLUDE POSSIBILITY OF DAMAGING ENGINE PARTS.

G. If any part were coated with corrosion preventive compounds, all traces of this compound and accumulated foreign matter must be removed.

H. Tubes which incorporate fixed ferrule and loose nut shall have seal retaining nut at fixed ferrule end of tube tightened first.

R 3. Preformed Packings

R CAUTION: PREFORMED PACKINGS MUST BE COATED WITH THIN FILM OF
R LUBRICANT PRIOR TO ASSEMBLY. THIS LUBRICATION,
R PLUS PROPER ASSEMBLY, WILL PREVENT DAMAGE TO PACK-
R INGS THAT COULD CAUSE ENGINE MALFUNCTION OR FAILURE.

R A. Preformed packing lubrication requirements are as follows:

Engine System	Packing Material And Specification	Lubrication Specification
Fuel	Fluorosilicone (AMS 7273)	Oil, PWA 521, Type I or II, or petrolatum, PMC 9609
Oil	Fluorocarbon (AMS 7276, 7278, 7280)	Oil, PWA 521, Type I or II
Air, water, or alcohol	Silicone (AMS 7267)	Petrolatum PMC 9609

R B. At all assembly operations, whenever silicone preformed packings of materials listed below are being installed, use only petrolatum (PMC 9609) or equivalent, as lubricant, applied sparingly, on packings. Colors of preformed packings which, in general, are affected are red and off-white. Ester type oils (turbine oils) must not be used.

Silicone Rubber Preformed Packing Materials Affected

AMS 3301	AMS 3305	AMS 3334	AMS 3345
AMS 3302	AMS 3315	AMS3335	AMS 3346
AMS 3303	AMS 3320	AMS 3336	AMS 3356
AMS 3304	AMS 3332	AMS 3338	AMS 3357

4. Installation of Preformed Packing and Jamnut Type Connector (Universal Fittings)

A. Install jamnut type connectors as follows: See Figure 401 (Sheet 1).

WARNING: FAILURE TO ACCOMPLISH INSTALLATION PER INSTRUCTIONS MAY RESULT IN SUBSEQUENT FAILURE, FIRE, EXTENSIVE DAMAGE AND LOSS OF LIFE.

(1) Coat male threads of fittings, preformed packing and backup ring with petrolatum (PMC 9609) or jet engine oil. Plastic packing requires no lubrication.

(2) Assemble nut on fitting with counterbored face toward engaging end.

WARNING: USE OF LEATHER BACKUP RINGS HAS BEEN DISCONTINUED TO PREVENT POSSIBILITY OF FUEL LEAKAGE.

(3) Work packing into nut counterbore.

(4) Install preformed packing on non-threaded annulus of fitting.

(5) Turn nut down until preformed packing is positioned in annulus firmly against threads to be installed in mating part.

(6) Install fitting into mating part, turning nut with fitting until preformed packing contacts mating part boss. This point can be determined by increasing torque. With fitting in this position and while holding nut to prevent its turning, screw fitting into mating part an additional one and one-half turns.

NOTE: From this point, fitting can be turned inward to a maximum of one additional turn for alignment purposes. If fitting tightens in nut before completing one and one-half turns or before fitting can be aligned, it is permissible for nut to turn with fitting for remainder of distance.

(7) With fitting held in properly aligned position, tighten jamnut to recommended torque and lockwire.

(8) Metal to metal contact between nut and mating part boss must be obtained without exceeding recommended torque values and no extrusion of preformed packing or backup ring is permitted. It is essential that proper values based on metal to metal contact mentioned above be observed when tightening jamnut. This will minimize possibility of fitting loosening and resultant thread wear.

B. Recommended torque limits and thread protrusion limits for various fittings are outlined in Figure 401 (Sheet 2). Measure thread protrusions as shown in Figure 401 (Sheet 3).

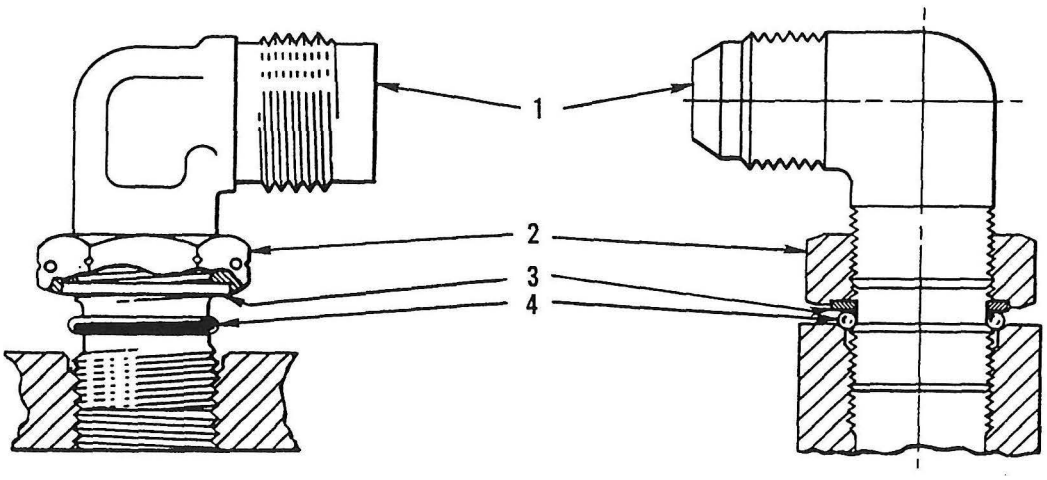
5. Assembly of Flexible Type Fittings

R A. Flexible Fittings, Packing, And Retainer

R See Figure 402.

R (1) Moisten seal and fitting threads with light film of engine
R oil or PMC 9609 petrolatum.

R (2) Install seal on tube end against ferrule.



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5-75

1. Connector Elbow
2. Jamnut
3. Packing
4. Seal

(a)

INITIAL CONTACT BETWEEN
SEAL AND HOUSING

Preformed Packing And Jamnut Type
Connector (Sheet 1)
Figure 401

THREAD PROTRUSION AND TORQUE LIMITS

THREAD SIZE	TORQUE LIMITS	FITTING PART NUMBERS	THREAD PROTRUSION LIMITS*
1.625-12	600-900	196826, 215812, 222090, 254498	1-2
		405623	0.900 to 1.000 inch from mating face of nut to mating face of coupling mount flange when nut is tight against adjacent part.
		332627, 462254	0.166" Max from undercut
		390998	0.476" Max from undercut
1.3125-12	500-700	183649, 198420, 214163, 253424	0-1
		226110, 227470, 323462	1/2 — 2-1/2
		183653	3-4
		170987 (with thread undercut)	1/2 — 1-1/2
		170987 (without thread undercut)	2-3
		417813	2-3
1.0625-12	300-500	235157, 307450, 314431, 317408	0-1
		226112	1-2
		418842	5-8
0.875-14	200-350	224913	2-3
		321677	1-2
0.750-16	150-250	223923, 278121	0.100" Max from undercut
		218217, 331583	0.234" Max from undercut
		232179, 443519	0-1
		341231	1/2 — 1-1/2
		155974, 321675	1-2
		150697, 227456, 361593	2-3
		355812	5-6
0.5625-18	75-125	229161	1-2
0.500-20	60-80	222172, 265050	1/2 — 1-1/2
		303035, 315335, 363010	1-2
		282715	2-1/2 — 3-1/2
		431952	0.105" Max from undercut
0.4375-20	40-65	190682	0.209" Max from undercut
		233548, 234097, 268652	0.080" Max from undercut
		240875, 360691	1/2 thread max
		168974, 170493, 183630, 237346	0-1
		243308, 252790, 331097, 433116, 454210	0-1
		164433, 224877, 249600, 252785	1/2 — 1-1/2
		260962, 266284, 307064, 361589, 388207	1/2 — 1-1/2
		210247,228640,276754	2-3
		348650, 381879	4-6
0.375-24	30-50	258086, 274359	1-3

*Limits shown are "Full Threads" exposed on the fitting, beyond the jamnut. A full thread is defined here as a thread crest with a complete root radius on each side of it.

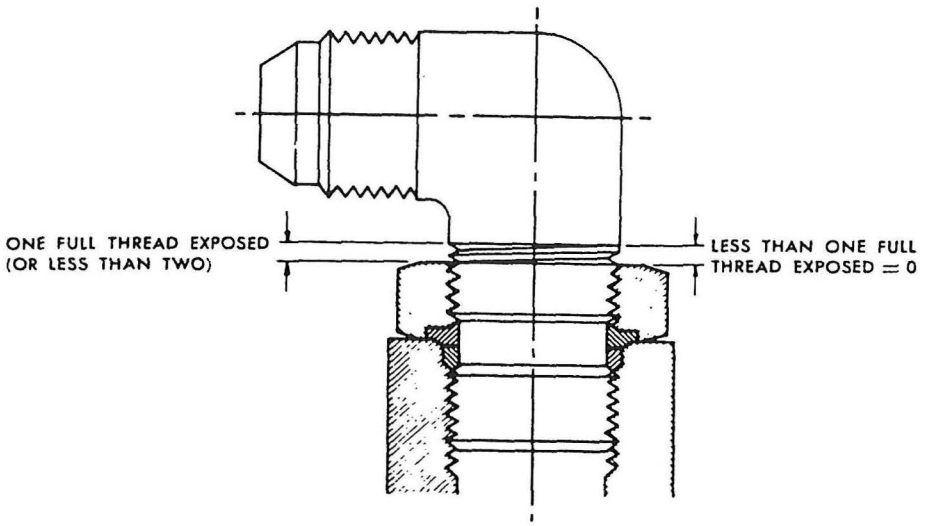
High limit on thread protrusion is set to be sure that at least three full lower threads of fitting are engaged under all tolerance conditions. Thread protrusions below low limit indicate possible connection faults associated with fittings installed too deep (Seal or packing omission or extrusion, very loose nut, or inadequate seal annulus). If fitting is found to have too many threads exposed upon periodic service check, fitting must be removed and reinstalled. If there are still too many threads exposed, fitting must have extreme tolerances and if installation procedure was followed correctly, proper thread engagement may be assumed.

UNSATISFACTORY CONNECTION CONDITIONS AND METHODS OF PREVENTION

CONDITION	POSSIBLE RESULT	INSPECTION INDICATION
1. No Packing and/or seal	Leakage	Possibly beyond Thread Limits or Leakage Check
2. Inadequate Seal Groove - Fitting too deep	Leakage	Too few threads protruding or visible packing extrusion
3. Inadequate Seal Groove - Fitting too high	Leakage or See No. 4	Too many threads protruding
4. Insufficient lower thread engagement	Lower thread failure	Too many threads protruding
5. Loose Nut - Nut Undertorqued	Vibration failure of Lower threads	Test torque, or too few threads protruding or no metal to metal contact
6. Seal or Packing Extrusion	See No. 5 (Torque lost due to relaxation of pinched packing)	No metal to metal contact or visible extrusion
7. Re-use of seals, repositioning of fitting after tightening nut	Leakage	Leakage check

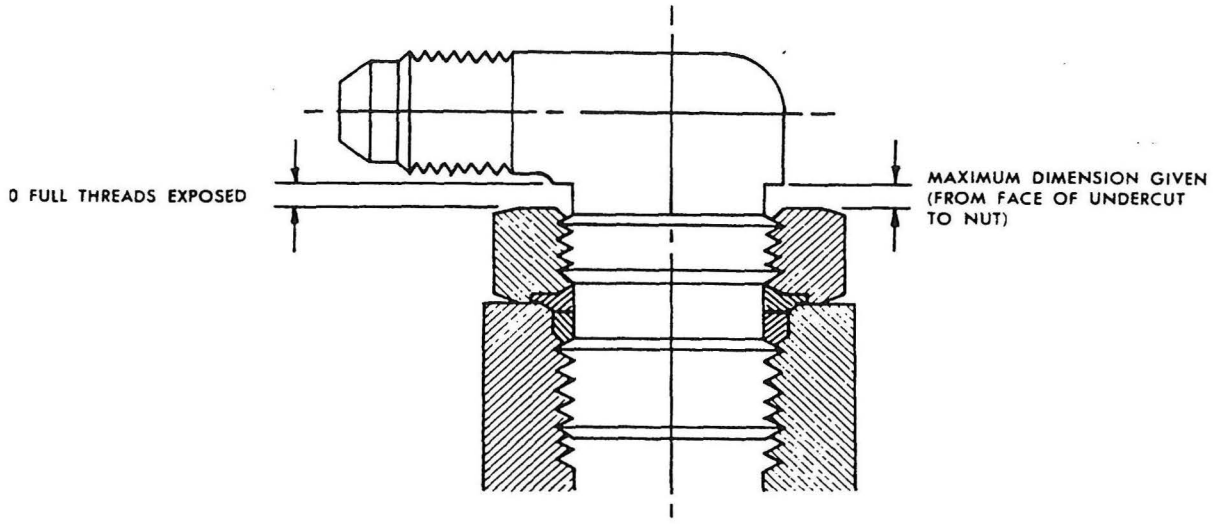
L-19071

Preformed Packing and Jamnut Type Connector
Figure 401 (Sheet 2)



(b)
TYPICAL POSITION AFTER
INSTALLATION (STANDARD FITTING)

$\left(\text{THREADS EXPOSED} = \frac{0+1}{2} = \frac{1}{2}\right)$



(c)
TYPICAL POSITION AFTER
INSTALLATION (UNDERCUT FITTING)

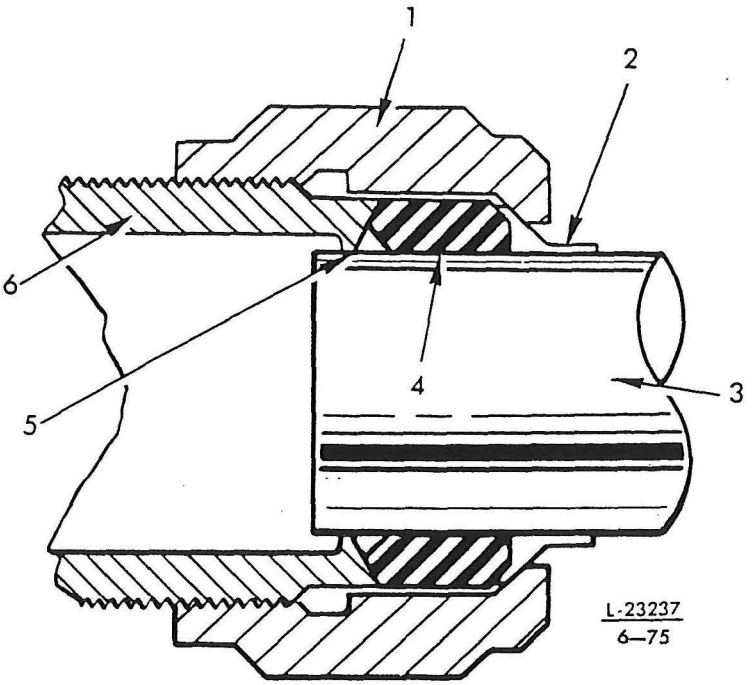
To check thread protrusion, count Whole Numbers of full threads exposed at each end of a diameter and use the average of these two readings. For example, one-half thread means that one (or less than two) full thread is visible on one side and zero or less than one full thread is visible 180 degrees away, as shown in (b). For limits other than zero, a reading error of one-half thread is expected. When there is a thread undercut at the upper end of the fitting thread, in some cases even a zero thread high limit would not ensure sufficient engagement. For these cases, maximum dimensions have been given, from the rear face of the undercut to the nut, as shown in (c).

WARNING

L-7523

Failure to accomplish installation in accordance with these instructions may result in subsequent failure, fire, extensive damage and loss of life.

ENGINE - DISMANTLING/ASSEMBLY



R 1. Nut

R 2. Ferrule

R 3. Tube

R 4. Packing Or Seal

R 5. Retainer

R 6. Connector

R Assembly Of Flexible Fitting,
R Packing, And Retainer
R Figure 402

R (3) Install retainer on tube positioning it against packing or
R seal. Minimize stretching of retainer to ensure tight fit.

R (4) Install tube to properly aligned connector and tighten nut
R to recommended torque. See Table V.

6. Installation Of Elbow Type Fittings

CAUTION: BEFORE TIGHTENING TUBE COUPLING NUTS, BE SURE ELBOWS ARE PROPERLY ALIGNED. TUBE ENDS MUST BE CENTERED AT ELBOWS AND FREE TO MOVE. BINDING OF TUBE AND FITTING OR MISALIGNMENT MUST NOT BE PRESENT.

R 7. Antigalling And Antiseize Compounds

R CAUTION: EXTREME CARE MUST BE EXERCISED TO ENSURE THAT ANTI-
R GALLING AND ANTISEIZE COMPOUNDS ARE APPLIED IN A
R THIN EVEN COAT AND THAT ALL EXCESS MATERIAL IS
R COMPLETELY REMOVED SO AS TO AVOID ITS GETTING INTO
R OR ONTO PARTS, PASSAGES, OR SURFACES WHERE IT MAY
R CAUSE MALFUNCTIONING OR EVEN FAILURE OF THE ENGINE.

R A. General

R (1) Extreme pressure lubricants may be applied to certain areas
R such as splined drives, various case snaps, bearing
R journals, etc., at assembly to prevent galling of highly
R stressed surfaces.

R (2) Antiseizure compounds may be applied at assembly to
R facilitate disassembly of certain hot section and turbine
R threaded fittings.

R (3) Penetrating oil may be used at disassembly to further
R facilitate disassembly of engines.

R B. Materials

R (1) Wet Fel-Pro C-200 or C-300 antigalling compounds are
R approved for threaded parts and mating faces of threaded
R and other parts in hot section and turbine areas.
R Optimum results are obtained with Fel-Pro C-200 baked on
R (SPOP 146), but use of wet Fel-Pro C-200 or C-300 brushed
R on without prior surface preparation or baking is permis-
R sible. In this latter use, less long-term durability is
R obtained.

R (2) dfg-123 (PMC 9934) colloidal graphite dry film lubricant in a volatile carrier has been found satisfactory for use on ball sockets and in assembly of snugly fitting parts such as bearing races, spacers and seals on hubs and shafts.

R (3) All accessory splines which do not normally receive lubrication through engine system must be lubricated with Plastilube No. 3 compound.

R CAUTION: SINCE MOLYBDENUM DISULFIDE IS NOT STABLE ABOVE 900°F (482°C), IT MUST NOT BE USED IN LOCATIONS WHERE OPERATING TEMPERATURES ARE IN EXCESS OF 900°F (482°C).

R (4) Molybdenum disulfide, in either its powder form (PMC 9523) or suspended in some vehicle such as alcohol or engine oil, has been found satisfactory for use in assembling combustion chamber cases, turbine nozzle cases, exhaust cases, turbine shaft splines and threads.

R (a) PWA 541 Antiseizing Compound Lubricant.

R 1 Thoroughly mix molybdenum disulfide powder and grade 1010 oil in the following proportions.

PMC 9523 Powder	80% ± 3% by weight
PMC 9852 Oil	20% ± 3% by weight

R 2 Continue mixing until lubricant is smooth, and free from lumps, cakes, skins, and grit.

R 3 Store lubricant in closed containers to ensure freedom from undue contamination.

R (5) Parker Thread Lub (PMC 9936) antigalling and antiseize compound is approved for spark igniter plug threads, studs, and steel threaded case assembly plugs.

R (6) Marvel Mystery Oil (PMC 9534) gage lubricant is approved for use at engine teardown to facilitate disassembly of engines.

R (7) Extreme pressure lubricant, Lubriplate No. 130A or equivalent, has been found satisfactory for use on all tight press fit splines.

ENGINE - DISMANTLING/ASSEMBLY

R C. Restrictions

R (1) Unless otherwise specified, antiseize or antigalling com-
R pounds must not be used at following locations:

R (a) All face splines.

R (b) All main rotor disk, hub, and spacer snaps.

R (c) Conical seats.

R (d) Fuel fittings.

8. Antiseize Compounds

R A. In order to facilitate subsequent disassembly, apply Fel-Pro C-200 antiseize compound to all threaded parts attached to hot section except silver plated threaded parts, fuel fittings, and locations where another compound is specified.

9. Gasket Lubricant (Gredag)

A. Where necessary, coat gasket surfaces with Gredag Lubricant to reduce possibility of gaskets adhering to surfaces of mating parts.

R NOTE: Gasket Lubricant is known as Gredag Lubricant No. 55
R Graphited, and may be procured from Acheson Industries,
R Inc., Acheson Colloids Division, 1635 Washington
R Street, Part Huron, Michigan 48061.

10. Keywashers

A. Definition and Purpose

(1) Keywasher is washer-like device which uses keys (tabs) to lock parts together.

(2) These instructions concern single or multiple hole keywashers with two or three unbent keys (or tabs) per hole.

(3) Unbent key is one which is bent, or locked, following installation of part, but which may be partially bent or preformed during manufacture.

ENGINE - DISMANTLING/ASSEMBLY

B. Locking Procedure

R (1) Once removed, new keywasher must be used at assembly. Use keywasher only one time.

(2) All keys on keywasher are to be bent as safeguard against reuse.

(3) When locking single hole keywasher, bend one key full against flat face on nut or bolt head to be locked. Other keys may be bent in any convenient manner.

(4) When locking multiple hole keywasher, bend one key for each hole full against flat face of nut or bolt head being locked. Other keys may be bent in any convenient manner.

(5) When installing keywashers which have ID tabs which mate with slotted shaft, proceed as follows.

(a) Use fine crocus cloth, stone, or file to remove spalled or rough surface from face of nut. Remove sharp edges from inside tool slots and around outside diameter of nut face.

(b) Using new washer, apply one to one mixture of molybdenum disulphide powder, Molykote Type Z, and engine oil to face of washer which contacts nut. Remove excess lubricant.

(c) Install washer, aligning ID tab with slot in shaft and retaining nut fingertight.

(d) Install alignment mark across exposed area of washer and shaft or part which mates with washer ID tab.

(e) Torque nut.

(f) Check alignment mark. Any misalignment indicates sheared or weakened ID locking tab. Remove washer and repeat above procedure using new washer, as necessary, to ensure proper locking of retaining nut.

(g) Bend external locking tabs of washer against nut. At least one tab shall be bent full against one flat of nut. Keywashers not having external tabs, crimp side into mating nut slot 180 degrees apart.

NOTE: If no special tool is provided for bending tabs, use brass drift.

C. Acceptable Standards

(1) Keywashers shall be considered properly locked when all keys for each hole have been bent against nut or head to be locked.

(2) One of keys must be full against flat face of nut or head with gap which does not exceed 0.020 inch.

11. Identification of Hardware Material, Particularly Nuts and Bolts R

A. Permanent type of material code designation has been adopted for use in these engines. Correct engine reassembly procedures require that particular attention be paid to material requirements for nuts and bolts used in hot section of engine. In these areas, where parts must be of material which is resistant to high operation temperatures, special heat resistant alloys are employed. It is imperative that at reassembly of engine or its components properly coded part be reassembled in its original location, if serviceable.

B. Code system employs use of letter, "C", for corrosion resistant steel for normal application and "H" for heat resistant alloys in hot section application. Stamped or embossed letter will be followed by number of one or more digits, such as C1, C8, H3, and H12. Bolt code identification will usually appear on top of head (see Figure 403) and nut identification on one side of hex (see Figure 404). When application is an AN or MS six digit part number, code identification "C" or "H" will be preceded by letter "E" as in EC3 or EH10.

NOTE: All AN and MS six digit part numbers, when manufactured of material in common temperature range (such as cadmium plated, low alloy steel parts), are also coded "E" to indicate, in part, close material quality control.

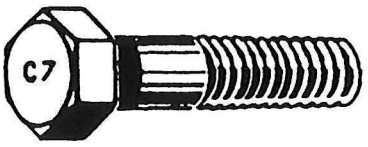
ENGINE - DISMANTLING/ASSEMBLY

C. Under step F is a complete list of specific material identification numbers. It is probable that new designations will be added from time to time. In event that material code number is preceded with letter"P", it will be noted that this is a temporary PWA designation which will be used until such time as a "C" or "H" number is adopted.

D. The adoption of this program will make it possible for service activities to avoid assembly of parts, with similar physical appearance, in locations which require high heat resistant parts. In this regard, it is required, at time of disassembly, that all similarly coded parts be segregated so that two or more physically similar parts with different code numbers will not be scrambled; and so that, at subsequent reassembly, properly coded parts are replaced in their proper locations.

CAUTION: NEVER ASSEMBLE A MATERIAL CODED PART WITH A "C" IDENTIFICATION IN A LOCATION WHICH REQUIRES AN "H" CODED PART AND VICE-VERSA. NEVER USE CADMIUM PLATED NUTS, BOLTS, OR ANY OTHER CADMIUM PLATED PART IN THE HOT SECTION OF THE ENGINE. REFER TO THE LIMITS AND EXTERNAL PARTS CHARTS FOR CORRECT LOCATION OF CODED PARTS.

E. Parts from several engines should not be scrambled at disassembly and cleaning, because, at time of engine manufacture, production requirements may necessitate one or more material substitutions in a block of engines. Subsequent engine reassembly, in field, with indiscriminate scrambling of hardware, may result in unnecessary confusion in sorting these parts for proper reassembly.



Bolt Code Identification
Figure 403

L-20884

Nut Code Identification
Figure 404

ENGINE - DISMANTLING/ASSEMBLY

F. Corrosion, Heat Resistant, and Special Material List

CORROSION RESISTANT MATERIALS

Material Specification	Code	Material Specification	Code
AMS 5640	C1	AMS 5624	C9
AMS 5628	C2	AMS 5639	C10
AMS 5515, 5516, 5517, AMS 5518, 5519, 5636 (Was C5), 5637, or 7472	C3	AMS 5738	C12
		AMS 5630	C13
AMS 7228	C4	AMS 5643	C14
AMS 5345, 5508, 5616, or AMS 7470	C6	AMS 5625	C15 (Was P10)
		AMS 5506, 5620, or 5621	C16
AMS 5610	C7		
		AMS 5644	C17
AMS 5504 (Was C11), AMS 5612, or 5613	C8	AMS 5743	C18

HEAT RESISTANT MATERIALS

Material Specification	Code	Material Specification	Code
AMS 7229	H1	AMS 5524 or 5648	H8
R AMS 7232	H2	AMS 5540, 5580 or 5665	H9
AMS 5526, 5527, 5720 (Was H13), 5721, 5722, or AMS 7476	H3	AMS 5521, 5572, or 5651	H11
		AMS 5522 or 5652	H12
AMS 5642	H4	AMS 5720	H13
AMS 5512, 5571, or 5646	H5	AMS 5542, 5667 (Was H10), or 5668	H14
AMS 5733 (PWA 746)	H6		
		Chromel	H15
AMS 5510, 5557, 5559, AMS 5570, 5576, or 5645	H7	Alumel	H16

ENGINE - DISMANTLING/ASSEMBLY

HEAT RESISTANT MATERIALS (Continued)

	Material Specification	Code	Material Specification	Code
R	AMS 5649	H17	AMS 5551, 5756, or 5757	H24
R	AMS 5532 or 5768	H18	AMS 5660, PWA 1003 (Was PWA 1002)	H25 (Was P11)
R	AMS 5525, 5731, 5732, AMS 5734, 5735 (Was PWA 747, P4), 5736, 5737, or AMS 7481	H19 or *Knurl	AMS 5706, 5708 (Was PWA 90), 5709, 7471, PWA 686, PWA 687 (Was CF236, P18), or PWA 1004	H26 (Was P15)
R	AMS 5514 or 5647	H20		
R			AMS 5759	H27
R	AMS 5754	H21 (Was P19)	AMS 5662 or PWA 1009	H28
R	AMS 5530 or 5750	H22		
R	AMS 5545, 5712, 5713, or AMS 7469	H23		

R *NOTE: Knurl on washer face diameter is sometimes used on double-hex castellated nuts for material identification instead of code.

TITANIUM OR TITANIUM ALLOY

	Material Specification	Code	Material Specification	Code
R	AMS 4921	T1 (Was P8)	AMS 4927	T4
R			AMS 4928 (Was PWA 682, P12), 4967, or 7461	T5
R	AMS 4923	T2		
R	AMS 4925	T3	AMS 4929	T6

ENGINE - DISMANTLING/ASSEMBLY

SPECIAL MATERIAL

	Material Specification	Code	Material Specification	Code
R	AMS 6304 (Was PWA 722,		PWA 91	P25
R	P5) 7454, 7455, or	S37 or		
R	7458	E37	PWA 1006, 1008, or 1013	P26
R	AMS 5620	P3	AMS 7236	P27
R	AMS 6302 (Was P9)	Inactive	AMS 5666	P28
R	PWA 1202	P20	ASTM A 453 Grade 660	660
R	PWA 1010	P21	ASTM A 193 B7	B7
R	AMS 7477	P23	ASTM A 193 B16	B16
R	AMS 7461	P24		

G. Stainless Steel Bolts With Reduced Pitch Diameters

(1) At engine manufacture, it is practice to provide bolts with reduced pitch diameter for use in hot sections of engines. This will minimize possibility of bolt and nut seizure. This is standard practice for locations where parts are subjected to temperatures in excess of 500°F (260°C).

12. Standard Torques

A. Use standard torques values in locations where no specific torque is given in text or clearance charts (Fits and Clearances Sections).

B. Torque values to be used for J threads are identical to torques applied to standard threads.

C. Torque limits listed in this section shall be interpreted as follows:

(1) Torque values in pound-inches.

(2) Angles of turn in degrees.

(3) Stretch values in inches.

D. Unless otherwise specified, thread lubricants shall be applied to parts which are to be torqued. Thread lubricant shall be
R engine oil, or equivalent, or specific antiseize compounds.

E. If part to be tightened is hot, allow sufficient time to elapse to allow temperature of part to reach temperature equilibrium with surrounding area before final torquing.

F. Extreme care should be exercised in joining of flanges or mating sections during assembly. When joining snap fits, it is essential that mating parts be properly seated prior to application of final torque. Unless specific procedures are provided in assembly instructions, parts should be seated by installing several bolts at regular intervals then applying uniform torque where required to seat mating surfaces. Once seating is assured, all bolts should be torqued to approximately 75 percent of final torque in a uniform stagger (180 degree, 90 degree, and 45 degree intervals, etc.) to preclude local overstressing of bolts or flange. Final torque should be applied in same sequence.

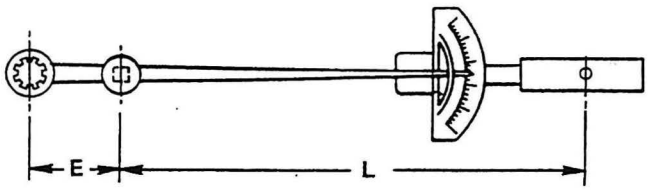
G. Torque applications should be done slowly and evenly for consistency and best possible accuracy. There may be instances, other than specific torque limits, where it is obvious that standard torque required should not be used due to kind of material or design of engine part involved. Common sense and good judgment should of course be exercised in such cases.

13. Torque Indicating Devices

See Figure 405.

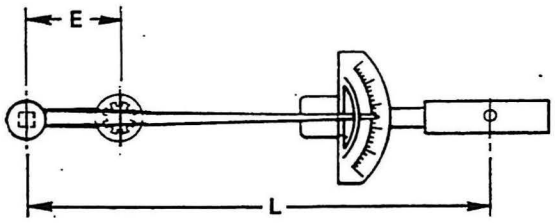
A. Check torque indicating devices per schedule listed below. Calibrate by means of weights and measured lever arm to make sure that there are no inaccuracies. Checking one torque wrench against another is not sufficient. Some wrenches are quite sensitive to way they are supported during tightening operation and every effort must be made to adhere to instructions furnished by respective manufacturers.

Tool	Calibration Check Time Element
Torque Wrenches - Set Type	1 Week
Torque Wrenches - Nonset Type	4 Weeks



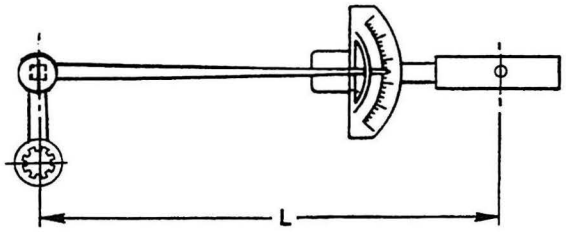
A CORRECTION OF THE INDICATED TORQUE READING IS REQUIRED WHEN AN ADAPTER IS USED, WHICH CHANGES THE EFFECTIVE LENGTH OF A TORQUE WRENCH. APPLY FOLLOWING FORMULA TO OBTAIN THE CORRECTED TORQUE READING.

$$R = \frac{L \times T}{L + E}$$



A CORRECTION OF THE INDICATED TORQUE READING IS REQUIRED WHEN AN ADAPTER IS USED, WHICH CHANGES THE EFFECTIVE LENGTH OF A TORQUE WRENCH. APPLY FOLLOWING FORMULA TO OBTAIN THE CORRECTED TORQUE READING.

$$R = \frac{L \times T}{L - E}$$



A CORRECTED TORQUE READING IS NOT REQUIRED WHEN AN ADAPTER IS USED WHICH DOES NOT CHANGE THE EFFECTIVE LENGTH OF THE TORQUE WRENCH

LEGEND

T = DESIRED TORQUE
E = EFFECTIVE LENGTH OF EXTENSION OR ADAPTER
L = EFFECTIVE LENGTH OF TORQUE WRENCH
R = CORRECTED TORQUE READING

NOTES

(1) DO NOT USE A HANDLE EXTENSION ON ANY TORQUE WRENCH.
(2) EFFECTIVE LENGTH OF PWA SPECIAL EXTENSIONS, ADAPTERS, AND WRENCHES IS STAMPED ON TOOL.

L-47816
4-75

Computing Effect Of Torque
Wrench Extensions
Figure 405

B. Torque Wrench and Extensions

Occasionally, it is necessary to use special extension or adapter wrench together with standard torque wrench. See
R Figure 405.

Example: Torque of 1440 pound-inches is desired on part using special extension having length of three inches from center to center of its holes and torque wrench measuring 15 inches from center of handle or handle swivel pin to center of its square adapter.

$$\text{Then: } R = \frac{LT}{L+E} = \frac{15 \times 1440}{15+3} = 1200$$

With axis of extension or adapter and torque wrench in straight line, tightening to wrench reading of 1200 pound-inches will provide desired torque of 1440 pound-inches on part.

NOTE: Effective length of P&WA special extensions, adapters, and wrenches is stamped on tool.

14. General Torque Recommendations

A. Lubricants And Lubrication

(1) Oil lubricated parts

(a) Torque limits given in this section for oil lubricated parts apply specifically to use of engine oil, or equivalent, on parts.

Continued on next text page.

(2) Antiseize Lubricated Parts.

(a) Torque limits given in this section for antiseize coated parts apply specifically to use of antiseize compounds applied in accordance with SPOP 145, 146, 156, 160, or 161, to wet application of Fel-Pro C-200 and C-300, and Ease-off 990, or to Kaylube 3.

B. Nuts, Bolts, And Screws

(1) General

(a) Torque values listed in Table I for nuts, bolts, and screws have been established to provide sufficient preload without overstressing parts and are based on materials having minimum ultimate tensile strengths of 125,000 pounds per square inch, equivalent to Rockwell C26 hardness for steel parts.

NOTE: The torque values specified in Table I apply to bolts in standard helical coil inserts as long as full thread engagement of insert is accomplished.

(2) Thin Nuts, Slotted Nuts

(a) Torque values in Table I shall apply to nuts where height of nut is greater than 75 percent of major diameter of thread. For thin nuts, where height of nut is 40 percent to 75 percent of size of major diameter, reduce torque values 50 percent. Slots in slotted nuts should be disregarded in figuring height of nut. Values do not apply to hollow bolts and screws.

(3) Lockwire and Cotterpin Requirements

(a) After a castle nut, screw or bolt has been tightened to proper torque, it should not be loosened to permit insertion of lockwire or a cotterpin. If slot in nut or lockwire hole in bolt or screw is not properly aligned at minimum torque limit, nut, screw or bolt should be further tightened to next aligning position, but maximum torque limit must not be exceeded. If alignment cannot be accomplished without exceeding maximum limit, back off nut, screw or bolt half a turn, then retighten. It may be necessary to select a new part.

ENGINE - DISMANTLING/ASSEMBLY

Thread Size**	Torque (lb.–in.)					
	Oil Lubricated			Antiseize Coated		
	Max.	Min.*		Max.	Min.*	
		Type I	Type II		Type I	Type II
.112–40	6	4.5	5	4.5	3.5	4
.138–32	11.5	8.5	10	8.5	6.5	7.5
.164–32	22	16	20	16.5	12.5	15
.164–36	24	18	22	18	13.5	16
.190–24	30	23	27	21.5	16	19.5
.190–32	36	24	32	26	19.5	23
.216–24	48	35	43	35	26	31
.216–28	50	35	45	38	28	34
.250–20	70	50	65	50	37	45
.250–28	85	65	75	60	45	54
.3125–18	150	110	135	105	80	95
.3125–24	170	125	150	120	90	110
.375–16	270	200	250	185	140	170
.375–24	300	225	275	215	160	190
.4375–14	425	325	375	300	225	270
.4375–20	475	350	425	340	255	310
.500–13	650	500	600	450	340	400
.500–20	750	550	675	515	390	460
.5625–12	950	700	850	675	500	600
.5625–18	1050	800	950	750	550	675
.625–11	1300	1000	1200	900	675	800
.625–18	1500	1150	1350	1025	775	925
.750–10	2300	1700	2100	1600	1200	1450
.750–16	2600	2000	2400	1800	1350	1600
.875–9	3700	2800	3400	2600	1950	2350
.875–14	4200	3200	3800	2900	2200	2600
1.000–8	5600	4200	5100	3900	2900	3500
1.000–12	6400	4800	5800	4300	3200	3850
1.125–7	7900	5900	7200	5400	4100	4900
1.125–8	8400	6300	7600	5700	4300	5100
1.250–7	11200	8400	10100	7700	5800	6900
1.250–8	11700	8800	10600	7900	5900	7100
1.375–6	14700	11000	13300	10100	7600	9100
1.375–8	15900	11900	14400	10600	8000	9500
1.500–6	19600	14700	17700	13300	10000	12000
1.500–8	21100	15800	19000	14000	10500	12600
1.750–5	30900	23200	27900	21100	15800	19000
1.750–8	34500	25900	31100	22700	17000	20400
2.000–4.5	46600	35000	42000	31700	23800	28500
2.000–8	52600	39500	47400	34400	25800	31000

*Use Type I minimum torque values where alignment of locking holes (for cotterpins, lockwire, etc.) is required at assembly. Use Type II minimum values where locking hole alignment is not required at assembly.

**For screws larger than 0.164 thread size having screwdriver slots only (no external wrenching provision):

1. For non-self-locking applications, 22 lb.–in. minimum is permissible.
2. For self-locking applications, permissible minimum torque is 22 lb.–in. plus torque required to turn screw through nut.

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Nuts, Bolts, Screws, and
Self-Locking Nuts on Studs
Table I

C. Self-Locking Nuts

(1) Free Spinning Locknuts

(a) A free spinning locknut is a nut that spins freely on a bolt or stud until it contacts mating surface, then additional torque causes activation of locking feature. Use torque values listed in Table I.

(2) Prevailing Torque Type Locknut

(a) A prevailing torque type locknut is a nut that spins freely on a bolt or stud until bolt or stud enters locking portion of nut; then, bolt or stud interferes with deformed section of nut causing a tight frictional hold on bolt or stud thread flanks. Use torque values listed in Table II except when nut is on a stud, then use torque values listed in Table I.

NOTE: Helical coil self-locking inserts are categorized as prevailing torque type locknuts. The torques for bolts used in such inserts are listed in Table II.

(b) Effective locking of slotted steel locknuts on bolts or studs requires full engagement of all locknut threads. It is not necessary for bolt or stud to protrude beyond outer end of locknuts because chamfered part of locknut ID does not exert a locking force on bolt or stud.

D. Steel Pipe Plugs In Aluminum And Magnesium Cases

(1) Torque values for steel pipe plugs in aluminum and magnesium cases listed in Table III have been established to provide for tightening plugs sufficiently to prevent leakage without overstressing cases. If a pipe plug is found to leak after it has been tightened to these limits and sealing compound has been applied to threads, it should not be tightened further, but should be removed and more sealing compound should be applied to threads; plug should then be reinstalled and retightened to indicated limits.

(2) When plugs are tightened in a hot engine, torques should be reduced about 20 percent to allow for difference in expansion between steel plugs and aluminum or magnesium cases.

ENGINE - DISMANTLING/ASSEMBLY

Thread Size	Torque (lb.–in.)	
	Oil Lubricated	Antiseize Coated
.112–40	6–7	5–6
.138–32	12–14	9–11
.164–32	23–26	18–20
.164–36	25–28	20–22
.190–24	32–35	24–27
.190–32	36–40	27–30
.216–24	48–54	36–40
.216–28	50–56	40–44
.250–20	74–82	55–62
.250–28	85–95	62–72
.3125–18	160–175	115–130
.3125–24	180–200	125–140
.375–16	270–300	200–220
.375–24	290–325	225–250
.4375–14	420–465	315–350
.4375–20	450–500	340–380
.500–13	630–700	450–500
.500–20	720–800	515–575
.5625–12	950–1050	675–750
.5625–18	1050–1150	750–825
.625–11	1250–1400	900–1000
.625–18	1450–1600	1030–1150
.750–10	2200–2450	1600–1750
.750–16	2500–2750	1750–1950
.875–9	3600–4000	2500–2850
.875–14	4000–4450	2800–3100
1.000–8	5400–6000	3800–4200
1.000–12	6000–6700	4000–4500
1.125–7	7600–8200	5300–5700
1.125–8	8000–8700	5500–6000
1.250–7	10500–11600	7300–8100
1.250–8	11000–12100	7500–8300
1.375–6	13800–15100	9600–10500
1.375–8	14900–16300	10000–11000
1.500–6	18200–20100	12500–13800
1.500–8	19500–21600	13100–14500
1.750–5	28500–31500	19600–21700
1.750–8	31700–35100	21000–23300
2.000–4.5	42800–47400	31800–32500
2.000–8	48200–53400	29300–35200

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Torques for Self-Locking Nuts and Bolts,
And For Bolts Used In Helical
Coil Self-Locking Inserts
Table II

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Thread size (ANPT or NPT)	Torque, (lb–in.)	Thread size (ANPT or NPT)	Torque (lb–in.)
.062	30– 40	.500	140–160
.125	30– 40	.750	210–230
.250	70– 85	1.000	285–315
.375	95–110	1.250	355–385

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Steel Pipe Plugs in Aluminum and Magnesium Cases
Table III

E. Hex-Head, Straight-Threaded Fittings And Plugs (MS9015, MS9193 Or Similar)

CAUTION: EXCESSIVE TIGHTENING WILL RESULT IN DAMAGE TO THREADS OF MATING PARTS.

(1) Torques listed in Table IV are based on strength of thread in cast aluminum or magnesium; they may be used in stronger materials.

F. PWA Flexible Fittings And Sealastic-Type Fittings

See Figure 405A.

(1) When assembling flexible fittings, packing and fitting threads must be lubricated with a light film of engine oil or petrolatum (PMC 9609). Packing must be bottomed and tube aligned before applying torque listed in Table V.

Thread size	Torque, lb-in.	Thread size	Torque, lb-in.
.250 -28	15- 20	1.0625-12	375-425
.3125-24	35- 40	1.1875-12	450-550
.375 -24	40- 50	1.250 -12	500-600
.4375-20	65- 75	1.3125-12	525-625
.500 -20	90-100	1.500 -12	600-700
.5625-18	110-120	1.625 -12	650-750
.625 -18	150-170	1.750 -12	650-750
.750 -16	200-225	1.875 -12	650-750
.8125-16	225-250	2.250 -12	650-750
.875 -14	250-275	2.500 -12	650-750
1.000 -12, -14	275-300		

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Hex-Head, Straight-Threaded
Fittings and Plugs Fittings and Plugs
Table IV

(2) It is expected that these flexible tube connections will experience slight loss of torque over a period of time due to seating of rubber in mating parts. To minimize this condition, parts should be torqued to listed value, then loosened, and torqued again to listed value.

G. Cone Seat Connectors

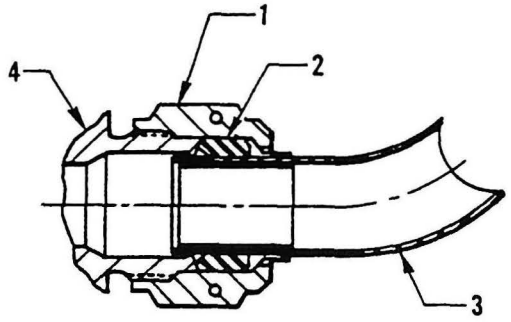
See Figure 405B.

(1) For 37 degree cone seat connectors without gaskets, use torque values listed in Table VI.

(2) For 37 degree cone seat connectors with nickel gaskets, use torque values listed in Table VII.

(3) Do not attempt to correct any leakage of a joint by over-torquing. Disassemble fitting and check for nicks, burrs, dirt, etc. If necessary, use new parts.

ENGINE - DISMANTLING/ASSEMBLY



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1. Nut; See Table V.
2. Packing
3. Tube
4. Fitting

PWA Flexible Fitting
Figure 405A

H. Jamnuts

See Figures 405B and 405C.

(1) Torques listed in Table VIII are to be used for all steel and aluminum jamnuts (locknuts) of type used on fittings for tube and hose connections.

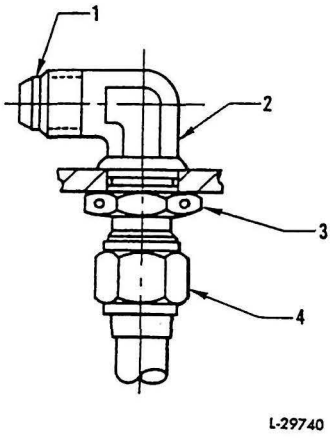
(2) On elbow fittings, jamnut shall be torqued after connecting tube or hose has been installed and properly aligned.

I. Installation Of Crush Type, Asbestos Filled Gaskets

(1) Install all crush type gaskets, except self-centering type, with unbroken surface against flange of plug or part being tightened against seal. Turn mating part until sealing surfaces are in contact, then tighten through angle of turn shown in Table IX for appropriate thread pitch.

R R R R R	Tube Dia.	Thread Size	Part Number for 75 Durometer A Packings: AMS 7260, 7267, or 7273	Torque lb-in	Part Number for 77 Durometer C (100 Durometer A) Packings: PWA 401	Torque lb-in
R	0.250	0.625-18	227407	25-30	399615	55-60
R	0.3125	0.6875-16	227413	30-35	451083	65-70
R	0.375	0.750-16	226366	30-35	410629	65-70
R			626155			
R	0.4375	0.8125-16	227419	45-50		
R	0.500	0.875-14	227401,	55-60	391009	100-120
R			598643,			
R			669480			
R	0.5625	1.000-12	227425	60-65		
R	0.625	1.0625-12	226195	65-70	443330	130-140
R	0.750	1.1875-12	227427	70-80	389114	140-160
R	0.875	1.375-12	227431	75-85	452427	150-170
R	1.000	1.500-12	227433	100-110	389847	200-220
R	1.125	1.625-12	227451	100-110	409309	200-220
R	1.250	1.750-12	227439	100-110	414121	200-220
R			598678			
R	1.500	2.125-12	227445	100-110	409179	200-220

ENGINE - DISMANTLING/ASSEMBLY



1. Cone Seat Connector, Before Assembling Mating Parts; See Table VI Or VII.
2. Bulkhead Fitting

R 3. Jamnut; See Table VIII.

4. Cone Seat Connector Nut; See Table VI Or VII.

Cone Seat Connector and
Bulkhead Fitting Jamnut
Figure 405B

Hose size	Tubing OD	Thread size	Torque, lb-in.		
			Aluminum fittings**	Steel and titanium fittings*	
			All lubricants	Oil lubricated	Anti-seize coated
-3	.1875	.375 -24	30- 50	70- 80	50- 60
-4	.250	.4375-20	40- 65	90- 100	65- 75
-5	.3125	.500 -20	60- 80	135- 150	100- 110
-6	.375	.5625-18	75-125	270- 300	200- 225
--	.4375	.625 -18	100-175	320- 350	225- 250
--	--	.6875-24	--	320- 350	225- 250
-8	:500	.750 -16	150-250	450- 500	340- 375
--	.5625	.8125-16	175-300	550- 600	400- 450
-10	.625	.875 -14	200-350	650- 700	475- 525
--	--	.875 -16	200-350	650- 700	475- 525
--	.6875	1.000 -12	275-450	800- 900	600- 675
--	--	1.000 -14	275-450	800- 900	600- 675
-12	.750	1.0625-12	300-500	900-1000	675- 750
--	.875	1.1875-12	400-600	1100-1200	825- 900
--	--	1.250 -12	400-650	1150-1300	900-1000
-16	1.000	1.3125-12	500-700	1300-1400	950-1050
--	1.125	1.500 -12	600-900	1500-1600	1050-1200
-20	1.250	1.625 -12	600-900	1700-1800	1150-1300
-24	1.500	1.875 -12	600-900	2100-2200	1500-1600

* If the nut or either of the mating sealing surfaces is aluminum, the required torque limits for aluminum fittings apply.

** For thrust reverser air line fittings, use torques for aluminum fittings, regardless of material, unless otherwise specified.

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37 Degree Cone Seat Connectors Without Gaskets
Table VI

Hose size	Tubing OD	Thread size	Torque, lb-in.		
			Steel fittings		Titanium fittings
			Oil lubricated	Anti-seize coated	Anti-seize coated*
-3	.1875	.375 -24	50- 60	40- 45	50- 60
-4	.250	.4375-20	90- 100	65- 75	90- 100
-5	.3125	.500 -20	135- 150	100- 110	135- 150
-6	.375	.5625-18	200- 220	150- 165	200- 220
--	.4375	.625 -18	250- 270	185- 200	250- 270
-8	.500	.750 -16	350- 400	270- 300	350- 400
--	.5625	.8125-16	400- 450	300- 350	400- 450
-10	.625	.875 -14	500- 550	360- 400	500- 550
--	.6875	1.000 -12	600- 700	480- 530	600- 700
-12	.750	1.0625-12	700- 800	540- 600	700- 800
--	.875	1.1875-12	800- 900	600- 675	800- 900
-16	1.000	1.3125-12	1000-1100	750- 825	1000-1100
--	1.125	1.500 -12	1300-1400	900-1000	1300-1400
-20	1.250	1.625 -12	1400-1500	1000-1100	1400-1500
-24	1.500	1.875 -12	1600-1700	1200-1300	1600-1700

* Spec PWA 550 and Spec PWA 586

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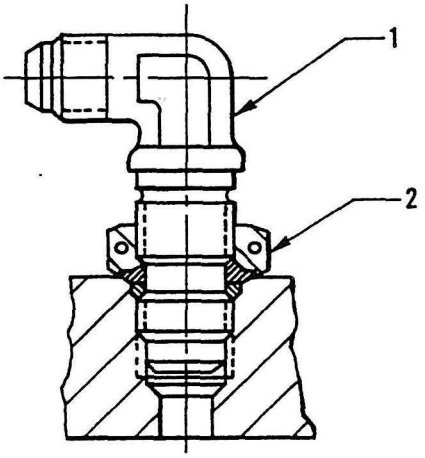
37 Degree Cone Seat Steel Connectors
With Nickel Gaskets
Table VII

ENGINE - DISMANTLING/ASSEMBLY



1. Boss Fitting; See Assembly Instructions, Section 70-00.
R 2. Jam Nut; See Table VIII.

Preformed Packing And Jamnut Type Connector
Figure 405C

Thread size	Torque, lb-in.	Thread size	Torque, lb-in.
.250 -28	14- 16	1.1875-12	350-390
.3125-24	22- 24	1.250 -12	380-420
.375 -24	28- 32	1.3125-12	475-525
.4375-20	38- 42	1.500 -12	570-630
.500 -20	58- 62	1.625 -12	570-630
.5625-18	70- 80	1.875 -12	570-630
.625 -18	95-105	2.250 -12	570-630
.750 -16	145-155	2.500 -12	570-630
.8125-16	165-185		
.875 -14	190-210		
1.000 -12	260-290		
1.0625-12	285-315		

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R

Jam Nuts
Table VIII

Thread Pitch on Part to be Tightened (Threads per Inch)	Angle of Turn (Degrees, ± 5 Degrees)*	
	Aluminum/Asbestos	Copper/Asbestos Nickel/Asbestos Steel/Asbestos
8	135	67
9	135	67
10	135	67
11	180	90
12	180	90
13	180	90
14	180	90
16	270	135
18	270	135
20	270	135
24	360	180
28	360	180

*These values provide for compression of approximately 40 percent for aluminum/asbestos and 20 percent for copper/asbestos, nickel/asbestos, and steel/asbestos gaskets.

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Metal-Asbestos Gaskets
Table IX

ENGINE - DISMANTLING/ASSEMBLY

J. Installing And/Or Attaching Various Components Of Ignition System And Thermocouple Systems

R See Figure 405C-1.

(1) Plug-In Type Threaded Connectors

(a) All plug-in type threaded connections should be torqued to finger tight plus a 45 degree maximum turn.

(2) Igniter Plugs

(a) Igniter plugs should be installed in engines with a torque of 300 - 360 pound-inches.

(3) Cigarette Type Electrical Connectors

(a) All cigarette type electrical connections (located at the end of intermediate voltage leads and high tension leads) should be torqued until connection is bottomed on its shoulder. This normally takes approximately 140 - 160 pound-inches of torque.

(4) Exhaust Temperature Probe Terminal Attaching Nuts and Thermocouple Harness To Lead Attaching Screws

(a) Torque these nuts and screws per Table X.

(5) Harness Terminal and Bus Bar Attaching Nuts in Exhaust Gas Temperature Junction Box

(a) Torque these nuts per Table XI.

Thread size	Torque, lb-in.
.138-32	8-10
.164-32	8-12
.190-32	10-15
.216-32	30-35
.250-32	35-40

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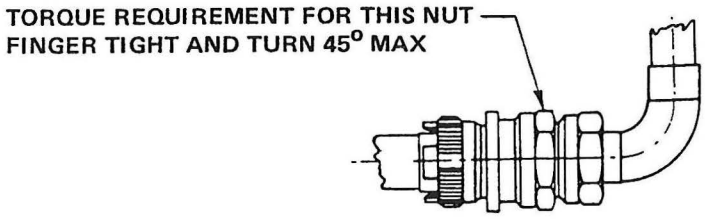
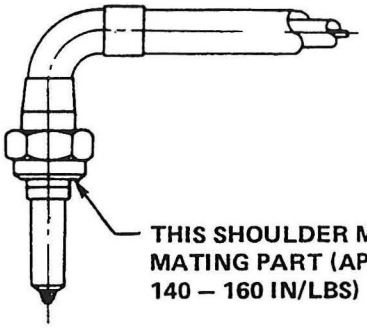
Temperature Probe Nuts and Screws
Table X



ELECTRICAL CONNECTORS
AN 3100 THRU AN 3108



LEADS –
ELECTRICAL CONNECTIONS

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Plug-In And "Cigarette"
Connector Installation
Figure 405C-1

Thread size	Torque, lb-in.
.190-32 .164-32	25-30 20-25

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Harness Terminal And Bus Bar Nuts
Table XI

R K. Torque Check For Reuse Of Self-Locking Nuts

R (1) Check self-locking nuts for adequate torque before reuse.
R Discard nut if locking capability is impaired. Do not
R attempt repair.

R (2) Torque limits.

R (a) Self-locking nuts shall be capable of meeting torque
R requirements in Table XII when lubricated with engine
R oil, and at room temperature.

R (b) For torque testing stainless steel, corrosion and heat
R resistant steel, nickel alloy steel, and AMS 6304 nuts,
R major, minor, and pitch diameters of bolts should be
R reduced 0.003 inch below dimensions specified for listed
R 0.190-32 UNF-3A, 0.190-24 UNC-3A and larger bolt sizes.
R See Table XII.

R (3) Unplated Nuts

R (a) Unplated stainless steel, corrosion resistant steel,
R nickel alloy steel, and AMS 6304 steel nuts that have
R threads undercut for plating at assembly, shall be silver
R plated 0.0003 - 0.0006 inch thick for test purposes, and
R checked for requirements of Table XII on unplated bolts
R threaded per Table XII.

R ENGINE - DISMANTLING/ASSEMBLY

Fine Thread Series			Coarse Thread Series		
Mating Bolt Thread Size**	Max Locking Torque*	Min Break-away Torque	Mating Bolt Thread Size**	Max Locking Torque*	Min Break-away Torque
.112 -48 NF-2A	3	0.5	.112 -40 NC-2A	3	0.5
.138 -40 NF-2A	6	1.0	.125 -40 NC-2A	4	1.0
.164 -36 NF-2A	9	1.5	.138 -32 NC-2A	6	1.0
.190 -32 UNF-3A	13	2.0	.164 -32 NC-2A	9	1.5
.250 -28 UNF-3A	30	3.5	.190 -24 UNC-3A	13	2.0
.3125-24 UNF-3A	60	6.5	.250 -20 UNC-3A	30	4.5
.375 -24 UNF-3A	80	9.5	.3125-18 UNC-3A	60	7.5
.4375-20 UNF-3A	100	14.0	.375 -16 UNC-3A	80	12.0
.500 -20 UNF-3A	150	18.0	.4375-14 UNC-3A	100	16.5
.5625-18 UNF-3A	200	24.0	.500 -14 UNC-3A	150	24.0
.625 -18 UNF-3A	300	32.0	.5625-12 UNC-3A	200	30.0
.750 -16 UNF-3A	400	50.0	.625 -11 UNC-3A	300	40.0
.875 -14 UNF-3A	600	70.0	.750 -10 UNC-3A	400	60.0
1.000 -14 NF-3A	800	92.0	.875 -9 UNC-3A	600	82.0
1.125 -12 UNF-3A	900	117.0	1.000 -8 UNC-3A	800	110.0
1.250 -12 UNF-3A	1000	143.0	1.125 -8 UNC-3A	900	137.0

*Installation or removal.
**Use the listed bolt sizes for torque testing cadmium plated nuts, carbon steel nuts, alloy steel nuts, and aluminum nuts.

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R Torque Limits For Reuse Of Self-Locking Nuts (Pound-Inches)
R Table XII

R (b) Unplated stainless steel, corrosion resistant steel,
R nickel alloy steel, and AMS 6304 steel nuts that are
R permanently attached to brackets as other similar
R parts, and that are not subsequently plated at assembly,
R shall be checked for requirements of Table XII with bolts
R that are plated 0.0003 - 0.0006 inch thick. Plated bolts
R 0.190 inch in diameter are larger shall have threads
R reduced 0.0003 from class 3A limits on major, minor, and
R pitch diameters. Bolts smaller than 0.190 inch in dia-
R meter shall have class 2A tolerances. See Table XII.

R R R (c) Unplated carbon or alloy steel nuts shall be cadmium plated 0.0002 - 0.0005 inch thick and checked with cadmium plated bolts threaded per Table XII.

R R (d) Unplated aluminum nuts shall be checked with cadmium plated bolts threaded per Table XII.

14A. Installation And Handling Of Ball And Roller Bearings

A. Wear a clean pair of gloves, made of an approved lint free material, when handling bearings.

B. When assembling inner races of bearings on their mating shafts, it will be necessary to expand inner race by using controlled heating. The inner race of demountable bearings and complete bearing assembly of nondemountable bearings may be raised to required temperature by immersion in a controlled hot oil bath. Shafts and bearing races must be checked for size and trueness before heating in order to avoid abnormal fits. Hot oil tanks used for expansion heating must be kept closed when not in use to minimize contamination of the oil by airborne dirt and abrasives.

C. Never allow bearings to rest on bottom of a hot oil tank since they may become contaminated from settlings and their temperature will be much higher than indicated oil temperature. A heavy screen or series of rods extending three or more inches above tank bottom will keep bearings surrounded by oil at a uniform temperature and will allow any dirt to settle at bottom of tank. Use engine oil thermostatically controlled at temperatures not exceeding 250°F (121°C). Change oil and clean tank periodically as necessitated by amount of use.

R 14B. Installation Of Cup Type Key Washers

R See Figure 405D.

R A. General. After nut has been correctly seated and tightened to
R required torque, cup type key washer shall be indented as
R specified. Where number of rounded slots in nut or bolt is
R less than required indentations listed, crimping must be
R accomplished at each available location. Portion of tool that
R forms indentations shall be spherically shaped and have spher-
R ical radius of not less than 0.050 inch.

R B. Position Control. To preclude shearing of tabs, position of
R cup washer shall be indicated by marking cup washer and adja-
R cent surface so that any rotation of cup washer can be detec-
R ted when torquing nut.

R C. Acceptance Standards

R (1) New cup type key washer was used.

R CAUTION: CUP TYPE KEY WASHERS THAT ARE LOOSE ENOUGH TO
R SHAKE OR RATTLE ARE NOT ACCEPTABLE.

R (2) Indentations were formed as shown. A properly secured cup
R washer will normally be tight, but in instances where there
R is not axial pinch on the diaphragm portion of washer,
R washer may be moved by hand through limits of tab clearance.

R (3) Indentations in any one washer shall be approximately same
R shape and size, and shall not be broken, cracked or torn.

R (4) Indentations in cup washer shall have been formed into
R rounded slots in nut when nut is provided with such slots.

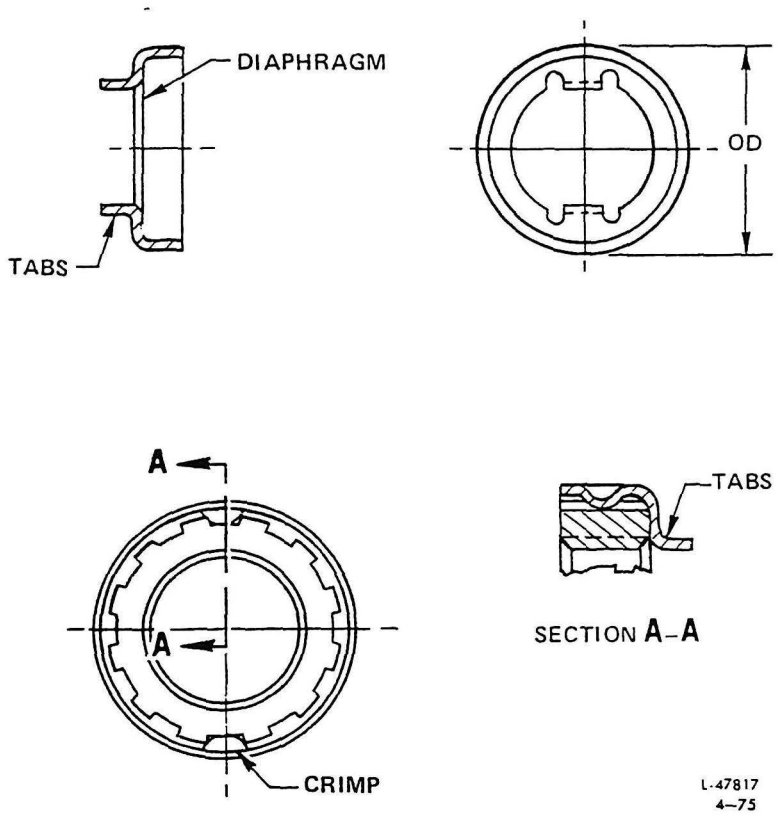
R (5) Cup washer has not moved during assembly.

R 14C. Installation Of Tab And Elliptical Type Key Washers

R A. Installation Of Tab Type Key Washers

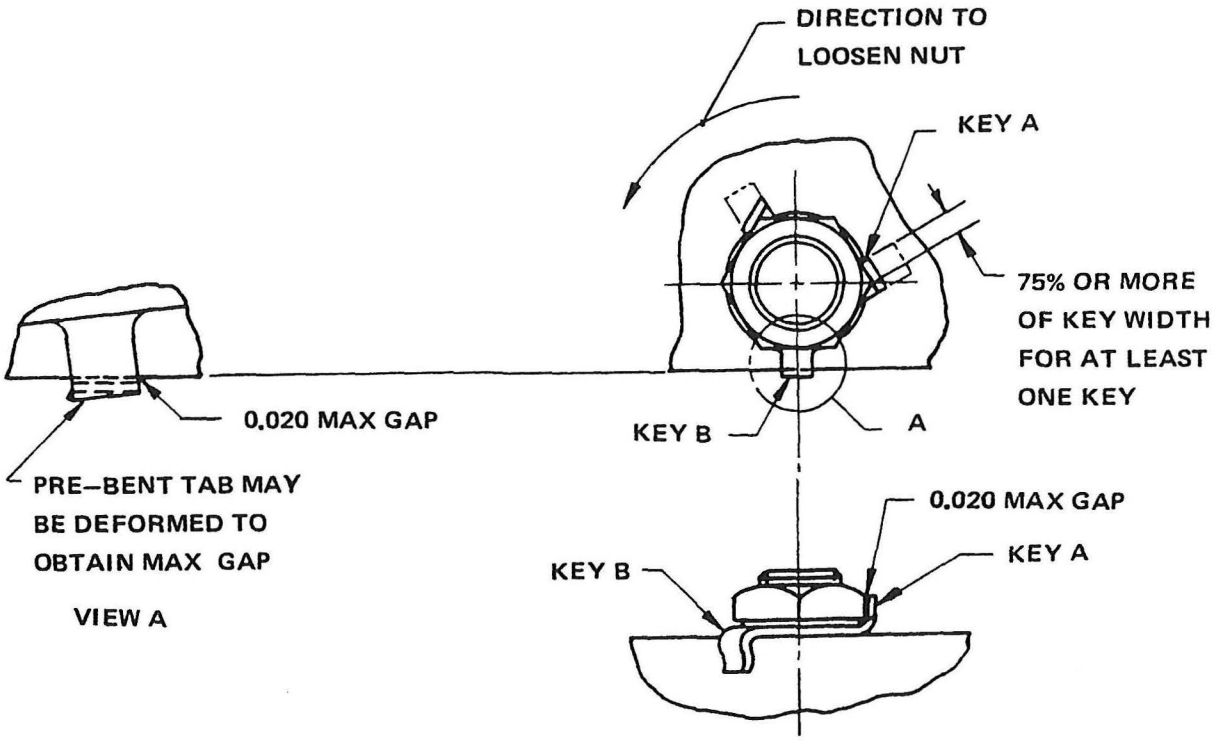
R See Figure 405E.

R (1) Key washers must be used only one time.

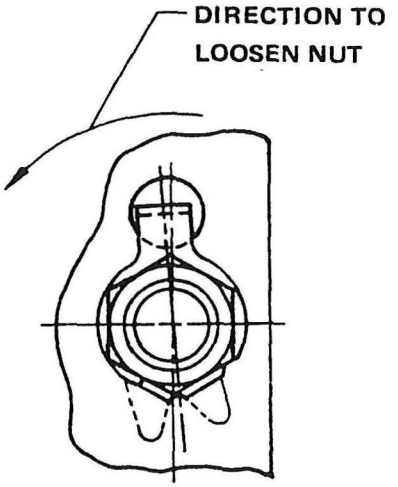


	Indentations Required	
Thread Size (Inches)	Number	Spacing
0.000 - 1.500	2	180° ± 30° Apart
1.500 - 2.500	4	90° ± 30° Apart
2.500 - 4.000	6	60° ± 15° Apart
Over 4.000	8	45° ± 15° Apart

Typical Crimping Of Internal And External Cup Type Key Washers
Figure 405D



PRE-BENT KEY OVERHANGING ADJACENT SURFACE



PRE-BENT KEY ANCHORED IN ADJACENT HOLE

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(2) Key washer shall be positioned such that unbent keys are as far as possible from axis of part to be locked. Prebent key, Key B, shall be tight to overhanging surface or braced against side of hole as shown to prevent possible movement of part being locked.

(3) All unbent keys on key washer are to be bent as safeguard against reuse.

(4) To preclude shearing of internal tabs, position of key washer shall be indicated by marking key washer and adjacent nonrotating surface so that any rotation of key washer can be detected when tightening nut.

B. Installation Of Elliptical Key Washers

See Figure 405F.

(1) Install elliptical type key washers as shown in referenced figure.

14D. Lockwiring Procedures

See Figures 405G and 405H.

A. Check fasteners to be lockwired to make sure that they have been correctly torqued and that lockwire holes are properly positioned in relation to each other. Never overtorque or loosen fasteners to obtain proper alignment of lockwire holes. Select another fastener, if necessary, to obtain proper alignment of lockwire holes with specified torque limits.

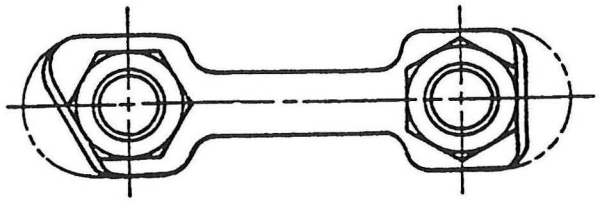
B. Install lockwire in a manner that tends to tighten and keep a part locked in place, counteracting the natural tendency of
R the part to loosen. Lockwire shall not have any additional
R tension imposed upon it other than original tension to prevent
R loosening. Where slack is required between tension points, it
R shall be specified. Install lockwire so that, after installa-
R tion, neither wire nor its adjacent parts will be subject to
R wear or excessive load.

ENGINE - DISMANTLING/ASSEMBLY

C. To prevent mutilations on twisted section of wire when using pliers, grasp wire at ends or at a point that will not be twisted. Lockwire must not be nicked, kinked, or multilated. Never twist excess wire ends off with pliers.

D. Lockwire must be taut when installed to prevent failure due to
R rubbing or vibration. Lockwire shall have approximately 7 to
R 10 twists per inch; one twist is defined as being produced by
R twisting wires through an arc of 180 degrees and is equivalent
R to one-half a complete turn. Do not overtighten.

E. When trimming ends, leave at least three complete turns after loop, exercising due care to prevent wire ends from falling into the engine.

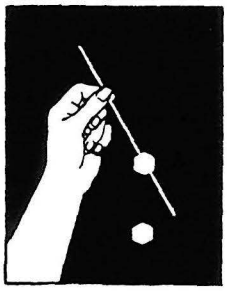


R NOTE: Key washer must be used only one time.
R Installation of this type of key washer
R shall be accomplished by bending washer
R up across one whole face of hexagon as
R shown with a 0.020 inch maximum gap
R between flat of nut and washer.

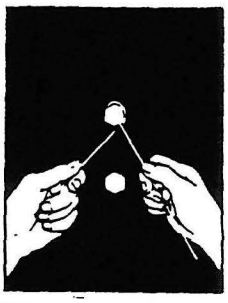
R Installation Of Elliptical Type Key Washer
R Figure 405F

ENGINE - DISMANTLING/ASSEMBLY

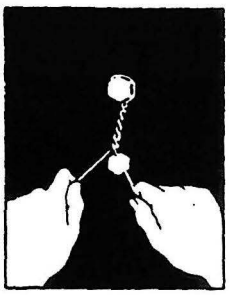
POSITION THE HOLES.



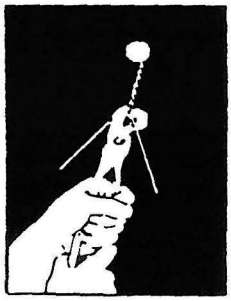
INSERT PROPER GAGE WIRE. TO DETERMINE THE PROPER WIRE TO BE USED IN CONJUNCTION WITH A PARTICULAR TIGHTENING OPERATION REFER TO THE CORRESPONDINGLY DESIGNATED ENGINE PARTS CATALOG OR ILLUSTRATED PARTS BREAKDOWN. LOCKWIRE WHICH IS SPECIALLY TREATED FOR 1800°F (982°C) APPLICATIONS HAS A DARK GRAY TO BLACK COLOR.



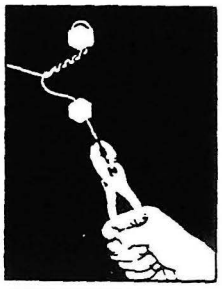
GRASP UPPER END OF THE WIRE AND BEND IT AROUND THE HEAD OF THE BOLT, THEN UNDER THE OTHER END OF THE WIRE. BE SURE WIRE IS TIGHT AROUND HEAD.



TWIST WIRE UNTIL WIRE IS JUST SHORT OF HOLE IN THE SECOND BOLT.



KEEPING WIRE UNDER TENSION, TWIST IN A CLOCKWISE DIRECTION UNTIL THE WIRE IS TIGHT. WHEN TIGHTENED THE WIRE SHALL HAVE APPROXIMATELY 7–10 TWISTS PER INCH.

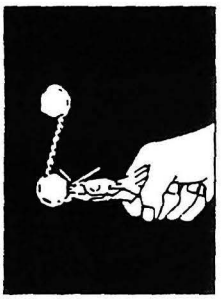


INSERT THE UPPERMOST WIRE, WHICH POINTS TOWARDS THE SECOND BOLT, THROUGH THE HOLE WHICH LIES BETWEEN THE NINE AND TWELVE O'CLOCK POSITIONS. GRASP THE END OF THE WIRE WITH A PAIR OF PLIERS AND PULL THE WIRE TIGHT.

BRING THE FREE END OF THE WIRE AROUND THE BOLTHEAD IN A COUNTERCLOCKWISE DIRECTION AND UNDER THE END PROTRUDING FROM THE BOLT HOLE. TWIST THE WIRE IN A COUNTERCLOCKWISE DIRECTION.

GRASP THE WIRE BEYOND THE TWISTED PORTION AND TWIST THE WIRE ENDS COUNTERCLOCKWISE UNTIL TIGHT.

DURING THE FINAL TWISTING MOTION OF THE PLIERS, BEND THE WIRE DOWN AND UNDER THE HEAD OF THE BOLT.



CUT OFF EXCESS WIRE WITH DIAGONAL CUTTERS.

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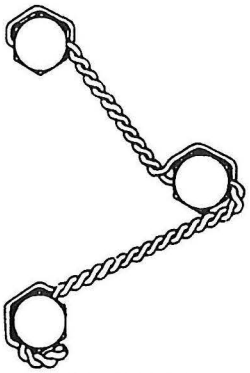
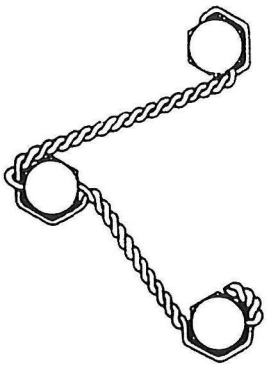
Lockwiring Technique
Figure 405G

EXAMPLE 1



EXAMPLE 2



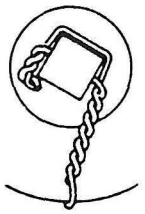
EXAMPLE 3

EXAMPLE 4

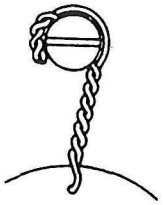
Examples 1, 2, 3, and 4 apply to all types of bolts, fillister head screws, square head plugs, and other similar parts which are wired so that the loosening tendency of either part is counteracted by tightening of the other part. The direction of twist — from the second to the third unit is counterclockwise to keep the loop in position against the head of the bolt. The wire entering the hole in the third unit will be the lower wire and by making a counterclockwise twist after it leaves the hole, the loop will be secured in place around the head of that bolt.

EXAMPLE 5

EXAMPLE 6

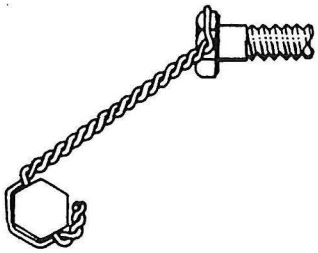


EXAMPLE 7



EXAMPLE 8

Examples 5, 6, 7 & 8 show methods for wiring various standard items. Note: Wire may be wrapped over the unit rather than around it when wiring castellated nuts or on other items when there is a clearance problem.

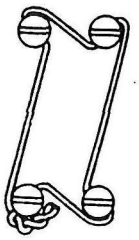


EXAMPLE 9

Example 9 shows the method for wiring bolts in different planes. Note that wire should always be applied so that tension is in the tightening direction.

EXAMPLE 10

Hollow head plugs shall be wired as shown with the tab bent inside the hole to avoid snags and possible injury to personnel working on the engine.



EXAMPLE 11

Correct application of single wire to closely spaced multiple group.

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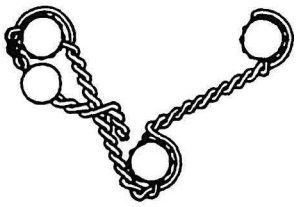
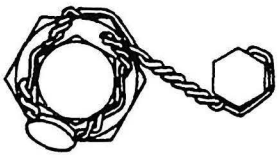
ENGINE - DISMANTLING/ASSEMBLY



EXAMPLE 12



EXAMPLE 13

Examples 12 & 13 show methods for attaching lead seal to protect critical adjustments.

EXAMPLE 14

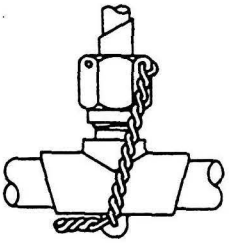
Example 14 shows bolt wired to a right angle bracket with the wire wrapped around the bracket.

EXAMPLE 15

Example 15 shows correct method for wiring adjustable connecting rod.

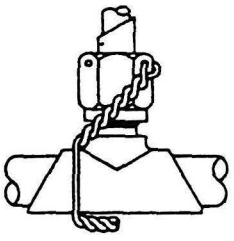
EXAMPLE 16

Example 16 shows correct method for wiring the coupling nut on flexible line to the straight connector brazed on rigid tube.

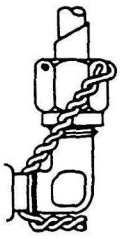


EXAMPLE 17

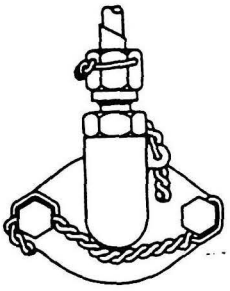
EXAMPLE 18



EXAMPLE 19



EXAMPLE 20



EXAMPLE 21

Fittings incorporating wire lugs shall be wired as shown in Examples 17 & 18. Where no lockwire lug is provided, wire should be applied as shown in Examples 19 & 20 with caution being exerted to ensure that wire is wrapped tightly around the fitting.

Small size coupling nuts shall be wired by wrapping the wire around the nut and inserting it through the holes as shown.

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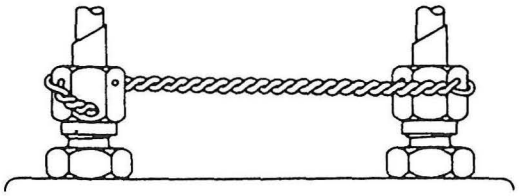
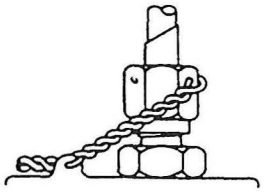
Examples Of Proper Lockwiring
Figure 405H (Sheet 2)

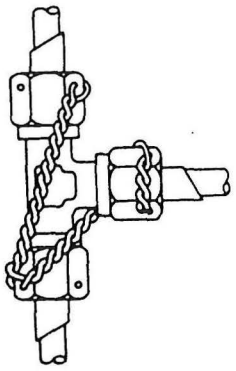
ENGINE - DISMANTLING/ASSEMBLY



EXAMPLE 22

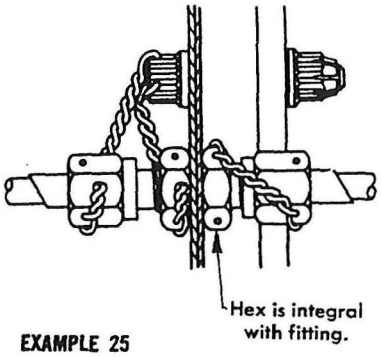


EXAMPLE 23



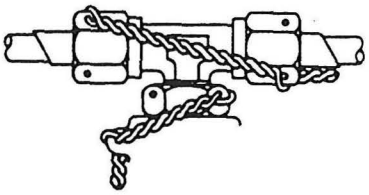
EXAMPLE 24

Coupling nuts attached to straight connectors shall be wired as shown when hex is an integral part of the connector.



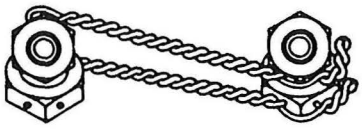
EXAMPLE 25

Coupling nuts on a tee shall be wired as shown above so that tension is always in the tightening direction.

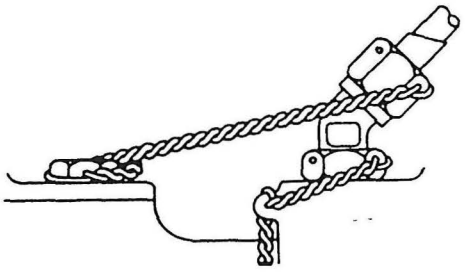


EXAMPLE 26

Straight Connector
(Bulkhead Type)



EXAMPLE 27



EXAMPLE 28

Examples 26, 27 & 28 show the proper method for wiring various standard fittings with check nut wired independently so that *it need not be disturbed when removing the coupling nut.*

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R F. Ends of lockwire must be bent toward part to avoid sharp or
R projecting ends which might present a safety hazard.

R 14E. Cotter Pinning

R A. General. Cotter pins are not reusable. New cotter pins must
R be used for each application.

R B. Locking Nuts With Cotter Pins

R See Figure 405I.

R (1) Before installing cotter pin, tighten nut to low side of
R required torque range, unless otherwise specified, then
R continue tightening until slot aligns with hole in bolt.
R If slot in nut does not line up with hole before maximum
R allowable torque is reached, back off nut, then retighten.
R If slot still does not line up, select new nut and repeat
R assembly procedure.

R (2) While preferred installation would locate centerline of
R hole in bolt midway into nut slot, any installation wherein
R more than 50 percent of cotter pin diameter is located
R below nut castellation is acceptable. In event 50 percent
R or more of cotter pin diameter is located above nut castel-
R lation, new nut must be selected and installed.

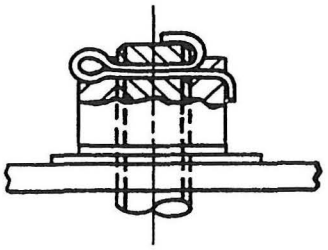
R (3) Install each cotter pin with head seated firmly in slot of
R nut with axis of eye at right angles to bolt. Bend prongs
R so that head and upper prong are firmly seated against
R bolt, and lower prong is firmly seated against correspond-
R ing nut flat. Upper prong may be cut off even with top of
R bolt to provide necessary clearance. Lower prong may also
R be cut off to provide necessary clearance and/or a snug fit
R against corresponding nut flat.

R C. Retaining Pins And Rod Ends With Cotter Pins

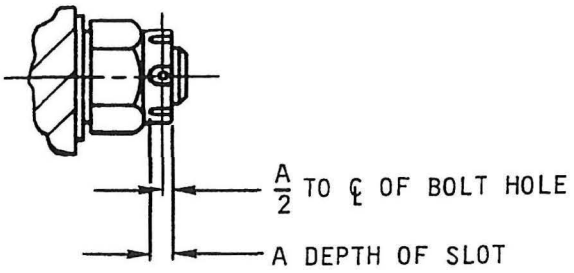
R See Figure 405J.

R (1) Install cotter pin with axis of eye parallel to shank of
R clevis pin or rod end. Bend prongs around shank of pin or
R rod end. Prongs may be cut to obtain normal end position.

R ENGINE - DISMANTLING/ASSEMBLY



PREFERRED INSTALLATION



LOCATION OF LOCKING
HOLE IN SLOT OF NUT

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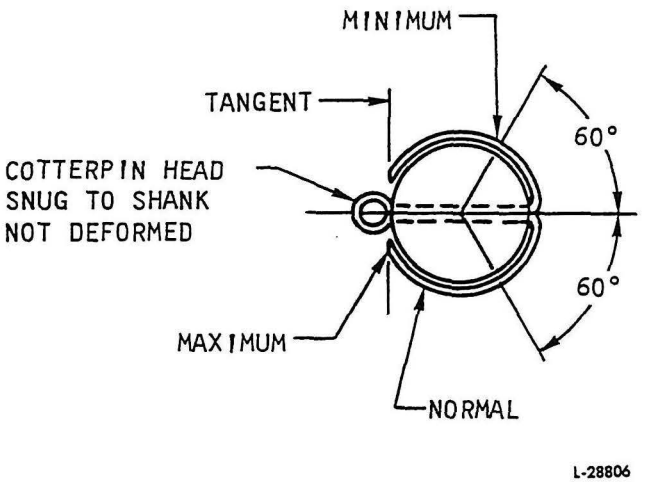
R ENGINE - DISMANTLING/ASSEMBLY



R Installing Cotter Pin On End Of Retaining Pin/Rod
R Figure 405J

14F. Installation of Retaining Rings

A. General. Retaining rings must be installed using approved retaining ring pliers. Internal type rings must not be compressed beyond point where ends of rings meet. External type rings must be expanded only enough to allow installation without becoming bent. After installation, ensure that each retaining ring is completely seated, without looseness or distortion, in its groove. Distorted or loose retaining rings must be replaced.

B. Plain Retaining Rings

(1) Plain retaining rings may contain slightly rounded edges on one side and sharp edges on opposite side. Slight rounding, caused by stamping die, is not a bevel and ring must not be classified as a beveled ring.

(2) Plain retaining rings must be installed only in square sided grooves. When one side of a plain ring has visibly sharper corners, this side must be installed away from detail part(s) being retained, so that sharp-edged side thrusts against groove.

R 14G. Guidelines For Reuse Of Damaged Engines And Engine Parts

R A. General

R (1) The following guidelines are provided to assist owners, operators and maintenance facilities in the disposition of engines and engine parts involved in Abnormal Operational Circumstances. Abnormal Operational Circumstances are defined as accidents or other events which fall outside of the operating envelope for the engine, aircraft and/or the engine/aircraft combination as originally certified and where inspection, refurbishment, and repair data are not addressed by FAA approved publications, i.e., engine manuals, service bulletins, etc. The data contained in these FAA approved publications normally address engine and engine parts which experience wear, deterioration, or damage through exposure to the normal day-to-day operating environment. The guidelines apply to the following engine associated abnormal operational circumstances:

R (a) Engine and engine parts unacceptable for continued aircraft usage. See Paragraph B.

R (b) Engines and engine parts potentially acceptable for
R continued aircraft usage. See Paragraph C.

R (2) For abnormal operational circumstances not addressed by
R these guidelines, Pratt & Whitney considers engines and
R engine parts unacceptable for continued aircraft usage
R unless reviewed and approved on a case-by-case basis.

R (3) The guidelines are based upon Pratt & Whitney's general
R experience in this area and therefore are to be used as
R general guidelines. In any particular incident, however,
R more complete information or inspection results may require
R alternate action. The engine or engine part owner should
R not rely upon the information in these guidelines without
R a thorough understanding of the damage to the engine or
R engine parts and its effect on engine operation. It should
R be understood that the following are only guidelines and
R that any and all responsibility for returning any engine
R or engine part to service remains with the engine or part
R owner.

R (4) The following are definitions of technical terms used in
R these guidelines:

R (a) Definitions from ATA World Airlines Technical Operations
R Glossary (WATOG).

R 1 Accident: An occurrence associated with the operations
R of an aircraft which takes place between the time any
R person boards the aircraft with the intention of flight,
R until such time as all such persons have disembarked,
R in which:

R a Any person suffers death or serious injury as a
R result of being in or upon the aircraft, or by
R direct contact with the aircraft or anything
R attached thereto; or

R b The aircraft receives substantial damage; or

R c Any damage is caused to the property of a third
R party.

R 2 Damage, accidental: Physical deterioration of an item
R caused by contact or impact with an object or influence
R which is not a part of the aircraft, or by improper
R manufacturing or maintenance practices.

R (b) Non-WATOG definitions used in the guidelines

R 1 Engine: Engines manufactured by Pratt & Whitney Division of United Technologies Corporation.

R 2 Engine parts: Parts sold by Pratt & Whitney and delivered as original equipment in an engine installed on an aircraft or in a spare engine or parts sold by Pratt & Whitney as new spare parts in support of an engine. Engine parts include Pratt & Whitney authorized vendor supplied accessories and components.

R 3 Abnormal operational circumstances: Accidents or other events which fall outside the operating envelope for the engine, aircraft, and/or the engine aircraft combination as originally certified and where inspection, refurbishment, and repair data are not addressed by FAA approved publications, i.e., engine manuals, service bulletins, etc.

R B. Abnormal Operational Circumstances - Engines And Engine Parts Unacceptable For Continued Aircraft Usage

R (1) Pratt & Whitney considers engines and engine parts involved in the following types of circumstances unacceptable for continued aircraft usage:

R NOTE: It is recognized that an aircraft could be damaged beyond economical repair without any resulting engine involvement. In such cases the engine and engine parts can be considered "not involved" in an abnormal operational circumstance.

R (a) Engines and engine parts installed in an aircraft totally destroyed by fire.

R (b) Engines and engine parts totally engulfed in fire to the extent that outer cases have been heat discolored and/or distorted or the engine is otherwise damaged by heat over a significant area of the engine, either external or internal.

R (c) Engine and engine parts installed in an aircraft totally destroyed by impact damage.

R C. Abnormal Operational Circumstances - Engines And Engine Parts
R Potentially Acceptable For Continued Aircraft Usage

R (1) Accidents

R (a) Pratt & Whitney considers engines and engine parts involved in the following types of accidents potentially acceptable for continued aircraft usage:

R 1 Engines and engine parts involved in an accident in which the nacelles and engines remain undamaged.

R 2 Engines or engine parts involved in a fire wherein a portion of the aircraft was destroyed but the engines were not subjected to fire damage.

R 3 Engines and engine parts involved in an accident wherein engines rotate freely, although impact damage to cases or other engine parts is evident.

R 4 Partially damaged engines which will not rotate freely as a result of superficial damage to cases, etc.

R 5 Engines subjected to partial or full immersion in fresh or salt water for a brief period of time.

R (b) Acceptance criteria for Paragraph C.(1)(a) engines or engine parts:

R 1 Engines and engine parts involved in accidents described in Paragraphs C.(1)(a)1 and C.(1)(a)2 can be considered "not involved" in an abnormal operational circumstance.

R 2 Engines and engine parts involved in accidents described in Paragraph C.(1)(a)3, C.(1)(a)4, and C.(1)(a)5 should be 100 percent disassembled and inspected.

R NOTE: Owners who are unable to perform the necessary tests or who are in doubt whether to accept or reject a part should contact Pratt & Whitney for assistance.

R D. Serious Operational Events

R (1) Pratt & Whitney considers engines and engine parts involved
R in the following types of serious operational events as
R potentially acceptable for continued aircraft usage provided
R the criteria defined are observed.

R (a) Single fan blade fractures outboard of mid-span shroud.

R NOTE: A single fan blade fracture occurring outboard of
R the mid-span shroud can cause varying degrees of
R engine damage. Refer to Inspection/Check for
R bird or object ingestion inspections and damage
R limits. In general, the following inspection
R guidelines can be applied to events where a single
R blade has fractured outboard of the mid-span
R shroud.

R 1 Check for evidence of core ingestion.

R 2 Inspect fan blade shrouds for evidence of shingling.

R 3 Inspect fan rubstrip for damage beyond limits.

R 4 Check fan exit guide vanes for damage.

R 5 Inspect engine externals for broken or cracked brackets
R and case flanges.

R 6 Borescope inspect compressor gaspath for excessive blade
R tip rub and blade-to-vane clash.

R (b) Single blade fracture inboard of mid-span shroud or mul-
R tiple fan blade fractures.

R NOTE: A fan blade fracture inboard of the mid-span shroud
R or multiple fractures generate a significant amount
R or rotor vibration. More extensive inspections
R with disassembly of the N1 rotor modules is
R required as a minimum. Further disassembly is
R required as inspection findings dictate.

R (c) Engines experiencing sudden stoppage.

R 1 Engines experiencing sudden stoppage usually as a result
R of significant ingestion or distress. In every instance
R of sudden stoppage a complete engine disassembly and
R 100 percent engine part inspection should be
R accomplished.

R (d) Engines involved in an operational fire (burnthrough, R bearing compartment, etc.).

R 1 Engines involved in an operational fire should be com- R pletely disassembled and all engine parts inspected.

R 2 If extinguishing agents have been applied to the engine, R gaspath cleaning is to be accomplished as quickly as R practical to prevent corrosion.

R E. "Impacted" And "Dropped" Engines

R (1) The damage or circumstances which can result in an R "Impacted" engine include impact with the ground, a R collision with a service vehicle, etc. An engine dragged R on the ground or against another object is considered an R impacted engine. "Dropped" engines refer to engines which R are dropped entirely or on either end.

R Inspection requirements for impacted and dropped engines are R similar and progressive in scope; that is, proceeding with R further disassembly is dependent on the degree of damage R found at each level of inspection.

R (a) For engine mounted on aircraft where pylon or nacelle R damage has occurred, inspect engine mount flanges, cases, R external components and plumbing, and gearbox housing and R mounts. If the impact was such that debris may have R entered the engine inlet, inspect engine for ingestion, R and check bleed system filters and valves for debris.

R 1 If no damage is noted, no further action is required.

R 2 If damage is noted to external components and plumbing, R replace damaged items.

R 3 If damage is noted to mount flanges, gearbox or gearbox R mounts or cases, remove engine.

R 4 Monitor chip detectors and oil filter on a more frequent R basis during the initial return of the engine to R service.

R (b) For dropped engines removal and disassembly are required.

ENGINE - DISMANTLING/ASSEMBLY

R F. Tailpipe Fires

R (1) In general tailpipe fires of short duration and extinguished
R by "motoring" the engine will probably have little detri-
R mental effect on exhaust area engine parts. (Refer to PWA
R Operating Instructions 190).

R (a) Inspect exhaust area for signs of scorching. Any parts
R which exhibit scorching including fan duct acoustic liners
R if so equipped, should be replaced.

R (2) Engines which experience a more persistent tailpipe fire
R or when starting overtemperature limits are exceeded during
R a tailpipe fire present a greater potential for thermal
R stress. Engine removal is required.

R G. Engine Contamination - Fire Extinguishing Agents

R NOTE: The following general information is provided to assist
R operators in determining appropriate actions for engines
R subjected to fire extinguishing agents. This informa-
R tion is applicable in instances where fires have been
R confined to burner and turbine gaspath areas, and over-
R temperature limits have not been exceeded.

R (1) There has been considerable effort expended to determine
R the effects of commonly used fire extinguishing agents
R (sodium bicarbonate, potassium bicarbonate and bromotri-
R fluoreomethane (CBrF3) on turbine engine parts.

R (2) The major concern with introducing dry powder chemicals
R into the engine is corrosion during subsequent engine oper-
R ation. This material can be extremely detrimental to hot
R section parts, as exposure to the engine operating environ-
R ment converts the bicarbonate compounds to carbonates, which
R then form a highly corrosive liquid flux.

R (3) Test results reveal stainless steels, nickel base alloys
R (coated or uncoated), and cobalt base alloys, show a high
R degree of susceptibility to chemical corrosion, even at
R temperatures considerably below the engine operating range
R of approximately 1200~F (649~C). Titanium, aluminum, mag-
R nesium, cadmium plate and nickel-cadmium plated low alloy
R steels evidenced no corrosion from bicarbonate compounds
R at engine operating temperatures.

R (4) Regarding the use of CBrF3, used primarily as an inflight
R fire extinguishing agent, one manufacturer of the compound
R stated that the products of decomposition will include cer-
R tain acids which may have a slight corrosive effect on
R metals when exposed to high temperatures. PWA 45, PWA 47,
R PWA 73, PWA 273, and PWA 275 coatings degrade completely
R from CBrF3 contact at 1800~F for short periods of time.

R (5) Although no specific testing has been done relative to the
R effects these agents have on the oil system, the oil system
R should also be considered because agents could enter the
R oil system through labyrinth seals.

R (6) Cleaning methods for engine subjected to fire extinguishing
R agents should be carefully adhered to in order to minimize
R damage.

15. Specific Fits And Clearances And Torque Recommendations

A. General

(1) Reference numbers on figures indicate location of fits, clearances, and parts for which torques are specified. A description of, and limits for, these fits, clearances, and torques are located in tables by corresponding reference numbers.

(2) In locations where no specific torque limit is given in clearance index charts, general torque recommendations given in this section apply.

B. Dimensions For Reference

(1) The Minimum and Maximum columns contain minimum and maximum blueprint dimensions for two mating parts. This information is furnished for reference only.

C. Limits

(1) The Minimum and Maximum columns contain desired fits and clearances between new parts. The figures in Replace column indicate allowable limit to which parts may wear before replacement is necessary at overhaul.

D. Terms and Symbols

(1) The symbol "T" in Minimum and Maximum column indicates tight fit. An asterisk (*) in Replace column indicates that parts should be replaced if any looseness is found. The term "By Selection" indicates that parts must be matched by choosing units that will provide correct fit. The term "Fit to" means that grinding, filing, or other fitting operation may be necessary to obtain desired fit at assembly. The symbol (#) means that gears shall be replaced when service use may have produced scuffing, pitting, galling, or excessive wear of any of parts. Unless otherwise specified, all fits are diametrical except spline fits which are calculated from chordal dimensions.

(2) Letter number codes on clearance charts enclosed with circle, such as "A12" are of contractor significance only and shall be ignored. Letter-number codes with parentheses, such as "(C-8)" relate to coordinates on outer margins of each clearance chart to facilitate location.

E. Units

(1) The figures in Minimum, Maximum, and Replace columns shall be interpreted as follows: torque in pound-inches and all other limits in inches.

F. General Torque Recommendations

(1) Torque Application

(a) Unless otherwise specified, thread lubricants shall be applied to parts which are to be torqued. Thread lubricant shall be engine oil, or equivalent, or specific antiseize compounds.

ENGINE - DISMANTLING/ASSEMBLY

(b) Where torque figures for castle nuts are provided in Minimum column only, these nuts shall be tightened to designated torque and then further tightened, if necessary, to properly align locking slot.

(c) Where torque figures for castle nuts are provided in Minimum and Maximum columns, alignment of locking slot must be obtained without exceeding maximum torque. If this is not possible, another nut shall be used.

(d) Nuts tightened to recommended torque shall not be loosened to permit insertion of lockwire or cotterpins.

(e) When retaining nuts securing heated parts must be torqued, allow parts to reach temperature equilibrium before final tightening to recommended torque.

ENGINE - DISMANTLING/ASSEMBLY

16. External Parts (JT3D-7BG)

A. Fits And Clearances

See Figure 406 (Sheets 1 through 4).

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1900	B	Fuel De-Icing Filter Cover Bushing Mounting Spacer			.0025	.0055	.007
1901	B	Fuel De-Icing Filter Cover Bushing Link Mount Spacer			.0025	.0055	.007
1902	B	Fuel De-Icing Filter Link Spacer			.0015	.0055	.007
1907	B	Intermediate Case	.5932	.5942			
		Bolt	.5792	.5832	.010	.015	.020
1908	B	Oil Pressure And Drain Adapter Bolt Sleeve Spacer	.5932	.5992			
		Bolt	.5792	.5832	.010	.020	.025
1909	B	Main Oil Filter Housing	.7137	.7147			
		Spacer	.7092	.7112	.0025	.0055	.007
1910	B	Oil Pressure And Drain Adapter	.7122	.7142			
		Spacer	.7092	.7112	.001	.005	.007
1911	B	Fuel Heater Lower Bracket	.374	.376			
		Bracket Sleeve Spacer	.371	.373	.001	.005	.007

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REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
1912	D	Gap Anti-Icing Tube Coupling Assembly (Select Gasket To Obtain)			.020		
1913	B	Bend Cup At Assembly, Edge Of Lip Must Contact Company Name Plate Securely All Around					
		Minimum clearance between tubes (except where clipped together) and also between tubes and engine case should be 0.125 inch unless otherwise specified.					
1975		Fuel Control To PD Valve Sensing Tube Assy. Condensation Trap Tube Nut			.070		

B. Torque Limits

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
2001	A	Compressor Bleed Actuator Screen Housing Connector			400	450	
2002	A	Oil Tank Plug			200	250	
2003	A	Tube Connector			525	625	

ENGINE - DISMANTLING/ASSEMBLY

REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
2004	A	Oil Tank Mounting Bracket Nuts					
		NOTE: Tighten until just before nut begins to tension strap. Check torque at this point; then, continue to tighten until 5 - 7 pound-inches above previously checked torque is reached.					
2005	A	Sparkigniter			300	360	
2009	A	Flexible Tube Connection			200	220	
2010	A	Flexible Tube Connection			140	160	
2011	A	Flexible Tube Connections			160	175	
2012	A	Flexible Tube Connection			60	65	
2013	A	Flexible Tube Connections			120	130	
		NOTE: Fits and Clearances for other external parts may also be found in the applicable major assembly fits and clearances section.					

17. External Parts (JT3D-7DSLG)

A. Fits And Clearances

See Figure 407 (Sheets 1 through 4).

	REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
	1902	A	Power Lever Linkage Bearing Housing Bracket Bearing Housing			.000	.002	.003
	1903	A	Power Lever Arm - Airframe Ball Bearing			.000	.002	.002
R R	1903A	A	Power Lever Arm - Sleeve Type Bearing			.0025	.0050	
	1904	A	Airframe Ball Bearing - Power Lever Linkage Bearing Housing			.000	.002	.002
R R R	1904A	A	Power Lever Linkage Bearing Housing - Sleeve Type Bearing			.001T	.001	
	1905	A	Power Lever Linkage Bearing Housing - Sleeve Spacer			.002	.004	.005
	1908	A	Power Lever Linkage Bearing Housing - Airframe			.000	.002	.002
R R R	1908A	A	Power Lever Linkage Bearing Housing - Sleeve Type Bearing			.0025	.0050	

ENGINE - DISMANTLING/ASSEMBLY

	REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
	1909	A	Airframe Ball Bearing - Shutoff Power Lever Arm			.000	.002	.002
R R	1909A	A	Shutoff Power Lever Arm-Sleeve Type Bearing			.001T	.001	
	1913	A	Sleeve Spacer - Shutoff Power Lever Arm			.000	.004	.005
	1915	A	Rod End Shutoff Lever Clevis - Bolt			.0015	.0025	.0030
	1916	A	Annular Ball Bearing - Bolt			.0005	.0015	.0015
	1917	A	Power Lever Arm - Annular Ball Bearing			.000	.001T	.000
	1918	D	Sleeve Spacer - Bolt			.0005	.0075	
	1919	D	Intermediate Case - Bolt			.0005	.0025	.0035
R	1922	D	Oil Adapter - Sleeve Spacer			.001	.005	.006
	1923	D	Sleeve Spacer - Bolt			.0005	.0075	
	1924	D	Adapter Oil - Sleeve Spacer			.001	.005	.007
	1925	D	Oil Filter - Sleeve Spacer			.0025	.0055	.007
R								

ENGINE - DISMANTLING/ASSEMBLY

	REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
	1932	B	Oil Tank Inner Bracket Assembly					
			Bushing	.4385	.4395			
			Bracket	.4370	.4380	.0005T	.0025T	
	1933	B	Oil Tank Upper And Lower Bracket Pin	.303	.304			
			Oil Tank Inner Bracket Assembly Bushing	.306	.311	.002	.008	
	1934	B	Oil Tank Upper And Lower Bracket Assembly Pin	.303	.304			
			Bracket	.3015	.3025	.0005T	.0025T	
R R R R R	1935	B	Bend Cup At Assembly. Edge Of Lip Must Contact Company Name Plate Securely All Around.					

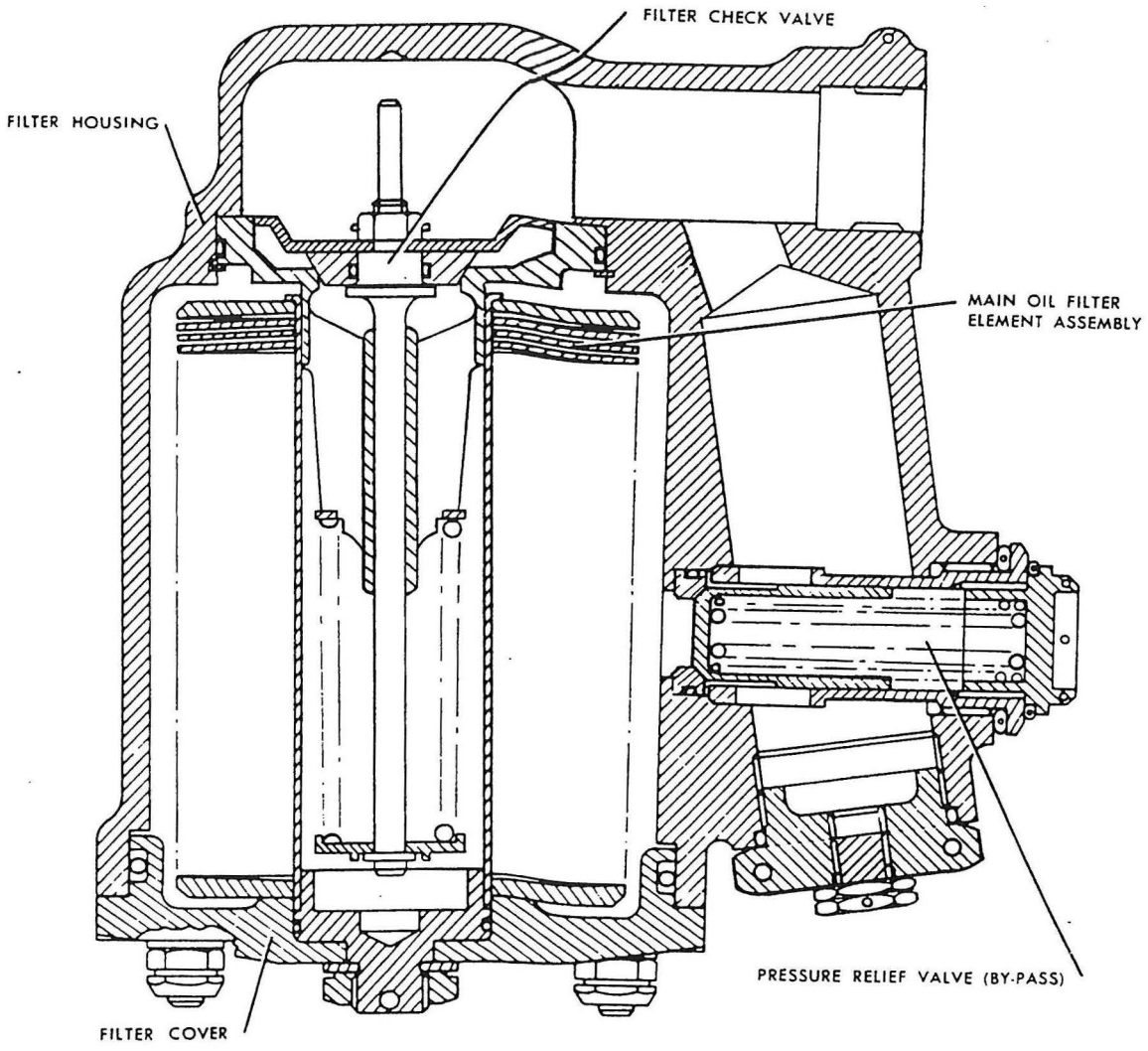
B. Torque Limits

	REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
	2001	A	Compressor Bleed Actuator Screen Housing Connector			400	450	
R R	2002	A	Oil Tank Mounting Bracket Nuts			5	7	
	2003	B	Oil Tank Drain Valve Spring At 270° CCW Turn			2.800	3.500	
R	2004	A	Tube Connector			525	625	
	2005	A	Igniter Plug			300	360	

ENGINE - DISMANTLING/ASSEMBLY

	REF. NO.	OIR	DESCRIPTION	REF. DIM. MIN	REF. DIM. MAX	LIMITS MIN	LIMITS MAX	REPLACE IF OVER
R R R	2006	A	Thermocouple Junction Box Terminal Nut			30	35	
	2009	A	Flexible Tube Connection			200	220	
	2013	A	Flexible Tube Connection			110	120	
	2014	A	Flexible Tube Connection			140	160	
	2015	A	Housing Power Lever Bearing Retaining Nut			150	200	
R R	2016	A	Flexible Tube Connections			160	175	
R R	2017	A	Flexible Tube Connections			60	65	
R R	2018	A	Flexible Tube Connections			120	130	
	2019	A	Arm Shutoff Power Lever Retaining Nut			100	150	
	2020	A	Clevis Rod End Shutoff Lever Bolt			25	75	
	2021		Thermocouple Harness-to-Retaining Nut 164-32			12	15	
	2022		Thermocouple Harness-to-Retaining Nut 190-32			12	15	

ENGINE - DISMANTLING/ASSEMBLY



Oil Filter Housing
Figure 409

(3) Remove bolts, washers, and spacers securing filter housing outside leg to clevis mounted on bracket on lower right front flange of intermediate case. Remove filter housing.

B. Installation

(1) Position oil filter housing to lower right location of intermediate case mount ring area inserting inner legs of housing between intermediate case mount rings and legs of oil adapter.

(2) Align holes of mount rings, filter housing, and oil adapter; then insert internal spacers (small ID inward) from inside through legs of oil adapter and then through legs of oil filter housing. Secure buildup by inserting bolts through mount rings of intermediate case and installing nuts on inside of legs. Torque bolts and nuts.

NOTE: Install bracket under bolt head of rear bolt to support fuel tube clip.

(3) Position front leg of filter housing to clevis mounted on bracket on lower right front flange of intermediate case.

(4) Install two spacers in clevis hole; then position washer on each side of clevis. Install washer under bolt head and insert bolt through leg of filter housing and through assembled clevis. Install locknut and tighten. Torque bolt and nut.

20. Removal/Installation of Main Oil Filter Element Assembly

See Figure 409.

A. Removal

(1) Remove nuts securing main oil filter cover to main oil filter housing assembly.

NOTE: On covers which incorporate puller grooves, engage PWA-30643 Puller in grooves and, using knocker action, remove cover. R R R

(2) Remove main oil filter element.

(7) Check to be sure that cover is seated against end plate and screens and spacers cannot be rotated by hand. If necessary, remove cover and add or remove sets of screens and spacers as directed above until requirements are met. Remove assembled element from fixture.

22. Removal/Installation of Oil Pressure Relief Valve (BY-Pass)

See Figure 409.

A. Removal

(1) Remove relief valve plug and spring from relief valve liner.

(2) Remove relief valve liner and valve from filter housing.

B. Installation

(1) Install relief valve, gasket and relief valve liner into oil filter housing.

(2) Insert spring into well of relief valve.

(3) Place gasket on relief valve liner and install plug. Torque plug.

23. Removal/Installation of Oil Pump

A. Removal

NOTE: Fuel control must be removed prior to removal of oil pump.

(1) Unfasten locknuts and washers securing oil pump front body to gearbox front housing.

(2) Remove lockwire from two nuts (adjacent to fuel control drive pad) on front face of oil pump and remove nut and washer closest to pump cover positioning pin.

CAUTION: DO NOT REMOVE REMAINING THREE NUTS EXCEPT NUT DIAGONALLY OPPOSITE MAY BE REMOVED IN PLACE OF ONE ABOVE.

(3) Carefully attach PWA-2536 Puller to extended threads of bolt from which above nut was removed. Using knocker action, remove oil pump from its cavity in gearbox front housing.

NOTE: Coupling may remain splined to hydraulic pump drive gearshaft or stay splined to end of oil pump drive-shaft when removing oil pump assembly complete.

B. Installation

(1) Moisten oil pump packings with engine oil and place them in oil pump rear and front body grooves and in rear body spacer assembly groove.

(2) Insert oil pump assembly in gearbox front housing.

NOTE: Be careful that oil pump coupling properly engages matching splines of hydraulic pump drive gearshaft in gearbox housing and those of oil pump drive shaft.

(3) Align oil pump cover with positioning pin and bolt holes.

(4) Secure oil pump to gearbox front housing with washers and locknuts. Torque locknuts.

24. Disassembly/Assembly of Oil Pump

See Figure 411.

A. Disassembly

(1) Unfasten nuts securing oil pump bodies together and remove washers and bolts.

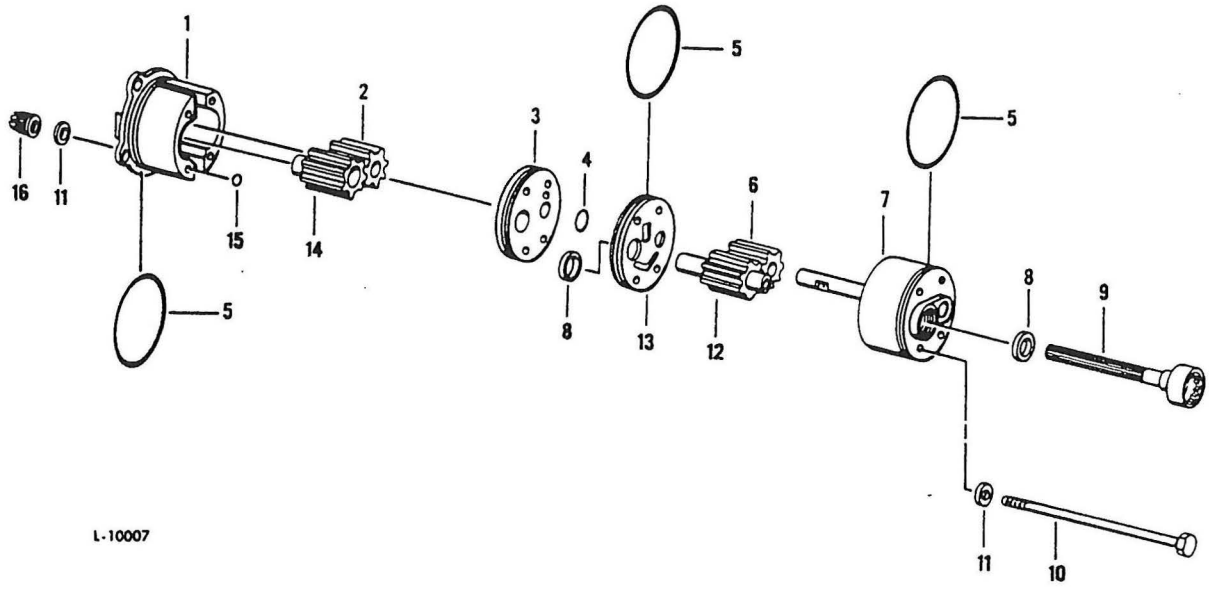
(2) Remove front oil pump body and four packings.

(3) Remove oil pump gearshaft.

(4) Remove oil pressure pump spur gear.

(5) Remove front oil pump body spacer.

ENGINE - DISMANTLING/ASSEMBLY



1. Front Oil Pump Body
2. Oil Pump Spur Gear
3. Oil Pump Body Front Spacer
4. Oil Pump Body Rear Spacer Packing
5. Oil Pump Packing
6. Oil Pump Spur Gear
7. Rear Oil Pump Body Assembly of
8. Oil Pump Body Seal
9. Oil Pump Drive Shaft
10. Oil Pump Body Bolt
11. Oil Pump Body Bolt Washer
12. Oil Pump Drive Spur Gearshaft
13. Oil Pump Body Rear Spacer Assembly
14. Oil Pump Gearshaft
15. Oil Pump Front Body Packing
16. Oil Pump Body Bolt Nut

NOTE: Parts must be assembled so that the gears will rotate freely.

Main Oil Pump
Figure 411

(6) Remove rear oil pump body spacer assembly; then remove seal and packing from spacer.

(7) Remove oil pump drive spur gearshaft.

(8) Remove oil pump spur gear.

(9) Remove oil pump drive shaft from rear oil pump body assembly. Remove seal from rear body.

B. Assembly

See Figure 411.

(1) Position oil pump rear body, oil pump drive shaft opening up, on bench; then place new seal on PWA-10381 Drift with seal element up. Install pilot of drift into bore of oil pump rear body and push seal into position to seat. Remove drift. Lubricate inside of seal with engine oil.

(2) Position oil pump rear body assembly (idler shaft end up) on bench; then lubricate inside of seal with engine oil.

(3) Install oil pump spur gear over rear body idler shaft and oil pump drive spur gearshaft in seal (internal splines up) to seat in oil pump rear body.

(4) Place oil pump rear body spacer on bench, seal opening up; then place new seal on PWA-10381 Drift with seal element up. Install pilot of drift into base of spacer and push seal into position to seat. Remove drift. Lubricate inside of seal with engine oil.

(5) Place packing in ID of idler shaft opening in rear body spacer and install spacer assembly over idler shaft and oil pump drive spur gearshaft to seat on oil pump rear body.

(6) Install oil pump front body spacer over idler shaft and gearshaft to seat on oil pump rear body spacer assembly.

(7) Install oil pump spur gear over idler shaft and oil pump gearshaft over installed oil pump drive spur gearshaft to seat on oil pump front body spacer.

(8) Place packings in four bottom openings in oil pump front body and install it over idler shaft and oil pump gearshaft to seat on oil pump front body spacer.

(9) Install four oil pump assembly bolts and washers through assembled oil pump, boltheads in rear, and secure with nuts. Tighten nuts hand tight.

(10) Install oil pump drive shaft through oil pump rear body to seat shaft shoulder on gearshaft and to engage internal splines of oil suction and oil pressure gearshafts. Rotate drive shaft to make certain gears rotate freely inside oil pump.

R NOTE: SB 4453 provides, as additional equipment, a
R positive lubricated hydraulic pump drive spline.
R SB 4453 provides a reworked and reidentified oil
R pump drive shaft that must be used with a reworked
R and reidentified hydraulic pump drive spur
R gearshaft.

CAUTION: CHECK TO MAKE CERTAIN THAT GEARS CONTINUE TO ROTATE FREELY AFTER TIGHTENING NUTS

(11) Torque and lockwire four nuts.

25. Removal/Installation of Oil Filter Check Valve

See Figure 409.

A. Removal

(1) Unfasten retaining ring which secures oil filter valve seat to oil filter housing.

(2) Remove oil filter valve seat (with disks and stem) from filter housing.

(3) Remove dowel pin from end of valve stem and slide off seat, spring, and washer.

(4) Remove cotterpin from nut and remove nut from shouldered end of valve stem.

(5) Remove upper and lower disks from stem.

ENGINE - DISMANTLING/ASSEMBLY

B. Installation

(1) Coat new packing with oil and install oil filter valve lower disk onto stem, conical side toward shoulder of stem.

(2) Install oil filter valve upper disk on stem against lower disk, concave side of disk away from lower disk.

(3) Install nut on stem and torque. Install cotterpin in nut and bend to secure.

(4) Slide build-up stem down into large ID end of oil filter valve seat.

(5) Place washer against lower end of valve seat; then install spring against washer on stem.

(6) Install spring seat over stem and secure spring and seat on valve stem with dowel.

(7) Coat new packing with engine oil and position it in groove of filter valve seat.

(8) Install assembled oil filter valve in oil filter housing.

(9) Secure valve in housing by installing retaining ring.

26. Removal/Installation of Accessory and Component Drives Gearbox

A. Removal

(1) Remove both hydraulic pad covers from each end of accessory and component drives gearbox; then install PWA-16566 and PWA-16567 Brackets to each of pads and secure with cover's retaining nuts.

(2) Attach PWA-6580 Sling to each of bracket spools and take up slack.

(3) Remove bolts securing locks retaining pins in diffuser case positioning bracket and accessory and component drives bearing housing; then using screwdriver or similar tool, remove locks and pins.

(4) Remove two bolts securing locks to brackets attached to diffuser case front flange.

(5) Using chain hoist, adjust accessory and component drives gearbox to take its load off of pins adjacent to bolts removed from diffuser case brackets.

(6) Using screwdriver or similar tool, pry pins and locks from brackets attached to diffuser case.

(7) Position dolly having small casters under gearbox and lower gearbox to dolly. Remove sling from spools of brackets and withdraw accessory and component drives gearbox under horizontal stand.

CAUTION: BECAUSE OF ANGULAR ENGAGEMENT OF COUPLING TO MAIN ACCESSORY COMPONENT DRIVE SHAFT, GEARBOX DOES NOT DROP VERTICALLY UNTIL GUIDE IN COUPLING IS COMPLETELY OUT OF ID OF SHAFT. THEREFORE, EXERT PRESSURE ON REAR OF GEARBOX TOWARDS FRONT OF ENGINE TO AID GUIDE IN COUPLING TO DISENGAGE FROM ID OF SHAFT DURING INITIAL LOWERING OF GEARBOX.

(8) Reinstall sling to bracket spools and raise gearbox; then install PWA-16177 Support to alternator drive pad on front of gearbox using engine bolts.

R (9) Install gearbox in PWA-16514 Stand and secure with ball-lock pins.

(10) Remove accessory and component drive shaft from inside diffuser case six o'clock strut.

NOTE: Wrap shaft in protective paper to prevent damage and contamination to splines.

B. Installation

(1) Coat splines with Lubriplate No. 130A or its equivalent; then install component drive shaft inside diffuser case six o'clock strut and into its mating spline in main accessory component drive gearshaft.

ENGINE - DISMANTLING/ASSEMBLY

(2) With hydraulic pad covers on each end of accessory and component drives gearbox removed, install PWA-16566 and PWA-16567 Brackets to each pad and secure them with cover's retaining nuts.

(3) Using PWA-6580 Sling and hoist, raise gearbox from PWA-16514 Stand and remove PWA-16177 Support to alternator drive pad on front of gearbox.

(4) Position gearbox assembly in flight position on dolly having casters; then remove sling.

(5) Using dolly, position gearbox assembly under six o'clock strut of diffuser case and reinstall sling to bracket spools.

(6) Coat splines of coupling in gearbox assembly with Lubriplate No. 130A or its equivalent, and with hoist, raise gearbox assembly from dolly while positioning guide of coupling in ID of component drive shaft in diffuser case strut, carefully install gearbox, placing lugs of gearbox assembly bracket in diffuser case positioning bracket.

CAUTION: BECAUSE OF ANGULAR ENGAGEMENT OF COUPLING TO MAIN ACCESSORY COMPONENT DRIVE SHAFT, GEARBOX ASSEMBLY CANNOT BE RAISED VERTICALLY AFTER COUPLING HAS ENTERED ID OF SHAFT. THEREFORE, EXERT PRESSURE ON FRONT OF GEARBOX TOWARD REAR OF ENGINE TO AID GUIDE IN COUPLING TO ENGAGE IN ID OF SHAFT DURING INITIAL RAISING OF GEARBOX.

(7) Align holes in diffuser case brackets with those in accessory and component drives bearing housing and insert retaining pins. Install locks on pins; then secure locks with bolts. Tighten bolts to recommended torque.

(8) Using chain hoist, align holes of gearbox links to those in brackets on diffuser case front flange and insert retaining pins. Install locks on pins; then secure locks with bolts. Torque and lockwire bolts.

(9) Remove brackets and sling.

27. Removal/Installation of Accessory and Component Drives Gearbox Breather Adapter (JT3D-7 BG) or Breather Elbow (JT3D-7 DSLG)

A. Removal

(1) Remove locknuts securing accessory and component drives gearbox breather adapter (JT3D-7 BG) or breather elbow (JT3D-7 DSLG) to oil pump pad on rear gearbox housing.

(2) Remove breather adapter or breather elbow.

(3) Remove plug and packing from breather adapter or unfasten and remove bolts, washers, and locknuts securing cover to elbow; then remove cover and gasket.

B. Installation

(1) For JT3D-7 (BG), using new packing, install plug on accessory and components drives gearbox adapter; then tighten plug to recommended torque and secure with lockwire or for JT3D-7 (DSLG) using new gasket, install accessory and component drives gearbox elbow cover on elbow and secure it with bolts, washers, and locknuts. Torque locknuts.

NOTE: Install washers under bolt heads and under nuts.

(2) Position adapter or elbow on pad at oil pump locations on rear gearbox housing and secure it using washers and locknuts. Torque locknuts.

28. Removal/Installation of Oil Pressure Relief Valve

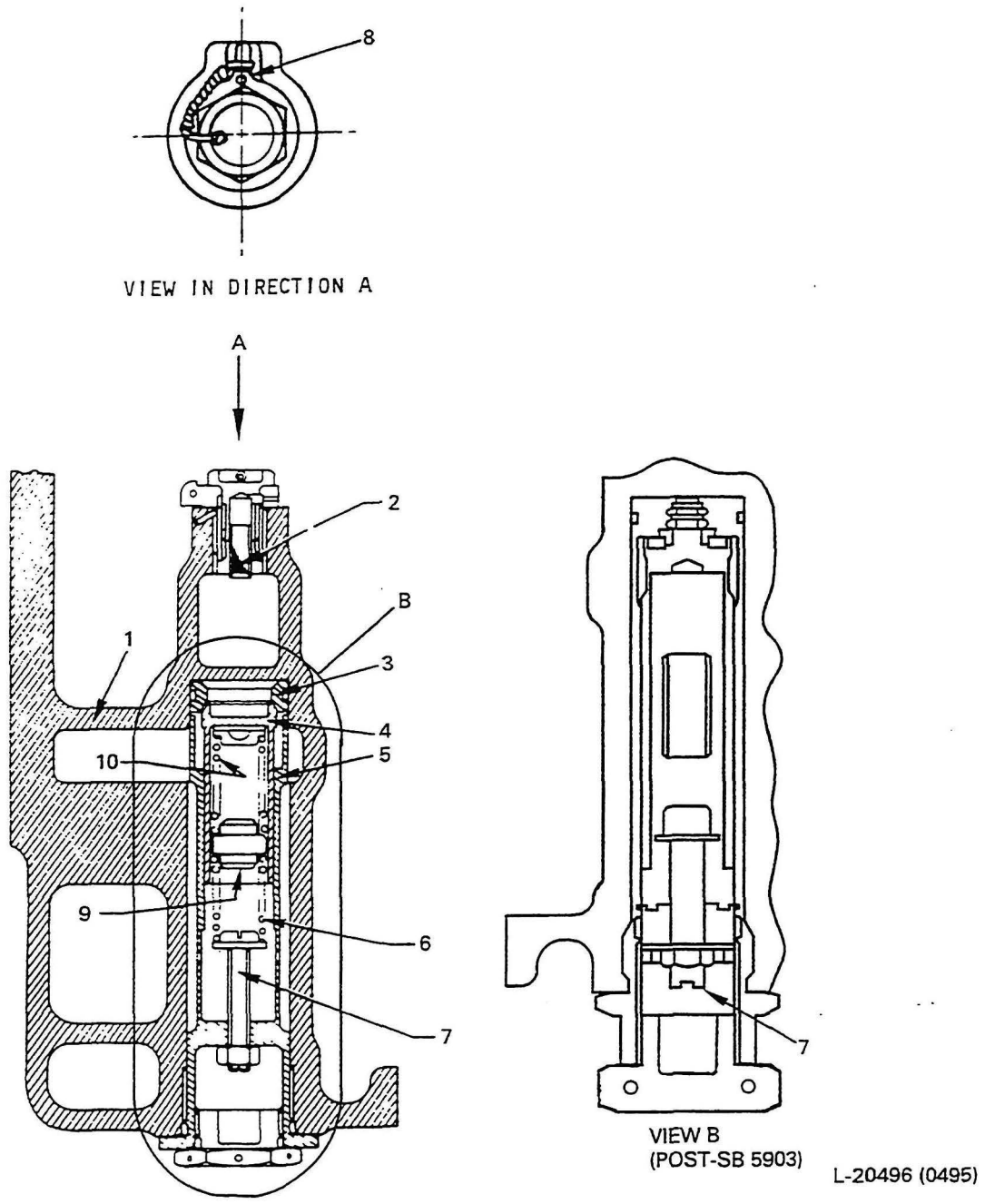
See Figure 412.

A. Removal

R (1) Pre-SB 5903:

R (a) Cut the lockwire that safeties the valve plug to the
R housing. Put a wrench on the hex of the valve body
R (adjacent to the housing surface) and remove the valve
R end plug with a wrench.

R (b) Remove the valve assembly from the gearbox with a wrench.
R Discard the valve body packings.



Oil Pressure Relief Valve
Figure 412

1. Gearbox
2. Strainer
3. Valve Seat
4. Valve
5. Valve Body
6. Outer Spring
7. Adjusting Screw
8. Do Not Lockwire Over Jet Port
9. Intermediate Spring Seat
10. Inner Spring

R Key To Figure 412

R (2) Post-SB 5903:

R NOTE: Post-SB 5903 the oil pressure relief valve is one
R assembly. It is possible to remove this valve
R assembly without removal of detail parts.

R (a) Cut the lockwire that safeties the valve plug to the
R housing. Put a wrench on the hex of the valve body
R (adjacent to the housing surface) and remove the valve
R assembly from the gearbox housing. Discard the valve
R body packings.

R B. Installation

R (1) Pre-SB 5903:

R (a) Put new packings (lightly lubricated with PWA 36500
R Assembly Fluid or PMC 9609 petrolatum) on the valve
R assembly and install the valve assembly in the gearbox
R bore (lower right side) of the front housing. Torque
R the valve assembly to standard torque.

R (b) Put a new packing (lightly lubricated with PWA 36500 Assembly Fluid or PMC 9609 petrolatum) on the valve end plug. Install the plug in the valve assembly.

R (c) Torque the plug to standard torque and safety it to the gearbox housing with lockwire.

R (2) Post-SB 5903:

R NOTE: Post-SB 5903 the oil pressure relief valve is one assembly. It is possible to install this valve assembly in the gearbox housing as a completed assembly, not as detail parts.

R (a) Put packings (lubricated lightly with PWA 36500 Assembly Fluid or PMC 9609 petrolatum) on the inner and outer ends of the valve housing.

R NOTE: Use ST1050-119 packing at the inner end of the valve assembly. Use ST1051-16 at the outer end of the valve assembly (under the hex flange).

R (b) Install the valve assembly in the gearbox housing. Use a wrench on the hex of the valve housing (do not put the wrench on the hex of the end plug) to torque the valve to 525 - 624 lb-in.

R (c) Make sure the end plug is in position (torqued to 275 - 300 lb-in.). Lockwire the end plug to the gearbox housing.

R NOTE: If the valve assembly was given a bench pressure check after assembly, the engine oil pressure will be approximately correct after this type of valve is installed, but it is recommended that oil pressure be monitored during subsequent engine run. Adjust the oil pressure as necessary (see Adjustment/Test). The oil pressure adjustment procedure for a post-SB 5903 valve assembly is the same as that for a pre-SB 5903 valve.

29. Disassembly/Assembly of Oil Presure Relief Valve

A. Disassembly

R (1) Pre-SB 5903:

R (a) Remove the valve from the valve body.

R (b) Remove the spring positioning plate, spring seat, and
R spring.

R (c) Remove the relief valve adjusting screw from the nut and
R remove these parts from the valve body.

R (d) Install the expander of PWA 16359 Puller in the valve
R bore in the gearbox front housing, through the seat
R behind the valve seat.

R (e) Expand the puller tightly in position. Hold the puller
R and turn the jamnut to remove the valve seat from the
R housing bore.

R (f) Remove the seat from the puller and discard the valve
R packing.

R (2) Post-SB 5903:

R (a) Hold the valve assembly by the hex at the outer end of
R the valve body.

R (b) Remove the end plug from the valve body.

R (c) Remove the nut and the adjuster support lock from the
R valve adjuster.

R (d) Turn out the pressure relief valve adjuster support and
R remove it from the valve housing.

R (f) Remove the outer valve spring, spring seat, and inner
R valve spring.

R (g) Remove the pressure relief valve assembly from the valve
R body.

R (h) Bend the key washer away from the nut at the inner end
R of the valve assembly. Remove the nut and the spacer
R sleeve below it from the end of the valve assembly.
R

R B. Assembly

R (1) Pre-SB 5903:

R (a) Install a new packing (lubricated with PWA 36500 Assembly
R Fluid or PMC 9609 petrolatum) in the groove of the valve
R seat.

R CAUTION: AFTER THE SEAT AND PACKING ARE INSTALLED IN THE
R HOUSING, USE A STRONG LIGHT TO MAKE SURE THAT
R THE PACKING STAYED IN THE SEAT GROOVE DURING
R INSTALLATION AND DID NOT ROLL OUT OF POSITION.

R (b) Put the seat on the pilot of PWA 16358 Drift and install
R it the bottom right side of the gearbox front housing.
R Push the seat firmly to the bottom of the cavity.

R (c) Install the relief valve positioning plate in the relief
R valve and install the valve spring seat on the plate.

R (d) Put the inner spring in the valve against the spring
R seat, then install the intermediate spring seat and outer
R spring as shown in the figure.

R (e) Turn the adjusting screw into its full depth in the
R valve body and install the nut on the screw.

R (f) Put the assembled relief valve in the valve body with the
R spring against the adjusting screw.

R (2) Post-SB 5903:

R CAUTION: DO NOT MIX PARTS FOR PN 779606 VALVE ASSEMBLY
R (POST-SB 5903) WITH PARTS FROM THE REPLACED
R ASSEMBLY.

R (a) Install the spacer sleeve on the inner end of the pres-
R sure relief valve assembly and install a key washer and
R nut to attach it in position. Torque the nut to 14 -
R 16 lb-in. and bend the tabs of the key washer to safety
R the nut.

R (b) Install the pressure relief valve assembly in the valve
R housing. Install the retaining ring in the housing with
R Truarc pliers.

R (c) Put the inner spring (left-hand coil), spring seat, and
R outer spring (right-hand coil) in the valve assembly.

R (d) Install the adjuster in the adjuster support with the
R slot outboard. Turn the adjuster screw in approximately
R one-half of its length in the adjuster support.

R (e) Put a new packing (AS3209-118), lubricated lightly with
R PWA 36500 Assembly Fluid (or PMC 9609 petrolatum) on the
R adjuster support and install the adjuster support in the
R outer end of the valve housing (be careful to engage the
R inner end of the adjuster in the outer valve spring).
R Turn the support down against its shoulder and torque it
R to 260 - 290 lb-in. (align a slot in the adjuster support
R with a slot on the inner wall of the housing).

R (f) Install a nut on the end of the adjuster with the
R adjuster support lock under the nut (the tab on the lock
R goes in the slots of the support and housing).

R (g) Tighten the adjuster nut against the support surface (do
R not put a measured torque on the nut until the valve
R assembly is adjusted).

R (h) Lubricate packings (ST1050-119 on the inner end,
R ST1051-16 on the outer end under the valve housing
R flange) lightly with PWA 36500 Assembly Fluid or PMC 9609
R petrolatum and install them on the outer grooves of the
R completed valve assembly.

R (i) Install a packing (AS3208-11, lubricated with PWA 36500
R Assembly Fluid or PMC 9609 petrolatum) on the end plug.
R Install the end plug in the valve. Torque the plug to
R 275 - 300 lb-in.

R NOTE: It is permitted to install the assembled valve in
R an engine without added pressure checks if the
R valve was given a bench test at assembly (see the
R JT3D Overhaul Manual). If there will be added
R tests of engine oil pressure after the valve is
R installed in an engine, do not torque the end plug
R at this time.

30. Removal/Installation of Oil Scavenge Pump (Inlet) Strainer

A. Removal

(1) Provide suitable container to catch draining oil; then unfasten and remove two bolts retaining oil scavenge pump strainer at bottom of accessory drives housing and remove strainer.

(2) Discard oil strainer packing and clean strainer.

B. Installation

(1) Install new oil strainer packing on strainer and install strainer in accessory drive housing.

31. Removal/Installation of Fuel Pump Drive Front Oil Seal (Engines Incorporating Fuel Pump Drive Spline Pressure Oil Lubrication)

A. Removal

(1) Remove seal retaining ring, PN 541170, from ID of retainer.

(2) Drill three one-eight inch holes approximately 120 degrees apart centered in metal face of seal

(3) Install three self-tapping screws (No. 8 blunt end recommended).

(4) Using suitable puller remove seal by pulling on the three screws.

CAUTION: LIMIT PENETRATION OF DRILL AND SCREWS TO 0.250 INCH OR LESS TO AVOID DAMAGE TO RETAINER.

B. Installation

(1) Place seal, P/N 436174, in retainer and over end of fuel pump shaftgear.

(2) Carefully seat seal in retainer.

(3) Replace seal retaining ring, P/N 541170, in retainer.

CAUTION: SEAL RETAINER P/N 566070, CANNOT BE REMOVED WITHOUT GEARBOX BEING SPLIT AND LUBRICATION NOZZLE REMOVED.

R 32. Removal/Installation of Combustion Chambers

A. Removal

NOTE: All aircraft component tubing which interferes with this operation must be removed. Before removal of any part, mark location of all clips and clamps to facilitate installation.

(1) With engine in horizontal position, support it at compressor intermediate case and turbine exhaust case.

(2) Remove high voltage leads from sparkigniters; then remove sparkigniters.

(3) Remove exhaust temperature thermocouple lead, rear bearing pressure and scavenge oil lines and combustion chamber drain line which extends rearward from fireseal.

(4) Remove all brackets and clips at front flange of turbine nozzle case (rear flange of combustion chamber outer rear case). Note their locations.

CAUTION: WITH COMBUSTION CHAMBER OUTER REAR CASE MOVED BACK, LOAD ABOUT TURBINE REAR MOUNT PLANE MUST NOT EXCEED 2650 POUND-INCHES. THIS RESTRICTION IS NECESSARY TO PREVENT LOAD ON ENGINE THAT COULD DAMAGE SEALS OR BEARINGS. THEREFORE, REMOVE AIRFRAME SILENCER AND REVERSER OR MAKE PROVISIONS TO ADEQUATELY SUPPORT THEM DURING THIS PHASE OF MAINTENANCE.

(5) Remove flange bolts and nuts securing combustion chamber outer rear case to shorter combustion chamber outer front case.

R ENGINE - DISMANTLING/ASSEMBLY

(6) Remove screws which attach sections of fireseal and remove these sections.

NOTE: This step may be omitted, but removing top sections of fireseal permits slightly larger work area.

(7) Position PWA-16210 Collar around approximate center of combustion chamber outer rear case and secure with swing bolt and nut.

(8) Using chain hoist, attach PWA-6580 Sling to collar spools and take up slack.

(9) Remove nuts which attach combustion chamber outer rear case to turbine nozzle case front flange.

(10) Slide combustion chamber outer rear case rearward over turbine nozzle case as far as it will go.

(11) Temporarily secure lower section of fireseal to combustion chamber outer front case rear flange using engine bolts and nuts.

(12) Number combustion chambers, using layout dye, from one to eight (clockwise) starting with top right hand chamber as viewed from rear.

(13) Remove all bolts securing combustion chamber clamps.

(14) Slide clamps forward on all of chambers.

(15) Slide combustion chambers rearward moving rear of chamber outward to disengage chamber lug from positioning bracket, to clear fuel nozzles; then rotate each chamber approximately ten degrees to disengage cross-over tubes. (See R Figure 413.)

(16) Only No. 5 combustion chamber contains two male cross-over tubes which requires this chamber to be removed first.

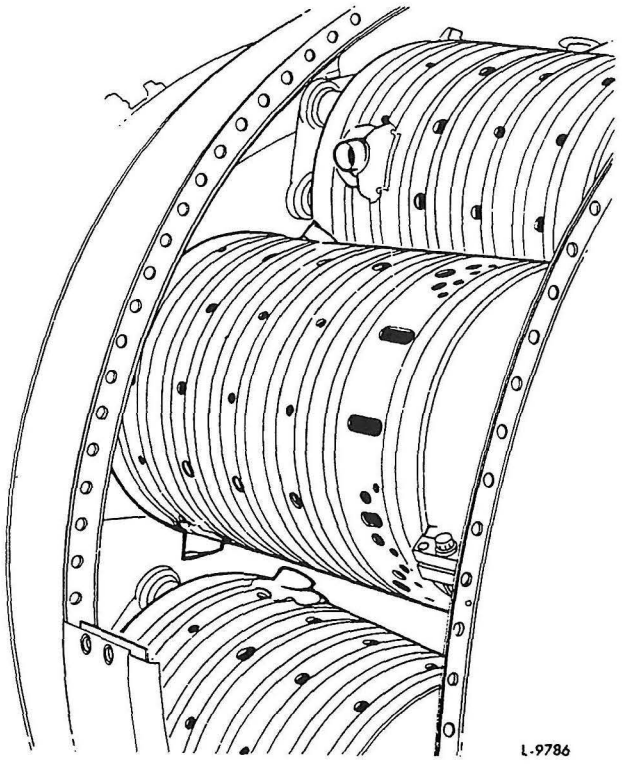
(17) Withdrawal sequence of combustion chambers in No. 5, 6, 4, 3, 7, 2, 8, and 1.

CAUTION: AVOID BENDING OR DAMAGING POSITIONING BRACKETS AND AIR PRESSURE ELBOW WHICH IS IN NO. 4 COMBUSTION CHAMBER. IF NECESSARY LOOSEN OR REMOVE POSITIONING BRACKETS.

(18) Install protective covers over fuel nozzle clusters.

R

ENGINE - DISMANTLING/ASSEMBLY



Preparing Combustion Chamber Liners
for Removal
Figure 413

R (19) Inspect fuel manifold for loose heatshields. No looseness is allowed. If looseness is found, replace fuel manifold heatshield and all insulation material. Refer to Section 73-5-1, Fuel Manifold Repair of Accessory Component Overhaul Manual, PN 411569.

B. Installation

CAUTION: DO NOT MIX DIFFERENT TYPES OF COMBUSTION CHAMBERS WITHIN SET. USE ONLY TYPE III CHAMBERS.

NOTE: Engines converted to smokeless burner configuration require use of new modified Type III combustion chambers and matching clamps that must only be used in this new configuration in complete sets even though old and new parts are physically interchangeable.

(1) The following precautions must be observed during chamber and chamber clamp installation.

(a) Chambers without hardfaced locating lugs are not acceptable for installation into engines.

(b) Chambers without hardfaced eleventh outer liners are not acceptable for installation into engines.

(c) Combustion chamber clamps which are not hardfaced in forward ID which mates with combustion chamber are not acceptable for installation into engines.

(d) Clamps, PN 622382, incorporating loose heat shield, PN 622379, installed (trapped) in center ID of clamp may not be operated without heat shield.

(e) Interchangeability of clamps within an engine set of eight is as follows: loose (trapped) heat shield type clamps and welded-in heat shield type clamps can be used in complete engine sets respectively (preferred) or may be combined within an engine set if desired. Intermixing of Hastelloy and steel clamps of either heat shield design is also permissible. Combinations of heat shielded (all types) and non-heat shielded type clamps within an engine set are not recommended.

NOTE: Engines converted to smokeless burner configuration require use of new combustion chamber clamps that must only be used in this new configuration in complete sets even though old and new clamps are physically interchangeable.

(2) Measure combustion chamber eleventh liner and record average OD.

(3) Measure both front and rear ID of clamp and record average ID and for clamps incorporating spacer, the spacer thickness required.

(4) Using actual sizes of parts, as recorded on combustion chamber, outlet duct, and clamp, calculate fit which will result when parts are assembled. For each of eight combinations of chamber, outlet duct, and clamp, fit must be as follows:

(a) Hastelloy material clamps (loose heat shield): PN 622382 clamp (must have PN 622379 heat shield assembled in place in center ID).

Clamp Front ID	9.783 - 9.789
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010L	
Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	
Clamp Center ID	9.898 - 9.902
Heat Shield OD	9.902 - 9.908
Fit 0.000 - 0.010T	

(b) Hastelloy material clamps (welded-in heat shield): PN 488124-SB1771, change letter E or later; PN 500183-SB1771, change letter C or later; PN 622378; and PN 644546.

Clamp Front ID	9.783 - 9.789
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010L	
Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	

(c) Hastelloy material clamps (non-heat shielded): PN 488124, change letter E or later; PN 500183, change letter C or later.

Clamp Front ID	9.778 - 9.784
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.005L - 0.005T	
Clamp Rear ID	9.779 - 9.785
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002L - 0.010T	

(d) Steel material clamps (welded-in heat shield): PN 488124-SB1771, prior to change letter E; PN 500183-SB1771, prior to change letter C; and PN 647338.

Clamp Front ID	9.778 - 9.784
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.005L - 0.005T	
Clamp Rear ID	9.775 - 9.781
Outlet Duct Portable OD	9.783 - 9.789
Fit 0.002T - 0.014T	

(e) Steel material clamps (non-heat shielded): PN 488124, prior to change letter E; PN 500183, prior to change letter C.

Clamp Front ID	9.773 - 9.779
Chamber Eleventh Liner OD	9.779 - 9.783
Fit 0.000 - 0.010T	
Clamp Rear ID	9.775 - 9.781
Outlet Duct Porthole OD	9.783 - 9.789
Fit 0.002T - 0.014T	

CAUTION: UNDER NO CIRCUMSTANCES IS AN ENGINE TO BE ASSEMBLED WITH EITHER CLAMP TO CHAMBER OR CLAMP TO PORTHOLE FIT OUTSIDE LIMITS.

(5) The most satisfactory condition is to mate chambers, clamps, and outlet duct portholes to achieve mean of fit limits at clamp to chamber and clamp to outlet duct porthole. However, clamp to chamber fit is more important than clamp to porthole fit.

(6) The desired fit may be achieved as follows:

(a) For welded-in heatshield and loose (trapped) heatshield type clamps, which use spacers between bolt flanges of clamp, select spacer of proper thickness from Table XIII.

NOTE: Even though clamp may have been received with pre-selected spacer attached, it may be necessary to select different spacer to obtain desired fit.

Spacer, PN 622383, is provided in the following thicknesses:

CL 7	0.045 - 0.047
CL 8	0.042 - 0.044
CL 9	0.039 - 0.041
CL 10	0.036 - 0.038
CL 11	0.033 - 0.035
CL 12	0.030 - 0.032
CL 13	0.027 - 0.029
CL 14	0.024 - 0.026
CL 15	0.021 - 0.023
CL 16	0.018 - 0.020
CL 17	0.015 - 0.017

Table XIII

R ENGINE - DISMANTLING/ASSEMBLY

(b) For non-heatshielded type clamps, which do not use spacer, select chambers and clamps to make up an engine set which will meet fit requirements or rework clamp to welded-in heatshield type, with spacer.

(7) When an engine set of chambers and clamps has been selected, mark chamber position on chamber, using non-permanent marking method, or some other system which will ensure that chamber/clamp combination will be installed in proper sequence, as follows:

Type III Chambers - 1-8-2-7-3-4-6-5

(8) For loose (trapped) heatshield type clamps, select a heatshield which will give the desired clamp to heatshield fit. Mark position on heatshield, using non-permanent marking method. Do not install heatshield into clamp ID at this time.

(9) Spread ends of clamp and position clamp around chamber just forward of eleventh liner with split in clamp aligned axially with locating lug on chamber. Retain with clamp/chamber combination any circumferential shims and/or spacers which are associated with clamp. Do this for each of the eight clamp/chamber combinations in the engine set.

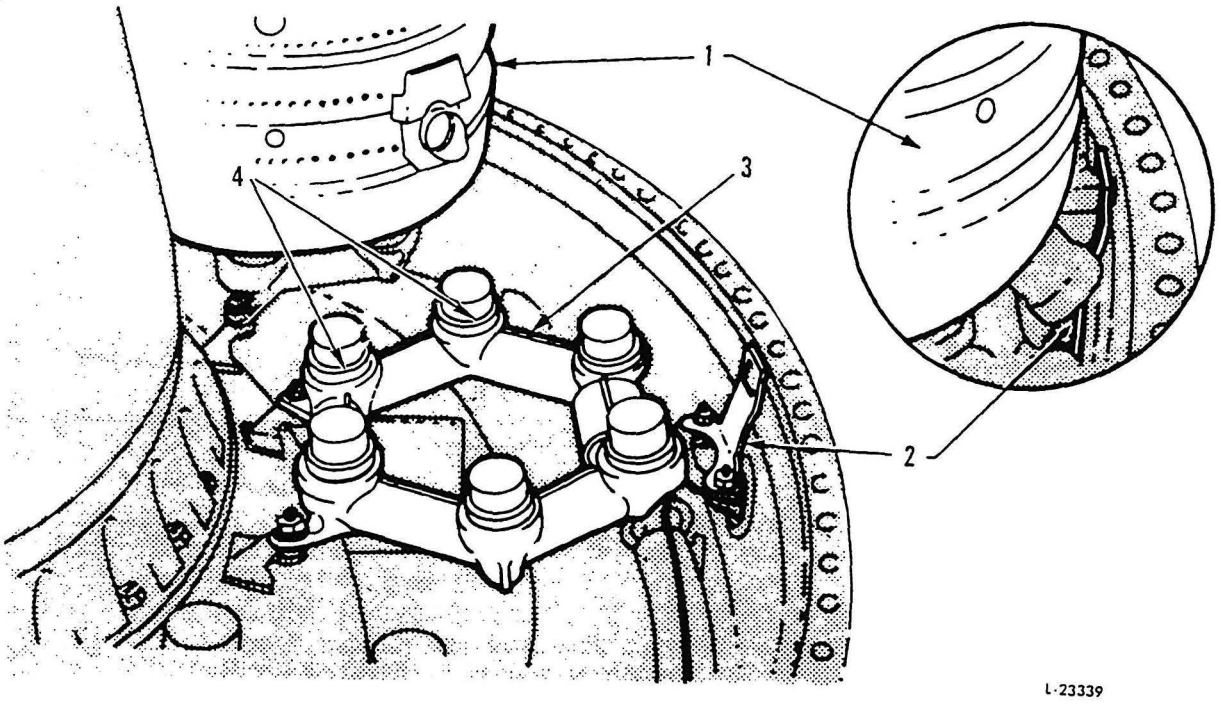
CAUTION: SPREAD CLAMP ONLY ENOUGH TO SLIP IT ONTO CHAMBER. EXCESSIVE SPREADING WILL PERMANENTLY DEFORM CLAMP. FOR WELDED-IN HEATSHIELD TYPE CLAMPS, DO NOT ALLOW CLAMP TO SPRING OR SNAP CLOSED ON CHAMBER SINCE THIS WILL BEND HEATSHIELD AND CLOSE GAP BETWEEN HEATSHIELD AND CLAMP BODY.

(10) Remove bolts securing combustion chamber outer front case to diffuser case. Raise case as far as it will go.

(11) For loose (trapped) heatshield type clamps, install heatshield into outlet duct porthole.

(12) With combustion chamber outer front case moved rearward and with chamber positioning bracket (installed on manifold OD mount studs) loosened, install first chamber in sequence to seat on fuel nozzle cluster with chamber lug in position
R to engage positioning bracket. See Figure 414.

R ENGINE - DISMANTLING/ASSEMBLY



1. Combustion Chamber

2. Combustion Chamber Positioning Bracket. Nuts Securing This Bracket Must Be Installed Loosely Enough To Permit Bracket To Lean Toward OD Of Engine During Chamber Installation.

3. Fuel Nozzle Cluster

4. Shoulder On Fuel Nozzle. Install Chamber So That Swirl Guides Seat On These Shoulders.

Combustion Chamber Installation
Figure 414

R ENGINE - DISMANTLING/ASSEMBLY

(13) While holding chamber seated against fuel nozzle cluster, spread ends of clamp only enough to permit slipping clamp toward outlet duct to engage around porthole.

NOTE: If circumferential shim is used in clamp rear ID to set fit, slide shim into place after clamp has been loosely engaged on outlet duct porthole.

(14) For loose heatshield type clamps, move heatshield toward chamber and engage heatshield in clamp center ID as clamp is moved toward outlet duct porthole.

(15) Pull ends of clamp toward each other with finger pressure while inspecting to ensure that clamp is engaged 360 degrees around porthole and if circumferential shim is used, to ensure that shim is in place. Engage the notch at split in clamp over the anti-rotation lug on outlet duct porthole.

CAUTION: IF CLAMP HAS TWO NOTCHES, ENSURE THAT ONLY THE NOTCH AT SPLIT IN CLAMP IS USED.

(16) While holding ends of clamp as nearly together as possible, install tabwasher, three clamp bolts, and, if used, spacer between ends of clamp and run bolts down fingertight.

R NOTE: See Figure 415 for clamp bolt arrangement. Do not use superseded type.

(17) Tighten clamp screws to recommended torque. Do not bend tabwasher at this time.

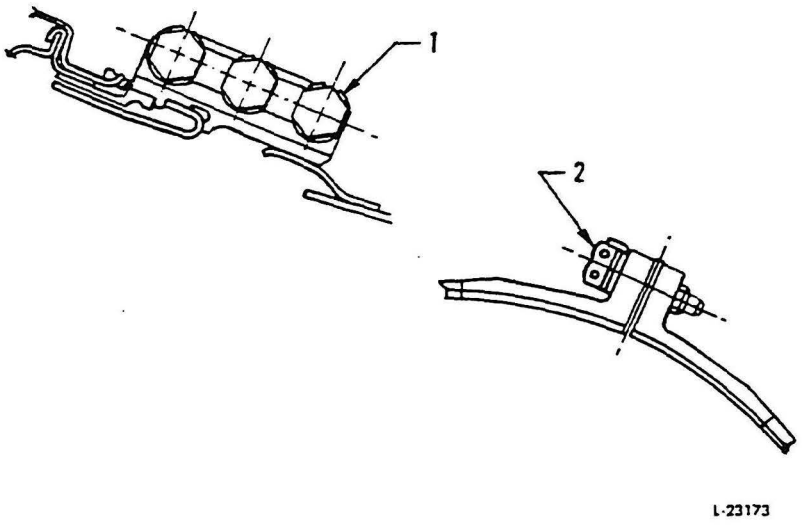
CAUTION: CHECK FOR PROPER ENGAGEMENT OF CLAMP ALL AROUND (360 DEGREES) ON FLANGE OF COMBUSTION CHAMBER OUTLET DUCT PORTHOLE AS CLAMP BOLTS ARE TIGHTENED.

(18) With combustion chambers seated against their respective fuel nozzle clusters, check to determine that some clearance exists between forward face of chamber locating lug and both diffuser case and forward end of slot in chamber
R positioning bracket. See Figure 416, No. 6.

NOTE: If check does not indicate some clearance, it is probable that some major repair problem exists in manifold or diffuser case manifold mounting lugs, or chamber locating lug, which must be defined and necessary parts replaced before proceeding with engine assembly.

R

ENGINE - DISMANTLING/ASSEMBLY



1. Single Hexhead Bolt Keywasher
2. Single Hexhead Bolt

Combustion Chamber Clamp Bolting Arrangement
Figure 415

(19) With each combustion chamber seated against its fuel nozzle cluster, measure relationship between rear (hardfaced) face of chamber lug and rear face of diffuser case flange. See Figure 416. Check Table XIV to determine that actual measurement is within limits specified for outer front case scallop depth, as marked on OD of front outer case near scallop. If all parts involved (manifold, manifold mount lugs in diffuser case chamber locating lug, outer front case scallop) individually meet limits defined in Section 72-00, Inspection/Check, then this measurement should fall between Column II and Column III of Table XIV.

(20) Further tighten clamp bolts part of a turn as necessary to make possible bending tabwasher against a flat on bolthead.
R Bend tabwashers and lockwire bolts.

(21) Remove lower fireseal section from engine.

(22) Install sparkigniters.

(23) Position PWA 16210 Collar around combustion chamber rear outer case at approximate center and secure with swing bolt and nut; then attach PWA 6580 Sling to spools of collar.

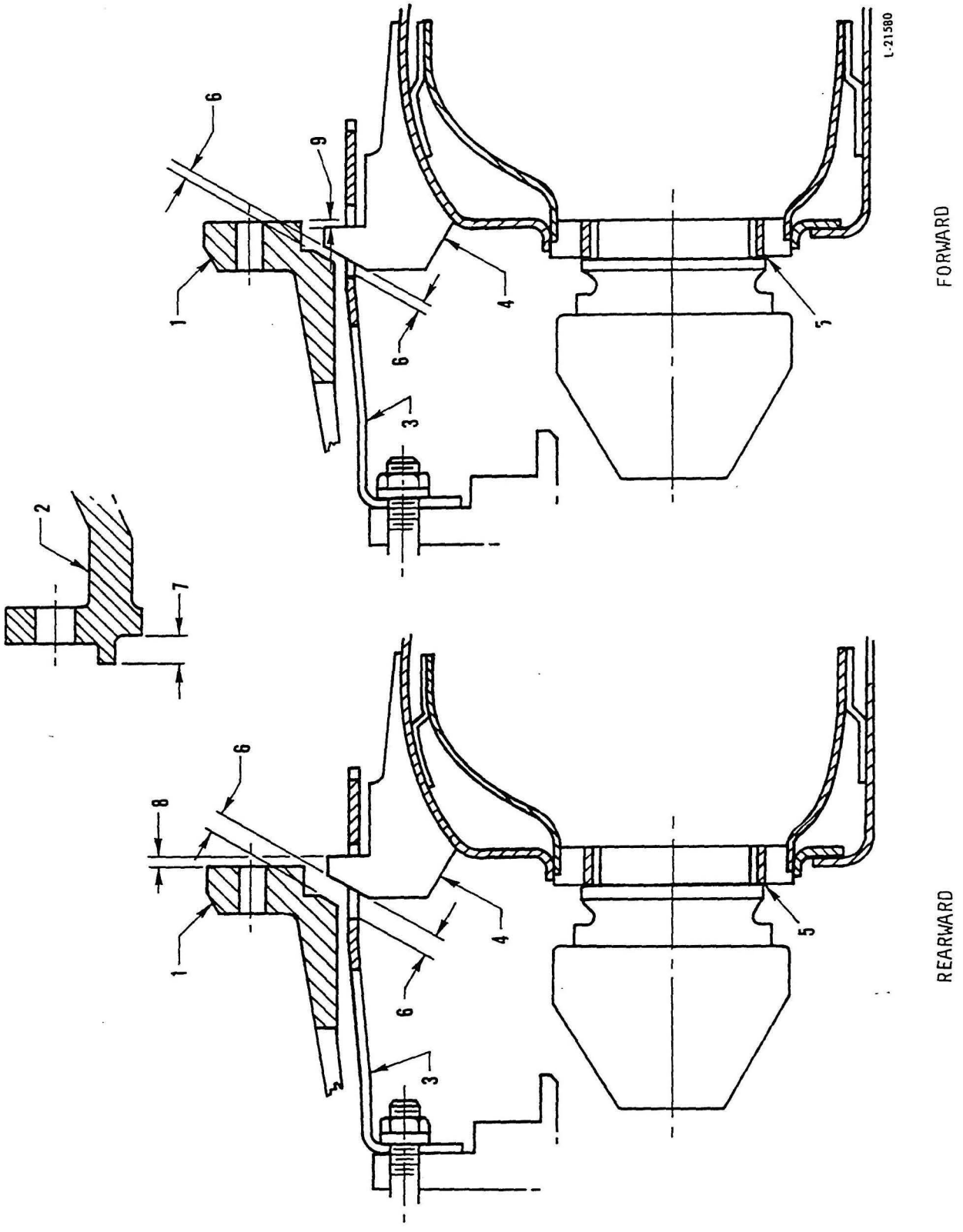
(24) Coat snap diameter on underside of rear flange and mating flange of turbine case with molybdenum disulfide anti-seize compound.

CAUTION: DO NOT BUMP CASE AGAINST COMBUSTION CHAMBER LINERS SINCE MISALIGNMENT WITH FUEL NOZZLES MAY OCCUR. BEFORE CLOSING GAP BETWEEN FLANGES VISUALLY CHECK EACH LINER FOR PROPER POSITIONING AND ALIGNMENT.

(25) Move combustion chamber case forward into position.

(26) Align bolt holes of combustion chamber rear outer case rear flange with gangbolts in turbine nozzle case front flange; then continue to move outer case forward, aligning offset hole, until front and rear flanges are joined.

(27) Reinstall three sections of fireseal and temporarily secure sections to mating front flanges with few bolts and lock-nuts (boltheads to rear).



Relation of Combustion Chamber Locating
Lug to Diffuser Case
Figure 416

ENGINE DISMANTLING/ASSEMBLY

1. Diffuser Case, Rear OD Flange

2. Combustion Chamber Outer Front Case, Front Flange

3. Combustion Chamber Positioning Bracket

4. Combustion Chamber Locating Lug

5. Zero Clearance Between Chamber Swirl Guide And Shoulder On Fuel Nozzle Body During This Check.

6. With Zero Clearance At No. 5, There Must Be Some Clearance Between Forward Angled Face Of Lug And Both Diffuser Case Flange And Positioning Bracket.

R 7. Depth Of Scallop In Front Flange Of Outer Front Case. Begin Reading Table XIV (Column I) At This Value.

R 8. Face Of Lug Rearward Of Diffuser Case Flange. Table XIV, Column III, Defines Maximum.

R 9. Face Of Lug Forward Of Diffuser Case Flange. Table XIV, Column II Defines Maximum.

Key to Figure 416

Combustion Chamber Outer Front Case - Scallop Depth	Acceptable Range - Chamber Lug Measurement Forward No. 9, Figure 416	Rearward No. 8, Figure 416
Column I	Column II	Column III
0.075	0.019	0.050
0.074	0.020	0.049
0.073	0.021	0.048
0.072	0.022	0.047
0.071	0.023	0.046
0.070	0.024	0.045
0.069	0.025	0.044
0.068	0.026	0.043
0.067	0.027	0.042
0.066	0.028	0.041
0.065	0.029	0.040
0.064	0.030	0.039
0.063	0.031	0.038
0.062	0.032	0.037
0.061	0.033	0.036
0.060	0.034	0.035
0.059	0.035	0.034
0.058	0.036	0.033
0.057	0.037	0.032
0.056	0.038	0.031
0.055	0.039	0.030

NOTE: Begin reading table at Column I (scallop depth). Read horizontally to find maximum forward and rearward measurements of lug face, relative to diffuser case flange.

R Table XIV

(28) Install rear of bolts and locknuts securing combustion chamber outer rear case front flange to shorter combustion chamber outer front case (bolthead to rear). Torque locknuts.

(29) Install two screws on each side securing fireseal section. Torque screws.

(30) Install brackets and clips, noted at disassembly, to front flange of turbine nozzle case (rear flange of combustion chamber outer rear case). Secure mating flanges, clips, and brackets with locknuts. Torque locknuts.

(31) Reinstall combustion chamber drain line, rear bearing pressure and scavenge oil lines, and exhaust temperature thermocouple lead.

(32) Using chain hoist and sling, loosen collar swing bolt and nut and remove collar.

(33) Connect sparkigniter leads and exhaust thermocouple lead. Replace all external parts to locations from which they were removed.

R 33. Starter Drive Oil Seal Replacement

R A. Removal of Seal and Housing Assembly

R (1) Remove starter, or drive pad cover from gearbox.

R (2) Remove drain plug and drain gearbox.

R (3) Remove snapring securing drive seal housing assembly in
R gearbox.

R (4) Using PWA-16157 Puller, insert puller jaws into seal
R housing and remove housing. Remove packing from seal
R housing outer groove.

R B. Seal Replacement

R (1) Place seal housing assembly into PWA-16161 Base, large ID
R down, so housing engages locating diameter provided on
R base. Using PWA-7143 Drift, press seal out of housing.

R ENGINE - DISMANTLING/ASSEMBLY

R (2) Place seal housing on bench, place seal onto housing and
R locate PWA-6676 Drift on face of seal. Drift oil seal into
R position.

R C. Installation of Seal Housing Assembly

R (1) Place a packing, lubricated with petrolatum, in starter
R drive oil seal housing outer groove.

R (2) Position seal housing assembly over starter drive coupling
R and drift to seat on shoulder of counter-bore in gearbox
R rear housing.

R (3) Install snapring securing oil seal housing assembly to
R gearbox rear housing.

R (4) Place a gasket on starter drive cover and secure gasket and
R cover to starter drive pad with washers and locknuts.
R Tighten locknuts to recommended torque.

R (5) Install drain plug with new seal into gearbox, tighten to
R recommended torque and lockwire.

R 34. Alternator Drive Oil Seal Replacement

R A. Removal of Seal and Housing Assembly

R (1) Remove locknuts and washers securing alternator drive pad
R cover to gearbox and remove cover and gasket.

R (2) Remove drain plug and drain gearbox.

R (3) Remove snapring securing drive oil seal housing assembly in
R gearbox.

R (4) Using PWA-16157 Puller, insert puller jaws into seal
R housing and remove housing. Remove packing from seal
R housing outer groove.

R B. Seal Replacement

R (1) Place seal housing assembly into PWA-16161 Base, large
R ID so housing engages locating diameter provided on base.
R Using PWA-7143 Drift, press seal out of housing.

R ENGINE - DISMANTLING/ASSEMBLY

R (2) Place alternator drive housing on bench, place seal onto
R housing and locate PWA-6676 Drift on face seal. Drift oil
R seal into position.

R C. Installation of Seal Housing Assembly

R (1) Place a packing in alternator drive oil seal housing outer
R groove.

R (2) Position seal housing assembly over alternator drive gear-
R shaft and to seat on shoulder of counter bore in gearbox
R front housing.

R (3) Install snapring securing oil seal housing to gearbox front
R housing.

R (4) Place a gasket on alternator drive cover and secure gasket
R and cover to pad with washers and locknuts. Tighten lock
R nuts to recommended torque.

R (5) Install drain plug with new seal into gearbox, tighten to
R recommended torque and lockwire.

R 35. Tachometer Drive Oil Seal Replacement

R A. Removal of Seal and Housing Assembly

R (1) Remove tachometer drive pad cover from gearbox.

R (2) Remove drain plug and drain gearbox.

R (3) Insert PWA-3790-50 Puller into tachometer drive gearshaft
R ID. Tightening knurled collar, secure puller lips to
R gearshaft ID. Using knocker action, remove tachometer
R drive housing from gearbox rear housing cavity and place on
R bench housing flange down.

R (4) Remove tachometer gearshaft bearing lockring from housing.

R (5) Using a drift, remove gearshaft and bearings from housing.

R (6) Remove retaining ring securing inner race of first bearing
R to gearshaft.

R ENGINE - DISMANTLING/ASSEMBLY

R (7) Using PWA-16338 Puller, locate jaws between two bearings with puller jaws contacting under face of first bearing and pilot of jackscrew in ID of gearshaft. Turn jackscrew and remove first bearing from gearshaft. Remove puller.

R (8) Remove sleeve spacer from gearshaft.

R (9) Position jaws of puller in cut-outs in shoulder of gearshaft to contact under side of inner race of second bearing. Turning jackscrew, with pilot in ID of gearshaft, remove bearing from gearshaft. Remove puller.

R NOTE: Provide container to store bearings until reassembly.

R (10) Place tachometer drive housing (flange face down) on bench. Using fiber drift, remove seal from housing.

R B. Installation of Gearshaft, Bearings and Oil Seal

R (1) Position tachometer drive gearshaft, gear end down, on an arbor press. Locate first bearing on end of gearshaft and, using PWA-16337 Drift, press bearing into position to seat on gearshaft shoulder. Remove drift. See Figure 417.

R (2) Install bearing spacer to seat on first bearing.

R (3) Install second bearing in same manner as first bearing. Remove drift and assembly from arbor press.

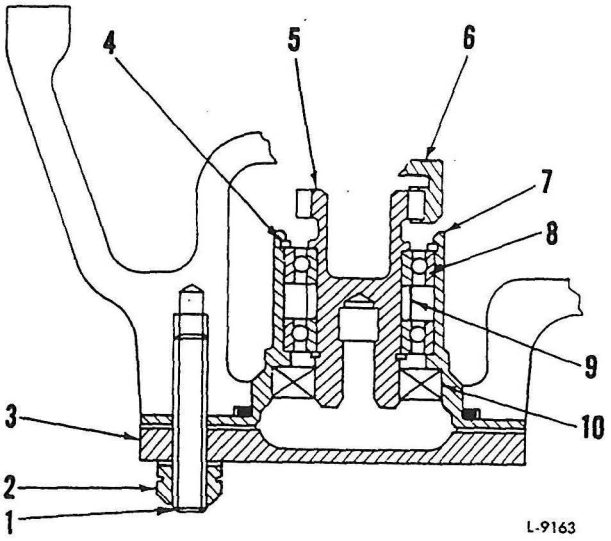
R (4) Secure bearings to gearshaft with retaining ring.

R (5) Position tachometer drive gearshaft housing (flange down) on a bench. Drive gearshaft and bearings into housing to seat on housing shoulder.

R (6) Install lockring in housing.

R (7) Position tachometer drive housing on PWA-30017 Base, then lubricate tachometer drive oil seal. Place PWA-14047 Guide into square hole in tachometer drive gearshaft; then place oil seal (element up) over guide and, using PWA-6841 or PWA-30016 Drift, seat seal on housing shoulder. See Figure 418. Remove drift and guide.

R ENGINE - DISMANTLING/ASSEMBLY



R 1. Stud

R 2. Locknut

R 3. Cover

R 4. Lockring

R 5. Tachometer Drive Gearshaft

R 6. Tachometer Drive Gear

R 7. Bearing Housing

R 8. Bearing (2)

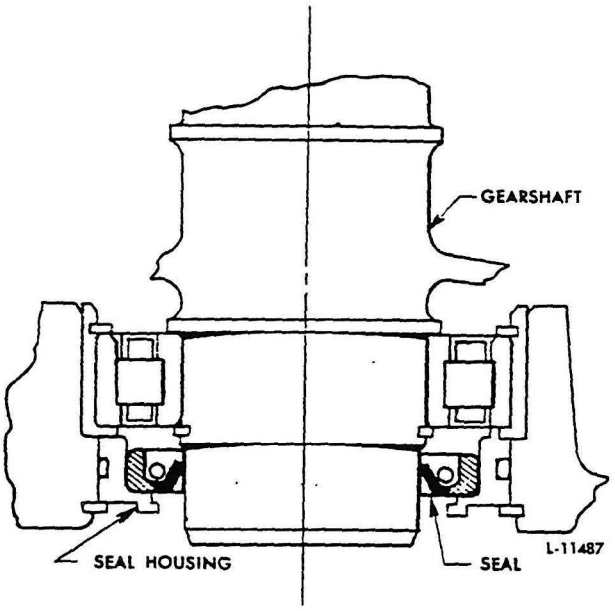
R 9. Spacer

R 10. Seal

R Tachometer Drive Gearshaft Assembly
R Figure 417

R

ENGINE - DISMANTLING/ASSEMBLY



R Typical Lip Type Oil Seal
R Figure 418

R ENGINE - DISMANTLING/ASSEMBLY

R (8) Place a packing in bottom side of tachometer drive gear-
R shaft housing; then insert housing assembly into four sided
R pad cavity in gearbox rear housing, meshing tachometer
R drive gearshaft with tachometer drive gear. See Figure 417.

R (9) Position a gasket on tachometer pad and install cover.
R Secure cover with washers and locknuts. Tighten locknuts
R to recommended torque.

R 36. Hydraulic Pump Drive Oil Seal Replacement

R A. Removal of Seal and Housing Assembly

R (1) Remove lock nuts and washers securing hydraulic pump drive
R cover to gearbox rear housing; remove cover and gasket.

R (2) Remove drain plug and drain gearbox.

R (3) Remove retaining ring securing hydraulic pump drive oil
R seal housing in gearbox.

R (4) Using PWA-16157 Puller, insert puller jaws into seal
R housing and remove housing. Remove packing from seal
R housing outer groove.

R (5) Using drift, remove oil seal from oil seal housing.

R B. Seal Replacement

R (1) Place PWA-16295 Base on bench; then position seal housing
R on base (large ID up).

R (2) Moisten new hydraulic pump drive lip type oil seal with
R engine oil and position it on PWA-16158 Drift with open
R face of seal up toward drift flange.

R (3) Install drift and seal into seal housing with pilot on
R drift engaging hole in base.

R (4) Using fiber mallet, seat seal in seal housing. Remove
R drift and housing from base.

R C. Installation of Seal and Seal Housing Assembly

R (1) Place PWA-16295 Base on a bench; then position hydraulic
R pump drive oil seal housing on base, large ID up.

(2) Lubricate hydraulic pump drive oil seal with petrolatum and position it on PWA 16158 Drift with open face of seal up towards drift flange.

(3) Install drift and seal into seal housing with pilot on drift engaging hole in base.

(4) Using fiber mallet, seat seal in seal housing. Remove drift and housing from base.

(5) Place packing in hydraulic pump drive oil seal housing outer groove.

(6) Position PWA 3095 Guide into splined ID of hydraulic pump drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into gearbox cavity and over guide to contact ID of oil seal. Drift housing assembly to seat on liner shoulder. Remove guide from gearshaft.

(7) Install snapring securing oil seal housing assembly to gearbox rear housing.

(8) Place gasket on hydraulic pump drive cover and secure gasket and cover to hydraulic pump drive pad with washers and locknuts. Tighten locknuts to recommended torque.

NOTE: SB 4453 provides, as additional equipment, a positive lubricated hydraulic pump drive spline. If gearbox housing assembly incorporates this system by SB 4453 but will be used on an engine that does not incorporate a hydraulic pump assembly, hydraulic pump drive gearshaft opening in gearbox must be covered by a plug, packing screw, and keywasher prior to installing hydraulic pump drive cover. See Figure 418A. Screw will
R be torqued to 24 - 36 pound-inches.

37. Fuel Pump Drive Front Oil Seal Replacement

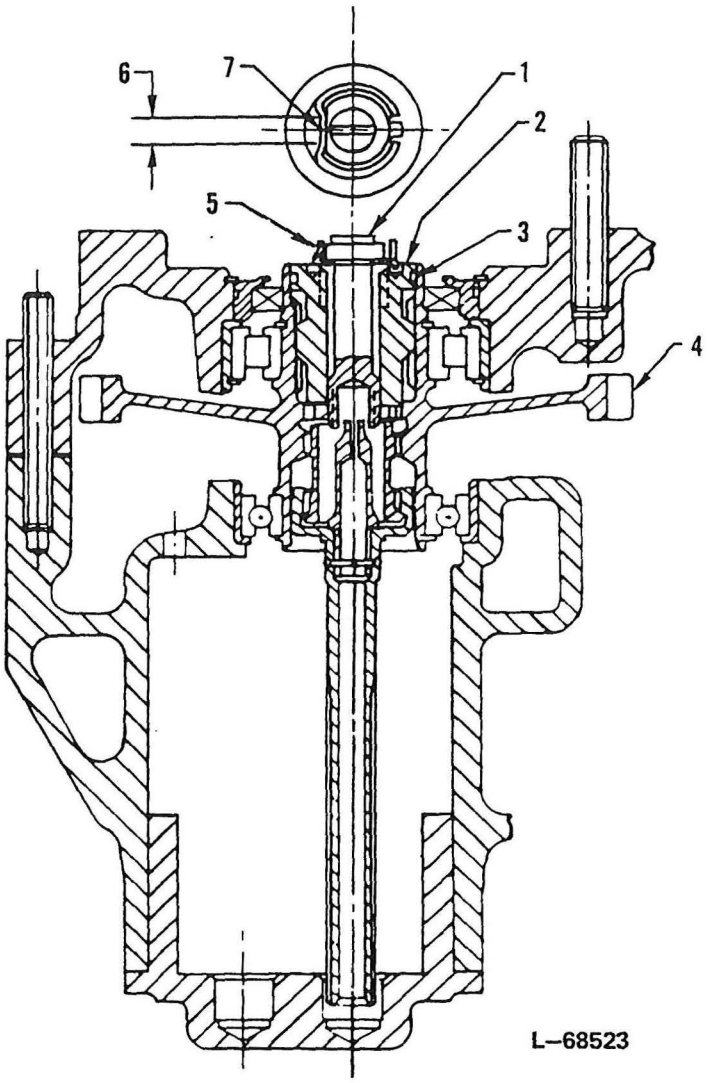
A. Removal of Seal and Seal Housing Assembly

(1) With fuel pump removed from gearbox, remove snapring securing oil seal housing assembly in gearbox.

(2) Using PWA 16157 Puller, insert puller jaws into seal housing and remove housing assembly.

(3) Place seal housing assembly on bench and remove snapring securing oil seal. Using drift remove oil seal.

ENGINE - DISMANTLING/ASSEMBLY



R 1. PN 765022 Screw. Torque To 24 - 36 lb-in.
R 2. PN 765020 Plug (0.750-10UNC-2B, SB 4453, Rev. 3)
3. MS9388-026 Packing
4. PN 766249 Gearshaft Assembly (Reference)
5. PN 765023 Key Washer
6. 0.200 Inch Minimum
R 7. Crimp Key Washer After Torquing Screw.

Installation Of Plug, Packing,
Screw, And Key Washer
Figure 418A

B. Seal Replacement

(1) Place PWA 16295 Base on bench; then position seal housing on base, large ID up.

(2) Moisten new fuel pump drive lip type oil seal with engine oil and position it on PWA 16158 Drift with open face of seal up toward drift flange.

(3) Install drift and seal into seal housing with pilot on drift engaging hole in base.

(4) Using fiber mallet, seat seal in seal housing. Remove drift and housing from base.

C. Installation

(1) Place packing in fuel pump drive oil seal housing outer groove.

(2) Position PWA 3095 Guide into splined ID of fuel pump drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into liner and over guide to contact ID of oil seal. Drift housing assembly to seat on gearshaft ball bearing outer race. Remove guide from gearshaft.

(3) Install snapring securing oil seal housing assembly to liner.

(4) Install suitable protective cover over fuel pump opening of gear box.

38. Fuel Pump Drive Rear Oil Seal Replacement

A. Removal

(1) Remove locknuts and washers securing de-oiler pad cover. For Douglas engines, remove oil breather elbow.

(2) Using PWA 16157 Puller, engage puller lugs with puller groove in oil seal housing. Turn puller jackscrew to drive pilot into fuel pump drive gearshaft ID and jack oil seal housing assembly from accessory drive rear housing.

(3) Remove packing and drift oil seal from housing.

ENGINE - DISMANTLING/ASSEMBLY

B. Seal Replacement

(1) Heat fuel pump drive rear oil seal housing in a hot oil bath. Position oil seal on pilot of PWA 16367 Drift with feather edge of seal facing drift. Place housing in an arbor press. Using press and drift, install and seat oil seal. Remove drift.

NOTE: For gearboxes incorporating fuel pump drive splined lubrication, use PWA 17078 Drift and PWA 10631 Base. After removing oil seal housing from hot oil bath, position it on PWA 10631 Base. Position oil seal on PWA 17078 Drift (feather edge of seal facing drift) and with aid of an arbor press, install and seat oil seal in housing.

C. Installation of Oil Seal Housing Assembly

(1) Install applicable Guide (PWA 16366 or PWA 16930 Guide) in end of fuel pump drive spur gearshaft.

(2) Install packing in recess on OD of oil seal housing.

(3) Slip ID of oil seal over OD of guide and onto OD of gearshaft. Remove guide.

(4) Use PWA 16768 Drift to seat housing and seal.

39. Fuel Control Drive Oil Seal Replacement

A. Removal

(1) With fuel control removed from gearbox, remove snapring securing oil seal housing assembly in gearbox.

(2) Using PWA 16157 Puller, insert puller jaws into seal housing and remove housing.

(3) Remove packing from seal housing outer groove.

(4) Using drift, remove oil seal from oil seal housing.

B. Seal Replacement

(1) Place fuel control drive oil seal housing (puller groove down) on a bench.

(2) Lubricate fuel control drive oil seal and position it on PWA 16162 Drift with open face of seal up towards drift flange. Place drift and seal on housing and press in until seal bottoms on shoulder in housing. Remove drift.

C. Installation of Oil Seal Housing

(1) Place a packing in fuel control drive oil seal housing outer groove.

(2) Position PWA 13030 Guide into splined ID of fuel control drive gearshaft to seat on shoulder of guide. Position oil seal housing assembly into liner and over guide to contact ID of oil seal. Drift housing assembly to seat on gearshaft ball bearing outer race. Remove guide from gearshaft.

(3) Install snapring securing oil seal housing assembly to liner.

(4) Install suitable protective cover over fuel control opening of gearbox.

40. Water Injection Pump Drive (Boeing)/Fuel Boost Pumps (Douglas) Oil Seal Replacement

A. Removal

(1) Remove locknuts and washers securing water injection pump drive cover from left end drive pad and remove cover.

(2) Remove retaining ring securing oil seal housing.

(3) Remove seal housing assembly using PWA 16463 Puller. Engage jaws of puller in groove in oil seal housing. Turn jackscrew of tool in so that pilot on end of jackscrew contacts end of water injection pump drive bevel gear. Continue to turn jackscrew in to jack oil seal housing out of bearing support.

(4) Place seal housing assembly on top of PWA 16454 Base with oil seal facing down.

(5) Position shoulder of PWA 16453 Drift against rear face of oil seal. Using an arbor press, push oil seal out of oil seal housing assembly.

B. Seal Replacement

(1) Position oil seal on pilot of PWA 16455 Drift.

(2) Install oil seal in seal housing by using an arbor press on the drift.

C. Installation of Seal Housing

(1) Install pilot of PWA 16460 Guide in splined end of water injection pump drive bevel gearshaft.

(2) Install a new lubricated packing on seal housing.

(3) Push seal and housing over guide until seal bottoms in bearing support.

(4) Secure housing with retaining ring.

(5) Position a gasket on drive pad and install cover, making certain that largest hole in cover lines up with shouldered stud on drive pad. Secure cover with washers and locknuts. Tighten locknuts to recommended torque.

41. Removal/Installation of Tachometer Drive Cover, Oil Seal Housing and Oil Seal (N1)

A. Removal

(1) Remove nuts and washers securing tachometer drive cover to four cornered pad on front accessory drive front support; then remove cover and gasket.

(2) Prior to removing oil seal housing, inspect housing area for oil leakage.

(3) Install PWA 7146 Puller jaws in oil seal housing puller groove; then using knocker action, remove tachometer drive oil seal housing and oil seal from front accessory drive front support.

(4) Remove oil seal ring from housing OD.

(5) Inspect carbon seal while it is still in housing. Remove seal from housing only if seal is to be replaced.

(6) Position tachometer drive oil seal housing (front face down) on bench.

(7) Using fiber drift, remove oil seal from housing.

B. Installation

(1) Coat O-ring seal with engine oil and install seal in OD groove of tachometer drive shaftgear seal housing.

(2) Position seal housing on front accessory drive front support tachometer pad, aligning housing flange holes with studs. Using drift, seat housing to bottom of pad.

(3) Position tachometer drive housing on PWA 30017 Base. Install PWA 14047 Guide in square drive of tachometer drive gearshaft; then moisten ID of lip type oil seal with engine oil and position seal on guide (spring toward ball bearings).

(4) Using PWA 6841 Drift or PWA 30016 Drift, seat oil seal on inside shoulder of oil seal housing. Remove drift and guide.

(5) Place gaskets on tachometer and governor pads; then position covers over studs and install washers and locknuts. Torque locknuts.

42. Removal/Installation of Inlet Cone Support Assembly

A. Removal

(1) Unfasten and remove bolts securing front accessory drive support assembly to No. 1 bearing front support.

(2) Using PWA 17412 Puller mounted on tachometer drive studs, remove front accessory drive support assembly from No. 1 bearing front support.

B. Installation

R NOTE: For Douglas installation, SB 4882 reworks/replaces
R inlet cone support to provide a support with studs and
R bolts of higher thermal expansion material. New studs
R must be used as a complete set in new or reworked sup-
R port. New bolts must be used as a complete set with
R supports incorporating new studs to obtain full benefit
R of SB 4882.

(1) Install a new lubricated packing in groove on OD of inlet cone support rear flange.

(2) Position inlet cone support assembly with its pin aligned with hole on front of inlet case against outer diameter of No. 1 bearing front support.

(3) Install washers, with depressions to fit grooves in support brackets in positions noted at disassembly, and bolts. Tighten bolts to recommended torque and bend tabs of tabwashers up to secure bolts.

R NOTE: For Douglas installation, SB 5083 introduces bolt, PN 777363. This bolt is directly interchangeable with bolt, PN AN103818, and it also can be used to replace bolt, PN 755873, if there is a worn lock groove at hole location. However, when replacing bolt, PN 755873, two or more adjacent bolts must be installed to facilitate lockwiring together with wire, PN 586822. Tab on key washer used with bolt, PN 777363, need not be turned up against bolt head.

R (4) Install cap on compressor inlet vane air transfer tube located at 10 o'clock position (viewed from front).

43. Removal/Installation of No. 1 Bearing and Front Accessory Drives Main Gear

A. Removal

(1) Install front compressor locating supports (PWA 16935 Supports) on fan discharge case at approximately 5 and 7 o'clock positions. Adjust screw jack to engage second stage compressor disk between blades and support compressor rotor.

(2) Unfasten two oil nozzle bolts and remove No. 1 bearing oil nozzle assembly.

(3) Remove two bolts securing No. 1 bearing oil strainer support to No. 1 bearing housing. Remove strainer support and No. 1 bearing oil strainer housing.

(4) Remove "L" shaped oil suction tube from eight o'clock position of bearing front support.

(5) Remove No. 1 bearing inner race retaining nut rivet.

ENGINE - DISMANTLING/ASSEMBLY

(6) Position PWA 16031 Wrench on No. 1 bearing inner race retaining nut. Install PWA 16249 Holder on studs of inlet cone support, engaging front accessory drives main gear to prevent rotation of rotor.

(7) Loosen No. 1 bearing inner race retaining nut with PWA 16031 Wrench. Remove rotor holder and wrench.

(8) If front accessory drivegear is of type secured by snapring, compress snapring clear of bearing inner race retaining nut lip and pull drivegear from hub. Use PWA 16050 Puller to remove drivegear, if necessary.

(9) Remove inner race retaining nut.

R (10) If front accessory drivegear is of type held in place by lip of No. 1 bearing retaining nut, not by snapring as in step (8), pull drivegear from hub using PWA 16050 Puller.

R (11) Remove rivet, then remove No. 1 bearing outer race retaining nut (lefthand thread) with PWA 16040 Wrench by engaging slots of retaining nut.

R (12) Remove bolts which secure No. 1 bearing housing to front and rear support.

R (13) Using PWA 16043 Puller, remove No. 1 bearing housing (with bearing outer race and rollers).

R (14) Install bearing housing front face down in PWA 30343 Base and drift out outer race and rollers, using PWA 30344 Drift.

CAUTION: DETAIL PARTS OF BEARING MUST BE KEPT IN THEIR ORIGINAL ASSEMBLIES. PROTECT BEARING BY STORING IN A SUITABLE CONTAINER.

R (15) Place lips of PWA 8193 Puller in puller groove of No. 1 bearing seal plate and, by turning jackscrews, remove seal plate together with No. 1 bearing inner race.

R (16) Reinstall No. 1 bearing housing on No. 1 bearing support.

R (17) Install PWA 16039 Spacer (dummy bearing) on front hub (and into housing).

R (18) Secure spacer and housing by installing inner race retaining nut handtight using PWA 16031 Wrench.

R (19) Remove two supports from fan discharge case.

B. Installation

(1) Install front compressor rotor PWA 16935 Locating Supports on fan discharge case at approximately 5 and 7 o'clock positions. Adjust screw jack to engage second stage compressor disk between blades to support compressor rotor.

(2) Using PWA 16040 Wrench, remove No. 1 bearing outer race retaining nut and, using PWA 3687 Puller, remove PWA-16039 Spacer (dummy bearing) from the No. 1 bearing housing and front compressor front hub.

R ENGINE - DISMANTLING/ASSEMBLY

R (3) Remove bolts securing No. 1 bearing housing to front
R support and remove bearing housing, indexing housing and
R support for later reassembly in same location. Temporar-
R ily secure front and rear supports with short bolts.

R (4) Heat bearing housing in hot oil and position housing front
R face up in PWA-30429 Base.

R (5) Install bearing outer race and rollers in housing as
R follows:

R (a) Assemble inner and outer race and rollers of bearing
R assembly, mating serial numbers on both inner and outer
R races on same side of assembly.

R (b) Install bearing assembly in PWA-30430 Drift with serial
R numbers on inner and outer races facing away from pilot
R detail of drift.

R (c) Position drift and bearing assembly in heated housing and
R drift bearing into housing. Allow temperature of parts
R to equalize and then remove drift and inner race.

R (6) Install outer race retaining nut using PWA-16040 Wrench,
R torque nut as follows:

R (a) Tighten nut to 2000 lb. in.

R (b) Mark location of nut with reference to mating part.

R (c) Turn nut through angle of 9° minimum to 12° maximum.

R (d) Loosen nut to 0 lb. in. and repeat step (a).

R (e) If mark on nut is in line with or beyond mating part
R reference mark within 0.050 inch maximum, apply final
R angle of turn per step (c).

R (f) If marks are not within limits, repeat steps (b), (c)
R and (d) in order, until marks are within limits. Then
R perform step (e).

(7) Install rivet in outer race retaining nut by inserting it from OD of bearing housing front flange. Flare rivet using
R PWA 31743 Riveter.

NOTE: For engines incorporating No. 1 bearing anti-rotational key, key should not be reinstalled to prevent possible damage from misassembly. Slotted bearing, seal and seal seat may be used without key.

(8) Install No. 1 bearing spacer (knife-edge seals to rear) on front compressor front hub.

NOTE: To ensure continuous seating contact of carbon seal plates and seal spacers, perform following blue check. This check must be done for each bearing seal and spacer build-up in engine except for No. 3 bearing seal. This check must precede final build-up of each bearing seal assembly.

(a) Apply bluing material to seating surfaces of carbon seal plates and seal spacers build-up.

NOTE: Inside diameters of seal plates and seal spacers do not have to be checked.

(b) Assemble seal plates and seal spacers on hubs and/or shafts, depending on which bearing is being installed.

(c) Wring build-up of seal plates and seal spacers together.

(d) Disassemble build-up and check seating surfaces for continuous contact.

(e) If necessary to obtain a continuous contact, lap seating surfaces to finish of 16 RMS or smoother; then recheck contact surfaces using bluing material.

(9) Coat No. 1 bearing seal plate with engine oil and install it (puller groove forward) on compressor front hub against No. 1 bearing spacer.

(10) Install PWA 16044 Compressor against front face of No. 1 bearing seal plate. Compress seal rearward by securing compressor in place with four screws in four of bearing housing holes.

NOTE: Before installing No. 1 bearing inner race, spray on a light coat of dfg-123 anti-galling lubricant on hub journal to eliminate scoring of hub at disassembly. Area to be lubricated must be clean and free of oil.

(11) Heat No. 1 bearing inner race in hot oil and, using PWA 7337 Drift, install No. 1 bearing inner race, serial numbers to front, on hub against seal plate.

(12) Lubricate a new preformed packing and install it in groove on outer diameter of front accessory drives main gear. Install gear in front hub, aligning rivet hole in gear with rivet hole in hub.

(13) Install No. 1 bearing inner race retaining nut on front compressor front hub. Tighten it up against bearing hand-tight, using PWA 16031 Wrench.

NOTE: If necessary, use following procedure to hold rotor. Position PWA 16031 Wrench for No. 1 bearing inner race retaining nut; then install PWA 16249 Holder on studs of inlet cone support, engaging front accessory drives main gear to prevent rotor movement (snapring-retained drivegear must be installed as directed below.) Wrench must be positioned before holder. Proceed as in step (13), then remove holder and wrench.

(14) Remove PWA 16044 Compressor.

(15) If front accessory drivegear is snapring retained type, install it temporarily in hub ID to provide counterforce for torque wrench. Snapring may be temporarily removed from drivegear for convenience.

R (16) Attach PWA 16041 Wrench to PWA 18872 Wrench using PWA 20333
R Adapter and PWA 20334 Plate (PWA 18872, with adapter and
R plate, supersedes PWA 8050). Position assembled wrenches so that PWA 16041 Wrench engages inner race retaining nut and front accessory drives main gear. Attach PWA 3755
R Hydraulic Pump to ram of PWA 18872 Hydraulic Wrench and tighten inner race retaining nut using following procedure:

(a) Tighten nut to 2000 lb-in.; turn through angle of 10° minimum to 15° maximum and then loosen to 0 lb-in.

(b) Tighten nut to 2000 lb-in.

(c) Mark location of nut with reference to mating part.

(d) Turn nut through angle of 10° minimum to 15° maximum.

(e) Loosen nut to 0 lb-in. and repeat step (b).

(f) If mark on nut is in line with or beyond mating part reference mark within 0.050 inch maximum, apply final angle of turn per step (d).

(g) If marks are not within limits, repeat steps (c), (d), and (e) in order, until marks are within limits. Then perform step (f).

NOTE: If front accessory drivegear is of type retained by bearing inner race retaining nut lip (see step (17), below) check clearance between front accessory drives main gear and No. 1 bearing inner race retaining nut with a 0.001 inch feeler gage. There must be no contact between gear and nut. If there is contact, disassemble and inspect parts.

(17) Secure inner race retaining nut with one of following procedures:

(a) Front accessory drivegear held by retaining nut lip; install rivet in nut from hub ID side through holes in
R drivegear and hub. Flare rivet with PWA 31743 Riveter.

(b) Front accessory drivegear held by snapring. Compress snapring (if used during torquing procedure) and remove drivegear from hub. Install rivet from hub ID side,
R through hole in hub. Flare rivet with PWA 31743 Riveter. Reinstall drivegear, lining up any hole in drivegear rim with rivet location in hub, and engage snapring behind retaining nut lip.

ENGINE - DISMANTLING/ASSEMBLY

R (18) Remove temporary bolts securing front and rear supports and install bearing housing and bearing outer race and rollers in front support, aligning indexing marks and bolt holes. Install bolts. Tighten bolts to recommended torque and lockwire.

R (19) Position two lubricated packings (larger one first) on longer section of "L" shaped oil suction tube. Install tube in opening at approximate eight o'clock position in No. 1 bearing front support. Position one lubricated packing on forward groove of oil suction tube.

R (20) Make certain steel pin securing No. 1 bearing oil strainer assembly in oil strainer body is in place. Position a new packing on oil strainer body and install body and strainer assembly into No. 1 bearing oil transfer tube of front support.

R (21) Secure body to No. 1 bearing housing with two bolts. Tighten bolts to recommended torque and lockwire.

R (22) Place a new packing over short tube between two boltholes of oil strainer body and install No. 1 bearing oil nozzle assembly on oil strainer body, long tube through hole in bearing housing. Install and tighten two bolts to recommended torque and lockwire.

NOTE: Prior to installation oil flow check nozzles per following procedure and Figure 419.

(a) Lower two tubes and raise oil inlet adapter of PWA 16012 Fixture.

(b) Install new packing on oil strainer body. Position body to fixture and secure with bolts.

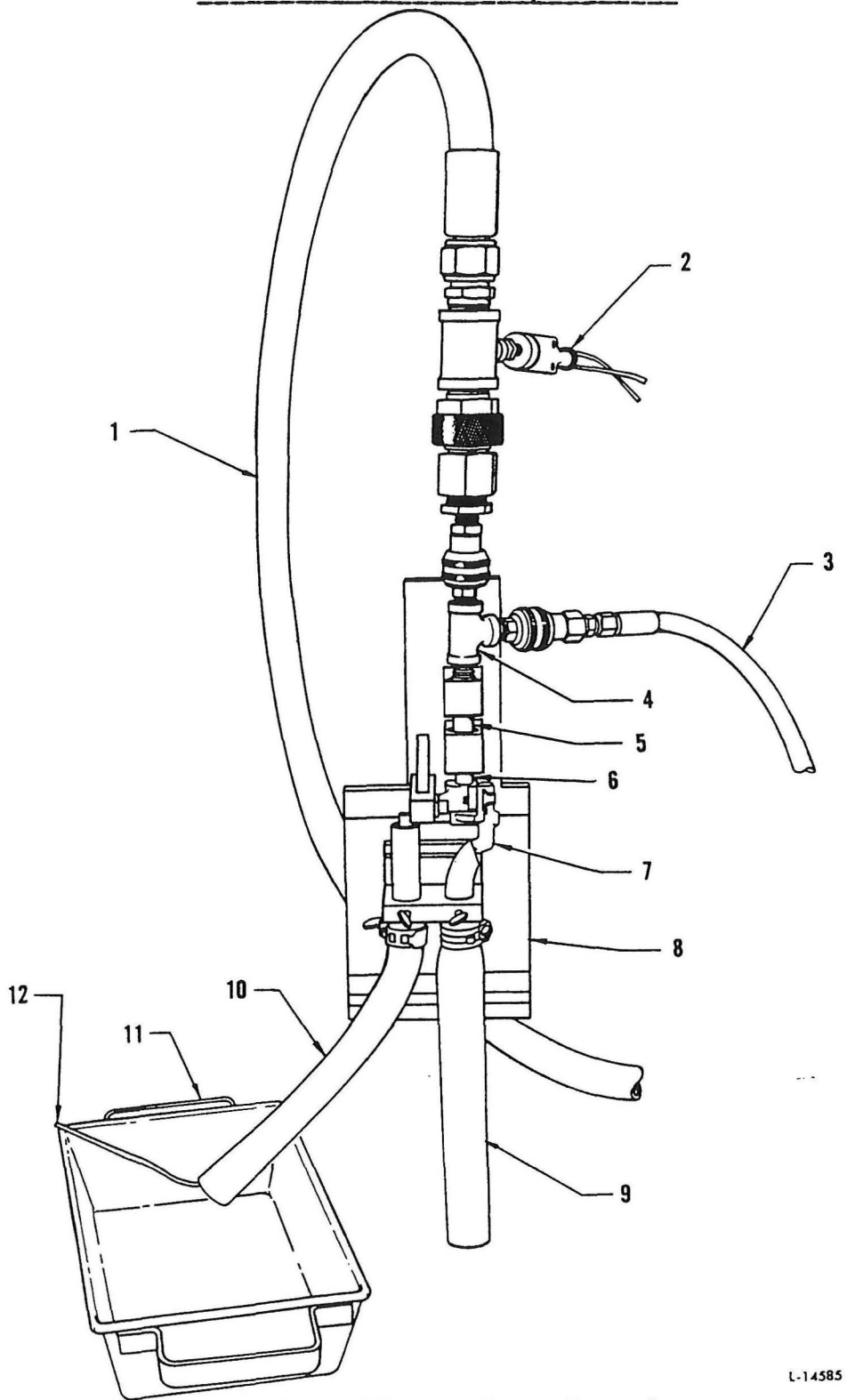
(c) Position No. 1 bearing oil nozzle assembly (jets pointing down) to body, installing new packing between parts, and secure with bolts.

(d) Position two oil tubes of fixture to nozzle jets and secure tubes.

(e) Install packing on each end of strainer element assembly and install strainer into boss of fixture to seat against installed body.

R

ENGINE - DISMANTLING/ASSEMBLY



R No. 1 Bearing Oil Nozzle and Seal Jet
R Oil Flow Check
R Figure 419

1. Oil in Hose
2. Oil in Temperature Thermocouple (Typical)
3. Oil Pressure Gage Connection
4. Oil Inlet Adapter
5. Strainer Element
6. Oil Strainer Body
7. Nozzle Assembly
8. PWA 16012 Fixture
9. No. 1 Bearing Jet Oil Flow
10. No. 1 Bearing Seal Jet Oil Flow
11. Oil Flow Container (Typical)
12. Oil Out Temperature Thermocouple (Typical)

Key to Figure 419

(f) Secure oil inlet adapter of fixture over strainer element assembly on transfer tube.

(g) Attach oil supply line from suitable test stand to inlet adapter of fixture. Regulate oil pressure at 40 psig ± 1 psi.

(h) Weigh oil flow from No. 1 bearing jet. Oil flow must be 2.5 to 3.0 lb/min.

(j) Weigh oil flow from No. 1 bearing seal jet. Oil flow must be 2.5 to 3.0 lb/min.

(k) Remove engine parts from fixture.

R (23) Remove supports from fan discharge case.

NOTE: Paragraph 44 must be complied with following above procedure.

44. Front Accessory Drive Support Assembly and No. 1 Bearing Section Air Pressure Check

A. Procedure

(1) Place a new seal in groove on rear face of assembled front accessory drive support.

(2) Align pin in front accessory drive support with hole in No. 1 bearing support, then bring front accessory drive support into position, making sure that scavenge pump and tachometer drive gears mesh properly with main accessory drive gear.

(3) Secure front accessory drive support to bearing support with washers and bolts. Tighten bolts to recommended torque and lockwire.

(4) Install PWA 10489 Connector to front compressor front bearing oil pressure fitting on compressor inlet case weldment.

(5) Connect air supply to connector.

(6) Regulate air supply to ten psi and check total air flow through flowmeter. Measured air flow must be within seven to twelve PPH.

(7) Disconnect air supply line and remove connector from No. 1 bearing pressure fitting.

NOTE: If this section is disassembled after air flow check, this air check must be repeated after assembly.

45. Numerical Tool List

PWA 2536 Puller

PWA 3095 Guide

PWA 3687 Puller

PWA 3755 Pump

PWA 3790-50 Puller

PWA 6580 Sling

PWA 6676 Drift

PWA 6841 Drift

PWA 7143 Drift

PWA 7146 Puller

PWA 7153 Fixture

PWA 7337 Drift

R PWA 8050 Wrench (Superseded by PWA 18872)

PWA 8193 Puller

PWA 8663 Saddle

PWA 8664 Adapter

PWA 8665 Adapter

PWA 8740 Adapter

PWA 9156-51 Protector

PWA 9156-52 Protector

ENGINE - DISMANTLING/ASSEMBLY

Numerical Tool List (continued)

PWA 10381 Drift
PWA 10489 Connector
PWA 10631 Base
PWA 10859 Sling
PWA 10860 Stand
PWA 10903 Support
PWA 13030 Guide
PWA 14047 Guide
PWA 16012 Fixture
PWA 16031 Wrench
PWA 16039 Spacer
PWA 16040 Wrench
PWA 16041 Wrench
R PWA 16042 Riveter (Superseded by PWA 31743)
PWA 16043 Puller
PWA 16044 Compressor
PWA 16050 Puller
PWA 16157 Puller
PWA 16158 Drift
PWA 16161 Base
PWA 16162 Drift
PWA 16177 Support
PWA 16210 Collar
PWA 16220 Adapter
PWA 16249 Holder
PWA 16295 Base
PWA 16337 Drift
PWA 16338 Puller
PWA 16358 Drift
PWA 16359 Puller
PWA 16366 Guide
PWA 16367 Drift
PWA 16375 Mount
PWA 16453 Drift
PWA 16454 Base
PWA 16455 Drift
PWA 16460 Guide
PWA 16463 Puller
PWA 16514 Stand
PWA 16566 Bracket
PWA 16567 Bracket
PWA 16768 Drift
PWA 16930 Guide
PWA 16935 Support
PWA 17078 Drift

ENGINE - DISMANTLING/ASSEMBLY

Numerical Tool List (continued)

PWA 17412 Puller

PWA 18872 Wrench
(Supersedes PWA 8050)

PWA 20333 Adapter

PWA 20334 Plate

PWA 30016 Drift

PWA 30017 Base

PWA 30343 Base

PWA 30344 Drift

PWA 30429 Base

PWA 30430 Drift

PWA 30643 Puller

PWA 31469 Riveter
R (Replaced by PWA 31743)

R PWA 31743 Riveter
R (Supersedes PWA 16042
R Replaces PWA 31469)

ENGINE - ADJUSTMENT/TEST

1. Engine Test

A. General

(1) This section contains procedures and limits for ground testing installed engines after repair. When trimming engine or making thrust check in conjunction with these tests, applicable airframe manufacturers curves, corrected for installation losses, must be used.

B. Engine Ground Safety Precautions

(1) General

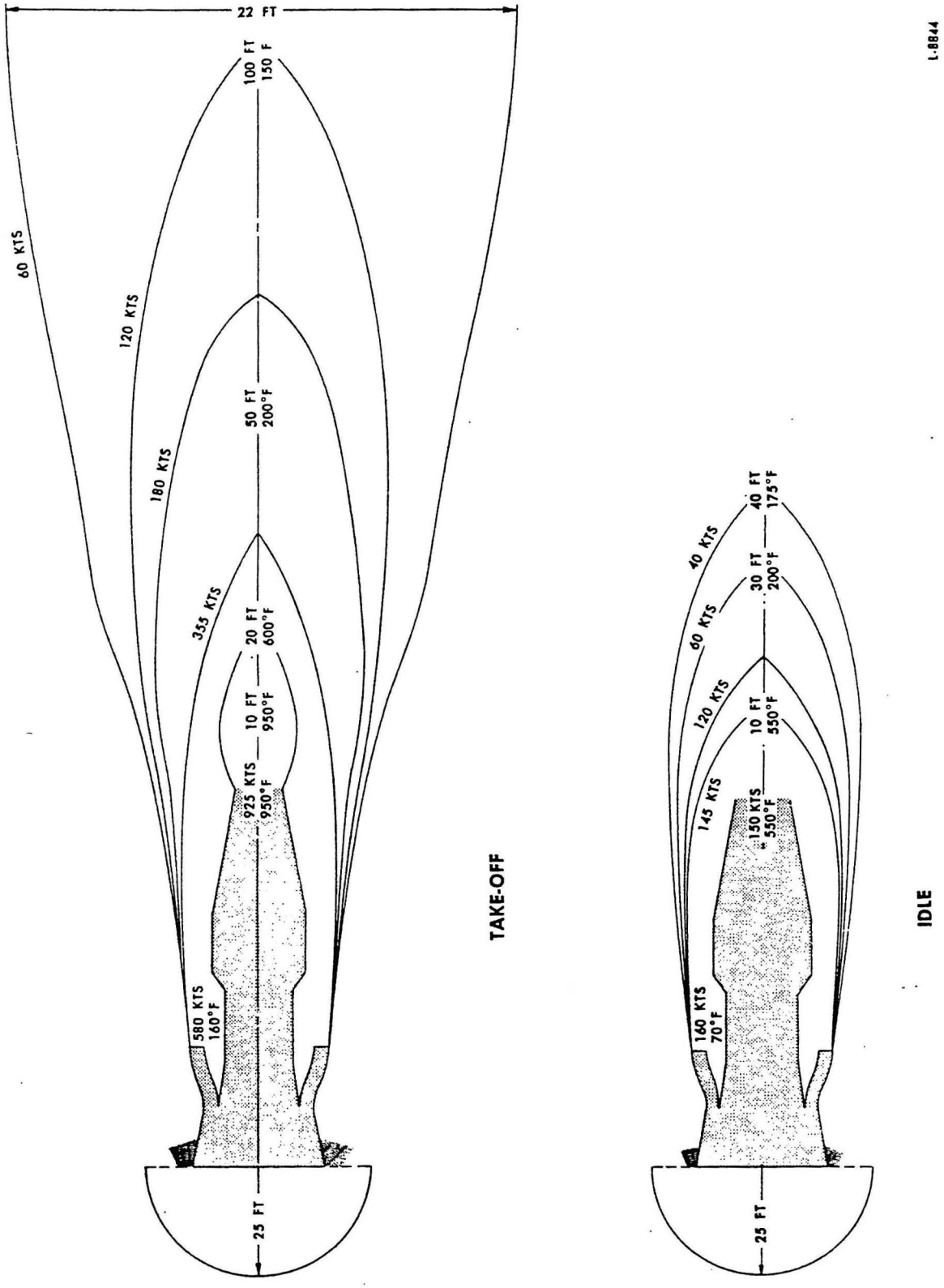
(a) Operating characteristics of jet engine powered aircraft have changed ground safety picture. To prevent injury to persons and damage to property, handling and working procedures must be modified to meet new exposures. On piston engine aircraft, propeller was carefully avoided. In case of jet engine powered aircraft, not only must one avoid engine intake ducts, but also exhaust nozzle where hot, high velocity exhaust gases are discharged. These gases are discharged forward, rather than rearward, when reverse thrust mechanism is actuated. For turbofan engines, fan discharge area must also be avoided as velocity of discharged air, particularly at high thrust settings, is sufficiently high to cause serious injury.

(b) Listed below are some of the general safety items which shall be supplemented according to needs of job, to prevent accidents.

(2) Air Intake

See Figure 501.

WARNING: ENGINE IS CAPABLE OF DEVELOPING ENOUGH SUCTION AT INLET DUCT TO PULL A MAN UP TO IT OR PARTIALLY INTO IT WITH POSSIBLE FATAL RESULTS. IT FOLLOWS THAT WHEN APPROACHING ANY TYPE OF JET ENGINE, PRECAUTIONS MUST BE TAKEN TO KEEP CLEAR OF INTAKE AIR STREAM. SUCTION NEAR INTAKE CAN ALSO PULL IN HATS, GLASSES, LOOSE CLOTHING AND WIPE-RAGS FROM POCKETS. ANY LOOSE ARTICLES MUST BE MADE SECURE OR REMOVED BEFORE WORKING AROUND ENGINE.



Turbofan Engine Hazard Areas
Figure 501

(3) Exhaust Characteristics

See Figure 501.

(a) Velocity. At high engine speeds, engine and fan exhaust may pick up and blow loose dirt, sizeable rocks, sand, and debris distance of several hundred feet. Therefore, due caution must be used in parking aircraft for runup to avoid injury to persons or damage to property or other aircraft. Blast fence is suggested if engines are going to be run up for trim and power adjustment in an area where there is not sufficient space available for dissipation of exhaust blast. During reverser operation the fan exhaust air and engine exhaust gases are discharged in a forward direction. The velocity of this discharge is sufficient to take a person off his feet resulting in possible injury. R R R R R

WARNING: PRIOR TO GROUND OPERATION OF THE THRUST REVERSER, ENSURE THAT AREA FORWARD OF ENGINE IS CLEAR AND WILL REMAIN CLEAR OF PERSONNEL. R R R R

(b) Temperature. High temperature will be found up to several hundred feet from exhaust nozzle depending on wind conditions. Closer to the engine temperature is high enough to deteriorate bituminous pavement, therefore concrete aprons are suggested for run-up areas. Occasionally when jet engine is started, excess fuel that has accumulated in tailpipe ignites and long flames are blown out of exhaust nozzle. Possibility of this hazard must be watched and all flammable materials kept in clear.

(c) Toxicity. Tests have indicated that carbon monoxide content is low but other gases are present which have disagreeable odor and are irritating in effect. Exposure will usually cause watering or burning sensation of eyes. Less noticeable but important is respiratory irritation which may be caused. For both these reasons, exposure must be avoided, particularly in confined spaces or pockets where concentration may build up.

(4) Engine Cool Down. After engine operation, no work or inspection shall be done on tailpipe for one-half hour (preferable longer). All other parts may usually be worked on without danger.

ENGINE - ADJUSTMENT/TEST

(5) Compressor Bleed Valve

(a) When checking bleed valve operation or doing other work in, or adjacent to, compressor bleed valve while engine is running, care shall be taken to stand clear during bleed valve open operation.

WARNING: WHEN BLEED VALVE OPENS, HIGH PRESSURE AIR AT HIGH VELOCITY IS DUMPED OVERBOARD. EXPERIENCE HAS PROVEN THAT FORCE OF THIS AIR, PARTICULARLY WHEN VALVE FIRST OPENS DURING DECELERATION FROM HIGH RPM, IS SUFFICIENT TO TAKE A PERSON OFF HIS FEET RESULTING IN POSSIBLE INJURY.

(6) Engine Noise

(a) Jet engines produce noise capable of causing temporary, as well as permanent, loss of hearing. Even short exposures to extreme noise may result in damage to ears and all personnel must use some means of protection. Therefore, use of cup type ear protection is recommended. Noise can effect ear mechanism in such a way as to cause unsteadiness or inability to walk or stand without reeling. If engines are to be serviced from aero-stands or platforms, these shall be equipped with protective railings to prevent falls.

(7) Engine Ignition

WARNING: JT3D ENGINE IGNITION SYSTEM IS CHARACTERISTICALLY HIGH IN ENERGY. NATURE OF SYSTEM IS SUCH AS TO RENDER IT HAZARDOUS, POSSIBLY FATAL, SOURCE OF ELECTRICAL SHOCK UNLESS NECESSARY PRECAUTIONS ARE EXERCISED.

(8) Fuel and Lubricating Oils

(a) All fuels have desiccating effect which drys skin. Precautions shall be taken to avoid contact as much as possible.

ENGINE - ADJUSTMENT/TEST

C. General Testing Information

(1) Because thrust developed by engine is indicated by difference in pressure or pressure ratio (which is also proportional to engine thrust) between engine air inlet and discharge pressure at jet nozzle, turbine discharge pressure by itself shall not be used directly as accurate indication of engine output. Compressor inlet pressure must also be taken into consideration on curves used whenever turbine discharge pressure alone is instrumented on engine. Compressor inlet pressure will be true barometric pressure.

(2) When using turbine discharge pressure or engine pressure ratio to check or trim engine, turbine discharge pressure or pressure ratio overshoot or higher than normal reading may be noted when power lever is first advanced to PART THRUST stop on cold engine. This overshoot will be followed by gradual drop in turbine discharge pressure until stabilized point is reached and turbine discharge pressure will remain constant. This overshoot will be noted in turbine discharge pressure gage but not on tachometer, as speed is governed and does not tend to overshoot. This overshoot is normal condition on cold engine and shall not be construed in any manner as engine test or trimming, engine must be allowed to stabilize.

(3) Symbols have been designated for various stations within engine and external working pressures and temperatures. These variables are listed below:

Amb	- Ambient Temperature (T) or Pressure (P)
Tamb	- Compressor Ambient Temperature
N1	- Low Pressure Compressor Rpm
N2	- High Pressure Compressor Rpm
Tt7	- Turbine Discharge Total Temperature
Pt7	- Turbine Discharge Total Pressure
Pt7/Pamb	- Engine Pressure Ratio
T.B.	- True Barometer (Inches Hg Absolute)

(4) Accuracy of instrumentation used for test shall conform to following:

Ambient Temperature	±2°F
Ambient Pressure (Pamb)	±0.01 in. Hg.
Turbine Discharge Pressure (Pt7)	±0.10 in. Hg.
Turbine Discharge Temperature (Tt7)	±5°F
Fuel Flow (Wf)	±1%
High Compressor (N2) Speed	±0.1%
Low Compressor Discharge Pressure (Ps3)	±0.25%

(5) Extent of repair and replacement will vary with each engine. Therefore, degree of test necessary to demonstrate satisfactory repair will vary also. To minimize ground running and to conserve fuel, this section provides five ground test procedures which are related to extent of repair or replacement. Before attempting to test engine after repair, applicable sections of "Test Reference Table" must be consulted to determine test required for any given engine repair.

(6) Engine Check Table provides general operating condition limits and references to necessary test curves for testing installed engine. Ratings listed in Engine Check Table are described as follows:

(a) WET TAKE-OFF This is maximum thrust available for TAKE-OFF Rating is obtained by actuating water injection system and setting computed Pt7 or Pt7/Pamb ratio.

R CAUTION: WATER MAY BE USED DOWN TO TEMPERATURE OF 20°F (-6.7°C) IF PROVISION IS MADE TO HEAT WATER SUFFICIENTLY TO KEEP IT FROM FREEZING

(b) DRY TAKE-OFF. This is maximum thrust available without use of water injection. Rating is obtained by positioning power lever to obtain computed DRY TAKE-OFF Pt7 or Pt7/Pamb ratio for existing ambient conditions.

(c) MAXIMUM CONTINUOUS (MAXIMUM CLIMB) MAXIMUM CONTINUOUS AND MAXIMUM CLIMB thrust are same. This is the maximum thrust that may be used continuously. Rating is obtained by adjusting power lever to obtain Pt7 or Pt7/Pamb determined for ambient conditions.

(d) MAXIMUM CRUISE This is maximum thrust approved for cruising.

(e) IDLE. This is not engine rating but, rather, power lever position suitable for minimum thrust operation on ground or in flight. It is obtained by positioning power lever in IDLE detent.

(f) REVERSE Reverse thrust will be obtained at power lever positions below IDLE.

D. Repair Test Reference Table

	UNITS REPAIRED OR REPLACED	MINIMUM THRUST REQUIRED FOR GROUND CHECK RUN
	Oil System	
R	Tubing, Oil Tank (If Supplied), Oil Filter, Pressure and Scavenge Pumps, Accessory Gearbox Seals (When Neither Gearbox Nor Fuel System Were Removed), Temperature Regulating Valve	Test A 104°F (40°C) Minimum Oil Temperature Recommended
R	Pressure Regulating Valve	Test A Permissible to Adjust Oil Pressure to 39-41 PSIG at Idle. 104°F (40°C) Minimum Oil Temperature Recommended
	Accessory Gearbox	Test B

ENGINE - ADJUSTMENT/TEST

UNITS REPAIRED OR REPLACED	MINIMUM THRUST REQUIRED FOR GROUND CHECK RUN
Fuel System	
Low Pressure:	Test A
Pump and Heater Filters, Fuel Heater, Tubing (Low Pressure)	
High Pressure:	Test C
Fuel Control and Fuel Pressurizing and Dump Valve Filters, Fuel Pressurizing and Dump Valve, Tubing (High Pressure), Fuel Pump, Fuel Nozzles, Fuel Manifold, Fuel-Oil Cooler	
Fuel Control	Test D
Hot Section	
Combustion Chambers, Outlet Duct, Nozzle Guide Vanes	Test B
Electrically Actuated Valves	
Anti-Icing Valve, Fuel De-Icing Valve	Visual
Bleed Control System	
Control and Valve, Tubing	Test E
Ignition	
Spark Igniters, Exciter Units, Leads	Aural Check or Perform Start
Instrumentation	
PT7 Probes and Tubing	Leak Check System With Shop Air
EGT Probes and Harness	Check With Portable Temperature Calibration Equipment

ENGINE - ADJUSTMENT/TEST

E. Engine Operating Conditions and Limits

(1) Engine Check Table

GROUND OPERATING LIMITS					
OPERATING CONDITION	TIME LIMIT (Minutes)	Maximum Observed EGT °F (°C) JT3D-7	JT3D-7A	Max. EGT Spread	Oil Press. Range PSIG (6) Normal (7)	Oil Temp. Range °F (°C) (9)
Wet Take-Off (1)	2 1/2	1067 (575)	-	-	40 - 60	104-195 (40-90)
R Dry Take-Off	5 (2)	1067 (575)	1049 (565)	200°F (111.1°C)	40 - 60	104-195 (40-90)
Maximum Continuous	Continuous	950 (510)	932 (500)	-	40 - 60	104-195 (40-90) (8)
Maximum Cruise and Below	Continuous	950 (510)	932 (500)	-	40 - 60	104-195 (40-90)
R Part Power Trim	Continuous	See Fig. 504 (3)	See Fig. 504 (3)	180°F (100°C)	40 - 60	104-195 (40-90)
Idle	Continuous	644 (340) (4)	644 (340) (4)	-	35 Minimum	104-270 (40-132) (10)
Starting	Not over 15 seconds	842 (450) (5)	842 (450) (5)	-	-	-
Acceleration	-	1067 (575)	1049 (565)	-	40 - 60	104-195 (40-90)

Maximum Allowable Operating Speed: 6850 (N1) and 10300 (N2)

R NOTES: (1) Operation with water is limited to ambient temperatures above 20°F (-6.7°C). Water may be used between 20° and 40°F (-6.7° and 4.4°C) only if provisions are made to heat water sufficiently to keep it from freezing.
R (2) If dry take-off thrust is used following wet take-off, total time during which take-off thrust may be used is limited to five minutes; time limit to commence when throttle was first advanced for wet take-off.
R (3) This curve is not a limit. It is given as a guide to indicate the Tt7 which, if exceeded, may signify an engine malfunction.
R (4) This is reference temperature which if exceeded would indicate an abnormal engine operating condition. Further operation of an engine exhibiting this condition should be at discretion of operator.
R (5) Time limit applies to this temperature.
R (6) Oil pressure gage should be vented to scavenge compartment.
R (7) Normal oil pressure is 40-60 psig. At throttle settings of 62 percent N2 rpm (approximately 6,000 rpm) and above, oil pressures between 35 and 40 psig are undesirable. Oil pressures below normal shall be corrected. Formerly established 40-55 psig range may be retained for use if desired. If 40-55 psig range is used, aircraft instrumentation and documentation may contain only these values for the normal range.
R (8) Normal engine oil-in temperatures for stabilized running at max continuous is shown in Figure 501A for engines with and without thermostatic bypass valves.
R (9) If fuel inlet temperature reaches 90°F (37°C) or more, maximum oil temperature is 205°F (96°C).
R (10) During transient deceleration oil-in temperature of 270°F (132°C) is allowable.

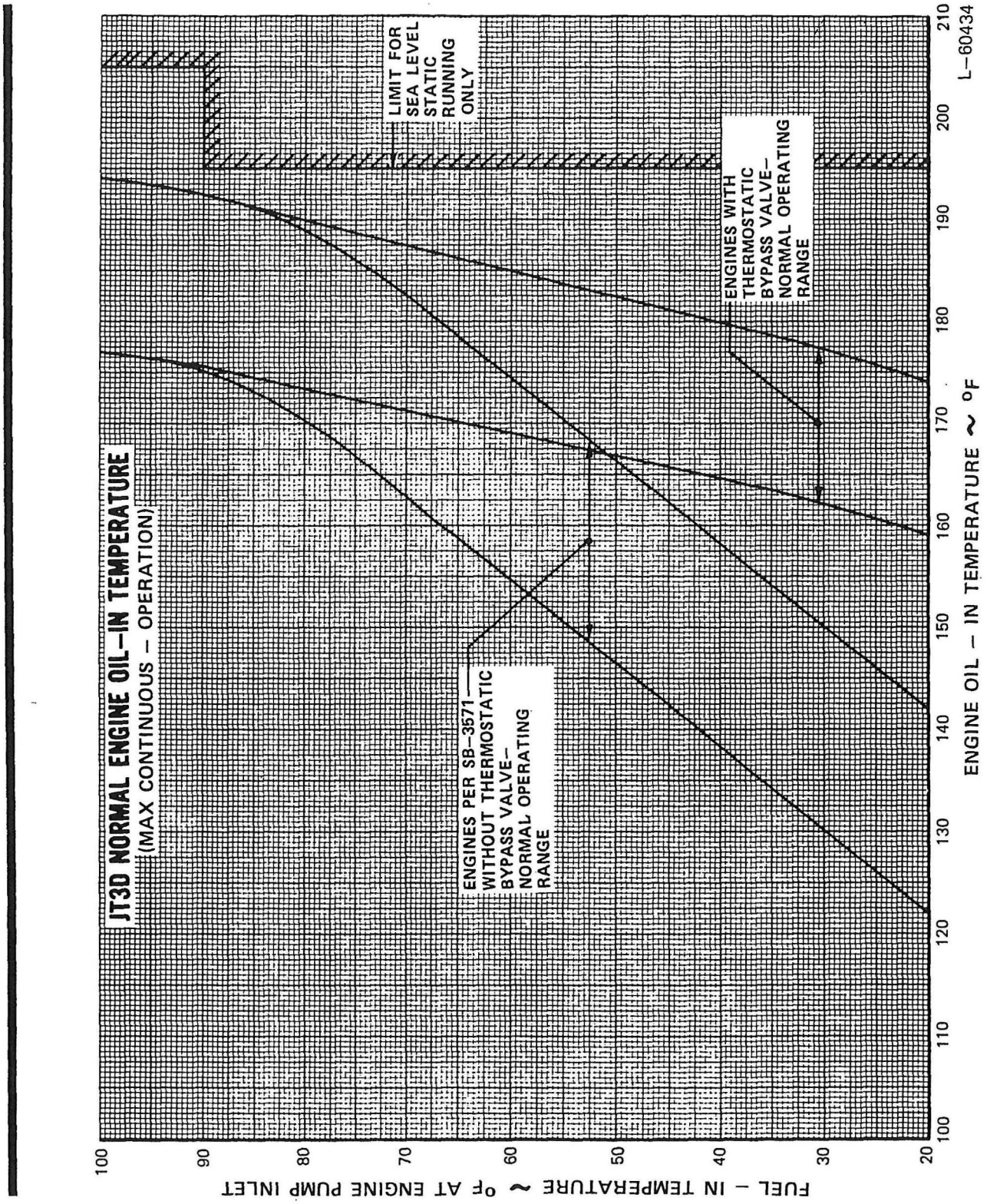
(2) Maximum Allowable Operating Speeds

(a) Low pressure (N1) compressor; 6,850 rpm (110.8 percent).

(b) High pressure (N2) compressor; 10,300 rpm (106.7 percent).

R
R (3) Fuel Drainage

(a) Total drainage of up to 6.5cc per minute is permitted from fuel system during operation on acceptance test. Several of components may develop leakages higher than their respective bench test figures in service. However, sum of acceptable service drain figures shall not exceed 6.5cc per minute. Drains must not be restricted by static pressure or line size.



R Normal Engine Oil-In Temperature
R Figure 501A

(b) Maximum Expected Drainage - Engine Fuel Drains

Component	During Operation	Following Shutdown
Fuel Manifold (1)		43 oz.
Drain (Fuel Pressurizing and Dump Valve)	6cc/min. (2)	
Combustion Chamber		3 oz.
Fuel Control	1 1/2cc/min. (3)	
Fuel Pump	1 1/2cc/min.	

Notes: (1) Pressurizing and dump valve will drain 3 oz. on a start. On false start, this 3 oz. plus normal shutdown drainage will occur.

(2) Component bench test drainage is 4cc/min. for this unit.

(3) If desired, fuel pump and fuel control leakage may be checked collectively. Collective leakage shall not exceed 1 1/2cc per minute. If collective leakage limit is exceeded, leakage shall be rechecked individually.

(4) Test Curves

R (a) Pressure Ratio Bleed Control Operating
R Limits (BG Models) ----------Figure 502,
R 502A

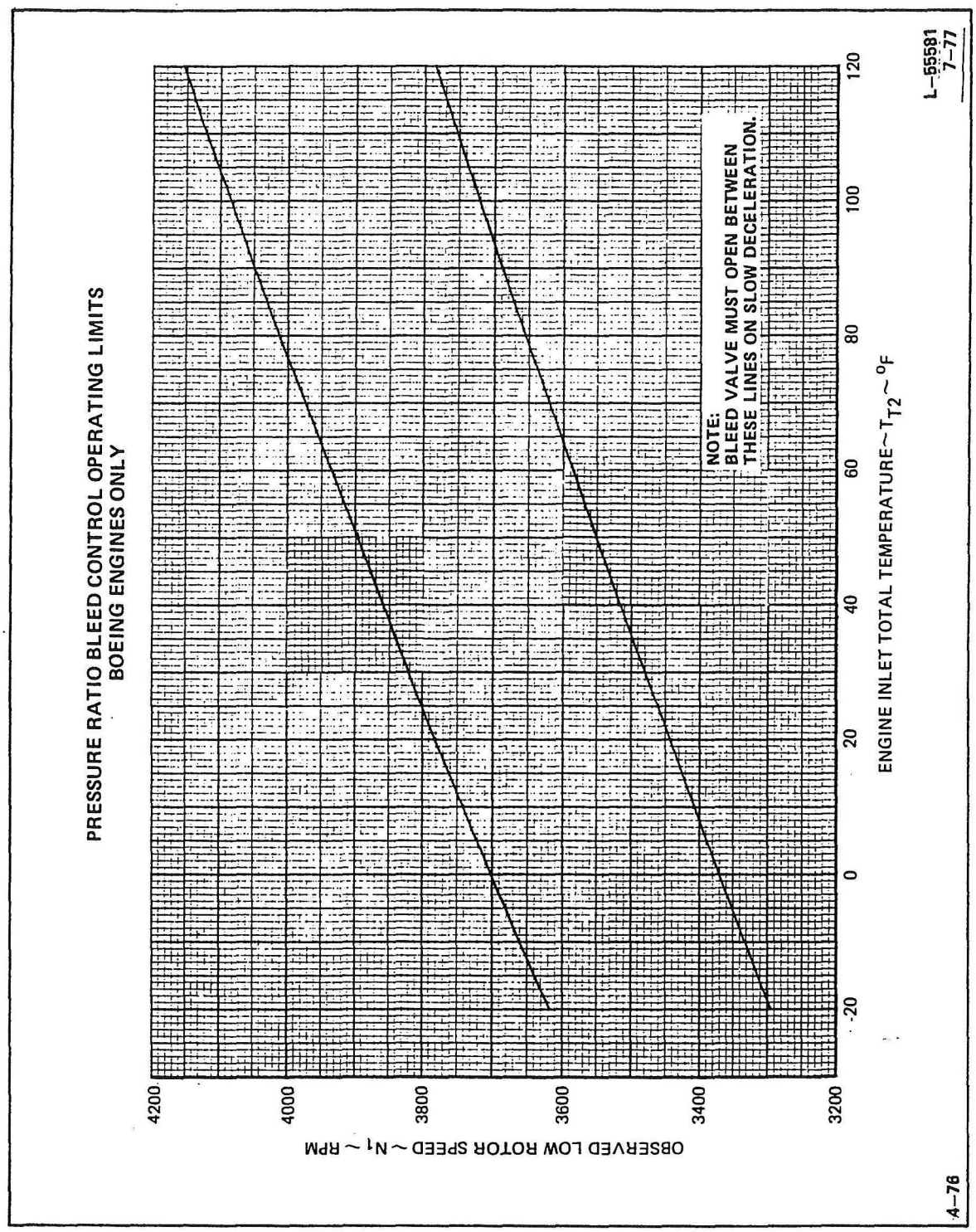
(b) Presure Ratio Bleed Control Operating Limits (DSLG Models) ----------Figure 503

(c) Maximum Observed EGT at Part Power Trim Stop ----------Figure 504

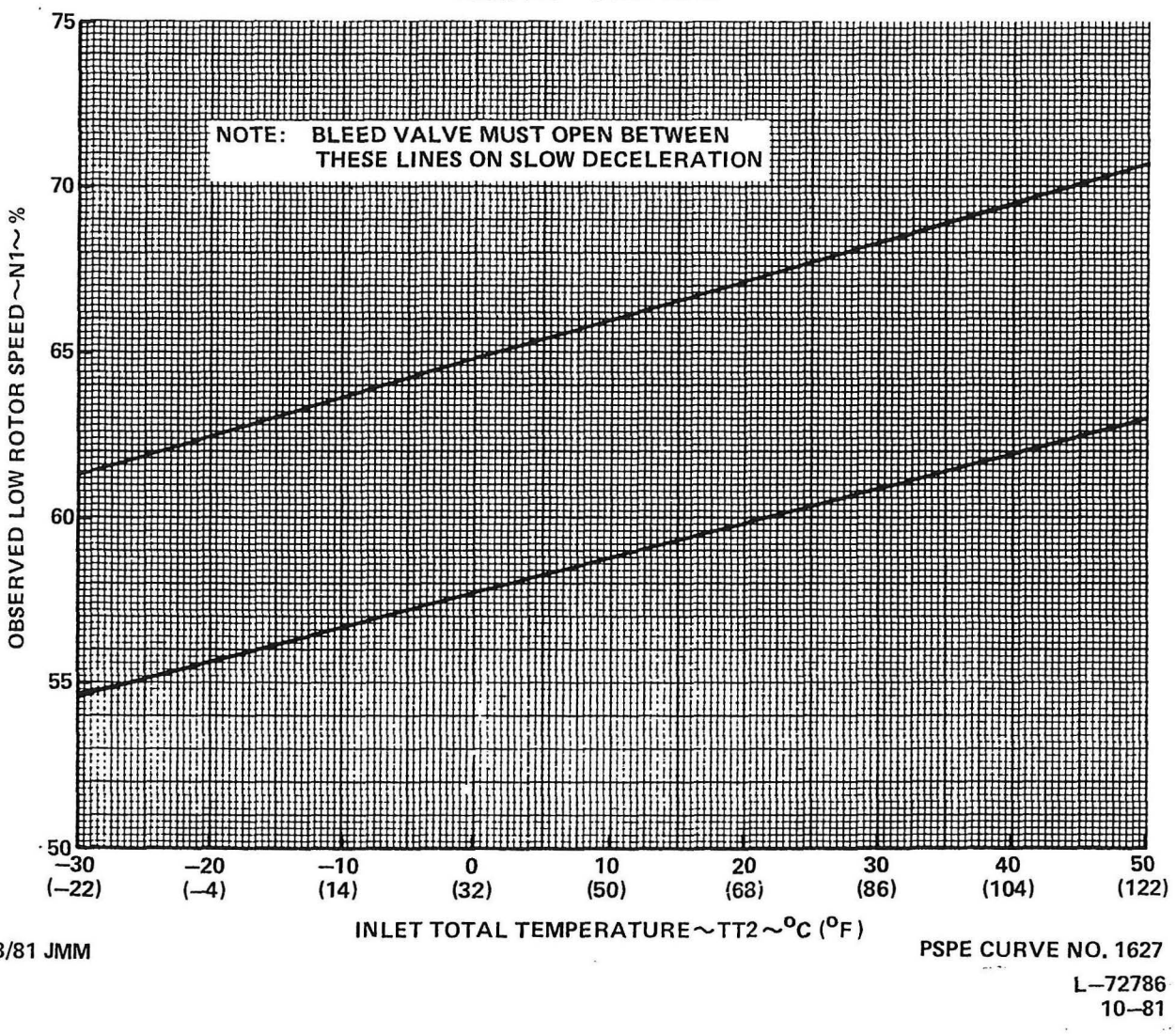
F. Pre-Starting Inspection Prior to Test

(1) Fuel System

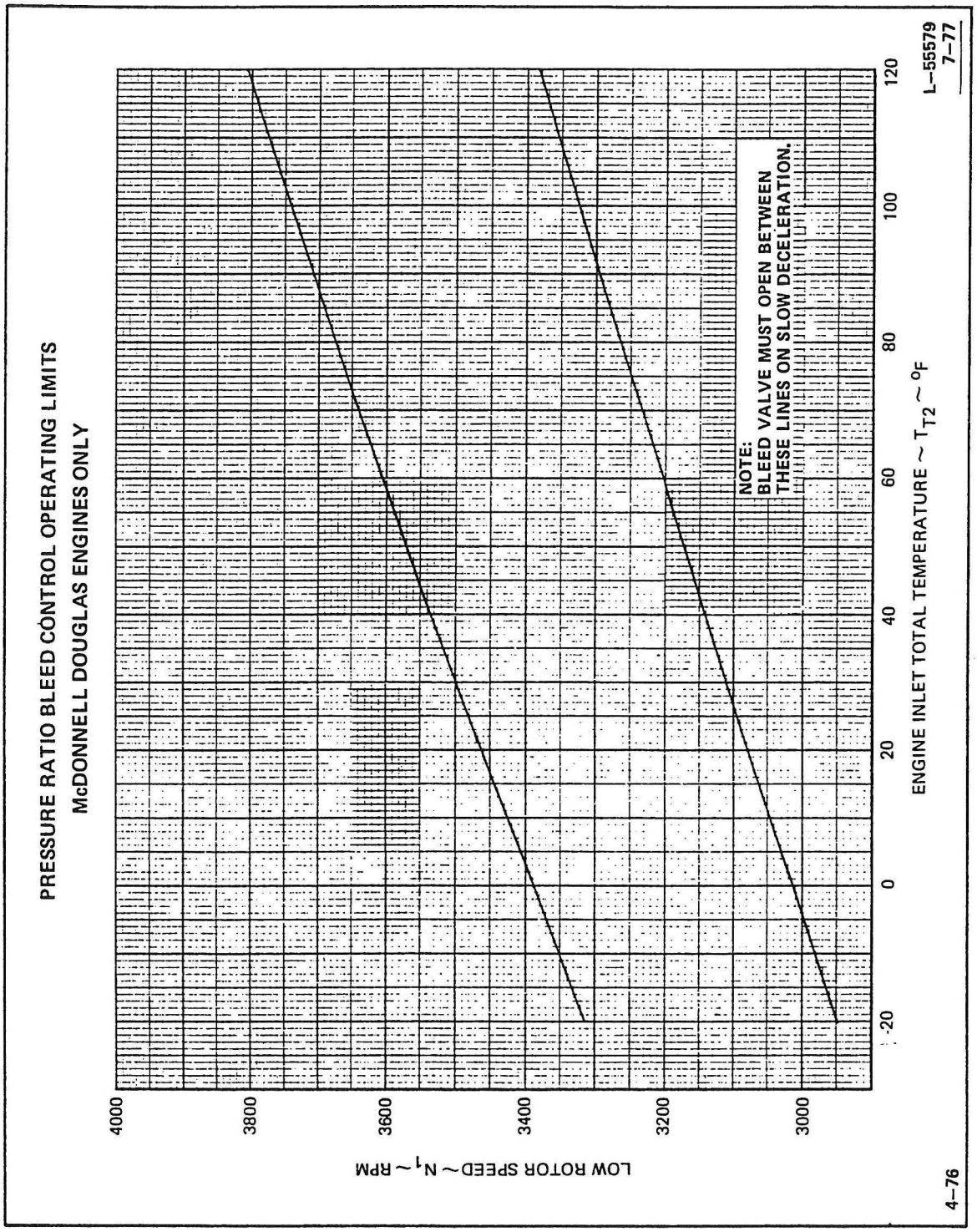
(a) Visually check all fuel system tubes and components for security and leakage



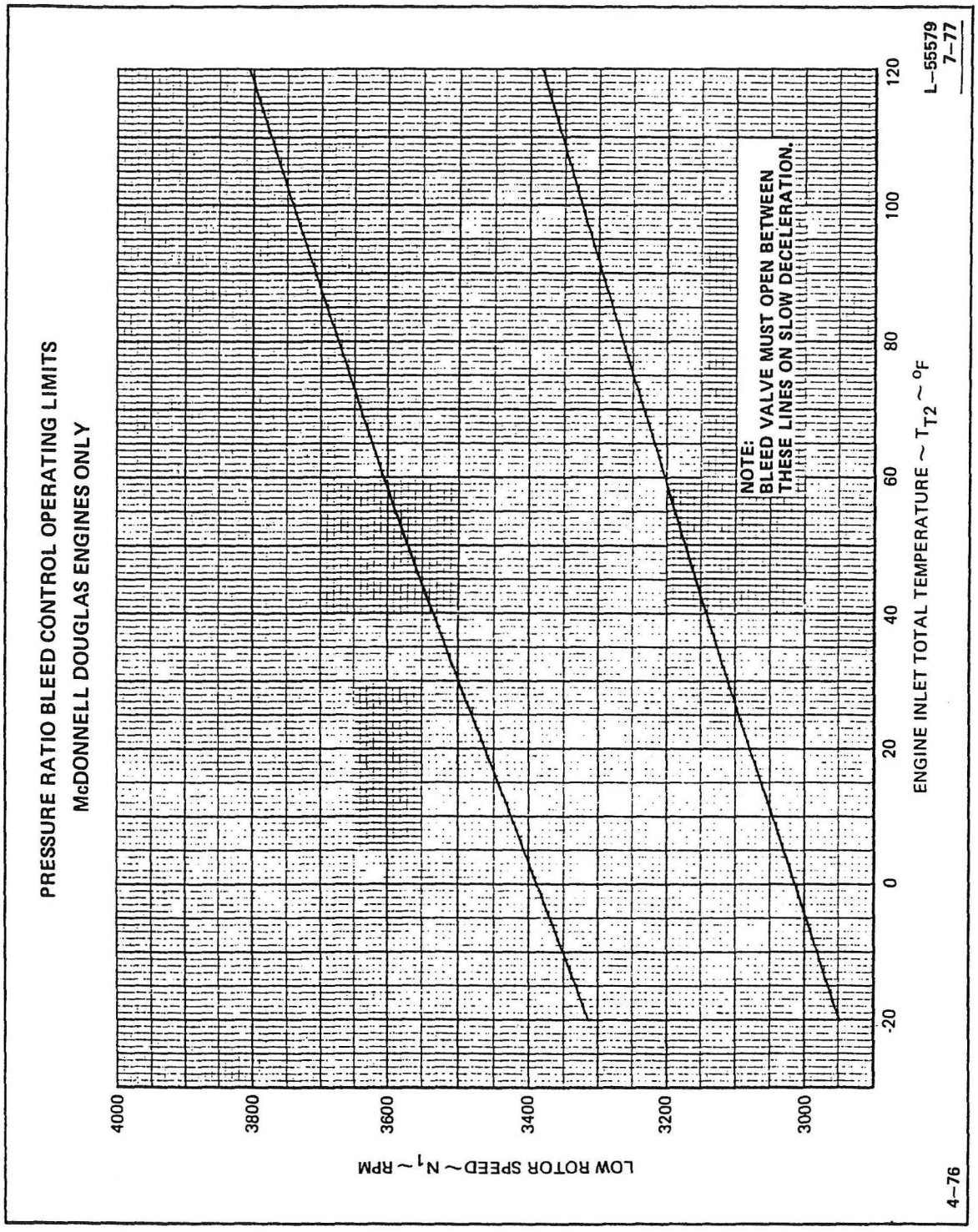
Pressure Ratio Bleed Control Operating Limits Curve (BG Models)
Figure 502



R Optional Pressure Ratio Bleed Control Operating Limits
R (N1 Vs Tt2) (JT3D-7,7A Boeing, Reference SB 5209)
R Figure 502A



Pressure Ratio Bleed Control Operating Limits Curve (DSLG Models)
Figure 503



Pressure Ratio Bleed Control Operating Limits Curve (DSLG Models)
Figure 503

(b) Remove, clean, and install fuel pump filters.

(c) Remove, clean, and install fuel control filters.

(d) Check fuel system for presence of water.

(e) Service fuel system with approved fuel conforming to Specification PWA-522.

NOTE: Engine must be ground tested and trimmed using same grade fuel as used for flight operations. Slight variations for any given power lever position will result if alternate fuels are used.

(2) Oil System

(a) Remove, disassemble, clean, and reinstall main oil strainer.

(b) Visually check all of oil system tubes and components for security and leakage.

(c) Fill oil tank with approved oil conforming to Specification PWA-521 synthetic oil.

(d) If oil is required after starting engine, engine shall be operated for approximately one minute at IDLE speed. This is required to make certain that any oil which may be in scavenge section of engine is returned to tank, thereby assuring accurate oil level check.

CAUTION: UP TO TWO GALLONS OF OIL MAY BE IN SCAVENGE SECTIONS; THEREFORE, OIL MUST NOT BE ADDED TO TANK UNTIL SCAVENGE SECTIONS ARE CLEARED. IF ABOVE PROCEDURE IS NOT FOLLOWED, EXCESSIVE OIL MAY BE ADDED WHICH WILL RESULT IN BUILD-UP OF SUFFICIENT INTERNAL PRESSURE TO RUPTURE TANK DURING ENGINE OPERATION.

ENGINE - ADJUSTMENT/TEST

(3) Electrical System

WARNING: BECAUSE VOLTAGE TO SPARKIGNITERS IS DANGEROUSLY HIGH, IGNITION SWITCH MUST BE IN "OFF" POSITION BEFORE REMOVAL OF ANY OF IGNITION SYSTEM COMPONENTS. APPROXIMATELY THREE MINUTES OF TIME MUST ELAPSE BETWEEN OPERATION OF IGNITION SYSTEM AND REMOVAL OF COMPONENTS. WHEN SPARKIGNITER LEAD IS DETACHED FROM SPARKIGNITER, TOUCH END OF LEAD TO SHELL OF IGNITER TO DISSIPATE RESIDUAL ENERGY.

(a) Check ignition system components for security.

CAUTION: INSUFFICIENT TORQUE ON HIGH TENSION LEAD NUT AT EXCITER AND IGNITER END CAN CAUSE IGNITION RADIATED NOISE TO BE PICKED UP BY AIRCRAFT RADIO EQUIPMENT. R R R R

(b) Remove both igniter plugs, energize and determine that both igniters are firing when DC system is energized and at least one igniter is firing when AC system is energized. Do not energize AC and DC systems simultaneously. Reinstall igniter plugs.

(c) For JT3D-7 (DSLG) engines, ignition system shall be checked by removing igniter plugs and observing that left igniter is firing when left exciter is energized and right igniter is firing when right exciter is energized. Reinstall igniter plugs.

(4) Instrumentation System

(a) Check engine instrumentation for security and general condition.

(b) Inspect pressure sensing probes for security.

(c) Visually check all indicating thermocouples for security.

(d) Check thermocouple harness and all lead insulations and shieldings for chafing and security.

(5) Engine Controls

(a) Check power lever for full travel, ease of movement and security.

ENGINE - ADJUSTMENT/TEST

NOTE: To prevent dilution of bearing lubricating medium, protect pre-packed bearings used in power cross shaft assembly during any washing process. Same precautions must be taken when fuel lines near this assembly are disconnected and fuel is, or may be, in these lines.

(b) Inspect compressor bleed valve, bleed valve control temperature sensing element and air tubes for security.

(6) Run Up Area and Engine Inlet Duct

(a) Prior to starting engine, inlet must be thoroughly inspected and cleaned of possible loose nuts, bolts, tools, and other objects which could cause engine damage and possible subsequent failure.

(b) Police inlet and exhaust areas to ensure against presence of foreign objects which could, under some circumstances, enter engine.

(7) Water Injection System

(a) Check that water does not have more than 10 parts per million total solids.

(b) At ambient temperatures below 40°F (4.4°C), check that water is heated sufficiently to prevent freezing.

G. Starting Procedure

(1) Following starting procedure is applicable to pneumatic starters and to combustion starters when used as pneumatic starters.

NOTE: If fuel lines have been disconnected or fuel control has been drained of fuel, prior to performing following, bleed air from control and fuel system. Open bleed vent at top of fuel control and motor engine over with fuel supply ON, Fuel Control Power Lever at IDLE and Fuel Control Shut-Off Lever OFF until all air is bled off. Catch excess fuel in container.

(a) Fuel Control Power Lever in IDLE.

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(b) Fuel Control Shut-Off Valve Lever OFF.

CAUTION: DO NOT OPEN FUEL SHUT-OFF LEVER BEFORE TURNING ON STARTER AND IGNITION.

(c) Electrical Master Switch ON.

(d) Fuel Supply Master Switch ON.

NOTE: Fuel inlet pressure must be 5 psi minimum.

(e) Engine Starter Switch ON.

NOTE: Check for oil pressure rise while cranking.

(f) Ignition switch ON when N2 speed reaches at least 10 percent.

CAUTION: CHECK FOR ROTATION OF BOTH COMPRESSORS PRIOR TO TURNING IGNITION SWITCH ON.

(g) Fuel Control Shut-Off Valve Lever ON.

(h) Ascertain that engine accelerates normally to IDLE rpm and that maximum allowable turbine discharge starting temperature, as noted in Engine Check Table, is not exceeded.

CAUTION: INSUFFICIENT AIR PRESSURE TO PNEUMATIC STARTER OR TO COMBUSTION STARTER THAT IS BEING USED AS PNEUMATIC STARTER, MAY NOT SUPPLY ENOUGH STARTER TORQUE TO START ENGINE PROPERLY, RESULTING IN HOT, HUNG, OR "TORCHING" STARTS. WHEN AIRBLEED FROM ANOTHER ENGINE IS USED TO OPERATE STARTER, CAUTION IS NECESSARY TO ENSURE THAT OPERATING ENGINE IS TURNING OVER FAST ENOUGH TO PROVIDE ADEQUATE SUPPLY OF PRESSURIZED AIR TO ENGINE BEING STARTED. ENGINE SHOULD NEVER BE PERMITTED TO TAKE LONGER THAN TWO MINUTED TO ACCELERATE TO IDLE RPM. IN EVENT OF TORCHING, HIGHER THAN USUAL EXHAUST GAS STARTING TEMPERATURES, TOO LONG ACCELERATION TIME, OR OTHER ABNORMALITIES DISCONTINUE STARTING ATTEMPT AND INVESTIGATE.

(i) Engine Starter Switch OFF when engine attains IDLE rpm.

(j) Ignition Switch OFF.

CAUTION: IF FUEL IS SHUT OFF INADVERTENTLY BY CLOSING FUEL SHUTOFF LEVER, DO NOT REOPEN FUEL VALVE AGAIN IN ATTEMPT TO REGAIN "LIGHT". WHENEVER ENGINE FAILS TO LIGHT, SHUT OFF FUEL AND IGNITION AND CONTINUE TURNING COMPRESSOR OVER WITH STARTER FOR 10 TO 15 SECONDS TO CLEAR OUT TRAPPED FUEL OR VAPOR. BEFORE ATTEMPTING ANOTHER START, ALLOW EITHER 30 SECOND FUEL DRAINING PERIOD OR PRESCRIBED STARTER COOLING PERIOD, WHICHEVER IS LONGER. STARTER MAY BE RE-ENGAGED AT ANY TIME AFTER COMPRESSOR HAS DECELERATED TO 40 PERCENT RPM OR LESS.

NOTE: Ignition system cycle must also be considered when making succession of starts or starting attempts. Cycle is two minutes ON - three minutes OFF; two minutes ON - 23 minutes OFF. For unsatisfactory starts see paragraph I and J. If it is found necessary to clear engine, see paragraph K for proper procedure.

H. Satisfactory start

(1) Satisfactory start condition exists if following conditions are met.

(a) Light up takes place within 20 seconds after Fuel Control Shut-Off Valve Lever is placed in ON position.

(b) Engine accelerates to approximately 58 to 65 percent rpm.

NOTE: 20 second time interval is arbitrary value. Actual time to light is dependent upon amount of torque supplied by starter.

(c) Exhaust gas temperature does not exceed starting temperature limits as indicated in Engine Check Table during transition period to IDLE rpm.

(d) Oil pressure is at least 35 psi.

(e) Exhaust gas temperature reduces to or below that temperature specified for IDLE as indicated in Engine Check Table after IDLE rpm has been obtained.

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I. Unsatisfactory Start

(1) This condition is broken into three phases:

(a) Hot Start. Exhaust gas temperature exceeds starting temperature limit as specified in Engine Check Table. Hot start can be anticipated by observing greater initial starting fuel flow than normal for given field elevation at instant fuel control shut-off valve is placed in ON position.

(b) No Start. Engine does not light up as evidenced by no rise in exhaust gas temperature, no increase in fuel flow or no sound indicating that fuel has ignited.

(c) False Start. After light up has occurred, rpm does not increase to that of IDLE, but remains at some lower point with exhaust gas temperature at or below maximum starting limit.

CAUTION: UNDER ALL CONDITIONS, IF FUEL CONTROL SHUT-OFF VALVE LEVER IS INADVERTENTLY MOVED TO OFF POSITION, THERE WILL BE IMMEDIATE FLAME OUT. DO NOT REOPEN SHUT-OFF VALVE AS IT WILL BE IMPOSSIBLE TO REGAIN LIGHT. DURING GROUND OPERATION INTRODUCING UNBURNED FUEL INTO ENGINE CAN CREATE FIRE HAZARD AND OVERHEATING OF ENGINE AND TAIL PIPE AREA. NORMAL STARTING SEQUENCE MUST BE REPEATED FOR EACH STARTING ATTEMPT. CHECK BOTH ROTORS FOR FREEDOM OF ROTATION PRIOR TO STARTING.

J. Unsatisfactory Start Procedure

(1) Following procedure is used in case of unsatisfactory start:

(a) Fuel Control Power Lever - IDLE.

(b) Fuel Control Shut-Off Valve Lever - OFF.

(c) Ignition Switch - OFF.

(d) Engine Starter Switch - OFF.

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(e) Fuel Supply Switch - OFF (when compressors stop rotating).

NOTE: Investigate to find reason for difficulty. If satisfactory start cannot be accomplished, refer to troubleshooting chart.

(f) Fuel drainage period of at least 30 seconds shall be allowed before another start is attempted.

NOTE: Engine coast down and subsequent motoring prior to next start is usually sufficient to purge engine of normal amounts of fuel admitted during unsuccessful start.

K. Clear Engine Procedure

(1) This operation will be used whenever it is desired to clear engine of trapped fuel or vapors.

(a) Fuel Control Power Lever - IDLE.

(b) Fuel Control Shut-Off Valve Lever - OFF.

(c) Ignition Switch - OFF.

(d) Fuel Supply Switch - ON.

(e) Engine Starting Switch - ON.

(f) Maintain engine rotation for 10 to 20 seconds.

(g) Engine Starting Switch - OFF.

(h) Fuel Supply Switch - OFF. (When compressors stop rotating.)

L. Shutdown Procedure

(1) In any instance where engine has been operated above approximately 85 percent rpm for periods exceeding one minute during last five minutes prior to shutdown, engine must be operated at below 85 percent rpm (preferable at IDLE) for period of five minutes in order to facilitate uniform cooling of parts. Following this five minute run for uniform parts cooling, engine should be accelerated to 75 percent rpm for approximately 30 seconds prior to shutdown to ensure proper oil scavenge from No. 1 bearing area. R R R R

This applies in particular to periods of prolonged operation at high rpm during engine trimming. If emergency stop from high power is necessary, both rotors must be checked for freedom of rotation just prior to restarting.

(2) Following steps shall be complied with when shutting down:

(a) Fuel Control Power Lever - IDLE.

(b) Allow time for cooling period as described above.

(c) Fuel Control Shut-Off Valve Lever - OFF.

NOTE: Fuel Control Shut-Off Valve must not be placed in OFF position when engine speed is above IDLE, except in emergencies.

(d) As compressors and turbines decelerate after shutdown, ascertain by listening that they do so freely without evidence of rubbing and binding.

(e) Fuel Supply Switch - OFF.

NOTE: Do not turn fuel supply switch OFF until engine stops rotating. This will ensure that fuel remains in lines and that engine driven fuel pump is properly lubricated.

M. Procedure for Determining Turbine Discharge Pressure (Pt7) or Engine Pressure Ratio (Pt7/Pamb) Values for Trimming and Thrust Checks

(1) Using sample curve (Figure 505) as guide, determine desired Pt7 or Pt7/Pamb values as follows:

CAUTION: FIGURE 505 IS INTENDED AS GUIDE ONLY. WHEN ACUTALLY TRIMMING OR CHECKING THRUST, AIRFRAME MANUFACTURER'S CURVE CORRECTED FOR INSTALLATION LOSSES MUST BE USED.

(a) Determine ambient air temperature as close to engine inlet as possible.

(b) Determine true barometric pressure at field elevation.

(c) Enter curve at "A" with temperature.

(d) Proceed downward to fuel control setting tolerance lines at points "B" and "C".

(e) If Pt7/Pamb is being employed, proceed horizontally to right and read Pt7/Pamb ratio variation at points "D" and "E".

(f) If Pt7 gage is being used, proceed horizontally from points "B" and "C" to that line which denotes true barometric pressure at points "F" and "G". Drop vertically to turbine discharge pressure line at points "H" and "J". Note this variation for trimming.

NOTE: DRY TAKE-OFF, Pt7 or Pt7/Pamb value is determined as above except single (minimum) "setting" line is used.

(g) WET PART THRUST trim and WET TAKE-OFF Pt7 or Pt7/Pamb values are determined as above using applicable water injection curves.

NOTE: Engine may be trimmed and/or checked using water down to ambient temperature of 20°F (-6.7°C) if provisions are made to heat water sifficiently to keep it from freezing. If heating facilities are not available, engine shall be trimmed and/or checked using 350 psig false reset signal at temperatures between 40°F (4.4°C) and 20°F (-6.7°C). At temperatures below 20°F (-6.7°C) false reset only must be used. R

N. Determination of Corrected N2 Speed

(1) Corrected N2 speed is determined by following formula:

$$\text{Corrected N2 rpm} = \frac{\text{Observed N2 rpm}}{\sqrt{\theta}}$$

$$\text{Where } \sqrt{\theta} = \sqrt{\frac{\text{Compressor Inlet Temperature } ^\circ R}{519}}$$ R

(2) From Figure 506, determine N2 correction factor ($\sqrt{\theta}$) for ambient inlet temperature.

(3) Divide observed N2 speed by $\sqrt{\theta}$.

Example:

Inlet Temperature = 82°F (27.8°C)

(From Figure 506) = 1.022

Observed N2 = 9465 rpm

$$\text{Corrected N2} = \frac{\text{Observed N2 rpm}}{\sqrt{\theta}} = \frac{9465}{1.022} = 9261 \text{ rpm}$$

O. Engine Adjustments

(1) Only allowable adjustments that can be made to fuel control are adjustments to IDLE, MAXIMUM and WATER INJECTION Trim Screws. Turning trim screw in clockwise direction will increase engine speed. All final adjustments should be made in increase rpm direction.

(2) Oil pressure adjusting screw is under plug located on bottom right side of accessory and components drives gearbox front housing. To adjust oil pressure, use PWA 16765 Wrench and remove relief valve plug. Then using PWA 16766 Wrench turn adjusting screw. Inner portion of tool engages slot of adjusting screw while locknut is loosened with outer portion of wrench. Turn adjusting screw clockwise to increase or counterclockwise to decrease oil pressure. When adjusting oil pressure at idle speed it is permissible to set pressure below 40 psi, but not below 35 psi, in order to
R assure pressure will remain in 40 to 60 psi range during operation above idle.

P. Test A. Ground Check at Idle

(1) Inspect and clean test area, engine, and engine operating components.

(2) Start engine.

R (3) Allow engine to run at IDLE for minimum of two minutes.
R For oil system repair/replacement, run as required for oil
R temperature to reach 100°F (38°C).

(4) Shut down.

(5) Inspect engine for evidence of fuel and/or oil leaks.

ENGINE - ADJUSTMENT/TEST

ROTOR SPEED CORRECTION FACTOR

T_{t2} °C	T_{t2} (°F)	$\sqrt{\theta}$	T_{t2} °C	T_{t2} (°F)	$\sqrt{\theta}$	T_{t2} °C	T_{t2} (°F)	$\sqrt{\theta}$
48.3	119	1.056	15.0	59	1.000	−18.3	−1	0.940
47.8	118	1.055	14.4	58	0.999	−18.9	−2	0.939
47.2	117	1.054	13.9	57	0.998	−19.4	−3	0.938
46.7	116	1.054	13.3	56	0.997	−20.0	−4	0.937
46.1	115	1.053	12.8	55	0.996	−20.6	−5	0.936
45.6	114	1.052	12.2	54	0.995	−21.1	−6	0.935
45.0	113	1.051	11.7	53	0.994	−21.7	−7	0.934
44.4	112	1.050	11.1	52	0.993	−22.2	−8	0.933
43.9	111	1.049	10.6	51	0.992	−22.8	−9	0.932
43.3	110	1.048	10.0	50	0.991			
42.8	109	1.047	9.4	49	0.990	−23.3	−10	0.931
42.2	108	1.046	8.9	48	0.989	−23.9	−11	0.930
41.7	107	1.045	8.3	47	0.988	−24.4	−12	0.929
41.1	106	1.044	7.8	46	0.987	−25.0	−13	0.928
40.6	105	1.043	7.2	45	0.986	−25.6	−14	0.927
40.0	104	1.042	6.7	44	0.985	−26.1	−15	0.926
39.4	103	1.041	6.1	43	0.984	−26.7	−16	0.925
38.9	102	1.041	5.6	42	0.984	−27.2	−17	0.924
38.3	101	1.040	5.0	41	0.983	−27.8	−18	0.923
37.8	100	1.039	4.4	40	0.982	−28.3	−19	0.922
37.2	99	1.038	3.9	39	0.981	−28.9	−20	0.921
36.7	98	1.037	3.3	38	0.980	−29.4	−21	0.920
36.1	97	1.036	2.8	37	0.979	−30.0	−22	0.919
35.6	96	1.035	2.2	36	0.978	−30.6	−23	0.918
35.0	95	1.034	1.7	35	0.977	−31.1	−24	0.917
34.4	94	1.033	1.1	34	0.976	−31.7	−25	0.916
33.9	93	1.032	0.6	33	0.975	−32.2	−26	0.914
33.3	92	1.031	0.0	32	0.974	−32.8	−27	0.913
32.8	91	1.030	−0.6	31	0.973	−33.3	−28	0.912
32.2	90	1.029	−1.1	30	0.972	−33.9	−29	0.911
31.7	89	1.029	−1.7	29	0.971	−34.4	−30	0.910
31.1	88	1.028	−2.2	28	0.970	−35.0	−31	0.909
30.6	87	1.027	−2.8	27	0.969	−35.6	−32	0.908
30.0	86	1.026	−3.3	26	0.968	−36.1	−33	0.907
29.4	85	1.025	−3.9	25	0.967	−36.7	−34	0.906
28.9	84	1.024	−4.4	24	0.966	−37.2	−35	0.905
28.3	83	1.023	−5.0	23	0.965	−37.8	−36	0.904
27.8	82	1.022	−5.6	22	0.964	−38.3	−37	0.903
27.2	81	1.021	−6.1	21	0.963	−38.9	−38	0.902
26.7	80	1.020	−6.7	20	0.962	−39.4	−39	0.901
26.1	79	1.019	−7.2	19	0.961	−40.0	−40	0.900
25.6	78	1.018	−7.8	18	0.960	−40.6	−41	0.899
25.0	77	1.017	−8.3	17	0.959	−41.1	−42	0.897
24.4	76	1.016	−8.9	16	0.958	−41.7	−43	0.896
23.9	75	1.015	−9.4	15	0.957	−42.2	−44	0.895
23.3	74	1.014	−10.0	14	0.956	−42.8	−45	0.894
22.8	73	1.013	−10.6	13	0.955	−43.3	−46	0.893
22.2	72	1.012	−11.1	12	0.954	−43.9	−47	0.892
21.7	71	1.012	−11.7	11	0.953	−44.4	−48	0.891
21.1	70	1.011	−12.2	10	0.952	−45.0	−49	0.890
20.6	69	1.010	−12.8	9	0.951	−45.6	−50	0.889
20.0	68	1.009	−13.3	8	0.950	−46.1	−51	0.888
19.4	67	1.008	−13.9	7	0.949	−46.7	−52	0.887
18.9	66	1.007	−14.4	6	0.948	−47.2	−53	0.886
18.3	65	1.006	−15.0	5	0.947	−47.8	−54	0.885
17.8	64	1.005	−15.6	4	0.946	−48.3	−55	0.883
17.2	63	1.004	−16.1	3	0.945	−48.9	−56	0.882
16.7	62	1.003	−16.7	2	0.944	−49.4	−57	0.881
16.1	61	1.002	−17.2	1	0.943	−50.0	−58	0.880
15.6	60	1.001	−17.8	0	0.942	−50.6	−59	0.879

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Rotor Speed Correction Factor Chart
Figure 506

ENGINE - ADJUSTMENT/TEST

Q. Test B. Ground Check at Maximum Cruise R

(1) Inspect and clean test area, engine and engine operating components. R R

(2) Determine MAXIMUM CRUISE Pt7 or Pt7/Pamb. R

(3) Start engine. R

(4) Allow engine to run at IDLE until readings have stabilized; then make following checks: R R

(a) Fuel Control Shut-Off Valve Lever fully ON and Fuel Control Power Lever - IDLE. R R

(b) Tachometer 58 to 65 percent rpm. R

(c) Exhaust Gas Temperature (see Engine Check Table). R

(d) Oil Pressure Gage - 35 psi minimum. R

(e) Fuel Pump Warning Light - OFF. R

NOTE: If start is made with engine which has cooled to ambient temperature of -31°F (-35°C) or below, it will be preferable to leave power lever at IDLE for two minutes to warm up engine. R R R R

(f) Anti-Icing Valves - CLOSED. R

NOTE: If running is to be done during icing conditions, anti-icing system must be in operation to prevent icing of engine inlet. During icing conditions with anti-icing system in operation, accurate power check readings of turbine discharge will not be available due to entrance of heated air into engine. R R R R R R R

(5) Advance Fuel Control Power Lever to produce turbine discharge pressure value determined in step (2) and maintain for minimum of five minutes.

R NOTE: If desired, when retarding power lever, check proper functioning of compressor bleed valve
R against limits in Pressure Ratio Bleed Control
R Operating Limits Curve. Operational check of anti-icing system is required only when component parts of this system are removed or disassembled during engine maintenance.

(6) Make certain that operating limits in Engine Check Table are not exceeded.

(7) Do not exceed engine maximum allowable operating speed.

(8) After completion of check, return power lever to IDLE.

(9) Shut down.

(10) Inspect engine for evidence fuel and/or oil leaks.

R. Test C. Ground Check at 4000 lb./hr. Fuel Flow

(1) Inspect and clean test area, engine and engine operating components.

(2) Start engine.

(3) Advance power lever as necessary until minimum of 4000 lb./hr. of fuel flow is observed. Maintain for minimum of
R two minutes.

(4) After completion of check, return power lever to IDLE.

(5) Shut down.

(6) Inspect engine for evidence of fuel and/or oil leaks.

S. Test D. Part Power Trim Check

NOTE: At temperatures below 0°F (minus 18°C) install 0.099 inch thick spacer to obtain power lever angle of 84.5 degrees. Be sure to use applicable Dry Reduced Thrust Trim Curve supplied by aircraft manufacturer. Use of spacers may result in some misalignment of Power Lever, therefore retrim to Dry Part Power Trim Curve as soon as ambient temperature permits.

ENGINE - ADJUSTMENT/TEST

(1) Inspect and clean run up area, engine, and engine operating components. R R

(2) From applicable curves, determine turbine discharge pressure values for WET and DRY PART POWER as described in Paragraph M. R R R

(3) Install Part Thrust Trim Stop. R

(a) Remove lockwire, compress spring, and rotate trim stop 180 degrees to activated position. R R

NOTE: Prior to operating newly installed fuel control or one which has been drained of fuel as result of fuel line replacement or filter inspection, air must be bled from fuel control. Open bleed vent at top of fuel control; then motor engine over with fuel supply ON, fuel control power lever at IDLE, and fuel control shut-off valve OFF, until all air has been bled off. Catch excess fuel in container. R R R R R R R R R R

(4) Start engine. R

(5) Allow engine to run at idling speed until readings have stabilized; then make following checks: R R

(a) Fuel Control Shut-Off Valve Lever fully ON and Fuel Control Power Lever - IDLE. R R

(b) Tachometer 58 to 65 percent rpm. R

(c) Exhaust Gas Temperature (see Engine Check Table). R

(d) Oil Pressure Gage - 35 psi minimum. R

(e) Fuel Pump Warning Light - OFF. R

NOTE: If start is made with engine which has cooled to ambient temperature of -31°F (-35°C) or below, it will be preferable to leave power lever at IDLE for two minutes to warm up engine. R R R R

ENGINE - ADJUSTMENT/TEST

(f) Anti-Icing Valves - CLOSED. R

NOTE: If running is to be done during icing conditions, anti-icing system must be in operation to prevent icing of engine inlet. No trimming of engine will be allowed during icing conditions. R R R R

(6) Advance Fuel Control Power Lever until it contacts PART THRUST trim stop. R

(7) Allow engine to stabilize and compare stabilized Pt7 or Pt7/Pamb reading with that determined in step (2). Trim engine as necessary. R R R

NOTE: Check that air extraction and accessory utilization is in accordance with requirements of trim curve. R R

CAUTION: REMOTE TRIMMING EQUIPMENT MUST BE USED, TO PREVENT INJURY TO PERSONNEL. R R

NOTE: During icing conditions with anti-icing system in operation, accurate trim checks cannot be made. R R

(8) Following procedure for water injection trimming shall be made only when temperature is 20°F (-6.7°C) or above. With power lever against PART THRUST trim stop, turn water injection switch ON. R R R R

NOTE: Water may be used down to ambient temperature of 20°F (-6.7°C) if provisions are made to heat water sufficiently to keep it from freezing. At any time temperature is below 20°F (-6.7°C) or when temperature is between 40°F (4.4°C) and 20°F (-6.7°C) and facilities for heating water are not available, false reset procedures outlined in Paragraph U. must be used. R R R R R R R R R

(9) Check Pt7 reading to meet requirement of applicable WET PART THRUST trim curve as determined in step (2). If Pt7 value does not meet requirements of curve, adjust fuel control Water Injector trimmer until Pt7 value can be met. Make final trim adjustment in increase rpm direction. Turn water injection switch OFF. R R R R R R

(10) Retard power lever to IDLE and check IDLE trim speed. If adjustment to IDLE trim screw is made, it will be necessary to recheck trim at PART THRUST. R R R

ENGINE - ADJUSTMENT/TEST

(11) Remove Part Thrust Trim stop.

(a) Rotate trim stop 180 degrees, depressing spring place trim stop in stored position, and lockwire.

(12) If desired, advance power lever to position that will give Pt7 value as determined from applicable curves described in Paragraph M. for DRY TAKE-OFF.

CAUTION: THERE IS NO POWER LEVER STOP AT TAKE-OFF: THEREFORE DURING ENGINE OPERATION AT TAKE-OFF POWER LEVER POSITIONS MAKE CERTAIN THAT LIMITING VALUES FOR Pt7, Tt7, N1, AND N2 ARE NOT EXCEEDED.

T. Test E. Ground Check For Bleed System Operation

(1) Inspect and clean test area, engine, and engine operating components.

(2) Start engine.

(3) Allow engine to run at IDLE.

R (4) Decelerate slowly and check that bleed operation occurs at
R proper N1 speed as determined by Pressure Ratio Bleed
R Control Operating Limits Curve.

(5) Shut down.

(6) Inspect engine for evidence of fuel and/or oil leaks.

U. False Reset Trim Procedure

(1) These procedures apply any time ambient temperature is below 20°F (-6.7°C) or when facilities for heating water are not available and ambient temperature is below 40°F (4.4°C).

(2) Determine Pt7 or Pt7/Pamb at which to set engine prior to applying reset signal.

(3) Determine target Pt7 or Pt7/Pamb at which engine is to be trimmed after reset signal is applied.

(4) Connect 350 psig signal to false reset fitting on fuel control.

(5) Run engine at Pt7 or Pt7/Pamb determined in step (2) above.

(6) Apply 350 psig signal and trim engine to Pt7 or Pt7/Pamb determined in step (3) above.

V. Engine Condition Check Based on EPR and Corrected N2 Speed

(1) Stabilize engine at an EPR of 1.37.

(2) Record observed N2 speed and ambient temperature.

(3) Correct observed N2 speed as outlined in Paragraph N.

(4) Compare corrected N2 speed with that stamped on data plate.

R (a) If corrected N2 speed exceeds data plate speed by more
R than 200 rpm (2 percent), check for leaks in Pt7 system,
R anti-icing system, compressor bleed system and for loose
R covers or caps on engine. If compressor contamination is
R suspected, perform engine cleaning using water wash or
R carboblast procedures. See Section 72-00, Engine -
R Cleaning.

(b) If corrected N2 speed is 100 rpm or more below data plate speed, perform hot section inspection and take necessary corrective action.

W. Exhaust Gas Temperature Spread Check

(1) Connect thermocouple connector to exhaust gas temperature indicator.

(2) Install Part Thrust trim stop.

(a) Remove lockwire, compress spring, and rotate trim stop 180 degrees to activated position.

(3) Start engine and make necessary IDLE checks.

NOTE: To obtain valid temperature spread check, engine must be properly trimmed.

(4) Advance power lever to trim stop. Allow engine to stabilize and then take readings of individual thermocouples. Exhaust gas temperature spread, difference between lowest and highest reading thermocouples, must not exceed limits given in Engine Check Table for PART THRUST operation.

NOTE: If exhaust gas temperature spread at PART THRUST exceeds limits and limit cannot be attained after equipment used, including thermocouples, is thoroughly checked, perform exhaust gas temperature spread check at DRY TAKE-OFF power as outlined below. If temperature spread is within DRY TAKE-OFF limits, engine is acceptable. If DRY TAKE-OFF limits cannot be met, perform clogged fuel nozzle check to locate faulty fuel nozzle or nozzles. Replace nozzles and repeat spread check.

(5) Retard power lever to IDLE

(a) Rotate trim stop 180 degrees, depress spring, place trim stop in stored position and lockwire.

NOTE: If PART THRUST temperature spread check is within limits, DRY TAKE-OFF temperature spread check (steps (6) through (8)) may be omitted.

(6) Advance power lever to predetermined DRY TAKE-OFF Pt7 value. Allow engine to stabilize and take readings of six thermocouples.

(7) Retard power lever to IDLE and shut down engine.

(8) If temperature spread, or average temperature exceeds limits given in Engine Check Table; or temperature of any one thermocouple exceeds measured harness average by 100°F (55.5°C), a condition of nozzle flow restriction or improper assembly of combustion chamber liners should be suspected.

(9) Remove thermocouple test equipment.

X. Engine Overspeed Limits And Inspection Procedures

R (1) For engines that incorporate tight (0.004 - 0.012 inch)
R axial "B" gap at second stage turbine outer airseal.

R (a) If N1 exceeds 6850 rpm (110.7 percent), but does not
R exceed 7100 rpm (114.8 percent) or N2 exceeds 10,300 rpm
R (106.7 percent), but does not exceed 10,500 rpm (108.7
R percent), perform inspection procedures outlined in step
R (b) below.

R ENGINE - ADJUSTMENT/TEST

R (b) Prior to any additional operation, check rotors for free
R rotation and visually inspect inlet and exhaust ducts for
R foreign particles or evidence of blade rub or vane
R nicking. If found satisfactory, continue engine in
R service after correcting cause of overspeed. If any
R abnormal conditions are evident, further inspection is
R necessary.

R (c) If N1 exceeds 7100 rpm (114.8 percent) or N2 exceeds
R 10,500 rpm (108.7 percent), shut down as soon as possible
R and send engine to overhaul for complete inspection.

R (2) For engines that do not incorporate tight axial "B" gap
R at second stage turbine outer airseal.

R (a) If N1 speed exceeds 6850 rpm (110.7 percent), a one-time
R flyback, not to exceed two take off cycles, is authorized
R to return engine to overhaul for teardown inspection.
R See Section 72-00, Engine General - Testing of overhaul
R manual for specific inspection requirements.

R (b) If N2 speed exceeds 10,300 rpm (106.7 percent) but does
R not exceed 10,500 rpm (108.7 percent), perform inspection
R procedures outlined in step (c).

R (c) Prior to any additional operation, check rotors for free-
R dom of rotation and visually inspect inlet and exhaust
R ducts for foreign particles or evidence of blade rub or
R vane nicking. If found satisfactory, continue engine in
R service after correcting cause of overspeed. If any
R abnormal conditions are evident, further inspection is
R necessary.

R (d) If N1 exceeds 7100 rpm (114.8 percent) or N2 exceeds
R 10,500 rpm (108.7 percent), shut down as soon as possible
R and send engine to overhaul for complete inspection.
R

ENGINE - ADJUSTMENT/TEST

Y. Overtemperature Limits and Inspection Procedure

CAUTION: WHEN EGT LIMITS ARE EXCEEDED, ENGINE SHOULD NOT BE SHUT DOWN ON EMERGENCY BASIS BUT SHOULD BE COOLED FOR 5 MINUTES UNLESS IT IS OBVIOUS THAT CONTINUED OPERATION WILL RESULT IN ADDITIONAL ENGINE DAMAGE REGARDLESS OF HOW ENGINE IS SHUTDOWN. IT SHOULD NOT BE RESTARTED UNTIL INSPECTION SHOWS THAT BOTH ENGINE ROTORS WILL ROTATE NORMALLY

(1) If EGT exceeds limit given in Engine Check Tables, engine has been subjected to overtemperature condition. Remedial action which must be taken depends on degree of temperature reached, length of time at temperature, and condition at which engine was being operated at time. Figures 507 through 508A present graphically action to be taken when engine has been subjected to overtemperature condition. Perform applicable inspection as outlined in steps (2) and (3).

(2) Visual inspection shall consist of inspecting exhaust duct and rear of turbine for any apparent damage.

(3) Hot section inspection shall consist of following:

(a) Inspect exhaust duct and rear of turbine for apparent damage.

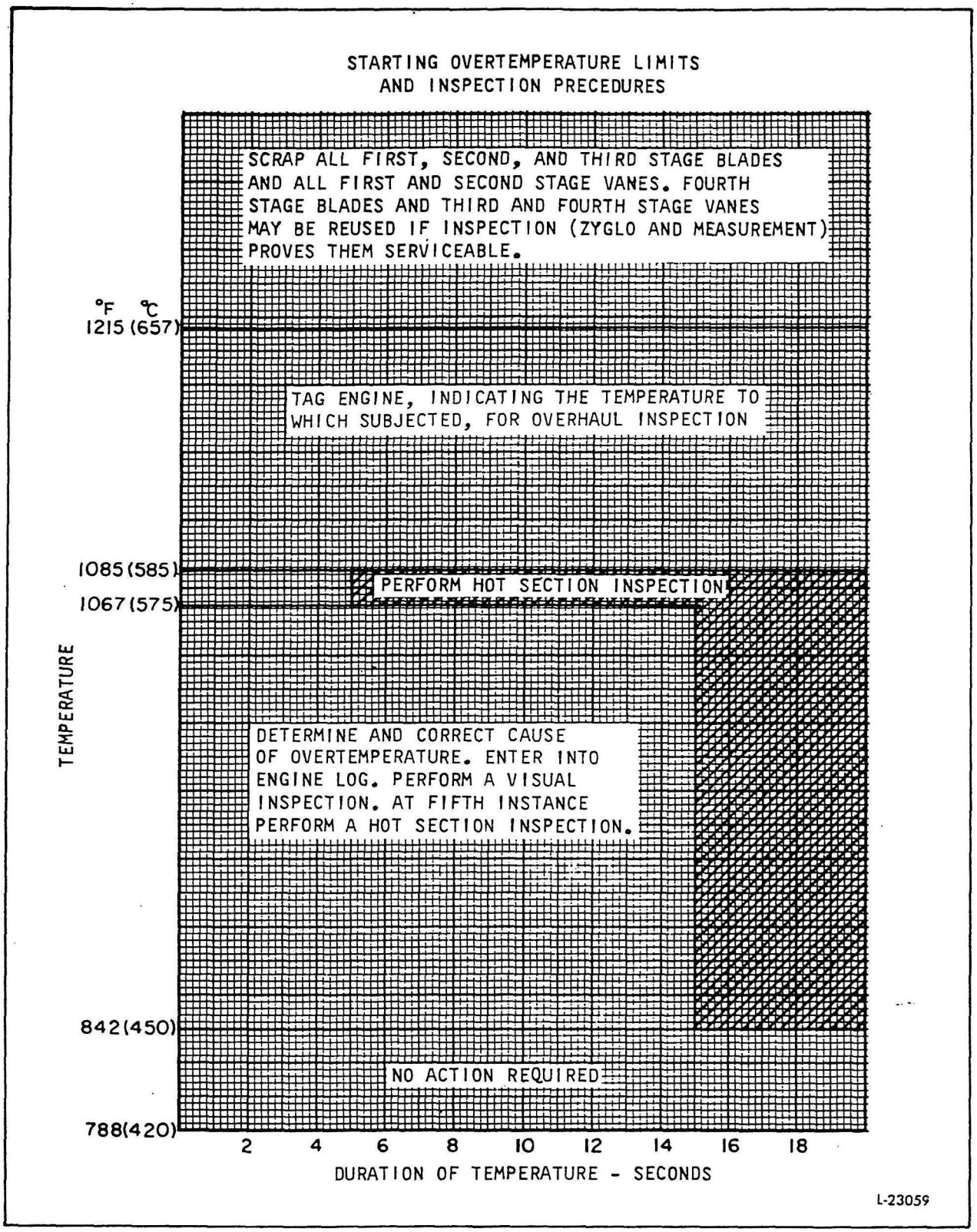
(b) Slide combustion chamber rearward, remove combustion chambers and inspect burner section and turbine nozzle guide vanes. Remove section of vanes and inspect first stage turbine blades. Subject parts should be inspected for excessive distortion.

(c) If results of inspection are satisfactory, engine may be continued in service after cause of overtemperature has been found and corrected. Perform stretch check on first stage turbine blades. If any blade exceeds maximum allowed stretch limit entire turbine shall receive a complete overhaul inspection.

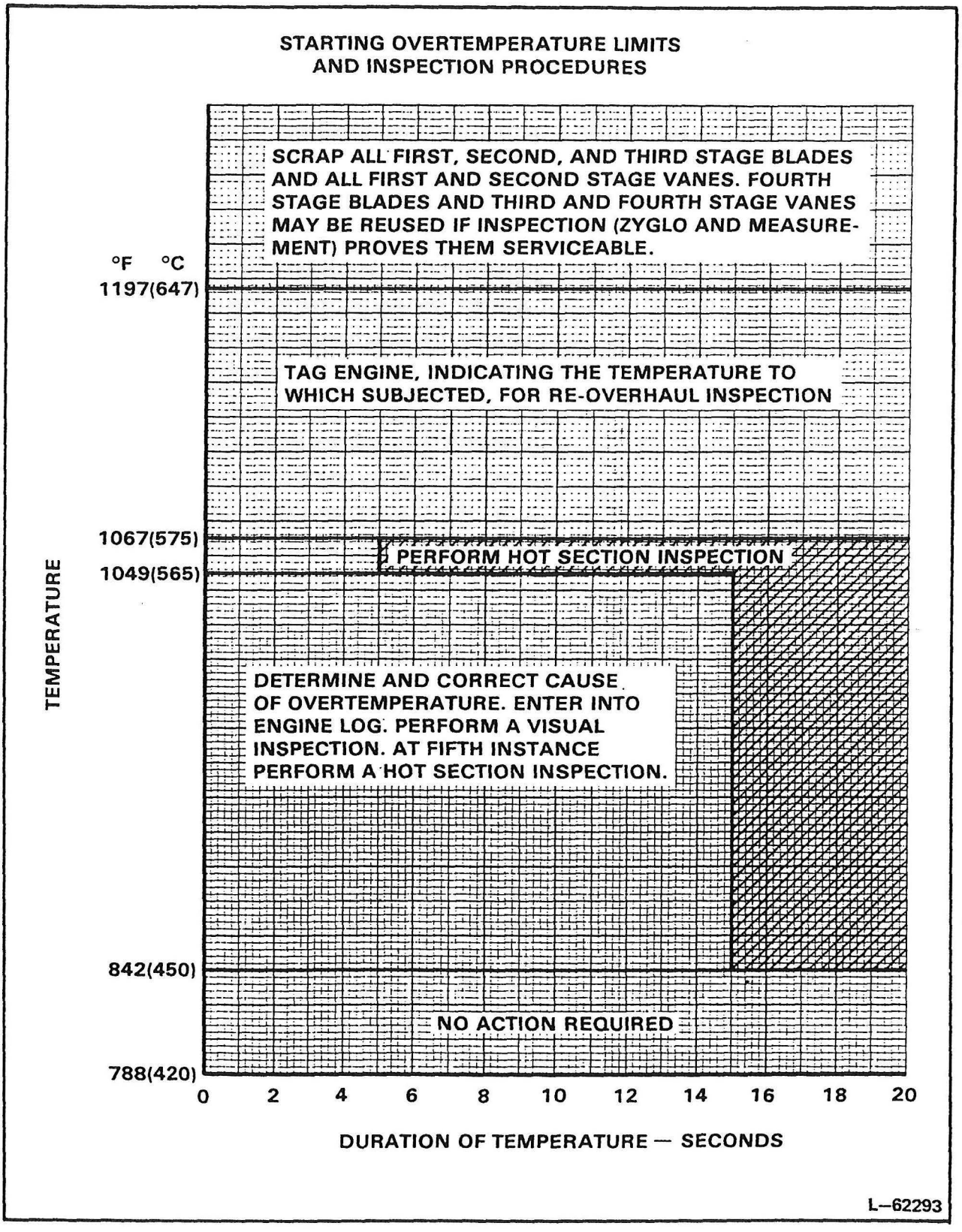
(d) If inspection indicates possible internal damage, all turbine disk and blade assemblies, turbine nozzle guide vanes (all stages) and inner shrouds must be tagged indicating overtemperature to which subjected and giwen complete overhaul inspection.

2. Numerical Tool List

PWA 16765 Wrench
PWA 16766 Wrench

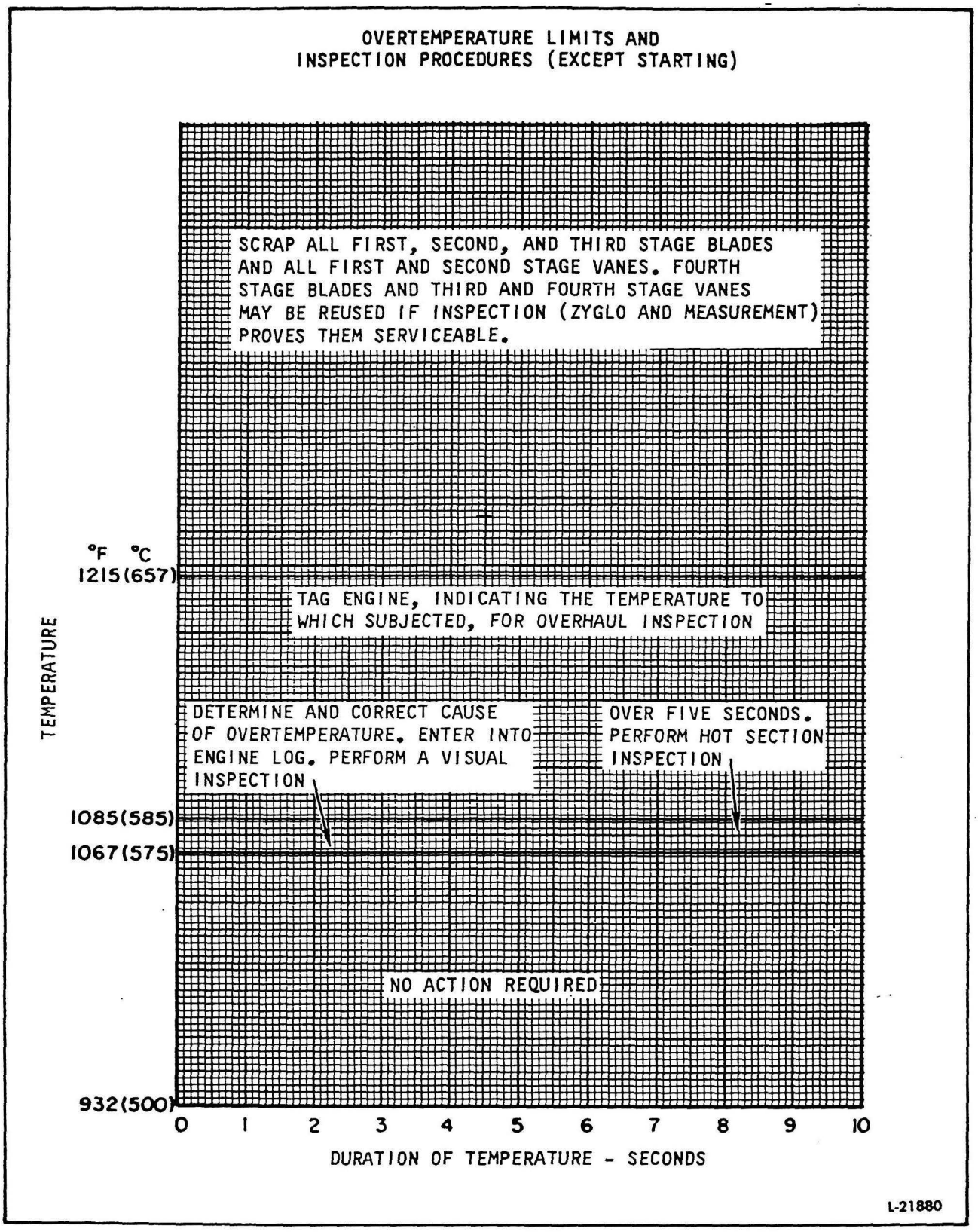


Starting Overtemperature Limits and Inspection Procedure (JT3D-7)
Figure 507

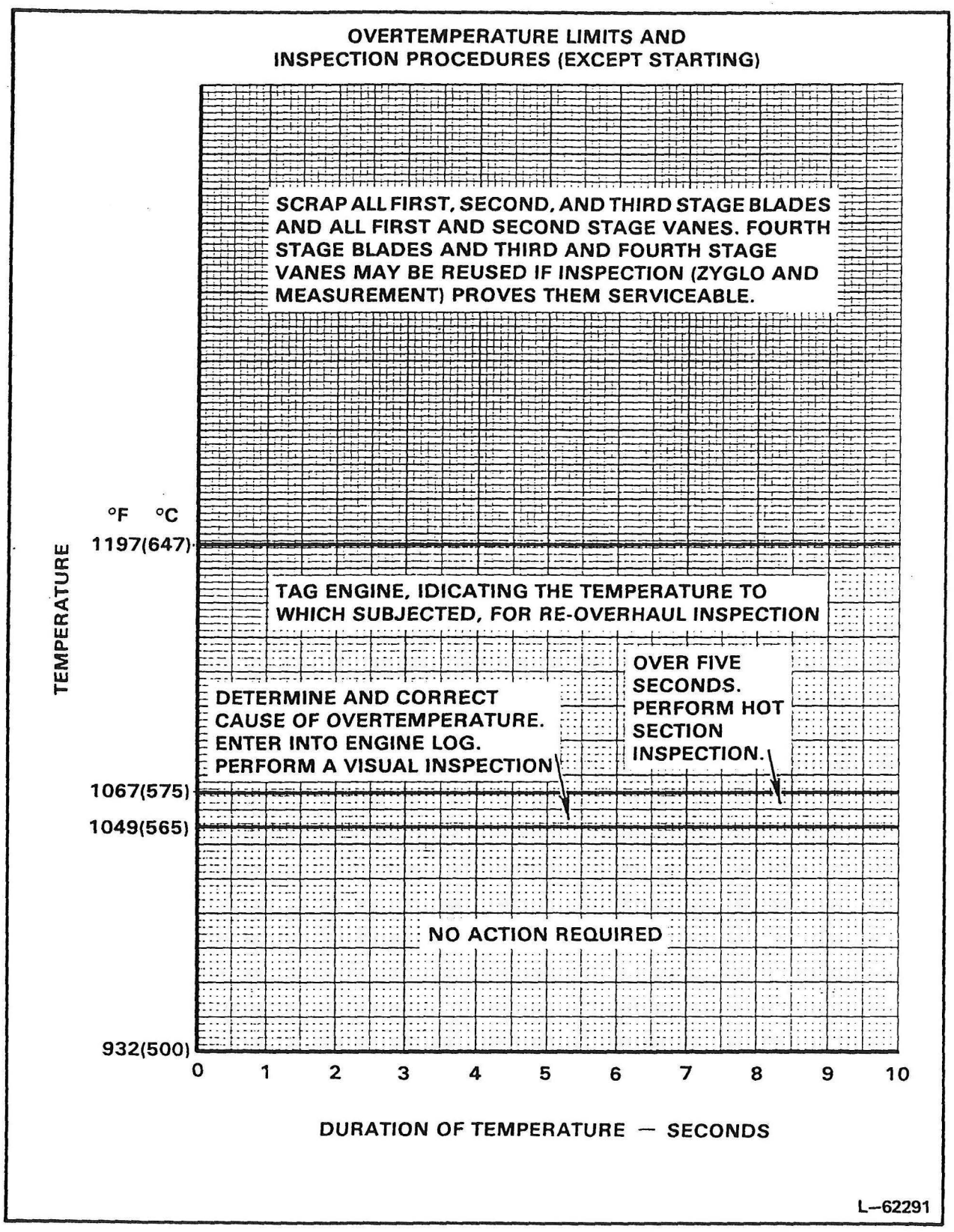


Starting Overtemperature Limits and Inspection Procedure (JT3D-7A)
Figure 507A

R Jun 15/78



Overtemperature Limits and Inspection Procedures (Except Starting) (JT3D-7)
Figure 508



R Overtemperature Limits And Inspection
R Procedures (Except Starting) (JT3D-7A)
R Figure 508A

ENGINE - INSPECTION/CHECK

1. Periodic Inspection

A. General

(1) These inspection procedures are normal function of operating organizations. They consist of required inspections and minor adjustments necessary on engine. Nature and conditions of engine operation determine time interval between required inspections. For this reason, intervals described in Periodic Inspection Chart in this section are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because extensive mass air flow tends to draw foreign objects into engine. Thoroughly clean entire engine compartment with vacuum cleaner after completion of any work. Keep compartment free of dirt, oil, grease, and remove all unused parts such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect exterior of engine without dismantling to ensure that all connections are tight and free from leaks and that lines, tubing, and controls are secure and properly locked.

(4) Check all engine controls for proper operation. Make certain that linkage from cockpit controls to engine units are connected in manner that permits full and free movement with sufficient friction to hold control in required position. See that controls are adjusted to permit overtravel of control lever to ensure full operation of engine unit.

(5) Suitable inlet cowl covers should be used during aircraft towing and at all times when not in service. As soon as engine has cooled sufficiently after operation, suitable exhaust nozzle cover should be installed.

R (6) Service life of certain parts is limited by maximum number
R of hours or cycles. Hours is defined as that accumulated
R time from the moment an aircraft leaves the surface of the
R Earth until it touches it at the next point of landing
R (flight time). In addition to keeping track of operating
R hours, an accurate record of cycles must be maintained.
R A cycle is defined as any flight, consisting of one take-
R off and landing regardless of length of flight and whether
R or not thrust reverser was used on landing. Touch and go
R landing and take-off is included in this definition.

NOTE: **This definition of cycle applies to engines in normal airline usage including moderate amount of routine pilot training. Any extended special usage such as might be incurred by assignment of one aircraft to extensive pilot training use for several months or assignment of any engine to flight test vehicle requires that any throttle changes equal to or greater than idle-to-maximum continuous, inflight or on ground, be recorded as cycle in obtaining total cycles on engine part.**

(7) **Service life of disks is to be limited to maximum accumulated hours or cycles, whichever occurs first. Refer to Overhaul Manual for maximum time or cycles on front compressor front hubs and disks for each engine model. Refer to Section 70-30, Standard Practices Manual, for additional information on service life.**

B. Periodic Inspection Chart

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
ENGINE GENERAL				
External Tubing, Hoses, and Electrical Leads	a. Security of all accessible connections, clamps, and brackets.	x	x	x
	b. Evidence of chafing and wear.	x	x	x
	c. Evidence of fuel or oil leakage.	x	x	x
Engine Mounts	a. Security of installation			x

ENGINE - INSPECTION/CHECK

	COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
			ROUTINE	MINOR	MAJOR
	COMPRESSOR				
	Inlet Guide Vanes	a. Nicks, dents, or other evidence of passage of foreign material.	x	x	x
	Inlet Case Cracks	a. Check for cracks in these locations: (Refer to specific periodic inspection for crack limits).			
		1. Inner Shroud			
		2. Outer Shroud			
		3. Vane-to-shroud welds	x	x	x
R R R R		4. Check for stripped attaching bolt hole threads in rear outer flange.	x	x	x
	Compressor Blade Locks - First Stage Fan	a. Check for looseness. See specific periodic inspection for limits	x	x	x
	Compressor Blade See Figure 601	a. Nicks, dents, or other evidence of passage of foreign material.	x	x	x
	Compressor Vanes See Figure 602 and Fan Discharge Case Struts, See Figure 603	a. Nicks, dents, or other evidence of passage of foreign material.	x	x	x
		b. Case may be used with maximum of 10 cracked struts without repair provided each crack is not over 1/2 inch long and does not extend into fillet area.	x	x	x
	Diffuser Case	a. Check for bulged and discolored areas which betray fuel nozzle or manifold discrepancies.	x	x	x

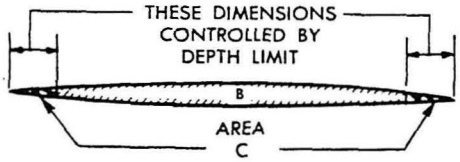
ENGINE - INSPECTION/CHECK

MAXIMUM ALLOWABLE REPAIR LIMITS — INCHES

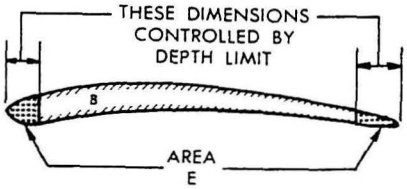
BLADE AREA		STAGES 1 AND 2
	A	3/4 R
	B	1/32 RB
	C	3/8 D
	D	NONE
	E	1/4 D
	F	1/16 D

R — RADIUS D — DEPTH
RB — ROUND BOTTOM

DAMAGE TO THE LEADING EDGE OF THE BLADES WITHIN TWO INCHES OF THE TIP MAY BE BLENDED TO A MAXIMUM DEPTH OF 1/16 INCH FOR A MAXIMUM OF SEVEN BLADES PER ENGINE.



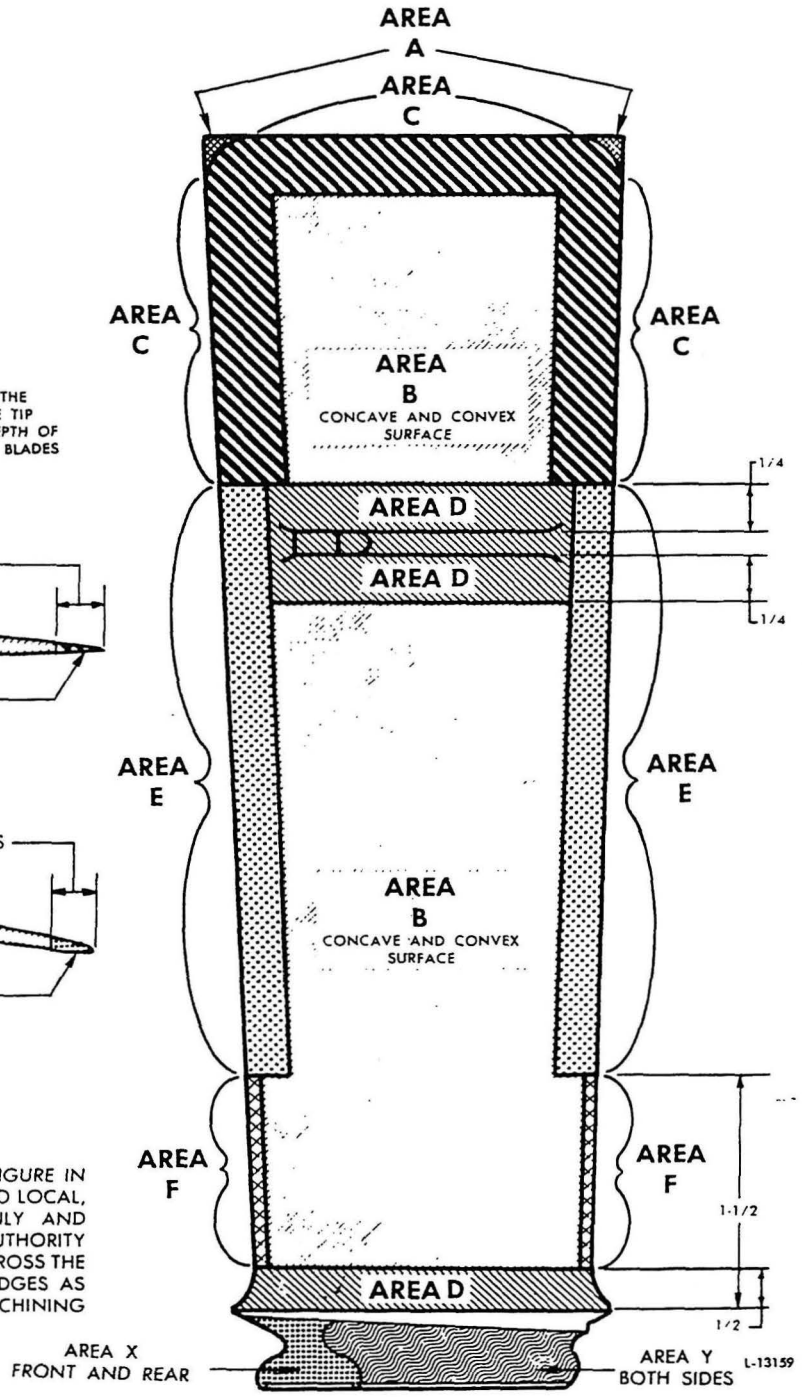
CROSS SECTION OF FAN BLADE ABOVE PART SPAN SHROUD



CROSS SECTION OF FAN BLADE BELOW PART SPAN SHROUD

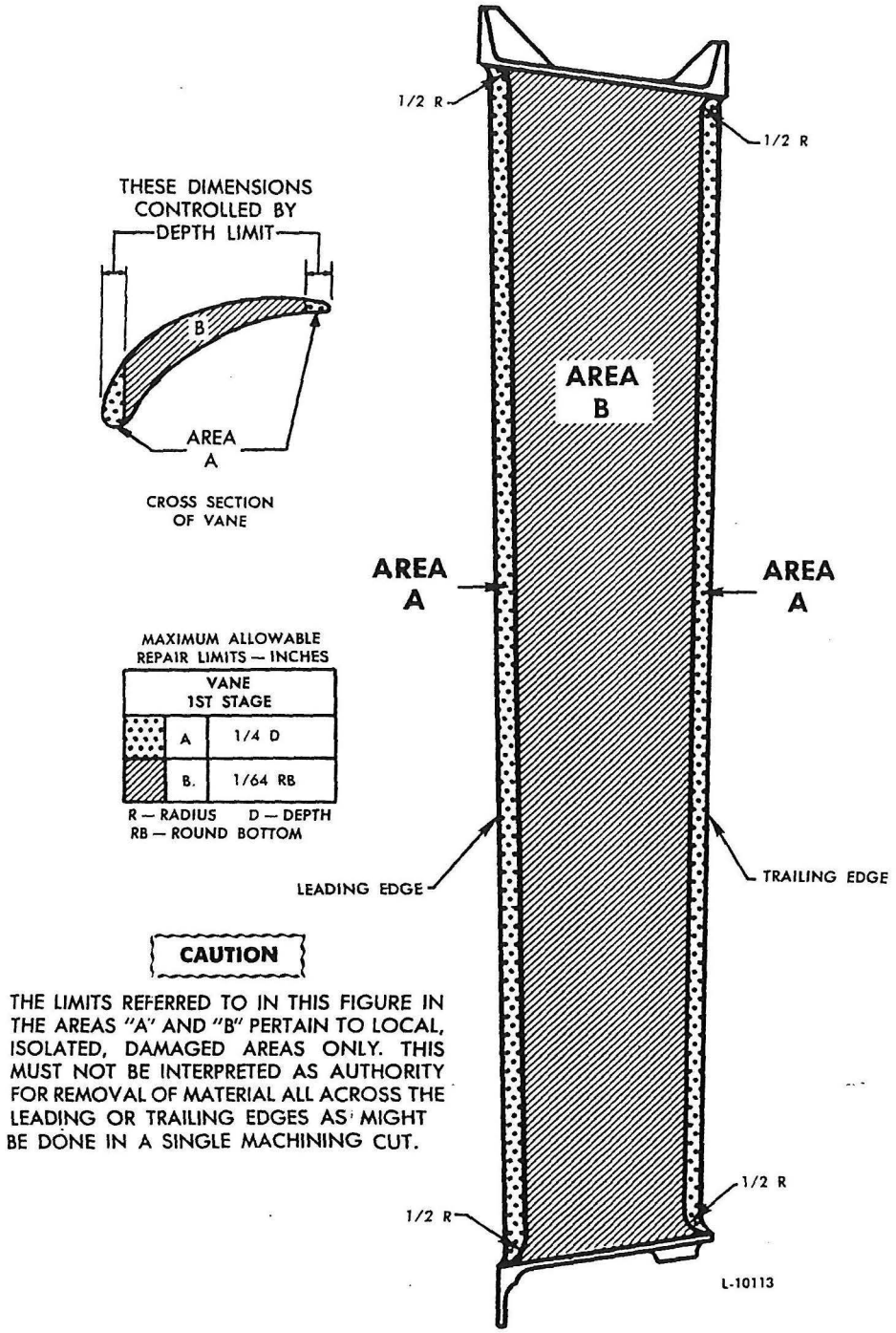
CAUTION

THE LIMITS REFERRED TO IN THIS FIGURE IN AREAS "C", "E" AND "F" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.

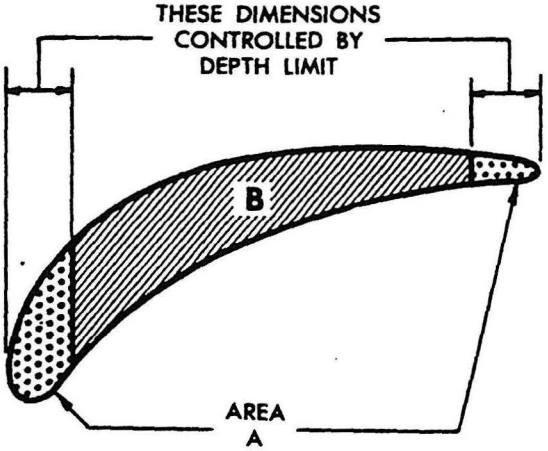


Compressor Fan Blades Inspection and Repair Limits
Figure 601

ENGINE - INSPECTION/CHECK



First Stage Vane Inspection and
Repair Limits
Figure 602



CROSS SECTION
FAN EXIT STRUT

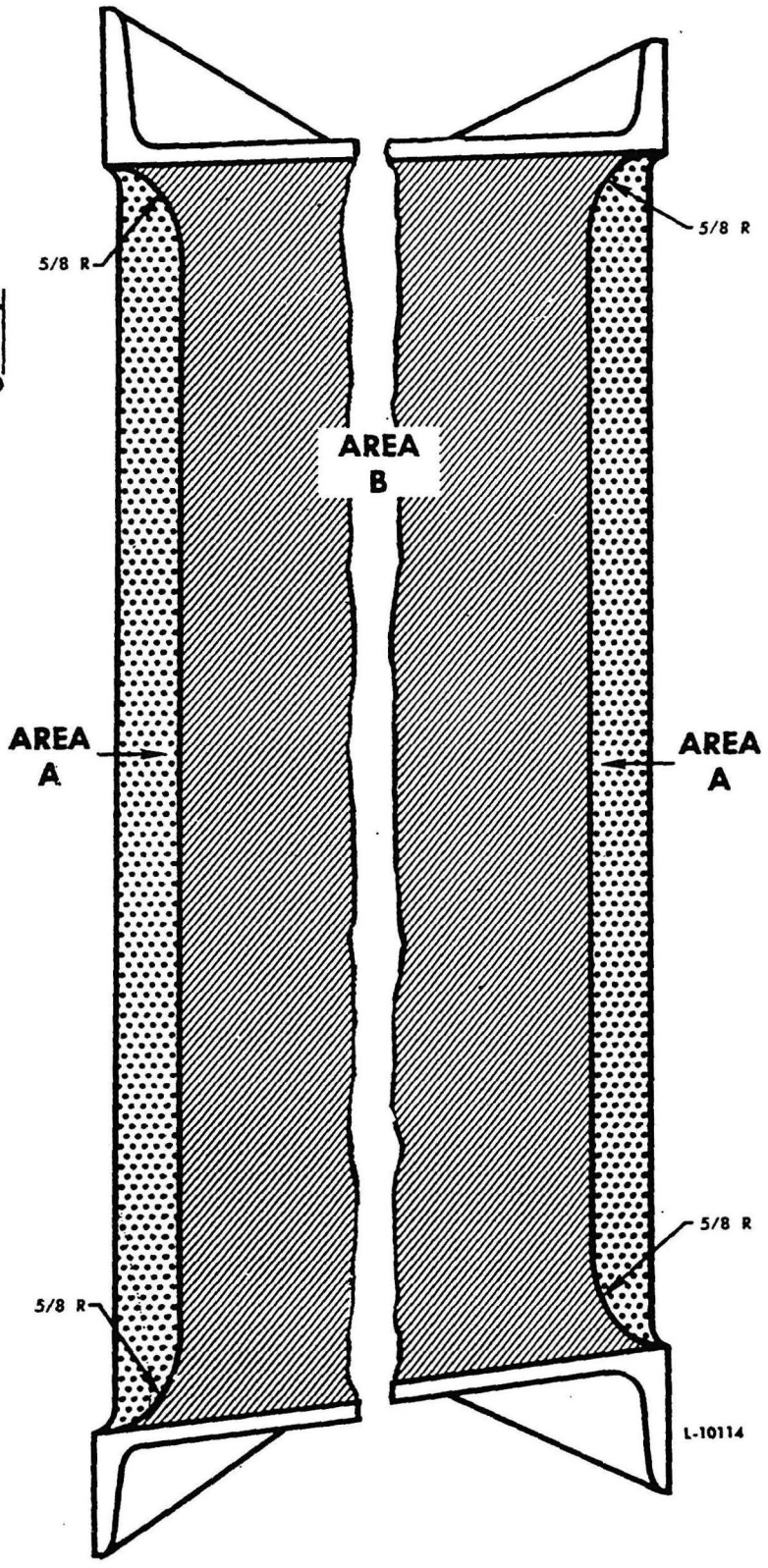
MAXIMUM ALLOWABLE
REPAIR LIMITS — INCHES

VANE FAN EXIT		
	A	5/16 D
	B	1/64 RB

R — RADIUS D — DEPTH
RB — ROUND BOTTOM

CAUTION

THE LIMITS REFERRED TO IN THIS FIGURE IN THE AREAS "A" AND "B" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.



Fan Discharge Case Strut Inspection
and Repair Limits
Figure 603

ENGINE - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
COMBUSTION CHAMBER, TURBINE, AND EXHAUST SECTION				
Combustion Chamber Case	a. Cracks, dents, distortion, and hot spots.	x	x	
Fuel Manifold and Nozzle Assembly	a. Remove assembly and replace with reconditioned unit.			x
R Fireseal	a. Cracks	x	x	
Combustion Chambers	a. Cracks, warpage, and localized overheating.			
	b. Cracked, broken, or worn locating flange lugs.			
	c. Proper positioning of flame cross-over tubes.			
Combustion Chambers Outlet Duct	a. Cracks and deterioration.			
Turbine Case	a. Localized overheating and warpage.		x	
First Stage Turbine Nozzle Guide Vanes	a. Cracks, burning, or impact damage.			
	b. Bowed vanes.			
First Stage Turbine Blades	a. Cracks or warpage.			
	b. Dents, nicks, or other evidence of indicating passage of foreign material. Use strong light.			
Fourth Stage Turbine Blades	a. Cracks or warpage.			
	b. Dents, nicks, or other evidence indicating passage of foreign material.			

ENGINE - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
Fourth Stage	a. Trailing edge for cracks and distortion. Rotate turbine and use strong light.			
Turbine Exhaust Struts	a. Distortion, cracks, nicks, and erosion.			
	b. Evidence of broken strut retaining lugs.		X	
ACCESSORY SECTION				
Acessory and Component Drives Gearbox	a. Check for oil leaks.	X	X	X

CAUTION: DO NOT TURN OR ATTEMPT TO TURN FOUR CASTLE NUTS IN CENTER PORTION OF OIL PUMP ASSEMBLY. THESE NUTS MAY BE LOCKWIRED AND SECURE OIL PUMP THROUGH BOLTS. THESE NUTS MAY BE TIGHTENED ONLY WHEN PUMP IS OUT OF GEARBOX ASSEMBLY.

OIL SYSTEM

R NOTE: There have been reported instances of No. 1
R bearing compartment static oil seepage due
R to residual oil not being scavenged from the
R bearing (No.1) compartment prior to shutdown.
R One way to ensure that excessive residual oil
R is not being left in the bearing compartment
R is to run the engine up to 75 percent power
R prior to shutdown if oil seepage is felt to
R be objectional. However, this run up may
R not always be convenient to perform. In
R this instance the following limits may
R be applied:
R
R a. 10 cc's of oil seepage
R per hour from the No. 1
R Bearing compartment is
R allowable if it is
R inconvenient to run engine
R up to 75 percent power
R prior to shutdown.

ENGINE - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
R OIL SYSTEM (Cont'd) R				
R	b. The 10 cc limit may not be measurable and should diminish over a relatively short period of time after shutdown. The seepage would be considered acceptable if it only wets the surface and does not accumulate into a puddle.			

CAUTION: DO NOT MIX DIFFERENT BRANDS OF OIL WHEN CHANGING OIL OR ADDING OIL BETWEEN CHANGES, SINCE CHEMICAL STRUCTURE OF DIFFERENT BRANDS OF SYNTHETIC OIL MAY DIFFER SUFFICIENTLY TO MAKE THEM INCOMPATIBLE WITH EACH OTHER.

Oil*	a. Check oil level.	X	X	X

NOTE: Oil should be checked and added as required within two hours after shutdown.

*See Paragraph C.

Oil Filter*	a. Metal particles and other foreign matter.		X	X
*See Paragraph C.	b. Damaged screens and spacers.		X	X

ENGINE - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME ROUTINE	MINOR	MAJOR
Oil Filter (Cont'd)	c. Proper installation and leakage.		X	X
	d. Adequate assembly tension (cannot rotate screen element by hand).		X	X
Oil Scavenge Pump Inlet Strainer See Paragraph C. (3). Breather System	a. Metal Particles and other foreign matter.		X	X
Differential Pressure Switch (Delta P). See Sub-paragraph C.	a. Actuation			
Breather System				
Breather Line Connection (Top of Diffuser Case)	a. Remove, clean and reinstall.			X

C. Specific Periodic Inspection

(1) Oil Change

R (a) Oil changes are not required if engine is operated 300 or more flight hours per year. For operation or less then 300 flight hours per year an oil change every six (6) months is recommended. See P&W Service Bulletin No. 238 for approved oils and methods for conversion to another brand of oil.

NOTE: When checking oil level and to facilitate a complete oil drain, engine should be operated for at least one minute at idle speed to assure that any oil which may be in the scavenge section of the engine is returned to the oil tank. When draining oil immediately after shutdown, it is only necessary to drain the oil tank to effect a complete oil change. Unlimited lapse of time between shutdown and oil drainage is permitted providing oil is drained from the N2 gearbox in addition to the oil tank.

R

(2) Main Oil Strainer

(a) Remove main oil strainer for inspection at every oil change and/or when any excessive vibration is experienced (over limits) or when any erractic change to oil pressure is noted (below 30 or above 55 PSIG).

NOTE: Main oil strainer inspection frequency shall not exceed 500 hours regardless of oil change frequency.

(b) Perform following procedure if few finely divided metal particles are found at first strainer check after installation of new or newly overhauled engine:

NOTE: Discovery of fine metal particles is not uncommon and is not normally cause for concern.

Clean and reinstall strainer.

Operate engine for at least ten minutes but not more than 20 minutes; then recheck strainer.

If there is no increase in quantity of metal particles, engine may be returned to service.

(c) When metal is found in oil strainer during routine inspection, strainer shall be cleaned or replaced and engine ground run at part power setting. Engine should be accelerated from idle to part power stop five times, then run at part power for approximately 20 minutes. Recheck strainer and, if clean, engine is ready for service. Check strainer after approximately 50 hours of operation.

NOTE: The 20 minute part power run may be reduced to 10 minutes, if desired, or to comply with airport noise regulations.

ENGINE - INSPECTION/CHECK

(d) Any engine not incorporating main oil strainer by-pass system that has been partially dissassembled to extent of exposing any bearing compartment except No. 1 bearing, must have main oil screen disassembled, inspected, and cleaned at periods not to exceed 12 hours. Screen checks will be continued until screen is free of contamination for two successive inspections.

CAUTION: IF CONTAMINANTS INDICATE ENGINE PART FAILURE OR CONTAMINANTS IN SUFFICIENT QUANTITY TO PLUG OIL SCREEN, ENGINE MUST NOT BE OPERATED UNTIL CAUSE OF DIFFICULTY HAS BEEN DETERMINED AND CORRECTED.

(3) Oil Scavenge Pump Inlet Strainer

(a) Check scavenge pump inlet strainer after installing new, repaired or overhauled engine. If strainer is clean, no further action is required. If strainer is contaminated, clean it, replace and check as for main oil strainer. See Paragraph C. (2) (b).

(b) There is no further need to inspect this strainer unless main oil strainer is found contaminated in which case perform above.

(4) Check differential pressure switch for actuation. Warning light should turn on at 50 ± 1.5 psi and should remain on as long as differential pressure is 50 ± 1.5 psi or greater.

R (4a) Fan Discharge Case Strut - Cracks
R
R (a) Fan discharge case struts with cracks exceeding limits
R specified in Periodic Inspection Chart may be continued
R in operation for a period not to exceed 150 hours
R provided cracks are not of a converging nature or could
R possibly liberate pieces, and only one crack per strut.
R
R (5) Inlet Case Cracks - Limits of Acceptability.
R
R NOTE: An inlet case with cracks exceeding limits of
R acceptability may be continued in operation for a
R period not to exceed 150 hours, provided cracks
R are not of a converging nature or could possibly
R liberate pieces.

ENGINE - INSPECTION/CHECK

R (a) If a crack in excess of one inch in outer surface of inner shroud is noted at inspection, it will be necessary to examine welds at inner end of inlet vanes and inner shroud flange to assure that inner end of vane is not breaking loose from inner shroud. This examination of inner surface of inlet case inner shroud can be made by looking through anti-icing holes in No. 1 bearing support web.

NOTE: Multiple cracks which indicate possible joining in such a manner so as to permit piece of shroud to enter inlet airstream, are not acceptable.

(b) For cracks running adjacent to weld bead and transversing weld bead, inlet case must be removed and cracks weld repaired. See Index 1, Figure 604.

NOTE: If type of crack noted above is found at a remote line station, periodic inspection must be made until aircraft returns to a station capable of repairing case.

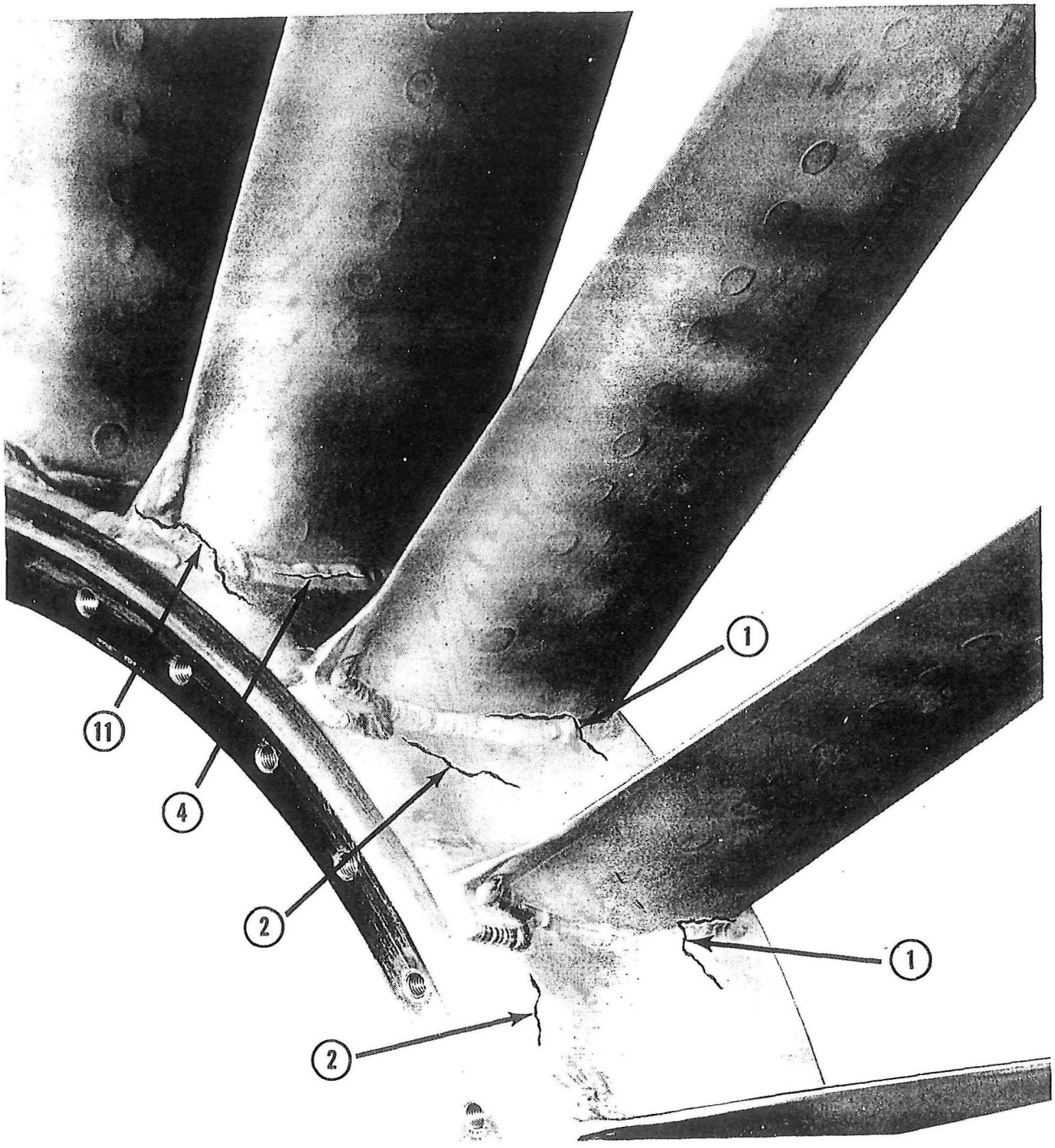
(c) Cracks in outer shroud inner box and innner shroud outer box (Index 2, Figure 604) are acceptable up to three inches in length if wholly contained in shroud skin and are not associated with cracks originating in vane skin at leading or trailing edges. These cracks are not to be of a converging nature. No more than three cracks are permitted in any 90 degree segment.

(d) Cracks in inner and outer vane end welds adjacent to vane skin (Index 3, Figure 605) are to be repaired when aircraft returns to maintenance station capable of making such repairs.

(e) Cracks in vane to shroud welds proper (Index 4, 13, Figures 604, 605) are acceptable up to three inches maximum in 50 percent of vanes.

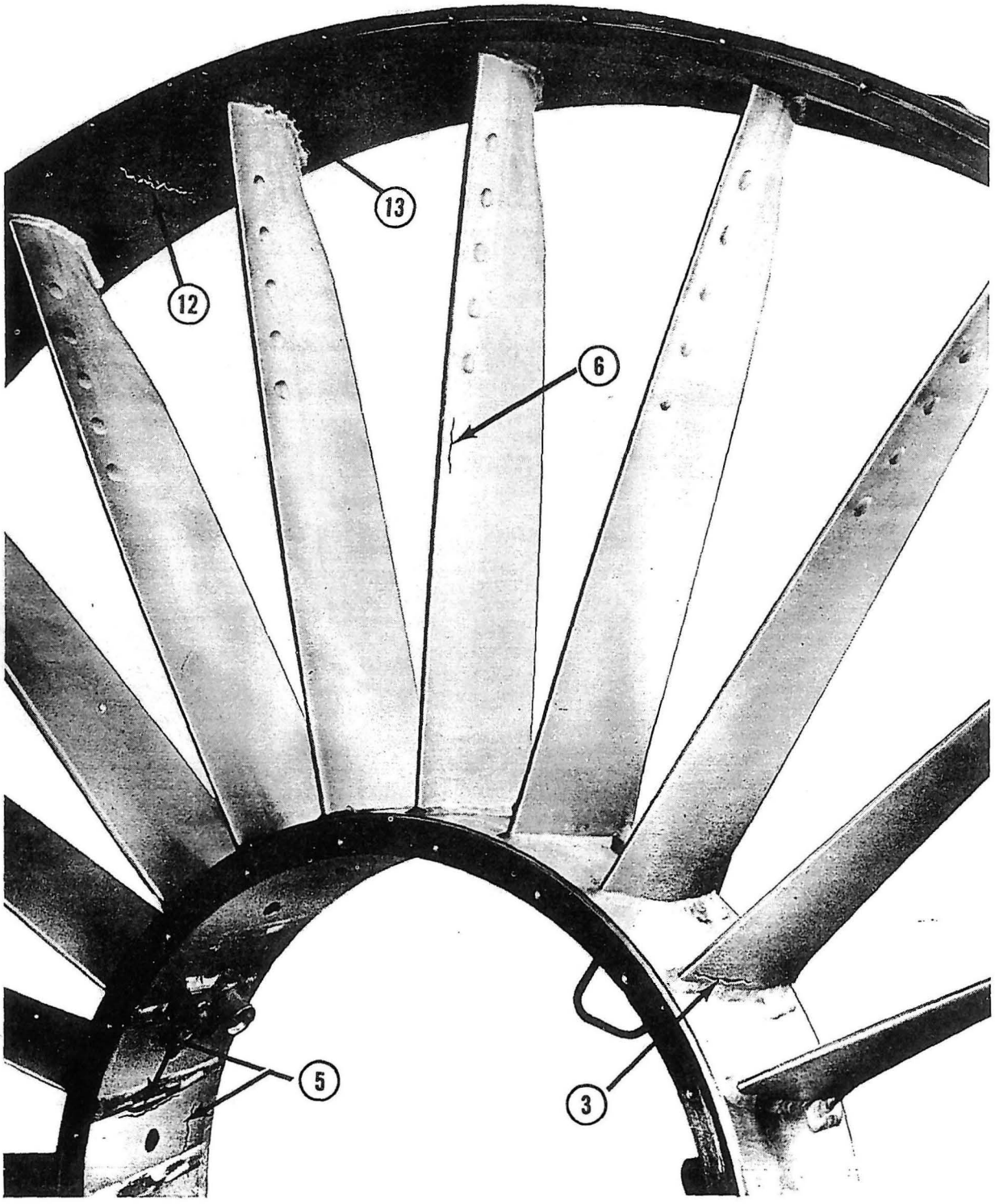
(f) Cracks in inner box segment (Index 5, Figure 605) are acceptable up to three inches maximum. These cracks must not be of a converging nature.

ENGINE - INSPECTION/CHECK



Inlet Case Crack Limits
Figure 604

ENGINE - INSPECTION/CHECK



Inlet Case Crack Limits
Figure 605

R (g) Cracks in outer surface of outer shroud are acceptable up to three inches maximum (Index 9, Figure 606). Cracks in weld around outer shroud brace (tea cup) are acceptable up to one inch maximum. See Index 7, Figure 606. A crack which extends from tea cup is acceptable if total length is less than three inches and length of crack around tea cup is less than one inch. These cracks are not to be of a converging nature.

(h) Cracks in weld bead at vane covers and/or shroud to vane (Index 8, Figure 606) are acceptable up to three inches maximum.

(i) Cracks in weld bead around various bosses in outer shroud (Index 10, Figure 606) are acceptable up to 180 degrees around boss leg.

(j) Cracks progressing into fin (Index 11, Figure 604) are not acceptable. These cracks must be weld repaired.

(k) Cracks are acceptable up to three inches long if wholly contained in shroud skin. See Index 12, Figure 605. A maximum of three cracks up to three inches long in any 90 degree sector are acceptable provided there is no convergence of cracks.

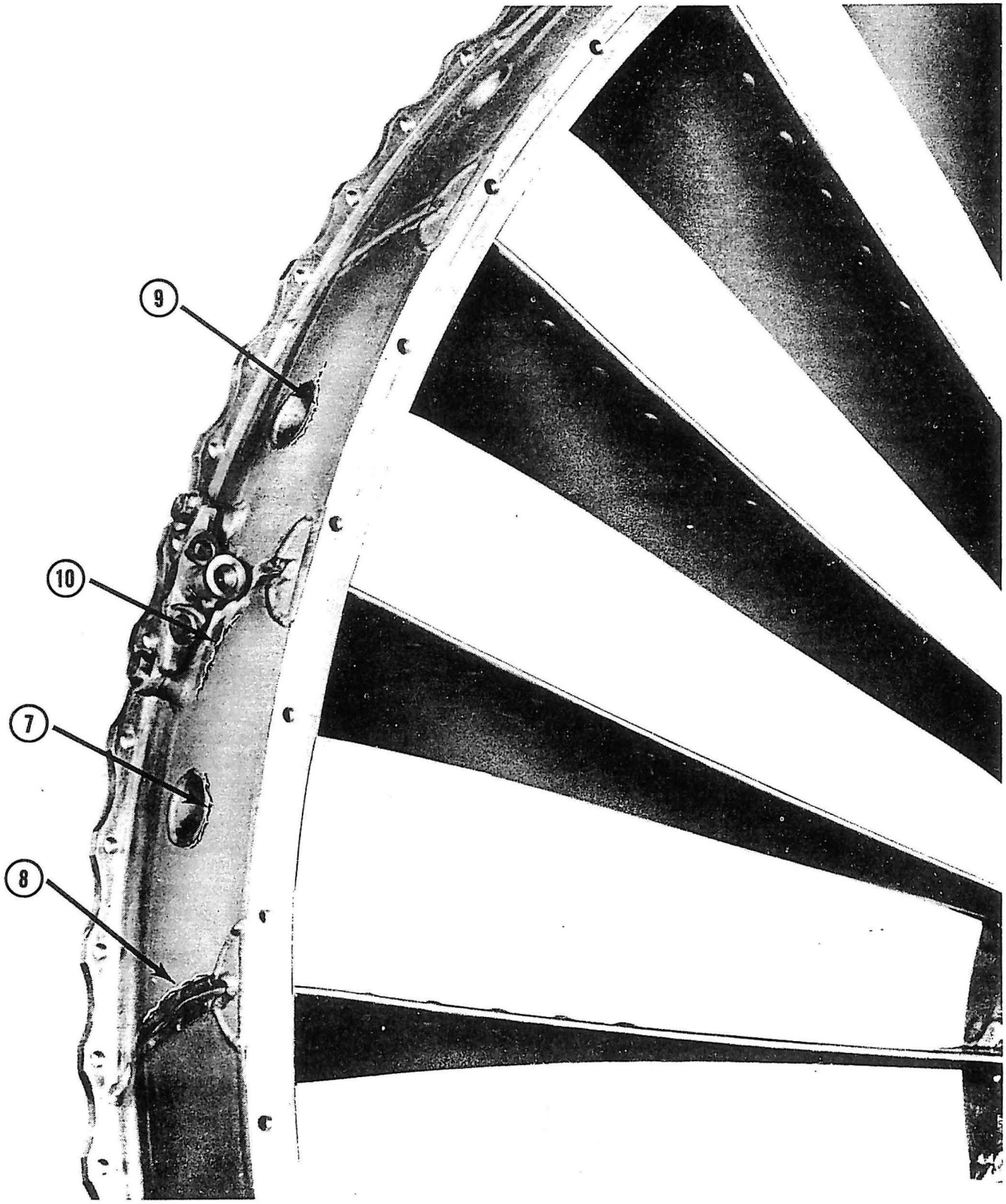
(5a) Inlet Case Vane - Mylar Tape Repair. Crack in vane skin (Index 1, 3, 6, Figure 604, 605) up to five inches in length and which are not of a converging nature, are permissible provided a temporary repair using Mylar tape is incorporated using following procedures.

(a) Stop drill both ends cracks.

NOTE: Exercise extreme care on vanes incorporating oil tubes.

(b) Clean area to be taped by scrubbing with stiff bristle brush using acetone or methyl ethyl ketone.

(c) Wipe dry with clean cloth to remove all residue.



Inlet Case Crack Limits
Figure 606

R (d) Wrap area of crack with Mylar tape but do not overlap tape.

NOTE: Mylar tape is available from Bordon Chemical Co., Mystic Tape Division, Northfield, ILL 60093 or Markem Machine Co., 150 Congress St., Keene, NH.

(e) Monitor crack progression every 10 aircraft hours.

NOTE: An inlet case with this repair may be continued in service until aircraft returns to a maintenance base capable of making permanent repairs or for a period of 50 aircraft hours, whichever first occurs.

(5b) Inlet Case Rear Flange Bolthole Threads. Check rear outer flange for stripped attached bolt hole threads. Repair stripped threads per Section 72-00, Engine - Approved Repair.

(5c) Inlet Guide Vanes Incorporating Heat Sensitive Paint. To Provide a method of detecting failed anit-icing regulators, selected vanes have been spot painted with heat sensitive paint, Initial color of paint is white.

(a) Inspect painted vanes. An ivory color indicates anti-icing system operating at approximately 302°F (150°C).

(b) Painted vanes with yellow color indicates anti-icing system operating at approximately 347°F (175°C).

(c) Failed anti-icing regulators result in elevated inlet guide vane temperatures which can be detrimental to life of vane filler material. Under normal operating conditions, inlet guide vane temperature should not exceed 302°F (150°c) during anti-icing system use. The existance of a yellow color suggest a malfunction of regulator valve and should be tagged for inspection, repair or possible replacement.

(6) First Stage Fan Blade Shift (Loose Lock).

NOTE: This procedure is applicable to "bat wing" type blade locks PN 512978 and 596216 only. PN 430242 and 478174 locks should no longer be used. See SB 1076, 3755.

(a) Blades found shifted forward up to 0.250 inch may be continued-in-service for additional 50 hours provided that existing on wing inspection/repair criteria is satisfied and blade locks can be rebent to provide acceptable restraint.

(b) Blades found shifted forward in excess of 0.250 inch must be removed from service immediately.

(c) The affected and adjacent blades/hub blade slots in rotors in which forward blade movement has occurred should be visually and fluorescent inspected and repaired to overhaul manual requirements prior to return to service.

(7) First Stage Fan Blade On Wing Repair And Flyback Limits

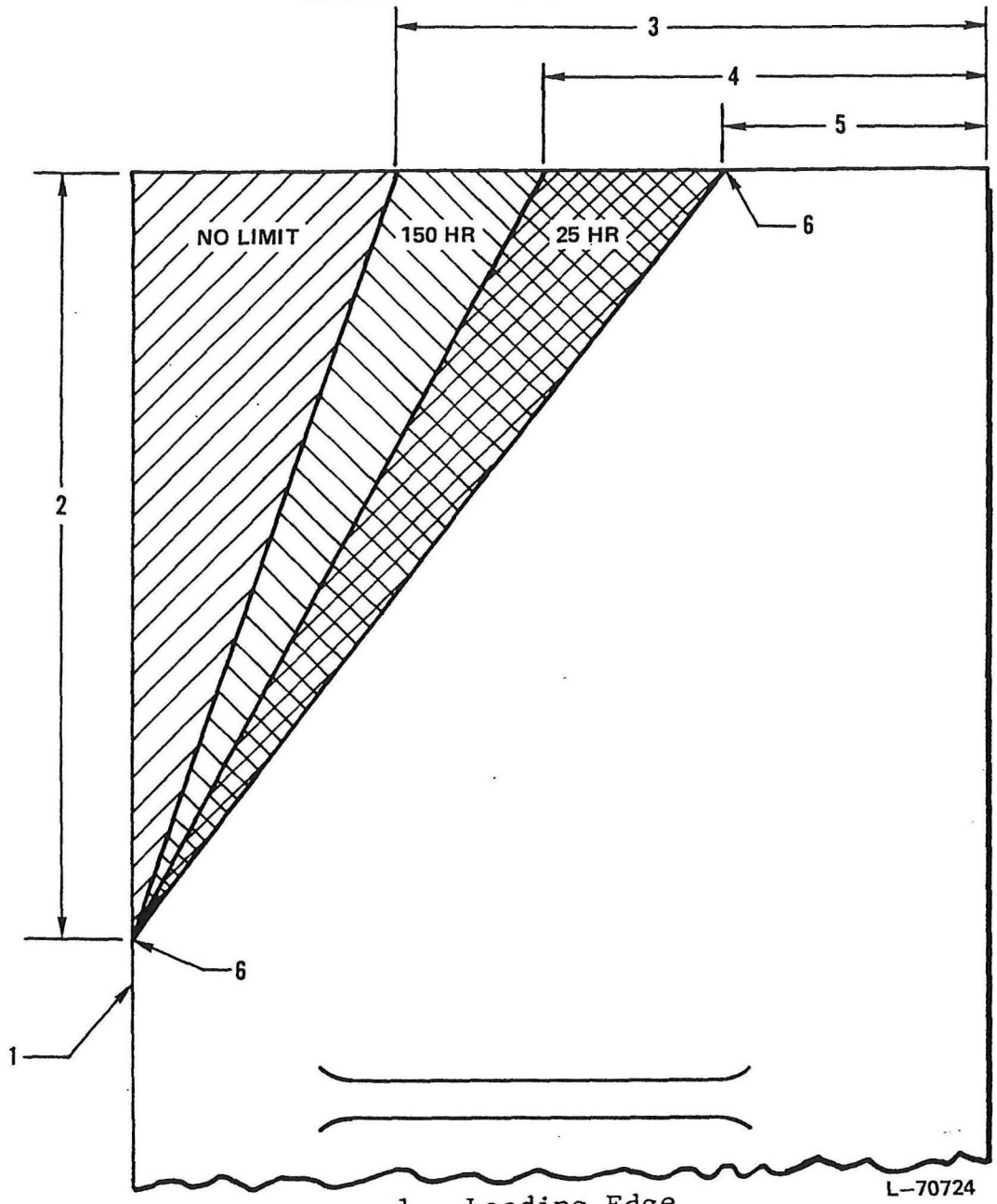
(a) First stage fan blades which have foreign object damage in excess of inspection and repair limits shown in Figure 601 may be continued in service, provided repair indicated in Figure 607 has been performed.

NOTE: Refer to Approved Repair section for repair procedure.

R (b) Inspect repair area with portable fluorescent penetrant. No cracks, tears, or sharp bottom nicks are permitted after repair.

R NOTE: If a blade, blended at a facility which does not
R have FPI capability, has no visible crack, it may
R continue-in-service for up to 50 hours after
R blending, or until the engine is at a maintenance
R facility where the FPI can conveniently be accom-
R plished, whichever occurs first. Other inspection
R or flyback limits for this blade of less than
R 50 hours cannot be exceeded.

(c) Do not repair more than a total of 6 blades per rotor to any cut or combination of cuts in Figure 607. Reworked blades may be adjacent or scattered throughout the rotor assembly. However, any individual blade incorporating the dimensions of either the 25 or 150 hour cut-back will restrict the time on that rotor to 25 or 150 hours as applicable.



1. Leading Edge
2. 4.50 Inches
3. 3.35 Inches
4. 2.50 Inches
5. 1.50 Inches
6. Smooth Blend

First Stage Fan Blade On Wing
Repair And Flyback Limits
Figure 607

ENGINE - INSPECTION/CHECK

R R R R (d) After any fod, either repaired or non repaired, all limits are valid only if continued use of damaged blades does not cause excessive imbalance of vibration during engine operation.

(e) Shingled blades (blades whose mid-span shrouds have overlapped due to foreign object ingestion) must be unshingled and may be continued in service for maximum of 20 hours if following conditions are met:

1 Shingled blades must be unshingled without further damage.

2 Visual inspection must confirm that mid-span shroud of shingled blade has not hit airfold of adjacent blade or radius between airfold and mid-span shroud of adjacent blade. Blades showing evidence of having been hit in this manner should be removed from service before further flight.

3 After 20 hour limit, shingled compressor blades should be removed and inspected for damage, cracks, and airfold displacement (bow). Refer to Overhaul Manual.

R R R R (7a) Ultrasonic inspection first stage fan blades for cracks in convex airfold-to-platform fillet radius near trailing edge per Alert Service Bulletin 5136 and time cycle given in Section V, Time Limits of overhaul manual.

(8) Turbine Blade Shroud Notch Wear Check (Broomstick Check)

(a) Check for blade looseness at intervals compatible with periodic aircraft checks. Excessive shroud notch wear can result in blade looseness and failure.

(b) Attach short length of rubber hose to wood pole or broomstick of sufficient length to reach fourth stage turbine blades through exhaust nozzle.

ENGINE - INSPECTION/CHECK

CAUTION: TO REDUCE POSSIBILITY OF BLADE SHROUD NOTCH DISENGAGEMENT, DO NOT USE POLE OR HOSE ATTACHEMENT TO ROTATE TURBINE.

(c) When engine is cold, press short length of hose lightly against turbine blades and rotate front compressor by hand in normal direction of rotation to produce strumming action of hose against blades.

(d) If blade rattling is noticed, blade looseness is evident and 4th stage turbine disk and blade assembly must be removed. Replace disk and blade assembly with an assembly containing blades with tight notches.

(9) Inspect and recondition fuel manifolds and nozzles per Section 73-5-1.

(10) First Stage Fan Blade Bow Check

(a) Place straight edge on convex surface of airfoil above midspan shroud approximately at center of airfold chord and perpendicular to blade root center plane.

(b) Maximum bow is then defined as no more than 1/8 inch gap between blade surface and straight edge at any point.

(c) No appreciable bow is allowed for 2nd stage fan blade.

2. Seventh Stage Disk - Front Compressor Rear Hub - Crack Inspection

R A. Inspection Requirements

R (1) All engines incorporating thin web seventh stage disks and thin flange front compressor rear hubs must be inspected with specified equipment per procedures outlined in this section and with Table I.

R (a) After rework per SB 1671 for disk and SB 1671R2 or subsequent for hub, follow-on eddy-current or wink zyglo inspection for JT3D-7 engines is 4000 cycles for disk and 3000 cycles for hub. These follow-on inspections are good only once. Subsequent repetitive on-the-wing or bench inspection must be performed every 1000 cycles there after.

ENGINE - INSPECTION/CHECK

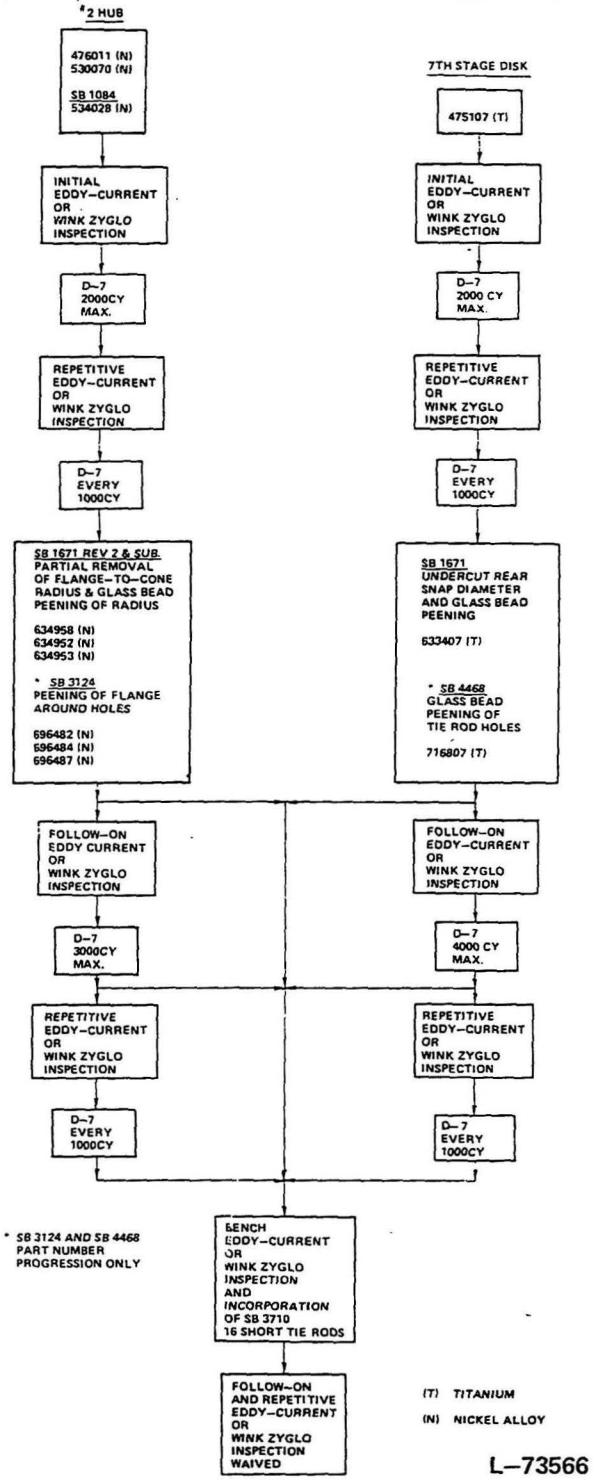


Table I

ENGINE - INSPECTION/CHECK

R (b) After rework per SB 1671 for disk and SB 1671R2 or
R subsequent for hub, bench eddy-current or wink zyglo
R inspection, and incorporation of SB 3710 (16 short
R tierods), follow-on and repetitive inspections are
R waived.
R
R (2) All engines incorporating thick web disks, PN 635498,
R 716707, 719407, 726907 and thick flange hubs, PN 635498
R 753528, are exempt from this inspection.
R
R (3) Inspection will be accomplished with use of eddy-currents
R and access to areas to be inspected may be gained by
R removing front accessory case cover, number one bearing
R inner race retaining nut and front accessory drive gear.
R
R NOTE: Engines which incorporate front accesory drivegear
R held by retaining ring (Reference SB 3701) do not
R require removal of inner race retaining nut.
R Compress retaining ring and remove gear to gain
R access to inside of rotor.

ENGINE - INSPECTION/CHECK

B. Equipment Required

(1) Magnaflux ED 500 series instrument or equivalent.

(2) PWA 30458, seventh stage compressor disk inspection tool.

(3) PWA 30518, front compressor rear hub inspection tool.

C. Equipment Operating Procedures for Front Compressor Rear Hub

(1) Connect PWA 30518 Inspection Tool to instrument. Turn instrument "ON" and allow 15 minutes minimum for warm up.

NOTE: Remove covering tape from end of probe prior to use in testing.

(2) Set "FREQUENCY" control to "0", highest frequency. Turn "SENSITIVITY" control to medium. Turn "BALANCE" control as required to obtain on scale readings.

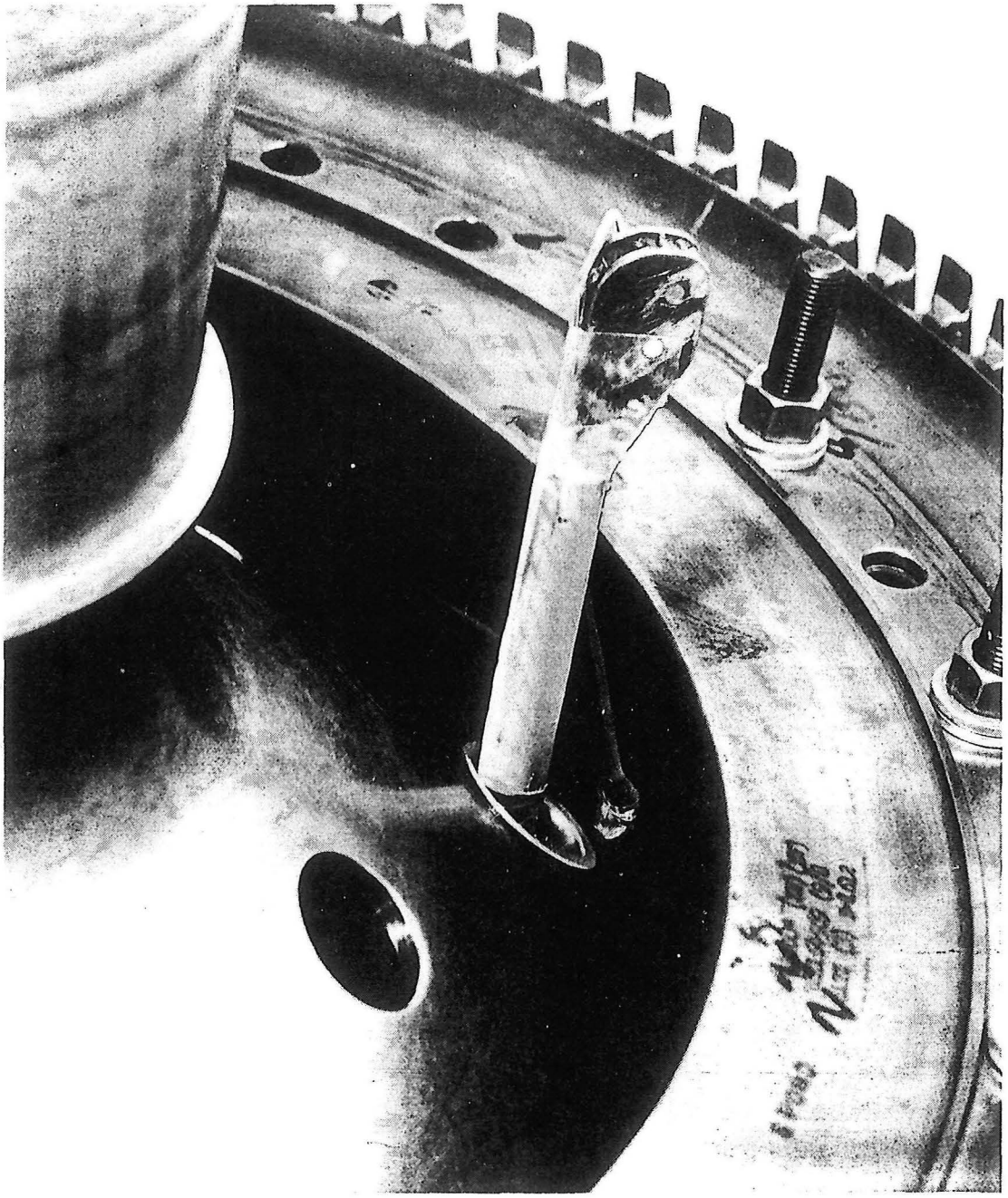
(3) Using portable light, locate lightening/counterweight hole (outer holes in conical section) of hub which is located near or at bottom of hub. See Figure 608.

CAUTION: EXERCISE EXTREME CAUTION TO PRECLUDE DAMAGE TO INSPECTION EQUIPMENT.

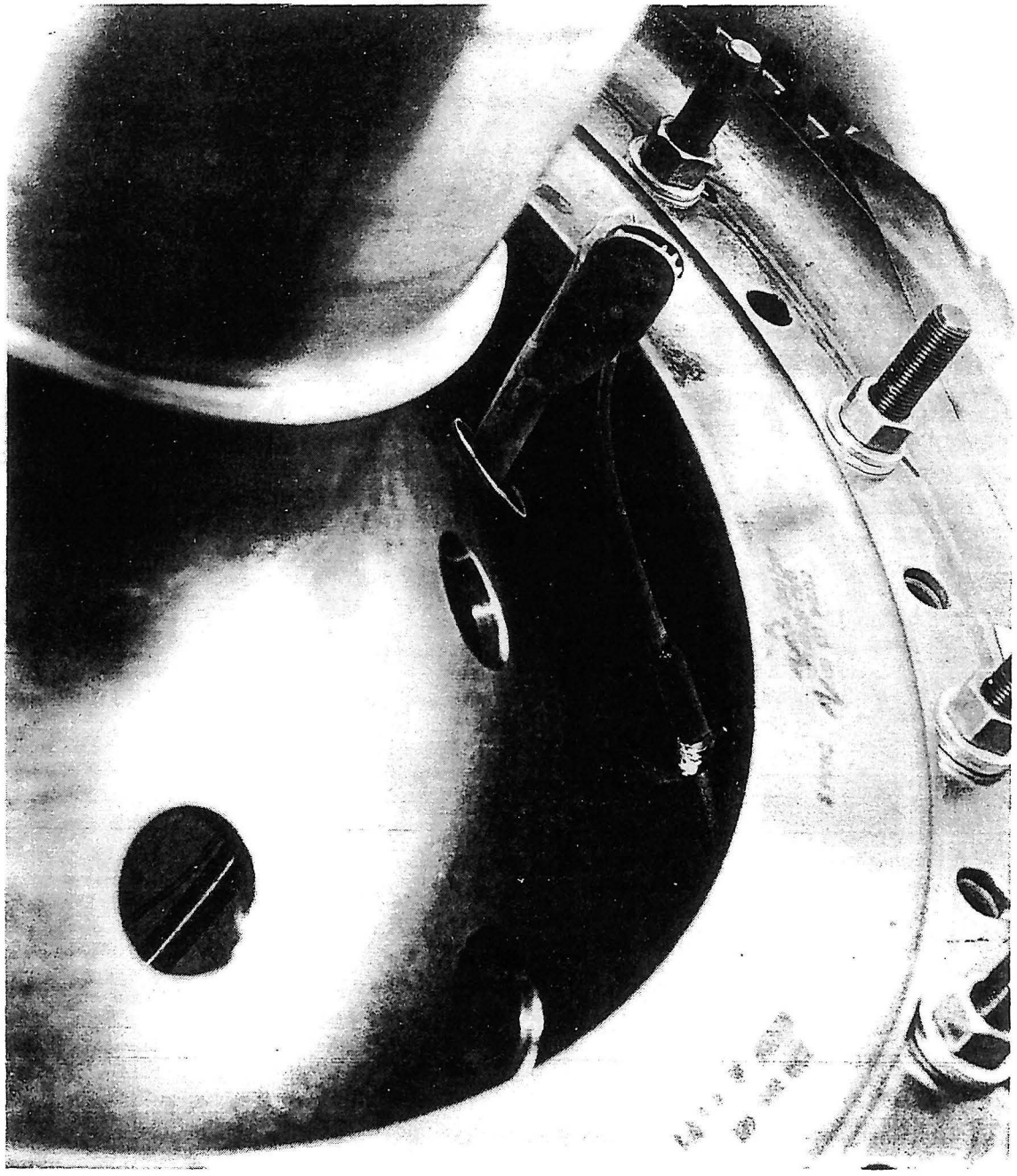
(4) Insert inspection tool through bore or No. 1 hub and lightening/counterweight hole.

(5) Pull trigger on tool handle to release eddy current probe head enough to rest probe head against conical section of rear side of hub. There should be no pressure on trigger once probe head has been positioned against hub.

(6) Cautiously extract tool toward front of engine until probe head has positioned itself in hub flange-bell-blend radius which is inboard of No. 7 - No. 8 rotor space flange ID. See Figure 609.



Probe Head Following Conical
Section of Hub (Rear Side)
Figure 608



Probe Head in Small Radius
of Hub (Rear Side)
Figure 609

(7) While observing micro-ampere meter, rotate tool and scan radius in both directions. Meter will indicate large deflections toward zero as probe passes tierod holes. These deflections may be standardized to -100 units by careful frequency selection.

(8) Select proper frequency.

(a) Turn "LIFTOFF" control to about 240 and repeat step (7).

(b) Continue adjusting "LIFTOFF" and "BALANCE" controls until a point is reached where tierod bolt proximity causes down scale meter deflection of 100 units. Tierod bolt effect should be no greater than 20 micro-ampere deflection toward zero. "FREQUENCY" control should be in No. 2 or No. 3 position.

(c) Release forward pressure on tool and carefully push toward rear of engine until probe head assumes a hozizontal position, and extract from lightening/counterweight hole.

(d) Extract tool from inside of engine through bore of No. 1 hub.

(e) Crack deflection definition of +150 units may be observed using a simulated cracked test piece.

(f) Instrument is now ready for inspection of hub radius.

D. Inspection of Front Compressor Rear Hub

(1) Repeat step C(3), except mark first hole that is being used for inspection with Magic Marker, to aid in determining starter point of inspection. Also repeat steps C(4), C(5) and C(6).

(2) Rotate probe slowly from one extreme to another and observe the meter for up scale deflection. Entire travel of probe head is approximately four inches. Indication of a crack will be noted on the meter up-scale when 100 micro-amperes or more are observed.

(3) Repeat steps C(8) (c) and C(8) (d).

(4) Repeat steps C(3), C(4), C(5), C(6) and C(8)(c) and inspect entire circumference of hub flange-bell-radius through remaining five lightening/counterweight holes.

(5) Crack indication(s) will require removal of engine from aircraft and disassembly to confirm indication(s).

ENGINE - INSPECTION/CHECK

E. Equipment Required (Alternate)

NOTE: Eddy current inspection of front compressor rear hub incorporating Ideal Specialty Company PN 6113 probe tip or PN 6123 arm and head assembly.

(1) Magnaflux ED 520 series instrument.

(2) PWA 30518 Inspection Tool or equivalent.

R

F. Equipment Operating Procedures

(1) Connect inspection tool to instrument. Turn instrument "ON" and allow to warm up for minimum of 15 minutes.

(2) Set "FREQUENCY CONTROL" to position 1,000, lowest frequency. Turn "SENSITIVITY" control to Hi.

(3) Place probe on hub crack standard and rotate "Balance Control" to bring meter to mid-scale.

(4) Slowly pass probe over crack and note meter deflection.

(5) Turn "FREQUENCY CONTROL" to lower position and repeat steps (3) and (4).

(6) Continue turning "FREQUENCY CONTROL" and checking hub crack standard until a position is found which gives maximum meter deflection in an up-scale direction. This should occur at frequency setting of approximately 600-800. Meter deflection should be at least 100 micro-amperes in up-scale direction.

(7) If no hub crack standard available:

(a) Starting at 1,000 frequency setting, lift off compensate on hub to be inspected.

(b) Remove probe from engine and place on PWA crack standard. Meter deflection should be at least 100 micro-amperes in up up-scale direction.

R ENGINE - INSPECTION/CHECK

R (c) If standard crack does not produce 100 micro-amperes, a
R hub standard must be obtained for system calibration.

R (8) Using external lighting (flashlight, drop-cord, etc.)
R locate a lightening/counterweight hole (outer holes in
R conical section) of hub which is located near or at the
R bottom of hub.

R (9) Insert inspection tool through bore of No. 1 hub and
R lightening/counterweight hole. Extreme caution should be
R exercised to preclude damage to inspection equipment.

R (10) Pull trigger on tool handle to release eddy current probe
R head enough to rest probe head against conical section of
R rear side of hub. There should be no pressure on trigger
R once probe head has been positioned against hub.

R (11) Cautiously extract tool toward front of engine until probe
R head has positioned itself in the hub flange-bell-blend
R radius which is inboard of #7-#8 rotor spacer flange I.D.

R (12) Rotate "BALANCE CONTROL" to bring meter to mid-scale.

R (13) The instrument is now ready for inspection of hub radius.

R G. Inspection of Front Compressor Rear Hub

R (1) Repeat step F8, except mark first hole that is being used
R for inspection with Magic Marker, to aid in determining
R starting point of inspection. Also repeat steps F9, F10
R and F11.

R (2) Rotate probe slowly from one extreme to another and observe
R the meter for up-scale deflection. Entire travel of probe
R head is approximately 4 inches. Indication of a crack will
R be noted on the meter up-scale when 50 micro-amperes or
R more are observed.

R (3) Release forward pressure on tool and carefully push toward
R rear of engine until probe head assumes a horizontal posi-
R tion, and extract from lightening/counterweight hole.

R (4) Inspect entire circumference of hub flange-bell-radius
R through remaining five (5) lightening/counterweight holes.

R (5) Crack indication(s) will require removal of engine from
R aircraft and disassembly to confirm indication(s).

ENGINE - INSPECTION/CHECK

H. Equipment Operating Procedures for Seventh Stage Disk

(1) Connect PWA 30458 Inspection Tool to instrument. Turn instrument "ON" and allow minimum warm up of 15 minutes.

(2) Follow instrument manufacturer's instructions for "FREQUENCY" and "LIFTOFF" adjustments.

(3) Crack deflection definition may be observed using simulated cracked test piece.

(4) Insert inspection tool through bore No. 1 hub.

(5) Locate and place probe head on bore of disk and turn "BALANCE" control to give midscale meter indication.

(6) The instrument is ready for inspection of front face of seventh stage disk.

I. Inspection of Seventh Stage Disk

(1) With probe head resting on bore of disk, slowly traverse web area with probe and observe meter. Engine may be rotated for this inspection. Caution should be exercised to preclude probe head jumping disk bore.

(2) Indication of a crack will be noted on meter scale when a deflection of meter from its mid-scale position is observed.

(3) Crack indication(s) will require removal of engine from aircraft and disassembly to confirm indication(s).

R 2A. Seventh Stage Disk-Front Compressor Rear Hub - Crack Inspection
R (Alternate - Eddy Current).

R A. Equipment

R (1) One Forster Defectometer 2.164 or 2.154 or one Magnaflux
R ED 1500 Eddy Current Generator.

R (2) Sensitivity setting blocks.

R (a) For PWA 1003 material hardware.

R (b) For AMS 4928 material hardware.

(c) Sensitivity blocks consist of a 2.0 x 2.0 x 0.040 inch thick section of appropriate material into which has been electrodischarge machined a slot centrally located in 2.0 x 2.0 inch face measuring 0.500 inch long x 0.010 inch wide x 0.018 - 0.022 inch deep.

(3) Eddy current probes

(a) Seventh stage disk probe (seventh stage disk front)

(b) Front Compressor rear hub probe (seventh stage disk rear)

NOTE: Probes are available from Dr. Forster, 7410 Reulinger, Grathwolster, West Germany.

B. Setup Procedure

(1) Turn instrument on and allow sufficient warm up time.

(2) Connect appropriate probe to instrument.

(3) Using "Fe POSITION", lift off compensate probe on sound portion of appropriate sensitivity setting block.

(4) Adjust "SENSITIVITY" to obtain convenient meter deflection between 1 and 5 units when "slot" portion of standard is traversed.

C. Inspection Procedure For Seventh Stage Disk

(1) Insert probe into engine.

NOTE: Complete instructions as to handling and mechanical adjustment of probe are included in manufactures manual.

(2) Make further adjustment to lift off compensation if necessary on at least two locations on disk to be sure compensation was adjusted on a sound portion of disk.

(3) Slowly revolve probe (or motor engine) while monitoring meter for upscale and return meter movements indicative of presence of crack.

(4) Indications equal to or exceeding amplitude obtained on sensitivity setting block will require removal of engine and disassembly to confirm crack indications. Indications of lesser amplitude than obtained on sensitivity setting block are acceptable.

ENGINE - INSPECTION/CHECK

D. Inspection Procedure For Front Compressor Rear Hub

(1) Insert probe through outer lightening hole (6 o'clock position) to rear of hub.

NOTE: Complete instructions as to handling and mechanical adjustment of probe are included in manufacturers manual.

(2) Make further adjustment to lift off compensation if necessary on at least two locations on hub to be sure compensation was adjusted on sound portion of hub.

(3) Rotate probe slowly from one extreme to the other while monitoring meter for upscale and return meter movements indicative of presence of crack.

(4) Repeat substep (3) at each outer lightening hole locations.

(5) Indications equal to or exceeding amplitude obtained on sensitivity setting block will require removal of engine and disassembly to confirm crack indications. Indications of lesser amplitude than obtained on sensitivity setting block are acceptable.

R 2B. Fan Case - Determination of Repair Band Material - Inspection (Eddy-Current)

A. Equipment

(1) One Defectometer 2.164 or 2.154.

(2) One Forster Pencil Probe FE/AUS 2.154 - 351.

(3) Test Samples

(a) Hastelloy "X", 2.0 x 0.049 inch thick.

(b) AMS 5504, 2.0 x 0.049 inch thick.

R B. Set Up Procedure

R (1) Set Deflectometer on FE position.

R (2) Set sensitivity control to minimum or full CCW position.

R (3) Turn on and allow instrument to warm up.

R (4) Lift off compensate on Hastelloy "X" test sample.

R (5) Place probe on AMS 5504 test sample. Needle should deflect to full scale on saturation.

R C. Inspection Procedure

R (1) Insert probe through inlet case, fan blades, and first stage vanes and place on band approximately half way across.

R (2) If needle deflects to full scale on saturation, material is AMS 5504.

R (3) If needle remains at zero or less than one, material is Hastelloy "X".

3. Combustion Chamber Lug Wear Pad - On Wing Radiography Inspection

WARNING: ISOTOPE RADIOGRAPHY MUST BE PERFORMED BY QUALIFIED PERSONNEL AND ALL APPROPRIATE SAFETY PRECAUTIONS MUST BE OBSERVED.

NOTE: Inspection procedure for cases with wear pads. Following cases do not have wear pads unless they were reoperated to SB 2384; PN 488961, 617071.

A. Move Aircraft To Remote Area That Affords Protection From Radioactivity.

ENGINE - INSPECTION/CHECK

B. Remove front accessory drive support and front accessory
R drive main gear per Section 72-00, Dismantling/Assembly.

C. Locally fabricate tube to accept Iridium-192, Type 100C Source. Insert cap in inner end of tube to provide locating stop for source when it is in position.

D. Locally fabricate tooling necessary to support tube in position.

E. Insert source guide tube into shaft of engine such that in exposed position source will be 84.1875 inches from front face of compressor inlet cone support assembly. See Figure 610.

NOTE: Exact source positioning is needed to obtain adequate radiographs for accurate wear determination. See Figure 611 a,b.

To insure that correct source positioning has been achieved, a test shot (800 curie-minute exposure) with a fast film such as Agfa Gaevert D-10 or equivalent is recommended. Source is correctly positioned if inner surface of radiographic image of "V" shaped contoured indenture, Figure 612, is between 0.216 and 0.256 inch (5.5 to 6.5 MM) from "H" flange, Figure 611 b.

F. Tape 4 inch by 7 inch Agfa Gaevert D-4 lead pack film onto the engine case at the eight positions shown in Figure 613. (Kodak "M" film may be used if D-4 is not available.)

NOTE: Equivalent type film may be used when exposures are adjusted to give same results.

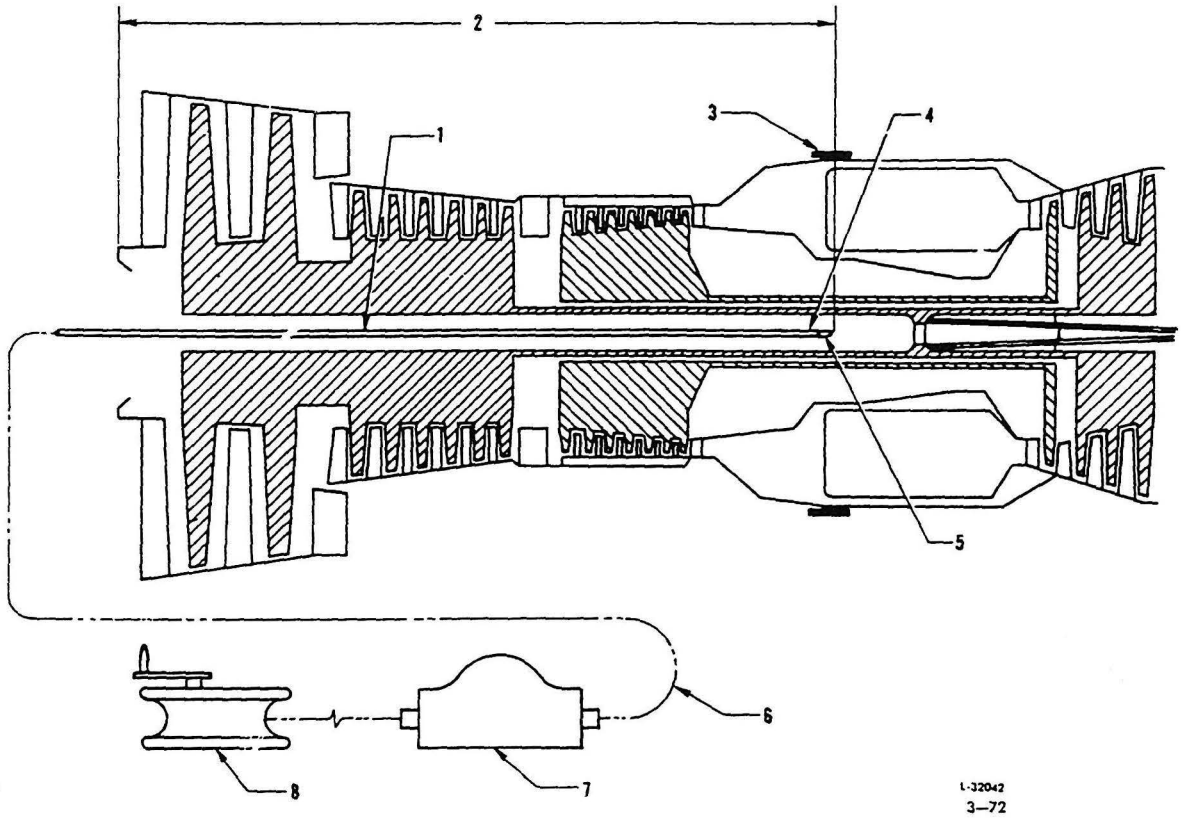
(1) Number films one through eight clockwise from rear starting at twelve o'clock position. Mark engine number on No. 1 film.

G. Obtain following gamma-ray projector equipment or equivalent.

(1) Technical Operations Model 529 Gamma Ray Projector Control.

(2) Technical Operations Model 533 Shielded Container.

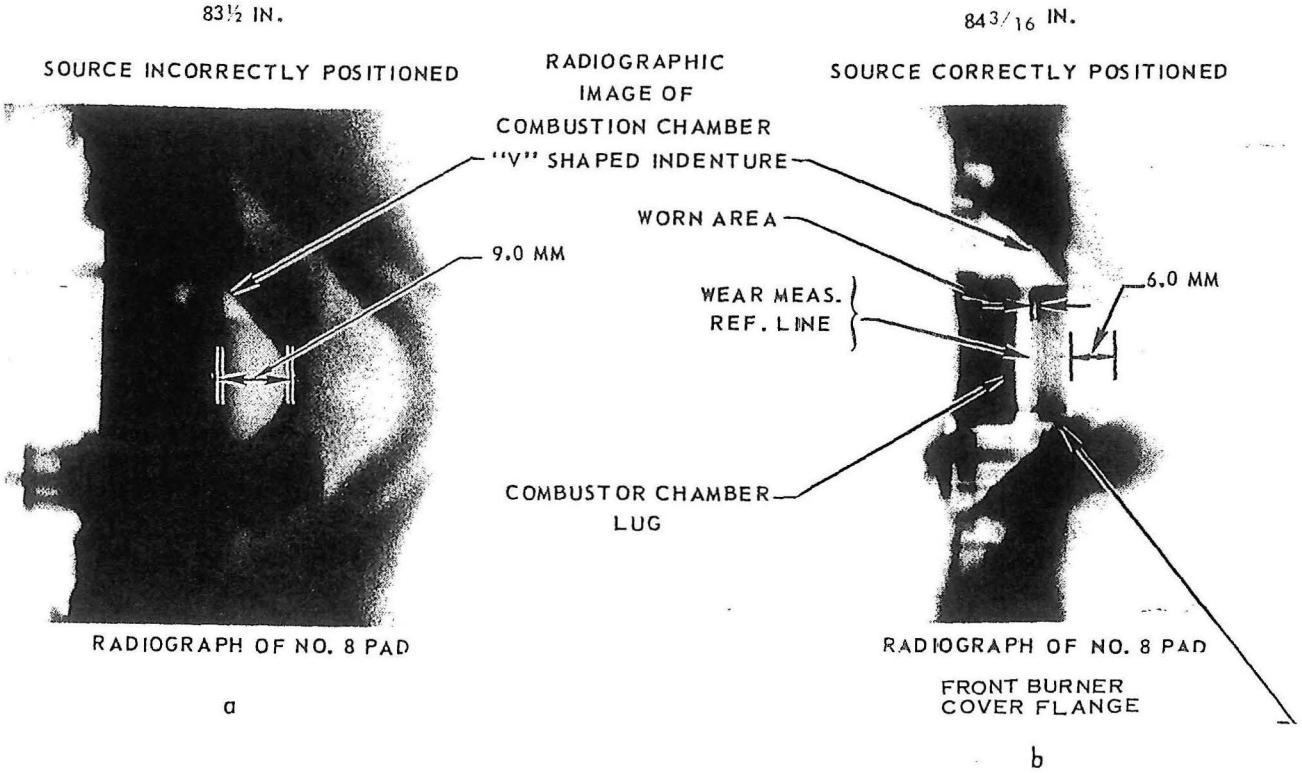
ENGINE - INSPECTION/CHECK



1. Capped Tube (Source Travels Inside).
2. 84.1875 Inches To Exposed Source.
3. Agfa Gaevert D-4 Lead Pack Film (4 x 7 Inches), 8 Sheets.
4. Iridium-192 Source.
5. Cap
6. Flexible Guide Tube.
7. Shielded Container.
8. Gamma Ray Projector Control.

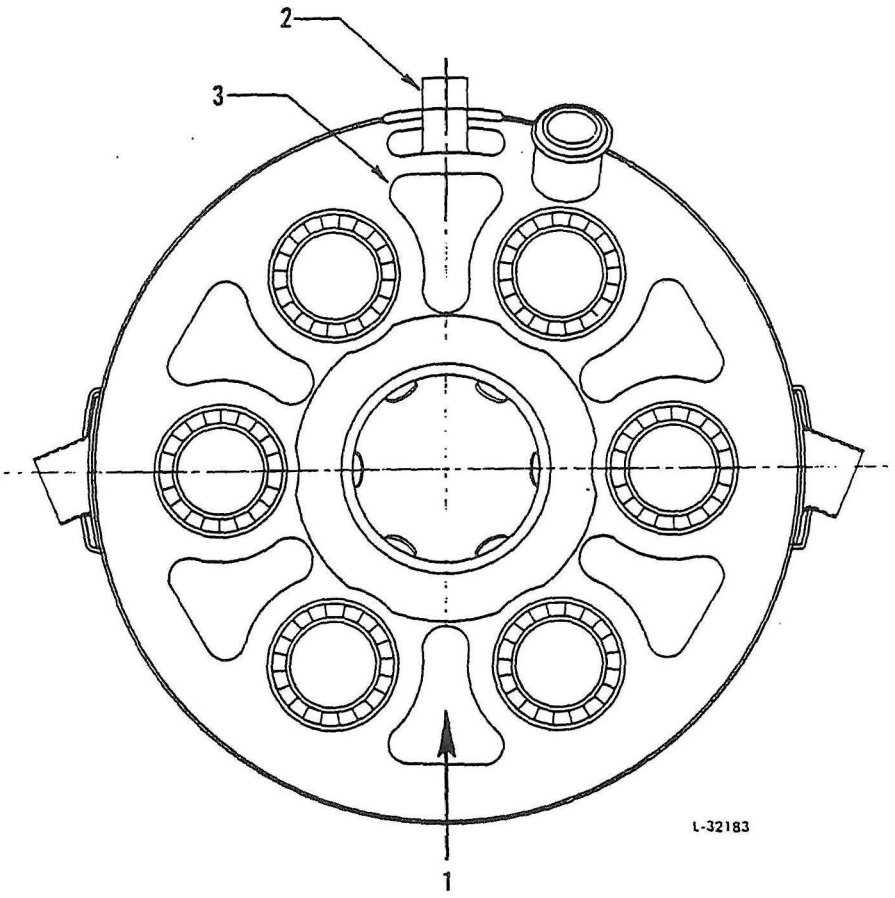
Isotope Inspection Of Combustion
Chamber Lug Wear Pads
Figure 610

ENGINE - INSPECTION/CHECK



Radiographic Image Of Combustion Chamber
Figure 611

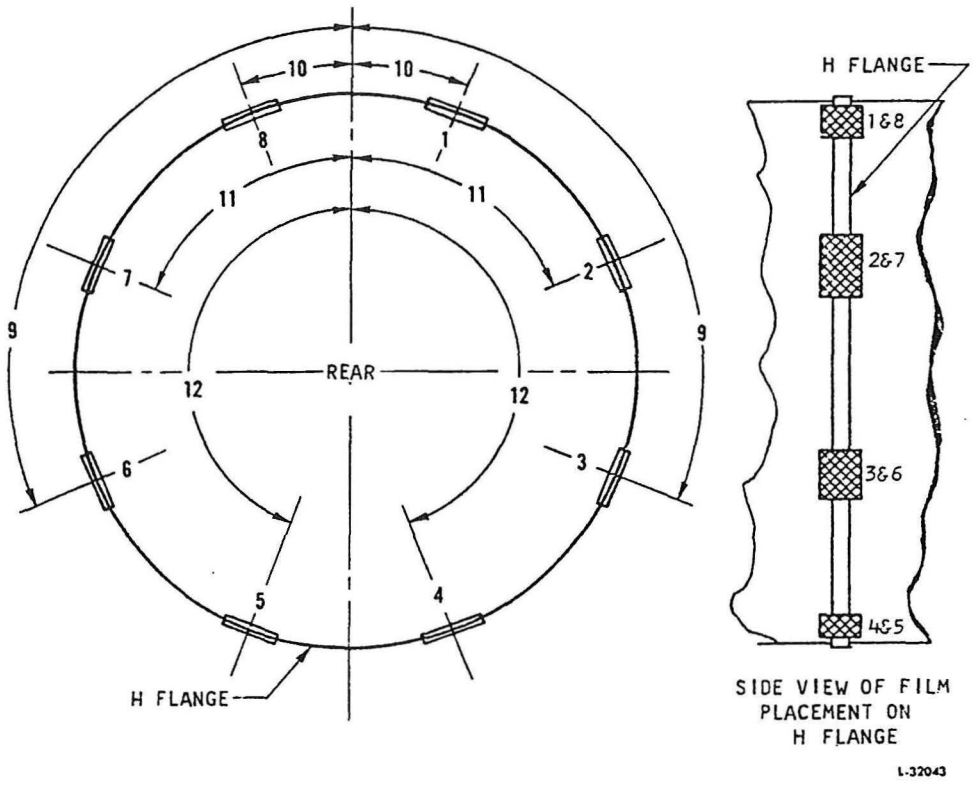
ENGINE - INSPECTION/CHECK



1. Source Projection.
2. Combustion Chamber Lug.
3. "V" Shaped Contoured Indenture.

Isotope Inspection Of Combustion
Chamber Lug Wear Pad
Figure 612

ENGINE - INSPECTION/CHECK



1 Thru 8. Film Locations

9. 39.5 Inches

10. 7.9 Inches

11. 23.7 Inches

12. 55.3 Inches

Film Locations For Isotope Inspection
Figure 613

(3) Flexible Guide Tube.

NOTE: Technical Operations Inc., Burlington, Mass. have indicated they would be willing to furnish equipment required.

H. Exposure film for 3000 curie-minutes (increase exposure by a factor of 1.33 if "H" film is used).

NOTE: Curie-minutes are determined from actual exposure in minutes multiplied by power source-type 100C power rated at time of exposure.

I. Develope film per manufacturers recommendations.

J. Interpret radiographs using a high intensity light box, film density approximately 4.0.

NOTE: Wear to a maximum depth of 0.015 inch will be allowed on pad at interim inspection periods with pad replacement required at next hot section.

R 4. Combustion Chamber Weldments

A. General

(1) Cracks in combustion chamber surfaces are usually of stress relieving nature and, as such, are not serious in that rate of growth decreases as crack lengthens. Thermal stresses, in effect, relieve original stress condition. It is usually normal to observe repetitive occurence of a given type of deterioration from chamber to chamber in given engine.

(2) To ensure consistency and to eliminate confusion in reports or inspection standards, use established nomenclature for various components of combustion chambers as shown in
R Figures 614 and 615.

R (3) Figures 616 through 617 show various types of combustion chamber deterioration which may be found in chambers at time of inspection. Following paragraphs will call out deteriorated areas and tell whether or not they can be repaired or replaced.

(4) Fluorescent penetrant inspect combustion chambers in accordance with SPOP 62.

NOTE: Particular attention should be given to all seam weld joints in inner and outer liner segments on both inside and outside liner surfaces.

(5) All cracks found in seam weld joints must be weld repaired.

B. Swirl Guide

(1) Unacceptable Conditions

(a) Cracks are not acceptable at any location in any Stellite swirl guide which was manufactured with slots in deflector.

(b) Wear in swirl guide ID or bore is usually localized. Wear to extent that swirl guide ID is increased to 1.263 inches or over at any point is unacceptable. Check ID using PWA-30018 Gage.

(c) Nicks, dents, grinding wheel marks, or other damage to swirl guide vanes, particularly leading edges, is not acceptable.

(2) Acceptable Conditions

(a) Thinning of swirl guide deflector due to erosion (no chunks missing) is acceptable after blending provided minimum deflector thickness of 0.025 inch can be achieved within maximum deflector ID.

(3) Acceptable Conditions With Repair

R (a) Slight burning of the swirl guide deflectors, reference numbers 2 and 4, Figure 616 is acceptable provided they are blended to the following limits:

1 No more than cumulative length of 1.30 inch of the ID of the deflector or a cumulative total of the length of six vanes (including six vane spaces) may be blended to one-half the lip height.

2 The blend must produce sound metal of generally uniform thickness. Do not remove more material than is necessary to achieve this.

3 Buckling of the lip of the deflector beyond the blended areas is acceptable provided the buckled area is not burned and the general contour of the ID circumference is uniform.

4 Thinned and slightly buckled areas of the deflector's lip are acceptable without rework when burning has not occurred.

C. Swirl Cup

(1) Unacceptable Conditions

R (a) Cracks in swirl cup are not acceptable. See Figure 618, No. 7A.

(b) Cracks in swirl cup saddles which exhibit burned or deteriorated material at edges of crack are not acceptaR ble. Cracks in this category are shown in Figure 617.

(c) Severe burning or blistering of swirl cup surface.

(d) Cracks in cap weld joining trailing edges of inner brace R tabs and swirl cup ID tabs as shown in Figure 618, No. 7B.

(e) Severe burning in swirl cup to inner brace joint.

(f) Cracks in cap weld joining swirl cup OD and outer brace trailing edges.

(g) Buckling of swirl cup OD to extent that displacement inward from normal contour exceeds 0.060 inch. Buckling R in this category is shown in Figure 618, No. 7D.

R (h) Buckling to extent shown in Figure 616, Index No. 1.

R (i) Cracks in baffle. See Figure 619.

(j) Cracks in baffle to swirl cup attaching weld.

(k) Clearance between baffle and swirl cup must be 0.055 to
R 0.070 inch. See Figure 620.

(2) Acceptable Conditions

(a) Light burning or blistering of surface of swirl cup, commonly found just outside swirl guides is acceptable after polishing to remove raised metal. This condition is usually more severe in chambers used in No. 4 and 5 positions in engine. An example of this condition is
R shown in Figure 616, Index No. 3.

(b) Buckling of swirl cup OD is acceptable without repair provided no cracking of swirl cup of swirl cup OD to outer brace cup weld is present and OD of swirl cup is displaced inward less than 0.060 inch from its normal contour. Buckling shown in Figure 618, Index No. 7A is approximately 0.060 inch limit and would be acceptable if no cracks were present.

(c) There is a tendency for swirl cup OD trailing edge to roll inward toward inner liner assembly. This is usually, though not always, accompanied by cracks in cap weld.
R This condition can be seen by comparing Figure 618, Index No. 7E with Index No. 7G. This condition is acceptable for further service, without repair, provided cap weld at all outer brace tabs is sound and swirl cup OD trailing edge has not rolled inward more than 0.060 inch from its normal contour. Straighten those sections of swirl cup periphery which are rolled inward in excess of 0.060 inch. Carefully inspect cap weld and outer brace for cracks after straightening swirl cup.

(3) Acceptable Conditions With Repair

(a) Cracks extending over 1/4 inch in length in the fuel nozzle swirl cups as shown in reference numbers 3, 5, and 7,
R Figures 616 and 617, are acceptable provided they are weld repaired.

R (b) Figure 619 shows ventilated (louver cooled) swirl cup configuration. All inspection criteria for earlier, non-louver cooled swirl cup apply to new louver cooled configuration. In addition, following criteria are added applicable only to louver cooled configuration:

1 Cracks in baffle must be repair welded. A copper shim or chill must be used in space between baffle and swirl cup to prevent burn through from restricting air flow.

2 Cracks in baffle to swirl cup attaching weld must be routed and repair welded.

3 Clearance between baffle and swirl cup must be 0.055 to 0.070 inch. If clearance is found below minimum, it is probably caused by distortion of swirl cup, not the baffle. Before bending baffle to restore clearance, inspect swirl cup for buckling and/or rolling inward of OD and correct these conditions if present. After bending baffle or swirl cup, inspect baffle attaching welds for cracks.

D. Outer Brace

(1) Unacceptable Conditions

(a) Cracks in outer brace.

E. Sparkigniter Sleeve and Burner Pressure Tube

(1) Unacceptable Conditions

(a) Cracks or burning at any point in parent material of sparkigniter sleeve, sparkigniter guide, and burner pressure tube.

(b) Cracks in weld attaching burner pressure tube and sparkigniter sleeve to swirl cup.

(2) Acceptable Conditions

(a) The sparkigniter guide must move freely but not loosely inside sparkigniter sleeve.

ENGINE - INSPECTION/CHECK

F. Combustion Chamber Bulging (Doming)

(1) Unacceptable Conditions

(a) In service, innermost edges of swirl guides have moved forward of outermost edges. Bulging is defined as offset between innermost and outermost edges of swirl guides. Bulging is excess of 0.025 inch is unacceptable.

(2) Acceptable Conditions

(a) If repairs to chamber are not required, bulging of less than 0.025 inch is satisfactory for further service.

G. Locating Lug

(1) Unacceptable Conditions

(a) If wear step in hardfaced locating lugs is 0.010 inch or more.

(2) Acceptable Condition

(a) Hardfaced locating lugs are acceptable provided wear step on rearward face is less than 0.010 inch.

H. Inner Liner Assembly

(1) Unacceptable Conditions

R (a) Cracks in inner liner. Example shown in Figure 625,
R No. 18.

R (b) Burning to extent shown in Figure 621, No. 9.

(c) Cracks in flanged front end inner liner around or emanating from six spot welds used, in early chambers only,
R to secure swirl cup inner brace. On Figure 625, No. 19, these spot welds are sketched in.

(d) Cracks around or emanating from spot welds or hand fusion plug welds used to secure flange of front end inner liner
R to cover. See Figure 625, No. 20, for location.

(2) Acceptable Conditions

(a) Light burning of tabs on inner liner assembly OD is
R acceptable without repair to extent shown in Figure 621,
R No. 8 and 10.

(b) Clearance between tabs on inner liner assembly OD and adjacent liner is from 0.070 to 0.120 inch. Tabs shall be cold formed as necessary to provide clearance in this range.

(c) The inner liner assembly must be concentric with respect to outer liner assembly within 0.100 inch. Cold forming may be employed to achieve this limit, followed by careful inspection for cracks in flange of front end inner liner.

(3) Acceptable Areas With Repair

(a) Location of cracks in inner liner assembly which do not automatically reject assembly are as follows. All cracks must be weld repaired.

(b) In ID of front end of inner liner, around and emanating from six spot welds used, in early chambers only, to secure inner liner assembly to swirl cup inner brace.

(c) In flange of front end inner liner, around or emanating from spot welds or hand fusion welds used to secure inner liner assembly to cover.

(d) In No. 1 inner liner only, circumferentially between small cooling air holes, between not more than four consecutive holes in any 120 degree sector (maximum of nine cracks per liner) provided groups are separated by a sector of sound material of at least 90 degrees.
R Examples are shown in Figure 625, No. 18.

R (4) No. 8A, Figure 621, illustrates the later slotless trailing edge inner liner, a design which will alleviate
R the conditions illustrated by Nos. 8, 9, and 10. Inner liner assemblies may be found with any number of slotless type individual liners interspersed among earlier slotted type. Inspection limits are the same for both slotted and slotless type liners and liner assemblies.

ENGINE - INSPECTION/CHECK

I. Outer Liner Assembly

(1) Unacceptable Conditions

(a) Burning of tabs in outer liner ID. A moderately severe example of burning downstream of cross-over tube is shown in Figure 623, No. 16.

(b) Circumferential cracks are defined as cracks in outer liner material located immediately adjacent and parallel to outer liner seam. They are illustrated in Figure 622, No. 15 and are unacceptable.

(c) Cracks other than true circumferential cracks as illustrated in Figure 622, No. 12.

(d) Cracks originating at cross-over tube hole, as shown by arrow in Figure 623, No. 16.

(e) Cracks between small cooling air holes in outer liners.

(f) Cracks in heatshield.

(g) Cracks in heatshield attaching welds.

(h) Cracks in cross-over tubes.

(i) Chafing wear at cross-over tube outlet to extent that less than 50 percent of original material remains.

(j) Distortion of cross-over tube or tube outlet.

(2) Acceptable Conditions

(a) Slight burning of tabs in outer liner ID to extent shown in Figure 624, Index No. 17.

(b) Clearance between tabs in outer liner assembly ID and adjacent liner is from 0.070 to 0.120 inch. Tabs shall be cold formed as necessary to provide clearance in this range.

(c) Dents or distortion of heatshields may be repaired by cold forming to original contour.

(d) Chafing wear at cross-over tube outlet, result of contact with mating tube of another chamber, is acceptable without repair provided 50 percent of original tube wall or material thickness remains.

(e) 85 percent or more of hardface coating of eleventh outer liner remains.

(f) Material thickness in spots where hardface has been worn away from eleventh outer liner is at least 0.030 inch.

(3) Acceptable Areas With Repair

R (a) Cracks underneath the flame tubes are not acceptable. See reference number 11, Figure 622. Repair this condition by replacing the flame tube.

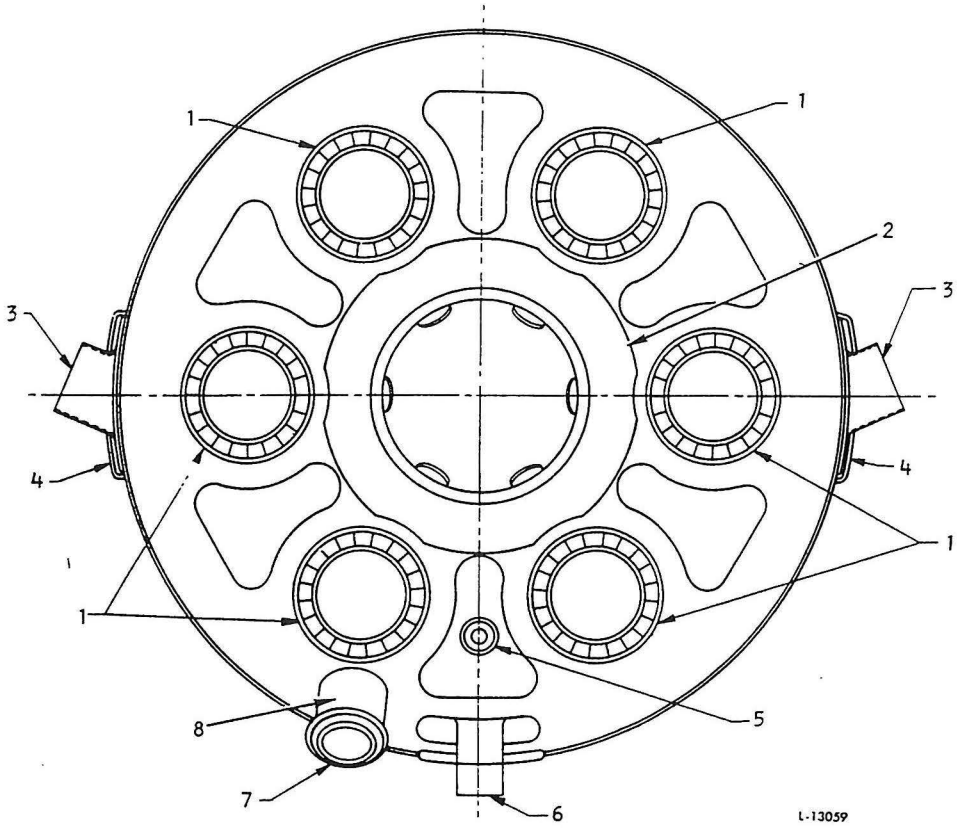
R (b) Burning on the inside of the liners directly underneath the flame tubes as shown in reference number 16, Figure 623, is not acceptable and must be repaired by patching the outer liners and replacing the flame tube.

R (c) Cracks in the outer liner as shown in reference number 12, Figure 622, are not acceptable. Repair this condition by patching the section.

R (d) Cracks extending from the large holes of the liners as shown in reference numbers 13 and 14, Figure 622, are not acceptable. Repair these cracks by welding.

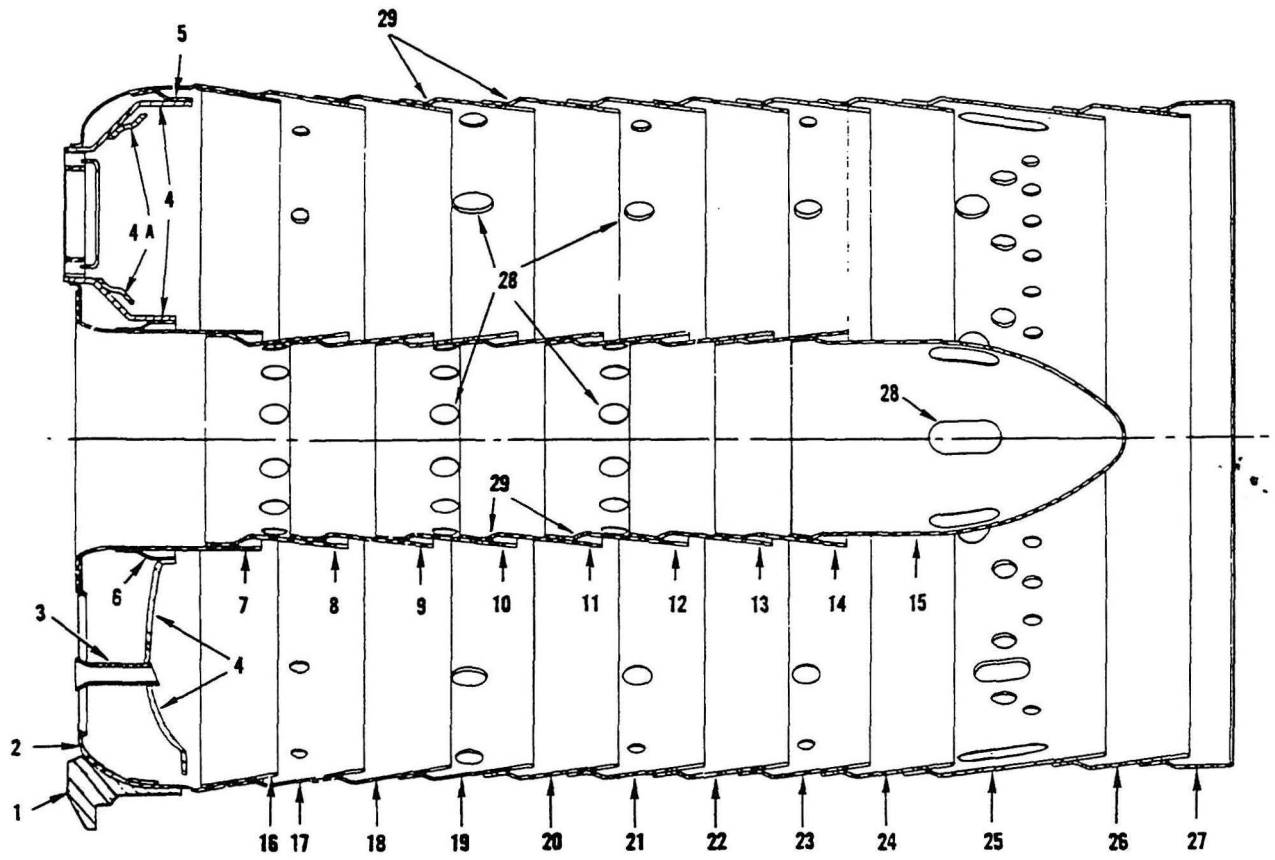
R (e) Circumferential cracks immediately above or below the seam weld in the outer liners as shown in reference number 15, Figure 622, must be weld repaired. Such crack openings in excess of 0.030 inch are not reparable. There is no restriction on the length of this type crack repair.

ENGINE - INSPECTION/CHECK



1. Swirl Guide
2. Front End Inner Liner
3. Cross-Over Tube
4. Heatshield
5. Burner Pressure Transfer Tube
6. Locating Lug
7. Igniter Plug Bushing
8. Igniter Plug Sleeve

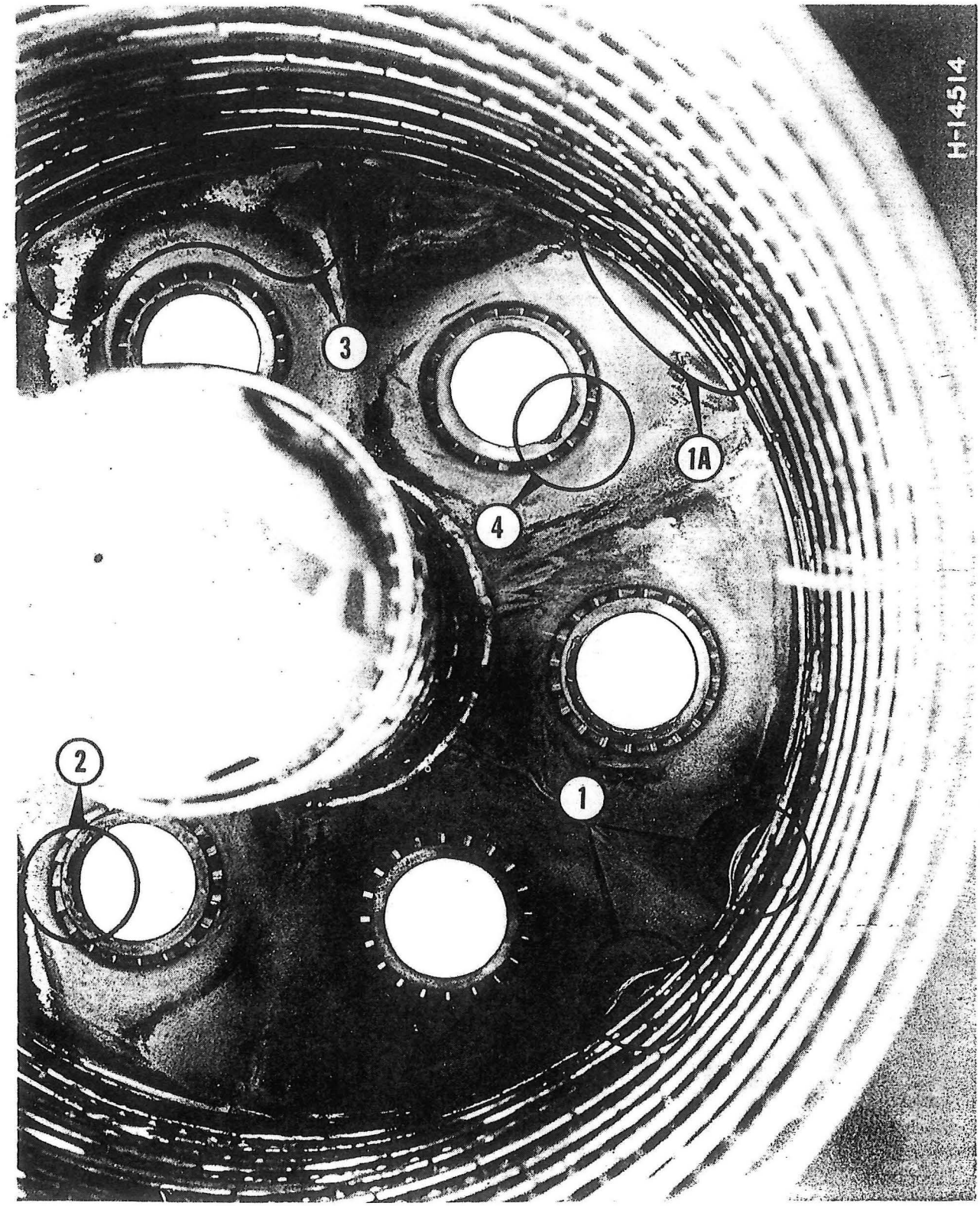
Combustion Chamber Nomenclature
Figure 614



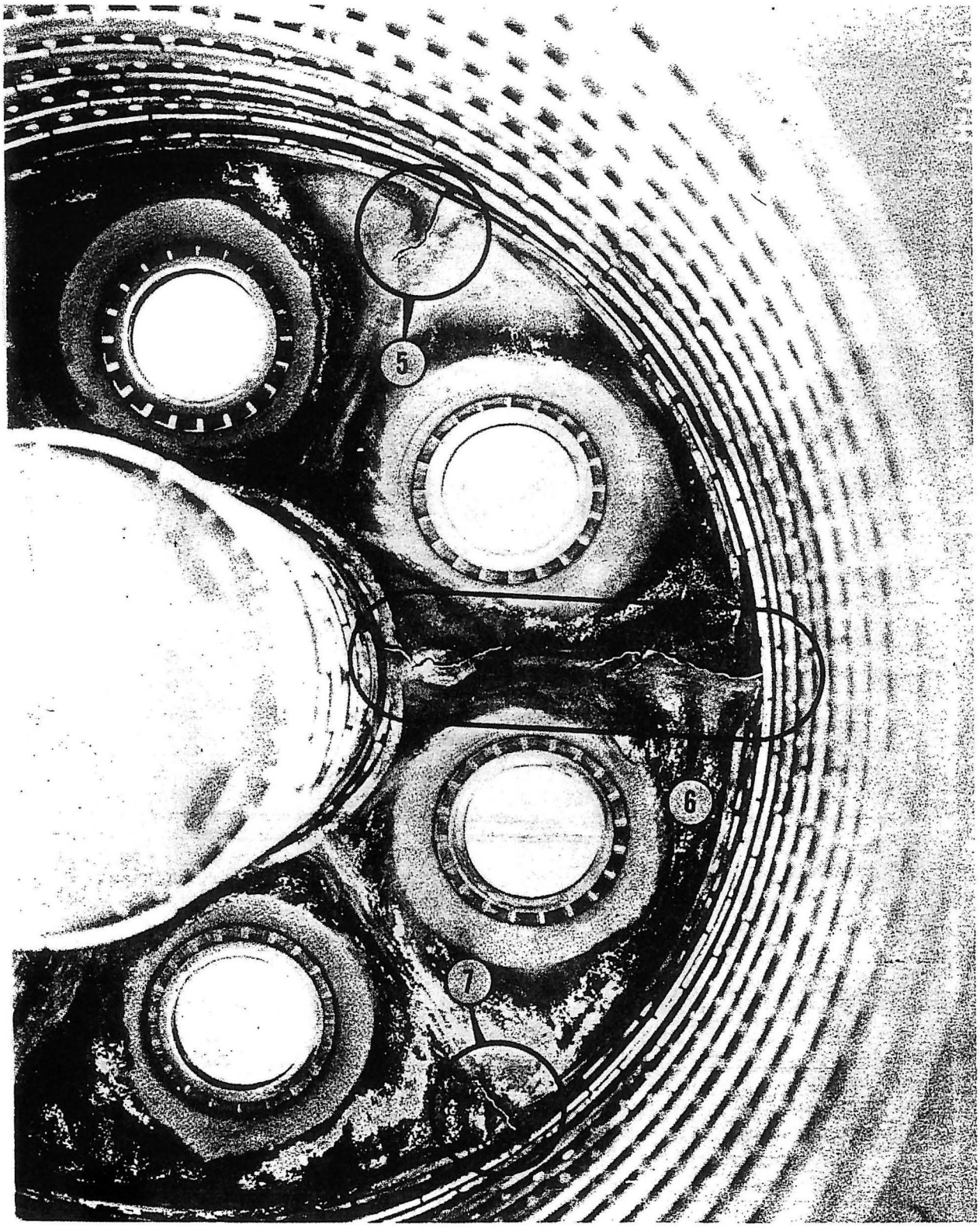
1.	Locating Lug	15.	Rear End Inner Liner
2.	Cover	16.	Front Outer Liner
3.	Burner Pressure Tube	17.	No. 1 Outer Liner
4.	Swirl Cup	18.	No. 2 Outer Liner
4A.	Baffle	19.	No. 3 Outer Liner
5.	Outer Brace	20.	No. 4 Outer Liner
6.	Inner Brace	21.	No. 5 Outer Liner
7.	Front End Inner Liner	22.	No. 6 Outer Liner
8.	No. 1 Inner Liner	23.	No. 7 Outer Liner
9.	No. 2 Inner Liner	24.	No. 8 Outer Liner
10.	No. 3 Inner Liner	25.	No. 9 Outer Liner
11.	No. 4 Inner Liner	26.	No. 10 Outer Liner
12.	No. 5 Inner Liner	27.	No. 11 Outer Liner
13.	No. 6 Inner Liner	28.	Combustion Air Holes
14.	No. 7 Inner Liner	29.	Cooling Air Holes

R NOTE: Head assembly includes Nos. 1 through 6. Inner liner
R assembly includes Nos. 7 through 15. Outer liner
R assembly includes Nos. 16 through 27.

Combustion Chamber Nomenclature
Figure 615

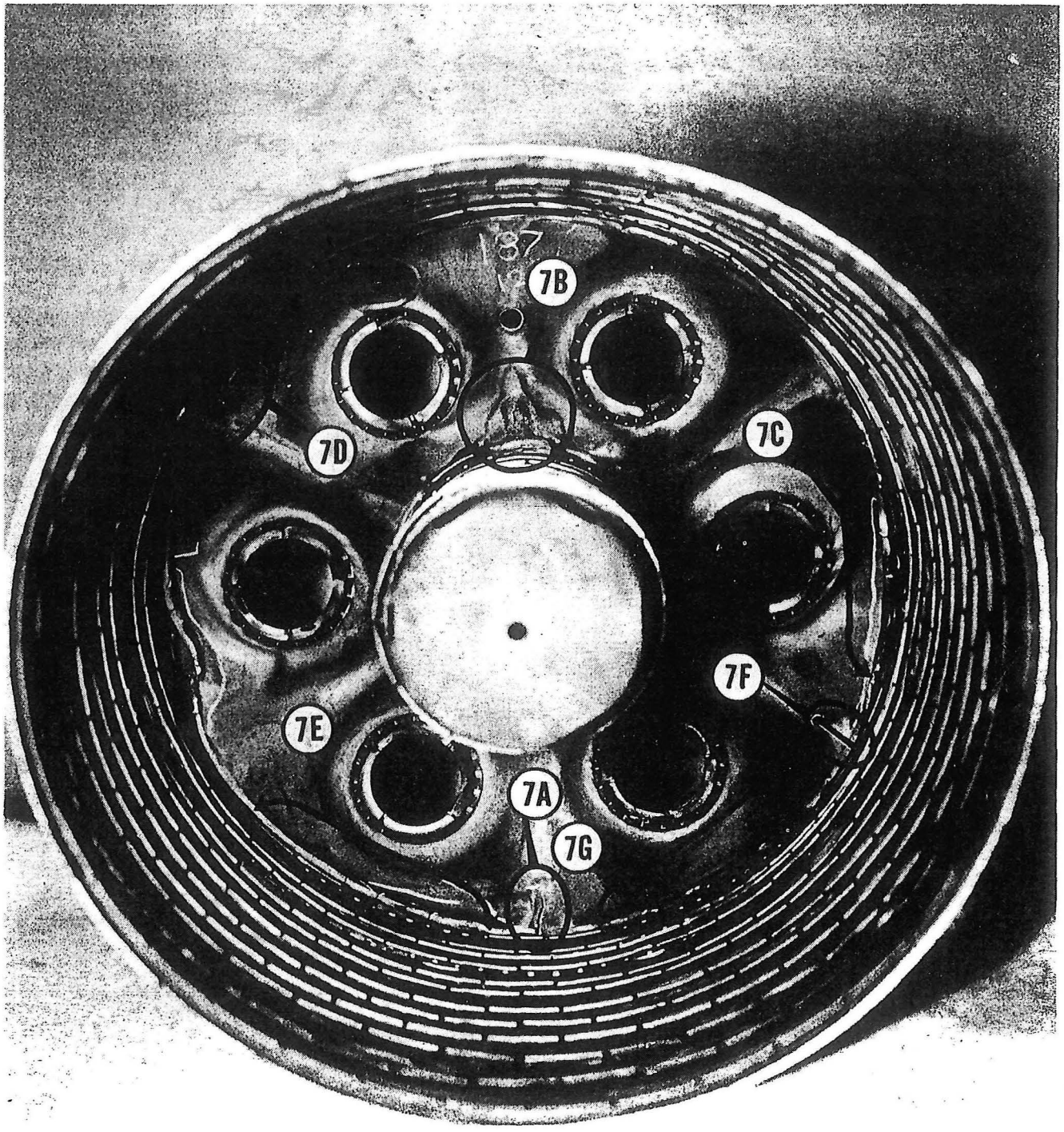


Combustion Chamber Inspection (H-14514)
Figure 616



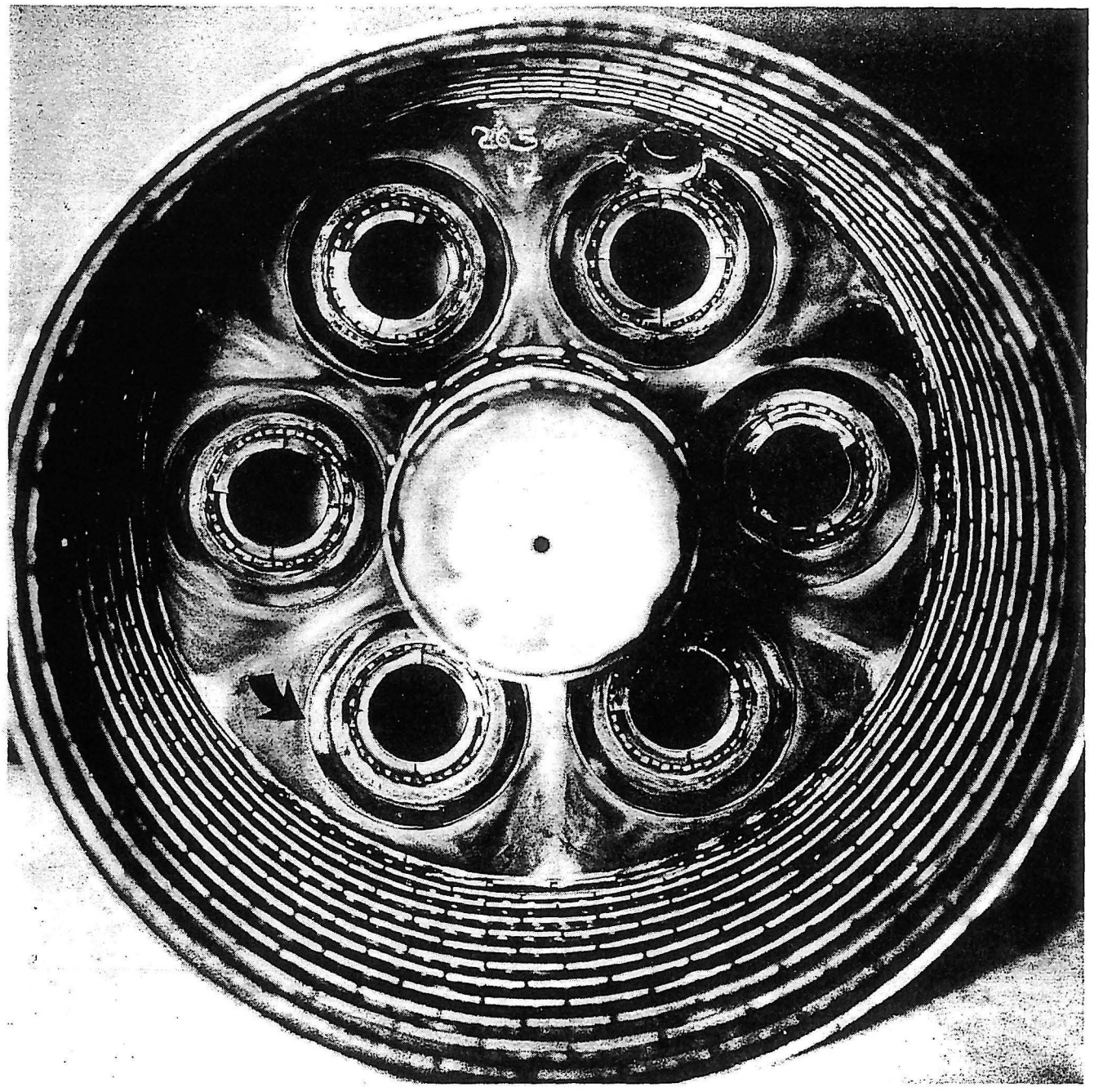
Combustion Chamber Inspection (H-14521)
Figure 617

ENGINE - INSPECTION/CHECK

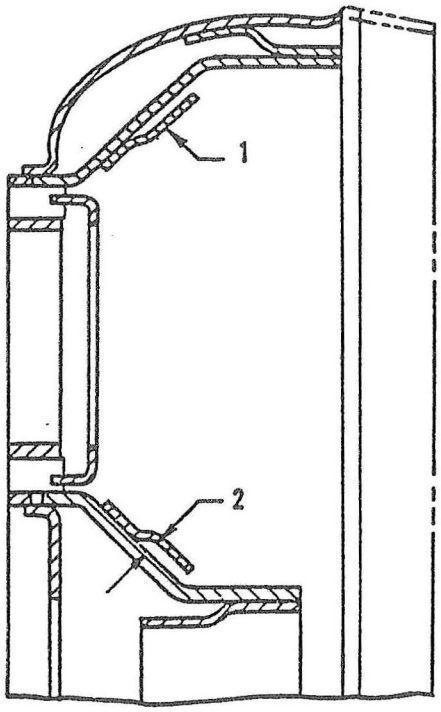


Combustion Chamber Inspection (XP-56902)
Figure 618

ENGINE - INSPECTION/CHECK



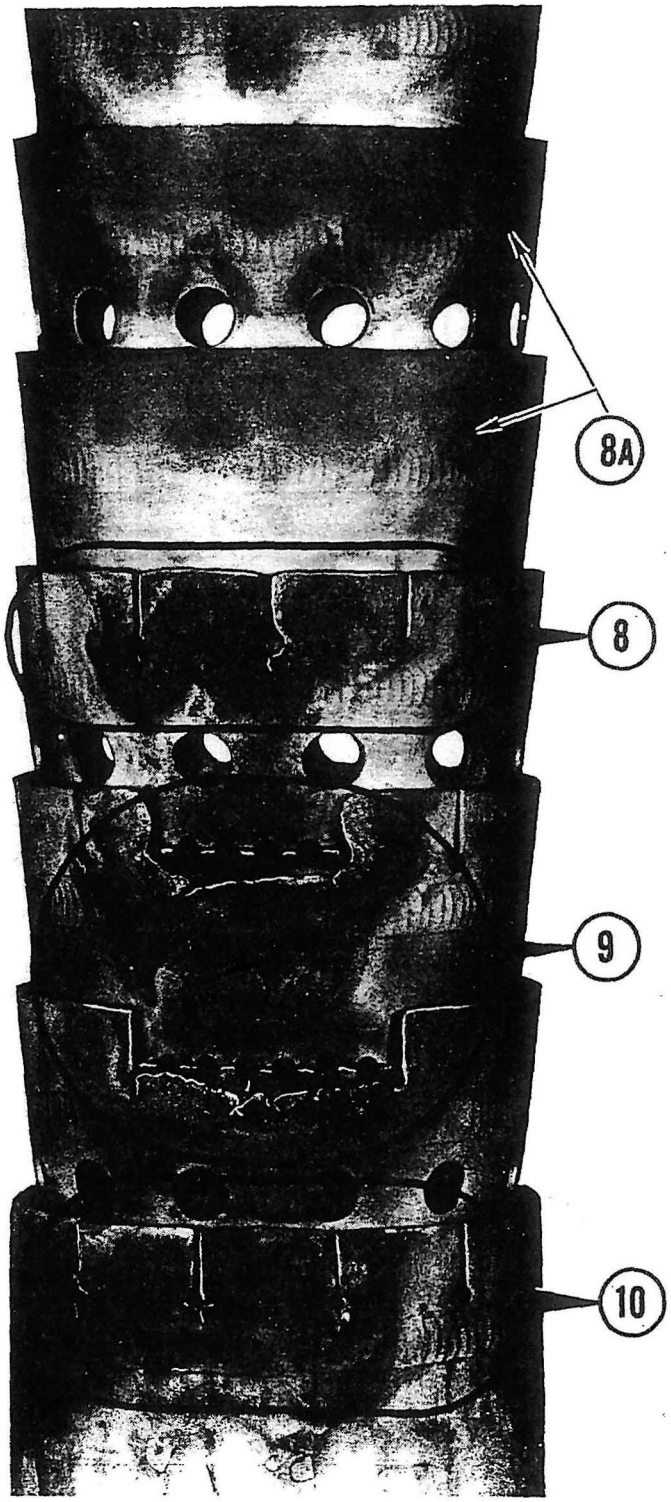
Combustion Chamber Inspection (XP-56905)
Figure 619



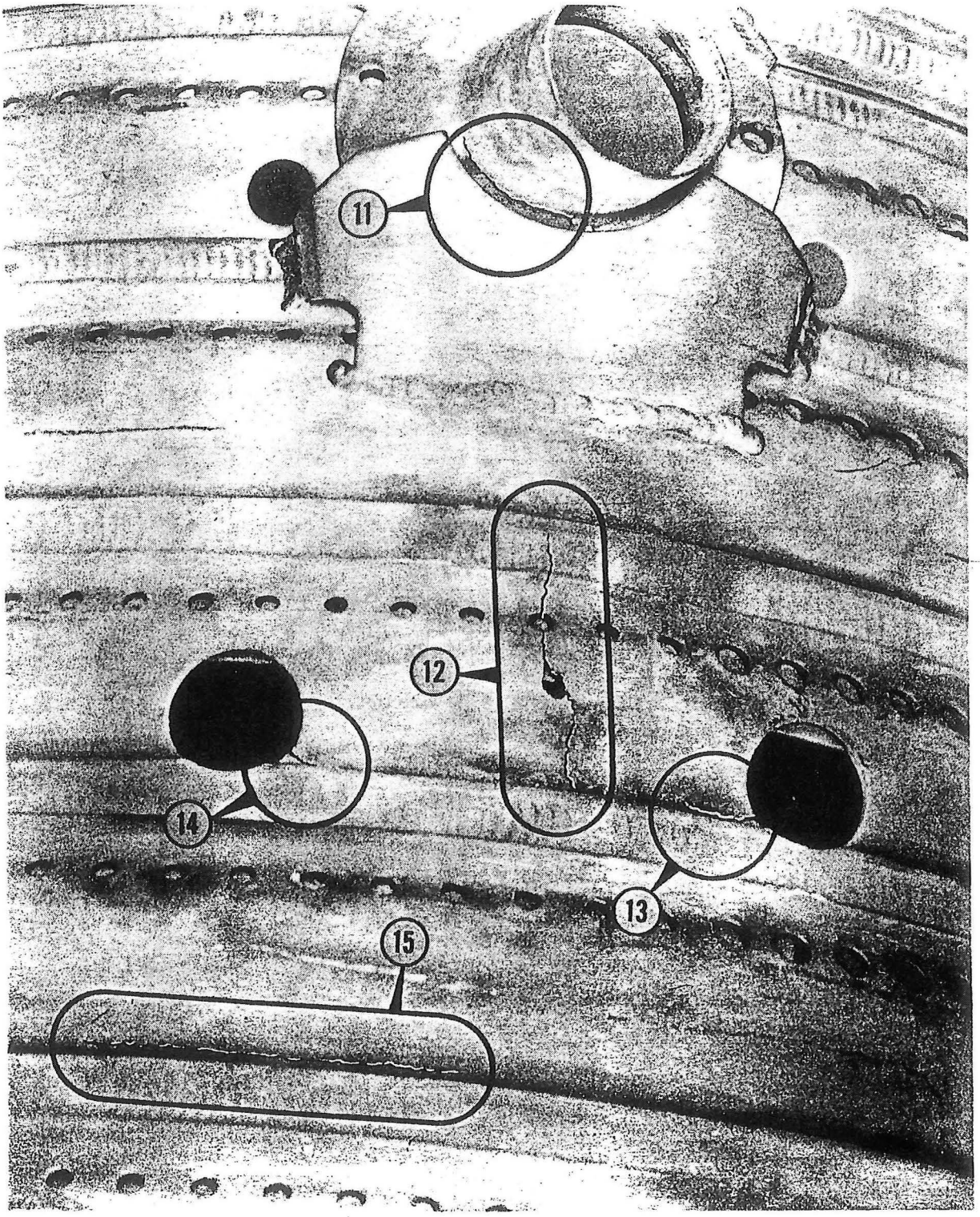
1. Baffle
2. 0.055 to 0.070 Inch

R Ventilated (Louver Cooled) Swirl Cup Baffle Clearance Figure 620

ENGINE - INSPECTION/CHECK

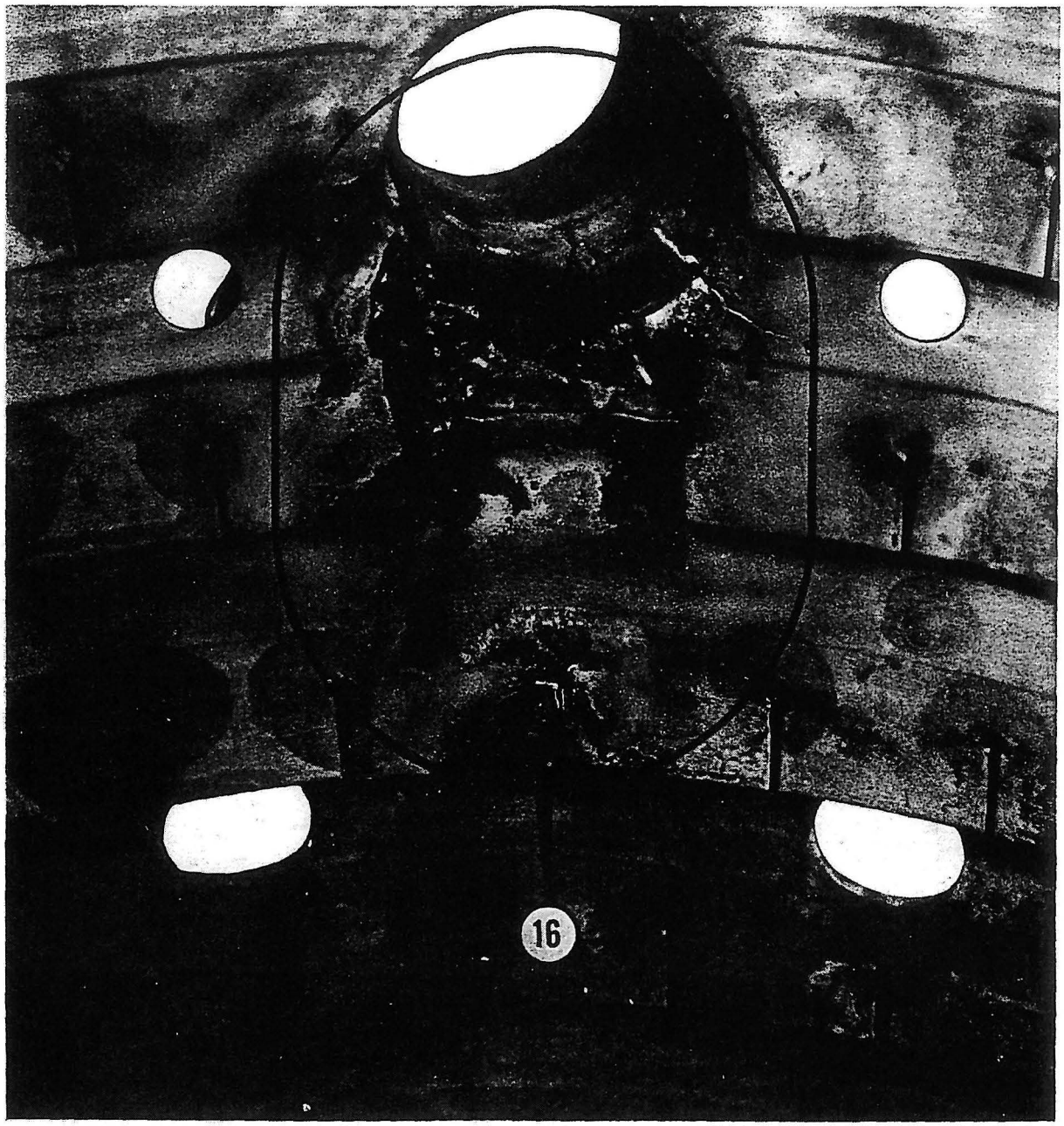


Combustion Chamber Inspection (H-14523)
Figure 621

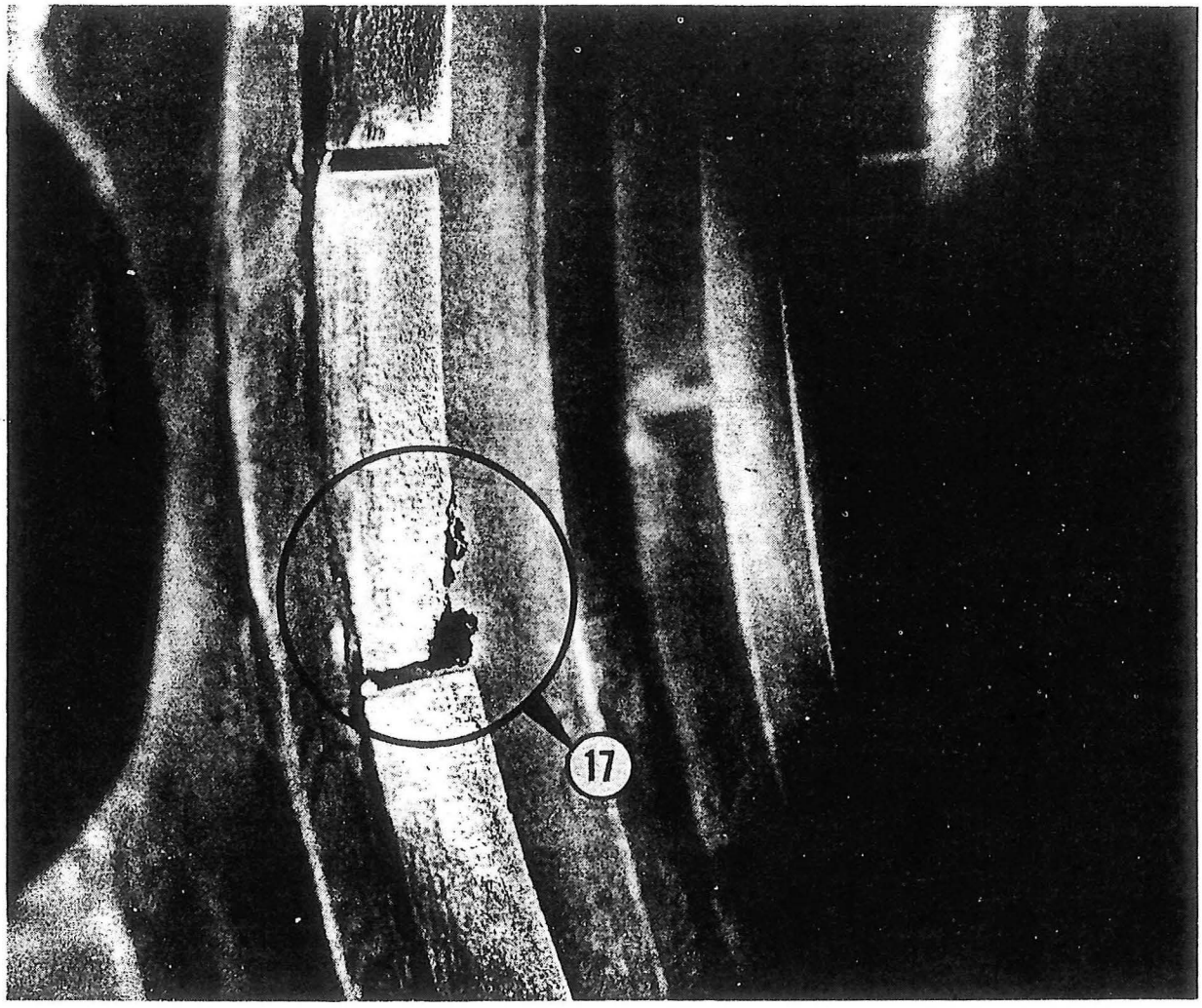


Combustion Chamber Inspection (H-14710)
Figure 622

ENGINE - INSPECTION/CHECK

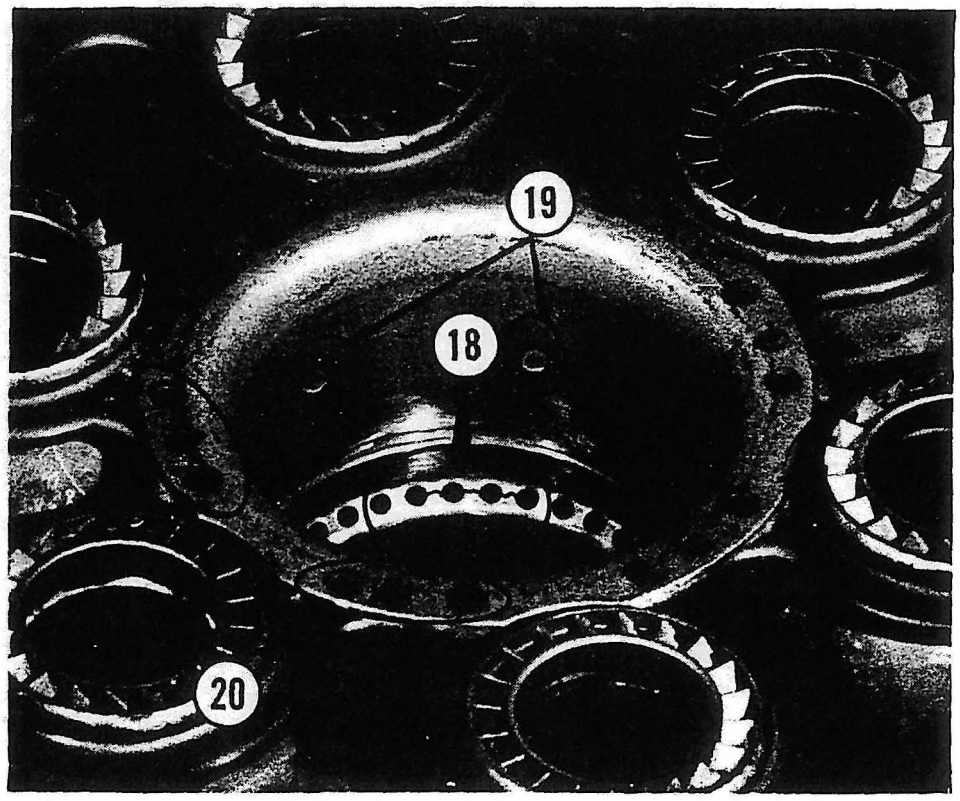


Combustion Chamber Inspection (H-14524)
Figure 623



Combustion Chamber Inspection (EXP-62817)
Figure 624

ENGINE - INSPECTION/CHECK



Combustion Chamber Inspection (H-51013)
Figure 625

ENGINE - INSPECTION/CHECK

5. Combustion Chamber Outer Case-to-Diffuser Case Flange Air Leakage Check

A. Minor air leakage during engine operation at flange between diffuser case and combustion chamber outer case is acceptable. Heavy, concentrated leakage probably indicates severe warpage or damage to flanges and should be investigated by disassembly sufficient to determine condition of flange. Air leakage can be determined by passing cloth along flange.

B. Marking is not permitted on combustion chamber outer case except at OD of front flange.

C. Inspect scallops in forward OD flange contacted by combustion chamber positioning lugs. Cases with scallops having hardface inlay worn 0.010 inch or more are unacceptable for further service until repaired.

R 5A. Combustion Chamber Outer Rear Case

R A. Cases being operated with one or two front flange bolt holes
R cracked through to flange OD must be inspected after each
R 500 hours of operation to assure that cracking does not
R initiate from cracked bolt holes toward center of case.
R Inspection to be visual with bolt removed at crack locations.
R If cracking is detected toward center of case, case cannot
R be continued in service. Repair for this cracking is not
R available and case is considered non-serviceable.

6. Combustion Chamber Outlet Duct

A. Anti-Rotation Lug (PN 570721)

(1) Inspect anti-rotation lug for bending and indications that outer wall has shifted in relation to diaphragm of duct. Bent lug may be repaired in accordance with Section 72-00, Approved Repair.

7. Turbine Vanes - Inspection Procedures

A. Disruptions in chromalized surfaces of first stage vane are not cause for rejection. Vanes having nicks or dents should be replaced. Visually inspect vanes for signs of bowing. Replace vanes which are bowed in excess of 0.075 inch on trailing edge with vanes of same classification. Straight edge and feeler gage stock shall be used to measure bowing. Any or all vanes may be replaced with vanes of same class without measuring nozzle guide vane area.

B. First Stage Nozzle Vanes Cracks-Trailing Edge

(1) First stage turbine guide vanes exhibiting cracks in trailing edge may be continued in service providing:

(a) Cracks do not exceed 0.400 inch in length.

(b) Cracks are separated by a minimum of 1.000 inch.

(c) Cracks are not within 0.500 inch of fillet area of OD and ID buttresses.

NOTE: Cracks in trailing edge only, exceeding 0.400 inch but less than 0.500 inch may remain in service for 200 hours maximum.

C. First Stage Turbine Nozzle Vanes Bow Detection - On The Wing Radiography Inspection

NOTE: Inspect all engines which show performance deterioration as determined by flight log monitoring.

(1) Move aircraft to remote area that affords protection from radioactivity.

WARNING: ISOTOPE RADIOGRAPHY MUST BE PERFORMED BY QUALIFIED PERSONNEL, AND ALL APPROPRIATE SAFETY PRECAUTIONS MUST BE OBSERVED.

(2) R Remove front accessory drive support and front accessory drive main gear per Section 72-00, Dismantling/Assembly.

(3) Locally fabricate tube to accept Iridium-192, type 100C source to fit through 0.490 inch diameter hole in turbine shaft bearing oil pressure tube and heatshield assembly. See Figure 626. Insert cap in inner end of tube to provide locating stop for source when it is in position. Mark tube 107.125 inches from capped end of reference on depth of insertion.

(4) Locally fabricate tooling necessary to support tube in position.

(5) R R Attach 0.010 inch thick lead screens on both front and back of film. Place film, Kodak type M 7 x 17 inches, around front of turbine nozzle case. Butt film against aft side of K flange and attach to flange by hinge on film holder. See Figure 626.

NOTE: Equivalent type film may be used when exposures are adjusted to give same results.

(a) Tape film to turbine nozzle case.

(b) Number films one through seven clockwise from rear starting at twelve o'clock position and placing numerals one inch aft of hinge of film holder. Mark engine number on No. 1 film.

(6) Crank source tube into core of engine until 107.125 inch mark on tube lines up with front face of compressor inlet cone support assembly.

(7) Obtain following gamma-ray projector equipment or equivalent.

(a) Technical Operations Model 529-Gamma Ray Projector Control.

(b) Technical Operations Model 533-Shielded Container.

(c) Flexible Guide Tube

NOTE: Technical Operations Inc., Burlington, Mass. have indicated they would be willing to furnish equipment required.

NOTE: Third light on control box is not used since source switch for this light cannot be used. Source switch will not pass through 0.490 inch diameter hole in turbine shafts bearing oil pressure tube and heatshield assembly.

(8) Using projector equipment crank source out and expose film for 875 curie/minutes.

NOTE: Curie/minutes are determined from actual exposure in minutes multiplied by power source - type 100C power rated at time of exposure.

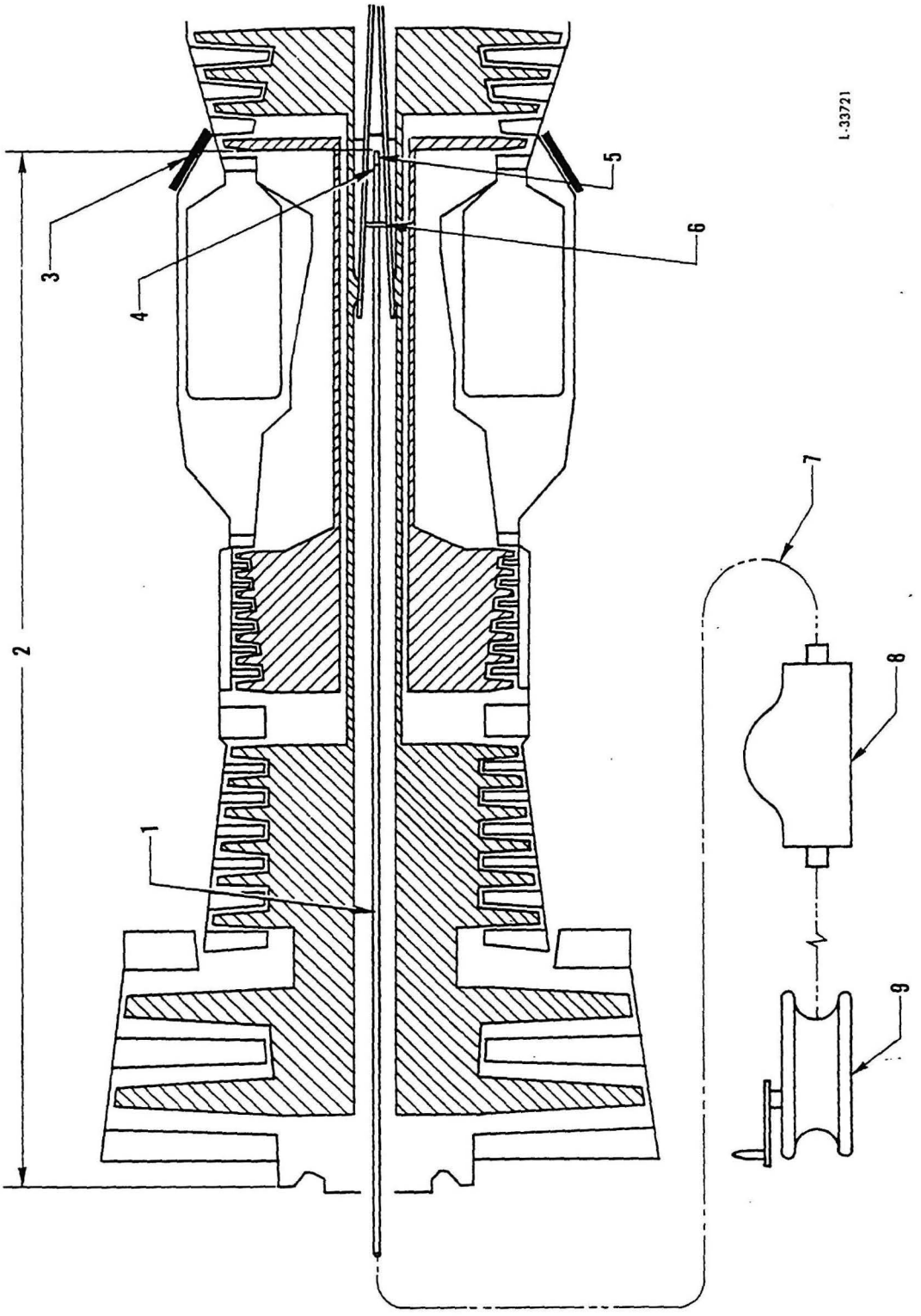
(9) Develop film per manufacturers recommendations.

(10) Analyze first stage turbine blade turbine nozzle vane condition and relationship.

(11) Replace all vanes that show evidence of abnormal bow. See
R Figure 627, No. 2.

NOTE: Limits of abnormal bow will be determined by each operator, which can only be arrived at by experience and repeated isotope inspections. Magnification factor will vary due to location of maximum bow along trailing edge of vanes.

ENGINE - INSPECTION/CHECK



Isotope Inspection Of First Stage
Turbine Nozzle Vanes
Figure 626

ENGINE - INSPECTION CHECK

1. Capped Tube (Source Travels Inside)
2. 107.125 Inches
3. Kodak Type M Film (7 x 17 Inches), 7 Sheets.
4. Iridium-192 Source
5. Cap
6. 0.490 - 0.510 Inch Diameter Hole in Turbine Shaft Bearing Oil Pressure Tube And Heatshield Assembly.
7. Flexible Guide Tube
8. Shielded Container
9. Gamma Ray Projector Control

Key to Figure 626

8. Turbine Blades - Inspection Procedure

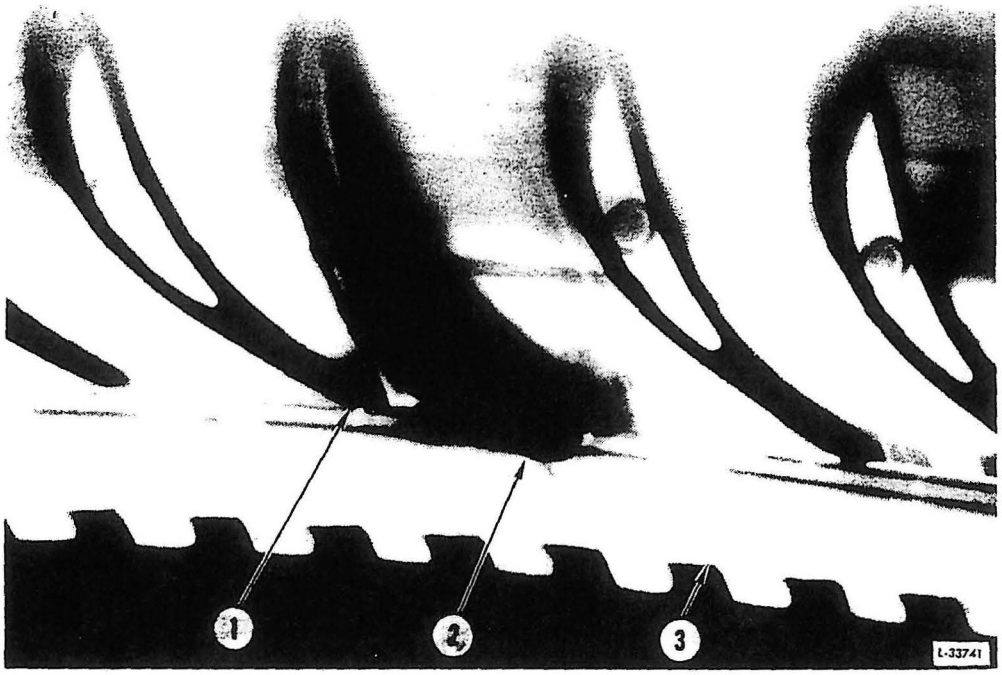
A. Blades with nicks or dents in airfoil within one-half inch of root platform (see Figure 628) can be blended if damage is not detectable on opposite side of airfoil from which they were struck and repair will not reduce local airfoil thickness by more than 0.005 inch or chord length by more than 0.010 inch. Blades with nicks or dents in airfoil (but not in above areas) may be blended if the detectable projection on opposite side of airfoil from which they were stuck is not more than 0.010 inch above adjacent undamaged surface and repair will not reduce local airfoil thickness by more than 0.015 inch or chord length by more than 0.025 inch. Any number of turbine blades may have axial play up to 0.015 inch at blade root and disk, providing rivet heads are sound and undamaged.

B. Turbine Blade Inspection

(1) Inspect first stage turbine blades for deformation of leading edge as follows:

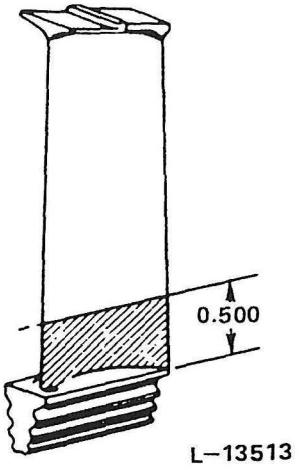
(a) With strong spot light (150 watts minimum), inspect each turbine blade for waviness or deformation of leading edge.

ENGINE - INSPECTION/CHECK



1. Trailing Edge Turbine Nozzle Vane
2. Bowed Turbine Nozzle Vane
3. Leading Edge Turbine Blade

First Stage Turbine Vane Bow
Figure 627



Turbine Blade Repair Limits
Figure 628

(b) Deformation due to overtemperature may appear as waviness and/or areas of varying airfoil thickness along leading edge (see Figure 629). Leading edge must be straight and of uniform thickness.

NOTE: Do not confuse deformation of leading edge with blending repairs to blade. If confusion exists, check blade for stretch.

(c) Remove segment of first stage vanes to facilitate inspection of blades.

(d) When any deformation of leading edge of first stage turbine blades is found, overtemperature condition has occurred. Therefore, reject all blades.

R 9. Deleted

10. Inspection of Engines Subjected to Overtemperature

See 72-00, Adjustment/Test.

11. Inspection of Engines Subjected to Overspeeding

See 72-00, Adjustment/Test.

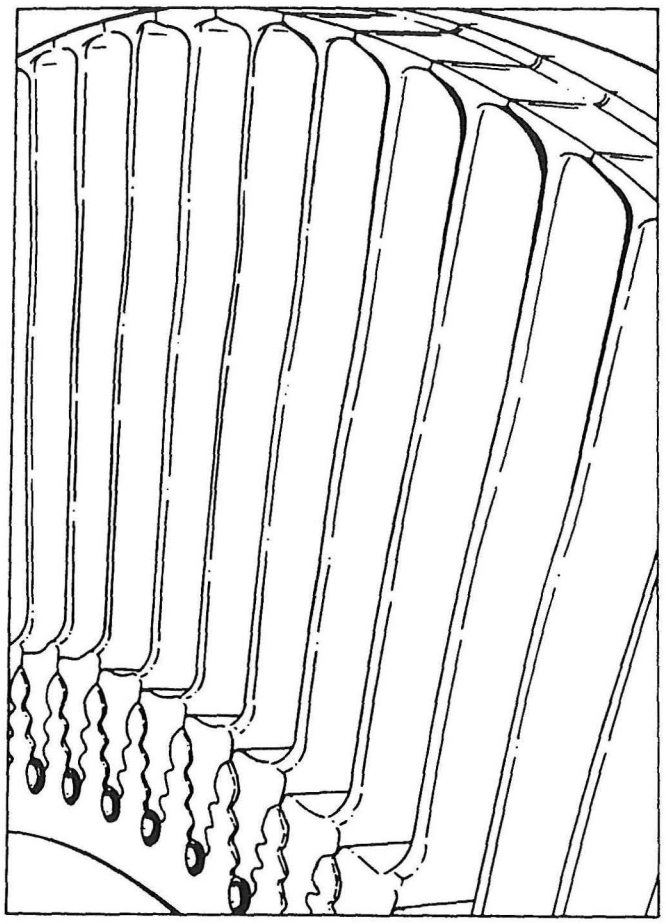
12. Freedom of Rotation Check

A. Following procedure is intended to provide freedom of rotation check in order to reduce possibility of subsequent damage by foreign objects.

CAUTION: ENGINE MUST BE TURNED IN NORMAL DIRECTION OF ROTATION ONLY (COUNTERCLOCKWISE WHEN FACING ENGINE INLET).

B. Prior to engine checkout, high compressor must be rotated by turning starter drive and low compressor rotated manually by first stage compressor blades.

C. If there is any unusual resistance or unusual sound, investigation must be made to determine cause.



L-48200
3-75

Turbine Blade Deformation
Figure 629

13. Front Compressor Case and Vane Assembly

A. First Stage Compressor Vane Spacer

(1) Cracked spacers may be continued is use until crack extends completely across spacer.

(2) Remove spacers which are cracked across entire spacers as follows:

(a) A maximum of six spacers may be removed.

(b) Do not remove two adjacent spacers or more than two spacers in same 90° quadrant.

ENGINE - INSPECTION/CHECK

B. Anti-Icing Air Ports

(1) Cracks in area of anti-icing air ports up to two inches may be continued in service to nearest repair facility.

(2) Weld repair cracks as soon as possible.

R 14. Inspection Of Engines Shut Down In Flight

R A. If there has been continuous positive indication of oil R pressure (5 psi or higher) following shutdown, engine may be R continued in service after satisfactory inspection of main R oil filter following servicing of engine and ground run-up.

R B. An engine windmilling for 30 minutes or less with less than R 5 psi oil pressure after shutdown may be continued in service R after satisfactory inspection of main oil filter, servicing, R and ground run-up.

R C. An engine windmilling for more than 30 minutes but less than R 60 minutes with less than 5 psi oil pressure after shutdown R may be continued in service after satisfactory inspection of R main oil filter, servicing, and ground run-up. Repeat oil R filter check after first flight, 15 hours, 50 hours, and 100 R hours.

R CAUTION: ANY POWER ON OPERATION AT OR ABOVE IDLE WITH OIL R PRESSURE OF 5 PSI OR LESS SHALL REQUIRE THAT ENGINE R BE SENT TO OVERHAUL FOR BEARING INSPECTION.

R D. Engines windmilling for more than 60 minutes with less than R 5 psi oil pressure after shutdown shall be sent to overhaul R for bearing inspection. Particular attention must be given R to No. 2, No. 4, and No. 5 bearings.

R NOTE: Operating conditions prior to and after interruption R and windmilling should be accurately recorded to R determine classification of windmills.

R E. If oil supply was shut off or interrupted for more than 10 R seconds at speeds in excess of windmilling or before engine R decelerated to windmilling speed following engine shutdown, R record conditions of operation and send engine to overhaul for R bearing inspection. Particular attention must be given to R No. 2, No. 4, and No. 5 bearings.

R NOTE: Interrupted shall be zero oil flow or pressure of less R than 5 psi.

(1) Bearing cages must not show excessive wear.

(2) There must be no evidence of ball or roller skidding.

(3) There must be no evidence of adverse effects due to overheating as indicated by color, general appearance, and hardness.

(4) Satisfactory bearings may be continued in use otherwise they must be replaced.

15. No. 6 Bearing Support Rod

A. If for any reason one or more No. 6 bearing support rods are broken, overhaul type inspection of front compressor drive turbine shaft shall be made.

16. Limits of Acceptability for Diffuser Case

A. Cracks at weld junction between struts and diffuser case outer skin may be repaired without disassembling engine provided following limits are met:

R (1) Cracks must not exceed six inches.

(2) Not more than one crack is permitted at each of seven strut locations. No crack or repair is permitted at gearbox tower shaft strut.

(3) A crack weld that redevelops cracks, may be repaired by rewelding. See Engine - Approved Repair.

B. Water Injection Bosses

(1) Cracks around water injection bosses may be repaired.

17. Turbine Exhaust Fairing Bushing Wear

See Figure 630.

A. Wear Limits

(1) Maximum acceptable wear is 0.015 inch on OD.

(2) Reject any parts worn over maximum amount.

(3) Replace bushings per Overhaul Manual Section 72-54-2, Repair.

ENGINE - INSPECTION/CHECK

R 18. No. 6 Bearing Oil Tube Heatshield or Exhaust Strut Guide Wear

R See Figure 630.

A. Wear Limits

(1) Maximum acceptable wear is 0.015 inch on the OD.

(2) Repair in accordance with Overhaul Manual Section 72-54-17 or 18.

R 19. Fairing Bushing To No. 6 Bearing Oil Tube Heatshield or Exhaust Strut Guide Clearance

R See Figures 630 and 631.

A. Wear Limits

(1) Maximum acceptable clearance between bushings and oil tube heatshield is 0.030 inch.

(2) Procedures for checking wear.

(a) Check relative movement between each vane on exhaust case by securing a dial indicator to exhaust case as shown in
R Figure 631.

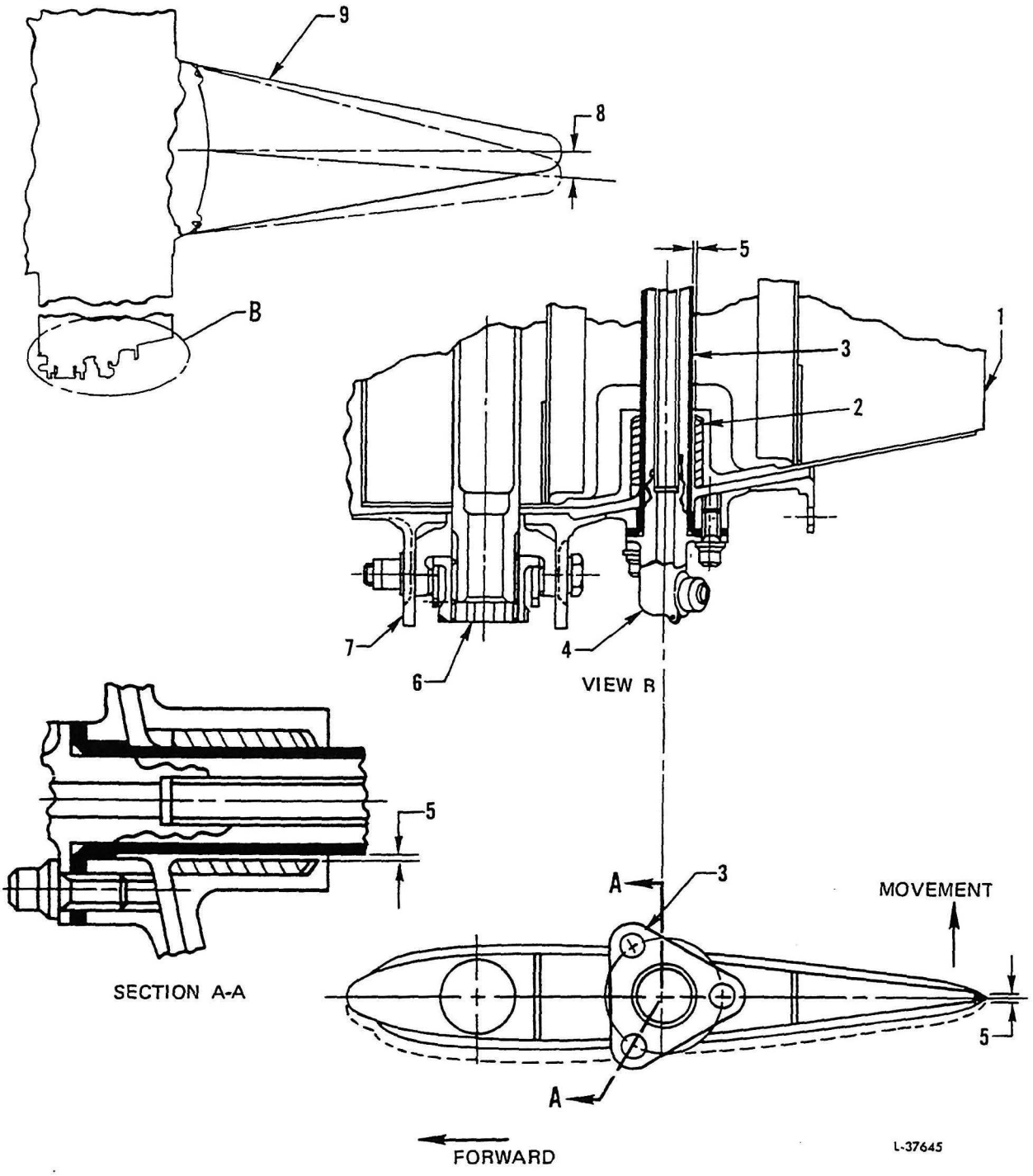
(b) As an alternate to step (a), measure relative movement trailing edge of turbine exhaust fairing. See Figure
R 630. Maximum acceptable movement at tip of tail cone is 0.050 inch in the horizontal or vertical directions. This indicates a heatshield or guide clearance of approximately 0.030 inch.

R 20. Fireseal - Boeing Installation

R A. Cracks In Fireseal

R (1) Inspect lower fireseal assembly for circumferential cracking in six o'clock area, outboard of bolt circle. Cracks up to 15 inches in length are reparable. See Approved Repair. Parts with cracks in excess of 15 inches can be salvaged by rework per Overhaul Manual.

ENGINE - INSPECTION/CHECK



Turbine Exhaust Fairing Bushing Wear Check
Figure 630

ENGINE - INSPECTION/CHECK

1. Turbine Exhaust Fairing (Trailing Edge)
2. Bushing
3. No. 6 Bearing Tube Heatshield
4. No. 6 Bearing Oil Scavenge Tube
5. 0.030 Inch (Approx.) When Maximum Movement Is Reached (Typical Four Places)
6. No. 6 Bearing Support Rod
7. Turbine Exhaust Case
8. 0.050 Inch Maximum Acceptable Movement At Tip Of Tail Cone
9. Tail Cone (Typical)

Key to Figure 630

R 20A. Inspection After Ingestion of Volcanic Ash

CAUTION: ENGINE INGESTION OF VOLCANIC ASH CAN CAUSE OPERATIONAL PROBLEMS INCLUDING LOSS OF POWER. EVEN IF PROBLEMS ARE NOT EXPERIENCED IMMEDIATELY, ASH CONTAMINATION OF ENGINE SYSTEMS CAN RESULT EVENTUALLY IN PERFORMANCE DETERIORATION, BLOCKED COOLING AIR PASSAGES, AND ABRASIVE DAMAGE.

A. When engine has experienced no operational problems subsequent to volcanic ash exposure, perform the following:

(1) Visually check engine inlet and exhaust areas for evidence of damage of excessive erosion.

(2) Borescope inspect high pressure compressor and high pressure turbine for evidence of the following:

(a) Excessive erosion

(b) Foreign object damage (FOD)

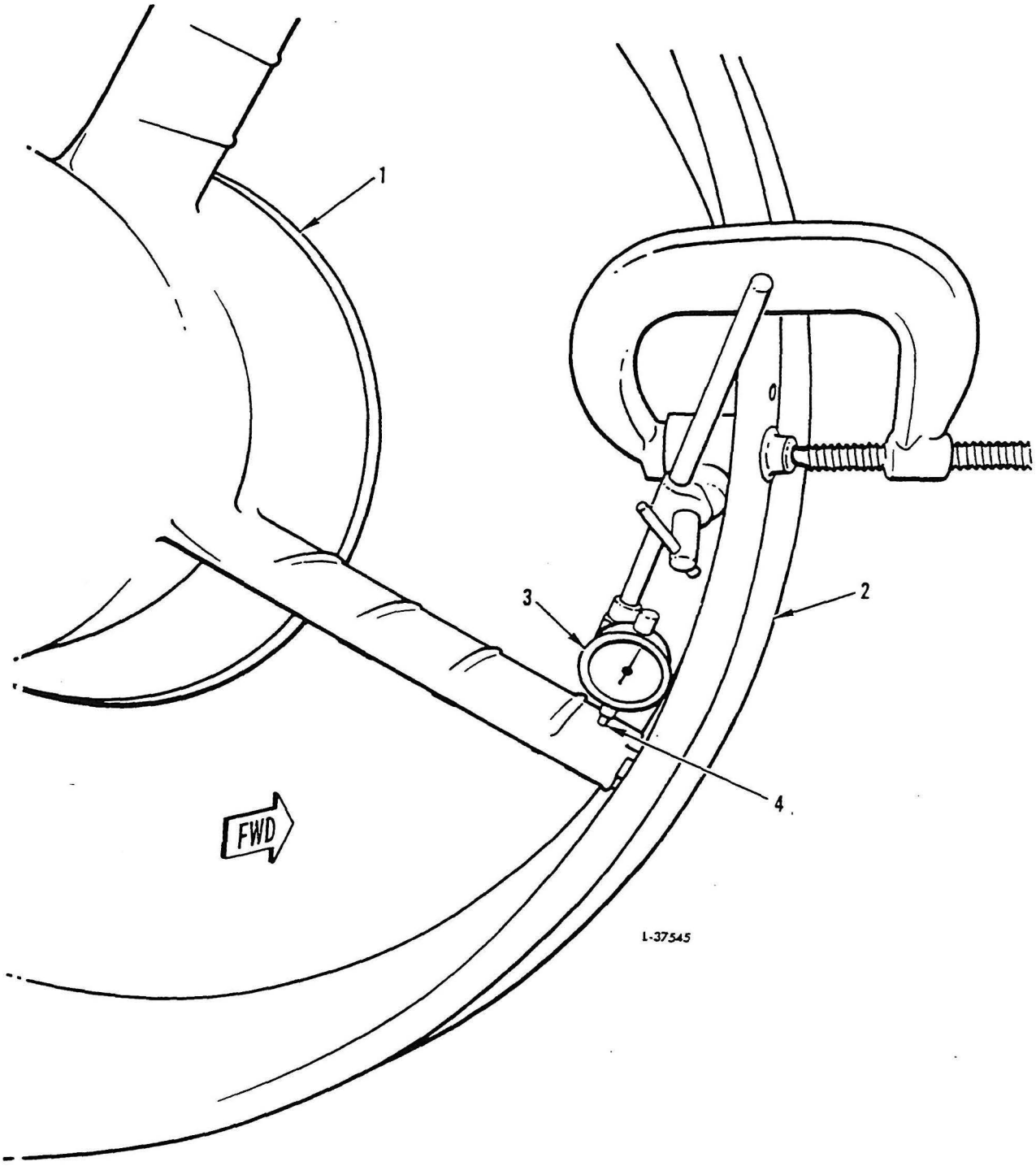
(c) Blockage of H.P. turbine airfoil cooling holes

(d) Build-up of ash deposits

(3) Remove chip detectors and examine for indications of engine damage.

(4) Drain, flush, and refill engine oil system. Retain oil sample for analysis.

(5) Remove and clean or replace all oil, fuel, and air filters. If contamination is found, retain sample for analysis.



1. Turbine Exhaust Fairing (Front)
2. Turbine Exhaust Case
3. Dial Indicator
4. Gage Contact Point At Centerline Of Fairing Bushing

Turbine Exhaust Fairing Bushing Wear Check
Figure 631

ENGINE - INSPECTION/CHECK

R NOTE: It is recommended that a 15 micron main oil filter element be installed if available. If not, oil change frequency should be increased.

(6) Ground run the engine to determine if a shift in performance parameters has occurred. If parameters are abnormal, engine should be replaced.

B. When engine has experienced operational problems subsequent to volcanic ash exposure, perform the following:

(1) Remove engine and route to disassembly facility.

NOTE: Engine records shall direct that engine be disassembled, inspected, and repaired, as necessary, paying particular attention to oil system, air-supplied components and turbine cooling passages.

21. Numerical Tool List

PWA 17205 Support

PWA 30018 Gage

PWA 30458 Probe

PWA 30518 Probe

ENGINE - CLEANING

1. Main Oil Filter Housing

A. Cleaning

R (1) Use SPOP 209 to remove surface oil from the housing.
R
R (2) Rinse in hot water.

R (3) If necessary, spray the part with PMC 9001 solvent to clean
R it.

2. Main Oil Filter Element Assembly

A. Main Oil Screens and Spacers

NOTE: Prior to cleaning, examine the screens and spacers for the presence of foreign matter which would indicate any unusual condition in engine. Save foreign matter and call it to attention of proper personnel.

(1) Slide the screen and spacers on a suitable rod provided with stops to prevent the screens and spacers from sliding off during cleaning operations.

(2) Loosen screens from spacers by sliding parts along rod and
R immerse them for few minutes in SPOP 209 solution.

R NOTE: Ultrasonic cleaning is permitted as an alternate
R procedure for these parts.

(3) Rinse the parts in petroleum solvent and blow them dry with an air jet.

(4) Examine parts for cleanliness and repeat cleaning operations if necessary.

B. Main Oil Filter Cover and Oil Scavenge Pump Inlet Strainer

R (1) Use SPOP 209 to remove surface oil from the parts.
R
R (2) Rinse in hot water.

R (3) If necessary, spray the parts with PMC 9001 solvent to
R clean them.

3. Flexible Tubes

A. Cleaning

(1) Remove all caps.

R (2) If necessary, clean the tubes by SPOP 209 (or put them in
R the cleaner). Use a brush if necessary.

(3) Drain the tubes thoroughly and remove all excess fluid with compressed air making absolutely certain no foreign material remains in the tubes.

(4) Reinstall caps.

R

R 4. Procedure for Cleaning Engine Air Passages

A. General

(1) Field cleaning of the air passages is intended for use on engines displaying definite evidence of performance deterioration due to accumulation of foreign material deposits on compressor blading. Deterioration due to this cause may be detected by repeated necessity to increase high pressure rotor (N2) speed in order to attain necessary part power Pt7 value. If, after complying with necessary procedures outlined in the test section and after field cleaning engine, N2 speed is still over maximum value, send engine to overhaul.

B. Cleaning Agent

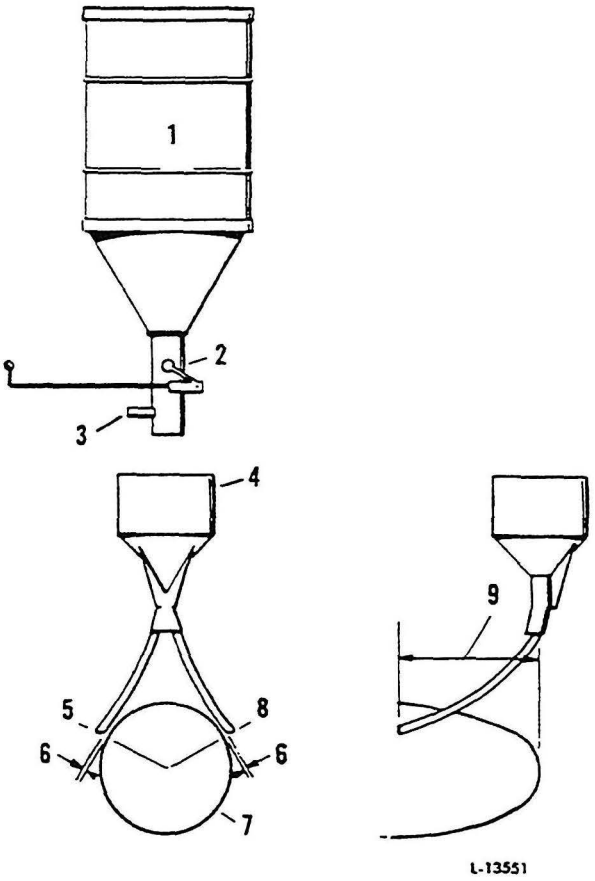
(1) Material approved by Pratt & Whitney for use as cleaning agent in field cleaning process is "Carboblast-Jet Engine Type", (PMC 3010). "Carboblast" is manufactured by Turco Products Inc., Los Angeles, CA. It is important to note that there is standard form of "Carboblast" which contains sufficient amount of rock to be considered totally unacceptable.

CAUTION: IF CLEANING PROCEDURE IS DONE WITH ENGINE IN AIRFRAME, IT WILL BE NECESSARY TO REMOVE FROM AIR INLET DUCT OF AIRFRAME, ANY COOLERS AND INSTRUMENTATION WHICH MAY B DAMAGED BY PASSAGE OF CLEANING MATERIAL.

C. Procedure

(1) Fabricate drum of about 55 gallon capacity with funnel outlet incorporating sliding sheet metal valve, and shutoff valve. Attach hopper, with two outlets of 3/4 inch tubing, to drum with four lengths of chain. Complete equipment will then approximate illustration shown in Figure 701. Position equipment above and slightly forward of engine inlet with two hopper discharge tubes at 2 and 10 o'clock positions. Secure discharge tubes to inlet duct or to screen if engine is on test stand. End of tubes must be as close as possible to nose cone, not over 1/4 inch away, in order to keep carboblast from going out fan discharge area.

ENGINE - CLEANING



R	1.	Drum	6.	1/4 Inch Maximum
R	2.	Valve	7.	Fairing
R	3.	Deleted	8.	Two O'Clock
R	4.	Hopper	9.	12 to 14 Inches
R	5.	10 O'Clock		

Carboblast Arrangement
Figure 701

ENGINE - CLEANING

CAUTION: ADJUST SLIDE VALVE TO PROVIDE FLOW OF CLEANING MATERIAL NOT TO EXCEED MAXIMUM OF 100 POUNDS IN 15 MINUTES. PERSONNEL USING THIS PROCEDURE SHALL BE CAUTIONED AGAINST INCREASING INJECTION RATE OF MATERIAL, SINCE INCREASED RATE MAY RESULT IN CONCENTRATION OF MATERIAL IN CONFINED AREAS OF ENGINE, WHERE FIRE, WHICH MIGHT CONCEIVABLY DAMAGE ENGINE PARTS, MAY OCCUR. PRIOR TO ACTUAL ENGINE RUNNING CHECK RATE OF DISCHARGE OF CARBOBLAST MATERIAL. RATE OF DISCHARGE WILL VARY CONSIDERABLY DEPENDING ON CARBOBLAST MOISTURE CONTENT.

(2) Remove or disconnect components from engine on order to avoid damage during cleaning operation. Complete removal of tubes which bleed air from compressor is not necessary provided stainless steel cover plate 0.032 inch thick is installed between tube and opening and bolts tightened. This then blanks off systems which use compressor air and prevents accumulation of cleaning material in other equipment. Remove or blank off following:

(a) Remove compressor bleed control temperature bulb band bellows from front accessory support.

(b) Remove left and right anti-icing air valves, tubes, compressor bleed valve screen housing, compressor bleed valve actuator supply tubes and water shut-Off valve air tube. Remove pressure sensing tube from front support case. Remove two fuel drain valve assemblies from combustion chamber outer case. Cap openings in cases and tube ends.

(c) Disconnect high pressure compressor bleed manifold and cap openings.

ENGINE - CLEANING

(d) It is not necessary to remove pressure probes or thermocouples from turbine exhaust case for carboblast cleaning operation. No precautions are required for thermocouples. 80 to 120 psi air pressure must be applied to pressure probe manifold during actual cleaning operation. If probes or thermocouples are removed, cap openings.

NOTE: Do not unfasten compressor discharge pressure tube at fuel pressurizing and dump valve.

(e) Remove any aircraft instrumentation in gas path and cover openings.

NOTE: Above operations are necessary to prevent accumulation of cleaning material in equipment or instrumentation, either engine or airframe mounted, which may cause malfunctioning of equipment.

(f) Pour 200 pounds of cleaning material into drum.

(g) Start engine; then, after warm-up at 85 percent, open valve at drum outlet without reducing power.

CAUTION: ENGINE MUST BE THOROUGHLY WARMED-UP AT 85 PERCENT FOR FIVE MINUTES BEFORE OPENING DRUM OUTLET.

NOTE: Provide for manual operation of compressor bleed valve utilizing external air source. Close bleed valve prior to introduction and cycle valve every five minutes during process. R R R R

(h) Accelerate engine to approximately 92 percent (Tach) N2 speed; then slowly decelerate and accelerate between 85 percent and 92 percent (Tach) N2 speed for period of five minutes.

(i) Operate engine at 90 percent to 92 percent (Tach) N2 speed for five minutes.

ENGINE - CLEANING

(j) Then, repeat acceleration and deceleration operation described above until complete 200 pounds of cleaning material is consumed.

NOTE: If desired Pt7 cannot be obtained using 200 pounds of cleaning material, steps outlined above should be repeated using another 200 pounds of cleaning material. Entire process for single run should take 30 to 40 minutes of engine operation, but not less than 30 minutes.

(k) Run engine for five minutes at idle; then shut down.

(l) If installed remove caps and closures which were temporarily installed over bleed and pressure line opening and operate engine for five minutes at up to 90 percent N2 speed; then run engine for five minutes at idle and shut down.

NOTE: Purpose of this run is to permit any cleaning material accumulated in bleed ports to be blown out.

CAUTION: MAKE CERTAIN THAT HIGH TEMPERATURE GASES ARE NOT DIRECTED AGAINST COMBUSTIBLE AIRCRAFT EQUIPMENT (SUCH AS WIRE BUNDLES).

(m) Install any aircraft instrumentation removed from gas path and high pressure compressor bleed manifold.

(n) Install left and right anti-icing air valves, tube, compressor bleed valve actuator supply tubes and water shut-off valve air tube as complete units.

(o) If removed, install pressure probes and thermocouples in turbine exhaust case.

(p) Install compressor bleed valve control temperature bulb on front accessory drive front support and pressure sensing tube on inlet guide vane and shroud case. Install two fuel drain valves in combustion chamber outer case.

CAUTION: CARE MUST BE EXERCISED IN INSTALLING FUEL DRAIN VALVES IN COMBUSTION CHAMBER OUTER CASE. PIN HOLE IN VALVE ASSEMBLY MUST BE PROPERLY ALIGNED WITH LOCATING PIN IN CASE.

(q) Retrim engine.

R 5. Nickel-Cadmium Plated Parts

CAUTION: DO NOT CLEAN ANY DIFFUSED NICKEL-CADMIUM PLATED SURFACE WITH AN ABRASIVE MATERIAL.

R 6. Liquid Washing Of Engine for Performance Improvement

NOTE: Engine performance deterioration, i.e., high power stalls, increase in low and high compressor speed, exhaust gas temperature, and thrust specific fuel consumption, may be due to contamination of blades and vanes of both compressors and turbines. This contamination may be removed by washing with fresh water or optional detergent solution while rotating engine with starter. The following procedure is recommended on a regular basis. However, since environmental conditions vary widely among operators, the frequency of a periodic liquid wash program or the desirability of detergent wash should be determined by each individual operator.

A. Water Wash Procedure

(1) Conduct pre-wash engine performance checks at EPR's of 1.37 (data plate), 1.60 and Take-Off EPR. At each point, operate engine for three minutes, then record N1, N2, EGT and fuel flow. For this check, engine air bleed and electrical load extraction shall be zero.

NOTE: Under icing conditions, thermal anti-icing may be used between check points.

(2) Shut down engine and allow at least 30 minutes for engine to cool.

(3) Pull ignition circuit breaker for engine being washed.

(4) Disconnect generator cooling inlet (Aft) supply duct (Boeing).

(5) Ensure that start lever for engine being washed is in "Off" position.

(6) Ensure that all anti-icing air shut-off, fuel de-icing heater shut-off and airframe bleed extraction shut-off valves (except engine bleed valves) are closed.

(7) Make certain N2 rotation is completely stopped, then engage starter and allow engine to reach full starting rpm. Do not exceed starter duty cycle.

WARNING: IN FOLLOWING SPRAY PROCEDURE, IF HOSE IS HAND HELD, OPERATOR MUST STAND AT LEAST THREE FEET FROM ENGINE INLET.

R (8) Using 3/4 inch ID or larger hose, spray clean potable water that is of drinking purity into engine inlet at 35 - 45 psi for 30 seconds while motoring engine with starter. Spray should be directed toward center of engines inlet but not directly at nose cone. Approximately 40 - 50 gallons of water may be discharged into engine in 30 second period.

NOTE: It is permissible to add sufficient alcohol (AMS 3002 or AMS 3004) to water to prevent freezing. Wash mixture of up to 50 percent alcohol may be used. See Tables I and II.

Percent Alcohol By Volume	Outside Air Temperature
3	40°F (4.4°C)
6	38°F (3.3°C)
9	36°F (2.2°C)
14	33°F (0.6°C)
17	31°F (-0.6°C)
20	28°F (-2.2°C)
22	26°F (-3.3°C)
23	25°F (-3.9°C)
27	20°F (-6.6°C)
32	15°F (-9.4°C)
36	10°F (-12.2°C)
39	5°F (-15°C)
43	0°F (-17.8°C)

Minimum Required Ethyl Or Isopropyl Alcohol To Water Mixture
Table I

ENGINE - CLEANING

Percent Alcohol By Volume	Outside Air Temperature
5	40°F (4.4°C)
10	33°F (0.6°C)
15	27°F (-2.8°C)
20	22°F (-5.6°C)
22	20°F (-6.6°C)
26	15°F (-9.4°C)
29	10°F (-12.2°C)
32	5°F (-15°C)
36	0°F (-17.8°C)

Minimum Required Methyl Alcohol
To Water Mixture
Table II

(9) Turn water off and release starter.

(10) Allow engine to drain for approximately five minutes.

(11) Repeat substeps (7) through (10) as desired (generally two to four times) to obtain incremental improvements in engine surge margin and performance, based on operator's experience.

(12) Inspect inlet guide vanes to ensure that they are undamaged.

(13) Reset ignition system circuit breaker for washed engine. Remove plug from fuel control P_b tube moisture trap and check for entrapped water. Reconnect generator cooling duct.

(14) Conduct engine post-wash performance check at EPR's of 1.37 (data plate), 1.60 and Take-Off EPR. At each point, operate engine for three minutes, then record N_1, N_2, EGT and fuel flow. For this check, engine air bleed and electrical load extraction will be zero. This step should be done immediately after washing engine.

CAUTION: DO NOT EXCEED GROUND STATIC OPERATION LIMITS FOR ANTI-ICING AIR SYSTEM.

(15) If engine is to remain inoperative for four hours or more, after washing, start engine and run at idle for five minutes. Operate anti-icing air shut-off, fuel de-icing heater shut-off and applicable airframe bleed extraction shut-off valves.

NOTE: Under very cold and windy weather conditions, even if water/alcohol mixture is used, there is a high probability of ice formation in engine in less than four hours if engine run-up is not performed following wash, to purge or evaporate residual water.

(16) Shut down engine and recheck fuel control Pb tube mixture trap for water.

B. Detergent Wash Procedure (Optional)

(1) Perform substeps (1) through (6) of water wash procedure.

R (2) Prepare 20 gallons of detergent solution (refer to Table III
R for SPMC 87 cleaner names and sources).

NUMBER AND NAME	SPECIFICATIONS	SOURCE CODE
SPMC 87-1 thru -13 Cleaner - Gaspath	SPMC 87-1: *Ardox 6343	K6858
	SPMC 87-2: **Ardox 6345	23373 or K6858
	SPMC 87-3: *Ardox/Leeder 252-L	23373 or K6858
	SPMC 87-4: *B & B 3100	21361
	SPMC 87-5: *B & B TC100	21361
	SPMC 87-6: *Cee-Bee R-674	71361
	SPMC 87-7: **PENAIR M-5704	56883
	SPMC 87-8: *Penetone 19A	56883
	SPMC 87-9: **IVAR RIVENAES R-MC	58913

R Detergent Cleaner Sources
R Table III

	NUMBER AND NAME	SPECIFICATIONS	SOURCE CODE
R		SPMC 87-10A:	
R		**Turboclean 2	K2884
R		SPMC 87-10B:	
R		**Turboclean 2 RTU	
R		SPMC 87-11A:	
R		**Turco 6783-3	OBYN5
R		SPMC 87-11B:	
R		**Turco 6783-10	
R		SPMC 87-12:	
R		*Turco T-5884	OBYN5
R		SPMC 87-13:	
R		**ZOK 27	U4628 or S0081

R NOTE: Gaspath cleaners identified with an asterisk (*) are
R solvent type cleaners. Gaspath cleaners identified by
R two asterisks (**) are detergent type cleaners.

R Detergent Cleaner Sources
R Table III (Continued)

(3) Make following preparations for washing (during cooling period, if desired).

(a) Disconnect Pt2, Ps3, and Ps4 lines to pressure ratio bleed control.

(b) Disconnect Pt2 and Pt7 lines to engine pressure ratio transmitter at low point on engine.

(c) Disconnect Pb sense line to fuel control at engine.

(d) Disconnect thrust reverser and hydraulic reservoir pressurization line at engine.

NOTE: It is not necessary to cap off fittings after disconnecting lines, providing fittings are offset to prevent water from entering line or unit.

(4) Motor engine with starter at approximately 2500 rpm N2.

R (5) Discharge approximately five gallons of cleaner solution into engine and release starter.

(6) Wait 20 minutes, then repeat substeps (4) through (6) three more times.

(7) Immediately water wash engine as directed in Step A., (7) through (10).

(8) Reconnect engine and airframe lines removed in substep (3).

(9) Reset ignition system circuit breaker for washed engine. Reconnect generator cooling duct.

(10) Check fuel control Pb tube moisture trap for water and perform performance calibration run as directed in Step A., (14) through (16).

R (11) Run the engine after this procedure to dry the inside of
R the engine.

C. Water Wash Procedure (Routine Use Version)

(1) This procedure is virtually identical to Step A., with exception that pre-wash, substep (1), and post-wash, substep (14), engine performance checks are not required. Operators who choose to follow a routine water washing schedule may use this procedure as a means of minimizing gaspath contamination or retarding turbine airfoil sulfidation.

ENGINE - APPROVED REPAIR

1. General

A. See Disassembly/Assembly Section for information concerning standard engine maintenance practices.

B. See Chapter 71, as required, for information concerning removal of airframe installed parts.

R 2. Combustion Chamber Outlet Duct

A. Anti- Rotation Lug (P/N 570721)

(1) Anti-rotation lug that is bent and does not extend out through center slot of duct flange may be repaired as follows:

(a) Tap end of lug, where it is welded to outer duct wall, to rotate outer wall and slip outer end of lug into center slot of duct flange. Straighten lug in center slot of flange as outer wall is slipped (rotated) back into position.

R 3. Removal/Installation of First Stage Nozzle Guide Vanes

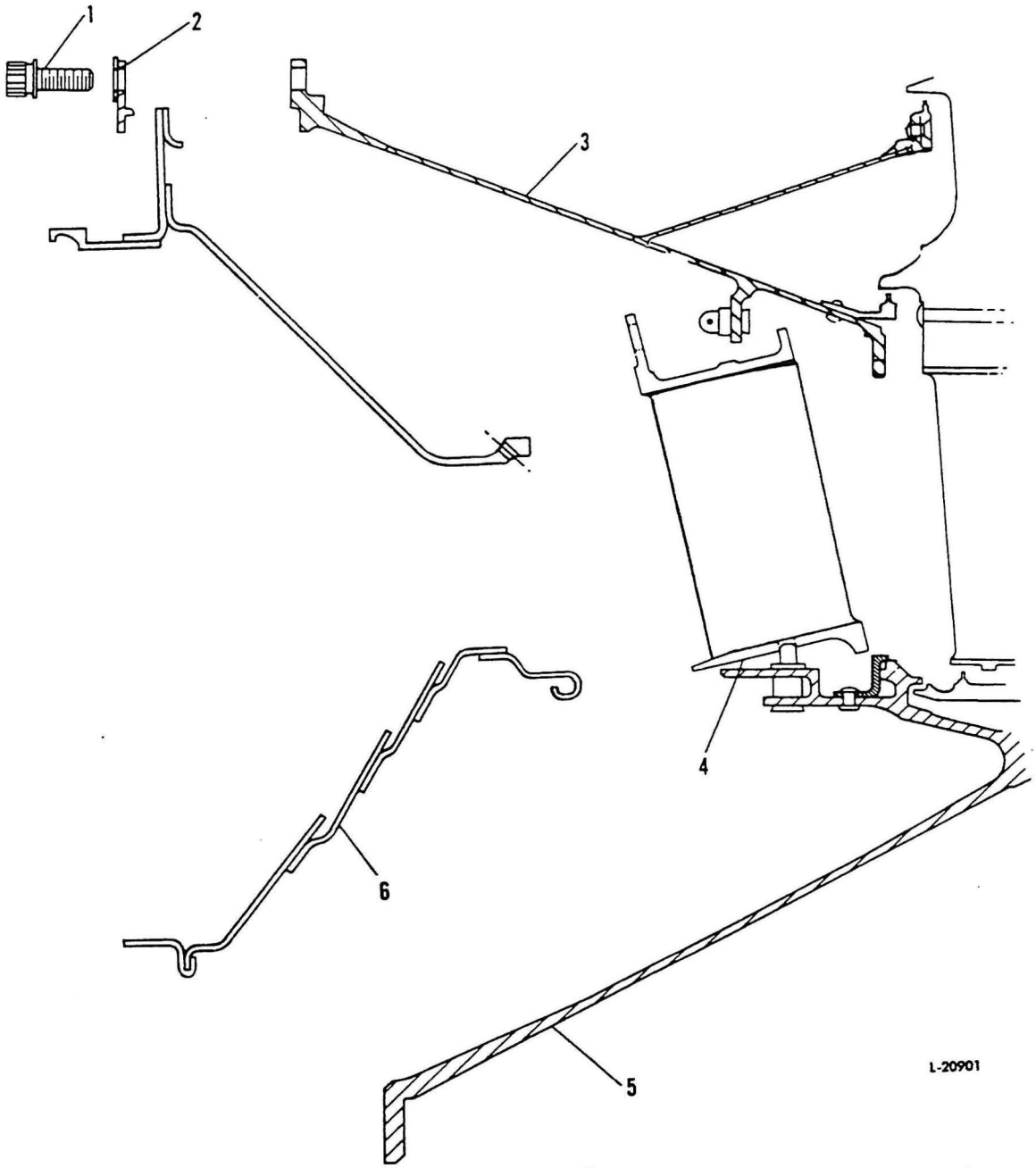
R See Figure 801.

A. Removal

NOTE: Combustion chambers must be removed in manner outlined
R in Section 72-00, Engine - Dismantling/Assembly.

CAUTION: TURBINE NOZZLE CASE IS SUPPORTED BY FIRST STAGE TURBINE NOZZLE GUIDE VANES MAKE CERTAIN NOZZLE CASE IS ADEQUATELY SUPPORTED IF SIZEABLE QUANTITY OF VANES ARE TO BE REMOVED. THIS MAY BE ACCOMPLISHED BY REPOSITIONING COMBUSTION CHAMBER OUTER FRONT CASE (ONLY) TO DIFFUSER CASE REAR FLANGE AND SECURING IT WITH SUFFICIENT BOLTS. INSTALL FOUR PWA-17205 SUPPORTS 90 DEGREES APART BETWEEN COMBUSTION CHAMBER OUTER FRONT CASE AND TURBINE NOZZLE CASE OR POSITION SADDLE ARRANGEMENT TO LOWER NECKED-DOWN SECTION OF TURBINE NOZZLE CASE. MAKE CERTAIN AIRFRAME SILENCER AND REVERSER ARE REMOVED OR ADEQUATELY SUPPORTED DURING THIS PHASE OF MAINTENANCE.

(1) Remove bolts; then remove clamp plates securing outlet duct to turbine nozzle inner case. Remove clamp plates.



1. Retaining Nut
2. Outlet Duct Clamp Plate
3. Turbine Nozzle Inner Case
4. Turbine Vane
5. Turbine Nozzle Outer Case
6. Combustion Chamber Outlet Duct

First Stage Nozzle Guide Vane Removal
Figure 801

(2) Mark one of fingers in outlet duct and its position in gangbolt assembly in nozzle case; then remove Allen screws securing eight gangbolt assemblies, spacers, and outlet duct to nozzle case front flange. Remove gangbolt assemblies while supporting outlet duct.

NOTE: Mark gangbolt assemblies to assure their reinstallation in proper location at assembly.

(3) Pull outlet duct forward to expose first stage nozzle vanes.

(4) Using approved method, number vanes and their location in order to assure their return to same location.

(5) Remove lockwire from vane retaining pin, and using rocking motion, pull vane forward from its seat. Remove as many vanes as required in this manner.

NOTE: When it is necessary to remove all vanes, 12 or more vanes should be left in (evenly dispersed) until after sufficient number of new vanes are installed to prevent cocking of turbine case. Number of vanes, up to 100 percent, may be replaced in nozzle assembly as long as each replacement vane is same class as vane which it replaces. If replacement by exact class is not possible, the new average class should be determined to be within limits by recalculation.

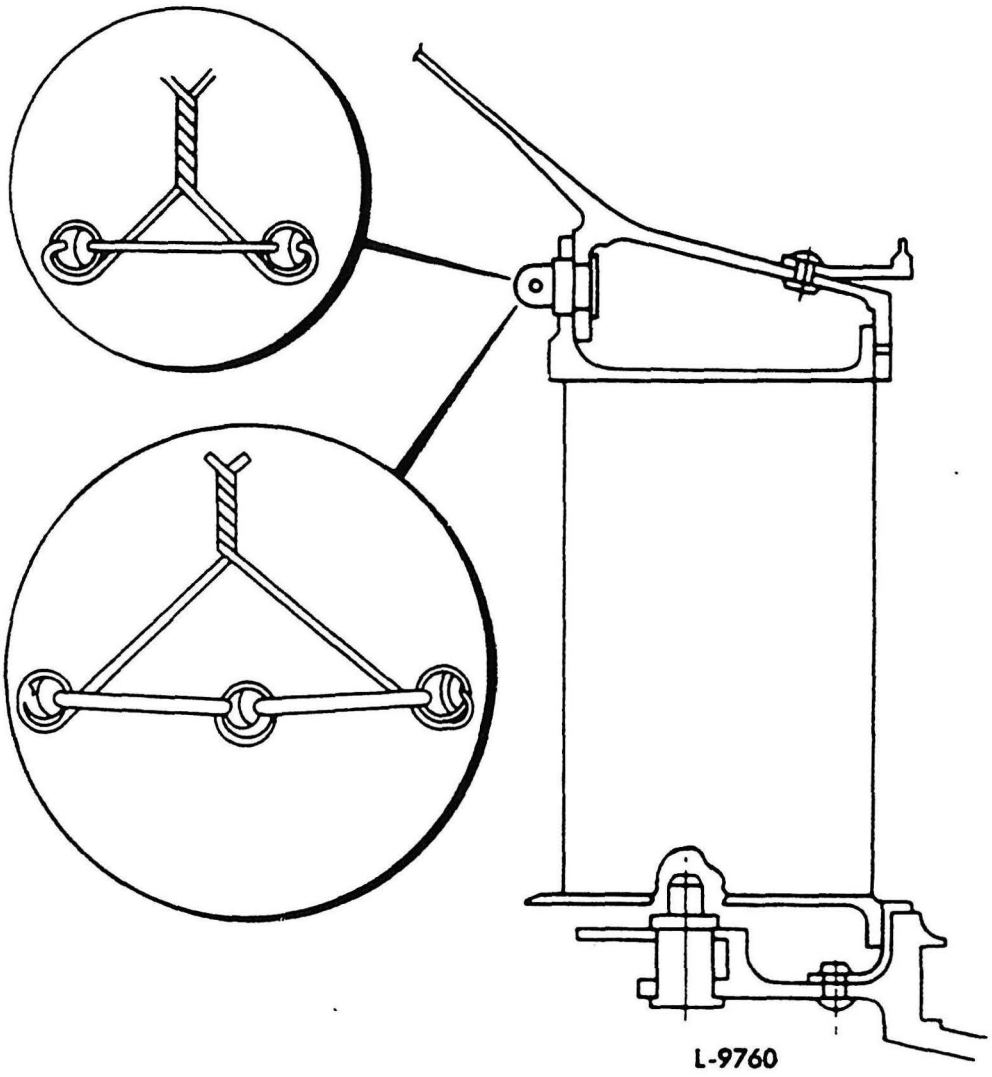
B. Installation

(1) Insert vanes into their seats and snap them into position, aligning vane retaining pins with their holes in vanes. Lockwire retaining pins in pairs, except, lockwire last
R three vanes together. See Figure 802.

NOTE: Make certain correct numbered vane or replacement (if required) is returned to its original position. Engines incorporating turbine stator support assembly, P/N 622402, must use vanes, P/N 536751. These vanes are installed with bolts, P/N 523514. Torque bolts and then lockwire as described in step (1).

(2) Position outlet duct assembly to turbine nozzle inner case and turbine nozzle case front flange in location marked at disassembly.

ENGINE - APPROVED REPAIR



First Stage Turbine Vanes Lockwiring
Figure 802

(3) Install a reinforcing plate between each outlet duct flange and turbine case front flange and an outlet duct positioning plate against front face of each flange so that each outlet duct flange is located between reinforcing plate and positioning plate.

NOTE: Hardfaced outlet duct flanges should be assembled between hardfaced reinforcing and positioning plates, but may be assembled between non-hardfaced plates.

CAUTION: DO NOT ASSEMBLE NON-HARDFACED OUTLET DUCT FLANGES BETWEEN HARDFACED REINFORCING AND POSITIONING PLATES.

(4) Position the seven-bolt gangbolts to retain the reinforcing and positioning plates and the flanges of combustion chamber outlet duct against the turbine nozzle case front flange. Secure gangbolts to nozzle case flange with socket head screws.

(5) Install outlet duct clamp plates and insert bolts securing them to turbine nozzle inner case. Torque bolts.

NOTE: Combustion chambers and combustion chamber outer cases shall be reinstalled as outlined in Section 72-00, Engine - Dismantling/Assembly.

R 4. Compressor Inlet Case (For Cases P/N 502337, 515226 and 633682)

A. Stripped Attaching Bolt Hole Threads - Rear Outer Flange

NOTE: This is an "on the wing" repair. See Overhaul Manual, Repair, Section 72-21-1 for disassembled weld repair.

R (1) Install Heli-Coil as shown on Figure 803.

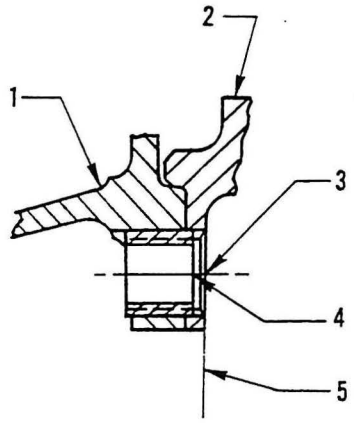
(2) Remove damaged material from flange by using drill size Q.

(3) Plug tap each hole using Heli-Coil Tool 1193-5.

NOTE: Tools specified are proprietary items, it is suggested they may be purchased from Heli-Coil Corporation, Danbury, Connecticut.

(4) Check threads in each hole using Heli-Coil thread gage 3694-5.

ENGINE - APPROVED REPAIR



VIEW SHOWING THREAD REPAIR

L-31927

1. Rear Flange Compressor Inlet Case
2. Front Flange Fan Case
3. Thread For 0.3125-24 Helical Coil Insert Chamfer 120° ± 5° Inclusive To 0.360 - 0.400 Diameter.
4. MS 124657 Insert As Required
5. Top Face Of First Coil To Be 0.75 To 1.00 Pitch Below This Surface, Break Off Tang At Notch.

Compressor Inlet Case Helical Insert Repair
Figure 803

(5) Install insert MS 124657 in inserting tool, Heli-Coil 535-5, and install insert in threaded hole.

(6) Remove inserting tool and break off tang to notch, using Heli-Coil break-off tool 1196-5.

B. Welded Braces to Reinforce Rear Outer Flange

NOTE: This is an "on wing" repair. See Overhaul Manual Repair Section on 72-21-1 for disassembled weld repair.

(1) Weld as shown on Figure 804.

(2) Stress-relieve not required for this repair.

C. Heat Sensitive Paint Application

NOTE: Application of heat sensitive paint provides a method of detecting failed anti-icing regulators by monitoring temperature of anti-icing air circulating through inlet vane and shroud assembly.

R (1) Clean vanes with SPOP 208 solvent and prepare surface with silicone carbide cloth. See Figure 804A for locations of vanes to be painted.

R (2) Apply heat sensitive paint to cover a 0.500 inch diameter
R area on vanes adjacent to the anti-icing inlet area (near
R the outer end of the vanes). See Figure 801A.

R NOTE: Heat sensitive paint is available as SC165 paint
R from:

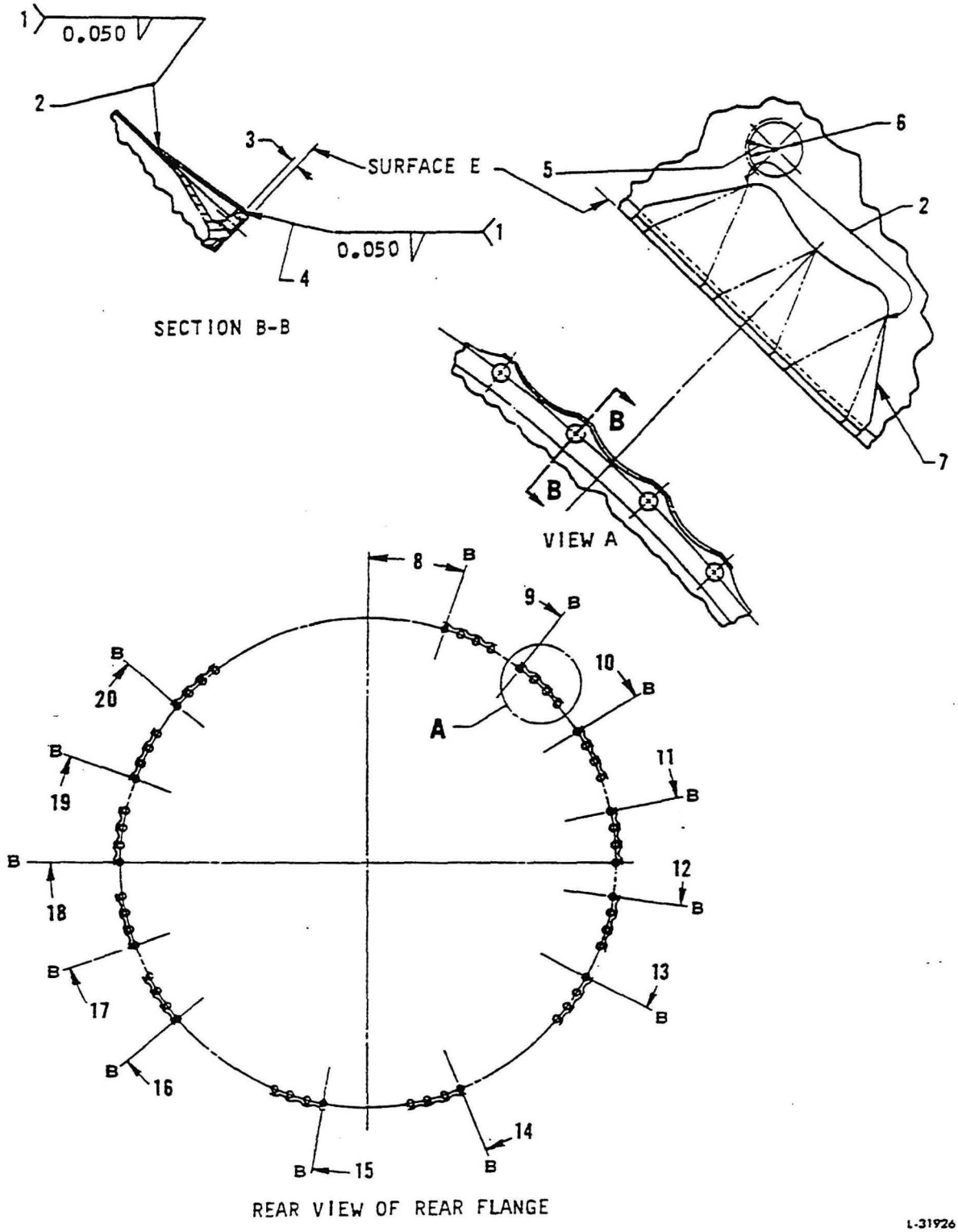
R Thermographics Measurements Ltd.
R 129 Harvard Street
R Brookline, MA 02146 USA

R Phone: (617) 734-1018
R

5. First Stage Fan Blade On Wing Repair And Flyback Limits

NOTE: First stage fan blades which have foreign object damage in excess of inspection and repair limits shown in Figure 601, Inspection/Check section may be continued-in-service by performing On Wing repair as indicated below.

ENGINE - APPROVED REPAIR



Compressor Inlet Case Rear Flange Reinforcement
Figure 804

ENGINE - APPROVED REPAIR

1. Weld Using AMS 4951 Filler Metal, Machine Gas Tungsten-Arc (TIG) Per Standard Practices Manual.
2. Weld For This Distance
3. 0.140 - 0.160 Inch
4. Weld Along Contour.
5. 0.531 - 0.594 Inch Radius - If Necessary Brace May Be Finished To This Dimension To Prevent Overlapping Diameter No. 6.
6. 1.028 - 1.048 Inch Diameter - Reference
7. Brace PN 692736, Required At Locations B.
8. 18° Reference
9. 38° Reference
10. 58° Reference
11. 78° Reference
12. 98° Reference
13. 118° Reference
14. 158° Reference
15. 190° Reference
16. 230° Reference
17. 250° Reference
18. 270° Reference
19. 290° Reference
20. 310° Reference

Key to Figure 804

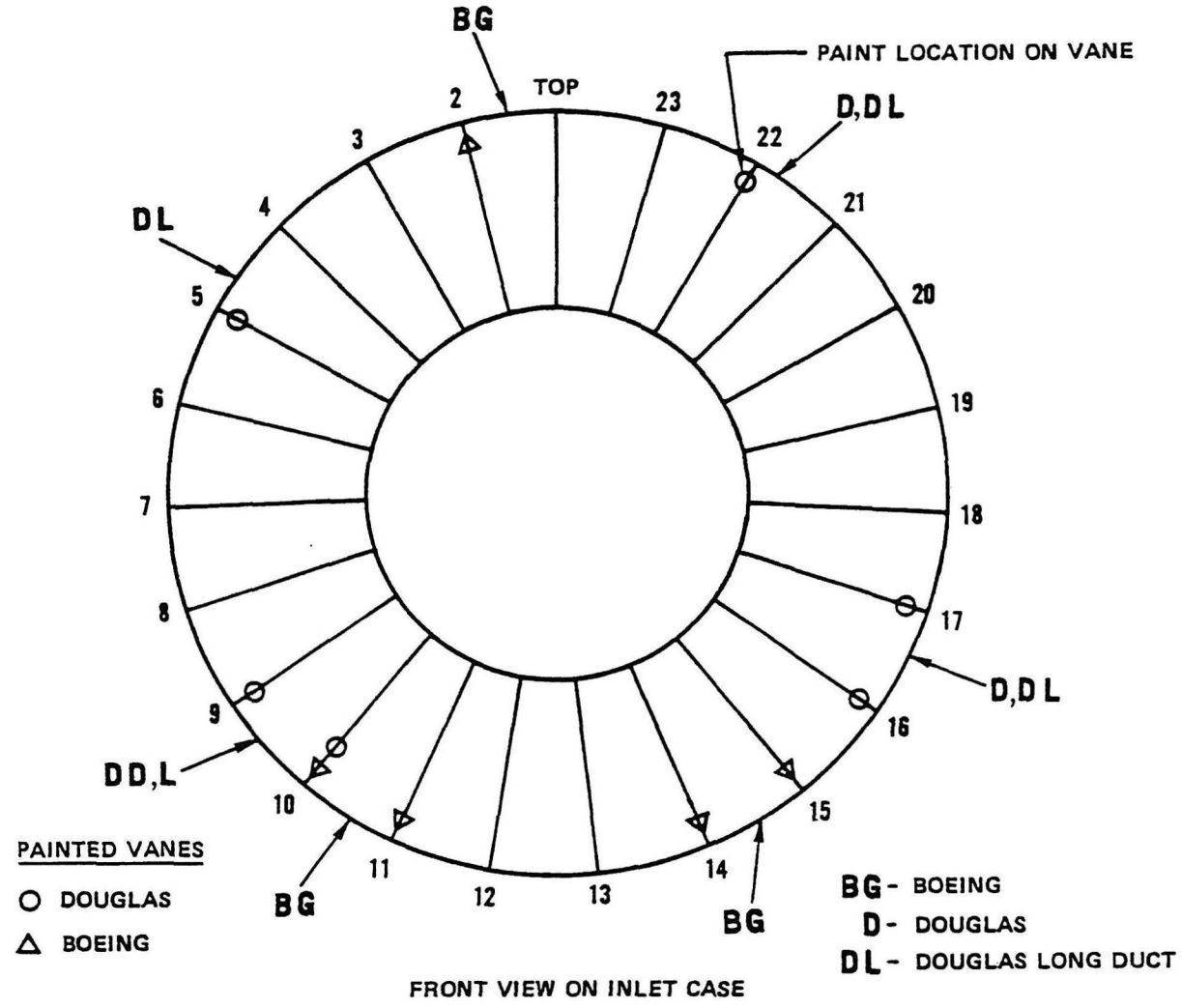
R B. Do not repair more than a total of 6 blades per rotor to any
R cut or combination of cuts in Figure 805. Reworked blades
R may be adjacent or scattered throughout the rotor assembly.
R However, any individual blade incorporating the dimensions
R of either the 25 or 150 hour cut-back will restrict the time
R on that rotor to 25 or 150 hours as applicable. Should all
R six blades be repaired to the dimensions of the 25 hour
R flyback cut, the following performance penalty may exist:

(a) Decrease in fan efficiency of approximately 5 percent.

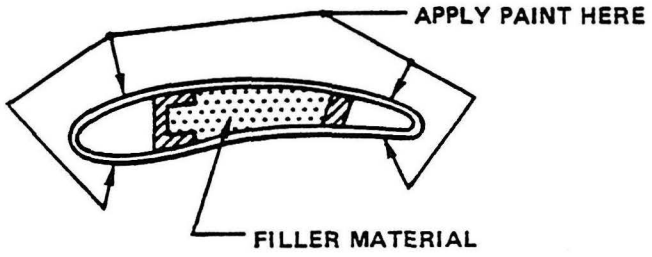
(b) Decrease in fan operating line of 2.1 percent.

ENGINE - APPROVED REPAIR

JT3D ANTI-ICING INLET LOCATIONS



FRONT VIEW ON INLET CASE



SECTION THROUGH VANE

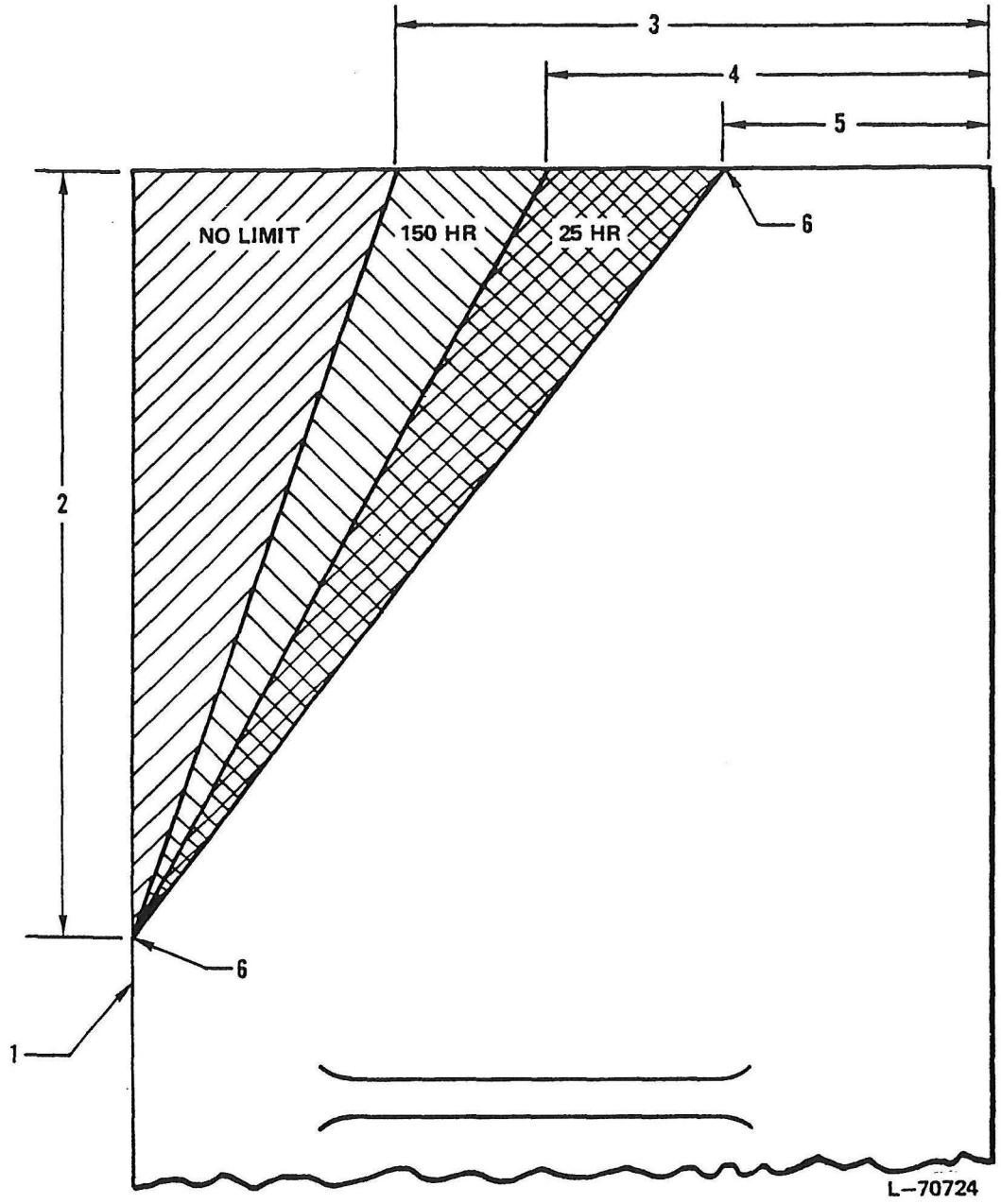
L-59132

R R R **72-00** Page 810

Locations For Application Of Heat Sensitive Paint
Figure 804A

Oct 1/77

ENGINE - APPROVED REPAIR



1. Leading Edge
2. 4.50 Inches
3. 3.35 Inches
4. 2.50 Inches
5. 1.50 Inches
6. Smooth Blend

First Stage Fan Blade F.O.D.
On Wing Repair And Flyback Limits
Figure 805

(c) Decrease in fan flow capacity of 0.8 percent resulting in 1.2 percent thrust loss.

(d) Increase in TSFC of 2 percent due to thrust loss.

C. Procedure

(1) Remove damage with hacksaw or other suitable hand tool.

(2) Insert piece of scrap sheet stock between blade tip and fan case.

CAUTION: AREA TO BE REWORKED WITH CUT-OFF WHEEL MUST BE COMPLETELY MASKED TO ENSURE THAT NO METAL SPLATTER CAN STRIKE ANY OTHER BLADE OR DISK SURFACE.

(3) Using a two inch diameter cut-off wheel, remove major portion of material to be removed.

NOTE: A minimum of 0.060 inch material must remain for hand filing and polishing to assure removal of any heat affected area.

(4) Use a Norton A601-OBNA2, Type I, Shape GWI (A) (2 x 1/32 x 1/4 inch) cut-off wheel or equivalent in an ARO air chuck, model 7015S which has an operating speed of 18,000 rpm maximum. A 3/16 inch rotary file may be used as an alternate tool to cut-off wheel.

(5) Hand file and polish leading edge where cut has been made.

(6) Finish all edges of repair area to form well-rounded radii with smooth surface.

(7) Inspect repaired blades as outlined in Inspection/Check section.

R R (8) Flyback cut must not create excessive imbalance and vibration in operation.

6. Deleted.

7. Front Compressor Case and Vane Assembly

A. Crack Repair

(1) Gas tungsten arc weld cracks in area of anti-icing air ports using AMS 5776 filler metal.

(2) Locally stress-relieve weld repaired area per Cycle 1A as follows:

(a) Heat to 600°F (316°C) and hold for 30 minutes.

(b) Increase to 800°F (427°C) and hold for 30 minutes.

(c) Increase to 1015° ± 15°F (546° ± 8°C) and hold for two hours.

(d) Cool to 500°F (260°C) not faster than 100°F (56°C) every 15 minutes.

ENGINE - APPROVED REPAIR

R 8. Tubing, Patch Repair

A. Suggested Flyback Repair Procedure For External Tubing

NOTE: This repair does not include high pressure fuel lines: main pump to fuel control, fuel control to fuel oil cooler, fuel oil cooler to pressurizing and dump valve and pressurizing and dump valve signal line.

(1) See Table I for repair procedure.

(2) Use AMS-5510 SST for patch doubler material and AMS-5570 SST for sleeve doubler material.

(3) Edge of patch shall not extend into tube bend.

(4) Repair within 0.250 inch of a ferrule.

(5) Minimum overlap of repair area 0.250 inch.

(6) Braze per Standard Practices Manual using AMS-3411 flux.

CAUTION: TUBES REPAIRED IN THIS MANNER SHALL BE REPLACED AFTER FLYBACK.

R (7) See Figure 807 for typical repair procedure.

(8) Pressure test

(a) Up to 0.500 OD at 700 psi.

(b) Over 0.500 to 0.750 OD at 500 psi.

(c) Over 0.750 to 1.000 OD at 300 psi.

R 9. First Stage Fan Blades

A. First Stage Fan Blades (Titanium) Blend, Repair

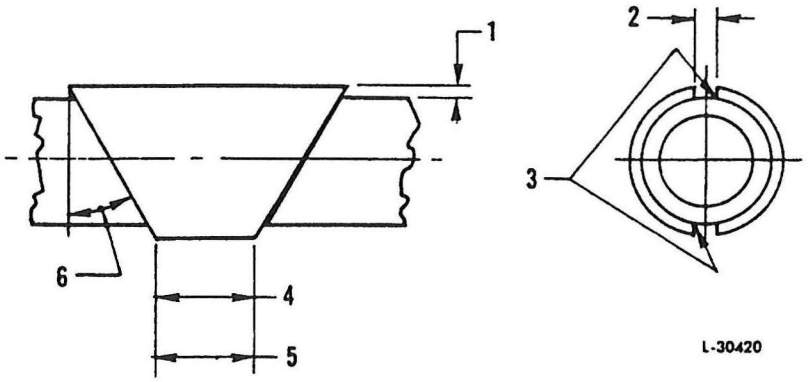
(1) Minor injuries to first stage fan blades (titanium) can be repaired provided the injury can be removed without exceeding allowable limits in Figure 601, Inspection/Check.

ENGINE - APPROVED REPAIR

Type Of Damage	Acceptable Damage	Method Of Repair	Repair Procedure
Dents (Distorted wall, no thickness reduction).	1. No sharp edges 2. Free passage of 80% ID of tube 3. Not within 0.250 inch of ferrule	Doubler repair	1. Straighten tube to acceptable limits 2. Doubler repair: A. Patch doubler for repair area up to 25% of tube OD wide and 50% of tube OD long. B. Sleeve doubler for repair area up to 50% of tube OD wide and 3x tube OD long
Nicks-(scratches, sharp edges, gouges).	Minor scratches and pitting not exceeding 0.003 inch deep.	Blending or doubler repair	1. Blending: A. Blend out to maximum depth of 0.005 inch B. 75% wall thickness must remain after blending. C. Blended area must not exceed 0.50 square inch. 2. Doubler repair: (Same as dents).
Wear (thin areas, clamps etc).	Wear up to 0.003 inch deep	Doubler repair	1. Doubler repair: A. Same as dents except sleeve doubler under all clamp and clip areas.
Holes (worn, punched, or open cracks)		Doubler repair and fusion weld repair	1. Doubler repair: (Same as dents). 2. Fusion weld repair: 0.025 maximum width, length to 1/2 tube diameter, maximum circumference 25% tube diameter, 100% penetration, underbead cannot exceed 25% wall thickness under 2 inch diameter, 10% over 2 inches diameter.

Table I

ENGINE - APPROVED REPAIR



1. 0.030 Inch Minimum
2. Gap Permissible, Two Places
3. Silver Braze Using AMS 3411 Flux. In Accordance With Standard Practices Manual.
4. 0.250 Minimum
5. 1.0 Inch Minimum Under Clip or Clamp
6. 30° Approximate, Four Places

ENGINE - APPROVED REPAIR

CAUTION: NICKS IN THE LEADING AND TRAILING EDGES BECOME INCREASINGLY CRITICAL THE CLOSER THEY ARE TO THE BLADE ROOT.

(a) A minimum blend equal to four times the depth of repair must be maintained on all blade blend repairs.

CAUTION: THE LIMITS REFERRED TO IN FIGURE 601 INSPECTION/CHECK IN AREAS "C", "E" AND "F" PERTAIN TO LOCAL, ISOLATED, DAMAGED AREAS ONLY AND MUST NOT BE INTERPRETED AS AUTHORITY FOR REMOVAL OF MATERIAL ALL ACROSS THE TIP AND LEADING OR TRAILING EDGES AS MIGHT BE DONE IN A SINGLE MACHINING CUT.

(b) Do not attempt to remove any injury by straightening.

(c) Check surface finish of the flameplated area of the mid-span shroud of first stage blades. Surface finish must be at least 80 RMS. If not within limits stroke flame-plated area 10 or 15 times with 180 grit aluminum oxide cloth. Recheck surface finish.

(2) Blend blades in accordance with the following procedure.

CAUTION: DENICKING AND BUFFING OF TITANIUM MUST BE DONE IN STRICT ACCORDANCE WITH THESE INSTRUCTIONS TO AVOID BURNING. DO NOT USE BELT TYPE SANDERS. BECAUSE OF DIFFICULTY IN HANDLING SMALL PARTS, AND INCREASE POSSIBILITY OF BURNING, TITANIUM COMPRESSOR BLADES WITH AN AIRFOIL LENGTH OF LESS THAN ONE AND THREE-QUARTERS OF AN INCH SHALL NOT BE REPAIRED BY POWER TOOLS.

WARNING: TITANIUM PARTS MUST NOT BE REWORKED ON EQUIPMENT INCORPORATING A WATER-WASH DUST COLLECTOR THAT IS USED TO REWORK STEEL PARTS. CLEAN UP TITANIUM DUST AT LEAST ONCE A DAY. DO NOT ALLOW TITANIUM DUST TO ACCUMULATE ON CLOTHING. AN ACCUMULATION OF TITANIUM DUST IS A FIRE HAZARD.

(a) Remove nicks, scratches or pits and radius sharp edges on parts by blending on polishing lathe with small wheel such as Carborundum Co. No. C36-P-BFX2 or equivalent using minimum wheel pressure. Do not operate at an arbor speed of more than 3,000 rpm.

(b) Blend out wheel marks, light nicks, scratches, pits and radius sharp edges on polishing lathe using cloth wheel (two sections) coated with adhesive precoat PMC-3091 and polishing compound PMC-3048.

NOTE: Use only minimum pressure when applying a part to wheel to avoid overheating. Use maximum of 2,400 rpm.

(c) Buff reworked areas using 12 inch diameter tampico brush and burring polishing compound PMC-3061, at 2,400 rpm maximum. Buff part so all polishing lines are parallel with length of airfoil, never across it. Maintain surface finish in repaired area as nearly comparable to new part as possible.

(d) Wipe part with soft cloth to remove residual polishing compound or other foreign material.

(e) Inspect repaired parts with portable fluorescent penetrant inspection method.

R 10. Fan Discharge Case Fairing

A. Tapped Holes - Helical Coil Reoperation

R See Figure 808.

(1) If threaded hole(s) are damaged, rework to acceptable condition by installing a helical coil insert. See referenced figure.

(2) Clean per SPOP 203.

(3) Use screws, P/N 701774, at installation.

NOTE: Reidentify to P/N 701773.

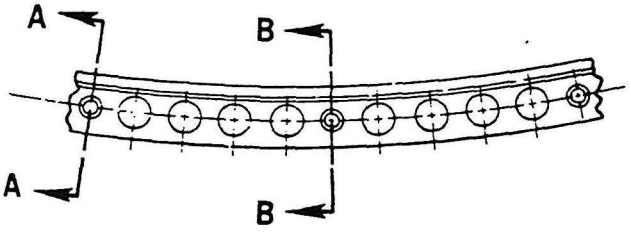
B. Tapped Hole Rework

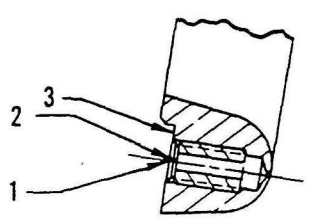
R See Figure 808.

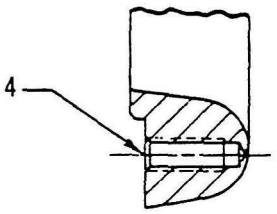
(1) Rework holes as per referenced figure. Clean per SPOP 203. Reidentify to P/N 701773.

(2) Use screws, P/N 701774, at installation.

ENGINE - APPROVED REPAIR







L-32204 SECTION A-A SECTION B-B

For Repair of Damaged Threads (Section A-A)

1. Thread for 0.190-24 Helical Coil Insert. Minor Diameter Depth 0.487 Inch Maximum. Drill Point 160° Minimum, Including Chamfer 120° ± 5° Included to 0.240 to 0.280 Diameter. Minimum Full Thread Depth 0.330 Inch.
2. MS122120 As Required. Before Assembling, Coat Mating Threads of Insert and Fairing Per AMS 3110 (Zinc Oxide Primer). Assemble Wet.
3. Top Face of First Coil To Be 1.0 to 1.5 Pitch Below This Surface. Break off Tang At Notch.

For Holes Not Requiring Thread Inserts (Section B-B)

4. 0.190-24 NC-3B Minor Diameter. Depth 0.500 Inch Maximum, Drill Point 160° Minimum Included Angle. Chamfer 90° ± 5° Included to 0.190 to 0.220 Inch Diameter. Minimum Full Thread Depth 0.407 Inch.

ENGINE - APPROVED REPAIR

11. Replacement of No. 6 Bearing Oil Pressure (Inner) and Oil Scavenge (Inner) Tube Assemblies

A. Procedure

(1) Remove turbine exhaust cone assembly.

(2) Unfasten screws and remove No. 6 bearing oil sump heat-shield.

(3) Unfasten coupling nuts at both ends of inner oil tube assemblies using PWA-30634 Wrench on wrenching hex on outer oil tubes to prevent transmitting torque load through tubing.

NOTE: For engines incorporating guides, PN 654472, reference SB 2081, unfasten guides from brackets attached to sump assembly and slide guide down sleeve away from inner oil tube so wrenching hex is accessible.

(4) Using PWA 30635 Wrench to hold brazed nut on brackets, unfasten clamps securing tubes to brackets on exhaust strut assembly. Remove tubes. Re-install new tube assemblies as required.

12. Diffuser Case - Crack Repair

A. General

R (1) A crack may be repaired by welding with AMS 5776 filler
R metal. See Section 72-00, Inspection/Check for limits of
R acceptability. Stress-relieve after welding at 1000° -
R 1030°F (538° - 554°C) for two hours.

R (2) A crack weld repair that redevlops cracks may be repaired
R by rewelding with AMS 5776 filler metal. Stress-relieve
R after welding at 1000° - 1030°F (538° - 554°C) for two
R hours. Otherwise repair must be made at overhaul.

NOTE: Use contact type pyrometer to gage temperature and stress relieved area must overlap and extend three inches in all directions from crack.

ENGINE - APPROVED REPAIR

B. Water Injection Bosses

CAUTION: USE SMALL DIAMETER WELD ROD TO REDUCE HEAT AND MINIMIZE DISTORTION.

(1) Weld and stress relieve cracks around water injection bosses per step A. (1) above.

13. Fireseal Crack Repair - Boeing Installation

A. Procedure - Circumferencial Cracks (Six O'clock Area), Lower Fireseal Assembly.

See Figure 809

(1) Stop drill ends of cracks.

(2) Provide clearance cut in spacer and rivet spacer onto fireseal.

(3) Predrill bolt holes in brace as shown in referenced figure.

(4) Install brace over face of fireseal and bolt on.

NOTE: The use of brace on fireseal necessitates longer bolts in holes encompassed by brace.

(5) At assembly, replace 6 Bolts, MS9035-12 with 6 bolts MS9035-13, 8 Bolts MS9035-13 with 8 Bolts MS9035-14 and 2 Bolts MS9035-14 with 2 Bolts MS9035-15, in area of lower fireseal.

(6) At first convenient opportunity, repaired part is to be reworked per Overhaul Manual instructions.

R 14. Turbine Exhaust Case - Bolt-on Doubler Installation

A. Doubler For Mount Rail Crack Repair (JT3D-7 BG).

NOTE: This repair is for turbine exhaust cases having cracks between engine mount holes and outer edge of mount rail, but only one of either mount rails can
R be reoperated. Bolt-on doubler can be used with or without existing tee plate, but any cracked cases
R which have bolt-on doublers added should be
R repaired at next scheduled overhaul.

ENGINE - APPROVED REPAIR

(1) Method of reoperation:

(a) Scheme I (if cracks are on rear mount rail).

See Figure 810 (Sheet 1 and 2).

1 Remove brackets at thermocouple locations.

R 2 Install bolt-on doubler, spacers, bolts and nuts at 45 degree locations.

3 Relocate thermocouple cables and add new brackets.

(b) Scheme II (if cracks are on front mount rail).

See Figure 811

R 1 Install bolt-on doubler, spacers, bolts and nuts at 45 degree locations.

R (2) Assemble bolt-on doubler in place on rail and install one mounting bolt through doubler, case rails, and spacer.

(a) Threaded end of bolt must not protrude past stack up more than 0.500 inch to ensure tapered bolt head is not seated.

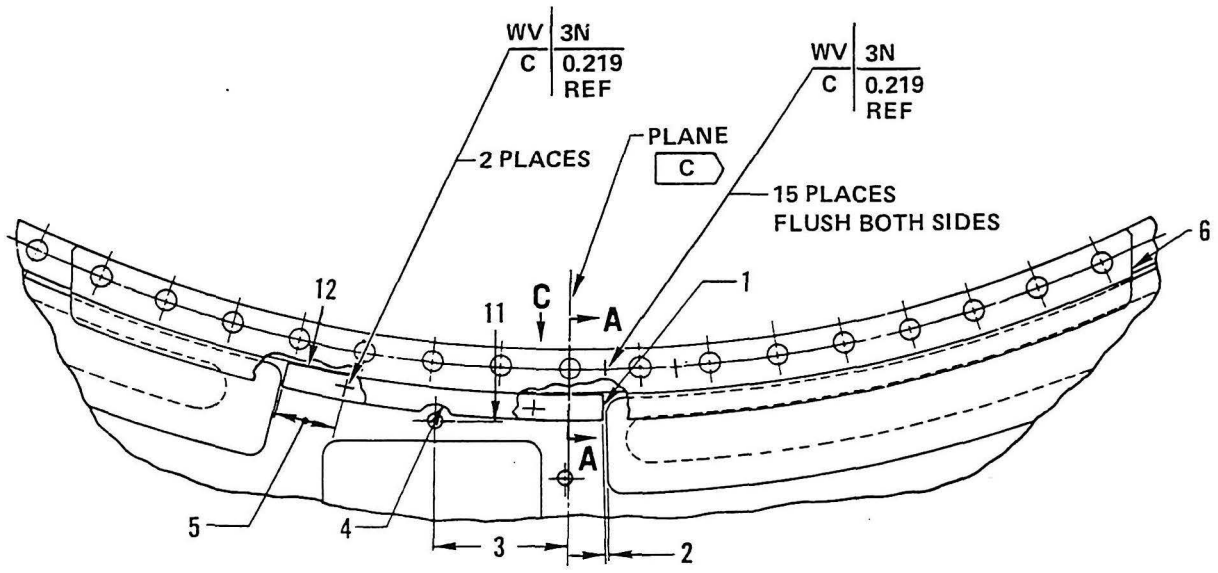
(3) Push down on unbolted doubler end until holes line up enough to install other bolt and spacer.

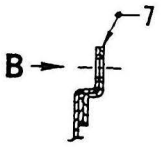
(4) Install doubler nuts and torque to standard torque for 0.500-20 thread size.

NOTE: If tapered head is not fully seated increase torque to 1500 inch-pounds maximum until head is seated and then back off torque to standard value.

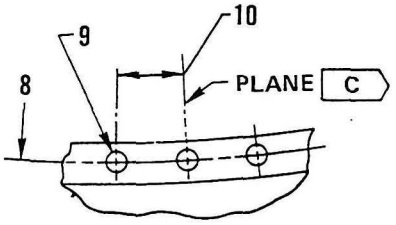
R B. Doubler For Mount Rail Crack Repair (JT3D-7DSLG)

R NOTE: This repair is for cases having cracks between engine
R mount holes and outer edge of flange on either front
R or rear rail flanges. Only one of either of rail
R flanges can be repaired by this procedure. Bolt-on
R doubler can be used with or without existing tee
R plate, but any cracked case which as bolt-on doublers
R added should be repaired at next scheduled overhaul.

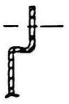




SECTION A–A



VIEW B

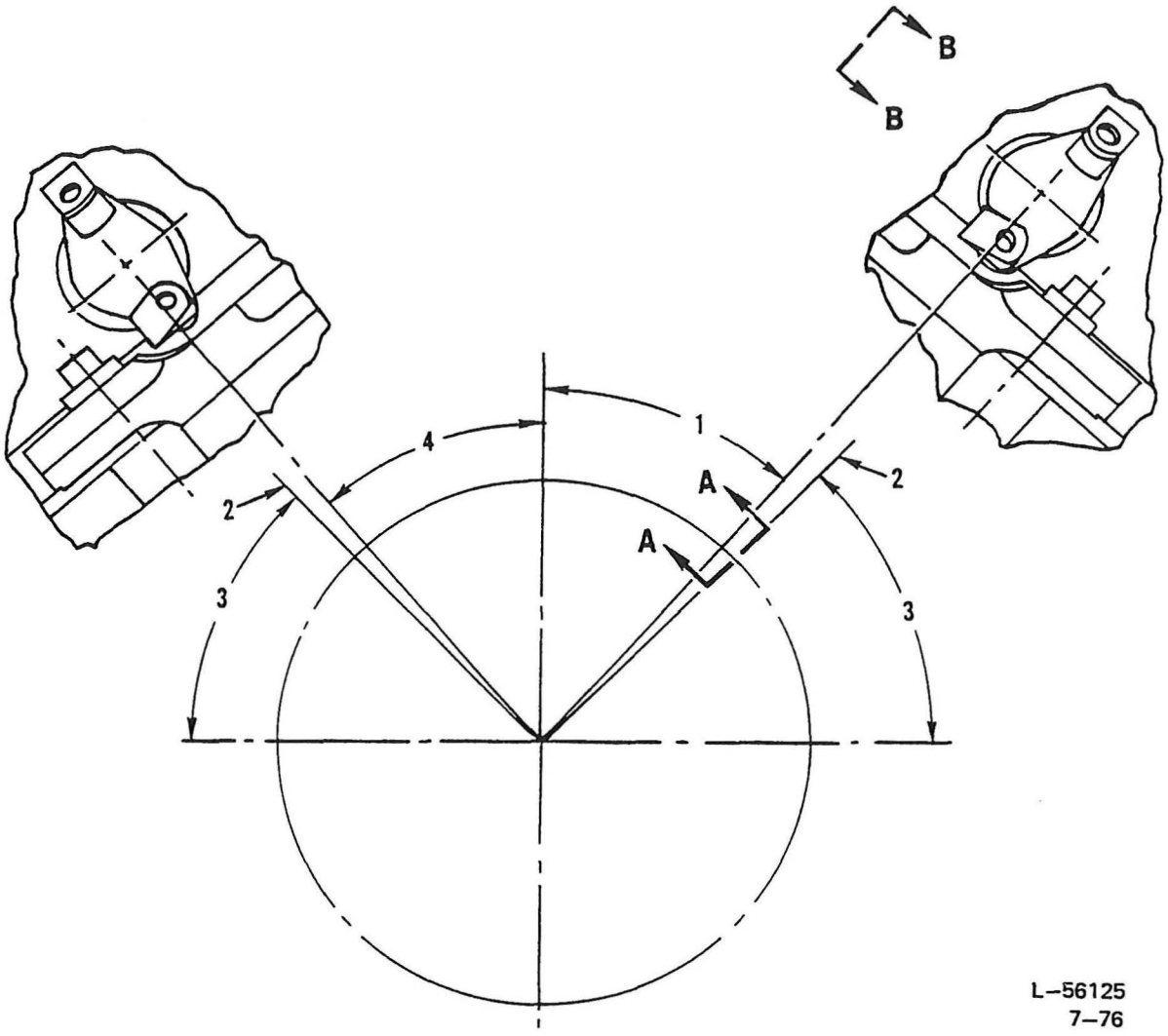


SECTION A–A
REPAIR OF FIRESEAL
PRIOR TO ASSEMBLY

L-41674
9–73

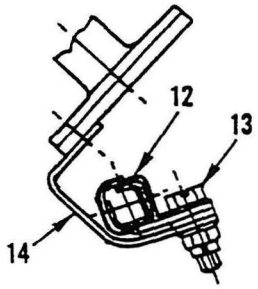
1. Spacer PN 702096
2. 0.010 Inch Maximum. Two Places. Machine Spacer If Necessary.
3. 2.100 Inches
4. 0.250 - 0.281 Inch Radius, Located Within 0.005 Inch Radius Of True Position.
5. 1.000 Inch, Both Ends
6. Brace, PN 702273
7. This ID Surface Of Brace, No. 6, Must Be Flush Or Below Adjacent ID Surface Of Fireseal.
8. 20.580 Inches Radius, Reference
9. 0.339 - 0.349 Inch Diameter Through Brace, No. 6 16 Holes Located From Holes In Fireseal.
10. 3 Degrees Reference
11. 21.430 Inches To Centerline
12. 21.110 - 21.150 Inches Radius

R ENGINE - APPROVED REPAIR

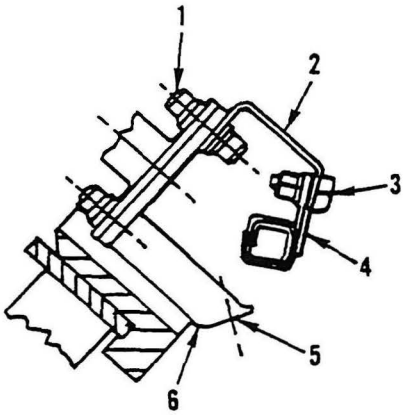


R 1. 41°
R 2. Bolt Location
R 3. 45°
R 4. 41° 30'

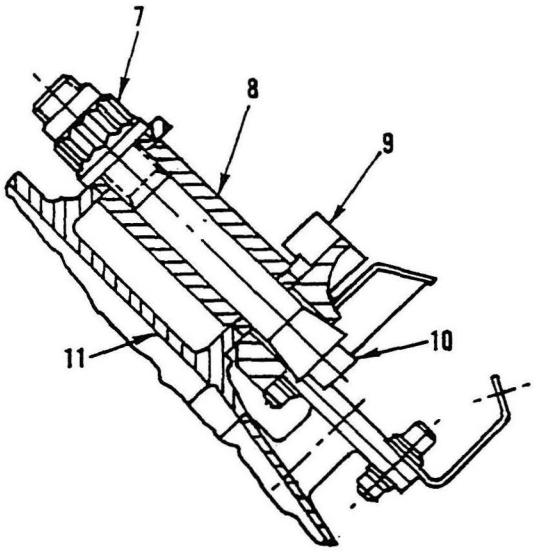
R Turbine Exhaust Case Rear
R Mount Rail Scheme I
R Figure 810 (Sheet 1)



VIEW B-B
PRIOR TO CHANGE



VIEW B-B
AFTER CHANGE



SECTION A-A

L-56131
7-76

Turbine Exhaust Case Rear
Mount Rail Scheme I
Figure 810 (Sheet 2)

ENGINE - APPROVED REPAIR

1. PN 315959 Nut And PN MS 9034-11 Screw Two Required
2. PN 760283 Bracket Two Required
3. PN 375094 Nut And PN MS 9316-04 Screw Two Required
4. Thermocouple Cable Clamp
5. Airframe Attachment Hole For Thrust Reverser Line Clamp.
6. PN 760281 Bracket Two Required
7. PN 754673 Nut Two Required
8. PN 754627 Spacer Two Required
R 9. PN 758648 Bolt-On Doubler
10. PN 758649 Bolts Two Required
11. Turbine Exhaust Case
12. Thermocouple Cable Clamp
13. Prior Screws, Spacers, Reuse Nuts
14. Prior Bracket

Key To Figure 810 (Sheet 2)

R (1) Cracks on rear mount flange.

R (a) Remove existing Pt7 manifold tube assembly.

R (b) Install bolt-on doubler, spacers, bolts, and nuts at
R locations shown in Figure 812 and as follows:

R 1 Assemble bolt-on doubler in place on flange and install
R one mounting bolt through bolt-on doubler, case flange,
R and spacer as shown. Threaded end of bolt must not
R protrude past stackup more than 0.500 inch to ensure
R tapered bolthead is not seated.

R 2 Push down on unbolted doubler end until holes line up
R enough to install other bolt.

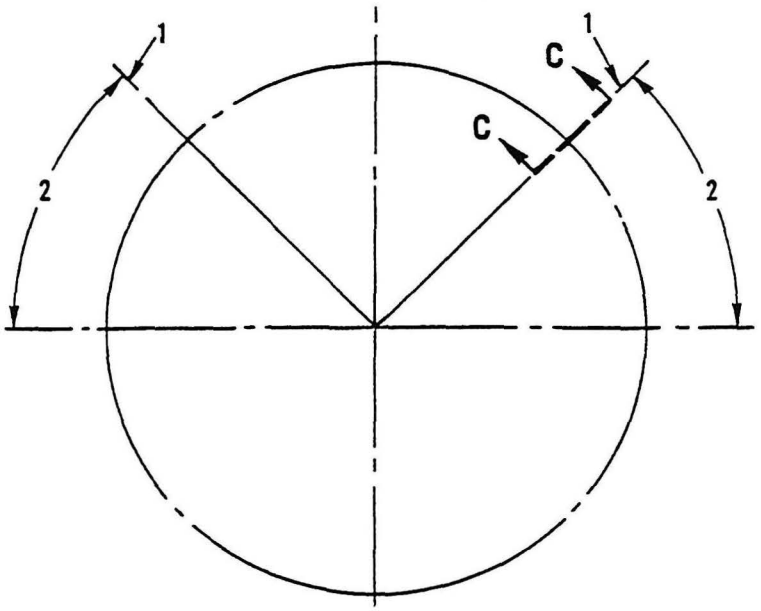
R 3 Install both nuts and tighten to standard torque for
R 0.500 - 20 thread size. If tapered head is not fully
R seated, increase torque to 1500 pound-inches maximum
R until head is seated and then back off torque to
R standard torque for 0.500 - 20 thread.

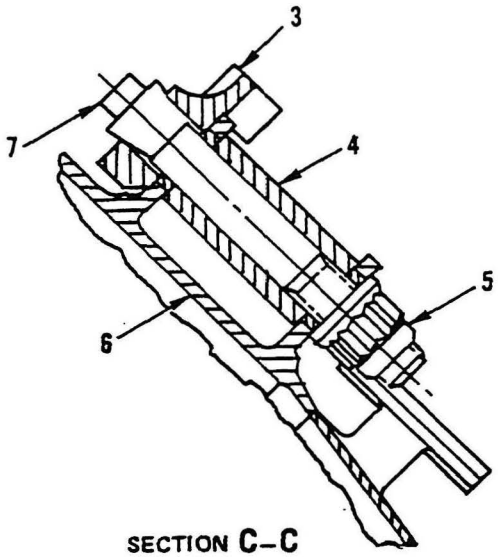
R (c) Install new Pt7 manifold tube assembly (PN 767963).

R (2) Cracks on front mount flange.

R (a) Remove existing Pt7 manifold tube assembly.

ENGINE - APPROVED REPAIR





SECTION C-C

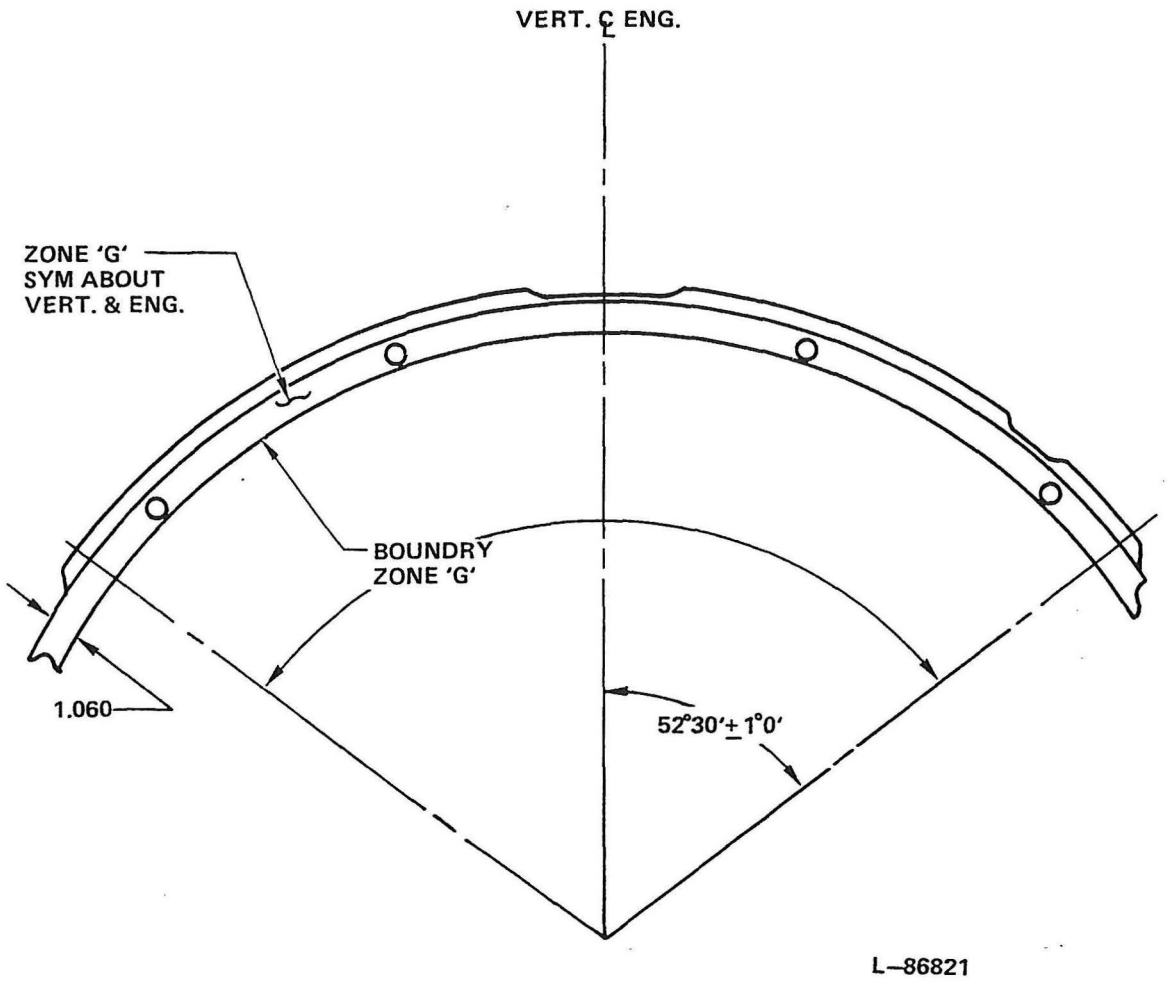
L-56123
7-76

1. Bolt Location
2. 45°
3. PN 758648 Bolt-On Doubler
4. PN 754627 Spacers Two Required
5. PN 754673 Nuts Two Required
6. Turbine Exhaust Case
7. PN 758649 Bolts Two Required

R

Turbine Exhaust Case Rear
Mount Rail Scheme II
Figure 811

R ENGINE - APPROVED REPAIR



R Turbine Exhaust Case Rail
R Crack Limit Locations
R View Looking Forward
R Figure 813

R ENGINE - APPROVED REPAIR

R D. Bolt On Reinforcing Plates (Doublers) May Not Be Used For
R Any Of The Following Conditions:

R (1) Turbine exhaust case rail with any crack from a ground
R handling hole located at 45 degrees on either side of
R the TDC of the case.

R (2) Cracks at mount holes extending inward and terminating
R beyond the limits of Figure 813 (Zone G).

R E. Reinforcing Plate (Doubler) Installation.

R (1) Position one reinforcing plate (doubler) PN 758648 on
R either of the turbine exhaust case rails as shown in
R Figure 814.

R (2) Insert a bolt PN 790027 through one end of the reinforcing
R plate (doubler) and the turbine exhaust case rail and
R install a nut fingertight only.

R (3) Shift the bolt until the nut face contacts the inner sur-
R face of the turbine exhaust case rail. Force the opposite
R end of the reinforcing plate (doubler) into alignment with
R the handling hole in the turbine exhaust case rail, and
R install a second bolt and nut also fingertight.

R (4) Tighten both nuts to a torque of 625 - 700 lb-in. and
R inspect the bolt heads. Both of the 15 degree tapered
R bolt heads must be fully seated in the reinforcing plate
R (doubler).

R NOTE: If necessary to fully seat the bolt heads either or
R both nuts may be further tightened to a torque of a
R maximum of 1000 lb-in. followed by an immediate
R reduction to a torque of 625 - 700 lb-in.

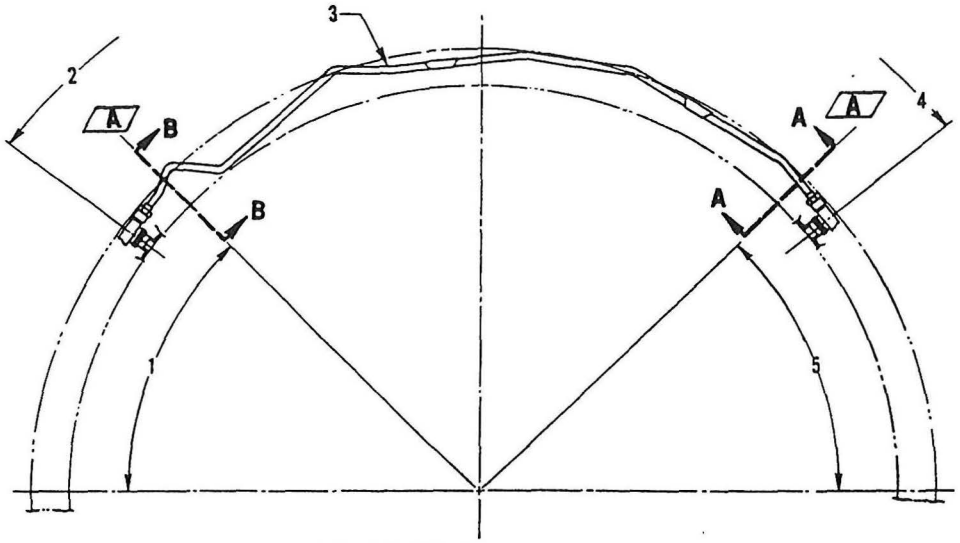
R (5) Position the second reinforcing plate (doubler) on the
R opposite turbine exhaust case rail and repeat the pro-
R cedure outlined above.

R F. Inspection Of Turbine Exhaust Cases Repaired Using Reinforcing
R Plates (Doublers)

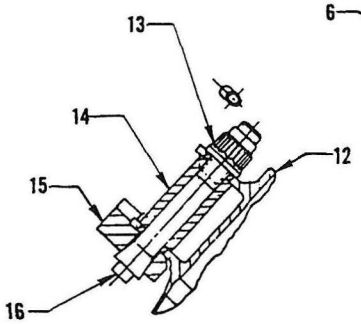
R (1) Frequent inspection is required after installation of bolt
R on reinforcing plates (doublers). The inspection schedule
R shall be the responsibility of each operator based upon
R rail crack propagation rates experienced in the class of
R service involved.

R

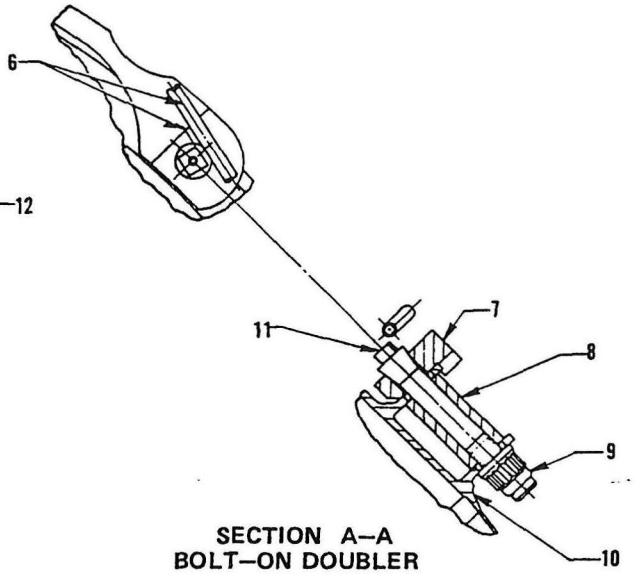
ENGINE - APPROVED REPAIR



SCHEMATIC FRONT VIEW
OF ENGINE MOUNT RING
AND UPPER PT 7 TUBE ASSY



SECTION B–B
BOLT–ON DOUBLER
INSTALLED ON REAR
MOUNT FLANGE.
TYP AT LOC A



SECTION A–A
BOLT–ON DOUBLER
INSTALLED ON FRONT
MOUNT FLANGE.
TYP AT LOC A

L–58408
9 –78

R Turbine Exhaust Case Mount
R Rail Repair (Douglas)
R Figure 812

1. 45°
2. 53° Reference
3. PN 767963 Pt7 Manifold Tube Assembly
4. 51° Reference
5. 45°
6. Install Bolt With This Flat Approximately Parallel With Axis Of Tube.
7. PN 767961 Bolt-On Doubler
8. PN 754627 Spacer
9. PN 754673 Nut
10. Turbine Exhaust Case
11. PN 758649 Bolt
12. Turbine Exhaust Case
13. PN 754673 Nut
14. PN 754627 Spacer
15. PN 767961 Bolt-On Doubler
16. PN 758649 Bolt

Key To Figure 812

(b) Install bolt-on doubler, spacer, bolts, and nuts at locations shown in Figure 812 and substep (1) (b).

(c) Install new Pt7 manifold tube assembly (PN 767963).

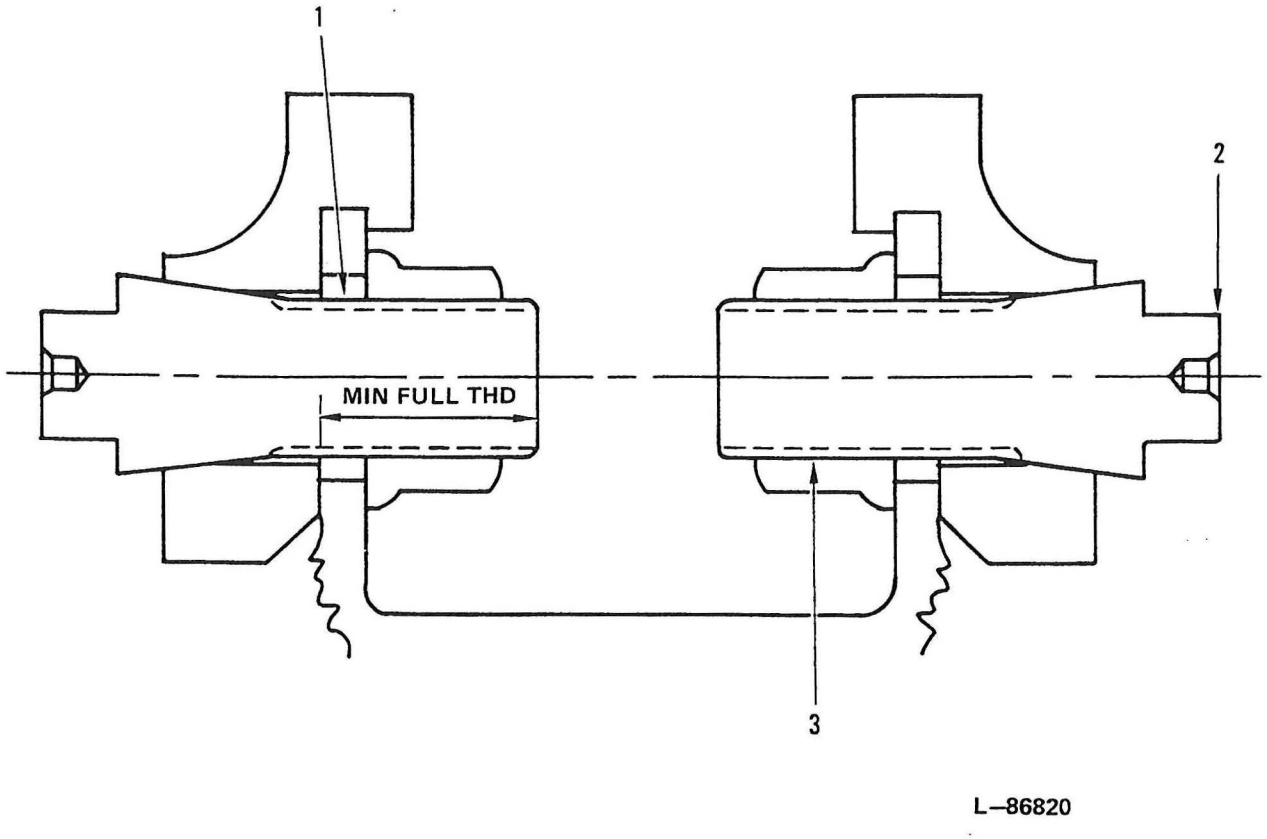
R C. Bolt On Reinforcing Plates (Doublers) For Turbine Exhaust Cases Exhibiting Cracks In Rails.

(1) Bolt on reinforcing plates (doublers) are intended only for temporary repair of cracked turbine exhaust case rails which are within the following limits.

(2) Bolt on reinforcing plates (doublers) may be installed while engine is installed on the aircraft.

(3) Bolt on reinforcing plates (doublers) may be installed on either or both turbine exhaust case rails. Turbine exhaust case may be continued in use within the following crack limits and after application of bolt-on reinforcing plates 758648 or 767961.

Limits:
(a) Rail cracks extending outward from the engine mounting holes toward the OD of the turbine exhaust case rails.
(b) Cracks extending inward from the turbine exhaust case rail OD toward the engine centerline and terminating within the limits of Figure 813 (Zone G).



R 1. 0.0015 - 0.0122 Inch, Reference Diameter
R 2. Same As PN 758649 Except For Overall Length And Thread
R Specification.
R 3. 0.625-18 UNJF-3A Thread Specification

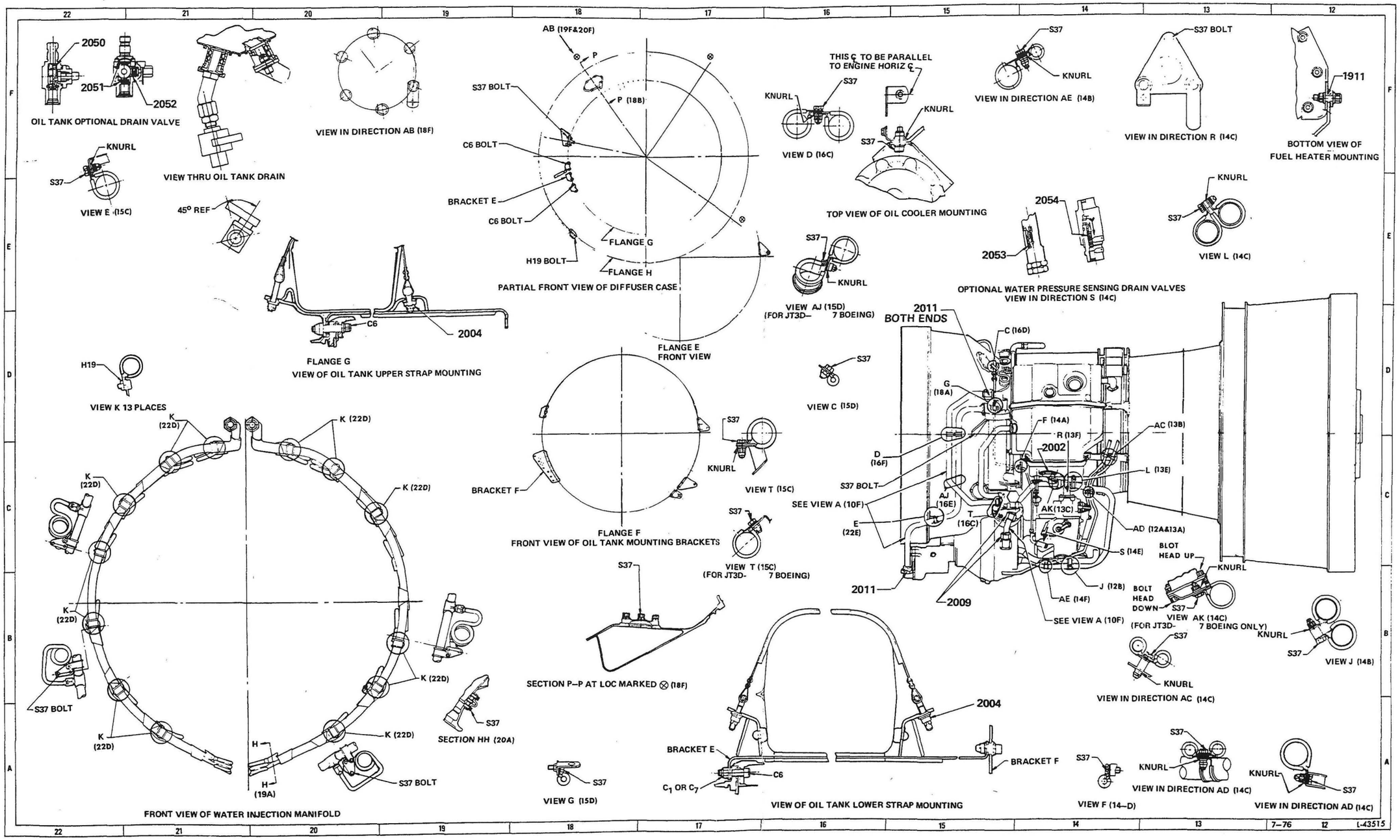
R Turbine Exhaust Case
R Bolt On Reinforcing
R Plates Installation
R Figure 814

R ENGINE - APPROVED REPAIR

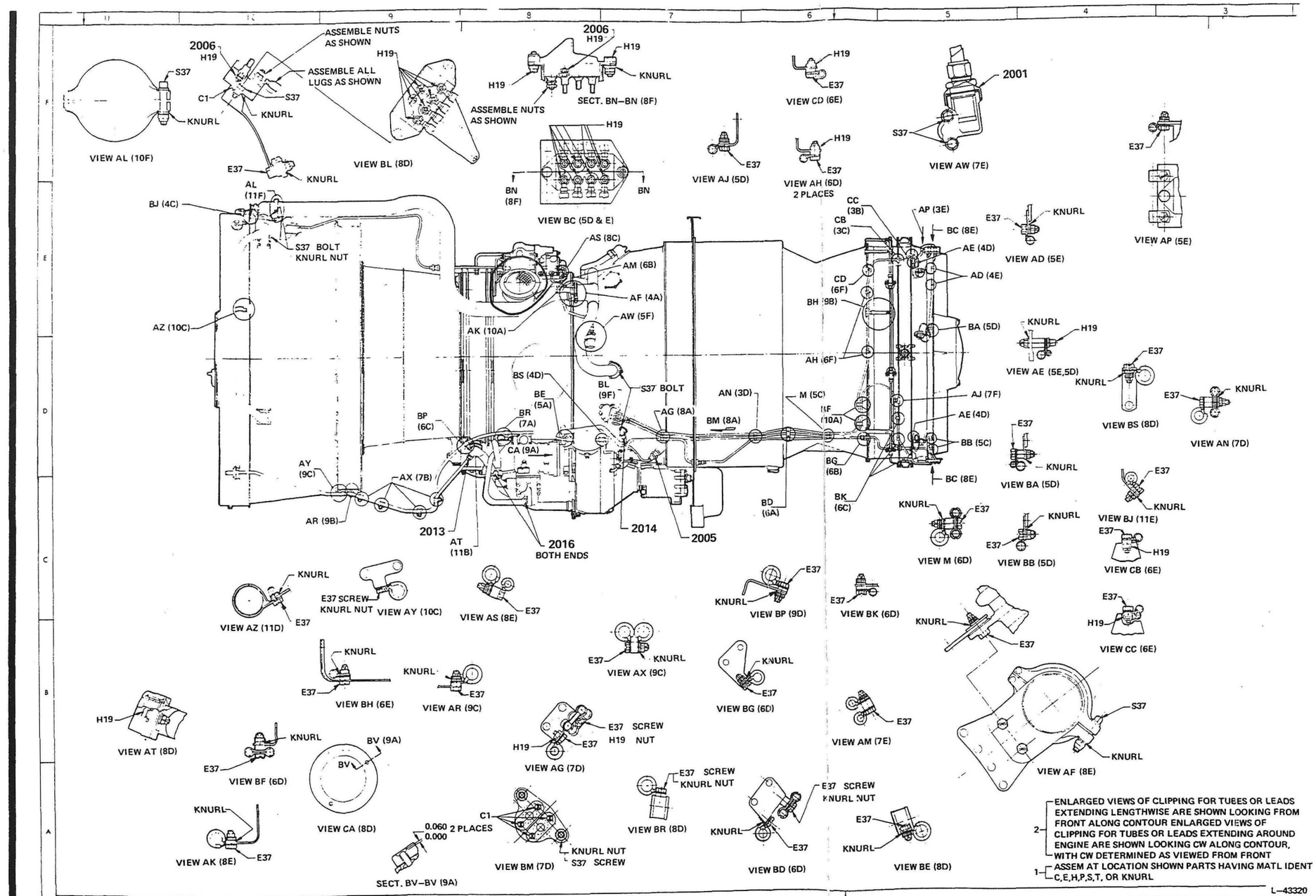
R (2) Turbine exhaust case may be continued in use only while
R rail cracks remain within the limits of Paragraph C.,
R steps (3)(a) and (b).

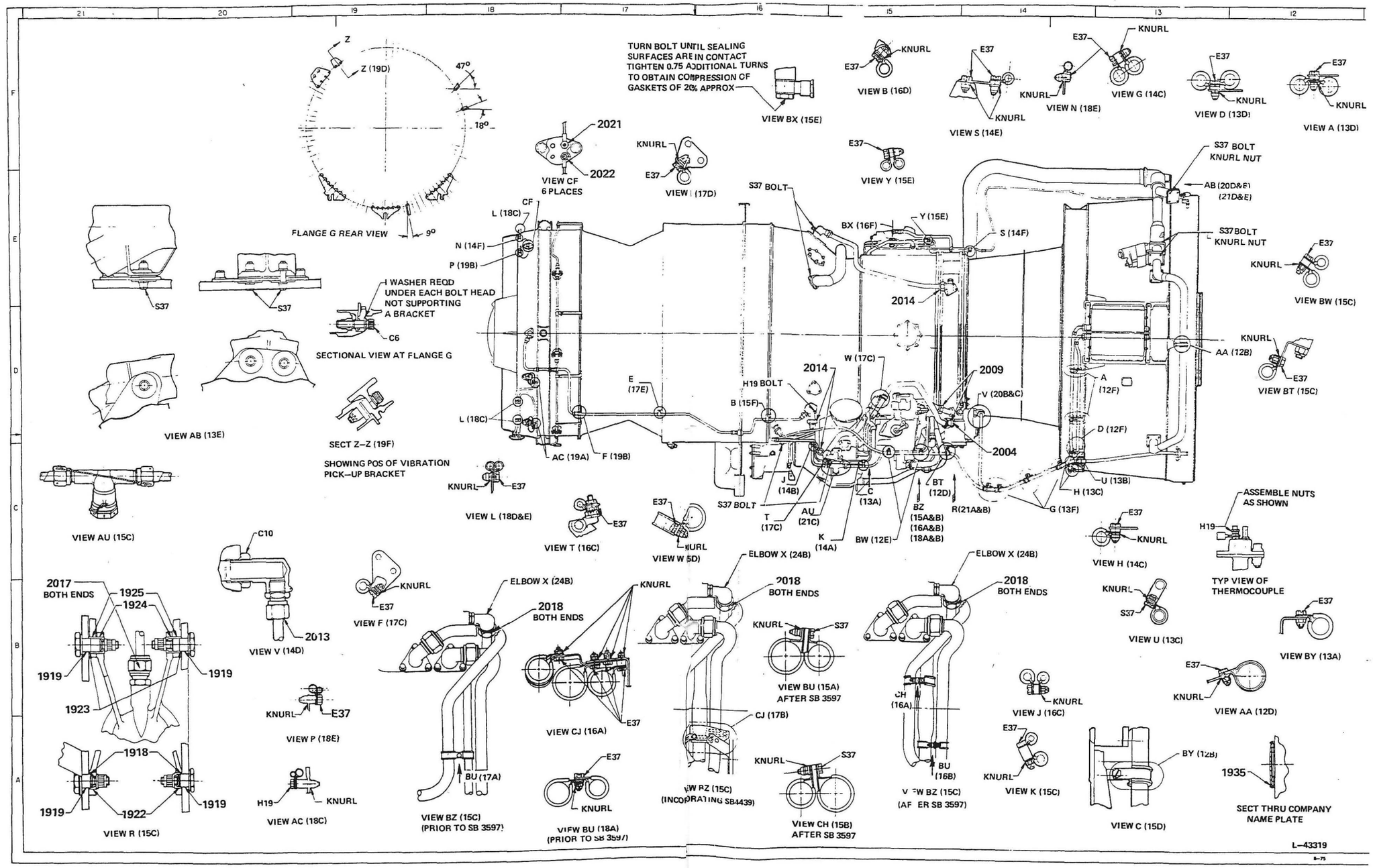
15. Numerical Tool List

PWA 17205 Support
PWA 30634 Wrench
PWA 30635 Wrench

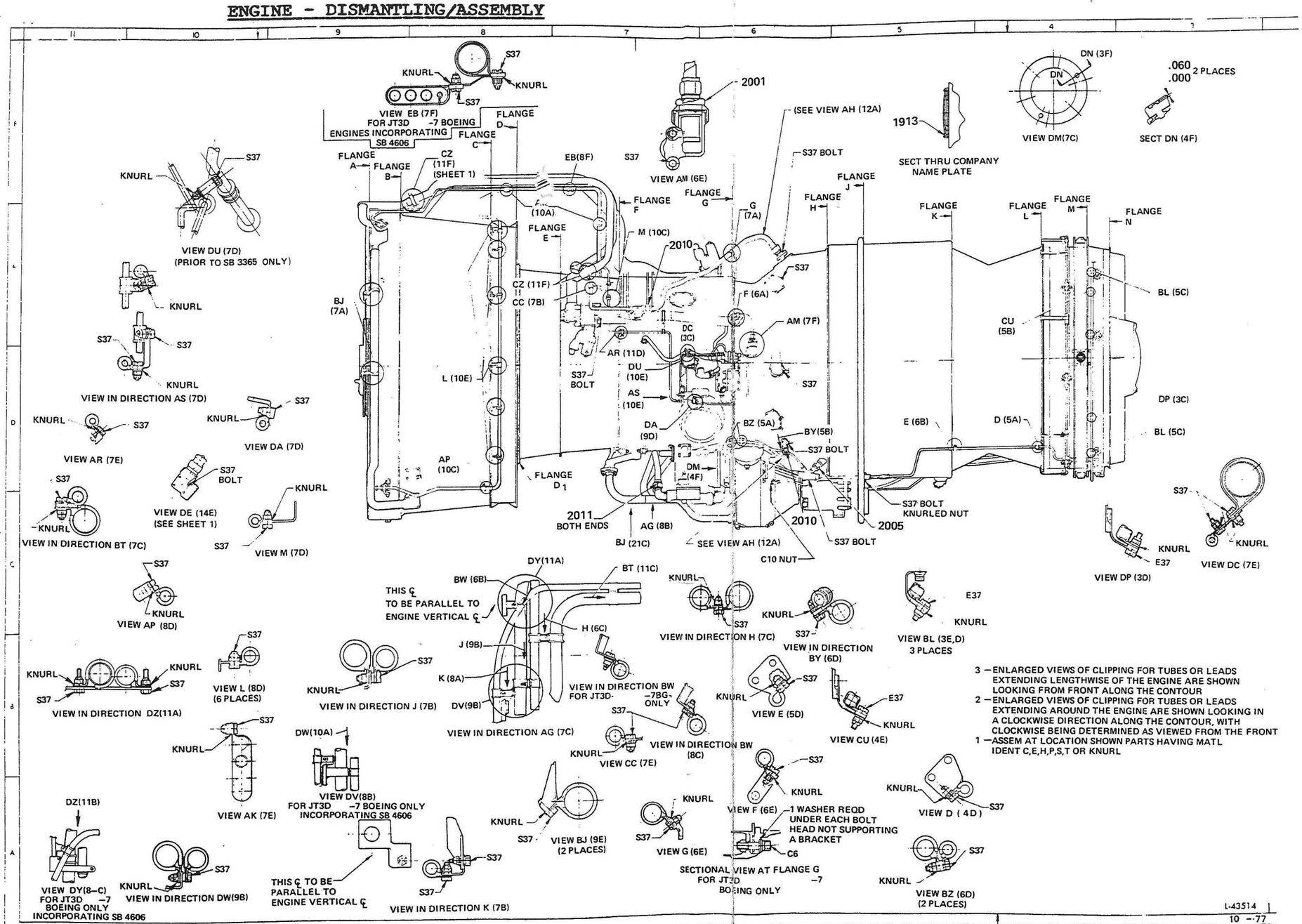

2050
2051
2052
OIL TANK OPTIONAL DRAIN VALVE
KNURL
S37
VIEW E (15C)
VIEW THRU OIL TANK DRAIN
VIEW IN DIRECTION AB (18F)
45° REF
AB (19F&20F)
P
P (18B)
S37 BOLT
C6 BOLT
BRACKET E
C6 BOLT
H19 BOLT
FLANGE G
FLANGE H
PARTIAL FRONT VIEW OF DIFFUSER CASE
C6
2004
FLANGE G
VIEW OF OIL TANK UPPER STRAP MOUNTING
FLANGE E
FRONT VIEW
THIS ℄ TO BE PARALLEL
TO ENGINE HORIZ ℄
KNURL
S37
VIEW D (16C)
KNURL
S37
TOP VIEW OF OIL COOLER MOUNTING
S37
KNURL
VIEW AJ (15D)
(FOR JT3D- 7 BOEING)
S37
VIEW C (15D)
S37
KNURL
VIEW T (15C)
S37
VIEW T (15C)
(FOR JT3D- 7 BOEING)
S37
KNURL
VIEW IN DIRECTION AE (14B)
S37 BOLT
VIEW IN DIRECTION R (14C)
1911
BOTTOM VIEW OF
FUEL HEATER MOUNTING
2054
2053
KNURL
S37
VIEW L (14C)
OPTIONAL WATER PRESSURE SENSING DRAIN VALVES
VIEW IN DIRECTION S (14C)
2011
BOTH ENDS
C (16D)
G
(18A)
F (14A)
R (13F)
2002
AC (13B)
L (13E)
D
(16F)
S37 BOLT
SEE VIEW A (10F)
E
(22E)
AJ
(16E)
T
(16C)
AK (13C)
AD (12A&13A)
S (14E)
J (12B)
AE (14F)
SEE VIEW A (10F)
2011
2009
BLOT
HEAD UP
KNURL
BOLT
HEAD
DOWN
S37
VIEW AK (14C)
(FOR JT3D- 7 BOEING ONLY)
S37
KNURL
VIEW IN DIRECTION AC (14C)
KNURL
S37
VIEW J (14B)
H19
VIEW K 13 PLACES
K
(22D)
K (22D)
K (22D)
K (22D)
K (22D)
K (22D)
K (22D)
K (22D)
S37 BOLT
H
H
(19A)
S37 BOLT
FRONT VIEW OF WATER INJECTION MANIFOLD
BRACKET F
FLANGE F
FRONT VIEW OF OIL TANK MOUNTING BRACKETS
S37
SECTION HH (20A)
S37
SECTION P–P AT LOC MARKED ⊗ (18F)
S37
VIEW G (15D)
BRACKET E
C6
C1 OR C7
2004
BRACKET F
VIEW OF OIL TANK LOWER STRAP MOUNTING
S37
VIEW F (14–D)
S37
KNURL
VIEW IN DIRECTION AD (14C)
KNURL
S37
VIEW IN DIRECTION AD (14C)
7–76
L-43515

ENGINE - DISMANTLING/ASSEMBLY



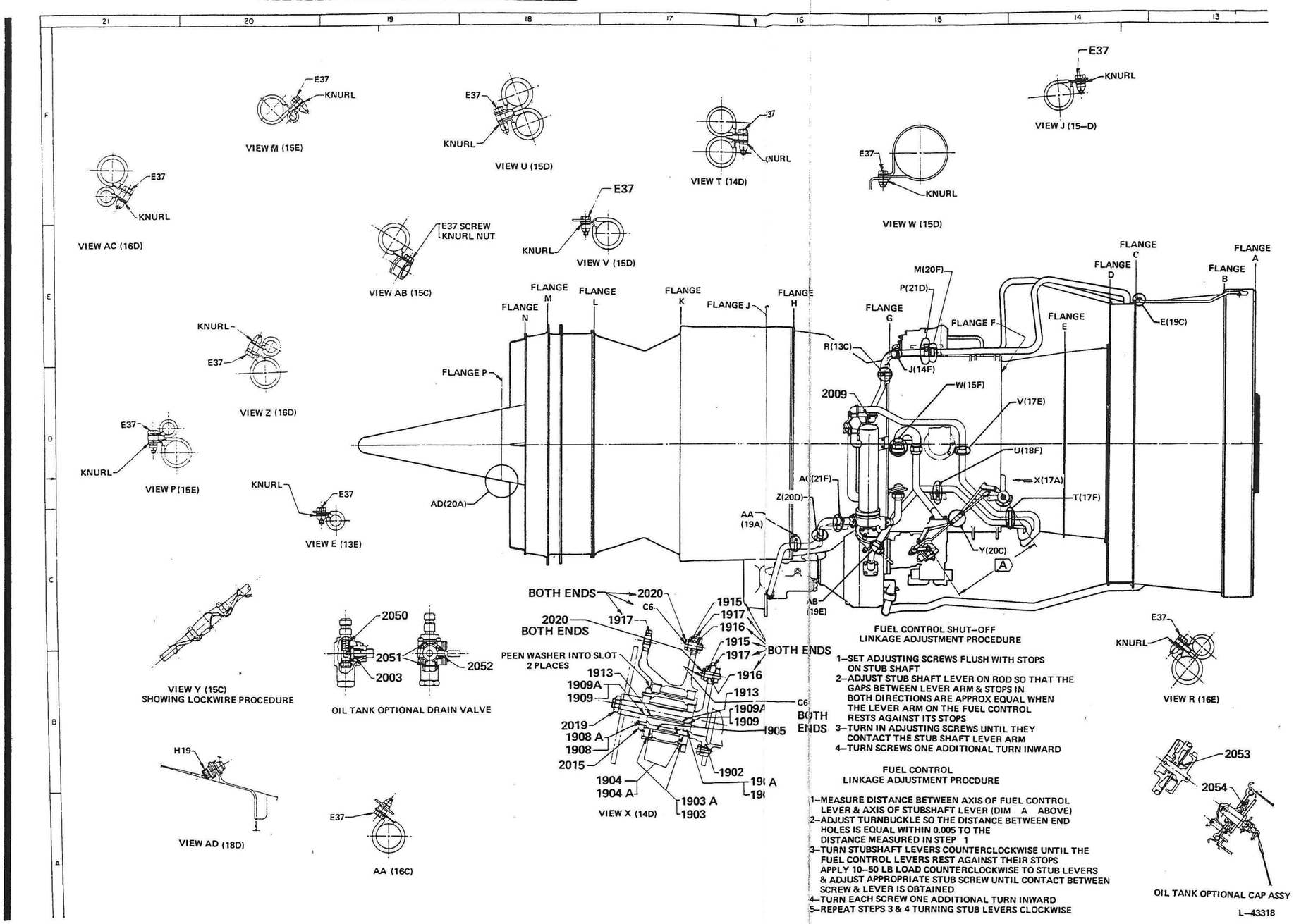

FLANGE G REAR VIEW
TURN BOLT UNTIL SEALING SURFACES ARE IN CONTACT TIGHTEN 0.75 ADDITIONAL TURNS TO OBTAIN COMPRESSION OF GASKETS OF 20% APPROX
VIEW BX (15E)
VIEW B (16D)
VIEW S (14E)
VIEW N (18E)
VIEW G (14C)
VIEW D (13D)
VIEW A (13D)
VIEW CF 6 PLACES
VIEW I (17D)
VIEW Y (15E)
VIEW BW (15C)
VIEW BT (15C)
VIEW AB (13E)
SECTIONAL VIEW AT FLANGE G
1 WASHER REQD UNDER EACH BOLT HEAD NOT SUPPORTING A BRACKET
SECT Z–Z (19F)
SHOWING POS OF VIBRATION PICK–UP BRACKET
VIEW L (18D&E)
VIEW T (16C)
VIEW W (15D)
VIEW AU (15C)
VIEW V (14D)
VIEW F (17C)
VIEW P (18E)
VIEW AC (18C)
VIEW R (15C)
VIEW BZ (15C) (PRIOR TO SB 3597)
VIEW CJ (16A)
VIEW BU (18A) (PRIOR TO SB 3597)
VIEW RZ (15C) (INCORPORATING SB4439)
VIEW BU (15A) AFTER SB 3597
VIEW CH (15B) AFTER SB 3597
VIEW BZ (15C) (AFTER SB 3597)
VIEW J (16C)
VIEW K (15C)
VIEW C (15D)
VIEW H (14C)
VIEW U (13C)
VIEW AA (12D)
VIEW BY (13A)
TYP VIEW OF THERMOCOUPLE
SECT THRU COMPANY NAME PLATE
ASSEMBLE NUTS AS SHOWN
S37 BOLT KNURL NUT
AB (20D&E) (21D&E)
S37 BOLT
BX (16F)
Y (15E)
S (14F)
N (14F)
P (19B)
L (18C)
CF
AC (19A)
F (19B)
E (17E)
H19 BOLT
B (15F)
W (17C)
2014
2009
V (20B&C)
2004
A (12F)
D (12F)
U (13B)
H (13C)
G (13F)
R(21A&B)
BT (12D)
BZ (15A&B) (16A&B) (18A&B)
J (14B)
C (13A)
AU (21C)
T (17C)
K (14A)
BW (12E)
CH (16A)
BU (16B)
CJ (17B)
AA (12B)
BY (12B)
2017 BOTH ENDS
1925
1924
1919
1923
1918
1922
2013
C10
2018 BOTH ENDS
ELBOW X (24B)
BU (17A)
2021
2022
KNURL
E37
S37
H19
1935
L–43319

ENGINE - DISMANTLING/ASSEMBLY

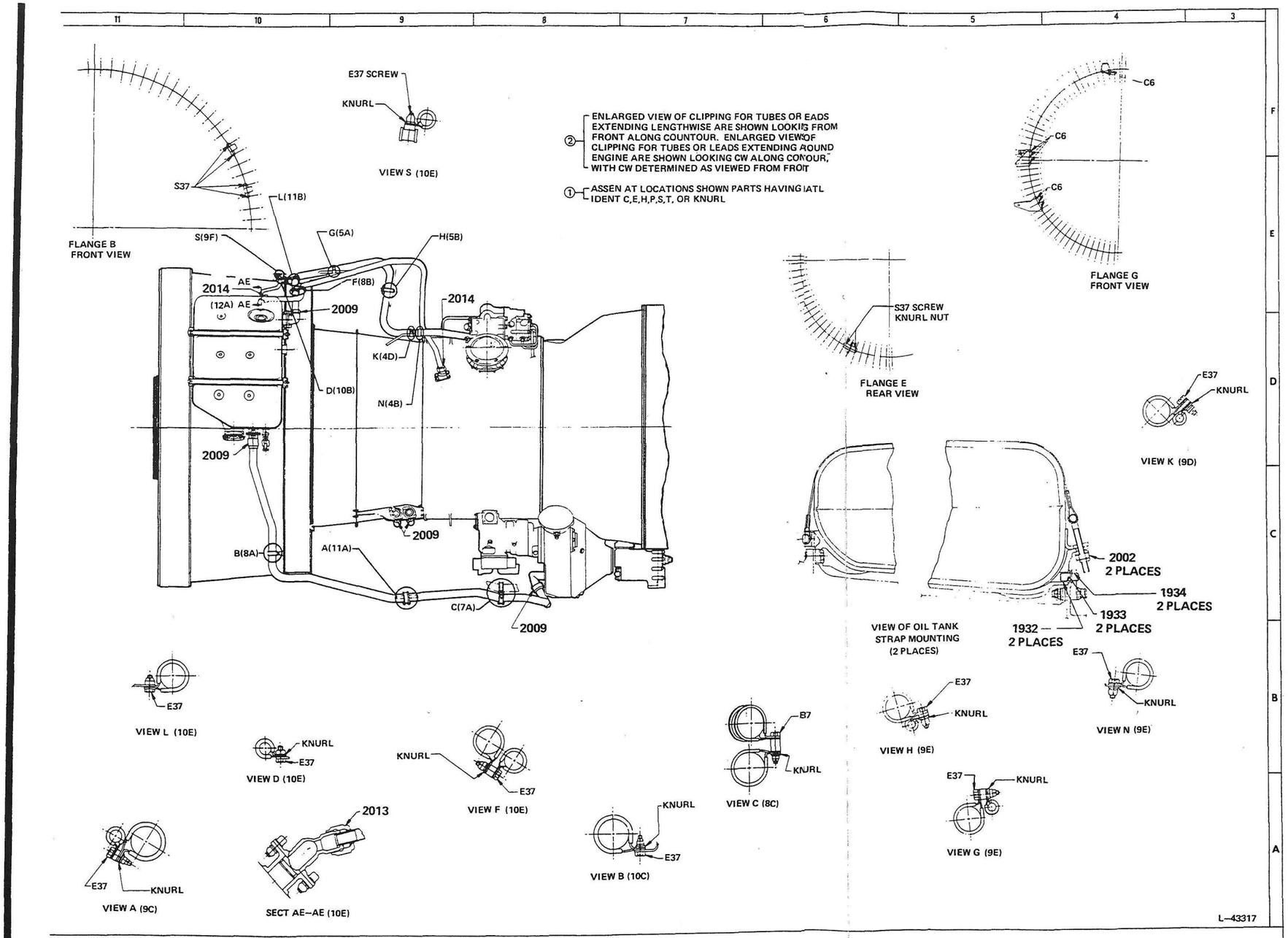


External Parts (JT3D-7 BG)
Figure 406 (Sheet 2)

R
R Dec 15/88


21
20
19
18
17
16
15
14
13
F
E
D
C
B
A
E37
KNURL
VIEW M (15E)
VIEW U (15D)
VIEW T (14D)
VIEW J (15–D)
VIEW W (15D)
VIEW AC (16D)
E37 SCREW
KNURL NUT
VIEW AB (15C)
VIEW V (15D)
VIEW Z (16D)
VIEW P (15E)
VIEW E (13E)
FLANGE A
FLANGE B
FLANGE C
FLANGE D
FLANGE E
FLANGE F
FLANGE G
FLANGE H
FLANGE J
FLANGE K
FLANGE L
FLANGE M
FLANGE N
FLANGE P
M(20F)
P(21D)
R(13C)
J(14F)
E(19C)
2009
W(15F)
V(17E)
U(18F)
X(17A)
T(17F)
AC(21F)
Z(20D)
AA (19A)
Y(20C)
A
AB (19E)
AD(20A)
VIEW Y (15C)
SHOWING LOCKWIRE PROCEDURE
2050
2051
2052
2003
OIL TANK OPTIONAL DRAIN VALVE
BOTH ENDS
2020
C6
1917
1915
1916
PEEN WASHER INTO SLOT
2 PLACES
1913
1909A
1909
2019
1908 A
1908
2015
1904
1904 A
1903 A
1903
1902
1905
VIEW X (14D)
FUEL CONTROL SHUT–OFF
LINKAGE ADJUSTMENT PROCEDURE
1–SET ADJUSTING SCREWS FLUSH WITH STOPS ON STUB SHAFT
2–ADJUST STUB SHAFT LEVER ON ROD SO THAT THE GAPS BETWEEN LEVER ARM & STOPS IN BOTH DIRECTIONS ARE APPROX EQUAL WHEN THE LEVER ARM ON THE FUEL CONTROL RESTS AGAINST ITS STOPS
3–TURN IN ADJUSTING SCREWS UNTIL THEY CONTACT THE STUB SHAFT LEVER ARM
4–TURN SCREWS ONE ADDITIONAL TURN INWARD
FUEL CONTROL
LINKAGE ADJUSTMENT PROCDURE
1–MEASURE DISTANCE BETWEEN AXIS OF FUEL CONTROL LEVER & AXIS OF STUBSHAFT LEVER (DIM A ABOVE)
2–ADJUST TURNBUCKLE SO THE DISTANCE BETWEEN END HOLES IS EQUAL WITHIN 0.005 TO THE DISTANCE MEASURED IN STEP 1
3–TURN STUBSHAFT LEVERS COUNTERCLOCKWISE UNTIL THE FUEL CONTROL LEVERS REST AGAINST THEIR STOPS APPLY 10–50 LB LOAD COUNTERCLOCKWISE TO STUB LEVERS & ADJUST APPROPRIATE STUB SCREW UNTIL CONTACT BETWEEN SCREW & LEVER IS OBTAINED
4–TURN EACH SCREW ONE ADDITIONAL TURN INWARD
5–REPEAT STEPS 3 & 4 TURNING STUB LEVERS CLOCKWISE
VIEW R (16E)
2053
2054
OIL TANK OPTIONAL CAP ASSY
L–43318
H19
VIEW AD (18D)
AA (16C)

ENGINE - DISMANTLING/ASSEMBLY



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The List of Effective Pages records not only each page of subject revision but also each previously issued page which is still current. Blank pages and pages which are no longer current do not appear on this list. If there is any question about the currency of the recipient's copy, it is recommended that each page of the manual be checked off against this List of Effective Pages. Any page which does not check out with this list, either by number or by date, shall be discarded.

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		401	Nov 1/67
		402	Nov 1/67
		403	Nov 1/67
		404	Nov 1/67
		405	Feb 1/72
		406	Oct 1/75
		601	Nov 1/67
		701	Nov 1/67
73-21-2		1	Nov 1/67
		2	Nov 1/67
		3	Nov 1/67
		4	Nov 1/67
		401	Nov 1/67
		402	Nov 1/67
		403	Nov 1/67
		404	Nov 1/67
		405	Feb 1/72
		406	Oct 1/75
		501	Nov 1/67
		502	Nov 1/67
		503	Nov 1/67
		504	Nov 1/67
		601	Nov 1/67
		701	Nov 1/67

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel System Function

Principal function of fuel system is to deliver fuel to engine at such pressures and flow rates as are required to achieve engine power output desired. Secondary function is automatic compensations for variations in altitude encountered in flight. Technical limitations in engine design impose a third function; that of limiting acceleration fuel flows so as to prevent surge and excessive engine pressures and temperatures. Final function of fuel system is establishment of minimum fuel flow to prevent "lean die-out" of flame of combustion during deceleration.

These four essential functions are accomplished by fuel system largely through intricate workings of its major component, engine-driven fuel control. Fuel control acts as a kind of intermediary between pilot and his engine. It translates his power lever signals to increase or decrease fuel flows, and it monitors certain flight variables of which pilot may not be aware, thereby relieving pilot of chore of continual power-setting adjustments.

R ## Description and Operation of Fuel System

R Fuel system employed in engine and functions of its various components may best be described by tracing passage of fuel from inlet connection of fuel pump to its ultimate discharge through fuel nozzles in engine combustion chambers.

R ### Fuel

R Fuel for engine shall conform to PWA 522 Specifications.

R Fuel contamination may occur in shipment, during transfer from one
R container to another, or in aircraft fuel system from scale, lint
R from packings and seals, and deterioration of fuel lines and hoses.
R Serious malfunction of engine will occur, even to extent of engine
R stoppage, as a result of contaminants in fuel reaching engine fuel
R system. It is important, that mesh screen in aircraft fuel system
R upstream of engine fuel pump be inspected periodically for removal
R of all foreign particles.

FUEL SYSTEM - DESCRIPTION AND OPERATION

R Fuel Tubes

R Aircraft fuel tubing will bring fuel to main fuel pump inlet. If
R PWA fuel anti-icing system (optional equipment) is used, large tube
R from pump carries fuel to fuel anti-icing fuel-heater buildup.
R Another tube returns fuel to pump from filter. If fuel anti-icing
R system is not installed, mounting holes in pump are blanked off.
R Two large tubes are mounted on bottom between fuel pump and fuel
R control. Forward tube is fuel return tube (high pressure) and
R rearward tube is fuel supply tube. Rearmost tube between pump and
R control is by-pass tube (low pressure). From right side of fuel
R control to right side of fuel pressurizing and dump valve, large
R tube supplies fuel to valve.

Fuel Pump

See Figure 1.

First component to be considered in engine fuel system is fuel pump. Pump is two stage, engine driven, by-pass equipped unit which receives fuel from aircraft fuel tank system and discharges it at predetermined pressures and quantities through fuel anti-icing system (optional equipment) to fuel control. Two, positive displacement, gear-type, pumping stages operate in series; boost stage discharging to fuel anti-icing system through heater and filter which in turn discharges into main stage and from there to fuel control.

R

Fuel Control

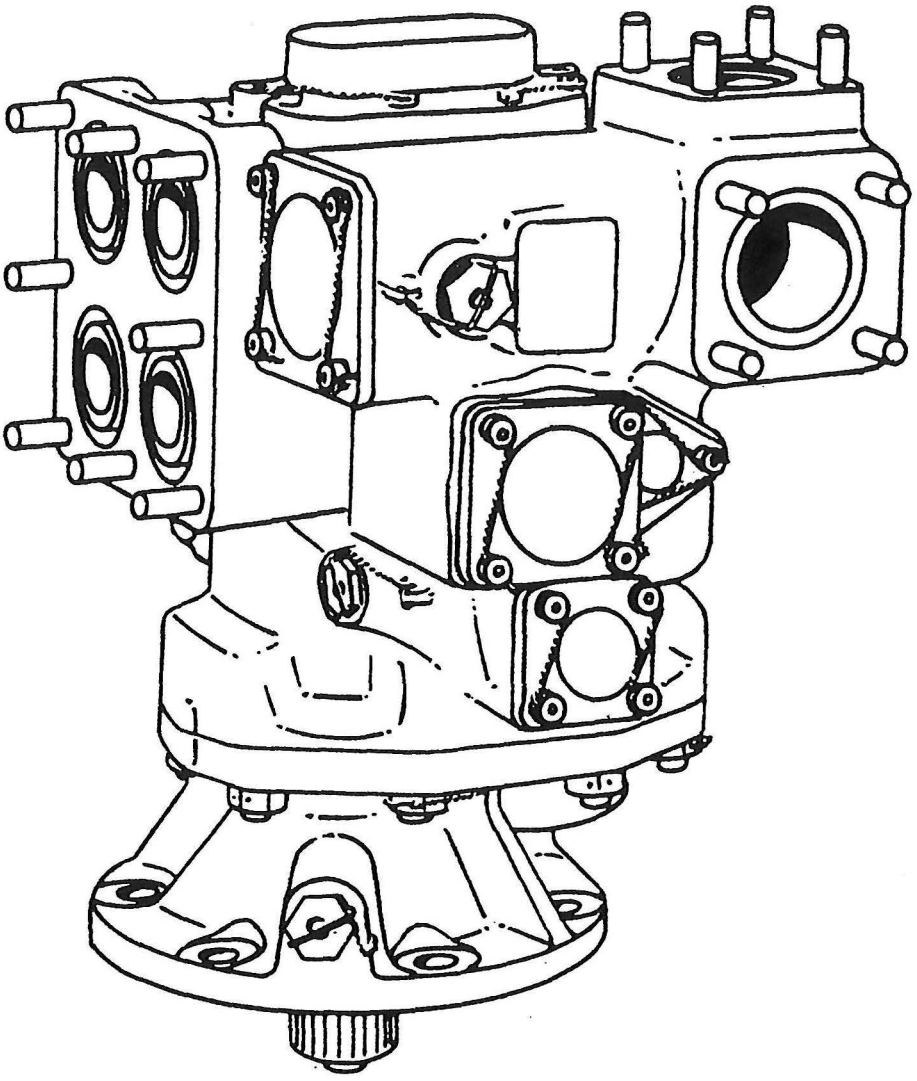
See Figure 2.

Fuel control is hydromechanical fuel metering unit designed to schedule fuel flow to control engine speed, thus governing thrust output. It provides correct flow of fuel to engine to establish and maintain engine speed selected by pilot. It accomplished this by varying fuel flow in response to changes in combustion chamber pressure, and in difference between desired speed and actual engine speed. Fuel from control is discharged into fuel-oil cooler (optional equipment) and then to fuel pressurizing and dump valve.

Fuel-Oil Cooler (Optional Equipment)

Metered fuel from fuel control enters fuel-oil cooler. This unit has been previously discussed under lubrication system since its prime function is to help cool oil in conjunction with airframe supplied
R air-oil cooler. It is a cylindrical unit mounted in front lower
R right quadrant of diffuser case. Fuel flows through tubes in core
R of cooler and oil circulates within housing and around the outside
R of core tubes. Heat from oil is transferred to fuel via conduction.
R Unit is discussed further in Oil Chapter. See Chapter 79.

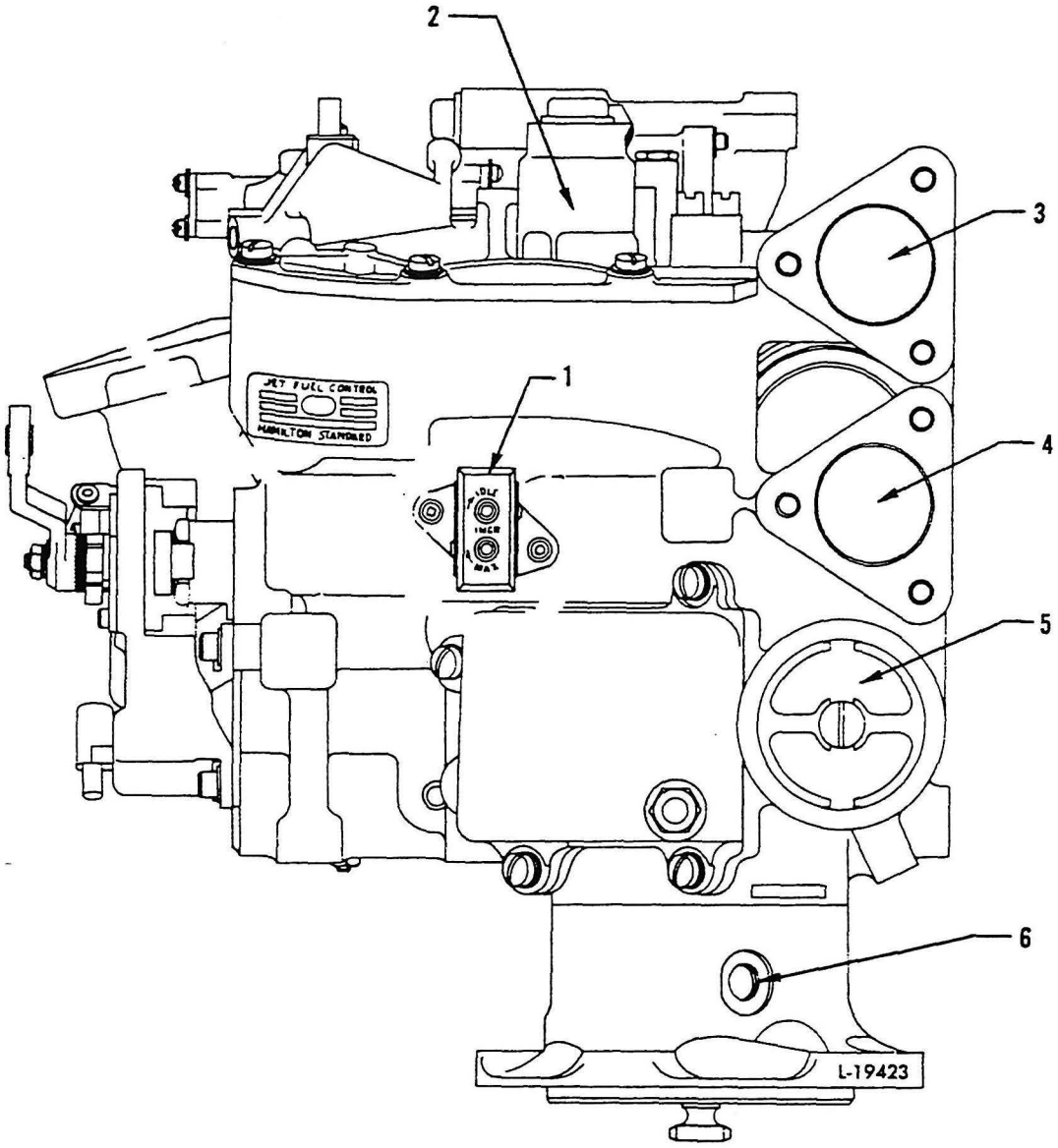
FUEL SYSTEM - DESCRIPTION AND OPERATION



L-5331

Fuel Pump
Figure 1

FUEL SYSTEM - DESCRIPTION AND OPERATION



R
1. Trim Screws (Adjustments)
2. Drain Pressure Valve, Low Pressure Return
3. High Pressure By-Pass Flow Outlet
4. Main Engine Fuel Inlet
5. Filters
6. Overboard Drain

Fuel Control
Figure 2

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel Pressurizing and Dump Valve

Discharge fuel from control via fuel-oil cooler passes into fuel pressurizing and dump valve. Purpose of this valve is to provide division of flow between primary and secondary nozzle orifices to ensure proper spray pattern for efficient fuel combustion. Also incorporated in fuel pressurizing and dump valve body is fuel dump valve which drains primary fuel manifold at shutdown. Dump valve is deactivated if SB 3721 has been incorporated.

Fuel Manifold

See Figure 3.

Fuel from fuel pressurizing and dump valve enters two piece engine fuel manifold which provides separate paths for primary and secondary fuel flow.

Fuel Nozzles

R See Figures 4 and 5.

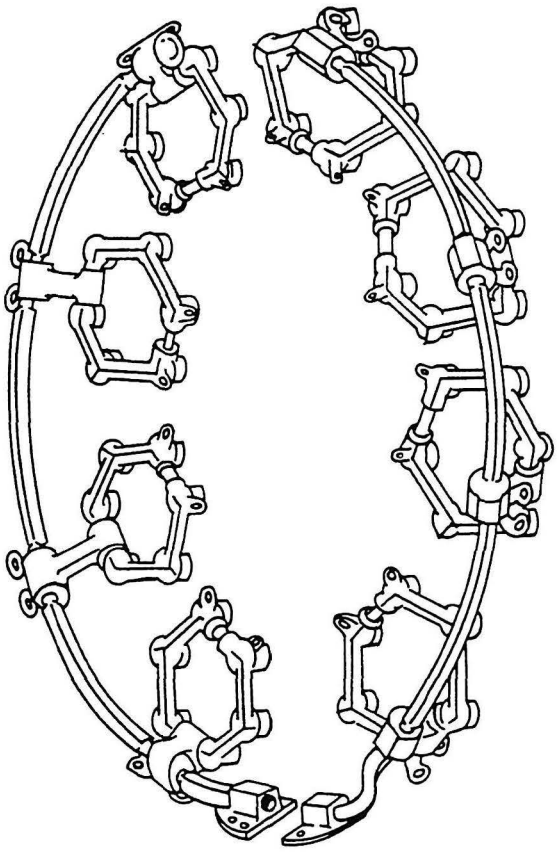
Installed in manifold are 48 dual orifice nozzles arranged in eight clusters of six nozzles each. Clusters project into accommodating aperatures in upstream end of each engine combustion chamber.

Nozzle is designed to discharge predetermined amount of fuel into combustion chamber when specified pressure drops are maintained across primary and secondary stages, acting both as an atomizing and metering device.

Drain Connections

Plugged drain connections are provided on fuel components as well as in combustion chamber case. Pressurizing and dump valve drain line, combustion chamber drain line, and fuel component drain lines are airframe installations.

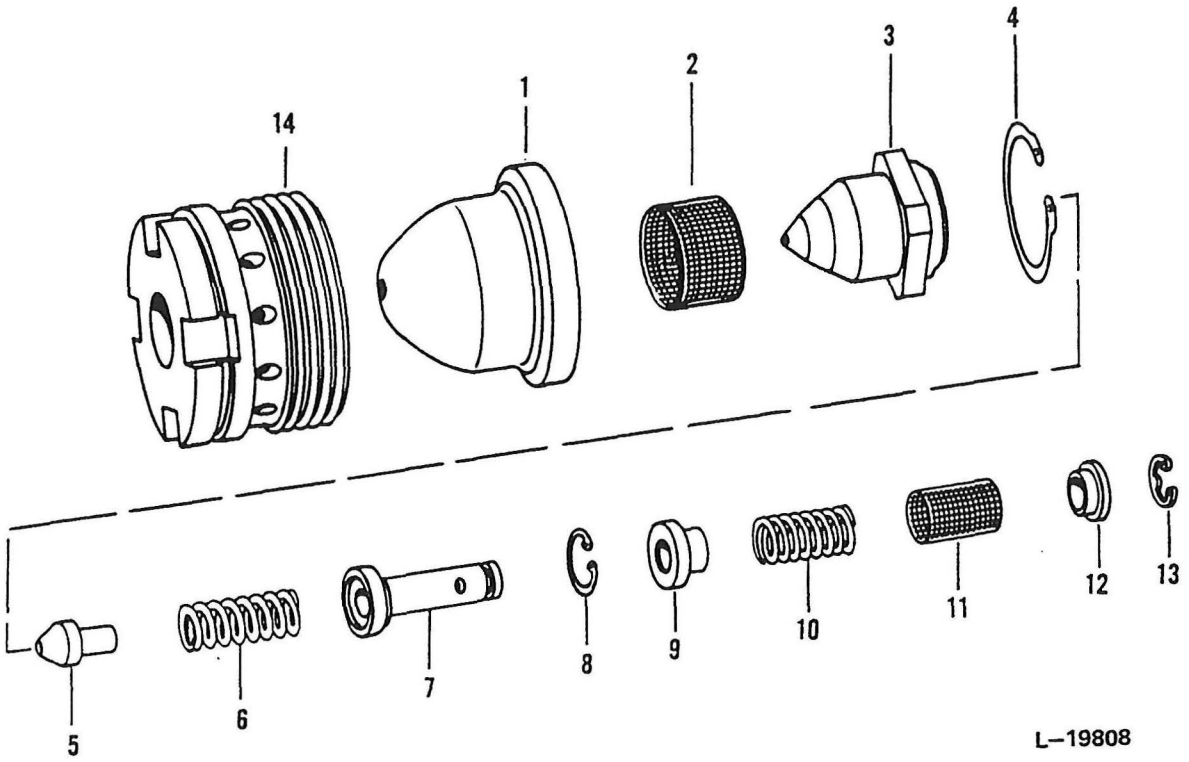
FUEL SYSTEM - DESCRIPTION AND OPERATION



L-5220

Fuel Manifold
Figure 3

FUEL SYSTEM - DESCRIPTION AND OPERATION

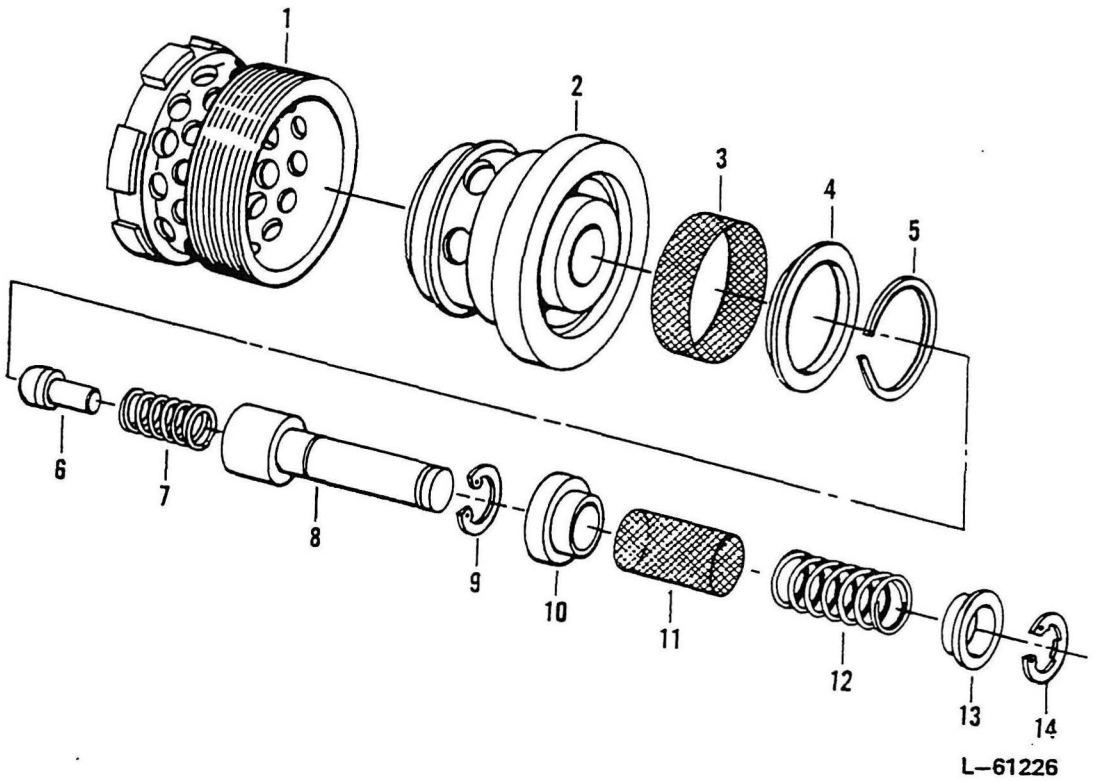


1.	Nozzle Body*	8.	Spring Seat Snapring
2.	Secondary Strainer	9.	Lower Primary Ferrule
3.	Insert*	10.	Spring (Primary)
4.	Insert Snapring	11.	Primary Strainer
5.	Primary Plug*	12.	Upper Primary Ferrule
6.	Spring	13.	Primary Strainer Snapring
7.	Spring Seat	14.	Retaining Nut

*Matched metering set - install in sets only.

R Non-Aerated Fuel Nozzle (PN 518125,
R 518126, 696093 and 696095)
Figure 4

FUEL SYSTEM - DESCRIPTION AND OPERATION



R 1. Retaining Nut
R 2. Fuel and Air Swirler
R 3. Secondary Strainer
R 4. Secondary Strainer Ferrule
R 5. Secondary Strainer Snapring
R 6. Primary Insert
R 7. Spring
R 8. Primary Strainer Body
R 9. Snapring Primary Strainer Body
R 10. Lower Primary Strainer Ferrule
R 11. Primary Strainer
R 12. Spring
R 13. Upper Primary Strainer Ferrule
R 14. Primary Strainer Snapring

Aerated Fuel Nozzel (PN 748822)
Figure 5

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel Anti-Icing System (Optional)

As has been discussed elsewhere, fuel delivered to engine must be free of all solid contaminants larger than that which will pass through screen, and also must be practically free of solid contaminants of smaller size. Serious fuel control malfunction will result if fuel containing quantity of dissolved or free water is furnished to fuel control system at temperatures which would cause ice crystals to enter control or to form ice within control. Fuel control can be protected by maintaining temperature of fuel entering fuel system high enough to prevent formation of ice from free or dissolved water.

Principal components of this system are air-fuel heater and fuel filter. Filter protects fuel system from ice, and heater thaws filter when fuel flow is restricted by ice. Heater is turned on and off by actuating fuel anti-icing valve located at inlet end of heater.

System is designed to be used intermittently, and heat is turned on only as needed to thaw filter when it becomes iced.

Under all normal conditions, heater will be operated in OFF position and there will be no heat added to fuel.

As ice collects on surface of filter, filter pressure drop will slowly increase. When filter pressure drop reaches a predetermined value, pressure warning switch turns on light in cockpit, warning flight crew that icing is being encountered. When this light goes on, flight crew will turn on heater for short period, not to exceed one minute, to thaw filter. When filter has been thawed, its pressure drop will return to normal, pressure drop warning light will go out, and heater will be turned off. Ice, then, may start again to build up on filter surface and pressure drop will slowly increase until it reaches the predetermined value at which time cycle will be repeated.

Fuel Anti-Icing Heater (Optional Equipment)

Fuel anti-icing heater is an air-fuel heat exchanger which is mounted on side of engine above and forward of fuel pump. It consists of air chamber surrounded by fuel jacket. Sixteenth stage air is circulated through air chamber. Heat from this air is transferred to fuel circulating in fuel jacket. Heater has boss to which temperature bulb may be attached.

FUEL SYSTEM - DESCRIPTION AND OPERATION

Fuel Anti-Icing Filter Assembly (Optional Equipment)

Fuel anti-icing filter assembly consists of 40 micron filter element encased in cylindrical housing. This assembly is connected through fuel line to heater as described above. Filter assembly is fitted with pressure drop warning switch, by-pass valve, and water drain plug.

Water Injection System (Optional Equipment)

Due to functional interrelationship of water injection system with engine fuel system, they should be discussed together. Detailed description of this system is covered in Chapter 82. It must be mentioned, however, that in conjunction with fuel control, a switch is operated which passes electrical power for opening or closing airframe supplied water injection shut-off valve. Also, sensing line from water injection control is attached to fuel control for resetting fuel controls maximum speed adjustment to higher setting during water injection.

FUEL SYSTEM - TROUBLESHOOTING

1. General

R A. Refer to Section 72-00, Engine - Troubleshooting.

FUEL SYSTEM - SERVICING

1. Draining Combustion Chamber Pressure Sensing Tube Condensation Trap

   A. Procedure

      (1) Cut lockwire and unscrew condensation trap plug.

      (2) Allow accumulated moisture to drain from tube.

      (3) Install new seal, replace plug. Tighten and lockwire plug.

FUEL SYSTEM - REMOVAL/INSTALLATION

1. General

A. Tube and Hose Disconnection or Removal

(1) Tag each disconnected or removed hose and tube as to nomenclature and location.

(2) Tag or note location of all clips to ensure their reinstallation in correct position.

(3) Cap all disconnected or removed tubes and hoses.

(4) Cap any openings into engine caused by hose and tube removal.

(5) During removal of external fuel tubes, it may be desirable or necessary to remove tubes from another system in order to facilitate disassembly. Care shall be taken however, to avoid scrambling parts from various systems.

2. Removal/Installation of Fuel Tubes (Without Fuel-Oil Cooling and/or Fuel De-Icing Equipment)

A. Removal

(1) Remove clip securing fuel pump-to-fuel control fuel pressure tube to fuel control-to-fuel pump return tube. Remove clip securing fuel pump-to-fuel control fuel pressure tube to oil pressure tube.

(2) Loosen nuts securing fuel pump-to-fuel control fuel pressure tube to elbows on control and on pump. Remove fuel pump-to-fuel control fuel pressure tube.

(3) Remove clip securing fuel control-to-fuel pump by-pass tube to bracket on intermediate case mount ring. Remove clip securing fuel control-to-fuel pump by-pass tube to fuel control-to-fuel pump return tube.

(4) Loosen nuts securing fuel control-to-fuel pump by-pass tube to elbows on control and on pump. Remove fuel control-to-fuel pump by-pass tube.

(5) Loosen nuts securing fuel control-to-fuel pump return tube to elbows on control and on pump. Remove tube.

(6) Remove clip securing condensation trap-to-fuel pressurizing and dump valve air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube.

R R R NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve fuel sensing tube has been removed.

(7) Loosen nuts securing condensation trap-to-fuel pressurizing and dump valve air sensing tube to elbow on fuel pressurizing and dump valve and connection on condensation trap. Remove condensation trap-to-fuel pressurizing and dump valve air sensing tube.

(8) Remove clip securing fuel control-to-condensation trap air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube.

(9) Loosen nuts securing fuel control-to-condensation trap air sensing tube to connection on condensation trap and reducer on fuel control. Remove fuel control-to-condensation trap air sensing tube.

(10) Remove bolts securing condensation trap and bracket to gearbox assembly. Remove condensation trap.

(11) Loosen nuts securing fuel control-to-fuel pressurizing and dump valve fuel sensing tube at elbows on fuel control and on fuel pressurizing and dump valve. Remove tube.

B. Installation

(1) Position fuel control-to-fuel pressurizing and dump valve fuel sensing tube to elbows on fuel control and on fuel pressurizing and dump valve. Secure tube to elbows with nuts. Torque and lockwire nuts.

R R R NOTE: On engines incorporating SB 3721, fuel control-to-fuel pressurizing and dump valve fuel sensing tube has been removed.

(2) Place condensation trap and bracket on right side of gearbox assembly. Secure trap and bracket with bolts to gearbox assembly. Torque and lockwire nuts.

(3) Position fuel control-to-condensation trap air sensing tube to connection on trap and reducer on fuel control. Secure tube with nuts. Torque and lockwire nuts.

(4) Position clip securing fuel control-to-condensation trap air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube at location noted at disassembly. Secure clip with screw and nut. Torque screw.

(5) Position condensation trap-to-fuel pressurizing and dump valve air sensing tube to trap and to fuel pressurizing and dump valve. Secure tube with nuts. Torque and lockwire nuts.

(6) Position clip securing condensation trap-to-fuel pressurizing and dump valve air sensing tube to fuel control-to-fuel pressurizing and dump valve fuel sensing tube at location noted at disassembly. Tighten screw to recommended torque.

(7) Coat new seals with engine oil and install one in each end of fuel control-to-fuel pump return tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Torque and lockwire nuts.

(8) Coat new seals with engine oil and install one in each end of fuel control-to-fuel pump by-pass tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Torque and lockwire nuts.

(9) Install clip securing fuel control-to-fuel pump by-pass tube to bracket on intermediate case mount ring and install clip securing fuel control-to-fuel by-pass tube to fuel control-to-fuel pump return tube in location noted at disassembly. Secure clips with screws and nuts. Tighten screws to recommended torque.

(10) Coat new seals with engine oil and install one in each end of fuel pump-to-fuel control fuel pressure tube; then install retainer in both ends. Position tube to elbows on control and on pump; then secure it with tube nuts. Torque and lockwire nuts.

(11) Install clip securing fuel pump-to-fuel control fuel pressure tube to fuel control-to-fuel pump return tube in location noted at disassembly. Secure clip with screw and nut. Tighten screw to recommended torque.

FUEL SYSTEM - REMOVAL/INSTALLATION

3. Removal/Installation of Fuel De-Icing Leads, Hose, and Tubes (Optional, JT3D-7 BG)

A. Removal

(1) Remove screw and nut that secure clips between anti-icing air supply tube and fuel de-icing air supply hose assembly. Remove clips.

(2) Remove bolts securing fuel de-icing hose assembly rear adapter to pad on diffuser case lower left quadrant; then remove bolts and nuts securing hose assembly front adapter to air shut-off valve located on top of heater assembly. Remove hose assembly.

(3) Loosen nuts securing heater-to-filter tube assembly to elbows on heater and on filter; then remove tube.

(4) Loosen nuts securing filter-to-pump tube assembly to elbows on fuel filter and on fuel pump; then remove tube.

(5) Remove nuts securing pump-to-heater tube assembly adapter to fuel pump adapter. Remove bracket and clip; then loosen tube nut securing tube to elbow on heater. Remove tube.

B. Installation

(1) Coat new packing and seal with fuel; then install packing on adapter end of pump-to-heater tube assembly and seal on other end. Install retainer on seal. Position tube to studded boss on fuel pump adapter and to lower rear elbow on heater. Install nuts on adapter and secure tube nut to elbow. Tighten nuts and tube nuts to recommended torque.

(2) Coat new seals with fuel and install them in each end of filter-to-pump tube. Install retainers in each end and position tube to rear facing elbow on fuel pump adapter and on filter. Tighten tube nuts to recommended torque.

(3) Coat new seals with fuel and install them in each end of heater-to-filter tube. Install retainers in each end and position tube to forward facing elbow on filter and topmost elbow on heater. Tighten tube nuts to recommended torque.

(4) Using new gaskets, position air supply hose assembly to pad in left quadrant of diffuser case and air shut-off valve located at top of heater assembly. Secure hose assembly to diffuser pad with bolts and to air shut-off valve with bolts and nuts. Tighten bolts and bolts and nuts to recommended torque.

4. Removal/Installation of Fuel Coolant Oil Cooler Fuel Tubes (Optional JT3D-7 BG)

A. Removal

NOTE: Tag or note location of clips to assure their installation in same position at assembly.

(1) Remove clip assembly securing cooler-to-control fuel tube to cooler-to-dump valve fuel tube; then remove clip securing cooler-to-dump valve fuel tube to bracket at 5 o'clock location on diffuser case rear flange.

(2) Remove nuts securing cooler-to-dump valve fuel tube flange to boss on top of fuel-oil cooler; then unfasten nut at elbow on fuel pressurizing and dump valve. Remove cooler-to-dump valve fuel tube.

(3) Remove tube nuts securing control-to-cooler fuel tube to elbows on top of control and on top of fuel-oil cooler. Remove tube.

B. Installation

(1) Coat two seals with fuel and install one in each end of control-to-cooler fuel tube; then install retainer in both ends. Position tube to elbows on top of cooler (topmost) and on top of control. Secure tube with nuts. Tighten tube nuts to recommended torque.

(2) Coat new seal with fuel and install it in dump valve end of tube; then install retainer. In flanged end of tube, install seal coated with fuel. Position flanged end of tube to fuel-oil cooler top studded boss and secure it with nuts. Fasten dump valve end to fuel pressurizing and dump valve elbow with tube nut. Torque and lockwire nuts.

(3) Position clip assembly between cooler-to-dump valve and cooler-to-control tubes at location noted at disassembly. Secure clip assembly with screw and nut. Tighten nut to recommended torque. Secure cooler-to-dump valve tube with clip to bracket at 5 o'clock location on diffuser case rear flange. Tighten nut to recommended torque.

5. Removal/Installation of Fuel-Oil Cooler Fuel Tubes (JT3D-7 DSLG)

A. Removal

(1) Unfasten nut on upper end of fuel flowmeter tube and remove bolts from flanged end of tube at pad on fuel control. Remove fuel flowmeter tube, seal and retainer from engine.

(2) Remove bolt and nut from clip securing fuel flowmeter adapter to center of diffuser case front flange and then remove bolts at lower flanged end of adapter to remove fuel flowmeter adapter and fuel tube connector from engine.

(a) Unfasten boss connection nut on fuel tube connector to disassemble fuel tube connector from fuel flowmeter adapter.

(3) Unfasten nut on oil cooler inlet fuel tube and remove straight adapter, packing, and retainer.

(4) Remove bolts in flanged end of oil cooler inlet fuel tube on front side of cooler and remove tube and packing.

(5) Remove screw and nut from clips securing two oil cooler tubes together. Remove screw and nut from clip securing oil cooler tube to bracket at center of intermediate case. Unfasten nut securing oil cooler tube to front coupling on bracket support attached to front case flange at approximate 7 o'clock position and then remove nuts securing flanged end of tube to top of cooler. Remove oil cooler tube from engine.

(6) Remove screws and nuts from clips on oil cooler tube. Unfasten nut securing forward end of tube to rear coupling on bracket support attached to front case flange and remove nuts from flanged end of tube on right side of gearbox. Remove tube and packing.

(7) Remove bolts securing two couplings to bracket support on front case flange and remove couplings.

(8) Remove screws and nuts from clips on oil cooler fuel outlet tube. Unfasten tube nut at lower end of tube and then remove nuts securing flanged end of tube to lower rear pad of cooler. Remove oil cooler fuel outlet tube, seal, packing, and retainer from engine.

(9) Remove nuts securing oil cooler fuel shut-off valve to rear side of pressurizing and dump valve and remove valve and packing from engine.

B. Installation

(1) Install packing on elbow end of fuel shut-off valve; then install valve over studs of pad on rear side of pressurizing and dump valve. Secure with washers and nuts.

(2) Install packing on flanged end of oil cooler outlet fuel tube and packing and retainer on nut end. Secure tube to pad at rear bottom outlet pad cooler with nuts. Secure other end of tube to fuel shut-off valve connection. Torque tube nut.

(3) Install tube couplings (2) in bracket support attached to front case flange at approximate 7 o'clock position. Flange of couplings to be positioned toward outside of support. Secure with bolts.

(4) Install packing on flanged end of oil cooler tube and packing and retainer on nut end. Install tube over studs of pad at top of cooler. Secure with nuts. Secure other end of tube to front coupling installed in step (3). Tighten tube nut to torque specified at Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly.

(5) Install packing on flanged end of oil cooler inlet tube and packing and retainer on nut end of tube. Secure flanged end of tube on four stud pad on right side of gearbox assembly with nuts. Secure other end of tube to rear coupling installed in step (3). Tighten tube nut to torque specified at Ref. No. 2009, Section 72-00 Engine - Dismantling/Assembly.

FUEL SYSTEM - REMOVAL/INSTALLATION

(6) Install packing on flanged end of oil cooler inlet fuel tube and packing and retainer on other end. Secure flanged end of tube to three stud pad on front side of cooler. Tighten nuts to recommended torque.

(7) Install straight adapter into tube installed in step (6). Install packing on adapter.

(8) Install clip at top of fuel flowmeter adapter. Install packing and retainer in adpater. Install boss connection nut onto fuel tube connector; then install connector onto flowmeter adapter by threading it onto connector. Secure with boss connection nut.

(9) Install adapter and connector assembled in step (8) onto the straight adapter installed in step (7). Secure with bolts and lockwire.

(10) Install seal and retainer on nut end of fuel flowmeter tube and packing on flanged end. Secure nut end of tube to connector and flanged end of tube to pad on fuel control. Secure with bolts and lockwire.

FUEL SYSTEM - INSPECTION/CHECK

1. Periodic Inspection

A. General

(1) These inspection procedures are normal function of operating organizations. They consist of required inspections and minor adjustments necessary on engine. Nature and conditions of engine operation determine time interval between required inspections. For this reason, intervals described in periodic inspection charts are labeled Routine, Minor, and Major.

(2) Engine compartment cleanliness is important because extensive mass air flow tends to draw foreign objects into engine. Thoroughly clean entire compartment with vacuum cleaner after completion of any work. Keep compartment free of dirt, oil, grease, and remove all unused parts, such as nuts, washers, and pieces of lockwire. Immediately cover all apertures resulting from disconnection of tubing or parts. Use external caps on all tube openings, not internal plugs.

(3) Carefully inspect exterior of engine without dismantling to ensure that all connections are tight.

B. Periodic Inspection Chart

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
Fuel	a. Presence of water at fuel tank only.	x	x	x
Engine Fuel Pump	a. Check for leakage.	x	x	x
	b. Security of quick disconnect clamp.		x	x
	c. Filter screen for foreign matter or damaged screen.	x	x	x
	NOTE: Filter screen must be checked frequently in new aircraft, and after fuel tank rework.			

FUEL SYSTEM - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
Fuel De-Icing Filter	a. Presence of water.	x	x	x
	b. Filter element for foreign matter.	x	x	x
Hydromechanical Fuel Control	a. Security of quick disconnect clamp.	x	x	x
	b. Electrical leads and connections for wear, damage, and security.	x	x	x
	c. Evidence of leakage.	x	x	x
	d. Security of mechanical linkage.	x	x	x
	e. Obstruction of fuel overboard drain line.	x	x	x
	f. Fuel control inlet filter (coarse filter) for foreign matter or damaged screen.	x	x	x
	NOTE: On new airplanes check and replace with clean screen after each flight until no contamination is found.			
	g. Servo fuel filter for foreign matter or damaged screen.	x	x	x
	NOTE: See Note under f. above. Frequency of inspection is contingent on degree of contamination of main (coarse) filter.			
	h. Accumulation of water in burner pressure bellows cavity.		x	x

FUEL SYSTEM - INSPECTION/CHECK

COMPONENT	NATURE OF INSPECTION	INSPECTION TIME		
		ROUTINE	MINOR	MAJOR
Pressurizing and Dump Valve	a. Security of accessible lines and fittings.	x	x	x
	b. Security of mounting.		x	x
	c. Inspect screen.		x	x
Fuel Manifold and Nozzles	a. Dissimilarity of carbon buildup. Lack of carbon buildup may indicate a clogged nozzle.			x
	NOTE: Check for plugged nozzles or spray discrepancy must be performed. See 73-15-1, Inspection/Check.			
	b. Broken or missing tablocks.			x
	c. Localized damage due to heat.			x

C. Specific Periodic Inspection

(1) Exhaust Gas Temperature Spread Check

(a) Periodically evaluate physical condition and flow characteristics of fuel nozzles.

NOTE: Integrity of testing equipment must also be checked.

FUEL SYSTEM - CLEANING/PAINTING

1. Cleaning Flexible Tubes

A. Procedure

(1) Removal all caps.

(2) Clean tubes by spraying with petroleum solvent, using brush, if necessary.

(3) Drain tubes thoroughly and remove all excess fluid with compressed air making absolutely certain no foreign material remains in tubes.

(4) Reinstall caps.

2. Cleaning Steel Tubes

A. Procedure

(1) Steel tubes may be cleaned as outlined above for flexible tubes.

(2) If harder to clean soils are encountered, clean as follows:

(a) Remove excessive oil.

(b) Immerse in appropriate cold carbon remover for ten to thirty minutes or more as required.

(c) Rinse thoroughly in hot water.

(d) If necessary, to remove any remaining cleaning compound, pressure wash with petroleum solvent, then remove all excess fluid with compressed air.

(e) Make certain no foreign material or cleaning compound remains in tubes.

(f) Reinstall caps.

FUEL PUMP - DESCRIPTION AND OPERATION

General

Two-stage fuel pump is an engine driven, by-pass equipped pump used to supply fuel at predetermined pressures and quantities to fuel control. It is driven by accessory gear train of engine at 0.344 of rear compressor speed. Pump is mounted on left front flange of gearbox assembly, under intermediate case.

It incorporates inlet fuel filter with self-relieving valve, two positive displacement gear type pumping elements, one relief valve, one check valve, one pressure regulating valve, and one drive shaft incorporating rotary seal.

Operation

Two positive displacement gear type pumping elements operate in series to supply fuel in required quantities and pressures to engine fuel control. These two pumping elements are arranged so that boost stage acts as pressure boost pump for main stage, which in turn supplies fuel to engine fuel control. Control of internal fuel pressures as well as main stage discharge pressure is maintained by group of three valves.

NOTE: Capitalized fuel port titles found in following text are equivalent to similar port identifications molded in pump castings.

Power to drive pump is supplied by engine through mounting pad which accommodates pump main drive shaft spline. Exterior plumbing is utilized to bring fuel to (1) inlet port, FUEL IN: (2) fuel from engine fuel control at body pressure to by-pass return port, BY PS RET: (3) engine fuel control main by-pass fuel to main stage return port, PRIM RET: (4) fuel from boost stage discharge port, SEC OUT (if incorporated, through engine fuel de-icer) to boost stage return port, SEC RET: and (5) fuel from main stage discharge port, PRIM OUT to engine fuel control.

Under normal operating conditions, fuel flows through pump from FUEL IN port and inlet fuel filter element and self-relieving valve to boost stage, out SEC OUT port through engine fuel de-icer (if incorporated) to the SEC RET port, to main stage and out of PRIM OUT port to engine fuel control. Fuel not required by engine is returned to pump through PRIM RET and BY PS RET ports.

FUEL PUMP - DESCRIPTION AND OPERATION

Main Stage Pressure Relief Valve "A": This pressure relief valve controls maximum value of pump discharge pressure and is set to open when main stage discharge fuel pressure reaches approximately 1050 psi. When valve is open, main stage discharge fuel flow is by-passed internally to inlet side of main stage pumping element. Normally, "A" valve is closed during operation.

Main Stage Inlet Check Valve "B": If boost element fails, this valve will open, providing fuel supply to main element. "B" valve is normally closed during operation.

Boost Stage Pressure Regulating Valve "D": This relief valve controls pressure of fuel delivered to engine fuel de-icer system (if incorporated), and therefore, pressure of fuel delivered to main stage inlet. Valve is set to open at between 45 and 65 psi above inlet pressure. When valve is open, fuel is recirculated internally to pump inlet.

Description

Aluminum alloy body houses pump, three valves, and filter. Flange adapter, bolted between pump body and gearbox housing drive pad, carries main drive shaft and its seal diaphragm assembly. Splined drive is used. Main pump gears are at drive end of body. Boost pump gears are driven by splined hub that fits into main pump gear. Filter screen is not spring-loaded by-pass type. "O" rings are used for sealing where necessary. Main stage pressure relief valve setting is shop adjustable with shims. Remaining valves are not adjustable.

FUEL PUMP - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel pump removal. See Chapter 73-00, Removal/Installation for tube removal and install instructions.

NOTE: See Chapter 72-00, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of fuel pump or fuel pump filter.

2. Removal/Installation of Fuel Pump

A. Removal

(1) Remove clips securing fuel pump-to-fuel control pressure tube. Loosen nuts securing tube to elbows on control and on pump and remove tube.

(2) Remove clips securing fuel pump-to-fuel control by-pass tube. Loosen nuts securing tube to elbows on control and on pump and remove tube.

(3) Remove clip securing fuel control-to-fuel pump return tube. Loosen nuts securing tube to elbows on control and on pump and remove tube.

(4) From engines on which optional equipment fuel de-icing heater is installed, remove clip securing fuel pump-to-fuel heater inlet tube. Loosen nut securing tube to heater elbow, remove three locknuts securing tube to pump and remove tube.

(5) From engines on which optional equipment fuel de-icing filter is installed, remove clips securing fuel de-icing filter-to-fuel pump tube. Loosen nuts securing tube to elbows on filter and on pump and remove tube.

(6) Back-off nut of bolt attached to accessory drive pad bracket; then loosen bolt to disengage mating part of accessory drive pad nut assembly. See Figure 401.

FUEL PUMP - REMOVAL/INSTALLATION

(7) Supporting fuel pump, turn pump and accessory drive pad nut assembly counterclockwise (front view) to disengage from mating adapter attached to accessory and component drives gearbox. Then carefully withdraw fuel pump to disengage mating splines.

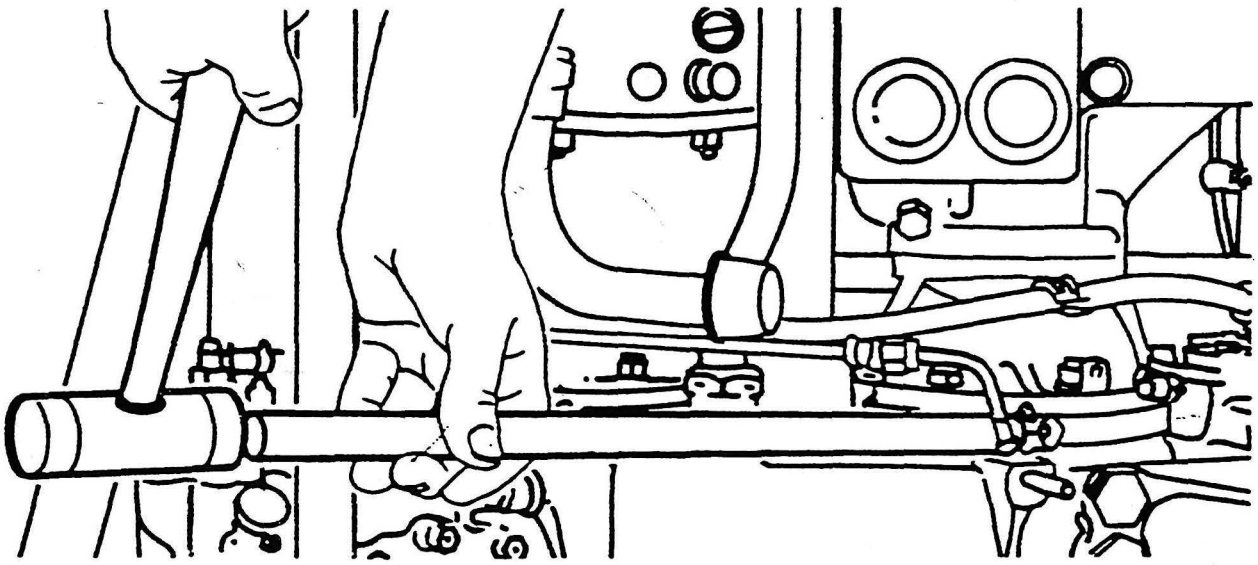
CAUTION: DO NOT LET WEIGHT OF FUEL PUMP BE TRANSMITTED TO PUMP SPLINES DURING REMOVAL.

(8) Remove packing from OD of accessory drive pad.

(9) Remove locknuts and washers securing accessory drive pad nut assembly and accessory drive pad to flange of fuel pump; then remove bolts, accessory pad, accessory pad nut assembly, and gasket from fuel pump mounting flange. Remove packing from fuel pump drive gearshaft. See Figure 402.

B. Installation

(1) Position fuel pump on bench with mounting flange toward operator.



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Loosening Mounting Adapter
Figure 401

FUEL PUMP - REMOVAL/INSTALLATION

(2) On engines having fuel pump drive splines lubricated by circulating engine oil, install new packing (5) on fuel pump driveshaft. See Figure 402.

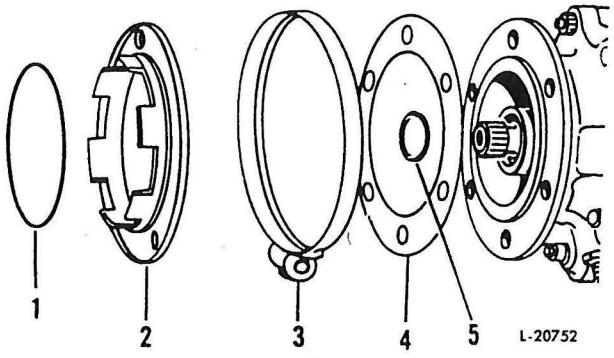
(3) Position gasket (4), accessory pad nut assembly (3) and accessory drive pad (2) on fuel pump mounting flange. Secure with bolts, washers, and locknuts, positioning locknuts to fuel pump side.

(4) Place a new packing (1) on flange of accessory drive pad.

CAUTION: PACKING MUST GO OUTSIDE FINGERS OF PAD.

(5) Coat fuel pump shaft mating splines sparingly with plastilube No. 3 compound.

CAUTION: FUEL PUMP DRIVE SPLINES ON SOME ENGINES ARE LUBRICATED BY ENGINE OIL WHICH CIRCULATES THROUGH OIL FEED HOLES DRILLED IN ACCESSORY DRIVE SHAFTGEAR. ON ENGINES THUS EQUIPPED, USE ONLY ENGINE OIL TO LUBRICATE PUMP AND SHAFTGEAR MATING SPLINES. DO NOT USE PLASTILUBE NO. 3 OR SIMILAR LUBRICANTS WHICH MIGHT PLUG OIL FEED HOLES.



1. Accessory Pad Packing
2. Accessory Pad
3. Accessory Pad Nut Assembly
4. Flange Gasket
5. Packing

Fuel Pump Mounting Arrangement
Figure 402

FUEL PUMP - REMOVAL/INSTALLATION

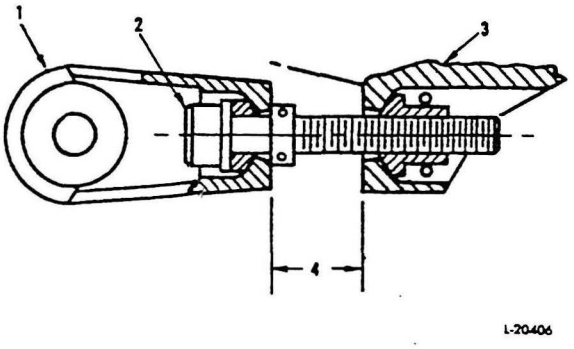
(6) Install fuel pump on accessory and component drives gearbox assembly.

(7) Secure pump by tightening accessory pad nut assembly to engage threads of adapter. Lock nut assembly by engaging detail nut with bolt of accessory drive nut bracket. Tighten bolt to recommended torque and lockwire.

(8) Check for thread wear of accessory pad nut by measuring distance between nut lug and attaching accessory drive nut bolt bracket. See Figure 403. Minimum distance specified at Index No. 4 is acceptable. Measurement of less than this limit is cause for rejection of accessory pad nut assembly.

(9) Check clearance between inner end of accessory drive pad nut assembly and fuel pump mounting pad of accessory drive gearbox assembly.

NOTE: When properly installed, clearance between inner end of accessory drive pad nut assembly and fuel pump mounting pad on accessory gearbox assembly shall be 0.029 to 0.052 inch and shall not vary more than 0.010 inch when checked at each 90 degree location.



1. Bracket
2. Bracket Bolt
3. Nut Lug
4. 0.625 Inch Minimum

Accessory Pad Nut Assembly
Wear Limit
Figure 403

(10) Install clips in locations noted at removal on fuel control-to-fuel pump return tube. Coat new seals with engine oil and install one in each end of tube. Install retainer in both ends, position tube to elbows on control and on pump, and secure tube with tube nuts. Torque and lockwire tube nuts; then secure clips with screws and nuts. Tighten screws to recommended torque.

(11) Install clip in locations noted at removal on fuel control-to-fuel pump by-pass tube. Coat new seals with engine oil and install one in each end of tube. Install retainer in both ends, position tube to elbow on control and on pump, and secure tube with tube nuts. Torque and lockwire tube nuts; then secure clip with screw and nut. Tighten screw to recommended torque.

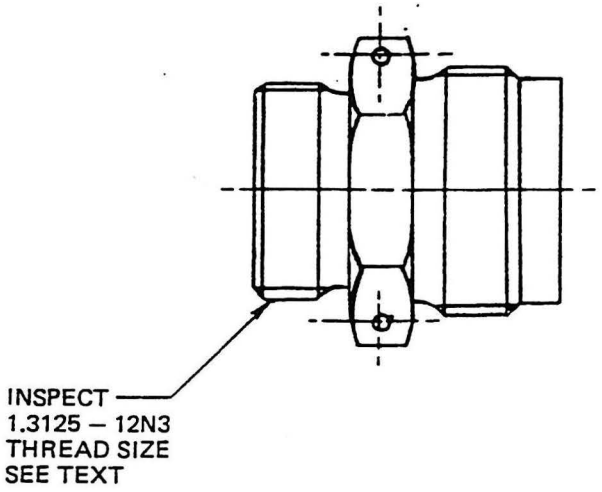
R (11a) For Douglas LD engines, inspect connector, PN 226109 (AMS 4120 Aluminum), for thread size of 1.3125 - 12 NS. Inspect threads over 0.0481 inch diameter wire pins. Reject any connector measuring 1.320 inch diameter or less. See Figure 403A. It is permissible to use adapter PN 590004 (AMS 5645 SST), in place of connector, PN 226109.

NOTE: For engines incorporating helicoil repair per SB 5321 also incorporate packing, PN MS9967-217, used with adapter, PN 590004, in place of packing, PN MS9387-16, used with connector, PN 226109.

CAUTION: WHEN INSTALLING PRESSURE TUBE, HOLD TUBE CONNECTOR SECURELY TO PREVENT OVER-TORQUE.

R (11b) Install connector or adapter into open port in fuel pump tube connector assembly. Tighten to a torque of 525 - 625 pound-inches.

R (12) Coat new seals with engine oil and install one in each end of fuel pump-to-fuel control fuel pressure tube; (JT3D-7BG) or supply tube (JT3D-7D SLG); then install retainer in both ends. Position tube to fitting on control to recommended torque and lockwire. Install clips in location noted at removal, securing tube, and secure with screws and nuts. Tighten screws to recommended torque.



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R Inspection Requirements for PN 226109 Tube Connector
R Figure 403A

(13) On engines which incorporate optional equipment fuel de-icing heater, coat new seals with engine oil and install appropriate seal in each end of fuel pump-to-fuel heater inlet tube; then install retainer on heater end of tube. Position tube to heater elbow and pump adapter. Secure tube nut to heater elbow. Secure three locknuts to pump adapter. Torque and lockwire tube nuts. Install clip in location noted at removal and secure with screw and nut. Tighten screw to recommended torque.

(14) On engines which incorporate optional equipment fuel de-icing filter, coat new seals with engine oil and install one in each end of fuel de-icing filter-to-pump tube. Install retainer in both ends, position tube to elbows on control and on pump, and secure tube with tube nuts. Torque and lockwire tube nuts. Install clips and secure with screws and nuts. Tighten screws to recommended torque.

FUEL PUMP - REMOVAL/INSTALLATION

3. Removal/Installation of Fuel Pump Strainer Assembly

See Figure 404.

A. Removal

(1) Remove cover attaching bolts and washers and lift strainer assembly out of housing.

B. Installation

(1) Place new rubber "O" ring packing coated with petrolatum, Snow White Parmo or equivalent, on strainer body and install strainer body in fuel pump housing.

(2) Secure with bolts, washers; torque bolts 20 to 30 pound- inches and lockwire.

4. Disassembly/Assembly of Fuel Pump Strainer Assembly

See Figure 404.

A. Disassembly

(1) Remove and discard snapring.

(2) Remove washers, fuel strainer element, spring and washer on end.

NOTE: Do not remove helical coil inserts from fuel strainer body unless inspection indicates replacement is necessary.

(3) Remove plug and "O" ring packing from end of fuel strainer body. Remove "O" ring packing which seals fuel strainer body to pump housing.

NOTE: "O" ring packing which seals fuel strainer body to fuel pump housing may make it extremely difficult to remove fuel strainer assembly from housing assembly. Use cover bolts as jacks to remove strainer assembly by screwing them into helical coil inserts. Screw bolts in evenly so as not to misalign assembly in housing.

FUEL PUMP - CLEANING/PAINTING

1. Fuel Pump Filter

A. Procedure

(1) Rinse filter in degreaser fluid or cleaning solvent; then dry with air jet.

(2) Clean lint-clogged screens as follows:

(a) Insert screen in saturated solution of 1 liter of concentrated sulfuric acid (commercial grade) and 20 grams of sodium dichromate (technical grade) for period of one minute. It may be necessary to heat solution to 150°F (66°C) in order to dissolve crystals.

(b) Remove acid solution from screen by rinsing thoroughly in clean water and drying with compressed air.

(c) Repeat steps (1) and (2) if any lint remains.

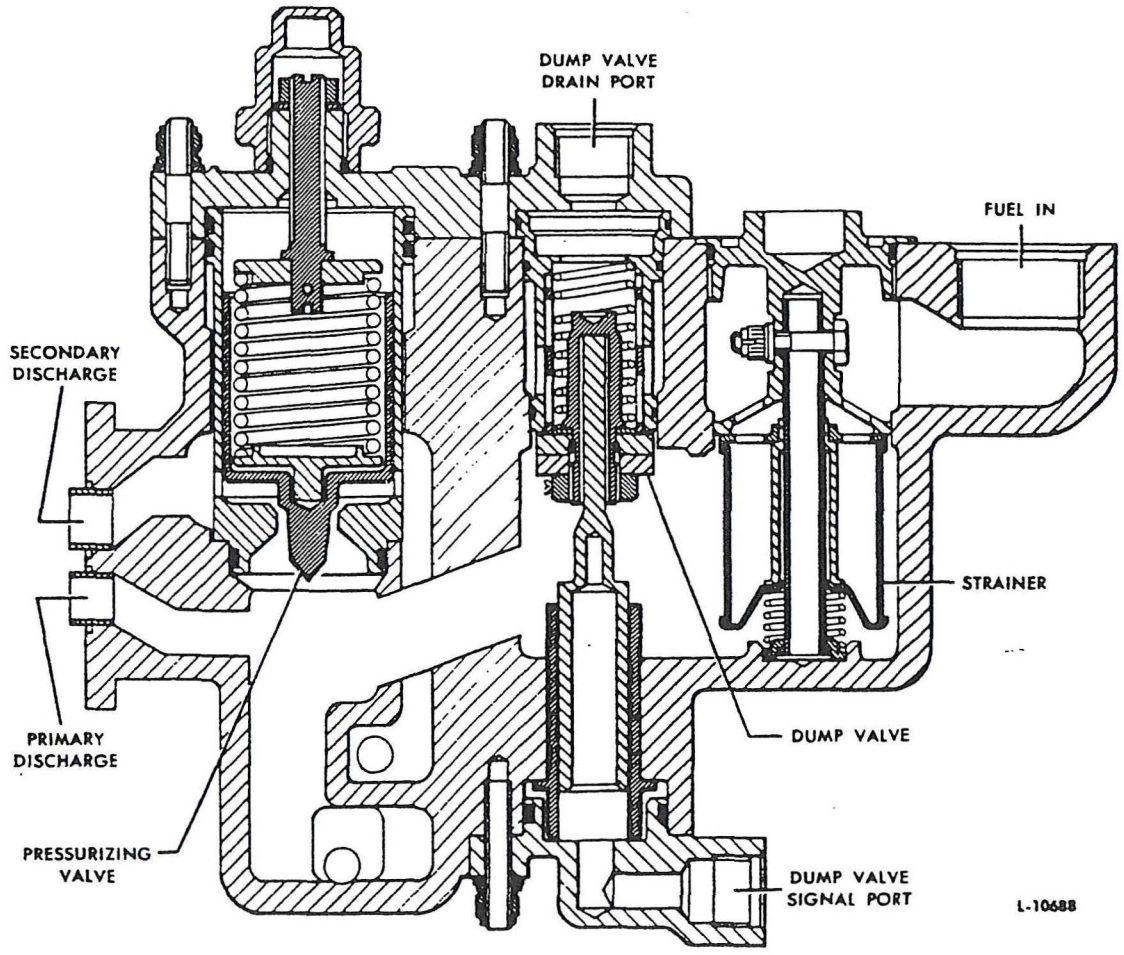
WARNING: AT CONCLUSION OF CLEANING PROCEDURE, DESTROY OR PROPERLY STORE PREPARED CLEANING SOLUTION.

FUEL PRESSURIZING AND DUMP VALVE - DESCRIPTION AND OPERATION

General

Fuel pressurizing and dump valve, which is downstream of engine fuel control, is connected to engine fuel manifold to which it discharges its fuel via two paths, primary and secondary fuel manifolds. Essential parts of fuel pressurizing and dump valve (see Figure 1) include fuel inlet screen, manifold dump or drain valve, and pressurizing or flow-dividing valve.

Fuel pressurizing and dump valve is located on outside of engine diffuser case at its rear bottom center. Four long bolts hold valve body, inlet spacer assembly and fuel inlet fitting together and fasten them to diffuser case.



Fuel Pressurizing and Dump Valve
Figure 1

FUEL PRESSURIZING AND DUMP VALVE - DESCRIPTION AND OPERATION

Inlet Screen

Fuel inlet screen, which filters all fuel before its introduction to fuel nozzles, is spring-loaded on its seat. This arrangement permits by-pass flow at 10 to 20 psi around it in event of screen clogging.

Dump or Drain Valve

Manifold dump or drain valve is a two-sided poppet valve which is opened by force of spring and is closed by hydraulically-actuated piston sliding in sleeve. Pump discharge pressure, directed by fuel control throttle operated pilot valve, is applied to chamber behind piston when pilot valve is moved out of "OFF" position. This pressure is sufficiently high to move piston and dump valve against spring force and thereby holds dump valve in closed position during engine operation. When pressure behind actuating piston is reduced to fuel control boost pressure by movement of throttle operated pilot valve to "OFF" position, the spring forces dump valve into open or dump position, thus permitting primary fuel manifold to drain overboard. Difference between area of dump valve proper and actuating piston exposed to primary manifold pressure prevents dump valve from opening until primary manifold has decreased to value below normal minimum operating value.

Pressurizing Valve

Fuel pressurizing valve consists of spring-loaded, stepped-area piston and cylinder assembly. One end of large diameter cylinder contains orifice and valve seat within which contoured small-diameter, pintle-type piston operates, and against which it seals to shut off fuel flow to secondary manifold. Spring end of piston in large diameter cylinder is vented to secondary fuel manifold. When primary chamber pressure, which surrounds pintle, becomes sufficient
R (250 psig for use with nonaerated fuel nozzles or 400 psig for
R aerated fuel nozzles) to overcome force due to spring plus burner pressure (same as secondary manifold pressure until valve opens), valve is forced open and fuel flows in large diameter cylinder and through fixed area radial slots in lower end of cylinder to secondary manifold. As fuel flow increases, pressure drop across these radial slots increases, which creates pressure drop across large piston adding to that across pintle piston to help overcome spring force. This stepped-area piston produces effect of negative spring-rate, thereby decreasing pressure difference between primary and secondary manifolds as fuel increases. Contour of pintle is designed to divide primary and secondary flows to give satisfactory nozzle spray characteristics at all fuel flow conditions.

FUEL PRESSURIZING AND DUMP VALVE - REMOVAL/INSTALLATION

1. General

A. Disconnect or remove all necessary tubes to permit fuel pressurizing and dump valve removal. See Chapter 73-00, Removal/Installation for tube removal and installation instructions.

NOTE: Refer to Chapter 72-00, Engine - Adjustment/Test for procedures to be followed subsequent to removal/installation of fuel pressurizing and dump valve or screen assembly.

2. Fuel Pressurizing and Dump Valve

A. Removal

(1) For engines which incorporate optional equipment oil cooler, disconnect tube nut which secures oil cooler-to-fuel pressurizing and dump valve tube to valve elbow.

(2) Disconnect tube nut which secures fuel control-to-fuel pressurizing and dump valve fuel sensing tube to valve elbow.

R NOTE: On engines incorporating SB 3721, fuel control-to-
R fuel pressurizing and dump valve fuel sensing tube
R has been removed.

(3) Disconnect tube nut which secures condensation trap-to-fuel pressurizing and dump valve air sensing tube to valve elbow.

(4) For engines which do not incorporate optional equipment oil cooler, disconnect tube nut which secures fuel control-to-pressurizing and dump valve pressure tube to valve elbow.

(5) Remove bolts securing fuel pressurizing and dump valve to diffuser case (inlet spacer assembly); then remove dump valve.

(6) Remove screws securing inlet spacer assembly; then remove assembly.

FUEL PRESSURIZING AND DUMP VALVE - REMOVAL/INSTALLATION

B. Installation

R NOTE: Engines converted to smokeless burner configuration
R require use of new pressurizing and dump valve that
R must only be used in this new configuration even
R though old and new valves are physically interchangeable.

See Figure 401.

CAUTION: CHEVRON TYPE SEALS ONLY MUST BE INSTALLED IN EACH INLET SPACER CONTAINING HARDENED SEATS. USE OF ANY OTHER TYPE SEAL WILL RESULT IN FUEL LEAKAGE.

(1) Install gaskets in two primary and two secondary fuel passages, and in burner pressure passage of adapter located on fuel manifold mating side of fuel inlet adapter.

(2) Install fuel manifold inlet adapter through fuel pressurizing and dump valve mount pad on bottom of diffuser case, engaging dowels in dowel holes of fuel manifold adapters.

(3) Secure fuel manifold inlet adapter to manifold adapters with screws.

(4) Install gaskets in cavities located around primary and secondary bushings of inlet adapter mating face on fuel pressurizing and dump valve.

(5) Position fuel pressurizing and dump valve in fuel manifold inlet adapter engaging bushing in mating holes. Secure fuel pressurizing and dump valve to diffuser case with bolts. Torque and lockwire bolts.

NOTE: Pressure check pressurizing and dump valve for leakage. See 72-00, Engine - Adjustment/Test.

(6) For engines which do not incorporate optional equipment oil cooler, coat new seal with engine oil and install seal on end of fuel control-to-pressurizing and dump valve pressure tube. Install retainer on end of tube. Position tube to elbow on valve and secure with tube nut. Torque and lockwire tube nut.

(7) For engines which incorporate optional equipment oil cooler, coat new seal with engine oil and install seal on end of oil cooler-to-fuel pressurizing and dump valve tube. Install retainer on end of tube. Postition tube to elbow on valve and secure with tube nut. Torque and lockwire tube nut.

OIL DRAIN VALVE - DESCRIPTION AND OPERATION

General

Oil drain valve is located at bottom of oil tank. Valve is held in closed position by constant spring force exerted on handle.
R Manually rotating handle ninety degrees in counterclockwise direction opens valve. Valve in this position will allow oil to drain from tank. Tension of spring will automatically return valve to
R closed position when handle is released (started from open position
R detent).

OIL DRAIN VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of Oil Drain Valve (JT3D-7 BG)

A. Removal

(1) Cut lockwire and loosen locknut which secures oil drain valve to oil tank connector.

(2) Unscrew drain valve from connector.

B. Installation

(1) Screw threaded end of drain valve into oil tank connector. Position handle so that it is 45 degrees forward from inboard of engine. Torque and lockwire locknut.

2. Removal/Installation of Oil Drain Valve (JT3D-7 DSLG)

A. Removal

(1) Cut lockwire and loosen locknut which secures oil drain valve to oil tank connector.

(2) Unscrew drain valve from connector.

(3) Remove bolts securing connector to oil tank. Remove packings from connector. Discard packings.

B. Installation

(1) Install lubricated packing on drain valve connector; then install connector on bottom rear boss of oil tank. Secure bolts and rear boss of oil tank. Secure bolts and nuts (bolt heads down). Install packing and retainer on oil drain valve; then install drain valve on connector, secure with nut. Torque and lockwire.

FUEL COOLANT OIL COOLER - DESCRIPTION AND OPERATION

General

R Fuel-oil cooler is a cylindrical unit mounted in front lower right
R quadrant of diffuser case. Fuel flows through tubes in core of
R cooler and oil circulates within housing and around outside of core
R tubes. Heat from oil is transferred to fuel via conduction. Engine oil which has not been heated sufficiently by engine operation to require cooling is prevented from entering cooler by a thermostatic valve located in inlet connection of cooler. Operation of thermostatic valve is controlled by oil-out-of-cooler temperature which
R determines whether oil by-passes or goes through cooler.

FUEL COOLANT OIL COOLER - MAINTENANCE PRACTICES

1. Removal/Installation of Fuel Oil Cooler

A. Removal

(1) Remove nuts and gaskets securing fuel-oil cooler bracket to diffuser case and to cover of right fluid drive on gearbox assembly.

(2) Remove fuel-oil cooler and brackets.

B. Installation

(1) Position fuel-oil cooler and brackets to studs on diffuser case and right fluid drive cover on gearbox assembly. Secure them with gaskets and nuts.

(2) Torque nuts.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

1. Removal/Installation of Oil Tank Oil Tubes (JT3D-7 BG)

A. Removal

(1) Remove bolts securing oil tank breather elbow to intermediate case mount ring area in upper right quadrant. Remove elbow, then remove oil tank breather tube.

(2) Remove bolts and nuts securing two hole flange of oil cooler-to-oil tank tube to mating flange on oil tank and remove nuts securing three hole flange in fuel-oil cooler; then remove oil cooler-to-oil tank tube.

(3) Loosen nuts securing gearbox-to-cooler oil tube to elbows on fuel-oil cooler and gearbox. Remove gearbox-to-cooler tube and nuts.

(4) Remove bolts and nuts securing oil tank-to-gearbox oil tube to flanged boss on lower section of oil tank and nuts securing this tube to studded boss on right side of gearbox assembly. Remove oil tank-to-gearbox oil tube.

(5) Remove nut securing oil drain valve assembly to oil drain connector tube at bottom of oil tank and remove oil drain valve assembly, packing, and retainer. Remove bolts and nuts in flange connector securing oil drain connector tube-to-oil tank and remove connector tube, flange connector and packing.

B. Installation

(1) Install oil tank drain valve at bottom of oil tank. Position handle so that it is 45° forward from inboard of engine. Torque and lockwire nut.

(2) Install two packings on oil tank end of oil tank-to-gearbox tube and one packing on gearbox end; then position tube on studs at gearbox end and insert other end in flanged boss on lower section of oil tank. Secure tube to oil tank with bolts and nuts and to gearbox with nuts. Torque bolts and nuts.

(3) Assemble fuel coolant oil cooler inlet elbow to bottom of oil cooler with new packing. Torque nuts.

(4) Using new lubricated packing or gasket, assemble accessory drives gearbox oil scavenge connector to side of gearbox with nuts and washers. Connector should face up. Torque nuts.

(5) Install nuts on gearbox-to-cooler tube so that threaded ends face outward; then install a ferrule on plain end of tube. Install new packing and retainer on each end. Position plain end of tube to elbow on fuel-oil cooler and secure threads of nut; then secure threads of other nut to elbow on gearbox. Torque tube nuts in accordance with Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly.

(6) Install two packings on oil tank end of oil cooler-to-oil tank tube and one packing on cooler end; then position tube on studs at cooler and insert other end in flnaged boss on left side of oil tank. Secure tube to oil tank with bolts and nuts and to cooler with nuts. Torque bolts and nuts.

(7) Install two packings each on both ends of oil tank external breather tube; then insert tube in opening at upper right of oil tank. Position elbow on other end of tube and using new packing, secure elbow to opening in intermediate case mount ring area in upper right quadrant with bolts. Torque and lockwire bolts.

(8) Install oil tank drain plug with new packing in bottom of oil tank. Torque plug in accordance with Ref. No. 2002, Section 72-00, Engine - Dismantling/Assembly.

2. Removal/Installation of Oil Tank Oil Tubes (JT3D-7 DSLG)

A. Removal

(1) Remove screws and nuts from clips securing oil tank breather tube to rear flange of front compressor front case at 12 o'clock location. Unfasten tube nut at tee on top of oil tank and remove bolts and locknuts securing flanged end of tube to inlet case one o'clock location. Remove breather tube, packing and retainer.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(2) Unfasten clips securing oil tank breather tube to oil tank-to-cooler scavenge tube. Loosen breather tube nuts on elbow at intermediate case 11 o'clock position and on tee at top of oil tank. Remove tube, packing, and retainers.

(3) Remove bolts securing elbow to intermediate case at 11 o'clock position and remove elbow and packing.

(4) Remove bolts and locknuts from tee at top of oil tank and remove tee and packing.

(5) Remove bolts and nuts from clips securing oil tank-to-cooler scavenge tube. Unfasten scavenge tube nut on elbow at top of oil cooler and tube nut on elbow on oil tank. Remove oil tank-to-cooler scavenge tube, packing, and retainers.

(6) Remove bolts and locknuts securing elbow to side of oil tank and remove elbow and packing.

(7) Unfasten clips securing oil supply tube and loosen tube nut on connector in gearbox and tube nut on connector in bottom of oil tank. Remove oil supply tube, packing, and retainers.

(8) Remove bolts and locknuts securing connector to bottom of oil tank and remove connector and packing.

(9) Unfasten nuts securing connector to front of gearbox and remove connector and packing.

(10) Unfasten nut securing oil tank drain valve assembly to connector at bottom of oil tank and remove drain valve assembly. Remove bolts and nuts from connector and remove connector and packing from oil tank.

B. Installation

NOTE: See Paragraph 9., Section 72-00, Engine - Dismantling/Assembly, for special torques.

(1) Install lubricated packing on drain valve connector; then install connector on bottom rear boss of oil tank. Secure with bolts and nuts (boltheads down). Install packing and retainer on oil drain valve; then install drain valve on connector. Secure with nut. Torque and lockwire.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(2) Install lubricated packing on adapter; then install adapter to middle flanged boss at bottom of oil tank. Secure with bolts, nuts, and washers. Install washers against nuts.

(3) Install packing on oil tank plug to be located on bottom front boss of oil tank and secure with bolts and nuts.

(4) Install lubricated packing and retainer on oil tank end and gearbox end of oil supply tube; then position tube to oil tank adapter and gearbox connector. Tighten tube nuts at both locations to torque specified at Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly. Lockwire tube nuts.

(5) Install lubricated packing on tube-to-boss elbow and secure to intermediate case pad at approximate 11 o'clock position with bolts. Install lubricated packing on oil tank tee; then insert end with packing against flange boss at top of oil tank. Secure with bolts and locknuts. Torque bolts.

(6) Install lubricated packing and retainer on each end of oil tank breather tube; then position tube to oil tank tee and to elbow at intermediate case 11 o'clock position. Tighten nuts to torque specified at Ref. No. 2014, Section 72-00, Engine - Dismantling/Assembly.

(7) Install lubricated packing on tube-to-boss elbow; then install tube to boss elbow at flanged boss located at upper rear portion of oil tank. Secure with bolts and nuts.

(8) Install lubricated packing and retainer on both ends of oil tank-to-cooler scavenge tube; then install tube on elbow on oil tank and elbow of oil cooler. Tighten nuts to torque specified at Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly, and lockwire.

(9) Install lubricated packing at flanged end of oil tank breather tube; then install packing and retainer at opposite end (tube nut end).

(10) Install breather tube flanged end at fitting at inlet case one o'clock location. Install other end at remaining opening of oil tank tee. Secure tube at flanged end with bolts and locknuts. Secure tube at oil tank end to torque specified at Ref. No. 2013, Section 72-00, Engine - Dismantling/Assembly.

3. Removal/Installation of Breather Tubes (JT3D-7 BG)

A. Removal

(1) Remove clip securing rear breather tube to clamp on diffuser case front flange; then remove nuts securing tube to elbow at approximate 12 o'clock position on diffuser case and tee in upper left quadrant of intermediate case. Remove tube.

(2) Remove bolts securing front breather tube to connection at approximate 12 o'clock position on inlet case and remove nut securing tube to tee on intermediate case. Remove tube.

(3) Remove bolts securing elbow to diffuser case. Remove elbow.

(4) Remove bolts securing tee to intermediate case. Remove tee.

B. Installation

(1) Using new packing, install breather tee on its pad in upper left quadrant of intermediate case. Secure tee with bolts and washers. Torque and lockwire bolts.

(2) Using new gasket, install breather elbow on its pad at approximate 12 o'clock position on diffuser case. Secure elbow with bolts. Torque and lockwire bolts. Install clip bracket on left and top locations of elbow flange with longer bolts.

(3) Position flange of front breather tube to flange of connector at 12 o'clock position on inlet case and insert rear end of tube into tee on intermediate case. Secure tube to tee with tube nut and to connector with bolts and locknuts. Secure clip to bracket at 11 o'clock position on front compressor rear case. Torque flange nuts and tube nut. Lockwire tube nut.

(4) Install tube nuts on plain end of rear breather tube so that threads of nuts are positioned outward, then install ferrule, packing, and retainer on plain end of tube and packing and retainer on ferruled end. Position tube to tee on intermediate case and elbow on diffuser case and secure it with tube nuts. Secure tube with clip to bracket on diffuser case front flange. Tighten tube rear nut on elbow to recommended torque. Torque tube front nut on tee in accordance with Ref. No. 2010, Section 72-00, Engine - Dismantling/Assembly. Lockwire tube nuts.

4. Removal/Installation of Breather Tubes (JT3D-7 DSLG)

A. Removal

(1) Remove nuts securing tube to elbow at approximate 12 o'clock position on diffuser case and upper right quadrant of intermediate case. Remove tube.

(2) Remove bolts securing elbow to diffuser case and remove elbow.

(3) Remove bolts securing elbow to intermediate case and remove elbow.

B. Installation

(1) Using new gasket, install breather tube elbow on its pad at top of diffuser case. Secure elbow with bolts. Torque and lockwire bolts.

(2) Using new packing, install plug in front breather elbow and torque plug. Install new packing on elbow and attach elbow to intermediate case between mounting flanges at approximately two o'clock position with bolts. Plug shall be facing up and elbow to rear. Torque and lockwire bolts.

(3) Install new packing and retainer on front end of breather tube and position tube between two elbows. Torque and lockwire tube rear nut. Torque tube front nut in accordance with Ref. No. 2014, Section 72-00, Engine - Dismantling/Assembly. Lockwire tube nut and elbow plug.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

5. Removal/Installation of Oil Scavenge Tubes (JT3D-7 BG)

A. Removal

(1) Unfasten No. 6 bearing oil scavenge rear tube at elbow, at approximately six o'clock position on rear of turbine exhaust case and nut securing tube to No. 6 bearing oil scavenge intermediate tube; then withdraw tube rearward through shielding tube in exhaust case mount rings and remove tube.

(2) Loosen nut securing No. 6 bearing oil scavenge intermediate tube to No. 6 bearing oil scavenge front tube; then remove intermediate tube.

(3) Remove bolts and nuts securing No. 6 bearing oil scavenge front tube retaining sleeve to fireseal.

(4) Unfasten tube nut securing No. 6 bearing oil scavenge front tube to elbow on left rear of gearbox; then draw tube forward through fireseal, and remove tube. Remove fireseal boss from tube.

(5) Loosen nuts securing No. 4 bearing-to-gearbox oil scavenge tube to elbow in lower left quadrant of diffuser case and to elbow on right front of gearbox and remove tube.

NOTE: This tube cannot be removed until fuel control, fuel pump, and airframe accessories installed on gearbox assembly are removed.

(6) Remove locknuts securing boss of manifold assembly to lower front center connection on gearbox assembly. Disconnect No. 1 bearing oil scavenge rear tube nut from manifold. Remove nuts and bolts securing manifold flange to oil scavenge adapter located at forward 6 o'clock location of intermediate case. Remove manifold.

(7) Remove nuts at No. 1 bearing oil scavenge rear and front tubes then remove No. 1 bearing oil scavenge intermediate tube.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(8) Remove clips securing No. 1 bearing oil scavenge rear tube to clamps on front compressor rear case flange. Remove No. 1 bearing oil scavenge rear tube.

(9) Remove bolts and locknuts securing flange of No. 1 bearing front tube to connection at seven o'clock location on inlet case; then remove clips securing tube to brackets on fan discharge case front flange. Remove tube.

B. Installation

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil scavenge front tube. Position tube to connection at seven o'clock location on inlet case and secure it with locknuts and bolts. Torque bolts. Secure tube clips to brackets on fan discharge case front flange in locations noted at disassembly. Torque clip screws.

(2) Position No. 1 bearing oil scavenge rear tube on right side of front compressor rear case and secure it to clamps on front compressor case rear flange in locations noted at disassembly. If No. 1 bearing oil pressure rear tube is installed, secure scavenge tube to pressure tube with clips in location noted at disassembly. Torque clip screws.

NOTE: If pressure tube is not installed, retaining clips may be installed at time of its assembly.

(3) Position No. 1 bearing oil scavenge intermediate tube to No. 1 bearing oil scavenge front and rear tubes and secure it with nuts. Torque and lockwire nuts.

(4) Coat new packings with engine oil and install them on both ends of compressor intermediate front bearing oil scavenge tube. On gearbox end of tube assembly, install boss flanged end out; then coat new packing with engine oil and install it in groove of boss. On tube connector end of tube assembly, install bushing flanged end in; then coat new packing with engine oil and install it on bushing. Position assembled tube assembly to gearbox assembly connection (lower front center) and to leg of oil tube connector. Secure tube assembly to gearbox with locknuts and to oil tube connector with bolts, washers (under boltheads) and locknuts. Torque bolts and locknuts. Connect nut of No. 1 bearing oil scavenge rear tube to tee connection on tube assembly. Torque and lockwire tube nuts.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(5) Using new packing coated with engine oil, secure compressor rear bearing to gearbox tube elbow to right front of gearbox with bolts. Torque and lockwire bolts.

(6) Using new packing coated with engine oil, position diffuser case elbow facing down to lower left quadrant of diffuser case. Secure elbow with bolts; installing airframe bracket assembly on two longer top bolts. Torque and lockwire bolts.

(7) Coat new packings with engine oil and install them on both ends of No. 4 bearing-to-gearbox oil scavenge tube; then install retainers on both ends. Position tube to elbow in left lower quadrant of diffuser case and to elbow on right front of gearbox assembly. Secure tube with nuts. Torque tube nuts in accordance with Ref. No. 2010, Section 72-00, Engine - Dismantling/Assembly. Lockwire tube nuts.

(8) Install nut, ring and new packing coated with engine oil on No. 6 bearing oil scavenge tube elbow and install elbow in left rear of gearbox. Torque and lockwire nut.

(9) Coat new packing with engine oil; then install it in its groove on ferrule of No. 6 bearing oil scavenge front tube. Place sleeve on tube (flange face forward) and slide it over tube and ferrule. Secure sleeve to fireseal using bolts and locknuts. Torque bolts. Secure tube to elbow on left rear of gearbox with tube nut. Torque and lockwire tube nuts.

(10) Position No. 6 bearing oil scavenge intermediate tube to front tube and secure it with nut. Install clips at turbine nozzle case front flange and turbine exhaust case front flange.

(11) Install No. 6 bearing oil scavenge rear tube forward through shielding tube in exhaust case mount ring and secure tube to intermediate tube with nut; then secure rear of tube to elbow on scavenge pad at approximate six o'clock position on rear of turbine exhaust case. Torque and lockwire tube nuts.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

6. Removal/Installation of Oil Scavenge Tubes (JT3D-7 DSLG)

A. Removal

(1) Unfasten No. 6 bearing oil scavenge rear tube nut securing it to No. 6 bearing oil scavenge intermediate tube; then remove bolts securing flange of tube to scavenge pad at approximate six o'clock position on rear of turbine exhaust case and remove tube.

(2) Remove clip securing No. 6 bearing oil scavenge intermediate tube to front exhaust case mount ring at approximate six o'clock position and clips securing tube to turbine exhaust case front flange and turbine nozzle case front flange. Loosen nut securing No. 6 bearing oil scavenge intermediate tube to No. 6 bearing oil scavenge front tube; then remove intermediate tube.

(3) Remove clip securing No. 6 bearing oil scavenge front tube to bracket in combustion chamber outer front case front flange.

(4) Remove tube nut securing No. 6 bearing oil scavenge front tube to elbow on left rear of gearbox; then draw tube forward through fireseal and remove tube.

(5) Disconnect clip securing No. 4 bearing-to-gearbox oil scavenge tube to clamp on diffuser case front flange (lower left segment).

(6) Loosen nuts securing No. 4 bearing-to-gearbox oil scavenge tube to elbow in lower left quadrant of diffuser case and to elbow on right front of gearbox assembly and remove tube.

NOTE: This tube cannot be removed until fuel control, fuel pump, and airframe accessories installed on gearbox assembly are removed.

(7) Remove locknuts securing boss of manifold assembly to lower front center connection on gearbox assembly. Disconnect No. 1 bearing oil scavenge tube nut from manifold. Remove bolts and nuts securing manifold flange to oil scavenge adapter located at forward six o'clock location of intermediate case. Remove manifold.

(8) Remove clip securing No. 1 bearing oil scavenge tube to front compressor front case rear flange; then remove bolts and locknuts securing flange of No. 1 bearing oil scavenge tube to connection at seven o'clock location of inlet case. Remove tube.

B. Installation

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil scavenge tube. Position tube to connection at seven o'clock location on inlet case and secure it with locknuts and bolts. Torque bolts. Secure tube clip to bracket on rear flange of front compressor case in location noted at disassembly. Torque clip screw.

(2) Coat new packings with engine oil and install them on both ends of manifold assembly. On gearbox end of manifold assembly, install boss flanged end out; then coat new packing with engine oil and install it in groove of boss. On oil adapter assembly end of manifold assembly, install bushing flanged end in; then coat new packing with engine oil and install it on bushing. Position assembled manifold to gearbox assembly connection (lower front center) and to leg of oil adapter assembly. Secure manifold assembly to gearbox assembly with locknuts and to oil adapter assembly with bolts, washers (under boltheads) and locknuts. Torque bolts and locknuts. Connect No. 1 bearing oil scavenge tube to "Y" connection of manifold assembly. Torque and lockwire tube nuts.

(3) Using new gasket coated with engine oil, position diffuser case elbow, facing down, to lower left quadrant of diffuser case. Secure elbow with bolts. Torque and lockwire bolts.

(4) Coat new packings with engine oil and install them on both ends of No. 4 bearing-to-gearbox oil scavenge tube; then install retainers on both ends. Position tube to elbow in left lower quadrant of diffuser case and to elbow on right front of gearbox assembly. Secure tube with nuts. Torque and lockwire nuts.

(5) Install clip securing No. 4 bearing-to-gearbox oil scavenge tube to clamp on diffuser case front flange (lower left segment).

(6) Install seal on sleeve of No. 6 bearing oil scavenge front tube and slide tube rearward through hole in fireseal. Torque bolts. Secure tube to elbow on left rear of gearbox with tube nut. Torque nuts. Install clip securing No. 6 bearing oil scavenge front tube to bracket on combustion chamber outer front case front flange.

(7) Position No. 6 bearing oil scavenge intermediate tube to front tube and secure it with nut. Install clips at turbine nozzle case front flange and turbine exhaust case front flange. Install clip to front exhaust case mount ring at approximate six o'clock position. Secure clips with screws and nuts. Torque tube nut and clip screws. Lockwire tube nut.

(8) Position No. 6 bearing oil scavenge rear tube to intermediate tube and secure it with tube nut; then secure flange of tube to scavenge pad at approximate six o'clock position on rear of turbine exhaust case with bolts. Torque bolts and tube nut. Lockwire tube nut.

7. Removal/Installation of Oil Adapter and Filter-to-Adapter Oil Pressure Tube

A. Removal

(1) Loosen nut securing filter-to-adapter oil pressure tube at oil filter housing; then loosen nut at oil adapter and remove tube.

(2) Remove bolts and locknuts securing oil adapter to intermediate case mount ring.

(3) Remove four internal spacers.

(4) Remove oil adapter.

B. Installation

(1) Coat new packing with engine oil and install it in groove of compressor intermediate bearing oil pressure tube flange in forward six o'clock location of intermediate case.

(2) Coat new packings with engine oil and install them in groove of nipple and outside rim of mating lip of oil adapter.

(3) Position oil adapter to intermediate case inserting nipple in compressor intermediate bearing oil pressure tube and aligning bolt holes of mount rings, filter housing, and adapter.

NOTE: Oil filter housing must be in position prior to installation of oil adapter.

(4) For JT3D-7 BG, install internal spacers (small ID inward) from inside through legs of oil adapter and then through legs of oil filter housing. Secure build-up by inserting bolts through mount rings of intermediate case and installing nuts on inside of legs. Torque bolts.

NOTE: Install bracket under bolt head of rear bolt to support fuel tube clip.

(5) For JT3D-7 BG, position external spacers between remaining legs of oil adapter (left side) and intermediate case mount rings. Install bolts and locknuts in manner previously described.

(6) For JT3D-7 DSLG, install larger internal spacers and bolt and nuts in manner outlined in step (4). Install smaller internal spacers (small ID in) from inside through remaining legs of oil adapter (left side). Install bolts and locknuts in manner previously described.

(7) Install tube nuts on filter-to-adapter oil pressure tube so that threads of nuts are outward at both ends. Install ferrule on plain end; then coat new packing with engine oil and install one on each end. Install retainer in both ends of tube. Position tube (plain end) in connector on filter housing; then install other end in connector of oil adapter. Torque and lockwire nuts.

5. Removal/Installation of Oil Pressure Tubes (JT3D-7 BG)

A. Removal

(1) If installed, remove clip securing thermocouple harness to No. 6 bearing oil pressure rear tube.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(2) Loosen nut securing No. 6 bearing oil pressure rear tube to elbow at three o'clock position on exhaust case and loosen nut on rear end of No. 6 bearing oil pressure intermediate tube; then remove rear tube by withdrawing it rearward from shielding tube located between exhaust case mount rings.

(3) If installed, remove clips securing thermocouple cable bracket at approximate five o'clock location on combustion chamber outer rear case rear flange.

(4) Loosen nut securing No. 6 bearing oil pressure front tube to intermediate tube; then remove No. 6 bearing oil pressure intermediate tube.

(5) Loosen nut securing No. 6 bearing oil pressure front tube to adapter at approximate five o'clock position on diffuser case; then remove tube from sleeve on fireseal by turning it and pulling it forward out of sleeve.

(6) Loosen nuts securing gearbox-to-rear bearings tube at previously mentioned adapter assembly and at manifold assembly mounted on right side of gearbox assembly. Remove tube.

(7) Loosen nut securing manifold assembly to top rear-facing connection on filter housing and remove nuts securing manifold assembly to gearbox assembly. Remove manifold assembly.

(8) Remove clip assembly; then loosen nut securing gearbox-to-oil filter housing tube to bottom rear facing connection on oil filter housing and remove nuts securing tube flange to pressure boss on left front of gearbox assembly. Remove tube.

(9) Loosen nuts securing No. 1 bearing oil pressure intermediate tube to No. 1 bearing oil pressure front and rear tube; then remove No. 1 bearing oil pressure intermediate tube.

(10) Remove clip assemblies securing No. 1 bearing pressure oil rear tube to No. 1 bearing scavenge oil rear tube.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(11) Loosen nut securing No. 1 bearing oil pressure rear tube to top forward-facing connection on oil filter housing and remove tube.

(12) Remove clips securing No. 1 bearing oil pressure front tube to front flange of fan discharge case.

(13) Remove bolts securing flange of No. 1 bearing oil pressure front tube to connection on approximate five o'clock location on inlet case. Remove tube.

B. Installation

(1) Install clips on No. 1 bearing oil pressure front tube in location noted at disassembly.

(2) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil pressure front tube; then secure tube to connector at five o'clock location of inlet case with bolts and locknuts. Torque bolts and locknuts. Secure clips to clamps on front flange of the fan discharge case with screws and nuts. Torque screws and nuts.

(3) Position No. 1 bearing oil pressure rear tube to nipple on top forward face of strainer housing and secure it with tube nut. Torque and lockwire nut.

(4) Fasten clip assemblies securing No. 1 bearing oil pressure rear tube to No. 1 bearing oil scavenge rear tube in locations noted at disassembly.

(5) Position No. 1 bearing oil pressure intermediate tube to front and rear tubes and secure it with tube nuts. Torque and lockwire nuts.

(6) Install new seal coated with engine oil and retainer on ferruled tube end of gearbox-to-oil strainer housing manifold and new seal on flanged end; then position tube to lower rear-facing connection on strainer housing with flanged end on pressure boss on right front of gearbox. Secure flanged end with nuts and other end with tube nut. Tighten flange nuts to recommended torque. Torque tube nut in accordance with Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly and lockwire.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(7) Install plug with new packing in tee on gearbox-to-strainer housing manifold and torque plug.

(8) Install new seal coated with engine oil and retainer on ferruled tube end of strainer-to-gearbox manifold assembly and new seal on flanged end. Position manifold assembly tube end to top rear facing connection on strainer housing and flanged end to boss on right side of gearbox housing. Secure manifold assembly to gearbox assembly with nuts and to filter housing with tube nut. Torque flange nuts. Torque tube nut in accordance with Ref. No. 2009, Section 72-00, Engine - Dismantling/Assembly, and lockwire.

(9) Install clip assembly securing manifold assembly to fuel tube using screw, spacer, and nut. Torque screw.

(10) Using new gasket, install rear bearing oil pressure adapter to pad on diffuser case at approximate five o'clock position with large connection facing down. Install bolts with air•rame bracket on rearmost bolt. Torque and lockwire bolts.

(11) Install tube nuts on plain end of gearbox to rear bearing oil pressure tube so that threads of nuts are positioned outward and then install ferrule on plain end of tube. Install new packings coated with engine oil and retainers on both ends of tube and attach tube assembly to oil filter to gearbox return manifold and large connection of rear bearing oil pressure adapter on diffuser case. Torque tube nuts in accordance with Ref. No. 2010, Section 72-00, Engine - Dismantling/Assembly, and lockwire.

(12) Install new seal coated with engine oil on external ferrule on No. 6 bearing oil pressure front tube; then install tube rearward through sleeve in fireseal and install tube to previously mentioned adapter and secure it with tube nut. Torque and lockwire nut.

(13) Position No. 6 bearing oil pressure intermediate tube to front tube and secure it with tube nut; then install clip assemblies to thermocouple lead. Torque tube nut, clip screws and nuts. Lockwire tube nuts.

(14) Insert No. 6 bearing oil pressure rear tube forward through shield tube in turbine exhaust case mount ring; then secure rear tube to intermediate tube and to elbow at three o'clock position of exhaust case with tube nuts. Torque and lockwire nuts.

(15) Secure thermocouple harness to No. 6 bearing oil pressure rear tube with clip assembly at location noted at disassembly. Using screw and nut, torque clip assembly.

9. Removal/Installation of Oil Pressure Tubes (JT3D-7 DSLG)

A. Removal

(1) If installed, remove clip securing thermocouple harness to No. 6 bearing oil pressure rear tube.

(2) Loosen nut securing No. 6 bearing oil pressure rear tube to elbow at three o'clock position on exhaust case and loosen nut on rear end of No. 6 bearing oil pressure intermediate tube; then remove rear tube by withdrawing it rearward from shielding tube located between exhaust case mount rings.

(3) If installed, remove clips securing thermocouple cable to bracket at approximate five o'clock location on combustion chamber outer rear case rear flange.

(4) Loosen nut securing No. 6 bearing oil pressure front tube to intermediate tube; then remove No. 6 bearing oil pressure intermediate tube.

(5) Loosen nut securing No. 6 bearing oil pressure front tube to adapter at approximate five o'clock position on diffuser case; then remove tube from sleeve on fireseal by turning it and pulling it forward out of sleeve.

(6) Loosen nuts securing gearbox-to-rear bearings tube at previously mentioned adapter assembly and at manifold assembly mounted on right side of gearbox assembly. Remove tube.

(7) Loosen nut securing manifold assembly to top rear-facing connection on filter housing and remove nuts securing manifold assembly to gearbox assembly. Remove manifold assembly.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(8) Remove clip assembly; then loosen nut securing gearbox-to-oil filter housing tube to bottom rear-facing connection on oil filter housing and remove nuts securing tube flange to pressure boss on left front of gearbox assembly. Remove tube.

(9) Remove clip securing No. 1 bearing oil pressure tube to bracket on front compressor case rear flange; then unfasten nut at filter housing connector (elbow) and remove bolts and locknuts securing tube flange to connection at five o'clock location of inlet case. Remove tube.

B. Installation

(1) Coat new packing with engine oil and install it in flanged end of No. 1 bearing oil pressure tube, and coat new packing and retainer with engine oil and install them in rear end of tube. Position No. 1 bearing oil pressure tube to connection at five o'clock location of inlet case and connector (elbow) on filter housing. Secure tube to connector with tube nut and to inlet case connection flange with bolts and locknuts. Torque tube nut and the bolts and locknuts. Lockwire tube nut. Reinstall clip to bracket on front compressor front case rear flange. Torque clip screw and nut.

(2) Install new seal coated with engine oil and retainer on ferruled tube end of gearbox-to-oil strainer housing manifold and new seal on flanged end; then position tube to lower rear-facing connection on filter housing with flanged end on pressure boss on right front of gearbox assembly. Secure flanged end with nuts and other end with tube nut. Torque nuts and tube nut. Lockwire tube nut.

(3) Install plug with new packing in tee on gearbox-to-strainer housing manifold and torque plug.

(4) Install new seal coated with engine oil and retainer on ferruled tube end of oil return manifold assembly and new seal on manifold end. Position manifold assembly tube end to top rear-facing connection on filter housing and manifold end to boss on right side of gearbox housing. Secure manifold assembly to gearbox assembly with nuts and to filter housing with tube nut. Torque nuts and tube nut. Lockwire tube nut.

EXTERNAL OIL TUBES - MAINTENANCE PRACTICES

(5) Install clip assembly securing gearbox-to-filter housing manifold to oil return manifold at location noted at disassembly. Torque screw and nut.

(6) Using new gasket, install rear bearing oil pressure adapter to pad on diffuser case at approximate five o'clock position with large connection facing down. Install bolts. Torque and lockwire bolts.

(7) Install new packings coated with engine oil and retainers on both ends of gearbox-to-rear bearings tube and install tube in large connection on adapter on diffuser case and connection on previously installed manifold. Torque and lockwire tube nuts.

(8) Install new seal coated with engine oil on external ferrule on No. 6 bearing oil pressure front tube; then install tube rearward through sleeve in fireseal and install tube to previously mentioned adapter and secure it with tube nut. Torque and lockwire nut.

(9) Install clip on the No. 6 bearing oil pressure front tube in location noted at disassembly. Secure clip with screw and nut. Torque screw and nut.

(10) Position No. 6 bearing oil pressure intermediate tube to front tube and secure it with tube nut; then install clip to bracket on combustion chamber outer rear case rear flange. Torque tube nut and clip screws and nuts. Lockwire tube nuts.

(11) Insert No. 6 bearing oil pressure rear tube forward through shield tube in turbine exhaust case mount ring; then secure rear tube to intermediate tube and to elbow at three o'clock position of exhaust case with tube nuts. Torque and lockwire nuts.

WATER INJECTION SYSTEM - DESCRIPTION AND OPERATION

General

An optional water injection system is installed on some JT3D-7 BG engines. System functions to increase engine thrust by means of two basic principles. First involves fact that engine thrust is increased with increasing mass air flow. Hence, by spraying water into air stream mass of material flowing through engine is increased and, consequently, thrust is increased. Second principle relates to cooling effect of water injected into engine gas path. Turbo engines are normally limited in their thrust output by fact that further increase of fuel flow would result in hot section temperatures beyond values which parts are capable of withstanding. Since injection of water effectively reduces hot section temperatures, fuel flows may be increased and greater thrusts thereby obtained. Since thrust increase is particularly desirable at take-off when an aircraft engine is called upon for its greatest output of power, water injection system is designed to function only at high engine power.

Engine water injection system injects water into diffuser case. Its contribution to thrust increase depends largely upon cooling principle, which permits higher fuel flow.

Description and Operation

Description and operation of water injection system can most easily be explained by tracing flow of water from tank to its discharge point in engine.

Placement, location, and number of system components may vary with aircraft installation, but generally system will follow same scheme. System is designed for operation at ambient temperatures above 20°F (-7°C).

Water from aircraft tank system is directed to shut-off valve which governs flow to water injection control. This shut-off valve is alerted by actuation of a cockpit switch, and valve opens or closes upon receipt of an electrical signal from fuel control water injection switch. When a power lever advance creates predetermined position, this switch supplies an "open" signal to shut-off valve. Conversely, when position is reduced to below water turn-on point, switch supplies "close" signal to shut-off valve.

WATER INJECTION SYSTEM - DESCRIPTION AND OPERATION

Water from open shut-off valve flows to water injection control. Since water injection system is only used when power settings are at or near their maximum, control does not vary or meter water flow. Instead it maintains constant pressure head across fixed orifice, thereby maintaining constant water flow to engine.

Water from control passes through a check valve and is then directed to split manifold from which it is sprayed into diffuser case. When water injection system is not in use, check valve prevents high temperature compressor discharge air from backing up into water injection system plumbing where it might damage controls or valves. Drain valve located downstream of water shut-off valve drains engine water lines when injection system is turned off, thus preventing water from freezing in these lines.

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WATER INJECTION SYSTEM - MAINTENANCE PRACTICES

1. Removal/Installation of Water Injection Tubing (Optional JT3D-7 BG)

NOTE: Tag or note location of all clamps and clips to assure their reinstallation in same position at assembly.

A. Removal

(1) Remove clips securing upper and lower signal tubes on right side of diffuser case.

(2) Loosen nuts securing tubes to each other, to connector on water injection adapter and to connection on fuel control. Remove tube.

(3) Loosen nuts; then remove control-to-check valve supply tube.

(4) Disconnect water injection check valve and attached manifold connector from right and left water injection manifold assemblies.

(5) Remove nuts securing clamps to right and left water injection manifold assemblies.

(6) Disconnect water injection manifold tube assemblies from right and left manifold assemblies and remove manifolds.

(7) Note location of curled water injection tube assemblies; then remove bolts securing tube assemblies to pads on diffuser case and remove brackets, tube assemblies, and gaskets.

B. Installation

(1) Place gaskets on pads on diffuser case; then position curled water injection tube assemblies on pads. Install brackets in locations noted at disassembly; then secure tube assemblies and brackets with bolts. Torque and lockwire bolts.

NOTE: Make certain tube assemblies are installed in their proper locations as noted at disassembly.

(2) Install right and left manifold assemblies by securing them to tube assemblies. Torque and lockwire nuts.

(3) Position clamps in locations noted at disassembly and secure them to brackets with nuts. Torque and lockwire nuts.

(4) Place water injection check valve and attached connector in position; then secure nuts of right and left manifold to connector. Tighten nuts to recommended torque.

(5) Insert new seal and retainer in control end of control-to-valve supply tube; then position tube between connection on check valve and connector on water injection control. Torque and lockwire nuts.

(6) Connect upper water injection signal tube to connector on water injection control and lower tube to tee-elbow on fuel control. Connect upper tube to lower tube. Torque and lockwire nuts.

(7) Install clip assemblies to signal tube at locations noted at disassembly.

2. Preservation of Water Injection System

A. Procedure

(1) Attach source of heated dehydrated air to water inlet pad. Actuate water shut-off valve to open position.

(2) Allow heated air at temperature not to exceed 250°F (121°C) to blow through system for minimum of ten minutes.

(3) On completion of procedure, return shut-off valve to closed position.

WATER INJECTION CONTROL - DESCRIPTION AND OPERATION

General

Water injection control consists of a housing and cap. Housing encloses sleeve valve and its liner, and cap encloses spring and its adjusting screw parts. Control is designed to meter constant water flow to water injection manifold. This is accomplished by means of pressure differential exerted on spring-loaded diaphragm which in turn actuates a perforated sleeve valve that regulates amount of water flow to manifold.

WATER INJECTION CONTROL - MAINTENANCE PRACTICES

1. Removal/Installation of Water Injection Control

A. Removal

(1) Disconnect signal, water supply, control-to-check valve and drain valve tubes from water injection control.

(2) Remove bolts securing control to support assembly and remove control.

B. Installation

(1) Secure control to support assembly with four bolts and washers. Tighten and lockwire bolts.

(2) Connect signal tube and control-to-check valve tube to water injection control. Tighten and lockwire nuts.

(3) Connect airframe water supply and drain valve tubes.

WATER PRESSURE SENSING DRAIN VALVES - DESCRIPTION AND OPERATION

Description

Water pressure sensing drain valve is composed of valve body, spring, valve or cone, retainer or cap, and "O" ring seals. Valve or cone is spring-loaded to open position.

Operation

There are two water pressure sensing drain valves in engine water injection system. One is mounted on fuel control and other is attached to water injection control. These valves are normally open under spring pressure. When water injection is turned on, water pressure overcomes spring pressure and closes valve. When water is turned off, valve opens to permit drainage of fluid from system. All surplus water remaining in system after take-off must be drained to prevent damage to system components due to freezing.

WATER INJECTION CHECK VALVE - DESCRIPTION AND OPERATION

Description

Water injection check valve is composed of a body, valve, spring, and appropriate gasket, seals, and connectors.

Operation

Water injection check valve is installed in water supply line between water injection control and water injection manifold. Valve is spring-loaded to closed position, and is open only during periods of water injection system operation. Purpose of this valve is to prevent high temperature compressor discharge air from backing up into water injection system tubing and damaging controls or valves.

WATER INJECTION CHECK VALVE - MAINTENANCE PRACTICES

1. Removal/Installation of Water Injection Check Valve

A. Removal

(1) Loosen two nuts securing check valve connector to manifold halves.

(2) Disconnect control-to-check valve tube from check valve by loosening nut.

(3) Remove check valve and connector as an assembly.

B. Installation

(1) Position check valve and connector assembly on manifold halves and tighten and lockwire nuts.

(2) Tighten and lockwire nut on control-to-check valve tube to check valve body.

WATER PRESSURE SENSING DRAIN VALVES - MAINTENANCE PRACTICES

1. Removal/Installation of Water Pressure Sensing Drain Valves

A. Removal

(1) Disconnect airframe drain tube from valve mounted at water injection control. Loosen and remove drain valve from elbow on control.

(2) Disconnect airframe drain tube from valve mounted on connector at fuel control. Loosen and remove drain valve from connector.

B. Installation

(1) With arrow pointing down, install drain valve and new seal on elbow at water injection control. Tighten valve and lockwire. Connect airframe drain tube to valve.

(2) With arrow pointing away from connector, install valve and new seal on connector at fuel control. Tighten valve and lockwire. Connect airframe drain tube to valve.

WATER INJECTION CONTROL STRAINER HOUSING - DESCRIPTION

General

Water injection inlet connector consists of a housing, and inlet screen and appropriate seals. This connector serves as connecting point for aircraft water supply line to water injection control.