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NAVAIR 02B-60A-3

## Handbook Overhaul Instructions

*MODELS T50-B0-4 AND T50-B0-8A*

**GAS-TURBINE ENGINE**

PART NO'S. 45-2240 and 45-3340-1

(Boeing)

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## TABLE OF CONTENTS

Section		Page
I	INTRODUCTION . . . . .	1/2
	1-1. General . . . . .	1/2
	1-4. Directional References . . . . .	1/2
II	GENERAL DESCRIPTION . . . . .	3
	2-1. Engine Functional Description . . . . .	3
	2-7. Operational Pressures and Temperatures . . . . .	3
	2-8. Gas Producer Section . . . . .	3
	2-13. Power Output Section . . . . .	5
	2-16. Fuel System . . . . .	5
	2-17. Engine Driven Boost Pump . . . . .	5
	2-18. Fuel Filter . . . . .	5
	2-19. Fuel Control Unit . . . . .	11
	2-22. Output Section Governor . . . . .	11
	2-23. Fuel Shutoff Valve . . . . .	11
	2-24. Fuel Nozzles . . . . .	11
	2-25. Lubrication System . . . . .	11
	2-26. Sumps . . . . .	11
	2-27. Lubrication System Pumps . . . . .	11
	2-28. Oil Filter . . . . .	11
	2-29. Oil Strainers . . . . .	11
	2-30. Pressure Relief Valve . . . . .	15
	2-31. Oil Cooler . . . . .	15
	2-32. Lubrication Oil Drains . . . . .	15
	2-33. Electrical System . . . . .	15
	2-36. Starter Relay . . . . .	15
	2-37. Ignition Relay . . . . .	15
	2-38. Ignition Exciter . . . . .	15
	2-39. Igniter Plugs . . . . .	15
	2-40. Starter Generator . . . . .	15
	2-41. Electrical System Junction Box . . . . .	15
	2-42. Speed Monitor . . . . .	15
	2-43. Exhaust Gas Temperature Circuit . . . . .	15
III	SPECIAL OVERHAUL TOOLS . . . . .	19
	3-1. General . . . . .	19
	3-2. Standard Tools . . . . .	19
	3-3. Handling Precautions . . . . .	19
IV	REMOVAL AND DISASSEMBLY . . . . .	29
	4-1. General . . . . .	29
	4-2. Precautions . . . . .	29
	4-3. Unpacking . . . . .	29
	4-4. Oil Cooler and Eductor . . . . .	29
	4-5. Output Section Governor and Control Linkage . . . . .	29
	4-6. Burner Section . . . . .	33
	4-7. Fuel System . . . . .	33
	4-8. Electrical System . . . . .	35
	4-9. Lubrication System . . . . .	36
	4-10. Engine Disassembly into Subassemblies . . . . .	39
	4-11. Gas Producer Section . . . . .	39
	4-12. Compressor Section . . . . .	44
	4-13. Accessories Section . . . . .	44
	4-14. Rotor Housing and Sump Section . . . . .	47
	4-15. Reduction Unit . . . . .	47

## TABLE OF CONTENTS (Continued)

Section		Page
V	CLEANING . . . . .	57
	5-2. Processes . . . . .	57
	5-3. Vapor Degreasing . . . . .	57
	5-4. Vapor Blast . . . . .	57
	5-5. Solvent Bath . . . . .	57
	5-6. Lacquer Thinner Bath . . . . .	57
	5-7. Alcohol Solvent Wash . . . . .	57
	5-8. Corrosion Prevention . . . . .	57
	5-9. Procedures . . . . .	57
	5-10. Aluminum Casting . . . . .	57
	5-11. Steel Parts . . . . .	58
	5-12. Engine Assembly . . . . .	58
	5-13. Gas Producer Section . . . . .	58
	5-14. Compressor Section . . . . .	58
	5-15. Burner Section . . . . .	58
	5-16. Accessories Section . . . . .	59/60
	5-17. Rotor Housing and Sump Section . . . . .	59/60
	5-18. Reduction Unit . . . . .	59/60
VI	INSPECTION, REPAIR AND REPLACEMENT . . . . .	61
	6-1. Definitions . . . . .	61
	6-2. Visual Inspection . . . . .	61
	6-3. Inspection Table . . . . .	61
	6-4. Inducer and Impeller . . . . .	61
	6-5. Inducer Blade Sharpening . . . . .	67
	6-6. Nozzle Ring . . . . .	67
	6-7. Burner Shell . . . . .	70
	6-8. Burner Dome . . . . .	70
	6-9. Burner Liner . . . . .	70
	6-10. Crossfire Tube and Elbows . . . . .	70
	6-11. Nozzle Box . . . . .	70
	6-12. Exhaust Collector . . . . .	72
	6-13. Eductor Assembly . . . . .	77
	6-14. Inner Cone . . . . .	77
	6-15. Gas Producer Wheel and Shaft Assembly . . . . .	77
	6-16. Gas Producer Turbine Wheel Minimum Diameter . . . . .	77
	6-17. Output Section Wheel and Shaft Assembly . . . . .	79
	6-18. Output Section Turbine Wheel Minimum Diameter . . . . .	79
	6-19. Wheel Hub . . . . .	79
	6-20. Turbine Blade Repair . . . . .	79
	6-21. Turbine Blade Replacement . . . . .	79
	6-22. Wheel and Shaft Balancing . . . . .	81
	6-23. Bearings . . . . .	81
	6-24. Bearing Failure . . . . .	82
	6-25. Bearing Caps . . . . .	82
	6-26. Bearing Retainers . . . . .	82
	6-27. Segmented Thrust Bearing . . . . .	82
	6-28. Gears . . . . .	82
	6-29. Cluster Gear Bearings . . . . .	82
	6-30. Cluster Gear Shaft . . . . .	82
	6-31. Planet Pinions and Planet Gears . . . . .	82
	6-32. Tachometer Gear Bushing . . . . .	82
	6-33. Oil Pump Drive Bracket . . . . .	82
	6-34. Oil Slinger and Sleeve . . . . .	83
	6-35. Oil Filter Element . . . . .	83
	6-36. Oil Filter Guide Assembly . . . . .	83
	6-37. Oil Dipstick Tube . . . . .	83
	6-38. Oil Seals . . . . .	83
	6-39. Oil Filler Cap . . . . .	84
	6-40. Retainer Nut . . . . .	84
	6-41. Cast Aluminum Parts Inspection and Repair . . . . .	84

## TABLE OF CONTENTS (Continued)

Section		Page
	6-42. Removal of Rosan Inserts . . . . .	84
	6-43. Removal of Rosan Two-Piece Studs . . . . .	84
	6-44. Installation of Rosan Inserts and Studs . . . . .	84
	6-45. Removal of Heli-Coil Inserts . . . . .	84
	6-46. Installation of Heli-Coil Inserts . . . . .	84
	6-47. Engine Wiring Harness . . . . .	84
	6-48. Fuel and Lubrication Systems Flexible Hoses Pressure Testing . . . . .	84
	6-49. Nozzle Box and Nozzle Ring Flow Test . . . . .	84A
	6-50. Gas Producer Turbine Shaft Dry Lubricant Application . . . . .	84E
	6-51. Gas Producer Turbine Shaft Hard Chrome Plating . . . . .	84G
	6-52. Output Turbine Shaft Hard Chrome Plating . . . . .	84G
VII	ASSEMBLY OF SUBASSEMBLIES . . . . .	85
	7-1. Precautions and Procedures . . . . .	85
	7-2. Reduction Unit . . . . .	85
	7-3. Rotor Housing and Sump Section . . . . .	89
	7-4. Accessories Section . . . . .	89
	7-5. Burner Section . . . . .	91
	7-6. Compressor Section . . . . .	91
	7-7. Gas Producer Section . . . . .	92
VIII	FINAL ASSEMBLY AND INSTALLATION . . . . .	97
	8-1. Engine Assembly . . . . .	97
	8-2. Lubrication System . . . . .	98
	8-3. Electrical System . . . . .	98
	8-4. Fuel System . . . . .	99
	8-5. Burner Section . . . . .	99
	8-6. Oil Cooler and Eductor . . . . .	100
	8-7. Output Section Governor and Control Linkage . . . . .	101
	8-8. Output Section Governor Control Linkage Adjustment . . . . .	101
IX	TESTING AFTER OVERHAUL . . . . .	105
	9-1. Engine Specifications . . . . .	105
	9-2. Operating Limits . . . . .	105
	9-3. Preoiling . . . . .	105
	9-4. Test Cell Installation . . . . .	105
	9-5. Engine Instrumentation . . . . .	106
	9-6. Engine Test . . . . .	106
	9-7. Test Data . . . . .	106
	9-8. Prestart Checks . . . . .	106
	9-9. Starting Precautions . . . . .	106
	9-10. Starting Procedure . . . . .	106
	9-11. Idle Speed Checks . . . . .	106
	9-12. Fuel Control Unit Checks . . . . .	106
	9-13. Test Run - Part A . . . . .	111
	9-14. Performance Acceptability . . . . .	111
	9-15. Test Run - Part B . . . . .	112
	9-16. Power Limiter Check . . . . .	114
	9-17. Power Control System Check Run . . . . .	114
	9-18. Final Engine Checks . . . . .	114
	9-19. Engine Log Book Entries . . . . .	114
	9-20. Preservation . . . . .	120
	9-21. Packing Engine for Shipment . . . . .	120
X	ACCESSORIES . . . . .	
	10-1. General . . . . .	125
	10-2. Gas Producer Lubrication and Scavenge Pump . . . . .	125
	10-3. Fuel Filter . . . . .	125
	10-4. Oil Pressure Switch . . . . .	126
	10-5. Accessory Drive Gear Box . . . . .	127

TABLE OF CONTENTS (Continued)

Section		Page
XI	TABLES OF LIMITS . . . . .	131
	11-1. General . . . . .	131
	11-2. Definitions . . . . .	131
	11-3. Engine Clearances . . . . .	131
	11-4. Torque Limits . . . . .	131

LIST OF ILLUSTRATIONS

Figure		Page
1-1	Major Engine Sections . . . . .	1/2
2-1	Engine Components . . . . .	4
2-2	Engine Cross Section . . . . .	6
2-3	Pressure-Temperature Air Cycle and Gas Flow Diagram . . . . .	9
2-4	Fuel Flow Diagram . . . . .	10
2-5	Fuel Control Unit . . . . .	12
2-6	Output Section Governor . . . . .	13
2-7	Lubrication System Schematic . . . . .	14
2-8	Electrical Wiring Diagram . . . . .	16
2-9	Igniter Plug, Cutaway View . . . . .	17
3-1	Nozzle Pressure Test Clamps . . . . .	21
3-2	Exhaust Gas Temperature Analyzer . . . . .	21
3-3	Universal Pressure Indicator . . . . .	21
3-4	Nozzle Ring and Nozzle Box Gage Set . . . . .	22
3-5	Engine Lifting Sling . . . . .	23
3-6	Engine Assembly Stand . . . . .	24
3-7	Output Wheel Balancing Fixture . . . . .	24
3-8	Gas Producer Wheel Balancing Fixture . . . . .	25
3-9	Turbine Wheel Cover (Typical) . . . . .	25
3-10	Impeller, Inducer and Anti-Icing Spinner Balancing Arbor . . . . .	26
3-11	Engine Handling Dolly . . . . .	26
4-1	Shipping Container . . . . .	30
4-2	Oil Cooler and Eductor Installation, Exploded View . . . . .	31
4-3	Output Section Governor and Control Linkage Installation, Exploded View . . . . .	32
4-4	Burner Section Installation, Exploded View . . . . .	34
4-5	Burner Section Removal . . . . .	35
4-6	Use of Burner Dome Wrench . . . . .	36
4-7	Fuel System Installation, Exploded View . . . . .	37
4-8	Electrical System Installation, Exploded View . . . . .	40
4-9	Lubrication System Installation, Exploded View . . . . .	42
4-10	Engine Subassemblies, Exploded View . . . . .	43
4-11	Separating Output Section and Gas Producer Section . . . . .	44
4-12	Gas Producer Section, Exploded View . . . . .	45
4-13	Removing and Installing Inducer Nut and Checknut . . . . .	47
4-14	Blade Position Numbering on Turbine Wheel Hub . . . . .	47
4-15	Compressor Section, Exploded View . . . . .	48
4-16	Accessories Section, Exploded View . . . . .	49
4-17	Removing Gas Producer Lubrication Pump . . . . .	50
4-18	Rotor Housing and Sump, Exploded View . . . . .	51
4-19	Reduction Unit, Exploded View . . . . .	53
4-20	Removing Planet Pinion Gears from Shafts . . . . .	56
6-1	Inducer Inspection . . . . .	66
6-2	Balancing Impeller and Anti-Icing Spinner . . . . .	67
6-3	Inducer Leading Edge Sharpening . . . . .	68
6-4	Nozzle Ring Inspection . . . . .	69
6-5	Gaging and Setting Nozzle Ring and Nozzle Box Vanes . . . . .	70
6-6	Burner Shell Inspection . . . . .	71
6-7	Burner Dome and Burner Liner Inspection . . . . .	71
6-8	Nozzle Box Inspection . . . . .	73
6-9	Exhaust Collector Inspection . . . . .	75
6-10	Exhaust Collector Weld Repair . . . . .	76

## LIST OF ILLUSTRATIONS (Continued)

Section		Page
6-11	Typical Eductor Assembly Crack Repair . . . . .	78
6-12	Inner Cone Weld Repair . . . . .	79
6-13	Wheel Hub Hardness Check . . . . .	80
6-14	Turbine Wheel Clip Installation . . . . .	81
6-15	Balance Grind Limits . . . . .	81
6-16	Oil Dipstick Tube Installation . . . . .	83
6-17	Nozzle Box and Nozzle Ring Flow Test Rig . . . . .	84B
6-18	Nozzle Box and Nozzle Ring Test Setup . . . . .	84C/84D
6-19	Nozzle Vane Bending . . . . .	84E
6-20	Gas Producer Turbine Shaft Dry Lubricant Application . . . . .	84F
6-21	Gas Producer Turbine Shaft Hard Chrome Plating . . . . .	84H
6-22	Output Turbine Shaft Hard Chrome Plating . . . . .	84I
7-1	Checking Reduction Unit Oil Spray Jet Dimension and Alignment . . . . .	86
7-2	Installing Planet Pinion Gears and Checking Displacement . . . . .	87
7-3	Lockwiring Exhaust Collector Insulation Blankets . . . . .	88
7-4	Checking Output Section Bearing Cap to Exhaust Collector Inner Cone Clearance . . . . .	90
7-5	Checking Lube Pump Bevel Gear Backlash . . . . .	90
7-6	Alignment of Burner Shell and Burner Liner Ports . . . . .	91
7-7	Cluster Gear Shaft and End Plate Alignment . . . . .	93
7-8	Checking Gas Producer Turbine Blade Trailing Edge to Nozzle Box Shroud Clearance . . . . .	93
7-9	Checking Rotor Runout . . . . .	94
7-10	Checking Gas Producer Turbine Blade Radial Clearance . . . . .	94
7-11	Checking Impeller to Compressor Case Clearance . . . . .	95
8-1	Checking Output Turbine Axial Clearance . . . . .	97
8-2	Governor Control Linkage Adjustment . . . . .	102
8-3	Checking Governor Control Linkage Torque . . . . .	103
9-1	Engine Test Data Chart . . . . .	107
9-2	Acceptance Test Schematic . . . . .	109
9-3	Maximum Allowable Exhaust Gas Temperature . . . . .	113
9-4	Torque vs. Inlet Air Temperature . . . . .	115
9-5	Differential Fuel Flow vs. Inlet Air Temperature . . . . .	117
9-6	Specific Fuel Consumption vs. Corrected Fuel Flow . . . . .	119
9-7	Differential Exhaust Gas Temperature vs. Inlet Air Temperature . . . . .	121
9-8	Gas Producer Speed Conversion - RPM to Percent . . . . .	123
10-1	Lubrication and Scavenge Pump . . . . .	126
10-2	Fuel Filter, Exploded View . . . . .	127
10-2A	Oil Pressure Switch Functional Test Schematic . . . . .	127
10-3	Accessory Drive Gearbox, Exploded View . . . . .	128
11-1	Engine Limits and Clearances . . . . .	133

## LIST OF TABLES

Table		Page
I	Functional Tool List . . . . .	19
II	Numerical List of Special Tools . . . . .	27
III	Inspection Requirements . . . . .	62
IIIA	Nozzle Box and Nozzle Ring Calibration Requirements . . . . .	84E
IV	Engine Specifications . . . . .	105
V	Acceptance Test Instrumentation . . . . .	110
VI	Operating Limits . . . . .	111
VII	Fuel Control Unit Regulated Test Run . . . . .	112
VIII	Engine Clearances . . . . .	131
IX	Torque Limits . . . . .	132

## SECTION I

## INTRODUCTION

1-1. GENERAL. This publication comprises the overhaul instructions for the Model T50-BO-4 and T50-BO-8A engines manufactured by The Boeing Company, P.O. Box 3955, Seattle, Washington, 98124.

1-2. Frequent reference is made to the Table of Limits, Section XI, and the Inspection Requirements Table, Section VI. Use of these tables for all operations involving measurement or use of gages.

1-3. Major engine sections are illustrated and identified in figure 1-1.

1-4. DIRECTIONAL REFERENCES. Right and left, clockwise and counterclockwise, upper and lower, and similar directional references apply to the engine as viewed from the rear (gas producer compressor air inlet) with the engine in a horizontal position and with the oil sump at the bottom of the engine.

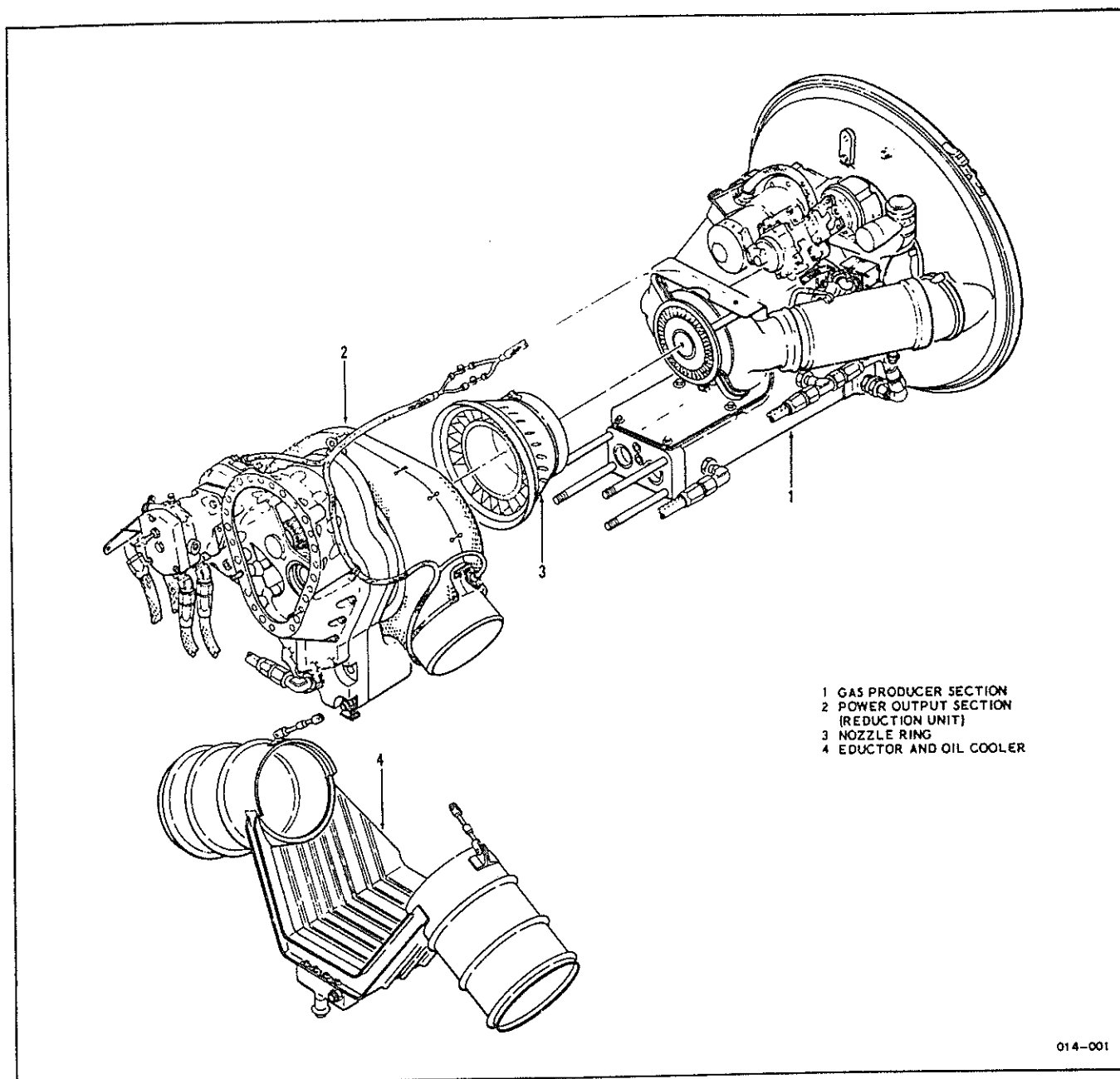


Figure 1-1. Major Engine Sections

## SECTION II

## GENERAL DESCRIPTION

2-1. **ENGINE FUNCTIONAL DESCRIPTION.** (See figures 2-1 and 2-2.) The Model T50-BO-4 and T50-BO-8A are lightweight free-shaft gas-turbine engines. The engines are manufactured primarily of aluminum and stainless steel, and have a dry weight of 334 pounds. Engine Specifications are listed in Table IV. Each engine consists of two basic sections: the gas producer section, and the power output section. Rotor speeds vary independently as required by the applied load because there is no mechanical coupling between the two rotors. The gas producer section uses part of the produced energy to maintain the operating cycle. The power output section converts the remaining energy into work through a system of reduction gears.

2-2. (See figure 2-3.) The operating air supply is drawn into the engine by the inducer, flows into the impeller, and is accelerated to near-sonic velocity. The impeller forces the air through the diffuser passages where most of the air velocity energy is converted to pressure energy as the air is slowed and collected in the compressor case plenum. The compressed air then flows into the two combustion chambers where fuel is injected and mixed with air for combustion. During the starting cycle, the fuel-air mixture is ignited by a combination sparking and glow coil igniter plug. After the starting cycle, combustion is self-sustaining as long as the correct amount of fuel and air continues to enter the chamber.

2-3. Approximately 25 percent of the compressed air supply is used for combustion. The remaining 75 percent is used for cooling, entering through slots and holes in the burner liner to form cooling air layers over the inside of the burner liner and between the liner and the burner outer shell.

2-4. The cooling air protects the burner liner and outer shell from high combustion temperatures and reduces the temperature of the hot gas to design temperature in the nozzle box. The hot gas stream passes through the fixed vanes of the nozzle box and is directed into the turbine wheel to power the gas producer rotor. The hot gas flow then passes through the nozzle ring duct where a second set of fixed vanes directs it into the output section turbine wheel. After powering the output section turbine wheel, the gasses are exhausted through the exhaust collector.

2-5. The exhaust collector directs the gasses through the eductor and exhaust stacks. The eductor functions as an aspirator, drawing cooling air through the oil cooler.

2-6. The fixed vanes, or stator blades, that direct the flow of the hot gas onto the turbine wheels are factory set to produce rated horsepower within allowable speed and exhaust gas temperature limits. The output turbine wheel and shaft assembly are driven by hot gas from the gas producer. A pinion gear machined on the shaft provides the first stage in gear reduction.

It drives three planet gears. The three planet gears are mounted on common shafts with the pinion planet gears. The pinion planet gears drive the output drive gear which is the last stage of gear reduction. The output drive gear is integral with the internally-splined output shaft.

2-7. **OPERATIONAL PRESSURES AND TEMPERATURES.** The gas turbine engine builds up energy through compression and combustion, then expends this energy for making itself operate and for usable power. The pressure and temperature figures are averages based on a standard day (16°C (60°F) ambient temperature and a barometric pressure of 29.92 inches of mercury). Air entering the inlet bell is compressed by the centrifugal compressor. There is an average pressure rise from 0 PSIG to 53.3 PSIG, and an average temperature rise from 16°C (60°F) ambient to 232°C (450°F). As the air flows through the burners, a pressure drop of approximately 2.0 PSIG occurs, producing an average pressure ahead of the stator blades of 51.4 PSIG. Fuel is ignited in the burners. Flame temperature in the burner core is approximately 1927°C (3500°F). Air is expended very rapidly in the liners due to the temperature rise resulting from combustion of fuel. The temperature of the air is decreased to 899°C (1650°F) by combining with the cooling air before reaching the stator blades in the nozzle box. As the high-velocity expanded gas passes through the gas-producer turbine wheel, energy is absorbed, the pressure drops to approximately 12.3 PSIG, and the temperature drops to approximately 743°C (1370°F). The output-turbine wheel then absorbs more energy, dropping the pressure to approximately 0.5 PSIG and the exhaust temperature to approximately 638°C (1180°F). Positive pressure in the exhaust collector ensures proper operation of the eductor for cooling engine oil.

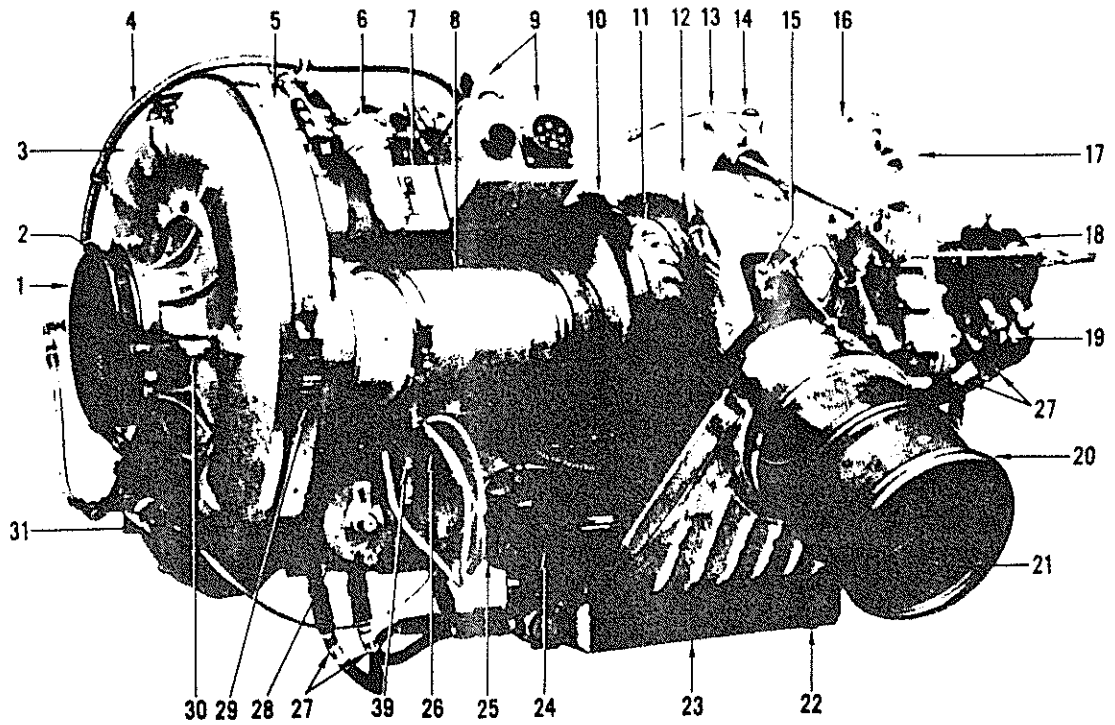
2-8. **GAS PRODUCER SECTION.** The gas producer section consists of a single-stage, single-entry centrifugal compressor directly coupled to a single-stage, axial-flow turbine wheel; two through-flow type combustion chambers; a nozzle box; an accessory drive section; and a rotor housing and sump.

2-9. The gas producer rotor consists of a turbine wheel and shaft upon which is mounted a pinion gear, a bearing sleeve, an oil slinger, an impeller, an inducer, a retaining nut, and a check nut. The rotor assembly is supported by two floating sleeve-type bearings, one floating radial bearing, and one floating segmented thrust bearing assembly.

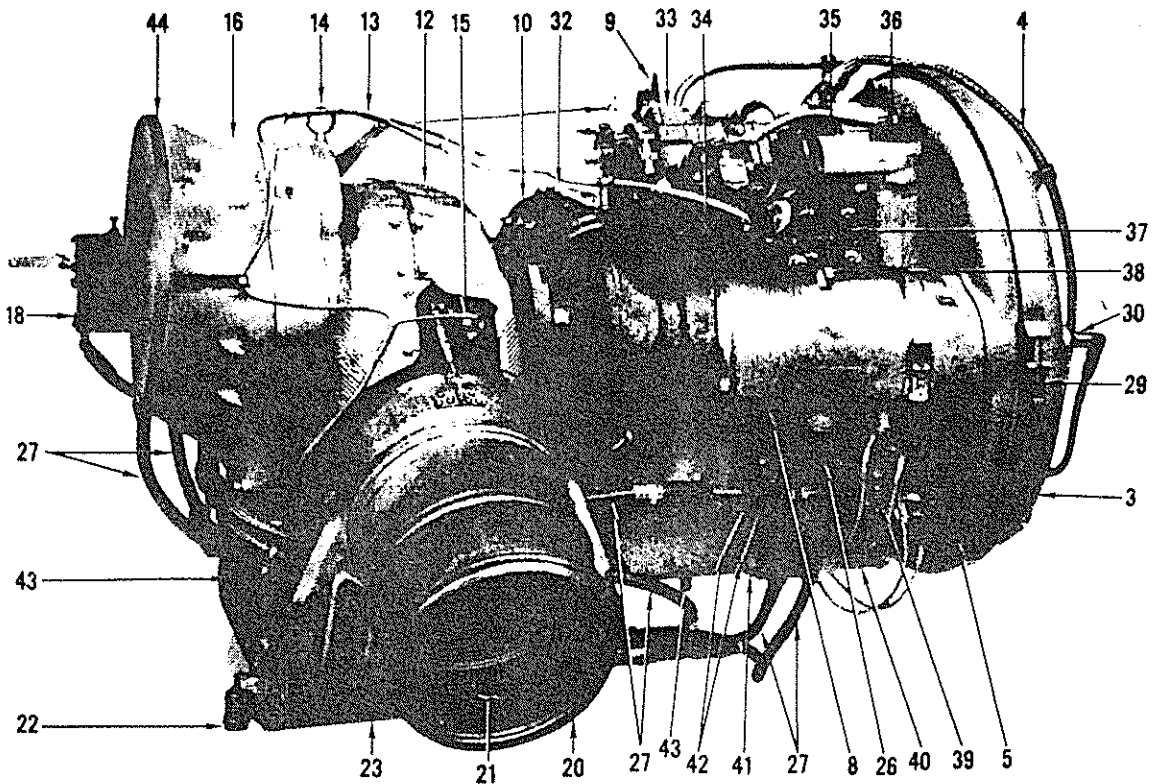
2-10. An enclosure for the rotor is formed by the rotor housing, the accessories drive housing, and accessories housing end plate. The impeller-inducer portion of the rotor is enclosed by the diffuser. The turbine portion of the rotor is enclosed by the nozzle box.

2-11. The diffuser encircles the inducer-impeller. There are eight passages in the diffuser, each with a





RIGHT SIDE VIEW



LEFT SIDE VIEW

Figure 2-1. Engine Components



## KEY TO FIGURE 2-1

1 Air Inlet Screen	15 Exhaust Gas Temperature Thermocouple (4)	30 Burner Fuel Inlet Bolt (2)
2 Compressor Air Intake Bell	16 Power Output Section	31 Fuel Shutoff Valve
3 Rear Compressor Housing	17 Mounting Flange Cover Plate	32 Heat Shield
4 Fuel Line	18 Output Section Governor	33 Fuel Control Unit
5 Front Compressor Housing	19 Output Section Lubrication Pump	34 Fuel Boost Pump
6 Low Pressure Fuel Filter	20 Educator	35 Breather
7 Starter-Generator	21 Exhaust Outlet (2)	36 Oil Filler Cap
8 Burner (2)	22 Oil Cooler Drain	37 Speed Monitor
9 Junction Box and Wiring Harness	23 Oil Cooler	38 Oil Dipstick
10 Nozzle Box	24 Ignition Exciter	39 Igniter Plug (2)
11 Nozzle Ring	25 Oil Sump Drain Plug	40 Gas Producer Section Lubrication Pump
12 Exhaust Collector	26 Crossfire Tube Elbow	41 Oil Sump
13 Exhaust Gas Temperature Thermocouple Harness	27 Oil Line (7)	42 Drain Tube (2)
14 Lifting Eye	28 Oil Filter	43 Magnetic Chip Detector (2)
	29 Compressor Case Clamp	44 Output Section Flange

plate mounted off the discharge end. The compressor case encloses the diffuser. Directly behind the diffuser and compressor is the accessories drive section, which houses the gear train for driving gas producer accessories. This gear train is driven by the pinion on the rotor shaft. It powers the gas producer lubrication pump, fuel control unit, and starter-generator. It also powers the fuel boost pump and speed monitor through an accessory drive gear box. The combination rotor housing and sump is at the center of the gas producer. Its upper portion houses the rotor; its lower portion is a lubrication system sump. Attached to the front of the rotor housing is the nozzle box. It contains a ring of fixed vanes in its nozzle diaphragm to direct the gas flow into the gas producer turbine wheel. The nozzle ring is an interstage duct with a set of fixed vanes to direct the gas flow into the power output section turbine wheel. The nozzle ring is clamped to the gas producer section and pilots in the output section. Four studs in the sump housing provide mounting for the output section. There are also two dowels between the mating surfaces to sustain shear loads.

2-12. A double outlet exhaust collector is attached between the output section and gas producer section. The outlets are located one on each side, pointing 25 degrees downward from the horizontal centerline. The educator is attached to the exhaust collector outlets and to the rotor housing and sump. The oil cooler is attached to the bottom of the educator.

2-13. POWER OUTPUT SECTION. The power output section comprises a rotor consisting of an axial-flow single-stage turbine, reduction gearing, accessory drive gearing, and an internally splined output gear.

2-14. The output section rotor consists of a turbine wheel and shaft assembly. Its turbine end is supported by a floating, sleeve-type bearing and a floating, segmented slipper thrust bearing. Its shaft end is supported in the output shaft by a floating sleeve bearing. The output shaft is supported in the housing by sleeve-type bearings. A triple countershaft, double reduction

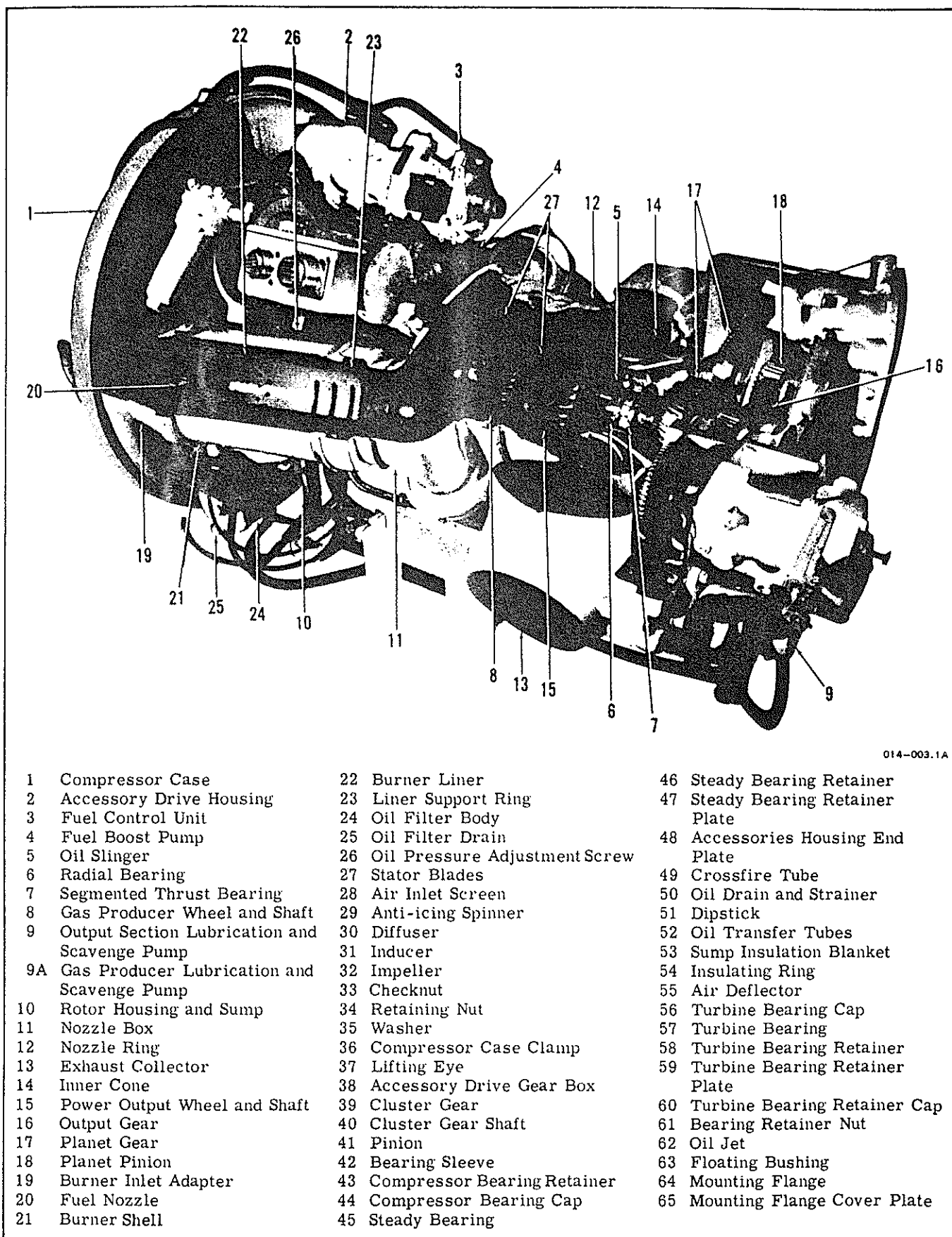
gear train reduces the turbine shaft speed to output shaft speed. The output gear has an internally-splined coupling end. The reduction ratio is 4.77:1.

2-15. An accessory drive gear train driven by the reduction gearing powers the output section lubrication pump and output section governor.

2-16. FUEL SYSTEM. The engine fuel system (see figure 2-4) consists of an engine-driven boost pump, a filter, a fuel control unit modulated by a power output section governor, an electrical fuel shutoff valve, two fuel nozzles, and all necessary fuel lines and fittings. The fuel control system is designed to supply the correct amount of fuel through all operating conditions required by the load power demand, and to maintain constant power output section speed.

2-17. ENGINE-DRIVEN BOOST PUMP. The fuel boost pump (4, figure 2-2), driven by the gas producer, is a positive-displacement, rotary-vane type pump which supplies fuel under pressure through the engine-mounted filter to the high-pressure pump. A balanced, adjustable relief valve mechanism, integral with the pump, provides constant discharge pressure at normal flow and speed requirements. A bypass valve is also incorporated to allow fuel to flow through the pump without appreciable pressure drop if the pump becomes inoperative. In the event of excessive pump overload, a drive pin is sheared, disengaging the pumping mechanism and preventing damage to the pump and engine accessory drive.

2-18. FUEL FILTER. Fuel discharged from the boost pump passes through the low-pressure fuel filter (6, figure 2-1) to the fuel control unit. The filter contains an expendable 10-micron paper element and a relief valve for bypassing fuel if the system is operated with a clogged filter element and differential pressure exceeds  $11 \pm 1$  PSIG. The case can be unscrewed, permitting removal and replacement of the filter element without disturbing fuel line connections.

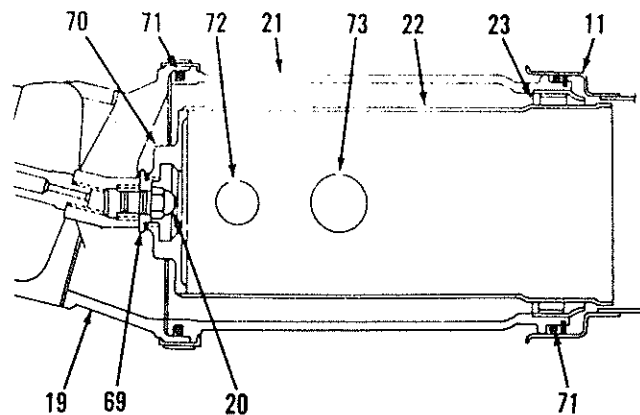


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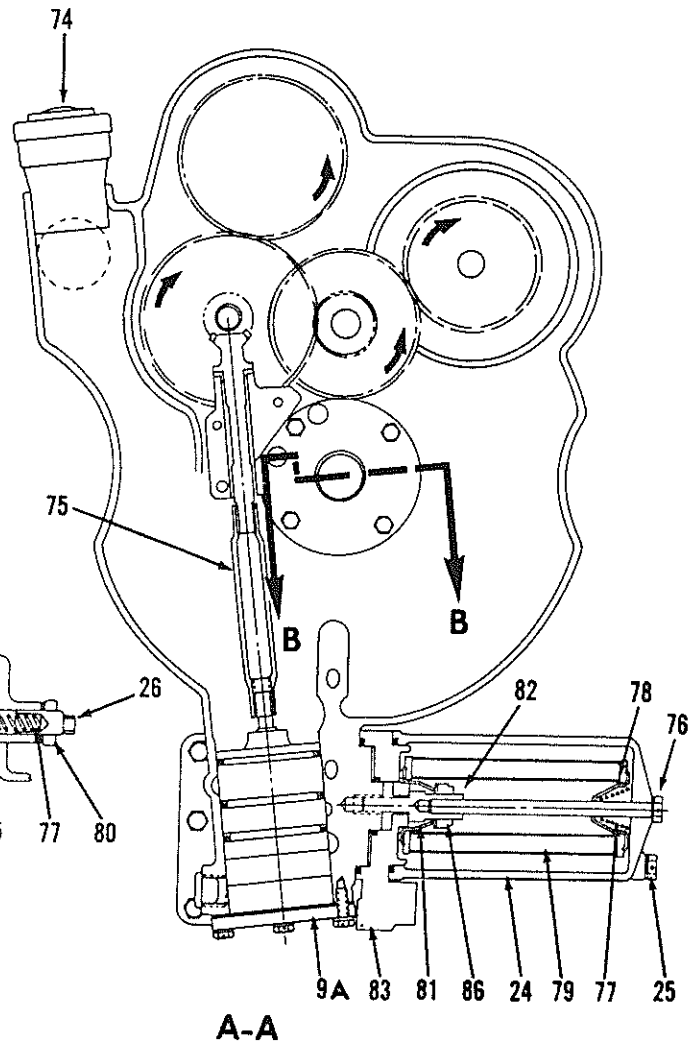
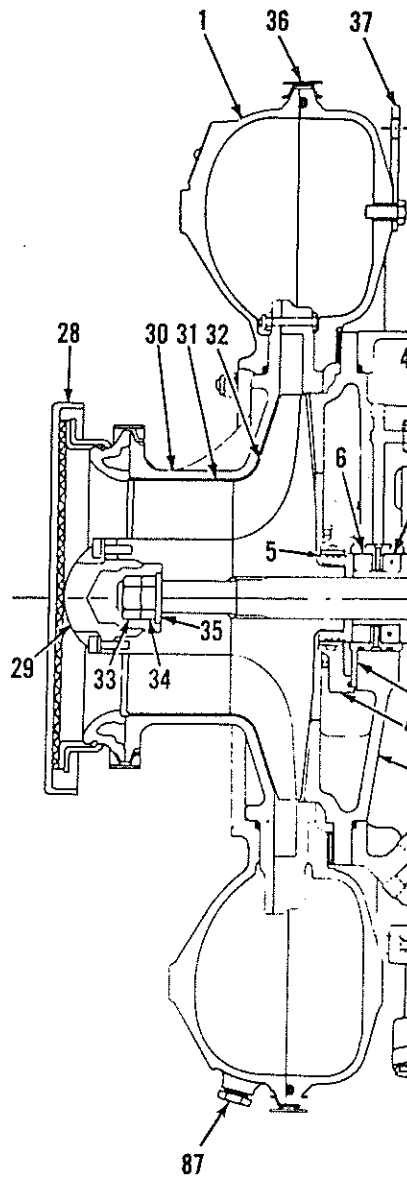
Figure 2-2. Engine Cross Section (Sheet 1 of 2)

- 66 Oil Strainer
- 67 Drain Plug
- 68 Burner Bolt
- 69 Fuel Nozzle Adapter
- 70 Burner Dome
- 71 Seal
- 72 Igniter Plug Port
- 73 Crossfire Tube Port
- 74 Oil Filler Cap
- 75 Pump Drive Shaft

- 76
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BURNER SECTION



A-A

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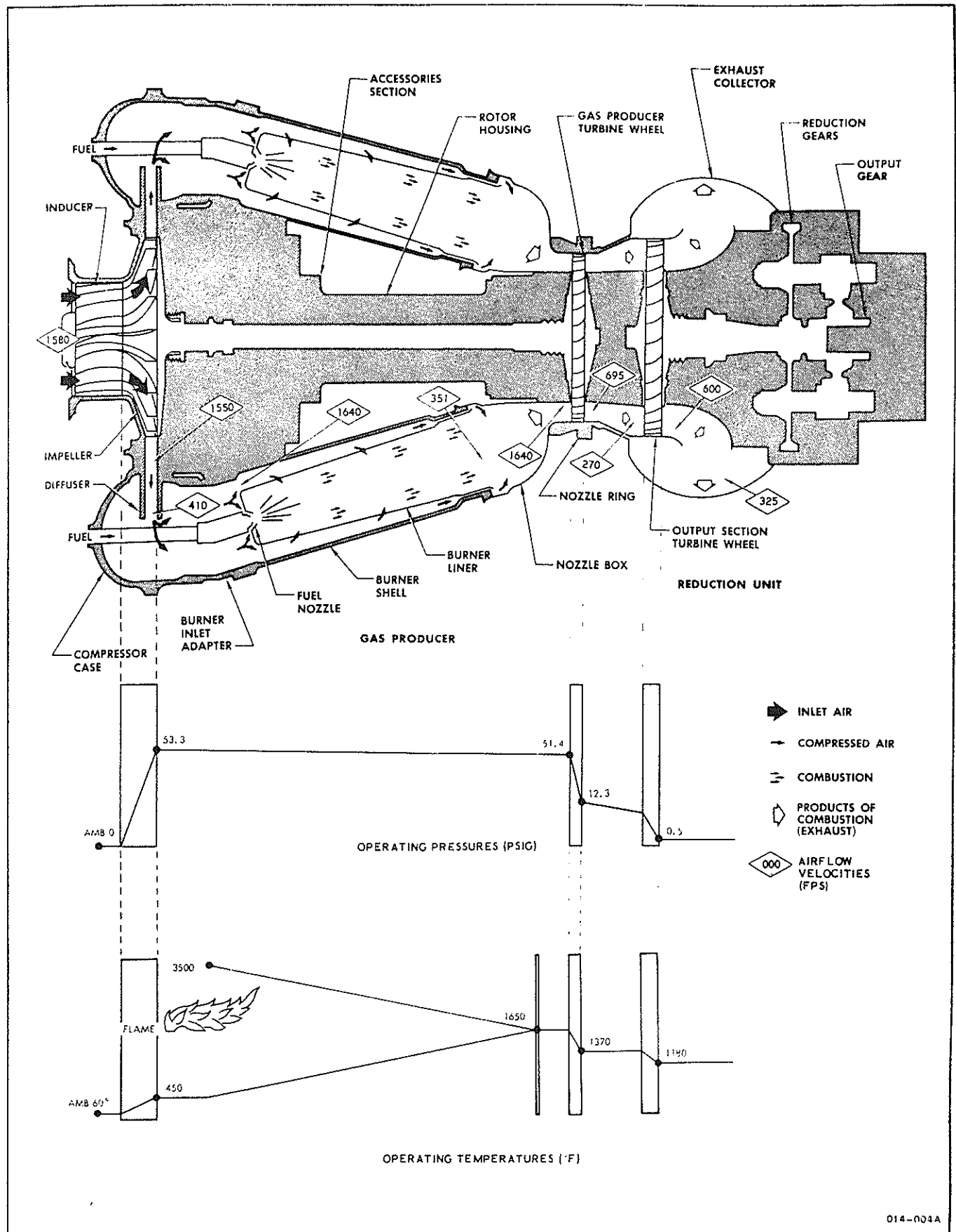
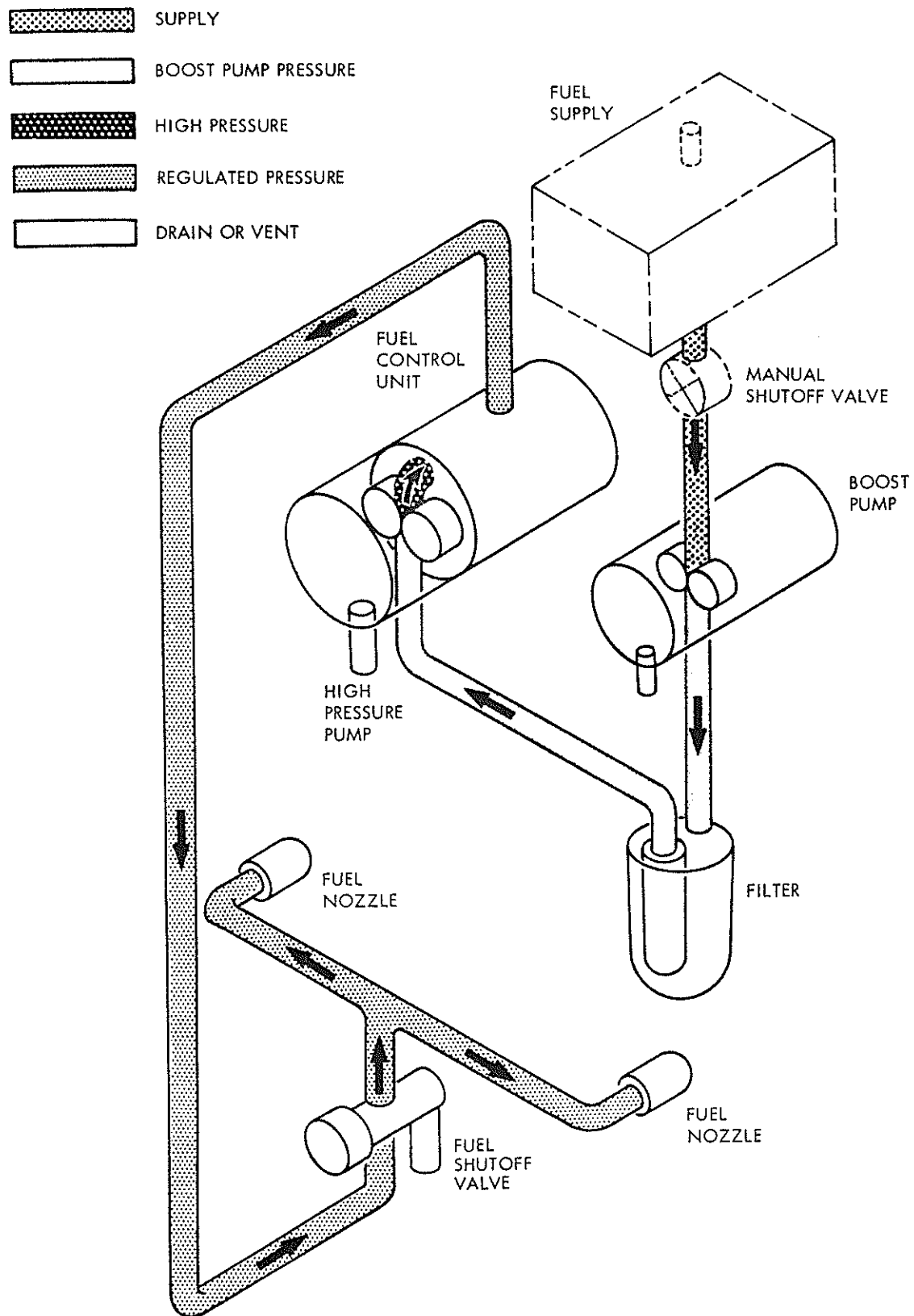


Figure 2-3. Pressure-Temperature Air Cycle and Gas Flow Diagram

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Figure 2-4. Fuel Flow Diagram

2-19. **FUEL CONTROL UNIT.** In the gas producer section, fuel delivery is primarily controlled by the following fuel control unit components (figure 2-5):

- a. High pressure fuel pump
- b. Steady-state speed governor and main metering valve
- c. Acceleration limiter
- d. Minimum flow valve

2-20. Fuel leaving the high pressure pump is regulated by the governor to maintain constant gas producer speed for any given position of the governor speed control lever. A 40-micron sintered bronze bypass type filter is incorporated in the fuel control unit immediately downstream of the high-pressure pump.

2-21. When the governor speed control lever is positioned for an increase in speed, the main metering valve, controlled by the governor, opens to increase the flow of fuel to the acceleration limiter. To prevent excessive fuel flow while speed is increasing, the acceleration limiter regulates the fuel flow to the burners in direct proportion to the rising compressor discharge pressure. This provides for controlled and uniform acceleration. When the speed control lever is positioned for a decrease in speed, the main metering valve closes. The minimum flow valve then allows sufficient fuel to bypass the metering valve to sustain combustion during deceleration. Regulation of fuel flow is resumed by the governor-controlled main metering valve as the gas producer speed nears the new lever setting.

2-22. **OUTPUT SECTION GOVERNOR.** (See figure 2-6.) A hydromechanical governor, mounted on the output section housing, senses the output shaft speed and varies gas producer speed automatically through a mechanical interconnecting linkage. The single operator's control lever on the output section governor may be positioned at the ground idle position or at the flight idle-to-rated position. At ground idle position, since only low speed is demanded from the power output section, minimum gas producer speed is established by the fuel control unit low speed stop screw. In the flight idle-to-rated range, the output section governor automatically regulates the speed of the gas producer section to maintain the output section speed as the load demands. Output section speed reduces slightly as load increases due to a built-in governor characteristic known as droop.

2-23. **FUEL SHUTOFF VALVE.** The fuel shutoff valve (31, figure 2-1), located between the fuel control unit and the fuel nozzles, is used to shut off the fuel to the engine and to drain the fuel lines between the shutoff valve and the nozzles when the engine is shut down. The valve is opened and closed electrically.

2-24. **FUEL NOZZLES.** The fuel nozzles (20, figure 2-2) inject an atomized spray of fuel into the combustion chambers. Fuel enters a nozzle through a 100 - 140 mesh strainer screen, passes through the swirler passages in the nozzle, and out the nozzle orifice. The swirler imparts a rotary motion to the fuel stream which aids atomization.

2-25. **LUBRICATION SYSTEM.** The engine is lubricated by a circulative oil system. (See figure 2-7.)

The system incorporates two lubrication pressure and scavenge pumps: one pump is located in the gas producer section and one on the output section. The two pumps are connected in parallel and deliver oil under pressure to all lubrication points in the engine. In addition, the system supplies oil to the output section governor. Major components of the system are:

- a. Gas producer section pump
- b. Power output section pump
- c. Gas producer two-element pressure and scavenge pump
- d. Power output section two-element pressure and scavenge pump
- e. Full-flow filter
- f. Pressure relief valve
- g. Filter bypass valve
- h. Two strainers (one in each sump)
- i. Oil cooler
- j. Oil cooler bypass valve
- k. Two magnetic sump plugs (one in each sump)

2-26. **SUMPS.** The engine is equipped with two oil sumps, one in the rotor housing and one in the output section. Each sump is provided with a drain, a strainer, and a magnetic chip detector. A dipstick (38, figure 2-1) is provided on the side of the engine for determining the oil level. The gas producer sump is filled through a filler opening (36) on the top left side of the engine. The reduction unit sump is filled by the flow of oil when the engine is started.

2-27. **LUBRICATION SYSTEM PUMPS.** Each of the two positive displacement lubrication pumps consists of a scavenge and pressure element. The gas-producer pump (9, figure 2-2) contains gerotor-type pumping elements, and is located in the gas producer sump. The output section pump (9A) contains vane-type pumping elements, and is mounted externally on the output section housing. Each pump is driven by accessory drive gearing. The scavenge element of each pump draws oil from the output section sump and delivers the oil to the gas producer sump. The pressure element of each pump draws oil from the gas producer sump and raises the oil pressure. The pressurized oil is pumped through the cooler and filter and through internal passages to engine bearings and gears. Spent oil is returned by gravity to its respective sump for recirculation.

2-28. **OIL FILTER.** The full-flow oil filter (24, figure 2-2) is mounted on the lower side of the accessory drive housing adjacent to the gas producer oil pump. The oil cooling adapter (83) serves as a seat for both the oil filter cover and oil filter element. Internal passages in the housing carry oil to and from the filter. A spring-loaded ball check valve permits delivery of unfiltered oil to the engine, should the filter become clogged. The 10-micron filter element is a standard replaceable full-flow paper unit.

2-29. **OIL STRAINERS.** The two oil strainers (50, 66, figure 2-2) are made of 30-mesh screen. Oil entering the pressure element of the gas producer pump passes through the strainer located in the gas producer sump. All of the oil that enters the scavenge elements of both pumps passes through the strainer (66) located in the output section sump.

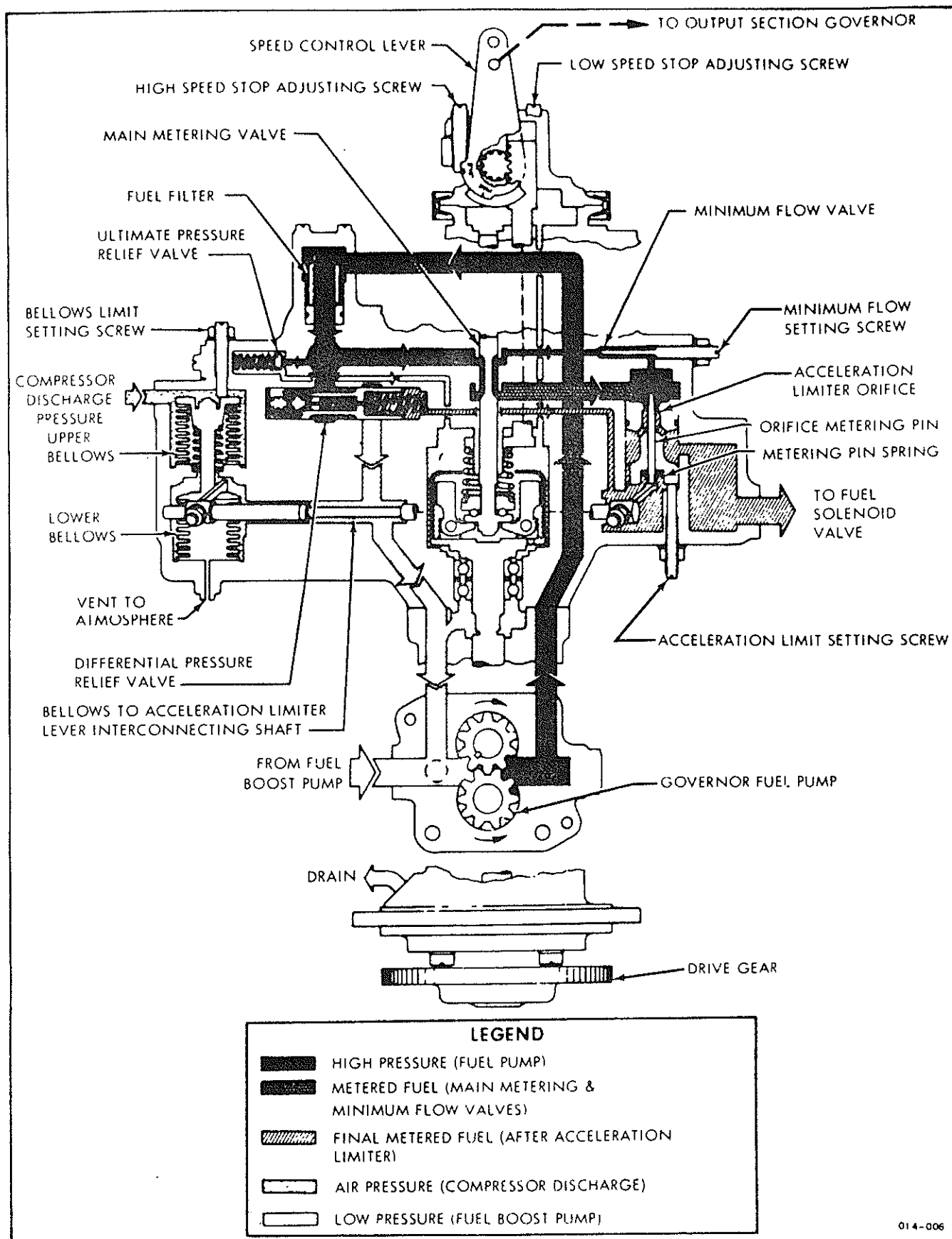


Figure 2-5. Fuel Control Unit



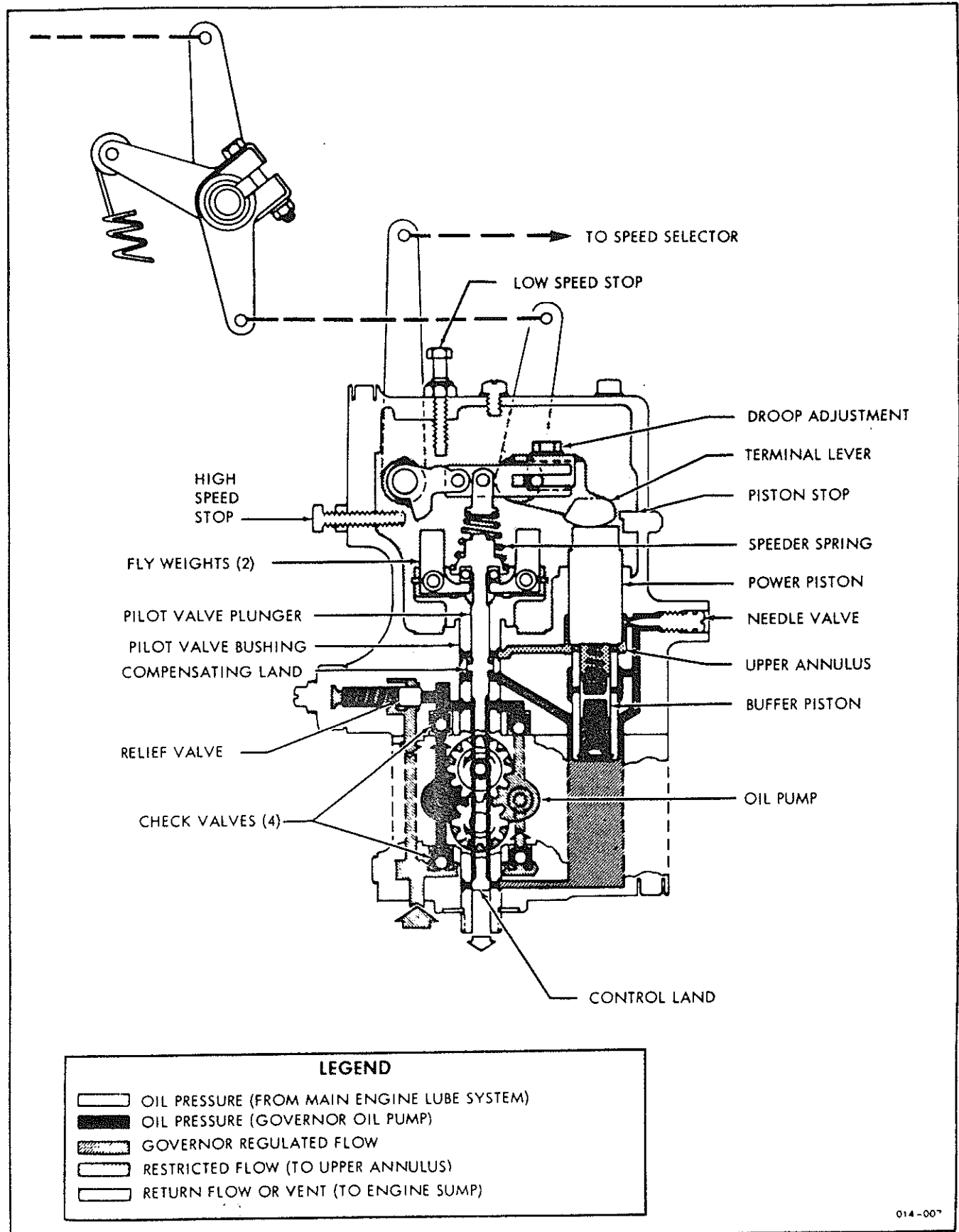


Figure 2-6. Output Section Governor

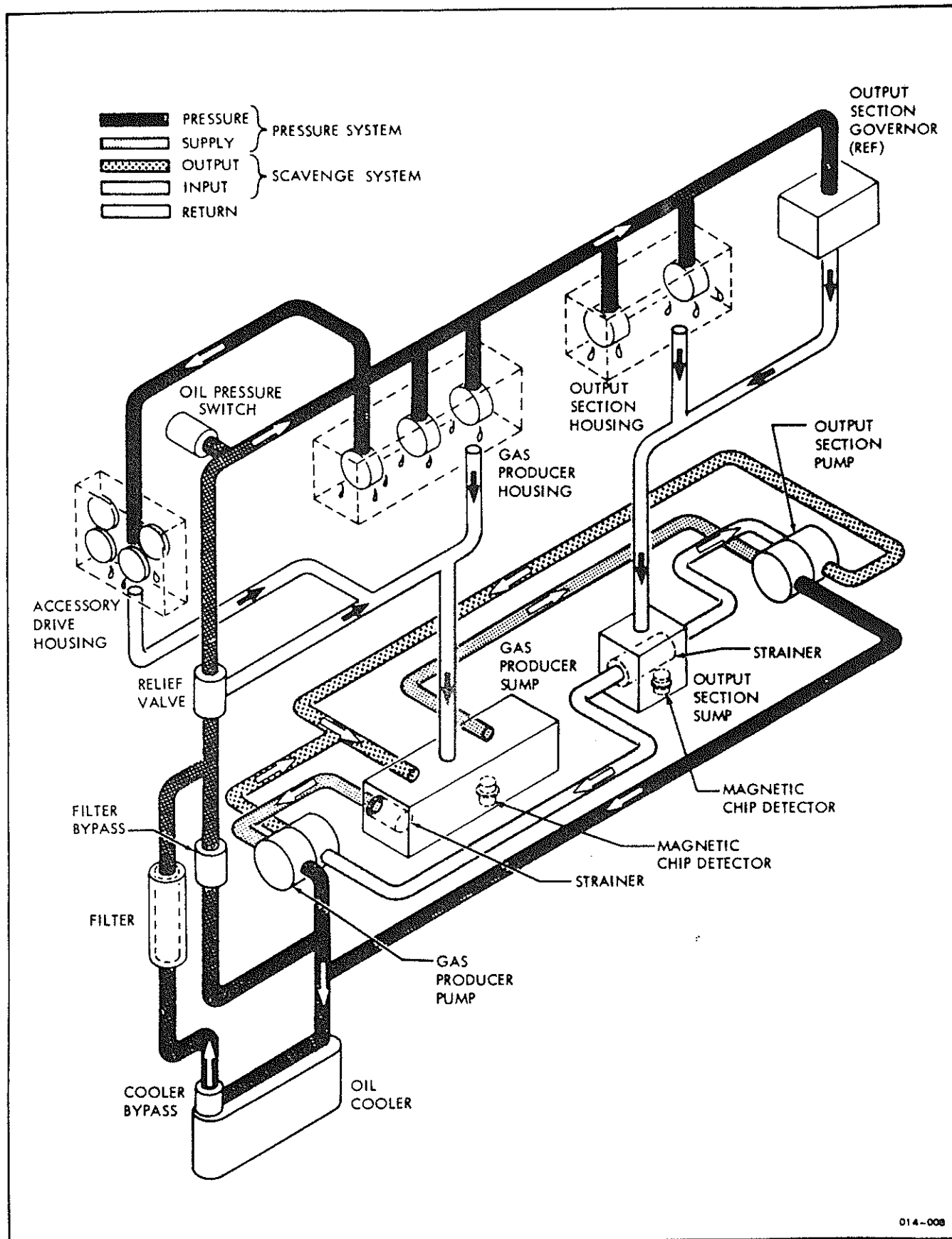


Figure 2-7. Lubrication System Schematic

2-30. **PRESSURE RELIEF VALVE.** A spring-loaded relief valve (26, 77, 80, and 85, figure 2-2) is provided on the starter-generator side of the rotor housing. It regulates the upper limit of the lubrication oil pressure at the entrance to the internal oil passages. By-passed oil is returned to the sump. The valve is set to maintain an operating oil pressure of 30 to 50 PSIG at rated speed with hot oil.

2-31. **OIL COOLER.** Before entering the engine, circulating oil passes through an oil-to-air cooler (23, figure 2-1). A thermostatic-type bypass valve is an integral part of the cooler. When the oil temperature is below 54°C (130°F), the thermostatic valve is open, permitting the oil to go directly from the cooler inlet port to the cooler outlet port without going through the cooler proper. When the oil temperature reaches 71°C (160°F), the thermostatic valve is fully closed, forcing oil through the cooling section. If oil passages through the cooler are obstructed and a pressure differential of 40 PSIG results, this valve will open to allow oil to bypass the cooler. The oil cooler is provided with a drain plug (22).

2-32. **LUBRICATION OIL DRAINS.** The lubricating oil may be drained by opening the rotor housing and oil sump drain plug (25, figure 2-1), oil cooler drain (22), and output section drain plug (67, figure 2-2).

2-33. **ELECTRICAL SYSTEM.** (See figure 2-8.) The engine uses a 24-volt DC electrical circuit for cranking, ignition, and for actuating the fuel solenoid shutoff valve. A chromel-alumel resistance circuit is used to sense and measure exhaust gas temperature.

2-34. Major electrical components furnished on the engine are:

- a. Starter-generator
- b. Ignition Exciter
- c. Two igniter plugs
- d. Electrical fuel shutoff valve
- e. Engine wiring harness with connections for external power source
- f. Speed monitor (for automatic start sequencer)
- g. Oil pressure switch

2-35. Major electrical components not furnished on the engine are:

- a. 24-volt DC power source
- b. Starter relay
- c. Ignition relay
- d. Start switch
- e. Fuel switch } or automatic start sequencer
- f. Tachometer generator and indicator
- g. EGT gage
- h. Adjustable EGT thermocouple circuit resistor

2-36. **STARTER RELAY.** A 200-ampere, intermittent duty starter relay must be provided in the starting circuit. The coil of this relay is connected to the start switch or automatic start sequencer. When the relay coil is energized, the relay contacts are closed, permitting power to be drawn from a 24-volt DC power source by the starter-generator. The starter relay operates only during the starting cycle.

2-37. **IGNITION RELAY.** The ignition relay, which is physically identical to the starter relay, provides

the means for energizing the ignition exciter and igniter plugs. This relay is also controlled by the start switch or automatic start sequencer. The ignition relay is used only during the start cycle.

2-38. **IGNITION EXCITER.** The 24-volt DC input capacitor-discharge ignition exciter (24, figure 2-1) is attached to the lower side of the rotor housing and sump. This unit provides a high voltage output for the igniter plugs during engine starting.

2-39. **IGNITER PLUGS.** (See figure 2-9.) An igniter plug, installed in a boss on the lower side of each burner shell, projects through the shell and into the burner liner. Each plug has two electrodes and a glow coil. The glow coil is connected to 24-volt DC power through the ignition relay. It is a resistance heating unit that vaporizes fuel in the electrode area. During the starting cycle, high voltage from the ignition boost coil is supplied to the center electrode, and low voltage is supplied to the glow coil. The igniter plugs are used only during engine starting, and are de-energized at the same time the starter is de-energized.

2-40. **STARTER-GENERATOR.** An air-cooled type starter-generator (7, figure 2-1) is mounted on the upper side of the accessory housing. It is in constant engagement with the gas producer accessory drive gear train. A fan inside the rear cover of the unit draws cooling air across the armature and commutator. The unit is a four-pole type with a series-wound field for starting and shunt-wound field for generating.

2-41. **ELECTRICAL SYSTEM JUNCTION BOX.** The electrical system junction box (9, figure 2-1) is mounted on the starter-generator and provides electrical connectors for connecting to the external 24-volt DC power source and the automatic start sequencer. A wiring harness connects all engine electrical accessories with the junction box.

2-42. **SPEED MONITOR.** The speed monitor (37, figure 2-1) is mounted on the accessory drive gear box, and contains two centrifugally operated switches which control the automatic start sequence. The speed monitor operates at a ratio of 0.1107 of gas producer speed, and is driven through the tachometer drive gear and accessory drive gear box. At 3,000 RPM gas producer speed the fuel-on switch closes, starting fuel delivery to the burners. At 12,000 RPM gas producer speed the starter-off switch opens, de-energizing the starter and ignition relays.

2-43. **EXHAUST GAS TEMPERATURE CIRCUIT.** (See figure 2-8.) The exhaust collector contains two chromel-alumel thermocouples mounted 180 degrees apart on each side. All four thermocouples are connected in parallel and provide an average exhaust gas temperature measurement. The thermocouple circuit is connected to a remotely located exhaust gas temperature (EGT) gage and a variable resistor. The resistor provides a means of obtaining the correct total resistance of the EGT circuit, excluding the gage. The following are the resistance values for the EGT circuit.

- a. Thermocouple harness only (Part No. 49-5406): 0.26 ( $\pm 0.02$ ) ohms.
- b. Engine-furnished portion of EGT circuit (between pins E and F of connector, Part No. SG3102E24-56P): 1.11 ( $\pm 0.15$ ) ohms.

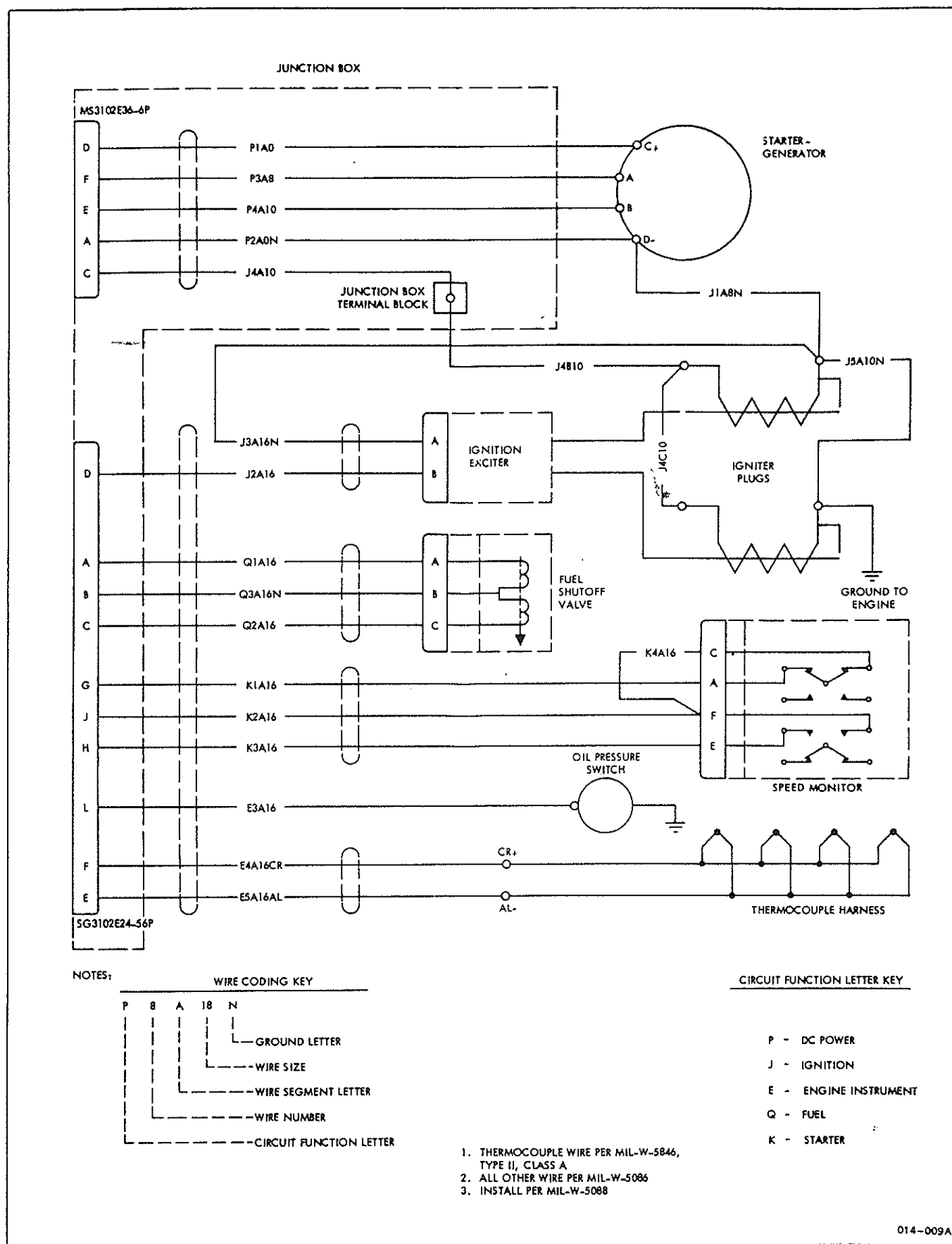


Figure 2-8. Electrical Wiring Diagram

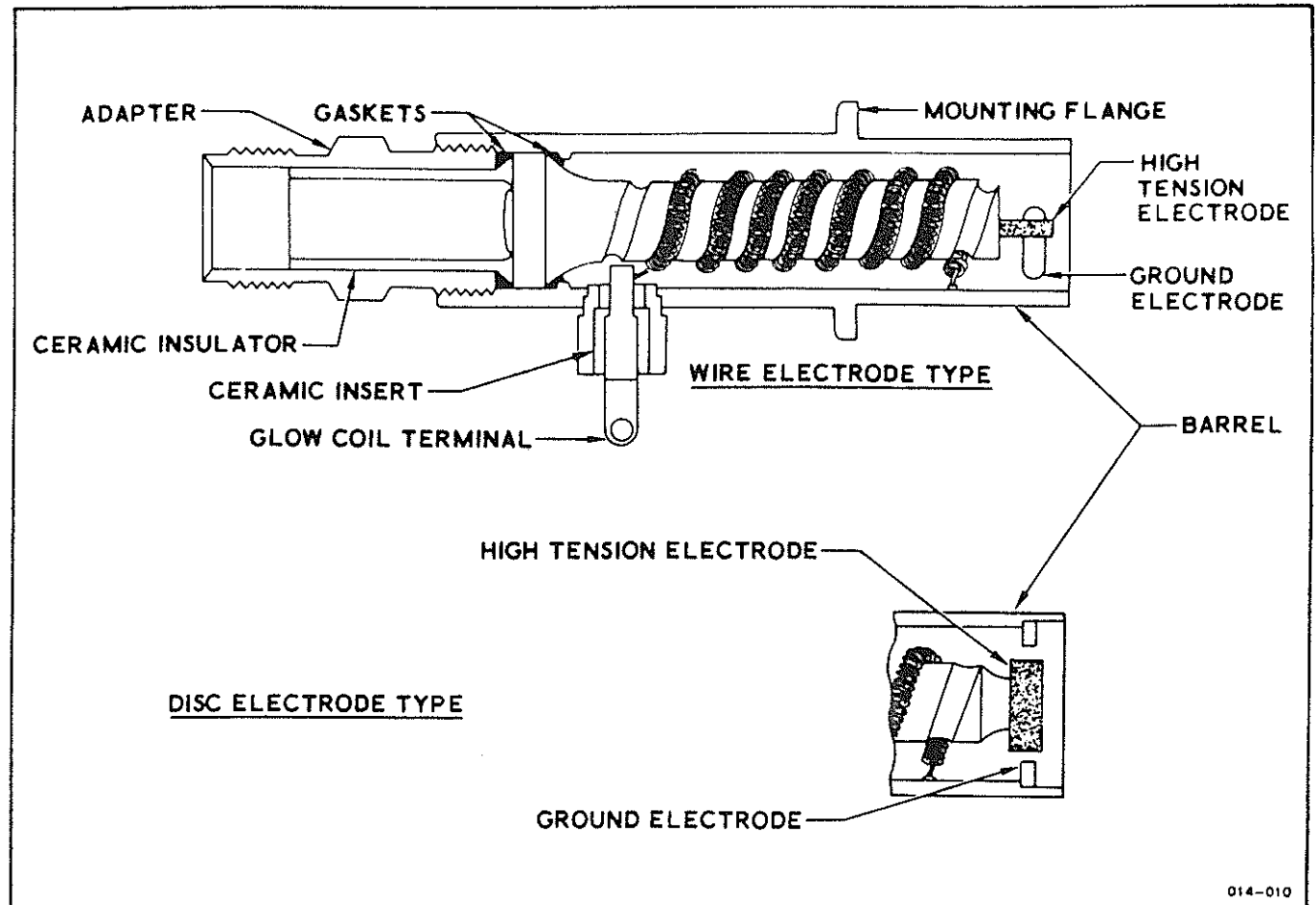


Figure 2-9. Igniter Plug, Cutaway View

## SECTION III

## SPECIAL OVERHAUL TOOLS

3-1. GENERAL. This section lists, both by function and in numerical order, the special tools applicable to the work prescribed in this handbook. Table I lists the tools by functional grouping, based on the equipment parts to which they are applicable. Table II is a numerical list of special tools required. References to the tools in other sections of this handbook are by the group number indicated in the functional tool list.

3-2. STANDARD TOOLS. The usual standard hand tools such as pliers, screwdrivers, wrenches, feeler gage, and torque wrenches are required.

3-3. HANDLING PRECAUTIONS. The following precautions should be observed in handling the engine or sections:

- a. Use plastic or rawhide hammer heads (never metal) when driving on any part of the engine.
- b. Never lift heavy parts by hand. Use a chain or powered hoist and special lifting yokes.
- c. Pressure or tension shall be evenly applied to all bearing pushers or pullers.
- d. Jack screws and attaching screws, bolts, and nuts shall be tightened in small increments on opposite planes.

Table I. Functional Tool List

Group Number	Function Tool Nomenclature	Tool Number	Figure Number	Notes
1	<u>Burner</u>			
	Burner Dome Wrench	F50299-4	4-6	Used to remove or install burner dome on adapter. Also used to remove or install assembly of burner dome, adapter, and nozzle in burner inlet adapter.
	Nozzle Pressure Test Clamp	F4-10035-1	3-1	Used to seal fuel nozzle orifice during pressure test.
	Pressure Test Stand	F4-10005-1* (or equivalent)		High pressure fluid source for pressure checking assembly of burner dome, fuel nozzle, nozzle adapter, and burner inlet adapter.
2	<u>Indicated EGT Check</u>			
	Exhaust Gas Temperature Analyzer		3-2	Used to provide separate calibrated EGT readings of the four thermocouple probes.
3	<u>Engine Handling</u>			
	Lifting Sling	F4-10014-10	3-5	Used to lift entire engine or gas producer section.
	Shipping Container	SK-3500-1-1	4-1	Used for shipping engine.
	Engine Assembly Stand	F50278-26	3-6	Used to secure engine for easy disassembly and build-up.
	Parts Rack	F50279-1* (or equivalent)		For storing and protecting parts.
	Engine Handling Dolly	F4-10025-7	3-11	Used for transporting engine.
	Engine Handling Dolly	F4-10097-1	3-11	Used for transporting engine.
4	<u>Engine Testing</u>			
	Universal Pressure Indicator	F4-10016	3-3	Used to read starting fuel pressure and other system pressures.

\*Contractor Recommended Tool

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Table I. Functional Tool List (Continued)

Group Number	Function Tool Nomenclature	Tool Number	Figure Number	Notes
5	<u>Engine Testing (Continued)</u>			
	Engine Test Base	F50271-1*		Used to determine engine power after overhaul.
	Performance Check Kit	F4-10017* (or equivalent)		Used to monitor gas producer speed during ground run.
	Strobe-Tachometer	F50270*		Used to closely monitor gas producer speed during test run.
	Oil Pressure Switch Wrench	F4-10130-1		Used to remove and install oil pressure switch.
	<u>Gas Flow Adjustment</u>			
	Nozzle Box Gage Set	F50264-1*	3-4	
	Gaging Tool	F50264-3		Used to check nozzle box flow areas.
	Bending Tool	F50264-2		Used to adjust nozzle box flow areas.
	Nozzle Ring Gage Set	F50266-1*	3-4	
6	Gaging Tool	F50266-3		Used to check nozzle ring flow areas.
	Bending Tool	F50266-2		Used to adjust nozzle ring flow areas.
6	<u>Lubrication Pump</u>			
	Lubrication Pump Test Stand	F50285-1*		Used to check gas producer lubrication pump output.
7	<u>Output Rotor</u>			
	Output Wheel and Impeller and Inducer Balancing Fixture	F50273-1*	3-7	Used to balance power output turbine wheel and shaft assembly and impeller and inducer assembly.
	Wheel Cover (Output Section)	F50281	3-9	Used to protect blades on power output turbine.
8	<u>Output Section</u>			
	Timing Fixture			Used to properly distribute load on output section gears.
9	<u>Wheel and Shaft Assembly (Gas Producer)</u>			
	Inducer Spanner Wrench	F4-10002	4-13	Used to hold inducer while tightening or loosening shaft nut.
	Gas Producer Wheel Balancing Fixture	F4-10018-1*	3-8	Used to balance gas producer turbine wheel and shaft. Also used with F4-10040-1 to balance gas producer inducer.
	Impeller, Inducer and Anti-Icing Spinner Balancing Arbor	F4-10040-1	3-10	Used to balance gas producer impeller and inducer in conjunction with F4-10018-1.
	Wheel Cover (Gas Producer)	F50280	3-9	Used to protect blades on gas producer turbine.
10	<u>Rotor Runout</u>			
	Dial Indicator Bracket	F4-10020-1	7-5 7-9	Used to position dial indicator for rotor runout check and for lube pump bevel gear backlash check.

\*Contractor Recommended Tool

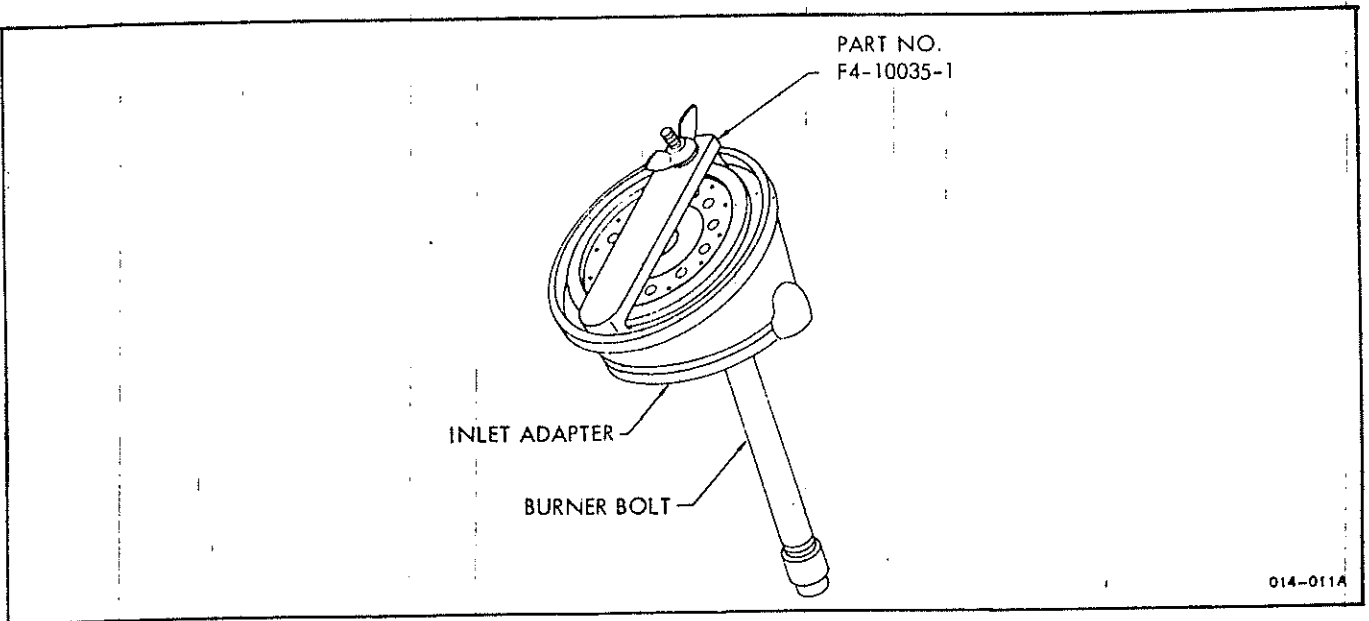


Figure 3-1. Nozzle Pressure Test Clamps

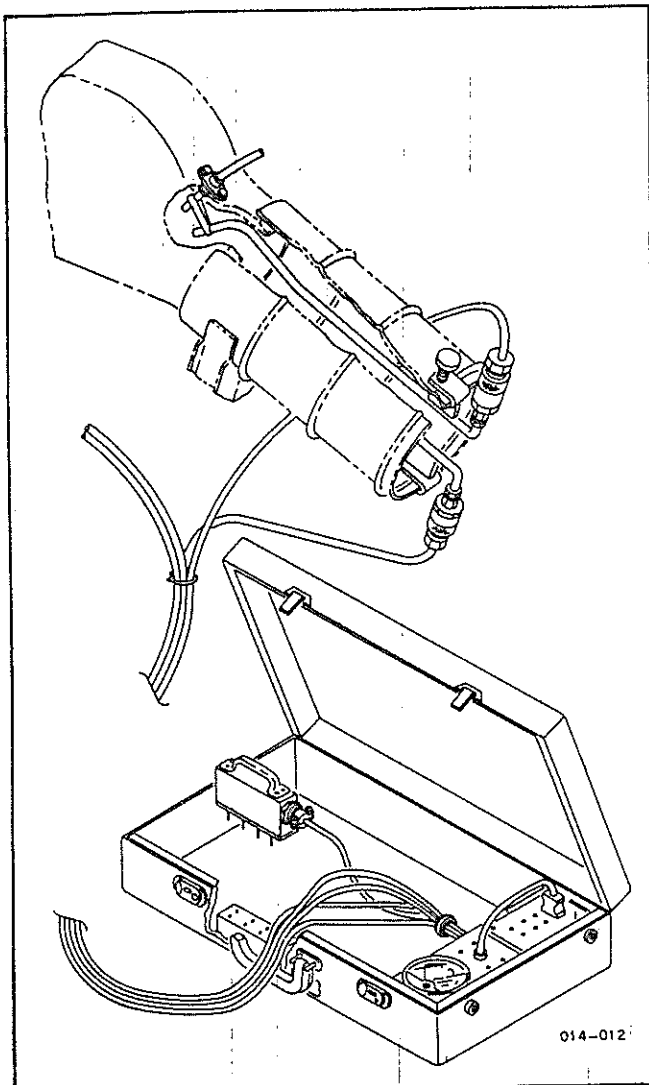


Figure 3-2. Exhaust Gas Temperature Analyzer

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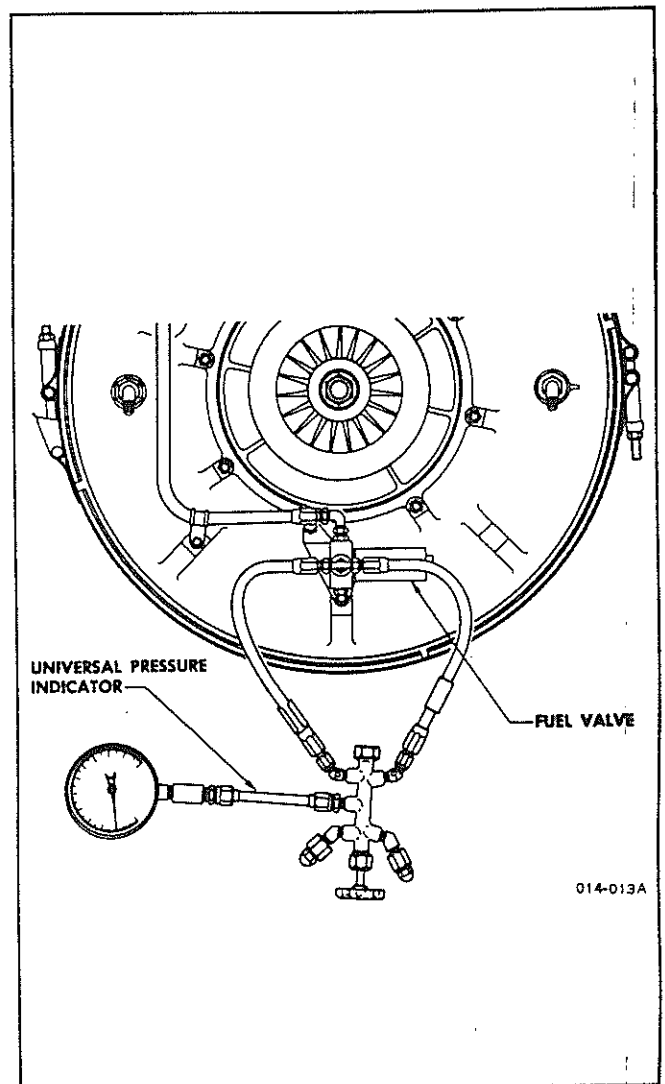


Figure 3-3. Universal Pressure Indicator



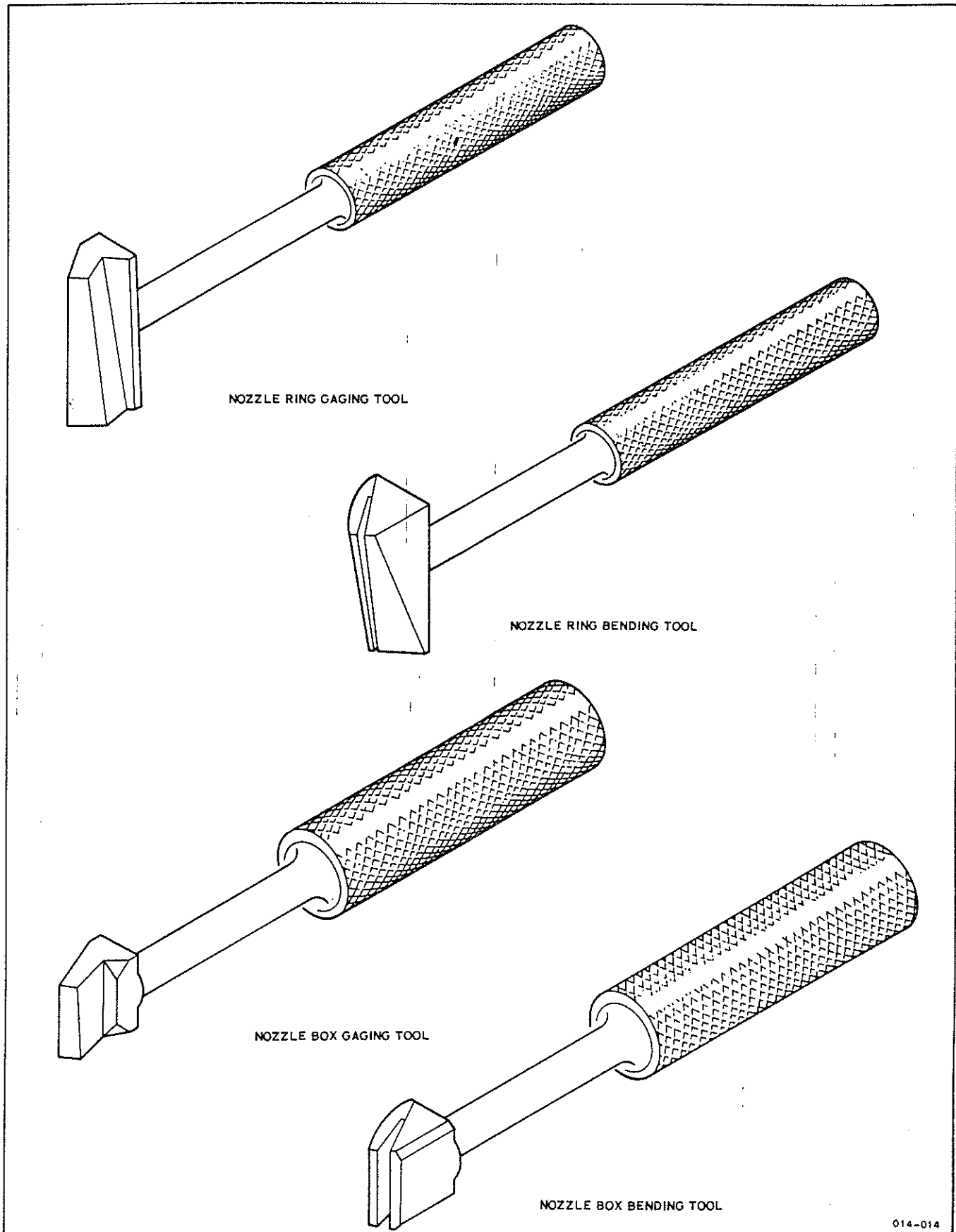
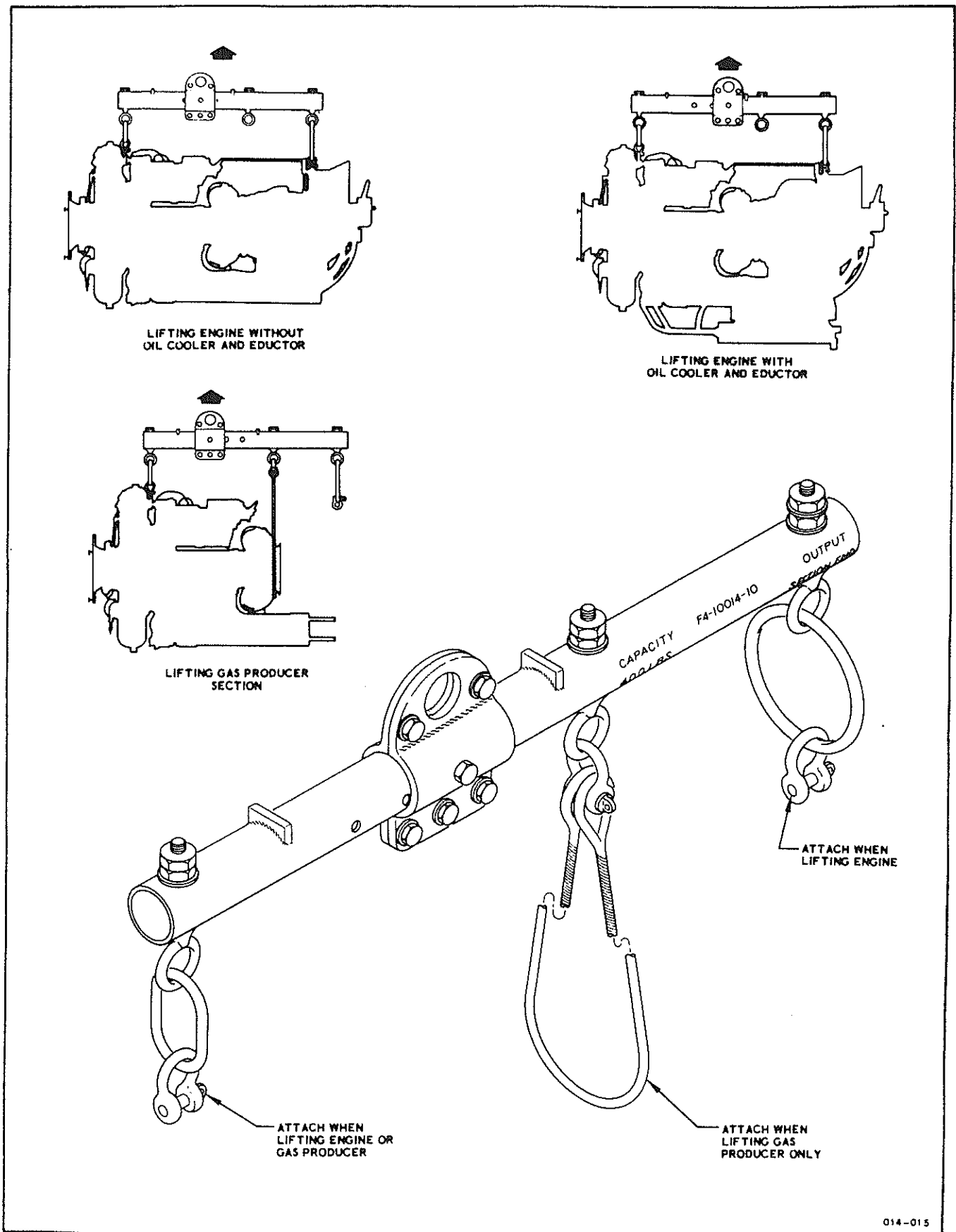


Figure 3-4. Nozzle Ring and Nozzle Box Gage Set



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Figure 3-5. Engine Lifting Sling

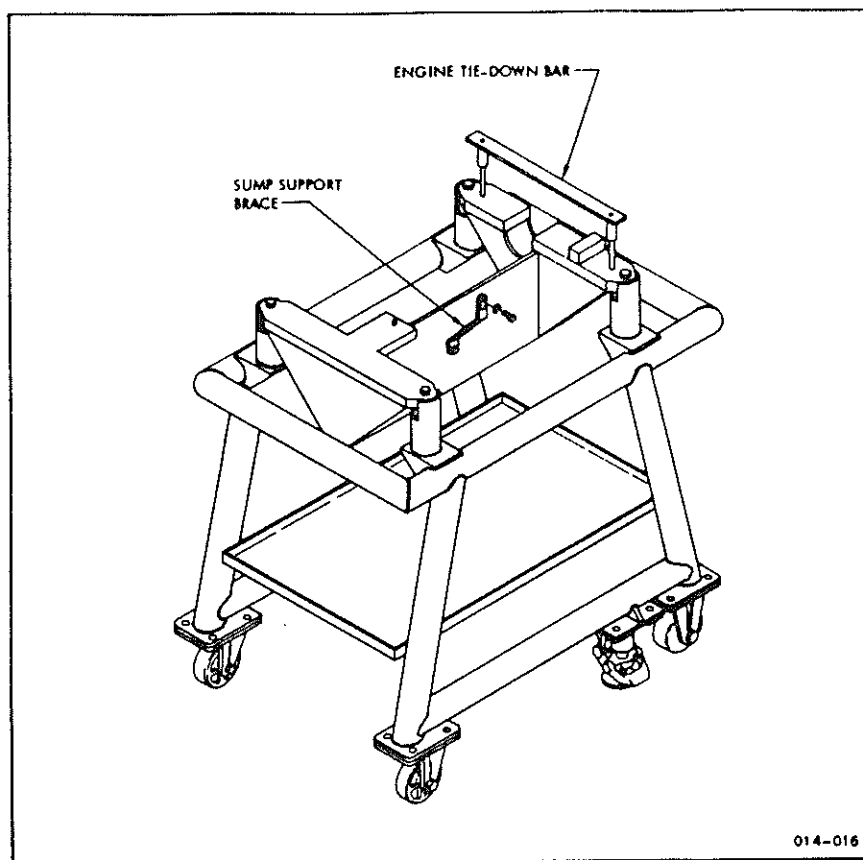


Figure 3-6. Engine Assembly Stand

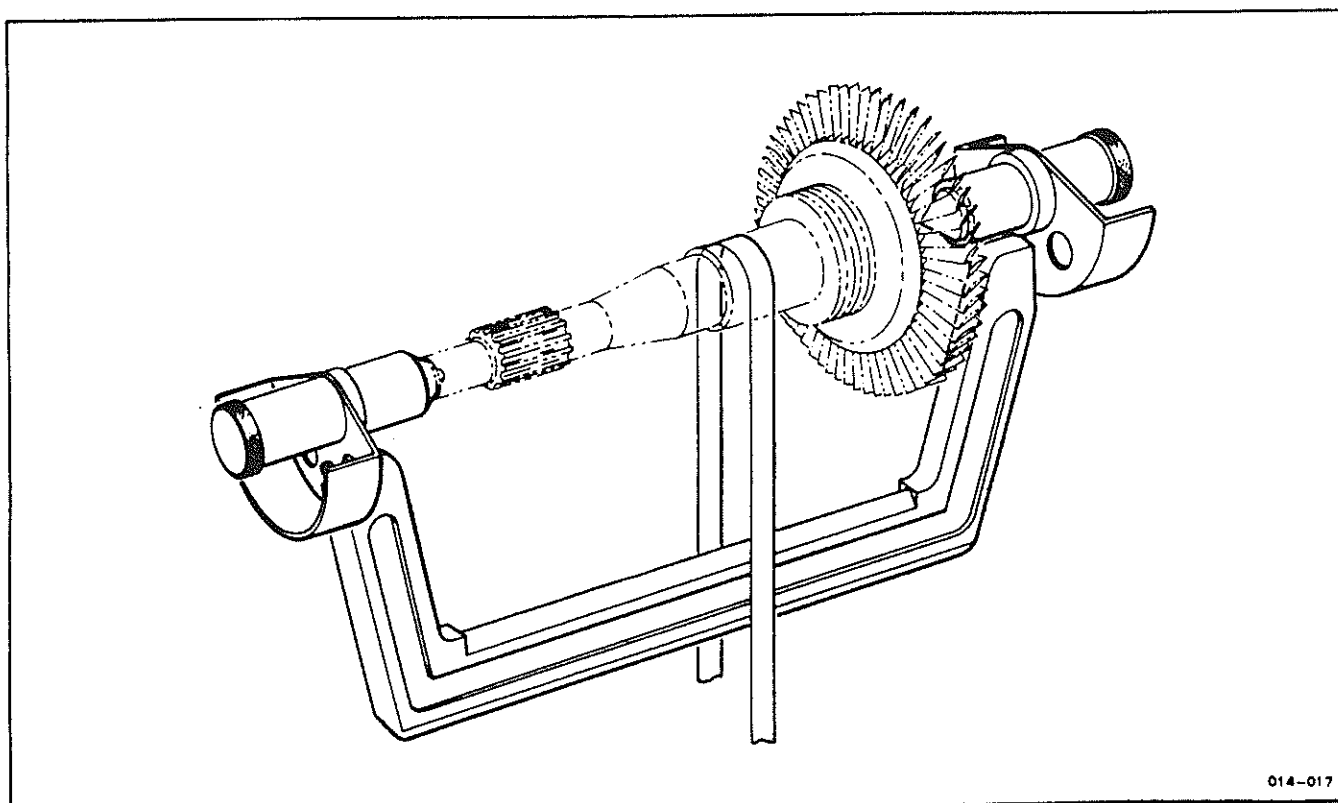


Figure 3-7. Output Wheel Balancing Fixture

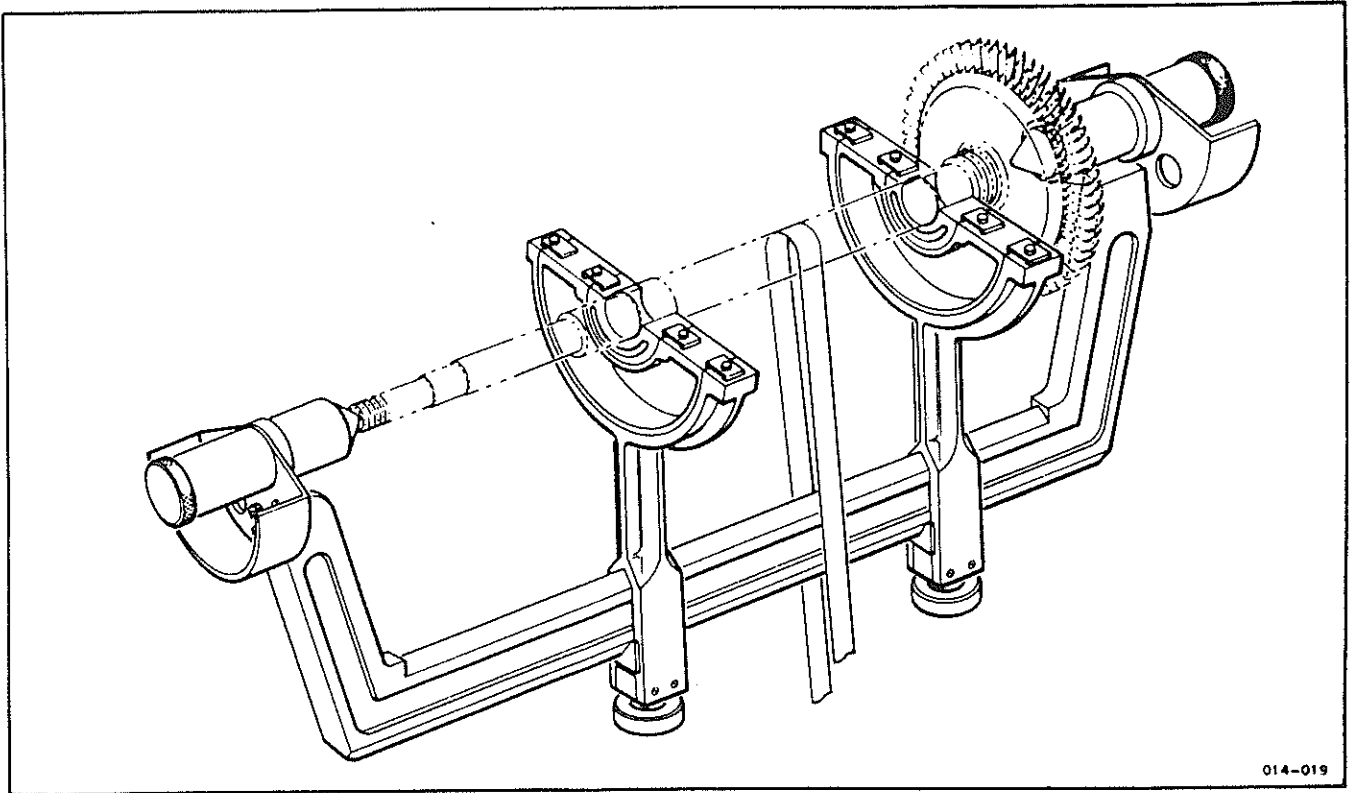


Figure 3-8. Gas Producer Wheel Balancing Fixture

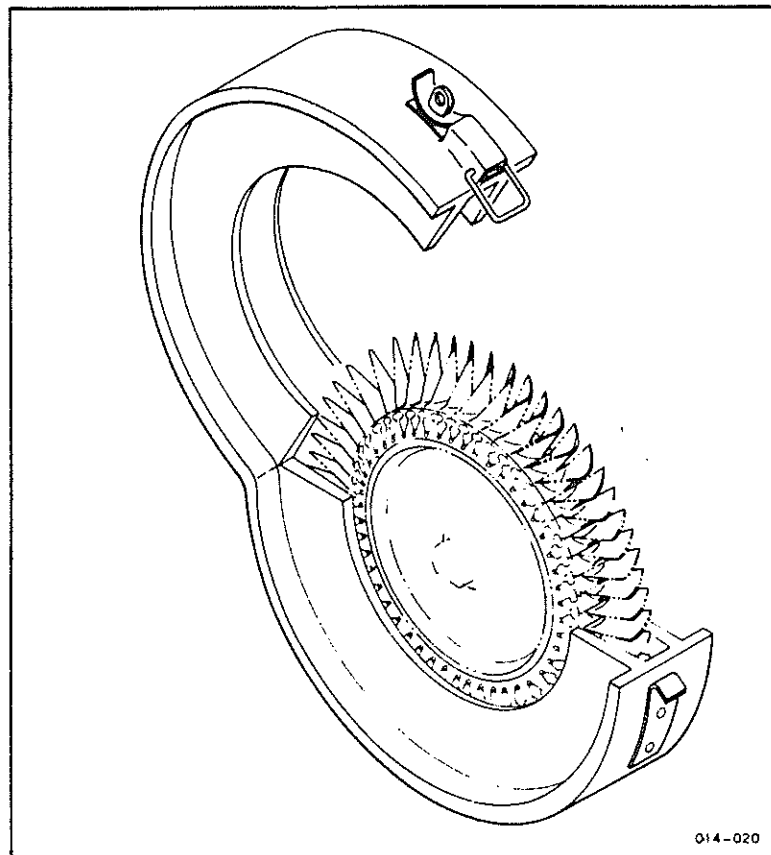


Figure 3-9. Turbine Wheel Cover (Typical)

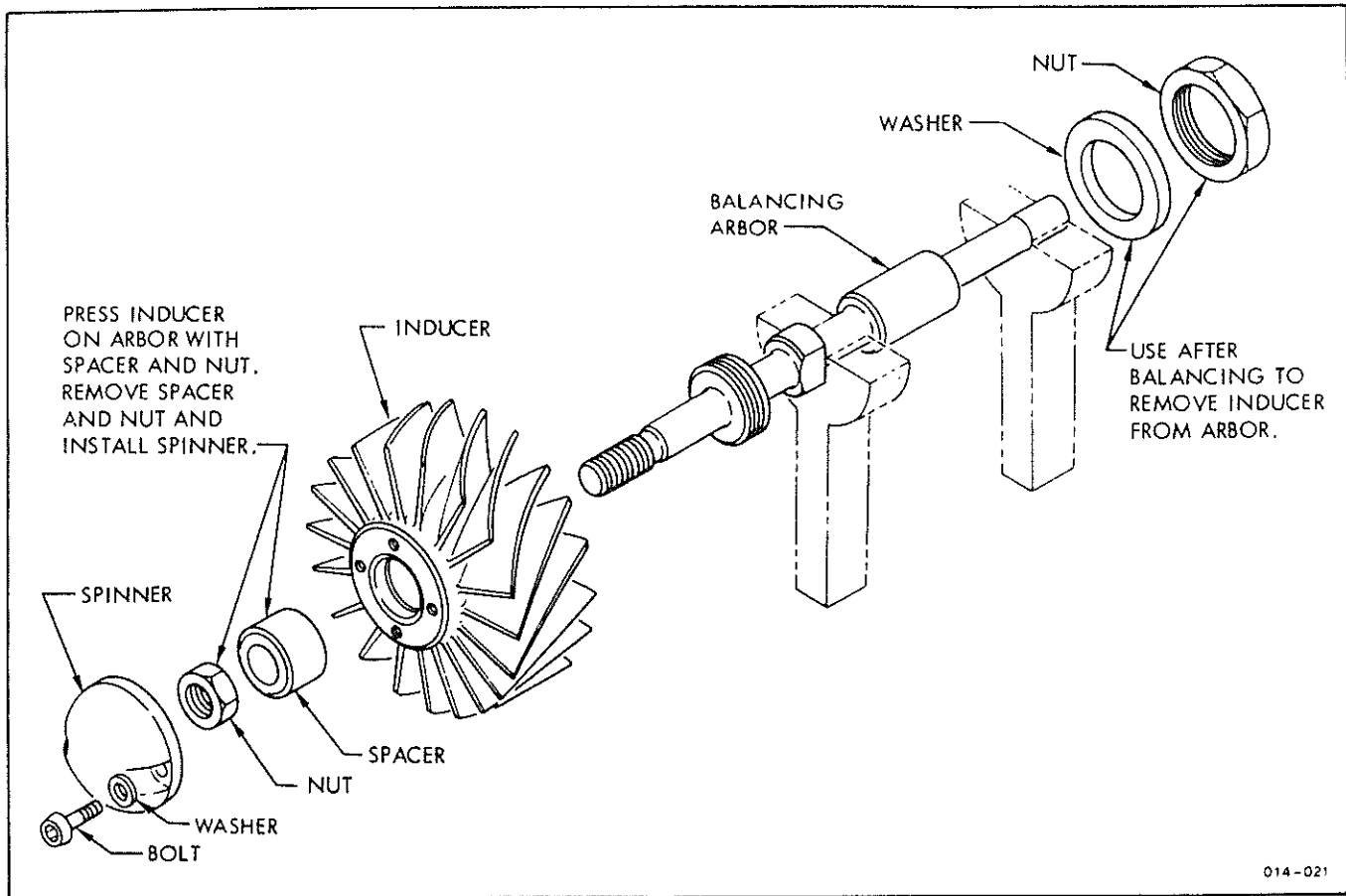


Figure 3-10. Impeller, Inducer and Anti-Icing Spinner Balancing Arbor

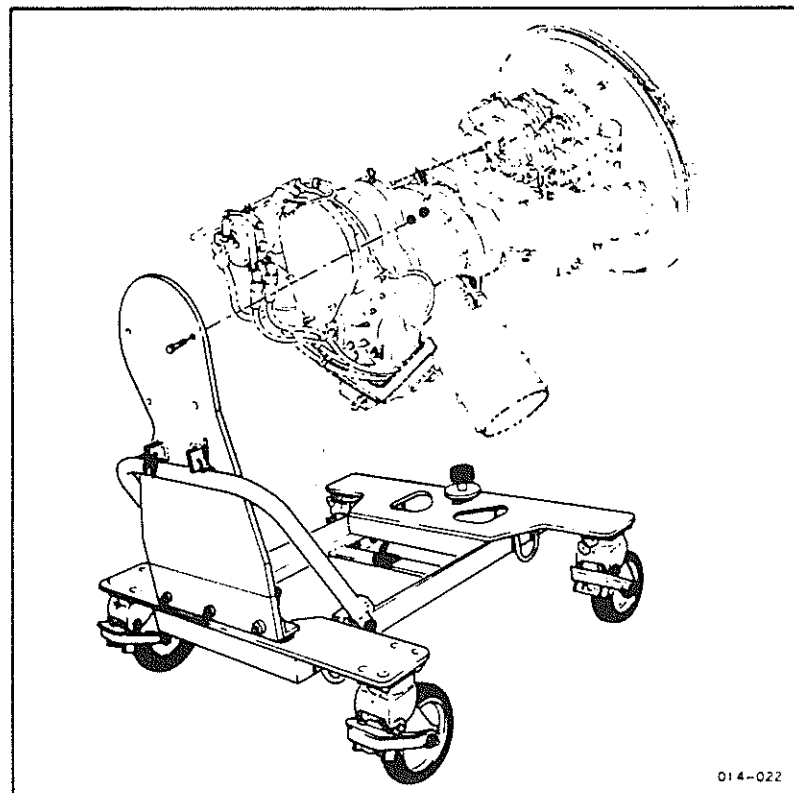


Figure 3-11. Engine Handling Dolly

Table II. Numerical List of Special Tools

Tool Number	Nomenclature	Group in Table I
F4-10002	Inducer Spanner Wrench	9
F4-10005-1	Pressure Test Stand	1
	Timing Fixture	8
F4-10014-10	Lifting Sling	3
F4-10016	Universal Pressure Indicator	4
F4-10017	Performance Check Kit	4
F4-10018-1	Gas Producer Wheel Balancing Fixture	9
F4-10020-1	Dial Indicator Bracket	10
F4-10025-1	Engine Handling Dolly	3
	Exhaust Gas Temperature Analyzer	2
F4-10035-1	Nozzle Pressure Test Clamp	1
F4-10040-1	Inducer and Anti-icing Spinner Balancing Arbor	9
F4-10097-1	Engine Handling Dolly	3
F4-10130-1	Oil Pressure Switch Wrench	4

Tool Number	Nomenclature	Group in Table I
F50264-1	Nozzle Box Gage Set	5
F50266-1	Nozzle Ring Gage Set	5
F50270	Strobe-Tachometer	4
F50271-1	Engine Test Base	4
F50273-1	Output Wheel and Impeller and Inducer Balancing Fixture	7
F50275	Impeller and Inducer Balancing Arbor	9
F50278-26	Engine Assembly Stand	3
F50279-1	Parts Rack	3
F50280	Wheel Cover (Gas Producer Section)	9
F50281	Wheel Cover (Output Section)	7
F50285-1	Lubrication Pump Test Stand	6
F50299-4	Burner Dome Wrench	1
SK3500-1-1	Shipping Container	3

SECTION IV  
REMOVAL AND DISASSEMBLY

4-1. GENERAL. The instructions in this section are given to enable overhaul personnel to completely disassemble the major assemblies and subassemblies of the engine. Procedures described in this section are arranged in normal order of disassembly.

4-2. PRECAUTIONS. Observe the following precautions during disassembly and handling of parts.

**WARNING**

Do not permit lubricating oil to contact skin longer than necessary. This oil contains tri-orthochlorethyl phosphate which is readily absorbed through the skin and can cause permanent paralysis.

a. Do not use lead pencils, grease pencils, or inks containing carbon for marking hot section parts. Graphite or lamp black particles deposited on stainless steel will carburize the steel at high temperatures, destroying the corrosion-resisting properties. Use chalk, soapstone, or approved inks.

b. Do not use zinc-plated tools on stainless steel parts. Stainless steel components corrode rapidly at temperatures above 450°C (850°F) after being scraped or rubbed by zinc-plated tools.

c. Discard all O-rings and gaskets exposed by disassembly.

d. During each stage of disassembly, examine all parts and assemblies for scoring or burning. Look for indications of work incorrectly performed during any previous overhauls. Report any such indications in accordance with current practice.

4-3. UNPACKING. (See figure 4-1.) Remove the engine from its shipping container according to the following instructions:

**NOTE**

For corrosion treatment, repair and overhaul of the shipping container, refer to Section IX of NAVWEPS 15-02-500. Preservation of Uninstalled Aircraft Engines. Refer to NAVAIR 02B-60A-4 for parts list.

a. Remove inspection port cover (1) and release air pressure from container by opening pressure relief valve located inside port.

b. Remove nuts (2), bolts (4), and lift cover (5) from container.

c. Refer to figure 3-5 and install engine lifting sling (Tool Group No. 3) on engine.

**NOTE**

Engine center of gravity, for lifting purposes, is in line with the rack housing portion of the fuel control unit cover assembly (see figure 2-2). If engine is to be lifted with a sling other than the special tool from Tool Group 3, be sure that lifting attachment is directly over this point.

d. Raise the sling until it is supporting the weight of the engine assembly; do not lift the engine.

e. Remove nuts (11) and bolts (12) attaching rear mount assembly (7) to channel assembly (6).

f. Remove nuts and bolts (27, 28, and 29) from front mount assembly (26).

**CAUTION**

Exercise care not to damage oil lines when removing engine.

g. Carefully lift the engine, including rear mount assembly (7) from container (42), first sliding the engine assembly away from front mount assembly (26) until the reduction unit mounting studs are clear of front mount assembly (26).

h. Loosen bolts (17) and slide side load brackets (14) away from the engine.

i. Remove nuts (32), bolts (33), spacers (31), rear mount assembly (7), and hold down bar (30) from the engine assembly.

j. Remove the engine records from record receptacle (43).

4-4. OIL COOLER AND EDUCTOR. (See figure 4-2.) Remove the oil cooler installation according to the following instructions.

a. Drain oil sumps (see paragraph 2-32).

b. Remove magnetic chip detectors (47, figure 4-9) and O-rings (48) before starting disassembly procedures to prevent damage to detectors.

c. Disconnect hose assembly (1, figure 4-2) from union (2) in oil cooler.

d. Disconnect hose assemblies (3 and 4) from tee (5) in oil cooler.

e. Remove union (2), nut (6), and O-ring (7) from oil cooler. Discard O-ring.

f. Remove tee (5), lock nut (8), and O-ring (9) from oil cooler. Discard O-ring.

g. Remove nuts (10), washers (11 and 12), bolts (13) and washers (13A) from reduction unit end of oil cooler (20).

h. Remove two bolts (14), and washers (15) from compressor end of oil cooler (20).

i. Remove plug (16) and gasket (17) from oil cooler.

j. Remove bolts (18) and washers (19) and remove oil cooler (20) from eductor assembly (23).

k. Remove clips (21), loosen turnbuckle barrels (22) and remove nut (24), washer (25), bolt (26), and fork (27) from each eductor assembly bracket. Discard clips.

l. Remove eductor assembly from power output section.

m. Remove nut (28), washer (29), bolt (30), and fork (31) from each exhaust collector bracket.

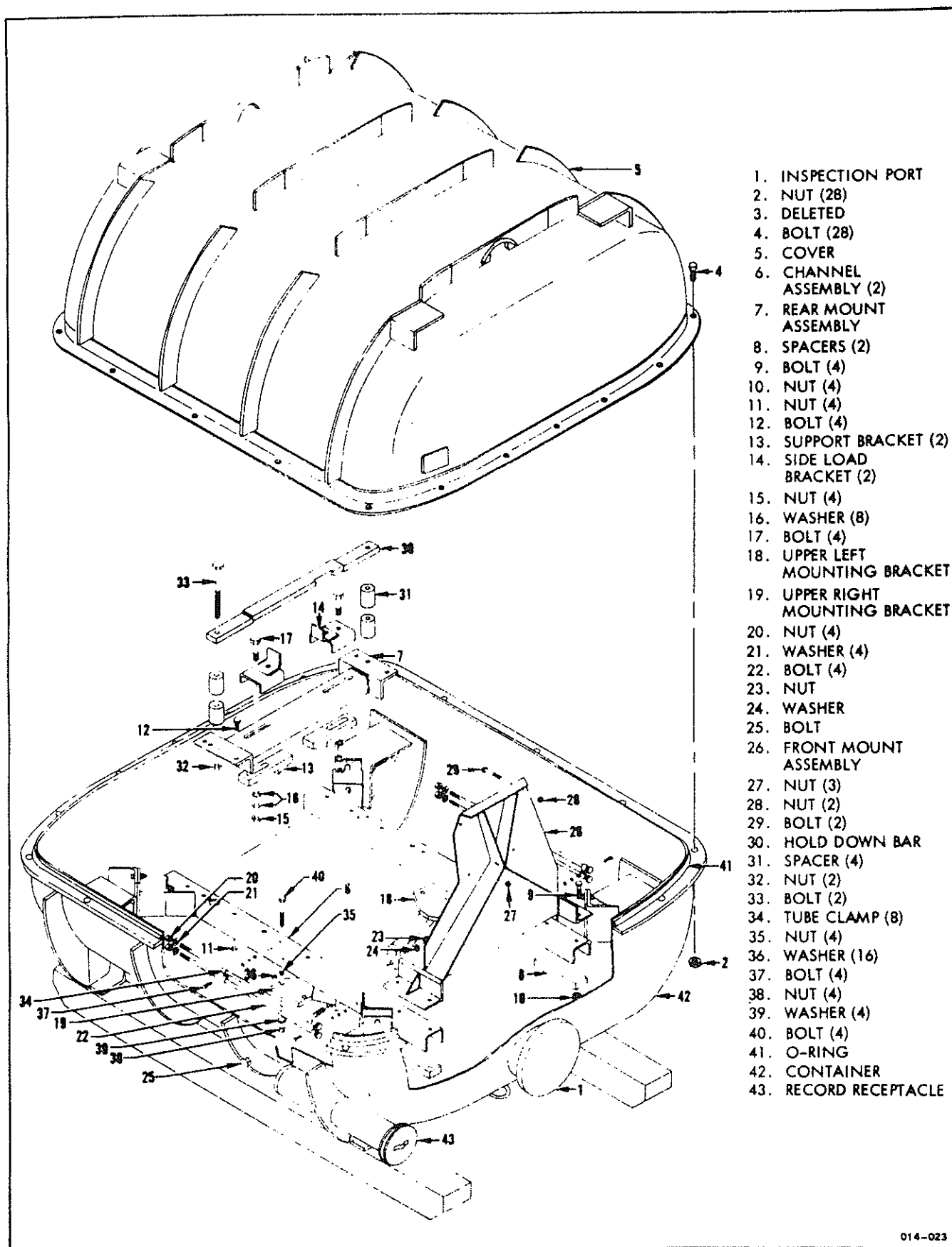
n. Do not remove bolts (32 and 33), washers (34, 35, and 36), or brackets (37 and 38) from compressor end of sump unless repair or replacement is necessary.

4-5. OUTPUT SECTION GOVERNOR AND CONTROL LINKAGE. (See figure 4-3.) Remove the governor and control linkage according to the following instructions:

a. Remove spring (1) from collar (21) and bracket assembly (30).

b. Remove nuts (2), washers (3), bolts (4), and control rod (5) from output governor lever (42) and shaft lever (17). Do not remove rod ends (6) or checknuts (7) from control rod unless damaged.

c. Remove nuts (8), washers (9), bolts (10) and control rod (11) from shaft lever and fuel control unit lever. Do not remove rod ends (12) or check nuts (13) from control rod unless damaged.



014-023

Figure 4-1. Shipping Container



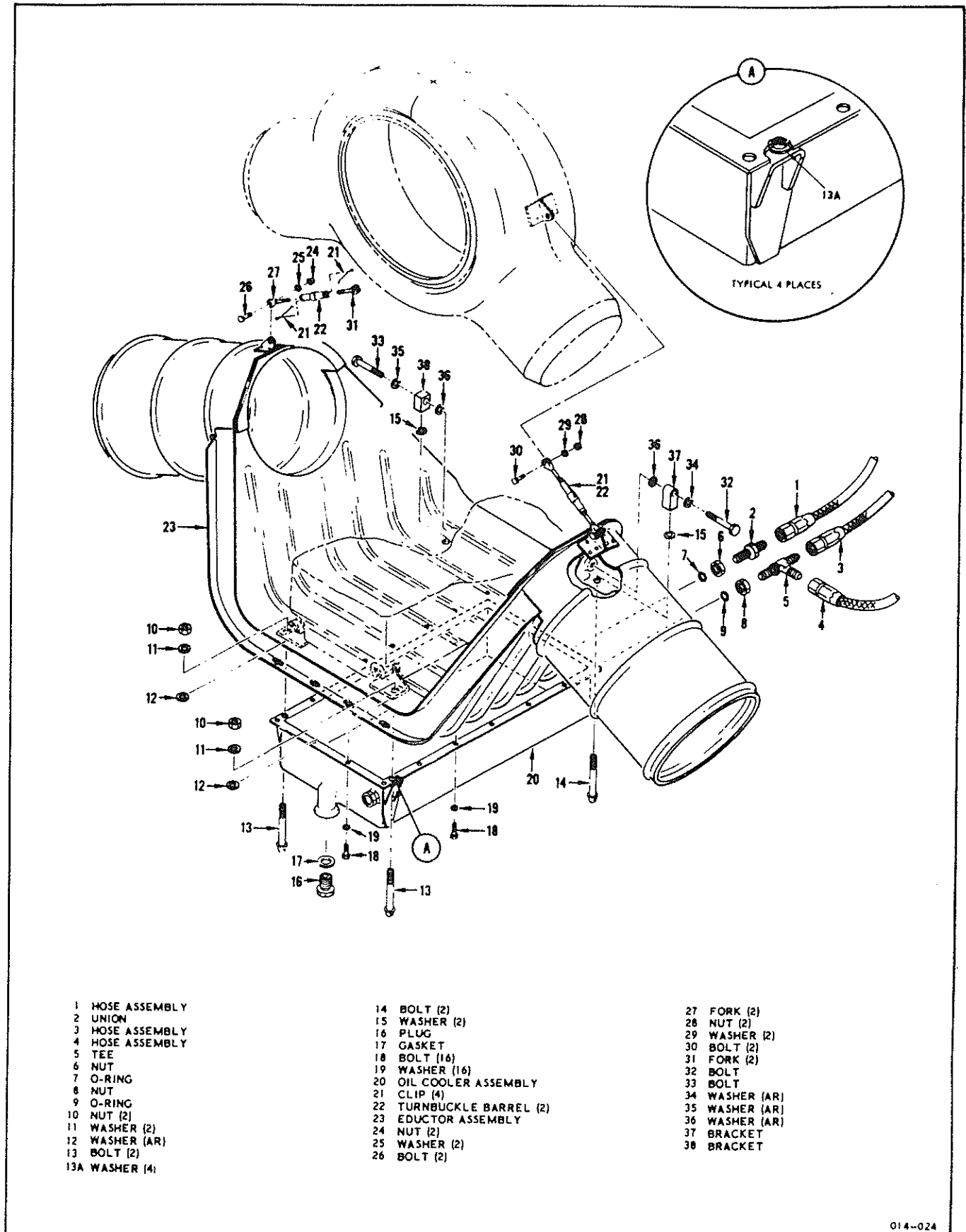


Figure 4-2. Oil Cooler and Eductor Installation, Exploded View

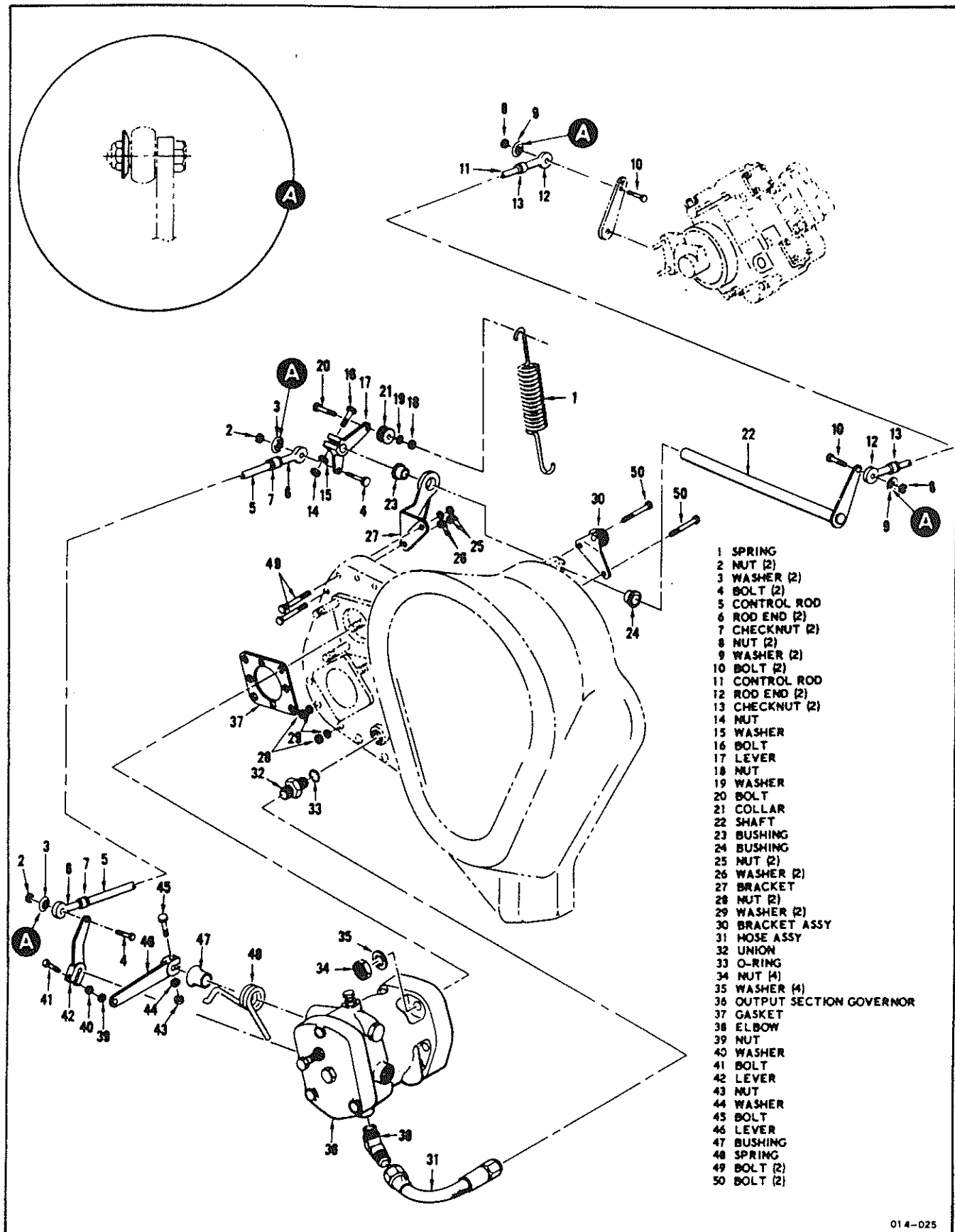


Figure 4-3. Output Section Governor and Control Linkage Installation, Exploded View

- d. Remove nut (14), washer (15), bolt (16), and lever (17) from shaft (22).
- e. Remove nut (18), washer (19), bolt (20), and collar (21) from lever (17).
- f. Slide shaft (22) from bracket (27) and boss on reduction unit.
- g. Remove bushings (23 and 24) from bracket (27) and boss on reduction unit.
- h. Remove nuts (25), washers (26), and bracket assembly (27). Reinstall washers (26) and nuts (25) finger tight.
- i. Remove nuts (28), washers (29), and bracket assembly (30). Reinstall washers (29) and nuts (28) finger tight.
- j. Disconnect hose assembly (31) from output section governor (36) and reduction unit. Remove union (32) and O-ring (33) from reduction unit. Discard O-ring.
- k. Remove nuts (34), washers (35), output section governor (36), and gasket (37) from reduction unit. Discard gasket. Do not remove elbow (38), nut (39), washer (40), bolt (41), lever (42), nut (43), washer (44), bolt (45), lever (46), bushing (47), or spring (48) from output section governor unless damaged.

4-6. BURNER SECTION. (See figure 4-4.) Remove the burner section according to the following instructions:

#### NOTE

For burner disassembly, use special tools from Group 1, Table I.

- a. Remove bolts (1), washers (2), and remove crossfire tube assembly (3 through 6) and gaskets (7) from burner shells. Discard gaskets.
- b. Remove bolts (3) and elbows (4) from crossfire tube (6); remove seal rings (5) from each elbow.
- c. Remove igniter plug electrical leads (30, 37 through 39, figure 4-8).
- d. Loosen nuts (8, figure 4-4) and remove burner inlet bolts (9), O-rings (10 and 11) and washers (12). Discard O-rings.
- e. Remove burners (13) by pushing burner being removed into nozzle box while swinging upstream end of burner outward (see figure 4-5). Pull burner from nozzle box when upstream end is clear of compressor case.
- f. Remove clamp (14, figure 4-4), and remove inlet adapter assembly (15) from burner shell (21).
- g. Remove O-ring (16) from upstream end of burner shell. Discard O-ring.
- h. Remove retaining ring (17) and graphite seal (18) from downstream end of burner shell. Do not discard graphite-coated asbestos O-ring (18) unless damaged.
- i. Remove liner (19) from burner shell (21). Do not remove liner support (20) from burner shell unless damaged.
- j. Remove remaining bolt (22) and washer (23), igniter plug (24) and gasket (25) from burner shell. Discard gasket and igniter plug.
- k. Remove screws (26); remove and discard gasket (27).
- l. Using special burner dome wrench, Tool Group No. 1, remove assembly of burner dome (28), shim (29), fuel nozzle (32), nozzle adapter (30), and O-ring (31) from inlet adapter (33). (See figure 4-6.) Remove burner dome (28, figure 4-4) fuel nozzle (32), and shim (29) from nozzle adapter (30). Discard fuel nozzle (32).

4-7. FUEL SYSTEM. (See figure 4-7.) Remove fuel system according to the following instructions:

- a. Remove nut (1) and bolt (2) and remove clamps (3) from hose assemblies (8 and 31).
- b. Remove bolt (4) and clamp (5) from compressor case.
- c. Disconnect and remove hose assemblies (6 and 7) from tee (26) in fuel shutoff valve, tee (11), and elbow (14) in burner inlet bolts.
- d. Disconnect hose assembly (8) from elbow (23) in fuel shutoff valve and elbow (67) in fuel control unit.
- e. Remove fittings, nuts, and O-rings (9 through 16) from burner inlet bolts. Discard O-rings (10, 12, and 15).
- f. Disconnect electrical connector from fuel shutoff valve (20).
- g. Remove bolt (17), washer (18), nut (19), and fuel shutoff valve and bracket assembly (20 through 30) from compressor case. Do not remove bolt (21) and bracket (22) from fuel shutoff valve (20) unless repair or replacement is necessary.
- h. Remove tee (26), elbow (23), plug (29), O-rings (24, 27, and 30) and nuts (25 and 28) from fuel shutoff valve (20). Discard O-rings.
- i. Disconnect and remove hose assembly (31) from elbow (45) in fuel filter and elbow (56) in fuel control unit pump.
- j. Disconnect hose assembly (32) from elbow (42) on fuel filter and elbow (92) on fuel boost pump. Remove bolt (51), washer (52), and clamp (53) and remove hose assembly (32).
- k. Remove bolts (33) and washers (34) and remove fuel filter and bracket assembly (35 through 47) from engine. Do not remove bracket (40) and attaching hardware (35 through 39) from fuel filter (41) unless repair or replacement is required.
- l. Remove fittings, nuts, and O-rings (42 through 47) from fuel filter (41). Discard O-rings (43 and 46).
- m. Disconnect and remove hose assembly (50) from nipple (84) on compressor case and elbow (59) in fuel control unit. Do not remove nipple (84) unless replacement is necessary.
- n. Disconnect drain tube (48) from elbow (89) in fuel boost pump, and drain tube (49) from elbow (64) in fuel control unit pump.
- o. Remove bolts (51), washers (52), fuel control unit (54), and gasket (55). Discard gasket.
- p. Remove elbow (56), O-ring (57), and nut (58) from fuel control unit pump.
- q. Remove elbow (59), O-ring (60), and nut (61) from reducer (62), and remove reducer (62) and O-ring (63) from fuel control unit. Discard O-rings.
- r. Remove elbow (64), O-ring (65), and nut (66) from fuel control unit pump. Discard O-ring.
- s. Remove elbow (67), O-ring (68), and nut (69) from fuel control unit. Do not remove nut (70), indicator plate (71), and lever (72) from fuel control unit unless damaged. Do not remove nuts (73), high speed stop screw (74), fine adjustment nut (75), and fine adjustment screw (76) from fuel control unit unless damaged. Do not remove screws (77), washers (78), filter cover (79), O-ring (80), filter (81), spring (82), and O-ring (83) from fuel control unit except for filter servicing.
- t. Remove bolts (85), washers (86), bracket (16, figure 4-8), fuel boost pump (87, figure 4-7), and gasket (88). Discard gasket.
- u. Remove fittings, nuts, and O-rings (89 through 96) from fuel boost pump. Discard O-rings (90 and 96).

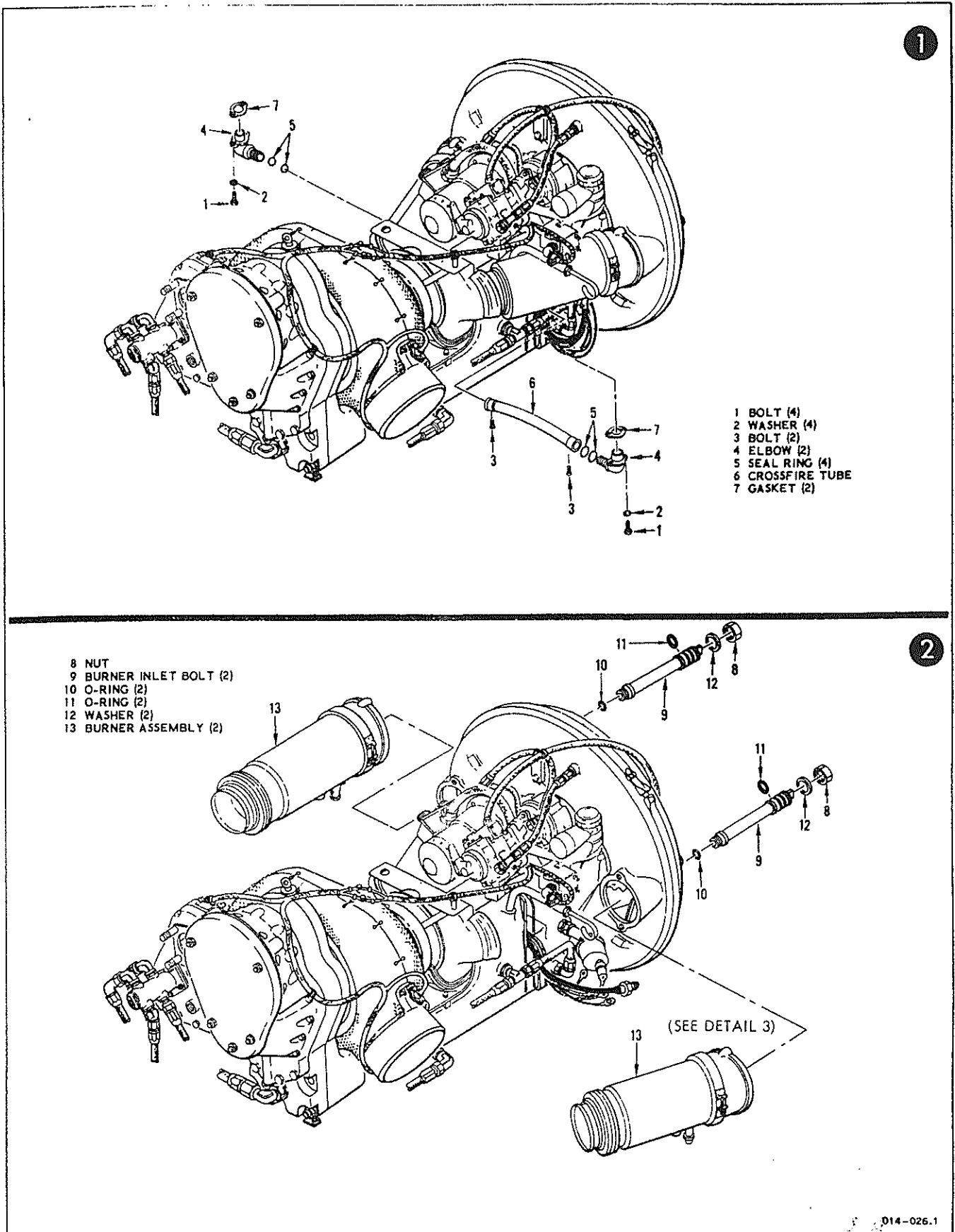


Figure 4-4. Burner Section Installation, Exploded View (Sheet 1 of 2)

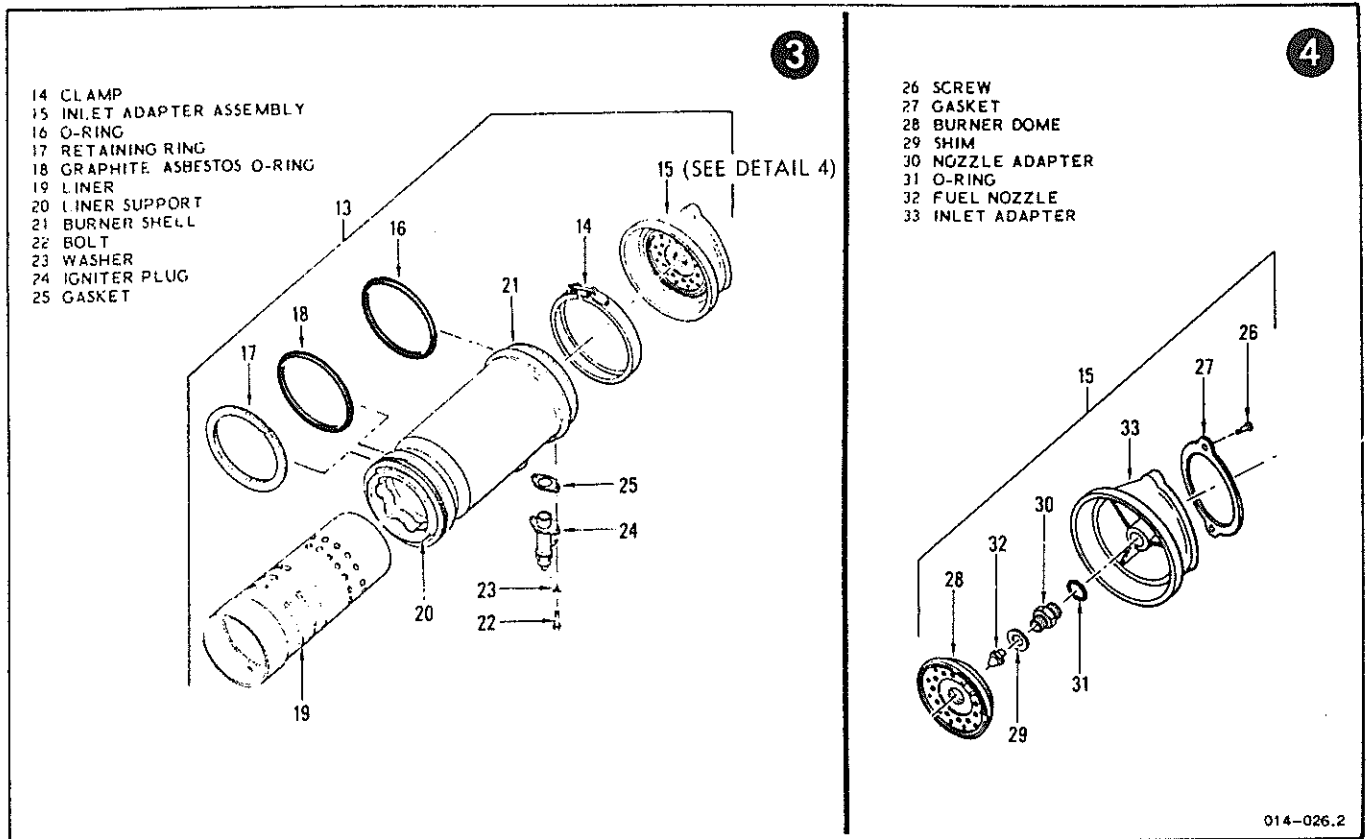
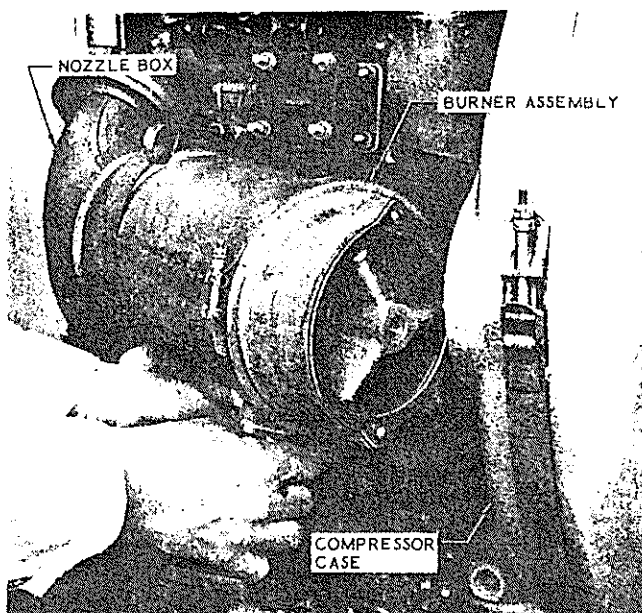


Figure 4-4. Burner Section Installation, Exploded View (Sheet 2 of 2)



014-027

Figure 4-5. Burner Section Removal

4-8. ELECTRICAL SYSTEM. (See figure 4-8.) Remove the electrical system according to the following instructions:

- a. Remove bolt (1), washer (2), nut (3), washer (4) and bolt (5); remove clamps (6) from reduction unit; re-

move nuts (7), washers (8), and bolts (9) from four thermocouples; remove nuts (10), washers (11) and bolts (12); remove thermocouple harness (13) from engine. Discard bolts (9), washers (8), and nuts (7).

b. Remove clamps (17 and 18) securing engine wire harness branches to mounting bracket (19) by removing nuts (14), and bolts (15 and 16). Remove bolts (20 and 21) and clamps (22 and 23) securing harness branch and high tension lead to rotor housing. Remove nut (24), bolt (25), washer (26), spacer (27), and clamp (28) securing thermocouple lead to exhaust collector heat shield.

c. Remove harness, ignition leads and fuel drain tube assemblies by removing bolt (29), clamps (30), and spacer (31). Remove bolts (32), washers (33) and clamp (34). Remove ignition exciter (35).

d. Remove nuts (36), washers (37), and screws (38) securing glow coil lead terminals (39) to igniter plugs. Remove high-tension leads (40) from igniter plugs. Remove bolts (41) and washers (42) securing ground lead terminals (43, 44, and 45) to igniter plugs.

## NOTE

There is only one ground lead terminal on left-hand side of engine. If burner sections have been removed, disregard step d.

- e. Remove screws (46) from junction box cover (50); loosen screws on clamp (47) and slide cover assembly (47 through 50) along harness. Inside junction box,

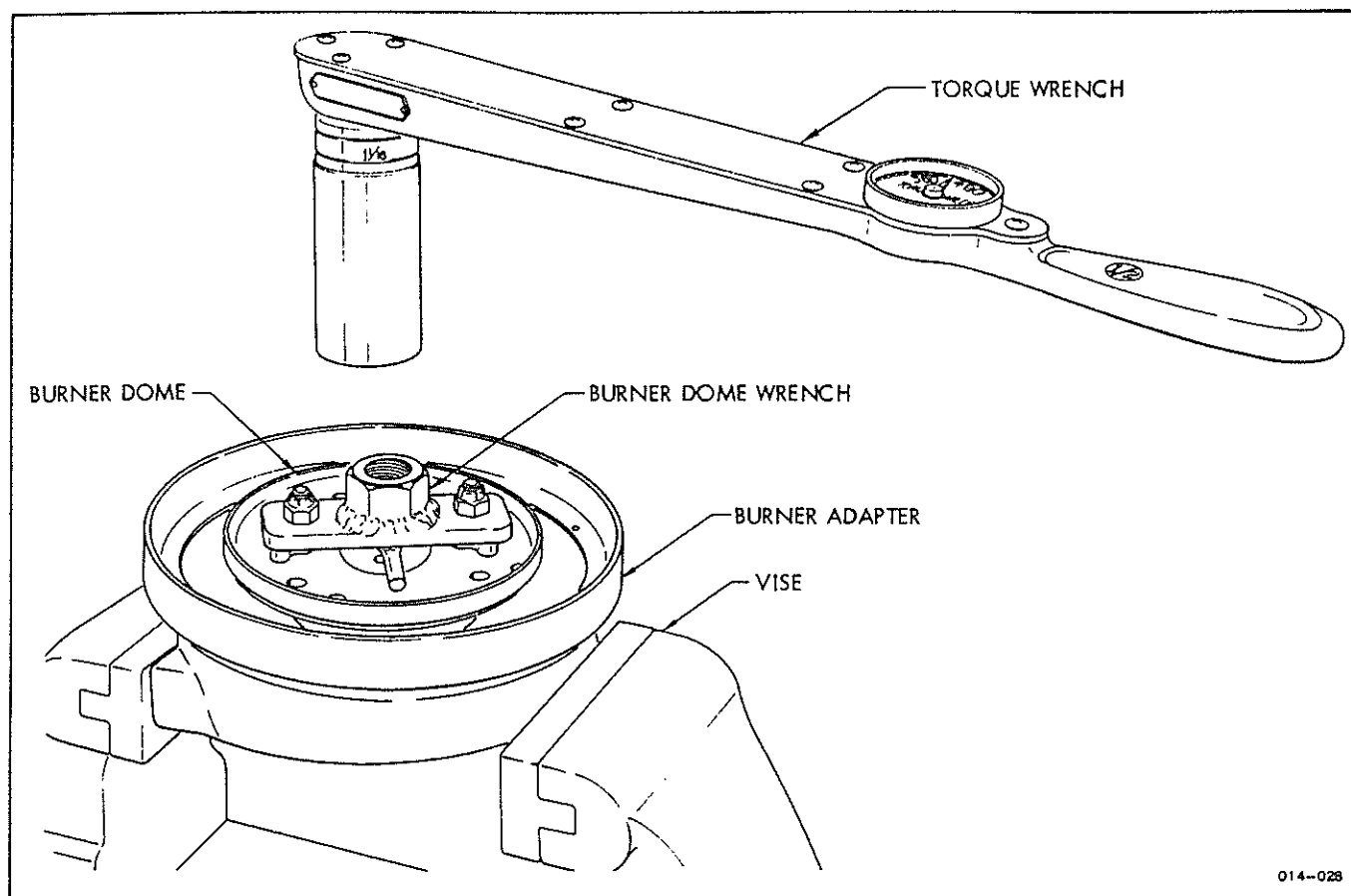


Figure 4-6. Use of Burner Dome Wrench

remove starter-generator terminal nut (51) and terminal block nut (52). Remove terminals (53, 54, and 55). Remove nuts (56) and screws (57) securing connector (58), and remove harness from junction box.

f. Disconnect connectors (59, 60, 61 and 61A) from speed monitor, ignition exciter, oil pressure switch and fuel valve. Remove harness assembly from the engine. Do not disassemble harness components unless repair or replacement is necessary.

**CAUTION**

When disconnecting connector (61A) from the fuel valve, hold the valve body while loosening connector to prevent body being turned loose from the base.

g. Remove nuts (62, 63, and 64) from starter-generator studs and remove harness lead terminals (65, 66, 67, and 68). Remove nuts (69) and screws (70) securing connector (71), and remove harness assembly from junction box. Do not disassemble harness assembly unless repair or replacement is necessary. Do not remove block assembly (72 through 74) unless repair or replacement is necessary.

h. Remove nuts (75 through 78), insulating bushings (79 through 82), and junction box assembly (83).

i. Remove bolts (84), washers (85), starter-generator (86) and gasket (87) from accessory housing. Discard gasket.

4-9. LUBRICATION SYSTEM. (See figure 4-9.) Remove the lubrication system according to the following instructions:

- Remove bolts (1), clamps (2 and 3), washers (4) and spacer (5) from output housing.
- Remove nuts (6), bolts (7), and clamps (8) from hose assemblies.
- Disconnect hose assembly (9) from union (28) and tee (25).
- Disconnect hose assembly (10) from elbow (44) in pump and union (15, figure 4-19) in reduction unit.
- Disconnect hose assembly (11, figure 4-9) from tee (25) in sump and elbow (38) in pump.
- Disconnect hose assembly (12) from elbow (22) in sump and union (41) in pump.
- Disconnect hose assembly (13) from elbow (35) in pump.
- Disconnect hose assemblies (14 and 15) from elbows (16 and 19) in gas producer section.
- Remove elbows (16 and 19), O-rings (17 and 20), and nuts (18 and 21) from gas producer section. Discard O-rings.
- Remove elbow (22), O-ring (23), and nut (24) from sump base. Discard O-ring.
- Remove tee (25), O-ring (26), and nut (27) from sump base. Discard O-ring.

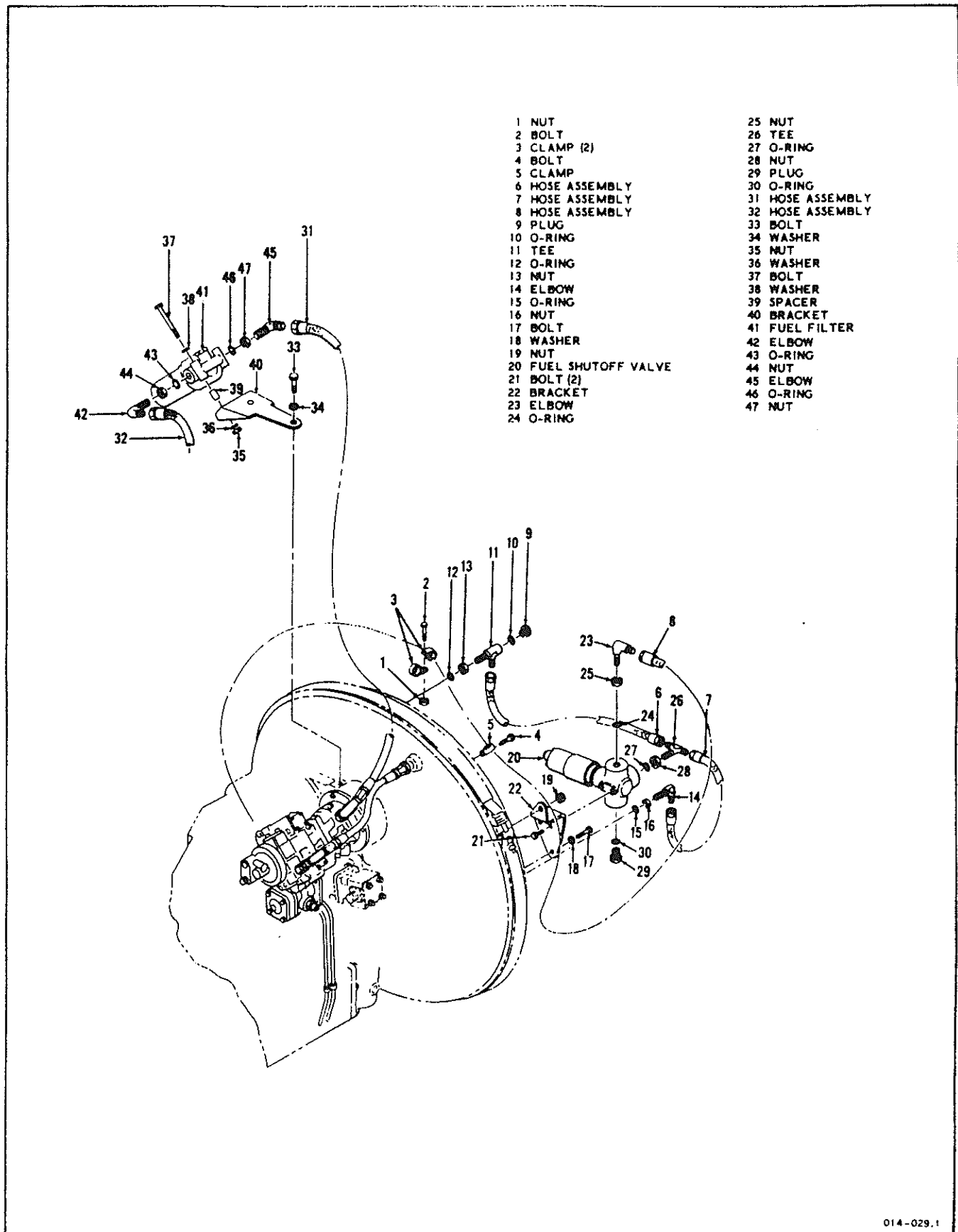


Figure 4-7. Fuel System Installation, Exploded View (Sheet 1 of 2)

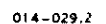


Figure 4-7. Fuel System Installation, Exploded View (Sheet 2 of 2)



- l. Remove union (28), O-ring (29), and nut (30) from accessories housing. Discard O-ring.
- m. Remove nuts (31), washers (32), lube pump (33), and gasket (34). Discard gasket.
- n. Remove elbows (35, 38, and 44), union (41), O-rings (36, 39, 42, and 45), and nuts (37, 40, and 46) from pump. Discard O-rings. Remove chip detectors (47) and seal assembly (48).

## NOTE

Seal assembly (48) consists of two parts: a steel washer and an O-ring.

#### 4-10. ENGINE DISASSEMBLY INTO SUBASSEMBLIES.

(See figure 4-10.) Disassemble the engine assembly according to the following instructions:

- a. Do not remove bolt (1), washer (2), and lifting lug (3) from compressor case unless damaged.
- b. Remove screen (4) from air inlet bell (6).
- c. Remove clamp (5) and air inlet bell (6) from compressor case.
- d. Remove nuts (7), washers (8), eductor mounting brackets (9), and washers (10) from reduction unit attaching studs and separate the reduction unit section (12) from the gas producer section (11). (See figure 4-11.) Remove two O-rings (13, figure 4-10) from between housings and discard.
- e. Remove clamp (14) and remove nozzle ring (15) from gas producer section.
- f. Check gas producer turbine wheel tip radial clearance in accordance with Table VIII, Section XI. If tip clearance is beyond limit, nozzle box is warped and should be replaced.

#### 4-11. GAS PRODUCER SECTION.

(See figure 4-12.) Disassemble the gas producer section according to the following instructions:

## NOTE

For gas producer disassembly, use special tools from Table I, Group 9.

- a. Remove nuts (1), speed monitor (2), and gasket (3) from engine. Discard gasket.
- b. Remove drain bolt (4), washer (5), and seal (6) from oil filter body.
- c. Loosen and remove bolt (7), washer (8), seal (9), oil filter housing (10), and O-ring (11). Discard O-ring and seal.
- d. Remove spring (12), washer (13), O-ring (14), oil filter retainer (15), and filter element (16). Discard O-ring and filter element.
- e. Remove bolts (17), washers (18), accessory drive gear box (19) and gasket (20). Discard gasket.
- f. Remove oil pressure switch (23), and O-ring (24). Loosen nut (24C) and remove adapter (24A), O-ring (24B), nut (24C), cap (24D), reducer (24E) and O-ring (24F).
- g. Remove nuts (25), washers (26), and remove compressor section (27) and shims (28) from accessory section. Record total thickness of shims (28) for reference during assembly.
- h. Remove bolts (29), washers (30) and spinner (31). Using special inducer wrench, Tool Group No. 9, remove nuts (32 and 33), washer (34), inducer (35), and impeller (36). (See figure 4-13.)

**CAUTION**

Spinner (31, figure 4-12), bolts (29), washers (30) and inducer (35) are matched parts and must be kept together.

- i. Remove screws (37). Using two 1/4-20 bolts in threaded holes in end plate (38), remove end plate and O-ring (39) from accessories section housing. Discard O-ring. Do not remove plug (40) from end plate unless replacement is required.

**CAUTION**

Removal of end plate (38) will leave cluster gear (41) and shaft (42) without support on one end. Exercise care when removing end plate to prevent cluster gear and shaft from falling.

- j. Slide cluster gear (41) with shaft (42) out of accessory drive housing.
- k. Remove shaft (42) from cluster gear (41). Do not remove aligning pin (43) from shaft (42), or bearings (44) from cluster gear (41), unless replacement is necessary.
- l. Remove bolts (45), washers (46), bearing cap (47), insert (48) and O-ring (49) from end plate. Discard O-ring.
- m. Remove oil slinger (50), bearing retainer (51), and radial bearing (52).
- n. Remove O-rings (53) from bearing retainer and discard.
- o. Remove air seal tube (55) and O-ring (54). Discard O-ring.
- p. Remove segmented bearing assembly (56), bearing sleeve (57), and pinion (58) from wheel and shaft assembly (59).

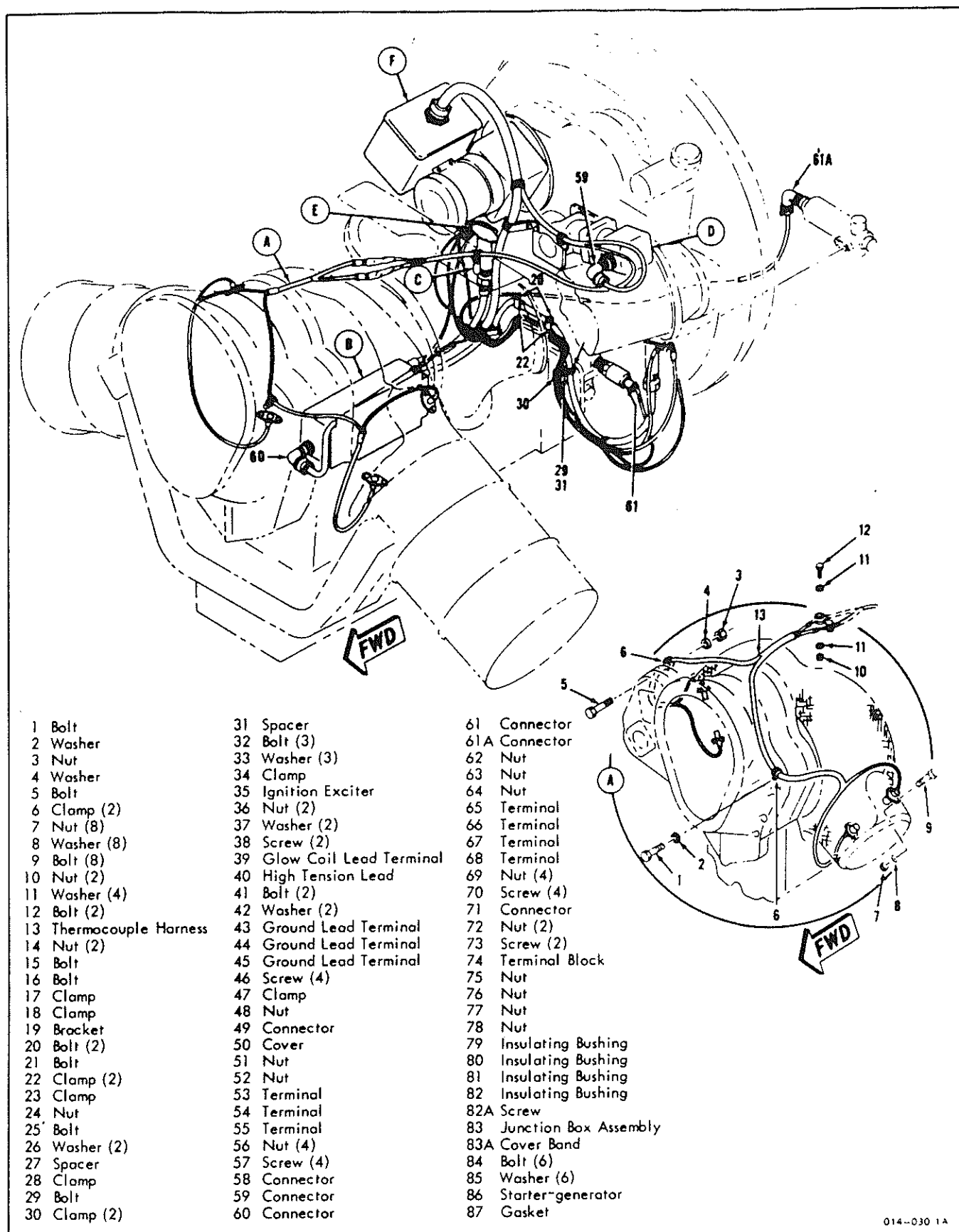
## NOTE

Because of a close-tolerance fit and occasional fretting, a suitable bearing or gear puller may be needed to remove bearing sleeve (57) and pinion (58) from shaft. Cover puller jaws with brass or other soft material and remove sleeve and pinion carefully to prevent damage to shaft.

- q. Remove wheel and shaft assembly (59) from nozzle box end of gas producer assembly.

**CAUTION**

Use care when removing wheel and shaft assembly from rotor housing. If shaft threads rub on bearings, damage will result. Install wheel cover, Tool Group No. 9, on wheel and shaft assembly (59) when assembly is removed from engine.



014-030 1A

Figure 4-8. Electrical System Installation, Exploded View (Sheet 1 of 2)

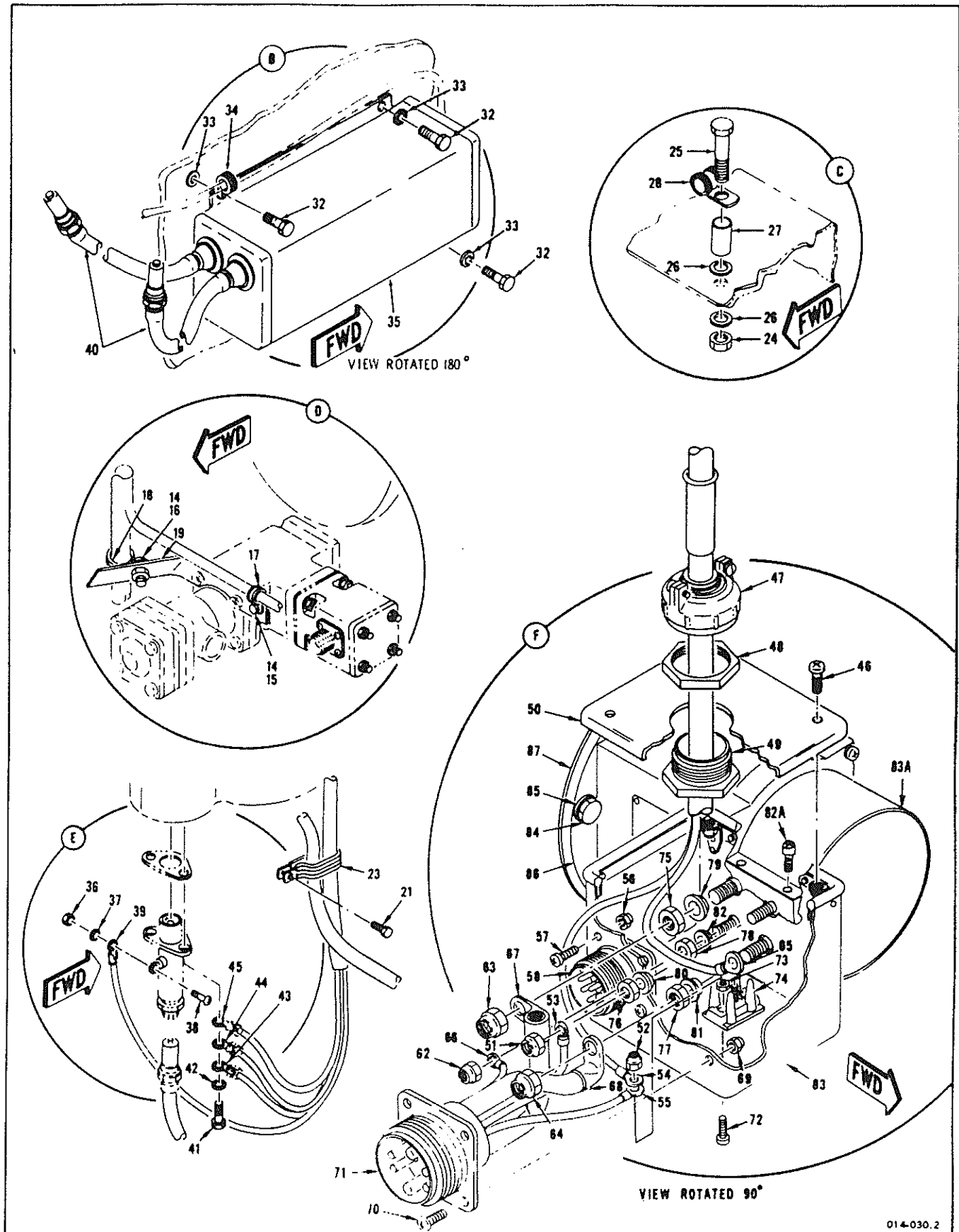
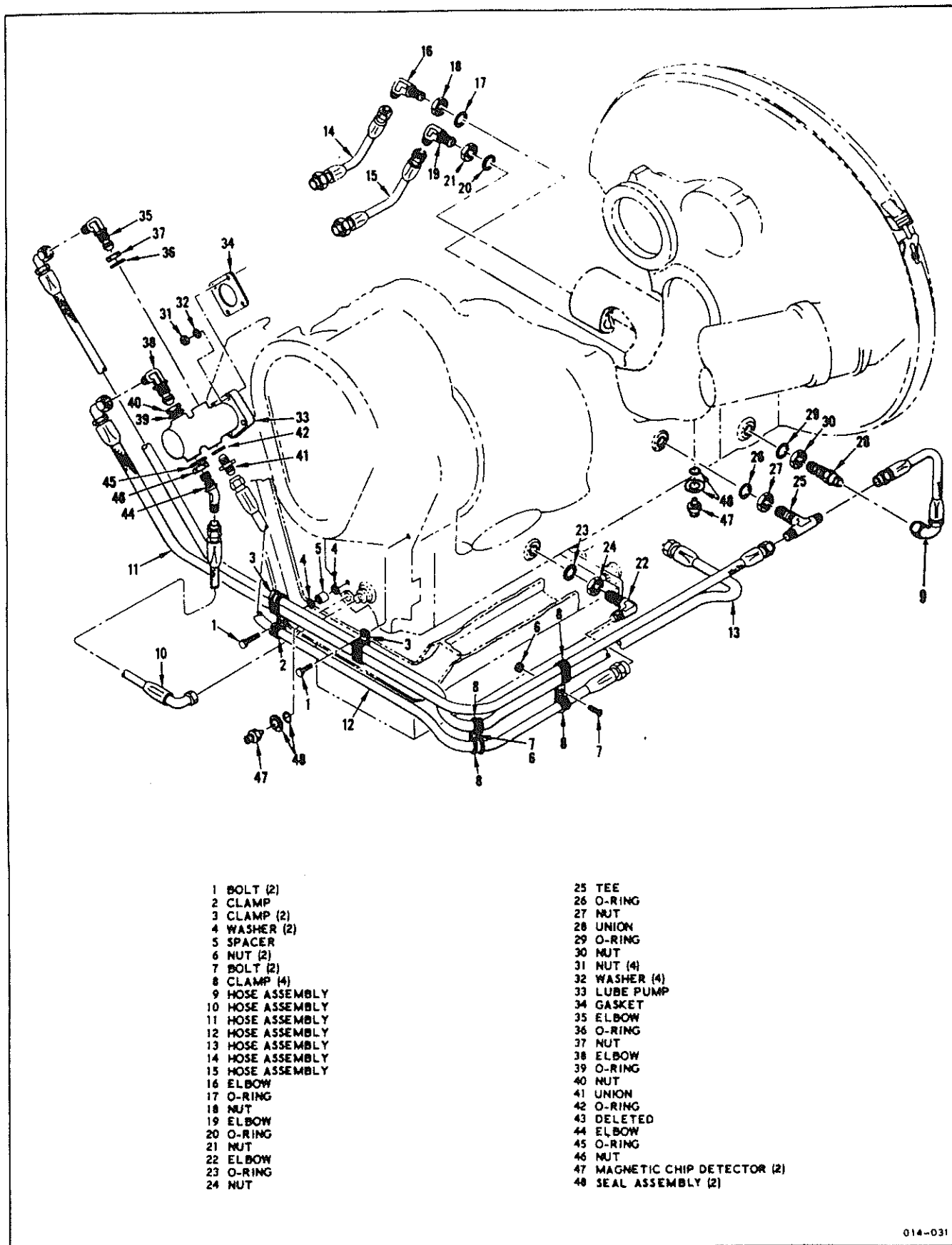
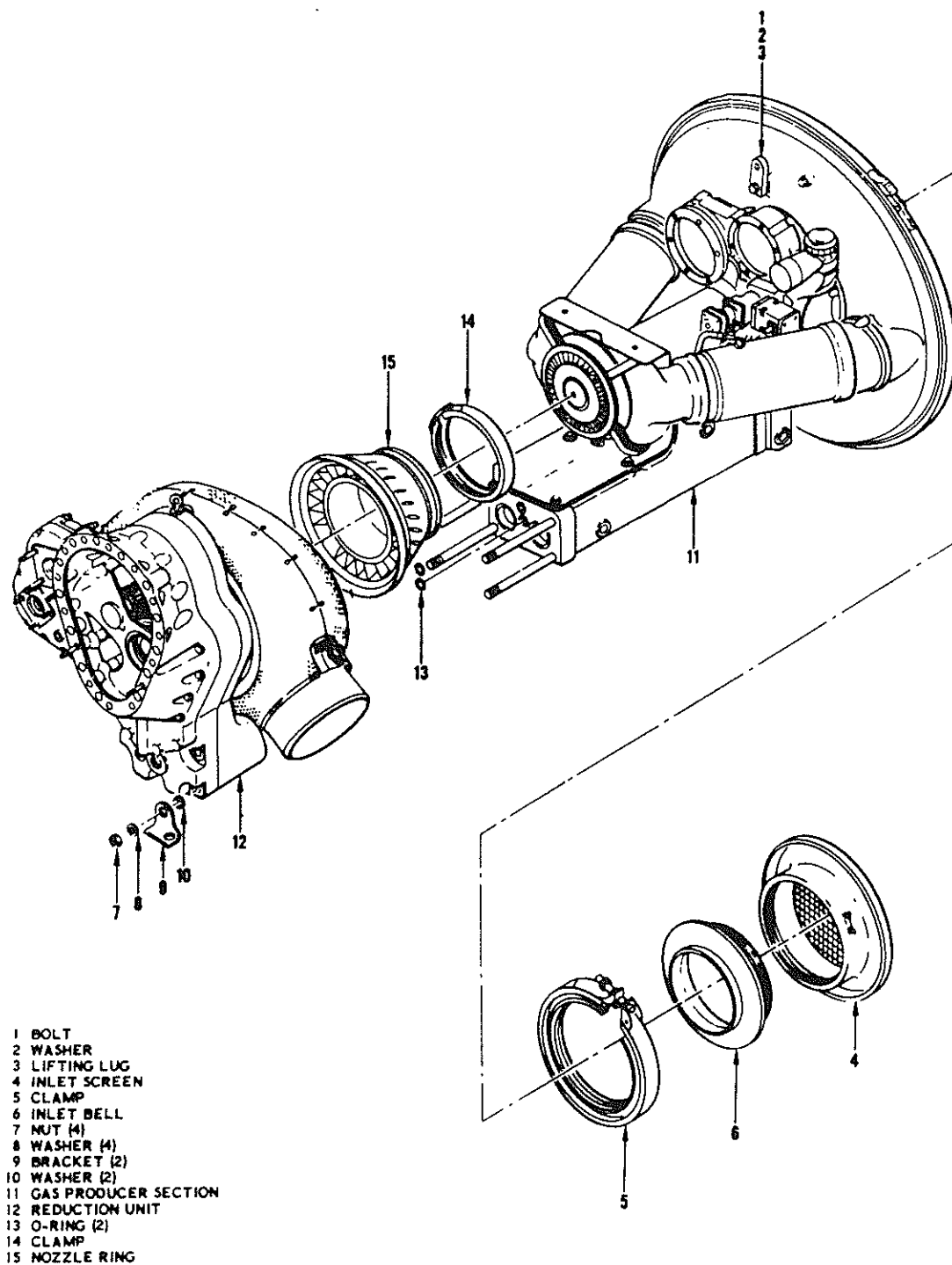


Figure 4-8. Electrical System Installation, Exploded View (Sheet 2 of 2)



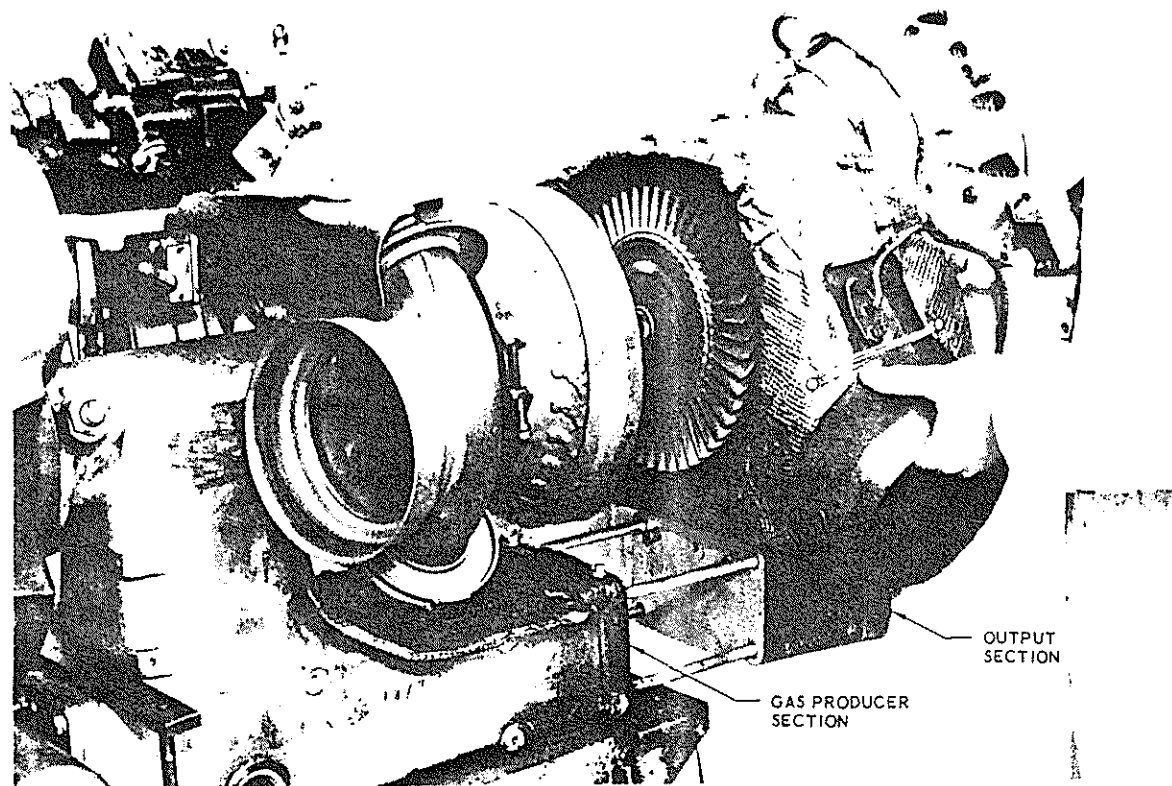
014-031

Figure 4-9. Lubrication System Installation, Exploded View



014-032

Figure 4-10. Engine Subassemblies, Exploded View



014-033

Figure 4-11. Separating Output Section and Gas Producer Section

#### NOTE

Measure wheel outside diameter before removing blades from wheel.

r. Remove turbine blades (60) and clips (61) from wheel hub after bending out tangs on clips.

#### CAUTION

Keep each set of turbine blades with its respective wheel and shaft assembly. When removing blades, keep them in consecutive order. All blades must be numbered consecutively on the base of the blade shank beginning with the number 1 position on the hub. Use noncarbonaceous ink to identify blades in the order of removal until number 1 position is located. Number 1 position is the slot between the keys marked with the part number and the number 1. If these numbers cannot be found, vibro-etch the hub part number and first three blade numbers as illustrated in figure 4-14. Etch the hub serial number on the key nearest the part number that is steel stamped at the center of the hub. (The serial number will also be found steel-stamped at the center of the hub.) After locating the number 1 slot, vibro-etch the correct position number on the base of each blade shank. If after inspection the blades are serviceable, install each blade in its original position. Installing blades in their original positions eliminates the need for rebalancing the wheel and shaft assembly during reassembly of the engine.

s. Remove nut (62, figure 4-12), washer (63), guide (64), gasket (65), adapter nut (66), and washer (67). Remove oil cooler adapter (68) and O-rings (69 and 70). Discard O-rings.

t. Remove relief valve (71), ball (72), and spring (73) from accessories housing.

u. Remove bolts (74) and washers (75) at rotor area and bolts (76) and washers (77) at sump area, and remove accessories housing (78) from rotor housing and sump (84).

v. Remove and discard gaskets (79 and 80).

w. Remove and discard O-rings (81, 82, and 83).

4-12. COMPRESSOR SECTION. (See figure 4-15.) Disassemble the compressor section according to the following instructions:

a. Remove clamp (1) and separate compressor casings (2 and 3).

b. Remove large O-ring (4) from outer flange and O-ring (5) from diffuser assembly (6). Discard O-rings.

c. Remove diffuser assembly (6) from casing.

d. Remove nuts (7), washers (8), bolts (9), spacers (10), and plates (11). Discard bolts (9) and nuts (7).

e. Remove drain plug (12) and O-ring (13). Discard O-ring.

4-13. ACCESSORIES SECTION. (See figure 4-16.) Disassemble the accessories section according to the following instructions:

a. Remove lubrication pump mounting bolts (1) and washers (2). Install two 1/4-20 bolts in threaded holes of pump flange. Screw bolts in evenly, far enough to loosen pump and gasket from housing. Use bolts as handles and remove pump assembly (3) and gasket (4) from housing. Discard gasket. (See figure 4-17.)

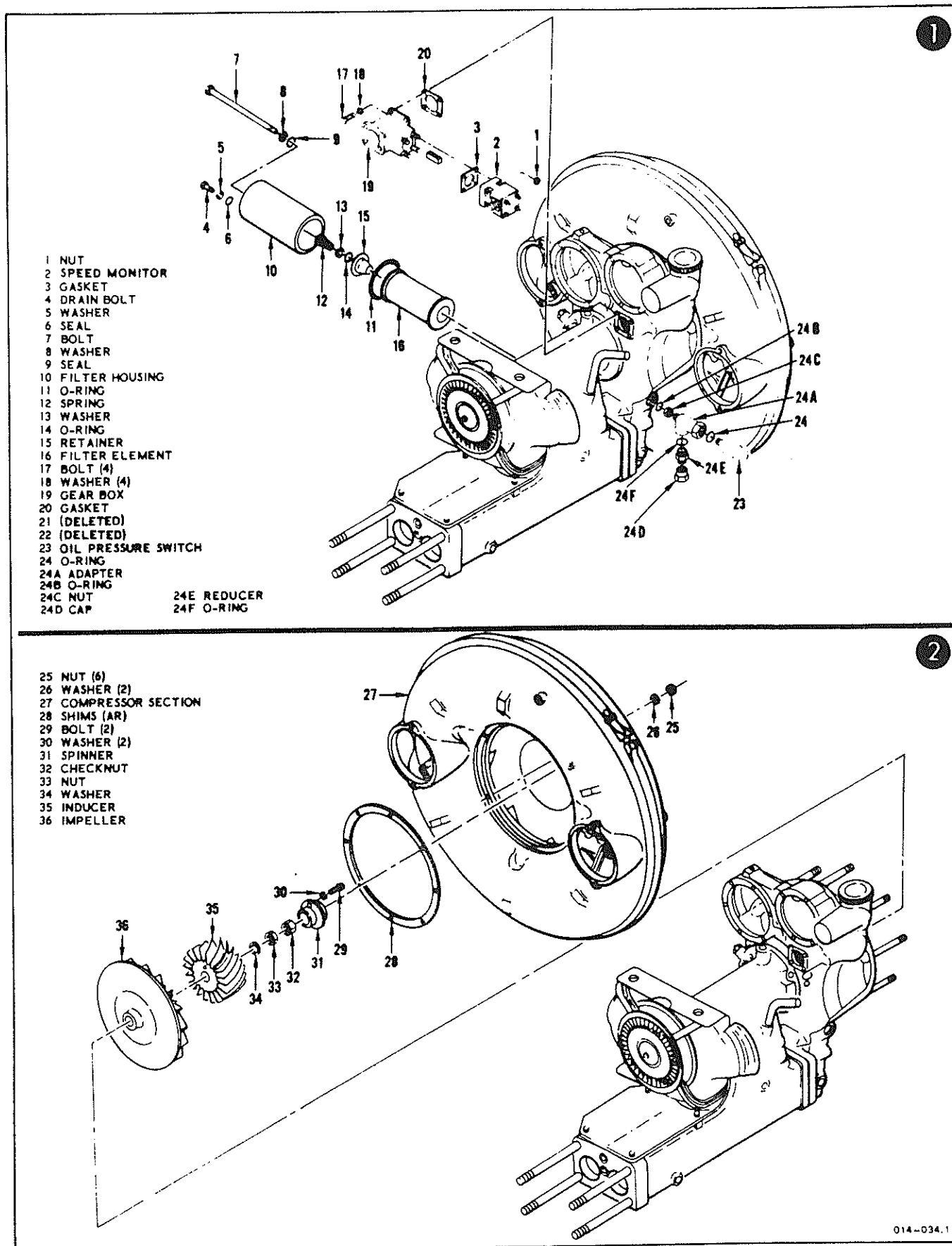
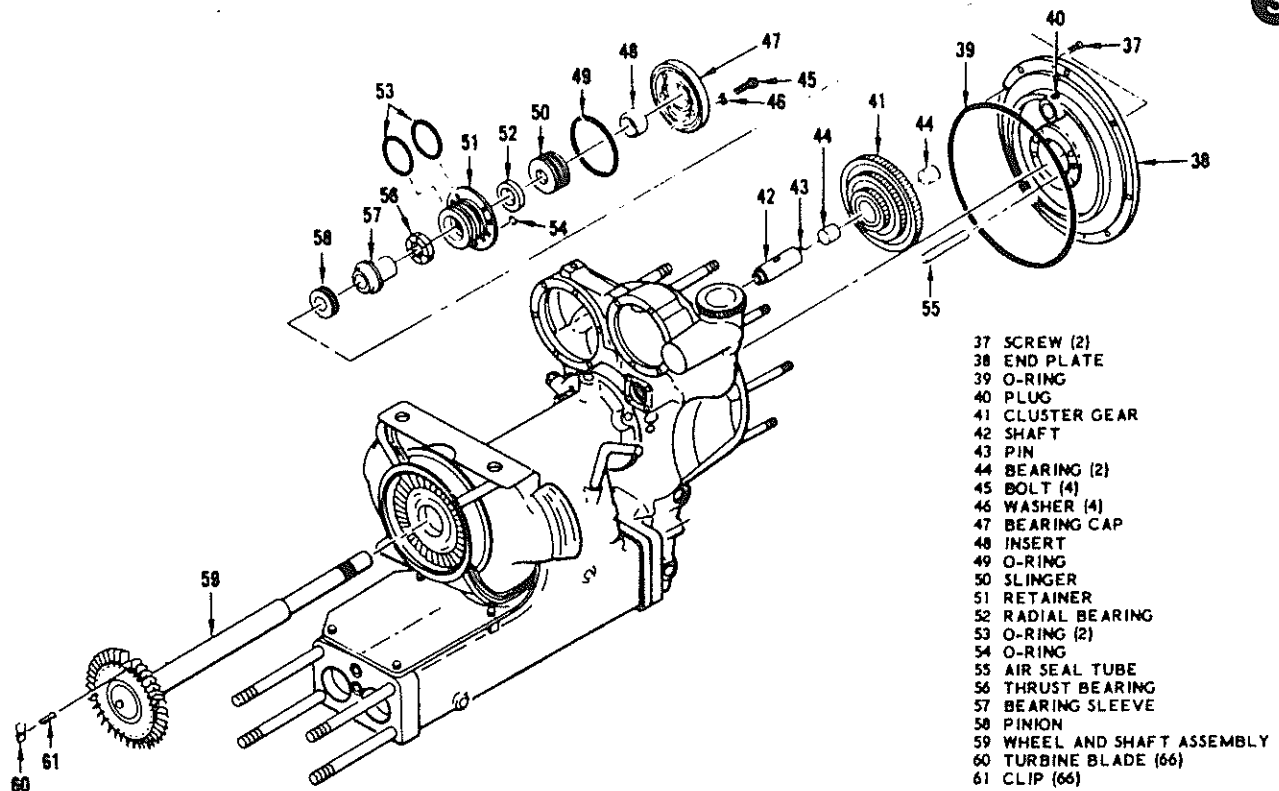


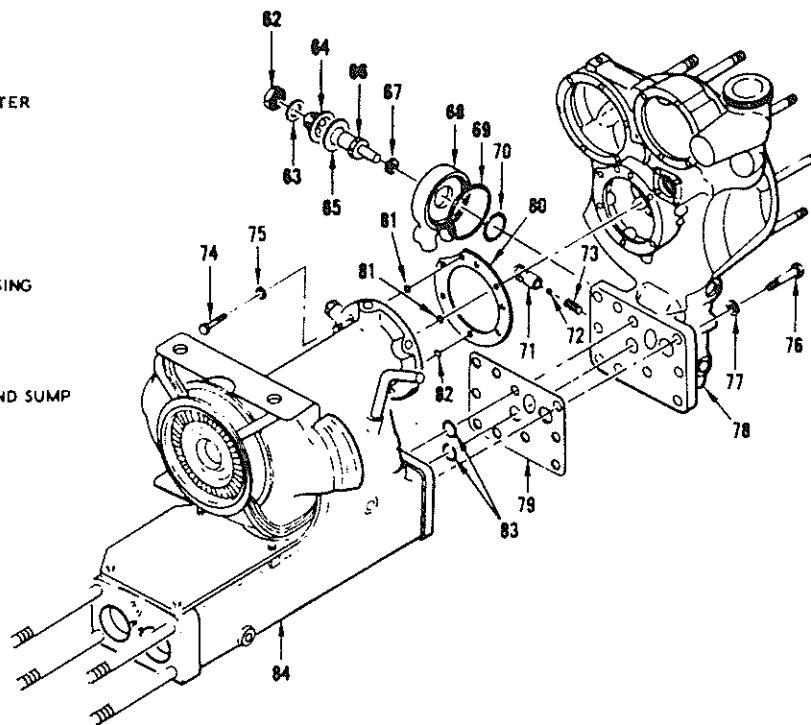
Figure 4-12. Gas Producer Section, Exploded View (Sheet 1 of 2)

3



4

- 62 NUT  
 63 WASHER  
 64 GUIDE  
 65 GASKET  
 66 ADAPTER NUT  
 67 WASHER  
 68 OIL COOLER ADAPTER  
 69 O-RING  
 70 O-RING  
 71 RELIEF VALVE  
 72 BALL  
 73 SPRING  
 74 BOLT (6)  
 75 WASHER (6)  
 76 BOLT (8)  
 77 WASHER (8)  
 78 ACCESSORIES HOUSING  
 79 GASKET  
 80 GASKET  
 81 O-RING (2)  
 82 O-RING  
 83 O-RING  
 84 ROTOR HOUSING AND SUMP



014-034.2

Figure 4-12. Gas Producer Section, Exploded View (Sheet 2 of 2)



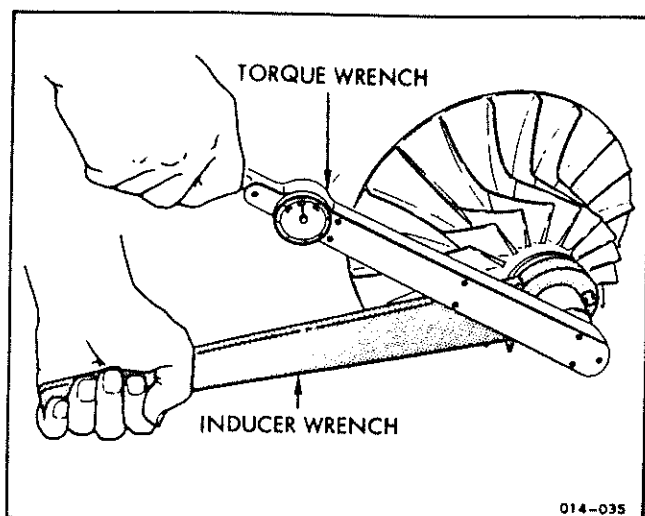


Figure 4-13. Removing and Installing Inducer Nut and Checknut.

- b. Remove pump drive shaft (5, figure 4-16). Remove and discard O-rings (6).
- c. Remove bolts (7 and 9) and washers (8) and remove lube pump drive bracket (10) from housing.
- d. Slide bevel gear (11) from bracket (10).
- e. Remove tachometer drive gear assembly (12) from housing (17). Do not remove bushing (13) unless replacement is necessary.
- f. Do not remove gasket (15) from filler cap (14) unless replacement is necessary. Do not remove filler and breather assembly (16) and attaching parts unless repair or replacement is required.

**4-14. ROTOR HOUSING AND SUMP SECTION.** (See figure 4-18.) Disassemble the rotor housing and sump section according to the following instructions:

- a. Remove oil dipstick (1).
- b. Remove nozzle box drain tube assembly (2) from elbow at bottom of nozzle box.
- c. Remove bolts (3) and air deflector (4) from center opening in nozzle box.
- d. Remove insulating ring (5), pin (6), insert (7), bearing cap (8), and gasket (9). Discard gasket.
- e. Remove bolts (10 and 11), lockwashers (12), washers (13), spacers (14) and insulation blanket (15) from housing.
- f. Remove nuts (16), washers (17), and bolts (18) and remove heat shield (19) from nozzle box.
- g. Remove nozzle box (22) from housing after removing bolts (20) and washers (21). Do not remove plug (23) and elbow (24) from nozzle box unless replacement is necessary.
- h. Remove bolts (25), retainer plate (26), retainer (27), and bearing (28) from housing.
- i. Remove bolts (29), washers (30), retainer plate (31), retainer (32), gasket (33), bearing (34), and O-ring (35) from housing. Discard gasket and O-ring.
- j. Remove oil tubes (36) from sump. Remove O-rings (37) from tubes and discard. Do not remove plugs (38) from sump unless replacement is necessary.
- k. Remove sump drain plug (39), gasket (40), and strainer (41) from housing. Discard gasket.
- l. Remove oil pressure regulator check nut (42), gasket (43), adjusting screw (44), spring (45), and piston (46) from housing (47).

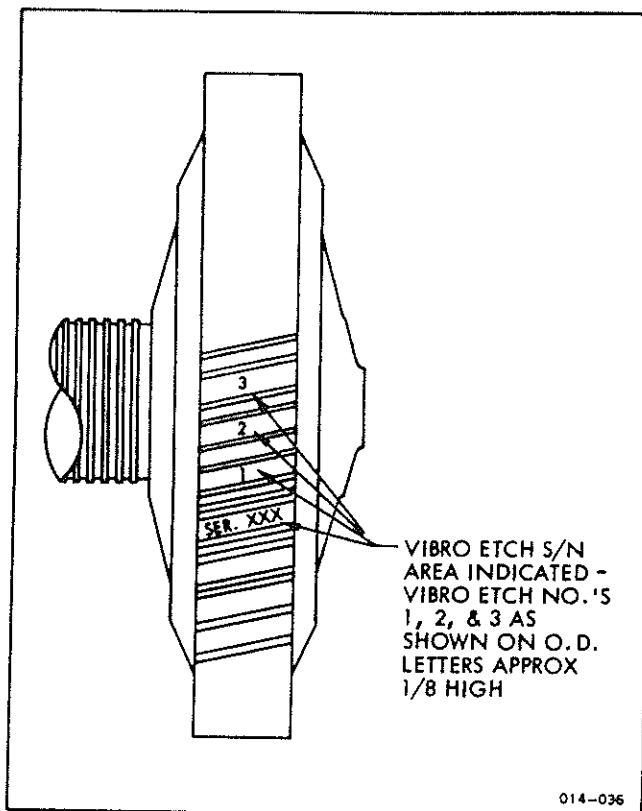


Figure 4-14. Blade Position Numbering on Turbine Wheel Hub.

**NOTE**

On engine units, Serial No. BO-E00001 through BO-E00104, replace adjusting screw (44) and piston (46) with new design relief valve assembly. On engines provided with new design relief valve assembly (44 and 46), parts must be kept together as a matched set.

**4-15. REDUCTION UNIT.** (See figure 4-19.) Disassemble the reduction unit according to the following instructions:

**NOTE**

For reduction unit disassembly, use special tools from Table I, Groups 7 and 8.

- a. Remove nuts (1), washers (2), bolts (3), and remove cover plate (4) and seal (5) from reduction unit mounting flange.
- b. Remove nuts (7), washers (8), cover plate (9) (if used) and gasket (10) from governor mounting pad; nuts (11), washers (12), cover plate (13) (if used) and gasket (14) from lubrication pump mounting pad. Discard gaskets.
- c. Remove oil screen centering union (15) and O-ring (16). Discard O-ring.
- d. Separate assembly of output housing and center housing (23) from input housing assembly (24) by removing bolts (17, 19, and 21), and washers (18, 20 and 22). Remove and discard gasket.

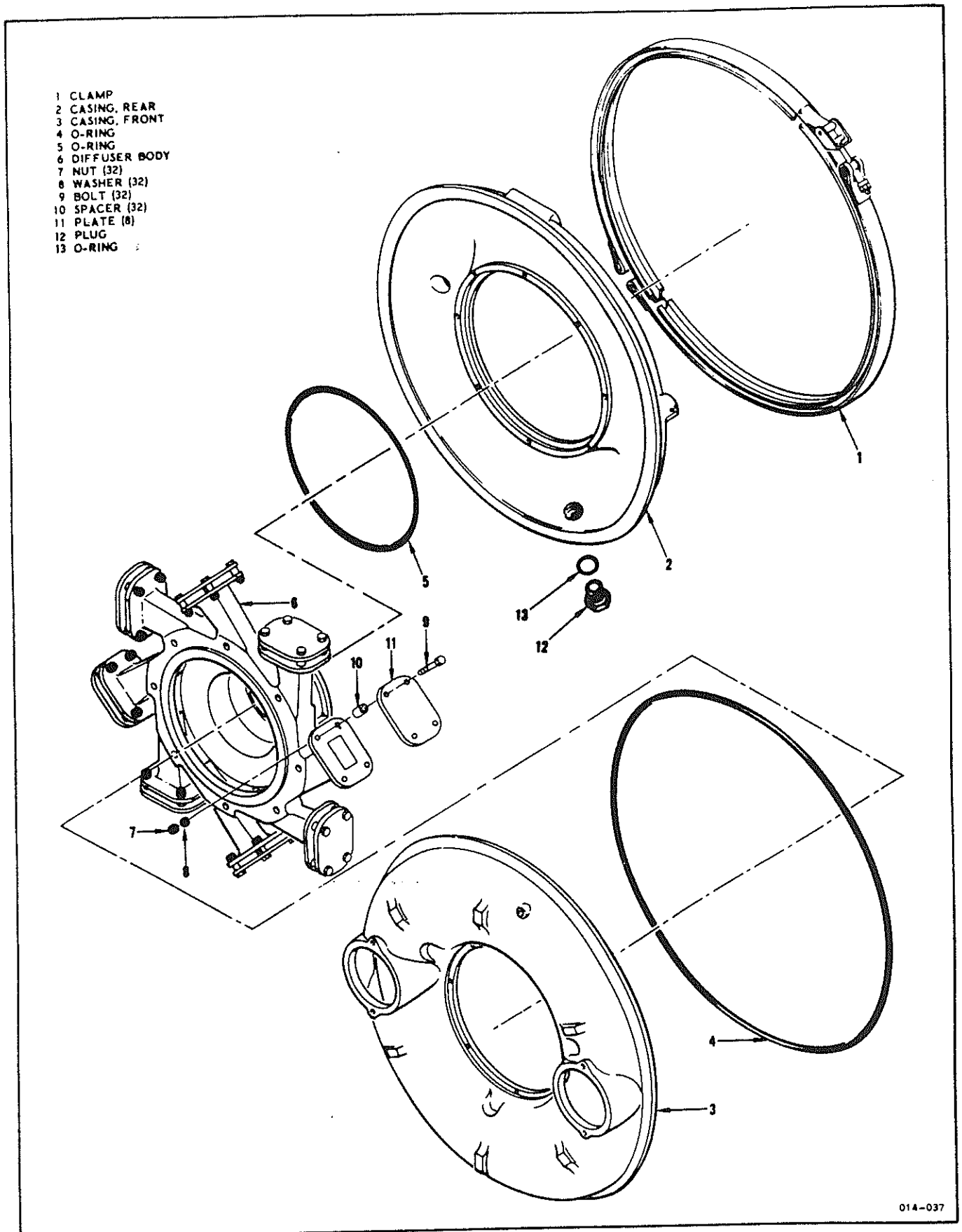


Figure 4-15. Compressor Section, Exploded View

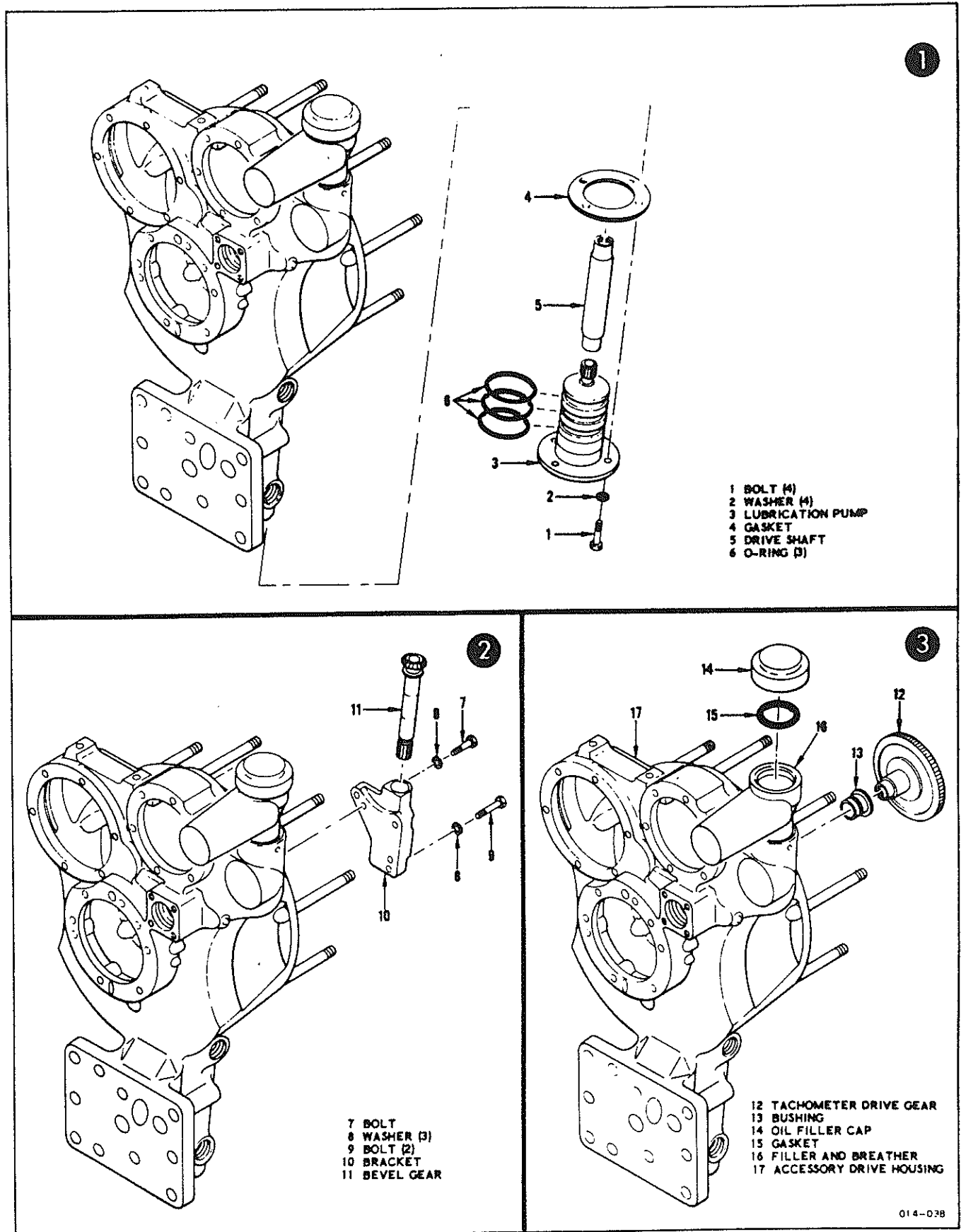


Figure 4-16. Accessories Section, Exploded View

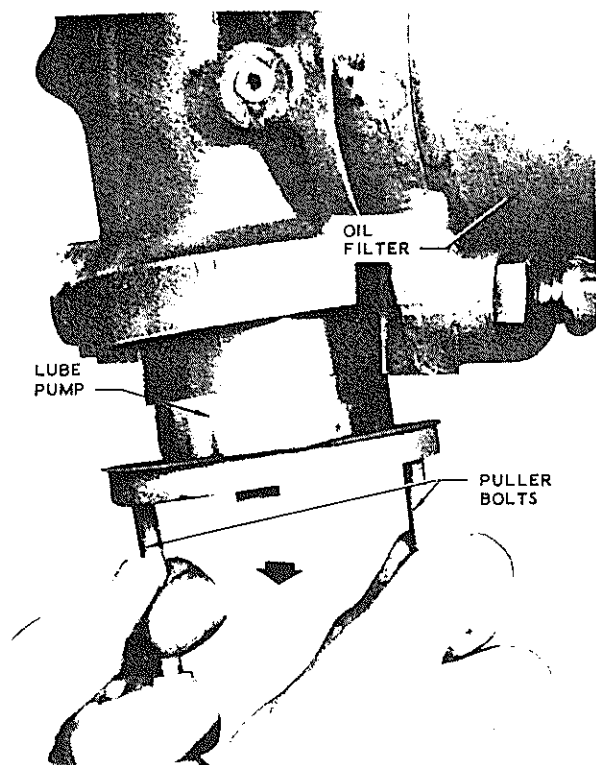


Figure 4-17. Removing Gas Producer Lubrication Pump

- e. Remove oil strainer (25) from between housings. Remove O-ring (27) from oil passage of input housing (24) and discard.

### CAUTION

Wheel and shaft assembly will drop from housing when retaining bolts are removed. Support wheel while performing the following step to prevent damage.

- f. Remove bolts (28) and washers (29) and remove assembly of turbine wheel, shaft and bearing assembly (30) from input housing.

### NOTE

Install wheel cover, Tool Group No. 7, on wheel when wheel, shaft and bearing assembly is removed from engine.

- g. Remove inner cone (31) from exhaust collector (33).  
 h. Remove nuts (32), and remove exhaust collector (33) from input housing (41).  
 i. Remove lockwire securing insulation blankets (34 and 35) to exhaust collector and remove insulation blankets. Do not remove dowel pins (36 and 43), plugs (37, 38, and 39), or lifting ring (40) from input housing (41) unless replacement is required.  
 j. Remove inner cone shims (42) from bearing cap flange. Remove gasket (44) from bearing retainer flange and discard.  
 k. Release bearing assembly from turbine wheel shaft by removing retainer nut (45). Lock pin (46) will shear.

- l. Slide bearing retainer unit (47 through 51) from shaft.  
 m. Remove radial bearing (48), segmented thrust bearing assembly (49), O-ring (50), and gasket (51) from retainer. Discard O-ring and gasket.  
 n. Slide bearing cap (52) from wheel and shaft assembly (55). Bend out tangs on retainer clips (54) and remove fir tree blades (53) and clips. Discard clips.

### NOTE

Measure wheel outside diameter before removing blades from wheel.

### CAUTION

Keep each set of turbine blades with its respective wheel and shaft assembly. When removing blades, keep them in consecutive order. All blades must be numbered consecutively on the base of the blade shank beginning with the number 1 position on the hub. Use noncarbonaceous ink to identify blades in the order of removal until number 1 position is located. Number 1 position is the slot between the keys marked with the part number and the number 1. If these numbers cannot be found, vibro-etch the hub part number and first three blade numbers as illustrated in figure 4-14. Etch the hub serial number on the key nearest the part number that is steel stamped at the center of the hub. (The serial number will also be found steel-stamped at the center of the hub.) After locating the number 1 slot, vibro-etch the correct position number on the base of each blade shank. If after inspection the blades are serviceable, install each blade in its original position. Installing blades in their original positions eliminates the need for rebalancing the wheel and shaft assembly during reassembly of the engine.

- o. Place assembly of output housing and center housing (56 through 66) on special timing fixture base and shaft assembly. This fixture prevents turning of the shaft while planet gear nuts are being removed.  
 p. Loosen and back off nuts (56) approximately 1/8 inch. Break planet pinion gears (58) loose from pinions (76) with bearing puller. Remove nuts (56) and washers (57) when gears are free on pinions. (See figure 4-20.)

### CAUTION

To protect planet gear teeth, place a soft metal strip (aluminum or copper) between gear and jaws of bearing puller.

- q. Remove nuts (59, figure 4-19), washer (60), bolts (61 and 62), and washers (63) and separate center housing assembly (64) from output housing assembly (65). Remove and discard gasket (66). Do not remove nuts (67), oil spray jets (68), plugs (69), accessory drive bearings (70), planet shaft bearings (71), output gear bearing (72), or dowel pins (73 and 74) from center housing (75) unless damaged.  
 r. Remove planet pinions (76) from output housing.

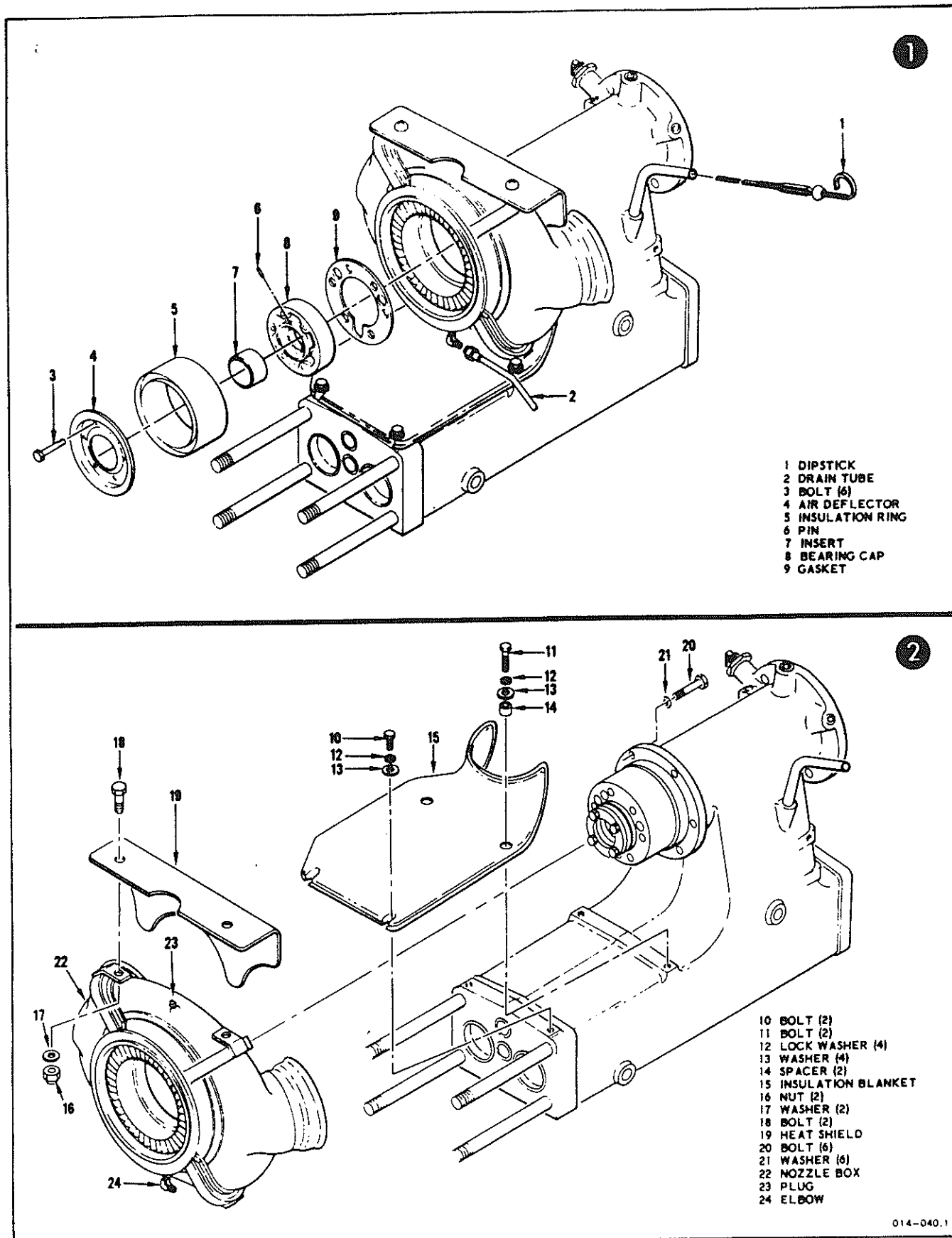


Figure 4-18. Rotor Housing and Sump, Exploded View (Sheet 1 of 2)

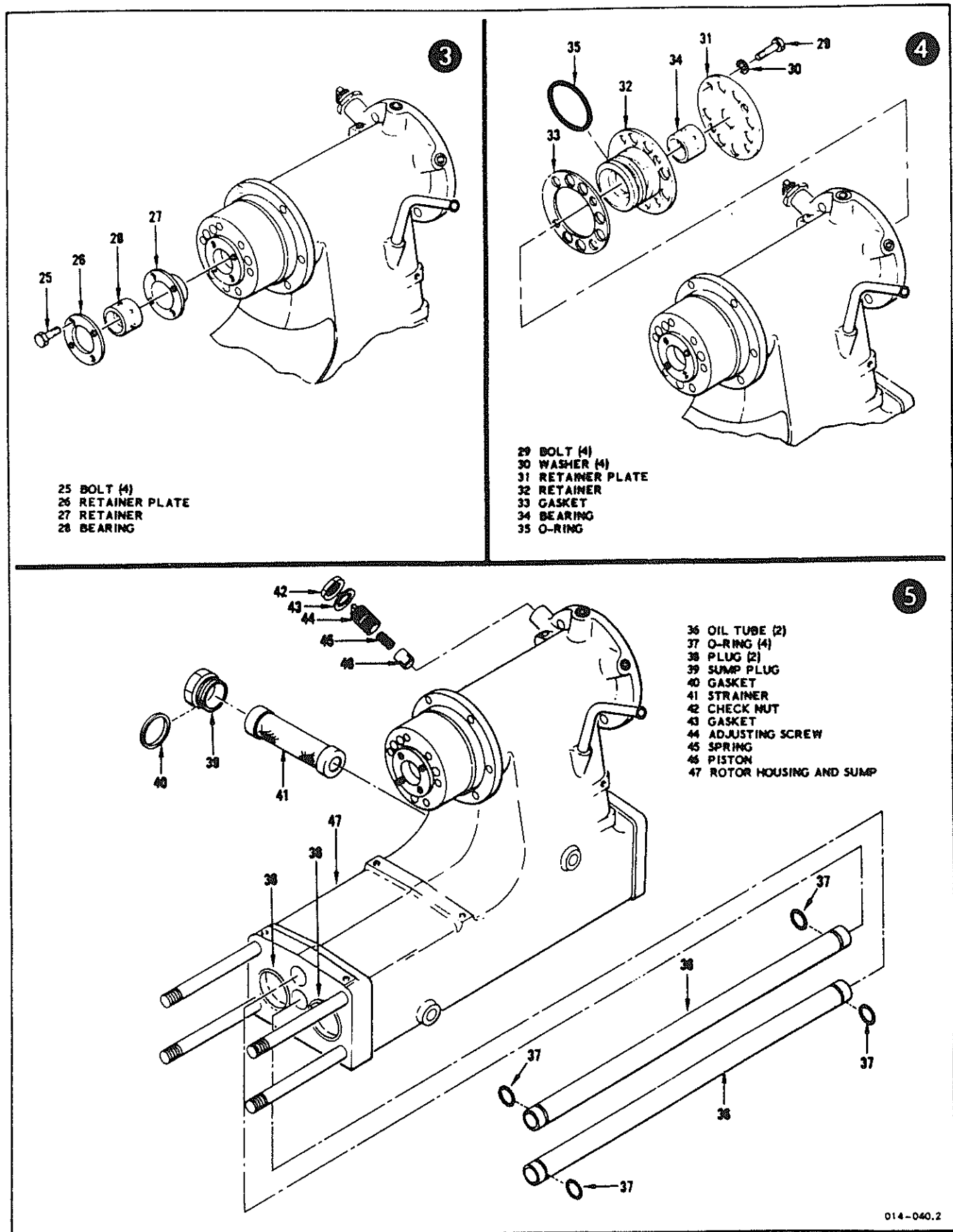


Figure 4-18. Rotor Housing and Sump, Exploded View (Sheet 2 of 2)

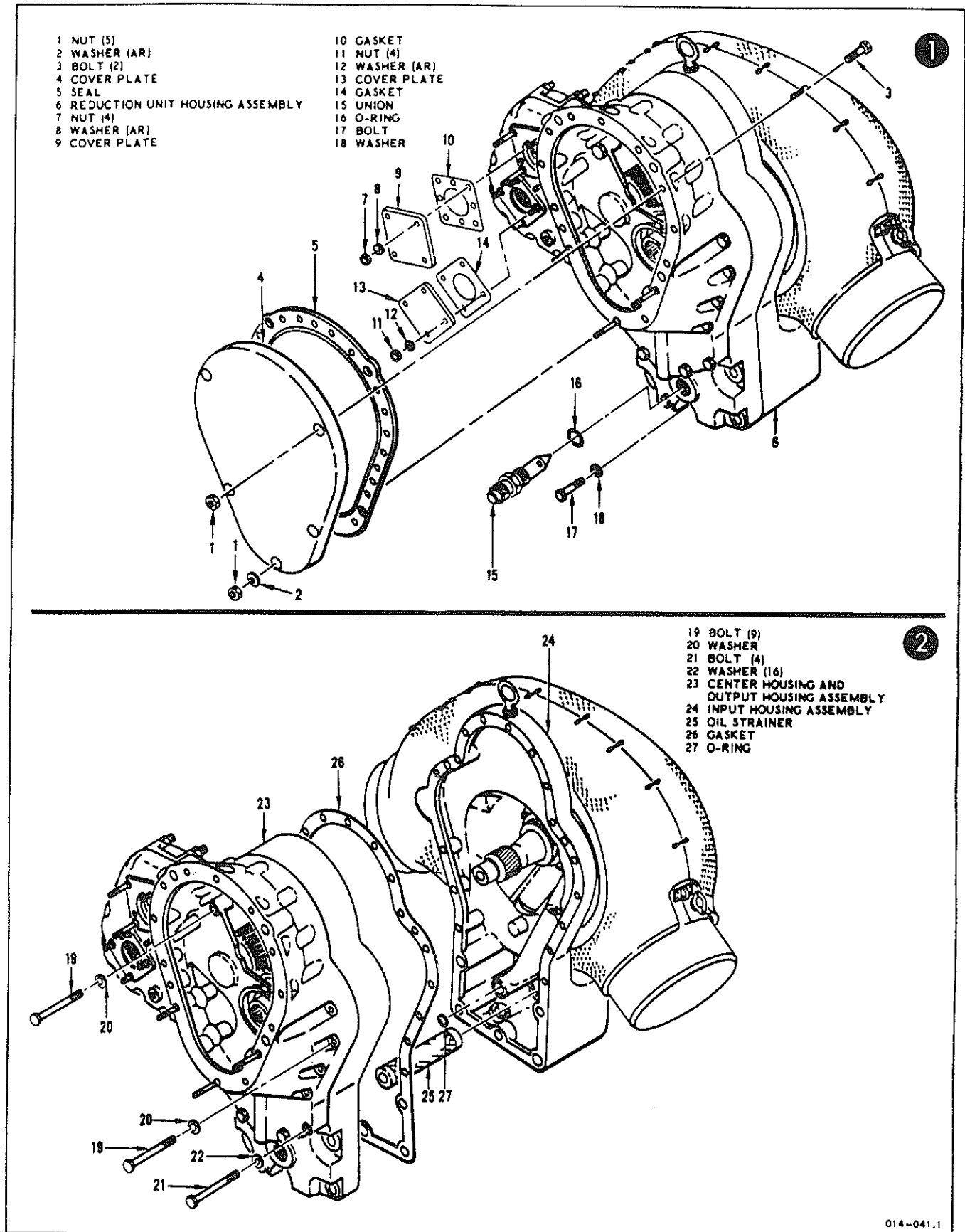


Figure 4-19. Reduction Unit, Exploded View (Sheet 1 of 3)

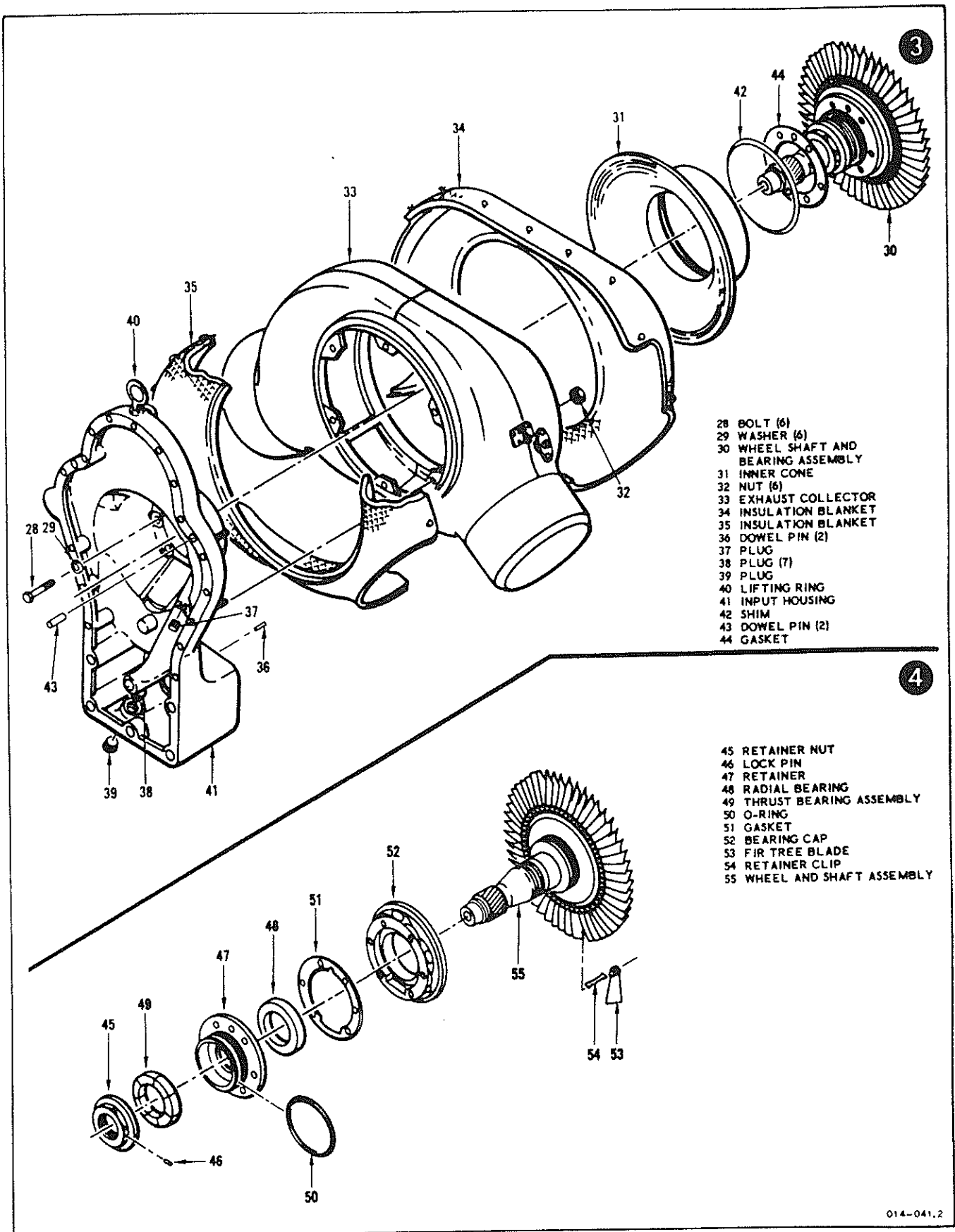


Figure 4-19. Reduction Unit, Exploded View (Sheet 2 of 3)



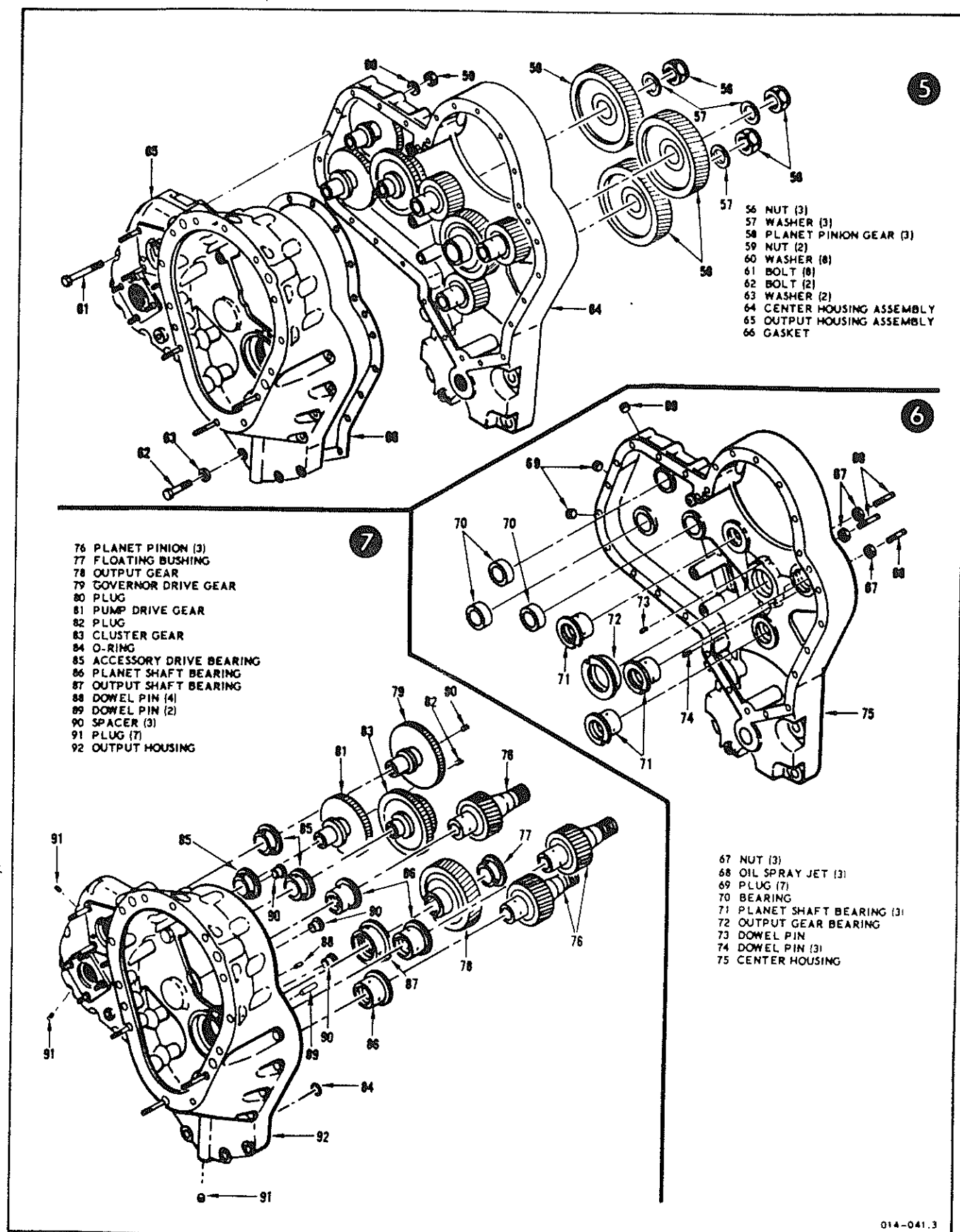
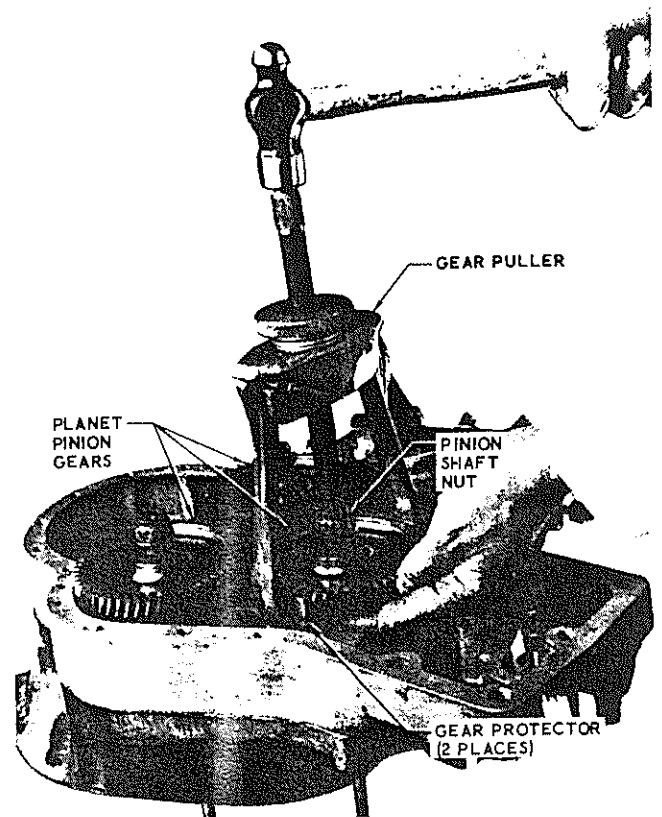


Figure 4-19. Reduction Unit, Exploded View (Sheet 3 of 3)

- s. Remove output shaft bushing (77) from output gear (78).
- t. Remove output gear (78) from output housing.
- u. Remove governor drive gear (79) from output housing. Do not remove plug (80) from gear unless replacement is required.
- v. Remove lubrication pump drive gear (81) from output housing. Do not remove plug (82) from gear unless replacement is required.
- w. Remove accessory drive cluster gear (83) from output housing.
- x. Remove and discard O-ring (84). Do not remove accessory drive gear bearings (85), planet shaft bearings (86), output shaft bearing (87), dowel pins (88 and 89), plugs (91) or spacer (90) from output housing (92) unless damaged.



014-042

Figure 4-20. Removing Planet Pinion Gears from Shafts

## SECTION V

## CLEANING

5-1. After disassembly clean all metal engine parts by vapor degreasing or solvent bath. If additional cleaning is required, use the following processes and procedures.

## 5-2. PROCESSES.

5-3. VAPOR DEGREASING. Suspend parts to be cleaned in a vapor degreaser using trichlorethylene, Military Specification MIL-T-7003. Vapor condenses on parts, dissolving and removing grease and dirt. Cleaning stops when parts reach same temperature as vapor. To prevent corrosion, allow each part to reach vapor temperature before removing from degreaser. If part is not thoroughly cleaned, repeat process.

**WARNING**

Take adequate precautions to prevent exposure of personnel to trichlorethylene vapors.

5-4. VAPOR BLAST. The vapor blast is a high-speed stream of vaporized water containing an abrasive. Use one-to-one mixture of 100-mesh and 200-mesh grit. Corrosion of ferrous parts is prevented by dipping them in corrosion-preventative solution after vapor blasting, or by including the corrosion preventive in the water and grit mixture. Blast cleaning tends to hide small defects; use lowest possible water pressure consistent with thorough cleaning.

**CAUTION**

Do not concentrate the blast in any one area, especially on sections such as blade edges. Do not blast-clean threaded, bearing or faying surfaces. Mask these surfaces with heavy tape or with a fiber, aluminum or copper sleeve. Do not blast-clean inducer or impeller. If vapor blast is used to clean aluminum castings, the casting should be reanodized.

5-5. SOLVENT BATH. Clean parts in a solvent bath with freshly filtered cleaning solvent, Federal Specification P-D-680, Type I. Remove stubborn deposits of foreign material with a stiff bristle brush. Flush all ports, passages and cavities. Dry parts with dry filtered compressed air or a clean lint-free cloth.

**WARNING**

Avoid breathing solvent vapors. Avoid skin contact with solvent. Observe fire precautions. Do not direct compressed air against any part of body.

5-6. LACQUER THINNER BATH. Immerse part in lacquer thinner, Military Standard MS35626, until foreign material is dislodged. Dry parts with dry filtered compressed air or a clean, lint-free cloth.

**WARNING**

Avoid breathing lacquer thinner vapors. Avoid skin contact with thinner. Observe fire precautions. Do not direct compressed air against any part of body.

5-7. ALCOHOL SOLVENT WASH. Clean external surfaces with a soft, lint-free cloth, or soft brush dampened with isopropyl alcohol, Military Specification MIL-F-5566.

5-8. CORROSION PREVENTION. After cleaning and drying ferrous parts, apply corrosion preventive compound, Military Specification MIL-C-6529. Mix compound thoroughly, then heat to approximately 104°C (220 F) to evaporate any suspended moisture.

## 5-9. PROCEDURES.

5-10. ALUMINUM CASTING. Use the following procedures for cleaning castings that show indications of corrosion or that have areas where the original anodizing has been removed. After cleaning, inspect parts in accordance with Section VI.

a. Vapor degrease casting prior to cleaning (see paragraph 5-3).

b. Immerse casting in alkaline cleaning solution Turco 2623 (Manufactured by Turco Products, Incorporated) for 5 minutes or longer.

c. Rinse casting in cold water.

d. Corrosion may be treated locally with a cotton swab saturated in chromic-sulfuric acid solution in the affected areas. The acid will brighten the affected areas and arrest the corrosive action. The initial makeup of a 100 gallon chromic-sulfuric acid solution is as follows (if a lesser quantity is desired, prepare in the same proportions):

1. 50 gallons water.

5-16. ACCESSORIES SECTION. (See figure 4-16.) Use lacquer thinner as required to soak baked oil from accessory drive housing (17). Apply corrosion preventive compound immediately after cleaning to drive shaft (5), bevel gear (11), and tachometer drive gear (12).

5-17. ROTOR HOUSING AND SUMP SECTION. (See figure 4-18.) Use vapor blast as required to clean bearing cap (8), nozzle box (22), and rotor housing and sump (47). Apply corrosion preventive compound immediately after cleaning to retainer plates (26 and 31), retainers (27 and 32), and air deflector (4).

a. Nozzle boxes (22) with coated (rough surface) vanes (Hastelloy, Part No. 45-2932-1) may be cleaned by any of the following cleaning processes without causing damage to the vane coating:

1. Vapor or solvent degreasing.
2. Hand scrubbing with a fiber bristle brush with solvents or cleaners.
- b. The above process or combinations thereof will remove light deposits for the purpose of penetrant inspection; however, they may not thoroughly remove moderate to heavy accumulations. Coated surfaces should be vapor blasted only when all other recommended cleaning processes have proven ineffective and further inspection operations are required. Vapor blast with caution and with the knowledge that some damage may result to

coated surfaces. Observe the following precautions:

1. Mask coated surfaces where possible.
2. Use 360-mesh or finer abrasive.
3. Hold vapor nozzle at least 8 inches away from coated surfaces.
4. Vapor blast only until the oxide film on coated surfaces has been removed.

**CAUTION**

Do not use chemical descaling treatments or cleaning processes other than those specified above on coated nozzle box surfaces. Injury to these coated surfaces will result.

5-18. REDUCTION UNIT. (See figure 4-19.) Use vapor blast as required to clean center housing (75), output housing assembly (65), input housing (41), exhaust collector (33), and hub and blades of wheel and shaft assembly (55). Use lacquer thinner, Military Standard MS35626, as required to soak baked oil from housings (63, 92, and 41) and inner cone (31). Apply corrosion preventive compound immediately after cleaning to gears (58, 79, 81, and 83), planet pinion (76), wheel and shaft assembly (55), retainer nut (45), retainer (47), and bearing retainer cap (52).

2. 35 pounds chromic acid (5 to 6 oz.  $\text{CrO}_3$  per gallon water).

3. 12 gallons sulfuric acid (24 to 29 oz.  $\text{H}_2\text{SO}_4$  per gallon water).

4. Fill tank to 100 gallon level with water and mix the solution completely.

5. Maintain the solution at 76.7°C (170°F) to 87.8°C (190°F).

e. Castings may be completely reanodized provided all steel parts such as studs, Heli-Coils, bolts and fittings are removed. If reanodizing is to be done, steps a through k will be eliminated. Strip off the old anodizing by immersing in a chromic-phosphoric acid solution for a period of 5 to 10 minutes at a temperature of 76.7°C (170°F) to 87.8°C (190°F). If anodizing is not removed within this length of time, repeat immersion for periods of 1 minute duration each until all anodizing is removed. The initial makeup of a 100 gallon chromic-phosphoric acid solution is as follows (if a lesser quantity is desired, prepare in the same proportions):

1. 50 gallons water.

2. 25 pounds chromic acid (3.0 to 4.4 oz.  $\text{CrO}_3$  per gallon water).

3. 4 gallons phosphoric acid 75% (5.0 to 6.7 oz.  $\text{H}_3\text{PO}_4$  per gallon water).

4. Dissolved metal in the amount of 2 ounces per gallon maximum.

5. Fill tank to 100 gallon level with water and mix the solution completely.

6. Maintain the solution at 82.2°C (180°F) to 100°C (212°F).

f. Rinse in cold water.

g. Apply alodine in accordance with Military Specification MIL-C-5541 to all bare areas.

h. Rinse again in cold water.

i. Rinse in hot water, temperature not to exceed 60.0°C (140°F).

j. Dry with clean, dry compressed air.

k. Package for storage if required.

5-11. STEEL PARTS. Use the following procedure for cleaning steel parts that show indications of corrosion or lacquer discoloration caused by hot oil or fuel. After cleaning, inspect the parts in accordance with Section VI.

a. Vapor degrease.

b. Immerse in a hot phosphosilicate cleaning solution for 5 to 10 minutes. Use the following solution:

1. Phosphosilicate in the quantity of 5 to 7 ounces per gallon of water.

Phosphosilicate Compound

(a) Sodium Metasilicate ( $\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$ )

Commercial grade, 98%  $\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$  30 ± 2%

(b) Caustic Soda NaOH flake or granulated, 76%  $\text{Na}_2\text{O}$  35 ± 2%

(c) Soda Ash ( $\text{Na}_2\text{CO}_3$ ) commercial grade, 58%  $\text{Na}_2$  9 ± 1%

(d) Nacconal NR (National Aniline and Chemical Co.) 1 ± 0.1%

(e) Sodium Tripolyphosphate ( $\text{Na}_5\text{P}_3\text{O}_{10}$ ) technical grade Balance

2. Maintain the solution at a temperature of 71.1°C (160°F) to 87.8°C (190°F).

c. Rinse in cold water.

d. Immerse in a solution of inhibited hydrochloric acid for a period of 1/2 minute to 5 minutes. The initial makeup of a 100 gallon inhibited hydrochloric acid solution is as follows (if a lesser quantity is desired, prepare in the same proportions):

1. 10 gallons water.

2. 76 gallons hydrochloric acid mixture (23 to 38 oz. of hydrochloric acid per gallon water).

3. 5 pints of either of the following (do not use a mixture of both):

(a) Turco Acryl inhibitor

(b) Amchem Rodine 213 inhibitor

4. Fill the tank to the 100-gallon level and mix completely.

5. Maintain the solution at room temperature.

e. Rinse in cold water. If there is a film or residue on the surface, spray the part with an air and water mixture to remove it.

f. Neutralize by dipping in the hot phosphosilicate cleaning solution.

g. Rinse again in cold water.

h. Rinse in hot water and dry with clean, dry compressed air.

i. Dip in preservative oil to prevent corrosion.

j. Wrap each part individually in grease-proof paper if parts are to be put in storage.

5-12. ENGINE ASSEMBLY. (See figure 4-10.) Degrease nozzle ring (15) either by vapor degreasing, hot alkaline bath, or by wiping with a clean cloth moistened with methyl ethyl ketone, Federal Specification TT-M-261, or toluene, Federal Specification JAN-T-171. Mechanically clean as required with vapor blast, fine grit blast, emery cloth, stainless steel wool, or stainless steel wire brush.

### CAUTION

Do not pickle nozzle ring in nitric-hydrofluoric acid solutions.

5-13. GAS PRODUCER SECTION. (See figure 4-12.) Use vapor blast as required to clean bearing cap (47), end plate (38) and hub and blades of wheel and shaft assembly (59, 60 and 61). Do not vapor blast inducer (35) or impeller (36). Use lacquer thinner as required to soak baked oil from retainer (51) and slinger (50). Apply corrosion preventive compound immediately after cleaning slinger (50), retainer (51), bearing sleeve (57), pinion (58), wheel and shaft assembly (59, 60, and 61), cluster gear (41), and shaft (42).

5-14. COMPRESSOR SECTION. (See figure 4-15.) Use vapor blast as required to clean compressor casing halves (2 and 3), body of diffuser assembly (6) and plates (11).

5-15. BURNER SECTION. (See figure 4-4.) Use vapor blast as required to clean burner shell (21), liner (19), burner dome (28), and inlet adapter (33).

## SECTION VI

## INSPECTION, REPAIR, AND REPLACEMENT

6-1. DEFINITIONS - In this section of the handbook, the following words are used in the sense explained by these definitions:

- a. Abrasion -- surface roughness caused by scraping, grinding, or wear by friction, usually due to fine particles on surfaces at assembly or carried in lubricating oil. May involve large areas or spots.
- b. Burning -- injury to surfaces by excessive heat from friction or other source, indicated by discoloration, often accompanied by flow of metal.
- c. Burnishing -- mechanical smoothing and brightening of a metal surface caused by rubbing with another surface, usually involving no loss of material but showing slight discoloration at outer edges. Operational burnishing is not detrimental provided there is no evidence of burning or piling up of metal.
- d. Burr -- sharp projection or rough edge resulting from machining operations, excessive wear, or mechanical damage such as scoring or gouging.
- e. Checkered -- having a network of fine surface cracks.
- f. Corrosion -- breakdown of the surface by chemical action, usually caused by the presence of corrosive agents.
- g. Dent -- small, smooth depression or hollow, usually caused by a blow or by chips between loaded surfaces.
- h. Flow (of metal) -- movement of surface metal leaving slight hollows and areas of metal build-up. Usually caused by excessive loading.
- i. Fretting -- metal breakdown on the contacting surfaces of two contacting metals, usually accelerated by vibration between the two surfaces, sufficient to produce localized deformation.
- j. Galling -- chafing, wearing away or transfer of metal from one surface to another by friction, usually caused by slight relative movement of two surfaces under high contact pressure.
- k. Glazing -- development of a hard, glossy coating on plain bearing surfaces, caused by varnish build-up from lubricating oil under heat and pressure.
- l. Gouging -- displacement of surface material by scooping out or piercing, usually caused by a fairly large foreign body between moving parts or by striking of a part by a pointed object.
- m. Nicks -- sharp indentations or notches where material has been chipped from a surface or edge by striking against some other object, usually caused by careless handling or foreign particles passing through an operating engine.
- n. Pitting -- small deep surface holes caused by corrosion or chipping. Corrosive pitting is usually caused by oxidation or reaction to some chemical. Mechanical pitting is usually caused by overloading, improper clearance, or the presence of foreign particles.
- o. Scratch -- narrow shallow groove caused by movement of a sharp object or particle across a surface. Usually due to careless handling or grit particles passing through operating engine.
- p. Scoring -- deep scratches or surface cuts made by sharp edges against a surface or by chips between loaded surfaces having relative motion.

q. Scuffing -- displacement of bits of surface material caused by scraping.

r. Spalled -- having roughened areas caused by the breaking off of tiny bits of material progressively from a point of damage such as a crack (as from gear teeth). Friction, heat, and loading contribute to the spalling action.

s. Varnish -- a hard coating of heat-baked oil. Builds up on bearing surfaces and is usually beneficial.

t. Warpage -- distortion usually resulting from heat.

6-2. VISUAL INSPECTION. A visual inspection involves viewing the part to determine its general physical condition and the extent of wear, deterioration, or distortion the part has undergone since the last build-up or overhaul of the engine. Visually inspect all engine parts for general physical conditions that may require repair or replacement. If inspection reveals corrosion on steel bolts, turnbuckle barrel, lifting lug, etc., it may be necessary to recadmium plate these parts to prevent further corrosion attack and to improve appearance.

**CAUTION**

Make certain that fluid used for penetrant inspections is not contaminated.

Only those parts requiring special types of inspection or attention to specific features, in addition to visual inspection, are listed in Table III. Besides inspection of all parts, examine the oil drained from the sump. If any contamination is found, thoroughly flush the oil passages in the accessory, rotor, and reduction unit housings. Remove all pipe plugs and force cleaning solvent, Federal Specification P-D-680, Type I, through the passages. Use solvent in accordance with paragraph 5-5. Determine the cause of contamination.

6-3. INSPECTION TABLE. Table III lists all parts requiring any special inspection. The inspection method required, dimensional limits for parts to be measured, and references to applicable paragraphs and illustrations are indicated in the table. Paragraphs and illustrations referenced give complete information on acceptable or rejectable condition, permissible repairs and repair methods, allowable crack limits, and other useful instructions. In the inspection column, F-P means fluorescent-penetrant method, M-P means magnetic-particle method. Parts measuring less than minimum specified in the dimensions column are to be rejected. Parts measuring greater than maximum specified in the dimensions column are to be rejected. OD means outside diameter. ID means inside diameter.

6-4. INDUCER AND IMPELLER. (See figure 6-1.) Inspect the inducer and the impeller for cracks, corrosion, pits, and condition of the protective coating. In-

Table III. Inspection Requirements

Fig. and Index No.	Nomenclature	Type of Inspection	Dimensional Limits		Inspection and Repair Information in Paragraph
			Min	Max	
(4-2)	<u>Oil Cooler and Eductor Installation</u>				
23	Eductor Assembly	F-P			6-13
(4-4)	<u>Burner Section</u>				
3 thru 6	Crossfire tube elbow assy (with seal rings in place)	Visual			6-10
6	Crossfire tube	Visual			6-10
19	Burner liner	F-P			6-9
21	Burner shell assembly, O.D.	Visual		6.03	6-7
28	Burner dome	Visual			6-8
(4-8)	<u>Electrical System Installation</u>				
	Engine Harness	Visual			6-47
	Junction Box Harness	Visual			6-47
(4-10)	<u>Engine Assembly</u>				
15	Nozzle Ring	F-P			6-6
(4-12)	<u>Gas Producer Section</u>				
16	Oil filter element				6-35
23	Oil pressure switch				10-4
35	Inducer	F-P			6-4
36	Impeller	F-P			6-4
44	Cluster gear bearings, I.D. (Do not remove)	M-P		0.7513	6-29
42	Shaft, O.D.	M-P	0.7448		6-30
47	Bearing cap, compressor-end	F-P			6-25, 6-24
50	Oil Slinger, O.D.	F-P	1.9930		6-34, 6-24
51	Bearing retainer, compressor-end, I.D.			2.1262	6-26, 6-24
52	Radial bearing, gas producer, O.D.		2.1178		6-23, 6-24

Table III. Inspection Requirements (Continued)

Fig. and Index No.	Nomenclature	Type of Inspection	Dimensional Limits		Inspection and Repair Information in Paragraph
			Min	Max	
(4-12)	<u>Gas Producer Section</u> (Continued)				
	Radial bearing, gas producer, I.D.			1.2450	
56	Segmented thrust bearing assembly				6-24, 6-27
	Midchord radial width		0.4350		
	Axial thickness		0.4290		
57	Bearing sleeve, O.D.	M-P	1.2393		6-23, 6-24
58	Pinion	M-P			6-24, 6-28
59	Wheel and shaft assembly, gas producer turbine wheel	F-P			6-15, 6-16, 6-19, 6-22
	Shaft	M-P			6-24
	Labyrinth, turbine-end, O.D.		1.4870		6-24
	Journal, turbine and steady bearings, O.D.		1.2488		6-24
60	Turbine wheel blade	F-P			6-20, 6-21
64	Oil filter guide				6-36
84	Rotor housing and sump	Visual			6-41
(4-15)	<u>Compressor Section</u>				
2	Rear Casing	Visual			6-41
3	Front Casing	Visual			6-41
6	Diffuser	F-P			6-41
(4-16)	<u>Accessories Section</u>				
10	Bracket, oil pump drive, I.D.			0.5015	6-33
11	Bevel gear and spline, pump drive, O.D.	M-P	0.4948		6-28
12	Gear, tachometer drive shaft, O.D.	M-P	0.8078		6-28
13	Bushing, tachometer gear, I.D.			0.8140	6-32
14	Cap, oil filler				6-39
17	Accessory drive housing	Visual			6-41



Table III. Inspection Requirements (Continued)

Fig. and Index No.	Nomenclature	Type of Inspection	Dimensional Limits		Inspection and Repair Information in Paragraph
			Min	Max	
(4-18)	<u>Rotor Housing and Sump Section</u>				
8	Bearing cap, turbine-end	F-P			6-25, 6-24
22	Nozzle box	F-P			6-11
27	Bearing retainer, turbine-end, I.D.			1.5045	6-26, 6-24
28, 34	Bearings, turbine-end and steady, I.D.			1.2532	6-23, 6-24
	O.D.		1.4988		
32	Bearing retainer, steady, I.D.			1.5045	6-26, 6-24
47	Rotor housing and sump	Visual			6-41
(4-19)	<u>Reduction Unit</u>				
31	Inner cone				6-14
33	Exhaust collector	F-P			6-12
41	Input housing	Visual			6-41
45	Retainer nut				6-40
47	Bearing retainer, I.D.			2.7267	6-26, 6-24
48	Radial bearing, O.D.		2.7185		6-23, 6-24
	I.D.			1.8550	
49	Thrust bearing set, segmented				6-24, 6-27
	Midchord radial width		0.4320		
	Axial thickness		0.3920		
52	Bearing retainer cap	M-P			6-25
53	Fir-tree blade	F-P			6-20, 6-21
55	Wheel, shaft, and pinion assembly				6-28, 6-17
	Wheel	F-P			6-18
	Shaft, journal, radial and thrust bearings (dia)	M-P	1.8495		6-24

Table III. Inspection Requirements (Continued)

Fig. and Index No.	Nomenclature	Type of Inspection	Dimensional Limits		Inspection and Repair Information in Paragraph
			Min	Max	
(4-19)	<u>Reduction Unit</u> (Continued)				
	Shaft, journal, floating bushing (dia)		1.0993		6-24
	Shaft, labyrinth, O.D.		2.6880		
58	Gear, planet pinion (3)	M-P			6-28, 6-31
70	Bearings (3), accessory drive			0.8796	6-23, 6-24
71	Bearings (3), planet shaft			0.9389	6-23, 6-24
72	Bearing, output gear			1.6284	6-23, 6-24
75	Center housing	F-P			6-41
76	Pinion, planet (3) shaft, O.D.	Visual M-P	0.9343		6-24, 6-28, 6-31
77	Bushing, floating, I.D.			1.1023	6-23
	O.D.		1.2457		
78	Gear, output, I.D.	M-P		1.2507	6-28
	Shaft, O.D.		1.6226		
79	Gear, governor drive	M-P			6-28
81	Gear assembly, pump drive	M-P			6-28
	Shaft, O.D.		0.8743		
83	Cluster gear, accessory drive	M-P			6-28
	Shaft, O.D.		0.8743		6-30
85	Bearing (3), accessory drive			0.8796	6-24
86	Bearing (3), planet shaft			0.9389	6-24
87	Bearing, output shaft			1.6284	6-24
92	Output housing, reduction unit	M-P Visual			6-41
(10-1)	<u>Lubrication and Scavenge Pump</u>				10-2
(10-3)	<u>Accessory Drive Gear Box</u>				10-5

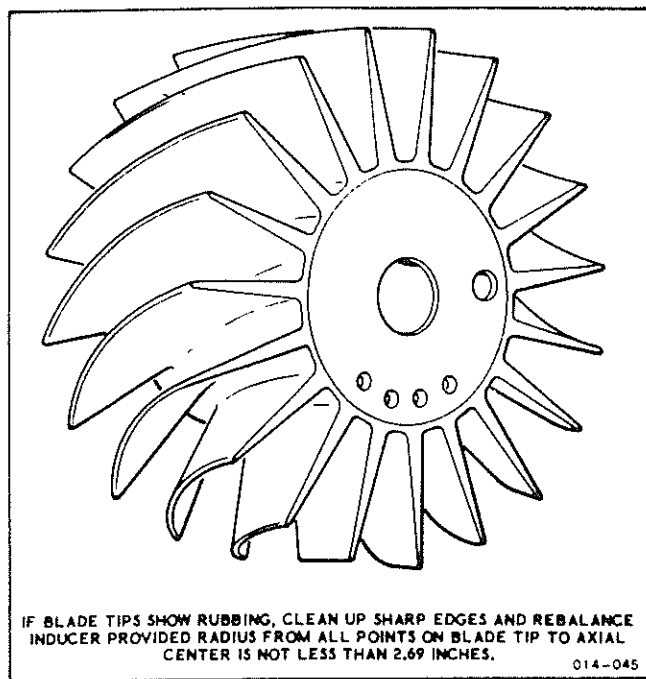


Figure 6-1. Inducer Inspection

spect the inducer for evidence of blade tip rub. Disposition of parts is as follows:

a. Reject the inducer or impeller if any cracks are present. Corrosion pits in the fillet radius of inducer and impeller is cause for rejection. If either inducer or impeller has corrosion pits in the blade area, the parts should be reanodized.

b. If inducer blade leading edges are nicked or eroded excessively due to ingestion of sand or other harmful foreign objects, the blades must be sharpened in accordance with paragraph 6-5. Rebalance inducer and remove remaining anodic coating and reapply in accordance with step c following.

c. Inducers with blade tip rub are acceptable for use after cleaning up sharp edges and rebalancing, provided the distance from all parts of all blade tips to the axial centerline of the inducer is not less than 2.69 inches. To balance the inducer, use the anti-icing inducer balancing arbor from Tool Group No. 9, and proceed as follows:

1. Press the inducer onto the balancing arbor, downstream side first, with the spacer and nut provided. Remove the nut and spacer.

2. Install the balancing arbor on the balancing fixture, using the half-bearings provided with the tool.

3. Balance the inducer statically and dynamically to less than 0.010 ounce-inch of imbalance. Remove material as necessary by drilling into the front or the back of the inducer hub, observing the following limits:

(a) Drill balancing holes on a 1 inch radius from the axial centerline of the inducer.

(b) Maximum hole diameter is 0.229 inch. Drill initially with a 3/16-inch drill, and enlarge the hole as necessary.

(c) Maximum hole depth is 0.620 inch. Drill a shallow hole initially and deepen as required.

(d) Minimum hole spacing is 0.400 inch center to center.

4. Remove the inducer and arbor assembly from the balancing fixture and install the anti-icing spinner on the inducer, ensuring that the matching alignment marks on the spinner, 1 attaching bolt, 1 washer, and the inducer are aligned.

5. Install the inducer, spinner, and arbor assembly on the balancing fixture. Balance the inducer and anti-icing spinner assembly statically and dynamically to less than 0.010 ounce-inch of unbalance. Remove material as necessary from inside the spinner to balance this assembly (see figure 6-2).

6. After balancing, remove the inducer from the arbor, using the special washer and nut provided with the arbor. Reanodize according to Military Specification MIL-A-8625, Type I.

d. Using the impeller and inducer balancing arbor from Tool Group No. 9, balance the impeller as follows:

1. Install the impeller on the arbor, and install this assembly on the balancing fixture.

2. Balance the impeller statically and dynamically to less than 0.010 ounce-inch of imbalance. Remove material as necessary from the back face of the impeller by grinding or sanding (see figure 6-2). Finish with 600 grit or finer abrasive paper. Remove material as necessary from the front of the impeller hub, observing the following limits:

(a) Drill balancing holes on a 1-inch radius from the axial centerline of the impeller.

(b) Maximum hole diameter is 0.250 inch. Drill initially with a 3/16-inch drill and enlarge the hole as necessary.

(c) Maximum hole depth is 0.380 inch. Drill a shallow hole initially and deepen it as required.

(d) Minimum hole spacing is 0.380 inch, center to center.

3. After balancing, remove the impeller from the arbor and reanodize in accordance with Military Specification MIL-A-8625, Type I.

e. Inspect the inducer and the impeller for corrosion, nicks, dents, and abrasion. If within acceptable limits, clean up with 600 grit or finer abrasive paper and reanodize in accordance with Military Specification MIL-A-8625, Type I.

f. Inspect protective coating of inducer and impeller. If any corrosion is visible, or if any metal or protective coating has been removed during balancing procedure, part must be reanodized. Check continuity of the protective coating using a standard ohmmeter on R X 1 scale. A good protective coating will show no continuity reading on the ohmmeter.

#### NOTE

Use blunt or rounded ohmmeter test probe tips and make very light contact with anodized surface. If sharp points are used, or if anodized surface is scratched, coating will be damaged and continuity will be indicated.

g. If the protective coating is satisfactory, the part may be returned to service. If the protective coating has been removed or damaged in any area, the part must be stripped and reanodized in accordance with Military Specification MIL-A-8625, Type I.

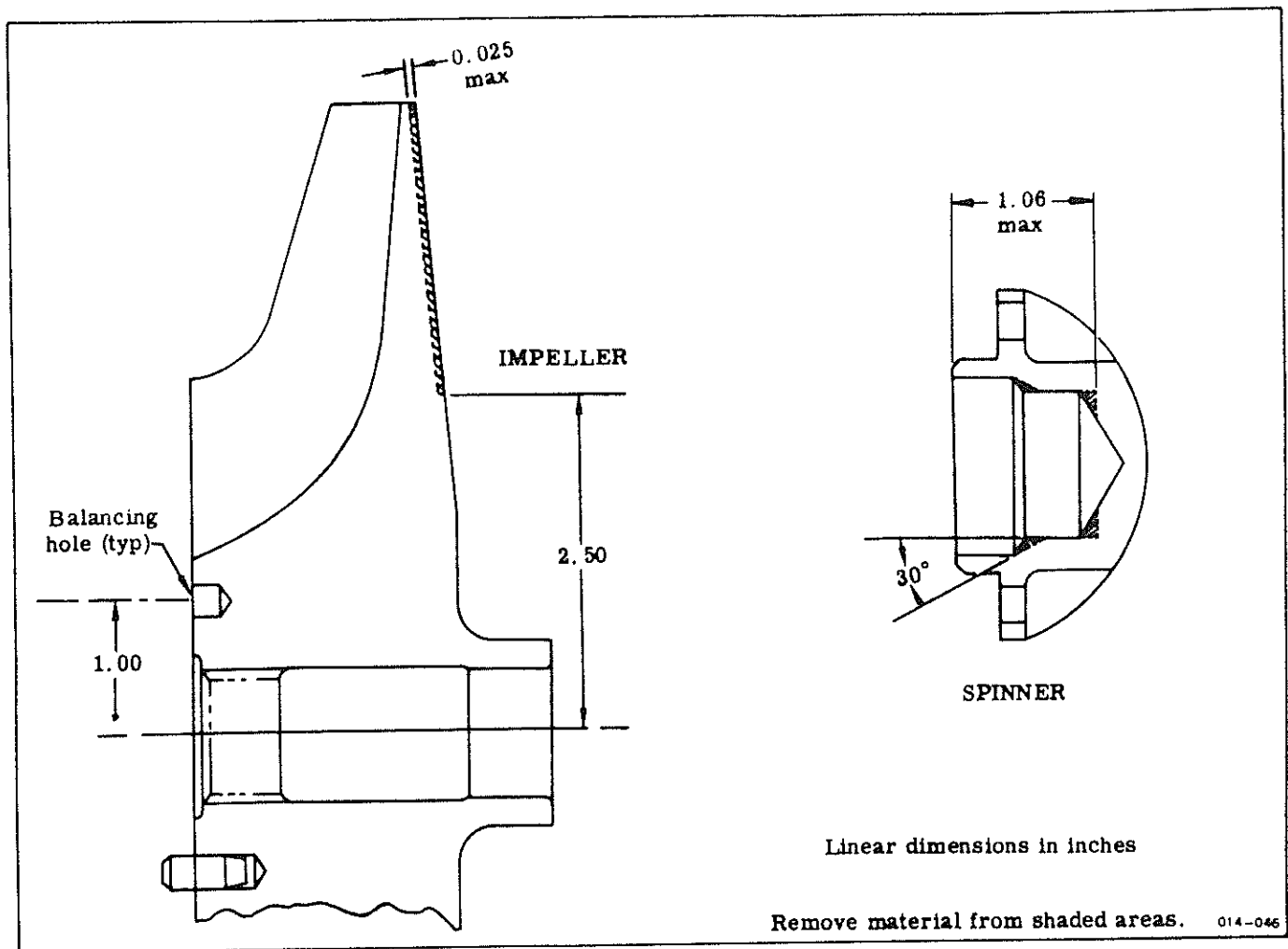


Figure 6-2. Balancing Impeller and Anti-Icing Spinner

**CAUTION**

Due to very close dimensional tolerance of inducer and impeller bores, the bores must be plugged or masked during both stripping and reanodizing processes. Some impellers have a steel dowel pin, which also must be masked before stripping and reanodizing.

#### 6-5. INDUCER BLADE SHARPENING. (See figure 6-3.) Sharpen inducer blade leading edge as follows:

- Mount inducer on mandrel.
- Make cut across leading edges of all blades with reference to 1.93 and 2.06 inch dimensions. Observe 3.0 reference diameter.
- The minimum length to which inducer chord may be reduced is 1.93 inches at the outer diameter and 2.06 inch at the inner diameter.
- Handshape 0.010 - 0.015 inch constant leading edge radius, observing blend requirements and airfoil thickness. Rubber bonded abrasive wheels and abrasive cloth tape may be used for this rework. Observe 125 micro inch surface finish requirement.
- A fillet radius of 0.12/0.09 inch must be maintained at the junction of blade and hub.

f. Metal removal must maintain a strait line along the inducer leading edge; however, metal may be removed locally on the outer 2/3 of blade to remove damaged spots to a maximum depth of 0.03 inch below leading edge. The repaired edge must blend smoothly with the blade contour.

g. Inducer parts affected by metal removal should be reanodized in accordance with Military Specification MIL-A-8625, Type I.

h. After blade sharpening, rebalance the inducer in accordance with paragraph 6-4.

#### 6-6. NOZZLE RING. (See figure 6-4.) Repair nozzle ring as follows:

- Machine to correct out-of-roundness as shown in figure 6-4. Discard any nozzle ring warped too severely for this repair.
- Repair nozzle ring sheet metal and weld cracks as follows:
  - Clean area to be repaired in accordance with paragraph 5-10.
  - Repair defects by inert tungsten arc welding with Hastelloy "W" or Hastelloy "X" alloy bare filler metal per AMS 5786 or 5798 respectively, manufactured by Haynes Stellite Co., Kokomo, Indiana. Seal nozzle ring at flanges and use an inert gas backup purge during welding. Grind or machine welds to previous contour in any area that will interfere with mating surfaces at

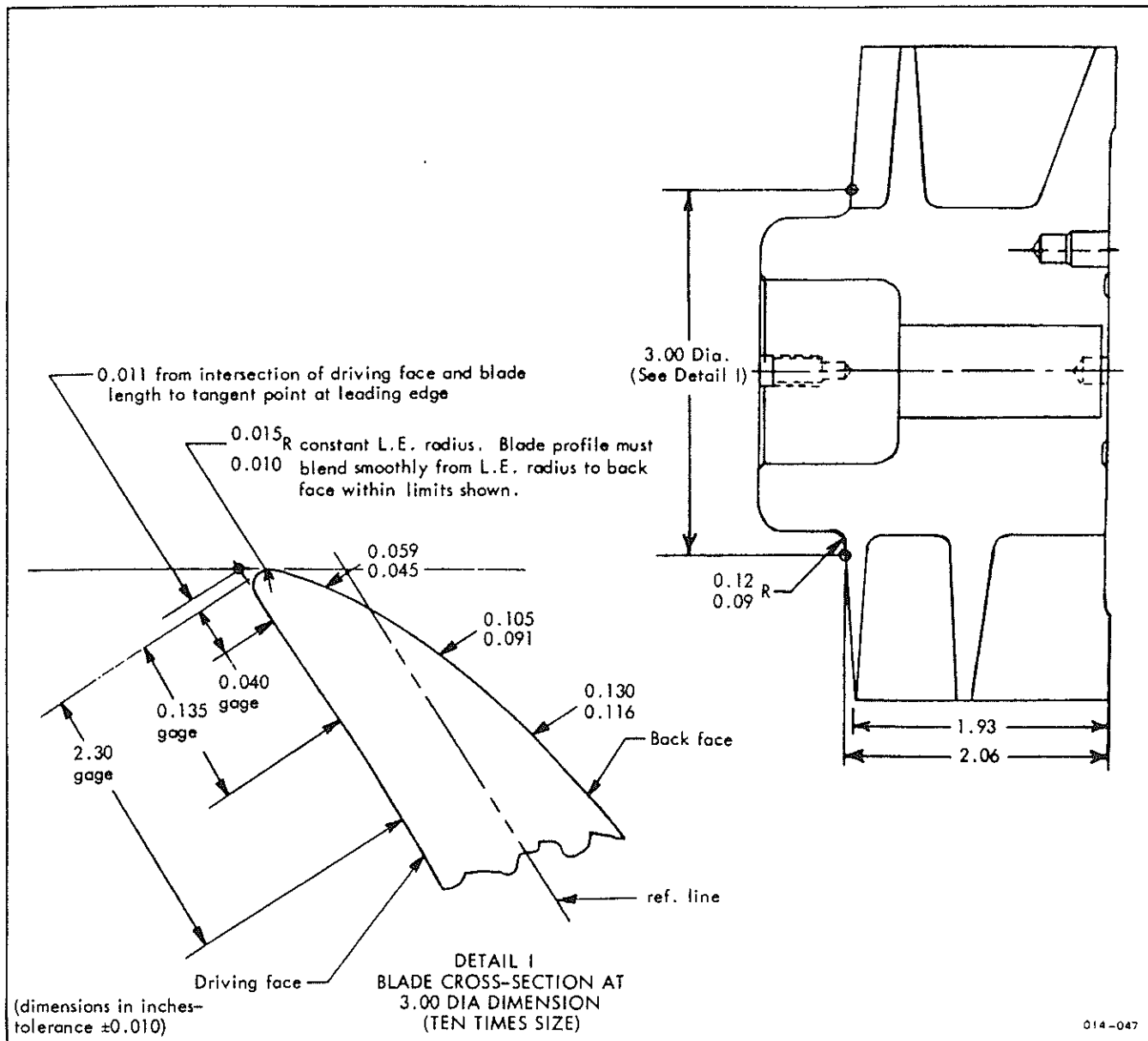


Figure 6-3. Inducer Leading Edge Sharpening

installation. Carefully blend all repair welds with surrounding metal to minimize stress-risers. Annealing after welding is unnecessary.

c. The maximum amount of metal which may be removed from the trailing edges of the nozzle ring guide vanes when grinding out cracks is as follows: 3/64 inch in from the guide vane trailing edge at its base (inner shroud), and 1/32 inch in from the guide vane trailing edge at its tip (outer shroud). An imaginary line connecting these two points limits the area which may be ground off. Round off the edges after grinding.

### CAUTION

Do not repair cracks in leading edges of guide vanes.

d. Cracks on nozzle ring vane surfaces other than leading or trailing edges, if not more than 0.015 inch

deep, may be removed locally by removing material to a depth of 0.015 inch. Blend area into existing contour of blade. If dye-penetrant crack indication still shows after this repair, replace vane. Pits in vanes caused by mechanical damage are permitted to a depth of 0.020 inch without rework. Corrosion pits are allowable to a depth of 0.010 inch without rework. Corrosion pits from 0.010 to 0.015 inch may be blended out as described above. Replace vanes having pits in excess of these limits as follows:

1. Remove vanes by carefully grinding out weld bead on outer shroud. Do not overgrind so as to thin out surrounding sheet metal.

2. Insert replacement vanes and use inert gas back-up purge during welding. Metal arc weld with Hastelloy "W" AC DC coated welding electrodes per AMS-5787, Type B, manufactured by Alloy Rod Co., York, Pa. Continue weld bead 0.375 ( $\pm 0.060$ ) inch past trailing edge to prevent underside trailing edge cracks.

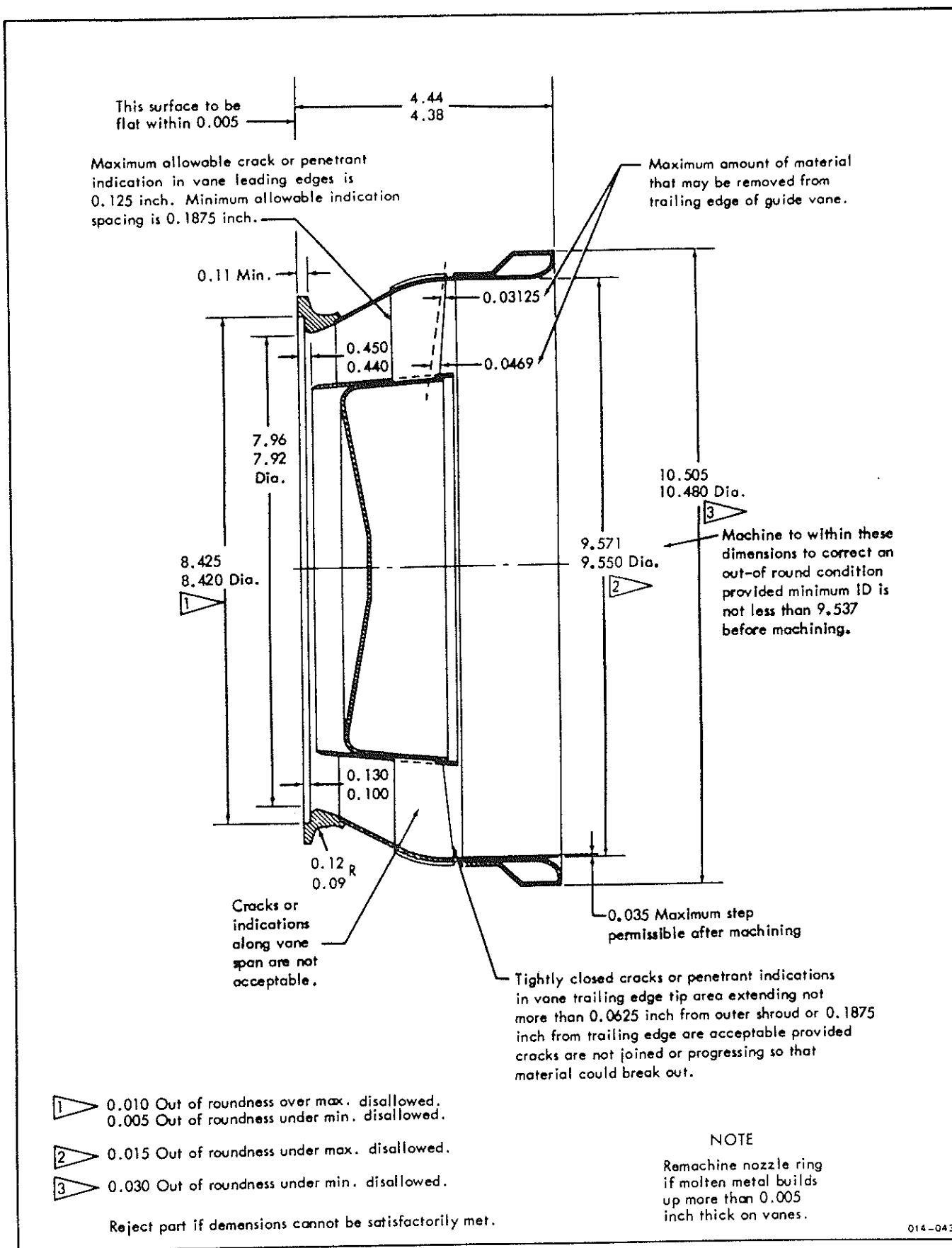


Figure 6-4. Nozzle Ring Inspection

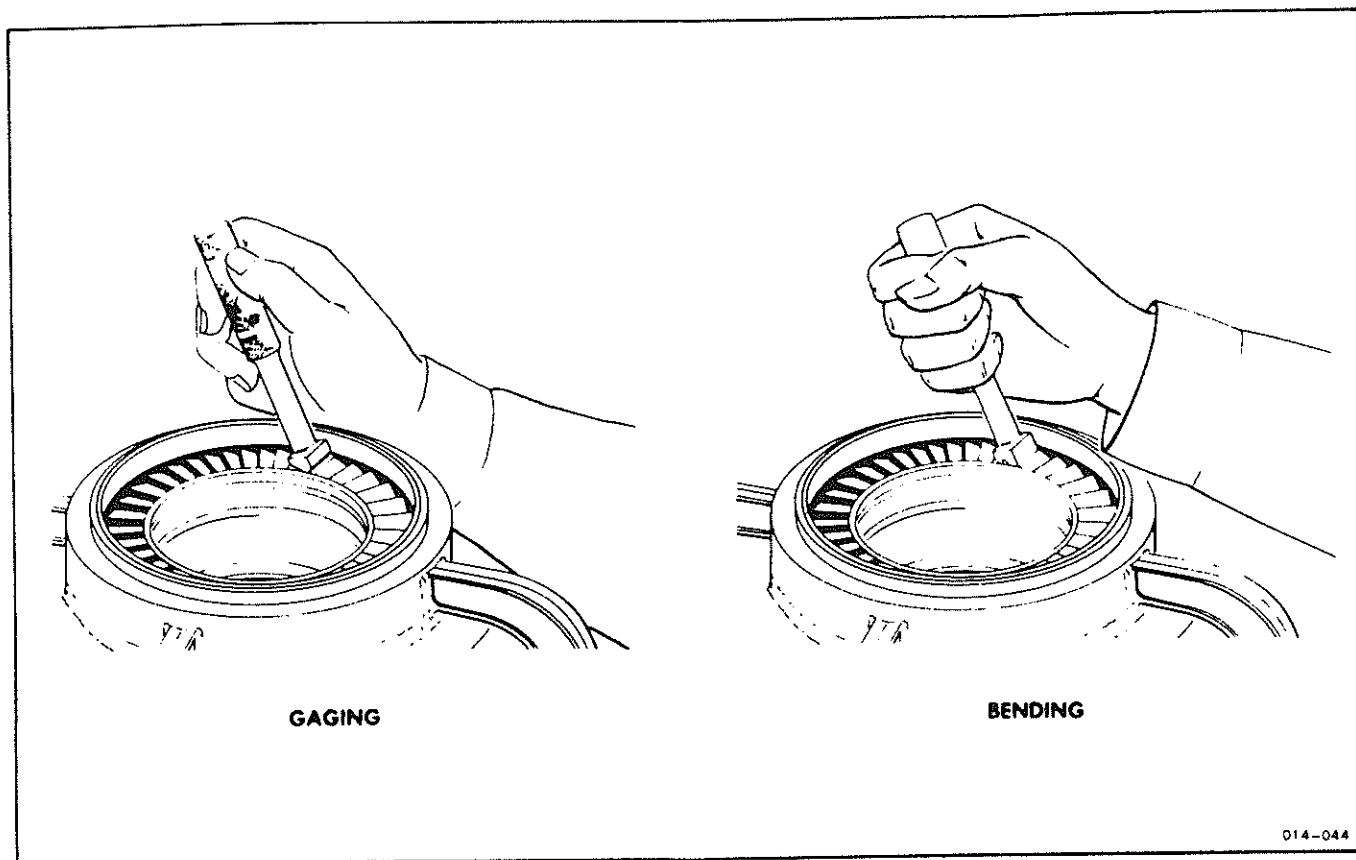


Figure 6-5. Gaging and Setting Nozzle Ring and Nozzle Box Vanes

e. Flow check nozzle ring in accordance with instructions in paragraph 6-49.

f. Perform fluorescent or dye penetrant inspection in accordance with Military Specification MIL-I-6866.

**6-7. BURNER SHELL.** Measure outside diameter of burner shell within area shown in figure 6-6. Refer to Table III for maximum outside diameter. Replace burner shell if maximum OD is exceeded. If any crack is found, replace the burner shell. When inspecting burner shell, leave liner support in place unless it is found to be damaged. A liner support may be procured separately if needed. Each new burner shell contains a liner support. If a liner support is to be replaced, the old one must be broken into pieces in order to remove it. Then the new liner support may be installed by pressing into position and bending tang into groove.

**6-8. BURNER DOME.** No repair is permitted on the burner dome. Replace dome if cracks exceed limits shown in figure 6-7. Special burner dome wrench from Tool Group No. 1 is required to install burner dome.

**6-9. BURNER LINER.** Liner repair is limited to rounding in case of warpage. Replace liner if cracks exceed limits shown in figure 6-7.

**6-10. CROSSFIRE TUBE AND ELBOWS.** Reject cracked crossfire tube elbows. Do not remove seal rings from acceptable elbows unless rings are broken or cracked, requiring replacement. Cracks in a crossfire tube should be repaired as follows:

a. Clean area to be welded. See Section V.

b. Repair tube cracks by tungsten arc welding with 19-9W Mo or AISI-347 alloy bare filler metal per AMS-5782 and AMS-5680, respectively.

c. Seal tube ends and inert gas purge inside of tube while welding. Carefully blend weld bead tube surface.

d. Perform fluorescent penetrant inspection in accordance with Military Specification MIL-I-6866. Annealing is unnecessary.

**6-11. NOZZLE BOX.** (See figure 6-8.) Nozzle boxes are acceptable with any amount of vane coating missing provided all other inspection requirements are met. Replace nozzle box if cracks exceed limits specified. Weld repair is limited to sheet metal and weld cracks. Repairs must be accomplished without distorting nozzle box so that critical clearances are affected. Perform weld repair as follows:

a. Clean area to be repaired. See Section V.

b. Repair by inert tungsten arc welding with Hastelloy "W" alloy bare filler metal per AMS-5786, manufactured by Haynes Stellite Co., Kokomo, Indiana.

c. Seal ports and flanges and inert gas purge during welding.

d. Grind or machine repair weld to original part contour in areas that will interfere with mating surfaces at installation.

e. Carefully blend all repair welds with surrounding metal to minimize stress-risers. Machine shroud after welding to obtain correct clearance.

f. Flow check nozzle box in accordance with instructions in paragraph 6-49.

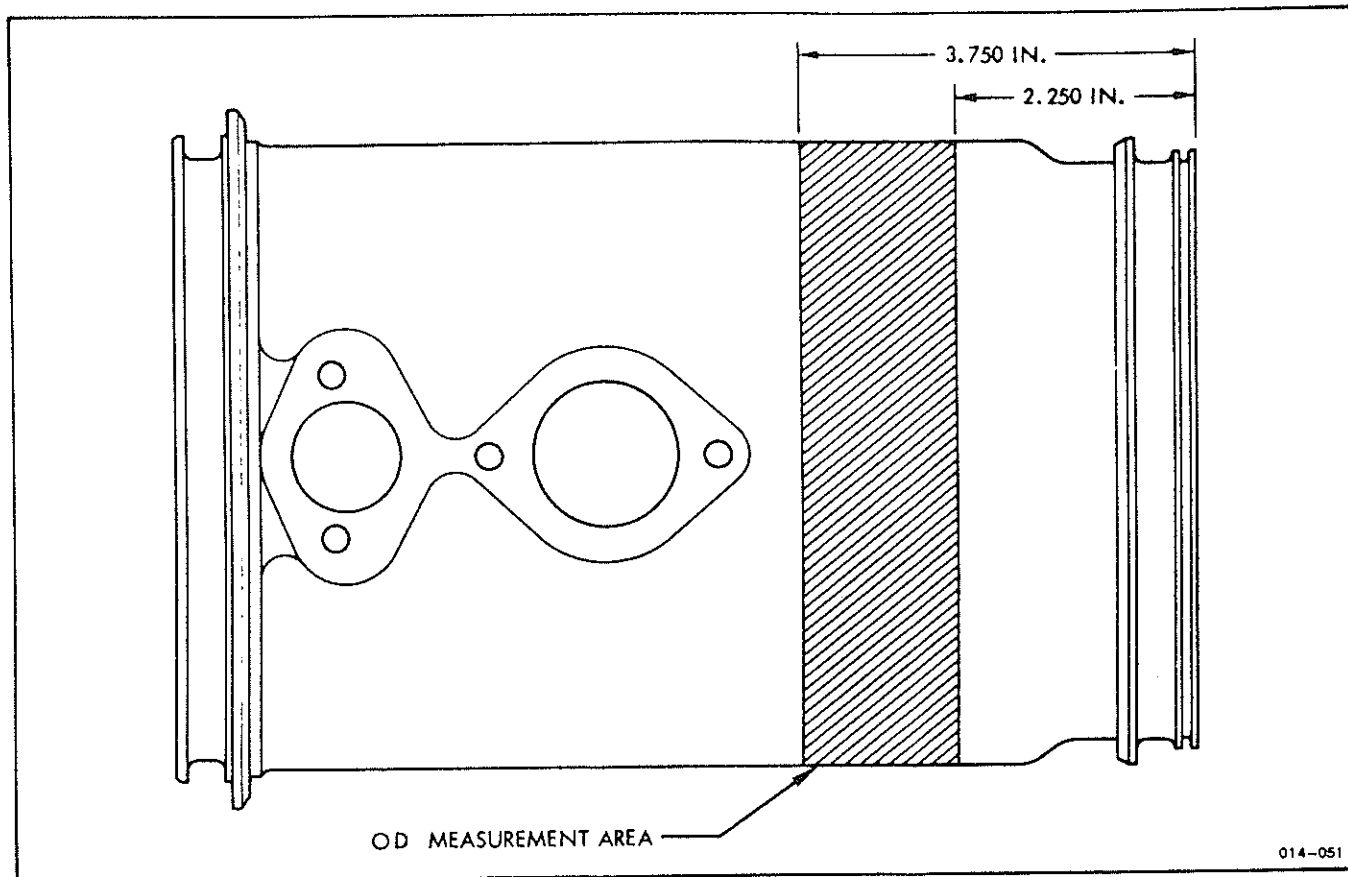


Figure 6-6. Burner Shell Inspection

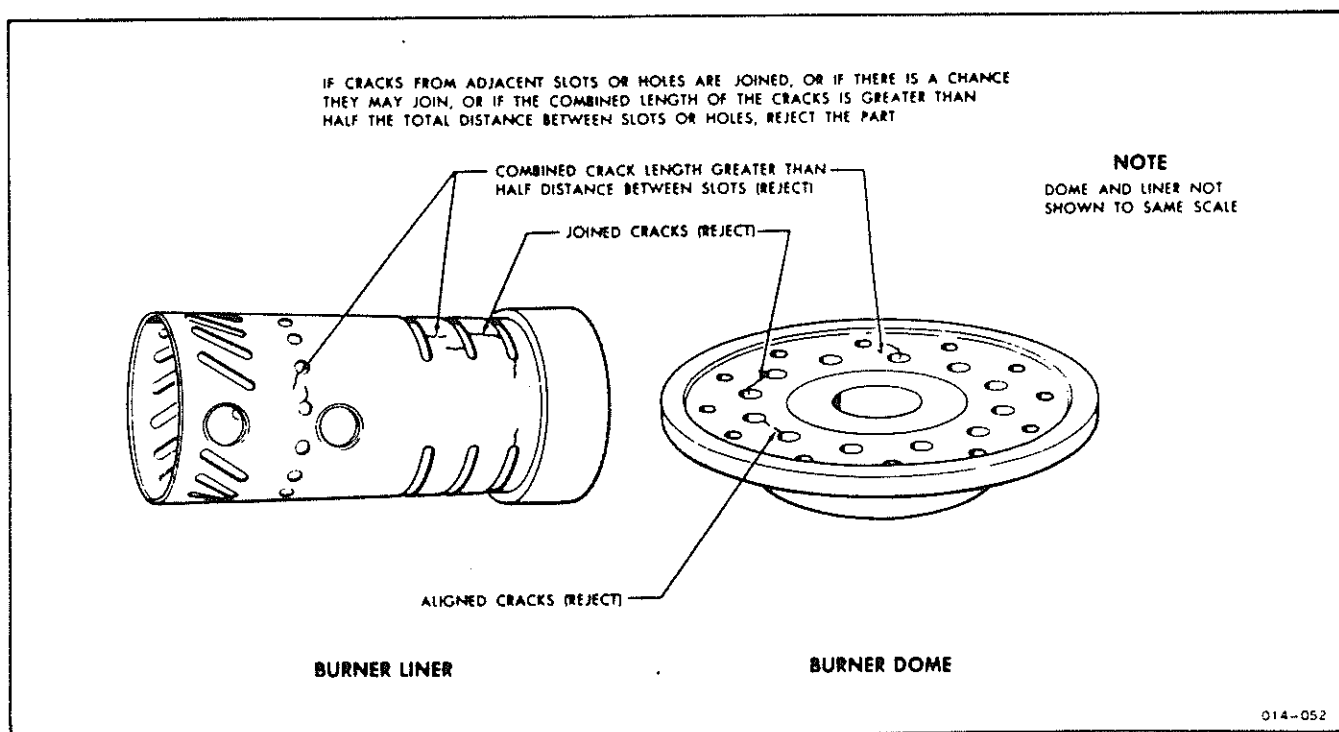


Figure 6-7. Burner Dome and Burner Liner Inspection



g. Perform fluorescent penetrant inspection in accordance with Military Specification MIL-I-6866. Annealing is unnecessary.

6-12. EXHAUST COLLECTOR. Dimensions and concentricities shown in figure 6-9 are for machining to correct out-of-round condition, which may hinder assembly with a new mating part or cause blade tip interference in the nozzle box. When machining to these dimensions, portions of the circumference may remain untouched at correct dimension. This is acceptable. Do not machine past dimension tolerance given. Minor denting of sheet metal is acceptable. Circumferential cracks adjacent to weldment at the skin attachment point of the mounting and seal rings are acceptable provided the combined length at the mounting ring or seal ring does not exceed 16 inches. No radial cracks into sheet metal are permissible. Cracked support bars must be removed and will not be replaced. Remove support bars by cutting with a hacksaw blade.

**CAUTION**

Avoid damage to surfaces of the surrounding area.

a. Make weld repairs as follows: (See figure 6-10.)

1. Mounting ring circumferential cracks. (Applies only to cracks in excess of total combined length of 16 inches.)

(a) Grind weld and base material to remove crack.

(b) Degrease using standard cleaning solvent, Federal Specification P-D-680, Type I. (See paragraph 5-5.)

(c) Clean by immersing in hot 35 percent nitric acid solution for 5 minutes and rinse.

(d) Reweld, using inert gas purge tungsten arc weld with 3/64 diameter 19-9 Wx bare filler rod (Hastelloy W optional), Military Specification MIL-R-5031A.

(e) Stress-relieve after welding by heating in furnace at  $899 \pm 14^{\circ}\text{C}$  ( $1650 \pm 25^{\circ}\text{F}$ ) for 1 hour and air cool.

(f) Vapor blast in accordance with standard cleaning procedures.

(g) Check mounting ring attachment surface for flatness. These surfaces must be normal to the seal ring bore within 0.005 inch total indicator reading.

(h) Fluorescent penetrant inspect all rework areas in accordance with Military Specification MIL-I-6866.

2. Seal ring circumferential cracks.

(a) Remove weld by grinding down into the seal ring 0.125 inch. Taper ends of undercut area back to edge of seal ring 1 inch past each end of the crack area.

(b) Degrease using standard cleaning solvent, Federal Specification P-D-680, Type I.

(c) Clean by immersing in hot 35 percent nitric acid solution for 5 minutes and rinse.

(d) Reweld undercut area flush with edge of seal ring. Use inert gas purge tungsten arc weld with 3/64 diameter 19-9 Wx bare filler rod (Hastelloy W optional), Military Specification MIL-R-5031A.

(e) Stress-relieve after welding by heating in furnace at  $899 \pm 14^{\circ}\text{C}$  ( $1650 \pm 25^{\circ}\text{F}$ ) for 1 hour and air cool.

(f) Vapor blast in accordance with standard cleaning procedures.

(g) Remachine inside diameter of seal ring to 10.515  $\pm 0.005$  inch. ID of seal ring must be concentric within 0.010 inch total indicator reading to ID of mounting ring flange. Chamfer edge in weld area to  $45 \pm 5$  degrees. Check dimensions of remachined area.

**NOTE**

Remachined ID of seal ring may not be round and may not have complete machining cleanup.

(h) Fluorescent penetrant inspect all rework areas in accordance with Military Specification MIL-I-6866.

3. Radial or circumferential cracks originating at the weldment of a thermocouple boss.

(a) Grind existing weld around boss flush with base material where adjacent to crack. Width of grind must equal 1/2 width of existing weld. Terminate weld 0.125 to 0.375 inch beyond end of cracks.

**CAUTION**

Do not grind base material.

(b) Degrease with solvent. See paragraph 5-5.

(c) Clean by immersing in hot 35 percent nitric acid for 5 minutes. Rinse in hot water.

(d) Weld crack, using inert gas purge tungsten arc weld with 3/64 diameter 19-9 Wx bare filler rod (Hastelloy "W" optional), Military Specification MIL-R-5031A.

**CAUTION**

Maintain surface to surface contact with copper backup sheet and base material while welding.

(e) Grind weld repair within 0.008 to 0.010 inch of base material. Grind weld only on outside of exhaust collector.

(f) Fluorescent-penetrant inspect all reworked areas in accordance with Military Specification MIL-I-6866.

(g) Stress-relieve by heating to  $899 \pm 14^{\circ}\text{C}$  ( $1650 \pm 25^{\circ}\text{F}$ ) for 1 hour and air cool.

(h) Vapor blast in accordance with standard cleaning procedure.

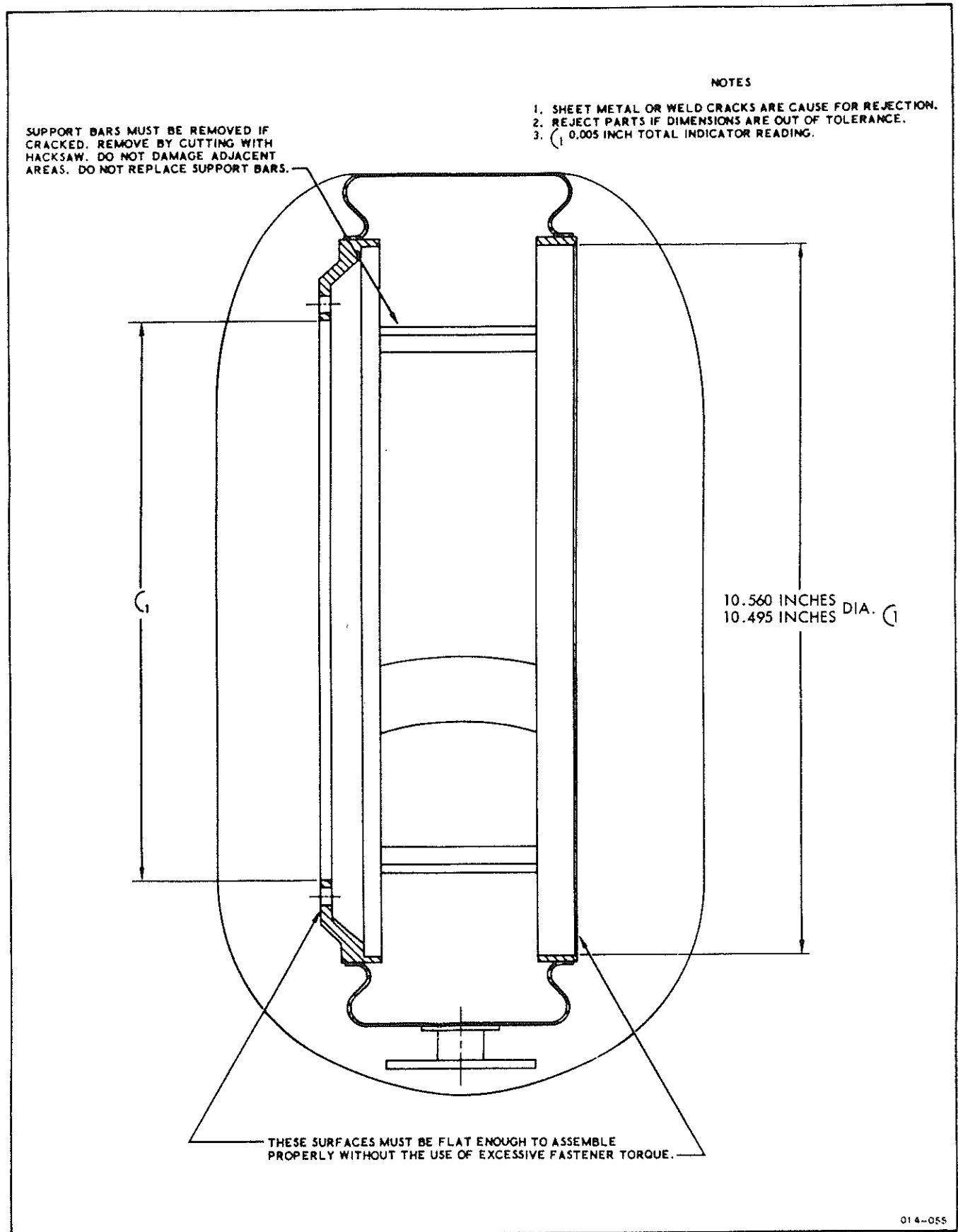
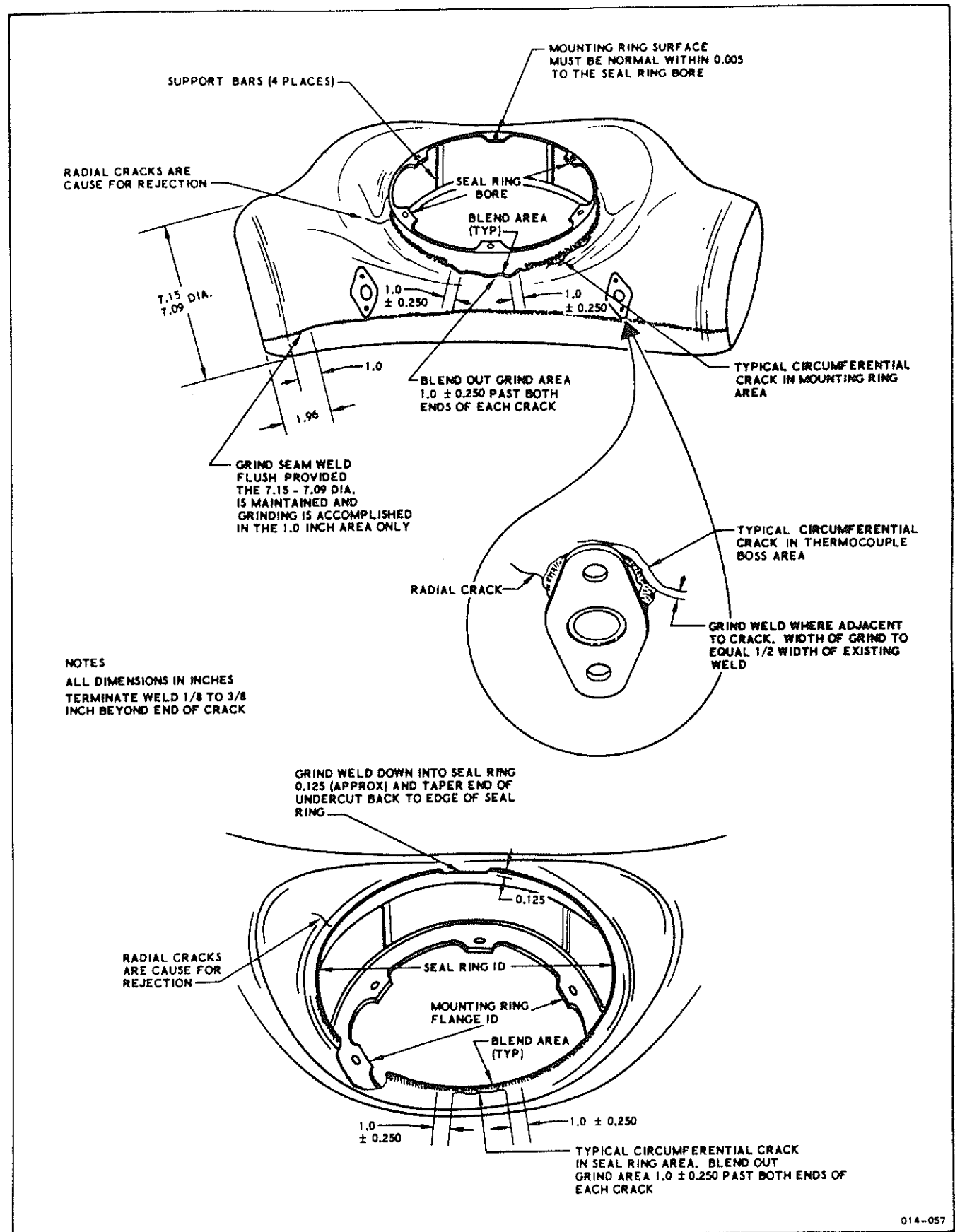


Figure 6-9. Exhaust Collector Inspection



014-057

Figure 6-10. Exhaust Collector Weld Repair

b. Removal of surplus seam weld material on exhaust collector outlets to eliminate weld bead contact with eductor.

1. Grind seam welds flush for a distance of one inch back from the major diameter of exhaust outlet. Diameter of 7.09 to 7.15 inches and minimum wall thickness of 0.085 inch must be maintained.

2. Fluorescent-penetrant inspect all grind areas.

6-13. EDUCTOR ASSEMBLY. (See figure 6-11.) Inspect eductor assembly for cracks. Pay particular attention to the areas defined in the illustration.

a. Make weld repairs of cracks as follows:

1. Drill a 1/16 inch diameter stop hole at ends of each crack. If crack is adjacent to welded area, grind existing weld flush with base material, then drill 1/16 inch diameter stop holes.

### CAUTION

Do not grind base material.

2. Weld crack, using inert gas purge tungsten arc weld with 0.035 inch diameter 19-9 Wx base filler rod (Hastelloy "W" optional), Military Specification MIL-W-8611. Place a 0.030 to 0.050 inch copper sheet under the base material to serve as a heat sink during welding operation.

### CAUTION

Ensure surface to surface contact between copper sheet and base material is maintained throughout welding procedure.

3. Grind weld to within 0.080 inch of base material.

4. Fluorescent-penetrant inspect all reworked areas in accordance with Military Specification MIL-I-6866.

5. Stress relieve by heating to  $899 \pm 14^{\circ}\text{C}$  ( $1650 \pm 25^{\circ}\text{F}$ ) for one hour and air cool.

6. Vapor blast in accordance with standard cleaning procedure.

b. Make weld repairs of circumferential cracks in top sheet of eductor originating at point of attachment of spacer to top sheet as follows:

1. Grind parent material of eductor top sheet that is still attached to spacer to remove uneven edges.

2. Grind eductor top sheet around crack area as required to remove uneven edges. Minimum gap between parent material attached to spacer and parent material of top sheet must be 0.030 to 0.090 inch after grinding.

3. Drill a 1/16 inch diameter stop hole at the end of cracks extending into the trimmed area.

4. Fabricate a 0.017 to 0.028 inch thick AISI 321 annealed steel doubler to dimensions shown in figure 6-11. Drill a 0.281 to 0.296 inch hole through doubler to match hole in spacer.

5. Degrease eductor assembly and doubler using standard cleaning solvent, Federal Specification P-D-680, Type I.

6. Pickle eductor assembly and doubler in a hot 35 percent nitric acid solution for 5 minutes. Rinse in hot water.

7. Seam or overlap spot weld doubler to eductor top sheet forming double row weld at ends of doubler in

accordance with Military Specification MIL-W-6858, Class C. Ensure hole in doubler is aligned with hole in spacer.

8. Weld cracks extending beyond periphery of doubler in accordance with Military Specification MIL-W-6858, Class C.

9. Fluorescent-penetrant inspect all reworked areas in accordance with Military Specification MIL-I-6866.

10. Stress relieve by heating to  $899 \pm 14^{\circ}\text{C}$  ( $1650 \pm 25^{\circ}\text{F}$ ) for one hour and air cool.

11. Vapor blast in accordance with standard cleaning procedures.

6-14. INNER CONE. Repair is permitted only in areas shown in figure 6-12.

6-15. GAS PRODUCER WHEEL AND SHAFT ASSEMBLY. If cracks are found in the turbine wheel hub, replace the wheel and shaft assembly. Repair is permitted on turbine blades only as described in paragraph 6-20. If any repair grinding is performed on any blade, the wheel and shaft must be rebalanced by following the instructions in paragraph 6-22. If the gas producer has experienced an impeller or gear train failure, check runout of the rotor shaft as follows:

a. Support the rotor wheel and shaft assembly by vee-blocks placed at the journal surfaces of the turbine end bearing and the steady (sleeve) bearing.

b. Using a dial indicator graduated to 0.0001 inch, check runout of the shaft at the compressor bearing sleeve journal. Runout at this point must not exceed 0.001 inch total indicator reading. If runout exceeds this limit, replace the wheel and shaft assembly.

6-16. GAS PRODUCER TURBINE WHEEL MINIMUM DIAMETER. Determine if diameter (blades installed) of the turbine wheel is acceptable by the following procedure:

### NOTE

Measure wheel diameter before removing blades from wheel.

a. Measure and record inside diameter of the nozzle box outer shroud. (See figure 6-8.)

b. Subtract 0.080 inch (maximum allowable tip clearance) from measurement recorded in step a. Remainder is the minimum allowable wheel diameter.

c. Measure and record wheel diameter at four equally spaced locations.

### NOTE

Blade tips damaged by contact with outer shroud of either the nozzle box or nozzle ring must be repaired. Remove material with a small hand stone or grinder. The original shape of the tip must be maintained. Remove an equal amount of material along entire tip span. Remove all rough or sharp edges.

d. If diameter of wheel assembly is equal to or greater than dimension obtained in step b, wheel assembly is usable. If diameter of wheel assembly is less than dimension obtained in step b, turbine blades must be replaced. Refer to paragraph 6-21 for turbine blade replacement instructions.

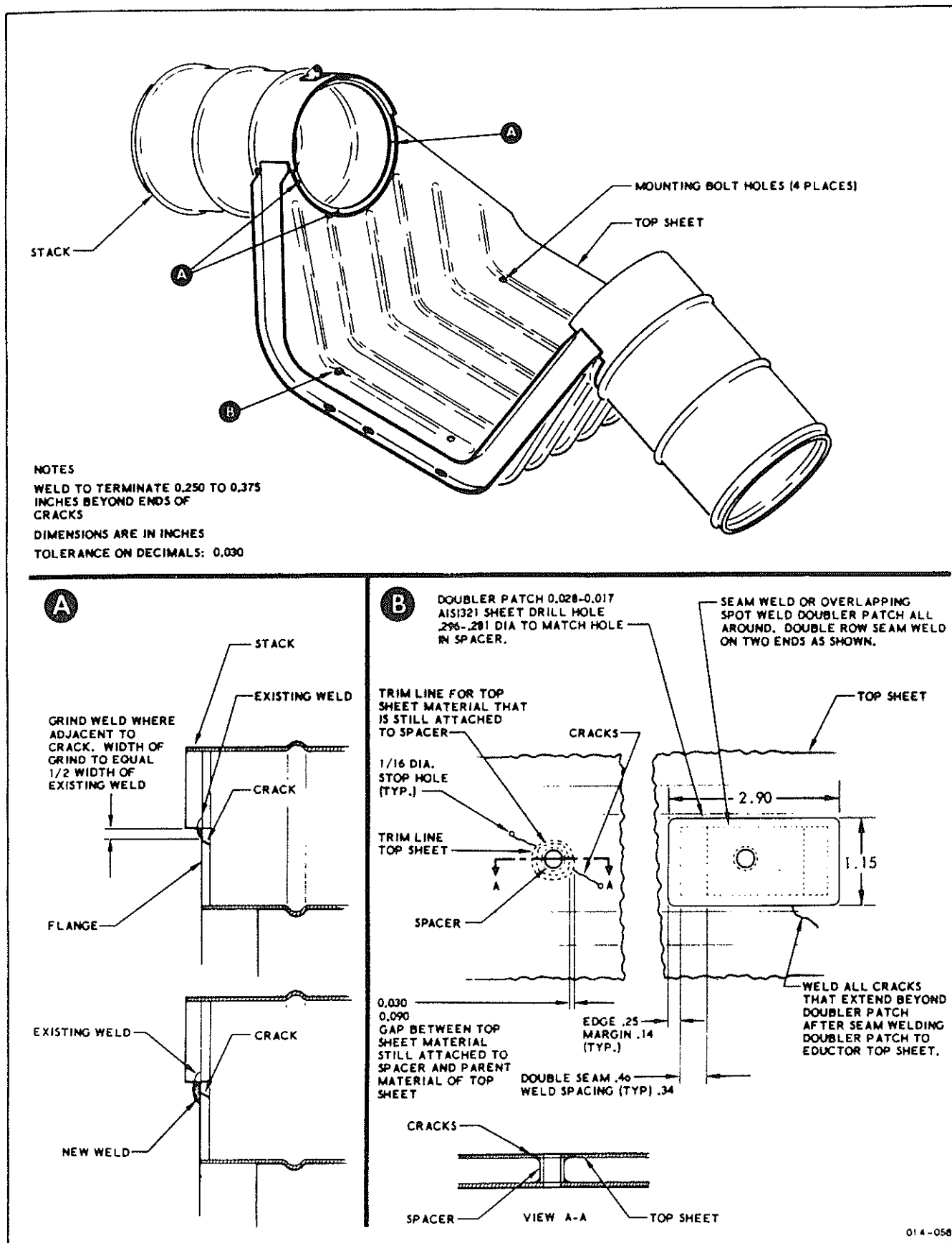


Figure 6-11. Typical Eductor Assembly Crack Repairs

6-17. **OUTPUT SECTION WHEEL AND SHAFT ASSEMBLY.** Reject assembly if cracks in hub are found. Repair is permitted on turbine blades only as described in paragraph 6-20. If any grinding is done, balance wheel and shaft assembly, refer to paragraph 6-22. If any blade is damaged beyond repair, refer to paragraph 6-21 for replacement instructions.

**CAUTION**

Do not damage blade keeper clips during grinding. Serious damage to the engine may result.

6-18. **OUTPUT SECTION TURBINE WHEEL MINIMUM DIAMETER.** Determine if the diameter (blades installed) of the turbine wheel is acceptable, by the following procedures:

**CAUTION**

Wheel diameter measurement must be accomplished before blades are removed from wheel.

- a. Measure and record the inside diameter of the nozzle ring outer shroud.
- b. Subtract 0.100 inch (twice the minimum allowable tip clearance) from the measurement recorded in step a. Result is the minimum allowable wheel diameter.
- c. Measure and record wheel diameter (blades installed) at four equally spaced locations.
- d. If diameter of wheel assembly is equal to or greater than dimension obtained in step b, wheel assembly is usable. If diameter of wheel assembly is less than dimension obtained in step b, turbine blades must be replaced. Refer to paragraph 6-21 for turbine blade replacement instructions.

**NOTE**

Blade tips damaged by contact with outer shroud of either the nozzle box or nozzle ring must be repaired. Remove material with a small hand stone or grinder. The original shape of the tip must be maintained. Remove an equal amount of material along entire tip span. Remove all rough or sharp edges.

- 6-19. **GAS PRODUCER OR OUTPUT TURBINE WHEEL HUB.** If wheel hub has been overheated (evidenced by burned blades), perform Rockwell hardness test. (See figure 6-13.) Hardness reading must be taken on a single key. Take three readings, one near each end of key (not closer than 1/16 inch), and one in center. Hardness must be within Rockwell range of A64 to A69.

6-20. **TURBINE BLADE REPAIR.** Cracks not more than 1/16 inch long in leading and trailing edges and mechanical damage to turbine blades may be repaired if it can be done within the limits of the following procedure:

- a. Cracks and mechanical damage may be ground out of the leading and trailing edges providing total depth of grind does not exceed 1/16 inch. Grinding must extend along entire length of blades, and be carefully blended with surfaces to maintain existing airfoil contour.

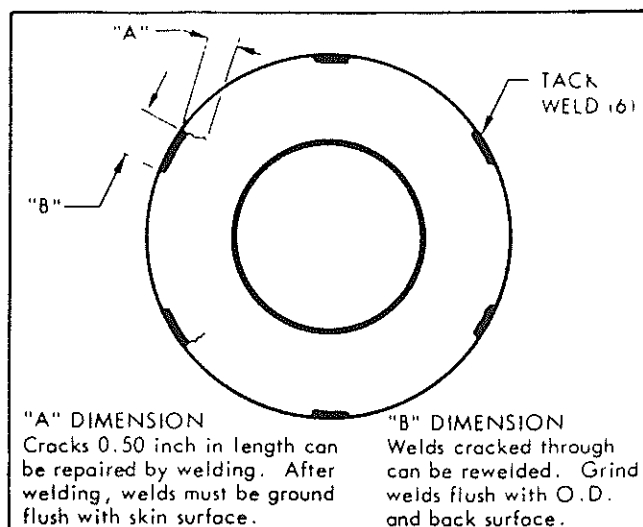


Figure 6-12. Inner Cone Weld Repair

014-056

- b. All metal pickup on airfoil surfaces must be removed by grinding or polishing.
- c. Rework of mechanical damage or penetrant indications on surfaces of blades is limited to 0.008 inch in depth and must be carefully blended.
- d. Damaged leading edge and trailing edge tip corners may be removed at a 45-degree angle to a maximum removal depth of 3/32 inch from original corner.
- e. Blade bending, as detectable with a straight-edge and feeler gage when compared with a new blade, is not acceptable. Blades bent in the area from mid-span to tip may be cold straightened. Penetrant inspection is mandatory following straightening. No penetrant indications or tool marks are allowable after straightening.
- f. Erosion, pitting, and mechanical damage up to 0.005 inch in depth is acceptable without rework. Smooth dents up to 0.010 inch are acceptable.

6-21. **TURBINE BLADE REPLACEMENT.** Partial or full fir-tree blade replacement is permitted. Full wheel blade replacement shall be accomplished as outlined in steps a, b, c, and d below. Any amount of partial blade replacement is permissible provided steps a, b, c, and d below are complied with.

- a. Electric etch position number on bottom of each new blade.
- b. Install blades in consecutive order starting with the Number 1 slot using new retainer clips. Blade replacement is made as follows:
  1. Install the replacement gas producer turbine blade (60, figure 4-12) (starting at Position 1 for full set replacement) with the concave side facing toward the wheel shaft. Count 33 blades and/or slots and install the second blade of the 2 blade set in the 33rd slot. Ensure that there are 32 blades and/or slots between the 2 replaced blades.
  2. Install the replacement power turbine blade (53, figure 4-19) (starting at Position 1 for full set replacement) with the concave side facing away from the wheel shaft. Count 25 blades and/or slots and install the second blade of the 2 blade set in the 25th slot. Ensure that there are 24 blades and/or slots between the 2 replaced blades.
- c. Insert new clips in wheel slots. Bend up clip ends as described in following steps: (See figure 6-14.)

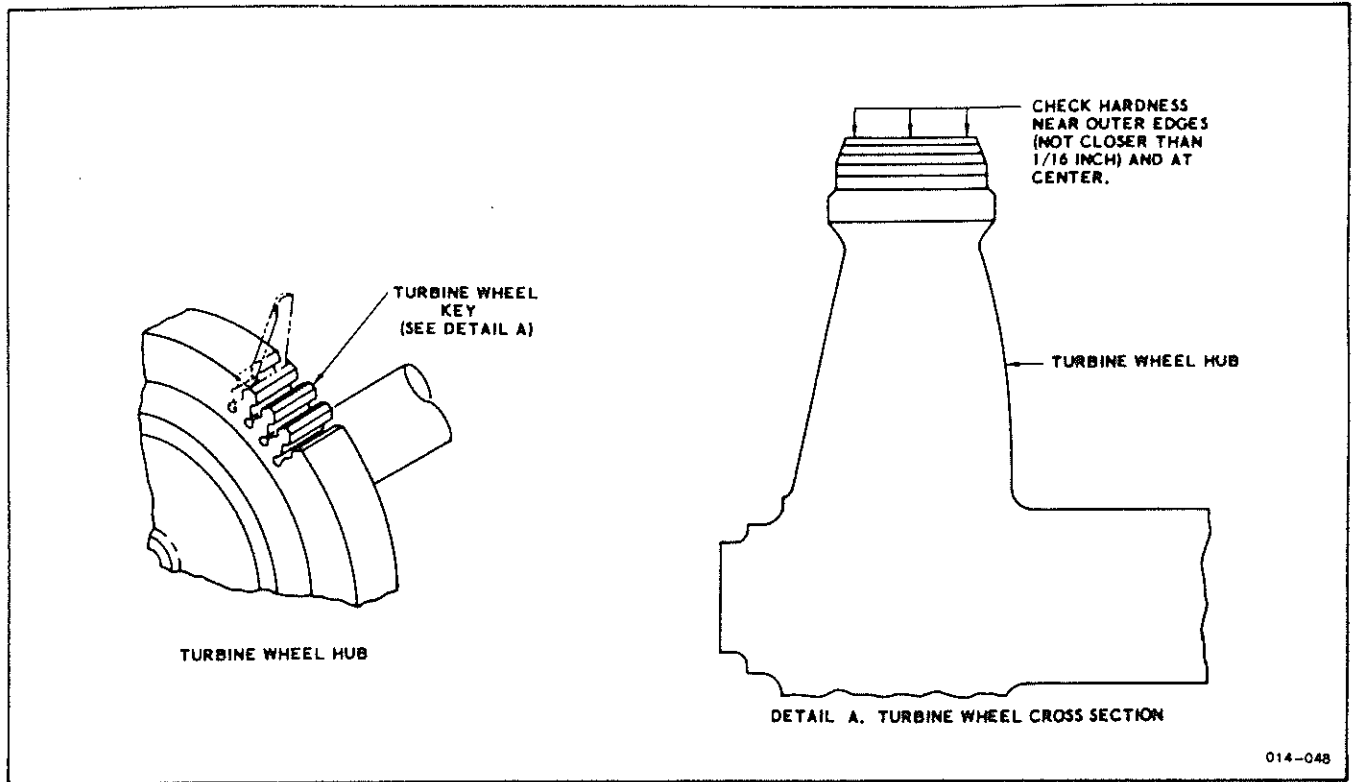


Figure 6-13. Wheel Hub Hardness Check

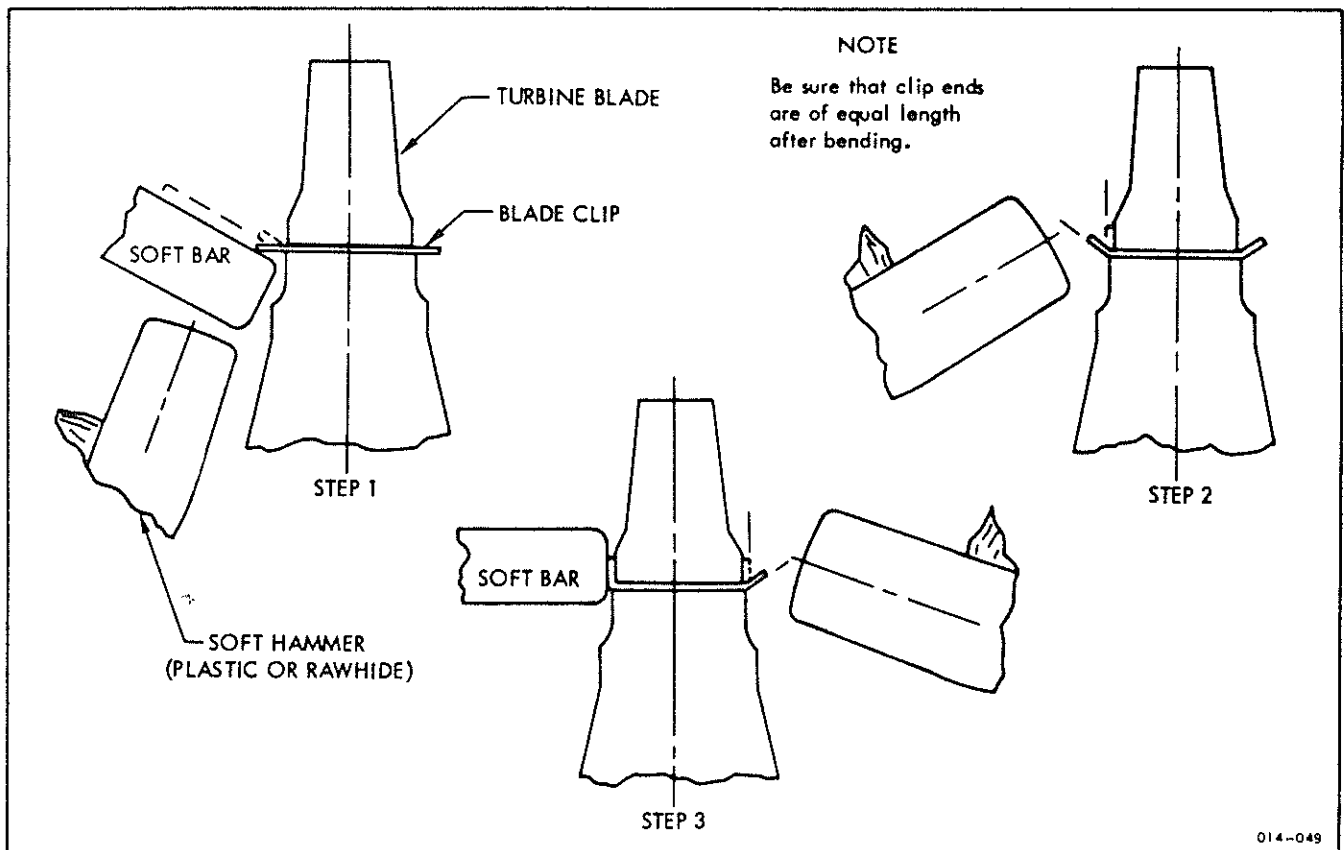


Figure 6-14. Turbine Wheel Clip Installation

1. Bend up clip end by placing a soft metal bar (aluminum) under clip end and striking bar with a soft hammer as shown in step 1. Repeat on opposite side.
2. Tap one clip end snug against wheel with a soft hammer as shown in step 2.
3. Tap opposite clip end snug against wheel with a soft hammer, backing up other side with a soft bar, as shown in step 3.
- d. Fluorescent or dye penetrant inspect blade clips after installation. No cracks are permitted.
- e. After full or partial fir-tree blade replacement, the wheel and shaft assembly shall be balanced as outlined in paragraph 6-22.
- f. When balancing has been completed, install turbine wheel cover from Tool Group No. 7 or 9.

**6-22. WHEEL AND SHAFT BALANCING.** Using special tool from (Tool Group No. 9 for gas producer and Tool Group No. 7 for output section) Table I, Section III, balance the gas producer or output section wheel and shaft assembly to less than 0.02 ounce-inch of unbalance. Remove material as required from grind area. (See figure 6-15 for location of grind area.) Material for balance may be removed down to 0.02 inch from wheel hub disc surface line. Minimum fillet radius in any direction must be 0.50 inch. Machine finish on the surface where material is removed must be 63 micro-inches. When spinning wheel and shaft assembly for balancing, be sure all blades are pressed as far toward the stub side of the wheel as possible.

### CAUTION

Do not damage blade keeper clips during grinding. Serious damage to the engine may result.

**6-23. BEARINGS.** Damage to bearings may result from improper clearance, lack of lubrication, corrosion, overload or uneven load distribution, heat, shock, extension of minor injuries such as scratches and nicks, introduction of foreign material such as grit or metal chips, and improper technique during assembly and disassembly. Evaluate bearings and determine disposition as follows:

- a. Abrasion and wear, usually caused by fine grit or contaminants, is acceptable if not more than 10 percent of the total bearing surface is affected and the surface is smooth.
- b. Burnishing is acceptable if it covers only the area carrying the load and there is no evidence of flowing or burning.
- c. Burning, indicated by discoloration or flow of material is not acceptable. Reject bearing and check related surfaces for lack of lubrication or improper clearance before installing a new bearing.
- d. Corrosion other than minor pitting or staining is not acceptable.
- e. Cracking or checkering indicates fatigue failure and is cause for rejection.

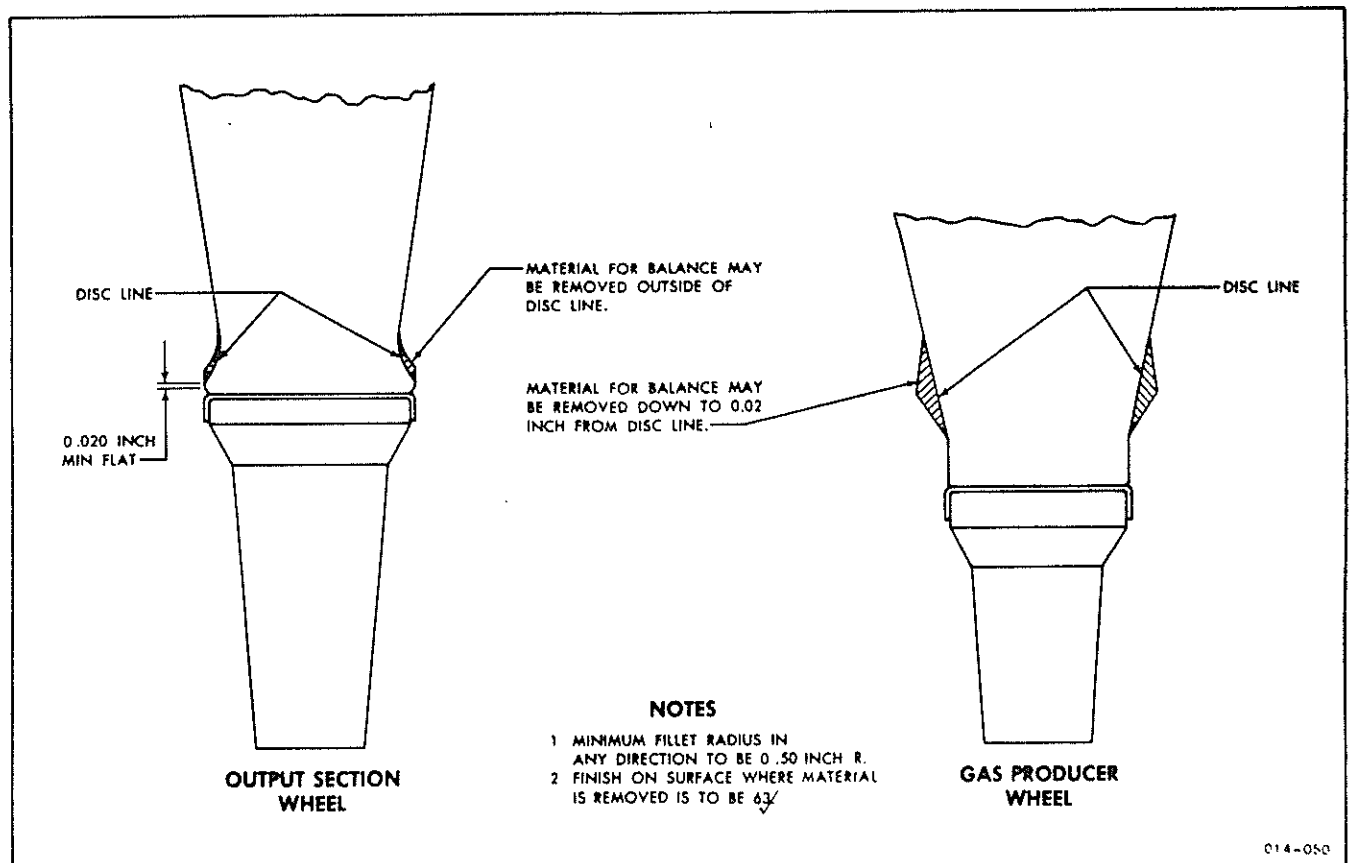


Figure 6-15. Balance Grind Limits



f. Flowing, movement of bearing material on bearing surface causing spreading or build-up, is cause for rejection.

g. Galling and scoring are acceptable if not more than 10 percent of the bearing surface is affected, and surface is smooth. Rework by burnishing lightly to remove sharp ridges. Inspect carefully with a six-power glass for imbedment of foreign particles. Reject bearing if evidence of imbedment is found.

h. Scratches are acceptable if they are light and cover no more than 10 percent of the bearing surface. No rework is required for such light scratches, but deeply or extensively scratched bearings must be replaced.

i. Varnish build-up or glazing is the natural result of pressure, oil, and heat on some bearings, and need not be removed.

**6-24. BEARING FAILURE.** If an engine is being re-built after a bearing failure, all affected parts must be carefully checked using the fluorescent-penetrant method for all stainless steel and aluminum parts and magnetic-particle inspection for steel and cast iron parts. Flush oil passages thoroughly with solvent under pressure.

**6-25. BEARING CAPS.** When repairing bearings, observe the following instructions:

a. If a radial or thrust bearing is replaced because of excessive wear, replace the adjacent bearing cap assembly or insert.

b. If either the gas producer turbine assembly or the output section turbine assembly is replaced, replace the related bearing cap assembly or insert.

c. When the gas producer thrust bearing is replaced, replace the related turbine-end bearing cap assembly or insert. Axial repositioning of the shaft affects both labyrinth seal areas.

d. If either turbine assembly is replaced, replace the respective turbine-end bearing cap assembly or insert.

e. Check the dimension of each land when checking the dimension of the bearing cap insert. Make certain there are no burrs. When checking ID, check dimension at area between the grooves worn by the labyrinth seal.

f. Replacement of bearings due to impregnation with foreign material or damage other than wear does not require replacement of bearing cap assemblies.

#### NOTE

If the bearing cap and insert and the labyrinth seal of turbine assembly are acceptable, they must be used in the same relationship as when removed from the engine. An acceptable turbine assembly may be reinstalled with a new bearing cap assembly or insert.

g. Replace insert in the gas producer turbine end bearing cap assembly (8, figure 4-18) as follows:

1. Remove pin (6) from bearing cap (8) by driving out from the inside.

2. Press insert (7) from cap (8).

3. Clean bearing cap in accordance with paragraph 5-5.

4. Press new insert (7) into bearing cap (8). Insert must be installed from turbine wheel side of bearing cap and must be flush to 0.005-inch below surface of cap.

5. Drill hole in insert for pin, using a number 41 drill. Use existing hole in bearing cap as a guide.

6. Machine ID of insert to a diameter of 1.504 ( $\pm 0.001$ ) inches. Chamfer both ends 0.01 to 0.02 inch by 45 degrees.

7. Install pin (6) in hole from inside of insert. Pin in installed position must be 0.01 to 0.05 inch outside of insert ID.

h. Replace insert in bearing cap (47, figure 4-12) as follows:

1. Press insert (48) from bearing cap (47).

2. Clean bearing cap in accordance with paragraph 5-5.

3. Press new insert (48) into bearing cap. Insert must be flush to 0.010-inch below surface of impeller end of bearing cap; ID of insert must be 2.0 inches minimum after pressing in place.

**6-26. BEARING RETAINERS.** Light scratches are acceptable. Reject if cracked, or if heavily gouged or scraped on bearing surface. Retainer must be flat enough to assemble properly without excessive fastener torque. Oil holes must be open.

**6-27. SEGMENTED THRUST BEARING.** If measurements of dimensions given in chart are not within limits, or if visual inspection reveals damage more severe than permitted in paragraph 6-23, replace bearing. No repair is allowed. If any segment is defective, replace the whole bearing. Bearings are matched sets of segments.

**6-28. GEARS.** Teeth sides should show normal shine resulting from contact with mating gear. Reject gear if any part is excessively worn or if any teeth are cracked or missing. If gear is rejected, inspect the mating gear carefully for similar damage.

**6-29. CLUSTER GEAR BEARINGS.** Inspect the bearings in place, by the instructions given in paragraph 6-23. If a bearing should be sufficiently damaged to require replacement, proceed as follows:

a. Remove both bearings with a suitable blind-hole bearing puller.

b. Chill new bearings and insert in gear. Bearings must be inserted flush to 0.010 inch below thrust surface.

**6-30. CLUSTER GEAR SHAFT.** Light scratches are acceptable. Reject gear shaft if heavily scored.

**6-31. PLANET PINIONS AND PLANET GEARS.** While inspecting, observe condition of tapers on these parts. If polished, lightly blast the tapered area only with silica grit (150 grit) to obtain from 32 to 80 micro-inch finish.

**6-32. TACHOMETER GEAR BUSHING.** Inspect the tachometer gear bushing without removing it from the housing unless replacement is necessary.

**6-33. OIL PUMP DRIVE BRACKET.** Examine surface condition. If bracket should require replacement (an extremely rare occurrence), it must be procured in a matched set with an accessory drive housing, or installed by an exacting drilling and fitting process. Instructions for such installation may be obtained from

the factory at the time of purchase of the part should such replacement become necessary.

#### NOTE

Do not mix parts of different engines.

6-34. **OIL SLINGER AND SLEEVE.** Inspect surfaces at inside diameter and end areas of oil slinger and sleeve for galling, fretting and corrosion. Light staining of the entire inside diameter area is acceptable. Minor galling and fretting affecting not more than 25 percent of the area is permissible. Parts should be free but not loose on the shaft. Do not attempt rework except for light cleaning with crocus cloth, Federal Specification P-C-458.

6-35. **OIL FILTER ELEMENT.** Remove used element from oil filter in sump base and install new element.

6-36. **OIL FILTER GUIDE ASSEMBLY.** Inspect condition of rubber gasket on the oil filter guide assembly. If damaged or detached, replace complete guide assembly.

6-37. **OIL DIPSTICK TUBE.** Check for looseness. If dipstick tube is loose, secure according to the following instructions: (See figure 6-16.)

- a. Remove loose dipstick tube.
- b. Clean mating surfaces, using one of the following cleaning procedures:
  1. If dried adhesive is present below scribe line on tube, remove by grit blasting with 150 grit aluminum oxide or equivalent.

#### NOTE

Mask area above scribe line to prevent removal of the cadmium plated protective surface.

2. If no dried adhesive is present below scribe line, clean as follows:

- (a) Wipe off all oil and grease.
- (b) Apply cleaning solvent, Federal Specification P-D-680, Type I, with clean, lint-free absorbent material, or vapor degrease using trichlorethylene, Military Specification MIL-T-7003.
- (c) Scrub surface with a clean fiber brush if necessary.
- (d) Wipe off solvent with clean, dry, lint-free cloth.
- (e) Repeat as necessary to remove all foreign material.

c. Prepare Epoxy Amine Adhesive, Epon 901, Grade 3, with catalyst B-3, Shell Chemical Co., Pittsburgh, California, or equivalent. Mix a 50-gram batch of adhesive containing 100 parts by weight of Epon 901 and 10.9 ( $\pm 0.5$ ) parts by weight of catalyst B-3. Do not thin Epon 901 or catalyst. Mix thoroughly and vigorously for 5 minutes.

#### WARNING

Epoxy adhesive may cause skin irritation. If skin contact occurs, wash affected area immediately with soap and water.

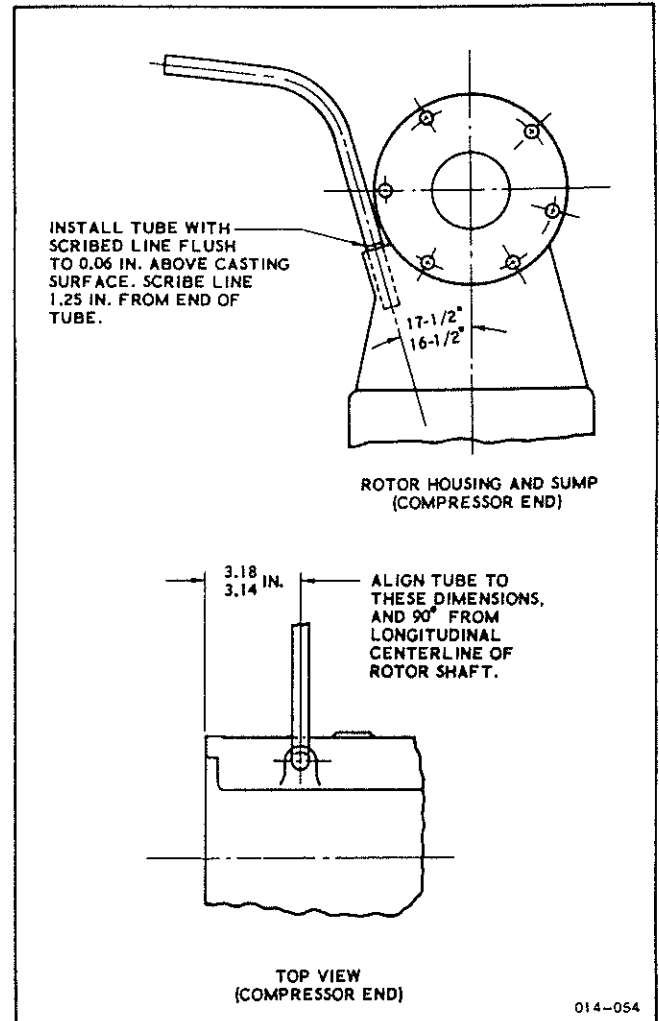


Figure 6-16. Oil Dipstick Tube Installation

- d. Apply adhesive evenly to both dipstick tube and rotor housing and sump assembly mating surfaces.

#### NOTE

Before adhesive has cured, it can be removed with methyl ethyl ketone, Federal Specification TT-M-261.

- e. Install dipstick tube in rotor housing and sump assembly. Position tube 90° to longitudinal centerline of rotor shaft and with scribe line flush to 0.060 inch above casting boss. A continuous bead of adhesive should be visible around tube. Maintain position of tube during curing process. See figure 6-16 for position and alignment dimensions.

f. Oven-cure rotor housing and sump assembly for 30  $\pm$  5 minutes at 118°C  $\pm$  5° (240°F  $\pm$  10°) and 90  $\pm$  5 minutes at 117°C  $\pm$  5° (350°F  $\pm$  10°). Optional cure is 30  $\pm$  5 minutes at 118°C  $\pm$  5° (240°F  $\pm$  10°) and 120  $\pm$  5 minutes at 149°C  $\pm$  5° (300°F  $\pm$  10°).

6-38. **OIL SEALS.** Remove and discard all oil seals. Install new oil seals.

6-39. OIL FILLER CAP. Inspect for chipped or otherwise removed paint from filler cap. Check that stencil on filler cap is legible and undamaged. If filler cap paint or stencil shows damage, touch up or repaint as follows:

- a. Apply chemical and solvent resistant flat black finish, BMS 10-11F or equivalent, as required.
- b. Apply yellow lacquer, Military Specification MIL-L-19537, to stencil as required to restore legibility. Stencil reads OIL FILLER CAP. - 6 QTS. around 0.5 inch radius in 18-point letters.

6-40. RETAINER NUT. The retainer nut requires only a surface check.

6-41. CAST ALUMINUM PARTS INSPECTION AND REPAIR. Inspect housings for cracks, giving special attention to the highly-stressed areas around mounting bolts and studs. Inspect press-fit bushings in place. If replacement is required, remove with a blind bearing puller. Install new bushings in accordance with accepted shop practice. Do not remove dowel pins unless replacement is required. Replace damaged Heli-coil and Rosan inserts and studs (see paragraphs 6-42 through 6-46). All mating surfaces must be flat and smooth for proper contact at assembly without excessive fastener torque. Cast aluminum parts may be required provided the repair does not alter the function of the part or cause warpage or excessive fastener torque. Repair cast aluminum parts according to the following procedure:

- a. Remove anodizing on area to be repaired.

#### NOTE

Use a stainless steel wire brush. High carbon steel will deposit ferrous metal in grind area causing a defective weld and corrosion.

- b. Remove necessary material in the area to be repaired.

#### CAUTION

Do not remove more material than required to provide for proper weld.

- c. Perform penetrant inspection to ensure preparation of entire defective area.
- d. Clean area with methyl ethyl ketone, Federal Specification TT-M-261, or toluene, Federal Specification JAN-T-171.

#### NOTE

Before welding, preheat casting to a maximum temperature of  $204^{\circ}\text{C} \pm 14^{\circ}$  ( $400^{\circ}\text{F} \pm 25^{\circ}$ ), indicated by a surface pyrometer.

- e. Inert tungsten arc weld with 716 filler metal, using a copper alloy backup plate to minimize warpage and strength reduction.
- f. Penetrant inspect weld, and brush anodize repaired area.

6-42. REMOVAL OF ROSAN INSERTS.

- a. Drill out inner serrations of lock rings and serrated collar of insert to depth of shoulder.

- b. Drive in screw extractor tool or similar tool.
- c. Screw out the insert.

6-43. REMOVAL OF ROSAN TWO-PIECE STUDS.

- a. Using a hollow mill at low speed, grind out inner serrations of lock ring and serrated collar to depth of shoulder.
- b. If lock ring fails to come out with stud, collapse lock ring with a punch.

#### NOTE

Alternate method: cut off stud shank flush with casting surface. Refer to paragraph 6-42.

6-44. INSTALLATION OF ROSAN INSERTS AND STUDS. Rosan inserts may be installed as a repair in stripped tapped holes in castings:

- a. Drill and counterbore with proper drill size.
- b. Tap threads to proper size and depth.
- c. Install sleeve in material with an inserting tool.
- d. Install sleeve in casting to a depth of 0.010 to 0.020 inch below surface.
- e. Locate lock ring on top of sleeve with pilot side down so that inner serrations contact sleeve.
- f. Press lock ring into position. Lock ring should be flush to 0.010 inch below surface.

6-45. REMOVAL OF HELI-COIL INSERTS.

- a. Insert Heli-Coil extracting tool in insert and tap lightly so that edge of blade grips insert.
- b. Apply heavy downward pressure, and at the same time rotate counterclockwise until insert is removed.

6-46. INSTALLATION OF HELI-COIL INSERTS.

- a. Using same thread size as original tap, retap hole to remove nicks and burrs.
- b. Insert new Heli-Coil of same size as damaged one with special inserting tool.
- c. Break off and remove driving tang from bottom of Heli-Coil.

6-47. ENGINE WIRING HARNESS. Repair in accordance with figure 2-8. Replace sleeving as required with Type HO Varglass non-fray sleeving, Varflex Corp., Rome, N.Y., or equivalent.

6-48. FUEL AND LUBRICATION SYSTEMS FLEXIBLE HOSES PRESSURE TESTING.

- a. Test lubrication system hoses (9 through 15, figure 4-9) and compressor discharge pressure hose (50, figure 4-7) by pressurizing with air at 250 PSIG.

#### WARNING

Submerge hoses in 6 inches or more of water when using air pressures of more than 50 PSIG.

- b. Test fuel system hoses (6, 7, 8, 31, and 32) by pressurizing with cleaning solvent, Federal Specification P-D-680, Type I, at 1500 PSIG.

#### WARNING

Provide adequate burst-protection shielding when using fluid pressures of more than 400 PSIG.

6-49. NOZZLE BOX AND NOZZLE RING FLOW TEST. Refer to figure 6-17 for a schematic representation of the test equipment and instrumentation required; refer to figure 6-18 for a schematic representation of the assembly and parts required for nozzle flow test. Nozzle box and nozzle ring must be checked following removal at overhaul, after a repair, or when a new box or ring is installed.

a. The following Test Equipment is required:

1. Gage, 0-120 inches water, Wallace and Tiernon, Belleville, New Jersey, Model FA 145 or equivalent.
2. Air Supply Fan, Alladin Heating Corporation, San Leandro, California, Model 25D20 or equivalent, driven by a 30 horsepower power source.
3. Calibration nozzle for measuring the airflow of nozzle boxes.
4. Calibration nozzle for measuring the airflow of nozzle rings.

#### NOTE

(See figure 6-17.) Both measuring nozzles are permanently installed in the flow test rig. When flow-checking nozzle assemblies, the measuring nozzle not in use must be covered with a tight cover plate.

b. Observe the following pressure measurements during testing:

1. Total gage pressure at the entrance to the measuring nozzle,  $P_h$  in inches of water.
2. Pressure differential,  $\Delta P$ , which is  $P_h$  minus the static gage pressure at the throat of the measuring nozzle in inches of water.
3. All pressure measurements must be read to the nearest 0.10 inch of water graduation on the dial of the gage.

c. Perform the following checks prior to each engine nozzle test.

1. Check the pressure gages to verify that the pointers are zeroed. If not, the gages must be calibrated by a qualified instrumentation facility. Pressure gages should be calibrated at 30 calendar day intervals. The gages must be accurate to within  $\pm 0.15$  inches of water.
2. Check each nozzle installation and all external doors for air leaks with 40 inches of water pressure differential across them before taking data.
3. Check the calibration of the rig by installing a standard nozzle of known area in the test section as shown in figure 6-18. The calibration procedure is the same used for flow-area determination, described in step d., and the limits of the observed  $\Delta P$  are given in table IIIA, columns 2 and 3.
4. If the test rig fails to calibrate within the specified limits in table IIIA, do not check the nozzle assemblies until the cause of the discrepancy is determined and corrected. Possible sources of trouble are:
  - (a) Air leaks.
  - (b) Pressure gage accuracy not within calibration limits.
  - (c) Damaged measurement and/or calibration nozzles.
- d. Perform nozzle test as follows, including step e for gas producer nozzle, or step f for power turbine nozzle.
  1. The engine nozzle assembly of which the flow area is to be determined is installed as shown in figure 6-18.
  2. Instrumentation for checking both turbine nozzles is the same, other than the items described above.

3. After the turbine nozzle is installed and the doors are properly closed, activate the fan. Adjust the bleed control valves to obtain a  $P_h$  gage (gage number 1 in figure 6-17) pressure as required in table IIIA column 1. Hold this condition for 1 minute to stabilize the air flow.

4. After the required  $P_h$  condition is obtained as required in paragraph 3 above the  $\Delta P$  pressure (gage number 2 in figure 6-17) of the convergent-divergent nozzle shall be recorded.

5. The observed  $\Delta P$  is then compared with the limits given in table IIIA.

6. The  $\Delta P$  of new nozzles (as manufactured) must be at least the value given in column 2 and not more than the value given in column 3. If the  $\Delta P$  is not within these limits, the stator vanes cannot be safely bent without cracking and the nozzle must be rejected.

7. If a new nozzle which meets the requirements of paragraph 6 above or if a used nozzle is to be flow checked, the nozzle must be adjusted to meet the limits given in table IIIA columns 4 and 5.

8. The adjusted nozzles are then installed in the engine and the engine performance checked. If resizing the nozzle is required to obtain satisfactory engine performance, the nozzles may be readjusted to the limits given in table IIIA columns 4 and 5.

e. Nozzle Box Test.

1. If the  $\Delta P$  measurement obtained in paragraph 7 above is more than the maximum (table IIIA, column 5) the stator vanes must be bent closer together until the observed  $\Delta P$  is within the required limits.

2. If the  $\Delta P$  measurement obtained in paragraph 7 above is less than the minimum (table IIIA, column 4) the stator vanes must be bent farther apart until the observed  $\Delta P$  is within the required limits.

3. Bending must be accomplished using special tool kit, gas producer nozzle vane bending tool kit, part number F50264-1.

4. Bending shall be accomplished as described in step g.

f. Nozzle Ring.

1. If the  $\Delta P$  measurement obtained in substep d7 above is more than the maximum (table IIIA, column 5), the stator vanes must be bent closer together until the observed  $\Delta P$  is within the required limits.

2. If the  $\Delta P$  measurement obtained in substep d.7 above is less than the minimum (table IIIA, column 4) the stator vanes must be bent farther apart until the  $\Delta P$  is within the required limits.

3. Bending must be accomplished using special tool kit; power output vane bending kit part number F50266-1.

4. Bending shall be accomplished as described in step g.

g. Nozzle Box and Nozzle Ring Adjustment Procedure (refer to figure 6-19).

1. The bending of the nozzle stator vanes must be accomplished as detailed in the following requirements.

2. The stator vanes must not be bent at the points at which they attach to the inner and outer shrouds.

3. The trailing edge of the stator vane must be bent so that the greatest amount of bend takes place equidistant from the inner and outer shrouds.

4. Bending must be accomplished so that the profile of the stator vane is a smooth continuous curve with no sharp bends in the profile.

5. All stator vanes must be bent an equal amount.

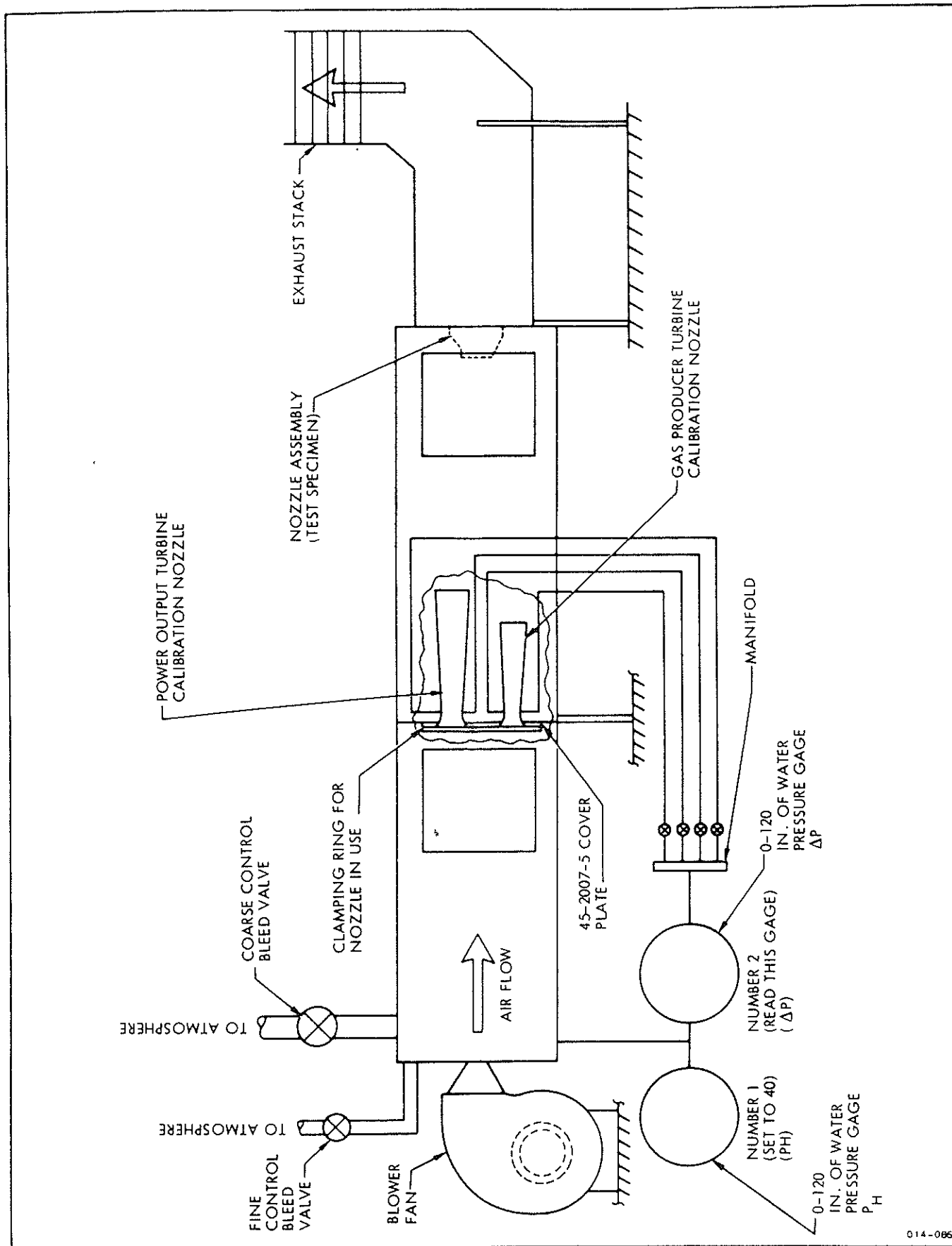
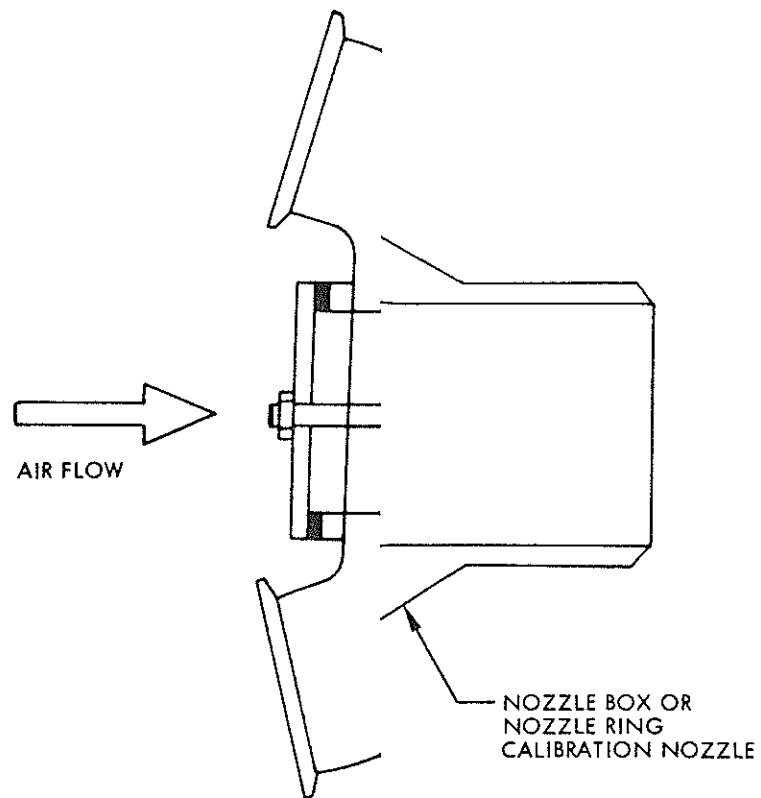


Figure 6-17. Nozzle Box and Nozzle Ring Flow Test Rig



ADAPTING D

NOZZLE BOX OR  
NOZZLE RING  
CALIBRATION NOZZLE

014 087

Ring Test Setup

84C/84D

Table IIIA. Nozzle Box and Nozzle Ring Calibration Requirements

Nomenclature	As Manufactured (New Nozzles)			After Adjustment	
	1 P <sub>h</sub> In. Water	2 $\Delta P$ Min. In. Water	3 $\Delta P$ Max In. Water	4 $\Delta P$ Min	5 $\Delta P$ Max
Nozzle Box Calibration Nozzle	40	39.5	39.7		
Nozzle Box	40	39.0	44.4	39.0	39.5
Nozzle Ring Calibration Nozzle	40	44.3	44.5		
Nozzle Ring	40	43.0	50.8	45.5	48.0

NOTE: The  $\Delta P$  limits given are based on the readings taken in the Boeing Flow Test Rig. Any variation in Rig component dimensions could produce inconsistent readings. Therefore, before using the above  $\Delta P$  limits, it must be verified that, with a known test specimen, the flow rig under consideration produces the same readings as those produced on the Boeing rig. If the readings are not the same, a correction factor will have to be applied accordingly.

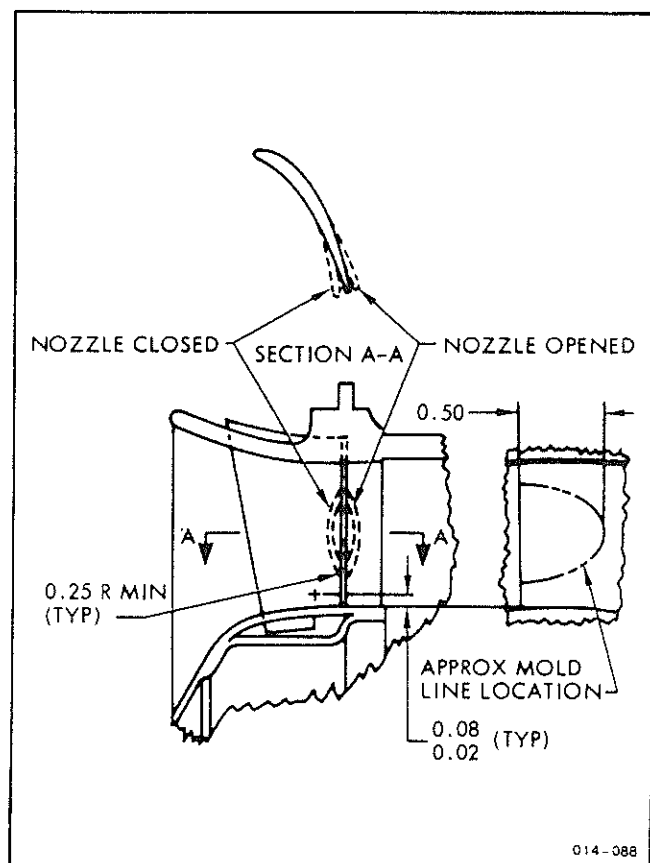


Figure 6-19. Nozzle Vane Bending

6. The final  $\Delta P$  must be recorded in the engine buildup records.

7. After adjustment, the nozzles must be fluorescent or dye penetrant inspected in accordance with Military Specification MIL-I-6866.

Added 15 December 1968

#### 6-50. GAS PRODUCER TURBINE SHAFT DRY LUBRICANT APPLICATION (See figure 6-20.)

a. Use Liquid dispersed solid film lubricant in accordance with Specification MIL-L-8937.

1. Note the following precautions:

(a) Damage may be repaired by stripping and recoating only. Remove uncured coating by swabbing with the lubricant thinner, followed by vapor degreasing. Dry, inspect for complete removal and reapply lubricant. Remove cured coating by standard processes which will not damage the part.

(b) Recoating of cured films to build up lubricant thickness or to correct defects is not allowed.

(c) Mechanical removal of cured coating (e.g., bur-nishing) to bring the thickness, of surface finish, into tolerance is not permitted.

2. Prepare surface for application. Tack-rag the surface by lightly wiping with a clean cheese-cloth moistened with solvent. Change to a clean cloth moistened with solvent as soon as soil is noticeable on the cloth. No visible solvent should appear on the surface.

3. Mix and thin dry lubricant materials as follows:

(a) Use material not older than 6 months from date of manufacture.

(b) Thin lubricant concentrate with thinner as recommended by manufacturer.

(c) Agitate lubricant continuously and vigorously, prior to and during application, to avoid settling and to maintain correct lubricant to binder ratio.

b. Spray Application

1. Make provision for continual and adequate agitation of the lubricant in the container while the spray gun is not in actual use.

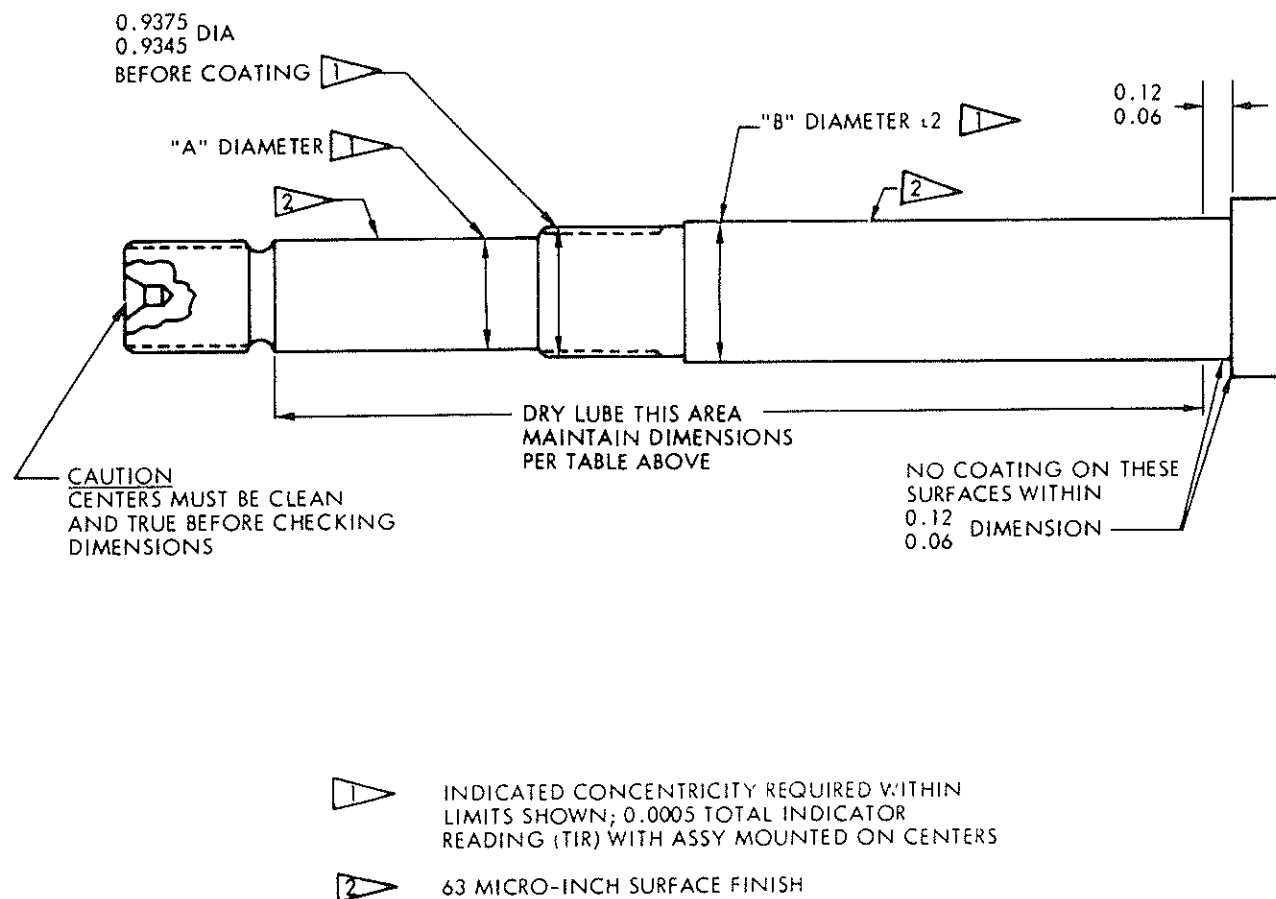
2. Apply a fine uniform wet spray over the part surface.

3. Shake the spray gun vigorously after each pass if material is not already under constant agitation.

4. Apply so that the final coat has a smooth appearance of uniform texture and color, and is continuous and homogenous with no trace of grit, rough particles,

DIAMETER	DIAMETER BEFORE COATING	DIAMETER AFTER DRY LUBE
A	0.7490 0.7488	0.7501 0.7498
B	0.9834 0.9832	0.9845 0.9842

NOTE: ALL DIMENSIONS SHOWN IN INCHES.



014-388

Figure 6-20. Gas Producer Turbine Shaft Lubricant Application



runs, dimples, cracks, blisters, foreign matter or separation of ingredients.

c. Aerosol, Dip, or Brush Application.

#### NOTE

Aerosol or dip application is preferred over brush application.

1. Thin and apply to ensure adequate lubricant mixing according to the manufacturer's instructions immediately prior to and during the actual application process. The final film must comply with b.4 above.

d. Curing

1. Air dry 15 minutes at room temperature prior to elevated temperature cure.

#### NOTE

Controlled ( $\pm 25^{\circ}\text{F}$ ) oven cure is preferable. However, for massive parts where only small areas require cure, the use of quartz or infra-red lamps is allowed.

2. Cure at the optimum conditions recommended by the lubricant manufacturer and to meet the performance requirements, except that part temperatures for steel parts shall not exceed  $204^{\circ}\text{C}$  ( $400^{\circ}\text{F}$ ).

#### CAUTION

Thick sections take longer to heat.

#### 6-51. GAS PRODUCER TURBINE SHAFT HARD CHROME PLATING (See figure 6-21.)

Scored or damaged bearing journals may be repaired by hard chrome plating.

a. Mount turbine wheel and shaft between centers on a suitable grinding machine. The shaft concentricity should be measured at the locations as shown in figure 6-21 prior to pre-plate grinding and must be within 0.0005-inch TIR.

#### CAUTION

It may be necessary to clean up both centers before pre-plate grinding bearing journals. If the 0.0005-inch TIR cannot be met, the center(s) should be repaired or shifted as required.

b. Check alignment of bearing journals in accordance with step c.3. below.

c. Wet grind damaged bearing journals to pre-plate dimension listed below. All shoulder radii must be per figure 6-21.

1. Turbine end bearing journal diameter 1.2390 to 1.2438.

2. Steady bearing journal diameter 1.2390 to 1.2438.

3. The above two bearing journals must be concentric to the shaft centerline with 0.0005-inch TIR.

d. Mask off all areas not to be plated.

e. Hard chrome plate bearing journals to approximately 0.003 to 0.004 larger than the finish dimensions. Chromium plate per specification QQ-C-320.

f. Prior to finish grinding check the concentricity as in step a. above to ensure that the centers have not been damaged during handling.

g. Finish grind bearing journals concentric to the shaft centerline with 0.0005-inch TIR to the following diameters:

1. Turbine end bearing journal diameter 1.2490 to 1.2498 inches.

2. Steady bearing journal diameter 1.2490 to 1.2498.

3. Shoulder radii must be per figure 6-21.

4. Break all sharp edges by grinding.

#### CAUTION

If the 0.0005-inch TIR cannot be met the center(s) should be repaired or shifted as required.

#### 6-52. OUTPUT TURBINE SHAFT HARD CHROME PLATING (See figure 6-22.)

Scored or damaged bearing journals may be repaired by hard chrome plating. This procedure must be followed carefully to prevent the possibility of hydrogen embrittlement after the plating operation.

a. Remove turbine blades from wheel.

b. Mount turbine wheel and shaft between centers on a suitable grinding machine. The shaft concentricity should be measured at the locations as shown in figure 6-22 prior to pre-plate grinding and must be within 0.0005 inch TIR.

#### CAUTION

It may be necessary to clean up both centers before pre-plate grinding bearing journals. If the 0.0005 inch TIR cannot be met, the center(s) should be repaired or shifted as required.

c. Check alignment of bearing journals in accordance with step d.3. below.

d. Wet grind damaged bearing journals to a pre-plate dimension listed below. All shoulder radii must be per figure 6-22.

1. Turbine end bearing journal diameters 1.8400 to 1.8430 inches.

2. Output shaft end bearing journal diameter 1.0900 to 1.0930 inches.

3. The above two bearing journals must be concentric to the shaft centerline with 0.0005 inch TIR.

e. Mask off all areas not to be plated.

f. Hard chromium plate bearing journals, in accordance with Federal Specification QQ-C-320, to approximately 0.003 to 0.004 inch larger than the finish dimension.

#### CAUTION

Immediately after plating operation, bake the wheel and shaft assembly in an oven at a temperature of  $275^{\circ}\text{F} \pm 25^{\circ}\text{F}$  for five to eight hours.

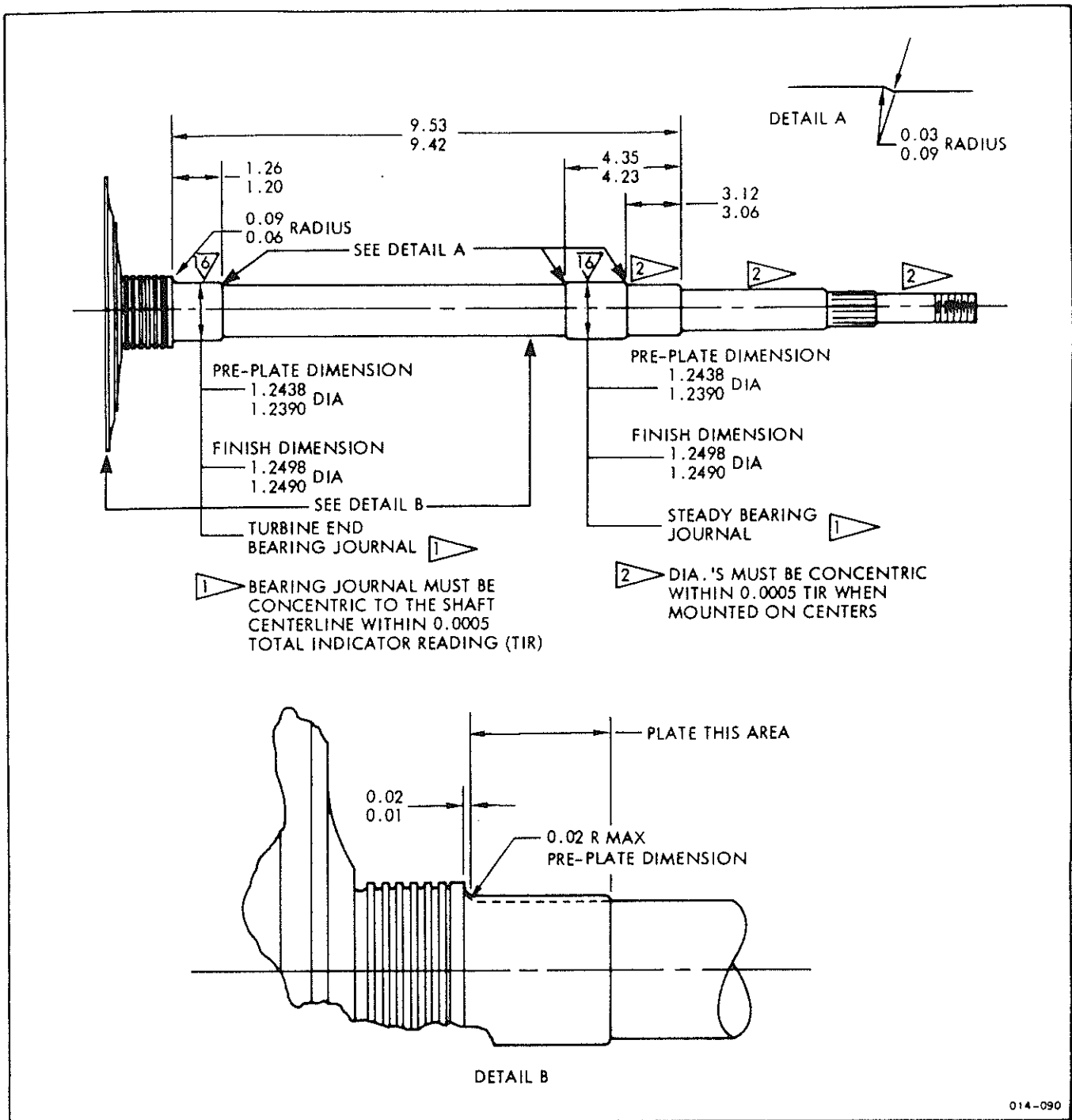


Figure 6-21. Gas Producer Turbine Shaft Hard Chrome Plating

g. Prior to finish grinding the concentricity should be checked as in step b above to insure that the centers have not been damaged during handling.

**CAUTION**

If the 0.0005 inch TIR cannot be met, the center(s) should be repaired or shifted as required.

h. Finish grind bearing journals concentric to the shaft centerline with 0.0005 inch TIR to the following diameters:

1. Turbine end bearing journal diameter 1.8497 to 1.8500 inches.
2. Output shaft end bearing journal diameter 1.0995 to 1.1000 inches.
3. Shoulder radii must be in accordance with figure 6-22.
4. Break all sharp edges by grinding.

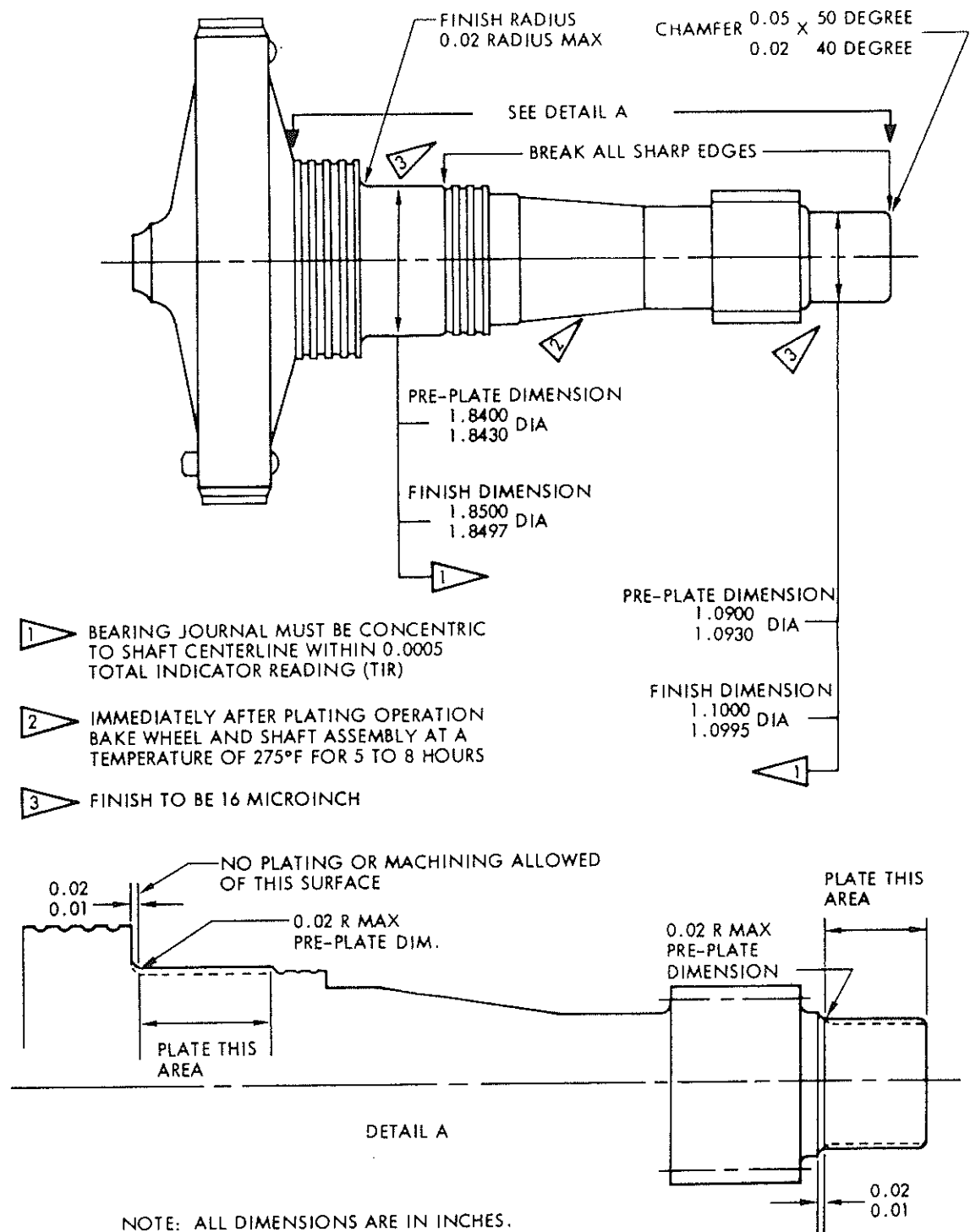


Figure 6-22. Output Turbine Shaft Hard Chrome Plating

SECTION VII  
ASSEMBLY OF SUBASSEMBLIES

7-1. PRECAUTIONS AND PROCEDURES. The following general precautions and instructions apply to work to be done during assembly of the subassemblies and major sections of this engine.

a. Do not use lead pencils, grease pencils, or carbonaceous inks.

b. Do not use antiseize compounds which contain zinc when bolting stainless steel parts, because zinc causes rapid and severe corrosion at temperatures above 450°C (850°F). Use MIL-A-907B antiseize compound for bolting parts that operate at temperatures up to 676°C (1250°F). Do not use zinc-plated tools for work on stainless steel parts of the engine. Zinc causes stainless steel components to corrode rapidly at temperatures above 450°C (850°F).

c. Lubricate burner section O-rings (11 and 16, figure 4-4) with Dow-Corning DC-200 Silicone compound before installing. Do not lubricate graphite-asbestos O-ring (18) until burner section installation. At this time lubricate it with Dow-Corning DC-7 Silicone compound. Lubricate fuel system O-rings with vaseline or mineral base oil. Lubricate all other O-rings except compressor section O-rings (4 and 5, figure 4-15) with engine lubricating oil. O-rings can be easily damaged during installation; exercise every precaution to prevent excessive stretching, nicking, or pinching. Do not slide or roll O-rings over threaded surfaces. Cover threads with thin paper before slipping O-ring in place over threads. Damage to O-rings at assembly is not readily apparent, being evidenced only by subsequent leakage or other malfunction. Handling O-rings with more than usual care will result in more reliable engine operation.

d. Lubricate pipe threads other than those located in the high temperature areas of the engine with fuel and oil resistant grease, Military Specification MIL-L-6032. Apply high temperature thread lubricant, Military Specification MIL-A-907B, to threads on components located in the high temperature areas of the engine.

e. All lockwire used on the engine should be MS20995 (NC20); MS20995 (NC32) or MS20995 (NC41) (corrosion-resistant lockwire, condition A, annealed) or equivalent and should be installed per Military Standard MS33540 (or equivalent).

f. Refer to Table IX in Section XI for torque values to be used in assembly of the subassemblies and major sections.

g. During assembly of the engine, liberally flood all bearings, journals, and gears with approved engine lubricating oil.

**CAUTION**

During reassembly, when necessary to lubricate, align or hold parts together, use special assembly fluid, Mobile Assembly Fluid RT-403A available from the Mobile Oil Company, New York, New York. Do not use synthetic engine oil, mineral oil, hydrogenated vegetable oil or soap type grease for this purpose.

7-2. REDUCTION UNIT. Use special tools from Tool Groups 7 and 8, Table I, Section III for assembly of reduction unit. (See figure 4-19.) Assemble reduction unit according to the following instructions:

a. If removed, install dowel pins (36 and 43), plugs (37, 38, and 39) and lifting ring (40) in input housing; dowel pins (73 and 74), plugs (69), oil spray jets (68) and nuts (67) in center housing, plugs (80 and 82) in governor and pump drive gears, and dowel pins (88 and 89), plugs (91) and spacers (90) in output housing (92).

1. Assemble lock nuts on oil spray jets and install jets in housing to a height of 0.95 inch from top of jet to boss in housing (see figure 7-1).

2. Turn jet the shortest distance required to align the orifice as illustrated in figure 7-1. The slot in top of jet, and the orifice must align within 5 degrees of the outer edge of the next jet (in counterclockwise direction). Lock jets in place with lock nuts.

b. If removed, install bearings (70 through 72, figure 4-19) center housing and bearings (85 through 87) in output housing.

c. Lubricate all bearings in center housing (75) and output housing (92).

d. Lubricate bearing journals on all output section gears.

e. Insert cluster gear (83), governor drive gear (79), and pump drive gear (81) in output housing (92).

f. Insert output gear (78) and three planet pinions (76) in output housing.

g. Install new lubricated O-ring (84) at output housing oil passage.

h. Place gasket (66) in position and install center housing assembly (64) on output housing assembly (65), making sure that all gear shafts enter bearings in center housing assembly (64) properly.

i. Secure center housing (64) to output housing assembly (65) with bolts (61 and 62), washers (60 and 63) and lock nuts (59).

j. Install lubricated floating bushing (77) in output gear (78).

k. Install three planet pinion gears (58) on tapered shafts of planet pinions (76). The shaft taper must be clean and free of oil.

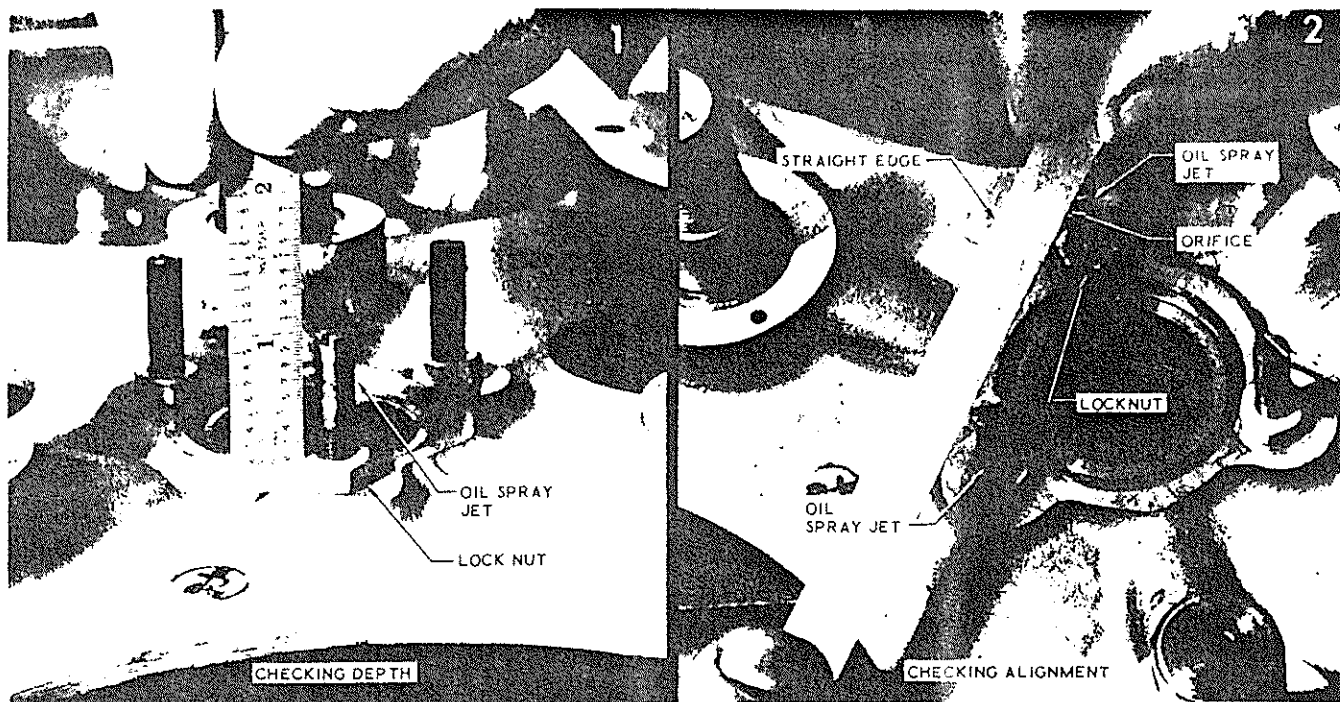
l. Lubricate faces of washers (57) and threads of nuts (56) lightly with petrolatum, Federal Specification VV-P-236. Install washers (57) and nuts (56); tighten nuts to a net torque value of 48 to 72 inch-pounds.

## NOTE

Net value is the torque required to tighten planet pinion gear (58) on planet pinion (76). This must be in addition to the torque required to turn nut (56) on planet pinion after all threads are engaged but before contact with washer (57). (See table X.)

m. Install shaft and handle tool of timing fixture through center housing into floating bushing (77), (see figure 3-8). Ensure that planet gears and tool are properly engaged.

n. Place housing assembly down on base and shaft



014-059

Figure 7-1. Checking Reduction Unit Oil Spray Jet Dimension and Alignment

assembly to prevent output gear (78, figure 4-19) from turning. (See figure 3-8.)

o. Rotate shaft and handle tool clockwise approximately 60 degrees while tapping the end of each planet pinion (76, figure 4-19) to ensure that each pinion planet gear and output gear are seated against the thrust surfaces of their respective bearings.

p. Decrease clockwise torque at shaft and handle tool until minimum load is applied to planet gear teeth. The planet gears are timed when zero backlash exists between each planet gear and the pinion on the shaft and handle tool. Repeat this step if necessary to meet the zero backlash requirement.

q. Mount a dial indicator on the housing assembly. (See figure 7-2.) Load dial indicator against the end face of one of the planet pinion gears (58, figure 4-19) and calibrate pointer at zero. Torque respective nut (56) until dial indicator shows 0.012 to 0.015 inch and record this displacement. The net torque applied must be within the range of 150 to 300 foot-pounds.

r. Repeat step q on each of the two remaining planet pinion gears (58). Displacement of these gears must be within 0.0025 inch of that recorded for the first gear. If gear displacement is not within this limit, remove planet pinion gears (58) and repeat steps k through r, installing gears on different shafts, or using new gears.

s. Apply 15 to 25 inch-pounds torque to shaft and handle tool. Check for backlash at each planet pinion gear (58) in three places through one revolution of the output gear (78).

t. Apply 90 foot-pounds torque clockwise to shaft and handle tool and check that planet gears do not slip on planet pinion shafts. If slippage occurs, remove planet gears and repeat steps k through t.

u. Remove shaft and handle tool. Check end play in each planet gear. End play must be 0.014 inch minimum.

v. Install fir-tree blades (53) on wheel and shaft assembly (55) with new retainer clips (54). Refer to paragraph 6-21 and figure 6-14 for installation procedure. Ensure that blades are installed with concave side facing away from shaft.

### CAUTION

If any fir-tree blades (53, figure 4-19) have been repaired or replaced, turbine wheel and shaft assembly (55) must be rebalanced in accordance with paragraph 6-22. Balancing is not required when installing the same complete set of blades that was removed during the disassembly if no blade repair or replacement has been made.

w. Install insulation blankets (34 and 35) on exhaust collector (33) and lace in place with lockwire. (See figure 7-3.)

x. Place exhaust collector (33, figure 4-19) on mounting studs in input housing (41) and secure with nuts (32).

y. Place inner cone (31) in exhaust collector mounting ring. Seat evenly, as far in as possible.

z. Install retainer (47) and bearing cap (52) with new gaskets (44 and 51) in place. Install and tighten bolts (28).

aa. Seat inner cone firmly in exhaust collector and measure the distance from rim of inner cone to upper surface of bearing cap at 3 equally spaced locations. (See figure 7-4.) Compute and record the average of the three measurements.

ab. Lift inner cone firmly against bearing cap and measure at the same locations as in step aa. Compute and record the average of these three measurements.

ac. Subtract the measurement recorded in step ab from that recorded in step aa. This difference is the clearance between bearing cap and inner cone. Add

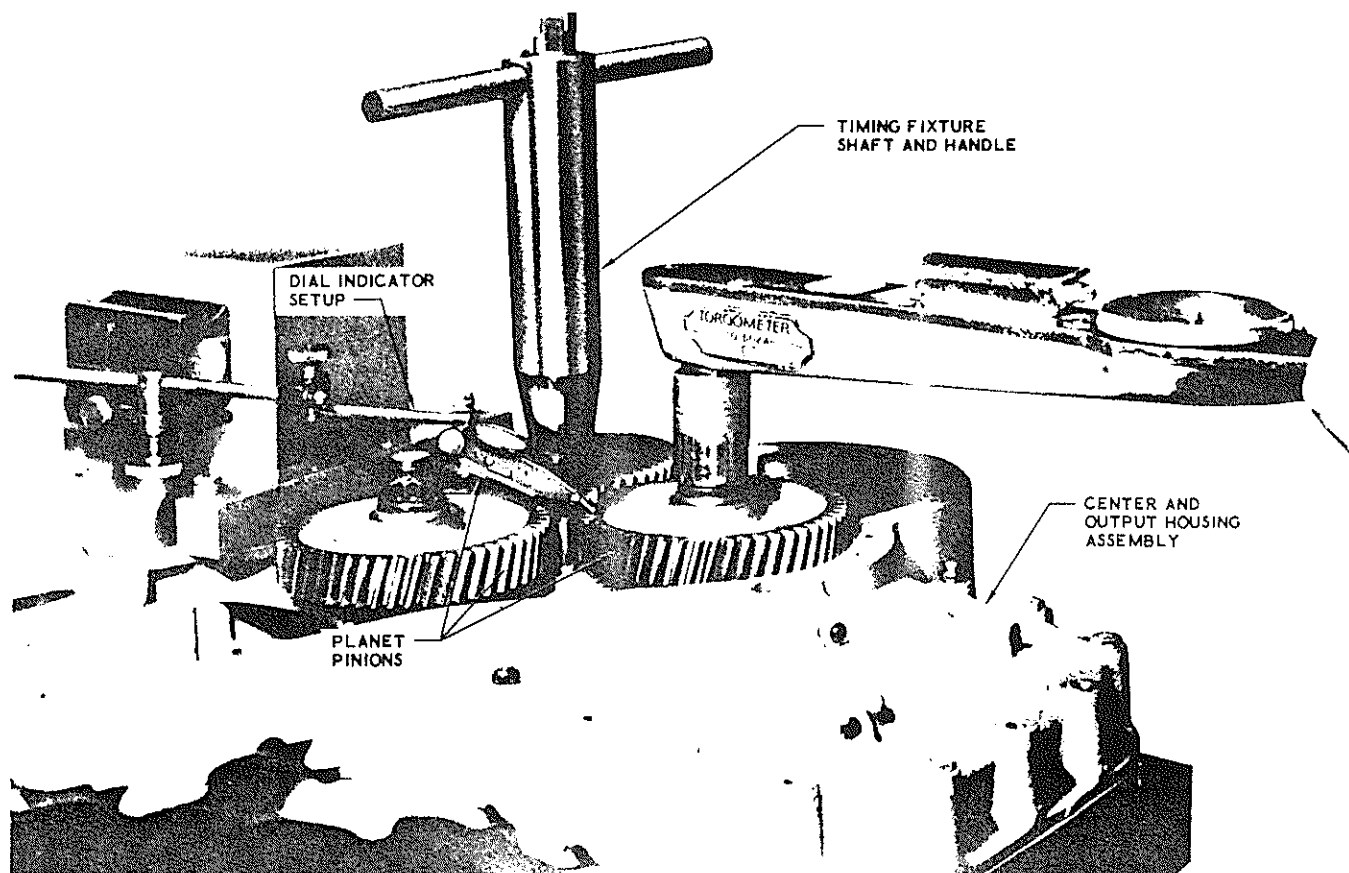


Figure 7-2. Installing Planet Pinion Gears and Checking Displacement

014-060

0.025 inch shims to obtain clearance of 0.001 to 0.026 inch.

**CAUTION**

Total shim thickness must never exceed 0.250 inch.

ad. Slide bearing cap (52, figure 4-19) onto wheel and shaft assembly (55).

**NOTE**

As an aid to assembly of the turbine wheel and bearing assembly, the heads may be removed from two AN74A-21 bolts and these bolts used to guide the bearing assembly into the input housing.

ae. Slide lubricated radial bearing (48) onto shaft.  
af. Position new gasket (51) on bearing cap (52) and place retainer (47) on bearing cap.

ag. Install lubricated thrust bearing assembly (49) in retainer (47).

ah. Install retainer nut (45) on shaft, snug against shaft shoulder. If lock pin holes in nut and shaft line up, install new lock pin (46) to 0.10 inch below surface of nut. If lock pin holes do not line up when nut is snug against shoulder, bring holes into alignment with no more than 650 inch-pounds torque.

ai. If holes do not align with 650 inch-pounds torque,

drill 11/64-inch diameter hole through nut at a point 180 degrees from the existing hole in the shaft. Drill only far enough to make a new centering hole in the shaft.

aj. Remove nut and drill a 7/32-inch diameter hole in the shaft at the new location and to a depth of 0.060 inch.

ak. Install retainer nut (45) and lock pin (46) according to step ah above.

al. Place new gasket (44) on retainer flange.

am. Install new, lubricated O-ring (50) on retainer (47).

**CAUTION**

Ensure that O-ring (50) is in groove farthest from flange of retainer, and not in oil groove.

an. Install shim (42) as determined in step ab.

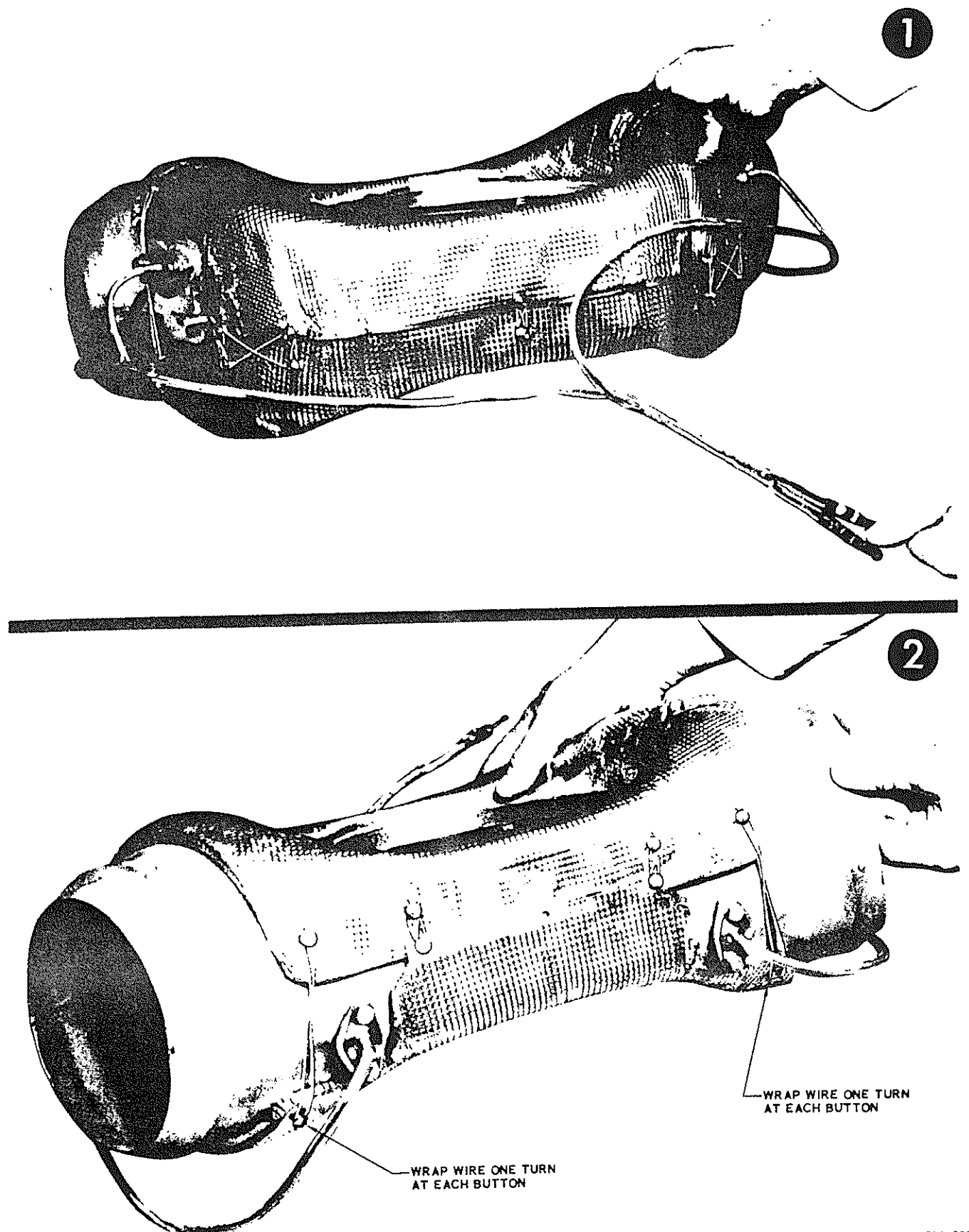
ao. Install assembled turbine wheel, shaft and bearing assembly (30) in input housing (41) and secure with bolts (28) and washers (29). Lockwire bolts.

ap. Insert oil strainer (25) in input housing assembly (24).

aq. Install new, lubricated O-ring (27) at input housing oil passage.

ar. Place gasket (26) in position and attach input housing assembly (24) to center housing and output housing assembly (23) with bolts (17, 19, and 21) and washers (18, 20, and 22).

as. Install union (15) and new, lubricated O-ring (16).



014-061

Figure 7-3. Lockwiring Exhaust Collector Insulation Blankets

- at. Place seal (5) on mounting flange studs.
- au. Install cover plate (4) with nuts (1), washers (2), and bolts (3).
- av. Install gasket (14), cover plate (13), washers (12) and nuts (11) on lube pump drive pad.
- aw. Install gasket (10), cover plate (9), washers (8) and nuts (7) on governor mounting flange.

7-3. ROTOR HOUSING AND SUMP SECTION. (See figure 4-18.) Assemble rotor housing and sump section according to the following instructions:

- a. Insert piston (46) and spring (45) in rotor housing and sump (47).

### CAUTION

Piston (46) and adjusting screw (44) are matched parts and must be installed as a set.

- b. Install adjusting screw (44), gasket (43), and check nut (42). Tighten nut to 475-500 inch-pounds torque.
- c. Install O-rings (37) on oil tubes (36) and install tubes in housing, flush at each end.
- d. Install new plugs (38) if removed during disassembly.
- e. Install strainer (41). Ensure that strainer is properly aligned in housing.
- f. Install new gasket (40) on sump plug (39) and install plug in housing.
- g. Install new, lubricated O-ring (35) on retainer (32).
- h. Place new gasket (33) on retainer flange and insert retainer into aft end of rotor housing bore.
- i. Slide lubricated bearing (34) into retainer (32).
- j. Install retainer plate (31) with bolts (29) and washers (30).
- k. Insert retainer (27) into forward side of rotor housing bore.
- l. Slide bearing (28) into retainer (27).
- m. Install retainer plate (26) with bolts (25).

### NOTE

Install drain elbow (24) and plug (23) in nozzle box (22) if removed during disassembly. Install elbow in boss on opposite side of nozzle box from serial number.

- n. Position nozzle box (22) on rotor housing with elbow down and serial number up. Install with bolts (20) and washers (21).
- o. Install insulation blanket (15) with bolts (10 and 11), spacers (14), washers (13), and lockwashers (12).

### NOTE

Install long bolts (11) and spacers (14) at aft end of insulation blanket (15).

- p. Install drain tube (2) on elbow (24).
- q. Install heat shield (19) with bolts (18), washers (17), and nuts (16).

### NOTE

Bolt (18) on right-hand side of heat shield is installed with thermocouple harness clamp and spacer. Install with electrical system (see figure 4-8).

- r. Place new gasket (9, figure 4-18) against rotor housing.

- s. Install bearing cap (8), insulation ring (5), and air deflector (4) using bolts (3).

### NOTE

Bearing cap (8), gasket (9), and air deflector (4) will align in only one position.

- t. Lockwire bolts (3) using single wire method.
- u. Install oil dipstick (1) in tube.

7-4. ACCESSORIES SECTION. (See figure 4-16.) Assemble accessories section according to the following instructions:

- a. Lubricate shaft of tachometer drive gear (12) and insert into bushing (13) in accessory drive housing (17).
- b. Lubricate and install bevel gear (11) in bracket (10), and install assembly in housing. Ensure that dowel pins are aligned and bevel gear teeth mesh.
- c. Bolt bracket in place with bolts (7 and 9) and washers (8).

### NOTE

Short bolt (7) goes in upper hole.

- d. Check lube pump drive bevel gear backlash as follows:

1. Mount special dial indicator bracket, Tool Group No. 10, and dial indicator on compressor mounting stud as shown in figure 7-5.

2. With tachometer drive gear held stationary against its bushing in the normal operating position, measure backlash at center of wear area on outer tooth of lube pump drive bevel gear. Backlash must be within 0.002 to 0.010 inch.

- e. Install new gasket (4, figure 4-16) on lubrication pump mounting flange, and new lubricated O-rings (6) on pump body.

- f. Reach into pump cavity in housing and check for rough edges on oil ports. Chamfer edges as required to prevent cutting of O-rings. Lubricate housing before installing pump.

- g. Slip drive shaft (5) over shaft spline on lubrication pump (3). Lightly lubricate O-rings and pump body with petrolatum, Federal Specification VV-P-236.

- h. Start lubrication pump (3), gasket (4), and drive shaft (5) into accessory housing.

### CAUTION

Before installing pump, check for and remove any rough or sharp edges in accessory section housing that could damage O-rings (6). Do not tap or drive pump into place; push firmly, rotating slightly if necessary, until pump flange seats against gasket and housing. Ensure that drive shaft splines are aligned while inserting pump in housing.

- i. Rotate bevel gear (11) and tachometer drive gear (12) until gear splines align with shaft drive (5) while inserting pump into housing.

- j. Bottom pump flange against housing and install with bolts (1) and washers (2). Lockwire bolts.



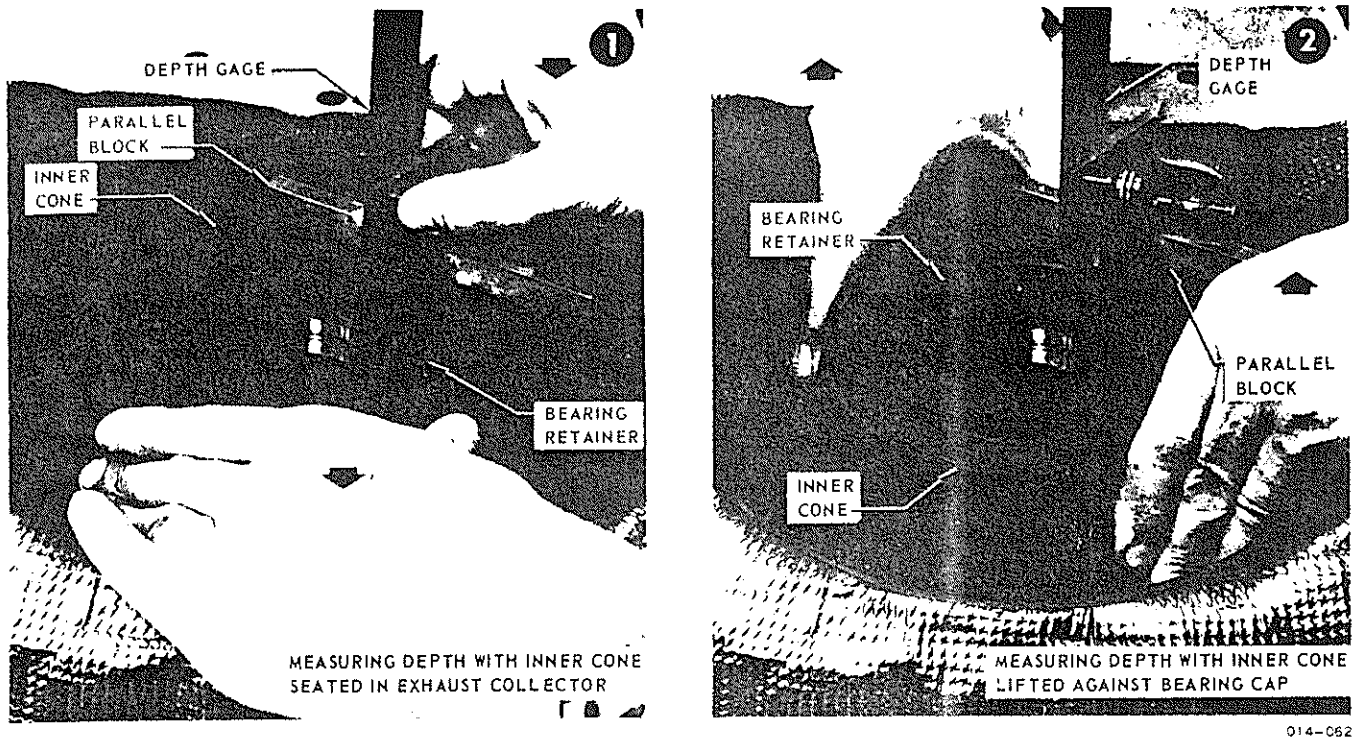


Figure 7-4. Checking Output Section Bearing Cap to Exhaust Collector Inner Cone Clearance

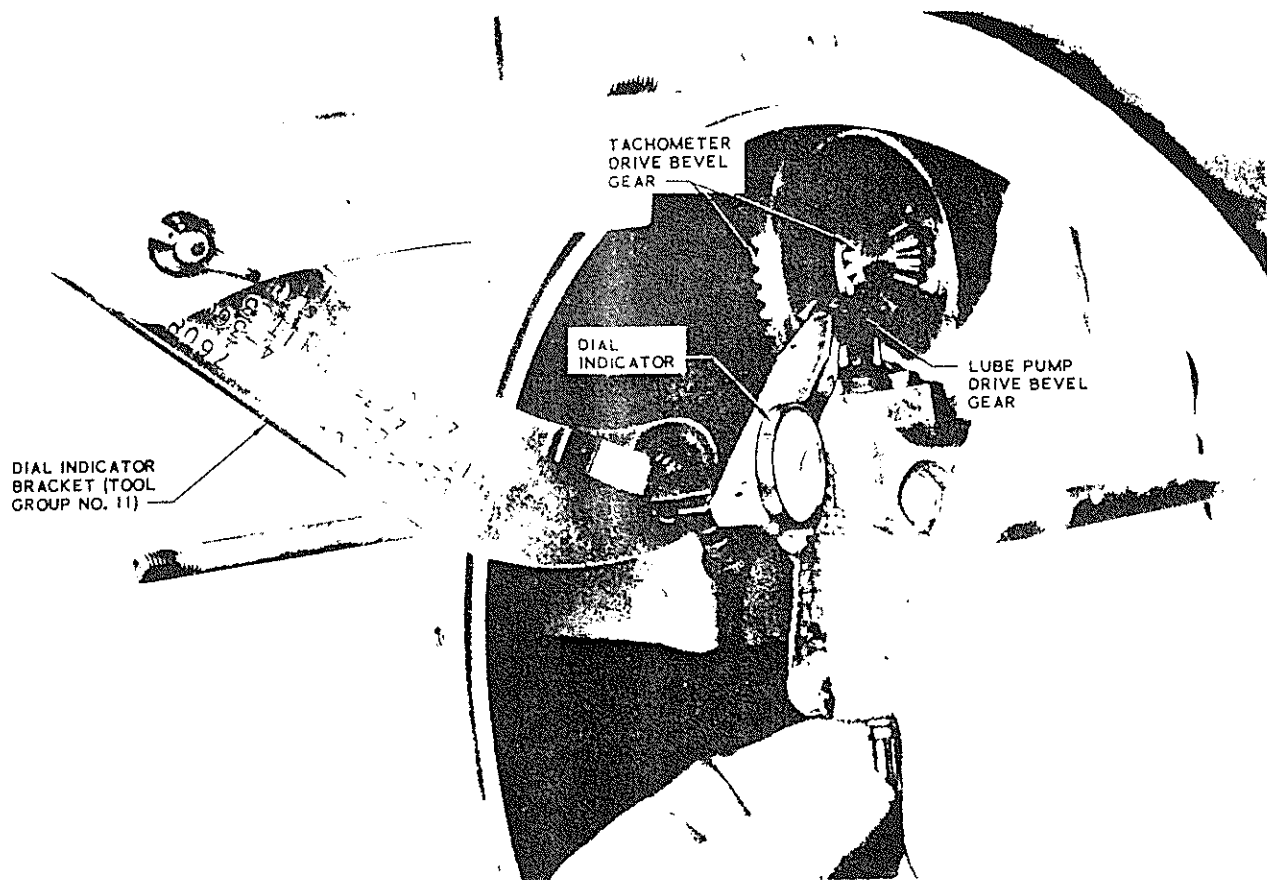


Figure 7-5. Checking Lube Pump Bevel Gear Backlash

7-5. **BURNER SECTION.** Use special tools from Tool Group 1, Table I, Section III for assembly of burner section. (See figure 4-4.) Assemble burner section according to the following instructions:

- a. Install new fuel nozzle (32) in nozzle adapter (30). Tighten to a torque value of 360 to 480 inch-pounds. Place same shim or shims on nozzle adapter that were removed during disassembly, if possible. If number of shims is not known, refer to Table VIII, Section XI for proper nozzle-to-dome gap, and shim accordingly. Gaps in both burners must be within 0.020 inch of each other. Use special burner dome wrench to install burner dome (28) on nozzle adapter (30). Tighten to torque value of 550 to 700 inch-pounds.
- b. Install new, lubricated O-ring (31) on nozzle adapter and install assembly of burner dome, nozzle, and adapter in inlet adapter (33). Tighten to a torque value of 360 to 480 inch-pounds.
- c. Install O-ring (10) on burner inlet bolt (9) and install burner inlet bolt in adapter assembly. Tighten to a torque value of 375 to 390 inch-pounds.
- d. Install special nozzle pressure test clamp on burner inlet adapter assembly. This tool blocks the fuel nozzle orifice during the following pressure test.
- e. Connect a pressurized source of test fluid, Military Specification MIL-F-7024, or inert gas to burner bolt.

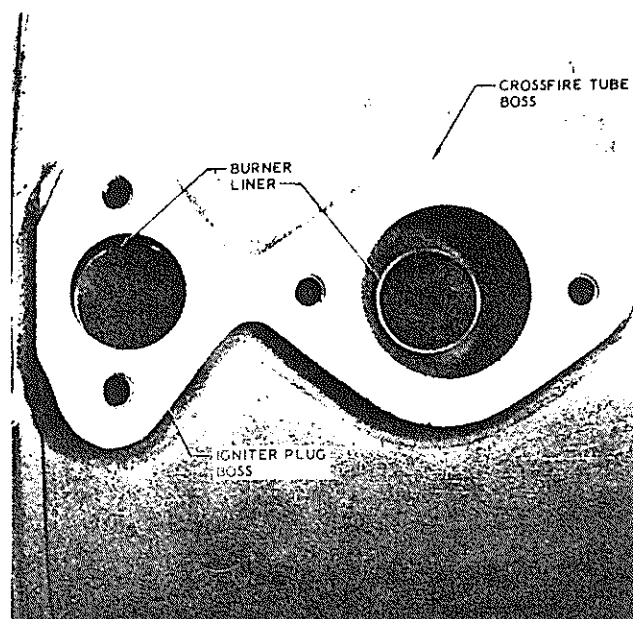
### WARNING

Do not use oxygen. Oxygen reacts violently with hydrocarbons.

- f. Apply 1200 PSIG to the assembly. There must be no leakage between inlet adapter (33) and nozzle adapter (30) or between nozzle adapter and nozzle (32). If gas is used, immerse assembly in water to detect leaks.
- g. Shut off pressure at source. Relieve pressure in test system by removing special nozzle pressure test clamp and letting pressure bleed off through the nozzle orifice, clearing the nozzle tip of foreign material.
- h. Remove burner inlet bolt (9) and O-ring (10). Discard O-ring.
- i. Insert burner liner (19) into downstream end of burner shell (21). Push liner into shell until igniter plug and crossfire tube bosses in liner align with respective bosses in burner shell.
- j. Align igniter plug port in burner liner with port in burner shell. (See figure 7-6.) Check visually or with finger.
- k. Install new igniter plug (24, figure 4-4) and gasket (25) with bolts (22) and washers (23). Install the glow coil lead wire to avoid shorting against the terminal boss.

### CAUTION

Igniter plug (24) must be seated properly to prevent burner liner from sliding downstream into nozzle box. Plug must slide freely into boss until plug flange and gasket contacts burner shell boss. Never force flange down with bolts. If burner liner is not properly retained according to these instructions, engine damage will result.



01 4-064

Figure 7-6. Alignment of Burner Shell and Burner Liner Ports

1. Install new, lubricated O-ring (16) on upstream end of burner shell (21) and join shell to inlet adapter assembly (15) with clamp (14).

### NOTE

Do not tighten clamp at this time.

### CAUTION

Use extreme care to avoid pinching O-rings at either end of burner shell. Damaged O-rings cause gas leaks, power loss, and high exhaust gas temperature.

- m. Install new gasket (27) on inlet adapter assembly with screws (26).
- n. Install new graphite seal (18) and retaining ring (17) on downstream end of burner shell.

7-6. **COMPRESSOR SECTION.** (See figure 4-15.) Assemble the compressor section according to the following instructions:

- a. Install plates (11) on diffuser body with new bolts (9), spacers (10), washers (8) and new nuts (7). Tighten nuts (7) to a torque value of 25 to 35 inch-pounds. Spacers must be installed between plates (11) and diffuser.
- b. Install new O-ring (4) in front casing (3). Lubrication is not required.
- c. Place diffuser assembly (6) in front casing (3).
- d. Install new O-ring (5) on diffuser assembly (6). Lubrication is not required.
- e. Place rear casing (2) on diffuser and front casing.
- f. Install clamp (1) on compressor casing flanges. Lubricate trunnion and strap interface, bolt threads and nut with Fel-Pro C5A. Determine run-on torque for both nuts. Apply 25 inch-pounds net torque to both

nuts. Maintain alignment of mounting holes while tightening. Using a soft mallet, tap on strap all around to seat retainer. Torque to a value of 35 to 40 inch-pounds net. Tap all around and retorque to 35 to 40 inch-pounds net. Steel stamp "NET TORQUE 35-40 IN. LB" on strap.

NOTE

Run-on torque is the torque required to start the nut turning when the nut is engaged, with at least two full threads of the bolt protruding beyond the outer end of the nut, and before the nut face contacts the surface of the part against which it is to be tightened. To determine net torque subtract run-on torque from the dial reading on the torque wrench. See table X for self-locking torque requirements.

NOTE

Align mounting holes of front and rear compressor cases and diffuser before tightening clamp.

g. Install plug (12) and new O-ring (13). Tighten plug to a torque value of 40 to 65 inch-pounds.

7-7. GAS PRODUCER SECTION. Use special tools from Tool Groups No. 9 and 10, Table I, Section III, for assembly of gas producer section. (See figure 4-12.) Assemble gas producer section according to the following instructions:

a. Place new, lubricated O-rings (83) in oil tube recesses on lower mating surface of rotor housing and sump (84).

b. Place new lubricated O-rings (81 and 82) in upper mating surface of rotor housing and sump.

c. Place new gaskets (79 and 80) in position on mating surfaces of rotor housing and sump.

d. Attach accessories housing (78) to rotor housing and sump (84) with bolts (76) and washers (77), through accessories housing, and bolts (74) and washers (75) through rotor housing and sump.

e. Drop ball (72) into relief valve (71) and tap sharply to seat ball. Place spring (73) in accessories housing (78). Screw relief valve (71) into housing until it bottoms.

f. Install new, lubricated O-rings (69 and 70) in oil cooler adapter (68) and attach adapter to accessory housing with adapter nut (66) and washer (67).

g. Place gasket (65), guide (64), and washer (63), over adapter nut (66) and tighten with nut (62) to a torque value of 30 ( $\pm 5$ ) inch-pounds more than that required to turn nut on thread.

h. Lubricate bearings (44) in cluster gear (41) and slide cluster gear on shaft (42). Install cluster gear and shaft assembly (41 through 44) in accessory drive housing.

i. Install plug (40) if removed and install new, lubricated O-ring (39) on end plate (38).

j. Install end plate (38) over accessory housing studs. (See figure 7-7.)

NOTE

Ensure that pin (43, figure 4-12) enters the drilled hole in the shaft support boss in end plate (38).

k. Install end plate retaining screws (37).

l. Install turbine blade (60) on wheel and shaft assembly (59) with new clips (61). Refer to paragraph 6-21 and figure 6-14 for installation procedure. Ensure that blades are installed with concave side facing toward shaft.

CAUTION

If any turbine blades (60) have been repaired or replaced, wheel and shaft assembly (59) must be balanced in accordance with paragraph 6-22. Balancing is not required if installing the same complete set of blades removed during disassembly and if no blade repair or replacement has been made. Ensure that each blade is installed in its original position. All turbine blades are numbered in consecutive order on the base of the blade shank. The first three slots on each wheel hub are numbered, with an arrow pointing to the number one slot.

m. Carefully insert wheel and shaft assembly (59) into nozzle box and rotor housing. With rotor in extreme upstream position, measure and record the distance between the trailing edges of the turbine blades and rear edge of the nozzle box outer shroud ring. (See figure 7-8.)

NOTE

This measurement represents the no-clearance condition. It will be compared with another measurement after rotor installation to determine turbine wheel-to-nozzle box inner shroud clearance.

n. Slide pinion (58, figure 4-12) onto wheel and shaft assembly (59) until bottomed against shoulder.

NOTE

Exercise care when installing pinion, because of close fit between pinion and shaft. Check for burrs. Do not force pinion onto shaft.

o. Install new, lubricated O-rings (53) on retainer (51).

p. Install lubricated radial bearing (52) and slinger (50) in retainer (51).

q. Install lubricated thrust bearing (56) on bearing sleeve (57).

r. Install assembly of bearing sleeve (57) and thrust bearing (56) in retainer (51).

s. Slide assembly of sleeve (57), bearings (52 and 56), retainer (51) and slinger (50) onto wheel and shaft assembly (59) until bearing sleeve (57) bottoms against pinion (58).

t. Install air seal tube (55) through end plate (38) and retainer (51).

NOTE

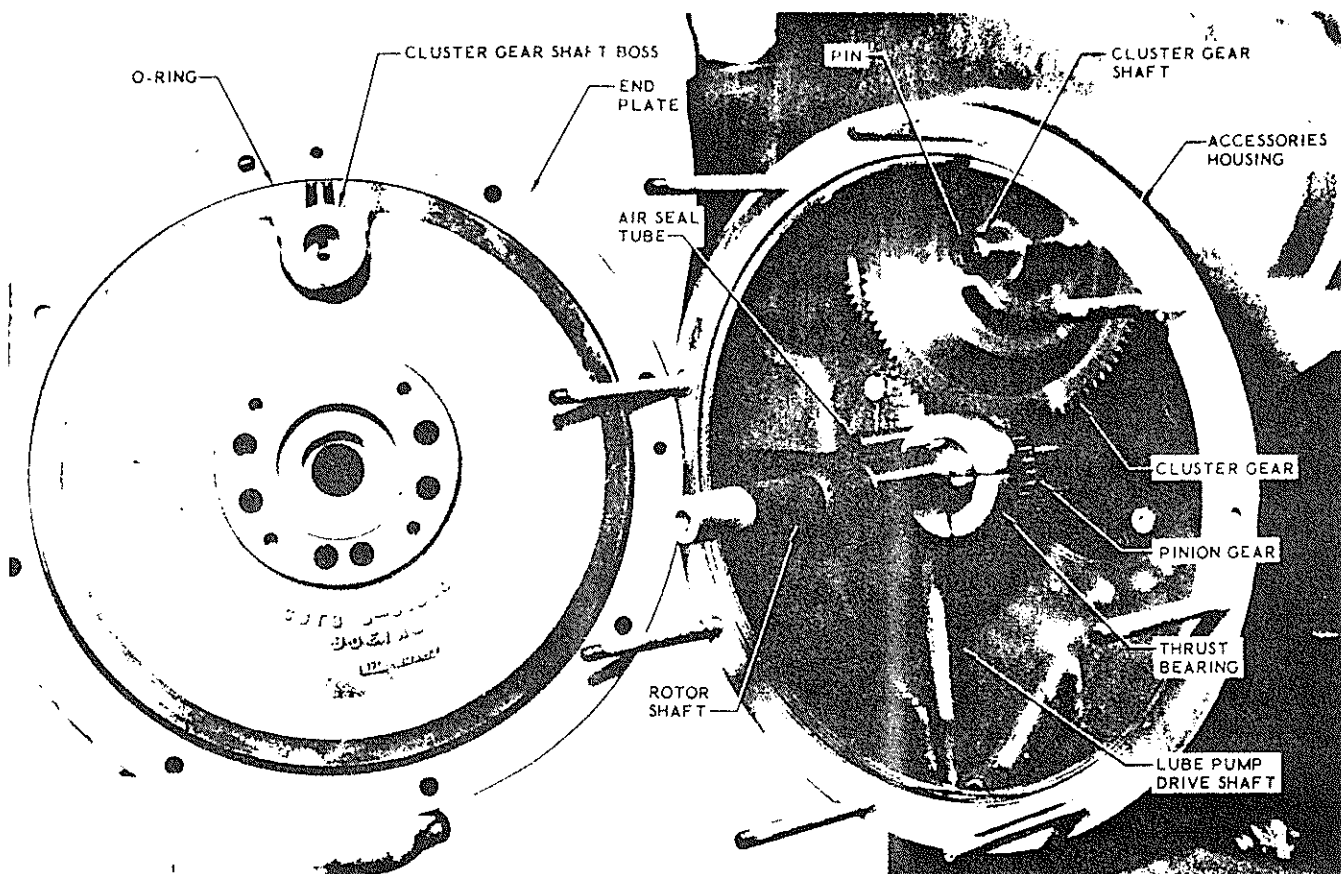
End of tube (55) must be flush with or below surface of retainer (51).

- u. Install new O-ring (54) on end of air seal tube (55).
- v. Install new, lubricated O-ring (49) on bearing cap (47).
- w. Install bearing cap (47) over retainer with four bolts (45) and washers (46). Lockwire bolts.
- x. Align blind spline and slide impeller (36) onto shaft.
- y. Position inducer (35) with aligning hole over dowel pin in impeller and slide onto shaft, seating against impeller. Install washer (34) and nut (33) on shaft finger tight.

**CAUTION**

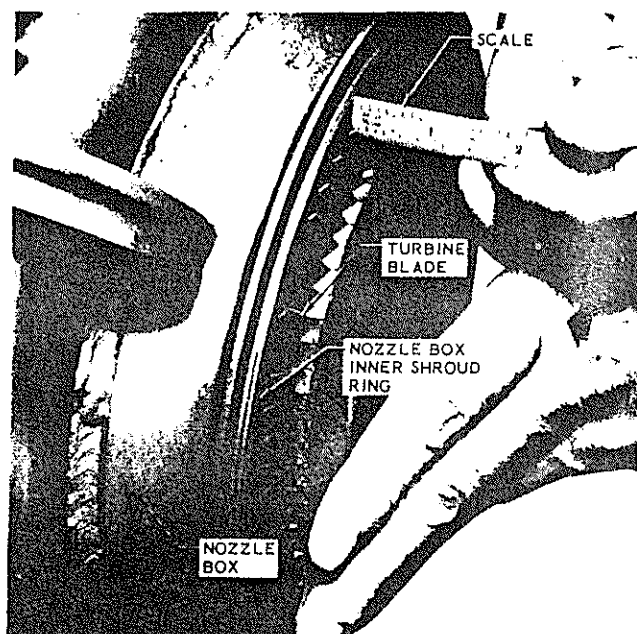
Ensure that all mating surfaces of parts stack (33 through 36, 47, and 57 through 59) are clean and free from irregularities. If not, an accurate run-out check cannot be obtained. (See figure 7-9.)

- z. Set up dial indicator (0.0001 inch graduations) mounted on special dial indicator bracket, Tool Group 10, Table I, Section III to measure runout on inducer hub just forward of inducer blade leading edges. (See



014-065

Figure 7-7. Cluster Gear Shaft and End Plate Alignment



014-066

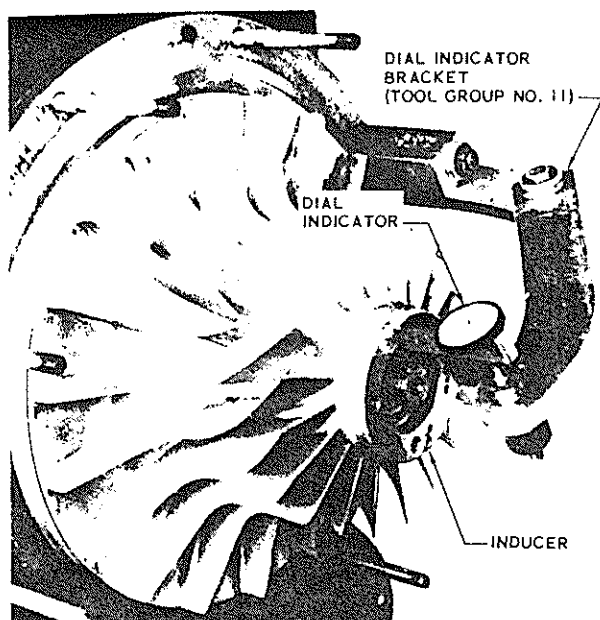
Figure 7-8. Checking Gas Producer Turbine Blade Trailing Edge to Nozzle Box Shroud Clearance

figure 7-9.) Measure and record runout and mark inducer with grease pencil at point of maximum runout.

aa. Tighten nut (33, figure 4-12) to a torque value of 500 to 600 inch-pounds, using special inducer wrench Tool Group 9, Table I, Section III (see figure 4-13). Remeasure and record runout. Mark inducer at point of maximum runout. Runout after tightening must be within 0.002 inch total indicator reading from runout before tightening. The two points must be within 45 degrees from each other. If either of these limits is exceeded, clean impeller and inducer and recheck. If limits are still exceeded, rotate each part individually 180 degrees with respect to the impeller and parts stack (washer, slinger, bearing sleeve, and pinion) rechecking each time until runout is within limits.

ab. Install and tighten check nut (32, figure 4-12) to a torque value of 200 to 250 inch-pounds. Align matchmarks on inducer (35), spinner (31), bolt (29), and washers (30) and install spinner with bolts (29) and washers (30).

ac. Check radial clearance between turbine wheel blade tips and inside diameter of nozzle box, with wheel forced outward in direction of measurement (to obtain smallest dimension). (See figure 7-10.) Check the turbine wheel axial clearance according to step ad. See Table VIII for proper radial and axial clearance. If clearance is not adequate, remove the nozzle box for inspection and repair or replacement.



014-067

Figure 7-9. Checking Rotor Runout

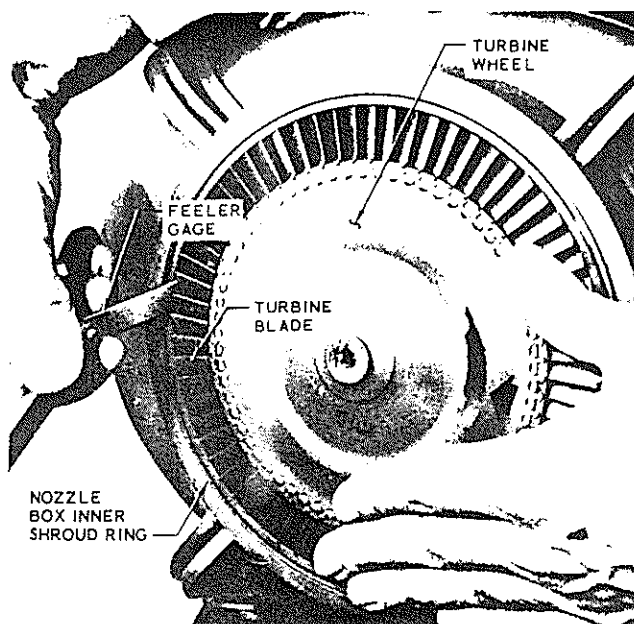
ad. Measure and record distance between trailing edges of turbine blades and downstream edge of nozzle box with wheel forced in the upstream position. (See figure 7-8.) Compare this dimension with the one taken in step m above. The trailing edges of the blades may be:

1. Inside downstream edge of nozzle box for both measurements;
2. Inside downstream edge of nozzle box for the first measurement and outside nozzle box for the second measurement;
3. Outside edge of the nozzle box for both measurements.

## NOTE

In substeps 1 and 3, the difference between the measurements represents the clearance. In substep 2, the sum of the measurements represents the clearance. See Table VIII, Section XI for proper axial clearance.

ae. Install new, lubricated O-ring (24F) on reducer (24E) and install assembly in adapter (24A), tightening to a torque value of 135 to 150 inch-pounds. Install nut (24C) and new, lubricated O-ring (24F) on adapter and install assembly in oil pressure port in accessory housing. Position adapter as shown and tighten nut (24C) to a torque value of 135 to 150 inch-pounds. Install cap (24D) on reducer (24E) and tighten to a torque value of 210 to 250 inch-pounds. Install new, lubricated O-ring (24) on oil pressure switch (23) and install assembly in adapter. Tighten to a torque value of 40 to 50 inch-pounds.



014-068

Figure 7-10. Checking Gas Producer Turbine Blade Radial Clearance

af. Install seal (9), and washer (8) on bolt (7). Insert assembly (7 through 9) in filter housing (10). Install spring (12), washer (13), O-ring (14), retainer (15), and filter element (16) in filter housing (10).

ag. Place new, lubricated O-ring (11) in seal groove in filter housing (10) and install assembly (7 through 16) in adapter on accessory housing.

ah. Install seal (6), washer (5), and drain bolt (4) in filter housing (10).

ai. Place four 1/8 inch diameter clay balls on leading edges of four equally spaced impeller blades. Dust clay balls with talcum powder.

aj. Assemble same thickness of shims (28) on compressor section mounting studs that was removed at disassembly.

ak. Position compressor section (27) on mounting studs (nameplate to top) and install with washers (26) and nuts (25).

al. Move rotor assembly to extreme upstream position (toward compressor section), then remove nuts (25), washers (26), and compressor section (27).

am. Trim outer end of compressed clay perpendicular to impeller blades and measure thickness (see figure 7-11.) This is the impeller to diffuser clearance. See Table VIII, Section XI for clearance required. If necessary, change thickness of shims between compressor section and accessory housing to obtain required impeller to diffuser clearance. Recheck clearance after any shim change.

an. Remove all clay from impeller and install compressor section on accessory section with washers (26, figure 4-12) and nuts (25).

ao. Install gasket (20) and gear box (19) with bolts (17) and washers (18).

ap. Install gasket (3) and speed monitor (2) with nuts (1).

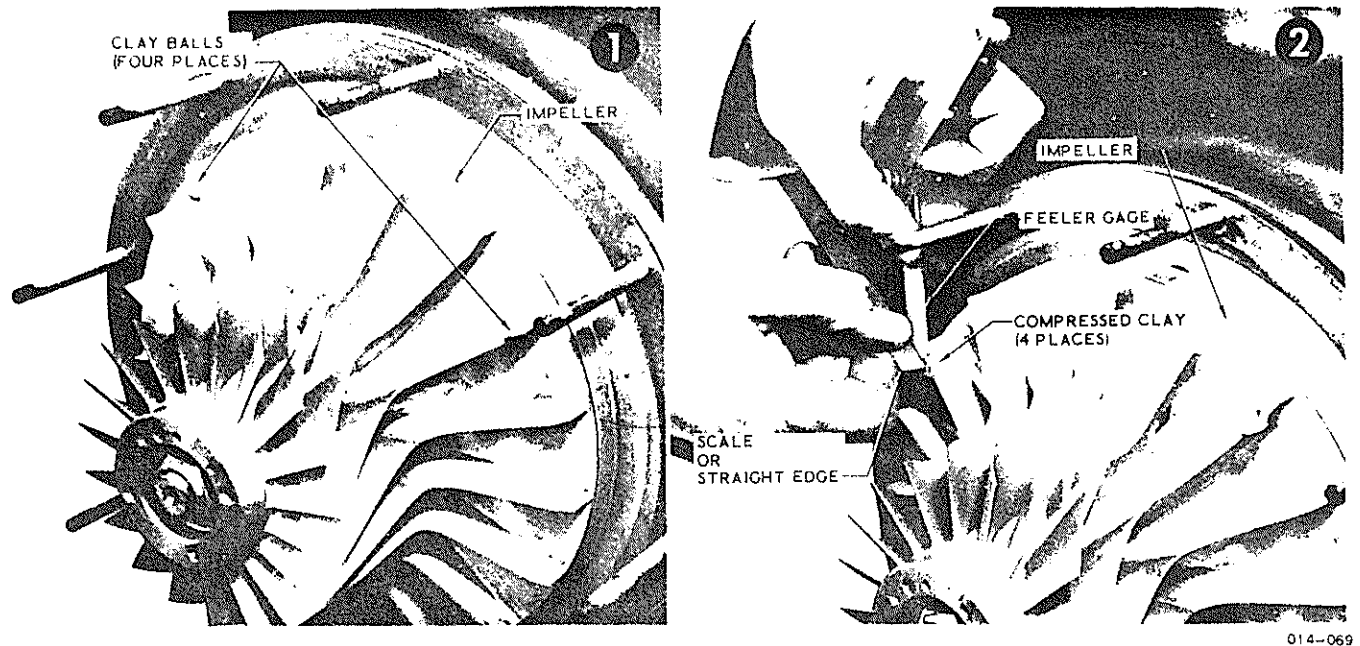


Figure 7-11. Checking Impeller to Compressor Case Clearance

## SECTION VIII

## FINAL ASSEMBLY AND INSTALLATION

8-1. ENGINE ASSEMBLY. Use special tools from Tool Group No. 3, Table I, Section III for engine handling. (See figure 4-10.) Assemble engine according to the following instructions:

- a. Attach nozzle ring (15) to gas producer section (11) with clamp (14). Tighten clamp to a net torque value of 30 to 45 inch-pounds, tapping while tightening to ensure proper seating. Do not retighten after engine run.

## NOTE

Net torque is the torque required to tighten nut on bolt, in addition to the run-on torque required to turn nut on bolt after all threads are engaged but before contact with trunnion. (See table X.)

**WARNING**

The above procedure must be followed when installing nozzle ring. If clamp is not installed properly, nozzle ring can spin during engine operation, possibly reaching burst speed.

- b. Check axial clearance between output section turbine wheel and inner shroud ring as follows:

1. Place three clay balls of approximately 3/8 inch diameter equally spaced on the nozzle ring inner shroud. (See figure 8-1.) Dust clayballs with talcum powder.
2. Slide reduction unit (12, figure 4-10) into place on gas producer sump base mounting studs, align dowel

pins with holes in sump and position reduction unit with exhaust collector over nozzle ring (15).

## NOTE

Position reduction unit carefully to ensure even compression of clay balls. Do not allow reduction unit to tip toward nozzle ring while installing or removing.

3. Install washers (10) and nuts (7) and tighten.
4. Remove nuts (7) and washers (10) and remove reduction unit from gas producer section.
5. Measure clearance of compressed clay balls at the deepest indentation on each ball. (See figure 8-1.) Clearance must be 0.160 inch minimum. (See figure 11-1.) If not within tolerance, send engine to overhaul facility.
6. Remove all clay from turbine wheel and nozzle ring.
- c. Install two new, lubricated O-rings (13, figure 4-10) in oil tube recesses on lower sump mating surface.
- d. Slide reduction unit section (12) into place on gas producer sump base mounting studs, center around nozzle ring (15), and align dowel pins with holes in sump.
- e. Install washers (10), brackets (9), washers (8), and nuts (7).
- f. Reach through exhaust collector with feeler gage and measure output section turbine wheel blade tip clearance. (This is the radial distance between blade tips and inside diameter of nozzle ring.) Refer to Table VIII, Section XI for required clearance. If clearance

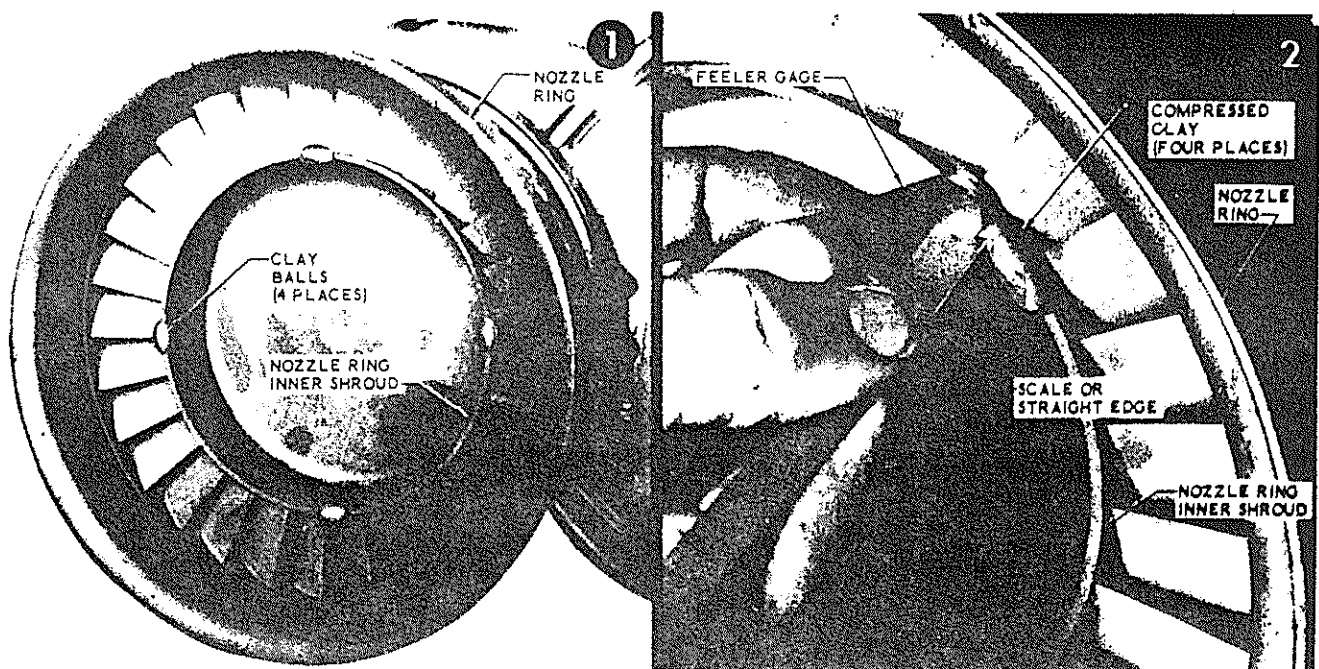


Figure 8-1. Checking Output Turbine Axial Clearance.

014-070



is less than minimum allowed, rotate nozzle ring. If no satisfactory position can be found, remove nozzle ring for inspection and/or replacement.

- g. Install inlet bell (6) on inlet flange with clamp (5).
- h. Install inlet screen (4) on inlet bell.
- i. Install lifting lug (3) with bolts (1) and washers (2) if removed.

8-2. LUBRICATION SYSTEM. (See figure 4-9.) Install lubrication system according to the following instructions:

- a. Install chip detectors (47) and seal assemblies (48).
- b. Install elbows (35, 38, and 44), union (41), and nuts (37, 40, 43, and 46) on lube pump (33) using new lubricated O-rings (36, 39, 42, and 45).
- c. Install lube pump (33) and new gasket (34) with washers (32) and nuts (31).
- d. Install union (28), nut (30), and new, lubricated O-ring (29) in accessory housing.
- e. Install elbow (22), nut (24), and new, lubricated O-ring (23) in sump base.
- f. Install tee (25), nut (27), and new, lubricated O-ring (26) in sump base.
- g. Install elbows (16 and 19), nuts (18 and 21), and new, lubricated O-rings (17 and 20) in accessory housing.
- h. Connect hose assemblies (14 and 15) to elbows (16 and 19) in accessory housing.
- i. Install hose assembly (9) between union (28) in accessory section and tee (25) in sump base.
- j. Connect hose assembly (13) to elbow (35) in lube pump.
- k. Install hose assembly (11) between tee (25) in sump base and elbow (38) in lube pump.
- l. Install hose assembly (12) between elbow (22) in sump base and union (41) in lube pump.
- m. Install hose assembly (10) between union (15, figure 4-19) in reduction unit and elbow (44, figure 4-9) in lube pump (33).
- n. Install clamps (8) on hose assemblies with bolts (7), and nuts (6).
- o. Install clamps (2 and 3) attaching hose assemblies (11 and 12) to output section with bolts (1), washers (4), and spacer (5).

8-3. ELECTRICAL SYSTEM. (See figure 4-8.) Install electrical system according to the following instructions:

#### NOTE

Refer to figure 2-8 for electrical schematic.

- a. Install ignition exciter (35) with bolts (32, figure 4-8) and washers (33).
- b. Install starter-generator (86) and new gasket (87) with bolts (84) and washers (85).
- c. Install terminal block assembly (72 through 74) if removed.
- d. Install junction box (83) over starter-generator terminal studs and secure with insulator bushings (79 through 82) and nuts (75 through 78). Tighten nuts (75 through 78) to a torque value of 10 to 15 inch-pounds.
- e. Install wiring harness and connector (71) in junction box assembly. Secure connector (71) with screws (70) and nuts (69). Connect harness lead terminals (65 through 68) to starter-generator terminals and terminal block (74), with nuts (62, 63, and 64). Tighten nuts

(63 and 64) to a torque value of 25 to 40 inch-pounds and nut (62) to a torque value of 12 to 15 inch-pounds.

- f. Install connector (58) in junction box assembly. Secure connector (58) with screws (57) and nuts (56). Attach terminals (55 and 54) to terminal block (74) and install nut (52). Install terminal (53) on starter-generator terminal and install nut (51). Tighten nuts (51 and 52) to a torque value of 12 to 15 inch-pounds.

g. Slide junction box cover assembly (47 through 50) into place; install four screws (46) and tighten screws on clamp (47).

- h. Route large branch of harness to bracket (19) and secure with clamps (17 and 18), bolts (15 and 16), and nuts (14). Feed harness branch leads down to igniter plugs, oil pressure switch, and ignition exciter, and position lead for fuel shutoff valve.

- i. Secure ground lead terminals (43, 44, and 45) with one bolt (41) and washer (42) at each igniter plug.

#### NOTE

There is only one ground lead terminal to igniter plug on left-hand side of engine.

Connect glow coil lead terminals (39) to igniter plugs with screws (38), washers (37), and nuts (36).

#### CAUTION

Tighten electrical connectors finger tight only and lockwire.

- j. Attach connector (60) to ignition exciter. Attach connectors (59, 61 and 61A) to speed monitor, oil pressure switch, and fuel valve.

#### NOTE

Install connector (61) on oil pressure switch by moving insulating shell and sleeve back on wire until terminal is exposed. Apply Dow-Corning DC-7 compound to mating surfaces of the pressure switch and electrical connector. Install terminal on oil pressure switch pin, then push sleeve and shell into rubber sleeve on switch.

- k. Secure leads on left-hand side of engine as follows: Secure igniter plug high tension long lead with one clamp (30); pressure switch lead and igniter plug low tension and ground leads with remaining clamp (30). Install bolt (29) and spacer (31).

#### NOTE

Fuel boost pump and fuel control unit drain lines (48 and 49, figure 4-7) must be installed under clamps (30).

- l. Secure large ignition high-tension lead routed across front of sump with clamps (22) and bolts (20).
- m. Secure harness leads on right-hand side of engine as follows: Install clamp (34) on harness branch to ignition exciter and secure with bolt (32) and washer (33) through mounting hole on ignition exciter. Lockwire bolts (32). Install clamp (23) on large harness branch and ignition exciter high-tension long lead and secure to sump with bolt (21).

- n. Connect high-tension leads from ignition exciter to igniter plugs. Tighten with 10 to 30 inch-pounds torque.
- o. Install thermocouple lead to exhaust collector heat shield with clamp (28), spacer (27), washers (26), bolt (25) and nut (24).
- p. Install thermocouple harness on exhaust collector with new bolts (9), washers (8), and nuts (7). Use washers (8) under heads of bolts (9) as required to obtain 0.06 inch minimum clearance between threaded ends of bolts and surface of exhaust collector.
- q. Secure thermocouple harness (13) to reduction unit with clamps (6), washers (2), and bolts (1 and 5).
- r. Connect alumel and chromel leads of thermocouple harness (13) to engine harness thermocouple lead terminals with bolts (12), washers (11), and nuts (10).

**NOTE**

Chromel and alumel leads may be identified with a permanent magnet or by color. Chromel terminal is non-magnetic and wire covering is white. Alumel terminal is magnetic and wire covering is green.

- s. Insulate terminals with thermosetting silicone tape No. 69, Minnesota Mining and Manufacturing Co., Minneapolis, Minnesota, or equivalent.

8-4. FUEL SYSTEM. (See figure 4-7.) Install fuel system according to the following instructions:

- a. Install union (95) and new, lubricated O-ring (96) in fuel boost pump inlet port.
- b. Install elbow (89), nut (91), and new, lubricated O-ring (90) in fuel boost pump drain port.
- c. Install elbow (92), nut (94), and new, lubricated O-ring (93) in fuel boost pump outlet port.
- d. Install fuel boost pump (87), and new gasket (88) on accessory gear housing with bolts (85) and washers (86).

**NOTE**

Engine wire harness bracket (19, figure 4-8) must be installed under top two bolts (85, figure 4-7) and washers (86).

- e. Connect drain tube (48) to elbow (89) on boost pump.
- f. Install elbow (64), nut (66), and new, lubricated O-ring (65) in drain port of fuel control unit pump.
- g. Install elbow (56), nut (58), and new, lubricated O-ring (57) in inlet port of fuel control unit pump.
- h. Install elbow (67), nut (69), and new, lubricated O-ring (68) in outlet port of fuel control unit.
- i. Install reducer (62), new, lubricated O-ring (63), elbow (59), nut (61), and new, lubricated O-ring (60) in fuel control unit compressor air inlet port.
- j. Install parts (70 through 83) if removed.
- k. Install fuel control unit (54) and new gasket (55) with bolts (51) and washers (52). Install clamp (53) on hose assembly (32) and under bolt (51) in top right-hand position.
- l. Connect drain tube (49) to elbow (64) on fuel control unit.
- m. Install nipple (84) in compressor case, if removed.
- n. Install hose assembly (50) between nipple (84) in compressor case, and elbow (59) in fuel control unit.
- o. Install elbow (42), nut (44), and new, lubricated O-ring (43) in inlet port of fuel filter (41).

- p. Install elbow (45), nut (47), and new, lubricated O-ring (46) in outlet port of fuel filter.
- q. If disassembled, assemble fuel filter and bracket parts (35 through 47) and install on engine with bolts (33) and washers (34).
- r. Connect hose assembly (32) between elbow (42) in filter assembly and elbow (92) on boost pump.
- s. Install hose assembly (31) between elbow (45) in fuel filter and elbow (56) in fuel control unit.
- t. Assemble fuel shutoff valve and bracket assembly (20 through 22) if disassembled.
- u. Install plug (29) and new, lubricated O-ring (30) in drain port of fuel shutoff valve (20).
- v. Install tee (26), nut (28), and new, lubricated O-ring (27) in outlet port of fuel shutoff valve (20).
- w. Install elbow (23), nut (25), and new, lubricated O-ring (24) in inlet port of fuel shutoff valve (20).
- x. Install assembly of fuel shutoff valve and bracket (20 through 30) with nut (19), washer (18), and bolt (17).
- y. Install elbow (14), nut (16), and new, lubricated O-ring (15) in burner inlet bolt on left-hand side of engine.
- z. Install tee (11), nut (13), and new, lubricated O-ring (12) in burner inlet bolt on right-hand side of engine and install plug (9) and new, lubricated O-ring (10) in tee (11).
- aa. Install hose assembly (6) between tee (26) in fuel shutoff valve and tee (11) in right-hand burner inlet bolt; install hose assembly (7) between tee (26) in fuel shutoff valve and elbow (14) in left-hand burner inlet bolt.
- ab. Install hose assembly (8) between elbow (23) in fuel shutoff valve and elbow (67) in fuel control unit.
- ac. Clamp hose assembly (8) to compressor case with clamps (5) and bolts (4).
- ad. Clamp hose assemblies (8 and 31) together with clamps (3), bolt (2), and nut (1).

8-5. BURNER SECTION. (See figure 4-4.) Install the burner sections according to the following instructions:

**CAUTION**

Do not damage burner gaskets. Before installing burner assembly, lubricate graphite-asbestos O-ring (18) with a light film of Dow Corning DC-7 or DC-11 silicone compound on the outer surface. Use fingers to compress and guide O-ring into place during installation. Do not allow O-ring to become deformed or damaged.

- a. Insert downstream ends of burner assemblies (13) into nozzle box inlet ports. Slide burner assemblies as far into nozzle box as possible and swing inlet ends toward gas producer until inlet adapters line up with outlet ports in the front of compressor section. Move burner assemblies toward compressor section until heads of gasket retaining screws index with holes in mating surfaces of compressor section outlet ports.

**CAUTION**

Do not damage burner gaskets.

- b. Install new, lubricated O-rings (10 and 11) on burner inlet bolts (9).

c. Screw burner inlet bolts (9) into center bosses of burner inlet adapters through compressor front casings and tighten to a torque value of 375 to 390 inch-pounds.

d. Install washers (12) and nuts (8) on burner inlet bolts (9) and tighten to a torque value of 375 to 390 inch-pounds.

e. Install seal rings (5) on crossfire tube elbows (4), separate gaps by 90 degrees or more, and install elbows in crossfire tube (6) with bolts (3).

f. Insert crossfire tube assembly (3 through 6) below burner assemblies with bend in tube toward compressor section. Place gaskets (7) on elbows (4), insert elbows in bosses of burner assemblies and install with bolts (1) and washers (2).

#### NOTE

Burner assemblies may be rotated as necessary to align elbows with bosses in burner shells.

g. Standing at right-hand side of engine, grasp crossfire tube and move tube lengthwise from burner to burner to check for binding on elbow seal rings. If binding is evident, rotate burner shell as required to obtain free fit. End play should be approximately 1/4 inch. When tube (6) is aligned, install clamp (14) as follows: Apply Fel-Pro C-5A high temperature thread lubricant to T-bolt threads, nut threads, nut thrust face and trunnion strap interface. Install clamp and tighten nuts to a net torque value of 5 to 8 inch-pounds. Lightly tap accessible portions of clamp strap with a soft mallet and retighten nut to a net torque value of 5 to 8 inch-pounds.

#### NOTE

Run-on torque is the torque required to start the nut turning when the nut is engaged, with at least two full threads of the bolt protruding beyond the outer end of the nut, and before the nut face contacts the surface of the part against which it is to be tightened. To determine net torque subtract run-on torque from the dial reading on the torque wrench. See table X for self-locking torque requirements.

#### CAUTION

Do not retighten nut unless clamp becomes loose and can be rotated by hand. If tightening becomes necessary, remove nut and reinstall per above procedure.

h. Install igniter plug electrical leads (39, 40, 43, 44, 45, figure 4-8). Tighten high tension leads (39) to a torque value of 10 to 30 inch-pounds.

8-6. OIL COOLER AND EDUCTOR. (See figure 4-2.) Install oil cooler and eductor according to the following instructions:

a. If brackets (37 and 38) were removed during disassembly, install with bolts (32 and 33) and washers (34, 35, and 36). Lockwire bolts (32 and 33).

#### NOTE

Washers (34, 35, and 36) may be used on either side of brackets (37 and 38). A mounting dimension of 7.794 ( $\pm 0.010$ ) inches must be maintained between tapped hole center of brackets. Quantity of washers used between bracket and sump on one side must be within one of quantity used between opposite bracket and sump.

b. Install oil cooler assembly (20) on eductor assembly (23) with bolts (18) and washers (19).

c. Assemble barrels (22), and forks (27 and 31).

#### NOTE

Stainless steel forks (31) must be used on exhaust collector side. These forks are non-magnetic and may be identified by use of a permanent magnet.

d. Position eductor assembly over exhaust collector outlets.

#### NOTE

Place eductor over one exhaust outlet and spring slightly to bring into place over the other outlet.

e. Install bolts (14) and washers (15) at the compressor end of the oil cooler, and washers (13A), bolts (13), washers (12 and 11), and nuts (10) at the reduction unit end of the oil cooler, observing the following:

1. A minimum clearance of 0.020 inch is required between the eductor assembly and the rotor housing brackets (9, figure 4-10). Use washers (12, figure 4-2) as necessary to obtain this clearance.

2. A minimum clearance of 0.050 inch is required between the eductor assembly and the exhaust collector ports. Use washers (12 and 15) as necessary between the eductor assembly and the rotor housing brackets (37 and 38, figure 4-2) and (9, figure 4-10) to obtain this clearance.

#### NOTE

If eductor part number 45-2460-2 is used (this eductor has no external flange around its exhaust collector ports), the minimum clearance between the eductor assembly and the exhaust collector ports is 0.020 inch.

3. A minimum clearance of 0.010 inch is required between all parts of linkage return spring (1, figure 4-3) and the eductor assembly. Loosen eductor mounting fasteners and reposition the eductor as necessary.

#### CAUTION

This clearance is critical. If the linkage return spring is allowed to rub on the eductor assembly, breakage of the spring can result, causing the output shaft to overspeed.

f. Check for point contact between eductor mounting ring and exhaust outlets. If point contact is found, grind off high spots to obtain minimum clearance.

g. Install the turnbuckle assemblies between the exhaust collector brackets and the eductor brackets with bolts (26), washers (25 and 29), and nuts (24 and 28).

h. Tighten turnbuckle barrels (22, figure 4-2) to eliminate play between eductor assembly (23) and all

8-7. OUTPUT SECTION GOVERNOR AND CONTROL LINKAGE. (See figure 4-3.) Install the output governor and control linkage according to the following instructions:

- a. Install output section governor (36) and new gasket (37) on reduction unit with nuts (34) and washers (35).
- b. Install union (32) and new, lubricated O-ring (33) in reduction unit.
- c. Install elbow (38) in output section governor if removed.
- d. Install hose assembly (31) between output section governor elbow (38) and reduction unit union (32).
- e. Install bracket assembly (30) with bolts (50) inserted through bracket and housing, and nuts (28) and washers (29) on far side.
- f. Install bracket (27) on reduction unit housing with nuts (25), washers (26), and bolts (49).
- g. Slide bushing (24) on shaft (22) with bushing flange against lever end of shaft.
- h. Insert shaft (22) and bushing (24) through boss on reduction unit housing with splined end of shaft through bracket (27).
- i. Install bushing (23) on shaft (22) and in bracket (27).
- j. Install lever (17) on shaft (22) with bolt (16), washer (15), and nut (14) so that lever (17) and the lever on opposite end of shaft (22) are 180 degrees apart and within 10 degrees of the same centerline.
- k. Install bolt (20), collar (21), washer (19), and nut (18) on lever (17), with collar on reduction unit side of lever.
- l. Attach spring (1) between collar (21) and bracket (30).
- m. Install check nuts (13) and rod ends (12) on control rod (11) if removed.
- n. Install control rod (11) between fuel control unit lever and shaft (22) with bolts (10), washers (9), and nuts (8). Washers (9) must be installed with concave surfaces next to nuts. Do not tighten until linkage adjustment is made. See paragraph 8-8.
- o. Install parts (41 through 48) on output section governor (36) if removed.
- p. Install check nuts (7) and rod ends (6) on control rod (5) if removed.
- q. Install control rod (5) between lever (17) and lever (42) with bolts (4), washers (3), and nuts (2). Washers (3) must be installed with concave surfaces next to nuts (2). Do not tighten until linkage adjustment is made. See paragraph 8-8.

8-8. OUTPUT SECTION GOVERNOR CONTROL LINKAGE ADJUSTMENT. Use special tool from Tool Group 8, Table I, Section III for output governor control linkage adjustment. Adjust the output section governor control linkage according to the following instructions. (See figures 8-2 and 8-3.)

- a. Disconnect return spring (11, figure 8-2) from spring lever (2). Disconnect control rod (10) from gas producer speed control lever (1), and control rod (9) from output governor lever (6).
- b. Rotate output governor lever (6) clockwise against internal stop (minimum fuel position). Lever (6) must be within 5 degrees of the vertical centerline. If adjustment is necessary, turn and hold terminal shaft (12) clockwise against the terminal stop (internal stop

in governor), using the slot in the end of shaft (12). Reposition governor lever (6) on shaft (12) as required.

#### NOTE

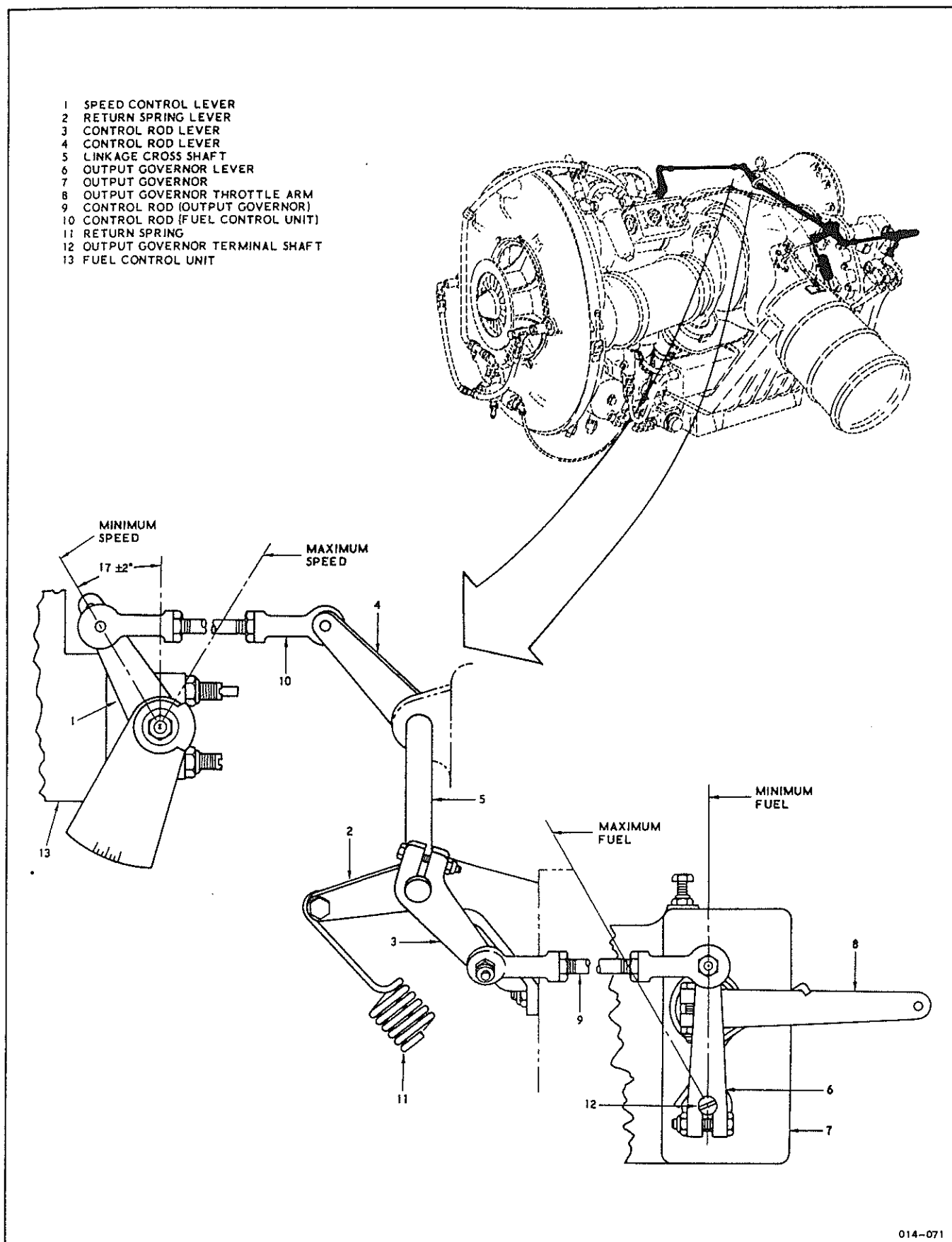
Ensure that control rod lever (3) is on shaft (12) as far as possible before securing.

- c. With output governor lever (6) at the minimum fuel position established in step b, check that the two control rod levers (3 and 4) on linkage cross shaft (5) are 180 degrees apart and on a common centerline with shaft (5)  $\pm 10$  degrees. If adjustment is necessary, reposition lever (3) on splines of shaft (5).
- d. Check end play of linkage cross shaft (5) at the shaft bearing boss on the output section housing. Measure end play between the base of control-rod lever (4) and cross-shaft bushing. Allowable end play is 0.020 to 0.120 inch. Adjust by repositioning control rod bracket on reduction unit housing.
- e. Rotate speed control lever (1) counterclockwise against low speed stop. Lever must be installed on shaft serrations that will position it closest to 18 degrees from vertical.
- f. Connect control rod (10) to inner hole in speed control lever (1) and to control rod lever (4). Rotate speed control lever (1) clockwise to maximum rated speed position. With lever in this position adjust the length of control rod (10) so that the centerline of control-rod levers (3 and 4) on the linkage cross shaft is parallel to the vertical mounting flange on the power output assembly (reduction unit).
- g. Rotate speed control lever (1) counterclockwise against low speed stop and connect return spring (11) to return spring lever (2).
- h. Rotate output governor lever (6) clockwise to its minimum fuel position. Connect control rod (9) to control rod lever (3) and to output governor lever (6). Adjust control rod (9) so that output governor lever (6) is 2 to 5 degrees counterclockwise from its minimum fuel stop when speed control lever (1) is against its low speed stop.

#### NOTE

Final trimming of the governor control linkage is accomplished following adjustment of the fuel control unit high and low speed stops to required settings. Control rods (9 and 10) should be adjusted so that the output governor (lever 6) does not contact its stops before speed control lever (1) on fuel control unit reaches minimum or maximum speed positions.

- i. Move linkage to rated-speed position (speed control lever (1) against high speed stop), and check for interference between cross shaft control rod lever (3) and return spring (11) (right-hand side of engine). If interference is encountered, make adjustments in the following order as required: disconnect spring (11) and reconnect end-for-end; adjust length of control rods (9 and 10); reposition return spring lever (2) on linkage cross shaft (5). Minimum clearance is 0.060 inch. The relationships and clearances established in steps b through h must be maintained.



014-071

Figure 8-2. Governor Control Linkage Adjustment

- j. Check the total angular travel of output governor lever (6) by moving speed control lever (1) from the minimum speed to maximum speed positions. Total travel of output governor lever (6) must not be less than 20 degrees after completing linkage adjustments.
- k. Check torque required to move output governor lever (6). Torque must be 45 to 55 inch-pounds. If torque is not within limits, replace return spring (11). (See figure 8-3.)

## NOTE

The relationship between control-rod levers and clearances established in above procedure must be maintained. The entire linkage mechanism must be readjusted if an adjustment is made to compensate for incorrect torque.

1. Ensure that all linkage and shaft lever bolts and nuts are secure.

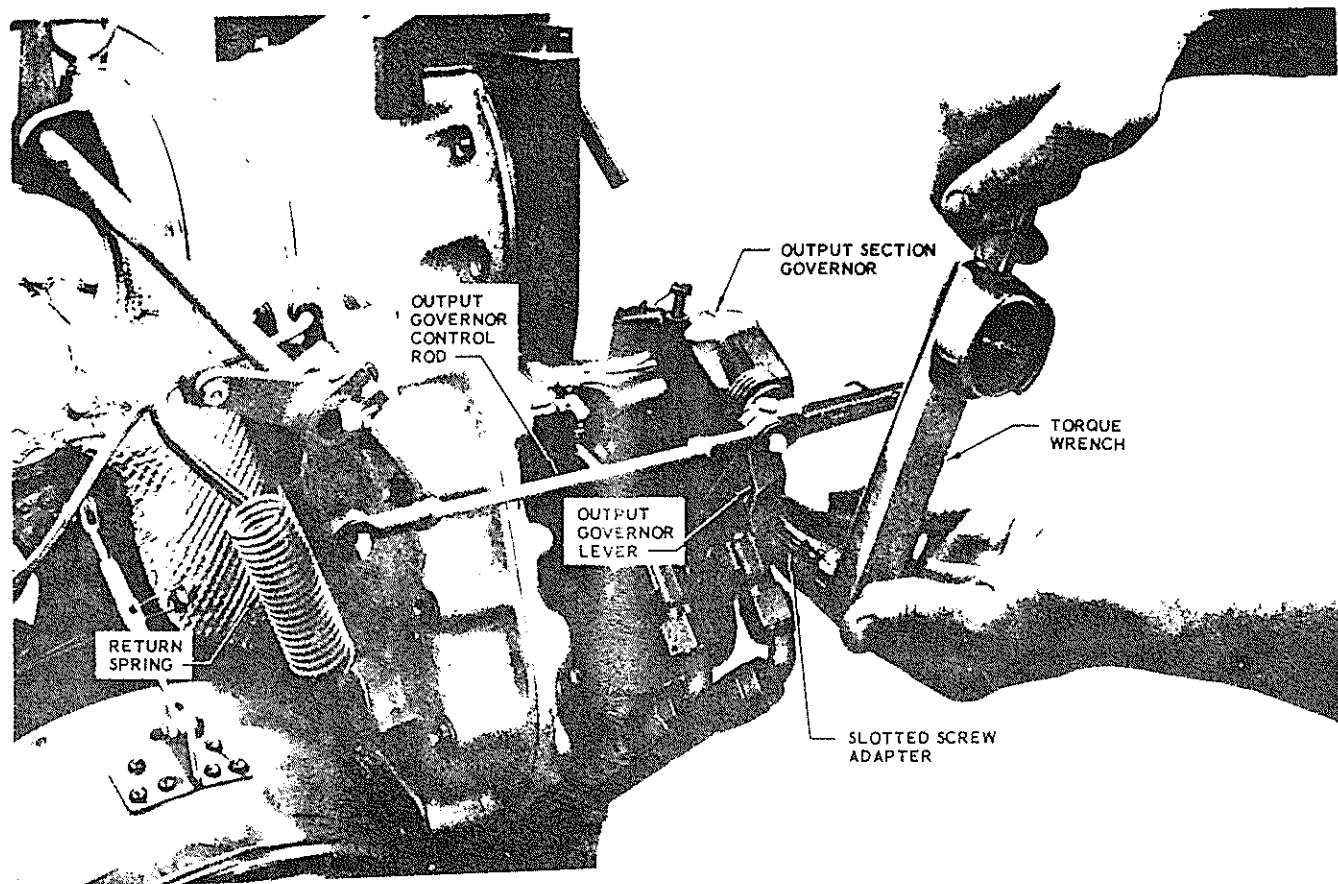


Figure 8-3. Checking Governor Control Linkage Torque

014-072

## SECTION IX

## TESTING AFTER OVERHAUL

9-1. ENGINE SPECIFICATIONS. Engine specifications are listed in Table IV.

9-2. OPERATING LIMITS. Engine operating limits are listed in Table VI; maximum allowable exhaust gas temperature is shown in figure 9-3.

9-3. PREOILING. Preoil the engine as follows:

- a. Fill the oil sump to the FULL mark on the dipstick with lubricating oil specified in table IV.
- b. Close the fuel shutoff valve and de-energize the circuit to prevent valve opening during the following step.
- c. Motor the engine for 30 seconds.
- d. Check the oil sump level with the dipstick and add oil as required.

## NOTE

The oil cooler will not be completely filled until the engine has been run at operating temperature.

- e. Motor the engine for another 30-second period, recheck the oil level and refill if necessary. Preoiling is complete when the sump level does not lower during the motoring cycle and oil pressure is indicated on the oil pressure gage.

9-4. TEST CELL INSTALLATION. Install engine in test cell according to the following instructions:

## NOTE

Exhaust eductor and oil cooler must be installed on engine.

## NOTE

If the engine is to be operated on the mobile test stand, the inlet air duct is not required. The air inlet screen must be installed and the engine must be positioned so that the inlet faces into the wind.

- a. Mount the engine on special engine test base (Tool Group No. 4).
- b. Align engine to dynamometer so that the output shaft face is at 90 degrees to the dynamometer axis within 0.005 inch total indicator reading, and so that the output shaft bore is parallel to dynamometer axis within 0.020 inch total indicator reading.
- c. Connect fuel line to fuel boost pump inlet.
- d. Disconnect control rods between output section governor and fuel control unit as outlined in paragraph 4-5. Connect the test cell throttle control rod to the gas

Table IV. Engine Specifications

Item	Specification
Fuel Specification	MIL-J-5624, grades JP4 and JP5
Oil Specification	MIL-L-23699 for ambient temperatures from -34°C (-30°F) to +54°C (+130°F), MIL-L-7808 for ambient temperatures from -34°C (-30°F) to -46°C (-50°F) (MIL-L-7808 is optional to MIL-L-23699 for ambient temperatures of -34°C (-30°F) to +54°C (+130°F)). MIL-O-6081, Grade 1010 for ambient temperatures from -46°C (-50°F) to -54°C (-65°F).
Oil Sump Capacity	6 U.S. quarts
System Capacity	8 U.S. quarts
Estimated Oil Consumption at Rated Power - Military - Normal	1 quart in 6:15 hrs. 1 quart in 8:20 hrs.
Output Shaft Rotation	Counterclockwise viewed from power output end of engine.
Gas Producer Tachometer Drive Ratio	0.1107 to 1.

producer fuel control unit lever. Secure the output section governor throttle arm in maximum speed position.

9-5. ENGINE INSTRUMENTATION. Instrument the engine according to figure 9-2 and Table V.

9-6. ENGINE TEST. The engine test run is conducted in two parts as follows:

- a. Part A, controlled by the fuel control unit.
- b. Part B, controlled by the output section governor.

9-7. TEST DATA. Entries will be made on the engine test run chart (see figure 9-1) in accordance with the following:

- a. At each gas producer and output section speed setting in part A (Table VII).
- b. Once during each test period of Part B.
- c. Test data will consist of:
  1. Time of day.
  2. Compressor pressure.
  3. Inlet air temperature.
  4. Inlet air flow.
  5. Nozzle box pressure.
  6. Fuel flow.
  7. Barometric pressure (In. Hg Abs).
  8. Oil pressure (gas producer gallery and output section).
  9. Oil temperature out of cooler.
  10. Oil temperature into cooler.
  11. Exhaust gas temperature (use thermocouple harness only during part B of test).
  12. Fuel pressure (supply and boost pump).
  13. Fuel nozzle pressure.
  14. Cell fuel supply pressure.
  15. Torque.
  16. Gas producer and output shaft speed (RPM and %).
  17. Engine vibration (check must be made during entire test run of engine).
  18. Total engine time.
  19. Power transients data. For each power transient (acceleration-deceleration cycle) performed, record the time required to accomplish the power transient, the maximum values of measured gas temperature, torquemeter reading, and engine speed attained during the power transient.

9-8. PRESTART CHECKS. Before starting the engine, perform the following:

- a. Check that electrical power and fuel are available to the engine.
- b. Check that engine mounting bolts and coupling bolts to dynamometer are secure.
- c. Check engine oil level and replenish if necessary.
- d. Check that engine is in operating condition.
- e. Open manual fuel valve.
- f. Bleed air from the fuel system by disconnecting the fuel lines from the burner inlet bolts, and motoring engine with the starter until fuel flows freely from fuel lines.

#### NOTE

Check for oil pressure indication while motoring engine.

g. Connect the fuel lines to the burner inlet bolts. Check that the fuel shutoff valve is closed.

h. Inform overhaul activity inspector that engine is ready for acceptance test.

9-9. STARTING PRECAUTIONS. Observe the following precautions while starting the engine:

- a. If the engine fails to accelerate to ground idle speed in 15 seconds on manual start, turn fuel off and continue cranking for 5 seconds to clear engine of fuel.

#### CAUTION

Allow a 2 minute cooling period between cranking cycles. After cranking for a total of 90 seconds, allow starter to cool for 10 minutes.

b. If engine fails to start on automatic start, switch to manual start, energize starter, and crank engine for 5 seconds to clear it of fuel.

c. If oil pressure is not indicated before 10,000 gas producer RPM, discontinue start.

9-10. STARTING PROCEDURE. Place the test cell throttle control in ground idle position and start the engine according to step a or b of the following instructions:

- a. Perform manual start as follows:
  1. Unload dynamometer.
  2. Energize starter and crank engine to 3000 gas producer RPM minimum.
  3. Open fuel shutoff valve.
  4. De-energize starter at 15,000 gas producer RPM.
- b. Perform automatic start by energizing automatic start switch.

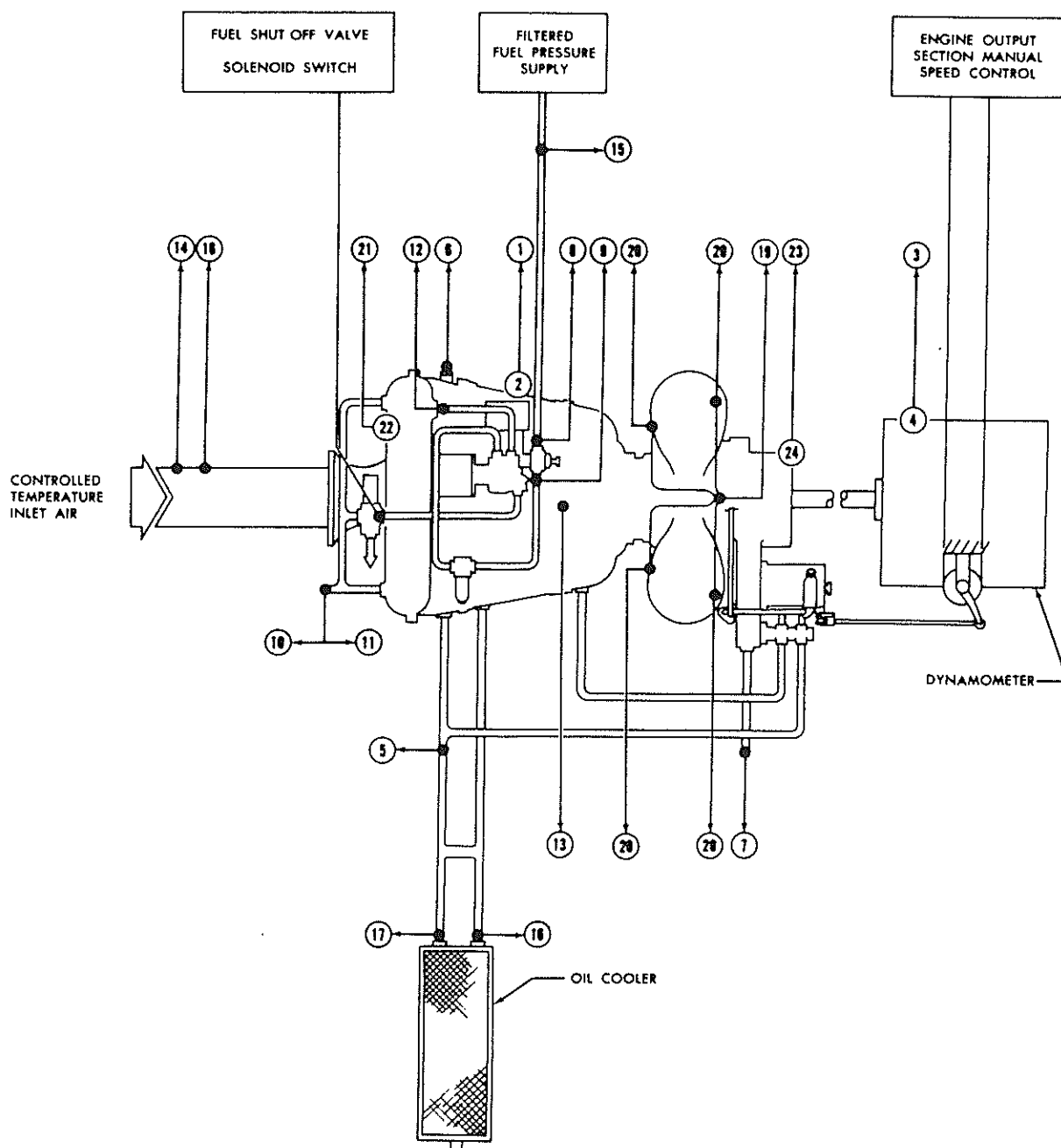
9-11. IDLE SPEED CHECKS. Before accelerating to rated speed, perform the following checks:

- a. Check oil pressure. Gas producer gallery pressure must be 25 PSIG minimum at ground idle and output section pressure must be 15 PSIG minimum.
- b. Check the engine for fuel, air, and oil leaks. Check accessories for leakage in accordance with the applicable NAVAIR Handbooks. Repair leaks if in excess of allowable limits, replacing units if necessary.
- c. Check that the engine driven fuel boost pump is delivering 18 to 28 PSIG at ground idle.
- d. Shut down engine.

9-12. FUEL CONTROL UNIT CHECKS. Perform the following fuel control unit checks:

- a. Check that idle stop is set at 23,000 ( $\pm 1000$ ) RPM with engine stabilized at idling temperature. Readjust if necessary.
- b. Check that minimum flow is correctly set by rapidly decelerating engine several times to demonstrate freedom from burner blowout. If burner blowout occurs, check all possible causes, repair fuel control unit or replace with new unit and repeat procedures in paragraph 9-8 through 9-11.





014-074

Figure 9-2. Acceptance Test Schematic

Table V. Acceptance Test Instrumentation

Instrument	Condition Check	Range and Units	Accuracy	Takeoff Point
Barometric Pressure	Atmospheric Pressure	25.1 to 30.86 In. Hg Abs	$\pm 0.02$ In. Hg	Ambient Air
Dial Gage	Compressor Discharge Pressure	0-100 PSIG	$\pm 1$ PSIG	Compressor Discharge Pressure Line
Vibration Meter	Gas Producer Vibration	0.1 to 1,000 g's and 0.0001 to 1 inch D.A.		
Vibration Pickup		50 g's continuous 500 g's Max.	$\pm 3\%$ of reading at 700 CPS	Top Bolt in Compressor Case and Compressor and accessory housing bolt circle
Vibration Meter	Power Section Vibration	0.1 to 1,000 g's and 0.0001 to 1 inch D.A.		
Vibration Pickup		50 g's continuous 500 g's Max.	$\pm 3\%$ of reading at 700 CPS	Top Bolt in Eductor Casing Input Housing Bolt Circle
Clock	Time of Day	Hours and minutes	$\pm 0.5$ minute	
Hourmeter	Total Running Time	Hours and 0.1 hour	$\pm 0.1$ hour	
Stop Watch	Transient Time	0-60 seconds 0-15 minutes	$\pm 1\frac{1}{3}\%$ of reading	
Tachometer Dial Indicator	Gas Producer Speed	0-110%	$\pm 1.0\%$	
Tachometer Generator (Shaft-to-tachometer generator gear ratio: 295:33)		3-phase, 2-pole and magnetic pickup with 60-tooth gear		Speed Monitor
Electronic Counter (Percent readout: 2.38.0-sec. gate rpm readout: 0.9032-sec. gate)	Gas Producer Speed	5 digit display	$\pm 0.03\%$	Speed Monitor
Tachometer Dial Indicator	Output Shaft Speed	0-7,000 RPM	$\pm 1.0\%$ RPM	Dynamometer Tach Switch
Tachometer Generator		3-phase, 2-pole		
Electronic Counter (RPM Readout: 1.5-sec. gate)	Output Shaft Speed	5 digit display	$\pm 0.03\%$	Dynamometer Shaft Magnetic Pickup with 40-tooth Gear
Overspeed Indicator	Output Shaft Speed	0-7,500 RPM	$\pm 150$ RPM	
Magnetic Pickup				Output Shaft
Rotometer	Fuel Flow	0-600 MM	MM converted PPH: $\pm 2$ PPH	Cell Fuel Supply Line to Engine
Dynamometer		0-450 HP		Output Shaft
Dial Indicator	Output Shaft Torque	0-500 lb-ft	$\pm 1$ lb-ft	
Pneumatic Load Cell	Dynamometer Shaft Torque	12 sq. in. diaphragm		
Brown Potentiometer Pyrometer	Inlet Air Temperature	Low range: 0-800 F	$\pm 2$ F	Cell Inlet Air Duct
I.C. Thermocouples (2)				
Brown Potentiometer Pyrometer	Exhaust Gas Temperature	High range: 0-2,000 F	$\pm 1\%$ at 800 F to 1,300 F	Engine Thermocouple Harness

Table V. Acceptance Test Instrumentation (Continued)

Instrument	Condition Check	Range and Units	Accuracy	Takeoff Point
Brown Potentiometer Pyrometer	Oil Temperature into Engine	Low range: 0-800°F	± 5 F	Inlet to the Oil Filter
I.C. Thermocouples (2)				
Bulb Thermometer	Fuel Temperature	30-240 F	± 2 F	Cell Fuel Supply Tank
Hydrometer	Fuel Specific Gravity			Cell Fuel Supply
Dial Gage	Oil System Pressure	0-200 PSIG	± 2 PSI	Point of Installation of Oil Pressure Switch
Three-tube Manometer Board	Inlet Air Flow	0-40 In. H <sub>2</sub> O	0.20-inch increments	Cell Inlet Air Duct

Table VI. Operating Limits

Item	Condition	Rating
Corrected Horsepower (minimum)	16 C (60°F) Inlet Air Temperature and 29.92 in. Hg	300 HP
Observed Torque	Maximum	328 FT-LBS
Gas Producer Speed	Maximum (Military Rated) Ground Idle Flight Idle	38,500 RPM 23,000 (±1000) RPM 27,000 - 31,000 RPM
Output Shaft Speed	Maximum Continuous Maximum Transient Military Rated	6900 RPM 7200 RPM 6000 (± 25) RPM
Fuel Boost Pressure	Supply to Engine	15 to 28 PSIG
Engine Oil Pressure	Ground Idle (output section) Flight Idle to Military Rated (gas producer)	25 PSIG (minimum) 30 PSIG (minimum)
Oil Temperature Into Engine (from cooler)	Normal Rated	102°C (215°F) maximum
Exhaust Gas Temperature	Maximum Temp. Average Maximum Temp. Differential Between Average of Four Individual Thermocouples and Harness	See figure 9-3 -7°C (20 F)
Acceleration Time	Ground Idle to Military Rated Flight Idle to Military Rated	5 to 10 seconds 5 Seconds Maximum
Vibration	Maximum (at 40-621 CPS)	15 G

c. Install new or repaired fuel control unit. Repeat operating procedures beginning with paragraph 9-8.  
d. Check starting fuel flow with special pressure indicator (Tool Group No. 4) by cranking engine at 4000 RPM minimum with compressor air line disconnected from fuel control unit. Starting flow must be 66 to 80 pounds per hour. Replace fuel control unit if limits are exceeded.

9-13. TEST RUN - PART A. Perform part A of the test run according to Table VII.

## NOTE

Running engine at ground idle for one minute prior to engine shutdown will prolong the useful life of hot section parts.

9-14. PERFORMANCE ACCEPTABILITY. Check performance acceptability as follows:

a. Refer to figure 9-3 and find inlet air temperature on the horizontal scale. Follow the vertical line to its point of intersection with the exhaust gas temperature curve. From this point, move straight to the left and read exhaust gas temperature (EGT) from the vertical scale. This is the maximum EGT allowable.

Example: Given - Inlet air temperature = 13 C (56 F)  
Solution - Maximum EGT read from figure 9-3 = 635°C (1177 F)

b. Refer to figure 9-4 and find inlet air temperature on the horizontal scale. Follow the vertical line to its point of intersection with the barometric pressure curve. From this point, move straight to the left and read torque required from the vertical scale. Adjust

Table VII. Fuel Control Unit Regulated  
Test Run

Gas Producer RPM	Output Shaft RPM	Minutes Duration
Ground Idle	2300 3000	15
34,330	4800 5000 5200 6000	15
36,130	5400 5600 5800 6000	15
37,480	5400 5600 5800 6000	15
*	6000	15

\*If limited by exhaust gas temperature, run at 37,930 RPM, speed at which required torque is attained. Refer to figure 9-4. See paragraph 9-14 for procedure.

dynamometer load to maintain 6000 RPM output shaft speed, and vary gas producer speed to obtain the required torque. This is the speed at which the engine will produce 300 hp on a 60°F standard day. If gas producer exceeds maximum speed specified in Table VI, reject the engine.

Example: Given - Inlet air temperature = 13°C (56°F)  
Barometric pressure = 30.1  
Solution - Torque read from figure 9-4 = 270  
Adjust gas producer speed to produce 270 ft-lbs torque at output shaft speed of 6000 RPM  
Gas producer speed = 38,170 RPM

c. Refer to figure 9-5 and find the observed inlet air temperature on the horizontal scale. Follow the vertical line to its point of intersection with the barometric pressure curve. From this point, move straight to the left and read differential fuel flow from the vertical scale. Record this value, noting the algebraic sign (plus or minus). Add differential fuel flow to the observed fuel flow if the sign is plus, subtract if the sign is minus. This is the fuel flow corrected for a 60°F standard day.

Example: Given - Observed inlet temperature = 13°C (56°F)  
Observed fuel flow = 290 lbs/hr  
Solution - Observed fuel flow = 290 lbs/hr  
Differential fuel flow from figure 9-5 = -4  
Corrected fuel flow = 286 lbs/hr

d. Refer to figure 9-6 and find the corrected fuel flow on the horizontal scale. Follow the vertical line to its point of intersection with the curve. From this point,

move straight to the left and read the specific fuel consumption (SFC) from the vertical scale. This is the SFC for a 60°F standard day. If the SFC is higher than .98, reject the engine.

Example: Given - Corrected fuel flow 286 lbs/hr  
Solution - SFC read from figure 9-6 0.954

e. Refer to figure 9-7 and find the observed inlet temperature on the horizontal scale. Follow the line vertically to its point of intersection with the curve. From this point, move straight to the left and read the EGT differential from the vertical scale. Record this value noting the algebraic sign (plus or minus). Add differential EGT to the observed EGT if the sign is plus, subtract if sign is minus. This is the EGT corrected for a 60°F standard day.

Example: Given - Observed inlet temperature = 13°C (56°F)  
Observed EGT = 616°C (1140°F)  
Solution - Observed EGT = 616°C (1140°F)  
EGT differential read from figure 9-7 = +2 (+3)  
Corrected EGT = 618°C (1143°F)

9-15. TEST RUN - PART B. Refer to paragraph 8-19 and connect the control linkage between the fuel control unit and the output governor.

a. Unload dynamometer.  
b. Start the engine and accelerate to ground idle speed. Adjust the output governor low and high speed stops as follows:

Ground Idle - 2800 <sup>+550</sup>/<sub>-1000</sub> RPM  
Military Rated - 6000 ± 25 RPM

#### NOTE

Low and high speed stops are sensitive. Make adjustments in increments of 1/6 turn or less.

1. Place the output governor throttle arm in the minimum speed position and check the output shaft speed by unloading the dynamometer until the output shaft speed is 3500 to 4000 RPM (gas producer should be at ground idle speed). Load dynamometer until gas producer speed begins to increase. The output shaft speed at which this occurs must be within the limits specified for ground idle. Adjust the output governor low speed stop as necessary.

2. With the output governor throttle arm held in maximum speed position by the torsion spring only, check military rated speed by loading the dynamometer until output shaft speed is 5700 RPM with gas producer at military rated speed and engine oil IN temperature between 180° and 190°F (82° and 89°C). Unload dynamometer until gas producer speed just begins to decrease; output shaft speed should not be less than 5950 RPM. Continue unloading dynamometer until gas producer speed reduces to 400 ± 50 RPM below military

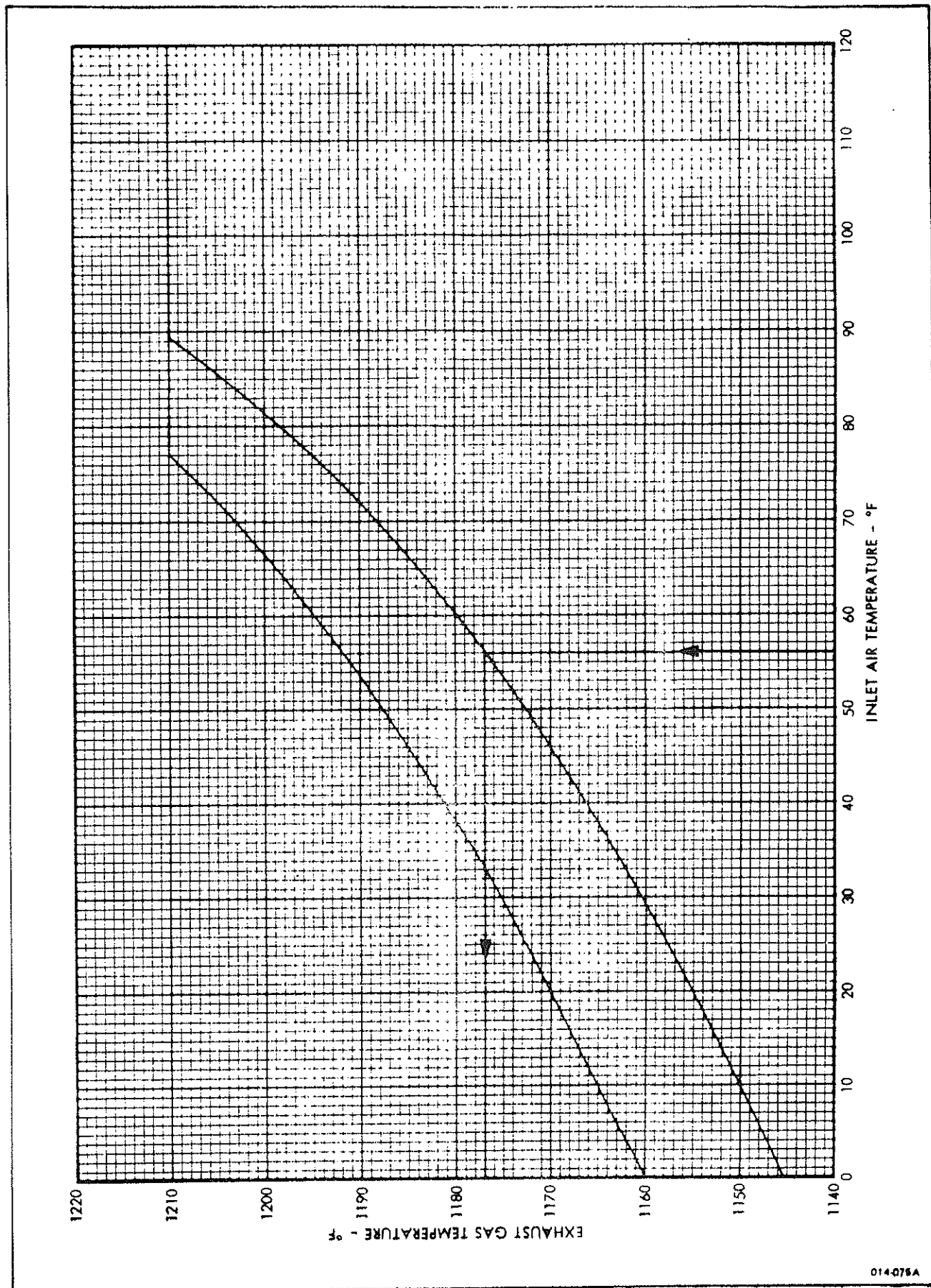


Figure 9-3. Maximum Allowable Exhaust Gas Temperature

rated speed. Output shaft speed at which this occurs must be  $6000 \pm 25$  RPM.

NOTE

An accurate output shaft speed check can be made only when unloading dynamometer. If gas producer speed is decreased below the desired RPM, dynamometer must be loaded again to 5700 RPM output shaft speed and the cycle repeated.

c. With the output governor throttle arm held in the maximum speed position by the torsion spring only, load the dynamometer enough to allow acceleration to military rated gas producer speed and approximately 5950 RPM output shaft speed. Run for 10 minutes at this setting.

d. Perform power transient check as follows: Accelerate engine to military rated gas producer speed (or as limited by EGT) and approximately 5950 RPM output shaft speed. Decelerate engine immediately to ground idle RPM then accelerate again to military rated speed and 5950 RPM output shaft speed.

e. Accelerate the engine to 98 percent of maximum gas producer RPM (see figure 9-8 for RPM to percent conversion) and approximately 6000 RPM output shaft speed. Run engine for 5 minutes at this setting.

f. Decelerate engine to ground idle and 2300-3000 RPM output shaft speed. Run for 5 minutes at this setting.

g. Shut down the engine.

h. After coast down, start and accelerate the engine to ground idle speed.

i. Load the dynamometer enough to allow acceleration to military rated gas producer speed (or as limited by EGT) and approximately 5950 RPM output shaft speed. Run for 5 minutes at this setting.

j. Decelerate engine to ground idle speed and run for 4 minutes.

k. Shut down the engine.

9-16. POWER LIMITER CHECK. Perform the power limiter check according to the following instructions:

a. Set the power limiter at the  $51^{\circ}\text{C}$  ( $\pm 60^{\circ}\text{F}$ ) position.

b. Start the engine and accelerate to military rated speed. Gas producer speed must be 3000 to 3600 RPM lower than high speed stop setting.

c. Return power limiter to the  $16^{\circ}\text{C}$  ( $\pm 60^{\circ}\text{F}$ ) position.

d. Decelerate engine to idle speed, run for 2 minutes and shut down.

9-17. POWER CONTROL SYSTEM CHECK RUN. Check output section governor droop as follows:

NOTE

Engine oil in temperature must be between  $82^{\circ}$  and  $89^{\circ}\text{C}$  ( $180^{\circ}$  and  $190^{\circ}\text{F}$ ).

a. With the output governor throttle arm held against its maximum speed stop by the torsion spring only, load the dynamometer to obtain an output shaft speed of 5700 RPM. This is to ensure that gas producer is at military rated speed.

NOTE

If high speed stop requires readjustment, see paragraph 9-15.

b. Unload dynamometer until gas producer speed reduces  $400 \pm 50$  RPM below military rated speed and record output shaft speed.

c. Continue to unload dynamometer until gas producer speed is  $30,000 \pm 50$  RPM and record output shaft speed.

d. Shut down the engine.

e. Subtract output shaft speed recorded in step c from that recorded in step b. The difference must be  $265 \pm 50$  RPM.

f. Check accessories for leakage in accordance with the applicable NAVAIR Handbooks. Repair leaks if in excess of allowable limits. If any engine components or accessories are replaced because of leakage, run engine again and check for leaks.

CAUTION

Perform steps b and c only by unloading dynamometer. If speed drops below the value required, recycle test starting with step a.

NOTE

If a major part or component fails at any time during the engine test, shut down the engine and accomplish the necessary repairs. Test run may be reinitiated at the discretion of the inspection department.

9-18. FINAL ENGINE CHECKS. Perform final engine checks according to the following instructions:

a. Check the oil pressure at ground idle speed and at military rated speed with engine oil IN temperature at  $82^{\circ}\text{C}$  ( $180^{\circ}\text{F}$ ) to  $93^{\circ}\text{C}$  ( $200^{\circ}\text{F}$ ). Adjust gas producer oil pressure to 30 to 50 PSIG at this temperature at military rated speed.

b. Check for burner blowout by rapidly moving throttle from military rated speed position to idle position.

c. Check engine for compressor surge by rapidly accelerating from idle to military rated speed. If surging occurs, notify overhaul activity engineering personnel.

d. Check acceleration time from ground idle to military rated speed with oil IN temperature between  $66^{\circ}\text{C}$  ( $150^{\circ}\text{F}$ ) and  $77^{\circ}\text{C}$  ( $170^{\circ}\text{F}$ ). Acceleration time must be 5 to 10 seconds.

e. Decelerate engine to ground idle speed and check for fuel, air, and oil leaks.

f. Shut down engine. Remove lube oil filter element and check for metal particles. Replace with new element.

g. Start engine and check run at flight idle speed for 5 minutes. Decelerate to ground idle speed and check for oil leaks. Shut down engine.

9-19. ENGINE LOG BOOK ENTRIES. When all runs are completed, enter the following data in the engine log book:

a. Gas producer speed at military rated power in both RPM and percent speed. Refer to figure 9-8 for conversion of RPM to percent speed. Find military rated gas producer RPM on horizontal scale. Follow in a vertical line to its point of intersection with the curve. From this point, move straight to the left and read percent speed from the vertical scale.

SECTION X  
ACCESSORIES

10-1. GENERAL. For overhaul instructions on the starter-generator, fuel control unit, output governor, fuel boost pump, fuel shutoff valve, oil cooler, speed monitor, ignition exciter, and output section lubrication pump, refer to applicable Navy publications. Overhaul instructions follow for all other engine accessories.

## 10-2. GAS PRODUCER LUBRICATION AND SCAVENGE PUMP.

- a. Leading particulars.
  1. Type of pump - positive displacement.
  2. Elements (2) - gerotor.
  3. Capacity at 3600 ( $\pm 50$ ) RPM - 5 GPM at 30 PSIG outlet pressure.
- b. To check pump output, use special tool from Group 6, Table I, Section III.
- c. Remove nuts (1, figure 10-1) and washers (2).
- d. Lift off upper housing (3) and upper spacer (4).
- e. Lift outer pump element (5) and inner pump element (6) out of upper spacer.
- f. Remove upper woodruff key (7).
- g. Lift off center housing (8).
- h. Remove spindle (9) and lower woodruff key (10).
- i. Lift off lower spacer (11), outer pump element (12), and inner pump element (13).

**CAUTION**

Scavenge pump outer and inner elements (5 and 6) and lubrication pump outer and inner elements (12 and 13) are matched parts. Keep each pair of elements together as a matched set to insure proper reassembly.

- j. Remove bolts (14) and seals (15) from lower housing (16). Discard seals.
- k. Clean pump parts in solvent bath, dry with filtered compressed air, and treat with corrosion preventive compound. (See Section V.)

**WARNING**

Use dry-cleaning solvent in a well-ventilated area. Avoid breathing fumes. Do not use near open flame. Serious injury may result.

- l. Visually inspect gerotor elements for cracks, wear, or spalling. Reject if cracked, spalled or excessively worn.
- m. Visually inspect drive shaft for distortion and excessive wear of spline. If shaft is bent or spline galled excessively, reject shaft.
- n. Visually inspect mounting flange for cracks or distortion. Reject unit if cracked, or if warped so that mating surfaces will not mate properly when fasteners are torqued to limit.

Changed 15 December 1968

## NOTE

No repair is permitted on the lubrication and scavenge pump. If any pump element is damaged requiring replacement, its mating element must also be replaced. The elements must be kept in matched pairs. Replace seals each time pump is disassembled.

## NOTE

Lower housing (16), lower spacer (11), center housing (8), upper spacer (4), and upper housing (3) have a scribe mark on the outside surface. Align these scribe marks to ensure proper assembly.

- o. Install bolts (14) with new seals (15) in lower housing (16).
- p. Place lower spacer (11) over bolts and insert outer pump element (12), then inner pump element (13).
- q. Insert lower woodruff key (10) in center spindle (9) and insert base of center spindle in housing with key in slot of inner pump element (13).
- r. Slip center housing (8) and then upper spacer (4) over center spindle and bolts.
- s. Insert outer pump element (5) in spacer.
- t. Place upper woodruff key (7) in spindle and slide inner pump element (6) over center spindle and over key into outer pump element.
- u. Slip upper housing (3) onto center spindle and bolts, place washers (2) and nuts (1) on bolts and tighten.
- v. Turn shaft by hand to check for freedom of rotation. Use special tool from Group 6, Section III (or equivalent) to test pump action.
- w. Use oil, Military Specification MIL-L-23699, as test fluid, at oil-in temperature between 46°C (50°F) and 73°C (100°F).
- x. Drive pump in counterclockwise direction, as viewed from the drive end, at 3600 ( $\pm 50$ ) RPM.
- y. With an inlet pressure at 0 PSIG, the pressure section of the pump shall discharge a minimum of 5 GPM at an outlet pressure of 30 PSIG minimum.
- z. With an inlet pressure of 0 PSIG, the scavenge section of the pump shall discharge a minimum of 5 GPM at an outlet pressure of 20 PSIG minimum.
- aa. If these requirements are not met, reject the pump.

## 10-3. FUEL FILTER.

- a. Leading particulars.
  1. Type: 10-micron replaceable cartridge.
  2. Relief valve: through-type; acts at 10 to 12 PSIG differential pressure drop.
- b. Break lockwire (1, figure 10-2) and unscrew housing (2) from filter head (11).
- c. Remove element (3) and O-rings (4 and 5) and discard.
- d. Remove plug (6). Remove and discard O-ring (7).
- e. Remove guide (8), spring (9) and spring housing (10) from filter head (11).

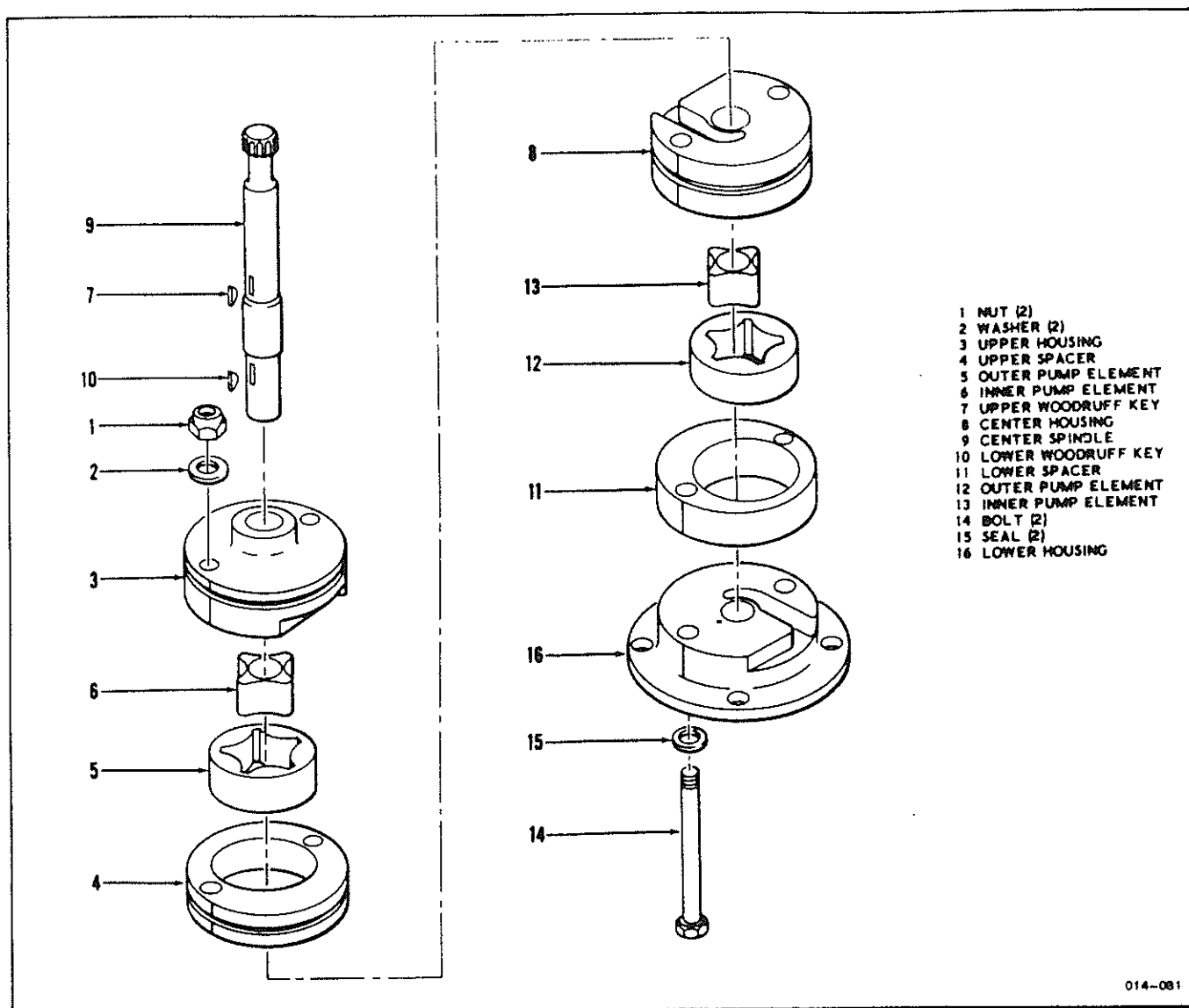


Figure 10-1. Lubrication and Scavenge Pump

f. Clean parts in dry-cleaning solvent bath and dry with filtered compressed air. (See Section V.)

**WARNING**

Use dry-cleaning solvent in a well-ventilated area. Avoid breathing fumes. Do not use near open flame. Serious injury may result.

g. Visually inspect case and head for cracks. Reject if cracked. Inspect condition of threads. Reject assembly if threads are excessively worn or damaged. Observe condition of relief valve plunger and seat. Reject assembly if defective.

**NOTE**

No repair is possible on this unit. Install new element at reassembly, using new O-rings. The required O-rings may be supplied with the replacement element.

- h. Place new O-ring (7) on relief valve plug (6).
- i. Install spring (9), guide (8), and spring housing (10) in filter head (11).
- j. Install plug (6). Tighten and lock wire.
- k. Place new O-rings (5) in end of new filter element (3) and (4) in groove in filter housing (2).
- l. Insert element (3) and screw housing (2) into place in filter head (10). Tighten housing (2) hand tight and lock wire.

**10-4. OIL PRESSURE SWITCH.**

- a. Clean up minor thread damage and minor nicks in wrenching flats. Reject switch if more extensive damage is evident.
- b. Functional test as follows:
  - 1. Install switch in a test set-up according to schematic diagram in figure 10-2A. Use hydraulic variable pressure input (0 to 50 PSIG), a pressure gage with 0 to 300 PSIG range, and a volt-ohm-milliammeter, Simpson 260, Series 111 or equivalent, set on R x 10,000 scale.



**CAUTION**

Do not set volt-ohm-milliammeter on any scale other than R x 10,000. Damage to switch will result.

2. Apply hydraulic pressure to switch, varying pressure between 0 and 40 PSIG and observe pressures at which the meter indicates opening and closing of the switch contacts. This will be indicated by deflection of the meter needle between approximately zero ohms and infinity. Actuating pressures must be between 24 PSIG and 32 PSIG. If not within these limits, replace the switch.

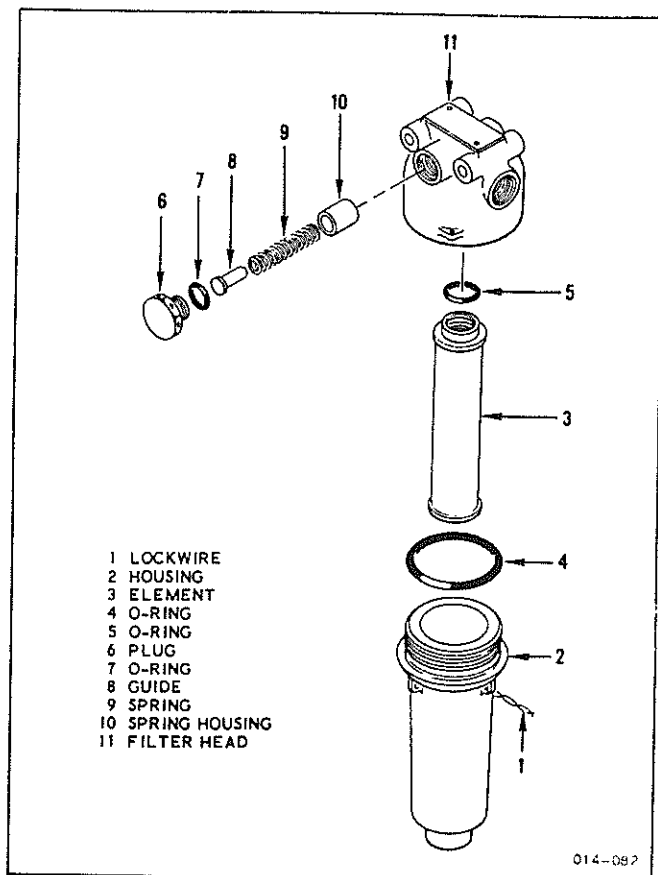


Figure 10-2. Fuel Filter, Exploded View

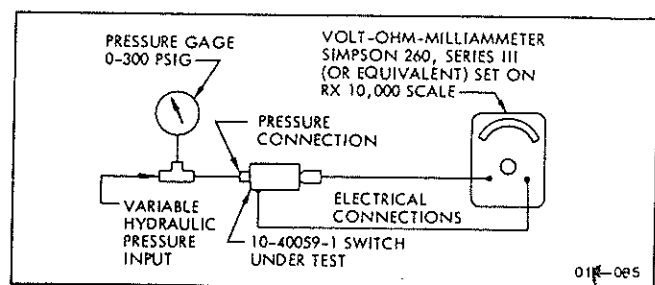


Figure 10-2A. Oil Pressure Switch Functional Test Schematic

**10-5. ACCESSORY DRIVE GEAR BOX.**

a. Remove screws (1, figure 10-3) and remove end plate (2) from gear housing.

- b. Remove O-ring (3) and seal (4) from end plate.
- c. Remove shim (5) from housing (11).
- d. Slide assembly of bevel gear and bearings (6 through 10) from housing.
- e. Remove snap ring (6) from bevel gear shaft.
- f. Remove bearing (7), spacer (8), and bearing (9) from shaft. Do not remove plug from bevel gear shaft unless replacement is necessary.
- g. Remove bolts (12), washers (13), and end plate (14), if used, from housing (22).
- h. Remove bearing retainer (16) from gear housing.
- i. Remove oil seal (17) from bearing retainer.
- j. Remove bevel gear (20) and bearing (18) from housing.
- k. Remove bearing (19) and shim (21) from gear housing. Record combined thickness of bearing and shim for reference during reassembly.
- l. Clean accessory drive gear box parts in solvent bath, dry with filtered compressed air, and treat with corrosion preventive compound. (See Section V.)

**WARNING**

Use cleaning solvent in a well-ventilated area. Avoid breathing fumes. Do not use near open flame. Serious injury may result from failure to heed this warning.

- m. Visually inspect gear teeth and splines for abnormal wear pattern, and gear and shaft assemblies (10 and 20) for cracks, spalling, and abnormal wear. Reject if cracked, spalled or excessively worn.
- n. Visually inspect bearings (7, 9, 18, and 19) for cracks, pitting and spalling. Check for smoothness of operation. Reject if cracked, pitted, spalled, or if roughness is encountered when turning.
- o. Inspect spacer (8), bearing retainer (16), end plates (2 and 14), and housing (22) for cracks. Reject if cracked.

**NOTE**

Repair is permitted only to the extent of replacing studs and threaded inserts in housing. Any damaged parts must be replaced. Replace seals each time gear box is disassembled.

p. If thickness of shim (21) removed at disassembly is not known, or if retainer (16), gear (20), or housing (22) is replaced, determine thickness of shim (21) as follows:

1. Install bearing (7) in housing (11) to approximately one-half the width of bearing.
2. Place housing (11) on a flat plate with the fuel boost pump mounting flange against the plate.
3. Determine thickness of shim (21) required as follows:
  - (a) Measure and record the shortest distance between the surface of the plate and bearing (7).
  - (b) Remove bearing (7) from housing; measure and record one-half the overall diameter of bearing (7).
  - (c) Record 0.725 inch, which is the required distance between the centerline of the shaft (10) and the lower edge of the outer race of bearing (19).
  - (d) Measure and record the width of the outer race of bearing (19).

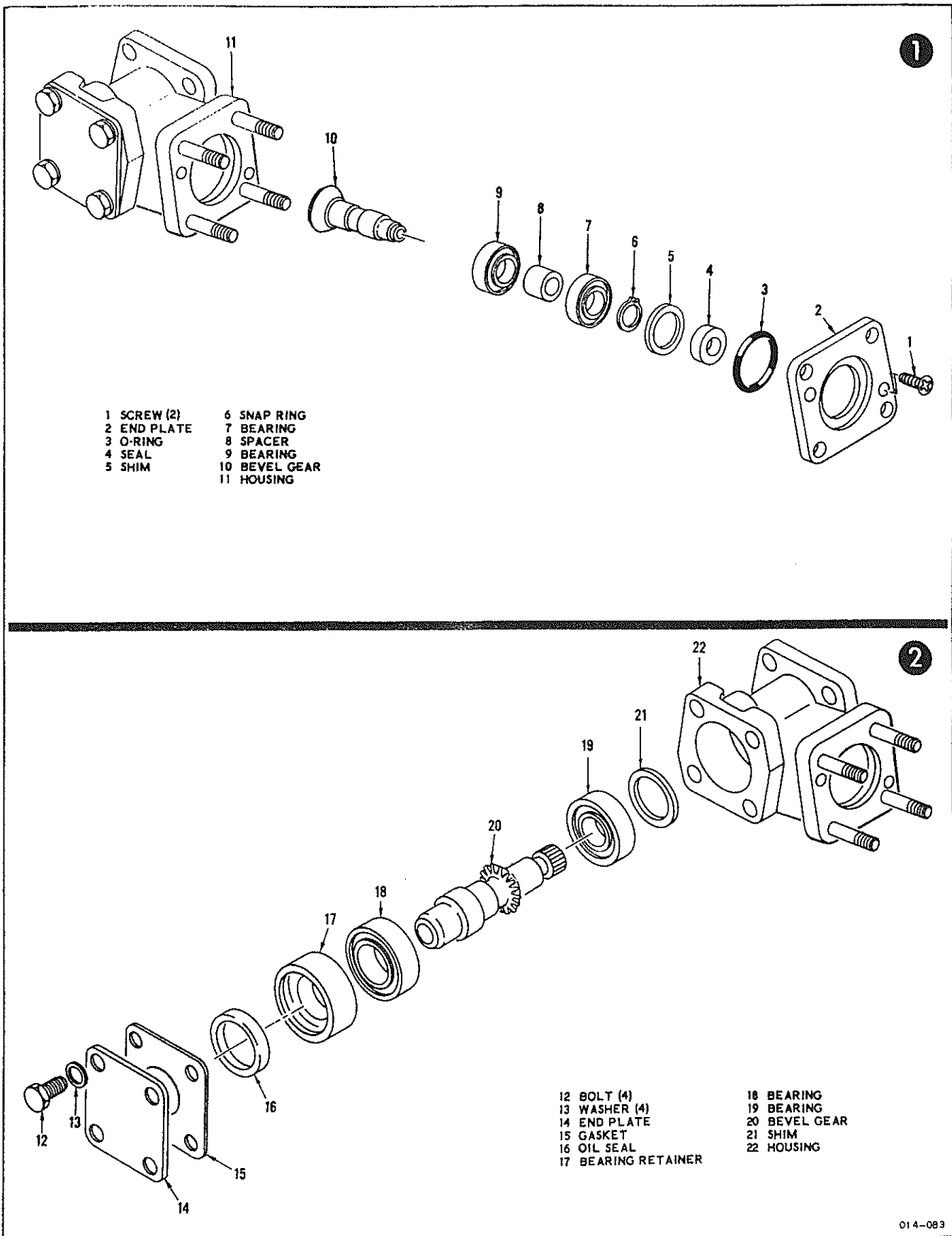


Figure 10-3. Accessory Drive Gearbox, Exploded View

(e) Measure and record the distance between the fuel boost pump mounting surface of housing (11) and the inside bearing shoulder at the opposite end of the housing.

(f) Add the measurements recorded in steps (a), (b), (c), and (d). Subtract this total from the measurement recorded in step (e). The result is the required thickness of shim (21).

#### NOTE

Shim (21) is made up of 0.003-inch laminations. Remove or add laminations as necessary to obtain the required thickness  $\pm 0.002$ -inch.

q. Install shim (21) and lubricated bearing (19) in housing (22). Select parts that total the same thickness as parts removed, or measure according to step p above.

r. Slide bevel gear (20) into bearing (19).

s. Install lubricated bearing (18) in housing (22) over bevel gear shaft.

t. Install new seal (17) in bearing retainer (16) and install assembly in housing (22).

#### NOTE

Lip of seal (17) must be toward shaft (20). Install seal in retainer (16) with outer surface of seal flush with inner face of counterbore in retainer.

u. Install gasket (15) and end plate (14) with bolts (12) and washers (13).

v. Install lubricated bearing (9), spacer (8), and lubricated bearing (7) on bevel gear (10), securing bearings and spacer on shaft with snap ring (6).

w. Slide assembly of gear and bearings into housing (11). Insert shim (21) of same thickness as shim removed at disassembly. If shim thickness is not known, or if any part other than bearings (7, 18, and 19), seals (4 and 17) and snap ring (6) has been replaced, bevel gear backlash must be checked. Backlash must be 0.002 to 0.006-inch at center of gear tooth contact area. Check as follows:

1. Place end plate (2) in position on housing (11) and secure with screws (1). Do not use O-ring (3) or seal (4) for this check.

2. Insert 1/4-inch square drive sliding tee-handle or similar fixture in the shaft of bevel gear (10).

3. Set up a dial indicator to take backlash reading on fixture at a radius of 0.550 inch from center of shaft.

4. Eliminate end play in driven (male splined) end of gear (20) and check backlash while pulling outward slightly on fixture.

x. If backlash is not within required tolerance repeat above procedure, adding or removing laminations from shim (5) until required backlash is obtained.

#### NOTE

Shim (5) is made up of 0.003-inch laminations.

y. Install new seal (4) in end plate (2) with lip of seal toward inside of housing (11); install new, lubricated O-ring (3) on end plate (2) and install end plate in housing with screws (1).

## SECTION XI

## TABLE OF LIMITS

11-1. GENERAL. This section contains all clearances, torque limits, and spring pressures which must be checked on the engine.

11-2. DEFINITIONS. The adjustment limits given in Table VIII are the maximum and minimum limits of the proper adjustment range for clearance between certain parts of the assembled engine or the minimum limits only where maximum limits are unnecessary.

All dimensional limits for individual parts inspection are given in Table III, Section VI.

11-3. ENGINE CLEARANCES. Engine clearance and end play limits are listed in Table VIII and are illustrated on figure 11-1.

11-4. TORQUE LIMITS. Torque limits are listed in Table IX.

Table VIII. Engine Clearance

Reference Letter	Figure No.	Description	Clearance (in.)	
			Min.	Max.
B	11-1	Impeller to diffuser case clearance	0.030	0.040
C	11-1	Turbine wheel to nozzle box axial clearance	0.054	
F	11-1	Turbine blade to nozzle box radial tip clearance	0.010	0.040
D	11-1	Turbine wheel to nozzle ring clearance	0.160	
E	11-1	Turbine blade to nozzle ring radial tip clearance	0.012	0.050
G	11-1	Nozzle to burner dome clearance (both burners to match within 0.020 inch)	0.050	0.100
A	11-1	Accessory drive gear bearing position limits	0.723	0.727
A	11-1	Accessory drive gear backlash limits	0.002	0.006

Table IX. Torque Limits

Standard Torque Values		Flare Tubing and Bulkhead-type Fittings		
Thread Size	Tension Type Nuts (Inch-Pounds)	Tubing Size (OD-inches)	Aluminum Alloy (Inch-Pounds)	Steel (Inch-Pounds)
8-32	12-15	1/8	20-30	
8-36		3/16		90-100
10-24	20-25	1/4	40-65	135-150
10-32		5/16	65-80	180-200
1/4-20	50-70	3/8	100-125	270-300
1/4-28	50-70			
5/16-18	80-90			
5/16-24	100-140			
3/8-16	160-185			
3/8-24	160-190			
7/16-14	235-255			
7/16-20	450-500			
1/2-13	400-480			
1/2-20	480-690			
9/16-12	500-700			
9/16-18	800-1000			
5/8-11	700-900			
5/8-18	1100-1300			
		Hose Assemblies		
		Hose Size (ID-inches)	Steel and Aluminum Fittings	
		3/16	85-100	
		1/4	100-120	
		5/16	155-180	
		3/8	210-250	
		1/2	340-420	

Table IX. Torque Limits (Continued)

Special Torque Values			Special Torque Values		
Component	Figure and Index No.	Torque Value (Inch-Pounds)	Component	Figure and Index No.	Torque Value (Inch-Pounds)
Burner dome to nozzle adapter	6, figure 11-1	550-700	Oil cooler drain plug	16, figure 4-2	210-250
Burner inlet adapter gasket retaining screws	26, figure 4-4	20-25	Oil pressure regulator valve check nut	42, figure 4-18	475-500
Burner inlet bolt	8, figure 11-1	375-390	Oil cooler adapter check nut	62, figure 4-12	25-35
Burner inlet bolt check nuts	9, figure 11-1	375-390	Oil filter drain bolt	4, figure 4-12	65-80
Compressor case drain plug	12, figure 4-15	40-65	Oil filter housing retaining bolt	7, figure 4-12	160-190
Diffuser plate nuts	7, figure 4-15	25-35	Output governor lever spring torque	10, figure 11-1	45-55
Fuel control unit filter retaining screws	77, figure 4-7	15-19	Output turbine bearing retainer nut	3, figure 11-1	450-650
Fuel nozzle to nozzle adapter	5, figure 11-1	550-700	Planet gear retaining nuts	2, figure 11-1	2300-2400
Fuel nozzle adapter to inlet adapter	7, figure 11-1	360-480	Starter-generator junction box terminal nuts:		
Ignition lead nuts	40, figure 4-8	10-30	Locknuts	75 thru 78, figure 4-8	10-15
Impeller assembly check nut	1, figure 11-1	200-250	3/8-24 and 5/16-24 self-locking nuts	63 and 64, figure 4-8	25-40
Impeller assembly retaining nut	1, figure 11-1	500-650	1/4-28 and 10-32 self-locking nuts	51, 52 and 62, figure 4-8	12-15
Magnetic chip detectors	47, figure 4-9	100-125			
Nozzle ring to nozzle box clamp	4, figure 11-1	30-45			
		Net torque*			

\*See Table X for self-locking nut torque limits.

Net torque is gross tightening torque less the self-locking torque.

Table X. Self-Locking Nut Torque Limits

Thread Series			Thread Series		
Fine			Coarse		
Size	Torque (In-Lbs)		Size	Torque (In-Lbs)	
	*Minimum Locking	*Maximum Locking		*Minimum Locking	*Maximum Locking
4-48	-	3	4-40	-	3
6-40	1.0	6	5-40	1.0	4
8-36	1.5	9	6-32	1.0	6
10-32	2.0	13	8-32	1.5	9
1/4-28	3.5	30	10-24	2.0	13
5/16-24	6.5	60	1/4-20	4.5	30
3/8-24	9.5	80	5/16-18	7.5	60
7/16-20	14.0	100	3/8-16	12.0	80
1/2-20	18.0	150	7/16-14	16.5	100
9/16-18	24.0	200	1/2-13	24.0	150
5/8-18	32.0	300	9/16-12	30.0	200
3/4-16	50.0	400	5/8-11	40.0	300
7/8-14	70.0	600	3/4-10	60.0	400
1-14	92.0	800	7/8-9	82.0	600
1 1/8-12	117.0	900	1-8	110.0	800
1 1/4-12	143.0	1000	1 1/8-8	137.0	900
			1 1/4-8	165.0	1000

\*The minimum to maximum locking torque range is used for determining the usability or reusability of a nut (self locking) and bolt combination.

Locking torque is the torque required to start the nut turning, when:

- The nut is engaged, with at least two full bolt threads protruding beyond the locking device of the nut.
- There is no axial load on the nut.

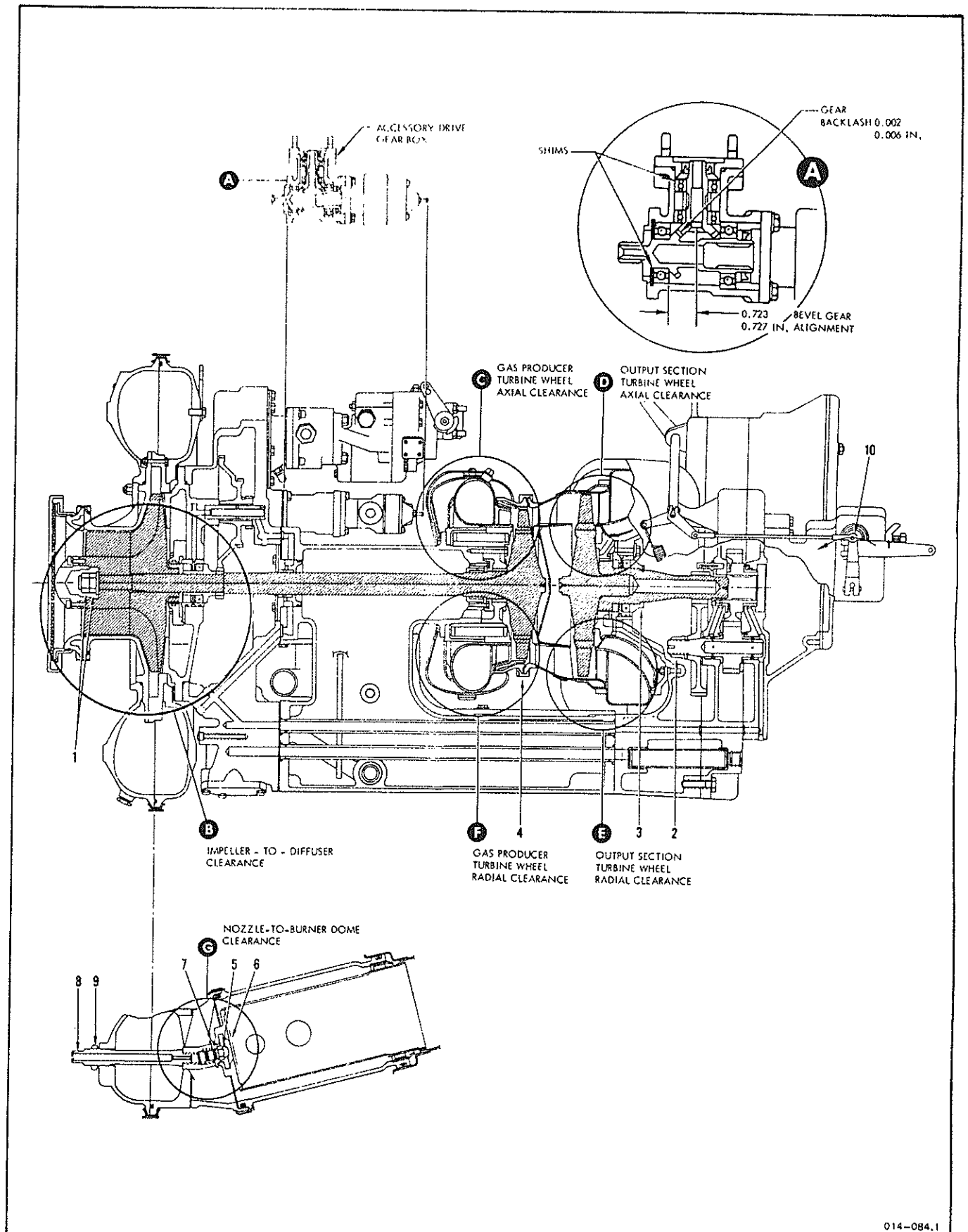


Figure 11-1. Engine Limits and Clearances (Sheet 1 of 2)

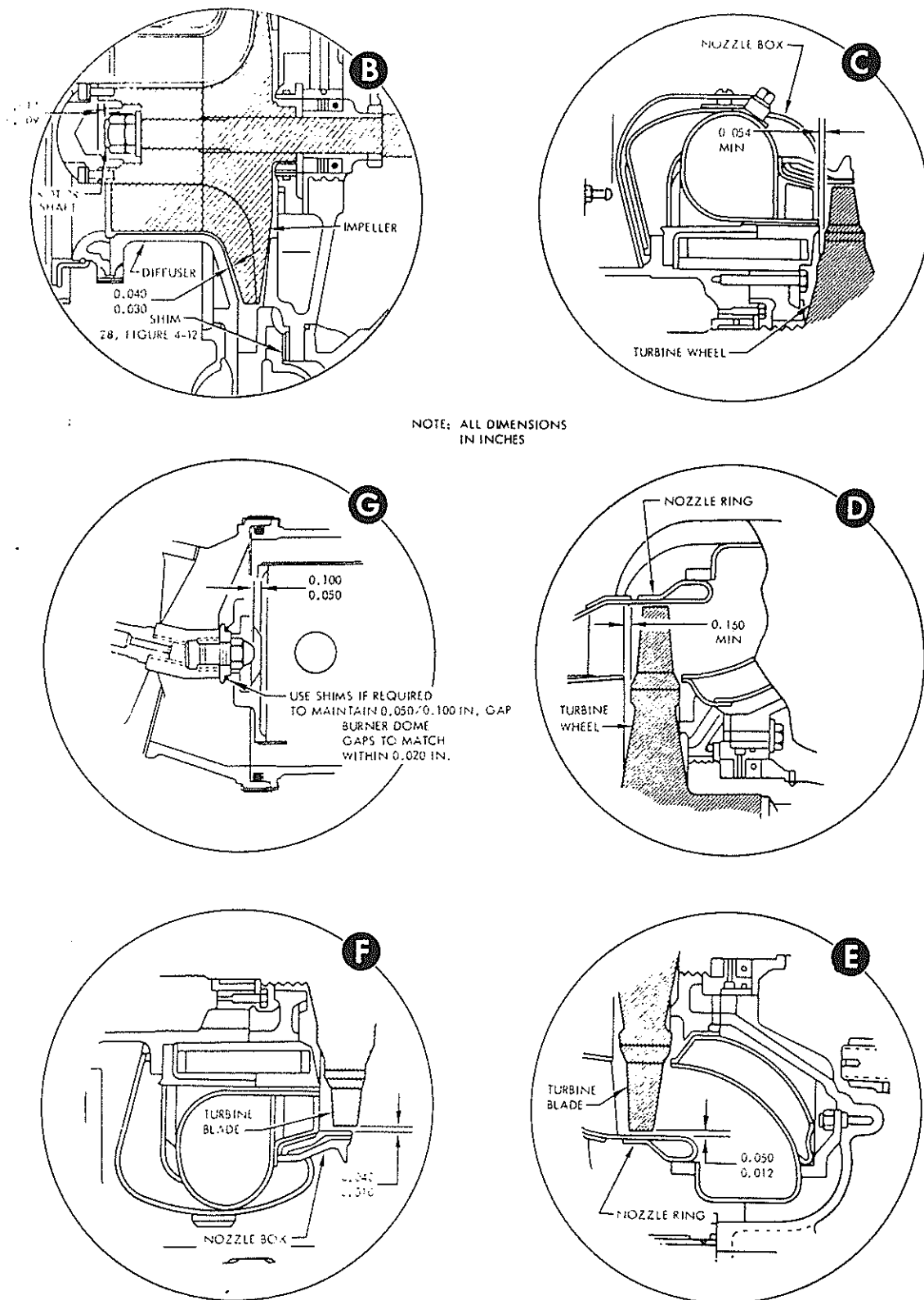


Figure 11-1. Engine Limits and Clearances (Sheet 2 of 2)