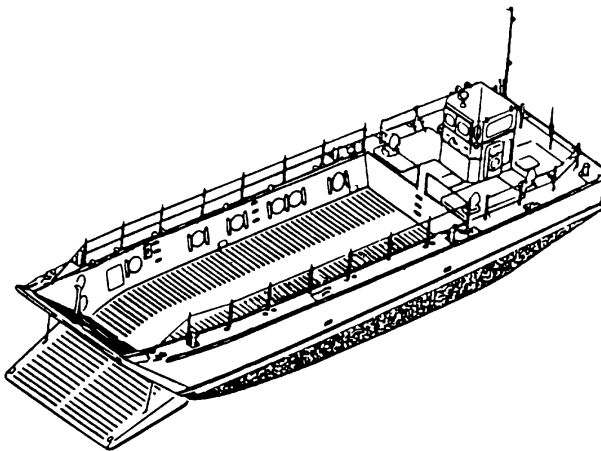


TECHNICAL MANUAL

**OPERATOR, UNIT AND INTERMEDIATE
(DIRECT AND GENERAL SUPPORT)
MAINTENANCE MANUAL**

**LANDING CRAFT, MECHANIZED
STEEL, DED, OVERALL LENGTH 74 FEET,
MOD 1, MARK VIII, NAVY DESIGN LCM-8**

**HULL NUMBERS 8500 THROUGH 8519 (MARINETTE MARINE CORP.)
NSN 1905-01-1690938.**



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APPENDIXES

Approved for public release; distribution is unlimited.

**HEADQUARTERS, DEPARTMENT OF THE ARMY
30 June 1989**

INTRODUCTION

This manual is printed in four volumes as follows:

TM 55-1905-221-14-1, consisting of Chapter 1 thru 4.

TM 55-1905-221-14-2, consisting of Chapter 5.

TM 55-1905-221-14-3, consisting of Chapter 6.

TM 55-1905-221-14-4, consisting of Chapter 6 (continued) and Appendices.

WARNING

DANGEROUS CHEMICALS

are used in this equipment

**SERIOUS INJURY OR DEATH
may result if personnel fail to observe
these safety precautions:**

- Be sure all cargo is secure, especially during rough seas.
- Corrosive battery electrolyte, and potassium hydroxide, are potentially dangerous to personnel and property. Wear rubber gloves, apron, and face shield when handling leaking batteries. If potassium hydroxide is spilled on clothing or other material, wash immediately with clean water. If spilled on personnel, start flushing the affected area immediately with clean water. Continue washing until medical assistance arrives.
- Wipe or flush any spillage. Volatile materials will not be brought aboard; electrical circuits will not be energized; fuel tanks will not be topped off; and engines will not be started before CO₂ fire-fighting equipment is available and operative.
- Observe NO SMOKING rules when refueling. Do not-work on live circuits. Tag circuit and warn other personnel not to energize the circuit. Never use a blow torch or other similar means for heating fuel or oil lines.

ASPHYXIATION DANGER

- Be sure engine room ventilators are open when operating the engine(s). The engine exhaust gases contain carbon monoxide, which is a colorless, odorless, and poisonous gas.
- All piping and exhaust lines shall be treated as being insulated with Asbestos material. Protective clothing and respirators shall be worn at all times when handling suspect asbestos-covered piping and exhaust lines.

WARNING (Continued)

SERIOUS INJURY OR DEATH

**may result if personnel fail to observe
these safety precautions:**

- Hatches must be opened before energizing any electrical circuit or starting engines. Do not smoke or use open flame in the vicinity when servicing batteries as hydrogen gas, an explosive is generated. Use only distilled water to maintain battery electrolyte level. Do not fill fuel tank while engine is running. Provide metallic contact between the fuel container and fuel tank to prevent a static spark from igniting fuel
- When cutting with a torch, or when welding, always station fire watches, ready with fire extinguishers, in the vicinity on both sides of the plate that is being cut or welded.
- Prior to cutting or welding on the ramp, remove drain plugs on both sides of the ramp and check if ramp interior is primer coated. If primer coated, flush thoroughly with steam, carbon dioxide, or water. Do not reinstall drain plugs until the cutting and/or welding operations is completed. Failure to take this precaution may result in explosion of accumulated primer vapors.
- When refueling, shut down the electrical system. Observe the no smoking rule. Do not permit anyone to operate tools or equipment which may produce sparks near the refueling operation. Sparks or fire may ignite the diesel fuel and produce an explosion.
- Fuel oil and other petroleum products are highly volatile in extreme heat. To minimize the possibility of explosion, wipe up all spills at once, see that fuel lines and valves are not leaking and pump bilges regularly.
- Before attempting to remove any compressed air system lines or components, relieve air pressure from system. Failure to do so may result in injury or possible death to maintenance personnel.
- Before disconnecting a line in the hydraulic system, bleed the pressure from the portion of the line. Failure to do so may result in injury or possible death to maintenance personnel.

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MAINTENANCE MANUAL

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STEEL: DED: OVERALL LENGTH 74 FEET
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HULL NUMBERS 8500 THROUGH 8519 (MARINETTE MARINE CORP.)
NSN 1905-01-169-0938

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REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistake or If you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to Commander, U S Army Troop Support Command, ATTN AMSTR-MCTS, 4300 Goodfellow Boulevard, St Louis, MO 63120-1798 A reply will be furnished directly to you

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CHAPTER 6

GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

- Overview
- Repair Parts and Special Tools
- Maintenance Procedures
- Troubleshooting

6-1. OVERVIEW

This Chapter describes the landing craft repairs and parts replacement that are the responsibility of General Support Maintenance. Maintenance tasks given in previous chapters are not repeated in this Chapter.

SECTION I. REPAIR PARTS AND SPECIAL TOOLS

6-2. REPAIR PARTS

See TM 55-1905-221-P for a listing of repair parts required for maintaining the landing craft.

6-3. SPECIAL TOOLS

Special tools required to perform General Support Maintenance of the Landing Craft are listed and illustrated in Appendix C.

SECTION II. TROUBLESHOOTING

6-4. GENERAL SUPPORT TROUBLESHOOTING

Table 6-1 contains troubleshooting information useful to you in diagnosing and correcting malfunctions or unsatisfactory operation of the landing craft.

- a. The troubleshooting table lists the common malfunctions and unsatisfactory conditions you are most likely to run into.

b. You should first find the malfunction in the table which most closely describes the problem; then perform the test, inspections and corrective actions in the order in which they are listed.

c. This manual cannot list all possible symptoms which may occur. If a condition exists which cannot be resolved by you, notify your supervisor.

d. You should verify the fault before performing troubleshooting.

NOTE

Before you use this table, be sure you have performed all applicable operating checks.

Table 6-1. Troubleshooting.

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
-------------	--------------------	-------------------

PROPULSION ENGINE

1. Engine Will Not Turn Over.

Hand crank engine at least one complete revolution. If engine cannot be rotated a complete revolution, internal damage is indicated.

Disassemble engine to determine cause and extent of damage. Refer to paragraphs 5-14, 5-15, 5-18 and 6-23 through 6-29.

2. Cranking Speed Low.

Step 1. Check electric starting motor.

Overhaul starting motor. Refer to paragraph 6-19.

Step 2. Check hydraulic starting system.

Refer to paragraphs 5-13.1 through 5-13.7.

Step 3. Check hydraulic starter motor.

Overhaul starting motor. Refer to paragraph 6-21.

3. Low Compression.

Step 1. Check for worn or broken compression rings.

Overhaul cylinder and replace rings. Refer to paragraph 6-27.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
	Step 2.	Check for nonfunctioning blower assembly. Overhaul blower. Refer to paragraph 6-35.
4. Governor Hunting (Unstable).		
	Step 1.	Check for faulty linkage to injectors. Adjust linkage. Refer to paragraph 5-14.
	Step 2.	Check for faulty governor. a. Repair governor. Refer to paragraph 5-14. b. Overhaul governor. Refer to paragraph 6-34.
5. Crankcase Pressure Excessive.		
	Step 1.	Check for cylinder blowby. Replace rings, piston or liner. Refer to paragraphs 6-27 and 6-29.
	Step 2.	Check blower mounting gasket for leakage. Replace mounting gasket. Refer to paragraph 6-35.
	Step 3.	Check cylinder block end plate gasket for leakage. Replace end plate gasket. Refer to paragraph 6-29.
6. High Oil Consumption.		
	Step 1.	Check for worn oil control rings. Replace rings. Refer to paragraph 6-27.
	Step 2.	Check for scarred pistons, rings or liners. Replace pistons, rings or liners. Refer to paragraph 6-27.
	Step 3.	Check for leaking blower oil seals. Repair blower. Refer to paragraph 6-35.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
<hr/>		
7. Oil Pressure Low.		
	Step 1. Check oil pump.	
		Overhaul oil pump. Refer to paragraph 6-26.
	Step 2. Check oil pressure regulator.	
		Replace defective oil pressure regulator.
8. Black Exhaust Smoke (Incompletely Burned Fuel).		
	Step 1. Check for faulty blower.	
	a. Clean liner.	
	b. Clean blower screen obstructions.	
	Step 2. Check for clogged blower screen or dirty cylinder liner parts.	
		Overhaul blower assembly. Refer to paragraph 6-35.
9. High Engine Coolant Temperature.		
		Check for damaged keel cooler.
	a. Repair keel cooler. Refer to paragraph 6-17.	
	b. Replace keel cooler damaged beyond repair.	
		Refer to paragraph 6-17.
10. Power Take-Off Assembly (Ramp Hoist Pump Drive) Inoperative.		
	Step 1. Check for worn clutch.	
	a. Repair clutch. Refer to paragraph 6-37.	
	b. Replace clutch damaged beyond repair. Refer to paragraph 6-37.	
	Step 2. Check for defective clutch release mechanism.	
		Repair clutch release mechanism. Refer to paragraph 6-37.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
-------------	--------------------	-------------------

- Step 3. Check for broken drive or other internal damage. Overhaul power take-off assembly. Refer to paragraph 6-37.

TRANSMISSION AND TRANSFER GEAR

1. Gear Inoperative (Drive Shaft Does Not Rotate).

Condition A - Selector valve in forward position.

- Step 1. Check for low oil pressure.
Replace defective oil pump relief valve. Refer to paragraph 6-36.
- Step 2. Check for defective oil pump.
Overhaul oil pump. Refer to paragraph 6-36.
- Step 3. Check for defective marine gear dump valve.
Clean, inspect and replace defective parts. Refer to paragraph 6-38.
- Step 4. Check for broken or worn selector valve forward piston seal rings.
Remove and replace forward piston seal rings.
Refer to paragraph 6-38.
- Step 5. Inspect for leaking pilot bearing oil seal.
Remove and replace pilot bearing oil seal.
- Step 6. Check for faulty flywheel.
a. Inspect flywheel and replace loose or missing passage plugs. Refer to paragraph 6-38.
b. Check emergency engagement bolts for tightness. Tighten loose bolts.
- Step 7. Check for damaged drive shaft seal rings.
Replace if worn or damaged. Refer to paragraph 6-28.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
	Step 8.	Check for worn forward clutch facings. Replace if worn. Refer to paragraph 6-38.
	Step 9.	Inspect clutch plate for damage. Replace clutch plate if sheared or loose on hub. Refer to paragraph 6-38.
	Step 10.	Inspect reduction gears and bearings for damage. Replace damaged or defective parts. Refer to paragraph 6-38.
Condition B - Selector valve in reverse position.		
	Step 1.	Check for low oil pressure. Replace defective oil pump relief valve. Refer to paragraph 6-36.
	Step 2.	Check for defective oil pump. Overhaul oil pump. Refer to paragraph 6-36.
	Step 3.	Check for defective marine gear dump valve. Clean, inspect and replace defective parts. Refer to paragraph 6-38.
	Step 4.	Check for broken or worn reverse piston seal rings. Remove and replace reverse piston seal rings. Refer to paragraph 6-38.
	Step 5.	Inspect clutch facings. Replace If worn. Refer to paragraph 6-38.
	Step 6.	Check for damaged planetary assembly. Disassemble and replace all damaged or defective parts with new ones.
	Step 7.	Inspect reduction gears and bearings for damage. Replace damaged or defective parts. Refer to paragraph 6-38.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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2. Oil Pressure Low.

Condition A - When selector valve is placed in any position-forward, neutral or reverse.

Step 1. Check for defective oil pump relief valve.

Replace defective oil pump relief valve. Refer to paragraph 6-38.

Step 2. Check for defective oil pump.

Overhaul oil pump. Refer to paragraph 6-36.

Step 3. Check for defective marine gear dump valve.

Clean, inspect and replace defective parts. Refer to paragraph 6-38.

Condition B - When selector valve is placed in forward.

Step 1. Check for worn or broken forward piston seal rings.

Remove and replace defective forward piston seal rings. Refer to paragraph 6-39.

Step 2. Check pilot bearing oil seal for leaks.

Remove and replace defective pilot bearing oil seal. Refer to paragraph 6-39.

Step 3. Check for defective dump valve.

Clean, inspect and replace defective parts. Refer to paragraph 6-39.

Step 4. Check for faulty flywheel.

a. Inspect flywheel and replace loose or missing passage plugs. Refer to paragraph 6-39.

b. Check emergency engagement bolts for tightness. Tighten loose bolts. Refer to paragraph 6-39.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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Step 5. Check drive shaft seal rings for damage.

Replace damaged or worn seal rings. Refer to paragraph 6-28.

Condition C - When selector valve is placed in reverse. Check for worn or broken reverse piston seal rings.

Remove and replace reverse piston seal rings. Refer to paragraph 6-39.

3. Geardragging: Drive Shaft Rotates with Selector Valve in Neutral.

Condition A - After moving selector valve from forward to neutral.

Step 1.a. Check for sticking forward clutch plate.

b. Inspect clutch plate for wear.

Replace clutch plate if facings are worn smooth or shows evidence of sticking.

Step 2. Check forward clutch plate for loose or broken facing material.

NOTE

Facing material may lodge between clutch plate and piston or reaction plate. Remove.

Replace clutch plate if facing is worn or broken.

Step 3. Inspect forward piston drive pins for burrs.

NOTE

Burred pins could prevent piston from moving into disengaged position.

Replace burred pins with new ones. Refer to paragraph 6-39.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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Step 4. Check forward piston for flatness.

Replace piston if warped. Refer to paragraph 6-39.

Step 5. Inspect planetary assembly for binding parts.

Overhaul planetary assembly and replace damaged or defective parts. Refer to paragraph 6-39.

Step 6. Inspect dump valves for varnish deposits or foreign material which may prevent valves from functioning properly.

a. Clean parts. Refer to paragraph 6-39.

b. Replace damaged parts. Refer to paragraph 6-39.

Step 7. Inspect drive shaft seal rings for broken rings or wear.

Replace defective parts. Refer to paragraph 6-38.

Condition B - After moving selector valve from reverse to neutral.

Step 1. Inspect reverse clutch plate for wear or signs of over-heating.

Replace defective clutch plate.

Step 2. Check reverse clutch plate for loose or broken facing material.

NOTE

Facing material may lodge between clutch plate and piston or reaction plate. Remove.

Replace clutch plate if facing is worn or broken.

Step 3. Inspect reverse piston drive pins for burrs.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
-------------	--------------------	-------------------

NOTE

Burred pins could prevent piston ,room moving into disengaged position.

Replace burred pins with new ones. Refer to paragraph 6-39.

Step 4. Check reverse piston for flatness.

Replace piston if warped. Refer to paragraph 6-39.

Step 5. Inspect planetary gear assembly for binding parts.

Overhaul planetary assembly and replace damaged or defective parts. Refer to paragraph 6-39.

4. Gear Slipping or Slow to Engage.

Condition A - With selector valve in forward position.

Step 1. Check for low oil pressure.

Replace defective oil pump relief valve. Refer to paragraph 6-36.

Step 2. Check for defective oil pump.

Overhaul oil pump. Refer to paragraph 6-36

Step 3. Check for defective marine gear dump valve.

Clean, inspect and replace defective parts. Refer to paragraph 6-39.

Step 4. Check for worn or broken forward piston seal rings.

Remove and replace forward piston seal rings.

Refer to paragraph 6-39.

Step 5. Check pilot bearing oil seal for evidence of leaking.

Remove and replace leaking pilot bearing oil seal.

Refer to paragraph 6-39.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
<hr/>		
Step 6. Check for faulty flywheel.		
	a. Inspect flywheel and replace loose or missing passage plugs. Refer to paragraph 6-39.	
	b. Check emergency engagement bolts for tightness. Tighten loose bolts. Refer to paragraph 6-39.	
Step 7. Check for damaged or defective drive shaft seal rings.		
	Replace worn, damaged or defective seal rings.	
	Refer to paragraph 6-38.	
Step 8. Check flatness on forward piston and reaction plate.		
	Replace piston and reaction plate if warped.	
	Refer to paragraph 6-39.	
Step 9. Inspect clutch facings for wear.		
	Replace clutch plate if facings are badly worn.	
	Refer to paragraph 6-39.	
Step 10. Inspect dump valves for varnish deposits or foreign material which may prevent valves from functioning properly.		
	a. Clean parts. Refer to paragraph 6-39.	
	b. Replace damaged parts. Refer to paragraph 6-39.	
Condition B - With selector valve in reverse position.		
Step 1. Check for low oil pressure.		
	Replace defective oil pump relief valve. Refer to paragraph 6-36.	
Step 2. Check for defective oil pump.		
	Overhaul oil pump. Refer to paragraph 6-36.	

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
	Step 3.	Check for defective marine gear dump valve. Clean, inspect and replace defective parts. Refer to paragraph 6-39.
	Step 4.	Check reaction plate and reverse piston for flatness. Replace if warped. Refer to paragraph 6-39.
	Step 5.	Inspect clutch facings for wear or evidence of over-heating. Replace clutch plate if worn or shows evidence of overheating. Refer to paragraph 6-39.
ALTERNATOR		
1. Alternator Fails to Charge.	Step 1.	Test for open isolation diode. Disassemble alternator and replace defective isolation diode. Refer to paragraph 6-18.
	Step 2.	Test for open rotor winding. Disassemble alternator and verify rotor winding continuity. Replace rotor if open. Refer to paragraph 6-18.
2. Unsteady or Low Charging Rate.	Step 1.	Test for grounded, shorted or open turns in stator coils. Disassemble alternator and replace stator. Refer to paragraph 6-18.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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Step 2. Test for grounded or shorted turns in rotor winding.

Disassemble alternator and replace rotor. Refer to paragraph 6-18.

Step 3. Test for shorted or open rectifier diode(s).

Disassemble alternator and test each diode plate for defective diode(s). Replace defective diode(s). Refer to paragraph 6-18.

ELECTRIC STARTING MOTOR

1. Starter Does Not Crank Engine Adequately.

Step 1. Check for worn commutator.

Repair commutator or replace armature if damaged beyond repair. Refer to paragraph 6-19.

Step 2. Test for open field coils on armature.

Disassemble starter and replace open field coils. Refer to paragraph 6-19.

Step 3. Test for open field coils on frame assembly.

Disassemble starter and replace open field coils. Refer to paragraph 6-19.

Step 4. Check for worn bearings.

Disassemble starter, overhaul and replace defective bearings.

STEERING SYSTEM

1. Steering Wheel Difficult to Turn.

Check for trapped dirt in helm unit.

a. Disassemble unit and thoroughly clean all surfaces of spool. Refer to paragraph 6-5.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
		b. Replace defective parts as necessary. Refer to paragraph 6-5.
2. Steering Wheel Continues to Turn After Being Started and Released.		
	Check for trapped dirt in helm unit.	
		a. Disassemble unit and thoroughly clean all surfaces of spool. Refer to paragraph 6-5.4.
		b. Replace defective parts as necessary. Refer to paragraph 6-5.4.
3. Steering Wheel Turns but Rudder Does Not.		
	Check for failure of helm unit.	
		a. Disassemble helm unit and clean surfaces of both sections. Refer to paragraph 6-5.4.
		b. Inspect for damaged parts. Refer to paragraph 6-5.4.
		c. Replace parts as required. Refer to paragraph 6-5.4.
4. Steering pump noisy.		
	Step 1. Inspect for air leaks at intake or shaft seal. (Oil in reservoir would probably be foamy).	
		a. Disassemble pump and replace seals. Refer to paragraph 6-5.1.
		b. Make sure all connections are tightened properly.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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Step 2. Check for misalignment of coupling.

a. Disassemble steering pump and inspect shaft seal bearing and other parts for damage.

Refer to paragraph 6-5.1.

b. Replace damaged parts. Refer to paragraph 6-5.1.

c. Realign coupled shafts. Refer to paragraph 6-5.1.

RAMP HOIST HYDRAULIC SYSTEM

1. Winch brake does not release.

Step 1. Check for leaking "O" rings or piston seals.

Disassemble winch and replace "O" rings and seals as required. Refer to paragraph 6-12.

Step 2. Check for s rings or piston seals.

Disassemble winch and replace "O" rings and seals as required. Refer to paragraph 6-12.

Step 2. Check for seized driven and driving plates.

Disassemble winch and repair as required. Refer to paragraph 6-12.

2. Erratic action of winch.

Check for defective relief valve.

Disassemble relief valve and inspect plungers, bushings, and pistons for defects.

Replace defective parts as required. Refer to paragraph 6-12.

Table 6-1. Troubleshooting (Continued).

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
3. Loss of oil in motor.		
Check for defective seal.		
Disassemble motor and replace seal. Refer to paragraph 6-12.		

SECTION III. MAINTENANCE PROCEDURES

The following is an index to the maintenance procedures.

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Cover and Crankshaft Pulley	6-42
Propeller, Propeller Shaft and	
Stuffing Box	6-16
Radio Set AN/YRC-46/47	6-7
Radio Set AN/VRC-80	6-8
Radio Set AN/GRC-URC-92	6-9
Ramp, Ramp Cables, Sheaves, Latch Mechanism and Seal	6-10
Rudder and Tiller	6-15
Rudder Angle Indicator	6-44
Starting Motors (Electric)	6-19
Winch	6-12

6-5. HYDRAULIC STEERING SYSTEM.

GENERAL

See figure 6-1 for diagram of steering system.

a. The hydraulic steering systems use medium pressure hydraulic fluid to actuate cylinders which position the rudders. Hydraulic fluid is supplied by the hydraulic pumps to the helm unit which is the principal metering and directional controlling device. By directing hydraulic fluid to one side or the other of the cylinders they will extend or retract giving the desired position to the rudders.

b. The helm unit and other valves control the direction and volume of flow of hydraulic fluid. The relief valve protects the system by limiting hydraulic fluid pressure. The flow control valve (flow divider) limits the volume of fluid to the valve at which this system is designed to work. The flow control valve (flow divider) divides the hydraulic fluid supplied into two flows (2.5 gpm) to the helm unit, and the remainder returned to the storage tank.

NOTE

- The steering system is designed to be supplied by one pump. Using both pumps will only cause a doubled by-pass flow resulting in excessive heating of hydraulic fluid. The steering system pump discharge valves should be set with one valve open and one valve closed.
- The hydraulic fluid for this system should be a high grade fluid compounded for use in a hydraulic system. Recommended hydraulic fluids are 2135 TH., MIL-L-17672, and 2075 TH., MIL-L-17672.

6-5. HYDRAULIC STEERING SYSTEM (Continued).

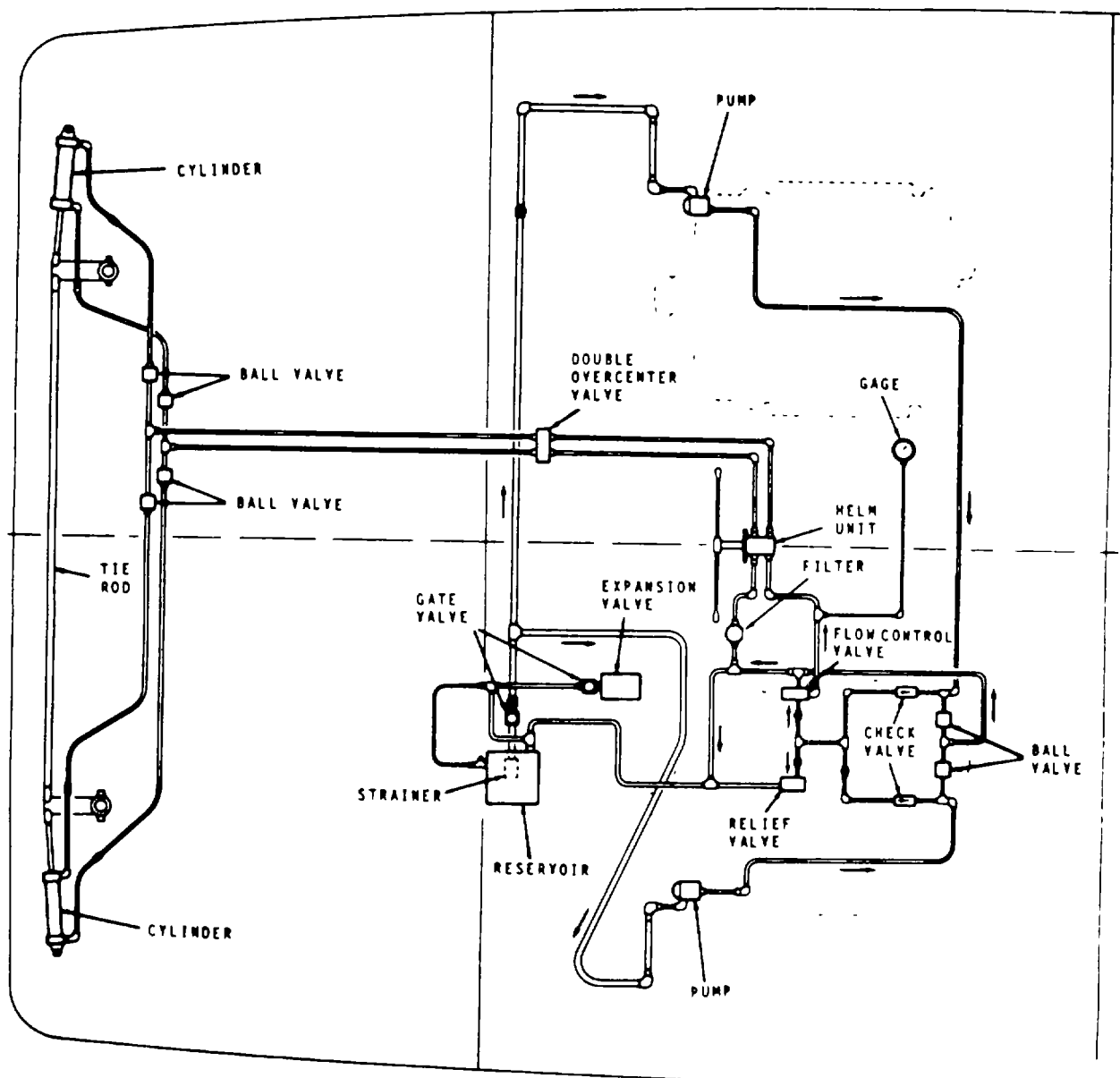


Figure 6-1. Hydraulic Steering System Diagram.

- c. The following is an index of the maintenance instructions.

<u>DESCRIPTION</u>	<u>PARAGRAPH</u>
Hydraulic Steering Pump	6-5.1
Hydraulic Pump Drive.....	6-5.2
Steering Cylinders	6-5.3
Steering System Helm Unit.....	6-5.4
Steering System Overcenter Valve.....	6-5.5
Steering System Relief Valve	6-5.6
Steering System Flow Control Valve.....	6-5.7

6-5.1. HYDRAULIC STEERING PUMP.

This task covers:

- | | | |
|----------------|---------------|---------------|
| a. Disassembly | c. Inspection | e. Overhaul |
| b. Cleaning | d. Repair | f. Reassembly |

INITIAL SETUP

Test Equipment
NONE

References
NONE

Special Tools
NONE

<u>Equipment Condition</u>	<u>Condition Description</u>
<u>Paragraph</u>	

Tools

5-7.1	Pump Removed
-------	--------------

General mechanic's tool kit
NSN 5180-00-629-9783

Material/PartsSpecial Environmental Conditions

Cartridge kit 912064 (62983)
Seal kit 922732 (62983)
Cleaning solvent P-D-680
Clean cloths

NONE

Personnel RequiredGeneral Safety Instructions

MOS 61C10

Observe WARNING in procedure.

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY

- | | | |
|------------------|---|------------------|
| 1. Steering Pump | a. Remove four capscrews (1) from pump cover (2).

b. Separate cover (2) from rotor ring (6).

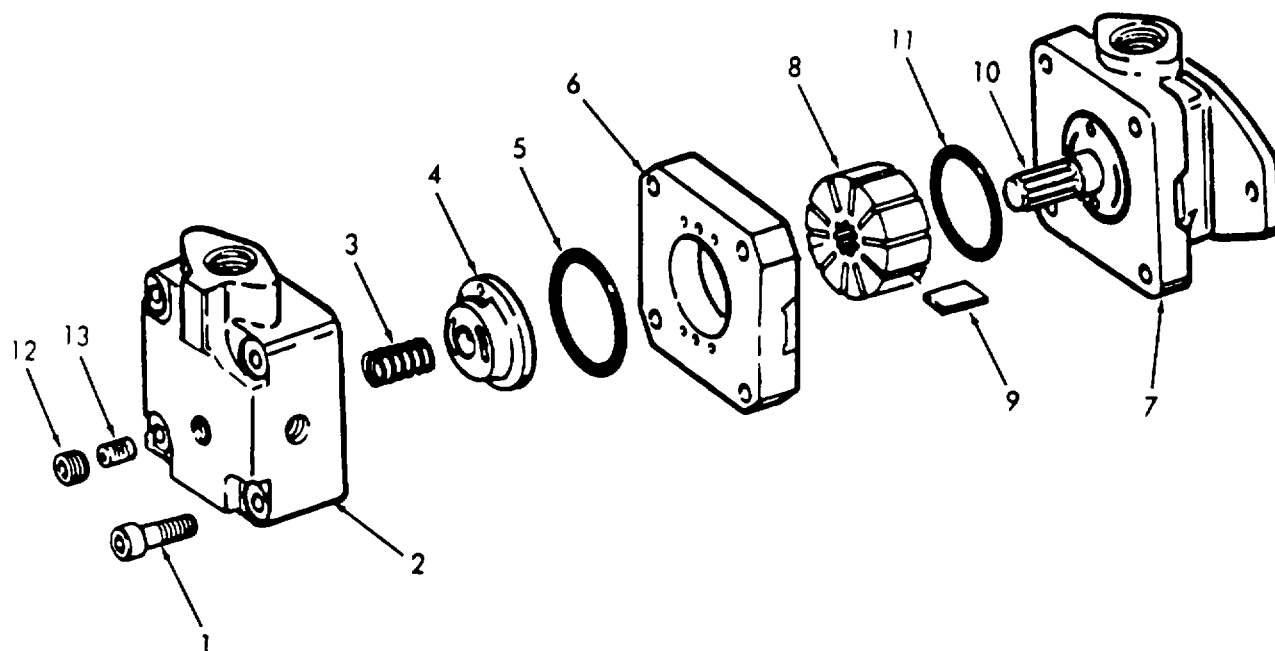
c. Remove pressure plate spring (3), pressure plate (4) and preformed packing (5). | Discard packing. |
|------------------|---|------------------|

6-5.1. HYDRAULIC STEERING PUMP (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- | | | |
|----|---|--------------------------|
| d. | Remove rotor ring (6) from body (7). | Discard ring. |
| e. | Remove rotor (8) and vanes (9) from pump shaft (10). | Discard rotor and vanes. |
| f. | Remove preformed packing (11) from pump body (7). | Discard packing. |
| g. | Remove screen plug (12) and screen (13) from cover (2). | |

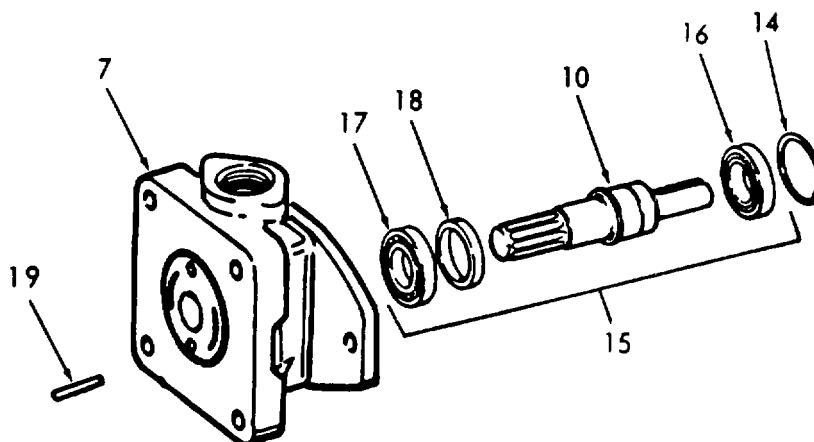


6-5.1. HYDRAULIC STEERING PUMP (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- | | | |
|----|---|-----------------------|
| h. | Remove bearing retaining ring (14). | Use snap ring pliers. |
| i. | Remove pump shaft (10) with bearings and seal attached as a unit (15) from pump body (7). | |
| j. | Remove bearings (16 and 17) and shaft Seal (18) from shaft (10). | Discard seal. |
| k. | Remove body alignment pins (19) from body (7). | If necessary |

**CLEANING**

- | | |
|------------------|--|
| 2. Steering Pump | a. Clean bearings with clean fuel oil. |
|------------------|--|

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100'-138°F (38°-59°C).

6-5.1. HYDRAULIC STEERING PUMP (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING (Cont)

- b. Clean other metal parts with dry cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

INSPECTION

- | | |
|------------------|--|
| 3. Steering Pump | <ul style="list-style-type: none"> a. Inspect spring for cracked coils or loss of tension. b. Inspect bearings for flat spots. c. Inspect splines on shaft for burrs or nicks. d. Inspect sealing surfaces and mounting surfaces of cover and pump body for ridges, burrs, nicks, or warping. e. Inspect pump shaft for burrs or nicks. |
|------------------|--|

REPAIR/OVERHAUL**NOTE**

Use new cartridge kit and seal kit.

- | | |
|---|---|
| 4. Steering Pump vanes, rotor, and seals. | <ul style="list-style-type: none"> a. Replace packings, ring, b. Replace defective screen. c. Replace defective pressure plate spring. |
|---|---|

6-5.1. HYDRAULIC STEERING PUMP (Continued).

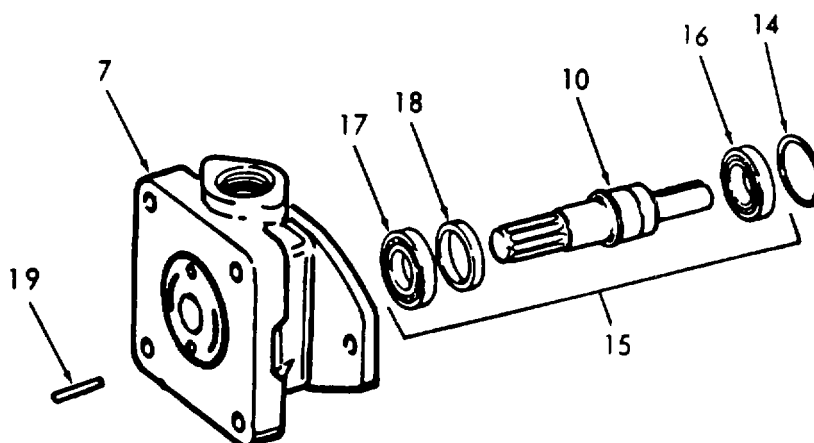
LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REPAIR/OVERHAUL (Cont)

- d. Remove ridges, burrs, or nicks from sealing surfaces of mounting surfaces of cover and pump body by lapping.
- e. Replace defective bearings.
- f. Replace other defective parts as required.

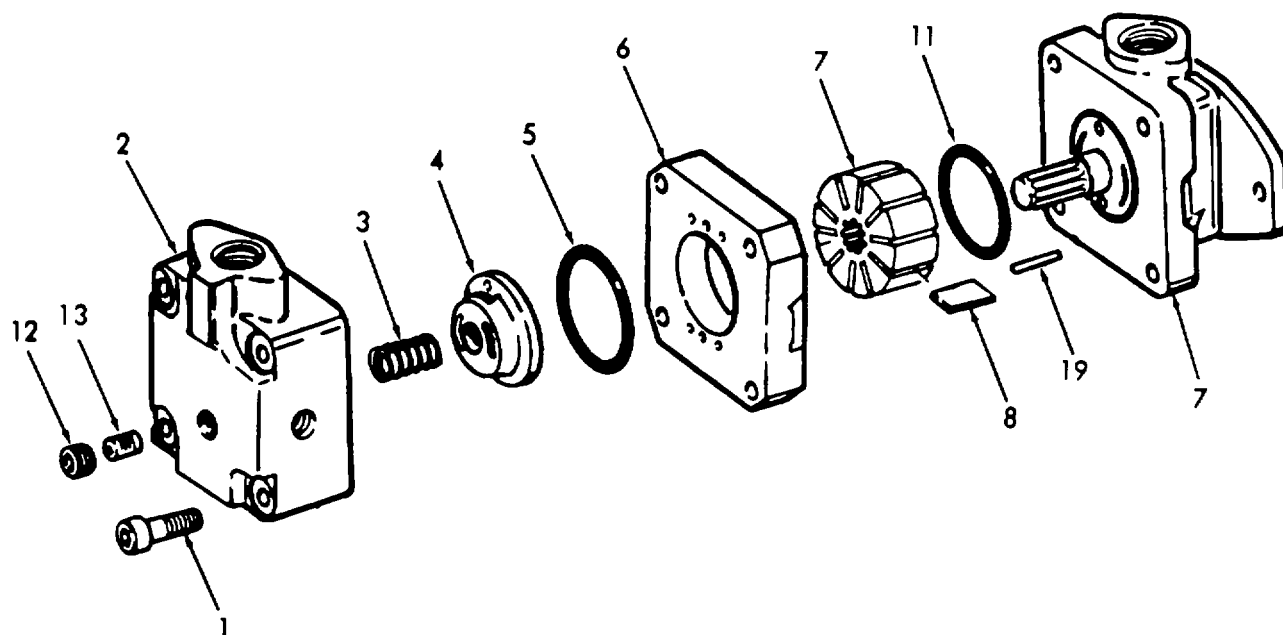
ASSEMBLY

- | | | |
|------------------|---|---------------|
| 5. Steering Pump | a. Install body alignment pins (19) in pump body (7). | If removed |
| | b. Insert shaft seal (18) over end of pump shaft (10). | Use new seal. |
| | c. Install bearing (17) flush with shaft seal. | |
| | d. Insert end of shaft (10) into pump housing and install bearing (16) onto other end of shaft. | |
| | e. Secure assembled unit (15) in body (7) with retaining ring (14). | 1A 14 |



6-5.1. HYDRAULIC STEERING PUMP (Continued).

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)		
	f. Install screen (13) and plug (12) in cover (2).	
	g. Install preformed packing (11) in pump body (7).	Use new packing.
	h. Insert vanes (9) in slots on rotor (8) and insert assembly into rotor ring (6).	Use new vanes, rotor, and ring.
	i. Install rotor ring (6) over alignment pins (19).	
	j. Position preformed packing (5), pressure plate (4) and spring (3) in place and install cover (2).	Use new packing.
	k. Secure cover with four cap screws (1).	



6-5.2. HYDRAULIC PUMP DRIVE COMPONENTS

This task covers:

- | | | |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Overhaul |
| b. Cleaning | d. Repair | |

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Equipment

<u>Condition</u>	<u>Condition Description</u>
Paragraph	

Tools

General mechanic's tool kit
NSN 5180-00-629-9783

5-7.2	Hydraulic pump removed
-------	------------------------

Material/Parts

Cleaning solvent Fed. Spec.
P-D-680
Clean cloths

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

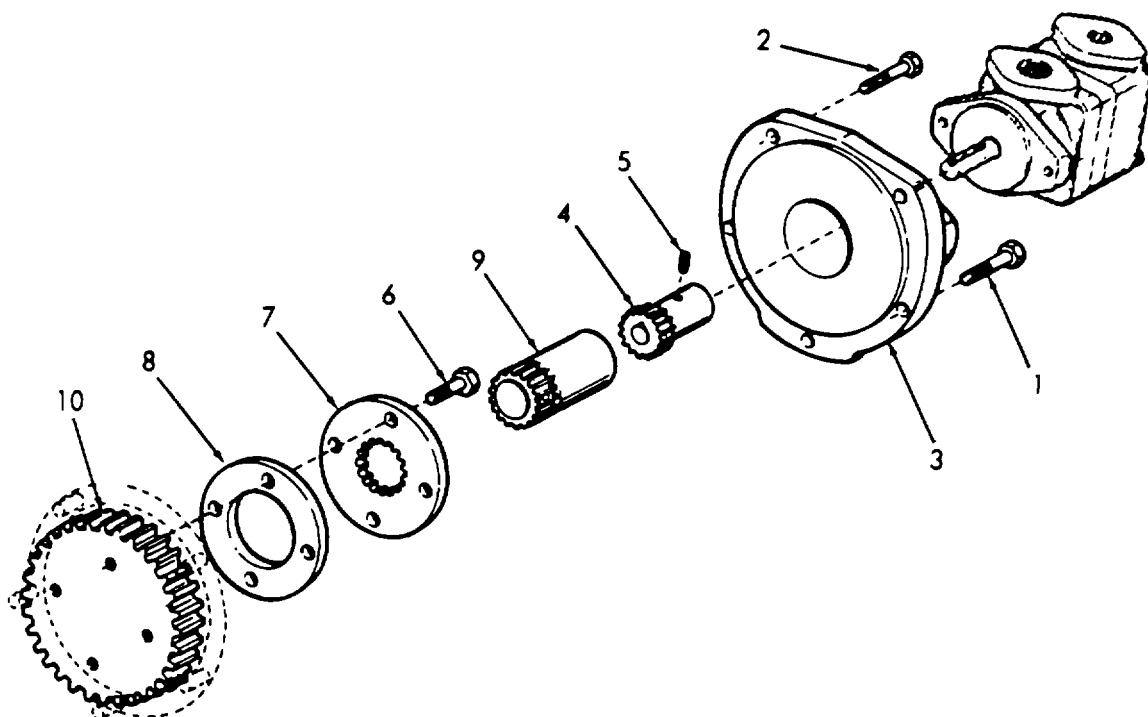
General Safety Instructions

Observe WARNING in procedure.

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

6-5.2. HYDRAULIC PUMP DRIVE COMPONENTS (Continued).

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
1. Drive	<ol style="list-style-type: none"> Remove adapter mounting Components bolts (1 and 2) and adapter pad (3). Remove adapter gear (4). (5) if necessary. Remove drive plate mounting bolts (6). Remove drive plate (7) and gear spacer (8) from cam shaft or balance shaft gear (10). Remove pump drive coupling (9) from drive plate (8). 	<p>Remove set screw</p> <p>Coupling (9) will stay in drive plate.</p>



6-5.2. HYDRAULIC PUMP DRIVE COMPONENTS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING

2. Drive Components

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100-138°F (38°-59°C).

Clean all parts in cleaning solvent, Fed. Spec. P-D-680 and dry thoroughly.

INSPECTION

3. Drive Components
 - a. Inspect teeth on adapter gear, drive plate and drive coupling for nicks or chipped teeth.
 - b. Inspect other parts for cracks, breaks, or other damage.

REPAIR

4. Drive Components

Replace damaged or defective parts as required.

6-5.2 HYDRAULIC PUMP DRIVE COMPONENTS (Continued)

LOCATION/ITEM

ACTION

REMARKS

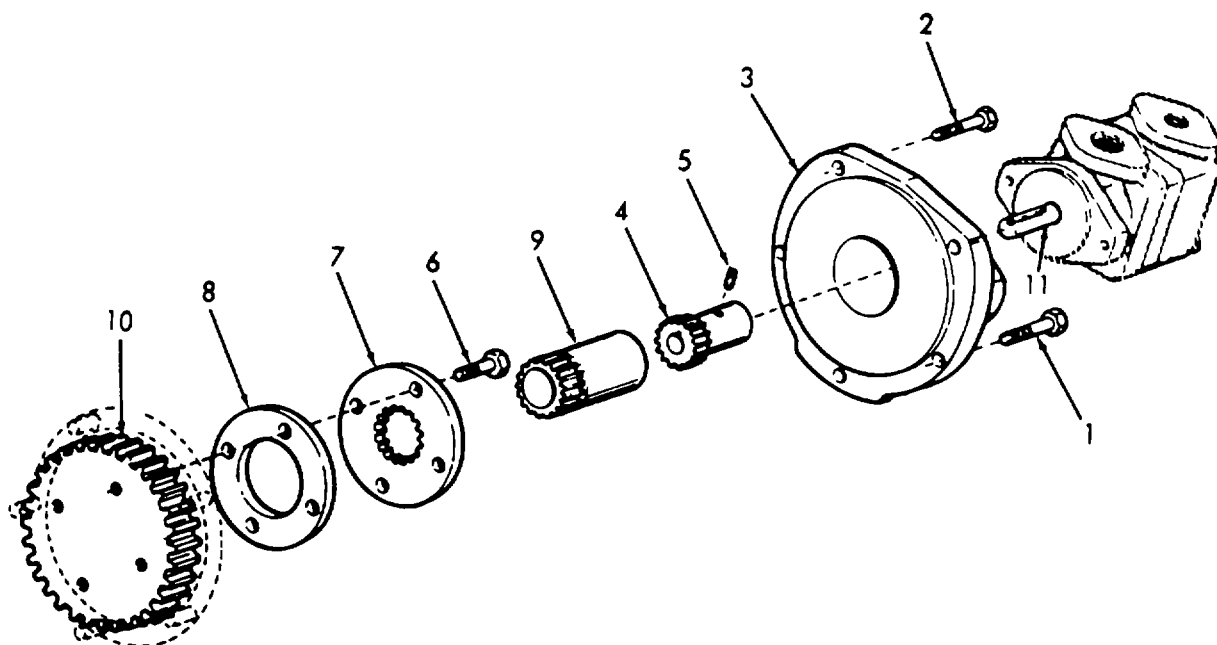
REASSEMBLY

5. Drive Components

- a. Position gear spacer (8) and drive plate (7) in place on cam shaft or balance shaft gear (10).
- b. Secure with mounting bolts (6).
- c. Install pump drive coupling (9) in mounting plate (7).
- d. Install setscrew (5) in adapter gear (4).
- e. Install adapter pad (3) onto flywheel housing with bolts (2 and 1).
- f. When installing adapter gear (4) onto pump shaft (11) accurate positioning is necessary for proper alignment of drive components.

If removed

Bolt (1) is
7/16-14 X 1-1/4
inch. Bolts
(2) are 1/2-13
X 1-1/4 inch.



6-5.3. STEERING CYLINDERS.

This task covers:

- a. Disassembly
- b. Cleaning

- c. Inspection
- d. Repair

- e. Overhaul
- f. Assembly

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Tools

General mechanic's tool kit
 NSN 5180-00-629-9783
 Safety goggles

Equipment Condition	Condition Description
5-7.3	Steering cylinders removed

Material/Parts

Cleaning solvent Fed. Spec.
 P-D-680
 Clean cloths
 Hydraulic fluid

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNING in Procedure

LOCATION/ITEM**ACTION****REMARKS****WARNING**

When using compressed air, wear safety goggles to avoid eye injury.

6-5.3 STEERING CYLINDERS (continued).

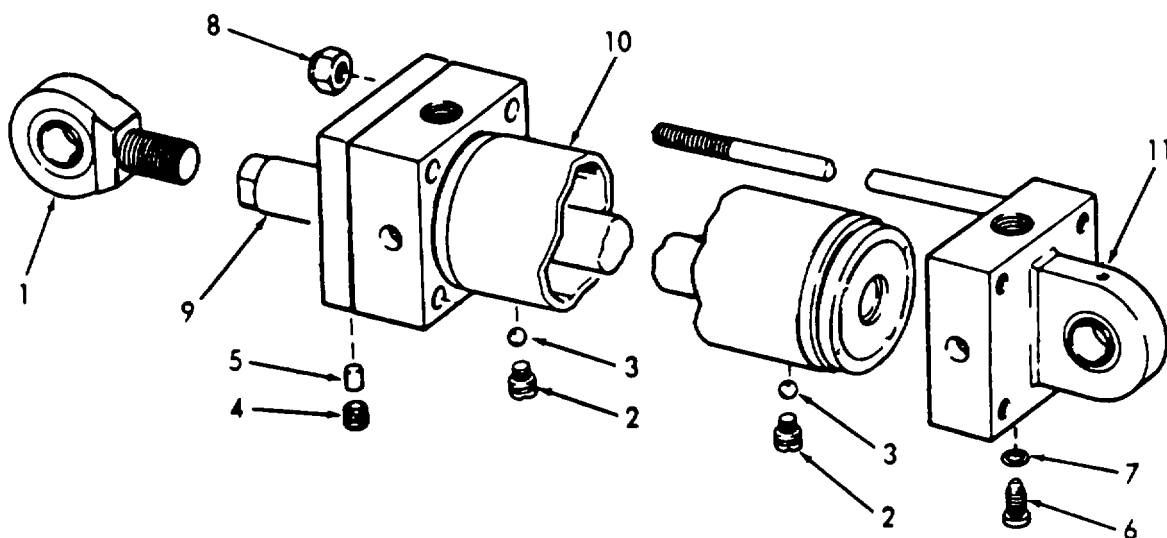
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY

- | | | |
|-----------------------|---|-----------------------------|
| 1. Steering Cylinders | a. Drain hydraulic fluid by manually cycling cylinder. | Compressed air can be used. |
| | b. Remove clevis (1) from piston rod (9). | Use flat on piston rod. |
| | c. Remove bleeder screws (2) and ball bearings (3). | |
| | d. Remove cartridge setscrew (4) and slug (5). | |
| | e. Remove cushion needle (6) and packing (7) from end cap cover (11). | Discard packing. |
| | f. Remove tie rod nuts (8). | |
| | g. Withdraw piston rod (9) assembly from cylinder (10). | |
| | h. Remove cylinder (10) from end cap cover (11). | |



6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY (Cont)	i. Remove cartridge retainer plate (12) and head cover (20) from piston rod (9).	
	j. Remove bearing cartridge (13), rod wiper (14), and rod bearing (15).	Discard rod wiper.
	k. Remove rod packing retaining ring (16) and packing (17).	Discard packing.
	l. Remove cartridge ring (18) and preformed packing (19) from head cover (20).	Discard packing.
	m. Remove lockscrew (21), piston (22), piston ring packings (23), and preformed packing (24).	Discard packings.
	n. Remove nose cushion (25) and packing (26).	Discard packing.
	o. Unscrew tie rods (27) from end cap cover (11).	
	p. Remove O-ring retainer (28) and packing (29) from end cover (11).	Discard packing.
	q. Remove self-locking screw (30), packing (31), spring (32), and check ball (33) from end cover.	Discard packing.

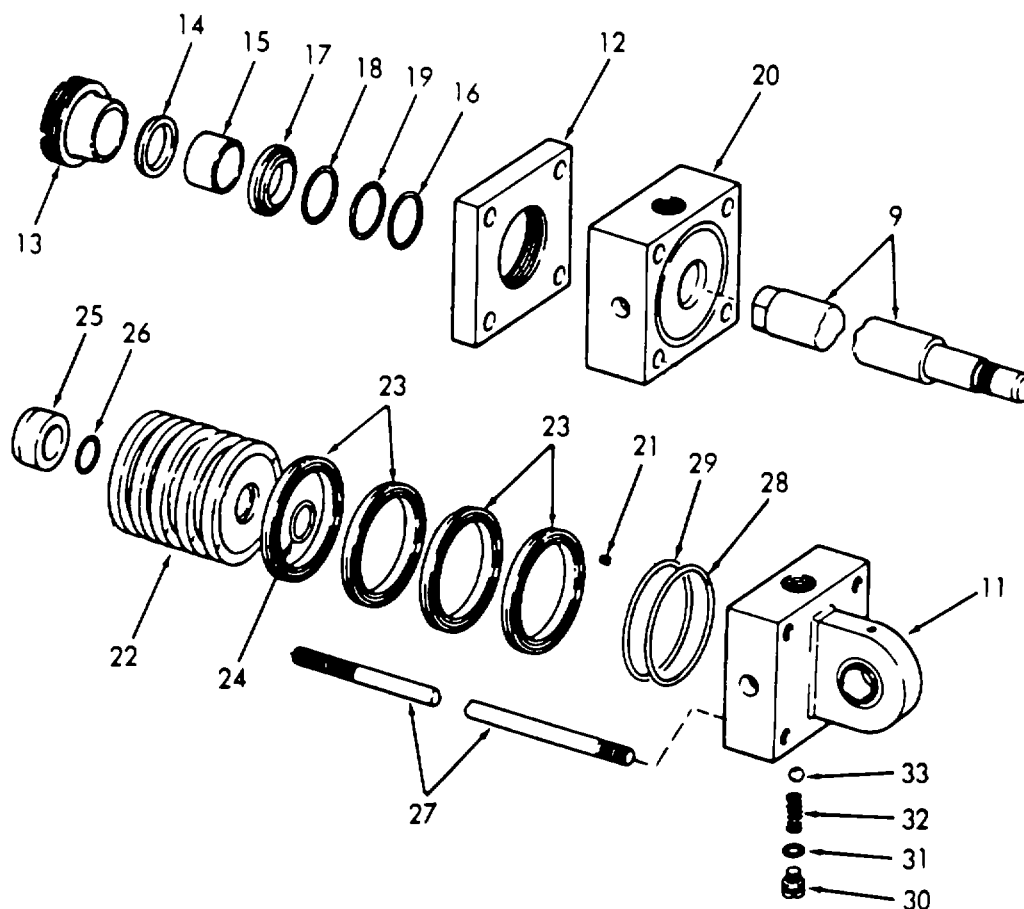
6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



CLEANING

2. Steering
Cylinders**WARNING**

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100°-138°F (38°-59°C).

Clean all metal parts using cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM	ACTION	REMARKS
INSPECTION		
3. Steering Cylinders	<ul style="list-style-type: none"> a. Inspect piston rod for scoring. b. Inspect threaded parts for thread damage. c. Inspect springs for cracked coils or loss of tension. d. Inspect end covers for nicks, burrs, cracks, or other damage. e. Inspect cylinder bore for wear. 	
REPAIR		
4. Steering Cylinders	Replace damaged parts with a serviceable-like item as required.	
OVERHAUL		
5. Steering Cylinders	<ul style="list-style-type: none"> a. Replace all packings, O-rings, seals, and rod wiper. b. Remove mild scores or nicks from piston rod by light stoning. c. Replace check balls. d. Replace all other parts that show signs of wear. 	

6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY

6. Steering
Cylinders

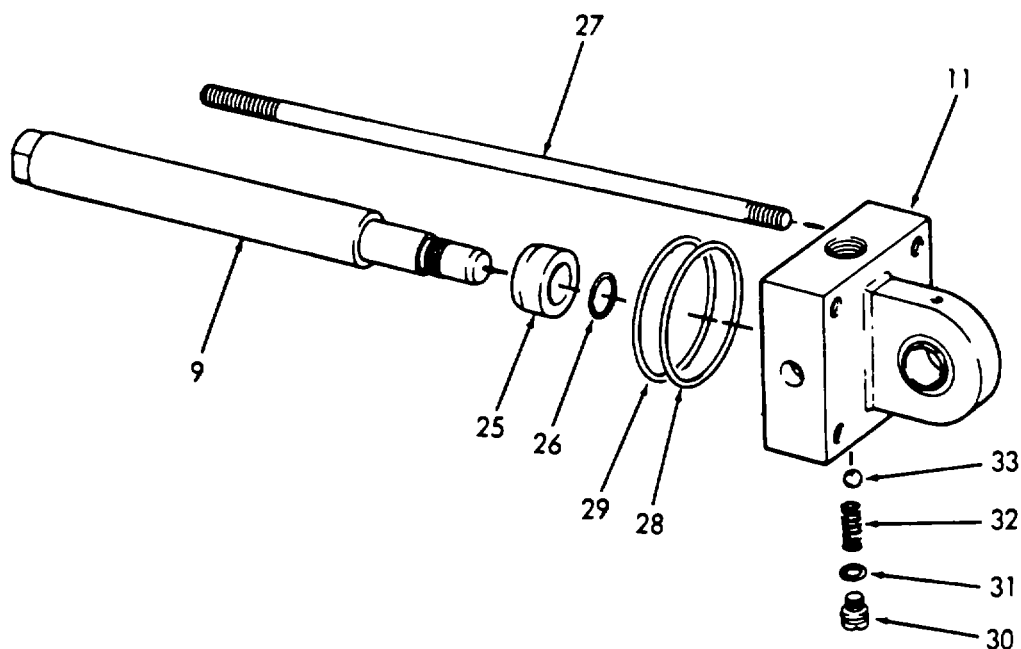
- a. Lightly lubricate all parts before installation.
- b. Install check ball (33), spring (32), packing (31), and self-locking screw (30) in end cap cover (11).
- c. Install end cover packing (29) retainer ring (28).
- d. Thread tie rods (27) into end cap cover (11).
- e. Install nose cushion packing (26) and nose cushion (25) on piston rod (9).

Use hydraulic fluid.

Use new check ball and packing.

Use new packing.

Use new packing.



6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)	f. Install preformed packing (24), piston ring packings (23), piston (22), onto piston rod (9) and secure with lockscrew (21).	Use new packings.
	g. Install cartridge seal packing (19), retaining ring (18), and end cover packing (29) in head cover (20).	Use new packing.
	h. Install head cover (20) on piston rod (9).	
	i. Install rod packing (17) and secure with retaining ring (16).	Use new packing.
	j. Install piston rod bearing (15), rod wiper (14) and bearing cartridge (13).	Use new bearing and wiper.
	k. Install cartridge retainer plate (12) on head cover (20).	
	l. Install cylinder (10) and piston rod (9) assembled into end cap cover (11).	
	m. Secure with tie rod nuts (8).	
	n. Install cushion needle packing (7) and cushion needle (6) in end cap cover (11).	
	o. Install cartridge slug (5) and setscrew (4) in cartridge retainer plate (12).	
	p. Install ball bearings (3) and bleeder screws (2) in cylinder (10).	
	q. Install clevis (1) onto piston rod (9).	Use flats on piston rod.

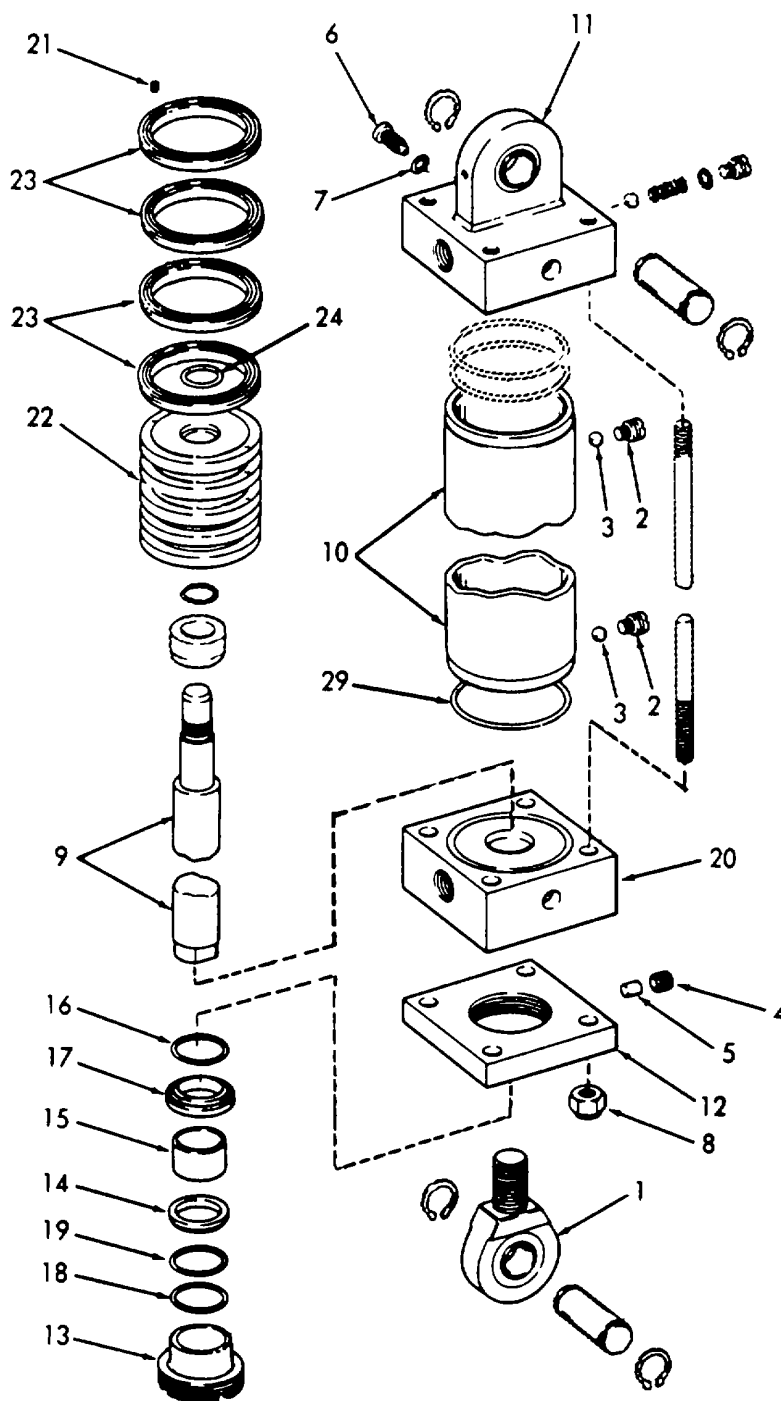
6-5.3 STEERING CYLINDERS (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)



6-5.3 STEERING CYLINDERS (Continued)

This task covers:

- | | | |
|----------------|---------------|-------------|
| a. Disassembly | c. Inspection | e. Overhaul |
| b. Cleaning | d. Repair | f. Assembly |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

Helm unit valve spring
installer J600057 (96151)

Tools

General mechanic's tool kit
NSN 5180-00-629-9783

Equipment
Condition
Paragraph

Condition Description

5-7.4

Helm Unit Removed

Material/Parts

Cleaning solvent, Fed. Spec.
P-D-680
Clean cloths
Paper towels
Seal kit 5140 (96151)
600 grit abrasive paper

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNING and CAUTION in
Procedure

LOCATION/ITEM**ACTION****REMARKS****NOTE**

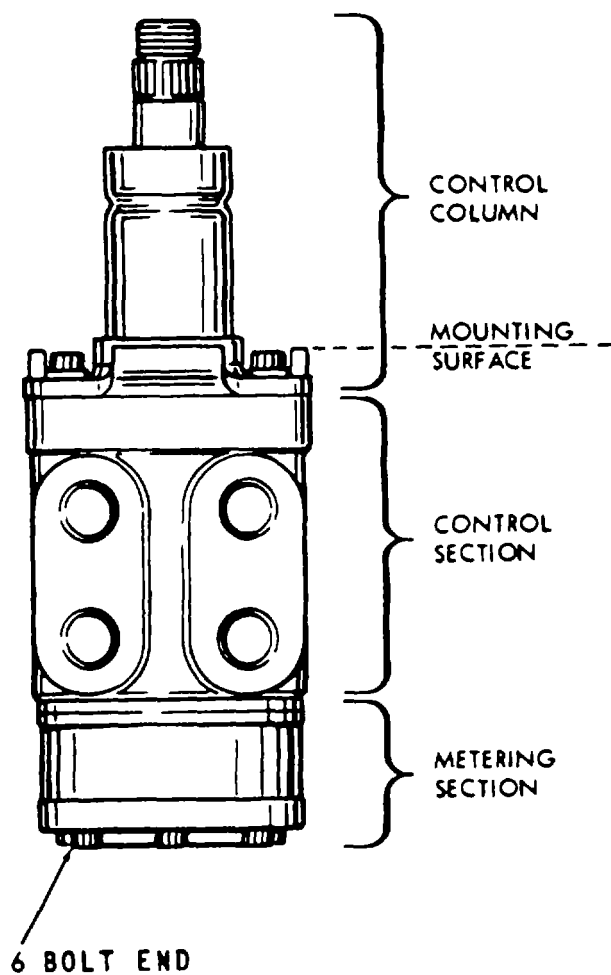
If there is a functional problem or leakage at the control section only, the disassembly of the control section end of the unit only be required. For this type of repair, leave the 6-bolt end assembled.

6-5.4. STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

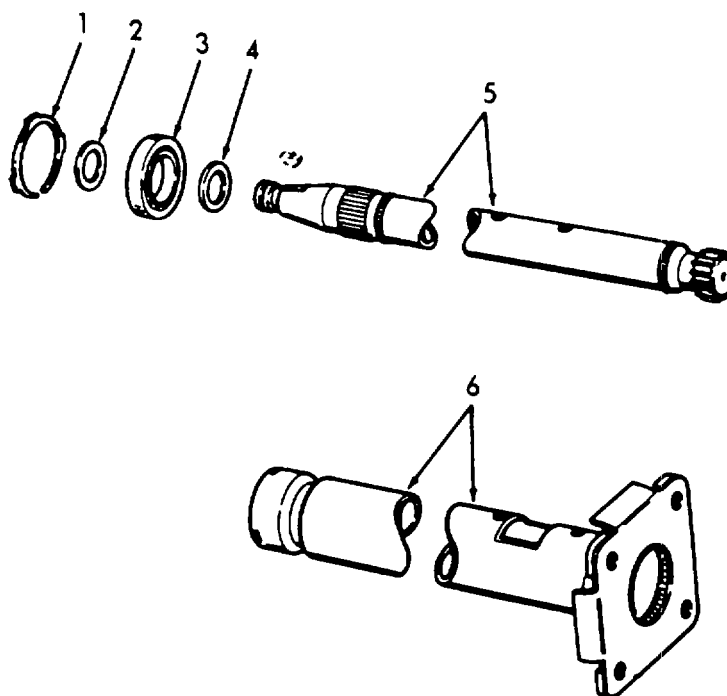
ACTION

REMARKS

DISASSEMBLY

1. Control
Column

- a. Remove retaining rings (1 and 2), bearing assembly (3) and retaining ring (4).
- b. Remove shaft assembly (5) from tube and flange assembly (6).

2. Helm Unit
Assembly

- a. If complete disassembly is necessary, clean all surface contamination and paint from the unit at points of separation. To clean unit, first plug all four ports (1), then wire brush around the metering area (2) and rinse and blow away all surface contamination.

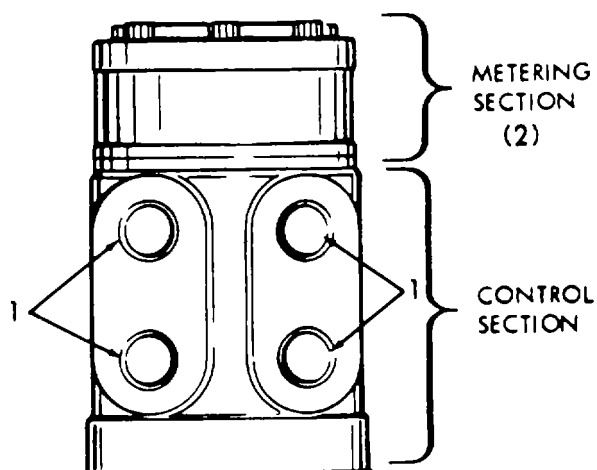
6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

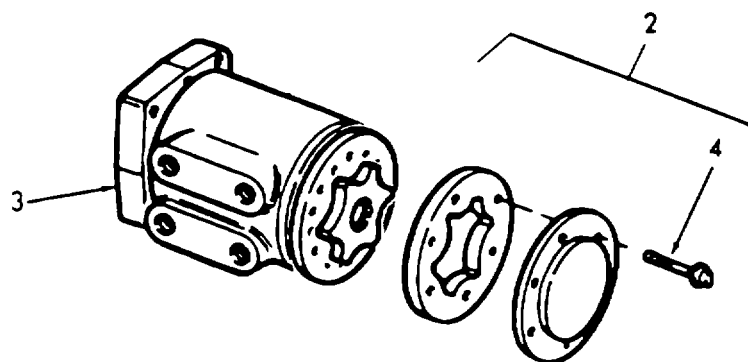
ACTION

REMARKS

DISASSEMBLY (Cont)



- b. Clamp unit in vise across mounting plate (3) edges with meter section up.
- c. Remove six capscrews (4) and carefully lift metering section (2) from unit.



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

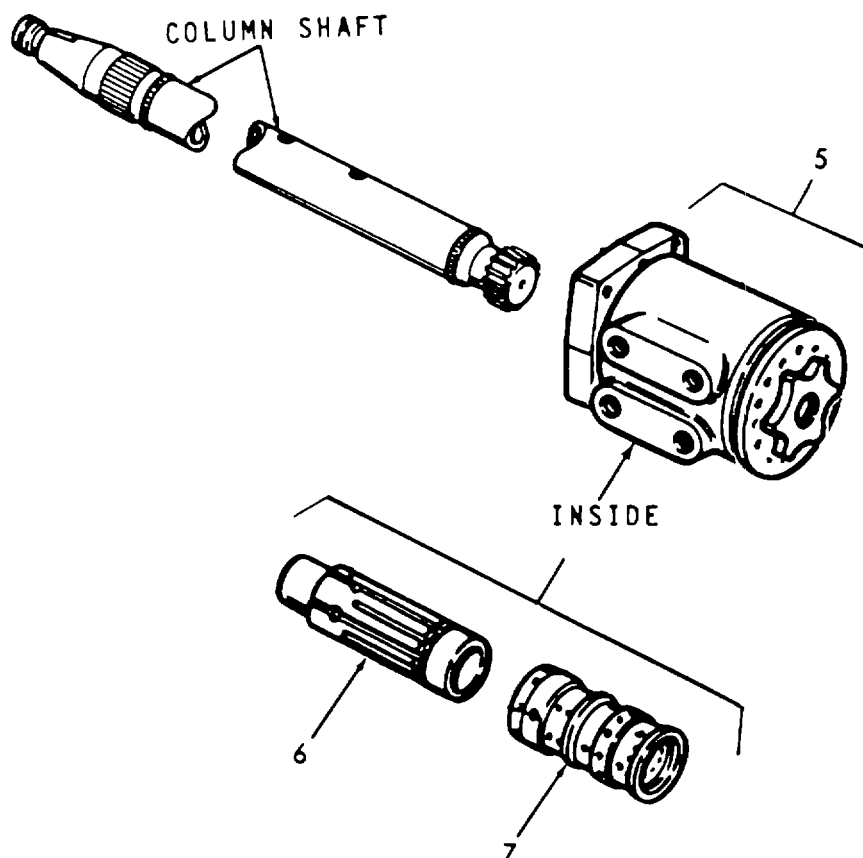
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- d. Remove control section (5) from vise and use column shaft to check for free rotation of the control spool (6) and sleeve parts (7).



3. End Cap

- a. Place a clean wooden block across vise throat to support spool parts and clamp unit across port face with control section (5) up.
- b. Remove four capscrews (8).
- c. Hold spool assembly down against block in vise as shown.

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- d. Remove mounting plate (9).

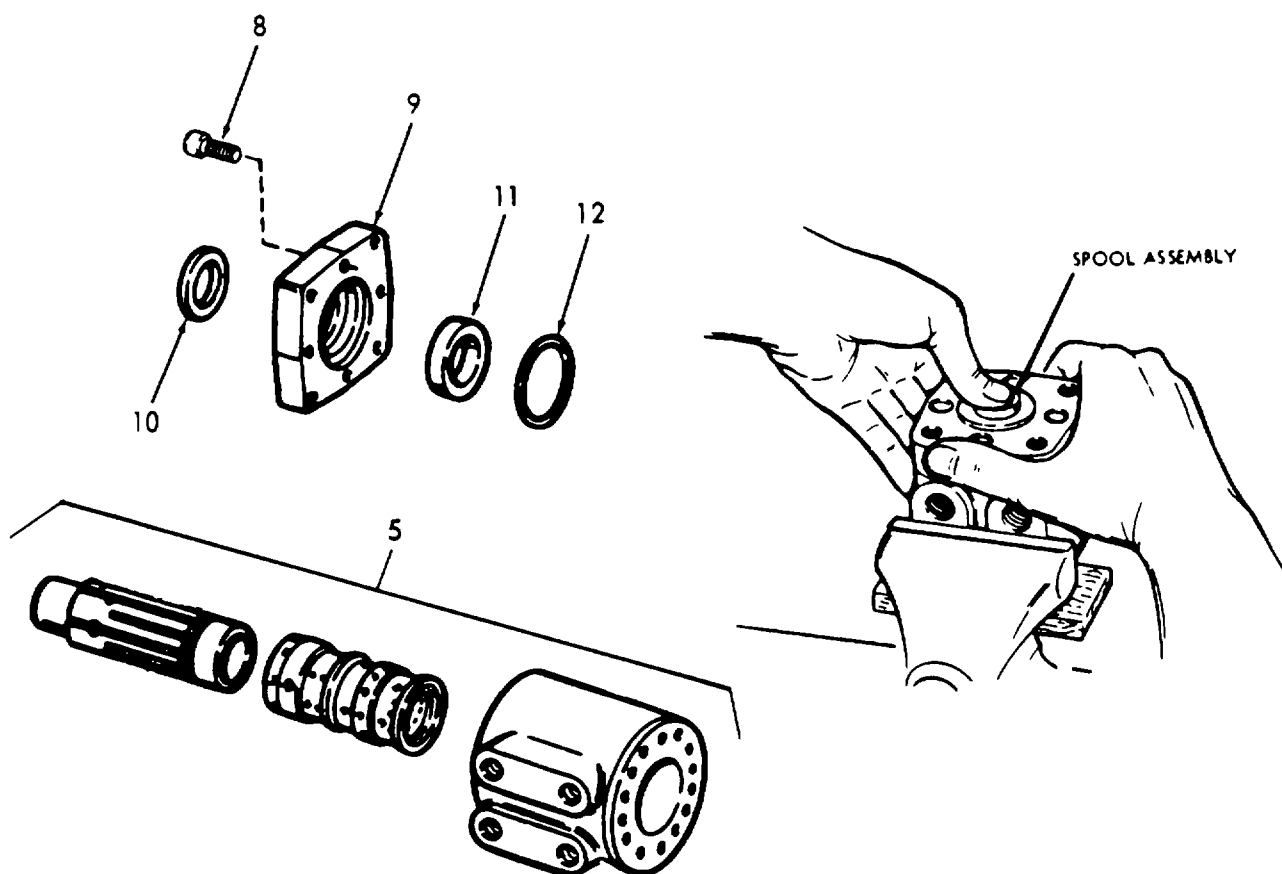
Inspect end cap and housing mating surfaces for obvious leakage path, wear, and seal condition.

- e. Remove oil seal (10).

Discard seal.

- f. Remove cap locator bushing (11) and preformed packing (12).

Discard pre-



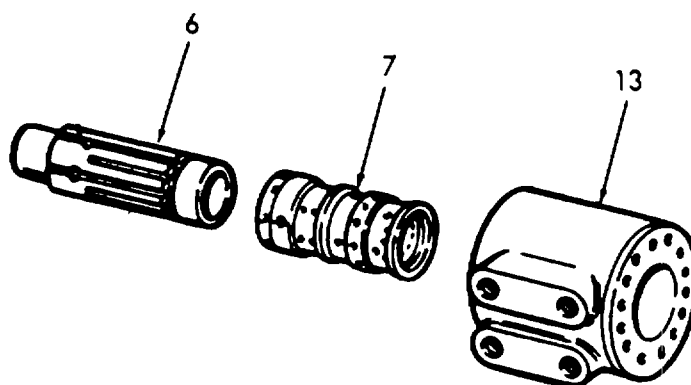
6-5.4 STEERING SYSTEM HELM UNIT (Continued)**LOCATION/ITEM****ACTION****REMARKS****DISASSEMBLY (Cont)**

4. Spool and
Sleeve
Assembly

CAUTION

When removing the spool and sleeve assembly, be extremely careful to prevent these parts from binding, as they are very closely fitted. They must generally be rotated slightly as they are withdrawn.

Place housing (13) on a solid surface with port face down, so that it can be held securely, remove spool (6) and sleeve assembly (7) from 14 hole end of housing (13).



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

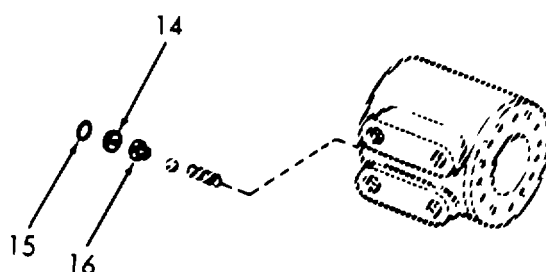
REMARKS

DISASSEMBLY (Cont)

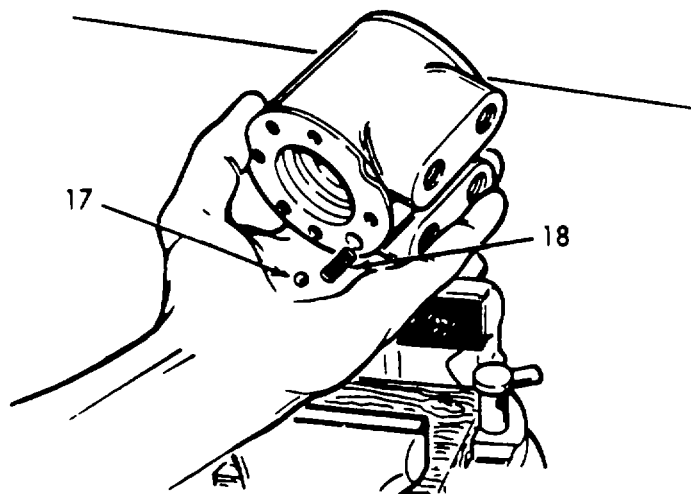
5. Check Valve and Centering Spring Set

- a. Place housing in vise, control end up and remove seal plug (14) and packing (15).
- b. Unscrew check valve seat (16).

Use 3/16 hex wrench.



- c. Position housing as shown and tap slightly with heel of hand.
- d. Hold check valve hole towards lowest corner and remove check valve seat (16), steel ball (17), and compression spring (18).

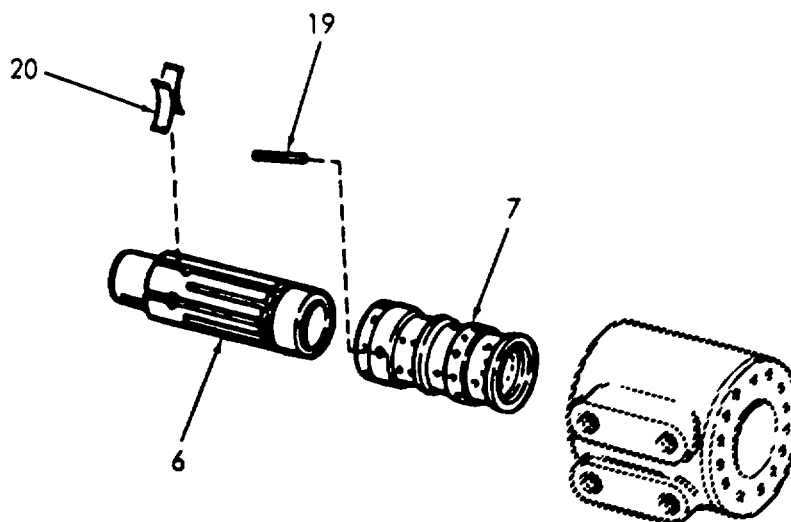


6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- e. Push inside lower edge of control spool (6) so that spool moves toward splined end (19) from control sleeve (7).
- f. Remove centering spring set (20) out of spring slot in spool (6).



6. Meter Gear Set

Remove end cap (21), shaft spacer (22), gerotor set (23), plate (24), and drive shaft (25) from housing (13).

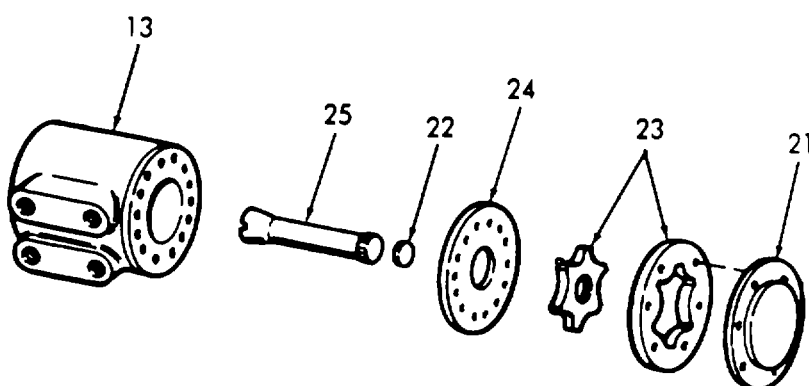
6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



CLEANING

7. Helm Unit

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100°-138°F (38°-59°C).

- a. Clean all parts, except packing, in cleaning solvent Fed. Spec. P-D-680.
- b. Set parts on clean paper towels to dry.
- c. Slightly scored parts can be cleaned with 600 grit abrasive paper by hand rubbing only.

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING (Cont)

- d. To prepare all surfaces of the meter section for reassembly and insure that all edges of the parts are burr free, place a piece of 600 grit abrasive paper face up on an extremely flat, clean, hard surface. The surface to be used for this purpose should be as flat as plate glass or better. If the 600 grit paper is new It should first be rubbed down with a scrap steel part to remove sharp grit which would produce scratches. The ends of the star gear can be used for this purpose if necessary. Then both sides of the ring gear, both sides of the plate, the 14 hole end of the housing and the flat side of the end cap should be cleaned lightly. Stroke each surface across the abrasive several times and observe the part. Any small bright area near an edge indicates a burr which must be removed. Hold the part so that contact with the abrasive is as flat as possible. (Do not push one edge down hard or the flatness will become rounded). Check each part after 6 to 10 strokes across the abrasive. After polishing each part, rinse clean in solvent and blow dry. Keep these parts absolutely clean until they are assembled.

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION

- | | | |
|--------------|--|--|
| 8. Helm Unit | <ul style="list-style-type: none"> a. Inspect threaded parts for thread damage. b. Inspect all moving surfaces for scoring or abrasions by dirt particles. | |
|--------------|--|--|

NOTE

Smooth burnished surfaces are normal in many areas.

- | | | |
|--|---|--|
| | <ul style="list-style-type: none"> c. Inspect springs for loss of tension. d. Inspect-drive shaft for burrs or nicks. e. Inspect splines on spool assembly for nicks or burrs. | |
|--|---|--|

REPAIR

- | | | |
|--------------|---|--|
| 9. Helm Unit | <ul style="list-style-type: none"> a. Replace defective threaded parts. b. Replace packing. c. Replace other defective parts as required with a serviceable-like item. | |
|--------------|---|--|

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS

OVERHAUL

10. Helm Unit

NOTE

Use seal kit 5140.

- a. Replace seals.
- b. Replace check seat steel ball.
- c. Replace springs.
- d. Replace packings.
- e. To prepare all surfaces of the meter section for reassembly and insure that all edges of the parts are burr free, place a piece of 600 grit abrasive paper face up on an extremely flat, clean, hard surface. The surface to be used for this purpose should be as flat as plate glass or better. If the 600 grit paper is new it should first be rubbed down with a scrap steel part to remove sharp grit which would produce scratches. The ends of the star gear can be used for this purpose if necessary. Then both sides of the ring gear, both sides of the plate, the 14 hole end of the housing, and the flat side of the end cap should be cleaned lightly. Stroke each surface across the abrasive several times and observe the part. Any small bright area near an edge indicates a burr which must be removed. Hold the part so that contact with

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS

OVERHAUL (Cont)

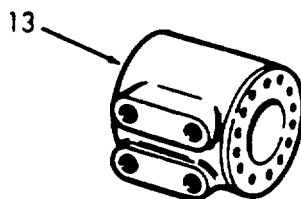
the abrasive is a flat as possible. (Do not push one edge down hard or the flatness will become rounded.) Check each part after 6 to 10 strokes across the abrasive. After polishing each part, rinse clean in solvent and blow dry. Keep these parts absolutely clean until they are assembled.

- f. Replace spool-sleeve assembly if any wear is indicated.
- g. Replace other damaged or defective parts as required.

ASSEMBLY

11. Control Parts
Assembly

- a. Place clean wooden block across vise throat and place housing (13) in vise with control end up. Clamp across port surface lightly.



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)		
	<p>b. Drop check valve compression spring (18) into the check hole with large end down. Drop check ball (17) into check hole and insure that it rests on top of the small end of the spring (18) within the hole. Place the check valve seat (16) on 3/16 hex wrench and screw into threads within check hole so that machined counterbore of the check seat is toward the ball. Tighten check seat. Test check ball action by pushing ball with small clean pin against spring force. Ball need not be snug against seat for proper function.</p>	<p>Torque check seat to 150 lb. in. (17.0 Nm).</p>
	<p>c. Install spool (6) within sleeve (7) carefully so that spring slots of both parts will be at same end. Rotate while sliding parts together. Test for free rotation. Spool should rotate smoothly in sleeve with finger tip force applied at splined end. Bring spring slots of both parts in line and stand parts on end of bench. Insert spring installation tool (Part No. J600057) through spring slots of both parts. Position 3 pairs of centering springs (20) (or 2 sets of 3 each) on bench so that extended edge is down and arched center section is together. In this position, center one end of spring set</p>	

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

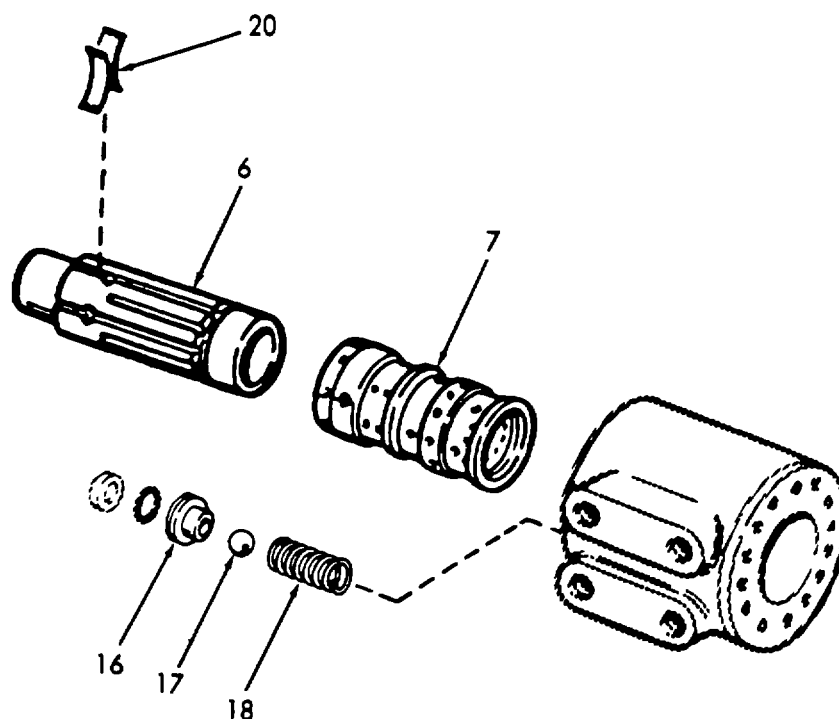
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

(20) into spring installation tool. Compress extended end of centering spring set (20) and push into spool sleeve assembly (6 and 7) withdrawing installation tool at the same time. Center the spring set (20) in the parts so that they push down evenly and flush with the upper surface of the spool and sleeve. Install centering pin (19) through spool assembly (6 and 7). Push into place until centering pin (19) is flush or slightly below the sleeve diameter at both ends.



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)	<p>d. Position the housing (13) on solid surface with the port face down. Start the spool assembly (6 and 7) so that the splined end of the spool enters the 14 hole end of the housing first. Be extremely careful that the parts do not cock out of position while entering. Push parts gently into place with slight rotating motion. Bring the spool assembly entirely within the housing bore until the parts are flush at the meter end or 14 hole end of the housing. Do not pull the spool assembly beyond this point (to prevent the cross pin from dropping into the discharge groove of the housing). With the spool assembly in this flush position, check for free rotation within the housing by turning with light finger force at the splined end. Hold the parts in this flush position and rest the 14 hold end of the assembly on the protective block on the vise throat and clamp lightly across the port face with the vise.</p>	
	<p>e. Install a new seal (15) on the plug (14). Install the plug in the check hole with a steady pressure while rocking it slightly so the seal (15) feeds in smoothly without cutting.</p>	<p>Use new packing.</p>

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

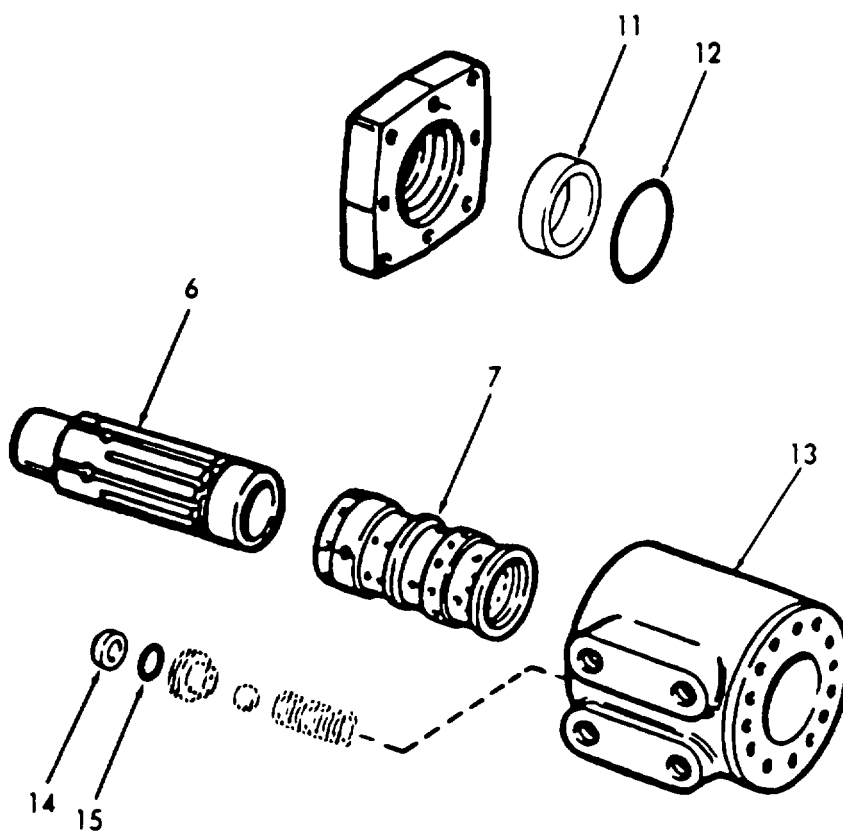
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- f. Place preformed packing (12) over end of spool assembly (6 and 7). Use new packing.
- g. Position the cap locator bushing (11) with large O.D. chamfer UP partly into end of housing. Insure that it seats against spool assembly flat and smooth by rotating with finger tips.



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)	<p>h. Check the mounting plate (9) carefully to insure that it is clean and in good condition. Insure that the mounting plate seal groove is clean and smooth. The seal (10) is slightly larger than its seal groove so it will be adequately retained in service. Push gently into place and smooth down into seal groove with finger tip. Press seal (10) into counter-bore so that the lip is directed away from the unit. Place the mounting plate subassembly (9) over spool shaft and slide down into place over cap locator bushing smoothly so that seal will not be disrupted in assembly. Aline bolt holes with tapped holes. Be certain that the mounting plate rests fairly flush against end of housing assembly so that the cap locator bushing is not cocked. Install four mounting plate capscrews (8).</p>	<p>Tighten capscrews (8) evenly and gradually to a torque setting of 250 lb. in. (28.3 Nm)</p>

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

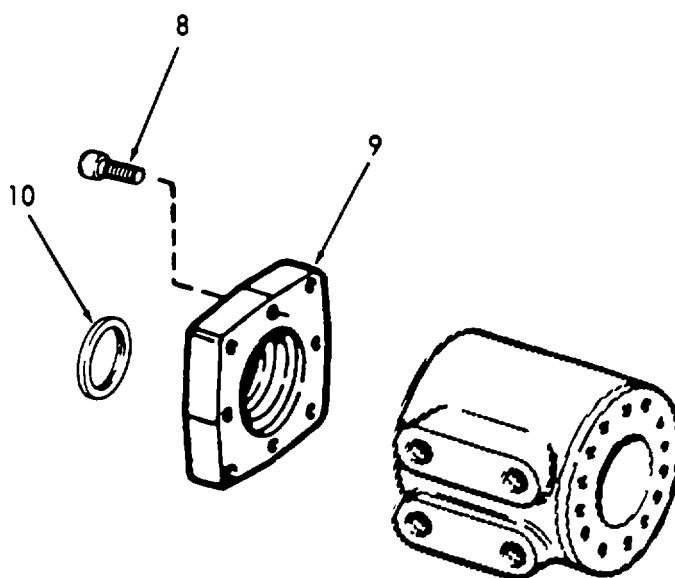
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- i. Reposition housing in vise (14 hole surface up) and clamp across the edges of the mounting plate. Check to insure that spool and sleeve are flush or slightly below the 14 hole surface of the housing. Clean the upper surface of the housing. Clean each of the flat surfaces of the meter section parts as it is ready for assembly in a similar way.



6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

12. Metering Section

WARNING

Alignment of the cross slot in the drive with valleys between the teeth of the meter gear star determines proper valve timing of the unit. There are 12 teeth on the spline and 6 pump teeth on the star. Alignment is exactly right in 6 positions and exactly wrong in 6 positions. If the parts slip out of position during this part of the assembly, repeat until you are certain that correct alignment is obtained.

- a. Place the plate (24) over the housing assembly (13) so that bolt holes in the plate align with the tapped holes in the housing. Place the meter gear ring (23) on the assembly so the bolt holes align. Place the splined end of the drive (25) within the meter gear star so that the slot at the control end of the drive is in alignment with the valleys between the meter gear teeth as shown. Push the splined end of the drive through the gear so that the spline extends about one half its length beyond the meter gear star and hold it in this position while installing into the unit. Note the position or direction of the centering pin within the unit. Enter the meter gear star (23A) into the meter gear (23) and wiggle the parts slowly in position so that the drive does not become disengaged from the

6-5.4 STEERING SYSTEM HELM UNIT (Continued)

LOCATION/ITEM

ACTION

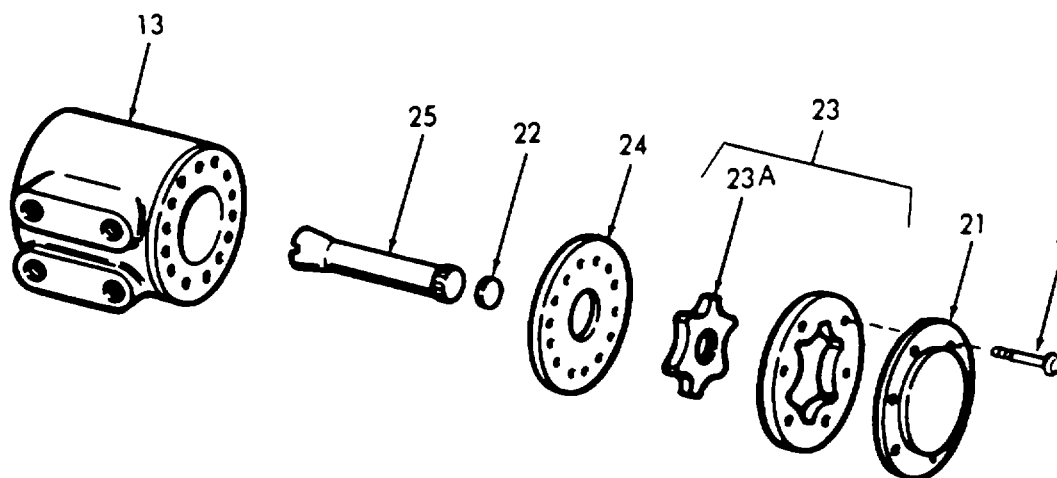
REMARKS

ASSEMBLY (Cont)

meter gear star. Hold the plate and meter gear ring in position on the assembly while the star is being installed. Rotate the meter gear star slightly to bring the cross slot of the drive into engagement with the centering pin and the splined end of the drive will drop down against the plate.

- b. Place the spacer (22) in position within the end of the meter gear star. If the spacer does not drop flush with the gear surface, the drive has not properly engaged the centering pin. RECHECK. Place the meter end cap (21) over the assembly and install two capscrews, finger tight, to maintain alignment of the parts. Install all six capscrews (4).

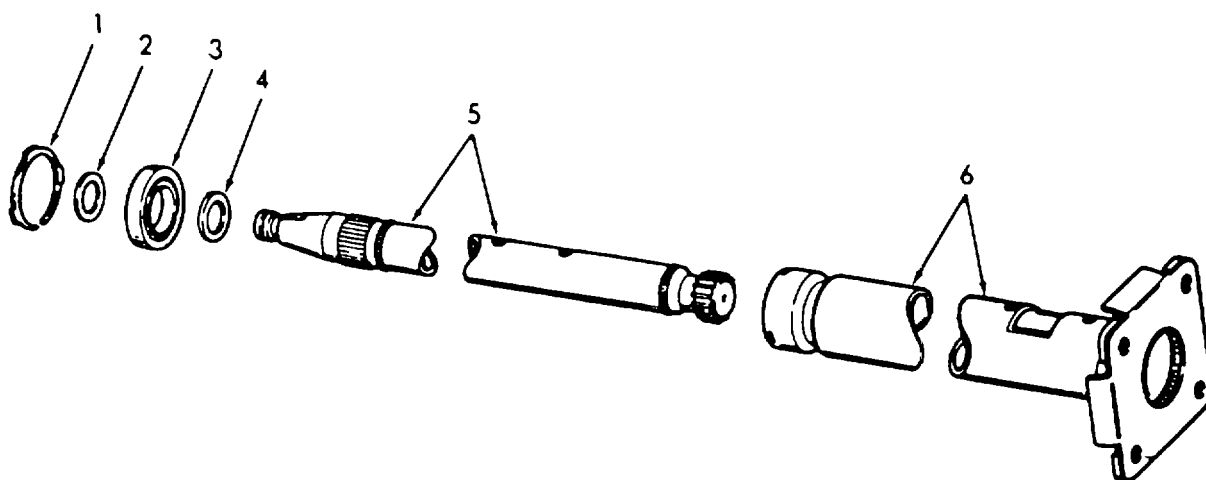
Torque cap-screws evenly and gradually to a torque of 150 lb. in. (17.0 Nm).



6-5.4 STEERING SYSTEM HELM UNIT (Continued)**LOCATION/ITEM****ACTION****REMARKS****ASSEMBLY (Cont)**

13. Control
Column

- a. Insert shaft assembly (5) into flange assembly (6).
- b. Install retaining ring (4), bearing assembly (3) and retaining rings (2 and 1).



6-5.5. STEERING SYSTEM OVERCENTER VALVE

This task covers:

- a. Disassembly
- b. Cleaning

- c. Inspection
- d. Repair

- e. Overhaul
- f. Assembly

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Equipment

Condition

Paragraph

Condition Description

5-7.5 Overcenter Valve Removed.

Tools

General mechanic's tool kit
NSN 5180-00-629-9783

Material/Parts

Cleaning solvent Fed. Spec.
P-D-680
Clean cloths

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNING in procedure.

6-5.5 STEERING SYSTEM OVERCENTER VALVE

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY

1. Overcenter Valve	a. Remove adjusting nut (1) and screw (2).	Do not remove nut (1) unless damaged or if screw is defective.
	b. Remove plug (3) and gasket (4).	
	c. Remove springs (5 and 6).	
	d. Remove spring end (7) and preformed packing (8).	
	e. Remove lapped assembly (9), teflon back-up (10), and preformed packing (11) from pump body.	
	f. Remove preformed packing (12) and leather back-up (13) from lapped assembly.	
	g. Remove plug (14), preformed packing (15), springs (16 and 17), and steel ball (18) from body (24).	
	h. Remove plug (19).	
	i. Remove plug (20) and preformed packing (21).	
	j. Withdraw piston assembly (22) from body (24).	
	k. Remove preformed packing (23) from piston.	

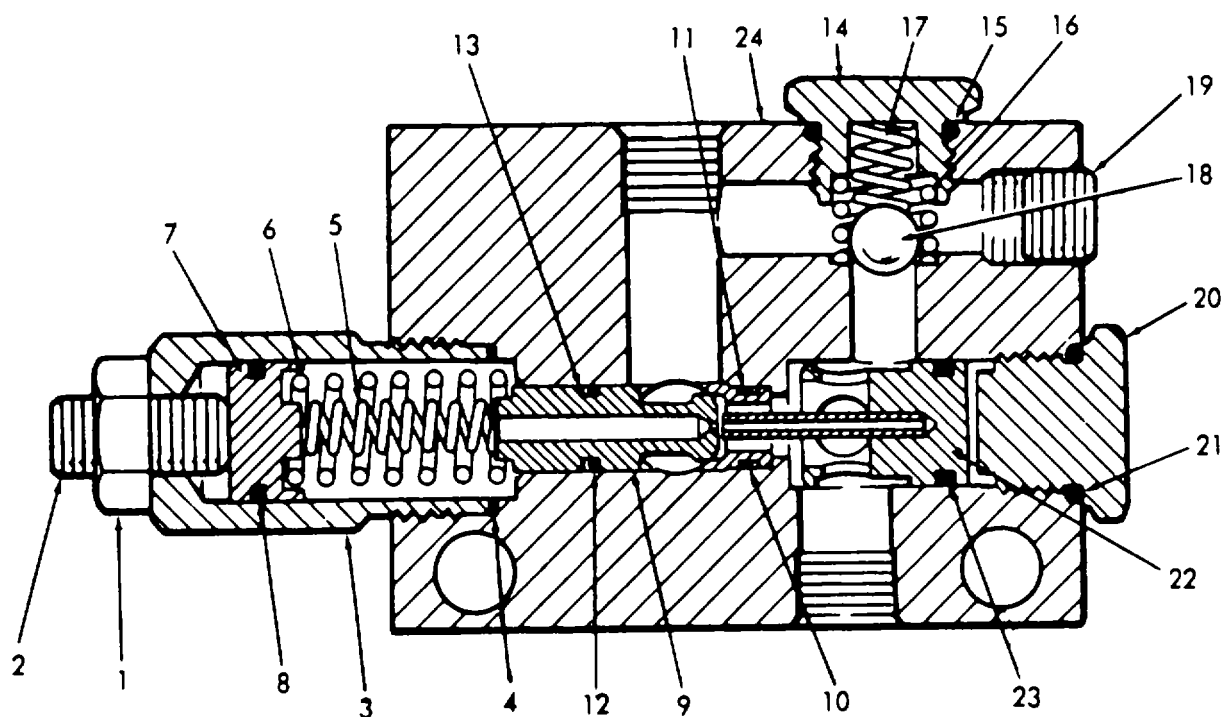
6-5.5 STEERING SYSTEM OVERCENTER VALVE

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



CLEANING

2. Overcenter Valve

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100°-138°F (38°-59°C).

Clean all metal parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

6-5.5 STEERING SYSTEM OVERCENTER VALVE

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION

- | | | |
|---------------------|--|--|
| 3. Overcenter Valve | <ul style="list-style-type: none"> a. Inspect threaded parts for thread damage. b. Inspect springs for distortion or loss of tension. c. Inspect steel ball for flat spots, nicks, burrs, or other damage. d. Inspect piston for burrs or scoring. e. Inspect body for cracks, breaks, or internal scoring. | |
|---------------------|--|--|

REPAIR

- | | | |
|---------------------|--|--|
| 4. Overcenter Valve | <ul style="list-style-type: none"> a. Replace all packings and gaskets. b. Replace damaged threaded parts. | |
|---------------------|--|--|

OVERHAUL

- | | | |
|---------------------|---|--|
| 5. Overcenter Valve | <ul style="list-style-type: none"> a. Replace all packings, gaskets, teflon and leather back-up rings. b. Replace steel ball. c. Replace springs. d. Remove burrs or score marks from piston assembly. e. Remove score marks from body interior. f. Replace other damaged or defective parts as required. | |
|---------------------|---|--|

6-5.5 STEERING SYSTEM OVERCENTER VALVE

LOCATION/ITEM

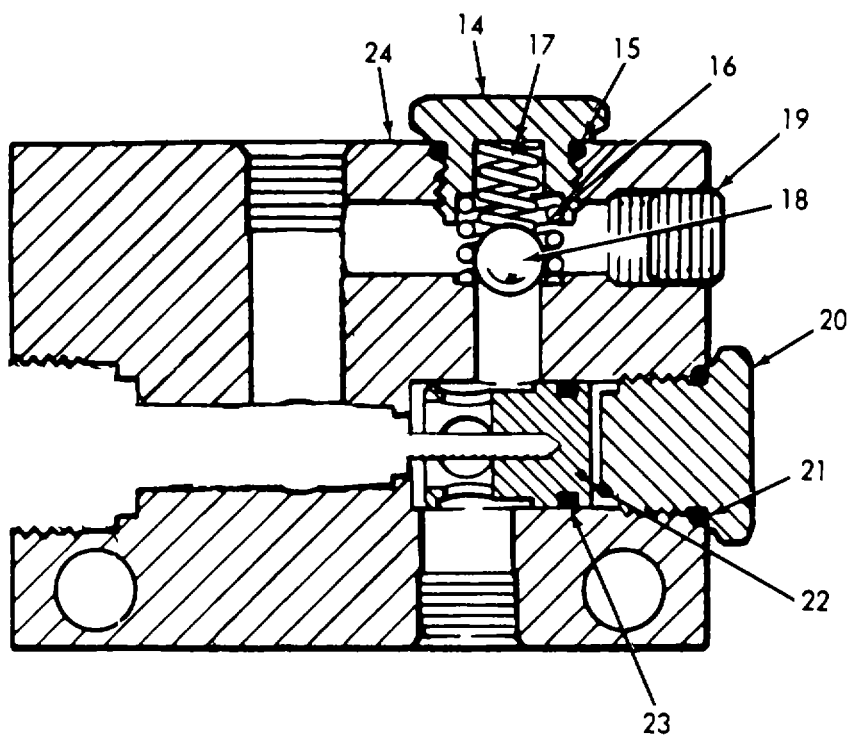
ACTION

REMARKS

ASSEMBLY

6. Overcenter Valve

- a. Install preformed packing (23) on piston.
- b. Insert piston assembly (22) into body (24).
- c. Install preformed packing (21) onto plug and install plug (20) in body (24).
- d. Install plug (19).
- e. Insert steel ball (18), springs (17 and 16), and preformed packing (15) in body.
- f. Secure with plug (14).



6-5.5 STEERING SYSTEM OVERCENTER VALVE

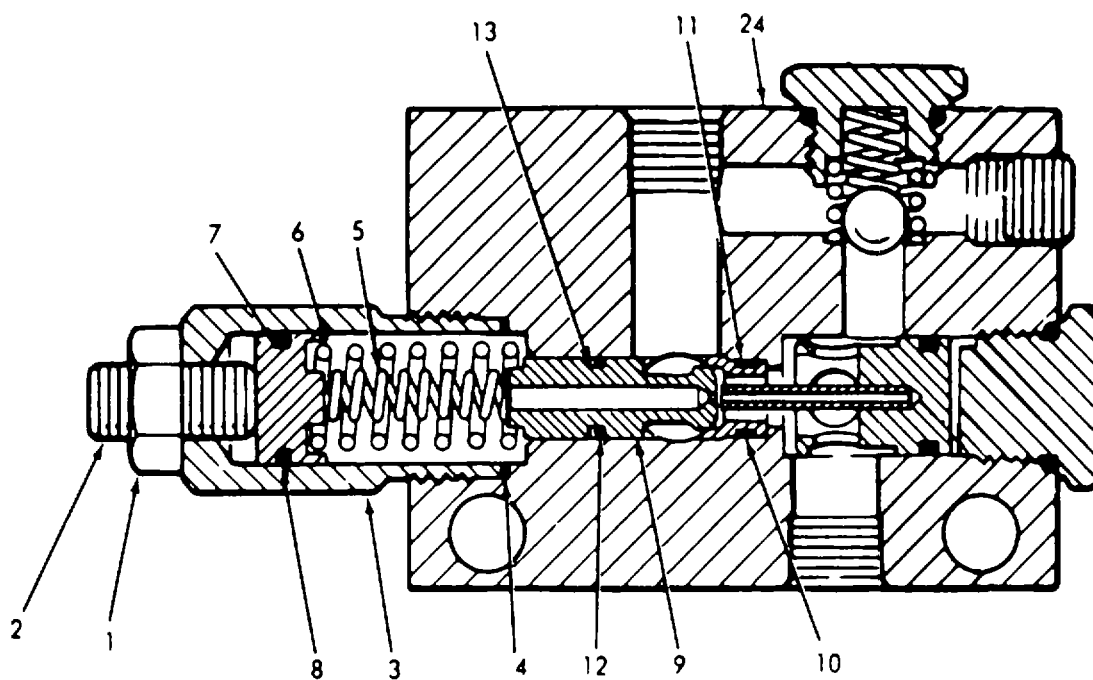
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- g. Install leather back-up (13) and preformed packing (12) onto lapped assembly (9).
- h. Place preformed packing (11) and teflon back-up (10) in body (24) and install lapped assembly (9).
- i. Install preformed packing (8), spring end (7) and springs (6 and 5) into body.
- j. Place gasket (4) onto plug (3), install plug and tighten.
- k. Install nut (1) onto screw (2). If removed
- l. Install screw (2).



6-5.6. STEERING SYSTEM RELIEF VALVE.

This task covers:

- a. Disassembly
- b. Cleaning

- c. Inspection
- d. Repair

- e. Overhaul
- f. Assembly

INITIAL SETUPTest Equipment

NONE

References

Para 2-7.6

Relief Valve Adjustment

Special Tools

NONE

Equipment Condition ParagraphCondition Description

5-7.6 Relief Valve Removed.

Tools

General mechanic's tool kit
NSN 5180-00-629-9783

Material/Parts

Cleaning solvent Fed. Spec.
P-D-680
Clean cloths

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNING in Procedure.

LOCATION/ITEM**ACTION****REMARKS****DISASSEMBLY**

1. Relief Valve

- a. Remove cap (1) and cap gasket (2).
- b. Loosen adjusting nut (3) and remove adjusting screw (4) and gasket (2).
- c. Remove cap (5) and cap gasket (6).

Do not remove
nut from screw
unless damaged.

6-5.6 STEERING SYSTEM RELIEF VALVE (continued)

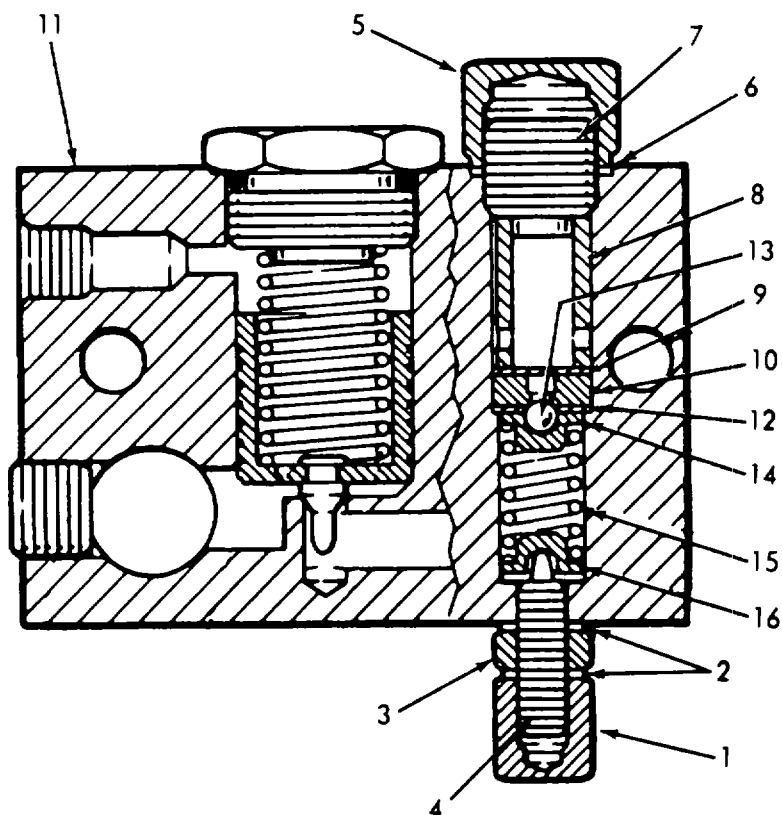
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- d. Remove screw (7), spacer (8), orifice plate (9), and seat (10) from valve body (11).
- e. Remove gasket (12), ball (13), spring end assembly (14), spring (15) and spring end (16).

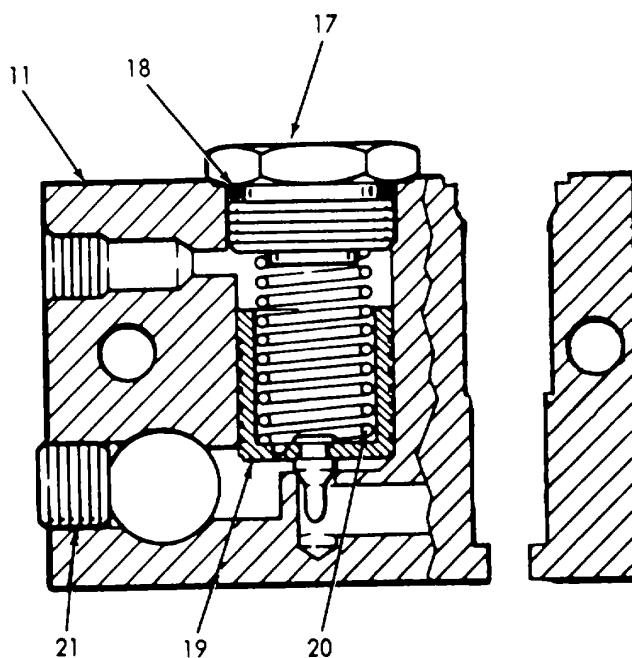


6-5.6 STEERING SYSTEM RELIEF VALVE (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- f. Remove plug (17) and preformed packing (18).
- g. Withdraw piston (19) and spring (20) from valve body (11).
- h. Remove plug (21).



6-5.6 STEERING SYSTEM RELIEF VALVE (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING

2. Relief Valve

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100°-138°F (38°-59°C).

Clean all metal parts in cleaning solvent, Fed. Spec. P-D-680 and dry thoroughly.

INSPECTION

3. Relief Valve

- a. Inspect threaded parts for thread damage.
- b. Inspect springs for distortion or loss of tension.
- c. Inspect piston for scoring or burrs.
- d. Inspect seat for wear.
- e. Inspect orifice plate and spacer for burrs or nicks.

REPAIR

4. Relief Valve

- a. Replace gaskets and packings.
- b. Replace defective threaded parts.

OVERHAUL

5. Relief Valve

- a. Replace worn seats.

6-5.6 STEERING SYSTEM RELIEF VALVE (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

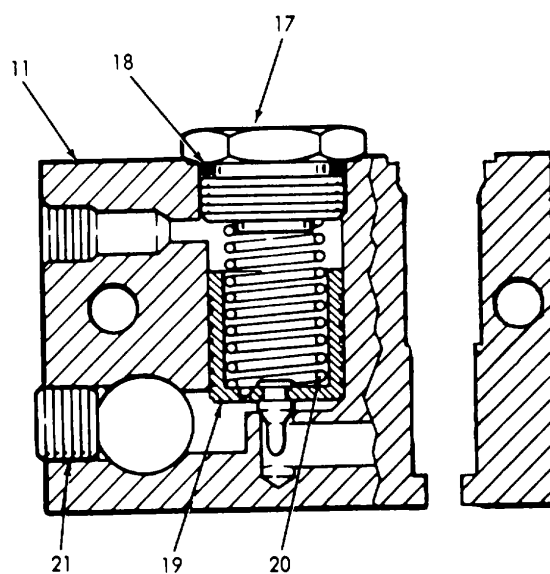
OVERHAUL (Cont)

- b. Replace springs.
- c. Replace all gaskets and packings.
- d. Replace scored piston.
- e. Replace worn orifice plate and spacer.
- f. Replace cracked valve body.

ASSEMBLY

6. Relief Valve

- a. Install plug (21).
- b. Insert spring (20) and piston (19) into valve body (11).
- c. Secure with packing (18) and plug (17).



6-5.6 STEERING SYSTEM RELIEF VALVE (Continued)

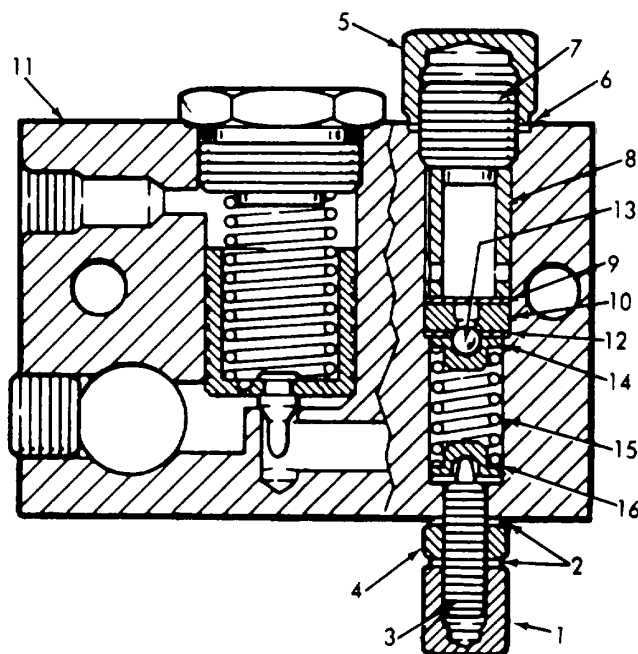
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- d. Insert spring end (16), spring (15), spring end assembly (14), ball (13) and gasket (12).
- e. Insert seat (10), orifice plate (9), spacer (8), and screw (7) into valve body (11).
- f. Install cap gasket (6) onto cap (5) and install cap.
- g. Install adjusting screw (3), gasket (2), and nut (4) and tighten.
- h. Install cap gasket (2) and cap (1).
- i. For adjustment, refer to paragraph 2-7.6.



6-5.7. STEERING SYSTEM FLOW CONTROL VALVE.

This task covers:

- a. Disassembly
- b. Cleaning

- c. Inspection
- d. Repair

- e. Overhaul
- f. Assembly

INITIAL SETUPTest Equipment

NONE

Special Tools

NONE

Tools

General mechanic's tool kit
NSN 5180-00-629-9783

Material/Parts

Cleaning solvent Fed. Spec.
P-D-680
Clean cloths

Personnel Required

MOS 61C10

References

NONE

Equipment

Condition Condition Description
Paragraph

5-7.7 Flow Control Valve Removed.

Special Environmental Conditions

NONE

General Safety Instructions

Observe WARNING in procedure.

LOCATION/ITEM**ACTION****REMARKS****DISASSEMBLY**

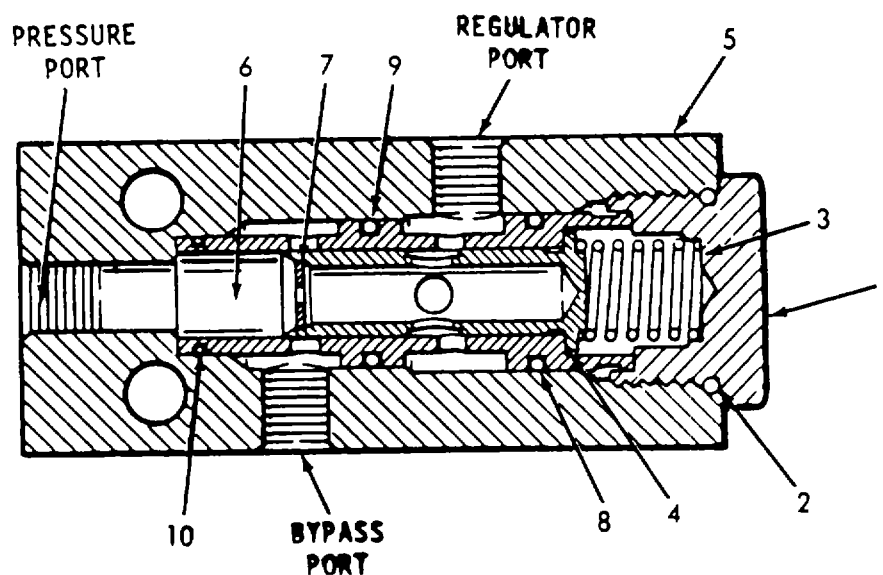
- | | |
|-----------------|---|
| 1. Flow Control | <ul style="list-style-type: none"> a. Remove cartridge (1) and preformed packing (2). b. Remove spring (3) and spring seat (4) from valve body (5). |
|-----------------|---|

6-5.7 STEERING SYSTEM FLOW CONTROL VALVE (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- c. Withdraw spool assembly (6) and gasket (7).
- d. Remove preformed packing (8, 9, and 10).

**CLEANING**

2. Flow Control Valve

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100°-138°F (38°-59°C).

Clean metal parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

6-5.7 STEERING SYSTEM FLOW CONTROL VALVE (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION

- | | | |
|-----------------------|--|--|
| 3. Flow Control Valve | a. Inspect threaded parts for thread damage. | |
| | b. Inspect spring for distortion or loss of tension. | |
| | c. Inspect spring seat for wear. | |
| | d. Inspect spool assembly for scoring or burrs or plugged holes. | |
| | e. Inspect cartridge for damage. | |
| | f. Inspect body for cracks. | |

REPAIR

- | | | |
|-----------------------|--------------------------------------|--|
| 4. Flow Control Valve | a. Replace packings and gaskets. | |
| | b. Replace defective springs. | |
| | c. Replace defective pressure parts. | |

OVERHAUL

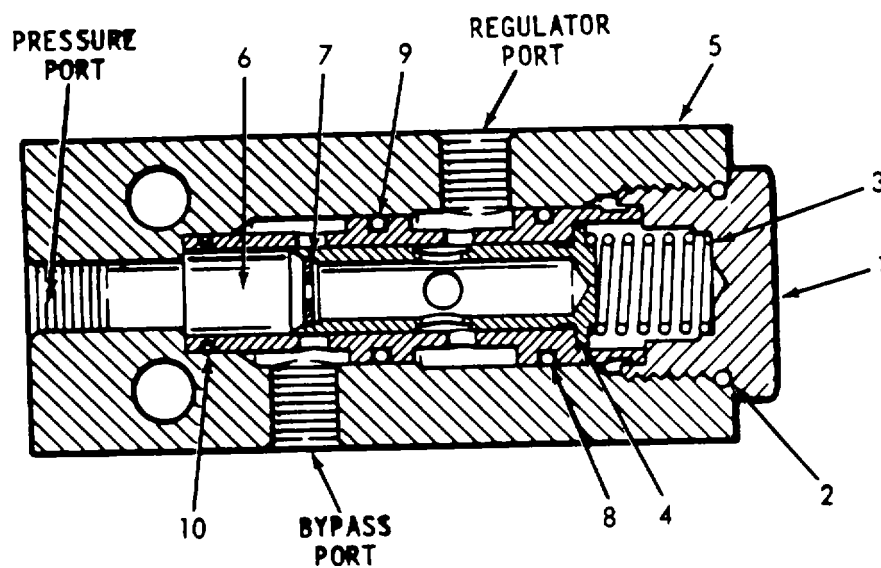
- | | | |
|-----------------------|----------------------------|--|
| 5. Flow Control Valve | a. Replace springs. | |
| | b. Replace spring seat. | |
| | c. Replace springs. | |
| | d. Replace spool assembly. | |
| | e. Replace cartridge. | |

6-5.7 STEERING SYSTEM FLOW CONTROL VALVE (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ASSEMBLY

- | | | |
|-----------------------|--|--|
| 6. Flow Control Valve | <ol style="list-style-type: none"> Install preformed packing (10, 9, and 8) on spool assembly (6). Install gasket (7) and spool assembly (6) in valve body (5). Install spring seat (4), spring (3). Install preformed packing (2) on cartridge (1), then install in valve body (5). | |
|-----------------------|--|--|



6-6. COMMUNICATION EQUIPMENT - ELECTTRIC POWER.

This task covers:

Maintenance

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Equipment
Condition

Condition Description

NONE

Tools

NONE

Material/Parts

NONE

Special Environmental Conditions

NONE

Personnel Required

MOS 31V

General Safety Instructions

NONE

LOCATION/ITEM

ACTION

REMARKS

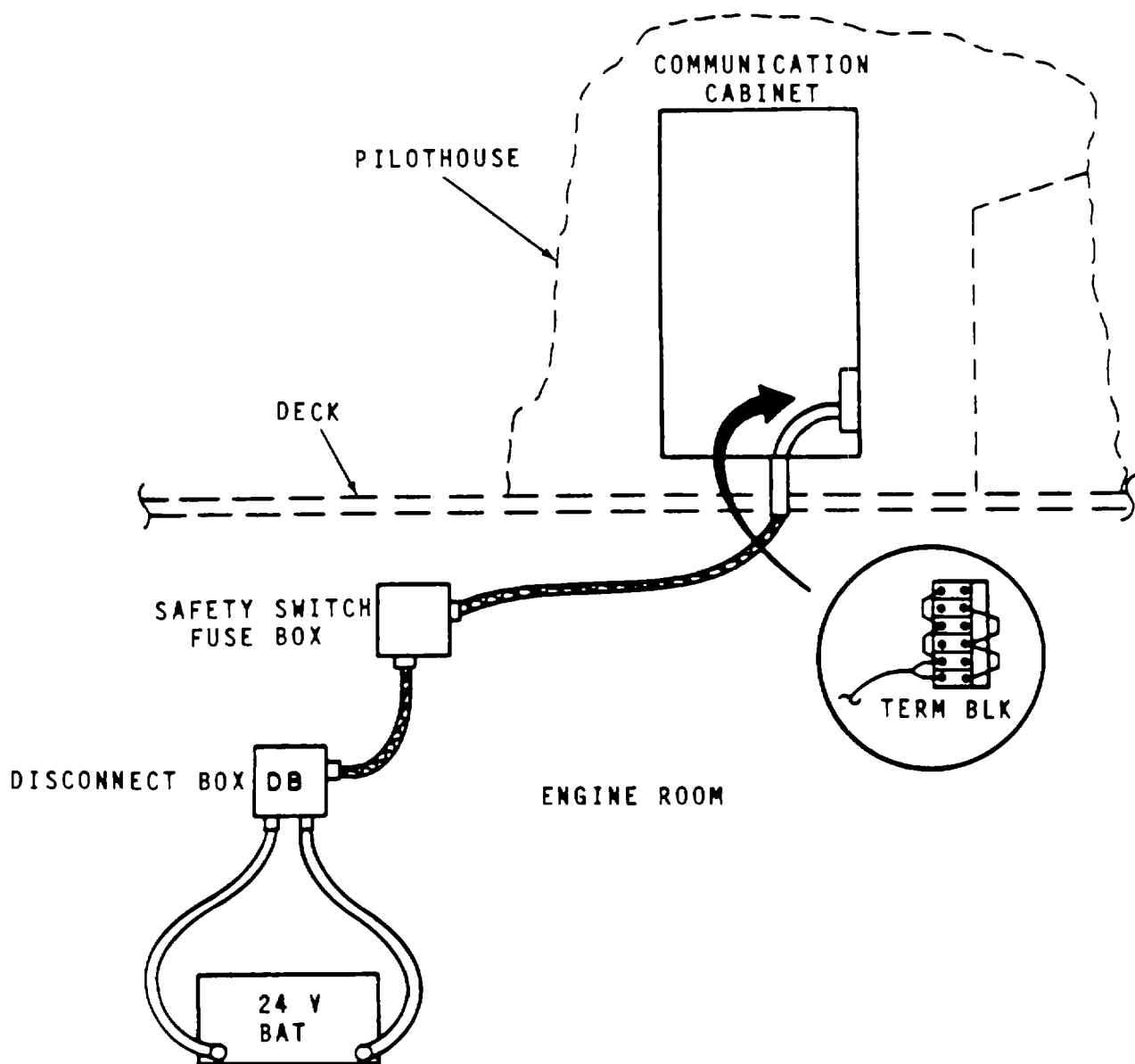
Refer to Direct Support personnel
for Maintenance Instructions
applicable to the electric power.

6-6. COMMUNICATION EQUIPMENT - ELECTRIC POWER (Continued).

LOCATION/ITEM

ACTION

REMARKS



6-7. RADIO SET AN/VRC-46/47.

This task covers:

Maintenance

INITIAL SETUPTest Equipment

NONE

References

TM 11-5820-401-12,
 TM 11-5820-401-34-2 and
 TM 11-5820-401-34-3

Special Tools

NONE

Equipment

<u>Condition</u>	<u>Condition Description</u>
Paragraph	

5-9	Radio Set removed
-----	-------------------

Tools

General Mechanic's Tool Kit
 NSN 5180-00-629-9783

Material/Parts

NONE

Special Environmental Conditions

NONE

Personnel Required

MOS 31V

General Safety Instructions

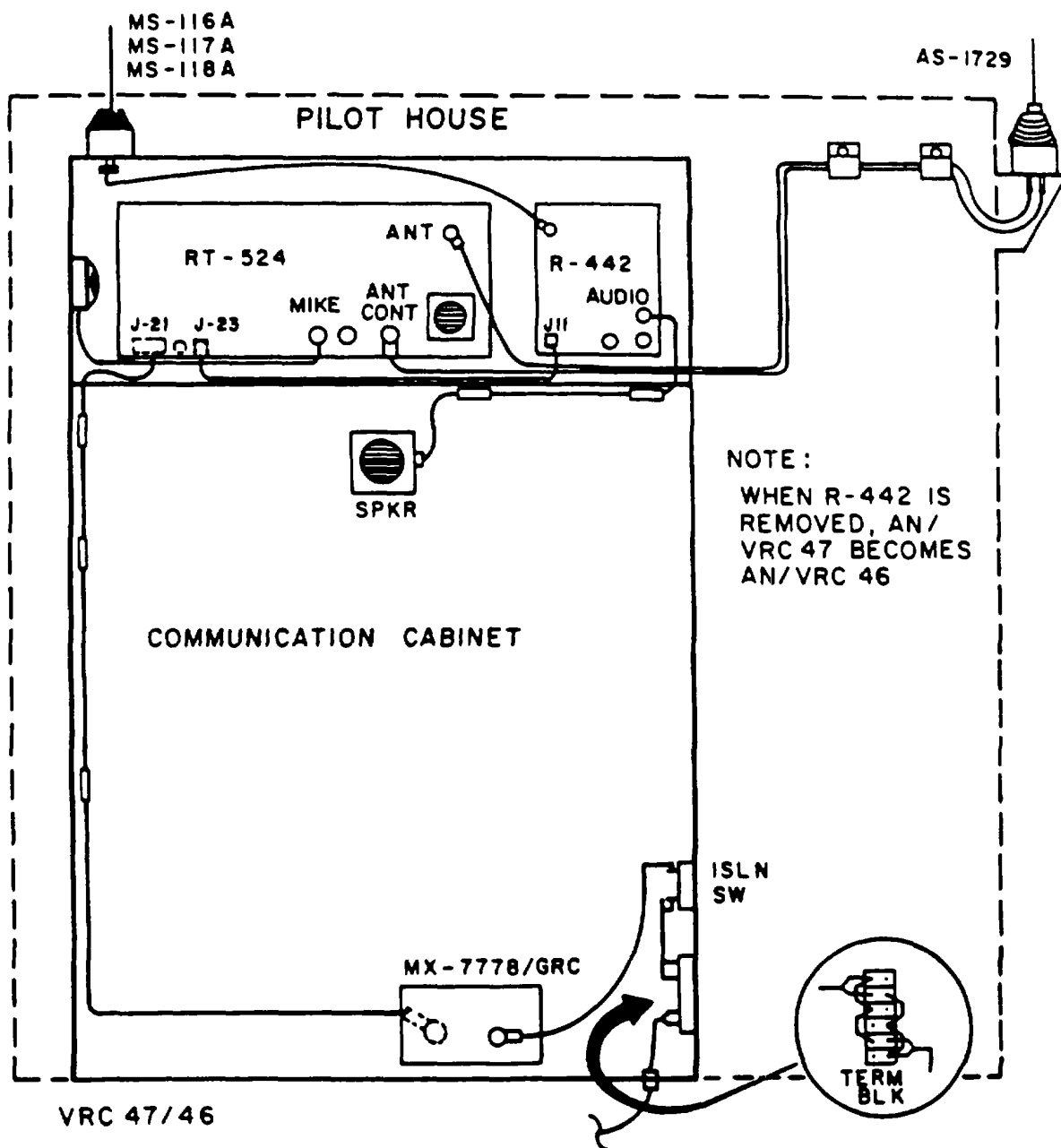
NONE

LOCATION/ITEM**ACTION****REMARKS**

- a. Refer to TM 11-5820-401-12 for Maintenance Instructions applicable to the Radio Set.
- b. Refer to TM 11-5820-401-34-2 and TM 11-5820-401-34-3 for Maintenance Instructions applicable to the Receiver-Transmitter RT-524/VCR used in conjunction with the Radio Set.

6-7. RADIO SET AN/VRC- 46/47 (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------



6-8. RADIO SET AN/VRC-80.

This task covers:

Maintenance

INITIAL SETUPTest Equipment
NONEReferences
TM 11-5820-820-12 and
TM 11-5820-820-30Special Tools

NONE

<u>Equipment Condition</u>	<u>Condition Description</u>
Paragraph	
5-10	Radio Set removed

Tools
General Mechanic's Tool Kit
NSN 5180-00-629-9783Material/Parts
NONESpecial Environmental Conditions
NONEPersonnel Required

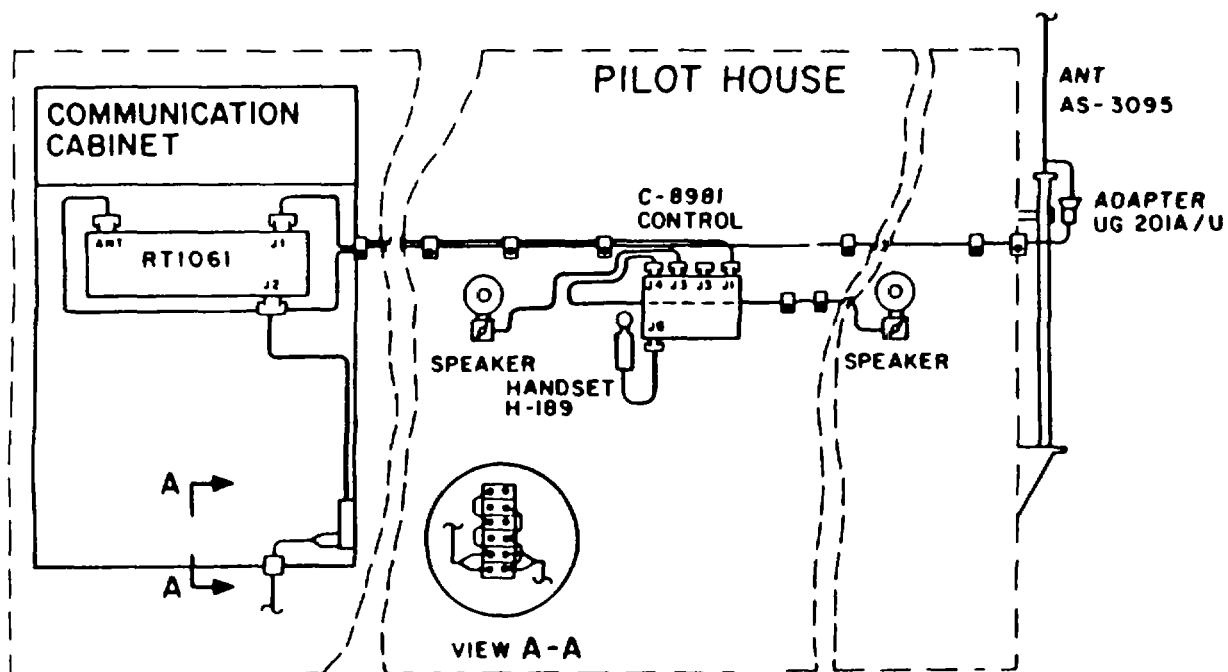
MOS 31VGeneral Safety Instructions

NONELOCATION/ITEMACTIONREMARKS

- a. Refer to TM 11-5820-820-12 for Maintenance Instructions applicable to the Radio Set.
- b. Refer to TM 11-5820-820-30 for Maintenance Instructions applicable to the Receiver-Transmitter used in conjunction with the Radio Set.

6-8. RADIO SET AN/VRC-30 (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------



6-9. RADIO SET AN/VRC-92.

This task covers:

Maintenance

INITIAL SETUP

Test Equipment
NONE

References
TM 11-5820-873-12 and
TM 11-5820-874-34
Equipment

Special Tools

NONE

Condition Condition Description
Paragraph

5-11 Radio Set removed

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts
NONE

Special Environmental Conditions
NONE

Personnel Required

MOS 31V

General Safety Instructions

NONE

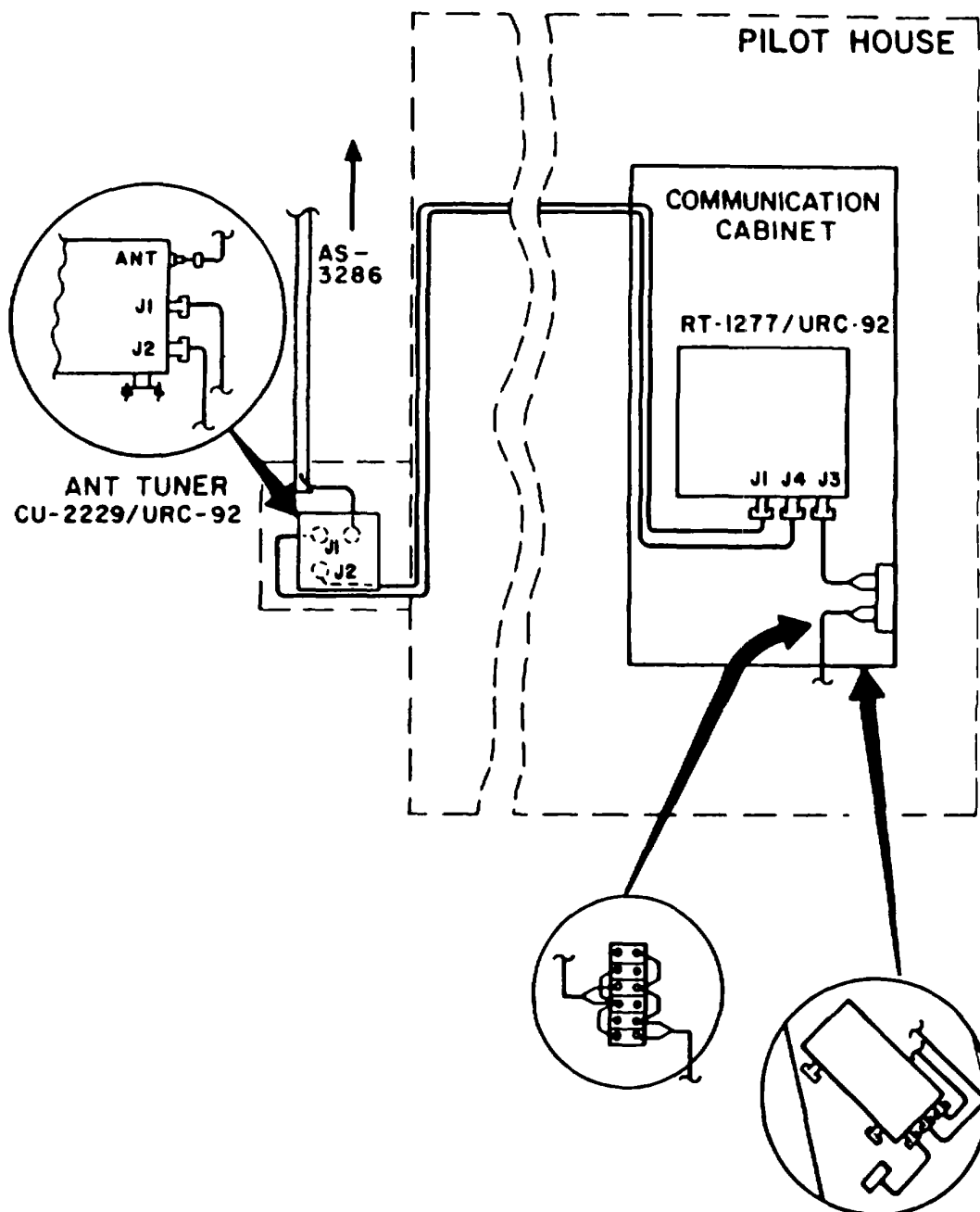
LOCATION/ITEM

ACTION

REMARKS

- a. Refer to TM 11-5820-873-12 and TM 11-5820-873-34 for Maintenance Instructions applicable to the Radio Set.
- b. Refer to Direct Support personnel for Maintenance Instructions applicable to the Receiver-Transmitter.

6-9. RADIO SET AN/VRC-92 (Continued).



6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL.

This task covers:

- | | | |
|----------------|-------------------|-----------------|
| a. Removal | d. Inspection | g. Installation |
| b. Disassembly | e. Repair/Replace | |
| c. Cleaning | f. Assembly | |

INITIAL SETUP

Test Equipment
NONE

References
NONE

Equipment

Special Tools

Condition Condition Description
Paragraph

NONE

NONE

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Hoist
Sledge hammer

Material/Parts

Special Environmental Conditions

Cleaning Solvent
Fed. Spec. P-D-680
Clean Cloths
Grease

NONE

Personnel Required

General Safety Instructions

MOS 61C10, 44B

Observe WARNINGS in procedure.

6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL

2. Ramp
Assembly
and Wire
Rope

NOTE

Use a lifting device capable of lifting thirty five (35) tons (31,751.30 kg) to raise the front end of the vessel.

- a. Attach lifting device and raise front end of vessel.
- b. Attach a suitable lifting device to ramp assembly (1).
- c. Lower ramp by hand far enough to permit access to the hinges and pins.
- d. Detach winch wire rope (2) from hull superstructure (3) and winch drum (4).
- e. Drive hinge pins out of hinges and carefully remove ramp (1) from vessel.
- f. Disconnect ramp lifting device.

6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL

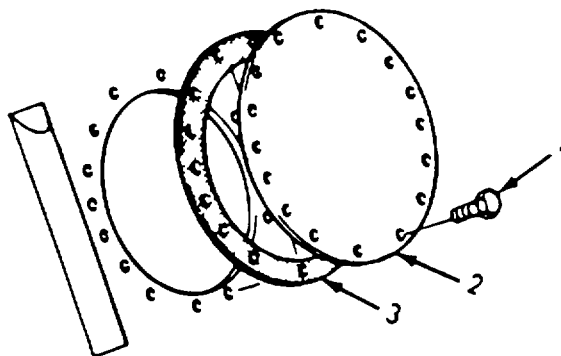
- Access Plates

NOTE

Remove access plates as required to gain entry into the various components for removal of ramp. Refer to figure below for a typical of access plates.

Remove plate mounting screws (1), plate (2) and gasket (3).

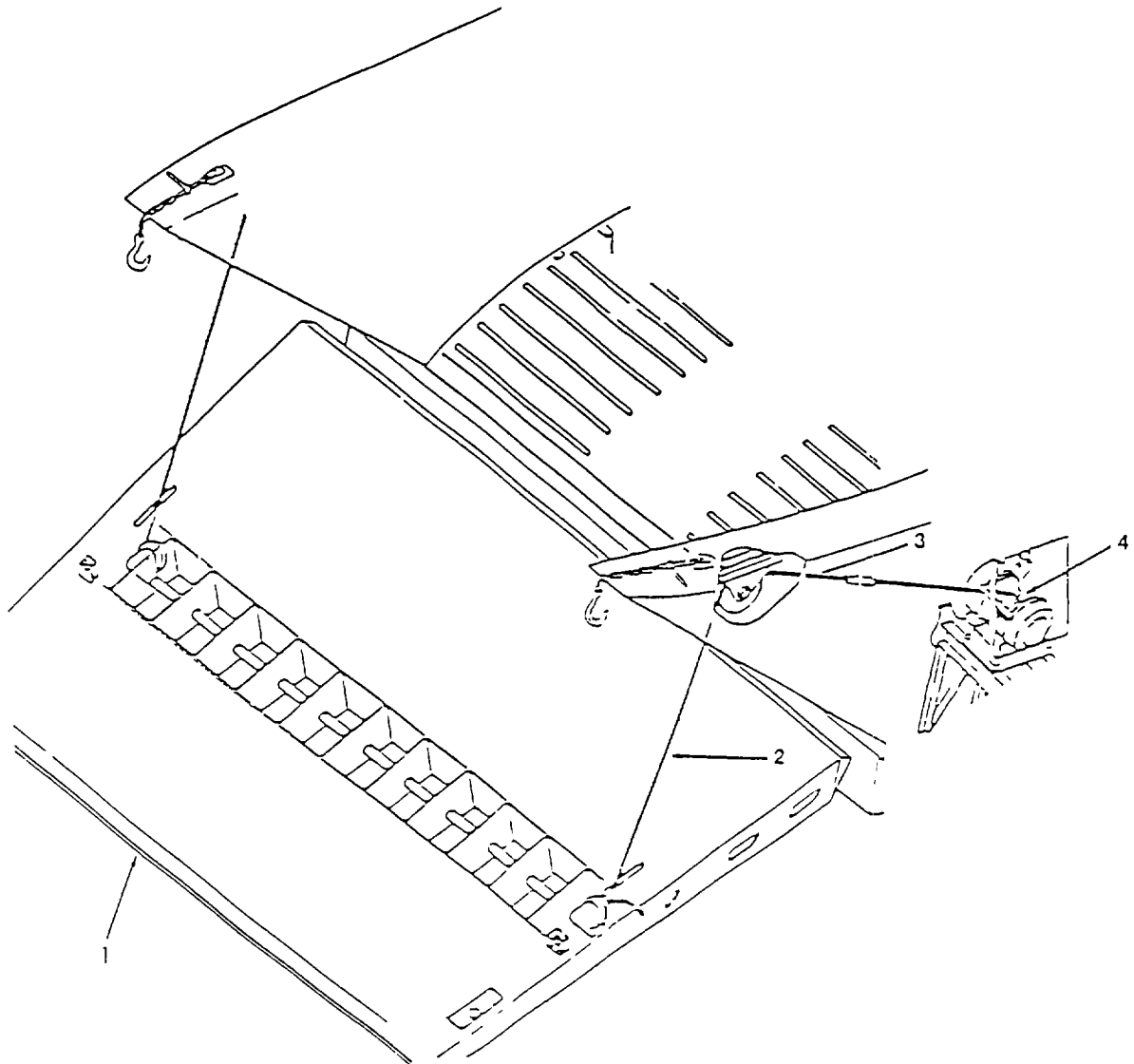
Discard gasket.



6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

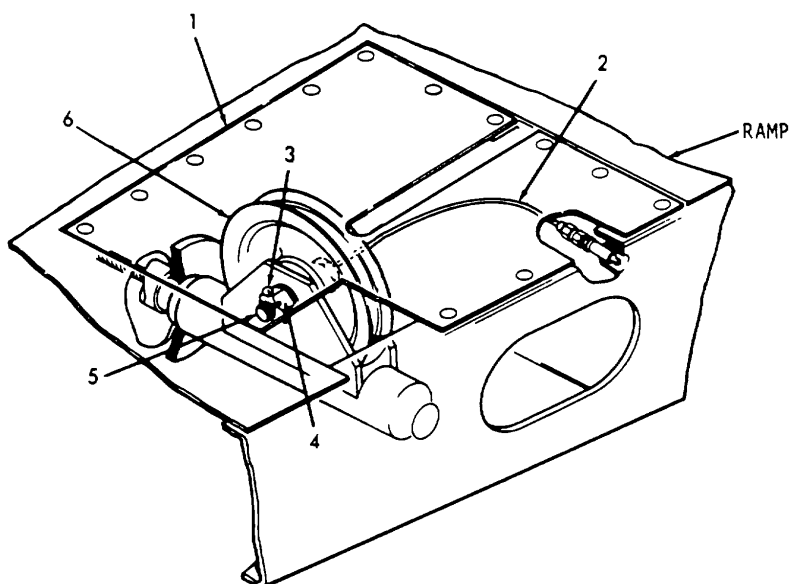


6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

- | | | |
|-----------------------|--|--|
| 3. Ramp Cable Sheaves | a. Remove access plate (1) to cable sheave. | |
| | b. Disconnect and remove hose assembly (2) used to lubricate sheave. | |
| | c. Remove cotter pin (3). | |
| | d. Remove castellated nut (4) from sheave pin. | |
| | e. Remove pin sheave (5) from sheave. | |
| | f. Remove sheave (6). | |
| | g. Remove remaining sheave in a similar manner. | |

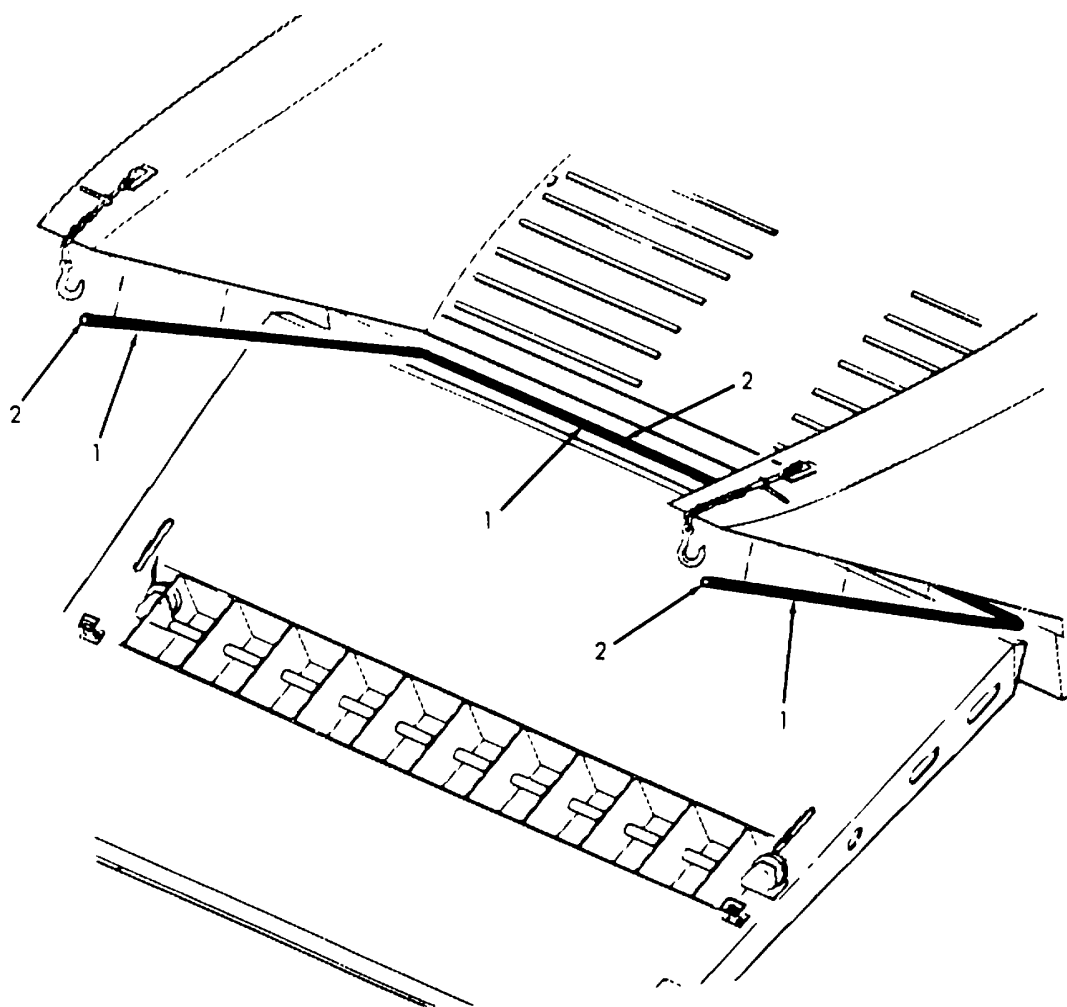


6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

- | | | |
|--------------|--|---|
| 4. Ramp Seal | a. Expand metal tube (1) securing seal (2) in place. | Use suitable pry bars to expand tube securing seal. |
| | b. Remove seal (2) from super-structure. | |



6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

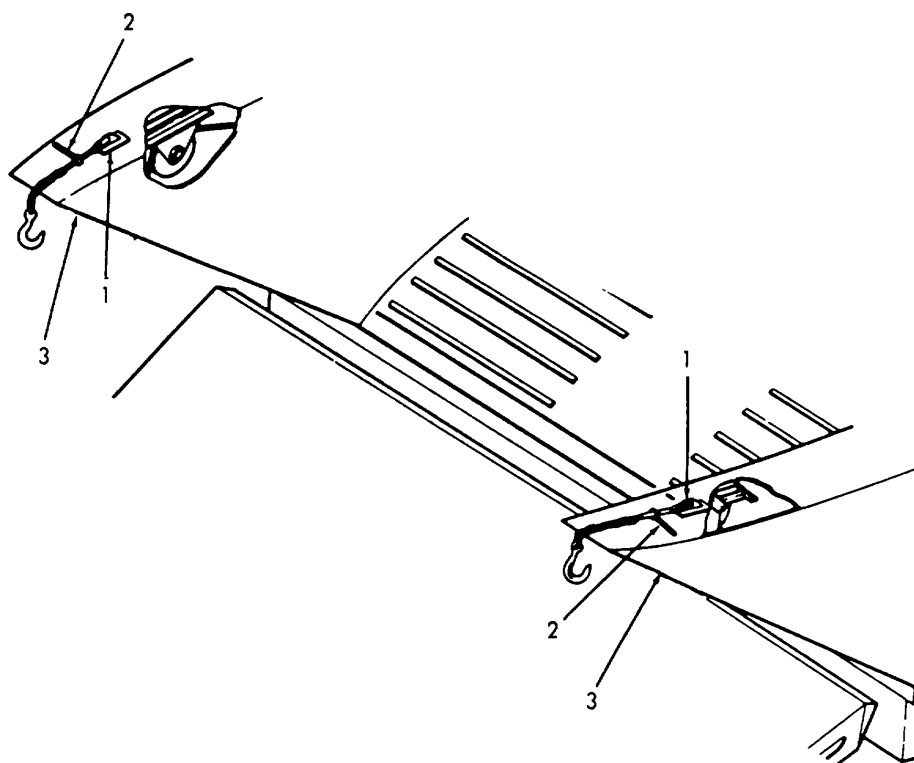
REMOVAL

5. Load Binders

WARNING

Welding must be accomplished by a qualified welder in accordance with standard welding procedures.

- a. Break weld (1) securing load binders (2) to bow (3).
- b. Remove load binders (2).

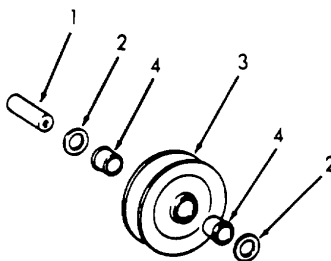


6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)

- | | | |
|------------------|--|----------------------------|
| 6. Cable Sheaves | a. Remove sheave pin (1).
b. Remove flat thrust washers (2) from sheave (3).
c. Remove bushing halves (4) from sheave (3). | Use arbor press to remove. |
|------------------|--|----------------------------|



CLEANING

- | | |
|-----------------------------------|--|
| 7. Ramp, Ramp Cables, and Sheaves | |
|-----------------------------------|--|

WARNING

Dry cleaning solvent, P-D-680, use to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

Clean parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

INSPECTION

- | | |
|-----------------------------------|---|
| 8. Ramp, Ramp Cables, and Sheaves | a. Inspect wire rope for broken strands, kinks or other damage. |
|-----------------------------------|---|

6-10. RAMP RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

- b. Inspect cable sheave, bushings, pins, and thrust washers for cracks, breaks or burrs.
- c. Inspect load binders for cracked or broken chain links or a defective ratchet.
- d. Inspect latch pins for burrs or cracks, threaded parts for thread damage, clevis and latch for cracks or breaks.

REPAIR/REPLACE

- | | |
|-----------------------------------|---|
| 9. Ramp, Ramp Cables, and Sheaves | <ul style="list-style-type: none"> a. Replace defective parts as required with a serviceable-like item. b. Remove burrs by grinding smooth or light stoning. c. Replace gaskets and seals. |
|-----------------------------------|---|

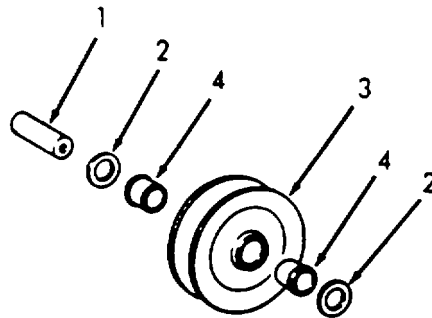
ASSEMBLY

- | | |
|-------------------------------------|---|
| 10. Cable Sheaves into sheaves (3). | <ul style="list-style-type: none"> a. Press bushing halves (4) Use arbor press. b. Install thrush washers (2) in sheave (3). c. Install sheave pin (1). |
|-------------------------------------|---|

6-10. RAMP RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ASSEMBLY (Cont)



6-10. RAMP RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

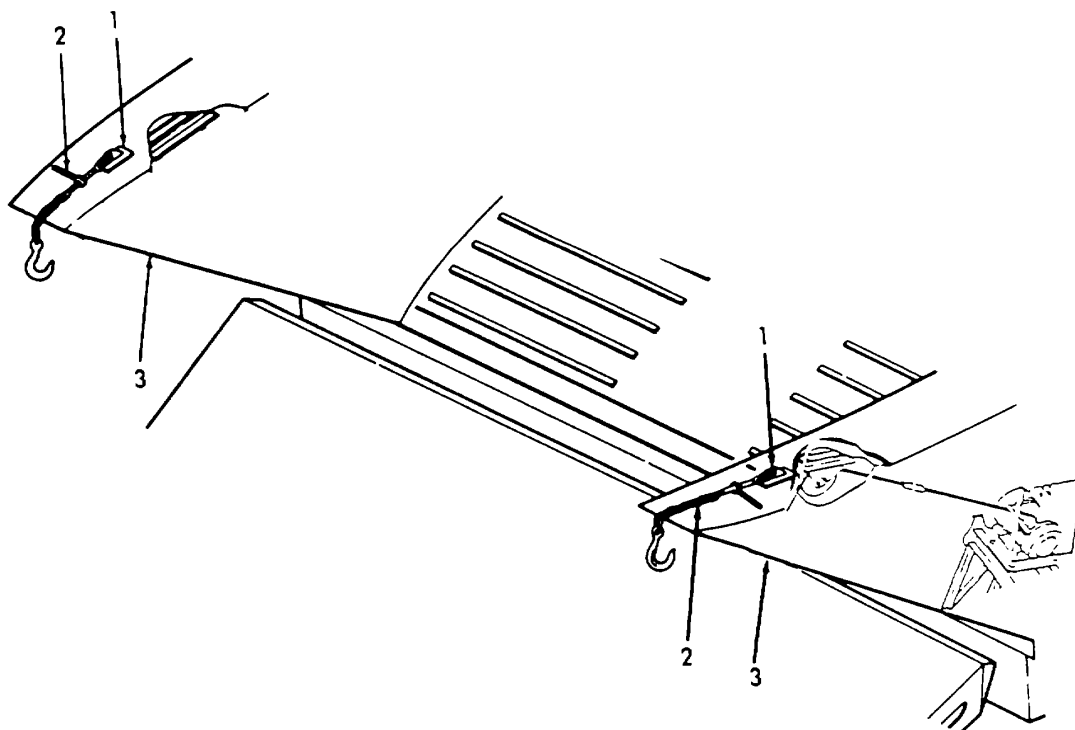
INSTALLATION

11. Load Binders

WARNING

Welding must be performed by a qualified welder only in accordance with standard welding procedures.

- a. Position load binders (2) in place on bow.
- b. Weld (1) to bow (3).
- c. Grind weld smooth.



6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

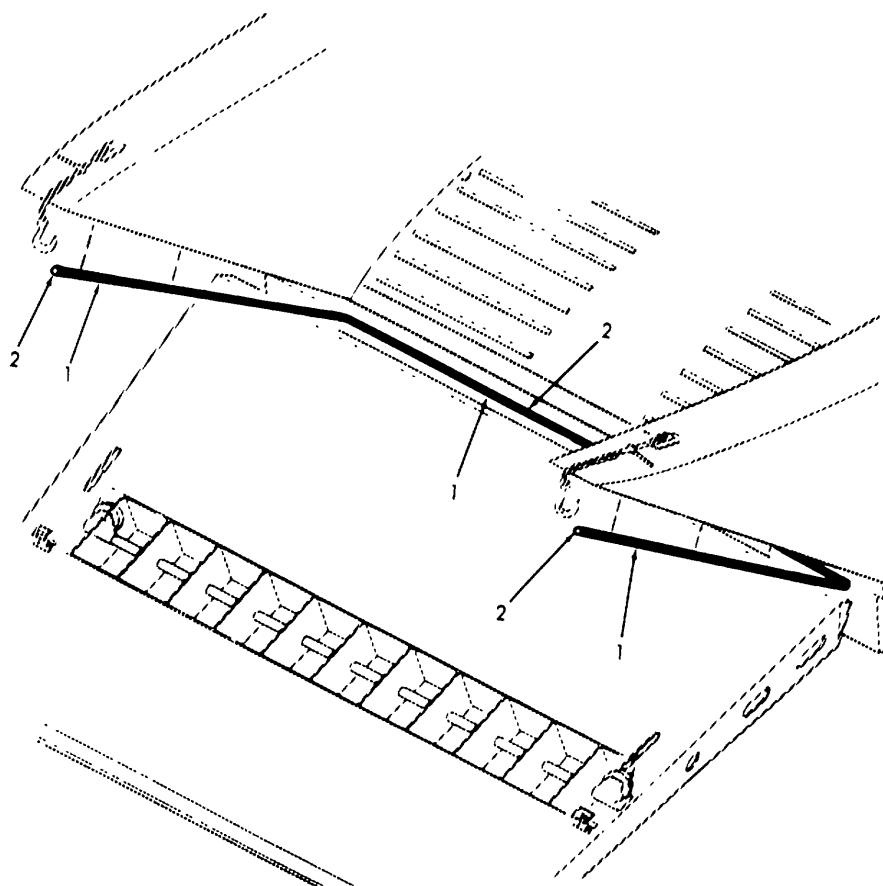
INSTALLATION (Cont)

12. Ramp Seal

a. Expand metal tube (1) far enough to accommodate seal.

Use suitable pry bars to expand tube.

b. Install seal (2).



6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

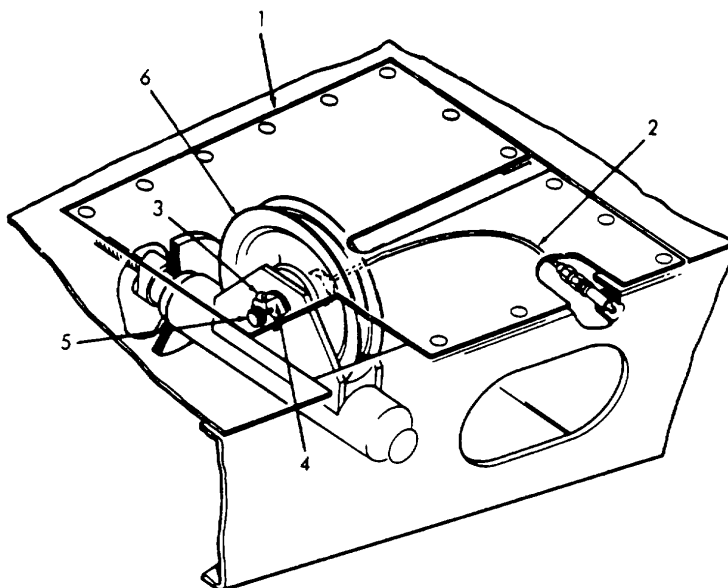
- | | | |
|-------------------|----------------------------------|--|
| 13. Cable Sheaves | a. Position sheave (6) in place. | |
| | b. Install pin (5) in sheave. | |

6-10. RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- c. Secure pin sheave (5) with castellated nut (4).
- d. Align holes in nut (4) with holes in pin (5) then secure with cotter pin (3).
- e. Reconnect lubricating hose (2) to sheave.
- f. Install access plate (1).
- g. Install remaining sheaves in a similar manner.



6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- | | | |
|---------------------------------|--|--|
| 14. Ramp Assembly and Wire Rope | <ul style="list-style-type: none"> a. Attach a suitable lifting device to the ramp assembly. b. Place ramp assembly (1) in position on bow. c. Attach one end of wire rope (2) to winch drum (4). d. Thread wire rope (2) through cable sheaves (5, 6, and 7) and secure to superstructure (3). e. Align ramp assembly (1) with holes in hinges and drive in hinge pins to secure. f. Raise ramp assembly by hand to lock in place. g. Remove lifting device. | |
|---------------------------------|--|--|

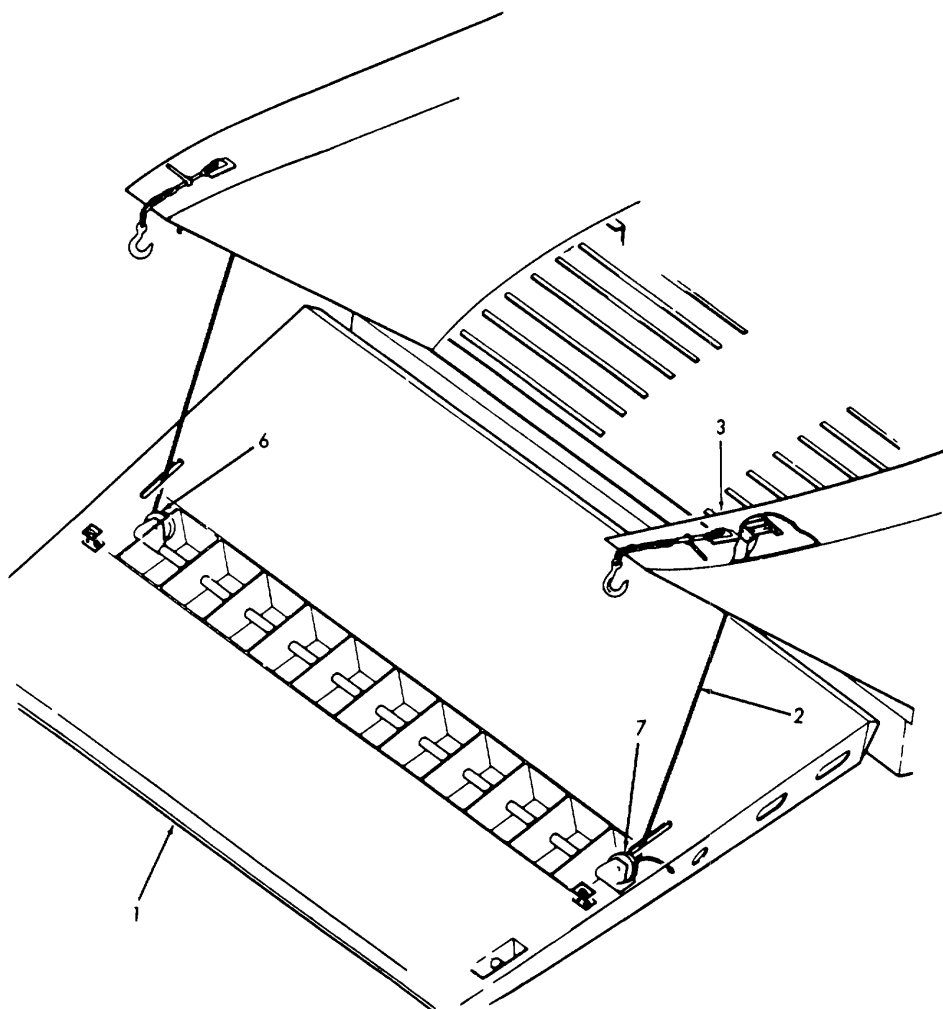
NOTE

Use a lifting device capable of lifting thirty-five (35) tons (31,751.30 kg) to lower front end of vessel.

6-10. RAMP RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEA L
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

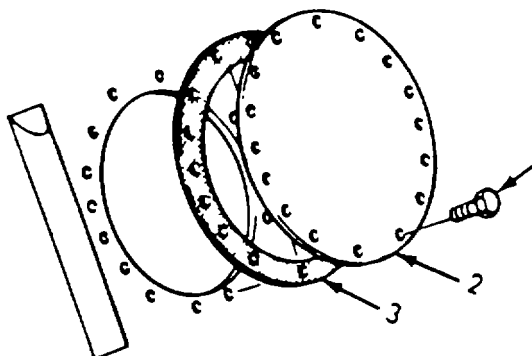


6-10. RAMP, RAMP CABLES, SHEAVES, LATCH MECHANISM AND SEAL
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

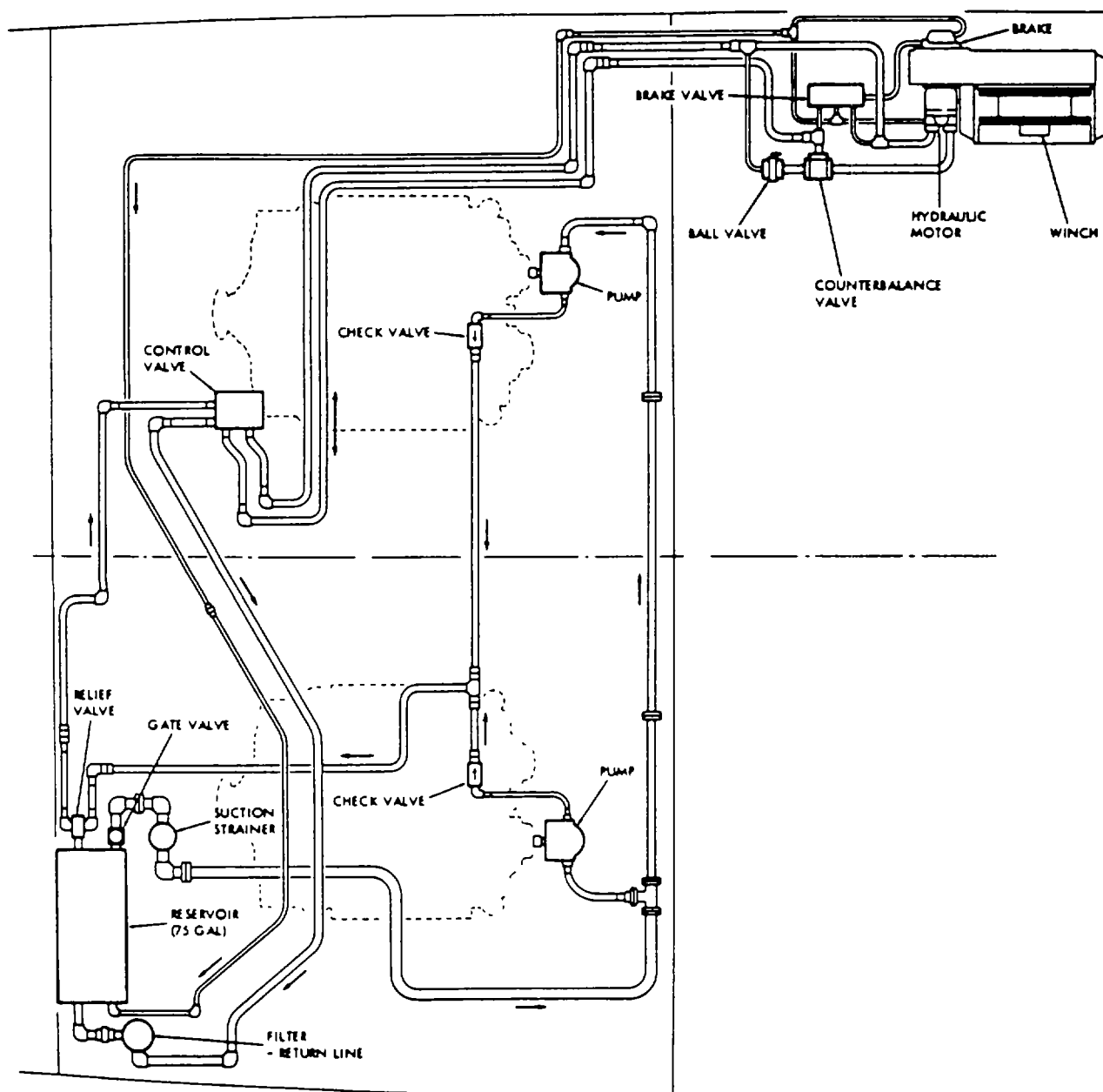
INSTALLATION (Cont)**15. Access Plates**

- a. Position access plate gaskets (3) in place.
- b. Install access plates (2) using screws (1).



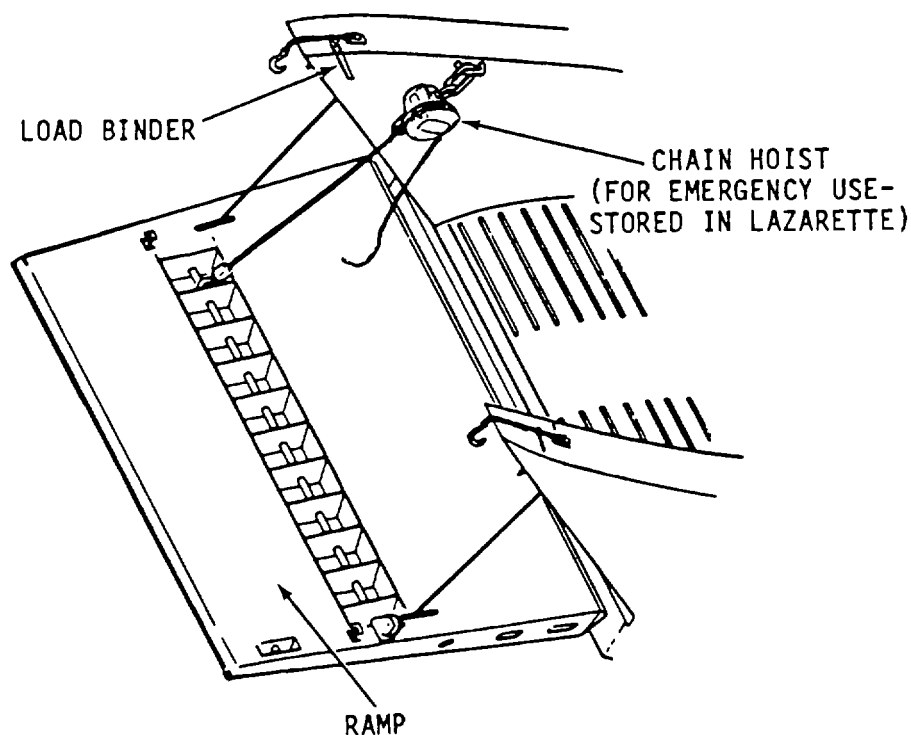
6-11. MOTOR, HYDRAULIC, RAMP WINCH.

- a. The ramp hoisting arrangement consists of a hoisting cable deadended to one side of the craft, running through fairlead sheaves through the ramp and to a winch on the opposite side. The winch is on the port side.
- b. The winch is powered by a hydraulic motor. Other system components include a four way control valve, counterbalance valve, two engine driven pumps, two check valves, suction line strainers, and return line filters. See figure below for ramp system diagram. Return hydraulic fluid from the counterbalance valve is routed to a reservoir.



6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

c. Emergency lowering of the ramp is accomplished by a manual brake release. Two chain hoists are stored in the lazarette to be used for emergency lifting or lowering of the ramp.



d. When removing components from the system, observe WARNING in procedure. Then, disconnect hydraulic lines, cap open ends, and leave lines in place unless in need of replacement. Fittings may be left in components unless fittings are damaged or components are to be replaced. When breaking hydraulic line connections, cap all open line ends and ports.

e. Replenish lost ramp system hydraulic fluid with fluid 2135 TH, MIL-17672B or 2075 TH, MIL-17672B. Refill the system through the tank filler.

6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

This task covers:

- | | | |
|----------------|----------------|-----------------|
| a. Removal | d. Inspection | g. Overhaul |
| b. Disassembly | e. Replacement | h. Assembly |
| c. Cleaning | f. Repair | i. Installation |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

EquipmentCondition Condition Description

NONE

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Cleaning Solvent
Fed. Spec. P-D-680
Clean lint free cloths
Hydraulic fluid 2135 TH,
MIL-17672B or 2075 TH,
MIL-17672B

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNINGS in procedure.

6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL

1. Hydraulic Lines

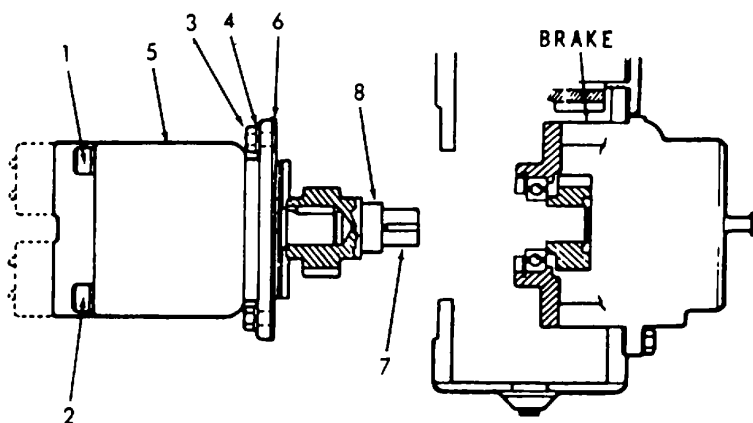
WARNING

The fluid pressure in the system must be released prior to servicing the motor or other parts to prevent possible injury to personnel or equipment.

- | | |
|---|--|
| a. Loosen hydraulic lines slowly to relieve pressure. | Drain lines into a suitable container. |
| b. Disconnect hydraulic lines (1 and 2) from motor. | Cap open ends. |

2. Motor

- | | |
|--|-----------------|
| a. Remove four capscrews (3) and lockwashers (4) securing motor. | |
| b. Remove motor (5) and mounting gasket (6). | Discard gasket. |
| c. Remove key (7) from gear shaft (8). | |



6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

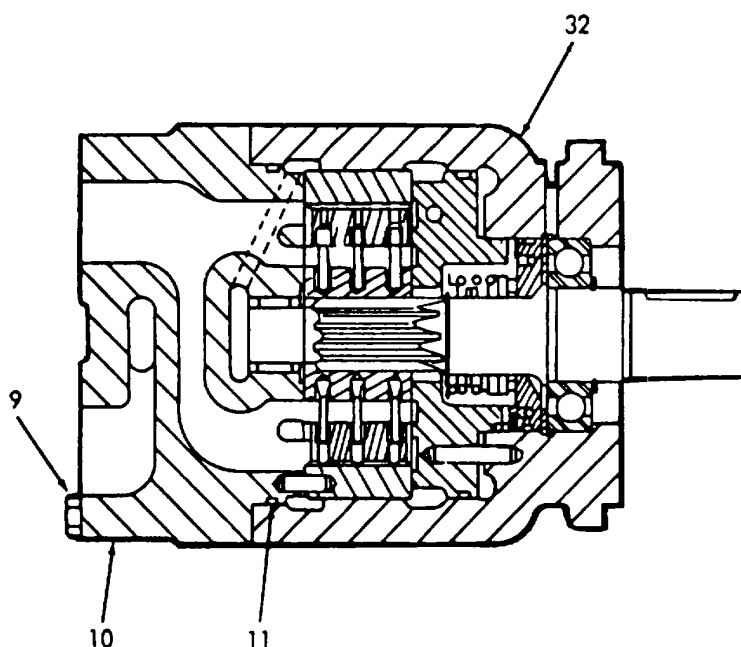
LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

3. Replace motor if damaged beyond repair.

DISASSEMBLY

4. Motor
- Remove four socket head cap screws (9) from end cap (10).
 - Remove end cap (10) from motor housing (32).
 - Remove preformed packing (11) Discard. from end cap (10).



6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

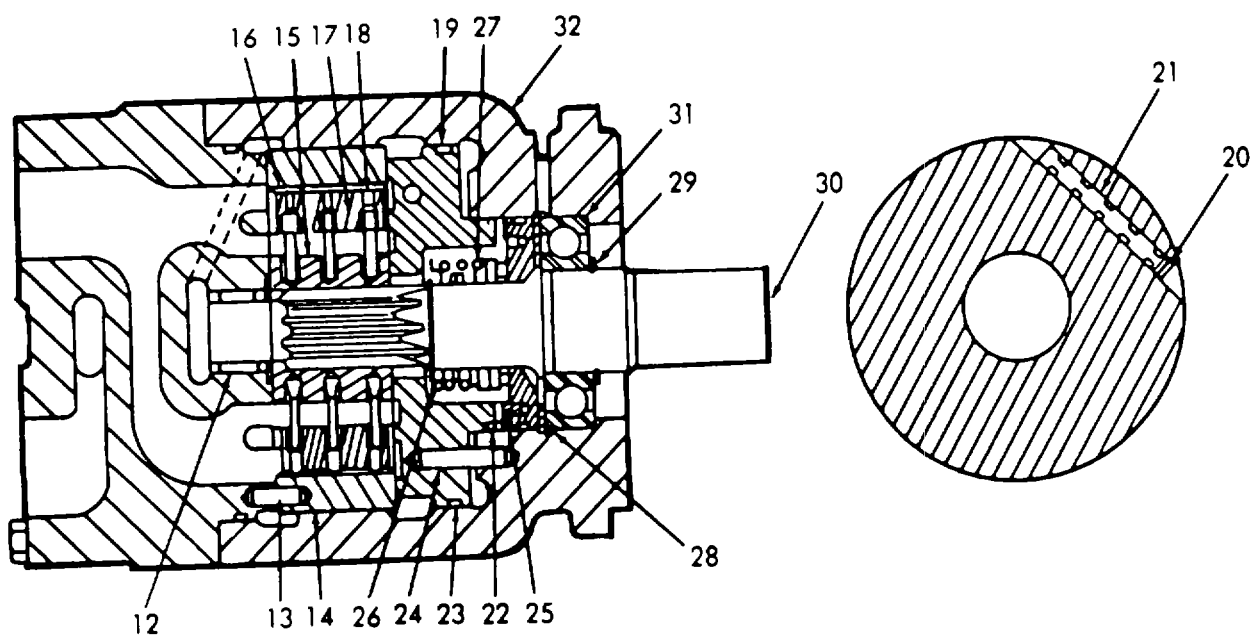
DISASSEMBLY (Cont)

- | | |
|---|-------------|
| d. Remove needle bearing (12) from end of shaft. | |
| e. Remove dowel pins (13). | If damaged. |
| f. Remove cam ring (14) and rotor (15). | |
| g. Remove rotor vane roll pins (16), vanes (17), and springs (18) from rotor. | |
| h. Remove front port plate (19). | |
| i. Remove setscrew (20) securing shuttle valve spool (21) and remove spool. | |
| j. Remove packings (22 and 23) from front port plate (19). | Discard. |
| k. Remove dowel pins (24) from port plate (19). | If damaged. |
| l. Remove spring washer (25). | |
| m. Remove retaining ring (26) and seal assembly (27). | |
| n. Remove retaining rings (28 and 29) securing shaft and remove shaft (30) from housing (32). | |
| o. Remove ball bearing (31) from shaft (30). | |

6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY (Cont)



6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

CLEANING

5. Motor

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59° C).

- a. Clean all metal parts in cleaning solvent, Fed. Spec. P-D-680, and dry thoroughly.
- b. Turn bearings by hand only when cleaning.

INSPECTION

6. Motor

- a. Inspect threaded parts for thread damage.
- b. Rotate needle bearing and ball bearing by hand and check for smooth and free rotation. Also, inspect balls, needles, and races for visible damage.
- c. Inspect rotor vane springs for distortion or loss of tension.
- d. Inspect rotor vanes and pins for burrs or nicks.
- e. Inspect shuttle valve spool for burrs or scoring.
- f. Check shaft keys for tight fit in keyway.

6-11. HYDRAULIC PUMP DRIVE COMPONENTS (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REPAIR

- | | | |
|----------|---|--|
| 7. Motor | <ul style="list-style-type: none"> a. Replace all packings and gaskets. b. Replace defective seal assembly. c. Remove score marks and minor scratches from shuttle valve spool by light stoning. d. Replace defective springs. e. Remove burrs from rotor vanes and pins. f. Replace cracked motor housing. | |
|----------|---|--|

OVERHAUL

- | | | |
|----------|---|--|
| 8. Motor | <ul style="list-style-type: none"> a. Replace ball and needle bearings. b. Replace all packings and gaskets. c. Replace seal assembly. d. Replace rotor vanes and springs. e. Replace end cap if warped or cracked. f. Replace front port plate if warped or cracked. g. Replace keys if loose in keyways. | |
|----------|---|--|

6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY		
9. Motor	<ul style="list-style-type: none"> a. Lubricate all seals and packings with clean hydraulic fluid before assembly. b. Install ball bearing (31) onto end of shaft (30). c. Insert shaft (30) into housing (32) and secure with retaining rings (29 and 28). d. Install seal assembly (27) and retaining ring (26). e. Install spring washers (25). f. Install dowel pins (24) in port plate (19). g. Install packings (23 and 22) in port plate (19). h. Install shuttle valve spool (21) and secure with setscrew (20). i. Install front port plate (19). j. Insert vane springs (18) and vanes (17) into slots on rotor (15). k. Secure springs and vanes in rotor with roll pins (16). l. Install rotor (15) and cam ring (14). m. Install dowel pins (13) in end cap (10). 	<p>If removed.</p> <p>Setscrew is 5/16-18. Torque to 70-90 lb. in. (7.9-10.2 Nm).</p> <p>If removed.</p>

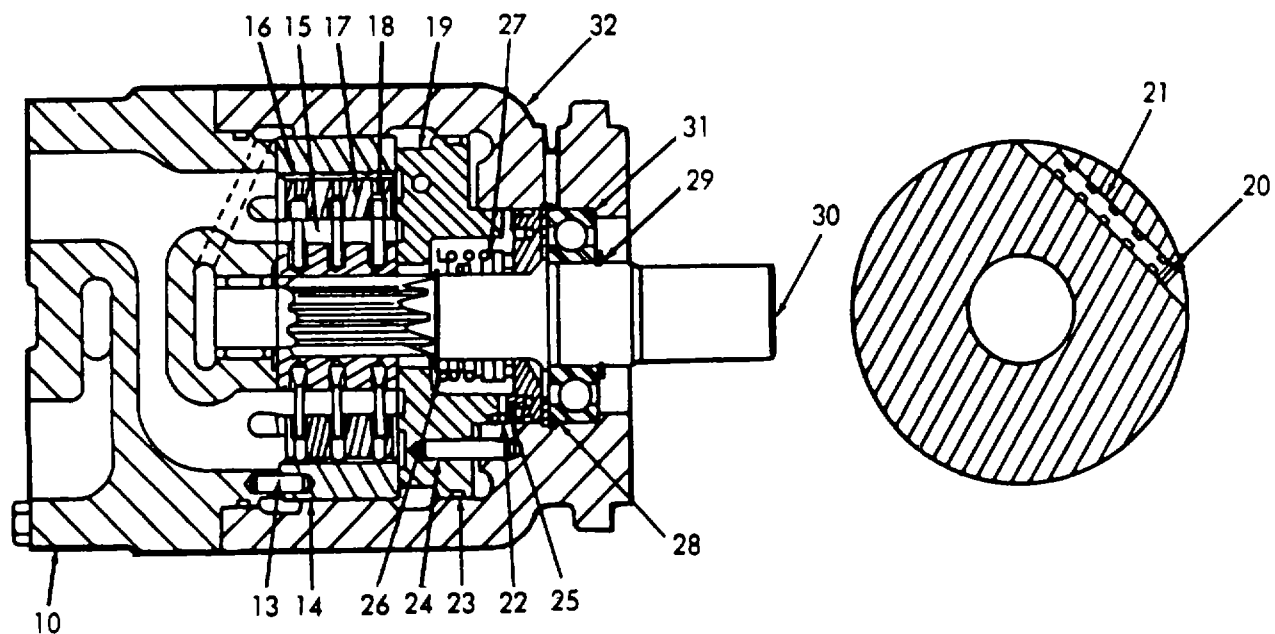
6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)



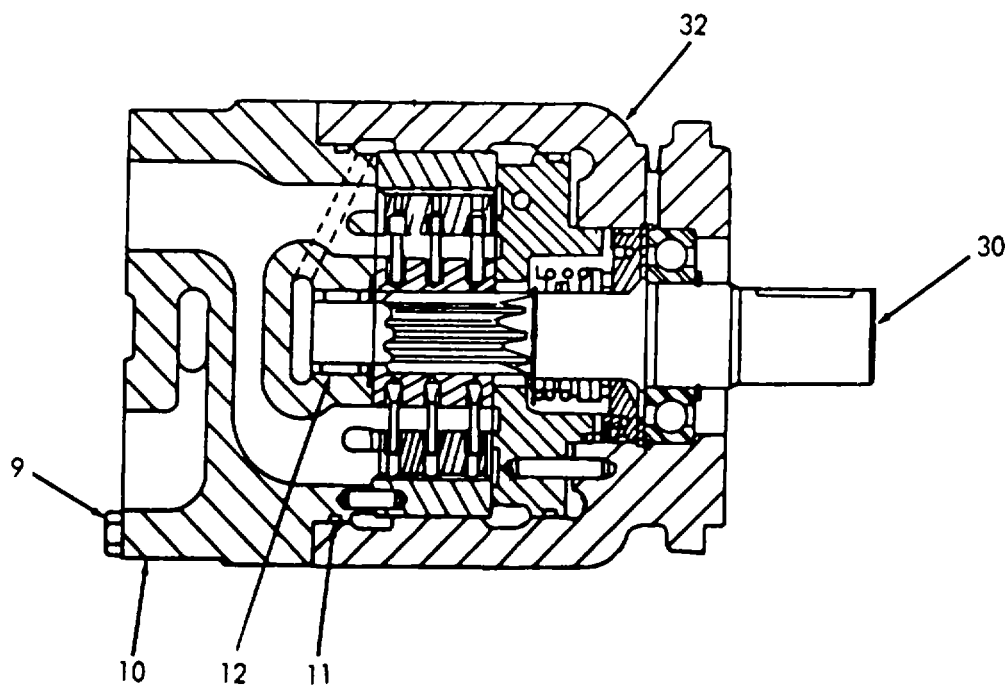
6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued)

LOCATION/ITEM	ACTION	REMARKS
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ASSEMBLY (Cont)

- n. Install needle bearing (12) onto end of shaft (30).
- o. Install preformed packing (11) in end cap (10).
- p. Position end cap (10) in place on housing (32) and secure with four socket head capscrews (9).

Screws are 5/8-11. Torque to 700-900 lb. in. (79.1-101.7 Nm).



6-11. MOTOR, HYDRAULIC, RAMP WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

INSTALLATION

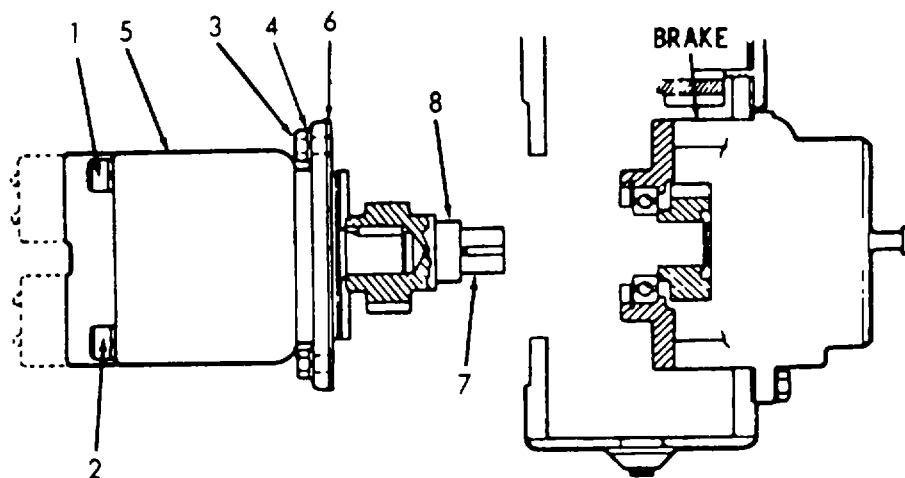
10. Motor Assembly

- a. Insert key (7) in keyway on gear shaft (8).
- b. Position gasket (6) in place and install motor (5) with lockwashers (4) and four capscrews (3).
- c. Reconnect hydraulic lines (2 and 1).
- d. Replenish lost hydraulic fluid through tank filler.
- e. Repressurize hydraulic system.

Screws are 1/2-13. Torque to 400-480 lb. in. (45.2-54.2 Nm).

Remove end caps.

Use fluid 2135TH, MIL-17672B, or 2075TH, MIL-17672B.



6-12. WINCH.

This task covers:

- | | | |
|----------------|----------------|-----------------|
| a. Removal | e. Replacement | i. Assembly |
| b. Disassembly | f. Repair | j. Installation |
| c. Cleaning | g. Overhaul | |
| d. Inspection | h. Lubrication | |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

Equipment
Condition
Paragraph

Condition Description

6-11

Motor removed,
disassembled, and
reassembled

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Cleaning Solvent
Fed. Spec. P-D-680
Clean lint free cloths
Hydraulic fluid 2135 TH,
MIL-17672B or 2075 TH,
MIL-17672B
SAE90 gear lubricant

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10, 44B

General Safety Instructions

Observe WARNINGS and CAUTIONS in
procedure.

6-12. WINCH (Continued)

LOCATION/ITEM

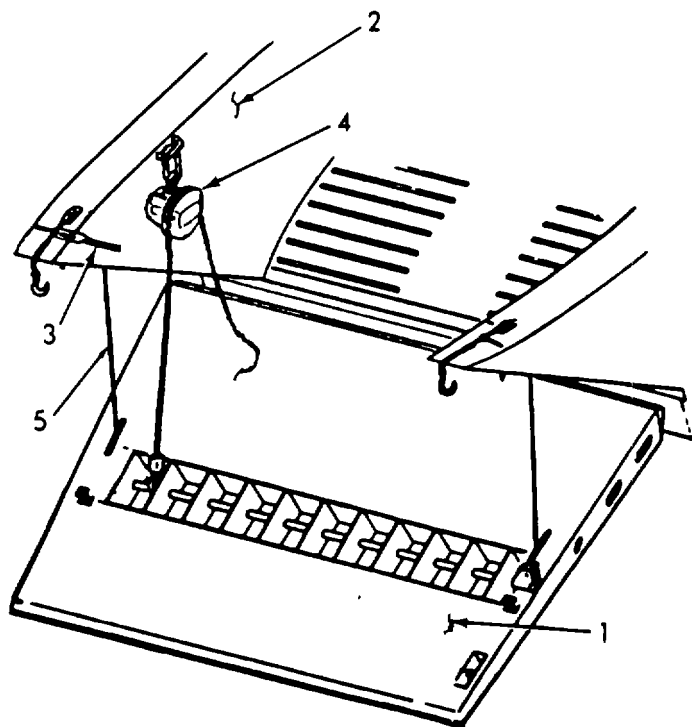
ACTION

REMARKS

REMOVAL

1. Winch

- a. Lower ramp (1) to ground if possible.
- b. When ramp cannot be lowered, secure to hull (2) with load binders (3) or chain hoists (4).
- c. Pay out ramp cable (5) and remove cable from winch drum.

**WARNING**

The fluid pressure in the system must be released prior to servicing the motor or other parts to prevent possible injury to personnel or equipment.

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

- d. Clean connections of hydraulic lines (6). Then loosen to relieve pressure and remove.

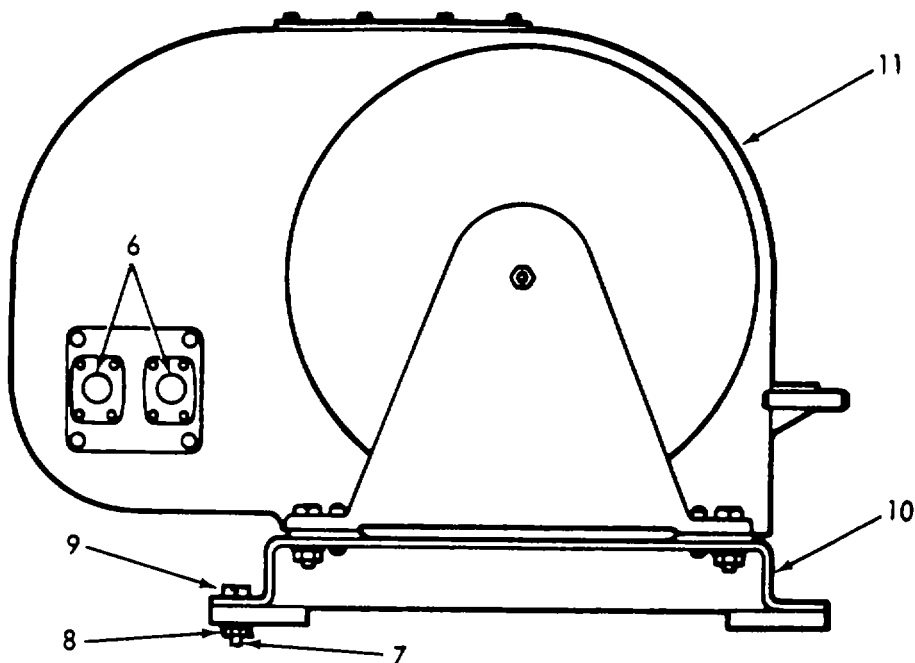
1. Two hydraulic lines to brake and two lines to the hydraulic motor.
2. Cap open ends.

- e. Remove hydraulic motor as per paragraph 6-11.

If necessary.

- f. Remove nuts (7), lockwashers (8), and bolts (9) from winch base (10).

- g. Using a suitable lifting device, remove winch (11) from hull.



6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY

2. Manual
Brake
Release

a. Remove cotter pins (1), pin (2), and handle (3) from control rod (7).

b. Remove handle grip (4) from handle (3).

If damaged.

c. Remove pivot pin (5), pivot (6), and control rod (7) from brakedrum.

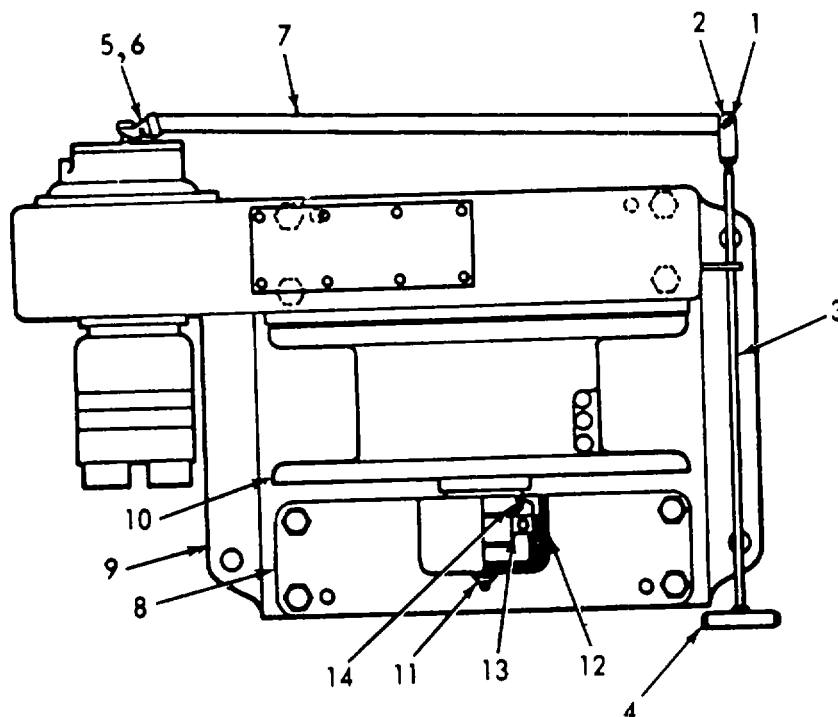
3. Drum
Support
and Drum

a. Remove drum support (8) from base (9) and drum (10).

b. Slide drum (10) from reduction gear output shaft.

c. Remove lubrication fitting (11) from drum shaft bearing.

d. Remove oil seal (12), ball bearing (13), and drum shaft bushing (14).



6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

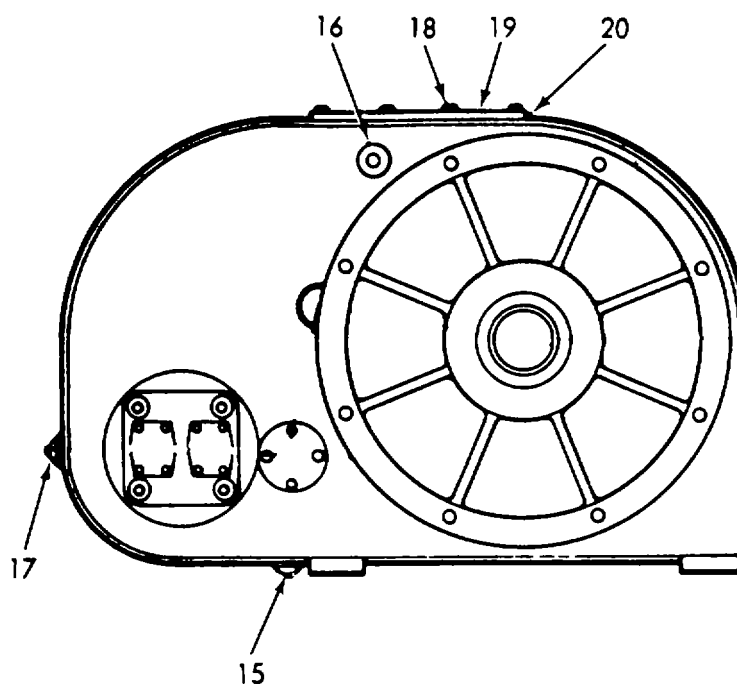
DISASSEMBLY (Cont)

4. Gear Reducer
Housing and
Cover Plate

- a. Remove drain plug (15) from bottom of housing.
- b. Remove fill plug (16) to allow air to enter housing and drain lubricant.
- c. Remove oil level plug (17) from housing.
- d. Remove cover plate capscrews (18), cover plate (19) and gasket (20).

Place a suitable container under housing to catch lubricant.

If damaged.



6-12. WINCH (Continued)

LOCATION/ITEM

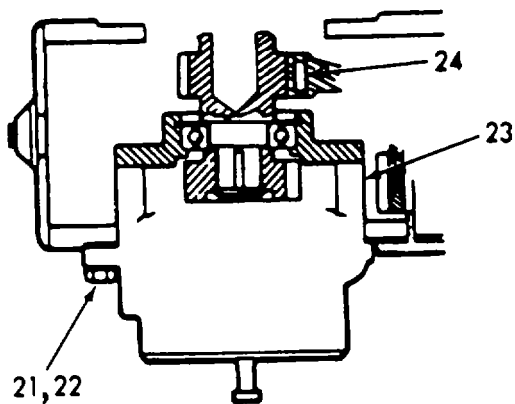
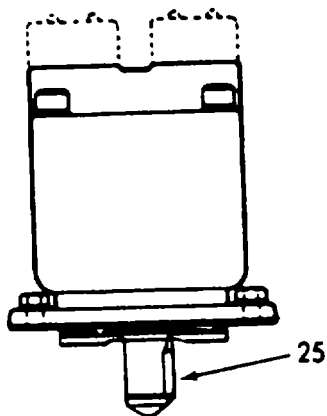
ACTION

REMARKS

DISASSEMBLY (Cont)

5. Brake Assembly

- a. Remove brake mounting cap screws (21), lockwashers (22) and brake assembly (23).
- b. Remove drive gear pinion (24) from motor and key (25).



6-12. WINCH (Continued)

LOCATION/ITEM

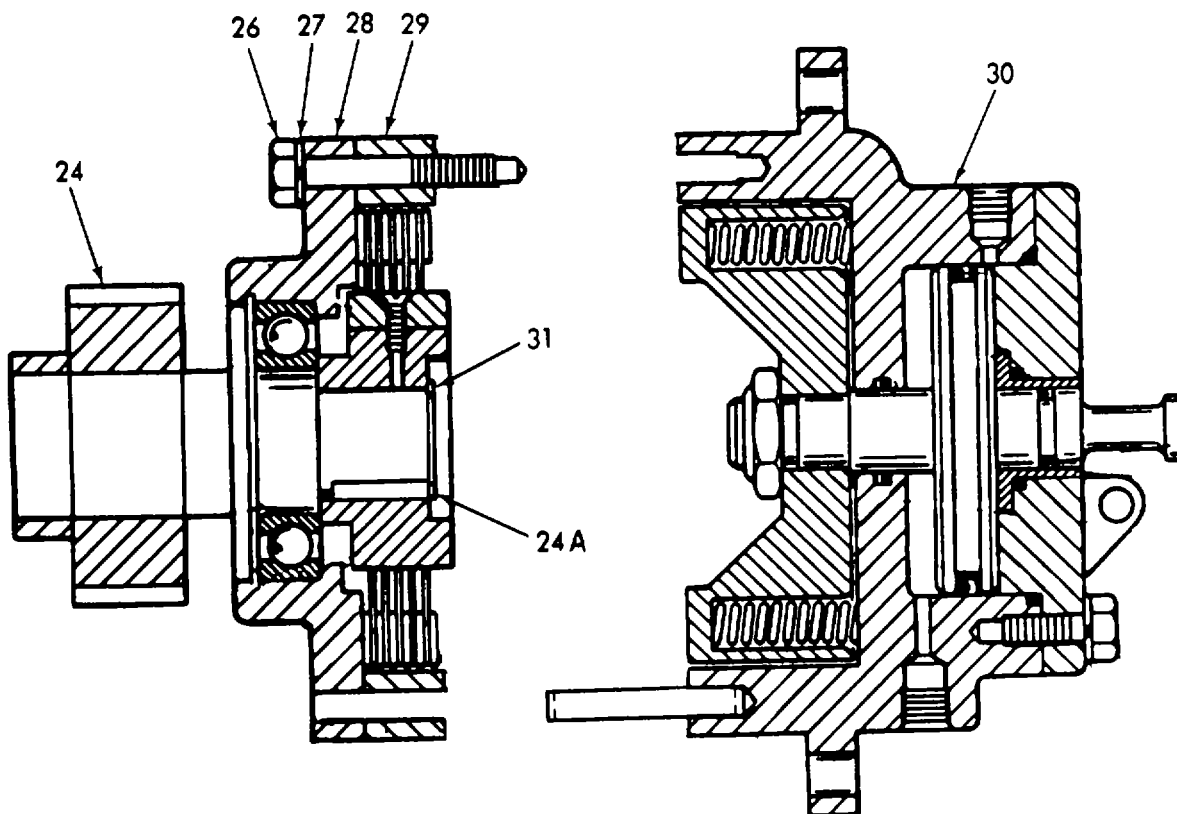
ACTION

REMARKS

DISASSEMBLY (Cont)

c. Disassemble brake as follows:

- (1) Remove bearing cap mounting capscrews (26), lock-washers (27), bearing cap (28), and brake ring (29) from housing (30).
- (2) Remove retaining ring (31).
- (3) Remove drive gear pinion (24) and key (24A).



6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- | | | |
|------|---|-------------|
| (4) | Remove brake ring (29) from bearing cap (28). | |
| (5) | Remove retaining ring (32) and bearing (33) from bearing cap (28). | |
| (6) | Remove driven discs (34) and driving plates (35). | |
| (7) | Remove three machine screws (36) from keys (37) and remove keys from hub (38). | |
| (8) | Remove cap to housing dowel pins (39). | If damaged. |
| (9) | Remove end cap mounting cap screws (40), lock-washers (41), and housing end cap (42). | |
| (10) | Remove plunger stop nut (43) from brake rod (44). | |
| (11) | Remove plunger (45) and springs (46) from housing (30). | |
| (12) | Withdraw brake rod (44) and assembled parts from housing (30). | |
| (13) | Remove retainer (47), and plunger rod packing (48), from housing (30). | |
| (14) | Remove piston packing (49) from piston. | |
| (15) | Remove packing (50) from brake rod. | |

6-12. WINCH (Continued)

LOCATION/ITEM

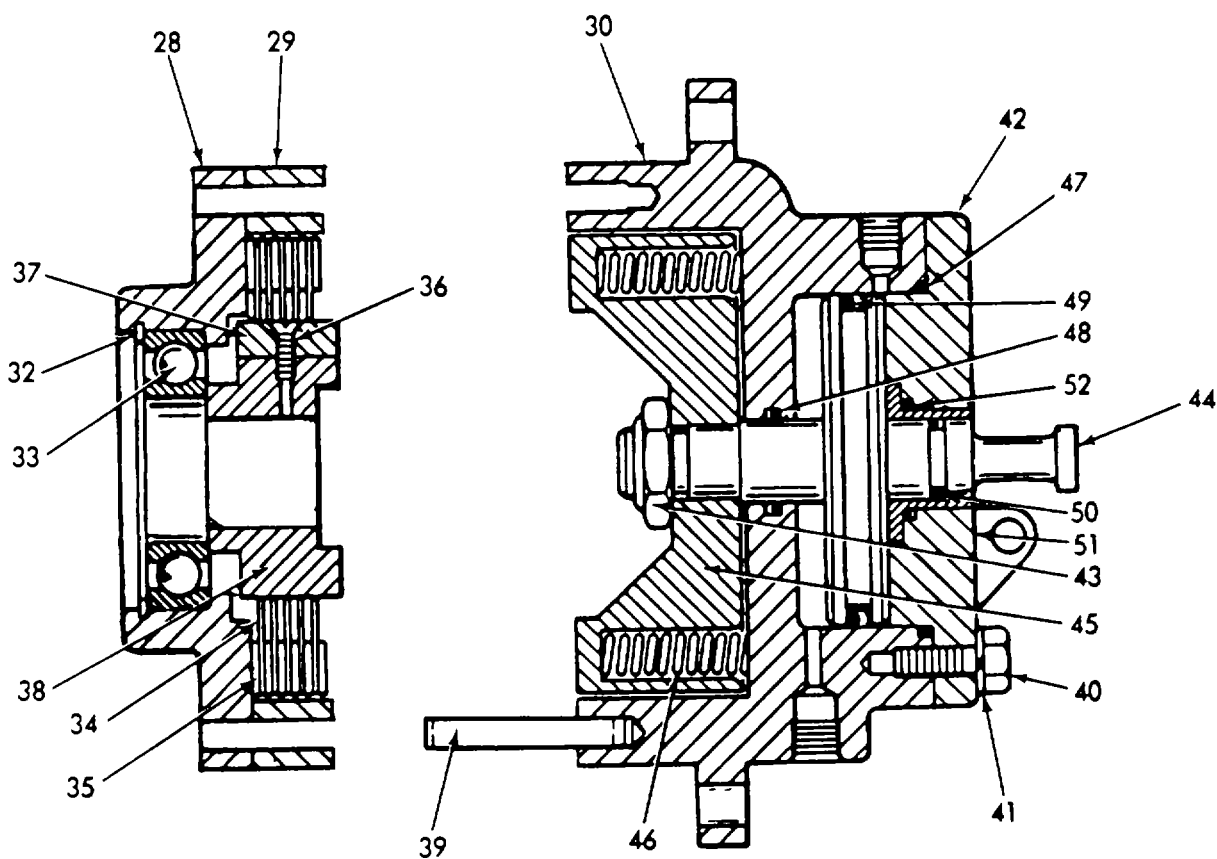
ACTION

REMARKS

DISASSEMBLY (Cont)

(16) Remove bushing (51) from rod plunger.

(17) Remove end cap bushing packing (52) from end cap (42).



6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

6. Gear Reducer

- a. Remove shaft retainer mounting capscrews (53), lockwashers (54), shaft retainer (55), and gasket (56).
- b. Remove shaft retainer cap screws (53), lockwashers (54), shaft retainer (57), and gasket (56).
- c. Remove idler gear cluster shaft (58), and cluster driving gear (59) as an assembly.
- d. Remove retaining rings (60) and drive gear roller bearings (61).
- e. Remove flange mounting capscrews (62) and lockwashers (63).
- f. Remove case flange (64), gasket (65), drum shaft (66) and spur gear (67).
- g. Remove gear spacer (68), oil seals (69 and 70), drum shaft ball bearing (71), and drum shaft (66) assembly.
- h. Remove screws (72) and ball bearing (73).
- i. Disassemble gear retaining rings (74), spur gear (67), and drum shaft (66).
- j. Remove screws (75), lockwashers (76) and idler gear shaft retainer (77) and gasket (78).
- k. Remove idler cap (79).
- l. Remove packing (80) from idler cap (79).

6-12. WINCH (Continued)

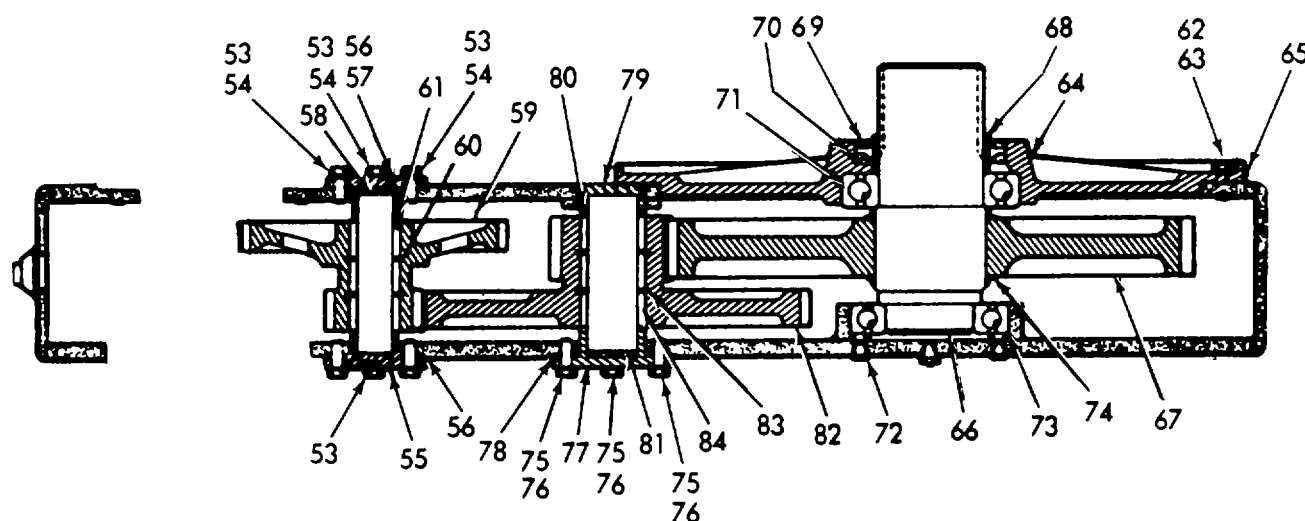
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- m. Remove idler gear shaft (81) and attached parts.
- n. Remove cluster gear (82), cluster gear bearing retaining rings (83), and roller bearings (84).



CLEANING

7. Winch

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

- a. Clean all metal parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

CLEANING (Cont)

- b. When cleaning bearings, turn them by hand only.

INSPECTION

8. Winch

- a. Rotate ball and needle bearings by hand to insure that they turn freely and smoothly.
- b. Inspect ball, needles, and races for visible damage.
- c. Check that gear teeth are smooth, are free from chips, pits, cracks, or wear and show normal tooth contact. If any gear teeth are damaged, check teeth of mating gear thoroughly for similar damage.
- d. Check that gear shafts are true and free from nicks, grooves, and scoring. If bearing surfaces are damaged, shaft must be replaced.
- e. Inspect driving and driven plates for wear on teeth or friction faces.
- f. Inspect piston seals and sealing surfaces for nicks, burrs, or minor scoring.
- g. Insure that shaft keys fit tight in corresponding keyways in both the shafts and gears.
- h. Inspect gear cases and covers for cracks or breaks.

6-12. WINCH (Continued)**LOCATION/ITEM****ACTION****REMARKS****REPLACEMENT**

- | | |
|----------|---|
| 9. Winch | Replace winch if damaged beyond repair. |
|----------|---|

REPAIR

- | | |
|-----------|---|
| 10. Winch | <ul style="list-style-type: none"> a. Replace all gaskets, seals, and packings. b. Replace defective ball and needle bearings. c. Replace defective gears. d. Remove minor scratches, nicks grooves, or scoring from gear shafts with a fine abrasive cloth or stone. e. Smooth out minor irregularities in gear teeth with fine polishing stone or wheel. |
|-----------|---|

OVERHAUL

- | | |
|-----------|---|
| 11. Winch | <ul style="list-style-type: none"> a. Replace all gaskets, seals, and packings. b. Replace all ball and needle bearings. c. Replace all shaft or gear machine keys if loose in corresponding keyways. d. Replace all worn or cracked gears. |
|-----------|---|

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

OVERHAUL (Cont)

- e. Replace gears if bearing surfaces are damaged.
- f. Weld broken gear cases and covers, using standard welding techniques, provided that repair can be made without misaligning bearing or shaft supporting members. Any broken part that could affect gear or shaft alignment when repaired must be replaced.

LUBRICATION

12. Winch

- a. Lubricate seals and packings liberally with hydraulic fluid before assembling.
- b. Lubricate gear reducer and winch bearings, gears, shafts, and seals liberally with SAE 90 gear lubricant before assembling. Lubricate bearing in winch support pedestal after assembly with waterproof anti-friction bearing grease. Lubricate until grease is visible outside seal on winch shaft. Fill gear reducer after assembly with SAE 90 gear lubricant to oil level plug on side of gear case.

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY

CAUTION

Be especially careful when installing cluster gear shafts in gear reducer to avoid damaging preformed packings as they pass through needle bearings inside gears.

NOTE

Use torque values listed below when reassembling winch.

Thread Size	Torque Ranges					
	Pound-inches			Newton-meters		
10-32	20	-	25	2.26	-	2.83
1/4-20	50	-	70	5.65	-	7.91
1/4-28	50	-	70	5.65	-	7.91
5/16-18	70	-	90	7.91	-	10.17
3/8-16	160	-	185	18.08	-	20.91
7/16-14	235	-	255	26.55	-	28.82
1/2-13	400	-	480	45.20	-	54.24
9/16-12	500	-	700	56.50	-	79.10
5/8-11	700	-	900	79.10	-	101.70
3/4-10	1150	-	1600	129.95	-	180.80

6-12. WINCH (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)		
13. Gear Reducer	a. Assemble roller bearings (84), retaining rings (83), cluster gear (82) on idler gear shaft (81).	
	b. Install packing (80) in idler cap (79).	
	c. Install assembled idler cap (79).	
	d. Install idler gear shaft (81) assembled.	
	e. Install idler gear shaft retainer (77), gasket (78) using screws (75) and lockwashers (76).	1. Use new gasket. 2. Torque screws.
	f. Assemble spur gear (67), retaining rings (74) on drum shaft (66).	
	g. Install bearing (73) and screws (72).	Torque screws.
	<p style="text-align: center;">NOTE</p> <p>Use seal expanding tool when sliding shaft through oil seals.</p>	
	h. Assemble gear spacer (68), oil seals (69 and 70), ball bearing (71) and drum shaft (66) assembly into case flange (64).	
	i. Install drum shaft, case flange (64) assembly, gasket (65) using screws (62) and lockwashers (63).	1. Use new gasket. 2. Torque screws.

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

j. Assemble drive gear roller bearings (61), retaining rings (60), cluster driving gear (59), and idler gear cluster shaft (58).

k. Install shaft retainer (57), gasket (56) using screws (53) and lockwashers (54).

1. Use new gasket.

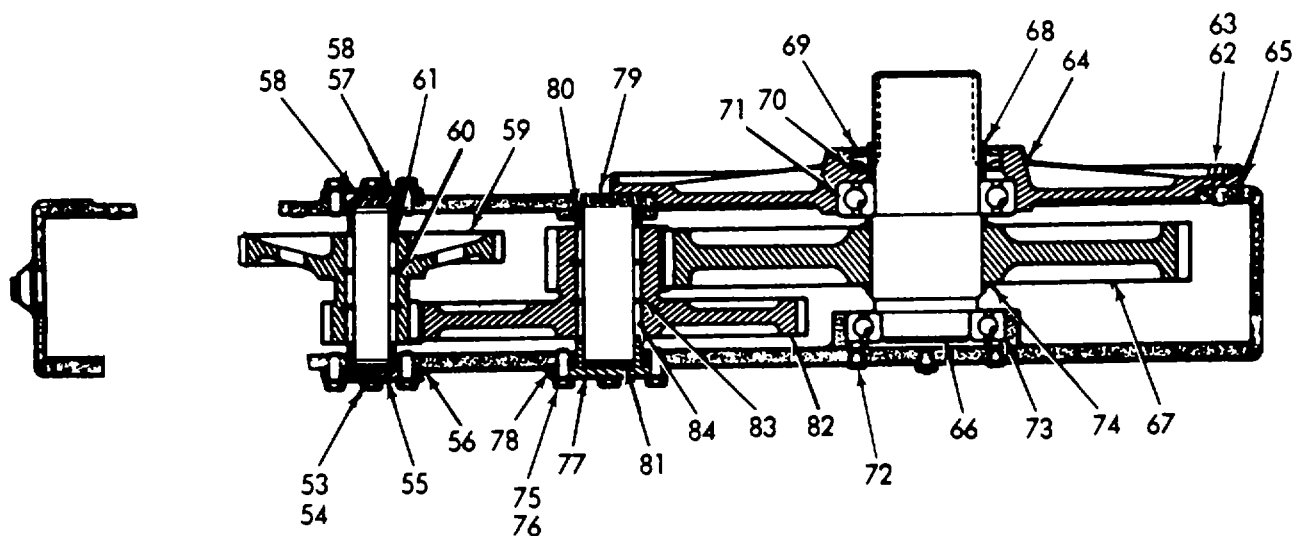
2. Torque screws.

l. Install idler gear cluster shaft (58) assembly.

m. Install shaft retainer (55), gasket (56) using screws (53) and lockwashers (54).

1. Use new gasket.

2. Torque screws.



6-12. WINCH (Continued)

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY (Cont)		
14. Brake	<ul style="list-style-type: none"> a. Install end cap bushing (51) and packing (52) in end cap (42). b. Place packing (50) onto brake rod, then install brake rod (44) in end cap (42). c. Install piston packing (49), plunger rod packing (48), and retainer (47). d. Install brake rod (44) and end cap (42) assembled in housing (30). e. Install springs (46) and plunger (45) over end of brake rod (44) and install plunger stop nut (43). f. Place end cap (42) in position on housing (30) and secure with lockwashers (41) and capscrews (40). g. Install dowel pins (39) in housing (30). h. Place brake ring (29) over protruding end of dowel pins (39). i. Alternate driving plates (35) and driven discs (34) and insert into brake ring (29). j. Place machine keys (37) into keyway on brake hub (37). k. Install ball bearing (33) in bearing cap (28) and secure with retaining ring (32). 	If removed.

6-12. WINCH (Continued)

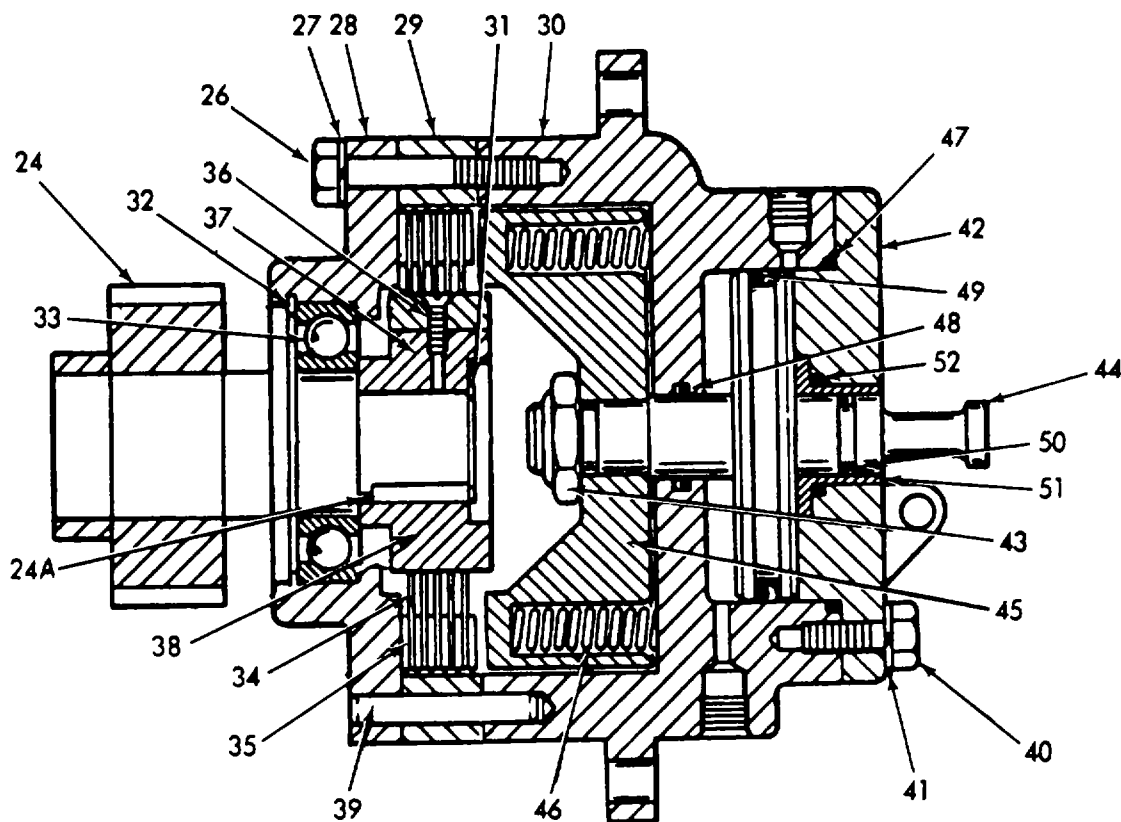
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- l. Place machine keys (37) in keyway in hub (38) and secure with machine screws (36).
- m. Insert drive pinion gear (24) and key (24A) through bearing cap (28) and hub (38).
- n. Position bearing cap (28) and assembled parts over ends of protruding dowel pins (39) and secure with lockwashers (27) and capscrews (26).



6-12. WINCH (Continued)

LOCATION/ITEM

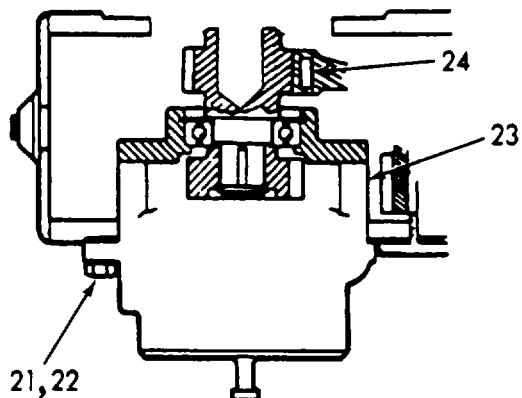
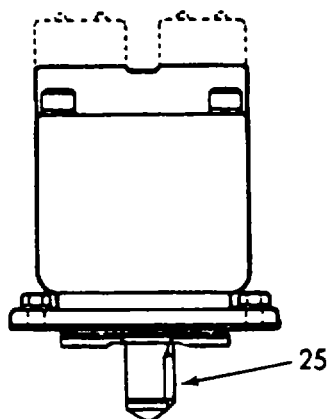
ACTION

REMARKS

ASSEMBLY (Cont)

15. Brake
Assembly

- a. Install pinion drive gear (24) and key (25).
- b. Position brake assembly (23) in place on pinion gear and secure brake assembly with lockwashers (22), and cap-screws (21).



6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

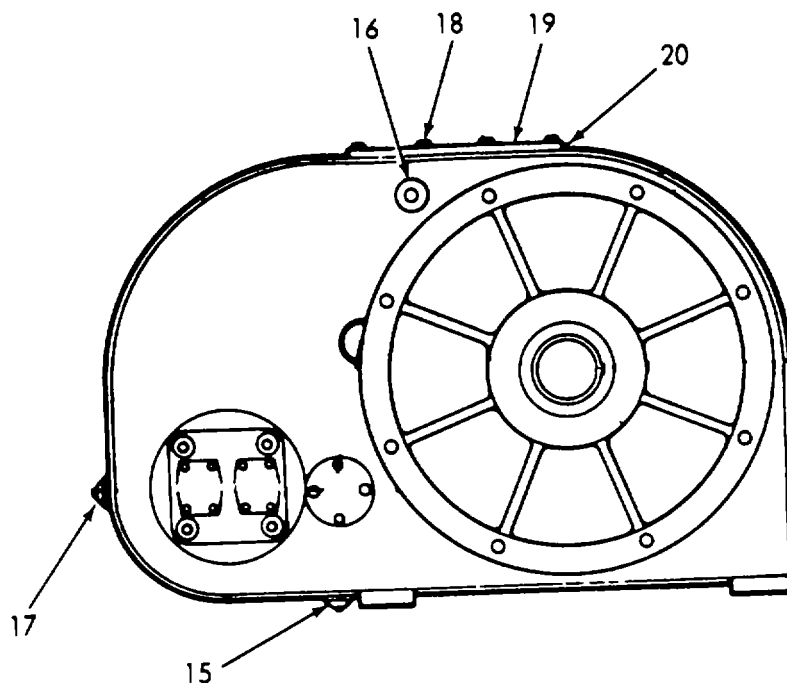
REMARKS

ASSEMBLY (Cont)

16. Gear Reducer
Housing and
Cover Plate

- a. Place cover plate gasket (20) in position on housing.
- b. Install cover plate (19) with capscrews (18).
- c. Install hydraulic motor.
- d. Install chain plug (15).
- e. Fill housing with SAE-90 gear lubricant to oil plug level (17).
- f. Install fill plug (16) and oil level plug (17).

Refer to paragraph 6-11.



6-12. WINCH (Continued)**LOCATION/ITEM****ACTION****REMARKS****ASSEMBLY (Cont)**

17. Drum Support
and Drum

NOTE

Install oil seal in drum support with lip toward winch to keep dirt, water, and other foreign material from entering the bearing.

- a. Install drum shaft bushing (14), ball bearing (13), and oil seal (12).
- b. Install lube fitting (11) into bearing (13).
- c. Slide brakedrum (10) onto reduction gear shaft.
- d. Install drum support (8) on base (9).

18. Manual Brake
Release

- a. Install pivot (6) onto control rod (7).
- b. Secure pivot and rod to brake with pivot pin (5).
- c. Install hand grip (4) on handle (3).
- d. Secure control rod (7) to handle (3) with pin (2) and secure pin (2) with cotter pins (1).

If removed.

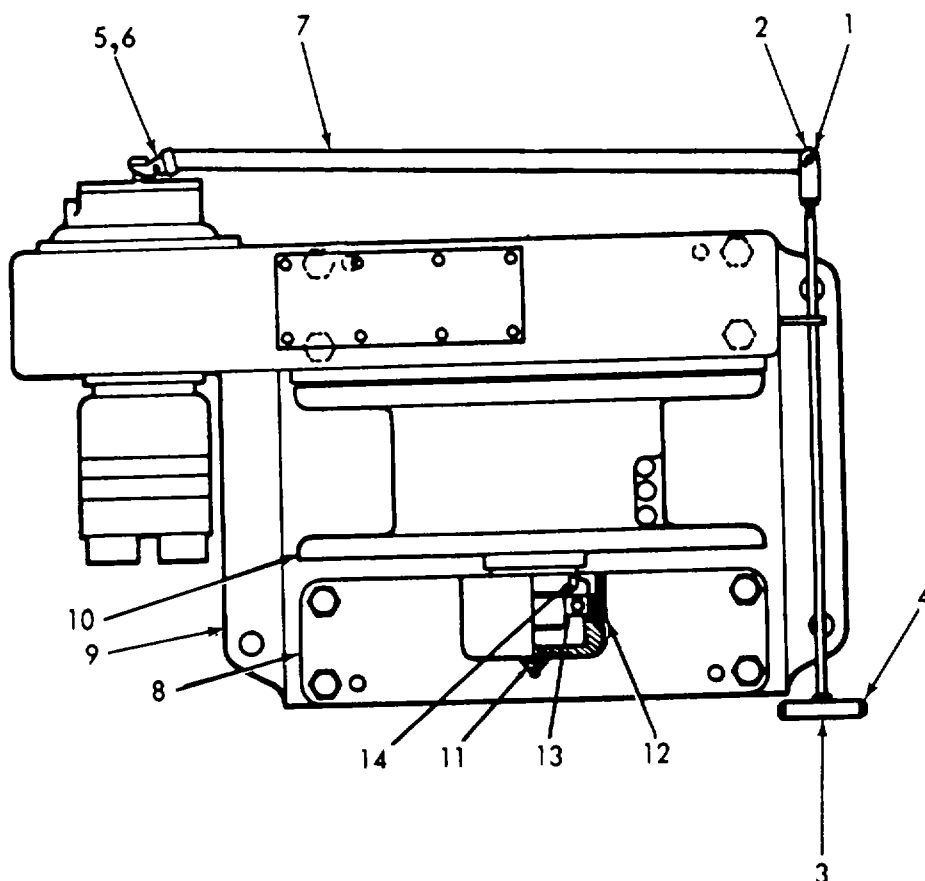
6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)



INSTALLATION

19. Winch

WARNING

Be sure that a suitable lifting device is available prior to installing winch on hull. Failure to use a lifting device could result in severe injury to personnel.

6-12. WINCH (Continued)

LOCATION/ITEM

ACTION

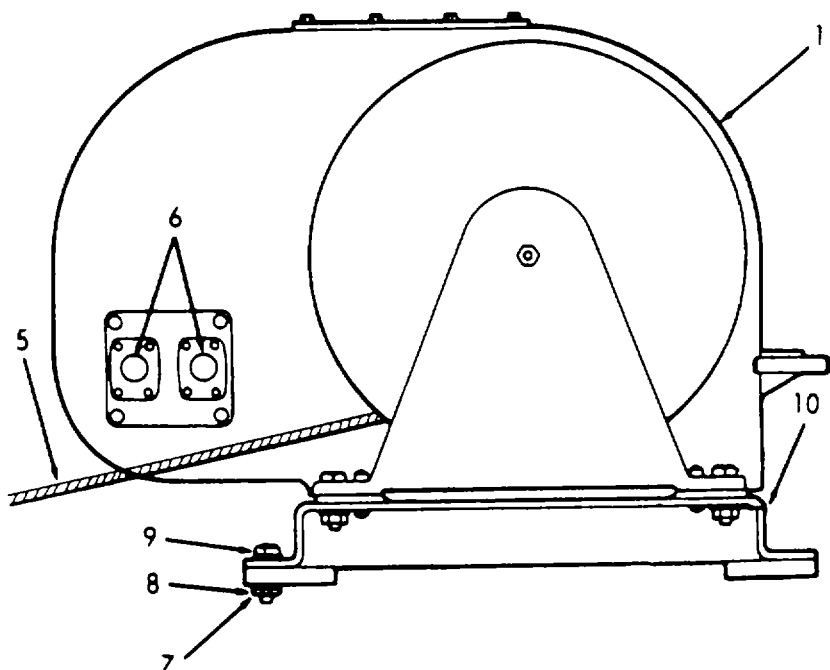
REMARKS

INSTALLATION (Cont)

- a. Using a suitable lifting device, install winch (11) in hull.
- b. Install bolts (9), lock-washers (8), and nuts (7) in winch base (10).
- c. Install hydraulic motor.
- d. Install hydraulic lines (6).
- e. Install ramp cable (5) on winch drum.
- f. Operate system and fill reservoir as necessary.

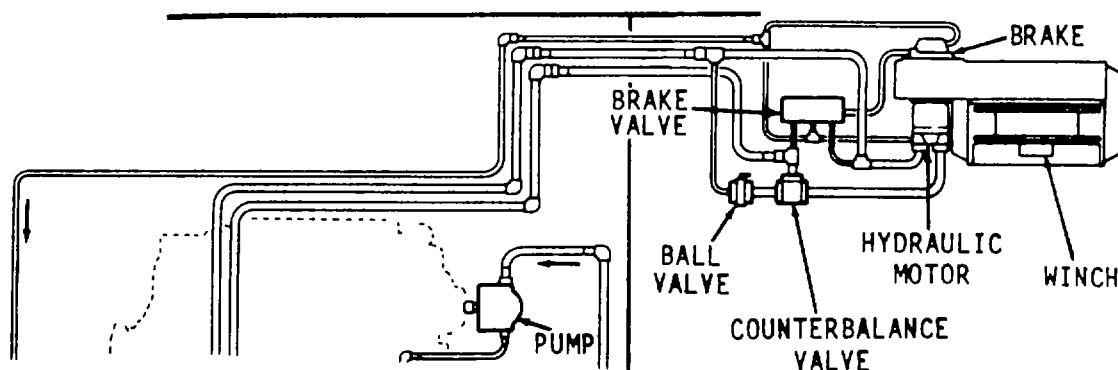
Refer to paragraph 6-11.

Remove end caps.



6-13. BRAKE VALVE, WINCH

See figure below for brake valve location. This is a spool-type, pressure-operated valve which directs hydraulic fluid to the brake release cylinder whenever pressure is applied to either port.



This task covers:

- | | | |
|----------------|-------------------|-----------------|
| a. Removal | c. Repair/Replace | e. Installation |
| b. Disassembly | d. Assembly | |

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Equipment Condition

Condition Description

NONE

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Clean cloths
Cleaning Solvent
Fed. Spec. P-D-680

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNINGS in procedure.

6-13. BRAKE, VALVE WINCH (Continued)**LOCATION/ITEM****ACTION****REMARKS****REMOVAL**

- | | | |
|----------|----------------------------|--|
| 1. Valve | a. Clean tube connections. | |
|----------|----------------------------|--|

WARNING

The fluid pressure in the system must be released prior to servicing the valve or other parts to prevent possible injury to personnel or equipment.

- | | |
|---|----------------|
| b. Disconnect hydraulic tubes from valve. | Cap open ends. |
| c. Remove valve. | |

DISASSEMBLY

- | | | |
|----------|--|-----------------|
| 2. Valve | a. Remove plug (1) and packing (2) from body (8). | Discard packing |
| | b. Remove spool (3). | |
| | c. Remove large spring (4) and spring seat washer (5). | |
| | d. Remove small spring (6). | |
| | e. Remove steel balls (7) from body (8). | |

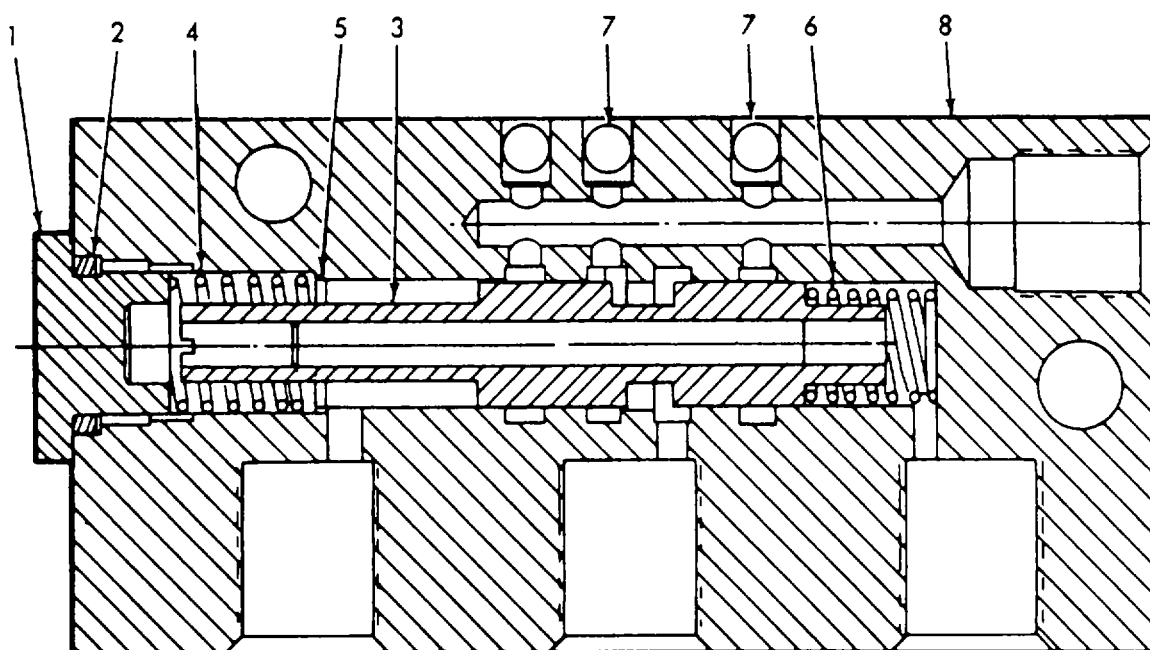
6-13. BRAKE VALVE, WINCH (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



CLEANING

3. Valve

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

Clean all metal parts in cleaning solvent
Fed. Spec. P-D-680 and dry thoroughly.

6-13. BRAKE VALVE, WINCH (Continued)**LOCATION/ITEM****ACTION****REMARKS****INSPECTION**

- | | |
|----------|---|
| 4. Valve | <ul style="list-style-type: none"> a. Inspect steel balls for pitting and flat spots. b. Inspect springs for distortion and loss of tension. c. Inspect interior of body for scores, rough spots or other damage. d. Inspect spool for nicks, burrs, or flat spots. |
|----------|---|

REPAIR/REPLACE

- | | |
|----------|--|
| 5. Valve | <ul style="list-style-type: none"> a. Replace valve if damaged beyond repair. b. Replace packing. c. Replace other damaged parts as required. |
|----------|--|

ASSEMBLY

- | | |
|----------|--|
| 6. Valve | <ul style="list-style-type: none"> a. Install steel balls (7) in body (8). b. Place small spring (6) on end of spool. c. Place spring seat washer (5) and large spring (4) over other end of spool (3). |
|----------|--|

6-13. BRAKE VALVE, WINCH (Continued)

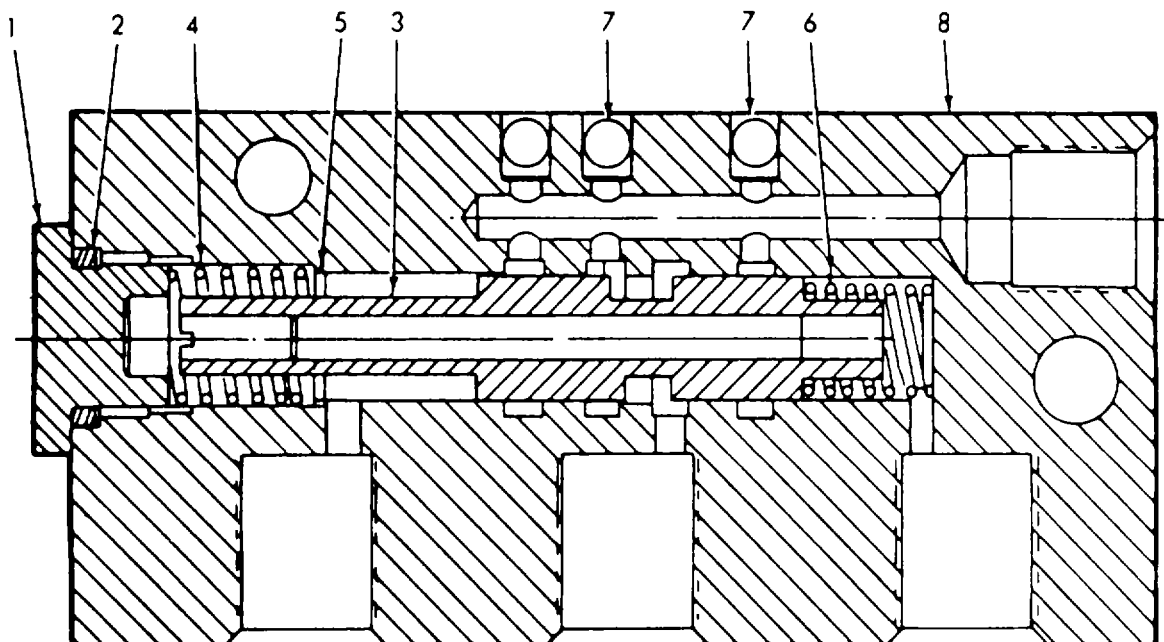
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- d. Insert assembled spool (3) into valve body (8).
- e. Insert packing (2) into valve body and install plug (1).



INSTALLATION

7. Valve

- a. Position valve in place.
- b. Reconnect tube connections.

Remove caps.

6-14. ANODES AND PLATING

Anodes should be replaced when they become wasted away to the point that they fail to provide adequate mass and surface area. They should also be replaced or re-attached if loose. Anodes for installation and replacement will conform to type ZHS of Military Specification MIL-A-18001. Type ZHS will be used for large vessels. Type ZHS measures 1.25 by 6 by 12 inches (31.75 by 152.40 by 304.80 mm); weighs approximately 23.5 pounds (10.66 kg), and has cast-in steel straps with protruding ends for attachment. Anodes will be located in the immediate vicinity of the propellers and will be symmetrically distributed. The distance between any two anodes will not be less than 2 feet (.6106 m). There are seven anodes used on the landing craft.

This task covers:

- | | | |
|---------------|------------|-----------------|
| a. Inspection | c. Removal | e. Installation |
| b. Service | d. Repair | |

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

NONE

Equipment Condition

Condition Description

Landing craft in drydock.

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Wire brush

Material/Parts

NONE

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

NONE

6-14. ANODES AND PLATING (Continued)

LOCATION/ITEM

ACTION

REMARKS

INSPECTION

- | | |
|-----------|--|
| 1. Anodes | <ul style="list-style-type: none"> a. Inspect anodes for loose mounting and missing hardware. b. Inspect for deterioration and corrosion. c. Insure that anodes have not wasted away to the point that they fail to provide adequate mass and surface area. |
|-----------|--|

SERVICE

- | | |
|-----------|--|
| 2. Anodes | <ul style="list-style-type: none"> a. Remove corrosion with a wire brush. b. Tighten loose hardware. |
|-----------|--|

REMOVAL

- | | |
|-----------|---|
| 3. Anodes | <ul style="list-style-type: none"> a. Remove mounting nuts (1) and washers (2) (if used) from anodes. b. Remove anodes (3) from hull (4). |
|-----------|---|

REPAIR

- | | |
|-----------|--|
| 4. Anodes | Replace damaged or defective anodes as required. |
|-----------|--|

6-14. ANODES AND PLATING (Continued)

LOCATION/ITEM

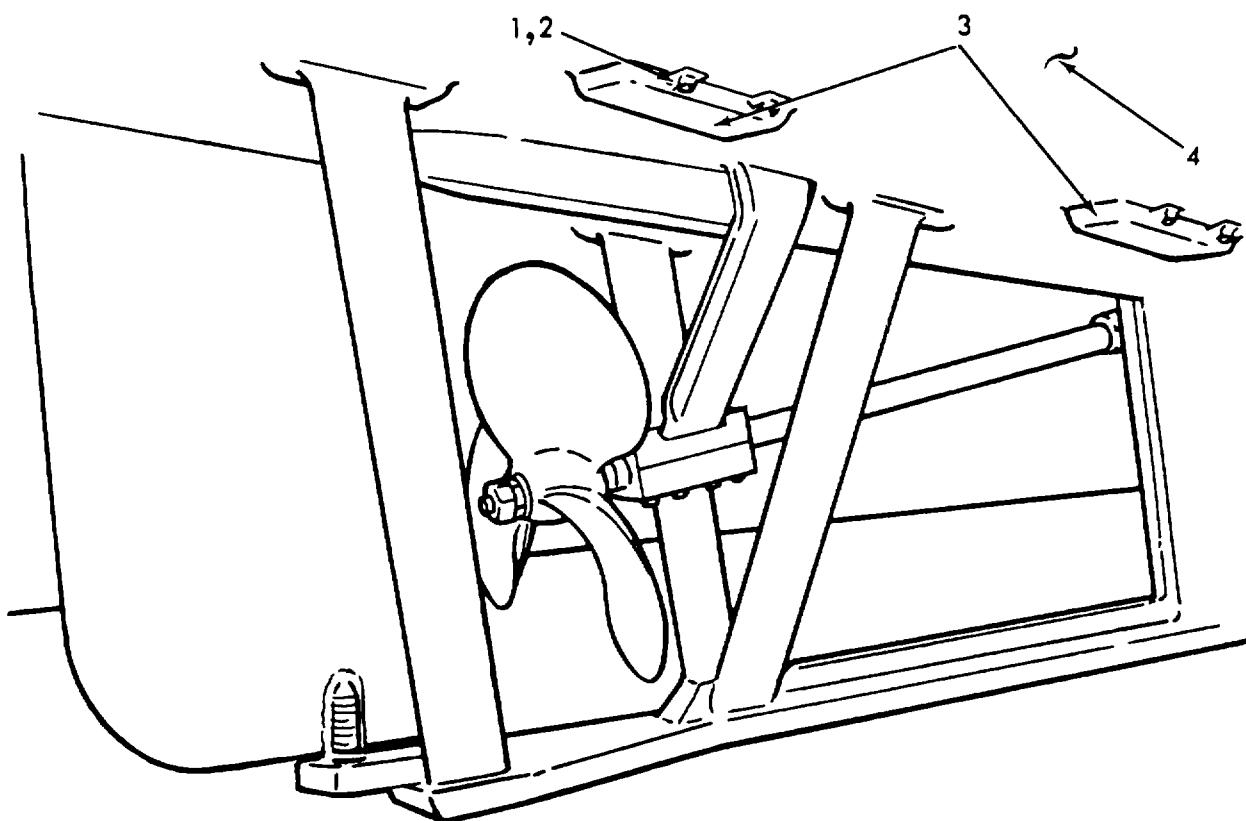
ACTION

REMARKS

INSTALLATION

5. Anodes

- a. Position anode(s) (3) in place on hull (4).
- b. Secure with washers (2) (if used) and nuts (1). Tighten securely.



6-15. RUDDER AND TILLER.

This task covers:

- | | | |
|---------------|----------------|-----------------|
| a. Inspection | d. Replace | g. Assembly |
| b. Removal | e. Disassembly | h. Installation |
| c. Cleaning | f. Repair | |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

Welding equipment

EquipmentConditionCondition Description

Landing craft in drydock.

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Wire brush

Material/Parts

Cleaning solvent
Fed. Spec. P-D-680
Clean cloths
Grease

Special Environmental Conditions

NONE

Personnel Required

MOS 61C100, 448

General Safety Instructions

Observe WARNING in procedure.

LOCATION/ITEM**ACTION****REMARKS****INSPECTION**

- | | |
|----------------------|---|
| 1. Rudder and Tiller | a. Visually inspect rudder, skeg bar, and shoe casting for breaks, cracks, bends and corrosion. |
| | b. Visually inspect bearing for cracks or breaks and corrosion. |

6-15. RUDDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

- c. Inspect for missing or loose hardware.
- d. Inspect tiller for loose or missing mounting hardware.

REMOVAL

2. Rudder

WARNING

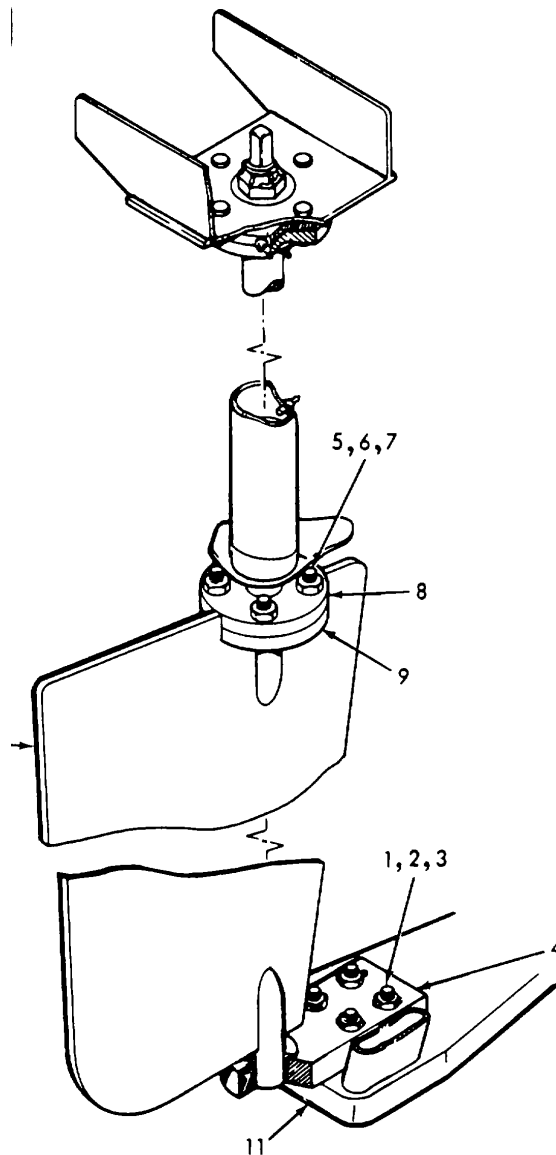
At least four (4) personnel are required to remove rudder assembly from the craft to avoid the possibility of injury. This assembly weight approximately 200 pounds (90.7 kg).

- a. Remove four cotter pins (1), nuts (2), and bolts (3) from rudder shoe casting (4).
- b. Remove four nuts (5), washers (6), and bolts (7) from upper flange (8) and lower flange (9).
- c. Allow rudder assembly (10) to drop approximately 1/4 inch (6.35 mm) to separate the flanges.
- d. Slide rudder assembly (10) aft to clear skeg bar (11) and remove from craft.

6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)



6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)

- | | | |
|-----------|---|--|
| 3. Tiller | <ul style="list-style-type: none">a. Remove clevis pin and disconnect clevis (1) from end of tie rod (2).b. Remove tie rod (2).c. Remove clevis pin and disconnect clevis (3) from end of hydraulic cylinder (4). | |
|-----------|---|--|

6-15 RUDER AND TILLER (Continued)

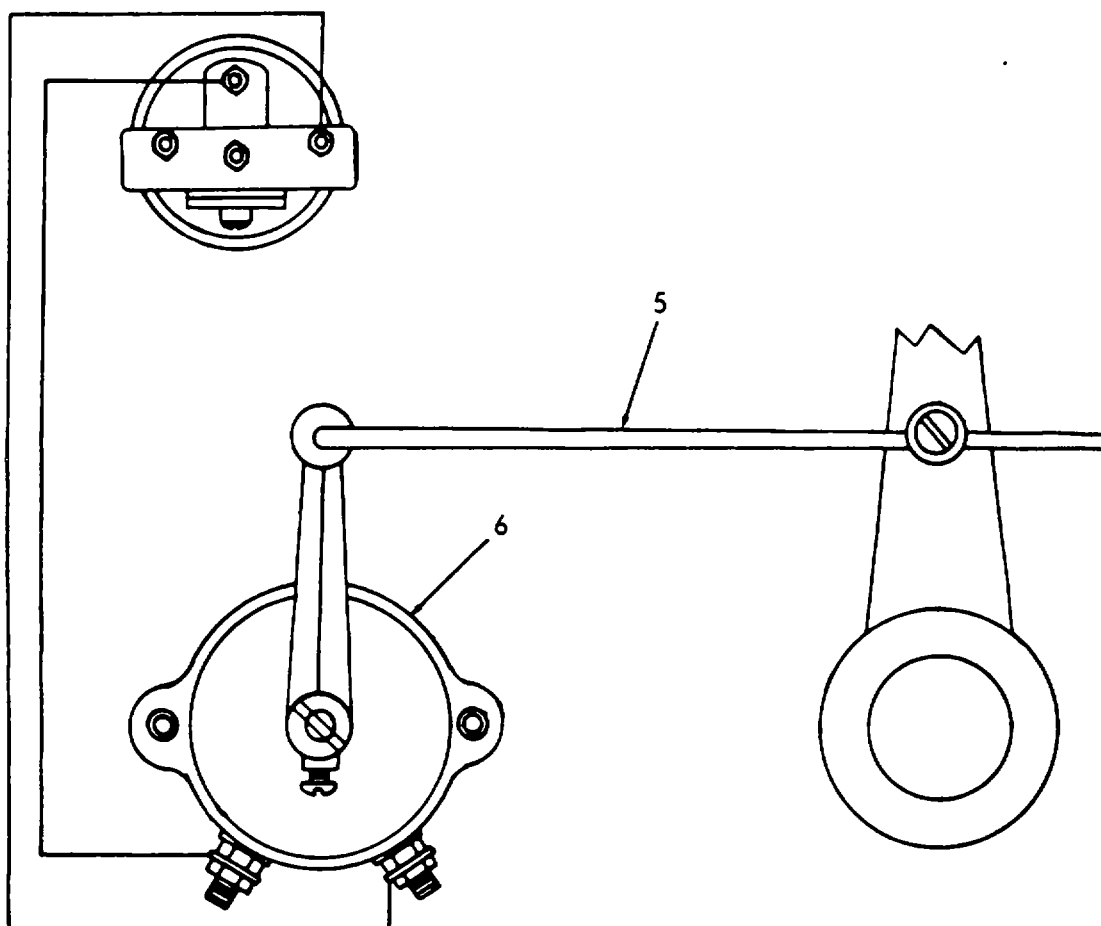
LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

- d. Disconnect arm (5) on rudder angle transmitter (6).



6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
REMOVAL (Cont)	e. Remove nuts (7), washers (8), and bolts (9) from crank assembly.	
	f. Remove crank assembly (10) from upper rudder stock (27).	
	g. Remove cotter pin (11) and nut (12), from upper rudder stock (27).	
	h. Remove flange mounting nuts (13), lockwashers (14), and capscrews (15).	
	i. Separate lower thrust flange (16), upper thrust flange (17), and thrust bearing (18).	
	j. Remove stuffing box mounting nuts (19), capscrews (20), gasket (21), from stuffing box (22).	
	k. Remove packing gland jamnuts (23), hex nuts (24), studs (25), from packing gland (26).	
	l. Remove upper rudder stock (27).	
	m. Remove packing gland (26) and stuffing box (22).	
	n. Remove flax packing (28) from stuffing box (22).	Discard packing.
	o. Remove lower thrust flange (16), upper thrust flange (17), and thrust bearing (18).	
	p. Remove sleeve bearing (29) from stuffing box.	Discard if damaged.

6-15 HYDRAULIC PUMP DRIVE COMPONENTS (Continued)

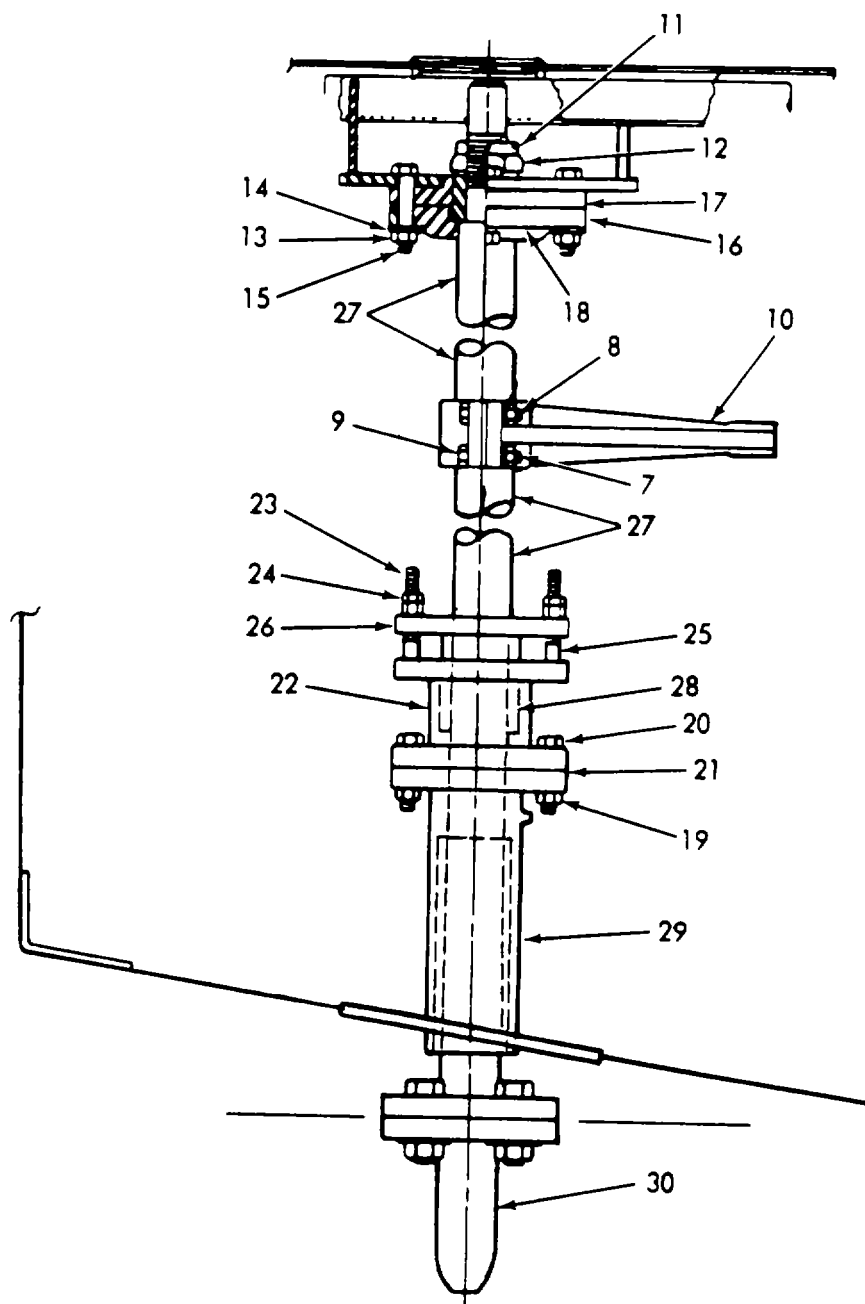
LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

q. Remove rudder shaft (30).



6-15 RUDDER AND TILLER (Continued)

LOCATION/ITEM

ACTION

REMARKS

CLEANING

4. Rudder and
Tiller

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

- a. Clean metal parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.
- b. Remove any corrosion by wire brushing.

REPLACE

5. Rudder

Replace rudder assembly if bronze gudgeon bearing is worn or the rudder is damaged beyond repair.

DISASSEMBLY

6. Rudder

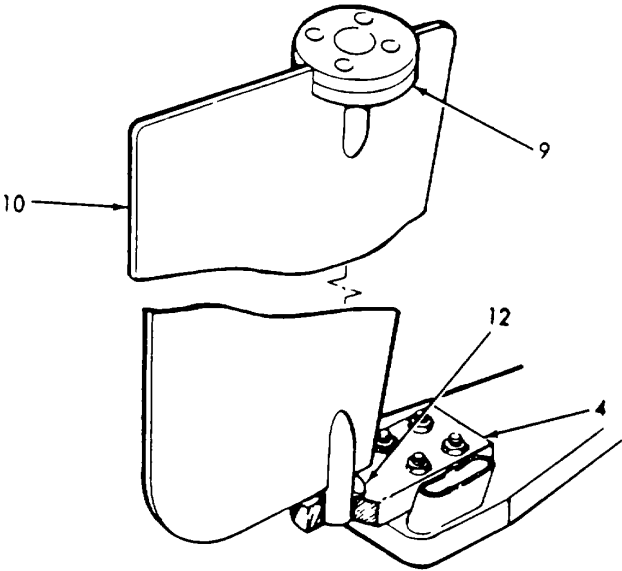
- a. Remove lower rudder flange (9) from rudder (10).
- b. Remove bronze gudgeon bearing (12) from rudder shoe casting (4).

If damaged.

6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY (Cont)



7. Tiller

No disassembly required.

REPAIR

8. Rudder and
Tiller

WARNING

Welding must be done by a qualified welder in accordance with standard welding procedures.

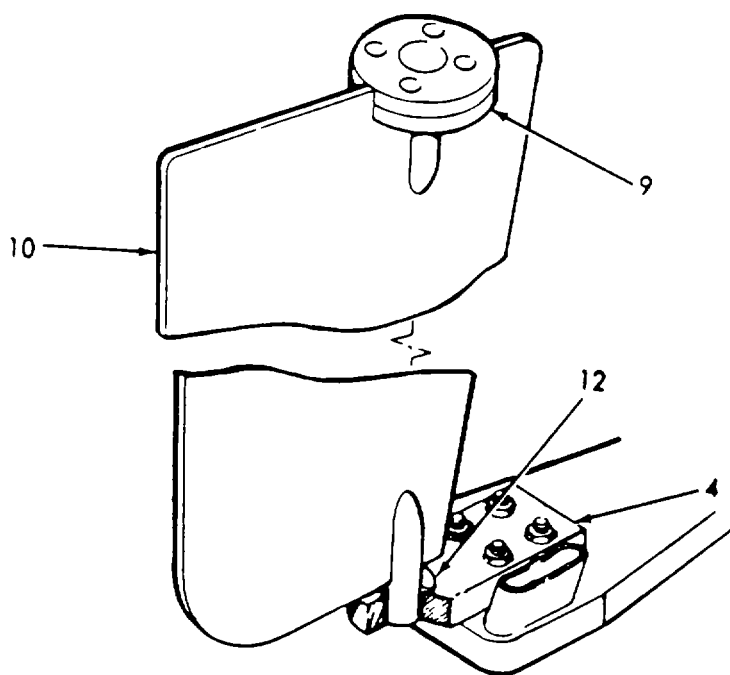
- a. Weld crack and breaks using standard welding procedures and grind smooth.

6-15 RUDER AND TILLER (Continued)**LOCATION/ITEM****ACTION****REMARKS****REPAIR (Cont)**

- b. Straighten bends.
- c. Remove corrosion by wire brushing.
- d. Replace damaged or defective hardware.

ASSEMBLY**9. Rudder**

- a. Install bronze gudgeon bearing (12) in rudder shoe casting (4).
- b. Install rudder shoe casting (4) on rudder (10).
- c. Install lower rudder flange (9) on rudder assembly (10).

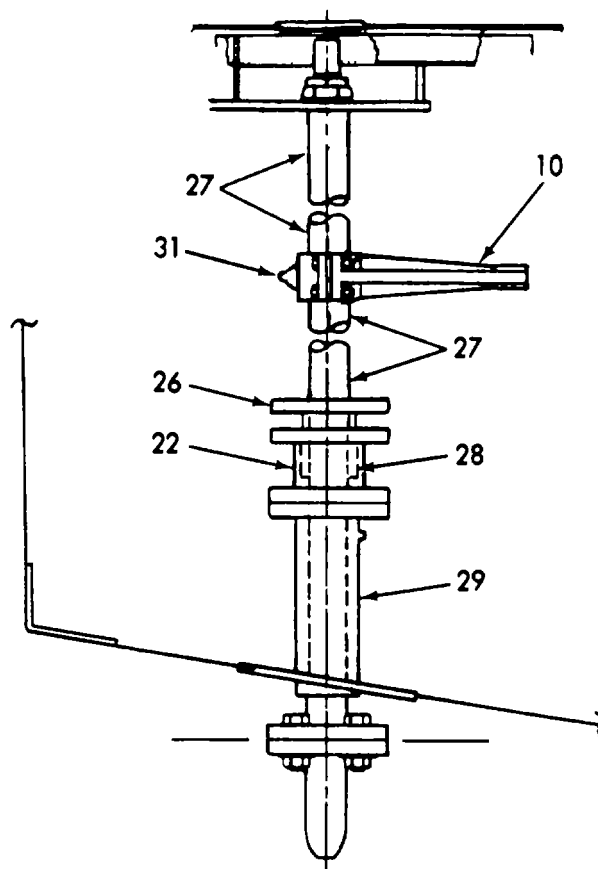


6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION

- | | | |
|------------|---|---------------------|
| 10. Tiller | a. Install lube fitting (31) in crank assembly (10). | If removed. |
| | b. Install sleeve bearing (29) in stuffing box (22). | Replace if damaged. |
| | c. Position upper rudder stock (27) in vessel. | |
| | d. Install flax packing (28) in stuffing box (22). | Use new packing. |
| | e. Place packing gland (26) over end of rudder stock. | |



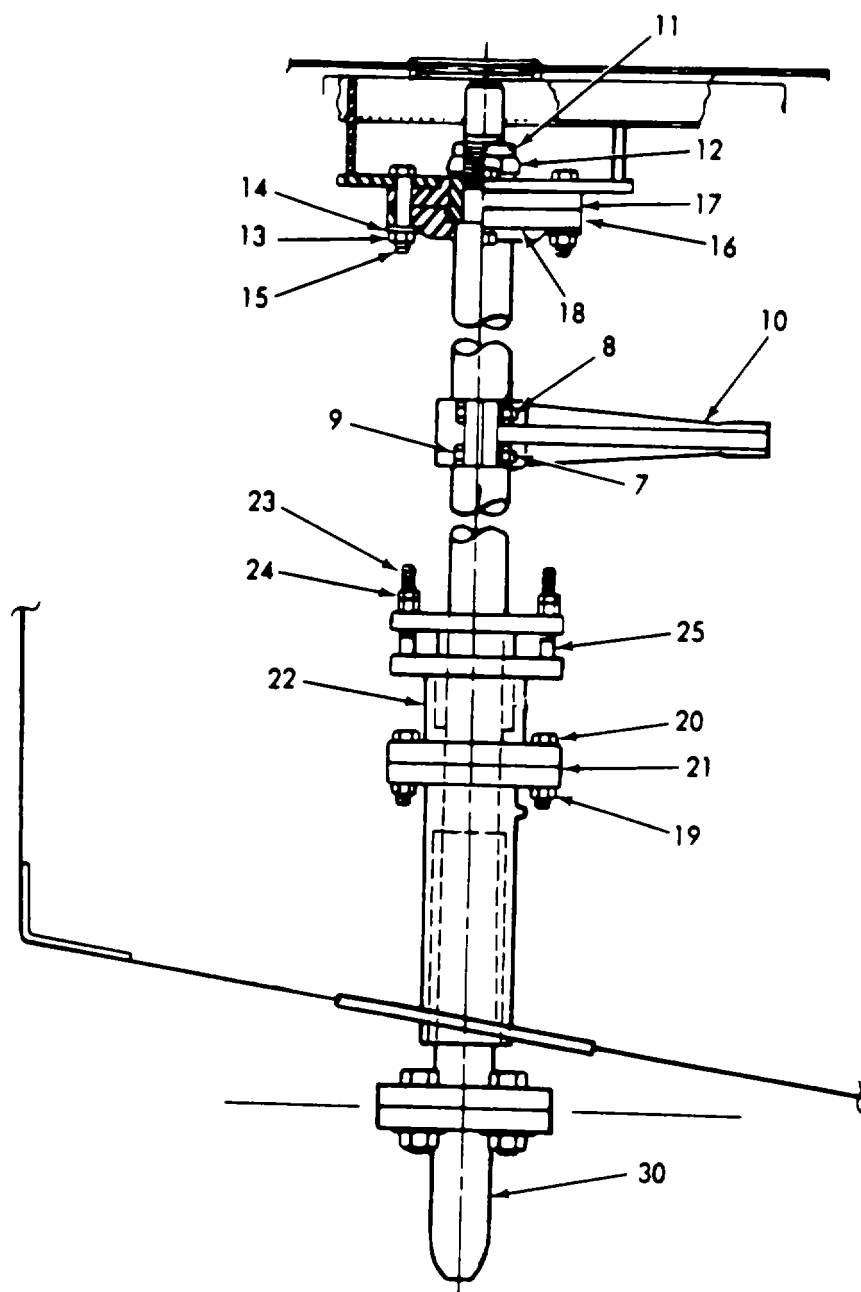
6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)	f. Install studs (25), nuts (24), and jamnuts (23) to secure.	Do not tighten.
	g. Position stuffing box (22) and gasket (21) in place.	
	h. Secure with capscrews (20) and nuts (19).	Do not tighten.
	i. Position thrust bearing (18) in place, then place upper thrust flange (17) and lower thrust flange (16) over bearing.	
	j. Place assembled tiller in place in vessel and secure flange assembly with cap screws (15), lockwashers (14), and flange mounting nuts (13).	
	k. Secure rudder stock assembly to vessel with nut (12).	
	l. Align holes in nut (12) with hole in rudder stock and install cotter pin (11).	
	m. Tighten nuts (19 and 24).	
	n. Install crank assembly (10) onto rudder shaft (30) with bolts (9), washers (8), and nuts (7).	

6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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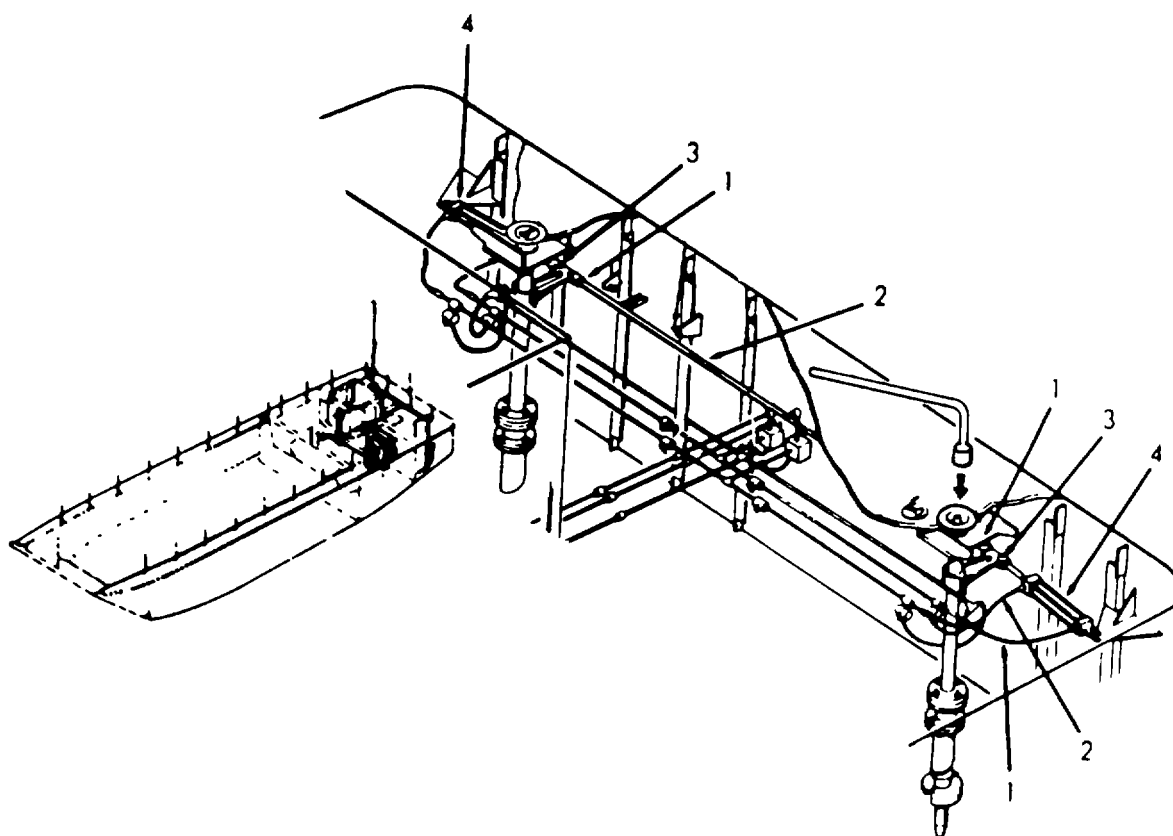


6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- | | | |
|--|--|--|
| | <ul style="list-style-type: none">o. Place tie rod (2) in position.p. Reconnect clevis (1) to end of tie rod (2).q. Reconnect clevis (3) on end of hydraulic cylinder (4), install clevis pin. | |
|--|--|--|

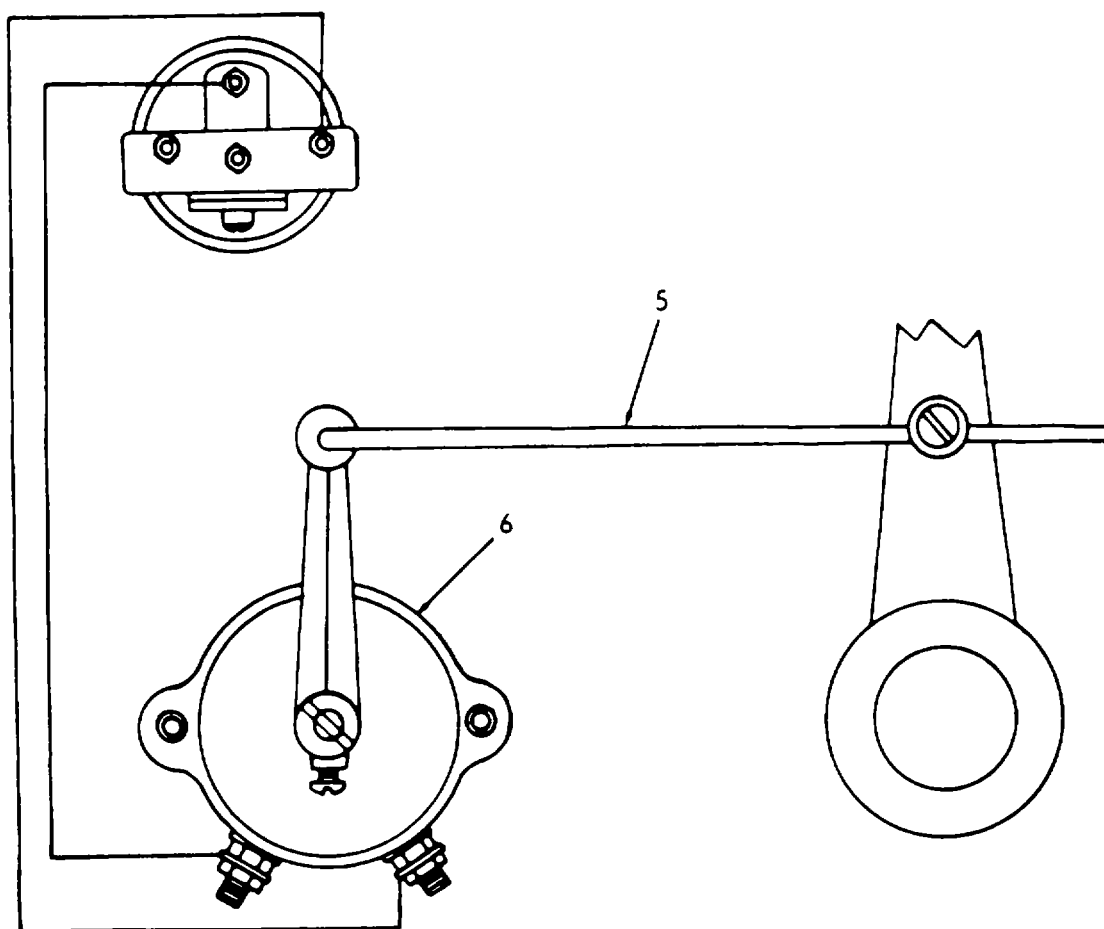


6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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- r. Reconnect arm (5) on rudder angle transmitter (6).



6-15 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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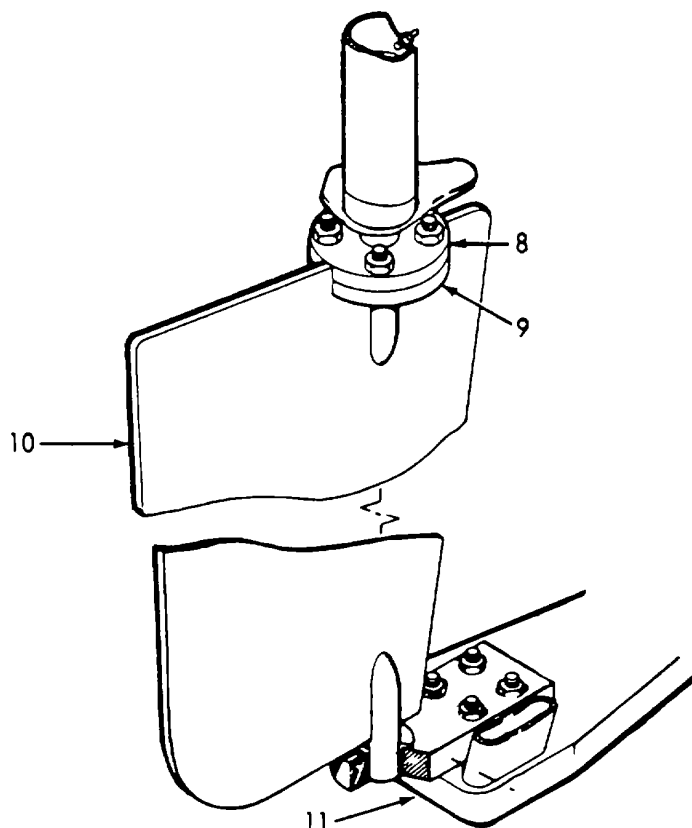
INSTALLATION (Cont)

11. Rudder

WARNING

At least four (4) personnel are required to install the rudder assembly in the craft to avoid the possibility of injury. This assembly weighs approximately 200 lbs (90.718 kg).

- a. Slide rudder assembly (10) into position on skeg bar (11).
- b. Lift up on rudder assembly (10) until lower rudder flange (9) and upper rudder flange (8) join together.



6-15 RUDER AND TILLER (Continued)

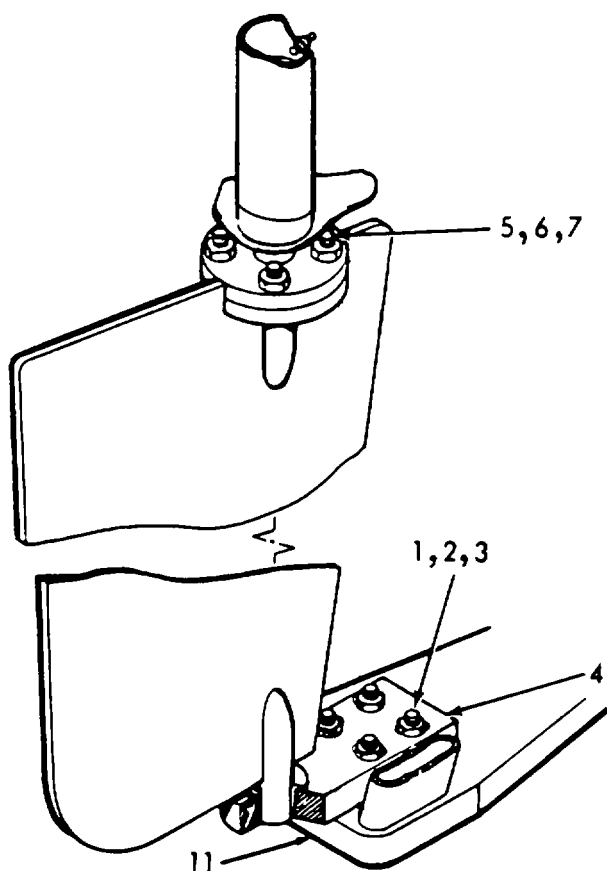
LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

NOTE

Ensure that rudder assembly aligns with bolt holes in skeg bar.

- c. Secure upper and lower flange with bolts (7), washers (6), and bolts (5).
- d. Secure rudder shoe casting (4) to skeg bar (11) with bolts (3), nuts (2) and cotter pins (1).



6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX.

This task covers:

- | | | |
|---------------|----------------|-----------------|
| a. Inspection | d. Cleaning | g. Repair |
| b. Service | e. Inspection | h. Installation |
| c. Removal | f. Replacement | i. Alignment |

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

Dial indicator

Equipment

Condition

Paragraph

Condition Description

6-15

Rudder removed
Landing craft in drydock.

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Pitch block
Welding set
Grinding tool
Anvi1
Forge
Metalizing set

Material/Parts

Cleaning solvent, P-D-680
Tags
Welding rods

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10, 44B, 44E
Diver

General Safety Instructions

Observe WARNINGS and CAUTIONS in
procedure.

6-16 RUDER AND TILLER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION IN WATER

WARNING

- Disconnect and tag negative lead from battery to prevent accidental starting before performing any maintenance.
- Tag hydraulic starting control in the pilot house and engine room to prevent accidental starting of engines before performing any maintenance.

- | | | |
|--------------------|--|--|
| 1. Propeller | <ul style="list-style-type: none"> a. Inspect propeller for bent, cracked or broken blades. b. Inspect for missing or damaged cotter pin. c. Inspect for loose propeller nut, and jamnut. d. Turn propeller by hand and check for binding on shaft. e. Inspect for corrosion. | |
| 2. Propeller Shaft | <ul style="list-style-type: none"> a. Inspect for missing or loose mounting hardware. b. Inspect shaft for visible breaks or cracks. c. Inspect for pitting and corrosion. | |
| 3. Stuffing Box | <ul style="list-style-type: none"> a. Inspect for loose or missing mounting hardware. b. Inspect for excess seepage. | |

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
SERVICE IN WATER		
4. Propeller	a. Remove corrosion.	
	b. Replace cotter pin	If necessary.
	c. Tighten loose jamnut or propeller nut.	
5. Propeller Shaft	a. Replace missing mounting hardware.	
	b. Tighten loose hardware.	
	c. Remove corrosion.	
6. Stuffing Box	a. Tighten adjusting nuts on studs, while turning propeller manually, until any seepage reaches a minimum.	Two personnel are required. Tighten adjusting nuts equally.
	b. Tighten locking nuts against adjusting nuts.	

REMOVAL OUT OF WATER

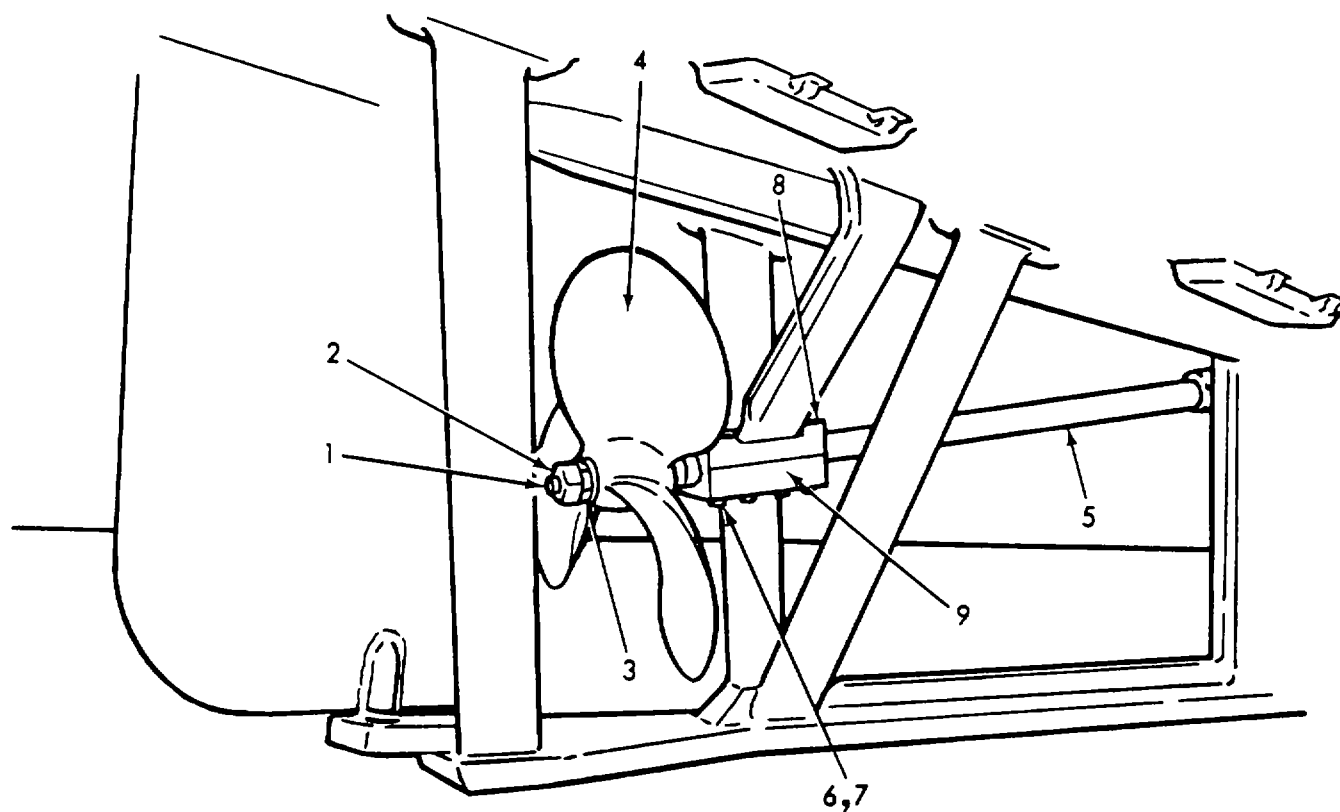
7. Propeller	a. Remove cotter pin (1).	
	b. Remove propeller nut (2) and jamnut (3) from propeller.	
	c. Remove propeller (4) from shaft (5).	
8. Strut Bearing	a. Remove nuts (6), washers (7), and screws (8) from strut bearing.	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL OUT OF WATER (Cont)

- b. Separate halves of strut bearing (9) and remove from propeller shaft (5).

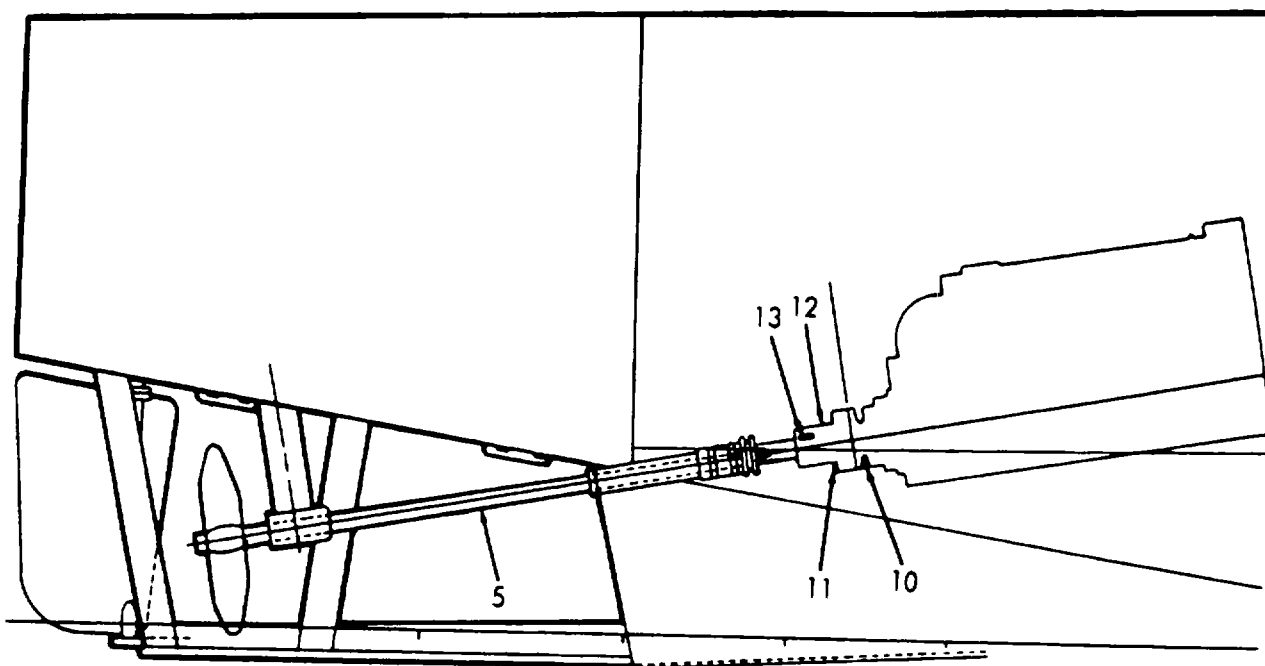


6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL

- | | | |
|-----------------------------|--|--|
| 9. Propeller Shaft Coupling | a. Remove nuts (10) and bolts (11) from shaft coupling (12). | |
| | b. Remove coupling (12) and key (13) from propeller shaft (5). | |



- | | | |
|--|--|--|
| 10. Flexible Hose, Stuffing Box, and Propeller Shaft | a. Remove nuts (14) and bolts (15) from upper portion of mounting plates (20). | |
| | b. Loosen hose clamps (16). Then remove flexible hose (17). | |

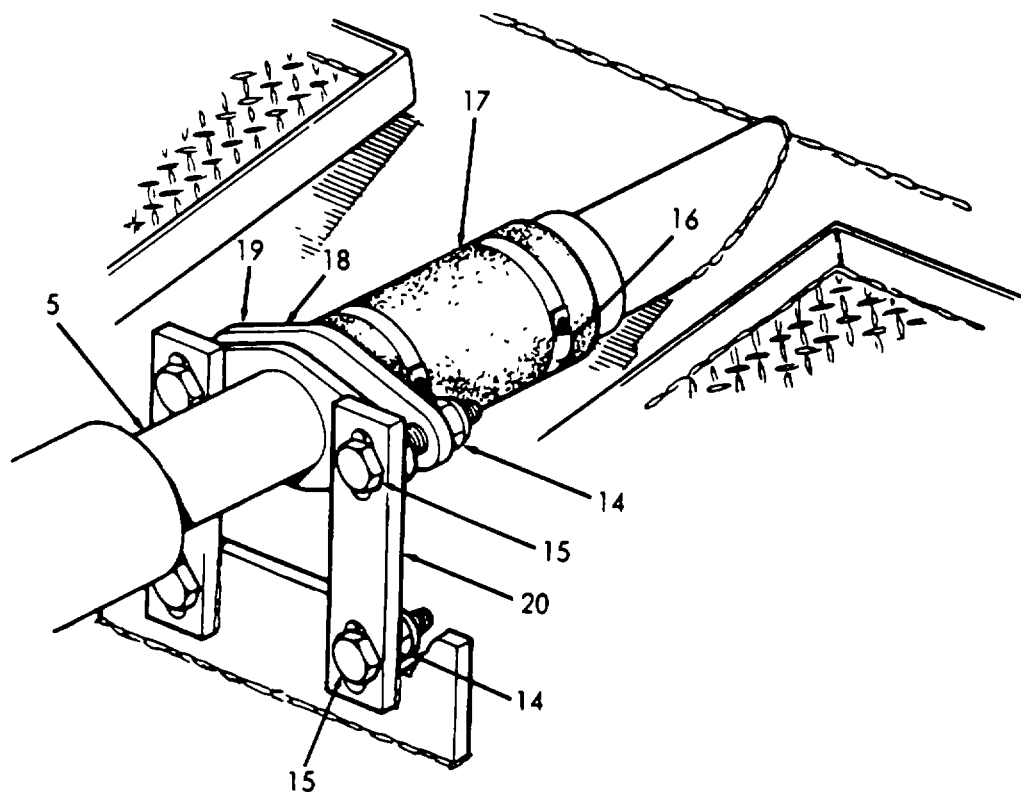
Slide clamps back over hose.

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)		
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- | | | |
|--|--|--|
| | c. Remove packing (18) from stuffing box 19 . | |
| | d. Remove remaining nuts (14), and bolts (15) from mounting plates (20). | |
| | e. Remove mounting plates (20). | |
| | f. Remove propeller shaft (5) from vessel. | |



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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CLEANING

11. Propeller, Propeller Shaft and Stuffing Box		
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WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100 - 138°F (38° - 59°C).

Clean metal parts in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

INSPECTION OUT OF WATER

12. Propeller	Inspect for cracked, bent, or corroded blades.
13. Propeller	a. Inspect for corroded areas. Shaft b. Inspect outboard shafting for pitting.

NOTE

Cracks found in shafting should be thoroughly probed to determine depth and length of cracks.

	c. Inspect shafting sections for straightness and cracks.
14 Stuffing Box and Flexible	a. Inspect hose for cracks, breaks, or deterioration. Hose b. Inspect hose clamps for cracks or breaks.

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

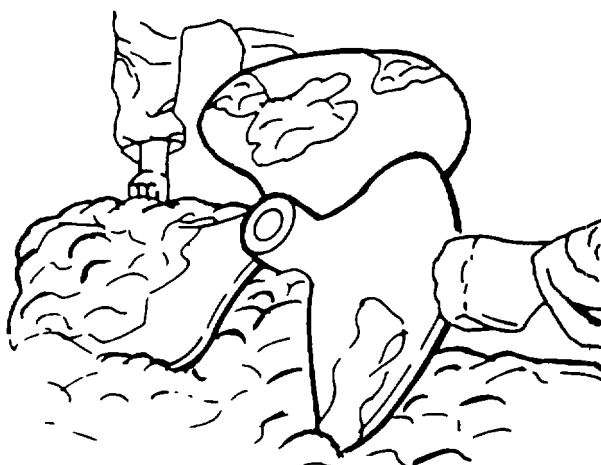
LOCATION/ITEM	ACTION	REMARKS
INSPECTION OUT OF WATER (Cont)		
	c Inspect stuffing box for cracks or breaks.	
15. Hardware	Inspect for crossed, stripped threads or other damage.	
REPLACE		
16. Propeller, Propeller Shaft and Stuffing Box	Replace defective parts as required.	
REPAIR		
17. Propeller	<p>a. <u>Repair</u> The tools necessary for small craft propeller repair are a blacksmith's forge, an anvil, files, and an oxacetylene torch. Straightening and finish work can be conveniently and economically executed in the field.</p> <p>b. <u>Importance of Propeller Straightening.</u> Straightening and balancing minimizes outboard bearing maintenance and avoids over-loading engines, loss of efficiency and speed, and poor performance of misshaped propeller.</p>	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

- c. Heating Propellers. Small bends or depressions in bronze propellers can be straightened while the propeller is cold. Because cold working hardens bronze, large bends or irregularities must be repaired using heat to prevent cold cracks from occurring. When heat is used, heat propeller to a dull red color in a forge or with a gas flame. For overall heating where large surfaces are involved, the forge is faster and gives a more uniform application of heat. Figure below shows a propeller being heated with a forge. For small or localized repairs, a gas flame should be used.



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM

ACTION

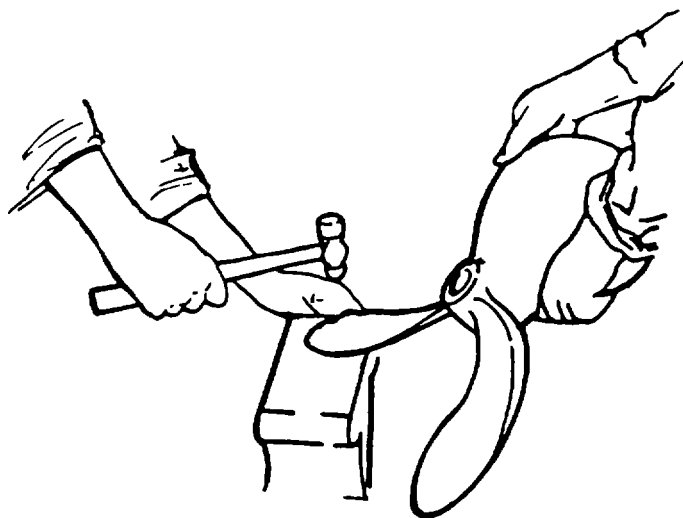
REMARKS

REPAIR (Cont)

CAUTION

Bronze becomes weak at high temperatures and the propeller, if struck, can sag or break. Exercise care when handling or repairing a heated propeller.

- d. Straightening the Blade.
On small propellers, tightly rolled bends are unrolled with blacksmith's tongs. Other irregularities are peened. It is advantageous to peen a bend on its concave or hollow side. On small propellers, strike the blade with a light hammer while backing the peening with the blade on an anvil. A typical peening operation is shown below. Large propellers are peened by using air hammers with a round edge caulking tool. The metal unrolls like wet



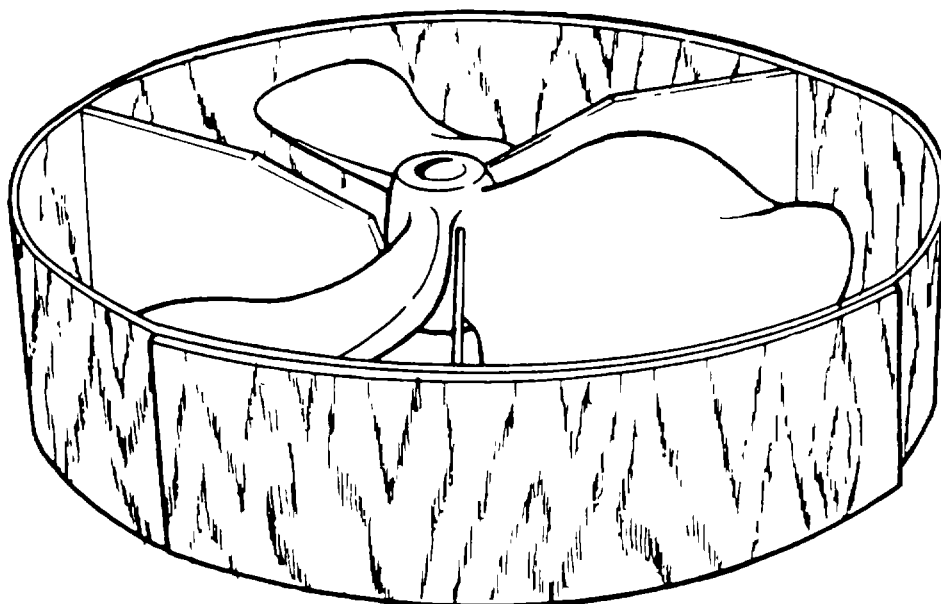
6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

leather under the hammer when the blade is at the correct temperature. Work should be stopped and the propeller reheated when the sound of the metal under the hammer changes from a dull, flat sound to a sharper, ringing sound. Most blades can be reshaped with two or three heatings. During straightening operations the propeller should be compared occasionally to a propeller pitch block.

- e. Making and Using a Pitch Block. A pitch block can be made by pouring concrete in a plywood box and shaping the upper surface of the concrete to fit a new propeller. The figure below shows a badly damaged propeller on a block before straightening.



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

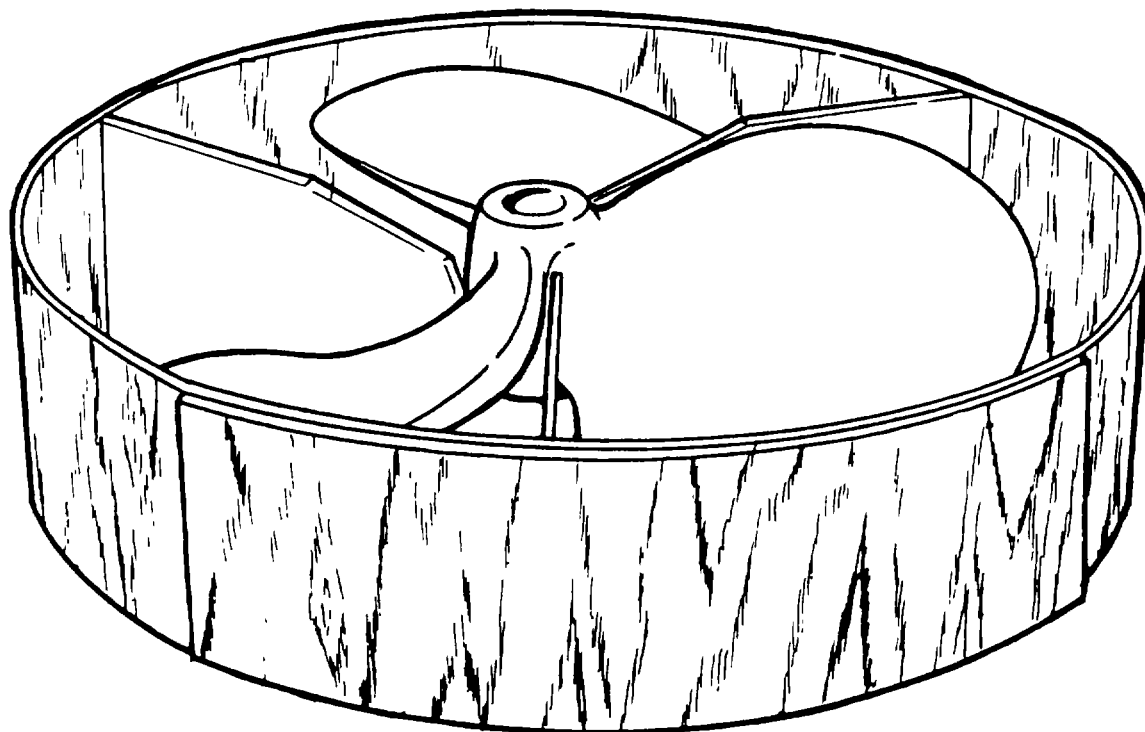
LOCATION/ITEM

ACTION

REMARKS

REPAIR (Cont)

Refer to the figure below showing the propeller on the pitch block after straightening. In figure below the upper edges of the blade are about an inch above the pitch block. This is because the pitch block is for a propeller with a pitch of 17 inches, where the propeller is a 24 inch diameter propeller with a pitch of 18 inches. An efficient blacksmith with an eye for blade configuration can determine the amount of shaping and pitch alignment.



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
REPAIR (Cont)	f. <u>Damaged, Notched Edges</u> The edges of the straightened propeller shown in figure above have notches. Normally notches of the size shown are not filled if other vessels are deadlined for repair. Damaged edge repair is covered in paragraphs i, j and k below.	
	g. <u>Repairs By Welding.</u> The location of the repair governs the kind of weld used and the care necessary. Root sections of the blade carry more stress than sections near the tip and therefore are critical. All metal deposits above the surface of the blade will have to be removed.	
	h. <u>Repair of Root Sections.</u> Because of the high stress on the blade between the hub and 0.4 radius, any repair in the root section is considered major repair, and a welding procedure that can be depended upon to produce a strong, sound weld substantially free of residual stresses should be used. Metallic arc welding, multiple-layer gas welding, and the hot-flow process are approved methods for root section repair.	
	i. <u>Repairs In Sections Outside The 0.4 Radius.</u> Repairs in these areas are relatively minor and can be accomplished with the use of multiple-layer gas welding or metallic arc welding.	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

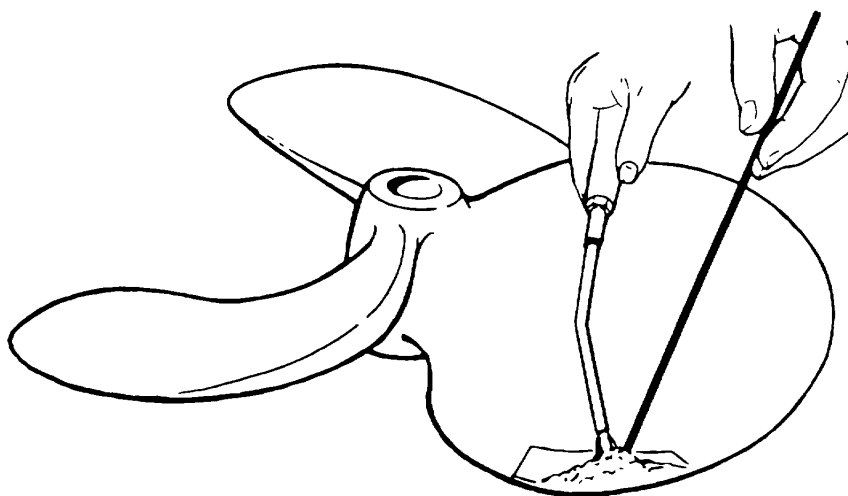
LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

NOTE

The use of silver brazing alloy or any other low temperature brazing alloy is not an approved method, as these alloys have insufficient hardness to resist the erosive action of high velocity water.

- (1) Repair of Cavitation Pits.
Cavitation pits can be weld-filled, using any approved method.
- (2) Repair of Blade Edges.
Broken propeller edges can be replaced by welding a corresponding edge from a discarded propeller, see figure below. Cracks are ground or cut open and then welded together. The entire crack must be round out or it will start cracking again. If necessary, blades can be built up with the same welding rods used in the process of welding. Small notches in the edges are sometimes filled by welding.



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

- j. Finishing Welded Areas. Beads should be ground or filed smooth to match original surface contours. Splatter and flux should be removed by scraping, chipping, and/or grinding or filing. Welded areas should be annealed if required.
- k. Metallic Arc Welding. For major or minor repair to manganese-bronze propellers, a covered aluminum-bronze electrode composed of 90 percent copper and 10 percent aluminum should be used. Phosphorous bronze rods should only be used for minor repairs, as these rods have only about one half the strength of the base metal. Each edge of the repair selections should be beveled 45 degrees (included angle 90 degrees) and the root of the bevel should be rounded to a minimum 1/4 inch radius; however, if the depth is over 1 inch, the sides can be beveled at 15 degrees after the width of the groove at the top exceeds 1-1/2 inches. The section to be repaired should be chipped to sound metal and positioned for down-hand welding. Welds can be made in the vertical position; however, suitable copper or carbon dams should be used to aid in supporting the weld metal. In order to obtain a proper joint, it is imperative that the base metal be locally preheated. The

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
REPAIR (Cont)	<p>preheat temperature should be between 600°F and 826°F (316°C and 427°C). In an emergency, a temperature of 400°F (204°C) can be used. An approved rod of 1/4-, 5/16- or 3/8-inch diameter should be used, especially on propeller sections over 3/8 inch thick. Smaller diameters, 5/32 inch and 3/16 inch, should not be used unless absolutely necessary, and then only when considerable preheating has been done. With sufficient preheat, lower values of the current ranges recommended by the electrode manufacturer can be used. Although lower currents are desirable, the operator's skill and experience must be considered. Therefore, higher currents are preferable to currents too low. Higher currents risk fine porosity in the weld metal, but currents too low risk poor fusion and slag inclusions.</p>	
	<ol style="list-style-type: none"> 1. <u>Hot-Flow Process.</u> The hot-flow process provides a satisfactory method for major repairs. This process consists of flowing molten metal of approximately the same chemical composition as the base metal into the joint. This flow washes away and replaces the parent metal and forms a continuous member upon solidification. Foundry and mold equipment is necessary for the use of this process. 	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

- m. Multiple-Layer Gas Welding.
The multiple-layer gas welding method is an approved for major and minor repairs of propellers. The edges to be welded are beveled to form a 75 degree, single V-groove weld for thickness less than 1-1/2 inches. A 75 degree double V-groove is used if the thickness of the section is greater than 1-1/2 inches (3.81 cm). A copper-zinc, low-fuming, welding rod of the proper size and in accordance with Military Specification MIL-R-19631 is used with a suitable brazing flux for repair of manganese-bronze propellers. A carefully adjusted oxidizing flame is essential for sound welds. A forehand method of welding should be used and the weld metal deposited in beads with limited oscillation not exceeding 1-1/2 times the diameter of the welding rod:
- p. Welding-Preheat and Stress Relief. Because copper-zinc alloys are susceptible to stress-corrosion or season cracking, stress must be relieved, as the propeller can crack after being returned to service. The use of local preheat above 400°F (204°C), preferably

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
REPAIR (Cont)	<p>between 600°F and 800°F (316°C and 427°C), will preclude the accumulation of harmful stresses. Hot-flow welds and large gas welds are automatically preheated and slowly cooled, and stress relief can be safely omitted after welding. Arc welds and small gas welds should be preheated with a torch or other suitable means and then cooled slowly. If it is considered more desirable to stress relief after welding, the following procedure is recommended. Heat slowly to 750°F (399°C) and hold at this temperature for at least 1 hour per inch of thickness of metal in the welded area; cool slowly, approximately 2°F (1°C), per minute, until metal is below 250°F (121°C), after which air-cooling is permissible. During all preheating, welding, or stress relieving, the propeller should be well supported in order to avoid sagging and distortion. Repairs, particularly to heavier sections of the propeller, should be performed with care in order to avoid thermal cracks or tears due to shrinkage stresses which can be imposed on the base metal.</p>	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
IREPAIR (Cont)		
18. Propeller Shaft Assembly	<p>a. Pitted Shafting. Cases of severe pitting in outboard shafting, resulting from damaged or porous covering, should be reported to the appropriate authority who will decide whether the shaft is suitable for further service. If the pitted shafting is approved for reconditioning, the sharp edges of the pits should be well rounded by grinding and the corroded areas should be dressed down to the solid metal surface. Ground out pits and corroded areas, if extensive and of shallow depth, should be filled with approved cavity build-up material. Pits and corroded areas beyond allowable depth should be build-up by welding and covered with a protective rubber or plastic material.</p> <p>b. <u>Vibrations</u>. If objectionable vibrations exist, the shafting sections should be removed and checked for straightness. Dial indicator run outs of shafting ends, measured at the propeller or coupling tapers, should total less than 0.003 inch (0.0015-inch eccentricity), which should prevent excitation of the first-order vibrations (one vibration per shaft revolution). Runouts in excess of 0.003 inch total, giving an unacceptable performance, must be rectified or replaced by a new shaft section.</p>	

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REPAIR (Cont)

- c. Bent Shafting. Approval by the appropriate authority should be obtained prior to straightening severely bent shafting. Repair to the shafting sections can be done by the spot heating method, or electric induction heating, after which the shaft is straightened by mechanically controlled forces.
- d. Cracks In Shafting. Cracks found in propulsion shafting should be thoroughly probed to determine the depth and length of the cracks. If shafting is determined to be repairable, weld crack by an approved method.
- e. Eccentricity. The dial indicator runout for any length of shafting, with respect to the axis of rotation and exclusive of journals and ends, should be limited to an eccentricity of approximately 0.003 inch. If, when the shafting is rotated 360 degrees, runouts greater than this figure are found, this eccentricity should be reduced to the lowest possible limit. A record should be kept of all installed shafting where eccentricities exceed 0.003 inch. Shafting should be replaced if objectionable vibration is still present.

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REPAIR (Cont)

- f. Electrolytic Action. Zinc protector collars on the shafting should be replaced as necessary. Steel shafting that is exposed to sea water should be protected from electrolyte action by a rubber or plastic protective covering when electrolytic action occurs between the steel shaft and the bronze bearing journal sleeve.
- g. Plugging Shaft Ends. All shafting that is exposed to sea water and has been bored throughout its entire length must have both ends plugged to prevent water from seeping into the hollow shaft and into the vessel. One method is by tapping the shaft bore with a tapered pipe thread. In this method, a threaded plug is fitted and installed with thread compound to insure the watertightness of the plug.

INSTALLATION OUT OF WATER

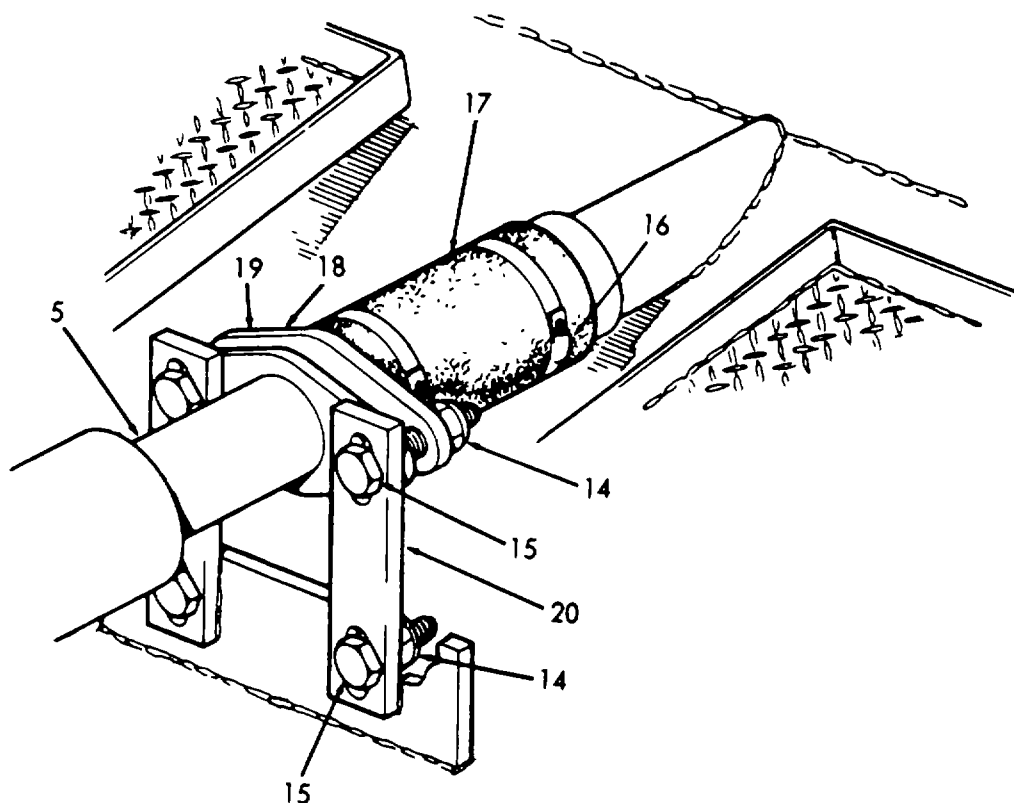
- | | |
|---|--|
| 19. Flexible Hose Stuffing Box, and Propeller Shaft | <ol style="list-style-type: none"> a. Place propeller shaft (5) in position in vessel. b. Install packing (18) in stuffing box (19). c. Position stuffing box (19) in place on propeller shaft (5). |
|---|--|

6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION OUT OF WATER (Cont)

- d. Secure with mounting plates (20), bolts (15), and nuts (14).
- e. Place hose clamps (16) over flexible hose (17).
- f. Install flexible hose (17) over ends of propeller shaft and secure with hose clamps (16).



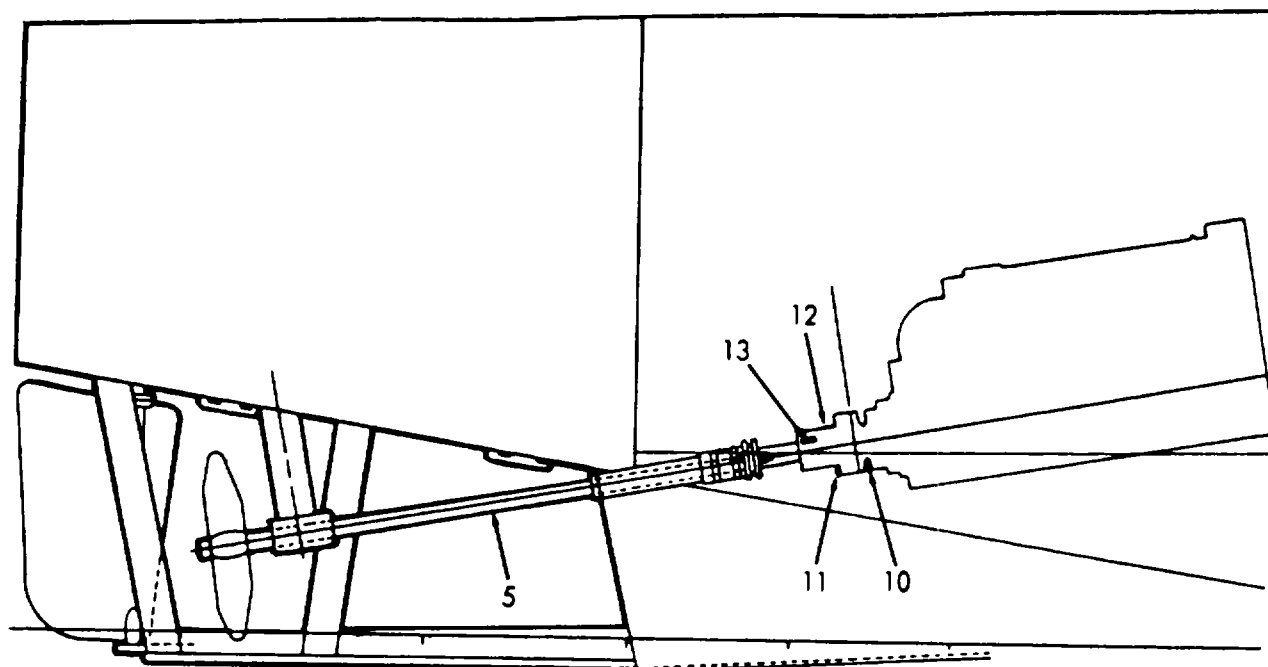
6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION OUT OF WATER (Cont)

20. Propeller
Shaft
Coupling

- Insert key (13) in keyway on propeller shaft (5).
- Place coupling (12) over end of propeller shaft (5).
- Secure with bolts (11) and nuts (10).



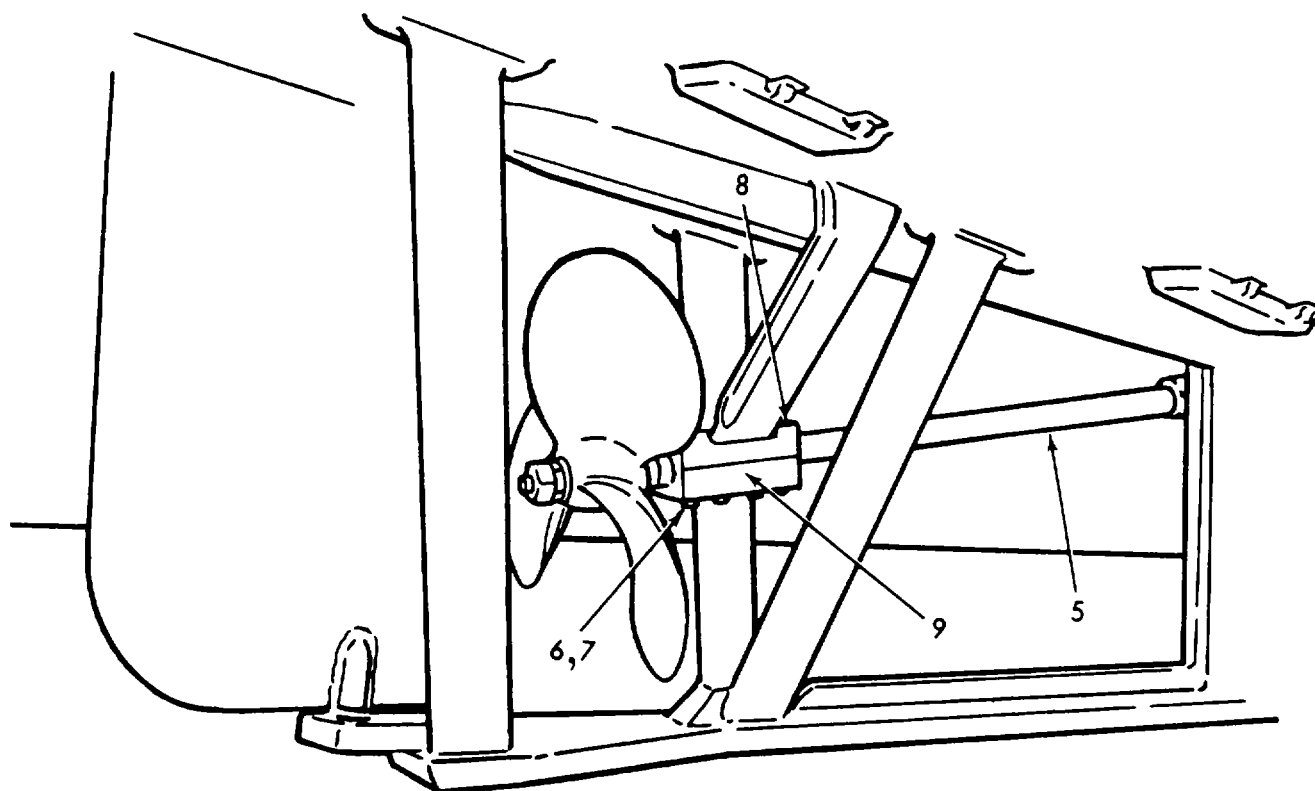
6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION OUT OF WATER (Cont)

21. Strut
Bearing

- a. Place halves of strut bearing (9) over propeller shaft (5).
- b. Secure with screws (8), washers (7), and nuts (6).



6-16 PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ALIGNMENT

22. Propeller
Shaft

- a. Alignment of shaft and bearings is not permanently fixed. The alignment changes with every docking due to changes in the keel blocking, temperature variations, and the direction of the sun's rays relative to the fore and aft line of the vessel. The alignment of shafting and bearings is affected by the temporary removal of machinery attached to the shafting or in the vicinity of the shafting because of the redistribution of weights and stresses. The alignment is not the same when the vessel is waterborne as when it is in drydock. The final alignment and bolting of the main propulsion shafting should always be done when the vessel is waterborne.
- b. The primary purpose for providing correct alignment is to eliminate shaft excited vibrations and to prevent an excessive pressure upon any localized portion of the shafting bearing surfaces (journal bearing areas). The longitudinal line connecting the lowest extremities of all shafting journals having the same diameter should form a continuous-faired line when the machinery is at operating temperature. When the shafting is correctly aligned

6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ALIGNMENT (Cont)

at rest, the bottoms of the shaft journals should be in contact with the bearing material. The bearing clearance at the horizontal centerline of the journal should be equally divided.

- c. In order to obtain and maintain acceptable alignment, the fundamentals of long-established and good practice are as follows:
 - (1) Each bearing shall guide and support the proportionate share of the shafting weight and load.
 - (2) When shaft couplings are broken, each overhanging shaft length will deflect from the true shaft centerline, depending upon the amount of overhanging shaft weight, the loading, and the location of the bearing supports.
 - (3) Alignment of sag charts have been prepared for most vessels showing relative flange positions and the angular slopes of shafting with the coupling bolts have been removed. With tie bearings adjusted to obtain these measurements, proper alignment of the shafting is insured when the coupling bolts are secured.

6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ALIGNMENT (Cont)**d. Methods of Determining Alignment.**

- (1) The proper location of the bearings on main propulsion shafting may be checked by running a line wire. This consists of rigging supports just clear of the end of the outer bearings of the set to be aligned. A length of piano wire is stretched between the supports. The supports must be rigid and not subject to deflection when the wire is put under tension. The wire should be attached to the supports in such a way that it can be accurately centered in the end bearings. After the wire has been centered in the end bearings, the wire forms the line of reference (when corrected for sag) for all the intervening bearings.

6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued).

LOCATION/ITEM

ACTION

REMARKS

ALIGNMENT (Cont)

- (2) Alignment of shafting by the optical method makes use of the line of sight, which for all practical purposes is a true line. This method consists of boring a large hole in the end of two boards. One board is fitted at each end bearing of the set to be aligned. A small hole (about 1/16 to 1/8 inch) is drilled in two pieces of thin sheet metal. The sheet metal is placed on the boards and the small holes are adjusted so that they are aligned with the center of the end bearings. A light is placed behind the board on one end and observed through the hole in the board at the other end. The intermediate boards are adjusted so that the light can be seen through all the holes. The center of these holes serves to establish the reference line.

6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued).**LOCATION/ITEM****ACTION****REMARKS****ALIGNMENT (Cont)**

- (3) When it is suspected that the shaft is out of alignment, it should be checked by slacking the coupling bolts at a coupling near the suspected area on the shaft. Feelers are inserted between the coupling flanges, and if there is a greater distance between the faces at one part of the coupling than at another, the shafts are out of alignment at these places.

INSTALLATION OUT OF WATER**23. Propeller**

- a. Coat propeller shaft (5) with a light coating of graphite and grease on shaft taper.
- b. Place propeller (4) over end of shaft (5).
- c. Secure with jamnut (3) and propeller nut (2).
- d. Align holes in shaft (5) with holes in nut (2) and install cotter pin (1).

6-16. PROPELLER, PROPELLER SHAFT, AND STUFFING BOX (Continued).

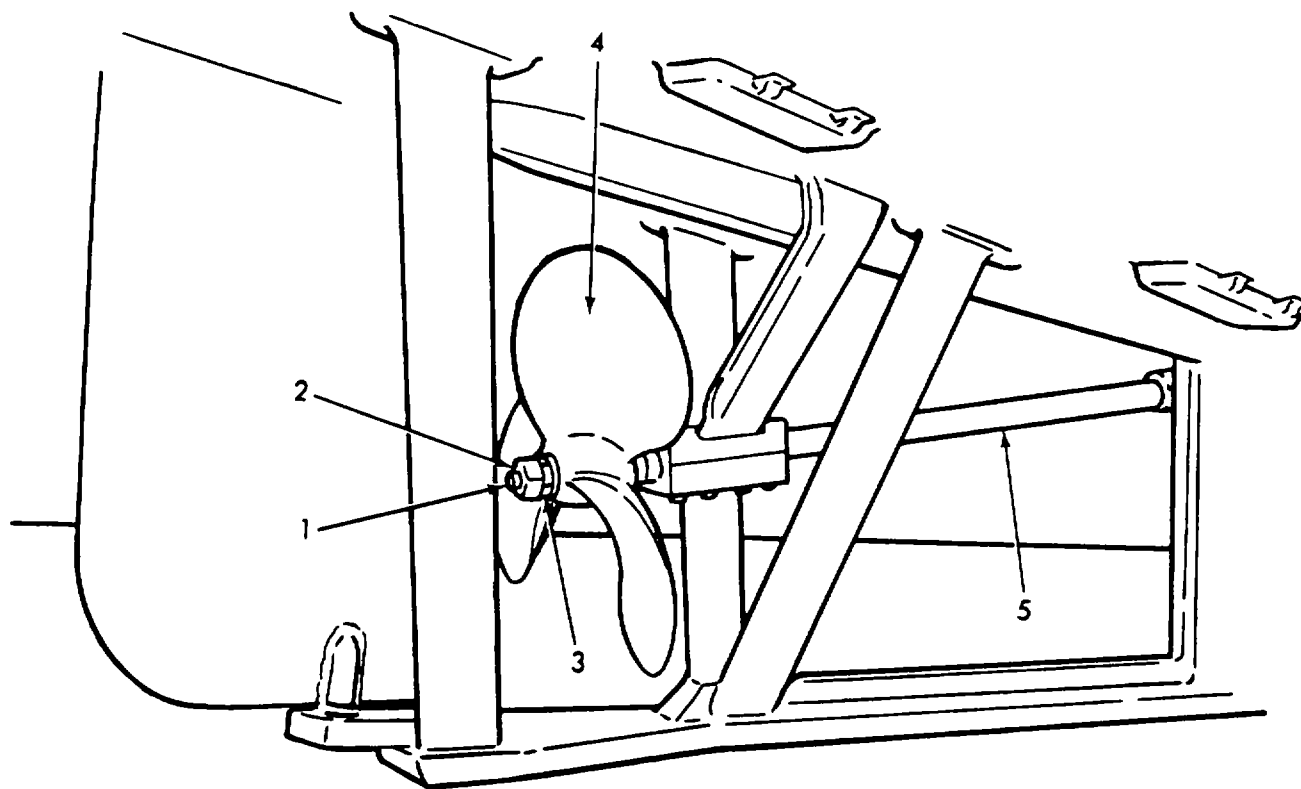
LOCATION/ITEM

ACTION

REMARKS

INSTALLATION OUT OF WATER (Cont)

- e. Reconnect negative battery lead and remove tag.
- f. Remove tags from hydraulic starting control in the pilot-house and engine room.



6-17. KEEL COOLERS

This task covers:

- | | | |
|---------------|-------------------|-----------------|
| a. Inspection | d. Testing | g. Installation |
| b. Removal | e. Inspection | |
| c. Cleaning | f. Replace/Repair | |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

Air compressor
 Tank to accommodate
 Keel Cooler

Equipment
Condition
Condition Description

Landing craft in dry dock and
 cooling system drained.

Tools

General Mechanic's Tool Kit
 NSN 5180-00-629-9783

Material/Parts

Muratic acid
 Oxalic acid

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Refer to CAUTION prior to removal.

LOCATION/ITEM**ACTION****REMARKS****INSPECTION**

- | | |
|----------------|---|
| 1. Keel Cooler | a. Inspect keel cooler for evidence of leaking. |
| | b. Inspect for missing or loose mounting hardware. |
| | c. Inspect hoses for cracks, breaks, and deterioration. |

6-17. KEEL COOLERS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSPECTION (Cont)

- d. Inspect hose clamps for looseness or leaking condition. Tighten as required.

REMOVAL

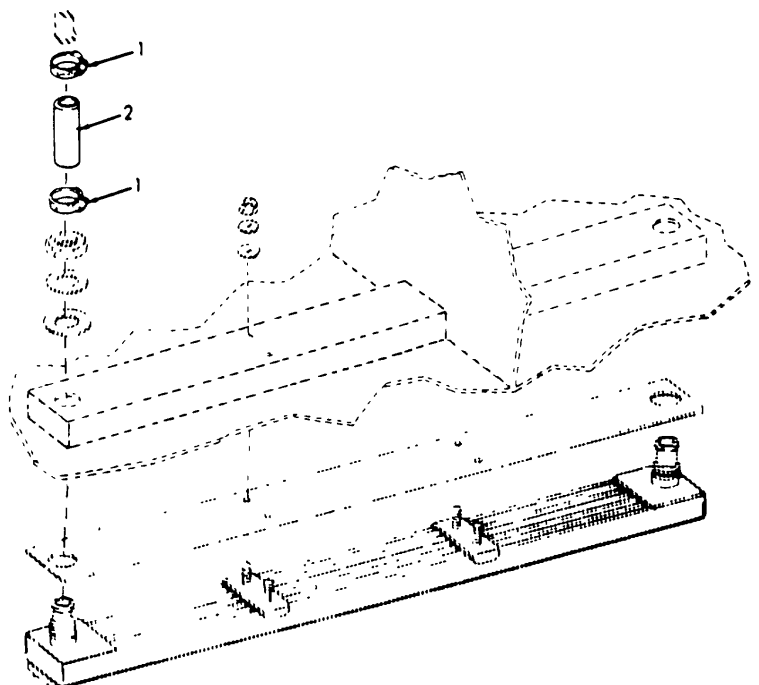
2. Keel Cooler

NOTE

Prior to removal of keel cooler, drain cooling system by removing drain plug from each end of the cooler.

- a. Loosen hose clamps (1) and slide onto flexible hose (2).
- b. Remove hose (2).

Do not remove hose clamps unless hose is to be replaced or clamp(s) are damaged.



6-17. KEEL COOLERS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

- | | | |
|----|--|-----------------|
| c. | Remove other hose in the same manner. | |
| d. | Remove pipe nuts (3), flat washers (4), and neoprene gaskets (5) from each end of keel cooler. | Discard gasket. |

CAUTION

Before further removal, station personnel beneath keel cooler to lower it when completely detached from recess to avoid damage to the cooler if it should fall.

- | | | |
|----|---|-----------------|
| e. | Remove nuts (6), flatwashers (7), and neoprene gasket (8) from cooler mounting studs (9). | Discard gasket. |
| f. | Remove keel cooler (10) and mounting gasket (11) from vessel. | Discard gasket. |
| g. | Repeat steps a. through f. to remove other keel cooler. | |

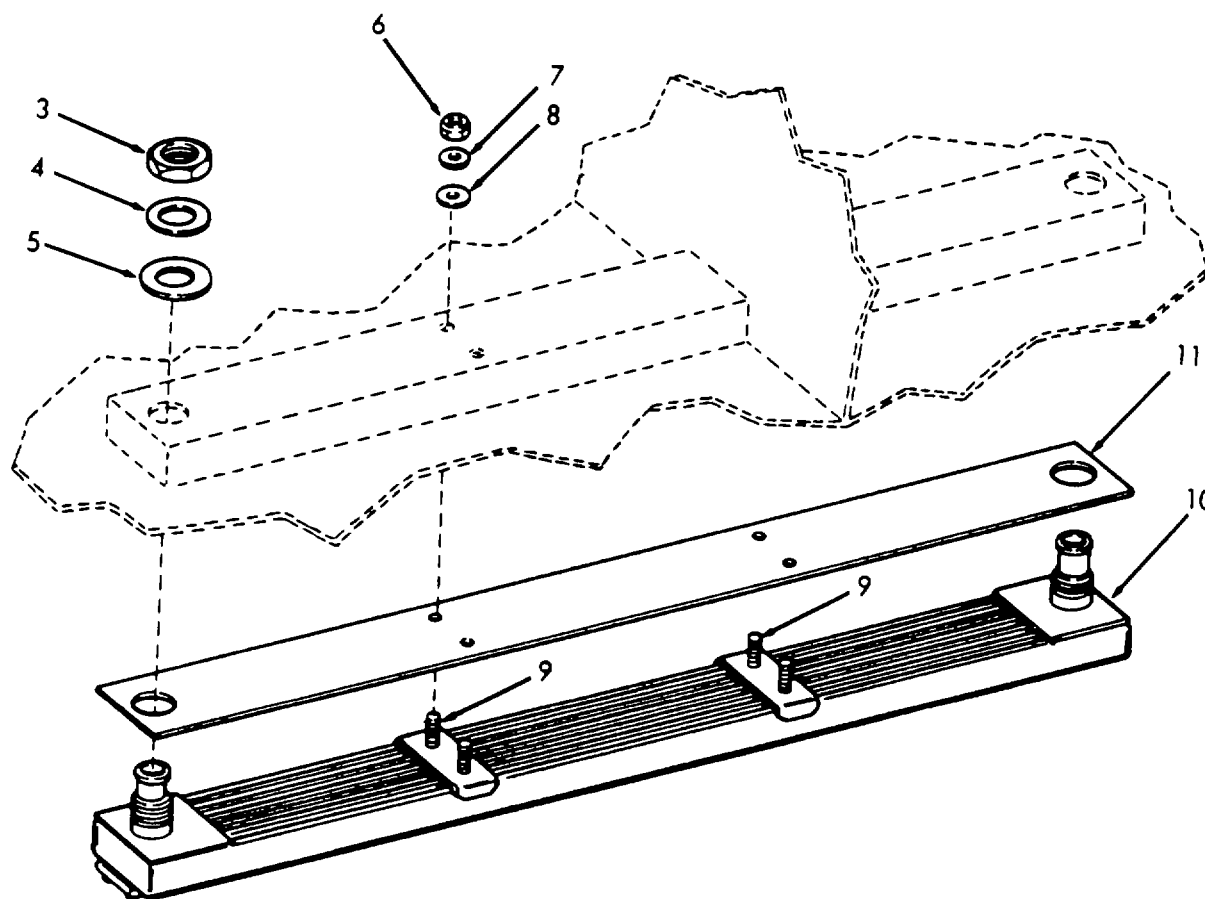
6-17. KEEL COOLERS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



CLEANING

3. Keel
Coolersa. Prepare a cleaning solution as
follows:

In a full gallon container, place $\frac{2}{3}$ water and $\frac{1}{3}$ Muriatic acid (by volume). After stirring thoroughly, add one pound of Oxalic acid and stir until Oxalic acid dissolves.

6-17. KEEL COOLERS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING (Cont)

- b. Fill cooler with cleaning solution.
- c. Allow solution to stand for a minimum of one minute, but at least until bubbling stops. Empty into sewer or disposal system and flush with fresh water.
- d. Refill cooler with solution and allow to stand until bubbling stops.
- e. Empty cooler of all the cleaning solution and flush cooler thoroughly with hot water.

TESTING

4. Keel Cooler
 - a. Provide seal for one inlet to hold air under pressure [approximately 20 psi (137.9 kPa)].
 - b. Prepare fitting for second inlet that has air line fitting.
 - c. Install both inlet fittings.
 - d. Pressurize cooler to approximately 10 psi (68.9476 kPa) and submerge cooler in clear water not allowing "seals" to be submerged.

6-17. KEEL COOLERS (Continued).

LOCATION/ITEM

ACTION

REMARKS

TESTING (Cont)

- e. Observe any air bubble that would indicate a leak.
- f. If a leak is found, cooler must be replaced.

INSPECTION

5. Keel Cooler

- a. Inspect inlets for damage to lip or threads.
- b. Inspect studs and mounting nuts for stripped or damaged threads.
- c. Inspect hoses for cracks, breaks, or deterioration.

REPLACE/REPAIR

6. Keel Cooler

- a. Replace keel cooler if leak(s) were found or keel cooler is damaged beyond repair.
- b. Replace all gaskets.
- c. Replace all damaged or defective hardware.
- d. Replace defective hoses or hose clamps.

6-17. KEEL COOLERS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSTALLATION

7. Keel Cooler

NOTE

Make certain that mounting gasket surface of cooler is free of any matter before installing gasket.

- a. Position mounting gasket (11) in place on cooler (10).

NOTE

Two (2) personnel are required to lift cooler into recess of hull for mounting.

- b. Place cooler and gasket into recess in hull.
- c. Place neoprene gaskets (8) and flatwashers (7) over mounting studs (9).
- d. Install nuts (6) to secure.
- e. Place neoprene gaskets (5) and flatwashers (4) onto pipes (12 and 13).
- f. Install pipe nuts (3) to secure.
- g. Place hose clamp (1) over hose.
- h. Place hose (2) over ends of piping.
- i. Slide hose clamps (1) into position and tighten securely.

Torque nuts to
7 - 9 ft.lb.
(9.5 - 12.2 Nm).

Torque nuts to
7 - 9 ft. 1 lb.
(9.5 - 12.2 Nm).

6-17. KEEL COOLERS (Continued).

LOCATION/ITEM

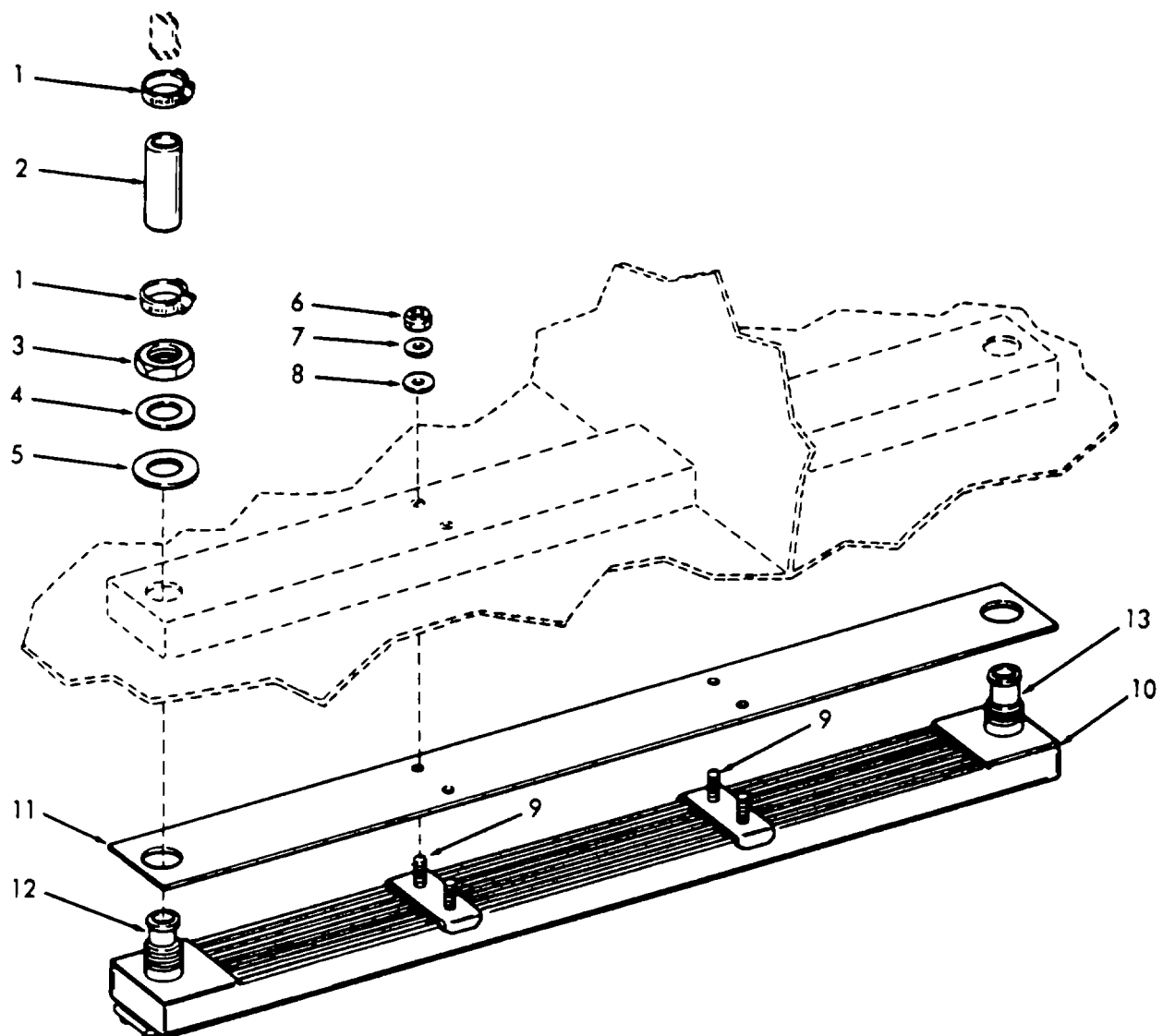
ACTION

REMARKS

INSTALLATION (Cont)

j. Repeat steps a through i to install other cooler.

k. Refill cooling system.



6-18. ALTERNATOR

This task covers:

- | | |
|----------------|-------------|
| a. Disassembly | c. Overhaul |
| b. Testing | d. Assembly |

INITIAL SETUPTest Equipment

DC ohmmeter or Multimeter

References

NONE

Special Tools

NONE

Equipment	<u>Condition Description</u>
<u>Condition</u>	
<u>Paragraph</u>	

5-12.1

Alternator disassembled
and reassembledTools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Soldering iron

Material/Parts

Solder Fed. Spec. QQ-S-571

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10, 51R

General Safety Instructions

NONE

LOCATION/ITEM**ACTION****REMARKS****DISASSEMBLY**

- | | |
|--|---|
| 1. Alternator
into Subas-
semblies | Refer to paragraph 5-12.1
for disassembly. |
| 2. Rear Housing
Assembly | |

NOTE

Make a note of all washers and insulators that are removed so they can be properly replaced during reassembly.

6-18. ALTERNATOR (Continued).

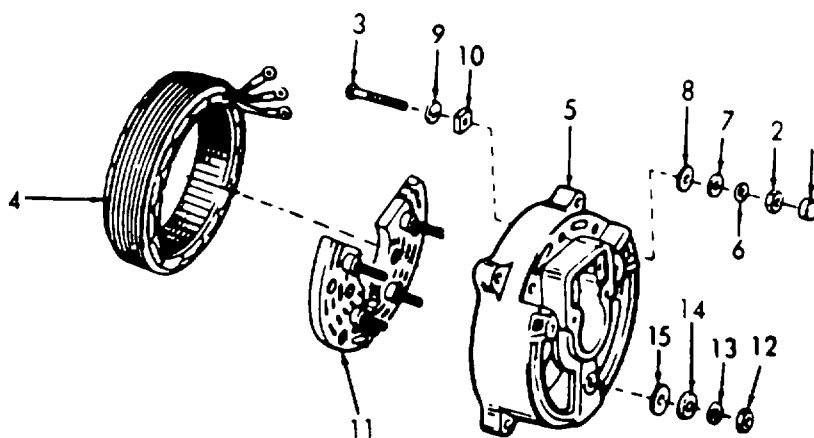
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- a. Remove three stud caps (1) and hex nuts (2) from three-phase winding carriage bolts (3) and disconnect stator wires.
- b. Separate stator assembly (4) from rear housing (5).
- c. Remove three hex nuts (2) securing carriage bolts (3) to rear housing.
- d. Remove carriage bolts (3), washers (6, 7, 8, and 9), and terminal insulators (10).
- e. Remove screw securing ground lead to negative rectifier diode heat-sink (11).
- f. Remove hex nuts (12) and washers (13, 14, and 15).



6-18. ALTERNATOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- g. Remove entire diode assembly (16) (with isolation diode (21) attached) from housing (6).
- h. Remove two acorn nuts (17), and washers (18, 19, and 20).
- i. Separate isolation diode assembly (21) from diode assembly (16).
- j. Remove carriage bolts (22), terminal lug (23), and insulator (24) from isolation diode assembly (21).
- k. Remove three harness assemblies (25) and capacitor assembly (26).
- l. Individual diode removal.
 - (1) Unsolder the connecting wires from the diodes.

CAUTION

When applying soldering iron to a diode lead connection, grasp the diode connection terminal with long nose pliers (between soldering iron and diode), to prevent overheating and thereby damaging a diode.

- (2) Set diode plate on a 3/4 inch to 1 inch diameter tubular tool or jig with the terminal facing down.

6-18. ALTERNATOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

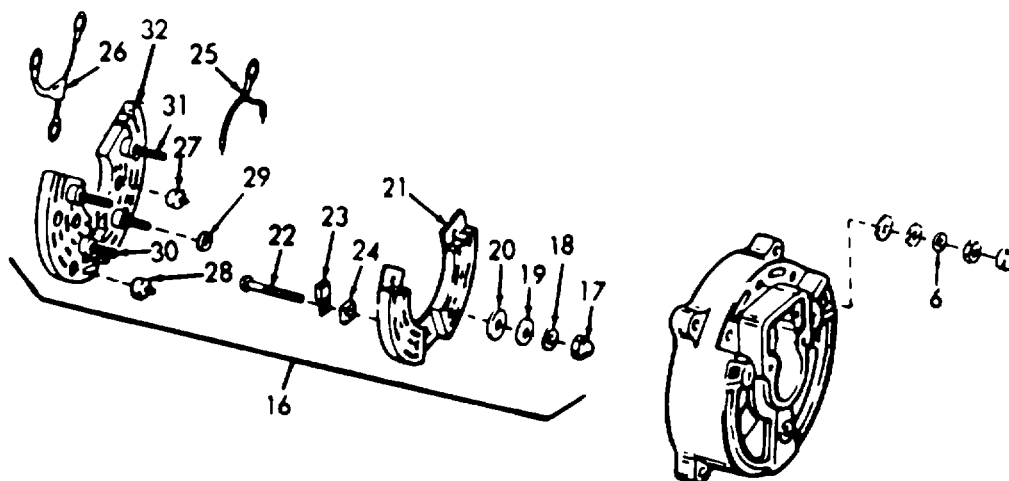
DISASSEMBLY (Cont)

- (3) Use a small round tool and arbor press to press diodes from heat-sinks (27 and 28).

CAUTION

Do not hammer diode to remove since a shock of this force will damage the diodes.

- (4) Remove diode ring insulators (29) and carriage bolt (30).
- (5) Remove carriage bolt (31), and heat-sink (32).



6-18. ALTERNATOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

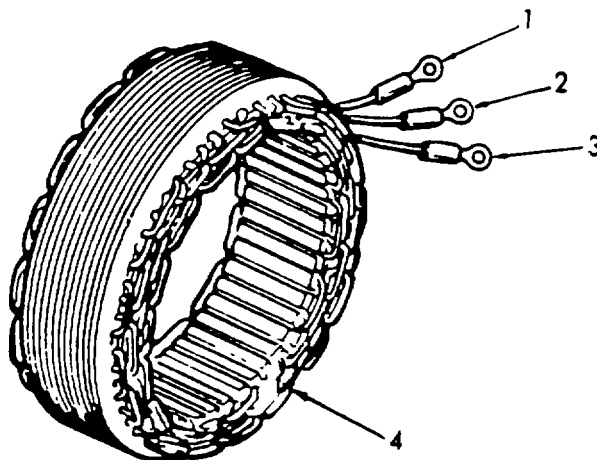
TESTING

3. Stator
Assembly

NOTE

Perform tests on electrical components using a suitable ohmmeter or multimeter as follows:

Check for short circuit between each stator lead and frame. Connect ohmmeter between each stator lead (1, 2, or 3), and stator frame (4) in turn. Ohmmeter should indicate open circuit or very high resistance. Stator assembly shall be replaced if winding(s) are shorted (no or low resistance).



4. Brush Assembly
and Rotor
Assembly

Refer to paragraph 5-12.1 for testing.

5. Rectifier
Diodes

- a. Check resistance of isolation diodes with ohmmeter. Each diode should indicate a high resistance in one direction and low resistance in other direction (ohmmeter leads reversed). Replace defective isolation diode(s).

6-18. ALTERNATOR (Continued).

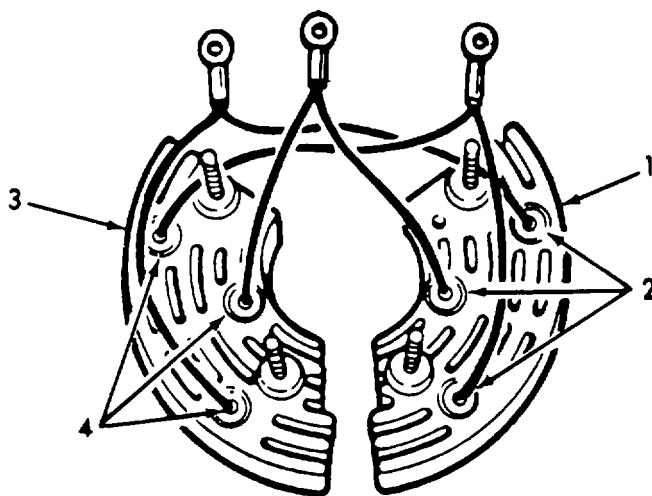
LOCATION/ITEM

ACTION

REMARKS

TESTING (Cont)

- b. Check negative rectifier diodes with an ohmmeter. Connect negative (-) ohmmeter probe to diode heat-sink (1), and positive (+) probe to each diode (2) terminal. Resistance should be low or zero. If resistance is high, diode is defective.
- c. Check negative rectifier diodes as specified in "b" above but with ohmmeter leads reversed. Resistance should be high or infinite. If resistance is low, diode is defective.
- d. Check positive rectifier diodes with an ohmmeter. Connect positive (+) probe to diode heat-sink (3) and negative (-) probe to each diode (4) terminal. Resistance should be low or zero. If resistance is high, diode is defective.



6-18. ALTERNATOR (Continued).**LOCATION/ITEM****ACTION****REMARKS****TESTING (Cont)**

- e. Check positive rectifier diodes as specified in "d" above but with ohmmeter leads reversed. Resistance should be high or infinite. If resistance is low, diode is defective. Replace all faulty diodes.

OVERHAUL

- 6.
 - a. Replace defective stator assembly.
 - b. Replace defective diodes.

ASSEMBLY

- 7. Rear Housing
 - a. Fit diodes (28 and 27) into diode holes in heat-sink (32).
 - b. Slowly rotate diode in the hole until the serration's on the diode are not lined up with the serrations made in the hole by the original diode. This insures good heat conduction and a secure mounting.
 - c. Press diodes (28 and 27) into their holes with a 1/2 Inch tubular tool. Make sure diode is completely seated.
 - d. Position the three harness assemblies (25) and capacitor assembly (26) onto diodes.

CAUTION

When soldering diodes, grasp the diode connection terminal with long-nose pliers (between soldering iron and diode) to prevent overheating and damage to the diodes.

6-18. ALTERNATOR (Continued).

LOCATION/ITEM

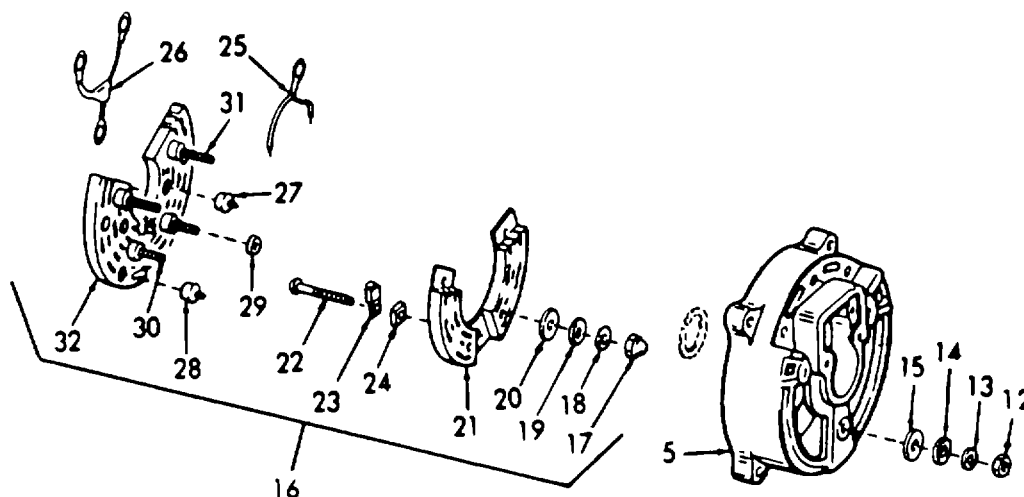
ACTION

REMARKS

ASSEMBLY (Cont)

- e. Solder harness assemblies and capacitor assembly to diodes using resin core solder (Fed. Spec. QQ-S-571).
- f. Install carriage bolts (31 and 30) in heat-sink (32).
- g. Install insulators (29).
- h. Install insulators (24), terminal lugs (23), and carriage bolts (22) into isolation diode assembly (21).
- i. Place isolation diode assembly (21) onto the two rectifier diode heat-sink assemblies (32).
- j. Install washers (20, 19, and 18) on protruding ends of carriage bolts and secure with acorn nuts (17).
- k. Place entire diode assembly (16) into the rear housing (5).
- l. Secure with washers (15, 14, and 13) and hex nuts (12).

Ensure harness and capacitor assemblies are connected properly.



6-18. ALTERNATOR (Continued).

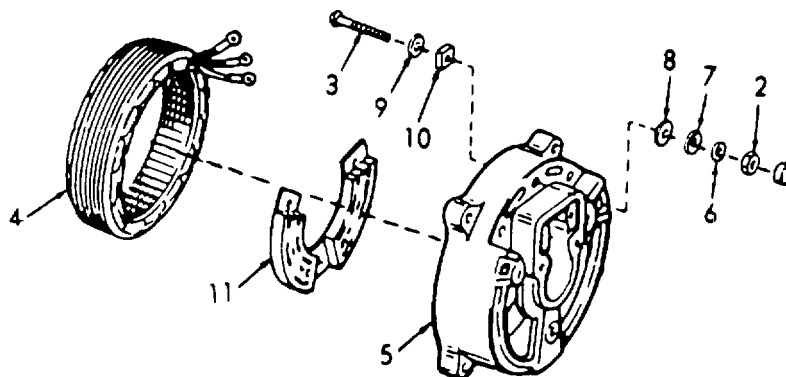
LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- m. Install self-tapping screw to secure ground lead to negative diode plate (11).
- n. Install terminal insulators (9) and washers (10) on carriage bolts (3).
- o. Insert carriage bolts into rear housing (5) and install washers (8, 7, and 6) on carriage bolts,
- p. Position stator wires (4) over protruding ends of carriage bolts (3) and secure with hex nuts (2), and stud caps (1).



8. Front Housing

Refer to paragraph 5-12.1 for assembly.

9. Rear Cover

Refer to paragraph 5-12.1 for assembly.

10. Alternator

Refer to paragraph 5-12.1 for assembly.

6-19. STARTING MOTORS (ELECTRIC).

This task covers:

- | | | |
|----------------|-------------|-------------|
| a. Disassembly | c. Overhaul | e. Assembly |
| b. Cleaning | d. Testing | f. Testing |

INITIAL SETUP**Test Equipment**

Ammeter
RPM indicator
Spring gauge
110-volt test lamp
Growler
Four 6 volt, 200 ampere
storage batteries
Varistor

References

NONE

Special Tools

Torque wrench

Equipment
Condition
Paragraph

Condition Description

5-12.2

Starter removed

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Soldering iron

Material/Parts

Flint paper Fed. Spec. P-P-111
Insulating tape MIL-I-3158
Varnish, MIL-V-1137 Grade CB
Rosin core solder QQ-S-571
Inhibited methyl chloroform

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10, 51R

General Safety Instructions

Refer to WARNING prior to
cleaning.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

DISASSEMBLY

- | | | |
|-----------------------------|---|--|
| 1. Cover Band Assembly | Refer to paragraph 5-12.2 and remove. | |
| 2. Drive Housing Assembly | Refer to paragraph 5-12.2 and remove. | |
| 3. Middle Bearing Assembly | Refer to paragraph 5-12.2 and remove. | |
| 4. Commutator End Bearing | Refer to paragraph 5-12.2 and remove. | |
| 5. Frame and Field Assembly | <ul style="list-style-type: none"> a. Unsolder four field coil assembly leads (1) from field terminal studs (17). b. Remove eight pole shoe screws (2), four pole shoes (3), and two field coil assemblies (4 and 5) from field frame (18). c. Remove field coil insulating strips (6 and 7). d. Remove ventilators (8 and 9) from field frame (18). e. Remove terminal stud nut (10), lockwasher (11), stud nut (12), lockwasher (13), washer (14), stud insulator (15), and insulated bushing (16), from terminal stud (17). f. Remove field terminal stud (17), insulation strip (19), flat washer (20), and inside insulator washer (21) from terminal stud (17). | |

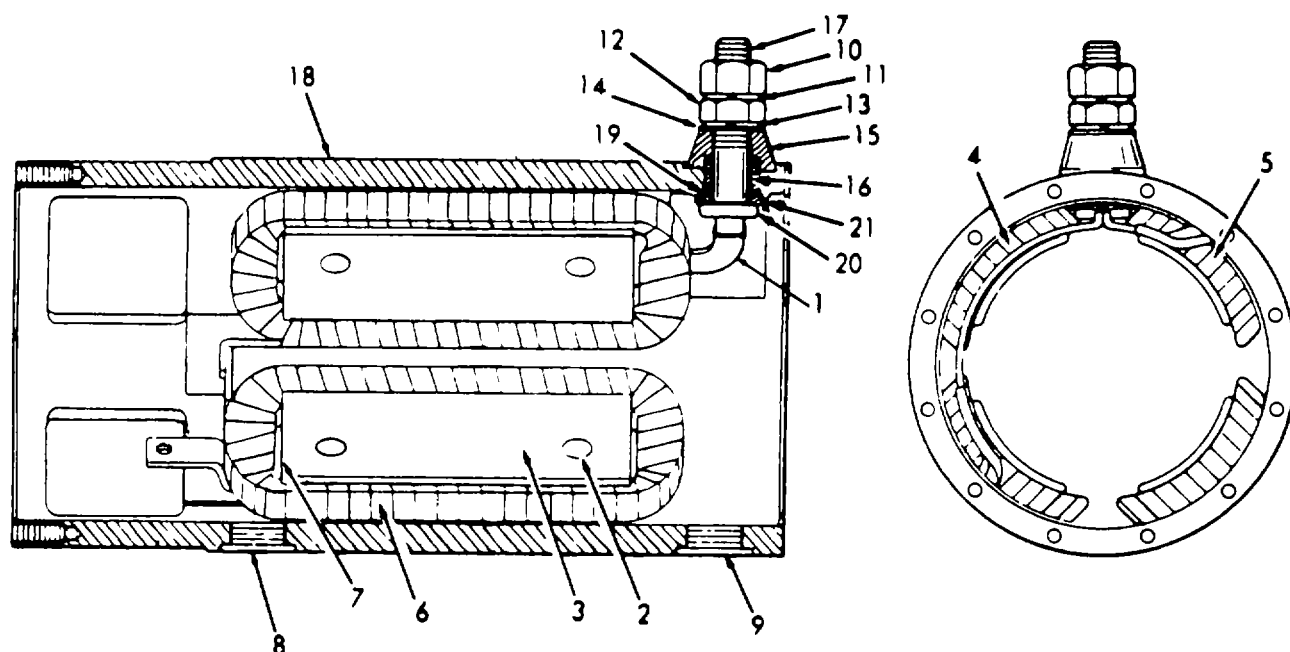
6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



CLEANING

6. Starting Motor

WARNING

Inhibited methyl chloroform is TOXIC and FLAMMABLE.

CAUTION

Do not clean armature or field coils by any degreasing method since this would damage insulation and possibly ruin the armature and field coil windings.

- a. To clean, wipe with a clean cloth slightly dampened with inhibited methyl chloroform.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

CLEANING (Cent)

- b. General cleaning of the commutator is done with No. 0/2 flint paper (Federal Specification P-P-111).
- c. The field coils should be cleaned by wiping with a clean, dry cloth. Be careful in handling the windings to avoid breaking or weakening the connecting straps between windings.

OVERHAUL

7. Starting Motor

- a. Replace brushes.
- b. The brush springs should have sufficient tension to provide the proper pressure between the brushes and commutator after the unit is assembled. This may be checked by placing the armature and commutator end frame together in their normal operating position. and then placing the brushes in their holders with the springs in place so that the tension of the springs against the brushes can be measured with a spring gauge. Correct spring tension should be 36 to 40 ounces (10 to 11 n). Replace springs if tension is not correct.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

OVERHAUL (Cont)

- c. If the bearings are worn more than 0.005 inch (0.127 mm) beyond maximum dimension, as listed below, they should be replaced. Wear will be greatest on the side which sustains the greatest thrust during cranking. After a new bearing is pressed into place, cross drill oil hole. Ream to finish size, as listed below, and remove burrs in oil passage. Finish size of bearings are:

	Inches	Millimeters
Drive end housing bearing, ID	0.8145 - 0.8165	20.688 - 22.263
Middle bearing, ID	0.997 - 0.999	25.324 - 25.375
Commutator end bearing, ID	0.562 - 0.564	14.275 - 14.326

- d. If the brush holders, spacer plates, insulators, etc., are bent, warped, cracked, burned, or otherwise damaged, replace parts as needed.
- e. The spring clutch Bendix drive assembly is serviced by replacing complete unit. The unit must be in good condition, with parts tightly fastened together. If pinion teeth are worn, burred, or chipped, replace Bendix drive assembly.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

- f. Any defective insulator, screw, washer, lead, stud, plate, etc., should be replaced. Replace any cracked, bent, worn, burned insulators or washers that are defective. Studs or screws which are bent, battered, broken, or which have crossed or damaged threads, must be replaced. Leads which have broken strands or frayed insulation are must be replaced.
- g. If the field insulation is charred or chafed so that the windings are exposed, it is sometimes possible to rewrap them with insulating tape (0.007 x 1/2 glass tape-Specification MIL-I-3158) and paint them with insulating varnish (Specification MIL-V-1137 grade CB). This operation must be executed with care and neatness since excessive bulkiness of the tape will prevent reassembling the windings under the pole shoes in the proper manner. Soldered connections must be made with rosin core solder (Federal Specification QQ-S-571).
- h. If the commutator is worn, out-of-round by more than 0.003 inch (.076 mm), has high mica, filled slot, or is burned, mount the armature by the shaft bearing surfaces in a lathe and take light cuts until the commutator is completely cleaned up.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

OVERHAUL (Cont)

NOTE

Make cut not deeper than necessary.

- (1) Under cut mica 1/32 inch (.793 mm).
- (2) Remove all burrs with 0/2 flintpaper.

TESTING

8. Starting Motor

a. Armature.

- (1) The armature leads may become grounded to the armature laminations due to deterioration of the insulation. This can be checked with a 110 volt test lamp and test points, checking from the commutator to the armature laminations. If the lamp lights, a ground exists, and the armature must be replaced.
- (2) The armature may become open circuited at the commutator riser bars as a result of long cranking periods, which overheat the unit and cause the armature leads to become open circuited.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

TESTING (Cont)

An open circuited armature is often easy to detect, since this condition produces some badly burned commutator bars with other bars fairly clean. Since the armature is of a welded construction such a condition will be rare, but if it does occur, replace the armature.

- (3) A short circuit may occur between adjacent armature leads due to deterioration of the insulation. To check an armature for short circuits, place armature on a growler and hold a thin steel strip lengthwise on the core parallel to the shaft. Slowly rotate the armature through a complete revolution. If a short circuit is present, the steel strip will become magnetized and vibrate. Inspect the commutator slots carefully, since copper or brush dust sometimes collects in the slots and shorts

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

TESTING (Cont)

adjacent bars. If short circuit still exists, replace armature.

b. Field coils.

- (1) The fields may become grounded to the frame due to deterioration of the insulation. This can be checked with a 110 volt test lamp and test points, checking from the field coil terminals to the frame. If the lamp lights, a ground exists, and the defective field coil must be replaced.
- (2) An open circuited field coil can be checked with a test lamp and test points, checking the two extremities of each field coil. If the test lamp fails to light, an open circuit exists and the defective field coil must be replaced.

6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

ASSEMBLY

- | | | |
|-----------------------------|---|--|
| 9. Frame and Field Assembly | <ul style="list-style-type: none"> a. Place inside insulator washer (21), flatwasher (20) and insulation strip (19) on field terminal stud (17) and insert into field frame (18). b. In order, place insulated bushing (16), stud insulator (15), washer (14), lockwasher (13), stud nut (12), lockwasher (11), and terminal stud nut (10) on terminal stud (17) and tighten nuts. c. Install ventilators (9 and 8) in field frame (18). d. Position in place the two pieces of field coil insulation strips (7 and 6). e. Position in field frame two field coil assemblies (5 and 4) and four pole shoes (3). f. Secure with pole screws (2). g. Resolder field coil leads (1) to terminal studs (17). | |
|-----------------------------|---|--|

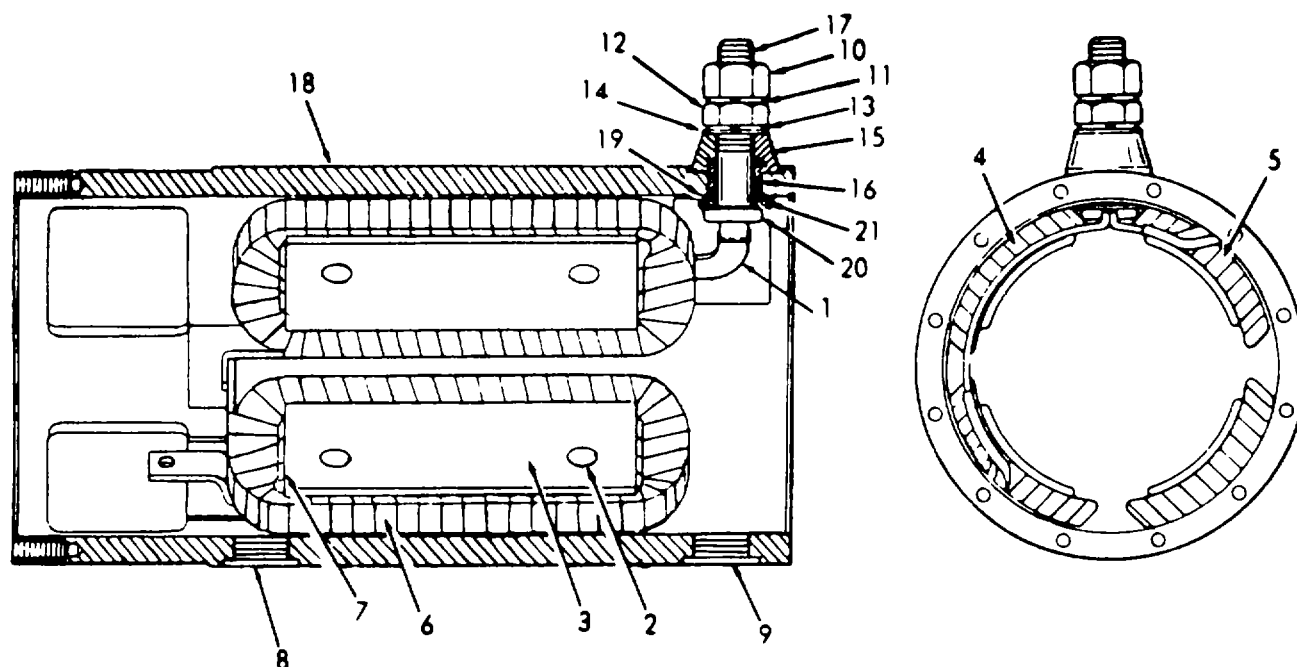
6-19. STARTING MOTORS (ELECTRIC) (Continued).

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)



- | | |
|-----------------------------|--|
| 10. Commutator End Bearing | Refer to paragraph 5-12.2 and install. |
| 11. Middle Bearing Assembly | Refer to paragraph 5-12.2 and install. |
| 12. Drive Housing Assembly | Refer to paragraph 5-12.2 and install. |
| 13. Cover Band Assembly | Refer to paragraph 5-12.2 and install. |

6-19. STARTING MOTORS (ELECTRIC) (Continued).**LOCATION/ITEM****ACTION****REMARKS**

TEST AFTER OVERHAUL

14. Starting Motor

NOTE

Before any testing, perform thorough inspection of starting motor for proper assembly, particularly electrical connections. Be sure sleeve bearings wicks and reservoirs have been lubricated.

a. No-load test.

Connect the starting motor in series with four 6 volt 200 amp storage batteries, a suitable variable resistor and control voltage, and an ammeter capable of reading several hundred amperes. If an rpm indicator is available, read the armature rpm as well as the current draw with the unit running free speed or no-load. The starting motor should meet the following specifications:

Maximum current	90 amperes
Voltage	23.3 vdc
Rpm (approx)	85000

b. Torque test.

Torque testing equipment is required for conducting a stall torque test of the starting motor. The torque developed, current drawn, and voltage are checked together. The starting motor should meet the following specifications:

Maximum current	500 amperes
Voltage	3.2 vdc
Minimum torque	22 ft.lb.(29.8 Nm)

6-20. HYDRAULIC RESERVOIRS.

This task covers:

- a. Cleaning b. Repair

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

Equipment
Condition
Paragraph
Condition DescriptionTools

5-13.1

Hydraulic reservoirs,
removed, disassembled,
reassembled and
installed

General Mechanic's Tool Kit
NSN 5180-00-629-9783
Welding set
Safety goggles

Material/Parts

Cleaning solvent P-D-680
Compressed air

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10, 44B

General Safety Instructions

Observe WARNINGS in procedure.

LOCATION/ITEM**ACTION****REMARKS****CLEANING**

1. Reservoir

WARNING

- Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).
- Wear protective eye goggles when using compressed air.

6-20. HYDRAULIC RESERVOIRS (Continued).

LOCATION/ITEM

ACTION

REMARKS

CLEANING

- a. Remove plugs from openings, empty reservoir and flush thoroughly.
- b. Clean reservoirs in cleaning solvent Fed. Spec. P-D-680 and dry thoroughly with moisture free compressed air.

REPAIR

2. Reservoir

WARNING

Be sure tank is filled with sand or water before attempting any welding. Welding must be done by a qualified welder only. Wear safety goggles.

- a. Plug all openings except filler entry.
- b. Fill reservoir with sand or water.
- c. Weld cracks and grind smooth.
- d. Straighten any dents.
- e. Replace reservoir if damaged beyond repair.

3. Mounting Brackets

- a. Weld any cracks or breaks and grind smooth.
- b. Straighten bent or distorted mounting brackets.

6-21. HYDRAULIC STARTING MOTOR.

This task covers:

- | | |
|----------------|------------------------|
| a. Disassembly | c. Inspection/Overhaul |
| b. Cleaning | d. Reassembly |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

Equipment
Condition
Paragraph

5-13.2

Condition DescriptionHydraulic starting motor
removed and disassembledToolsGeneral Mechanic's Tool Kit
NSN 5180-00-629-9783
Safety gogglesMaterial/PartsClean cloths
Cleaning solvent Fed. Spec
P-D-680Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNINGS in procedure.

LOCATION/ITEM**ACTION****REMARKS****DISASSEMBLY**

- | | |
|------------------------|---|
| 1. Starter
Assembly | Refer to paragraph 5-13.2
and disassemble starter. |
|------------------------|---|

6-21. HYDRAULIC STARTING MOTOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

CLEANING

2. Starting Motor

WARNING

Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

- a. Clean all parts with cleaning solvent Fed. Spec. P-D-680 and dry thoroughly.

WARNING

Wear safety goggles when cleaning passages with compressed air to avoid the possibility of eye injury.

- b. Clean all passages with compressed air.

INSPECTION/OVERHAUL

3. Starter

- a. Pinion gear housing (1).
 - (1) Visually check housing for cracks or other damage.
 - (2) Examine bearing (2) for damage or wear.
 - (3) Replace if necessary.

6-21. HYDRAULIC STARTING MOTOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

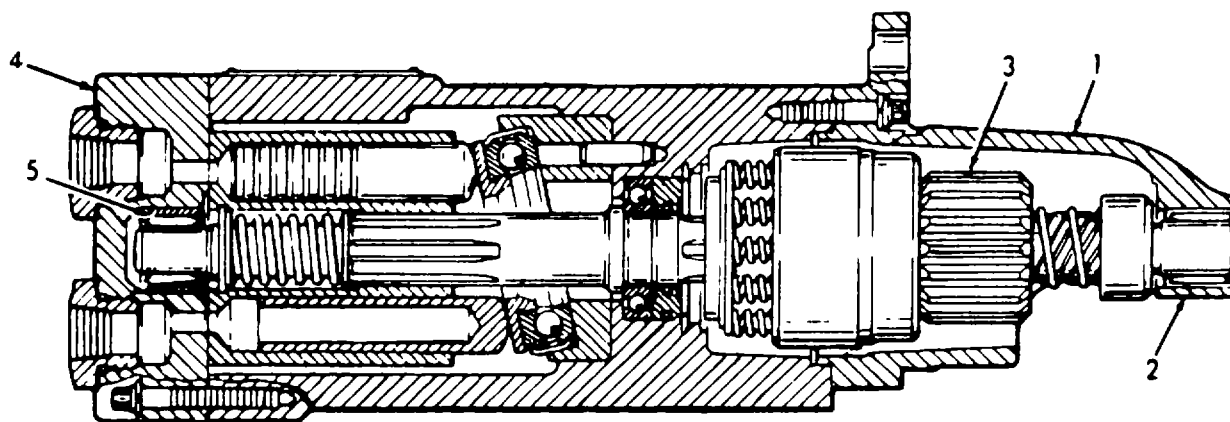
INSPECTION/OVERHAUL (Cont)

b. Drive assembly (3).

- (1) Examine pinion gear to be sure that teeth are not worn excessively or chipped from interference with ring gear.
- (2) Check to insure that the compressing springs are not damaged or broken.

c. Port plate assembly (4).

- (1) The port plate face, where cylinder rides, must be smooth and free of scoring.
- (2) Check the bearing (5) and replace if necessary.



6-21. HYDRAULIC STARTING MOTOR (Continued).

LOCATION/ITEM

ACTION

REMARKS

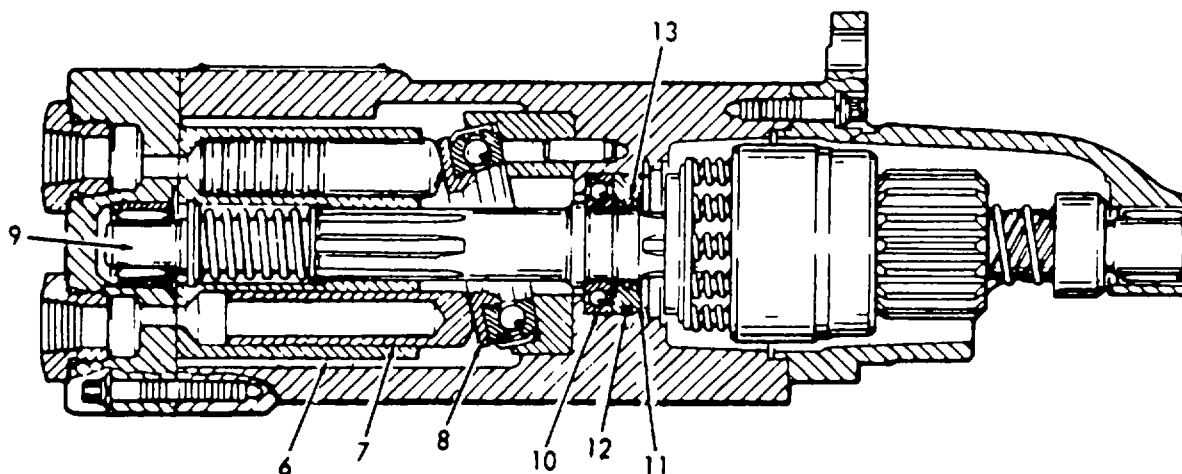
INSPECTION/OVERHAUL (Cont)

- d. Motor barrel (6).
 - (1) Examine the potted face of the cylinder for scratching or scoring.
 - (2) Slight scuff marks can be removed by lapping on a surface plate.
 - (3) The bores of the cylinder should be smooth and free of scoring.
- e. Pistons (7).
 - (1) The diameter of the pistons (7) should be smooth and free of scoring.
 - (2) The closed end of the pistons may show brinelling where they contact the thrust bearing plate (8), but no burrs or flat spots are permissible.
- f. Shaft (9).
 - (1) Check the ends of the shaft for wear or scoring.
 - (2) The splines should be smooth and free of nicks.
 - (3) Check the bearing (10) and replace if necessary.
- g. Seal assembly (11).
 - (1) Replace seals (12 and 13).

6-21. HYDRAULIC STARTING MOTOR (Continued)

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

INSPECTION / OVERHAUL (Cont)



- h. Replace all other gaskets and seals.
- i. Replace ball bearings and needle bearings.
- j. Replace all other damaged or defective parts as required.

REASSEMBLY

4. Starter

Refer to paragraph 5-13.2 and reassemble the starter.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS.

This task covers:

- | | | |
|------------|------------------------|-----------------|
| a. Removal | c. Overhaul | e. Installation |
| b. Repair | d. Run-In Instructions | |

INITIAL SETUPTest Equipment

Dynamometer
Diagnostic Test Kit J9531

References

NONE

Special Tools

Engine Lifting Tools

Equipment
Condition
Condition Description

NONE

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material / Parts

NONE

Special Environmental Conditions

Do not drain engine oil into bilges.
Use the oil collection and recovery
system to collect engine oil.

Personnel Required

4

General Safety Instructions

Observe WARNING in procedure.

LOCATION / ITEM**ACTION****REMARKS****REMOVAL**

- | | |
|--------------------------------|--|
| 1. Engine Room
Access Hatch | a. Remove seventy six nuts (1),
and flat head screws (2). |
|--------------------------------|--|

WARNING

Do not damage hatch gasket around edge of hatch.

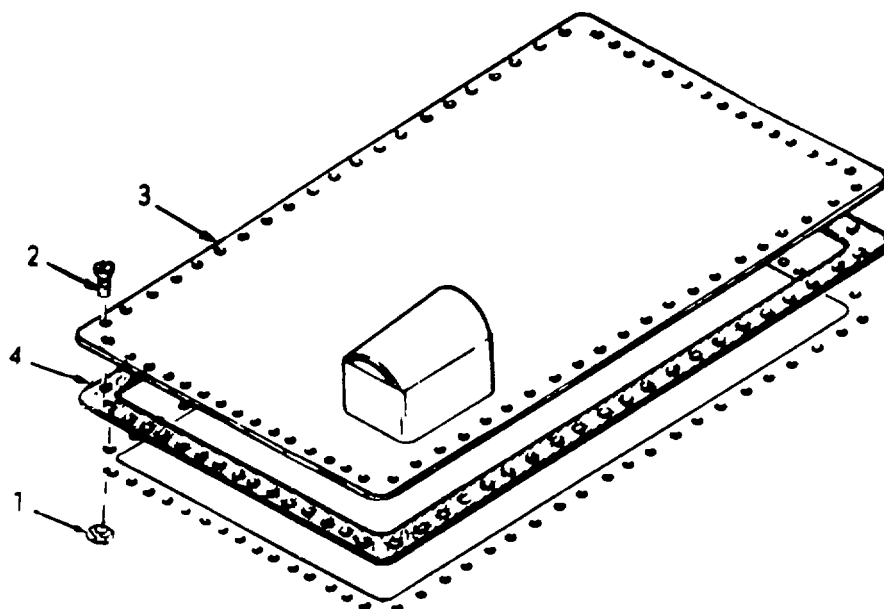
- | |
|---|
| b. Carefully pry up edge of
hatch (3). |
|---|

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

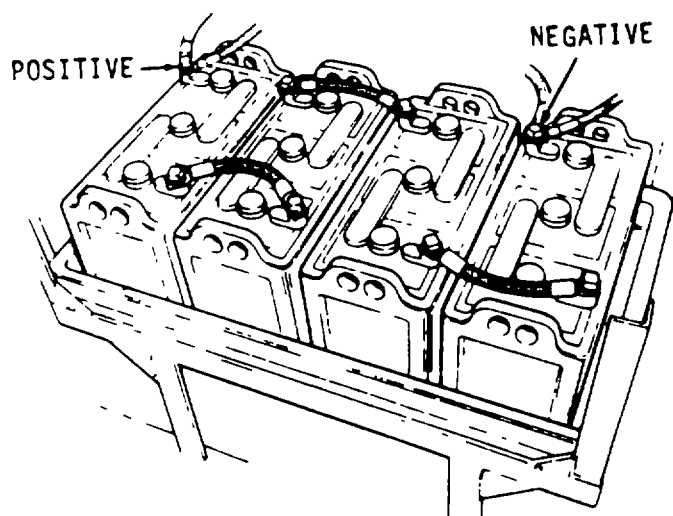
REMOVAL (Cont)

- c. Remove hatch (3).
- d. Remove gasket (4) if damaged.



2. Battery

Disconnect negative (ground) wire at battery.

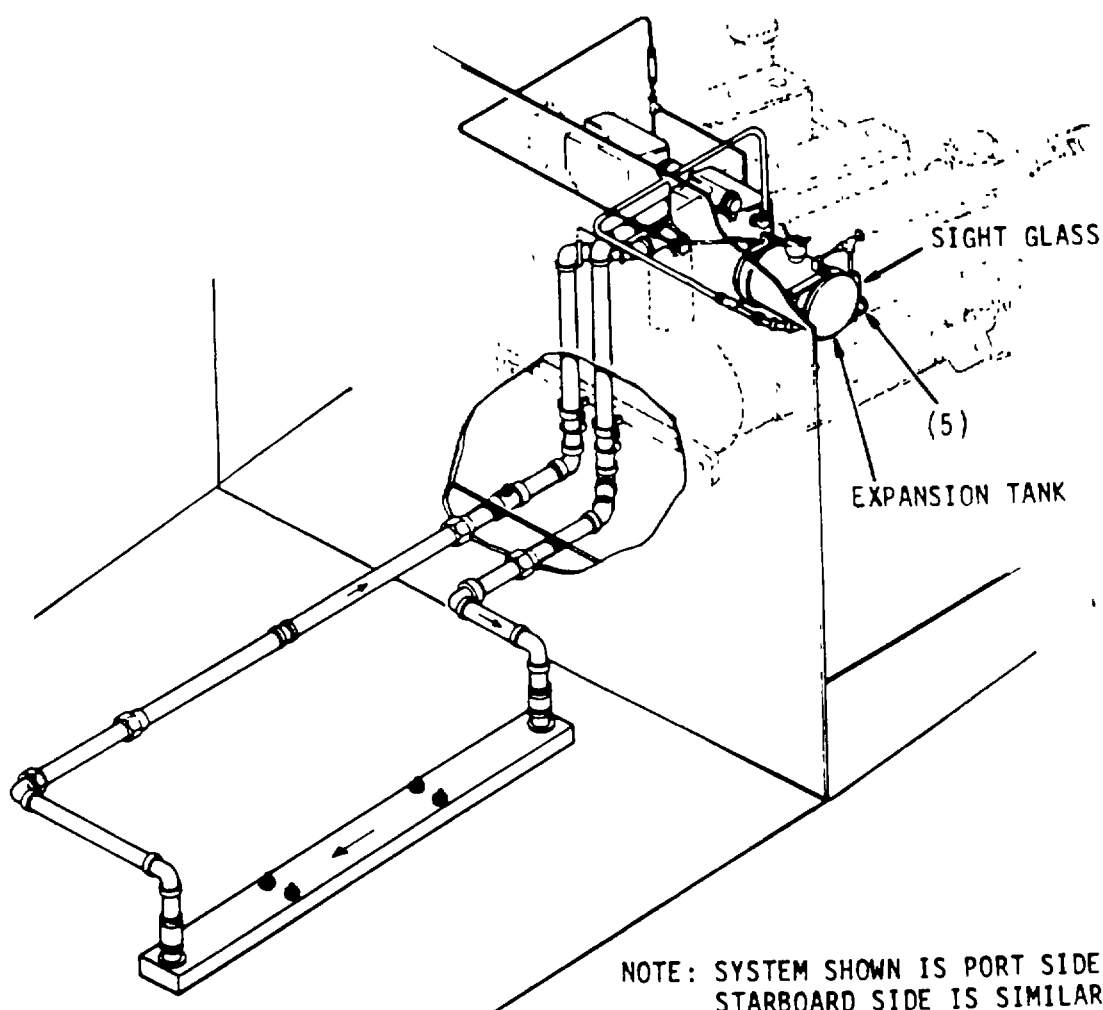


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- | | | |
|------------------------------|--|--|
| 3. Engine Fresh Water System | a. Open drain cock (5) on expansion tank and drain contents into a suitable container. | |
|------------------------------|--|--|

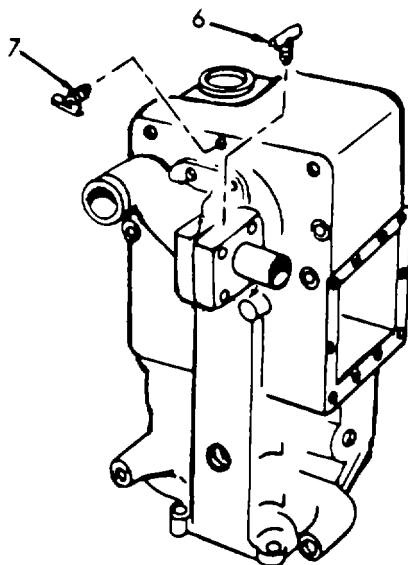


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

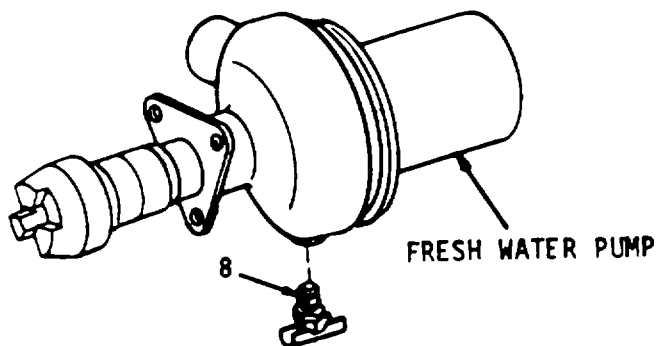
LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- b. Open drain cock (6) and vent cock (7) on heat exchanger and drain contents into a suitable container.



- c. Open drain cock (8) on the fresh water pump and drain contents into a suitable container.

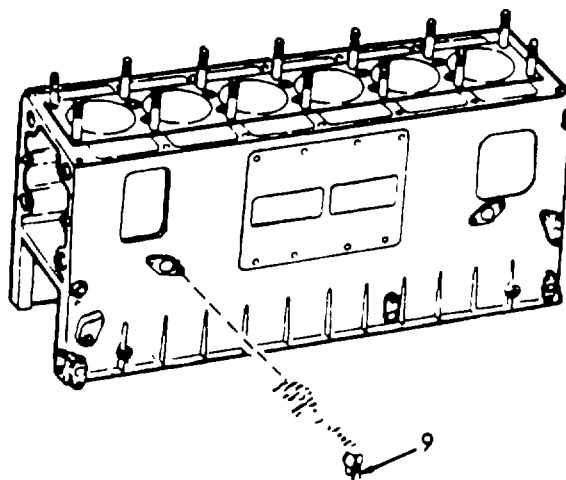


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- d. Open drain cock (9) on engine blocks and drain contents into a suitable container.



4. Engine and Transmission Oil

NOTE

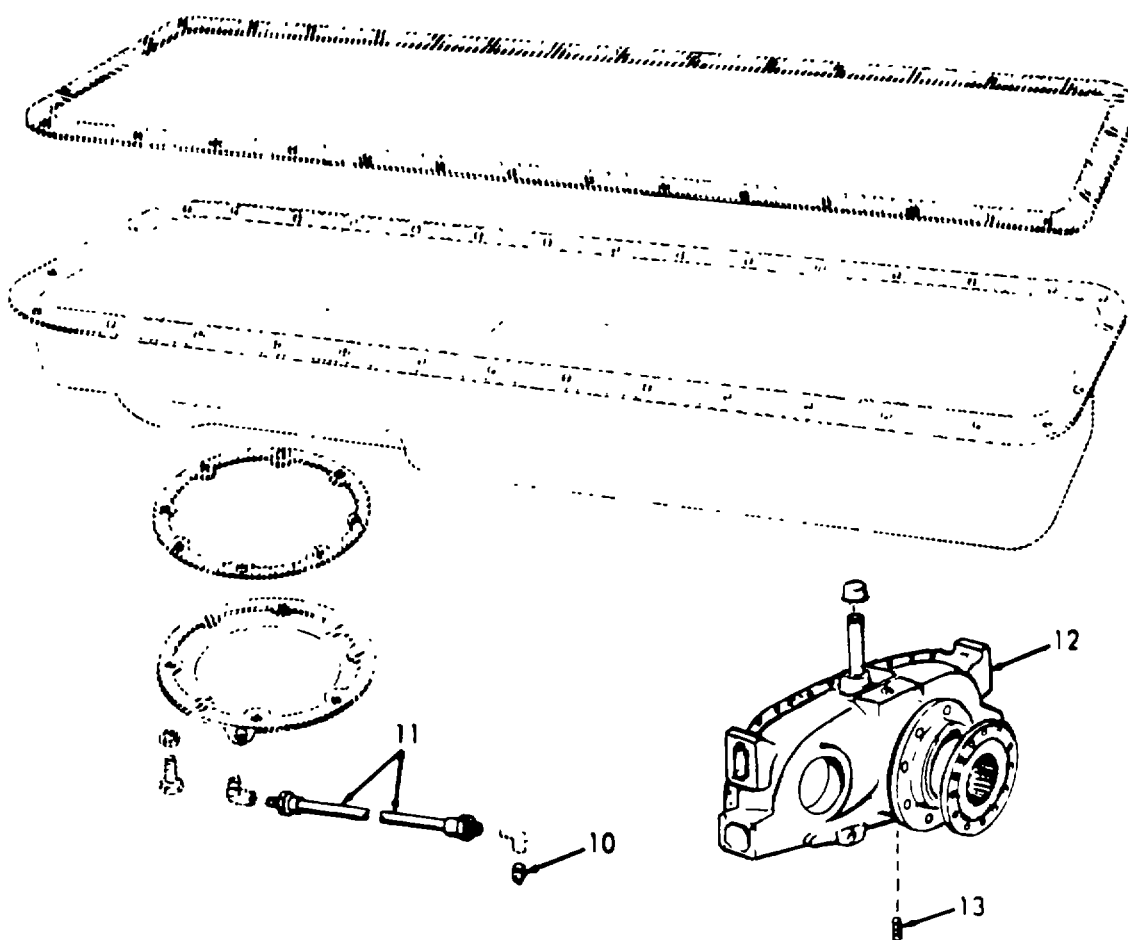
Do not drain oil into bilges use oil separation and recovery system to collect used oil.

- a. Remove plug (10) on end of oil pan drain tube (11).
- b. Remove power transfer gear (12) oil by removing a drain plug (13) located at the lower rear side of the gear housing. Collect the drained oil in a suitable container.
- c. Remove mounting brackets for oil drain tubes as necessary.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)]		
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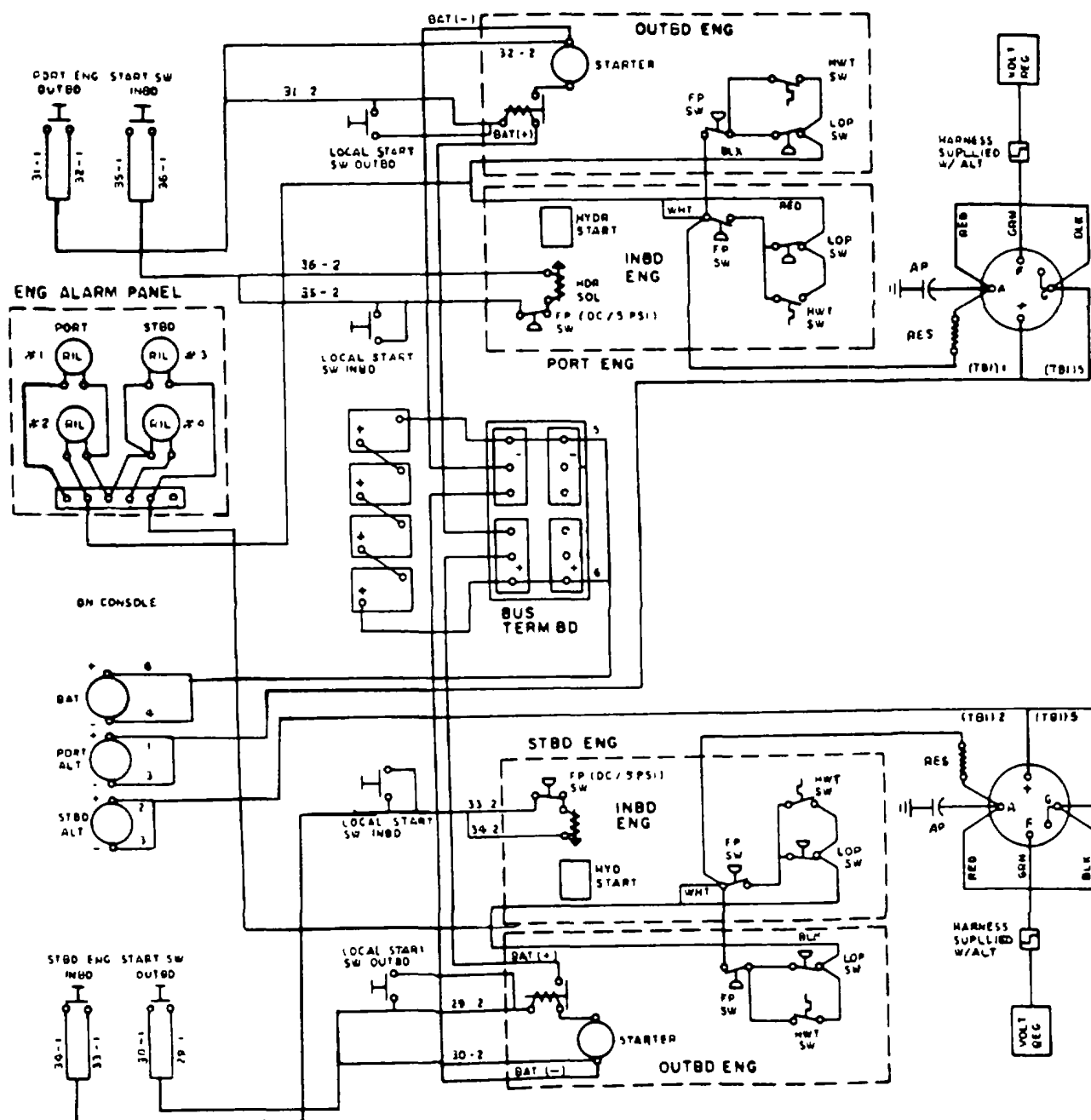
5. Electrical
Wiring to
Engine
Sending
Units

Refer to the following schematics
and wiring diagrams. Disconnect
and tag all electrical leads.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)]



Wiring

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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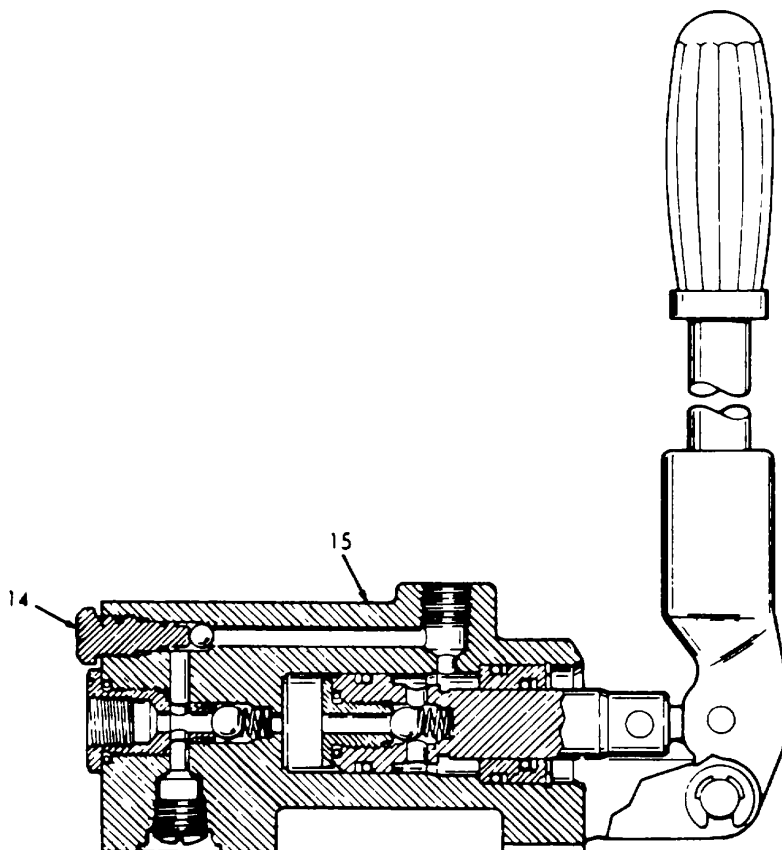
REMOVAL (Cont)

6. Hydraulic
Starting
System

WARNING

Prior to performing any work on the hydraulic starting system make sure the hydraulic pressure is released.

- a. Open pressure relief valve (14) on the hand pump (15).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

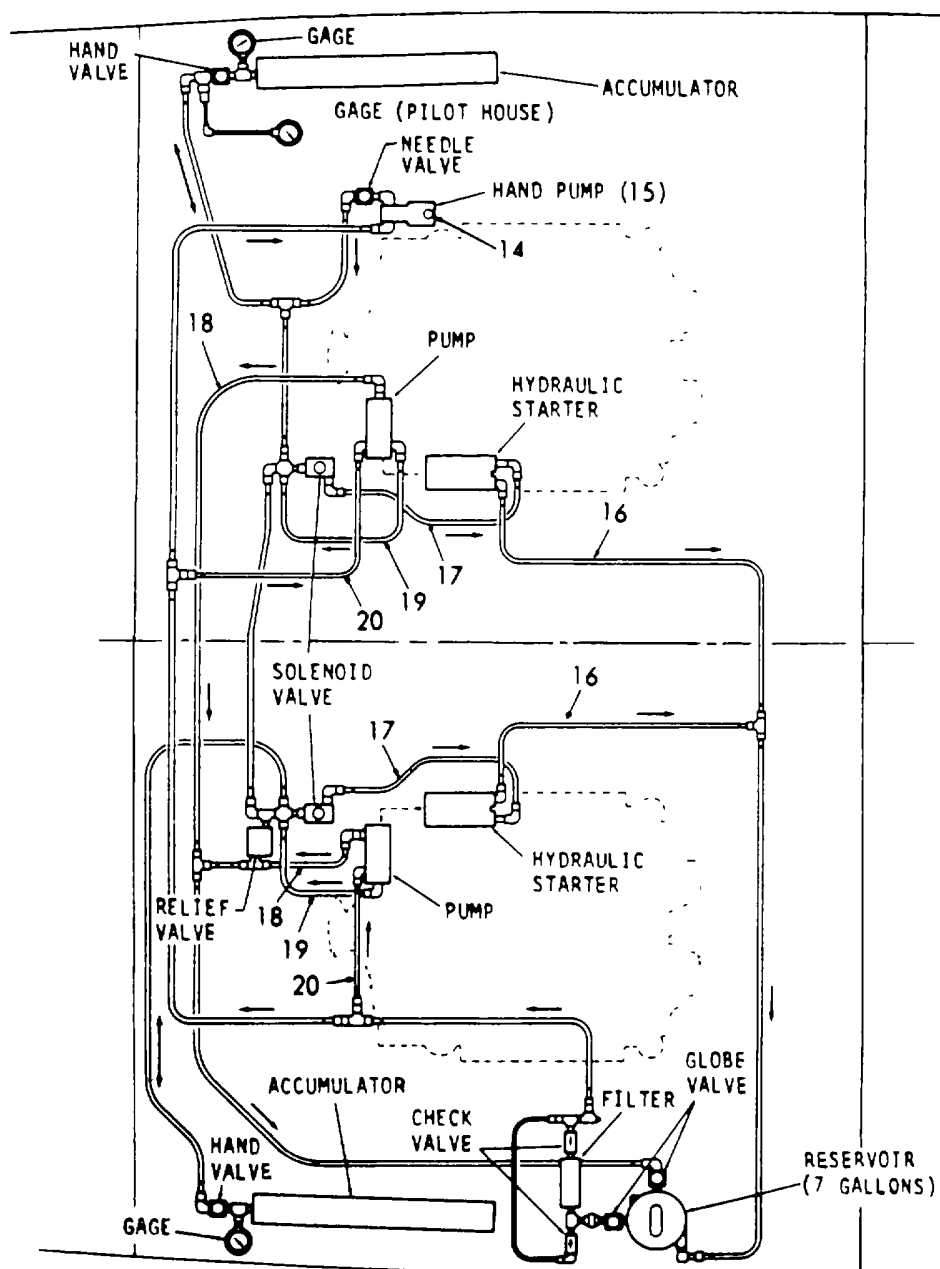
NOTE

- Tag all hoses prior to disconnecting.
- Drain hydraulic fluid into a suitable container.
- Install dust covers on all openings.
 - b. Disconnect return hose (16) from starter to reservoir.
 - c. Disconnect input hose (17) from solenoid valve (control valve) to starter.
 - d. Disconnect hose (18) from pump to reservoir.
 - e. Disconnect hose (19) from pump to solenoid valve (control valve).
 - f. Disconnect hose (20) from filter to pump.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)		
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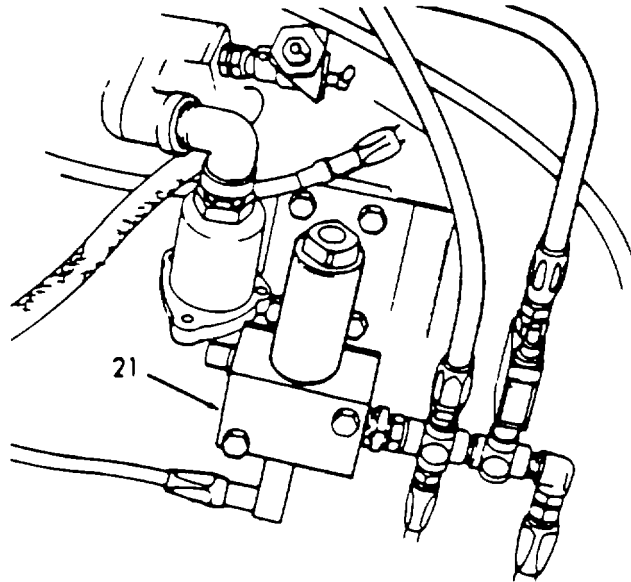
Hydraulic Starting System

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- g. Tag and disconnect wiring to solenoid valve (21).



7. Electric Starting Motor

NOTE

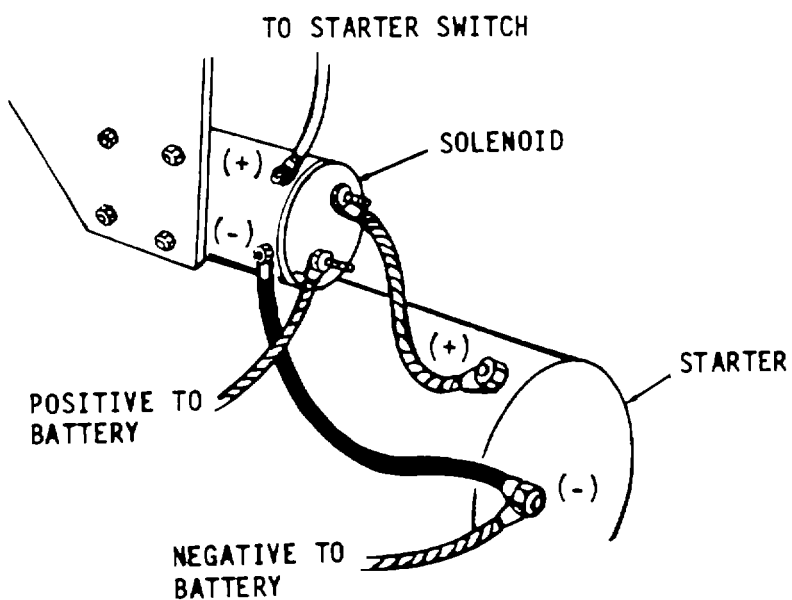
Refer to schematics in step 5.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND R UN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- a. Disconnect and tag negative electrical lead to starter motor.
- b. Disconnect and tag positive electrical leads to starter solenoid.



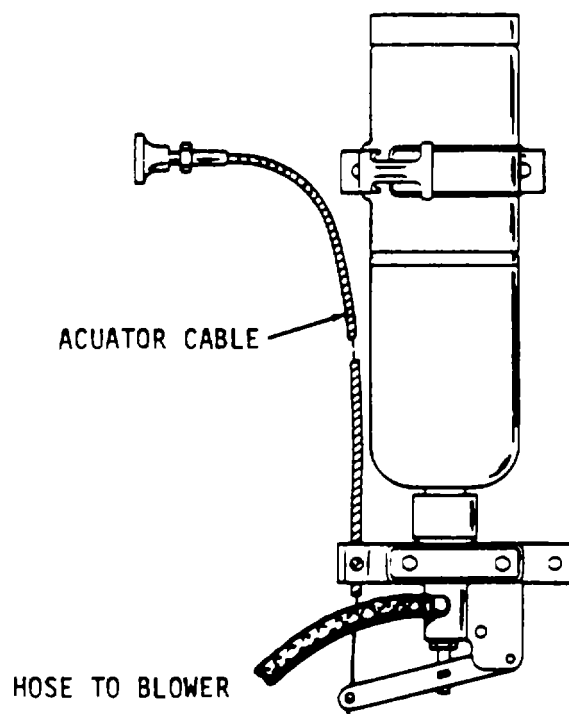
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)		
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8. Starting Aid

Disconnect hose from
starting aid to air inlet
on blower.



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

- | | | |
|---------------|--|--|
| 9. Fuel Lines | a. Turn off fuel intake line valve (24) on aft engine room bulkhead. | |
|---------------|--|--|

NOTE

- When disconnecting fuel lines, drain into a suitable container.
- Cap fuel line fittings to prevent entry of dirt into lines.

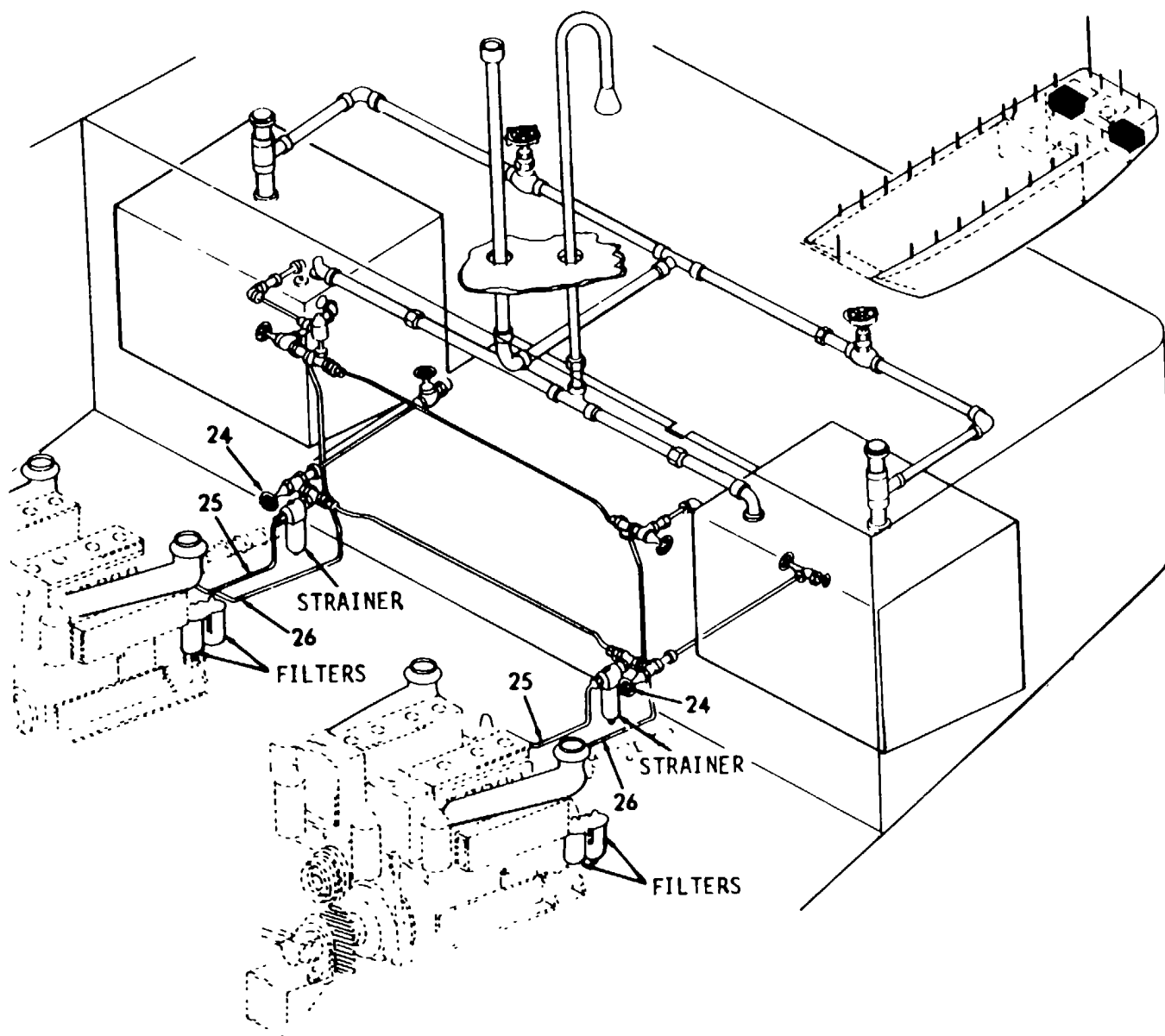
b. Disconnect fuel hose (25) from intake to strainers.

c. Disconnect fuel hose (26) from engine to return line.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)		
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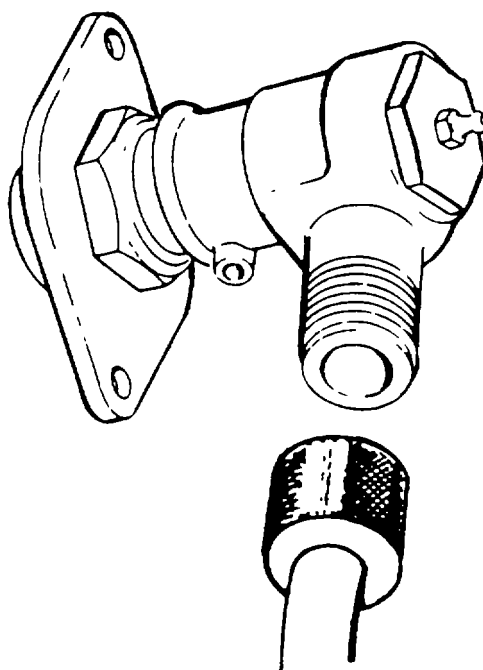
6-22. POWER UNIT - MULTIPLE ENGINE RE MOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

10. Tachometer
Drive

Remove mechanical tachometer
drive shaft at engine.



11. Ramp Hoist
Pump

- Remove screws (27), and lockwashers (28), then remove coupling guard (29).
- Remove nuts (30), lockwashers (31), and screws (32) that attach pump (33) to its base.

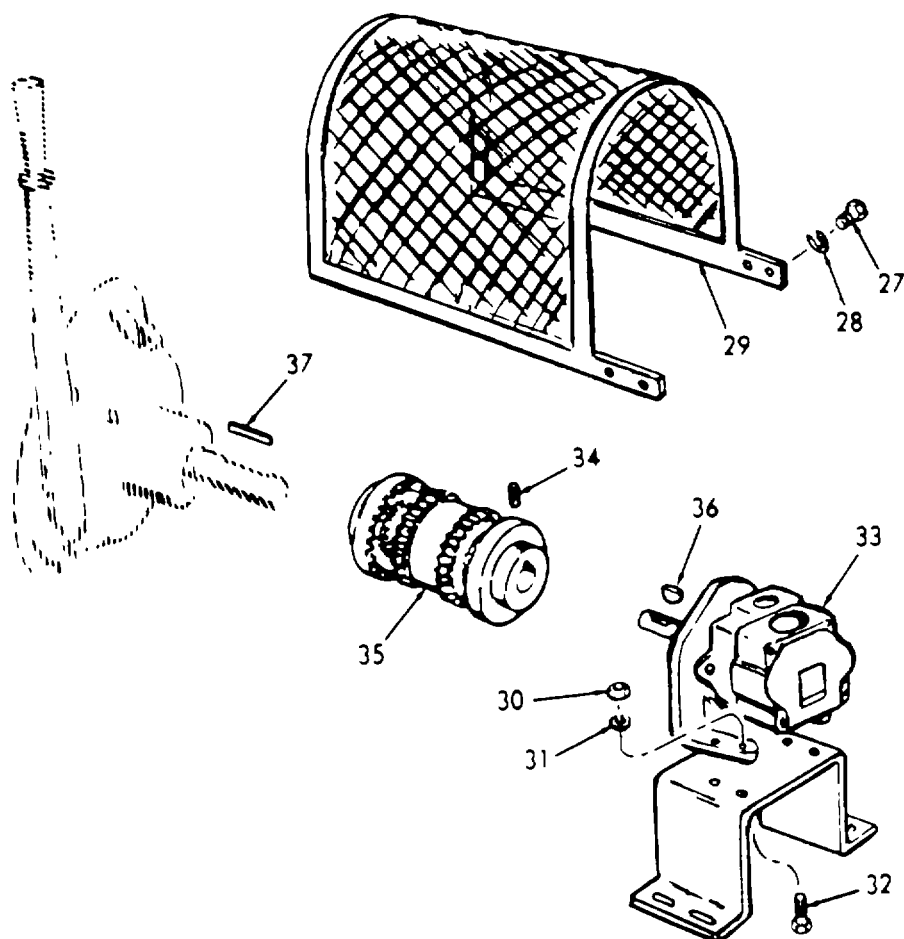
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
-----------------	--------	---------

REMOVAL (Cont)

c. Loosen setscrew (34), and slide coupling (35) to gain access for key (36), and (37) removal.

d. Remove coupling (35).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

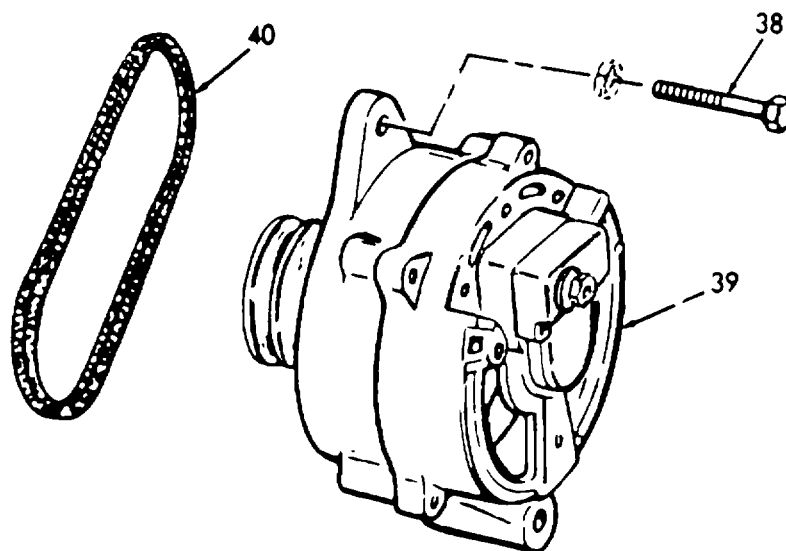
12. Alternator shroud.

a. Remove protective

If necessary.

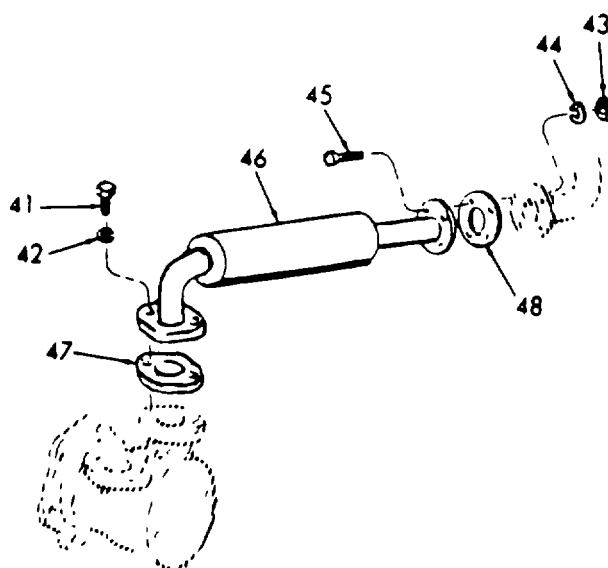
b. Loosen bolt (38), and move alternator (39) to release belt (40) tension.

c. Remove belts (40) from alternator (39) and front of inboard engine.



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

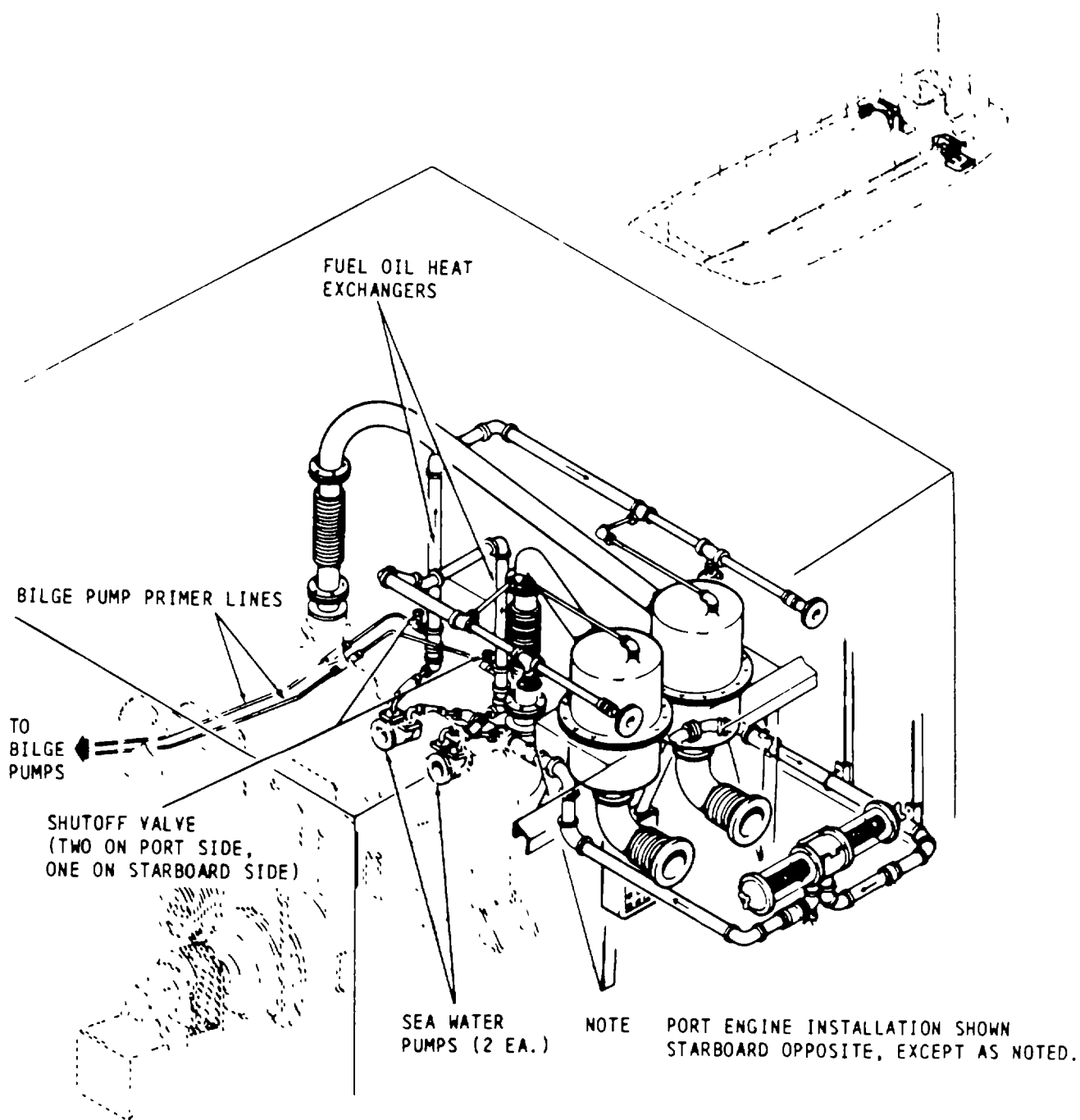
LOCATION / ITEM	ACTION	REMARKS
REMOVAL (Cont)		
13. Raw Sea Water System	a. Remove screws (41) and lockwashers (42).	
	b. Remove nuts (43), lockwashers (44), and screws (45).	
	c. Remove hose (46), and gaskets (47 and 48).	Discard gaskets.
	d. Disconnect bilge pump primer lines.	
	e. Remove water piping as necessary to allow clearance for propulsion unit removal.	
	f. Refer to step 9 and disconnect fuel lines to heat exchangers.	



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

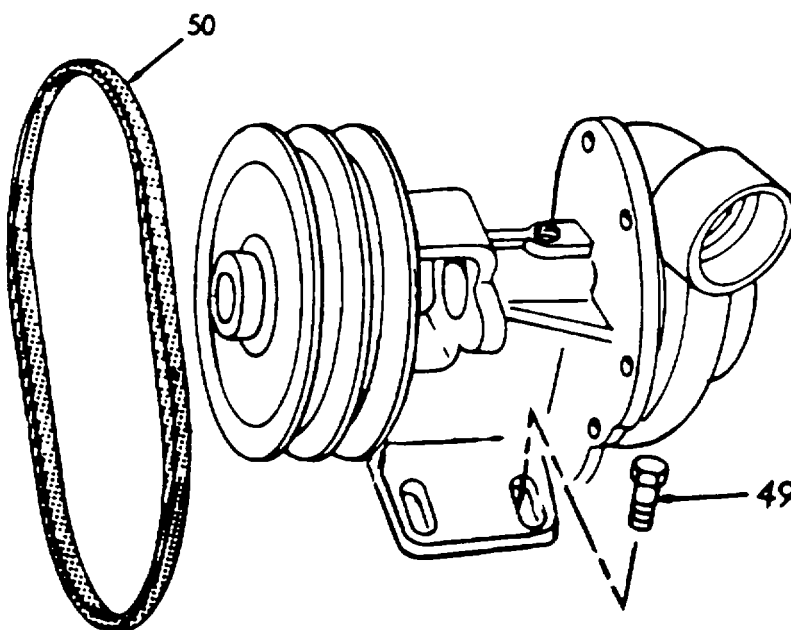


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

- | | | |
|-----------------|--|--|
| 14. Bilge Pumps | a. Loosen mounting bolts (49). | |
| | b. Move pump to release belt (50) tension. | |
| | c. Remove belt(s) (50). | |

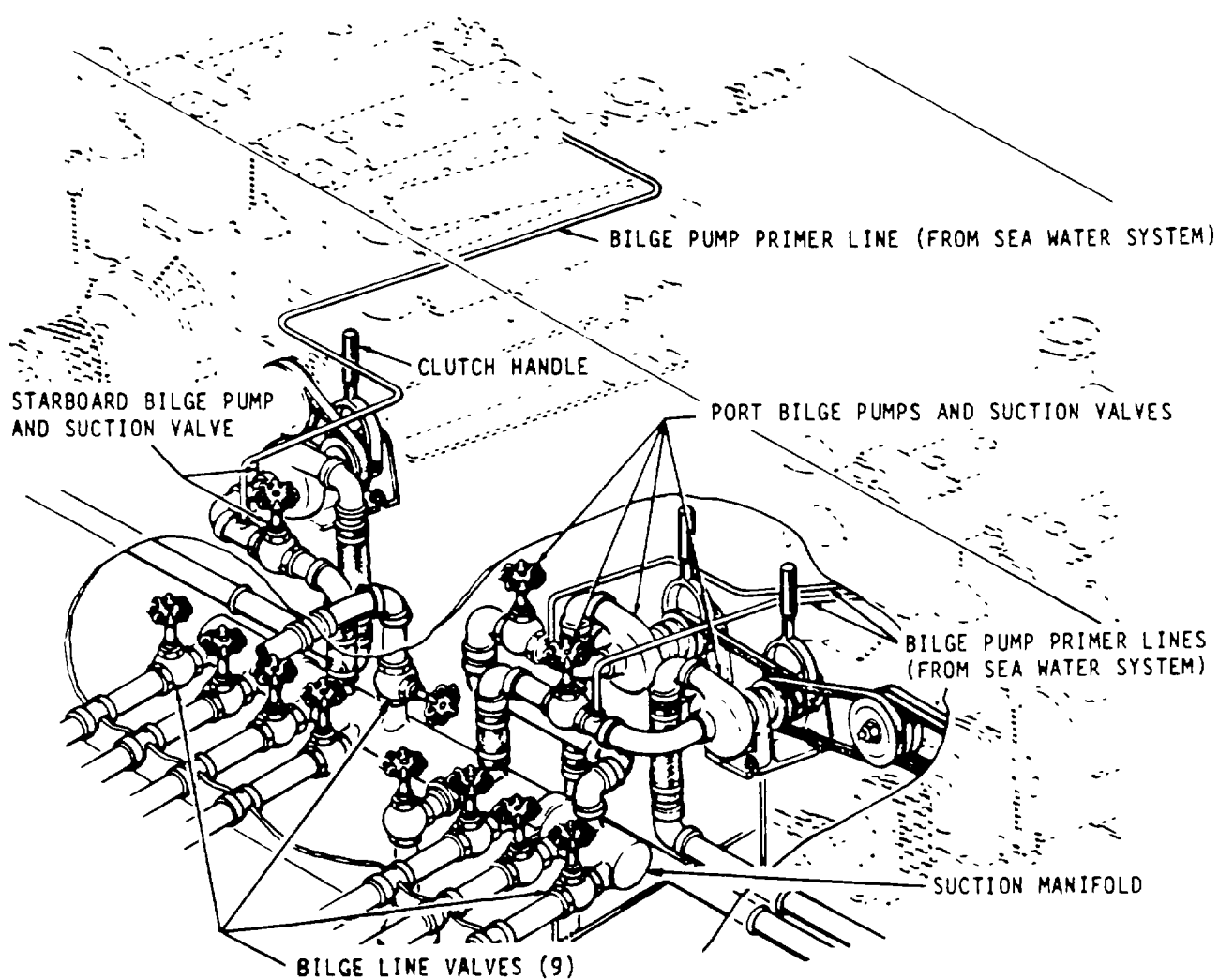


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

- d. Remove bilge pump primer lines.
- e. Remove hose clamps and hoses on inlet and outlet of pumps.

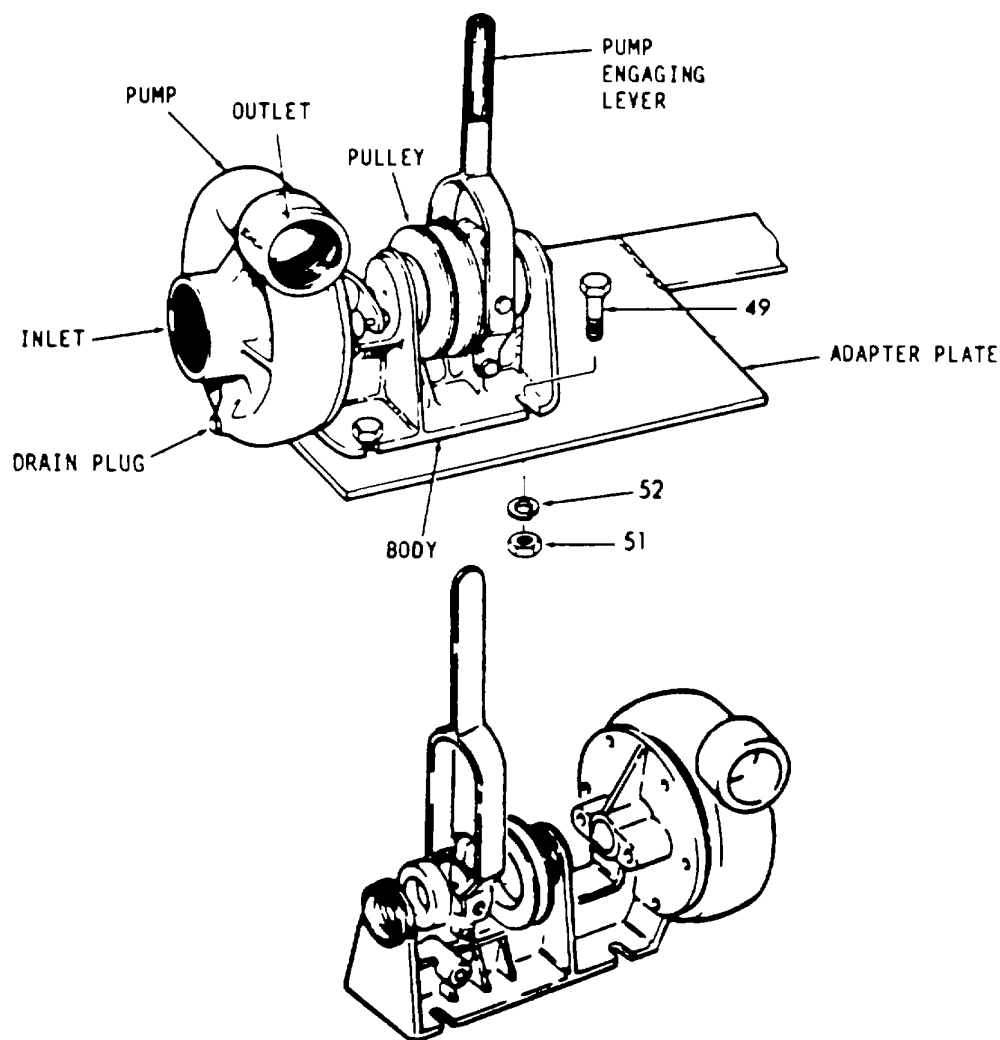


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

- f. Remove nuts (51), lockwashers (52), and bolts (49).
- g. Remove bilge pumps.
- h. Remove piping as needed to make propulsion unit removal easy.

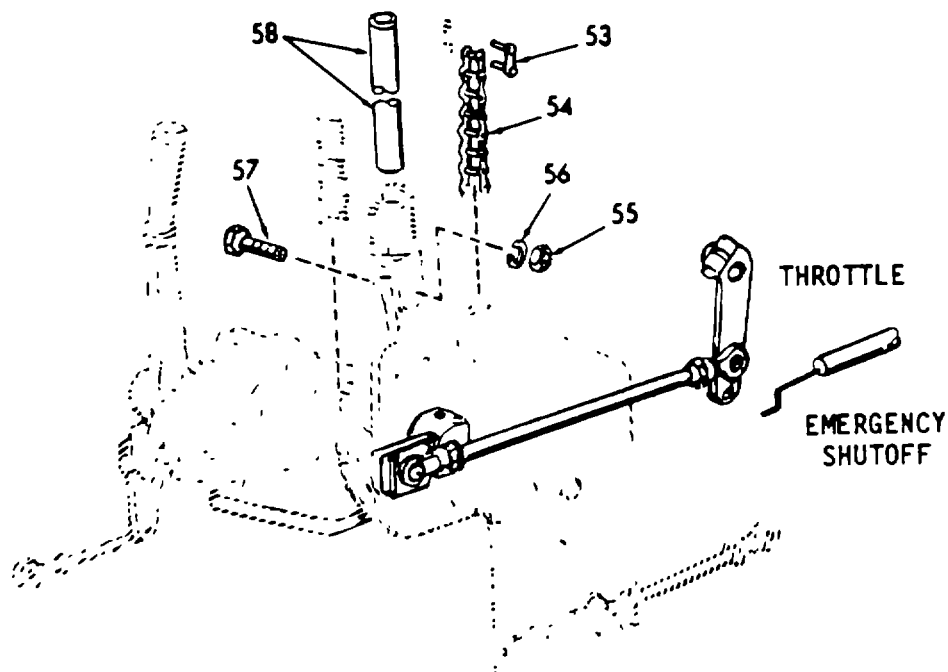


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

- | | | |
|---------------------|---|--|
| 15. Engine Controls | <p>a. Remove connecting link (53) and chain (54).</p> <p>b. Remove nut (55), lockwasher (56), screw (57), and strut (58).</p> | |
|---------------------|---|--|

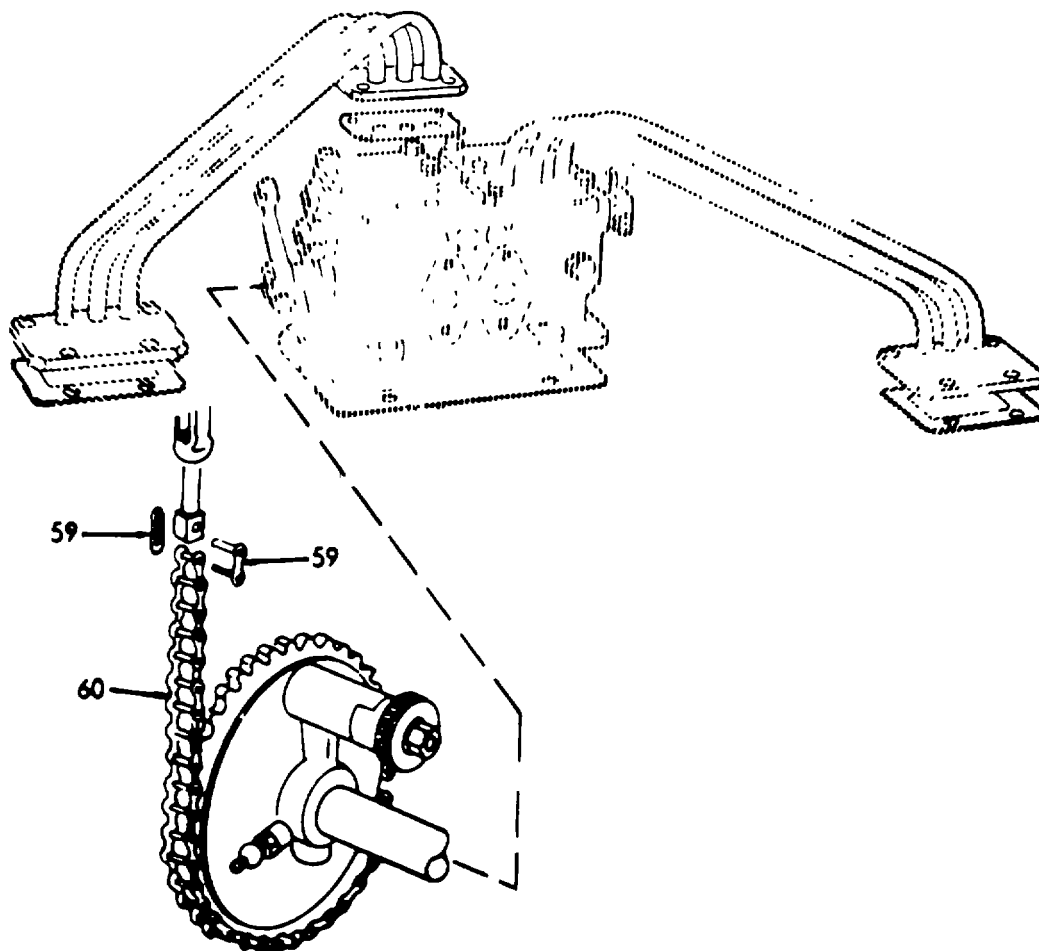


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)		
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- c. Remove engine stop cables.
- d. Remove neutral throttle cables.
- e. Remove overspeed shutoff cables.
- f. Remove connecting link (59), and chain (60).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

16. Exhaust
Pipes

WARNING

Wear breathing and face protection devices when handling and removing asbestos coverings.

- a. Remove asbestos pipe straps and pipe coverings as needed.
- b. Remove nuts (74), lockwashers (75), and screws (76).
- c. Remove nuts (77), lockwashers (78), and screws (79).
- d. Remove flexible pipe (80), and gaskets (81).
- e. Remove nuts (82), lockwashers (83), and screws (84).
- f. Remove gasket (85).

NOTE

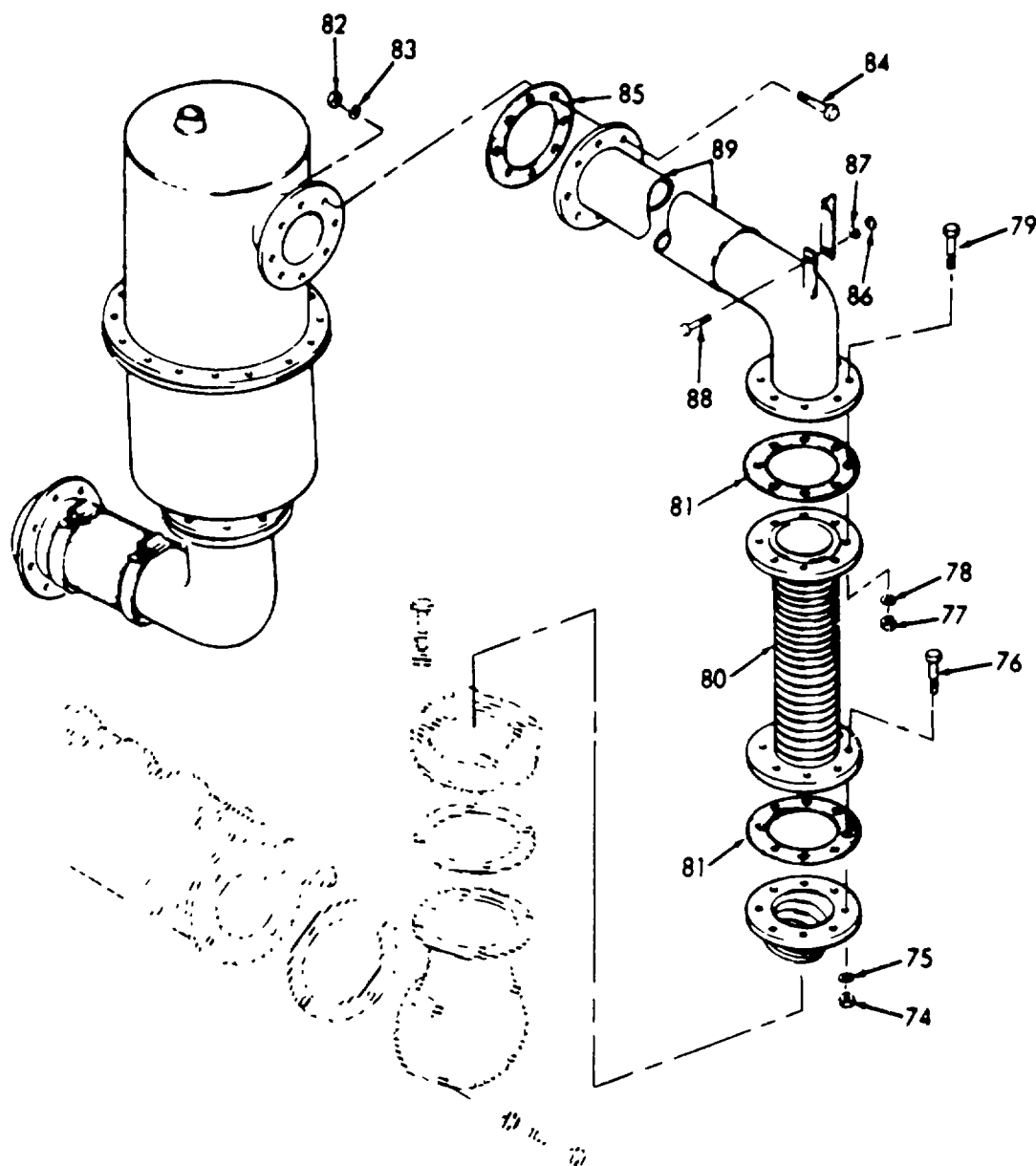
The following step requires 3 persons.

- g. Remove nut (86), lockwasher (87), screw (88), and exhaust pipe assembly (89).
- h. Perform the previous steps a. through g. on the other engine.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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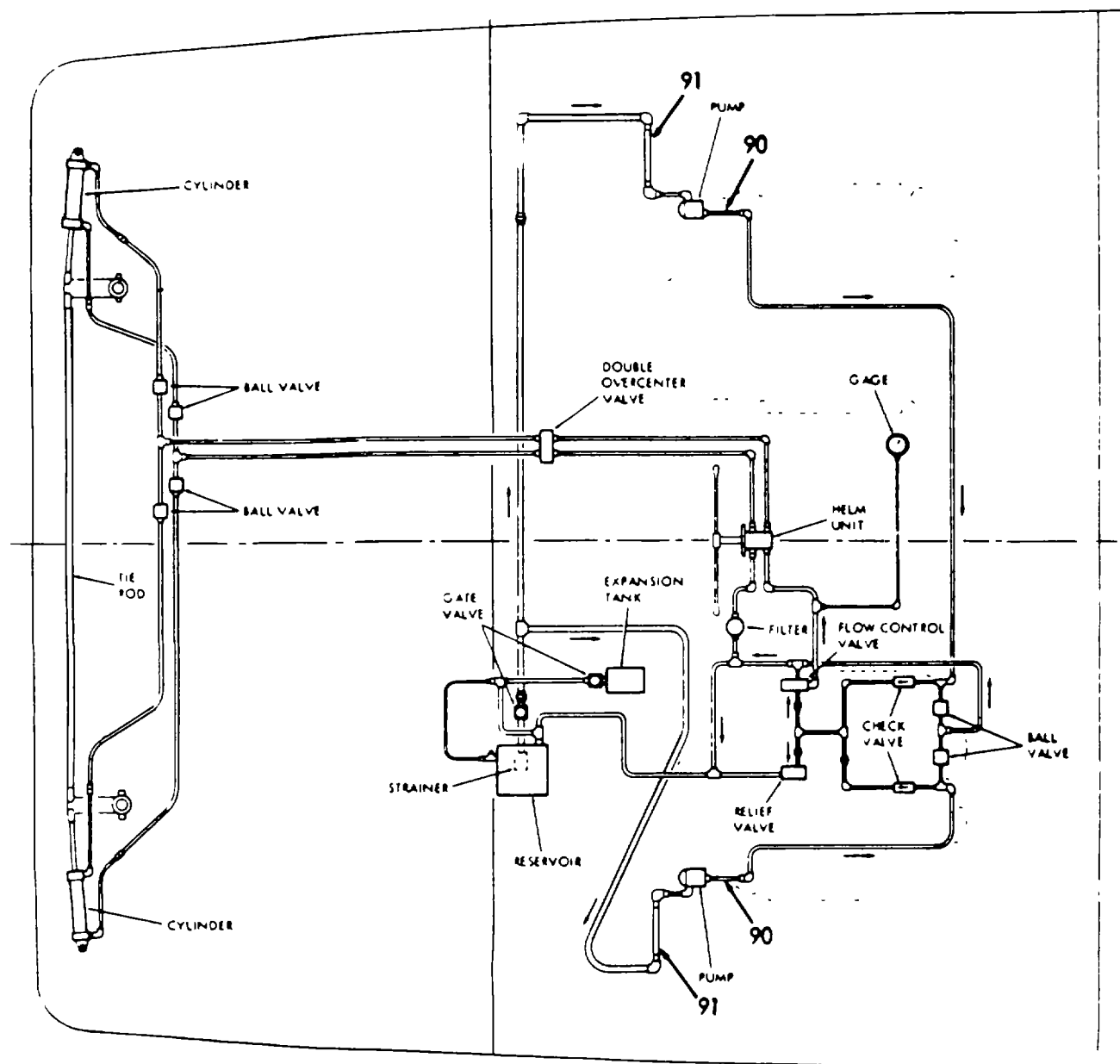
REMOVAL (Cont)17. Hydraulic
Steering
System**NOTE**

- When disconnecting hydraulic lines, drain into a suitable container.
- Cap hydraulic line fittings to prevent entry of dirt into lines.
 - a. Disconnect hose (90)
at swivel fitting.
 - b. Disconnect hose (91)
at swivel fitting.
 - c. Disconnect, tag and
remove any piping
that would interfere
with propulsion unit
removal.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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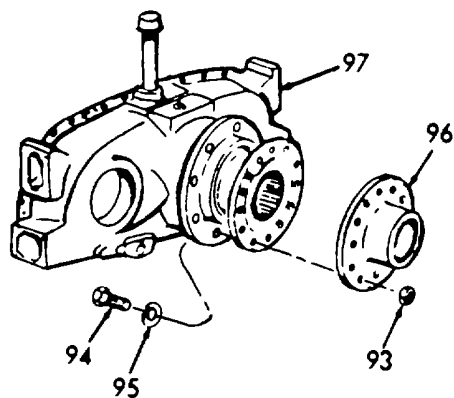
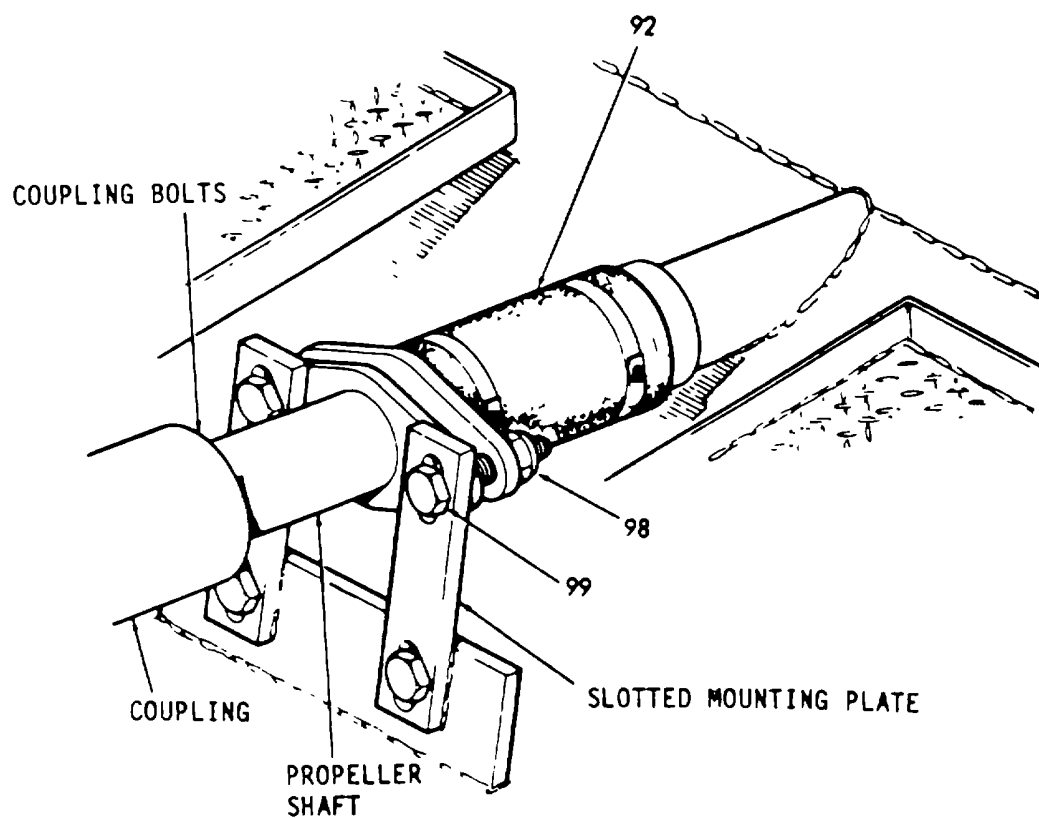
REMOVAL (Cont)

- | | | |
|------------------------|--|--|
| 18. Propeller
Shaft | <ul style="list-style-type: none">a. Loosen hose (92) at propeller shaft coupling.b. Remove nuts (93), bolts (94), and lockwashers (95) that secure the propeller shaft flange (96) to the transmission output shaft flange (97).c. Remove nuts (98), and bolts (99).d. Slide the propeller shaft back 6 to 8 inches (15 to 20 cm) to permit removal of the propulsion unit without damaging the flanges. | |
|------------------------|--|--|

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)



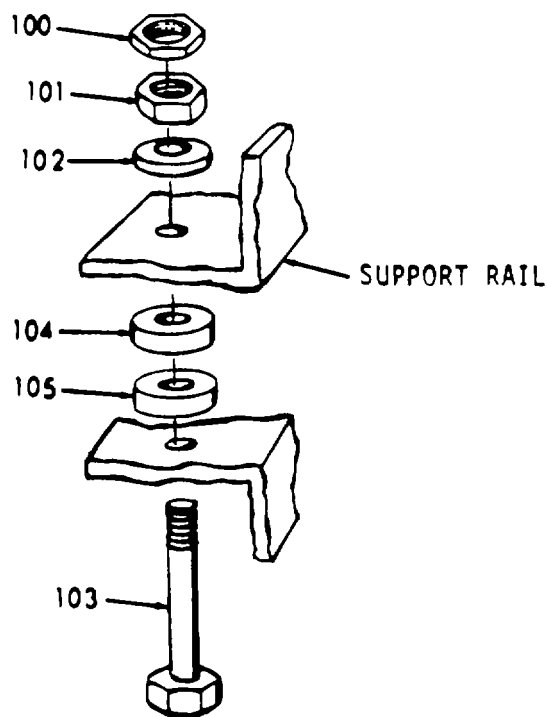
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)

19. Propulsion
Unit
Foundation

- a. Remove eight jamnuts (100), nuts (101), washers (102) and screws (103).
- b. When the propulsion unit is lifted, remove eight resilient mounts (104), and chocks (105).



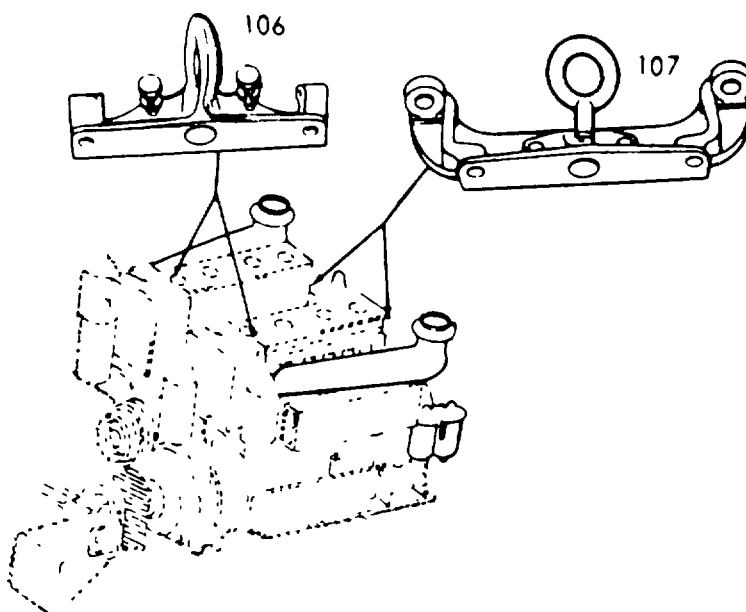
20. Propulsion
Unit
Removal

- a. Attach chains or cables to lifting brackets (106 and 107).

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION / ITEM	ACTION	REMARKS
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REMOVAL (Cont)



WARNING

During propulsion unit removal operation all persons should keep clear of engine and hoisting equipment.

- b. Using appropriate lifting equipment, carefully raise the the propulsion unit approximately 6 inches (15 cm).

Make sure all lines and cables are free before continuing to remove the propulsion unit from the craft.

REPAIR

21. Propulsion Unit

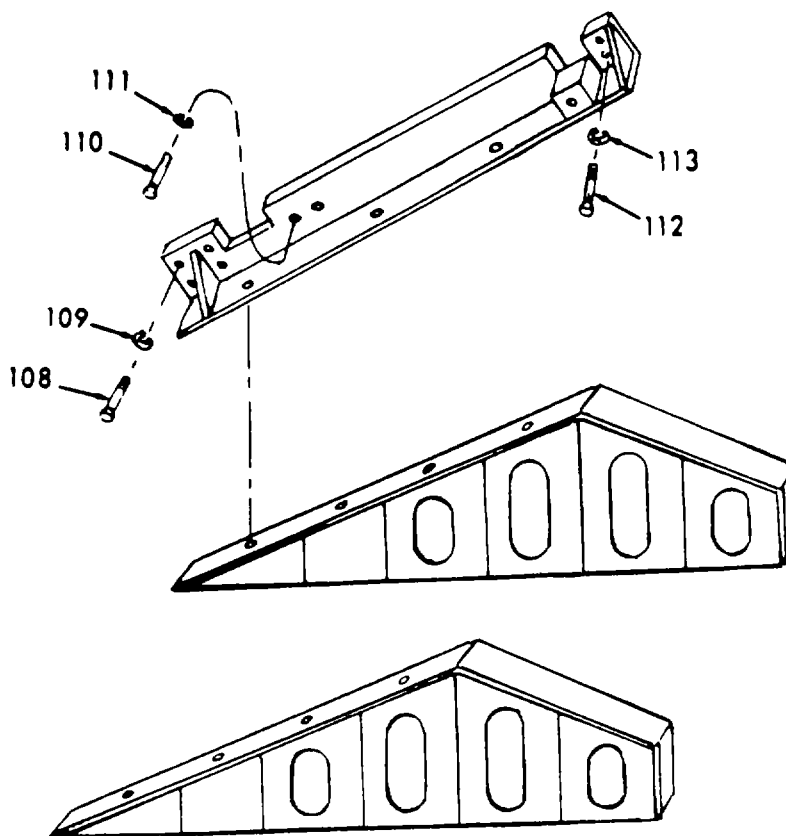
- a. Repair or replace any damaged or defective component.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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REPAIR(Cont)		
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- b. Remove bolts (108), and lockwashers (109) that attach the transfer gear housing to the base.
- c. Remove bolts (110), and lockwashers (111) that attach the flywheel housing to the base.
- d. Remove bolts (112) and lockwashers (113) that attach either the power take-off adapter or vibration dampner cover to the base.



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
OVERHAUL		
22. Propulsion Unit	<ul style="list-style-type: none"> a. Cam and Balance Shafts - Refer to Paragraph 6-23. b. Idler Gear and Bearings - Refer to Paragraph 6-24. c. Engine Oil Pump - Refer to Paragraph 6-26. d. Pistons and Connecting Rods - Refer to Paragraph 6-27. e. Crankshaft - Refer to Paragraph 6-28. f. Engine Block - Refer to Paragraph 6-29. g. Fuel Pump - Refer to Paragraph 6-30. h. Fuel Injectors - Refer to Paragraph 6-31. i. Fresh Water Pump - Refer to Paragraph 6-32. j. Raw Water Pump - Refer to Paragraph 6-33. k. Governor - Refer to Paragraph 6-34. l. Blower - Refer to Paragraph 6-35. m. Transmission Oil Pump - Refer to Paragraph 6-36. n. Power take-off - Refer to Paragraph 6-37. 	

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

- o. Marine Gear - Refer to Paragraph 6-38.
- p. Flywheel Housing - Refer to Paragraph 6-40.
- q. Power Take-Off Coupling and Vibration Damper - Refer to Paragraph 6-41.
- r. Cylinder Head - Refer to Paragraph 5-15.

23. PREPARATION FOR STARTING ENGINE FIRST TIME

The operator should read and follow these instructions before attempting to start the engine.

NOTE

When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below.

a. Cooling System.

Attach hoses to remote engine cooling components. Open the cooling system vents.

Remove the filler cap and fill the cooling system with a protective solution consisting of high boiling point antifreeze. Keep the liquid level about 2 inches below the filler neck to allow for fluid expansion.

Use a quality rust inhibitor in the cooling system.

Close the vents after filling the cooling system.

Prime the raw water pump by removing the pipe plug in the inlet elbow and adding water. Open the raw water system.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

b. Lubrication System.

The lubricating oil on the upper parts of new or overhauled engines, and engines which have been in storage, may not be enough when the engine is started. It is recommended that the upper engine parts be prelubricated by removing the valve rocker cover and pouring approximately two quarts of the same oil used in the crankcase over the rocker arms and push rods.

Fill the engine crankcase to the proper level with the Heavy Duty Lubricating Oil specified.

Check the oil level in the crankcase with the dipstick on the side of the engine. Remove the dipstick, wipe the lower end with a clean cloth, insert and remove it again to check the oil level. Keep the oil at the proper level.

Refer to Lubrication Order Chart for proper lubrication.

c. Transmission.

Fill the hydraulic marine gear to the proper level with lubricant specified.

d. Fuel System.

Attach a fuel tank. If the unit is equipped with a fuel supply valve, it must be opened.

To ensure prompt starting, the fuel system between the pump and the fuel return manifold should be filled with fuel. If the engine has been out of service for a considerable length of time, the filter between the fuel pump and the injectors should be primed. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a Hydrostarter, use a priming pump to make sure fuel lines, manifolds, and injectors are full of fuel before attempting to start the engine.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

e. Lubrication Fittings.

Fill all the grease cups and lubricate all fittings with all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

f. Storage Battery.

Check the battery; the top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE

When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

g. Clutch.

Disengage the clutch or clutches.

h. Initial Engine Start (Electric).

Start an engine equipped with an electric starting motor as follows: Make sure the emergency stop is pushed all the way in, then set the throttle in the IDLE position. Press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

On twin units, move the master throttle lever to "IDLE" and engage cranking motors, one at a time.

CAUTION

To prevent serious damage to the starter, if the engine does not start, do not press the starter switch again while the starter motor is running.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION / ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

- i. Initial Engine Start (Hydrostarter).

Start an engine equipped with a Hydrostarter as follows:

Raise the Hydrostarter Accumulator Pressure with the hand pump until the gage reads as indicated in the chart.

Ambient Temperature	Pressure Gage Reading
Above 40°F	1500 psi
40°F to 0°F	2500 psi
Below 0°F	3300 psi

NOTE

Use the priming pump to make sure the fuel filter, fuel lines, manifolds, and injectors are full of fuel before attempting to start the engine. During cold weather add starting fluid at the same time the Hydrostarter motor lever is moved. Do not wait to add starting fluid after the engine is turning over.

Set the engine controls for starting-throttle at least half open.

Push the Hydrostarter control lever, to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve as soon as the engine starts, to conserve the accumulator pressure and to avoid excessive over-running of the starter drive clutch assembly.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)		
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24. RUNNING.

a. Oil Pressure.

Observe the oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating system. The pressure should not fall below 30 psi at 1200 rpm and normal operating pressure should be higher.

b. Warm-Up.

Run the engine at part throttle and no-load for approximately five minutes, allowing it to warm up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

c. Inspection.

While the engine is running at operating temperature, check for water, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

d. Temperature.

Normal engine coolant temperature is 160° to 185°F.

e. Crankcase.

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached; allow the oil to drain back into the crankcase and check the oil quantity. Add oil, if necessary, to bring it to the proper level on the dipstick.

f. Clutch.

Do not engage the clutch at engine speeds over 850 rpm.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

g. Cooling System.

Remove the heat exchanger tank cap SLOWLY after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add a high boiling point type antifreeze.

h. Marine Gear.

Check the marine gear oil pressure.

i. Avoid Unnecessary Engine Idling.

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTE

When prolonged engine idling is necessary, maintain at least 800 rpm.

25. STOPPING

a. Throttle.

Release the load and decrease the engine speed. Allow the engine to run at half speed or lower with no-load for four or five minutes before closing the throttle and stopping the engine.

The emergency shut-down system should never be used to stop the engine except in an emergency. Use of the emergency shut-down can cause oil to be sucked past the oil seals into the blower housing.

b. Fuel System.

If the unit is equipped with a fuel valve, close it.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

c. Exhaust System.

If a drain or valve is used in the exhaust line or silencer, open it to drain the condensation.

d. Cooling System.

Drain the cooling system if It is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

e. Crankcase.

Check the oil level in the crankcase with the dipstick. Add oil, if necessary, to bring it to the proper level.

f. Marine Gear.

Check and replenish the oil supply in the marine gear.

g. Clean Engine.

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Make the necessary adjustments and minor repairs to correct difficulties which became apparent to the operator during the last run.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

OVERHAUL (Cont)

	Idle	1200 rpm	1800 rpm	2000 rpm
Lubricating Oil Pressure--psi				
Normal.....		30-60	38-60	40-60
Minimum for safe operation		18	27	30
Air Box Pressure--inches mercury (Minimum with zero exhaust back pressure)				
Full Load		1.7	4.3	6.0
No Load		0.5	1.6	1.8
Air Box Pressure--inches mercury (Minimum with maximum exhaust back pressure)				
Full Load		3.2	7.6	10.1
No Load		1.3	4.2	5.0
Air Inlet Restriction--inches water (Maximum)				
Dirty Air Silencer		12.4	25.0	30.0
Clean Air Silencer		9.0	15.0	18.0
Crankcase Pressure--inches water (Maximum)				
6-71 engine.....		2.0	2.8	3.1
Exhaust Back Pressure--inches mercury (Maximum)				
Full Load		1.5	3.3	4.0
No Load		1.0	2.1	2.6
Fuel Pressure--inlet manifold--psi Normal				
.080" Restriction		45-65	45-65	45-65
Minimum		30	30	30
Fuel Spill, no-load-gpm (Minimum)				
.080" Restriction.....		.8	.9	.9
Compression Pressure--psi at 600 rpm (at sea level)				
Average, new engine	565			
Minimum	515			

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
OVERHAUL (Cont)		
ALL SPEEDS		
Fuel Pump Lift, (Maximum)--Feet		4
Coolant Temperature--Engine, Degrees F. (Normal)		160-185
Lubricating Oil Temperature--Engine, Degrees F. (Normal)		200-225
Torqmatic Marine Gear Oil Pump Pressure--psi		
(Maximum)		125
(Minimum)		90
Torqmatic Marine Gear Oil Temperature		
Degrees F. (Maximum) Reverse		225
Degrees F. (Average) Forward		200

26. ENGINE RUN-IN INSTRUCTIONS.

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners, or bearings, the engine must be RUN-IN prior to release for service.

A typical run-in schedule is shown below.

NOTE

Before starting the RUN-IN or starting up the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on "Preparation for Starting Engine First Time".

The dynamometer provides an excellent method of detecting improper tune-up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (160°-185°F) should be maintained throughout the RUN-IN.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

A dynamometer heat exchanger should have a coolant free flow rating equal to the water flow requirement of 57 gallons per minute.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10°F higher than the water inlet temperature. Though a 10°F temperature rise across an engine is recommended, it has been found that a 15°F temperature rise maximum can be permitted.

A thermostat is used in the engine to control the coolant flow; therefore, be sure it is fully operative or the engine will overheat during the RUN-IN.

The overhauled engine should be tested without a thermostat if the dynamometer has a water standpipe with a regulator, such as a Taylor valve or its equivalent.

Change the lubricating oil and replace the oil filter elements after completing the RUN-IN to remove any metallic or foreign material accumulated during this period.

a. Dynamometer Test and Run-in Procedures.

(1) The Basic Engine.

Performance ratings center about the basic engine. The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only the optional equipment actually required to run the engine. The addition of any other engine driven equipment would result in a brake horsepower less than the indicated values in the "Basic Run-In Horsepower Schedule" below. The following are included on the basic engine--blower, fuel pump, water circulating pump, and governor. The following typify items not considered on the basic engine, battery charging generator, raw water pump, torqmatic converter, power take-off, torqmatic marine gear, etc.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the test report form. The effects of this additional equipment on engine performance should then be considered when evaluating test results.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

(2) Dynamometer.

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

BASIC RUN-IN HORSEPOWER SCHEDULE

Speed RPM	Time Minutes	Horsepower
1200	10	42
1800	30	135
*1800	30	164
*2100	30	180
*2300	30	196

* Run at only one of the speeds shown, whichever is at or nearest to the governed speed and reset governor after final run, if necessary.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

The power absorbed is measured generally in torque (lb-ft) on a suitable scale. This value for a given engine speed will show the horsepower developed in the engine by the following formula:

$$\text{Engine Horsepower} = \frac{\text{Torque} \times \text{RPM}}{5250}$$

Some dynamometers indicate direct horsepower readings. Therefore, the use of the formula is not required when using these units.

b. Test and Run-in Procedures.

During the actual operation, all data taken should be recorded immediately on an Engine Test Report (see sample).

(1) Instrumentation.

Certain instrumentation is necessary so that data required to complete the report form may be obtained. The following list contains both the minimum amount of the instruments and the proper location of fittings to the engine so that their readings represent a true evaluation of engine conditions. Diesel diagnosis test kit J 9531 contains all the instruments necessary to carry out the various tests.

- (a) Oil pressure gage installed in one of the engine main oil galleries.
- (b) Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the cylinder block.
- (c) Water temperature gage installed in water outlet manifold.
- (d) Adaptor for connecting pressure gage or mercury manometer to engine air box.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

OVERHAUL (Cont)

ENGINE TEST REPORT

Date _____ Unit Number _____
Repair Order Number _____ Model Number _____

A PRE-STARTING											
1. PRIME LUBE OIL SYSTEM		2. PRIME FUEL SYSTEM		3. ADJUST VALVES AND BRIDGES		4. TIME INJECTOR		5. ADJUST GOVERNOR		6. ADJUST INJECTOR RACKS	
B BASIC ENGINE RUN-IN						C BASIC RUN-IN INSPECTION					
TIME AT SPEED	TIME		RPM	BHP	WATER TEMP.	LUBE OIL PRESS	1. Check oil at rocker mechanism				
	START	STOP					2. Inspect for lube oil leaks				
							3. Inspect for fuel oil leaks				
							4. Inspect for water leaks				
							5. Check and tighten all external bolts				
							6.				
D INSPECTION AFTER BASIC RUN-IN											
1. Tighten Cylinder Head & Rocker Shaft Bolts						4. Adjust Governor Gap					
2. Adjust Valves (Hot)						5. Adjust Injector Racks					
3. Time Injectors						6.					
E FINAL RUN-IN											
TIME		TOP RPM		BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L				
START	STOP	NO LOAD	FULL LOAD								
BLOWER INTAKE RES. - F/L		FUEL OIL PRESSURE RET. MAN. F/L		WATER TEMP FULL LOAD		LUBE OIL TEMP. F/L		LUBE OIL PRESSURE FULL LOAD		IDLE SPEED	
F INSPECTION AFTER FINAL RUN											
1. Inspect Air Box, Pistons, Liners, Rings						6. Tighten Oil Pump Bolts					
2. Inspect Blower						7. Inspect Oil Pump Drive					
3. Check Generator Charging Rate						8. Replace Lube Filter Elements					
4. Wash Oil Pan, Check Gasket						9. Tighten Flywheel Bolts					
5. Clean Oil Pump Screen						10. Rust Proof Cooling System					
REMARKS											
Final Run OK'd _____ Dynamometer Operator _____ Date _____											
NOTE, Operator must initial each check and sign this report.											

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

- (e) Adaptor for connecting pressure gage or water manometer to crankcase.
- (f) Adaptor for connecting pressure gage or mercury manometer to exhaust manifold at flange.
- (g) Adaptor for connecting vacuum gage or water manometer to blower inlet.
- (h) Adaptor for connecting fuel pressure gage to fuel inlet manifold or fuel pump lines.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors will be helpful:

$$\begin{aligned}\text{Inches of water} &= \text{psi} \times 2.75 \\ \text{Inches of mercury} &= \text{psi} \times 2.04\end{aligned}$$

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

(2) Run-In and Test.

The procedure outlined below will follow the order of the sample "Engine Test Report".

(a) Pre-starting.

- 1 Fill lubrication system as outlined under "Lubricating System--Preparation for Starting Engine First Time".
- 2 Prime the fuel system as outlined under "Fuel System--Preparation for Starting Engine First Time".
- 3 A preliminary valve clearance adjustment must be made before the engine is started. See "Valve Clearance Adjustment".
- 4 A preliminary injector timing check must be made before starting engine. See "Injector Timing"
- 5 Preliminary governor adjustments must be made
- 6 Preliminary injector rack adjustment.

(b) Basic Run-in.

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this run-in will be a test of the workmanship of the mechanic who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also inspect the exhaust system, being sure that it is properly connected to the engine. Always start engine with minimum dynamometer resistance.

After engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb-ft on the torque gage (or 10-15 hp on horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and protect them from damage.

Set the engine throttle at idle speed, check lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the Engine Test Report sample which establishes the sequence of events for test and run-in, the Basic Run-in Horsepower Schedule which indicates the speed (rpm), length of time and the horsepower required for each phase of the test. Also, refer to the Operating Conditions which present the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

It is important that the following items be observed:

- 1 Any engine to be run at speeds in excess of 1800 rpm must be equipped with a vibration damper. The Basic Run-in does not require the use of a vibration damper; however, if the Final Run-In is to be above 1800 rpm, a damper must be installed. A viscous damper must be used on models operated at 2000 rpm or above.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

2 Engine governors in most cases must be set at the maximum full load speed designated for the run-in. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the period of run-in.

After checking the engine performance at idle and being certain the engine and dynamometer are operating properly, increase the engine speed to 1200 rpm and apply the load indicated on the Basic Run-In Horsepower Schedule. The engine should be run at this speed and load for 15 minutes to allow sufficient time for coolant temperature to reach the normal operating range. Record length of time, speed, horsepower, coolant temperature and lubricating oil pressure on the Engine Test Report.

Run engine at each speed and rating for the length of time indicated in the Basic Run-In Horsepower Schedule. This is the Basic Run-In. During this phase, engine performance will improve as new parts begin to "seat-in". Record all the required data.

(c) Basic Run-In Inspection.

While the engine is undergoing the Basic Run-In, check each item indicated in Section "C" of the Engine Test Report. Check for fuel oil or water leaks in the rocker arm compartment.

Upon completion of the Basic Run-In and Inspection, the load should be removed from the dynamometer and the engine speed gradually reduced to idle and the engine finally stopped.

(d) Inspection After Basic Run-In.

The primary purpose of this inspection is to provide a fine engine tune-up. First, the cylinder head and rocker arm shaft bolts should be tightened to the proper torque. Next, the applicable tune-up procedure should be completed.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

(e) Final Run-In.

After all tests have been made and the Engine Test Report form completed through Section "D", the engine is ready for final test. This portion of the test and run-in procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shut-down for one hour or longer, it will be necessary to have a warm-up period of 15 minutes at the same speed and load used for warm-up in the Basic Run-In. If piston rings, cylinder liners or bearings have been replaced as a result of findings in the Basic Run-in, the entire Basic Run-In should be repeated as though the run-in and test procedure were started anew.

All readings observed during the Final Run-In should fall within the range specified in the table under Operating Conditions and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

Water temperature of the engine should be taken during the last portion of the Basic Run-In at full load. It should be recorded and should be within the specified range.

Lubricating oil temperature reading must be taken while engine is operating at full load and after engine has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

Lubricating oil pressure should be recorded in pounds per square inch after being taken at engine speeds indicated in Operating Conditions.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

Fuel oil pressure may be taken by removing the 1/4" pipe plug from the end of the fuel inlet manifold and attaching a 0-100 psi gage. Pressure should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine rpm during the Basic Run-In.

Air box pressure should be checked while the engine is operating at maximum rpm and load. This check may be made by attaching a suitable gage (0-15 psi) or manometer (10-0-10) to an air box drain or to a hand hole cover prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure, in inches of mercury, should be recorded.

Crankcase pressure should be checked while the engine is operating at maximum run-in speed. Attach a gage or manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the run-in indicating that new rings are beginning to be "seated".

The inlet restriction should be measured in inches of water while the engine is operating at maximum run-in speed and should fall within the specified limits. Record this reading on the Engine Test Report. Attach the gage to a fitting installed in the 1/4" pipe tapped hole located in the air inlet housing.

Exhaust back pressure should be recorded in inches of mercury and should be within the designated limits. Many exhaust manifolds are provided with a 1/8" pipe tapped hole near the outlet flange. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so the fitting does not protrude into the stack.

Determine the maximum rated horsepower for this engine from the engine option plate at the full load speed to be used during the Final Run-In. Apply the load thus determined to the dynamometer. The engine should be run at this speed and load for 30 minutes. While making the Final Run-In, the engine should develop, within 5%, the maximum rated horsepower indicated for the speed at which it is operating. If this horsepower is not developed, the cause should be determined and corrections made.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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OVERHAUL (Cont)

When the above conditions have been met, and with the engine running, start the Final Run-In by adjusting the maximum no-load speed to conform with that specified. This speed may be either greater or lesser than the maximum speed used during the Basic Run-In. This will ordinarily require a governor adjustment.

All information required in section "E", Final Run-In, of the Engine Test Report should be determined and filled in. After the prescribed time for Final Run-In has elapsed, the load should be removed from the dynamometer and the engine speed gradually reduced to idle and the engine stopped. The Final Run-In is complete.

(f) Inspection After Final Run-In.

After the Final Run-In and before the Engine Test Report is completed, a final inspection must be made. This inspection will provide final assurance that the engine and accessories required in the installation are in proper working order. During this inspection the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rust-proofing the fuel system. A rust inhibitor should be introduced into the cooling system.

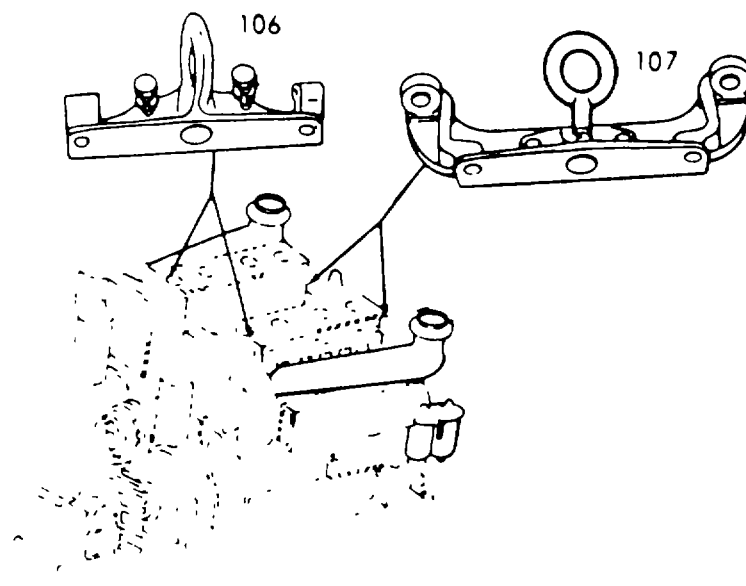
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION		
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27. Propulsion Unit		
------------------------	--	--

- | | | |
|--|---|--|
| | a. Attach chains or cables to lifting brackets (106 and 107). | |
|--|---|--|



WARNING

During propulsion unit installation operation all persons should keep clear of engine and hoisting equipment.

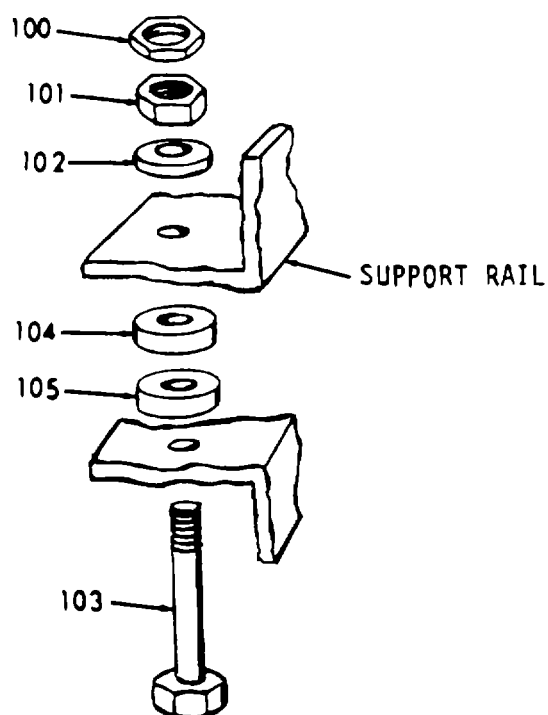
- | | | |
|--|--|--|
| | b. Using appropriate lifting equipment carefully lower the propulsion unit until it is approximately 6 inches from the foundation. | |
|--|--|--|

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- c. Install eight resilient mounts (104) and chocks (105).
- d. Install eight screws (103), washers (102), nuts (101), and jam nuts (100).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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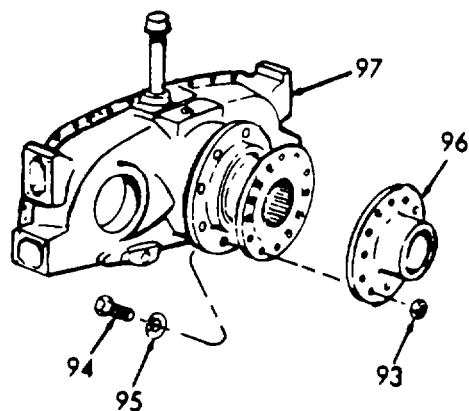
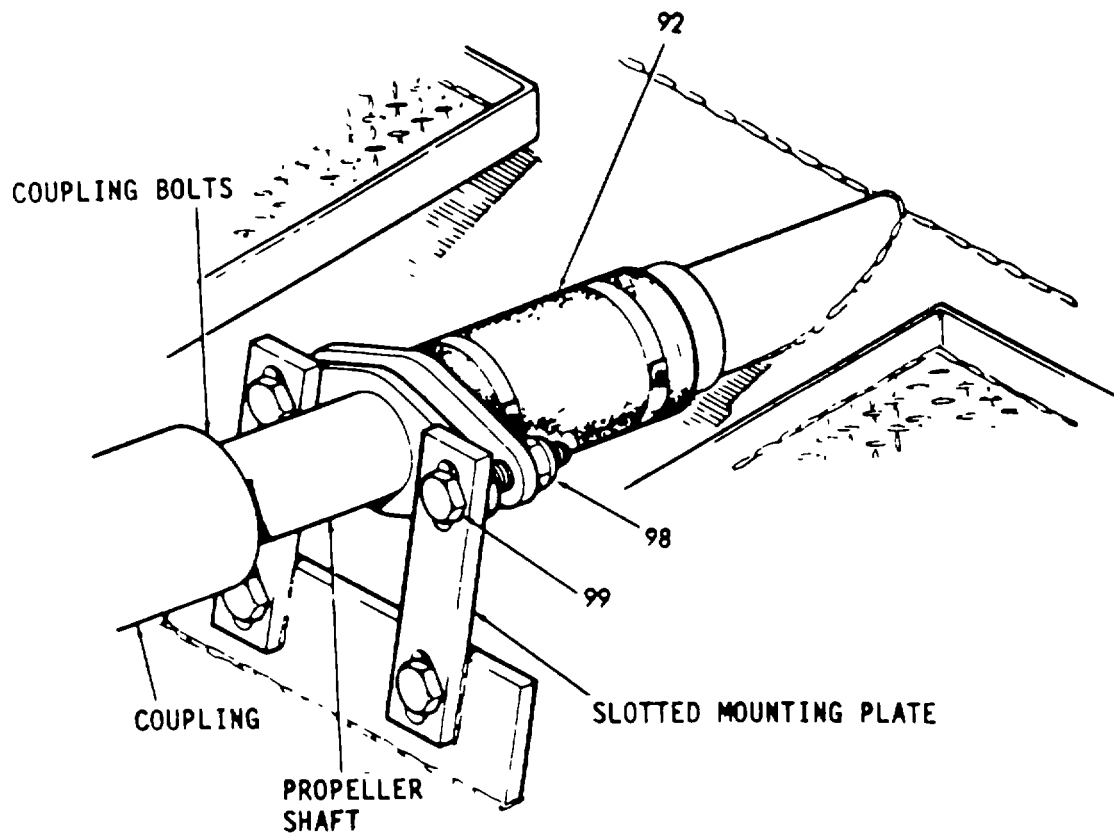
INSTALLATION (Cont)

- | | | |
|------------------------|---|--|
| 28. Propeller
Shaft | <ul style="list-style-type: none">a. Slide the propeller shaft until the flange (97) and propulsion unit flange (96) meet. Refer to paragraph 3-18 for alignment procedure.b. Install bolts (99) and nuts (98).c. Install bolts (94), lockwashers (95) and nuts (93).d. Tighten hose (92) at propeller shaft coupling. | |
|------------------------|---|--|

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

29. Steering
System

NOTE

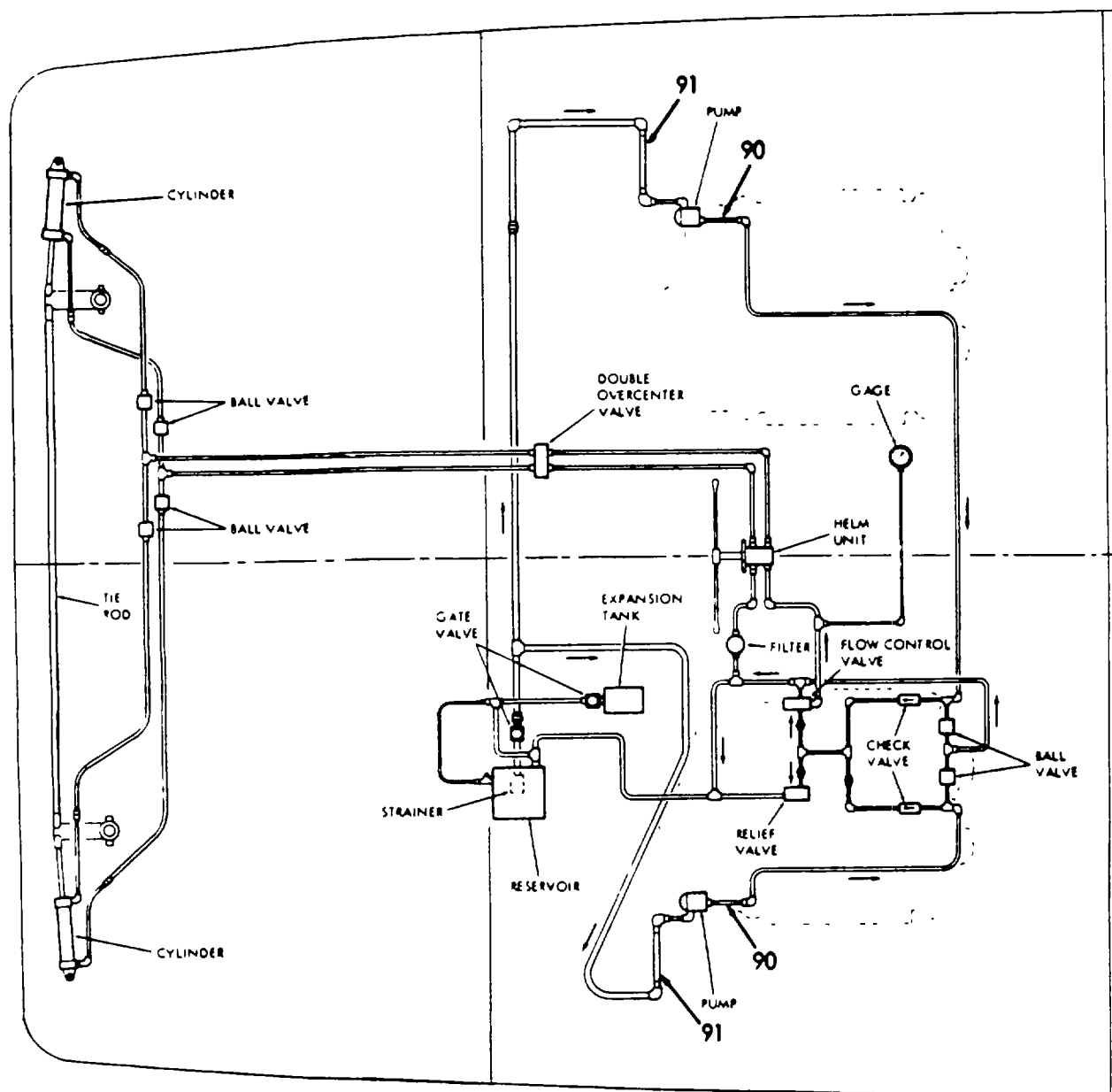
Remove all caps prior to installation.

- a. Reconnect hose (91)
at swivel fitting.
- b. Reconnect hose (90)
at swivel fitting.
- c. Reinstall any piping
that was removed to
facilitate propul-
sion unit removal.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

30. Exhaust
Pipes

NOTE

The following step requires 3 persons.

- a. Install exhaust pipe assembly (89), screw (88), lockwasher (87), and nut (86).
- b. Install new gasket (85) and screws (84), lockwashers (83), and nuts (82).
- c. Install flexible pipe (80) and new gaskets (81) using screws (79), lockwashers (78), and nuts (77).
- d. Install screws (76), lockwashers (75), and nuts (74).

WARNING

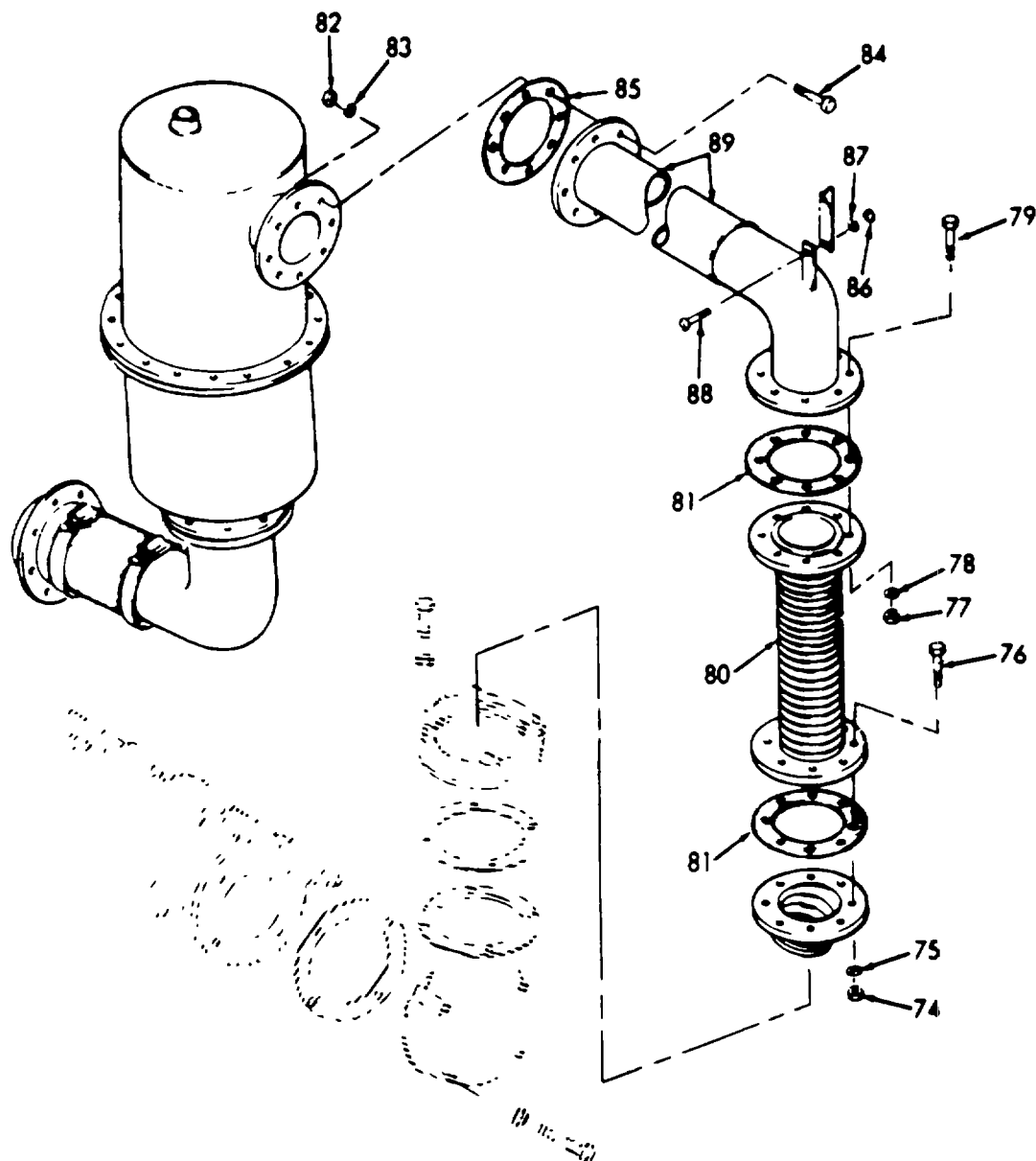
Wear breathing and face protection devices when handling and installing asbestos coverings.

- e. Install asbestos pipe coverings and pipe straps.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

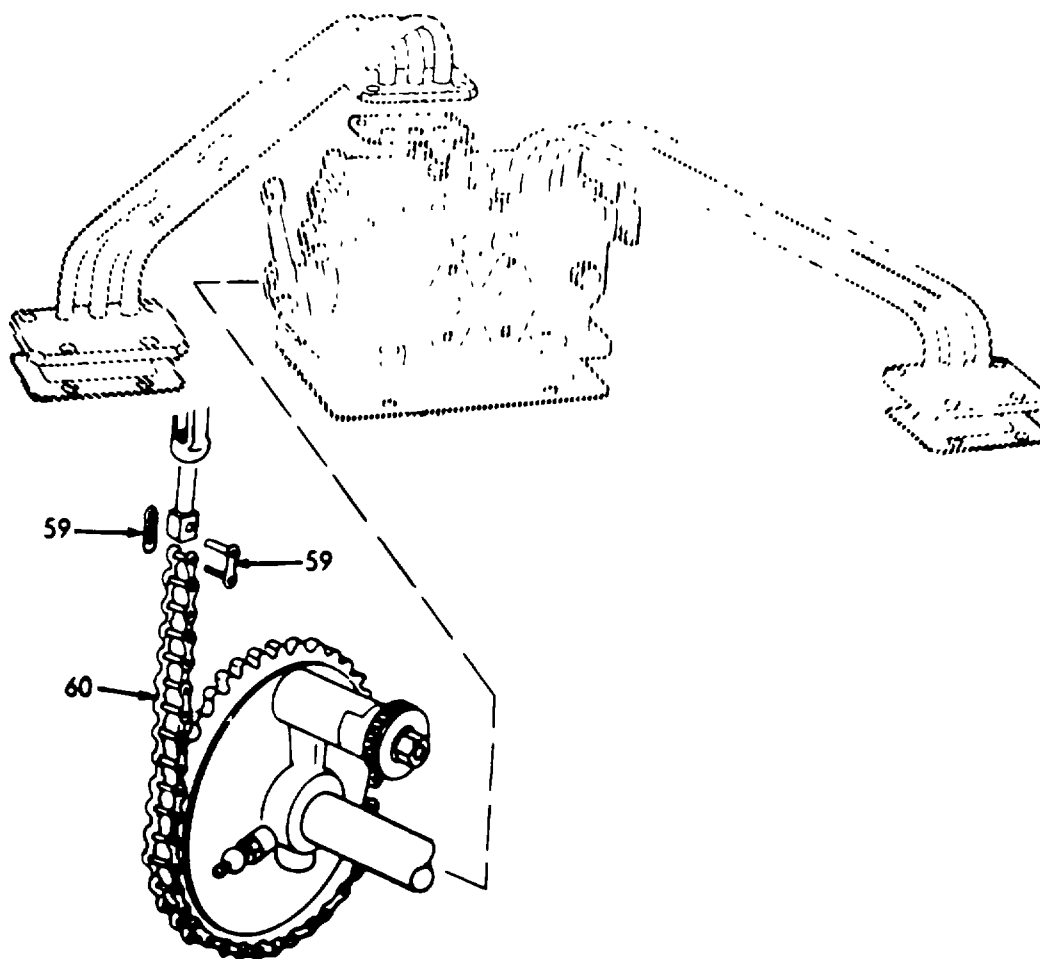
LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

31. Engine
Controls

NOTE

- a. Install chain (60) and connecting link (59).

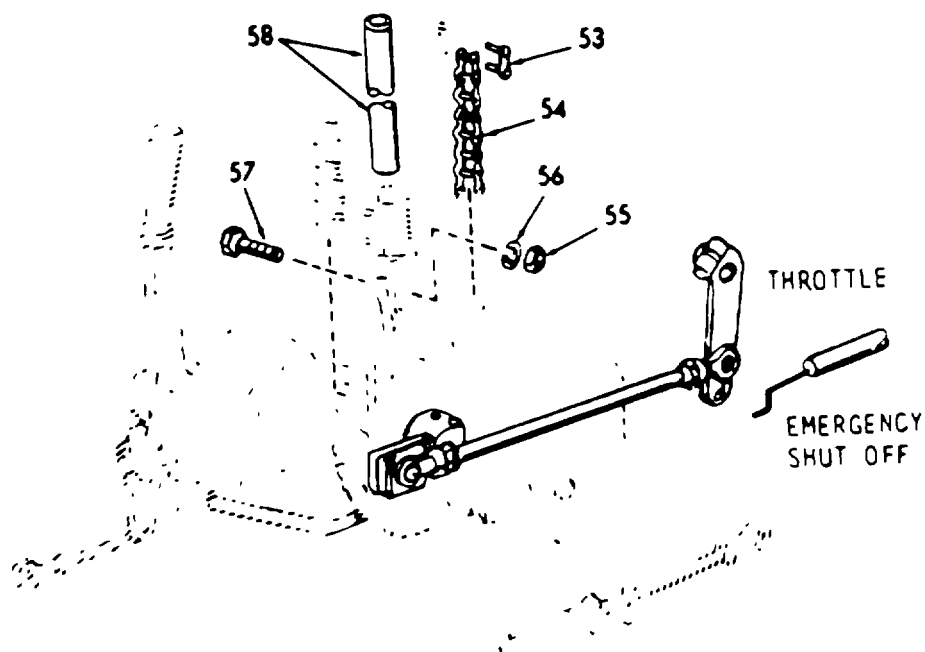


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- b. Install overspeed shut-off cable.
- c. Install neutral throttle cable.
- d. Install engine stop cables.
- e. Install strut (58) using screw (57), lockwasher (56), and nut (55).
- f. Install chain (54) and connecting link (53).



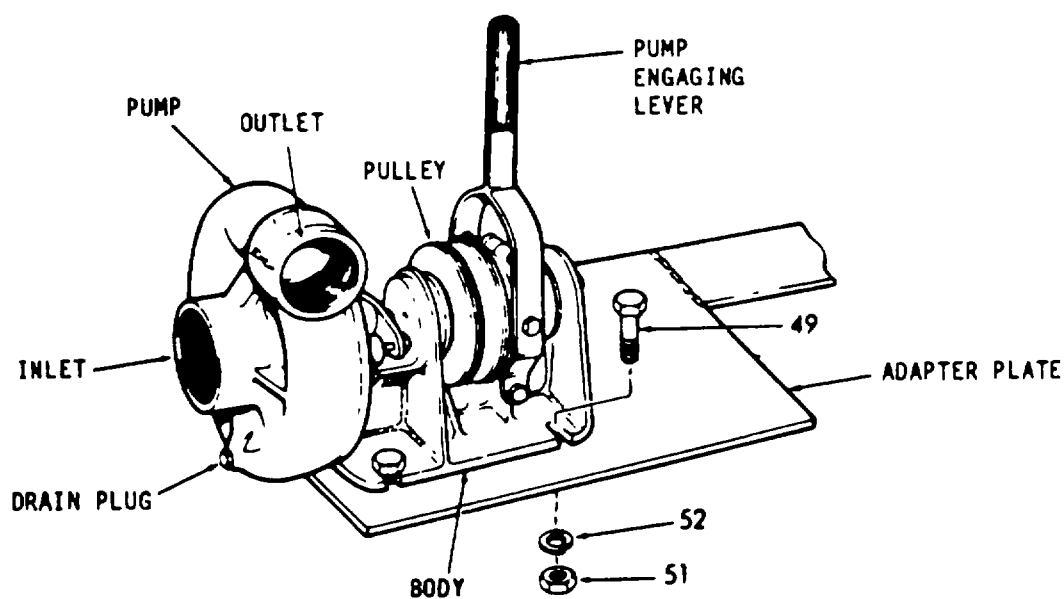
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

32. Bilge Pumps

- a. Install bilge pumps using bolts (49), lockwashers (52), and nuts (51).

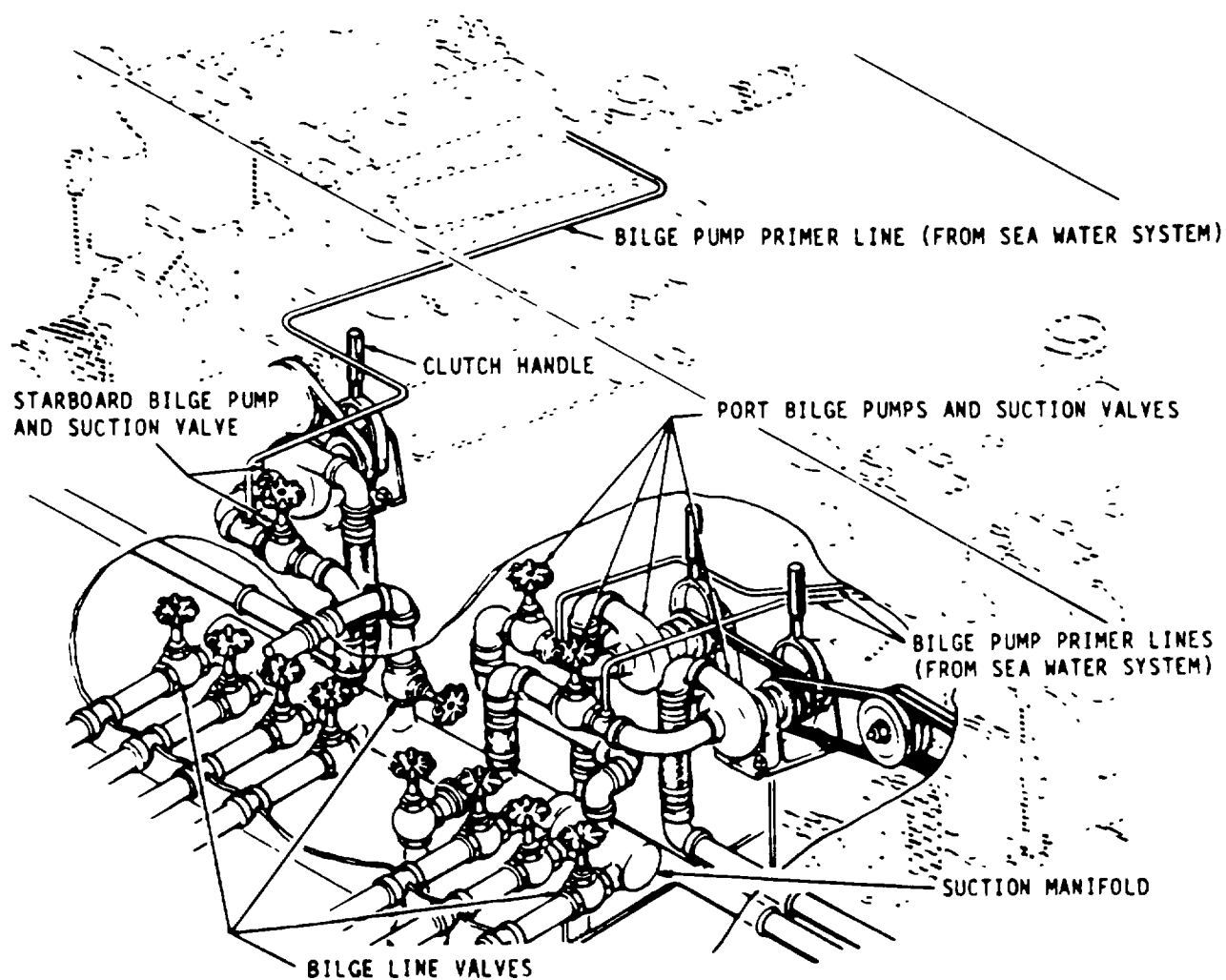


- b. Install hoses and hose clamps on inlet and outlet of pumps.
- c. Install bilge pump primer lines.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

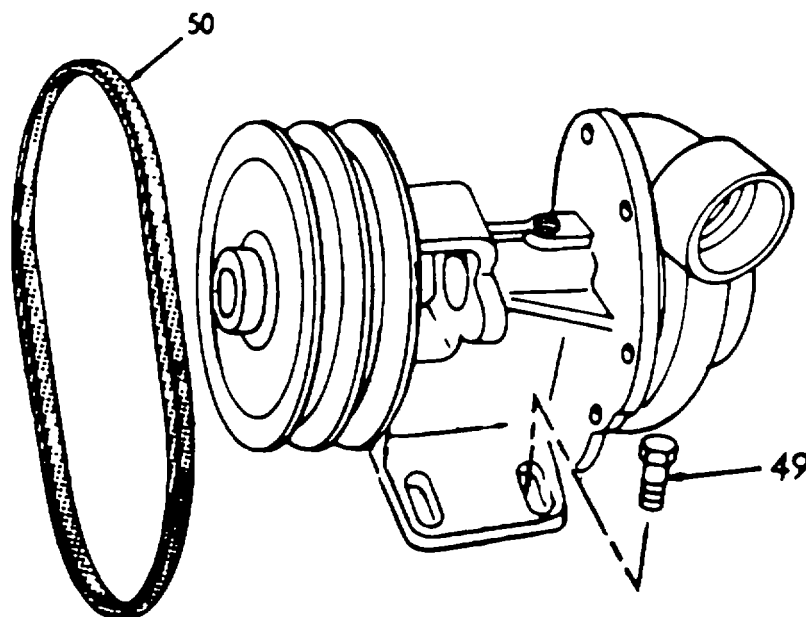


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- d. Install belt(s) (50).
- e. Move pump to tighten belt(s) (50) and tighten bolts (49).
- f. Install piping removed to facilitate propulsion unit removal.

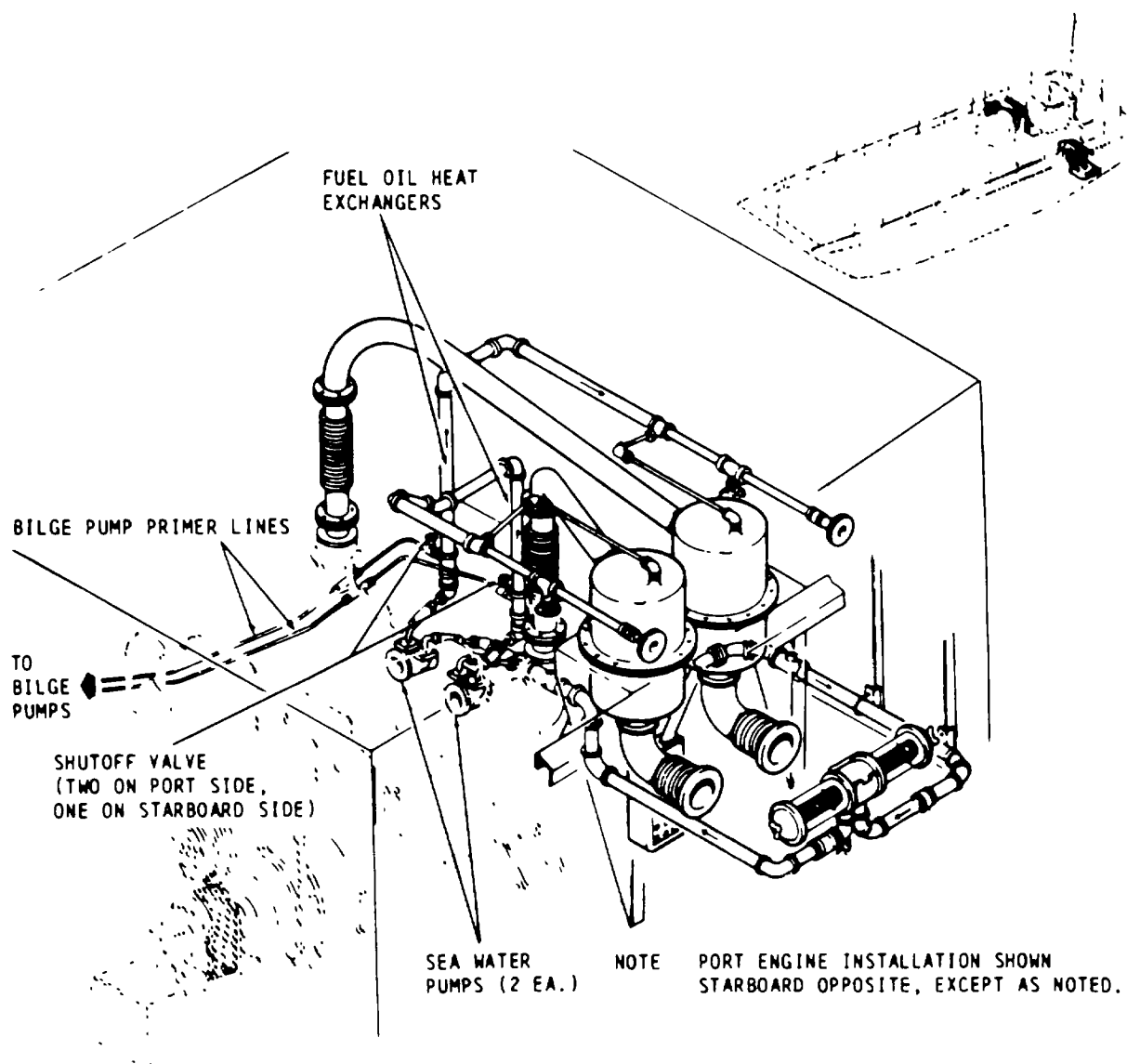


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- | | | |
|--------------------------|--|--|
| 33. Raw Sea Water System | a. Install fuel lines to heat exchanger. | |
| | b. Install piping removed to facilitate propulsion unit removal. | |
| | c. Reconnect bilge pump primer lines. | |

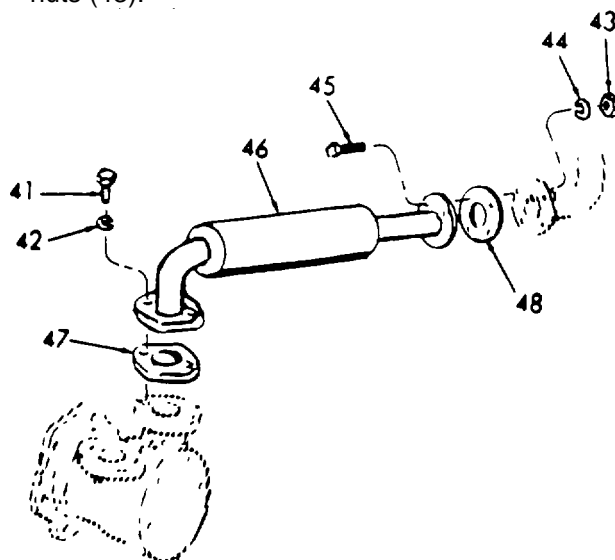


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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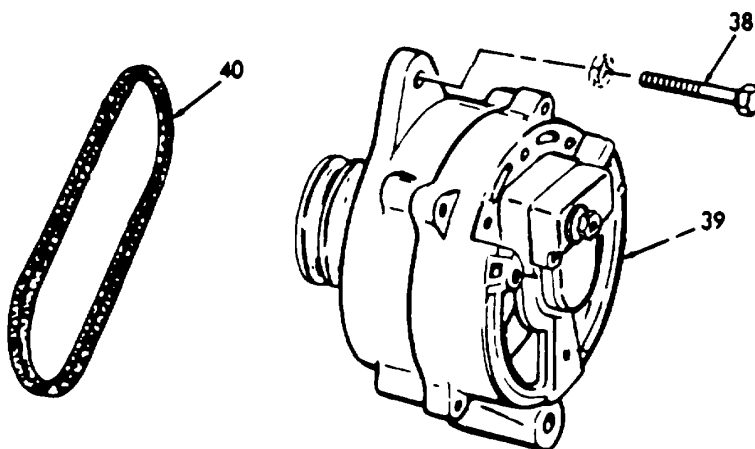
INSTALLATION (Cont)

- d. Install hose (46), new gaskets (47 and 48), using screws (41 and 45), lockwashers (42 and 44), and nuts (43).



34. Alternator

- a. Install belts (40) on alternator (39) and inboard engine.
- b. Move alternator (39) to tighten belts (40), tighten bolt (38).
- c. Install shroud if removed.



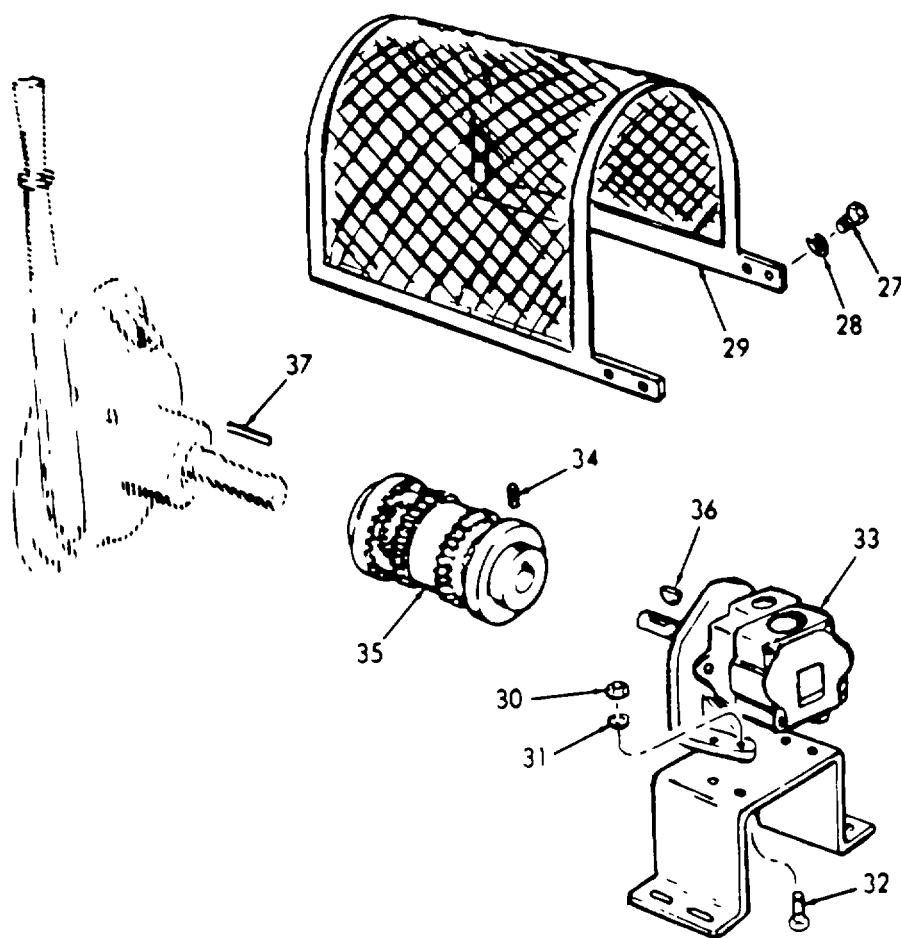
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

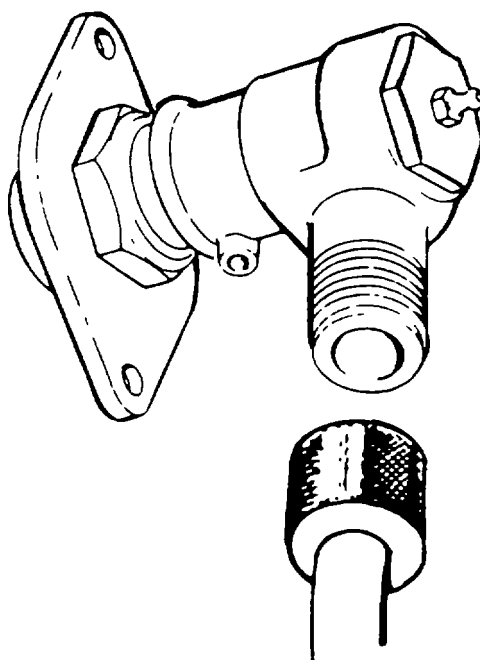
35. Ramp
Hoist
Ramp

- a. Install coupling (35) and keys (36 and 37). Tighten setscrew (34).
- b. Install screws (32), lockwashers (31), and nuts (30) that attach pump (33) to its base.
- c. Install coupling guard (29) using screws (27) and lockwashers (28).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)36. Tachometer
DriveInstall tachometer drive at
engine.

37. Fuel Lines

NOTE

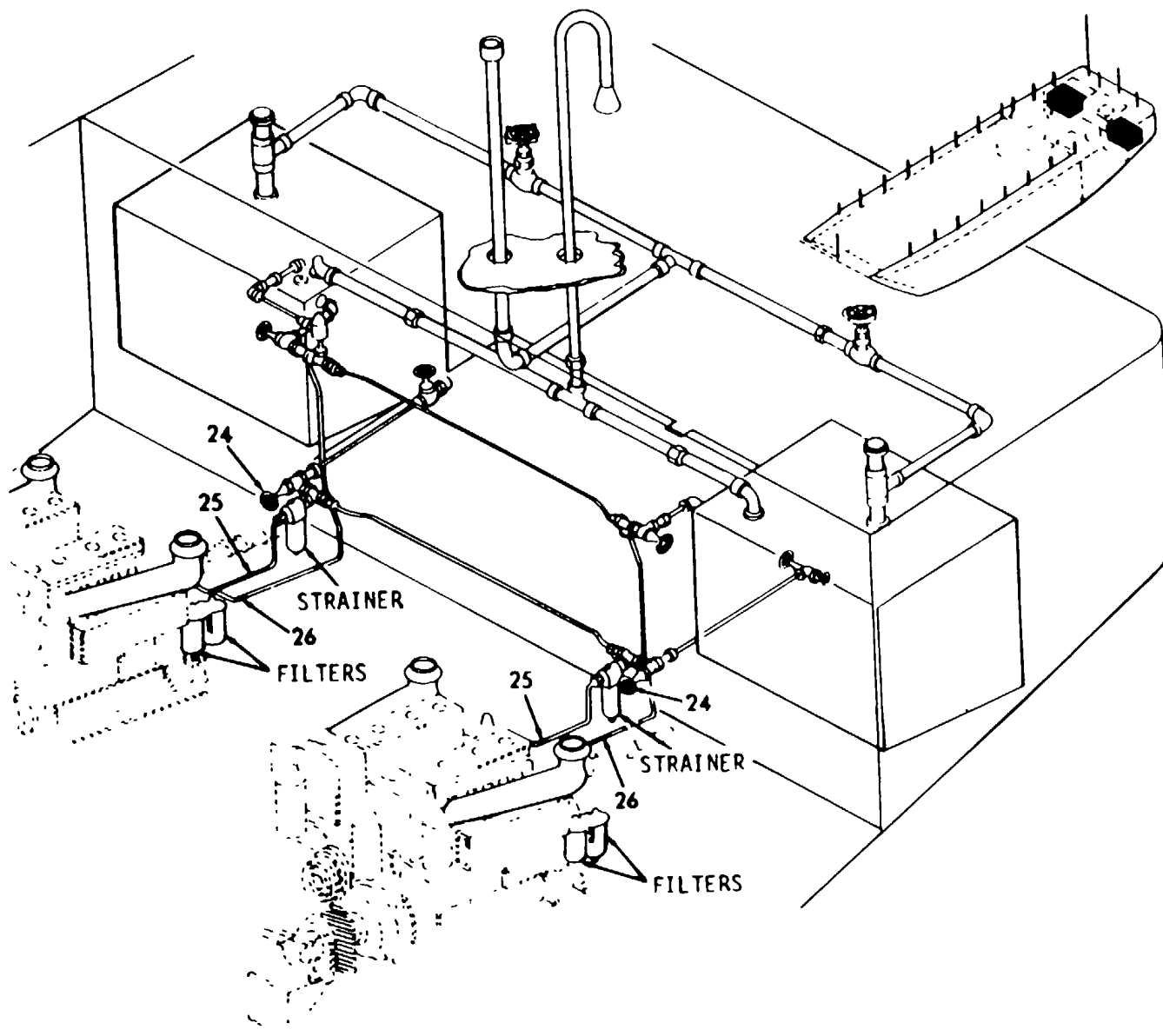
Remove protective caps before installation.

- Reconnect fuel return hose (26) to engine.
- Reconnect fuel hose (25) from intake to strainers.
- Turn on fuel intake line valves (24).

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



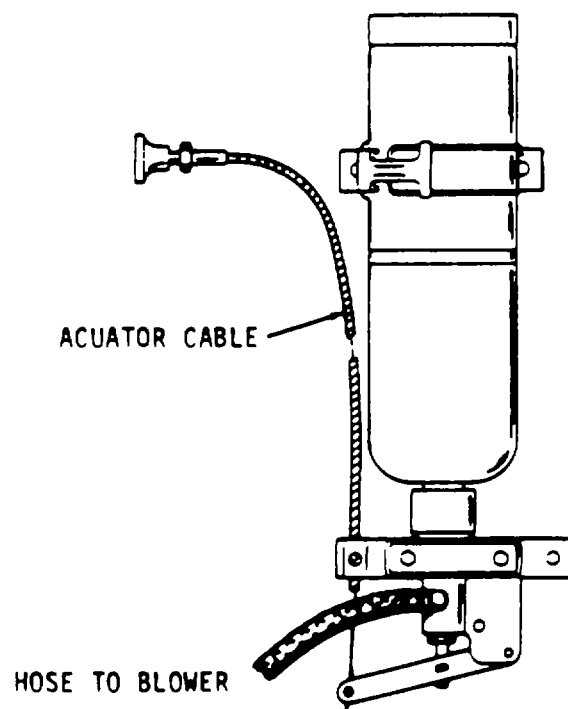
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

38. Starting
Aid

Install hose from starting aid
to air inlet on blower.



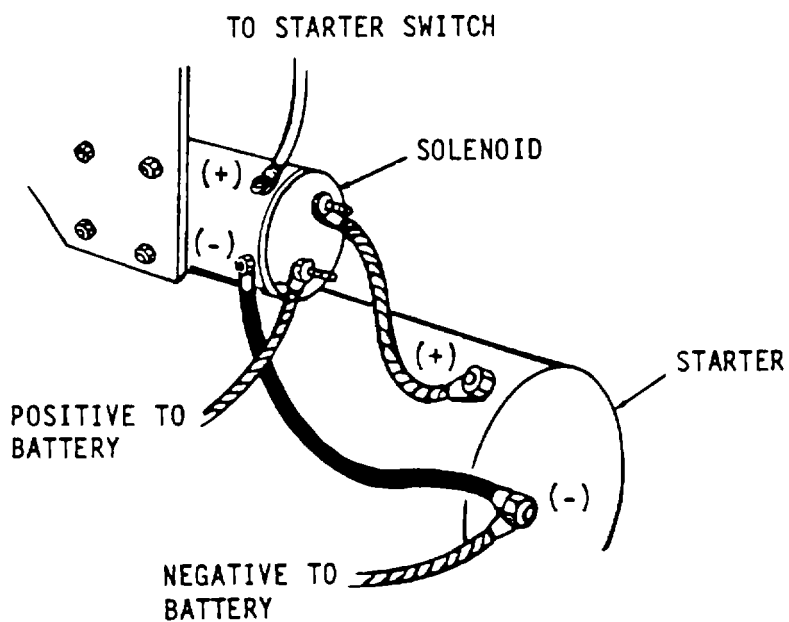
39. Electric
Starting
Motor

- Reconnect positive electrical lead to starter solenoid.
- Reconnect negative electrical lead to starter motor.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



40. Hydraulic
Starting
System

NOTE

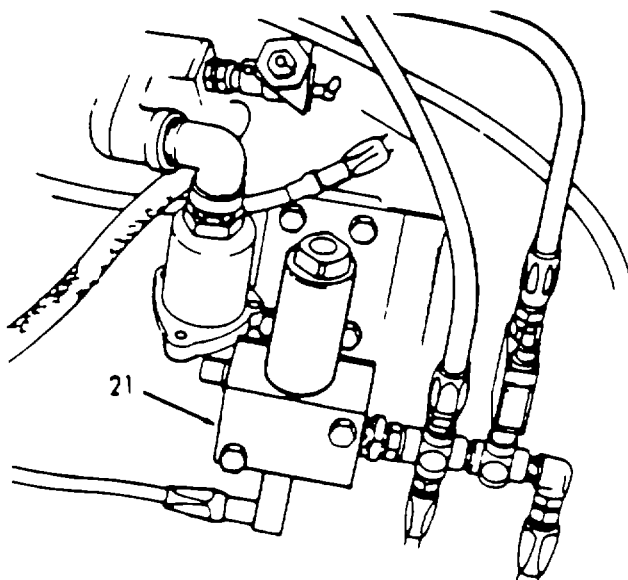
Remove protective covers when installing hoses.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- b. Reconnect wiring to solenoid valve (21).



- c. Reconnect hose (20) from filter to pump.
- d. Reconnect hose (19) from pump solenoid valve (control valve).
- e. Reconnect hose (18) from pump to reservoir.
- f. Reconnect input hose (17) from solenoid valve (control valve) to starter.
- g. Reconnect return hose (16) from starter to reservoir.

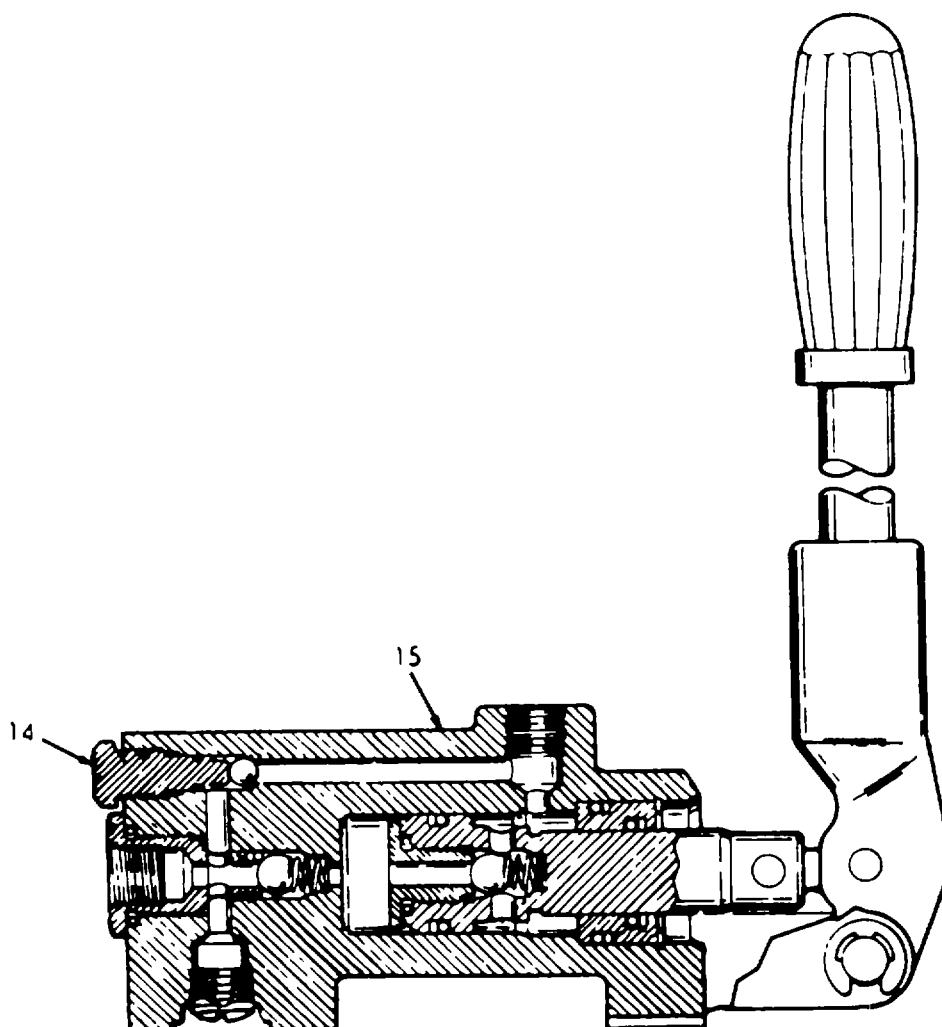
See pages 3-496, 3-497, and 3-498.

6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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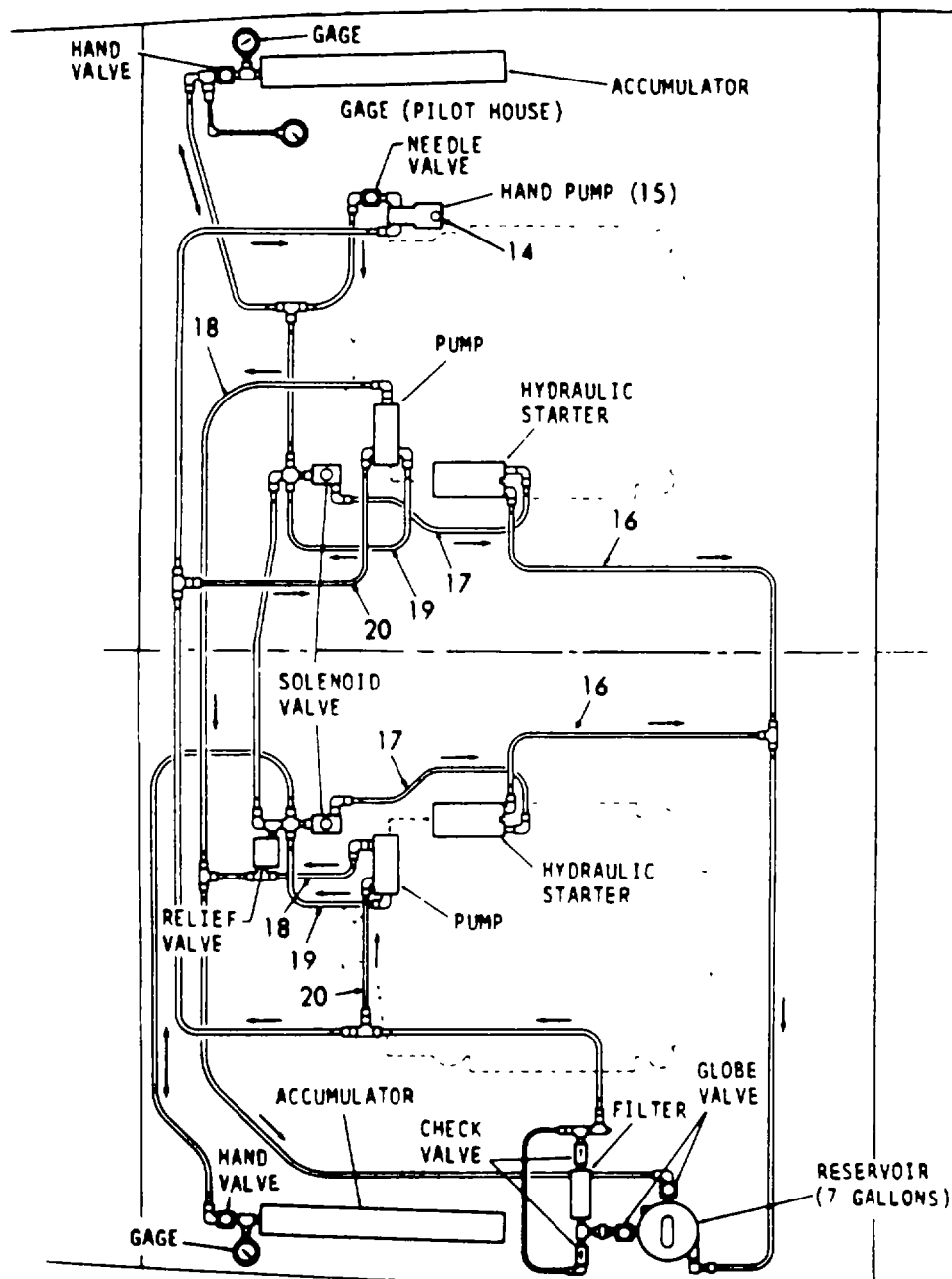
- h. Close pressure relief valve (14) on hand pump (15).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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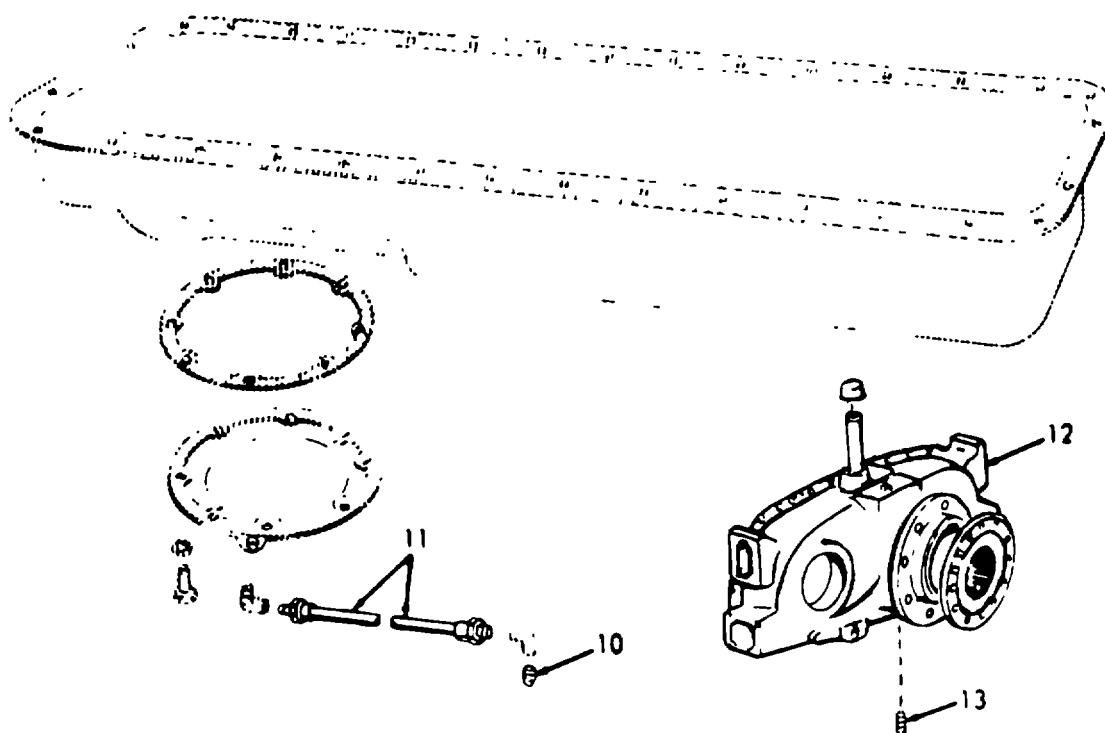
INSTALLATION (Cont)

- | | | |
|---|---|--|
| 41. Electrical
Wiring to
Engine
Sending
Units | Refer to schematics in step 5
and reconnect all electrical
wiring. | |
| 42. Engine and
Transmission
Oil | a. Install oil drain tube
mounting brackets.

b. Install drain plug (13) in
power transfer gear (12).

c. Install drain plug (10) on
end of oil pan drain tube
(11).

d. Install oil in engines and
power transfer case. | |



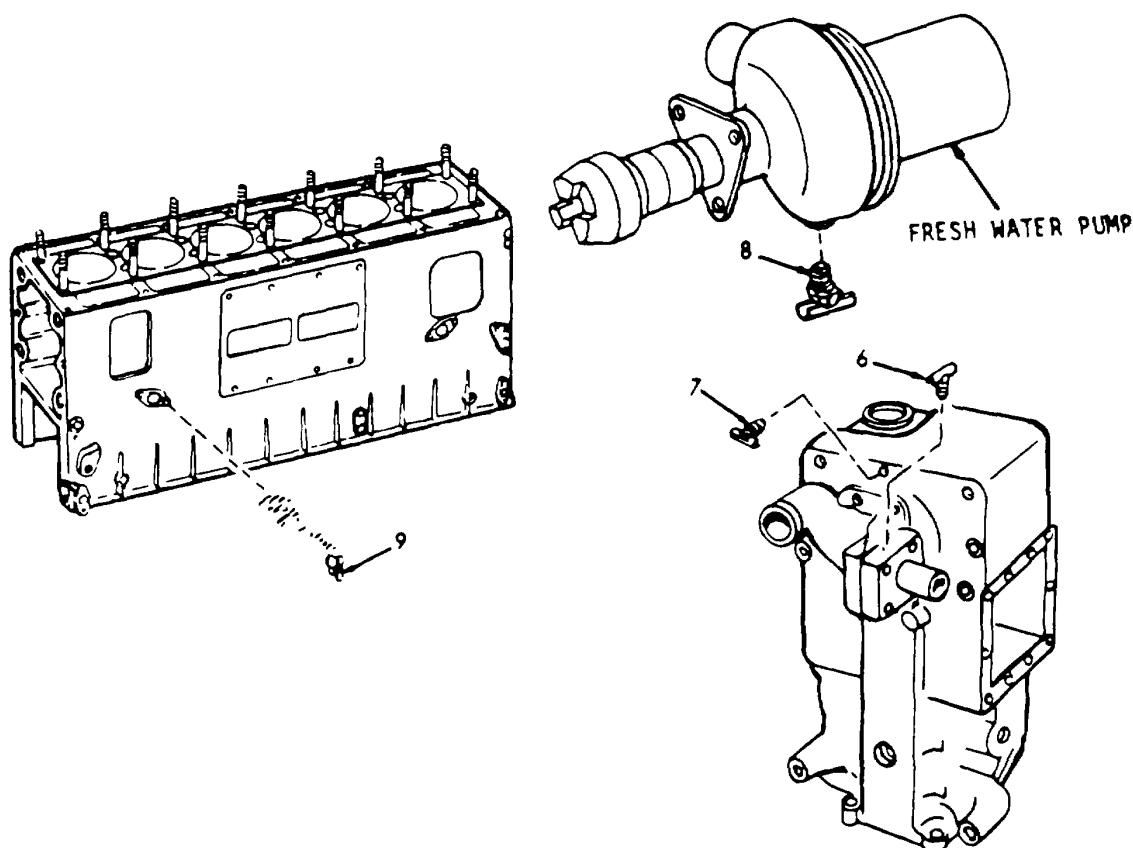
6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

43. Fresh Water System

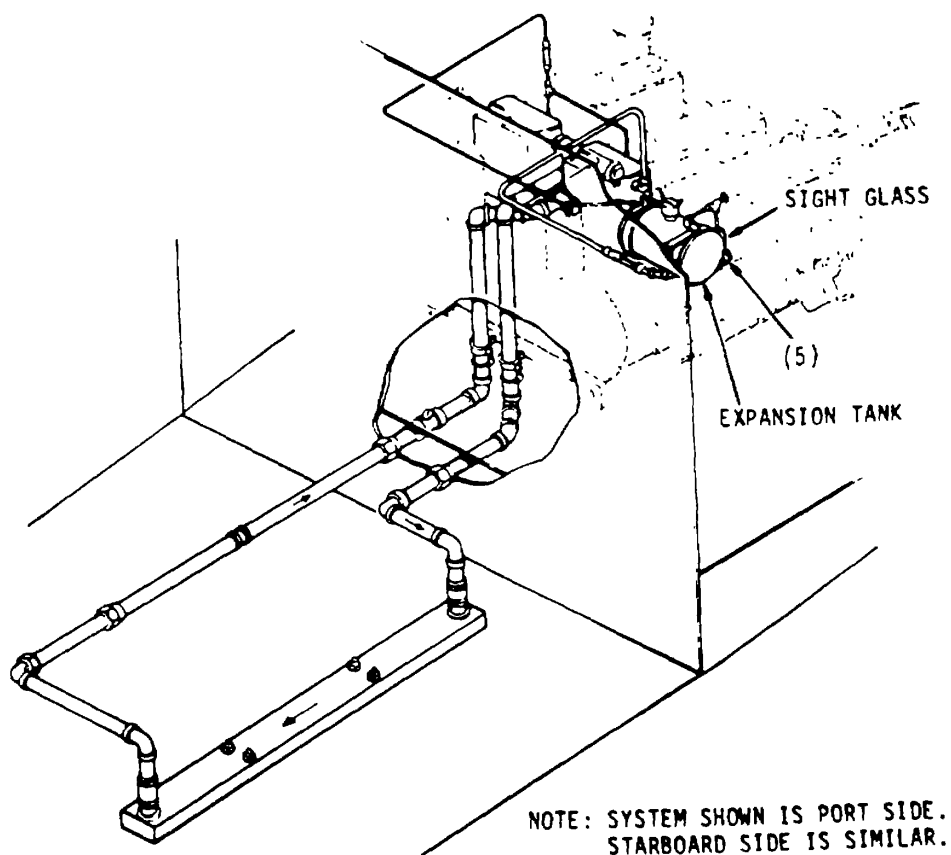
- Close drain cock (9) on engine block.
- Close drain cock (8) on the fresh water pump.
- Close drain cock (6) on the heat exchanger.
- Close drain cock (5) on expansion tank.
- Refill fresh water system and close vent cock (7).



6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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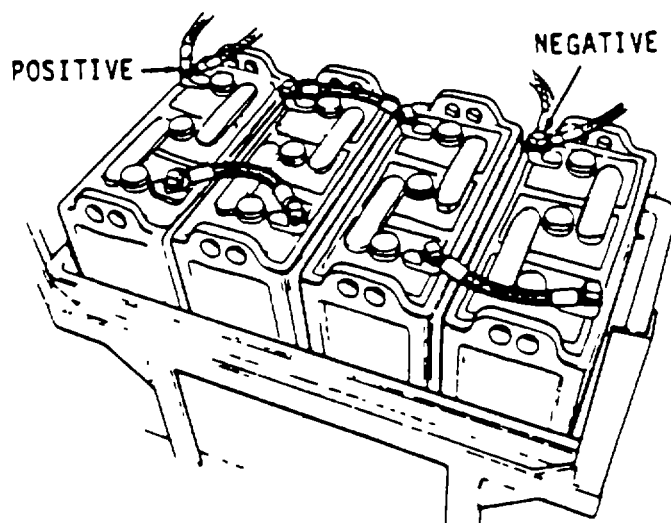


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- | | | |
|-------------|--|--|
| 44. Battery | Reconnect negative (ground) wire to battery. | |
|-------------|--|--|

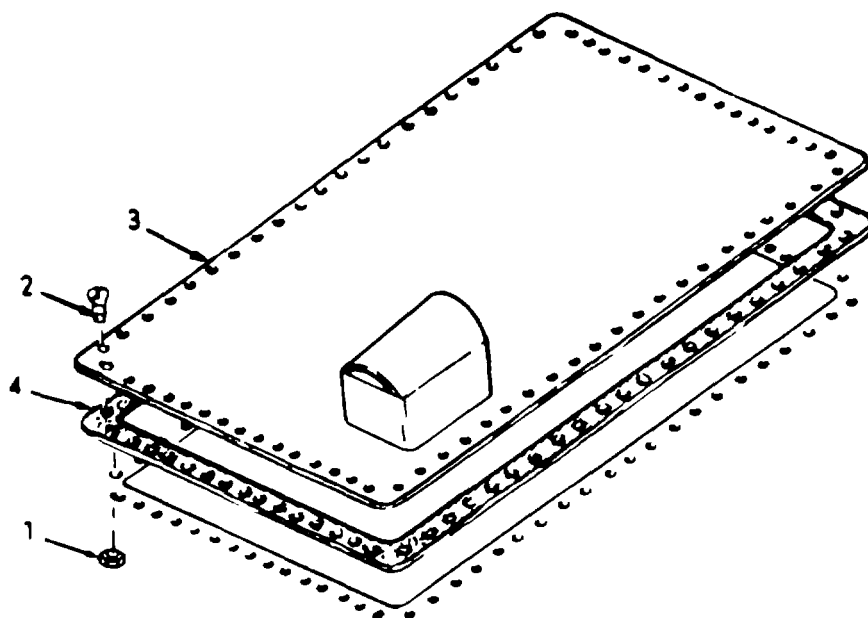


6-22. POWER UNIT - MULTIPLE ENGINE REMOVAL - AND RUN-IN INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)45. Engine
Room
Hatch

- a. Install new gasket (4) if the old gasket was damaged.
- b. Install hatch (3) using seventy six screws (2) and nuts (1).



6-23. CAM AND BALANCE SHAFT BEARINGS.

The following is an index to the maintenance procedures:

<u>DESCRIPTION</u>	<u>PARAGRAPH</u>
Gear Train and Engine Timing	6-23.1
Balance Weights and Cover	6-23.2
Camshaft and Balance Shaft	6-23.3
Camshaft and Balance Shaft Gear	6-23.4

3-23.1. GEAR TRAIN AND ENGINE TIMING.

a. General.

A completely enclosed train of five helical gears is located at the rear end of the engine. A gear bolted to the crankshaft flange drives the camshaft and balance shaft gears, as well as the blower drive gear, through an idler gear mounted between the crankshaft and balance shaft gears on the RB and LD engines, and between the crankshaft and camshaft gears on the RD and LB engines.

The camshaft gear and balance shaft gear mesh with each other and run at the same speed as the crankshaft. Since these two gears must be in time with each other, and the two as a unit in time with the crankshaft gear, the letter "O" is placed on one tooth of one of the gears with a corresponding mark at the root of the mating teeth of the other gear.

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft, as shown on RD, and LD engines, or the camshaft, as shown on RB and LB engines, has left-hand helical teeth.

The idler gear rotates on a double-row, tapered roller bearing mounted on a stationary hollow hub. This hub is accurately located on the cylinder block end plate, at the right-hand side of the LB and LD engines and at the left-hand side of the RB and RD engines, as viewed from the gear train end.

A blower drive gear is located on the blower side to transmit power to the blower, governor, fuel pump and water pump.

Since, as stated above, the cam and balance shafts must be in time with the crankshaft, identification marks are located on two teeth of the idler gear with corresponding match marks stamped on the crankshaft gear and the camshaft or balance shaft gear.

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).

Balance weights, one fastened to the inner face of each gear (camshaft and balance shaft) are important in maintaining perfect engine balance. These are in addition to the weights cast integral with the gears.

Gear train noise is usually an indication of excessive gear lash, scoring, pitting or excessive bearing wear. Therefore, when noise develops in a gear train, the flywheel housing should be removed and the gear train and its bearings inspected. A rattling noise usually indicates excessive gear lash whereas a whining noise is a result of too little gear lash.

Excessive wear and scoring may result from abrasive substances or foreign material in the oil, introduced in the engine by such means as removal of the rocker cover without first cleaning away the dirt.

The backlash between the various mating gears in the helix steel gear train ranges from .003" to .008" with new parts.

Since the camshaft and balance shaft gears each have the same number of teeth as the crankshaft gear, they will turn at crankshaft speed. However, as the blower drive gear has only about half as many teeth as the camshaft or balance shaft gear, it turns at approximately twice the speed of the crankshaft.

b. Lubrication.

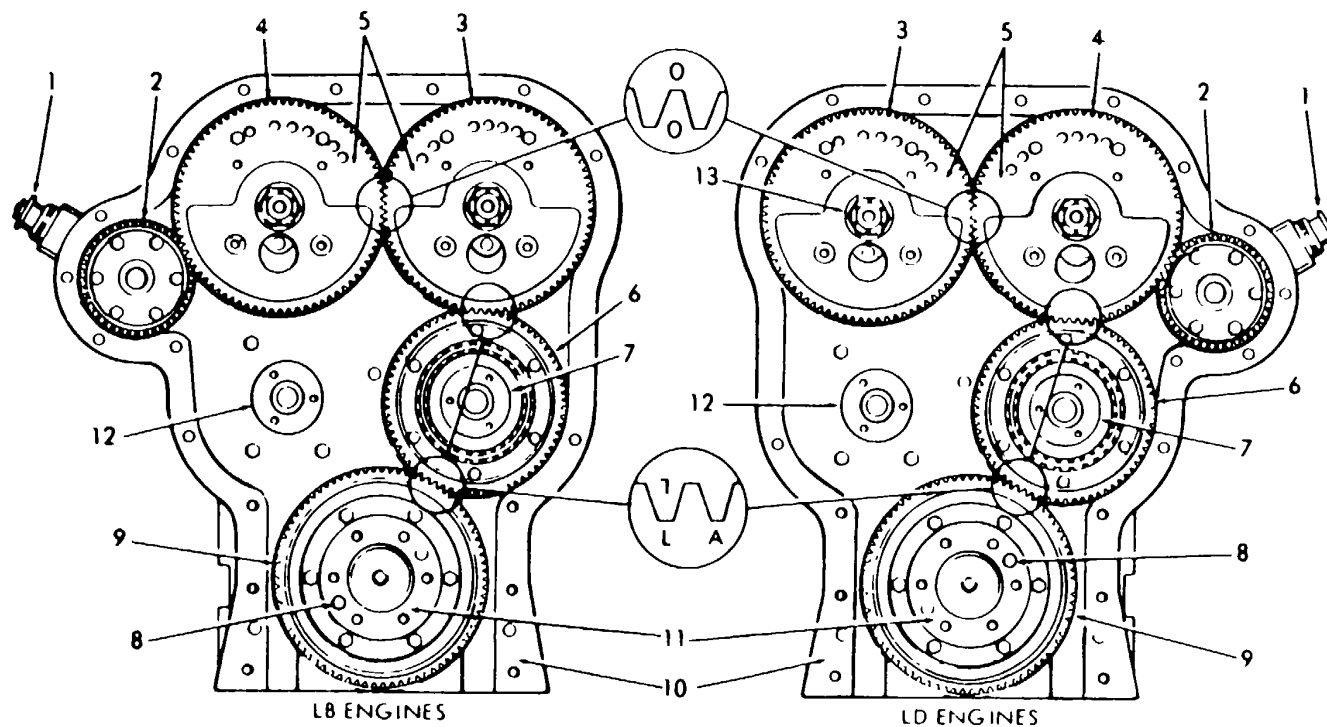
The gear train is lubricated by overflow oil from the camshaft and balance shaft pockets spilling into the gear train compartment. A certain amount of oil also spills into the gear train compartment from the camshaft and balance shaft end bearings, and idler gear bearings. The blower drive gear bearing is lubricated through an external pipe leading from the main cylinder block oil gallery to the gear hub bearing support. The idler gear bearing is pressure lubricated by oil passages in the idler gear hub which connect to the oil gallery in the cylinder block.

c. Engine Timing.

The correct relationship between the crankshaft and camshaft must be maintained to properly control fuel injection and the opening and closing of the exhaust valves.

The crankshaft timing gear can be mounted in only one position due to one attaching bolt hole being offset. The camshaft gear can also be mounted in only one position as a result of the location of the keyway relative to the cams. Therefore, when the engine is properly timed, the markings on the various gears will match as shown below.

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).

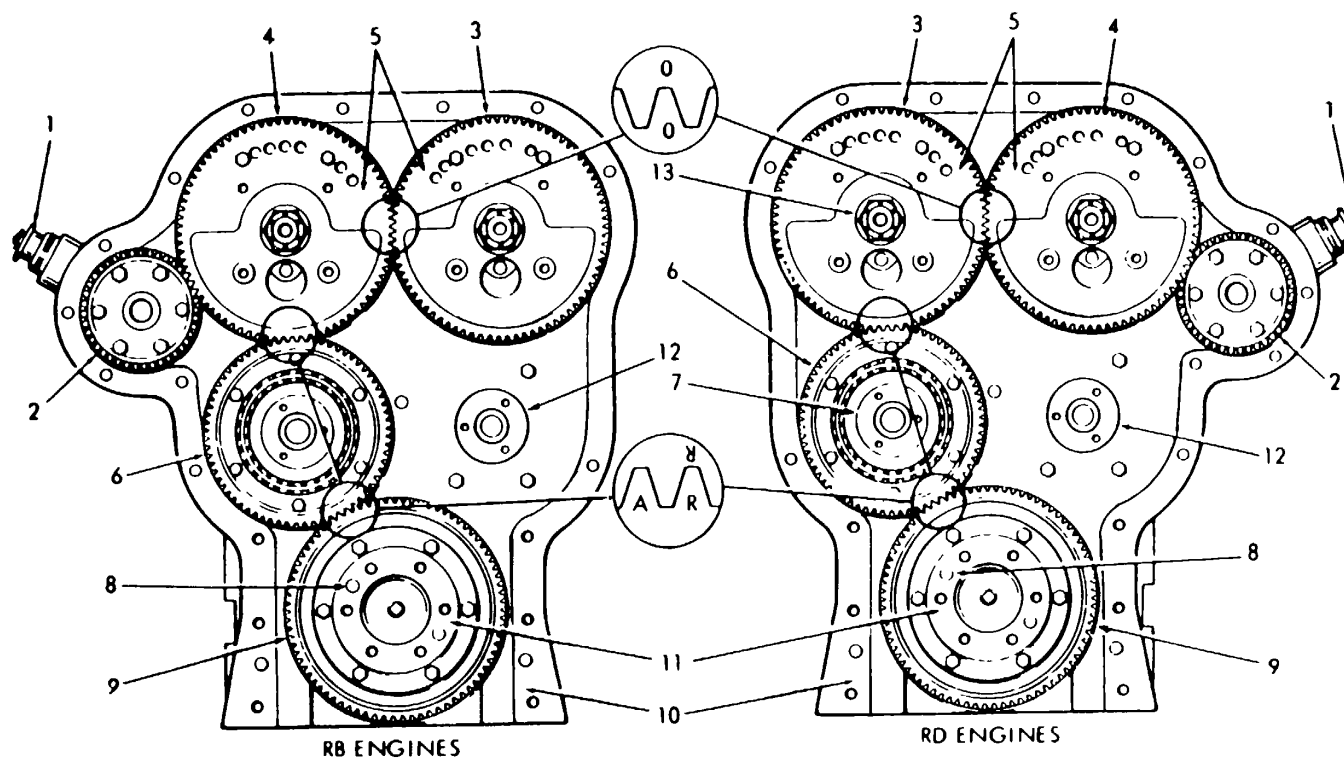


1. Oil Filler Cap
2. Blower Drive Gear
3. Camshaft Gear
4. Balance Shaft Gear
5. Rear Balance Weight
6. Idler Gear
7. Idler Gear Hub

8. Crankshaft Dowel
9. Crankshaft Gear
10. Cylinder Block End Plate (Rear)
11. Crankshaft
12. Spacer, Idler Gear Hole
13. Gear Retaining Nut

Gear Train and Timing Marks Left Hand Rotation Engines

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).



1. Oil Filler Cap
2. Blower Drive Gear
3. Camshaft Gear
4. Balance Shaft Gear
5. Rear Balance Weight
6. Idler Gear
7. Idler Gear Hub

8. Crankshaft Dowel
9. Crankshaft Gear
10. Cylinder Block End Plate (Rear)
11. Crankshaft
12. Spacer, Idler Gear Hole
13. Gear Retaining Nut

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).

An engine which is "out of time" may result in pre-ignition, uneven running and a loss of power.

When an engine is suspected of being out of time, due to an improperly assembled gear train, a quick check can be made without having to remove the flywheel and flywheel housing by following the procedure outlined below.

d. Checking Engine Timing.

Access to the vibration damper or crankshaft pulley, to mark the top-dead-center position of the selected piston, and to the front end of the crankshaft or flywheel for barring the engine over is necessary in performing the timing check. Then, proceed as follows:

- (1) Remove the cylinder head rocker cover.
- (2) Select any cylinder for the timing check -- it is suggested that a cylinder adjacent to one of the cylinder head cover studs be chosen since the stud may be used for mounting a dial indicator.
- (3) Remove the fuel lines (at the cylinder selected) and install shipping caps on injector fuel fittings to prevent the entry of dirt. Make sure that the valve and injector rocker arms are all in the "up" position, then remove the rocker shaft bracket bolts and swing the rocker arm assemblies back out of the way. Remove the injector assembly.
- (4) Carefully place (do not drop) a rod approximately 12" long through the injector hole and on top of the piston.

With the throttle in the NO FUEL position, turn the crankshaft slowly in the direction of rotation of the engine, and stop when the rod reaches the end of its upward travel. Remove the rod and turn the crankshaft opposite the direction of rotation between 1/16 and 1/8 of a turn.

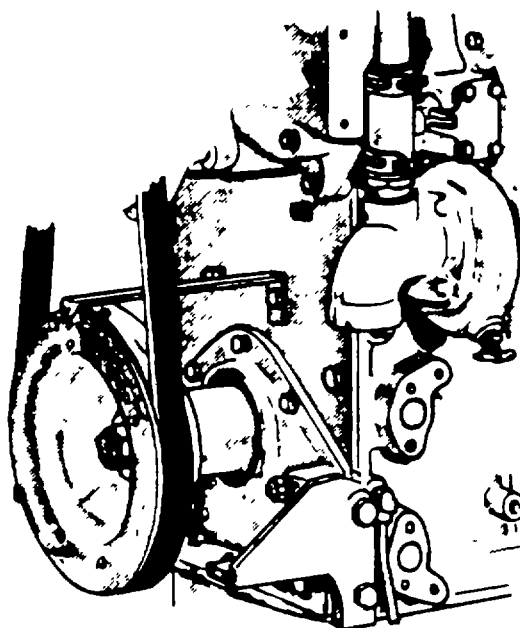
- (5) Select a dial indicator with .001" graduations and with a spindle movement of at least 1". Use suitable mounting attachments for the indicator so that it can be mounted over the injector hole in the cylinder head. Provide an extension for the spindle of the indicator. The extension must be long enough to contact the piston as it approaches its upper position.
- (6) Mount the indicator over the injector hole and tighten mountings sufficiently to hold the indicator rigid.

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).

The mounting leg may be threaded into the rocker cover stud; or, the stud may be removed from the cylinder head and the leg threaded into the tapped hole, depending upon the length of the rod used in making up the mounting attachments.

Make sure that the spindle extension is free in the injector hole, does not burr, and is free to travel its full 1 inch movement.

- (7) Provide a suitable pointer and attach it to the crankshaft front cover or engine front end plate as illustrated. The pointer should extend over the vibration damper, or crank- shaft pulley, whichever is used.



- (8) Rotate the crankshaft in the direction of rotation slowly until the hand on the dial indicator just stops moving.
- (9) Rotate the crankshaft in the direction of rotation until the indicator hand just starts to move. Reset dial to "0". Continue turning the crankshaft slowly until the indicator reading is .010"--then stop turning.

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).

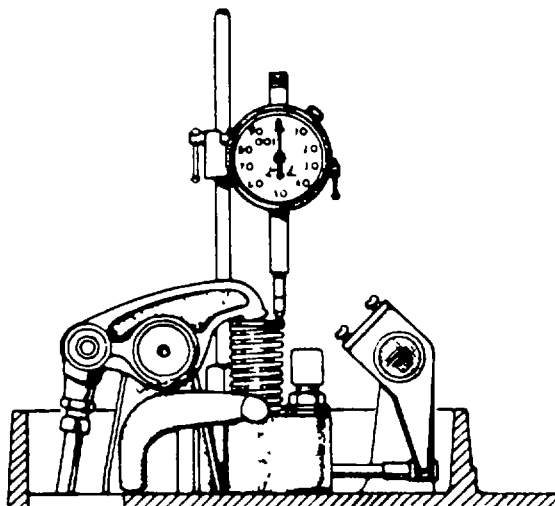
- (10) Scribe a line on the damper (or crankshaft pulley) in line with the end of the pointer.
- (11) Rotate the crankshaft opposite the direction of rotation slowly until the hand of the dial indicator just stops moving.
- (12) Rotate the crankshaft opposite the direction of rotation until the indicator hand just starts to move. Reset dial to "0". Continue turning the crankshaft slowly until indicator reading is .010 inch--then stop turning.
- (13) Scribe a second line on the vibration damper (or crankshaft pulley) in the same manner as in Step 10.
- (14) Scribe a third line halfway between the first two lines. This is positive top-dead-center. The three scribed lines are shown on the crankshaft pulley. Remove the indicator from the engine.

NOTE

Make certain that the crankshaft pulley retaining bolt is not loosened while turning the crankshaft. The bolt must be tightened to 290-310 lb-ft torque if it becomes loose.

- (15) Install the injector assembly. Swing the injector and valve rocker arms back into position and install the rocker arm brackets and tighten the bolts to 90-100 lb-ft torque. Adjust the valve clearance and time the injector. Rotate the crankshaft until the exhaust valves in the selected cylinder are open.
- (16) Install the dial indicator again so the spindle of the indicator rests on top of the injector follower as illustrated. Set the indicator dial to "0". Rotate the crankshaft slowly in the direction of rotation, and stop when the TDC mark on the vibration damper or crankshaft pulley lines up with the pointer.

6-23.1. GEAR TRAIN AND ENGINE TIMING (Continued).



(17) Note the reading on the dial indicator and compare with the following:

- if the indicator reading is .223" to .233", the engine is in time.
- if the indicator reading is .188" to .204", timing is one tooth retarded.
- if the indicator reading is .249" to .257", timing is one tooth advanced.

After completing the timing check, remove the dial indicator. Remove the shipping caps from the injector, and install the injector fuel lines, making sure that they are tightened to prevent any leaks.

Remove the pointer attached to the front of the engine. Adjust the exhaust valves and time the injectors as outlined in paragraph 5-14.

Install the cylinder head rocker cover.

Refer to the following:

Camshaft and Balance Shaft Gears	Paragraph 6-23.4
Idler Gear and Bearing	Paragraph 6-24
Crankshaft Timing Gear	Paragraph 6-28

6-23.2. BALANCE WEIGHTS AND COVER.

a. Balance Weight Cover.

The front balance weight cover encloses the front engine balance weights and also serves as a support for the heat exchanger and engine brace.

The balance weight cover requires no servicing. However, when an engine is being completely reconditioned, or the camshaft, balancer shaft, or front balance weights need replacing, the balance weight cover must be removed.

b. Balance Weights.

Both rotating and reciprocating forces are completely balanced in the engines. The eccentric rotating masses of the crankshaft and connecting rods are balanced by counterweights on the crankshaft cheeks.

The reciprocating masses (the piston and part of the rod) produce an unbalanced couple by virtue of an arrangement on the crankshaft in which reciprocating masses though equal, are not opposite. This unbalanced couple, which tends to rock the engine from end to end, is balanced by an arrangement of rotating counterweights, mounted at the front and rear ends of the camshaft and balance shaft, which produce a couple equal and opposite in magnitude. Consequently, the engine will operate smoothly and in balance throughout its entire speed range.

Each set of weights (weights on one shaft comprise a set) rotates in an opposite direction with respect to the other. When the two weights at either end of the engine are in a vertical plane, their centrifugal forces are in the same direction and oppose the unbalanced couple; when they are in a horizontal plane, the centrifugal forces of these balance weights are opposite and are therefore cancelled. The front balance weights are eccentric in a direction opposite to the rear balance weights; therefore, rotation will result in the desired couple, effective only in a vertical plane.

The balance weights consist of two eccentric weights at each end of the engine. On six cylinder engines, additional weights are attached to the gears. The front balance weights are keyed to the front end of the camshaft and balance shaft. The front balance weights must be removed whenever the camshaft or balance shaft is removed.

6-23.2. BALANCE WEIGHTS AND COVER.

This task covers:

- | | |
|------------|-----------------|
| a. Removal | c. Inspection |
| b. Repair | d. Installation |
-

INITIAL SETUP**Test Equipment**

NONE

References

NONE

Special Tools

Torque wrench

Equipment

<u>Condition</u>	<u>Condition Description</u>
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6-22	Propulsion Unit Removal
5-21	Heat Exchanger - Removal

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Grease
Fuel oil

Special Environmental Conditions

Do not drain engine oil into bilges.
Use the oil collection and recovery
system to collect engine oil.

Personnel Required

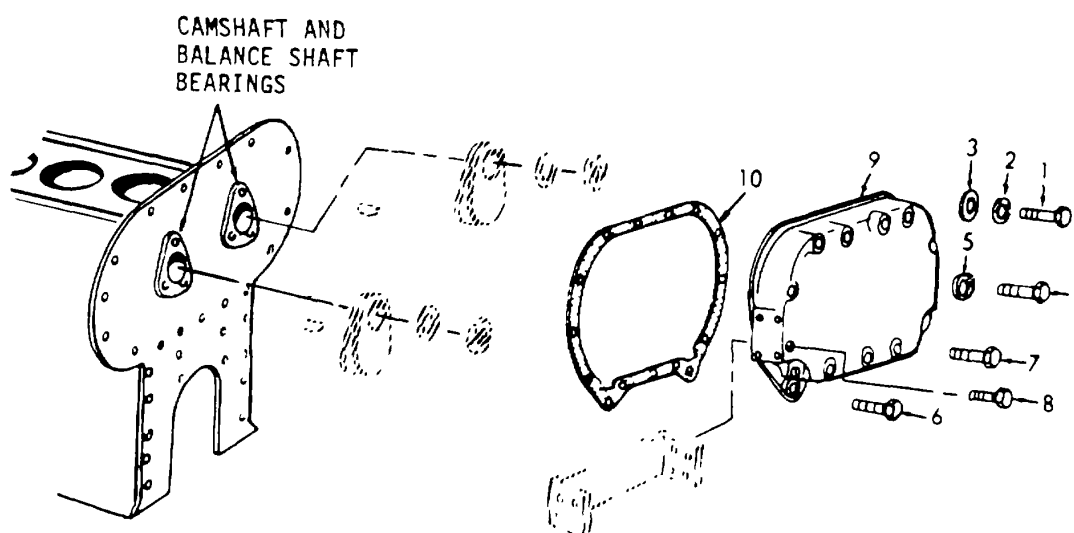
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General Safety Instructions

Observe WARNING in procedure.

6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
1. Balance Weight Cover	a. Remove heat exchanger.	Refer to paragraph 2-21.
	b. Remove nine screws (1), lockwashers (2), and flatwashers (3).	Screws are 3/8-24 x 3 inch.
	c. Remove two screws (4), and lockwashers (5).	Screws are 3/8-16 x 3-1/2 inch.
	d. Remove two screws (6).	Screws are 3/8-16 x 1-7/8 inch.
	e. Remove one screw (7).	Screw is 3/8-24 x 1-1/2 inch.
	f. Remove one screw (8).	Screw is 3/8-24 x 4 inch.
	g. Remove cover (9), and gasket (10).	Remove all traces of the old gasket.



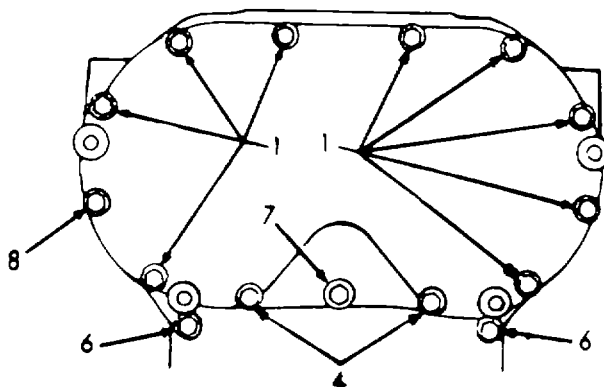
6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM

ACTION

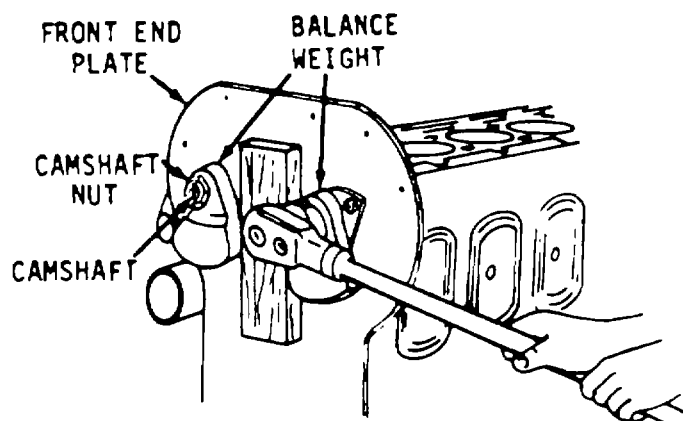
REMARKS

REMOVAL (Cont)



2. Balance Weights

- a. Place a block of wood between the balance weights to prevent rotation.

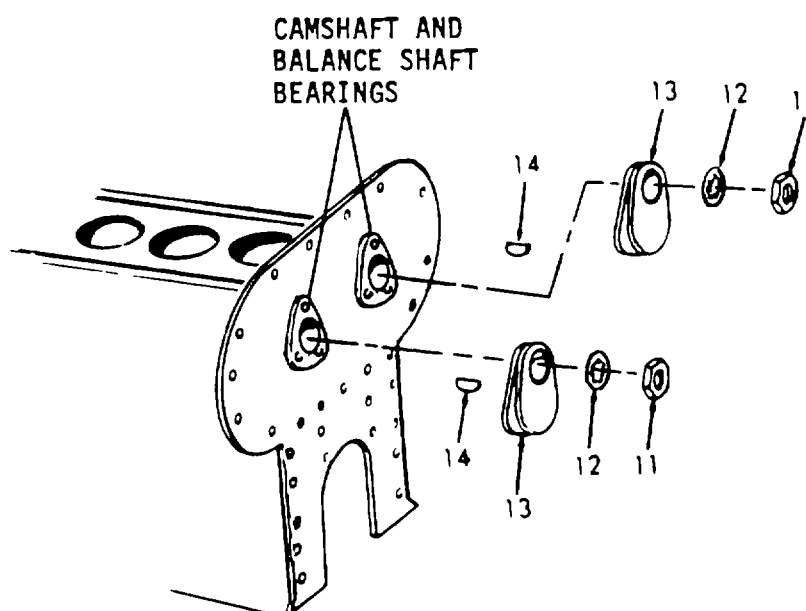


6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)

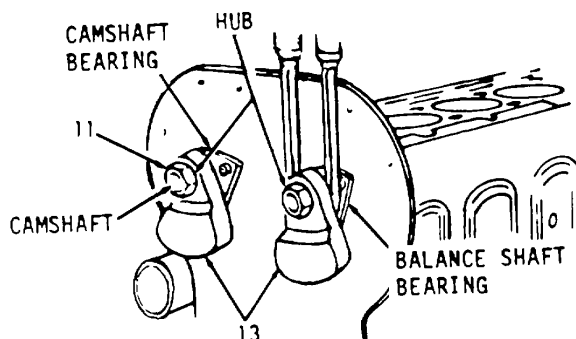
- b. Loosen the camshaft and balance shaft nuts (11) which retain the balance weights to the shafts using a 1-1/2" socket wrench and remove the nuts (11), and internal tooth lockwashers (12).
- c. Force the balance weight (13) off the end of each shaft, using two heavy screw drivers or pry bars between the heads of the bearing retaining bolts and the balance weight.
- d. Remove Woodruff keys (14).



6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)



CLEANING

3. Balance Weights and Cover

WARNING

Wear protective eye goggles when using compressed air.

Clean all parts thoroughly with clean fuel oil, then dry with compressed air.

INSPECTION

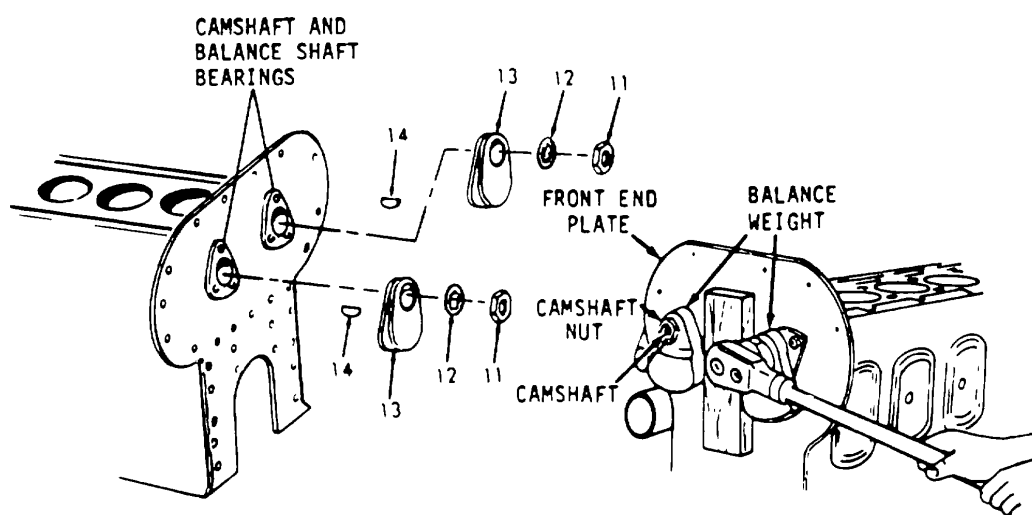
- | | | |
|--|---|------------------------------|
| <ol style="list-style-type: none"> 4. Balance Weights and Cover | <ol style="list-style-type: none"> a. Inspect all parts for damage. | <p>Replace if necessary.</p> |
| | <ol style="list-style-type: none"> b. If the thrust surface (side facing the camshaft or balance shaft thrust washers) of the balance weight hub is damaged, it will be necessary to install a new balance weight. | |

6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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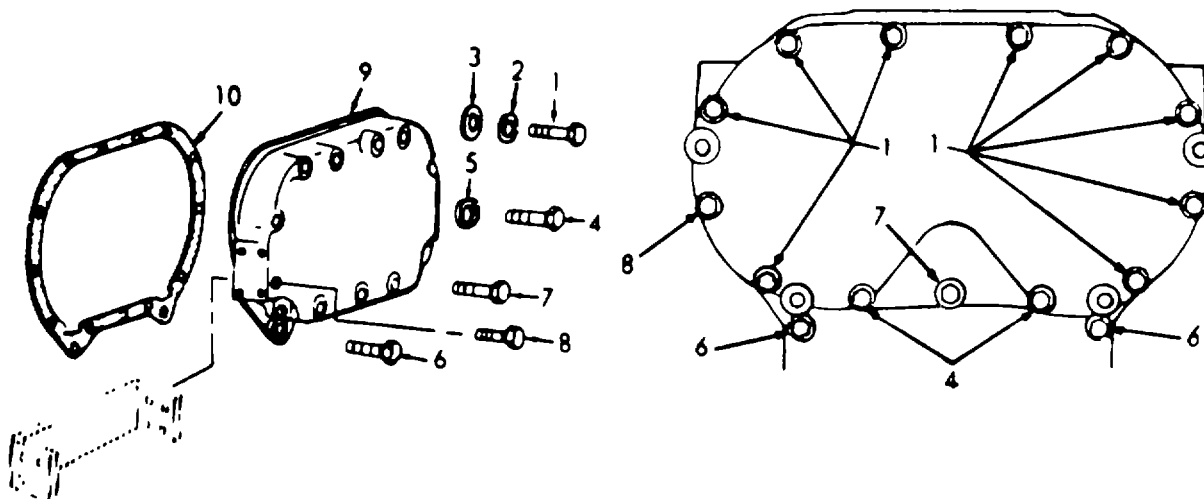
INSTALLATION

- | | |
|--------------------|--|
| 5. Balance Weights | <p>a. Apply heavy cup grease to the steel faces of the thrust washers ("B" engines), and set the washers up against the camshaft and balance shaft bearings.</p> <p>b. Install Woodruff keys (14) in the keyways at the front end of the camshaft and the balance shaft.</p> <p>c. Align the keyway in the balance weight (13) hub with the key (14) in the shaft and slide the balance weight on the camshaft.</p> <p>d. Slide the balance weight (13) on the balance shaft. Slip the internal tooth lockwashers (12) over the end of each shaft. Start the nuts (11) on both shafts.</p> <p>e. Place a block of wood between the balance weights as shown and tighten the nuts to 300-325 lb-ft (406.7-448.6 Nm) torque.</p> |
|--------------------|--|



6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)		
6. Balance Weight Cover	a. Affix a new gasket (10) on cover-to-front end plate bolting flange.	
	b. Install cover (9).	
	c. Install nine screws (1), lockwashers (2), and flatwashers (3).	Screws are 3/8-24 x 3 inch.
	d. Install two screws (4), and lockwashers (5).	Screws are 3/8-16 x 3-1/2 inch.
	e. Install two screws (6).	Screws are 3/8-16 x 1-7/8 inch.
	f. Install one screw (7).	Screw is 3/8-24 x 1-1/2 inch.
	g. Install one screw (8).	Screw is 3/8-24 x 4 inch.

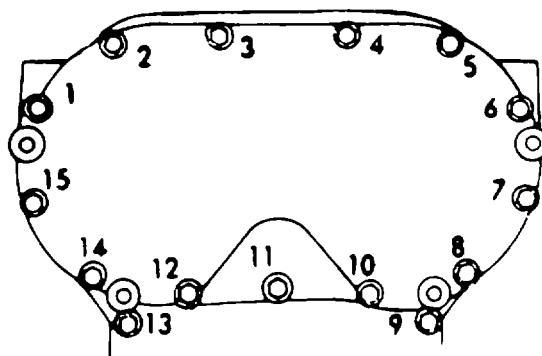


6-23.2. BALANCE WEIGHTS AND COVER (Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

- h. The following figure illustrates the recommended tightening sequence for the screws which attach the balance weight cover to the engine. The screws numbered one, six, seven and fifteen must be tightened hand-tight, first. Then, the tightening sequence of snug, tight, and finally, to torque tightness of 25 to 30 ft-lb (33.9-40.7 Nm) must be followed in the sequence indicated by the numbers.

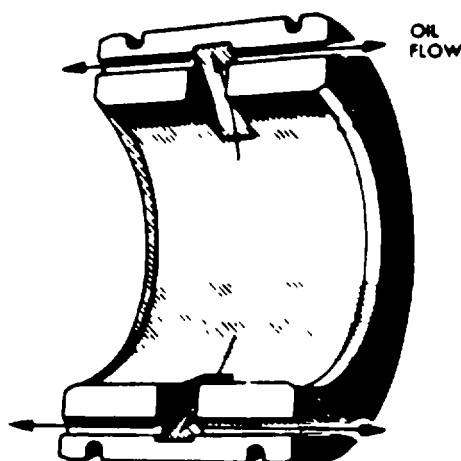


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.

LOCATION/ITEM	ACTION	REMARKS
a. Camshaft.		
(1)	The camshaft and the balance shaft are located near the top of the cylinder block and each may be located on either side of the engine depending upon engine rotation. The camshaft actuates the valve and injector operating mechanism.	
(2)	The accurately ground cams on the camshaft ensure efficient, quiet, cam follower roller action, and are heat treated to provide a hard wear surface.	
(3)	Both ends of the cam and balance shaft are supported by a bearing assembly which consists of a flanged housing and two bushings. In addition, intermediate two-piece bearings support the camshafts at uniform intervals throughout their length. The intermediate bearings are secured to the camshaft by lock rings, thus permitting them to be inserted in the cylinder block with the shafts. Each intermediate bearing is secured in place, after the camshafts are installed, with a lockscrew threaded into a counterbored hole in the top of the cylinder block.	
(4)	On both the cam and balance shafts the gear thrust load is absorbed by two thrust washers one on each end of the rear end shaft bearings of "D" basic engines and at the front of the "B" engines. The thrust washers bear against thrust shoulders.	

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
b. Lubrication.		
(1)	Lubricating oil is supplied under pressure to the bearings from the longitudinal main gallery through a horizontal transverse passage at each end of the cylinder block, then up the connecting vertical passages in each corner of the block to the cam and balance shaft end bearings. The camshaft intermediate bearings are lubricated by the oil from the end bearings passing through the drilled passage in the shaft.	
(2)	The lower halves of the camshaft intermediate bearings are grooved along the horizontal surface that mates with the upper halves of the bearings. Oil from the passage in the camshaft is forced through the milled slots in the bearing and then out the grooves to furnish additional oil to the cam follower assemblies. This permits the cam pocket to be filled rapidly to the operating oil level immediately after starting the engine.	



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.

This task covers:

a. Removal

b. Inspection

c. Installation

INITIAL SETUPTest Equipment

Micrometers
Feeler Gages
Fillet Radius Gage

References

Para 5-27 Water Pump - Removal
Para 6-23.2 Front Balance Weight
 Cover - Removal
Para 6-40 Flywheel and Housing
 Removal
Para 5-15 Cylinder Head - Removal

Special Tools

Puller J4558-01
Torque wrench
Puller J 1902-01
Hammer (plastic or rawhide)
Adapter J6202-1
Adapter J8183
Spacers J6202-2

Equipment
Condition
Paragraph

Condition Description

6-22 Propulsion Unit Removed

Tools

General Mechanic' s Tool Kit
NSN 5180-00-629-9783

Material/Parts

Fuel oil
Gasket Kit P/N 5196375
Clean rags
Grease

Special Environmental Conditions

NONE

Personnel Required

2

General Safety Instructions

Observe WARNING when using
compressed air.

LOCATION/ITEM**ACTION****REMARKS****REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED**

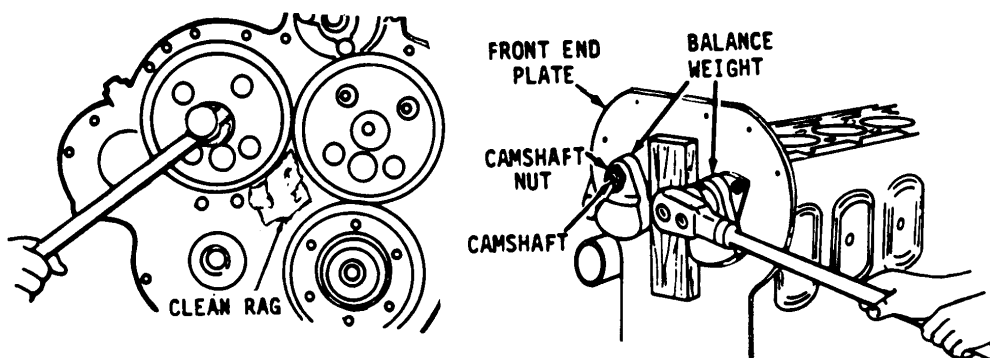
1. Camshaft
Assembly

a. Remove cylinder heads.

Refer to para-
graph 5-15.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)		
	b. Remove flywheel and flywheel housing.	Refer to paragraph 6-40.
	c. Remove water pump.	Refer to paragraph 5-27.
	d. Remove front balance weight cover.	Refer to paragraph 6-23.2.
	e. Remove screws (1), lockwashers (2), and nut retaining plate (3).	
	f. Wedge a clean rag between gears. Remove nuts (4), and lockwashers (5) from both ends of camshaft.	A block of wood can be placed between the balance weights.



- g. Remove setscrew (6) and intermediate bearings (7).
- h. The three screws (8), and lockwashers (9) that secure the camshaft bearings to the rear end plate of the engine may be removed by inserting a socket wrench through the hole in the webs of the camshaft drive gears (10).

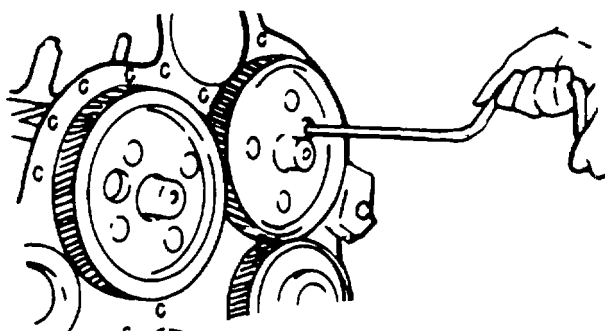
6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM

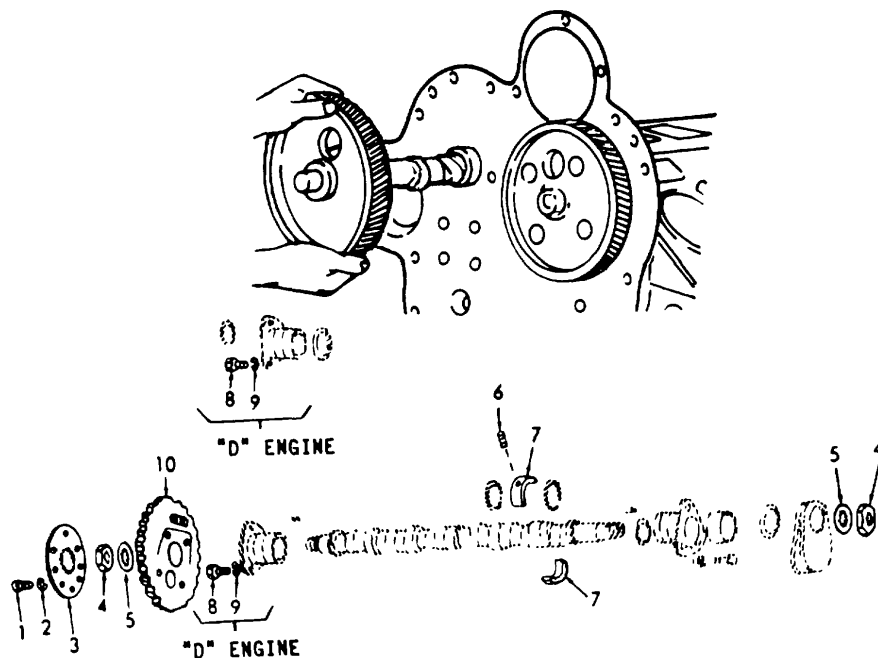
ACTION

REMARKS

REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)



- i. Remove camshaft, bearing and gear assembly from cylinder block.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

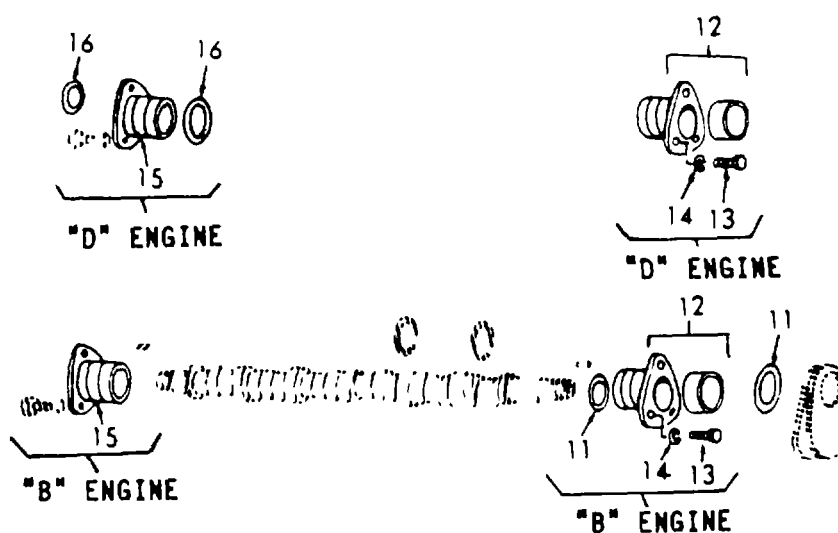
NOTE

If the thrust washers (11), located between the bearings and thrust shoulders at the front end of the shafts on the "B" engines are not removed with the shafts, they should be pulled out when removing the bearings, proceed to step j.

- j. The camshaft front bearings (12) (and thrust washers "B" engines) may be removed after taking out the screws (13), and lockwashers (14) that hold the bearings to the end plate and cylinder block. Pry under the bearing flange with a suitable tool if the bearing cannot be withdrawn by hand.

NOTE

On the "D" engine the rear bearing (15) and thrust washers (16) are removed when the shaft and gear assembly is removed.

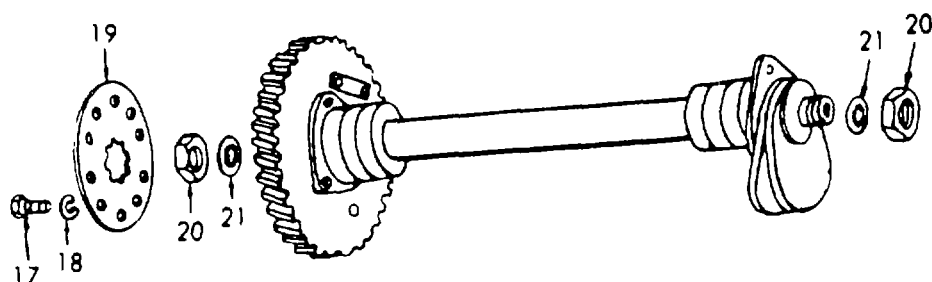
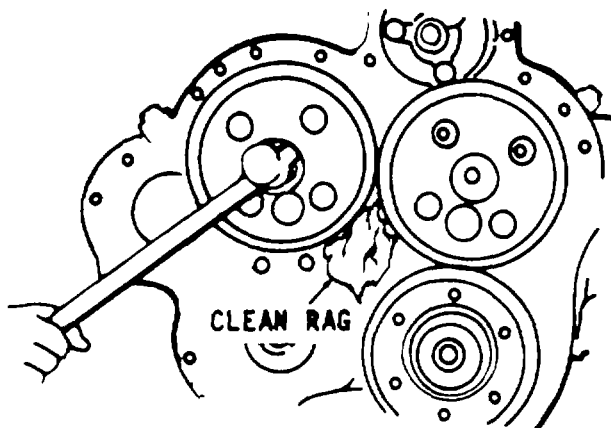


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- | | | |
|------------------|---|--|
| 2. Balance Shaft | a. Remove screws (17), lock-washers (18), and nut retaining plate (19). | |
| | b. Wedge a clean rag between gears. Remove nuts (20), and lockwashers (21) from both ends of the balance shaft. | |

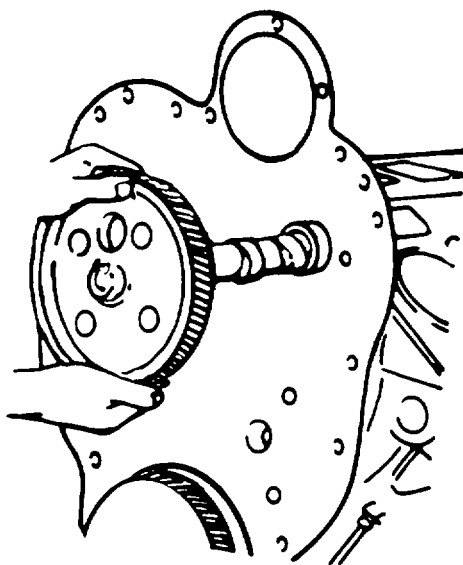


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- c. The three screws (22), and lockwashers (23) that secure the balance shaft bearing to the rear end plate of the engine may be removed by inserting a socket wrench through the hole in the webs of the balance shaft drive gear (24).
- d. Remove balance shaft and gear assembly from cylinder block.



NOTE

If the thrust washers (25) located between the bearing and thrust shoulders at the front end of the shaft on the "B" engines are not removed with the shafts, they should be pulled out when removing the bearings, proceed to step e.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM

ACTION

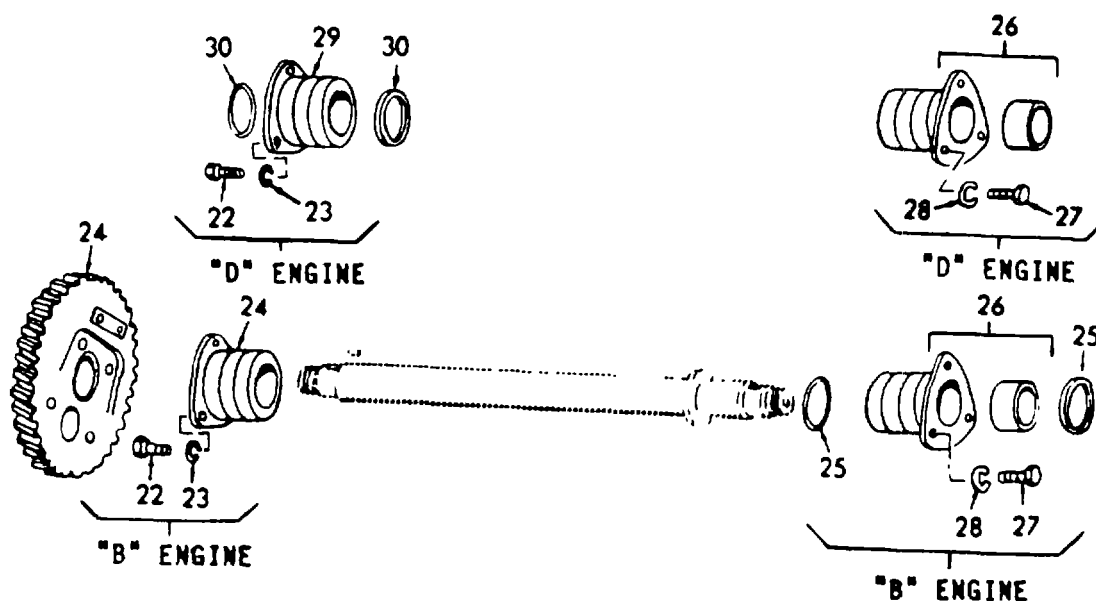
REMARKS

REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- e. The balance shaft front bearings (26) (and thrust washers "B" engines) may be removed after taking out the screws (27), and lockwashers (28) that hold the bearings to the end plate and cylinder block. Pry under the bearing flange with a suitable tool if the bearing cannot be withdrawn by hand.

NOTE

On the "D" engine the rear bearing (29), and thrust washers (30) are removed when the shaft and gear assembly is removed.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR INSTALLED
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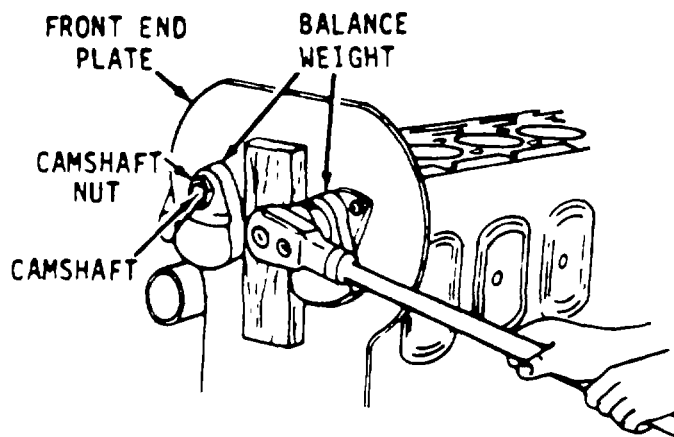
3. Camshaft
Assembly

NOTE

The camshaft may be removed and replaced without removing the flywheel housing and disconnecting the transmission if there is space enough to slide the shaft out through the front of the engine.

- a. Remove the front balance weight cover and place a wood block between the balance weights.

Refer to paragraph 6-23.2 to remove balance weight



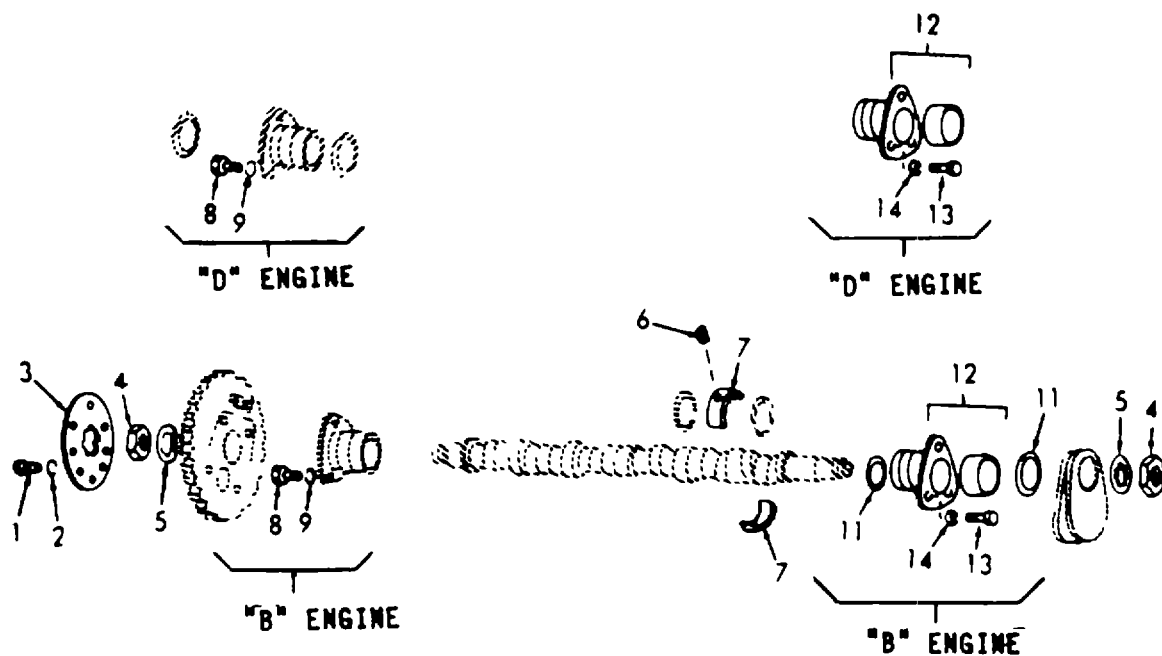
- b. Detach the gear nut retainer (3) after removing the screws (1), and lockwashers (2).
- c. Loosen and remove the nut (4), and lockwashers (5) at each end of the camshaft.
- d. Refer to the procedure outlined in paragraph 6-23.2 and remove the balance weights.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR INSTALLED

- e. Remove the thrust washers (11) between the bearings and balance weight hubs (12) ("B" engines only).
- f. Remove the lock screws (6) that secure the camshaft intermediate bearings (7).
- g. Remove the three screws (13), and lockwashers (14) that secure the camshaft bearing to the front end plate.

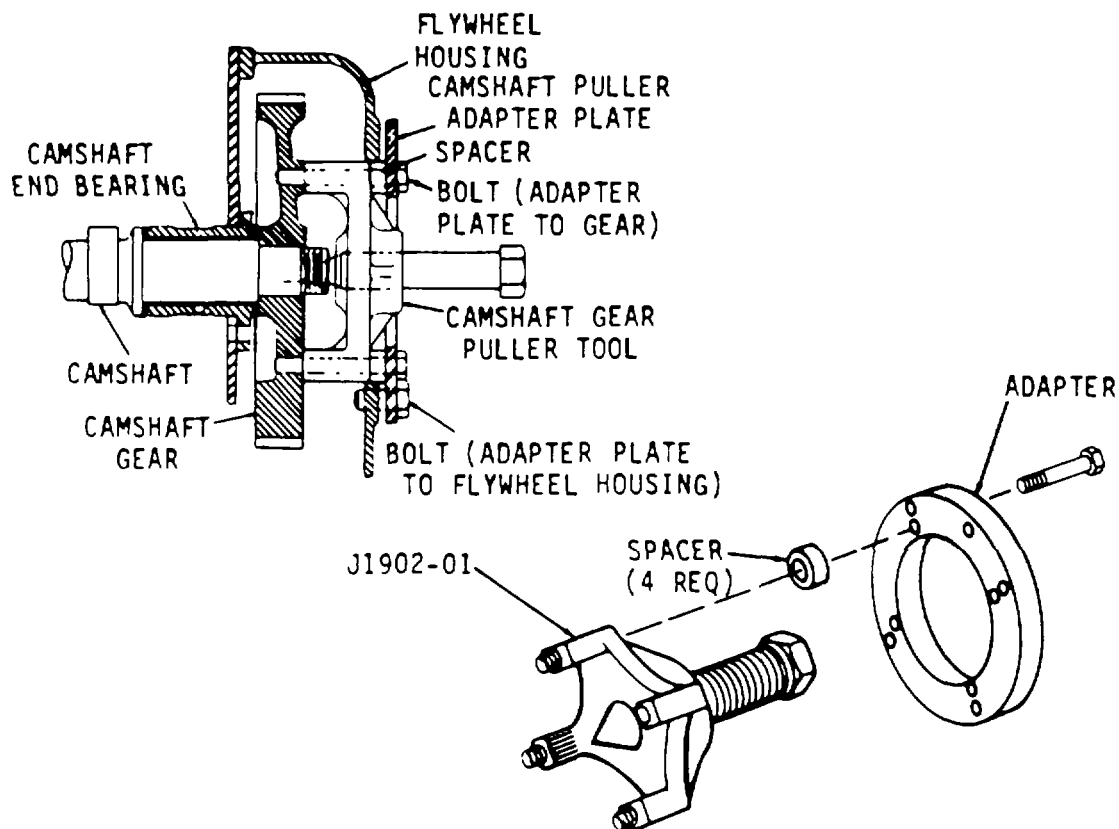


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR INSTALLED (Cont)

- h. Install the camshaft gear puller, J1902-01, four spacers, J6202-2 and camshaft gear puller adaptor plate J6202-1 on the camshaft gear.

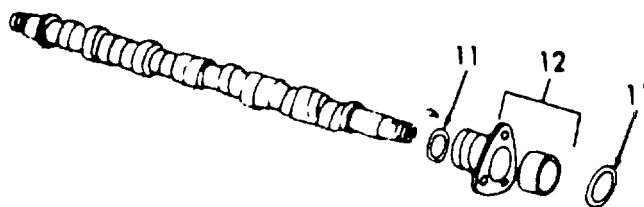


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL - FLYWHEEL HOUSING AND MARINE GEAR INSTALLED (Cont)

- i. Turn the center screw of the puller clock-wise to disengage the camshaft gear.
- j. Do not remove the puller or adaptor plate until the camshaft is reinstalled. The adaptor plate, secured to both the flywheel housing and the camshaft gear, will hold the gear (thrust washer on "D" engines) securely in place and in alignment which will aid in the reinstallation of the camshaft.
- k. Remove the front bearing (12) from the camshaft and pull out the inner thrust washer (11) ("B" engines). Then pull the camshaft and intermediate bearings from the cylinder block.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
4. Camshaft or Balance Shaft	a. Remove camshaft gear (10) or balance shaft gear (24) from the camshaft (31) or balance shaft (32).	Refer to paragraph 6-23.4 for gear removal.
	b. Slide the rear bearing (15) or (29) and thrust washers (16) or (30) (on the "D" engine) off the shaft.	
	c. Remove lockrings (33), and intermediate bearings halves (7)	
	d. Remove the end plugs (34 and 35) from each camshaft, to facilitate the removal of any foreign material lodged behind the plugs, as follows: <ol style="list-style-type: none"> 1. Clamp the camshaft in a vise equipped with soft jaws, being careful not to damage the cam lobes or machined surfaces of the shaft. 2. Make an indentation in the center of the camshaft end plug with a 31/64" drill (carbide tip). 3. Punch a hole as deeply as possible with a center punch, to aid in breaking through the hardened surface of the plug. 	Discard plugs.

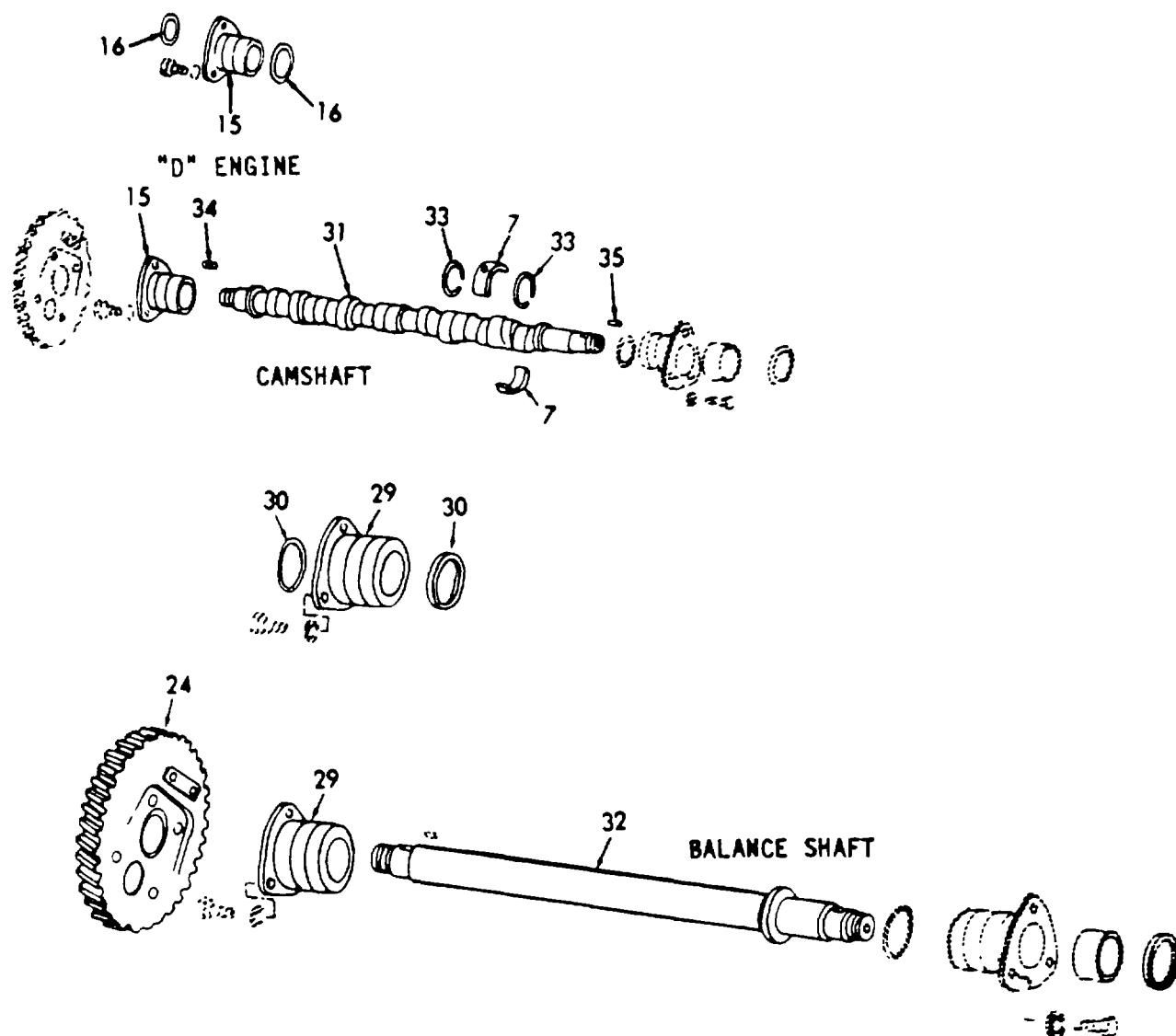
6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY (Cont)

4. Then, drill a hole straight through the center of the plug with a 1/4" drill (carbide tip).
5. Use the 1/4" drilled hole as a guide and re-drill the plug with a 5/16" drill (carbide tip).
6. Tap the drilled hole with a 3/8"-16 tap.
7. Thread a 3/8"-16 adaptor J8183 into the plug. Then attach a slide hammer to the adaptor and remove the plug by striking the weight against the handle.
8. Insert a length of 3/8" steel rod in the camshaft oil gallery and drive the remaining plug out.

NOTE

If a steel rod is not available, remove the remaining plug as outlined in Steps 1 through 7.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
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CLEANING

4. Camshaft and Balance Shaft

WARNING

Wear protective eye goggles when using compressed air.

Soak the camshaft and balance shaft in clean fuel oil. Then, run a wire brush through the oil gallery to remove any foreign material or sludge. Clean the exterior of the camshaft and balance shaft and blow out the oil gallery and the oil holes with compressed air. Clean the gears, bearings and related parts with fuel oil and dry them with compressed air.

INSPECTION

5. Camshaft and Balance Shaft

- a. Inspect the cams and journals for wear or scoring. If the cams are scored, inspect the cam followers. Also, inspect the camshaft and balance shaft and threads for damage.
- b. Check the cam followers if the cam surfaces are scored. See paragraph 2-15.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS.
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION (Cont)

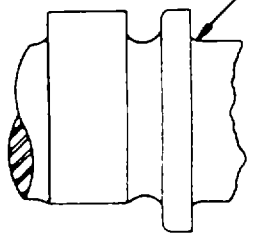
- c. Inspect both faces of the thrust washers. Those that are excessively scored or worn must be replaced. New thrust washers are available in standard (.120 to .122 inch thick) and oversize (.005 or .010 inch). The clearance between the thrust washer and the thrust shoulder of the shafts is .004 to .012 inch with new parts, or a maximum of .018 inch with used parts.
- d. When the thrust surfaces of a camshaft or balance shaft are ground undersize, special care must be taken as follows:
 1. Leave a 1/32 to 3/32 inch radius between the bearing surface of the thrust collar shoulder and the bearing surface of the camshaft.
 2. Leave a .010 to .030 inch radius between the bearing surface of the thrust collar shoulder and the bearing surface of the balance shaft.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS. (Continued).

LOCATION/ITEM	ACTION	REMARKS
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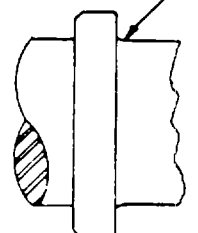
INSPECTION (Cont)

1/32" TO 3/32" RADIS



CAMSHAFT

.010 TO .030" RADIS



BALANCE SHAFT

NOTE

A fillet radius gage may be used to measure the specified radii.

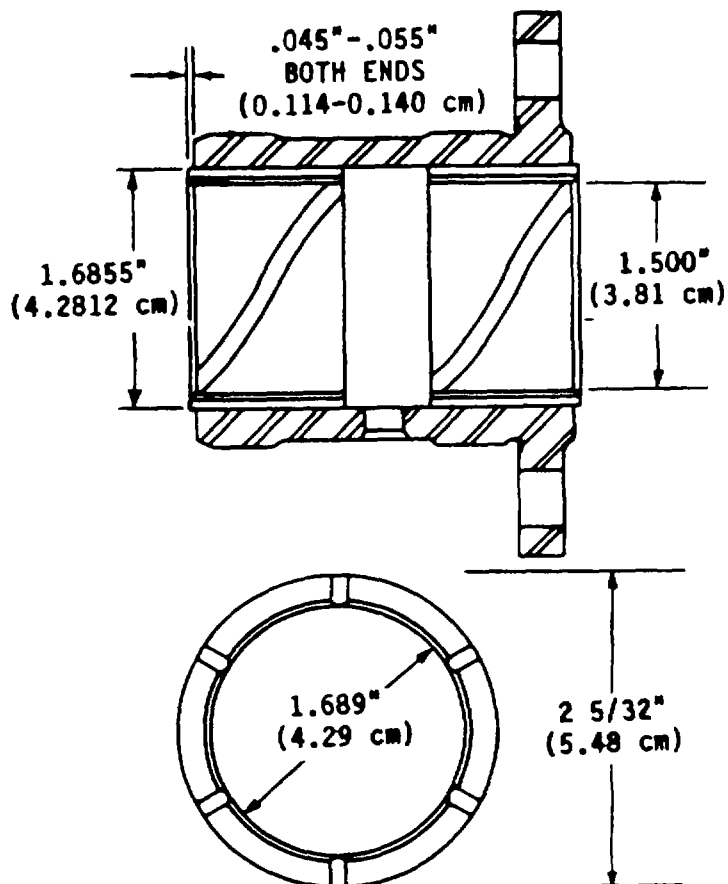
- e. Examine the faces of the shaft end bearings and any other surface which comes into contact with the thrust washers. Parts that are badly marred must be replaced, slight scratches may be cleaned up with an oil stone.
- f. Inspect the bushings in the shaft end bearings. Replace the bushings or end bearing assemblies if they are worn excessively or the bushings have turned within the bearing. New bushings must be finished bored to a 20 rms finish after installation and tested for the correct press fit. The correct press fit is indicated if the bushing does not turn when a 2000 pound end load is applied. This test is of special importance with engines that

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION (Cont)

operate at high (2300 rpm) speeds. The inside diameter of the bushings must be square with the rear face of the bearing with .0015 inch total indicator reading, and concentric within the outside diameter of the bearing retainer within .002 inch total indicator reading. The bushings must project from .045 to .055 inch (0.114 to 0.140 cm) from each end of the bearing.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION (Cont)	<p>g. The clearance between the camshaft and balance shaft end journals and the end bearing bushings is .0025 to .004 inch with new parts, or a maximum of .006 inch with used parts. End bearings are available in .010 or .020 inch undersize for use with shafts that are worn or have been reground and the clearances exceed the specified limits.</p> <p>h. Replace excessively scored or worn camshaft intermediate bearings. The clearance between the camshaft journals and the intermediate bearings is .0025 to .005 inch with new parts, or a maximum of .009 inch with worn parts. Camshaft intermediate bearings are available in .010 and .020 inch undersize for use with worn or reground shafts in which the clearances exceed the specified limits. Examine the intermediate bearing lock screws and the tapped holes in the block. Damaged holes in the cylinder block may be plugged, redrilled and tapped. Discard lock-screws with damaged threads.</p>	

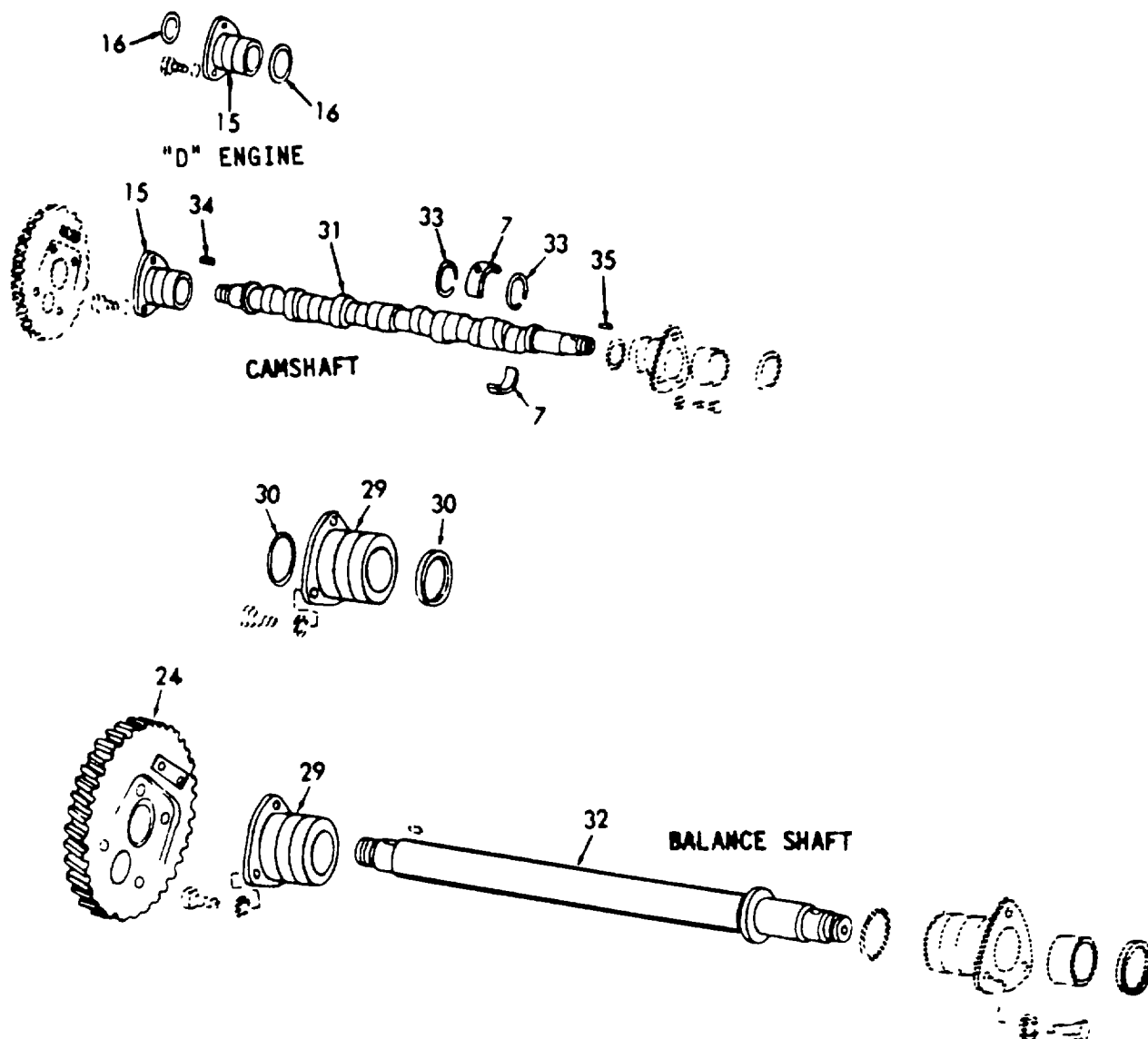
6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
REASSEMBLY		
6. Camshaft and Balance Shaft	<p>a. Install new end plugs (34 and 35) in the camshaft.</p> <p>b. Apply grease to the steel face of end thrust washers. Then, place a thrust washer (16 and 30) against each end of the cam and balance shaft rear bearings (15 and 29) ("D" engines). The steel faces of the thrust washers must be towards the bearing.</p> <p>c. Lubricate the rear cam and balance shaft journals and slide the rear bearings (15 and 29) on each shaft with the mounting flange of the bearing toward the gear end of the shaft.</p> <p>d. Install the gears (10 and 24) on the shafts as outlined in paragraph 3-27.4.</p> <p>e. Lubricate the camshaft intermediate bearing journals. Then, place the two halves of each intermediate bearing (7) on the camshaft journal and lock the halves together with the two lockrings (33). Install each lockring with the gap over the upper bearing and the ends on equal distance above the split line of the bearing.</p>	

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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REASSEMBLY (Cont)



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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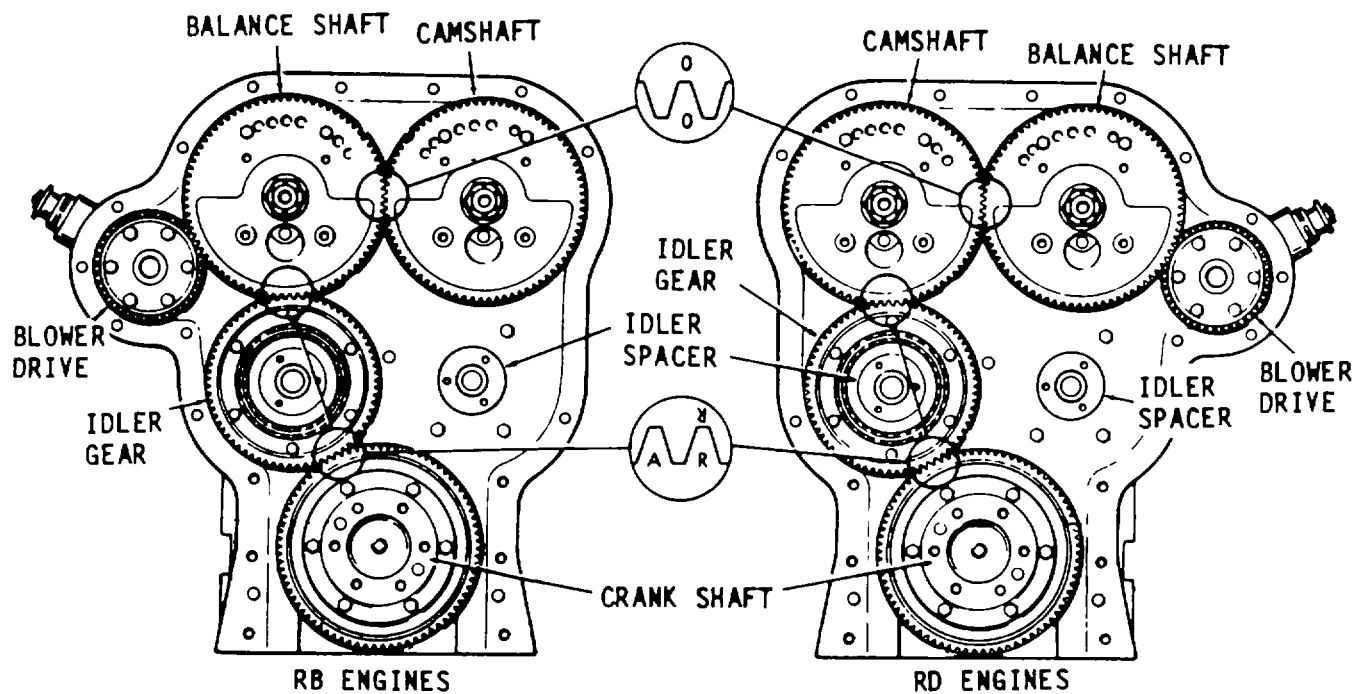
INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED

- | | |
|-------------------------------|---|
| 7. Camshaft and Balance Shaft | <p>a. Insert the front end of the camshaft into the opening opposite the blower side of the engine. Push the camshaft into the cylinder block until the camshaft gear teeth almost engage the teeth of the idler gear. Use care when installing the camshaft to avoid damaging the cam lobes.</p> |
|-------------------------------|---|

NOTE

The right hand gear (viewing the engine from the flywheel end) whether it is attached to the cam or balance shaft has left-hand helical teeth.

- b. Align the timing marks on the mating gears as shown below, and slide the camshaft gear in place.

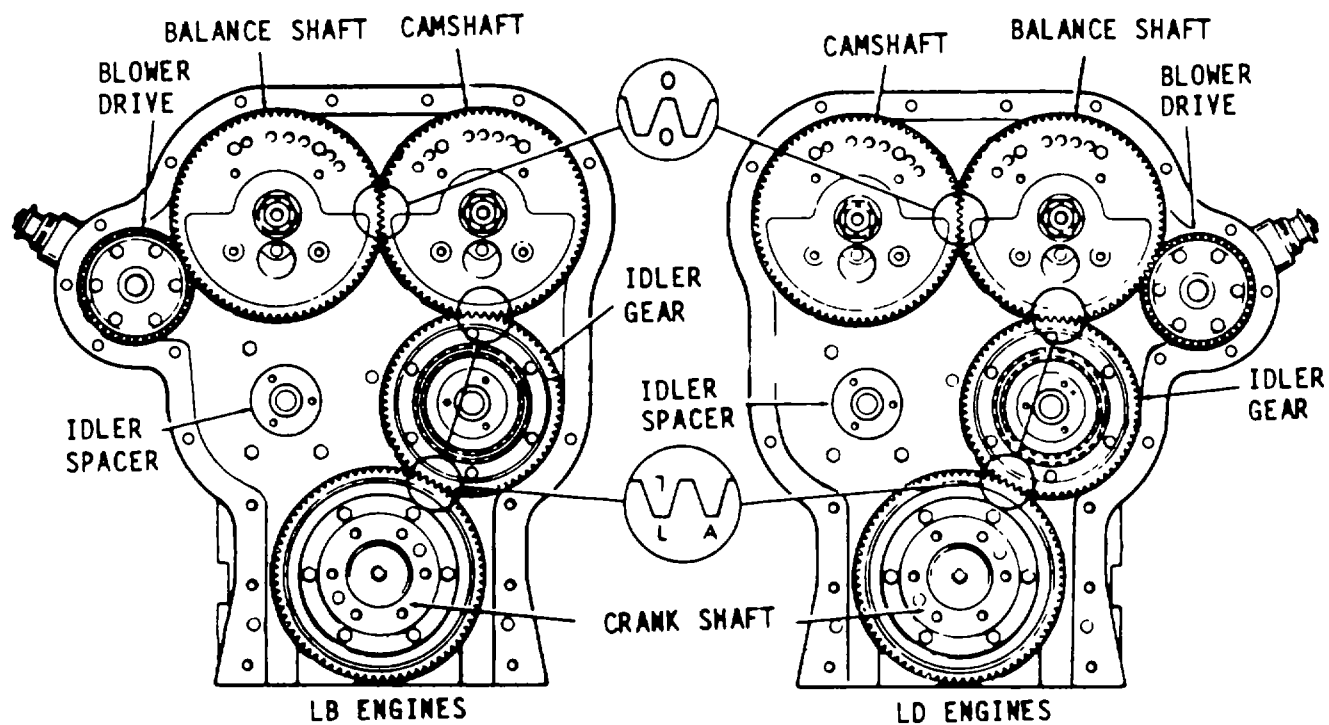


Gear Train and Timing Marks - Right Hand Rotation Engines.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS
(Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)



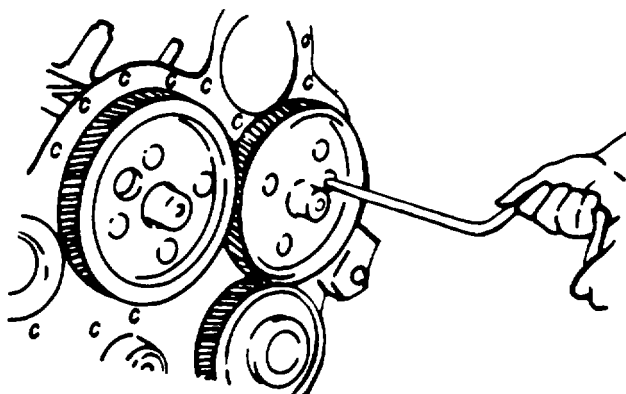
Gear Train and Timing Marks - Left Hand Rotation Engines.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)
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- c. Secure the camshaft gear bearing (15) to the cylinder block with the three screws (8), and lockwashers (9). The camshaft gear may be turned to accommodate the screws through the hole in the gear web. Tighten the screws to 35-40 lb-ft (47.5-54.2 Nm) torque.



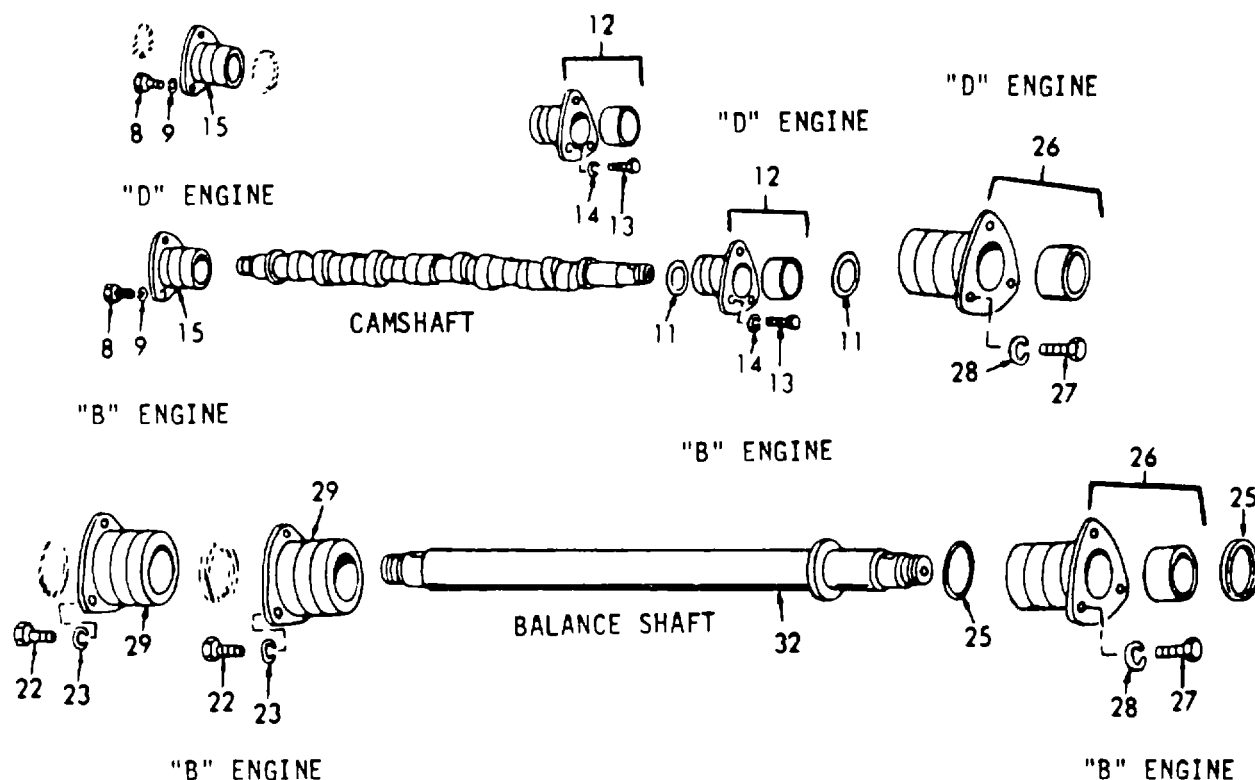
- d. Insert the balance shaft (32) into the bore in the cylinder block and push it in until the teeth of the balance shaft gear almost engage the camshaft gear teeth.
- e. Align the timing marks on the mating gears and slide the balance shaft gear into place.
- f. Secure the balance shaft rear bearing (29) to the cylinder block with the three screws (22), and lockwashers (23). The balance shaft gear may be turned to accommodate the screws through the hole in the gear web. Tighten the screws to 35-40 lb-ft (47.5-54.2 Nm) torque.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- g. Apply grease to the steel face of each thrust washer (11 and 25). Then, place a thrust washer against the inner end of the cam and balance shaft front end bearing (12 and 26) ("B" engines). The steel face of the thrust washer must be against the bearing.
- h. Install the cam and balance shaft front end bearings (12 and 26) with the screws (13 and 27) and lockwashers (14 and 28). Tighten the screws to 35-40 lb-ft (47.5-54.2 Nm) torque.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)		
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CAUTION

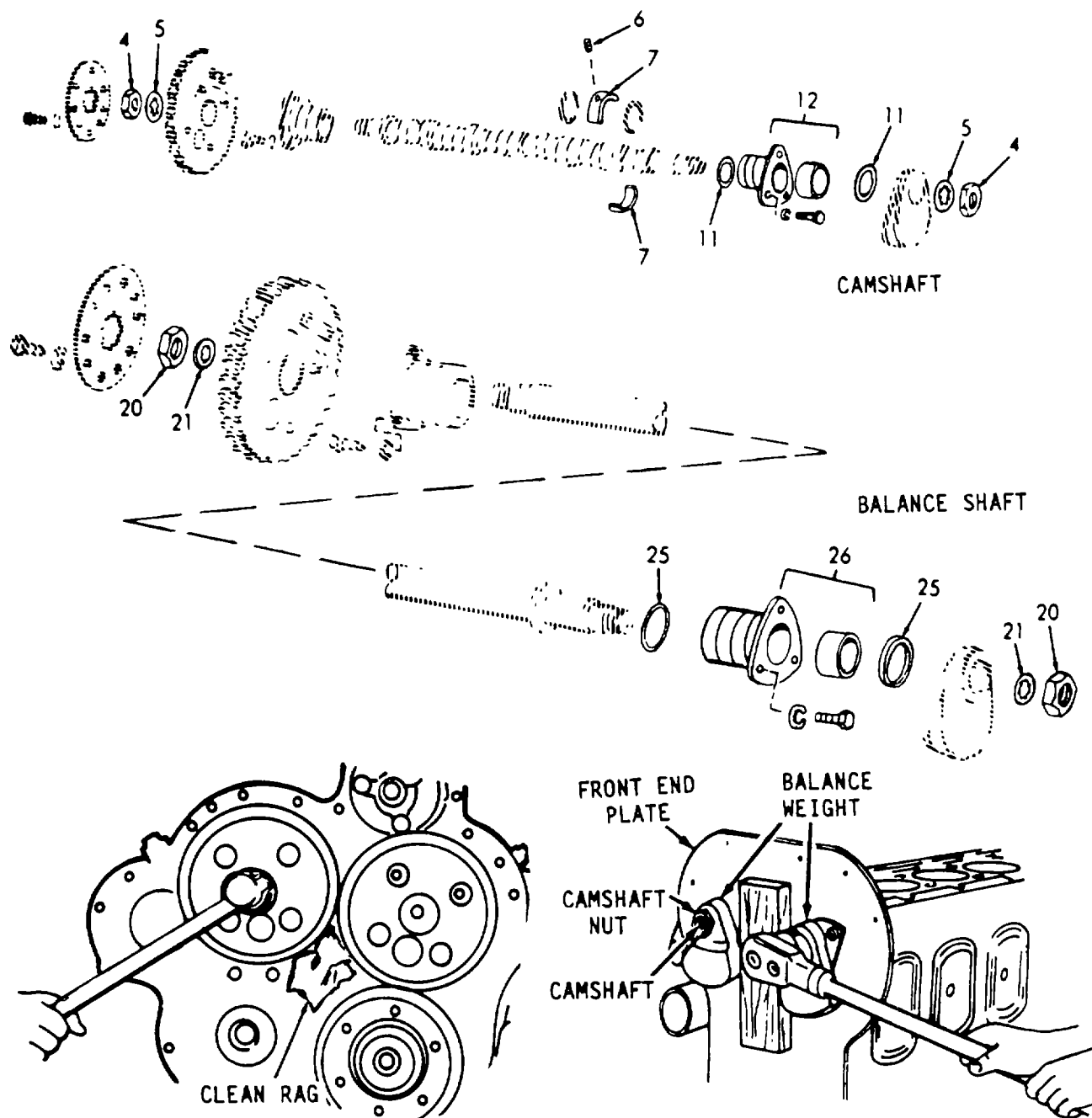
Install the front bearings with care to avoid dislodging the thrust washers. Do not hammer the bearings into the cylinder block.

- i. Apply grease to the steel face of each thrust washer (11 and 25) and place them so that the steel faces are against the outer end of the cam and balance shaft front bearings (12 and 26) on the "B" engines.
- j. Turn the camshaft intermediate bearings (7) until the holes in the bearings are in alignment with the threaded holes in the cylinder block. Install the lockscrews (6) and tighten them to 15-20 lb-ft (20.3-27.1 Nm) torque.
- k. Install the front balance weights on the shafts as outlined in paragraph 3-27.1.
- l. Place an internal tooth lock washer (5 and 21) on the end of each shaft and start the nuts (4 and 20) on both shafts.
- m. Use a wood block, between the balance weights or wedge a clean cloth between the cam and balance shaft gears to prevent their turning. Tighten the nuts (4 and 20) to 300-325 lb-ft (406.7-443.6 Nm) torque.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

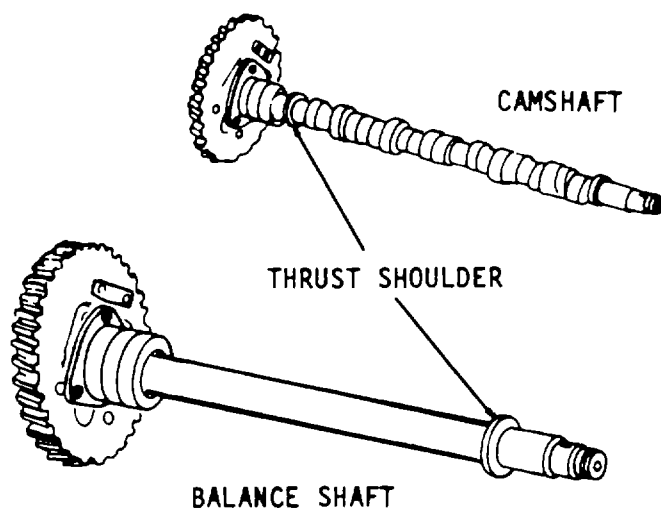


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)
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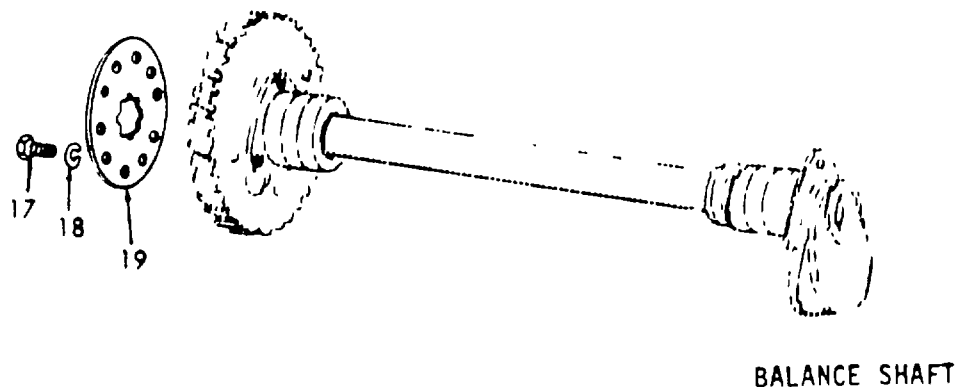
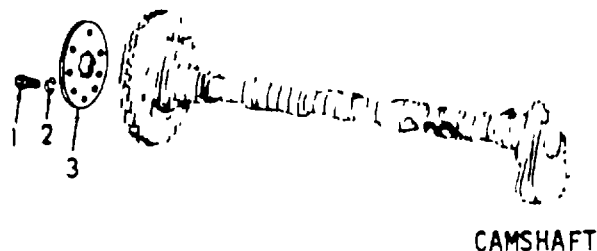
- n. Install the camshaft gear nut retainer (3) with screws (1), and lockwashers (2). Install the balance shaft gear nut retainer (19) with screws (17), and lockwashers (18). Tighten the screws to 35-39 lb-ft (47.5-52.9 Nm) torque.
- o. Check the clearance between the thrust washer and the thrust shoulder of both the cam and balance shaft. The specified clearance is .004" to .012" with new parts, or a maximum of .018" with used parts.



6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)		
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- | | |
|---|--|
| p. Check the backlash between the mating gears. The backlash is .004 to .006 inch. | A maximum of .012 inch with used parts. |
| q. The backlash between the various mating gears ranges between .003 to .008 inch with new parts. | A maximum of .010 inch between worn gears. |

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- | | |
|-------------------------------|---|
| 8. Camshaft and Balance Shaft | <ul style="list-style-type: none"> a. Install a Woodruff key in the drive gear end of the camshaft and insert this end into position from the front end of the engine. Push the shaft in until it slides into the rear end bearing (15). Use care in the installation of the camshaft to prevent damage to the cam lobes. b. On the "D" engines, apply grease to the steel face of the thrust washer (16) and install it with the steel face against the bearing (15). c. Align the key in the shaft with the keyway in the camshaft drive gear (10) and start the shaft into the gear. Tap the shaft into the gear with a soft (plastic or rawhide) hammer. |
|-------------------------------|---|

CAUTION

On the "D" engines, make sure the thrust washer is in the correct position to prevent pushing the bushing into the bearing or damage to the bushing.

- d. Remove the camshaft gear puller, spacers and adaptor plate. Install gear retaining lockwasher (5), and nut (4). Finger tighten the gear retaining nut (4) on the shaft.

6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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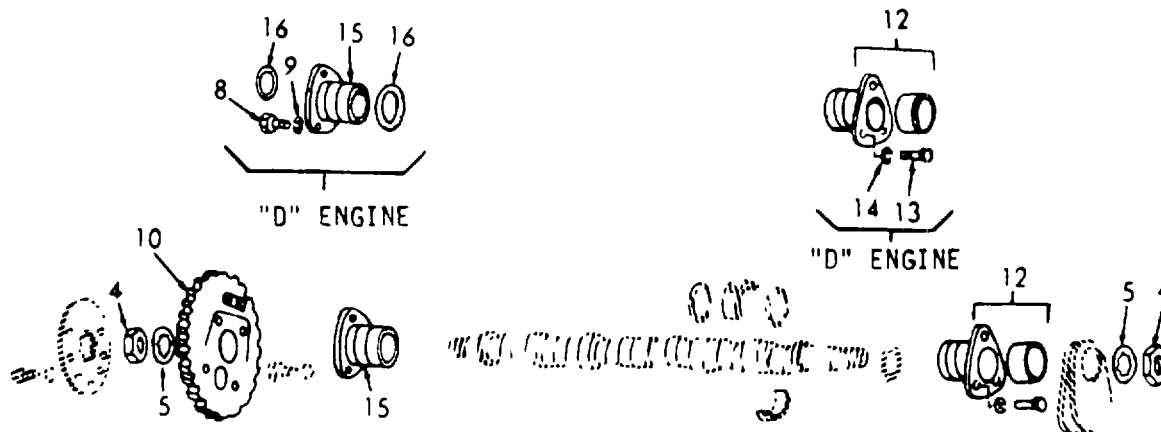
INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- e. Install the front end bearing (12) (and thrust washers (11) "B" engines). Install screws (13), and lockwashers (14). Tighten screws to 35-40 lb-ft (47.5-54.2 Nm) torque.

CAUTION

Apply grease to the steel faces of the thrust washers and insure that the steel faces are towards the bearing.

- f. Install the balance weight on the front of the camshaft, paragraph 3-27.1.
- g. Start the balance weight retaining nut (4), and lockwasher (5) on the camshaft. Place a wood block between the balance weights. Tighten the gear retaining nut; then, tighten the balance weight nut to 300-325 lb-ft (406.7-448.6 Nm) torque.

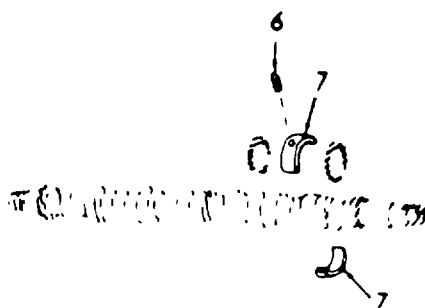


6-23.3. CAMSHAFT AND BALANCE SHAFT - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION - FLYWHEEL HOUSING AND MARINE GEAR REMOVED (Cont)

- h. Align the holes in the camshaft intermediate bearings (7) with the tapped holes in the top of the cylinder block. Install and tighten the lockscrews (6) to 15-20 lb-ft (20.3-27.1 Nm) torque.



6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR.

The camshaft and balance shaft gears, located at the flywheel end of the engine, mesh with each other and run at the same speed as the crankshaft. Either one of the gears may be driven from the crankshaft timing gear, through an idler gear, depending upon engine rotation. Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft (LD, RD engines) or camshaft (LB, RB engines), has left-hand helical teeth, and the left-hand gear has right-hand helical teeth. The idler gear mates with the left-hand gear on right-hand rotation engines, and with the right-hand gear on left-hand rotation engines.

Since the camshaft and balance shaft gears must be in time with each other, the letter "O" is stamped on one tooth of one of the gears with a corresponding mark at the root of the mating tooth of the other gear. Also, since these two gears as a unit must be in time with the crankshaft, identification marks (letter "R" or "L" for right-hand or left-hand rotation engines, respectively) are located on either the camshaft gear or balance shaft gear and the mating idler gear (see paragraph 6-23.1).

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. A gear nut retainer, with a double hexagon hole in the center, fits over the nut and prevents loosening of the nut. The retainer is attached to the gear by bolts threaded into tapped holes in the gear. These tapped holes are also utilized in mounting an accessory drive on the camshaft or balance shaft gear. The same two gears are used as camshaft and balance shaft gears. A small balance weight is attached to the inner face of each gear. A different size weight is secured with two 3/8"-24 X 1--1/4" bolts. These weights are important in maintaining perfect engine balance.

6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR.

This task covers:

- | | |
|-------------|-----------------|
| a. Removal | c. Inspection |
| b. Cleaning | d. Installation |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

Puller Tool J1902-01
Gear Installer Tool J1903

Equipment
Condition Condition Description
Paragraph

6-23.3 Camshaft and Balance
 Shaft - Removal

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Fuel oil

Special Environmental Conditions

NONE

Personnel Required

2

General Safety Instructions

Observe WARNING in procedure.

LOCATION/ITEMACTIONREMARKS**REMOVAL**

1. Gears

a. Remove camshaft and balance shaft.

Refer to paragraph 6-23.3.

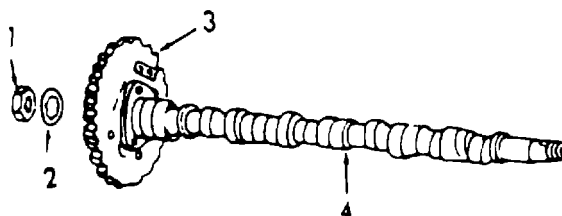
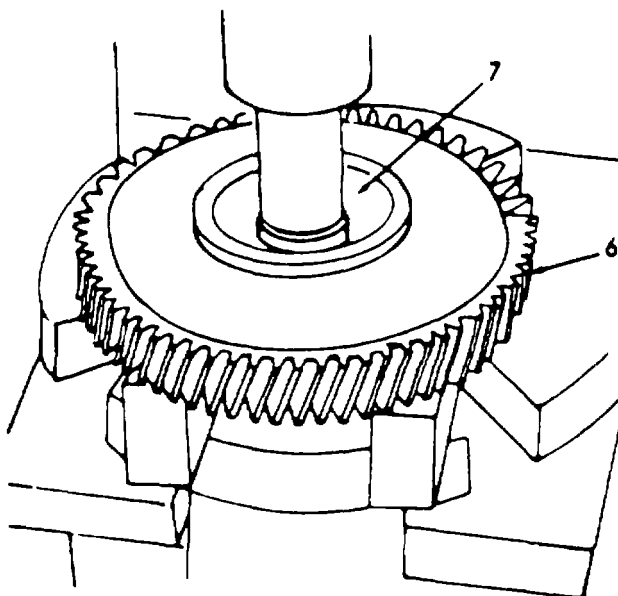
b. Support the camshaft suitably in soft jaws of bench vise, being careful not to damage the cams.

6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

- c. Remove the nut (1), and lock-washer (2) retaining the gear (3) on the camshaft (4).
- d. Back out the puller screw of tool J1902-01 and attach the puller to the outer face of the gear with four bolts.

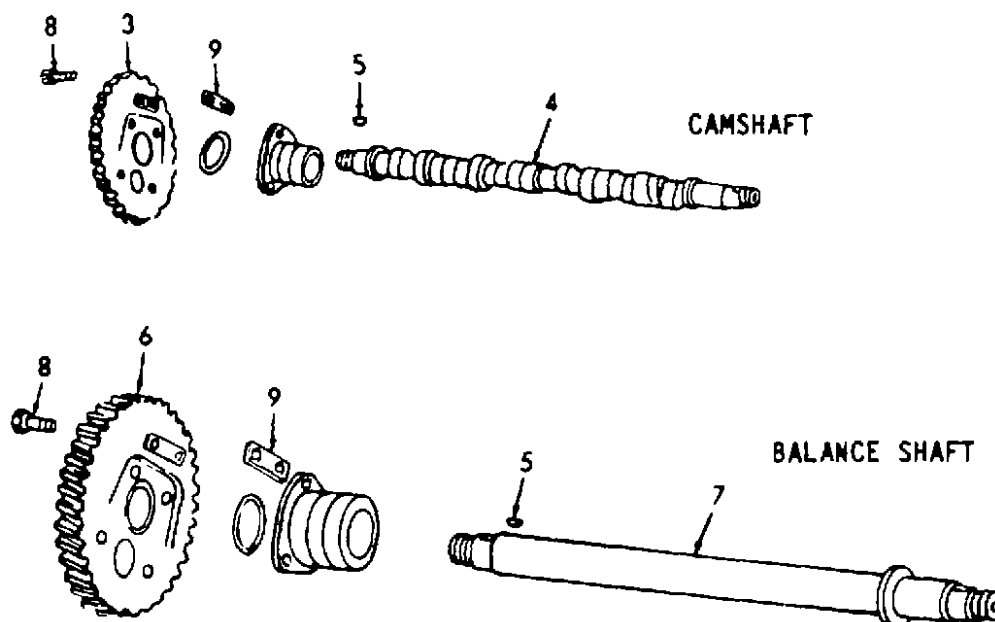


6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL (Cont)

- e. Turn the puller screw down against the end of the shaft to remove the gear (3).
- f. Remove Woodruff key (5) from the camshaft (4).
- g. Remove the gear (6) from the, balance shaft (7) in a similar manner.
- h. If necessary, remove the two weight retaining screws (8) and remove the balance weights (9) from each gear.
- i. Remove the key (5) from the balance shaft (7).



6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING

2.

WARNING

Use protective eye goggles when using compressed air.

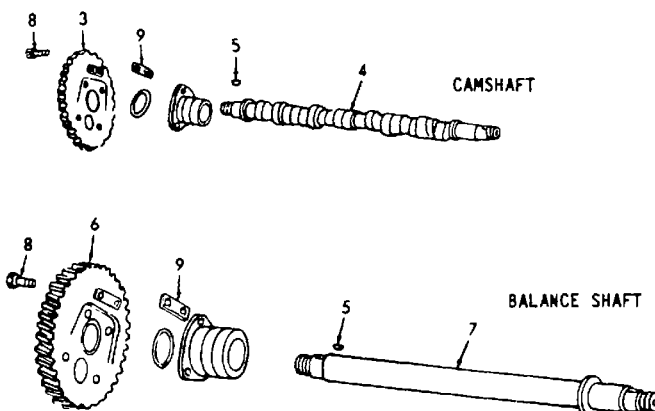
Clean the gears with fuel oil and dry with compressed air.

INSPECTION

3. Examine the gear teeth for evidence of scoring, pitting and wear. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

INSTALLATION

4. a. Install balance weights (9) and screws (8). If removed



6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- b. Lubricate the shaft journals and place the camshaft and balance shaft end bearings (10) in place, with bolting flanges facing toward gear ends of shafts. If unit being serviced is a "D" engine, install the thrust washers (11) between the end bearings and the thrust shoulders of the shafts, and between the end bearings and the gears.

NOTE

Be sure steel faces of thrust washers are next to bearings.

- c. Install Woodruff keys (5) for gears in both shafts.

NOTE

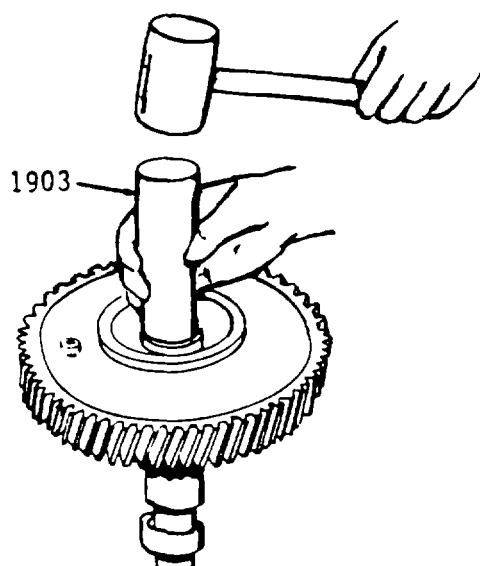
Note that the teeth on one gear form a right hand helix and on the other a left hand helix. When viewing the engine from the flywheel end, the gear with right-hand helical teeth is located on the left side and the gear with left hand helical teeth is located on the right side of the engine.

- d. Rest the non-gear end of camshaft (4) or balance shaft (7) on a wood block and start the gear onto the other end of the shaft by hand so the keyway aligns with the key and with the flat finished face of the gear away from the bearing.
- e. Use gear installer, J1903 to drive the gears onto the camshaft and balance shaft.

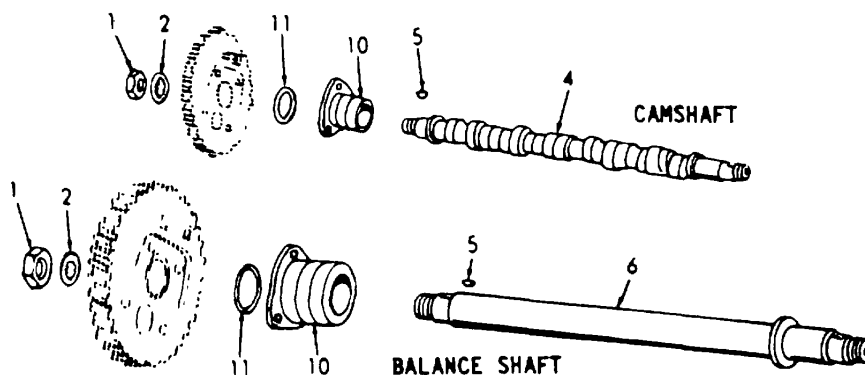
6-23.4. CAMSHAFT AND BALANCE SHAFT GEAR (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

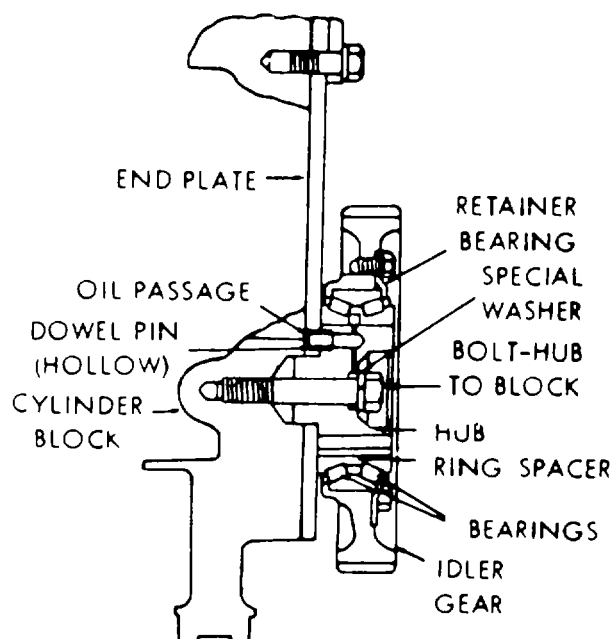


- f. Start the nuts (1), and lock-washers (2) on their respective shafts by hand. Tighten the nuts after the shafts have been installed in the cylinder block.
- g. Install the camshaft and balance shaft in the engine as outlined in paragraph 6-23.3.



6-24. IDLER GEAR.

The idler gear mounts on a double row, tapered roller bearing which, in turn, is supported on a stationary hub. A hollow pin serves a two-fold purpose; first, as a locating dowel it prevents the idler gear hub from rotating and, second, the hollow pin conducts oil under pressure from an oil gallery in the cylinder block through a passage in the gear hub to the roller bearing inner races.



The inner races of the idler gear bearing are pressed onto the gear hub and, therefore, do not rotate since the hub is doweled to the end plate and bolted to the cylinder block and also bolted to the flywheel housing. A spacer separates the two bearing inner races.

The bearing outer race has a light press fit in the idler gear and is held against a flanged lip inside the idler gear on one side and by a retainer secured tightly with six bolts on the other side.

A right-hand helix gear with "L" timing marks is provided for left hand rotation engines, and a left-hand helix gear with "R" timing marks is provided for right-hand rotation engines, see paragraph 3-27.

An idler gear hole spacer (dummy hub) is used on the side opposite the idler gear. NO gasket is used between the idler gear hub or dummy hub and the flywheel housing. The flywheel housing bears against the inner races of the idler gear bearing and also against the dummy hub. Three self-locking bolts and steel washers are used to attach the flywheel housing at the idler gear and dummy hub locations. The washers seat in 7/8" spot faces at the flywheel housing attaching bolt holes, thus preventing oil leakage at these locations.

6-24.**IDLER GEAR.**

This task covers:

- | | | |
|----------------|---------------|-----------------|
| a. Removal | d. Inspection | g. Installation |
| b. Disassembly | e. Reassembly | |
| c. Cleaning | f. Test | |

INITIAL SETUP**Test Equipment**

Spring Gage

References

NONE

Special Tools

Arbor Press

Equipment

<u>Condition</u>	<u>Condition Description</u>
Paragraph	

6-40	Flywheel Housing Removed
------	--------------------------

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Fuel oil
Engine oil

Special Environmental Conditions

NONE

Personnel Required

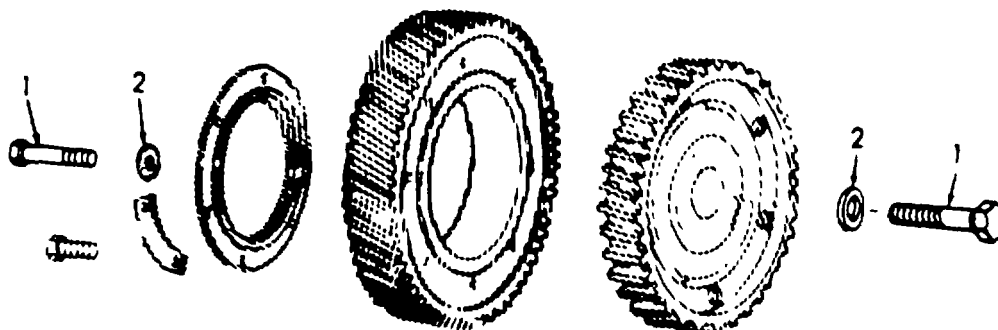
MOS 61C10

General Safety Instructions

Observe WARNING in procedure.

6-24. IDLER GEAR. (Continued).**REMOVAL - FLYWHEEL HOUSING REMOVED**

1. Idler Gear
 - a. Remove screw (1), and flatwasher (2).
 - b. Remove gear hub and bearing assembly.

**NOTE**

Before removing the idler gear assembly, check the bearing by grasping the rim of the gear with both hands and rocking it. If the gear wobbles or shakes, the bearing must be replaced. If there is no perceptible wobble, it is only necessary to check the bearing preload before reinstalling the idler gear and bearing assembly.

6-24. IDLER GEAR.

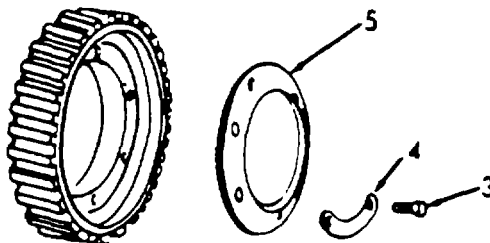
LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY

NOTE

While removing or installing an idler gear bearing, the bearing **MUST** be rotated to avoid the possibility of damaging the bearing by brinelling the bearing races. Brinelling refers to the marking of the races by applying a heavy load through the rollers of a non-rotating bearing in such a way that the rollers leave impressions on the contact surfaces of the races. These impressions may not be easily discerned during normal inspection. For example, a bearing may be brinelled if a load were applied to the inner race of the bearing assembly in order to force the outer race into the idler gear bore, thus transmitting the force through the bearing rollers. A brinelled bearing may have a very short life.

2.
 - a. Remove screws (3), bearing retainer locks (4), and bearing retainer (5).



6-24. IDLER GEAR.

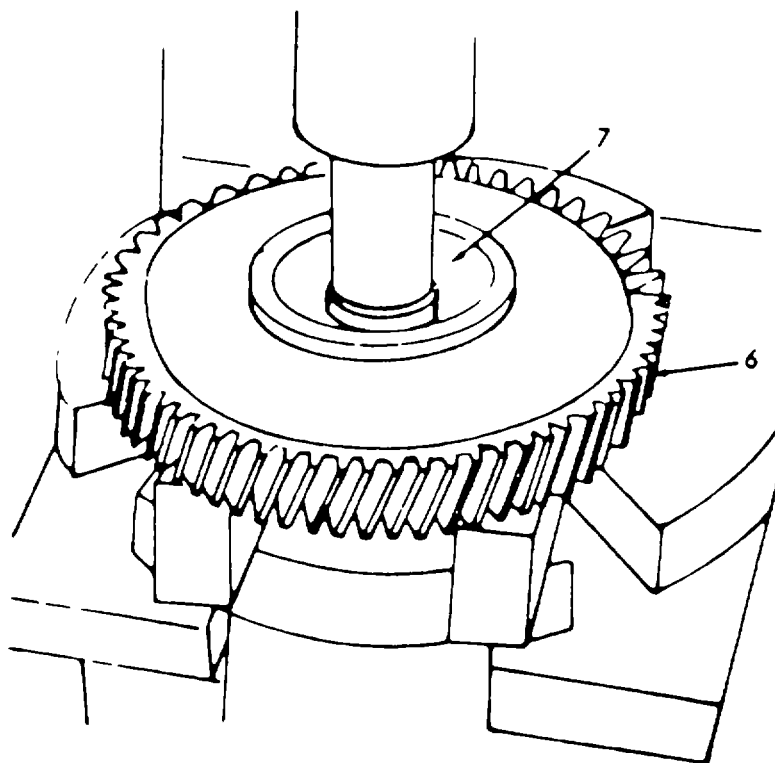
LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY (Cont)		
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NOTE

The component parts of the idler gear bearing are matched; therefore, matchmark the parts during disassembly to ensure reassembly of the parts in their original positions.

- b. Place the idler gear assembly (6), and hub (7) in an arbor press, with the inner bearing cone supported on steel blocks as shown. While rotating the idler gear to prevent brinelling of the bearing, press the hub out of the bearing.

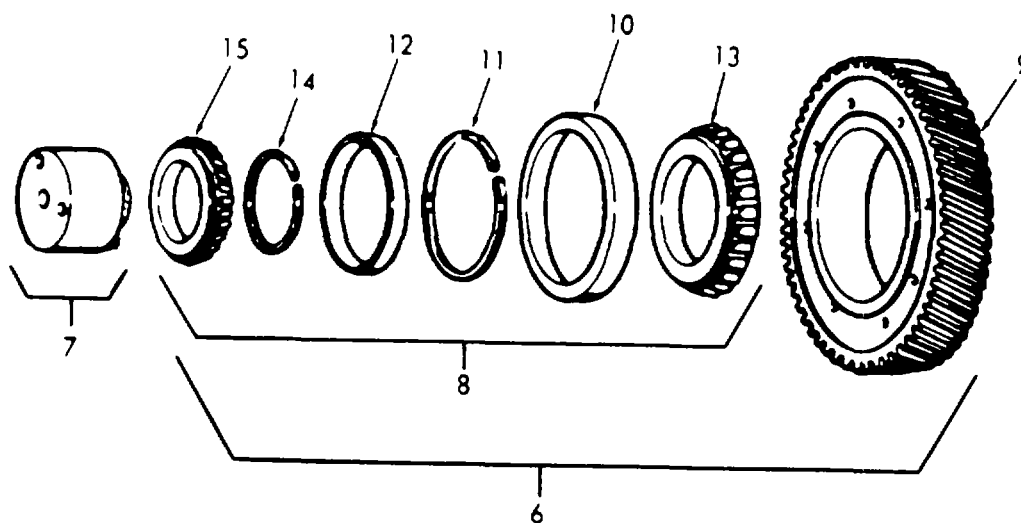


6-24. IDLER GEAR.

LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY (Cont)

- c. Use a brass drift alternately at the four notches provided in the shoulder of the gear to tap the bearing assembly (8) cup(s) from the idler gear (9).
- d. Disassemble inner bearing cup (10), outer spacer ring (11), outer bearing cup (12), inner bearing cone (13), inner spacer cone (14), and outer bearing cone (15).



6-24. IDLER GEAR.

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING

3.

WARNING

Use protective eye goggles when using compressed air.

Wash all of the parts thoroughly in clean fuel oil and dry them with compressed air.

INSPECTION

4.

- a. Examine the gear teeth for evidence of scoring, pitting, or wear. Also, examine the idler gear hub for wear or damage.
- b. Inspect the bearing carefully for wear, pitting, scoring, or flat spots on the rollers or cups.

REASSEMBLY

5.

NOTE

Use the match marks previously made to ensure assembly of the idler gear bearing (8) parts in the same positions from which they were removed. Then proceed as follows:

- a. Support idler gear (9) shoulder down on the bed of an arbor press.

6-24. IDLER GEAR.

LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

- b. Start bearing cup inner (10) into gear numbered side up. Press flat against the shoulder of gear.

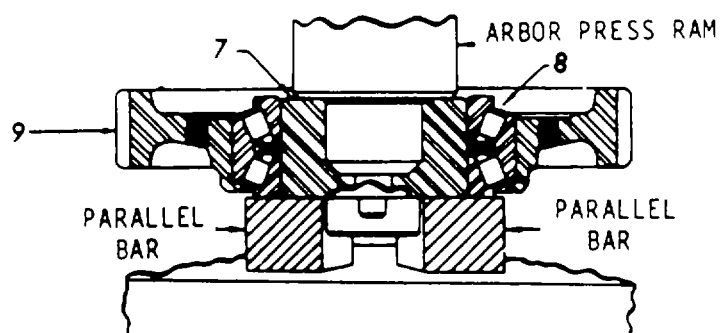
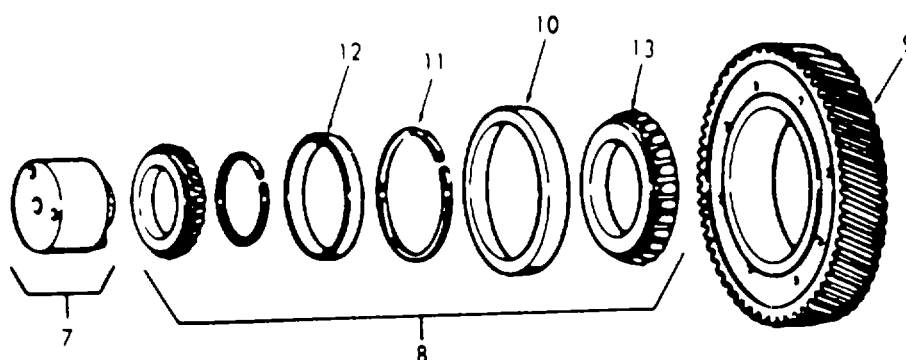
Use a flat steel plate between the ram of the press and the bearing cup.

- c. Lay outer spacer ring (11) on the face of the bearing cup.

- d. Start bearing cup outer (12) into gear numbered side up. Press flat against the spacer ring.

Use a flat steel plate between the ram of the press and the bearing cup.

- e. Press inner bearing cone (13) on idler gear hub (7) until flush with inner hub mounting face.



6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
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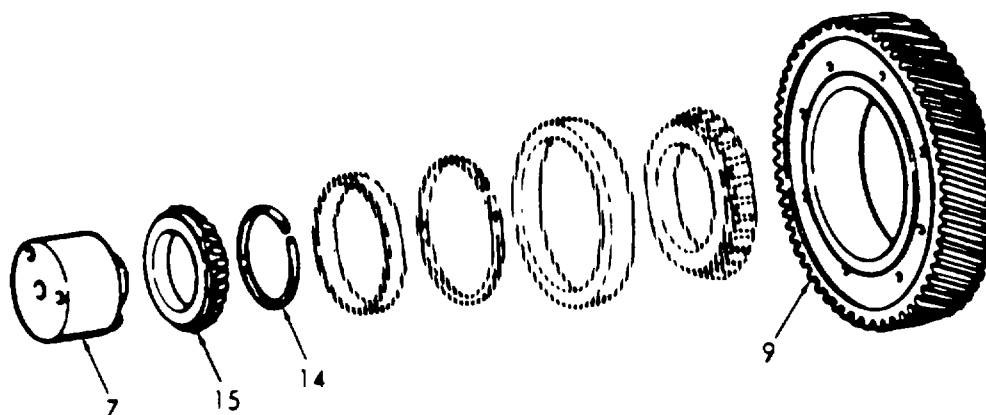
REASSEMBLY (Cont)

- f. Install the inner spacer ring (14) on the idler gear hub (7) so that the oil hole in the hub is 180° from the gap in the inner spacer ring.
- g. Position the idler gear (9) with both cups over the hub and inner bearing cone.

CAUTION

The bearing cones must be supported so as not to load the bearing rollers during this operation.

- h. Press the outer bearing cone (15) over the hub, while rotating the gear to seat the rollers properly between the cones.



6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

TEST

6.
 - a. Prior to installing and securing the bearing retainer, check the pre-load of the bearing assembly.
 - b. The rollers in the bearing are loaded between the bearing cup and the bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and the cup. In the idler gear bearing, a slight pre-load is applied by means of a selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub. This method of pre-loading is measured, in terms of "pounds-pull", by the effort required at the outer diameter of the gear to turn the bearing cup in relation to the bearing cones.
 - c. Check the bearing pre-load whenever the idler gear assembly is removed from the engine for service or for an engine overhaul.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
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TEST (Cont)

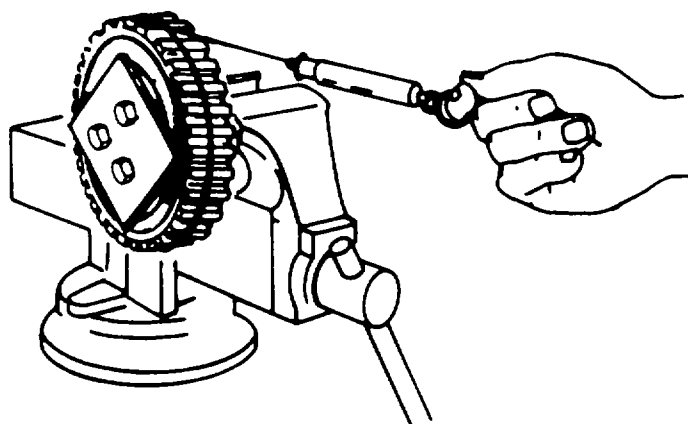
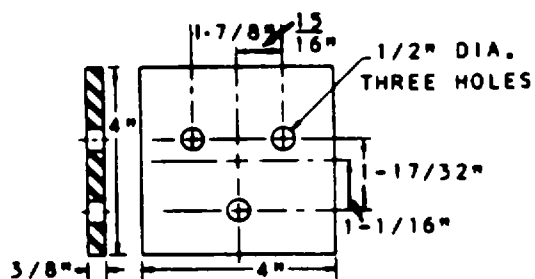
- d. The idler gear bearing must be clean and lubricated with engine oil before checking the pre-load. If a new bearing has been installed, "work in" the bearing by rotating the gear back and forth several times.
- e. If the crankshaft and camshaft gears are not mounted on the engine, the torque required to rotate the idler gear may be checked by mounting the idler gear in position on the engine, using a 4" square, 3/8" thick steel plate against the hub and cone as outlined below.
 1. Mount the idler gear assembly on the engine.
 2. Install the idler gear hub retaining bolt and washer and tighten the bolt to 80-90 lb-ft (108.5-122.0 c.Nm) torque.
 3. Place the steel plate (lower plate shown below) against the hub and bearing. Insert three 3/8"-16 bolts through the plate and thread them into the hub. Tighten the bolts to 25-40 lb-ft (33.9-54.2 Nm) torque.
 4. Tie one end of a piece of lintless 1/8" cord around a 1/8" round piece of wood (or soft metal stock). Place the wood between two

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

TEST (Cont)

of the gear teeth and wrap the cord around the gear several times as shown. Attach the other end of the cord to a spring scale. Maintain a steady pull on the cord and scale, 90° to the axis of the hub, and note the pull, in pounds and ounces, required to start the gear rotating. Make several checks to obtain an average reading. If the pull is within 1/2 Lb (2.22 N) minimum to 6 lbs. 12 oz. (30.03 N) maximum, and does not fluctuate more than 2 lbs. 11 oz. (11.98 N), the Idler gear and bearing assembly is satisfactory for use.



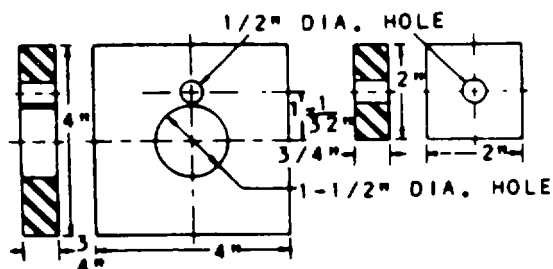
6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
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TEST (Cont)

- f. If the crankshaft and camshaft gears are mounted on the engine, a suitable fixture, which may be held in a vise, can be made as shown. Three plates, a 1/2"-13 X 2-3/4" bolt, 1/2"-13 nut, and two 1/2" plain washers are required. The plates are made from steel stock. Check the pre-load on the bearings as follows:

1. Attach two of the steel plates (two upper plates) to the idler gear hub with the 1/2"-13 bolt, washers, and nut as shown. Tighten the bolt to 80-90 lb-ft (108.5-122.0 Nm) torque.

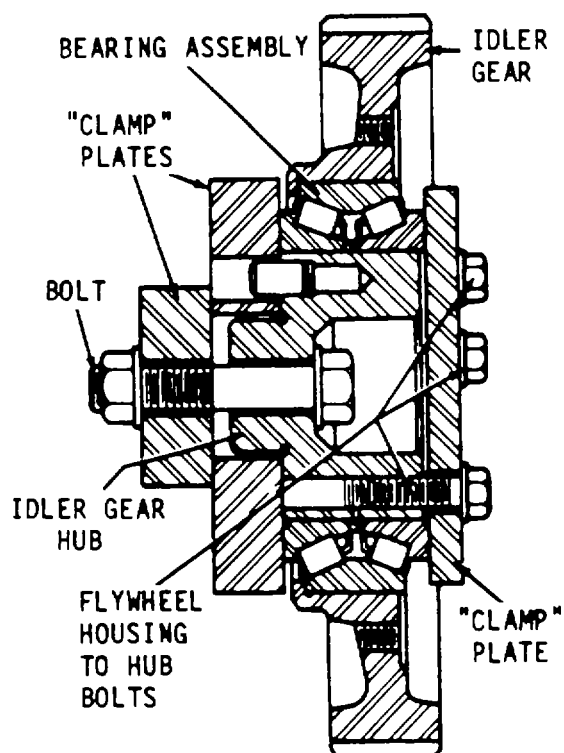


2. Attach the third plate to the idler gear hub with three 3/8"-16 bolts. Tighten the bolts to 25-40 lb-ft. (33.9-54.2 Nm) torque.
3. Clamp the idler gear assembly and fixture in a vise.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
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TEST (Cont)



4. Attach a cord to the idler gear and spring scale and check the bearing pre-load as outlined in step e.4.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
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TEST (Cont)

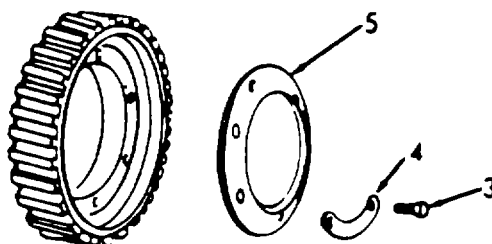
- g. If the scale reading is within the specified 1/2 to 6-3/4 lbs. (2.22 to 30.03 N) specified but fluctuates more than 2 lbs. 11 ounces (11.98 N) the idler gear and bearing assembly must NOT be installed on the engine. Fluctuations in scale reading may be caused by the races not being concentric to each other, damage races or rollers, or dirt or foreign material within the bearings. In these cases, the bearing should be inspected for the cause of fluctuation in the scale readings and corrected or a new bearing installed.
- h. A scale reading which exceeds the specified maximum indicates binding of the bearing rollers, or rollers improperly installed. When the scale reading is less than the specified minimum, the bearing is more likely worn and the bearing should be replaced.
- i. After pre-load check is completed, remove the steel plates and install the bearing retainer (5) as follows:
 - 1. Attach the bearing retainer to the idler gear with six screws (3) and three screw locks (4). Tighten the screws to 24-29 lb-ft (32.5-39.3 Nm) torque.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

TEST (Cont)

2. Bend the ears of each screw lock against the flat side of the attaching screw heads to secure the screws.



INSTALLATION

7. Idler Gear

- a. Position the crankshaft gear and camshaft gear so the timing marks will align with those on the idler gear.

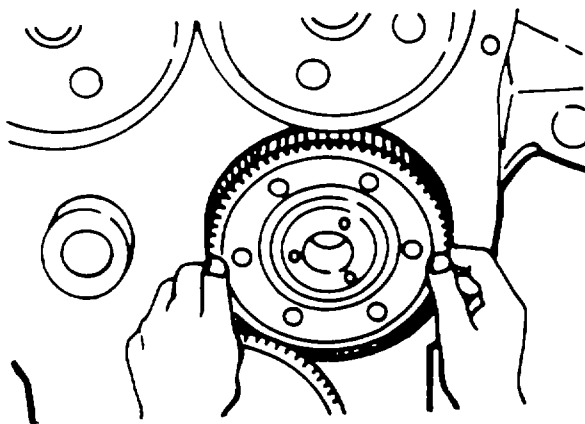
Refer to paragraph 6-23.1.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- b. With the timing marks in alignment, start the idler gear in mesh with the crankshaft gear and camshaft gear, and simultaneously rotate the gear so the hollow pin in the hub registers with the oil hole in the end plate.

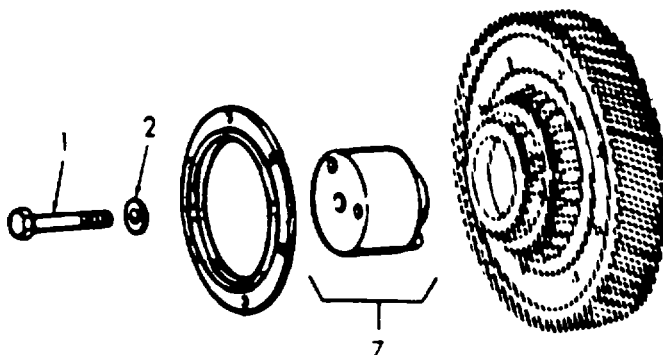


- c. Roll the idler gear into position and align the hollow pin with the hole in the end plate. Then, gently tap the hub until it seats against the end plate.
- d. Install screw (1), and flat-washer (2) after making sure the hub (7) is tight against the end plate. Tighten screw to 80-90 lb-ft (108.5-122.0 Nm) torque.

6-24. IDLER GEAR.(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)



REPAIR

- | | |
|-----------------------------------|--|
| 7. Idler Gear Hole Spacer (Dummy) | <p>a. Remove screw (1), flatwasher (2), spacer (3), and dowel (4), as required for repair.</p> <p>b. Install idler gear hole spacer (dummy hub). Tighten screw to 80-90 lb-ft (108.5-122.0 Nm) torque.</p> <p>c. Lubricate the idler gear bearing and gear teeth liberally with clean engine oil.</p> <p>d. Check the backlash between the mating gears. The backlash must be .003" to .008" between new gears and must not exceed .010" between worn gears.</p> |
|-----------------------------------|--|

6-25. OIL PAN.

This task covers:

- a. Inspection
- b. Removal

- c. Cleaning
- d. Repair

- e. Installation

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

Equipment Condition Paragraph	Condition Description
6-22	Propulsion Unit-Removal

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Cleaning solvent P-D-680

Special Environmental Conditions

NONE

Personnel Required

MOS 61C10

General Safety Instructions

Observe WARNING in procedure.

LOCATION/ITEM**ACTION****REMARKS****INSPECTION**

- | | | |
|------------|---|--|
| 1. Oil Pan | a. Inspect for dents, cracks, and breaks. | |
| | b. Inspect for signs of leaking. | |
| | c. Inspect for missing hardware. | |

REMOVAL

- | | | |
|----|--|--|
| 2. | a. Remove oil drain tube mounting bracket. | |
|----|--|--|

6-25. OIL PAN (CONTINUED).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

b. Remove pipe plug (1), elbow (2), drain tube (3), and elbow (4).

c. Remove bolts (5), and lockwashers (6).

d. Pry the oil pan (7), and gasket (8) from the engine block.

Remove all traces of gasket from block and pan.

e. Maneuver oil pan away from engine and base.

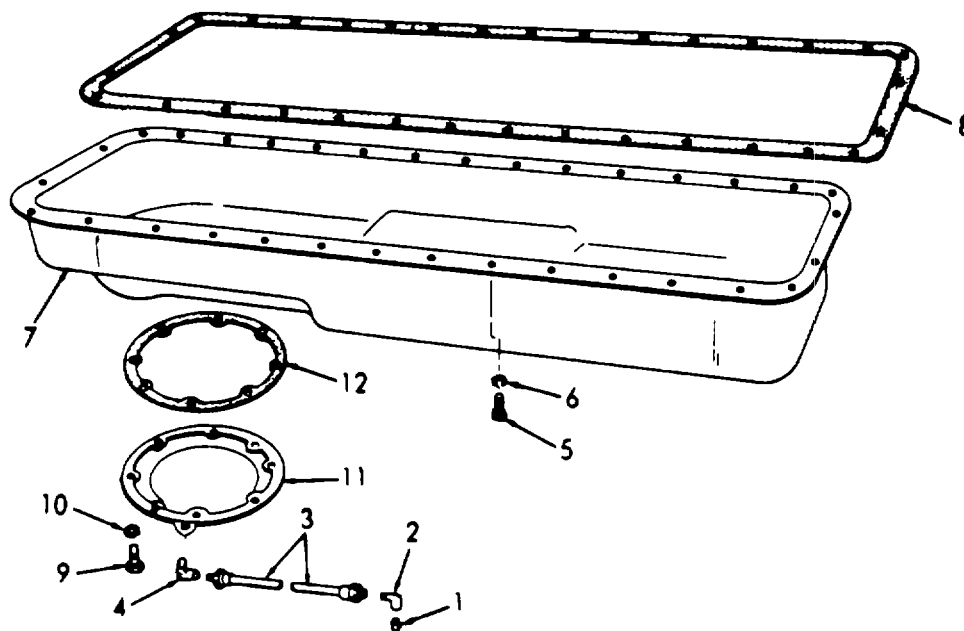
f. Remove bolts (9), and lockwashers (10).

If necessary

g. Remove sump cover (11) and gasket (12).

1. If necessary

2. Remove all traces of gasket from pan and cover.



6-25. OIL PAN (CONTINUED).

LOCATION/ITEM

ACTION

REMARKS

CLEANING

3.

WARNING

Dry cleaning solvent, P-D-680, used to clean parts is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. DO NOT use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).

Clean all metal parts with dry cleaning solvent (P-D-680) and dry thoroughly.

REPAIR

4.

Remove rust and corrosion, straighten dents, and weld minor cracks and breaks.

Discard all parts that are damaged beyond repair.

INSTALLATION

5.

- a. Install sump cover (11) and a new gasket (12) using bolts (9), and lockwashers (10).
- b. Install oil pan (7), and a new gasket (8) using bolts (5), and lockwashers (6).

6-25. OIL PAN (CONTINUED).

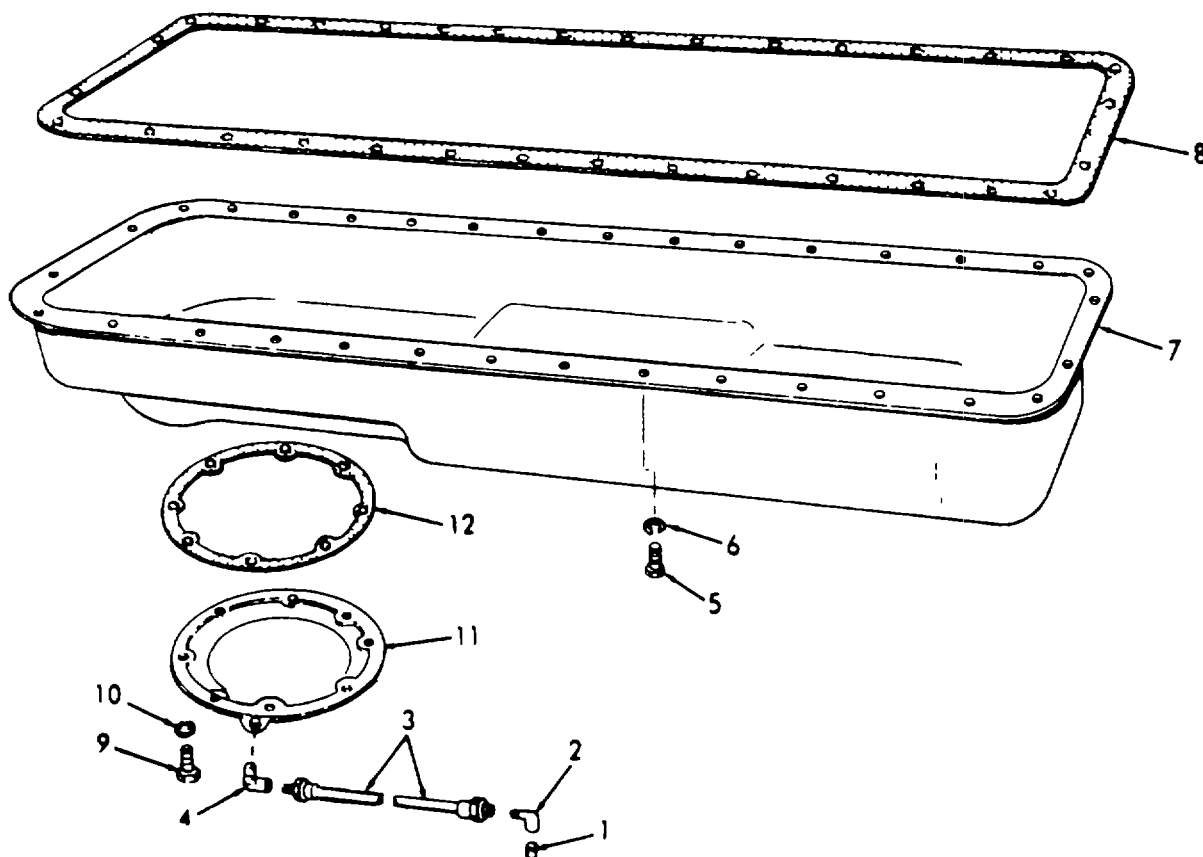
LOCATION/ITEM

ACTION

REMARKS

INSTALLATION (Cont)

- c. Install elbow (4), drain tube (3), elbow (2), and pipe plug (1).
- d. Reinstall oil drain tube mounting bracket.
- e. Refill engine with oil.



6-26. OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS .

- a. The gear-type oil pump is mounted on the first and second main bearing caps and is gear-driven from the front end of the crankshaft.
- b. The oil pump helical gears rotate inside a housing. The drive gear is keyed to the drive shaft which is supported inside the housing on two bushings with a drive-driven gear keyed to the outer end of the shaft. The driven gear is supported on the driven gear shaft which is pressed into the pump body.
- c. An integral plunger-type relief valve by-passes excess oil to the inlet side of the pump when the pressure in the oil lines exceeds 105 pounds per square inch (724 kPa).
- d. An inlet pipe, attached to the inlet opening in the pump body, leads to the inlet screen which is mounted with brackets to a main bearing cap.
- e. The inlet screen is located below the oil in the pan and serves to strain out any foreign material which might damage the pump.
- f. The oil pump inlet screen should be removed and cleaned periodically in addition to the cleaning it receives each time the engine is reconditioned.
- g. An idler gear is mounted on a support bracket which is attached to the pump body.
- h. Pressure lubrication of the idler gear bushing is provided by means of a drilled passage in the pump body and a connecting passage in the idler gear support bracket.
- i. The maintenance procedures are as follows:

<u>DESCRIPTION</u>	<u>PARAGRAPH</u>
Lube Oil Pump Assembly	6-26.1
Lube Oil Pressure Regulator	6-26.2
Lube Oil Distribution System	6-26.3

6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS .

This task covers:

- | | | |
|----------------|---------------|-----------------|
| a. Removal | c. Inspection | e. Installation |
| b. Disassembly | d. Reassembly | |
-

INITIAL SETUP
Test Equipment

Feeler gage

References
Paragraph

6-26.2 Oil Pressure Regulator

Special Tools

Torque wrench
Puller J8174

Equipment
Condition
Paragraph
Condition Description

6-25	Oil Pan Removal
6-26.3	Lube Oil Distribution System Removal

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Gasket Kit P/N 5192108
Overhaul Kit P/N 5194801

Special Environmental Conditions

Do not drain oil into bilges.
Use oil/water separation and
recovery system to collect
used oil.

Personnel Required

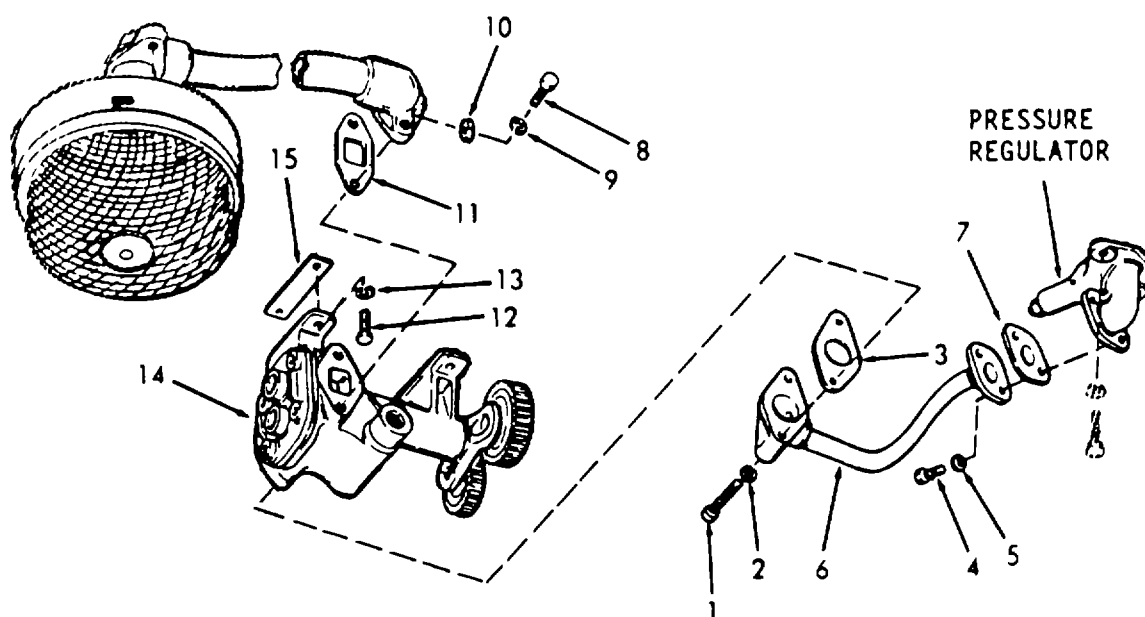
1

General Safety Instructions

Observe all CAUTIONS and
WARNINGS.

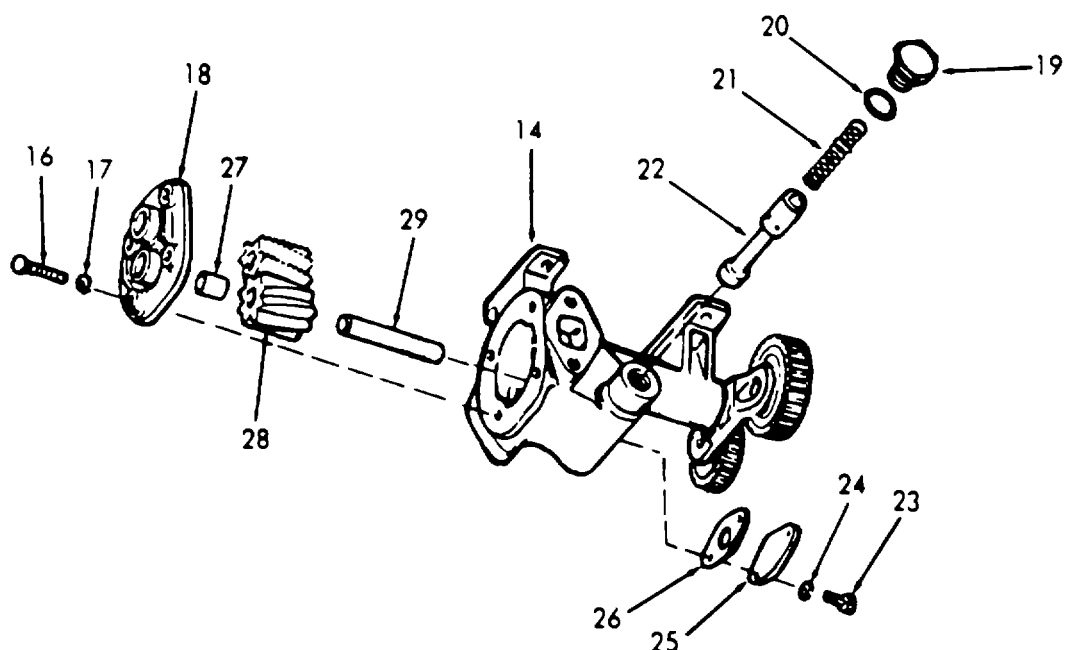
6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Oil Pump	a. Remove screws (1) and lockwashers (2).	
	b. Remove gasket (3).	Discard gasket.
	c. Remove screws (4) and lockwashers (5).	
	d. Remove outlet pipe (6).	
	e. Remove gasket (7).	Discard gasket.
	f. Remove screws (8), lockwashers (9), and flatwashers (10).	Discard gasket.
	g. Remove gasket (11).	Discard gasket.
	h. Remove screws (12), and lockwashers (13).	
	i. Remove oil pump (14), and shims (15).	Do not discard shims.



6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
2. Lube Oil Pump	a. Remove screws (16), and lock-washers (17).	
	b. Remove cover (18).	
	c. Remove valve plug (19), and copper gasket (20) from both sides.	Discard gaskets.
	d. Jar pump body (14) to loosen spring (21) and valve (22).	Discard spring.
	e. Remove screws (23) and lockwashers (24).	
	f. Remove pad cover (25) and gasket (26).	Discard gasket.
	g. Remove bushings (27) from cover (18).	Discard bushings.
	h. Remove driven gear (28) and shaft (29).	Discard gear and shaft.



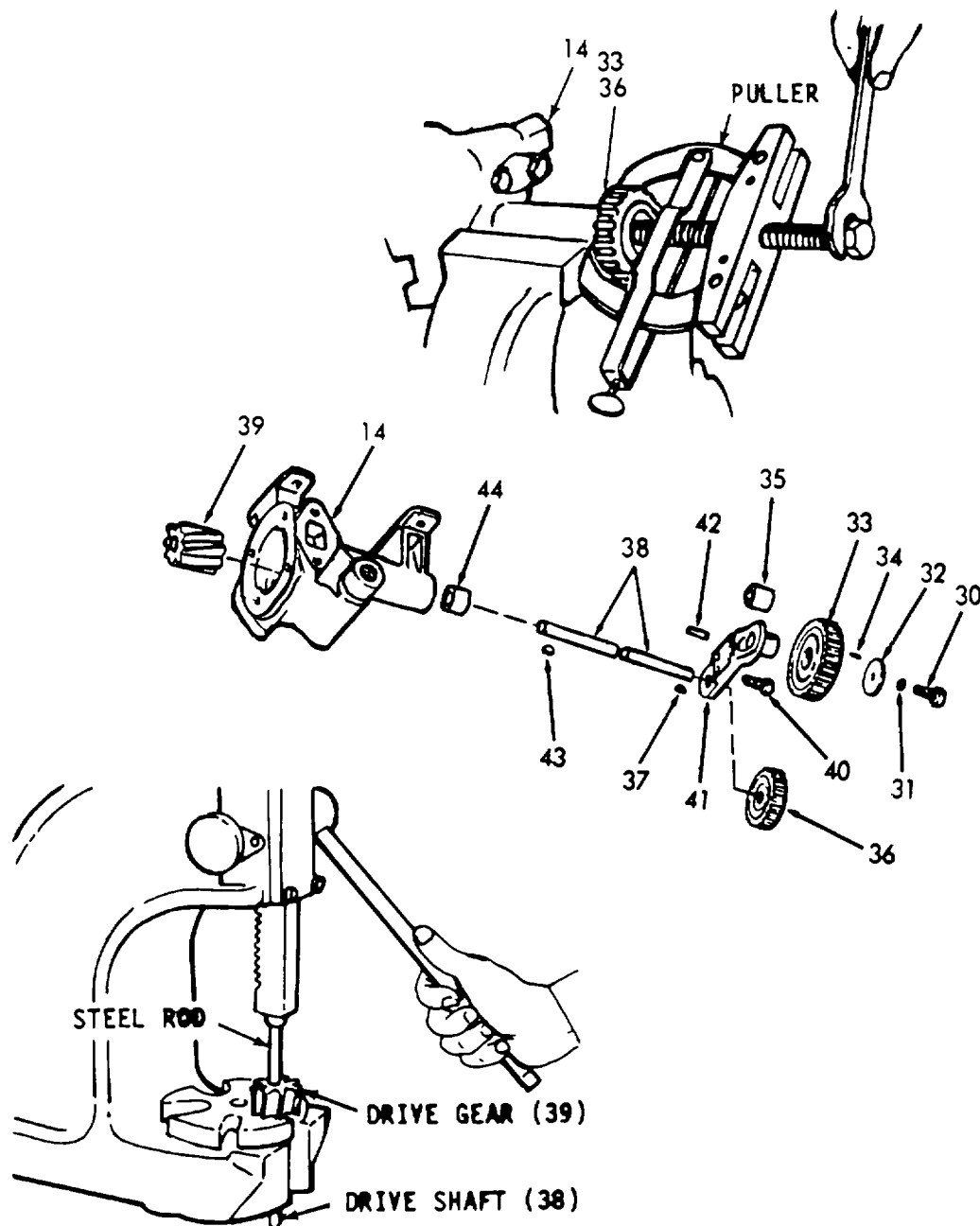
6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY (Cont)		
	i. Remove screw (30), lockwasher (31), and idler gear washer (32).	
	j. Remove idler gear (33).	
	k. Remove headless pin (34).	If necessary
	l. Remove bushing (35).	Discard if damaged.
	m. Clamp pump body (14) in vice. Remove driven gear (36), and woodruff key (37) from shaft (38).	Use gear puller J8174. Discard gear, shaft and key.
	n. Remove shaft (38) and drive gear (39) from body (14) as an assembly.	Discard if disassembly is required. Refer to step q.
	o. Remove screw (40), and idler gear support (41).	
	p. Remove dowel pin (42).	If necessary
	q. Position drive gear (39), shaft (38), and woodruff key (43) on bed of arbor press with long end of shaft extending down through slot in bed plate and with the face of the gear resting on the plate. Place a short 1/2 inch round steel rod on the end of the shaft. Press the shaft from the gear.	The drive gear, key and the shaft are part of the overhaul kit.
	r. Remove bushings (44).	Discard.

6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS
(CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
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DISASSEMBLY (Cont)



6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS
(CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION		
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3.

WARNING

Wear eye goggles for protection when using compressed air.

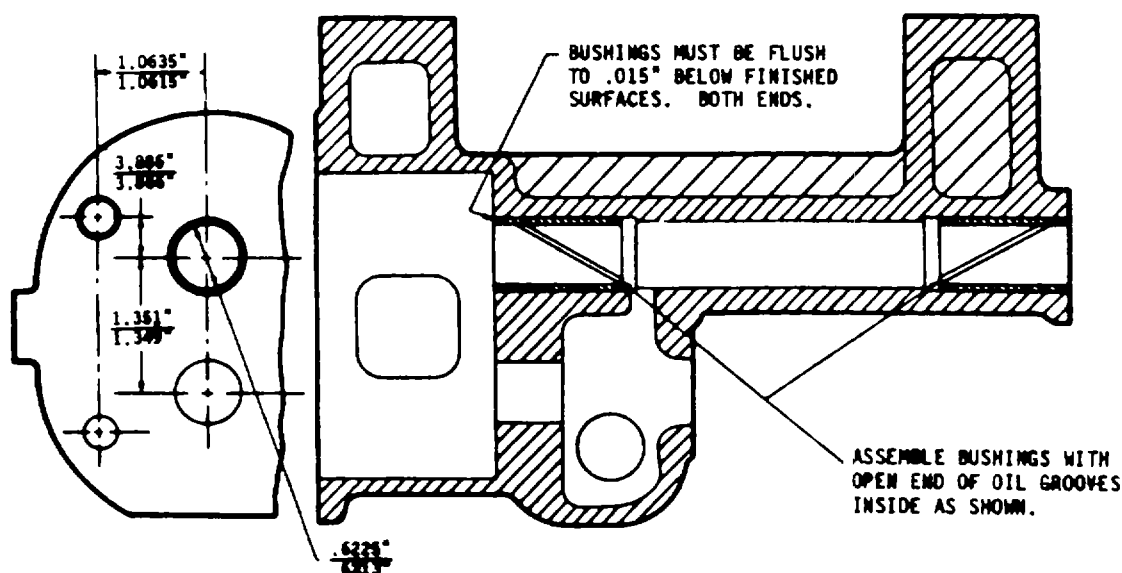
- a. Wash all parts in clean fuel oil and dry them with compressed air.
- b. Examine the gear cavity in the pump body and the drive shaft bushings. If the driven gear bushings are worn, replace the bushings. Service replacement bushings in the driven gears must be reamed after assembly. Bushings used with the .499 inch diameter driven gear shaft must be reamed to .500 inch \pm .0005 inch and bushings used with the .623 inch diameter shaft must be reamed to .625 inch \pm .0005 inch.
- c. Inspect the bushings in the pump body and cover. If the bushings are worn excessively, replace the pump and cover assemblies unless suitable boring equipment is available for finishing the new bushings. When installing new bushings, replace all of the bushings. The bushings must be located and positioned as shown below. Also, the gear bore and the bushing bore in both the pump body and cover must be

6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

concentric within .001 inch.
The shaft-to-pump body-bushing clearance with new parts is .0008 inch to .0025 inch.
The shaft-to-pump cover bushing clearance with new parts is .0010 inch to .0027 inch.



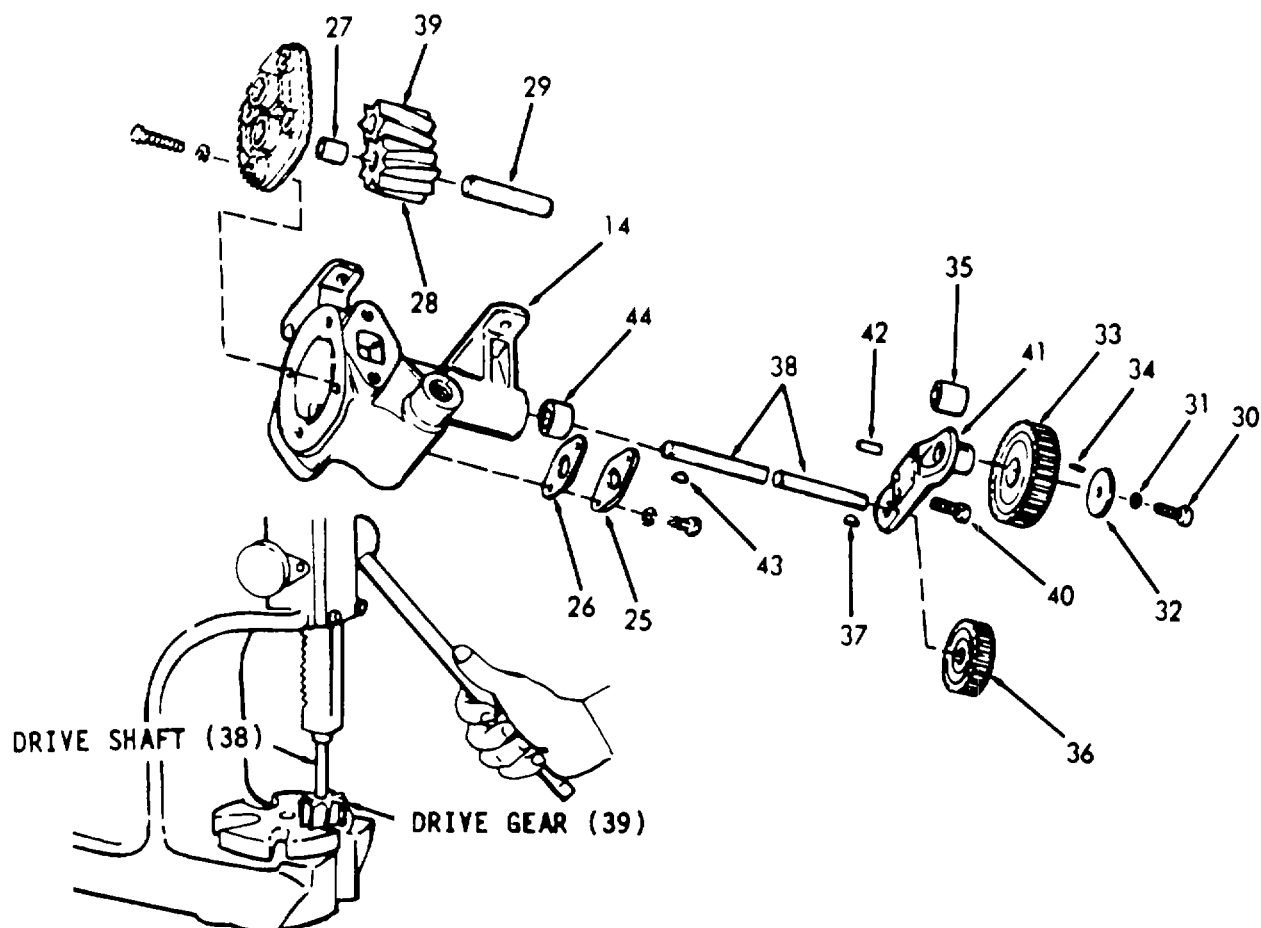
- d. In an efficient oil pump, the gears should have a free-running fit (with no perceptible looseness) in the pump housing. If the gear teeth are scored or worn, install new gears. The use of excessively worn gears will result in low engine oil pressure which in turn, may lead to serious damage throughout the engine.
- e. Inspect the pressure relief valve and its seat in the pump body. If necessary, install new parts.

6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
REASSEMBLY		
4.	<ul style="list-style-type: none"> a. Press bushings (44) into body (14). b. Insert woodruff key (43) in shaft (38). Apply a light coat of engine oil to the shaft. Start the shaft squarely into the bore of the gear (39). Press shaft into gear using an arbor press. The gear must be 6-15/16 inches from the keyway end of the shaft. c. Install dowel pin (42). d. Install idler gear support (41), and screw (40). e. Install drive gear (39), and shaft (38) assembly in body (14). f. Position driven gear (36) and woodruff key (37) on the end of the shaft (38) with the extended hub side up away from the body. Insert a .005 feeler ribbon between the gear and the body. Press the gear on the shaft until the clearance is .005 between the body and the gear. g. Install bushing (35). h. Lubricate idler gear (33) with engine oil. Install with flat side facing the support (41). 	<p>Use new bushings.</p> <p>Use new gear, key and shaft.</p> <p>If removed</p> <p>Use new gear, key and shaft.</p> <p>Use new bushing.</p>

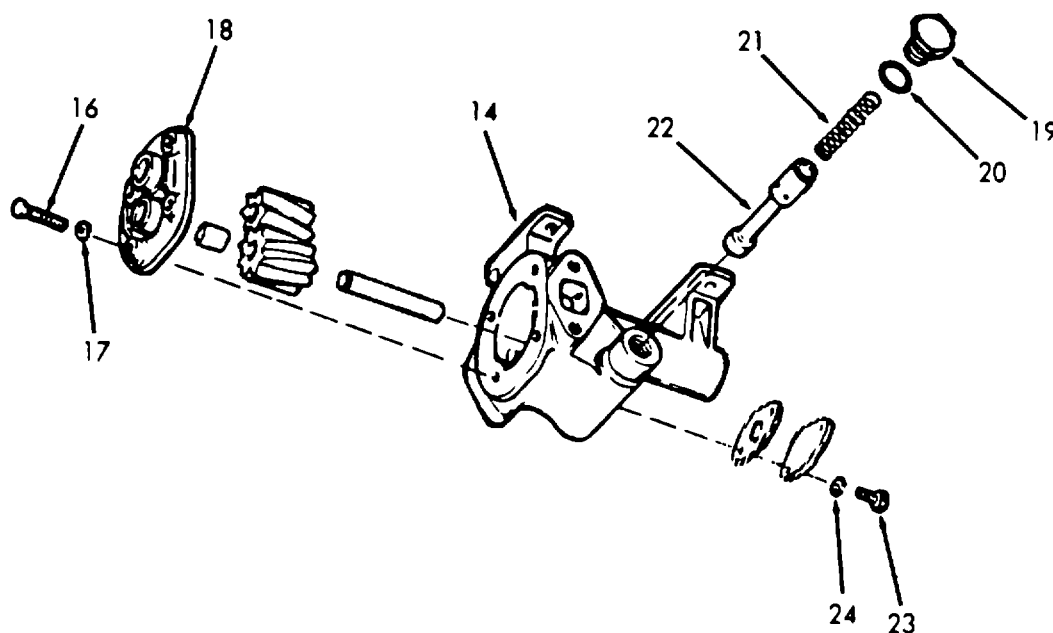
6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
REASSEMBLY (Cont)		
	i. Rotate idler gear washer (32) and lockwasher (31) so that the slot in each washer engages the headless pin (34). Install screw (30).	
	j. Install driven gear (28) and shaft (29).	Use new gear and shaft.
	k. Install bushings (27).	Use new bushings.
	l. Install pad cover (25) and	Use new gasket. gasket (26).



6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
REASSEMBLY (Cont)]	m. Install screws (23), and lock-washers (24).	
	n. Install valve plug (19), and copper gasket (20) in body (14) on side opposite the inlet opening.	Use new copper gasket.
	o. Place valve (21), and spring (22) in body (14). Install second valve plug (19), and copper gasket (20).	Use new copper gasket and spring.
	p. Install cover (18), screws (16), and lockwashers (17).	
	q. The oil pump must turn freely after assembly. Any bind in the pump must be removed prior to installation.	

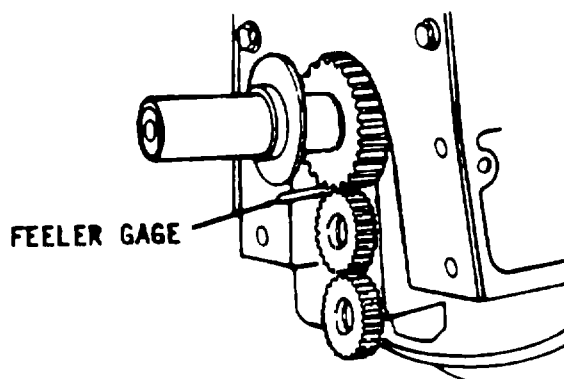
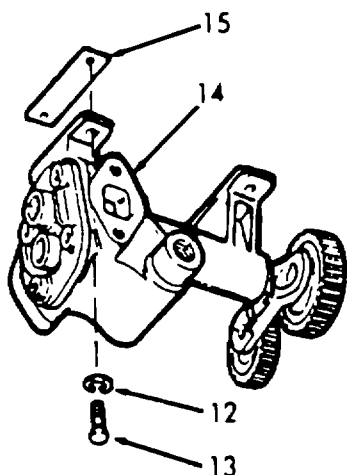


6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION

5.
 - a. Hold the oil pump (14) and shim (15) against the main bearing caps so the idler gear meshes with the driving gear on the crankshaft.
 - b. Insert the four screws (12), and lockwashers (13) through the mounting feet of the pump and into the bearing caps. Align the pump so that the teeth of the crankshaft gear and the idler gear are parallel; then tighten the bolts to 35-39 ft-lb (47.8-53.2 Nm) and check clearance between the gear teeth with a feeler gage. Proper clearance between the crankshaft gear and the idler gear is .005 inch (0.013 cm) minimum - .012 inch (0.030 cm) maximum.



6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS (CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

CAUTION

Always check the clearance between the crankshaft gear and the oil pump idler gear with the engine in the upright or running position.

If shims were used between the pump mounting feet and the bearing caps and new gears are not installed, the same shims (cleaned), or the same number of new (identical) shims should be installed and the number then adjusted to obtain the proper clearance between gear teeth. However, if new gears have been installed, a larger number of shims will be required under the mounting feet. In either event, the pump must be tightened on the bearing cap before the clearance between the gear teeth is measured.

NOTE

When adjusting for gear tooth clearance by installing or removing shims, the same number of shims must be changed under each foot so that the pump will always be level on the main bearing caps. The insertion or removal of one .005 inch (0.013 cm) shim will change the gear tooth clearance by .0035 inch (0.0089 cm).

- | | |
|---|--|
| c. Assemble gasket (11), screws (8), lockwashers (9), and flatwashers (10). | Use new gasket.
Leave screws loose. |
| d. Assemble gasket (7) outlet pipe (6), screws (4), and lockwashers (5) | Use new gasket.
Leave screws loose. |

6-26.1. LUBE OIL PUMP ASSEMBLY - MAINTENANCE INSTRUCTIONS
(CONTINUED).

LOCATION/ITEM	ACTION	REMARKS
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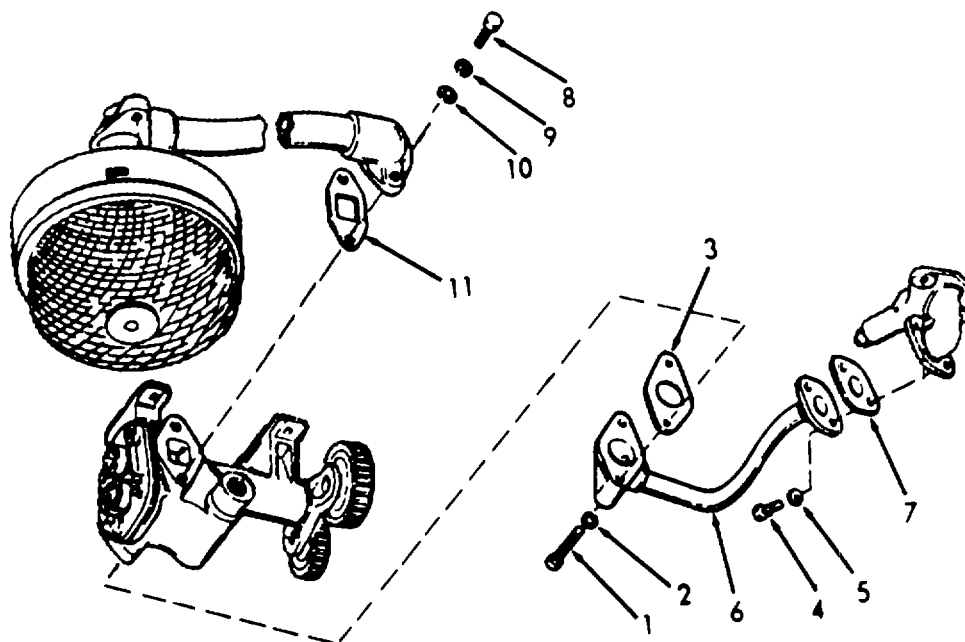
INSTALLATION (Cont)

- e. Assemble gasket (3), screws (1), and lockwashers (2).

Use new gasket.
Leave screws
loose.

NOTE

When attaching the pump outlet and the pressure regulator, none of the screws should be tightened until all the screws have been started. After all screws are started, the outlet pipe screws (1) should be tightened alternately, then the pressure regulator screws (8) should be tightened, and finally the pipe to-regulator screws (4) should be secured. This procedure prevents twisting the outlet pipe.



6-26.2. LUBE OIL PRESSURE REGULATOR - MAINTENANCE INSTRUCTIONS.**LOCATION/ITEM****ACTION****REMARKS**

a. Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of oil temperature, by means of a regulator installed between the oil pump outlet pipe and the cylinder block.

b. The regulator assembly consists of a body, a hollow piston-type valve, a compression spring, and a plug to retain the spring in the body.

c. The valve is held on its seat by the spring, which is compressed by the plug screwed into the valve opening in the regulator body. The entire assembly is bolted to the lower flange of the cylinder block and sealed against oil leaks by a gasket between the two members. When conditions are such that the oil pressure at the valve exceeds 50 pounds per square inch (35.2 kg/cm sq) the valve is forced from its seat and oil from the engine gallery is by-passed to the engine oil pan. Thus, stabilized lubricating oil pressure is maintained at all times regardless of oil temperature.

d. Under normal conditions, the pressure regulator should require very little attention. If sludge has been allowed to accumulate in the lubricating system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

e. Whenever the lubricating oil pump is removed for inspection, the regulator valve and spring should also be removed, thoroughly cleaned in fuel oil and inspected.

6-26.2. LUBE OIL PRESSURE REGULATOR - MAINTENANCE INSTRUCTIONS. (Continued)

This task covers:

- | | | |
|----------------|---------------|-----------------|
| a. Removal | c. Inspection | e. Installation |
| b. Disassembly | d. Reassembly | |

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

NONE

Equipment
Condition
ParagraphCondition Description

6-25

Oil Pan Removal

ToolsGeneral Mechanic's Tool Kit
NSN 5180-00-629-9783Material/PartsGasket Kit P/N 5193114
Fuel oilSpecial Environmental Conditions

NONE

Personnel Required

1

General Safety Instructions

Observe all WARNINGS.

LOCATION/ITEM**ACTION****REMARKS****REMOVAL**

- | | | |
|------------------------------|---|-----------------|
| 1. Oil Pressure
Regulator | a. Remove screws (1), and lock-
washers (2). | |
| | b. Remove gasket (3). | Discard gasket. |
| | c. Remove screws (4), and lock-
washers (5). | |

6-26.2. LUBE OIL PRESSURE REGULATOR - MAINTENANCE INSTRUCTIONS. (Continued)

LOCATION/ITEM

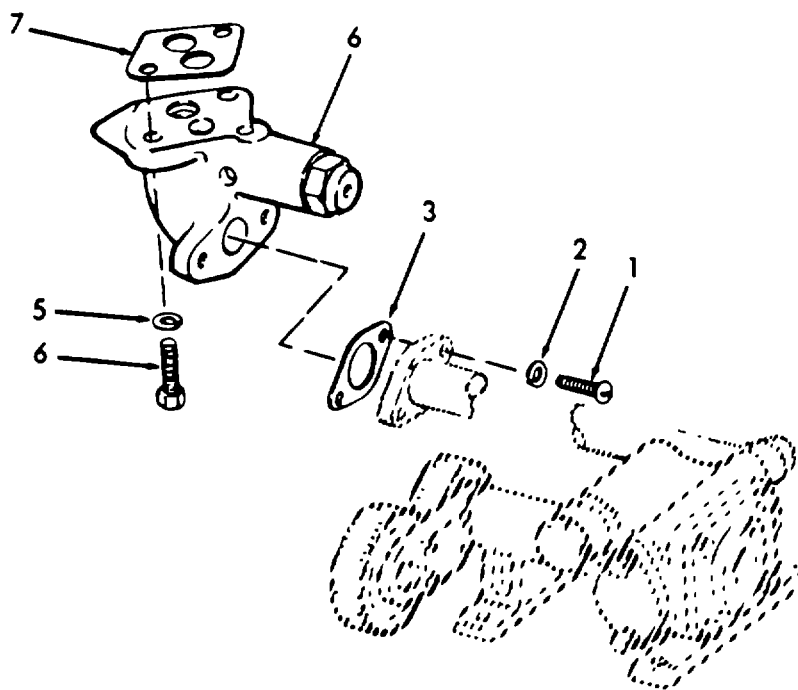
ACTION

REMARKS

REMOVAL (Cont)

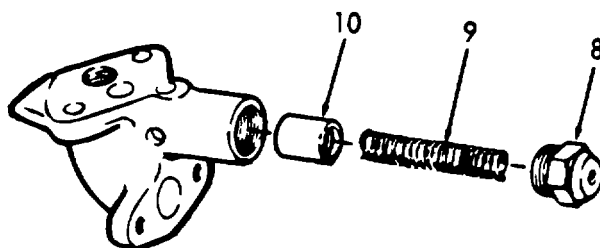
- d. Remove regulator (6), and gasket (7).

Discard gasket.



DISASSEMBLY

- 2.
- Clamp the flange of the body in a vise and remove the plug (8).
 - Remove spring (9), and valve (10).



6-26.2. LUBE OIL PRESSURE REGULATOR - MAINTENANCE INSTRUCTIONS. (Continued)

LOCATION/ITEM

ACTION

REMARKS

INSPECTION

3.

WARNING

Wear eye goggles for protection when using compressed air.

- a. Clean all parts in fuel oil and dry with compressed air.
- b. Inspect all parts for wear or damage.

REASSEMBLY

4.

- a. Apply clean engine oil to the outer surface of the valve (10) and slide the valve into the regulator body, closed end first.
- b. Insert the spring (9) into valve. While compressing the spring, start the plug (8) into the body. Tighten the plug.

INSTALLATION

5.

- a. Remove all traces of the old gaskets from the regulator body, cylinder block, and pump outlet pipe flange.
- b. Affix new gasket (7) to the regulator body with oil passage holes in the gasket in alignment with the oil passages in the body.

6-26.2. LUBE OIL PRESSURE REGULATOR - MAINTENANCE INSTRUCTIONS. (Continued)

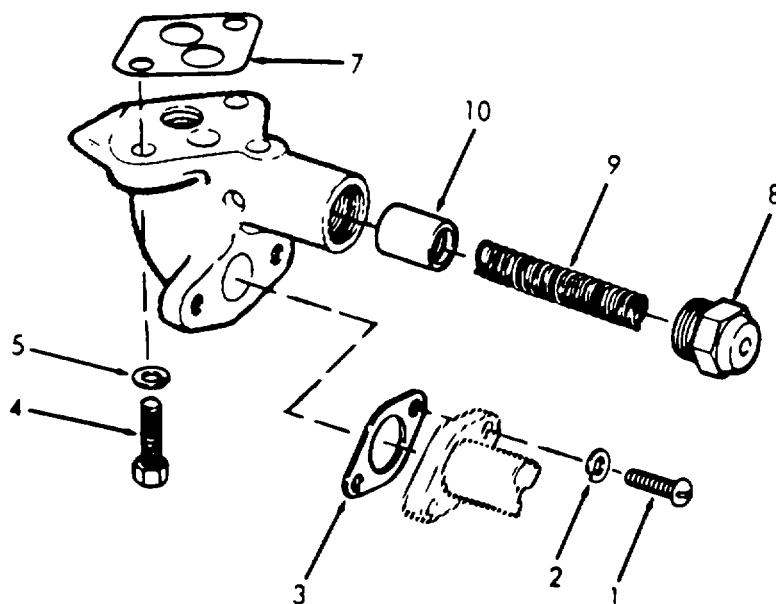
LOCATION/ITEM

ACTION

REMARKS

INSTALLATION (Cont)

- c. Install screws (4), and lockwashers (5).
- d. Insert new gasket (3).
- e. Install screws (1), and lockwashers (2).



This task covers:

- ## INITIAL SETUP

NONE

NONE

NONE

Condition Description

6-25

Oil Pan Removal

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Fuel oil
Gasket kit P/N 5192108

NONE

1

Observe all WARNINGS.

REMOVAL

1. Oil Pump Inlet Screen
 - a. Remove retainer (1), and screen (2).
 - b. Remove two nuts (3), lock-washers (4), and screws (5).
 - c. Remove cover (6).

6-26.3. LUBE OIL DISTRIBUTION SYSTEM - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM	ACTION	REMARKS
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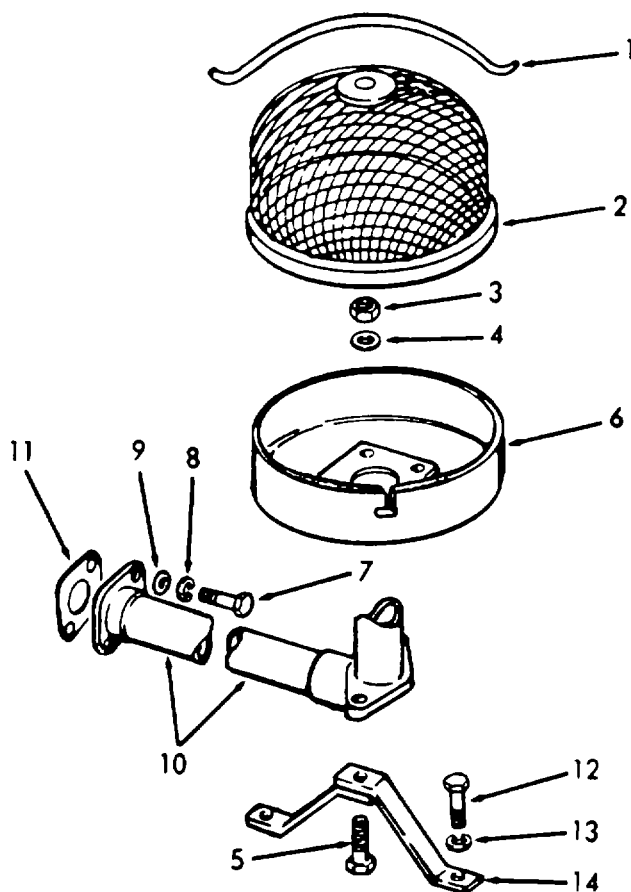
REMOVAL (Cont)

d. Remove screws (7), lock-washers (8), and flatwashers (9).

e. Remove inlet pipe (10), and gasket (11).

Discard gasket.

f. Remove screws (12), lock-washers (13), and brackets (14).



6-26.3. LUBE OIL DISTRIBUTION SYSTEM - MAINTENANCE INSTRUCTION

(Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION

2.

WARNING

Wear eye goggles for protection when using compressed air.

- a. Clean all parts in clean fuel oil and dry with compressed air.
- b. Inspect all parts for wear or damage.

INSTALLATION

3.

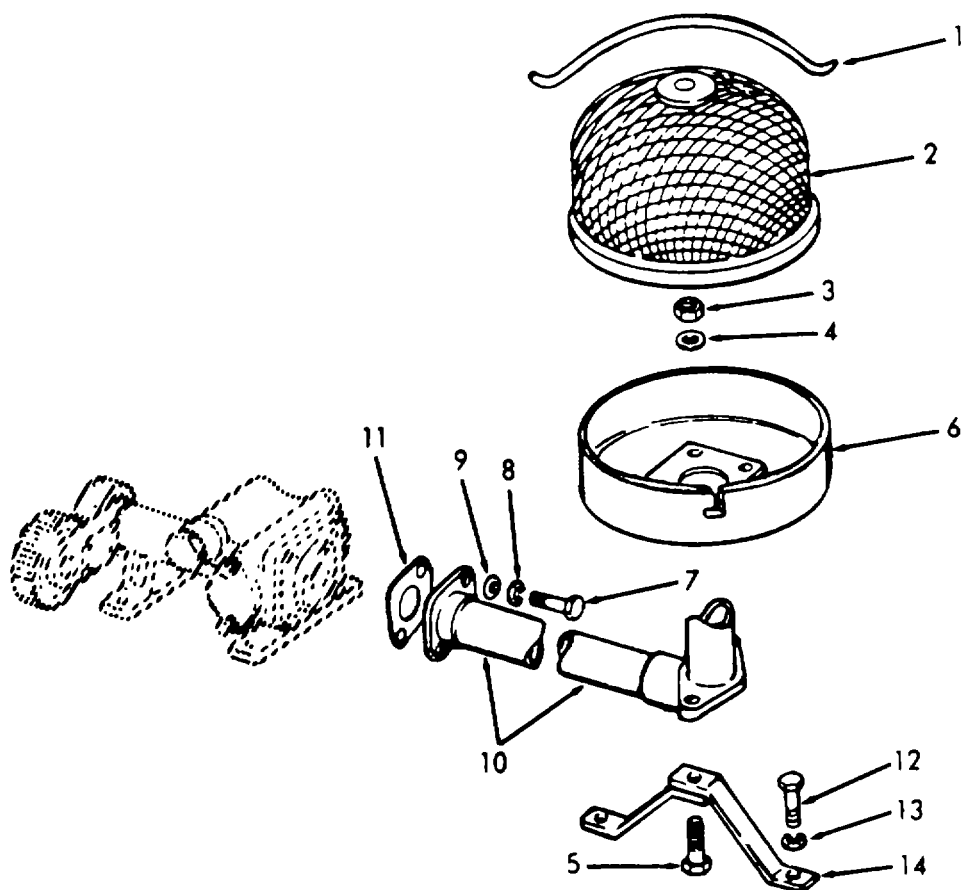
- a. Install brackets (14), screws (12), and lockwashers (13).
- b. Reassemble inlet pipe (10), gasket (11), screws (7), lockwashers (8), and flatwashers (9).
- c. Reassemble screws (5), cover (6), nuts (3), and lockwashers (4).
- d. Reassemble screen (2), and retainer (1).

Use new gasket.

6-26.3. LUBE OIL DISTRIBUTION SYSTEM - MAINTENANCE INSTRUCTION
(Continued)

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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6-27. PISTONS, CONNECTING RODS, AND LINERS .

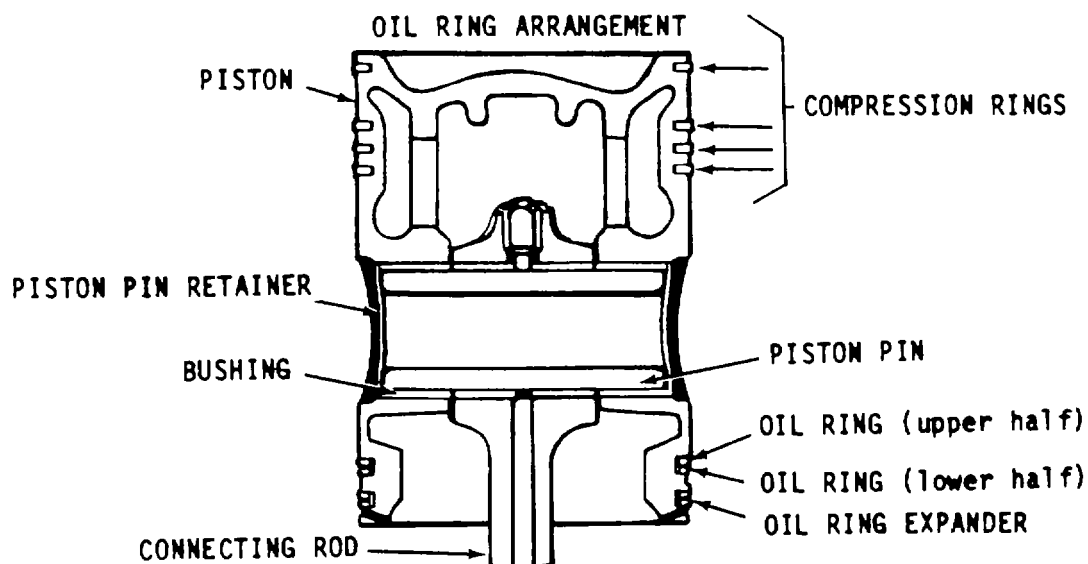
DESCRIPTION	PARAGRAPH
Piston	6-27.1
Connecting Rods	6-27.2
Connecting Rod Bearings	6-27.3
Cylinder Liner	6-27.4

6-27.1. PISTON - MAINTENANCE INSTRUCTIONS .

a. The trunk-type malleable iron piston is plated with a protective coating of tin which permits close fitting, reduces scuffing and prolongs piston life. The top of the piston forms the combustion chamber bowl and is designed to compress the air into the close proximity to the fuel spray.

b. Each piston is internally braced with fin-shaped ribs and circular struts, scientifically designed to draw heat rapidly from the piston crown and transfer it to the lubricating oil spray to ensure better control of piston ring temperature.

c. The piston is cooled by a spray of lubricating oil directed at the underside of the piston head from a nozzle in the top of the connecting rod, by fresh air from the blower to the top of the piston and indirectly by the water jacket around the cylinder.



d. Each piston is balanced to close limits by machining a balancing rib, provided on the inside at the bottom of the piston skirt.

6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

e. Two bushings, with helical grooved oil passages, are pressed into the piston to provide a bearing for the hardened, floating piston pin. After the piston pin has been installed, the hole in the piston at each end of the pin is sealed with a steel retainer. Thus lubricating oil returning from the sprayed underside of the piston head and working through the grooves in the piston pin bushings is prevented from reaching the cylinder walls.

f. Each piston is fitted with compression rings and oil control rings. Eight equally spaced drilled holes just below each oil control ring groove permit excess oil, scraped from the cylinder walls, to return to the crankcase.

g. When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

h. The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to the extent that the plating or grooves are gone, compression should be within operating specifications.

i. Excessively worn or scored pistons, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid a recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

j. Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick.

k. Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

This task covers:

- | | | |
|-------------------|----------------|-----------------|
| a. Pre-Inspection | c. Disassembly | e. Reassembly |
| b. Removal | d. Inspection | f. Installation |

INITIAL SETUPTest Equipment

Feeler gage
Spring scale

References

NONE

Special Tools

Assembly tool piston ring
J8128

EquipmentConditionParagraphCondition Description

6-25	Oil Pan removed
5-15	Cylinder Head removed
6-26.1	Lube Oil Pump removed
6-26.3	Oil Inlet: Pipe removed

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Cleaning solvent P-D-680
Engine oil

Special Environmental Conditions

Do not drain oil in bilges. Use
oil separation and recovery
system to collect drained oil.

Personnel Required

2

General Safety Instructions

Observe all WARNINGS in procedure.

LOCATION/ITEM**ACTION****REMARKS****PRE-INSPECTION**

- | | | |
|-----------------------------------|--|------------------|
| 1. Piston
Compression
Rings | a. Remove air box covers, nuts,
flatwashers, lockwashers,
covers, and gaskets. | Discard gaskets. |
| | b. Observe cylinder liners.
Check that piston rings are
free, and are not worn to the
extent that plating or grooves
are gone. | |

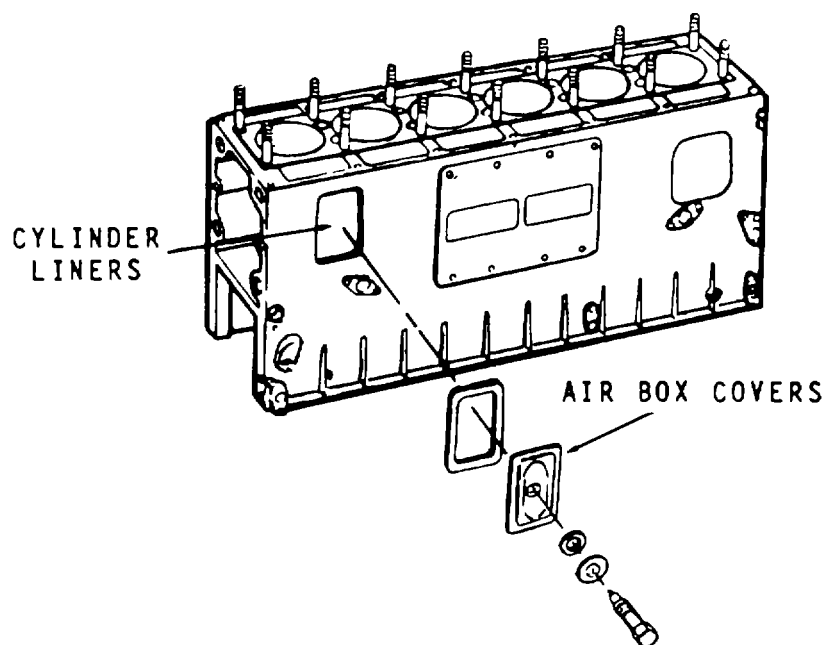
6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM

ACTION

REMARKS

PRE-INSPECTION (Cont)



REMOVAL

2. Piston and Connecting Rod

a. Drain cooling system.

b. Remove oil. Then remove oil pan.

c. Remove oil inlet pipe.

d. Remove lube oil pump.

e. Remove cylinder head.

Pump oil into a suitable container. Refer to paragraph 6-25.

Refer to paragraph 6-26.3.

Refer to paragraph 6-26.1.

Refer to paragraph 5-15.

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM

ACTION

REMARKS

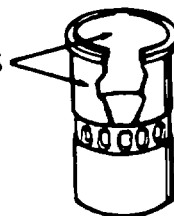
REMOVAL (Cont)

- f. Remove the carbon deposits from the upper inner surface of the cylinder liner. Use a ridge cutter to remove any ridge in the cylinder liner at the top of the piston ring travel.

NOTE

Move the piston to the bottom of its travel and place a cloth over the top of the piston to collect the cuttings. After the ridge has been removed, turn the crankshaft to bring the piston to the top of its stroke and carefully remove the cloth with the cuttings.

REMOVE CARBON DEPOSITS



- g. Remove nut (1), bearing cap (2), and lower bearing shell (3).
- h. Push the piston and rod assembly out through the top of the cylinder block.
- i. Reassemble lower bearing shell (3), bearing cap (2), and nuts (1) to connecting rod.

The piston cannot be removed from the bottom of the cylinder block.

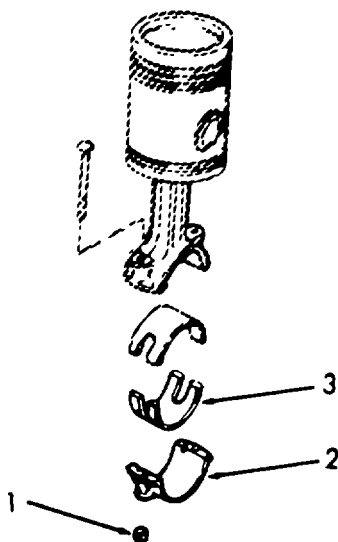
6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



DISASSEMBLY

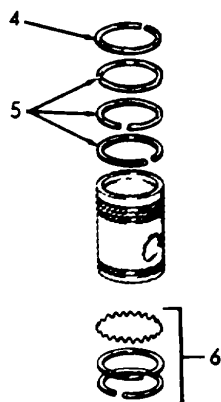
3. Piston and Connecting Rod

- a. Place piston and connecting rod assembly in a vise with soft jaws.
- b. Remove ring (compression fire) (4).
- c. Remove three compression rings (5).
Remove oil rings (6).

Use tool J8128.

Use tool J8128.

Use tool J8128.



6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

- e. Punch a hole through the center of one of the piston pin retainers (9), with a narrow chisel or punch and pry the retainer from the piston.

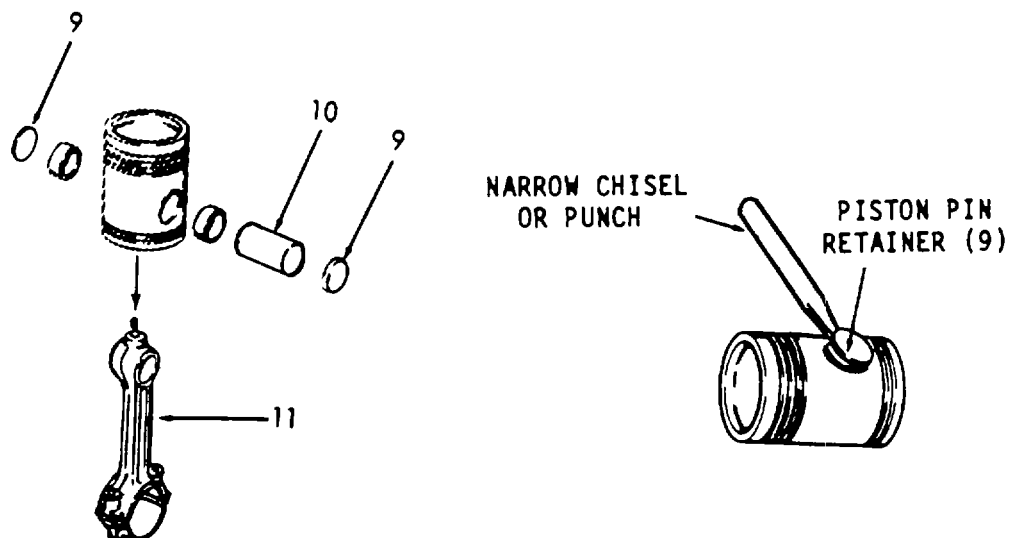
Be careful not to damage the piston or bushings.

- f. Remove piston pin (10).

- g. Remove connecting rod (11).

- h. Drive out remaining piston pin retainer (9).

Use a brass rod or a suitable tool.

**CAUTION**

Do not remove the bushings from the piston. They are not serviced separately.

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM

ACTION

REMARKS

CLEANING

4. Piston
Component

WARNING

- Dry cleaning solvent, P-D-680, used to clean parts, is potentially dangerous to personnel and property. Avoid repeated or prolonged skin contact. Do not use near open flame or excessive heat. Flash point of solvent is 100° - 138°F (38° - 59°C).
- Wear protective eye goggles when using compressed air.
 - a. Clean the piston components with fuel oil and dry them with compressed air. If fuel oil does not remove the carbon deposits, use a chemical solvent P-D-680 that will not harm the piston pin bushings or the tin-plate on the piston.
 - b. The upper part of the piston, including the compression ring lands and grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. However, use care to avoid damage to the tin-plating on the piston skirt. Clean the ring grooves with a suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

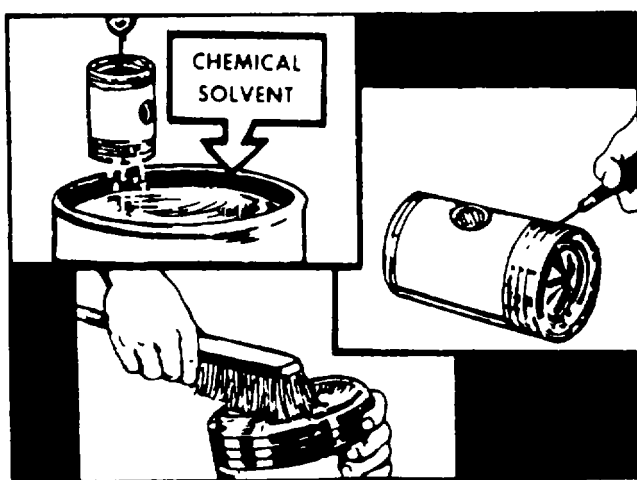
LOCATION/ITEM

ACTION

REMARKS

CLEANING (Cont)

- c. Clean the inside surfaces of the piston and the oil drain holes in the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.



INSPECTION

5. Piston

- a. If the tin-plate on the piston and the original grooves in the piston rings are intact, it is an indication of very little wear.
- b. Examine the piston for score marks, cracks, damaged ring groove lands or indications of overheating. A piston with light score marks which can be cleaned up may be reused. Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots on the piston may be the result of an obstruction in the connecting rod oil passage.

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

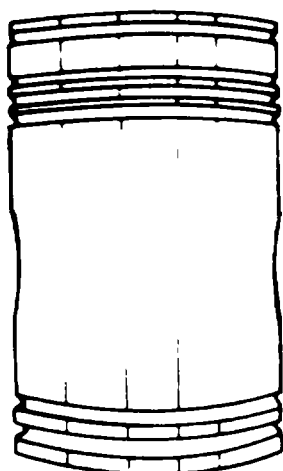
LOCATION/ITEM

ACTION

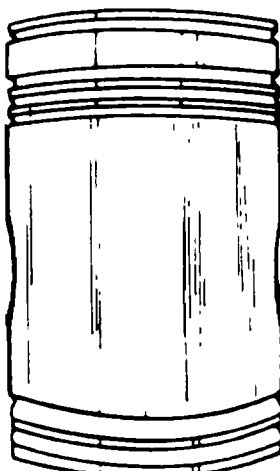
REMARKS

INSPECTION (Cont)

- c. Replace the piston if cracks are found across the internal struts. Use the magnetic particle inspection method for locating cracks in the piston.



THIS PISTON SUITABLE FOR INSTALLATION AS IS.



SLIGHTLY SCORED. USE ONLY AFTER REMOVING SCORE MARKS BY POLISHING WITH CROCUS CLOTH OR HARD INDIA STONE.



BADLY SCORED. UNFIT FOR USE.

6. Cylinder Liner and Block Bore

Check the cylinder liner and block bore for excessive out-of-round, taper or high spots which could cause failure of the piston.

Refer to paragraph 6-27.4.

7. Connecting Rod and Piston Pin

Inspect.

Refer to paragraph 6-27.2.

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

- | | | |
|-----------------------|--|--|
| 8. Piston Pin Bushing | <p>If the piston is to be reused, measure the piston pin bushings and the piston pin. The inside diameter of a new bushing in the piston is 1.5025 inches to 1.5030 inches (3.8164 cm to 3.8176 cm), and the outside diameter of a new piston pin is 1.4996 inches to 1.5000 inches (3.8090 cm to 3.8100 cm). The piston pin-to-bushing clearance with new parts is .0025 inch to .0034 inch (0.0064 cm to 0.0086 cm). A maximum clearance of .010 inch (0.025 cm) is allowable with worn parts.</p> | |
| 9. Other | <p>Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).</p> | |

CAUTION

Do not remove the bushings from the piston. They are not serviced separately.

REASSEMBLY

- | | |
|---------------------|--|
| 10. Piston fitting. | <p>a. Piston and cylinder liner</p> <p>(1) Measure the piston skirt diameter lengthwise and crosswise of the piston pin bore. Measurements should be</p> |
|---------------------|--|

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM	ACTION		REMARKS			
<div>REASSEMBLY (Cont)</div>						
	taken at room temperature (70°F or [21 C]). The taper and out-of-round measured from a point 1.88 inch (4.78 cm) from the top of the piston to the bottom of the piston must not exceed .0005 inch (0.0013 cm). Refer to table below for piston diameter specifications.					
ENGINE PARTS (Standard Size, New)	MINIMUM (inches)	(cm)	MAXIMUM (inches)	(cm)	LIMITS (inches)	(cm)
Piston:						
Height (centerline of bushing to top)	3.5430	8.9992	3.5480	9.0119		
Diameter (above compression rings)	4.2225	10.7252	4.2255	10.7328		
Diameter (at skirt)	4.2428	10.7767	4.2450	10.7823		
Clearance--piston skirt-to-liner ... ..	.0045	.0114	.0083	.0211	.0120	.0305
Out-of-round .....		.0005		.0013		
Taper .....		.0005		.0013		
Compression rings:						
Gap (top-fire ring) .....	.0230	.0584	.0380	.0965	.0600	.1524
Gap (No. 2, 3 and 4) .....	.0180	.0457	.0430	.1092	.0600	.1524
Clearance--ring-to-groove:						
No. 1 (top-fire ring) .....	.0040	.0102	.0060	.0152	.0180	.0457
No. 2 .....	.0100	.0254	.0130	.0330	.0220	.0559
No. 3 and 4 .....	.0040	.0102	.0070	.0178	.0130	.0330
Oil control rings:						
Gap ..	.0080	.0203	.0230	.0584	.0430	.1092
Clearance .....	.0015	.0038	.0055	.0140	.0080	.0203

6-27.1. PISTON - MAINTENANCE INSTRUCTION (Continued)

LOCATION/ITEM	ACTION	REMARKS
REASSEMBLY (Cont)		
(	<p>(2) A new cylinder liner has an inside diameter of 4.2495 to 4.2511 inch (10.7937 to 10.7978 cm). The piston-to-liner clearance, with new parts, will vary with the particular piston diameter. A maximum clearance of .012 inch (0.031 cm) is allowable with used parts.</p> <p>(3) With the cylinder liner installed in the cylinder block, hold the piston upside down in the liner and check the clearance in four places 90° apart.</p> <p>(4) Use feeler gage set to check the clearance. The spring scale, attached to the proper feeler gage, is used to measure the force in pounds required to withdraw the feeler gage.</p> <p>(5) Select a feeler gage with a thickness that will require a pull of six pounds (26.7 N) to remove. The clearance will be .001 inch (0.003 cm) greater than the thickness of the gage used, i.e., a .004 inch (0.010 cm) feeler gage will indicate a clearance of .005 inch (0.013 cm) when it is withdrawn with a pull of six pounds (26.7 N). The feeler gage must be perfectly flat and free of nicks and bends.</p>	

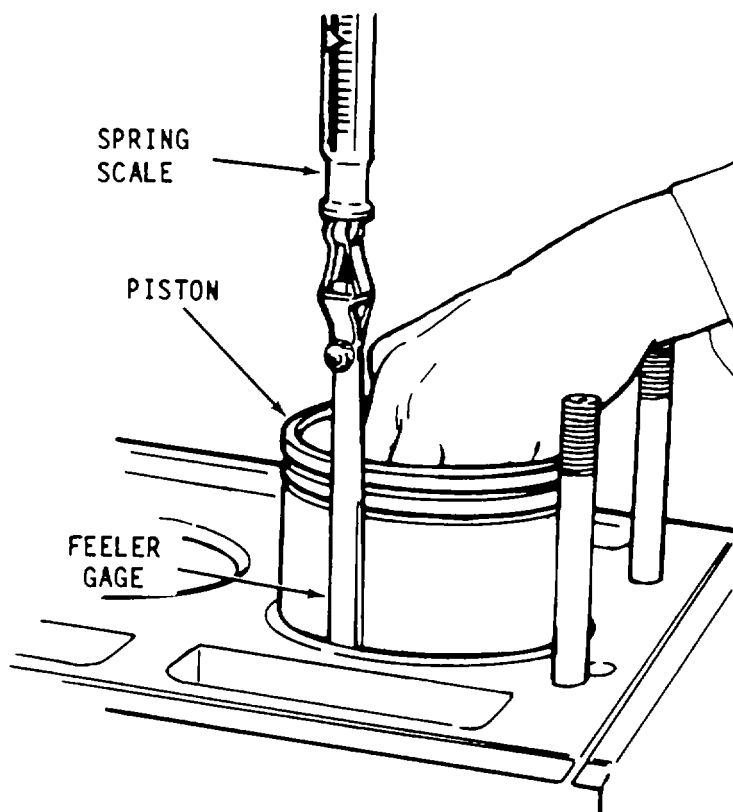
6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)



- (6) If any bind occurs between the piston and the liner, examine the piston and liner for burrs. Remove burrs with a fine hone (a flat one is preferable) and check the clearance.

b. Piston ring fitting.

- (1) Each piston is fitted with a fire ring, three compression rings and two oil control rings.

6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

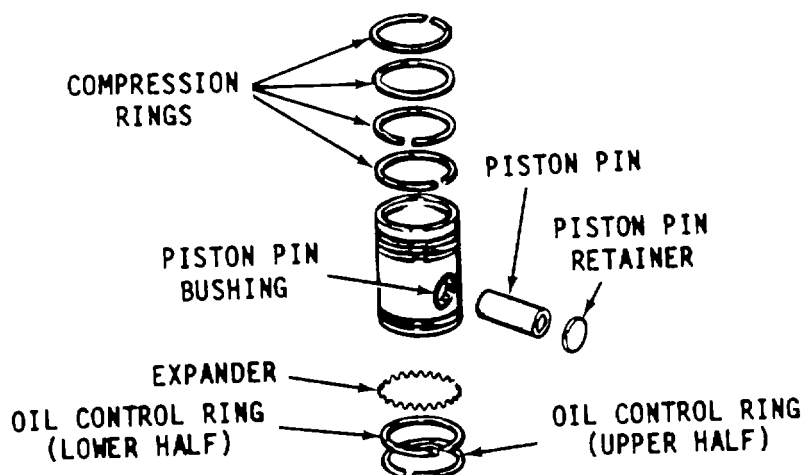
LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

- (2) The top compression (fire) ring can be identified by the bright chrome on the bottom side and black oxide or copper color on the top. The pre-stressed fire ring is further identified by an oval mark.



- (3) A pre-stressed compression ring is also used in the ring groove immediately below the fire ring.
- (4) A two-piece oil control ring is used in both oil ring grooves in the piston and a peripheral abutment type oil ring expanders.

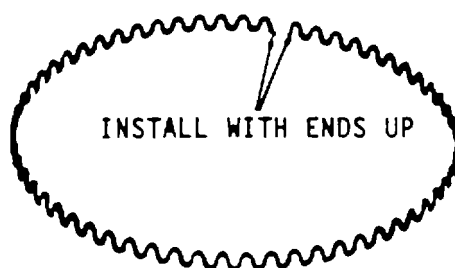
6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

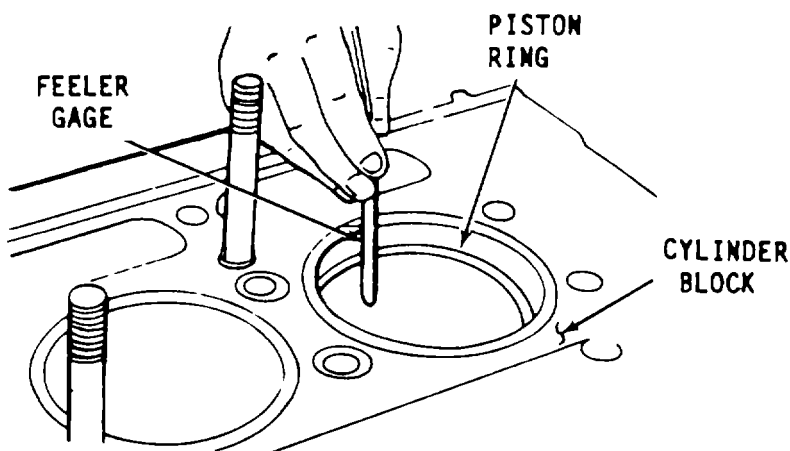
REMARKS

REASSEMBLY (Cont)



PERIPHERAL ABUTMENT

- (5) All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used piston or cylinder liner is installed.
- (6) Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of ring travel. Use a piston to push the ring down to be sure it is parallel with the top of the liner. Then measure the ring gap with a feeler gage. Refer to ring gap specifications.



6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

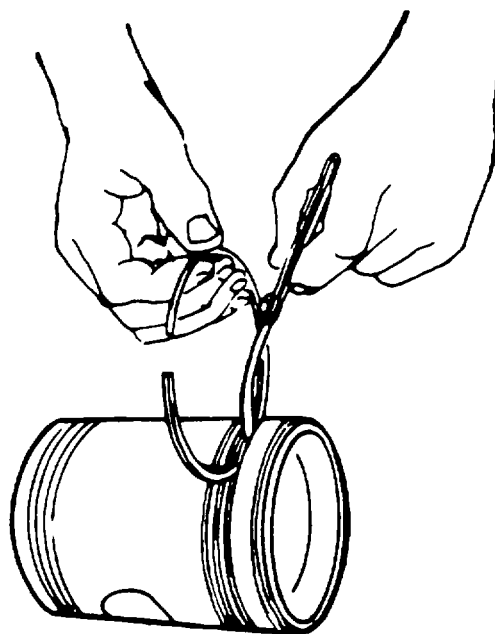
LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

- (7) If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is from the outer surface to the inner surface. This will prevent any chipping or peeling of the chrome plate on the ring. The ends of the ring must remain square and the chamfer on the outer edge must be approximately .015 inch (0.038 cm).
- (8) Check the ring side clearance as shown. Refer to ring side clearances.



6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

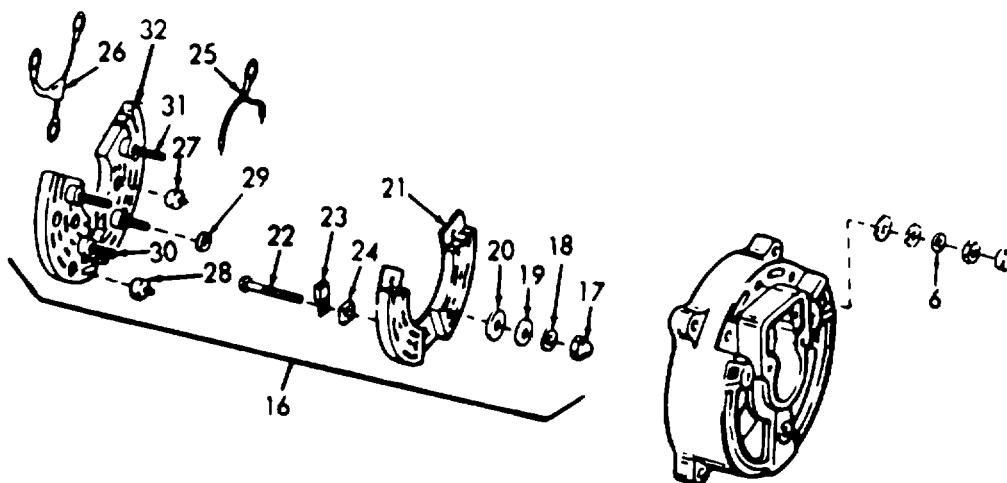
REASSEMBLY (Cont)

- c. Assemble piston and connecting rod.
- d. Lubricate piston and all piston rings before installation. Use engine oil.
- e. Install compression rings (5) starting with the bottom ring. Use tool J8128.

CAUTION

To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston.

- f. Install compression fire ring (4). Use tool J8128.



6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

CAUTION

When installing the top compression (fire) ring, be sure tapered face marked "T" or "top" is toward the top of the piston.

- | | | |
|----|---|-------------------------|
| g. | Stagger compression rings (4 and 5) gaps around the piston. | Rotate rings on piston. |
| h. | Install ring expander (7) in oil control ring groove. Install with the legs of the free ends toward the top of the piston. With the free ends pointing up, a noticeable resistance will be encountered during installation of the piston if the ends of the expander are overlapped and corrective action can be taken before ring breakage occurs. | |

CAUTION

When installing the oil control rings, use care to prevent overlapping the ends of the ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control rings and result in high lubricating oil consumption.

- i. Install the upper and lower halves of the oil control rings (8). Install by hand. Do not use tool. Install the upper half with the gap 180° from the gap in the expander. Then install the lower half with the gap 45° from the gap in the upper half of the ring. Make sure the scraper edges are facing down (toward the bottom of the piston).

6-27.1. PISTON - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

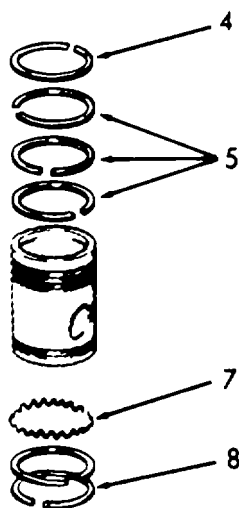
ACTION

REMARKS

REASSEMBLY (Cont)

NOTE

- The upper oil control ring is chrome-flashed on the sides, in addition to chrome-plate on the face.
- The scraping edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.
- If there is a noticeable resistance during installation of the piston, check for an over-lapped ring expander.



INSTALLATION

11. Piston,
Connecting
Rod and
Cylinder
Liner

For installation refer to
Paragraph 6-27.4.

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS

- a. Each connecting rod (trunk-type piston) is forged to an "I" section with a closed hub at the upper end and a bearing cap at the lower end. The connecting rod is drilled to provide lubrication to the piston pin at the upper end and is equipped with a nozzle to spray cooling oil to the underside of the piston head. An orifice is pressed into a counterbore at the lower end of the oil passage to meter the flow of oil.
- b. A helically-grooved bushing is pressed into each side of the connecting rod at the upper end. The cavity between the inner ends of these bushings registers with the drilled oil passage in the connecting rod and forms a duct around the piston pin. Oil entering this cavity lubricates the piston pin bushings and is forced out the spray nozzle to oil the piston. The piston pin floats in the bushings of both the piston and connecting rod.
- c. This paragraph also includes assembly of the piston onto a connecting rod.

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).**LOCATION/ITEM****ACTION****REMARKS**

This task covers:

- a. Removal
- b. Cleaning

- c. Inspection
- d. Disassembly

- e. Reassembly
- f. Assembly

INITIAL SETUPTest Equipment

NONE

References

NONE

Special Tools

Remover connecting rod
 spray nozzle J8995
 Reamer set, connecting
 rod bushing J1686-03
 Installer and remover set
 piston and connecting
 rod J1513-02 (part J7032)
 Holder J7632

Equipment
Condition
Paragraph
Condition Description

6-25	Oil Pan removed
5-15	Cylinder Head removed
6-26.1	Lube Oil Pump removed
6-26.3	Oil Inlet Pipe removed
6-26.1	Piston removed

Tools

General Mechanic's Tool Kit
 NSN 5180-00-629-9783

Material/Parts

Cylinder kit P/N 5149262
 Engine oil

Special Environmental Conditions

Do not drain oil in bilges. Use
 oil separation and recovery system
 to collect drained oil.

Personnel Required

1

General Safety Instructions

Observe all CAUTIONS and WARNINGS.

LOCATION/ITEM**ACTION****REMARKS****REMOVAL**

1. Engine

- a. Remove oil from oil pan, then
 remove.

Pump oil into
 a suitable
 container.
 Refer to para-
 graph 6-25.

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

- | | | |
|----|------------------------|----------------------------|
| b. | Remove oil inlet pipe. | Refer to paragraph 6-26.3. |
| c. | Remove lube oil pump. | Refer to paragraph 6-26.1. |
| d. | Remove cylinder head. | Refer to paragraph 5-15. |

2. Connecting Rod(s)

NOTE

The connecting rod bearing caps are numbered 1, 2, etc., with matching numbers stamped on the connecting rods. When removed, each bearing cap and the bearing shells must always be reinstalled on the original connecting rod.

- | | | |
|----|--|---------------------------------|
| a. | Remove nuts (1). | |
| b. | Remove bearing cap (2). | |
| c. | Push connecting rod (3) and piston assembly up into the cylinder liner. | |
| d. | Remove bolts (4). | |
| e. | Remove upper bearing shell (5) from connecting rod. shell with sharp tool. | Do not pound on edge of bearing |
| f. | Remove lower bearing shell (6), if necessary. shell with sharp tool. | Do not pound on edge of bearing |
| g. | Disassemble piston. | Refer to paragraph 6-27.1. |

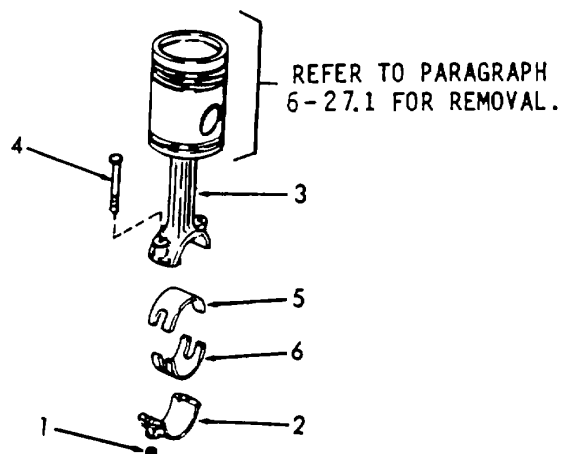
6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



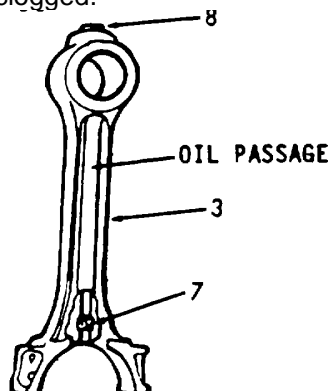
CLEANING

3. Connecting Rod

WARNING

Wear protective eye goggles when using compressed air.

Clean the connecting rod (3) and piston pin with fuel oil and dry them with compressed air. Blow compressed air through the drilled oil passage in the connecting rod to be sure the orifice (7), oil passage and spray nozzle (8) are not clogged.



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION		
4. Connecting Rod	Inspect connecting rod (3) for cracks. Magnetic particle is the preferred method.	
5. Connecting Rod Bushings	Check the connecting rod bushings (9) for indications of scoring, overheating or other damage. Bushings that have overheated may become loose and creep together, thus blocking off the supply of lubricating oil to the piston pin and spray nozzle.	
6. Piston Pin	<p>Inspect the piston pin (10) for signs of fretting. Bushings that have overheated may become loose and creep together, thus blocking off the supply of lubricating oil to the piston pin and spray nozzle.</p> <p>When reusing a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear.</p> <p>Since it is subjected to downward loading only, free movement of the piston pin is desired to secure perfect alignment and uniform wear. Therefore, the piston pin is assembled with a full floating fit in the connecting rod and piston bushings, with relatively large clearances. Worn piston pin clearances up to .010 inch (.025 cm) are satisfactory.</p>	

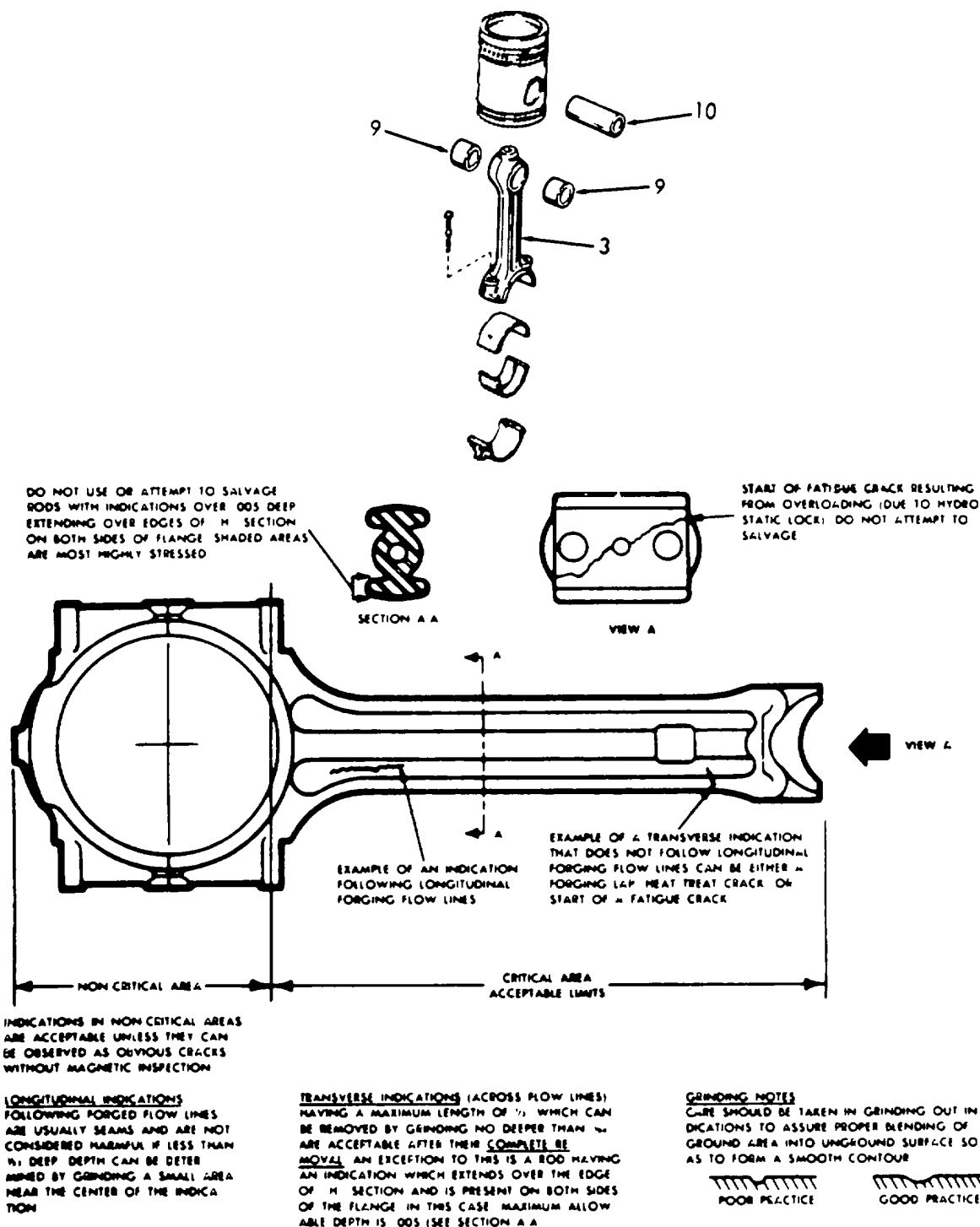
6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSPECTION (Cont)



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
7. Bushings	Clamp under end of connecting rod (3) in holder, so that bore in the bushings is aligned with the hole in the base of the holder. Place bushing remover in the connecting rod bushing. Insert handle in the remover and drive the bushings (9) from the rod (3).	Use tools J7632, J1513-2, and J1513-3 when installing bushings on connecting rod.
8. Spray Nozzle (8)	<p>a. Remove connecting rod bushings (9).</p> <p>b. Insert spray nozzle remover through the upper end of the connecting rod and insert the pin, in the curved side of the tool, in the opening in the bottom of the spray nozzle (8). Support the connecting rod and tool in an arbor press. Place a short sleeve directly over the spray nozzle. Then press the nozzle out of the connecting rod. Remove the tool.</p>	<p>Refer to step 7.</p> <p>Use tool J8995.</p>

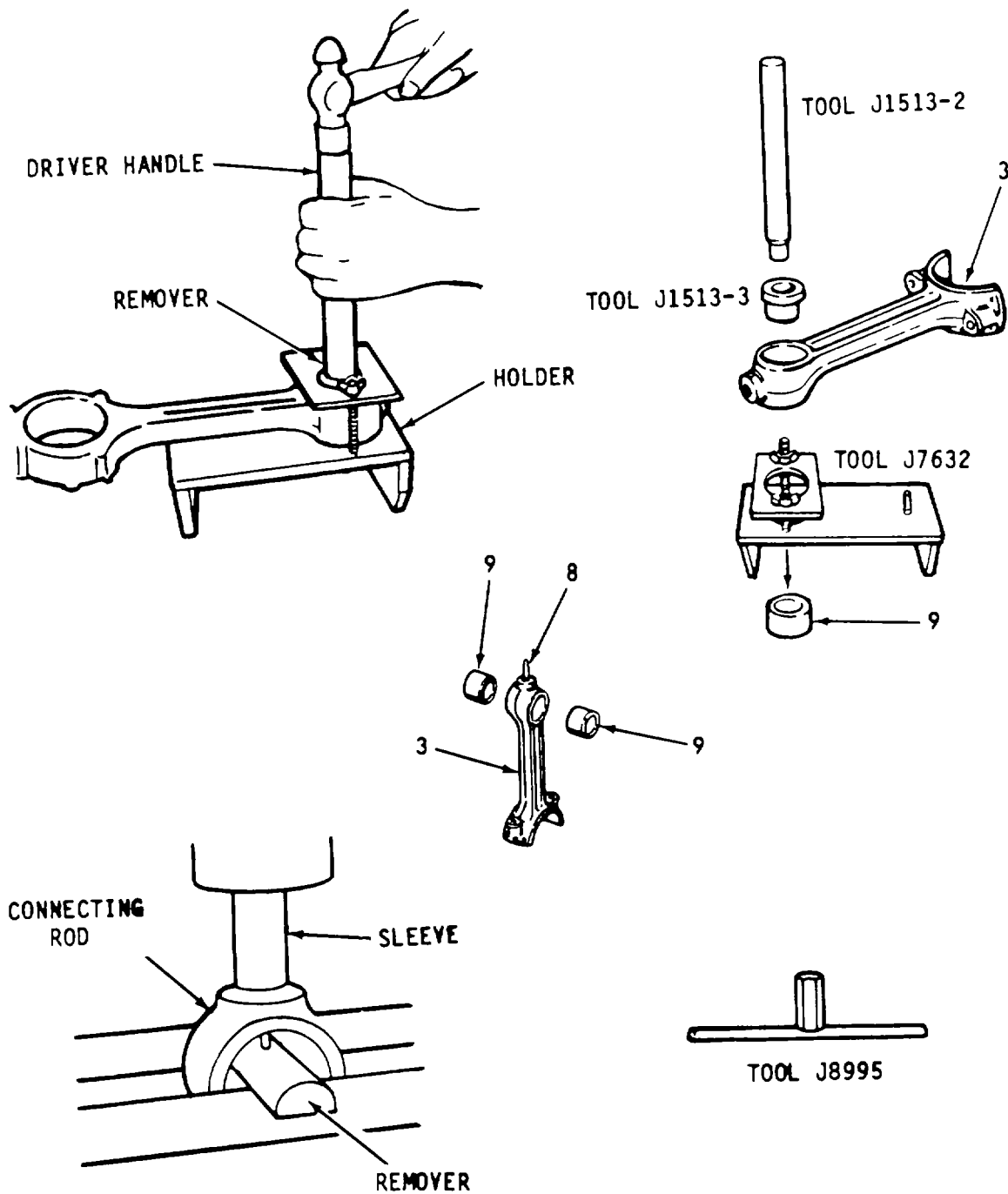
6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

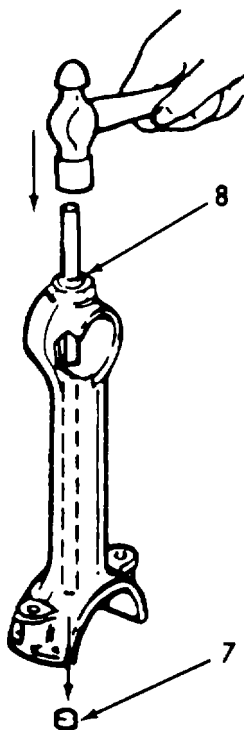
LOCATION/ITEM

ACTION

REMARKS

DISASSEMBLY (Cont)

9. Orifice (7)
- Remove spray nozzle (8).
 - Insert a rod in the oil passage and drive the orifice (7) from the lower end of the connecting rod.



REASSEMBLY

10. Orifice

Install orifice (7) in the upper bearing area.

Install orifice
0.3125 inch
(0.7938 cm) from
lower surface.

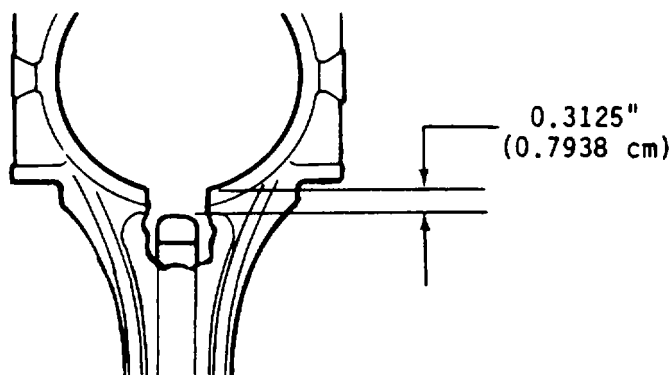
6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

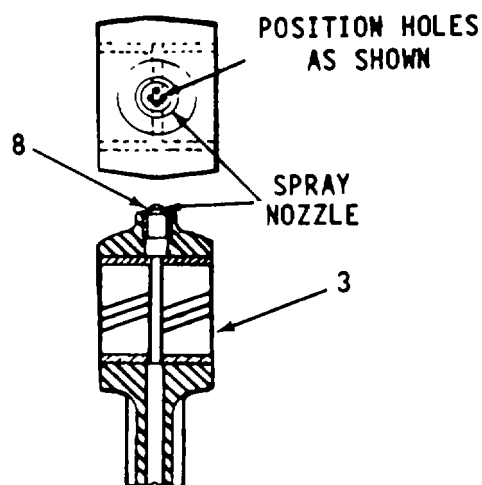
REASSEMBLY (Cont)



11. Spray Nozzle

- a. Insert spray nozzle (8) straight into counterbore of connecting rod (3).
- b. Support the connecting rod in the arbor press. Place a short 3/8 inch I.D. sleeve on top of the nozzle and press the nozzle into the connecting rod until it bottoms in the counterbore.

Align holes in spray nozzle as shown.



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

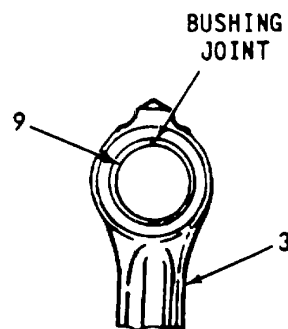
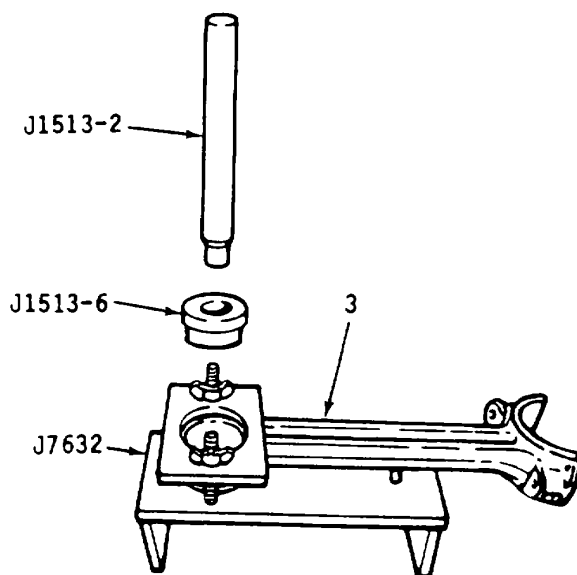
12. Bushings

- a. Clamp upper end of connecting rod (3) assembly in holder.

Use tool J7632. Align the bore of the bushing with the hole in the base of the tool.

- b. Start a new bushing (9) straight into the bore of the connecting rod, with the bushing joint at the top of the rod. Insert installer in bushing, Then insert handle in the installer. Drive the bushing in until the flange of the installer bottoms on the connecting rod.

Use installer tool J1513-6, and handle tool J1513-2.



- c. Turn the connecting rod (3) over in the holder and install the second bushing in the same manner.

NOTE

The bushings must withstand an end load of 2000 pounds (907 kg) without moving after installation.

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

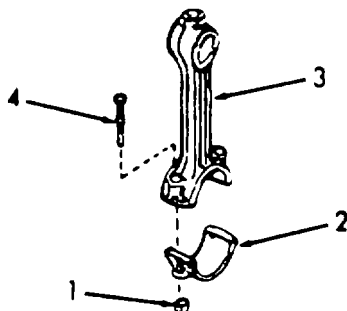
ACTION

REMARKS

REASSEMBLY (Cont)

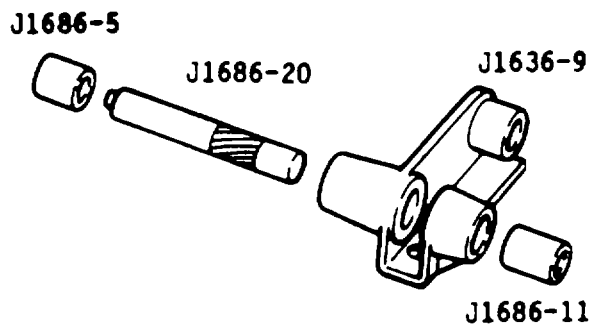
13. Bushing
Reaming

- a. Assemble connecting rod (3), bolts (4), bearing cap (2), and nuts (1).



- b. Ream the bushing to size, using tool set J1686-03, as follows:

- (1) Clamp reaming fixture J1686-9 in a bench vise.
- (2) Position sleeve adapter J1686-13 on the arbor of the fixture.



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

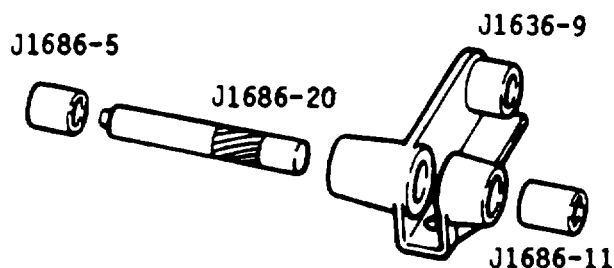
LOCATION/ITEM

ACTION

REMARKS

REASSEMBLY (Cont)

- (3) Place the crankshaft end of the connecting rod on the arbor of the fixture and tighten the connecting rod cap nuts to 60-70 lb-ft (81-95 Nm) torque (lubrite nut) or 65-75 lb-ft (88-102 Nm) torque (plain nut).
- (4) Slide the front guide bushing J1686-11 (with the pin end facing out in the fixture).
- (5) Align the upper end of the connecting rod with the hole in the reaming fixture.
- (6) Install the rear guide bushing J1686-5 on reamer J1686-20, then slide the reamer and bushing into the fixture.



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continue d).

LOCATION/ITEM	ACTION	REMARKS
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REASSEMBLY (Cont)

- (7) Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For best results, use only moderate pressure on the reamer.
- (8) Remove the reamer and the connecting rod from the fixture, blow out the chips and measure the inside diameter of the bushings. The inside diameter of the bushings must be 1.5015 to 1.5020 inch (3.8138 to 3.8151 cm). This will provide a piston pin-to-bushing clearance of .0015 to .0024 inch (0.0038 to 0.0061 cm) with a new piston pin. A new piston pin has a diameter of 1.4996 to 1.5000 inch (3.8090 to 3.8100 cm).

NOTE

Piston bushings are installed in piston (refer to paragraph 6-27.1).

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY		
14. Connecting Rod to Piston	a. Lubricate piston pin (10), piston bushings (12), and connecting rod bushings (9).	Use clean engine oil. Refer to paragraph 6-27.1.
	b. Place piston (11) in holding fixture.	Use tool J1513-1.
	c. Place piston pin retainer (13) on piston, then place crowned end of installer against the retainer. Place handle on installer. Strike the handle enough to deflect the retainer and seat it evenly in the piston.	Use tools J1513-4, and J1513-2

CAUTION

Do not drive the retainer in too far or the piston bushing may be moved inward and result in reduced piston pin end clearance.

- | | |
|--|---------------------------------------|
| <p>d. Place the upper end of the connecting rod (3) between the piston pin bosses and in line with the piston pin holes.</p> <p>e. Slide the piston pin (10) in place. If the piston pin-to-bushing clearances are within the specified limits, the pin will slip into place without the use of force.</p> <p>f. Place piston pin retainer (13) on piston; then place crowned end of installer against the retainer. Place handle on installer. Strike the handle just hard enough to deflect the retainer and seat it evenly in the piston.</p> | <p>Use tools J1513-4 and J1513-2.</p> |
|--|---------------------------------------|

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

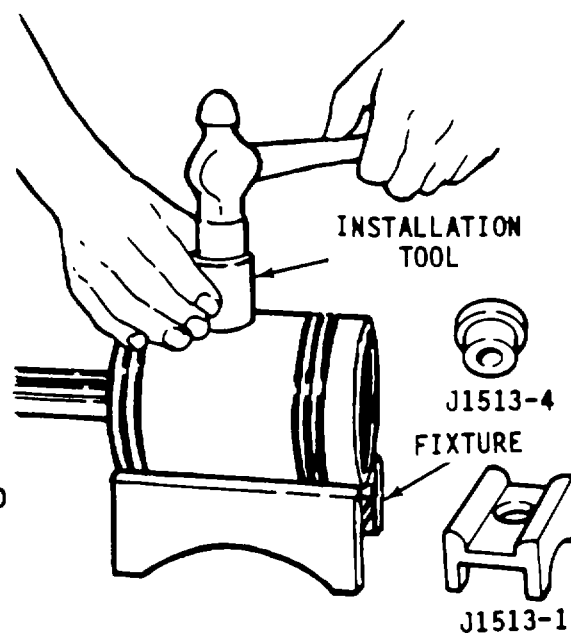
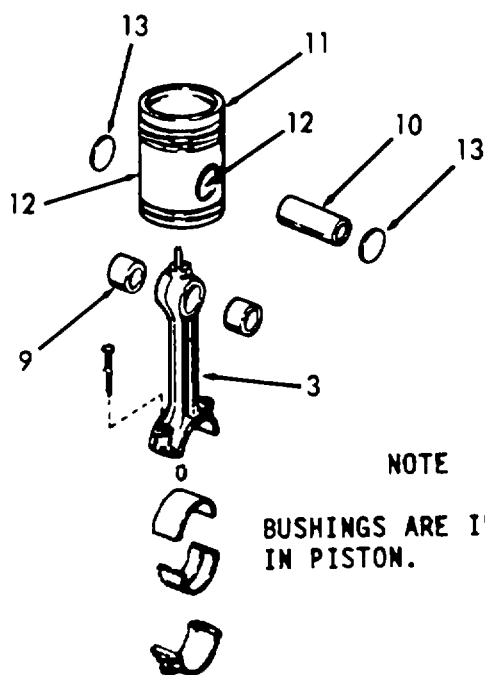
REMARKS

ASSEMBLY (Cont)

CAUTION

Do not drive the retainer in too far or the piston bushing may be moved inward and result in reduced piston pin end clearance.

- g. After the piston pin retainers have been installed, check for piston pin (10) end clearance by cocking the connecting rod (3) and shifting the pin in its bushings.



6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

- h. One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushings, from reaching the cylinder walls. Check the retainers for proper sealing as follows:
- (1) Place the piston and connecting rod assembly upside down on a bench.
 - (2) Pour clean fuel oil in the piston to a level above the piston pin bosses.
 - (3) Dry the external surfaces of the piston in the area around the retainers and allow the fuel oil to set for about fifteen minutes.
 - (4) Check for seepage of fuel oil around the retainers. If the fuel oil leaks around the retainers, install new retainers. In extreme cases it may be necessary to replace the piston.

6-27.2. CONNECTING ROD - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY (Cont)

WARNING

Wear protective eye goggles when using compressed air.

- (5) After the leakage test is completed, empty the fuel oil from the piston, dry the parts with compressed air and lubricate the piston pin with clean engine oil.
 - i. Assemble piston and connecting rod assembly, and cylinder liner.
- Refer to paragraph 6-27.4.

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS.

a. The connecting rod bearing shells are precision made and are replaceable with shim adjustments. They consist of an upper bearing shell seated in the connecting rod and a lower bearing shell seated in the connecting rod case. The bearing shells are prevented from endwise or radial movement by a tang at the parting line at one end of each bearing shell.

b. Multiple layer copper-lead coplating or aluminum triplating bearings are used. These bearings have an inner surface (matrix), of copper-lead or aluminum. A thin deposit of babbitt is plated onto the matrix. This babbitt overlay has excellent resistance to friction, corrosion and scoring tendencies which, combined with the material of the matrix, provides improved load carrying characteristics. These bearings are identified by the satin silver sheen of the babbitt when new and a dull gray after being in service.

c. The upper and lower connecting rod bearing shells are different and are not interchangeable. Both shells are notched midway between the bearing edges approximately 3/4 of an inch in from each parting line. The lower bearing shell has a circumferential oil groove that terminates at the notched ends. These notches maintain a continuous registry with the oil hole in the crankshaft connecting rod journal, and provide a constant supply of lubricating oil to the connecting rod bearings, piston pin bushings and spray nozzle through the oil passage in the connecting rod.

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).**LOCATION/ITEM****ACTION****REMARKS**

This task covers:

a. Removal

b. Inspection

c. Installation

INITIAL SETUP**Test Equipment**

Micrometer

References

NONE

Special Tools

Torque wrench

**Equipment
Condition
Paragraph****Condition Description**

6-25

Oil Pan and Dipstick Removal

6-26.1

Lubricating Oil Pump Removal

ToolsGeneral Mechanic's Tool Kit
NSN 5180-00-629-9783

6-26.3

Lube Oil Distribution
System - Inlet Pipe Removal**Material/Parts**

Engine oil

Special Environmental ConditionsDo not drain oil in bilges. Use
oil separation and recovery
system to collect drained oil.**Personnel Required**

1

General Safety Instructions

NONE

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL

1. Engine

- a. Remove oil from oil pan.
Then remove oil pan.

Pump oil into a suitable container. Refer to paragraph 6-25.

- b. Remove oil inlet pipe.

Refer to paragraph 6-26.3.

- c. Remove lube oil pump.

Refer to paragraph 6-26.1.

2. Connecting Rod(s)

NOTE

The connecting rod bearing caps are numbered 1, 2, etc., with matching numbers stamped on the connecting rods. When removed, each bearing cap and the bearing shells must always be reinstalled on the original connecting rod.

- a. Remove nuts (1).
- b. Remove bearing cap (2).
- c. Push connecting rod (3) and piston assembly up into the cylinder liner.
- d. Remove upper bearing shell (4) from connecting rod.
- e. Remove lower bearing shell (5) from bearing cap (2)

Push far enough to permit access to upper bearing shell.

Do not pound on edge of bearing shell with sharp tool.

Do not pound on edge of bearing shell with sharp tool.

NOTE

Do not remove another bearing cap or bearing shells.

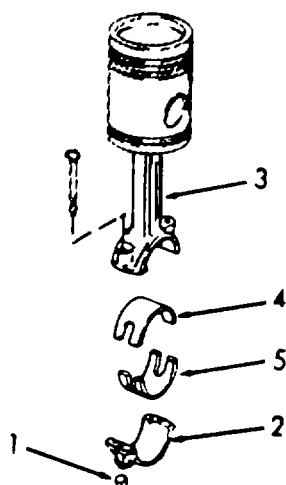
6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



INSPECTION

3. Bearing Shells

- a. Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low or no oil.

- (1) Clean the upper and lower bearing shells and inspect them for scoring, pitting, flaking, chipping, cracking, loss of babbitt or signs of overheating. If any

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

of these defects are present, the bearings must be discarded. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are NOT detrimental to this type of bearing. The bearing should not be replaced for these minor surface imperfections. The upper bearing shells, which carry the load, will normally show signs of distress before the lower bearing shells do.

- (2) Inspect the backs of the bearing shells for bright spots which indicate they have been shifting in their supports. If such spots are present, discard the bearing shells.
- (3) Measure the thickness of the bearing shells, using a micrometer and ball attachment. The minimum thickness of a worn standard connecting rod bearing shell should not be less than .1230 inch (0.3124 cm) and, if either bearing

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

shell is thinner than this dimension, replace both bearing shells. A new standard bearing shell has a thickness of .1238 to .1243 inch (0.3145 to 0.3157 cm).

4. Connecting Rod

Inspect bearing bore for burrs, foreign particles and so forth.

5. Crankshaft Journal

Check the clearance between the connecting rod bearing shells and the crankshaft journal. This clearance may be checked by means of a soft plastic measuring strip which is squeezed between the journal and the bearing. The maximum connecting rod bearing-to-journal clearance with used parts is .006 inch (0.015 cm).

INSTALLATION

6. Connecting Rod(s)

NOTE

Do not replace one connecting rod bearing shell alone. If one bearing shell requires replacement, install both new upper and lower bearing shells. Bearing shells are available in .010 inch, .020 inch, and .030 inch undersize for service with reground crankshafts.

6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)	a. Install the upper bearing shell (4) (the one without the continuous oil groove) in the connecting rod. Be sure the tang on the bearing shell fits in the groove in the connecting rod.	
	b. Wipe crankshaft journal clean and lubricate with clean engine oil.	
	c. Pull connecting rod and piston assembly down until the upper bearing seats firmly on the crankshaft journal.	
	d. Assemble bearing cap (2) and lower bearing shell (5).	Note the number stamped on the connecting rod and the bearing cap and install the lower bearing shell (the one with the continuous oil groove) in the bearing cap, with the tang on the bearing shell in the groove in the bearing cap.
	e. Install bearing cap (and lower bearing shell assembly) (2) and nuts (1).	Torque to 60-70 lb-ft (81-95 Nm) torque (lubrite nut) or 65-75 lb-ft (88-102 Nm) torque (castellated nut).

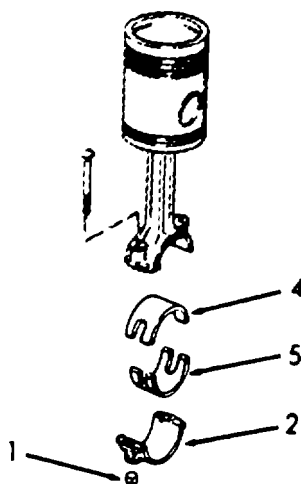
6-27.3. CONNECTING ROD BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSTALLATION (Cont)



f. Install lube oil pump.

Refer to
paragraph 6-26.1.

g. Install oil inlet pipe.

Refer to paragraph
6-26.3.

h. Install oil pan.

Refer to
paragraph 6-25.

i. Fill engine with oil.

Refer to
Lubrication
Oil Chart.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS.

a. The replaceable type cylinder liner is machined and heat treated to provide a long wearing scuff-resistant surface. The flange at the top fits into a counterbore in the cylinder block and rests on a replaceable cast iron insert which permits accurate alignment of the cylinder liner. Compression is sealed with an individual laminated compression gasket for each cylinder.

b. The liner is cooled by a water jacket in the cylinder block and by the scavenging air introduced into the cylinder through the air inlet ports around the liner. These ports are machined at an angle to create a uniform swirling motion to the air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

c. The wear on a liner and piston is directly related to the amount of abrasive dust and dirt introduced into the engine combustion chamber through the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound and will result in rapid wear. To avoid pulling contaminated air into the cylinder, the air silencer must be serviced regularly.

d. This paragraph also includes installation of the piston and connecting rod assembly into the cylinder liner. Next these components are installed in the engine.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

This task covers:

- a. Removal b. Inspection c. Installation

INITIAL SETUP**Test Equipment**

Gage cylinder diameter
checking J5347-01
Gage master ring J5580-1

References

NONE

Special Tools

Hold down clamp cylinder
liner J21793-01
Remover cylinder liner
J1918-02
Ring compressor J3272-01

**Equipment
Condition
Paragraph****Condition Description**

5-14	Rocker Arm Cover Removal
6-25	Oil Pan Removed
5-15	Cylinder Head Removed
6-26.1	Lube Oil Pump Removed
6-27.1	Piston Removed

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Lubricant - Cindol 1705
Engine oil

Special Environmental Conditions

Do not drain oil in bilges. Use
oil separation and recovery
system to collect drained oil.

Personnel Required

2

General Safety Instructions

NONE

LOCATION/ITEM**ACTION****REMARKS****REMOVAL**

- | | | |
|-----------|---|--|
| 1. Engine | a. Remove rocker arm cover. | Refer to paragraph 5-14. |
| | b. Remove oil from oil pan, then, remove the oil pan. | Pump oil into a suitable container - then refer to paragraph 6-25. |

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).**LOCATION/ITEM****ACTION****REMARKS****REMOVAL (Cont)**

- | | | |
|----|-----------------------|----------------------------|
| c. | Remove lube oil pump. | Refer to paragraph 6-26.1. |
| d. | Remove cylinder head. | Refer to paragraph 5-15. |
| e. | Remove piston. | Refer to paragraph 6-27.1. |

2. Cylinder
Liner

NOTE

It is very important that the proper method is followed when removing a cylinder liner. Do not attempt to push the liner out by inserting a bar in the liner ports and rotating the crankshaft, otherwise the piston may be damaged or the upper ring groove may collapse.

- | | | |
|-----|--|--------------------|
| a. | To remove the cylinder liner proceed as follows: | |
| (1) | Remove bolt (A), and lower shoe (B) from shaft (C). | Use tool J1918-02. |
| (2) | Lower the lower shoe through the cylinder liner. | |
| (3) | Lower the shaft (C) into the cylinder liner. | |
| (4) | Attach lower shoe (B) and bolt (A) to shaft (C). Place the shoe on the bottom edge of the liner with the flat on the shoe parallel with the crankshaft bore. | |

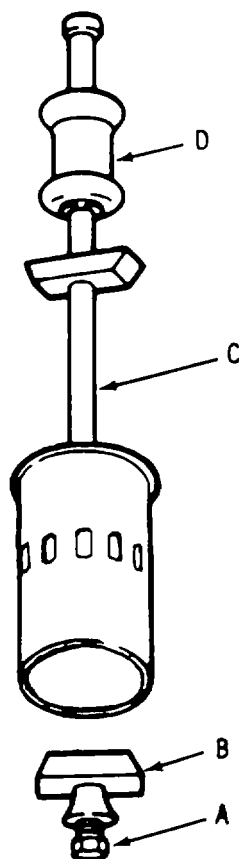
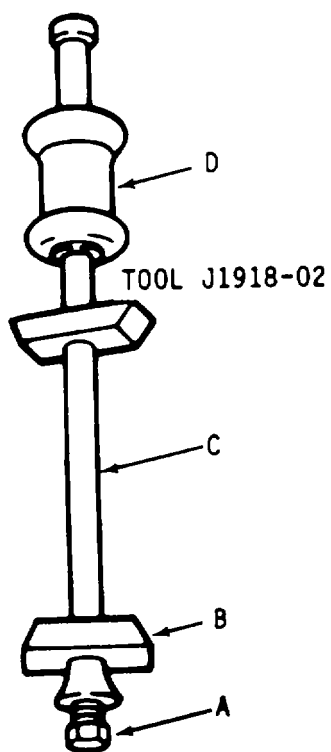
6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

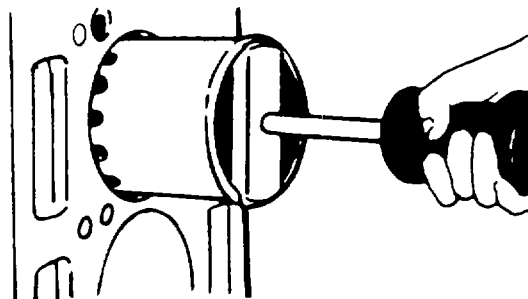
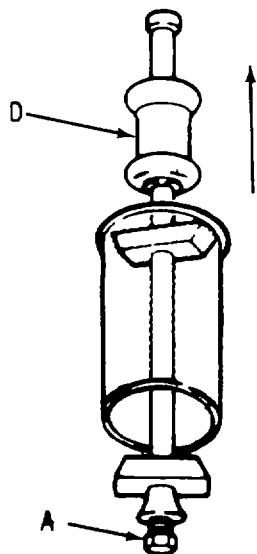
LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

- (5) Hold the lower shoe and bolt assembly in the pulling position. Place the upper shoe with the flat in the same position as the lower shoe. Adjust and tighten bolt (A).
- (6) Grasp handle (D) and pull up sharply. Pull up until cylinder liner is removed from cylinder.
- (7) Disassembly tool from cylinder liner.



3. Cylinder
Liner
Insert

Remove and tag insert and shims
(if used).

Remove from
counterbore or
engine block.

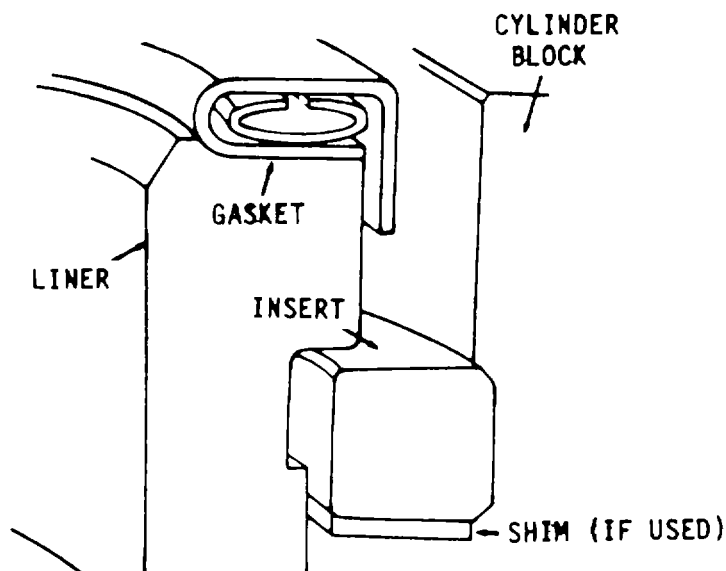
6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)



INSPECTION

4. Cylinder
Liner

- a. Clean liner thoroughly.
- b. Inspect liner for cracks or excessive scoring. Discard. A slightly scored liner may be cleaned-up and reused.
- c. Inspect liner for excessive liner-to-block clearance or block bore distortion. Excessive liner-to-block clearance or block bore distortion will reduce heat transfer from the liner to the block and to the engine coolant. Poor contact between the liner and the block bore may be indicated by strains or low pressure areas on the outer surface of the liner.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

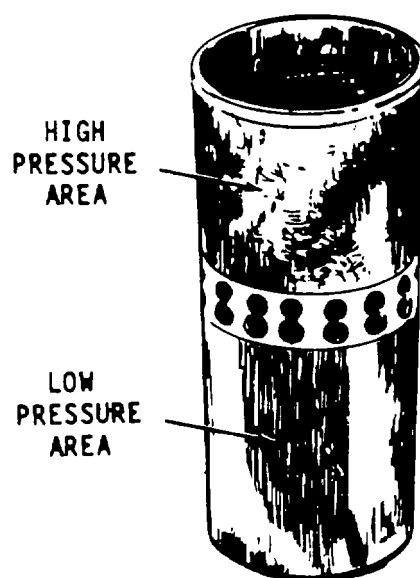
LOCATION/ITEM

ACTION

REMARKS

INSPECTION (Cont)

- d. Examine the outside diameter of the liner for fretting. Fretting is the result of a slight movement of the liner in the block bore during engine operation, which causes material from the block to adhere to the liner. These metal particles may be removed from the surface of the liner with a coarse, flat stone.



6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSPECTION (Cont)

- | | | |
|----|--|--|
| e. | Inspect for cracks at the flange. The liner flange must be smooth and flat on both the top and bottom surfaces. The liner insert must also be smooth and flat on the top and bottom surfaces. Replace the insert if there is evidence of brinelling. | |
| f. | Inspect the block bore and check the liner-to-block clearance whenever a liner is removed. If the clearance exceeds zero to .002 inch (0.0051 cm), it will be necessary to bore the block for an oversize liner. | |

NOTE

- Cylinder liners are available in .001, .005, .010, .020 and .030 inch oversize on the outside diameter. When an oversize liner is used, the amount of oversize is stamped on top of the cylinder block adjacent to the liner counterbore.
- New service liners, standard and oversize, have an inside diameter of 4.2495 to 4.2511 inch (10.7937 to 10.7978 cm).
- Do not modify the surface finish in a new service liner. Since the liner is properly finished at the factory, any change will adversely affect the seating of the piston rings.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION (Cont)	<p>g. Install the liner in the proper bore of the cylinder block and measure the inside diameter at the various points shown. Use cylinder bore gage J5347-01, which has a dial indicator calibrated in .001 inch increments, as it is rather difficult to obtain accurate measurements with a micrometer. Set the cylinder bore gage on zero in master ring gage J5580-1. Also check the liner for taper and out-of-round. To reuse the liner, the taper must not exceed .002 inch and the out-of-round must not exceed .0025 inch. In addition, the ridge formed at the top of the ring travel must be removed. If the out-of-round exceeds .0025 inch rotate the liner 90° in the block bore and recheck.</p>	

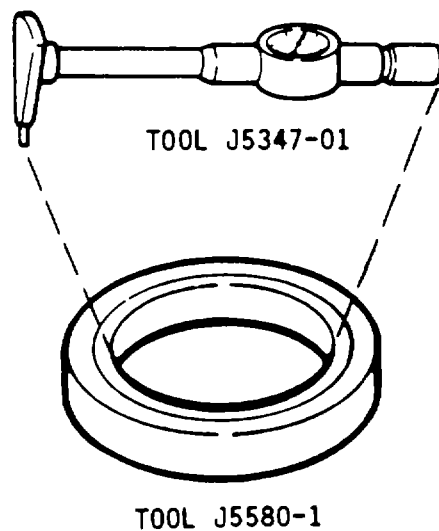
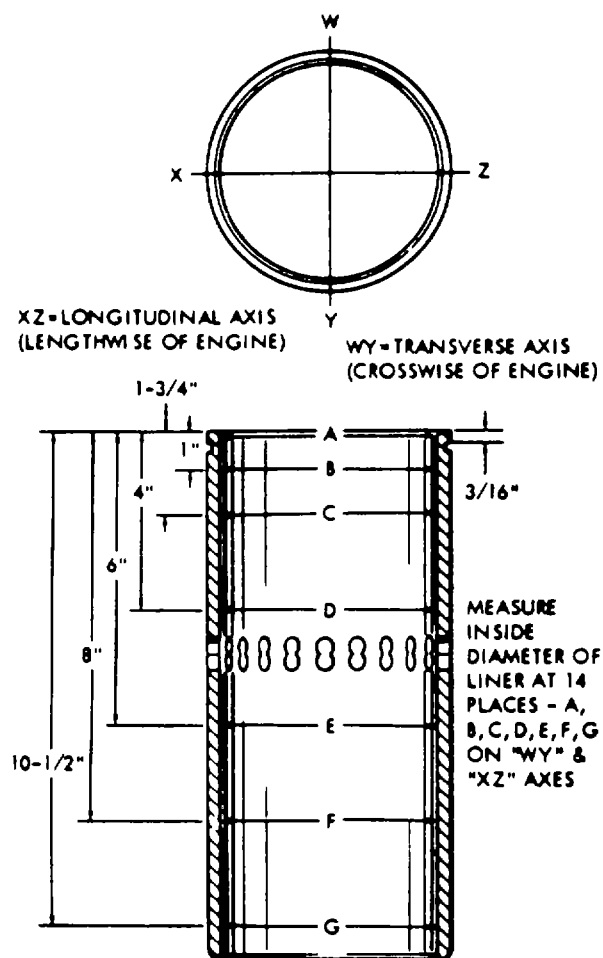
6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSPECTION (Cont)

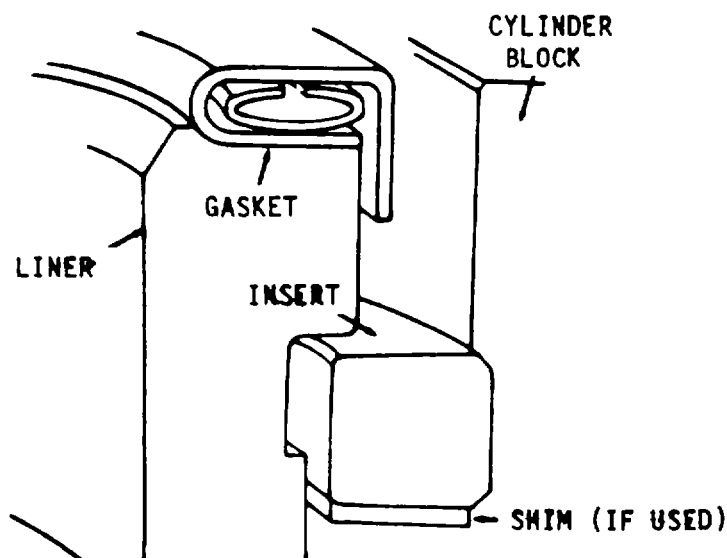


6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION

- | | |
|-----------------|--|
| 5. Engine Block | <p>a. Wipe clean engine block bore and counterbore.</p> <p>b. Insert cylinder liner insert in block counterbore. Use a standard size liner insert 0.1705 to 0.1800 inch (0.4559 to 0.4372 cm).</p> |
|-----------------|--|



- | | |
|-------------------|---|
| 6. Cylinder Liner | <p>a. Push the cylinder into the cylinder block until the liner flange rests on the insert. Do not use excessive force to install the liner. The liner should slide smoothly in place with thumb pressure. If a new liner cannot be pushed in place, light honing of the block bore may be necessary to obtain the desired fit for best heat transfer liner-to-block clearance.</p> |
|-------------------|---|

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

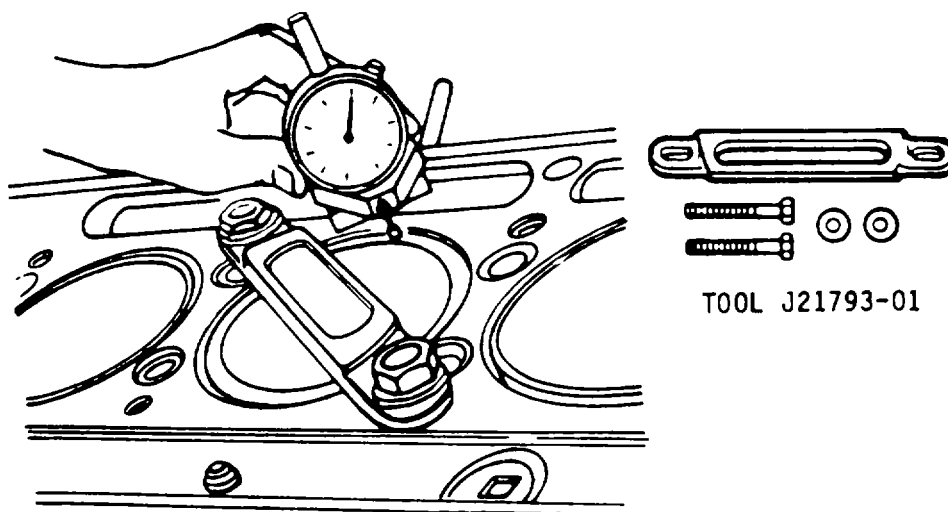
LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

Minimum	Maximum	Limit
.0000 (.0000 cm)	.0020 (.0051 cm)	.0025 (.0064 cm)

b. Install hold down clamp.

Use tool
J21793-01.



c. Measure the distance from the top of the liner to the top of the block with a dial indicator. The liner flange must be .045 to .050 inch (.1143 to .1270 cm) below the surface of the block. However, even though all of the liners are within these specifications, there must not be over .002 inch (.0051 cm) difference in depth between any two adjacent liners when measured along the cylinder longitudinal center line.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

NOTE

A .002 inch (.0051 cm) thick shim is available for adjusting the liner height. The shim must be installed underneath the liner insert. Do not cut the shim for installation. Liner inserts which are .0015 inch (.0038 cm) thicker or thinner than standard are also available for service.

- d. Matchmark the liner and the cylinder block with chalk or paint so the liner may be reinstalled in the same position in the same block bore. The matchmarks should be on the side opposite the camshaft.
- e. Remove hold down clamp and cylinder liner.

NOTE

Do not remove the liner insert.

- | | | |
|---------------------------------------|--|--|
| 7. Piston and Connecting Rod Assembly | a. Lubricate piston, rings, and inside surface of ring compressor. | Use tool J3272-01. Use lubricant cindol 1705 oil |
|---------------------------------------|--|--|

NOTE

Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

- b. Place compressor on wood block with chamfered end up.

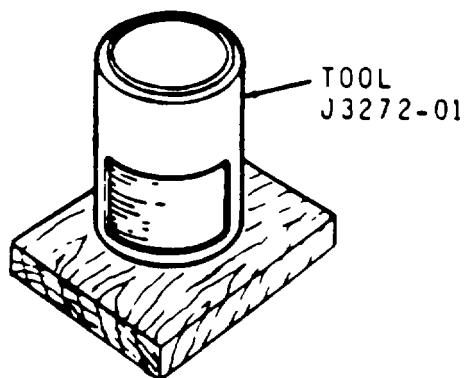
6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

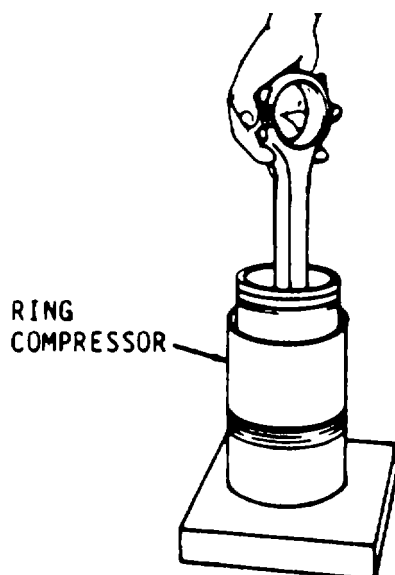
ACTION

REMARKS

INSTALLATION (Cont)



- c. Position (stagger) the piston ring gaps properly on the piston. Make sure the ends of the oil control ring expanders are not overlapped.
- d. Start the top of the piston straight into the ring compressor. Then push the piston down until it contacts the wood block.



6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- e. Note the position of the matchmark and place the cylinder liner, with the flange end down, on the wood block.
- f. Place the ring compressor and the piston and connecting rod assembly on the liner so the numbers on the rod and cap are aligned with the matchmark on the liner.

NOTE

The numbers on the side of the connecting rod and cap identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification numbers must be stamped in the same location as on the connecting rod that was replaced.

- g. Push the piston and connecting rod assembly down into the liner until the piston is free of the ring compressor.

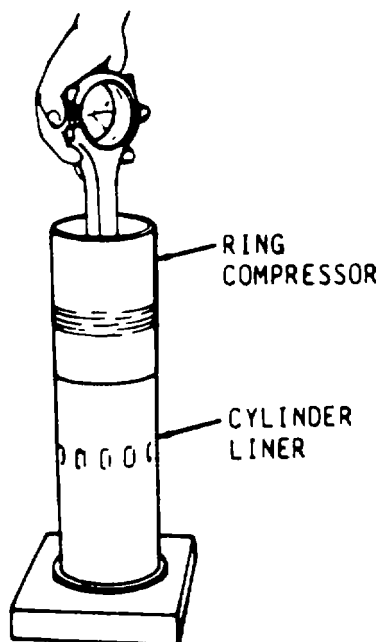
CAUTION

Do not force the piston into the liner. The peripheral abutment type expanders apply considerably more force on the oil ring than the standard expander. Therefore, extra care must be taken during the loading operation to prevent ring breakage.

- h. Remove connecting rod cap and ring compressor. Push piston down until the compression rings pass the cylinder liner ports.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM**ACTION****REMARKS**

INSTALLATION (Cont)

8. Cylinder Liner,
Piston and
Connecting Rod
Assembly

NOTE

- If any of the pistons and liners are already in the engine, use hold-down clamps to retain the liners in place when the crankshaft is rotated.
- Rotate the crankshaft until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel. Wipe the journal clean and lubricate it with clean engine oil.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM**ACTION****REMARKS**

INSTALLATION (Cont)

- a. Install upper bearing shell (1) in connecting rod (2). Lubricate. The upper bearing shell does not have a continuous oil groove. Lubricate the bearing shell with clean engine oil.

NOTE

Each connecting rod and its cap is numbered on one side 1, 2, etc. These numbers identify the caps with the rods and indicate the particular cylinder in which they are used. Maintain these positions when assembling the engine.

- b. Position the piston rod and liner assembly (3) in front of the cylinder block bore so the identification number on the rod face the outer edge of the cylinder block and the matchmarks on the liner and the block are in alignment. Guide the end of the connecting rod through the block bore carefully to avoid damaging or dislodging the bearing shell. Slide the piston, rod and liner assembly straight into the block bore until the liner flange rests against the insert in the counterbore in the block.
- c. Push or pull the piston and connecting rod (2) into the liner until the upper bearing shell is firmly seated on the crankshaft journal.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

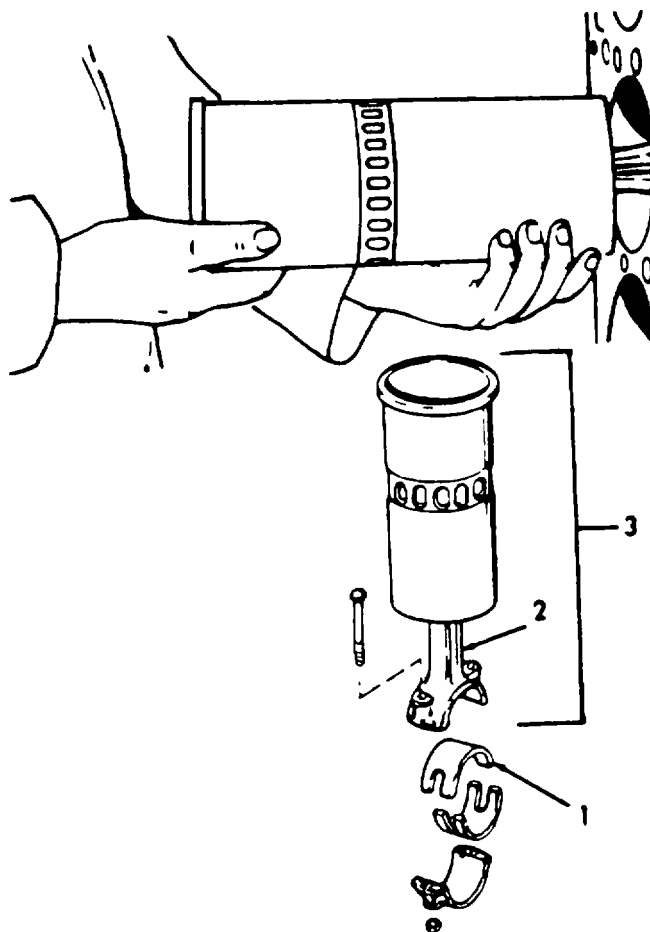
ACTION

REMARKS

INSTALLATION (Cont)

CAUTION

The distance from the vertical center line of the connecting rod bolts to the edges of the rod are not equal. Therefore, when installing the piston and connecting rod assembly, be sure that the narrow side of the two connecting rods on the crank- shaft journal are together to avoid cocking of the rod.



6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

- d. Assemble lower bearing shell (4) and bearing cap (5) and lubricate. The lower bearing shell has a continuous oil groove from one parting line to the other. Lubricate the bearing shell with clean engine oil.
- e. Bearing cap with bearing shell, connecting rod (2), nuts (6), and bolts (1) install the bearing cap and the bearing shell on the connecting rod with the identification numbers on the cap and the rod adjacent to each other. Tighten the connecting rod bolt nuts to 60-70 lb-ft (81-95 Nm) torque (notch or imbedded "O" lubrite nut) to 65-75 lb-ft (88-102 Nm) torque (castellated nut).
- f. Check the connecting rod (2) side clearance. The clearance between each pair of connecting rods should be .006 to .012 inch (0.015 to 0.030 cm) with new parts.

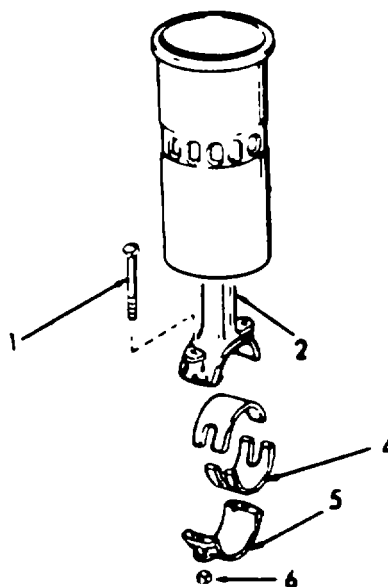
NOTE

- Install the remaining liner, piston and rod assemblies in the same manner. Use hold-down clamps to hold each liner in place.
- After all of the liners and pistons have been installed, remove the hold-down clamps.

6-27.4. CYLINDER LINER - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)



- | | |
|---|----------------------------|
| g. Install cylinder head.
Use new compression gaskets, gaskets, water seals and oil seals. | Refer to paragraph 5-15. |
| h. Install lube oil pump. | Refer to paragraph 6-26.1. |
| i. Install oil pan. | Refer to paragraph 6-25 |
| j. Install rocker arm cover. | Refer to paragraph 5-14. |
| k. Add engine oil, and coolant. | |

6-28. CRANKSHAFT AND MAIN BEARINGS.

The maintenance instructions for the crankshaft and the main bearings are contained in the following paragraphs:

<u>DESCRIPTION</u>	<u>PARAGRAPH</u>
Crankshaft Bearings	6-28.1
Crankshaft	6-28.2
Crankshaft Seals	6-28.3
Crankshaft Timing Gear	6-28.4

3-32.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS.

a. The crankshaft main bearings shells are precision make and are replaceable without machining. They consist of an upper bearing shell seated in each cylinder block main bearing support and a lower bearing shell seated in each main bearing cap. The bearing shells are prevented from endwise or radial movement by a tang at the parting line at one end of each bearing shell. The tangs on the lower bearing shells are off-center and the tangs on the upper bearing shells are centered to aid correct installation.

b. The bearing caps are numbered 1, 2, 3, etc., indicating their respective positions and when removed, must always be reinstalled in their original position.

c. An oil hole in the groove of each upper bearing shell, midway between the parting lines, registers with a vertical oil passage in the cylinder block. Lubricating oil, under pressure, passes from the cylinder block oil gallery by way of the bearing shells to the drilled passages in the crankshaft, then to the connecting rods and connecting rod bearings.

d. The lower main bearing shells have no oil grooves; therefore, the upper and lower bearing shells must not be interchanged.

e. Thrust washers on each side of the rear main bearing, absorb the crankshaft thrust. The lower halves of the two-piece washers are doweled to the bearing cap; the upper halves are not doweled.

f. Main bearing trouble is ordinarily indicated by low or no oil pressure. All of the main bearing load is carried on the lower bearings; therefore, wear will occur on the lower bearing shells first. The condition of the lower bearing shells may be observed by removing the main bearing caps.

h. Check the oil filter elements and replace them if necessary. Also check the oil by-pass valve to make sure it is operating freely.

This task consists of:

a.	Removal
b.	Inspection
c.	Installation

INITIAL SETUP

Test Equipment

Cylinder Diameter Gage
J5347-01
Micrometer
Micrometer ball
attachment J4757

References

NONE

Special Tools

Torque wrench
Hammer, soft

Equipment

Condition	Condition Description
Paragraph	

- 6-22 Power Unit Removal
- 6-25 Oil Pan Removal
- 6-26.1 Lube Oil Pump Removed
- 6-26.3 Oil Inlet Pipe Removed

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Bearing Set P/N 5192874
Engine oil
Thread compound
International #2

Special Environmental Conditions

Do not drain oil into bilges. Use oil separation and recovery system to collect drained oil.

Personnel Required

2

General Safety Instructions

NONE

6-28.1. CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1 Engine	a. Remove oil from oil pan. Remove oil pan.	Use a suitable container. Refer to paragraph 6-25.
	b. Remove oil inlet pipe.	Refer to paragraph 6-26.3.
	c. Remove lube oil pump	Refer to paragraph 6-26.1.
2. Main Bearings 1 through 6		

NOTE

- All crankshaft main bearing journals, except the rear journal, are drilled for an oil passage. Therefore, the procedure for removing the upper bearing shells with the crankshaft in place is somewhat different on the drilled journals than on the rear journal.
- If shims are used between the oil pump and the main bearing caps, save the shims so that they may be reinstalled in exactly the same location.
- Remove one main bearing cap at a time and inspect the bearing shells as outlined under inspection. Reinstall each bearing shell and bearing cap before removing another bearing cap.
 - a. Remove bolts (1), and lock-washers (2).
 - b. Insert two bolts in bearing cap (3), leaving bottom of head accessible. Pry cap off.

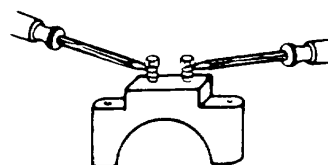
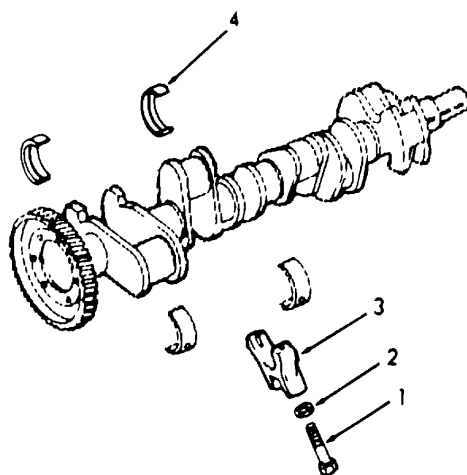
6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS(Continued).

LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

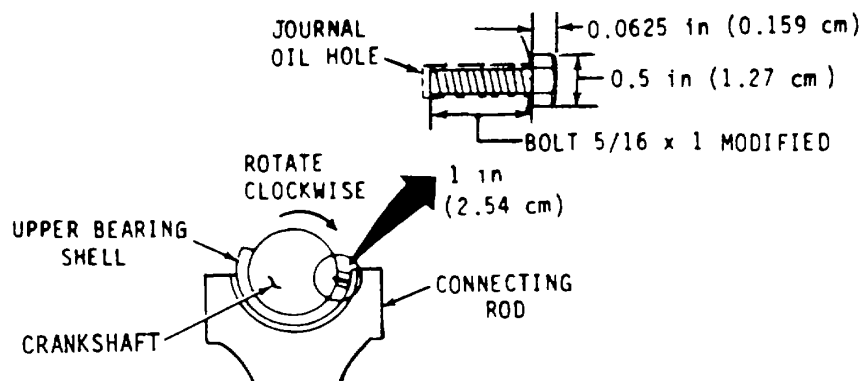


- c. Insert bolt in upper main bearing shell (4) crankshaft journal oil hole. Modify head to 1/2 inch (1.27 cm).

Make bolt from 5/16 x 1 (standard bolt). Modify head to 1/2 inch (1.27 cm).

- d. Rotate crankshaft to the right (clockwise), and roll bearing shell out of piston. Remove bolt. the bearing shell.

The head of bolt must not extend beyond the outside diameter of



6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

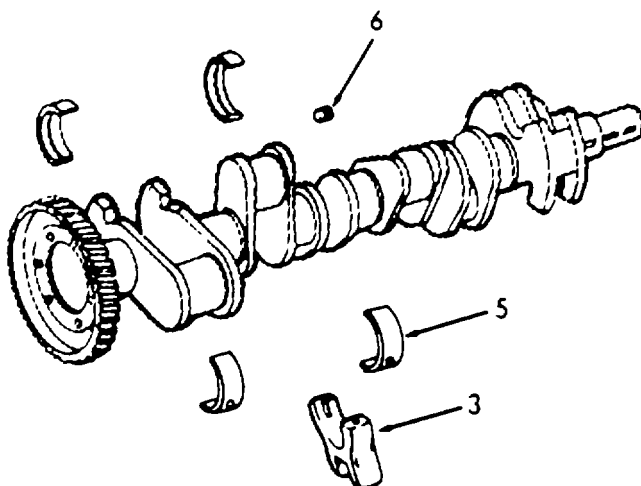
LOCATION/ITEM

ACTION

REMARKS

REMOVAL (Cont)

- e. Remove lower housing shell (5) from bearing cap (3).
- f. Remove pipe plug (6), if necessary.



3. Main Bearing Number 7

- a. Remove bolts (7), and lock-washers (8).
- b. Insert two bolts in bearing cap (9), leaving bottom of head accessible. Pry cap off.
- c. Remove upper main bearing shell (10) by tapping on edge of bearing with a small, curved rod, revolving the crankshaft at the same time to roll the bearing shell out.
- d. Remove upper thrust washers (11) by pushing on end of washers with a small rod. Force washers around and out.

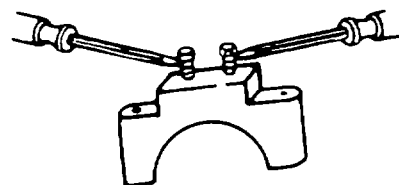
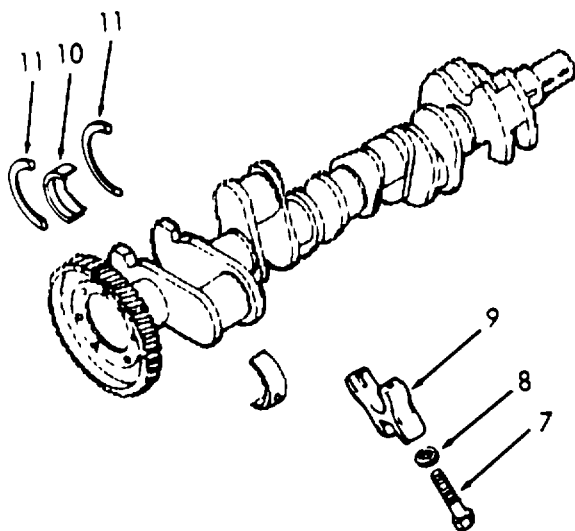
6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

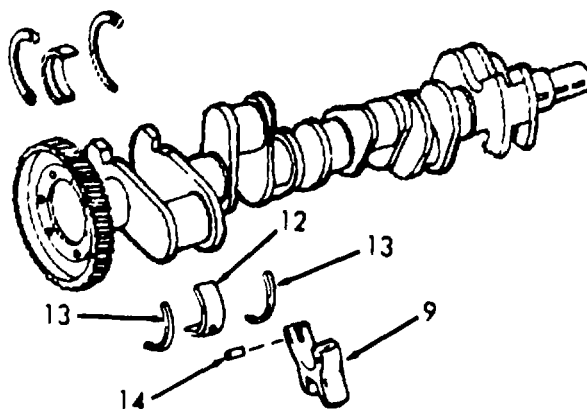
ACTION

REMARKS

REMOVAL (Cont)



- e. Remove lower bearing shell (12), and lower thrust washers (13) from bearing cap (9).
- f. Remove dowel pins (14) if necessary.



6-28.1. CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION		
4. Upper Bearing Shells and Lower Bearing Shells	<p>a. Clean and inspect for scoring, pitting, flaking, etching, loss of babbitt, and signs of overheating. The lower bearing shells which carry the load will normally show signs of distress before the upper bearing shells. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are not detrimental to this type of bearing. They should not be replaced for these minor surface imperfections since function of the bearings is in no way impaired and they will give many additional hours of trouble-free operation.</p> <p>b. Inspect the backs of the bearing shells for bright spots which indicate they have been moving in the bearing caps or bearing supports. If such spots are present, discard the bearing shells.</p> <p>c. Measure the thickness of the bearing shells at point "C", 90° from the parting line. Tool J5347-01, placed between the bearing shell and a micrometer, will give an accurate measurement. The bearing shell thickness will be the total thickness of the steel ball in the tool, and the bearing shell, less the diameter of the ball. This is the only practical method for</p>	Use micrometer ball attachment J4757.

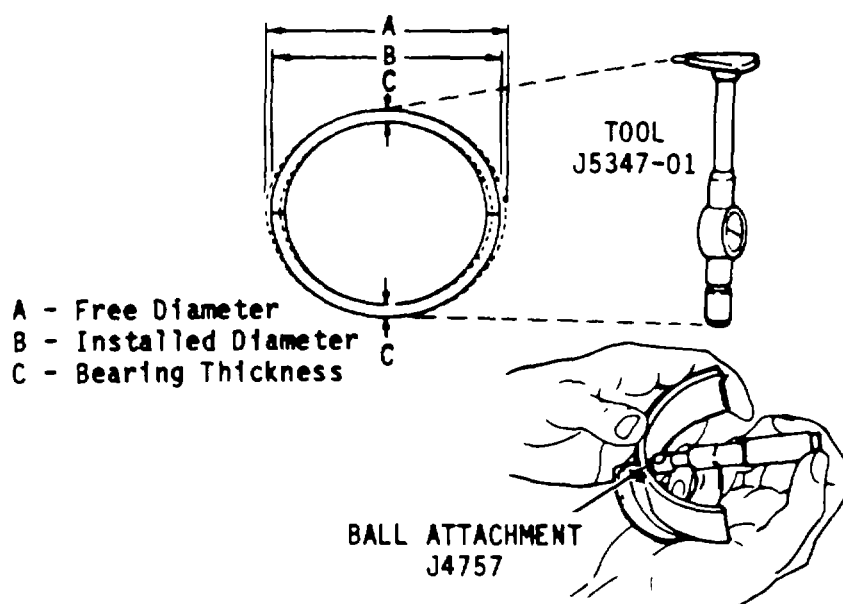
6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION (Cont)

measuring bearing thickness, unless a special micrometer is available for this purpose. The minimum thickness of a worn standard main bearing shell is .1540 inch (0.3912 cm) and, If any of the bearing shells are thinner than this dimension, replace all of the bearing shells. A new standard bearing shell has a thickness of .1545 to .1552 inch (0.3922 to 0.3957 cm).

Bearing Size	Bearing Thickness	Minimum Thickness
Standard	.1548"/.1553"	.1530"
.002" Undersize	.1558"/.1563"	.1540"
.010" Undersize	.1598"/.1603"	.1580"
.020" Undersize	.1648"/.1653"	.1630"
.030" Undersize	.1698"/.1703"	.1680"



6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION (Cont)	<p>d. Check the clearance between the main bearings and the crankshaft journals. This clearance may be determined with the crankshaft in place by means of a soft plastic measuring strip which is squeezed between the journal and the bearing. Measure the outside diameter of the crankshaft main bearing journals and the inside diameter of the main bearing shells when installed in place with the proper torque on the bearing cap bolts. When installed, the bearing shells are .001 inch (.0025 cm) larger in diameter at the parting line than 90° from the parting line.</p> <p>e. The bearing shells do not form a true circle when not installed. When installed, the bearing shells have a squeeze fit in the main bearing bore and must be tight when the bearing cap is drawn down. The crush assures a tight, uniform contact between the bearing shell and bearing seat. Bearing shells that do not have sufficient crush will not have uniform contact, as shown by shiny spots on the back, and must be replaced. If the clearance between any crankshaft journal and its bearing shells exceeds .0060 inch (.0152 cm), all of the bearing shells must be discarded and replaced. This clearance is .0016 to .0050 inch (.0041 to .0127 cm) with new parts.</p>	

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION (Cont)

- f. Before installing new replacement bearings, it is very important to thoroughly inspect the crankshaft journals. Very often, after prolonged engine operation, a ridge is formed on the crankshaft journals in line with the journal oil holes. If this ridge is not removed before the new bearings are installed, then, during engine operation, localized high unit pressures in the center area of the bearing shell will cause pitting of the bearing surface. Also, damaged bearings may cause bending fatigue and resultant cracks in the crankshaft. Refer to paragraph 3-32.2 under Crankshaft Inspection for removal of ridges and inspection of the crankshaft.
- g. Do not replace one main bearing shell alone. If one bearing shell requires replacement, install both new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSPECTION (Cont)		
5 Upper and Lower Thrust Washers	Inspect thrust washers. If the washers are scored or worn excessively or the crankshaft end play is excessive, they must be replaced. Improper clutch adjustments can contribute to excessive wear on the thrust washers. Inspect the crankshaft thrust surfaces. If after dressing or regrinding the thrust surfaces, new standard size thrust washers do not hold the crankshaft end play within the specified limits, it may be necessary to install an oversize thrust washer on one or both sides of the rear main bearing. A new standard size thrust washer is .1190 to .1220 inch (.3023 to .3099 cm) thick. Thrust washers are available in .005 and .010 inch (.0127 and .0254 cm) oversize.	
INSTALLATION		
6. Upper Bearing Numbers 1 Through 6	a. Clean and lubricate the upper bearing shells (4).	Use clean engine oil.

NOTE

The upper and lower main bearing shells are not alike: the upper bearing shell is grooved and drilled for lubrication - the lower bearing shell is not. Be sure to install the grooved and drilled bearing shells in the cylinder block and the plain bearing shells in the bearing caps. Otherwise, the oil flow to the bearings and to the upper end of the connecting rods will be blocked off. Used bearing shells must be reinstalled on the same journal from which they were removed.

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)		
	b. Install upper bearing shells (4).	Start the plain end of bearing shell around the crankshaft journal so that when the bearing is in place the tang will fit into the groove in the bearing support.
7. Lower Bearing Numbers 1 through 6	a. Clean and lubricate the lower bearing shells (5).	Use clean engine oil.
	b. Install, so that the tang on the bearing fits into the groove in the bearing cap (3).	
8. Upper Bearing Number 7	a. Clean and lubricate the upper bearing shell (10), and thrust washers (11).	Use clean engine oil.

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)		
	b. Inspect upper bearing shell (10), and thrust washers (11) for burrs.	Remove from washer seats. The slightest particle of dirt or burr may decrease the clearance between washers and crankshaft.
	c. Slide upper halves of thrust washers (11) into place.	
	d. Install upper bearing shell (10).	Remove the slightest particle of dirt or burr from washer seat. These may decrease the clearance between washers and crankshaft.
9. Lower Bearing Number 7	a. Clean and lubricate lower bearing shell (12), and thrust washers (13).	Use clean engine oil.
	b. Inspect lower bearing shell (12), and thrust washers (13) for burrs.	Remove the slightest particle of dirt or burr from washer seat. These may decrease the clearance between washers and crankshaft.
10. Bearing Cap Numbers 1 Through 6	a. Place a small quantity of compound on threads and head contact area of bolts (1).	Use International Compound #2 or equivalent.
	b. Position bearing caps (3) on crankshaft.	

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)

NOTE

The main bearing caps are bored into position and stamped 1, 2, 3, etc. They must be installed in their original positions in the cylinder block.

	c. Install bolts (1) and lock-washers (2) and draw up tight. Then rap the bearing cap sharply with a soft hammer to seat the bearing caps. Tighten bolts uniformly.	Torque to 180-190 ft-lb (244.1-257.6 Nm).
11. Bearing Cap Number 7	a. Place a small quantify of compound on threads and the head contact area of bolts (7).	Use International Compound #2 or equivalent.
	b. Position bearing caps (9) on crankshaft.	
	c. Install bolts (7) and lock-washers (8). Draw up tight. Rap the bearing cap sharply with a soft hammer to seat the bearing caps.	Torque to 70-75 ft-lb (94.9-101.7 Nm).

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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<div>INSTALLATION (Cont)</div>		
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NOTE

If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

12. Engine	a. Install lube oil pump.	Refer to paragraph 6-26.1.
	b. Install oil inlet pipe.	Refer to paragraph 6-26.3.

NOTE

If shims were used between the lube oil pump and the bearing caps, install them in their original positions.

c. Install oil pan and fill with oil.	Refer to paragraph 6-25.
---------------------------------------	--------------------------

6-28.2. CRANKSHAFT - MAINTENANCE INSTRUCTIONS.

- a. The crankshaft is one-piece steel forging, heat-treated to ensure strength and durability. The main and connecting rod bearing journal surfaces and fillers on all crankshafts are induction hardened.
- b. Complete static and dynamic balance of the crankshaft has been achieved by counterweights incorporated into the crankshaft.
- c. The crankshaft end play is controlled by thrustwashers located at the rear main bearing cap of the engine. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within the crankshaft and cylinder block.
- d. Two dowels and six tapped holes are provided in the rear end of the crankshaft for locating and attaching the flywheel. One hole is unequally spaced so that the flywheel can be attached in only one position.
-

This task covers: a. Removal b. Inspection c. Installation

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

Chain hoist
Gear puller

Equipment

Condition	Description
Paragraph	

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

6-25	Power Unit Removal
6-42	Crankshaft Pulley Removal
6-25	Oil Pan Removal
5-15	Cylinder Head Removal
6-40	Flywheel and Housing Removal
6-26.3	Oil Inlet Pipe Removal

Material/Parts

NONE

Special Environmental Conditions

Do not drain oil into bilges. Use
oil/water separation and recovery
system to collect drained oil.

Personnel Required

1

General Safety Instructions

NONE

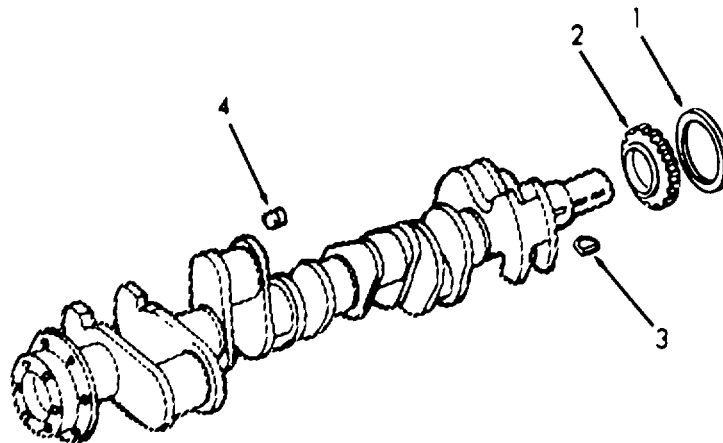
6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Engine	a. Pump engine oil into a suitable container. b. Disconnect engine mounts. c. Remove oil pan. d. Remove lube oil pump. e. Remove flywheel and housing. f. Remove crankshaft pulley. g. Remove front engine support. h. Remove cylinder head. i. Remove connecting rod bearing caps. j. Remove pistons and connecting rods. k. Remove timing gear.	Refer to paragraph 6-25. Refer to paragraph 6-26.1. Refer to paragraph 6-40. Refer to paragraph 6-42. Refer to paragraph 6-37. Refer to paragraph 5-15. Refer to paragraph 6-28.1. Refer to paragraph 6-27. Refer to paragraph 6-42.
2. Oil Pump Drive Gear	a. Remove oil deflector (1). b. Install a gear puller and remove oil pump drive gear (2). c. Remove woodruff key (3).	
3. Crankshaft	Remove pipe plugs (4), if necessary.	

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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REMOVAL (Cont)



INSPECTION

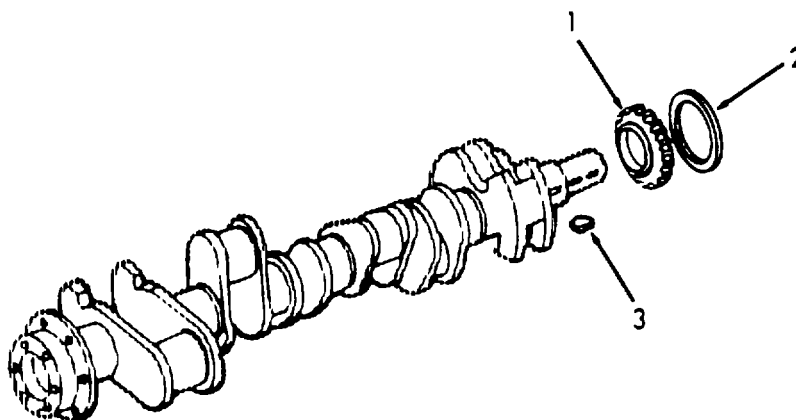
4. Engine
 - a. Inspect crankshaft for cracks which start at an oil hole and follow the journal surface at an angle of 45° to the axis.
 - b. Inspect crankshaft for cracks or wear around keyways.
 - c. Inspect crankshaft for overheating.
 - d. Inspect crankshaft oil seal for roughness or grooves.
 - e. Check crankshaft gears for damage.

6-28.1 CRANKSHAFT BEARINGS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION

- | | | |
|------------------------|--|--|
| 5. Oil Pump Drive Gear | <p>a. Place woodruff key (3) in crankshaft. Slide oil pump drive gear (2) on crankshaft. The gear should be tight against the shoulder on the crankshaft.</p> <p>b. Install oil deflector (1).</p> | |
|------------------------|--|--|



- | | | |
|----------------|--|--------------------------|
| 6. Timing Gear | Install. | Refer to paragraph 6-42. |
| 7. Crankshaft | Install in engine. | |
| 8. Engine | Replace all assemblies and parts remove in step 1 above. | |

6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS.

- a. The crankshaft power take-off adapter is mounted against the cylinder block end plate at the lower front end of the engine. The engine is supported at the front end by engine supports attached to the front cover.
- b. It will be necessary to remove the crankshaft power take-off adapter to remove and install the crankshaft.
- c. An oil seal is used at each end of the crankshaft to retain the lubricating oil in the crankcase. The sealing lips of the oil seals are held firmly, but not tight against the crankshaft sealing surfaces by a coil spring.
- d. The front oil seal is pressed into the crankshaft power take-off adapter. The lip of the seal bears against a removable spacer or vibration damper inner cone on the end of the crankshaft.
- e. A double-lip oil seal is used in engines where there is oil on both sides of the oil seal; the lips of the seal face in opposite directions. The rear oil seal is pressed into the flywheel housing.
- f. Oil leaks indicate worn or damaged oil seals. Oil seals may become worn or damaged due to improper installation, excessive main bearing clearances, excessive flywheel housing bore runout or grooved sealing surfaces on the crankshaft or oil seal spacers. To prevent a repetition of any oil seal leaks, these conditions must be checked and corrected.

6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

This task covers: a. Removal b. Inspection c. Installation

INITIAL SETUP

Test Equipment
NONE

References
NONE

Special Tools

Hammer (soft)
Seal installer J9783
Seal installer J9727

<u>Equipment</u> <u>Condition</u> <u>Paragraph</u>	<u>Condition Description</u>
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6-26	Power Unit Removal
6-37	Power Take-off Removal
6-42	Crankshaft Pulley Removal
6-25	Oil Pan Removal
6-40	Flywheel and Housing Removal
6-26.1	Lube Oil Pump Removal
6-26.3	Oil Inlet Pipe Removal
6-27.1	Piston Removal

Tools

General Mechanics Tool Kit
NSN 5180-00-629-9783

Material/Parts

Oil seal /N 5115454
Oil seal P/N 5127821
Grease or vegetable
shortening
Engine oil

Special Environmental Conditions

NONE

Personnel Required
1

General Safety Instructions
NONE

6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Power Take-off Adapter	Remove power take-off adapter as per paragraph 3-41.	
2. Crankshaft Front Cover	Remove front cover as per paragraph 3-45.	
3. Oil Seal (Front)	a. Drive the oil seal (1) out of front cover. Clean seal bore in the front cover. b. Remove spacer (2) and woodruff key (3). c. Remove oil slinger (4).	Discard oil seal.
<p style="text-align: center;">NOTE</p> <p>When necessary, an oil seal may be removed without removing the front cover or flywheel housing. This may be done by drilling diametrically opposite holes in the seal casing and threading metal screws, backed by flatwashers, into the casing. Remove the seal by prying against the washers with pry bars.</p>		
4. Oil Seal Rear	a. Remove flywheel and flywheel housing. b. Drive the oil seal (5) out of the flywheel housing. Clean the seal bore in the flywheel housing.	Refer to paragraph 6-40.

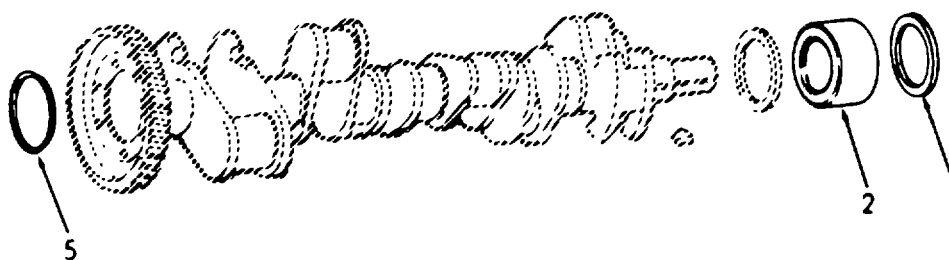
6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSPECTION

- | | | |
|-----------|--|--|
| 5. Engine | a. Inspect rear oil seal (5) for wear due to the rubbing action of the oil seal. Inspect for dirt build-up or fretting by the action of the flywheel. Check for oil leaks.

b. Inspect front oil seal (1) and spacer (2) for wear or dirt build-up. Check for oil leaks. | |
|-----------|--|--|



INSTALLATION

NOTE

Oil seals are made of an oil-resistant, synthetic rubber which is pre-lubricated with a special lubricant. Do not remove this lubricant. Keep the sealing lip clean and free from scratches. In addition, a plastic coating which acts as a sealant has been applied to the outer surface of the casing. Do not remove this coating.

- | | | |
|-------------------|---|--|
| 6. Front Oil Seal | a. Install oil slinger (4) with the dished outer diameter of the slinger facing away from the gear. Then install spacer (2) and woodruff key (3). | |
|-------------------|---|--|

6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
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INSTALLATION (Cont)		
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- | | | |
|--|--|--|
| | <ul style="list-style-type: none">b. Coat the lip of the new oil seal (1) lightly with grease or vegetable shortening. Position the seal in the front cover with the lip of the seal pointed toward the inner face of cover.c. Drive the seal into the front cover with installer J9783. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing.d. Remove excess sealant from front cover and seal. | |
|--|--|--|

6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION (Cont)		
7. Rear Oil Seal	<ul style="list-style-type: none"> a. Coat the lip of the oil seal (5) lightly with engine oil (single lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal. b. Drive the seal into the housing with installer J9727 and handle until it is seated against the seal spacer (if used) or on shoulder in the housing bore. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing. If it is necessary to install the oil seal with the flywheel housing on the engine, place oil seal expander against end of crankshaft. Then, with the lip of the seal pointed toward the engine, slide the seal over the tool and onto the crankshaft. Remove the seal expander and drive the seal in place with installer J9727 and handle. c. Remove any excess sealant from the flywheel housing and the seal. 	

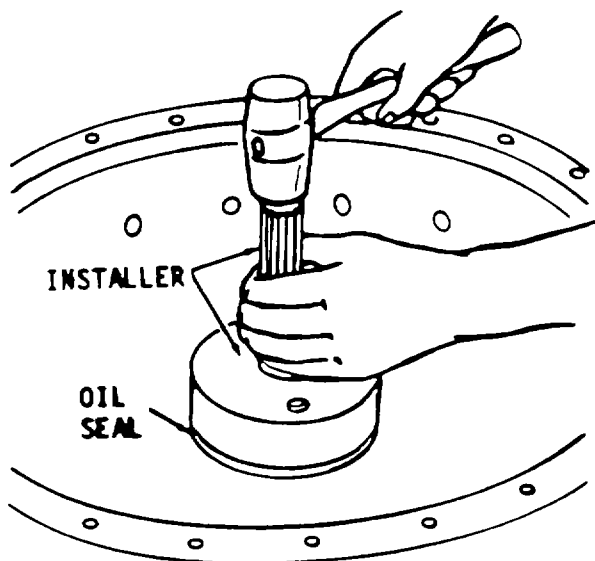
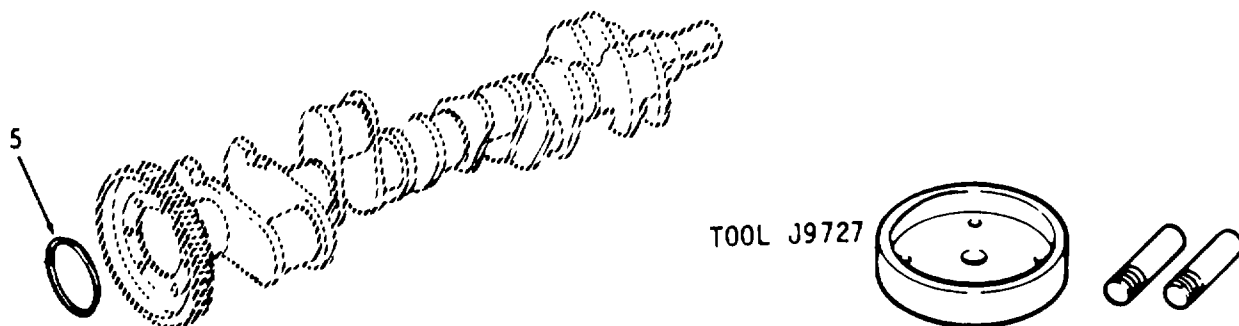
6-28.3. CRANKSHAFT SEALS - MAINTENANCE INSTRUCTIONS (Continued).

LOCATION/ITEM

ACTION

REMARKS

INSTALLATION (Cont)



8. Front Cover or Power Take-off Adapter

- a. Install front cover as per paragraph 6-41.
- b. Install power take-off adapter as per paragraph 6-37.

9. Flywheel Housing

Replace the flywheel housing and flywheel.

Refer to paragraph 6-40.

6-28.4. CRANKSHAFT TIMING GEAR - MAINTENANCE INSTRUCTIONS.

a. The crankshaft timing gear is bolted to the flange at the rear end of the crankshaft and drives the camshaft gear (LB and RD engines) or balance shaft gear LD, and RB engines) through an idler gear. One gear attaching bolt hole is offset so that the gear can be attached in only one position.

b. Since the camshaft and balance shaft gears must be in time with the crankshaft, timing marks are located on two teeth of the idler gear with corresponding match marks stamped on the crankshaft gear and camshaft and balance shaft gears, see paragraph 3-28.

c. Left hand helix gear with a letter "L" timing mark is provided for left-hand rotation engines, and a right-hand helix gear with a letter "R" timing mark is provided for right-hand rotation engines.

NOTE

The present crankshaft gears also are stamped with advance timing mark letter "A".

This task covers:

- | | | | |
|------------|-------------|---------------|-----------------|
| a. Removal | b. Cleaning | c. Inspection | d. Installation |
|------------|-------------|---------------|-----------------|
-

INITIAL SETUP

Test Equipment

NONE

References

NONE

Special Tools

Gear puller

Equipment

<u>Condition</u>	<u>Condition Description</u>
------------------	------------------------------

6-22

Power Unit Removal

6-40

Flywheel Housing Removal

Tools

General Mechanic's Tool Kit
NSN 5180-00-629-9783

Material/Parts

Fuel oil

Special Environmental Conditions

NONE

Personnel Required

1

General Safety Instructions

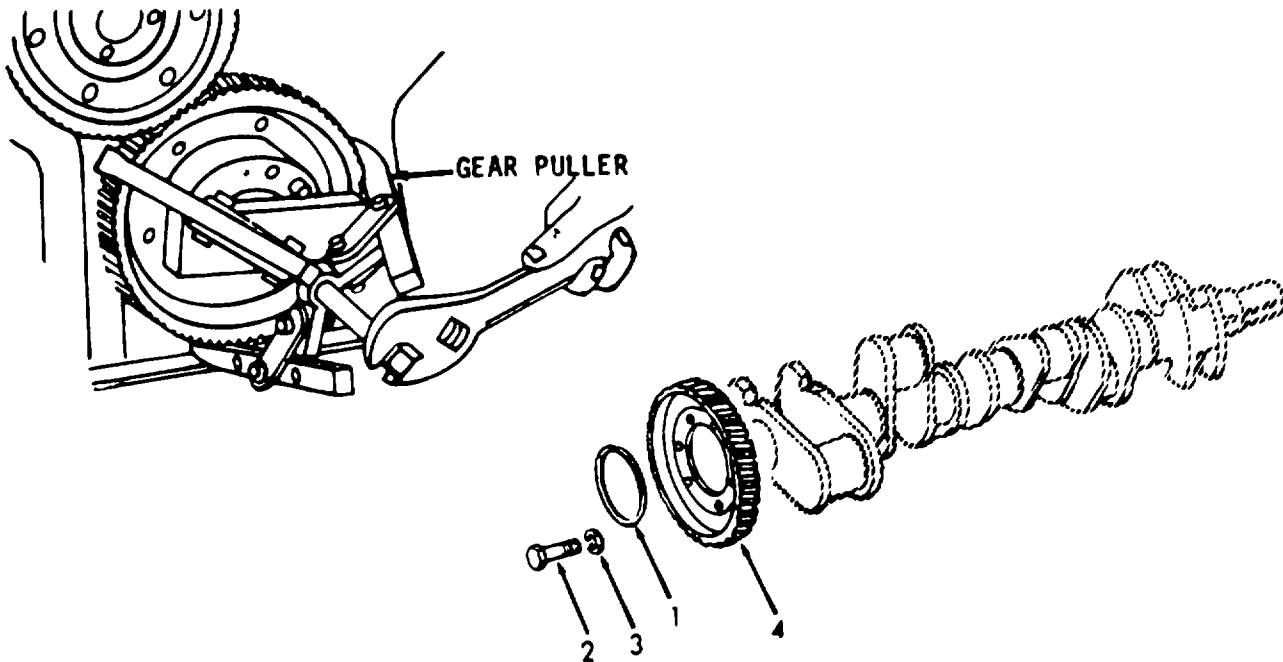
Observe WARNING in procedure.

6-28.4. CRANKSHAFT TIMING GEAR - MAINTENANCE INSTRUCTIONS

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

REMOVAL

- | | | |
|---------------------------|---|--|
| 1. Crankshaft Timing Gear | <ol style="list-style-type: none">Remove crankshaft rear oil sleeve (1). To remove the sleeve, peen the outside diameter of the sleeve until the sleeve stretches sufficiently so it can be slipped off the crankshaft.Remove six bolts (2) and lockwashers (3) securing the gear (4) to the crankshaft.Provide a base for the puller screw by placing a steel plate across the hole in the end of the crankshaft, then remove the gear with a suitable puller. Be careful so the gear teeth will not be damaged. | |
|---------------------------|---|--|



6-28.4. CRANKSHAFT TIMING GEAR - MAINTENANCE INSTRUCTIONS(Continued).

LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

CLEANING

2

WARNING

Wear protective eye goggles when using compressed air.

Clean the gear with fuel oil and dry with compressed air.

INSPECTION

3

Examine the gear teeth for evidence of scoring, pitting, and wear. If it is severely damaged or worn, install a new gear. Also, check the other gears in the gear train.

INSTALLATION

4.

- a. Position the gear (4) on the rear end of the crankshaft with the flat finished hub of the gear facing toward the cylinder block and with all six bolts holes in the gear aligned with the tapped holes in the crankshaft. As one bolt hole is offset, the gear can be attached in only one position.
- b. Align the timing marks "L" or "R" on the crankshaft gear tooth with the corresponding mark on the idler gear.

6-28.4. CRANKSHAFT TIMING GEAR - MAINTENANCE INSTRUCTIONS (Continued).

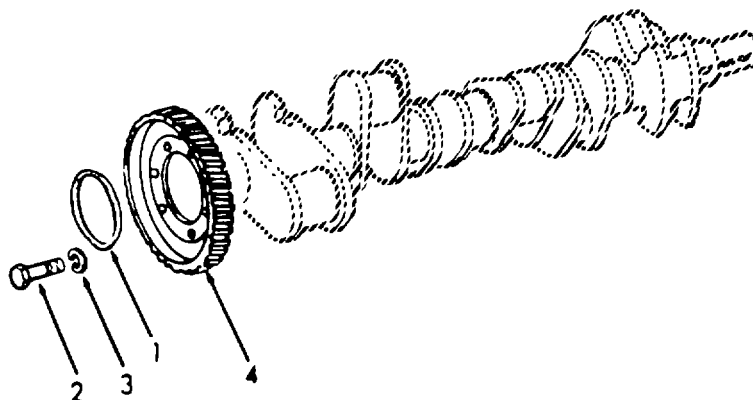
LOCATION/ITEM	ACTION	REMARKS
---------------	--------	---------

INSTALLATION (Cont)

NOTE

When advanced timing is required align the timing mark "A" with the corresponding mark on the idler gear.

- c. Start the six 3/8"-24 bolts (2) with lockwashers (3) through the gear and into the crankshaft. Then draw the gear tight against the shoulder on the crankshaft. Tighten the bolts to 35-39 lb-ft (47.5-52.9 Nm) torque.
- d. Check the backlash with the mating gear. The backlash should be .003 to .008 inch (.008 to .020 cm).
- e. Install a new crankshaft rear oil seal sleeve (1).



NOTE

Chapter 6 continues on page 6-514 in Volume 4.

By Order of the Secretary of the Army:

CARL E VUONO
General, United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN, II
Brigadier General, United States Army
The Adjutant General

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The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
 1 decimeter = 10 centimeters = 3.94 inches
 1 meter = 10 decimeters = 39.37 inches
 1 dekameter = 10 meters = 32.8 feet
 1 hectometer = 10 dekameters = 328.08 feet
 1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigram = .035 ounce
 1 decagram = 10 grams = .35 ounce
 acres
 1 hectogram = 10 decagrams = 3.52 ounces
 1 kilogram = 10 hectograms = 2.2 pounds
 1 quintal = 100 kilograms = 220.46 pounds
 1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce
 1 deciliter = 10 centiliters = 3.38 fl. ounces
 1 liter = 10 deciliters = 33.81 fl. ounces
 1 dekaliter = 10 liters = 2.64 gallons
 1 hectoliter = 10 dekaliters = 26.42 gallons
 1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

<i>To change</i>	<i>To</i>	<i>Multiply by</i>	<i>To change</i>	<i>To</i>	<i>Multiply by</i>
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit	5/9 (after	Celsius	°C
	temperature	subtracting 32)	temperature	

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