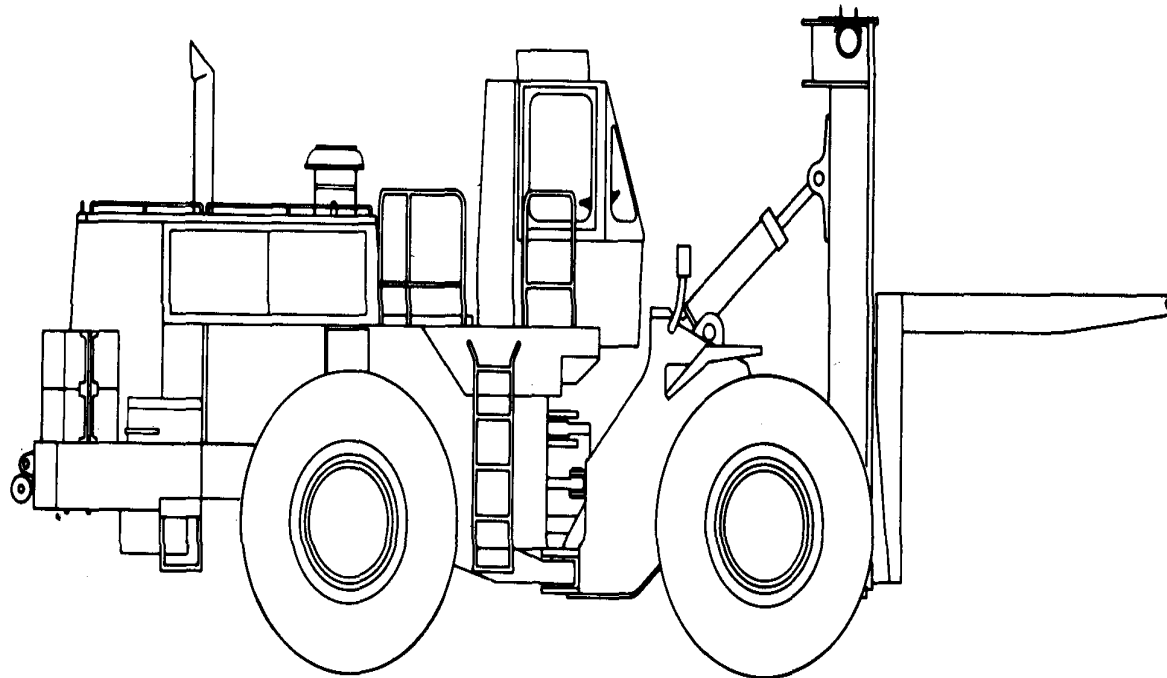


**TECHNICAL MANUAL  
DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL**



**TRUCK, CONTAINER HANDLER  
ROUGH TERRAIN, 50,000 LB CAPACITY  
DED, PT, NSN 3930-01-082-3758  
WITH TOPHANDLER(S)**

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CHANGE

No. 1

HEADQUARTERS  
DEPARTMENT OF THE ARMY  
WASHINGTON D.C., 14 AUGUST 1989

**DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL  
TRUCK, CONTAINER HANDLER: ROUGH TERRAIN  
50,000 LB CAPACITY, DED, PT  
NSN 3930-01-082-3758 WITH TOPHANDLER(S)**

TM 10-3930-641-34-1, 31 August 1981, is changed as follows:

1. Remove old pages and insert new pages as indicated below.
2. New or changed material is indicated by a vertical bar in the margin of the page and by a vertical bar adjacent to the TA number.

**Remove pages**

v and vi  
1-1 and 1-2  
3-131 and 3-132

**Insert pages**

v and vi  
1-1 and 1-2  
3-131 and 3-132

3. File this change sheet in front of the publication for reference purposes.

By Order of the Secretary of the Army:

Official:

WILLIAM J. MEEHAN II  
*Brigadier General, United States Army*  
*The Adjutant General*

CARL E. VUONO  
General, United States Army  
Chief of Staff

Distribution:

To be distributed in accordance with DA Form 12-25F, Direct Support and General Support maintenance requirements for Truck, Container Handler, 50,000 LB Capacity, Rough Terrain.

**WARNING**

If you sustain any injuries, no matter how slight, follow the first aid procedures outlined in FM 21-11.

**WARNING****CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU**

Carbon monoxide is without color or smell, but can kill you. Breathing air with carbon monoxide produces symptoms of headache, dizziness, loss of muscular control, a sleepy feeling, and coma. Brain damage or death can result from heavy exposure. Carbon monoxide occurs in the exhaust fumes of fuel-burning heaters and internal combustion engines. Carbon monoxide can become dangerously concentrated under conditions of no air movement. Precautions must be followed to insure crew safety when the personnel heater, main or auxiliary engine of any vehicle is operated for any purpose.

1. DO NOT operate engine of vehicle in a closed place unless the place is well ventilated.
2. DO NOT idle engine for long periods.
3. DO NOT drive any vehicle with inspection plates, cover plates, or engine compartment doors removed unless necessary for maintenance purpose.
4. BE ALERT at all times during vehicle operation for exhaust odors and exposure symptoms. If either is present, IMMEDIATELY VENTILATE personnel compartments. If symptoms persist, remove affected person to fresh air; keep warm; DO NOT PERMIT PHYSICAL EXERCISE; if necessary, give artificial respiration.

FOR ARTIFICIAL RESPIRATION, REFER TO FM21-11.

5. BE AWARE: the field protective mask for nuclear-biological chemical (NBC) protection will not protect you from carbon monoxide poisoning.

THE BEST DEFENSE AGAINST CARBON MONOXIDE POISONING IS GOOD VENTILATION.

Go on to Sheet 2

**WARNING**

Do not wear loose clothing or jewelry that could catch in controls.

Do not smoke when fueling machine.

Do not smoke when inspecting or servicing batteries.

Put range selector in neutral and engage parking brake before starting engine.

Move all mast controls to HOLD before starting engine.

Be sure all personnel are away from machine and area.

Be sure all obstacles are moved from operating area.

Be sure all safety guards and covers are in place.

Note all hazards in your operating area.

Start engine only in a well ventilated area.

Test mast controls for proper function before beginning machine operations.

This vehicle is not intended for riders, do not allow riders on the vehicle.

Look behind vehicle when backing up.

Go on to Sheet 3

**WARNING**

Know the stopping distance for your vehicle at any given speed. Regulate travel speed accordingly.

Never coast.

Carry load close to ground.

Be aware of the height of your vehicle (13 ft. 3 in. to top of cab and 14 ft. 0 in. to top of mast with mast in park position). Stay clear of electric wires and overhangs.

Be aware of the weight of your vehicle (113,000 lbs. unloaded). Stay a safe distance from cliffs, deep excavations, or other dangerous areas.

Do not drive the loaded vehicle on a grade of more than 15%.

Do not drive the unloaded vehicle on a grade of more than 25%.

Always stop engine and lower mast before leaving vehicle.

There is no room for a man in the pivot area when the vehicle is turning.

The ROPS will no longer protect you if it has been structurally altered or damaged or if the vehicle has been involved in a rollover accident.

When servicing the machine, attach DO NOT OPERATE tags to the controls.

End  
**iii/(iv blank)**

DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL  
TRUCK, CONTAINER HANDLER: ROUGH TERRAIN 50,000 LB  
CAPACITY, DED, PT, NSN 3930-01-082-3758 WITH TOPHANDLER(S)

**REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS**

You can help improve this manual. If you find any mistakes 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 Tank-Automotive Command, ATTN: AMSTA-MB, Warren, MI 48397-5000. A reply will be furnished to you.

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**Section I. GENERAL INFORMATION**

---

**SCOPE**

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Type of Manual: Direct Support and General Support Maintenance


Model Number and Equipment Name: Rough Terrain Container Handler (RTCH)

Purpose of Equipment: Load and unload shipping containers

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**MAINTENANCE FORMS, RECORDS AND REPORTS**


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Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by I DA Pam 738-750, The Army Maintenance Management System (TAMMS). 

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**REPORTING OF EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR)**

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EIR can and must be submitted by anyone who is aware of an unsatisfactory condition with the equipment design or use. It is not necessary to show a new design or list a better way to perform a procedure, just simply tell why the design is unfavorable or why a procedure is difficult. EIR may be submitted on SF 368 (Quality Deficiency Report). Mail directly to Commander, U.S. Army Tank-Automotive Command, Warren, MI 48397-5000, ATTN: AMSTA-QRD. We'll send you a reply. 

**Change 1 1-2**

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WARRANTY INFORMATION

---

The Rough Terrain Container Handler is warranted by Caterpillar Tractor Co. for 15 months or 1500 hours of operation, whichever comes first. Warranty starts on the date found on DA Form 2410 or DA Form 2408-16 in the log book. Report all defects in material or workmanship to your supervisor, who will take appropriate action.

**Section II. EQUIPMENT DESCRIPTION AND DATA**

Refer to TM 10-3930-641-20 for a description of the vehicle and its major components, operating and performance data, and dimensions. Refer to page 2-69 for wear, fits, tolerances and torque values for assemblies and subassemblies of the vehicle.

---

EQUIPMENT PURPOSE, CAPABILITIES AND FEATURES

---

PURPOSE

1. Handles ISO (International Standards Organization) designation 1A or 1C cargo containers or Sealand Containers.
2. Handles and stacks containers.

3. Loads and unloads flatbed trailers and rail cars.
4. Makes over-the-shore landings.

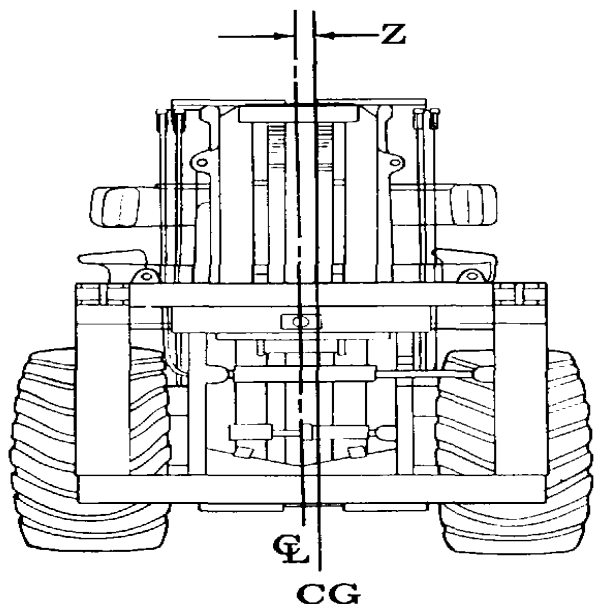
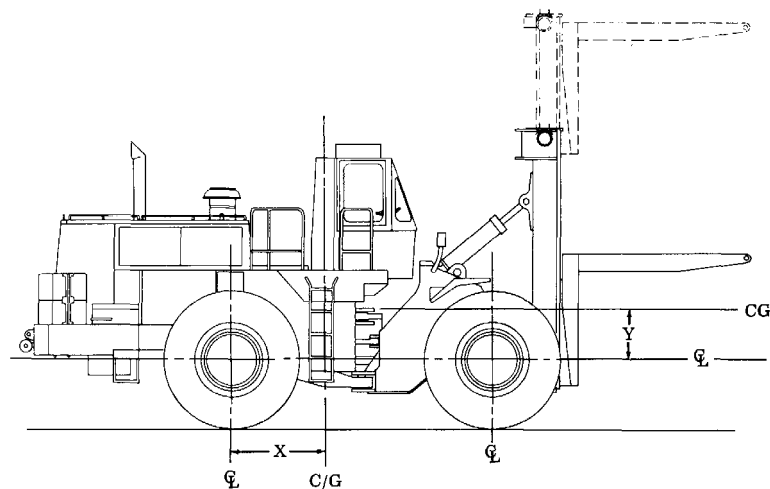
CAPABILITIES AND FEATURES

1. Operates over rough terrain - including beaches, snow, mud and cross country.
2. Fords up to 60 inches (152 cm) of salt water.
3. Comes with a 20 ft. (6.1 m) tophandler and may also have a 35 ft (10.6 m) or 40 ft (12.2 m) tophandler.

4. Raises, lowers, tilts forward or backward, sideshifts or sidetilts a container load.
5. Lifts a load from 12 in. (30 cm) below ground level to 118 in. (300 cm) above ground level (measured to bottom of container).
6. Articulated (bends in center) for easy load handling.

EQUIPMENT WEIGHTS AND WEIGHTS AND CENTER OF GRAVITY

- Total Weight: 105,120 lb. (47,700 kg)
- Front Axle: 39,000 lb. (18,000 kg)
- Front Section: 40,000 lb. (18,100 kg)
- Rear Axle: 65,520 lb. (29,700 kg)
- Rear Section: 65,000 lb. (29,000 kg)
- Mast: 14,710 lb. (6670 Kg)
- Fork: 5,920 lb. (2690 kg)
- Counterweights
  - Rear: 16,000 lb. (7300 kg)



X = 55.94 in. (142 cm)  
 Y = 24.29 in. (61.7 cm)-- 59.13 in. (50.2 cm)  
 from groundline  
 Z = 0.197 in. (0.500 cm)

NOTE  
 Weight is with 70%  
 fuel in tanks, mast  
 vertical, with fork,  
 no tophandler

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**Section I. REPAIR PARTS, SPECIAL TOOLS AND EQUIPMENT**

---

REPAIR PARTS

---

Repair parts are listed and illustrated in the repair parts and special tools list, TM 10-3930-641-34P, covering direct support and general support maintenance for this equipment.

---

SPECIAL TOOLS, TMDE AND SUPPORT EQUIPMENT

---

Refer to TM 10-3930-641-34P for special tools, TMDE and equipment you will need for maintaining the vehicle. refer to Appendix C for instructions for fabricating tools you will need.

## Section II. TROUBLESHOOTING

The Symptoms Index table starts on page 2-4. It lists the MALFUNCTIONs (symptoms) which can occur on the vehicle and serves as an index to the troubleshooting table to help you decide where to begin troubleshooting.

The troubleshooting table, beginning on page 2-8, lists MALFUNCTIONs, tests or inspections, and corrective actions that must be performed to restore the operating condition of the vehicle.

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## ENGINE TROUBLESHOOTING

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

## 1. WILL NOT CRANK WHEN POWER SWITCH IS ON START

Step 1. Check main disconnect switch.

Turn disconnect switch to ON position. (See TM 10-3930-641-10.)

Step 2. Check battery output.

a. Charge battery.

b. Replace faulty batteries. (See TM 10-3930-641-20.)

Step 3. Test starting solenoid.

Replace solenoid. (See TM 10-3930-641-20.)

Step 4. Inspect starting motor. Look for discolored coils.

Repair starting motor. (See page 3-187.)

Step 5. Test wiring circuit.

Repair/replace as necessary. (See TM 10-3930-641-20.)

**NOTE**

If preceding steps do not solve problem, disconnect upper drive shaft. Then try to start engine. If engine still doesn't start, go to Step 6.

Step 6. Determine if problem is internal.

a. Remove fuel injection nozzles and check for coolant in cylinders.

Replace cylinder head if cracked. (See page 3-217.)

Replace gaskets whether head is cracked or not.

b. Remove engine and disassemble as required. (See Chapter 3.)

Check the following for possible causes:

Bearing seizure, rod or main.

Piston seizure.

Wrong pistons installed in engine.

Failed timing gears.

Replace component(s) that have failed.

## ENGINE TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

## 2. ENGINE CRANKS BUT WILL NOT START OR IS HARD TO START

Step 1. Check fuel supply.

Add fuel.

Step 2. Cranking speed is too slow. Check batteries for weak charge or faulty batteries.

a. Charge batteries. (See TM 10-3930-641-20.)

b. Replace faulty batteries. (See TM 10-3930-641-20.)

Step 3. Inspect fuel filter.

Install new elements. (See TM 10-3930-641-20.)

Step 4. Inspect fuel lines for dirt or breaks.

Clean or replace fuel lines.

Step 5. Test fuel transfer pump.

When starting engine, fuel transfer pump discharge should be a minimum of 30 psi (205 kPa). If discharge pressure is less than 20 psi (140 kPa), check for air in system or dirty fuel filter. If fuel pressure is still low, remove and repair fuel transfer pump. (See page 3-58.)

Step 6. Check for bad quality fuel.

a. Replace fuel.

b. Replace fuel filter element. (See TM 10-3930-641-20.)

Step 7. Check fuel injection timing.

Adjust fuel ratio control. (See page 3-75.)

Step 8. Inspect fuel shut-off solenoid.

Replace/repair fuel shut-off solenoid. (See TM 10-3930-641-20.)

Step 9. Inspect fuel bypass valve.

Clean valve of restrictions.

Step 10. Check valve clearance.

Adjust to specified valve clearance. (See page 3-268.)

ENGINE TROUBLESHOOTING (CONT)

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

3. ENGINE MISFIRES OR RUNS ROUGH

- Step 1. See if fuel pressure is low.
  - a. Check fuel tank and add fuel if needed.
  - b. Check for leaks, crimps, or bends in fuel lines between fuel tank and fuel transfer pump.
  - c. Check fuel transfer pump. Fuel transfer pump discharge pressure should be 30 psi (205 kPa).  
Repair/replace fuel transfer pump. (See page 3-58.)
- Step 2. Check for air in system.  
Find leak and correct it. (See TM 10-3930-641-20.)

NOTE

**Air will generally get into system on suction side of fuel transfer pump.**

- Step 3. Look for leak, crimp, or break in fuel line between fuel injection pump and fuel injection valve.  
Replace line.
- Step 4. Test for defect in fuel injection nozzle or fuel injection pump.  
Test procedure:  
Run engine at rpm's that produce misfiring. Loosen the fuel line nut on injection pump one cylinder at a time. The faulty cylinder will not change the way engine runs.  
Repair/replace the fuel injection nozzle or fuel injection pump for that cylinder. (See page 3-29.)
- Step 5. Check valve clearance. (See page 3-268.)  
Adjust valve clearance. (See page 3-268.)
- Step 6. Inspect for bent or broken push rod.  
Replace push rod. (See page 3-264).

4. ENGINE WILL NOT TURN HIGHER THAN 1000 TO 1200 RPM'S

- Step 1. Inspect governor control arm for a restriction to movement.  
Remove restriction. (See page 3-95.)
- Step 2. Check adjustment of governor control linkage.  
Adjust linkage. (See TM 10-3930-641-20.)

ENGINE TROUBLESHOOTING (CONT)

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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5. ENGINE STALLS AT LOW RPM

- Step 1. Check for low fuel pressure.  
See no. 3, step 1.
- Step 2. Check to see if idle RPM is too low.  
Adjust governor so idle RPM is same as rack setting. (See page 3-102.)

NOTE

Only technicians with training in governor adjustments should make the adjustment.

- Step 3. Inspect fuel injection pumps.  
Repair/replace fuel injection pump. (See page 3-32.)
- Step 4. Check governor control linkage.  
Adjust governor control linkage. (See TM 10-3930-641-20.)
- Step 5. Check governor control linkage.  
Adjust governor control linkage. (See TM 10-3930-641-20.)

6. ENGINE HUNTS OR ENGINE CHANGES SPEEDS SUDDENLY BY ITSELF (NO ADJUSTMENT FROM OPERATOR)

- Step 1. Inspect governor.  
Replace parts that are broken or not up to specification. (See page 3-83.)
- Step 2. Inspect fuel transfer pump.  
Repair pump. (See page 3-58.)
- Step 3. Check for free travel of fuel rack.  
Clean/adjust fuel rack. (See page 3-102.)
- Step 4. Check fuel injection pumps for correct installation.  
Install correctly. (See page 3-31.)

## ENGINE TROUBLESHOOTING (CONT)

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

## 7. ENGINE DOES NOT DEVELOP FULL POWER

- Step 1. See if quality of fuel is bad.
  - a. Replace with good quality fuel.
  - b. Replace fuel filter elements. (See TM 10-3930-641-20.)
- Step 2. Check for restrictions of air inlet.  
Replace air filter elements. (See TM 10-3930-641-20.)
- Step 3. Check governor linkage for travel or defective parts.
  - a. Adjust linkage to get full travel.
  - b. Repair governor linkage. (See page 3-95.)
- Step 4. Inspect turbocharger for problems causing poor performance.  
Replace or repair as necessary. (See page 3-107.)
- Step 5. Check for low fuel pressure.  
See no. 3, step 1.
- Step 6. Check for too low rack setting.  
Adjust rack setting. (See page 3-102.)
- Step 7. Inspect for wrong valve clearance.  
Adjust. (See page 3-268.)
- Step 8. Check for wrong fuel injection timing.  
Adjust. (See page 3-102.)
- Step 9. Check fuel transfer pump.  
Repair. (See page 3-58.)

ENGINE TROUBLESHOOTING (CONT)

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

8. UNUSUAL ENGINE VIBRATION

- Step 1. Inspect engine supports.
  - a. Tighten all loose capscrews or nuts.
  - b. Replace defective engine supports. (See page 3-3.)
- Step 2. Test fan assembly for fan blade out of balance.  
 Test procedure:  
 Remove fan belts and operate engine at speed that had vibration. If there is no vibration, repair or replace fan assembly. (See TM 10-3930-641-20.)
- Step 3. Check pulley or vibration damper for loose bolts.  
 Tighten bolts on pulley or vibration damper. (See TM 10-3930-641-20.)
- Step 4. Check for defects in pulley or vibration damper.
  - a. Tighten capscrews or replace pulley. (See TM 10-3930-641-20.)
  - b. Repair/replace vibration damper. (See TM 10-3930-641-20.)

9. LOUD COMBUSTION NOISE (ENGINE KNOCKS)

- Step 1. See if fuel quality is bad.
  - a. Replace fuel.
  - b. Replace fuel filter elements.
- Step 2. Inspect fuel injection nozzles for defects.  
 Replace nozzles. (See page 3-29.)
- Step 3. Inspect fuel injection pumps for defects.  
 Repair pumps. (See page 3-36.)
- Step 4. Check fuel ratio control.  
 Reset ratio control. (See page 3-75.)

## ENGINE TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

## 10. LOUD CLICKING NOISE FROM VALVE COMPARTMENT

Step 1. Check for damaged springs or locks on valves.

Replace springs or locks as needed. (See page 3-255.)

Step 2. Check lubrication in valve compartment.

Look for a strong flow of oil at high rpm and a small flow of oil at low rpm. If there is little or no oil flow from all passages, repair engine oil pump. If there is little or no oil flow from one passage, but a sufficient flow from other passages, then the passage is clogged. Clean the passage.

Step 3. Check for too much valve clearance. (See page 3-268.)

Adjust valve clearance. (See page 3-268.)

Step 4. Check for damaged valve bridge.

a. Replace bridge and adjust. (See page 3-255.)

b. Readjust valve clearance. (See page 3-268.)

Step 5. Inspect for bent push rods.

Replace push rods. (See page 3-264.)

Step 6. Remove and inspect camshaft.

Replace if damaged. (See pages 3-273, 3-283.)

Step 7. Inspect valve lifters.

Repair/replace. (See page 3-264.)

Inspect camshaft lobes for damage from lifters. (See page 3-283.)

Replace camshaft if lobes are damaged. (See page 3-273.)

## 11. LOUD MECHANICAL NOISE IN ENGINE

Step 1. Inspect timing gears for damage.

Replace if necessary. (See page 3-291.)

Step 2. Inspect camshaft for damage.

Replace if necessary see pages 3-273, 3-283.)

## ENGINE TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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## 11. LOUD MECHANICAL NOISE IN ENGINE (CONT)

- Step 3. Inspect connecting rod bearings.  
Replace if necessary. (See page 3-347.)
- Step 4. Inspect pistons for damage.  
Replace or repair as necessary. (See page 3-338.)

**NOTE**

**If piston assembly is replaced, then the cylinder liner must also be replaced. (See page 3-239.)**

- Step 5. Inspect crankshaft for damage.  
Replace if necessary. (See page 3-319.)

## 12. OIL IN COOLING SYSTEM

- Step 1. Inspect for defect in oil cooler core.  
Repair. (See TM-750-254)
- Step 2. Replace head gaskets. (See page 3-217.)
- Step 3. Replace spacer plate gaskets. (See page 3-246.)

## 13. FUEL USE IS EXCESSIVE

Use driver's report to decide if increased use of fuel has been gradual or sudden.

A sudden increase

- Step 1. Check for fuel leaks.  
Replace leaking fuel lines or components. (See TM 10-3930-641-20.)

## ENGINE TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

## 13. FUEL USE IS EXCESSIVE (CONT)

Step 2. Check for internal fuel leaks.

## NOTE

An increase in engine oil level indicates an internal fuel oil leak.

a. Check piston rings. (See page 3-365.)

Replace rings and cylinder liners.

b. Check injection valve connections.

Tighten/replace.

A gradual increase

Step 3. Small increases in fuel use can be caused by factors affecting normal running.

(See **MALFUNCTION** no. 3 and no. 7.)

Step 4. Check fuel ratio control.

Adjust ratio control. (See page 3-75.)

Step 5. Check injector nozzles for defects.

Replace nozzles. (See page 3-29.)

## 14. ENGINE HAS OIL AT EXHAUST

Step 1. Check for oil flooding in valve compartment.

Install plugs in both ends of rocker arm shaft. (See page 3-211.)

Step 2. Inspect valve guides for wear.

Replace valve guides. (See page 3-262.)

Step 3. Inspect piston rings.

Replace piston rings and cylinder liners. (See pages 3-355 and 3-239.)

## ENGINE TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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## 15. COOLANT IN LUBE OIL

Step 1. Disassemble and inspect engine oil cooler core.

Repair/replace. (See page 3-152.)

Step 2. If engine oil cooler core is not the problem then begin engine disassembly.

a. Remove cylinder head and check for cracks or defects.

Replace if defective. (See page 3-217.)

**NOTE**

**A new spacer plate gasket and cylinder head gasket must be used whenever heads are disassembled.**

b. Inspect cylinder liner seals for defects.

Replace seals. (See page 3-239.)

c. Inspect cylinder blocks for cracks or defects. (See page 3-250.)

Replace block. (See Chapter 3.)

d. If above components were not defective, assume the fault was the cylinder head gasket.

Replace head gasket. (See page 3-217.)

## 16. BLACK OR GRAY SMOKE FROM EXHAUST

Step 1. Inspect air inlet filter for obstruction.

Replace air filter element. (See TM 10-3930-641-20.)

Step 2. Inspect fuel ratio control.

Adjust/repair. (See page 3-75.)

Step 3. Inspect fuel injection pumps.

Adjust or repair. (See pages 3-32, 3-36.)

ENGINE TROUBLESHOOTING (CONT)

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

17. WHITE OR BLUE SMOKE FROM EXHAUST (ENGINE USING EXCESSIVE LUBE OIL)

- Step 1. Check for engine oil past specified level.  
Remove engine oil to specified level.
- Step 2. Check fuel ratio control.  
Adjust ratio control. (See page 3-75.)
- Step 3. Excessive oil consumption caused by engine misfiring or running rough.  
See **MALFUNCTION** no. 3.
- Step 4. Inspect turbocharger for oil seal defect.

**NOTE**

**Oil will be present in air inlet manifold if oil seal leaks.**

- Replace oil seal. (See page 3-128.)
- Step 5. Remove fuel injection nozzle and crank engine. Check for coolant in pistons.  
Replace cracked heads. (See page 3-217.)
- Step 6. Inspect valve guides for wear.  
Replace valve guides. (See page 3-262.)
- Step 7. Inspect piston rings for wear.  
Replace piston rings. (See page 3-355.)
- Step 8. Inspect cylinder liners for wear.  
Replace cylinder liners. (See page 3-239.)

**NOTE**

**If rings are replaced then liners must be replaced.**

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**ENGINE TROUBLESHOOTING (CONT)**

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**18. LOW ENGINE OIL PRESSURE**

Step 1. Inspect engine oil filter element.

Replace elements. (See TM 10-3930-641-20.)

Step 2. Check bypass valve for defects.

Replace or repair as necessary. (See page 3-146.)

Step 3. Check oil cooler core.

a. Repair or replace or clean as necessary. (See page 3-152.)

b. Change oil. (See TM 10-3930-641-12.)

Step 4. Check oil pressure gage and sending unit for defects.

Replace oil pressure gage or sending unit. (See TM 10-3930-641-20.)

Step 5. Check for fuel in engine oil.

See Malfunction no. 13, step 2.

Step 6. Oil pump suction tube or bell is defective.

a. Repair or replace suction tube. (See page 3-143.)

b. Repair or replace bell. (See page 3-143.)

Step 7. Check oil pump relief valve.

Clean or repair valve. (See page 3-146.)

Step 8. Inspect oil pump.

Replace defective parts or pump. (See page 3-146.)

Step 9. Inspect for excessive clearance between camshaft and camshaft bearings. (See page 3-283.)

Replace bearings or camshaft as necessary. (See pages 3-280, 3-283.)

Step 10. Inspect for excessive bearing clearance on idler gear. (See page 3-291 and page 2-67.)

Replace idler gear bearings. (See page 3-291.)

Step 11. Inspect crankshaft and crankshaft bearings for excessive clearance. (See pages 3-345, 3-347.)

Replace crankshaft bearings. (See page 3-338.)

**ENGINE TROUBLESHOOTING CONT)**

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

**19. ENGINE OVERHEATS**

Step 1. Check coolant level. (See TM 10-3930-641-20.)  
 Add coolant. (See TM 10-3930-641-20.)

Step 2. Inspect radiator core for debris.  
 Clean radiator core. (See TM 10-3930-641-20.)

Step 3. Check fan belts for tightness and cracks or wear.  
 a. Tighten loose fan belts. (See TM 10-3930-641-20.)  
 b. Replace cracked or worn fan belts. (See TM 10-3930-641-20.)

**NOTE**

**Fan belts must be replaced as a set.**

Step 4. Check engine oil level.  
 Fill to specified level. (See LO 10-3930-641-12.)

Step 5. Check water temperature gage.  
 Replace gage if defective. (See TM 10-3930-641-20.)

Step 6. Determine if vehicle is being continuously overloaded.

**NOTE**

**RTCH is rated for 50,000 lb. load capacity.**

Direct operator not to exceed rated load capacity.

Step 7. Inspect pressure cap for defects.  
 Replace pressure cap. (See TM 10-3930-641-20.)

Step 8. Check fuel ratio control.  
 Adjust ratio control. (See page 3-75.)

Step 9. Test water temperature regulator. (See TM 10-3930-641-20.)  
 Replace water temperature regulator. (See page TM 10-3930-641-20.)

**ENGINE TROUBLESHOOTING (CONT)**

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

**19. ENGINE OVERHEATS (CONT)**

- Step 10. Inspect water pump.  
 Repair water pump. (See page 3-168.)
  
- Step 11. Check for cracked cylinder head or blown head gasket.  
 Replace head or gasket. (See page 3-217.)
  
- Step 12. If the problem does not seem to be caused by engine or engine components:  
 Check the torque converter and transmission for overheating.  
 See Transmission Troubleshooting. (See page 2-44.)  
 See Torque Converter Troubleshooting. (See page 2-41.)

**20 ENGINE STARTING MOTOR DOES NOT TURN OVER**

- Step 1. Check main disconnect switch.  
 Turn on.
  
- Step 2. Check battery.  
 Recharge/replace.
  
- Step 3. Check wiring or starting switch.  
 Replace/repair. (See TM 10-3930-641-20.)
  
- Step 4. Test starting motor solenoid.  
 Replace solenoid. (See TM 10-3930-641-20.)
  
- Step 5. Test starting motor.  
 Repair starting motor. (See page 3-187.)

**21. ALTERNATOR DOES NOT CHARGE**

- Step 1. Inspect drive belt.
  - a. Adjust drive belt. (See TM 10-3930-641-20.)
  - b. Replace worn drive belt. (See TM 10-3930-641-20.)
  
- Step 2. Inspect wiring for defects.
  - a. Check charging circuit.
  - b. Check ground return circuit.
  - c. Check battery connections.  
 Repair or replace as necessary. (See TM 10-3930-641-20.)

**ENGINE TROUBLESHOOTING (CONT)**

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

**21. ALTERNATOR DOES NOT CHARGE (CONT)**

Step 3. Inspect brushes. (page 3-183.)  
 Replace brushes. (See page 3-176.)

Step 4. Inspect rotor for defects.  
 Replace rotor. (See page 3-176.)

**22. ALTERNATOR HAS LOW OR IRREGULAR DISCHARGE**

Step 1. Inspect wiring for defects.  
 a. Check charging circuit.  
 b. Check common return circuit.  
 c. Check battery connections.  
 Repair/replace as necessary. (See TM 10-3930-641-20.)

Step 2. Inspect brushes. (See page 3-183.)  
 Replace brushes. (See page 3-176.)

Step 3. Inspect alternator regulator.  
 a. Adjust regulator to higher charging rate. (See TM 10-3930-641-20.)  
 b. Replace alternator regulator. (See page 3-176.)

Step 4. Inspect rotor for defects.  
 Repair/replace. (See page 3-176.)

Step 5. Test rectifier diodes.  
 Replace defective diodes. (See page 3-176.)

**23. ALTERNATOR DISCHARGE RATE IS TOO HIGH**

**NOTE**

**When alternator discharge rate is too high, lights burn out and battery uses more than one ounce of water per week.**

Step 1. Inspect all connections for alternator and alternator regulator.  
 Tighten all connections.

**ENGINE TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****23. ALTERNATOR DISCHARGE RATE IS TOO HIGH (CONT)**

Step 2. Inspect alternator regulator.

- a. Adjust regulator to lower charging rate. (See page TM 10-3930-641-20.)
- b. Replace regulator. (See page 3-176.)

**24. ALTERNATOR IS NOISY**

Step 1. Inspect drive belt.

Replace drive belt. (See page TM 10-3930-641-20.)

Step 2. Inspect alternator drive pulley.

- a. Check torque of retaining nut.  
Tighten according to specification. (See Appendix D.)
- b. Check keyway.  
Replace pulley if keyway is worn and loose. (See TM 10-3930-641-20.)

Step 3. Check alinement of pulley and drive belt.

Aline drive belt and pulley. (See TM 10-3930-641-20.)

Step 4. Check for shorts in rectifier diodes.

Replace diodes as necessary. (See TM 10-3930-641-20.)

Step 5. Check alternator bearings.

Replace bearings. (See page 3-176.)

Step 6. Check runout of rotor shaft.

Replace rotor. (See page 3-176.)

**25. ENGINE HAS HIGH EXHAUST TEMPERATURE (HOT, THICK EXHAUST SMOKE)**

Step 1. Check exhaust system for restrictions.

Remove restrictions.

Step 2. Check air inlet, after turbocharger, for leaks.

Repair leaks.

Step 3. Check air inlet for restrictions.

Remove restrictions.

Replace filter elements. (See TM 10-3930-641-20.)

**ENGINE TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****25. ENGINE HAS HIGH EXHAUST TEMPERATURE (HOT, THICK EXHAUST SMOKE) (CONT)**

Step 4. Check fuel injection timing. (See TM 10-3930-641-20.)

Adjust timing. (See TM 10-3930-641-20.)

Step 5. Check fuel rack setting.

Adjust setting. (See TM 10-3930-641-20.)

Step 6. Check valve clearance.

Adjust valve clearance. (See page 3-268.)

Step 7. Check cylinder compression. (See TM 10-3930-641-20.)

Replace defective components (See pages 3-355, 3-217.)

**26. VALVE CLEARANCE GREATER THAN SPECIFICATION**

Step 1. Check for defects.

Adjust valve clearance if no defects. (See page 3-268.)

Step 2. Defects can be caused by improper lubrication.

Check oil flow according to malfunction no. 10, step 2.

Step 3. Inspect rocker arm for wear at face that contacts bridge. (See page 3-211.)

a. Replace rocker arm. (See page 3-207.)

b. Adjust valves. (See page 3-268.)

**NOTE**

**When adjusting rocker arms, measure clearance between rocker arm face and bridge.**

Step 4. Inspect bridge for wear. (See page 3-217.)

a. Replace bridge. (See page 3-217.)

b. Adjust valve clearance. (See page 3-268.)

Step 5. Inspect push rods for wear. (See page 3-264.)

Replace push rods. (See page 3-264.)

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**ENGINE TROUBLESHOOTING (CONT)**

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**26. VALVE CLEARANCE GREATER THAN SPECIFICATION (CONT)**

Step 6. Inspect valve lifters for wear or damage.

- a. If worn, replace. (See page 3-264.)
- b. If damaged, inspect camshaft for damage and replace. (See pages 3-283, 3-273.)

Step 7. Camshaft cams worn or damaged.

- a. Replace camshaft. (See page 3-273.)
- b. Adjust valve clearance. (See page 3-268.)

**27. VALVE CLEARANCE LESS THAN SPECIFICATION**

Step 1. Inspect valve seat for wear.

Replace valve seat. (See page 3-260.)

Step 2. Inspect valve face for wear or damage.

Replace valve. (See page 3-255.)

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**HYDRAULIC SYSTEM TROUBLESHOOTING GUIDES****(Sheet 1 of 2)**

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**NOTE**

**A failure of any component of the hydraulic system indicates the presence of other problems in the system. When troubleshooting the hydraulic system remember that the problem you correct may be the end result of a series of malfunctions that the operator or organizational maintenance didn't recognize - so, when you replace components, stop and think and look for causes of components failure.**

When troubleshooting the hydraulic system, examine the filter element - use a sharp knife and slice it open. When you see large metal particles you must drain, flush and refill the system after you make necessary repairs.

When the hydraulic oil cooling system is functioning normally, the hydraulic oil will cool on the return trip of the loading cycle. If the loading cycle is short, the oil will not get a chance to cool.

A quick and effective solution to air leaks at the hose connections is simply to add another hose clamp on the leaky connection.

Testing system for air.

If an excessive amount of air bubbles are found in the hydraulic reservoir sample bottle, do the following steps to find the source of the air leak.

1. Allow the hydraulic system to remain idle for a short period. It is characteristic of this type of system, that a short period of idleness will cause the air bubbles to disappear.
2. Run the engine at high idle with control levers in NEUTRAL position.
3. Take a sample from the reservoir and check for the presence of air bubbles. If there are bubbles in the oil then the air leak is on the suction side of the oil pump.
4. If there are no bubbles, maintain the engine speed at high idle and cycle the mast circuit, lift, tilt, side positioning, one at a time.
5. After each circuit, take a sample and check for bubbles.

**NOTE**

**When pump failure is the problem, there are three areas to investigate.**

1. High oil temperature
2. Cavitation
3. Aeration

**Go on to Sheet 2**

1. High oil temperature, 2100F. (990C) or above, begins to harden and erode the cylinder wiper seals. Faulty seals allow air and usually dirt to enter the hydraulic system. Entry of dirt and air into the system occurs at the rod end of the cylinder, because of the partial vacuum formed when lowering a load. If the filter is clogged, or if the dirt particles are small enough to get past the filter, they will cause wear in the pump.
2. Cavitation is caused by a restriction to the flow of oil on the suction side of the pump. This causes a condition in which the pump's capacity is greater than the supply of oil available to the pump. A small restriction causes a partial vacuum which results in bubbles in the oil. The action of these bubbles striking the pump components is to cause erosion of the components. A large restriction will decrease the lubrication of the pump, causing friction and heat in the components. As the temperature increases, the tolerances will decrease and the pump will seize. Cavitation is characterized by a high pitch whine that increases in intensity as the pump rpms increase.
3. Aeration arises from the same problems as cavitation, but the small bubbles have air in them. One source of air may be a leak in the suction side of the pump. Another source of air may be the result of high oil temperature hardening and eroding the cylinder wiper seals. Aeration is characterized by a sound like the pump is pumping marbles.

**End**

## HYDRAULIC SYSTEM TROUBLESHOOTING

## MALFUNCTION

## TEST OR INSPECTION

## CORRECTIVE ACTION

## HYDRAULIC SYSTEM

**1. HYDRAULIC SYSTEM WILL NOT LIFT LOAD**

Step 1. Inspect for air leaks on low pressure side of hydraulic oil pump (suction side).

Repair. (See page 7-13.)

Step 2. Test relief valve for proper operation. (See TM 10-3930-641-20.)

Adjust relief valve. (See TM 10-3930-641-20.)

Step 3. Inspect hydraulic pump for worn components.

a. Repair/replace. (See page 7-5.) Drain and flush system (see LO 10-3930-641-12.)

b. Find and correct the cause of pump failure (cavitation, aeration, dirty oil).

Step 4. Inspect hydraulic pump drive for damage.

Repair/replace as necessary.-(See page 7-5.)

Step 5. Inspect mast sliding blocks, rollers, and chains for proper lubrication.

Lubricate components as necessary. (See LO 10-3930-641-12.)

Step 6. Inspect carriage rollers and bearings for wear.

Replace/repair as necessary. (See page 7-94.)

Step 7. Check adjustment of mast with other lifting components. (See page 7-76.)

Adjust mast as necessary. (See page 7-76.)

**2. CARRIAGE WILL NOT LOWER CORRECTLY**

Step 1. Check for restrictions in lift line.

Clean/replace. (See TM 10-3930-641-20.)

Step 2. Check lift cylinder packing nut for tightness.

Loosen packing nut.

Step 3. Inspect lift cylinder flow control valve.

Clean/repair as necessary. (See page 7-44.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**2. CARRIAGE WILL NOT LOWER CORRECTLY (CONT)**

Step 4. Inspect control valve lift spool.

Clean/replace as necessary. (See page 7-44.)

Step 5. Inspect mast sliding blocks, rollers and bearings for proper lubrication. (See LO 10-3930-641-12.)

Lubricate components as necessary. (See LO 10-3930-641-12.)

Step 6. Inspect carriage rollers and bearings for wear.

Replace/repair as necessary. (See page 7-94.)

Step 7. Check adjustment of mast with other lifting components. (See page 7-76.)

Adjust mast as necessary. (See page 7-76.)

**3. MAST TILTS OR LIFTS TOO SLOWLY**

Step 1. Inspect for air leaks on low pressure side of hydraulic pump (suction side).

Repair. (See page 7-13.)

Step 2. Test relief valve for proper operation. (See TM 10-3930-641-20.)

Adjust relief valve. (See TM 10-3930-641-20.)

Step 3. Inspect hydraulic pump for worn components.

a. Repair/replace as necessary. (See page 7-5.)

b. Find and correct the cause of the pump failure. (Dirty oil, cavitation, aeration).

Step 4. Check engine performance.

Tune engine.

Step 5. Inspect tilt cylinder rods for damage.

Replace as necessary. (See page 7-54.)

Step 6. Check lift or tilt cylinder packing nuts for tightness.

Loosen packing nuts. (See page 7-54 or 7-66.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**4. LIFT OR TILT CYLINDERS DO NOT HOLD POSITION WITH HYDRAULIC CONTROL LEVERS IN NEUTRAL POSITION**

Step 1. Inspect lines and fittings for leaks.

Replace leaking lines and tighten fittings.

Step 2. Inspect cylinder piston seals.

Replace seals. (See page 7-54 or 7-66.)

Step 3. Inspect control valve.

a. Check for worn valve spools.

Replace valve spools. (See page 7-44.)

b. Check valve spool springs.

Replace springs. (See page 7-44.)

c. Inspect control valve check valves.

Replace check valves. (See page 7-44.)

**5. HYDRAULIC PUMP DOESN'T WORK**

Step 1. Check oil level of hydraulic reservoir.

Add oil. (See page LO 10-3930-641-12.)

Step 2. Check viscosity of oil.

Drain system and add oil with correct viscosity. (See LO 10-3930-641-12.)

Step 3. Check for restriction in pump suction or discharge lines.

Clean lines.

Step 4. Check for air leaks in pump suction line.

Repair/replace. Tighten fittings.

Step 5. Inspect pump drive for damage.

Repair/replace. (See TM 10-3930-641-20.)

Step 6. Inspect pump for worn components. (See page 7-5.)

a. Repair/replace. (See page 7-13.)

b. Find and correct the cause of pump failure (cavitation, aeration, dirty oil).

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**6. NOISY HYDRAULIC PUMP**

Step 1. Inspect oil level.

Add oil. (See LO 10-3930-641-12.)

Step 2. Oil viscosity too high.

Drain system and replace oil. (See LO 10-3930-641-12.)

Step 3. Inspect filter for dirt.

Clean filter. (See TM 10-3930-641-20.)

Step 4. Inspect pump suction line for restriction.

Clean suction line.

Step 5. Inspect pump.

a. Check for worn or damaged components.

Replace/repair. (See page 7-13.)

b. Find and correct the cause of pump failure (cavitation, aeration, dirty oil).

c. Flush and clean system. (See TM 10-3930-641-20.)

**7. OIL TEMPERATURE TOO HIGH**

Step 1. Check oil level.

Add oil. (See LO 10-3930-641-12.)

Step 2. Check for blocked oil line.

Clean oil line.

Step 3. Determine if system has been overloaded.

**NOTE**

**RTCH is rated to carry 50,000 lb. loads.**

Do not exceed rated load capacity

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****7. OIL TEMPERATURE TOO HIGH (CONT)**

- Step 4. Oil viscosity too low.  
Drain system and replace oil. (See LO 10-3930-641-12.)
- Step 5. Test relief valve for low setting. (See page 7-44.)  
Adjust relief valve. (See page 7-44.)
- Step 6. Inspect pump for wear.  
Replace/repair. (See page 7-5.)
- Step 7. Inspect hydraulic cooler core for debris.  
Clean core. (See TM-750-254.)

**8. CONTROL SPOOLS FOR HYDRAULIC CONTROL VALVE DO NOT MOVE EASILY**

- Step 1. High temperature hydraulic oil indicator is on.  
Allow hydraulic oil temperature to cool. (See Malfunction no. 7.)
- Step 2. Check for foreign material in fluid.  
Drain and flush system. (See LO 10-3930-641-12.)  
Clean filters. (See page TM 10-3930-641-20.)  
Replace hydraulic oil. (See LO 10-3930-641-12.)
- Step 3. Inspect linkages for tilt and lift levers.  
Repair/replace and adjust. (See TM 10-3930-641-20.)
- Step 4. Check the torque of fastening capscrews of valve assembly.

**NOTE**

**Improper torque settings will cause the control valve body to twist.**

**Retorque all fastening capscrews. (See Appendix D.)**

- Step 5. Inspect lift or tilt spools.  
Replace if bent or damaged. (See page 7-44.)
- Step 6. Inspect spool return springs.  
Replace springs. (See page 7-44.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****9. CONTROL VALVE SEALS LEAK**

Step 1. Check for foreign material under the seal.

- a. Clean valve.
- b. Replace seals. (See page 7-44.)

Step 2. Check for worn or damaged seals.

Replace seals. (See page 7-44.)

Step 3. Check valve spools for wear or damage.

Replace spools. (See page 7-44.)

Step 4. Check for looseness of seal plates.

Tighten plates. (See page 7-44.)

**10. THE LOAD LOWERS WHEN LIFT LEVER IS MOVED FROM NEUTRAL TO RAISE POSITION**

Step 1. Check for foreign material in check valve.

Clean. (See page 7-44.)

Step 2. Inspect check valve for wear on poppet and seat.

Replace poppet and seat. (See page 7-44.)

**11. THE HYDRAULIC SYSTEM WILL NOT HOLD A LOAD**

Step 1. Check for oil bypass between valve and body.

Replace control valve. (See page 7-44.)

Step 2. Check for oil bypass between cylinder and piston.

Replace cylinder assembly. (See page 7-44.)

Step 3. Test spool for centering.

Replace that section. (See page 7-44.)

Adjust control linkage. (See TM 10-3930-641-20.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**12. SPOOLS DO NOT RETURN TO NEUTRAL**

Step 1. Inspect control linkage alinement.  
Adjust control linkage. (See TM 10-3930-641-20.)

Step 2. Check torque on fastening capscrews in valve section.

**NOTE**

**Improper torque settings will cause the valve body to twist out of alinement.**

**Retorque capscrews. (See Appendix D.)**

Step 3. Inspect for bent spools.  
Replace spools (See 7-44.)

Step 4. Check for broken springs.  
Replace springs. (See page 7-44.)

Step 5. Check valve and system for foreign particles - drain system.  
Replace hydraulic oil. (See LO 10-3930-641-12.)

**13. NO MOVEMENT OR "BOUNCY" ACTION OF HYDRAULIC SYSTEM**

Step 1. Check for air in the system.  
Bleed air. (See TM 10-3930-641-20.)

Step 2. Test relief valve setting. (See page 7-44.)  
Adjust/replace. (See page 7-44.)

Step 3. Check for full movement of spool  
Adjust/replace. (See page 7-44.)

Step 4. Inspect valve body for internal cracks.  
Replace. (See page 7-44.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**14. RELIEF VALVE DOES NOT OPEN AT HIGH PRESSURE**

Step 1. Check for plugged orifice in relief valve assembly.  
Check valve orifice.

Step 2. Check to see if relief valve is installed backwards. (See page 7-44.)  
Install relief valve correctly. (See page 7-44.)  
Adjust. (See page 7-44.)

**15. LEAKAGE OF OIL INSIDE CYLINDER**

Step 1. Check piston seals for wear.  
Replace. (See repair procedure for cylinder.)

Step 2. Inspect cylinder for damage.  
Repair. (See repair procedure for cylinder.)

**16. TILT CYLINDER PISTON RODS SHOW WEAR**

Check alinement of cylinders.  
Aline cylinders. (See page 7-54.)

**17. SCRATCHES ON CYLINDER RODS.**

Inspect wiper rings for dirt and foreign material.  
Clean/replace wiper rings. (See repair procedure for cylinder.)

**18. CARGO TOPHANDLER DOES NOT LOCK**

Step 1. Inspect hydraulic lines and fittings.  
Tighten/replace. (See TM 10-3930-641-20.)

Step 2. Inspect twistlock assemblies.  
Repair/replace. (See page 9-24.)

Step 3. Check adjustment of control linkage.  
Adjust linkage. (See TM 10-3930-641-20.)

Step 4. Inspect spool for defects.  
Replace spool. (See page 7-44.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**HYDRAULIC SYSTEM TEE TESTS****19. MAIN RELIEF VALVE SETTING IN TOO HIGH OR TOO LOW.**

TEE test no. 1 indicates system pressure is too high or too low.  
Reset main relief valve.

**20. FLOW LOSS PERCENTAGES ARE 15% OR MORE AT 2000 RPM AND ARE APPROXIMATELY THE SAME AT 700 RPM.**

TEE tests 4 thru 7. (See page 7-133.)  
Step 1. Clean or repair relief valve.  
Step 2. Repair or replace hydraulic pump.  
Step 3. Repair cylinders.  
Step 4. Repair or replace control valves.

**21. FLOW LOSS PERCENTAGES ARE 15% OR MORE AT 2000 RPM AND FLOW LOSSES AT 700 RPM ARE MORE THAN 3 GPM HIGHER THAN AT 2000 RPM.**

TEE tests 4 thru 7. (See page 7-133.)  
Step 1. Repair or replace pump.  
Step 2. Repair or replace control valves.

**22. FLOW LOSS PERCENTAGES ARE 15% OR LESS AT 2000 RPM AND THE FLOW LOSSES AT 700 RPM ARE MORE THAN 3 GPM HIGHER THAN AT 2000 RPM**

TEE tests 4 thru 7. (See page 7-133.)  
Step 1. Repair leaks in the circuit.  
Step 2. Repair or replace control valves.

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**23. FLOW LOSS PERCENTAGES ARE 15% OR MORE AT 2000 RPM, BUT FLOW LOSSES ARE LESS THAN 15 GPM AT 700 RPM.**

TEE tests 4 thru 7 indicate aeration of oil. (See page 7-133.)

Step 1. Correct air leaks on low side of circuit (suction side of pump).

Step 2. Add oil to hydraulic tank.

Step 3. Change to correct grade of oil.

**24. FLOW LOSS PERCENTAGES FOR TESTS 4 AND 5 IS 15% OR MORE; FOR TESTS 6 AND 7 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Step 1. Replace seal in mast cylinder piston.

Step 2. Repair or replace control valve.

**25. FLOW LOSS PERCENTAGE FOR TEST 4 IS 15% OR MORE; FOR TESTS 5, 6, AND 7 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Repair or replace lift control valve.

**26. FLOW LOSS PERCENTAGE FOR TEST 5 IS 15% OR MORE; FOR TESTS 4, 6, AND 7 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Repair or replace control valve.

**27. FLOW LOSS PERCENTAGE FOR TESTS 6 AND 7 IS 15% OR MORE; FOR TESTS 4 AND 5 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Step 1. Replace tilt cylinder piston seals.

Step 2. Repair or replace tilt valve.

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**28. FLOW LOSS PERCENTAGE FOR TEST 6 IS 15% OR MORE; FOR TESTS 4, 5, AND 7 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Step 1. Repair or replace tilt valve.

Step 2. Tighten piston rod nuts.

**29. FLOW LOSS PERCENTAGE FOR TEST 7 IS 15% OR MORE; FOR TESTS 4, 5, AND 6 IT IS 0 TO 15%.**

TEE tests 4 thru 7. (See page 7-133.)

Repair or replace tilt valve.

**30. FLOW LOSS PERCENTAGE FOR TEST 12 IS 10% OR MORE; FOR TESTS 4 THRU 7 IT IS 15% OR MORE.**

TEE tests 12 and 4 thru 7. (See page 7-133.)

Repair or replace hydraulic pump. (See page 7-5.)

**31. FLOW LOSS PERCENTAGE FOR TEST 12 IS 0 TO 10%; FOR TESTS 4 THRU 7 IT IS 15% OR MORE**

TEE tests 12, and 4 thru 7. (See page 7-133.)

Step 1. Repair or replace control valve.

Step 2. Repair or replace cylinders.

**32. FLOW LOSS PERCENTAGE FOR TEST 12 IS 10% OR MORE. FLOW DIFFERENTIAL FOR TEST 12 IS HIGHER THAN TEST DIFFERENTIAL FOR TEST 14 BY MORE THAN 0 GPM.**

TEE tests 12 and 14 indicate aeration of oil, or pump cavitation.

Step 1. Find source of air leak in low side of system, (pump suction).

Step 2. Fill the hydraulic tank to the correct level.

Step 3. Drain and fill the system with the correct oil.

Step 4. Remove restrictions from the pump suction line.

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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- 33. FLOW LOSS PERCENTAGE FOR TEST 12 IS 10% OR MORE. FLOW DIFFERENTIAL FOR TEST 12 IS MORE THAN 0 GPM HIGHER THAN THE FLOW DIFFERENTIAL FOR TEST 14. TESTS 15 THRU 22 HAVE THE SAME FLOW DIFFERENTIAL.**

TEE tests 12 and 14, and 15 thru 22. (See page 7-139.) Indicate oil aeration.

Step 1. Drain and fill system with correct oil.

Step 2. Correct leaks on low side of system (pump suction side).

Step 3. Disassemble pump and reassemble correctly.

- 34. IN TESTS 15 THRU 22, THE FLOW DIFFERENTIAL IS THE SAME FOR THE FIRST FEW TESTS, BUT SUDDENLY DROPS AT ONE OF THE TESTS AND REMAINS THE SAME FOR THE REST OF THE TESTS. FOR EXAMPLE, TESTS 15, 16, AND 17 ARE THE SAME, BUT THE FLOW DIFFERENTIAL DROPS AT TEST 18 AND STAYS THE SAME FOR TESTS 19 THRU 22.**

TEE tests 15 thru 22. (See page 7-141.) Indicate pump cavitation.

Remove restriction in pump suction line.

- 35. TESTS 24 THRU 28 INDICATE LEAKAGE IN ONE OR MORE OF THE CYLINDERS. (SEE PAGE 7-145.)**

TEE tests 24 thru 28. (See page 7-145.)

Do the BLOCKED RIGHT CYLINDER TEST. (See page 7-144.)

- 36. TESTS 24 AND 25 INDICATE LEAKAGE IN CONTROL VALVES.**

TEE tests 24 and 25. (See page 7-145.)

Repair or replace the control valve. (See page 7-44.)

- 37. TEST 26 AND 27 INDICATE LEAKAGE IN CONTROL VALVE.**

TEE tests 26 and 27. (See page 7-145.)

Repair or replace tilt control valve. (See page 7-44.)

## HYDRAULIC SYSTEM TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**38. TEST 28 INDICATES LEAKAGE IN THE SIDE SHIFT CONTROL VALVE.**

TEE test 28. (See page 7-145.)

Repair or replace side shift control valve.

**39. TEST 25 INDICATES LEAKAGE IN THE SIDE TILT CONTROL VALVE.**

TEE test 28. (See page 7-145.)

Repair or replace side tilt control valve.

**40. TEST 24 AND 31 INDICATE LEAKAGE IN LEFT TILT CYLINDER.**

TEE tests 24 and 31. (See pages 7-145 and 7-148.)

Step 1. Replace piston seals. (See page 7-54.)

Step 2. Tighten piston nut.

Step 3. Replace cylinder assembly if damaged.

**41. TESTS 4 AND 31 INDICATE LEAKAGE IN RIGHT TILT CYLINDER.**

TEE tests 4 and 31.

See Malfunction no. 40.

## TORQUE CONVERTER TROUBLESHOOTING

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**1. TORQUE CONVERTER OVERHEATS**

Needle of torque converter oil temperature gage is in red area.

- Step 1. Check oil level in output transfer gear case.  
Add oil to proper level. (See LO 10-3930-641-12.)
- Step 2. Check coolant level in engine radiator.  
Fill to proper level. (See LO 10-3930-641-12.)
- Step 3. Check oil cooler for restrictions.  
a. Clean oil cooler.  
b. Repair or replace oil cooler. (See page 4-197.)
- Step 4. See if vehicle has been operated continuously at overload capacity.  
Tell operator not to exceed rated load capacity.
- Step 5. Test temperature gage.  
Replace temperature gage. (See TM 10-3930-641-20.)
- Step 6. Check oil pump.  
Repair or replace. (See page 4-179.)

**2. CONVERTER OUTLET RELIEF VALVE TAP SHOWS HIGH PRESSURE**

Check adjustment of converter outlet relief valve.  
Adjust/repair. (See page 4-225.)

## TRANSFER GEAR CASES AND DRIVE LINE COMPONENTS TROUBLESHOOTING

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****1. SYSTEM LOSES OIL**

Step 1. Check drain plug.

Tighten drain plug.

Step 2. Check for loose housing bolts.

Tighten housing bolts.

Step 3. Check for leaking gaskets.

Replace gaskets. (See page 4-124.)

Step 4. Check for defective oil seals.

Replace oil seals. (See page 4-124.)

Step 5. Check for cracked transfer gear cases.

Replace transfer gear cases. (See page 4-124.)

**2. NOISY TRANSFER GEARS**

Step 1. Inspect transmission oil level.

Add oil. (See LO 10-3930-641-12.)

Step 2. Inspect main drive shaft universal joints.

a. Tighten capscrews on connections.

b. Replace drive shaft if universal joints are damaged. (See pages 4-306, 4-308.)

c. Check drive shaft support bearings.

Replace if damaged. (See pages 4-306, 4-308.)

Step 3. Remove, disassemble, and inspect transfer gears.

Repair as necessary. (See page 4-119.)

**3. FRONT OR REAR DIFFERENTIAL IS INOPERATIVE**

Step 1. Check oil levels.

a. Inspect for oil leaks from worn seals, gaskets or cracked cases.

Repair or replace as necessary. Add oil. (See LO 10-3930-641-12.)

b. Inspect breather.

Replace if plugged. (See TM 10-3930-641-20.)

TRANSFER GEAR CASES AND DRIVE LINE COMPONENTS TROUBLESHOOTING

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

**3. FRONT OR REAR DIFFERENTIAL IS INOPERATIVE (CONT)**

Step 2. Inspect for broken gear teeth.

Replace gears as necessary. (See page 4-271.)

Step 3. Inspect bearings.

Replace if damaged. (See page 4-271.)

**4. FINAL DRIVE IS LOCKED**

Step 1. Check oil levels.

a. Inspect for oil leaks from worn seals, gaskets or cracked cases.

Repair or replace as necessary. (See page 4-254.)

b. Inspect breather.

Replace if plugged. (See TM 10-3930-641-20.)

Step 2. Inspect for broken gear teeth.

Replace gears as necessary. (See page 4-254.)

Step 3. Inspect bearings.

Replace if damaged. (See page 4-254.)

## TRANSMISSION TROUBLE SHOOTING

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**1. TRANSMISSION ENGAGES, BUT ENGINE STALLS AND VEHICLE DOESN'T MOVE**

Step 1. Inspect output transfer gears for damage.

Repair as necessary. (See page 4-138.)

Step 2. Inspect differentials for damage

Repair as necessary. (See page 4-271.)

Step 3. Inspect final drives for damage.

Repair as necessary. (See page 4-254.)

Step 4. Inspect transmission.

a. Check for damaged parts.

Repair as necessary. (See page 4-68.)

b. Determine if more than two clutches engage when a direction and speed are selected.

**NOTE**

**Power is transmitted through the transmission by engaging two clutches in combination, using the direction selection lever.**

**When the operator uses the selection lever, first a speed clutch engages, then a direction clutch engages.**

**TRANSMISSION TROUBLESHOOTING (CONT)**

**MALFUNCTION**

**TEST OR INSPECTION**

**CORRECTIVE ACTION**

**1. TRANSMISSION ENGAGES, BUT ENGINE STALLS AND VEHICLE DOESN'T MOVE (CONT)**

The following chart shows the clutch combinations for each speed.

<b>TRANSMISSION SPEED</b>	<b>CLUTCHES ENGAGED IN TRANSMISSION</b>
Fourth Speed Forward	2 and 3
Third Speed Forward	2 and 4
Second Speed Forward	2 and 5
First Speed Forward	2 and 6
Neutral	3
First Speed Reverse	1 and 6
Second Speed Reverse	1 and 5
Third Speed Reverse	1 and 4
Fourth Speed Reverse	1 and 3

Adjust transmission pressure control valve so only the correct combination of clutches engage for each speed selected. (See page 4-202.)

**2. TRANSMISSION SELECTION LEVER DOES NOT STAY IN EITHER DIRECTION WHILE ENGINE IS RUNNING AND PARKING BRAKE IS OFF**

Test and inspect transmission control lock. (See page 4-210.)  
Adjust or repair as necessary. (See pages 4-217, 4-234.)

**3. WARNING ALARM DOES NOT SOUND WHEN TRANSMISSION SELECTION LEVER IS MOVED FROM NEUTRAL WHILE ENGINE IS RUNNING AND PARKING BRAKE IS ON**

Step 1. Inspect direction control linkage for defects or incorrect adjustment. (See TM 10-3930-641-20.)  
Adjust linkage and replace defective parts. (See TM 10-3930-641-20.)

Step 2. Test warning switch.  
Replace warning switch. (See TM 10-3930-641-20.)

Step 3. Test back-up alarm warning alarm.  
Replace warning alarm. (See TM 10-3930-641-20.)

**TRANSMISSION TROUBLESHOOTING (CONT)**

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**3. WARNING ALARM DOES NOT SOUND WHEN TRANSMISSION SELECTION LEVER IS MOVED FROM NEUTRAL WHILE ENGINE IS RUNNING AND PARKING BRAKE IS ON (CONT)**

Step 4. Test warning system wiring circuit. (See TM 10-3930-641-20.)  
Repair as necessary. (See TM 10-3930-641-20.)

Step 5. Inspect transmission control lock.  
Repair and adjust as necessary. (See pages 4-217, 4-221.)

**4. BACK-UP WARNING ALARM DOES NOT SOUND WHEN TRANSMISSION SELECTION LEVER IS PUT IN REVERSE**

Step 1. Inspect direction control linkage for defects or incorrect adjustment.  
Adjust linkage and repair defective parts. (See TM 10-3930-641-20.)

Step 2. Test warning alarm switch. (See TM10-3930-641-20.)  
Replace warning alarm switch. (See TM 10-3930641-20.)

Step 3. Test back-up warning alarm.  
Replace back-up warning alarm. (See TM 10-3930-641-20.)

Step 4. Test back-up alarm wiring circuit.  
Repair circuit as necessary. (See TM 10-3930-641-20.)

**5. TRANSMISSION SELECTION LEVER DOES NOT RETURN TO NEUTRAL WHEN A DIRECTION IS SELECTED AND ENGINE IS RUNNING WITH THE PARKING BRAKE ON**

Step 1. Test and inspect transmission control lock group. (See pages 4-217, 4-221.)  
Adjust or repair as necessary. (See pages 4-217, 4-234.)

Step 2. Test parking/emergency brake system.  
Adjust or repair as necessary. (See TM 10-3930-641-20.)

## TRANSMISSION TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****6. TRANSMISSION WILL NOT SHIFT FROM ONE SPEED TO ANOTHER SPEED**

Inspect speed control linkage for incorrect adjustment and broken or defective parts.

Adjust linkage. (See TM 10-3930-641-20.)

Replace defective parts and then adjust linkage. (See TM 10-3930-641-20.)

**7. TRANSMISSION WILL NOT SHIFT FROM ONE DIRECTION TO ANOTHER DIRECTION**

Inspect direction control linkage for incorrect adjustment and broken or defective parts.

Adjust linkage. (See TM 10-3930-641-20.)

Replace defective parts and then adjust linkage. (See TM 10-3930-641-20.)

**8. TRANSMISSION OVERHEATS**

Step 1. Inspect oil level.

Add oil. (See LO 10-3930-641-12.)

Inspect system to determine where loss occurred and repair or replace as necessary.

Step 2. Inspect magnetic strainer in output transfer gear case.

Clean. (See TM 10-3930-641-20.)

Step 3. Inspect oil cooler.

Clean or repair core as necessary. (See page 7-22.)

Step 4. Inspect oil pump for worn or damaged parts.

Repair oil pump. (See page 4-188.)

Step 5. Inspect all lines and fittings for restrictions.

Clean lines and fittings. Remove kinks and restrictions from all oil lines.

Step 6. Test operation of sequence and pressure control valve. (See page 4-237.)

Add or remove spacers till valve functions correctly. Converter inlet pressure should be 130 psi.

(See pages 4-237, 4-205.)

Step 7. Determine if problem is that clutches do not completely disengage.

Test sequence and pressure control valve. (See page 4-237.) Sequence valve should open at 265 psi to 275 psi.

Add or remove spacers till pressure is correct. (See pages 4-237, 4-205.)

**TRANSMISSION TROUBLESHOOTING (CONT)**

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**9. TRANSMISSION SHIFTS SLOWLY**

Step 1. Inspect oil level.

Add oil. (See LO 10-3930-641-12.)

Step 2. Inspect oil pump.

a. Check for air leaks on suction side of oil pump. (See TM 10-3930-641-20.)

Repair leaks. (See TM 10-3930-641-20.)

b. Inspect oil pump for worn or damaged parts.

Repair oil pump as necessary. (See page 4-188.)

Step 3. Inspect control linkages for improper adjustment or damaged parts.

Repair or adjust linkages as necessary. (See TM 10-3930-641-20.)

Step 4. Test transmission sequence and pressure control valve. (See page 4-237.)

Repair or adjust as necessary. (See pages 4-237, 4-205.)

**10. TRANSMISSION SHIFTS ROUGHLY. (VERY SUDDENLY.)**

Step 1. Check adjustment of control linkages.

Adjust. (See TM 10-3930-641-20.)

Step 2. Test pressure setting of relief valve. (See page 4-231.)

Adjust valve using spacers. (See page 4-231.)

Step 3. Inspect spring of load piston in sequence and pressure control valve.

Replace spring. (See page 4-205.)

Step 4. Inspect springs of sequence and pressure control valve.

Replace if worn or damaged. (See page 4-205.)

**TRANSMISSION TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****11. TRANSMISSION DOES NOT WORK WHEN SPEED SELECTION LEVER IS PLACED IN ANY SPEED**

Step 1. Failure of transmission to operate at all indicates the total breakdown of some component, or components.

Investigate the following potential causes of low oil pressure. Bear in mind that it may be a combination of these factors.

- a. Check oil level in transfer gear case.  
Add oil. (See LO 10-3930-641-12.)
- b. Inspect oil pump and oil pump drive for damage.  
Repair oil pump or oil pump drive. (See page 4-188.)
- c. Inspect for air leaks on suction side of pump.  
Repair as necessary. (See TM 10-3930-641-20.)
- d. Test adjustment of relief valve. (See page 4-231.)  
Repair or readjust as necessary. (See pages 4-231, 4-228.)
- e. Test transmission pressure control valve. (See page 4-202.)  
Adjust or repair as necessary. (See page 4-205.)

Step 2. Inspect torque converter for damaged parts.  
Repair as necessary. (See page 4-17.)

Step 3. Inspect input transfer gears for damaged parts.  
Repair as necessary. (See page 4-124.)

Step 4. Inspect transmission for damaged parts.  
Repair as necessary. (See page 4-68.)

Step 5. Inspect output transfer gears for damaged parts.  
Repair as necessary. (See page 4-138.)

Step 6. Inspect differentials for damaged parts.  
Repair as necessary. (See page 4-271.)

**12. VEHICLE MOVES WHEN SELECTION LEVER IS IN NEUTRAL**

Step 1. Inspect direction control linkage for correct adjustment of damaged parts.

- a. Replace damaged parts. (See TM 10-3930-641-20.)
- b. Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Test sequence and pressure valve. (See page 4-237.)  
Adjust/repair. (See page 4-205.)

**TRANSMISSION TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****13. TRANSMISSION STAYS ENGAGED WHEN LEFT BRAKE PEDAL IS PUSHED**

Test and inspect transmission neutralizer valve. (See page 6-7.)

Adjust or repair valve. (See page 6-7.)

**14. TRANSMISSION DOES NOT WORK IN ANY FORWARD SPEED**

Step 1. Inspect adjustment of direction control linkage.

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 2 clutch (forward direction clutch).

a. Check for worn or damaged parts.

Replace as necessary. (See page 4-68.)

b. Check for low oil pressure due to malfunctioning sequence and pressure control valve. (See page 4-237.)

Adjust pressure differential and safety valve. (See page 4-237.)

**15. TRANSMISSION DOES NOT WORK IN ANY REVERSE SPEED**

Step 1. Inspect adjustment of direction control linkage.

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 1 clutch (reverse direction clutch).

a. Check for worn or damaged parts.

Replace as necessary. (See page 4-68.)

b. Check for low oil pressure due to malfunctioning sequence and pressure control valve. (See page 4-237.)

Adjust pressure differential and safety valve. (See page 4-237.)

**16. TRANSMISSION DOES NOT WORK IN FIRST SPEED, FORWARD OR REVERSE**

Step 1. Inspect adjustment of speed control linkage.

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 6 clutch (first speed clutch).

a. Check for worn or damaged parts.

Replace as necessary. (See page 4-68.)

b. Check for low oil pressure due to malfunctioning sequence and pressure control valve. (See page 4-237.)

Adjust sequence and pressure control valve. (See page 4-237.)

## TRANSMISSION TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**17. TRANSMISSION DOES NOT OPERATE IN SECOND SPEED FORWARD OR REVERSE**

Step 1. Inspect adjustment of speed control linkage.  
Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 5 clutch (second speed clutch).

- a. Check for worn or damaged parts  
Replace as necessary. (See page 4-68.)
- b. Check for low oil pressure due to malfunctioning sequence and pressure control valve. (See page 4-237.)  
Adjust valve. (See page 4-237.)

**18. TRANSMISSION DOES NOT WORK IN THIRD SPEED FORWARD OR REVERSE**

Step 1. Inspect adjustment of speed control linkage.  
Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 4 clutch (third speed clutch).

- a. Check for worn or damaged parts.  
Replace as necessary (See page 4-68.)
- b. Check for low oil pressure due to malfunctioning sequence and pressure control. (See page 4-2371.)  
Adjust valve. (See page 4-237.)

**19. TRANSMISSION DOES NOT WORK IN FOURTH SPEED FORWARD OR REVERSE**

Step 1. Inspect adjustment of speed control linkage.  
Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect No. 3 clutch (fourth speed clutch).

- a. Check for worn or damaged parts.  
Replace as necessary. (See page 4-68.)
- b. Check for low oil pressure due to malfunctioning sequence and pressure control valve. (See page 4-237.)  
Adjust valve. (See page 4-237.)

## TRANSMISSION TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**20. TRANSMISSION HAS LOW CLUTCH PRESSURES**

Step 1. Test operation of relief valve. (See page 4-231.)

Add spacers to load piston to increase clutch pressure. (See page 4-234.)

Step 2. Inspect clutch seal rings.

Repair or replace. (See page 4-68.)

**STEERING SYSTEM TROUBLESHOOTING (CONT)**

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**1. VEHICLE DOESN'T TURN WHEN STEERING WHEEL IS TURNED**

Step 1. Inspect flow control valve.

- a. Check for and remove any foreign matter.
- b. Replace valve springs. (See page 6-28.)

Step 2. Inspect pilot relief valve or valve seat for defects.

Repair as necessary. (See page 6-28.)

Step 3. Inspect pilot relief valve seat seal for defects.

Replace seal. (See page 6-28.)

**2. VEHICLE TURNS BY ITSELF**

Step 1. Determine if flow balance spool returns to neutral after a turn.

Adjust or repair as necessary. (See page 6-28.)

Step 2. Inspect sleeve valves in hand metering unit for foreign material. (See page 6-14.)

Clean sleeve valves.

Step 3. Inspect hand metering unit centering springs.

Replace centering springs. (See page 6-14.)

**3. AT HIGH SPEEDS, VEHICLE TURNS TOO FAST TO MAKE SMALL STEERING CORRECTIONS**

Step 1. Test flow control valve for correct adjustment. (Page 6-28.)

Remove shims from flow balance spool to increase steering time. (See page 6-28.)

Step 2. Determine if flow balance spool moves freely.

- a. Inspect metering orifice on flow balance spool for foreign material.  
Clean flow balance spool.
- b. Inspect springs of flow balance spool.  
Replace springs. (See page 6-28.)

**STEERING SYSTEM TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****4. STEERING WHEEL IS HARD TO TURN**

Step 1. Allow hydraulic oil to warm up to normal operating temperature.

Step 2. Inspect pilot lines of hand metering unit for restrictions.  
Clean or replace lines. (See TM 10-3930-641-20.)

Step 3. Check to see that pilot lines of hand metering unit are connected to the proper ports.  
Reconnect pilot lines correctly. (See page 6-14.)

**5. VEHICLE TURNS TOO SLOWLY IN ONE DIRECTION**

Do a metering time check to determine the difference in steering times of left and right turns. (See page 6-74.)

- a. If turn to right is faster than left, add flow balance shims to flow balance valve.
- b. If turn to right is slower than turn to left, remove shims from flow balance valve. (See page 6-88.)

**6. VEHICLE TURNS TOO SLOWLY IN EITHER DIRECTION**

Step 1. Do a steering time check. Steering time should be no more than 2.6 to 3.0 seconds. (See page 6-74.)  
Add shims to flow control valve to increase steering speed. (See page 6-24.)

Step 2. Test flow from primary steering pump. (See page 6-74.)  
Repair pump. (See page 6-52.)

Step 3. Inspect flow balance spool to see if it moves all the way.  
Replace spool. (See page 6-28.)

**7. VEHICLE DOES NOT TURN SMOOTHLY**

Step 1. Inspect flow control valve for free movement.  
Repair or replace valve. (See page 6-28.)

Step 2. Hand metering unit supply line has been installed in steering valve body, in the field test port instead of the correct port.  
Install supply line in correct port. (See page 6-14.)

---

**STEERING SYSTEM TROUBLESHOOTING (CONT)**


---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****8. STEERING WHEEL IS HARD TO TURN WHEN STEERING QUICKLY AWAY FROM A FULL TURN**

Inspect ball check and plug assembly in neutralizer valve. Determine if there is enough clearance between ball check and stud assembly. (See TM 10-3930-641-20.)

Repair or replace stud assembly as necessary. (See page 6-7.)

**9. STEERING WHEEL CAN STILL BE TURNED WHEN VEHICLE IS AT FULL TURN**

Step 1. Check adjustment of striker assembly. (See TM 10-3930-641-20.)

Readjust striker assembly. (See TM 10-3930-641-20.)

Step 2. Inspect neutralizer valve ball check seat for defects.

Repair valve seat or replace neutralizer valve. (See page 6-10.)

Step 3. Determine if relief valve opens before striker assembly moves neutralizer valve stem.

a. Readjust striker assembly to correct setting. (See TM 10-3930-641-20.)

b. Adjust relief valve setting. Use shims till relief valve opens at 2425 lbs. to 2575. (See page 6-10.)

**10. VEHICLE TURNS CORRECTLY WHEN MOVING, BUT IS SLOW TURNING IN BOTH DIRECTIONS WHEN CARRYING LOAD**

Step 1. Inspect relief valve.

a. Look for leakage past relief valve seat.

Replace seat. (See page 6-28.)

b. Look for leakage past relief valve seals.

Replace seals. (See page 6-28.)

Step 2. Check for leakage past both ball resolver seats.

Replace resolver ball and seat assembly. (See page 6-28.)

Step 3. Inspect flow control valve.

Repair/replace. (See page 6-28.)

**11. VEHICLE TURNS CORRECTLY WHEN MOVING BUT IS SLOW TURNING IN ONE DIRECTION WHEN CARRYING LOAD**

Inspect ball resolver valve.

a. If vehicle turns slowly in a right turn, replace upper seat and seal in ball resolver valve. (See page 6-28.)

b. If vehicle in a left turn, replace lower seat and seal in ball resolver valve. (See page 6-28.)

## STEERING SYSTEM TROUBLESHOOTING (CONT)

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**STEERING SYSTEM TEE TESTS**

- 12. RELIEF VALVE SETTING IS HIGHER OR LOWER THAN IT SHOULD BE (TEE TEST 1), AND: PERCENT OF FLOW LOSS FOR TEST 4 AND 5 IS 15% TO 50%.**

Test 1. (See page 6-84.)

Clean relief valve.

Adjust relief valve.

- 13. PERCENT OF FLOW LOSS IS 15% OR MORE FOR TEST 4 AND 5.**

Tests 4 and 5. (See page 6-84.)

Step 1. Repair or replace pump.

Step 2. Clean or repair relief valve.

Step 3. Replace piston seals for steering cylinders.

Step 4. Repair or replace steering control valve.

Step 5. Repair or replace hand metering unit.

Step 6. Repair or replace diverter valve.

- 14. PERCENT OF FLOW LOSS IS 15% OR MORE FOR TEST 4, FLOW LOSS IS 0 TO 15% FOR TEST 5.**

Tests 4 and 5. (See page 6-74.)

Step 1. Repair or replace steering control valve.

Step 2. Repair or replace follow-up linkage.

Step 3. Repair or replace relief valve.

- 15. PERCENT OF FLOW LOSS IS 15% OR MORE FOR TEST 5. FLOW LOSS IS 0 TO 15% FOR TEST 4.**

See Malfunction no. 13.

**STEERING SYSTEM TROUBLESHOOTING (CONT)**

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**16. PERCENT OF FLOW LOSS IS 10% OR MORE FOR TEST 8. FLOW LOSS IS 15% OR MORE FOR TESTS 4 AND 5.**

Tests 4, 5, 8. (See page 6-74.)

Step 1. Repair or replace pump.

Step 2. Repair or replace steering control valve.

Step 3. Repair or replace steering cylinders.

**17. PERCENT OF FLOW LOSS IS 0 TO 10% FOR TEST 8. FLOW LOSS IS 15% OR MORE FOR TESTS 4 AND 5.**

Test 4, 5, 8. (See page 6-74.)

Step 1. Repair or replace steering control valve.

Step 2. Repair or replace steering cylinders.

**18. PERCENT OF FLOW LOSS IS 10% OR MORE FOR TEST 8. FLOW DIFFERENTIAL FOR TEST 10 IS HIGHER BY 0 GPM OR MORE THAN FLOW DIFFERENTIAL FOR TEST 8.**

Test 8, 10. (See page 6-74.)

Repair or replace pump.

**19. PERCENT OF FLOW LOSS IS 10% OR MORE FOR TEST 8. FLOW DIFFERENTIAL FOR TEST 9 IS HIGHER THAN THE FLOW DIFFERENTIAL FOR TEST 10 BY 0 GPM OR MORE.**

Test 8, 10. (See page 6-74.)

Step 1. Correct problems that contribute to aeration of the oil.

Step 2. Correct the problems causing pump cavitation.

## STEERING SYSTEM TROUBLESHOOTING (CONT)

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****20. PERCENT OF FLOW LOSS IS 10% OR MORE FOR TEST 8. FLOW DIFFERENTIAL FOR TEST 8 IS MORE THAN 0 GPM FOR TEST 10. TEST 11 THRU 18 HAVE SAME FLOW DIFFERENTIAL.**

Tests 8, 10, and 11 thru 18. (See page 6-74.)

Step 1. Fill hydraulic tank.

Step 2. Drain system and fill with correct oil.

Step 3. Repair air leaks.

Step 4. Repair or replace pump. Check for correct assembly.

**21. FLOW DIFFERENTIAL FOR EACH OF THE TESTS 11 THRU 18 SUDDENLY BECOMES LOWER AT ONE TEST AND THE FLOW RATE IS THE SAME FOR THE REMAINING TESTS. FOR EXAMPLE: 11 AND 12 ARE WITHIN 1 GPM, BUT 13 IS 8 GPM LESS THAN 12, AND 13, 14, 15, 16, 17, AND 18 ARE WITHIN 1 GPM OF EACH OTHER.**

Tests 11 thru 18. (See page 6-74.)

Correct the source of pump cavitation; a restriction in the suction line.

**22. LEAKAGE IN VALVES.**

Test 20 and 21. (See page 6-74.)

Step 1. Clean or repair relief valve.

Step 2. Replace steering valve body or spool.

Step 3. Repair or replace hand metering unit.

Step 4. Repair or replace diverter valve.

**23. LEAKAGE IN EITHER THE LEFT CYLINDER OR THE RIGHT CYLINDER.**

Tests 20, 24, 4. (See page 6-74.)

Step 1. Replace piston seals.

Step 2. Tighten piston nut.

Step 3. Replace cylinder.

**BRAKES TROUBLESHOOTING**

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**1. BRAKES DO NOT STOP VEHICLE**

- Step 1. Inspect brake linkage.  
Adjust brake linkage. (See TM 10-3930-641-20.)
- Step 2. Inspect brake pedal travel.  
Adjust brake pedal. (See TM 10-3930-641-20.)
- Step 3. Inspect for restrictions in hydraulic lines.  
Clean/Replace.
- Step 4. Check nitrogen charge.  
Charge accumulator. (See page 5-21.)
- Step 5. Inspect pump for wear or damaged parts.  
Repair/Replace.
- Step 6. Inspect brake components for wear or damage.  
Repair/Replace. (See page 5-38.)

**2. BRAKES ARE SLOW TO STOP VEHICLE**

- Step 1. Inspect brake pedal travel.  
Adjust brake pedal travel. (See TM 10-3930-641-20.)
- Step 2. Inspect for leaking lines or fittings.  
Replace/Tighten. (See TM 10-3930-641-20.)
- Step 3. Inspect for restrictions in brake lines.  
Clean lines.
- Step 4. Check nitrogen charge. (See page 5-21.)  
Charge accumulator. (See page 5-21.)

**BRAKES TROUBLESHOOTING (CONT)**

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**2. BRAKES ARE SLOW TO STOP VEHICLE (CONT)**

Step 5. Inspect brake control valve spool.

- a. Inspect spool.  
Replace spool. (See page 5-31.)
- b. Inspect springs..  
Replace springs. (See page 5-31.)

Step 6. Check pump for worn parts.

Repair/Replace. (See page 6-59.)

**3. BRAKES RELEASE SLOWLY**

Step 1. Inspect brake control linkage adjustment.

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect lines for restrictions.

Clean lines.

Step 3. Inspect brake control valve spool and springs.

Replace spool or springs. (See page 5-31.)

**4. BRAKES DO NOT RELEASE**

Step 1. Inspect linkage for binding.

Repair/Replace. (See TM 10-3930-641-20.)

Step 2. Inspect return spring on brake control valve piston.

Replace. (See page 5-31.)

**5. BRAKES GRAB**

Inspect brake discs and plates for damage.

Replace/Repair. (See page 5-44.)

**BRAKES TROUBLESHOOTING (CONT)****MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION****6. BRAKES FEEL SOFT OR SPONGY**

Check for air in system.

Bleed air from system. (See TM 10-3930-641-20.)

**7. TRANSMISSION DOES NOT DISENGAGE WHEN LEFT BRAKE PEDAL IS PUSHED**

Step 1. Inspect adjustment of brake control linkage.

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect neutralizer valve.

Inspect spools and springs.

Replace spools or springs. (See page 5-31.)

Step 3. Inspect transmission valve.

Repair/Replace. (See page 4-157.)

**8. ACCUMULATOR PRESSURE IS NOT WITHIN RANGE**

Step 1. Test cut-out pressure. (See page 5-14.)

Adjust cut-out pressure by adding or removing shims to charging spool springs. (See page 5-14.)

Step 2. Check cut-in pressure. (See page 5-14.)

Cut-in pressure must be within 475 psi to 575 psi of cut-out pressure.

Adjust by adding or removing shims to detent ball spring on the opposite end of spool.

**ACCUMULATOR VALVE RELIEF VALVE DOESN'T WORK**

Step 1. Inspect valve.

Repair/Replace. (See page 5-14.)

Step 2. Test relief valve cut-out pressure. (See page 5-31.)

Add or remove shims until relief cut-out pressure is 2650 psi to 2750 psi. (See page 5-14.)

## BRAKES TROUBLESHOOTING (CONT)

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**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

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**10. EMERGENCY BRAKE DOESN'T WORK****NOTE**

**Use parking/emergency brake test. (See TM 10-3930-641-10.)**

Step 1. Inspect parking brake control valve linkage for correct adjustment or defective parts.

- a. Adjust linkage. (See TM 10-3930-641-20.)
- b. Replace defective parts. (See TM 10-3930-641-20.)

Step 2. Inspect for wear of plates and discs.

Replace plates and discs if thickness of plate and disc assembly is less than 1.394 in.

Step 3 Test compression of springs. (See page 5-63.)

Replace springs. (See page 5-63.)

Step 4. Inspect parking brake control valve.

Check for bent valve stem.

Replace valve stem and seals. (See page 5-63.)

**11. EMERGENCY BRAKE DOESN'T DISENGAGE WHEN RELEASED PRIOR TO OPERATION OF VEHICLE**

Step 1. Inspect linkage for correct adjustment. (See TM 10-3930-641-20.)

Adjust linkage. (See TM 10-3930-641-20.)

Step 2. Inspect for leakage around valve stem.

- a. Inspect valve stem plug and seal.

Retorque valve stem plug (7 lbs to 11 lbs).

- b. Inspect valve stem for wear.

Replace valve stem. (See page 5-63.)

## BRAKES TROUBLESHOOTING (CONT)

---

**MALFUNCTION****TEST OR INSPECTION****CORRECTIVE ACTION**

---

**11. EMERGENCY BRAKE DOESN'T DISENGAGE WHEN RELEASED PRIOR TO OPERATION OF VEHICLE (CONT)**

Step 3. Inspect release piston for restriction of travel.  
Repair/Replace. (See page 5-63.)

Step 4. Test brake pump discharge pressure. (See page 5-62.)  
Repair pump. (See page 5-62.)

**Section III. GENERAL MAINTENANCE**

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**GENERAL MAINTENANCE PRACTICES**

General maintenance practices are given in this section. This information will not be repeated in any other part of this manual.

**SAFETY**

Safety is always the most important consideration when working on this vehicle. Understand completely the job to be done and use common sense and proper tools. Don't just do the job. Do it safely.

**REMOVING PARTS**

Always respect the weight of a part. Use a hoist whenever necessary. Don't lift heavy parts by hand. A hoist and adjustable lifting beam or sling are needed to remove most parts. The lengths of chains or cables from the hoist to the part being lifted should be equal and parallel and should be positioned directly over the center of the part. Never leave a part hoisted in mid-air.

Always use blocking to support the part that has been hoisted. If you cannot remove a part, check to see that all capscrews and attached hardware have been removed. Check to see if any parts are in the way of the part being hoisted.

When removing hoses, wiring or tubes, always tag each part to ensure proper installation.

**CLEANING**

Keep all dirt out of parts. The vehicle will perform better. Seals, filters, and covers are used in this vehicle to keep it clean. They must be kept in good shape to help the vehicle run well.

Clean and look at all parts when removing parts. Make sure all holes and passages are clean and open. After cleaning parts, be sure to cover them with a clean cloth, paper, or other clean material. Make sure the part is clean when it is installed.

Always clean around air lines, hydraulic lines, or covers before removing them. Plug, tape, or put caps on holes and openings to keep dirt out.

**DISASSEMBLY AND ASSEMBLY**

Always put together or take apart one part at a time. Do not work on two parts at the same time. Be sure to make all adjustments. Always check your work when you are finished. Make sure everything is done.

Check the adjustments for the last time by operating the vehicle. If all adjustments are correct, the vehicle is ready to go back to work.

---

**REPAIR AND REPLACEMENT PROCEDURES**

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**(Sheet 1 of 3)****HARDWARE AND THREADED PARTS**

Install helical thread inserts when inside threads in castings are stripped, damaged, or not able to withstand desired torque.

Replace capscrews, nuts, studs, washers, spacers, and small common hardware if missing or damaged in any way. Repair minor thread damage by cleaning out the threads using a tap or die.

Replace all damaged or missing lubrication fittings.

**BELTS, WIRING, HOSES AND LINES**

Replace belts, hoses, clamps, electrical wiring, electrical switches, circuit breakers, or fuel lines if they fail to meet prescribed standards.

**INSTRUMENTS AND GAGES**

Replace defective or broken instruments and gages. Replace dials and glass that are so scratched or discolored that it is difficult to read.

**BALL AND ROLLER BEARINGS**

Anti-friction bearings must be handled in a special way. To keep out dirt and abrasives, cover the bearings as soon as they are removed.

Wash bearings in a non-flammable cleaning solution. Knock out packed lubricant inside by tapping the bearing against a wooden block. Wash bearings again. Cover bearings with clean material, and set them down to dry.

Then coat bearings with oil. Wrap them in clean paper.

**Go on to Sheet 2**

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**REPAIR AND REPLACEMENT PROCEDURES****(Sheet 2 of 3)**

Make sure the chamfered side of the bearing faces the shoulder when installing bearings against shoulders. Before pressing bearings into place, lubricate them and all metal surfaces they contact. Put pressure only on the part of the bearing that directly contacts the mating part.

Always use the proper tools and fixtures for removing and installing bearings. Special tools and fixtures that are needed are listed in the manual.

Bearings do not usually need to be removed. Remove bearings only if it is necessary.

**SLEEVE BEARINGS**

Do not remove a sleeve bearing unless it is damaged, very worn, or loose in its bore. If you must remove a sleeve bearing, press it out.

When pressing or driving, put pressure right in line with the bore. Use a bearing driver or a bar with a smooth flat end to drive a bearing. Never use a hammer.

If there are oil holes, make sure they are alined.

**GASKETS**

Always replace used gaskets with new gaskets. Never use the same gasket twice. Make sure the gasket holes match up with holes in the mating part.

If gasket must be made, make sure to cut holes to match up with the mating part. Use material that is the right type and thickness.

Serious damage to the machine can happen if any holes on the part are blocked by the gasket.

**LIP TYPE SEALS**

Lip seals are usually used to seal oil or grease. To seal in oil, the lip is usually put facing toward oil to be sealed. To seal grease, the lip usually faces away from grease.

Seals should not be removed. Only remove seals to get at other parts or if the seal is damaged or worn.

Leaking oil or grease usually means that a seal is damaged and needs to be replaced. Replace leaking seals so that bearings don't overheat. Do not use the same seal twice.

Soak new rawhide seals in warm oil for one half hour before using them, if possible. Put in wiper edge seal with wiper edge turned in direction recommended. When putting seals in place, use shims around shafts and shoulders.

**Go on to Sheet 3**

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**REPAIR AND REPLACEMENT PROCEDURES**

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**(Sheet 3 of 3)****PACKINGS**

Packing seals and O-rings (preformed packings) should always be replaced if they are removed from the mated part. To prevent leaks, put a coating of the same lubricant being sealed on seals before putting them on the part.

**GEARS**

Always use the tools listed in the manual to work on gears. Always watch for damaged or worn teeth on gears.

Burs and rough spots should be removed with a honing stone or crocus cloth before putting gear in place. Lubricate mating surfaces before pressing gears on shafts.

**SHAFTS**

If a shaft does not come out easily, check that all nuts and capscrews have been removed. See if other parts are in the way before using force.

Shafts fitted to tapered splines should be very tight. If shafts are not tight, disassemble and check tapered splines. Discard parts that are worn. Make sure tapered splines are clean, dry, and free of burs before putting them in place. Press mating parts together tightly.

Clean off rust compound from all machined surfaces of new parts.

**PART REPLACEMENT**

Replace worn, damaged, or defective parts with new parts.

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## **CLEANING**

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### **PART PROTECTION**

Before cleaning, protect rubber items (hoses, boots, electrical insulation) from cleaning solutions. Protect them with a grease proof barrier material. Remove the rubber part if it cannot be protected.

### **CLEANING PROCESS**

Any cleaning method may be used as long as it does not damage a part. Cleaning is necessary so that parts can be checked. d. Rusted paint areas must be stripped to bare metal before repainting.

### **RUST OR CORROSION REMOVAL**

Rust and corrosion can be removed with a wire brush, abrasive cloth, sand blasting, vapor blasting, or rust remover. Use buffing or a crocus cloth on highly polished parts that are rusted.

### **BEARINGS**

Remove shields and seals from bearings before cleaning. Bearings with permanent shields and seals must not be cleaned in a solution.

Clean open bearings by soaking them in a petroleum cleaning solution. Never use a solution with chlorine in it.

Bearings should stand and dry. Do not use compressed air to dry. Do not spin bearings while they are drying.

Section IV. SPECIFICATIONS

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**NOTE**

Numbers in parentheses before each specification procedure refer to numbers on the related illustration.

**TIMING GEARS (FRONT OF THE ENGINE) SPECIFICATIONS**

(Sheet 1 of 1)

- (1) 6N2532 Gear on the drive for the fuel injection pump.
- (2) 7N8345 Gear for the engine valve camshaft.

**NOTE**

**Make alignment of "V" mark as shown.**

- (3) 4N1948 Gear for the water pump.
- (4) 7N7586 Idler Gear (small) and 4N868 Balance Gear (large).

**NOTE**

**Make alignment "V" marks as shown.**

- (5) Bore in the bearing  
(new)..... 2.5060 + .0014 (63.602 + 0.036 mm)

Diameter of the shaft  
(new)..... 2.5000 + .0005 in. (63.500 + 0.013 mm)

- (6) End clearance (new) ..... 006 to .014 in. (0.15 to 0.35 mm)

- (7) Plate. The lubrication groove must be against the gear.

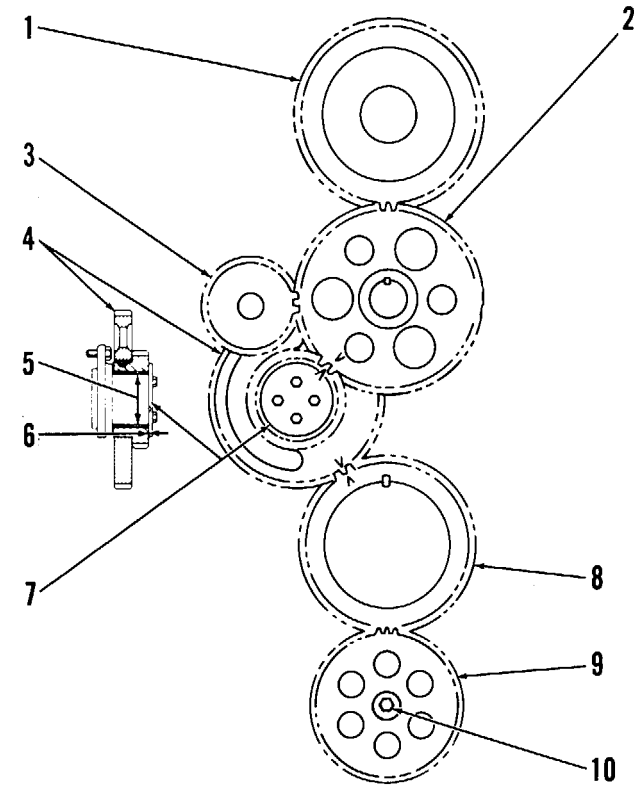
- (8) Crankshaft gear 7N7591.

**NOTE**

**Make alignment "V" mark as shown.**

- (9) 797592 Gear for the engine oil pump.

- (10) Torque for bolt.....40 + 5 lb. ft. (54 + 7 N.m)



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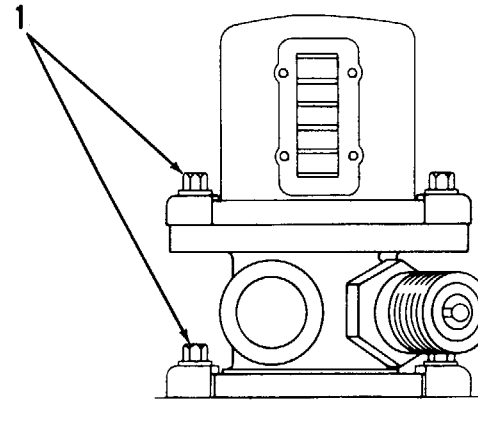
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**DRIVE FOR TACHOMETER AND SEVICE METER SPECIFICATIONS**

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- (1) Torque for four clamp bolts .....8 + 2 lb. ft. (11 + 3 N.m)



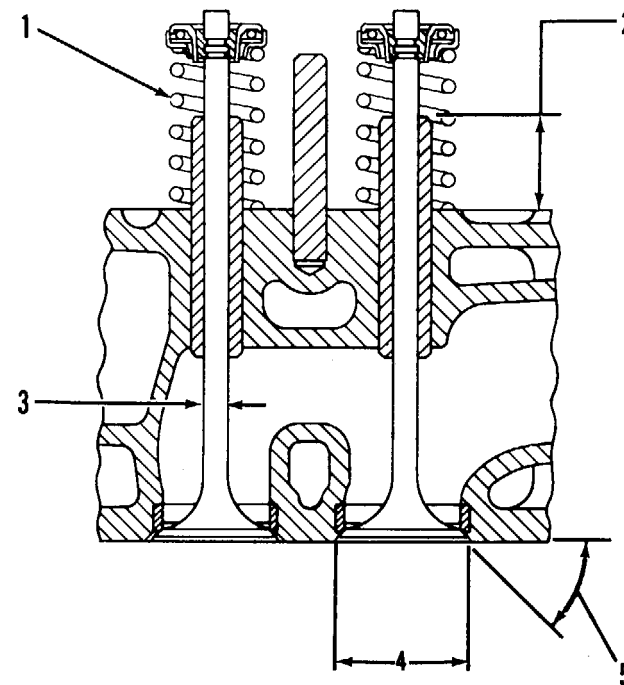
TYPICAL EXAMPLE

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**VALVES SPECIFICATIONS**

(Sheet 1 of 2)

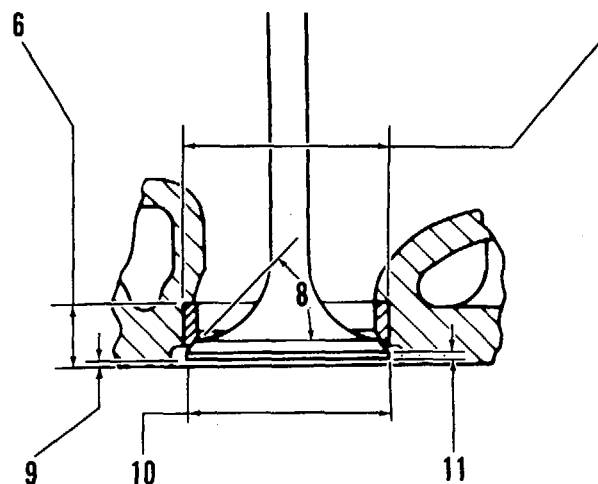
- (1) 4N5906 Spring for valves (new):
  - Length under test force ..... 2.165 in. (54.9 mm)
  - Test force ..... 77.5 + 3.9 lb. (35.2 + 1.8 kg)
  - Use again minimum load at length under test force ..... 71 lb. (32.2 kg)
  - Length of spring at valve open position ..... 1.665 in. (42.3 mm)
  - Use again minimum load at valve open position ..... 191 lb. (86.6 kg)
  - Free length after test ..... 2.47 in. (62.7 mm)
  - Outside diameter ..... 1.250 in. (31.8 mm)
  - Spring must not be bent more than ..... 0.086 in. (2.2 mm)
- (2) Height to top of valve guide..... 1.27 + .03 in. (32.3 + 0.8 mm)
- (3) Diameter of valve stem (new)..... .3717 + .0003 in. (9.441 + 0.008 mm)
  - Use again minimum:
  - 7N4580 Exhaust..... 3704 in. (9.41 mm)
  - 4N5654 Intake..... 3708 in. (9.41 mm)
  - Bore in valve guide with guide installed in the head (new)..... 3735 + .0010 in. (9.487 + 0.025 mm)
- (4) Diameter of valve head:
  - Exhaust valve ..... 1.646 + .005 in. (41.81 + 0.13 mm)
  - Intake valve ..... 1.771 + .005 in. (44.98 + 0.13 mm)
- (5) Angle of intake valve face ..... 29-1/4° + 1/40



**VALVES SPECIFICATIONS**

(Sheet 2 of 2)

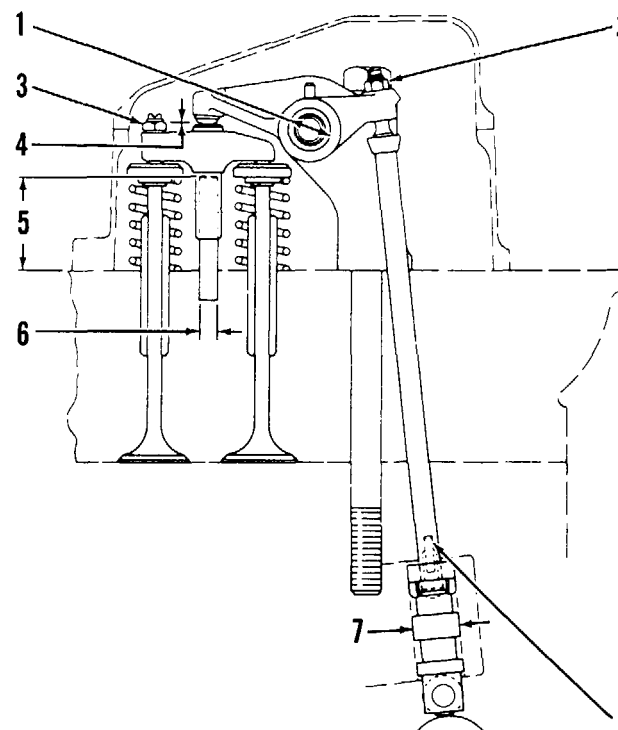
- (5) Angle of exhaust valve face ..... 44-1/40 + 1/40
  
- (6) Depth of bore in head for valve seat insert..... 512 ± .015 in. (13.00 ± 0.38 mm)
  
- (7) Diameter of valve seat insert for exhaust valve ..... 1.6870 + .0005 in. (42.850 + 0.013 mm)  
 Bore in head for valve seat insert for exhaust valve..... 1.684 ±.001 in. (42.77 ± 0.03 mm)
  
- (7) Diameter of valve seat insert for intake valve..... 1.8120 + .0005 in. (46.025 ± 0.013 mm)  
 Bore in head for valve seat insert for intake valve..... 1.809 ± .001 in. (45.95 ± 0.03 mm)
  
- (8) Angle of face of intake valve seat insert ..... 300 ± 1/40
  
- (8) Angle of face of exhaust valve seat insert ..... 450° 1/40
  
- (9) Dimension from top of closed valve to face of head:  
 Maximum permissible dimension for intake and exhaust ..... 042 in. (1.07 mm)  
 Minimum permissible dimension for intake and exhaust ..... 002 in. (0.05 mm)
  
- (10) Outside diameter of the face of the valve seat insert:  
 Exhaust seat..... 1.591 + .005 in. (40.41 ± 0.13 mm)  
 Intake seat..... 1.734 ± .005 in. (44.04 + 0.13 mm)
  
- (11) Use again" thickness of valve lip:  
 Exhaust valve ..... 080 in. (2.03 mm)  
 Intake valve ..... 099 in. (2.51 mm)



**ROCKERS ARMS, LIFTERS, AND BRIDGES SPECIFICATIONS**

(Sheet 1 of 2)

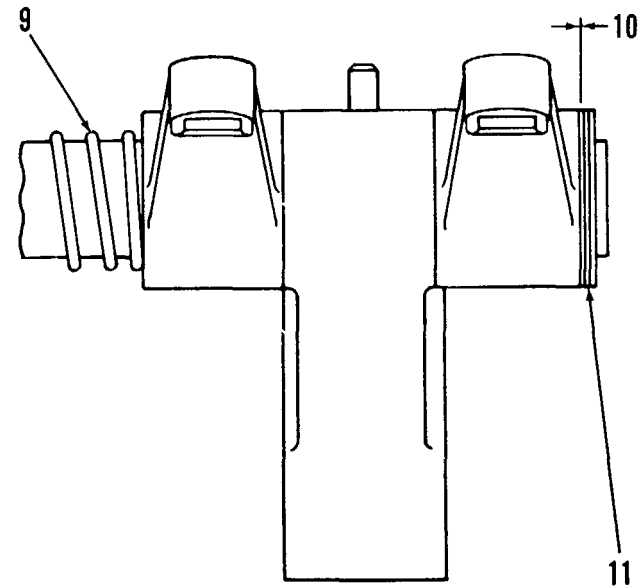
- (1) Bore in rocker arm for shaft (new) ..... 9765 + .0005 in. (24.803 + 0.013 mm)  
Diameter of shaft (new)..... 9745 + .0005 in. (24.752 + 0.013 mm)
- (2) Torque for locknut for valve adjustment screw .....22 + 3 lb. ft. (30 + 4 N.m)
- (3) Torque for locknut for bridge adjustment screw .....22 f 3 lb. ft. (30 + 4 N.m)
- (4) Clearance for valves:  
Intake valves ..... 015 in. (0.38 mm)  
Exhaust valves ..... 030 in. (0.76 mm)
- (5) Height to top of dowel..... 2.10 + .02 in. (53.3 + 0.5 mm)
- (6) Diameter of dowel (new)..... 4334 + .0001 in. (11.008 + 0.003 mm)  
Bore in bridge for dowel (new) ..... 4350 + .0012 in. (11.049 + 0.030 mm)  
Bore in head for dowel ..... 4322 + .0008 in. (10.978 + 0.020 mm)
- (7) Diameter of valve lifter (new).....1.09850 + .00025 in. (27.9019 i 0.0064 mm)  
Bore in block for valve lifter (new)..... 1.1005 + .0008 in. (27.953 + 0.019 mm)
- (8) Guide springs must not be used again. Always install new guide springs.



TA098808  
Go on to Sheet 2

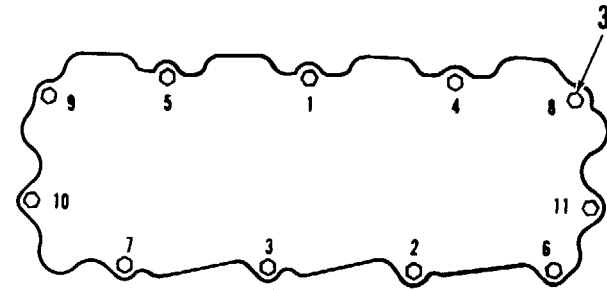
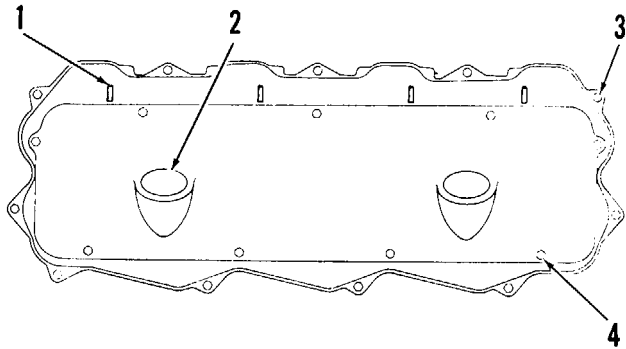
**ROCKER ARMS, LIFTERS, AND BRIDGES SPECIFICATIONS (CONT)**

- (9) 2N7229 Spring:  
 Length under test force ..... 2.92 in. (74.2 mm)  
 Test force ..... 10 to 12 lb. (4.5 to 5.4 kg)  
 Free length after test ..... 7.50 in. (114.3 mm)  
 Outside diameter ..... 1.17 in. (29.7 mm)
- (10) Clearance for rocker arms  
 (both ends) ..... 0.005 to .040 in. (0.13 to 1.02 mm)
- (11) Use 2N7228 Washer as needed to get this clearance.



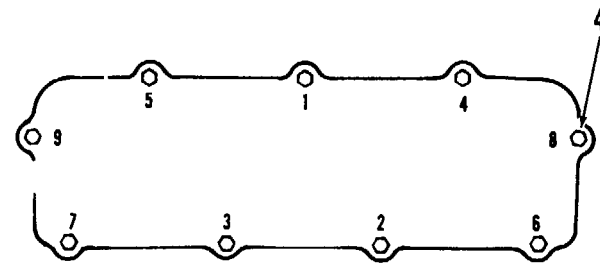
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VALVE COVERS SPECIFICATIONS



TIGHTENING SEQUENCE FOR BASE  
18 + 5 lb. ft. (24 + 7 N.m)

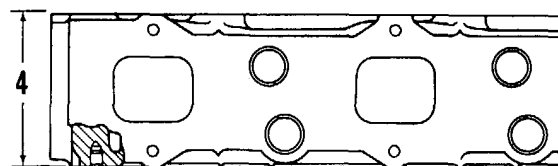
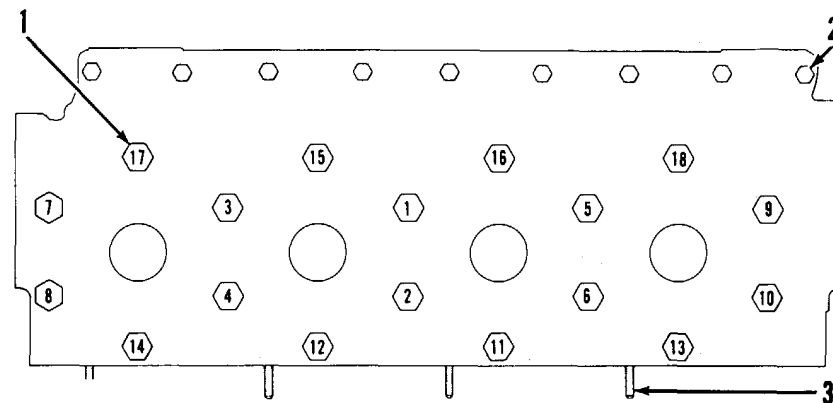
- (1) Torque for four studs (for locks of fuel injection lines).....10 + 3 lb. ft. (14 + 4 N-m)
- (2) Bore for adapter or plug. For installation, clean contact surfaces of bore and adapter or plug with quick cure primer and put retaining compound on the surfaces.
- (3) Tighten the bolts for the base in the number sequence shown to .....18 5 lb. ft. (24 + 7 N.m)
- (4) Tighten the bolts for the cover in the number sequence shown to .....18 + 5 lb. ft. (24 + 7 N.m)



TIGHTENING SEQUENCE FOR COVER  
18 + 5 lb. ft. (24 + 7 N-m)

**CYLINDER HEADS SPECIFICATIONS**

- (1) Large bolts (3/4 inch). Put engine oil on all bolt threads and tighten the bolts in the following step sequence:
  - Step 1. Tighten bolts from 1 to 14 in number sequence to.....200 + 20 lb. ft. (272 + 27 N.m)
  - Step 2. Tighten bolts from 1 to 14 in number sequence to.....330 + 15 lb. ft. (449 + 20 N.m)
  - Step 3. Tighten bolts from 1 to 14 in number sequence again to.....330 + 15 lb. ft. (449 + 20 N-m)
  - Step 4. Install the rocker arms for the engine valves.
  - Step 5. Tighten bolts from 15 to 18 in number sequence to.....200 + 20 lb. ft. (272 + 27 N.m)
  - Step 6. Tighten bolts from 15 to 18 in number sequence to.....330 + 15 lb. ft. (449 + 20 N-m)
  - Step 7. Tighten bolts from 15 to 18 in number sequence again to.....330 + 15 lb. ft. (449 + 20 N-m)
  - Step 8. Tighten the nine small bolts (2) to.....32 ± 5 lb. ft. (44 + 7 N-m)
- (2) Small bolts (3/8 inch). See Step 8, above.
- (3) Torque for eight studs in each cylinder head .....20 ± 3 lb. ft. (27 + N.m)
- (4) Height of cylinder head (new)..... 4.440 +.010 in. (112.78 ± 0.25 mm)

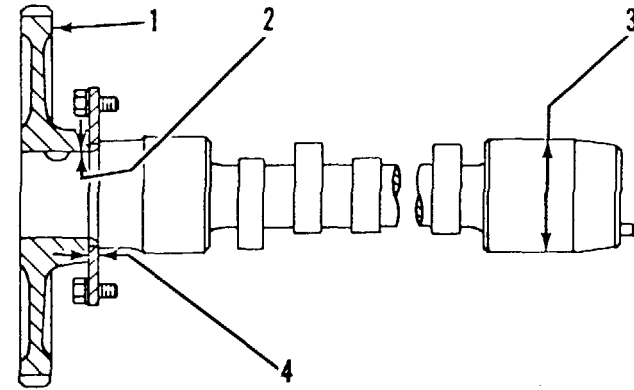


TA098811

**CAMSHAFT AND EXHAUST MANIFOLD SPECIFICATIONS**

**CAMSHAFT**

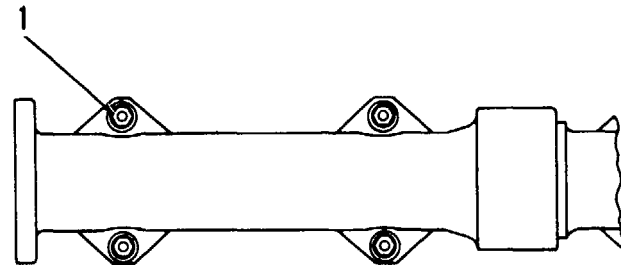
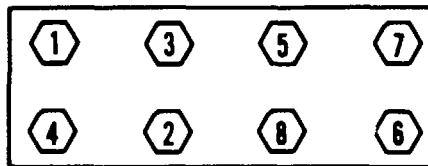
- (1) Maximum permissible temperature of the gear for installation on the camshaft  
(do not use a torch) .....600F (3150C)
- (2) Tight fit between the gear and camshaft..... 0025 to .0055 in. (0.060 to 0.140 mm)
- (3) Diameter of the surfaces (journals) for the camshaft bearings  
(new)..... 2.7500 + .0005 in. (69.850 + 0.013 mm)  
Bore in front and rear bearings for the camshaft  
(new)..... 2.7547 + .0019 in. (69.969 + 0.048 mm)  
Bore in three inner bearings for the camshaft  
(new)..... 2.7552 + .0024 in. (69.982 + 0.061 mm)
- (4) Thickness of thrust plate  
(new)..... 183 + .001 in. (4.65 + 0.03 mm)  
End play of the camshaft..... 004 to .010 in. (0.10 to 0.25 mm)



**EXHAUST MANIFOLD**

- (1) Torque for nuts (Use anti-seize compound on threads):
  - a. Tighten nuts in sequence
  - to .....38 + 5 lb. ft. (52 + 7 N-m)

**TIGHTENING SEQUENCE**

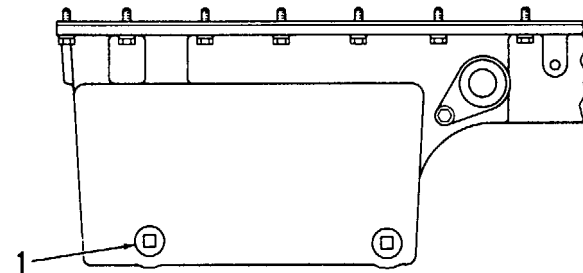
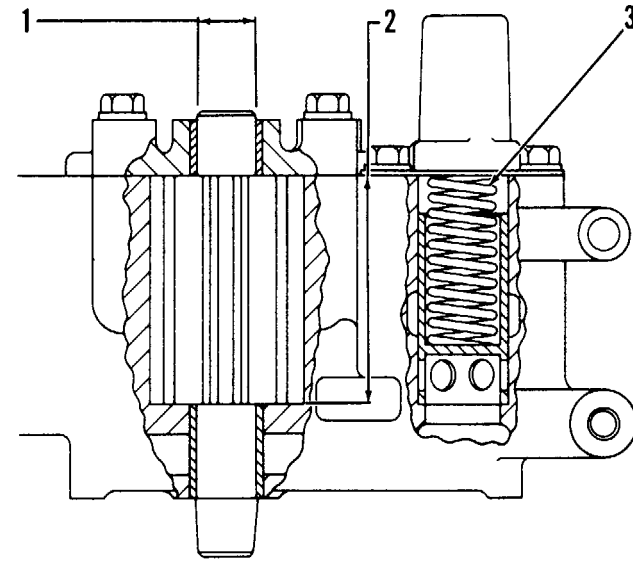


**OIL PUMP SPECIFICATIONS**

Rotation (seen from the drive end)..... counterclockwise  
 Test on test stand, with SAE 10W oil at 1200F (490C)

Output.....72 U.S. gpm (272 liter/min)  
 at a pressure of..... 45 psi (3.2 kg/cm<sup>2</sup>) (310 kPa)  
 with pump at.....2550 rpm  
 Output.....38 U.S. gpm (144 liter/min)  
 at a pressure of..... 81 psi (5.7 kg/cm<sup>2</sup>) (558 kPa)  
 with pump at.....2550 rpm

- (1) Diameter of drive shaft  
 (new)..... 8747 + .0002 in. (22.217 + 0.005 mm)  
 Bore in bearings for drive shaft  
 (new)..... 8763 + .0003 in. (22.258 ± 0.008 mm)  
 Diameter of idler shaft  
 (new)..... 747 ± .0002 in. (22.217 ± 0.005 mm)  
 Bore in bearings for drive  
 shaft (new)..... 8763 ± .0003 in. (22.258 ± 0.008 mm)
- (2) Length of gears  
 (new)..... 3.1250 + .0010 in. (79.375 + 0.025 mm)  
 Depth of bores for  
 gears (new) ..... 3.1300 ± .0008 in. (79.502 ± 0.020 mm)
- (3) 2S2760 Spring (oil pressure relief):  
 Length under test force ..... 4.64 in. (117.9 mm)  
 Test force ..... 110 + 5.5 lb. (49.9 ± 2.5 kg)  
 Free length after test ..... 6.02 in. (152.9 mm)  
 Outside diameter ..... 1.063 in. (27.00 mm)
- (1) Torque for three plugs with round head  
 and square boss.....45 + 8 lb. ft. (61 ± 11 N.m)



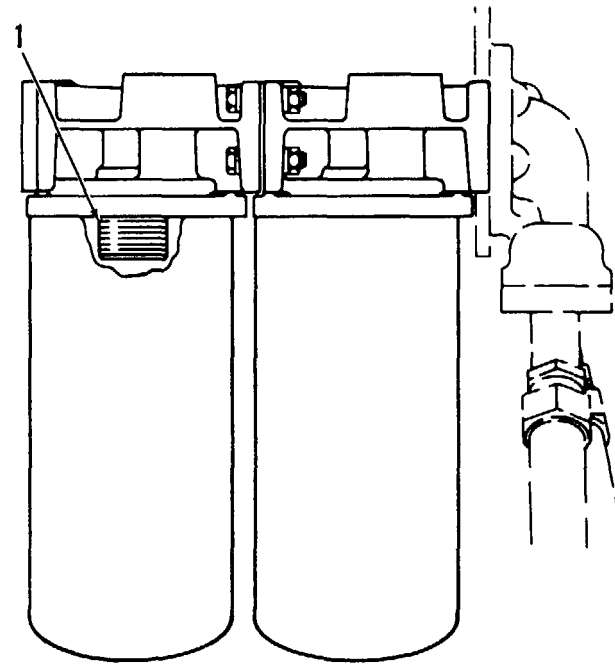
OIL PAN

TA098813

## OIL FILTER (REMOTE MOUNTED) SPECIFICATIONS

(Sheet 1 of 1)

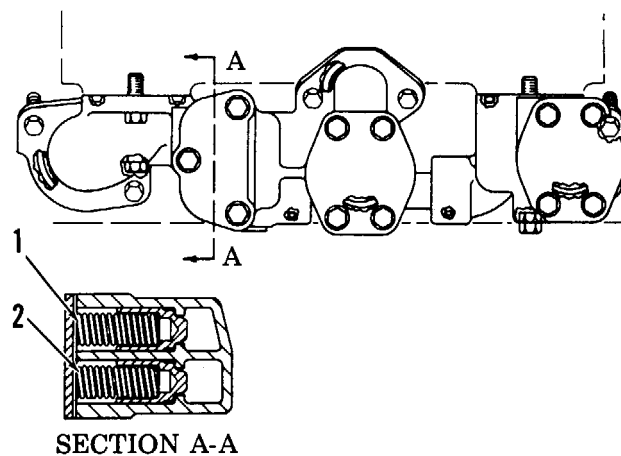
- (1) Torque for the center studs under the filter base [put thread lock compound on last .40 in. (10 mm) of thread at base end of studs]..... $60 \pm 10$  lb. ft. ( $82 + 14$  N.m)



TA098814

**OIL BYPASS VALVES SPECIFICATIONS**

- (1) 4N8150 Spring for the filter bypass valve:  
 Length under test force ..... 2.175 in. (55.25 mm)  
 Test force ..... 17.0 + 1.3 lb. (7.7 + 0.6 kg)  
 Free length after test ..... 3.69 in. (93.7 mm)  
 Outside diameter ..... 81 in. (20.6 mm)
- (2) 4N8150 Spring for the cooler bypass valve:  
 Length under test force ..... 2.175 in. (55.25 mm)  
 Test force ..... 17.0 + 1.3 lb. (7.7 + 0.6 kg)  
 Free length after test ..... 3.69 in. (93.7 mm)  
 Outside diameter ..... 81 in. (20.6 mm)



TA098815

**CYLINDER BLOCK SPECIFICATIONS**

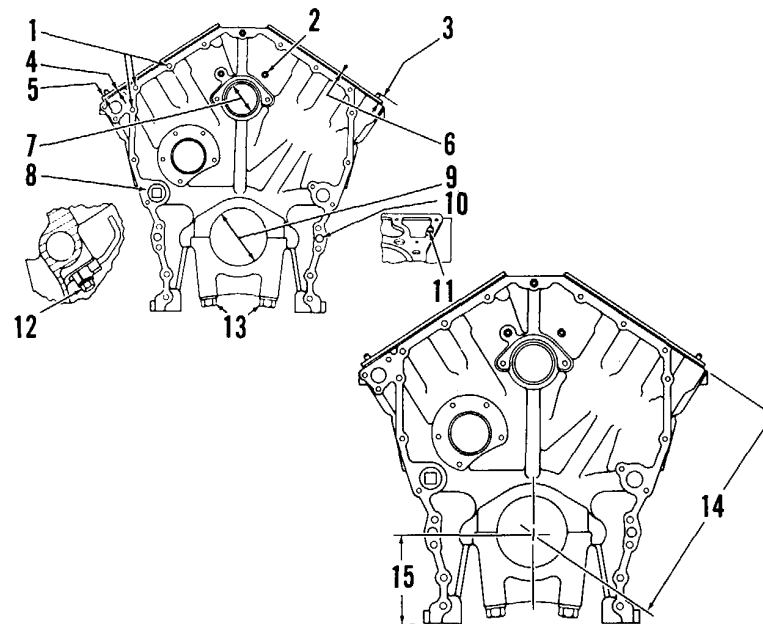
- (1) Torque for three studs to hold the water pump.....20 + 3 lb. ft. (27 + 4 N.m)
- (2) Plug (two on front and two on rear). See note below.
- (3) Length of dowels (four) out of the block face ..... .73 + .02 in. (18.5 + 0.5 mm)
- (4) Thickness of the gasket between the cylinder block and top plates ..... 008 + .001 in. (0.20 + 0.03 mm)
- (5) Thickness of the top plates ..... 338 + .001 in. (8.59 + 0.03 mm)
- (6) Refer to CYLINDER LINER PROJECTION, for the height of the liner.
- (7) Bore in the block for the camshaft bearings (five bores) ..... 3.0250 + .0007 in. (76.835 + 0.018 mm)
- (8) Torque for one plug on front and two on rear of the block (see note below) .....60 + 10 lb. ft. (82 + 14 N.m)
- (9) Bore in the block for the main bearings: standard, original size (new)..... 5.1138 + .0005 in. (129.891 + 0.013 mm)  
.025 in. (0.64 mm) larger than original size ..... 5.1388 + .0005 in. (130.526 + 0.013 mm)
- (10) Length of dowels (four) out of the front and rear faces of the block ..... 75 + .02 in. (19.1 + 0.5 mm)
- (11) Plug without threads (two) near the front and near the rear of the cylinder block, on top. See note below.
- (12) Torque for the eight bolts that hold the piston cooling tubes .....18 + 5 lb. ft. (24 + 7 N.m)
- (13) Torque for the bolts that hold the caps for the main bearings: Install the main bearing caps with the marks (arrow) toward the front of the engine. Install each cap in the same place from where it was removed. The cap with number 1 on its bottom goes in the front of the block. All other caps also have numbers for position.
  - a. Put engine oil on the threads of the bolts.
  - b. Tighten the bolts on left side to ..... 190 + 10 lb. ft. (258 + 14 N.m)

- c. Tighten the bolts on right side to ..... 190 + 10 lb. ft. (258 + 14 N.m)
- d. Put a mark on each bolt and cap.
- e. Tighten the bolts on right side, from the mark ..... 120°
- f. Tighten the bolts on left side, from the mark ..... 120°

**NOTE**

**Put sealer on the threads of 20 plugs installed without a seal, and on two plugs (11) without threads.**

- (14) Dimension (new from centerline of crankshaft bearing bore to top of block (top deck) ..... 16.500 + .006 in. (419.10 + 1.15 mm)
- (15) Dimension (new) from centerline of crankshaft bearing bore to bottom of block (pan rails) ..... 6.500 + .004 in. (165.10 + 0.10 mm)

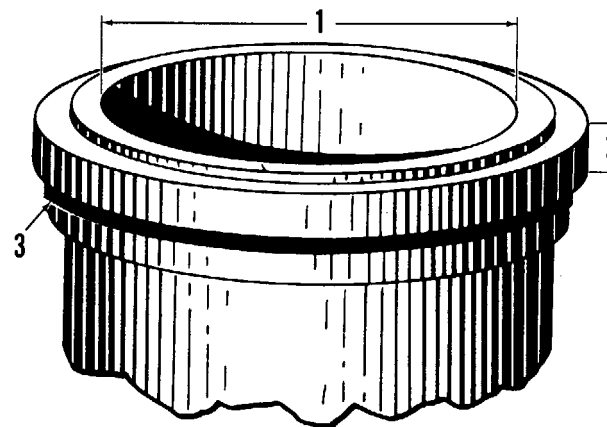


CYLINDER LINER SPECIFICATIONS

For installation:

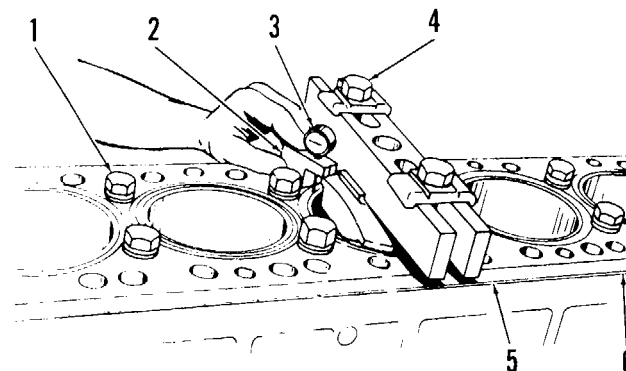
- a. Put liquid soap on grooves and seals on lower part of liner.
- b. Put a 9L5854 Filler Band completely in SAE30 oil for a moment.
- c. Install the band (3) around the groove under the liner flange.
- d. Install the liner in the cylinder block immediately, before expansion of the band.

- (1) Bore in liner  
 (new)..... 5.401 .001 in. (137.19 + 0.03 mm)  
 Maximum permissible bore when measured near upper end of the wear surface of the cylinder liner (worn)..... 5.408 in. (137.36 mm)  
 "Use again" maximum bore (when measured near upper end of the wear surface of the cylinder liner) ..... 5.405 in. (137.29 mm)
- (2) Thickness of flange on liner..... .3500 + .0008 in. (8.890 + 0.020 mm)
- (3) Filler band.



**CYLINDER LINER PROJECTION SPECIFICATIONS**

- (1) Install gasket (6) and spacer plate (5) with bolts (1). Tighten bolts (1) evenly in four steps:
  - 1st step ..... 10 lb. ft. (14 N-m)
  - 2nd step ..... 25 lb. ft. (34 N-m)
  - 3rd step ..... 50 lb. ft. (68 N-m)
  - 4th step ..... 70 lb. ft. (95 N-m)
- (2) Install tooling as shown. Tighten bolts (4) evenly in four steps:
  - 1st step ..... 5 lb. ft. (7 N.m)
  - 2nd step ..... 15 lb. ft. (20.4 N-m)
  - 3rd step ..... 25 lb. ft. (34 N.m)
  - 4th step ..... 50 lb. ft. (68 N.m)
- (3) Measure cylinder liner projection with dial indicator (3) in a cylinder liner projection tool (2) as shown. Measure at four places around each cylinder liner near the clamped area. Average of four projection measurements from any cylinder liner must be ..... 005 + .003 in. (0.13 + 0.08 mm)
  - Maximum permissible difference between all four measurements ..... 001 in. (0.03 mm)
  - Maximum permissible difference between average projection of any two cylinder liners next to each other ..... 001 in. (0.03 mm)
- (4) Minimum permissible depth to machine counterbore to adjust cylinder liner projection ..... 030 in. (0.76 mm)
  - Maximum permissible depth to machine counterbore to adjust cylinder liner projection ..... 045 in. (1.14 mm)
 Install a .030 in. (0.76 mm) shim plus any added shims necessary to get the correct cylinder liner projection.



SHIM THICKNESS, COLOR CODE, AND PART NUMBER				
.007 in. (0.18 mm)	.008 in. (0.20 mm)	.009 in. (0.23 mm)	.015 in. (0.38 mm)	.030 in. (0.76 mm)
BLACK	RED	GREEN	BROWN	BLUE
5S8138	5S8139	5S8140	5S8141	5S8142

**NOTE**

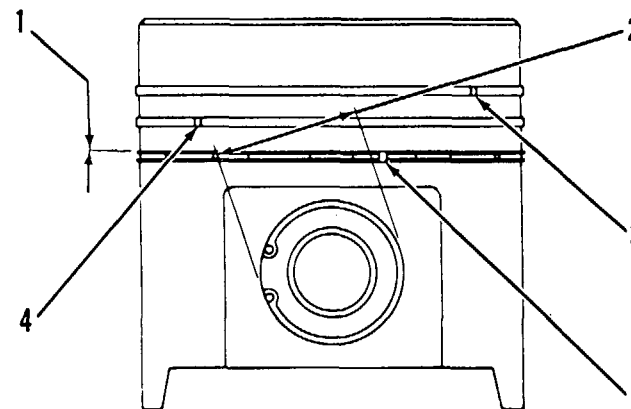
**Be sure that the .030 in. (0.76 mm) shim is directly under the cylinder liner flange.**

Put liquid gasket on the top of the top shim and on the bottom of the bottom shim before installing.

TA098818

**PISTON AND RINGS SPECIFICATIONS**

- (1) Clearance between oil ring and groove..... .0020 + .0010 in. (0.051 + 0.025 mm)
- (2) Bore in piston for pin (new)..... 2.0005 + .0002 in. (50.81 + 0.005 mm)  
 Clearance between pin and bore in piston (new)..... .0007 + .0004 in. (0.018 + 0.010 mm)  
 Maximum permissible clearance between piston pin and bore in piston (worn) ..... .002 in. (0.05 mm)  
 Clearance between ends of piston ring, installed in cylinder liner with bore size of ..... 5.401 in. (137.19 mm)\*
- (3) Top ring ..... .0285 + .0075 in. (0.724 ± 0.191 mm)  
 (Install the top ring with the mark "UP-1" toward the head of the piston.)
- (4) Center ring..... .0425 + .0075 in. (1.080 ± 0.191 mm)  
 (Install the center ring with the mark "UP-2" toward the head of the piston.)
- (5) Oil ring ..... 0.225 + .0075 in. (0.572 + 0.191 mm)  
 (Install the ring spring with its point of junction 180° from the ring gap.)

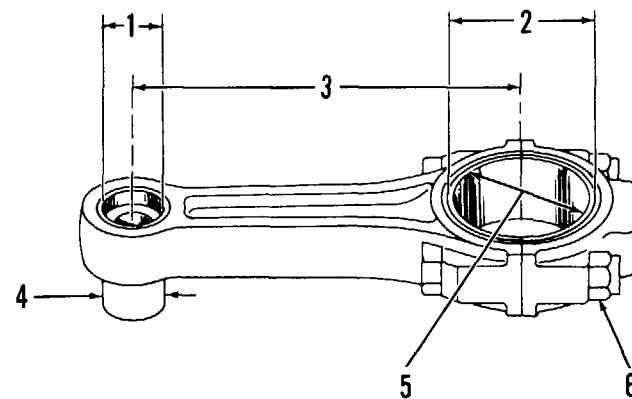


\*Increase in clearance between ends of piston rings for each .001 in. (0.025 mm) increase in size of cylinder liner bore: .003 in. (0.076 mm).

TA098819

**CONNECTING ROD SPECIFICATIONS**

- (1) Bore in bearing for piston pin (new)..... 2.1820 to 2.1830 in. (55.423 to 55.449 mm)  
Maximum permissible clearance between bearing and piston pin (worn)..... 003 in. (0.08 mm)
- (2) Bore in connecting rod for bearing, with nuts tight to specifications (6) ..... 4.0748 ± .0005 in. (103.500 + 0.013 mm)
- (3) Distance between center of bearings..... 10.300 + .002 in. (261.62 ± 0.05 mm)
- (4) Diameter of piston pin (new)..... 1.9998 + .0002 in. (50.795 + 0.005 mm)
- (5) Bore in bearing for crankshaft..... 3.8236 to 2.8258 in. (97.119 to 97.175 mm)  
Clearance between bearing and crankshaft (new)..... 0028 to .0066 in. (0.071 to 0.168 mm)  
Maximum permissible clearance between bearing and crankshaft (worn)..... 010 in. (0.25 mm)
- (6) Torque on nut for connecting rod:
  - a. Put engine oil on threads and nut seat.
  - b. Tighten both nuts to .....60 + 6 lb. ft. (82 + 8 N.m)  
Mark each nut and end of bolt.
  - d. Again tighten both nuts (from mark) ..... 120°



**NOTE**

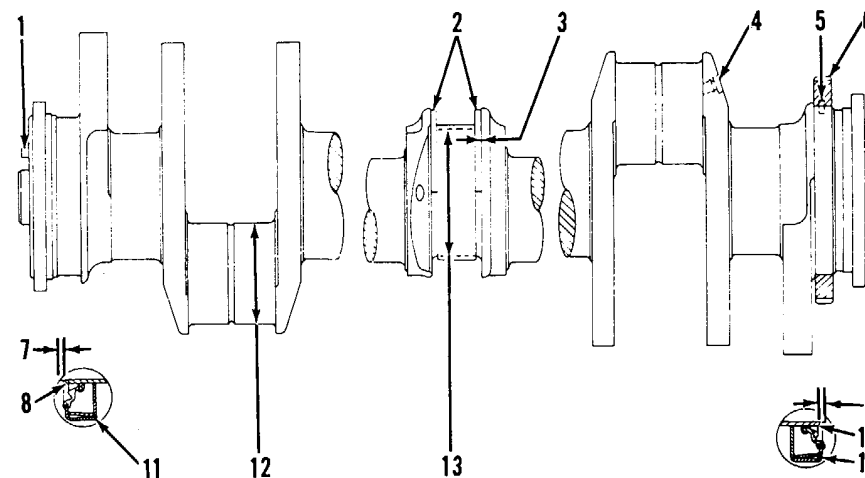
The connecting rod must be installed so the chamfer on the edge of bore (5) is near the corner on the crankshaft. The flat side of bore (5) must be against the other connecting rod on the same crankshaft pin.

Side clearance between two connecting rods on same crankshaft pin (new)..... 011 to .029 in. (0.28 to 0.74 mm)

TA098820

**CRANKSHAFT SPECIFICATIONS**

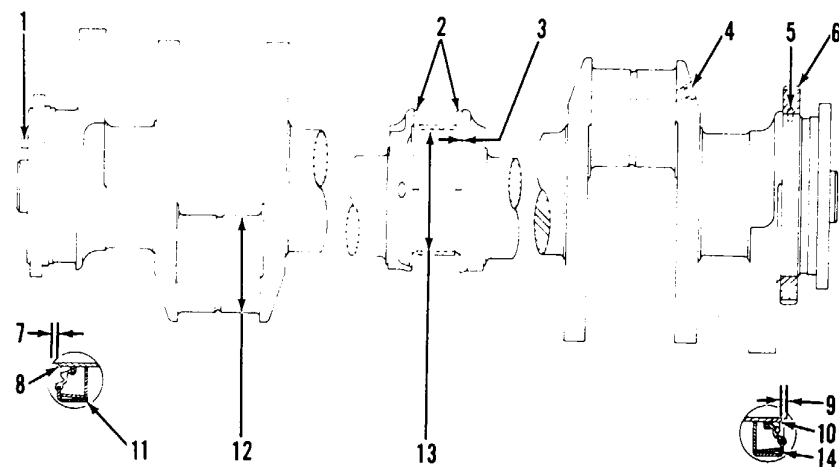
- (1) Length of pin out of crankshaft face..... 25 .02 in. (6.4 ± 0.5 mm)
- (2) Thrust plates, at center main bearing.
- (3) End play for the crankshaft (new)..... 006 to .020 in. (0.15 to 0.50 mm)
- (4) Torque for five plugs..... 17 + 3 lb. ft. (23 + 4 N.m)  
"Stake" (make a mark with a punch) the crankshaft to hold the plug tight.
- (5) Length of dowel out of the crankshaft..... 16 + .02 in. (4.1 ± 0.5 mm)
- (6) Maximum permissible temperature of the gear for installation on the crankshaft.....400F (2040C)
- (7) Distance from the rear face of the crankshaft to the rear side of the sleeve ..... 18 + .02 in. (4.6 ± 0.5 mm)
- (8) Rear wear sleeve. Install as follows:
  - a. Clean the inner surface of the sleeve and the outer surface of the crankshaft with quick cure primer.
  - b. Put 9S3265 Retaining Compound on the cleaned surfaces.
  - c. Install the sleeve on the crankshaft, with the chamfer on the outside.
- (9) Distance from the front face of the crankshaft to the front side of the sleeve ..... 0 to .03 in. (0 to 0.8 mm)
- (10) Front wear sleeve. Install as follows:
  - a. Clean the inner surface of the sleeve and the outer surface of the crankshaft with quick cure primer.



TA098821  
Go on to Sheet 2

**CRANKSHAFT SPECIFICATIONS (CONT)**

- b. Put retaining compound on the cleaned surfaces.
  - c. Install the sleeve on the crankshaft, with the chamfer on the outside.
- (11) Install the rear seal in the position shown.
- (12) Diameter of the surfaces (journals) for the connecting rod bearings:  
 Standard, original size  
 (new)..... 3.8200 + .0008 in. (97.028 + 0.02 mm)  
 For bearings .025 in. (0.64 mm)  
 smaller than original  
 size 3.7950 + .0005 in. (96.393 + 0.013 mm)  
 For bearings .050 in. (1.27 mm)  
 smaller than original  
 size 3.7700 + .0005 in. (95.758 + 0.013 mm)
- (13) Diameter of the surfaces (journals) for the main bearings:  
 Standard, original size  
 (new)..... 4.7500 + .0008 in. (120.650 + 0.02 mm)  
 For bearings .025 in. (0.64 mm)  
 smaller than original  
 size 4.7250 + .0008 in. (120.015 + 0.02 mm)  
 For bearings .050 in. (1.27 mm)  
 smaller than original  
 size 4.7000 + .0008 in. (119.380 + 0.02 mm)  
 Clearance between main bearings  
 and crankshaft  
 (new)..... .0036 to .0073 in. (0.091 to 0.186 mm)  
 Maximum permissible clearance between  
 main bearings and crankshaft..... .010 in. (0.25 mm)
- (14) Install the front seal in the position shown.

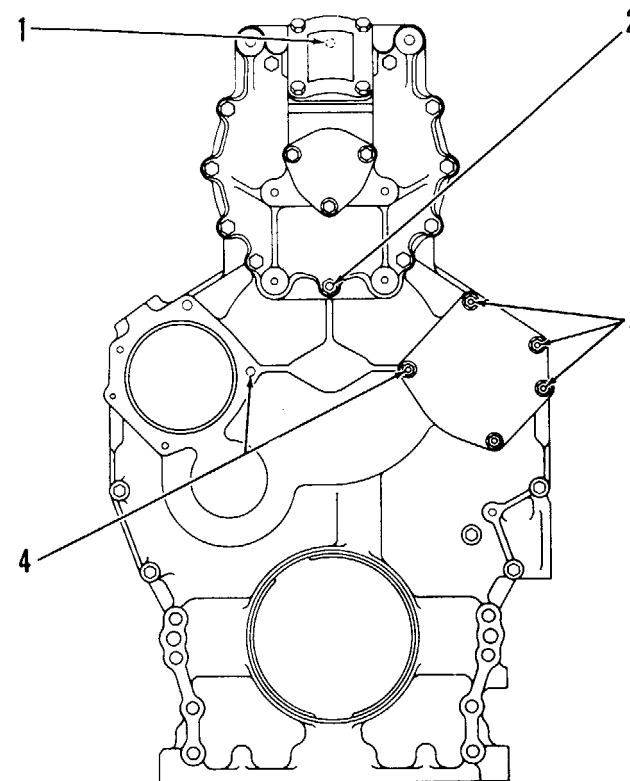


End

TA098822

**TIMING GEAR HOUSING SPECIFICATIONS**

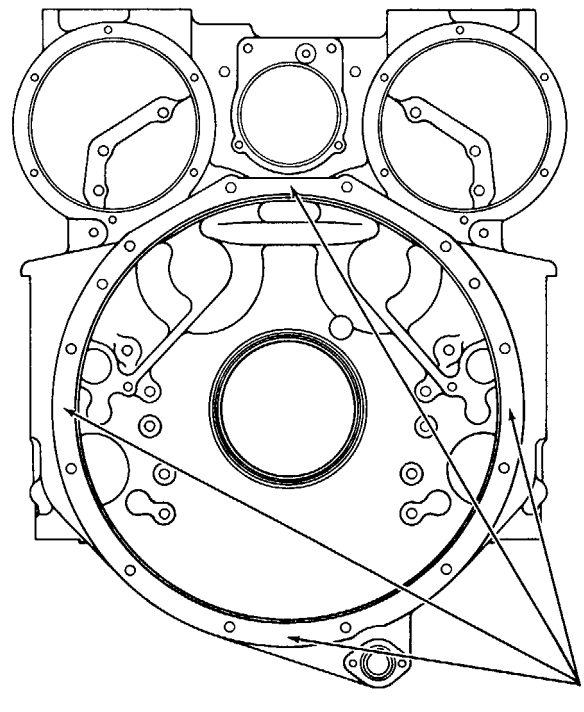
- (1) Torque for stud on back of the housing .....20 + 3 lb. ft. (27 + 4 N.m)
- (2) Torque for stud (put thread lock compound on the stud threads) ..... 10 + 3 lb. ft. (14 ± 4 N.m)
- (3) Torque for three studs .....20 ± 3 lb. ft. (27 ± 4 N.m)
- (4) Put sealer on the threads of two studs for installation in the housing.



TA098823

**FLYWHEEL HOUSING SPECIFICATIONS**

- (1) Maximum permissible change from an exact vertical face (face run-out) at 4 points (total indicator reading)..... .012 in. (0.30 mm)



TA098824

**FLYWHEEL HOUSING BORE SPECIFICATIONS**

NOTE: Write the dial indicator measurements with their positive (+) and negative (-) notation (signs). This notation is necessary for making the calculations in the chart correctly.

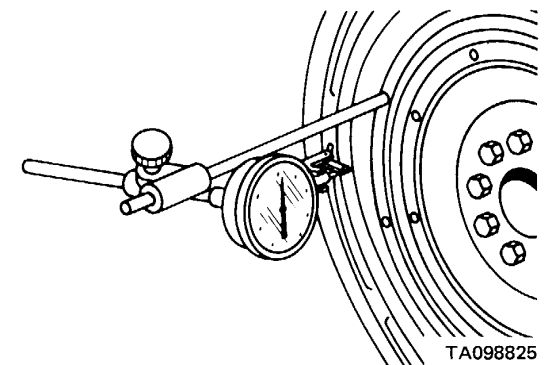
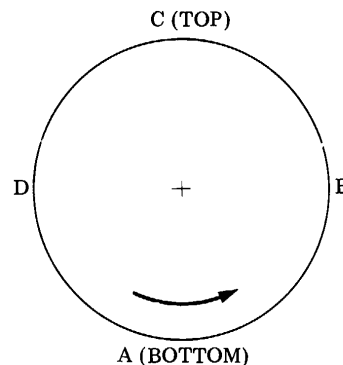
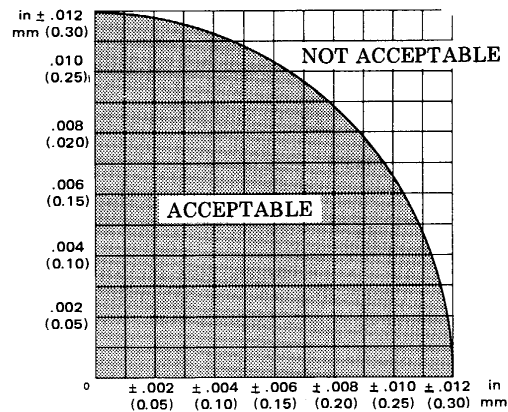
- (1) With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crankshaft up against the top bearing. Write the measurement for bearing clearance on line 1 in column (C).
- (2) Divide the measurement from Step 1 by 2. Write this number on line 1 in columns (B) and (D).
- (3) Turn the crankshaft to put the dial indicator at (A). Adjust the dial indicator to "0" (zero).
- (4) Turn the crankshaft counterclockwise to put the dial indicator at (B). Write the measurement in the chart.
- (5) Turn the crankshaft counterclockwise to put the dial indicator at (C). Write the measurement in the chart.
- (6) Turn the crankshaft counterclockwise to put the dial indicator at (D). Write the measurement in the chart.
- (7) Add lines I and II by columns.
- (8) Subtract the smaller number from the larger number in line III in columns (B) and (D). The result is the horizontal "eccentricity" (out of round). Line III, column (C) is the vertical eccentricity.

**CHART FOR DIAL INDICATOR MEASUREMENTS**

	Position of dial indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial indicator reading	II	0			
Total of lines 1 and 2	III	0	••	•	••

• Total vertical eccentricity (out of round).  
 •• Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

- (9) On the graph for total eccentricity find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.
- (10) If the point of intersection is in the range marked "Acceptable" the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable" do Step 11.
- (11) Loosen the bolts holding the flywheel housing to the cylinder block. Hit the flywheel housing lightly with a hammer to put it in the correct position. Tighten the bolts holding the flywheel housing to the cylinder block and do Steps 1 through 10 again.



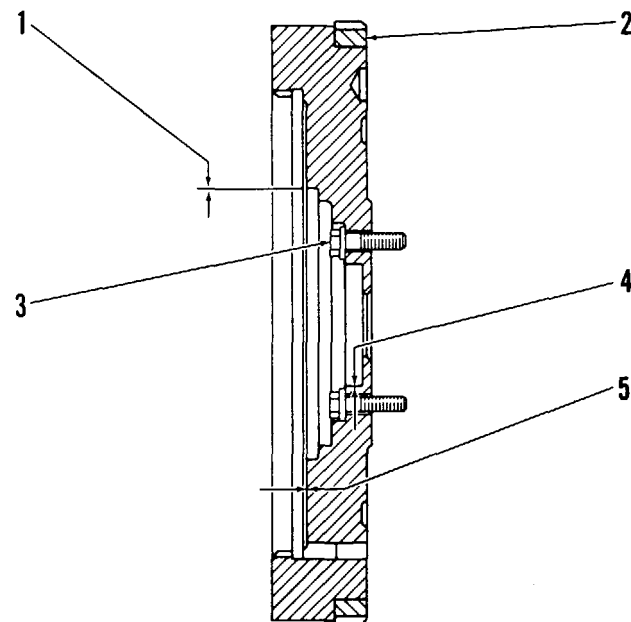
**FLYWHEEL SPECIFICATIO**

- (1) Maximum permissible change in distance from center of bore (eccentricity) during one rotation (total indicator reading)..... 006 in. (0.15 mm)
- (2) Gear. Maximum temperature for installation.....6000F (3160C)

**NOTE**

Install gear with chamfer on teeth in direction shown.

- (3) Torque for the bolts that hold the flywheel to the crankshaft.....200 + 20 lb. ft. (270 + 27 N.m)
- (4) Maximum permissible change in distance from center of bore (eccentricity) during one rotation (total indicator reading)..... 005 in. (0.13 mm)
- (5) Maximum permissible change from an exact vertical face (run out) during one rotation (total indicator reading)..... .006 in. (0.15 mm)



TA098826

**ALTERNATOR SPECIFICATIONS**

24V Delco Remy Number 1117248

Polarity is negative ground.

Speed for testing ..... 5000

Rotation can be either direction.

Output when cold:

Fasten carbon pile to battery to get maximum output ..... 54A

Rated output, hot ..... 50A

Field current at 24V and 800F (270C) ..... 2.5 to 2.9 A

Voltage regulator:

Voltage setting range ..... 26 to 30 V

Adjust voltage setting to ..... 28 V

Then increase speed to get maximum output ..... 50A

(1) Torque for nut holding pulley ..... 75 ± 5 lb. ft. (102 ± 7 N.m)

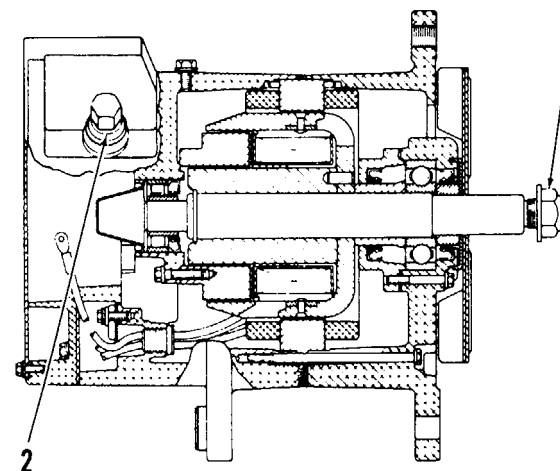
(2) Torque for output terminal ..... 10 ± 1 lb. ft. (14 ± 1.4 N.m)

Torque for bolts holding bottom

of alternator to bracket ..... 24 ± 3 lb. ft. (33 ± 4 N.m)

Torque for bolt holding top of alternator

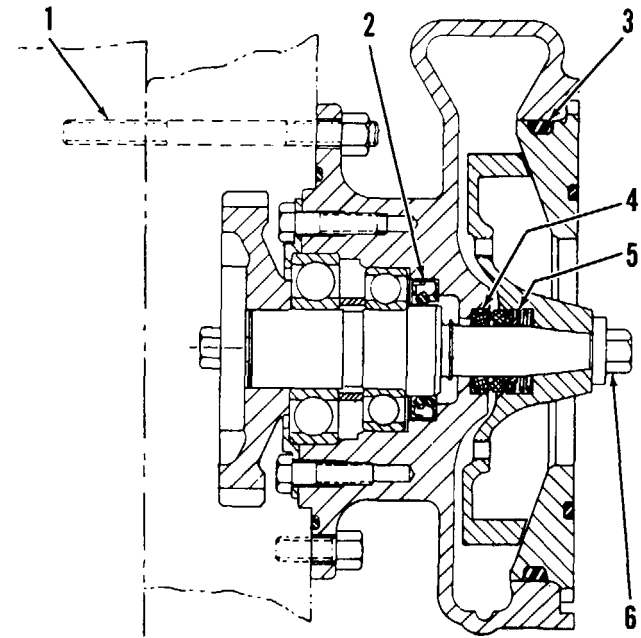
to adjust strap ..... 56 ± 7 lb. ft. (76 ± 10 N.m)



TA098827

**WATER PUMP SPECIFICATIONS**

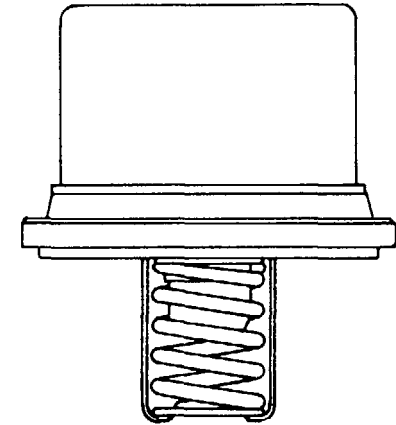
- (1) Torque for three long studs in cylinder block .....20 + 3 lb. ft. (27 ± 4 N.m)  
Put sealer on threads of short stud in front housing.
- (2) Oil seal. Put engine oil on the seal lip. Assemble with the lip toward the bearings.
- (3) Seal. Put a thin layer of engine oil in the bore for the seal.
- (4) Water seal and ring:
  - a. Put engine oil on the seal.
  - b. Install the seal and ring together in the housing bore, with the shiny face of the ring outside.
- (5) Seal assembly:
  - a. Remove the spring from the seal.
  - b. Put engine oil inside the seal assembly.
  - c. Install the seal assembly around the shaft until the carbon face makes contact with the shiny face of the ring (4).
  - d. Install the spring.
- (6) Torque for the nut that holds the impeller.....28 + 1 lb. ft. (38 + 1.4 N.m)



TA098828

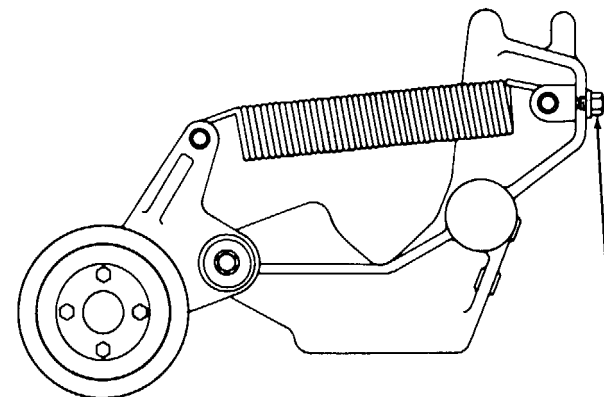
WATER TEMPERATURE REGULATOR SPECIFICATIONS

Approximate temperature when completely open ..... 197°F (92°C)  
Distance regulator is opened at  
197°F (92°C) ..... 375 in. (9.53 mm)



TA098829

(1) Torque for the adjustment  
nut..... $32 \pm 5$  lb. ft. ( $43 \pm 7$  N m)



V-BELT TENSION CHART						
BELT SIZE	WIDTH BELT TOP		WIDTH TOP OF PULLEY GROOVE		BELT TENSION "INITIAL"*	BELT TENSION "USED"**
	in.	mm	in.	mm	GAGE READING	GAGE READING
5V	.625	15.88	.600	15.24	$120 \pm 5$	$90 \pm 10$
11/16	.688	17.48	.625	15.88	$120 \pm 5$	$90 \pm 10$
MEASURE TENSION OF BELT FARTHEST FROM THE ENGINE						
*“INITIAL” BELT TENSION is for a new belt.						
**“USED” BELT TENSION is for a belt which has more than 30 minutes of operation at rated speed of engine.						

RADIATOR SPECIFICATIONS

- (1) 2S3080 Pressure Relief Cap:
- (2) for stud for  
filler cap .....40 ± 5 lb. ft. (54 ± 7 N m)
- (3) Hump on hose to be centered between ends of two pipes.

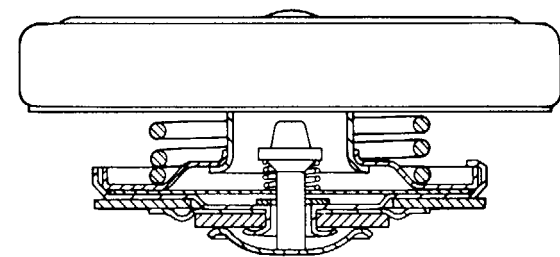
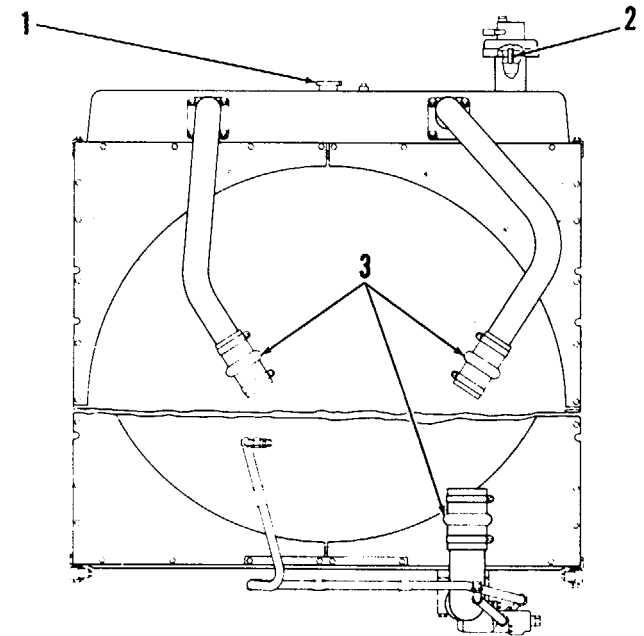
**COOLING SYSTEM  
PRESSURE CAP**

2S3080 Pressure Relief Cap:

Minimum pressure that makes relief  
valve open ..... 12 psi (0.84 kg/cm<sup>2</sup>) (83 kPa)

Maximum pressure that makes relief  
valve open ..... 15 psi (1.05 kg/cm<sup>2</sup>) (103 kPa)

Maximum vacuum necessary to make relief  
valve open ..... 0.6 psi (0.04 kg/cm<sup>2</sup>) (4 kPa)

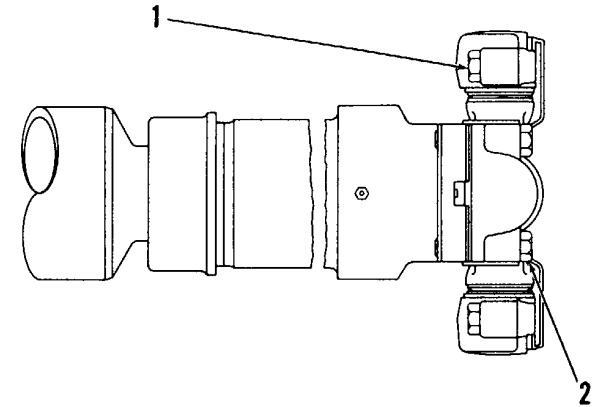


TA098831

PROPELLER SHAFTS SPECIFICATIONS

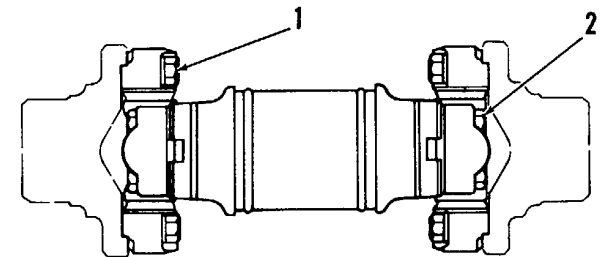
DRIVE SHAFT  
(Bearing Cage to Front Differential)

- (1) Torque for bolts that hold drive shaft to differential (four) .....  $120 \pm 10$  lb. ft. ( $160 \pm 14$  N m)
- (2) Torque for bolts that hold universal joint to shaft (four) .....  $120 \pm 10$  lb. ft. ( $160 \pm 14$  N m)



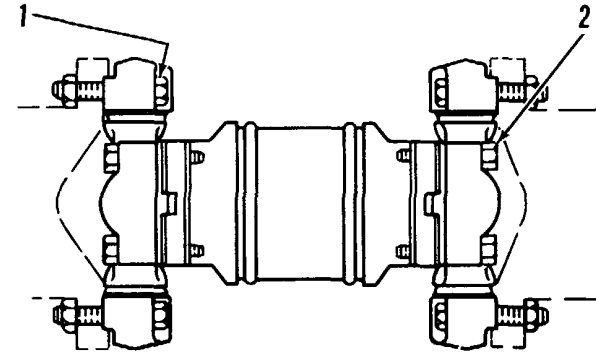
DRIVE SHAFT  
(UPPER)

- (1) Torque for bolts (eight) .....  $100 \pm 10$  lb. ft. ( $135 \pm 14$  N m)
- (2) Torque for bolts that hold universal joint together (eight) .....  $100 \pm 10$  lb. ft. ( $135 \pm 14$  N m)



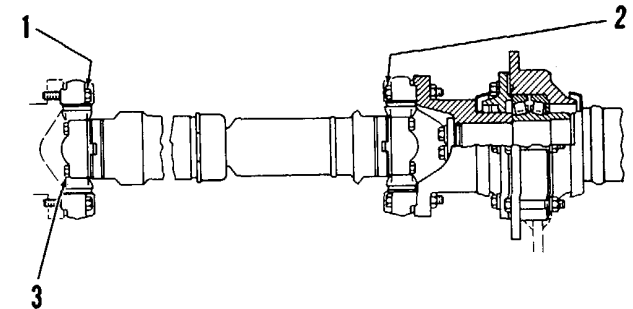
DRIVE SHAFT  
(Transfer Gears to Rear Differential)

- (1) Torque for bolts (eight) ..... 100 ± 10 lb. ft. (135 ± 14 N m)
- (2) Torque for bolts that hold universal joint together (eight) ..... 120 ± 10 lb. ft. (160 ± 14 N m)



DRIVE SHAFT  
(Transfer Gears to Bearing Cage)

- (1) Torque for bolts (four) ..... 100 ± 10 lb. ft. (135 ± 14 N-m)
- (2) Torque for bolts (four) ..... 100 ± 10 lb. ft. (135 ± 14 N-m)
- (3) Torque for bolts that hold universal joint together (eight) ..... 120 ± 10 lb. Ft. (160 ± 14 N-m)



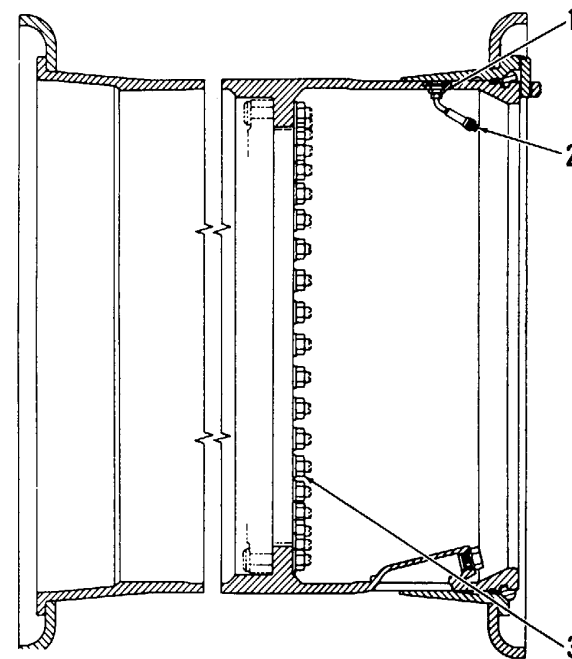
RIM GROUP

(1) Tighten the nut on spud assembly to .....188 ± 12 lb. in. (21.3 ± 1.3 N-m)

Tighten stem housing assembly into spud assembly to .....75 ± 5 lb. in. (8.5 ± 0.6 N-m)

(2) Torque for valve cap .....25 ± 5 lb. in. (2.8 ± 0.6 N m)

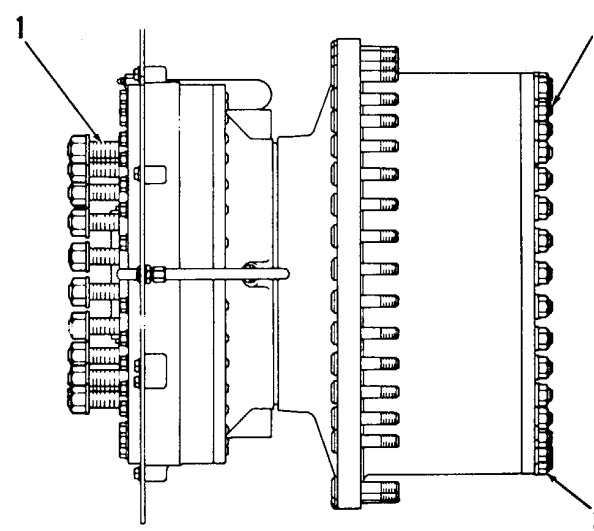
(3) Torque for 40 nuts .....350 ± 35 lb. ft. (470 ± 45 N m)



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Go on to Sheet 2

FINAL DRIVES, BRAKES AND WHEELS

- (1) Torque for 22 studs .....260 ± 30 lb. ft. (354 ± 40 N m)
- (2) Torque for 34 studs ..... 150 ± 15 lb. ft. (205 ± 20 N m)
- (3) Torque for 34 nuts .....390 ± 55 lb. ft. (530 ± 75 N m)

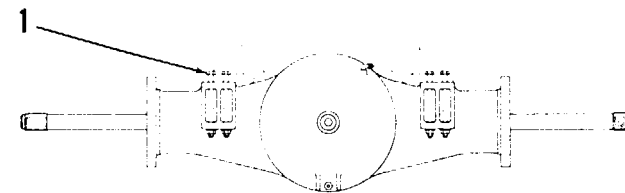


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End

AXLES SPECIFICATIONS

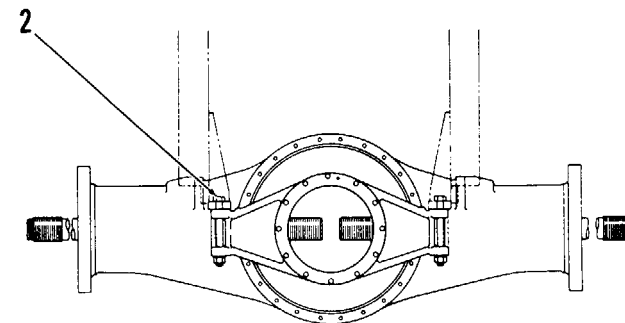
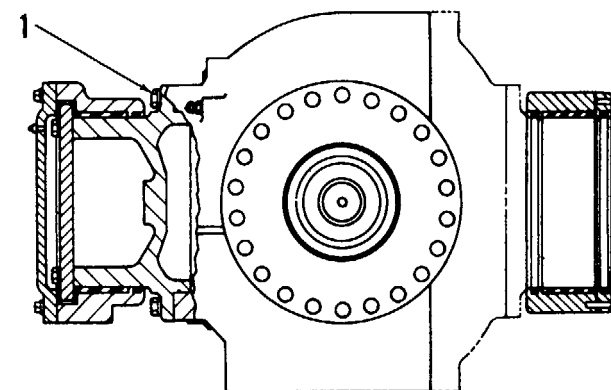
FRONT AXLE GROUP (FIXED)

- (1) Torque for 12 bolts and nuts.....825 ± 80 lb. ft. (1125 ± 110 N-m)



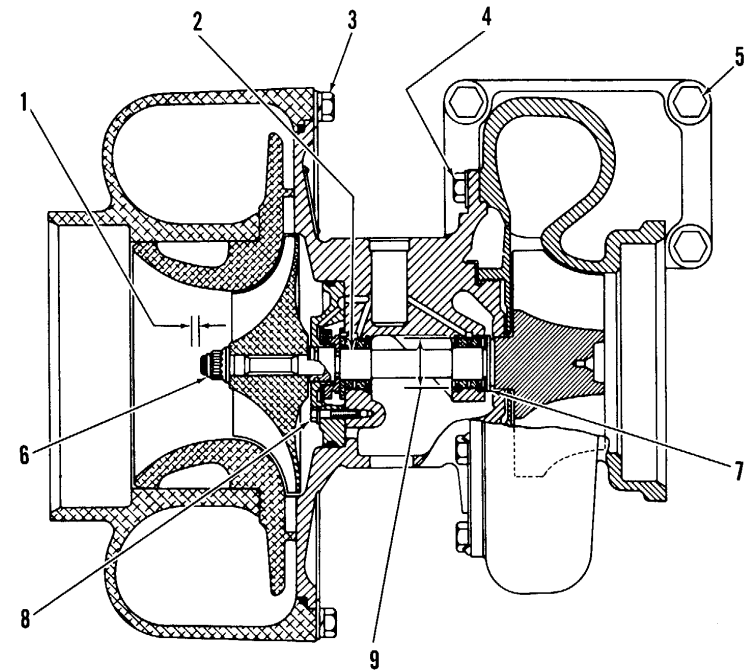
REAR AXLE GROUP (OSCILLATING)

- (1) Torque for 16 bolts .....350 ± 35 lb. ft. (470 ± 45 N-m)
- (2) Torque for 12 bolts and nuts..... 825 ± 75 lb. ft. (1125 ± 100 N-m)



TURBOCHARGER SPECIFICATIONS

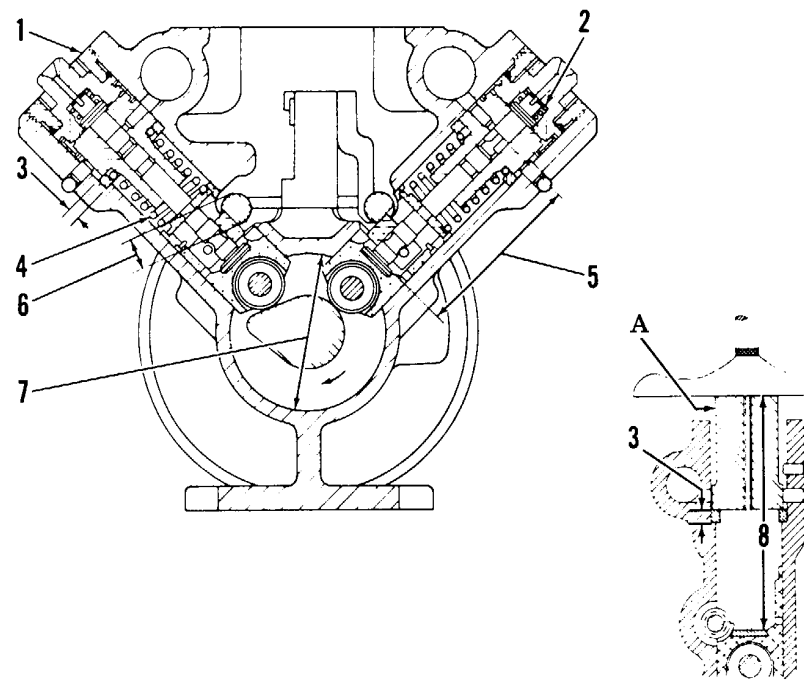
- (1) End play for shaft.....  $.0065 \pm .0025$  in. ( $0.165 \pm 0.063$  mm)  
Radial clearance for  
the shaft.....  $.004$  to  $.009$  in. ( $0.10$  to  $0.23$  mm)
- (2) Bore in the  
bearing.....  $.6268$  to  $.6272$  in. ( $15.921$  to  $15.931$  mm)  
Diameter of surface on shaft  
(journal) for the  
bearing.....  $.6250$  to  $.6254$  in. ( $15.875$  to  $15.885$  mm)
- (3) Put gasket sealer on bolts  
holding compressor housing and  
tighten to.....  $105 \pm 5$  lb. in. ( $12 \pm 1$  N-m)
- (4) Put anti-seize compound  
on bolts holding turbine housing and  
tighten to.....  $175 \pm 15$  lb. in. ( $20 \pm 2$  N m)
- (5) Put anti-seize compound on threads:  
Tighten bolts holding  
turbocharger to .....  $40 \pm 4$  lb. ft. ( $54 \pm 5$  N m)
- (6) Install impeller as follows:
  - a. Get temperature of impeller to  $350^{\circ}\text{F}$  ( $177^{\circ}\text{C}$ ) for 10  
minutes maximum.
  - b. Install impeller on shaft.
  - c. Tighten nut to.....  $150$  lb. in. ( $17$  N-m)
  - d. Let impeller cool to below .....  $150^{\circ}\text{F}$  ( $70^{\circ}\text{C}$ )
  - e. Loosen nut and put lubricant on threads and washer face.
  - f. Tighten nut to .....  $30$  lb. in. ( $3$  N m)
  - g. Then tighten nut an added .....  $90^{\circ}$
- (7) Clearance between ends of oil seal  
ring (earlier) .....  $.001$  to  $.006$  in. ( $0.03$  to  $0.15$  mm)  
Clearance between ends of oil seal  
ring (later)  $.008$  to  $.015$  in. .... ( $0.20$  to  $0.38$  mm)
- (8) Torque for bolts holding  
thrust plate.....  $35 \pm 5$  lb. in. ( $4 \pm 1$  N-m)
- (9) Bore in  
housing.....  $.9827$  to  $.9832$  in. ( $24.961$  to  $24.973$  mm)  
Outside diameter of  
the bearing.....  $.9780$  to  $.9785$  in. ( $24.841$  to  $24.854$  mm)



FUEL INJECTION SPECIFICATIONS

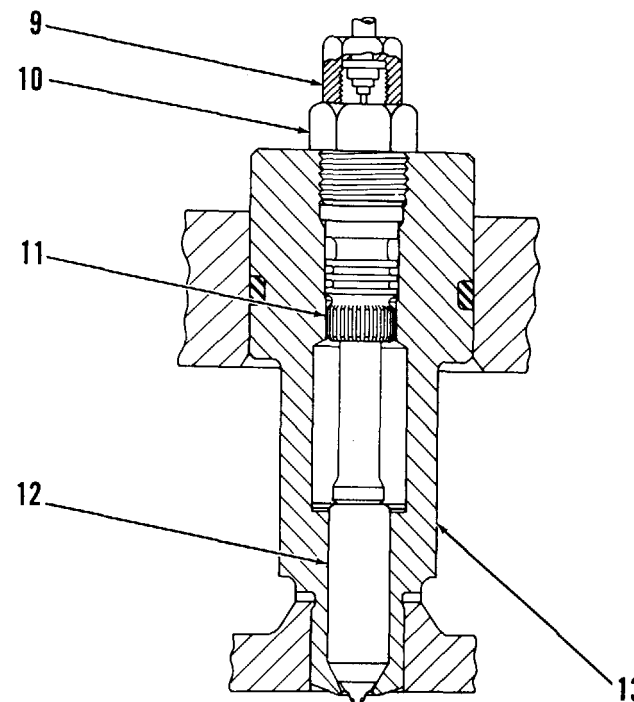
- Firing order (injection sequence)..... 1,8,4,3,6,5,7,2
- Injection timing before TC (top center)..... 11°
- (1) Torque for bushing ..... 150 ± 10 lb. ft. (204 ± 14 N m)
- (2) S8634 Spring:
  - Length under test force .....321 in. (8.15 mm)
  - Test force .....190 ± .010 lb. (0.086 ± 0.005 kg)
  - Free length after test .....418 in. (10.62 mm)
  - Outside diameter .....388 in. (9.86 mm)
- (3) Thickness of spacers:
  - 5M6297 Spacer .....170 in. (4.32 mm)
  - 2M4208 Spacer .....174 in. (4.42 mm)
  - 2M4209 Spacer .....178 in. (4.52 mm)
  - 2M4210 Spacer .....182 in. (4.62 mm)
  - 2M4211 Spacer .....186 in. (4.72 mm)
  - 2M4212 Spacer .....190 in. (4.83 mm)
  - 5M2691 Spacer .....194 in. (4.93 mm)
  - 5S7189 Spacer.....198 in. (5.03 mm)
- (4) 1S7592 Spring:
  - Length under test force .....1.522 in. (38.66 mm)
  - Test force .....22.6 ± 1.1 lb. (10.250 ± 0.500 kg)
  - Free length after test .....1.751 in. (44.48 mm)
  - Outside diameter .....1.00 in. (25.4 mm)
- (5) Length of pump plunger
  - (new)..... 2.7212 ± .0015 in. (69.118 ± 0.038 mm)
  - Minimum permissible length
  - (worn) .....2.7147 in. (68.953 mm)
- (6) Bores for the racks:
  - Bore in housing, at the rear
  - (new)..... 5023 ± .0015 in. (12.758 ± 0.038 mm)
  - Bearing at the front
  - (new)..... 5023 ± .0013 in. (12.758 ± 0.033 mm)
  - Diameter of fuel racks
  - (new)..... .4985 ± .0002 in. (12.662 ± 0.005 mm)
  - Maximum permissible clearance between rack
  - and bearings (worn) .....007 in. (0.18 mm)

- (7) Bore in bearings for the camshaft (new) .....2.1255 ± .0010 in. (53.988 ± 0.025 mm)
- Diameter of bearing surfaces of the camshaft (new) .....2.1220 ± .0005 in. (53.899 ± 0.013 mm)
- Maximum permissible clearance between the bearings and the camshaft ..... .010 in (0.25 mm)
- (8) Timing dimension for the fuel injection pumps, with 8S7167
- Gage (A):
  - On engine .....4.343 ± .002 in. (110.31 ± 0.05 mm)
  - Off engine ..... 4.394 ± .002 in. (111.61 ± 0.05 mm)



FUEL INJECTION SPECIFICATIONS (CONT)

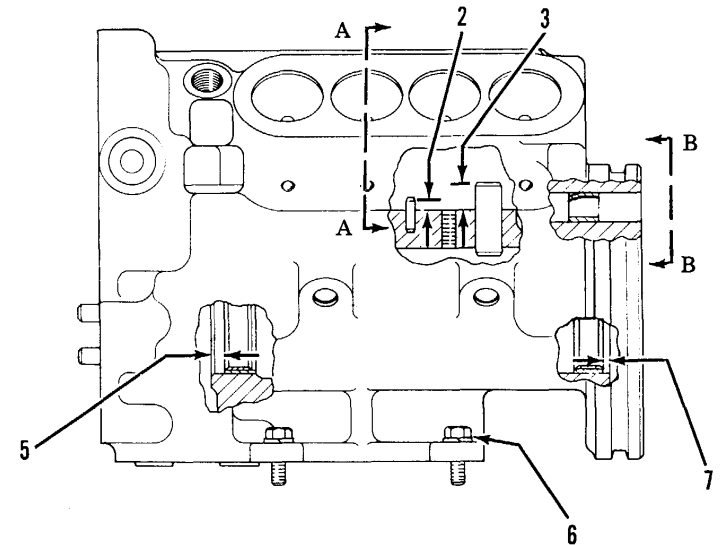
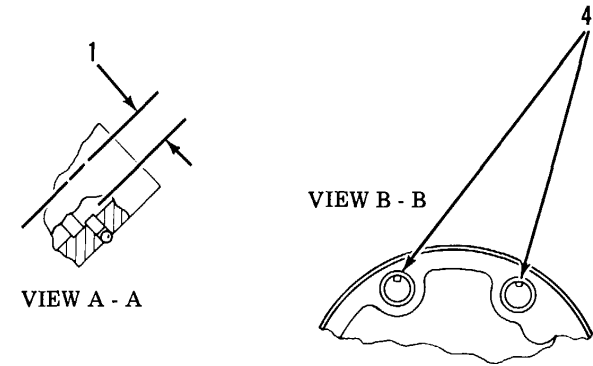
- (9) Torque for all nuts that hold the fuel lines ..... $30 \pm 5$  lb. ft. ( $41 \pm 7$  N m)
- (10) Torque for the nuts that hold the nozzles ..... $55 \pm 5$  lb. ft. ( $75 \pm 7$  N m)
- (11) Body.
- (12) Nozzle. Tighten nozzle finger tight on body (11).
- (13) Torque for direct injection adapter ..... $150 \pm 10$  lb. ft. ( $205 \pm 14$  N m)



TA098839  
End

FUEL INJECTION PUMP HOUSING SPECIFICATIONS

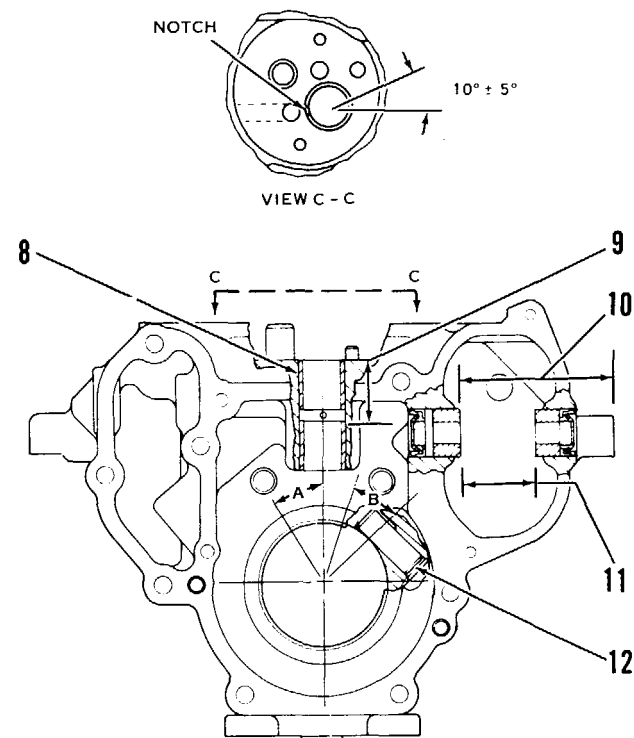
- (1) Install dowel to get a dimension from centerline of fuel injection pump bore to dowel (seal dowel hole with aluminum ball) .....584 ± .002 in.(14.83 ± 0.05 mm)
- (2) Install pin to get a dimension of .....188 in. (4.78 mm)
- (3) Install dowel to get a dimension of .....480 in. (12.19 mm)
- (4) The center of the bearing tab must be within .002 in. (0.05 mm) of a vertical line that goes thru the center of the bearing and parallel to vertical centerline of injection pump housing.
- (5) Bearing joint must be within area "A" (30° to the left of vertical) and oil hole must be in area "B." Install bearing to get a dimension of .....19 in. (4.8 mm)
- (6) Torque for bolts that hold fuel injection housing..... 40 ± 5 lb. ft. (54 ± 7 N-m)
- (7) Bearing joint must be within area "A" (30° to the left of vertical) and oil hole must be in area "B." Install bearing to get a dimension of .....04 in. (1.0 mm)



TA098840  
Go on to Sheet 2

FUEL INJECTION PUMP HOUSING SPECIFICATIONS (CONT)

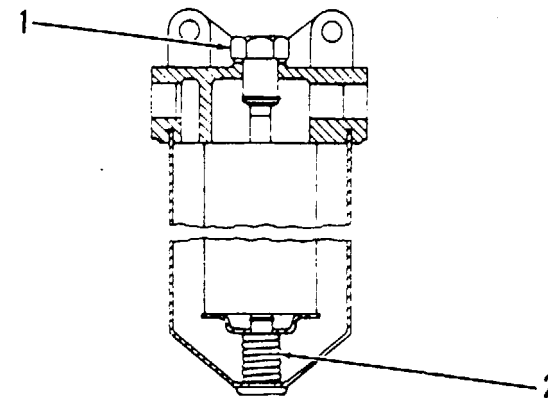
- (8) Install bearing end with sharp corner even with surface. Notch must be in position shown in view CC.
- (9) Distance from end of bearing to surface of housing.....1.12 in. (28.4 mm)
- (10) Distance from end of bearing to face of boss on housing..... $2.975 \pm .020$  in. ( $73.03 \pm 0.51$  mm)
- (11) Distance between the bearings for the shaft..... $1.370 \pm .020$  in. ( $34.80 \pm 0.51$  mm)
- (12) Install pin until pin contacts bottom of housing.



TA098841  
End

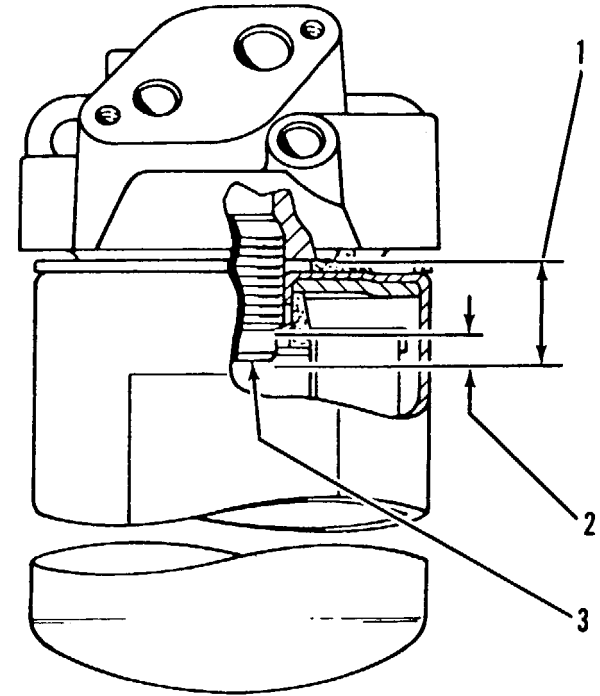
PRIMARY FUEL FILTER SPECIFICATIONS

- (1) Torque for nut.....18 ± 3 lb. ft. (24 ± 4 N-m)
- (2) 7S9323 Spring:
  - Length under test force .....1.10 in. (27.9 mm)
  - Test force .....27.7 to 32.3 lb. (12.6 to 14.7 kg)
  - Free length after test .....1.68 in. (42.7 mm)
  - Outside diameter ......68 in. (17.3 mm)



SECONDARY FUEL FILTER SPECIFICATIONS

- (1) Distance that stud may extend from base  
(measured from sealing surface of base)  
to end of stud.....  $.97 \pm .05$  in. ( $24.6 \pm 1.3$  mm)
- (2) Do not damage sealing surface.
- (3) Torque for stud (put thread lock  
compound on the end of the stud  
that goes into the base).....  $50 \pm 10$  lb. ft. ( $68 \pm 14$  N-m)



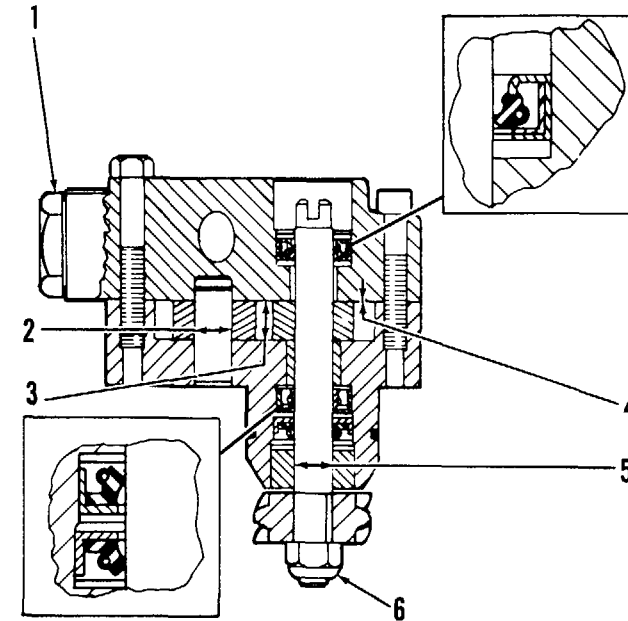
FUEL TRANSFER PUMP SPECIFICATIONS

- (1) Torque for plug of safety bypass valve.....27 + 3 lb. ft. (37 ± 4 N m)
  
- 6N1069 Spring for safety bypass valve:
  - Length under test force .....1.337 in. 33.96 mm)
  - Test force .....5.85 ± .29 lb. (2.654 ± 0.132 kg)
  - Free length after test .....2.107 in. (53.52 mm)
  - Outside diameter .....406 in. (10.31 mm)
  - Pressure of fuel to open the valve ..... 30 psi (2.11 kg/cm<sup>2</sup>) (207 kPa)
- (2) Diameter of the shaft..... 4914 ± .0003 in. (12.482 ± 0.008 mm)
- Bore in the gear .....4926 + .0003 in. (12.512 ± 0.008 mm)
- Clearance between shaft and gear (new) .....006 to .0018 in. (0.015 to 0.046 mm)
- (3) Depth of the bore in the body (new).....4995 ± .0003 in. (12.687 ± 0.008 mm)
- (4) Clearance between the gears and the cover (new).....001 to .002 in. (0.02 to 0.05 mm)
- (5) Diameter of the shaft .....4937 ± .0001 in. (12.540 ± 0.003 mm)
- Bore in the bearings (both) .....4953 ± .0005 in. (12.581 ± 0.013 mm)
- Maximum permissible clearance between bearings and shaft (worn).....003 in. (0.08 mm)

**NOTE**

**The shaft must rotate freely when the cover bolts are tight.**

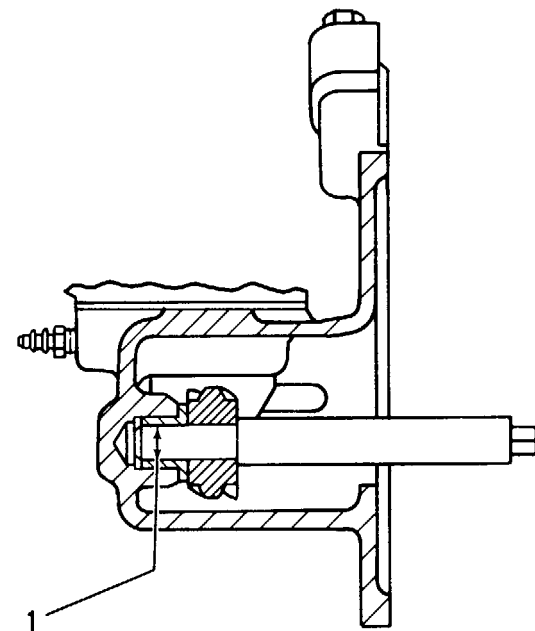
- (6) Torque for nut.....22 ± 5 lb. ft. (30 ± 7 N m)



**FUEL TRANSFER PUMP DRIVE SPECIFICATIONS**

(Sheet 1 of 1)

- (1) Bore in bearing  
(new) .....  $.4709 \pm .0013$  in. ( $11.961 \pm 0.033$  mm)
  
- Diameter of shaft  
(new) .....  $.4688 \pm .0002$  in. ( $11.908 \pm 0.005$  mm)

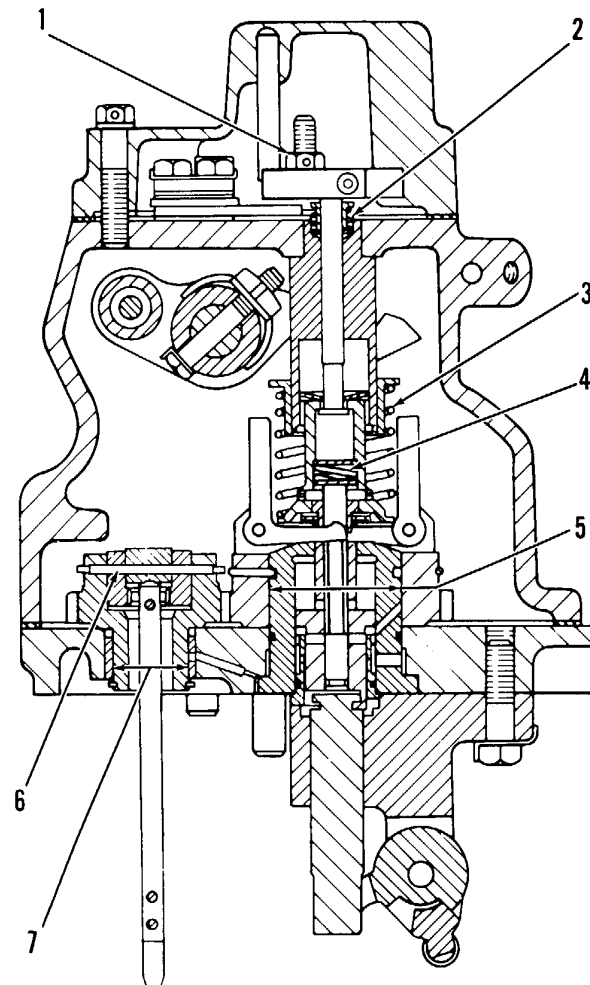


TA098845

**GOVERNOR SPECIFICATIONS**

(Sheet 1 of 2)

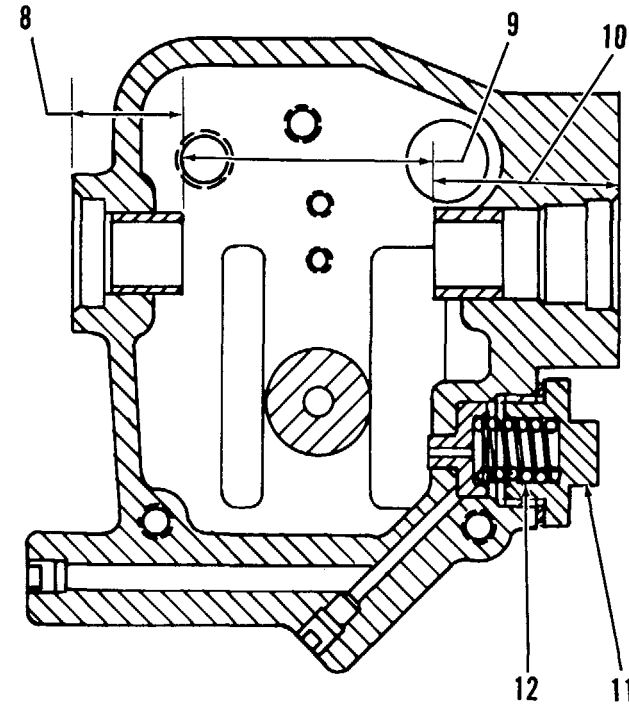
- (1) Torque for nut ..... 9 ± 3 lb. ft. (12 ± 4 N.m)
- (2) 2S7235 Spring for the collar:  
 Length under test force ..... .375 in. (9.53 mm)  
 Test force ..... .39 ± .03 lb. (0.177 ± 0.014 kg)  
 Free length after test ..... 68 in. (17.3 mm)  
 Outside diameter ..... .43 in. (10.9 mm)
- (3) 9L6448 Spring for the governor:  
 Color code ..... one green stripe, one yellow stripe  
 Put force on spring of ..... 4.00 lb. (1.814 kg)  
 Then add more force to make spring  
 shorter by ..... .900 in. (22.86 mm)  
 Total test force ..... 16.6 ± .30 lb. (7.530 ± 0.136 kg)  
 Free length  
 after test ..... 2.24 ± .03 in. (56.9 ± 0.8 mm)  
 Outside diameter ..... 1.39 in. (35.3 mm)
- (4) 9M6303 Spring:  
 Length under test force ..... 180 in. (4.57 mm)  
 Test force ..... 10.0 ± 5 lb. (4.54 + 0.23 kg)  
 Free length after test ..... .344 in. (8.74 mm)  
 Outside diameter ..... .480 in. (12.19 mm)
- (5) Diameter of the outer surface of the cylinder  
 (new) ..... 1.5000 ± .0005 in. (38.100 ± 0.013 mm)  
 Bore in the gear  
 (new) ..... 1.5020 ± .0005 in. (38.151 ± 0.013 mm)
- (6) Note: Put marks in alignment on pinion-stop-and gear before installing  
 dowel.
- (7) Bore in the bearings  
 (new) ..... 8765 ± .0015 in. (22.263 ± 0.038 mm)  
 Diameter of the gear, at the hub  
 (new) ..... 8735 ± .0005 in. (22.187 ± 0.013 mm)



TA098846  
 Go on to Sheet 2

**GOVERNOR SPECIFICATIONS (CONT)**

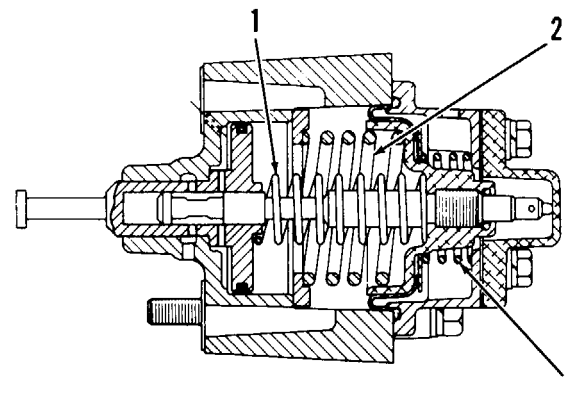
- (8) Distance from the face of the housing to the end of the bearing for the governor control shaft .....  $.998 \pm .005$  in. ( $25.35 + 0.13$  mm)
- (9) Distance between the bearings for the governor control shaft .....  $2.385 \pm .005$  in. ( $60.58 + 0.13$  mm)
- (10) Distance from the face of the housing to the end of the bearing for the governor control shaft .....  $1.708 \pm .004$  in. ( $43.38 \pm 0.10$  mm)
- (11) Torque for plug .....  $27 \pm 5$  lb. ft. ( $37 \pm 7$  N-m)
- (12) 1S9312 Spring for speed limiter:  
 Length under test force.....  $.86$  in. ( $21.84$  mm)  
 Test force .....  $2.38 \pm .19$  lb. ( $1.080 \pm 0.086$  kg)  
 Free length after test .....  $2.62$  in. ( $66.5$  mm)  
 Outside diameter .....  $.671$  in. ( $17.04$  mm)



TA098847

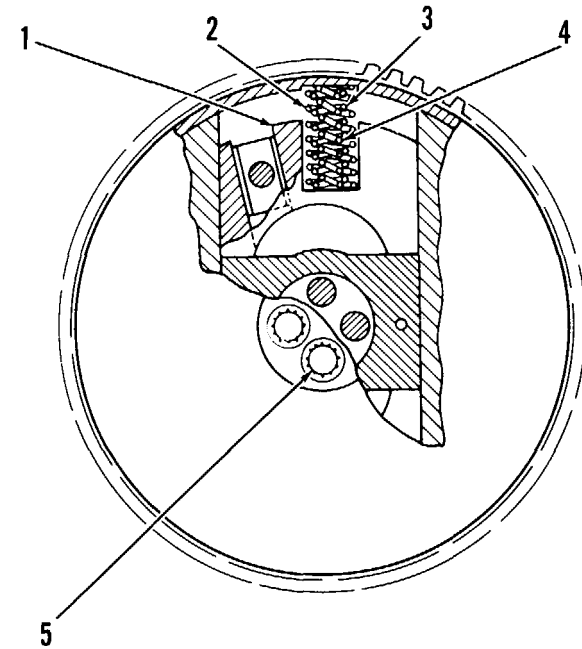
End

- (1) 6N515 Spring:
  - Length under test force ..... 1.81 in. (46.0 mm)
  - Test force ..... 6.84 ± .40 lb. (3.100 ± 0.180 kg)
  - Free length after test ..... 2.95 in. (74.9 mm)
  - Outside diameter ..... .810 in. (20.57 mm)
- (2) 7N209 Spring:
  - Length under test force ..... 1.210 in. (30.73 mm)
  - Test force ..... 32.0 ± 2.9 lb. (14.5 ± 1.3 kg)
  - Free length after test ..... 1.49 in. (37.8 mm)
  - Outside diameter ..... 1.780 in. (45.2 mm)
- (3) 6N513 Spring:
  - Length under test force ..... 600 in. (15.24 mm)
  - Test force ..... 32.0 ± 2.9 lb. (14.5 ± 1.3 kg)
  - Free length after test ..... 1.22 in. (31.0 mm)
  - Outside diameter ..... 1.28 in. (32.5 mm)



**FUEL INJECTION PUMP DRIVE SPECIFICATIONS**

- (1) Weight (two).
- (2) 6N5164 Outer Spring:
  - Length under test force ..... 2.64 in. (67.41 mm)
  - Test force ..... 11.25 ± 56 lb. (5.103 ± 0.254 kg)
  - Free length after test ..... 3.40 ± .03 in. (86.4 ± 0.8 mm)
  - Outside diameter ..... 1.00 in. (25.4 mm)
- (3) 6N5165 Medium Spring:
  - Length under test force ..... 2.654 in. (67.41 mm)
  - Test force ..... 8.57 ± .43 lb. (3.887 ± 0.195 kg)
  - Free length after test ..... 3.40 ± .03 in. (86.4 ± 0.8 mm)
  - Outside diameter ..... .79 in. (20.1 mm)
- (4) 6N5163 Inner Spring:
  - Free length ..... 1.63 ± .03 in. (41.4 ± 0.8 mm)
  - Outside diameter ..... .59 in. (15.0 mm)
- (5) Torque for the four bolts ..... 100 ± 5 lb. ft. (136 ± 7 N.m)



TA098849

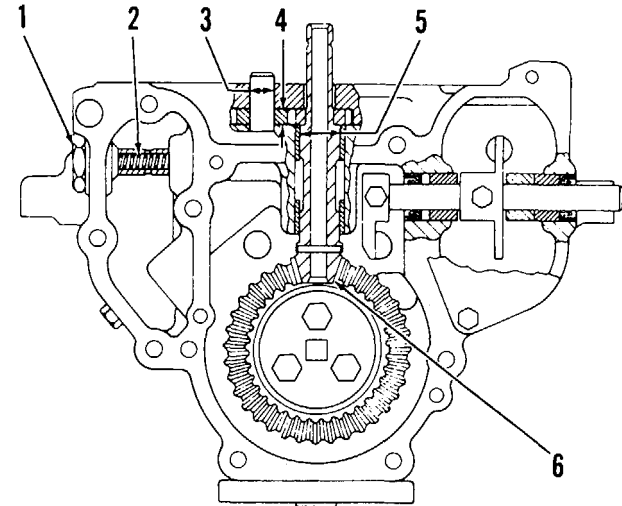
DRIVE AND OIL PUMP FOR THE GOVERNOR SPECIFICATIONS

- (1) Body of bypass valve for the oil pump.
- (2) 7L8696 Spring, inside the valve body (1):
  - Length under test force..... 1.13 in. (28.7 mm)
  - Test force..... 7.2 ± .4 lb. (3.266 i 0.181 kg)
  - Free length after test..... 1.37 ± .01 in. (34.8 ± 0.3 mm)
  - Outside diameter ..... 29 in. (7.4 mm)
- (3) Bore in the gear
  - (new)..... .4926 ± .0003 in. (12.512 ± 0.008 mm)
  - Diameter of the shaft (new).....4914 ± .0003 in. (12.482 ± 0.008 mm)
- (4) Depth of the bore in the pump cover
  - (new)..... 2520 ± .0003 in. (6.401 ± 0.008 mm)
  - Thickness of the gears (new)..... 2500 ±.0005 in. (6.350 ± 0.013 mm)
- (5) Bore in the bearings
  - (new)..... 7517 ± .0010 in. (19.093±0.025 mm)
  - Diameter of the pinion shaft (new)..... 7485 ± .0005 in. (19.012 ± 0.013 mm)

**NOTE**

**Install the bearings even with the ends of the bore in the housing.**

- (6) Minimum gear clearance (backlash) ..... 001 in. (0.03 mm)



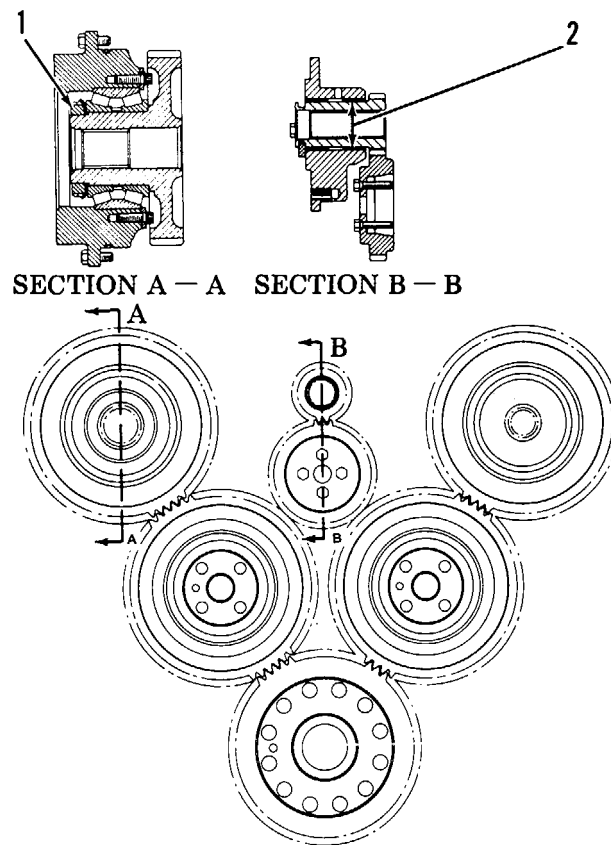
REAR GEAR GROUP SPECIFICATIONS

(Sheet 1 of 1)

- (1) Torque for nut ..... 300 ± 50 lb. ft. (408 ± 68 N.m)
- (2) Bore in bearing in adapter assembly.....2.0040 ±.0015 in. (50.902 ± 0.038 mm)

**NOTE**

Put "V" marks in alignment on balancer gear and crankshaft gear with No. 1 cylinder T.D.C.



**STARTING MOTOR SPECIFICATIONS**

(Sheet 1 of 1)

24V Delco Remy Number 1109775

Rotation is clockwise when seen from drive end.

Minimum speed with no load	5500 rpm
Maximum speed with no load	7500 rpm

Current consumption (draw) at no load:

Minimum with solenoid at 20V	95 A
Maximum with solenoid at 20V	120 A

Clearance between pinion and housing  
(pinion clearance)

36 in. (9.14 mm)

- (1) Tension of brush spring 80 oz. (2.270 kg)
- (2) Torque for screws that hold nose housing to lever housing 13 to 17 lb. ft. (18 to 23 N-m)
- (3) Torque for terminal nuts 20 to 25 lb. ft. (27 to 34 N-m)

**STARTER SOLENOID**

24V Delco Remy Number 1119832

Current consumption (draw):

Current at 20V	40 to 45.5 A
Current at 20 to 24V	40 to 54.6 A

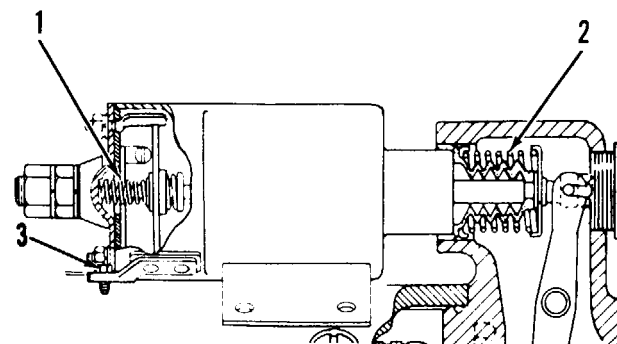
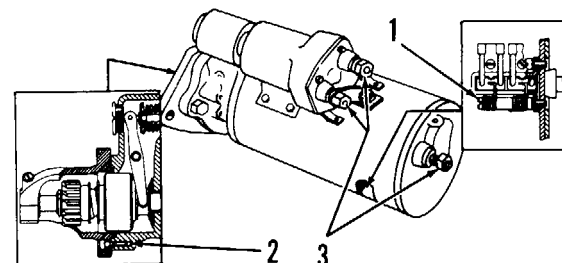
(1) 4M1815 Spring for contact release:

Length under test force	.42 in. (10.7 mm)
Test force	8.5 to 9.5 lb. (3.9 to 4.3 kg)
Free length after test	.830 ± .015 in. (21.11 ± 0.38 mm)
Outside diameter	.875 ± .010 in. (22.23 ± 0.25 mm)

(2) 9M7609 Spring to return the clutch lever:

Length under test force	1.56 in. (39.6 mm)
Test force	14 ± .5 lb. (6.4 ± 0.2 kg)
Free length after test	2.79 in. (70.9 mm)
Outside diameter	1.393 ± .015 in. (35.38 ± 0.38 mm)

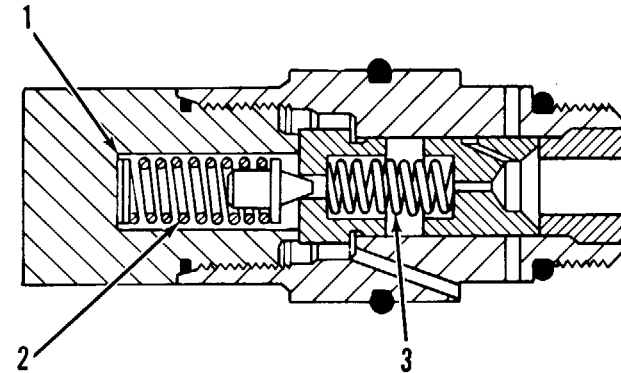
(3) Torque for terminal screws 16 to 30 lb. in. (1, 8 to 4.0 N-m)



RELIEF VALVES FOR TILT CIRCUIT SPECIFICATIONS

(Sheet 1 of 1)

Opening pressure of relief valve (rod end)	2100 ± 50 psi (14, 500 ± 345 kPa)
With an oil flow of	10 ± 1 U.S. gpm (38 ± 4 litre/min)
Opening pressure of relief valve (head end)	3150 ± 50 psi (21, 730 ± 345 kPa)
With an oil flow of	10 ± 1 U.S. gpm (38 ± 4 litre/min)
(1) Thickness of one 5J6153 Shim	007 in. (0.18 mm)
One shim will change pressure	85 psi (590 kPa)
Thickness of one 6J8696 Shim	048 in. (1.22 mm)
One shim will change pressure	580 psi (3985 kPa)
(2) 8J322 Spring:	
Length under test force	1.454 in (36.93 mm)
Test force	30.4 ± 2.4 lb. (137 ± 11 N)
Free length after test	1.656 in. (42.06 mm)
Outside diameter	.438 in. (11.13 mm)
(3) 8H3532 Spring:	
Length under test force	1.00 in. (25.4 mm)
Test force	19.8 to 23.2 lb. (89 to 101 N)
Free length after test	1.656 in. (42.06 mm)
Outside diameter	.344 in. (8.74 mm)
Torque for the cap	75 ± 5 lb. ft. (100 ± 7 N-m)

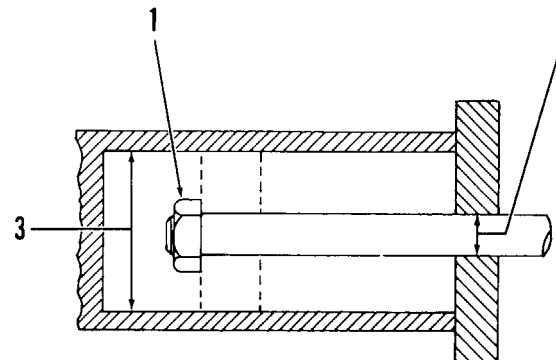


TA098853

## TILT CYLINDER SPECIFICATIONS

(Sheet 1 of 1)

- |   |  |
|---|--|
| (1) Torque for nut with lubricant on threads    | $2250 \pm 25$ lb. ft. ( $3580 \pm 36$ N.m)   |
| (2) Bore in a new head<br>Diameter of a new rod | $2.498 \pm .002$ in. ( $63.45 \pm 0.05$ mm)<br>$3.2480 \pm .0015$ in. ( $82.50 \pm 0.04$ mm) |
| (3) Bore in a new cylinder                      | $7.040 \pm .005$ in. ( $178.82 \pm 0.13$ mm)   |



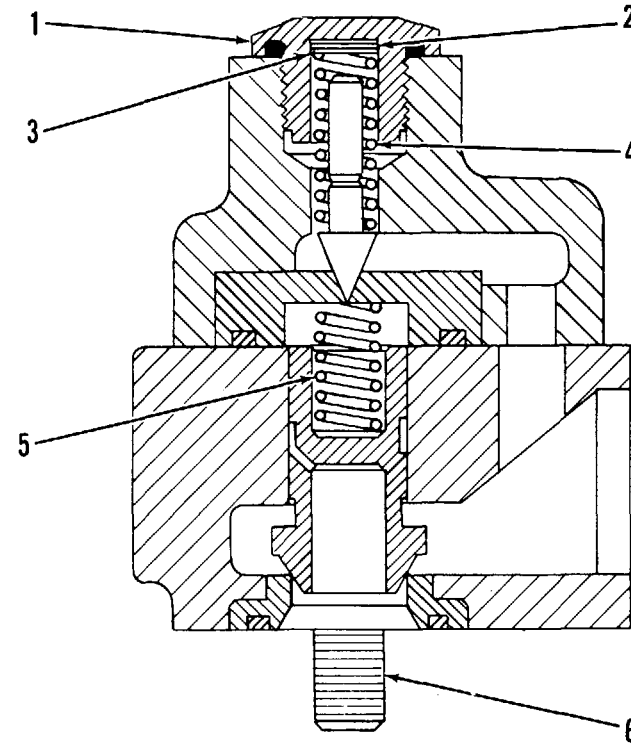
TA098854

**RELIEF VALVE FOR MAIN SYSTEM PRESSURE SPECIFICATIONS**

(Sheet 1 of 1)

**RELIEF VALVE FOR MAIN SYSTEM PRESSURE  
(3G2627)**

Opening pressure of relief valve	3000 ± 50 psi (20, 700 + 345 kPa)
With an oil flow of	142 ± 3 U.S. gpm (539 ± 11 litre/min)
(1) Torque for plug	80 5 lb. ft. (110 + 7 N.m)
(2) Thickness of one 3J7473 Shim One shim will change pressure	005 in. (0.13 mm) 35 psi (240 kPa)
(3) Thickness of one 3J7470 Shim One shim will change pressure	048 in. (1.22 mm) 340 psi (2335 kPa)
(4) 2J6089 Spring for pilot valve: Length under test force Test force Free length after test Outside diameter	1.43 in. (36.3 mm) 64 to 70 lb. (285 to 310 N) 1.74 in. (44.2 mm) 49 in. (12.4 mm)
(5) 5J4664 Spring for dump valve: Length under test force Test force Free length after test Outside diameter	1.14 in. (29.0 mm) 7.7 to 9.5 lb. (34 to 42 N) 1.43 in. (36.3 mm) 500 ± .016 in. (12.7 ± 0.41 mm)
(6) Torque for bolts (two) (mounting to main body)	60± 2 lb. ft. (80 ± 3 N-m)



TA098855

**HYDRAULIC PUMP SPECIFICATIONS**

(Sheet 1 of 1)

5R4477 Pump Group - Gear Specifications

Rotation is clockwise when seen from drive end.

Type of pump: gear

For test, use SAE 10W oil at 1500F (650C)

Test at Full Speed:

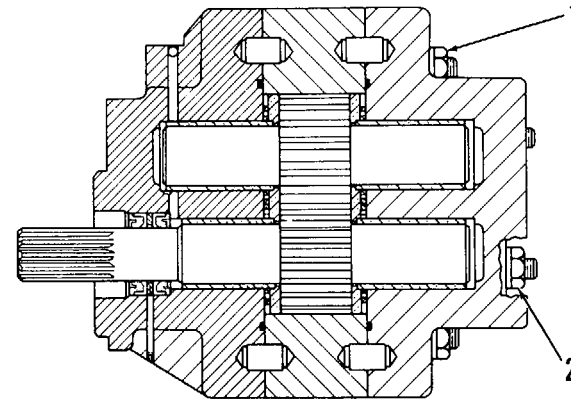
Output	68.3 U.S. gpm (258 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	2100 rpm
with engine at	2100 rpm
Output	66.2 U.S. gpm (251 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	2100 rpm
with engine at	2100 rpm

Test at Half Speed:

Output	31.3 U.S. gpm (118 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	1050 rpm
with engine at	1050 rpm
Output	24.6 U.S. gpm (93 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	1050 rpm
with engine at	1050 rpm

(1) Torque for nuts 290 ± 10 lb. ft. (394 ±13 N.m)

(2) Torque for nuts 290 ±10 lb. ft. (394 ±13 N-m)



**TILT AND SIDE SHIFT CONTROL VALVE SPECIFICATIONS**

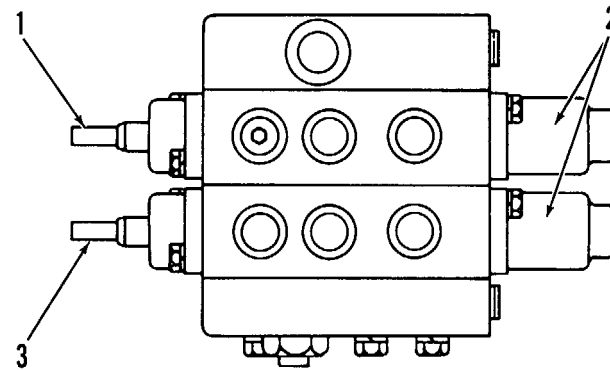
(Sheet 1 of 1)

5R4506 Valve Group - Control (Two Section)

- (1) Valve stem for tilt.
- (2) 206772 Springs (on valve stems):

Length under test force	1.125 in. (28.5 mm)
Test force	60.2 ± 6 lb. (265 ± 27 N)
Length under test force	945 in. (24 mm)
Test force	90 ± 9 lb. (400 ± 40 N)
Free length after test	1.49 in. (37.8 mm)
Outside diameter	1.541 in. (39 mm)
Rate (of force)	165 lb. per in. (735 N)
Wire diameter	162 in. (4 mm)

- (3) Valve stem for lift.

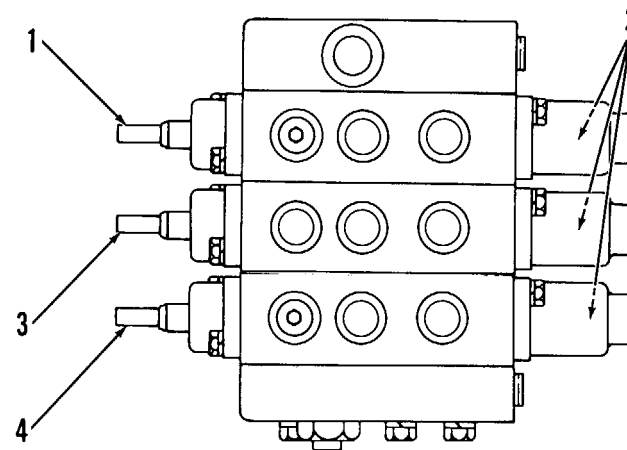


5R4507 Valve Group - (Three Section)

- (1) Valve stem for side shift.
- (2) 246632 Springs (on valve stems):

Length under test force	937 in. (23.9 mm)
Test force	28.4 ± 2.8 lb. (127 ± 12 N)
Length under test force	605 in. (15.3 mm)
Test force	55.4 ± 5.5 lb. (247 ± 24 N)
Free length after test	1.225 in. (31 mm)
Outside diameter	990 in. (25 mm)
Rate (of force)	81.5 lb. per in. (362 N)
Wire diameter	105 in. (2.6 mm)

- (3) Valve stem for side tilt.
- (4) Valve stem for twist locks.



TA098857

**HYDRAULIC FILTER SPECIFICATIONS**

(Sheet 1 of 1)

## (1) 7J2983 Spring (outer):

Length under test force 2.53 in. (64.26 mm)

Test force 60 ± 5 lb. (267 ± 22 N)

Free length after test 8.65 in. (204.85 mm)

Outside diameter 6.0 in. (152.4 mm)

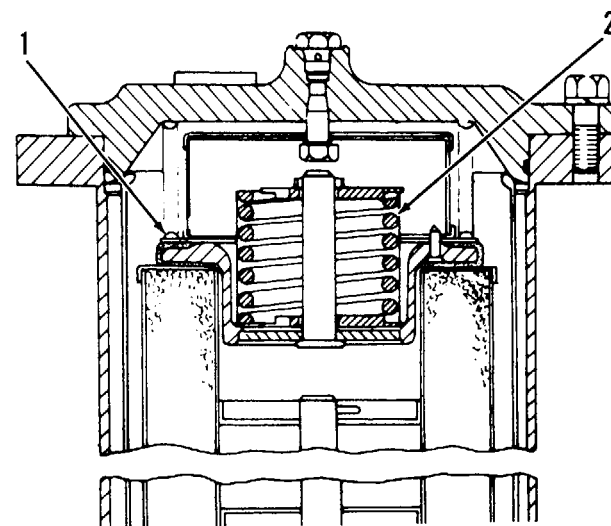
## (2) 3G3273 Spring (inner):

Length under test force 2.19 in. (55.6 mm)

Test force 221 ± 18 lb. (984 ± 80 N)

Free length after test 5.66 in. 143.8 mm)

Outside diameter 3.25 in. 82.5 mm)



TA098858

**BRAKE FILTER SPECIFICATIONS**

(Sheet 1 of 1)

**(6P4603)**

- (1) 9M1936 Spring for bypass valve:

Length under test force	1.35 ± .02 in. (34.3 ± 0.5 mm)
Test force	12.2 ± .98 lb. (54 ± 4 N)
Free length after test	1.86 ± .02 in. (47.2 ± 0.5 mm)
Outside diameter	562 ± .010 in. (14.27 ± 0.25 mm)

- (2) After the housing is against the filter base, tighten the housing by hand.

- (3) 3S8652 Spring:

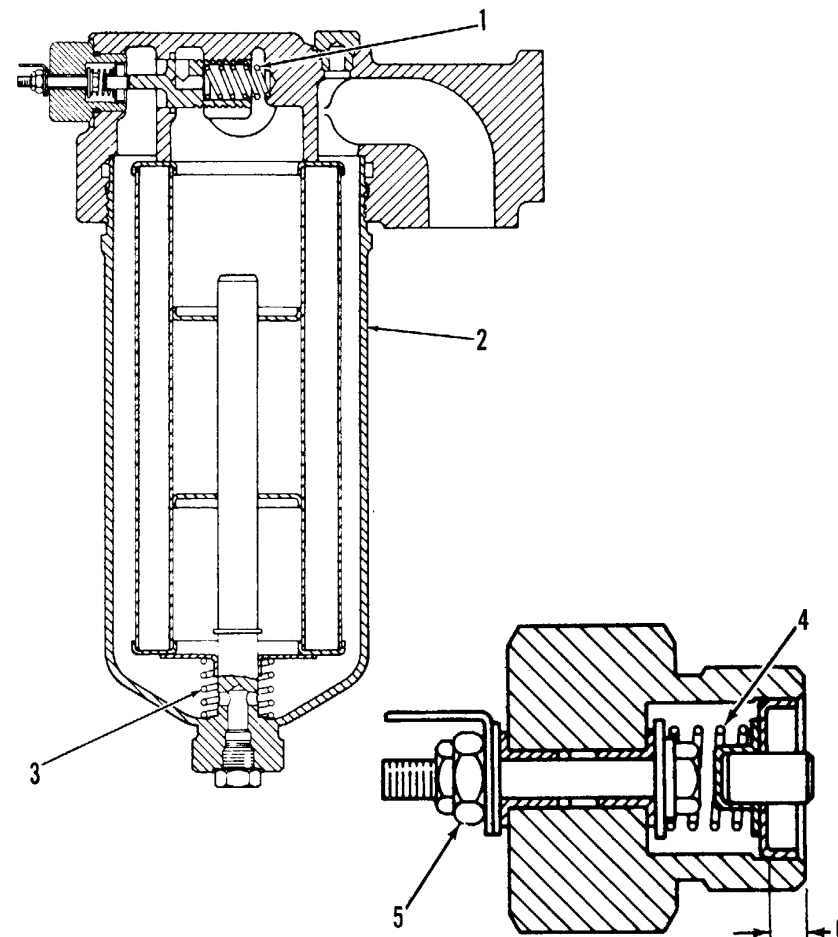
Length under test force	1.00 ± .02 in. (25.4 ± 0.5 mm)
Test force	31.6 to 37.2 lb. (141 to 165 N)
Free length after test	3.80 ± .02 in. (96.5 ± 0.5 mm)
Outside diameter	1.38 ± .02 in. (35.1 ± 0.5 mm)

- (4) 3D4073 Spring for switch:

Length under test force	679 in. (17.25 mm)
Test force	1.00 ± .05 lb. (4.5 ± 0.2 N)
Free length after test	1.34 in. (34.0 mm)
Outside diameter	470 in. (11.94 mm)

- (5) Torque for nut  $10 \pm 2$  lb. in. (1.1 ± 0.2 N.m)

- (6) Distance plug is installed into body must be  $.190 \pm .010$  in. (4.83 ± 0.25 mm)



**STEERING CONTROL VALVE SPECIFICATIONS**

(Sheet 1 of 1)

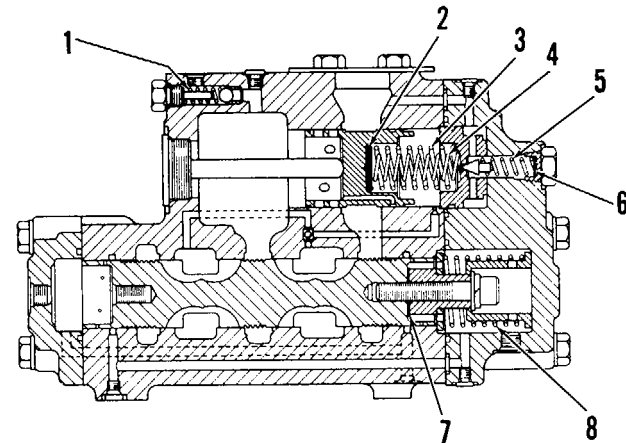
- (1) 9H2367 Spring for check valve:  
 Length under test force .94 in. (23.9 mm)  
 Test force 33 ± .03 lb. (1.47 ± 0.13 N)  
 Free length after test 1.16 in. (29.5 mm)  
 Outside diameter 34 in. (8.6 mm)
- (2) Shims for flow control valve:  
 8M8211 Shim thickness .010 in. (0.25 mm)  
 Three 8M8211 Shims will change the steering time (stop to stop) at high idle by approximately 06 second  
 7M8538 Shim thickness 036 in. (0.91 mm)  
 Three 7M8538 Shims will change the steering time (stop to stop) at high idle by approximately 2 second
- (3) 8J2635 Spring (outer) for flow control valve:  
 Length under test force 2.40 in. (61.0 mm)  
 Test force 36.2 ± 5.5 lb. (161.0 ± 24.5 N)  
 Free length after test 2.75 in. (69.9 mm)  
 Outside diameter 1.20 in. (30.5 mm)
- (4) 8J2634 Spring (inner) for flow control valve:  
 Length under test force 2.46 in. (62.5 mm)  
 Test force 25.8± 5.1 lb. (114.8 ± 22.7 N)  
 Free length after test 2.75 in (69.9 mm)  
 Outside diameter 81 in. (20.6 mm)
- (5) 4F7115 Spring for pilot valve:  
 Length under test force 1.34 in. (34.1 mm)  
 Test force 50.1 to 58.8 lb. (222.8 to 261.5 N)  
 Free length after test 1.69 ± .06 in. (42.9 ± 1.6 mm)  
 Outside diameter 469 in. (11.91 mm)
- (6) Pressure relief setting for steering system 2500 ± 75 psi (175.8 ± 5.3 kg/cm2) (17, 240 ± 520 kPa)
- 3J7473 Shim for pilot valve:  
 Shim thickness 005 in. (0.13 mm)  
 One shim will change the relief pressure by 40 psi (2.8 kg/cm2) (276 kPa)

- 3H2549 Shim for pilot valve:  
 Shim thickness .010 in. (0.25 mm)  
 One shim will change the relief pressure by 80 psi (5.6 kg/cm2) (552 kPa)
- (7) Cylinder flow balance shims:  
 8B3115 Shim thickness 010 in. (0.25 mm)  
 Two shims will change the steering time at high idle by approximately 1 second

**NOTE**

**The addition of 8B3115 shims will cause a faster right turn (stop to stop) and a slower left turn. The result is opposite when shims are removed.**

- (8) 9J4071 Spring for valve spool:  
 Length under test force 2.17 in. (55.1 mm)  
 Test force 24.1 ± 3.6 lb. (107.2 ± 16.0 N)  
 Free length after test 2.50 in. (63.5 mm)  
 Outside diameter 2.07 in. (52.6 mm)



STEERING HYDRAULIC PUMP (AND BRAKE PUMP) SPECIFICATIONS

(Sheet 1 of 1)

Rotation is clockwise when seen from drive end.

Type of pump: Gear

For test, use SAE 10W oil at 1500F (650C)

LARGE SECTION OF PUMP (Drive end) (Steering)

Test at Full Speed:

Output	93.0 U.S. gpm (352.0 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	2000 rpm
with engine at	2000 rpm
Output	90.0 U.S. gpm (341.0 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	2000 rpm
with engine at	2000 rpm

Test at Half Speed:

Output	43.0 U.S. gpm (163.0 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	1000 rpm
with engine at	1000 rpm
Output	40.0 U.S. gpm (151.0 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	1000 rpm
with engine at	1000 rpm

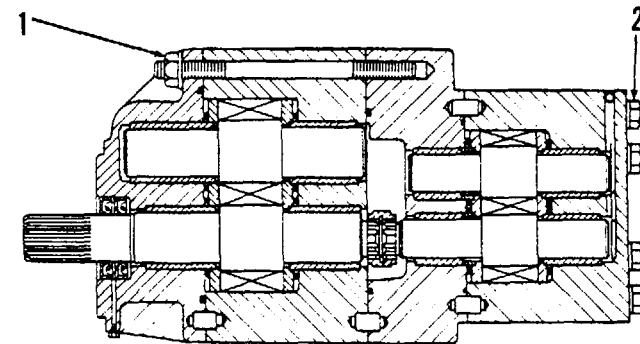
SMALL SECTION OF PUMP (Cover end) (Pilot and Brakes)

Test at Full Speed:

Output	36.0 U.S. gpm (136.0 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	2000 rpm
with engine at	2000 rpm
Output	33.0 U.S. gpm (125.0 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	2000 rpm
with engine at	2000 rpm

Test at Half Speed:

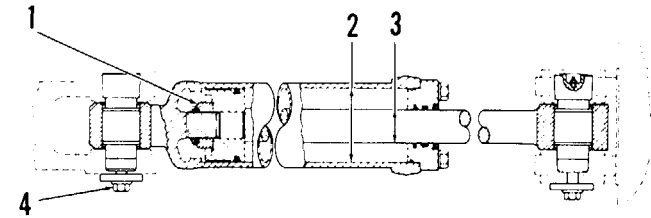
Output	17.0 U.S. gpm (64.0 liter/min)
at a pressure of	100 psi (690 kPa)
with pump at	1000 rpm
with engine at	1000 rpm
Output	16.0 U.S. gpm (61.0 liter/min)
at a pressure of	1000 psi (6900 kPa)
with pump at	1000 rpm
with engine at	1000 rpm
(1) Torque for nuts	175 ± 10 lb. ft. (240 ± 14 N-m)
(2) Torque for bolts	85 ± 5 lb. ft. (115 ± 7 N-m)



**STEERING CYLINDER AND MOUNTING SPECIFICATIONS**

(Sheet 1 of 1)

- (1) Torque for nut with lubricant on threads                     $1600 \pm 160$  lb. ft. ( $2180 \pm 218$  N.m)
- (2) Bore in new cylinder                     $5.00 + .005$  or  $- .002$  ( $127.00 + 0.13$  or  $- 0.05$  mm)
- (3) Bore in new head                     $2.254 \pm .002$  in. ( $57.25 + 0.05$  mm)  
       Diameter of new rod .                     $2.2480 \pm .0015$  in. ( $57.099 \pm 0.038$  mm)
- (4) To get the correct torque on bolts (four places):
  - (a) Tighten bolts to                     $265 \pm 35$  lb. ft. ( $360 \pm 48$  N-m)
  - (b) Hit the joint (connection) with a hammer until the torque goes below                     $140$  lb. ft. ( $190$  N-m)
  - (c) Tighten bolts to                     $265 \pm 35$  lb. ft. ( $360 \pm 48$  N-m)
  - (d) Hit the joint (connection) with a hammer until the torque goes below                     $210$  lb. ft. ( $286$  N-m)
  - (e) Final torque for bolts (two)                     $265 \pm 35$  lb. ft. ( $360 \pm 48$  N-m)



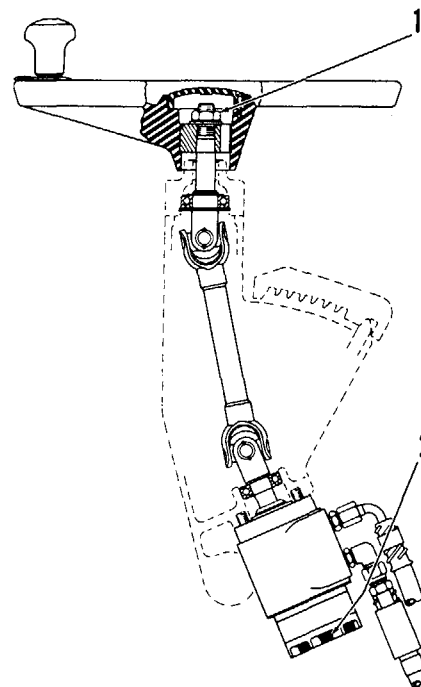
**NOTE**

**Install the pin so that the groove on the end of the pin is parallel ( $\pm 100$ ) with the cylinder.**

**STEERING CONTROL GROUP SPECIFICATIONS**

(Sheet 1 of 1)

- (1) Torque for nut  $37 \pm 3$  lb. ft. ( $50 \pm 4$  N-m)
- (2) Torque for bolts  $21 \pm 3$  lb. ft. ( $29 \pm 4$  N-m)



**NEUTRALIZER VALVES SPECIFICATIONS****(Sheet 1 of 1)****(1) 1A8096 Spring for ball check valve:**

Length under test force	.56 in. (14.3 mm)
Test force	4.0 t .3 lb. (17.8 + 1.3 N)
Free length after test	.94 in. (23.8 mm)
Outside diameter	.32 in. (8.1 mm)

**(2) 7B8194 Spring for stem:**

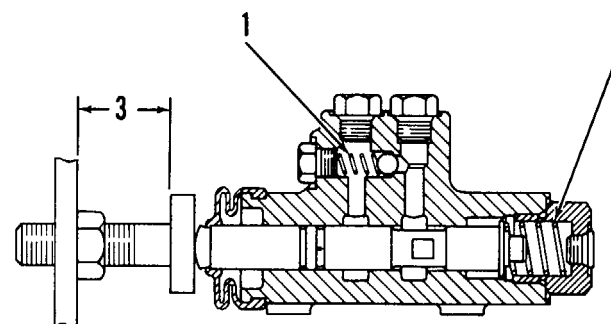
Length under test force	1.16 in. (29.4 mm)
Test force	30.0 ± 2.4 lb. (133.4 * 10.7 N)
Free length after test	2.17 in. (55.2 mm)
Outside diameter	.91 in. (23.1 mm)

**(3) Approximate dimension between face of striker (stud assembly) and mounting bracket**

1.56 in. (39.6 mm)

**To check the striker adjustment:**

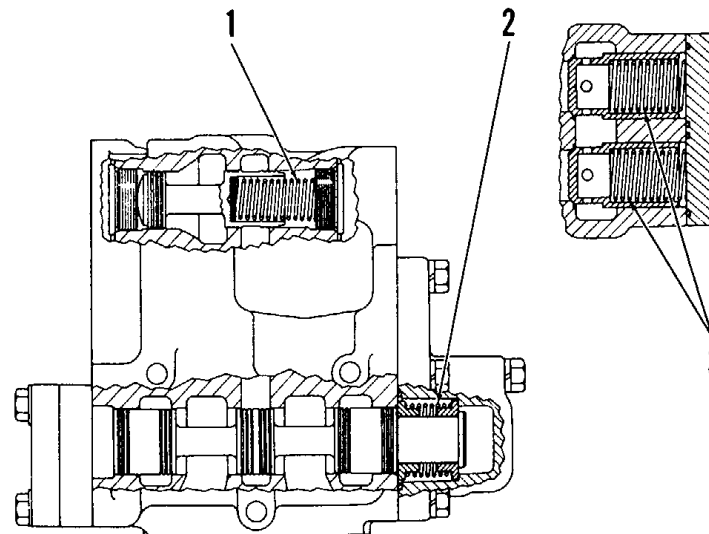
- (a) Put a .50 in. (12.7 mm) ball of putty (or similar material) on the front frame stops.
- (b) Raise the bucket about one foot and release the brakes.
- (c) With the engine at high idle, steer rapidly into both stops.
- (d) The thickness of the putty must then be .12 to .18 in. (3.0 to 4.6 mm) after the turns.
- (e) If necessary, adjust the strikers until this dimension is correct.



DIVERTER VALVE GROUP FOR SUPPLEMENTAL STEERING SPECIFICATIONS

(Sheet 1 of 1)

- (1) 8J1705 Spring for diverter spool:  
 Length under test force ..... 2.17 in. (55.1 mm)  
 Test force ..... 12.5 i 1.1 lb.(55.6 t 4.9 N)  
 Free length after test ..... 3.25 in. (82.6 mm)  
 Outside diameter ..... 1.125 in. (28.6 mm)
- (2) 8J6785 Spring for reversing spool:  
 Length under test force ..... 1.26 in. (32.0 mm)  
 Test force ..... 10.3 i .8 lb. (45.8 i 3.6 N)  
 Free length after test ..... 2.06 in. (52.3 mm)  
 Outside diameter ..... 1.946 in. (49.43 mm)
- (3) 1J9533 Spring for check valves (two):  
 Length under test force ..... 2.25 in. (57.2 mm)  
 Test force ..... 10.5 ± .5 lb. (46.7 ± 2.2 N)  
 Free length after test ..... 5.75 in. (146.1 mm)  
 Outside diameter ..... 1.375 in. (34.93 mm)



TA098865

SUPPLEMENTAL STEERING PUMP SPECIFICATIONS

(Sheet 1 of 1)

Type of pump: Gear

For test use SAE 10W oil at 1500F (650C)

Test at Full Speed:

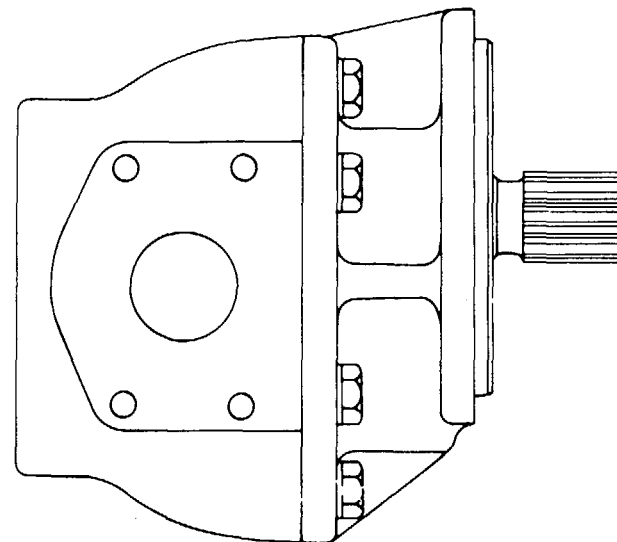
Output ..... 78.0 U.S. rpm (295.3 litre/min)  
 at a pressure of ..... 500 psi (35.0 kg/cm<sup>2</sup>) (3450 kPa)  
 with pump at ..... 2000 rpm  
 with engine at ..... 2000 rpm

Output ..... 76.0 U.S. rpm (287.7 litre/min)  
 at a pressure of ..... 1500 psi (105.0 kg/cm<sup>2</sup>) (10,300 kPa)  
 with pump at ..... 2000 rpm  
 with engine at ..... 2000 rpm

Test at Half Speed:

Output ..... 3.80 U.S. rpm (143.8 litre/min)  
 at a pressure of ..... 500 psi (35.0 kg/cm<sup>2</sup>) (3450 kPa)  
 with pump at ..... 1000 rpm  
 with engine at ..... 1000 rpm

Output ..... 36.0 U.S. rpm (136.3 litre/min)  
 at a pressure of ..... 1500 psi (105.0 kg/cm<sup>2</sup>) (10,300 kPa)  
 with pump at ..... 1000 rpm  
 with engine at ..... 1000 rpm



TA098866

SUPPLEMENTAL STEERING FLOW SWITCH SPECIFICATIONS

(Sheet 1 of 1)

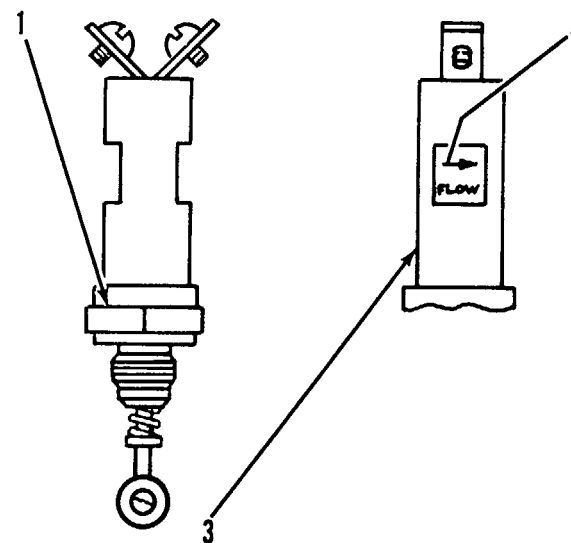
With hydraulic oil at 1500F (660C):

Circuit opens at..... 6.2 + .4 U.S. gpm (23.5 + 1.5 liter/min)

Circuit closes at..... 3.6 + .4 U.S. gpm (12.6 + 1.5 liter/min)

Installation Procedure:

- (1) Install switch and tighten lower body to a torque of ..... 190 + 20 lb. In. (21.5 + 2.3 N m)
- (2) Put the upper body in position so that the arrow points in the direction of flow ..... Away from main steering pump.
- (3) Torque used to put upper body in position ..... 42 ± 18 lb. in. (4.7 + 2.0 N m)

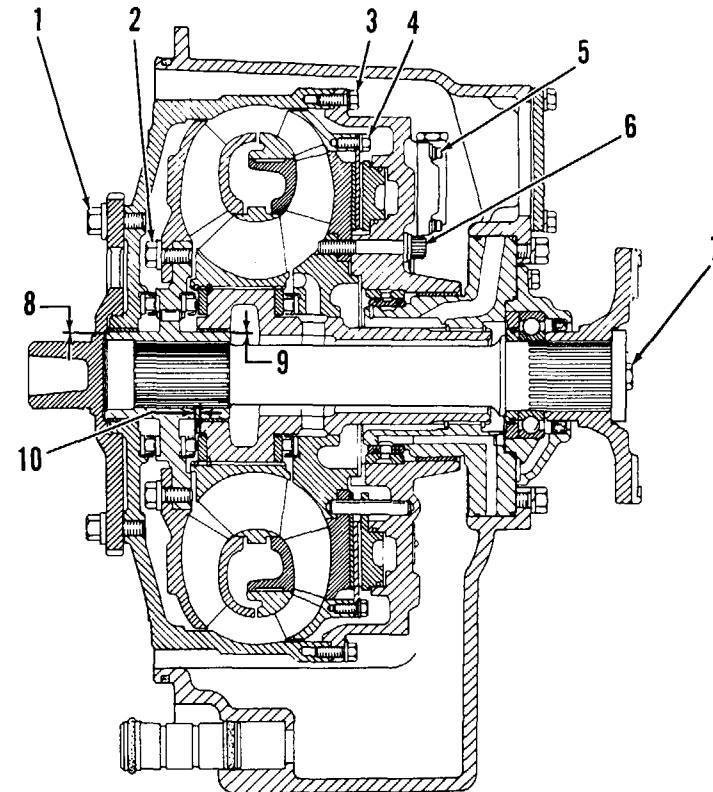


TA098867

TORQUE CONVERTER SPECIFICATIONS

(Sheet 1 of 2)

- (1) Torque for the bolts that fasten flange to converter housing .....81 + 4 lb. ft. (111 + 5 N m)
- (2) Torque for the bolts that fasten turbine to the hub .....81 +4 lb. ft. (111 i 5 N m)
- (3) Torque for bolts that fasten converter housing to clutch housing .....36 + 2 lb. ft.(46 + 3 N m)
- (4) Torque for bolts that fasten disc to outer impeller .....20 + 1 lb. ft.(25 ± 1 N m)
- (5) Torque for bolts that fasten centrifugal valve to clutch housing .....20 + 1 lb. ft.(25 ± 1 N m)
- (6) Torque for bolts that fasten inner impeller to clutch housing .....85 + 5 lb. ft.(115 + 7 N m)
- (7) Torque for the bolt that fastens the retainer to output shaft ..... 85 \* 5 lb. ft.(115 + 7 N-m)
- (8) Clearance between hub and bearing in cover assembly:  
Across the diameter ..... 0025 to .0065 in. (0.064 to 0.165 mm)
- (9) Clearance between hub and bearing in carrier assembly:  
Across the diameter ..... 0028 to .0068 in. (0.071 to 0.173 mm)
- (10) Clearance between bearing and plate ..... 0020 to .0826 in. (0.051 to 2.098 mm)
- (11) Clearance between stator and turbine:  
Across the diameter ..... 032 + .010 in. (0.81 ± 0.25 mm)
  
- Maximum permissible clearance across the diameter ..... 048 in. (1.22 mm)

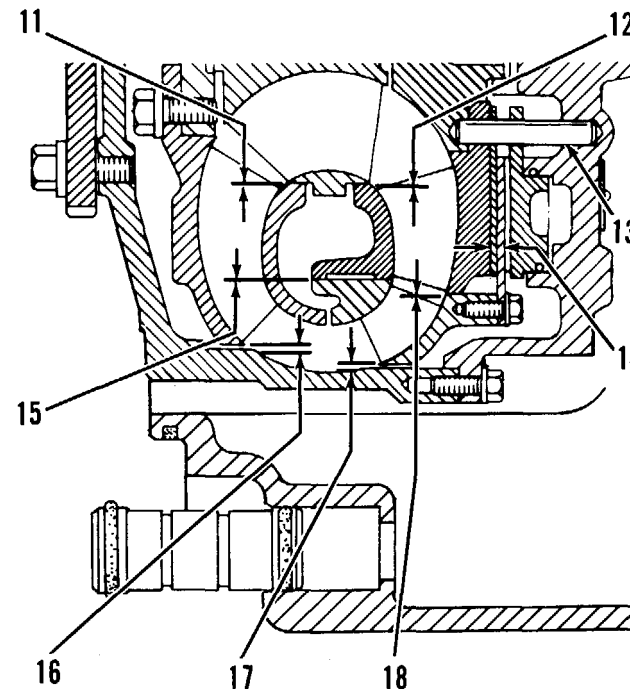


TA098868  
Go on to Sheet 2

TORQUE CONVERTER SPECIFICATIONS (CONT)

(Sheet 2 of 2)

- (12) Clearance between stator and inner impeller:  
 Across the diameter .....  $.032 \pm .010$  in. (0.81 ± 0.25 mm)  
 Maximum permissible clearance across  
 the diameter .....  $.048$  in. (1.22 mm)
  
- (13) 1M3151 Pin for the clutch:  
 Length.....  $2.688 \pm .010$  in. (68.28 ± 0.25 mm)  
 Outside  
 diameter .....  $.4975 \pm .0005$  in.  $12.637 \pm 0.013$  mm)
  
- (14) Thickness of one new 2P9336 Disc  
 Assembly and one new  
 2P5698 Disc .....  $.330$  to  $.346$  in. (8.38 to 8.79 mm)
  
- (15) Clearance between outer impeller and inner impeller:  
 Across the diameter .....  $.057 \pm .008$  in (1.45 ± 0.20 mm)  
 Maximum permissible clearance across  
 the diameter .....  $.086$  in (2.18 mm)
  
- (16) Clearance between turbine and converter housing:  
 Across the diameter .....  $.090 \pm .020$  in (2.29 ± 0.51 mm)  
 Maximum permissible clearance across  
 the diameter .....  $.135$  in (3.43 mm)
  
- (17) Clearance between converter housing and outer impeller:  
 Across the diameter .....  $.090 \pm .013$  in (2.29 ± 0.33 mm)  
 Maximum permissible clearance across  
 the diameter .....  $.135$  in (3.43 mm)
  
- (18) Clearance between outer impeller and inner impeller:  
 Across the diameter .....  $.040 \pm .015$  in (1.02 ± 0.38 mm)  
 Maximum permissible clearance across  
 the diameter .....  $.060$  in (1.52 mm)



TA098869  
 End

RELIEF VALVE FOR CONVERTER OUTLET SPECIFICATIONS

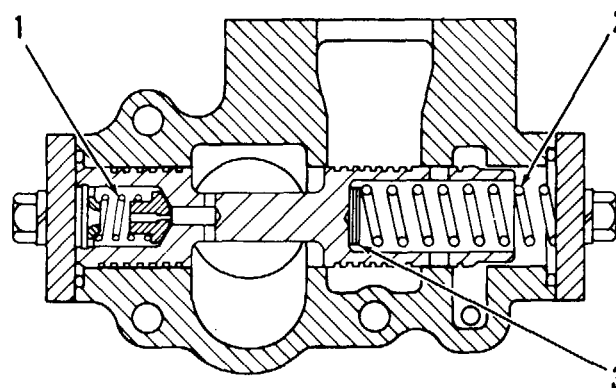
(Sheet 1 of 1)

- (1) 5M9548 Spring for poppet valve:  
 Length under test force ..... 84 in (21.3 mm)  
 Test force ..... 1.0 + .08 lb. (4 + 0.4 N)  
 Free length after test ..... 1.34 in (34.0 mm)  
 Outside diameter ..... 48 in (12.2 mm)
- (2) 8M8627 Spring (white stripe) for relief valve:  
 Length under test force ..... 2.11 in (53.6 mm)  
 Test force ..... 88.8 ± 7.1 lb (395 + 32 N)  
 Free length after test ..... 3.10 in (78.7 mm)  
 Outside diameter ..... 780 in (19.81 mm)
- (3) 5M9623 Spacers:  
 Thickness of one spacer ..... 036 in (0.91 mm)  
 Outside diameter of spacer ..... 812 in (20.62 mm)  
 One spacer will change

pressure ..... 2.64 psi (18.2 kPa)

5M9624 Spacers:  
 Thickness of one spacer ..... 010 in (0.25 mm)  
 Outside diameter of spacer ..... 812 in (20.62 mm)  
 One spacer will change  
 pressure..... 73 psi (5.0 kPa)

5M9622 Spacers:  
 Thickness of one spacer ..... 062 in (1.57 mm)  
 Outside diameter of spacer ..... 812 in (20.62 mm)  
 One spacer will change  
 pressure..... 4.53 psi (31.2 kPa)



TA098870

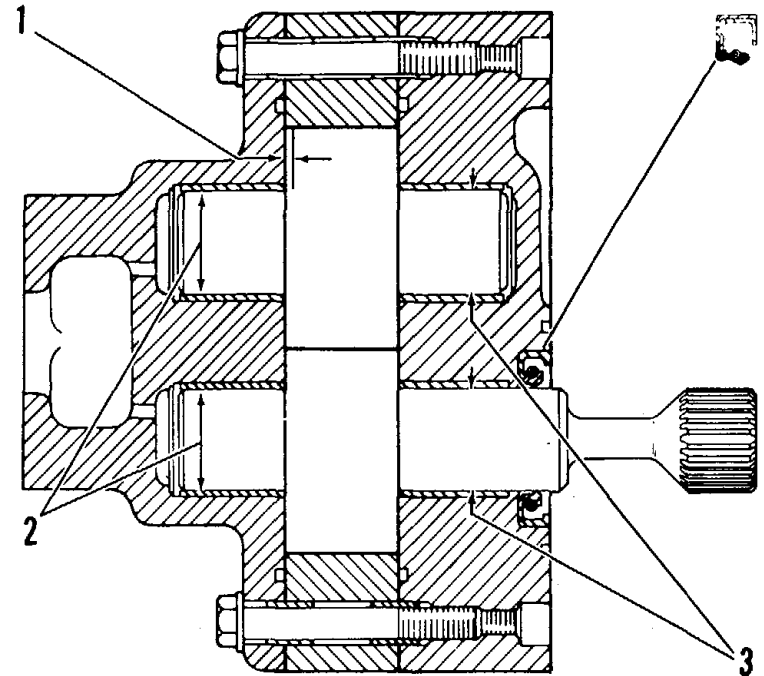
TRANSMISSION OIL PUMP SPECIFICATIONS

(Sheet 1 of 1)

Type .....Gear  
 Number of sections ..... One  
 Rotation (seen from drive end)..... Counterclockwise

Output [(bench test using SAE 10W oil at 120°F  
 (49°)] 30.4 U.S..... rpm (115.1 litre/min) minimum  
 At a speed of ..... 1800 rpm  
 At a pressure of ..... 350 psi (2400 kPa)

- (1) Clearance between gears and covers  
 (new)..... 0019 to .0035 in (0.048 to 0.089 mm)
- (2) Bore of bearings  
 (new)..... 1.2511 to 1.2517 in (31.778 to 31.793 mm)
- (3) Diameter of shafts  
 (new)..... 1.2495 to 1.2499 in (31.737 to 31.747 mm)



TA098871

SEQUENCE AND PRESSURE CONTROL VALVE SPECIFICATIONS

(Sheet 1 of 1)

Torque for bolt that holds the torque converter control cable in the cover .....22 i 3 lb ft (28 t 4 N-m)

(1) 2P5751 Spring (outer with yellow stripe):  
Free length after test ..... 3.53 + .19 in (89.7 + 4.8 mm)  
Outside diameter ..... 580 in (14.73 mm)

Test of spring:

1. Put spring in compression under a force of .....3.25 lb (14.5 N)
2. Increase the force until the length of the spring decreases an additional ..... 1.400 in (35.56 mm)
3. At this time, the force on the spring

must be 13.00 i .59 lb .....(57.9 ± 2.6 N)

(2) 6P5405 Spring (inner):  
Free length after test ..... 3.25 in (82.6 mm)  
Outside diameter ..... 422 in (10.72 mm)

Test of spring:

1. Put spring in compression under a force of ..... 1.75 lb (7.8 N)
2. Increase the force until the length of the spring decreases an additional ..... 1.000 in (25.40 mm)
3. At this time, the force on the spring must be ..... 6.50 i .24 lb (28.9 t 1.1 N)

(3) 4M1751 Spacers:  
Thickness of one spacer ..... 016 in (0.41 mm)  
Outside diameter of spacer ..... 594 in (15.09 mm)  
One spacer will change pressure ..... 1.46 psi (10.1 kPa)

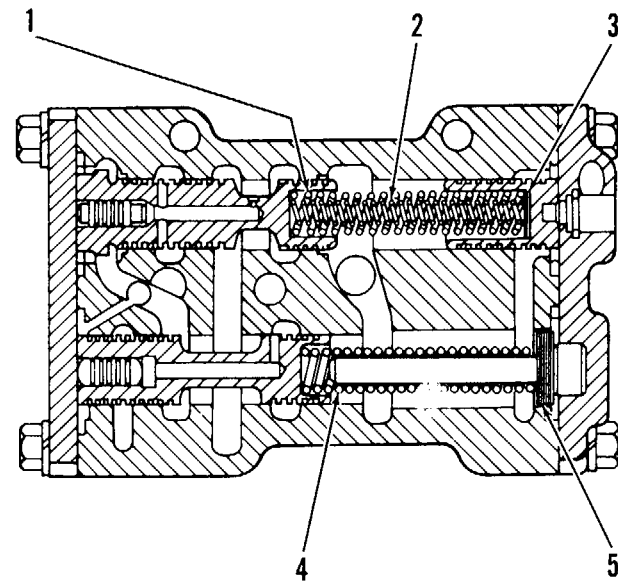
(3) 5S7001 Spacers:  
Thickness of one spacer ..... 036 in (0.91 mm)  
Outside diameter of spacer ..... 557 i .002 in (14.15 ± 0.05 mm)  
One spacer will change pressure ..... 3.27 psi (22.6 kPa)

(4) 2P5755 Spring for sequence valve:  
Length under test force ..... 3.42 in (86.9 mm)

Test force ..... 25.4 i 2.0 lb (113 i 9 N)  
Free length after test ..... 4.86 in (123.4 mm)  
Outside diameter ..... 562 in (14.27 mm)

(5) 8S6214 Spacers:  
Thickness of one spacer ..... 016 in (0.41 mm)  
Outside diameter of spacer ..... 906 in (23.01 mm)  
One spacer will change pressure approximately ..... 4 psi (25 kPa)

(5) 8S6215 Spacers:  
Thickness of one spacer ..... 036 in (0.91 mm)  
Outside diameter of spacer ..... 906 in (23.01 mm)  
One spacer will change pressure approximately ..... 8 psi (55 kPa)

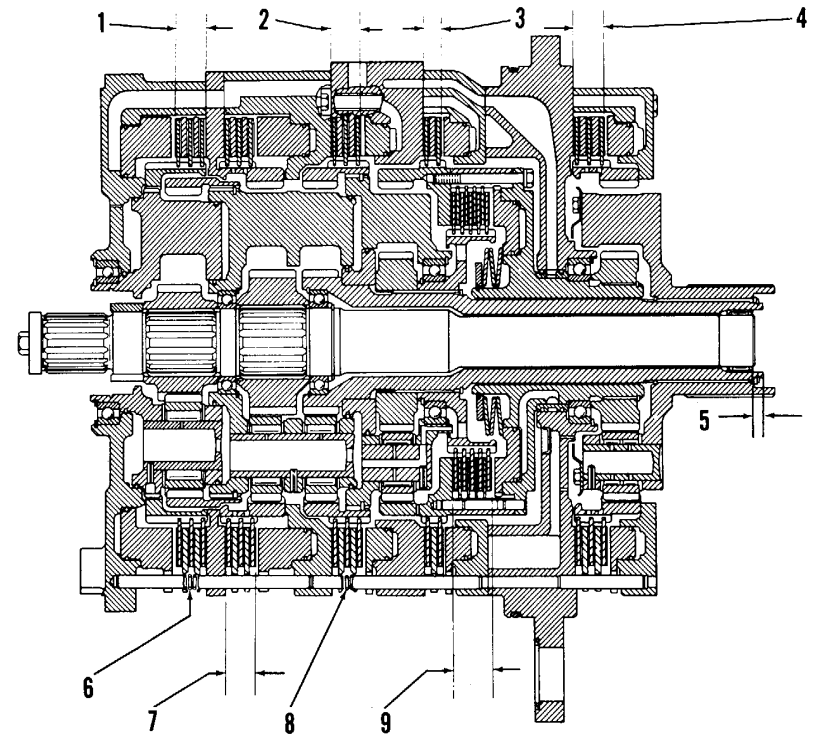


TA098872

TRANSMISSION SPECIFICATIONS

(Sheet 1 of 1)

- (1) Thickness of three new discs and two new plates for the  
No ..... 1 clutch 1.175 to 1.205 in (29.85 to 30.6 mm)
- (2) Thickness of three new discs and two new plates for the  
No ..... 3 clutch 1.175 to 1.205 in (29.85 to 30.61 mm)
- (3) Thickness of two new discs and one new plate for the  
No ..... 4 clutch 696 to .714 in (17.68 to 18.14 mm)
- (4) Thickness of three new discs and two new plates for the  
No ..... 6 clutch 1.175 to 1.205 in (29.85 to 30.61 mm)
- (5) Distance to install bearing in shaft ..... 375 in (9.53 mm)
- (6) 2P5755 Spring for No ..... 1 and No 2 clutches:  
Length under test force ..... 3.42 in (86.9 mm)  
Test force ..... 25.4 \* 2 lb (113 t 9 N)  
Free length after test ..... 4.86 in (123.4 mm)  
Outside diameter ..... 563 in (14.30 mm)
- (7) Thickness of three new discs and two new plates for the  
No ..... 2 clutch 1.175 to 1.205 in (29.85 to 30.61 mm)
- (8) 9H5537 Spring for No ..... 3, No 4 and No 6 clutches:  
Length under test force ..... 1.84 in (46.7 mm)  
Test force ..... 28.75 + 2.30 lb (128.0 i 10.3 N)  
Free length after test ..... 2.47 in (62.7 mm)  
Outside diameter ..... 563 in (14.30 mm)
- (9) Thickness of five new discs and four new plates for  
No ..... 5 clutch 1.448 to 1.502 in (36.78 to 38.15 mm)



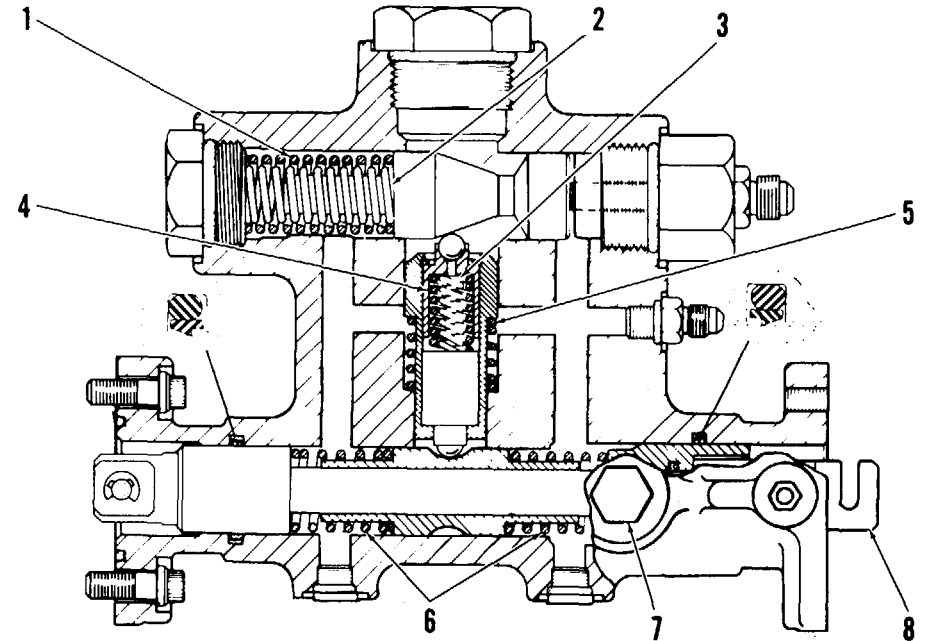
TA098873

TRANSMISSION CONTROL LOCK SPECIFICATIONS

(Sheet 1 of 1)

- (1) 2V7248 Spring:  
 Length under test force ..... 1.969 in (50.01 mm)  
 Test force ..... 28.1 i 1.41 lb (125 i 6.3 N)  
 Free length after test ..... 2.789 in (70.84 mm)  
 Outside diameter ..... 1.122 in (28.50 mm)
  
- (2) 2V7249 Spring:  
 Length under test force ..... 1.969 in (50.01 mm)  
 Test force ..... 18.0 i .9 lb (80 ± 4 N)  
 Free length after test ..... 2.756 in (70.00 mm)  
 Outside diameter ..... 794 in (20.17 mm)
  
- (3) 2V7247 Spring:  
 Length under test force ..... 1.969 in (50.01 mm)  
 Test force ..... 23.6 ± 1.2 lb (105 i 5.3 N)  
 Free length after test ..... 2.244 in (57.00 mm)  
 Outside diameter ..... 350 in (8.89 mm)
  
- (4) 2V7225 Spring (outer):  
 Length under test force ..... 1.969 in (50.01 mm)  
 Test force ..... 46.1 \* 2.3 lb (205 i 10 N)  
 Free length after test ..... 2.372 in (60.25 mm)  
 Outside diameter ..... 598 in (15.19 mm)
  
- (5) 2V7246 Spring:  
 Length under test force ..... 984 in (24.99 mm)  
 Test force ..... 15.7 t .8 lb (70 ± 3.6 N)  
 Free length after test ..... 1.535 in (38.99 mm)  
 Outside diameter ..... 1.197 in (30.40 mm)
  
- (6) 2V7224 Springs:  
 Length under test force ..... 1.166 in (29.62 mm)

- Test force ..... 39.5 ± 1.98 lb (177 ± 8.6 N)
- Free length after test ..... 1.814 in (46.08 mm)
- Outside diameter ..... 1.130 in (28.70 mm)
- (7) Torque for plug ..... 13 i 1 lb ft (17 + 2 N m)
- (8) Torque for nut (with 9S3263 Thread Lock  
 on the threads) ..... 52 ± 11 lb ft (73 i 15 N-m)

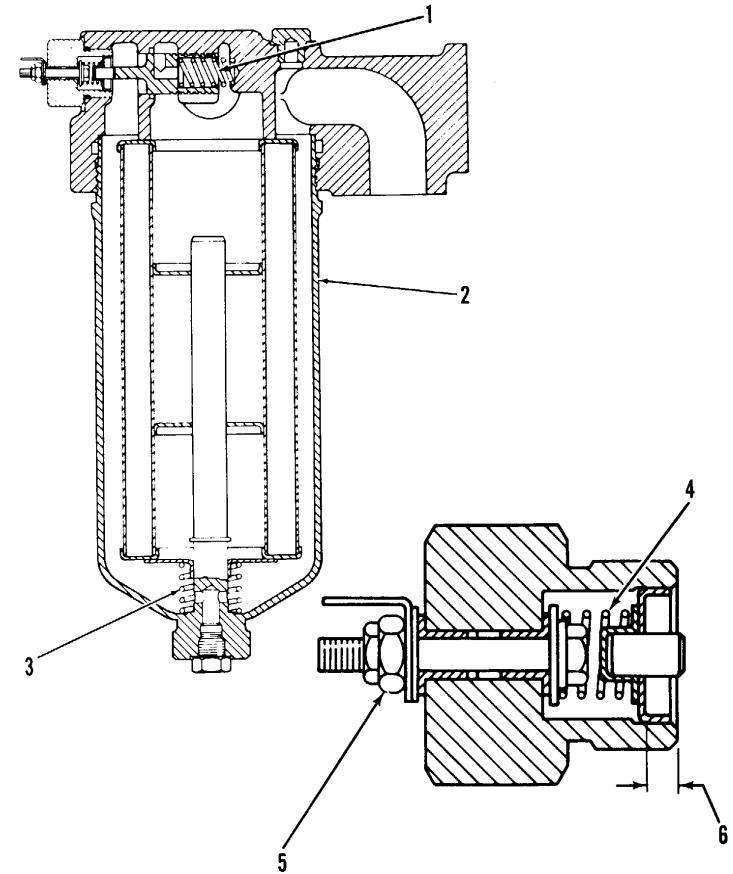


TA098874

TRANSMISSION OIL FILTER SPECIFICATIONS

(6P4603)

- (1) 9M1986 Spring for bypass valve:  
 Length under test force ..... 1.00 in (25.4 mm)  
 Test force ..... 24.9 ± 2.0 lb (111 i 9 N)  
 Free length after test ..... 1.86 in (47.2 mm)  
  
 Outside diameter ..... 50 in (12.7 mm)
- (2) After the housing is against the filter base, tighten the housing by hand
- (3) 3S8652 Spring:  
 Length under test force ..... 1.00 in (25.4 mm)  
 Test force ..... 31.6 to 37.2 lb (141 to 166 N)  
 Free length after test ..... 3.80 in (96.5 mm)  
 Outside diameter ..... 1.38 in (35.1 mm)
- (4) 3D4073 Spring for switch:  
 Length under test force ..... 679 in (17.25 mm)  
 Test force ..... 1.00 ± .05 lb (4.5 ± 0.2 N)  
 Free length after test ..... 1.34 in (34.0 mm)  
 Outside diameter ..... 470 in (11.94 mm)
- (5) Torque for nut..... 10 ± 2 lb in (1.1 t 0.2 N-m)
- (6) Distance plug is installed into body must be..... 190+ .010 in (4.83 ± 0.25 mm)



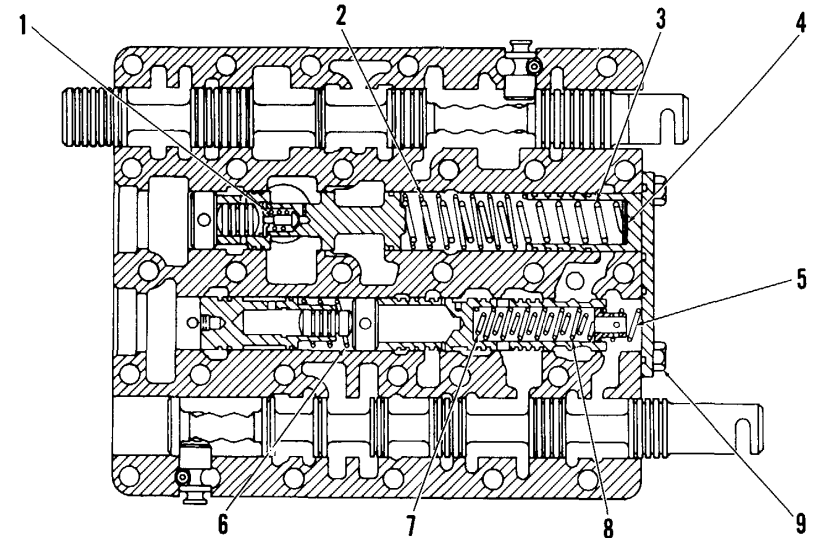
TA098875

TRANSMISSION PRESSURE CONTROL VALVE SPECIFICATIONS

(Sheet 1 of 2)

- (1) 4M2381 Spring:  
 Length under test force ..... 48 + .02 in (12.2 i 0.5 mm)  
 Test force .....517 f .041 lb (2.30 + 0.18 N)  
 Free length after test ..... 89 + .02 in (22.6 i 0.5 mm)  
 Outside diameter ..... 300 + .010 in (7.62 + 0.25 mm)
- (2) 6P4976 Spring (outer):  
 Length under test force ..... 1.628 in (41.35 mm)  
 Test force ..... 19.8 + 1.6 lb (88 + 7N)  
 Free length after test ..... 3.000 in (76.20 mm)  
 Outside diameter ..... 1.080 in (27.43 mm)
- (3) 9P3041 Spring (inner):  
 Length under test force ..... 3.55 in (90.2 mm)  
 Test force ..... 60.2 + 4.8 lb (268 + 22 N)  
 Free length after test ..... 4.62 in (117.3 mm)  
 Outside diameter ..... 835 in (21.21 mm)
- (3) 6P4974 Spring (inner):  
 Length under test force..... 3.547 in (90.09 mm)  
 Test force ..... 60.2 + 4.8 lb (268 ± 22 N)  
 Free length after test ..... 4.622 in (117.40 mm)  
 Outside diameter ..... 835 in (21.21 mm)
- (4) 5M9622 Spacer:  
 Thickness of one spacer ..... 062 in (1.57 mm)  
 Outside diameter ..... 812 in (20.62 mm)  
 One spacer will change pressure  
 approximately ..... 14.2 psi (98 kPa)
- (4) 5M9623 Spacer:  
 Thickness of one spacer ..... 036 in (0.91 mm)  
 Outside diameter ..... 812 in (20.62 mm)  
 One spacer will change pressure  
 approximately ..... 8.2 psi (57 kPa)

- (4) 5M9624 Spacers:  
 Thickness of one spacer ..... 010 in (0.25 mm)  
 Outside diameter ..... 812 in (20.62 mm)  
 One spacer will change pressure  
 approximately ..... 2.29 psi (15.8 kPa)
- (5) 6P9785 Spring (yellow stripe):  
 Length under test force ..... 767 in (19.48 mm)  
 Test force ..... 5.28 i .27 lb (23.5 + 1.2 N)  
 Free length after test ..... 1.250 in (32.00 mm)  
 Outside diameter ..... 480 in (12.19 mm)

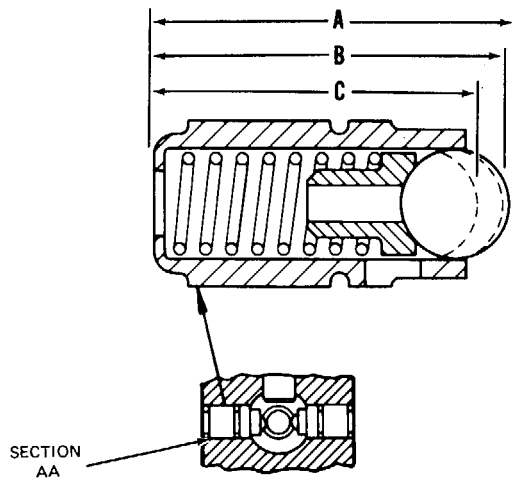
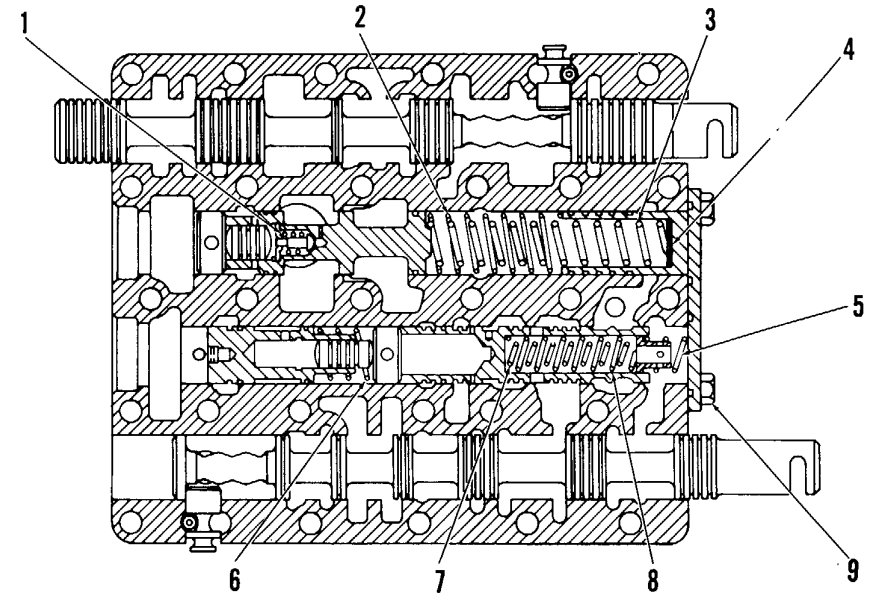


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Go on to Sheet 2

TRANSMISSION PRESSURE CONTROL VALVE SPECIFICATIONS (CONT)

- (6) 6P4978 Spring for converter inlet valve:  
 Length under test force ..... 1.069 in (27.15 mm)  
 Test force ..... 15.1 + .76 lb (67 \* 3.4 N)  
 Free length after test ..... 1.500 in (38.10 mm)  
 Outside diameter ..... .969 in (24.61 mm)
- (7) 6P9783 Spring (inner) (yellow stripe):  
 Length under test force ..... 2.220 in (56.39 mm)  
 Test force ..... 13.9 i .7 lb (62 i 3 N)  
 Free length after test ..... 3.488 in (88.60 mm)  
 Outside diameter ..... .434 in (11.02 mm)
- (8) 6P9784 Spring (outer) (yellow stripe):  
 Length under test force ..... 2.220 in (56.39 mm)  
 Test force ..... 29.3 i 1.46 lb (131 i 6.5 N)  
 Free length after test ..... 3.488 in (88.60 mm)  
 Outside diameter ..... .640 in (16.26 mm)
- (9) Torque for bolts (three)..... 22 ± 3 lb ft (30 i 4 N m)



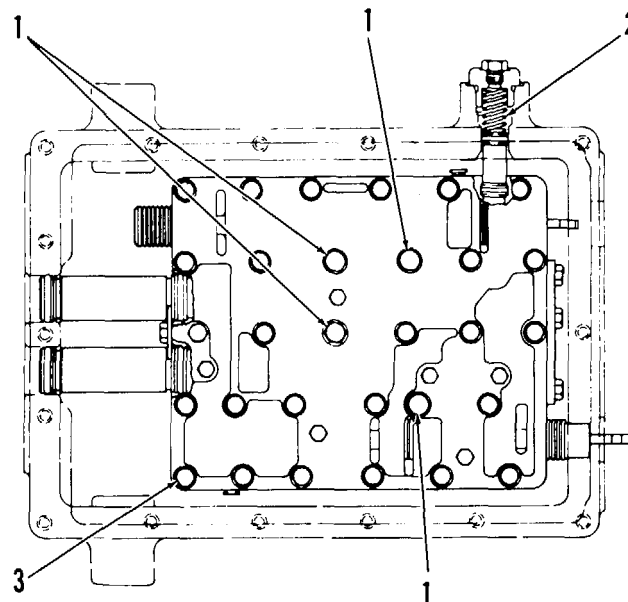
Section AA 7S4607 Detent Assembly (four):

- (A) Maximum free length ..... 1.215 in (30.86 mm)
- (B) A force of 7.2 i .7 lb..... (32 i 3 N) must hold the ball at ..... 1.180 in (29.97 mm)
- (C) A force of 10.1 i 1.0 lb..... (45 + 4 N) must hold the ball at ..... 1.090 in (27.69 mm)

TRANSMISSION HYDRAULIC CONTROLS SPECIFICATIONS

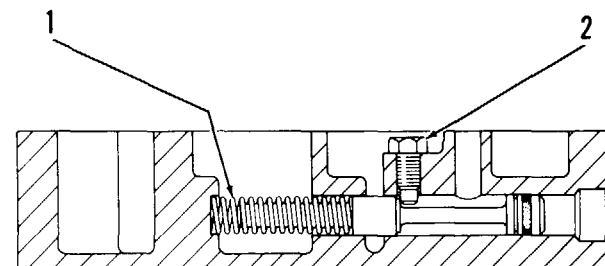
(Sheet 1 of 1)

- (1) Torque for bolts (four) .....35 + 3 lb ft (48 + 4 N m)
- (2) 4B8710 Spring:
  - Length under test force ..... 1.313 in (33.35 mm)
  - Test force ..... 30.5 to 36.5 lb (136 to 163 N)
  - Free length after test ..... 1.938 in (49.23 mm)
  - Outside diameter ..... 683 in (17.35 mm)
- (3) Torque for 26 bolts .....22 + 3 lb ft (28 + 4 N m)



TRANSMISSION NEUTRALIZER VALVE

- (1) 8P1556 Spring:
  - Length under test force ..... 2.060 in (52.32 mm)
  - Test force ..... 13.4 + 1.08 lb (60 + 4.8 N)
  - Free length after test ..... 2.960 in (75.18 mm)
  - Outside diameter ..... 516 in (13.11 mm)
- (2) Torque for bolt .....22 + 3 lb ft (28 + 4 N m)

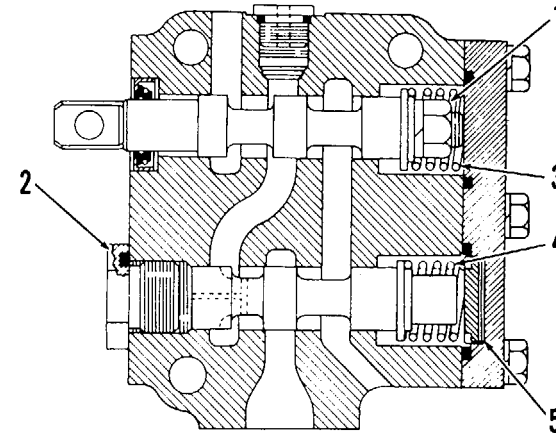


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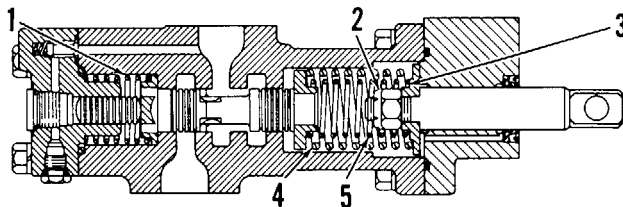
TRANSMISSION NEUTRALIZER VALVE SPECIFICATIONS

(Sheet 1 of 1)

- (1) Torque for nut.....35 + 3 lb ft (45 + 4 N m)
- (2) Torque for plug ..... 80 lb ft (110 N-m)
- (3) 4J3832 Spring:
  - Length under test force ..... 1.12 in (28.4 mm)
  - Test force .....19.4 + 1.6 lb (86 + 7 N)
  - Free length after test ..... 2.81 in (71.4 mm)
  - Outside diameter ..... 1.22 in (31.0 mm)
- (4) 4J8971 Spring for retarding valve spool:
  - Length under test force ..... 75 in (19.0 mm)
  - Test force .....60 + 4.8 lb (267 + 21 N)
  - Free length after test ..... 1.53 (38.9 mm)
  - Outside diameter ..... 1.22 in (31.0 mm)
- (5) Thickness of 5J9100 Shim ..... 005 in (0.13 mm)  
 Thickness of 7M8538 Spacer..... 036 in (0.91 mm)



BRAKE JONTROL VALVE



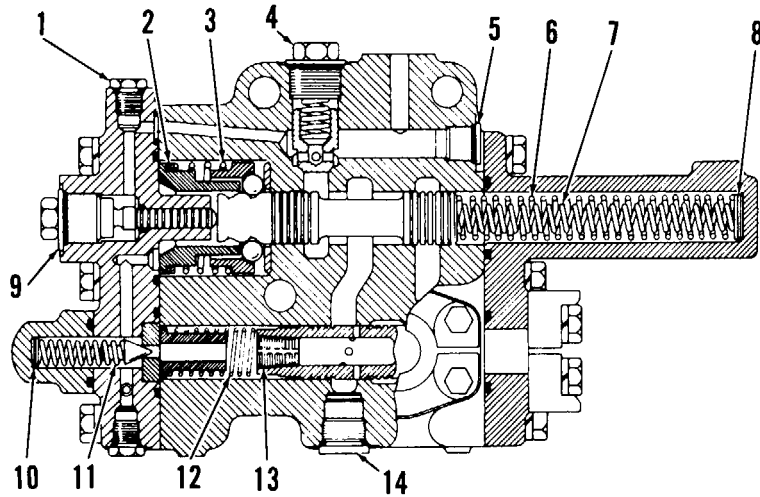
Maximum pressure with pedal fully pushed in and accumulator at full charge with engine operating at full rpm ..... 800±25 psi (5500 + 170kPa)

- (1) 4J6802 Spring:
  - Length under test force ..... 1.44 in (36.5 mm)
  - Test force .....26.5 + 2.1 lb (118 + 9 N)
  - Free length after test ..... 2.94 in (74.7 mm)
  - Outside diameter ..... 1.41 in (35.9 mm)
- (2) Torque for nut.....35 + 3 lb ft (45 ± 4 N m)
- (3) Thickness of 9J5624 Shim ..... 030 in (0.76 mm)  
 One shim will change  
 pressure ..... 13 psi (90 kPa)
- (4) 4J3303 Spring:
  - Length under test force ..... 2.0 in (50.8 mm)
  - Test force ..... 44.8 + 3.6 lb (199 ± 16 N)
  - Free length after test ..... 2.38 in (60.4 mm)
  - Outside diameter ..... 1.69 in (42.9 mm)
- (5) 4J3302 Spring:
  - Length under test force ..... 1.94 in (49.2 mm)
  - Test force ..... 32.4 lb (144 N)
  - Free length after test ..... 2.31 in (58.7 mm)
  - Outside diameter ..... 1.25 in (31.7 mm)

TA098879

ACCUMULATOR CHARGING VALVE SPECIFICATIONS

(Sheet 1 of 1)



- Open pressure of relief valve .....2700 i 50 psi (18,600 i 345 kPa)
- Cutout pressure of charging valve ..... 1950 to 2025 psi (13,400 to 13,970 kPa)
- (1) Torque for plug ..... 13 i 2 lb ft (18 + 3 N m)
- (2) Use 5J835 Shim to adjust difference between cutout to cut-in pressure of ..... 575 + 100 psi (3950 + 690 kPa)
- (3) S1850 Spring:  
 Length under test force .....2.06 in (52.3 mm)  
 Test force .....12 + lb (53 + 4 N)  
 Free length after test ..... 3.25 in (82.5 mm)  
 Outside diameter ..... 1.86 in (47.3 mm)
- (4) Torque for plug of check valve .....50 + 3 lb
- (5) Torque for plug .....25 i 3 lb ft (35 ± 4 N-m)

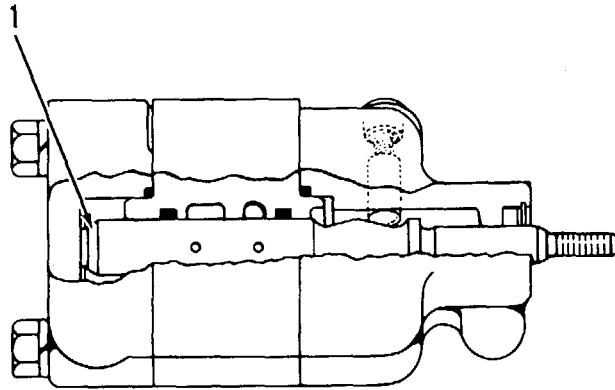
- (6) 4J6808 Spring for cutout valve (outer):  
 Length under test force 4.94 in (125.5 mm)  
 Test force 64.1 ± 5.1 lb (285 + 22 N)  
 Free length after test 7.58 in (192.5 mm)  
 Outside diameter 85 in (21.6 mm)
- (7) 4J6809 Spring for cutout valve (inner):  
 Length under test force 5.52 in (140.2 mm)  
 Test force 56.0 + 4.5 lb (250 + 20 N)  
 Free length after test 7.01 in (178.0 mm)  
 Outside diameter 58 in (14.8 mm)
- (8) Thickness of 4J6806 Shim 048 in (1.22 mm)  
 One shim will change pressure 33 psi (230 kPa)
- (9) Torque for plug 50 + 3 lb ft (70 + 4 N m)
- (10) Thickness of 3J7473 Shim 005 in (0.13 mm)  
 One shim will change pressure 40 psi (280 kPa)  
 Thickness of 3J7470 Shim 048 in (1.22 mm)  
 One shim will change pressure 380 psi (2635 kPa)
- (11) 4F115 Spring for relief valve (red stripe):  
 Length under test force 1.34 in (34.1 mm)  
 Test force 50.1 to 58.8 lb (222 to 261 N)  
 Free length after test 1.69 i .06 in (42 ± 1.5 mm)  
 Outside diameter 47 in (11.9 mm)
- (12) 8J4508 Spring for flow control valve:  
 Length under test force 1.63 in (41.4 mm)  
 Test force 15.92 i 1.28 lb (70.8 i 5.7 N)  
 Free length after test 3.61 in (91.7 mm)  
 Outside diameter 81 in (20.6 mm)
- (13) Torque for orifice plug (thread lock compound on threads) 20 \_ 2 lb ft (25 i 3 N-m)
- (14) Torque for plug 42 + 3 lb ft (58 + 4 N-m)

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PARKING BRAKE CONTROL VALVE SPECIFICATIONS

(Sheet 1 of 1)

(1) Torque for plug in stem ..... $9 \pm 2$  lb. ft. ( $12 \pm 3$  N m)

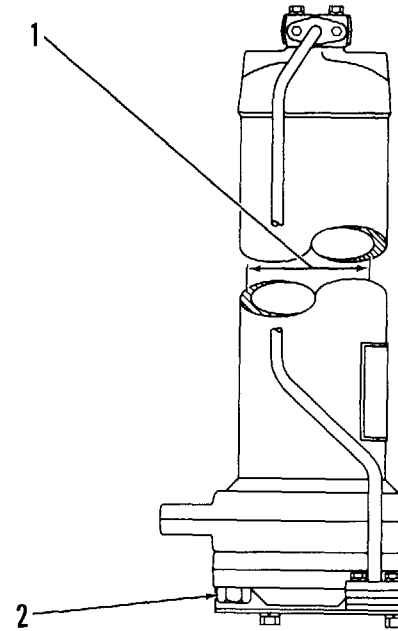


ACCUMULATOR

Pressure of Nitrogen .....800 psi (5500 kPa)

(1) Bore of new cylinder .....  $5.000 + .005$  or  $-.002$  in.  
( $127.00 + 0.13$  or  $-0.05$  mm)

(2) Torque for six bolts .....  $700 \pm 25$  lb. ft. ( $950 \pm 35$  N m)



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EMERGENCY AND PARKING BRAKE SPECIFICATIONS

- (1) Torque for bolt ..... 100 + 10 lb. ft. (135 \* 14 N m)
- (2) Thickness of three new plates and four new discs ..... 1.509 to 1.551 in. (38.33 to 39.40 mm)

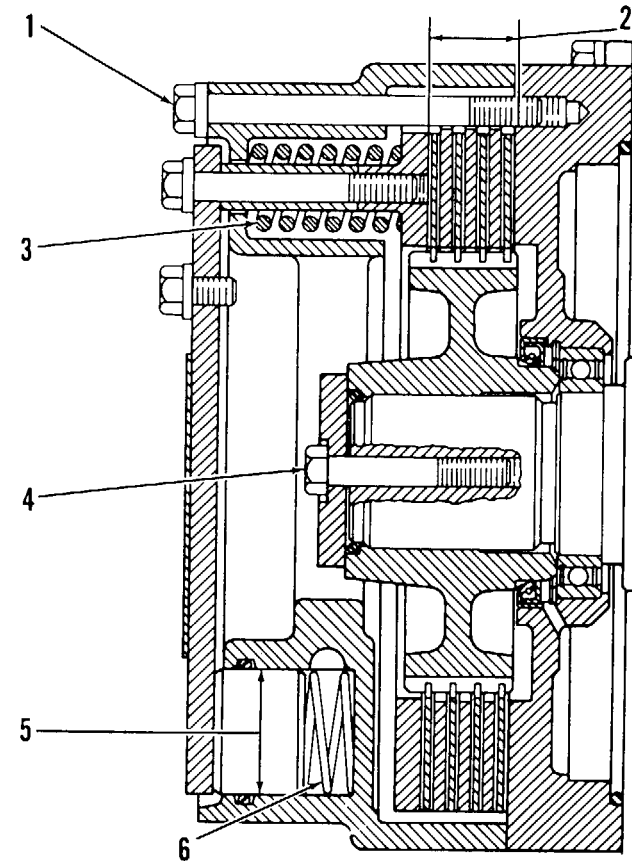
Minimum permissible thickness of three used plates and four used discs ..... 1.394 in. (35. 41 mm)

- (3) 7S3997 Spring for activating brakes:
  - Length under test force ..... 2.730 in. (69.34 mm)
  - Test force ..... 875 ± 70 lb. (3894 + 311 N)
  - Free length after test ..... 3.258 in. (82.75 mm)
  - Outside diameter ..... 1.688 in. (42.88 mm)

- (4) Torque for bolt ..... 85 + 5 lb. ft. (115 ± 7 N-m)
- (5) Bore in housing for release piston ..... 2.2505 + .0005 in. (57.163 ± 0.013 mm)

Outside diameter of release piston ..... 2.2480 ± .0005 (57.0992 \* 0.013 mm)

- (6) 7S3999 Spring for brake release piston:
  - Length under test force ..... .66 in. (16.8 mm)
  - Test force ..... 27.2 + 22. lb. (121 ± 10 N)
  - Free length after test force ..... 1.159 in. (29.44 mm)
  - Outside diameter ..... 2.197 in. (55.80 mm)



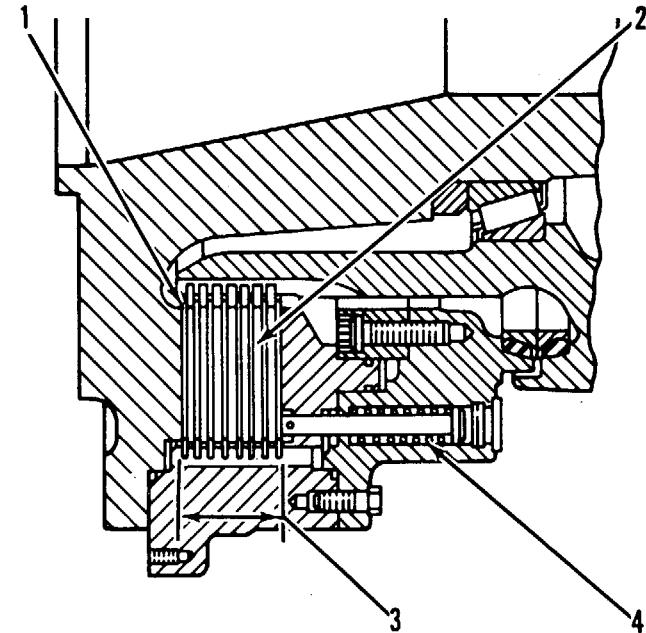
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WHEEL BRAKE SPECIFICATIONS

NOTE

Because of the wear characteristic on the outside faces of the two outside 7D7504 Plates, they must be installed in exactly the same position as they were before assembly. Put oil on plates and discs at assembly.

- (1) 7D7504 Plate thickness:
  - New .....0950 + .0025 in. (2.413 + 0.064 mm)
  - Minimum worn .....090 in. (2.29 mm)
- (2) 5D6329 Disc thickness:
  - New .....200 + .005 in. (5.08 + 0.13 mm)
  - Minimum worn .....180 in. (4.57 mm)
- (3) 7 discs and 8 plates  
(all new) .....2.160 ± .055 in. (54.86 + 140 mm)
  - Minimum thickness  
(worn plates and discs) ..... 1.98 in. (50.3 mm)
- (4) 6M8252 Spring, piston return:
  - Length under test force .....2.50 in. (63.5 mm)
  - Test force ..... 83.7 + 4.18 lb. (371 ± 18 N)
  - Free length after test .....2.81 in. (71.4 mm)
  - Outside diameter .....776 in. (19.71 mm)



NOTE

To get the minimum permissible thickness, measure the thickness of each plate and disc, then add all of these measurements. When a disc is checked for thickness, measure the depth of each groove in the disc. The depth of a groove must be more than .018 in. (0.46 mm).

TA098883

CHAPTER 3

ENGINE MAINTENANCE INSTRUCTIONS

	Page		Page
Section I	Engine Removal/installation ..... 3-2	Section VII	Rocker Shaft Components ..... 3-206
	Engine Maintenance Instructions ..... 3-2		
Section II	Fuel System Maintenance ..... 3-26	Section VIII	Cylinder Heads ..... 3-216
	Fuel System Components ..... 3-26		Cylinder Liner ..... 3-239
	Fuel System Maintenance Instructions ..... 3-28		Spacer Plates ..... 3-246
Section III	Air Inlet and Exhaust System ..... 3-106	Section IX	Valve Components ..... 3-254
	General ..... 3-106		Valve Seat Inserts ..... 3-260
	Turbocharger ..... 3-107		Valve Guides ..... 3-262
			Push Rods and Valve Lifters ..... 3-264
			Valve Clearance Setting ..... 3-268
Section IV	Engine Lubrication System ..... 3-133	Section X	Camshaft ..... 3-272
	General ..... 3-133		Camshaft Bearings ..... 3-280
	Oil Filter Support, Adapter, and Flanges ..... 3-136	Section XI	Timing Gears and Accessory Drive Gears ..... 3-287
	Oil Pan ..... 3-140		
	Oil Pump ..... 3-143	Section XII	Flywheel ..... 3-308
Section V	Cooling System ..... 3-151	Section XIII	Crankshaft and Main Bearings ..... 3-320
	General ..... 3-151		
	Engine Oil Cooler ..... 3-152	Section XIV	Piston Assembly ..... 3-349
	Radiator ..... 3-155		Piston and Connecting Rods ..... 3-350
	Radiator and Shroud ..... 3-162		Finding Top Center Position ..... 3-371
	Water Pump ..... 3-168		
Section VI	Engine Electrical System ..... 3-175		
	Alternator ..... 3-175		
	Starting Motor ..... 3-175		

**Section I. ENGINE REMOVAL/INSTALLATION**

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ENGINE MAINTENANCE INSTRUCTIONS

---

This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Engine front support and trunnion removal/installation
- b. Engine removal
- c. Engine installation

---

LIST OF TASKS

---

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Engine front support and trunnion removal/ installation	3-3	2-13
2	Engine removal	3-6	none
3	Engine installation	3-17	none

ENGINE FRONT SUPPORT AND TRUNNION REMOVAL/INSTALLATION

(Sheet 1 of 3)

This task covers: Removal and installation of engine front support and trunnion.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

Page 2-13

Special Tools

Hydraulic jack

Support beam

Personnel Required

One mechanic

Equipment Condition

Engine OFF and cooled.

Oil drained.

Crankcase guard removed.

Vibration damper and pulley removed.

References

Pulley and Vibration Damper  
Removal and Installation,  
TM 10-3930-641-20

Crankcase Guard Removal,  
TM 10-3930-641-20

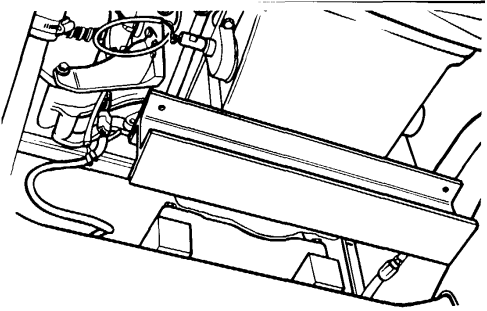
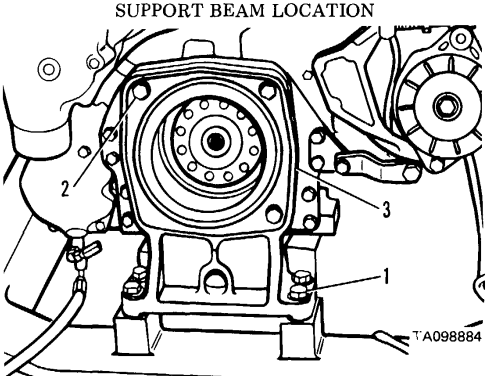
Torque Limits Chart, page D-1

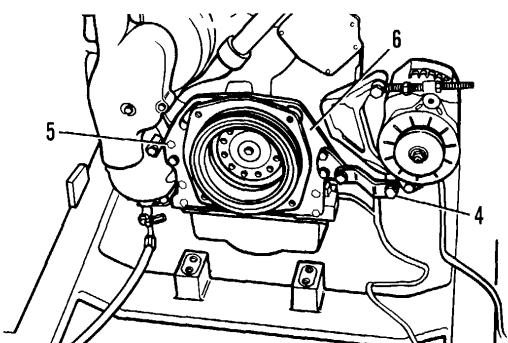
LO 10-3930-641-12

General Safety Instructions

Use extreme caution in installing jacking device.  
Do not let jack, beam, or engine slip. Serious  
injury could result.

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">REMOVAL</div>		
1. Oil pan	Remove four capscrews so beam may be installed.	
	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">WARNING</div>	
2. Support beam and four capscrews	Use extreme caution when installing jacking device. Do not let jack, beam, or engine slip. Serious injury could result.	
3. Capscrews (1)	a. Install beam under oil pan.	
	b. Place hydraulic jack under center of beam. Do not lift yet.	
	a. Loosen four at frame.	
	b. Using hydraulic jack, raise engine until support (3) is free of frame.	TA098884 Go on to Sheet 3
	c. Remove capscrews (1).	
4. Capscrews (2)	Remove.	
5. Engine support (3)	Remove	

LOCATION/ITEM	ACTION	REMARKS
6. Capscrew (4)	Loosen at alternator support bracket.	 <p style="text-align: right; font-size: small;">TA098885</p>
7. Capscrews (5)	Remove eight which hold trunnion to timing gear cover.	
8. Trunnion (6)	Remove.	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">INSTALLATION</div>		
1. Trunnion (6)	Position on timing gear cover	
2. Capscrews (5)	Install and tighten.	See Torque Limits Chart, page D-1.
3. Capscrew (4)	Tighten.	See Torque Limits Chart, page D-1.
4. Engine support (3).	Position on trunnion	
5. Capscrews (2)	Install and tighten.	See Torque Limits Chart, page D-1.
6. Capscrews (1)	a. Install. Do NOT tighten b. Lower engine. c. Tighten capscrews.	See Torque Limits Chart, page D-1.
7. Support beam and jacks.	Remove hydraulic jack and support beam	
8. Capscrews	Install four removed from oil pan and tighten.	See Torque Limits Chart, page D-1.

END

ENGINE REMOVAL

(Sheet 1 of 11)

This task covers: Removal of engine.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

None

Equipment Condition

Battery disconnected.  
Coolant drained.  
Hydraulic oil drained.  
Engine oil drained.  
Transmission oil drained.  
Hoods removed.  
Muffler removed.  
Crankcase guards removed.

Special Tools

Hoist  
Hoist chains  
Lifting beam  
Ratchet puller

Personnel Required

Five mechanics

References

Maintenance of the battery, TM 10-3930-641-20  
Maintenance of the cooling system,  
TM 10-3930-641-20  
Maintenance of the hydraulic lift components,  
TM 10-3930-641-20  
Maintenance of the engine, TM 10-3930-641-20  
Maintenance of the transmission,  
TM 10-3930-641-20  
Maintenance of the body, cab and hull,  
TM 10-3930641-20  
Maintenance of the exhaust system,  
TM 10-3930-641-20  
Crankcase guard removal, TM 10-3930-641-20  
LO 10-3930-641-12

General Safety Instructions

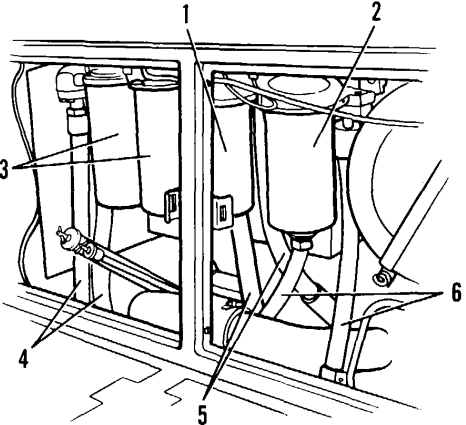
Use a suitable lifting hoist and chains when removing engine. Weight of engine is 5,500 lb. (2495 Kg.).

Be sure wheels of vehicle are blocked before removing engine.

Go on to Sheet 2

ENGINE FRONT SUPPORT AND TRUNNION REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
1. Battery	<p style="text-align: center;">NOTE</p> <p>Tag all hoses, tubes, harnesses and cables before disconnecting.</p> <p>a. Tag cables.</p> <p>b. Disconnect cables.</p>	See TM 10-3930-641-20.
2. Coolant	Drain.	See TM 10-3930-641-20.
3. Hydraulic oil	Drain.	See TM 10-3930-641-20.
4. Engine oil	Drain.	See TM 10-3930-641-20.
5. Transmission oil	Drain.	See TM 10-3930-641-20.
6. Hoods	<p style="text-align: center;">NOTE</p> <p>Radiator and guard do not have to be removed. If suitable lift is available, the engine and torque converter can be lifted straight out of top of machine.</p> <p>Remove.</p>	See TM 10-3930-641-20.
Go on to Sheet 3		

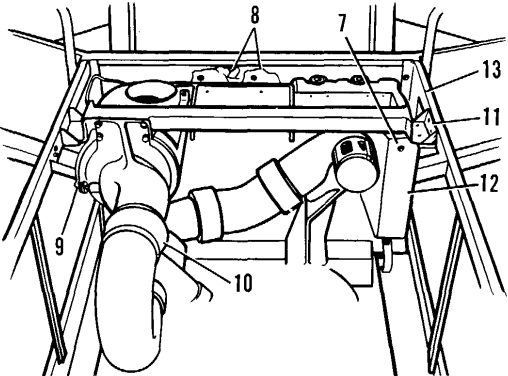
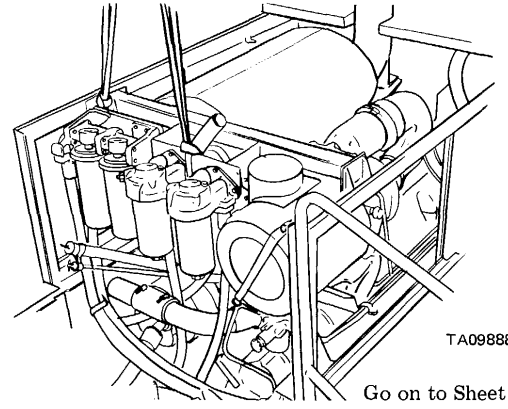
LOCATION/ITEM	ACTION	REMARKS
7. Muffler	Remove.	See TM 10-3930-641-20.
8. Crankcase guards	Remove.	See TM 10-3930-641-20.
9. Radiator and guard	Remove.	See page 3-162.
10. Engine side access panels	Remove.	See TM 10-3930-641-20.
11. Engine oil filter (3), transmission oil filter (1), hydraulic oil filter (2)	Remove.	
12. Hose assemblies (4), (5) and (6)	Tag and disconnect from filter bases and cap.	
13. Wire assemblies (8)	Tag and disconnect from transmission and hydraulic bases and tag.	
14. Wire assembly (9)	Tag and disconnect from air cleaner sending unit and tag.	

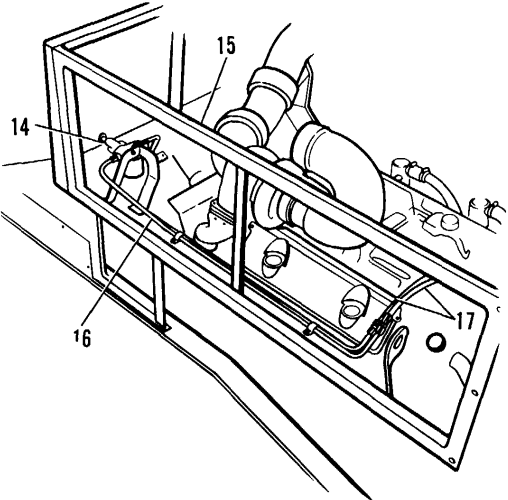
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Go on to Sheet 4

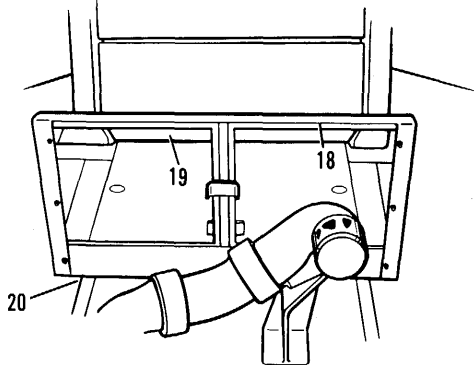
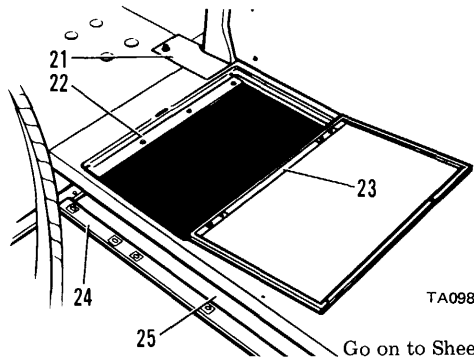
ENGINE FRONT SUPPORT AND TRUNNION REMOVAL/INSTALLATION (CONT)

(Sheet 4 of 11)

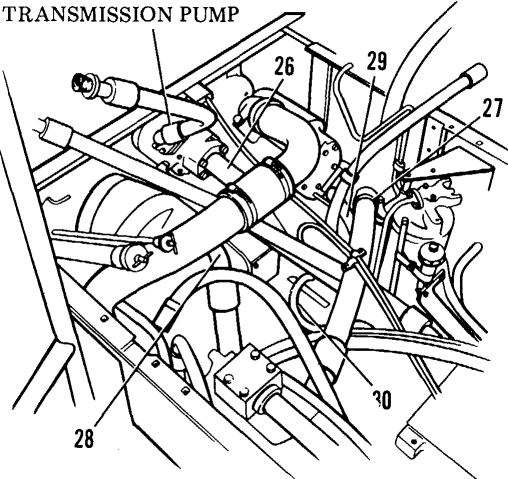
LOCATION/ITEM	ACTION	REMARKS
15. Air cleaner elbow clamps (10)	Loosen.	
16. Air cleaner precleaner	Remove.	
17. Hoist	Attach.	
18. Filter base support bolts (11) and (7)	Remove three each side from frame assemblies.	
19. Filter bases and air cleaner	Using hoist, remove as a unit (180 lb. - 82 Kg.) and set on blocking.	
20. Wires to ether starting aid	a. Tag and disconnect. b. Remove clips securing harness to frame (13).	
21. Ether tube	Disconnect at engine. (See TM 10-3930-641-20.)	TA098888 Go on to Sheet 5
22. Ether starting aid bracket	Remove.	
23. Shield (12)	Remove.	
24. Frame (13)	a. Fasten hoist to frame assembly (55 lb.-25 Kg.) b. Remove six capscrews. c. Remove frame and set on ground.	
Go on to Sheet 5		

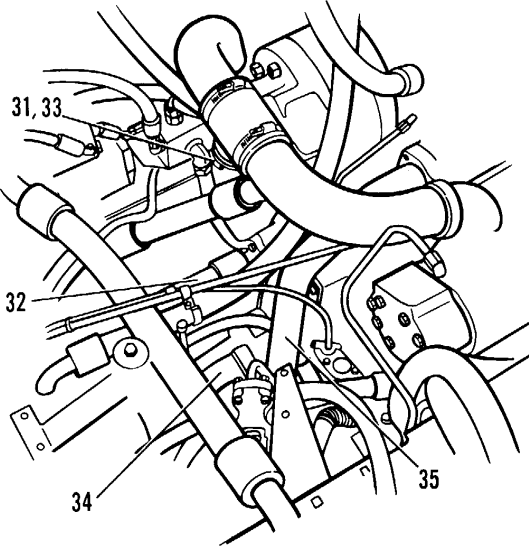
LOCATION/ITEM	ACTION	REMARKS
25. Fuel lines (14) and (16)	a. Disconnect from fuel filter. b. Cap or plug.	 <p style="text-align: right;">TA098889</p>
26. Fuel lines (17)	a. Disconnect from fuel filter hose assemblies. b. Cap or plug.	
27. Frame assembly (15) with filter assembly attached	a. Fasten hoist to frame. b. Remove five capscrews. c. Lift frame assembly (55 lb. - 25 Kg.) with hoist and set on ground.	

Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
28. Wiring harness (18)	a. Disconnect from main wiring harness. b. Tag.	
29. Capscrews at base of door assembly (19)	Remove from engine oil line and transmission clips.	
30. Door assembly (19)	a. Fasten hoist to door assembly. b. Remove five capscrews (20). c. Lift door assembly with hoist and set on ground	
31. Floor plates (21)	Remove from each side.	
32. Governor control and torque converter control cable clips on access door frame (23)	Remove capscrews and nuts (25).	TA098890 Go on to Sheet 7

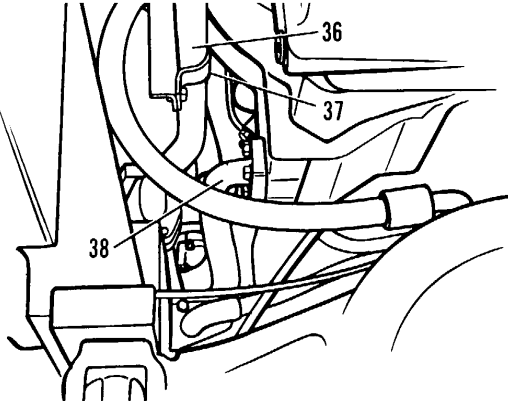
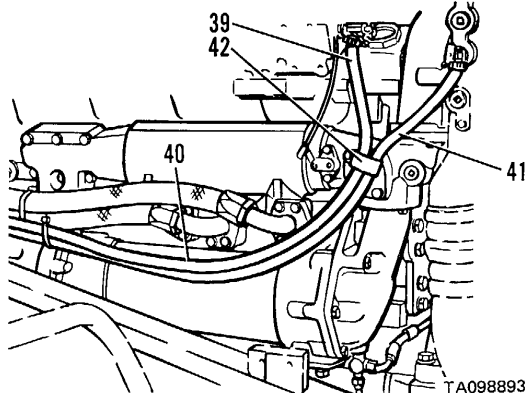
Go on to Sheet 7

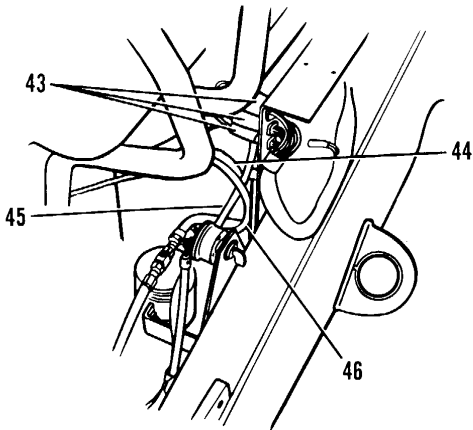
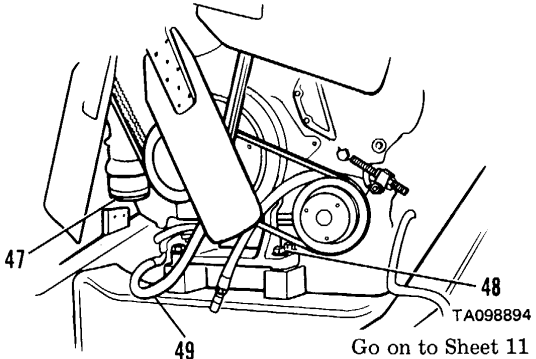
LOCATION/ITEM	ACTION	REMARKS
33. Clip on front of access door (23)	Remove.	 <p>TRANSMISSION PUMP</p> <p>TA098891</p>
34. Access door frame (23)	a. Remove bolts (22) from each side. b. Use hoist to remove door assembly (23) (160 lb. - 73 Kg).	
35. Support (24)	Remove capscrews and support.	
36. Transmission pump	a. Disconnect tube assembly (26) by loosening clamp at lower end. b. Cap or plug openings.	
37. Steering and brake hydraulic pump.	a. Disconnect hose assemblies (27) and (29). b. Cap or plug openings.	
38. Implement pump	a. Disconnect hose assembly (28). b. Cap or plug openings.	
	Go on to Sheet 8	

LOCATION/ITEM	ACTION	REMARKS
39. Torque converter control valve	a. Disconnect hose assembly (30). b. Cap or plug openings.	
40. Transmission oil line (35)	Remove capscrew and clip from torque converter control valve.	
41. Hose assembly (32)	a. Disconnect from transmission. b. Cap or plug opening.	
42. Hydraulic supply line to implement pump	Loosen two hose clamps (31) and (33).	
43. Drive shaft (34)	Disconnect from torque converter.	
44. Governor control cable	a. Disconnect from governor. b. Remove nuts holding cable to engine bracket. c. Pull cable to transmission.	

TA098892

Go on to Sheet 9

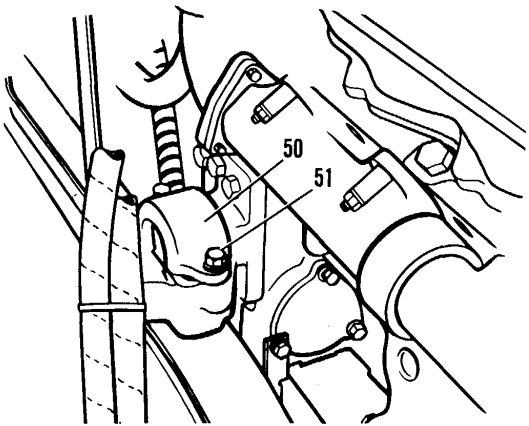
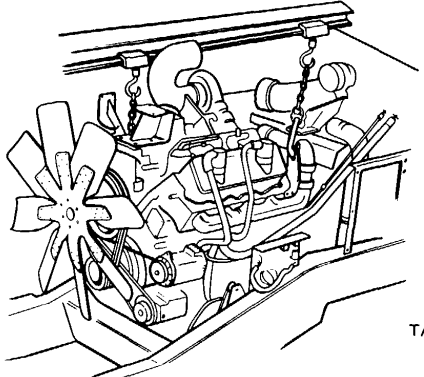
LOCATION/ITEM	ACTION	REMARKS
45. Drain hose	Remove from engine oil pan.	
46. Torque converter	a. Disconnect hose assembly (38). b. Cap or plug openings. <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 10px auto;">NOTE</div> Have container ready to catch coolant when lines are disconnected.	
47. Transmission oil cooler lines	a. Disconnect two lines (36) from oil cooler. b. Remove two capscrews and clamp (37). c. Disconnect bottom line from torque converter and remove. d. Cap or plug openings. <div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 10px auto;">NOTE</div> Have container ready to catch coolant when lines are disconnected.	
48. Heater hoses (39) and (41).	a. Disconnect from engine and cap. b. Remove capscrew from clip (42) holding heater hose to engine.	TA098893 Go on to Sheet 10
49. Engine oil cooler	a. Disconnect two hose assemblies (40). b. Cap or plug openings. Go on to Sheet 10	

LOCATION/ITEM	ACTION	REMARKS
50. Wiring harness (43)	Disconnect and tag.	
51. Battery wires (45) and (46) and ground wire (44).	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">NOTE</div> <p>Steps 50 thru 52 have already been performed if radiator was removed.</p>	
52. Bottom radiator tube assembly	Disconnect from starting motor and tag.	
53. Bottom radiator tube assembly	<p>a. Disconnect hose assembly (49).</p> <p>b. Cap or plug openings.</p>	
54. Mounting bolts (48)	Loosen clamp on water pump hose (47) and remove assembly.	
54. Mounting bolts (48)	Remove.	

Go on to Sheet 11

TA098894

Go on to Sheet 11

LOCATION/ITEM	ACTION	REMARKS
55. Mounting capscrews (51) and caps (50)	Remove from each side of engine. (Two on front, four on rear.)	
56. Engine shield plate	Remove to allow hoist attachment.	
57. Engine and torque converter	<div style="border: 1px solid black; padding: 5px; display: inline-block;">WARNING</div>	
	<p>Do not put an overload on ratchet puller when engine and torque converter are being removed.</p> <p>a. Fasten hoist securely to lifting eyes as shown at right.</p> <p>b. Use ratchet puller to make converter and engine level as shown.</p> <p>c. Remove engine and converter from chassis.</p>	
	<p>NOTE</p> <p>Engine and converter weight is 5,500 lb. (2495 Kg.)</p>	
	<p>d. Place engine on suitable stand.</p> <p style="text-align: center;">NOTE</p> <p>Attach hoist to beam so that chain at front of engine (fan end) is farther out on beam than chain at rear end. Usually a difference of two hole positions is correct.</p>	

TA098895

End

ENGINE INSTALLATION

(Sheet 1 of 9)

This task covers: Installation of the engine.

INITIAL SETUP

Test Equipment

None

Special Tools

Hoist  
 Hoist chains  
 Lifting beam  
 Ratchet puller

Materials/Parts

None

Personnel Required

Five mechanics

References

LO 10-3930-641-12  
 Fan removal/installation,  
 TM 10-3930-641-20  
 Engine removal, page 3-6

Troubleshooting Reference

None

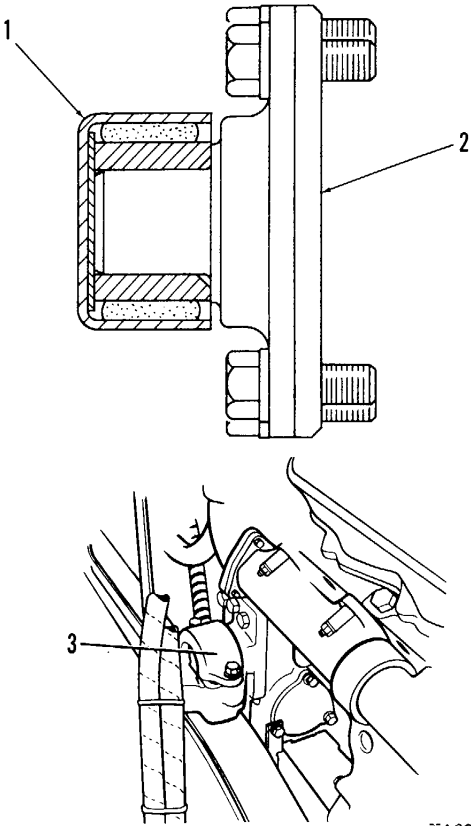
Equipment Condition

Fan removed from engine.  
 Engine may be installed while radiator is either removed or installed in vehicle.

General Safety Instructions

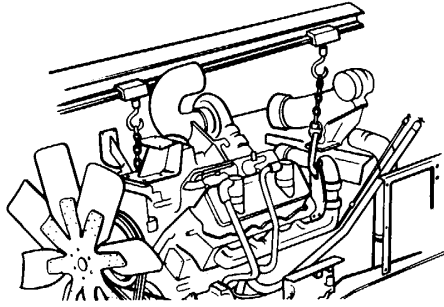



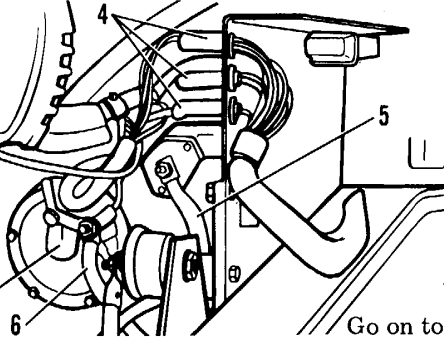
Use a suitable lifting hoist and chains when installing engine. Weight of engine is 5,500 lb. (2495 Kg). Be sure wheels of vehicle are blocked before installing engine.

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<p>1. Rear engine supports (change if necessary)</p>	<p>a. Remove mount assembly (1) from support (2).</p> <p>b. Install new mount assembly (1) on support (2) until inner cup is tight against shoulder of pin.</p> <p>c. Make sure support (2) is installed with as little space as possible between mount assemblies and rear face of cylinder block.</p> <p style="text-align: center;">NOTE</p> <p>Make sure hydraulic supply line and hydraulic pumps are aligned before lowering engine to its mounts.</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;"> <p style="text-align: center; margin: 0;">WARNING</p> </div> <p>Do not put an overload on ratchet puller when engine and torque converter are being moved.</p>	 <p style="text-align: right; font-size: small;">TA098396 Go on to Sheet 3</p>

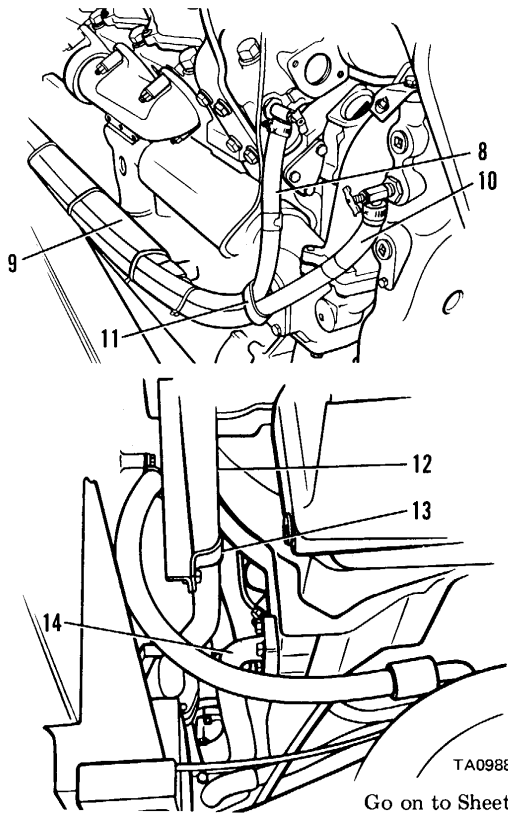
ENGINE FRONT SUPPORT AND TRUNNION REMOVAL/INSTALLATION (CONT)

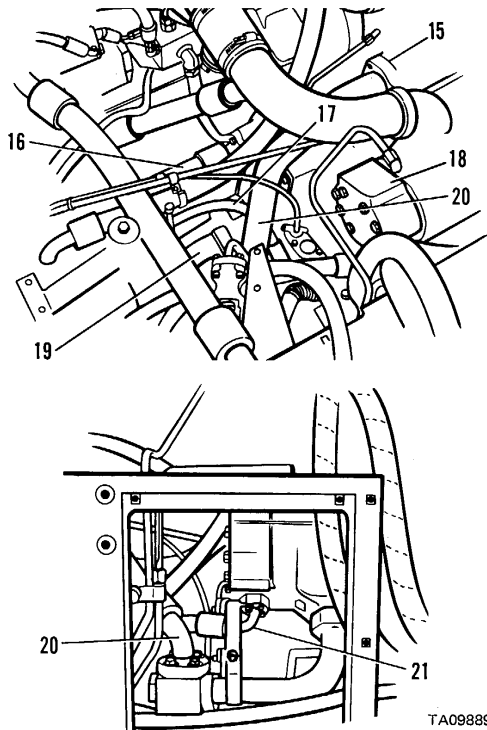
(Sheet 3 of 9)

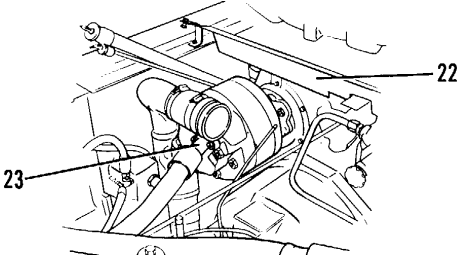
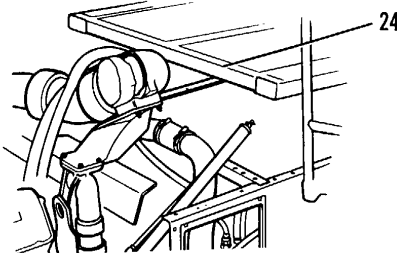
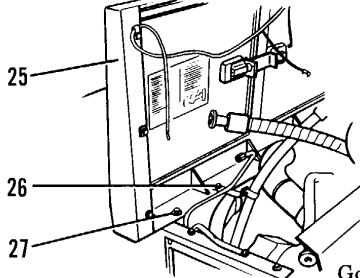
LOCATION/ITEM	ACTION	REMARKS
<p>2. Engine, torque converter</p>	<p>a. Fasten hoist to engine lifting eyes.</p> <p>b. Lower torque converter and engine into position</p> <p style="text-align: center;">NOTE</p> <p>Position engine in rear engine supports first.</p>	
<p>3. Frame capscrews</p>	<p>Install four capscrews at front of engine to frame.</p>	
<p>4. Caps and bolts</p>	<p>Install caps (3) and capscrews on each side of engine on rear engine supports.</p>	
<p>5. Wiring harness groups (4)</p>	<p>Connect to plugs on back of relay panel.</p>	
<p>6. Frame ground wire and battery cables (5) and (6)</p>	<p>Connect to starter (7).</p> <p style="text-align: center;">NOTE</p> <p>Make sure caps and plugs are removed from hoses and openings before hoses are reconnected.</p>	 <p style="text-align: right;">TA098897 Go on to Sheet 4</p>

ENGINE FRONT SUPPORT AND TRUNNION REMOVAL/INSTALLATION (CONT)

(Sheet 4 of 9)

LOCATION/ITEM	ACTION	REMARKS
7. Transmission oil cooler	Connect tube assembly (12).	 <p>TA098898</p> <p>Go on to Sheet 5</p>
8. Transmission oil cooler lines clamp (13).	Install.	
9. Engine oil cooler	Connect two hose assemblies (9). Secure clamp to bracket.	
10. Heater hoses (8) (10)	Connect to engine.	
11. Heater hose clip (11)	Secure to engine with capscrew.	
12. Drive shaft (19)	Connect to torque converter. Tighten capscrews to a torque of 90-110 lb. ft. (122-150 N-m).	
13. Torque converter	Connect hose assembly (14).	
14. Oil pan drain hose	Install.	
15. Hoist	Disconnect and remove.	
16. Hydraulic supply line clamps	Tighten.	

LOCATION/ITEM	ACTION	REMARKS
17. Transmission oil pump (15)	Connect tube assembly (20) and install cap-screw and clip that secures tube to torque converter.	 <p>TA098899</p> <p>Go on to Sheet 6</p>
18. Torque converter control valve	Connect hose assembly (17).	
19. Transmission hose assembly (16).	Connect.	
20. Accumulator valve hose assembly (21)	Connect to brake and steering hydraulic pump (18).	
21. Steering control valve hose assembly (20)	Connect to tube assembly on brake and steering hydraulic pump.	
22. Governor control cable	<p>a. Connect cable to governor.</p> <p>b. Tighten capscrews to hold cable to engine bracket.</p>	

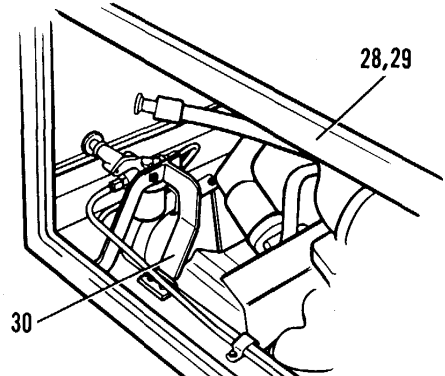
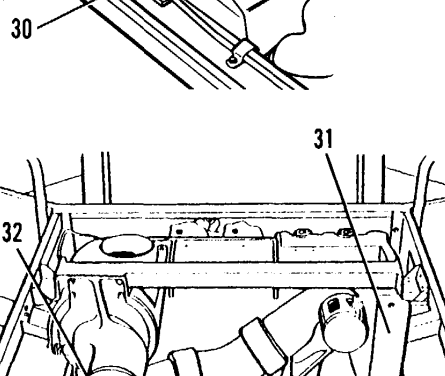
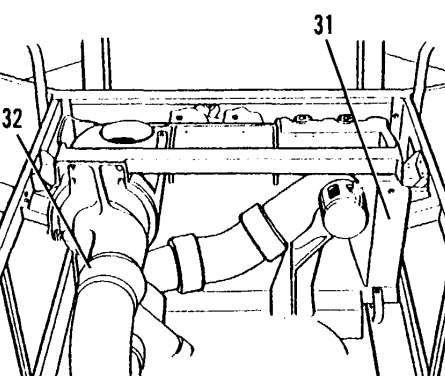
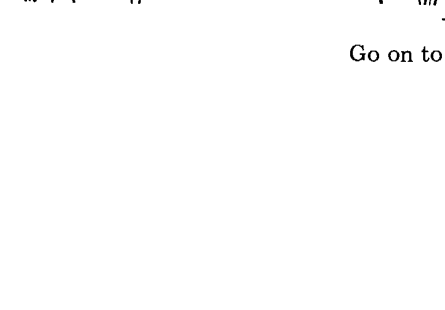
LOCATION/ITEM	ACTION	REMARKS
23. Implement pump	Connect hose assembly (23).	
24. Support (22)	Install with four capscrews and washers.	
25. Access door assembly (24)	a. Put into position. b. Secure with the eight capscrews.	
26. Governor and torque converter control cable	Fasten to access door assembly.	
27. Floor plates	Install on each side of cab.	
28. Door assembly (25)	a. Fasten hoist to assembly. b. Put into position on support. c. Secure with capscrews (27). d. Remove hoist.	
29. Engine oil lines and transmission oil filter line	Secure to bracket with capscrews (26).	
		

TA098900

Go on to Sheet 7

**ENGINE INSTALLATION (CONT)**

(Sheet 7 of 9)

LOCATION/ITEM	ACTION	REMARKS
30. Frame assemblies (28) and (29)	a. Fasten hoist to frame. b. Install frame. c. Remove hoist.	
31. Fuel injection pump lines and fuel lines	Connect to fuel lines on frame assembly (28).	
32. Fuel priming pump and bracket (30)	Install and connect fuel lines to pump.	
33. Shield (31)	Install with two capscrews and bracket on right side.	
34. Filter base and air cleaner support	Install base and support. Remove hoist.	
35. Shield	Secure to filter base support with three capscrews.	
36. Air filter hose (32)	Position hose and tighten hose clamps.	
		

TA098901

Go on to Sheet 8

**ENGINE INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
37. Filter bases and hose assemblies (37), (38) and (39)	Connect.	
38. Engine oil filters (36), transmission oil filter (34), hydraulic oil filter (3)	Install. See TM 10-3930-641-20.	
39. Wiring harness (33)	Connect to filter bases, air cleaner sensor and main wiring harness. See TM 10-3930-641-20.	
40. Engine side access covers and panel	Install.	
41. Radiator and guard	Install. See page 3-162.	
42. Fan assembly	Install. See TM 10-3930-641-20.	
43. Fan guards	Install. See TM 10-3930-641-20.	
44. Muffler	Install. See TM 10-3930-641-20.	
45. Hoods	Install. See TM 10-3930-641-20.	
46. Crankcase guards	Install. See TM 10-3930-641-20	

**ENGINE INSTALLATION (CONT)**

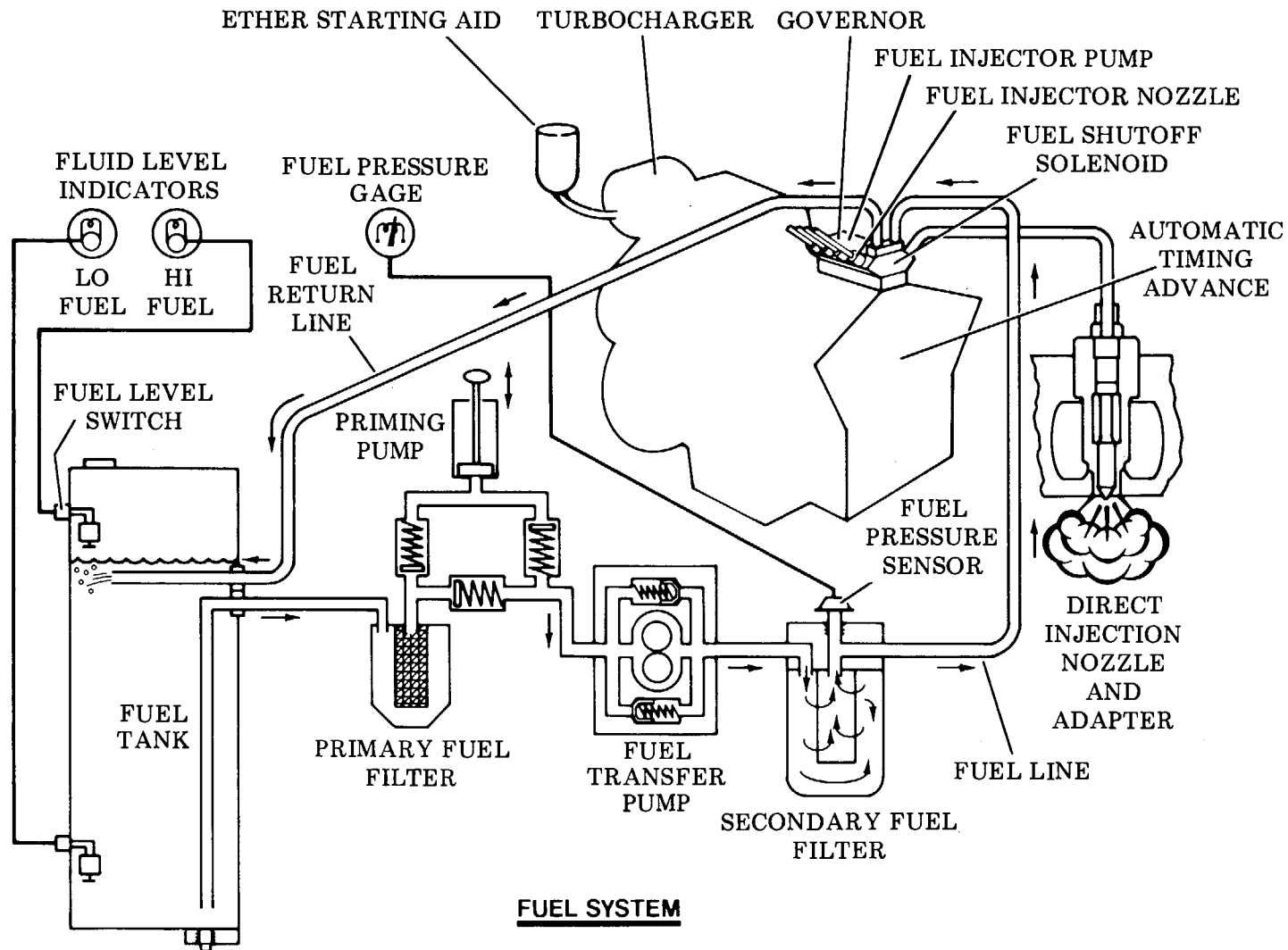
LOCATION/ITEM	ACTION	REMARKS
47. Coolant	Fill to correct level.	See TM 10-3930-641-20.
48. Hydraulic oil	Fill to correct level.	See TM 10-3930-641-20.
49. Engine oil	Fill to correct level.	See TM 10-3930-641-20.
50. Transmission oil	Fill to correct level.	See TM 10-3930-641-20.
51. Battery	Connect battery cables to terminals.	See TM 10-3930-641-20.

## Section II. FUEL SYSTEM MAINTENANCE

**FUEL SYSTEM COMPONENTS**

(Sheet 1 of 2)

1. **FUEL TANK.** Located next to the cab on the left side of the vehicle. The capacity of the tank is 165 gal. (625 liters). The tank has a drain valve at the bottom and a filler screen and cap at the top. Fuel level is monitored with two indicator lights in the operator's compartment.
2. **FUEL LINES.** Carry fuel from the tank to various components of the fuel system and provide return routes for unused fuel.
3. **PRIMARY FUEL FILTER.** Filters all fuel from the fuel tank before it enters the fuel transfer pump. The filter may be disassembled and the element can be cleaned. The fuel filter is found behind the access door behind the operator's compartment.
4. **PRIMING PUMP.** A hand operated pump located in the primary fuel filter base. It is used to eliminate air in the fuel system. After a fuel system component has been replaced it will be necessary to pump the air from the system.
5. **TRANSFER PUMP.** Draws fuel from the fuel tank through the primary fuel filter, then pumps fuel through the secondary fuel filter into the fuel injector pump. The pump is gear driven and located on top of the engine.
6. **SECONDARY FUEL FILTER.** Located under the left access panel, this is the final filter before the fuel reaches the injector pump. It is to be thrown away and replaced when necessary.
7. **FUEL PRESSURE GAGE.** A gage in the operator's compartment which monitors the fuel pressure on the output side of the secondary fuel filter.
8. **FUEL SHUTOFF SOLENOID.** Electrically operated solenoid fastened to the fuel injector pump. Depressing the ENGINE STOP switch in the operator's compartment electrically activates the solenoid restricting the fuel passage and stops the engine.
9. **INJECTION PUMP.** A camshaft gear driven pump which provides each injection nozzle with a metered amount of high pressured fuel at a precise time. Located on top of the engine, the pump housing has a V shape with four pumps on each side.
10. **AUTOMATIC TIMING ADVANCE.** A system of weights, springs and slides built into the gear which drives the fuel injection pump. Centrifical force changing the location of these movable parts, also advances or retards the gear position. Since this gear drives the pump the fuel injection timing is also advanced or retarded.
11. **INJECTION NOZZLES.** The high pressured fuel from the injection pump is sent through the injection nozzle. The nozzle changes the fuel to the correct characteristic (spray pattern) for good combustion. One is located in each cylinder.
12. **GOVERNOR.** Located above the fuel injection pump the governor is controlled by the accelerator pedal. Centrifical force changes the position of a set of weights. Depending on the position of the accelerator pedal and the load of the engine these weights will change the supply of fuel to the engine.
13. **ETHER STARTING AID.** Delivers a measured amount of ether into the turbocharger outlet for ease in cold weather starting. The ether is stored under pressure in a cylinder and the amount to be sprayed into the outlet is controlled by a valve electrically activated from the instrument panel.



**FUEL SYSTEM**

FUEL SYSTEM MAINTENANCE INSTRUCTIONS

This section covers maintenance of these fuel system components for direct support maintenance personnel:

- a. Fuel injection nozzles.
- b. Fuel injection pump
- c. Fuel injection pump housing
- d. Fuel transfer pump
- e. Governor

LIST OF TASKS

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Fuel injection nozzles removal/installation.	3-29	2-10, 2-13, 2-16
2	Fuel injection pump removal/installation.	3-32	2-11, 2-17
3	Fuel injection pump disassembly/assembly.	3-36	2-13, 2-17
4	Fuel injection pump housing removal/installation.	3-41	2-13, 2-17
5	Fuel injection pump housing disassembly/assembly.	3-47	2-13, 2-17
6	Fuel transfer pump disassembly/assembly.	3-58	2-9, 2-10, 2-11
7	Fuel shutoff solenoid removal/installation.	3-64	TM 10-3930-641-20
8	Fuel ratio control removal/installation.	3-67	2-9, 2-16
9	Fuel ratio control disassembly/assembly.	3-70	2-9, 2-16
10	Fuel ratio control adjustment.	3-75	2-9, 2-13,2-16,2-20
11	Governor removal/installation.	3-79	2-8
12	Governor assembly/disassembly.	3-83	2-11
13	Governor throttle control removal/installation.	3-95	2-10, 2-12
14	Governor adjustments.	3-102	2-11, 2-12

FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

(Sheet 1 of 3)

This task covers: Removal and installation of fuel injection nozzles.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-10, 2-13, 2-16

Equipment Condition

Engine OFF

Engine access panels open

Special Tools

Extractor, Fuel Nozzle Adapter,  
5P6229

Personnel Required

One mechanic

Socket, Fuel Line, 5P144

References

Maintenance of the fuel system,  
TM 10-3930-641-20.

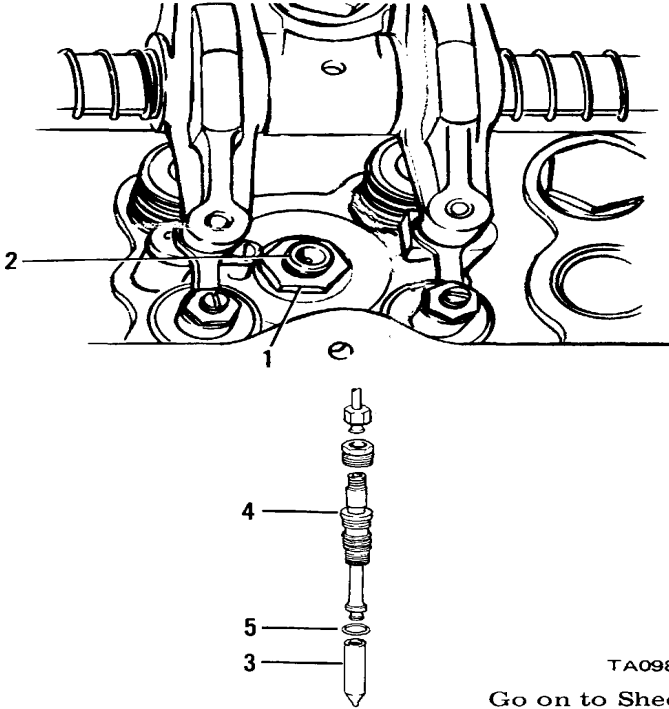
General Safety Instructions

Main disconnect switch OFF.

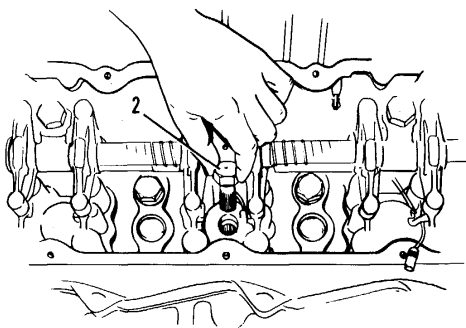
No smoking.

Go on to Sheet 2

FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 10px;">REMOVAL</div> <ol style="list-style-type: none"> <li>1. Valve covers</li> <li>2. Fuel line to injection valve</li> <li>3. Nut (1) that secures injection valve (2) to the adapter</li> <li>4. Injection valve assembly (2)</li> <li>5. Nozzle assembly (3)</li> </ol>	<p>Remove.</p> <ol style="list-style-type: none"> <li>a. Remove with socket 5P144.</li> <li>b. Cap all fuel line openings.</li> </ol> <p>Remove.</p> <p>Remove using extractor FP6229.</p> <ol style="list-style-type: none"> <li>a. Remove from valve body (4).</li> <li>b. Remove seal (5).</li> </ol>	<p>See TM 10-3930-641-20.</p> 

FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">INSTALLATION</div>		
1. New seal (5)	a. Coat with clean diesel fuel. b. Install on valve body (4).	
2. Nozzle assembly (3)	a. Install on valve body. b. Tighten finger-tight.	See TM 10-3930-641-20.
3. Diesel fuel	Put a small amount in the adapter bore.	
4. Fuel injection valve assembly	Install using 5P6229 extractor.	
5. Nut (1)	a. Install. b. Tighten to $55 \pm 5$ lb. ft. ( $75 \pm 7$ N.m).	
6. Fuel injection line	a. Coat seal with clean diesel fuel. b. Install and tighten to $30 \pm 5$ lb. ft. ( $40 \pm 7$ N.m) using 5P144 socket.	
7. Valve covers	Install.	

TA098991

End

**FUEL INJECTION PUMP REMOVAL AND INSTALLATION**

This task covers: Removal of fuel injection pump.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-11, 2-17

Equipment Condition

Engine OFF

Special Tools

Injector pump removal wrench, 8S4613

Injector extractor, 8S2244

Timing pin, 5P9697

Personnel Required

One mechanic

References

None

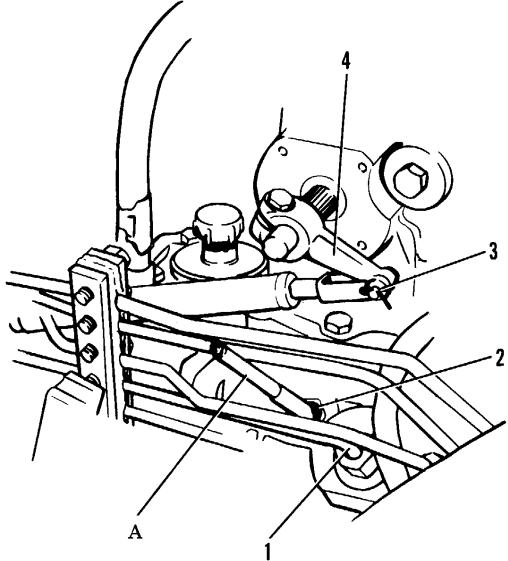
General Safety Instructions

Main disconnect switch OFF.  
No smoking.

Go on to Sheet 2

Go on to Sheet 2

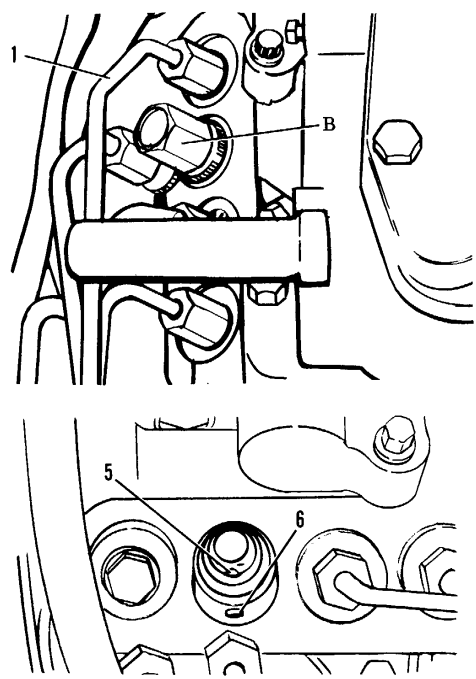
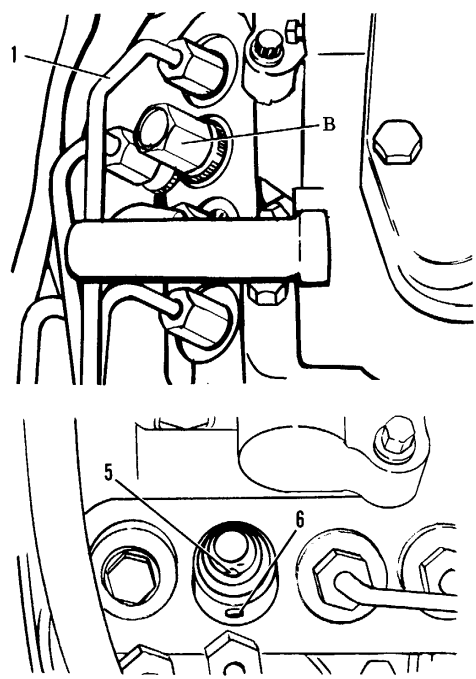
FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; text-align: center;">REMOVAL</div> <ol style="list-style-type: none"> <li>1. Plug</li> <li>2. Timing pin, 5P9697, (A)</li> <li>3. Governor control link (3)</li> <li>4. Governor control (4)</li>   <li>5. Lines from fuel injection pumps (1)</li> </ol>	<p>Remove from location (2).</p> <p>Install in location (2) with square end down.</p> <p>Disconnect.</p> <ol style="list-style-type: none"> <li>a. Move to full ON position.</li> <li>b. Racks are now in center position.</li> </ol> <ol style="list-style-type: none"> <li>a. Remove.</li> <li>b. Cap all fuel openings.</li> <li>c. Remove seals.</li> </ol>	

TA095992

Go on to Sheet 3

FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

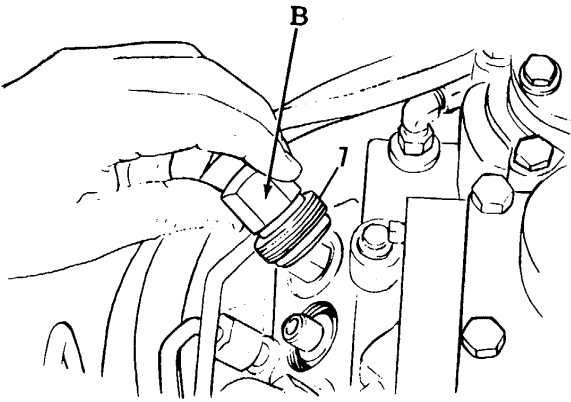
LOCATION/ITEM	ACTION	REMARKS
6. Wrench, 8S4613, (B) 7. Fuel injection pump	Use to loosen bushings.  Remove using extractor, 8S2244.	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">INSTALLATION</div>	1. Injection pump  a. Install in housing bore so gap in gear segment aligns with pin hole (5). b. Install so groove in barrel aligns with pin (6). c. Install pump completely, using 8S2244 extractor.	

TA098993

TA098993

Go on to Sheet 4

FUEL INJECTION NOZZLE REMOVAL AND INSTALLATION

LOCATION/ITEM	ACTION	REMARKS
2. Seal and bushing (7)	a. Install in pump housing bore. b. Bushing should turn into threads of housing with fingers until flush with housing, if pump is in correct position. c. Tighten bushing to torque of 140-160 lb. ft. (190-218 N.m) with 8S4613 wrench.	
3. Washer	Install on bushing (7).	
4. Fuel lines	Connect to pumps and torque to 25-35 lb. ft. (32-48 N-m).	
5. Governor control link (3)	Install.	
6. Injection pumps	Check for correct installation with engine stopped.	
	<p style="text-align: center;"><b>CAUTION</b></p> <p><b>If one or more of injection pumps has been installed wrong, then damage to engine is possible. Precautions to shut down engine should be taken immediately.</b></p>	
7. Timing pin, 5P4185	Remove and install plug (2).	

TA098994

END

**FUEL INJECTION PUMP DISASSEMBLY/ASSEMBLY**

(Sheet 1 of 5)

This task covers: Disassembly and assembly of the fuel injection pump, not including fuel injection pump housing.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-13, 2-17

Equipment Condition

Fuel injection pump removed.

Special Tools

None

Personnel Required

One mechanic

References

Fuel injection pump removal/installation,  
page 3-32.

General Safety Instructions

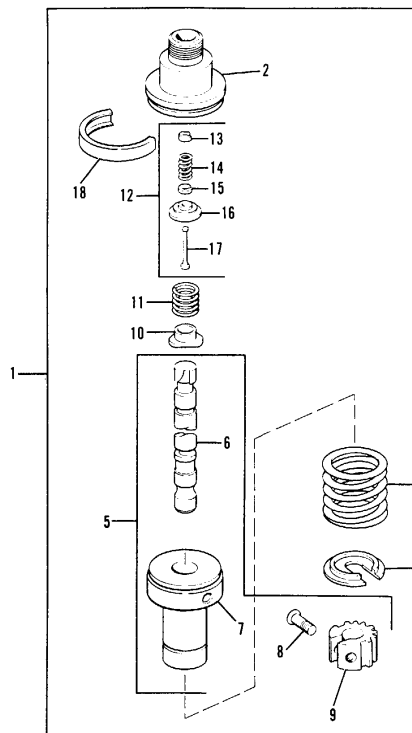
No smoking.

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;">DISASSEMBLY</div> <div> <ul style="list-style-type: none"> <li>1. Ring (18)</li> <li>2. Bonnet (2)</li> </ul> </div>	<p style="text-align: center;"><b>CAUTION</b></p> <p><b>When injection pumps, spacers and lifters are removed from injection pump housing, keep parts of each pump together so they can be installed back in original position.</b></p> <p>Remove. Separate from plunger and barrel assembly (5).</p> <p style="text-align: center;"><b>3-37</b></p>	<p style="text-align: right;">TA098995 Go on to Sheet 3</p>

FUEL INJECTION PUMP DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 3 of 5)

- 1. Fuel injection pump
- 2. Bonnet
- 3. Spring
- 4. Washer
- 5. Plunger and barrel assembly
- 6. Plunger
- 7. Barrel
- 8. Screw
- 9. Gear
- 10. Collar
- 11. Spring
- 12. Check valve assembly
- 13. Retainer
- 14. Spring
- 15. Spacer
- 16. Valve
- 17. Check
- 18. Ring



**NOTE**  
Do not disassemble 12.  
(Includes 13, 14, 15, 16, 17.)

**NOTE**  
6, 8, and 9 should be treated as a  
single assembly and NEVER  
disassembled.

LOCATION/ITEM	ACTION	REMARKS
	<p><b>CAUTION</b></p> <p><b>Be careful when injection pumps are disassembled. Do not cause damage to surface on plunger. Plunger and barrel for each pump are made as set. Do not put plunger of one pump in barrel of another pump. If one part has wear then install a complete new pump assembly. Be careful when plunger is put into bore of barrel.</b></p>	
3. Washer (4) and spring (3)	Remove from barrel (7).	
4. Collar (10), spring (11) and valve assembly (12)	Remove from bonnet (2).	
5. Plunger (6)	Separate from barrel assembly (5).	
6. Gear segment (9)	Remove from barrel (7).	
<b>3-39</b>		Go on to Sheet 5

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">ASSEMBLY</div>		Refer to Fuel Injection Pump Installation, page 3-32.
1. Washer (4) and spring (3)	Position on plunger and barrel assembly (5).	
2. Check valve assembly (12), spring (11) and collar (10)	Position in bonnet (2).	
3. Bonnet (2) and barrel (7)	Connect with ring (18).	
4. Seal	Keep with bonnet for use at installation.	
5. Spacer	a. Position in pump housing bore. b. Correct spacer should be with each pump.	
6. Gear segment (9)	Aline gear gap with groove in barrel (7) and bonnet (2)	
<b>3-40</b>		

End

**FUEL INJECTION PUMP HOUSING REMOVAL AND INSTALLATION**

(Sheet 1 of 6)

This task covers: Removal/installation of fuel injection pump housing.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Preformed packing and seals, if required

Troubleshooting Reference

Pages 2-13, 2-17

Equipment Condition

Engine off and cooled.  
Fuel injection lines removed.

Special Tools

Tool, engine turning, 9S9082

Pin, timing, 5P9697

Fuel Socket line, 5P144

Personnel Required

One mechanic

References

Fuel transfer pump removal/installation,  
TM 10-3930-641-20

Fuel injection lines removal/installation,  
TM 10-3930-641-20

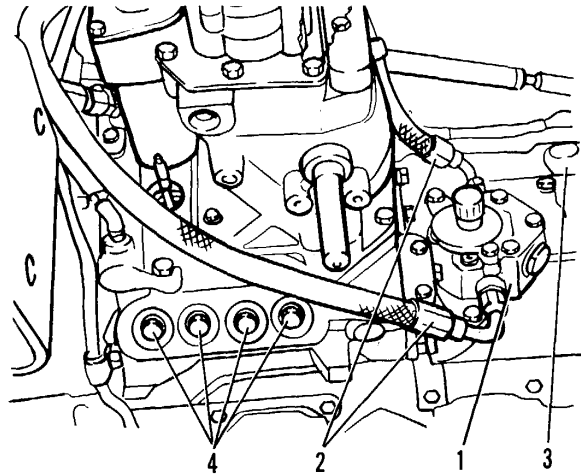
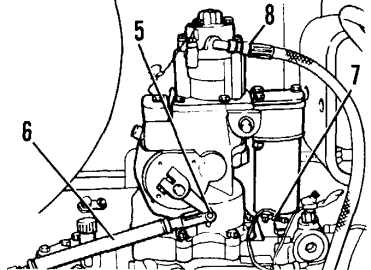
Finding top center position, page 3-371

General Safety Instructions

Main disconnect switch OFF.

No smoking.

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

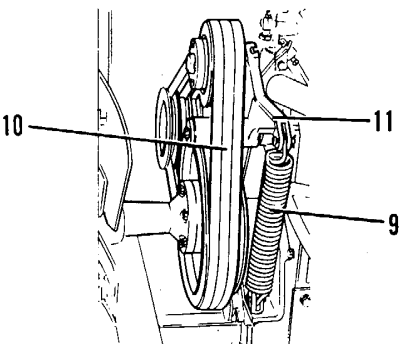
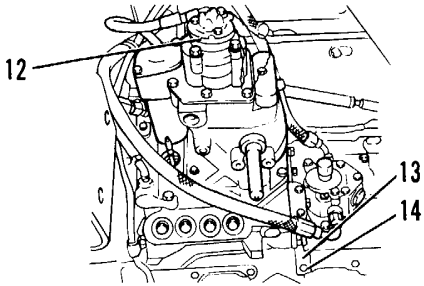
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">REMOVAL</div>		<p>See page 3-371.</p>
1. Fuel injection pump	<p>Time the fuel pump (no. 1 cylinder top center compression stroke).</p>	<p>See page 3-371.</p>
2. Fuel transfer pump (1)	<p>a. Tag and disconnect lines (2). b. Remove fuel line support bracket (3).</p>	
3. Governor	<p>a. Tag and disconnect fuel lines (4) from governor plate using 5P144 socket, fuel line. b. Remove control cable (6) by removing cotter pin and pin (5). c. Remove control cable from bracket.</p>	
4. Fuel ratio control	<p>Tag and disconnect air line (8).</p>	
5. Fuel shut-off solenoid	<p>Disconnect at connectors (7).</p>	

See TM 10-3930-641-20.

TA098997

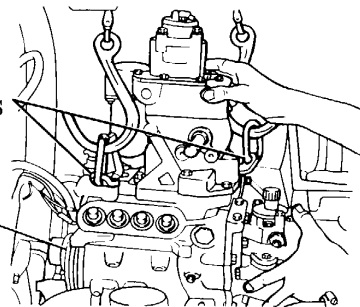
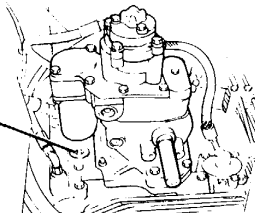
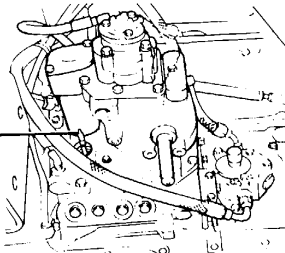
Go on to Sheet 3

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

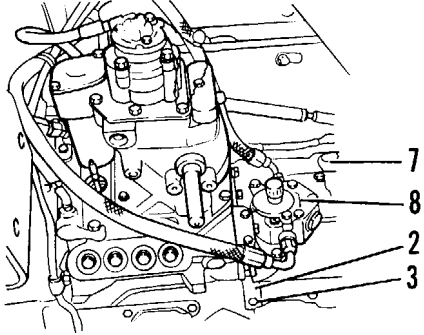
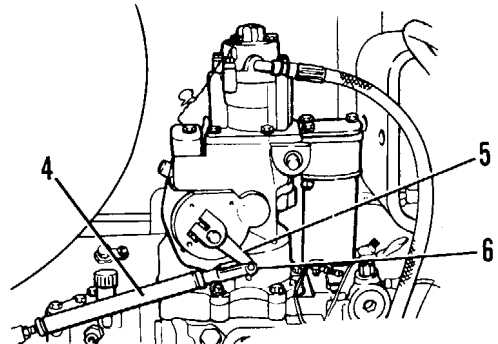
LOCATION/ITEM	ACTION	REMARKS
6. Belt tightener (11)	a. Remove fan belts (10). b. Disconnect spring (9). c. Remove belt tightener (11).	
7. Automatic timing advance housing	a. Remove cover.	
<b>CAUTION</b>  <b>Do not drop retainer (12) in the housing.</b>		
<b>CAUTION</b>  <b>Do not turn engine crankshaft while automatic timing advance unit is off the camshaft at fuel injection pump housing. Can damage timing gears.</b>		
8. Fuel pump housing	a. Remove cap screws (14), washers, spacers, and brackets (13). b. Install link brackets. c. Remove pump housing. Weight of housing is 110 lb. (50 kg).	TA098998

Go on to Sheet 4 et 4

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
<p>8. Fuel pump housing (Cont)</p> <div style="border: 1px solid black; padding: 5px; text-align: center; margin: 10px 0;">                     INSTALLATION                 </div> <p>1. Fuel pump housing</p>	<p>d. Inspect O-ring and seal (15). If needed make replacement.</p> <p>a. Install O-rings and seal (15).                      b. Remove plug (1).                      c. Insert timing pin, 5P4185, and turn camshaft until pin fits into groove.                      d. Lift housing into position, using link brackets.                      e. Install housing making sure camshaft is in the automatic timing advance unit.</p>	<div style="text-align: center;">  <p>LINK BRACKETS</p> <p>15</p> </div> <p>Use grease to hold O-rings in place.</p> <div style="text-align: center;">  <p>1</p> <p>Use engine turning pinion 9S9082 if needed.</p> </div> <div style="text-align: center;">  <p>TIMING PIN</p> </div> <p style="text-align: right;">TA098999 Go on to Sheet 5</p>

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
1. Fuel pump housing (Cont)	f. Install spacers, washers, capscrews (3) and brackets (2).	
2. Fuel shut-off solenoid	Connect wires.	
3. Governor control cable (4)	a. Place in position. b. Install in bracket and tighten nut. c. Connect to lever (5) with pin (6) and cotter pin.	
4. Fuel ratio control	Install air lines.	
5. Fuel lines	a. Install on governor plate. b. Install support bracket (7). c. Connect to fuel transfer pump (8).	
3-45		

Go on to Sheet 6

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
6. Automatic timing advance	a. Install retainer and bolts that hold the automatic timing advance unit to pump camshaft. b. Torque bolts to 20 lb. ft. (27 N.m) with timing pin in. c. Remove timing pin and torque bolts to 100 ± 5 lb. ft. (135 ± 7 N-m). d. Install gasket and cover.	See page 2-13.
7. Belt tightener	a. Install. b. Install fan belts.	See TM 10-3930-641-20. See TM 10-3930-641-20.
8. Fuel injection lines	Install, using 5P144 socket, fuel line.	See TM 10-3930-641-20.

End

**FUEL INJECTION PUMP HOUSING DISASSEMBLY/ASSEMBLY (Sheet 1 of 11)**

This task covers: Disassembly and assembly of fuel injection pump housing.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-13, 2-17

Equipment Condition

Pump housing removed.  
Governor removed from pump housing.

Special Tools

Personnel Required

Pin, timing, 5P9697

One mechanic

Wrench, injector pump removal, 8S4613

Extractor, injector, 8S2244

References

Fuel injection pump removal/installation, page 3-41.

Finding top center position, page 3-371.

Governor removal/installation, page 3-79.

General Safety Instructions

No smoking.

Go on to Sheet 2

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

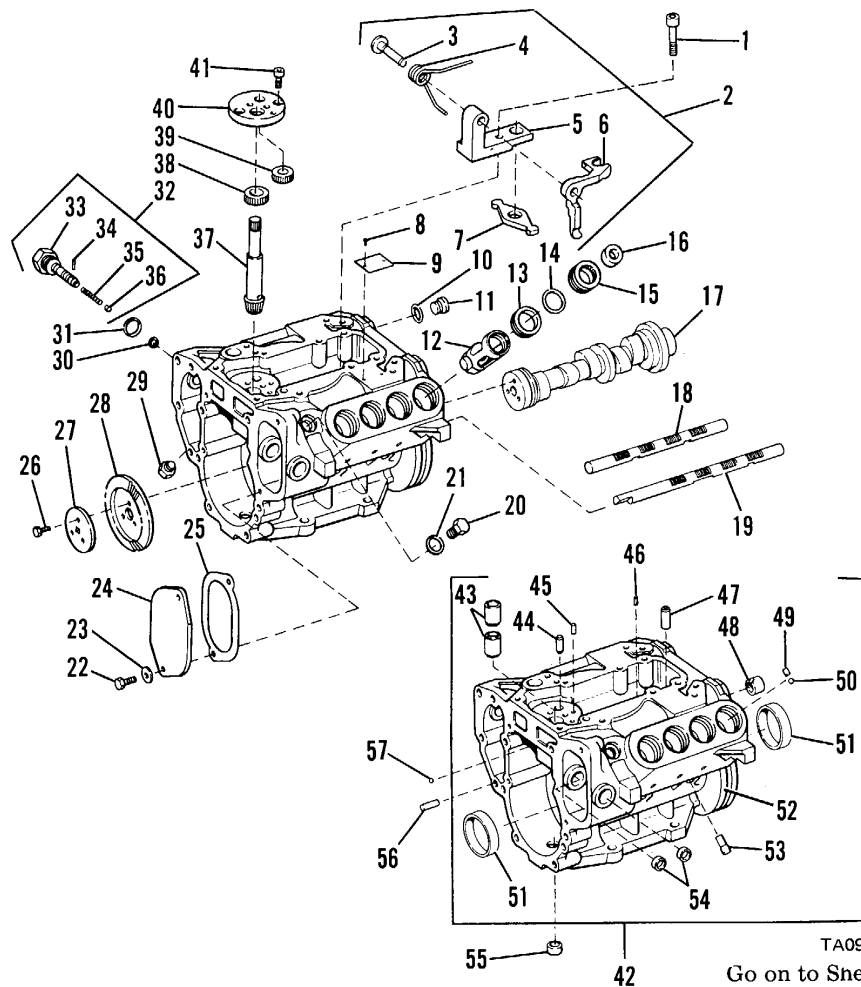
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">DISASSEMBLY</div>	<p><b>CAUTION</b>  <b>Housing must be placed on wooden blocks to prevent damage to inlet and outlet ports.</b></p>	<p>See Sheet 3 for for illustration.</p>
1. Capscrew (22) and cover (24)	Remove.	
2. Capscrews and rear cover assembly.	Remove. Discard gasket.	
3. Shaft and gear	Remove from rear cover assembly.	
4. Bushing	Remove from rear cover assembly.	
5. Two capscrews (41) and cover (40)	Remove.	
6. Capscrews (26), retainer (27) and gear (28)	Remove from pump camshaft (17).	
7. Idler gear (39)	Remove from pump housing.	
8. Pinion gear (37)	Remove.	
9. Drive gear (38)	Remove.	
10. Bypass valve (32)	Remove.	
	3-48	Go on to Sheet 3

FUEL INJECTION PUMP HOUSING DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 3 of 11)

Fuel Injection Pump Group

1. Capscrew	30. Preformed packing
2. Bracket assembly	31. Preformed packing
3. Pin	32. Valve assembly, bypass
4. Spring	33. Body
5. Bracket	34. Pin
6. Lever	35. Spring
7. Link	36. Piston
8. Screw	37. Pinion gear assembly
9. Plate	38. Gear, drive
10. Preformed packing	39. Gear, idler
11. Plug	40. Cover
12. Lifter assembly	41. Capscrew
13. Spacer	42. Housing assembly
14. Preformed packing	43. Bearing
15. Bushing	44. Shaft, idler gear
16. Washer	45. Dowel
17. Camshaft	46. Pin
18. Rack	47. Pin
19. Rack	48. Bearing, fuel rack
20. Plug	49. Pin
21. Preformed packing	50. Ball
22. Capscrew	51. Bearing
23. Washer	52. Housing
24. Cover	53. Pin
25. Gasket	54. Bearing
26. Capscrew	55. Pin
27. Retainer	56. Pin
28. Gear	57. Ball
29. Plug	

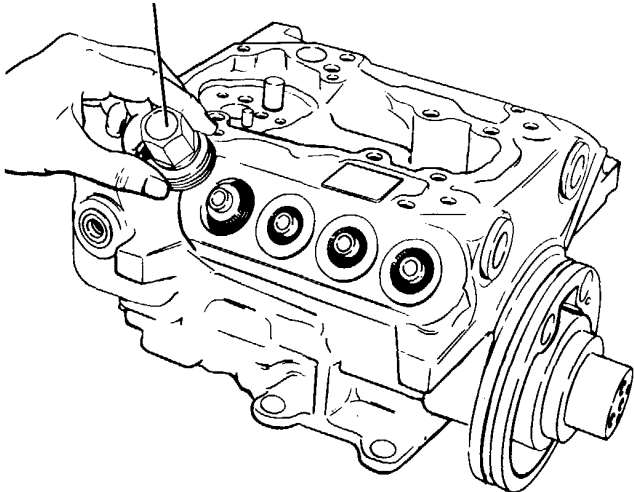


TA099001

Go on to Sheet 4

Go to Sheet 4

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
11. Preformed packing (31), pin (34), piston (36), and spring (35)	Remove from valve body.	
12. Bushing (15)	Remove from each injection pump.	Use a bushing removal wrench, 8S4613, and extractor, 8S2244.
13. Washers (16)	Remove.	
14. Injection pumps	Remove as follows: a. Identify each pump by its location in the pump housing. b. Hold fuel racks in the center (zero) position. c. Carefully remove each pump with extractor tool.	EXTRACTOR 
15. Capscrew (1), bracket (5) and link (7)	Remove.	
16. Right fuel rack (18) and left fuel rack (19)	Remove and identify.	
17. Spacer (13) and lifter (12)	Remove and identify by location.	

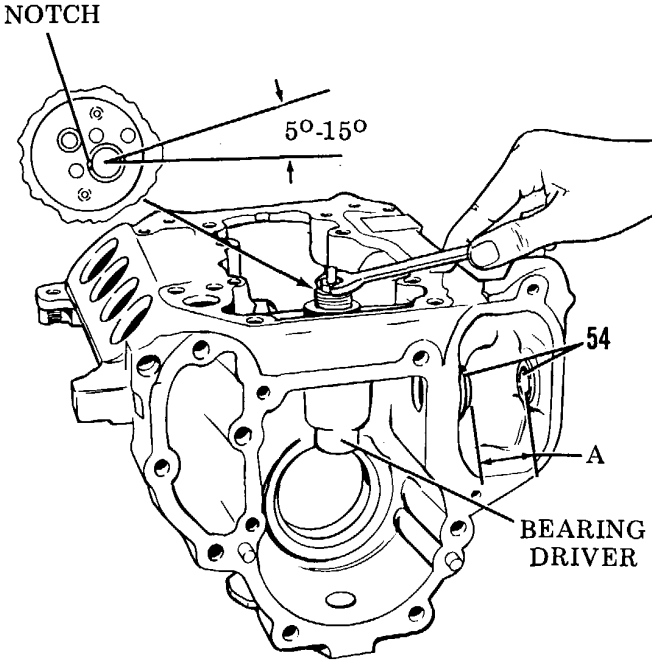
FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
18. Camshaft (17)	Remove from pump housing.	
19. Upper and lower pinion gear bearings (43)	Remove.	
20. Dowel (45) and idler gear shaft (44) puller.	Remove from pump housing using dowel puller.	
21. Fuel rack bearings (48)	Remove.	
22. Lip seals and bearings (54)	Remove with drive plate.	
23. Front and rear camshaft bearings (51)	Remove with bearing puller.	
<div style="border: 1px solid black; padding: 5px; display: inline-block;">ASSEMBLY</div>		
1. New fuel rack bearing (48) for right fuel rack	Install as follows: <ol style="list-style-type: none"> <li>a. Aline dowels of fixture assembly with left fuel rack bore.</li> <li>b. Fasten fixture assembly to pump housing with capscrew.</li> <li>c. Place new bearing in position between the fixture assembly and the fuel rack bore. Tab of bearing must be up.</li> <li>d. Aline the driver with the bearing. Push driver until shoulder of driver makes contact with fixture.</li> </ol>	

FUEL INJECTION PUMP HOUSING REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
2. Left fuel rack bearing.	Turn fixture assembly and aline dowels with right fuel rack bore.  Follow same steps as for right bearing.	
3. Front and rear camshaft bearing (51)	Install.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Aline oil holes in bearings with oil holes in pump housing.</b></p> Rear bearing must be installed so outer face is 0.19 in. (0.48 cm) from rear surface of pump housing.  Front housing must be installed so outer face is 0.04 in. (0.10 cm) from front surface of pump housing.	
4. Lip seal	Install with outside bearing (54) with lip towards the outside.	
5. Outside bearing (54)	Install with driver.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Install bearing until the bearing face is 1.505 in. (38.227 mm) from outer face of pump housing face.</b></p>	

FUEL INJECTION PUMP HOUSING DISASSEMBLY/ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
6. Inside bearing (54)	Install from inside pump housing.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>The distance (A) between bearings must be 1.37 in. (34.798 mm).</p>	
7. Lip seal	Install with inside bearing (54).	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Lip of seal must be away from bearing (54). Seal must be even with inner housing surface.</p>	
8. Lower bearing (43) of pinion gear	Install with bearing driver.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Chamfer must be toward inside. Install bearing until face is even with lower surface of bearing bore.</p>	
9. Upper bearing (43) of pinion gear	Install with bearing driver.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Chamfer must be toward inside. Notch of bearing must be as shown. Install bearing until face is even with upper surface of bearing bore.</p>	
10. Camshaft (17)	Install.	

TA099003  
Go on to sheet 8

LOCATION/ITEM	ACTION	REMARKS
11. Spring (35), piston (36), pin (34), preformed packing (31) and (30)	Install in valve body (33).  <p style="text-align: center;"><b>NOTE</b></p> <b>Pin (36) must extend out from either side of valve body.</b>	
12. Oil bypass valve (32)	Install.	
13. Shaft (44)	Install.	
14. Dowel (45)	Install.  <p style="text-align: center;"><b>NOTE</b></p> <b>After installation the height of the shaft must be 0.66 in. (1.65 cm) and the height of the dowel must be 0.25 in. (0.64 cm).</b>	
15. Lifters (12)	Install.  <p style="text-align: center;"><b>NOTE</b></p> <b>If new lifters or spacers are used then the fuel pump timing must be reset.</b>	See page 3-268.
16. Left fuel rack (19) and right fuel rack (18)	Install.	

FUEL INJECTION PUMP HOUSING DISASSEMBLY/ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
17. Link (7)	Install.	
18. Bracket (5)	Install without, letting bracket turn	
19. Timing pin, 5P9697, and spacer (13)	Install in pump housing to hold fuel racks at zero (center) position.	
20. Injection pumps bushings (15) and performed packing (14)	<p>Install with extractor and wrench as follows:</p> <ul style="list-style-type: none"> <li>a. As each pump is installed, turn camshaft until the lobe for that pump is at its lowest point.</li> <li>b. Put the space in gear segment in alignment with the groove in pump barrel. Put the injection pump straight down into the housing bore with the space in gear segment engaged with the pin in the lifter and the groove in barrel engaged with the dowel in the pump housing.</li> <li>c. Install bushing (15) in the pump housing bore. If the injection pump is in the correct position, bushing will screw into the threads of the pump housing with the fingers until it is even with the housing.</li> <li>d. Tighten bushings (15) to a torque of 140 to 160 lb. ft. (203.4 + 13.5 N-m) with injection pump wrench. Install the felt washer for each injection pump.</li> <li>e. Check the fuel rack movement after each pump is installed.</li> </ul>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Rack must move at least 0.8 in. (2.0 cm) from centered position after pumps are installed.</b></p> <p style="text-align: right;">Go on to Sheet 10</p>

LOCATION/ITEM	ACTION	REMARKS
21. Idler gear (39)	Install on shaft.	
22. Drive gear (38)	Install.	
	<p><b>NOTE</b></p> <p><b>Bevel side of gear must be down. Teeth of idler gear and drive gear must be aligned.</b></p>	
23. Pump cover (40)	Install.	
24. Pinion gear of pinion assembly	Install as follows: <ol style="list-style-type: none"> <li>a. Use an 11/16" (1.75 cm) socket and a "C" clamp with a 9" (23 cm) opening.</li> <li>b. Drive the pinion gear until the drive gear contacts the shoulder of the pinion gear shaft.</li> </ol>	
25. Camshaft gear (28)	Install.	
26. Retainer (27) and capscrew (26)	Install on gear (28).	
27. Cover (24) and gasket (25)	Install.	

**FUEL INJECTION PUMP HOUSING DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
28. Bushing	Install in rear cover.	
29. Shaft and gear	Install in rear cover.	
30. Gasket and cover	Install on pump housing.	

**FUEL TRANSFER PUMP DISASSEMBLY AND ASSEMBLY**

This task covers: Disassembly and assembly of fuel transfer pump.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Liquid gasket material

Troubleshooting Reference

Pages 2-9, 2-10, 2-11

Equipment Condition

Fuel transfer pump removal/installation,

Special Tools

Seal driver

Personnel Required

One mechanic

References

Fuel transfer pump removed from vehicle.  
TM 10-3930-641-20

General Safety Instructions

No smoking.

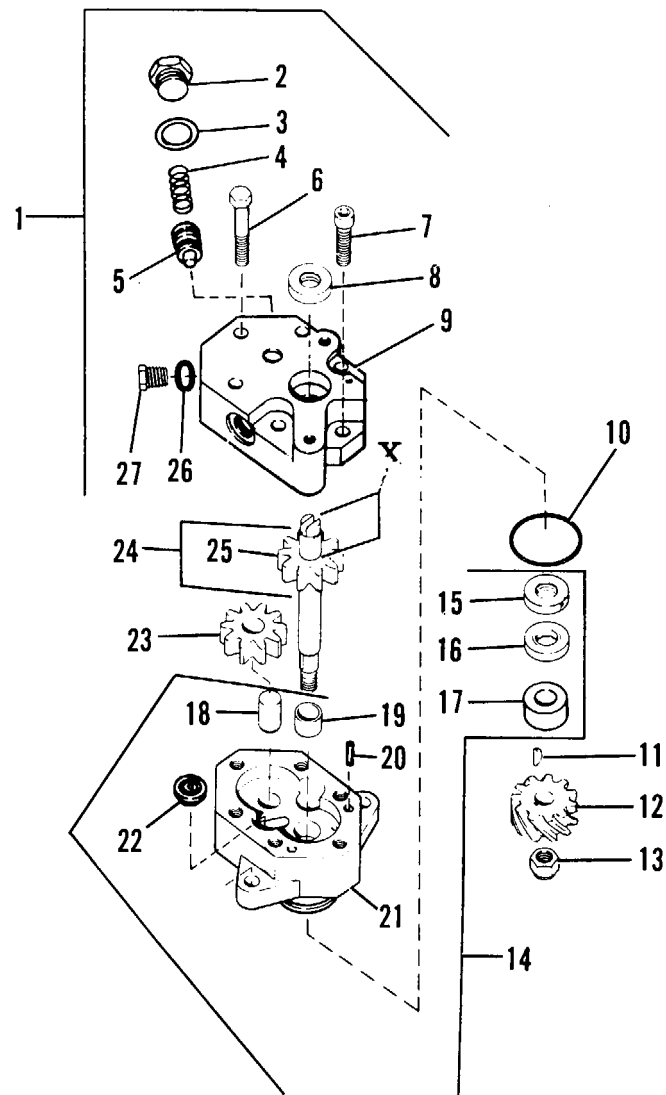
**FUEL TRANSFER PUMP DISASSEMBLY AND ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY</b>		
1. Capscrew and washers	Remove from tachometer drive.	See tachometer drive removal/installation, TM 10-3930-641-20.
2. Tachometer drive	Remove.	
3. Capscrews (6)	Remove six capscrews; three socket head and three hex head.	
4. Cover (9) and pump body (21)	Separate.	
5. Lip type seal (8)	Remove from cover (9).	
6. Plug (2), seal (3), spring (4) and plunger (5)	Remove from cover (9).	
7. Nut (13)	Remove from shaft (24).	
8. Gear (12) and key (11)	Remove.	

Go on to Sheet 3

FUEL TRANSFER PUMP DISASSEMBLY AND ASSEMBLY (CONT)

- |                        |                           |
|------------------------|---------------------------|
| 1. Fuel transfer pump  | 15. Seal                  |
| 2. Plug                | 16. Seal                  |
| 3. Gasket              | 17. Bearing               |
| 4. Spring              | 18. Shaft                 |
| 5. Plunger assembly    | 19. Bushing               |
| 6. Capscrew            | 20. Ferrule               |
| 7. Capscrew            | 21. Body                  |
| 8. Seal                | 22. Valve assembly, check |
| 9. Cover               | 23. Gear, idler           |
| 10. Packing, performed | 24. Shaft assembly        |
| 11. Key                | 25. Gear, drive           |
| 12. Gear               | 26. Packing               |
| 13. Nut                | 27. Plug                  |
| 14. Body assembly      |                           |





**FUEL TRANSFER PUMP DISASSEMBLY AND ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
9. Shaft (24) and gear (25)	Remove as unit.	
10. Drive gear (25)	Remove from shaft (24) with press.	
11. Idler gear (23)	Remove.	
12. Bushing (19), two lip type seals (15) and (16) and bottom bearing (17)	Remove from pump body (14).	
13. Check valve (22)	Remove.	
<b>ASSEMBLY</b>		
1. Bushing (19)	Install in body (14) with tooling so that it is flush with body.	
2. Check valve (22)	Install in body.	
3. Lip type seal (15)	Install until it is 0.95-0.99 in. (24.1-25.1 mm) from bottom surface of body (14) and with lip toward bushing (19).	
4. Lip type seal (16)	Install until it is 0.54-0.58 in. (13.7-14.7 mm) from bottom surface of body (14) and with lip turned away from seal (15).	

FUEL TRANSFER PUMP DISASSEMBLY AND ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
5. Bearing (17)	Install in body (14) so that it is flush with surface of pump body.	
6. Gear (25)	a. Heat to no more than 600°F (316°C). b. Install on shaft (24) until dimension X is 1.947-1.967 in. (49.46-49.96 mm).	
7. Driveshaft and gear (24)	a. Install in body (14). b. Tighten nut to a torque of 17-27 lb. ft. (24-36 N m).	
8. Idler gear (23)	Install in body (14).	
9. Lip type seal (8)	Install with seal driver until it is 0.13-0.17 in. (3.3-4.3 mm) below surface of cover (9) with lip toward inside.	
10. Plunger (5), spring (4), seal (3) and plug (2)	a. Install in cover (9). b. Tighten plug to a torque of 24-30 lb. ft. (32-40 N m).	

LOCATION/ITEM	ACTION	REMARKS
11. Liquid gasket material	<p style="text-align: center;"><b>CAUTION</b></p> <p><b>Do not allow liquid gasket to enter pump.</b></p> <p>Apply on surface of cover (9).</p>	
12. Cover (9)	<p>Install on pump body (14).</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Drive shaft must turn freely after capscrews that secure transfer pump together are tightened.</b></p>	
13. Tachometer drive	<p>Install.</p>	
14. Performed packing (10) for pump body	<p>Replace.</p>	

See TM 10-3930-641-20.

**FUEL SHUTOFF SOLENOID REMOVAL AND INSTALLATION**

(Sheet 1 of 3)

This task covers: Removal and installation of fuel shutoff solenoid.

**INITIAL SETUP**Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

TM 10-3930-641-20

Equipment Condition

Engine OFF.

Special Tools

None

Personnel Required

One mechanic

References

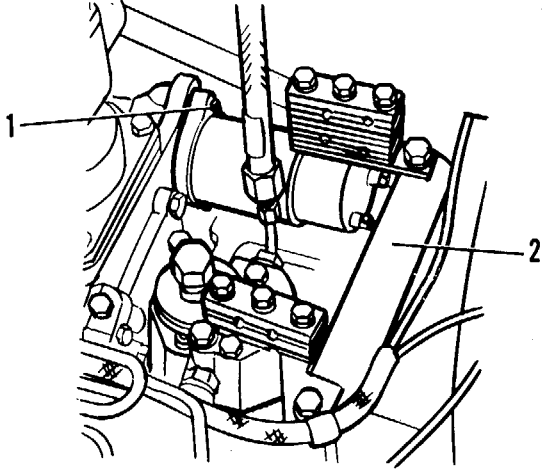
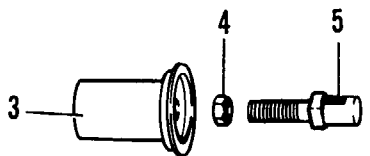
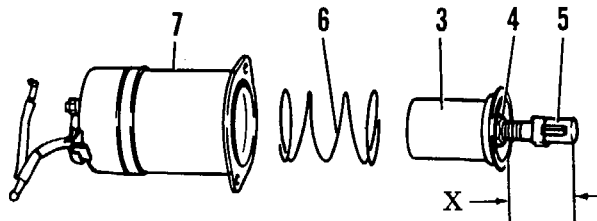
None

General Safety Instructions

Main disconnect switch OFF.

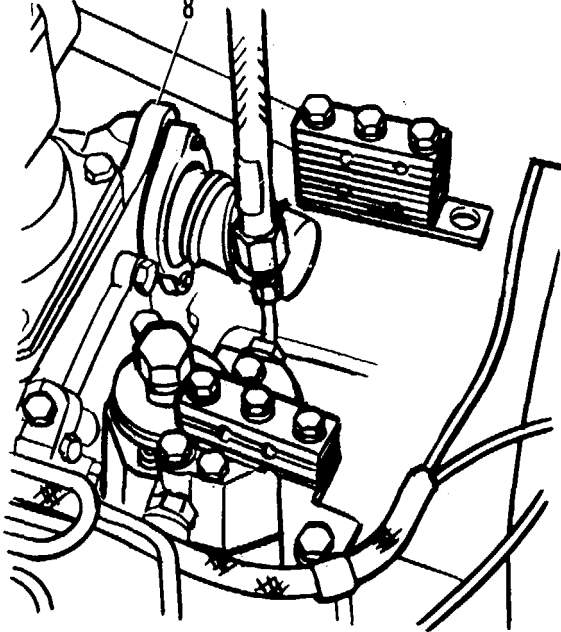
No smoking.

**FUEL SHUTOFF SOLENOID REMOVAL AND INSTALLATION**

LOCATION/ITEM	ACTION	REMARKS
<b>REMOVAL</b>		
1. Fuel line support (2)	Remove.	
2. Two capscrews (1) that secure shutoff solenoid	Remove.	
3. Solenoid	a. Remove.	
	b. Tag electric wires for assembly later.	
	c. Disconnect wires.	
4. Spring (6), plunger (3) and shaft (5)	Remove from fuel pump rack lever.	
5. Nut (4) and shaft (5)	Remove from plunger (3).	
<b>INSTALLATION</b>		
1. Nut (4)	a. Install on shaft (5) and shaft in plunger (3).	
	b. Adjust nut until dimension (X) is 1.39 in. (35.3 mm).	
<b>NOTE</b>		
<b>Dimension (X) is distance between nut and end of opening in shaft.</b>		
2. Shaft (5), plunger (3) and spring (6)	a. Install in solenoid housing (7).	
	b. Install as unit on fuel pump rack lever.	

TA099005  
Go on to Sheet 3

FUEL SHUTOFF SOLENOID REMOVAL AND INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS	
3. Electric wires	Connect.		
4. Gasket and solenoid	Position on injection pump adapter (8) and secure with capscrews.		
	<p><b>NOTE</b> Shorter bolt in bottom hole.</p>		
5. Fuel line support	Install.		

TA099006  
End

**FUEL RATIO CONTROL REMOVAL/INSTALLATION**

This task covers: Removing and installing the fuel ratio control.

**INITIAL SETUP**

Test Equipment

None

Materials/Parts

Lockwire

Seals

Gasket

Troubleshooting Reference

Pages 2-9, 2-16

Equipment Condition

Engine shut down.

Engine starting aid cartridge removed.

Special Tools

None

Personnel Required

One mechanic

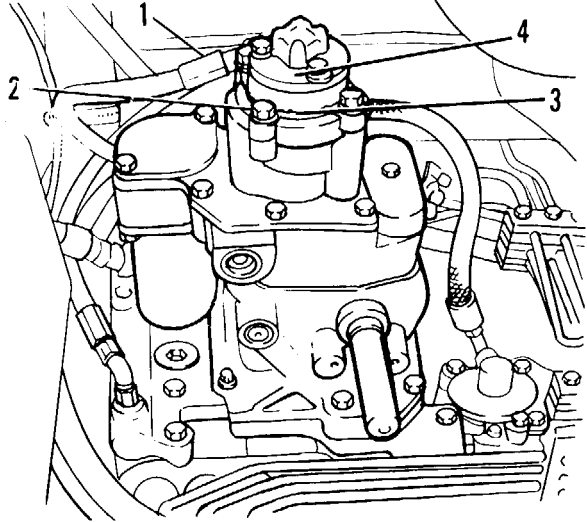
References

Adjust fuel ratio control, page 3-75.

Starting aid cartridge removal/installation,  
TM 10-3930-641-20.

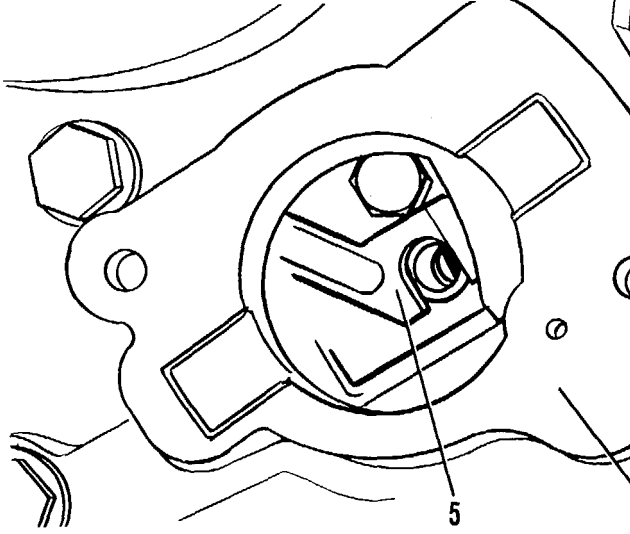
General Safety Instructions

Main disconnect switch OFF.

LOCATION/ITEM	ACTION	REMARKS
<b>REMOVAL</b>		
1. Air line (1)	Disconnect from fuel ratio control.	
2. Lockwire	Remove from capscrews.	
3. Capscrews (2)	Remove.	
4. Fuel ratio control (4)	a. Pull up and toward front of engine to remove from groove in stop collar.	
	b. Remove.	
5. Gasket (3)	Remove.	

TA099007  
Go on to Sheet 3

FUEL RATIO CONTROL REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS	
<b>INSTALLATION</b>			
1. Gasket (3)	Install.		
2. Fuel ratio control (4)	a. Install.  b. Make sure valve assembly engages groove (5) in collar of governor.		
3. Two capscrews (2)	Install.		
4. Air line (1)	Connect.		
5. Fuel ratio control	Adjust		
6. New lockwire and seals	Install on capscrews (2).		
See page 3-75.			

TA099008  
End

This task covers: Disassembling and reassembling the fuel ratio control.

**INITIAL SETUP**

Test Equipment

None

Materials/Parts

Gasket

Preformed packing (3)

Refer to page 3-72 (items 15, 27, 30)

Troubleshooting Reference

Pages 2-9, 2-16

Equipment Condition

Fuel ratio control removed from vehicle.

Special Tools

None

Personnel Required

One mechanic

References

Remove/install fuel ratio control,  
page 3-67

General Safety Instructions

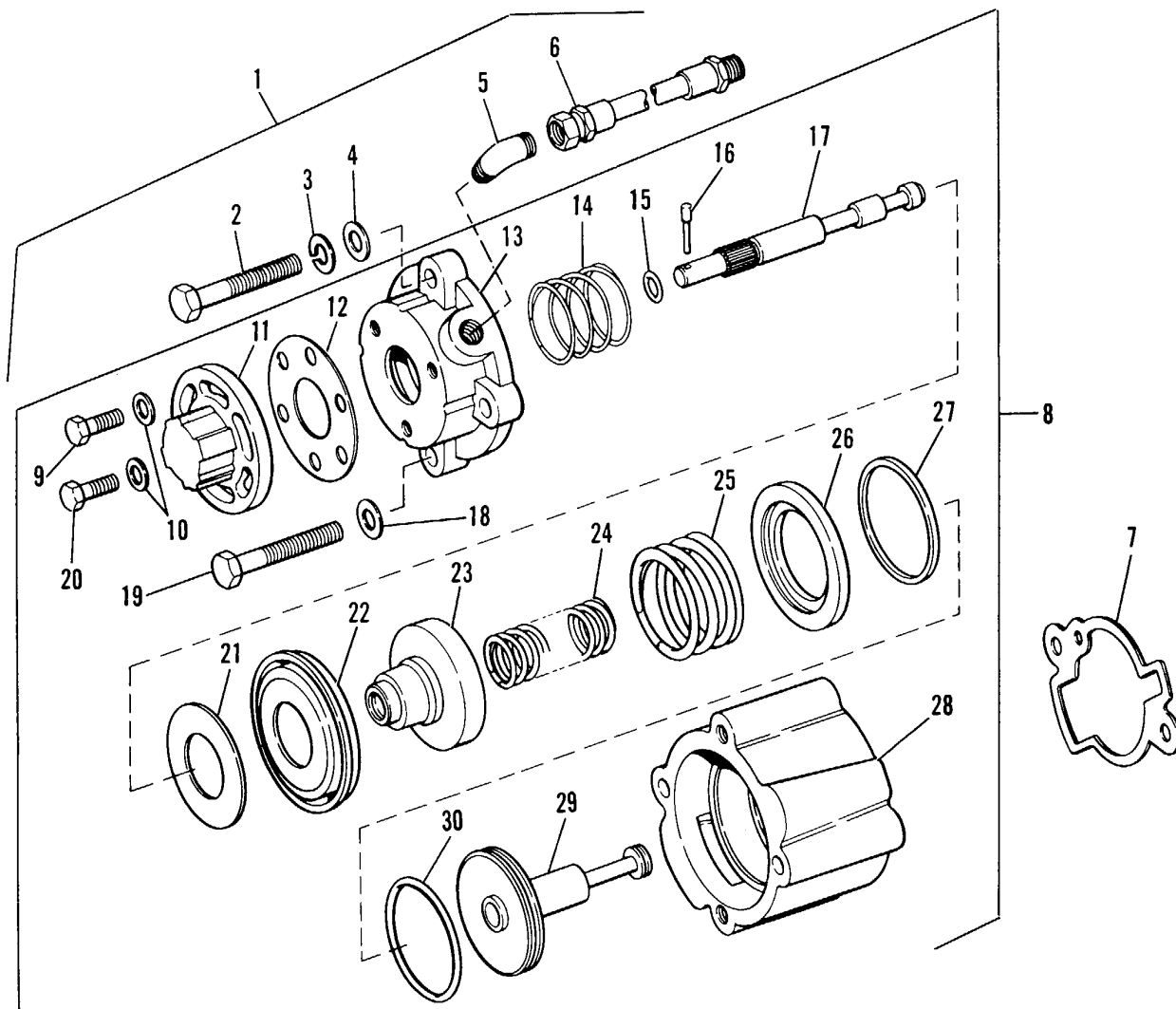
Be careful when releasing spring-loaded parts.

No smoking.

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY</b>		
1. Capscrews (2) and (19)	Remove.	
2. Diaphragm cover (13)	Remove.	
3. Control assembly (8)	Remove.	
4. Retainer (26) and springs (24) and (25)	Remove.	
5. Preformed packing (27) and (30)	Remove and discard.	
6. Capscrews (9) and (20)	Remove.	
7. Cover (11)	Remove.	
8. Valve (17), diaphragm (22), washer (21) and spring (14)	Remove.	

FUEL RATIO CONTROL DISASSEMBLY/ASSEMBLY (CONT)

1. Fuel ratio control assembly
2. Capscrew
3. Lockwasher
4. Washer
5. Elbow
6. Hose assembly
7. Gasket
8. Control assembly
9. Capscrew
10. Washer
11. Cover
12. Gasket
13. Diaphragm cover
14. Spring
15. Preformed packing
16. Pin
17. Internal valve
18. Washer
19. Capscrew
20. Capscrew
21. Washer
22. Diaphragm
23. Retainer assembly
24. Spring
25. Spring
26. Spring retainer
27. Preformed packing
28. Diaphragm housing
29. Limiter valve
30. Preformed packing



LOCATION/ITEM	ACTION	REMARKS
9. Pin (16)	Remove from valve (17).	
10. Retainer assembly (23)	Remove from valve (17).	
<b>REASSEMBLY</b>		
1. Preformed packing (15)	a. Coat with clean engine oil OE/HDO 30. b. Install in cover (13) with lip of seal toward inside of cover.	
2. Valve (17)	a. Install in cover (13). b. Secure with pin (16).	
3. Spring (14) and washer (21)	Install.	
4. Diaphragm (22)	a. Install on valve assembly (29). b. Place assembly in cover (13).	
5. Cover (11) and gasket (12)	a. Install on diaphragm cover (13). b. Secure with capscrews (9) and (20) and washers (10).	

LOCATION/ITEM	ACTION	REMARKS
6. Preformed packing (27) and (30)	a. Coat with clean engine oil OE/HDO 30. b. Install.	
7. Springs (24) and (25) and retainer assembly (23)	Install.	
8. Housing (28)	a. Install. b. Secure with capscrews (2) and (19) and washers (3), (4) and (18).	
	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Fuel ratio control must be adjusted before installation.</b></p>	See page 3-75.

End

**FUEL RATIO CONTROL ADJUSTMENT**

This task covers: Adjustment of fuel ratio control.

**INITIAL SETUP**

Test Equipment

Dial indicator

Materials/Parts

Seals

Lockwire

Troubleshooting Reference

Pages 2-9, 2-13, 2-16, 2-20

Equipment Condition

Fuel rack setting correct.

Special Tools

None

Personnel Required

One mechanic

References

Fuel rack setting, page 3-80.

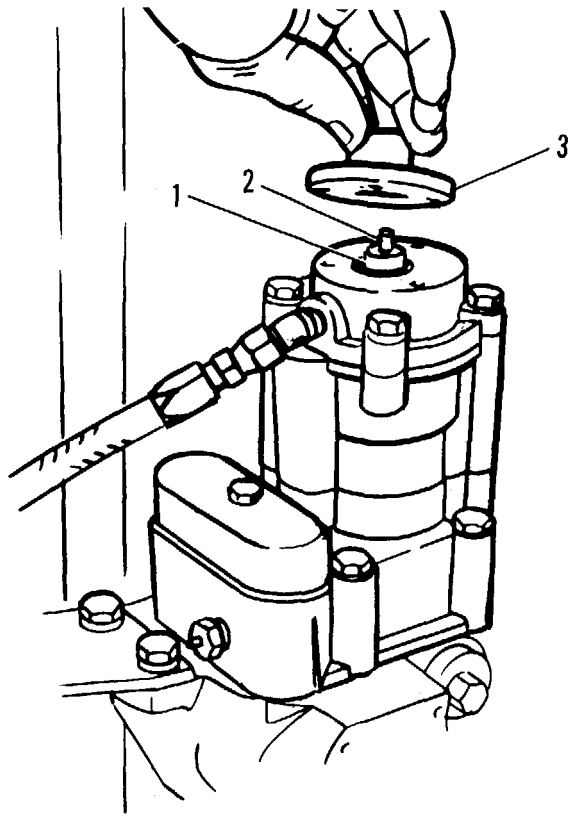
Governor adjustments, page 3-102.

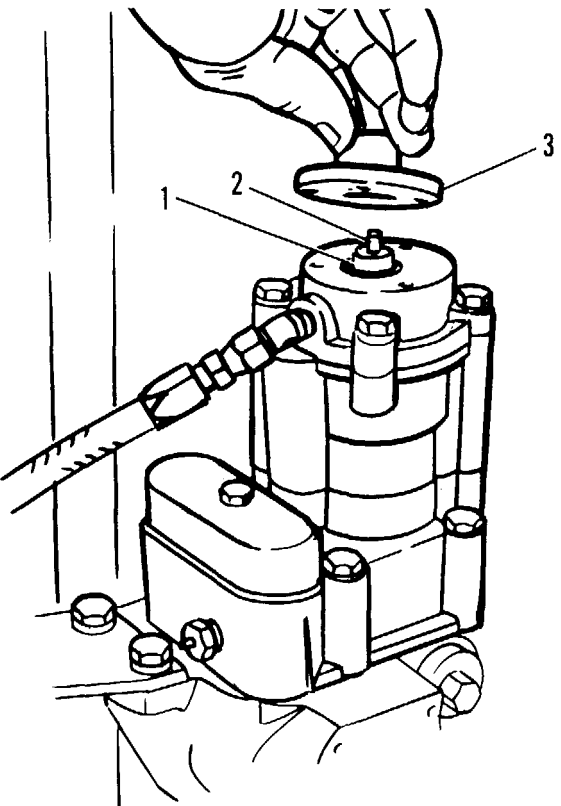
General Safety Instructions

Main disconnect switch OFF.

No smoking.

FUEL RATIO CONTROL ADJUSTMENT (CONT)

LOCATION/ITEM	ACTION	REMARKS
1. Fuel rack setting	Check. See page 3-80.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Fuel rack setting must be correct before adjustment for hydraulic air-fuel ratio control can be checked or changed.</p>	
2. Wire and seal	Remove.	
3. Capscrews	Remove.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Set dial indicator for measurement of rack movement from zero position.</p>	
4. Cover (3)	Remove from hydraulic air-fuel ratio control.	
5. Engine	Start.	
	<p style="text-align: center;"><b>WARNING</b></p> <p>Be careful when working around an engine that is running.</p>	
6. Valve (1)	Push end in and hold in for two or three seconds.	
<p>action will manually move valve into operating position.</p>		<p>This</p> 

LOCATION/ITEM	ACTION	REMARKS
7. Governor control lever	a. Rapidly move in FUEL-ON direction. b. Read measurement on dial indicator.	
	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Read quickly and carefully because dial on indicator will be at its peak for only a moment.</b></p>	
8. Valve (1)	a. Turn clockwise with cap (3) to increase limited rack position. b. Turn counterclockwise to decrease limited rack position.	
9. Steps (5) and (6)	Repeat until proper measurement is achieved.	
10. Cover (3)	a. Aline with pin (2) in valve and turn to aline with nearest capscrew holes after final adjustment. b. Secure with capscrews.	

TA099011  
Go on to Sheet 4

**FUEL RATIO CONTROL ADJUSTMENT (CONT)**

LOCATION/ITEM	ACTION	REMARKS
11. Engine	Stop.	
12. Capscrews	Install.	
13. Wire and seal	Install on capscrews.	

This task covers: Removal and installation of governor.

**INITIAL SETUP**

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-8

Equipment Condition

Area around governor clean and dry,

Special Tools

Timing pin, 5P9697

Personnel Required

One mechanic

References



Governor adjustments, page 3-102.

General Safety Instructions

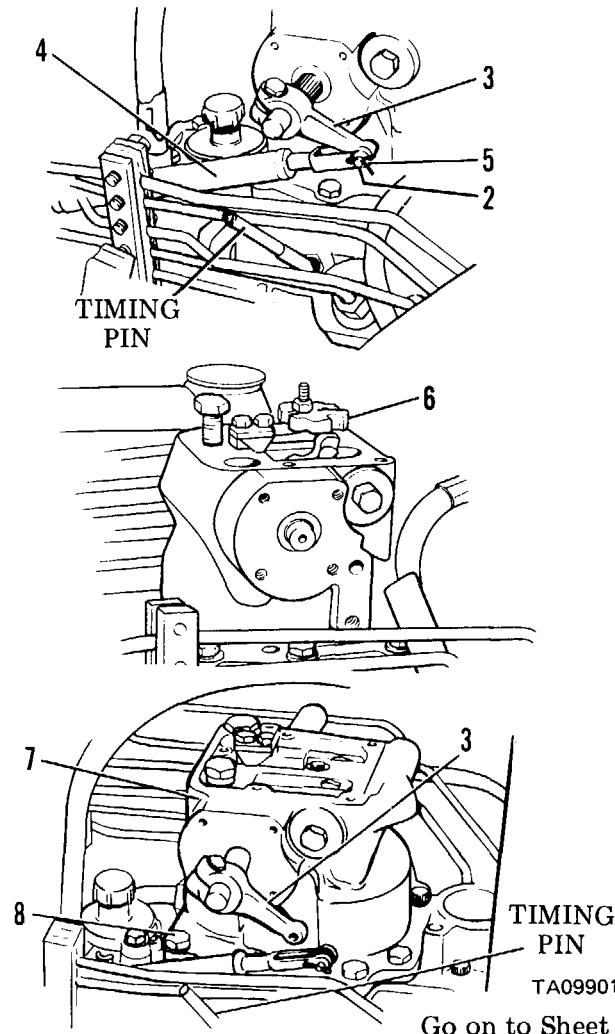
Main disconnect switch OFF.

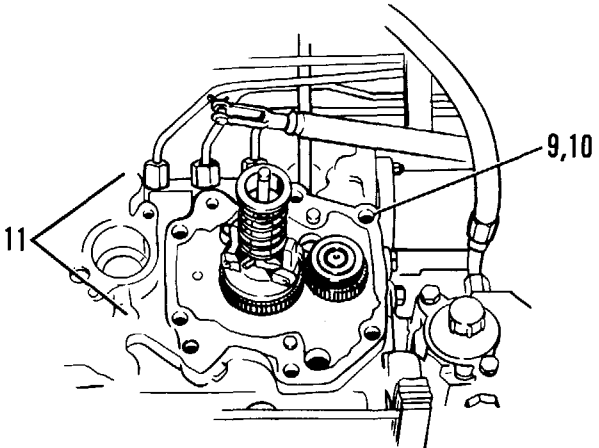
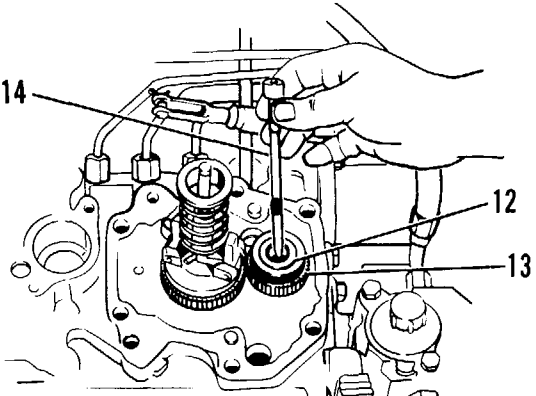
No smoking.

**GOVERNOR REMOVAL AND INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<b>REMOVAL</b>		
1. Fuel ratio control (1)	Remove. See page 3-67.	
2. Cotter pin (2) and pin (5)	Remove.	
3. Governor control cable (4)	Disconnect from lever (3).	
4. Capscrews, cover and cover gasket	Remove from governor housing.	
5. Allen head capscrew	Remove from stop collar (6).	
6. Stop collar (6)	Remove.	
7. Timing pin	a. Install in fuel injection pump housing. b. Be sure correct end is used.	
8. Governor control lever (3)	Move until timing pin is in place and racks are in center (zero) position.	
9. Capscrews (8) and governor housing (7)	Remove.	

3-80



LOCATION/ITEM	ACTION	REMARKS
10. Fuel lines (11) 11. Capscrews (9) and governor plate (10)	Disconnect from governor plate (10). Remove.	
<b>INSTALLATION</b>	<b>CAUTION</b>	
1. Gasket 2. Governor plate (10) and capscrews (9)	Install on injection pump housing. a. Install on fuel pump housing. b. Be sure pins are aligned. c. Install fuel lines (11).	
3. Stop (12)	<p style="text-align: center;"><b>NOTE</b></p> <b>Racks must be held against rack stop pin and governor lever engaged in groove in left hand rack.</b> a. Install in gear (13). b. Make sure wide space in stop (12) aligns with wide space on drive pinion.	

TA099013  
Go on to Sheet 4

**GOVERNOR REMOVAL AND INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
4. Drive assembly (14)	Install.	
5. Gear (13), stop and drive assembly	Aline holes.	
6. Pin and ring	Install. See (14) and (17) page 3-85.	
7. Gasket and governor housing (7)	Install on governor plate.	
8. Spring and stop collar (6)	a. Install.	
	b. Secure with Allen head capscrew.	
9. Timing pin	Remove.	
10. Governor	Adjust.	See Governor Adjustment, page 3-102.
11. Gasket and cover (2)	a. Install on governor housing.	
	b. Make sure pin in cover aligns with notch in collar.	
12. Fuel ratio control (1)	Install.	See page 3-67.
	<b>3-82</b>	End

**GOVERNOR DISASSEMBLY/ASSEMBLY**

(Sheet 1 of 12)

This task covers: Disassembly and assembly of the governor.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-11

Equipment Condition

Governor removed from vehicle.

Special Tools

Driver group

Personnel Required

One mechanic

Snap ring pliers

References

Governor removal/installation, page 3-79.

Governor adjustments, page 3-102.

General Safety Instructions

Main disconnect switch OFF.

No smoking.

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 2 of 12)

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY I		
1. Governor	Remove from vehicle.	See Governor Removal Installation, page 3-79.
2. Torque spring group (97 thru 105)	a. Bend lock (98) away from capscrews (97).  b. Remove assembly from plate (44).	
3. Highidle screw (35)	Remove from housing (5).	
4. Low idle screw (36)	Remove from housing (5).	
5. Lock	Bend away from capscrew (20).	
6. Capscrew (20)	Remove from control lever (29).	
7. Shaft (24) and control lever (29)	Remove.	
8. Lip type seals (2) and bearings (4), (7)	Remove from housing (5).	

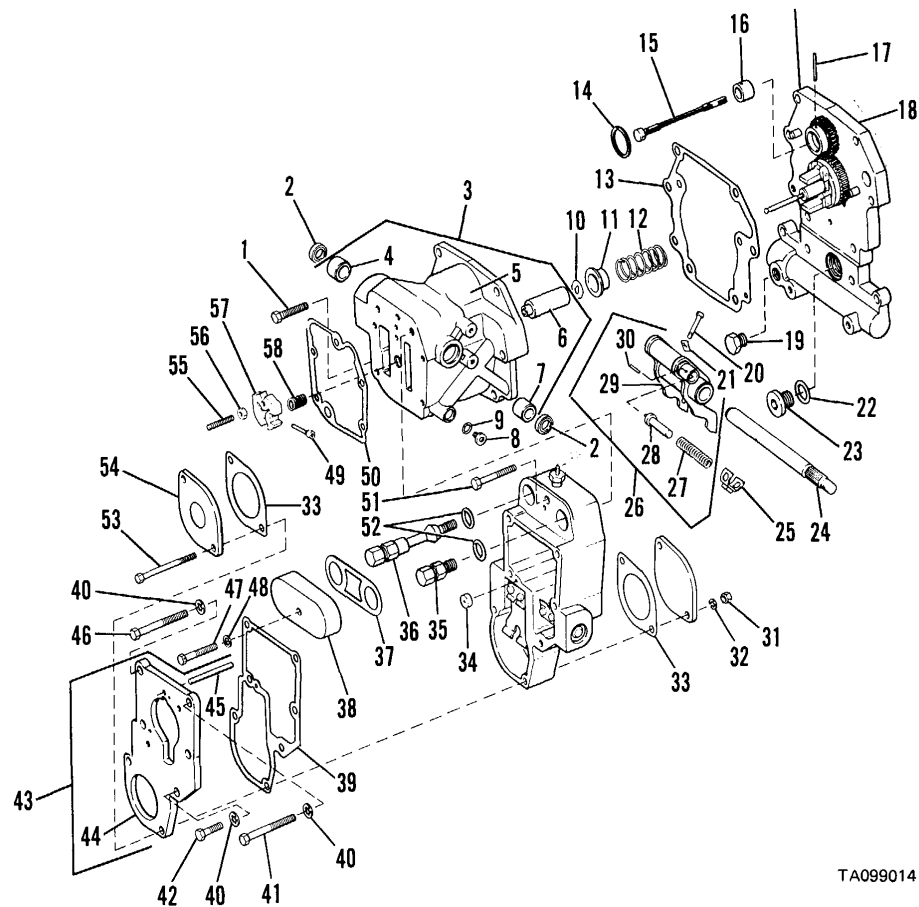
Go on to Sheet 3

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

- 1. Capscrew
- 2. Seal
- 3. Housing assembly
- 4. Bearing
- 5. Housing
- 6. Guide
- 7. Bearing
- 8. Plug
- 9. Packing
- 10. Spring washer
- 11. Seat
- 12. Spring
- 13. Gasket
- 14. Retainer ring
- 15. Drive assembly
- 16. Stop
- 17. Pin
- 18. Plate
- 19. Plug
- 20. Capscrew
- 21. Lock
- 22. Seal
- 23. Plug
- 24. Shaft
- 25. Band assembly
- 26. Lever
- 27. Spring
- 28. Plunger
- 29. Lever
- 30. Pin

- 31. Nut
- 32. Flat washer
- 33. Gasket
- 34. Strainer
- 35. High idle screw
- 36. Low idle screw
- 37. Gasket
- 38. Cover
- 39. Gasket
- 40. Flat washer
- 41. Capscrew
- 42. Capscrew
- 43. Plate assembly
- 44. Plate
- 45. Pin
- 46. Capscrew
- 47. Capscrew
- 48. Flat washer
- 49. Capscrew
- 50. Gasket
- 51. Capscrew
- 52. Packing
- 53. Capscrew
- 54. Cover
- 55. Screw
- 56. Nut
- 57. Collar
- 58. Spring

**SEPARATE FIGURE**



3-85

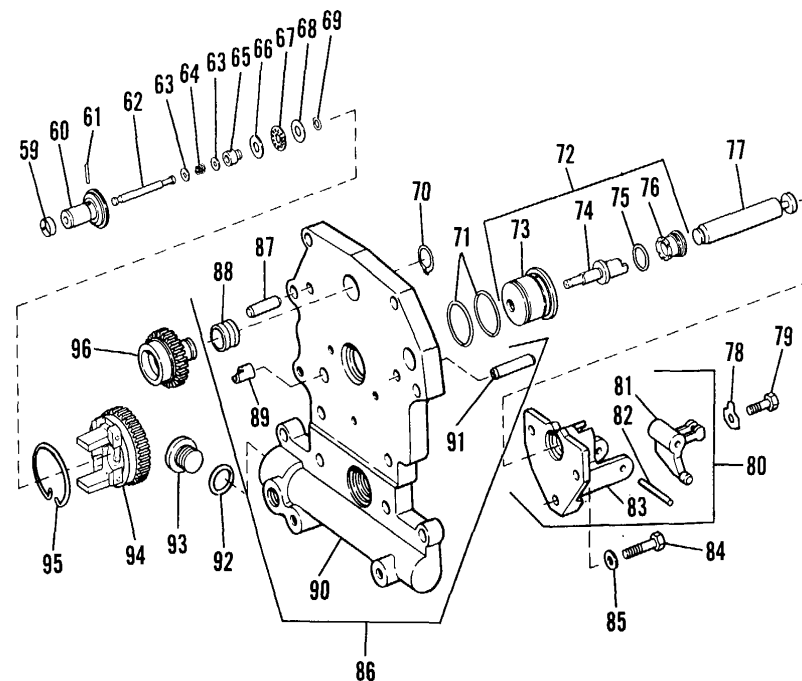
TA099014

Go on to Sheet 5

GOVERNOR PLATE ASSEMBLY

- 59. Retainer ring
- 60. Seat
- 61. Pin
- 62. Bolt
- 63. Flat washer
- 64. Spring
- 65. Sleeve
- 66. Race
- 67. Bearing
- 68. Race
- 69. Locking ring
- 70. Retainer ring
- 71. Preformed packing
- 72. Piston assembly
- 73. Cylinder
- 74. Piston assembly
- 75. Packing
- 76. Sleeve
- 77. Pin

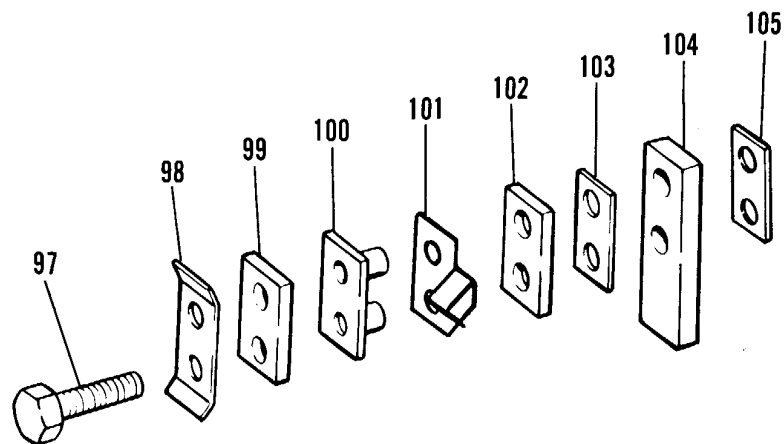
- 78. Lock
- 79. Capscrew
- 80. Bracket assembly
- 81. Lever
- 82. Pin
- 83. Bracket
- 84. Capscrew
- 85. Flat washer
- 86. Plate assembly
- 87. Pin
- 88. Bearing
- 89. Pin
- 90. Plate
- 91. Pin
- 92. Packing
- 93. Plug
- 94. Weight assembly
- 95. Lock ring
- 96. Gear



TA099015  
Go on to Sheet 5

**TORQUE SPRING GROUP**

- |                            |                             |
|----------------------------|-----------------------------|
| 97. Capscrew               | 102. Torque spring retainer |
| 98. Locknut                | 103. Shim                   |
| 99. Torque spring retainer | 104. Load stop              |
| 100. Insulator             | 105. Insulator              |
| 101. Contact               |                             |



**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)****(Sheet 6 of 12)**

LOCATION/ITEM	ACTION	REMARKS
9. Seat (11), spring washer, flat washer (10) and spring washer	Remove.	
10. Spring (12) and spring washer	Remove.	
11. Ring (59)	Remove from seat (60).	
12. Pin (61)	Remove from seat (60).	
13. Seat (60) and governor bolt (62)	Remove as unit.	
14. Governor bolt (62)	Remove from seat (60).	
15. Washers (63), spring (64), sleeve (65)	Remove.	
16. Ring (69), race (68), bearing (67) and race (68)	Remove from bottom of sleeve (65).	

**Go on to Sheet 7**

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 7 of 12)

LOCATION/ITEM	ACTION	REMARKS
17. Lock ring (95)	Remove from flyweight assembly (94).	
18. Flyweight assembly (94)	Remove.	
19. Lock (78)	Bend from capscrew (79).	
20. Capscrew (79)	Remove.	
21. Bracket (83) and pin (82)	Remove as unit.	
22. Servo piston assembly (72)	Remove through bottom of governor plate (90).	
23. Shaft (82)	Remove from bracket with hammer and punch.	
24. Lever (81) and spring (not shown)	Remove from bracket.	

**Go on to Sheet 8**

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 8 of 12)

LOCATION/ITEM	ACTION	REMARKS
25. Piston (74)	Remove from cylinder (73).	
26. Sleeve (76)	Remove from cylinder (73).	
27. Preformed packings (71)	Remove from cylinder (73).	
28. Seal (75)	Remove from sleeve (76).	
29. Dowel (17)	Remove.	
30. Drive assembly (15) and stop (16)	Remove.	
31. Retaining ring (14)	Remove from bottom of gear (96).	
32. Gear (96)	Remove.	
33. Bearing (88)	Remove from governor plate (90).	

**NOTE**  
**If it is necessary to replace dowels in governor then see illustration at right for current installation dimensions.**

**TA099017**  
**Go on to Sheet 9**

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 9 of 12)

LOCATION/ITEM	ACTION	REMARKS
<b>ASSEMBLY</b>		
1. Bearing (88) for drive gear (96)	Using suitable driver, install in governor plate until bearing is 0.020 in. (0.51 mm) from surface of plate.	
2. Drive gear (96)	Install.	
3. Ring (70)	Install with snap ring pliers.	
4. Valve and piston assembly (74)	Install in sleeve (76).	
5. Preformed packings (75)	Replace on sleeve (76).	
6. Preformed packings (71)	Replace.	
7. Servo piston valve, piston, sleeve and cylinder assembly (72)	a. Install through bottom of governor plate.  b. Aline notch in cylinder (73) with bolt hole in governor plate (90).	
8. Spring that returns lever (81)	Install on lever (81).	
9. Lever (81)	a. Position in bracket (83).  b. Install pin (82).	

Go on to Sheet 10

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 10 of 12)

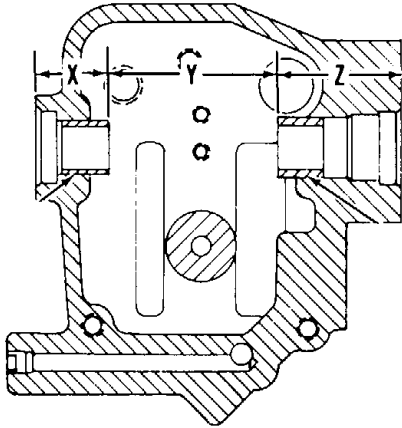
LOCATION/ITEM	ACTION	REMARKS
10. Pin (77)	Install in bracket (83) with grooves engaged in outer lever (81).	
11. Bracket (83)	a. Position on governor plate with pin (77) engaged in servo piston assembly. b. Secure with capscrews and locks.	
12. Flyweight and gear assembly	a. Install on servo piston assembly (72). b. Install lock (95).	
13. Race (66), bearing (67) and race (68)	Install on sleeve (65).	
14. Ring (69)	Install under race (68) on sleeve.	
15. Top washer (63), spring (64) and bottom washer (63)	Position on top of sleeve and valve assembly (65).	
16. Governor bolt (62)	Install in seat (60).	
17. Seat (60) and bolt	Position on sleeve (65) with hole in seat (60) aligned with hole in sleeve.	
18. Ring (59)	Install and hold in position with pin (61).	

TA099018

Go on to Sheet 11

GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 11 of 12)

LOCATION/ITEM	ACTION	REMARKS
19. Spring washer (10)	Install over governor bolt (62).	
	<p><b>NOTE</b>  <b>Concave side of washers should face up.</b></p>	
20. Spring (12), spring washer (10), flat washer and spring washer (10)	Install.	
21. Seat (11)	Install.	
22. Bearing (4)	Using drive plate, install until dimension (Z) is 1.704-1.712 in. (43.28-43.48 mm).	 <p>The diagram shows a cross-section of a governor housing. Dimension X is the distance from the left edge to the center of a bearing. Dimension Y is the distance between the centers of two bearings. Dimension Z is the distance from the center of a bearing to the right edge of the housing.</p>
23. Bearing (7)	<p>a. Using drive plate, install until dimension (X) is 0.993-1.003 in. (25.22-25.48 mm).</p> <p>b. Dimension (Y) must be 2.380-2.390 in. (60.45-60.71 mm).</p>	
24. Lip type seals (2) in governor housing (5)	Install.	
	<p><b>NOTE</b>  <b>Lip must point toward inside of housing.</b></p>	

TA099228

Go on to Sheet 12

**GOVERNOR DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 12 of 12)

LOCATION/ITEM	ACTION	REMARKS
25. Lever (29)	Position in governor housing.	
26. Shaft (24)	Install.	
27. Lock (21) band assembly (25) and capscrew that secure lever (29) to shaft (24)	Install.	
28. Insulator (105), load stop (104), shim (103), retainer (102), contact (101), insulator (100), retainer (99), lock (98) and capscrews (97)	Install in governor housing.	
29. High idle screw (35) and low idle screw (36)	Install.	
30. Governor	a. Install  b. Adjust.	See Governor Removal Installation, page 3-79, and Governor Adjustment, page 3-102.

**End**

**THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION**

**(Sheet 1 of 7)**

This task covers: Replacement and adjustment of governor pedal.

INITIAL SETUP

Test Equipment

Steel rule

Protractor

Special Tools

None

Materials/Parts

Governor pedal and linkage

Seal

Personnel Required

One mechanic

References

None

Troubleshooting Reference

Pages 2-10, 2-12

Equipment Condition

Engine OFF

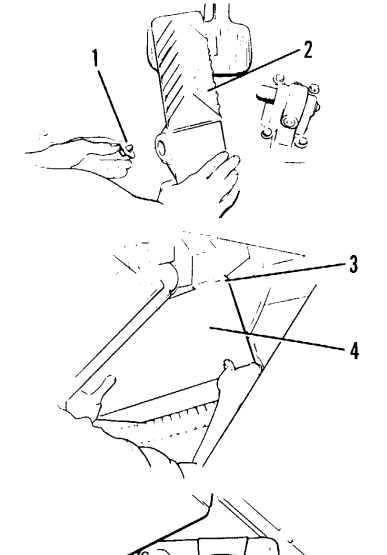
General Safety Instructions

Main disconnect switch OFF

**Go on to Sheet 2**

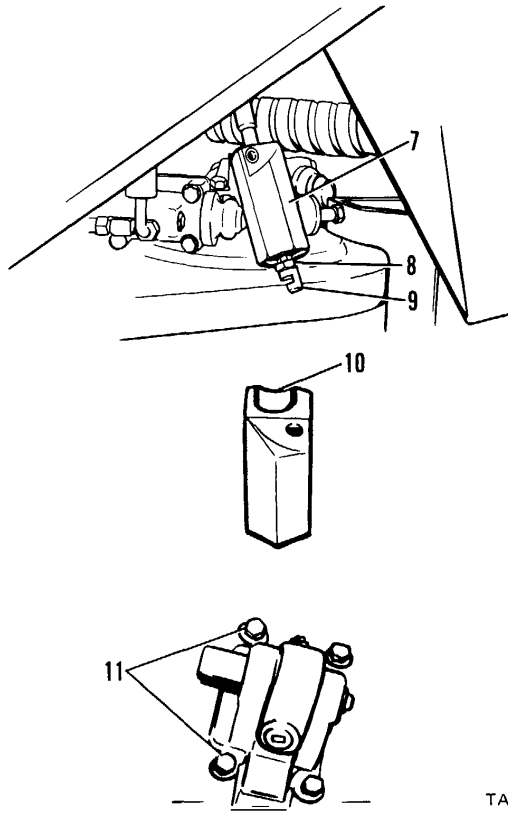
**THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION (CONT)**

(Sheet 2 of 7)

LOCATION/ITEM	ACTION	REMARKS
<b>REMOVAL</b>		
1. Capscrew and washer (1)	Remove.	
2. Treadle (2)	Remove.	
3. Four capscrews, nuts, and lockwashers (3) holding governor linkage housing (4).	Remove.	
4. Governor linkage housing (4)	Remove.	
5. Capscrew and nut (5) on cable housing	Remove.	
6. Cable housing (6)	Unscrew and slide up on cable.	
7. Cable	Disconnect from linkage housing (7).	

**THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION (CONT)**

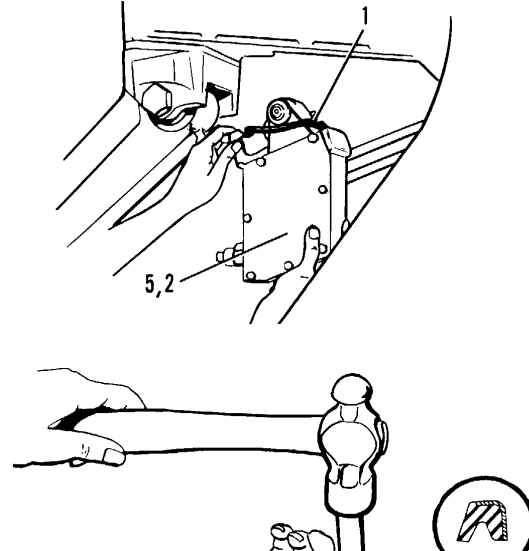
(Sheet 3 of 7)

LOCATION/ITEM	ACTION	REMARKS
8. Nut (8)	Loosen and remove coupler (9) from cable.	
9. Cable housing (6) and nut (8)	Remove.	
10. Seal (10)	Remove from cable housing (6).	
11. Four capscrews and lockwashers (11), inside cab.	Remove.	
<p><b>NOTE</b> Housing will fall out when capscrews are removed.</p>		

TA099020

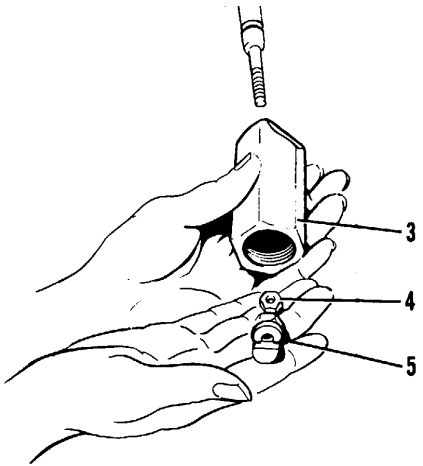
THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION (CONT)

(Sheet 4 of 7)

LOCATION/ITEM	ACTION	REMARKS
12. Linkage housing (5) and gasket	Remove.	
<b>INSTALLATION</b>		
1. Gasket (1) and linkage housing (2)	Install and fasten with capscrews.	
2. Seal	Install in cable housing (3)	
	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Install seal with lip of seal toward inside of housing till seal is even with face of housing.</b></p>	

THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION (CONT)

(Sheet 5 of 7)

LOCATION/ITEM	ACTION	REMARKS
3. Cable housing (3) coupler (5).	Install on cable with nut (4) and cable	
4. Coupler (5)	Connect to plunger (6).	
5. Cable housing (3)	Install in linkage housing.	

**NOTE**

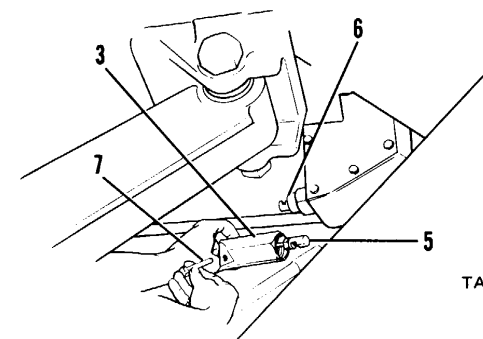
If the hole in the cable housing is not in alignment with the groove in the cable, then remove the cable housing and adjust the coupler on the cable. Tighten the nut on the cable and again connect the coupler to the plunger and install the cable housing.

6. Capscrew (7)

Install through cable housing (3) and install nut.

**NOTE**

Bolt (7) must go through groove in the cable.



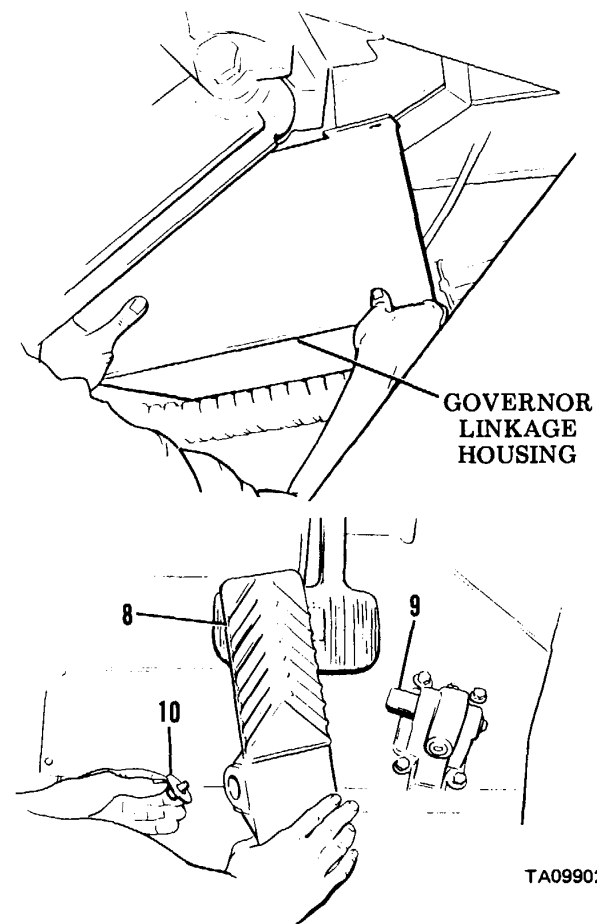
TA099022

Go on to Sheet 6

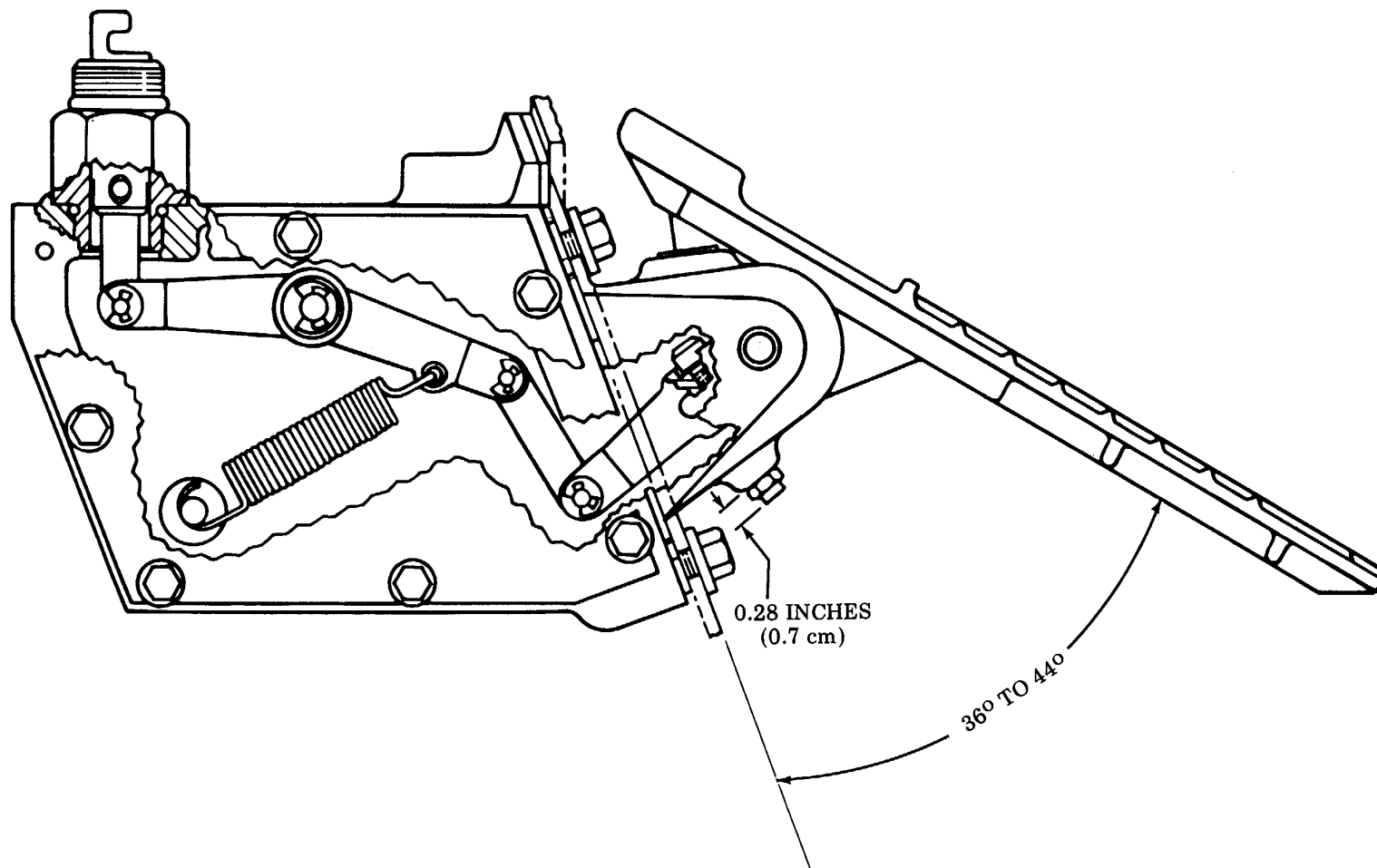
THROTTLE CONTROL (GOVERNOR PEDAL) REMOVAL/INSTALLATION (CONT)

(Sheet 6 of 7)

LOCATION/ITEM	ACTION	REMARKS
7. Governor linkage housing	Lift into position and install four capscrews, lockwashers, and nuts.	
8. Treadle (8)	Install on splined shaft (9).  <b>NOTE</b> Install treadle so it makes an angle of 36 -44 degrees with respect to floor. (See page 3-101.)	
9. Bolt and washer (10)	Install in end of shaft (9).	



TA099023



TA099024

End

**GOVERNOR ADJUSTMENTS**

(Sheet 1 of 3)

This task covers: Adjustment of governor.

INITIAL SETUPTest Equipment

Tachometer, calibrated

Special Tools

None

Materials/Parts

None

Personnel Required

Two mechanics

References

Governor assembly/disassembly,  
page 3-83.

Troubleshooting Reference

Pages 2-11, 2-12

Equipment Condition

As stated in procedure

General Safety Instructions

Be careful around running engines.  
No smoking.

**Go on to Sheet 2**

GOVERNOR ADJUSTMENT (CONT)

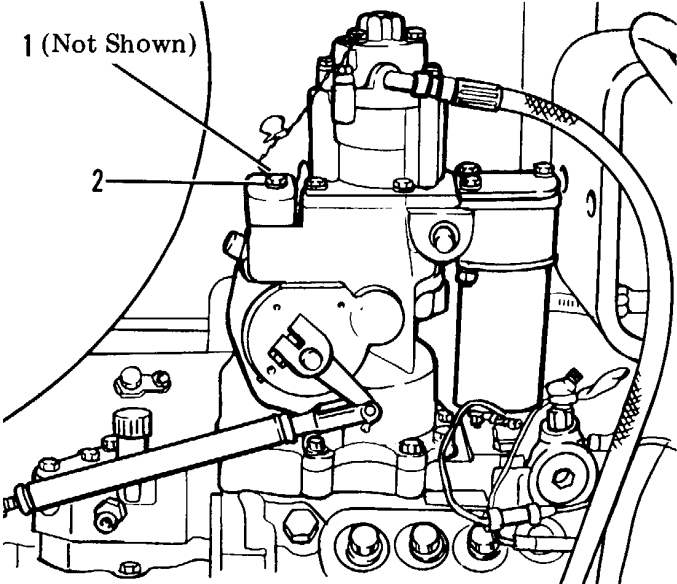
(Sheet 2 of 3)

LOCATION/ITEM	ACTION	REMARKS
<p>1. Engine</p> <p>2. Tachometer</p>	<p style="text-align: center;"><b>NOTE</b> Use an accurate tachometer to check engine RPM.</p> <p style="text-align: center;"><b><u>WARNING</u></b> Be careful when working around an engine that is running.</p> <p>Start.</p> <p>Position on shaft of tachometer drive:</p> <p>a. High idle rpm 2320.</p> <p>b. Low idle rpm 700.</p> <p style="text-align: center;"><b>NOTE</b> If rpms aren't right, go on to step 3 to adjust.</p>	<p>See TM 10-3930-641-10</p> <p>Man in cab needed to move governor lever from low idle to high idle positions for this adjustment.</p>

Go on to Sheet 3

**GOVERNOR ADJUSTMENT (CONT)**

(Sheet 2 of 3)

LOCATION/ITEM	ACTION	REMARKS
3. Adjustment screw (1)	Turn to change low idle rpm.	
4. Adjustment screw (2)	Turn to change high idle rpm.	
5. Step 2	Repeat after adjustments to check settings.	

3-104

!5

End

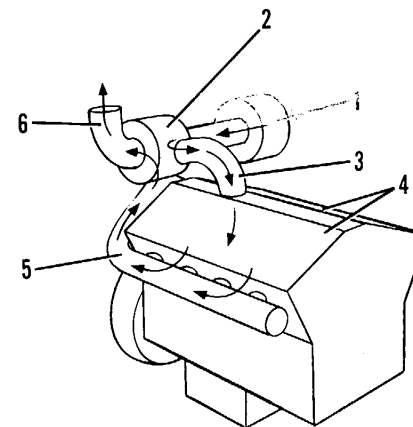
Section III. AIR INLET AND EXHAUST SYSTEM

**AIR INLET AND EXHAUST SYSTEM**

(Sheet 1 of 1)

Air inlet and exhaust system components are:

1. Air cleaner
  2. Turbocharger
  3. Inlet manifold
  4. Cylinder heads
  5. Exhaust manifolds
  6. Exhaust pipe and muffler
1. AIR CLEANER. A dual element, dry type. Outside air is drawn through the filter elements by a vacuum created in the turbocharger. When one, or both, of the elements get clogged, a "high vacuum" switch in the air cleaner housing turns on the PLUGGED AIR FILTER indicator on the instrument panel.
  2. TURBOCHARGER. Pulls in the clean air from the air cleaner and compresses it. The turbocharger is driven by the engine exhaust gases; the exhaust gases turn the turbine wheel, which causes the compressor wheel to turn. The compressed air then goes to the inlet manifold of the engine. As the load on the engine goes up, more fuel is supplied to the engine. This causes more exhaust which turns the turbocharger faster supplying the engine with additional air.
  3. INLET MANIFOLD. Mounted on top of the engine the manifold distributes the compressed air from the turbocharger. There are eight passages, one going to each cylinder.
  4. CYLINDER HEADS. Contains the valve components necessary for the engine to intake oil and exhaust burnt fuel. For each cylinder there are two intake valves and two exhaust valves. The fuel injection nozzles are located in the cylinder heads to inject the fuel into the cylinders.
  5. EXHAUST MANIFOLDS. Located on each side of the engine, the manifolds are joined together to deliver all the engine exhaust gases through the turbocharger.
  6. MUFFLER AND EXHAUST PIPE. Connects to the outlet of the turbocharger to quiet and carry the exhaust gases away from the engine compartment.



TA099026  
End

## AIR INLET AND EXHAUST SYSTEM

This section covers maintenance of these air inlet and exhaust system components for direct support maintenance personnel:

- a. Turbocharger
- b. Exhaust manifold

**LIST OF TASKS****(Sheet 1 of 1)**

TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Turbocharger removal/installation	3-107	2-12
2	Turbocharger disassembly/assembly	3-112	2-8
3	Turbocharger oil lines removal/installation	3-117	2-8
4	Turbocharger oil supply line removal/ installation	3-120	2-8
5	Turbocharger oil return line removal/ installation	3-122	2-8
6	Turbocharger air lines removal/installation	3-124	2-8
7	Turbocharger air lines inspection	3-128	2-18
8	Exhaust manifold removal/installation	3-131	2-8

**End**

**TURBOCHARGER REMOVAL/INSTALLATION**

(Sheet 1 of 5)

This task covers: The removal and installation of the turbocharger.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-12

Special Tools

Hoist

Personnel Required

Two mechanics

Equipment Condition

Engine OFF

References

Muffler removal/installation,  
TM 10-3930-641-20

Hood removed

Muffler removed

Air cleaner removal/installation,  
TM 10-3930-641-20

Air cleaner removed

General Safety Instructions

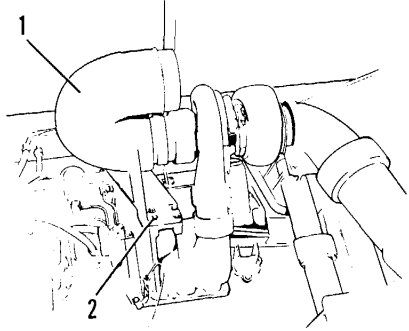
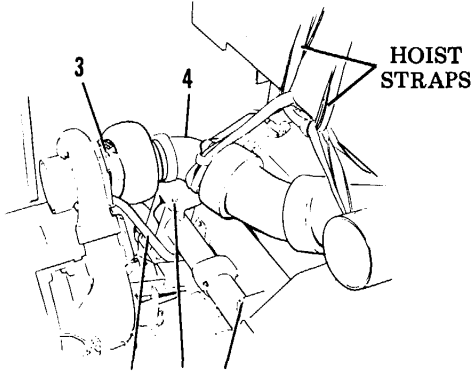
Hood removal/installation,  
TM 10-3930-641-20

Main disconnect switch OFF

**Go on to Sheet 2**

**TURBOCHARGER REMOVAL/INSTALLATION (CONT)**

(Sheet 2 of 5)

LOCATION/ITEM	ACTION	REMARKS
<p><b>REMOVAL</b></p>		
<p>1. Capscrews (2), elbow (1)</p>	<p>Remove from turbocharger.</p>	
<p>2. Exhaust elbow (4)</p>	<p>a. Fasten to hoist.</p>	
	<p>b. Remove capscrews (5) and (7)</p>	
	<p>c. Remove elbows and coupling as unit.</p>	
	<p><b>NOTE</b></p>	
	<p><b>Elbow and coupling unit weighs 102 lb.</b></p>	
	<p><b>(46 kg).</b></p>	

10039027

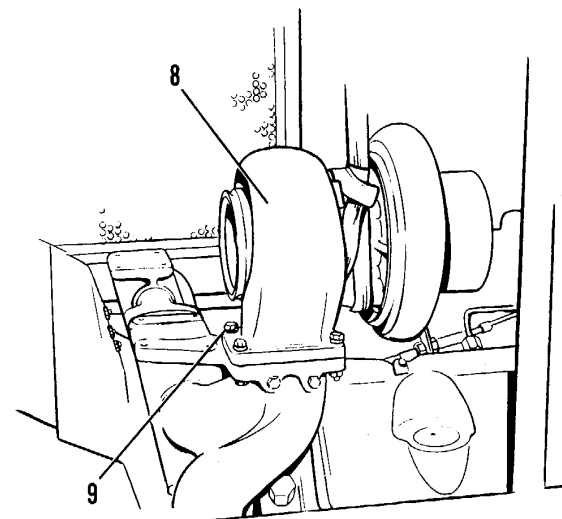
Go on to Sheet 3

**TURBOCHARGER REMOVAL/INSTALLATION (CONT)**

(Sheet 3 of 5)

LOCATION/ITEM	ACTION	REMARKS
3. Oil supply line (3)	Disconnect from top of turbocharger and cylinder block.	
4. Capscrew and clip that secure oil supply line	Remove.	
5. Oil supply line	Remove.	
6. Oil drain line (6)	Remove.	
7. Turbocharger (8)	Fasten to hoist.	
8. Capscrew (9) and nuts that secure turbocharger to exhaust manifold	Remove.	
9. Turbocharger (8)	Remove.	

**NOTE**  
**Turbocharger weighs 56 lb. (25 kg).**

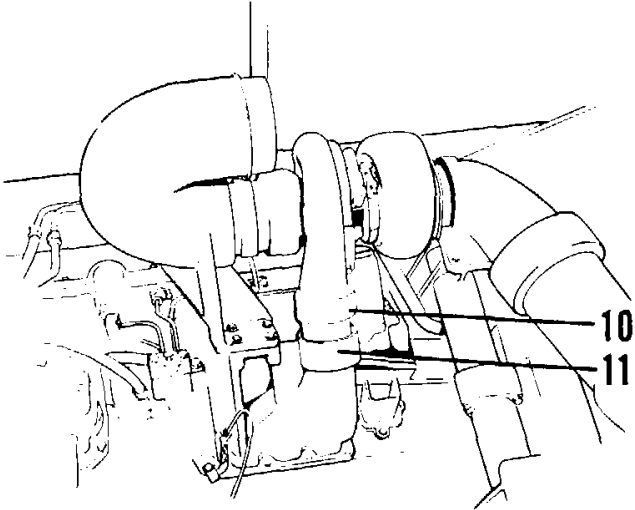


TA099028

Go on to Sheet 4

**TURBOCHARGER REMOVAL/INSTALLATION (CONT)**

(Sheet 4 of 5)

LOCATION/ITEM	ACTION	REMARKS
<b>INSTALLATION</b>		
1. Pipe (10)	a. Lubricate seals with clean SAE 30 oil.	
	b. Install in turbocharger.	
2. Turbocharger (8)	Position on engine.	
3. Gaskets between turbocharger and flywheel housing.	a. Lubricate with anti-seize compound.	
	b. Tighten to a torque of 36-44 lb. ft. (49-59 N-m).	
4. Capscrews that secure turbocharger	Install.	
5. Oil drain line (6)	Install.	
6. Oil supply line (3) and gasket	Install.	

1A099029

Go on to Sheet 5

## TURBOCHARGER REMOVAL/INSTALLATION (CONT)

(Sheet 5 of 5)

LOCATION/ITEM	ACTION	REMARKS
7. Exhaust elbows (4)	Position on engine.	
8. Capscrews and nuts that secure exhaust elbows	a. Lubricate with anti-seize compound.  b. Install.  <p style="text-align: center;"><b>NOTE</b></p> <b>If bracket was removed from exhaust elbow,</b> be sure nuts are tightened to a torque of 17-23 lb. ft. (23-31 N-m).	
9. Seals for pipe (11)	Lubricate with clean SAE 30 oil.	
10. Elbow (1)	a. Install on pipe (11).	
b. Secure with capscrews and washers.		

End

**TURBOCHARGER DISASSEMBLY/ASSEMBLY**

(Sheet 1 of 5)

This task covers: Disassembly of turbocharger.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

None

Special Tools

None

Personnel Required

One mechanic

Equipment Condition

Turbocharger removed

Engine OFF

References

Turbocharger removal/installation,  
page 3-107.

General Safety Instructions

Main disconnect switch OFF

**Go on to Sheet 2**

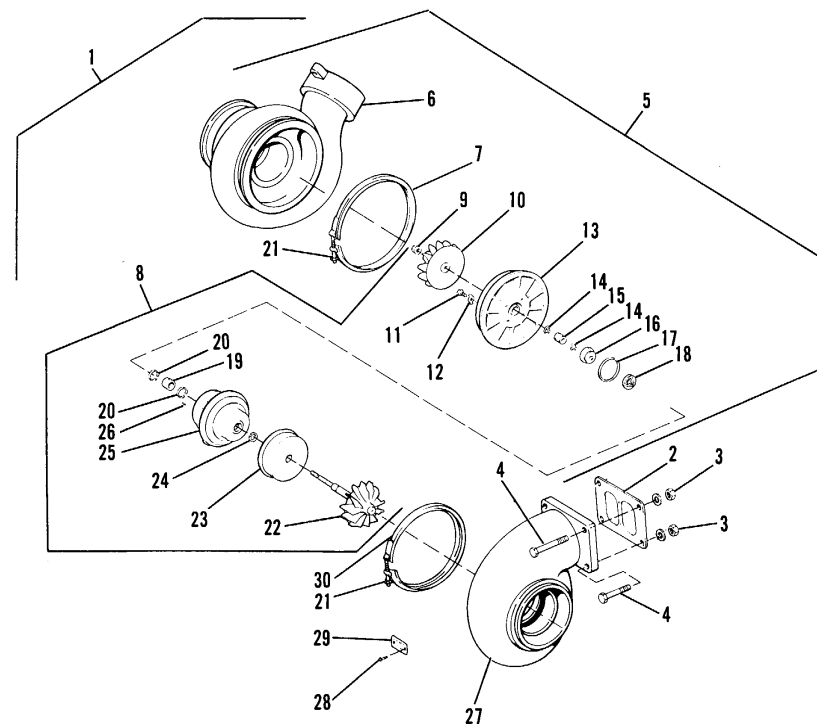
**TURBOCHARGER DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">DISASSEMBLY</div>		
1. V-Band coupling (7)	Remove from compressor housing (6).	
	<p>NOTE</p> <p>Use a grease pencil to make a line across the parts for easy reassembly later.</p>	
2. "V"-Band coupling (30)	Remove from turbine housing (27).	
3. Nut (9)	Remove	Disassemble center assembly.
4. Compressor wheel (10)	Remove.	
	<p>NOTE</p> <p>Use press to remove wheel.</p>	
5. Backplate (13)	Remove capscrew (11), lockplate (12) and remove backplate.	
6. Seal ring (14) and seal	Remove and remove thrust spacer (15), ring (14) from backplate (13).	

Go on to Sheet 3

**TURBOCHARGER DISASSEMBLY/ASSEMBLY (CONT)**

1. Turbocharger, basic
2. Gasket
3. Locknut
4. Capscrew
5. Cartridge assembly
6. Compressor housing
7. V-band coupling
8. Wheel assembly
9. Nut
10. Compressor wheel
11. Capscrew
12. Lockplate
13. Backplate
14. Seal ring
15. Thrust spacer
16. Thrust collar
17. Seal ring
18. Thrust bearing
19. Bearing kit
20. Retaining ring
21. Locknut
22. Shaft and wheel assembly
23. Turbine wheel shroud
24. Piston ring
25. Center housing assembly
26. Pin
27. Turbine housing
28. Drive screw
29. Nameplate
30. V-band coupling



TA099030  
Go on to Sheet 4

**TURBOCHARGER DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
7. Thrust collar (16)	Remove, and take off thrust bearing (18).	
8. Retaining ring (20)	Remove.	
9. Retaining ring (20) and bearing (19)	Remove from center housing assembly (25).	
10. Piston ring (24)	Remove.	
11. Turbine wheel shroud (23)	Remove.	
<div style="border: 1px solid black; padding: 2px; display: inline-block;">ASSEMBLY</div>	<p>NOTE</p> <p>Use the grease pencil marks to line up the parts correctly.</p>	
1. Turbine wheel shroud (23)	Install on shaft and wheel assembly (22).	
2. Piston ring (24)	Insert in center housing assembly (25).	
3. Retaining ring (20)	Place in center housing assembly and insert bearing (19) and the other retaining ring (20).	

Go on to Sheet 5

**TURBOCHARGER DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
4. Snap ring (14), thrust spacer (15) and snap ring (14)	Install in backplate (13).	
5. Thrust collar (16) and thrust bearing (18)	Install in center housing assembly (25).	
6. Seal ring (17)	Install in backplate (13).	
7. Capscrew (11) and lockplate (12)	Install in backplate (13).	
8. Backplate assembly	Place on shaft of shaft and sheel assembly (22), against center housing assembly (25).	
9. Center assembly	Secure to turbine housing using V-band coupling (30).	
10. Compressor housing (6)	Secure to assembly using V-band coupling (7).	
	<div style="border: 1px solid black; padding: 5px; display: inline-block;">WARNING</div>	
	Unit must spin freely before installation.	

**TURBOCHARGER OIL LINES REMOVAL/INSTALLATION**

This task covers: Removal and installation of turbocharger oil lines.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-8

Equipment Condition

Engine OFF

Special Tools

None

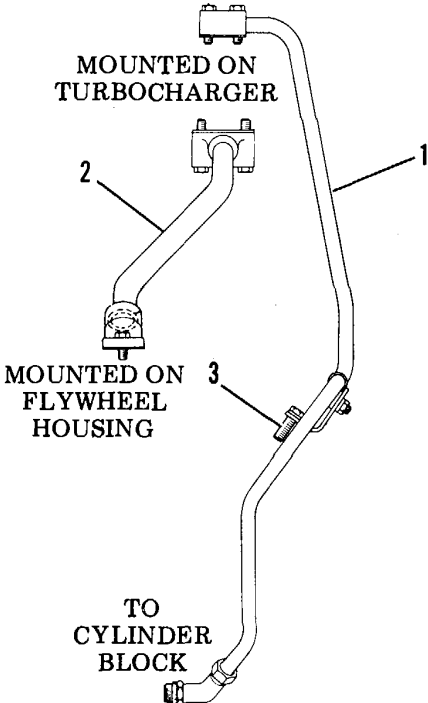
Personnel Required

One mechanic

References

Muffler removal/installation,  
TM 10-3930-641-20.  
Air cleaner removal/installation,  
TM 10-3930-641-20.

General Safety Instructions  
Main disconnect switch OFF

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">REMOVAL</div> <ol style="list-style-type: none"> <li>1. Muffler</li> <li>2. Air cleaner</li> <li>3. Oil supply line (1) at top of turbocharger and cylinder block</li> <li>4. Capscrew (3) that secures oil line (3)</li> <li>5. Oil drain line (2)</li> </ol>	<p style="text-align: center;">NOTE</p> <p style="text-align: center;">Tag all lines before disconnecting.</p> <p>Remove.</p> <p>Disconnect.</p> <p>Remove.</p> <ol style="list-style-type: none"> <li>a. Remove.</li> <li>b. Remove oil line (1).</li> </ol> <p>Disconnect from turbocharger and flywheel housings.</p>	<p>See TM 10-3930-641-20.</p> <p>See TM 10-3930-641-20.</p> <div style="text-align: center;">  <p>MOUNTED ON TURBOCHARGER</p> <p>MOUNTED ON FLYWHEEL HOUSING</p> <p>TO CYLINDER BLOCK</p> </div>
	3-118	<p>TA099031 Go on to Sheet 3</p>

**TURBOCHARGER OIL LINES REMOVAL AND INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION		
1. Oil drain line (2) from turbocharger to flywheel housing.	Connect.	
2. Oil supply line (1) from top of turbocharger and cylinder block	a. Connect.	
	b. Secure with clip and capscrew (3).	
3. Air cleaner assembly	Install.	See TM 10-3930-641-20.
4. Muffler	Install.	See TM 10-3930-641-20.

**TURBOCHARGER OIL SUPPLY LINE REMOVAL/INSTALLATION**

This task covers: Removal and installation of turbocharger oil supply line.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Gasket

Seal

Bucket or pan

Troubleshooting Reference

None

Equipment Condition

Engine OFF

Parking brake control OUT

Special Tools

None

Personnel Required

One mechanic

References

Torque Values Chart, Page D-1.

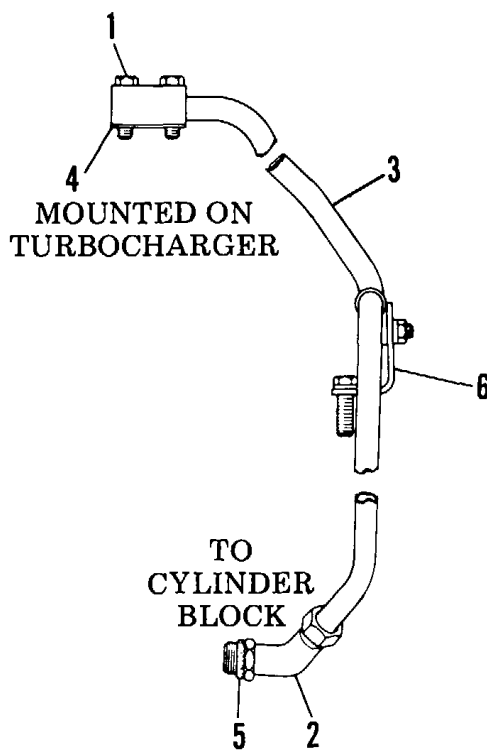
General Safety Instructions

Use caution with lines.  
Hot oil causes burns.

Protect parts of vehicle from oil spillage.  
Catch oil in small bucket or pan.

Go on to Sheet 2

**TURBOCHARGER OIL SUPPLY LINES REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">REMOVAL</div> <ol style="list-style-type: none"> <li>1. Capscrews (1).</li> <li>2. Elbow (2)</li> <li>3. Line (3)</li> <li>4. Gasket (4)</li> <li>5. Seal (5)</li> </ol>	<p>Remove.</p> <p>Loosen.</p> <p>Separate from clip (6) and remove.</p> <ol style="list-style-type: none"> <li>a. Clean gasket material from turbocharger.</li> <li>b. Install new gasket.</li> <li>a. Check for damage.</li> <li>b. Replace if necessary.</li> </ol>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">INSTALLATION</div> <ol style="list-style-type: none"> <li>1. Line (3)</li> <li>2. Elbow (2)</li> <li>3. Capscrews (1)</li> </ol>	<p>Position between turbocharger and cylinder block.</p> <p>Install.</p> <p>Install and tighten.</p>	<p>See Torque Limits Chart, page D-1.</p> <p style="text-align: right;">TA099032 End</p>

**TURBOCHARGER OIL RETURN LINE REMOVAL/INSTALLATION**

(Sheet 1 of 2)

This task covers: Removal and installation of turbocharger oil return line and gasket.

INITIAL SETUPTest Equipment

None

Materials/Parts

Gasket (2)

Seal (5)

Bucket or pan

Troubleshooting Reference

Page 2-8

Equipment Condition

Engine OFF and cooled.

Special Tools

None

Personnel Required

One mechanic

References

Torque Values Chart, page D-1.

General Safety Instructions

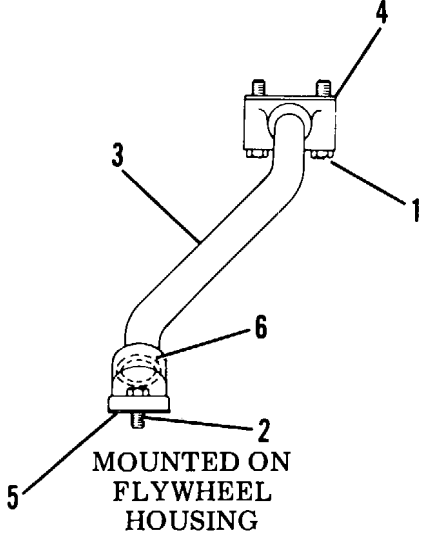
Use caution with lines.

Hot oil causes burns.

Protect parts of vehicle from spillage.

Catch oil in small pan or bucket.

**TURBOCHARGER OIL RETURN LINES REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;">REMOVAL</p> <p>1. Capscrews (1) 2. Capscrews (2) 3. Line (3)</p>	<p>Remove. Remove. Remove.</p>	 <p style="text-align: center;">MOUNTED ON FLYWHEEL HOUSING</p>
<p style="text-align: center;">INSTALLATION</p> <p>1. Gaskets (4, 5)</p>	<p>a. Clean gasket material from turbocharger and flywheel housing. b. Install new gaskets.</p>	
<p>2. Seal (6)</p>	<p>a. Check for damage. b. Replace if necessary.</p>	
<p>3. Line (3)</p>	<p>Position between flywheel housing and turbocharger.</p>	
<p>4. Capscrews (1)</p>	<p>Install and tighten.</p>	<p>See Torque Limits Chart, page D-1.</p>

**TURBOCHARGER AIR LINES REMOVAL/INSTALLATION**

This task covers: Removal and installation of turbocharger air lines.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-8

Equipment Condition

Engine cool

Special Tools

Hoist

Personnel Required

One mechanic

References

Turbocharger removal/installation,  
page 3-107.

General Safety Instructions

Main disconnect switch OFF.

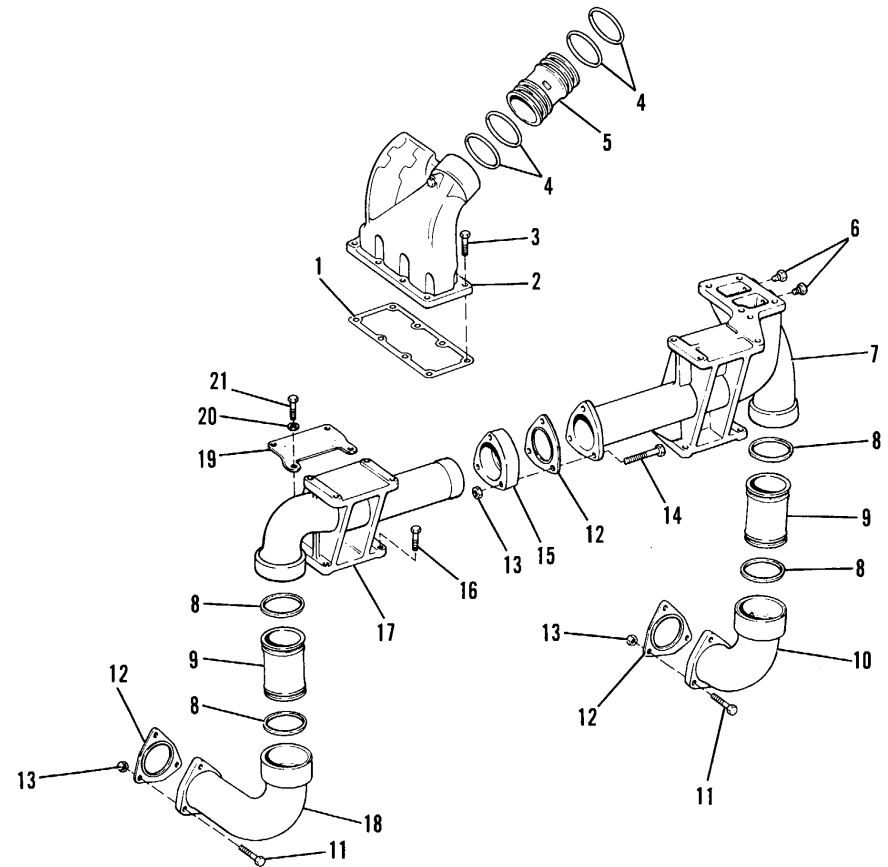
Go on to Sheet 2

**TURBOCHARGER AIR LINES REMOVAL AND INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Turbocharger	Remove.	See page 3-107.
2. Hoist	Fasten to air lines group.	See page 3-126.
3. Capscrews (16) that hold air lines to Engine	Remove.	
4. Manifolds (17) and (7), Couplings (9)	Remove with hoist. Remove.	
5. Seals (8)	Remove.	
6. Capscrews (11), nuts (13) and elbows (10) and (18)	Remove.	
7. Gasket (12)	Remove.	
8. Preformed packing (4)	Remove.	
9. Pipe (5)	Remove.	
10. Elbow (2), gasket for manifold (17)	Remove by: a. Remove capscrews (3) b. Disconnect ether starting aid line. c. Remove elbow (2) and gasket (1).	See ether starting aid kit removal/installation, TM 10-3930-641-10.
<b>3-125</b>		Go on to Sheet 3

**TURBOCHARGER AIR LINES REMOVAL AND INSTALLATION (CONT)**

1. Gasket
2. Elbow
3. Capscrew
4. Preformed packing
5. Air pipe
6. Pipe plug
7. Turbocharger mounting manifold
8. Metal seal ring
9. Exhaust coupling
10. Exhaust elbow
11. Capscrew
12. Manifold gasket
13. Nut
14. Capscrew
15. Collar
16. Capscrew
17. Crossover manifold
18. Exhaust elbow
19. Bracket assembly
20. Flat washer
21. Capscrew



TA099034  
Go on to Sheet 4

**TURBOCHARGER AIR LINES REMOVAL AND INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION		
1. Gasket (12) and elbows (10) and (18)	Install and secure with capscrews and nuts.	
2. Seals (8)	Install.	
3. Couplings (9)	Install.	
4. Manifold (17) and (7)	a. Install with hoist.	
	b. Secure with capscrews (16).	
5. Gasket (1) and elbow (2)	Install and secure with capscrews (3).	
6. Pipe (5) and preformed packing (4)	Install.	
7. Turbocharger	Install.	See page 3-107.
	<b>3-127</b>	End

**TURBOCHARGER AIR LINES INSPECTION**

This task covers: Inspection of turbocharger air lines.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

Page 2-18

Equipment Condition

Engine running

Special Tools

None

Personnel Required

Two mechanics

References

None

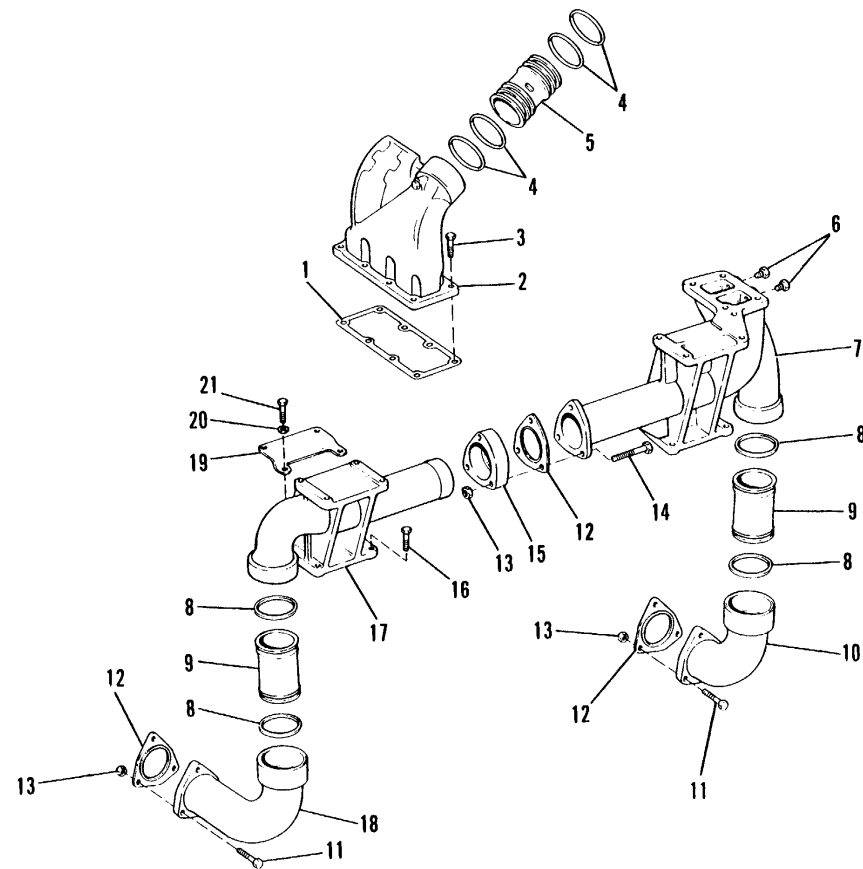
General Safety Instructions

Be careful around running engine.

Go on to Sheet 2

**TURBOCHARGER AIR LINES INSPECTION (CONT)**

1. Gasket
2. Elbow
3. Capscrew
4. Preformed packing
5. Air pipe
6. Pipe plug
7. Turbocharger mounting manifold
8. Metal seal ring
9. Exhaust coupling
10. Exhaust elbow
11. Capscrew
12. Manifold gasket
13. Nut
14. Capscrew
15. Collar
16. Capscrew
17. Crossover manifold
18. Exhaust elbow
19. Bracket assembly
20. Flat washer
21. Capscrew



TA099035  
Go on to Sheet 3

**TURBOCHARGER AIR LINES INSPECTION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
1. Gaskets under manifolds (7) and (17) and gaskets (1) and (12)	<b>Check for leaks or damage at exhaust manifold mounts.</b>	If you find leaks or damage, replace gaskets.
2. Gaskets (12)	Check for leaks and damage at collar (15).	
3. Seal (4)	Check for leaks at pipe (5).	
4. Pipe (5), elbows (10, (18), and (2) connectors (9), manifolds (7) and (17),and collar (15).	<b>Check for looseness and leaks. Tighten if necessary.</b>	
		End
	3-130	

**EXHAUST MANIFOLD REMOVAL/INSTALLATION**

This task covers: Removal and installation of the exhaust manifold.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Exhaust manifold gasket

Anti-seize compound

Troubleshooting Reference

None

Equipment Condition

Engine off and cooled

Muffler removed

Special Tools

None

Personnel Required

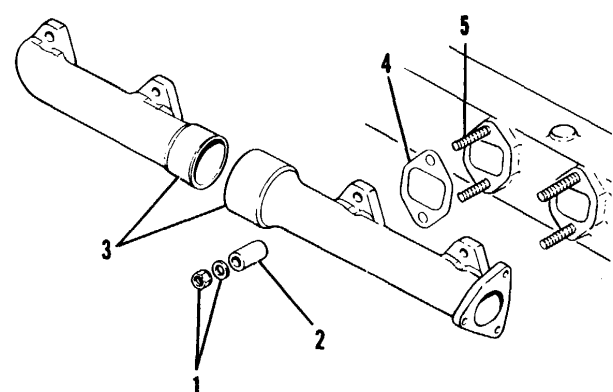
One mechanic

References

Muffler removal/installation,  
TM 10-3930-641-20.

General Safety Instructions

Main disconnect switch OFF

LOCATION/ITEM	ACTION	REMARKS								
<div style="border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 10px;"><b>REMOVAL</b></div> <ol style="list-style-type: none"> <li>1. Locknuts and washers (1)</li> <li>2. Spacers (2)</li> <li>3. Manifolds (3)</li> <li>3.1. Exhaust manifold studs (5).</li> <li>4. Gasket (4)</li> </ol>	<p>Remove eight (4 each side).</p> <p>Remove eight (4 each side).</p> <p>Remove.</p> <p>If one or more studs are broken, replace all studs. Disassemble and clean manifold. Apply antiseize compound (Item 20, Appendix B) to slip joints and studs.</p> <p>Replace.</p>									
<div style="border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 10px;"><b>INSTALLATION</b></div> <ol style="list-style-type: none"> <li>1. Gasket (4)</li> <li>2. Manifolds (3)</li> <li>3. Spacers(2)</li> <li>4. Locknuts and washers (1)</li> </ol>	<p>Install.</p> <p>Install.</p> <p>Install.</p> <ol style="list-style-type: none"> <li>a. Install thumb tight.</li> <li>b. Torque in sequence to 33 to 43 lb. ft. (45 to 59 N-m).</li> </ol>	<p style="text-align: center;">NOTE</p> <p style="text-align: center;">Apply anti-seize compound to threads.</p> <div style="border: 1px solid black; padding: 5px; text-align: center; margin: 10px auto; width: fit-content;"> <table style="border-collapse: collapse; width: 100%;"> <tr> <td style="border: 1px solid black; padding: 5px; text-align: center;">1</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">3</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">5</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">7</td> </tr> <tr> <td style="border: 1px solid black; padding: 5px; text-align: center;">4</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">2</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">8</td> <td style="border: 1px solid black; padding: 5px; text-align: center;">6</td> </tr> </table> </div> <p style="text-align: center;">TIGHTENING SEQUENCE</p>	1	3	5	7	4	2	8	6
1	3	5	7							
4	2	8	6							

Change 1 3-132

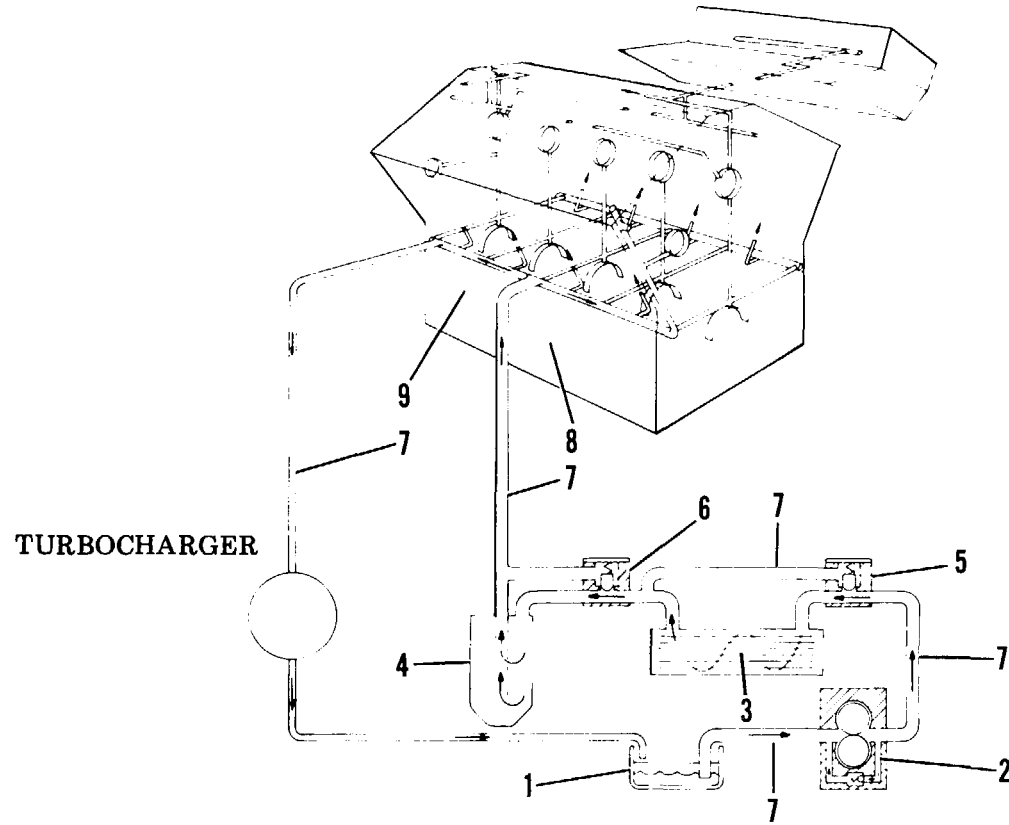
## Section IV. ENGINE LUBRICATION SYSTEM

**ENGINE LUBRICATION SYSTEM DESCRIPTION****(Sheet 1 of 2)**

Engine lubrication system consists of:

1. Oil pan
2. Oil pump
3. Oil cooler
4. Oil filters
5. Oil cooler bypass valve
6. Oil filter bypass valve
7. Oil lines and passages
8. Oil level switch
9. Oil pressure switch
1. OIL PAN. Seals the bottom of the engine and functions as a reservoir for storing engine lubricating oil. A plug is provided in the bottom for draining engine oil.
2. OIL PUMP. A gear type driven by a gear on the engine crankshaft. The pump's function is to supply the engine lubrication system with oil flow. Oil is pulled from the oil pan and sent to the oil cooler.
3. OIL COOLER. Reduces the temperature of the engine lubricating oil by transferring the heat of the oil to the engine cooling system.
4. OIL FILTERS. Removes foreign particles from the engine lubricating oil. A spin on type which are replaced when necessary.
5. OIL COOLER BYPASS VALVE. Provides immediate lubrication to the engine when the engine is cold. The valve also provides for continuous lubrication if the oil cooler has a restriction in it.
6. OIL FILTER BYPASS VALVE. Provides immediate lubrication to the engine, for a few seconds, when the engine is started cold. The valve also provides the engine with continuous lubrication when the filters are plugged.
7. OIL LINES AND PASSAGES. Provide the lubrication system with a means of oil flow.
8. OIL LEVEL SWITCH. Activates a warning light informing the operator that engine oil level is low.
9. OIL PRESSURE SWITCH. Activates a gauge informing the operator of the running engine oil pressure.

Go on to Sheet 2



- 1. Oil pan
- 2. Oil pump
- 3. Oil cooler

- 4. Oil filter
- 5. Oil cooler bypass
- 6. Oil filter bypass

- 7. Oil lines
- 8. Oil level switch
- 9. Oil pressure switch

ENGINE LUBRICATION SYSTEM

This section covers maintenance of these Engine lubrication components for direct support Maintenance personnel:

- a. Oil pan removal/installation
- b. Oil pump removal/installation
- c. Oil pump disassembly/assembly
- d. Oil filter support, adapter, and flange removal/installation

**LIST OF TASKS**

**(Sheet 1 of 1)**

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Oil filter support, adapter, and flange removal/ installation.	3-136	None
2	Oil pan removal/installation.	3-140	None
3	Oil pump removal/installation.	3-143	2-19
4	Oil pump disassembly/assembly.	3-146	2-19

3-135

End

**OIL FILTER SUPPORT, ADAPTER, AND FLANGE REMOVAL/INSTALLATION**

This task covers: Removal and installation of oil filter support, adapter and flanges.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Gasket

Troubleshooting Reference

None

Equipment Condition

Engine OFF and cooled.

Oil filter lines removed.

Oil filters removed.

Special Tools

None

Personnel Required

One mechanic

References

Torque values chart, page D-1

Oil filter lines removal and installation,  
TM 10-3930-641-20

Oil filter removal/installation,  
TM 10-3930-641-20

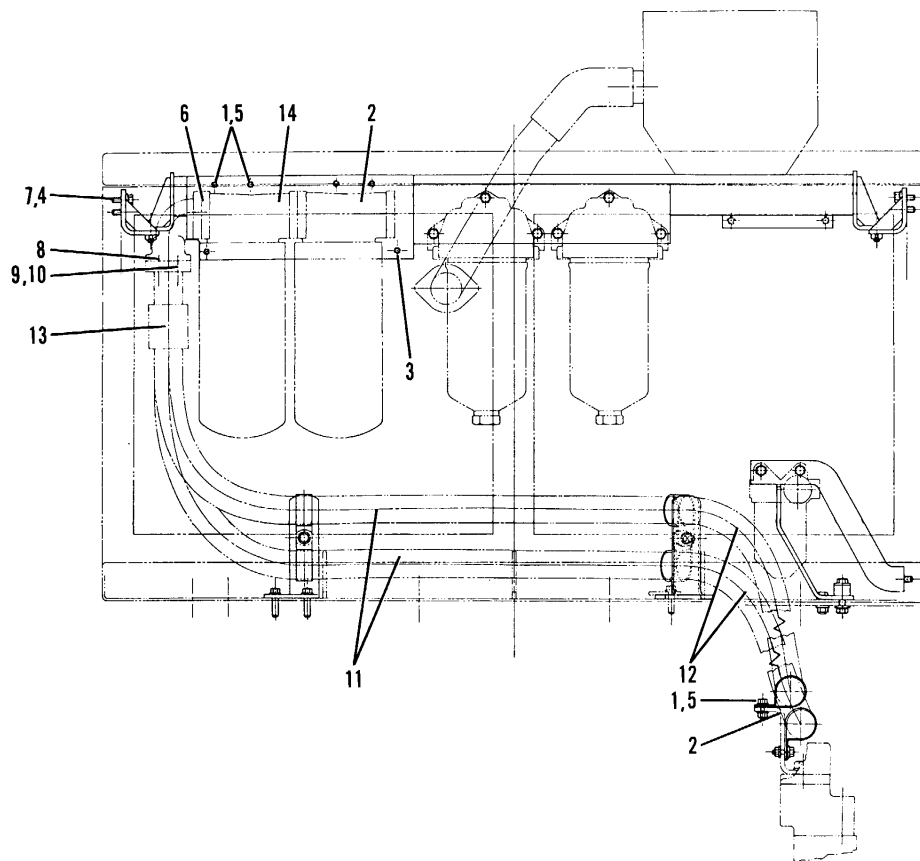
Engine lubrication, LO 10-3930-641-12

General Safety instructions

Be careful when replacing fittings that oil  
does not spill. Hot oil causes burns.

OIL FILTER SUPPORT, ADAPTER, AND FLANGE REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">REMOVAL</div>		
1. Capscrews (9) and washers (10)	Remove.	
2. Flanges (8)	a. Remove. b. Clean off gasket material. c. Remove seal (13).	Items 1 and 2 are at both filter and oil cooler ends of oil filter lines.
3. Capscrews (7) and washers (4)	Remove.	
4. Oil filter base	a. Remove. b. Clean off gasket material.	
5. Capscrews (1)	Remove.	
6. Adapter (14) and support (2)	Remove.	
	<p><b>3-137</b></p>	<p>Go on to Sheet 3</p>



- 1. Capscrew
- 2. Support
- 3. Capscrew
- 4. Washer
- 5. Nut
- 6. Gasket
- 7. Capscrew
- 8. Flange
- 9. Capscrew
- 10. Washer
- 11. Hose Assembly
- 12. Hose Assembly
- 13. Seal
- 14. Adapter

**OIL FILTER SUPPORT, ADAPTER, AND FLANGE REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">INSTALLATION</div>		
1. Adapter (14) and support (2)	Install with capscrews (1). Tighten capscrews.	See Torque Limits Chart, Page D-1.
2. Oil filter base	a. Install gaskets (6). b. Position base between adapter and support. c. Install and tighten capscrews (7) and washers (4) through base into adapter on support.	See Torque Limits Chart, Page D-1.
3. Flanges (8)	Install with capscrews (9) and washers (10). Tighten capscrews.	See Torque Limits Chart, Page D-1.
	<b>3-139</b>	End

**OIL PAN REMOVAL/INSTALLATION**

This task covers: Removal and installation of oil pan.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Oil gasket

Troubleshooting Reference

None

Equipment Condition

Engine OFF.

Front crankcase guard removed.

Special Tools

None

Personnel Required

One mechanic

References

Crankcase guard removal/installation,  
TM 10-3930-641-20.

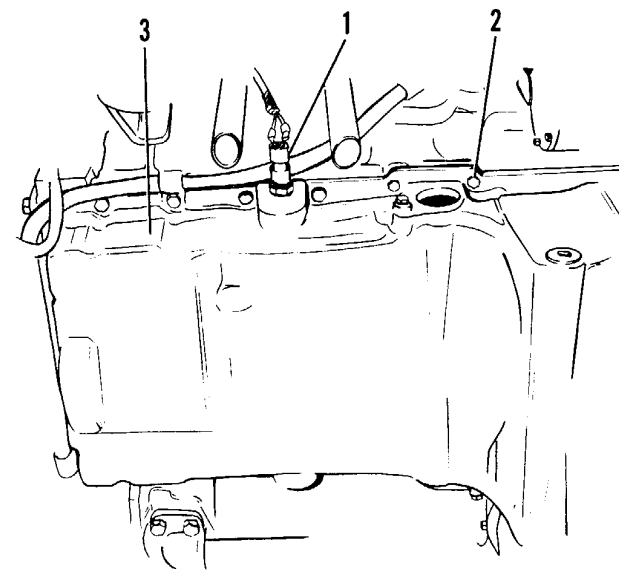
Drain engine oil, LO 10-3930-641-12.

General Safety instructions

Main disconnect switch OFF.

**OIL PAN REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Crankcase guard (front)	Remove.	See TM 10-3930-641-20.
2. Crankcase	Drain.	See TM 10-3930-641-20, LO 10-3930-641-12
3. Oil pan capscrews (2)	a. Label.	
	b. Disconnect	
4. Oil pan capscrews (2)	Remove	
5. Oil pan (3) and pan gasket	Remove	



Go on to Sheet 3

OIL PAN REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">INSTALLATION I</div>		
1. Oil pan gasket	Put in position. <p style="text-align: center;">NOTE</p> Apply clean grease to gasket surface to hold gasket in place.	
2. Two 3/8-16 NC x 4 guide bolts (1)	Install at opposite ends in cylinder block. <p style="text-align: center;">NOTE</p> The guide bolts will insure correct alinement of pan during installation.	
3. Oil pan (2)	Put in position and install half of the oil pan cap screws.	
4. Guide bolts	Remove.	
5. Oil pan cap screws	Install remaining cap screws and tighten securely.	
6. Oil level switch (3) leads	Connect.	
	<p><b>3-142</b></p>	

TA099040  
End

**OIL PUMP REMOVAL/INSTALLATION**

**(Sheet 1 of 3)**

This task covers: Removal and installation of engine oil pump.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-19

Equipment Condition

Oil pan removed.

Engine OFF.

Special Tools

None

Personnel Required

One mechanic

References

Oil pan removal/installation, page 3-140.

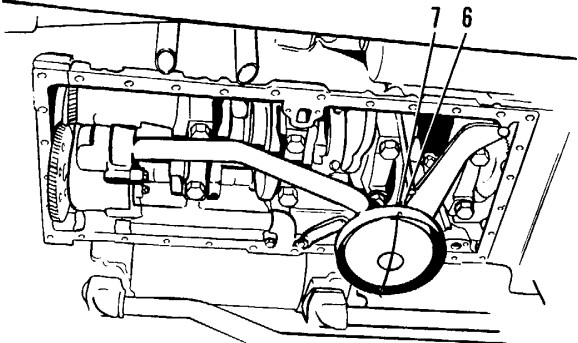
General Safety Instructions

Main disconnect switch OFF.

Go on to Sheet 2

**OIL PUMP REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; margin-bottom: 10px; text-align: center;"><b>REMOVAL</b></div> <ol style="list-style-type: none"> <li>1. Capscrews (1) (2) (3)</li> <li>2. Oil suction bell (4) supply tube, bracket</li> <li>3. Oil outlet tube (5)</li> <li>4. Oil pump capscrews (6)</li> <li>5. Oil pump (7)</li> </ol>	<p>Remove.</p> <p>Remove as a unit.</p> <p>Remove.</p> <p>Remove.</p> <p>Remove.</p> <p style="text-align: center;"><b>NOTE</b></p> <p style="text-align: center;"><b>Mark capscrews and location for correct installations.</b></p>	<p style="text-align: right;">TA099041</p> <p style="text-align: right;">Go on to sheet 3</p>

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center; border: 1px solid black; padding: 2px;"><b>INSTALLATION</b></p> <p>1. Oil pump (7)</p> <p>2. Oil outlet tube (5), suction bell (4), supply tube, bracket.</p> <p>3. Capscrews (1), (2), (3)</p>	<p>Put in position on engine and secure with the three capscrews (6).</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Length of capscrews is important. Be sure and install correctly.</b></p> <p>Install.</p> <p style="text-align: center;"><b>NOTE</b></p> <p>Put clean engine oil on all O-ring seals before outlet and suction tubes are installed.</p> <p>Install.</p>	 <p style="text-align: right;">TA099042</p> <p style="text-align: right;">End</p>

**OIL PUMP DISASSEMBLY/ASSEMBLY**  
**1 of 5)**

(Sheet

This task covers: Disassembly and assembly of oil pump.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Refer to page 3-149

Troubleshooting Reference

Page 2-19.

Equipment Condition

Oil pump removed.

Special Tools

Puller

Personnel Required

One mechanic

References

Oil pan removal/installation, page 3-140.

Oil pump removal/installation page 3-143.

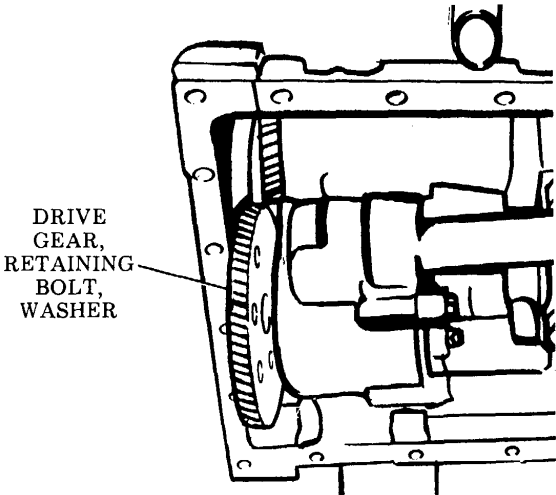
General Safety Instructions

Main disconnect switch OFF.

Go on to Sheet 2

OIL PUMP DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 2 of 5)

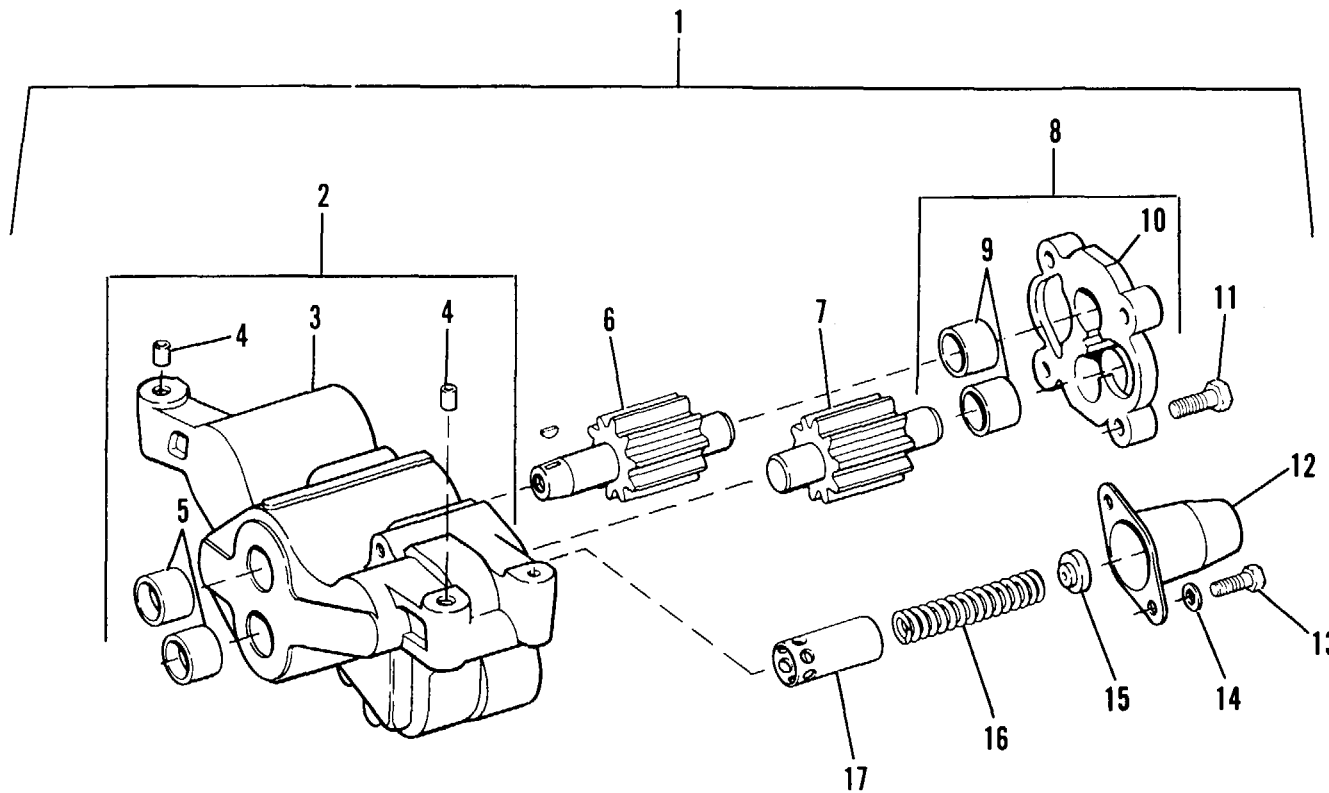
LOCATION/ITEM	ACTION	REMARKS
<p><b>DISASSEMBLY</b></p>		
<p>1. Drive gear retaining bolt, washer</p>	<p>Remove.</p>	
<p>2. Drive gear</p>	<p>Remove using suitable puller.</p>	
<p>3. Key</p>	<p>Remove from drive shaft.</p>	
<p>4. Bypass valve retainer (12)</p>	<p>a. remove capscrews 913) and washers (14).</p>	
	<p>b. Remove.</p>	
	<p><b>NOTE</b></p>	
<p>5. Bypass valve (17), spring (16), and spacer (15)</p>	<p><b>Spring is under tension. Back off capscrews one turn at a time.</b></p>	
<p>6. Cover (10)</p>	<p>Remove.</p>	
<p>6. Cover (10)</p>	<p>a. Remove screws 911).</p>	
	<p>b. Remove from pump body 93).</p>	
	<p><b>NOTE</b></p>	
<p>6. Cover (10)</p>	<p>Mark across pump and cover to be able to put back in same position.</p>	

TA099043

Go on to Sheet 3

OIL PUMP DISASSEMBLY/ASSEMBLY (CONT)

1. Engine oil pump
2. Body assembly
3. Body
4. Dowel
5. Bearing
6. Shaft assembly
7. Shaft assembly
8. Cover assembly
9. Bearing
10. Cover
11. Capscrew
12. Retainer
13. Capscrew
14. Flat washer
15. Spacer
16. Spring
17. Bypass valve



TA099044

Go on to Sheet 4

**OIL PUMP DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
7. Bearings (9) 8. Shaft assemblies (6) and (7) 9. Bearings (5) 10. Dowels (4)	Using suitable driver remove from cover. Remove from pump body (3) Using suitable driver, remove from pump body. Inspect for damage. Replace if necessary.	
<div style="border: 1px solid black; padding: 2px; display: inline-block;"><b>ASSEMBLY</b></div>		
1. Bearings (5)	a. Using suitable driver, install in pump body.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Install bearings s split bearings is 30° ± 15° from center line of pump outlet passage.</b></p> b. Coat with clean engine oil.	
2. Idler gear shaft (7), drive gear idler (6)	a. Install in oil pump body (3). b. Coat with clean engine oil.	
3. Bearings (9)	Using suitable driver, install in pump cover.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Install bearing so split in bearings is 30° ± 15° from center line of bearing bores toward oil pump outlet passage.</b></p>	

Go on to Sheet 5

OIL PUMP DISASSEMBLY/ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
4. Bypass valve (17), spring (16), spacer (15), retainer (12).	a. Install. b. Secure with capscrews (13) and washer (14).	
5. Key	Install in drive gear shaft (6).	
6. Drive gear (7)	a. Install.	
7. Cover assembly (8)	b. Install capscrews (11) and tighten to a torque of $40 \pm 5$ lb. Ft. ( $54.2 \pm 6.8$ N·m)	
<b>NOTE</b>		
<b>Be sure pump turns freely after assembly.</b>		

End

Section V. COOLING SYSTEM

**COOLING SYSTEM MAINTENANCE INSTRUCTIONS**

This section covers maintenance of these cooling system components for direct support maintenance personnel:

- a. Radiator.
- b. Water Pump
- c. Engine oil cooler

**LIST OF TASKS**

(Sheet 1 of 1)

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Engine oil cooler removal/installation.	3-152	2-17, 2-19
2	Radiator removal/installation.	3-155	None
3	Radiator and shroud removal/installation.	3-162	None
4	Water pump disassembly/assembly.	3-168	2-21

**ENGINE OIL COOLER REMOVAL/INSTALLATION**  
**1 of 3)**

(Sheet

This task covers: Replacement of engine oil cooler.

INITIAL SETUP

Test Equipment

None

Special Tools

Hoist

Materials/Parts

Preformed packing

Gaskets

Personnel Required

One mechanic

References

Replace coolant, TM 10-3930-641-20,  
 LO 10-3930-641-12.

Troubleshooting Reference

Pages 2-17, 2-19

Equipment Condition

Coolant drained from cooling system.

Oil drained from engine oil cooler.

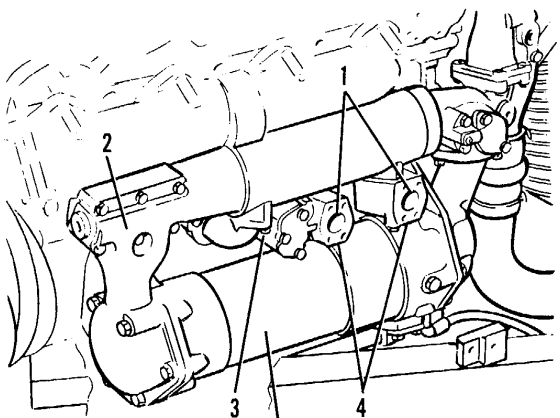
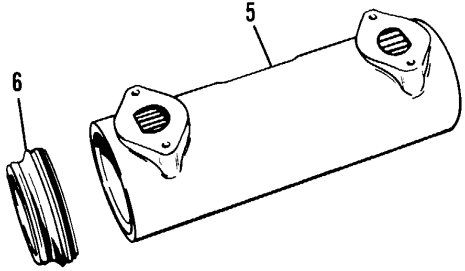
Left rear access door open.

General Safety Instructions

Main disconnect switch OFF.

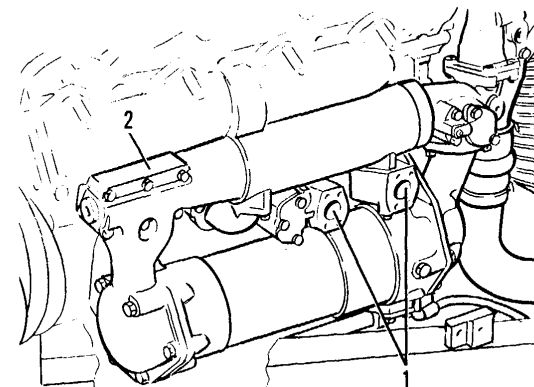
Go on to Sheet 2

**ENGINE OIL COOLER REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; text-align: center; margin-bottom: 10px;"><b>REMOVAL</b></div> <ol style="list-style-type: none"> <li>1. Two oil filter hose assemblies (1).</li> <li>2. Bonnet (2)</li> <li>3. Four capscrews (3) and (4) that hold engine oil cooler</li> <li>4. Engine oil cooler (5)</li> <li>5. Adapter (6)</li> <li>6. Preformed packing on adapter (6)</li> </ol>	<p>Disconnect from manifold (1).</p> <p>Remove from engine and transmission oil cooler.</p> <p>Remove.</p> <p>Remove.</p> <p>Remove from engine oil cooler (5).</p> <p>Discard.</p>	 <p>The diagram shows a side view of the engine oil cooler assembly. Callout 1 points to a hose assembly connected to the manifold. Callout 2 points to the bonnet. Callouts 3 and 4 point to the four capscrews that secure the cooler. Callout 5 points to the engine oil cooler itself. Callout 6 points to the preformed packing on the adapter.</p>
<div style="border: 1px solid black; padding: 2px; text-align: center; margin-bottom: 10px;"><b>INSTALLATION</b></div> <ol style="list-style-type: none"> <li>1. Engine oil cooler</li> <li>2. Four capscrews (4) and (3) that hold engine oil cooler</li> </ol>	<p>Install.</p> <p>Install.</p>	 <p>The diagram shows the engine oil cooler (5) and the adapter (6) with preformed packing. Callout 5 points to the cooler, and callout 6 points to the adapter.</p> <p style="text-align: right;">TA099045 Go on to Sheet 3</p>

**ENGINE OIL COOLER REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
3. New preformed packings.	Install on bonnet.	
4. Bonnet (2)	Install.	
5. Two oil filter hose assemblies	Attach to manifold (1).	
6. Oil	Fill crankcase to specified level.	See LO 10-3930-641-12.
7. Cooling system	Fill with coolant.	See TM 10-3930-641-20.



TA099046

End

**RADIATOR REMOVAL/INSTALLATION**

This task covers: Replacement of radiator

INITIAL SETUP

Test Equipment

None

Materials/Parts

Radiator assembly

Troubleshooting Reference

Page 2-8.

Personnel Required

Two mechanics

Equipment Condition

Cooling system drained.

Fan removed.

Rear hood removed.

Rear crankcase guard removed.

References

Coolant replacement, TM 10-3930-641-20.  
Fan assembly removal/installation,  
TM 10-3930-641-20.

Hood removal/installation,  
TM 10-3930-641-20.

Crankcase guards removal/installation,  
TM 10-3930-641-20.

Repair per TB-750-14.

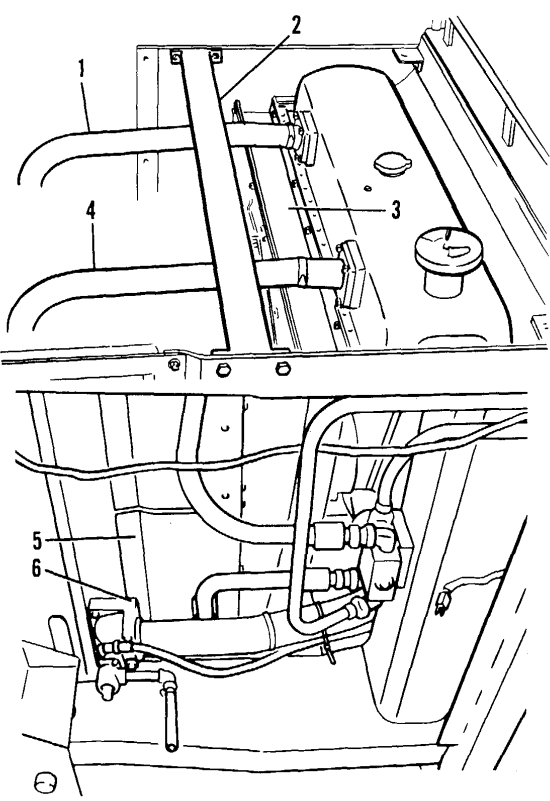
General Safety Instructions

Allow coolant to cool before draining.

Special Tools

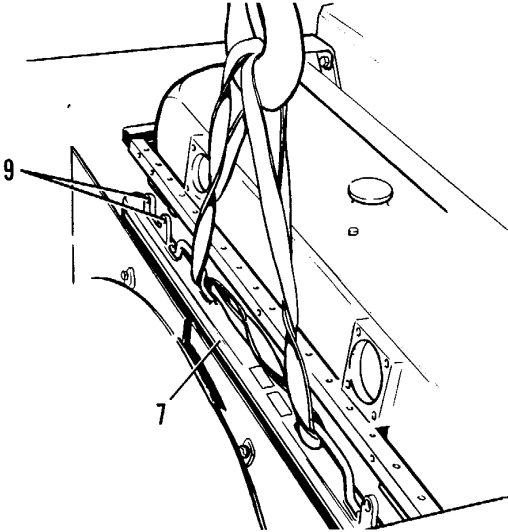

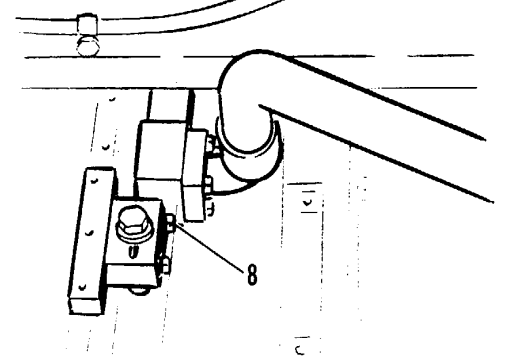
Two 7/16 - 14 NC forged  
eyebolts

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; text-align: center; margin-bottom: 10px;"><b>REMOVAL</b></div> <ol style="list-style-type: none"> <li>1. Channel (2), tube assemblies (1) and (4) and channel (3)</li> <li>2. Tube assembly (6)</li> <li>3. Shield (5)</li> </ol>	<p>Remove.</p> <p>Disconnect from radiator bottom tanks assembly.</p> <p>Remove.</p>	 <p style="text-align: right;">TA099047</p> <p style="text-align: right;">Go on to Sheet 3</p>

**RADIATOR REMOVAL/INSTALLATION (CONT)**  
**3 of 7)**

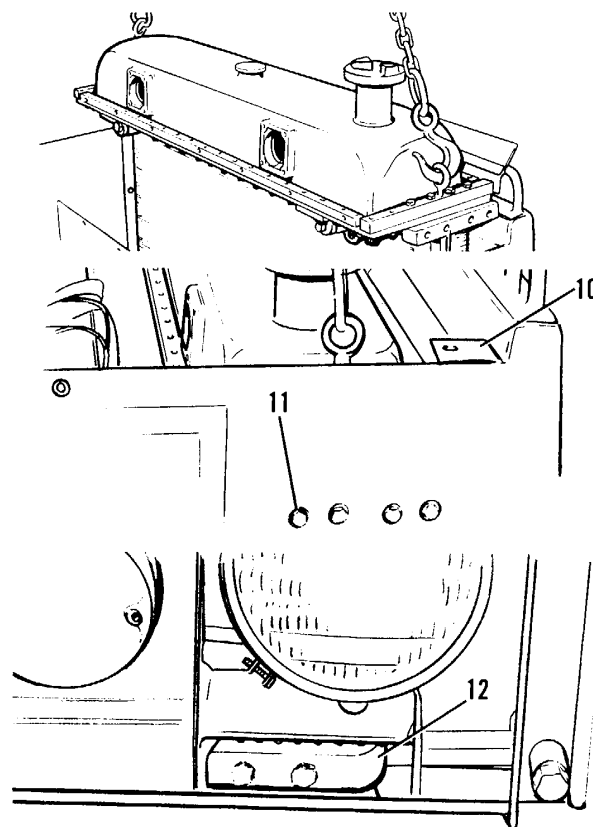
(Sheet

LOCATION/ITEM	ACTION	REMARKS
<p>4. Hydraulic oil cooler (7)</p>	<p>Fasten hoist to lift handles.</p> <p style="text-align: center;"><b>NOTE</b></p> <p style="text-align: center;"><b>Hydraulic oil cooler weighs 134 lb. (60.8 kg).</b></p>	
<p>5. Four capscrews (9) that hold top of oil cooler in position</p>	<p>Remove.</p>	
<p>6. Four bolts (8) that hold bottom of hydraulic oil cooler in position</p>	<p>Remove.</p>	

**RADIATOR REMOVAL/INSTALLATION (CONT)**

(Sheet 4 of 7)

LOCATION/ITEM	ACTION	REMARKS
7. Hydraulic oil cooler	Lower to rest on frame.	
8. Radiator	Install two 7/16-14 NC forged eyebolts in holes provided at both ends of radiator tank top.	
9. Radiator	Fasten hoist to eyebolts.	
10. Two rear hood brackets (10)	Remove.	
11. Capscrews (11)	Remove from each side of radiator.	
12. Clamps (12) at bottom of radiator	Remove.	



**NOTE**

Radiator weighs 500 lb (227 kg).

13. Radiator	Remove.	
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TA099049

Go on to Sheet 5

RADIATOR REMOVAL/INSTALLATION (CONT)

(Sheet 5 of 7)

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;"><b>INSTALLATION</b></div>		
1. New radiator (1)	Install two 7/16-14 NC forge eyebolts in holes provided at either end of radiator tank top.	
2. Radiator (1)	Place in position.	
3. Capscrews (3) to hold radiator in position	Install.	
4. Rear hood brackets (2)	Install	
5. Clamps (4) to hold bottom of radiator in position	Install.	
6. Hoist	Remove.	
7. Eyebolts	Remove.	

TA099050

Go on to Sheet 6

RADIATOR REMOVAT,/INSTALLATION (CONT)

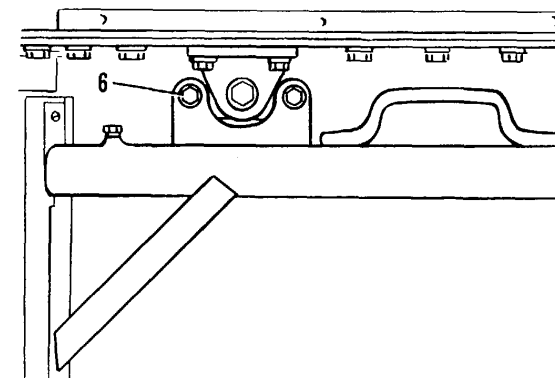
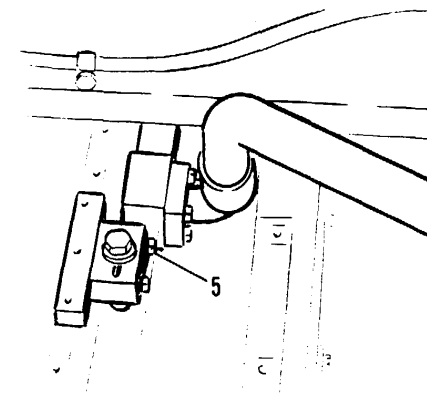
(Sheet 6 of 7)

LOCATION/ITEM	ACTION	REMARKS
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8. Hydraulic oil cooler	Fasten hoist to lift handles and lift into position in radiator guard.	
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9. Four capscrews (5) to hold bottom of hydraulic oil cooler in position.	Install.	
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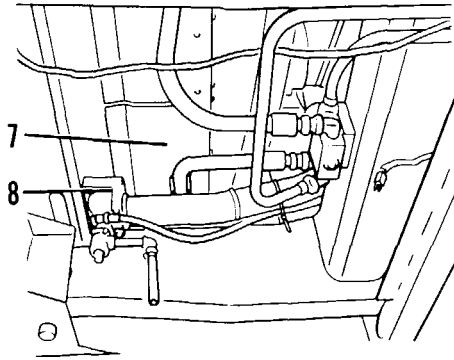
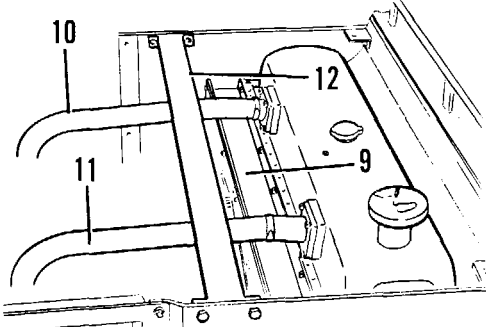
10. For capscrews (6) to hold top of hydraulic oil cooler in position.	Install.	
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TA099051

Go on to Sheet 7

RADIATOR REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
11. Shield (7)	Install on bottom of radiator.	
12. Tube assembly (8)	Connect to bottom of radiator.	
13. Channel (9), tube assemblies (10) and (11) and channel (12)	Install.	
14. Cooling system	Fill.	
15. Rear hood	Install.	Refer TM 10-3930-641-20. Refer MIL-A-46153.
16. Rear crankcase guard	Install.	Refer TM 10-3930-641-20. Refer TM 10-3930-641-20.

**RADIATOR AND SHROUD ASSEMBLY REMOVAL/INSTALLATION**

This task covers: Removal and installation of radiator and shroud assembly.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Radiator and shroud assembly.

Buckets

Troubleshooting Reference

None

Equipment Condition

Engine OFF.

Rear hood and rear crankcase guard removed.

Coolant drained from cooling system.

Fan assembly removed.

Special Tools

None

Personnel Required

Two mechanics

References

Hood removal/installation,  
TM 10-3930-641-20.

Crankcase guards removal/installation,  
TM 10-3930-641-20.

Coolant replacement, TM 10-3930-641-20.

Fan assembly removal/installation,  
TM 10-3930-641-20.

General Safety Instructions

When performing this task, use hoist of suitable lifting capacity to prevent injury to personnel or damage to vehicle.

Main disconnect switch OFF.

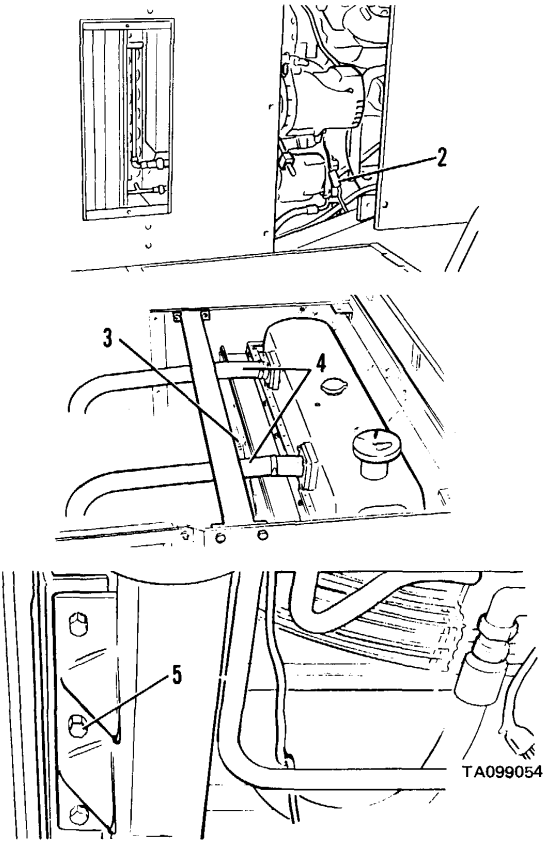
Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; text-align: center; margin-bottom: 10px;"><b>REMOVAL</b></div> <p>1. Capscrews (1) that hold frame assemblies to top of radiator guard</p>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Tag all harnesses, lines. Tubes and hoses before disconnecting.</b></p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Radiator and shroud assembly weighs 1850 lb (839 kg).</b></p>	<div style="text-align: center;"> </div> <p style="text-align: center;"><b>RIGHT REAR VIEW</b></p> <p style="text-align: right;">TA099053</p> <p style="text-align: right;">Go on to Sheet 3</p>

1

RADIATOR AND SHROUD ASSEMBLY REMOVAL/INSTALLATION (CONT)

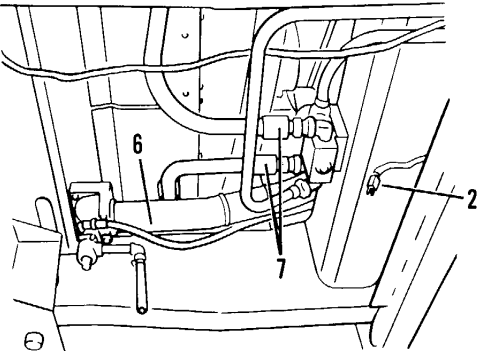
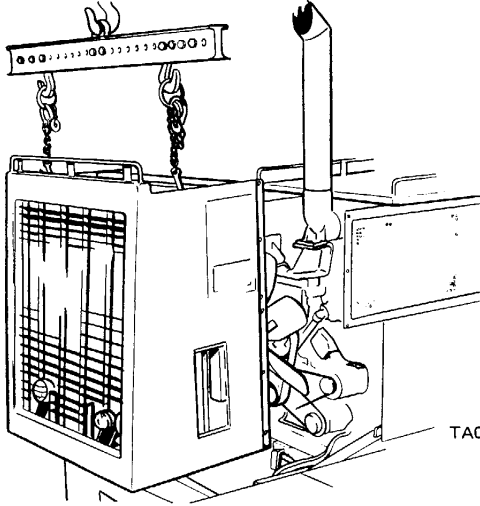
(Sheet 3 of 6)

LOCATION/ITEM	ACTION	REMARKS
2. Front panels on each side of radiator guard.	Remove.	
3. Wiring harness (2) for rear lights at alternator.	Disconnect.	
4. Fan guard bolts (3)	Remove and remove fan guard.	
5. Tube assemblies (4)	Remove.	

Go on to Sheet 4

RADIATOR AND SHROUD ASSEMBLY REMOVAL/INSTALLATION (CONT)

(Sheet 4 of 6)

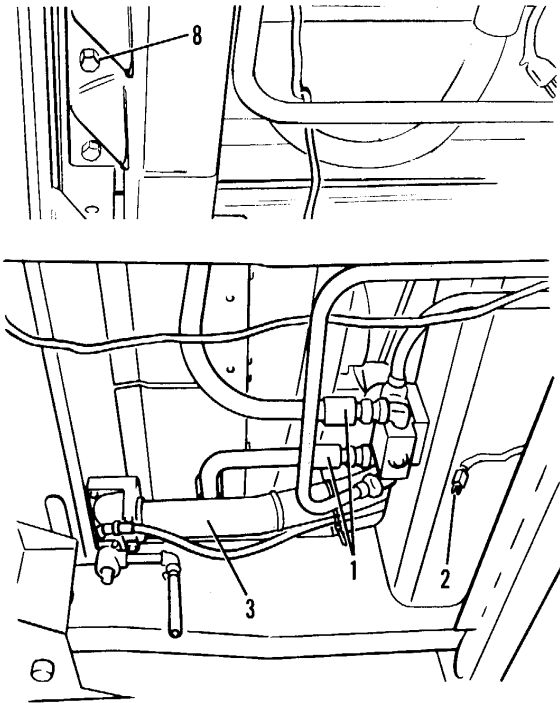
LOCATION/ITEM	ACTION	REMARKS	
6. Wiring harness (2)	Remove straps and fasten to radiator guard.		
7. Tube assembly (6)	Disconnect from radiator.		
8. Hose assemblies (7)	Disconnect from cooler b-pass valve.		
<b>NOTE</b>			
<b>Hydraulic oil will be trapped in tube assembly (6). Have a container ready to catch oil.</b>			
9. Two 7/16-14 NC forge eyebolts.	Install in holes provided in radiator top tank.		
10. Six bolts (5) that hold radiator guard to frame	Remove.		
11. Radiator and shroud assembly	Fasten hoist and remove.		
<b>NOTE</b>			
<b>Weight of radiator and guard is 1850 lb. (839 kg).</b>			
<b>NOTE</b>			
<b>Always replace gaskets and hose assemblies. Old ones will be too deformed for reuse.</b>			
1. New radiator and shroud assembly	Install two 7/16-14 NC eyebolts in holes provided in radiator tank top and lift into position.	<p style="text-align: right;">TA099055</p>	

**INSTALLATION**

Go on to Sheet 5

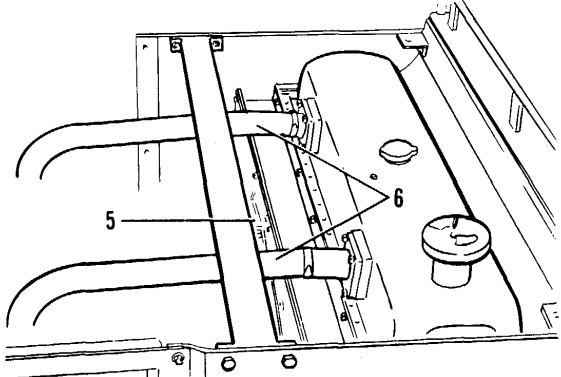
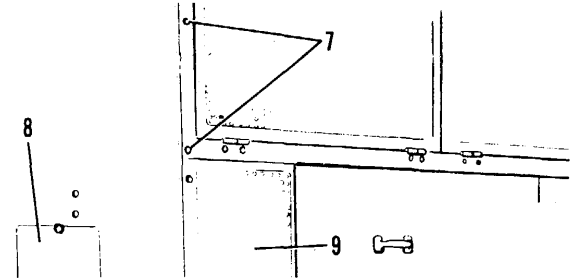
RADIATOR AND SHROUD ASSEMBLY REMOVAL/INSTALLATION (CONT)

(Sheet 5 of 6)

LOCATION/ITEM	ACTION	REMARKS
<ul style="list-style-type: none"> <li>2. Six bolts (8) that hold radiator guard to assembly</li> <li>3. Hose assemblies (1)</li> <li>4. Wiring harness (2)</li> <li>5. Tube assembly (3)</li> </ul>	<ul style="list-style-type: none"> <li>Install.</li> <li>Connect to cooler by-pass valves.</li> <li>Connect at alternator and fasten to straps.</li> <li>Connect to radiator.</li> </ul>	 <p style="text-align: right;">TA099056 Go on to Sheet 6</p>

RADIATOR AND SHROUD ASSEMBLY REMOVAL/INSTALLATION (CONT)

(Sheet 6 of 6)

LOCATION/ITEM	ACTION	REMARKS
6. Fan guards (5)	Install.	 <p>Refer TM 10-3930-641-20. Refer TM 10-3930-641-20. Refer TM 10-3930-641-20</p>  <p>TA099057</p> <p>End</p>
7. Tube assemblies(9)	Install.	
8. Capscrews (7) that hold frame assemblies to radiator guard	Install.	
9. Small panel (8)	Install.	
10. Front panels (9)	Install.	
11. Rear hood and rear crankcase guard	Install.	
12. Cooling system	Fill with coolant.	
13. Fan assembly	Install..	

**WATER PUMP DISASSEMBLY/ASSEMBLY**

This task covers: Disassembly and assembly of water pump.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Water pump rebuild kit

Water pump gasket and seal kit

Troubleshooting Reference

Page 2-21

Equipment Condition

Engine OFF.

Water pump removed from vehicle.

Special Tools

Gear puller

One capscrew 5/16-18 NC x 5 long

Drive plate

Step plate

Personnel Required

One mechanic

References

Water pump removal/installation,  
TM 10-3930-641-20.

General Safety Instructions

Main disconnect switch OFF.

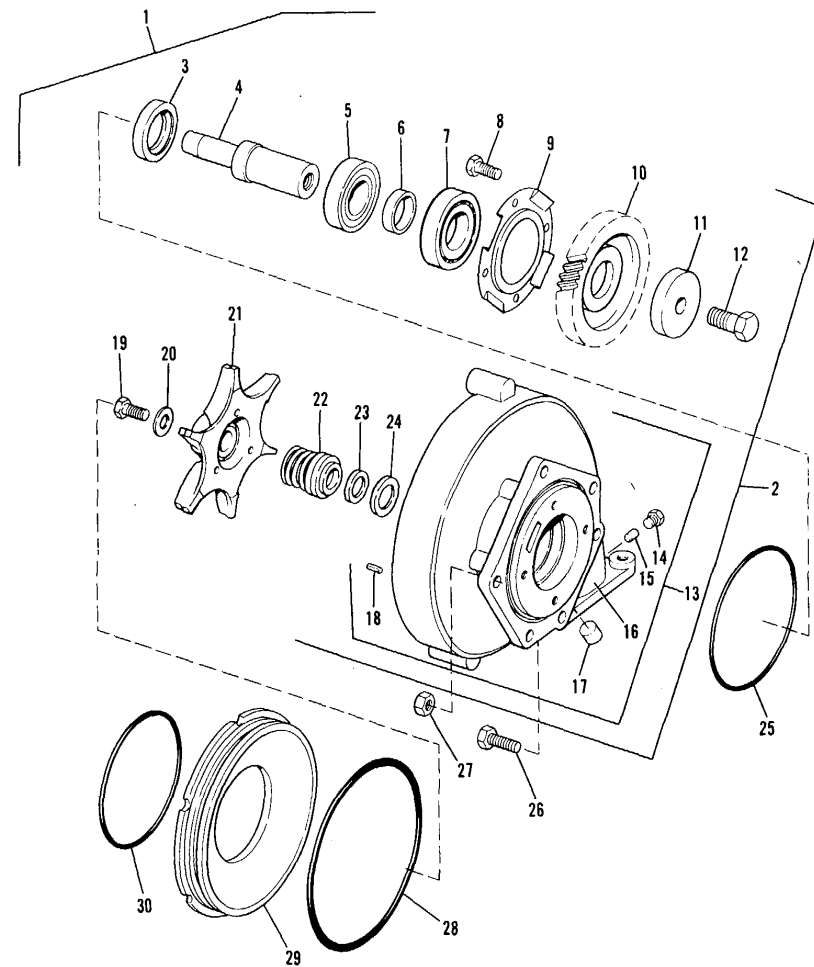
Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY</b>		
1. Preformed packing (30)	Remove.	
2. Adapter (29)	a. Remove, using screwdriver. b. Remove preformed packing (28) from edge of adapter.	
3. Capscrew (19)	a. Remove. b. Remove washer (20).	
4. Impeller (21)	Remove using a puller and two 5/1618 NC x 5 capscrews.	
5. Seal assembly (22)	Remove.	
6. Ring (23) and seal (24)	Remove.	
7. Gear (10)	a. Remove capscrew (12) and retainer (11) that secure gear. b. Remove gear with suitable puller.	
8. Capscrews (8)	Remove.	

Go on to Sheet 3

**WATER PUMP DISASSEMBLY/ASSEMBLY (CONT)**

1. Water Pump and Mounting Hardware
2. Water Pump Group
3. Seal
4. Shaft
5. Bearing
6. Spacer
7. Bearing
8. Capscrew
9. Retainer
10. Gear
11. Retainer
12. Capscrew
13. Housing Assembly
14. Plug
15. Ferrule
16. Housing
17. Filter
18. Pin
19. Capscrew
20. Washer
21. Impeller
22. Seal Assembly
23. Ring
24. Seal
25. Preformed Packing
26. Capscrew
27. Nut
28. Preformed Packing
29. Adapter
30. Preformed Packing



TA099058

Go on to Sheet 4

## WATER PUMP DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 4 of 7)

LOCATION/ITEM	ACTION	REMARKS
9. Retainer	Remove.	
10. Preformed packing (25)	Remove.	
11. Shaft (4) and bearings	Remove as a unit.	
12. Bearings (7) and (5)	a. Remove bearing (7).	
	b. Remove spacer (6).	
	c. Remove bearing (5).	
13. Lip type seal (3)	Remove from gear side of pump.	
14. Ring (23) and seal (24)	Remove from impeller side of pump.	

Go on to Sheet 5

LOCATION/ITEM

ACTION

REMARKS

ASSEMBLY

NOTE

Place clean engine oil or glycerine on seal.

1. Lip type seal (3)

Install using a suitable drive plate.

2. Shaft (4)

Install bearing (5), spacer (6) and bearing (7) on shaft (4).

3. Retainer (9) and preformed packing (25)

Install.

4. Gear (10)

a. Install.

b. Install capscrew (12) and retainer (11) that hold gear (10) to shaft (4).

Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
5. Seal (24) and ring (23)	a. Put clean water on seal (24). b. Install seal (24) with ring (23).  <b>NOTE</b> <b>Polished face of ring must be toward outside of pump.</b>	
6. Seal assembly (22)	a. Remove spring from seal. b. Put clean water on the inside of seal (22). c. Push seal on shaft until carbon face contacts polished face of ring (24). d. Install spring.	

LOCATION/ITEM	ACTION	REMARKS
7. Impeller (21)	a. Install impeller (21). b. Install washer (20) and capscrew (19). c. Tighten to a torque of 26-30 ft. lbs. (3642 N m).	
8. Preformed packings (30) and (28)	a. Put clean engine oil or glycerine on seals. b. Install on adapter (29).	
9. Adapter (29)	Install in housing with notch aligned with pin (18).	
<p><b>NOTE</b>  <b>Use a press to insert adapter.</b></p>		

**Section VI. ELECTRICAL SYSTEM MAINTENANCE INSTRUCTIONS**

This section covers maintenance of these electrical system components for direct support maintenance personnel:

- a. Alternator
- b. Starting motor

**LIST OF TASKS**

(Sheet 1 of 1)

TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Alternator disassembly/assembly	3-176	2-22, 2-23
2	Test alternator	3-183	2-22
3	Starting motor disassembly/assembly	3-187	2-8, 2-21
4	Test starting motor	3-200	2-8

This task covers: Disassembly/assembly of the alternator

**INITIAL SETUP**

Test Equipment

Multimeter  
Alternator test stand

Materials/Parts

As required

Troubleshooting Reference

Page 2-22, 2-23,  
TM 10-3930-641-20

Equipment Condition

Alternator removed from engine

Special Tools

Arbor press  
Steel rule

Personnel Required

One mechanic

References

Electrical Troubleshooting,  
TM 10-3930-641-20  
Alternator removal/installation,  
TM 10-3930-641-20

General Safety Instructions

Main disconnect switch OFF

LOCATION/ITEM	ACTION	REMARKS
1. Cover plate	27. Screw	
2. Screw	28. Insulation	
3. Lockwasher	29. Heat sink assembly	
4. Screw	30. Insulator	
5. Lockwasher	31. Washer	
6. Cover	32. Washer	
7. Gasket	33. Screw	
8. Lead assembly	34. Screw	
9. Screw	35. Rotor assembly	
10. Washer	36. Screw	
11. Lockwasher	37. Fan and baffle assembly	
12. Screw assembly	38. Locknut	
13. Hex nut	39. Washer	
14. Regulator assembly	40. Slinger	
15. Grommet	41. Collar	
16. Housing assembly	42. Lip type seal	
17. Bearing well plug	43. Screw	
18. Bushing	44. Lockwasher	
19. Special needle roller bearing	45. Drive end frame	
20. Special needle bearing race	46. Ball bearing	
21. Field coil support assembly	47. Collar	
22. Stator assembly	48. Gasket	
23. Insulator assembly	49. Retainer assembly	
24. Grommet	50. Lip type seal	
25. Clip	51. Cap screw	
26. Stud assembly	52. Lockwasher	

TA 099059  
Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY</b>		
1. Lock nut (38) and washer (39)	Remove.	
2. Baffle and fan assembly (37)	Remove	Use appropriate puller for pulley removal.
3. Slinger (40) and four screws (43) with lockwashers (44)	Remove.	
4. Drive end frame (45) and rotor assembly (35)	Remove from rectifier housing.	
5. Rotor (35) screws (36) retainer assembly (49), gasket (48)	Remove from drive end frame.	
6. Bearing race (20)	Remove.	Use appropriate arbor press.
7. Bearing (46) collar (47) and seal (50)	Remove from retainer assembly (49).	Use appropriate arbor press.
8. Seal (42)	Remove from drive end frame.	
9. Screws, (2) lockwashers (3) cover plate (1) screws (4) lockwashers (5) cover (6), gasket (7)	Remove.	

LOCATION/ITEM	ACTION	REMARKS
10. All electrical fasteners, nuts, screws or bolts	Remove.	
11. Stator assembly (22)	Remove.	Apply grease to grommet (24) for easy removal.
12. Screws (27) and field coil and support assembly (21)	Remove.	Apply grease to grommet for easy removal (15).
13. Screws (9) washers (10) and regulator (14)	Remove.	
14. Screws (9) washers (31) and heat.. sink assembly (29)	Remove.	
15. Bearing well plug (17) and bushing (18)	Remove	Use appropriate arbor press.

Go on to Sheet 5

LOCATION/ITEM	ACTION	REMARKS
<b>ASSEMBLY</b>		
1. Bearing race (20)	Install new race on rotor	Use appropriate press and install .08 in. (.20 cm) past end of shaft.
2. Bearing (19)	Install in rectifier housing	First press in bearing to a depth of .03 in. (0.87 cm) then press greased seal into a depth of .08 in. (.20 cm). Install plug, using a press.
3. Bearing well plug (17)	Apply grease to bearing and fill bearing plug 3/4 with grease. Install bearing plug.	
4. Heat sink assembly (29), screws (9) and washers (31 and 32) and insulator (30)	Install heat sink assembly into rectifier housing using washers and screws.	
5. Regulator (14)	Install into rectifier housing.	
6. Field coil support assembly (21)	Install into rectifier housing using screws.	
7. Stator assembly (22)	Install.	

Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
8. All electrical fasteners, nuts, screws or bolts	Route all electrical leads and secure with proper fasteners.	
9. Gasket (7) cover (6) lockwashers (5) screws (4) cover plate (1) lockwashers (3) and screws (2)	Install to rectifier housing.	
10. Seal (42)	Install in drive end frame (lip towards bearing).	Use appropriate press then fill 3/4 with grease.
11. Seal (50), collar (47), and bearing (46)	Install seal, collar and bearing in retainer (seal lip and collar flare face bearing).	Grease the bearing and fill the seal lip 3/4 before pressing bearing in place.
12. Retainer assembly (49) gasket (48) and screws (36)	Install retainer assembly with gasket in drive end frame.	
13. Rotor (35)	Install rotor through drive end frame.	

Go on to Sheet 7

LOCATION/ITEM	ACTION	REMARKS
14. Collar (41) slinger (40) fan and baffle assembly (37) washer (39) and locknut (38)	Successively install parts to rotor shaft	Tighten locknut to a torque of 75 lb. ft. (102 N m).
15. Drive end frame, rotor washers and screws.	Assemble frame and rotor assembly to rectifier housing using screws and washers.	Assembly is complete.

This task covers: Testing the alternator

**INITIAL SETUP**

Test Equipment

Multimeter

Materials/Parts

None

Troubleshooting Reference

Page 2-22, TM 10-3930-641-20

Equipment Condition

Test may be performed with alternator removed or installed in vehicle.

Special Tools

None

Personnel Required

One mechanic

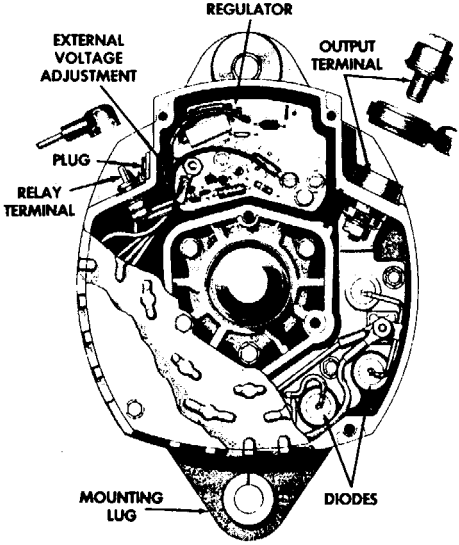
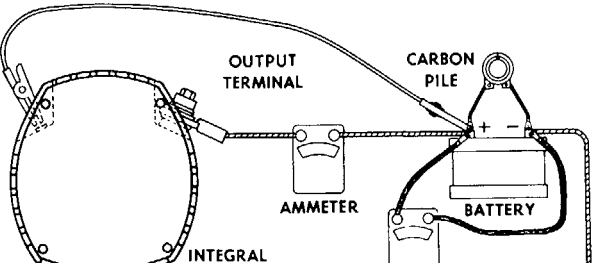
References

Electrical Troubleshooting,  
TM 10-3930-641-20  
Alternator disassembly/  
assembly, page 3-176.

General Safety Instructions

None

LOCATION/ITEM	ACTION	REMARKS
<b>ELECTRICAL TESTS</b>		
1. Diodes	Check all six diodes by attaching a multimeter (set on low scale on ohmmeter) to diode lead and diode case. Then reverse leads and note meter reading.	If both readings are the same the diode is bad. A good diode will give one high and one low reading. Replace diodes using an arbor press.
2. Field coil (check for ground)	Connect multimeter to coil frame (ground) and one lead.	If meter reading is low the coil is grounded. Replace. See page 3-176
3. Field coil (check for open)	Connect multimeter to the coil leads. See page 3-176	If the meter reading is high, the coil is open. Replace.
4. Stator (check for ground)	While one multimeter lead is kept on the frame move the other lead to three stator leads and note the 3 readings.	If the meter reading is low in any of the 3 test windings the stator is grounded. Replace.
5. Stator (check for open)	Successively connect between each pair of stator leads with the multimeter.	If meter reading is high the stator windings are open. Replace. See page 3-176

LOCATION/ITEM	ACTION	REMARKS												
<b>OUTPUT CHECK</b>														
1. Rotor	<p>After reassembly of alternator you must first magnetize the rotor as follows:</p> <ol style="list-style-type: none"> <li>a. Connect the alternator to the battery in a normal manner.</li> <li>b. Momentarily connect a jumper lead from the positive terminal of the battery to the relay terminal as shown at lower right. This procedure applies to both negative and positive ground systems.</li> </ol>													
2. Battery	Battery must be fully charged.													
3. Carbon pile	<p>Must be turned off as you increase the alternator speed. Observe the voltmeter and refer to the chart below.</p> <table border="1"> <thead> <tr> <th>SYSTEM VOLTAGE</th> <th>RATED VOLTAGE</th> <th>OPERATING RANGE</th> </tr> </thead> <tbody> <tr> <td>12</td> <td>14.0</td> <td>13.0-15.0</td> </tr> <tr> <td>24</td> <td>28.0</td> <td>26.0-30.0</td> </tr> <tr> <td>32</td> <td>37.5</td> <td>33.0-39.0</td> </tr> </tbody> </table> <p>If the voltage rises above the operating range replace the voltage regulator. (See page 3-176).</p>	SYSTEM VOLTAGE	RATED VOLTAGE	OPERATING RANGE	12	14.0	13.0-15.0	24	28.0	26.0-30.0	32	37.5	33.0-39.0	
SYSTEM VOLTAGE	RATED VOLTAGE	OPERATING RANGE												
12	14.0	13.0-15.0												
24	28.0	26.0-30.0												
32	37.5	33.0-39.0												

TA 099060  
Go on to Sheet 4

LOCATION/ITEM	ACTION	REMARKS
4. Alternator speed	If voltage does not exceed the preceding chart, increase alternator speed as required but do not exceed 5000 rpm. Adjust carbon pile to obtain maximum current output. Observe ammeter.	If the voltmeter reads within 10% of the output stamped on nameplate, the unit is good. If it is not good proceed to step 5.
5. Output 5% or below	Recheck the field coil	If the coil checks good replace the regulator. See page 3-176
6. Output between 5% and the recommended 10%	Recheck the field coil, stator and diodes.	Repair as required and retest.

This task covers: Starter motor; disassembly/assembly

**INITIAL SETUP**

Test Equipment

Spring tester  
Multimeter

Materials/Parts

Thread sealer  
O-ring (2)  
As required

Troubleshooting Reference

Page 2-8, 2-21, TM 10-3930-641-20

Equipment Condition

Starter removed from engine

Special Tools

None

Personnel Required

One mechanic

References

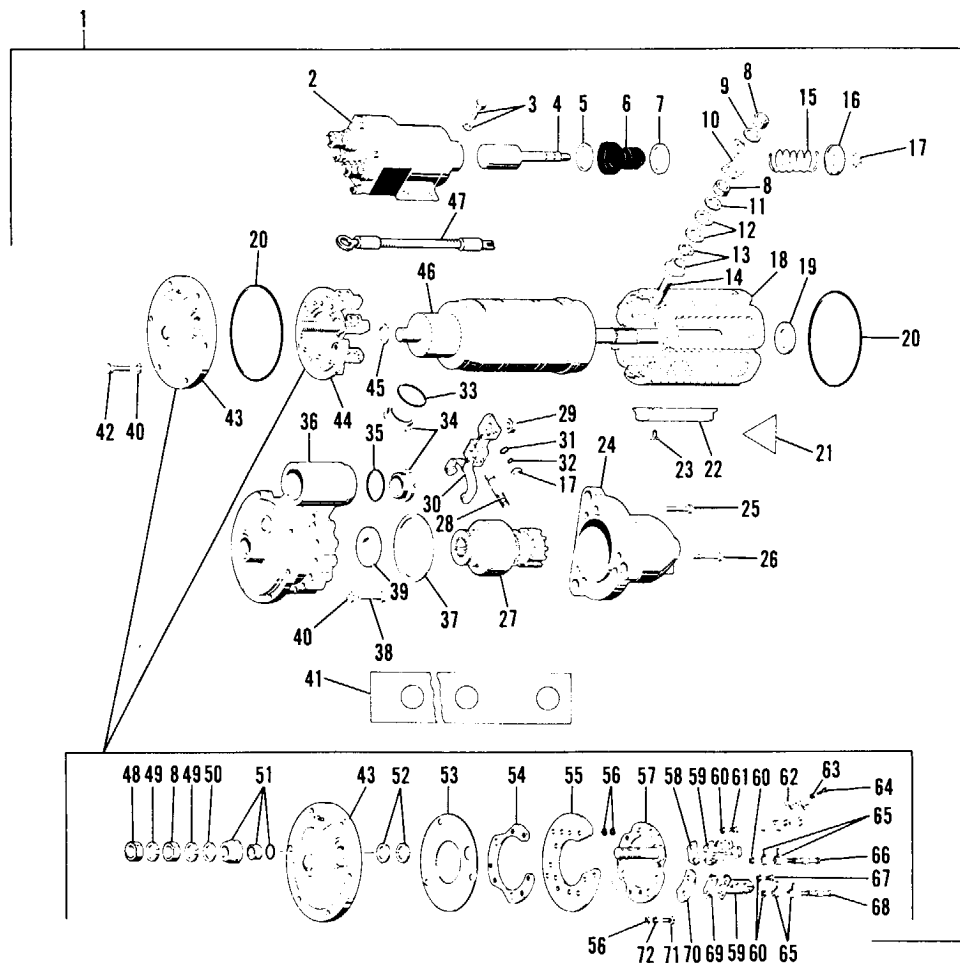
Starter motor removal/  
installation, TM 10-3930-641-20.

General Safety Instructions

None

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY (MAJOR COMPONENTS)</b>		
1. Housing	Scribe a line across the drive housing, drive assembly and commutator end frame.	This will allow for the same alignment when reassembling.
2. Nut and lead (47)	Remove.	
3. Screws (26 and 25), drive (27) housing (24) and gasket (37)	Remove.	
4. Inspection plug (34), preformed. packing (33) and screws (42)	Remove	Mark the screw holes for replacement.
5. Screws (38) washers (40) commutator end frame assembly (43), (20), (44) and washer (39)	Remove	A slight rap from a wood block may be necessary to loosen the end frame.
6. Armature (46)	Remove from the frame	

1. Starting motor assembly
2. Switch
3. Washer and screw
4. Plunger
5. Washer
6. Plunger boot
7. Washer
8. Nut
9. Lockwasher
10. Washer
11. Insulator washer
12. Insulator washer
13. Preformed packing and bushing
14. Terminal stud
15. Spring
16. Spring retainer
17. Snap ring
18. Field coil
19. Washer
20. Preformed packing
21. Insulation triangle
22. Pole shoe
23. Screw
24. Drive housing
25. Capscrew
26. Capscrew
27. Drive assembly
28. Lever shaft
29. Nut
30. Lever
31. O-ring
32. O-ring
33. Preformed packing
34. Inspection plug
35. Preformed packing
36. Lever housing



37. Preformed packing
38. Capscrew
39. Washer
40. Lockwasher
41. Insulator
42. Capscrew
43. Frame
44. Plate assembly
45. Washer
46. Armature
47. Lead
48. Nut
49. Lockwasher
50. Washer
51. Insulator assembly
52. Washer
53. Insulator
54. Plate support
55. Insulator
56. Washer
57. Plate and stud
58. Plate
59. Brush holder
60. Lockwasher
61. Capscrew
62. Brush
63. Lockwasher
64. Screw
65. Brush spring
66. Screw
67. Screw
68. Screw
69. Plate
70. Insulator
71. Screw
72. Lockwasher

TA 099061

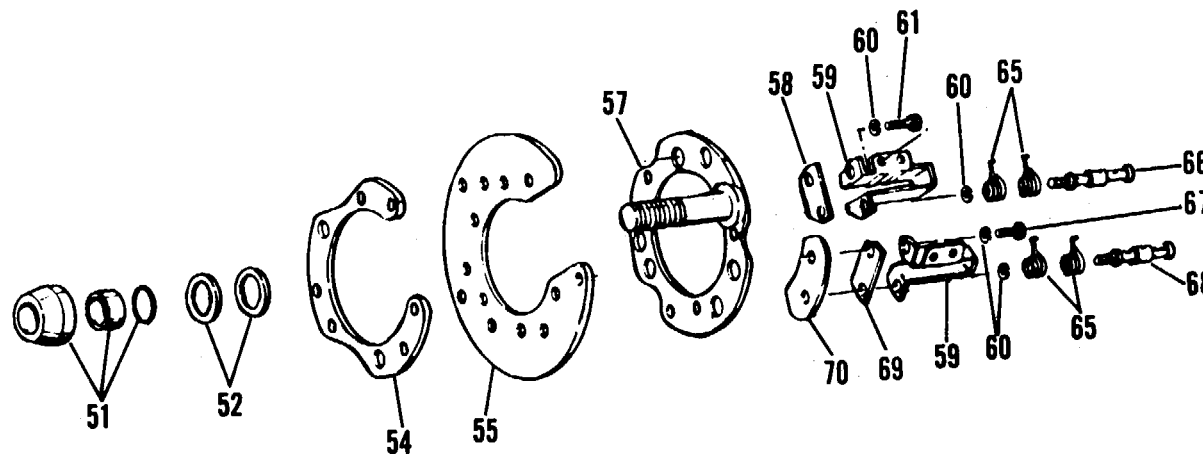
Go on to Sheet 4

LOCATION/ITEM	ACTION	REMARKS
7. Inspection plug (34) preformed. packing (35) and nut (29)	Remove	
8. Screws (38) washer (40) lever housing (36), preformed packing (37) and washer (39)	Remove	A slight rap from a wood block may be necessary to loosen the housing.
9. Screws and washers (3) and switch assembly (2)	Remove from the frame as an assembly.	

LOCATION/ITEM	ACTION	REMARKS
<b>DISASSEMBLY (MINOR COMPONENTS)</b>		
1. Drive housing assembly (24)	Inspect	See inspection procedure 2.
2. Drive clutch assembly (27)	Inspect	Drive clutch gets replaced as a unit.
3. Lever housing (36)	Disassemble if parts replacement is necessary.	
4. Plunger assembly (4)	Disassemble if parts are to be replaced by removing the snap ring (17).	
5. Switch (2)	None	See testing procedure 9 (page 3-203).
6. Frame assembly (43)	Remove field coil only if it is to be replaced	See testing procedure 10 (page 3-203).
7. Commutator end plate assembly (44)	Separate from the brush holder assembly	See testing procedure 15 (page 3-205).

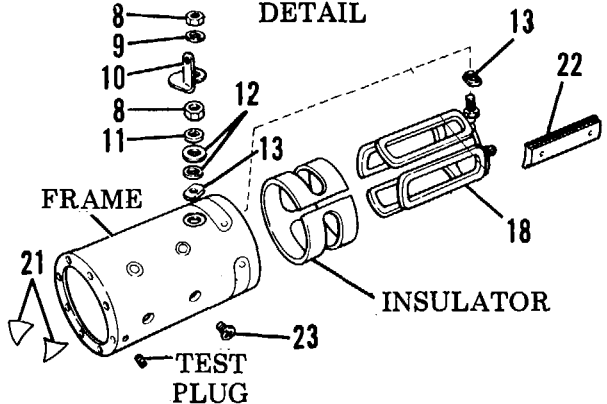
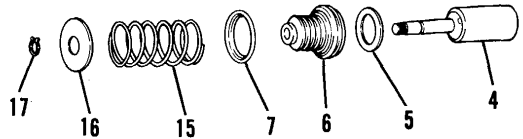
Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
8. Brush holder assembly	Disassemble if part replacement is necessary	See test procedure 14 (page 3-205).

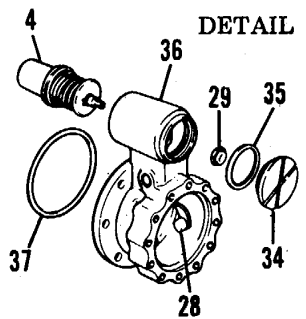
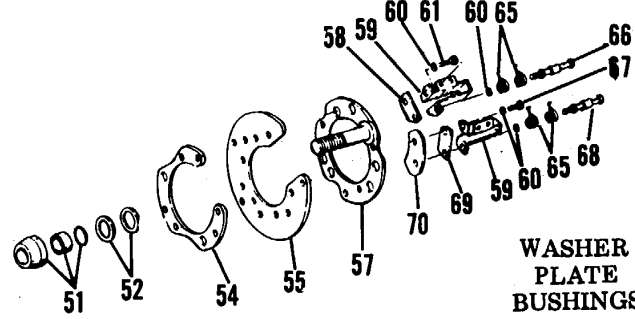


- 51 Insulator assembly
- 52 Insulating washer
- 54 Plate support
- 55 Insulator
- 57 Plate and stud
- 58 Plate
- 59 Brush holder
- 70 Insulator

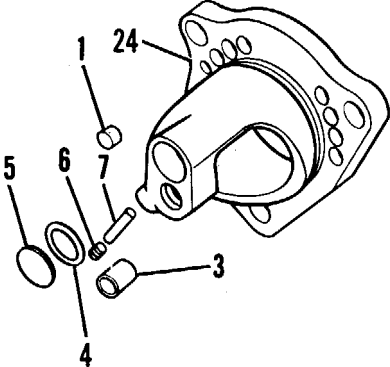
- 60 Lockwasher
- 61 Machine screw
- 65 Brush spring
- 66 Grounded brush holder screw
- 67 Machine screw
- 68 Insulated brush holder screw
- 69 Plate

LOCATION/ITEM	ACTION	REMARKS														
<p style="text-align: center;"><b>ASSEMBLY</b></p> <p>1. Field coil (18), pole shoes (22) and screws.</p> <p>2. Switch</p> <p>3. Plunger assembly (4)</p>	<p>If the field coil or pole shoes were removed be sure you install the insulator, gaskets and bushing in the proper locations. Before installing the pole shoes screws, coat them with a thread sealer.</p> <p>Remount the switch to the frame with the four screws and washers.</p> <p>Assemble on the plunger (4) the flat washer (5) plunger boot (6), washer (7), spring (15), spring retainer (16), and last the snap ring (17), which holds the assembly together.</p>	 <p style="text-align: center;"><b>DETAIL</b></p> <p>8 9 10 8 11 12 13 13 22 18 21 23</p> <p>FRAME INSULATOR TEST PLUG</p> <p>ε ε 1</p> <table border="0"> <tr> <td>11. Insulator washer</td> <td>21. Insulator</td> </tr> <tr> <td>12. Insulator washer</td> <td>22. Pole shoe</td> </tr> <tr> <td>13. Preformed packing</td> <td>23. Pole shoe screw</td> </tr> </table> <p>Use a thread sealer on the screws.</p>  <table border="0"> <tr> <td>4. Solenoid plunger</td> <td>15. Helical compression spring</td> </tr> <tr> <td>5. Flat washer</td> <td>16. Spring retainer</td> </tr> <tr> <td>6. Plunger boot</td> <td>17. Snap ring..</td> </tr> <tr> <td>7. Washer</td> <td></td> </tr> </table> <p style="text-align: right;">TA 099062 Go on to Sheet 8</p>	11. Insulator washer	21. Insulator	12. Insulator washer	22. Pole shoe	13. Preformed packing	23. Pole shoe screw	4. Solenoid plunger	15. Helical compression spring	5. Flat washer	16. Spring retainer	6. Plunger boot	17. Snap ring..	7. Washer	
11. Insulator washer	21. Insulator															
12. Insulator washer	22. Pole shoe															
13. Preformed packing	23. Pole shoe screw															
4. Solenoid plunger	15. Helical compression spring															
5. Flat washer	16. Spring retainer															
6. Plunger boot	17. Snap ring..															
7. Washer																



LOCATION/ITEM	ACTION	REMARKS
5. Plunger assembly (4)	Install the plunger assembly (4) in the housing (36) with the nut (29). Install the new preformed packing (35), plug (34), and o-ring (31).	 <p><b>DETAIL</b></p> <ul style="list-style-type: none"> <li>4. Plunger assembly</li> <li>28. Lever shaft</li> <li>29. Nut</li> <li>34. Inspection plug</li> <li>35. Preformed packing</li> <li>36. Lever housing</li> <li>37. Preformed packing</li> </ul>
6. Brush plate assembly	Assemble the plate support (54), insulator (55), plate and stud (57) insulator (70), plate (69) and brush holders (59). Install the brush springs (65), grounded brush holder screw (66) and the insulated brush holder screw (68).	 <p><b>DETAIL</b></p> <p><b>WASHER PLATE BUSHINGS</b></p> <ul style="list-style-type: none"> <li>51. Insulator assemble</li> <li>52. Insulating washer</li> <li>54. Plate support.</li> <li>55. Insulator</li> <li>57. Plate and stud</li> <li>58. Plate</li> <li>59. Brush holder</li> <li>60. Lockwasher</li> <li>61. Machine screw.</li> <li>65. Brush spring</li> <li>66. Grounded brush holder screw</li> <li>67. Machine screw</li> <li>68. Insulated brush holder screw</li> <li>69. Plate</li> <li>70. Insulator</li> </ul>

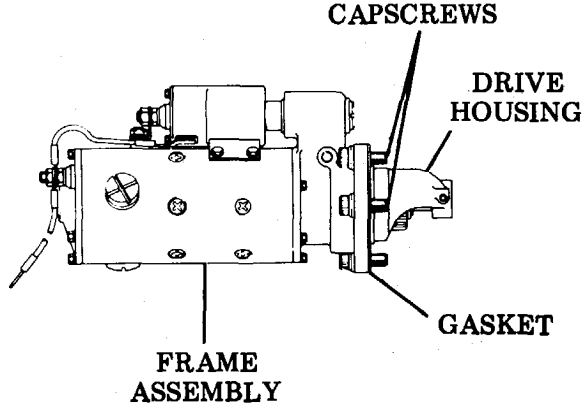
LOCATION/ITEM	ACTION	REMARKS
<p>7. Frame (43) (commutator end)</p>	<p>If a new bushing (5) was installed it must be reamed to 0.6860--0.6880 in. (17.4240-17.4750 mm).</p> <p>Install the preformed packing (8), plugs (4) (9), insulating bushing (2), oiled wick (7) and the pipe plug (6).</p>	<p><b>DETAIL</b></p> <ul style="list-style-type: none"> <li>2. Insulating bushing</li> <li>3. Terminal stud insulator</li> <li>4. Expansion plug</li> <li>5. Bushing</li> <li>6. Pipe plug</li> <li>7. Wick</li> <li>8. Preformed packing</li> <li>9. Expansion plug</li> <li>43. Frame</li> </ul>
<p>8. Brush plate assembly</p>	<p>Install the brush plate assembly (2) on the end frame (43), using a new preformed packing (20).</p>	<p><b>DETAIL</b></p> <ul style="list-style-type: none"> <li>4. Hexagon nut</li> <li>5. Lockwasher</li> <li>6. Flat washer</li> <li>8. Flat washer</li> <li>9. Lockwasher</li> <li>10. Panhead machine screw</li> <li>20. Preformed packing</li> <li>43. Frame assembly</li> <li>44. Brush holder terminal stud</li> <li>59. Brush plate assembly</li> </ul>

LOCATION/ITEM	ACTION	REMARKS
<p>9. Drive housing (24)</p>	<p>If a new bushing (3) was installed, ream it to 0.6240-0.6260 in. (15.84960-15.9000 mm).</p> <p>Install the oiled wick (7), pipe plug (6) felt plug (4), retaining plug (5) and the rubber plug (1).</p>	<p><b>DETAILS</b></p>  <ul style="list-style-type: none"> <li>1. Rubber plug</li> <li>3. Bushing</li> <li>4. Felt plug</li> <li>5. Retaining plug</li> <li>6. Pipe plug</li> <li>7. Wick</li> <li>24. Housing</li> </ul>
<p>10. Lever housing assembly (36)</p>	<p>While inserting the plunger into the switch, mount the lever housing to the frame using the screws and washers.</p>	
<p>11. Drive assembly</p>	<p>Install the thrust washers thru the drive assembly in the lever housing (36) using grease on the contact areas.</p>	<p>M</p>

TA 099066  
Go on to Sheet 12

LOCATION/ITEM	ACTION	REMARKS
12. Armature (46)	Place the thrust washer (45) on the commutator end of the armature.  Place the end plate and brush holder assembly (59) onto the armature.	Grease should be applied to the commutator end bushing surface and the armature shaft splines before assembling.
13. Brushes (62)	Place the brushes (62) in the holders.	
14. Spacer	Place over the splined shaft end.	
15. Armature and end plate	Install into the frame assembly and secure with screws and washers.	If original parts are used, aline the marks which you scribed on the housings before disassembly.
16. Inspection plug (34)	Install new gaskets and inspection plugs.	

Go on to Sheet 13

LOCATION/ITEM	ACTION	REMARKS
17. Drive housing (24)	Install on frame assembly using a new pre-formed packing (37).	<p>Torque capscrews 13 to 17 lb. ft. (17.6-23 N m)</p>  <p>The diagram shows a side view of the drive housing assembly. It consists of a rectangular frame assembly with a drive housing attached to its right side. A gasket is positioned between the frame and the drive housing. Several capscrews are used to secure the drive housing to the frame. Labels with leader lines point to 'CAPSCREWS', 'DRIVE HOUSING', 'GASKET', and 'FRAME ASSEMBLY'.</p>
18. Starter	Test before installing on vehicle.	See starter motor testing, page 3-200

TA 172210  
End

This task covers: Testing the starter motor

**INITIAL SETUP**

Test Equipment

Growler  
Multimeter  
Spring scale

Materials/Parts

None

Troubleshooting Reference

Page 2-8, TM 10-3930-641-20

Equipment Condition

Starter removed from vehicle

Special Tools

Arbor press  
Lathe

Personnel Required

One mechanic

References

Electrical troubleshooting,  
TM 10-3930-641-20  
Starter motor removal/  
installation,  
TM 10-3930-641-20

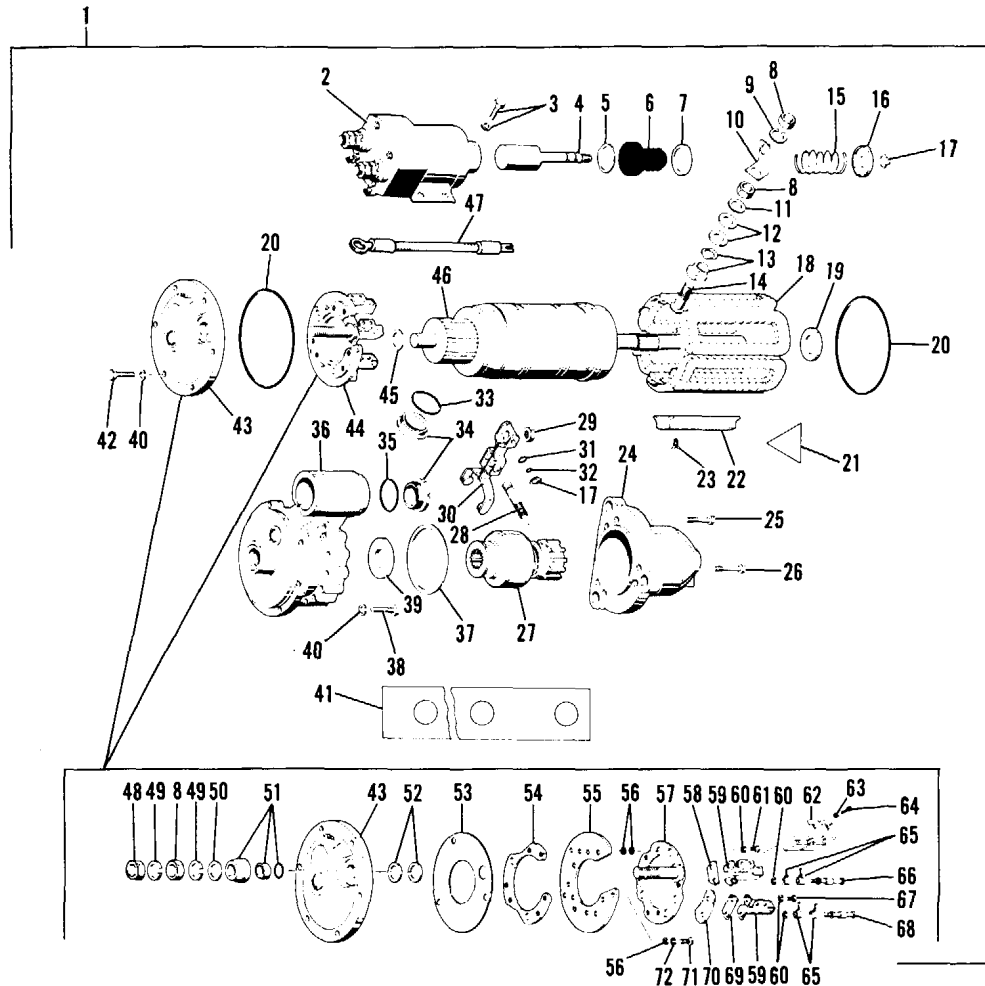
General Safety Instructions

None

LOCATION/ITEM	ACTION	REMARKS
<b>INSPECTION/REPAIR</b>		
1. All parts	Clean, then visually check all parts for damaged or worn conditions. Replace all gaskets and seals.	Replace as needed.
2. Drive housing (24)	If the sleeve inside diameter is not 0.624-0.626 in. (15.850-15.900 mm) it must be replaced. Check the wick.  Check rubber plug, expansion plug, pipe plug, gasket and wick.	Use a press for replacement.  Replace as needed.
3. Drive assembly (27)	Visually check for damage.	Replace as a unit.
4. Lever housing (36)	If sleeve inside diameter is not 0.8335-0.8355 in. (2.1171-2.1222 mm) replace the sleeve.	Use a press for replacement. Discard old seals and gaskets.
5. Shift lever (30)	If lever bore inside diameter is not 0.5100--0.5120 in. (12.9540-13.004 mm) it should be replaced.	
6. Lever shaft (28)	If shaft diameter is not 0.4980-0.5000 in. (12.540-12.7000 mm) it should be replaced.	

STARTER MOTOR TESTING (CONT)

1. Starting motor assembly
2. Switch
3. Washer and screw
4. Plunger
5. Washer
6. Plunger boot
7. Washer
8. Nut
9. Lockwasher
10. Washer
11. Insulator washer
12. Insulator washer
13. Preformed packing and bushing
14. Terminal stud
15. Spring
16. Spring retainer
17. Snap ring
18. Field coil
19. Washer
20. Preformed packing
21. Insulation triangle
22. Pole shoe
23. Screw
24. Drive housing
25. Capscrew
26. Capscrew
27. Drive assembly
28. Lever shaft
29. Nut
30. Lever
31. O-ring
32. O-ring
33. Preformed packing
34. Inspection plug
35. Preformed packing
36. Lever housing
37. Preformed packing
38. Capscrew
39. Washer
40. Lockwasher
41. Insulator
42. Capscrew
43. Frame
44. Plate assembly
45. Washer
46. Armature
47. Lead
48. Nut
49. Lockwasher
50. Washer
51. Insulator assembly
52. Washer
53. Insulator
54. Plate support
55. Insulator
56. Washer
57. Plate and stud
58. Plate
59. Brush holder
60. Lockwasher
61. Capscrew
62. Brush
63. Lockwasher
64. Screw
65. Brush spring
66. Screw
67. Screw
68. Screw
69. Plate
70. Insulator
71. Screw
72. Lockwasher



37. Preformed packing
38. Capscrew
39. Washer
40. Lockwasher
41. Insulator
42. Capscrew
43. Frame
44. Plate assembly
45. Washer
46. Armature
47. Lead
48. Nut
49. Lockwasher
50. Washer
51. Insulator assembly
52. Washer
53. Insulator
54. Plate support
55. Insulator
56. Washer
57. Plate and stud
58. Plate
59. Brush holder
60. Lockwasher
61. Capscrew
62. Brush
63. Lockwasher
64. Screw
65. Brush spring
66. Screw
67. Screw
68. Screw
69. Plate
70. Insulator
71. Screw
72. Lockwasher

## STARTER MOTOR TESTING (CONT)

(Sheet 4 of 6)

LOCATION/ITEM	ACTION	REMARKS
7. Plunger assembly (4)	Visually check	Disassemble and proceed to step 8.
8. Plunger spring (15)	Check for proper tension using a spring Compressor. A force of 13.5-14.5 lbs (18-19 N-m) at a height of 1.56 in. (39.60 mm) is required.	Replace if it doesn't meet these specifications.
9. Switch (2)	Test for shorts or grounds with an ohmmeter Inspect thoroughly.	Unit is not repairable. Replace as a unit.
10. Field coil (18)	Check for insulation breakdown. Attach ohmmeter probes to frame and a field coil terminal. The reading should not be less than one megohm.	Replace if found to be defective.
11. Armature (46)	Check these dimensions. Commutator end shaft 0.6835--0.6845 in. (17.3860-17.3860 mm), drive end shaft 0.622(-0.6230 in. (28.9150-29.2960 mm), center of the armature shaft near the splines 0.8225-0.8240 in. (20.8915-20.9296 mm). The armature commutator 2.1930-2.3180 in. (55.7022-58.8772 mm).	Commutator must be concentric to the shafts within 0.002 in. (.05 mm).

Go on to Sheet 5

STARTER MOTOR TESTING (CONT)

(Sheet 5 of 6)

LOCATION/ITEM	ACTION	REMARKS
12. Armature (46)	<p>Check for ground with a multimeter. Check for shorts with a growler. Check for out of round conditions on the commutator by installing the armature in a vise. If the surface of the commutator is damaged or out of round it must be resurfaced or replaced. The mica should be cut 0.025-0.032 in. (6.35-8.13 mm) below the commutator surface.</p>	<p>Replace if necessary.</p>
13. Commutator resurfacing	<p>Rotate armature at 8000 rpm in a lathe. Take very light cuts across the commutator finishing with a cut of no more than 0.002 in. (.05 mm) Do not cut smaller than 2.1930 in. (55.7022 mm). Check the mica for proper undercut. Use either a power undercutting tool or cut it by hand.</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>The mica undercut of 0.025-0.032 in. (6.35-8.13 mm) is very critical. Do not widen the commutator slots as you cut, but do not leave mica on the edges in a radius form.</b></p>	<p style="text-align: center;"><b>RIGHT WAY</b> MICA MUST BE CUT AWAY CLEAN BETWEEN SEGMENTS.</p> <p style="text-align: center;"><b>WRONG WAY</b> MICA MUST NOT BE LEFT WITH A THIN EDGE NEXT TO SEGMENTS.</p>

TA 099068  
Go on to Sheet 6

STARTER MOTOR TESTING (CONT)

(Sheet 6 of 6)

LOCATION/ITEM	ACTION	REMARKS
13. Commutator resurfacing (continued)	Finish commutator by rotating in a lathe at 1500 rpm and polishing with no. 0/2 sandpaper.	
14. Brush holder assembly	<p>Check brush spring tension with a suitable spring scale. It should not read less than 80 oz.</p> <p>Check for cracks or extremely worn parts.</p> <p>Brush should be at least 1/2" in length.</p>	If one brush or spring is found defective, replace the entire set with a brush kit.
15. Frame (commutator end)	If sleeve inside diameter is not 0.6860-0.6880 in. (17.4244-17.4752 mm) it must be replaced.	Use a press for replacement.

End

**Section VII. ROCKER SHAFT COMPONENTS**

This section covers maintenance of these engine components for direct support and general support maintenance personnel:

- a. Rocker shaft removal/installation
- b. Rocker shaft disassembly/assembly

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**LIST OF TASKS** **(Sheet 1 of 1)**

---

TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Rocker shaft removal/installation	3-207	2-24
2	Rocker shaft disassembly/assembly	3-211	2-16, 2-24

**ROCKER SHAFT REMOVAL/INSTALLATION****(Sheet 1 of 4)**

This task covers: Removal and installation of rocker shaft.

INITIAL SETUPTest Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Page 2-24

Equipment Condition

Valve covers removed.

Special Tools

Valve lifter tool set, 5P7433

Socket, 5P144

Personnel Required

One mechanic

References

Valve clearance setting, page 3-268

Valve covers removal/installation,

TM 10-3930-641-20.

General Safety Instructions

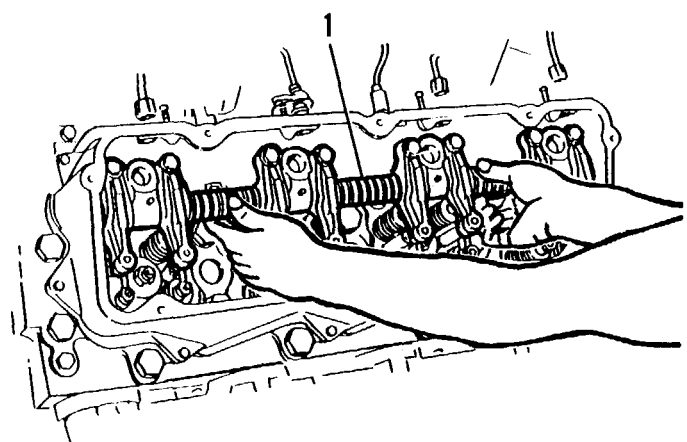
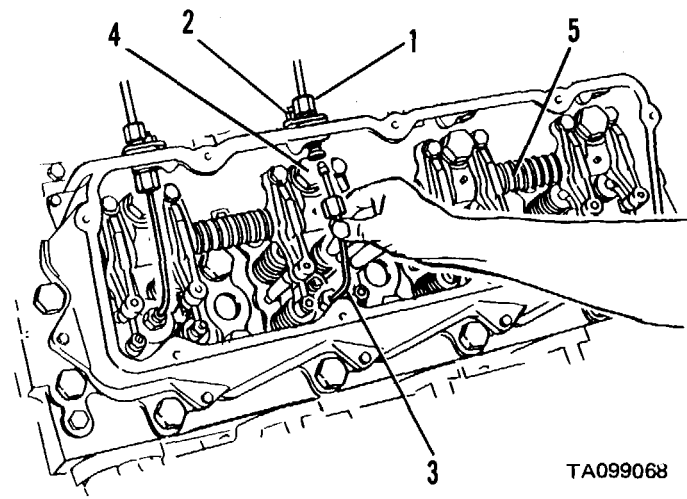
Main disconnect switch OFF.

Go on to Sheet 2

ROCKER SHAFT REMOVAL/INSTALLATION (CONT)

(Sheet 2 of 4)

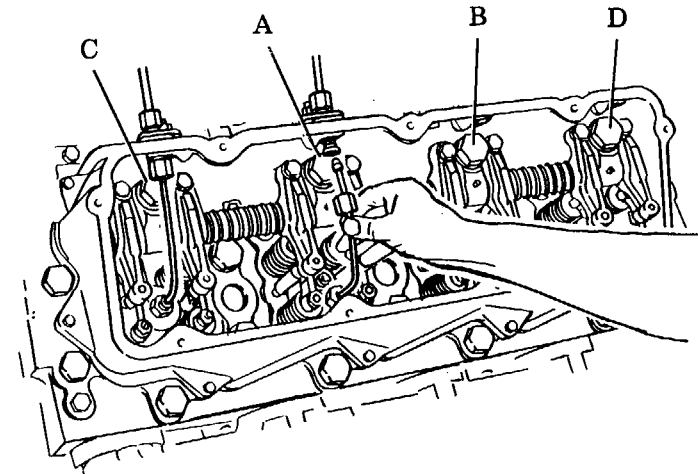
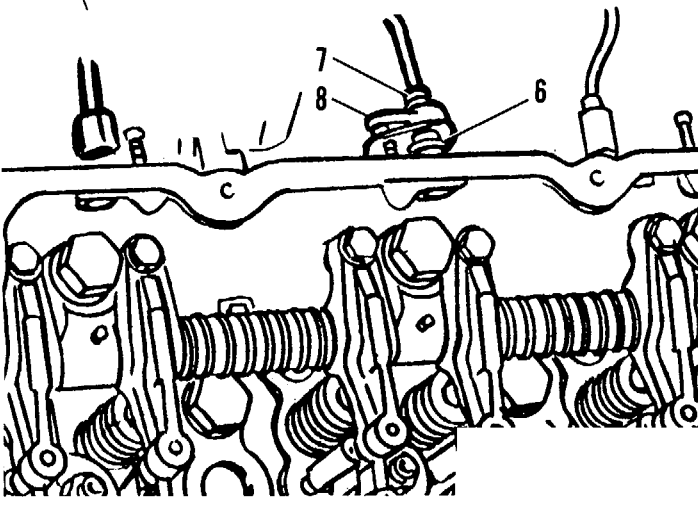
LOCATION/ITEM	ACTION	REMARKS
1. Fuel lines (3)	a. Disconnect and remove. b. Cap fuel line openings.	
2. Nuts, washers (2)	Remove.	
3. Locks (1), fuel line adapters	Remove from valve cover base.	
4. Rocker shaft capscrews (4)	Remove.	
	<p><b>NOTE</b> Loosen the capscrews evenly, alternating from one to the next until all are completely loose.</p>	
5. Rocker shaft assembly (5)	Remove.	
<u>INSTALLATION</u>		
1. Rocker shaft assembly (1)	Put in position on cylinder head.	
	<p><b>NOTE</b> Make sure rocker arms and push rods are alined before capscrews that secure rocker shafts are tightened.</p>	



TA099069  
Go on to Sheet 3

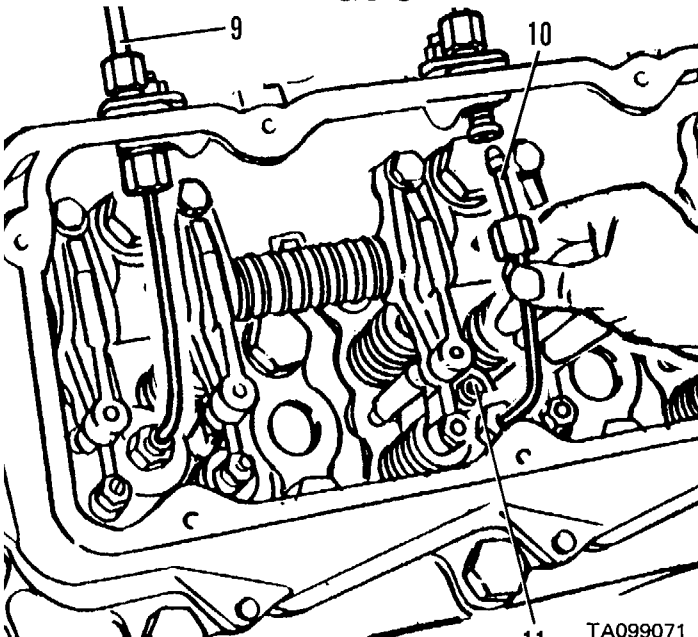
ROCKER SHAFT REMOVAL/INSTALLATION (CONT)

(Sheet 3 of 4)

LOCATION/ITEM	ACTION	REMARKS
2. Rocker shaft capscrews	<p>a. Coat threads with clean oil.</p> <p>b. Tighten capscrews in lettered sequence shown at right. Torque in three steps:</p> <p>Step 1: 200 + 20 lb. ft. (271.2 + 27.1 N m)</p> <p>Step 2: 330 + 15 lb. ft. (447.4 + 20.3 N-m)</p> <p>Step 3: 330 + 15 lb. ft. (447.4 + 20.3 N-m)</p>	
3. O-ring seal (6)	Coat with clean engine oil.	
4. Spacers, fuel line adapters (7)	Install.	
5. Locks (8)	Install.	

**ROCKER SHAFT REMOVAL/INSTALLATION (CONT)**

(Sheet 4 of 4)

LOCATION/ITEM	ACTION	REMARKS
6. Fuel line seals (11)	Coat with clean engine oil.	
7. Fuel lines (10) and (9)	Connect to fuel line adapters.	
8. Fuel line nuts	Tighten to torque of 30 + 5 lb. ft. (40.7 + 6.8 N m) with Socket (5P144).	See Valve Clearance setting, page 3-268.
9. Valves	Adjust clearance.	

End

**ROCKER SHAFT ASSEMBLY - DISASSEMBLY/ASSEMBLY**

(Sheet 1 of 5)

This task covers: Disassembly and assembly of rocker shaft assembly.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-16, 2-24

Equipment Condition

Valve covers removed.

Rocker shafts removed.

Special Tools

Puller group

Personnel Required

One mechanic

References

Rocker shaft removal/installation,  
page 3-207.

Valve covers removal/installation,  
TM 10-3930-641-20.

General Safety Instructions

Main disconnect switch OFF.

Go on to Sheet 2

**ROCKER SHAFT ASSEMBLY - DISASSEMBLY/ASSEMBLY (CONT)**

(Sheet 2 of 5)

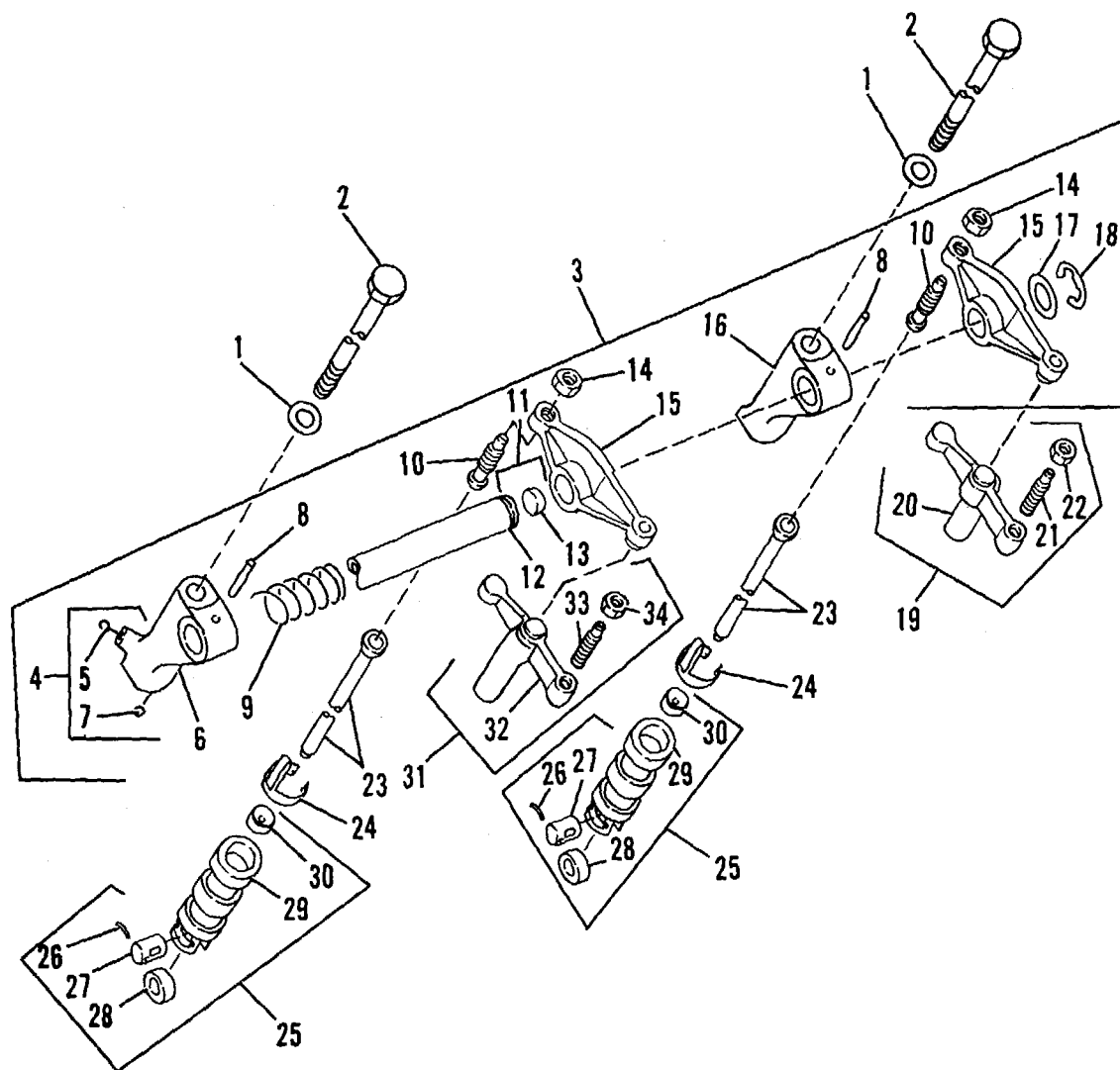
LOCATION/ITEM	ACTION	REMARKS
<u>DISASSEMBLY</u>		
1. Retaining ring (18)	Remove from end of shaft.	
2. Washers (17), rocker arm (15)	Remove.	
3. Bracket pin (8)	Using puller, remove pin from rocker arm shaft.	
4. Bracket (16), rocker arm (15), spring (9)	Remove.	
5. Remainder of rocker shaft assembly	Disassemble in same manner.	
<p style="text-align: center;"><b>NOTE</b>  <b>The center brackets do not have pins.</b></p>		
<p><b>3-212</b></p>		

Go on to Sheet 3

ROCKER SHAFT ASSEMBLY - DISASSEMBLY/ASSEMBLY (CONT.)

(Sheet 3 of 5)

1. Washer
2. Capscrew
3. Rocker arm group
4. Bracket assembly
5. Ball
6. Rocker arm shaft bracket
7. Ball
8. Pin
9. Spring
10. Screw
11. Rocker shaft assembly
12. Rocker arm shaft
13. Cup plug
14. Nut
15. Rocker arm assembly
16. Rocker arm shaft bracket
17. Washer
18. Retaining ring
19. Intake bridge assembly
20. Bridge
21. Machine screw
22. Nut
23. Push rod valve
24. Lifter guide spring
25. Lifter valve assembly
26. Lockwire
27. Roller pin
28. Roller
29. Body
30. Insert
31. Exhaust bridge assembly
32. Bridge
33. Machine screw
34. Nut



TA099072  
Go on to Sheet 4

**ROCKER SHAFT ASSEMBLY - DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<p><u>ASSEMBLY</u></p>	<p><b>NOTE</b>  <b>Be sure all parts are clean before assembly.</b></p>	
<p>1. Rocker shaft (12)</p>	<p>Coat with clean engine oil.</p>	
<p>2. Center springs (9), rocker arms (15), brackets (16)</p>	<p>Install.</p>	
<p>3. Tape</p>	<p>a Apply to shaft on each side of bracket.  b Aline hole in bracket with hole in shaft.  c Mark tape on each side of hole.</p>	

Go on to Sheet 5

ROCKER SHAFT ASSEMBLY - DISASSEMBLY/ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
4. Pin (8)	Install until it extends .34 in surface of bracket.	(8.6 mm) above
	<p><b>NOTE</b>  <b>Be sure pin aligns with marks on tape before it is driven into shaft.</b></p>	
5. Tape	Remove.	
6. Rocker arm (15), washers (17), retainer (18).	Install.	
	<p><b>NOTE</b>                      Install enough washers to make end play on each end of shaft .005 - .040 in. (0.12- 1.01 mm)</p>	
	3-215	

End

**Section VIII. CYLINDER HEADS**

This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Cylinder heads removal/installation
- b. Cylinder heads disassembly/assembly
- c. Cylinder liner removal/installation
- d. Spacer plates removal/installation

Also instructions for inspection of: cylinder block, cylinder liners.

**LIST OF TASKS:**

(Sheet 1 of 1)

TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Cylinder heads removal/installation.	3-217	2-15, 2-17, 2-21
2	Cylinder heads disassembly/assembly.	3-231	None.
3	Cylinder liner removal/installation.	3-239	2-15, 2-16
4	Spacer plates removal/installation.	3-246	2-15
5	Cylinder block inspection	3-250	2-17
6	Cylinder liners inspection	3-252	None.

**CYLINDER HEADS REMOVAL/INSTALLATION**

(Sheet 1 of 14)

This task covers: Removal and installation of cylinder heads.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Cylinder head

Troubleshooting Reference

Pages 2-15, 2-17, 2-21

Special Tools

None

Personnel Required

One mechanic

Spacer plate gasket

Equipment Condition

Muffler, turbocharger, exhaust manifolds removed.

References

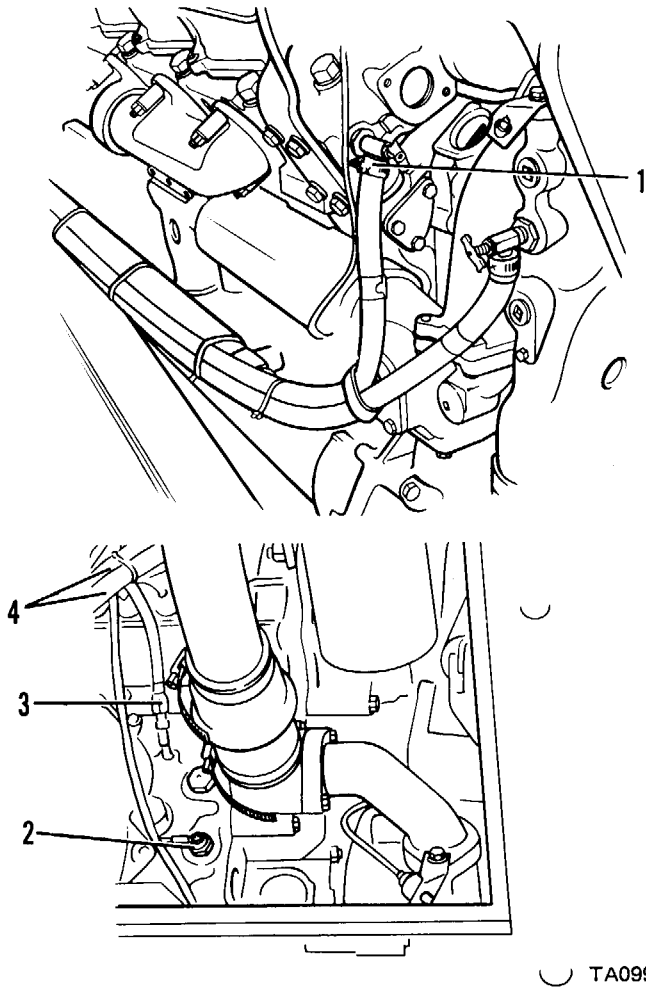
Spacer plates removal/installation, page 3-246.  
 Engine specifications, page 2-69..  
 Valve clearance setting, page 3-268.  
 Muffler removal/installation, TM 10-3930-641-20.  
 Turbocharger removal/installation, page 3-107.  
 Exhaust manifolds removal/installation, page 3-13  
 Coolant replacement, TM 10-3930-641-20.  
 Valve covers removal/installation. TM 20-3930-64  
 Water temperature regulators removal/installation  
 TM 10-3930-641-20.  
 Rocker shaft removal/installation, page 3-207.

General Safety Instructions

Main disconnect switch OFF

Go on to Sheet 2

CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
<p><u>REMOVAL</u></p> <ol style="list-style-type: none"> <li>1. Cooling system</li> <li>2. Radiator top tank lines</li> <li>3. Water temperature regulator housings</li> <li>4. Right hand cylinder head</li> </ol>	<p><b>NOTE</b> Tag all lines and hoses before disconnecting.</p> <p>Drain. See TM 10-3930-614-20.</p> <p>Remove from each side of the engine.</p> <p>Remove. See TM 10-3930-641-20.</p> <ol style="list-style-type: none"> <li>a. Disconnect heater hose (1) from fitting.</li> <li>b. Disconnect wire assembly (2) from the sensor unit.</li> <li>c. Disconnect air line (3) from cylinder head.</li> <li>d. Disconnect fuel lines (4) at fittings.</li> </ol>	 <p style="text-align: right;">TA099072</p>

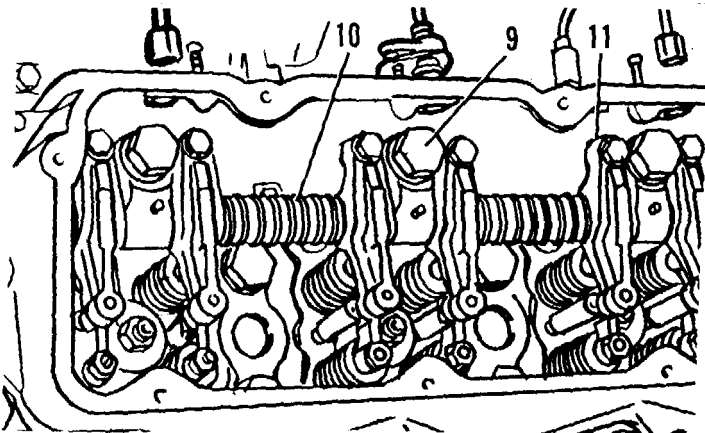
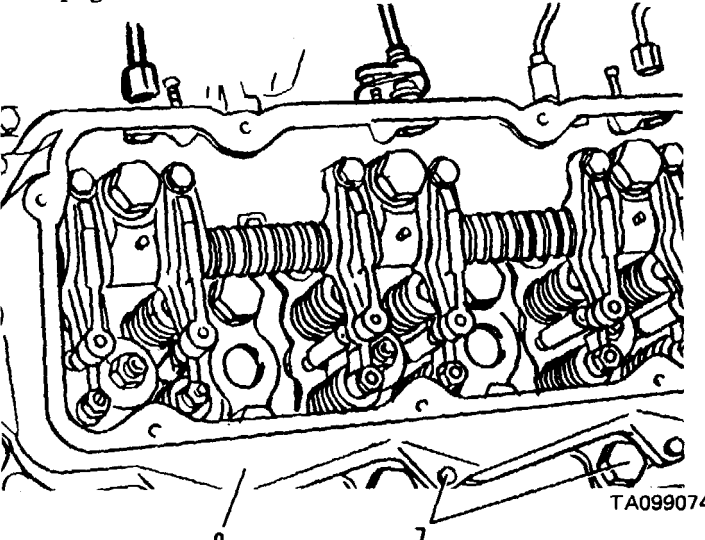
TA099073  
Go on to Sheet 3

CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

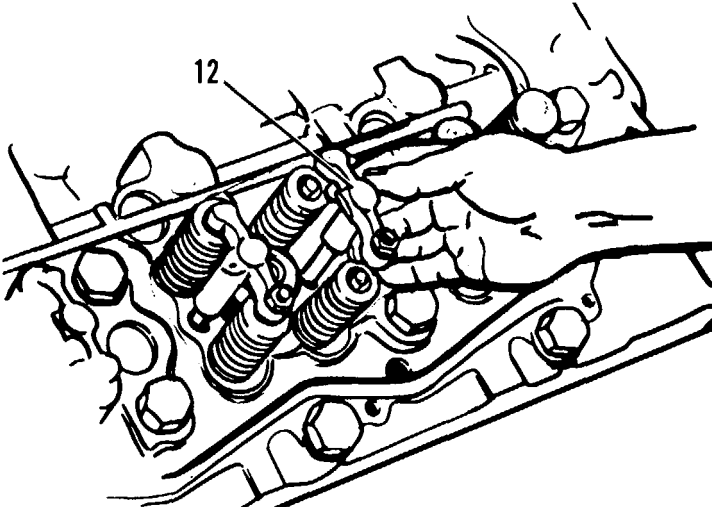
LOCATION/ITEM	ACTION	REMARKS
4. Right hand cylinder head (cont.)	e Remove valve cover. (See TM 10-3930-641-20.) <b>NOTE</b> <b>Cap or plug all fuel line openings.</b>	
5. Left hand cylinder head	Remove valve cover.	
6. Fuel lines	a. Disconnect adapter assembly (5) at valve cover base.  b. Remove from injectors (6) and adapter assembly using special socket.	<p>The diagram shows a cross-section of an engine cylinder head. Two fuel lines are visible at the top, labeled '5'. Below them, an injector is labeled '6'. A hand is shown using a special socket to disconnect the adapter assembly (5) from the injector (6). The drawing is a line drawing showing the internal components of the cylinder head, including the valves and the fuel injection system.</p>

TA099073

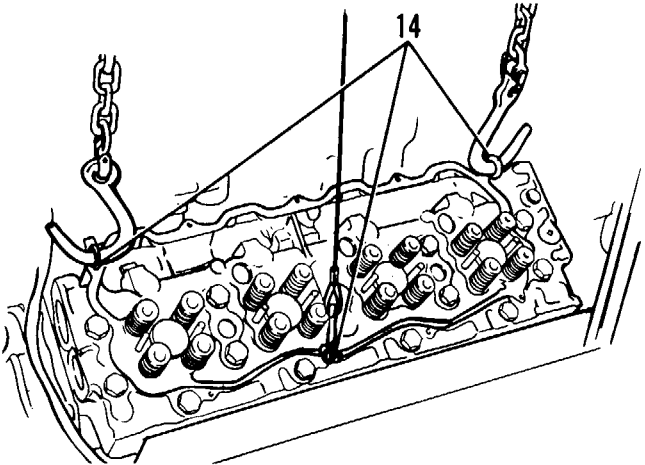
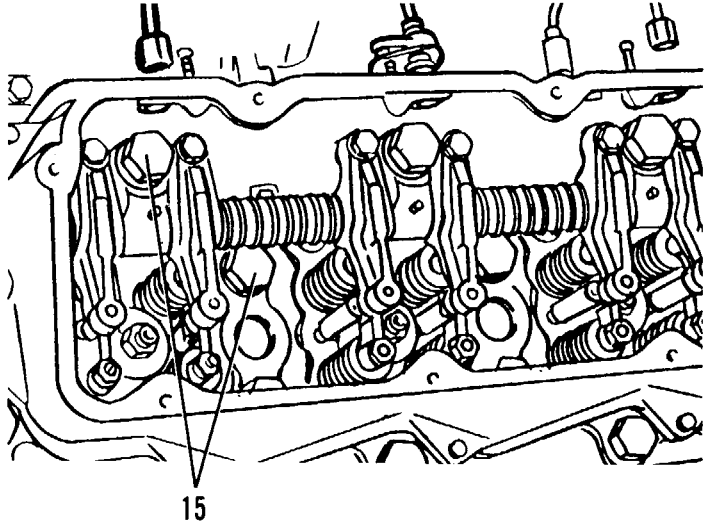
CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
7. Valve cover base capscrews (7)	Remove.	 <p>See page 3-207.</p>  <p>TA099074</p>
8. Valve cover base (8)	Remove.	
9. Rocker shaft bolts (9)	Remove.	
10. Rocker shaft assembly (10)	Remove.	
11. Push rods (11)	Remove.	
<p><b>NOTE</b> Cap or plug all fuel line openings.</p>		<p>Go on to Sheet 5</p>

CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
12. Valve bridges (12)	a. Tag for easy installation later. b. Remove.	
13. Bracket to automatic timing advance housing	a. Remove 3/8" capscrew that secures housing to rear bracket (13). b. Remove front and rear brackets (13) and (14). c. Remove remainder of 3/8" head capscrews.	

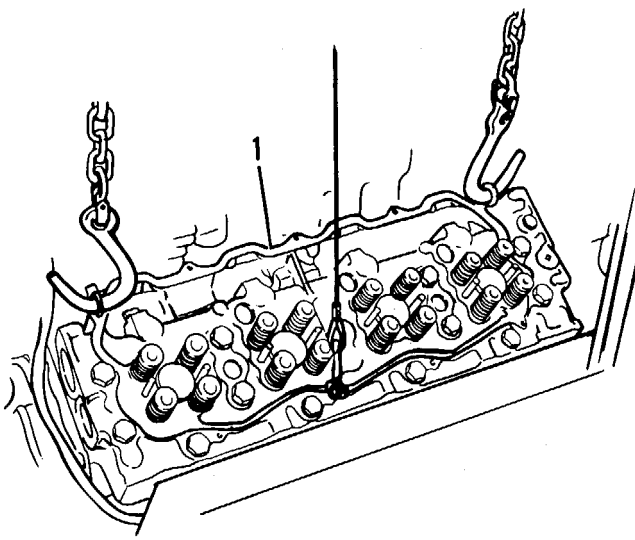
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Go on to Sheet 6

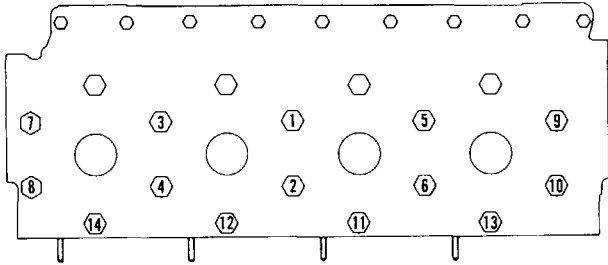
LOCATION/ITEM	ACTION	REMARKS
14. Three 5/16-18 NC forged eyebolts (14)	Install in cylinder head.	
15. Hoist	Fasten to eyebolts.	
<p style="text-align: center;"><b>NOTE</b> The cylinder head weighs 200 lb. (90.7 kg).</p>		
16. Cylinder head bolts (15)	Remove.	
17. Cylinder head	Remove.	

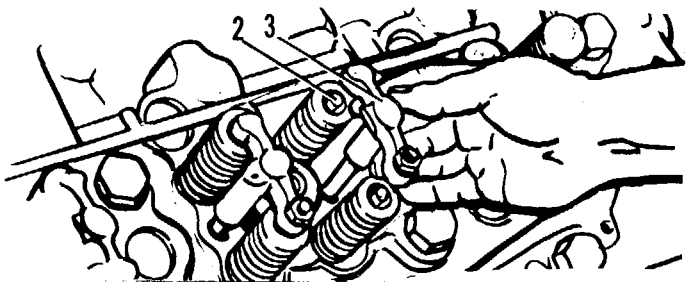
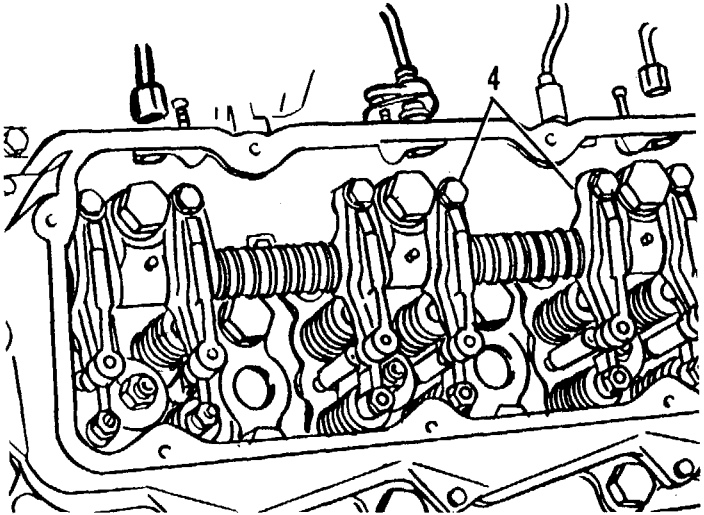
TA099076

Go on to Sheet 7

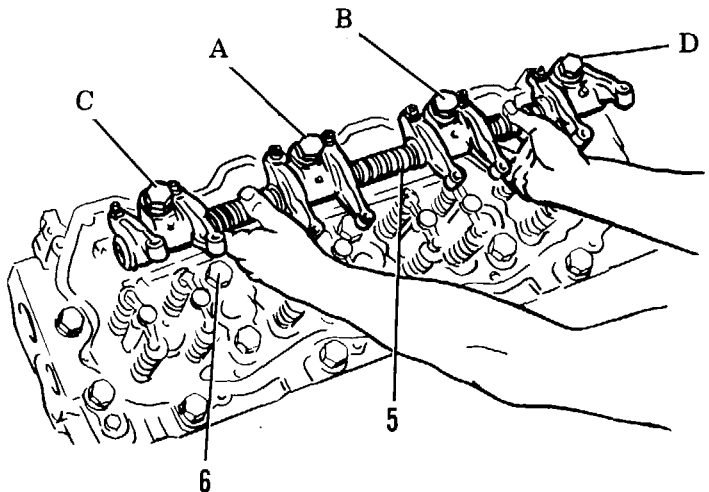
CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
INSTALLATION		
1 Spacer plate, bottom surface of cylinder head	<p><b>NOTE</b> The spacer plate gasket must be replaced whenever the cylinder head is removed. Clean thoroughly.</p>	
2 Spacer plate gasket	Install.	See Spacer Plate Removal/Installation, page 3-246.
3 Head gasket and seals	Install.	
	<p><b>NOTE</b> Don't use adhesives on head gasket or seals.</p>	
4 Cylinder head (1)	Put into position on spacer plate.	 <p style="text-align: right;">TA099077</p> <p style="text-align: right;">Go on to Sheet 8</p>

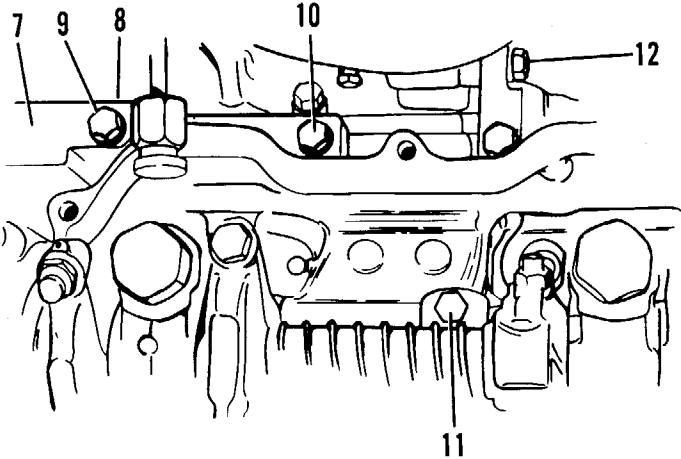
LOCATION/ITEM	ACTION	REMARKS
5. Cylinder head bolts	<p><b>NOTE</b>  <b>Guide bolts can be used to help aline cylinder head with spacer plate.</b></p>	
6. Cylinder head bolts and washers	<p>Coat threads with clean engine oil.</p> <p>a. Install finger tight.</p> <p>b. Tighten each bolt in the sequence shown at right to a torque of 200 + 20 lb. ft. (271.2 + 27.1 N-m);</p> <p>c. Tighten each in the same sequence to 330 + 15 lb: ft. (447.4 + 20.3 N.m).</p>	

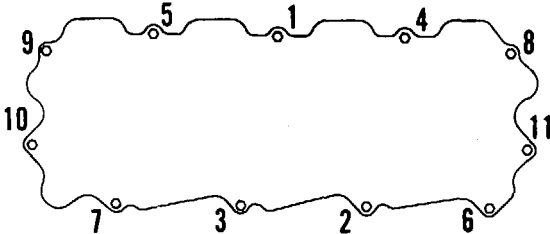
LOCATION/ITEM	ACTION	REMARKS
7. Valve bridge dowels (2)	<p>d. Again tighten each in that sequence to 330 + 15 lb. ft. (447.4 + 20.3 N-m).</p> <p>Coat with clean engine oil.</p> <p><b>NOTE</b>  <b>Check dowel height and diameter. If dowels do not meet specifications, replace them.</b></p>	
8. Valve bridges (3)	Install.	See ENGINE SPECIFICATIONS, page 2-69.
9. Push rods (4)	Install.	

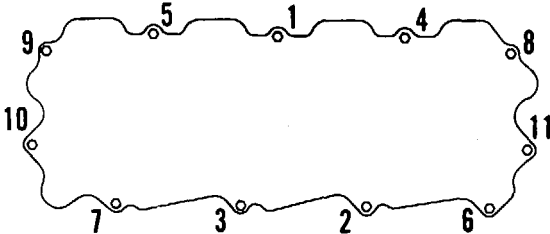
CYLINDER HEADS REMOVAL/INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
10. Rocker shaft assembly (5)	<ul style="list-style-type: none"> <li>a. Put in position on cylinder head.</li> <li>b. Aline push rods with rocker arms.</li> </ul>	
11. Rocker shaft bolts and washers (6)	<ul style="list-style-type: none"> <li>a. Install finger tight.</li> <li>b. Tighten each bolt in the sequence shown at right to a torque of 200 + 20 lb. ft. (271.2 + 27.1 N m).</li> <li>c. Tighten each in the same sequence to 330 + 15 lb. ft. (447.4 + 20.3 N m).</li> <li>d. Again tighten each in that sequence to 330 + 15 lb. ft. (447.4 + 20.3 N-m).</li> </ul>	

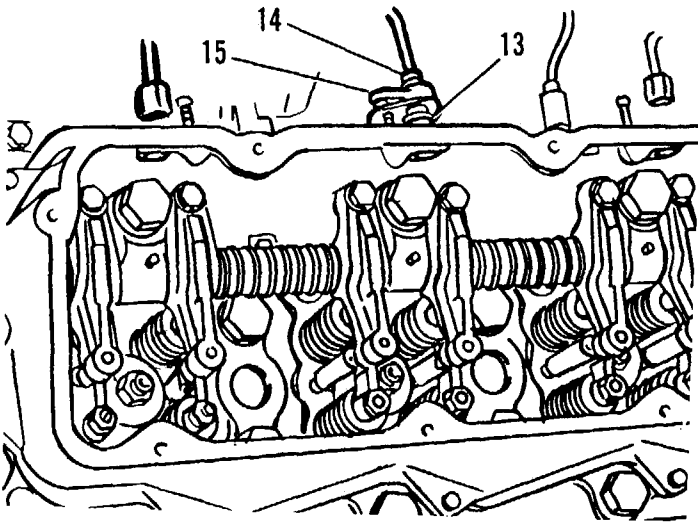
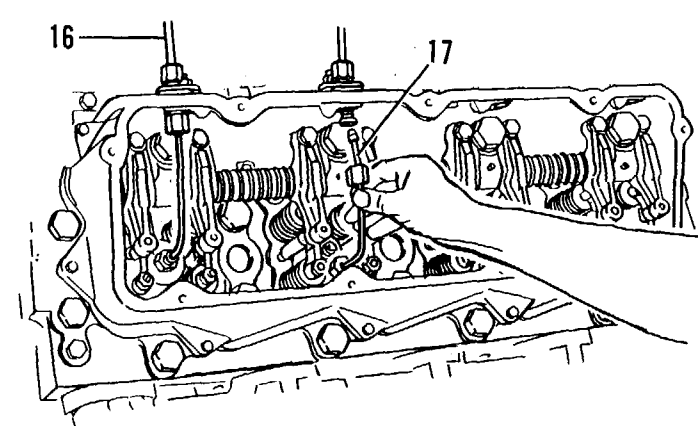
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Go on to Sheet 11

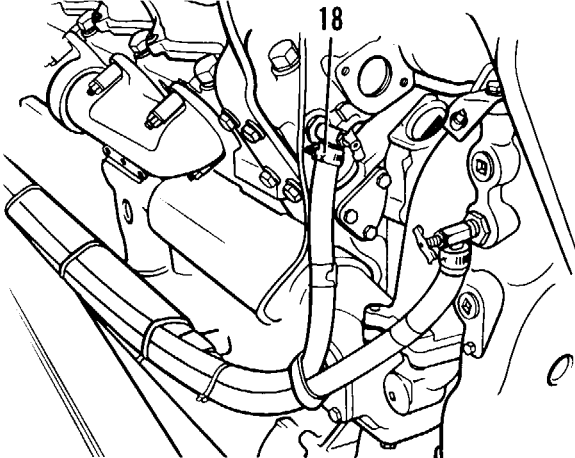
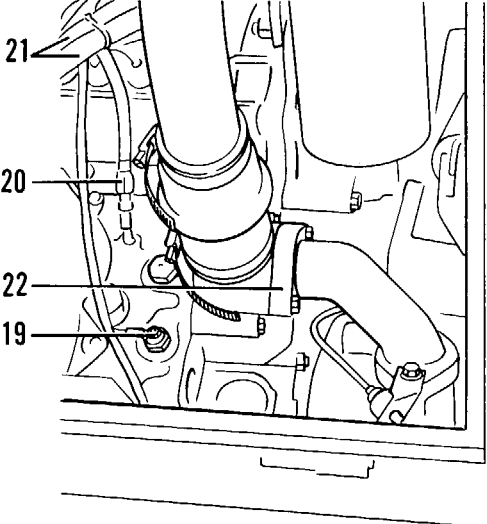
LOCATION/ITEM	ACTION	REMARKS
12. Bracket (7), spacer (8)	Install.	
13. Bracket bolts (9) (10)	Tighten finger tight.	
14. Automatic timing advance housing bracket bolt (9)	Tighten to standard torque.	
15. Bracket bolts (9) (10)	Tighten to a torque of 32 + 5 lb ft(43.4 + 6.8 N-m).	
16. Bolts (11)	Tighten finger tight.	
17. Bolts (12)	Tighten to standard torque.	

LOCATION/ITEM	ACTION	REMARKS
18. Head bolts (11)	Tighten to a torque of 32 + 5 lb ft (43.4 + 6.8 N m).	
19. Remainder of 3/8" head bolts	Tighten to a torque of 32 + 5 lb ft 43.4 + 6.8 N m).	
	<p><b>NOTE</b>  <b>If exhaust manifold studs were removed, install new studs and tighten each to a torque of 20 + 3 lb. ft. (27.1 + 4.1 N m).</b></p>	
20. Valves	Adjust clearance.	See Valve Clearance Setting, page 3-268.
21. Valve cover base	<p>a. Position on cylinder head.</p> <p>b. Tighten bolts in sequence shown at right to a torque of 18 + 5 lb. ft. (24 + 7 N-m).</p>	



TA099082  
 Go on to Sheet 13

LOCATION/ITEM	ACTION	REMARKS
22. O-ring seal (13)	Coat with clean engine oil.	
23. Spacers, fuel line adapters (14)	Install.	
24. Locks (15)	Install.	
25. Fuel lines (16)	a. Connect to fuel line adapters.	
26. Fuel lines (17)	b. Tighten fuel line nuts to a torque of 30 + 5 lb. ft. (40.7 + 6.8 N m).	
	a. Coat O-ring seals with clean engine oil.	
	b. Use special socket to loosely connect fuel lines to fuel line adapters.	
	c. Tighten fuel line nuts to a torque of 30 + 5 lb. ft. (40.7 + 6.8 N-m).	

LOCATION/ITEM	ACTION	REMARKS
27. Valve covers	Install.	
28. Right hand cylinder head	a. Connect heater hose (18) to fitting. b. Connect wire assembly (19) to sensor unit. c. Connect air line (20) to cylinder head. d. Connect fuel lines (21) at fittings.	
29. Water temperature regulator housing (22)	Install. See TM 10-3930-641-20.	
30. Radiator top tank lines	Install.	
31. Cooling system	Fill with coolant to the correct level. See TM 10-3930-641-20.	

CYLINDER HEADS DISASSEMBLY/ASSEMBLY

(Sheet 1 of 8)

This task covers: Disassembly, inspection and assembly of cylinder head.

INITIAL SETUP

Test Equipment

Micrometer (1")

Feeler gages

Straight edge

Materials/Parts

As required.

Spacer plate gasket

Troubleshooting Reference

None

Equipment Condition

Cylinder head assembly removed.

Special Tools

None

Personnel Required

One mechanic

References

Injection nozzles removal/installation, page 3-29.  
 Valves removal/installation, page 3-255.  
 Engine specifications, page 2-69  
 Valve guides removal/installation, page 3-262.  
 Valve seat inserts removal/installation, page 3-260  
 Cylinder heads removal/installation, page 3-217.

General Safety Instructions

Cylinder head weights 200 lbs. (90.7 Kg);  
 handle with a hoist.

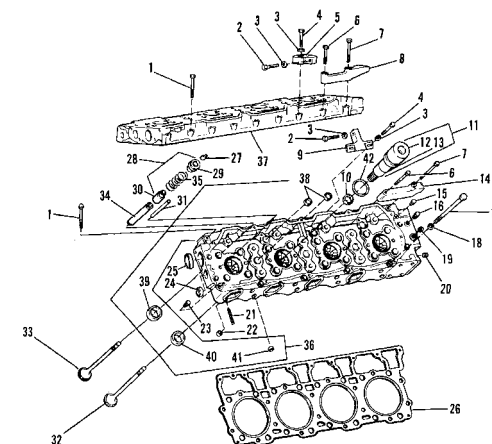
CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)

LOCATION/ITEM	ACTION	REMARKS
<u>DISASSEMBLY</u>		
1. Cylinder head assembly	Rinse with solvent to remove surface dirt and sludge.	
2. Timing gear housing support (8) and (14)	Remove.	
3. Fuel pump brackets (5) and (9)	Remove.	
4. Injector adapter assemblies (11)	a. Remove  b. Check for cracks or internal obstructions, heat discoloration and corrosion.	See injection nozzles removal/installation, page 3-29.
5. Valves (32) and (33), valve springs (35), rotocoils (28)	Remove.	See valves removal installation, page 3-255.
<b>NOTE</b>		
<b>Do not buff with wire brush to remove carbon deposits. This will cause deep scratches in valve.</b>		
6. Valves (32) and (33)	Remove carbon deposits with solvent, crocus cloth, scotch brite buffing pad, or glass bead method.	

Go on to Sheet 3

**CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)**

- |     |                                  |     |                           |
|-----|----------------------------------|-----|---------------------------|
| 1.  | Capscrew                         | 37. | Cylinder head             |
| 2.  | Capscrew                         | 38. | Cup plug                  |
| 3.  | Washer                           | 39. | Exhaust valve seat insert |
| 4.  | Capscrew                         | 40. | Intake valve seat insert  |
| 5.  | Fuel pump bracket - LH           | 41. | Cup plug                  |
| 6.  | Capscrew                         | 42. | Performed packing         |
| 7.  | Capscrew                         |     |                           |
| 8.  | Timing gear housing support - LH |     |                           |
| 9.  | Fuel pump bracket - RH           |     |                           |
| 10. | Gasket                           |     |                           |
| 11. | Injector adapter assembly        |     |                           |
| 12. | Adapter                          |     |                           |
| 13. | Tube                             |     |                           |
| 14. | Timing gear housing support - RH |     |                           |
| 15. | Pipe plug                        |     |                           |
| 16. | Pipe plug                        |     |                           |
| 17. | Capscrew                         |     |                           |
| 18. | Washer                           |     |                           |
| 19. | Pipe plug                        |     |                           |
| 20. | Pipe plug                        |     |                           |
| 21. | Taperlock stud                   |     |                           |
| 22. | Seal                             |     |                           |
| 23. | Pipe plug                        |     |                           |
| 24. | Plug                             |     |                           |
| 25. | Cup plug                         |     |                           |
| 26. | Gasket                           |     |                           |
|     | Cylinder Head Group              |     |                           |
| 27. | Valve retainer lock              |     |                           |
| 28. | Rotocoil assembly                |     |                           |
| 29. | Rotocoil                         |     |                           |
| 30. | Oil shield                       |     |                           |
| 31. | Pin                              |     |                           |
| 32. | Intake valve                     |     |                           |
| 33. | Exhaust valve                    |     |                           |
| 34. | Valve guide                      |     |                           |
| 35. | Spring                           |     |                           |
| 36. | Cylinder head assembly           |     |                           |



Go on to Sheet 4  
3-233

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## CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 4 of 8)

LOCATION/ITEM	ACTION	REMARKS
6. Valves (32) and (33) (cont)	<p>b. Check stems and stem tips for pitting or scratches.</p> <p>c. Check that stem diameter is within specifications.</p> <p><b>NOTE</b>  <b>Measure valve stem in three different locations. Measurement at top of stem (where valve does not contact valve guide) will be closest to specification for new valve.</b></p> <p>d. Check valve heads for cracks, rounded edges, burning, cupping or uneven wear.</p> <p>e. Check that valve face and lip (margin) are within serviceable limits.</p> <p>f. If valve is unserviceable, replace it.</p> <p style="text-align: center;"><b>Go on to Sheet 5 3-234</b></p>	See Engine Specifications, page 2-69.

## CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)

Sheet 5 of 8)

LOCATION/ITEM	ACTION	REMARKS
7. Valve springs (35)	<ul style="list-style-type: none"> <li>a. Clean in suitable solvent.</li> <li>b. Check that spring tension and height are within specifications.</li> <li>c. Replace if necessary.</li> </ul>	See Engine Specifications, page 2-69.
8. Rotocoils (29), valve retainers (27)	<ul style="list-style-type: none"> <li>a. Clean in solvent.</li> <li>b. Check for excessive wear or damage.</li> <li>c. Replace if necessary.</li> </ul>	See Engine Specifications, Page 2-69.
9. Cylinder head plugs, pipe plugs (15) and (16), cup plugs	<ul style="list-style-type: none"> <li>c. Replace if necessary.</li> </ul> <p>Remove.</p> <p style="text-align: center;"><b>Go on to Sheet 6 3-235</b></p>	

LOCATION/ITEM	ACTION	REMARKS
<p>10. Cylinder head (37)</p>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Steam cleaning is an alternate - but less effective - method of cleaning cylinder heads. If it is the only method available, be sure to use a soap and steam solution. Flush the inner passages several times from every possible opening. Dry with compressed air and take rust preventive measures immediately.</b></p> <ul style="list-style-type: none"> <li>a. Clean in hot tank containing caustic soda.</li> <li>b. Check for cracks using dye penetrant, magnetic field fluorescent or other suitable method.</li> <li>c. Check that warpage is within specifications.</li> </ul> <p style="text-align: center;"><b>NOTE</b></p> <p><b>To check warpage, place straight edge across machined surface (bottom side) of head. Then use feeler gage to determine gap under straight edge. Check in several places.</b></p> <p style="text-align: center;"><b>Go on to Sheet 7 3-236</b></p>	<p>See Engine Specifications, page 2-69.</p>

CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 7 of 8)

LOCATION/ITEM	ACTION	REMARKS
10. Cylinder head (37) (cont)	d. If necessary, resurface head to eliminate warpage.	
	<p><b>NOTE</b>  <b>If head cannot be resurfaced without exceeding tolerance for minimum height, replace it.</b></p>	
<b><u>ASSEMBLY</u></b>		
1. Valve guides (34)	a. Check diameter of guides to insure proper guide-to-valve stem clearance.	See Engine Specifications, page 2-69.
	b. Replace if necessary.	See Valve Guides Removal/Installation, page 3-262.
2. Valve seat inserts (39) and (40)	a. Check for cracks or signs of uneven wear.	See Engine Specifications, page 2-69.
	b. Check that insert is within specifications.	See Valve Seat Inserts Removal/Installation, page 3-260.
	c. Replace if necessary.	
<p><b>Go on to Sheet 8</b>  <b>3-237</b></p>		

## CYLINDER HEAD DISASSEMBLY/ASSEMBLY (CONT)

(Sheet 8 of 8)

LOCATION/ITEM	ACTION	REMARKS
3 Valve bridge dowels	Check dowel height and diameter not meet specifications, replace them.	If dowels do See Engine Specifications, page 2-69.
4 Cylinder head plugs, pipe plugs (15) and (16), cup plugs (25), (38) and (41)	Install.	
5 Valves (32), valve springs (35), rotocoils (28)	Install	See Valves Removal/Installation, page 3-255.
6 Injector adapter assemblies (11)	Install	See Injection Nozzles Removal/Installation, page 3-29.
7 Fuel pump brackets (5) and (9)	Install.	
8 Timing gear housing support (8) and	Install.	
<b>End 3-238</b>		

---

**CYLINDER LINER REMOVAL/INSTALLATION**

---

(Sheet 1 of 7)

This task covers: Removal and installation of cylinder liners.

**INITIAL SETUP****Test Equipment**

Cylinder liner projection gage

**Special Tools**

None

**Materials/Parts**

Cylinder liner

**Personnel Required**

One mechanic

**References**

Cylinder liner (projection) height adjustment, page 2-86.

Piston removal/installation, page 3-350.

Coolant replacement, TM 10-3930-641-20.

**Troubleshooting Reference**

Pages 2-15, 2-16

**Equipment Condition**

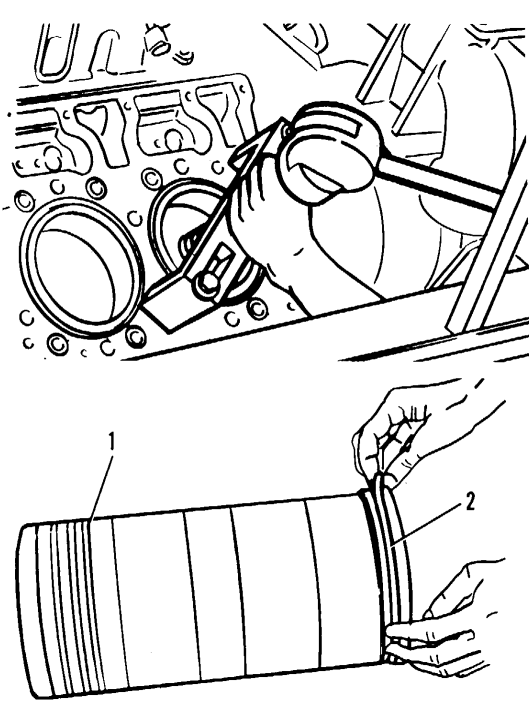
Pistons removed

**General Safety Instructions**

None

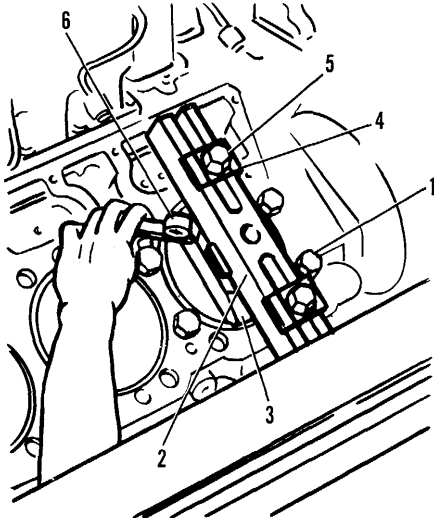
**Go on to Sheet 2  
3-239**

**CYLINDER LINERS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<p><b>REMOVAL</b></p> <ol style="list-style-type: none"> <li>1. Cylinder block</li> <li>2. Crankshaft journals</li> <li>3. Cylinder liners</li> <li>4. Seals (1), filler band (2)</li> </ol>	<p><b>NOTE</b>  <b>If cylinder liner is replaced, the piston assembly must be replaced too.</b>                      Drain coolant. See TM 10-3930-641-20.                      Cover to protect from water and dirt.                      Remove, using cylinder liner removal/ installation kit as shown at right.                      Remove from each liner.</p> <p style="text-align: center;"><b>Go on to Sheet 3 3-240</b></p>	

CYLINDER LINER REMOVAL/INSTALLATION (CONT)

(Sheet 3 of 7)

LOCATION/ITEM	ACTION	REMARKS
<p><b>INSTALLATION</b></p>		
<p>1. Cylinder liner, cylinder block bores</p>	<p>a. Clean in clean non-flammable solvent.                      b. Install liners in cylinder block.</p>	
	<p><b>NOTE</b></p>	
	<p><b>Spacer plate must be installed for following operation.</b></p>	
	<p>Check as follows:</p>	
<p>2. Cylinder liner (projection) height</p>	<p>a. Install four puller crossbar bolts and washers (1) around each cylinder liner as shown at right Tighten the bolts evenly to a torque of 70 lb.-ft (95 N.m).</p>	
	<p>b. Install crossbar (2), plate (3), plates (4), bolts and washers (5) on the first liner to be measured.</p>	
		
	<p>Go on to Sheet 4 3-241</p>	

TA099087

LOCATION/ITEM	ACTION	REMARKS
<p>2. Cylinder liner (projection) height (cont)</p>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Be sure the bar is in position at the center of the liner and the liner surface is clean.</b></p> <p>c. Tighten bolts (5) evenly to a torque of 50 lb ft (67.8 N-m)</p> <p>d. Check the distance from the bottom edge of the bar (2) to the top edge of the spacer plate The distance on each end of the bar must be the same.</p> <p style="text-align: center;"><b>Go on to Sheet 5 3-242</b></p>	

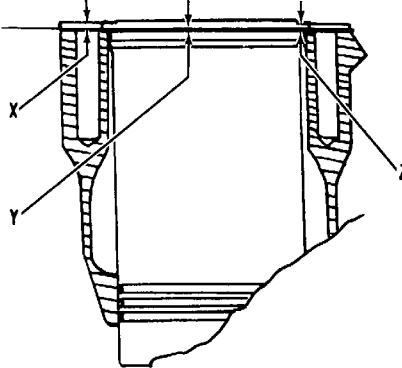
## CYLINDER LINER REMOVAL/INSTALLATION (CONT)

(Sheet 5 of 7)

LOCATION/ITEM	ACTION	REMARKS
2. Cylinder liner (projection) height (cont)	<p>e. Check liner (projection) height with a liner projection gage (6) at four locations around the liner.</p> <p>Liner projection height must be .005 + .003 in (0.13 + 0.08 mm) The difference between the four measurements on the same liner must not exceed .001 in. (0.03 mm) The difference between liner (projection) height for liners next to each other must not exceed .001 in (0.03 mm).</p> <p><b>NOTE</b>  <b>If liner is turned in cylinder block it can make a difference in liner (projection) height.</b></p> <p style="text-align: center;"><b>Go on to Sheet 6 3-243</b></p>	

CYLINDER LINER REMOVAL/INSTALLATION (CONT)

(Sheet 6 of 7)

LOCATION/ITEM	ACTION	REMARKS
<p>2. Cylinder liner (projection) height (cont)</p>	<p>f. If liner projection height is not <math>.005 + .003</math> in. (<math>0.13 + 0.08</math> mm), check the thickness of the following parts:                      Spacer plate (X): <math>.338 + .001</math> in. (<math>8.59 + 0.03</math> mm).                      Spacer plate gasket (Y): <math>.008 : .001</math> in. (<math>0.20 + 0.03</math> mm).                      Cylinder liner flange (Z): <math>.350 \pm .0008</math> in. (<math>8.89 \pm 0.020</math> mm).  <b>NOTE</b>                      All surfaces must be clean and dry when the spacer plate gasket is installed.</p> <p style="text-align: center;">Go on to Sheet 7 3-244</p>	

TA099088

## CYLINDER LINER REMOVAL/INSTALLATION (CONT)

(Sheet 7 of 7)

LOCATION/ITEM	ACTION	REMARKS
2. Cylinder liner (projection) height (cont)	g. If necessary, adjust cylinder liner (projection) height	- See Cylinder Liner (Projection) Height Adjustment, page 2-86.
3. Cylinder liners	<p>When (projection) height of each cylinder liner is determined to be correct, install each in the following way:</p> <p>a. Put a mark on cylinder liner and block so cylinder can be installed in same position.</p> <p>b. Remove puller crossbar and cylinder liner projection gage.</p> <p>c. Remove liner to be installed.</p> <p>d. Put liquid soap on seals (1), grooves of liner and bore of block.</p> <p style="text-align: center;"><b>End</b> <b>3-245</b></p>	

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**SPACER PLATES REMOVAL/INSTALLATION**

(Sheet 1 of 4)

This task covers: Removal and installation of spacer plate.

**INITIAL SETUP**

**Test Equipment**

None

**Special Tools**

Six screws (3/8-16 NC x 1-1/2)

**Materials/Parts**

Spacer plate

Spacer plate gasket

**Personnel Required**

One mechanic

**References**

Cylinder head removal/installation, page 3-217.  
Muffler removal/installation, TM 10393064120.  
Turbocharger removal/installation, page 3-107.  
Exhaust manifolds removal/installation, page 3-131  
Coolant replacement, TM 10393064120.  
Water temperature regulators removal/installation TM 10-3930-641-20.  
Rocker shaft removal/installation, page 3-207.

**Troubleshooting Reference**

Page 2-15

**Equipment Condition**

Cylinder heads removed

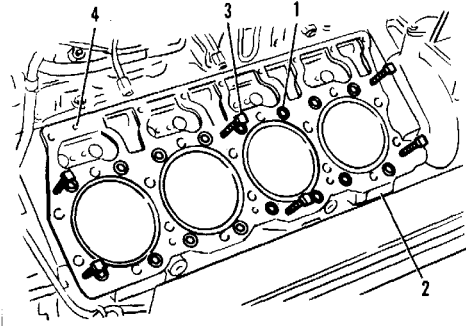
**General Safety Instructions**

Main disconnect switch OFF.

**Go on to Sheet 2  
3-246**

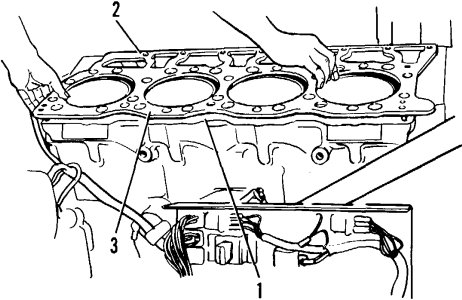
**SPACER PLATES REMOVAL/INSTALLATION (CONT)**

(Sheet 2 of 4)

LOCATION/ITEM	ACTION	REMARKS
<p><b>REMOVAL</b></p> <p>1. Seals (1)</p> <p>2. Six 3/8-16 NC forcing screws (3)</p> <p>3. Spacer Plate</p> <p>4. O-ring seal (4)</p>	<p>Remove from spacer plate (2).</p> <p>a. Install around perimeter of spacer plate.</p> <p>b. Tighten evenly until spacer plate is free of dowels.</p> <p><b>CAUTION</b></p> <p><b>Do not damage dowels as spacer plate is removed.</b></p> <p>Remove.</p> <p>Remove from under spacer plate.</p> <p style="text-align: center;"><b>Go on to Sheet 3 3-247</b></p>	 <p style="text-align: right;">TA099089</p>

**SPACER PLATES REMOVAL/INSTALLATION (CONT)**

(Sheet 3 of 4)

LOCATION/ITEM	ACTION	REMARKS
<b><u>INSTALLATION</u></b>		
1. Spacer plate gasket (1), O-ring seal (2)	<p><b>NOTE</b>                      Be sure spacer plate and machined surface of cylinder block are clean and dry.                      Put new gasket and seal into position over the dowels on the cylinder block.</p> <p><b>CAUTION</b>                      Do not use adhesive on the gasket.                      Install.</p>	
2. Spacer plate (3)	<p style="text-align: center;">Go on to Sheet 4 3-248</p>	<p style="text-align: right;">TA099090</p>

**SPACER PLATES REMOVAL/INSTALLATION (CONT)**

(Sheet 4 of 4)

LOCATION/ITEM	ACTION	REMARKS
3. Water Seals 4. Cylinder liner projection	Install new seals in the spacer plate. Check.	Engine specifications, page 2-69.
	<b>End 3-249</b>	

---

**CYLINDER BLOCK INSPECTION**

(Sheet 1 of 2)

This task covers: Cleaning and inspection of cylinder block.

**INITIAL SETUP****Test Equipment**

Magnetic flux fluorescent light  
inspection kit

**Special Tools**

None

**Materials/Parts**

None

**Personnel Required**

One mechanic

**References**

Engine specifications, page 2-69.

**Troubleshooting Reference**

Page 2-17

**Equipment Condition**

Cylinder block stripped

**General Safety Instructions**

Main disconnect switch OFF.

**Go on to Sheet 2  
3-250**

CYLINDER BLOCK INSPECTION (CONT)

(Sheet 2 of 2)

LOCATION/ITEM	ACTION	REMARKS
Cylinder block	<p>a. Clean in agitating tank containing caustic soda solution.</p> <p><b>NOTE</b></p> <p><b>Steam cleaning is an alternate method of cleaning the cylinder block but is not as effective. If it is the only method available, use a soap and steam solution. Immediately flush the inner passages from every possible opening. Dry with compressed air and take rust preventive measures immediately.</b></p> <p>b. Check for cracks using dye penetrant, magnetic flux fluorescent or other suitable method.</p> <p>c. Check that cylinder block is within specifications.</p> <p style="text-align: center;"><b>End</b> <b>3-251</b></p>	<p>See Engine Specifications, page 2-69.</p>

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**CYLINDER LINER INSPECTION**

---

(Sheet 1 of 2)

This task covers: Inspection of the cylinder liner.

**INITIAL SETUP****Test Equipment**

None

**Special Tools**

None

**Materials/Parts**

None

**Personnel Required**

One mechanic

**References**

Engine specifications, page 2-69.

Cylinder liners removal/installation,  
page 3-239.

**Troubleshooting Reference**

None

**Equipment Condition**

Cylinder liners removed

**General Safety Instructions**

None

**Go on to Sheet 2  
3-252**

## CYLINDER LINER INSPECTION (CONT)

(Sheet 2 of 2)

LOCATION/ITEM	ACTION	REMARKS
<p><b><u>INSPECTION</u></b></p> <p>1. Cylinder liner</p> <p>2. Cylinder block bore</p>	<p>a. Check for cracks, vertical scoring and pitting.</p> <p>b. Check inside diameter for excessive wear, taper and out-of-roundness.</p> <p>Check visually for cracks and signs of distortion.</p> <p><b>End</b> <b>3-253</b></p>	<p>See Engine Specifications, page 2-69.</p>

**Section IX. VALVE COMPONENTS**

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**VALVE COMPONENTS MAINTENANCE INSTRUCTIONS**

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This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Valves removal/installation
- b. Valve seat inserts removal/installation
- c. Valve guides removal/installation
- d. Push rods and valve lifters removal/installation
- e. Valve clearance setting

---

**LIST OF TASKS**

**(Sheet 1 of 1)**

---

TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Valves removal/installation.	3-255	2-14, 2-25
2	Valve seat inserts removal/installation.	3-260	2-25
3	Valve guides removal/installation.	3-262	2-16, 2-18
4	Push rods and valve lifters removal/ installation	3-264	2-10, 2-14, 2-24
5	Valve clearance setting.	3-268	2-9, 2-10, 2-12, 2-24

**VALVES REMOVAL AND INSTALLATION**

(Sheet 1 of 5)

This task covers: Removal and installation of engine intake or exhaust valve.

**INITIAL SETUP**

**Materials/Parts**

**Troubleshooting Reference**

**Test Equipment**

Intake or exhaust valve

Pages 2-14, 2-25

Valve spring tester

**Personnel Required**

**Equipment Condition**  
Cylinder heads removed

**Special Tools**

One mechanic

**General Safety Instructions**  
Main disconnect switch OFF.

None

**References**

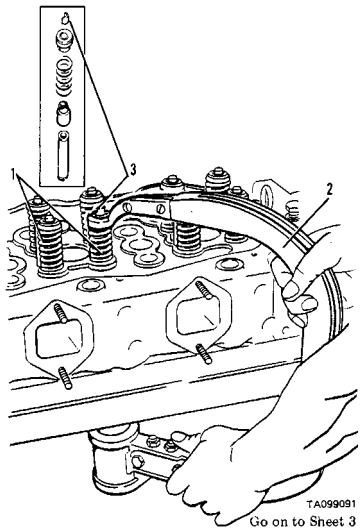
Cylinder head removal/installation, page 3-217.

Make sure valve lock is properly installed before releasing spring tension.

**Go on to Sheet 2  
3-255**

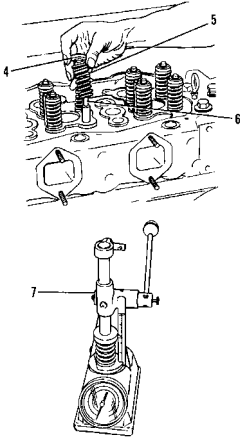
VALVES REMOVAL AND INSTALLATION (CONT)

(Sheet 2 of 5)

LOCATION/ITEM	ACTION	REMARKS
<p><b>REMOVAL</b></p> <ol style="list-style-type: none"> <li>1. Valve spring (1)</li> <li>2. Valve lock (3)</li> <li>3. Valve spring compressor</li> </ol>	<p>Compress with valve spring compressor (2). Remove two halves. Remove.</p>	 <p style="text-align: right;">TA099091 Go on to Sheet 3</p>
	<p>Go on to Sheet 3 3-256</p>	

VALVES REMOVAL AND INSTALLATION (CONT)

(Sheet 3 of 5)

LOCATION/ITEM	ACTION	REMARKS
<p>4. Valve rotator (4), spring (5), valve (6)</p> <p>5. Valve spring</p>	<p><b>NOTE</b>  <b>Before removing valves, mark each with the identity of the port it was taken from.</b>                      Remove and note location of each valve for installation.                      Check spring force with valve spring tester (7). Spring force must be 77.5 + 3.9 lb (104.4 + 5.4 N-m) when the length of spring under force is 2.165 in. (54.99 mm). If spring doesn't meet this specification, replace it.</p> <p style="text-align: center;"><b>Go on to Sheet 4 3-257</b></p>	 <p>The technical drawings in the Remarks column include: 1) A perspective view of a valve assembly with callouts 4, 5, and 6. Callout 4 points to the valve rotator, 5 to the valve spring, and 6 to the valve. 2) A side view of a valve spring tester, labeled with callout 7, which is used to measure the spring force.</p>

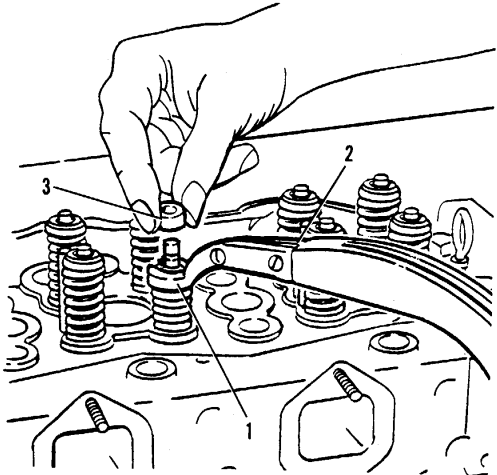
TA099092

## VALVES REMOVAL AND INSTALLATION (CONT)

(Sheet 4 of 5)

LOCATION/ITEM	ACTION	REMARKS
<b>INSTALLATION</b> 1. Valve	a. Coat stem with clean engine oil. b. Install. <b>NOTE</b> <b>Be sure to install each valve in its correct location.</b> c. Check that valve installed height is within specifications. If it is not, the valve seat must be reground.  <b>Go on to Sheet 5 3-258</b>	See Engine Specifications, page 2-69.

VALVES REMOVAL AND INSTALLATION (CONT)

LOCATION/ITEM	ACTION	REMARKS
2. Valve spring, rotocoil (1)	a. Install.	
3. Valve lock (3)	b. Compress with valve spring compressor (2). Install with thick end up.	
4. Valve spring compressor	<p><b>WARNING</b> Lock can be thrown from valve when spring compressor is released if lock has not been installed correctly.</p> <p>Remove.</p> <p><b>NOTE</b> Tap valve with soft hammer to check that spring, rotator, and lock have been installed correctly.</p>	

End  
3-259

TA099093

**VALVE SEAT INSERTS REMOVAL/INSTALLATION**

(Sheet 1 of 2)

This task covers: Removal and installation of valve seat inserts.

**INITIAL SETUP**

**Test Equipment**

None

**Special Tools**

Valve seat extractor/installation tool

**Materials/Parts**

Valve seat inserts

**Personnel Required**

One mechanic

**References**

Valve covers removal/installation,  
TM 10-3930-641-20

Valve removal/installation, page 3-255  
Cylinder heads removal/installation, page 3-21'

**Troubleshooting Reference**

Page 2-25

**Equipment Condition**

Valves removed

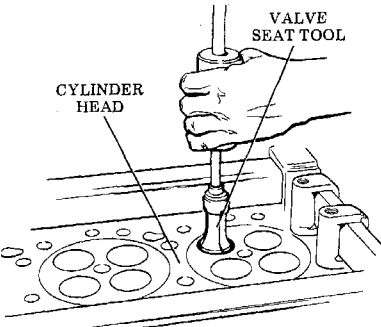
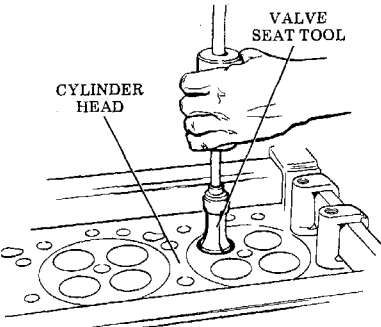
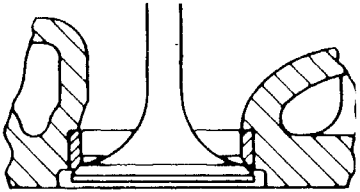
**General Safety Instructions**

None

**Go on to Sheet 2  
3-260**

VALVE SEAT INSERTS REMOVAL/INSTALLATION (CONT)

(Sheet 2 of 2)

LOCATION/ITEM	ACTION	REMARKS
<p><b>REMOVAL</b> 1. Valve seat inserts</p>	<p>Remove with suitable valve seat extractor/ installation tool as shown at right. Clean and remove burs.</p>	
<p>2. Valve seat bore <b>INSTALLATION</b> 1. Valve seat inserts</p>	<p>a Lower temperature until valve seat inserts fit easily. b. Install with extractor/installation tool. c. Grind to correct specifications. Clean thoroughly to remove all dirt and metal shavings.</p>	
<p>2. Cylinder head, valve seat inserts</p>		<p>See Engine Specifications, page 2-69.</p>
		
	<p>End 3-261</p>	<p>TA099094</p>

**VALVE GUIDES REMOVAL/INSTALLATION**

(Sheet 1 of 2)

This task covers: Removal and installation of valve guides.

**INITIAL SETUP****Test Equipment**

None

**Special Tools**

Valve guide driver

Bushing

**Materials/Parts**

Valve guide

**Personnel Required**

One mechanic

**References**

Engine specifications, page 2-69.

Valve cover removal/installation,  
TM 10-3930-641-20.

Valve removal/installation, page 3-255.

Cylinder heads removal/installation, page 3-21

**Troubleshooting Reference**

Pages 2-16, 2-18

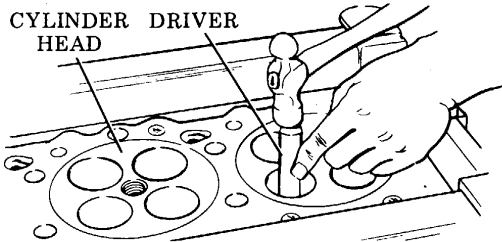
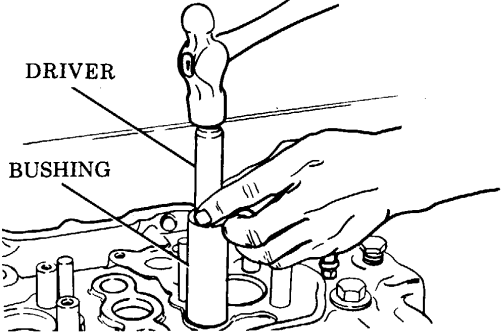
**Equipment Condition**

Valves removed

**General Safety Instructions**

None

**Go on to Sheet 2**  
**3-262**

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>REMOVAL</b></p> <ol style="list-style-type: none"> <li>1. Valve guides</li> <li>2. Outside surface of replacement (new) valve guides</li> </ol>	<p>Remove with suitable driver as shown at right.</p> <p>Coat with clean engine oil.</p>	 <p>CYLINDER DRIVER HEAD</p>
<p style="text-align: center;"><b>INSTALLATION</b></p> <ol style="list-style-type: none"> <li>1. New valve guides</li> </ol>	<ol style="list-style-type: none"> <li>a. Install as shown with suitable driver and bushing.</li> </ol> <p style="text-align: center;"><b>NOTE</b></p> <p><b>The purpose of the bushing is to limit the amount each guide is driven into the cylinder head.</b></p> <ol style="list-style-type: none"> <li>b. Check inside diameter of guides to insure proper valve-to-guide clearance.</li> <li>c. Ream if necessary.</li> </ol>	 <p>DRIVER</p> <p>BUSHING</p> <p>See Engine Specifications, page 2-69.</p>

TA099095

End

3-263

PUSH RODS AND VALVE LIFTERS REMOVAL/INSTALLATION

(Sheet 1 of 4)

This task covers: Removal and installation of push rod and valve lifter.

INITIAL SETUPTest Equipment

None

Materials/Parts

Push rod

Valve lifter

Troubleshooting Reference

Pages 2-10, 2-14, 2-24

Special Tools

Tool, engine turning, 9S9082

Tool set, valve lifter, 5P7433

Handle assembly, 5P6599

Lever assembly, FT1322 (See Appendix C)

Personnel Required

One mechanic

Equipment Condition

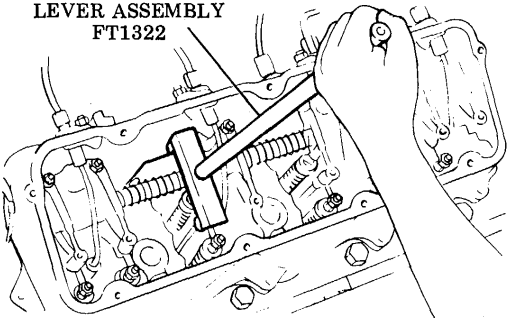
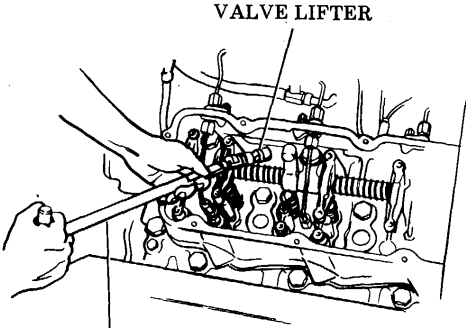
Valve covers removed from engine

ReferencesValve cover removal/installation,  
TM 10-3930-641-20General Safety Instructions

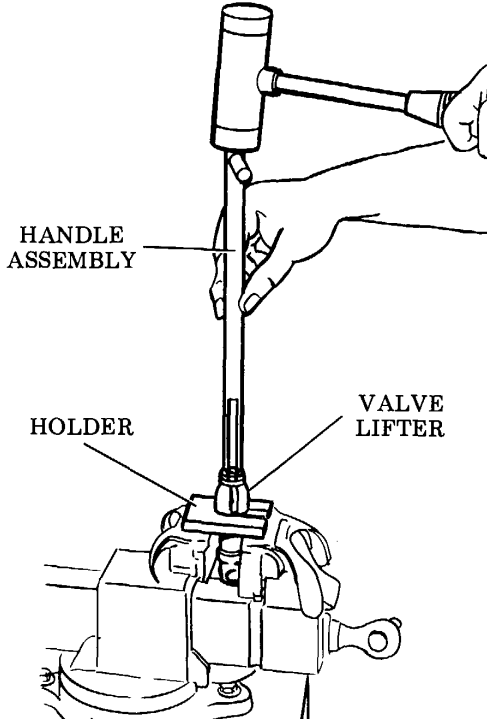
None

Go on to Sheet 2

**3-264**

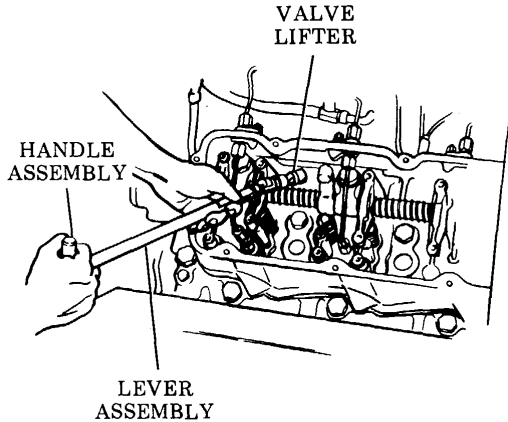
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL</div>	<p>1. Crankshaft Turn with engine turning tool 9S9802 until rocker arm is no longer under pressure.</p> <p>2. Push rod a. Separate from rocker arm using FT1322. b. Remove.</p> <p>3. Rocker arm Remove.</p> <p>4. Valve lifter Remove as shown at right using Handle Assembly (5P2408) and Nut (5P2685) from Valve Lifter Tool Set 5P7433.</p> <p>5. Spring Remove from lifter.</p>	<p style="text-align: center;">LEVER ASSEMBLY FT1322</p>  <p style="text-align: center;">VALVE LIFTER</p>  <p style="text-align: center;">HANDLE ASSEMBLY</p>

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>INSTALLATION</b></p> <p>1. Guide spring</p> <p>2. Lifter, Handle Assembly.</p>	<p style="text-align: center;"><b>CAUTION</b></p> <p><b>Install new guide springs on valve lifters whenever lifters are removed from engine.</b></p> <p>Install on valve lifter using Handle Assembly with Nut attached, Holder, and soft hammer.</p> <ol style="list-style-type: none"> <li>a. Remove from Holder</li> <li>b. Install Handle in center of Assembly.</li> <li>c. Coat lifter with clean engine oil.</li> <li>d. Position lifter in cylinder block with spring in alignment with hole in block.</li> </ol>	

TA099097

Go on to Sheet 4

LOCATION/ITEM	ACTION	REMARKS	
2. Lifter, Handle Assembly (cont.)	e. Install lifter by pushing Handle Assembly into Lever Assembly as shown at right.	 <p>The diagram illustrates the installation of a valve lifter handle assembly. A hand is shown pushing a handle assembly into a lever assembly. Labels indicate the VALVE LIFTER, HANDLE ASSEMBLY, and LEVER ASSEMBLY.</p>	
3. Push rod	Install		
4. Rocker arm	Put in position over push rod.		

TA099097  
End

VALVE CLEARANCE SETTING

This task covers: Adjusting valve clearance of intake and exhaust valves.

INITIAL SETUP

Test Equipment

Feeler gauge

Materials/Parts

None

Troubleshooting Reference

Pages 2-9, 2-10, 2-12, 2-24

Special Tools

Tool, Engine Turning 9S9082

Personnel Required

One mechanic

Equipment Condition

Engine shut down

References

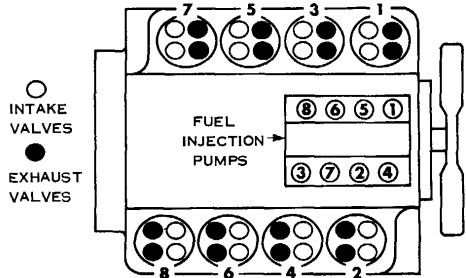
Engine specifications, page 2-69.

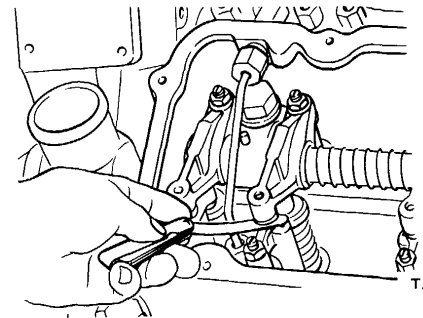
Valve cover removal/installation,  
TM 10-3930-641-20.

Finding top center position, page 3-371.

General Safety Instructions  
Main disconnect switch OFF.

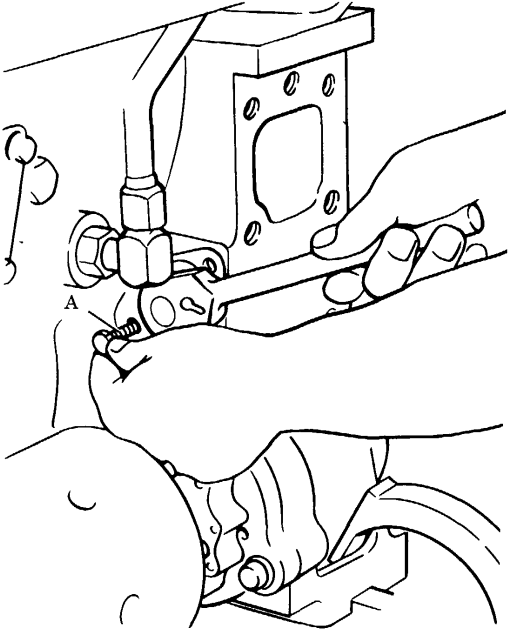
Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
1. Valve covers	Remove	See TM 10-3930-641-20.
2. No. 1 piston	Set to top center (TC) on compression stroke.	See page 3-371.
3. Intake valve clearance -cylinders No. 1, 2, 5, 7	<p>NOTE</p> <p>The diagram at right identifies positions of valves and fuel injection pumps. You will need to know this to perform this task.</p>	 <p style="text-align: center;">CYLINDER AND VALVE LOCATION</p>
	<p>a. Measure between rocker arm and bridge using feeler gauge. Should be 0.015 in. (0.38 mm).</p>	



TA099098

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
3. Intake valve clearance -cylinders No. 1, 2, 5, 7 (cont.)	b. Adjust if necessary.  c. Tighten valve nut to a torque of 19-25 lb ft (26-34 N-m) and recheck adjustment.	
4. Exhaust valve clearance -cylinders No. 1, 3, 4, 8	a. Measure between rocker arm and bridge. Should be 0.030 in. (0.76mm).  b. Adjust if necessary.  c. Tighten valve nut to 19-25 lb ft (26-34 N.m) and recheck adjustment.	
5. Timing bolt (A)	a. Remove.  b. Use engine turning tool (9S9082) and rotate flywheel 3600 (one full turn) counterclockwise (when looking at flywheel).  c. Reinstall.	
<p><b>NOTE</b></p> <p><b>No. 6 piston is now at TC.</b></p> <p>Go on to Sheet 4</p>		

TA099099

VALVE CLEARANCE SETTING (CONT)

LOCATION/ITEM	ACTION	REMARKS
6. Intake valve clearance -cylinders No. 3, 4, 6, 8	a. Measure Should be 0.015 in. (0.38mm).  b. Adjust if necessary.  c. Tighten valve nut to 19-25 lb ft (26-34 N.m) and recheck adjustment.	
7. Exhaust valve clearance-cylinders No. 2, 5, 6, 7	a. Measure. Should be 0.030 in. (0.76mm).  b. Adjust if necessary.  c. Tighten valve nut to 19-25 lb ft (26-34 N.m) and recheck adjustment.	
8. Timing bolt	a. Remove from flywheel.  b. Install with cover.	
9. Valve covers	Install.	See TM 10-3930-641-20.

End

3-271

Section X. CAMSHAFT

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CAMSHAFT MAINTENANCE INSTRUCTIONS

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This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Camshaft removal/installation
- b. Camshaft bearings removal/installation

Also instructions for inspection of: camshaft

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LIST OF TASKS

(Sheet 1 of 1)

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Camshaft removal/installation.	3-273	2-14, 2-25
2	Camshaft bearings removal/installation.	3-280	2-19
3	Camshaft inspection.	3-283	2-14, 2-19, 2-25

CAMSHAFT REMOVAL/INSTALLATION

This task covers: Removal and installation of camshaft.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Camshaft

Troubleshooting Reference

Pages 2-14, 2-25

Equipment Condition

Engine OFF

Special Tools

Tool, engine turning 9S9082

Personnel Required

One mechanic

References

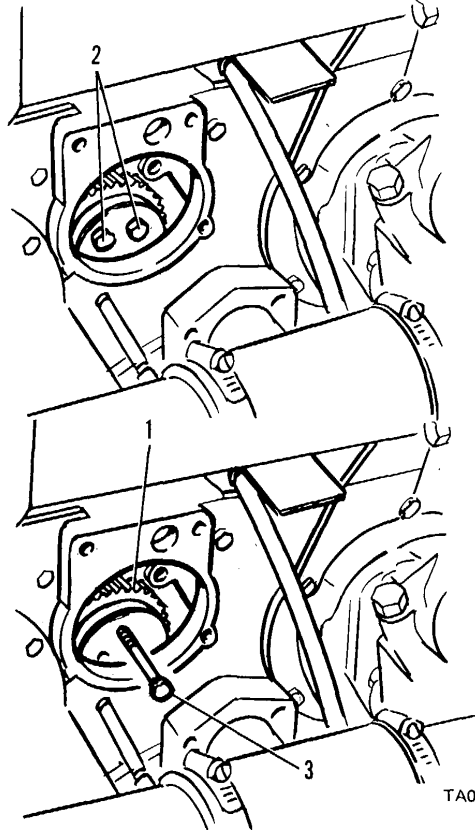
Timing gear cover removal/installation,  
page 3-288

General Safety Instructions

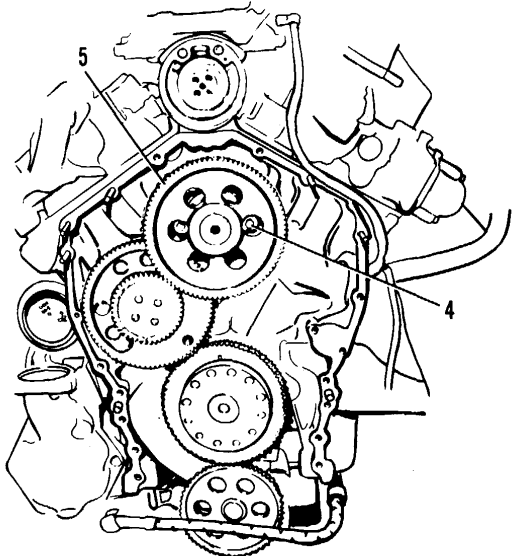
Main disconnect switch OFF.

Go on to Sheet 2

**3-273**

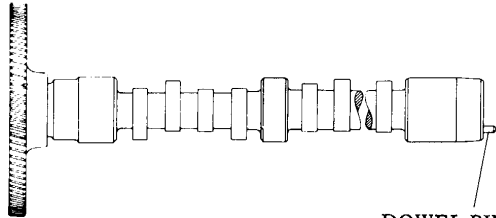
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">REMOVAL</div> <ol style="list-style-type: none"> <li>1. Engine</li> <li>2. Four camshaft rear gear bolts (2)</li> <li>3. Camshaft rear gear (1)</li> <li>4. Engine</li> <li>5. Bolt (5/16-18 NC x 5) (3)</li> </ol>	<p>Turn with Engine Turning Tool until bolts in camshaft rear gear (1) are visible.</p> <p>Remove.</p> <p>Pull loose from camshaft.</p> <p>Turn until "V" marks on timing gears align.</p> <p>Install through camshaft rear gear into camshaft.</p>	 <p style="text-align: right; font-size: small;">TA099100</p>

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
6. Camshaft front plate capscrews (4)	Remove.	
7. Camshaft assembly (5)	Pull approximately 2 in. (50.8 mm) out of the cylinder block.	
8. Camshaft rear gear	<div style="border: 1px solid black; padding: 5px; text-align: center; margin: 10px 0;"><b>CAUTION</b></div> <p>Camshaft rear gear must be securely fastened with wire. If not, gear will fall into flywheel housing when bolt (3) is removed. Engine must then be removed to recover gear.</p>	
9. Bolt (3)	Fasten to the flywheel housing with wire.	
9. Bolt (3)	Remove from the camshaft rear gear.	

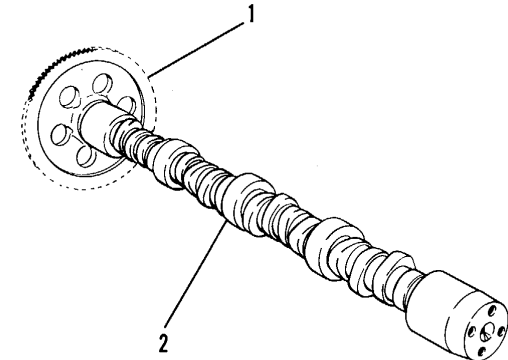
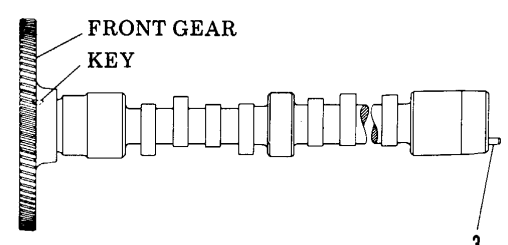
TA099101

Go on to Sheet 4

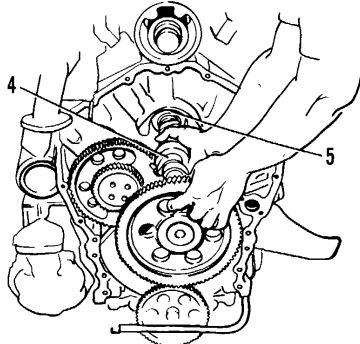
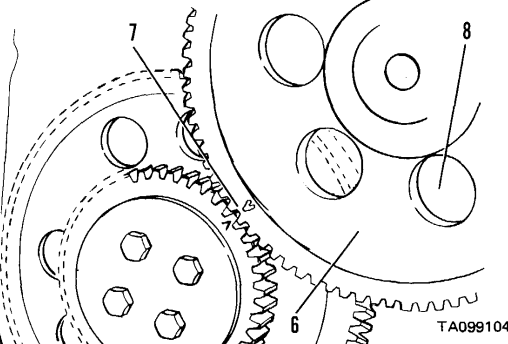
LOCATION/ITEM	ACTION	REMARKS
10. Camshaft rear gear	Remove.	
11. Camshaft assembly (5)	Remove from cylinder block.  <div style="border: 1px solid black; padding: 2px; display: inline-block; text-align: center;">CAUTION</div>  <b>Be careful not to damage camshaft lobes, journals and bearings as camshaft is removed.</b>	 <p style="text-align: right;">DOWEL PIN</p>
12. Camshaft front gear	Remove, using a press and drive plate.	
13. Dowel pin	Remove from tapered end of camshaft.	

TA099102

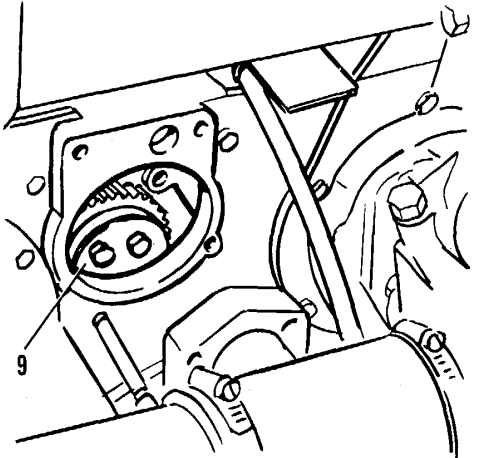
Go on to Sheet 5

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>INSTALLATION</b></p> <p>1. Camshaft front gear (1)</p> <p>2. Dowel pin (3)</p>	<p style="text-align: center;"><b>NOTE</b> Be sure key is in position before installing camshaft front gear.</p> <p style="text-align: center;"><b>CAUTION</b> Do not use a torch.</p> <p>a. Heat to maximum temperature of 600°F (315°C).</p> <p>b. Install gear on camshaft (2).</p> <p>Install in camshaft to extend. 345 + .010 in. (8.76 + 0.25 mm) from camshaft end.</p>	  <p style="text-align: right;">TA099103</p>

Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
3. Camshaft (4), camshaft bearings (5).	Coat lobes, journals and bearing surfaces inside cylinder block) with clean engine oil	
4. Camshaft	Install until rear of camshaft is even with rear of cylinder block.	
5. Camshaft rear gears	a. Fasten to flywheel housing with safety wire. b. Position gear and install bolt (5/16-18 NC x 5) through rear gear into camshaft.	
6. Camshaft (6)	a. Align "V" mark on camshaft with "V" mark on crankshaft gear (7) b. Install camshaft all the way into cylinder block.	

Go on to Sheet 7

LOCATION/ITEM	ACTION	REMARKS
7. Camshaft front plate	Position and secure with the two plate capscrews (8).	
8. Camshaft rear gear	a. Align dowel hole in rear gear (9) with dowel in camshaft. b. Install gear. c. Remove safety wire and bolt from camshaft rear gear.	
9. Camshaft rear gear capscrews	Install.	
<p style="text-align: center;"><b>NOTE</b></p> <p><b>It may be necessary to turn the engine with the engine turning tool (9S9082) to line up the two capscrew holes.</b></p>		TA099105

End

3-279

CAMSHAFT BEARINGS REMOVAL/INSTALLATION

This task covers: Removal and installation of camshaft bearings.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Camshaft bearings

Troubleshooting Reference

Page 2-19

Equipment Condition

Camshaft, flywheel housing, and pistons removed from engine

Special Tools

None

Personnel Required

One mechanic

References

Camshaft removal/installation, page 3-273

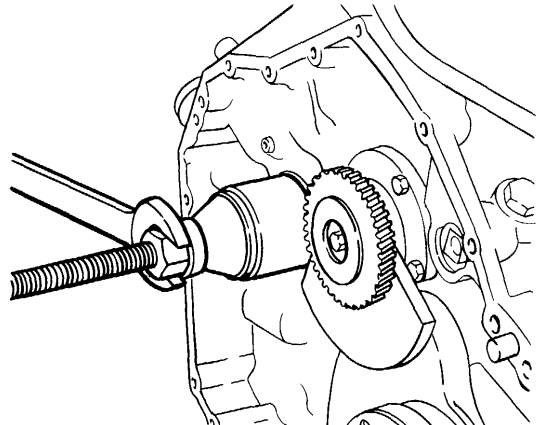
Flywheel housing removal/installation, page 3-3

Piston and connecting rod removal/installation, page 3-350

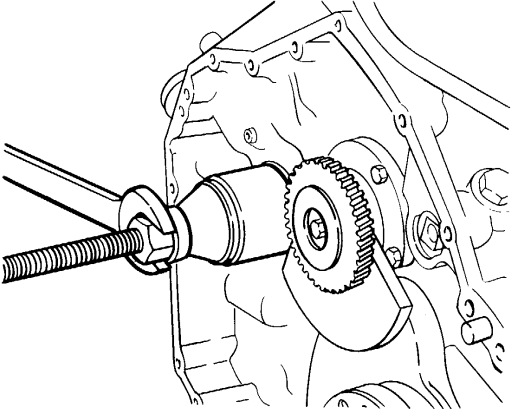
General Safety Instructions

None

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>REMOVAL</b></p> <p>Camshaft Bearings</p>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Replace bearings when excessively scored or worn, replace.</b></p> <p>a. Remove rear bearing using suitable camshaft bearing removal/installation tool.</p> <p>b. Remove other four bearings in same manner.</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Start at rear of engine block and move toward front.</b></p> <p style="text-align: center;"><b>CAUTION</b></p> <p><b>Be sure each bearing is correctly aligned before installation. Oil hole in each bearing must align with corresponding hole in bearing bore.</b></p>	 <p style="text-align: right;">TA099106</p>
<p style="text-align: center;"><b>INSTALLATION</b></p>		

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
1. Rear camshaft bearing	Install as shown using suitable camshaft bearing removal/installation tool.	
2. Three inside camshaft bearings	Install in same manner.	
3. Front camshaft bearing	Install in same manner.	
<p><b>NOTE</b></p> <p>Front camshaft bearing must be installed 1.33 + .004 in. (33.8 + 0.1 mm) from machined surface on front of cylinder block (shown at right).</p>		
<p>End</p> <p><b>3-282</b></p>		

TA099107

CAMSHAFT INSPECTION

This task covers: Cleaning and inspection of camshaft.

INITIAL SETUP

Test Equipment

Magnetic field fluorescent light kit

Micrometer (2")

Dial indicator

Materials/Parts

Solvent

Stiff bristle brush

Troubleshooting Reference

Pages 2-14, 2-19, 2-25

Equipment Condition

Camshaft removed from engine

Special Tools

None

Personnel Required

One mechanic

References

Camshaft removal/installation, page 3-273

General Safety Instructions

None

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
1. Camshaft.	<ul style="list-style-type: none"> <li>a. Clean with solvent and stiff bristle brush</li> <li>b. Check for cracks using dye penetrant, magnetic field fluorescent, or other suitable method.</li> <li>c. Support on U-blocks and use dial indicator to measure runout. Runout should not exceed 0.002 in. (0.050 mm) at center bearing.</li> </ul>	
2. Camshaft bearing journals	<ul style="list-style-type: none"> <li>a. Check for signs of uneven wear, scratches, deterioration of finish, and score marks.</li> <li>b. Check that diameter of bearing journals is within specifications.</li> </ul>	See Engine specifications, page 2-69.
3. Camshaft lobes	Check for pitting and uneven or excessive wear.	
	End	

ENGINE OIL FILTER AND COOLER BYPASS VALVES REMOVAL/INSTALLATION

(Sheet 1 of 2)

This task covers: Replacement of engine oil filter and cooler bypass valves.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Gaskets

Troubleshooting Reference

Pages 2-17, 2-19

Special Tools

None

Personnel Required

One mechanic

Equipment Condition

Coolant drained from cooling system.

Oil drained from engine oil cooler.

Left rear access door open.

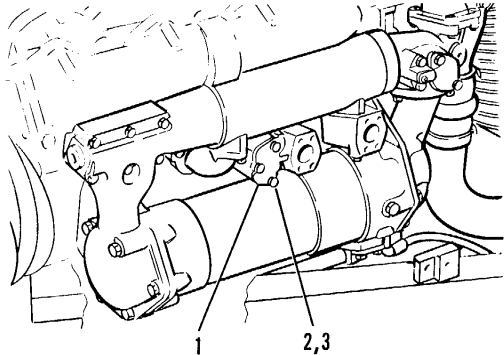
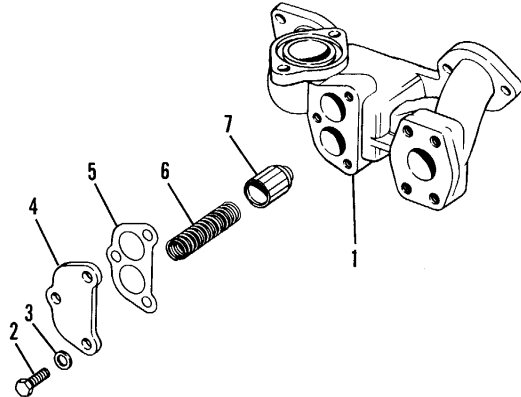
References

Replace coolant, TM 10-3930-641-20, LO 10-3930-641-12.

General Safety Instructions

Main disconnect switch OFF.

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>REMOVAL</b></p> <p>1. Bypass valve (1)</p> <p>2. Springs (6) and plungers (7)</p>	<p>Remove three capscrews (2) and washers (3) from bypass valve cover (4), remove cover and gasket (5).</p> <p>Remove from valve (1).</p>	
<p style="text-align: center;"><b>INSTALLATION</b></p> <p>1. Two springs (6) and plungers (7).</p> <p>2. Cover (4) and gasket (5)</p>	<p>Install in valve (1)</p> <p>Install on valve (1) and secure with three capscrews (2) and washers (3).</p>	

TA172259

End

**Section XI. TIMING GEARS**

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**TIMING GEARS MAINTENANCE INSTRUCTIONS:**

---

This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Timing gears cover removal/installation.
- b. Timing gears removal/installation.

---

**LIST OF TASKS:**

(Sheet 1 of 1)

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Timing gears cover removal/installation.	3-288	2-14, 2-19
2	Timing gears removal/installation.	3-291	2-14, 2-19

TIMING GEAR COVER REMOVAL/INSTALLATION

(Sheet 1 of 3)

This task covers: Removal and installation of timing gear cover.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Timing gear cover

Cover gasket

Troubleshooting Reference

Pages 2-14, 2-19

Special Tools

None

Personnel Required

One mechanic

Equipment Condition

Muffler, water pump, fan, fan drive, vibration damper, pulley, alternator, automatic timing advance, oil pan, engine front support, and trunnion removed from engine.

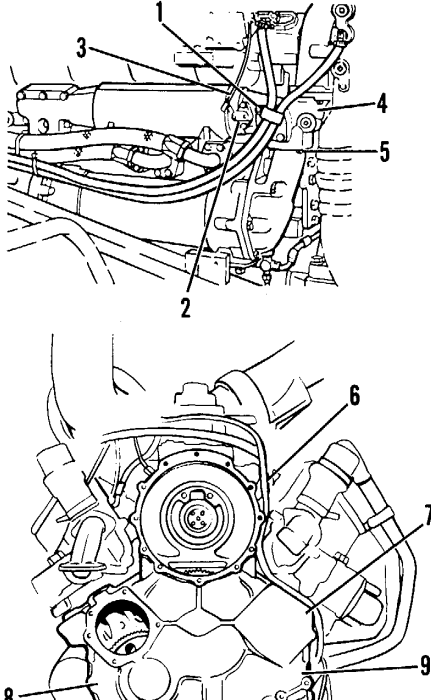
References

- Muffler removal/installation, TM 10-3930-641-20
- Water pump removal/installation, page 3-168
- Fan assembly removal/installation, TM 10-3930-641-20
- Fan drive removal/installation, TM 10-3930-641-20
- Vibration damper removal/installation, TM 10-3930-641-20
- Pulley removal/installation, TM 10-3930-641-20
- Alternator removal/installation, TM 10-3930-641-2
- Automatic timing advance, removal/installation, TM 10-3930-641-20
- Oil pan removal/installation, page 3-140
- Engine front support and trunnion removal/installation, page 3-3

Go on to Sheet 2

General Safety Instructions

None

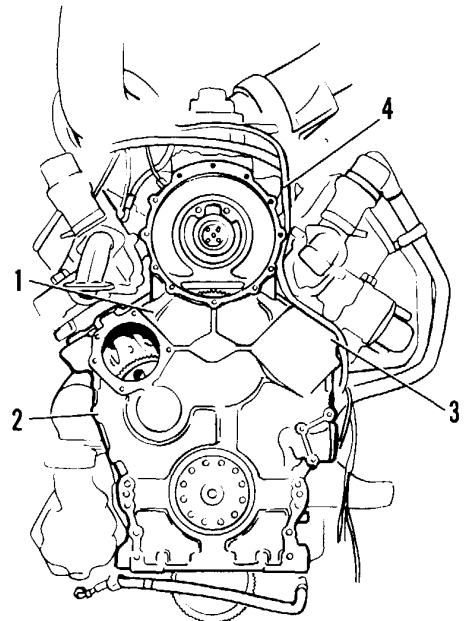
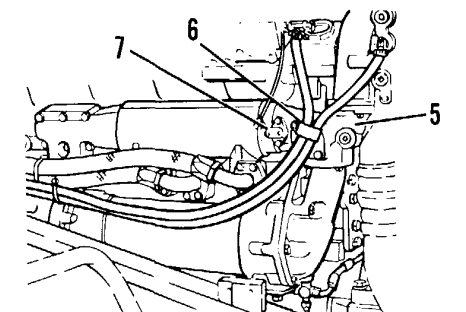
LOCATION/ITEM	ACTION	REMARKS
<b>REMOVAL</b>		
1. Alternator bracket	Remove. (See TM 10-3930-641-20.)	
2. Heater hose clip	Remove capscrew (1).	
3. Sensor unit (2)	Disconnect wire (3).	
4. Elbow (4), capscrews (5)	Remove.	
5. Clip retaining capscrew (6)	Remove.	
6. Nuts (7), capscrews (8), timing gear cover (9), cover gasket	Remove.	

**CAUTION**

**Do not damage crankshaft front seal when timing cover is removed.**

TA990108

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">INSTALLATION</div>		
1. Crankshaft front wear sleeve, front seal	Coat with clean engine oil.	
2. Seal pilot	Install in crankshaft front seal.	
3. Gasket, timing gear cover (1)	a. Position gasket on cylinder block. b. Install timing gear cover and secure with the three capscrews (2) and three nuts (3).	
4. Clip (4)	Secure to timing gear cover with capscrews.	
5. Elbow (5)	a. Replace O-ring seal and gasket if necessary. b. Put in position and secure with the three capscrews.	
6. Heater hose clip (6)	Install and secure with capscrew to hold heater hoses in position.	
7. Sensor unit (7)	Connect wire.	
8. Alternator bracket	Install.	

TIMING GEARS REMOVAL/INSTALLATION

This task covers: Removal and installation of timing gears.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Timing gear

Troubleshooting Reference

Pages 2-14, 2-19

Special Tools

None

Personnel Required

One mechanic

Equipment Condition

Engine timing cover removed. Camshaft removed or pulled approx. 4 in. (10.2 cm) from cylinder block.

References

Timing gear cover removal/installation, page 3-288

General Safety Instructions

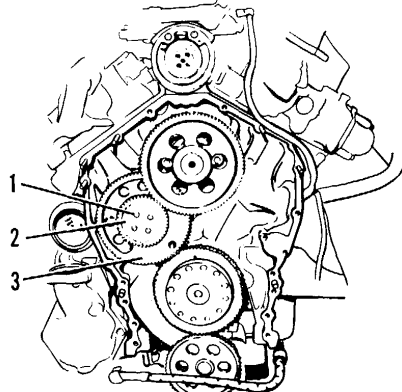
None

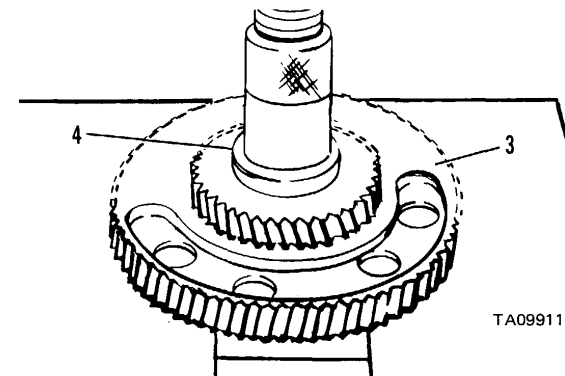
Camshaft removal/installation, page 3-273

Engine specifications, page 2-69

Go on to Sheet 2

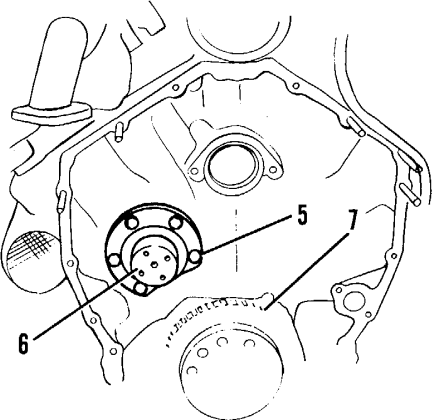
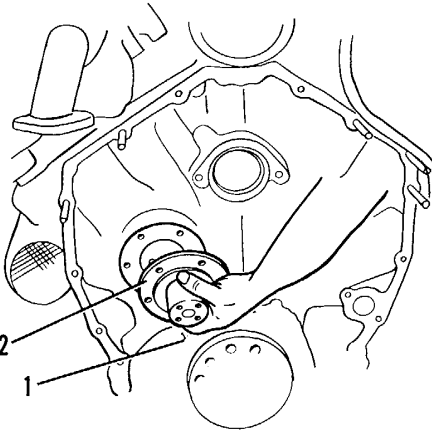
**3-291**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">REMOVAL</div>		
1. Capscrews (1) and plate (2)	Remove.	
2. Balancer gear (3)	Remove.	
3. Balancer gear bearing (4)	Remove from balancer gear using drive plate and a press.	
4. Capscrews (5)	Remove.	



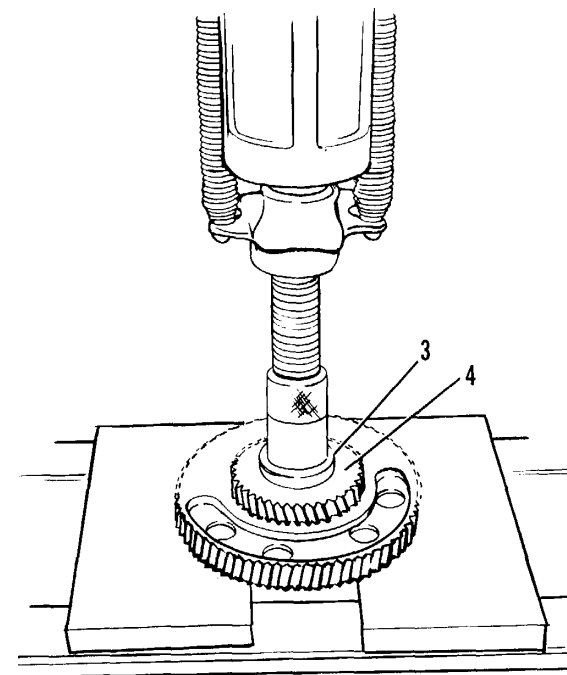
TA099112

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
5. Shaft (6)	Remove.	
6. Crankshaft gear (7)	Remove using suitable puller.	
<div style="border: 1px solid black; padding: 5px; display: inline-block;">INSTALLATION</div>	<p><b>NOTE</b></p> <p>When installing crankshaft gear, make sure notch on gear aligns with pin on crankshaft.</p> <p>a. Heat to maximum temperature of 4000F (2040C).</p> <p>b. Install on shaft.</p>	
1. Crankshaft gear (1)		TA099113

Go on to Sheet 4

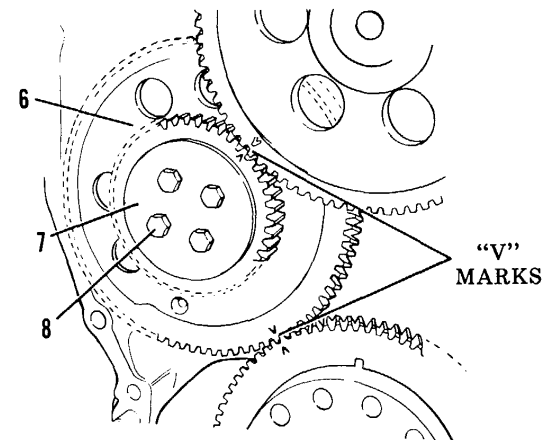
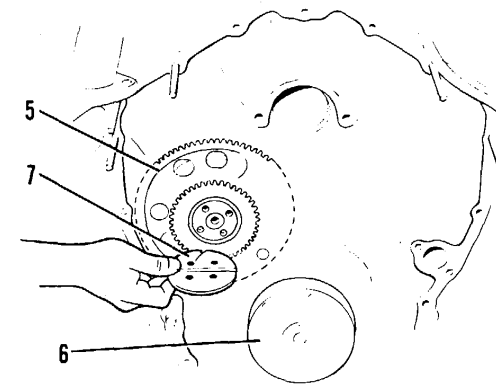
LOCATION/ITEM	ACTION	REMARKS
2. Shaft (2)	Using the five capscrews, secure to cylinder block.	
	<p style="text-align: center;"><b>NOTE</b></p> <p>Balancer gear bearing must be installed so notches in bearing align with groove in gear and joint of bearing is in center of heavy section of gear.</p>	
3. Gear (4)	Place over hole on balancer gear.	
4. Balancer gear bearing (3)	Press into place.	



Go on to Sheet 5

**TIMING GEARS REMOVAL/INSTALLATION (CONT)(SHEET 5 OF 5)**

LOCATION/ITEM	ACTION
5. Balancer gear (5)	Install.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>"V" mark on balancer gear must align with "V" mark on crankshaft (6).</b></p>
6. Plate (7)	a. Install with grooved side facing gear. b. Secure with four capscrews (8).



TA099115

End

---

**ACCESSORY DRIVE GEARS AND HOUSINGS REMOVAL/INSTALLATION**

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This task covers: Removal and installation of accessory drive gears and housings.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-6 & 2-7

Equipment Condition

Pumps removed

Special Tools

None

Personnel Required

One mechanic

References

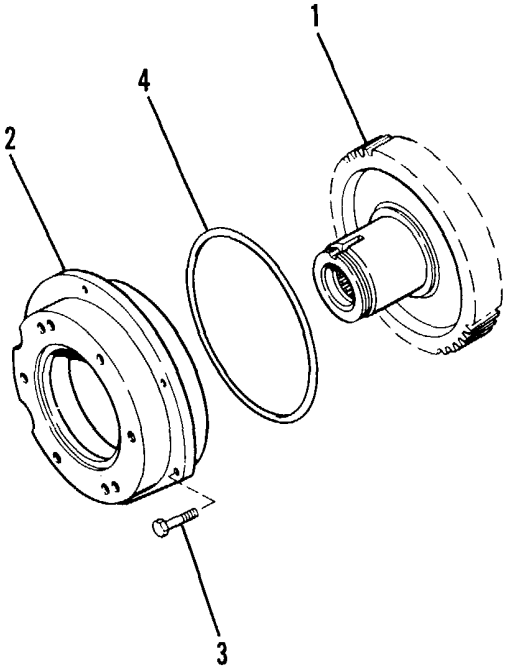
None

General Safety Instructions

None

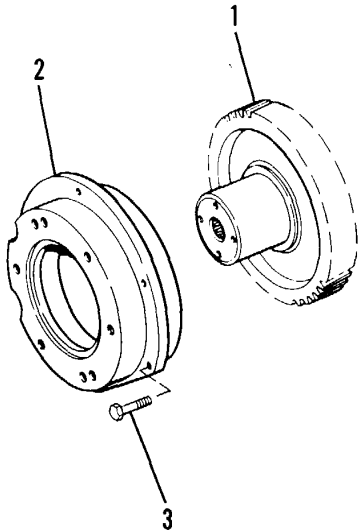
Go on to Sheet 2

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">REMOVAL</div>		
<p>Implement pump drive gear (1) and housing (2)</p>	<p>Remove bracket and bolts (3). Install a 5/8"-IINC eyebolt and attach hoist.</p> <p>Use a gear puller and remove housing with gear.</p> <p style="text-align: center;"><b>NOTE</b></p> <p>The pump drive weighs 67 lb. (30 kg).</p>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">INSTALLATION</div>		
<p>1. Implement pump drive gear (1) and housing (2)</p>	<p>Install o-ring seal (4) onto housing (2). Lubricate bore of flywheel housing with clean engine oil.</p>	
<p>2. Hoist</p>	<p>Install eyebolt into housing and attach hoist.</p>	

TA172250

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
<p>3. Pump drive assembly</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 10px auto;">REMOVAL</div>	<p>Position assembly into flywheel housing. Install bracket and secure with cap-screws (3).</p>	
<p>1. Steering and brake pump drive gear (1) and housing (2)</p>	<p>Remove capscrews (3) securing housing (2). Install a 5/8"-11NC eyebolt and attach using a gear puller and remove housing with gear.</p> <p style="text-align: center;"><b>NOTE</b></p> <p>The pump drive weighs 67 lb. (30 kg).</p>	

TA172261  
Go on to Sheet 4

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">INSTALLATION</div>		
<p>1. Steering and brake pump drive gear (1) and housing (2)</p>	<p>Install O-ring seal (4) onto housing (2). Lubricate bore of flywheel housing with clean engine oil.</p>	
<p>2. Hoist</p>	<p>Install eyebolt into housing and attach hoist.</p>	
<p>3. Pump drive assembly</p>	<p>Position assembly into flywheel housing. Secure with capscrews (3).</p>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">REMOVAL</div>		
<p>Transmission pump drive (1)</p>	<p>Remove capscrews (2) and remove pump drive assembly (1).</p>	
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">INSTALLATION</div>		
<p>Transmission pump drive (1)</p>	<p>Install o-ring seal onto housing. Lubricate flywheel housing bore with clean engine oil. Install assembly into flywheel housing and secure with capscrews (2).</p>	

TA172262

End

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

This task covers: Disassembly and assembly of accessory drive gears and housings.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-6 & 2-7

Equipment Condition

Drive gear and housing assemblies removed

Special Tools

None

Personnel Required

One mechanic

References

None

General Safety Instructions

None

Go on to Sheet 2

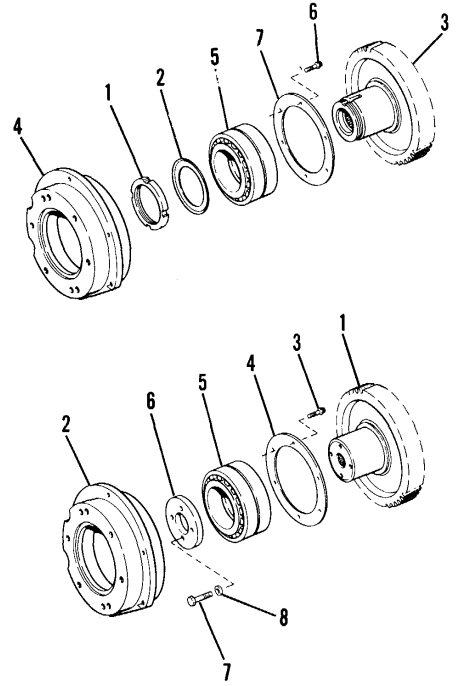
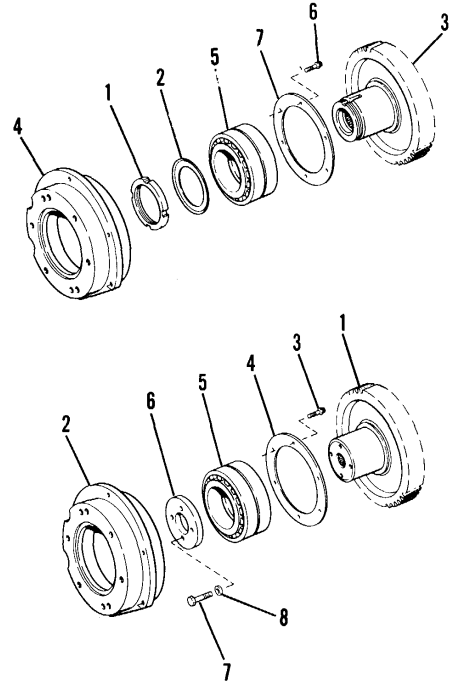
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">DISASSEMBLY</div>		
<p>Implement pump drive gear and housing.</p>		
<p>1. Nut (1) and lock (2)</p>	<p>Remove with spanner wrench.</p>	
<p>2. Gear (3)</p>	<p>With arbor press and adapter remove the gear (3) from housing (4).</p>	
<p>3. Bearing cone</p>	<p>Remove from housing (4).</p>	
<p>4. Spacer and bearing cone</p>	<p>Remove from gear (3). Discard bearing cone.</p>	
<p>5. Bearing cup</p>	<p>Remove capscrews (6) and retainer (7) from housing (4). Remove bearing cup from housing.</p>	

TA172263  
Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">ASSEMBLY</div>		
<p>1. Bearing cone (5) on gear (3)</p>	<p>Heat bearing cone in oil to a maximum temperature of 2750 (1350 C). Position gear (3) with shaft up and install bearing cone over shaft. The large diameter of cone against the gear.</p>	
<p>2. Spacer</p>	<p>Install onto gear on top of bearing cone.</p>	
<p>3. Bearing cup</p>	<p>With arbor press install cup into housing (4).</p>	
<p>4. Housing (4)</p>	<p>Install retainer (7) and secure with cap-screws (6). Position housing (4) onto gear (3).</p>	

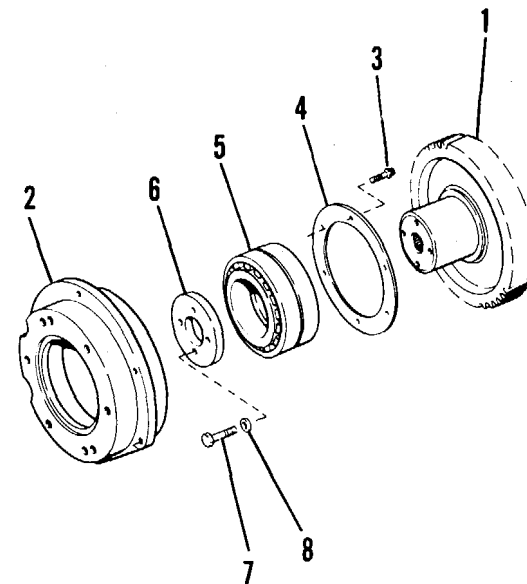
TA 172264  
Go on to Sheet 4

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
5. Bearing cone	With arbor press and adapter install bearing cone onto gear (3).	
6. Lock (2) and nut (1)	Install new lock (2) and nut (1) onto gear (3).	
<p><b>NOTE</b></p> <p>Tighten nut after assembly has been installed into flywheel housing.</p>		
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">DISASSEMBLY</div>		
1. Steering and brake pump drive gear (1) and housing (2)	Remove capscrews (7), washers (8) and retainer (6).	
2. Gear (1)	With arbor press and adapter remove gear (1) from housing (2).	<p>TA172265</p> <p>Go on to Sheet 5</p>

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

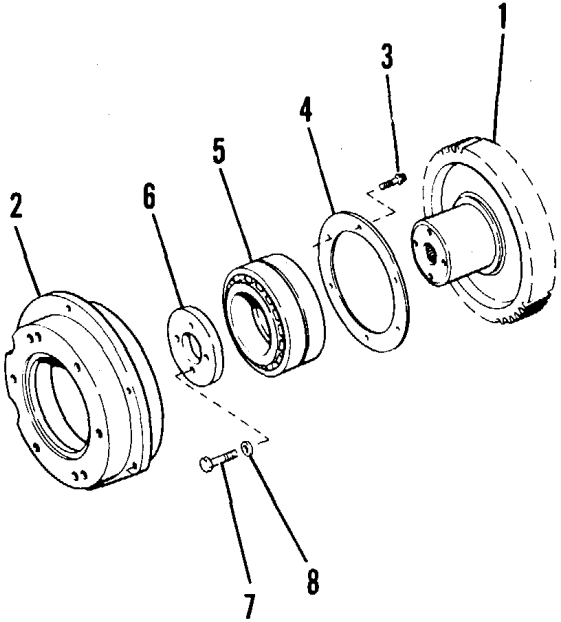
LOCATION/ITEM	ACTION	REMARKS
3. Bearing cone	Remove from housing (2).	
4. Spacer and bearing cone	Remove from gear (1). Discard bearing cone.	
5. Retainer (4)	Remove capscrews (3) and remove retainer from housing (2).	
6. Bearing cup	Remove from housing (2).	
<div style="border: 1px solid black; padding: 2px; display: inline-block;">ASSEMBLY</div>		
1. Bearing cone (5) on gear (1)	Heat bearing cone in oil to a maximum temperature of 2750 (1350 C). Position gear (1) with shaft up and install bearing cone. The large diameter of cone against the gear.	



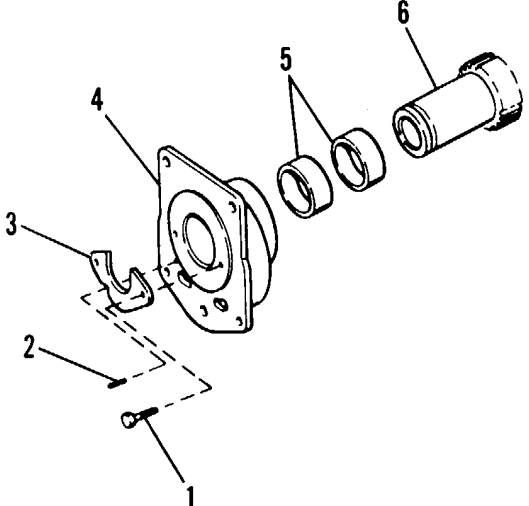
TA172266

Go on to Sheet 6

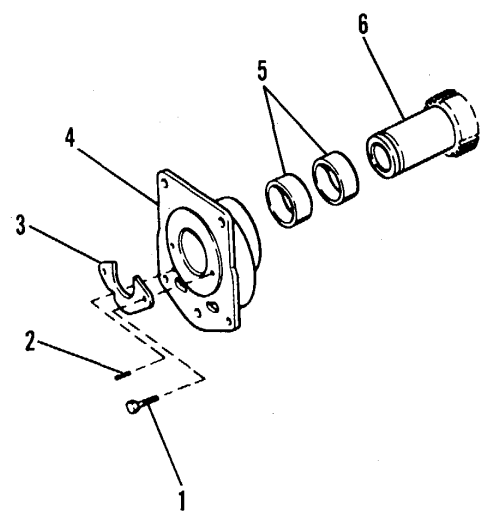
**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS	
2. Spacer	Install onto gear (1) on top of bearing cone.		
3. Bearing cup	With arbor press install cup into housing (2).		
4. Housing (2)	Install retainer (4) and secure with capscrews (3). Position housing (2) onto gear (1).	 <p>The diagram shows an exploded view of the timing gear assembly. Component 1 is the gear. Component 2 is the housing. Component 3 is a cap screw. Component 4 is a retainer. Component 5 is a bearing cup. Component 6 is a spacer. Component 7 is a cap screw. Component 8 is a washer. Dashed lines indicate the assembly sequence and alignment of the parts.</p>	
5. Bearing cone	With arbor press and adapter install bearing cone onto gear (1).		
6. Retainer (6)	Install onto gear (1) and secure with cap-screws (7) and washers (8).		
TA 172267			
3-305			Go on to Sheet 7

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 2px; display: inline-block;">DISASSEMBLY</div>		
<p>1. Transmission pump drive gear housing (4)</p>	<p>Remove pin (2), bolts (1) and washer (3). Remove gear (6) from housing (4).</p>	
<p>2. Bearings (5)</p>	<p>With arbor press and adapter remove bearings (5) from housing (4).</p>	
<div style="border: 1px solid black; padding: 2px; display: inline-block;">ASSEMBLY</div>		
<p>1. Bearings (5)</p>	<p>With arbor press and adapter install outer bearing even with outer face of housing (4) and inner bearing even with the inner face.</p>	
<p>2. Gear (6)</p>	<p>Install in housing (4).</p>	

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
3. Washer (3)	Install onto housing (4) and secure with capscrews (1).	 <p>The diagram shows an exploded view of the timing gear assembly. Component 1 is a cap screw, 2 is a pin, 3 is a washer, 4 is a housing, 5 consists of two washers, and 6 is a cylindrical gear component. Arrows point from the labels to their respective parts in the assembly.</p>
4. Pin (2)	Install into housing (4).	

3-307

TA172269

End

**Section XII. FLYWHEEL**

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FLYWHEEL MAINTENANCE INSTRUCTIONS

---

This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Flywheel housing removal/installation
- b. Flywheel removal/installation

---

LIST OF TASKS

---

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Flywheel housing removal/installation .	3-309 None	
2	Flywheel removal/installation.	3-315 None	

FLYWHEEL HOUSING REMOVAL/INSTALLATION

(Sheet 1 of 6)

This task covers: Removal and installation of flywheel housing.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Anti-seize compound

Troubleshooting Reference

None

Equipment Condition

Engine on engine stand. Turbocharger, flywheel, electric starting motor, oil pan and pump drives removed.

Torque converter removed.

Personnel Required

One mechanic

Special Tools

None

References

Engine specifications, page 2-69  
 Engine removal, page 3-6  
 Engine installation, page 3-17  
 Turbocharger removal/installation, page 3-107  
 Flywheel removal/installation, page 3-315  
 Starting motor removal/installation,  
 TM 10-3930-641-20  
 Oil pan removal/installation, page 3-140  
 Steering brake pump removal/installation,  
 page 6-2  
 Hydraulic pump removal/installation, page 7-5  
 Torque converter removal/installation, page 4-7

General Safety Instructions

None

Go on to Sheet 2

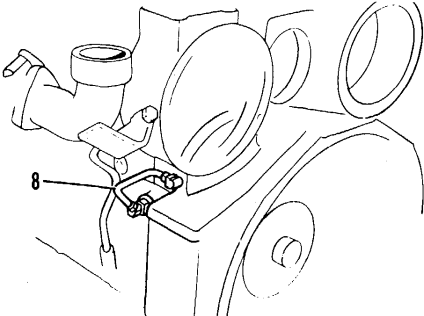
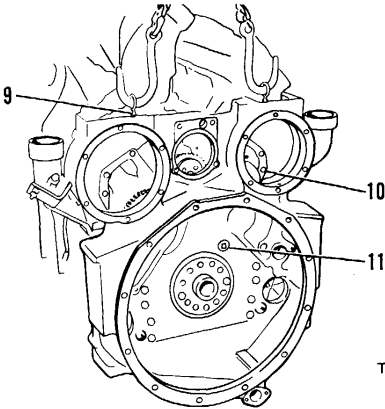
**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">REMOVAL</div>		
<p>1. Two bolts (5/8-18 NF x 4)</p>	<p>Install to hold crankshaft rear gear in position.</p>	
<p>2. Three capscrews and nuts (2)</p>	<p>Remove from center exhaust coupling.</p>	
<p>3. Eight exhaust bracket capscrews and nuts (6)</p>	<p>Remove.</p>	

TA099116

Go on to Sheet 3

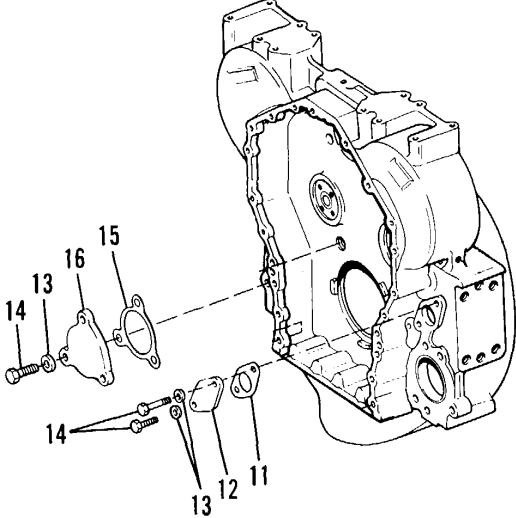
**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

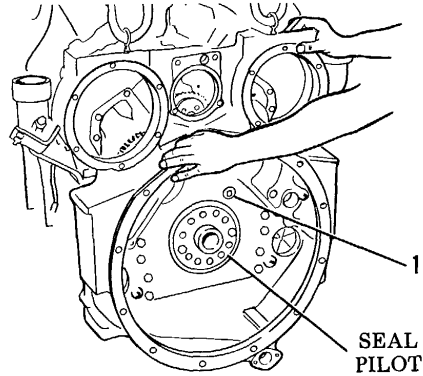
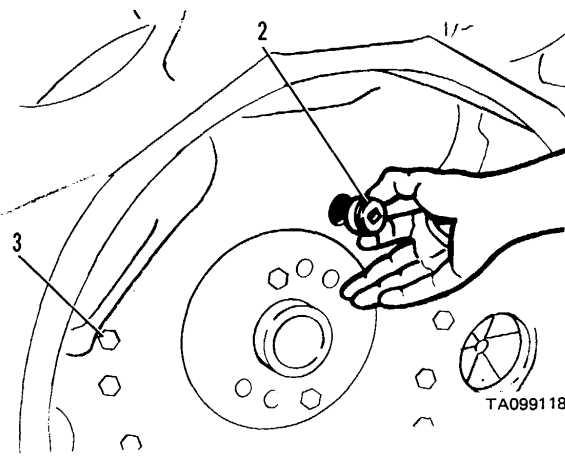
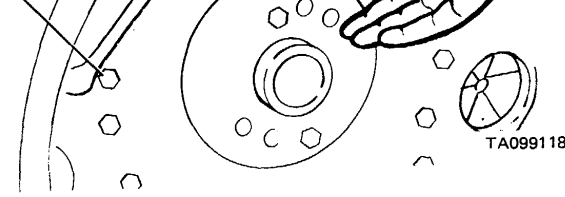
LOCATION/ITEM	ACTION	REMARKS
4. Exhaust pipes (3), couplings (5) and (7)	Remove.	
5. Oil line (8)	Remove.	
6. Two forged eyebolts, 3/8-16 NC (9)	Install in flywheel housing.	
7. Hoist	Fasten to eyebolts.	

Go on to Sheet 4

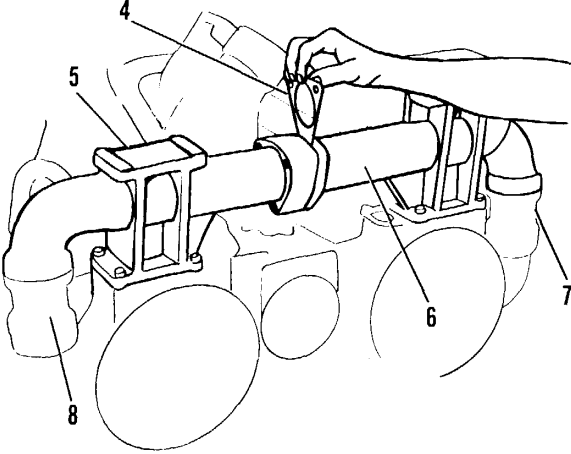
TA099117

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
8. Plug (11)	Remove from flywheel housing. (This is to help make housing replacement easier.)	
9. Twenty-one flywheel housing capscrews (10)	Remove.	
10. Flywheel housing	Remove. Check for cracks and pieces broken out. Replace if necessary.	
<p><b>NOTE</b></p> <p>Weight of the flywheel housing is 340 lb. (154 kg).</p>		
11. Flywheel housing covers (12) and (16)	Remove capscrews (14) and washers (13). Remove covers (12) and (16) with gaskets (11) and (15).	
<div style="border: 1px solid black; padding: 5px; display: inline-block;">INSTALLATION</div>		
1. Flywheel housing covers (12) and (16)	Position covers (12) and (16) with new gaskets (11) and (15) onto housing. Secure with capscrews (14) and washers (13).	
2. Flywheel housing gasket	Position on cylinder block.	
3. Crankshaft rear wear sleeve, seal	<p>a. Coat with clean engine oil.</p> <p>b. Install.</p>	
4. Seal pilot	Install in crankshaft rear seal.	

LOCATION/ITEM	ACTION	REMARKS
5. Two eyebolts, 3/8-16 NC	Install in flywheel housing.	
6. Hoist	Fasten to flywheel housing.	
7. Flywheel housing	Put in position.	
<p><b>NOTE</b></p> <p>Use plug hole (1) to visually align the "V" marks on the balancer gear and the crankshaft rear gear with cylinder number one at top center.</p>		
8. Seal Pilot	Remove.	
9. Twenty-one flywheel housing cap-screws (3)	Install.	
10. Plug (2)	Install.	
11. Oil line	Install.	

**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
12. Exhaust pipes (5), and (6)	Install and secure with the exhaust bracket capscrews.	
13. Exhaust pipe gasket (4)	Put in position between exhaust pipes.	
14. Exhaust pipe capscrews, nuts	Coat threads with Anti-Seize Compound or equivalent and install.	
15. Exhaust pipe couplings (7) and (8)	Install.	
16. Two bolts, 5/8-18 NF x 4	Remove from crankshaft rear gear.	
17. Flywheel housing gasket	Trim along oil pan rail.	
	<b>3-314</b>	

TA099119

End

**FLYWHEEL REMOVAL/INSTALLATION**

(Sheet 1 of 5)

This task covers: Removal and installation of flywheel.

INITIAL SETUP

Test Equipment

None

Materials/Parts

Flywheel

Troubleshooting Reference

None

Equipment Condition

Engine on engine stand

Torque converter removed

Special Tools

None

Personnel Required

Two mechanics

References

Engine removal, page 3-6

Engine installation, page 3-17

Torque converter removal/installation, page 4-7

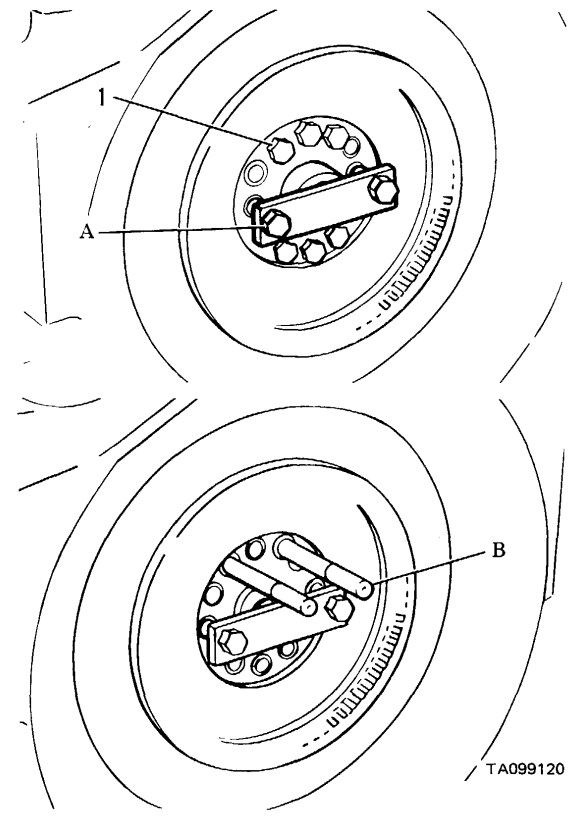
General Safety Instructions

Be sure flywheel does not fall off lifting arm.

Go on to Sheet 2

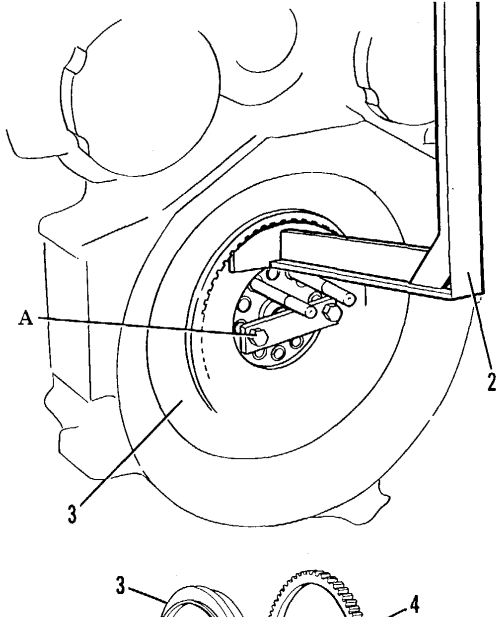
**TIMING GEARS REMOVAL/INSTALLATION (CONT)**

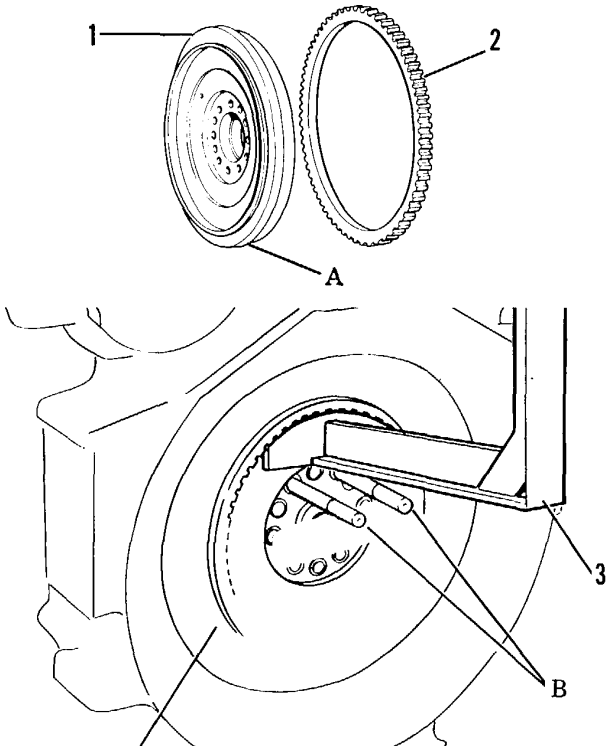
LOCATION/ITEM	ACTION	REMARKS
<div style="border: 1px solid black; padding: 5px; display: inline-block;">REMOVAL</div>		
1. Flywheel bolts (1)	Remove six of the capscrews that hold the flywheel in position.	
2. Crankshaft gear	Hold in place using bracket (A) as shown at right.	
3. Flywheel bolts	Remove the remainder of the bolts (1)	
4. Two guide bolts (5/8-18 NF x 7 in. long) (B)	Install in crankshaft.	



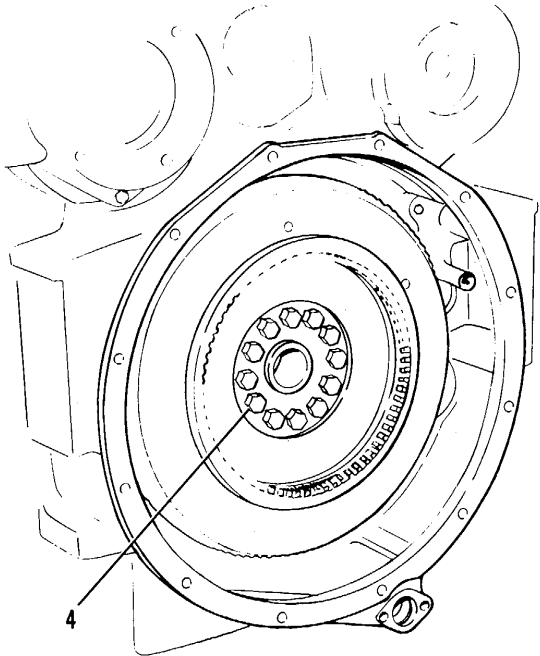
TA099120

Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
5. Lifting arm (2)	Fasten to a hoist and put in position in groove of flywheel as shown at right.	
6. Flywheel (3)	Pull onto bracket (A).	
7. Bracket (A)	Remove.	
<p style="text-align: center;"><b>WARNING</b></p> <p><b>To prevent injury, do not let flywheel fall off lifting arm as it is being removed. Weight of flywheel is 96 lb. (44 kg.).</b></p>		
8. Flywheel	Remove using lifting arm (2).	
9. Ring gear (4)	Lay flywheel (3) flat on a work surface with the ring gear (4) up. Remove ring gear.	
<p style="text-align: center;"><b>CAUTION</b></p> <p><b>Do not use a torch to remove the ring gear.</b></p>		

LOCATION/ITEM	ACTION	REMARKS	
<b>INSTALLATION</b>			
1 Ring gear (2)	Lay flywheel flat on a work surface with ring gear groove up. Heat ring gear (2) evenly until it will slide over flywheel boss.	See specifications page 2-96 for detailed instructions.	
<b>NOTE</b>			
<b>Be sure ring gear seats fully onto shoulder (A) of flywheel.</b>			
2 Guide bolts (B)	Install in crankshaft.		
<b>WARNING</b>			
<b>To prevent injury, do not let flywheel (1) fall off lifting arm (3) as it is being installed. Weight of the flywheel is 96 lb. (44 kg.).</b>			
3 Lifting arm (2)	Fasten to hoist and install in groove of flywheel as shown at right.		
4 Flywheel (1)	Put in position on guide bolts (B).		

Go to Sheet 5

LOCATION/ITEM	ACTION	REMARKS
5. Flywheel capscrews (4)	a Coat with clean engine oil or Multipurpose Grease.  b. Install six of the capscrews (4) to hold flywheel position.	
6. Guide bolts	Remove.	
7. Flywheel capscrews (4).	Install the remainder of the capscrews (4).	

Section XIII. CRANKSHAFT AND MAIN BEARINGS

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CRANKSHAFT MAINTENANCE INSTRUCTIONS:

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This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Crankshaft removal/installation
- b. Crankshaft seals removal/installation
- c. Crankshaft main bearings removal/installation

Also instructions for inspection of: crankshaft main bearings, crankshaft

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LIST OF TASKS

(Sheet 1 of 1)

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TASK NO	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Crankshaft removal/installation	3-321	None
2	Crankshaft seals removal/installation	3-331	None
3	Crankshaft main bearings removal/ installation.	3-338	2-19
4	Crankshaft main bearings inspection	3-345	2-19
5	Crankshaft inspection	3-347	2-19

CRANKSHAFT REMOVAL/INSTALLATION:

This task covers: Removal and installation of crankshaft.

**INITIAL SETUP**

Test Equipment

Dial indicator

Materials/Parts

Crankshaft

Troubleshooting Reference

None

Special Tools

None

Personnel Required

Three mechanics

Equipment Condition

Engine removed and on test stand.  
Oil pump, timing gear cover, flywheel housing and pistons removed from engine.

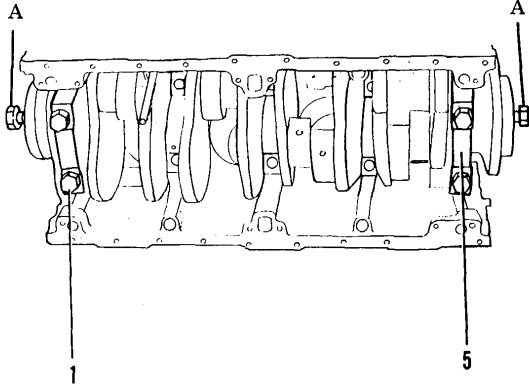
References

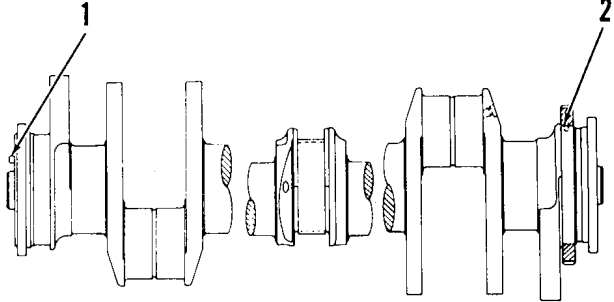
Crankshaft main bearing removal/installation, page 3-338  
Engine removal, page 3-6  
Engine installation, page 3-17  
Oil pan removal/installation, page 3-140  
Oil pump removal/installation, page 3-143  
Timing gear cover removal/installation, page 3-288  
Piston and connecting rod removal/installation, page 3-350

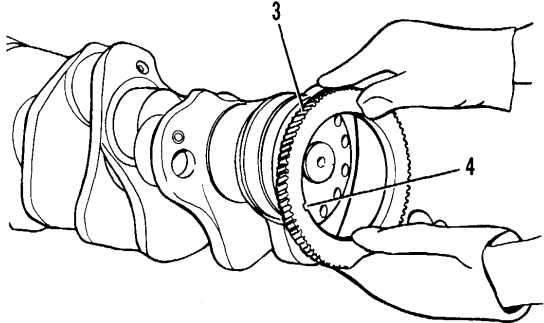
General Safety Instructions

None



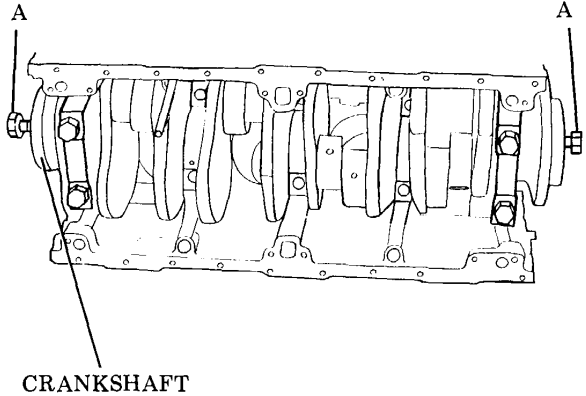
LOCATION/ITEM	ACTION	REMARKS
3. Two flywheel bolts	Install a bolt in each end of the crankshaft.	
4. Hoist	Fasten to the crankshaft using bolts (A).	
5. Nos. 1 and 5 main bearing caps	Remove.	
6. Crankshaft	Remove.	
<p><b>NOTE</b> The crankshaft weighs 270 lb. (122 kg.).</p>		
<p><b>CAUTION</b> Be careful not to damage crankshaft journals when crankshaft is removed.</p>		

LOCATION/ITEM	ACTION	REMARKS
7. Crankshaft gear	Remove using a suitable gear puller and step plate.	
8. Crankshaft dowel and pin	Remove using dowel puller group and extractors.	
<b>INSTALLATION</b>		
1. Crankshaft pin (1)	Install in crankshaft end. (Pin should extend 0.025 + 0.02 in. (.64 + 0.5 mm) from end.)	
2. Crankshaft dowel (2)	Install in crankshaft. (Dowel should extend 0.16 + 0.02 in. (4.1 + 0.5 mm) from crankshaft surface.)	

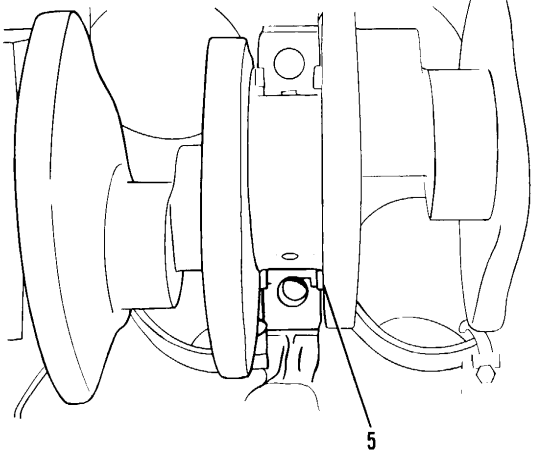
LOCATION/ITEM	ACTION	REMARKS
<p>3. Crankshaft gear (3)</p> <p>4. Upper main bearings, crankshaft journals</p>	<p>a. Heat to a maximum temperature of 400°F (204°C).</p> <p>b. Position gear so that groove (4) on gear aligns with dowel (2).</p> <p>c. Install gear.</p> <p>Coat with clean engine oil.</p>	

TA099127  
Go on to Sheet 6

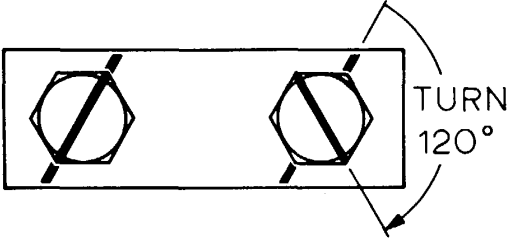
CRANKSHAFT REMOVAL/INSTALLATION (CONT)

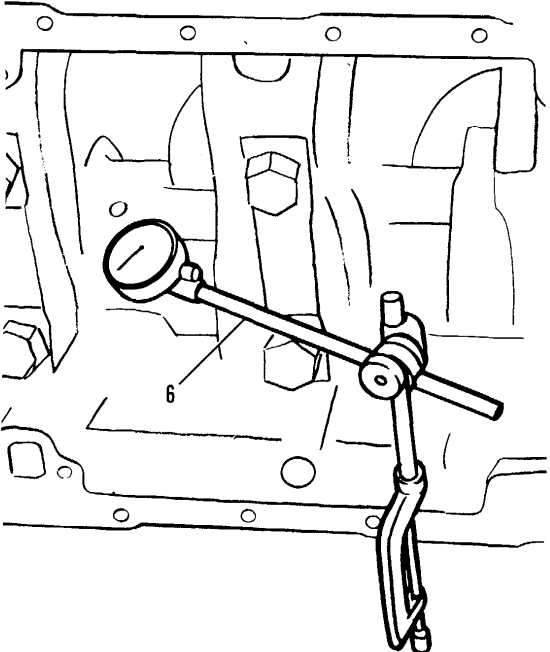
LOCATION/ITEM	ACTION	REMARKS
5. Two flywheel bolts	Install a bolt in each end of crankshaft.	
6. Hoist	Fasten to the bolts (A) at each end of crankshaft.	
7. Crankshaft	Install.	
<p><b>CAUTION</b></p> <p>Do not damage the crankshaft journals. Be sure the "V" mark on the crankshaft gear aligns with the "V" mark on the idler gear.</p>		

LOCATION/ITEM	ACTION	REMARKS
8. Lower main bearings	Coat with engine oil and install.	See Crankshaft Main Bearing Removal/Installation, page 3-338.
9. Bearing Clearances	Check.	
10. Nos. 1 and 5 main bearing caps.	a. Coat cap bolt threads with clean engine oil.  b. Install caps and secure bolts finger tight.	
<p style="text-align: center;"><b>NOTE</b>  <b>Be sure arrow on each cap points toward front of block.</b></p>		Go on to Sheet 8

LOCATION/ITEM	ACTION	REMARKS
11. No. 3 upper main bearing thrust plates (5)	Install.  <b>NOTE</b> <b>Check that side labeled "Block Side" faces toward cylinder block.</b>	
12. Nos. 2 and 3 main bearing caps	a. Coat cap bolts with clean engine oil.  b. Install caps and secure bolts finger tight.  <b>NOTE</b> <b>Be sure arrow on each cap faces toward front of block.</b>	

TA099129  
Go on to Sheet 9

LOCATION/ITEM	ACTION	REMARKS
13. Main bearing cap bolts	<ul style="list-style-type: none"> <li>a. Tighten bolts on tab end of each cap to a torque of <math>190 \pm 10</math> lb. ft. (<math>257.6 \pm 13.6</math> N m).</li> <li>b. Tighten bolts on other end of each cap to a torque of <math>190 + 10</math> lb. ft. (<math>257.6 + 13.6</math> N m).</li> <li>c. Scribe a mark across top surface of each bolt head and cap.</li> <li>d. Tighten the bolts opposite the tab end of each cap until the marks are 120° apart.</li> <li>e. Tighten the bolts on the tab end of each cap until the marks are 120° apart.</li> </ul>	 <p style="text-align: right;">TURN 120°</p>

LOCATION/ITEM	ACTION	REMARKS
14. Crankshaft	<p>Check end play with dial indicator (6).                      End play for new thrust plates must be 0.006 to 0.020 in. (0.152 to 0.508 mm).                      Maximum end play for used thrust plates is 0.035 in. (0.89 mm).</p> <p style="text-align: center;"><b>NOTE</b>                      Be sure dial indicator is against a machined surface.</p>	

This task covers: Removal and installation of crankshaft front and rear seals.

**INITIAL SETUP**

Test Equipment

Depth micrometer

Materials/Parts

Quick cure primer

Retaining compound

Crankshaft seals

Troubleshooting Reference

Page 2-15

Equipment Condition

Front seal: Vibration damper and pulley removed.

Rear seal: Flywheel removed.

Special Tools

None

Personnel Required

One mechanic

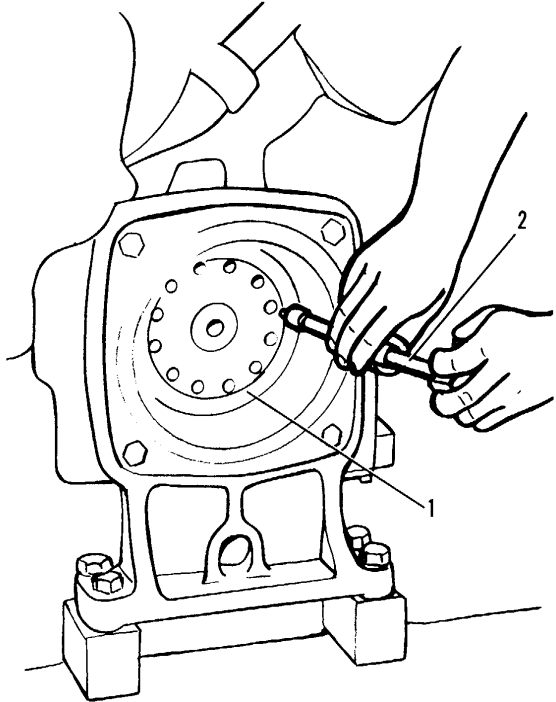
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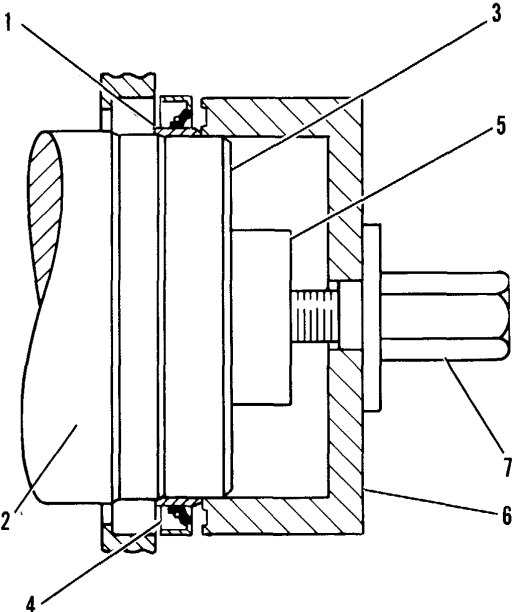
Vibration damper and pulley removal/installation, TM 10-3930-241-20

Flywheel removal/installation, page 3-315

General Safety Instructions

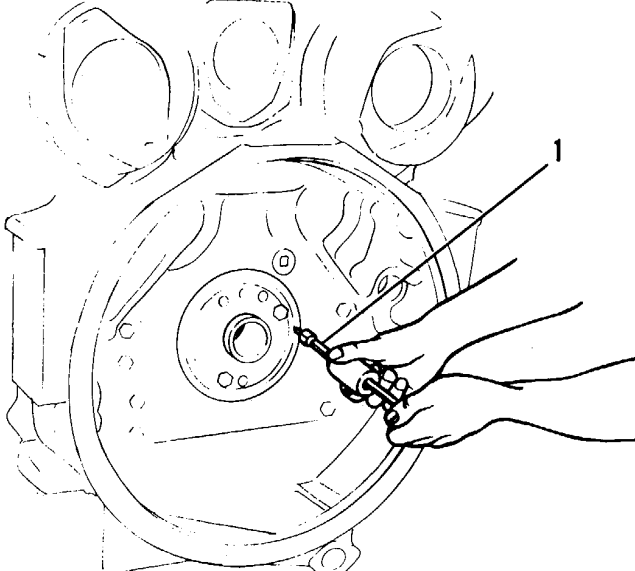
None

LOCATION/ITEM	ACTION	REMARKS
<p>FRONT SEAL</p> <p><b>REMOVAL</b></p>		
<p>1 Front seal (1)</p>	<p>Remove, using puller (2) as shown at right.</p> <p><b>NOTE</b>  <b>Front wear sleeve must be replaced whenever front seal is removed.</b></p>	 <p>The diagram illustrates the removal of a front seal from a crankshaft housing. A hand is shown using a puller tool (labeled 2) to extract the front seal (labeled 1) from its bore. The crankshaft housing is mounted on a stand.</p>
<p>2 Front wear sleeve</p>	<p>a. Install ring (from wear sleeve removal tool kit) into seal bore.</p> <p>b. Install distorted (from wear sleeve removal tool kit) between ring and the wear sleeve.</p> <p>c. Turn distorter until its edge makes a crease in the wear sleeve. Do this in two or more places until wear sleeve is loose.</p> <p>d. Remove ring and wear sleeve.</p>	

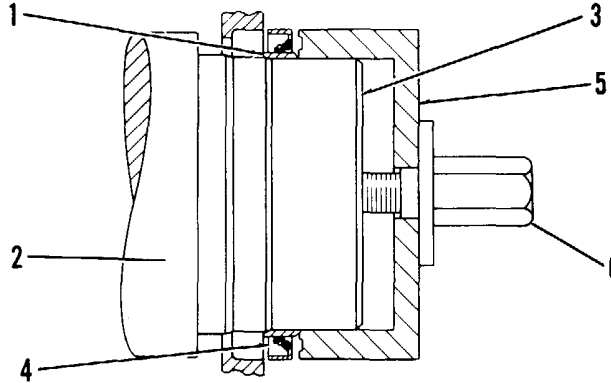
LOCATION/ITEM	ACTION	REMARKS
<p style="text-align: center;"><b>INSTALLATION</b></p> <p>1. Wear sleeve (1), crankshaft (2)</p> <p>2. Locator (3), bolts</p> <p>3. Front seal (4), wear sleeve (1)</p>	<p>a. Apply quick cure primer to wear sleeve inside diameter and crankshaft outside diameter.</p> <p>b. After primer has set, apply retaining compound to wear sleeve inside diameter and crankshaft outside diameter.</p> <p>Install on front of crankshaft.</p> <p>a. Coat lip of front seal and outside diameter of wear sleeve with clean engine oil.</p> <p>b. Install front seal on wear sleeve.</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Make sure lip of seal is toward inside of engine and outside diameter bevel of wear sleeve is toward outside of engine.</b></p> <p>c. Put wear sleeve and front seal in position on locator.</p>	<p style="text-align: center;">CRANKSHAFT SEAL AND WEAR SLEEVE INSTALLATION TOOL</p> 

LOCATION/ITEM	ACTION	REMARKS
4. Spacer (5)	Install on stud of locator.	
5. Installer (6)	Put in position on locator.	
6. Nut (7)	a Coat base with clean engine oil. b. Install on locator. c. Tighten nut until inside surface of installer comes into contact with spacer.	
<b>CAUTION</b>		
<b>On some engines, if seal goes against bottom of bore, a resistance (increase in torque) will be felt on nut. Do not tighten nut too tightly or the case (body) of the seal will be damaged.</b>		
7. Locator, spacer, installer, nut	Remove.	
8 Front seal, wear sleeve	Check that position of each is correct. Distance from front face of crankshaft to front edge of wear sleeve must be $0.02 \pm 0.01$ in. ( $0.508 \pm 0.254$ mm). Distance from front end of crankshaft to metal face of seal must be 0.05 in. (1.27 mm).	

Go on to Sheet 5

LOCATION/ITEM	ACTION	REMARKS
<p>REAR SEAL</p> <p>REMOVAL</p>	<p>1 Flywheel</p> <p>Remove. (See flywheel removal/installation, page 3-315.)</p> <p>2. Crankshaft rear seal</p> <p>Remove using puller (1) as shown at right.</p> <p><b>NOTE</b>  <b>Rear wear sleeve must be replaced whenever rear seal is removed.</b></p> <p>3 Rear wear sleeve</p> <p>a. Install ring (from wear sleeve removal tool kit) into the seal bore.</p> <p>b. Install distorter (from wear sleeve removal tool kit) between the ring and the wear sleeve.</p> <p>c. Turn distorter until its edge makes a crease in the wear sleeve. Do this in two or more places until the wear sleeve is loose.</p> <p>d. Remove ring and wear sleeve.</p>	

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 Go on to Sheet 6

LOCATION/ITEM	ACTION	REMARKS
<p><b>INSTALLATION</b></p> <p>1 Wear sleeve (1), crankshaft (2)</p> <p>2. Locator (3), bolts</p> <p>3. Rear seal (4), wear sleeve</p>	<p>a Apply quick cure primer to wear sleeve inside diameter and crankshaft outside diameter.</p> <p>b. After primer has set, apply retaining compound to wear sleeve inside.</p> <p>Install on crankshaft gear.</p> <p>a Coat lip of rear seal and outside diameter of wear sleeve with clean engine oil.</p> <p>b. Install front seal on wear sleeve as shown at right.</p> <p><b>NOTE</b>  <b>Make sure lip of seal is toward front of engine and outside diameter bevel of wear sleeve is toward outside of engine.</b></p> <p>c. Put wear sleeve and front seal in position on locator.</p>	

LOCATION/ITEM	ACTION	REMARKS
4. Installer (5)	Put in position on locator.	
5. Nut (6)	a. Coat base with clean engine oil. b. Install on locator. c. Tighten nut until installer has reached end of its travel (when installer contacts locator).	
6. Locator, installer, nut	Remove.	
7. Rear seal, wear sleeve	Check that position of each is correct. Distance from rear face of crankshaft to rear edge of wear sleeve must be 0.08 in. (2.03 mm). Distance from rear face of crankshaft to metal face of seal must be 0.18 in. (4.57 mm).	

End

This task covers: Removal and installation of crankshaft main bearings.

**INITIAL SETUP**

Test Equipment

1 in. Micrometer

Plastigage

Dial indicator

Materials/Parts

Crankshaft main bearings

Troubleshooting Reference

Page 2-19

Equipment Condition

Engine removed

Oil pump removed

Special Tools

Tool, engine turning, 9S9082

Personnel Required

One mechanic

References

Engine removal, page 3-6

Engine installation, page 3-17

Oil pump removal/installation, page 3-143

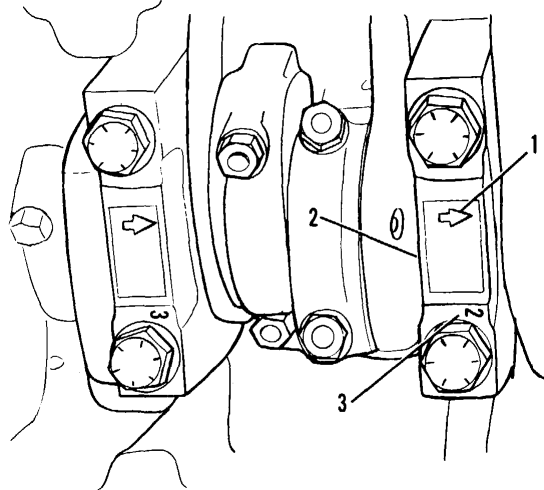
Crankshaft main bearings inspection, page 3-345

Engine specifications, page 2-69

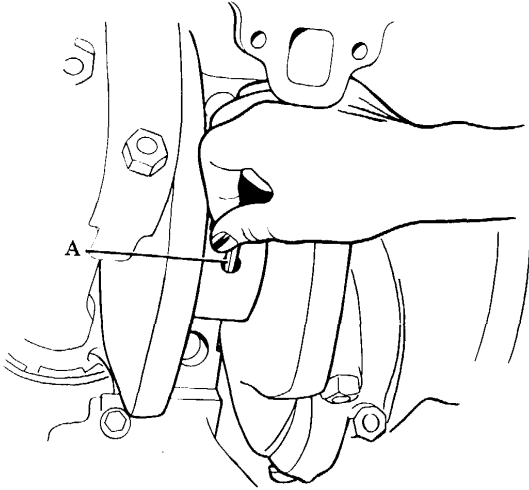
General Safety Instructions

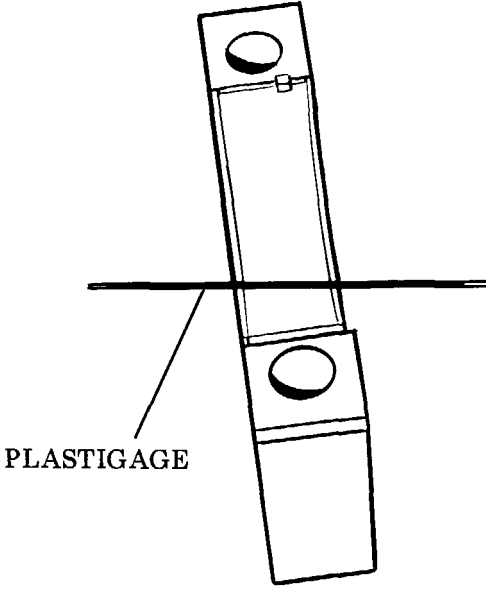
None

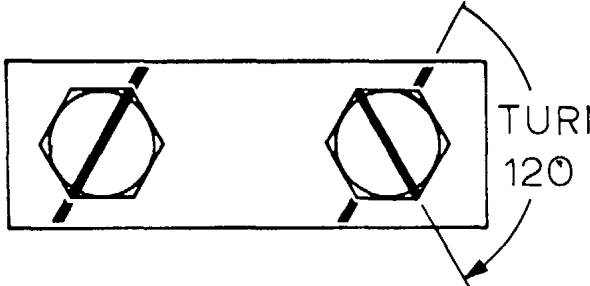
Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<p align="center"><b>REMOVAL/INSTALLATION</b></p> <p>1. Main bearing caps</p> <p>2. Nos. 2, 3 and 4 main bearing caps</p> <p>3. Lower main bearings</p> <p>4. No. 3 upper main bearing</p>	<p>To insure correct installation later, check the location of each.</p> <p align="center"><b>NOTE</b></p> <p><b>Each cap (2) is labeled with its number (3) and an arrow (1) that points toward the front of the block.</b></p> <p>Remove.</p> <p>Remove.</p> <p>Remove thrust plate from each side.</p> <p align="center"><b>CAUTION</b></p> <p><b>Using tool, engine turning, 9S9082, be sure to turn crankshaft in right direction (direction in which upper main bearing is pushed out, tab end first). If crankshaft is turned in wrong direction, bearing tab will be pushed between crankshaft and cylinder block, causing damage to both.</b></p>	

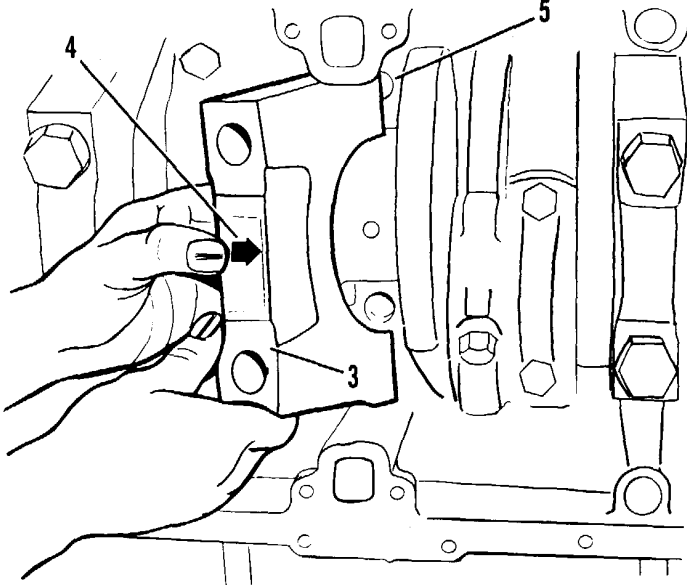
TA099136  
Go on to Sheet 3

LOCATION/ITEM	ACTION	REMARKS
5. Crankshaft	a Turn until special bearing tool (A) can be installed in oil hole as shown at right.  b. Continue turning crankshaft until tool pushes upper main bearing out, tab end first.	
6 Lower main bearings	a Coat with clean engine oil.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Bearing cap and bearing surface must be clean and dry.</b></p> b. Install.	
7 Upper bearings	a Coat with clean engine oil.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Cylinder block bearing surface must be clean and dry.</b></p> b. Install upper bearing in the cylinder block with bearing tool.  <p style="text-align: center;"><b>NOTE</b></p> <p><b>Be sure bearing tabs are properly seated in grooves on bearing caps and bearing saddles in cylinder block.</b></p>	

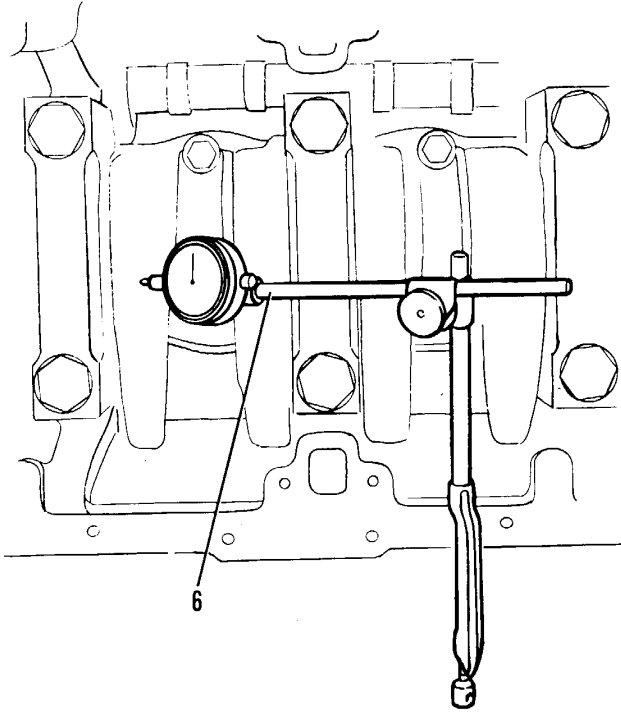
LOCATION/ITEM	ACTION	REMARKS
<p>8. Bearing clearance</p>	<p style="text-align: center;"><b>CAUTION</b></p> <p>To check bearing clearance, the crankshaft will have to be lifted up and held against the upper halves of the main bearings. Do not try to support crankshaft in this position by the wire. Use a jack under the crankshaft counterweight next to the bearing which is to be measured.</p> <p>Using plastigage, check as follows:</p> <ol style="list-style-type: none"> <li>a. Put plastigage in position as shown at right.</li> <li>b. Put clean oil on threads of the cap bolts.</li> <li>c. Install the caps and tighten all bolts finger tight.</li> <li>d. Tighten the bolts on the tab end of each cap to a torque of 190 ± lb. ft. (257 ± 13.6 N-m).</li> <li>e. Tighten the bolts on the other end of each cap to a torque of 190 ± 10 lb. ft. (257.6 ± 13.6 N m).</li> </ol>	 <p>The diagram illustrates the application of plastigage for bearing clearance measurement. It shows a vertical crankshaft journal with a bearing cap positioned over it. A horizontal line represents the bearing surface. A label 'PLASTIGAGE' with a leader line points to the gap between the cap and the journal, indicating where the plastigage should be placed.</p>

LOCATION/ITEM	ACTION	REMARKS
8. Bearing clearance (cont)	<p>f. Scribe a mark across each bolt head and cap.</p> <p>g. Tighten the bolts opposite the tab end an additional 1200.</p> <p>h. Tighten the bolts on the tab end an additional 1200.</p> <p style="text-align: center;"><b>NOTE</b></p> <p><b>Make sure the bearing caps have been installed correctly. The identification number on each (3) must align with the number stamped on the left side of the cylinder block. The arrow (4) must point toward the front of the block.</b></p> <p>i. Remove main bearing caps and plastigage.</p> <p>j. Measure thickness of plastigage to determine bearing clearance. Clearance for new bearings must be 0.0036 to 0.0073 in. (0.091 to 0.186 mm). Maximum clearance for used bearings is 0.010 in. (0.25 mm).</p> <p>k. Once correct clearance has been obtained, install and retighten bearing cap, following steps 8c thru 8h above.</p>	<p style="text-align: center;"><b>NOTE</b></p> <p><b>Do not use an impact wrench on the journal to be measured or a journal next to the one to be measured. This will cause a compression of the plastigage that will cause an incorrect indication.</b></p> <div style="text-align: center;">  </div> <p style="text-align: right;">TA0991 39 Go on to Sheet 6</p>

**CRANKSHAFT MAIN BEARINGS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
9. No. 3 upper main bearing	<p>Install thrust plate (5) on each side.</p> <p style="text-align: center;">NOTE</p> <p>Thrust plates must be installed so that side marked "Block Side" faces toward the cylinder block.</p> <p style="text-align: center;">NOTE</p> <p>No. 3 main bearing is the only one that has thrust washers.</p>	
10. Nos. 2, 3 and 4 main bearing caps	<p>a. Install.</p> <p>b. Tighten cap bolts using procedure given in 8C thru 8h above.</p>	
11. Nos. 1 and 5 main bearings	<p>Install and check clearance following same procedure used for Nos. 2, 3 and 4 main bearings (steps 5 thru 8 above).</p>	

**CRANKSHAFT MAIN BEARINGS REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
12. Crankshaft	<p>Check end play with dial indicator (6). End play for new thrust plates must be within 0.006 to 0.020 in. (0.152 to 0.508 mm). Maximum end play with used thrust plates is 0.035 in. (0.89 mm).</p> <p style="text-align: center;">NOTE</p> <p>Be sure the dial indicator is against a machined surface.</p>	

3-344

1039141  
End

**CRANKSHAFT MAIN BEARINGS INSPECTION**

This task covers: Inspection of crankshaft main bearings.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

Page 2-19

Special Tools

None

Personnel Required

One mechanic

Equipment Condition

Engine removed

Oil pump removed

Crankshaft removed

Pistons and connecting rods removed

References

Engine removal, page 3-6

Engine installation, page 3-17

Oil pump removal/installation, page 3-143

Crankshaft removal/installation, page 3-321

Crankshaft main bearings removal/installation,  
page 3-338

Piston and connecting rod removal/installation,  
page 3-350

General Safety Instructions

None

**CRANKSHAFT MAIN BEARINGS INSPECTION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
Crankshaft main bearings	<ul style="list-style-type: none"> <li>a. Check for score marks, metal flaking, imbedded metal particles, grooves or deep scratches.</li> <li>b. Inspect back of bearing halves for bright spots which indicate bearings have been moving in caps or cylinder block.</li> <li>c. Replace bearings that are excessively worn. If one or more bearing halves require replacement, all bearing halves must be replaced.</li> </ul> <p style="text-align: center;"><b>3-346</b></p>	

End

**CRANKSHAFT INSPECTION**

This task covers: Cleaning and inspection of crankshaft.

INITIAL SETUP

Test Equipment

Magnetic field fluorescent light kit

Dial indicator

Micrometer

Materials/Parts

Solvent

Troubleshooting Reference

Page 2-19

Equipment Condition

Engine removed

Crankshaft removal/installation, page 3-321

Oil pump removal/installation, page 3-143

Piston and connecting rod removal/installation,

Special Tools

None

Personnel Required

One mechanic

References

Engine specifications, page 2-69  
 Crankshaft removed from cylinder block  
 Oil pump removed  
 Pistons and connecting rods removed  
 page 3-350

General Safety Instructions

None

## CRANKSHAFT MAIN BEARINGS INSPECTION (CONT)

LOCATION/ITEM	ACTION	REMARKS
1. Crankshaft	<ul style="list-style-type: none"> <li>a. Clean thoroughly, using suitable solvent.</li> <li>b. Flush all passages until cleaning solution flows through each and is free of dirt.</li> <li>c. Dry with compressed air.</li> <li>d. Check for cracks using dye penetrant, magnetic field fluorescent, or other suitable method.</li> <li>e. Support on V-blocks and check runout on intermediate bearing journals.</li> </ul>	See Engine specifications, page 2-69.
2. Crankshaft journals	<ul style="list-style-type: none"> <li>a. Inspect for score marks, scratching or discoloration due to excessive heat.</li> <li>b. Check for excessive taper and out-of-roundness.</li> <li>c. Check that each journal diameter is within specifications.</li> </ul>	See Engine specifications, page 2-69.

3-348

End

**Section XIV. PISTON ASSEMBLY**

This section covers maintenance of these engine components for direct support maintenance personnel:

- a. Piston and connecting rod removal/installation
- b. Piston and connecting rod assembly/disassembly
- c. Connecting rod bearings removal/installation

Also instructions for inspection of: pistons and connecting rods, connecting rod bearings.

**LIST OF TASKS**

(Sheet 1 of 1)

TASK NO.	TASK	REF (PAGE)	TROUBLESHOOTING REF (PAGE)
1	Piston and connecting rod removal/installation	3-350	2-15
2	Piston and connecting rod assembly/disassembly	3-355	2-16, 2-18
3	Connecting rod bearings removal/installation	3-359	2-15
4	Piston and connecting rod inspection	3-365	2-16
5	Connecting rod bearing inspection	3-369	None
6	Finding top center position	3-371	None

**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION:**

This task covers: Removal and installation of piston assembly and connecting rod.

INITIAL SETUP

Test Equipment

Feeler gage

Materials/Parts

Tape

Troubleshooting Reference

Page 2-15

Equipment Condition

Cylinder heads and oil pump removed from engine.

Special Tools

None

Personnel Required

One mechanic

References

Connecting rod bearing removal/installation, page 3-359.  
 Cylinder heads removal/installation, page 3-217.  
 Oil pump removal/installation, page 3-143.  
 Crankcase guard removal/installation, TM 10-3930-641-20.

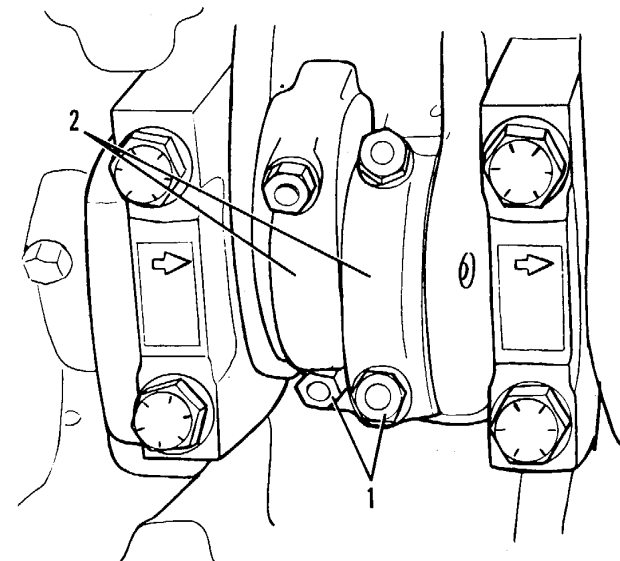
General Safety Instructions

None

Go on to Sheet 2

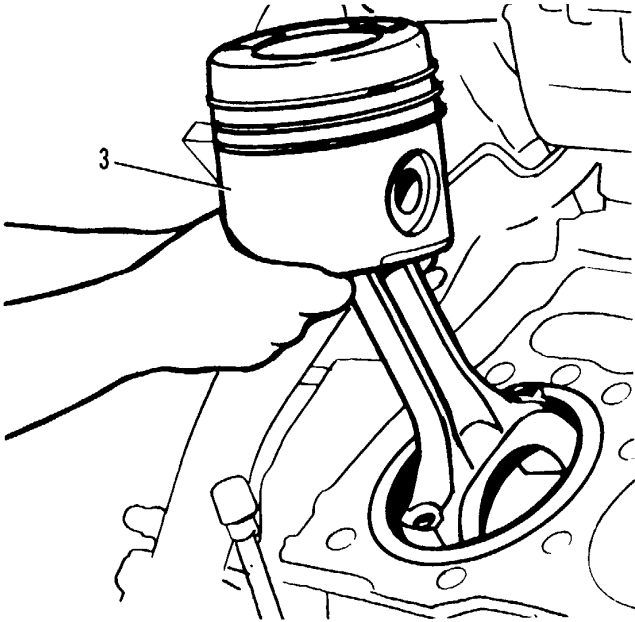
**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
REMOVAL		
1. Cylinder liner	Using a ridge reamer, remove carbon at top of cylinder liner.	
2. Crankshaft	Rotate until piston is at bottom dead center.	
3. Connecting rod nuts (1)	Remove.	
4. Bearing cap (2)	Remove.	
NOTE	<p>Before removing connecting rods, cover connecting rod bolt threads with rubber hose or tape to prevent scratching crankshaft.</p>	
3-351		



TA099142  
Go on to Sheet 3

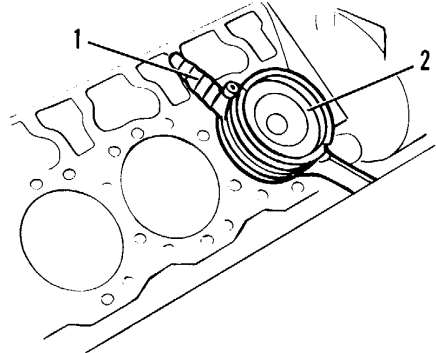
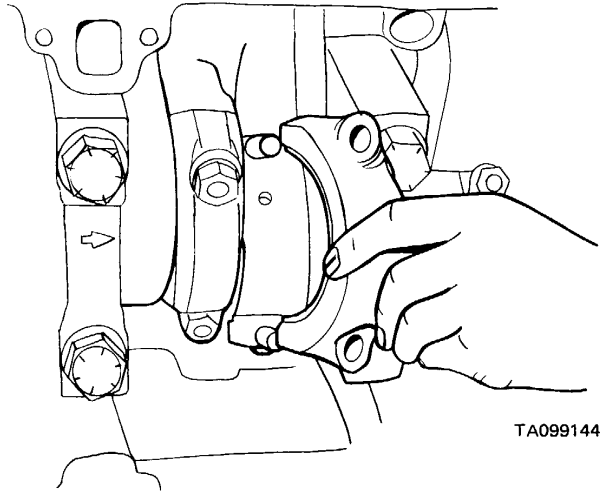
**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
5. Connecting rod bolts 6. Piston assembly (3)	Remove. Push up through cylinder and remove.	
<p style="text-align: center;">INSTALLATION</p> 1. Piston rings, connecting rod bearings, cylinder liner. 2. Connecting rod bearings	Coat with clean engine oil. Replace, if necessary.	

See connecting rod bearing removal/installation, page 3-359.

TA099143  
 Go on to Sheet 4

**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<p>3. Piston assembly</p>	<p>a. Insert in correct bore.</p> <p>b. Install piston ring compressor (1) on piston assembly (2).</p> <p>c. Using wooden rod (or hammer handle), softly tap piston assembly into bore until rod bearing seats on crankshaft journal.</p> <p style="text-align: center;">NOTE</p> <p>Next install piston assembly that rides the same crankshaft journal but occupies bore on opposite bank.</p> <div style="border: 2px dashed black; padding: 5px; text-align: center; margin: 10px 0;"> <p><b>CAUTION</b></p> </div> <p>Make sure each piston assembly is installed so that flat sides of connecting rods face each other and chamfered sides face toward crankshaft.</p>	  <p style="text-align: right; font-size: small;">TA099144</p>

**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT):**

(Sheet 5 of 5)

<b>LOCATION/ITEM</b>	<b>ACTION</b>	<b>REMARKS</b>
4. Connecting rod bearings	Check clearances.	See connecting rod bearing removal/installation, page 3-359.
5. Connecting rod bolts	Coat with clean engine oil.	
6. Connecting rod cap	Install and secure finger tight with the two nuts.	
7. Connecting rod nuts	a. Tighten each to a torque of 60 + 6 lb. ft. (82.3 + 8.2 N-m). b. Put a mark across the nuts and bolts. c. Tighten each nut an additional 1200.	
8. Connecting rods	Check side clearance between the two connecting rods on each crankshaft journal. Clearance must be 0.003 to 0.033 in. (0.08 to 0.84 mm) for new rods.  <div style="text-align: center;"><b>3-354</b></div>	

End

**PISTON AND CONNECTING ROD DISASSEMBLY/ASSEMBLY (CONT):**

This task covers: Disassembly and assembly of piston and connecting rod.

INITIAL SETUP

Test Equipment

None

Materials/Parts

As required

Troubleshooting Reference

Pages 2-16, 2-18

Equipment Condition

Piston and connecting rod removed from engine.

Special Tools

None

Personnel Required

One mechanic

References

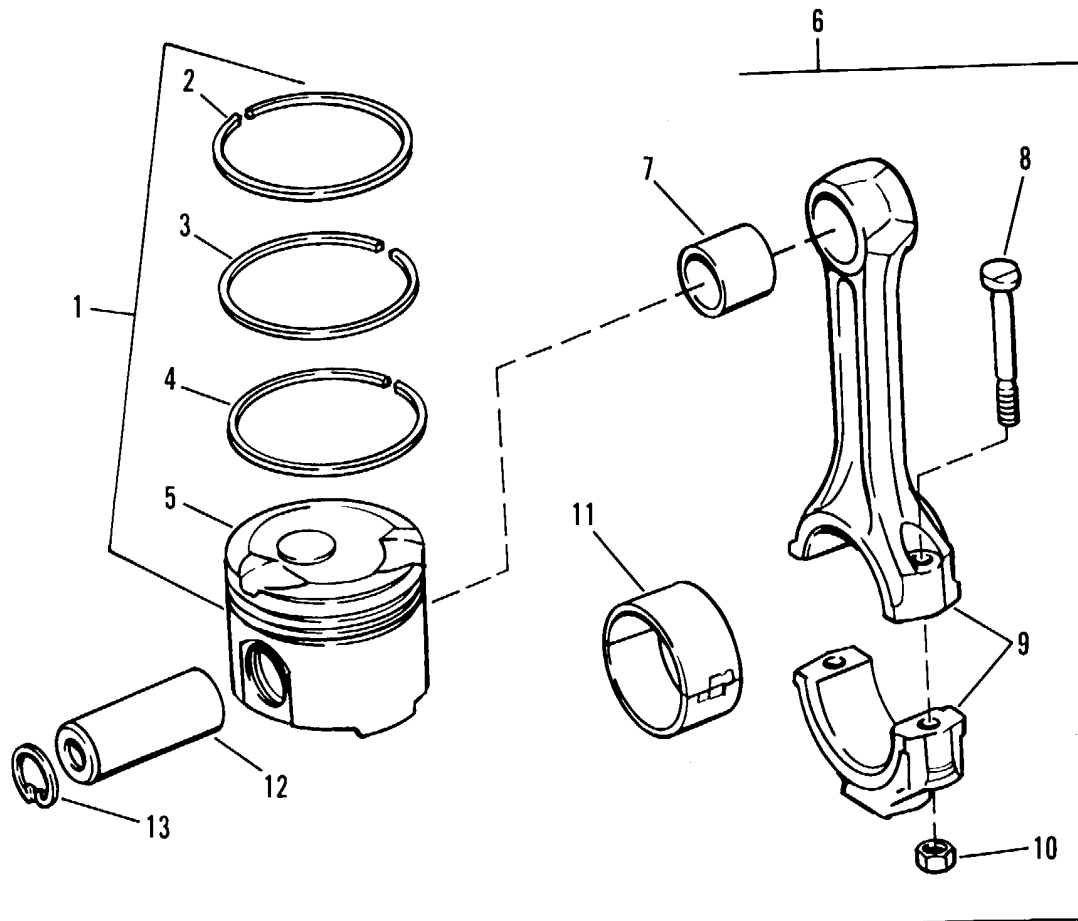
Engine specifications, page 3-67.  
Piston and connecting rod removal/installation, page 3-350.

General Safety Instructions

None

**PISTON AND CONNECTING ROD DISASSEMBLY/ASSEMBLY (CONT)**

1. Piston Group
2. Top Piston Ring
3. Intermediate Piston Ring
4. Oil Regulating Piston Ring
5. Piston Assembly
6. Connecting Rod Assembly
7. Sleeve Bearing
8. Bolt
9. Connecting Rod
10. Hex. Nut
11. Connecting Rod Bearing
12. Piston Pin
13. Retaining Ring



1 AUG 93 145  
Go on to Sheet 3

**PISTON AND CONNECTING ROD DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
DISASSEMBLY		
1. Retaining rings (13)	Remove using suitable snap ring pliers.	
2. Piston pin (12) and connecting rod (9)	Remove from piston (5).	
3. Sleeve bearing (7)	Remove from connecting rod eye using press and driver.	
4. Piston rings (2), (3), (4)	Remove from piston using piston ring expander.	
NOTE	NOTE	
	It may not be necessary to remove sleeve bearing. See engine specifications, page 2-69, to determine if bearing is excessively worn.	
<b>3-357</b>		

Go on to Sheet 4

**PISTON AND CONNECTING ROD DISASSEMBLY/ASSEMBLY (CONT)**

LOCATION/ITEM	ACTION	REMARKS
ASSEMBLY		
1. Piston rings (2) (3) (4)	Install on piston (5).  NOTE Stagger ring gaps 120 degrees and be certain two top rings have top side up.	
2. Connecting rod (9)	a. Install sleeve bearing (7) in rod eye.  b. Correctly position connecting rod in piston.	
3. Piston pin (12)	Install.	
4. Retaining rings (13)	Install using suitable snap ring pliers.	
	<b>3-358</b>	End

**CONNECTING ROD BEARINGS REMOVAL/INSTALLATION:**

This task covers: Removal and installation of connecting rod bearings.

INITIAL SETUP

Test Equipment

Plastigage

1 in. Micrometer

Materials/Parts

Connecting rod bearings

Troubleshooting Reference

Page 2-15

Equipment Condition

Engine OFF and cooled  
Oil pump removed

Special Tools

None

Personnel Required

One mechanic

References

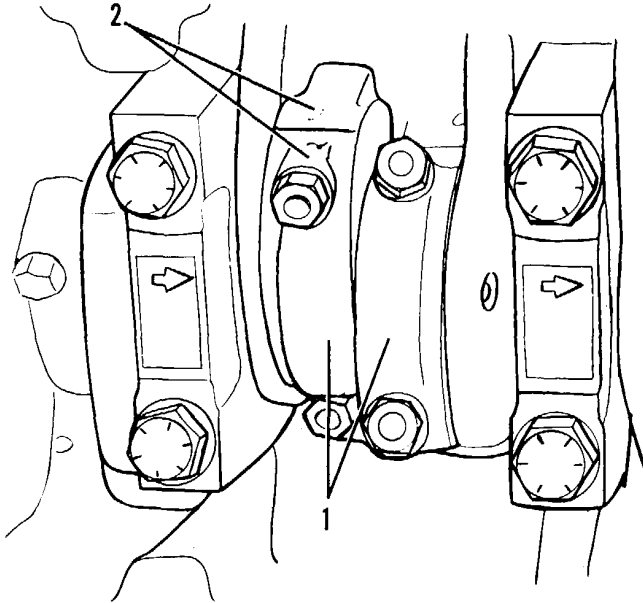
Oil pump removal/installation,  
page 3-143.

General Safety Instructions

None

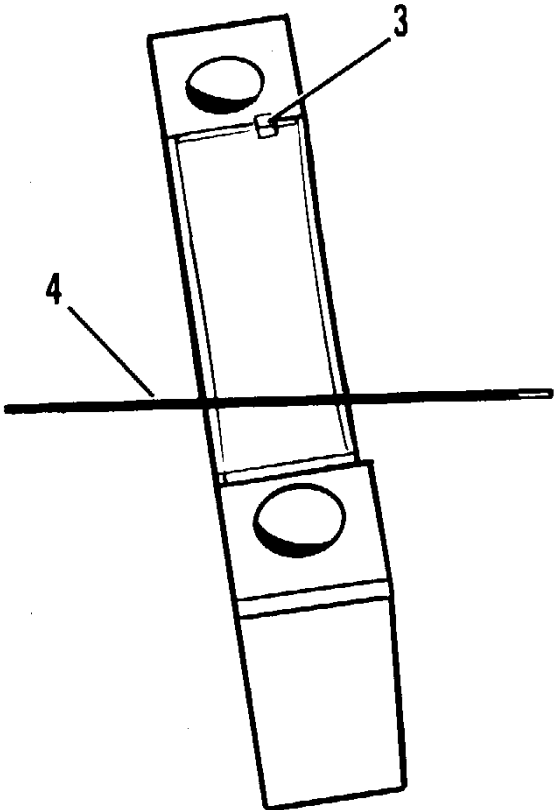


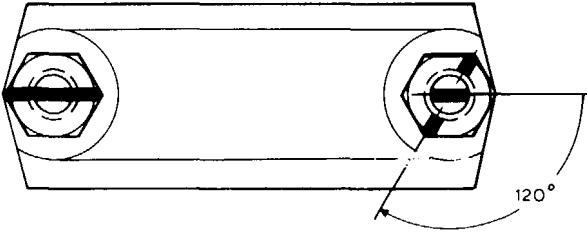
**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
3. Bearing cap	Remove	
4. Lower bearing	Remove from cap.	
5. Connecting rod	Push slightly away from crankshaft.	
6. Upper bearing	Remove	
	<div style="border: 2px dashed black; padding: 5px; text-align: center; width: fit-content; margin: 0 auto;"> <b>CAUTION</b> </div>	
	Be careful not to damage crankshaft journals. Do not turn crankshaft while any connecting rod caps.	
	3-361	
		

**PISTON AND CONNECTING ROD REMOVAL/INSTALLATION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
<p>INSTALLATION</p> <p>1. Upper bearing</p>	<p>a. Install in connecting rod.</p>	
	<p>NOTE</p>	
	<p>Be sure bearing tab (3) is correctly seated in groove in connecting rod.</p>	
	<p>b. Coat bearing surface with clean engine oil.</p>	
<p>2. Crankshaft journal</p>	<p>Coat with clean engine oil.</p>	
<p>3. Connecting rod</p>	<p>Put into position on crankshaft journal.</p>	
<p>4. Lower bearing</p>	<p>a. Coat bearing surface with clean engine oil.</p>	
	<p>b. Install in connecting rod cap.</p>	
	<p><b>3-362</b></p>	<p>Go on to Sheet 5</p>

LOCATION/ITEM	ACTION	REMARKS
5. Bearing clearance	<p style="text-align: center;">NOTE</p> <p>Be sure bearing tab (3) is properly seated in groove in bearing cap.</p> <p>Using plastigage (4), check as follows:</p> <ol style="list-style-type: none"> <li>a. Put plastigage in position as shown at right.</li> <li>b. Coat threads of cap bolts with clean engine oil.</li> <li>c. Install the cap and tighten cap nuts finger tight.</li> </ol> <p style="text-align: center;">NOTE</p> <p>Be sure you have the right cap and be sure it is installed correctly. The flat side of each cap must face toward the middle of the crankshaft journal.</p>	

LOCATION/ITEM	ACTION	REMARKS
5. Bearing clearance (cont)	<ul style="list-style-type: none"> <li>d. Tighten each nut to a torque of 60 + 6 lb. ft. (82.3 + 8.1 N.m).</li> <li>e. Scribe a mark across each nut and bolt as shown at right.</li> <li>f. Tighten each nut an additional 1200.</li> <li>g. Remove bearing cap and plastigage.</li> <li>h. Measure thickness of plastigage to determine bearing clearance. Clearance for new bearings must be 0.0028 to 0.0066 in. (0.071 to 0.168 mm). Maximum clearance for used bearings is 0.010 in. (0.25 mm).</li> <li>i. Once correct clearance has been obtained, install and retighten bearing cap, following steps d, e and f above.</li> </ul>	

3-364

End

**PISTON AND CONNECTING ROD INSPECTION:**

This task covers: Cleaning and inspection of piston and connecting rod.

INITIAL SETUP

Test Equipment

Micrometer, 6 in.  
 Micrometer, 3 in.  
 Inside micrometer, 3 in.  
 Inside micrometer, 6 in.

Materials/Parts

Solvent

Troubleshooting Reference

Page 2-16

Equipment Condition

Piston assemblies removed from  
 cylinder block.

Special Tools

None

Personnel Required

One mechanic

References

Engine specifications, page 2-69.  
 Piston and connecting rod removal/installation,  
 page 3-350.  
 Oil pump removal/installation, page 3-143.

General Safety Instructions

None

**PISTON AND CONNECTING ROD INSPECTION (CONT):**

LOCATION/ITEM	ACTION	REMARKS
<p>1. Piston (connecting rod and piston rings removed)</p>	<p>a. Soak in suitable solvent to remove all carbon deposits.</p> <p>b. Clean ring grooves using suitable ring groove tool.</p> <p style="text-align: center;"><b>CAUTION</b></p> <p>Do not cut any material from ring lands or bottom of groove.</p> <p>c. Check for cracks.</p> <p>d. Inspect skirt for scores, pitting or cracks.</p> <p>e. To insure correct piston - to - cylinder clearance, check piston diameter.</p> <p style="text-align: center;"><b>3-366</b></p>	<p>See Engine specifications, page 2-69.</p> <p style="text-align: right;">Go on to Sheet 3</p>

**PISTON AND CONNECTING ROD INSPECTION (CONT):**

LOCATION/ITEM	ACTION	REMARKS
2. Piston pin	<ul style="list-style-type: none"> <li>f. Check for excessive out-of-roundness.</li> <li>g. Install new rings and check ring end gap with feeler gage.</li> <li>h. Check ring-to-groove clearance.</li> <li>i. Replace piston if excessively worn.</li> <li>a. Clean in suitable solvent.</li> <li>b. Check for proper clearance in pin bore.</li> <li>c. Replace if necessary</li> </ul>	<p>See Engine specifications, page 2-69.</p> <p>See Engine specifications, page 2-69.</p> <p>See Engine specifications, page 2-69.</p>

**3-367**

Go on to Sheet 4

**PISTON AND CONNECTING ROD INSPECTION (CONT):**

(Sheet 3 of 4)

LOCATION/ITEM	ACTION	REMARKS
3. Connecting rod bearing cap nuts, bolts	a. Clean in suitable solvent. b. Inspect for thread damage.	
4. Connecting rod	a. Clean in suitable solvent. b. Check for bends, breaks, cracks or other damage. c. Using an inside micrometer, check connecting rod bore diameter with bearings installed. d. Check connecting rod bore for taper and out-of-roundness.	See Engine specifications, page 2-69.
5. Sleeve bearing (piston pin bearing)	a. Check for proper bearing-to-pin clearance. b. If necessary, replace bearing.	See Engine specifications, page 2-69.

**3-368**

End

**CONNECTING ROD BEARINGS:**

This task covers: Inspection of connecting rod bearings.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

None

Equipment Condition

Connecting rod bearings removed.

Special Tools

None

Personnel Required

One mechanic

References

Connecting rod bearings removal/installation,  
page 3-359.

General Safety Instructions

None

**3-369**

Go on to Sheet 2

**CONNECTING ROD BEARINGS INSPECTION (CONT)**

LOCATION/ITEM	ACTION	REMARKS
Connecting rod bearings	<p>a. Check for roughness, discoloration, metal flaking or embedded metal particles.</p> <p>b. Inspect back of bearing halves for bright spots which indicate bearings have been moving in connecting rod bore.</p> <p style="text-align: center;">NOTE</p> <p>Minor scratches in the bearing, caused by abrasive material rolling between the bearing and journal, are not necessarily harmful and do not indicate that the bearing needs to be replaced.</p> <p style="text-align: center;"><b>3-370</b></p>	

End

**FINDING TOP CENTER POSITION:**

This task covers: Positioning No. 1 piston at top center (TC) on the compression stroke.

INITIAL SETUP

Test Equipment

None

Materials/Parts

None

Troubleshooting Reference

None

Equipment Condition  
Engine shut down.

Special Tools

Tool, engine turning 9S9082

Personnel Required

One mechanic

References

Engine specifications, page 2-69.

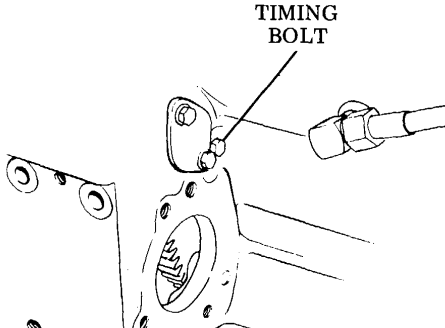
Valve cover removal/installation,  
TM 10-3930-641-20.

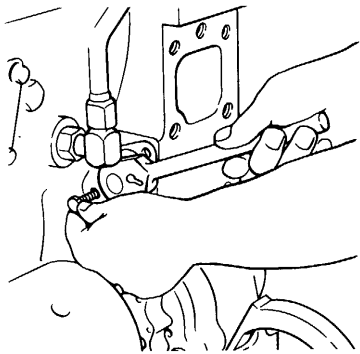
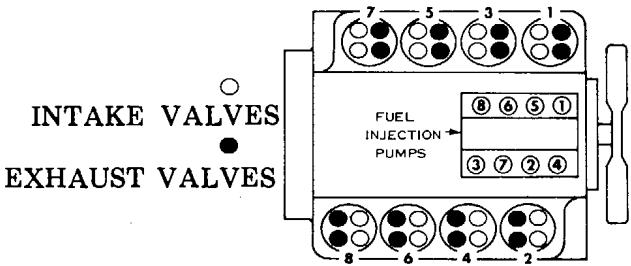
General Safety Instructions

Main disconnect switch off.

**3-371**

Go on to Sheet 2

LOCATION/ITEM	ACTION	REMARKS
<p>1. Valve covers</p>	<p style="text-align: center;"><b>NOTE</b></p> <p>This procedure is the starting point for all engine timing procedures.</p> <p>The timing bolt is stored as shown and can be installed in either the left or right side of the engine.</p> <p>There are two threaded holes in each side of the flywheel. The timing bolt will fit into only the correct hole.</p> <p>Remove.</p> <p style="text-align: center;"><b>3-372</b></p>	<div style="text-align: right; margin-bottom: 10px;">  </div> <p>See TM 10-3930-641-20.</p> <p style="text-align: right;">TA099149 Go on to Sheet 3</p>

LOCATION/ITEM	ACTION	REMARKS
2. Plug	Remove from timing hole location. Remove two capscrews - one short and one long timing bolt.	 <p>This removes play from timing gears.</p> <p>No. 1 piston is now at top center (TC).</p> <p>Valves should be closed if No. 1 piston is on compression stroke.</p>
3. Cover	Remove cover.	
4. Engine turning tool (9S9082)	Place in position to turn engine. Install long timing bolt.	
5. Flywheel	<p>a. Turn clockwise (when looking at flywheel) about 30 degrees.</p> <p>b. Turn counterclockwise until you can install the timing bolt into the flywheel</p>	
6. Valves for No. 1 cylinder	Observe.	
3-373		 <p style="text-align: center;">CYLINDER AND VALVE LOCATION</p>

LOCATION/ITEM	ACTION	REMARKS
	<p>b. If valves are not closed, turn flywheel 360 degrees (1 turn) counterclockwise and install the timing bolt.</p> <p style="text-align: center;">NOTE</p> <p>If you turn the flywheel so the hole in the flywheel passes the hole in the flywheel housing,</p> <p>a. Turn the flywheel back (clockwise) at least 30 degrees beyond the hole in the flywheel.</p> <p>b. Turn the flywheel counterclockwise to the hole again.</p> <p style="text-align: center;"><b>3-374</b></p>	<p style="text-align: right;">End</p>

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