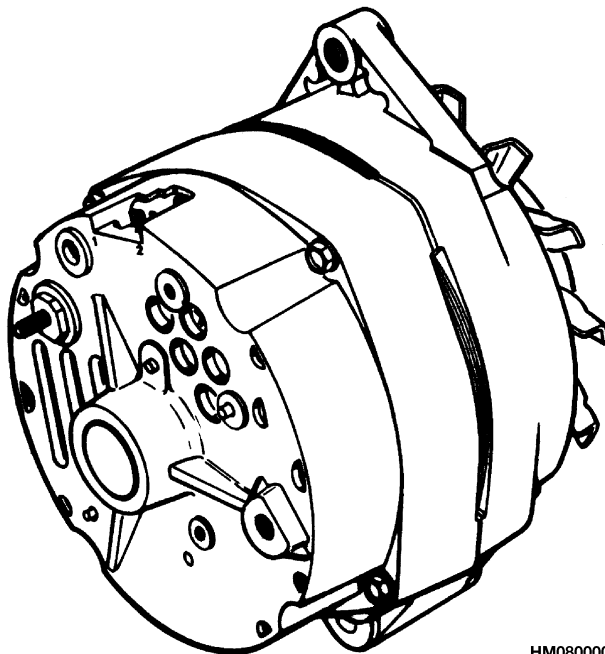


# **ALTERNATOR WITH REGULATOR**

**DELCO, MOTOROLA, AND  
LEECE-NEVILLE**

**COVERS DELCO, MOTOROLA, AND  
LEECE-NEVILLE ALTERNATORS USED  
ON HYSTER LIFT TRUCKS**



HM080000

# ***HYSTER***

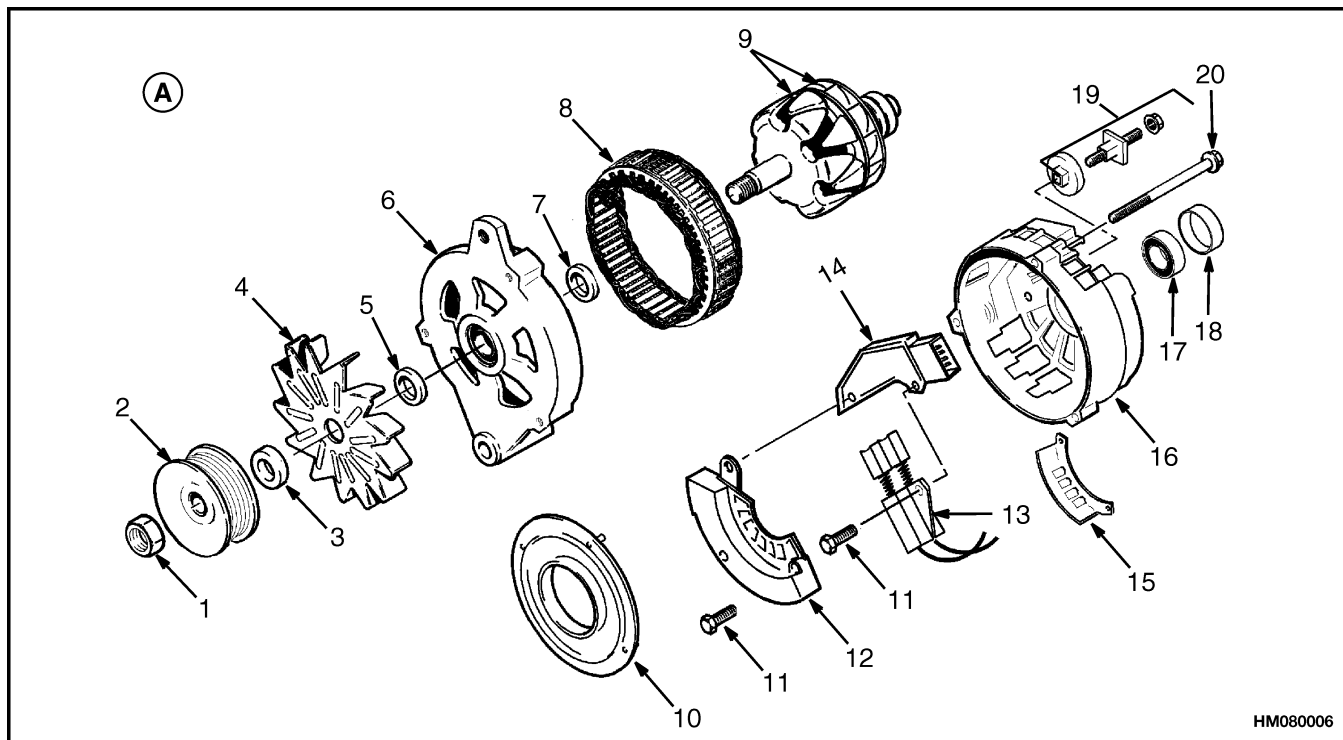
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HM080006

**A. DELCO**

- |                   |                        |                   |
|-------------------|------------------------|-------------------|
| 1. NUT            | 8. STATOR              | 15. COVER         |
| 2. PULLEY         | 9. ROTOR AND FAN       | 16. REAR HOUSING  |
| 3. COLLAR         | 10. BAFFLE             | 17. BALL BEARING  |
| 4. OUTSIDE FAN    | 11. SCREW              | 18. RETAINER RING |
| 5. OUTSIDE COLLAR | 12. DIODE BRIDGE       | 19. TERMINAL SET  |
| 6. FRONT HOUSING  | 13. BRUSHES AND HOLDER | 20. BOLT          |
| 7. INSIDE COLLAR  | 14. VOLTAGE REGULATOR  |                   |

**Figure 6. Type B Alternator, Exploded View****Assemble**

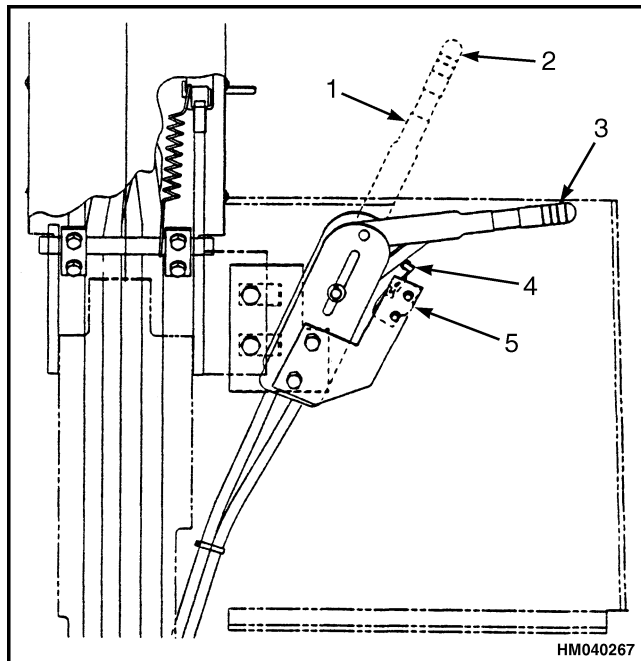
1. If the bearing was removed from the rear housing, install a new retainer ring. See Figure 6.

**CAUTION**

**The bearing is not completely installed until Step 11 is complete.**

2. Install a new bearing by pushing on the new bearing outer race until the bearing hits the bottom in the rear housing.
3. Assemble the voltage regulator, diode bridge, and brush holder on a flat surface. Put crimps in the connectors or solder the connectors to fasten and connect the parts as originally assembled. Use a pin to hold the brushes in the brush holder.
4. Put a thin coating of silicon grease on the inside of the rear housing under the diode bridge.
5. Install the bridge, regulator, and brush holder assembly in the rear housing and install the screws as removed during disassembly.
6. Install the baffle and use a punch to fasten the pins.
7. Align the marks made during disassembly and install the stator in the rear housing. Use pliers on the connectors of the diode bridge to keep heat from the diodes. Use a soldering iron to connect the stator leads to the connectors.

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
There is no charge from the alternator.	The brushes are worn or damaged.	Install new brushes.
	Weak springs for brushes. Brushes or brush holders do not move freely.	Install new parts.
	Dirt on the slip rings.	Clean or install new parts.
There is no charge from the alternator. The indicator light or ammeter indicates a discharged condition when the rpm is high and the load is high.	There is an electrical ground in the field winding.	Replace rotor or alternator.
	Drive belt is not tight or is broken.	Adjust or replace drive belt.
Ammeter or the indicator light indicates a discharged condition at all speeds.	There is a short circuit in the diodes.	Install new parts.
	There is an electrical ground at the end of the windings.	Replace rotor or alternator.
	The voltage regulator has damage.	Replace voltage regulator.



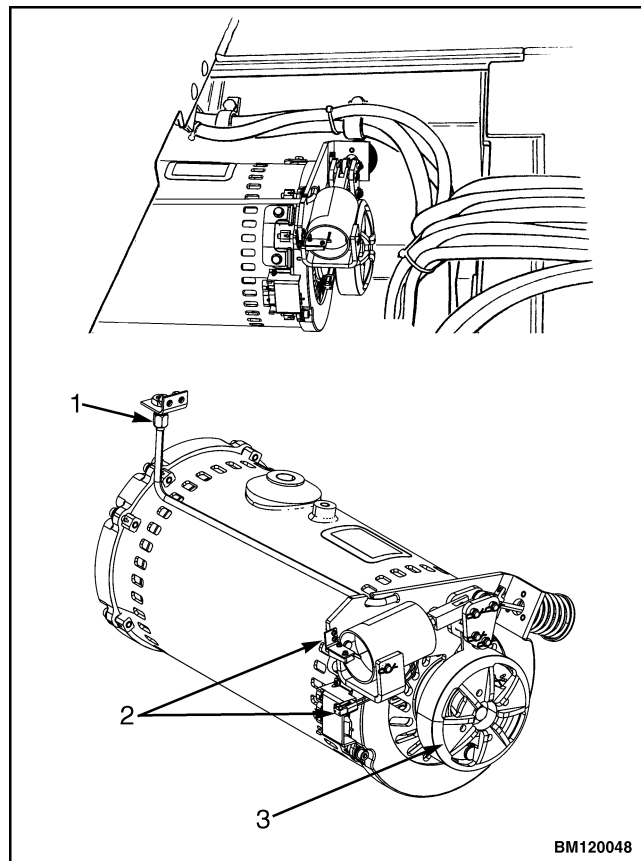
- |                        |                      |
|------------------------|----------------------|
| 1. PARKING BRAKE LEVER | 3. RELEASED POSITION |
| 2. APPLIED POSITION    | 4. SWITCH LEVER      |
|                        | 5. SWITCH            |

**Figure 6. Parking Brake Arrangement for Lift Truck Models E3.50-5.50XL (E70-120XL, E70-120XL<sub>3</sub>) (C098) and E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098)**

**SEAT BRAKE**

Lift truck models E3.50-5.50XL (E70-120XL, E70-120XL<sub>3</sub> (C098) and E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098) covered in this manual may be equipped with an optional seat brake that is attached to the traction motor and is actuated automatically when the operator leaves seat. See Figure 7. When correctly adjusted, this brake will hold lift truck with a capacity load on a 15% grade [a slope that increases 1.5 m increase in 10 m (1.5 ft increase in 10 ft)]. Make sure service brakes operate correctly before checking operation of seat brake. If brake does not hold lift truck on grade, seat brake must be adjusted by authorized service personnel.

For adjustment procedures for seat brake used on E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098) lift trucks, go to the section Seat Brake Assembly in this manual. For adjustment procedures for seat brake used on E3.50-5.50XL (E70-120XL, E70-120XL<sub>3</sub> (C098) lift trucks, see the section **Frame 100** SRM 284.



**NOTE: TRACTION MOTOR AND SEAT BRAKE FOR LIFT TRUCK MODELS E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098) SHOWN.**

1. GUIDE PIPE CONNECTION
2. ELECTRICAL CONNECTION
3. SEAT BRAKE

**Figure 7. Traction Motor and Seat Brake Assembly**

**CAUTION**

When the piston is removed or installed, make sure the cylinder bore and piston is not scratched or damaged.

6. Remove lock wire and piston stop plate. Carefully remove piston from cylinder.
7. Remove spring and check valve.

**Clean and Inspect**

**WARNING**

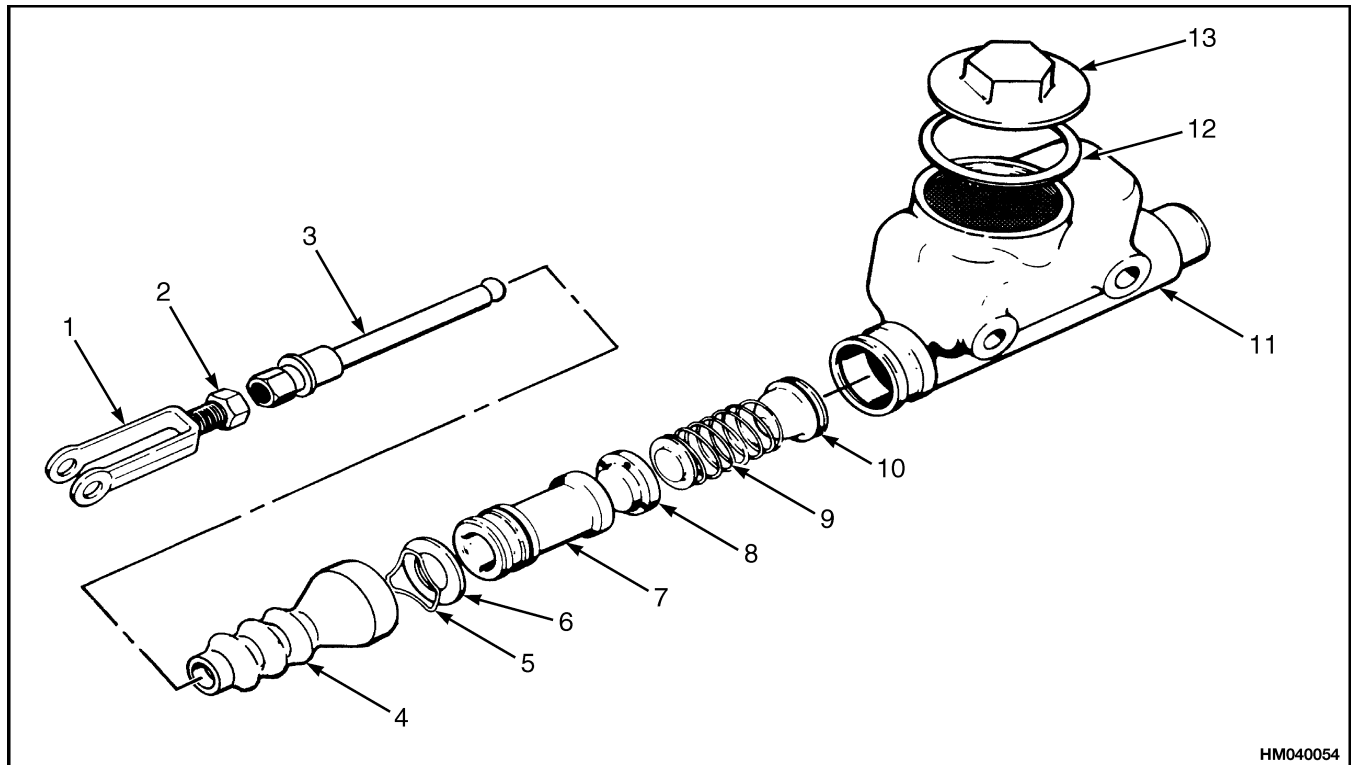
Compressed air can move particles so that they cause injury to the user or to other personnel. Make sure that the path of the compressed air is away from all personnel. Wear protective

goggles or a face shield to prevent injury to the eyes.

**CAUTION**

DO NOT use an oil solvent to clean the master cylinder, wheel cylinder, or the brake linings. Use a solvent approved for cleaning of brake parts. Do not put oil or grease in the brake fluid or on the linings.

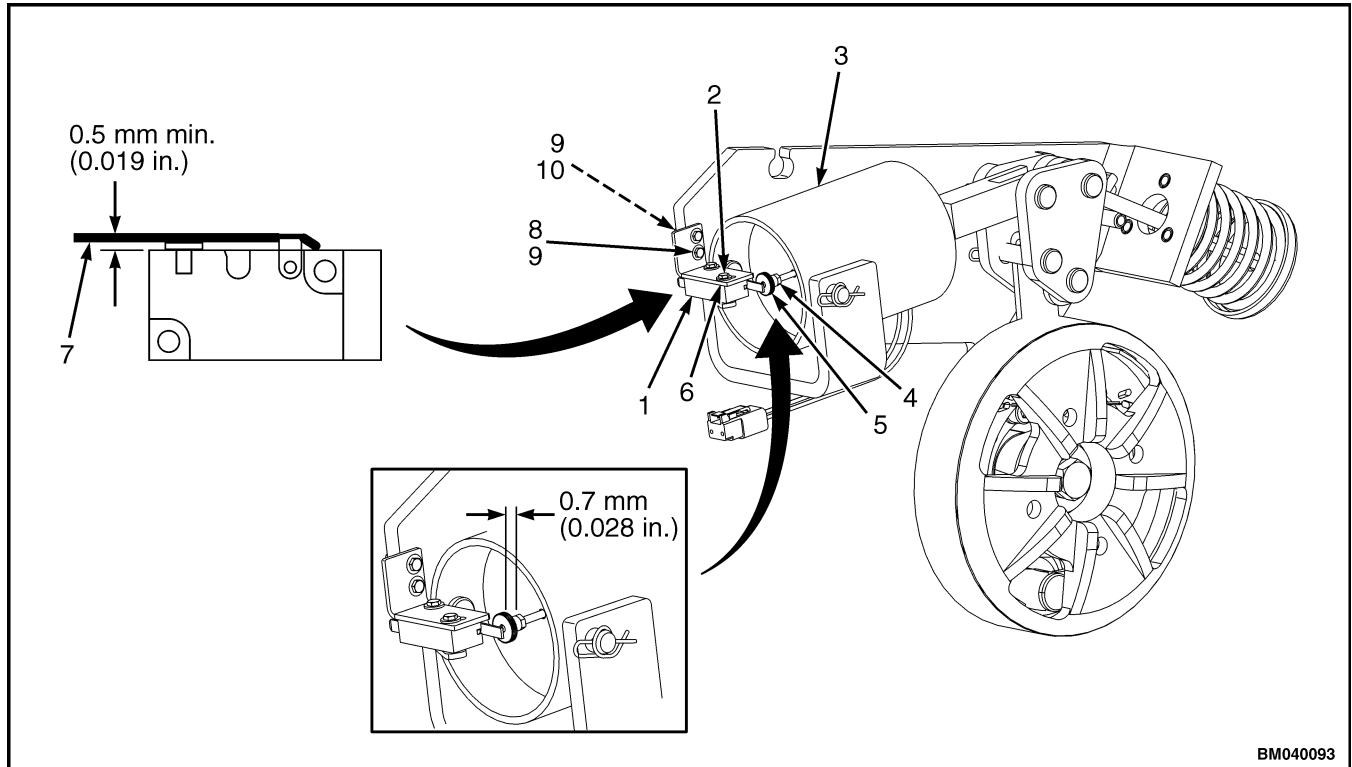
1. Clean all parts of master cylinder. Use compressed air to dry parts. Keep oil and grease off parts and out of brake fluid.
2. Inspect bore of master cylinder and machined surfaces of piston. Replace a master cylinder that has a damaged bore or piston.



**NOTE:** MASTER CYLINDER FOR LIFT TRUCK MODELS E3.50-5.50XL (E70-120XL, E70-120XL<sub>3</sub>) (C098) AND E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098) SHOWN.

- |              |                      |                 |
|--------------|----------------------|-----------------|
| 1. ROD END   | 6. PISTON STOP PLATE | 11. BODY        |
| 2. JAM NUT   | 7. PISTON ASSEMBLY   | 12. GASKET      |
| 3. PUSH ROD  | 8. PRIMARY CUP       | 13. FILLER PLUG |
| 4. BOOT      | 9. RETURN SPRING     |                 |
| 5. LOCK WIRE | 10. CHECK VALVE      |                 |

*Figure 15. Master Cylinder*



BM040093

- |                    |            |
|--------------------|------------|
| 1. TRACTION SWITCH | 6. BRACKET |
| 2. CAPSCREWS       | 7. LEAF    |
| 3. SOLENOID        | 8. SCREW   |
| 4. JAM NUT         | 9. WASHER  |
| 5. THUMB WHEEL     | 10. NUT    |

**Figure 23. Traction Cutoff Switch Adjustment**

### Cable Adjustment

**NOTE:** The Solenoid and Traction Cutoff Switch adjustment must be completed before adjusting the release cable.

**NOTE:** When handle is in the UP position, brake is released. When handle is in the DOWN position, brake is applied.

**NOTE:** The solenoid must **NOT** be energized when performing this procedure.

**NOTE:** When the handle is in the UP position, the air gap between the leaf and the switch housing must be 0.5 mm (0.019 in.) minimum.

1. With brake fully assembled, and the handle in the UP position. Pull the cable tight through the wire stop. Insert excess cable into the handle. See Figure 24.

2. Move the handle to the DOWN position.
3. Pull the handle back into the UP position, and check for drag by rotating the brake drum by hand.
4. If the brake drags while the handle is in the UP position, lower the handle, loosen the wire stop, pull cable through, and retighten the wire stop. Repeat Step 3 and Step 4 until the brake no longer drags. Lower the handle to the DOWN position.
5. Adjust handle by tightening nut to 0.85 N•m (7.5 lbf in) so that the washers clamp onto the handle but allows handle to pivot easily.

## Description

The purpose of the cooling system is to control the operating temperature of the engine (and in some units, the transmission, brakes, and hydraulic system). A centrifugal water pump circulates coolant through passages in the engine block and the radiator. A thermostat is installed in the water outlet fitting on the engine. As the coolant flows through the radiator, the fan moves air through the radiator to help cool the system.

The coolant is a mixture of water and antifreeze. The antifreeze prevents the coolant from freezing in cold weather, and thereby preventing damage to the engine and radiator. The antifreeze also prevents rust and lubricates the water pump.

### RADIATOR

The radiator is the heat exchanger for the cooling system. The fan causes air to flow through the radiator and reduces the temperature of the coolant. The auxiliary coolant reservoir is connected to the radiator by a hose. As the engine gets hot, the coolant expands. During expansion, coolant moves from the radiator to the reservoir. When the engine stops, the coolant becomes cool and contracts. The coolant in the reservoir flows back into the radiator. In this way, the radiator is kept filled with coolant during normal operation.

On units with a powershift transmission, an oil cooler is built into the radiator. Oil from the transmission flows through coils in the radiator tank to help control the oil temperature.

### RADIATOR CAP

The radiator cap is a pressure-vent type that lets the pressure in the cooling system increase to 103 kPa (15 psi). The pressure in the system prevents vapor from forming in the coolant flowing to the water pump. This action maintains the efficiency of the water pump and the performance of the cooling system. The increase in pressure also raises the boiling point of the coolant mixture to approximately 125°C (257°F) at sea level.

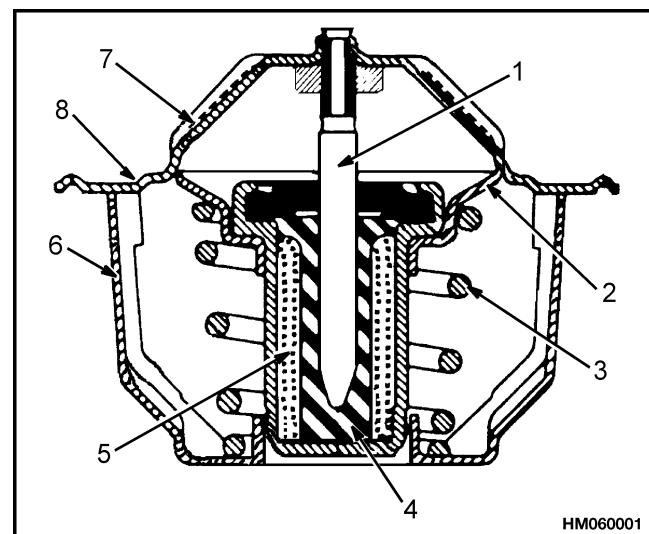
The radiator cap has a pressure valve and a vacuum valve. The pressure valve is held against its seat by a spring. The pressure valve opens when the pressure in the cooling system exceeds 103 kPa (15 psi). The vacuum valve is held against its seat

by another spring. The vacuum valve opens to relieve the vacuum created when the coolant temperature decreases. In certain conditions this vacuum can cause the radiator or top hose to collapse.

### THERMOSTAT

The thermostat is a device that controls coolant flow by opening and closing to regulate coolant temperature. The thermostat uses a wax pellet to control its operation. The wax pellet expands when it is heated and contracts when it is cold. When heated, the wax pellet pushes on the piston, causing the valve in the thermostat to open. As the wax pellet cools, it contracts and lets a spring close the valve. When the engine is first started and the coolant is cold, the thermostat remains closed. During this time the coolant circulates through the engine, letting it warm quickly. As the engine becomes warm the thermostat opens, letting coolant circulate through the radiator.

The opening and closing of the thermostat helps keep the coolant within the operating limits of the system. The same thermostat is used for summer and winter seasons. Do not operate the engine without a thermostat. The engine will take longer to get warm and may run improperly. See Figure 2.



- |               |                |
|---------------|----------------|
| 1. PISTON     | 5. WAX PELLETT |
| 2. VALVE SEAT | 6. FRAME       |
| 3. SPRING     | 7. FLANGE      |
| 4. DIAPHRAGM  | 8. VENT HOLE   |

*Figure 2. Typical Thermostat*

# INTRODUCTION

## GENERAL

This section has the description of the frame and some connected parts. See FIGURE 1. Procedures for the removal and installation of the counterweight, hood, overhead guard, and engine (including the transmission and radiator) are described in REPAIRS. Checks for the operator restraint system and procedures for the repair of tanks and replacement of safety labels are included.

## DESCRIPTION

The frame is one weldment and includes the hydraulic tank and the fuel tank for gasoline or diesel fuel.

There is a counterweight for each capacity of lift truck. The counterweights are similar, but are different weights. The muffler is fastened to the frame inside of the counterweight.

An overhead guard is fastened to the cowl at the front of the lift truck and to a frame plate at the rear of the lift truck.

The hood is connected to the frame plate with hinges. A gas controlled spring gives assistance when raising the hood and holds the hood in the open position. The floor plates can be removed for access to the transmission and other components.

## REPAIRS

### WARNING

**The lift truck must be put on blocks for some types of maintenance and repair. The removal of the following assemblies will cause large changes in the center of gravity: mast, drive axle, engine and transmission, and the counterweight. When the lift truck is put on blocks, put additional blocks in the following positions to maintain stability:**

a. Before removing the mast and drive axle, put

blocks under the counterweight so that the lift truck can not fall backward.

b. Before removing the counterweight, put blocks under the mast assembly so that the lift truck can not fall forward.

**The surface must be solid, even, and level when the lift truck is put on blocks. Make sure that any blocks used to support the lift truck are solid, one piece units.**

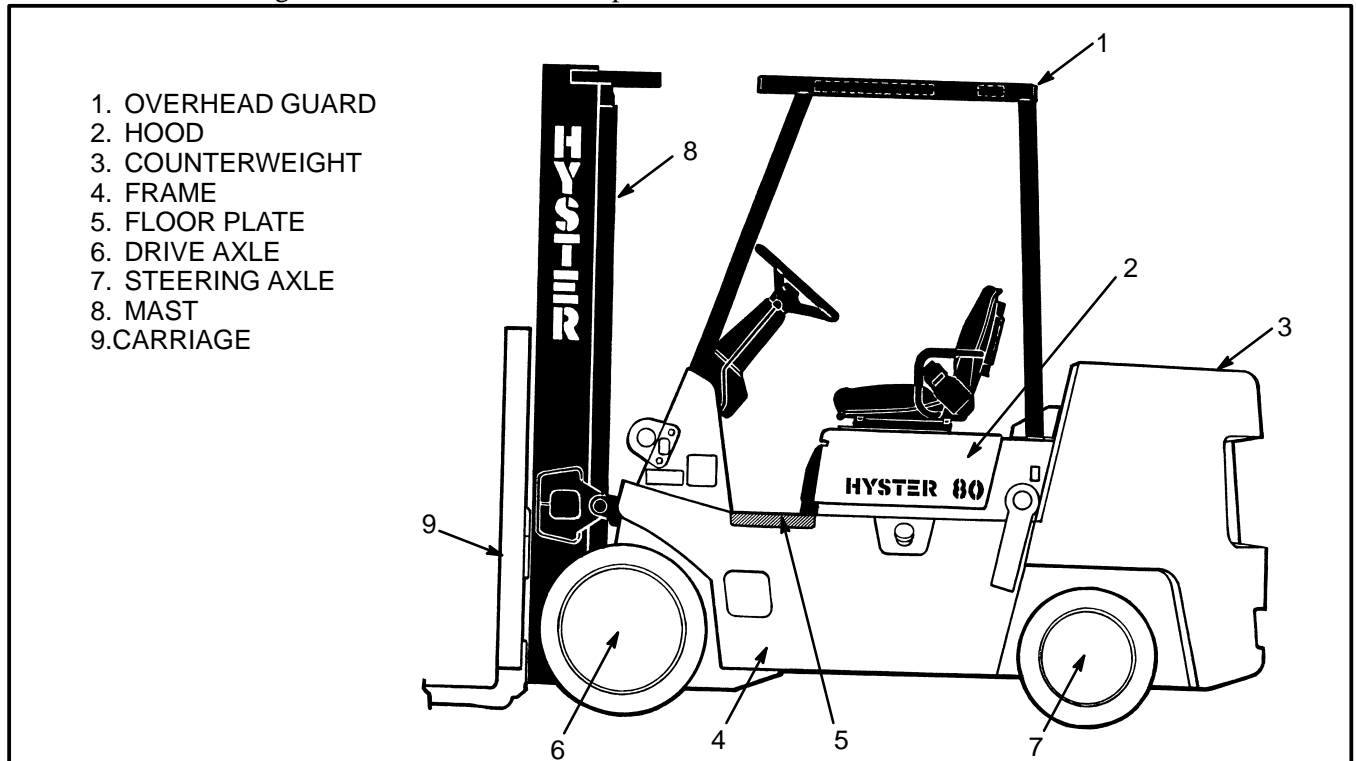


FIGURE 1. FRAME AND CONNECTED PARTS

er inspection. When making inspections, use a light that is approved for locations with flammable vapors.

- g. Put plugs in all the openings in the tank. Wait 15 minutes, then remove the inlet and outlet plugs. Test a sample of the vapor with a special indicator for gas vapors. If the amount of flammable vapors is above the lower flammable limit, repeat the cleaning procedures.

### Chemical Solution Method of Cleaning

If the tank cannot be cleaned with steam, use the following procedure:

- a. Mix a solution of water and trisodium phosphate or a cleaning compound with an alkali base. Follow the instructions given by the manufacturer.
- b. Fill the tank with the cleaning solution. Use compressed air to mix the solution in the tank.
- c. Drain the tank. Flush the inside of the tank with hot (boiling) water. Make sure all the cleaning compound is removed.
- d. Make an inspection of the inside of the tank. If the tank is not clean, repeat steps 1 through 3. Make another inspection of the tank. When making inspections, use a light that is approved for locations with flammable vapors.
- e. Check the tank for flammable vapors using special indicator for gas vapors. If the amount of flammable vapors is not below the lower flammable limit, repeat the cleaning procedures.

### Other Methods Of Preparation For Repair

If nitrogen gas or carbon dioxide gas is available, prepare the tank for welding using these gases. See the manual *Safe Practices For Welding and Cutting Containers That Have Held Combustibles* by the American Welding Society, A6.0–65. If these gases are not avail-

able, another method using water can be used as follows:

- a. Fill the tank with water to just below the point where the work will be done. Make sure the space above the level of the water has a vent.
- b. Use acceptable welding practices to repair the tank. See the American National Standard “Safety in Welding and Cutting,” ANSI Z 49.1 – 1973.

### SAFETY LABELS (See FIGURE 8.)

#### WARNING

Safety labels are installed on the lift truck to give information about operation and possible hazards. It is important that all safety labels are installed on the lift truck and can be read.

**DO NOT add to or modify the lift truck. Any change to the lift truck, the tires or its equipment can change the lifting capacity. The lift truck must be rated as equipped and the nameplate must show the new capacity rating. Contact your dealer for Hyster lift trucks for a replacement nameplate.**

If necessary, install new and correct labels as follows:

#### WARNING

**Cleaning solvents can be flammable and toxic, and can cause skin irritation. When using cleaning solvents, always follow the recommendations of the manufacturer.**

- a. Make sure the surface is dry and has no oil or grease. Do not use solvent on new paint. Clean the surface of old paint with a cleaning solvent.
- b. Remove the paper from the back of the label. Do not touch the adhesive surface.
- c. Carefully hold the label in the correct position above the surface. The label cannot be moved after it touches the surface. Put the label on the surface. Make sure that all air is removed from under the label and the corners and edges are tight.

## ROCKER ARM STUDS (EARLY MODELS)

These studs are pressed into the head.

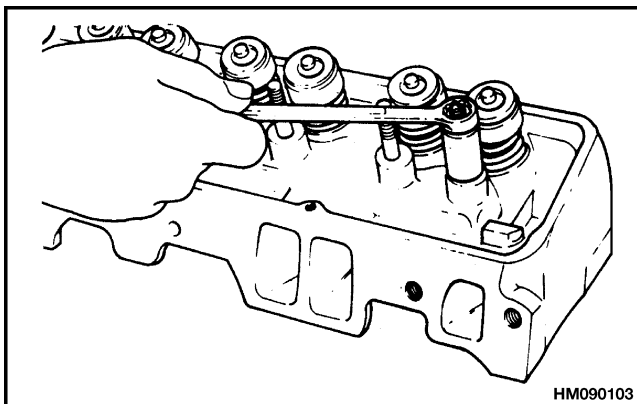
Replace a stud that has damaged threads or is loose in the cylinder head. New studs are available in the following oversizes: 0.003 in. and 0.013 in.

1. To remove old stud, install spacer, flat washer, and nut to damaged stud. Use a wrench to remove damaged stud. See Figure 8.

### CAUTION

Do not attempt to install an oversized stud without reaming the stud hole to the new size. Installation of an oversized stud without reaming the stud hole can cause cracks in the cylinder head.

2. Use a reamer of the correct size for new oversized stud. Apply SAE 90 lubricant to new stud during installation. Install new stud as shown in Figure 9.



NOTE: EARLY MODELS ONLY.

*Figure 8. Rocker Arm Stud Removal*

## ROCKER ARM STUDS (LATE MODELS)

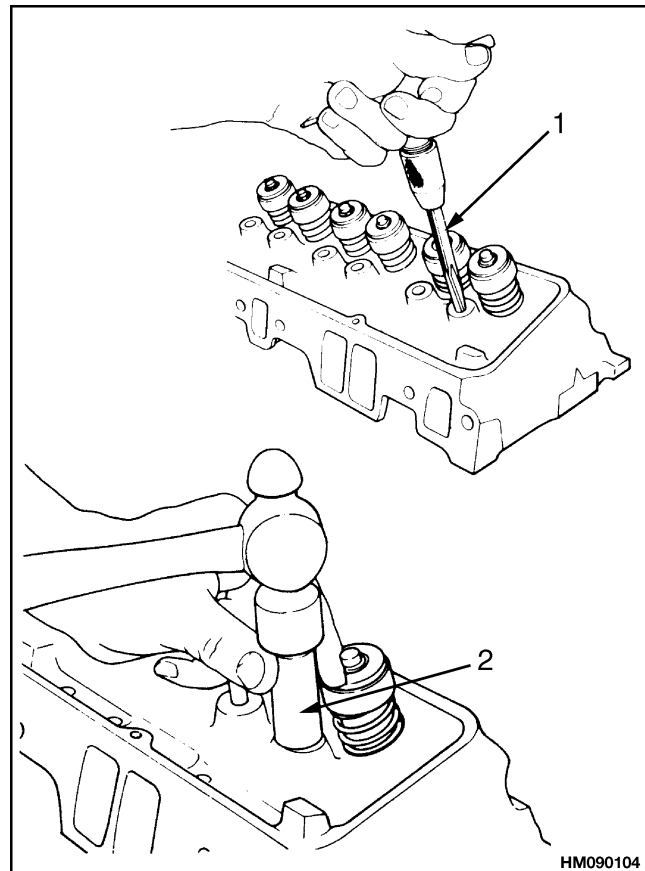
### WARNING

DO NOT remove a stud from the cylinder head when the engine is hot. Some of the studs fit into coolant passages and can release pressure and hot coolant when removed. The steam and boiling coolant can cause burns.

### CAUTION

Disposal of lubricants and fluids must meet local environmental regulations.

Drain the cooling system before replacing the studs. The studs for late model engines have threads that hold them to the cylinder head. See Figure 10. A stud that has damaged threads must be replaced with a new stud. If the threads in the head are damaged, a thread repair kit can be used. If the damaged threads cannot be repaired with a thread repair kit, then the head must be replaced.



NOTE: EARLY MODELS ONLY.

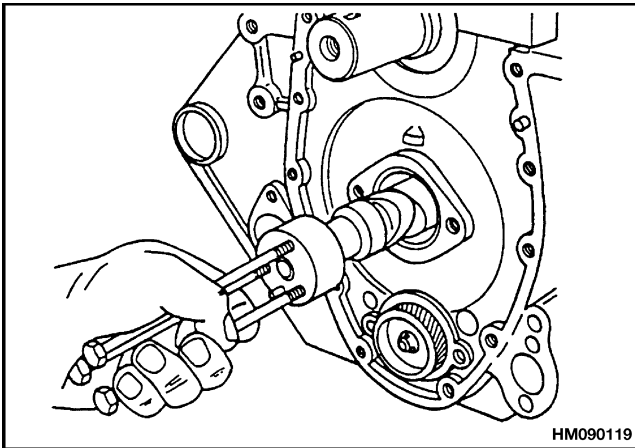
1. REAMER
2. INSTALLATION TOOL

*Figure 9. Rocker Arm Stud Installation*

## CAMSHAFT

### Remove

1. Remove intake manifold, push rods, lifter guides, and valve lifters.
2. Remove timing cover as described in section Timing Cover. Align timing marks. Remove timing chain, sprockets, and camshaft retainer.
3. Install two or three 5/16-18 capscrews that are 100 to 125 mm (4 to 5 in.) long into camshaft. See Figure 31. These capscrews will make the camshaft easier to control. Carefully remove camshaft from cylinder block. All camshaft bearings are the same size. Do not damage bearings or camshaft during removal.



**NOTE:** LATE MODEL SHOWN, OTHER MODELS SIMILAR.

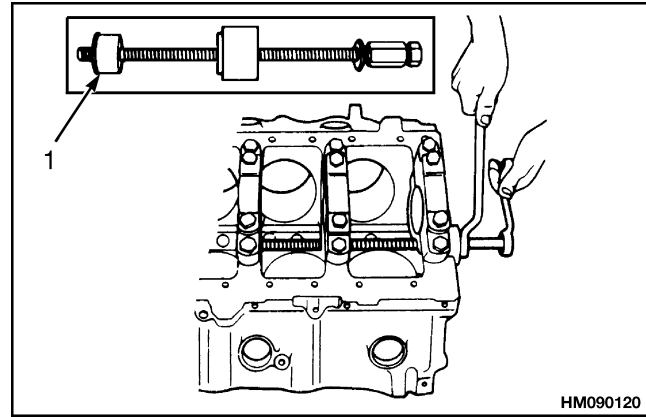
*Figure 31. Camshaft*

4. If necessary, use a special tool as shown in Figure 32 to remove camshaft bearings. Remove front and rear bearings last.

### Inspect

Inspect entire camshaft for any signs of wear or damage. Measure diameter of each bearing surface on camshaft. Do the measurement at different positions

on the surface of the bearing to see if they are round. If the difference of the readings for each bearing is more than 0.025 mm (0.001 in.), replace camshaft. Check for a bent camshaft or excessive camshaft runout. If runout exceeds 0.065 mm (0.0026 in.), the camshaft is bent and should be replaced.



1. TOOL FOR CAMSHAFT BEARINGS

*Figure 32. Camshaft Bearings*

### Install

1. Use a special tool as shown in Figure 32 to install camshaft bearings. See Figure 33. Install front and rear bearings first. Make sure oil holes in bearings are aligned with oil holes in block. Use a sealant on rear camshaft plug and install plug in block. Make sure plug is even with or 0.80 mm (0.03 in.) below surface of block.
2. Lubricate camshaft lobes with a molybdenum lubricant. Lubricate camshaft bearings with engine oil. Install two or three 5/16-18 capscrews that are 100 to 125 mm (4 to 5 in.) long into camshaft. See Figure 31. These capscrews will make camshaft easier to control. Carefully install camshaft in cylinder block.
3. Lubricate and install retainer for camshaft. Tighten capscrews to 14 N•m (125 lbf in).
4. Install gear for the balance shaft as described in procedures for Balance Shaft.

## PISTON, CLEAN AND INSPECT

### WARNING

Commercial cleaning solvents can be flammable and toxic and can cause severe skin irritation. When using commercial cleaning solvents, always comply with the solvent manufacturer's recommended safety precautions.

Compressed air can move particles so they cause injury to the user or to other personnel. Make sure the path of the compressed air is away from all personnel. Wear protective goggles or a face shield to prevent injury to the eyes.

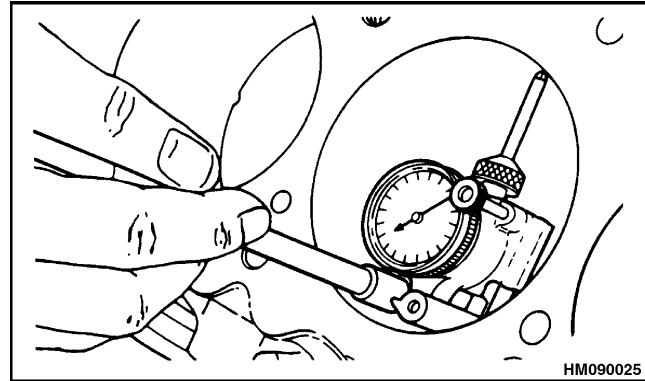
1. Use solvent to clean pistons and connecting rods. Use compressed air to dry parts.
2. Clean piston ring grooves with a ring groove cleaning tool.
3. Clean piston oil lubrication holes and slots.
4. Inspect pistons for wear, cracks, and damage. Replace a piston that is worn or damaged.

**NOTE:** If the cylinder bore must be repaired, the piston must be changed to the correct oversize. Check clearance of piston in its cylinder after surface of cylinder bore has been finished with a hone.

5. Check clearance of piston pin in piston. The normal clearance is shown in the Engine Specifications. The piston pin will normally fall from the hole in the piston by its own weight. The piston pin is a press fit in the connecting rod. The piston and piston pin are a matched set and must be replaced as a unit if the clearances are greater than the specifications.

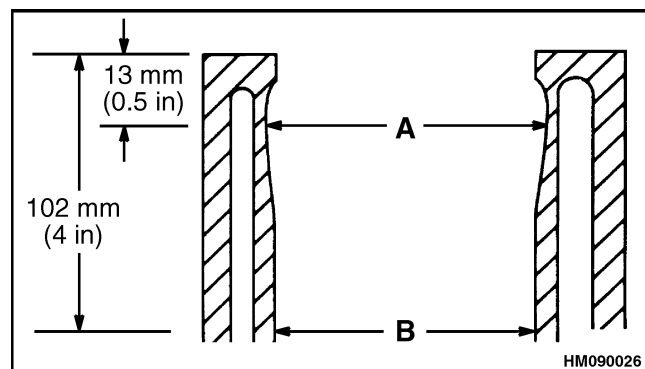
## CYLINDER BORES, INSPECT AND REPAIR

Inspect cylinder bores for wear and damage. Measure cylinder bores in several positions as shown in Figure 50. Measure cylinder bore at right angles to centerline to find any distortion from wear. A cylinder that is out-of-round greater than 0.05 mm (0.002 in.) must be repaired.



**Figure 50. Cylinder Bore Measurement**

Measure cylinder bore in positions from top to bottom to find any taper from wear. A normal wear pattern for a cylinder bore is shown in Figure 51. A cylinder that has a taper (measurement A that is 0.127 mm (0.005 in.) greater than measurement B) must have a new bore. A tool called a hone can be used to remove a small amount of taper from a cylinder bore. Use a boring machine to repair a badly worn cylinder bore. The boring machine will make a more accurate cylinder bore. The hone is then used to finish the surface of the cylinder bore.



**Figure 51. Pattern for Normal Cylinder Wear**

A cylinder bore that has been repaired with a hone or a boring machine must be fitted with a piston that is the correct size. Measure outer diameter of piston and inner diameter of cylinder bore as shown in Figure 52. Using different oversize pistons in the engine does not affect the dynamic balance of the engine. Replacement pistons from standard size to 0.508 mm (0.020 in.) oversize normally have the same weight. The clearance specifications between a piston and its cylinder bore is shown in Engine Specifications.

**HYDRAULIC VALVE LIFTER**

Leak rate	12 to 90 seconds with 50-lb load
Body diameter	21.3868 to 21.4046 mm (0.8420 to 0.8427 in.)
Plunger travel	3.175 mm (0.125 in.)
Clearance in bore	0.0635 mm (0.0025 in.)
Lifter bore diameter	21.425 to 21.450 mm (0.8435 to 0.8445 in.)

**CAMSHAFT**

Variation from front to rear of a cam lobe	Taper with larger dimension away from No. 1 piston
Bearing journals, diameter (All engines)	47.45 to 47.48 mm (1.8681 to 1.8693 in.)
Bearing journals, clearance	0.01778 to 0.9685 mm (0.0007 to 0.0381 in.)
Variation of a bearing journal in either diameter or axial direction	0.03 mm (0.001 in.)
Axial clearance	0.10 to 0.30 mm (0.004 to 0.012 in.)

**PISTONS**

Piston diameter (see gauge points in Figure 52)	
Cylinder Bore Out-of-round (see Figure 50)	0.0508 mm (0.002 in.)
Maximum cylinder taper	0.025 mm (0.001 in.)
Clearance at bottom of cylinder	0.068 mm (0.0027 in.)
Piston ring to groove clearance for piston rings (see Figure 53)	
Compression rings	0.107 mm (0.0042 in.)
Oil ring to groove clearance	
Early Models	0.203 mm (0.008 in.) max
Late Models	0.508 to 2.032 mm (0.02 to 0.08 in.)
Piston ring end clearance (see Figure 54)	
Compression rings	
Early Models	0.89 mm (0.035 in.)
Late Models	1.524 to 0.88 mm (0.06 to 0.035 in.)
Oil ring	
Early Models	1.65 mm (0.065 in.)
Late Models	0.23 to 1.65 mm (0.009 to 0.065 in.)
Piston pin to piston clearance	0.025 mm (0.001 in.)
Piston pin to connecting rod clearance	0.020 to 0.040 mm (0.0008 to 0.0016 in.)

## Description

This section has a description and the service procedures for the High Energy Ignition (HEI) system for General Motors engines. See Figure 1.

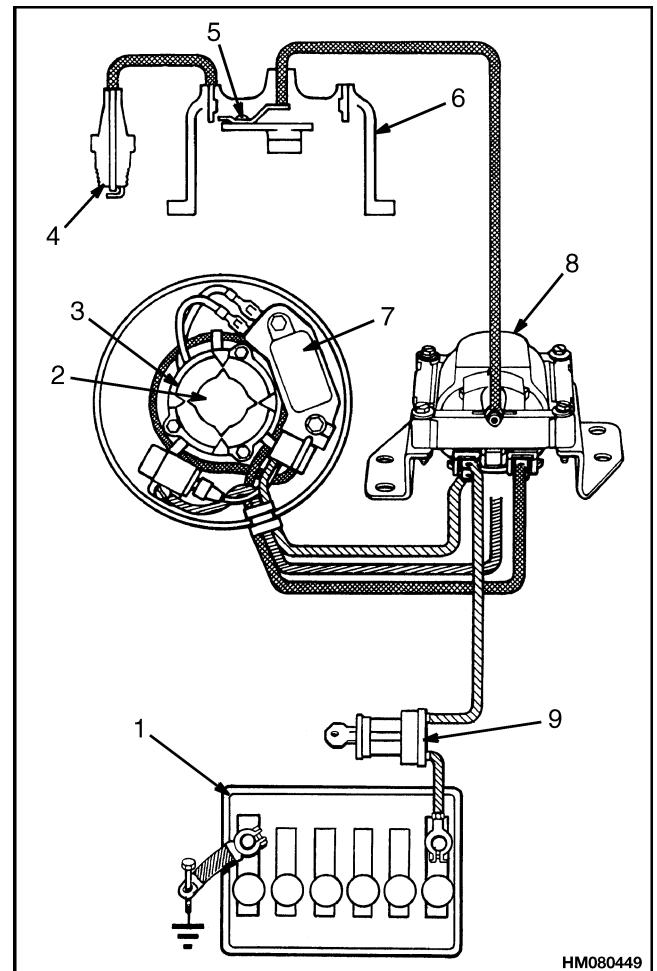
The High Energy Ignition (HEI) system generates the spark which starts combustion. The main parts of the system are: the battery, key switch, distributor, ignition coil, spark plugs, and the wires. If the engine is starting or running, current flows from the battery to the key switch, primary winding of the ignition coil, electronic module and returns to the battery. A magnetic field is generated in the primary winding of the coil when current flows through it. The pole piece and sensing coil sends a signal to the electronic module to interrupt primary current. When the current flow in the primary windings are interrupted, the decreasing magnetic field generates a high voltage in the secondary windings of the coil.

The distributor rotor applies the secondary (high) voltage to the correct spark plug at the correct time. The secondary voltage is applied to the rotor. The rotor transfers this high voltage to one of the terminals in the distributor cap. When the high voltage is applied through the high voltage wire to the spark plug, the spark in the spark plug starts combustion in the cylinder.

The parts that generate the voltage signal for the electronic module are shown in Figure 2. The timer core of the distributor shaft has a tooth for each cylinder in the engine. The pole piece also has a tooth for each cylinder. A permanent magnet is fastened under the pole piece. A sensing coil is put in the center of the magnet and pole piece. When the teeth are aligned, the magnetic field from the permanent magnet will have a path. The magnetic field generates a voltage signal in the sensing coil. When the teeth are not aligned, the magnetic path is removed. This disables the magnetic field and the voltage signal.

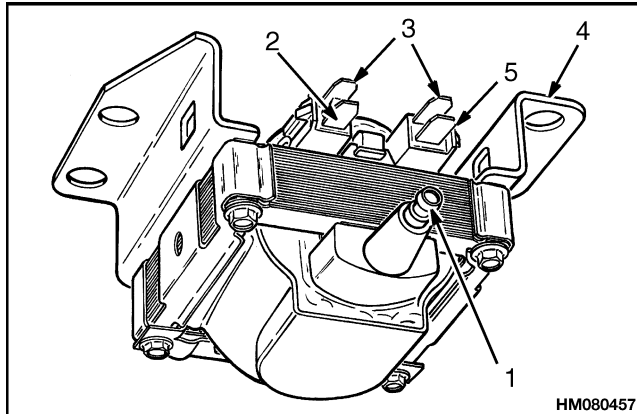
The electronic module is an electronic switch which controls the current in the primary of the ignition coil. The basic circuit is shown in Figure 3. When the electronic module receives a voltage signal from the sensing coil, the electronic module activates ON. Current now flows through the primary winding

of the ignition coil. The flow of current generates a magnetic field around both windings. When the sensing coil removes the voltage signal, the electronic module deactivates OFF. Current stops flowing in the primary winding. The magnetic field decreases quickly. This changing magnetic field generates a high voltage in the secondary winding.



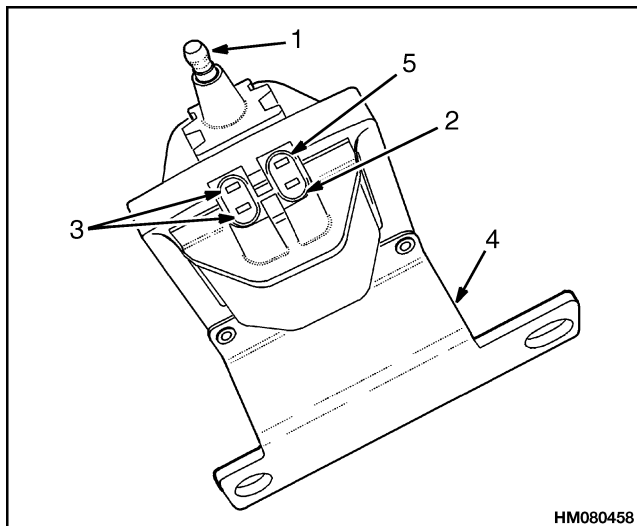
- |                                  |                         |
|----------------------------------|-------------------------|
| 1. BATTERY                       | 5. ROTOR                |
| 2. TIMER CORE                    | 6. DISTRIBUTOR CAP      |
| 3. POLE<br>PIECE/SENSING<br>COIL | 7. ELECTRONIC<br>MODULE |
| 4. SPARK PLUG                    | 8. IGNITION COIL        |
|                                  | 9. KEY SWITCH           |

*Figure 1. HEI System*



- |                        |                     |
|------------------------|---------------------|
| 1. SECONDARY TERMINAL  | 3. PRIMARY TERMINAL |
| 2. TACHOMETER TERMINAL | 4. FRAME            |
|                        | 5. BATTERY TERMINAL |

**Figure 9. Some Four- and Six-Cylinder Models Ignition Coil**



- |                        |                     |
|------------------------|---------------------|
| 1. SECONDARY TERMINAL  | 3. PRIMARY TERMINAL |
| 2. TACHOMETER TERMINAL | 4. FRAME            |
|                        | 5. BATTERY TERMINAL |

**Figure 10. GM V6 Models Ignition Coil**

### Install

**NOTE:** It is normal for a new coil to be loose in the frame.

1. Turn coil so terminals are on top. See Figure 9 and Figure 10. Put coil frame on studs that fasten coil to engine. Install and tighten nuts.
2. Connect primary wiring harness to coil. Push connector until latches lock.
3. Install dust cover over primary wiring connector.
4. Connect secondary wire to coil. Push connector until latches lock.
5. If removed, connect battery wire to negative terminal of battery. Tighten nut on capscrew.

### V8, SOME FOUR- AND SIX-CYLINDER MODELS

#### Remove

1. Disconnect wire from negative terminal of battery.
2. Unlock holder for secondary wires. See Figure 11. Remove secondary wires by carefully pulling on holder.
3. Disconnect wiring harness for primary wires from side of distributor.
4. Unlock four latch screws that fasten cap to housing. Remove distributor cap from distributor.

**NOTE:** Some V8-350 models used three screws to fasten the cover. Some V8-350, four- and six-cylinder models use two screws to fasten cover.

5. Remove screws that hold coil cover to distributor cap. Remove cover.

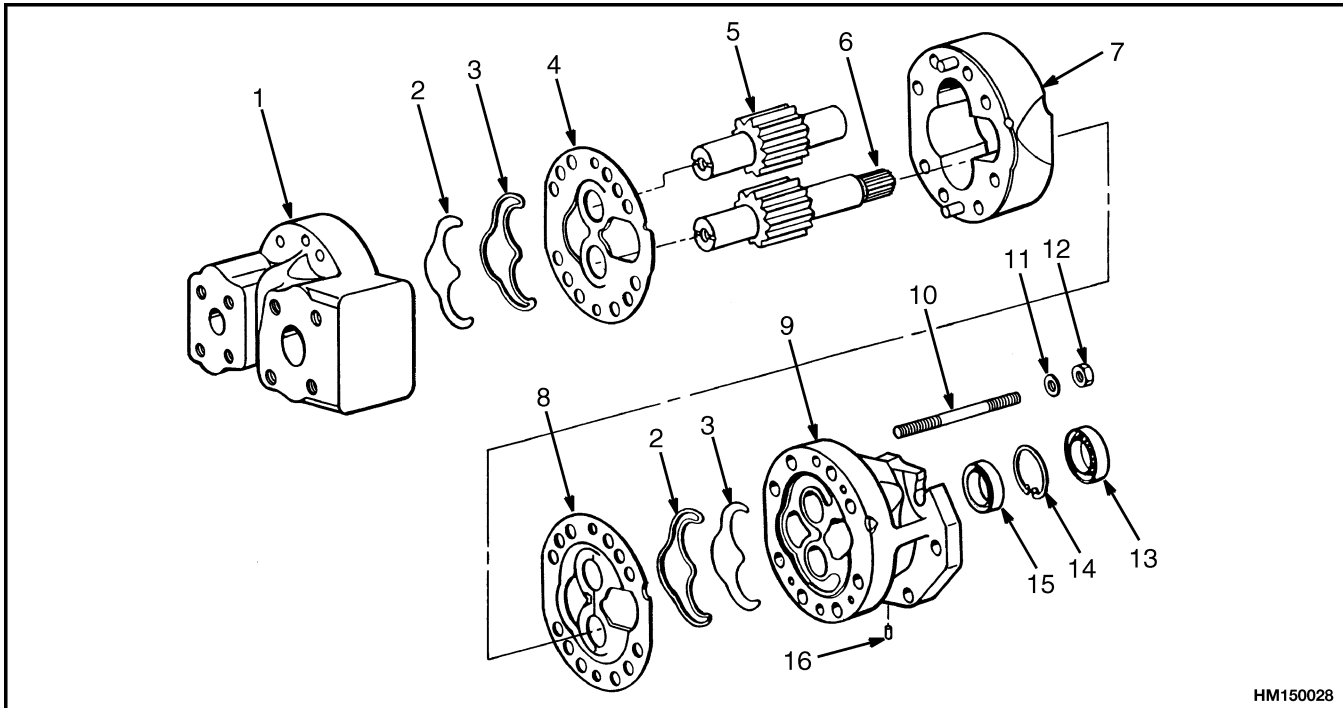


#### CAUTION

**Do not damage the ground wires.**

6. Remove four screws that hold coil to distributor cap. Loosen terminals of primary wires by pushing from connector side of cap. Carefully remove coil and primary wires.
7. Check rubber seal, spring, and resistor brush in cap for damage. Check cap for cracks or other damage. Replace parts that are damaged.

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
Engine does not run correctly.	Ignition timing is not correct.	Perform proper timing procedures. See Ignition Timing Adjustment.
	New spark plugs are needed.	Replace spark plugs. See Spark Plugs Replacement.
	High voltage wires are damaged.	Perform high voltage wire checks. See High Voltage Wires Check.
	Moisture or dirt in the distributor cap.	Clean and dry distributor cap.
	Distributor cap is damaged.	Replace distributor cap.
	Centrifugal mechanism is damaged.	Replace centrifugal mechanism. See Distributor Repair.
	Ignition coil is damaged.	Replace ignition coil. See Ignition Coil Replacement.
	Sensing coil is damaged.	Replace Sensing Coil. See Sensing Coil Replacement.
The electronic module is damaged.	Replace electronic module. See Electronic Module Replacement.	



HM150028

**NOTE:** THERE CAN BE A VARIATION OF INTERNAL PARTS ON DIFFERENT MODELS OF LIFT TRUCKS.

- |                     |                |
|---------------------|----------------|
| 1. REAR COVER       | 9. FRONT COVER |
| 2. SEAL GLAND       | 10. STUD       |
| 3. SEAL RETAINER    | 11. WASHER     |
| 4. REAR WEAR PLATE  | 12. NUT        |
| 5. DRIVEN GEAR      | 13. SEAL       |
| 6. DRIVE GEAR       | 14. SNAP RING  |
| 7. GEAR HOUSING     | 15. SEAL       |
| 8. FRONT WEAR PLATE | 16. PIN        |

**Figure 7. Hydraulic Gear Pump Single-Stage**

**NOTE:** Some pump bodies will show gear marks where the gears rotate because of the small clearances between the parts. These gear marks do not indicate a worn or damaged pump unless the pump will not supply the volume and pressure shown in the specifications.

**3.** Inspect gear housing for wear or grooves. Most wear occurs on the inlet side of the gear chamber. Put a straight edge across the inlet side of the gear chamber. If a 0.13 mm (0.005 in.) thickness gauge fits between the straight edge and the housing, the gear housing must be replaced. If the gear housing is worn, inspect bearings for wear. If the system pressure is too high, the gear housings will wear quickly. Grooves in the gear

chamber indicate dirt is in the oil. Small holes in the outlet side of the gear chamber indicate that cavitation has occurred. Make sure inlet hose, fittings, and tank have no restrictions. Cavitation can also occur when the engine speed is too high.

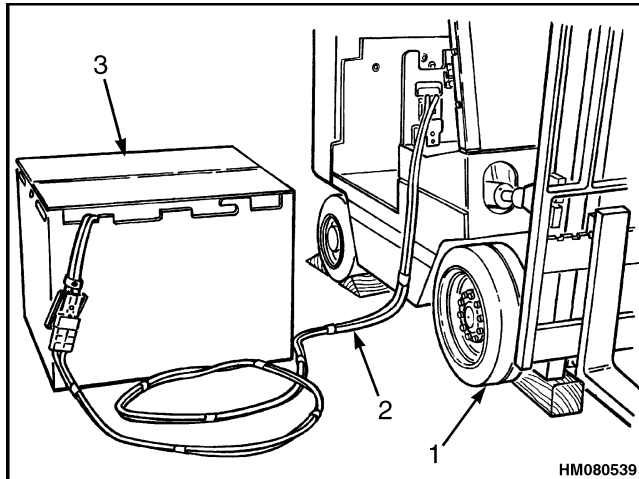
If the surfaces of the gear chamber or gear teeth have blue marks, the pump was too hot. Heat damage in the pump can be caused by hot oil or lack of oil. Check front seal surface to see if air was entering the pump through the front seal. Make sure the oil is the correct viscosity. The wrong viscosity oil can increase leakage within the pump. Leakage inside the pump increases the oil temperature.





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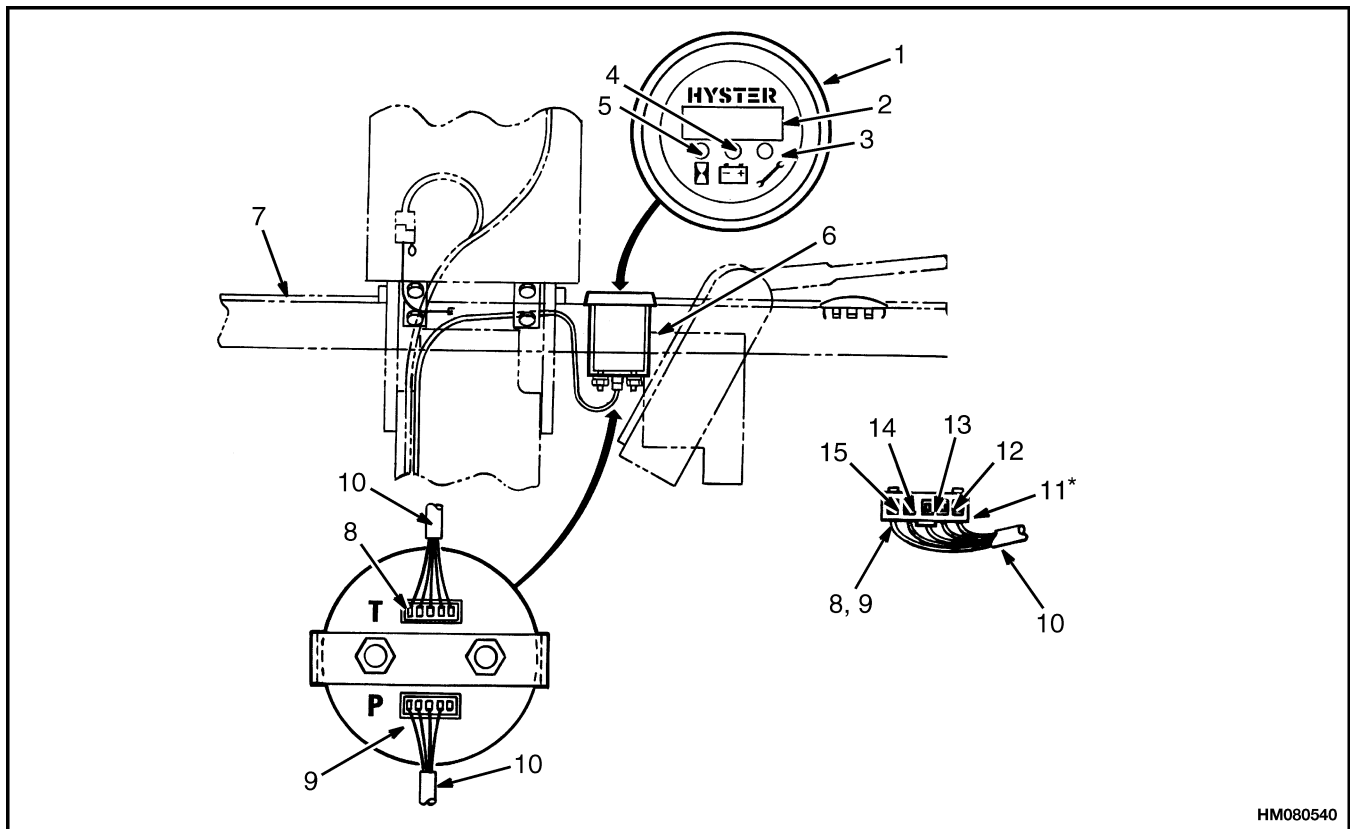


**Legend for Figure 8**

Connect the battery so that the motor can be operated. The battery must be removed for access to the motor. Use a jumper cable to connect the battery to the lift truck. Raise the drive wheels. See "How to Raise Drive Wheels" in the **Periodic Maintenance** section for your lift truck or the **Operating Manual** for your lift truck.

- 1. RAISE DRIVE WHEELS
- 2. JUMPER CABLE
- 3. BATTERY

**Figure 8. Connect Battery so Motor can be Operated**



**Figure 9. GE Instrument Panel Display and Plug Connector (E40-60XL)**

## Brush Wear Indicators

The brush wear indicators illuminate when the motor brushes must be replaced. The sensor wires for the brush wear indicators are an insert in the brush material when it is made. The sensor wires are insulated from the brush material. When the brush wears within approximately 0.060 inch of the brush lead, the insulation between the sensor wire and the

brush material is destroyed. The connection between the brush and the sensor wire causes the indicator to illuminate.

The operation of the brush wear indicators can be checked during periodic maintenance. The battery must be removed from the lift truck for access to the motors.

## Adjustments - General

There are no adjustments to perform except for some battery indicators. Refer to the section **Battery Indicators** 2260 SRM 138 to adjust the battery indicators. Refer to the section **EV-100LXT/LX/LXP**

**EV-200LXT/LX Motor Controller & Diagnostic Handset, Description, Checks, Repairs, Adjustments, and Troubleshooting** 2200 SRM 460 to adjust the I.T.W. display panel.

## Replacement - General Information



### WARNING

**Before replacing any components, fully lower all parts of the mast and tilt it forward until the tips of the forks touch the ground. This action will prevent the mast from lowering suddenly if the control lever is accidentally moved.**

**ALWAYS disconnect the battery and remove the key before replacing components.**

**Never have any metal on your fingers, arms, or neck. These metal items can accidentally make an electrical connection and cause an injury.**

**NOTE:** None of the electrical components of this section can be repaired. All bad components must be replaced.

Meters, display panels, most indicators, and senders are not repairable items. The most accurate and usually easiest checks for proper operation of individual

meters, indicators, or senders is direct replacement. The most common cause of failure is poor connections or damaged or improper wiring and not the meter indicator or sender. This section only has the replacement procedures. Before a meter, display panel, indicator, or sender is replaced, make the following checks:

1. Check that other meters and electrical circuits operate correctly.
2. Check that the battery is fully charged, has a good ground (diesel, gasoline and LPG units only), and the cable terminals are clean and tight.
3. Check that the wiring and connections to the meter, indicator, or sender are tight and in good condition.

*Legend for Figure 23*

- |   |  |
|---|--|
| <ol style="list-style-type: none"> <li>1. TOP COVER</li> <li>2. FILTER FOR LED INDICATORS</li> <li>3. HOUSING FOR LED INDICATORS</li> <li>4. KEY SWITCH</li> <li>5. ASSEMBLY HOUSING</li> <li>6. O-RING GASKET</li> <li>7. BUZZER</li> <li>8. FIBER INSULATING WASHERS</li> </ol> | <ol style="list-style-type: none"> <li>9. CIRCUIT BOARD (LH) FOR BATTERY INDICATOR</li> <li>10. BATTERY INDICATOR</li> <li>11. JUMPER HARNESS</li> <li>12. HOURMETER</li> <li>13. GASKET FOR HOURMETER</li> <li>14. CIRCUIT BOARD FOR LED INDICATORS</li> <li>15. GASKET FOR LED INDICATORS</li> </ol> |
|---|--|

8. If necessary, install a new O-ring gasket. Carefully install the O-ring gasket in the groove of the top cover. Carefully install the top cover assembly over the LED indicators and assembly housing without damaging either the LED gasket or O-ring gasket. Make sure the O-ring gasket is still correctly aligned with the cover and housing before installing the screws. Install the eight screws that fasten the top cover to the panel housing and tighten them in a cross pattern.

**PERFORMANCE DISPLAY PANEL, REPLACE PARTS**

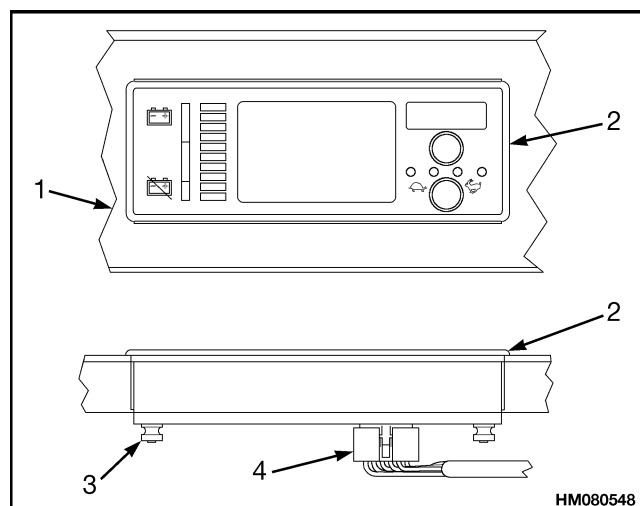
**NOTE:** The only replaceable parts of the Performance display panel are the O-ring seal, key switch, wires to the key switch, and the housing that fastens to the steering column. All other parts of the panel must be replaced as a single unit. See Display Panel Assembly, Replace of this section.

## Dash Mount Display Panel (EV100/200ZX Motor Controllers) Replacement

**REMOVE AND REPLACE**

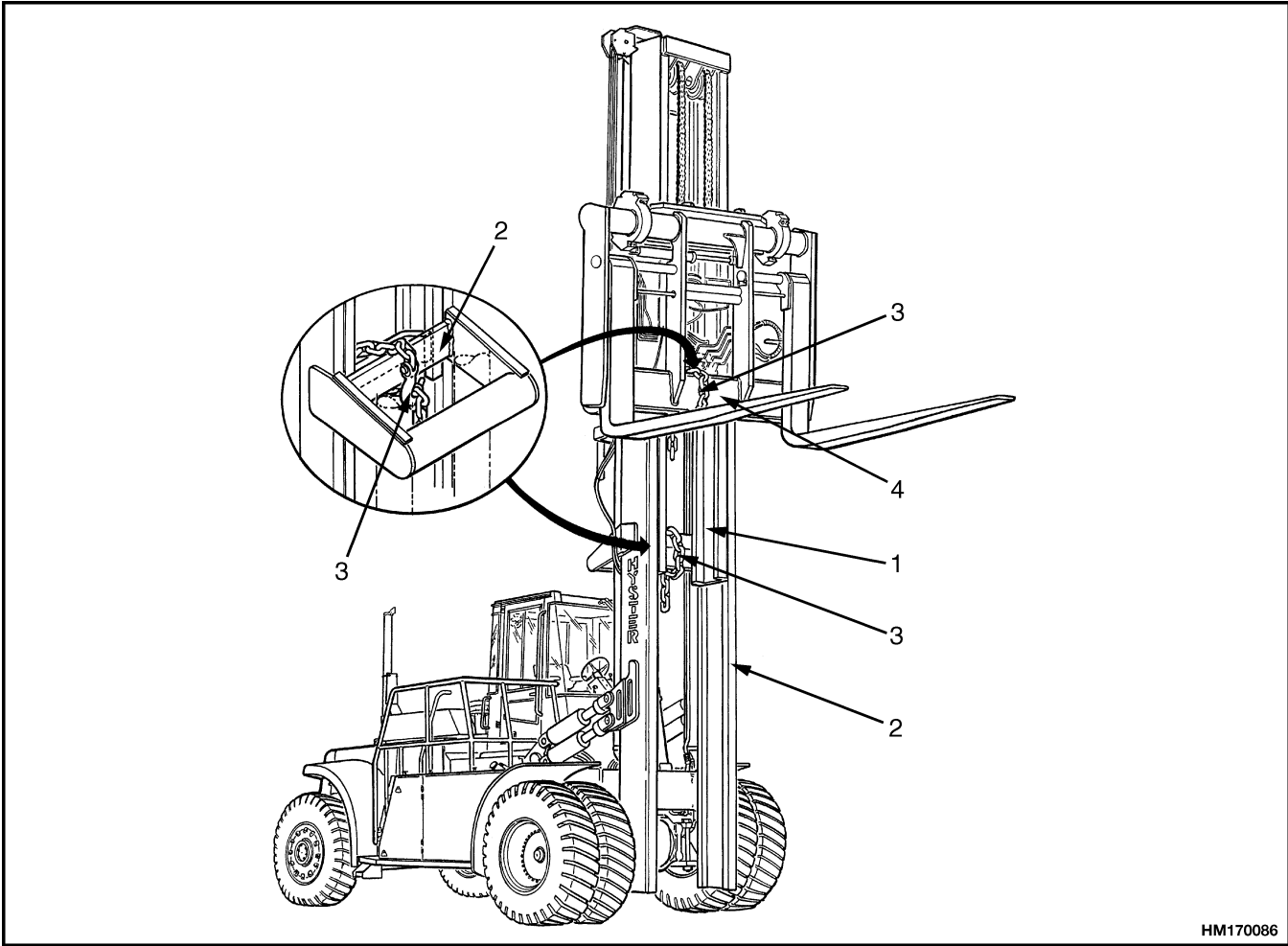
The display panel is in the dash. See Figure 24. The display panel cannot be repaired and must be replaced if it has a malfunction. These display panels must be replaced as a unit.

1. Disconnect the battery.
2. Disconnect the plug connector on the back of the display panel. Access is under the dash.
3. Remove the four nuts that fasten the display panel and lift it up out of the dash.
4. Install the replacement display panel in the dash.
5. Install and tighten the nuts that fasten the display panel in the dash and install the plug connector.



- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. DASH PANEL</li> <li>2. DISPLAY PANEL</li> <li>3. MOUNT NUTS</li> </ol> | <ol style="list-style-type: none"> <li>4. PLUG CONNECTOR</li> </ol> |
|--|---|

*Figure 24. Dash Mount Display Panels*



HM170086

- 1. INNER WELDMENT
- 2. OUTER WELDMENT

- 3. HOOK
- 4. CARRIAGE

**Figure 1. Mast**

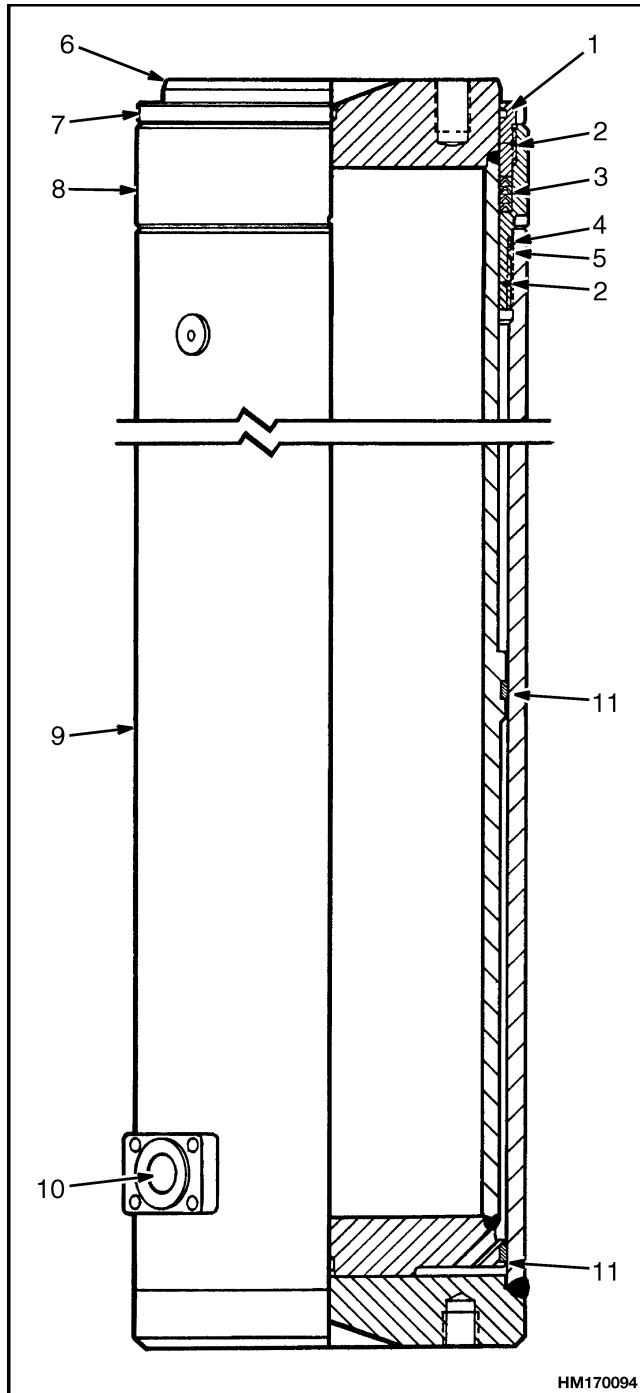


Figure 10. Displacement Cylinders

**Legend for Figure 10**

**NOTE:** OIL LEAKAGE IS NOT CONTROLLED BY THE TORQUE ON THE PACKING GLAND. TIGHTEN THE PACKING RETAINER TO STOP OIL LEAKS. REPLACE CHEVRON-STYLE PACKING WHEN PACKING RETAINER CANNOT COMPRESS PACKING FURTHER TO CONTROL OIL LEAKS. DO NOT TIGHTEN MORE THAN NECESSARY TO STOP OIL LEAKS.

- |                          |                           |
|--------------------------|---------------------------|
| 1. WIPER                 | 7. PACKING RETAINER       |
| 2. NYLON RING            | 8. PACKING GLAND          |
| 3. CHEVRON-STYLE PACKING | 9. CYLINDER SHELL         |
| 4. BACKUP RING           | 10. INLET AND OUTLET PORT |
| 5. O-RING                | 11. WEAR RING             |
| 6. ROD HEAD              |                           |

**CYLINDERS (TWO-SPEED)**

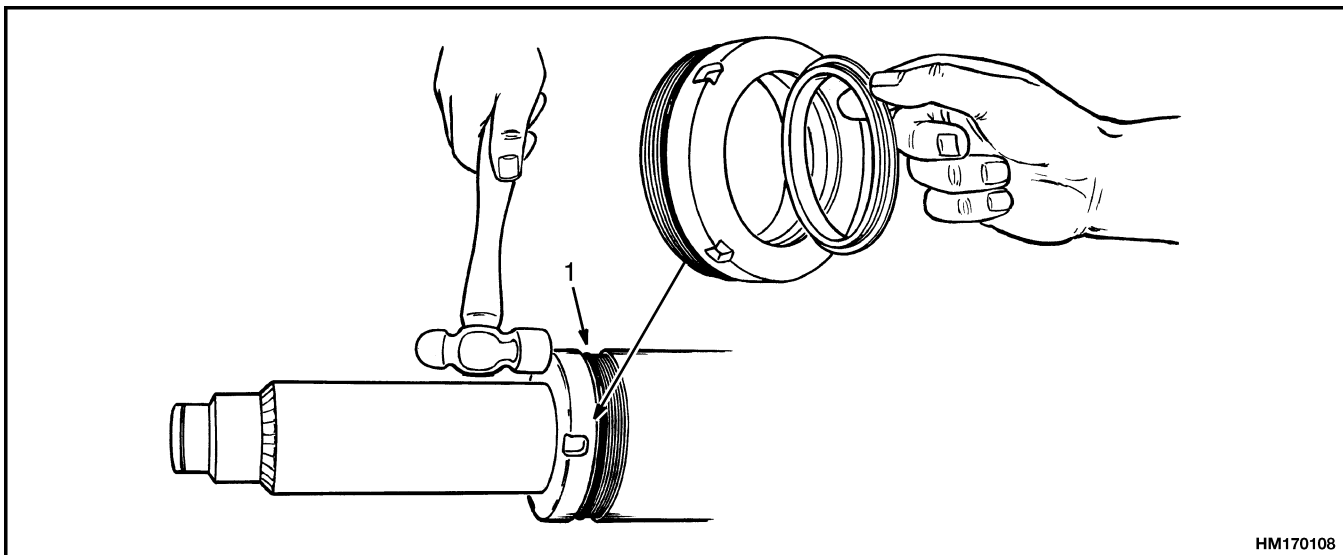
Two-speed lift cylinders are single-stage lift cylinders with a special valve and path for the hydraulic oil. The lift cylinder is filled with oil on both sides of the piston. For loads less than 45% of the rated capacity, the cylinder rod can be extended at high speed. When the cylinder rod extends, the oil on the rod side of the piston transfers to the bottom of the piston. When the oil transfers, the increase almost doubles the flow of oil to the base of the cylinder. The pump pressure is applied to both sides of the piston. The area on the bottom of the piston is greater than the rod side of the piston. The difference in force pushes the piston up the cylinder. See Figure 11.

For loads greater than 45% of capacity, the cylinder rod extends at normal speed. A special valve senses the increased oil pressure caused by the load. The oil is returned from the rod side of the lift cylinder to the hydraulic tank. All of the pump pressure is applied to the bottom side of the piston. The cylinder rod extends at a slower speed, but can lift a greater load. The two-speed lifting system is used only with standard masts. A two-speed lift system is used on the following lift trucks:

S60-80B	H150-250E
S125-150A	H150-275H
H60-80C	H250-300A
H300-350B	P125-180A
H110-150F	P150-200B

**STEP 4.**

Install a new wiper ring and spring on the retainer. Install the retainer against the packing gland nut. Lightly hit the retainer to move against the internal threads in the cylinder shell. Use a spanner to tighten the retainer.



1. O-RING

## Lift Cylinders for VISTA® Masts

### DESCRIPTION

All lift cylinders for Vista® masts are single-action hydraulic cylinders. The hydraulic force is applied only in one direction. When hydraulic oil enters one end of the lift cylinder, the hydraulic force extends the piston rod. When the force is removed, the weight of the carriage and inner mast causes the piston rod to retract.

The most common maintenance problem is the repair of oil leaks. If the bore of the shell of the lift cylinder is damaged and cannot be repaired, the lift cylinder must be replaced.

VISTA® two-stage, three-stage, and four-stage masts have two main lift cylinders. The free-lift mast has two main lift cylinders and a shorter free-lift cylinder. See Figure 17 and Figure 18.

Spacers are used in some cylinders to limit the stroke of the piston rod. Worn spacers must be replaced with the same size spacer.

The free-lift cylinder has a single-lip seal on the piston to prevent hydraulic oil leaks past the piston and

retainer. The piston rod is a smaller diameter than the piston.

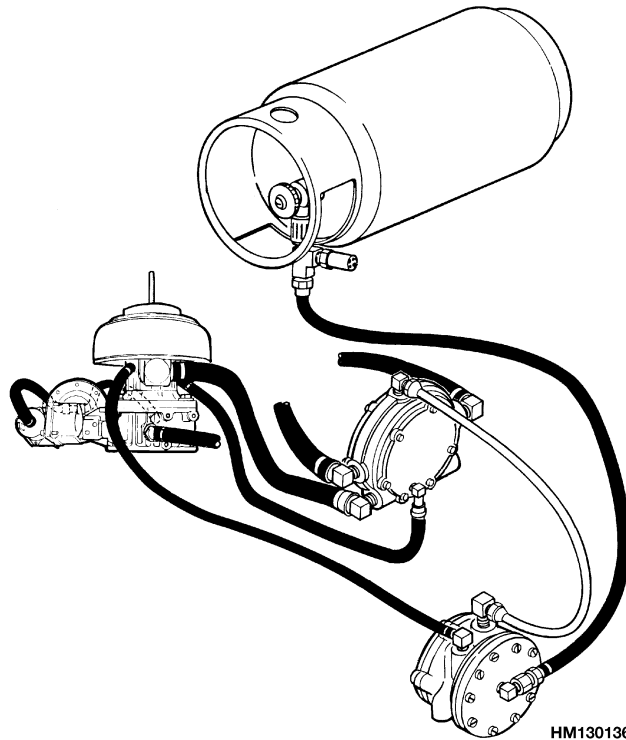
During operation, some hydraulic oil will leak past the piston area to the rod end of the lift cylinder. Small leaks are permitted if the internal leak rate of the hydraulic system is not greater than the specification. An internal check valve is installed in the piston of the free-lift cylinders. When the piston rod extends, the pressure increases more quickly on any oil in the rod end of the lift cylinder. The hydraulic oil transfers through the check valve to the piston end of the free-lift cylinder. This action prevents hydraulic damage to the single lip seal and the wiper ring. See Figure 19.

### Lowering Control Valve

A lowering control valve is installed in the hydraulic line to the bases of the lift cylinders. See Figure 20. The lowering control valve permits easy entry of hydraulic oil into the cylinders, but gives a restriction when the rods retract. This restriction controls the

# LPG FUEL SYSTEM

H3.50-5.00XL (H70-110XL) [G005];  
H6.00-7.00XL (H135-155XL) [F006];  
S3.50-5.50XL (S70-120XL) [D004];  
S6.00-7.00XL (S135-155XL) [B024];  
S3.50-5.50XM (S70-120XM) [E004]



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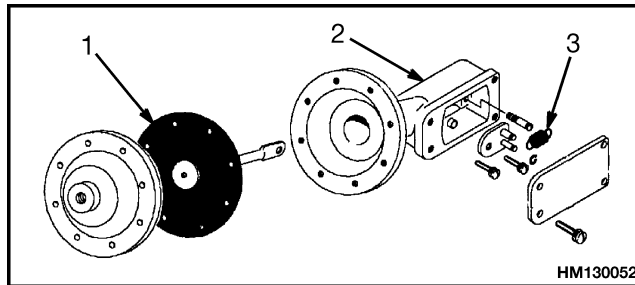
# **HYSTER**

### GOVERNOR

The governor is installed between the carburetor and the intake manifold. See Figure 10 and Figure 11. The solenoid valve is installed to the body of the governor. The governor controller is on the cowl in the operator's compartment. Vacuum lines connect the diaphragm of the governor to the solenoid valve and the throttle body of the governor. The governor controller is electrically connected to the solenoid valve and the ignition distributor.

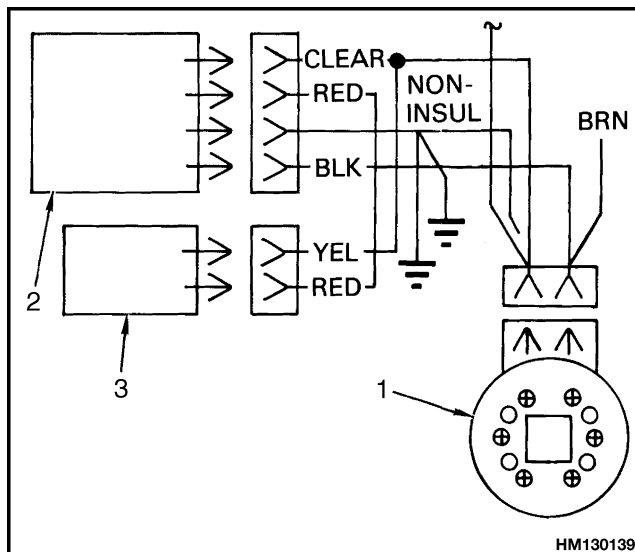
The operation of the governor is controlled by an electronic controller. Manifold vacuum provides the force to actuate the governor while the controller regulates this force. The governor has two throttle plates that are connected to a diaphragm. Linkage from the diaphragm closes the throttle plates. A spring in the governor opens the throttle plates.

The electronic controller is connected to the distributor and controls the operation of the solenoid valve. The solenoid valve controls the vacuum at the diaphragm in the governor. When the solenoid valve is not energized, it is open and manifold vacuum does not affect the governor. During operation, the electronic controller receives engine speed (rpm) signals from the distributor. The controller compares these signals with an internal reference in the circuit for the controller. When the engine speed signal is more than the internal reference, current flows to the solenoid valve. The solenoid valve closes, causing manifold vacuum to operate the diaphragm. When actuated, the diaphragm works against the governor spring to close the throttle plates and decrease engine speed. The solenoid valve opens and closes as necessary to keep the engine speed within the governor limits.



- 1. DIAPHRAGM ASSEMBLY
- 2. GOVERNOR BODY
- 3. CONTROL SPRING

Figure 10. Governor

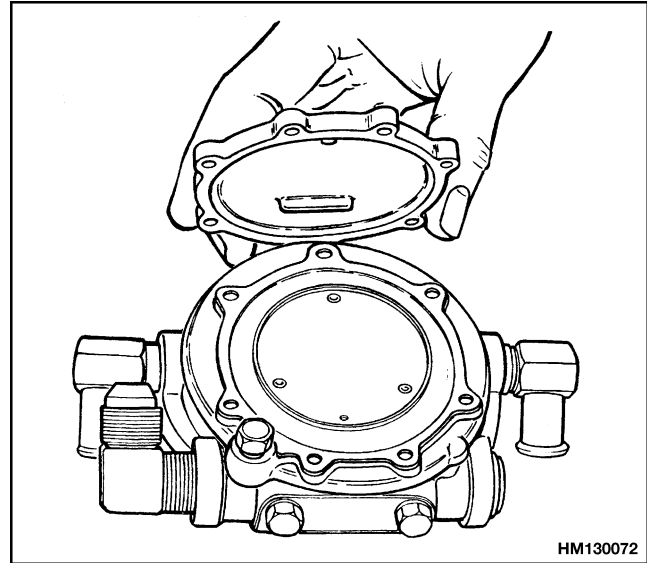


- 1. DISTRIBUTOR
- 2. GOVERNOR CONTROLLER
- 3. SOLENOID VALVE

Figure 11. Governor Circuit

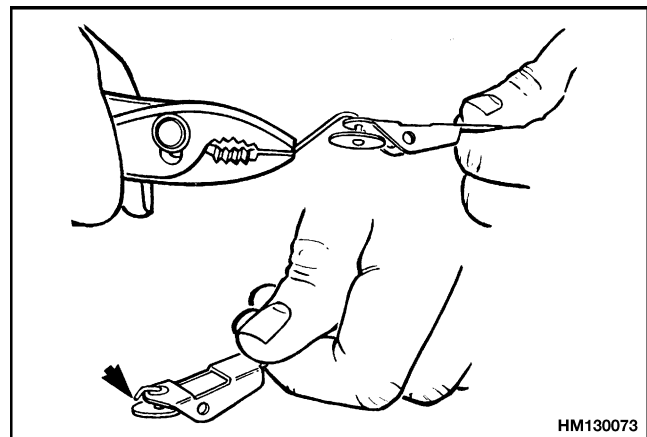
**STEP 5.**

Install the cover. Tighten screws to 2.4 N•m (21 lbf in).



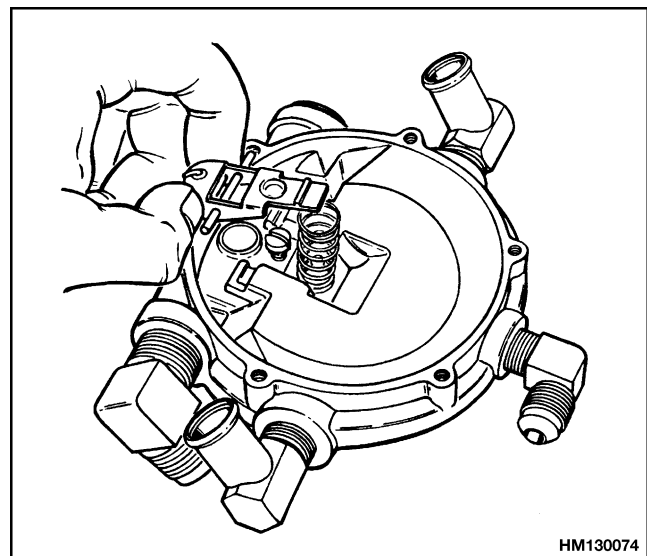
**STEP 6.**

Remove vapor valve pad from valve lever. Install a new valve pad in the lever. Leave pad loose enough against lever so that pad can tilt for alignment against the seat. Bend and cut the pin shown.



**STEP 7.**

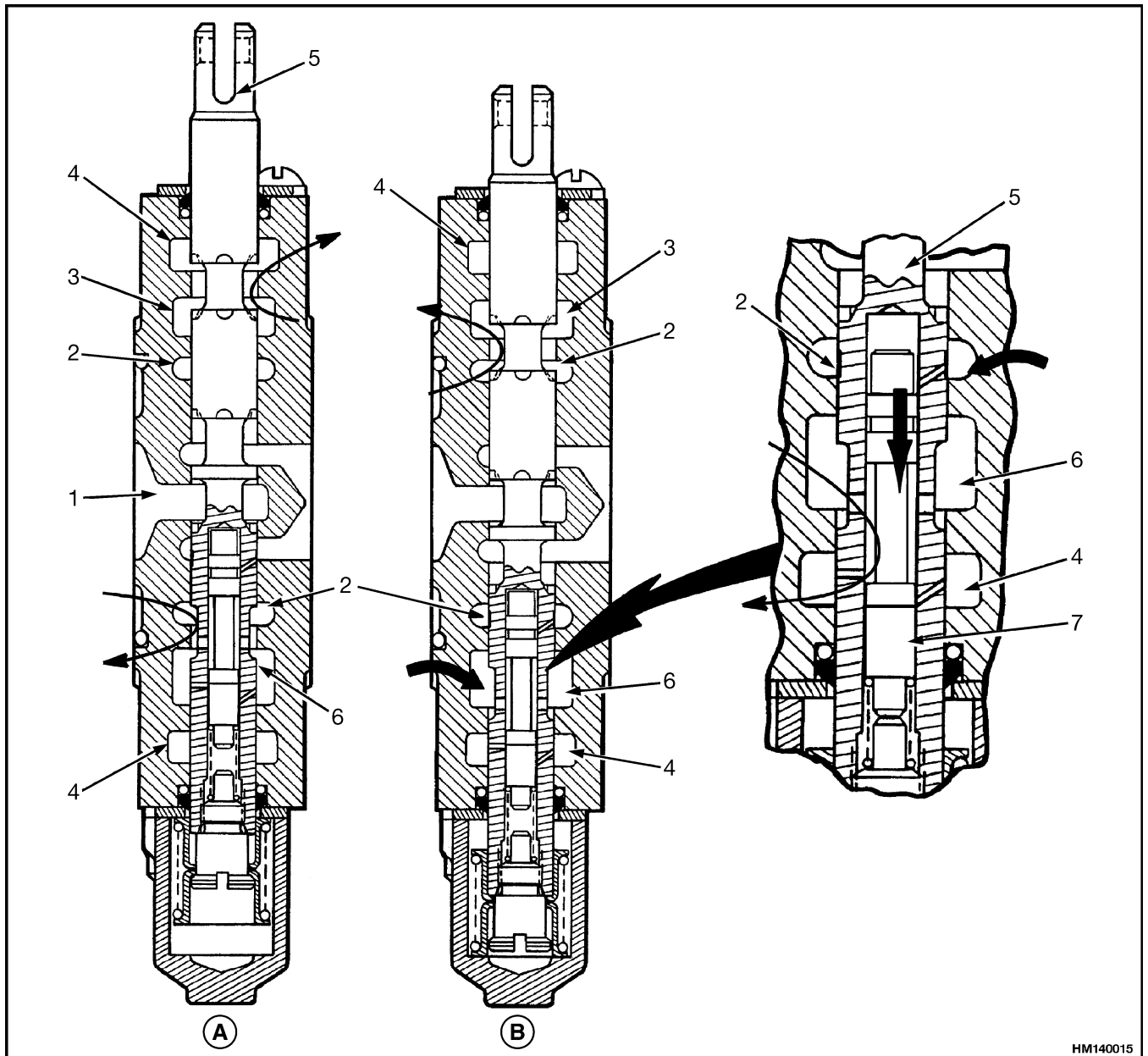
Put valve spring in position on housing. Put lever assembly over spring. Install screw so that head of screw is holding the pivot pin.



PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
Engine does not idle smoothly. (Cont.)	Fuel valve on the tank is in the wrong port.	Install fuel valve in the correct port.
	Idle control actuator is not adjusted correctly or the vacuum hose is disconnected.	Connect vacuum hose. Adjust the idle control actuator.
Loss of power.	Air filter is dirty.	Check air restriction indicator. Clean or install new filter element.
	PCV system has a restriction.	Remove restriction. Install new PCV valve.
	Governor is damaged.	Install new governor.
	Power mixture valve is not adjusted correctly.	Adjust power mixture valve.
	Hose from vaporizer to carburetor has leaks.	Repair leak or install new hose.
	Diaphragm in carburetor is damaged.	Install new diaphragm.
	Wrong type of fuel.	Clear system of wrong fuel. Fill tank with correct fuel.
	Hose from vaporizer to carburetor has a restriction or is too small.	Remove restriction or install new or larger hose.
	Vaporizer is damaged.	Repair or install new vaporizer.
Engine stops running.	Valve on fuel tank is closed.	Open fuel valve at the tank.
	Fuel tank is empty.	Install tank that has fuel.
	Hose from fuel tank is too close to the exhaust pipe.	Locate new hose away from heat source.
	Vacuum line to filter unit is disconnected.	Connect vacuum line.
	Filter unit is damaged.	Install new filter unit.
	Vaporizer is damaged.	Repair or install new vaporizer.
	Carburetor is damaged.	Install new carburetor.
	Hose to carburetor is damaged.	Install new hose.

flows from the supply cavity through a section of the spool to the rod side of the tilt cylinders. The check valve prevents the movement of the load until the

system pressure is great enough to control the load. Oil from the piston end of the tilt cylinders returns through the main control valve to the hydraulic tank.



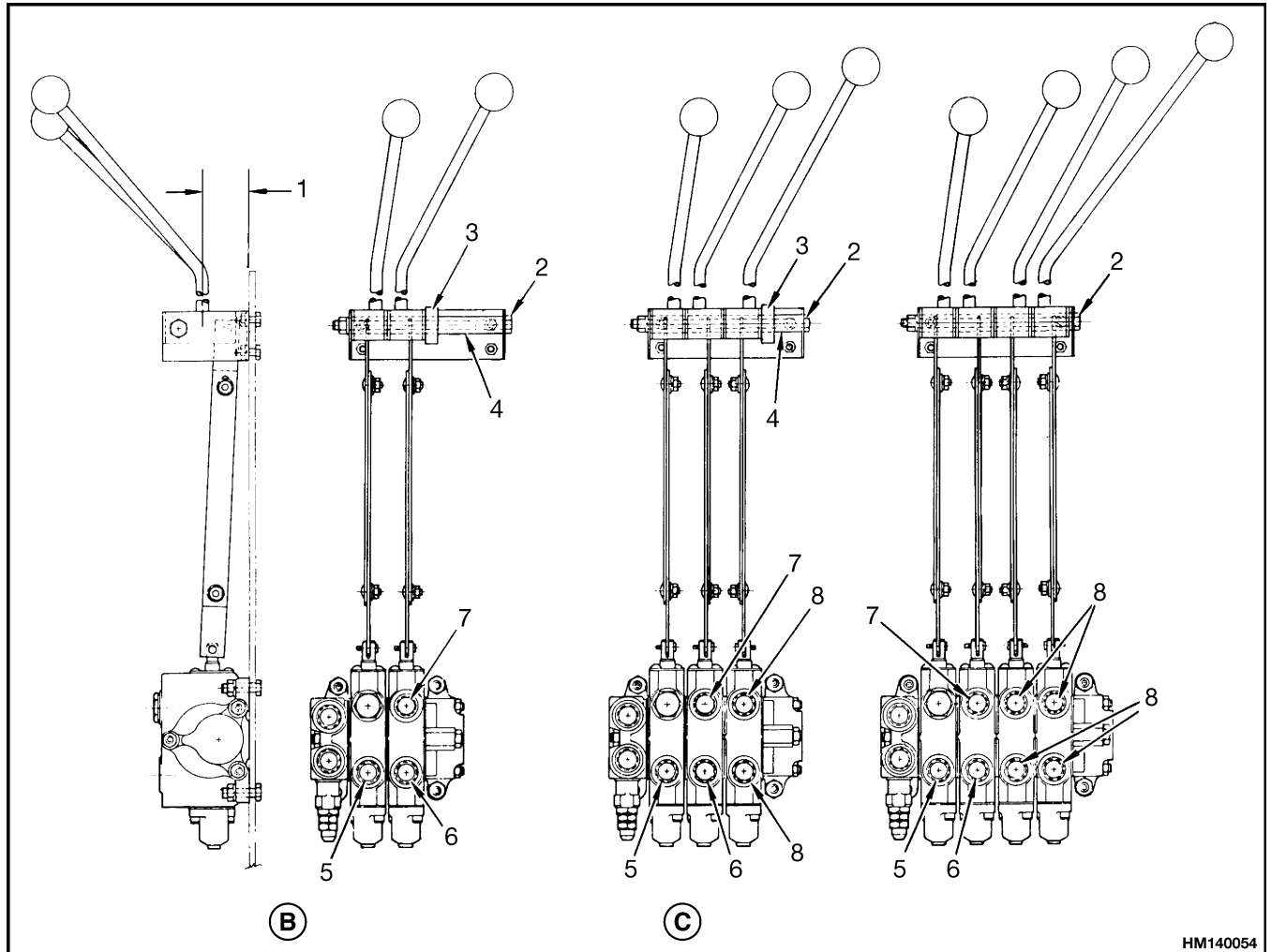
**A. TILT BACKWARD**

- 1. OPEN CENTER PASSAGE
- 2. SUPPLY CAVITY
- 3. TO/FROM PISTON END OF TILT CYLINDERS
- 4. DRAIN CAVITY

**B. TILT FORWARD**

- 5. TILT SPOOL
- 6. TO/FROM ROD END OF TILT CYLINDERS
- 7. TILT CONTROL SPOOL

**Figure 4. Tilt Spool Operation**



**NOTE:** AUXILIARY CONTROL LEVER MUST BE PUSHED TO THE RIGHT TO ENGAGE THE THIRD CONTROL VALVE SPOOL. WHEN RELEASED, THE CONTROL LEVER MUST RETURN TO THE LEFT.

**A.** ALL UNITS [EXCEPT EARLIER PRODUCTION H2.00-3.00XL (H40-60XL)]

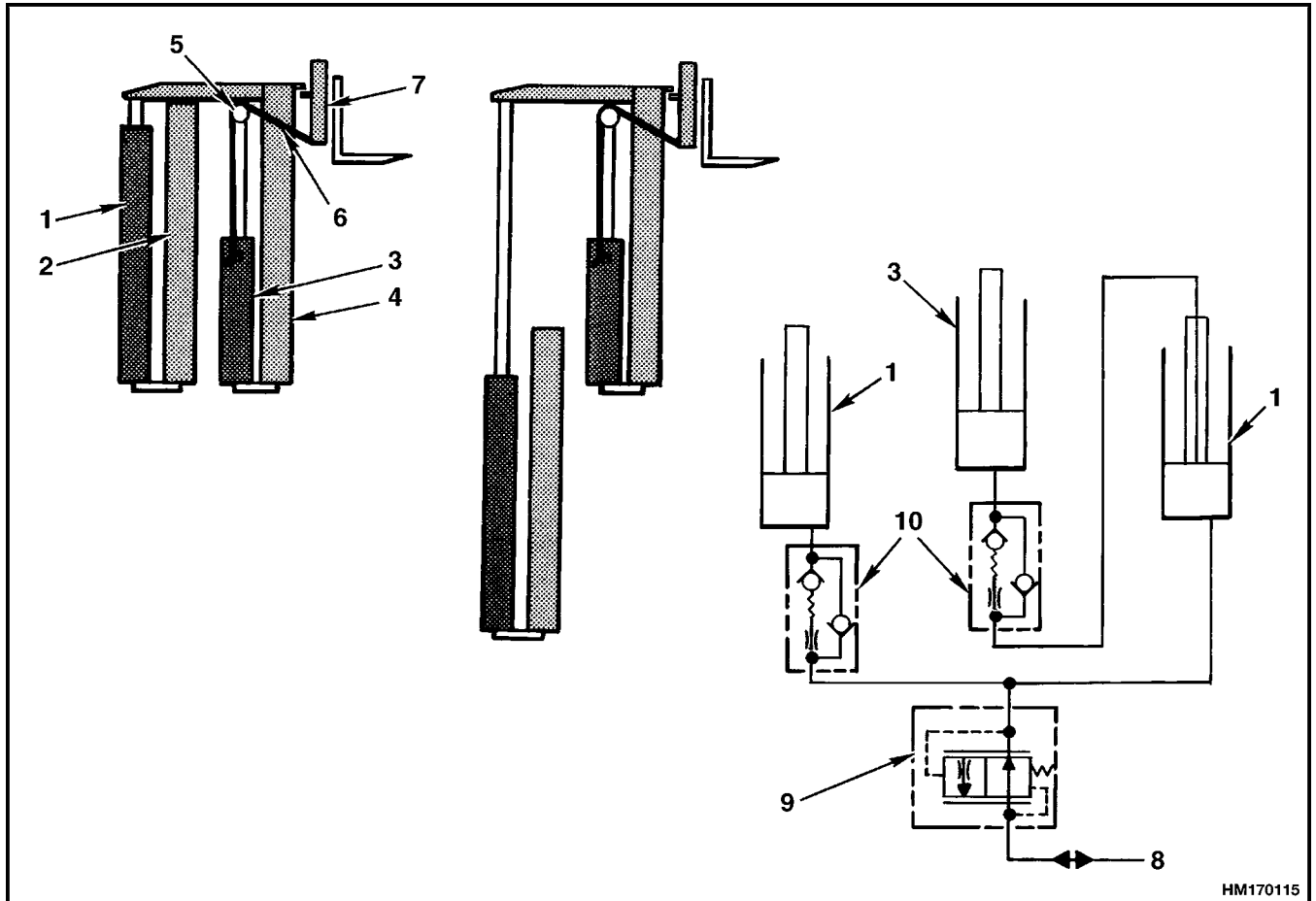
**B.** ALL UNITS

1. ADJUST LENGTH OF LINKAGE SO LEVERS ARE 51.5 mm (2.02 in.) FROM COWL IN NEUTRAL POSITION
2. CAPSCREW [TIGHTEN TO 19 N•m (14 lbf ft)]
3. COLLAR, TIGHTEN SETSCREW TO 7 N•m (62 lbf ft)
4. PIVOT SPACER
5. TO THE LIFT CYLINDER
6. TILT BACKWARD

**C.** EARLIER PRODUCTION H2.00-3.00XL (H40-60XL) UNITS

7. TILT FORWARD
8. AUXILIARY FUNCTION [FOR SIDESHIFT CARRIAGE: UPPER PORT IS "Y" = LEFT SIDESHIFT (LEVER FORWARD). LOWER PORT IS "X" = RIGHT SIDESHIFT (LEVER BACKWARD)]
9. AUXILIARY FUNCTION
10. CAPSCREW
11. SPACER

**Figure 9. Control Lever Arrangement (Sheet 2 of 2)**



1. MAIN LIFT CYLINDER (2)
2. OUTER WELDMENT
3. FREE-LIFT CYLINDER
4. INNER WELDMENT
5. CHAIN SHEAVE

6. LIFT CHAIN
7. CARRIAGE
8. FROM MAIN CONTROL VALVE
9. EXTERNAL LOWERING CONTROL VALVE
10. INTERNAL LOWERING CONTROL VALVE

**Figure 3. Two-Stage Mast With Full Free-Lift**

During lowering, the main lift cylinders lower first because they have a greater load. After the main lift cylinders have retracted, the free-lift cylinder lowers. All of the oil from the lift cylinders flows through the lowering control valves to the hydraulic tank.

### THREE-STAGE MAST WITH FULL FREE-LIFT

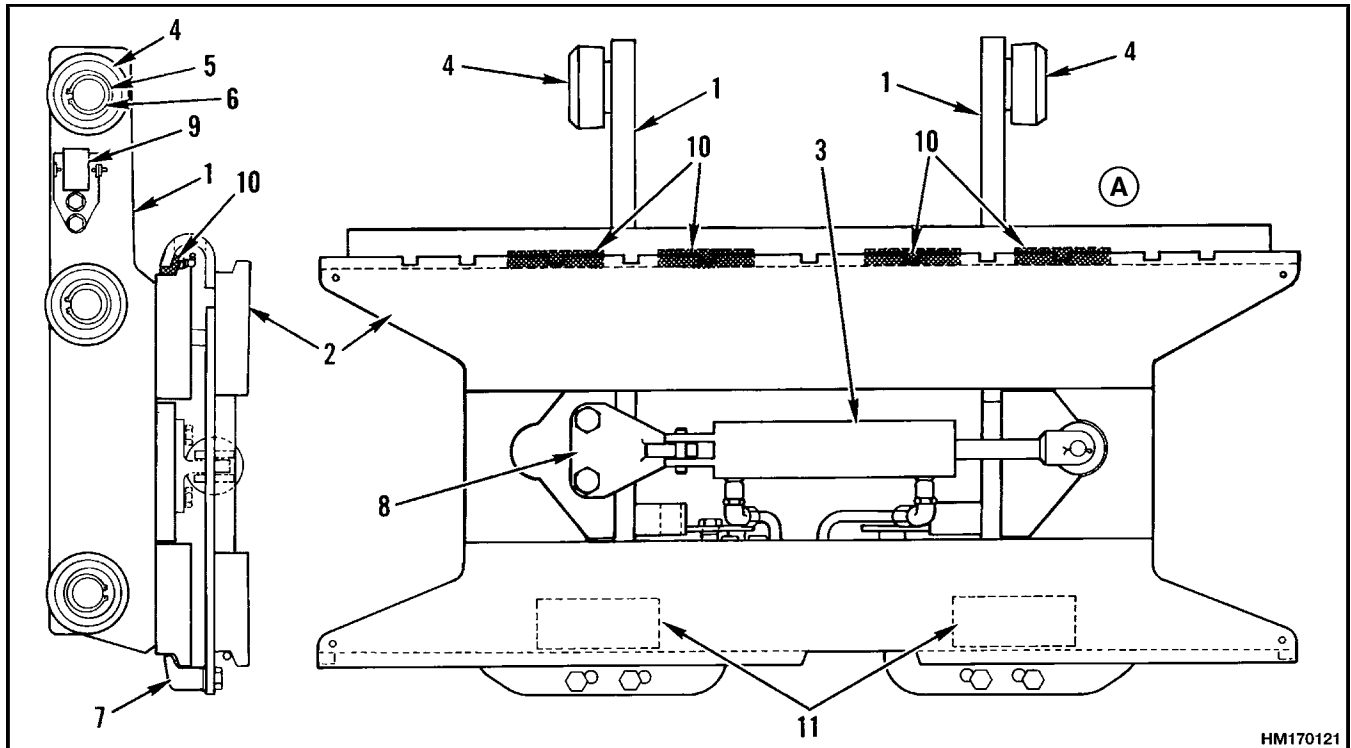
The Vista Three-Stage mast has an outer, an intermediate and an inner weldment. See Figure 4. Three single stage lift cylinders are used on the mast to raise the carriage and extend the weldments. The weldments are telescopic and have load roller and strip bearing arrangements similar to the two-stage

mast. The two main lift cylinders are installed at the back of the outer weldment. The base of each lift cylinder is held on a mount at the bottom of the outer weldment. The hydraulic fittings for the lift cylinders go through holes in the mounts. The top of each main lift cylinder (cylinder rod) fits into a guide at the top of the intermediate weldment. The free-lift cylinder is installed in the inner weldment.

The two main lift chains fasten at one end near the top of the outer weldment. The lift chains then go over sheaves at the top of the intermediate weldment and fasten at the bottom of the inner weldment. The free-lift chains are connected to a mount behind the free-lift cylinder. The chains then go over the sheaves and connect to the carriage.

*Legend for Figure 12*

- |                              |  |
|------------------------------|--|
| A. H3.50-4.00XL-5 (H70-80XL) | C. BACK OF CARRIAGE                              |
| B. FACE OF CARRIAGE          | D. H4.00XL-6, H4.50-5.00XL (H90-100XL)           |
| 1. CARRIAGE                  | 8. SIDE ROLLER                                   |
| 2. APRON                     | 9. CHAIN ANCHOR (FREE-LIFT AND THREE-STAGE MAST) |
| 3. SIDESHIFT CYLINDER        | 10. FORK PIN                                     |
| 4. LOAD ROLLER               | 11. SHIMS  |
| 5. GUIDE ROLLER              | 12. SNAP RING                                    |
| 6. THRUST ROLLER             | 13. BEARING SEGMENT                              |
| 7. KEEPER PLATE              |  |

**A. S/H3.50-4.50XL (S/H70-110XL)**

- |                       |                     |
|-----------------------|---------------------|
| 1. CARRIAGE           | 7. CARRIAGE HOOK    |
| 2. APRON              | 8. CYLINDER MOUNT   |
| 3. SIDESHIFT CYLINDER | 9. SIDE ROLLER      |
| 4. LOAD ROLLER        | 10. BEARING SEGMENT |
| 5. SHIMS              | 11. BEARING BLOCK   |
| 6. SNAP RING          |                     |

*Figure 13. Sideshift Carriages*

6. Install sideshift cylinder in carriage. Install anchor pins or nuts at both ends of the cylinder. After the nut at the apron is just tight, loosen nut 1/4 turn. Connect hydraulic lines to cylinders.
7. Install side rollers and load rollers on carriage. Tighten capscrews for side rollers to 65 N•m (50 lbf ft).

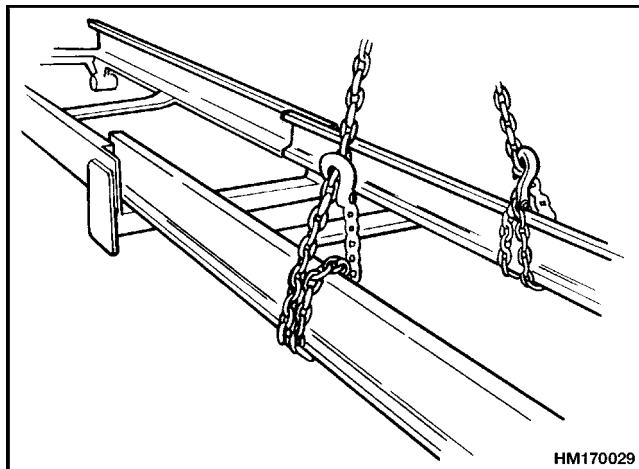
*Legend for Figure 20*

- |                   |  |   |
|-------------------|--|---|
| 1. OUTER WELDMENT | 9. SNAP RING                           | 16. MOUNT FOR H3.50-5.00XL<br>(H70-110XL)   |
| 2. INNER WELDMENT | 10. PIVOT PIN                          | 17. MOUNT FOR S/E3.50-5.50XL<br>(S70-120XL) |
| 3. LIFT CYLINDER  | 11. LIFT TRUCK FRAME                   | 18. HANGER CAP                              |
| 4. LIFT CHAIN     | 12. SPACER                             | 19. BEARING HALF                            |
| 5. CHAIN SHEAVE   | 13. EXTERNAL LOWERING<br>CONTROL VALVE |   |
| 6. CHAIN ANCHOR   | 14. FREE-LIFT CYLINDER                 |   |
| 7. LOAD ROLLER    | 15. STRIP BEARING                      |   |
| 8. SHIMS          |  |   |

- Slide inner weldment half-way out of top of outer weldment. Connect lifting device to center of inner weldment. See Figure 21. Slide inner weldment out of outer weldment until stub shafts are in notches of outer weldment. Remove inner weldment from outer weldment.
- Remove and disassemble chain sheaves as necessary for cleaning and repair.

**CLEAN AND INSPECT**

Clean and inspect parts of free-lift mast using the same procedures as described for two-stage mast.



*Figure 21. Inner Weldment*

**ASSEMBLE**

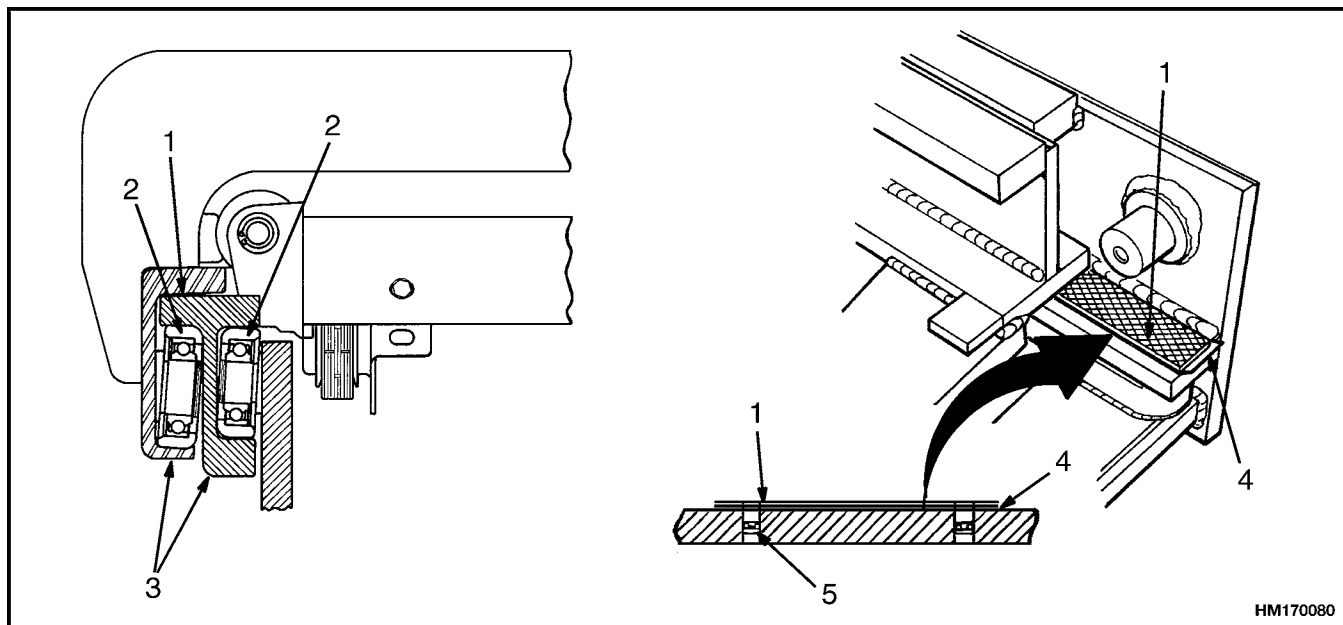
**NOTE:** The shims for the load rollers keep the weldments parallel and give correct clearance. During assembly, the location of the shims will be approximately the same as they were before disassembly.

Check clearance and adjust shims for wear or changes because of repairs. The strip bearings are also adjusted by using shims. See Mast Adjustments in this section for the instructions to make the necessary adjustments.

- Connect lifting device to center of inner weldment (see Figure 21). Put stub shafts through notches in outer weldment. Slide inner weldment into outer weldment so stub shafts are seen at top and bottom of weldments.
- Install strip bearings and shims on outer weldment. Apply grease to bearing surface. See Figure 19.
- Install load rollers and shims on both weldments. Check clearance of load rollers and strip bearings as described in Mast Adjustments and Carriage Adjustment.
- Install chain sheave assembly on free-lift cylinder. Install free-lift cylinder on inner weldment.
- Install lift cylinders. Make sure spacers, when installed, are in their original positions at the bottom mounts. Push inner weldment to engage rods of lift cylinders. Install washers and snap rings at top of lift cylinders. Install capscrews, spacers, and washers at lift cylinder mounts. Tighten capscrews at mounts to 53 N•m (40 lbf ft).
- Install lowering control valve on outer weldment. Connect hydraulic lines and fittings between lowering control valve, lift cylinders, and free-lift cylinder.
- Connect lift chains to chain anchors at mount on inner weldment. Attach wires between ends of lift chains and bottom crossmember to control lift chains during installation.

**INSTALL**

Install free-lift mast using the same procedures described for the two-stage mast. See Figure 20. See header hoses arrangement in Figure 24.



1. STRIP BEARING
2. LOAD ROLLER
3. WELDMENTS

4. SHIMS
5. O-RING

*Figure 29. Strip Bearings Adjustment*

## Carriage Adjustment

1. Install the load rollers and side rollers on the carriage. Install the shims for the load rollers in the same sequence on the stub shaft as before disassembly. Do not put any shims under the top load rollers. See Figure 28.
2. Use a lifting device to raise the carriage up the inner weldment. Find the point of tightest fit between the load rollers and the inner weldment.
3. Remove the carriage from the mast. Adjust the shim arrangement for each load roller for clearance between the roller and the inner weldment. Maximum clearance is 0.8 mm (0.030 in.) at the point of tightest fit. Repeat Step 2 and Step 3 if necessary.
4. Install the shims for the side rollers. Use a lifting device to raise the carriage up the inner weldment. Find the point of tightest fit between the

side rollers and the inner weldment. Adjust the shim arrangement under each side roller so that maximum clearance is 0.8 mm (0.030 in.) at the point of tightest fit.

5. Keep the shim arrangement on each side of the carriage approximately equal. The carriage must be parallel with the inner weldment within 1.5 mm (0.060 in.).

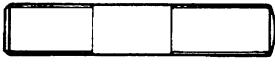
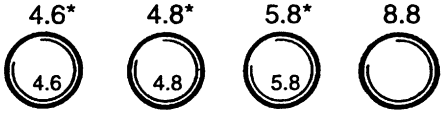


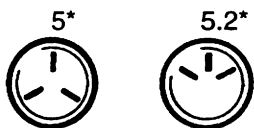


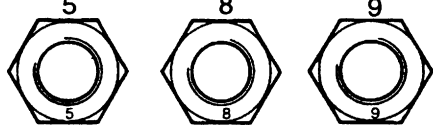
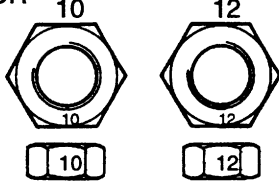
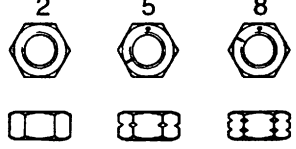
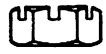
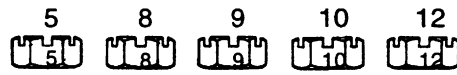

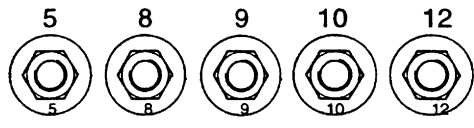


### CAUTION

**Too much grease will cause the rollers to slide and wear flat areas on the rollers.**

6. After adjustment, lubricate the channels with a thin layer of grease.

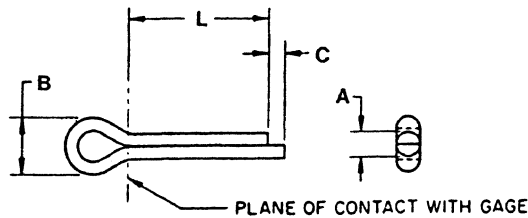
Table 2. Studs and Nuts

TYPE OF FASTENER	METRIC FASTENERS STRENGTH LEVELS: PROPERTY CLASS * MARKINGS NOT REQUIRED	INCH FASTENERS STRENGTH LEVELS: SAE GRADES * MARKINGS NOT REQUIRED
 <p>STUDS</p>	<p>4.6*    4.8*    5.8*    8.8</p>  <p>9.8    10.9    12.9</p>  <p>MARKINGS FOR SIZE M5 AND LARGER</p> <p>OR</p>  <p>OPTIONAL GEOMETRIC SYMBOLS FOR SIZES M5 THRU M11 ONLY.</p>	<p>5*    5.2*</p>  <p>8*    8.1</p> 
 <p>HEX NUTS</p>	<p>5    8    9</p>  <p>OR</p> <p>10    12</p> 	<p>OR</p> <p>2    5    8</p> 
 <p>HEX SLOTTED NUTS</p>	<p>5    8    9    10    12</p> 	<p>MARKINGS NOT REQUIRED</p>
 <p>HEX FLANGE NUTS</p>	<p>5    8    9    10    12</p> 	<p>MARKINGS NOT REQUIRED</p>

HM210067

*Table 11. Cotter Pin Dimensional Data*

Nominal Length L	Length Range		Nominal Size - Part Numbers	
	max	min	13.0 mm (0.500 in.)	16.00 mm (0.625 in.)
19.05 mm (0.750 in.)	20.5 mm (0.807 in.)	18.3 mm (0.720 in.)		
25.4 mm (1.00 in.)	26.9 mm (1.060 in.)	23.9 mm (0.940 in.)		
31.75 mm (1.250 in.)	33.3 mm (1.310 in.)	29.2 mm (1.150 in.)		
38.1 mm (1.500 in.)	40.9 mm (1.610 in.)	36.6 mm (1.440 in.)		
44.45 mm (1.750 in.)	46.0 mm (1.810 in.)	42.9 mm (1.690 in.)	0221889	
50.8 mm (2.000 in.)	52.3 mm (2.060 in.)	49.3 mm (1.940 in.)	0221890	
57.15 mm (2.250 in.)	58.7 mm (2.310 in.)	55.1 mm (2.170 in.)	0221891	
63.5 mm (2.500 in.)	65.0 mm (2.560 in.)	62.0 mm (2.440 in.)	0221892	
69.85 mm (2.750 in.)	72.1 mm (2.840 in.)	68.3 mm (2.690 in.)	0221893	0221895
76.2 mm (3.000 in.)	81.3 mm (3.200 in.)	74.7 mm (2.940 in.)	0015291	0221896
88.9 mm (3.500 in.)	91.4 mm (3.600 in.)	87.4 mm (3.440 in.)	0015292	0221897
101.6 mm (4.000 in.)	113.3 mm (4.460 in.)	98.8 mm (3.890 in.)	0015293	0221898



EXTENDED PRONG

HM211587

The MSTS module must always know the speed at which the engine is operating. The engine speed signal is generated by the ignition module. The signal converter in the ignition module changes the signal voltage from the sensing coil to a square wave reference signal to the MSTS module. This square wave reference signal for engine speed is called REF HI. The MSTS module must also have a reference to compare with REF HI. An additional wire between the MSTS module and the ignition module is called REF LO. The REF HI and REF LO connections give the EEPROM in the MSTS module the necessary information about engine speed.

The other two wires between the MSTS module and the distributor control the Electronic Spark Timing and are called EST and BYPASS.

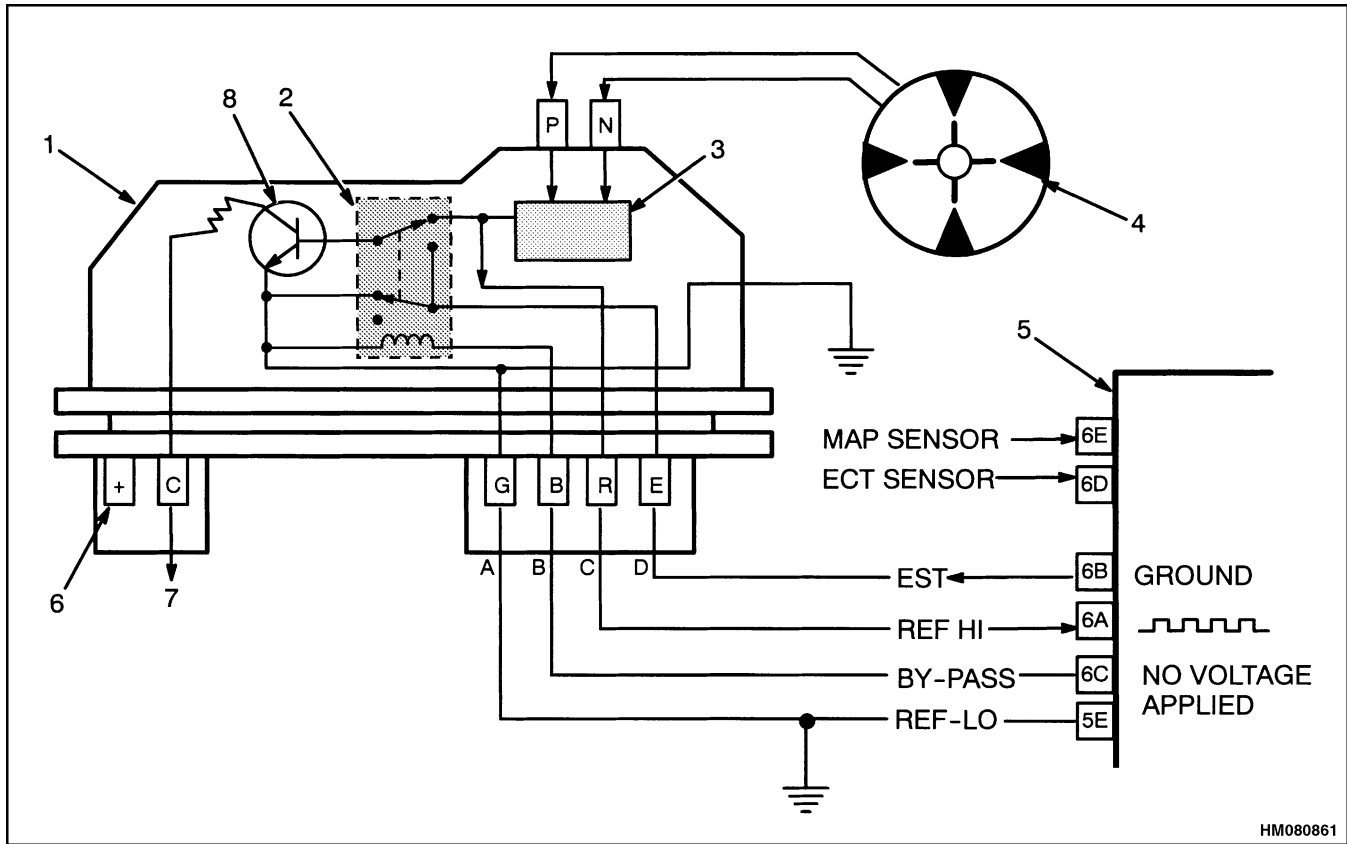
**NOTE:** The ignition module controls spark timing only when the engine is being started. The MSTS module controls the spark timing during engine operation. The ignition module will also control the spark timing if there are some failures in the signals to the MSTS module. This backup mode of operation will often permit operation of the engine so that the lift

truck can be moved to an area for repair. The results of the failures in signals to the MSTS module is described in the paragraphs under MSTS Module Corrections.

### WHEN ENGINE IS BEING STARTED

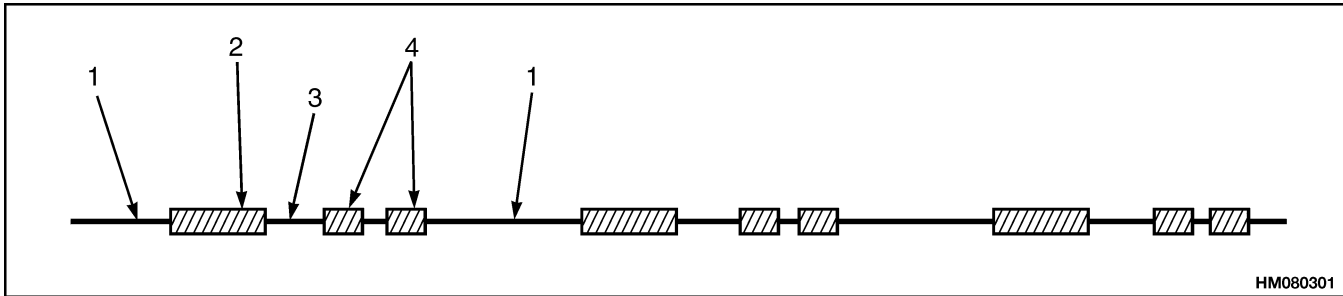
When the engine is rotated by the starter, the electronic relay is in the deenergized position. See Figure 5. The sensing coil is connected through the square wave generator to the base of the transistor.

When the sensing coil applies a positive voltage (the square wave voltage is increasing) to the transistor, the transistor goes **ON**. When the voltage from the sensing coil changes to negative (the square wave voltage is decreasing), the transistor goes **OFF**. When the transistor is **ON**, current flows through the primary winding of the ignition coil. When the transistor goes **OFF**, the current flow through the primary winding stops. The changing magnetic field in the primary winding generates a high voltage in the secondary winding of the ignition coil. This high voltage generates a spark at the spark plug.



HM080861

Figure 5. Ignition Module When Engine is Being Started



1. LONG PAUSE                      2. FLASH                      3. PAUSE                      4. FLASH-FLASH

*Figure 12. Diagnostic Trouble Code-12 Example*

**Clearing Diagnostic Trouble Codes (DTC's)**

To clear the stored Diagnostic Trouble Codes from the MSTs, do the following.

1. Install the CodeMate Tester into the diagnostic connector. See the preceding section Connecting CodeMate Tester.
2. Turn the ignition key to **ON**, but do not start the engine.
3. Place the CodeMate test switch to the **ON** position.
4. Turn the ignition switch to **OFF** for five seconds.
5. Turn the ignition switch to **ON** and verify that DTC-12 is the only code in the MSTs memory.
6. When testing is complete, place the CodeMate test switch to **OFF**, turn the ignition key to **OFF**, and disconnect the CodeMate Tester from the diagnostic connector.
7. Secure the diagnostic connector to the MSTs bracket.

**ON-BOARD DIAGNOSTIC (OBD) SYSTEM CHECK**

The On-Board Diagnostic (OBD) System Check is a troubleshooting method to find a problem caused by a malfunction in the electronic engine control system. It must be the starting point for any troubleshooting. See Figure 13.

The data shown in Table 1 can be used for comparison after doing the troubleshooting checks and finding the on-board diagnostics working correctly with

no trouble codes shown. The data are an average of display values from normally operating vehicles and show a display of a normally operating system.

After the visual/physical inspection, the On-Board Diagnostic (OBD) System Check is the starting point for all troubleshooting procedures.

The correct procedure to find a problem is to follow two basic steps.

1. Are the On-Board Diagnostics working? This is determined by doing the OBD System Check. Since this is the starting point for the troubleshooting procedures, always begin here.
2. Is there a Diagnostic Trouble Code? If there is a DTC, go directly to the flowchart for that DTC number. This determines if the fault is still there.

**Test Description**

The numbers below are a reference to the numbers in bold in Figure 13.

1. The MIL should be **ON** steady with the ignition **ON** and the engine **OFF**. To isolate the malfunction if the MIL does not light, refer to Figure 15.
2. Diagnostic Trouble Code (DTC) 12 means no rpm reference pulses from the ignition module. This is correct when engine is not running.
3. For list of valid DTC's, refer to the MSTs Diagnostic Trouble Codes, Table 3. An invalid DTC may be the result of a faulty MSTs.
4. If the engine does not start, refer to the troubleshooting diagram (Figure 18).

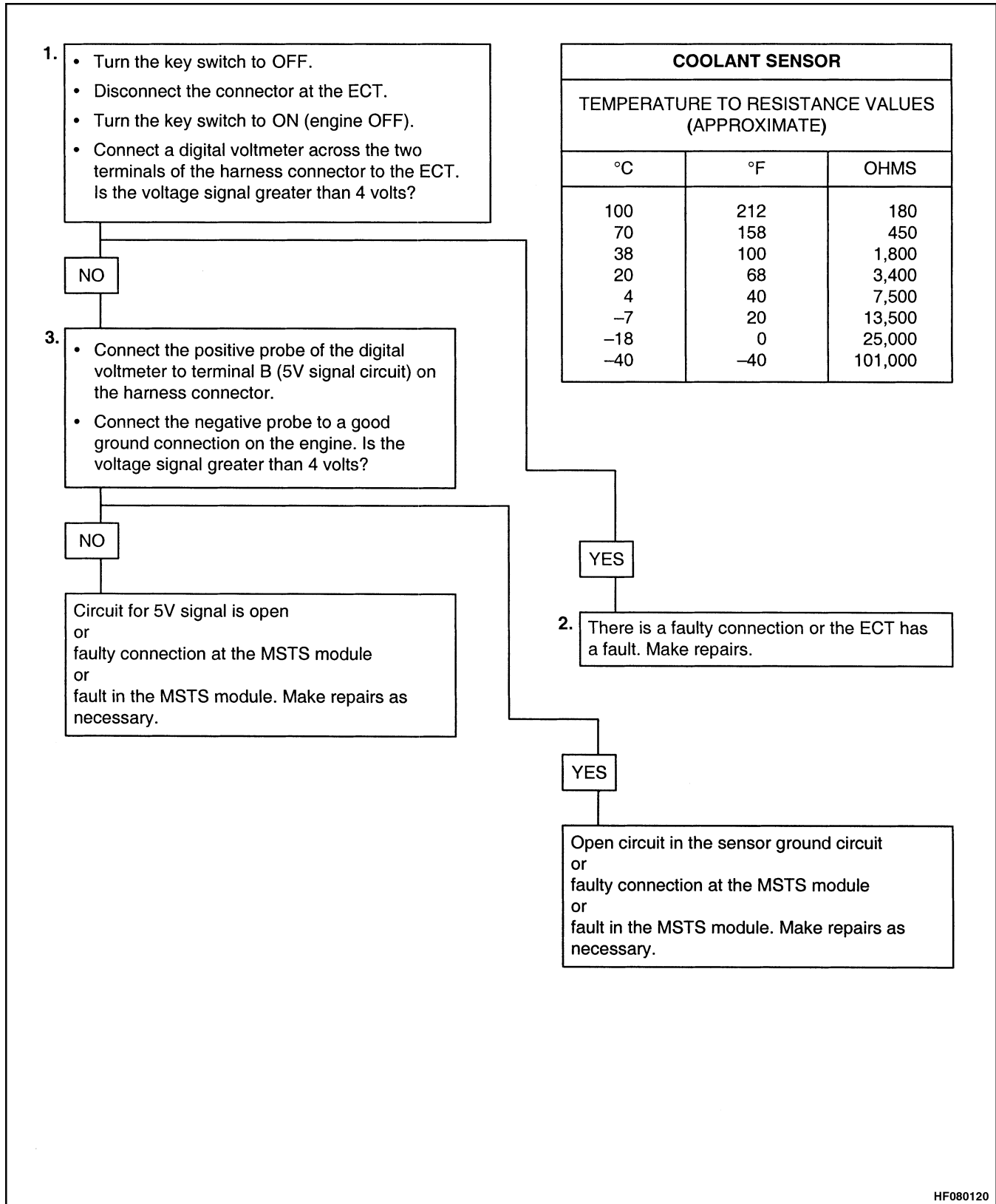


Figure 21. ECT Sensor Troubleshooting Diagram (Low Temperature)

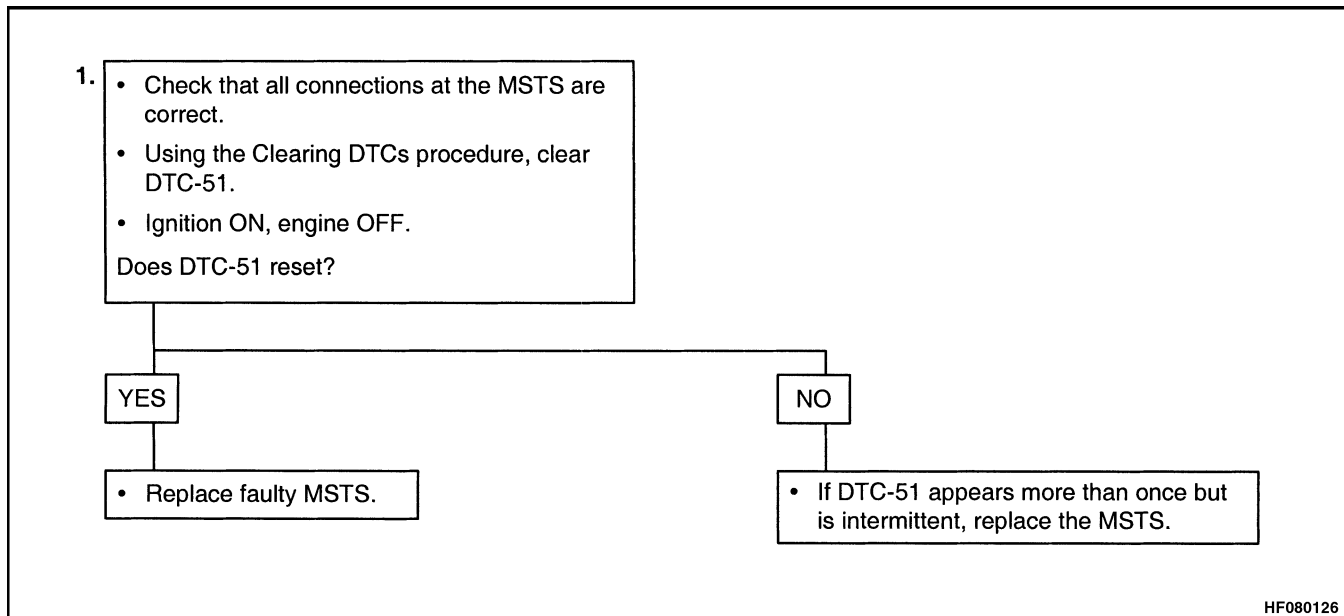
## DTC-51 MSTS Failure

### CIRCUIT DESCRIPTION

The Electronic Control Module (MSTS) does an internal check. If the internal check fails, the MSTS sets DTC 51.

The number below is a reference to the number in bold in Figure 30.

1. This step checks the MSTS. If a Code-51 is set and all connections are correct, replace the MSTS.



*Figure 30. MSTS Failure*

## Distributor Repair

A distributor with a separate ignition coil is used on all MSTS engines. The ignition coil is connected to the rotor in the distributor through a high-voltage wire. The operation of the ignition module and the magnetic pulse generator is described under Operation at the beginning of this section.

When the current in the primary circuit of the ignition coil quickly decreases, the induction in the secondary circuit sends a high voltage pulse (35,000 volts) to the rotor in the distributor. The rotor is aligned with one of the leads to a spark plug wire and this high voltage pulse is sent to one of the spark plugs.

### REMOVE



### CAUTION

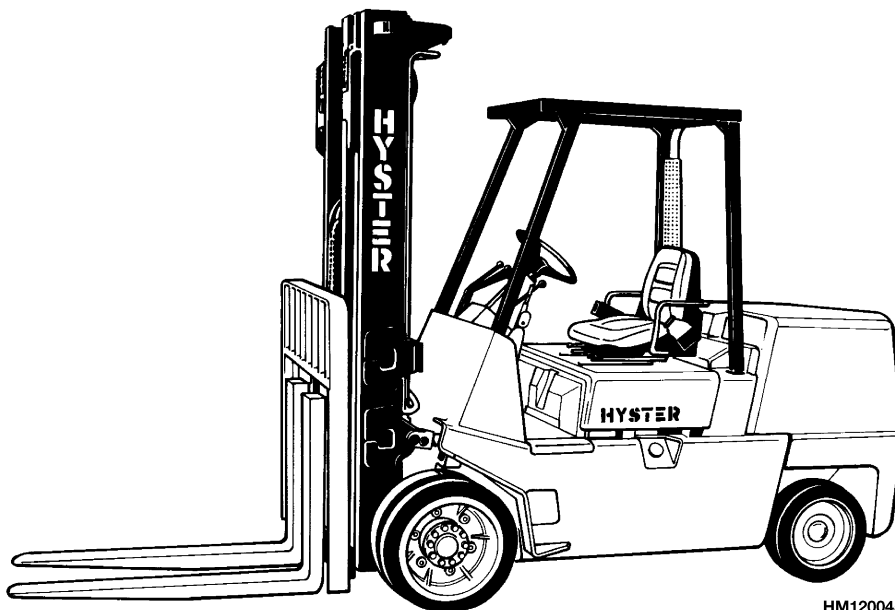
Carefully lift and release lock tabs on connectors to distributor. Lock tabs can be easily broken if too much force is applied with a screwdriver or other tool.

Never permit TACH CONN. terminal to touch ground. Ignition module or ignition coil can be damaged.

1. Disconnect battery negative (ground) cable.
2. If removal of the spark plug wires is not required for the repairs, leave them connected to distributor cap. Remove two capscrews that fasten distributor cap to distributor. Move distributor cap away from work area.

# PERIODIC MAINTENANCE

S3.50-5.50XL (S70-120XL) [D004];  
S6.00-7.00XL (S135-155XL) [B024, C024]



HM120045

# **HYSTER**

Table 1. Maintenance Schedule (Continued)

Item No.	Item	8 hr/ Daily	250 hr/ 6 wks	350 hr/ 2 mo	500 hr/ 3 mo	1000 hr/ 6 mo	2000 hr/ 1 yr	Procedure or Quantity	Specification
19	Mast Pivots		L					2 Fittings	Multipurpose Grease See NOTE 1
15	Forks	X		X				Check Condition	
16	Lift Chains	X	L	X				Check Condition and Lubrication	Engine Oil
	Pedals, Levers, Linkages, Cables, Hinges, Seat Rails					L		As Required	Engine Oil
17	Speed Reducer and Differential Oil, Single-Speed Powershift S3.50-5.50XL (S70-120XL)					X	C	5.7 liter (6.0 qt) See NOTE 6	SAE 80W-90 SAE 85W-140
17	Speed Reducer and Differential Oil, Two-Speed Powershift S6.00-7.00XL (S135-155XL, XL <sub>2</sub> , and S155XLS)					X	C	14.2 liter (15.0 qt) See NOTE 6	SAE 80W-90 SAE 85W-140
17	Manual Transmission, Differential Oil S3.50-5.50XL (S70-120XL) (B024)					X	C	14.2 liter (15.0 qt)See NOTE 6	SAE 80W-90 SAE 85W-140
20	Powershift Transmission Oil (Single-Speed) S3.50-5.50XL (S70-120XL)	X					C	15.1 liter (16 qt) See NOTE 5	Hyster Part Number 336831 Change oil filter when transmission oil is changed.
X=Check C=Change L=Lubricate									

## Fuel System

### WARNING

All fuels are very flammable and can burn or cause an explosion. Do not use an open flame to check the fuel level or to check for leaks in the fuel system. If there is a leak in the fuel system, extra care must be used during the repair. Do not operate the lift truck until a leak is repaired.

Check the fuel system for leaks and the condition of parts. When fuel is added to the lift truck, see the section, **How To Add Fuel To The Lift Truck** procedures in the **Operating Manual**.

### Primary Fuel Filter, Diesel Engine

1. Drain the water from the primary fuel filter. See Figure 8. Open the valve on the bottom of the filter canister. Drain some fuel (and any water) into a cup until clean fuel flows from the filter.
2. Close the valve.

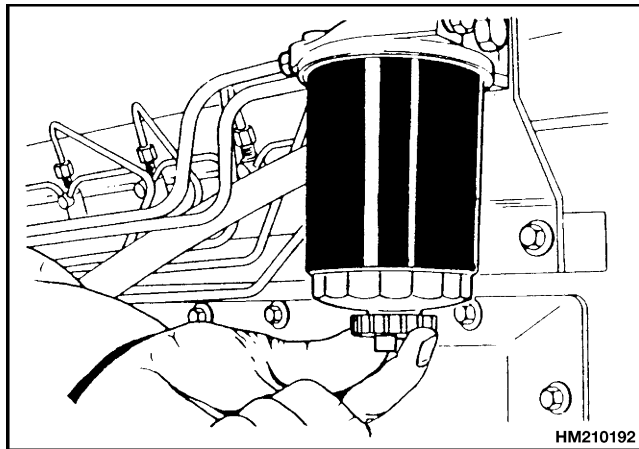


Figure 8. Primary Fuel Filter

## Battery

### WARNING

The acid in the electrolyte can cause injury. If the electrolyte is spilled, use water to flush the area. Use a solution of sodium bicarbonate (soda) to make the acid neutral. Acid in the eyes must be flushed with water immediately. Wear eye protection.

Batteries generate explosive fumes. Keep the vents in the caps clean. Keep sparks or open

flame away from the battery area. Do not make sparks from the battery connections. Disconnect the battery ground cable when doing maintenance.

Keep the battery and cable terminals clean. See Figure 2 and Figure 4. Check the electrolyte level (unless a maintenance-free battery). Keep the electrolyte level above the separators and plates. Use distilled water. Do not fill the battery more than to the bottom of the internal filler neck.

If the battery becomes discharged and requires a booster battery to start the engine, follow these procedures carefully when connecting the jumper cables:

1. Always connect the positive jumper cable to the positive terminal of the discharged battery and the negative jumper cable to the negative terminal.
2. Always connect the jumper cable that is the ground cable last.
3. Always connect the jumper cables to the discharged battery before connecting them to the booster battery.

## Tires and Wheels

### CAUTION

Check all wheel nuts after 2 to 5 hours of operation: when new lift trucks begin operation and on all lift trucks when the drive wheels have been removed and installed. Tighten the nuts in a cross pattern to the correct torque value shown in the Maintenance Schedule. When the nuts stay tight for 8 hours, the interval for checking the torque can be extended to 350 hours.

Check the tires for damage. See Figure 9. Check the tread and remove any objects that will cause damage. Check for bent or damaged rims. Check for loose or missing parts. Remove any wire, straps, or other material wrapped around the axle.

Make sure the drive wheel nuts are tight. Tighten the wheel nuts in a cross pattern to the correct torque value shown in the Maintenance Schedule.

## Maintenance Procedures Every 250 Hours or 6 Weeks

**NOTE:** Do these procedures in addition to the 8-hour checks.

### ENGINE OIL AND FILTER, GM V-6

#### **WARNING**

Long-term exposure to used engine oil may cause skin irritation or cancer. Wash with detergent and water.

Disposal of lubricants and fluids must meet local environmental regulations.

#### **CAUTION**

Never run the engine without oil.

**NOTE:** Change the oil filter for the engine after the first 100 hours of operation on new lift trucks.

Change the oil filter at the same time engine oil is changed. Use the correct oil as shown in the Maintenance Schedule. Apply clean oil to the gasket of the new filter and install. Turn the filter until the gasket touches, then tighten 1/2 to 3/4 turn with your hand. Start the engine. Check the area around the oil filter for leaks.

### MAST, LUBRICATION

#### **WARNING**

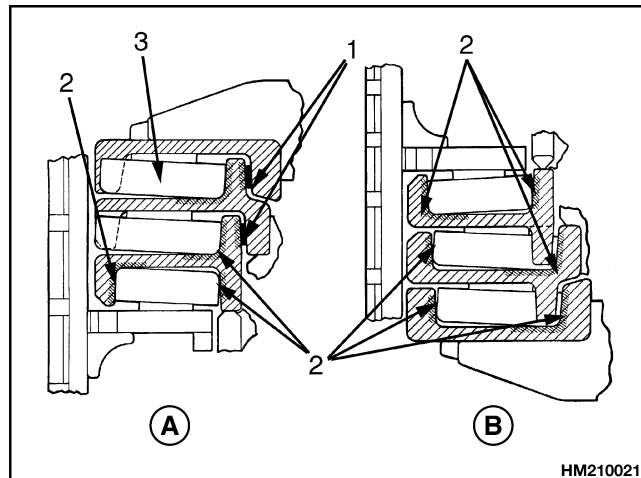
Do not work under a raised carriage. Lower the carriage or use a safety chain. Use the safety chain to prevent the carriage and the inner or intermediate weldments from lowering when servicing the mast and lift chains. Make sure the moving parts are attached to parts that cannot move.

1. Lubricate the sliding surfaces and the load roller surfaces along the full length of the channels as shown in Figure 19. Apply lubricant only to the indicated surfaces.

**NOTE:** The load rollers and sheaves have sealed bearings and do not need additional lubrication.

2. Lubricate the pivot pins for the mast at the grease fittings on the pivot pins. Use multipurpose grease.

3. If a sideshift carriage is installed, lubricate the fittings for the rollers or the sliding surfaces with multipurpose grease.



- A.** UPPER LOAD ROLLERS  
**B.** LOWER LOAD ROLLERS

1. LUBRICATE STRIP BEARINGS SURFACE
2. LUBRICATE LOAD ROLLER SURFACES
3. LOAD ROLLER

*Figure 19. Mast Lubrication*

### LIFT CHAINS, LUBRICATION

#### **WARNING**

Do not repair a worn or damaged lift chain. Replace a worn or damaged lift chain with a new chain. If a pair of lift chains is used in the mast, both lift chains must be replaced.

Lubricate the lift chains with SAE 20 engine oil. The best procedure is to remove the chains from the lift truck and soak them in engine oil.

### CRANKCASE BREATHER, GM V-6 ENGINE

Check the crankcase breather after every engine oil change. If the crankcase breather is worn or damaged, replace it with a new breather. Tighten the breather with your hand. See Figure 4.

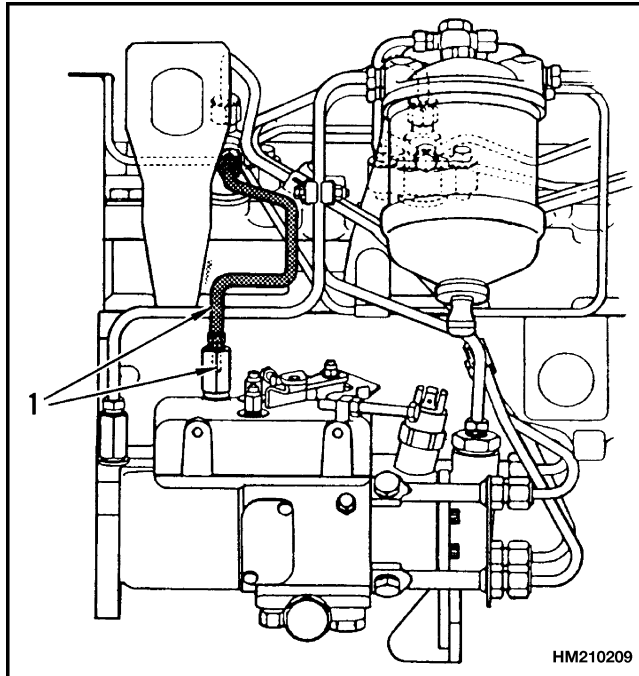
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1. VENT TUBE

**Figure 36. Fuel Injection Pump With Vent Tube**

### Fuel Injection Pump With Vent Screw

Some engines have a vent screw that must be loosened to remove air from the fuel system. The engine cannot be started if there is air in the fuel system. The air must be removed from the fuel system if any part of the fuel system has been disconnected. Also remove the air if there was a leak in the low pressure part of the fuel system while the engine was running.

1. Make sure there is fuel in the fuel tank. Refer to the **How to Add Fuel to Lift Truck** procedures in the **Operating Manual**.
2. Loosen the fitting at the top of the final fuel filter. Remove air from system by following steps 1 through 5 in Figure 37. Operate the lever under the fuel pump until fuel, without air bubbles, comes out of the fitting. Tighten the fitting.
3. Turn the key to the **ON** position to activate the shutoff solenoid.
4. Loosen the vent screw at the top of the injection pump. Operate the lever under the fuel pump until fuel, without air bubbles, comes out of the threads. Tighten the vent screw.
5. Loosen the fitting for the fuel line at the cold start aid. Operate the lever under the fuel pump until fuel, without air bubbles, comes out of the threads. Tighten the fitting.
6. Loosen the fittings at two of the fuel injectors. Disconnect the wire at the shutoff solenoid so the engine will not start. Use the starter to rotate the engine until fuel, without air bubbles, comes out of the threads. Tighten the fittings. Make sure all other fuel line fittings are tight.

The engine is now ready to start. If the engine runs correctly for a short time and then stops, or runs rough, check for air in the fuel system. Make sure you check for leaks in the low pressure (suction) part of the fuel system.

## Hood Latch Check



### WARNING

**The hood, hood latch, and hood striker must be correctly adjusted for the correct operation of the operator restraint system.**

1. Install the floor plate and tighten the capscrews. See Figure 14.
2. Install the latch striker in the highest slot position on the floor plate. Check that the latch striker is in the center of the jaws of the hood latch.
3. Close the hood to the fully closed position. The hood latch has two positions. The hood is fully closed after two clicks of the latch.

4. Loosen the capscrews for the latch striker just enough to let the striker move. Push the hood down until the hood just touches the rubber bumpers on the frame. Make sure the latch striker is still in the center of the hood latch. Tighten the capscrews for the striker.
5. Check the operation of the hood latch. Have an operator sit in the seat. Make sure that the hood is fully closed (two clicks). Also check that the hood touches the rubber bumpers. If necessary, repeat Step 4.

## Lift Chain Adjustments



### WARNING

**When working on or near the mast, see Safety Procedures When Working Near Mast in this section.**

**Never allow anyone under a raised carriage. Do not put any part of your body in or through the lift mechanism unless all parts of the mast are completely lowered and the engine is STOPPED.**

**Do not try to find hydraulic leaks by putting your hand on hydraulic components under pressure. Hydraulic oil can be injected into the body by the pressure.**

**During test procedures for the hydraulic system, fasten the load to the carriage with chains to prevent it from falling. Keep all personnel away from the lift truck during the tests.**

When the lift chains are correctly adjusted:

- The tension will be the same on each chain of the chain set. Check tension by pushing on both chains at the same time.
- The chain length will be correct.
- The chains must travel freely through the complete cycle.

**NOTE:** When the chain adjustments are complete, make sure that the threads on the nuts of the chain anchors are completely engaged. Make sure that all of the adjustment is not removed from the chain anchors. The chain anchors must be able to move on their mounting.

1. When adjusting the lift chains on forklift trucks equipped with either pin- or hook-type forks installed, start with Step 2. If the forklift truck is normally equipped with a hook-type carriage and has an attachment without forks, go to Step 3. If the forklift truck is normally equipped with a pin-type carriage and has an attachment without forks, go to Step 4.

**NOTE:** Prior to performing adjustment procedures, make sure that the forklift truck is parked on a level surface and that the mast is in the vertical position.

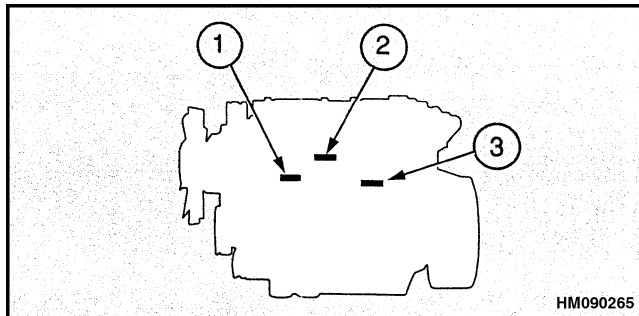
2. Adjust the chain anchors which support the carriage until the bottom of the fork heel is  $6 \pm 3$  mm ( $0.25 \pm 0.12$  in.) above the floor level. See Figure 44.

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### ENGINE SERIAL NUMBER CODES

The engine number is on a label on the side or the rear of the engine block. See Figure 3.



- 1. PART NUMBERS FOR FUEL INJECTION PUMP
- 2. ENGINE SERIAL NUMBER
- 3. EMISSIONS LABEL

**Figure 3. Serial Number Locations**

A typical serial number has the following code:

<b>AR</b>	<b>30126</b>	<b>U</b>	<b>510256</b>	<b>B</b>
1	2	3	4	5

where:

- 1 = Type of engine; AR = 1004-42, (-42 4 liter engine) YG = 1006-60, YH = 1006-60T (-60 6 liter engine)
- 2 = Parts list number
- 3 = Country of manufacture (U = manufactured in the United Kingdom)
- 4 = Serial number
- 5 = Year of manufacturer. The letter indicates the year of manufacture. The letters I, O, Q, R, and Z are not used.

If parts or service are required for your engine, the complete engine number must be given to your dealer.

### ENGINE DATA

The specifications and tolerance details for engine repair are in a chart at the end of this section.

#### 1004-42 (AR) ENGINE (Low Governed Speed)

- Power Rating at 2100 rpm..... 60.0 kW (80.5 bhp)
- Number of cylinders..... 4
- Firing order ..... 1-3-4-2

- Bore and stroke ..... 103 × 127 mm (4.055 × 5.000 in.)
- Displacement..... 4.23 liter (258 in.<sup>3</sup>)
- Compression Ratio ..... 18.5:1
- Minimum oil pressure..... 207 kPa (30 psi)
- (at 2400 rpm and normal operating temperature)
- Governor speed (no load)

See the **Periodic Maintenance** section for your model of lift truck.

- Idle Speed ..... 725 to 775 rpm

#### Thermostat

- Begin to open ..... 77 to 85°C (170 to 185°F)
- Fully open..... 92 to 98°C (198 to 208°F)

#### Valve clearance (cold)

- Inlet ..... 0.20 mm (0.008 in.)
- Exhaust ..... 0.45 mm (0.018 in.)

#### 1004-42 (AR) ENGINE (High Governed Speed)

- Power Rating at 2400 rpm..... 61.5 kW (82.4 bhp)

- Number of cylinders..... 4

- Firing order ..... 1-3-4-2

- Bore and stroke ..... 103 × 127 mm (4.055 × 5.000 in.)

- Displacement..... 4.23 liter (258 in.<sup>3</sup>)

- Compression Ratio ..... 18.5:1

- Minimum oil pressure..... 207 kPa (30 psi)

- (at 2400 rpm and normal operating temperature)
- Governor speed (no load)

See the **Periodic Maintenance** section for your model of lift truck.

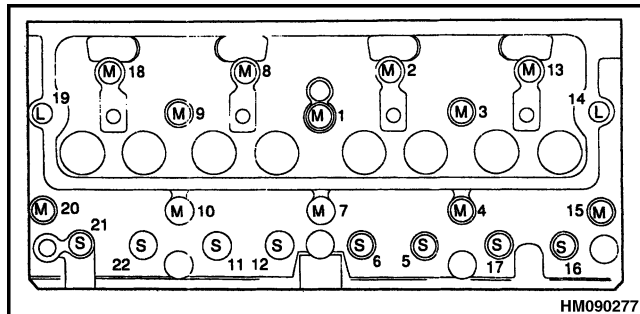
- Idle Speed ..... 725 to 775 rpm

#### Thermostat

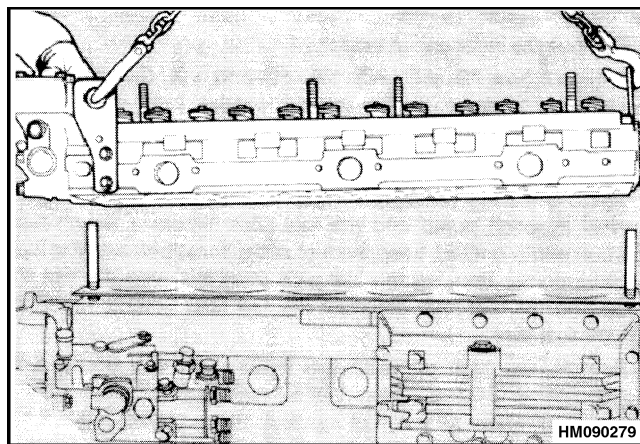
- Begin to open ..... 77 to 85°C (170 to 185°F)
- Fully open..... 92 to 98°C (198 to 208°F)

#### Valve clearance (cold)

- Inlet ..... 0.20 mm (0.008 in.)
- Exhaust ..... 0.45 mm (0.018 in.)



**Figure 21. Cylinder Head Tightening Sequence, Four-Cylinder Engines**



**Figure 22. Cylinder Head Installation**

**CAUTION**

There are three lengths of capscrews. **S** = short, **M** = medium, **L** = long. Figure 20 and Figure 21 show their positions in the engine. Make sure that the capscrews are installed in the correct positions.

4. Lubricate the capscrews with a thin coat of oil and install them into their holes in the cylinder head. When the cylinder head and gasket are held in position, remove the two studs and install the two capscrews in those positions. The four 1/2 UNF capscrews on the four-cylinder (AR) engines are in positions 2, 8, 13, and 18. See Figure 21.
5. Evenly tighten the capscrews in the sequence shown in Figure 20 or Figure 21. The final torque on the capscrews is 110 N•m (81 lbf ft) for the six-cylinder engines and 45 N•m (33 lbf ft) for the four-cylinder engines.
6. Make sure all of the capscrews are tightened to the correct torque described in Step 5. The capscrews must be further tightened in the sequence

shown in Figure 20 or Figure 21 according to the following procedure:

**Six-Cylinder Engines**

- a. The short capscrews (**S**) must be tightened an additional 150° (2.5 flats).
- b. The medium capscrews (**M**) must be tightened an additional 180° (3.0 flats).
- c. The long capscrews (**L**) must be tightened an additional 210° (3.5 flats).

**Four-Cylinder Engines**

- a. The short capscrews (**S**) must be tightened an additional 120° (2 flats).
- b. The medium capscrews (**M**) must be tightened an additional 120° (2 flats).
- c. The long capscrews (**L**) must be tightened an additional 150° (2.5 flats).
- d. The four 1/2 UNF capscrews in position 2, 8, 13, and 18 must be tightened an additional 180° (3 flats).

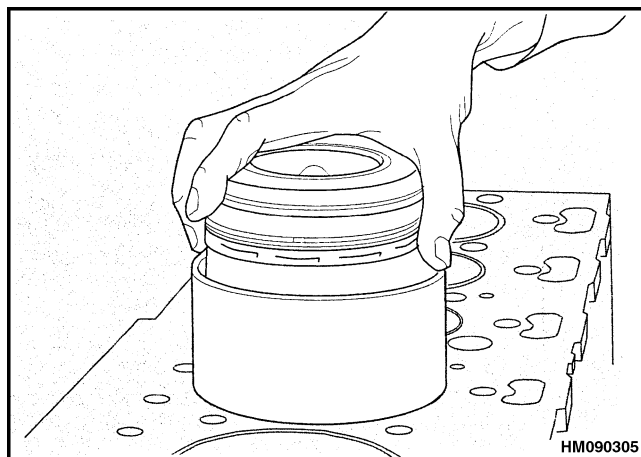
**NOTE:** A special tool shown in Figure 23 can be used for this procedure to measure the tightening angles. If an angle gauge is not available, make a mark in a line with one of the corners of the capscrew. See Figure 24 and Figure 25. Make another mark at the correct angle (counterclockwise) on the edge of the flange of the cylinder head for each capscrew and according to the length of each capscrew. Tighten each capscrew in the correct sequence until the two marks are aligned.

7. Install the push rods in the engine. Make sure that the end of each push rod fits correctly in the tappet socket.
8. Install the rocker arm assembly per Rocker Arm Assembly, Install.
9. Adjust the valve clearances per Valve Clearance Adjustments.
10. Install the fuel injectors per Fuel Injectors, Install.
11. Install the high pressure fuel lines between the fuel injection pump and the fuel injectors. Use a separate wrench to prevent movement of the outlets of the fuel injection pump when the fuel lines are connected. Tighten the connection nuts to 22 N•m (16 lbf ft).

## Install

Special Tools: Piston installation tool (piston ring compressor)  
Piston height tool  
Dial indicator gauge

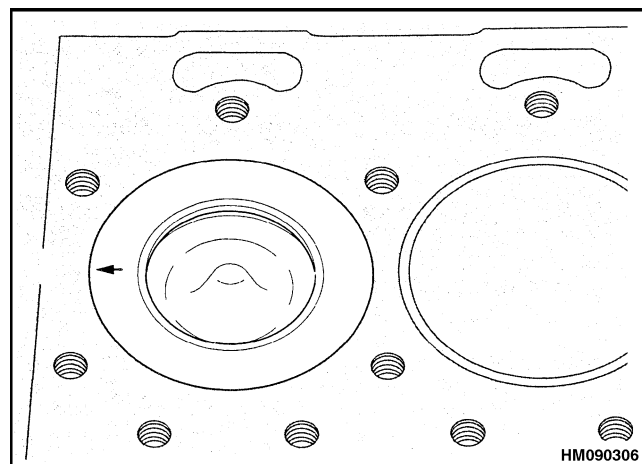
1. Make sure all of the parts are clean. Lubricate the parts with engine oil as they are installed.
2. Turn the crankshaft until the position for the connecting rod to be installed is at the lowest position on the crankshaft.
3. Install the upper bearing half into the connecting rod. Make sure that the location tab is installed correctly into its position in the connecting rod. See Figure 41.
4. Put the piston installation tool at the top of the cylinder. See Figure 44. The tool has a bore with a taper to compress the piston rings when the piston and connecting rod assembly is installed. Make sure the smaller end of the taper is toward the cylinder block.
5. Put the spaces in the three piston rings so that they are 120° apart. Put the connecting rod through the piston installation tool and permit the piston to enter the tool. The piston and connecting rod must be turned so that the connecting rod does not hit the cooling jet for the piston.



**Figure 44. Piston Installation Tool**

6. When the connecting rod has passed the cooling jet during installation, the arrow or "FRONT"

mark on the piston must be turned toward the end of the engine with the cooling fan. See Figure 45.



**Figure 45. Piston in Bore Position**

7. Lubricate the lower half of the rod bearing and install it into the bearing cap.
8. Install the bearing cap on the connecting rod. Make sure that the assembly number on the bearing cap is the same as the number on the connecting rod. Make sure that the two assembly numbers are on the same side of the connecting rod as shown in Figure 42.
9. Connecting rods with nuts. Install and tighten the nuts evenly to a torque of 125 N•m (92 lbf ft). Make sure that the crankshaft turns freely.

Connecting rods with capscrews. Install and tighten the capscrews evenly to a torque of 155 N•m (114 lbf ft). Make sure that the crankshaft turns freely.

10. Measure the height of the piston above the top of the engine block with a dial indicator gauge. The crankshaft must be turned so that the piston is at TDC in the engine block. Put the dial indicator on the top of the engine block and measure the height of the piston above the face of the engine block. See Figure 46.

The correct height of the piston above the engine block is 0.36 to 0.50 mm (0.014 to 0.020 in.). **The tops of the pistons must not be changed or machined.**

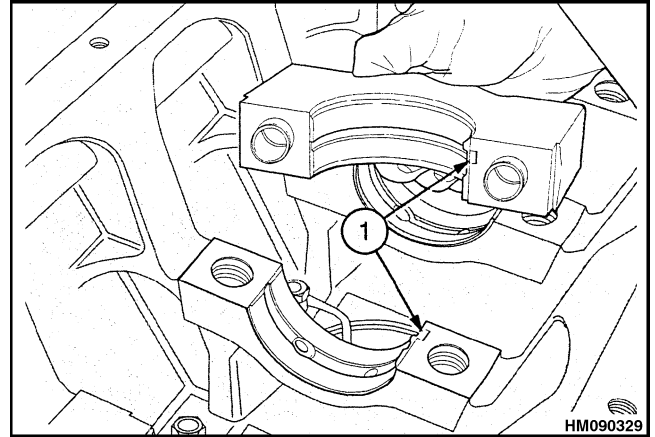
## Inspect

Inspect the bearings for wear and other damage. If a bearing is worn or damaged, replace both halves of the shell bearings and check the condition of the other bearings.

## Install

**NOTE:** Only the upper half of the bearing has lubrication holes and it must be installed into the engine block.

1. Lubricate the upper bearing half with engine oil. Install the plain end of the bearing between the crankshaft journal and the side of the bearing housing that has the location slot. Carefully slide the bearing half into the bearing housing until the location tab fits into the location slot.
2. Lubricate the lower bearing half with engine oil and install it into the bearing cap. Make sure the location tab is installed correctly into the location slot.
3. Make sure that the location thimbles are installed in either the bearing cap or the bearing housing of the engine block. Make sure that the orientation of the location slots for the bearing halves are correct as shown in Figure 68. Install the bearing cap.
4. Make sure the capscrews are in good condition. Install the capscrews into the bearing cap. Tighten the capscrews gradually and evenly. Tighten the capscrews to a final torque of 265 N•m (195 lbf ft).
5. Make sure that the crankshaft rotates freely. If the thrust washers have been removed and installed again, the axial movement of the crankshaft must be checked. See Thrust Washers in the following paragraphs.
6. Install the components that were removed for access to the main bearing.
7. Install the oil sump.



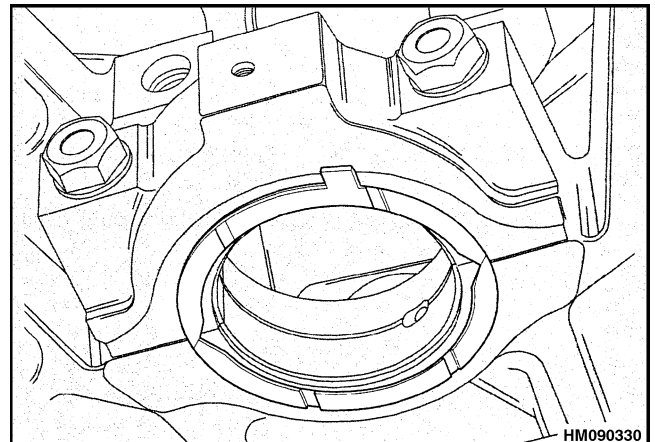
1. LOCATION SLOTS FOR MAIN BEARING HALVES

*Figure 68. Main Bearing Cap Orientation*

## THRUST WASHERS

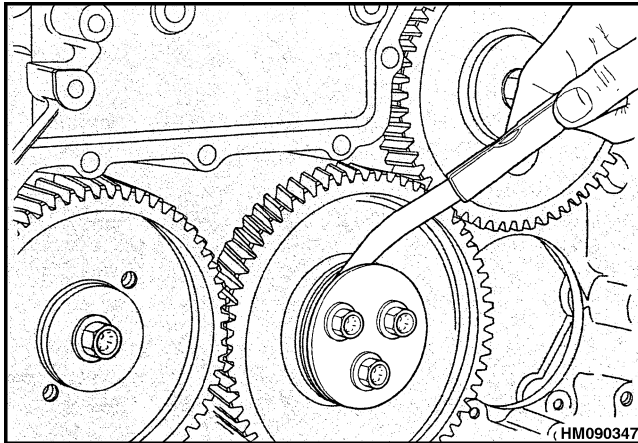
### Crankshaft Axial Movement, Check

The axial movement of the crankshaft is controlled by two half thrust washers installed on each side of the center main bearing. See Figure 69. The axial clearance can be checked with a spacer gauge inserted between the crankshaft and the thrust washer. See Figure 70. A dial indicator can be used to check the axial movement from the end of the crankshaft as shown in Figure 71. The normal axial movement is 0.05 to 0.38 mm (0.002 to 0.015 in.). The maximum axial movement permitted is 0.51 mm (0.020 in.).



*Figure 69. Thrust Washers*

3. Install the plate for the idler gear and the three capscrews. Tighten the capscrews to 44 N•m (32 lbf ft).
4. Check the clearance between the bushings of the idler gear and the plate of the idler gear. The correct clearance is 0.10 to 0.20 mm (0.004 to 0.008 in.). A maximum service limit is 0.38 mm (0.015 in.). See Figure 86.



**Figure 86. Idler Gear Hub Clearance Check**

5. For engines that use the idler gear assembly with needle roller bearings - inspect the components for wear and other damage and replace them as necessary. Lightly lubricate the components with clean lubricating oil before assembly onto the hub. See Figure 84. Position the idler gear hub with the lubrication hole to the top. See Figure 85. Put the rear spacer in position on the hub. Put the rear thrust washer in position on the rear spacer. Put bearings in position on the hub in the same position as they were removed. Lightly lubricate the bore and thrust washer faces of the gear with clean lubricating oil and put the gear in position on the bearings. Put the front spacer in position on the hub then put the front thrust washer in position on the spacer. Put the plate in position. The plate has TOP stamped on the front face as the holes in the plate are not equally spaced. Fit the setscrews and tighten them to 44 N•m (33 lbf ft).
6. Check the timing gear clearances as shown in Figure 89. The minimum clearances for all gears is 0.08 mm (0.003 in.).

7. Install the timing case cover, coolant pump, crankshaft pulley, fan drive pulley, drive belts, and fan. See Timing Case Cover, Install.

## AIR COMPRESSOR DRIVE, BENDIX

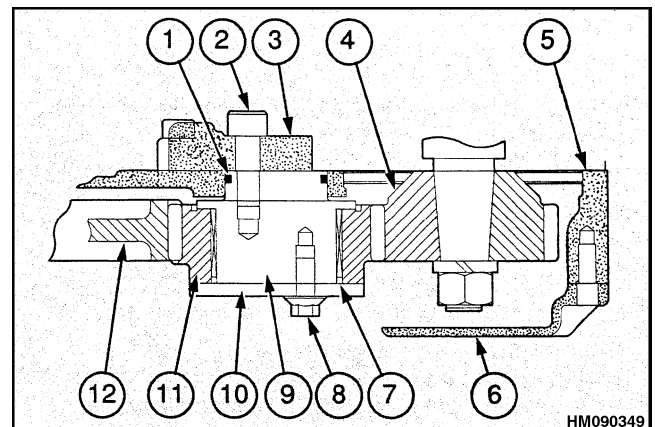
### Disassemble



#### CAUTION

**Do not turn the engine crankshaft nor the crankshaft for the air compressor. If either crankshafts are moved, the air compressor must be timed to the engine.**

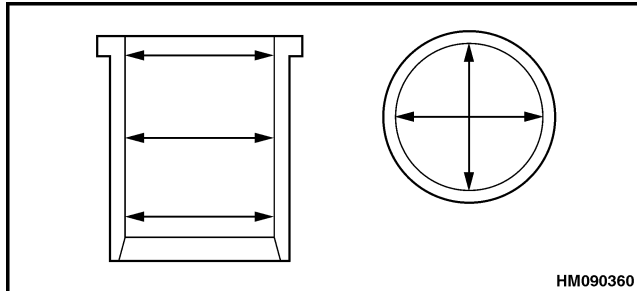
1. Set the number one piston to TDC as described in the Engine Timing section.
2. Remove the timing case cover as described in Timing Case Cover, Remove.
3. Remove the three capscrews shown. See Figure 87. Remove the cover plate. Remove the idler gear and the needle bearings from the idler hub.



- |                               |                       |
|-------------------------------|-----------------------|
| 1. O-RING                     | 7. NEEDLE BEARING     |
| 2. CAPSCREW                   | 8. CAPSCREW (3)       |
| 3. BRACKET                    | 9. IDLER HUB          |
| 4. DRIVE GEAR, AIR COMPRESSOR | 10. COVER PLATE       |
| 5. TIMING CASE                | 11. IDLER GEAR        |
| 6. COVER, TIMING CASE         | 12. ENGINE IDLER GEAR |

**Figure 87. Bendix Compressor Drive**

4. Remove the three capscrews which fasten the idler hub to the bracket. Remove the idler gear hub. See Figure 88.



**Figure 99. Where to Measure Cylinder Liner for Wear Check**



### CAUTION

Do not use "Flex-hone" to repair cylinder liners.

Damaged or worn liners must be replaced.

New piston rings must be fitted when the cylinder liner is replaced.

An engine can have high oil consumption with very little wear of the liner bores, if the surfaces of the liners are glazed.

Specialist training and equipment is needed to machine the finish of a partially finished liner.

- Partially finished cylinder liners must be bored and then diamond honed, silicon carbide base honed and silicon carbide plateau honed to the finished size to conform to the dimensions in the Engine Data section. Specialist training and equipment is needed to machine a partially finished liner. For further information contact your nearest Perkins Distributor.

### Remove

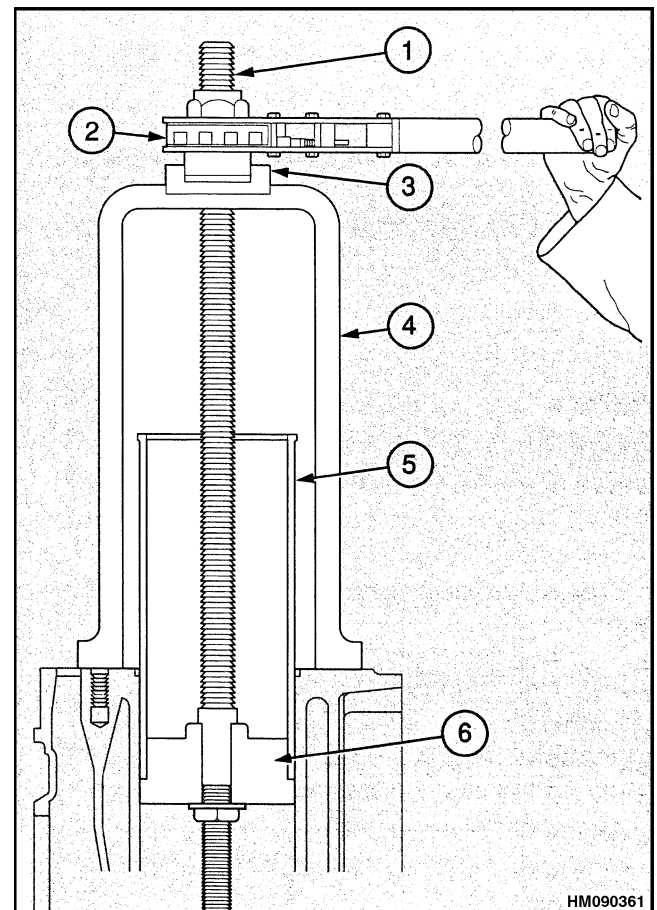
Special Tools: Removal and installation tool and adapters for cylinder liners  
Piston height tool  
Dial indicator gage

**NOTE:** If several cylinder liners must be removed, or a cylinder liner is very tight, a recommendation is to remove the crankshaft and use a press to remove the cylinder liners. The removal and installation tool can also be used to remove and install a cylinder liner if a press is not available or the crankshaft must stay in the engine. This procedure can be difficult.

- Disassemble the engine as necessary. The piston, connecting rod, and piston cooling jet must be

removed from the engine for each cylinder liner that must be removed.

- Turn the crankshaft to give access to the cylinder liner and protect the bearing journal.
- Install the removal and installation tool over the center of the cylinder liner as shown in Figure 100. Make sure that the base of the tool is not on top of the flange of the next cylinder liner.



- |                          |                    |
|--------------------------|--------------------|
| 1. THREADED ROD          | 5. CYLINDER LINER  |
| 2. HANDLE                | 6. REMOVAL ADAPTER |
| 3. BEARING               |                    |
| 4. SHELL REMOVAL ADAPTER |                    |

**Figure 100. Cylinder Liner Removal**

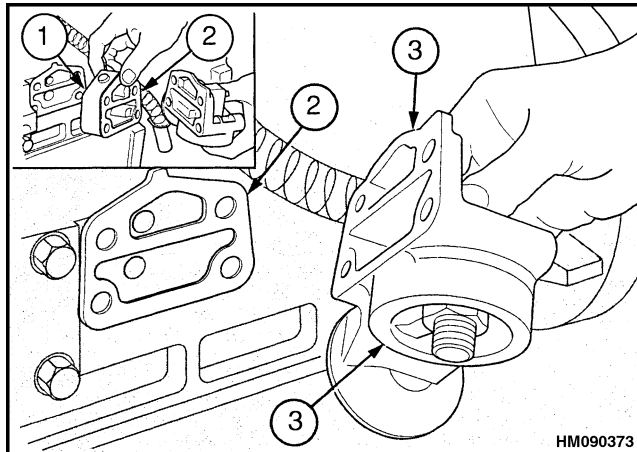
- Make sure that the lugs on the top of the removal adapter engage flats on the threaded rod. Install the nut and washer on the threaded rod and tighten the nut against the removal adapter. Turn the handle to remove the cylinder liner from the cylinder block. Use lubricating oil on the moving parts to reduce the friction.

2. Clean the filter head.
3. Add some clean engine oil to the new filter cartridge. Apply clean engine oil to the gasket.
4. Install the new filter cartridge and tighten by hand only.
5. When new oil has been added and the engine can be operated, start the engine. Check the area around the filter for leaks.

## FILTER HEAD

### Remove and Install

1. Put a drain pan under the filter head.
2. Remove the filter cartridge.
3. Remove the canister type oil cooler from the filter head, if one is used.
4. Remove the flexible pipes from the filter head, if they are used.
5. Remove the capscrews and remove the filter head from the cylinder block. See Figure 114. Discard the gasket.



1. ADAPTER
2. GASKET
3. FILTER HEAD

**Figure 114. Filter Head Replacement**

6. Clean the gasket face of the filter head and the cylinder block.

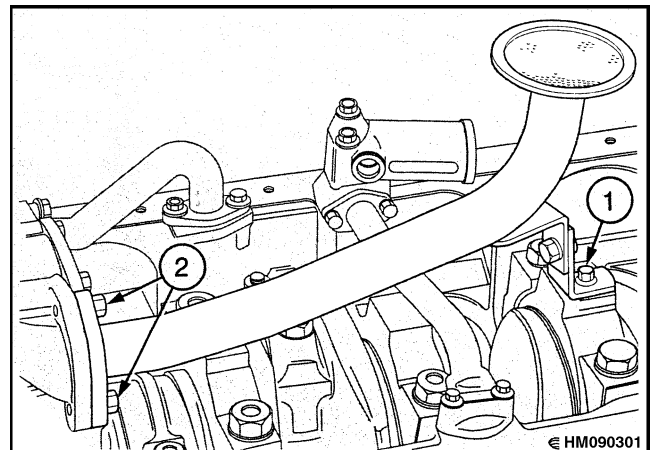
**NOTE:** Some engines have an adapter between the cylinder block and the filter head. If an adapter is used, two gaskets are used.

7. Fit the new gasket to the filter head, the gasket is installed dry.
8. Apply Loctite to the first three threads of the capscrews and tighten the capscrews.
9. Install the oil cooler to the filter head, if used.
10. Install the flexible pipes to the filter head, if used.
11. If the oil cooler is integral with the cylinder block, fit a new gasket to the flange of the oil cooler pipes. Fit the flange to the filter head and tighten the capscrews.
12. Install a new filter cartridge.

## OIL SUMP

### Remove

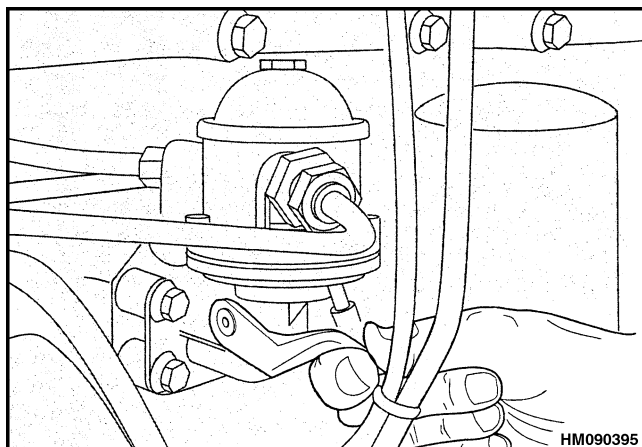
1. Drain the engine oil. Remove the capscrews and the two nuts that fasten the oil sump to the engine block. Lower the oil sump. Remove the gasket.
2. Clean the oil sump with mineral oil solvent.
3. If the suction line and oil strainer must be removed, see Figure 115. Remove the capscrew that holds the bracket to the main bearing cap. Remove the two capscrews from the flange of the suction line and remove the suction line and screen. Clean the faces of both flanges.



1. SUPPORT BRACKET, MAIN BEARING CAP
2. CAPSCREWS, FLANGE, SUCTION PIPE

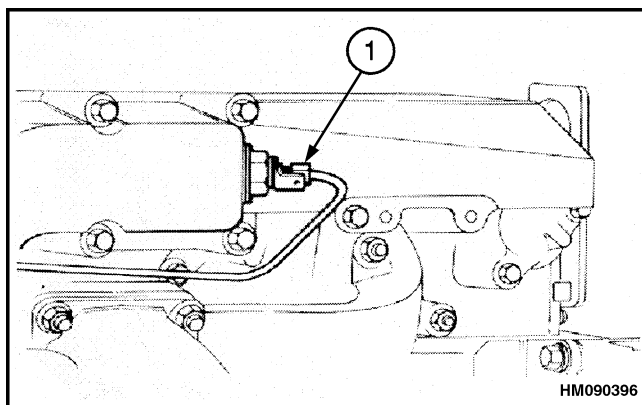
**Figure 115. Oil Sump Screen Removal**

- b. Operate the priming lever on the fuel pump until fuel, without air bubbles, comes from the loosened connection bolt. If the lobe on the camshaft has moved the internal lever of the fuel pump to the highest point of its lift, the priming lever will not operate. The crankshaft must be rotated one revolution to move the lobe on the camshaft. See Figure 138.



**Figure 138. Rotate Crankshaft**

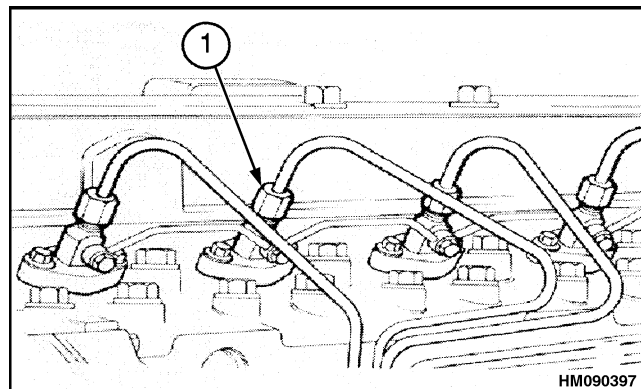
- c. Loosen the connection on the inlet to the cold start aid. Operate the priming lever on the fuel pump until fuel, without air bubbles, comes from the loosened connection. Then tighten the connection. See Figure 139.



1. CONNECTION

**Figure 139. Loosen One Connection on Inlet to Cold Start Aid**

- d. Loosen the connections at two of the inlets to the fuel injectors. Operate the engine with the starter motor until fuel, without air bubbles, comes from the loosened connections. Then tighten the connection to 22 N•m (16 lbf ft). See Figure 140.



1. CONNECTION

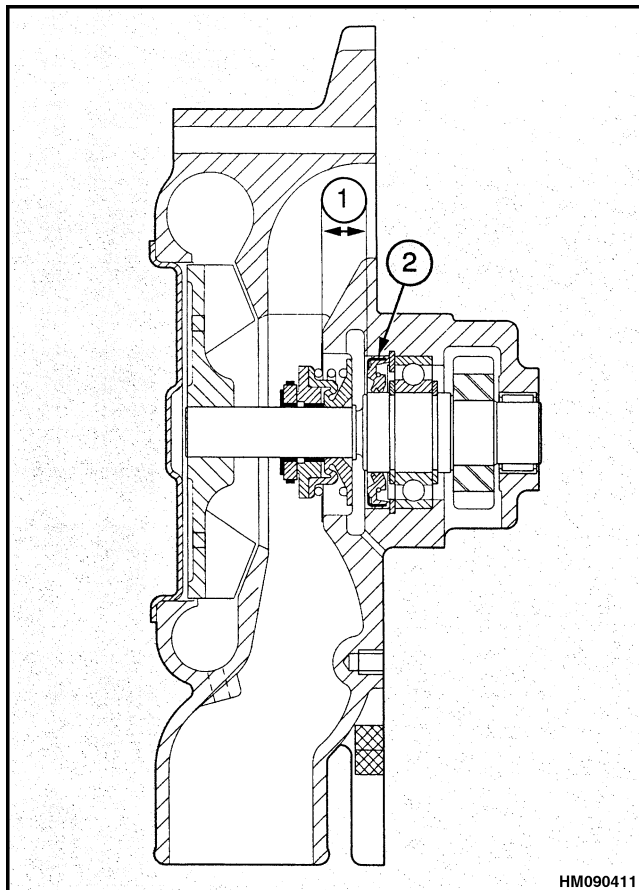
**Figure 140. Loosen Another Connection on Inlet to Cold Start Aid**

- The engine is now ready to start. If there is still a small amount of air in the fuel system, the engine sometimes runs correctly for a short time and then stops. If a second attempt to start the engine causes the engine to run correctly for a short time and then stop, or runs roughly, check for air in the fuel system. Make sure you check for leaks in the low pressure (suction) part of the fuel system.
- After the engine starts, operate the engine at idle speed for five minutes to make sure all of the air is removed from the fuel system.

### FUEL FILTER, REPLACE

**NOTE:** Four-cylinder engines normally have a water separator and a fuel filter. Six-cylinder engines normally have two fuel filters.

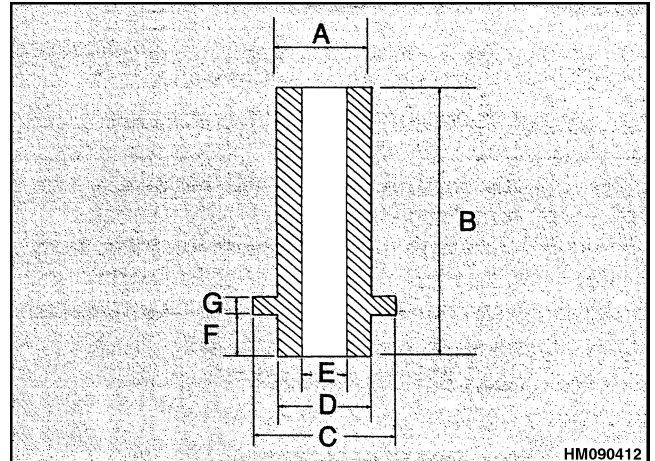
6. Remove the spacer that is a support for the shaft at the end with the pump gear. Continue to press the ball bearing into the housing. Then install the snap ring.
7. Install the new snap ring. Make sure the bevel edge of the snap ring is toward the oil seal. This snap ring holds the shaft and bearing assembly in the pump body.
8. Lightly lubricate the oil seal with clean engine oil. See Figure 154. Install the tapered tool PD.247 onto the shaft with the tapered end toward the bearing. The purpose of the tapered tool is to make sure the lip of the oil seal is correctly fitted when the oil seal is pressed into position. Push the oil seal over the tapered tool and into position in the pump body. The flat face of the oil seal is toward the impeller.



1. 14.5 mm (0.57 in.) DISTANCE BETWEEN OIL SEAL AND FLANGE FOR COOLANT SEAL
2. OIL SEAL

**Figure 154. Coolant Pump Seals Oil Seal Installation**

9. Press the oil seal into the oil seal space in the pump body. The tool shown in Figure 155 can be made to press the oil seal into position. The tool will also prevent axial distortion of the oil seal when it is pressed onto the shaft.



- |                       |                       |
|-----------------------|-----------------------|
| A. 40.0 mm (1.57 in.) | E. 29.0 mm (1.14 in.) |
| B. 80.0 mm (3.15 in.) | F. 14.5 mm (0.57 in.) |
| C. 60.0 mm (2.36 in.) | G. 12.0 mm (0.47 in.) |
| D. 42.0 mm (1.65 in.) |                       |

**Figure 155. Installation Tool for Oil Seal**

10. Use the tool to press the oil seal into the pump body until the seal is 14.5 mm (0.57 in.) from the end of the flange for the coolant seal. When the seal is in position, continue to apply force for approximately 10 seconds to make sure the oil seal remains in position when the force is released.

**CAUTION**

**Do not lubricate the coolant seal. It is important that the coolant seal is not contaminated with oil or grease. If the seal is held in the hand, only touch the edge of the outside flange. Make sure the green sealant that is applied to the coolant seal just behind the flange is not damaged.**

11. Push the coolant seal onto the shaft until it touches the counterbore for the coolant seal. See Figure 156. The widest part of the coolant seal is toward the oil seal. Make sure the coolant seal is aligned with the counterbore and use a press and adapter to push the coolant seal into the counterbore. Make sure the adapter only pushes on the outer flange of the coolant seal. Continue to apply force for approximately ten seconds to

**Table 3. Inlet Valves (Continued)**

Depth of valve head below face of cylinder head to Production limit (see Figure 171 and Figure 172):  
 (Engine YG and YH).... 1.40 to 1.70 mm (0.055 to 0.067 in.)  
 (Engine AR)..... 0.40 to 0.60 mm (0.016 to 0.024 in.)

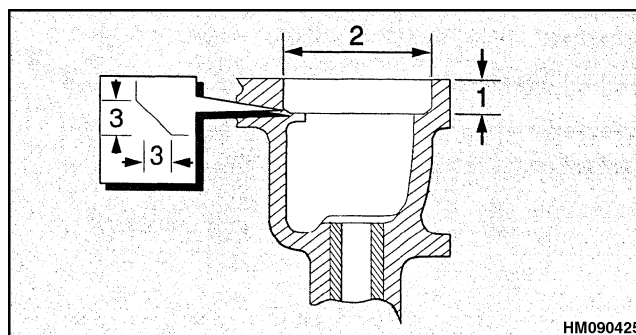
Depth of valve head below face of cylinder head to Service limit (see Figure 171 and Figure 172):  
 (Engine YG and YH).... 1.95 mm (0.077 in.)

**Table 3. Inlet Valves (Continued)**

(Engine AR)..... 0.805 mm (0.032 in.)

Total length  
 (Engine YG and YH).... 122.67 to 123.30 mm (4.829 to 4.854 in.)  
 (Engine AR)..... 123.75 to 124.40 mm (4.872 to 4.897 in.)

Seal arrangement..... Rubber seal installed on valve guide (green)



Engine Types YG to YH:	Engine Type AR:
<b>Inlet Valves</b> 1 = 10.585 to 10.715 mm (0.4167 to 0.4219 in.) 2 = 45.535 to 45.560 mm (1.7927 to 1.7937 in.) 3 = Radius 0.38 mm (0.015 in.) Maximum	<b>Inlet Valves</b> 1 = 10.585 to 10.715 mm (0.4167 to 0.4219 in.) 2 = 48.035 to 48.060 mm (1.8911 to 1.8921 in.) 3 = Radius 0.38 mm (0.015 in.) Maximum
<b>Exhaust Valves</b> 1 = 10.585 to 10.715 mm (0.4167 to 0.4219 in.) 2 = 43.535 to 43.560 mm (1.7139 to 1.7149 in.) 3 = Radius 0.38 mm (0.015 in.) Maximum	<b>Exhaust Valves</b> 1 = 10.585 to 10.715 mm (0.4167 to 0.4219 in.) 2 = 44.035 to 44.060 mm (1.7336 to 1.7346 in.) 3 = Radius 0.38 mm (0.015 in.) Maximum

**Figure 171. Dimensions of Recesses for Valve Seat Inserts**

**Table 4. Exhaust Valves**

Diameter, valve stem ..... 8.938 to 8.960 mm (0.351 to 0.3528 in.)

Clearance in valve guide ..... 0.040 to 0.84 mm (0.0016 to 0.0033 in.)

Maximum clearance in valve guide  
 Production limit ..... 0.104 mm (0.0041 in.)  
 Service limit ..... 0.121 mm (0.0048 in.)

Diameter, valve head

**Table 4. Exhaust Valves (Continued)**

(Engine YG and YH)... 40.88 to 41.12 mm (1.609 to 1.619 in.)

(Engine AR)..... 41.88 to 42.12 mm (1.649 to 1.658 in.)

Angle of valve face ..... 45° or 30°

Depth of valve head below face of cylinder head to Production limit (see Figure 171 and Figure 172):  
 (Engine YG and YH)... 1.50 to 1.80 mm (0.059 to 0.071 in.)  
 (Engine AR)..... 0.40 to 0.60 mm (0.016 to 0.024 in.)

**Table 27. Camshaft Gear (Continued)**

Outside diameter, hub of camshaft .....	34.90 to 34.92 mm (1.3741 to 1.3747 in.)
Clearance fit, gear on hub .....	0.008 to 0.048 mm (0.0003 to 0.0019 in.)

**Table 28. Gear for Fuel Injection Pump**

No. of teeth .....	56
Bore .....	36.00 to 36.06 mm (1.417 to 1.419 in.)
Clearance fit, gear on hub .....	0.003 to 0.075 mm (0.0001 to 0.0030 in.)

**Table 29. Crankshaft Gear**

No. of teeth .....	28
Diameter, bore .....	47.625 to 47.650 mm (1.8750 to 1.8760 in.)
Diameter, hub for gear on crankshaft .....	47.625 to 47.645 mm (1.8750 to 1.8758 in.)
Press fit of gear on crankshaft .....	-0.020 to +0.048 mm (-0.0008 to +0.0019 in.)

**Table 30. Idler Gear and Hub**

No. of teeth .....	63
Diameter, gear bore .....	57.14 to 57.18 mm (2.2495 to 2.2512 in.)
Diameter, gear bore if equipped with needle roller bearings .....	69.01 to 69.03 mm (2.717 to 2.718 in.)
Width, gear with split bushing assembly .....	30.14 to 30.16 mm (1.186 to 1.187 in.)
Width, gear with flange bushing assembly .....	50.78 to 50.80 mm (1.9992 to 2.000 in.)
Outside diameter, hub .....	50.70 to 50.74 mm (1.9960 to 1.9975 in.)

**Table 30. Idler Gear and Hub (Continued)**

Outside diameter, hub if equipped with needle roller bearings .....	54.987 to 55.000 mm (2.1648 to 2.1654 in.)
Clearance, bushings on hub .....	0.04 to 0.10 mm (0.0016 to 0.0039 in.)
Axial movement:	
to Production limit .....	0.10 to 0.20 mm (0.004 to 0.008 in.)
to Service limit .....	0.38 mm (0.015 in.)
Axial movement if equipped with needle roller bearings .....	
to Service limit .....	0.24 to 0.33 mm (0.009 to 0.013 in.)
to Service limit .....	0.38 mm (0.015 in.)
Gear clearance (all) .....	0.08 mm (0.003 in.)

**ENGINE BLOCK ASSEMBLY**

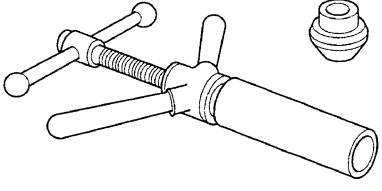
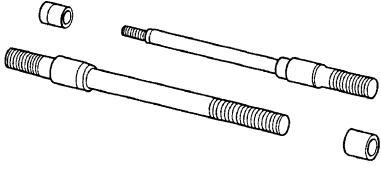
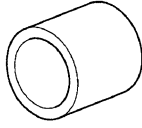
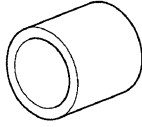
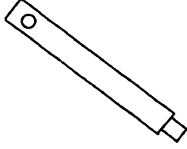
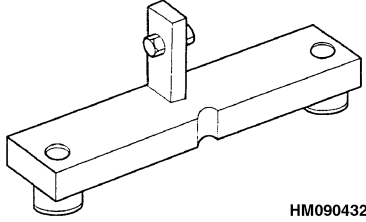
Refer to the following tables for specifications for the engine block assembly.

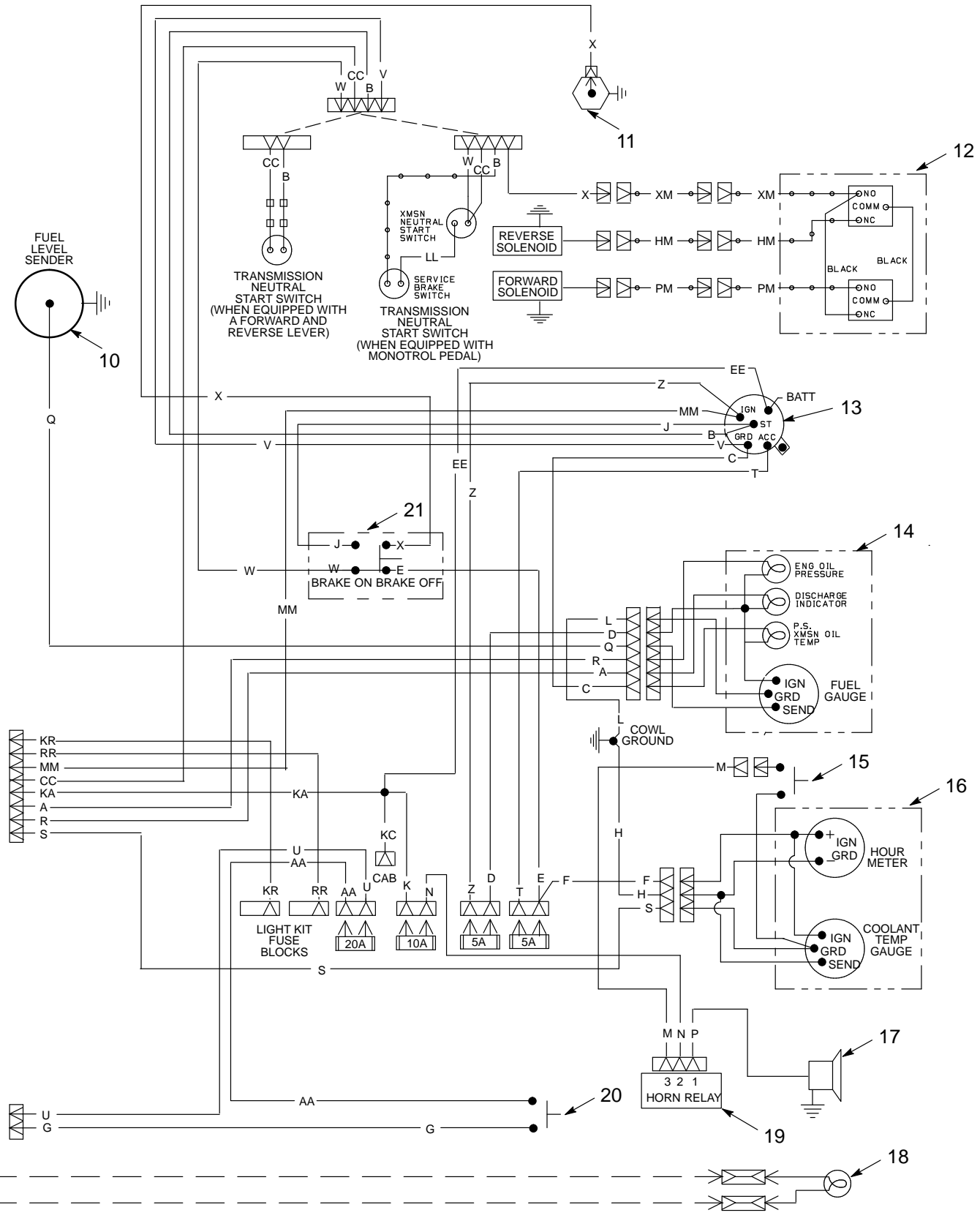
**Table 31. Cylinder Block (Engine AR)**

Height between top and bottom faces .....	441.12 to 441.33 mm (17.367 to 17.375 in.)
Diameter of cylinder bore .....	103.000 to 103.025 mm (4.055 to 4.0561 in.)
Maximum wear of cylinder bore .....	0.15 mm (0.006 in.)
Diameter of first oversize cylinder bore .....	103.500 to 103.525 mm (4.0748 to 4.0757 in.)
Diameter of second oversize cylinder bore .....	104.000 to 104.025 mm (4.0944 to 4.0954 in.)

**NOTE:** Two oversize pistons are available in service: 0.5 mm (0.020 in.) and 1.0 mm (0.040 in.)

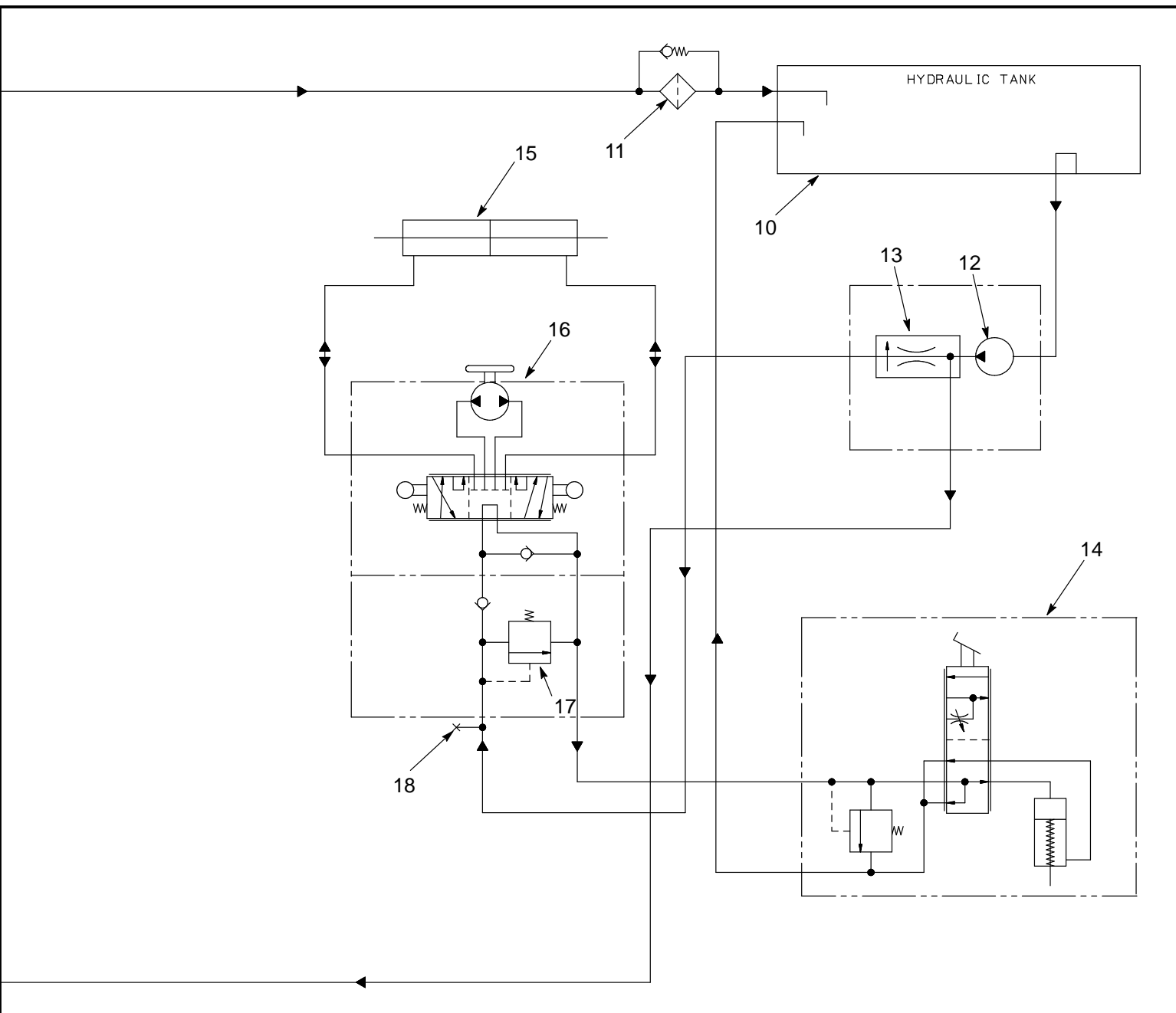
## Special Tools\*

 <p style="text-align: center;">HM090428</p>	<p>Remove and replace tool for valve guides.</p>
 <p style="text-align: center;">HM090429</p>	<p>Adapter tool for use with tool for valve guides.</p>
 <p style="text-align: center;">HM090430</p>	<p>Adapter tool (inlet valves) for use with tool for valve guides.</p>
 <p style="text-align: center;">HM090430</p>	<p>Adapter tool (exhaust valves) for use with tool for valve guides.</p>
 <p style="text-align: center;">HM090431</p>	<p>Timing pin for Lucas fuel injection pumps.</p>
 <p style="text-align: center;">HM090432</p>	<p>Gauge for piston height, valve depth, and cylinder liner flange; for use with dial gauge.</p>
<p>Contact your Perkins dealer for special tools.</p>	



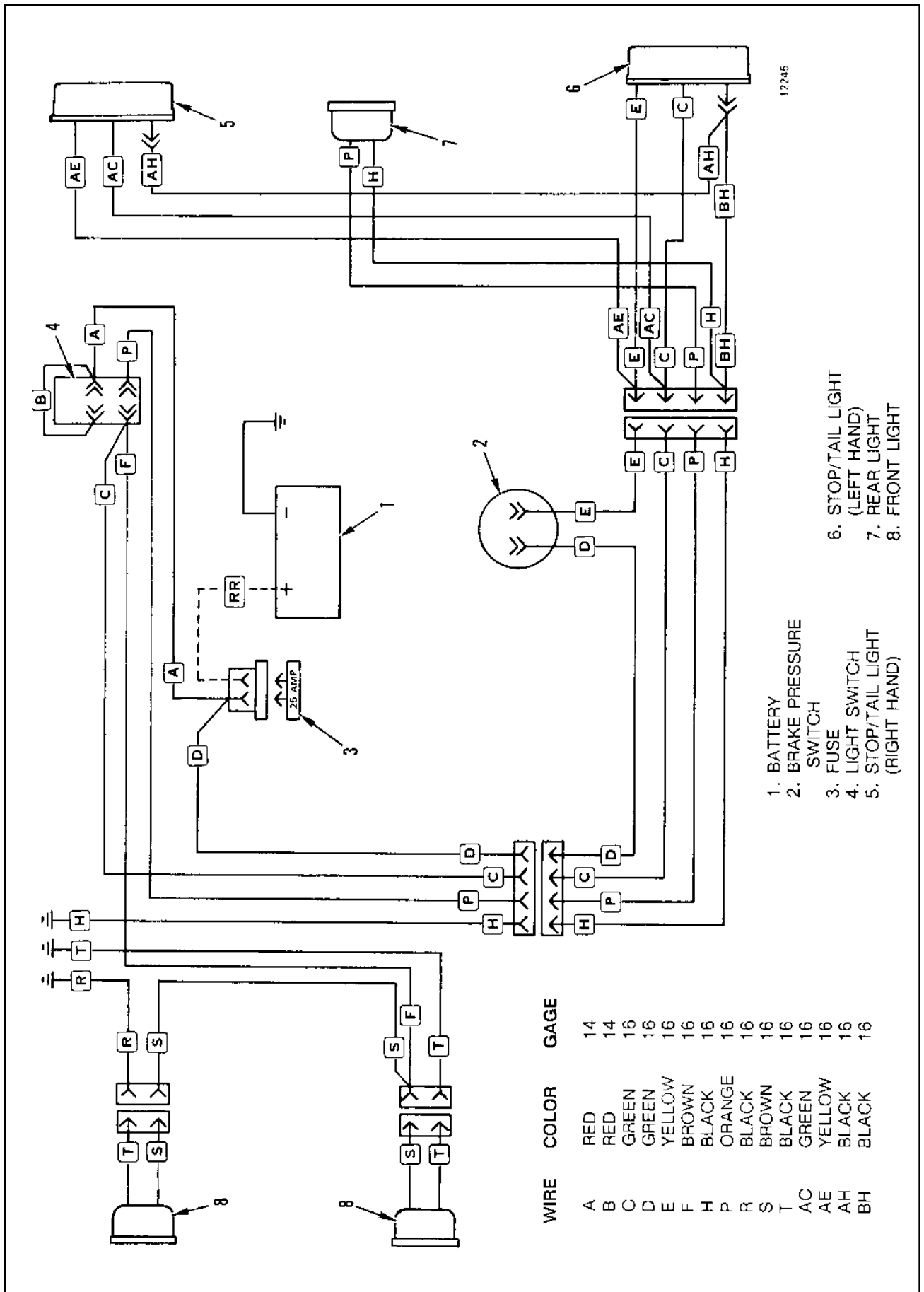
**INSTRUMENT PANEL ELECTRICAL SCHEMATIC**

FIGURE 1. DIESEL ENGINE WIRING SCHEMATIC



- 10. HYDRAULIC TANK
- 11. HYDRAULIC FILTER
- 12. HYDRAULIC PUMP
- 13. FLOW CONTROL VALVE
- 14. BRAKE BOOSTER
- 15. STEERING CYLINDER
- 16. STEERING CONTROL UNIT
- 17. RELIEF VALVE, STEERING
- 18. TEST PORT, STEERING PRESSURE

FIGURE 6. HYDRAULIC SYSTEM SCHEMATIC



17245

- 1. BATTERY
- 2. BRAKE PRESSURE SWITCH
- 3. FUSE
- 4. LIGHT SWITCH
- 5. STOP/TAIL LIGHT (RIGHT HAND)
- 6. STOP/TAIL LIGHT (LEFT HAND)
- 7. REAR LIGHT
- 8. FRONT LIGHT

WIRE	COLOR	GAGE
A	RED	14
B	RED	14
C	GREEN	16
D	GREEN	16
E	YELLOW	16
F	BROWN	16
H	BLACK	16
P	ORANGE	16
R	BLACK	16
S	BROWN	16
T	BLACK	16
AC	GREEN	16
AE	YELLOW	16
AH	BLACK	16
BH	BLACK	16

FIGURE 6. ELECTRICAL SCHEMATIC FOR THE LIGHT CIRCUIT

## 1.23 CYLINDER HEAD ASSEMBLY

### 1.24 Removal

1. If the engine is still in the lift truck, do the following procedures:

- a. Drain the cooling system.
- b. Disconnect the battery terminals.
- c. Disconnect the sender unit for the coolant temperature gauge.

2. ENGINES AA and YA. Remove the hose from the air filter at the inlet manifold.

ENGINES AB and YB. Remove air filter connection at the compressor inlet of the turbocharger.

3. Remove the fuel line between the cold start aid in the inlet manifold and the fuel filter. Disconnect the electrical connection.

4. ENGINES AB and YB. Remove the boost control line between the front of the inlet manifold and the fuel injection pump.

5. Remove the inlet manifold.

6. ENGINES AB and YB. Disconnect all connections to the turbocharger and remove the turbocharger. See 1.108 Turbocharger, Removal.

7. Remove the exhaust manifold.

8. Remove the low pressure fuel lines between the fuel injection pump and the fuel filter. Remove the fuel filter bracket and the fuel filter.

9. Remove the high pressure fuel lines. Put plugs in the open ports of the fuel injection pump.

10. Remove the return fuel line from the fuel injectors.

11. Remove the fuel injectors from the cylinder head. Keep the fuel injectors clean and prevent damage to the nozzles.

12. ENGINES YA and YB. If a compressor is installed, remove the coolant pipe between the cylinder head and the compressor. Remove the coolant pipe between the by-pass connection and the compressor.

13. Loosen the hose clamp and remove the coolant by-pass hose from the cylinder head. Remove the capscrews and remove the coolant by-pass connection and the hose.

14. ENGINES AA and AB. Remove the oil cooler. See 1.164 Oil Cooler, Removal.

15. Remove the valve cover. See 1.11 Valve Cover, Removal.

16. Remove the Rocker arm assembly. See 1.14 Rocker Arm Assembly, Removal.

17. Remove the push rods.

18. Loosen the capscrews for the cylinder head evenly in a reverse sequence from the sequence shown in FIGURE 11. or FIGURE 12.

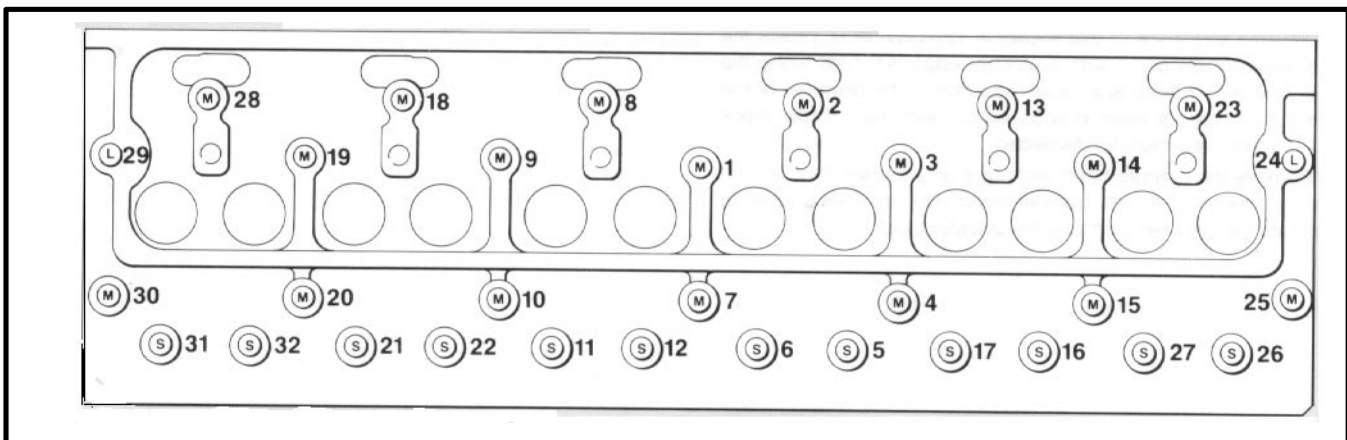


FIGURE 11. CYLINDER HEAD TIGHTENING SEQUENCE, 6-CYLINDER ENGINES

bracket to the main bearing cap. Remove the two capscrews from the flange of the suction line and remove the suction line and screen. Clean the faces of both flanges.

5. Remove the bearing cap and rod bearings as described under 1.39 Rod Bearings, Removal. Mark the bearing caps and rod bearings so that they can be installed again in their original positions.

6. Push the piston and connecting rod out of the top of the cylinder liner.

### **⚠ CAUTION**

**Do not permit the connecting rods to hit the cooling jets for the pistons. If a cooling jet is hit, the alignment must be checked and the cooling jet replaced if necessary.**

7. Inspect the bearing surfaces on the crankshaft for damage.

## **1.44 Installation**

Special Tools: Piston installation tool  
(piston ring compressor)  
Piston height tool  
Dial indicator gauge

1. Make sure all of the parts are clean. Lubricate the parts with engine oil as they are installed.

2. Turn the crankshaft until the position for the connecting rod to be installed is at the lowest position on the crankshaft.

3. Install the upper bearing half into the connecting rod. Make sure that the location tab is installed correctly into its position in the connecting rod. See FIGURE 31.

4. Put the piston installation tool at the top of the cylinder. See FIGURE 33. The tool has a bore with a taper to compress the piston rings when the piston and connecting rod assembly is installed. Make sure the smaller end of the taper is toward the engine block.



FIGURE 33. PISTON INSTALLATION TOOL

5. Put the spaces in the three piston rings so that they are 120° apart. Put the connecting rod through the piston installation tool and permit the piston to enter the tool. The piston and connecting rod must be turned so that the connecting rod does not hit the cooling jet for the piston.

6. When the connecting rod has passed the cooling jet during installation, the arrow or “FRONT” mark on the piston must be turned towards the end of the engine with the cooling fan. When the piston is in this position, the combustion bowl in the top of the piston will be towards the side of the engine with the fuel injection pump. See FIGURE 34.

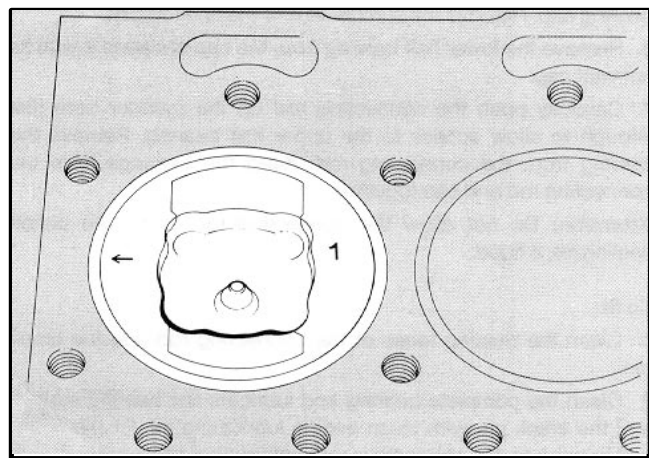


FIGURE 34. POSITION OF THE PISTON IN BORE

7. Lubricate the lower half of the rod bearing and install in into the bearing cap.

8. Install the bearing cap on the connecting rod. Make sure that the assembly number on the bearing cap is the same as the number on the connecting rod. Make sure

8. Remove the timing gears and the timing case. See the sections 1.75 through 1.92 Timing Case And Timing Gears.

9. Remove the flywheel and the flywheel housing. See 1.172 Flywheel and 1.176 Flywheel Housing, Removal.

10. Remove the rear oil seal housing. See 1.63 Oil Seal, Replacement.

11. If the engine is not already in a position with the crankshaft facing up, turn the engine to that position. Remove the suction pipe and oil strainer. See FIGURE 30. Remove the capscrew that holds the bracket to the main bearing cap. Remove the two capscrews from the flange of the suction pipe and remove the suction pipe and screen. Clean the faces of both flanges. Remove the oil pump, delivery tube and relief valve. See 1.117 through 1.121 on the oil pump and relief valve.

12. Remove the bridge piece over the rear main bearing. Make a note if there is a round rubber seal at each end of the bridge piece where it joins the crankcase. Some engines have rubber seals and other engines have sealant.

13. Remove the bearing caps and lower bearing halves from the connecting rods. Make an arrangement so that the parts for each connecting rod will be assembled again in their original positions. Carefully push the pistons into their bores a small amount so that the connecting rods are separated from the crankshaft.

### CAUTION

**Make sure the cooling jets for the pistons are not damaged or moved out of alignment. If a cooling jet is hit, the alignment must be checked and the cooling jet replaced if necessary.**

14. Make sure that the main bearing caps are marked with their position number. Remove the main bearing caps, lower bearing halves, and the upper and lower thrust washers. Keep all the parts in an arrangement so that the parts can be installed in their original positions.

15. Lift the crankshaft from the engine block. Remove the upper bearing halves and put each of them with their lower bearing half.

## 1.73 Inspection

Check the crankshaft for wear and other damage. The maximum wear and out-of-round on the bearing journals is 0.04 mm (0.0016 in).

The bearing journals on standard crankshafts can be ground to the following diameters smaller than the original size:

0.25 mm (0.010 in)

0.50 mm (0.020 in)

0.75 mm (0.030 in)

Special bearings are available for these sizes.

The crankshaft must be replaced if the surface must be ground more than 0.75 mm (0.030 in).

The area on the crankshaft flange for the rear oil seal can be machined to remove wear marks if the oil seal has been used in all four positions. See the ENGINE SPECIFICATIONS. The minimum diameter of this area is 133.17 mm (5.243 in).

## 1.74 Installation

1. Make sure that all of the oil passages are clean.

2. Make sure all of the bearings and bearing caps are clean. Install the upper bearing halves into their positions in the connecting rods and the housings for the main bearings. Make sure that the position tags of the bearings fit into their position slots. Lubricate the bearings with engine oil.

3. Install the crankshaft in position on the main bearings.

4. Lubricate the thrust washers with engine oil. Slide the upper halves of the thrust washers into their positions in the engine block. Make sure that the sides of the thrust washers with the grooves are against the crankshaft.

5. Install the lower halves of the thrust washers into the main bearing cap. Make sure that the location tags are in their correct positions.

6. Make sure that the location thimbles are installed in either the bearing cap or the bearing housing of the engine block. Make sure that the orientation of the location slots for the bearing halves are correct as shown in FIGURE 50. Lubricate the bearing and thrust washers with engine oil. Install the bearing cap.

**is hit, the alignment must be checked and the cooling jet replaced if necessary.**

20. Make sure that the main bearing caps are marked with their position number. Remove the main bearing caps, lower bearing halves, and the upper and lower thrust washers. Keep all the parts in an arrangement so that the parts can be installed in their original positions.

21. Lift the crankshaft from the engine block. Remove the upper bearing halves and put each of them with their lower bearing half.

22. Carefully remove the pistons and connecting rod assemblies from the engine.

23. Remove the camshaft and tappets. See 1.95 Camshaft And Tappets, Removal.

24. ENGINES AB and YB. Remove the cooling jets for the pistons.

### **1.100 Inspection**

1. Make sure all of the oil and coolant passages in the engine block are clean.

2. Check the engine block for cracks and damage.

**NOTE:** The top face of the engine block can not be machined because the cylinder liners and pistons will not fit.

3. Check the front bushing for the camshaft for wear. If a new bushing must be installed, use a puller to remove the old bushing. Make sure the oil hole for the new bushing is away from the engine when it is installed. Make sure the oil hole is aligned with the passage in the engine block when it is installed. Use a press to install a new bushing and align it in position in the engine block.

### **1.101 Assembly**

1. Make sure all the parts are clean.

2. Remove the screw plugs from the engine block and clean the threads. Apply a sealant to the threads of the plugs and install them in the engine block.

3. ENGINES AB and YB. Install the cooling jets for the pistons. See 1.55 Cooling Jets, Installation.

4. Install the crankshaft and the rear oil assembly. See 1.63 through 1.74 Crankshaft Assembly sections.

5. Install the flywheel housing and flywheel. See 1.174 Flywheel and 1.177 Flywheel Housing section.

6. Install the tappets and the camshaft. See 1.96 Camshaft And Tappets, Installation.

7. Install the relief valve, oil pump, suction line and oil strainer. See the sections 1.119 through 1.124 .

8. Install the timing case and the timing gears. See The sections 1.78 through 1.93 Timing Case And Timing Gears

9. Install the cylinder head assembly. See 1.25 Cylinder Head Assembly, Installation.

10. Install the starter motor.

11. Install the fuel pump.

12. ENGINES AB and YB. Install the turbocharger. See 1.109 Turbocharger, Installation.

13. Install the oil filter assembly and the oil sump. See 1.115 Oil Sump, Installation.

14. Install the oil cooler. See 1.167 Oil Cooler, Installation.

15. Install the fuel injectors, fuel lines, fuel filter, and fuel injection pump. See 1.128 through 1.148 Fuel System sections.

16. Install the coolant pump, fan drive pulley, and fan. See 1.157 through 1.162 Cooling System sections.

17. Install the alternator and mount brackets.

R. Install the drive belts and adjust the tension. See 1.178 Drive Belts.

18. Install the engine into the lift truck.

19. Remove the air from the fuel system before operating the engine. See 1.136 Remove Air From The Fuel System.

## **1.102 CYLINDER LINER**

### **1.103 Inspection**

Check the cylinder liners for wear and damage. Check for wear in the liner as shown in FIGURE 67. and FIGURE 68. The wear limit is 0.25 mm (0.010 in).

speeds. When the engine speed is lower, there is a reduced air supply to the cylinders. A mechanical governor controls the maximum engine speed.

The fuel injectors receive fuel under high pressure from the fuel injection pump. The fuel injectors are set by the manufacturer, but must be checked according to the maintenance schedules. See **PERIODIC MAINTENANCE**. The operation pressure of a fuel injector can be changed by adding or removing shims above the spring in the fuel injector.

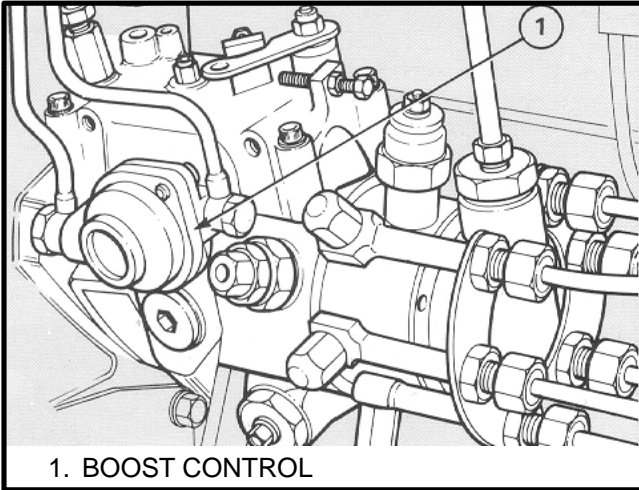


FIGURE 86. FUEL INJECTION PUMP WITH BOOST CONTROL, ENGINES AB AND YB

The fuel pump has a diaphragm that is actuated by a lever. The lever is actuated by a lobe on the camshaft. The fuel pump has a small lever that can be operated with your hand to “prime” the fuel pump.

**NOTE:** Good operation of the fuel injection system requires clean fuel and no dirt can be permitted in the system. Always clean carefully around a connection before it is disconnected. Install covers on open ports during maintenance. When the fuel system is opened for maintenance, the air must be removed from the fuel system before the engine is operated.

## 1.126 CAV FUEL INJECTION PUMP

### 1.127 Removal

Special Tools: Gear Puller  
Adaptors for gear puller  
Wrench (spanner) for flange nuts

1. Disconnect all of the fuel lines from the fuel injection pump. Disconnect the engine stop control. Disconnect the control rod to the fuel injection pump.

2. Remove the gear cover from the cover of the timing case. Remove the nut and lock washer for the gear.

3. Turn the crankshaft so that the woodruff key in the gear for the fuel injection pump is towards the top of the engine. See 1.86 Gear For The Fuel Injection Pump, Removal.

4. Remove the capscrew and the nut for the support bracket that is under the fuel injection pump.

5. Remove the flange nuts that hold the fuel injection pump to the timing case. A special wrench can be required if there is a limit to the access to the nuts.

6. Use a puller to remove the gear for the fuel injection pump. Make sure that the woodruff key does not fall into the timing case.

7. Remove the fuel injection pump from the engine.

### 1.128 Installation

1. Align the timing marks on the timing gears as shown in FIGURE 88. See 1.87 Gear For The Fuel Injection Pump, Installation.

2. Turn the drive shaft of the fuel injection pump so that the key slot aligns with the key slot in the gear. Install the woodruff key and install the gear onto the drive shaft.

3. Align the mark on the flange of the fuel injection pump with the mark on the timing case. See FIGURE 87. Install the flange nuts for the fuel injection pump.

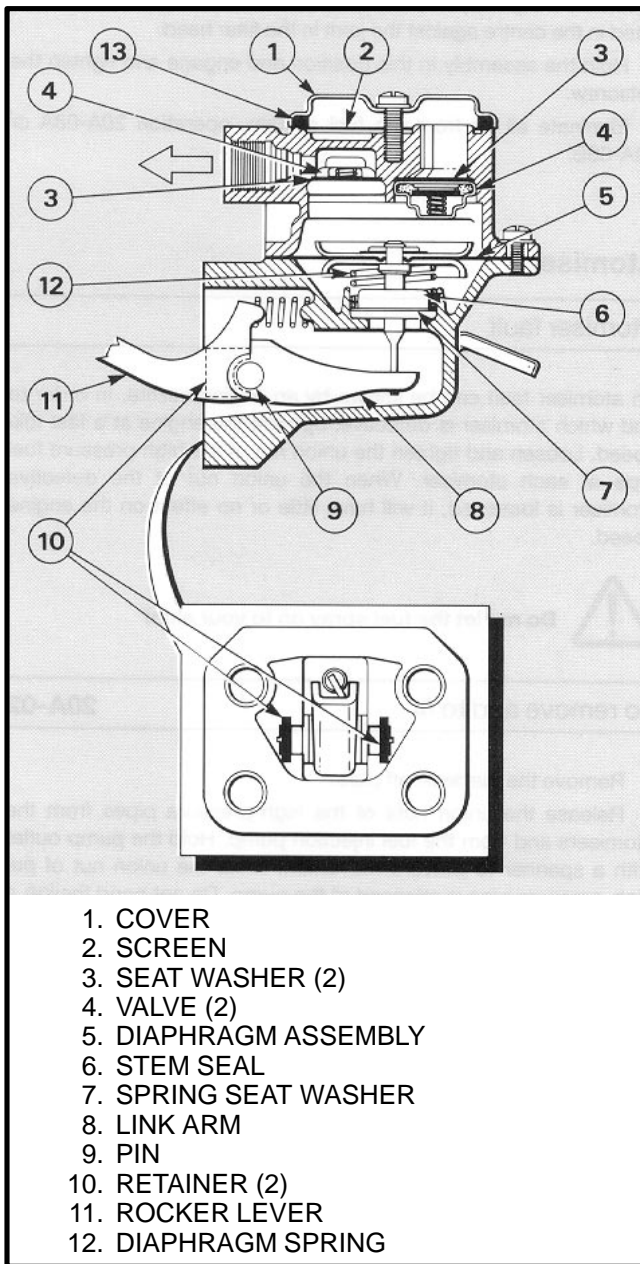


FIGURE 101. FUEL PUMP, DISASSEMBLY

### 1.147 Assembly

1. Install new seat washers (2). Push new valves (4) into position. The valves are the same, but they are installed in the opposite directions from each other. See FIGURE 101. to make sure that the valves are installed in the correct position. When the valves are correctly installed, use a punch on the edge of the valve housings to hold the valves in position. Use the punch in six places around each valve to hold the valve in position.

2. Install the rocker lever (11), pin (9), and the link arm assembly (8) into position in the body of the fuel pump. Install the return spring. Make sure that the ends of the return spring are in their correct positions.

3. Use a small hammer and a drift or a punch to install the retainers (10) in their grooves in the body of the fuel pump until they fasten the pin (9). Use a punch to close the ends of the grooves to fasten the retainers in position.

4. Install the diaphragm spring (12) into its position under the diaphragm (5). Put the spring seat washer (7) and the new stem seal (6) into position on the pull rod. Make sure that the small diameter at the top of the stem seal is on the round part of the pull rod.

5. Put the diaphragm assembly into position over the lower half of the body of the fuel pump. Align the blade of the pull rod with the slot in the link arm. Press down lightly on the diaphragm until the notch in the pull rod is in the slot in the link arm. Then turn the diaphragm 90° in either direction. This action will engage and retain the pull rod in the slot of the link arm.

6. Push the rocker arm towards the body of the fuel pump until the diaphragm is level the the flange half. Install the top half of the body in position. Align the reference marks. Keep the pressure on the rocker arm and install the lock washers and screws. Tighten the screws evenly around the circumference of the fuel pump.

7. Install the screen (2) and the cover (1). Make sure that the rubber seal is fitted correctly and tighten the screw that hold the cover.

### 1.148 Installation

1. See FIGURE 100. The lobe on the camshaft must be in the minimum lift position before the fuel pump is installed. Use a new gasket and install the fuel pump on the engine block. Install the lock plates and capscrews. Tighten the capscrews to 22 Nm (16 lbf ft).

2. Connect the fuel lines to the fuel pump. Install the heat shield.

3. Loosen the connection bolt on top of the filter as shown in FIGURE 96.

4. Operate the priming lever on the fuel pump until fuel, without air bubbles, comes from the loosened connection bolt. See (2 of 5) of FIGURE 96.

5. When the engine can be operated again, check for leaks.

FIGURE 118. If only the compressor is to be removed, remove the five capscrews that hold the compressor flange to the drive housing. Remove the other three capscrews that hold the compressor to the drive housing.

7. Remove the compressor from the drive housing or remove the compressor and its drive housing from the engine. Make sure that the alignment dowels are still in position.

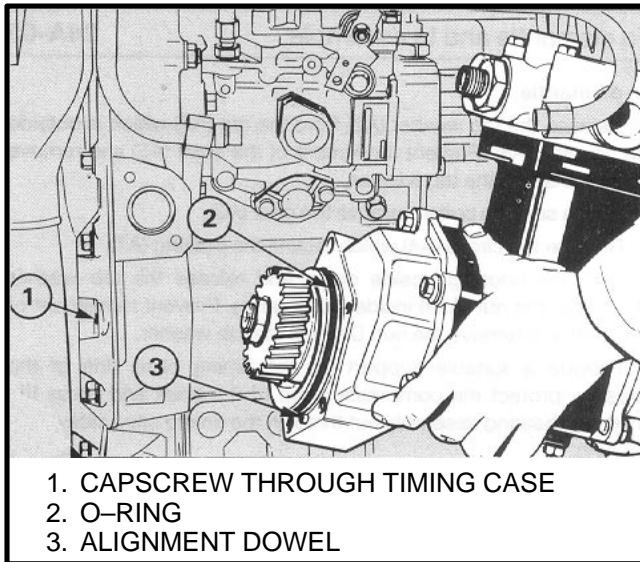


FIGURE 118. AIR COMPRESSOR REMOVAL AND INSTALLATION, WABCO

### 1.186 Compressor Drive, Inspection

Check the drive gears for wear and damage.

Check the bushing (1) for wear. See FIGURE 119.

**NOTE:** For The Disassembly And Assembly Of The Air Compressor, see the **SERVICE MANUAL** section for your air compressor.

### 1.187 Air Compressor, Installation, WABCO

1. If the drive housing has been removed, install a new O-ring (2) and lubricate it with clean engine oil. See FIGURE 118.

2. See FIGURE 118. or FIGURE 119. Make sure the alignment dowels are installed correctly. Install the compressor or the compressor and drive housing. Install and tighten the capscrews.

3. Install the support bracket for the compressor. Make sure that a side force is not applied to the compressor when the support bracket is installed.

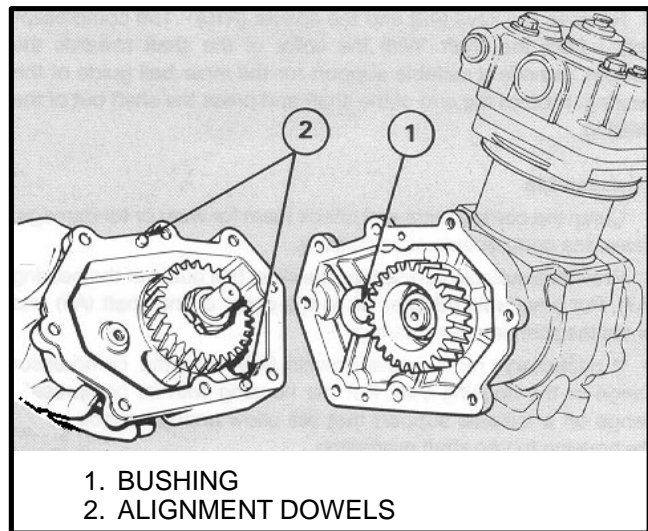


FIGURE 119. AIR COMPRESSOR, REMOVAL FROM THE DRIVE ASSEMBLY, WABCO

4. If an oil pump for the steering system is fastened to the back of the compressor housing, install it.

5. Install the oil pipe between the compressor and the engine block.

6. Install the pipe connections to the cylinder head of the compressor.

7. Fill the cooling system with correct coolant.

8. When the engine can be operated, check for leaks.

### 1.188 Compressor Drive, Disassembly, WABCO

1. See FIGURE 120. Raise the tabs on the lock washer (2). Hold the shaft so that it does not turn and remove the nut (1). Discard the lock washer (2).

**NOTE:** Some compressor drives do not have a lock washer (2). Loctite® thread adhesive is used to lock the nut (1) to the shaft (5).

2. Use a puller to remove the gear (3).

3. Remove the snap ring (4).

4. Raise the tabs on the lock washer (12). Hold the shaft so that it does not turn and remove the nut (13). Discard the lock washer (12).

**NOTE:** Some compressor drives do not have a lock washer (12). Loctite® thread adhesive is used to lock the nut (13) to the shaft (5).

5. Press the shaft (5) and bearing (7) from the side of the housing that fastens to the timing case.

After the crankshaft has been machined, remove any sharp edges from the oil holes for lubrication.

specifications. The finished sizes for machined crankshafts are shown in FIGURE 130.

Surface finish and fillet radii must be according to the

Item	Undersize		
	0.25 mm (0.010 in)	0.51 mm (0.020 in)	0.76 mm (0.030 in)
1	75.905 to 75.926 mm (2.9884 to 2.9892 in)	75.651 to 75.672 mm (2.9784 to 2.9792 in)	75.397 to 75.418 mm (2.9684 to 2.9692 in)
2	63.216 to 63.236 mm (2.4888 to 2.4896 in)	62.962 to 62.982 mm (2.4788 to 2.4796 in)	62.708 to 62.728 mm (2.4688 to 2.4696 in)
3	39.47 mm (1.554 in) maximum		
4	37.82 mm (1.489 in) maximum		
5	44.68 mm (1.759 in) maximum		
6	40.55 mm (1.759 in) maximum		
7	133.17 mm (5.243 in) maximum		
8	Do not machine this diameter		
9	3.68 to 3.96 mm (0.145 to 0.156 in)		

Surface finish for all bearing journals must be 0.4 microns (16 micro inches).  
Surface finish for all radii must be 1.3 microns (51 micro inches).

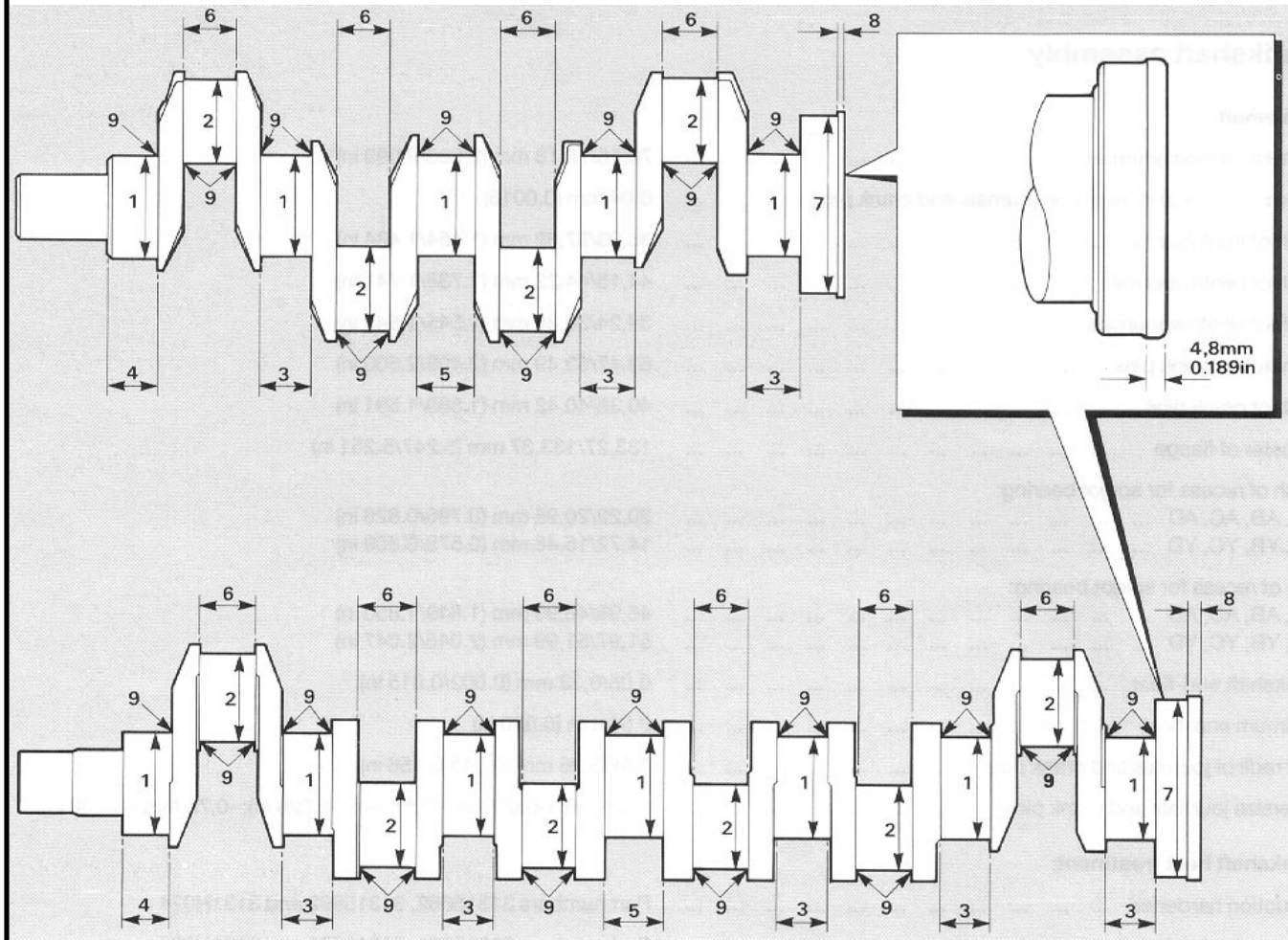
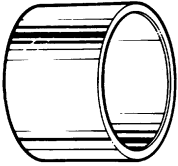

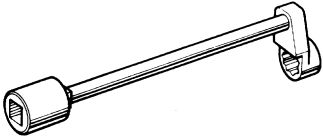
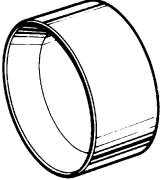

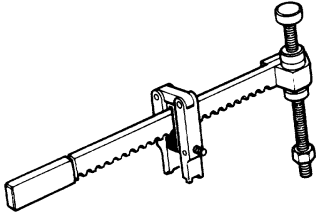
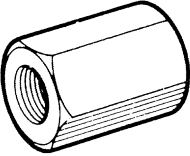
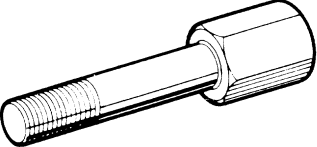
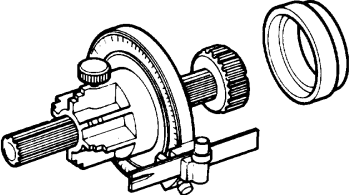


FIGURE 130. SPECIFICATIONS, CRANKSHAFT OVERHAUL

	<p><b>PD.170-3</b> Sleeve for use with PD.170.</p>
	<p><b>PD.170-4</b> Seal adaptor for use with PD.170.</p>
	<p><b>PD.199</b> Spanner (wrench) for flange nuts of fuel injection pump.</p>
	<p><b>PD.206</b> Replacement tool for pistons.</p>
	<p><b>PD.208</b> Dial gauge for use with PD.41D.</p>
	<p><b>PD.6118B</b> Valve spring compressor.</p>
	<p><b>PD.6118-7</b> Stud adaptor for use with PD.6118B.</p>
	<p><b>PD.6118-8</b> Capscrew adaptor for use with PD.6118B.</p>
	<p><b>MS67B</b> Timing gauge.</p>

## Direction Spool, Manual Control

This direction spool is actuated by the direction control lever. See Figure 8. The spool has three positions: **FORWARD**, **NEUTRAL**, and **REVERSE**. The spool is held in each position by a detent ball. The spool actuates the neutral start switch. The oil flow to the direction spool comes from the inching spool. There is no oil flow past the direction spool when the spool is in the **NEUTRAL** position. When the spool is moved to **FORWARD** or **REVERSE**, oil flows to the accumulator through the drain spool, the modulation spool and the forward or reverse clutch.

## Direction Spool, MONOTROL Pedal

**NOTE:** Applying the parking brake actuates a switch that de-energizes the Forward and Reverse solenoids.

This direction spool is actuated by the oil flow from two solenoids installed on the top of the control valve. See Figure 8. The spool has three positions: **FORWARD**, **NEUTRAL**, and **REVERSE**. The spool is held in the **NEUTRAL** position by a spring arrangement. The oil flow to the Forward and Reverse solenoids comes from the inching spool. There is no oil flow past the direction spool when the spool is in the **NEUTRAL** position. When the spool is actuated by one of the solenoids, oil flows to the accumulator through the drain spool, the modulation spool, and the forward or reverse clutch.

## Modulation Spool

The modulation spool works with the drain spool orifice to control the movement of the accumulator. See Figure 8. The oil flow that goes through the drain spool also pressurizes the modulation spool. The oil pressure can push against the modulation spool to open the drain passage. Oil that is not needed for modulation of the clutch assemblies flows through the drain passage.

Figure 9 shows the pressure change in the modulation circuit when a clutch is being applied.

## Accumulator

The accumulator is used to slow the ratio of clutch engagement. See Figure 8. This delay reduces the shock and stress to the drive train when engaging

the transmission or changing the direction of travel. When a clutch is engaged, the oil flow for the clutch must go to the accumulator and fill the chamber. The time it takes for the accumulator to fill controls the time it takes for the clutch to engage.

## Drain Spool

The drain spool is a spool and spring assembly that controls the flow of oil to and from the accumulator. See Figure 8. When a direction change is occurring, oil flows through an orifice in the drain spool and then flows to the accumulator. As the chamber for the accumulator fills, the oil pressure is adjusted by the modulation spool. When a direction change first starts, pressure to the drain spool decreases. The spring pressure of the accumulator causes the accumulator spool to push the oil from the cavity. The oil from the accumulator pushes the drain spool against its spring, letting the oil flow to the drain circuit.

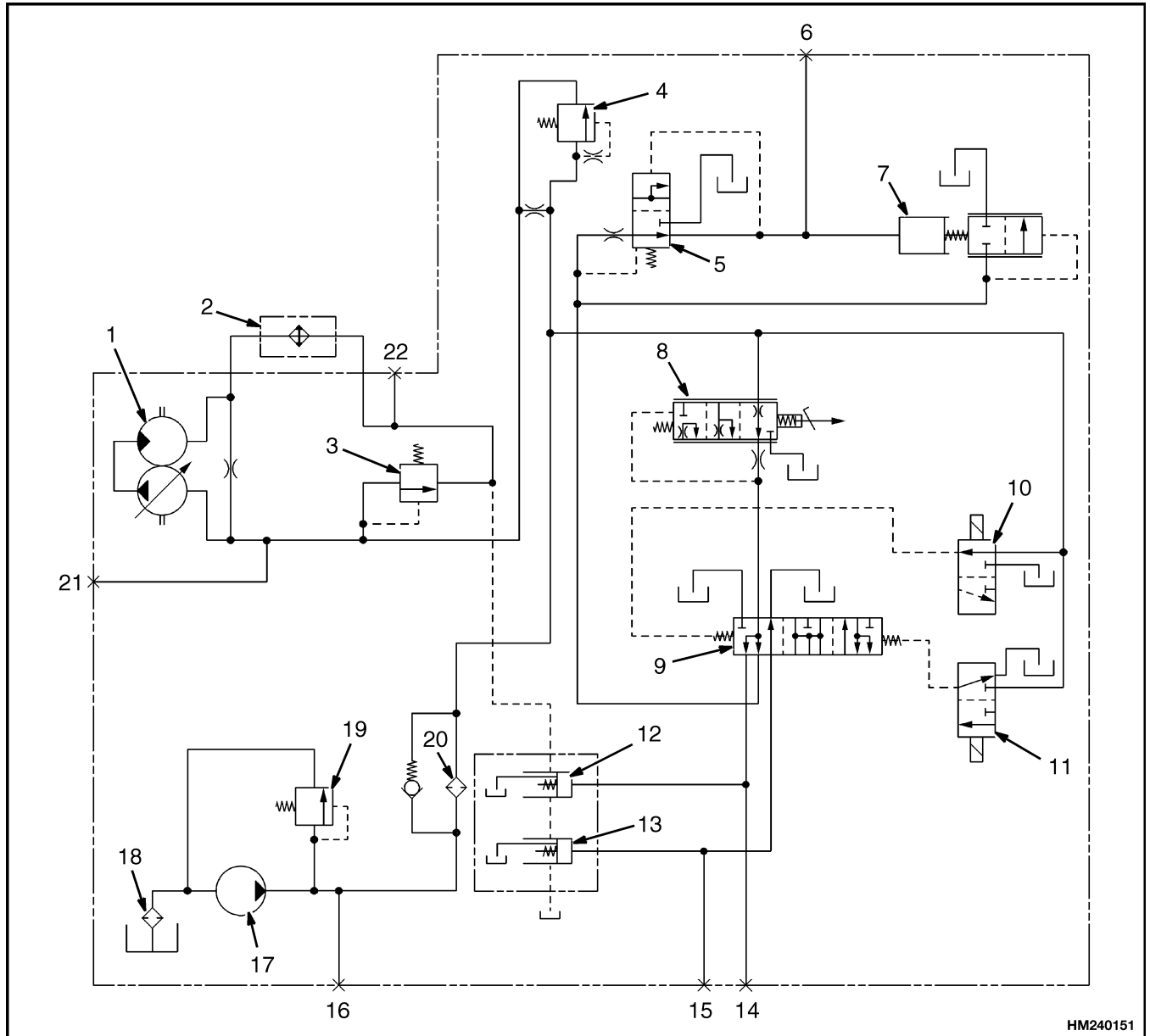
## MONOTROL PEDAL

**NOTE:** The information below for the MONOTROL pedal applies to early model S3.50-5.50XL (S70-120XL) (D004) lift trucks.

The MONOTROL pedal controls the speed of the engine and the operation of the direction spool. See Figure 10 and Figure 11. The pedal pad is held to the pedal frame by a pivot shaft. The pedal pad rotates on the shaft and is held in the **FORWARD** or **REVERSE** position by magnets in the pedal frame. There are two switches in the MONOTROL pedal assembly. A switch on the cowl is actuated by the parking brake lever. The operation of this switch controls the flow of battery power to the MONOTROL pedal switches and the starter circuit. When the parking brake is applied, the starter circuit is energized and the MONOTROL circuit is de-energized. When the parking brake is released, the MONOTROL circuit is energized and the starter circuit is de-energized. The engine can only be started after applying the parking brake or depressing the inching/brake pedal. When the MONOTROL pedal is in the **FORWARD** position, both pedal switch buttons are actuated. Battery power flows through both pedal switches to energize the Forward solenoid. When the MONOTROL pedal is in the **REVERSE** position, both pedal switch buttons are released. Battery power flows through both pedal switches to energize the Reverse solenoid.

*Legend for Figure 17*

- |                                |                                     |
|--------------------------------|-------------------------------------|
| 1. TRANSMISSION HOUSING        | 14. REVERSE CLUTCH                  |
| 2. OIL PUMP                    | 15. FORWARD SOLENOID                |
| 3. CONTROL VALVE               | 16. REVERSE SOLENOID                |
| 4. OIL FILTER                  | 17. MODULATION SPOOL                |
| 5. TORQUE CONVERTER            | 18. ACCUMULATOR                     |
| 6. OIL COOLER                  | 19. DRAIN SPOOL                     |
| 7. COLD OIL RELIEF             | 20. MODULATION CHECK PORT           |
| 8. SYSTEM REGULATOR            | 21. LUBRICATION PRESSURE CHECK PORT |
| 9. CLUTCH REGULATOR            | 22. FORWARD CLUTCH CHECK PORT       |
| 10. TORQUE CONVERTER REGULATOR | 23. REVERSE CLUTCH CHECK PORT       |
| 11. INCHING SPOOL              | 24. TORQUE CONVERTER CHECK PORT     |
| 12. DIRECTION SPOOL            | 25. SYSTEM PRESSURE CHECK PORT      |
| 13. FORWARD CLUTCH             |                                     |

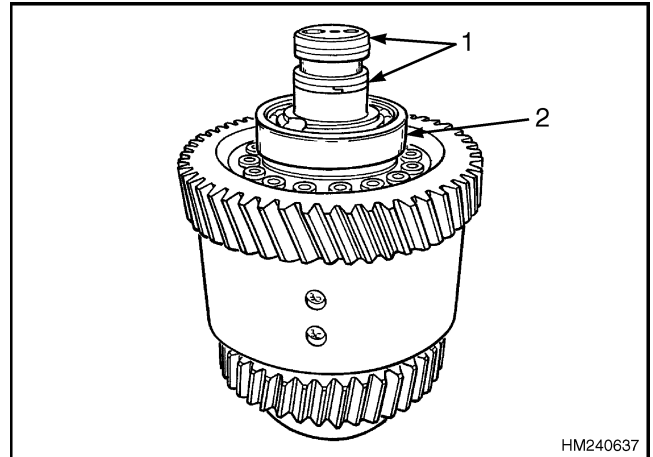


- |                               |                                     |
|-------------------------------|-------------------------------------|
| 1. TORQUE CONVERTER           | 12. REVERSE CLUTCH                  |
| 2. OIL COOLER                 | 13. FORWARD CLUTCH                  |
| 3. TORQUE CONVERTER REGULATOR | 14. REVERSE CHECK PORT              |
| 4. CLUTCH PRESSURE REGULATOR  | 15. FORWARD CHECK PORT              |
| 5. QUICK DUMP VALVE           | 16. PUMP PRESSURE CHECK PORT        |
| 6. MODULATOR CHECK PORT       | 17. PUMP                            |
| 7. MODULATOR REGULATOR        | 18. SCREEN                          |
| 8. INCHING SPOOL              | 19. PUMP RELIEF VALVE               |
| 9. DIRECTION SPOOL            | 20. OIL FILTER                      |
| 10. REVERSE SOLENOID          | 21. TORQUE CONVERTER CHECK PORT     |
| 11. FORWARD SOLENOID          | 22. LUBRICATION PRESSURE CHECK PORT |

**Figure 24. Hydraulic Schematic for Reverse S3.50-5.50XL (S70-120XL) and S3.50-5.50XM (S70-120XM) (Later Model)**

**STEP 5.**

Remove seal rings from shaft. Remove bearing from shaft.



1. SEAL RING
2. BEARING

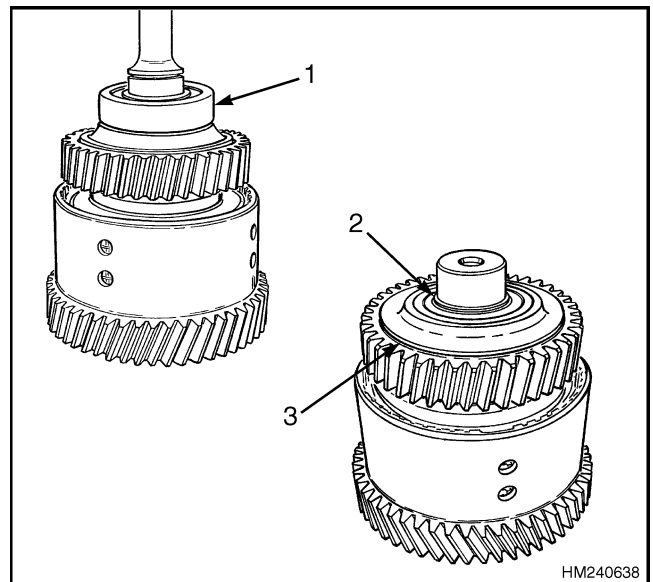
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**Reverse Clutch, Disassemble**

Disassemble reverse shaft as follows:

**STEP 1.**

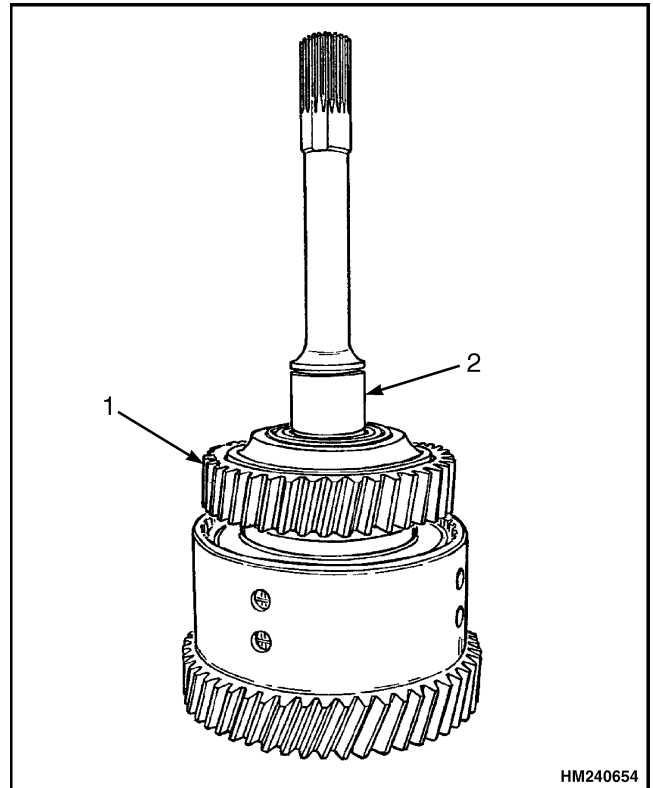
Put clutch housing in vise. Pull bearing from shaft. Remove snap ring that holds bearing for hub on shaft. Remove clutch hub from shaft.



1. BEARING
2. SNAP RING
3. HUB

**STEP 6.**

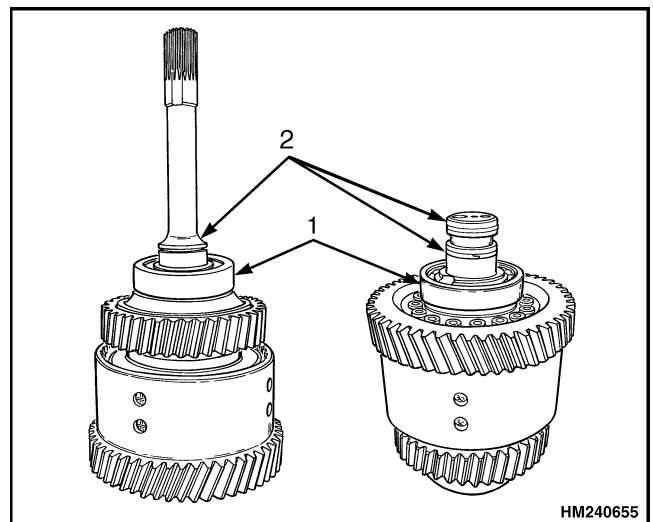
Install hub on shaft. Make sure teeth on hub align with all friction discs. Install snap ring on shaft.



1. HUB
2. SNAP RING

**STEP 7.**

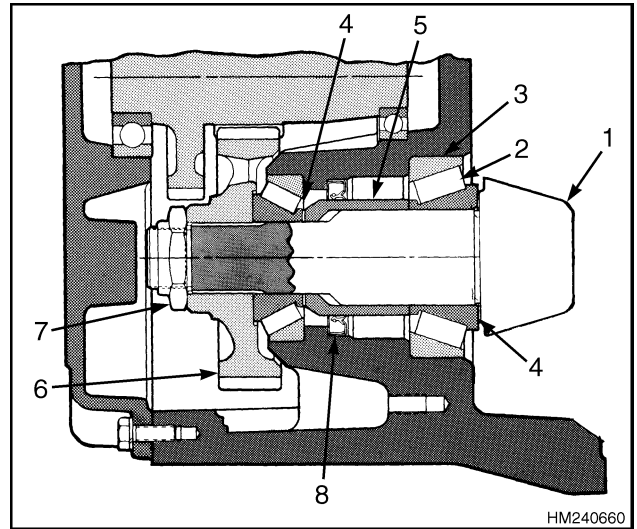
Install bearings on both ends of shaft. Install seal rings on shaft. Make sure ends of seal rings are connected together.



1. BEARINGS
2. SEAL RINGS

**STEP 2.**

If the same ring and pinion and pinion bearings are to be installed again, use the same shim and spacer arrangement that was removed. If a new ring gear and pinion or new bearings must be installed, see the instructions in STEP 3 for installation of a new pinion assembly.



1. PINION
2. BEARING CONE
3. BEARING CUP
4. SHIM
5. SPACER
6. OUTPUT GEAR
7. NUT
8. OIL SEAL

**STEP 3.**

Install bearing cups for pinion in transmission housing. Do not install oil seal at this time. Install shims on pinion. Use a press to install bearing cone on pinion. Install pinion in transmission housing. Install spacer, shim, and bearing cone on pinion. Install output gear and nut.

**NOTE:** The special nut for the output gear can be used only once. The installation and removal of the special nut several times can damage the threads on the pinion. When making adjustments, use a nut with tapered end removed. When adjustment is correct, install new nut.

**STEP 4.**

Tighten nut for output gear to 750 N•m (550 lbf ft). Check rotating torque of pinion caused by preload on bearings. The limits are 1.7 to 3.4 N•m (15 to 30 lbf in). Add or remove shims between spacer and bearing cone near output gear to adjust bearing preload. When adjustment is correct, check adjustment of ring gear and pinion as described in STEP 5 through STEP 12.

**STEP 5.**

The ring gear and pinion are made in sets. Both the ring gear and pinion must have the same number. The adjustments of the ring gear and pinion are correct when the gear clearance, contact pattern, and bearing preload are correct.

**STEP 6.**

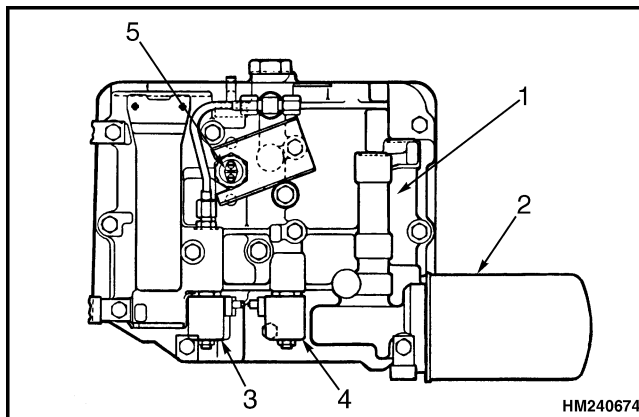
The dimension on the end of the pinion is the variation from the standard Gauge Distance. The Gauge Distance is the distance from the center of the ring gear to the bearing shoulder behind the pinion. Shims must be added between the pinion and the outer bearing cone to adjust for manufacturing tolerances.

## Control Valve Repair

### REMOVE, EARLY MODEL S3.50-5.50XL (S70-120XL) LIFT TRUCKS

**NOTE:** The procedures described below for removing the control valve pertain to early model S3.50-5.50XL (S70-120XL) (D004) lift trucks. To remove the control valve for later model S3.50-5.50XL (S70-120XL) (D004) lift trucks and for S3.50-5.50XM (S70-120XM) (E004, F004) lift trucks, see the Remove and Disassemble, Later Model S3.50-5.50XL (S70-120XL) Trucks and S3.50-5.50XM (S70-120XM) Lift Truck Models section.

1. Disconnect linkages at spools. Disconnect wires at switch on control valve. Disconnect return line for oil cooler at control valve.
2. Remove oil filter from control valve. If transmission has a MONOTROL pedal, remove solenoid assemblies. Remove capscrews holding control valve to transmission. See Figure 6.



- |                     |                         |
|---------------------|-------------------------|
| 1. CONTROL VALVE    | 4. FORWARD SOLENOID     |
| 2. OIL FILTER       | 5. NEUTRAL START SWITCH |
| 3. REVERSE SOLENOID |                         |

**Figure 6. Control Valve With MONOTROL Control**

### DISASSEMBLE, EARLY MODEL S3.50-5.50XL (S70-120XL) LIFT TRUCKS

**NOTE:** The procedures described below for disassembling the control valve pertain to early model S3.50-5.50XL (S70-120XL) (D004) lift trucks. To disassemble the control valve for later model S3.50-5.50XL (S70-120XL) (D004) lift trucks and for S3.50-5.50XM (S70-120XM) (E004, F004) lift trucks, see Remove and Disassemble, Later

Model S3.50-5.50XL (S70-120XL) Trucks and S3.50-5.50XM (S70-120XM) Lift Truck Models section.

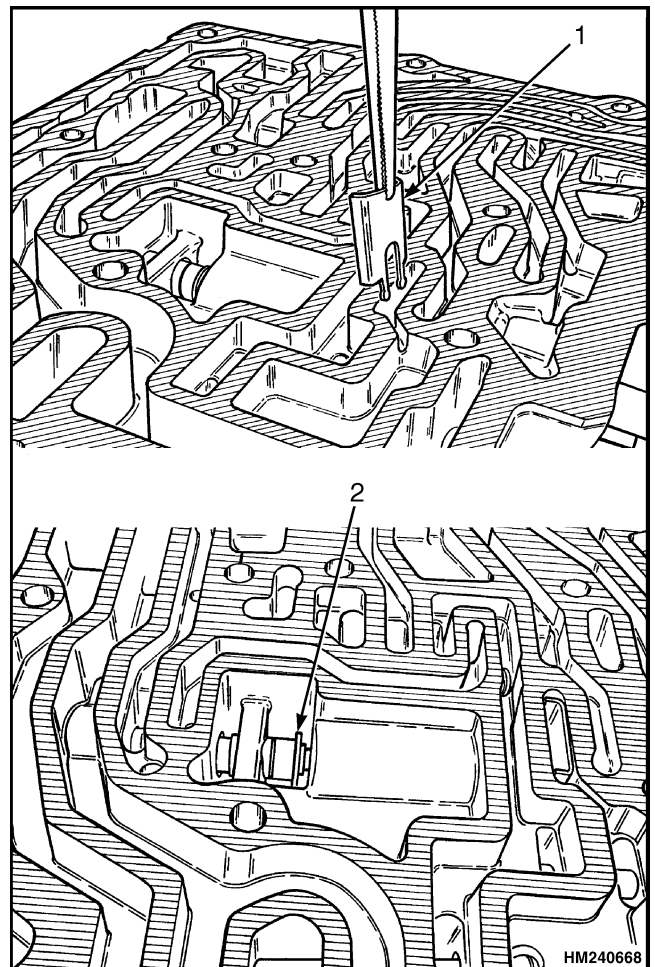
**NOTE:** Make sure the area for disassembling the control valve is clean. Keep parts from each bore together.



#### WARNING

The springs behind the plugs in the control valve can release quickly when the plugs are removed. Be careful when disassembling the control valve.

1. Remove stop for inching plunger and direction spool (manual control). See Figure 7.



1. STOP FOR INCHING PLUNGER
2. WASHER FOR INCHING SPOOL

**Figure 7. Control Valve Stops**

shown in Figure 15. Loosen lock nut and rotate screw for magnet counterclockwise until it stops. Set dial indicator to zero. Rotate screw for magnet clockwise until gauge needle moves 0.25 mm (0.01 in.) from zero. This adjustment makes sure magnet is in contact with plate in pedal pad. Rotate screw for magnet counterclockwise until gauge needle indicates zero. Rotate screw for magnet clockwise until gauge needle indicates 0.05 mm (0.002 in.) movement. Tighten lock nut to 5.2 N•m (46 lbf in) without changing adjustment.

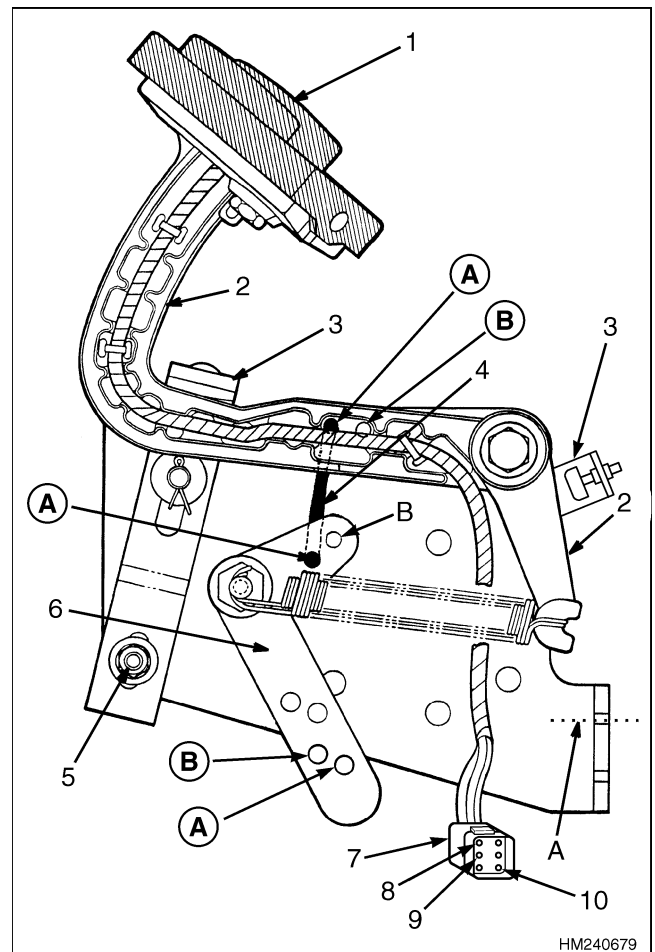
- d. Use an ohmmeter to check operation of switches. When **FORWARD** side of pedal is depressed, there must be a complete circuit between red (battery) and black (forward solenoid) wires. When **REVERSE** side of pedal is depressed, there must be a complete circuit between red (battery) and yellow (reverse solenoid) wires.
- e. Push on **FORWARD** side of pedal. Place dial indicator on **FORWARD** side of pedal pad as shown. Connect an ohmmeter between red and black wires. Check that there is a complete circuit between wires. Push on **REVERSE** side of pedal. Pedal must move 1.00 mm (0.039 in.) minimum from **FORWARD** position before circuit is disconnected.

**NOTE:** It is important for correct operation of MONOTROL pedal that magnets have correct strength.

4. Test strength of magnets as follows (see Figure 16):
  - a. Place pedal assembly in vise. Use spring scale to change pedal from **FORWARD** and **REVERSE** positions as shown in Figure 16.
  - b. When pushing on spring scale, it must take 13.3 to 31.1 N (3.6 to 7.0 lbf) to change from **FORWARD** to **REVERSE** and **REVERSE** to **FORWARD** positions. If force is not within specifications, replace magnet(s).
5. With pad located in either **FORWARD** or **REVERSE**, check to assure a minimum of 2.0 mm (0.079 in.) total pad travel when changed to opposite position. If 2.0 mm (0.079 in.) is not obtained, do adjustment again. If 2.0 mm

(0.079 in.) is still not obtained, replace pedal pad.

6. Install capscrew, washers, tube, and nut that hold pedal assembly to bracket. Connect link between pedal and crank as shown in Figure 18.
7. Install pedal return springs. Make sure throttle cable is connected to correct position as shown in Figure 18.



- A.** GASOLINE TRUCKS  
**B.** LPG/DIESEL TRUCKS

- |                      |                                  |
|----------------------|----------------------------------|
| 1. PEDAL PAD         | 8. REVERSE SOLENOID (WHITE WIRE) |
| 2. PEDAL FRAME       | 9. FORWARD SOLENOID (GREEN WIRE) |
| 3. PEDAL RETURN STOP | 10. BATTERY (RED WIRE)           |
| 4. LINK              |                                  |
| 5. CAPSCREW          |                                  |
| 6. CRANK             |                                  |
| 7. SWITCH CONNECTOR  |                                  |

**Figure 18. MONOTROL Pedal, S3.50-5.50XM (S70-120XM) Lift Trucks**

**Table 3. Transmission Oil Pressure Check, Early Model S3.50-5.50XL (S70-120XL) Lift Trucks**

Port No.	Transmission Pressures*	
	1	System Pressure
2	Torque Converter Pressure	765 to 903 kPa (111 to 131 psi)
3	Clutch Pressure	827 to 965 kPa (120 to 140 psi)
4,5	Solenoid Pressure	927 to 1003 kPa (134 to 145 psi)
6,7	Lubrication Pressure	96 to 138 kPa (14 to 20 psi)

\*Oil temperature is at least 82°C (180°F) and engine speed at 2000 rpm.

**CLUTCH PRESSURE CHECK PORT**

There is a common check port for both clutch assemblies. With engine running at 2000 rpm, correct reading at common check port is 827 to 965 kPa (120 to 140 psi). Pressure at each of the four clutch check ports is the same. Pressure difference between the four check ports must not be more than 69 kPa (10 psi). If any pressures are not correct, see Troubleshooting procedures.

**INCHING PRESSURE**

Use gauge at common clutch check port. With engine running at 2000 rpm, push on inching pedal. Pressure at gauge will drop quickly from clutch pressure of 927 to 1003 kPa (134 to 145 psi) to 476 to 558 kPa (69 to 81 psi). As inching pedal is depressed further, pressure will continue to decrease. When inching pedal is completely depressed, pressure will be zero. If inching function does not work correctly, see Troubleshooting procedures.

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This section is for the following models:  
Delco Starters used on Hyster Lift Trucks

PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
The starter makes too much noise.	The solenoid has damage.	Replace solenoid.
	The ring gear has damage.	Install new parts.
	The drive clutch has damage.	Install new parts.
	The battery is discharged or has damage.	Recharge or replace battery.
	The starter brushes are worn or dirty.	Replace brushes.

**STEERING AXLE H6.00-7.00XL (H135-155XL, H135-155XL<sub>2</sub>) (F006, G006), H8.00-16.00XL (H165-360XL) (D019, E007), AND H8.00-12.00XM (H170-280HD) (F007, G007, H007), H13.00-14.00XM (H300-330HD) (E019, F019, G019), H16.00XM-6 (H360HD) (E019, F019, G019), H10.00-12.00XM-12EC (H360HD-EC) (E019, F019, G019)**

## Remove



### WARNING

Put the lift truck on blocks. Follow the procedures for raising the lift truck described in the Operating Manual for this lift truck. The surface must be solid, even, and level. Make sure the blocks are solid, one-piece units. Make sure the lifting devices used during repairs can lift the weight of the parts.

The steering axle can be removed without removing the counterweight.

1. Make sure wheels are set for straight travel. Put blocks under frame in front of steer wheels, so steering axle can be removed. Top of axle frame must have clearance under counterweight so steering axle can be removed.
2. It is not required, but it can make removal of the axle easier if the wheels are removed. Disconnect hydraulic lines at steering cylinder. Install caps on cylinder and put plugs in hydraulic lines. Caps will prevent spindles from turning when axle is removed from under the lift truck.
3. Remove two dust covers from openings of bearing caps.
4. Slide a floor jack or forks of another lift truck under steering axle. Raise lifting device until it holds weight of axle assembly. Remove four capscrews and washers that fasten two bearing caps to frame. Remove bearing caps and slowly lower axle assembly. Carefully remove axle assembly from under lift truck.

## Install



### WARNING

Excessive play in the pivot bushings will result in increased shock loadings to the pivot pins and increased movement of the axle, and may affect steering responsiveness. If movement in the pivot bushings is more than 4 mm (0.16 in.), or damage to the O-ring seals exists, replace the bushings, flanges, and O-rings.

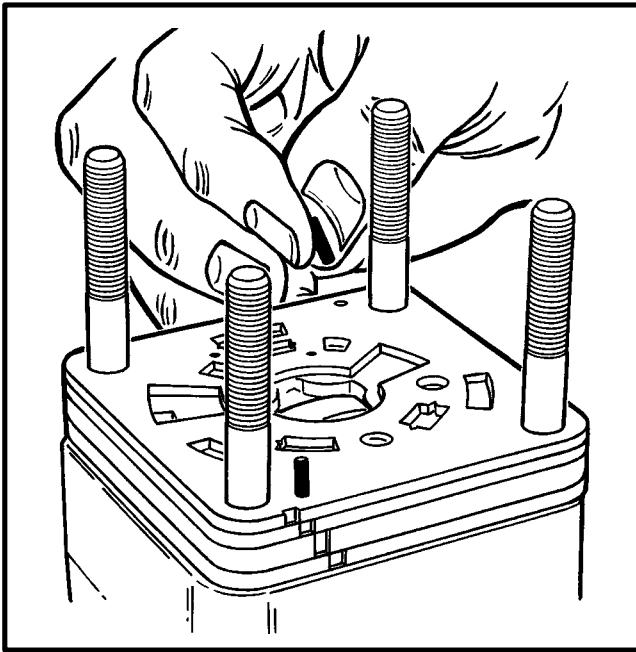
1. Install O-ring, spacer, and shims on each pivot shaft. Lubricate pivot shafts with multipurpose grease and install fiber bushing. See Figure 2 and Figure 4.
2. Use a floor jack or another lift truck to put steering axle into position in frame. Make sure fiber bushings fit into mounts of frame.
3. Install bearing caps.

**H6.00-7.00XL (H135-155XL, H135-155XL<sub>2</sub>) (F006, G006) units.** Tighten capscrews to 320 N•m (236 lbf ft).

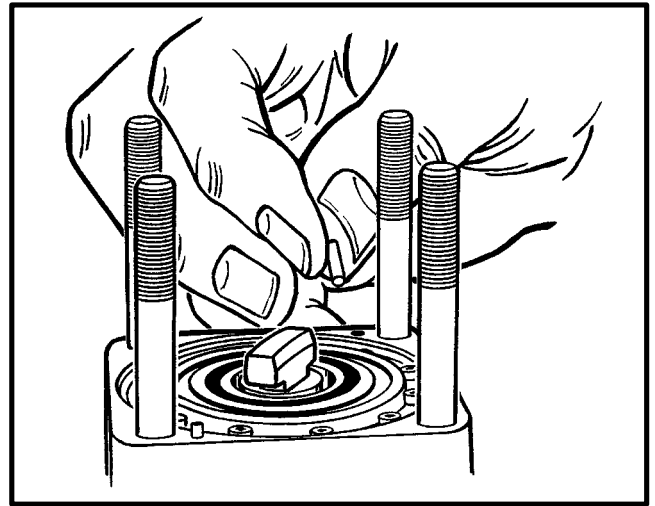
**H8.00-16.00XL (H165-360XL) (D019, E007), and H8.00-12.00XM (H170-280HD) (F007, G007, H007), H13.00-14.00XM (H300-330HD) (E019, F019, G019), H16.00XM-6 (H360HD) (E019, F019, G019), H10.00-12.00XM-12EC (H360HD-EC) (E019, F019, G019) units.** Tighten capscrews to 380 N•m (280 lbf ft). After installation, make sure there is zero clearance between shims and frame. Add or remove shims as necessary to get zero clearance.

4. Install dust covers in openings of bearing caps.
5. Remove plugs and caps, and connect hydraulic lines to steering cylinder. Install wheels if they were removed.
6. Operate steering system to remove air from system. Turn steering wheel several times from one wheel stop to other wheel stop. Check for hydraulic leaks.

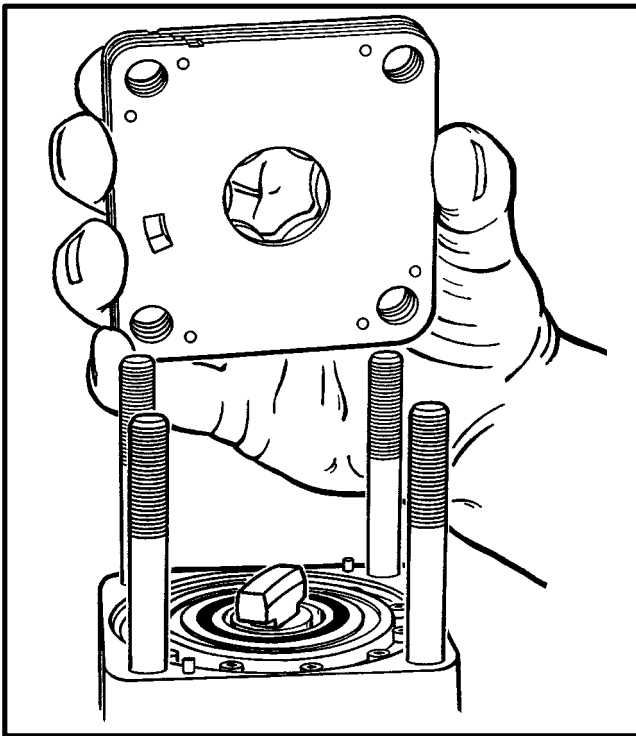
PROBLEM	POSSIBLE CAUSE	PROCEDURE OR ACTION
Slow or difficult steering.	Relief valve for the steering system needs adjustment.	Adjust or install new relief valve.
	Low oil pressure from the hydraulic pump.	Check for restrictions. See Troubleshooting Chart in the <b>Hydraulic System</b> SRM for your lift truck.
	Seal in the steering cylinder has a leak.	Install new seal.
	Steering control unit is worn or has damage.	Repair or install new control unit.
Steering wheel turns the tires in the wrong direction.	The hydraulic lines are not connected correctly at the steering cylinder or at the steering control unit.	Connect lines properly. Remove air from system.
Steering function continues after the steering wheel stops.	The steering control unit was assembled wrong or has damage.	Repair or install new control unit.
There is air in the steering system.	The oil level in the tank is low.	Add hydraulic oil as necessary. Check for leaks.
	Air was not removed after repair to the hydraulic or steering system.	Remove air from system.
	The hydraulic pump has an air leak at the inlet.	Repair system. Remove air from system.



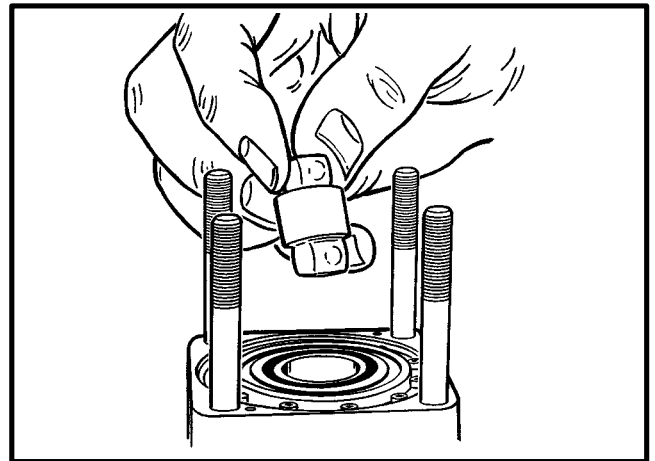
11. Remove the two alignment pins (11) that align the port manifold, valve ring, and isolator manifold.



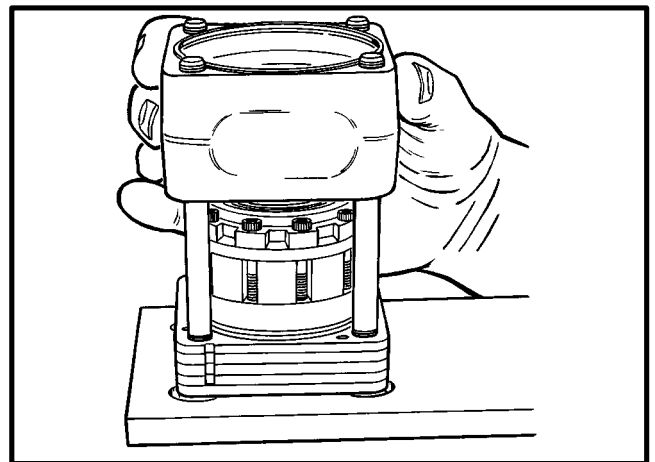
13. Remove the two alignment pins from the metering ring.



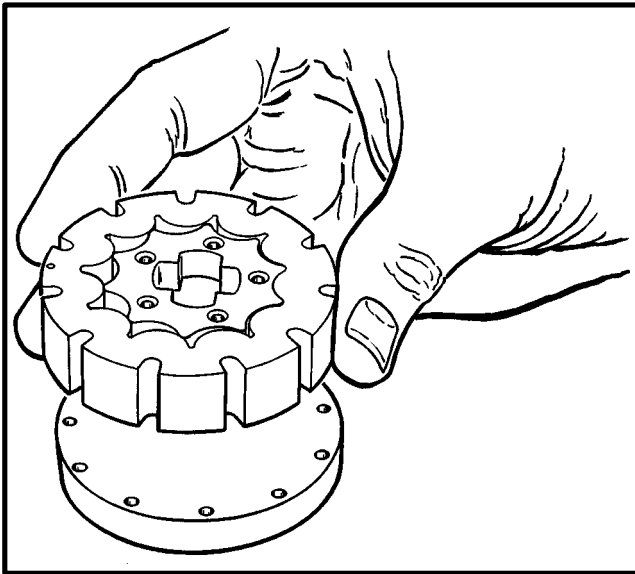
12. Remove the isolator manifold (15). Inspect the surfaces of the isolation manifold. The rotation of the valve plate will normally polish a pattern in the isolator manifold. A similar pattern will be on the opposite side of the isolator manifold caused by the commutator cover. An acceptable part can have this pattern if there are not scratches, grooves, or other damage.



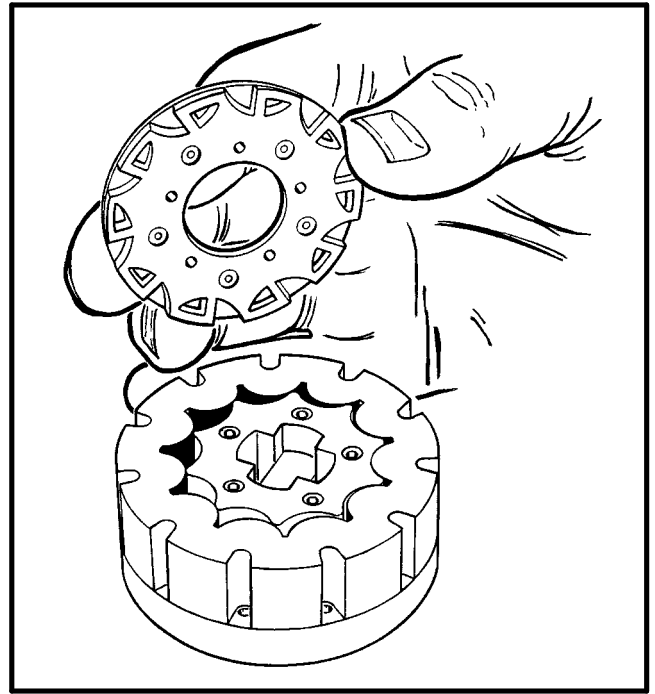
14. Remove the drive link (16). Inspect the ends of the drive link for wear. The four contact surfaces can not have wear or have grooves. Replace a worn drive link.



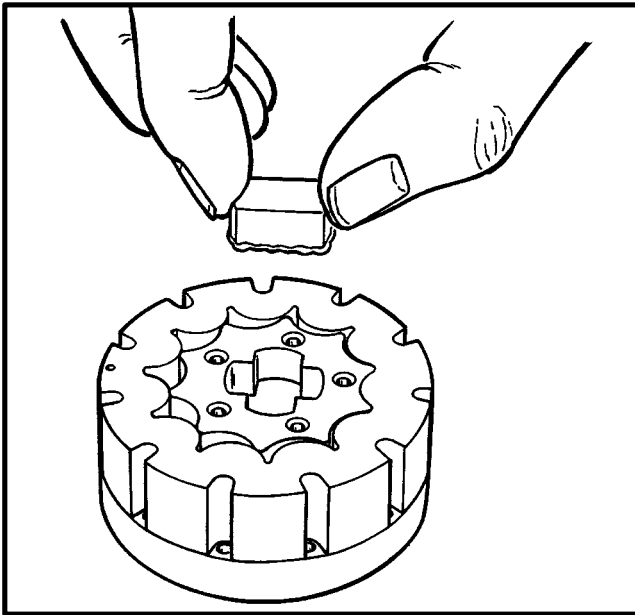
15. Remove the metering ring (17). Discard the two seal rings (3). Inspect the bore of the metering ring for grooves. Replace a worn metering ring.



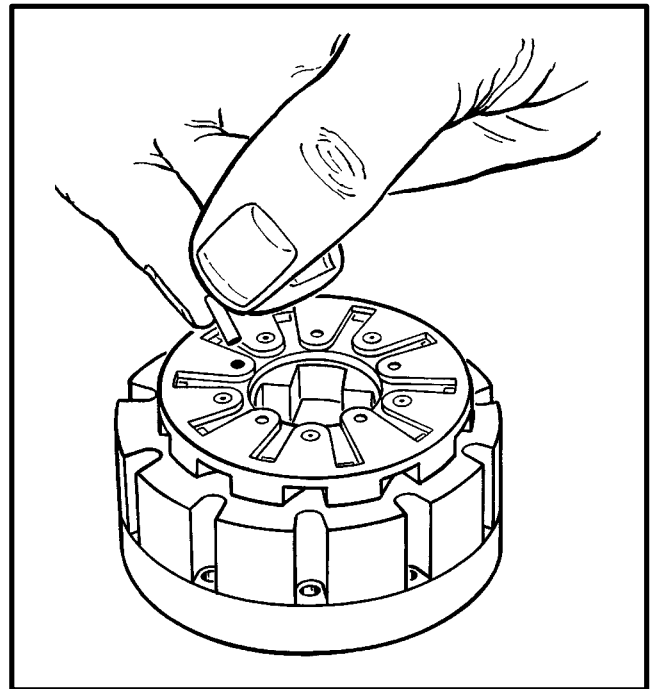
13. Assemble the metering assembly. Put the drive plate (26) on a clean surface. Put the rotor assembly on the drive plate. Align the 11 slots with the threaded holes in the drive plate.



15. Put the commutator (22) on top of the rotor. Align the five holes for the alignment pins.



14. Apply a small amount of grease to the spacer (23) and install it in the drive slot of the rotor. The purpose of the grease is to hold the parts in position during assembly.



16. Install the alignment pins. Make sure that the alignment pins are below the surface of the commutator.

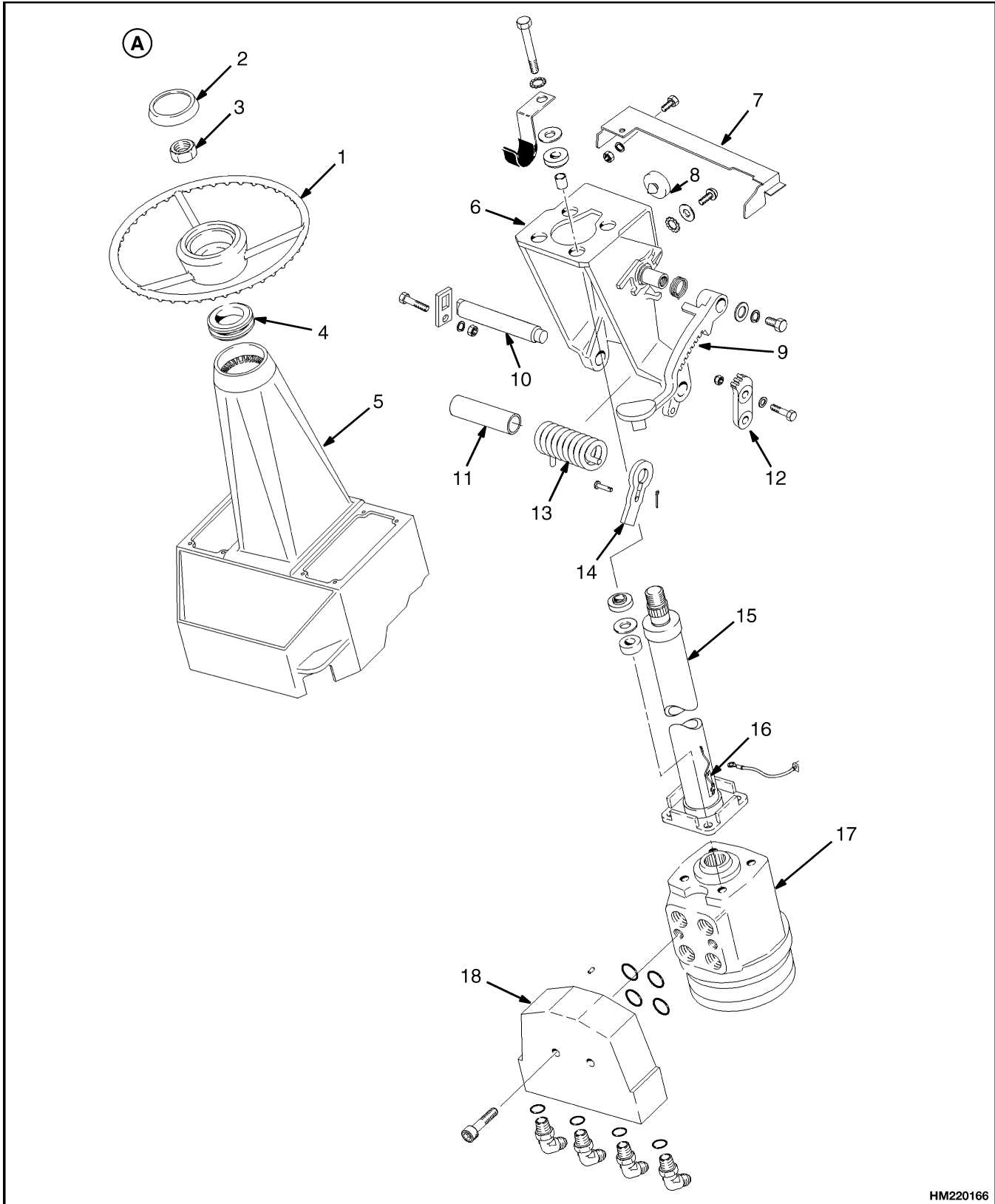
## TROUBLESHOOTING

** CAUTION**

**Temperatures greater than 93°C (200°F) will cause damage to the seals and cause leaks.**

**NOTE:** This Troubleshooting is only for the steering control unit and does not include the steering system. Make sure the steering system is correct before doing the troubleshooting for the steering control unit.

TROUBLE	POSSIBLE CAUSE	PROCEDURE OR ACTION
The steering wheels do not move when the steering wheel is turned.	The oil level is low or there is no oil in the tank. The steering control unit is damaged. No oil flow from the steering control unit to the steering cylinder. The sleeve and spool in the control unit will not move. Hydraulic hoses not connected or have damage.	Fill tank to the correct level. Check for leaks. Repair or install new control unit. Repair or install new components. Check for leaks. Install new components.  Check for leaks. Tighten connections. Install new components as necessary.
Slow or difficult steering.	Relief valve for the steering system is not adjusted correctly. Low oil pressure from the hydraulic pump. Seal in the steering cylinder has a leak. Hydraulic lines are too small or have restrictions. Steering control unit is worn, not assembled correctly or has damage.	Adjust or install new relief valve.  Check for restrictions. See Troubleshooting Chart, "Hydraulic System". Repair cylinder. Install new seal or new cylinder. Remove restrictions. Install larger or new hydraulic lines. Repair or install new control unit.
Steering wheel turns the tires in the wrong direction.	The hydraulic lines are not connected correctly at the steering cylinder or at the steering control unit.	Connect lines correctly. Remove air from the system.
Steering function continues after the steering wheel stops.	The steering control unit is assembled wrong or has damage.	Repair or install new control unit.
The steering operation is not smooth.	The oil level in the tank is low. Air was not removed after repair to the hydraulic system. The steering control unit is assembled wrong or has damage. The hydraulic pump has a leak at the inlet.	Fill tank. Check for leaks. Remove air from the system.  Repair or install new control unit.  Fix leaks. Remove air from the system.

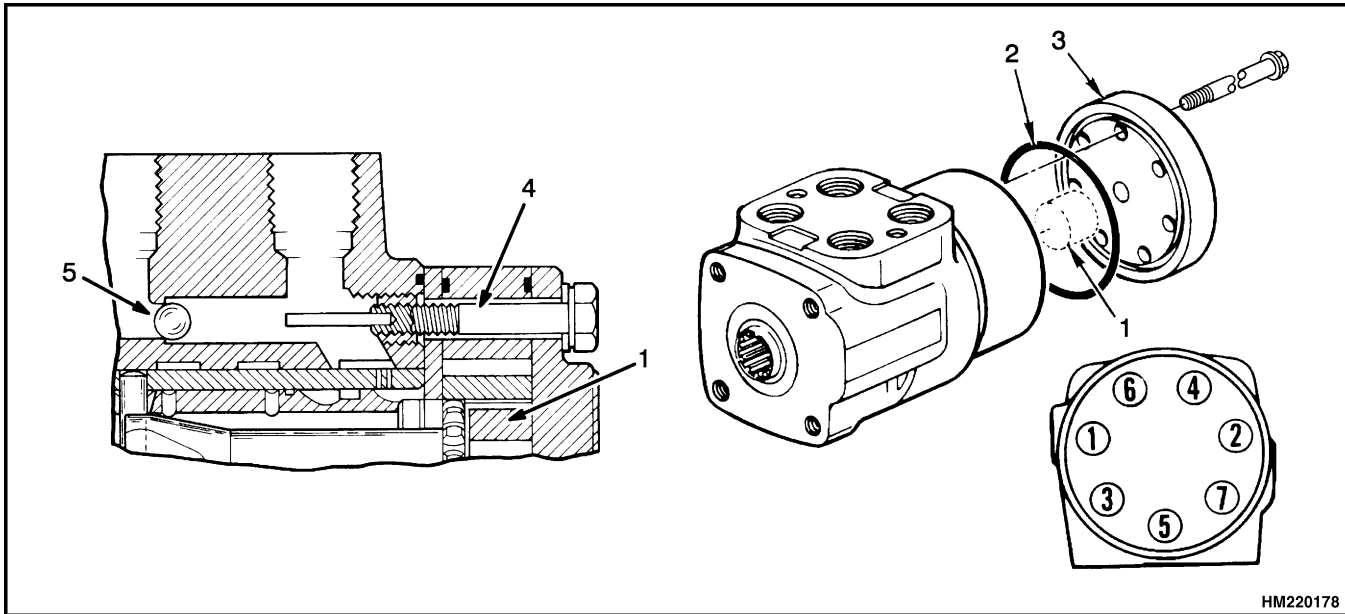


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Figure 4. Steering Wheel and Steering Column Assembly

**STEP 8.**

When used, install the spacer. Install the O-ring and the cover. Tighten the capscrews for the cover in the sequence shown to 17 N•m (150 lbf in); then tighten them to 30 N•m (265 lbf in). Make sure the capscrew with the pin fits in the hole for the check ball.

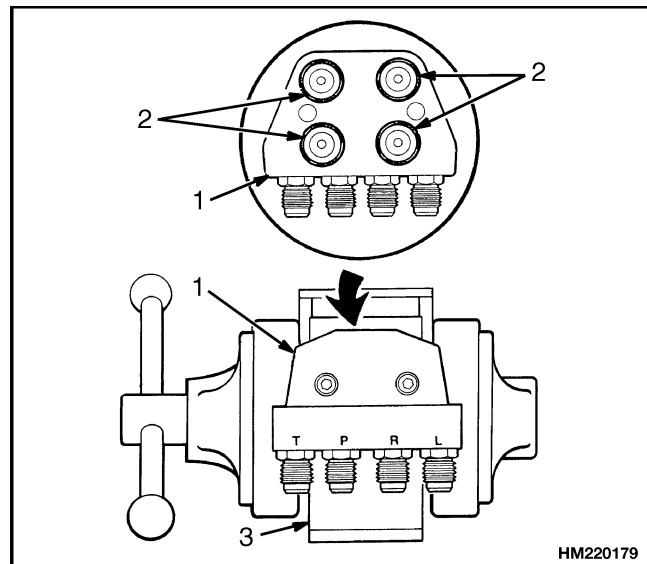


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- |           |               |
|-----------|---------------|
| 1. SPACER | 4. CAPSCREW   |
| 2. O-RING | 5. CHECK BALL |
| 3. COVER  |               |

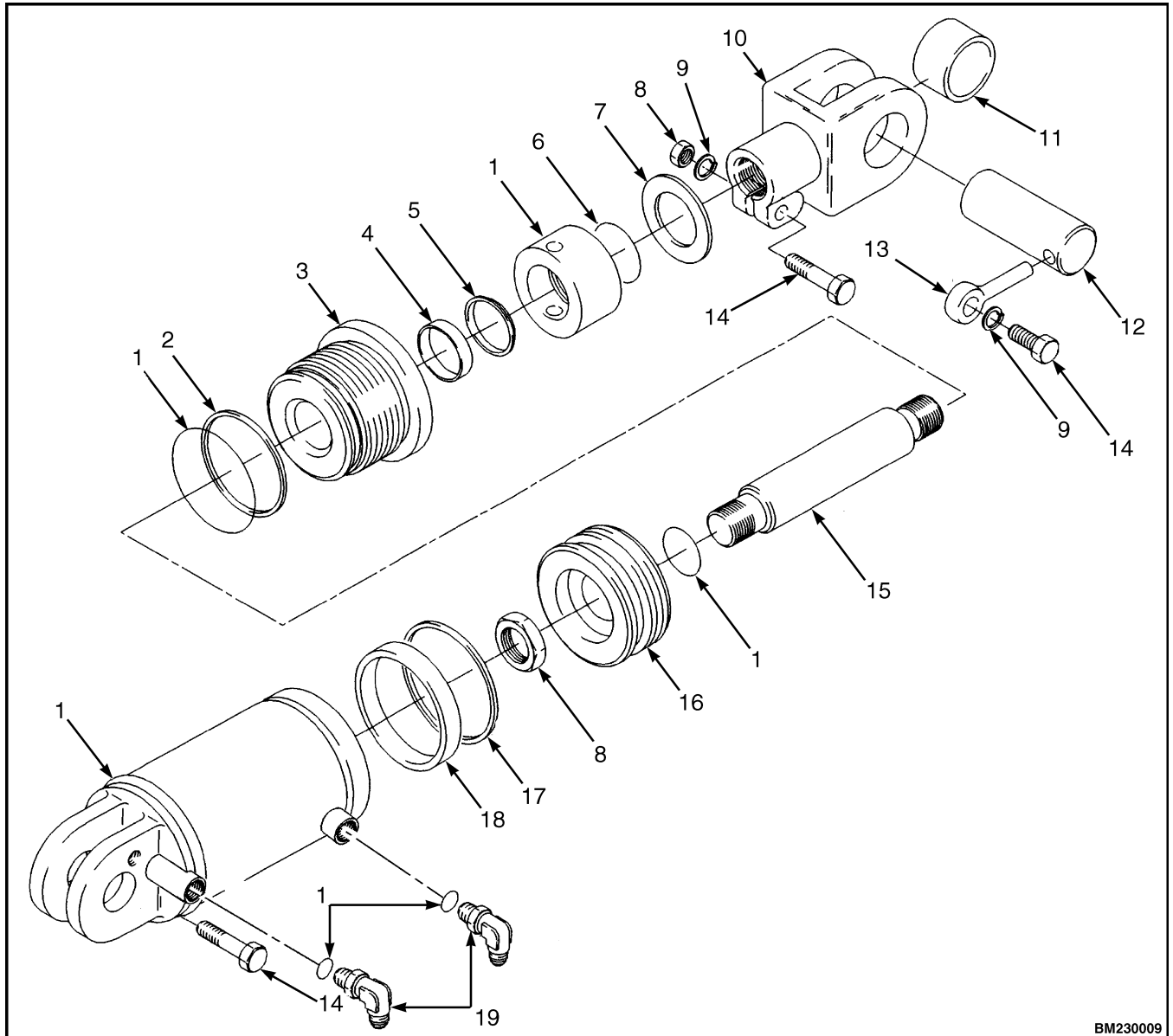
**STEP 9.**

When used, install the manifold block and O-rings on the steering control unit. Tighten the capscrews for the manifold block to 40 N•m (30 lbf ft).



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- |                          |
|--------------------------|
| 1. O-RING                |
| 2. MANIFOLD BLOCK        |
| 3. STEERING CONTROL UNIT |



BM230009

- |                              |                     |
|------------------------------|---------------------|
| 1. O-RING                    | 11. BUSHING         |
| 2. BACKUP RING               | 12. ANCHOR PIN      |
| 3. CAP/RETAINER              | 13. ANCHOR RETAINER |
| 4. ROD SEAL                  | 14. CAPSCREW        |
| 5. ROD WIPER                 | 15. ROD             |
| 6. SHIM [3.0 mm (0.120 in.)] | 16. PISTON          |
| 7. SHIM [1.5 mm (0.060 in.)] | 17. PISTON SEAL     |
| 8. NUT                       | 18. GUIDE RING      |
| 9. LOCKWASHER                | 19. FITTING         |
| 10. ROD END                  |                     |

**Figure 4. Tilt Cylinders for E3.50-5.50XL, E3.50-5.50XL<sub>3</sub> (E70-120XL, E70-120XL<sub>3</sub>) (C098) and E3.50-5.50XL, E4.50XLS (E70-120Z, E100ZS) (D098/E098) Models**

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