Chapter 4

Mitsubishi Engine (Workman S/N Below 220000001)

Liquid Cooled Diesel Engine

Table of Contents

General Information

Most repairs and adjustments require tools which are commonly available in many service shops. Special tools are described in the Special Tools section. The use of some specialized test equipment is explained, however, the cost of the test equipment and the specialized nature of some repairs may dictate that the work be done at a qualified diesel engine repair facility.

The engine is manufactured by Mitsubishi Heavy Industries Limited. Service and repair parts for Mitsubishi engines are supplied through TORO Distributors. Repair parts may be ordered by TORO Part Number. If no parts list is available be sure to provide your dealer or distributor with the TORO Model Number and Serial Number.

The engine model number is cast onto the injection pump side of the cylinder block (Fig. 1a). The serial number is stamped on the injection pump mounting surface of the crankcase (Fig. 1b). There is also a model and serial number decal on the valve cover.

Figure 1a

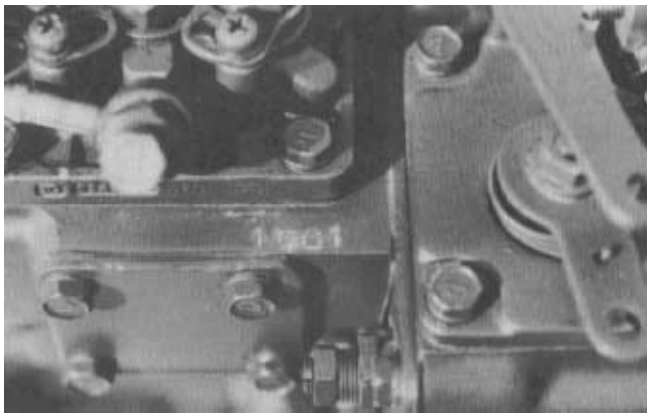


Figure 1b

Specifications

The illustrations (Figs. 2a and 2b) will give information about the general construction of the engine.

Refer to the specifications listed in this section when performing tests on the engine or examining parts for wear. Some specifications are included in the service procedures later in this chapter.

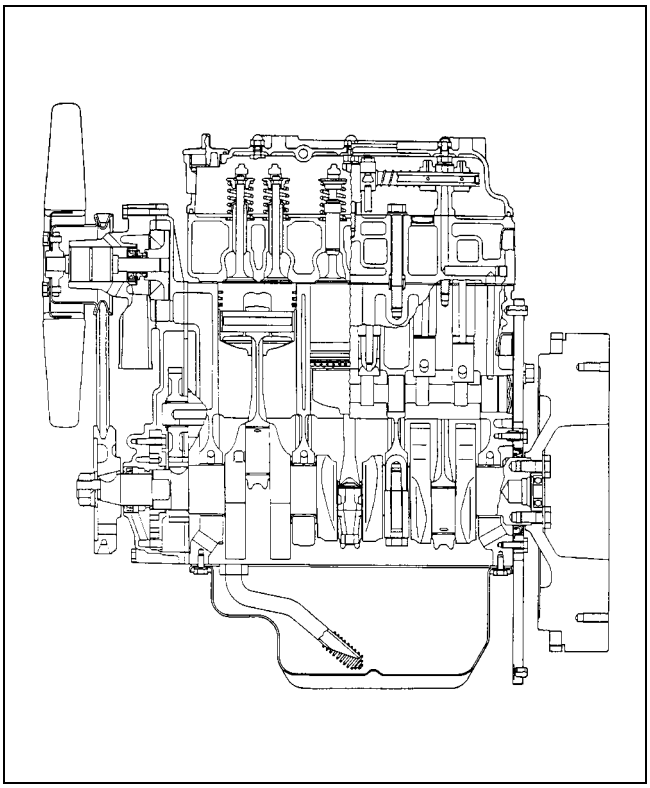


Figure 2a

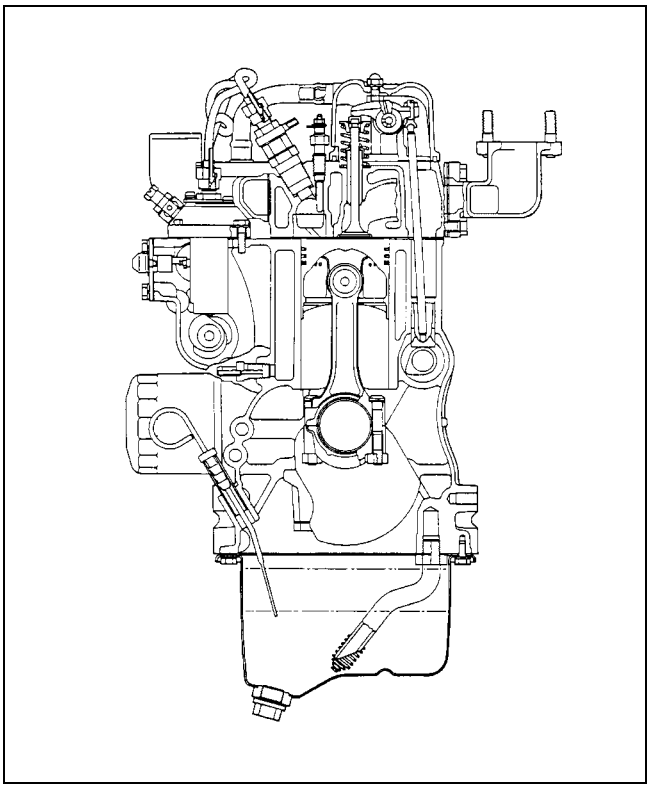


Figure 2b

General

Item	Specification
Make/Designation	Mitsubishi L3Ca-62TG or L3Ea-62TG, overhead valve, vertical in-line, 4 cycle diesel
Combustion Chamber	Swirl chamber type
Number of Cylinders	3
Bore x Stroke L3Ca-62TG L3Ea-62TG	 70 x 70 mm (2.76 x 2.76 in.) 76 x 70 mm (2.99 x 2.76 in.)
Total Displacement L3Ca-62TG L3Ea-62TG	 808 cc (49.3 $in.^3$) 952 cc (5.1 $in.^3$)
Compression Ratio	23:1
Firing Order	1 - 3 - 2
Dry Weight (approximate)	75 kg (165 lb.)
Fuel	Diesel
Fuel Injection Pump	Bosch type NC
Governor	Centrifugal weight type
Fuel Injector Nozzle	Throttle type
Fuel Injection Pressure	(140 kg/cm^2) 1990 psi
Lubrication System	Forced lubrication
Oil Pump	Gear type
Oil Filter	Paper element filter (full flow type)
Crankcase Oil Capacity: including filter of 0.5 liter (0.6 qt.) capacity - FULL / LOW	 3.6 / 1.8 liter (3.8 / 1.9 qt.)
Cooling System	Forced circulation, water cooling
Water Pump	Centrifugal type
Cooling System Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 4.3 liter (4.5 qt.)
Starter	Solenoid shift type 1.6 kW (12 volt)
Alternator	AC type 12 volt 40A
Glow Plug	Sheathed type

Engine

Item	Standard Specification	Repair Limit	Service Limit
Governor	Mechanical/Centrifugal		
High Idle (no load)	3600 rpm		± 50 rpm
Idle Speed (no load) L3Ca-62TG L3Ea-62TG	 1500 rpm 1600 rpm		 ± 50 rpm ± 50 rpm
Compression	28 kg/cm^2 (398 psi) at 280 rpm	25 kg/cm^2 (356 psi)	22 kg/cm^2 (313 psi)
Pressure Difference Between Cylinders	2.5 kg/cm^2 (36 psi) max.		
Cylinder Injection Order	1 - 3 - 2		
Injection Timing	19^o B.T.D.C. (at smoke set position) ± 1.5^o	19^o ± 2^o	
Cylinder Head Bottom Surface Flatness (distortion) Valve Guide I.D. Valve Seat Angle Valve Seat Width Valve Seat Sinkage	 Within 0.05 mm (0.002 in.) 6.6 mm (0.26 in.) 45^o 1.3 - 1.8 mm (0.051 - 0.071 in.)	 0.1 mm (0.004 in.) 2.5 mm (0.1 .in.)	 –1 mm (– 0.039 in.)
Valve Clearance (cold) (both intake and exhaust)	0.25 mm (0.01 in.)		
Valves Valve Head Dia. (IN) Valve Head Dia. (EX) Overall Length Valve Stem O.D. Stem to Guide Clearance (IN) Stem to Guide Clearance (EX) Valve Seat Face Angle Valve Head Thickness (margin width) Valve Head Sinkage (from cyl. head bottom face)	 26.7 mm (1.051 in.) 24.7 mm (0.972 in.) 94 mm (3.701 in.) 6.6 mm (0.260 in.) 45^o 1 mm (0.039 in.) 0.5 mm (0.020 in.)		 0.10 mm (0.004 in.) 0.15 mm (0.006 in.) 0.5 mm (0.020 in.) 1.5 mm (0.06 in.)
Valve Spring Free Length Installed Load/Height (IN) Installed Load/Height (EX) Squareness	 40.5 mm (1.595 in.) 5.94 kg/35.5 mm (13.1 lb./1.4 in.) 14.84 kg/28 mm (32.7 lb./1.1 in.) 3^o	 39.3 mm (1.547 in.)	 –15% –15% 3^o
Rocker Arm I.D. Rocker Arm to Shaft Clearance	12 mm (0.472 in.)		 0.2 mm (0.008 in.)
Cylinder Block Cylinder Bore L3Ca-62TG L3Ea-62TG Tolerance on Oversize Cylinder Bore Taper Gasket Fitting Surface Distortion Camshaft Hole Diameter Front No. 2 No. 3 Rear	 70 mm (2.7559 in.) 76 mm (2.9921 in.) Each Oversize 0 to 0.03 mm (0.001 in.) Within 0.01 mm (0.0004 in.) Within 0.05 mm (0.002 in.) 42 mm (1.654 in.) (ball bearing hole) 33 mm (1.299 in.) 33 mm (1.299 in.) 33 mm (1.299 in.)	 +0.2 mm (0.0079 in.) +0.2 mm (0.0079 in.) 0.1mm (0.004 in.)	 +0.45 mm (0.0177 in.) +0.45 mm (0.0177 in.)

Engine (cont.)

Item	Standard Specification	Repair Limit	Service Limit
Piston			
Type	Solid		
Material	Aluminum alloy		
Piston Outside Diameter (skirt end)			
L3Ca-62TG	70 mm (2.756 in.)		
L3Ea-62TG	76 mm (2.992 in.)		
Piston to Cylinder Wall Clearance			0.2 mm (0.008 in.)
Oversize	0.25, 0.50 mm (0.01, 0.02 in.)		
Protrusion from cylinder block top surface	0.9 mm (0.035 in.)		
Piston Pin			
Type	Semi-floating		
Outside Diameter	18 mm (0.709 in.)		
Pin to Piston Clearance			0.08 mm (0.003 in.)
Pin to Connecting Rod Clearance	Press-fit load: 1000 ± 500 kg (2200 ± 1100 lb.)		
Piston Rings			
Number of Rings			
2 Compression	No. 1: Chrome plated, semi-keystone type No. 2: Tapered		
1 Oil	Chrome plated ring with coil expander		
Compression Ring Width	2 mm (0.079 in.)		
Oil Ring Width	3 mm (0.118 in.)		
Compression Ring Side Clearance (No. 2)	0.05 - 0.09 mm (0.002 - 0.004 in.)		0.2 mm (0.008 in.)
Oil Ring Side Clearance	0.03 - 0.07 mm (0.001 - 0.003 in.)		0.2 mm (0.008 in.)
Ring Gap	0.15 - 0.40 mm (0.006 - 0.016 in.)		1.5 mm (.060 in.)
Connecting Rod			
Type	Forged I-beam		
Bend and Twist	Within 0.05 mm (0.002 in.)		0.15 mm (0.006 in.) max.
Big End Thrust Clearance	0.1 - 0.35 mm (0.004 - 0.014 in.)		0.5 mm (0.02 in.)
Connecting Rod Bearings			
Oil Clearance			0.15 mm (0.006 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		
Crankshaft			
Type	Fully counterbalanced		
Bend	Within 0.03 mm (0.001 in.)		0.05 mm (0.002 in.)
End Play	0.05 - 0.175 mm (0.002 - 0.007 in.)		
Journal O.D.	43 mm (1.693 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Pin O.D.	40 mm (1.575 in.)	– 0.15 mm (– 0.006 in.)	– 0.70 mm (– 0.028 .in)
Finish Undersize			
Journal U.S. 0.25 mm (0.01 in.)	42.715 - 42.730 mm (1.6817 - 1.6823 in.)		
Journal U.S. 0.50 mm (0.02 in.)	42.465 - 42.480 mm (1.6719 - 1.6724 in.)		
Pin U.S. 0.25 mm (0.01 in.)	39.715 - 39.730 mm (1.5636 - 1.5642 in.)		
Pin U.S. 0.50 mm (0.02 in.)	39.465 - 39.480 mm (1.5537 - 1.5543 in.)		
Main Bearings			
Oil Clearance			0.10 mm (0.004 in.)
Undersize	0.25, 0.50 mm (0.01, 0.02 in.)		

Engine (cont.)

Item	Standard Specification	Repair Limit	Service Limit
Camshafts			
Drive System	Gear		
Front Journal	Ball bearing		
Journal to Cylinder Block Hole Clearance			0.15 mm (0.006 in.)
Cam Lobe Major Diameter (both intake and exhaust)	27.37 mm (1.078 in.)		– 1.0 mm (– 0.0433 in.)
Cam Lobe Major Diameter (pump cam)	30 mm (1.224 in.)		– 0.7 mm (– 0.028 in.)
Tappets			
Outside Diameter	19 mm (0.748 in.)		
Tappet to Cylinder Block Hole Clearance			0.15 mm (0.006 in.)
Push Rod Bend	Within 0.3 mm (0.012 in.)		

Lubrication System

Item	Standard Specification	Repair Limit	Service Limit
Oil Capacity	3.6 liter (3.8 qt.) including oil filter		
API Service Class	CD		
Viscosity			
Above 68°F (20°C)	SAE 30 or 10W-30		
41°F to 68°F (5° to 20°C)	SAE 20 or 10W-30		
Below 41°F (5°C)	SAE 10W-30		
Oil Pump			
Type	Gear type		
Check Valve Opening Pressure	3 ± 0.3 kg/cm^2 (42.66 ± 4.27 lb/in^2) at 1000 rpm		
Outer Rotor to Housing Clearance	0.100 - 0.196 mm (0.004 - 0.008 in.)	0.3 mm (0.012 in.)	
Outer Rotor Thrust Clearance	0.04 - 0.10 mm (0.002 - 0.004 in.)	0.25 mm (0.01 in.)	
Oil Pressure Switch			
Indicator Lamp Lighting Pressure	7.1 lbs/in^2 (0.5 kg/cm^2)		

Fuel System

Item	Standard Specification	Repair Limit	Service Limit
Fuel Pump Delivery Rate	225 cc (13.73 in^3) or more (15 sec., 12V)		
Fuel Injection Pump Model Injection Timing (B.T.D.C.)	 ND-PFR-NC $19^o \pm 1.52^o$ (at SS)	 $19^o \pm 2^o$	
Nozzles Type Injection Start Pressure	 Throttle type 140 kg/cm^2 (1991 psi)	 140 $^{+10}/_{-0}$ kg/cm^2 (1991 $^{+142}/_{-0}$ psi)	

Governor System

Item	Standard Specification	Repair Limit	Service Limit
Type	Centrifugal weight type		

Cooling System

Item	Standard Specification	Repair Limit	Service Limit
Coolant Capacity Engine Only Total System (approximate)	 1.8 liter (1.9 qt.) 4.3 liter (4.5 qt.)		
Thermostat Valve Cracking Temperature	 88° C (190° F)		

Electrical System

Item	Standard Specification	Repair Limit	Service Limit
Starter			
Type	Solenoid shift type		
Nominal Output	1.6 kW - 12V		
Direction of Rotation	Clockwise as viewed from pinion side		
No-load Characteristics (Cold)			
Terminal Voltage	11.5V		
Current	100A or less		
Speed	3000 rpm or more		
Load Characteristics			
Terminal Voltage	7.7 V		11.5V
Current (torque)	300A (0.98 kg/m (6.7 ft-lb) or more)		0.7 kg/m (5 ft-lb)
Speed	980 rpm or more		
Height of Brush	17 mm (0.67 in.)		6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)		
Commutator O.D.	38.7 mm (1.52 in.)		– 1.0 mm (– 0.4 in.)
Depth of Commutator Undercut	0.5 mm (0.02 in.)		0.2 mm (0.008 in.)
Pinion Gap	0.5 - 2.0 mm (0.02 - 0.08 in.)		
Thrust Gap	0.5 (0.02 in.) or less		
Alternator			
Nominal Output	12V - 40A		
Direction of Rotation	Clockwise as viewed from pulley side		
Output Characteristics - Hot			
Terminal Voltage	13.5V		
Current / Speed	21A / 2500 rpm 37A/5000 rpm		
Regulated Voltage	14.7 ± 0.3V		
Glow Plugs			
Rated Voltage	10.5V DC		
Rated Current (when rated voltage is applied for 30 seconds)	9.7A ± 1.0A		
Resistance	0.16 ohm (at room temperature)		
Glow Plug Indicator			
Rated Current	29A		
Voltage Across Terminals (at 29A)	1.7V ± 0.2V		

Tightening Torque

The Mitsubishi diesel engine has many bolts and capscrews of special materials and sizes. It is very important that special care be used to replace all bolts and capscrews in their proper location during assembly of the engine. The torque specifications in American Standard and Metric as listed below MUST be followed in order to have the assembled engine conform to the original specifications.

Item	Size (Width across flat of hex head)	Specification
Cylinder Head Bolt,Main (Wet) Cylinder Head Bolt, Sub. (Wet)	M10 (14) M8 (12)	7.5 - 8.5 KgM (54 - 62 ft-lb) 2.0 - 3.0 Kgm (15 - 22 ft-lb)
Connecting Rod Cap Nut	M8 (14)	3.2 - 3.5 KgM (23 - 25 ft-lb)
Flywheel Bolt	M10 (17)	8.5 - 9.5 KgM (62 - 69 ft-lb)
Crankshaft Pulley Nut	M16 (24)	10.0 - 12.0 KgM (72 - 87 ft-lb)
Main Bearing Cap Bolt	M10 (17)	5.0 - 5.5 KgM (36 - 40 ft-lb)
Rocker Stay Bolt	M8 (12)	1.5 - 2.2 KgM (11 - 16 ft-lb)
Rocker Cover Nut	M6 (10)	0.5 - 0.7 KgM (4 - 5 ft-lb)
Nozzle Holder (fitting to engine)	M20 (21)	5.0 - 6.0 KgM (36 - 43 ft-lb)
Nozzle Union Collar Fixing Nut	M12 (17)	2.5 - 3.0 KgM (18 - 22 ft-lb)
Nozzle Retaining Nut	M16 (21)	3.5 - 4.0 KgM (25 - 29 ft-lb)
Fuel Injection Pipe Nut	M12 (17)	2.5 - 3.5 KgM (18 - 25 ft-lb)
Delivery Valve Holder	M16 (17)	3.5 - 3.9 KgM (25 - 28 ft-lb)
Injection Pump Hollow Screw	M10 (14)	1.0 - 1.5 KgM (7 - 11 ft-lb)
Injection Pump Air Vent Screw	M6 (10)	0.5 - 0.7 KgM (4 - 5 ft-lb)
Solenoid Locknut	M30 (36)	4.0 - 5.0 KgM (29 - 36 ft-lb)
Water Temperature Gauge Joint	M16 (23)	2.0 - 3.0 KgM (15 - 22 ft-lb)
Thermoswitch	M16 (19)	1.9 - 2.7 KgM (14 - 20 ft-lb)
Thermo Gauge Unit	M16 (17)	1.9 - 2.7 KgM (14 - 20 ft-lb)
Oil Filter	M20	1.1 - 1.3 KgM (8 - 9 ft-lb)
Oil Relief Plug	M18 (22)	4.0 - 5.0 KgM (29 - 36 ft-lb)
Oil Drain Plug	M18 (19)	5.0 - 6.0 KgM (36 - 43 ft-lb)
Glow Plug	M10 (12)	1.5 - 2.0 KgM (11 - 14 ft-lb)
Glow Plug Lead Wire Fitting Nut	M4 (7)	10 - 15 KgCM (9 - 13 in-lb)

Special Tools

Order special tools from *TORO SPECIAL TOOLS AND APPLICATIONS GUIDE (Commercial Products)*. Some tools may be available from a local supplier.

Filter Cleaner

Filter cleaner (Fig. 3). Mix with water and use solution to wash the Donaldson air cleaner element.

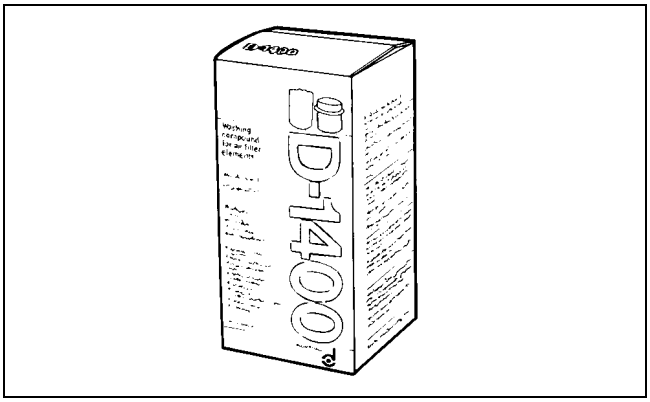


Figure 3

Diesel Engine Compression Test Kit

Diesel engine compression test kit (Fig. 5). 0-1000 PSI Gauge allows testing of diesel engines to check general operating condition of engine. Includes case, guage with hose, glow plug hole adapters and instructions.

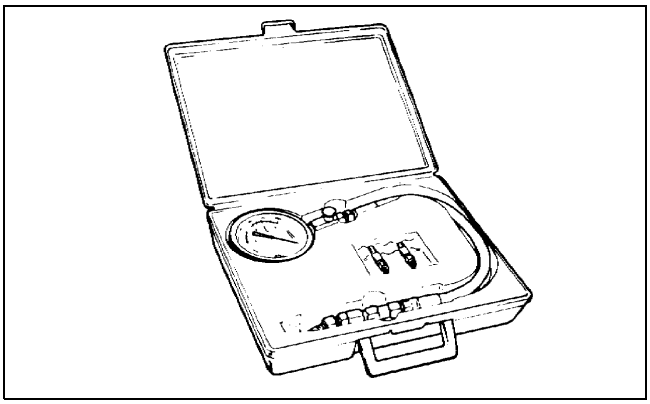


Figure 5

Piston Pin Tool

Piston pin tool (Fig. 6) is used to remove and install the wrist pin without distorting the piston. Inludes an adapter for use with Mitsubishi and most other engines.

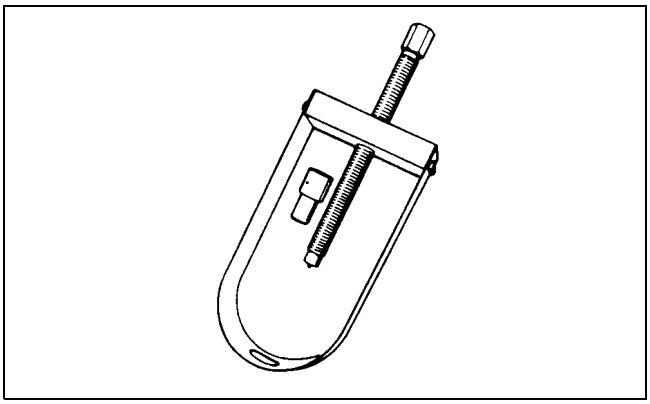


Figure 6

Nozzle Tester

Nozzle tester (Fig. 7). Tests condition and opening pressure of fuel injector nozzles.

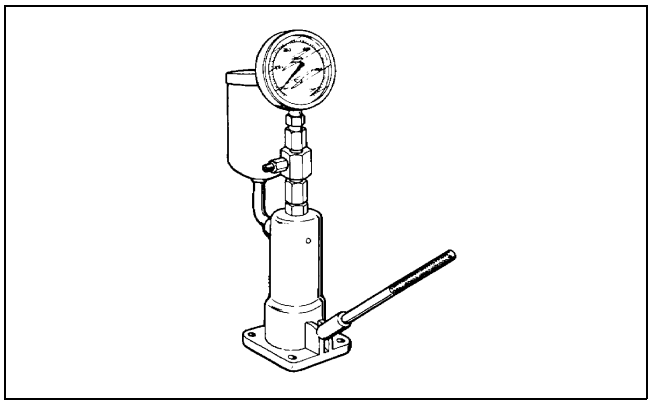


Figure 7

Nozzle Tester Adapter

Nozzle tester adapter (Fig.8) is required to test the fuel injection nozzles.

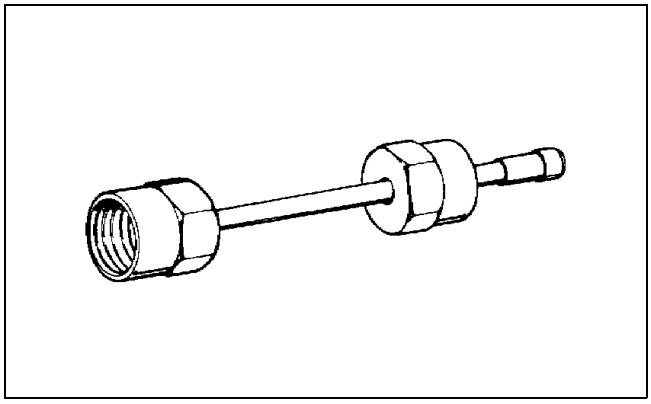


Figure 8

Adjustments

Valve Clearance

Check the valve clearance after the first 50 hours of operation and every 600 hours of operation after that.

1. The engine must be cold when the valve clearance is checked.

2. Remove the air breather hose from the rocker cover.

3. Remove the rocker cover nuts and washers. Remove the rocker cover.

4. Tighten the cylinder head bolts to the proper torque. The rocker assembly must be removed before tightening the cylinder head bolts. When tightening the cylinder head bolts, lower the coolant level in the engine, loosen the bolts slightly and then re-tighten in the sequence shown (Fig. 9).

M10 head bolt torque: 7.5 - 8.5 KgM (54 - 62 ft-lb)
M8 head bolt torque: 2.0 - 3.0 KgM (15 - 22 ft-lb)
Rocker stay bolt torque: 1.5 - 2.2 KgM (11 - 16 ft-lb)

5. Rotate the crankshaft until the TDC mark (located next to the injection timing mark(s) on the pulley lines up with the registration mark on the gear case (Fig. 10). This will be TDC on cylinder No. 1.

NOTE: There are two TDC positions (compression and intake strokes). At compression TDC the rocker arms will not move when the crankshaft pulley is rotated a small distance each way. Compression TDC is where the valves are to be adjusted.

6. Measure the valve clearance by using a thickness gauge inserted between the valve stem and rocker arm. The correct valve clearance for both the intake and exhaust valves is 0.25 mm (0.01 in.).

7. To adjust the valve clearance, loosen the adjusting lock nut and turn the rocker arm adjusting screw clockwise or counterclockwise until you get the correct clearance (Fig. 11). Tighten the locknut securely. Check to make sure that the clearance was not changed while tightening the locknut.

8. Perform steps 6 and 7 of this procedure for cylinder No. 2 and 3 while at their TDC position. Turn the crankshaft 240^{o} clockwise to get No. 3 cylinder TDC. Turn the crankshaft an additional 240^{o} clockwise to get No. 2 cylinder TDC.

9. Install the rocker cover. Install the rocker cover nuts and washers. Install the air breather hose on the rocker cover.

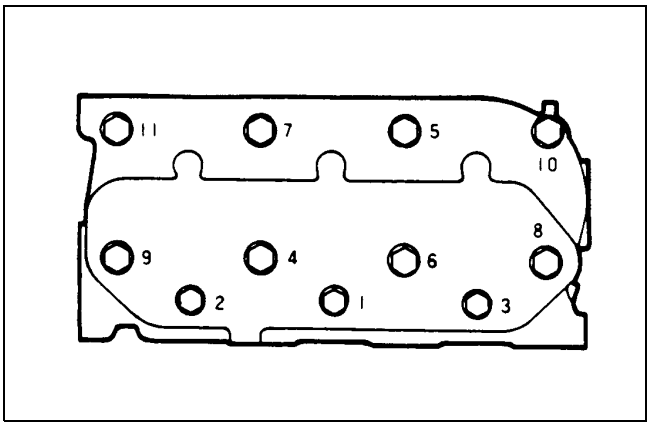


Figure 9

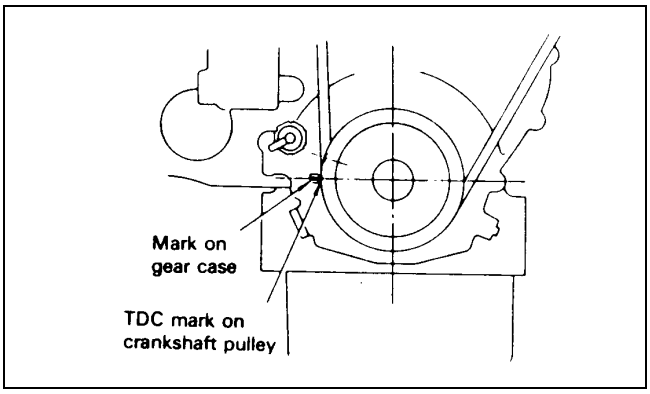


Figure 10

Figure 11

Engine Speed Adjustments

Adjustments to the engine speed settings are not normally necessary unless the throttle linkage, injection pump, or governor mechanism have been repaired, rebuilt, replaced or are not operating correctly.

If your machine is not equipped with the optional tachometer, use a vibration-type tachometer to set engine speed.

WARNING

Engine must be running to do these adjustments. To guard against possible personal injury, engage parking brake and keep hands, feet, face and other parts of body away from fan or other moving parts.

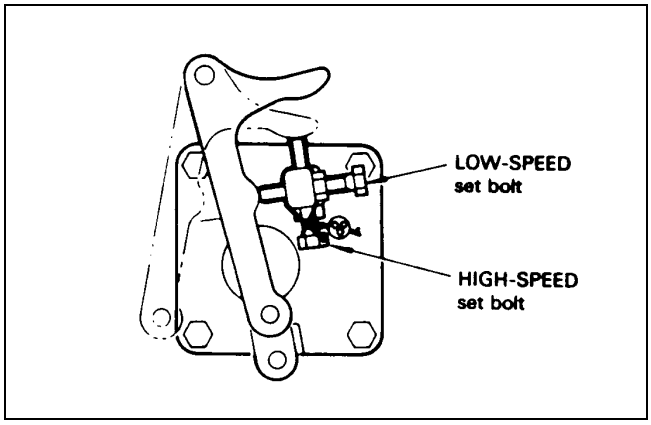


Figure 12

High Speed Adjustment

NOTE: Specified rpm is with no load on engine.

The high speed set bolt has been set properly and sealed at the factory. Never tamper with the seal unless necessary.

1. The engine should be at operating temperature. Make sure the parking brake is engaged.

2. Loosen the lock nut on the high speed set bolt (Fig. 12).

4. Adjust maximum engine speed to 3600 ±50 rpm by rotating the high speed set bolt. Tighten the lock nut.

5. Install a wire and lead seal on the high speed set bolt.

Idle Speed Adjustment

NOTE: Specified engine rpm is with no load on engine.

1. The engine should be at operating temperature. Make sure the parking brake is engaged.

2. Move the throttle control lever to the idle position (against the stop plate). Open the hood.

3. Loosen the lock nut on the low speed set bolt (Fig. 12).

4. Adjust idle speed by rotating the low speed set bolt. Tighten the lock nut.

Engine Model L3Ca-62TG: 1500 ± 50 rpm
Engine Model L3Ea-62TG: 1600 ± 50 rpm

Accelerator Pedal Adjustment

If engine throttle lever does not contact high idle stop when accelerator pedal is fully depressed, an adjustment to the accelerator cable is required.

1. Put vehicle into position on a level surface, stop engine and engage parking brake.

NOTE: Engine must NOT be running and return spring must be attached.

2. Adjust ball joint on accelerator cable to allow 0.100 - 0.250 inch clearance between accelerator pedal and top of diamond tread floor plate, when a 25 lb. force is applied to center of pedal. Tighten locknut.

NOTE: If you cannot get proper accelerator pedal adjustment, put ball joint in another hole in engine throttle lever.

IMPORTANT: Maximum high idle speed is 3650 RPM. Do not move high idle stop bolt to get proper accelerator pedal adjustment.

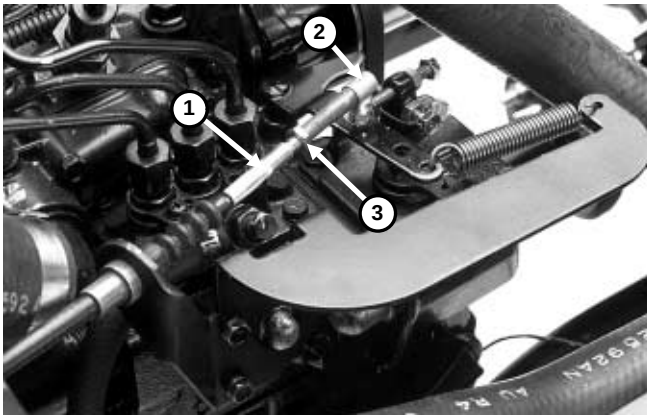


Figure 13

1. Accelerator cable
2. Ball joint
3. Locknut

Troubleshooting

Giving Immediate attention to any indication of a problem can prevent major failures, and increase the life of the engine.

Never make more that one adjustment at a time, then locate the trouble by a process of elimination. Remember the cause is usually SIMPLE, rather than mysterious and complicated.

(1) Engine Fails to Start

Problem/Probable Cause	Possible Remedy
● Slow Cranking Speed	
1. Engine oil viscosity is too high.	Use correct oil.
2. Battery is discharged.	Charge the battery.
3. Battery plates sulfated.	Replace the battery.
4. Battery terminal dirty or poor connection.	Clean the terminals/repair or tighten cables.
5. Starter failure.	Repair or replace starter.

(1) Engine Fails to Start (continued)

Problem/Probable Cause	Possible Remedy
● Injection system	
1. Air in fuel line.	Purge air from the fuel system.
2. Fuel filter is clogged.	Clean/replace filters.
3. Injection pressure is low.	Adjust injection pressure of nozzle.
4. Poor nozzle spray.	Clean or replace the nozzle.
5. Poor injection pump pressure.	Repair or replace injection pump.
6. Incorrect fuel.	Use recommended fuel.
7. Injection timing is advanced.	Adjust injection timing.
● Low Compression	
1. Valve clearance is incorrect.	Adjust valve clearance.
2. Valve seat surface is rough, or burnt.	Finish surface by lapping. Replace valve and guide.
3. Valve spring is broken.	Replace the spring.
4. Leaking cylinder head gasket.	Replace the gasket.
5. Piston rings are seized.	Overhaul the engine.
6. Piston rings and cylinder are worn.	Overhaul the engine.
● Glow plug is burnt out.	Replace the glow plug.
● Glow plug does not glow red hot.	Poor wiring connection.
● Governor lever position incorrect.	Adjust governor lever.
● Governor spring broken or disconnected.	Repair governor spring.

(2) Low Power

Problem/Probable Cause	Possible Remedy
● Low Compression	Refer to "starting failure, low compression."
● Injection system faulty	
1. Injection timing is incorrect.	Adjust the injection timing.
2. Injection volume is insufficient.	Repair or replace pump.
3. Injection pressure is low.	Inspect the injection nozzle, adjust pressure.
● Lack of fuel	
1. Air in fuel system.	Inspect fuel line connections.
2. Filter is clogged.	Clean/replace filters.
3. Fuel tank is contaminated.	Clean the fuel tank.
● Air cleaner is clogged	Clean the air cleaner; replace the element if unserviceable.
● Engine overheats	
1. Low or incorrect coolant level.	Check coolant.
2. Improper belt tension.	Adjust belt tension.
3. Defective water pump.	Replace water pump.
4. Radiator clogged, or leaks pressure.	Clean/repair the radiator, inspect hoses and cap.
5. Injection timing is incorrect.	Adjust the injecting timing.
6. Engine oil is low.	Add engine oil.
7. Defective thermostat.	Replace thermostat.
● Carbon build-up in muffler.	Decarbon muffler.

(3) Excessive Oil Consumption

Problem/Probable Cause	Possible Remedy
● Oil leaks	
1. Oil seals worn.	Check for wear, and replace if worn.
2. Gaskets leaking.	Replace the gasket.
3. Loose fasteners.	Retighten fasteners.
4. Drain plug is loose.	Tighten the plug.
5. Pipe plugs at oil pump loose.	Tighten the plugs.
● Burning Oil	
1. Ring end gaps positioned wrong.	Stagger end gaps properly.
2. Connecting rod bent or twisted.	Overhaul engine.
3. Piston rings worn.	Replace the rings. Overhaul engine.
4. Piston and cylinder are worn.	Overhaul engine.
5. Faulty valve stem seal.	Replace valve stem seal.
6. Valves or valve guides worn.	Replace the valves or valve guides.

(4) Abnormal Engine Noises

Problem/Probable Cause	Possible Remedy
● Crankshaft and main bearing	
1. Worn crankshaft.	Repair or replace crankshaft; inspect bearings.
2. Worn or damaged bearings.	Replace bearings; inspect crankshaft.
● Connecting rod and bearings	
1. Connecting rod bearing worn.	Replace bearing; inspect crankshaft.
2. Worn crankpin.	Repair or replace crankshaft; inspect bearing.
3. Twisted connecting rod.	Replace connecting rod.
● Piston, piston pin, and piston rings	
1. Cylinder is worn.	Overhaul engine.
2. Piston pin is worn.	Replace piston and pin, inspect cylinder, rod, and rings.
● Rocker arm mechanism and relative parts	
1. Camshaft is worn.	Replace camshaft.
2. Excessive valve clearance.	Adjust the valve clearance.
3. Worn timing gear.	Replace the timing gear; inspect mating gears.
4. Worn fan shaft bearings.	Replace the bearing/shaft.

(5) Engine Runs Rough

Problem/Probable Cause	Possible Remedy
● Injection pump mechanism	
1. Irregular injection pump volume.	Repair or replace injection pump.
2. Faulty control rack function.	Repair or replace injection pump.
3. Worn delivery valve.	Replace the delivery valve.
4. Faulty injection nozzle.	Repair or replace nozzle.
● Governor mechanism	
1. Governor lever sticking.	Inspect/repair governor.
2. Stretched or weak governor spring.	Replace the spring.

Glow Plug Test

CAUTION

Be careful while handling or testing glow plugs. Glow plugs become extremely hot. Accidental contact with the heated plug tip could cause personal injury.

1. Disconnect the wire lead(s) to the glow plug.

2. Remove the glow plug.

3. Inspect the glow plug for signs of a burnt glow plug end tube.

NOTE: If the metal of the glow plug end is melted, it is a sign of cylinder overheating. (See Engine Overheats in the Troubleshooting section of this chapter.)

4. Connect the positive (+) battery terminal to the glow plug terminal, and the negative (–) battery terminal to the plug body (Fig. 15). If the glow plug glows red-hot, the glow plug is operating correctly.

5. Replace any glow plugs that do not operate correctly.

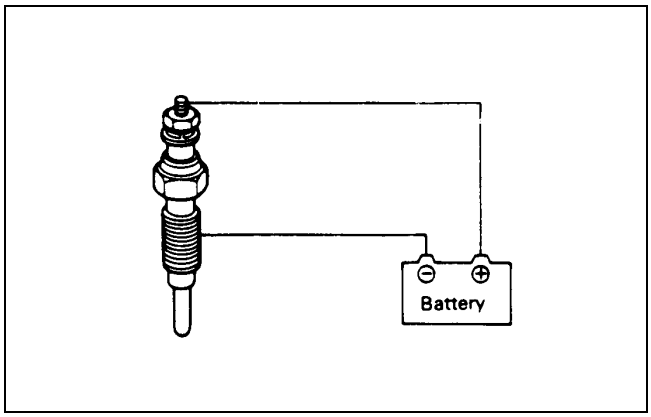


Figure 15

Compression Test

Normal cylinder compression is 28 kg/cm^2 (398 psi) at 280 rpm (normal cranking speed). The engine should be warm - coolant temperature of 50^o C (120^o F).

IMPORTANT: DO NOT put oil into the combustion chamber before performing a compression test. Damage may result because of "hydraulic" forces acting upon the piston and connecting rod.

1. Remove the glow plug lead wires and glow plugs from all three cylinders.

2. Insert the compression gauge adapter into the glow plug hole. (See the Special Tools section of this chapter.)

3. Connect the high pressure compression gauge to the adapter (Fig. 16).

4. Disconnect the fuel stop solenoid electrical connector to prevent fuel delivery during the compression test (Fig. 17). This will prevent wash-down of the cylinders and inaccurate readings.

5. Crank the engine with the starter motor until you get a stable gauge reading.

6. Normal compression is 28 - 32 kg/cm^2 (398 - 455 psi). If the pressure is less than 25 kg/cm^2 (356 psi) it will be necessary to find the cause of low compression. (See Engine Fails to Start - Low Compression in the Troubleshooting section of this chapter.)

7. Repeat the test for the other two cylinders. Difference between cylinders should be no more than 2.5 kg/cm^2 (36 psi).

8. Connect the fuel stop solenoid electrical connector.

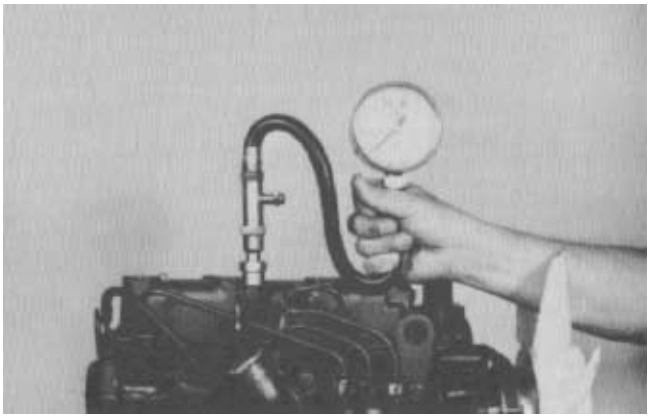


Figure 16

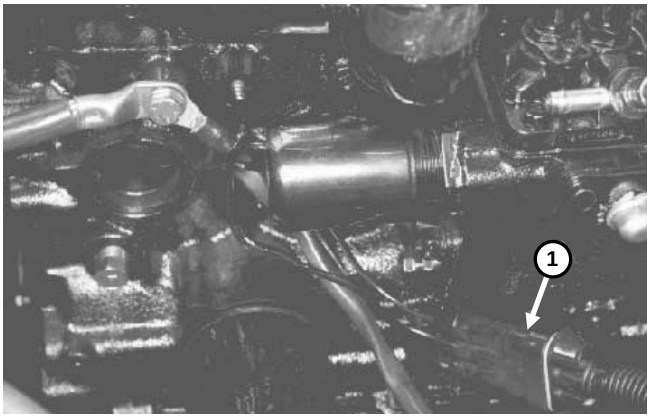


Figure 17

1. Fuel stop (ETR) solenoid electrical connector

Nozzle Tests

There are several tests to examine the condition of the injection nozzles. These tests require the use of a nozzle tester and nozzle tester adapter. (See the Special Tools section of this chapter.)

DANGER

The nozzle tester forces fuel from the nozzle under extremely high pressure. Always point the nozzle tip away from yourself and any other personnel. Contact with the fuel stream, even though it appears to be a mist can cause fuel to penetrate clothing and skin. If fuel is injected into the skin get proper medical attention from a doctor immediately. A serious infection or other reaction can develop if the injury is not properly treated. Tighten all adapter fittings to prevent leaks. If a leak is suspected, use a piece of cardboard, not your hands to search for a leak.

CAUTION

To prevent possible injury, wear eye protection when operating the nozzle tester.

IMPORTANT: Always use fresh filtered fuel in the nozzle tester. Use of dirty fuel can damage the precision parts of the injector nozzle. It is a good practice to:

1. Bolt the tester securely to the test bench.

2. Use a drain pan to catch fuel.

3. Flush the adapter by pumping the handle of the tester slowly several times before attaching the nozzle to be tested.

Injection Pressure Test

The diesel engine requires that fuel be sprayed into the combustion chamber at a precise point in the compression stroke. The point at which this fuel injection occurs is determined by the injection timing. If the nozzle is defective, damaged or adjusted incorrectly, starting failures, low power output, or engine knocking can occur.

1. Securely fasten the nozzle to the adapter.

2. Pump the handle several times to purge air from the nozzle mechanism.

3. Allow pressure to dissipate before performing the test.

4. Operate the pump handle slowly and observe the gauge to determine the pressure at which the nozzle opens and the fuel is sprayed.

5. Verify that starting pressure is within the following limits: Minimum starting pressure is 140 kg/cm^2 (1991 psi); Maximum starting pressure is 150 kg/cm^2 (2134 psi).

6. Starting pressure can be adjusted by adding or removing shims from the nozzle. (See Nozzle Service in the Fuel System Repairs section of this chapter.) A 0.1 mm shim will cause a 10 kg/cm^2 (142 psi) starting pressure difference. Shims are available from 1.25 mm to 1.7 mm thick in 0.5 mm increments.

7. Repeat the test after installing shim to verify that a correct starting pressure has been obtained.

Chattering Test

Proper and free operation of the nozzle valve can be determined by the chattering test.

1. Securely fasten the nozzle to be tested to the adapter.

2. Operate the pump handle slowly (ten strokes per minute). As the pump pressure reaches the starting pressure the nozzle valve will chatter as it opens and closes rapidly. A nozzle which does not chatter may be the result of a binding or bent nozzle valve.

Nozzle Leakage Test

A nozzle that leaks fuel from the nozzle orifice must be replaced.

1. Securely fasten the nozzle to the adapter.

2. Wipe all fuel from the nozzle.

3. Operate the pump until the pressure is approximately 108 kg/cm^2 (1536 psi). Maintain this pressure to the nozzle.

4. Watch for leaks where the threaded nozzle body threads into the retaining nut. Leaks in this area would indicate a bad seat between the distance piece and/or the body or nozzle assembly.

5. If leakage occurs, verify that the body is tightly fastened in the retaining nut. If the leak continues, replace the nozzle.

6. While pressure is being applied, watch for an accumulation of fuel at the tip of the nozzle (Fig. 18). A small

amount of fuel may be present due to a previous chattering test - this would be normal. If the fuel accumulates and drips down during the test (about ten seconds) the nozzle assembly is defective and must be replaced.

Spray Test

For proper combustion, the nozzle must effectively atomize the injected fuel.

1. Operate the pump handle at a rate of 20 - 30 strokes per minute.

2. Observe the injector nozzle spray. The spray pattern should be finely atomized in a broad, straight stream (Fig. 19).

3. If the nozzle fails to spray properly, it must be cleaned, repaired or replaced. (See Nozzle Service in the Fuel System Repairs section of this chapter.)

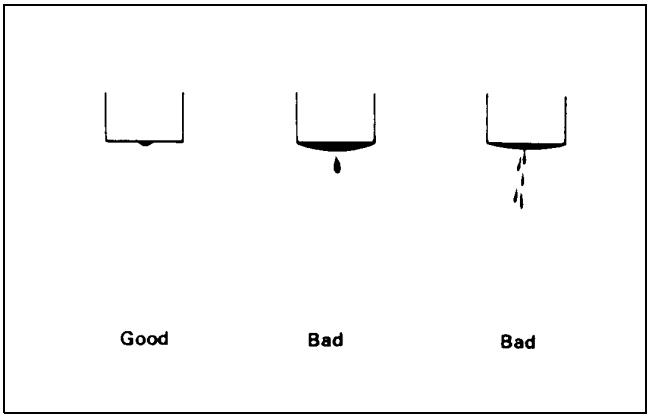


Figure 18

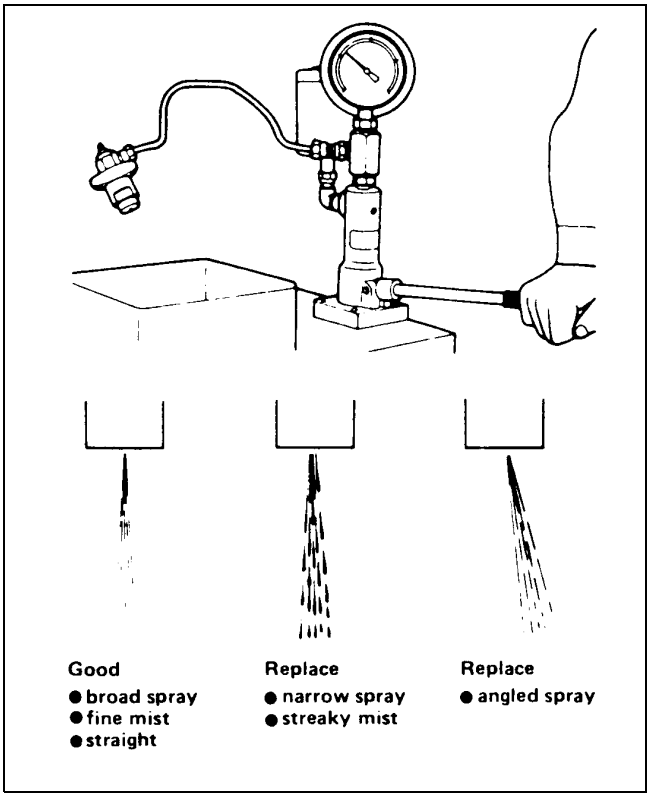


Figure 19

Injection Pump Test

Calibration of fuel delivery volumes, pressure and distribution between pump barrels should be performed by a professional diesel engine service shop. Special test fixtures and equipment are required.

It is possible to determine if the fuel injection pump requires service through a process of elimination using other fuel system tests. The following test procedure will help isolate fuel system difficulties.

1. Make sure that fuel is being supplied to the injector pump. (See Fuel Pump Test in this section and Bleeding Air From the Fuel System in the Fuel System Repairs section of this section.)

2. Check the operating condition of the injection nozzles to make sure that the injection pressure is correct. (See Injection Pressure Test in this section of the book.)

3. Make sure that the injection pump is providing sufficient fuel pressure to operate the nozzle by performing the following procedures:

A. Loosen the fuel delivery pipe from the number one nozzle.

B. Remove the nozzle from the cylinder head.

C. Connect the fuel delivery pipe to the nozzle assembly so the tip of the nozzle is pointed away from the engine. Tighten the fitting securely.

D. Push accelerator pedlal to the floor. Turn the ignition key to the START position to crank the engine. Observe the nozzle.

DANGER

The injection pump forces fuel from the nozzle under extremely high pressure. Always point the nozzle tip away from yourself and any other personnel. Contact with the fuel stream, even though it appears to be a mist can cause fuel to penetrate clothing and skin. If fuel is injected into the skin get proper medical attention from a doctor immediately. A serious infection or other reaction can develop if the injury is not properly treated. Tighten all adapter fittings to prevent leaks. If a leak is suspected, use a piece of cardboard, not your hands to search for a leak.

If the nozzle produces an atomized mist of fuel the injector pump for that cylinder is operating properly. Failure of the nozzle to inject fuel can indicate a injection pump cylinder that is not operating correctly.

5. Repeat the test for the other cylinders.

Injection Timing Test

Injection timing can be adjusted by installing shims under the pump body. The timing is important because it determines when the fuel enters the combustion chamber.

The most accurate method of timing is done with an electronic diesel timing tester (available from major tool supply companies).

The following method is an initial setting for starting the machine.

1. Remove the number one injection pipe from both the pump and nozzle. (The number one cylinder is opposite from the flywheel end of the engine.)

2. Set up the injection pump for the test:

A. Remove the delivery valve holder (Fig. 20). Remove the delivery valve and spring. The valve seat must remain in place.

B. Replace the valve holder and tighten it in place.

C. Connect the fuel injection pipe to the nozzle holder so the open end of the pipe will discharge fuel into a container.

3. Put the throttle control in the middle of its range of travel.

4. Slowly rotate the crankshaft counterclockwise from the flywheel end (normal rotation) until the IT marks (injection timing marks) on the crankshaft pulley are approximately 1/2 in. (21 mm) from alignment with the stationary pointer on the engine gear case (Fig. 21). Make sure the number one cylinder compression stroke is approaching by checking the push rods. Both push rods on the number one cylinder should be loose and the valves closed. If either push rod is tight, rotate the engine crankshaft one full revolution and inspect the push rods again.

5. Turn the ignition switch ON so the fuel pump will supply fuel through the injection pump and out the number one injection pipe.

6. Rotate the engine crankshaft slowly in the normal direction until the flow from the number one injection pipe just stops. This is the moment of actual injection timing. (A screwdriver inserted between the transmission drive hub and rubber coupler will provide control and leverage to slowly rotate the engine crankshaft.)

NOTE: Wear of the internal parts in the injection pump may allow the fuel to continue to drip from the injection pipe. If the slowest flow rate exceeds 1 drop in 5 seconds, repair of the pump should be considered.

7. Standard injection timing can be confirmed by the IT marks on the crankshaft pulley and the stationary pointer on the crankcase (Fig. 21).

The center mark on the pulley represents 19^{o} BTDC; standard fuel injection timing. The outside marks represent 21^{o} BTDC and 17^{o} BTDC; the acceptable range of injection timing.

Shims are available in different sizes from 0.2 to 1.0 mm thick. Adding or removing a shim, 0.1 mm thick, will change injection timing by 1^{o}. Increase shim thickness if injection is too early. Decrease shim thickness if injection is too late. (See Injection Pump Service in the Fuel System Repairs section of this chapter.)

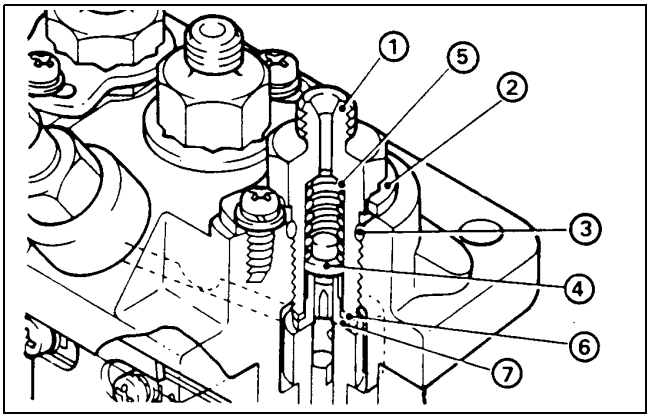


Figure 20

1. Delivery valve holder
2. Holder stopper
3. O-ring
4. Delivery valve
5.Spring
6. Gasket
7. Valve seat

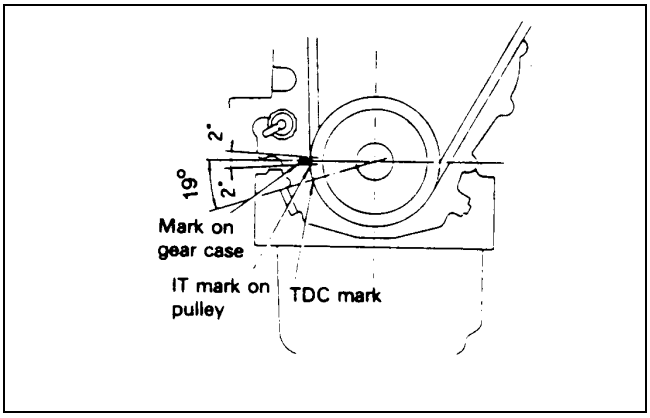


Figure 21

Fuel Pump Test

1. Turn the ignition switch to the ON position. Test for pump operation by listening for the pump oscillating sound, or by feeling for vibration which indicates the pump is operating.

2. If no pumping action occurs when the ignition switch is turned on, connect a 12 volt DC battery directly to the pump (Fig. 22). If the pump now operates, check for an electrical failure of the pump circuit, eg. fuses, connections, wires, etc.

3. The delivery of the fuel pump may be checked by disconnecting the fuel lines from the water separator and fuel filter and routing them to a can of filtered diesel fuel and a drain pan (Fig. 22). Activate the pump and measure the amount of fuel pumped in during a 15 second time interval. The standard pump rate is approximately 8 ounces (225 cc) in 15 seconds.

4. If the fuel delivery rate is below the standard value the pump should be disassembled and checked. (See Fuel Pump Service in the Fuel System Repairs section of this chapter.)

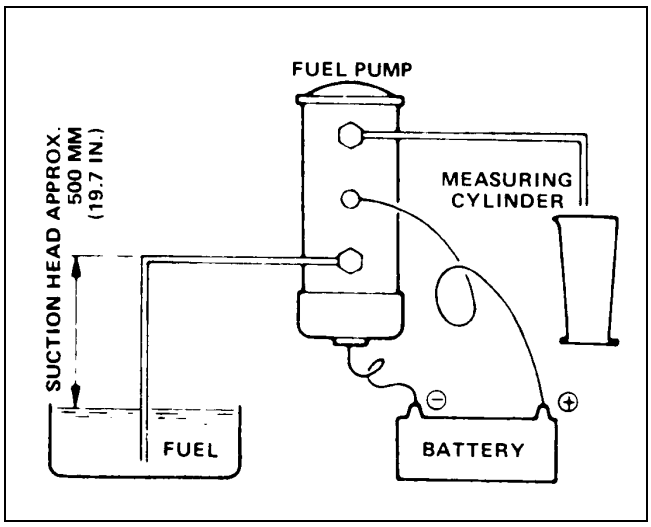


Figure 22

Thermostat Test

If the engine overheats and a faulty thermostat is suspected, the thermostat should be tested.

1. Remove the thermostat (see Thermostat Removal and Installation in the External Engine Component Repair section of this chapter).

2. Put the thermostat in a container of water with a thermometer and heat the water (Fig. 23).

Valve cracking temperature: 88^{o} C (190^{o} F).

3. If the thermostat fails to open, only partially opens, or sticks, it should be replaced.

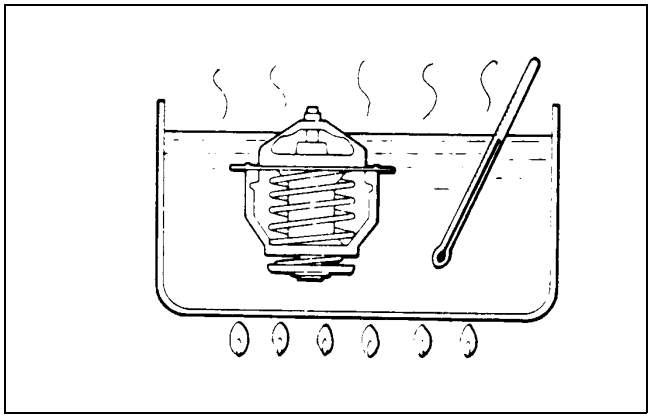


Figure 23

Fuel Stop (ETR) Solenoid

The Workman 3300-D/4300-D has an energize-to-run (ETR) fuel stop solenoid. The solenoid will stop injector pump fuel delivery with any electrical failure in the RUN circuit.

1. Disconnect the wire connector and remove the fuel stop solenoid from the engine.

2. Connect a 12 volt battery so the positive (+) battery terminal is connected to terminals A (hold) and B (pull) (Fig. 22). Connect the negative (–) battery terminal to solenoid terminal C (common). The plunger should retract to the dimension shown.

IMPORTANT: Do not connect Voltage to terminal B (pull) for more than 30 seconds or damage to the solenoid coil could result.

3. With the battery connected the same as step 2, disconnect the battery from solenoid terminal B (pull). The plunger should remain pulled in.

4. Disconnect the battery from terminal A (hold). The plunger should return to the extended position.

5. Check the solenoid internal spring tension. The spring must have 9.2 lbs (4.2 kg) minimum force with the plunger in the extended position.

Replace the fuel stop solenoid if it fails any of the above tests (See Replacing and/or Adjusting Stop Solenoid).

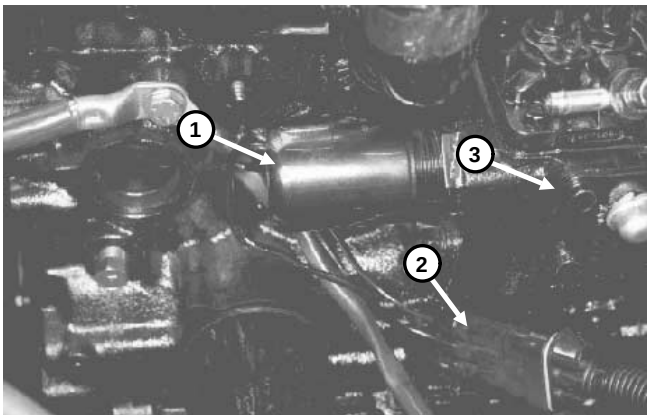


Figure 24

1. Fuel stop (ETR) solenoid
2. Wire connector
3. Governor tie rod cover

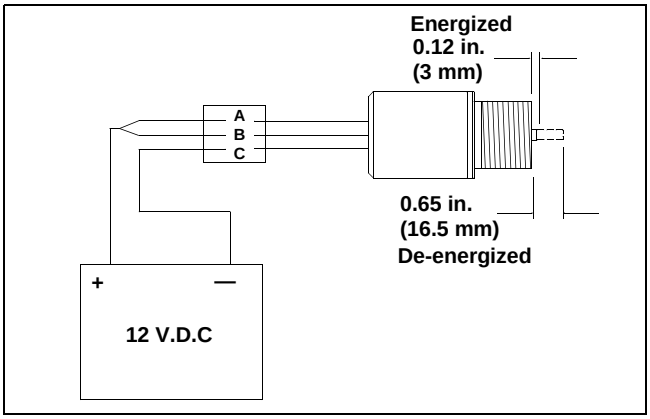


Figure 25

A. Hold
B. Pull
C. Common (ground)

To Test While Connected to Wire Harness

1. Remove the governor tie rod cover so you can observe the solenoid plunger.

2. Hold the manual fuel stop lever back to prevent fuel delivery. Turn the key switch to the START position and quickly return it to the ON position. The solenoid plunger should be retracted.

3. Turn the key switch to the OFF position. The solenoid plunger should extend.

NOTE: You can also test operation without removing the governor tie rod cover. Listen for an audible “click” as the solenoid extends and retracts while doing steps 2 and 3 of the above procedure. This will not show if the solenoid is adjusted correctly or if it is fully extending and retracting. (See Replacing and/or Adjusting the Stop Solenoid in the External Engine Component Repair section.)

Engine Oil Pressure Switch

The switch is normally closed (NC) and opens with pressure.

The switch opens at approximately 8 psi.

1. Turn ignition key switch ON. Oil pressure lamp should be on.

If bulb is not on:

1. Disconnect wire from switch and touch wire to a good ground.

2. If lamp comes on, replace switch.

3. If lamp does not come on check lamp and/or wiring between lamp and switch for continuity.

If lamp is on with engine running:

1. Shut off engine immediately.

2. Check switch by disconnecting wire. Light should go out.

3. If light is still on, check for short circuit in wiring.

4. Install test gauge in engine oil pressure switch port. Start engine and check for 30 psi minimum at 1500 rpm. If engine pressure is good, replace switch. If engine pressure is low, DO NOT operate the engine.

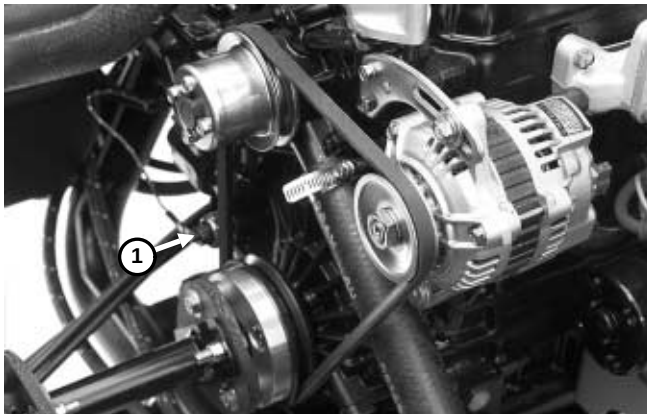


Figure 26

1. Engine oil pressure switch

Temperature Gauge Sender

1. Lower the coolant level in the engine and remove the temperature gauge sender.

2. Put the switch in a container of oil with a thermometer and heat the oil.

3. With an Ohm meter connected as shown, the following resistance readings should be indicated.

90.5 - 117.5 ohm at 160° F (70° C)
21.3 - 26.3 ohm at 207° F (115° C)

CAUTION

Handle hot oil with special care to prevent personal injury or fire.

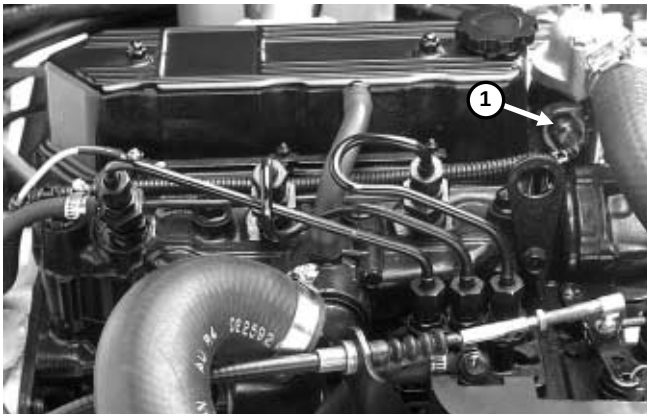


Figure 27

1. Temperature gauge sender

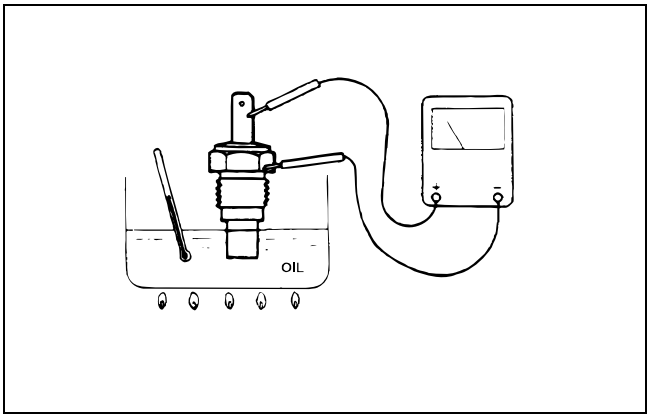


Figure 28

Checking Starter Pinion Gap

1. Install 12 volt battery between the “S” terminal and the starter body. The pinion should protrude and stop.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

2. Lightly push the pinion back and measure the return stroke (called pinion gap).

3. If the pinion gap is not within standard range of 0.5 - 2.0 mm (0.02 - 0.08 in.), adjust it by increasing or decreasing the number of packings on the magnetic switch. The gap is decreased as the number of packings increases.

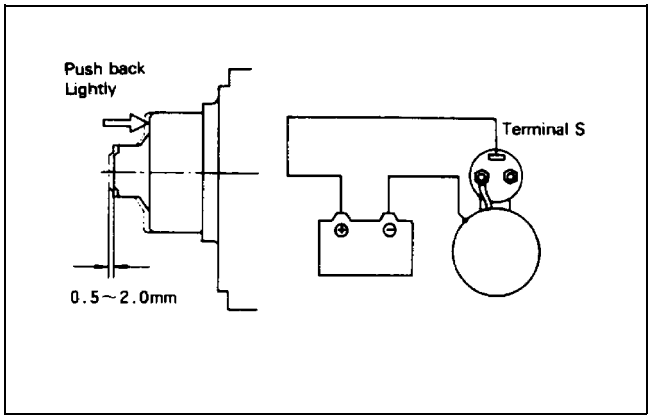


Figure 29

Starter No-Load Test

1. Connect a 12 volt battery, ammeter and voltmeter to the starter as shown.

2. When terminals “S” and “B” are connected the pinion should protrude and the starter should run smoothly.

Terminal voltage: 11.5V
Current: 100 A
Speed: 3000 rpm

No-Load Test Results

Low speed and high current draw:

- High friction (faulty bearings, bent armature shaft).
- Shorted armature.
- Grounded armature or fields.

Failure to operate with high current draw:

- Direct ground in terminals or fields.
- “Frozen” bearings.

Failure to operate with no current draw:

- Open field circuit.

Low speed and low current draw:

- Open armature coils - check commutator for badly burned bars after disassembly.

High speed and high current draw:

- Poor contact between brushes and commutator (broken brush springs, worn brushes, high insulation between commutator bars).
- High internal resistance (poor connections, damaged leads, dirty commutator or open field circuit).
- Shorted fields.

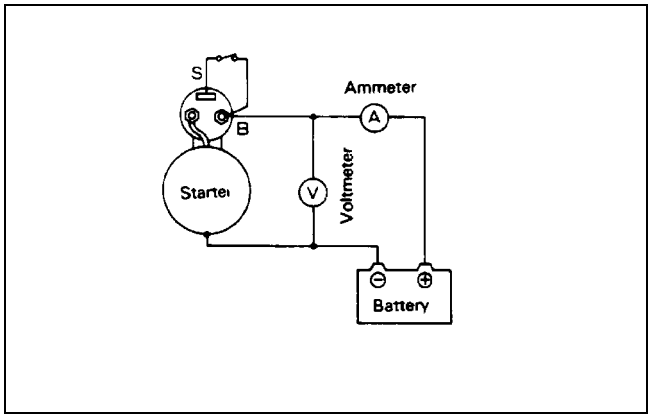


Figure 30

Magnetic Switch (Solenoid) Attraction Test

1. Disconnect the wire from terminal “M” (Fig. 31).

2. Connect a 12 volt battery to the magnetic switch terminals “S” and “M”. The pinion must protrude.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

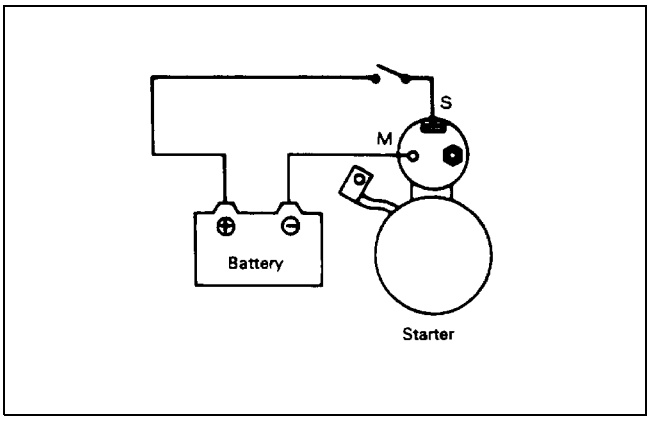


Figure 31

Magnetic Switch (Solenoid) Holding Test

1. Disconnect the wire from terminal “M”.

2. Connect a 12 volt battery to the magnetic switch terminal “S” and the starter body. Pull out the pinion fully. The pinion must remain at that position even when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

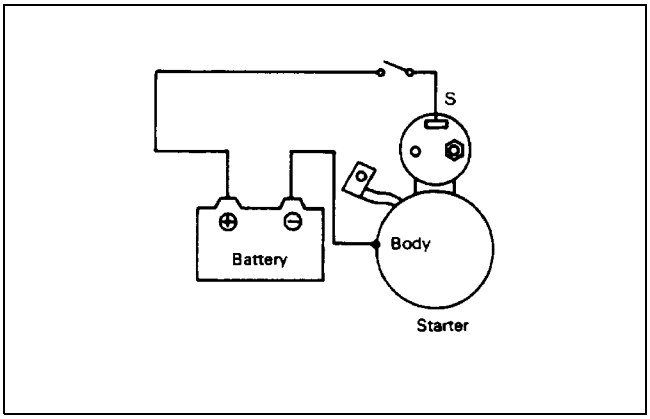


Figure 32

Magnetic Switch (Solenoid) Return Test

1. Disconnect the wire from terminal “M”.

2. Connect a 12 volt battery to the magnetic switch terminal “M” and the starter body. Pull out the pinion fully. The pinion must return to its original position when released.

IMPORTANT: Never apply battery voltage to the starter for longer than 10 seconds.

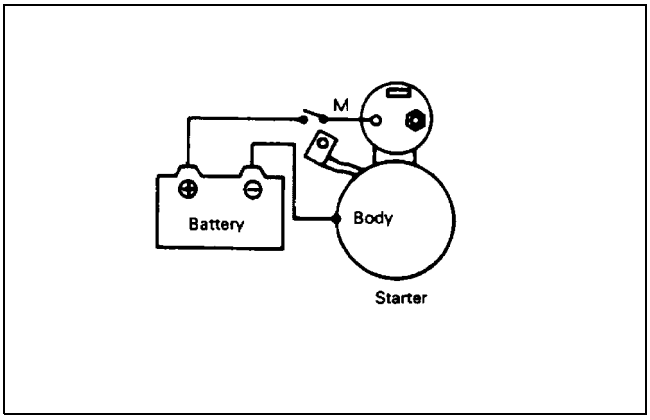


Figure 33

Alternator Regulated Voltage Test

1. Install an ammeter between the positive (+) terminal of the battery and terminal “B” of the alternator.

2. Ground alternator terminal “L” through a voltmeter.

3. Note that the voltmeter shows 0 volts when the ignition key switch is in the OFF position. The voltmeter will show voltage lower than battery voltage when the ignition key switch is in the ON position (engine not running).

4. Start the engine.

5. Run the engine with the alternator at 1300 and 2500 rpm and observe the voltmeter with all accessories OFF, Ammeter below 5 A. Regulated voltage will decrease slightly as alternator temperature increases.

Regulated voltage: 13.5 V

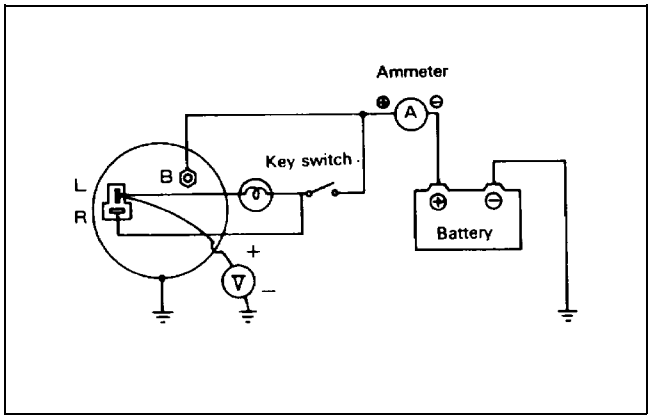


Figure 34

Alternator Output Test

1. Disconnect the battery ground (–) cable.

2. Install an ammeter between the positive (+) terminal of the battery and terminal “B” of the alternator.

3. Ground alternator terminal “B” through a voltmeter.

4. Connect the battery ground (–) cable.

5. Start the engine.

6. Run the engine with the alternator at 2500 and 5000 rpm and observe the voltmeter with all electrical load applied. Read the maximum indication on the ammeter with the voltmeter showing 13.5 V.

Output Characteristics (Hot):

21 A at 2500 rpm
37 A at 5000 rpm

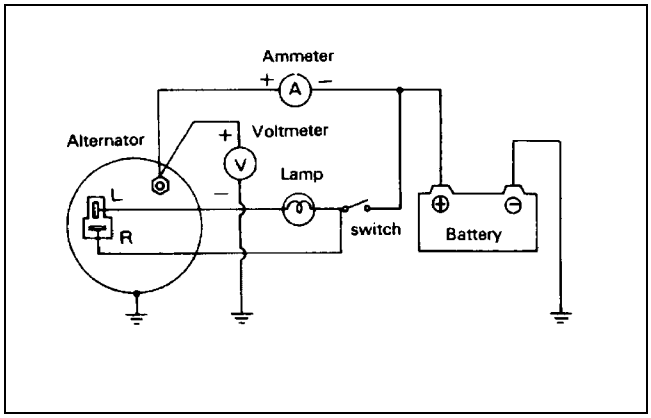


Figure 35

Preparation for Engine Repair

1. Before cleaning and disassembly, carefully check for problems that cannot be found after the engine has been cleaned or disassembled (e.g. oil leaks from cracked components, gaskets or loose fittings, damaged air cleaner or breather hoses that could cause cylinder wear, etc.). Make a note of any problems that you find.

2. Clean or wash the engine exterior thoroughly before disassembly.

IMPORTANT: Do not spray water on a hot engine. Injection pump seizure or other failures could result.

3. Do not disassemble or remove parts that do not require disassembly.

4. Disassemble the engine in proper order, arranging the parts the disassembled parts neatly. Apply clean engine oil to disassembled parts, as necessary to prevent rust.

5. Keep the work area clean; dirt causes engine failures.

6. Be very careful when working on fuel system components. Cover the work area with clean paper. Store components of the nozzles or injector pump in clean fuel oil. Do not allow components to strike each other or other objects. Wet hands with clean diesel fuel before handling these parts.

Engine Compression

The time interval to overhaul the engine can most accurately be determined by regular and systematic cylinder compression measurement. (See Compression Test in the Testing section of this chapter.)

Cylinder and Cylinder Block Overhaul

Before removing any parts, disassembly or overhaul of the Mitsubishi engine, it is very important to understand the nature and probable cause of the problem that made an overhaul necessary.

When the engine trouble is caused by worn cylinders, rings or valves, one or more of the following symptoms will occur:

1. Low engine power, and a decrease in compression pressure.

2. Increased fuel consumption.

3. Increased lubricating oil consumption.

4. Poor engine starting.

5. Loud noises in the engine.

It is important to find the cause of the engine failure before beginning repair. Symptoms 2 and 3 in the above list can be a result of excessive fuel injection, improper injection timing, or nozzle and injection pump wear. Poor starting may be a result of electrical problems. Noises may be associated with a mechanical part outside the engine. Excess fuel or oil consumption may be the result of leaks. (See the Troubleshooting section of this chapter.)

Another indicator of the need for an overhaul is oil consumption. Make sure the engine does not leak oil. when the oil consumption between the oil change maintenance interval is approximately 1-1/2 times normal (150%), engine overhaul should be considered.

With a good knowledge of how the engine operates, access to maintenance and compression test records, and information in the Troubleshooting section of this chapter, unnecessary disassembly and inspection can be eliminated.

Belt Replacement and Adjustment

Alternator Belt

1. Loosen bolt securing alternator brace to engine and bolt securing alternator to brace (Fig. 36).

2. Remove two capscrews securing drive shaft coupler to engine crankshaft pulley.

3. Move drive shaft out of the way so belt can be removed and new one installed.

4. Install new belt.

5. Connect drive shaft coupler to engine crankshaft pulley with two capscrews and washers.

6. To adjust belt tension, insert pry bar between alternator and engine and carefully pry alternator out until proper tension is achieved. To check tension, depress belt midway between crankshaft and alternator pulleys with 22 lbs. of force. A new belt should deflect 0.3 to 0.5 inch and a used belt 0.4 to 0.55 inch. Tighten alternator and brace bolts to secure adjustment.

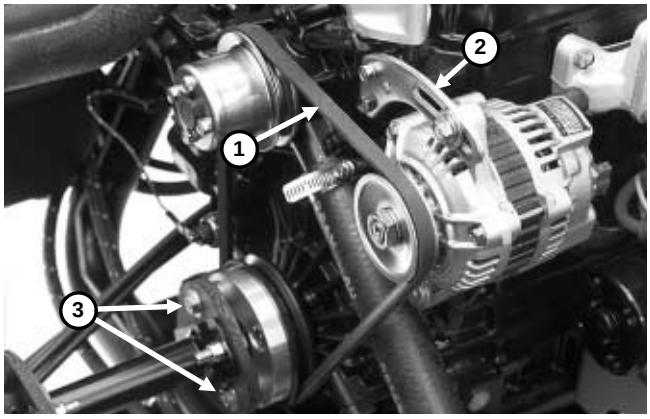


Figure 36

1. Alternator belt
2. Alternator brace
3. Capscrews and washers

Fan Belt

1. Loosen locknut on idler pulley (Fig. 37).

2. Remove belt by carefully moving around fan blades.

3. Install new belt.

4. To adjust belt tension, loosen idler pulley mounting nut and move pulley to increase tension. To check tension depress belt midway between fan and drive shaft pulleys with 22 lbs. of force. A new belt should deflect 0.48 to 0.58 inch and a used belt 0.55 to 0.65 inch. Tighten nut to secure adjustment.

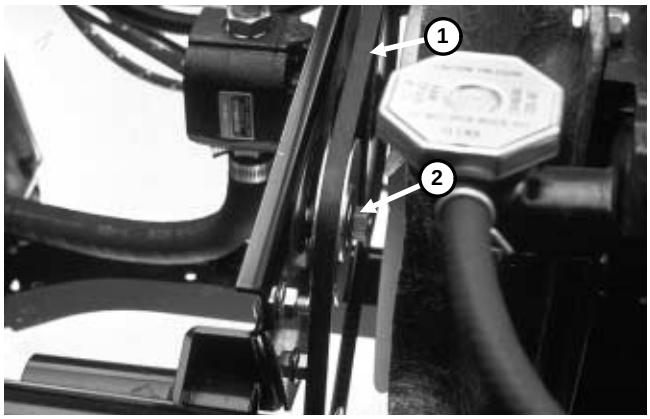


Figure 37

1. Fan belt
2. Idler pulley

Thermostat Removal and Installation

1. Lower the coolant level to below the thermostat.

2. Loosen the hose clamp and disconnect the hose from the water outlet fitting.

3. Remove the water outlet fitting and gasket (Fig. 38).

4. Replace the thermostat if necessary (See Thermostat Test in the Testing section of this chapter).

5. Do not allow the thermostat flange to protrude from the water outlet fitting joint. Do not place thermostat stay in the direction of thermoswitch hole. Use a new gasket when installing the water outlet fitting.

6. Check for damaged hoses or damaged hose clamps. Replace as required. Install the hose on the water outlet fitting and tighten the hose clamp.

7. Fill the cooling system to the proper level with a 50/50 solution of clean, soft water and ethylene glycol antifreeze (See Checking the Cooling System and Changing Coolant in the Maintenance section of this book.).

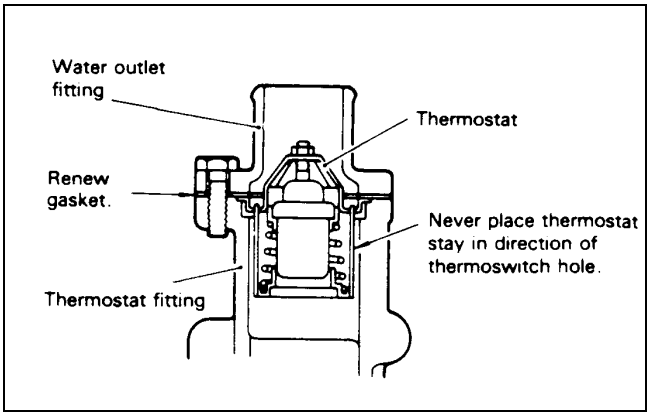


Figure 38

Water Pump Service

1. Drain the cooling system.

2. Remove the drive belt from the water pump and alternator.

3. Loosen the hose clamp and disconnect the hose from the water pump.

4. Remove the water pump (Fig. 39).

5. Check the water pump for cracks or leaks. Rotate the water pump shaft by hand. If the bearings do not rotate smoothly, or are noisy replace the water pump with a new water pump. There are no replaceable parts in the water pump.

6. Install the water pump and a new gasket onto the cylinder block.

7. Check for damaged hoses or damaged hose clamps. Replace as required. Install the hoses on the water pump and tighten the hose clamps.

8. Install the alternator / water pump drive belt and adjust belt tension (see Belt Tension Adjustment).

9. Fill the cooling system with a 50/50 solution of clean, soft water and ethylene glycol antifreeze.

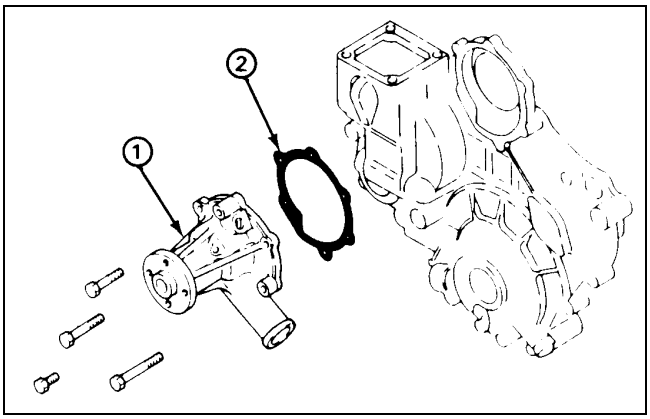


Figure 39

1. Water pump
2. Gasket

Electrical System Repairs

Alternator Removal and Installation

1. Disconnect the negative (–) cable from the battery.

2. Disconnect the wire from terminal “B” on the back of the alternator.

3. Disconnect the alternator wiring harness connector.

4. Loosen alternator brace bolt and alternator support bolt (Fig. 40). Push the alternator toward the engine and remove the belt.

5. Remove the alternator.

6. Reverse steps 1 - 5 to install the alternator. Make sure the spacer and shim is installed on the alternator support bolt between the alternator lower rear bracket and gear case bracket (Fig. 41).

7. Insert a pry bar between the alternator and engine and pry out alternator. Apply only enough pressure to get the correct belt tension.

8. Hold the alternator in position after you get proper belt tension and tighten the alternator brace bolt. Tighten the alternator support bolt. To check tension, depress belt midway between crankshaft and alternator pulleys with 22 lbs. of force. A new belt should deflect 0.3 to 0.5 inch and a used belt 0.4 to 0.55 inch.

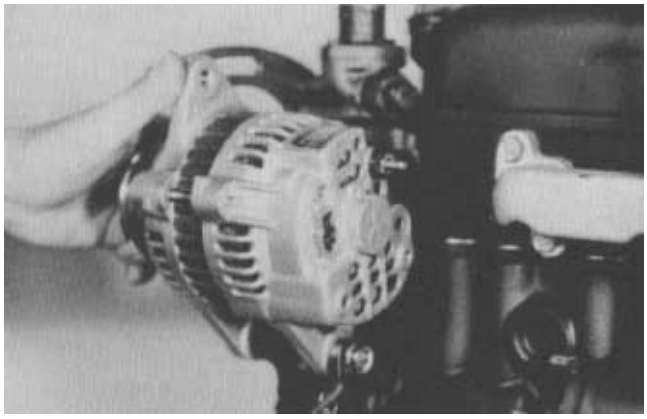


Figure 40

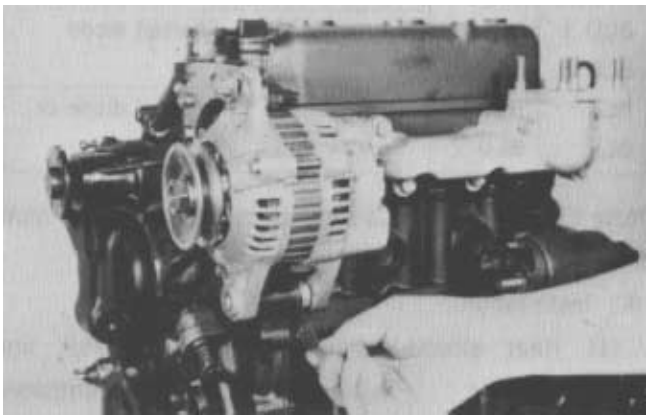


Figure 41

Starter Removal and Installation

1. Disconnect the negative (–) cable from the battery.

2. Disconnect the wires from the starter solenoid (Fig. 42).

3. Remove the two cap screws and washers securing the starter to the bracket.

4. Remove the starter.

5. Reverse steps 1 - 4 to install the starter.

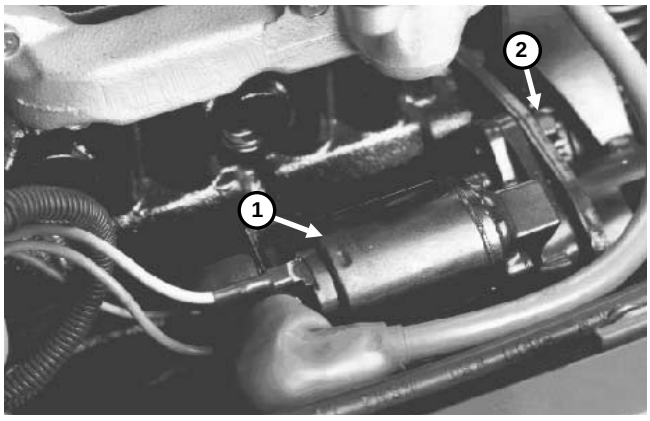


Figure 42

1. Starter solenoid **2. Cap screw and washer (2)**

Replacing and/or Adjusting Engine Stop Solenoid

An improperly adjusted stop solenoid can result in failure of the engine to stop when the key switch is turned off or could cause injection pump damage or malfunction.

Removing the Stop Solenoid

1. Stop the engine. If the engine will not stop when the ignition key switch is turned off, manually push the stop lever (located next to the injection pump on the engine) toward the rear of the machine until the engine stops.

2. Disconnect the solenoid electrical connector.

3. Loosen the nut securing the solenoid to the engine and unscrew the solenoid.

4. If you will be installing a new solenoid, remove the gasket and nut from the old solenoid and install them on the new solenoid. Thread the nut completely on the new solenoid.

Installing and/or Adjusting the Stop Solenoid

1. Remove the governor tie rod cover (Fig. 43).

2. Apply thread sealant to the solenoid threads.

3. Thread the solenoid into the engine.

4. Thread the solenoid into the engine while moving the tie rod back and forth (Fig. 44). Stop screwing the solenoid into the engine when there is no free play in the tie rod.

5. Turn the solenoid outward (counterclockwise) 1/4 to 1/2 turn. There should be a small amount of free play in the injector pump control rack 0.01 - 0.03 in. (0.3 - 0.7 mm).

IMPORTANT: No free play in the control rack with the solenoid de-energized (plunger out) may cause injection pump damage or malfuntion. Excess free play 0.04 in. (1 mm) or more will prevent the engine from stopping when the solenoid is de-energized.

6. Remove the cover cap screw from the engine to get access to the solenoid nut (Fig. 43).

7. Hold the solenoid body to prevent it from turning and tighten the nut against the engine to secure the adjustment. Do not over tighten the nut. If the nut is over tightened, the solenoid may become distorted and will not operate correctly.

8. Install the cover cap screw that was removed from the engine in step 6.

9. Connect the solenoid electrical connector.

10. Install the governor tie rod cover.

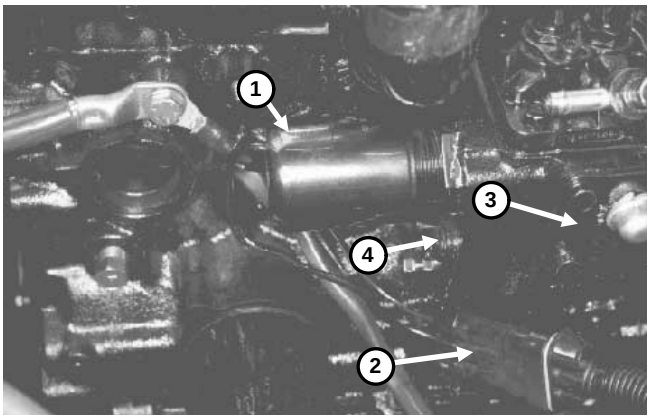


Figure 43

1. Fuel stop (ETR) solenoid
2. Solenoid electrical connector
3. Governor tie rod cover
4. Cover cap screw

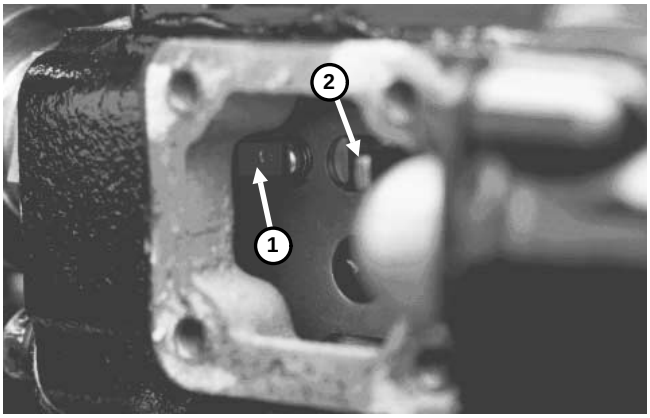


Figure 44

1. Solenoid plunger
2. Tie rod

Glow Plug Replacement

Replace the glow plug(s) if they do not operate correctly. (See Glow Plug Test in the Testing section of this chapter.)

1. Remove the nut and lead wire.

2. Clean the area around the glow plug. This will prevent dirt or other contamination from falling through the glow plug hole into the cylinder.

3. Remove the glow plug.

4. Install a new glow plug. Tighten the glow plug to a torque of 11-14.5 ft-lb (1.5-2 KgM).

5. Install the lead wire and nuts.

Oil Pressure Switch Replacement

The engine is equipped with an oil pressure switch (Fig. 45). This switch activates a lamp on the control panel and a buzzer if the oil pressure drops below safe levels during operation.

Pressure switch ON pressure: 0.5 kg/cm^2 (7 psi)

Replace the switch if it is not operating correctly. Before installing the switch put a small amount of Loctite #567 Thread Sealant (or equivalent) on the switch threads. When installing the switch make sure the sealant does not block the oil hole in the switch.

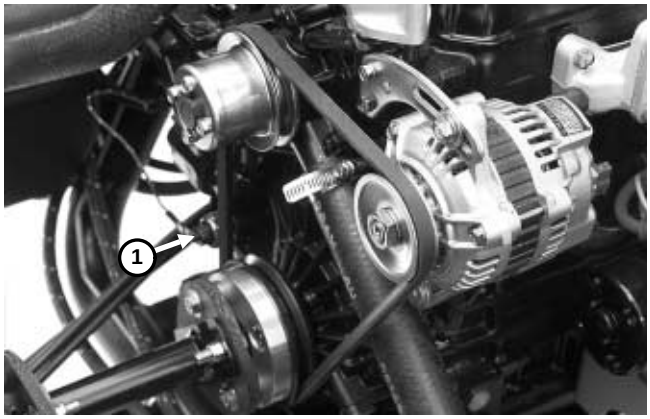


Figure 45

1. Oil pressure switch

Starter Service

Disassembly and Inspection

1. Remove the starter from the engine (see Starter Removal and Installation).

2. Disconnect wire from magnetic switch terminal “M”.

3. Loosen two screws securing the magnetic switch. Remove the magnetic switch.

4. Remove two through bolts and screws securing the brush holder. Remove the rear bracket.

5. With the two brushes in the floating state, remove the yoke and brush holder assembly. Pull the armature out.

6. Remove the cover, pry the snap ring out and remove the washer.

7. Unscrew the bolts and remove the center bracket. As the bracket is removed, washers for pinion shaft end play adjustment will come off.

8. Pull out the reduction gear lever and lever spring from the front bracket.

9. Pry the snap ring out on the pinion side and pull out the pinion and pinion shaft.

10. Remove the ball bearings from each end of the armature with a bearing puller. The bearing that is press-fitted in the front bracket cannot be removed. Replace the bracket assembly if the bearing is worn or damaged.

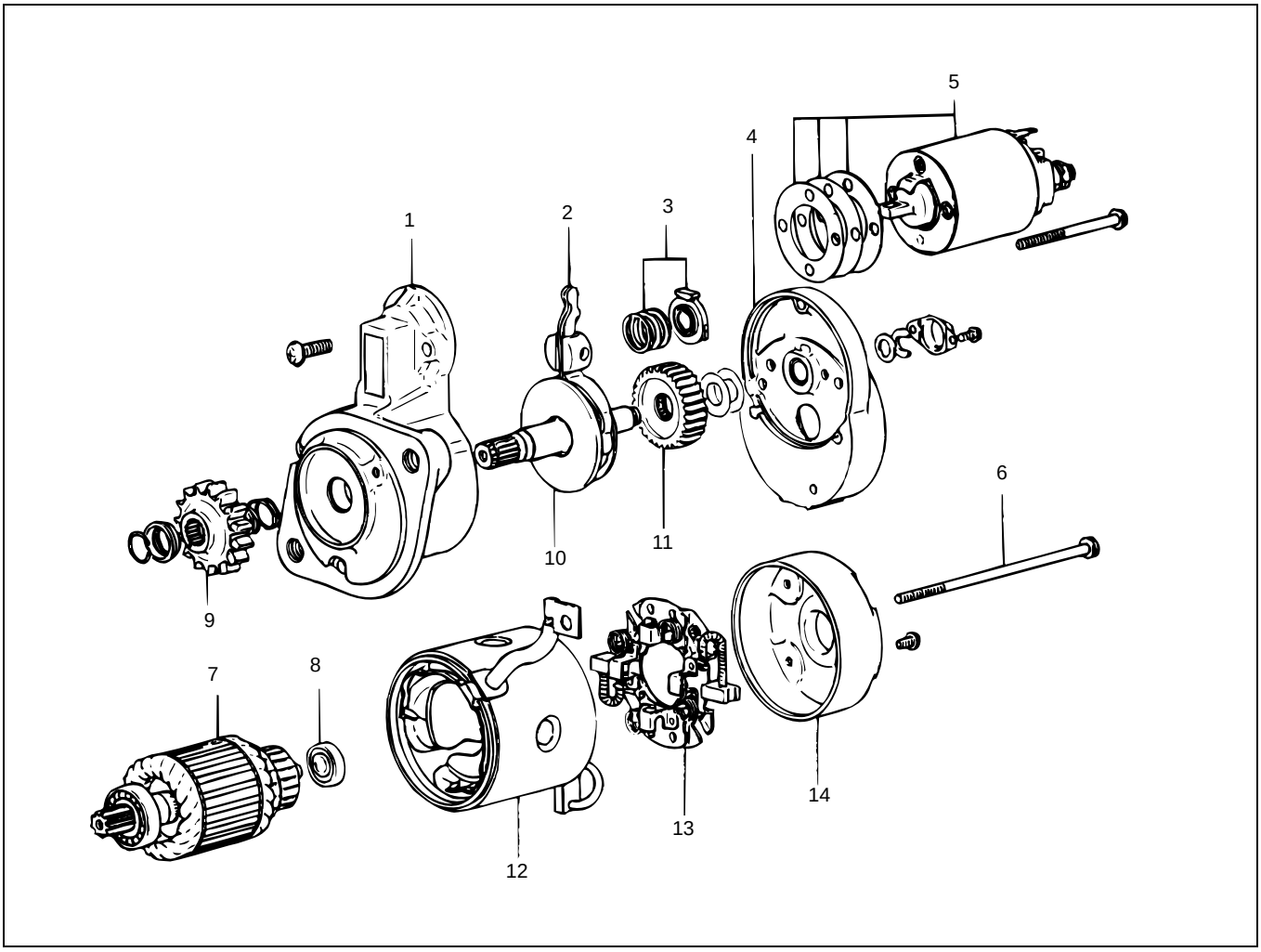


Figure 46

1. Front bracket assembly
2. Lever assembly
3. Spring set
4. Center bracket assembly
5. Switch assembly
6. Through bolt
7. Armature
8. Rear bearing
9. Pinion
10. Pinion shaft assembly
11. Gear
12. Yoke assembly
13. Brush holder assembly
14. Rear bracket

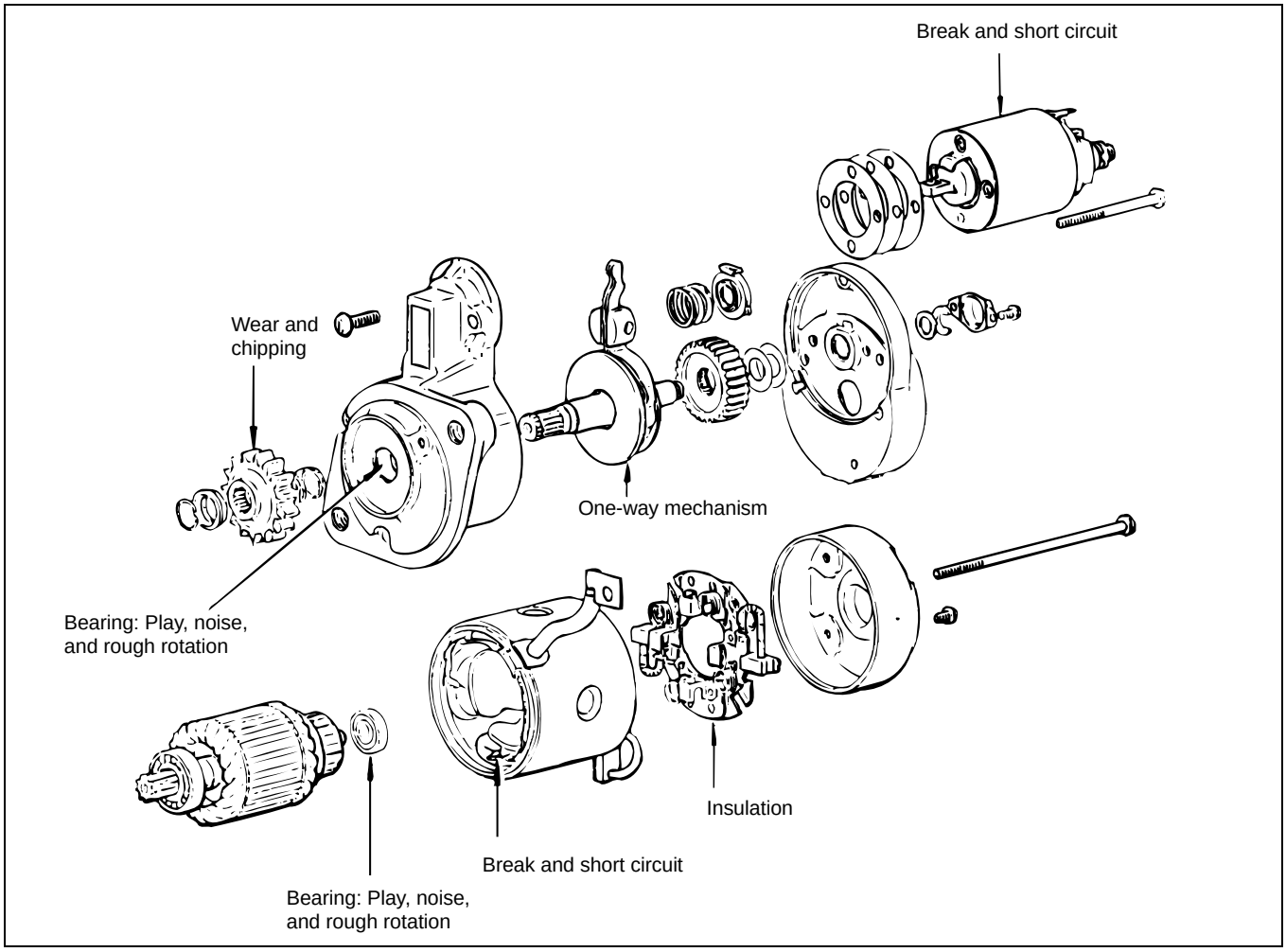


Figure 47

10. Check the magnetic switch for continuity between terminals “S” and “M” and between terminals “S” and body. If there is continuity (or zero ohm is indicated), replace the magnetic switch.

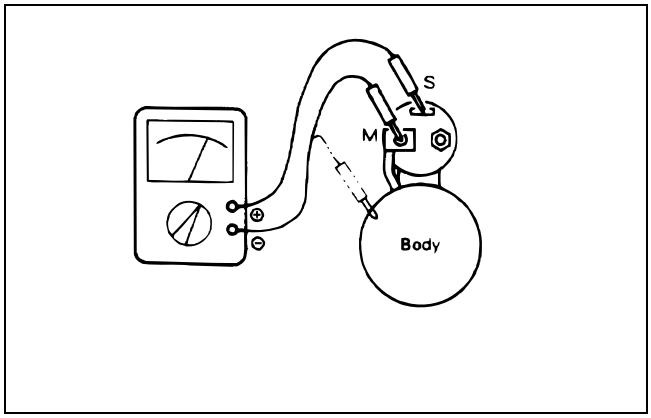


Figure 48

11. Put the armature on a growler tester to check for a shorted armature. A burned commutator bar is an indication of a shorted armature. With the growler turned on, put a thin strip of steel or a hacksaw blade on the armature as it is slowly rotated. If the metal strip vibrates over a winding, that winding is short circuited. Short circuited windings are sometimes caused by metal in the commutator bridging the gap from on commutator bar to the next. By removing the bridged metal, this condition can be corrected. If this does not correct the short replace the armature.

12. Measure the commutator O.D. and depth of undercut. Repair or replace if the service limit is exceeded. Check the commutator outside surface for dirt and roughness. If rough, polish the commutator with fine (00 or 000) sandpaper. DO NOT use emery cloth.

Item	Standard	Service Limit
Commutator O.D.	38.7 mm (1.52 in.)	– 1.0 mm (– 0.4 in.)
Depth of Undercut	0.5 mm (0.02 in.)	0.2 mm (0.008 in.)

13. Check the brushes. Replace if worn beyond the service limit. Check the brush spring tension. Replace the springs if tension is less than the service limit. Check for insulation between the positive brush holder and holder base. If poorly insulated, replace the holder assembly. Check the brush holders for proper staking.

Item	Standard	Service Limit
Height of Brush	17 mm (0.67 in.)	6 mm (0.24 in.)
Spring Pressure	3 kg (6.6 lb.)	

14. Check for continuity between one end of field coil (brush) and yoke. There should be no continuity. Check for continuity between both ends of coil (brushes). There should be continuity if the field coil is good. Check the poles and coil for tightness.

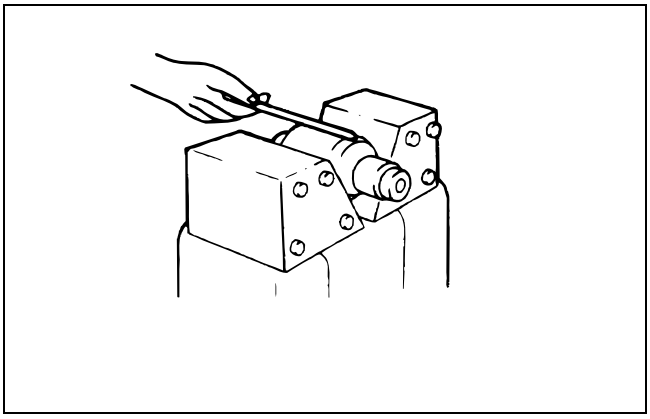


Figure 49

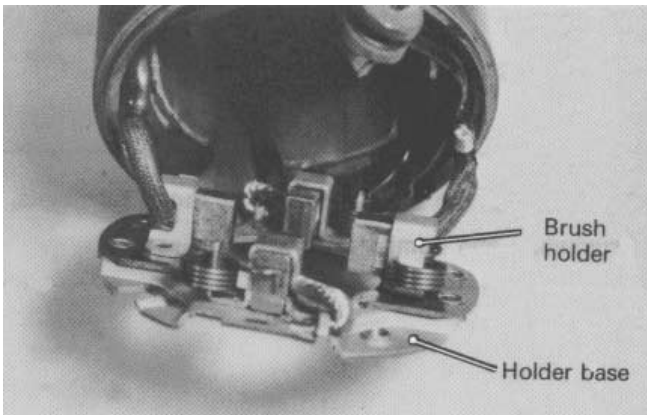


Figure 50

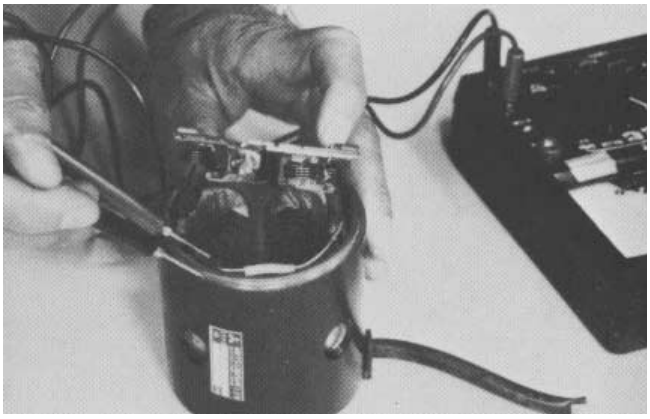


Figure 51

Assembly and Adjustment of Starter

1. Reverse steps 1 - 10 under Disassembly and Inspection and also following the following instructions:

2. Set the pinion shaft end play (thrust gap) to 0.5 mm (0.02 in.) or less by inserting an adjusting washer between the center bracket and reduction gear.

A. Fit the pinion shaft, reduction gear washer and snap ring to the center bracket.

B. Measure end play by moving the pinion shaft in and out. If end play exceeds 0.5 mm (0.02 in.), increase the number of adjusting washers.

3. Put grease on the following parts whenever the starter has been overhauled:

Armature shaft gear and reduction gear
All bearings
Bearing shaft washers and snap rings
Bearing sleeves
Pinion
Sliding part of lever

IMPORTANT: Never put grease on terminals, brushes, commutator or surface that mounts to the engine.

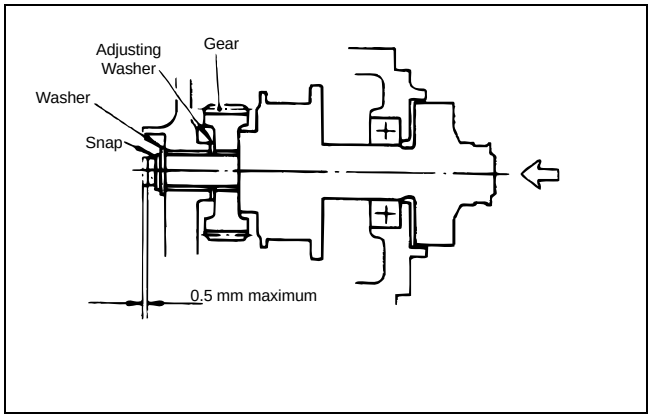


Figure 52

Alternator Service

Disassembly and Inspection

1. Remove the alternator from the engine (see Alternator Removal and Installation).

2. Remove the three through bolts.

3. Use a solder iron to heat the rear bracket around the rear bearing to 120 - 140^{o} F (50 - 60^{o} C). Separate the front and rear brackets by prying with a screwdriver blade inserted between the brackets.

IMPORTANT: Be careful not to insert the blade too far causing damage to the windings.

4. Put the rotor in a vise. Remove pulley nut and pull off the pulley and spacer.

5. Pull the rotor assembly from the front bracket.

6. Unsolder the stator core lead wires. Remove the stator assembly.

IMPORTANT: To prevent damage to the diodes, heat the stator core lead wires only long enough to remove.

7. Disconnect the capacitor from terminal “B”.

8. Loosen the screws securing the rectifier and remove the rectifier.

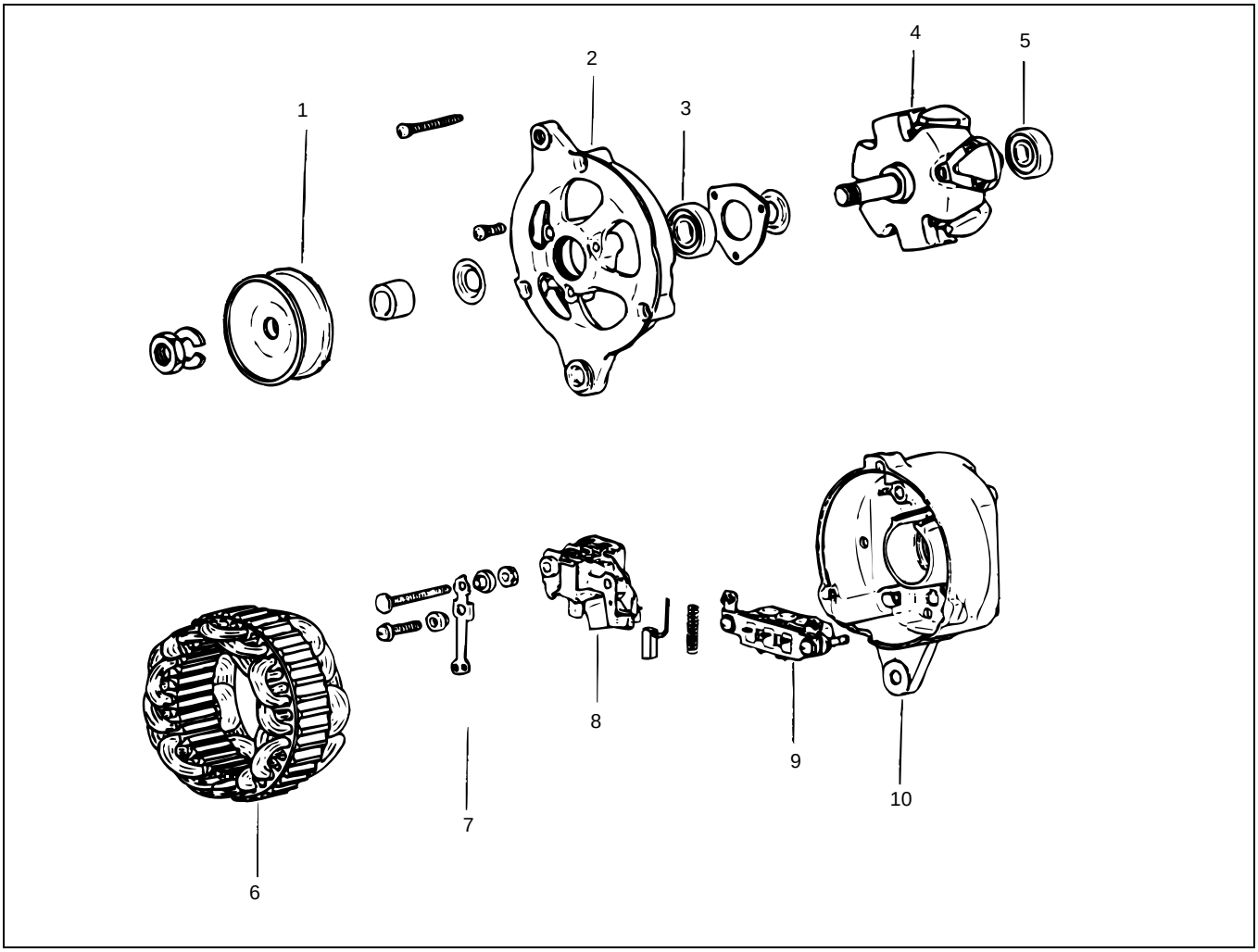


Figure 53

1. Pulley
2. Front bracket assembly
3. Front bearing
4. Rotor assembly
5. Rear bearing
6. Stator
7. Terminal set assembly
8. Regulator assembly
9. Rectifier assembly
10. Rear bracket assembly

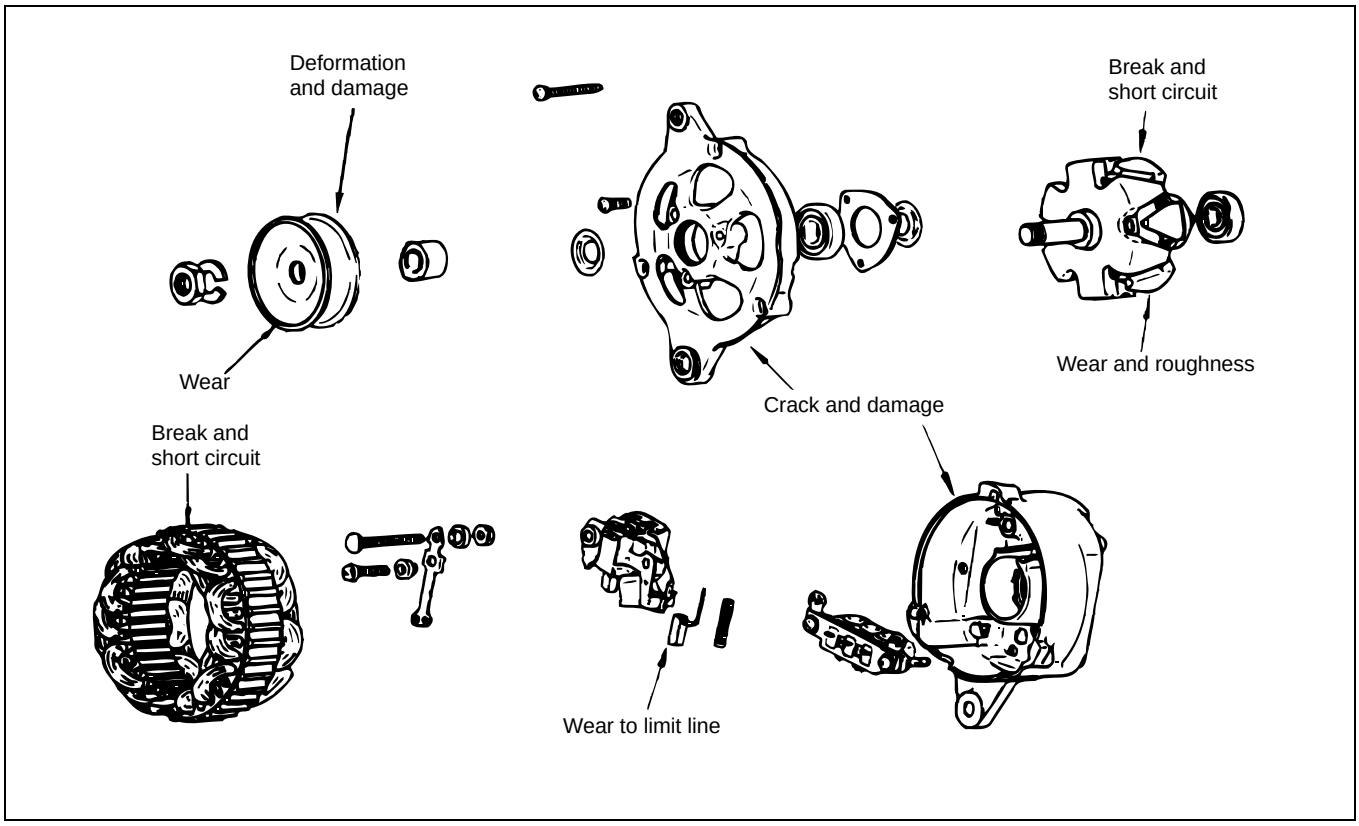


Figure 54

9. Check each diode in the rectifier for conduction. Connect an ohm meter across the lead wire and diode case. The diode is normal if its resistance is large in one direction and small in the reverse direction. If there is equal resistance in both directions the diode is damaged. Replace the rectifier assembly if a diode is damaged.

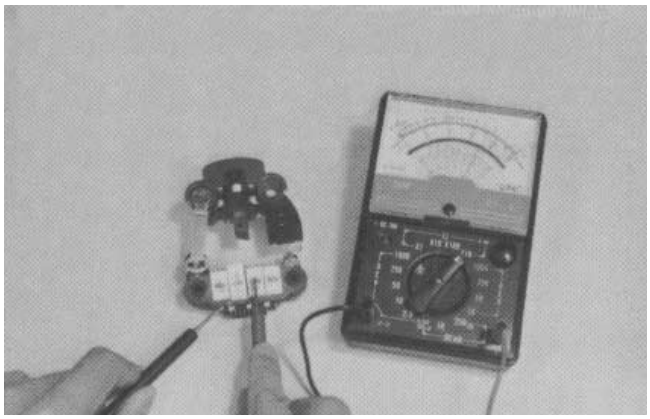


Figure 55

10. Check the field coil for continuity between the slip rings. If there is no continuity, replace the field coil.

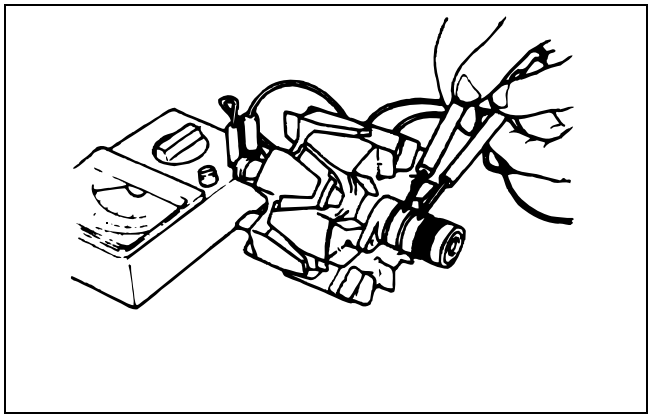


Figure 56

11. Check for continuity between a slip ring and shaft (core). Replace the field coil if there is continuity.

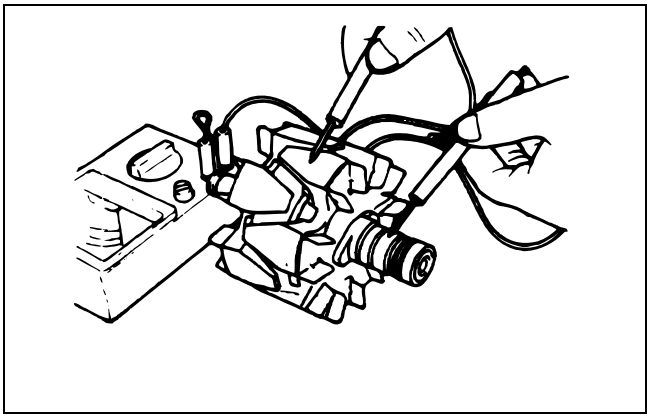


Figure 57

12. Check for continuity between lead wires of the stator coil. Replace the stator coil if there is no continuity.

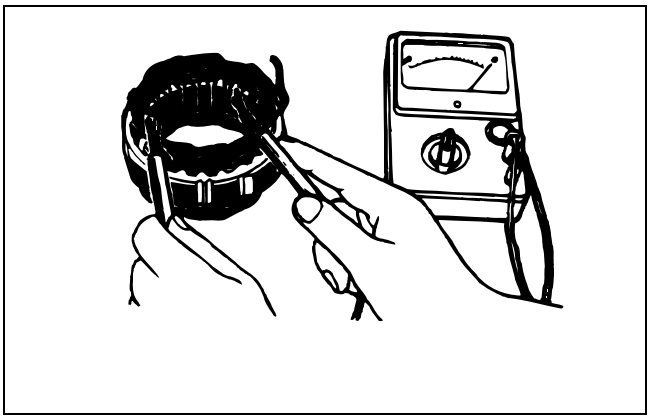


Figure 58

13. Check for continuity between each lead wire and stator core. Replace the stator coil if there is continuity.

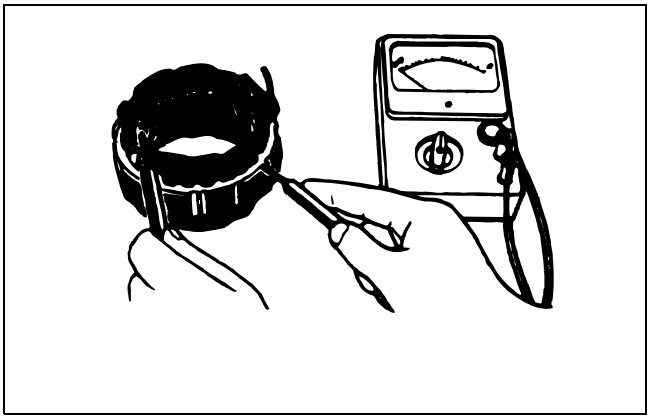


Figure 59

Assembly of Alternator

1. Reverse steps 1 - 8 under Disassembly and Inspection and also following the following instructions:

2. The rear bearing has an eccentric groove. Install the snap ring so its projection fits in the deepest part of the groove.

3. When installing a new rear bearing, press fit the bearing with its groove facing the slip ring side.

4. Heat the rear bracket when press fitting the rear bearing into the bracket.

IMPORTANT: Put a wire through the small hole in the rear bracket to lift the brushes before installing the rotor to the rear bracket. Remove the wire after the rotor is installed.

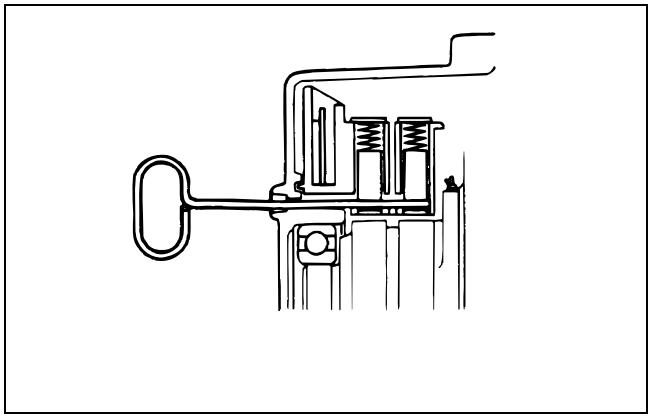


Figure 60

Governor System Repairs

Governor Operation

The governor keeps the engine operating at a constant speed by balancing the centrifugal force acting on the governor weights and the governor spring tension. As the engine picks up speed, the governor weights open to move the sliding shaft forward. The shaft pushes on the governor lever to move the injector control rack and decrease the fuel injection rate. At the same time the governor spring is pulled by the governor lever until the spring force is balanced with the centrifugal force of the governor weights, thus maintaining constant engine speed.

When the speed control lever is pulled toward high speed, the governor spring is pulled. The spring pulls on the governor lever to move the governor control rack and increase the fuel injection rate. As engine speed increases, the governor weight centrifugal force also increases until it is balanced with the governor spring force, thus maintaining a constant engine speed.

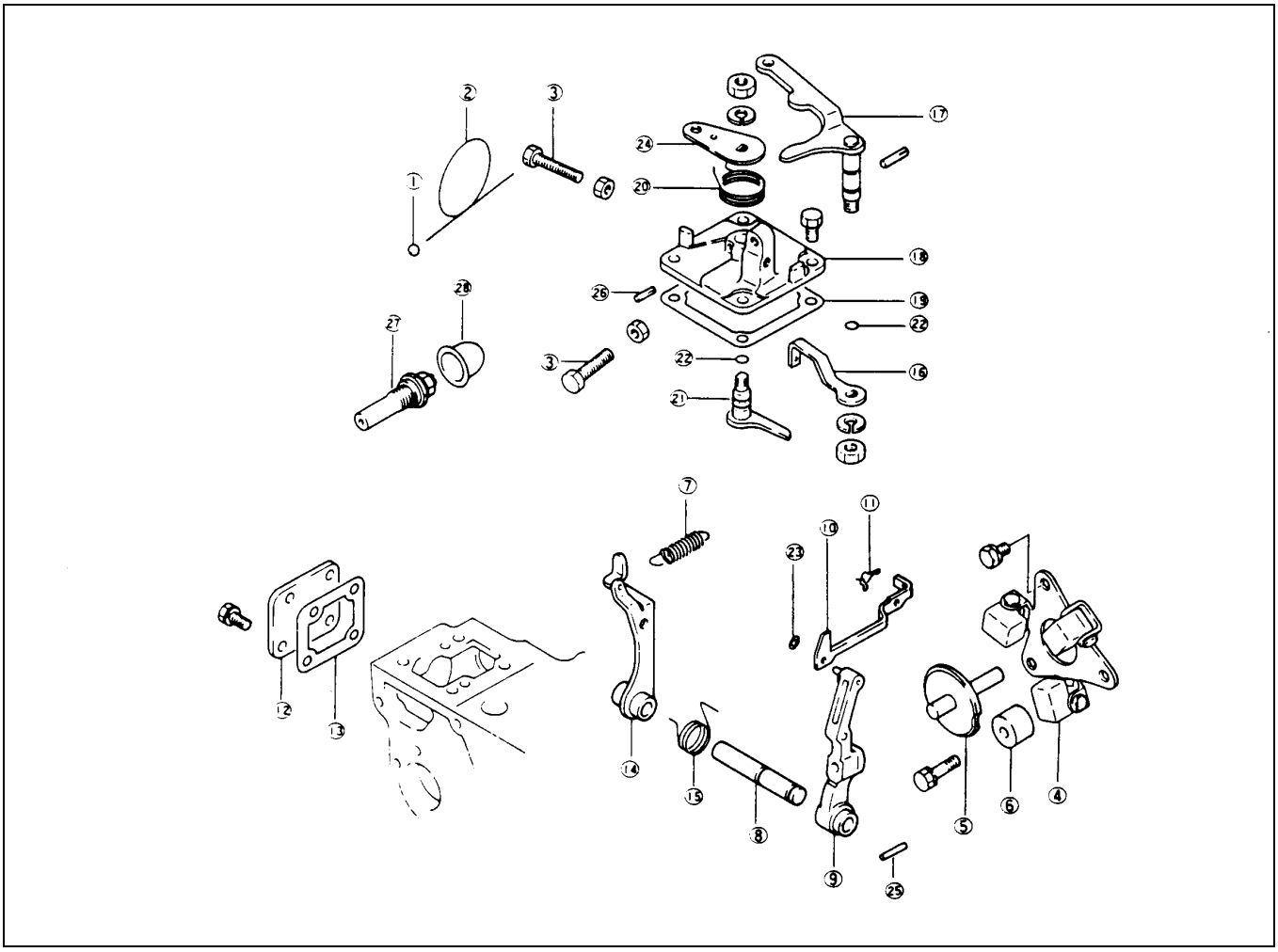


Figure 61

1. Sealing metal
2. Sealing wire
3. Speed adjustment screw
4. Governor weight assembly
5. Sliding shaft
6. Stopper
7. Governor spring
8. Governor shaft
9. Governor lever
10. Tie rod
11. Tie rod clip
12. Tie rod cover
13. Tie rod cover gasket
14. Tension lever
15. Start spring
16. Governor spring lever
17. Speed control lever ass'y
18. Governor cover gasket
19. Governor cover gasket
20. Return spring
21. Stop lever assembly
22. O-ring
23. Snap ring
24. Stop lever
25. Grooved pin (3 x 20 mm)
26. Grooved pin (3 x 14 mm)
27. Torque spring set
28. Sealing cap

Governor Inspection

A governor failure can cause engine starting failure, loss of engine speed control, or engine surging (hunting). Before removal and disassembly of the engine the following inspections are recommended:

1. Remove the governor tie rod cover (Fig. 41).

2. While holding the stop lever (Fig. 14) in the stop position (towards the rear of the machine) turn the ignition key switch quickly to the START position and release it to the ON positon. This will retract the stop solenoid plunger, allowing movement of the injection pump control rack.

3. Push the tie rod forward only with only enough force to overcome the spring pressure and operate the speed control lever (or throttle lever). You should feel the governor lever, under spring tension, move the tie rod and control rack as the lever is operated.

4. If the control rack does not move move correctly, disconnect the tie rod from the injection pump control rack. Make sure the injection pump control rack moves freely. If it does not, check for injection pump problems.

5. Failure of the speed control lever or governor lever to move when the tie rod is disconnected may indicated a problem with internal parts of the governor.

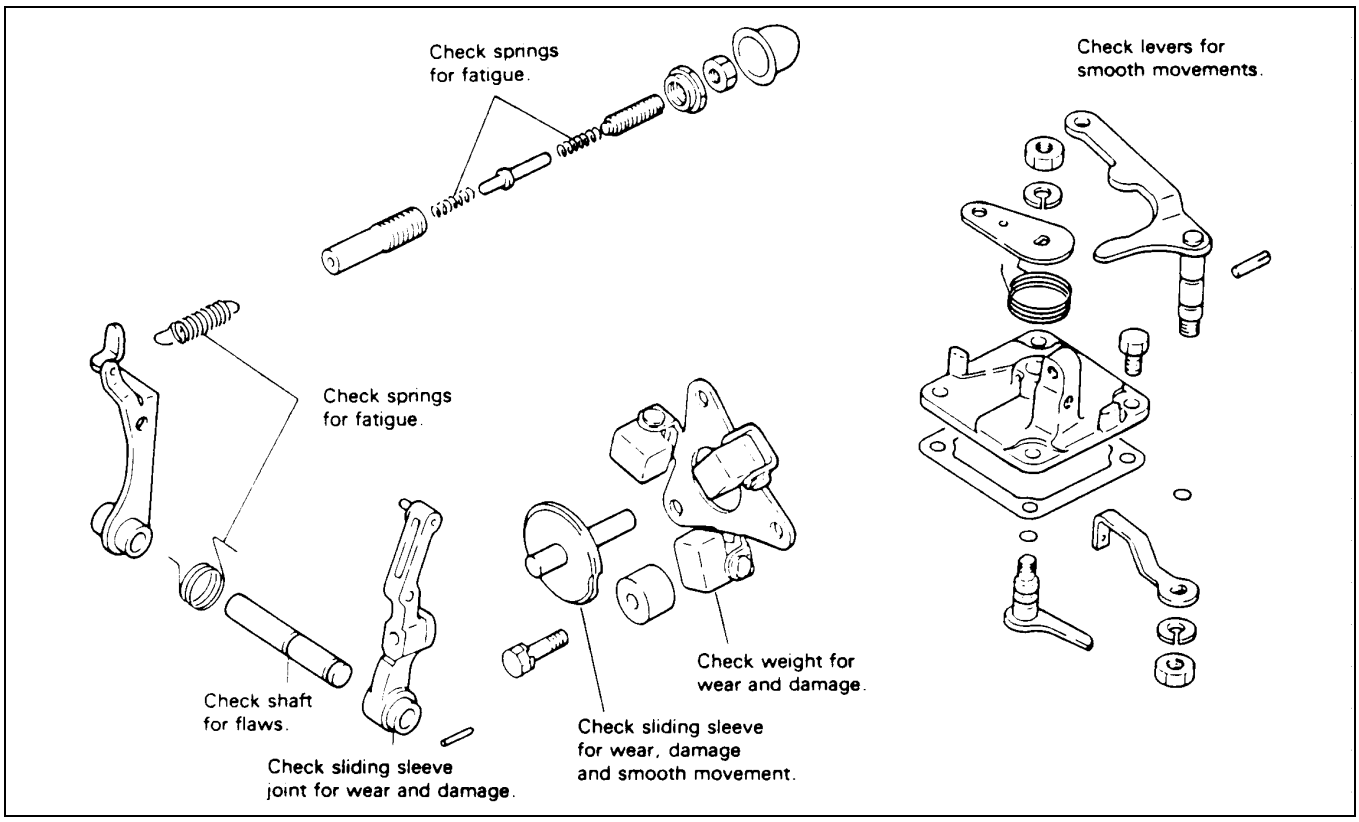


Figure 62

Governor Service

1. Remove the tie rod cover (Fig. 33).

2. Remove the tie rod clip and disconnect the tie rod from the injection pump control rack.

3. Disconnect the governor spring from the tension lever.

4. Remove the cover assembly.

5. Removing the levers:

A. To remove the levers, pull out the grooved pins from the governor lever, stop lever and speed control lever.

B. Loosen the bolts securing the levers and shafts.

6. Installing the levers:

A. Coat the o-rings with oil before installation.

B. Install the levers and shafts. After press fitting each grooved pin, check the shaft for smooth operation.

C. Install the governor spring lever and speed control lever so there is a minimum play of angle between levers (Fig. 35) .

D. The governor spring should not deflect more than 20 mm (0.8 in.) when installed.

9. Inspect all parts for wear or damage and smooth operation.

10. Reverse steps 1 - 4 to reassemble. After assembly, make sure that the governor mechanism operates smoothly.

NOTE: Further governor repairs require removal of the gear case (See Gear Case and Oil Pump in the Cylinder Block Overhaul section of this chapter).

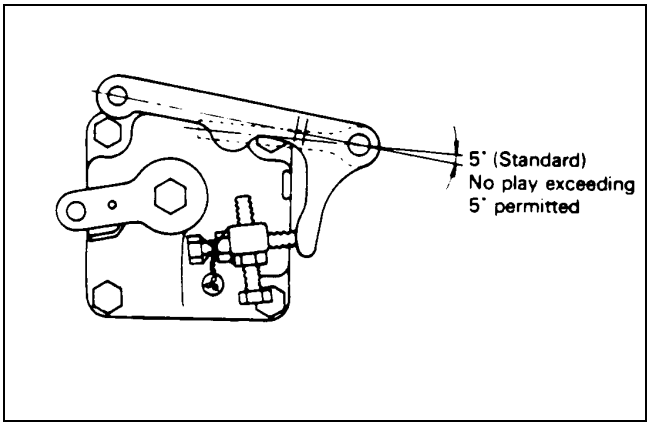


Figure 35

Installation of Torque Spring Set

IMPORTANT: Torque spring set adjustment has been done and sealed at the factory. Do not remove, disassemble or adjust this device unless necessary. The torque spring set adjustment is very sensitive. Improper adjustment can vary fuel delivery to under power or over fuel the engine.

1. Engage the parking brake. Make sure the high speed set bolt is adjusted to the correct engine speed of 3600 ±50rpm (See Adjusting Engine Speed).

NOTE: Specified rpm is with no load on engine.

2. Operate the engine at high idle speed.

3. Turn the torque spring set (Fig. 36) clockwise until engine speed drops approximately 50 rpm from high idle speed.

4. From this position, turn the back the torque spring set (counterclockwise) “N” turns. Lock the torque spring set in position with the special nut.

Engine Model L3Ca-62TG: N = 2.5
Engine Model L3Ea-62TG: N = 2.6

5. Install the sealing cap.

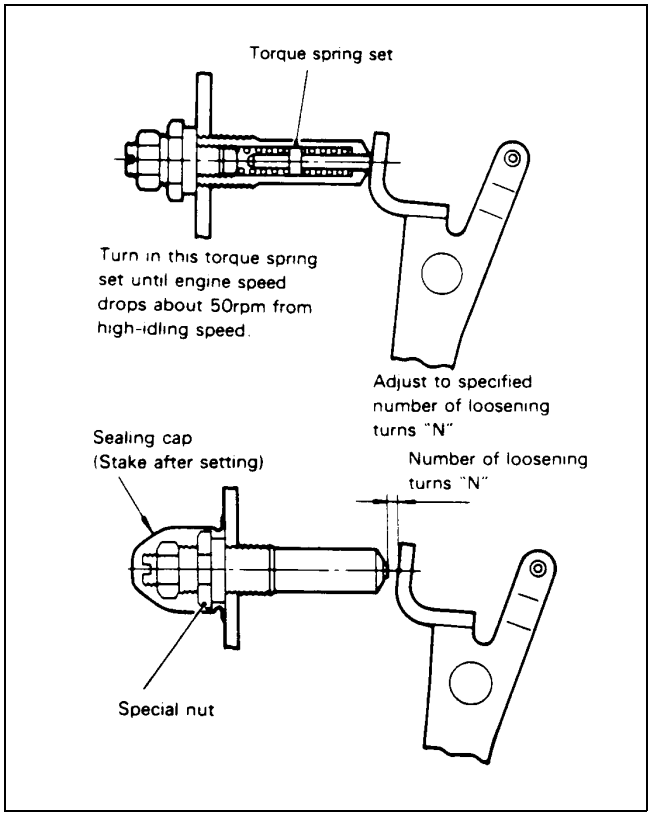


Figure 36

Assembly of Torque Spring Set

If the torque spring set has been disassembled or parts replaced, reassemble and adjust the torque spring set using the following procedure.

IMPORTANT: The torque spring set has been adjusted and sealed at the factory. Do not remove, disassemble or adjust this device unless necessary. The torque spring set adjustment is very sensitive. Improper adjustment can vary fuel delivery to under power or over fuel the engine.

1. Assemble the torque spring set as shown in Figure 37.

2. Use a screwdriver operated by fingertips to lightly tighten adjustment screw until resistance to rotation is felt. Lightly lock the screw in position with locknut.

3. Set dial on spring scale to zero (0). Tighten spring case until a value of 1270^{+10}_{-0} grams is obtained. Lock the spring case in that position with special nut.

4. Temporarily loosen adjustment screw until to get a value of 1070 grams then retighten the screw until a value of 1270^{+0}_{-10} grams is attained. Lock the adjustment screw in position with locknut.

5. To inspect torque spring set for proper adjustment, use a test set up as shown (Fig. 38). Gradually push scale against torque spring set until stopper is moved (or pointer of dial indicator moves). Check that load applied to torque spring at that moment is 1250^{+20}_{-30} grams.

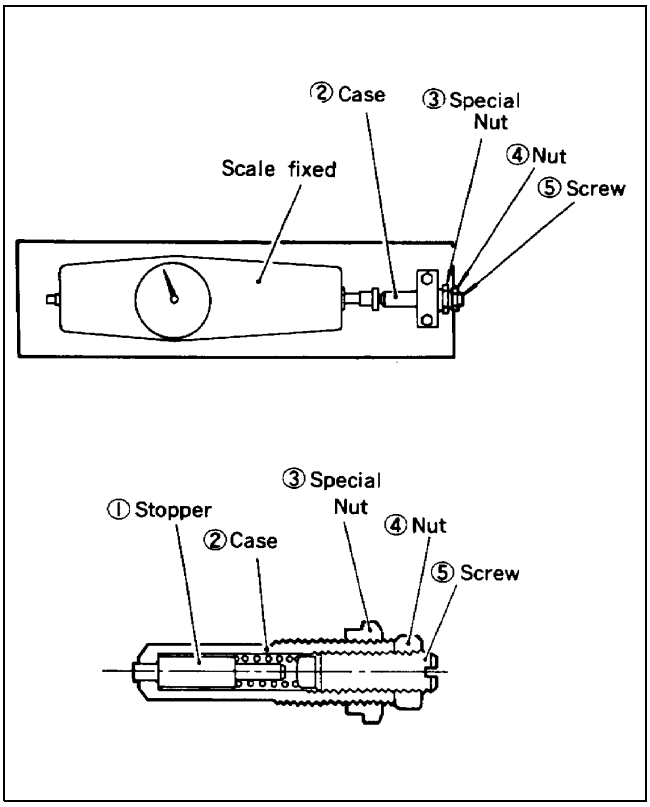


Figure 37

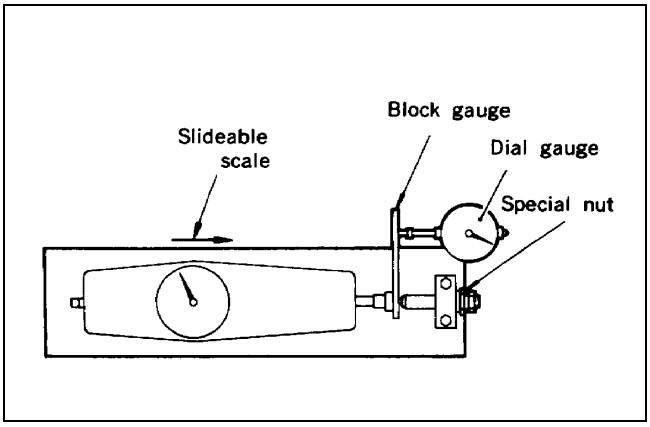


Figure 38

Fuel System Repairs

When cleaning the engine, DO NOT spray water onto a hot injection pump. This could cause the fuel pump to seize and be damaged.

When working on the fuel system, ALWAYS make sure that the equipment and work area is clean. The close tolerance parts of the fuel system can be easily damaged by dirt.

Wash fuel system parts in clean fresh diesel fuel. If parts are removed for a period of time, store them in containers of clean diesel fuel to prevent corrosion.

Bleeding the Fuel System

1. With the engine OFF, loosen the air bleed screw on the fuel filter / water separator (Fig. 39).

2. Turn the ignition key switch to ON position. The electric fuel pump will begin to operate and force fuel out around the air bleed screw. Fuel will fill the filter bowl and then flow out around the screw. When a solid stream of fuel flows out around the screw, tighten the screw and turn the key switch OFF.

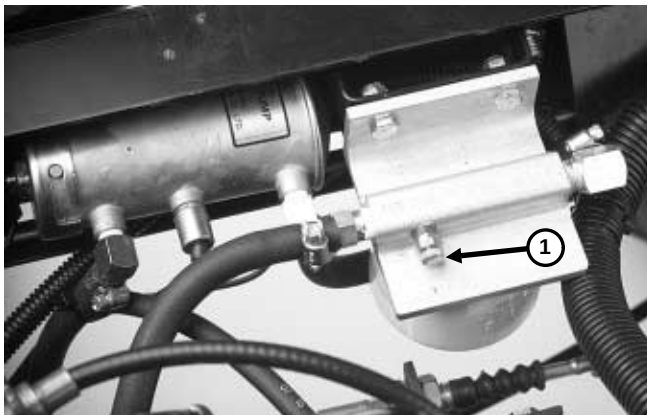


Figure 39

1. Bleed screw

3. Open the air vent screw on the fuel injection pump (Fig. 40).

4. Turn the ignition key switch to the ON position. The electric fuel pump will begin to operate and force fuel out around the injection pump air vent screw. When a solid stream of fuel flows out around the screw, tighten the screw and turn the key switch OFF.

NOTE: Normally the engine should start after this procedure. If the engine does not start, air may be trapped between the injection pump and injectors (See Bleeding Air From the Injectors in this section of the book.)

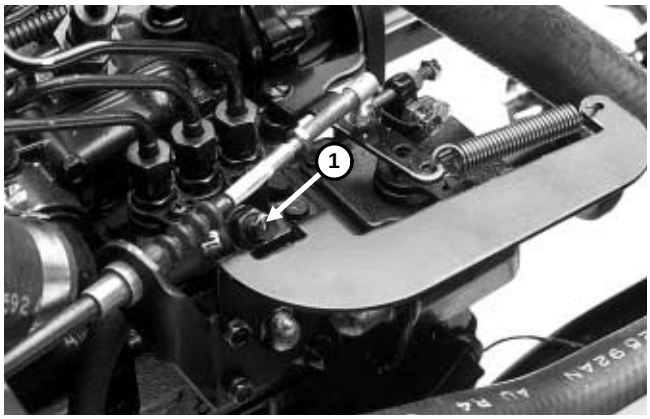


Figure 40

1. Fuel injection pump air vent screw

Bleeding Air From the Injectors

This procedure should only be used if the fuel system has been purged of air. (See Bleeding the Fuel System in this section of the book.)

1. Loosen the pipe connection at the number one nozzle and holder assembly on the cylinder head (Fig. 41).

2. Push accelerator pedal to the floor.

3. Turn the ignition key to the START position to crank the engine and pump fuel to the nozzles. Turn the ignition key to the OFF position when a steady stream of fuel flows out of the loose pipe connection.

4. Tighten the pipe connector.

5. Repeat steps 1 - 4 for the No. 2 and No. 3 injector nozzle and holder.

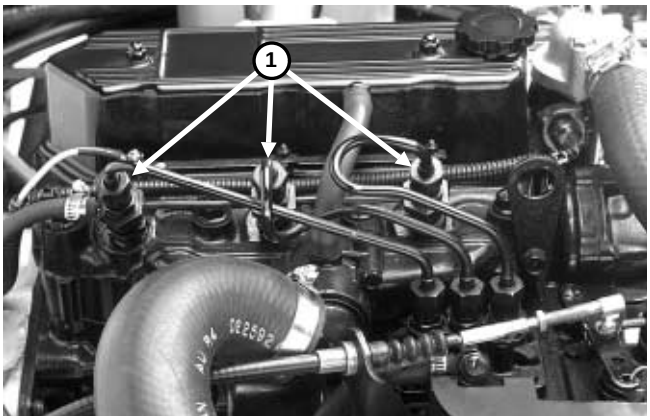


Figure 41

1. Fuel injector nozzle and holder (3)

Fuel Pump Service

The only serviceable parts of the fuel pump are the magnet, filter, and the gaskets on each end of the filter.

1. Disconnect the fuel pump wires from the wiring harness and ground connection.

2. Disconnect the fuel hoses from the pump. Plug the fuel lines.

3. Remove the two screws which secure the pump to the frame.

4. Use a 17 mm wrench to remove the cover from the fuel pump (Fig. 42). Remove the gasket, magnet and filter element.

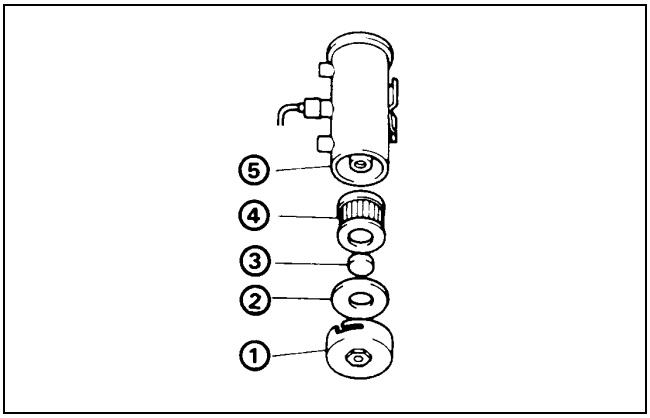


Figure 42

1. Cover
2. Cover gasket
3. Magnet
4. Filter
5. Body

5. Carefully remove the spring retainer from the end of the plunger tube (Fig. 43). Remove the washer, o-ring, valve, plunger spring and plunger.

IMPORTANT: Be careful not to bend or deform the plunger tube while disassembling the fuel pump. If the plunger tube is bent, the fuel pump plunger will bind and the pump will need to be replaced.

6. Install the plunger (valve side out), plunger spring, valve, o-ring, washer and spring retainer. Make sure the plunger operates freely.

7. Install the filter and cover gaskets, magnet, filter and cover. Tighten the cover to prevent air leaks.

8. Install the fuel pump to the frame. Connect the fuel lines and electrical wires.

9. Bleed the fuel system. (See Bleeding the Fuel System in this section of the book.)

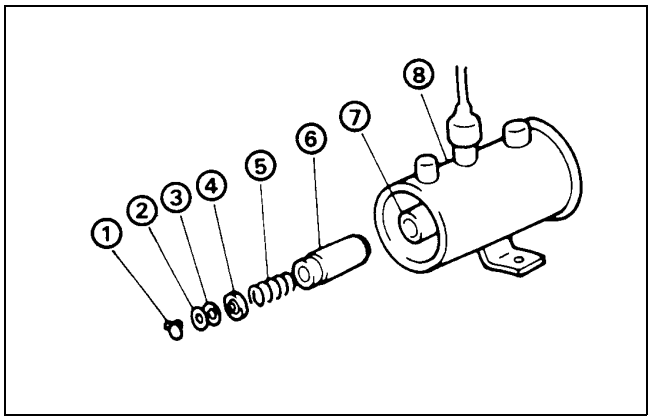


Figure 43

1. Spring retainer
2. Washer
3. O-ring
4. Valve
5. Plunger spring
6. Plunger
7. Plunger tube
8. Body

Injection Pump Service

Do not attempt the disassemble the injection pump unless it is necessary. If the pump is damaged or defective, it is recommended to replace the pump.

IMPORTANT: Clean the injection pump and the area near the injection pump before removing or servicing it. DO NOT spray water onto a hot injection pump.

Removing and Installing the Injection Pump

1. Remove the engine stop solenoid (see Replacing and/or Adjusting Engine Stop Solenoid in the External Engine Component Repair section of this chapter).

2. Disconnect the fuel pipes from the injector nozzles and injection pump delivery valve holders. Loosen the hose clamp and disconnect the fuel hose.

3. Remove the tie rod cover. Remove the tie rod clip and disconnect the tie rod from the injection pump control rack (Fig. 45).

4. Remove the four (4) injection pump mounting bolts. Remove the injection pump from the cylinder block. Make a note of the number and thickness of the adjusting shims under the pump. (The shims determine the injection timing.)

5. Reverse steps 1 - 4 to install the injection pump. Make sure the Engine Stop Solenoid is adjusted correctly. (See Replacing and/or Adjusting Engine Stop Solenoid in the External Engine Component Repair sectoin of this chapter.)

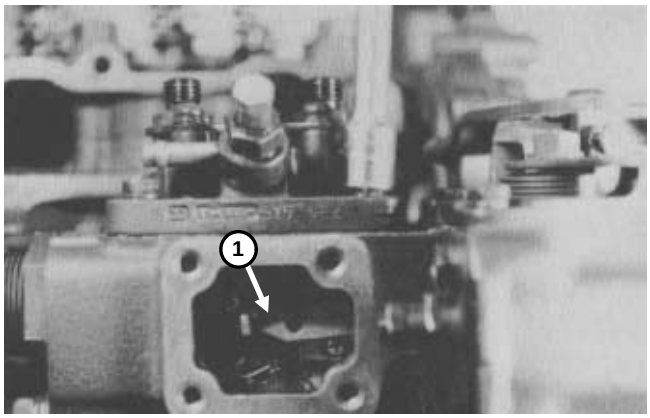


Figure 45

1. Tie rod (disconnected)

Injection Pump Disassembly

IMPORTANT: Do not mix the delivery valves, delivery valve seats, plungers or plunger barrels from one cylinder to another. These are parts are "matched sets". Handle these parts carefully. Place the parts in a container of clean diesel fuel to prevent corrosion.

1. Remove the stopper holder. Remove the delivery valve holder (Fig. 46).

2. Remove the valve spring, delivery valve and o-ring. Remove the gasket and valve seat.

3. Remove the tappet roller and stopper pin. Remove the tappet and adjusting shim.

4. Remove the lower seat from the plunger. Remove the plunger spring and upper seat

5. Remove the two screws securing the bracket to the pump housing. Remove the control rack.

IMPORTANT: DO NOT loosen the adjusting screws on the control rack for each cylinder. If these parts are removed, it is necessary to measure fuel injection quantity with a pump tester and cam box.

7. Remove the sleeve and plunger. Remove the plunger barrel upward from the pump housing.

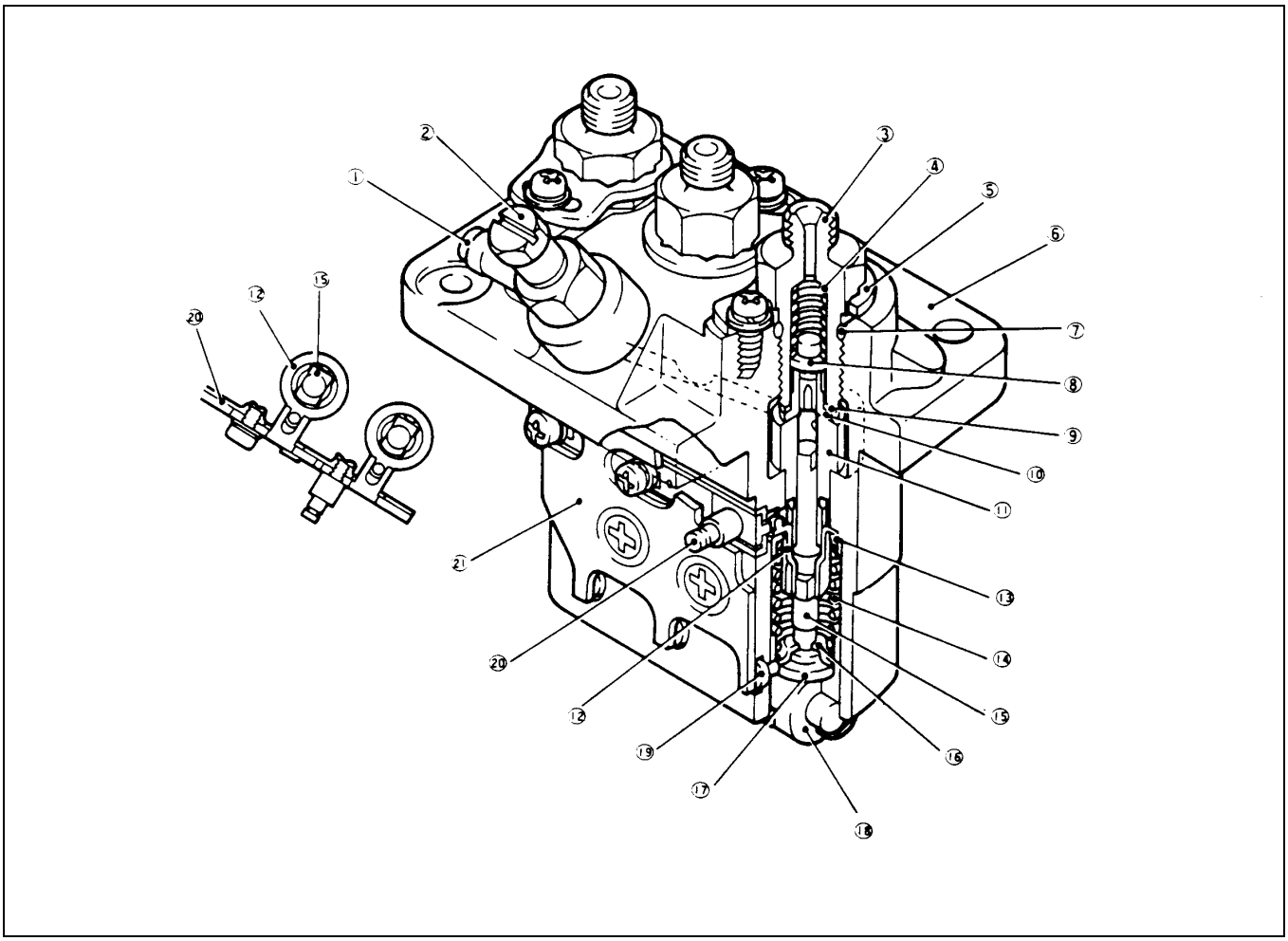


Figure 46

1. Union collar
2. Air vent screw
3. Delivery valve holder
4. Valve spring
5. Holder stopper
6. Housing
7. O-ring
8. Delivery valve
9. Gasket
10. Valve seat
11. Plunger barrel
12. Sleeve
13. Upper seat
14. Plunger spring
15. Plunger
16. Lower seat
17. Adjusting shim
18. Tappet roller
19. Pin
20. Control rack
21. Bracket

Injection Pump Inspection

Inspect the injection pump parts for proper operation, wear, corrosion, seizure, etc. (Fig. 47). Replace worn or damaged parts.

Injection Pump Assembly

1. Insert the plunger barrel into the housing.

2. Install the delivery valve seat, gasket, delivery valve and valve spring. Install the o-ring on the delivery valve holder. Temporarily tighten the delivery valve holder.

3. Insert the control rack. Insert the sleeve. Align the match mark on the rack with that on the pinion (sleeve).

4. Insert the upper seat. Insert the plunger spring.

5. Fit the lower seat to the plunger. Insert the plunger into the barrel (Fig. 48).

6. Push in the tappet roller assembly and install the stopper pin.

7. Tighten the delivery valve holder to a torque of 3.5 - 3.9 Kgm (25 - 28 ft-lb). Install the holder stopper.

9. Before installing the injection pump, make sure the control rack slides smoothly, with little resistance. If the control rack binds, it is assembled incorrectly or parts are dirty. The pump must then be reassembled correctly and/or cleaned.

10. Install the injection pump to the cylinder block. Make sure that the same number and size shims that were under the pump when it was removed are installed.

11. Install the fuel line and delivery pipes.

12. Bleed air from the fuel system. (See Bleeding the Fuel System and Bleeding Air From the Injectors in this section of the book.)

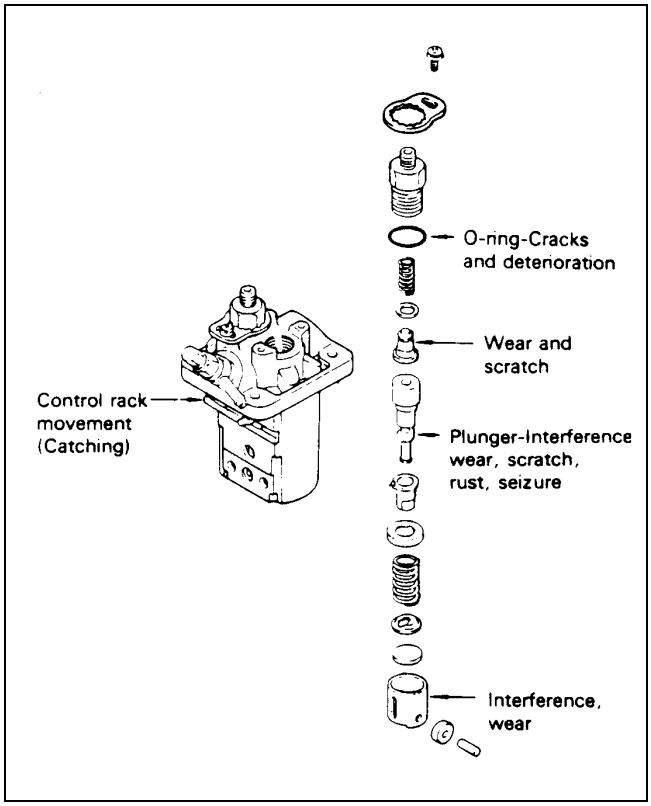


Figure 47

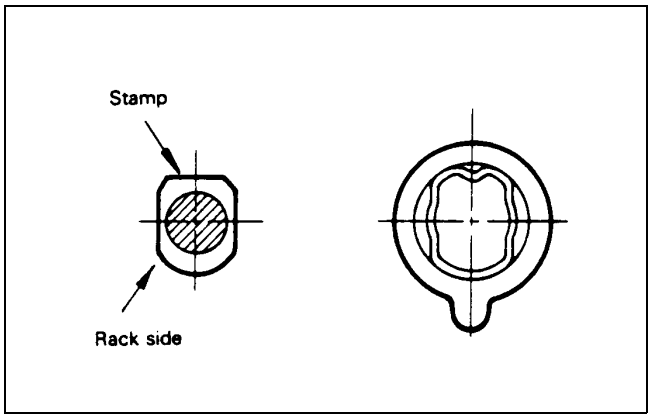


Figure 48

Nozzle Service

IMPORTANT: When servicing the injection nozzles make sure that the engine and fuel delivery pipes are clean to prevent dirt from entering cylinder or nozzle. Do not mix components of one nozzle with the other.

Nozzle Removal and Disassembly

1. Disconnect the injection pipes and fuel return pipe.

2. Remove the injector nozzle from the cylinder head.

NOTE: Further disassembly of the nozzle is not required for the nozzle to be tested. (See Nozzle Tests in the Testing section of this chapter.)

3. Secure the nozzle holder in a vise that has aluminum or brass jaw plates. To prevent deformation do not clamp the vise onto the retaining nut (Fig. 49).

4. Remove the retaining nut, shim washer, spring, pin, and distance piece.

6. Remove the nozzle assembly from the retaining nut. If it is difficult to remove, tap it lightly with a rubber or wooden mallet. IMPORTANT: Be careful not to hit or damage the protruding tip of the nozzle needle valve.

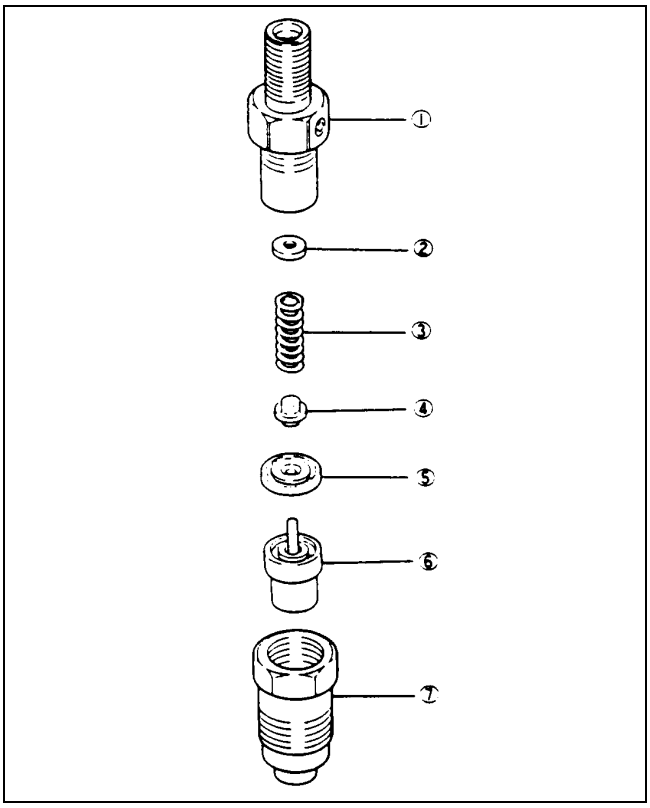


Figure 49

1. Body
2. Shim washer
3. Pressure spring
4. Pin
5. Distance piece
6. Nozzle assembly
7. Retaining nut

Nozzle Inspection and Cleaning

1. Clean the inside and outside of the retaining nut in clean diesel fuel or kerosene to remove carbon or fuel deposits. Inspect the lower seating surface for rust or damage. The sealing area may be restored with emery cloth.

2. Remove carbon or lacquer deposits from the nozzle by cleaning in clean diesel fuel or kerosene. Stubborn deposits can be removed with a brass wire brush.

IMPORTANT: Do not use a steel brush, steel wool, etc. Take special care not to scratch the needle valve in the nozzle assembly.

3. Clean the body, shim, spring, pin and distance piece in clean diesel fuel or kerosene.

4. Inspect the removed parts (Fig. 50). Replace any worn or damaged parts.

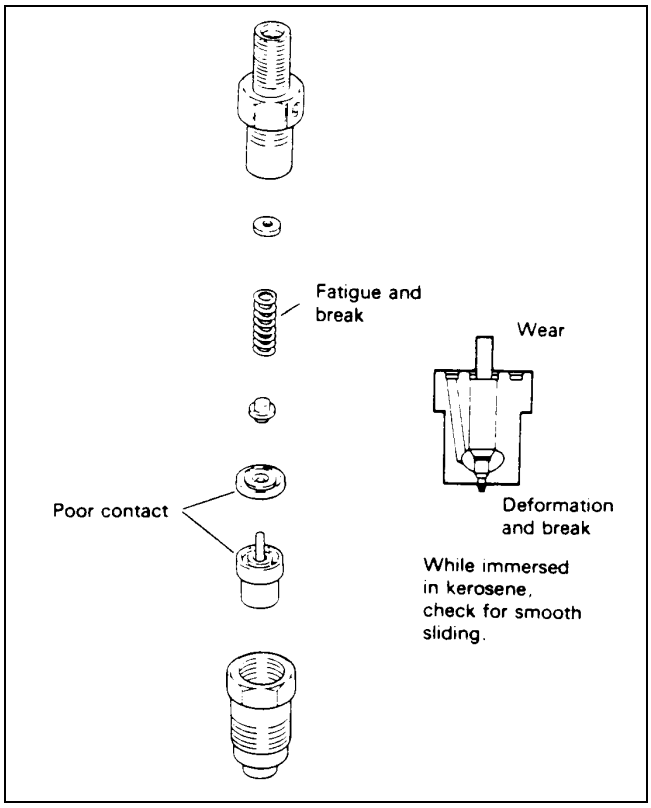


Figure 50

Nozzle Assembly and Testing

1. Install the nozzle assembly, distance piece and pin into the retaining nut.

2. Install the shim and pressure spring the body. Assemble the body to the retaining nut. Put the nozzle holder in a vise. Tighten the body and nut to a torque of 3.5 - 4.0 KgM (25 - 29 ft-lb) (Fig. 51).

3. Test the nozzle for proper operation. (See Nozzle Tests in the Testing section of this chapter.)

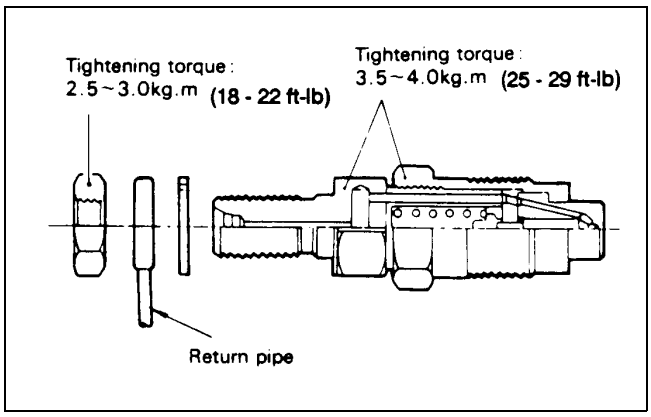


Figure 51

Nozzle Installation

1. Clean the nozzle holder fitting surface on the cylinder head. Install a new nozzle holder gasket onto the nozzle.

2. Install the nozzle holder into the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

3. Install the fuel return pipe. Tighten the retaining nut to a torque of 2.5 - 3.0 KgM (18 - 22 ft-lb) (Fig. 49).

4. Install the fuel injection pipes. Tighten the nut to a torque of 2.5 - 3.5 KgM (18 - 25 ft-lb).

5. Bleed air from the fuel system (See Bleeding the Fuel System and Bleeding Air From the Injectors in this section of the book.)

Removing and Installing the Engine

Removing the Engine

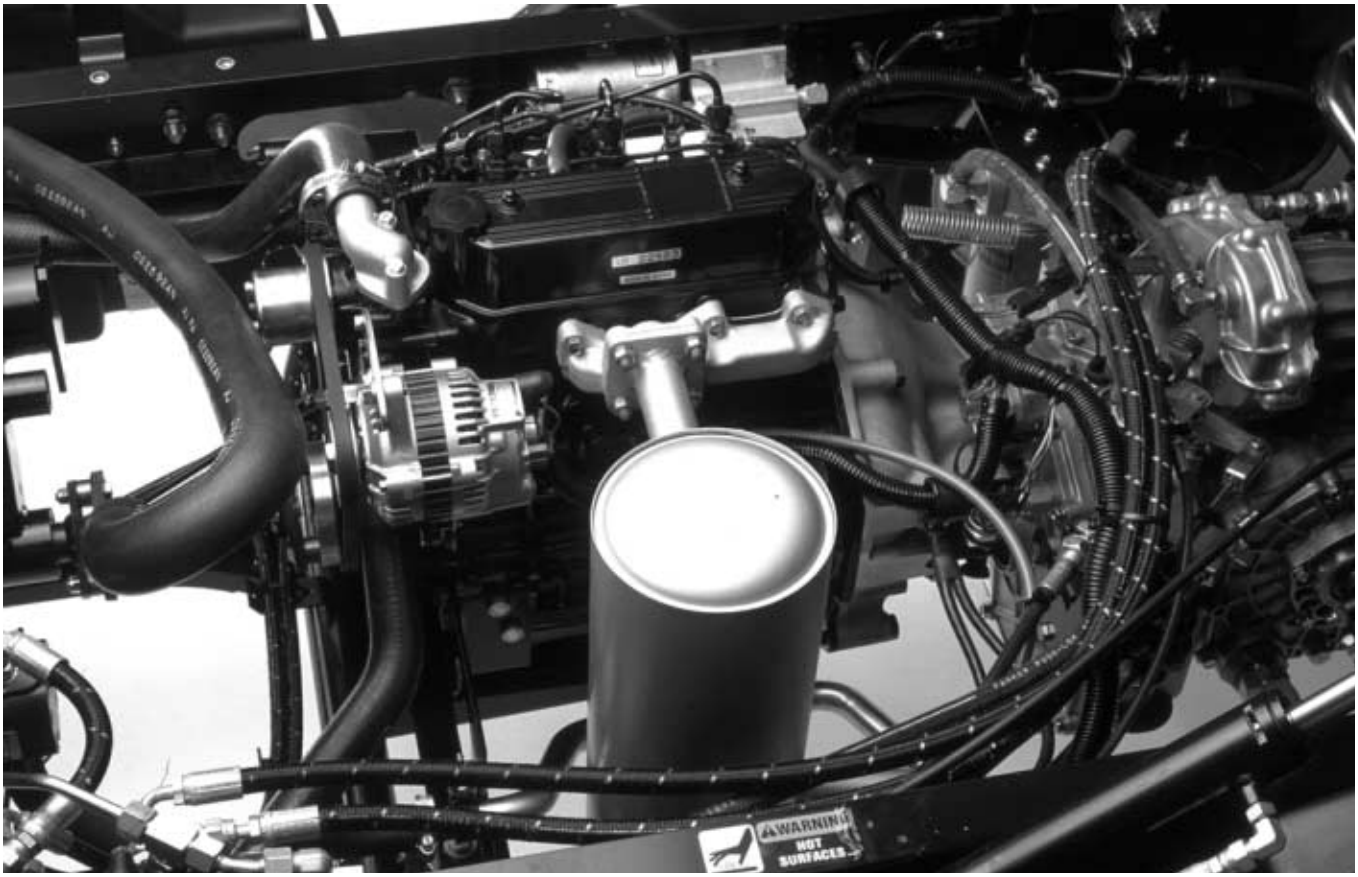


Figure 52

1. Put machine on a level surface and engage parking brake. Stop the engine and remove key from ignition switch. Remove the bed or other attachment(s). Allow engine and radiator to cool.

2. Disconnect positive (+) and negative (–) battery cables from battery.

3. Open radiator cap. Put a drain pan under radiator. Open radiator drain valve and allow coolant to drain into drain pan.

CAUTION

DO NOT open radiator cap or drain coolant if engine or radiator is hot. Pressurized, hot coolant can escape and cause burns.

Ethylene-glycol antifreeze is poisonous. Dispose of it properly or store in a properly labeled container away from children or pets.

4. Disconnect coolant and radiator hoses from engine.

5. Remove plug from right side cylinder block to drain coolant from engine.

6. Disconnect air intake hose from engine.

7. Remove the muffler.

8. Disconnect fuel hose from injector pump. Plug end of fuel line to prevent contamination. Disconnect fuel return hose from rear fuel injector on engine.

9. Disconnect and label electrical leads that attach to engine and transaxle.

10. Remove hydraulic pump drive shaft (connected to engine crankshaft pulley).

11. Disconnect throttle cable from governor lever on engine. Remove retaining ring securing throttle cable to bracket and pull throttle cable out of bracket.

12. Remove clamps and wire ties where wiring harness, hydraulic hoses or cables are attached to the engine.

13. Put blocking under transaxle for support.

14. Attach a hoist or block and tackle to engine for support.

15. Remove two (2) capscrews and locknuts securing front engine mounts to frame.

16. Remove capscrews securing clutch bell housing to engine.

17. Use a hoist or block and tackle to remove engine from chassis. One person should operate hoist or block and tackle and the other person should help guide engine out of chassis. Move engine forward before lifting to disengage transaxle input shaft from clutch.

18. Remove brackets and accessories from engine as necessary.

Installing the Engine

1. To install the engine, perform steps of Removing the Engine in reverse order.

2. Install a new engine oil filter. Fill engine with the correct oil. Fill the cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water. Check for oil and coolant leaks and repair as necessary.

3. Adjust accelerator pedal cable (See Accelerator Pedal Adjustment).

Cylinder Head Overhaul

Cylinder Head Removal

1. If the engine will not be removed from the vehicle, lower the coolant level in the engine. Loosen the hose clamp and remove the upper radiator hose from the thermostat housing. Disconnect the coolant bypass hose from the thermostat housing.

2. Remove plug from left side of cylinder block to drain the coolant from head and cylinder block.

3. Remove the muffler.

4. Remove the alternator (see Alternator Removal and Installation in the External Engine Component Repair section of this chapter).

5. Remove the glow plug lead wires.

6. Remove the fuel injection pipes and return pipe.

7. Remove the rocker cover and gasket.

8. Loosen the rocker stay attaching bolts. Remove the rocker assembly (Fig. 59).

9. Loosen the cylinder head bolts. Use the sequence shown in Figure 60. Remove the cylinder head assembly including the intake and exhaust manifolds.

10. Remove the cylinder head gasket. Use a scraper tool to remove the cylinder head gasket from the cylinder head and cylinder block. Make sure all of the gasket material is removed. Do not damage or scratch the cylinder head or cylinder block surfaces.

11. Remove the intake and exhaust manifolds from the cylinder head. Remove thermostat housing and thermostat.

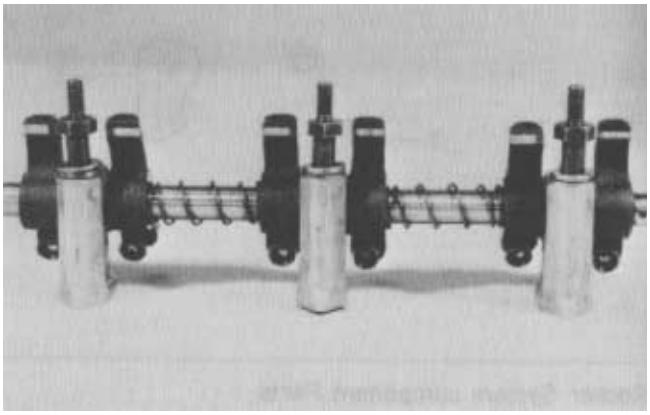


Figure 59

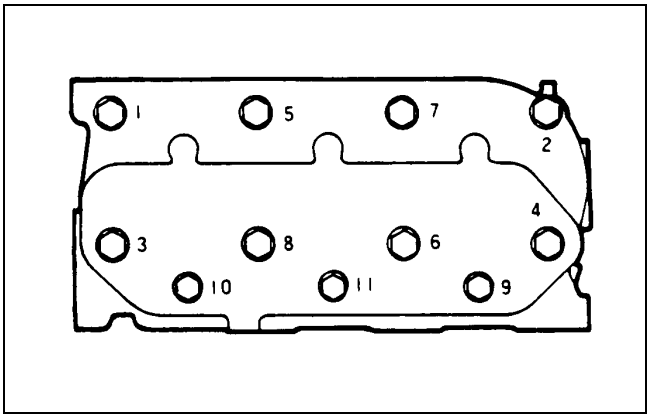


Figure 60

Cylinder Head Service

1. Use a valve lifter tool to compress the valve spring (Fig. 61). To remove each valve retainer, depress the retainer against the valve spring and remove the retainer lock (Fig. 62). Remove the valve retainer, spring and valve. Keep each valve and other parts for each cylinder separate so they can be reinstalled in the same cylinder.

2. Examine each valve for burning, pitting, heavy carbon deposits or wear. The condition of the valves can give important information about other components that may require service (example: improper valve clearance, worn valve guides, damaged seals, etc.). Remove the valve seals.

3. Inspect the cylinder head for coolant leaks or damage before cleaning.

4. Remove all of the carbon deposits from the combustion chamber using a scraper and wire brush.

5. Clean the cylinder head thoroughly with solvent or degreasing solution and allow it to dry. Inspect carefully for cracks.

6. Remove all carbon deposits from the valve guide bores with a valve guide cleaner. Use a valve guide bristle brush to remove loosened carbon deposits in the valve guide. Push a solvent soaked cloth through the valve guides to remove all foreign material.

7. Use compressed air to clean out the oil passages. Make sure the oil passages are not plugged.

CAUTION

Warn other personnel in the area before using compressed air. To prevent injury, wear safety glasses, goggles or a face shield.

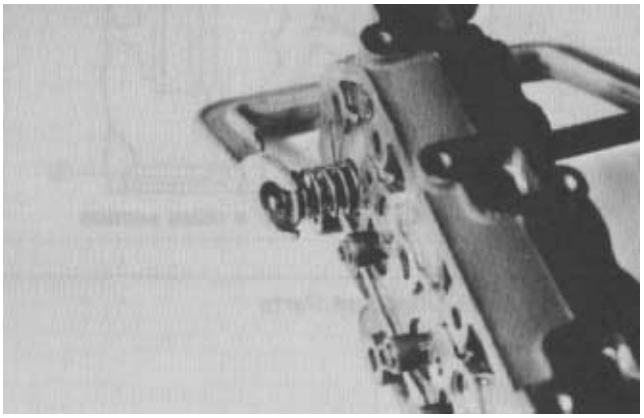


Figure 61

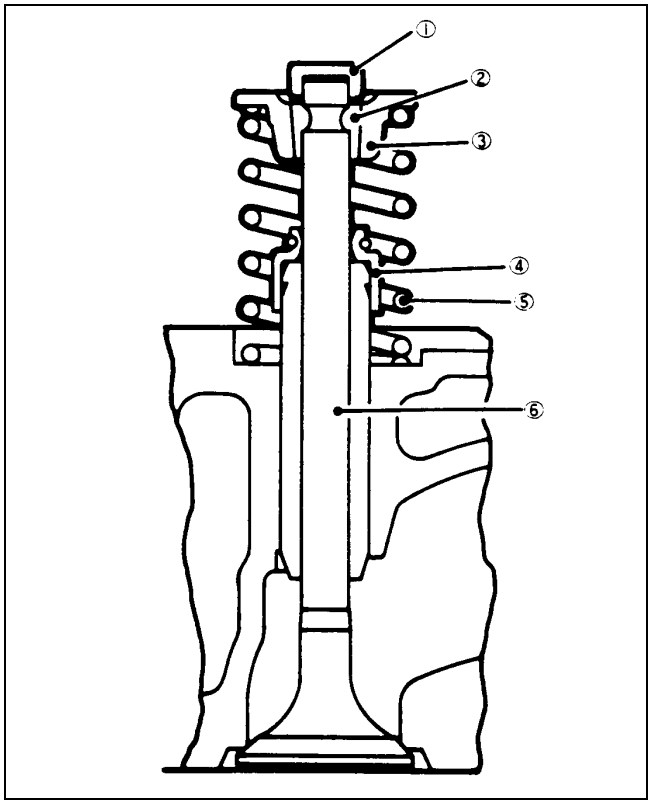


Figure 62

1. Valve stem cap
2. Retainer lock
3. Valve spring retainer
4. Valve stem seal
5. Valve spring
6. Valve

8. Use a straight edge and feeler gauge to check the flatness of the cylinder head lower surface (Fig. 63). Be sure to check the surface variation crosswise, lengthwise, and diagonally. If the variation in surface flatness exceeds (0.05 mm) 0.002 in. , the cylinder head or cylinder block must be replaced or resurfaced.

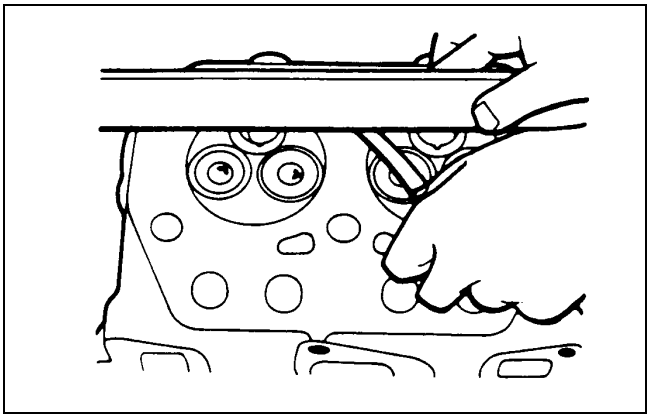


Figure 63

Valve Guides

1. Use a micrometer and a small hole gauge to check the valve guide to valve stem clearance. The valve and valve guide should be replaced if the clearance exceeds the following limits:

Valve guide to valve stem clearance

Intake valve: 0.10 mm (0.004 in.)
Exhaust valve: 0.15 mm (0.006 in.)

2. Use a valve guide removing mandrel with a pilot section to remove the valve guide. Push the valve guide up from the bottom of the cylinder head.

3. To install the new valve guide press it in from the top of the cylinder head, using the valve guide mandrel. Install the valve guide so the installed height is 13.5 - 14.5 mm (0.531 - 0.571 in.) above the cylinder head (Fig. 64).

4. After installing the new valve guide, check the valve guide to stem clearance. If the clearance is smaller than standard, it will be necessary to ream the valve guide bore to get the proper clearance.

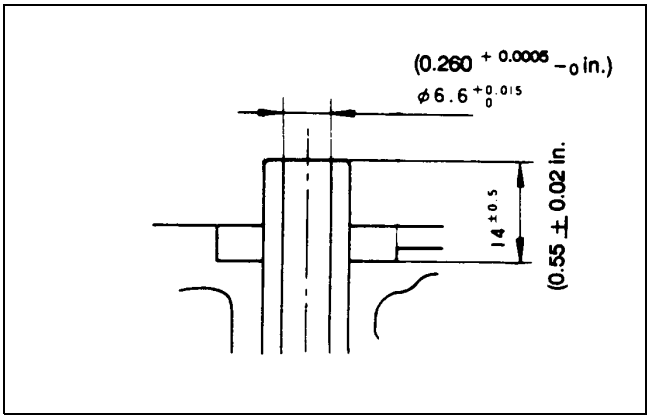


Figure 64

Valves

1. Carefully clean each valve with a wire wheel to remove all carbon deposits.

2. Check the valve face and valve stem for excessive wear, damage, cracks or deformation. If any of these conditions exist, the valve must be replaced. It is possible to reface the valve if the valve head thickness (margin width) is not less than the service limit (Fig.65). If the margin of the resurfaced valve is less than the service limit, replace the valve.

Minimum valve head thickness (margin width):
0.5 mm (0.020 in.)

3. Check the tip of the valve stem for wear or pitting. Replace the valve if the tip is worn.

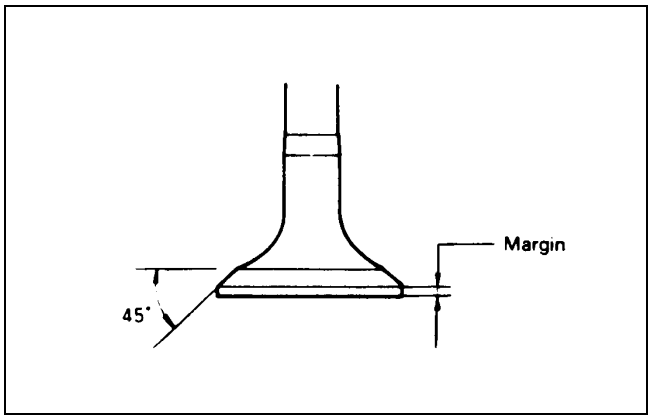


Figure 65

Valve Seats

1. Check the valve seats for damage and indications of incorrect contact (Fig. 66).

Maximum valve sinkage: 1.5 mm (0.06 in.)

2. The valve seat can be resurfaced (Fig. 67). Resurface the valve seat so it contacts the mid-portion of the valve face.

3. After cutting new valve seats, use lapping compound to lap the valve to the seat. After lapping, thoroughly clean the valve seat and valve areas to remove any traces of lapping compound.

4. Put a light coat of Prussion blue dye on the valve seat area. Install the valve. Hold the valve down and rotate it 1/4 turn, then turn the valve back to the original position. Remove the valve and examine the valve seat. The valve seat should show an even wear pattern from contact with the valve. Examine the valve. The dye should be evenly distributed around the valve and in the center of the valve face.

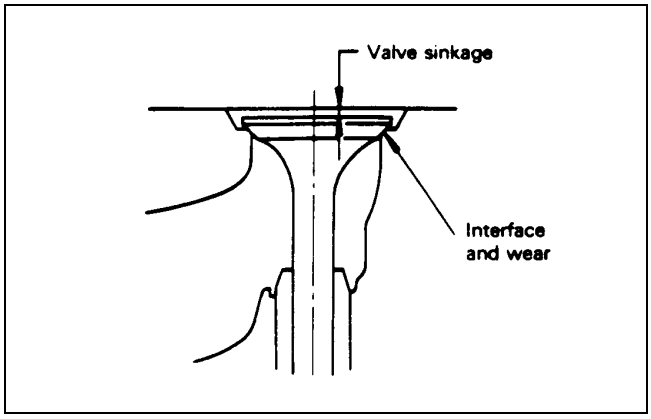


Figure 66

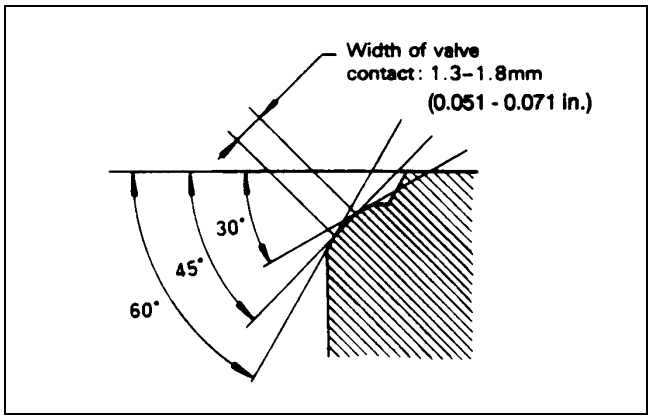


Figure 67

Valve Springs

1. Check the valve springs for rust, pitting, cracks or other damage.

2. Check the squareness of the valve spring by putting it upright on a level surface. Any spring that is 3^{o} or more out of square must be replaced.

3. Measure the spring free length. Any spring that has a free length of 39.3 mm (1.55 in.) or less must be replaced.

4. Over a period of time, valve springs can lose some of their tension. The spring must be replaced if the tension is less than the service limit. (Fig. 68)

Minimum Installed Load/Height

(IN) 5.05 kg / 35.5 mm (11 lb. / 1.4 in.)
(EX) 12.61 kg / 28 mm (27 lb. / 1.1 in.)

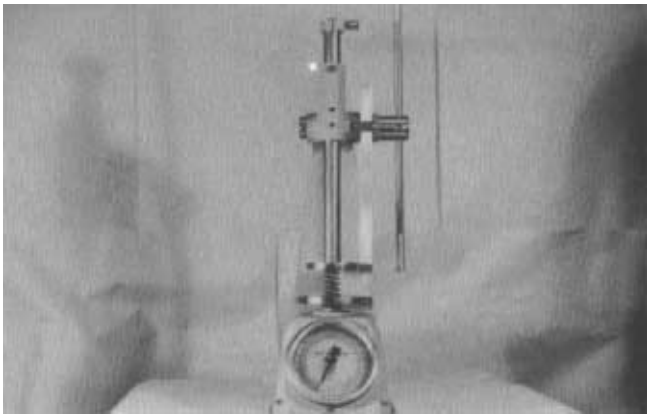


Figure 68

Rocker Arm and Rocker Shaft

1. Remove the snap ring on each end of the rocker shaft. Remove the rocker arm stay bolts. Remove rocker arm stays, spring and rocker arms from the shaft (Fig. 69).

2. Inspect each rocker arm for wear at the valve tip and push rod contact surfaces. Replace any worn or damaged rocker arms.

3. Inspect the rocker shaft for wear or damage. Replace the rocker shaft if it is worn or damaged.

4. Measure the rocker arm inside diameter and the shaft outside diameter. Replace the shaft if the rocker arm to shaft clearance is more than 0.02 mm (0.008 in.).

5. Make sure the oil passages in the rocker shaft and rocker arms are open. Clean if necessary.

IMPORTANT: When assembling the rocker assembly, make sure the identification mark (small drilled hole near the end of the shaft) is at the front and facing the valve side.

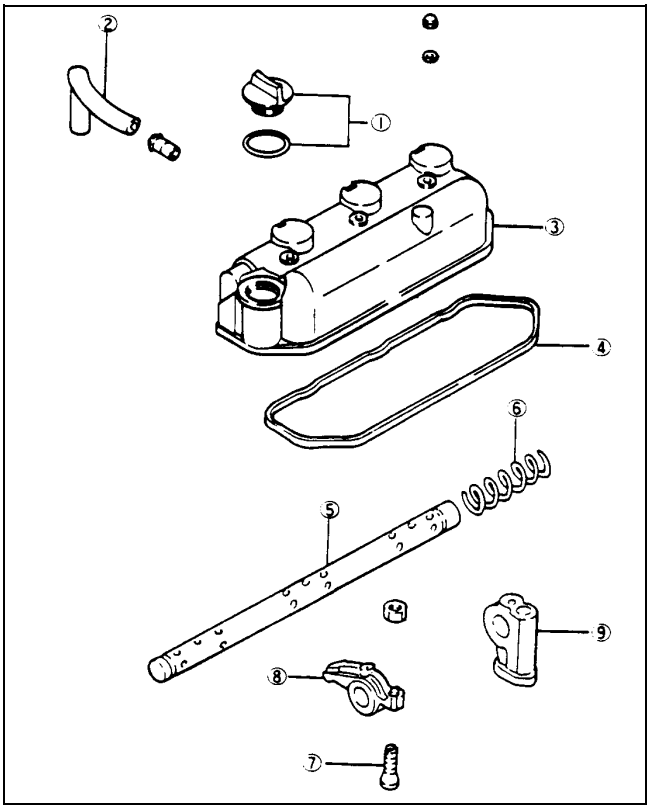


Figure 69

1. Oil filler cap
2. Breather hose
3. Rocker cover
4. Rocker cover gasket
5. Rocker shaft
6. Rocker spring
7. Adjusting screw
8. Rocker arm
9. Rocker stay

Cylinder Head Assembly and Installation

1. Install the thermostat housing. Use a new gasket.

2. Install the intake and exhaust manifolds. Use new gaskets.

3. Make sure the valve guides are properly installed (Fig. 64).

4. Install new valve stem seals onto the valve guides (Fig. 70). DO NOT install used seals.

5. Apply a coating of oil to the valve stems and insert them in proper order, into the valve guides. Install the valve springs and valve retainers. Compress the spring with a valve lifter, then install the retainer lock.

IMPORTANT: Be careful not to damage the spring and stem seal by over compressing the spring during installation.

6. Install the nozzle holders in the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

7. Install the glow plugs in the cylinder head and tighten to a torque of 5.0 - 6.0 KgM (36 - 43 ft-lb).

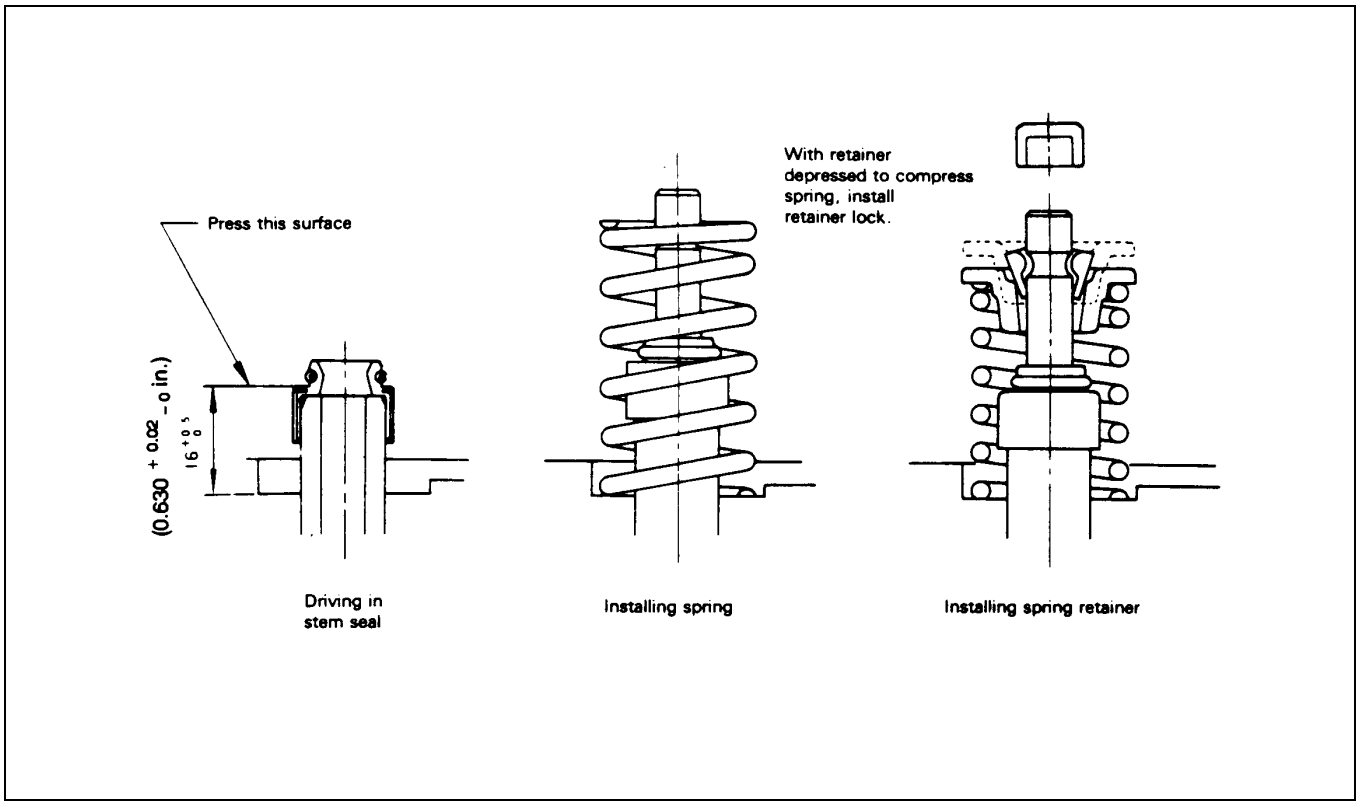


Figure 70

8. Make sure that the cylinder head and cylinder block surfaces are clean. Put a new gasket on the cylinder head. Insert dowel pins into two cylinder head bolt holes to assist in mounting the head onto the block. Carefully put the cylinder head into position on the cylinder block. Remove the dowel pins. Insert the cylinder head bolts.

IMPORTANT: Do not put any sealant on the cylinder head gasket.

9. Tighten the cylinder head bolts in the order shown in Figure 71. Tighten the bolts to approximately one-third the specified torque, then two-thirds and finally to the final specified torque.

M10 head bolt torque: 7.5 - 8.5 KgM (54 - 62 ft-lb)
M8 head bolt torque: 2.0 - 3.0 KgM (15 - 22 ft-lb)

10. Install the fuel return pipe. Install the fuel delivery pipes. When tightening the nut on each end of the pipe hold the delivery valve holder or nozzle holder with a wrench to prevent turning.

11. Apply engine oil to the inside surface of the rocker arm bushings. Install the rocker arms, spring and rocker arm stays on the rocker shaft. Install the rocker shaft so the identification mark (small drilled hole near the end of the shaft) is at the front and facing the valve side. Install the bolts through each stay and into the shaft. Install the snap ring on each end of the shaft.

12. Install the rocker arm and shaft assembly on the cylinder head. Tighten the rocker arm stay bolts to a torque of 1.5 - 2.2 KgM (11 - 16 ft-lb)

13. Adjust the valve clearance. (See Checking and Adjusting Valve Clearance in the Adjustments section of this chapter.)

14. Install the rocker cover and gasket. Install the breather hose to the rocker cover and intake manifold.

15. Install the glow plug lead wires.

16. Install the alternator.

17. Install the muffler.

18. Install the upper radiator hose and tighten the hose clamps. Install the coolant bypass hose to the thermostat housing and tighten the hose clamps.

19. Fill the cooling system with a 50/50 solution of ethylene glycol antifreeze and clean, soft water. Check for oil and coolant leaks and repair as necessary.

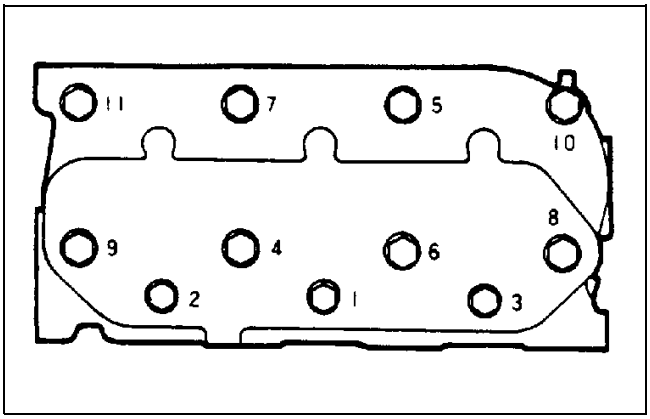


Figure 71

Cylinder Block Overhaul

NOTE: The engine must be removed from the vehicle chassis and put in an engine stand. (See Removing and Installing The Engine.)

Gear Case and Oil Pump

1. Remove the crankshaft pulley.

2. Remove the fuel injection pump. (See Injection Pump Service in the Fuel System Repairs section of this chapter.)

3. Disconnect the governor spring from the tension lever. Remove the governor cover assembly from the gear case. (See the Governor System Repairs section of this chapter.)

4. Remove the water pump. (See Water Pump Service in the External Engine Component Repair section of this chapter.)

5. Remove the alternator. (See Alternator Removal and Installation in the External Engine Component Repair section of this chapter.)

6. Remove the gear case assembly (Fig. 72).

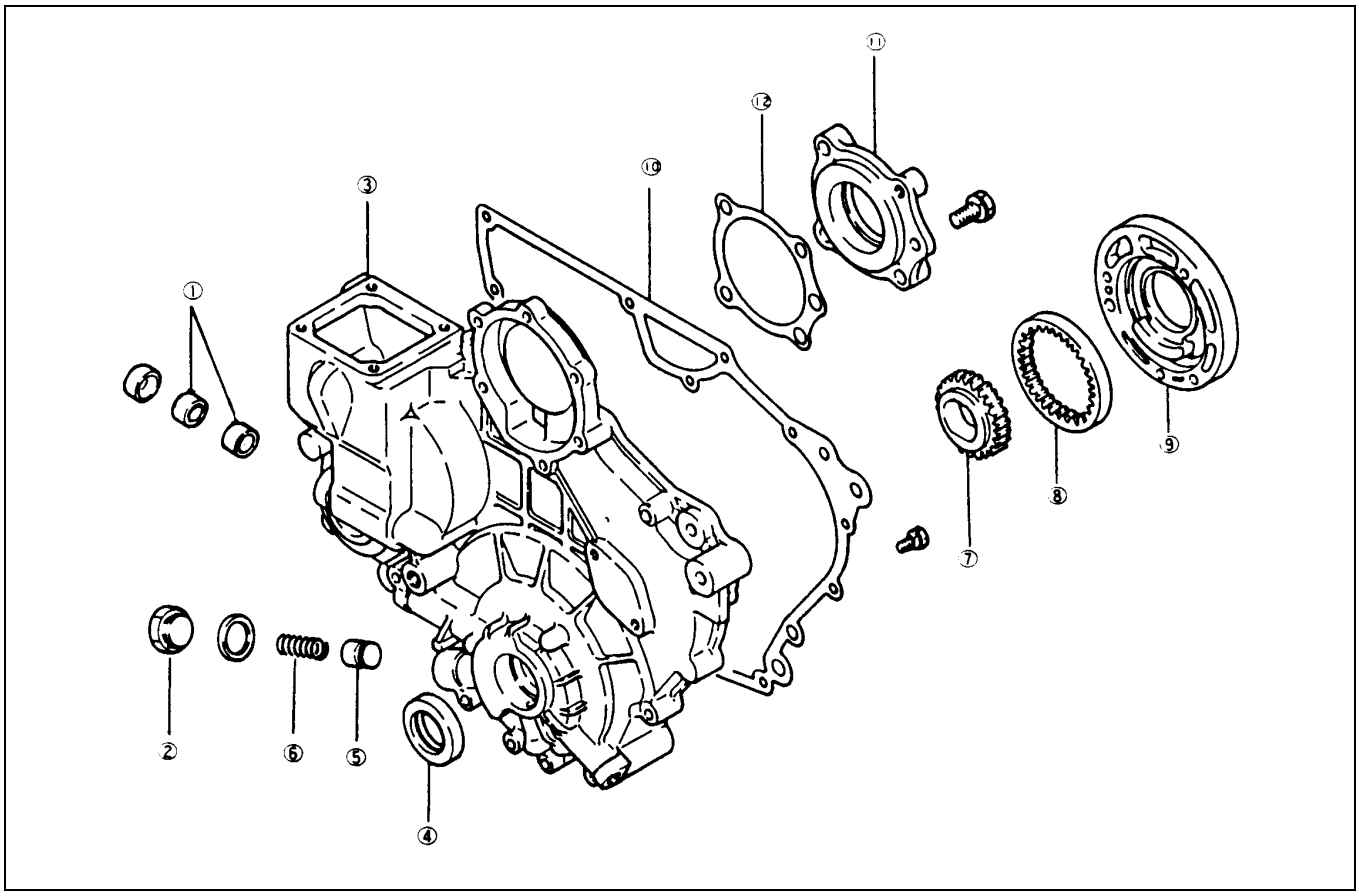


Figure 72

1. Bushings
2. Plug
3. Gear case
4. Front oil seal
5. Relief plunger
6. Relief spring
7. Oil pump inner gear
8. Oil pump outer gear
9. Oil pump housing
10. Gear case gasket
11. High pressure pump gear housing
12. Housing gasket

7. Check removed parts for wear or damage (Fig. 73).
Replace parts as necessary.

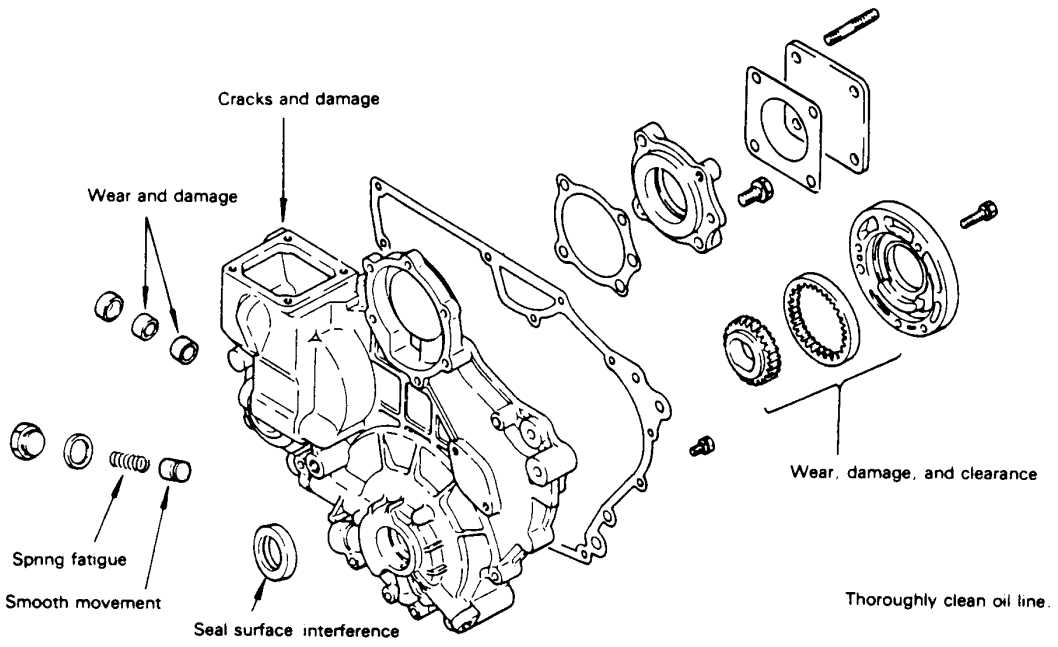


Figure 73

8. Check the governor parts for wear or damage (Fig 74). Replace parts as necessary.

A. Remove the expansion plug (Fig 75). Be careful to not scratch the gear case.

B. Pull out the grooved pin.

C. Remove the shaft, spring and levers.

D. If necessary replace the governor bushings (Fig. 76).

E. Install the shaft, spring and levers. Press fit the expansion plug into the hole in the gear case.

9. Reverse steps 1 - 6 to reassemble the gear case. Use new gaskets when assembling the gear case.

IMPORTANT: Install a new front oil seal before installing the gear case. Apply a thin coat of oil to the circumference and lip of the oil seal.

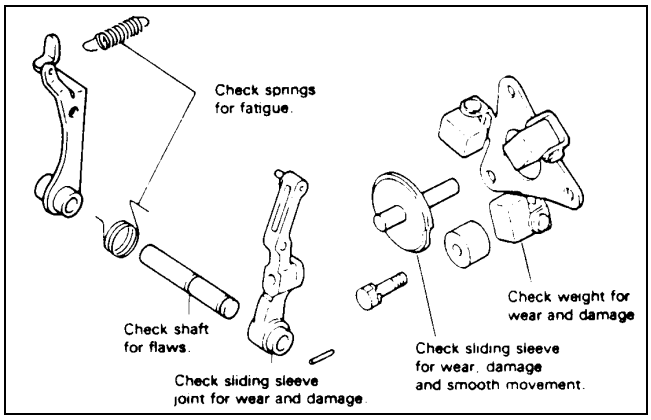


Figure 74

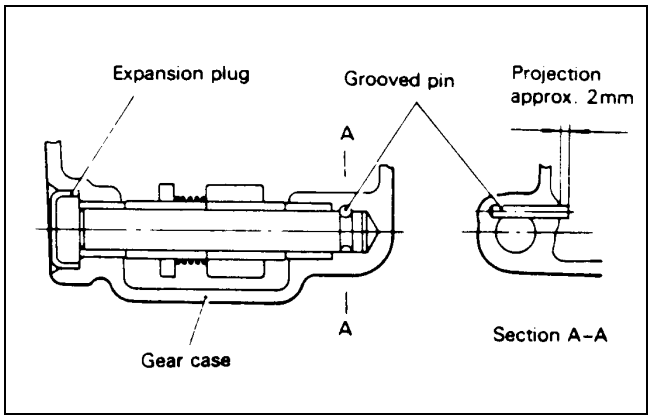


Figure 75

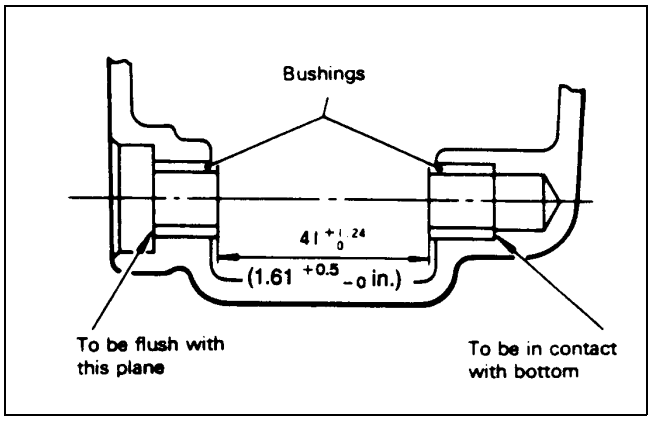


Figure 76

Timing Gears and Camshafts

1. Remove the cylinder head (see Cylinder Head Removal in the Cylinder Head Overhaul section of this chapter).

2. Remove the gear case (see Gear Case and Oil Pump in this section).

3. Remove the snap ring and remove the idle gear (Fig. 77).

4. To remove the injection pump camshaft:

   A. Remove the governor weight assembly (Fig. 33).

   B. Remove camshaft rear cover.

   C. Remove the stopper bolt (Fig. 78).

   D. Pull out the camshaft from the front of the cylinder block.

5. To remove the valve camshaft:

   A. Pull the push rods and tappets out of the cylinder block.

   B. Remove the camshaft stopper bolt.

   C. Pull the camshaft out of the cylinder block (Fig 79).

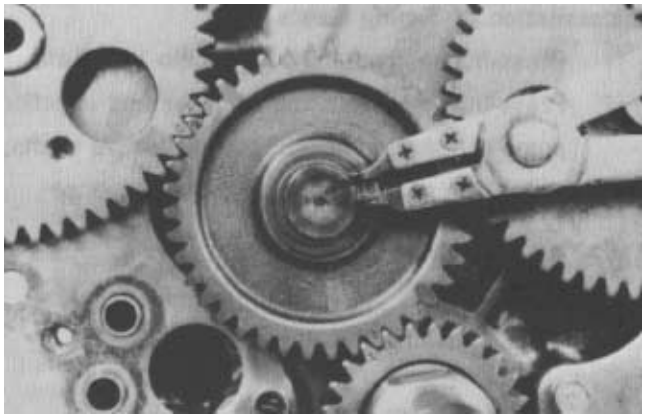


Figure 77

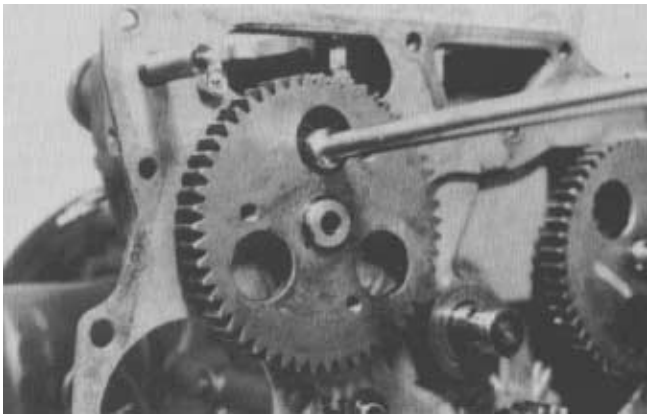


Figure 78

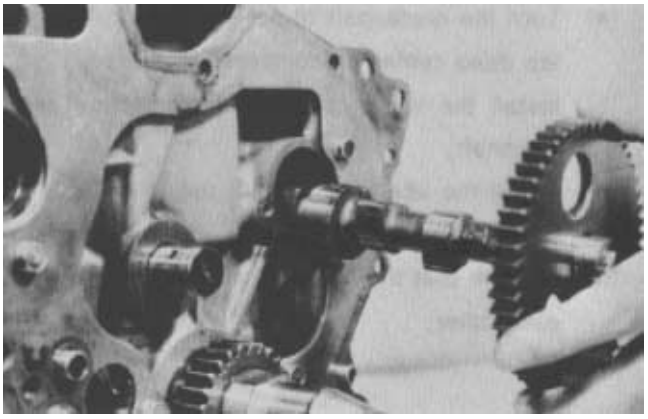


Figure 79

6. Check the gears for incorrect tooth contact, wear and damage. Replace any gears that are badly worn or damaged.

Maximum idle gear bushing to shaft clearance:
0.2 mm (0.008 in.)

Maximum backlash between gears in mesh:
0.3 mm (0.012 in.)

7. Inspect the camshaft parts (Fig. 80). Replace any parts that are worn or damaged.

Major diameter of cam:
Injection pump cam: 29.3 - 30 mm (1.154 - 1.181 in.)
Valve cam: 26.37 - 27.37 mm (1.038 - 1.078 in.)

Push rod bend: within 0.3 mm (0.012 in.)

Tappet to cylinder block hole clearance:
0.15 mm (0.006 in.) maximum

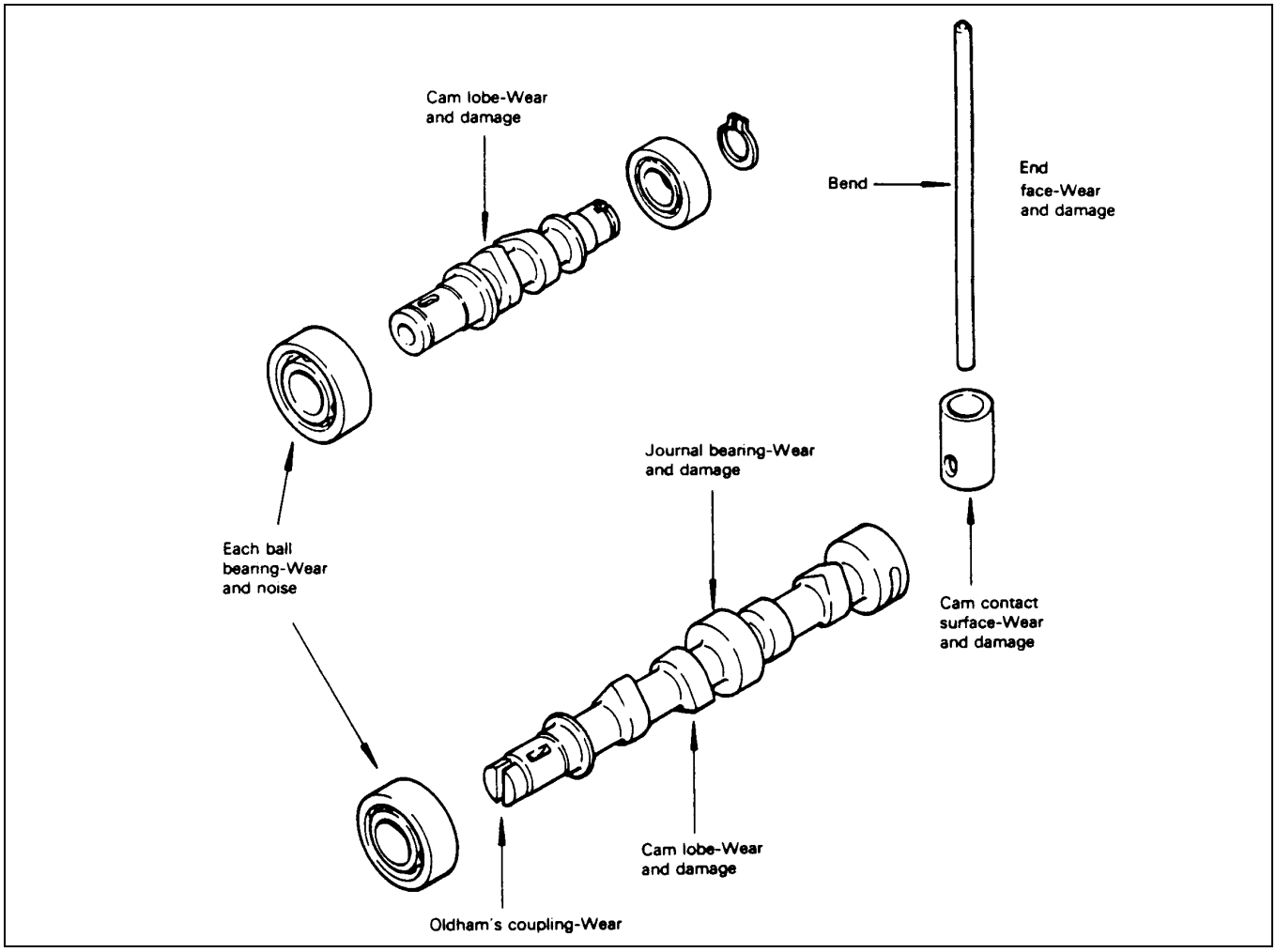


Figure 80

8. Before installing the camshafts and timing gears, turn the crankshaft to set the No. 1 cylinder to top dead center (TDC) of the compression stroke. Reverse steps 1 - 5 to install the camshafts and timing gears (Fig. 81).

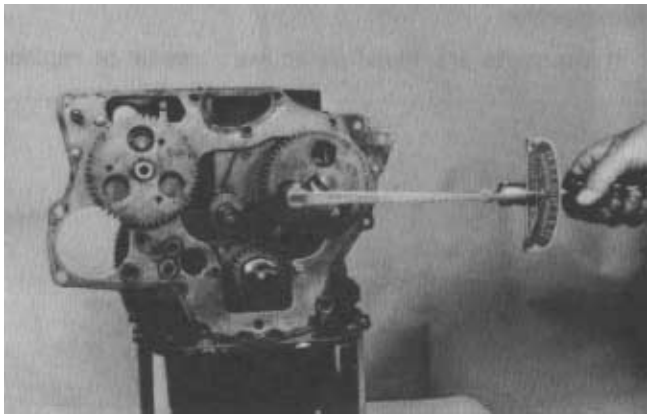


Figure 81

9. With the crankshaft set to No. 1 cylinder TDC, install the idle gear so the timing marks on all the gears are in alignment (Fig. 82).

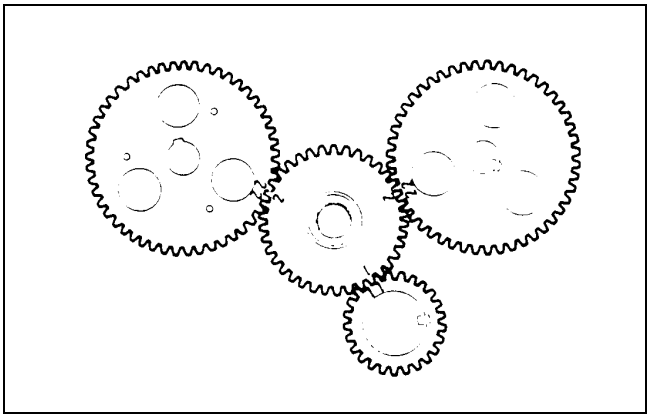


Figure 82

Piston and Connecting Rod

1. Remove the cylinder head (see Cylinder Head Removal in the Cylinder Head Overhaul section of this chapter).

2. Remove the oil pan and gasket.

3. Remove the oil screen

NOTE: Before removing the pistons, mark the number of the cylinder onto the top of each piston and on the side face of each connecting rod (on the large end). When the piston and connecting rod is removed be careful to prevent damage to the piston or bearing surfaces.

4. Use a ridge removing tool to remove the ring ridge from each cylinders. This will prevent damage to the rings and pistons.

5. Remove the connecting rod end caps and bearings (Fig 83). Keep these parts in cylinder number order so they can be reinstalled in the same cylinder. Use a wood block to push the pistons and connecting rods up out from the bottom of the block. Take care not to scratch the crankshaft pin and cylinder.

6. Check each piston for wear, signs of seizure or nicks. Replace the piston if it is damaged.

7. Thoroughly clean the carbon deposits from the piston and ring grooves. A ring groove cleaner, or piece of discarded ring may be used to clean the ring grooves.

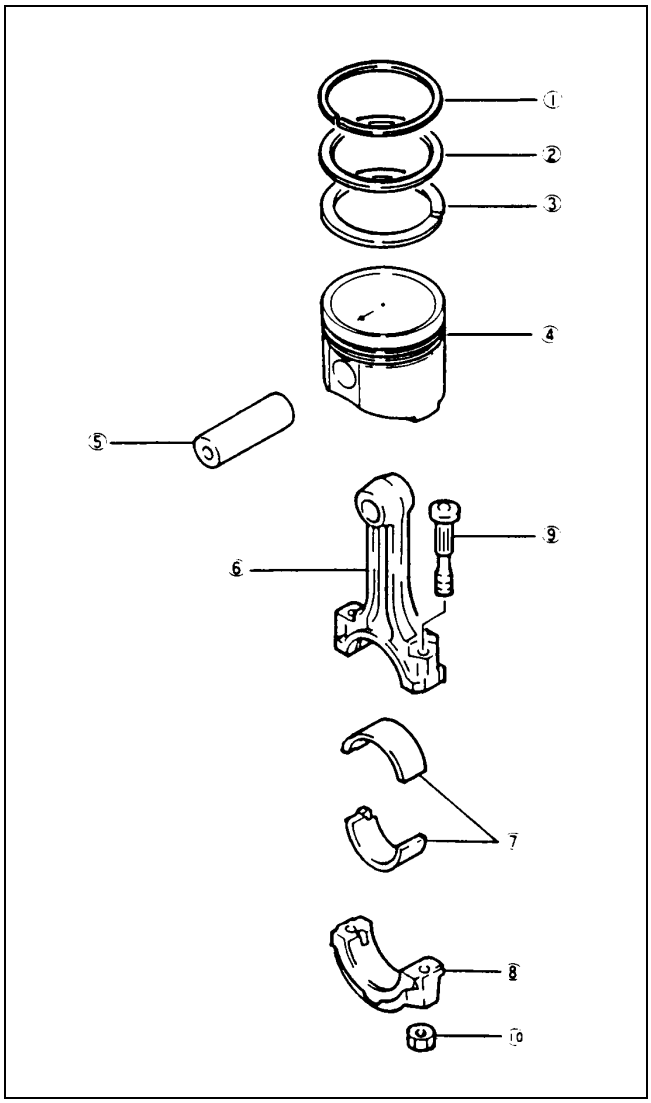


Figure 83

1. Piston ring No. 1
2. Piston ring No. 2
3. Oil ring
4. Piston
5. Piston pin
6. Connecting rod
7. Connecting rod bearing
8. Connecting rod cap
9. Connecting rod bolt
10. Connecting rod nut

8. Measure the piston outside diameter (Fig. 84). (See Cylinder Block in this section).

Maximum piston to cylinder wall clearance:
0.3 mm (0.012 in.)

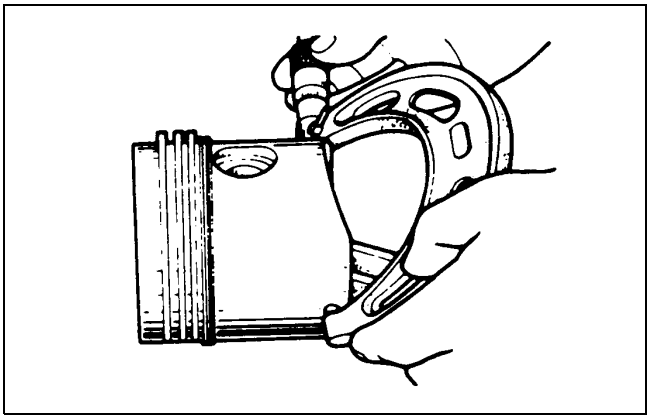


Figure 84

9. Use a thickness gauge to check the piston ring side clearance (Fig. 85).

If the piston ring side clearance exceeds the service limit, the ring must be replaced. If the clearance still does not meet specifications with a new ring the piston must be replaced. (See the Specifications section of this chapter.)

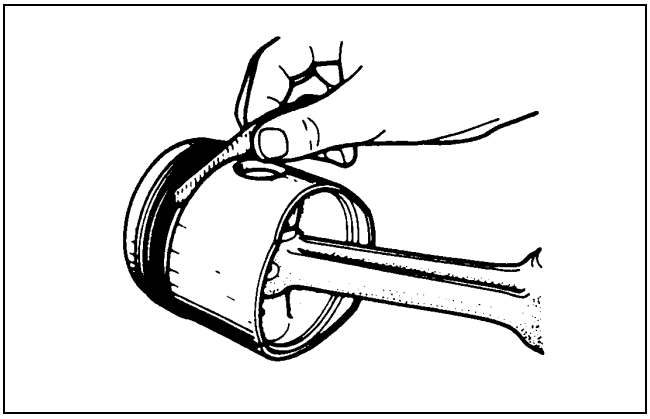


Figure 85

10. Measure the piston ring end gap. Insert the ring into the least worn area of the cylinder by pushing it into place with the piston (Fig. 86). If the gap exceeds 1.5 mm (0.060 in.) the ring must be replaced.

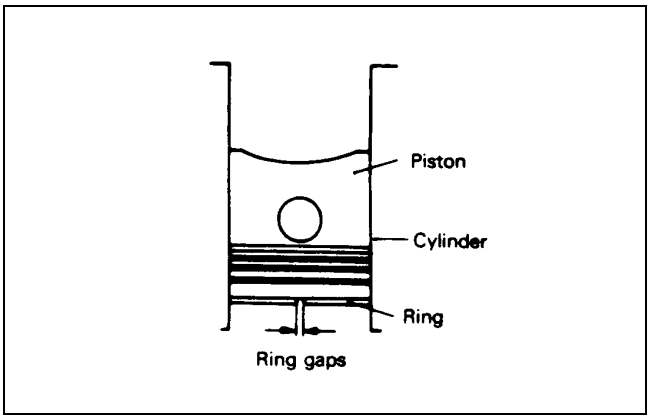


Figure 86

11. To remove the piston from the connecting rod press the piston pin from each piston. Use the piston setting tool (Fig. 87).

IMPORTANT: Do not attempt to remove the piston pins by driving then out with a hammer. A stuck piston pin, requiring excessive pressure to remove, should be replaced.

12. Check for bending or distortion of the connecting rod. The service limit for bend and distortion is 0.15 mm (0.006 in.). Replace the connecting rod if damaged or out of specification.

13. To assemble the piston to the connecting rod, press the piston pin into the set position. Use the piston pin setting tool (Fig. 88). Make sure the identification mark of the rod and the arrow mark on the piston head are directed up.

Pin press fitting force: 500 - 1500 kg (1100 - 3300 lb.)

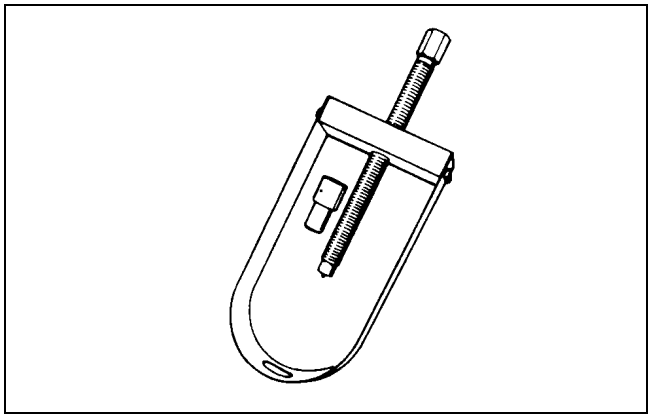


Figure 87

14. Assemble each connecting rod and bearing to the crankshaft in proper order. Use a feeler gauge to measure the side clearance between the connecting rod end and crankshaft (Fig. 89). Replace the connecting rod assembly if the side clearance is more than the specified amount.

Maximum connecting rod side clearance: 0.5 mm (0.02 in.)

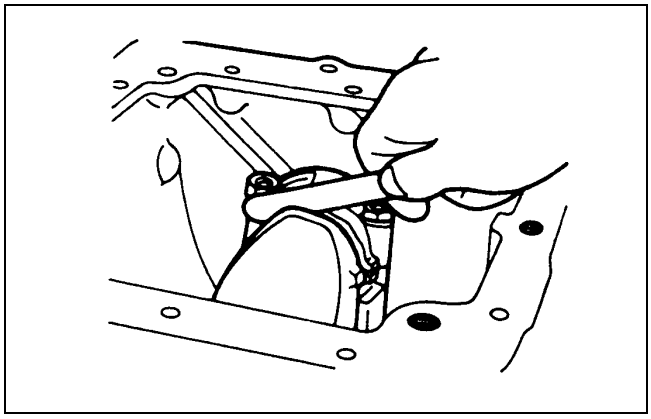


Figure 89

15.Install the piston rings. Each piston ring has different shape. Make sure they are installed in the proper position and with the ring gaps in the directions as illustrated (Fig. 90).

16. Insert the piston and connecting rod assembly into the cylinder block using a ring compressor and a wooden block. Make sure the arrow mark on top of the piston is facing toward the front of the engine.

17. Install the connecting rod bearings and end caps. Make sure the notches on the bearings and connecting rod are aligned. Tighten the end cap retaining bolts to a torque of 3.2 - 3.5 KgM (23 - 25 ft-lb).

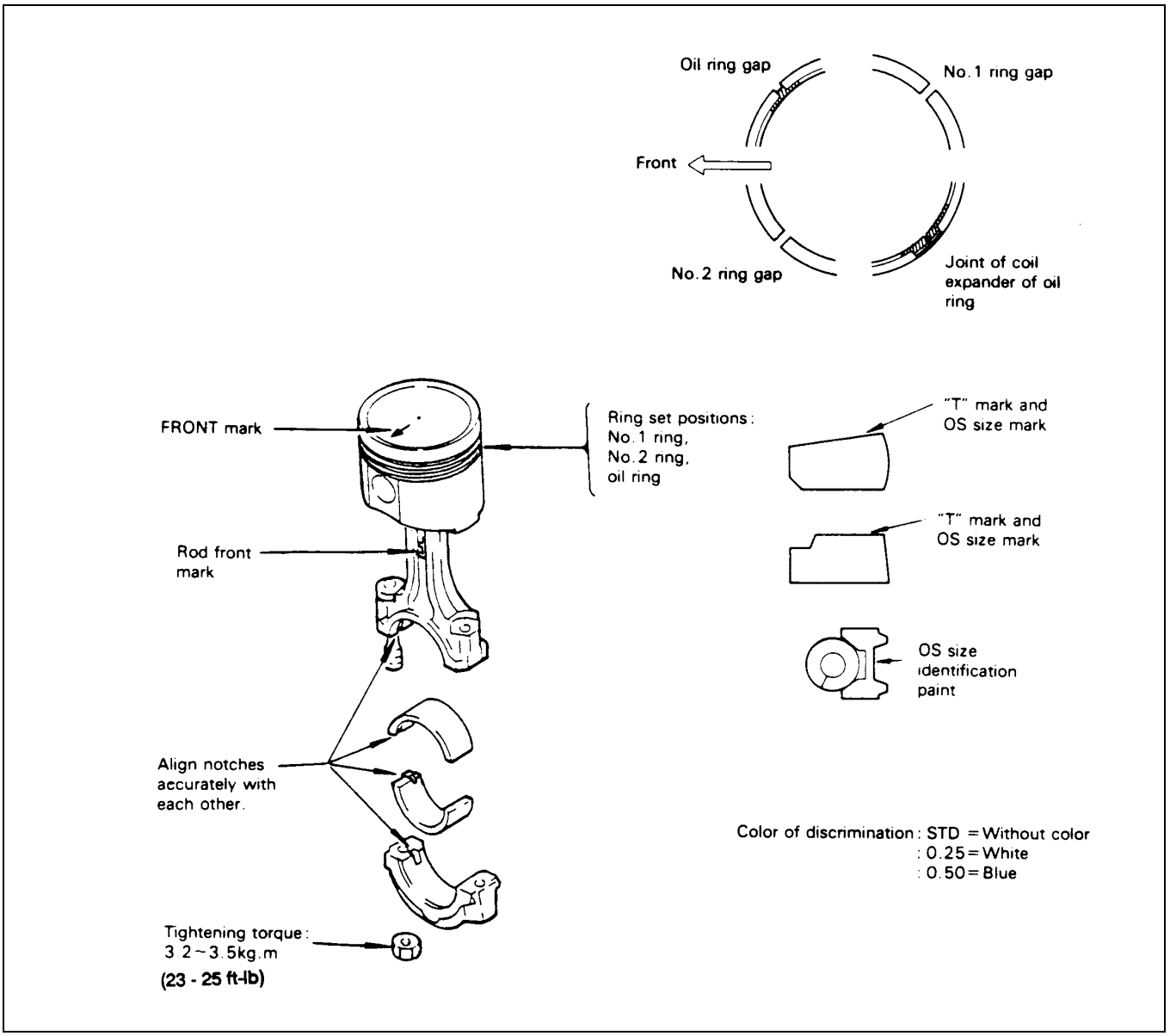


Figure 90

Crankshaft

1. Perform steps 1 - 5 under Piston and Connecting Rod in this section.

2. Remove the flywheel.

3. Remove the rear oil seal case.

4. Remove the main bearing caps (Fig. 91). Keep each set of bearings together with its bearing cap.

5. Remove the crankshaft.

6. Inspect the removed parts. Repair or replace any worn or damaged parts (Fig. 92).

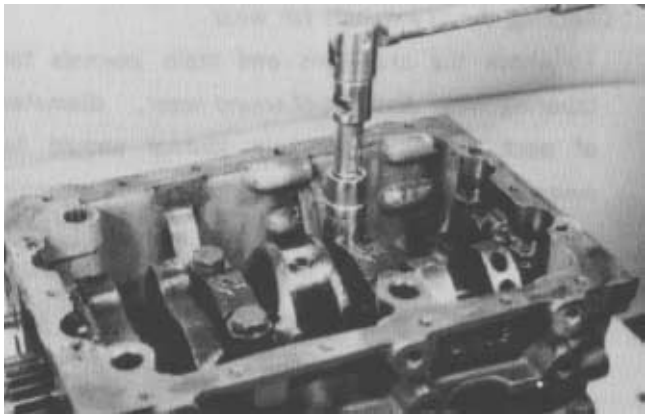


Figure 91

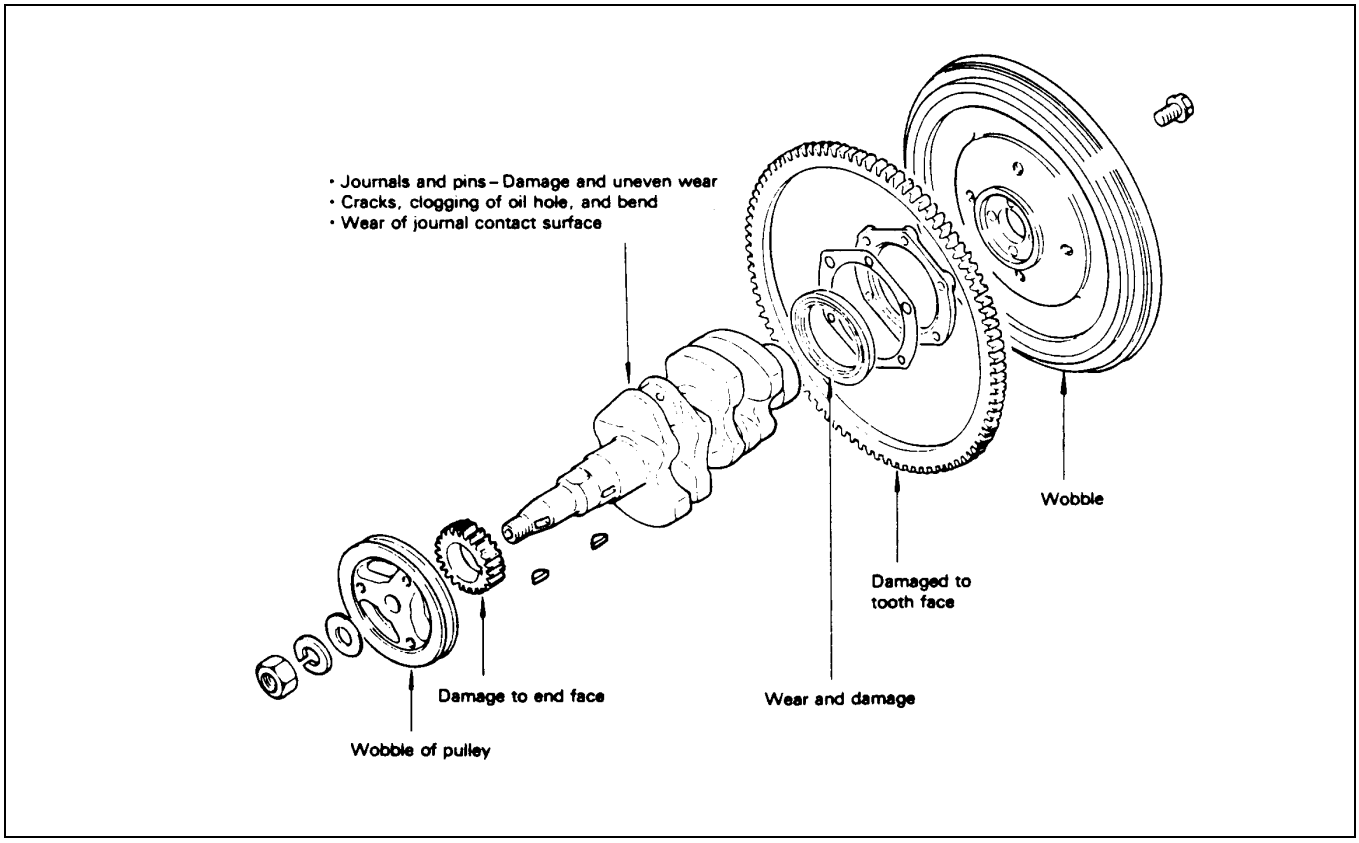


Figure 92

6. Measure the crankshaft for “run-out” (bend). Mount the crankshaft in a pair of V-blocks (or live centers) and use a dial indicator to measure the run-out in the crankshaft (Fig. 103). The maximum allowable crankshaft run-out is 0.05 mm (0.002 in.).

7. Check the crank journals and crankpins for damage, out of round wear or tapering wear. The diameter of each crankpin or main journal should be measured at two places, “1" and ”2", in two directions, “A” and “B” (Fig. 104).

Main journal diameter: 42.3 mm (1.665 in.) minimum
Crankpin diameter: 39.3 mm (1.547 in.) minimum

8. Check the crankshaft oil clearance. Oil clearance is calculated by subtracting the diameter of the main journal or crankpin from the inside diameter of the main bearing or rod bearing. The inside diameter of each crankpin or main journal should be measured at two places, “1" and ”2", in two directions, “A” and “B” (Fig. 105) after the bearing cap is installed at the proper torque. If the oil clearance exceeds the service limits, install a new bearing. If installing the new bearing does not reduce the clearance to within service limits, the crankshaft must be reground and oversize bearings installed.

Tightening Torque:
Main bearing cap bolt 5.0 - 5.5 KgM (23 - 25 ft-lb)
Rod bearing cap nut 3.2 - 3.5 KgM (36 - 40 ft-lb)

Crankpin oil clearance: 0.15 mm (0.006 in.)
Journal oil clearance: 0.10 mm (0.004 in.)

NOTE: If using Plastigauge to measure the oil clearance, put a piece of Plastigauge onto the crankpin or journal, and tighten the bearing cap (with bearing) in place. DO NOT rotate connecting rod or crankshaft when the Plastigauge is in place. Rotating will destroy the Plastigauge. Remove the bearing cap and measure the width of the Plastigauge to determine the clearance. If the oil clearance exceeds the service limits, install a new bearing. If installing the new bearing does not reduce the clearance to within service limits, the crankshaft must be reground and oversize bearings installed.

9. To install a new oil seal, pry the seal out with a screwdriver and drive a new seal into the oil seal case.

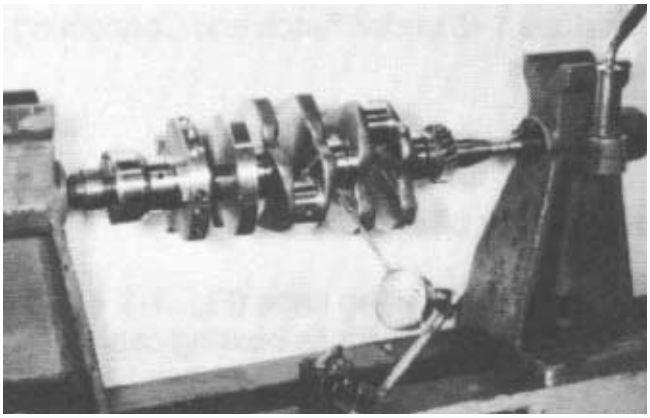


Figure 93

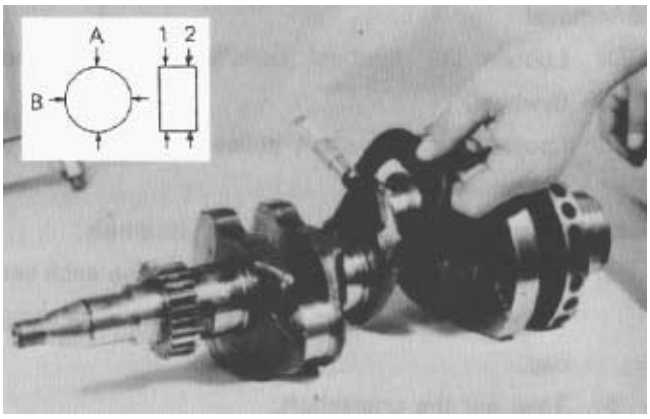


Figure 94

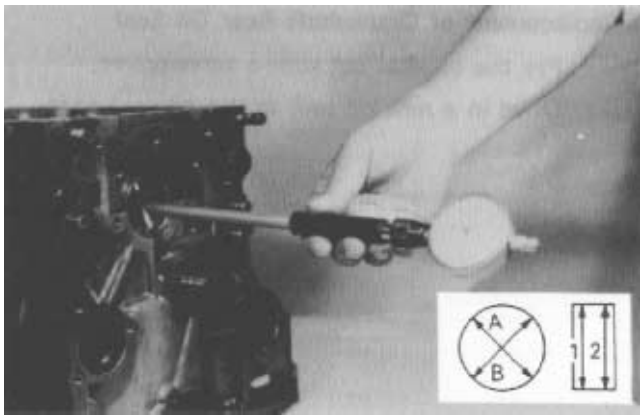


Figure 95

10. Reverse steps 1 - 5 to install the crankshaft (Fig. 97). When installing the No. 1 and No. 4 bearing caps, apply sealant (Permatex No. 2 or equivalent) to the upper surface that meets with the cylinder block.

11. Use a dial indicator to measure the crankshaft end play. If end play exceeds specifications, replace all the main bearings.

Crankshaft end play: 0.05 - 0.175 mm (0.002 - 0.007 in.)

12. Apply sealant (Permatex No. 2 or equivalent) to the outside surface of the side seals. Install the side seals with the radius towards the outside of the engine (Fig. 96).

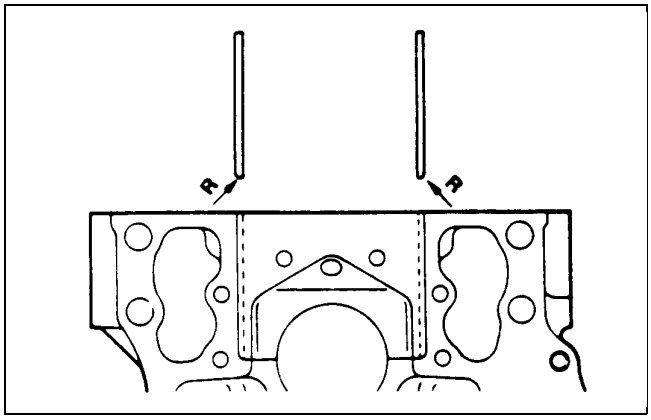


Figure 96

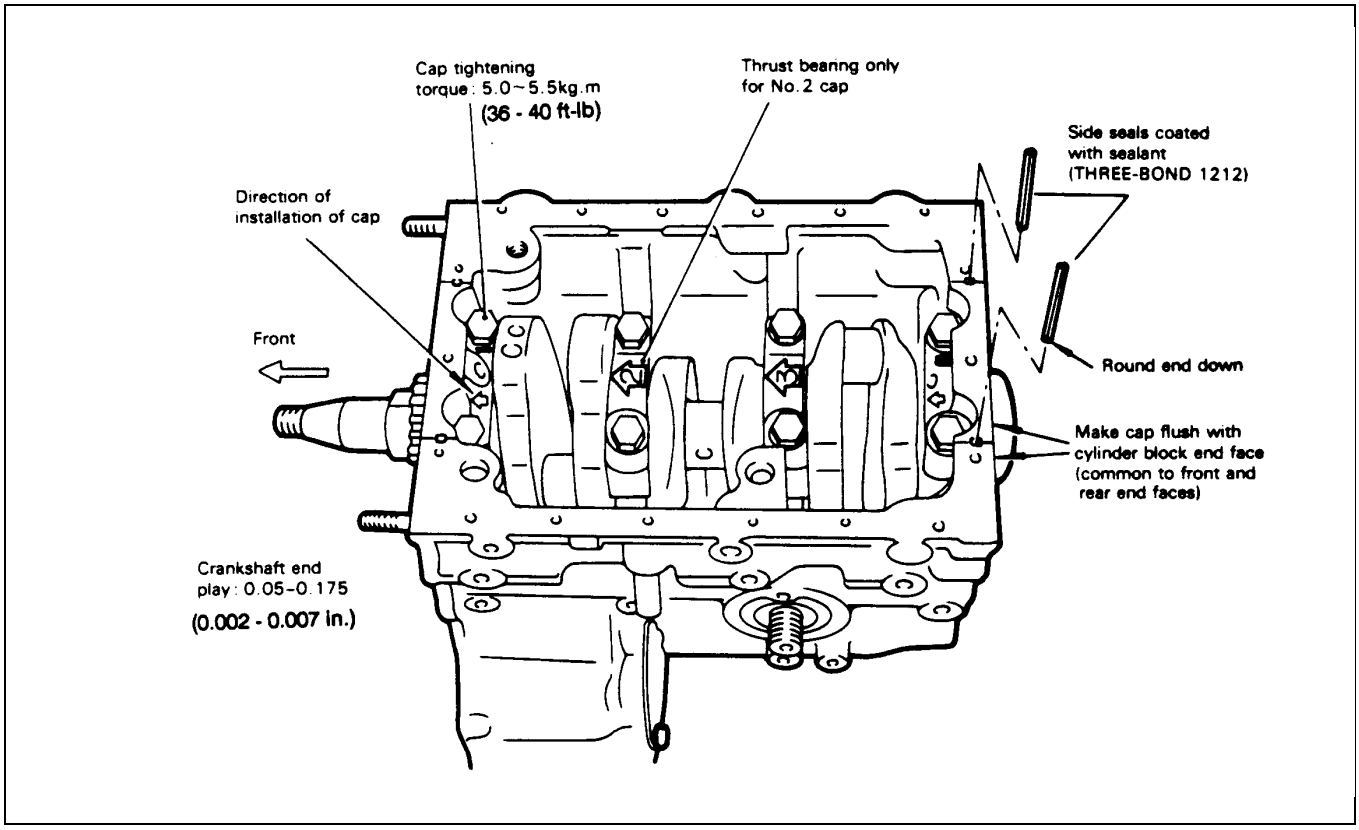


Figure 97

Cylinder Block

Before cleaning check the cylinder block for coolant leaks, oil leaks or damage. Clean all parts to remove dirt, oil, carbon deposits and water scale.

Check the cylinder block for cracks or other damage. Check the water jacket for water scale and rust. Replace the cylinder block if necessary.

Measure each cylinder bore size in six locations (Fig. 98). The cylinder must be rebored and over-sized piston and rings installed if the diameter exceeds the standard by 0.2 mm (0.0079 in.). Examine the cylinder bore diameter readings to determine the amount of taper in the cylinder. If the taper exceeds 0.01 mm (0.0004 in.), the cylinder must be rebored and oversized piston and rings installed.

Engine Model L3Ca-62TG Standard Bore: 70 mm (2.7559 in.)
Engine Model L3Ca-62TG Standard Bore: 76 mm (2.9921 in.)

IMPORTANT: If one cylinder is rebored, all cylinders must be rebored to the same specifications.

NOTE: See the Specifications section of this chapter for oversize finishing sizes. After machining, install the piston and piston rings corresponding to the reworked cylinder size.

NOTE: When the cylinder bore is worn a small amount and only the piston rings require replacement, check for groove wear in the upper part of the cylinder. Hone the cylinder if necessary.

Reboring Cylinder

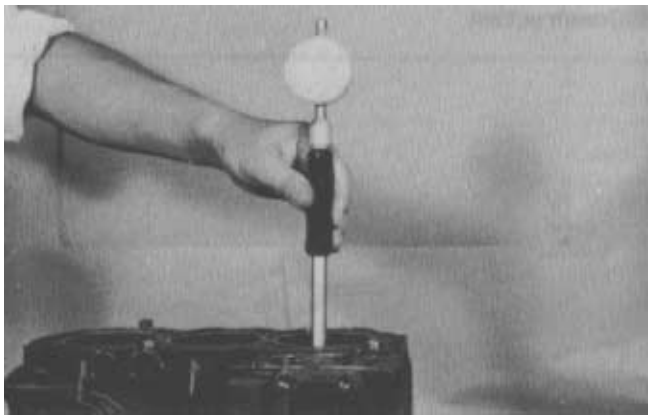
1. Select a piston:

0.25, 0.50 mm (0.01, 0.02 in.) oversize

2. Measure the piston diameter (Fig. 84).

3. Reboring finish dimension = (Piston O.D.) + (Clearance) – (Honing allowance).

Clearance: 0.071 - 0.084 mm (0.0028 - 0.0033 in.)
Honing allowance = 0.02 mm (0.0008 in.)



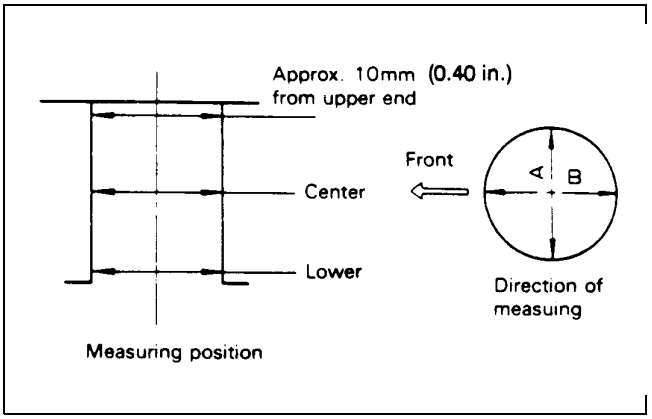


Figure 98