MITSUBISHI DIESEL ENGINES

SERVICE MANUAL

K3A – K3B – K3C – K3D – K3E

DIESEL ENGINES

'86 - 10

MITSUBISHI HEAVY INDUSTRIES

HE0916 HF1139 HG0222 HG1772 (200) (S)

FOREWORD

This service manual, prepared for the benefit of service mechanics, describes the construction and service procedures of the Mitsubishi K3 model diesel engines.

To ensure proper, effective and fast service and enable the engine to provide top performance over an extended period of time, you are urged to read this manual carefully.

INDEX

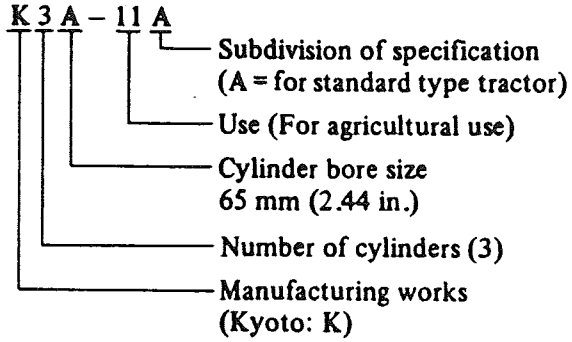
1. Engine Model and Engine Number

1. Engine Models and Classification

Model	Classification	Use
K3A	11 series	For all types of agricultural tractors
K3B	11 series 13 series 31 series 61 series	For all types of agricultural tractors For all types of agricultural tractors For all types of industrial machines For exports and all types of agricultural and industrial machines
K3C	11 series	For all types of agricultural tractors
K3D	11 series 13 series 11C 31 series 61 series	For all types of agricultural tractors For all types of agricultural tractors Combines For all types of industrial machines For exports and all types of agricultural and industrial machines
K3E	13 series	For all types of agricultural tractors

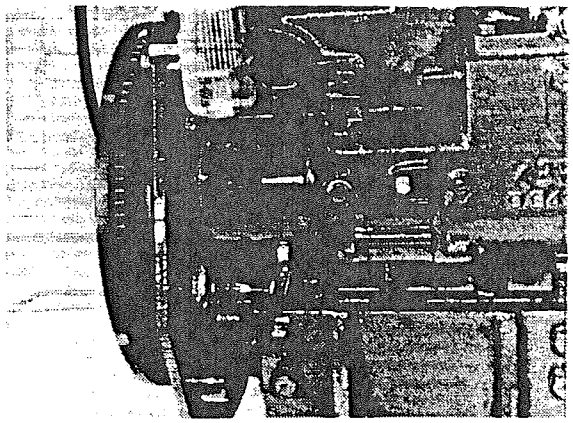
2. The engine model may be broken down as follows.

Example: K3A–11A

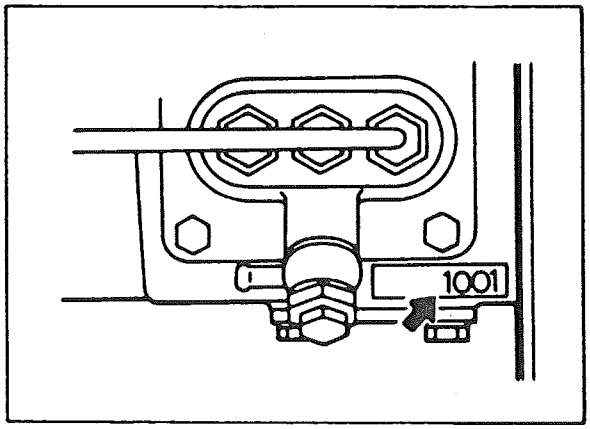


3. The engine model is embossed on the pump mounting side of the crankcase.
4. The engine number is stamped on the injection pump mounting surface of the crankcase.
5. Stamped engine numbers are as shown below.

Model	Stamped number
K3A	1001 ~
K3B	1001 ~
K3C	1001 ~
K3D	1001 ~
K3E	1001 ~



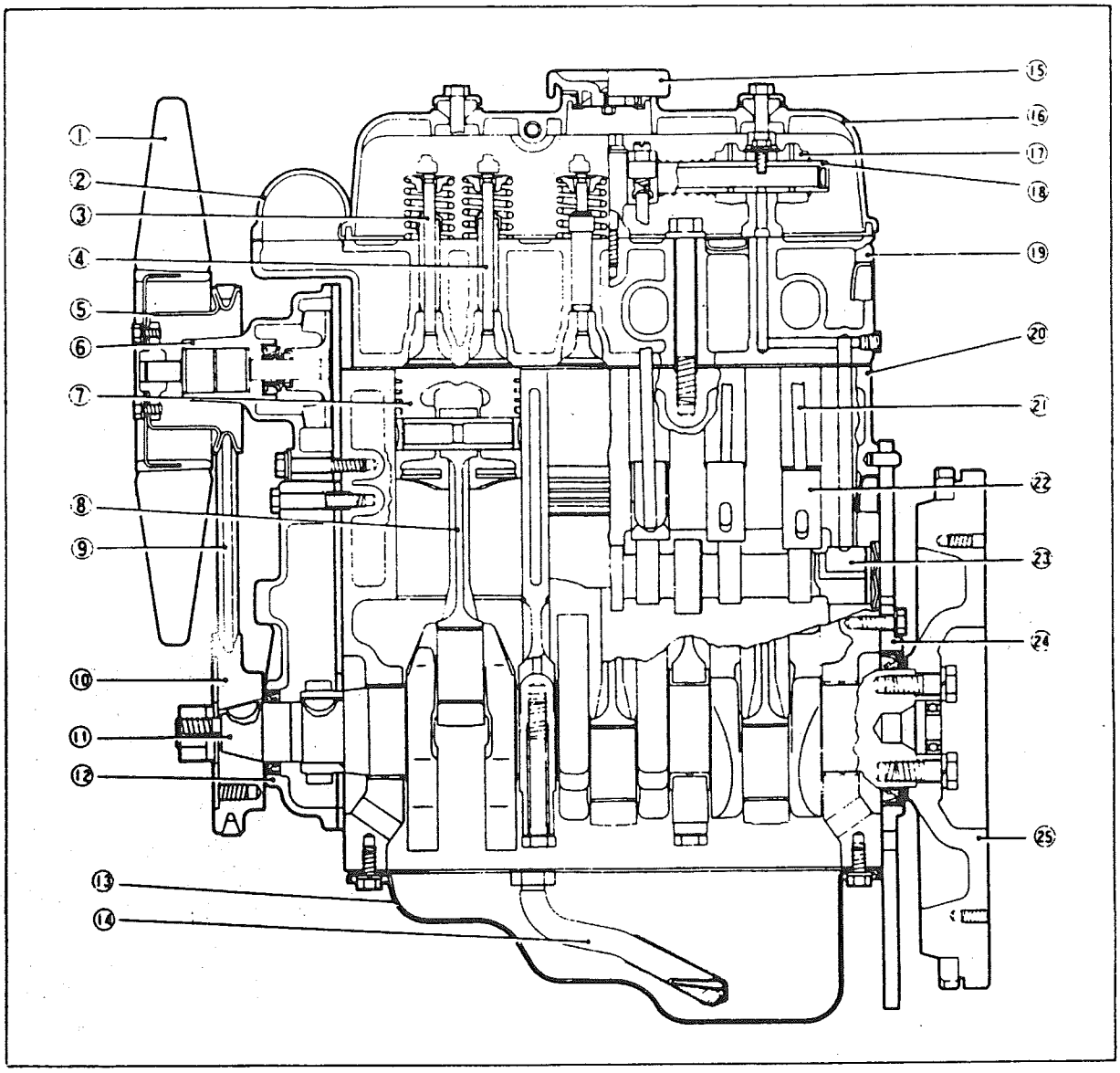
Location of Engine Model Number



Location of Engine Number

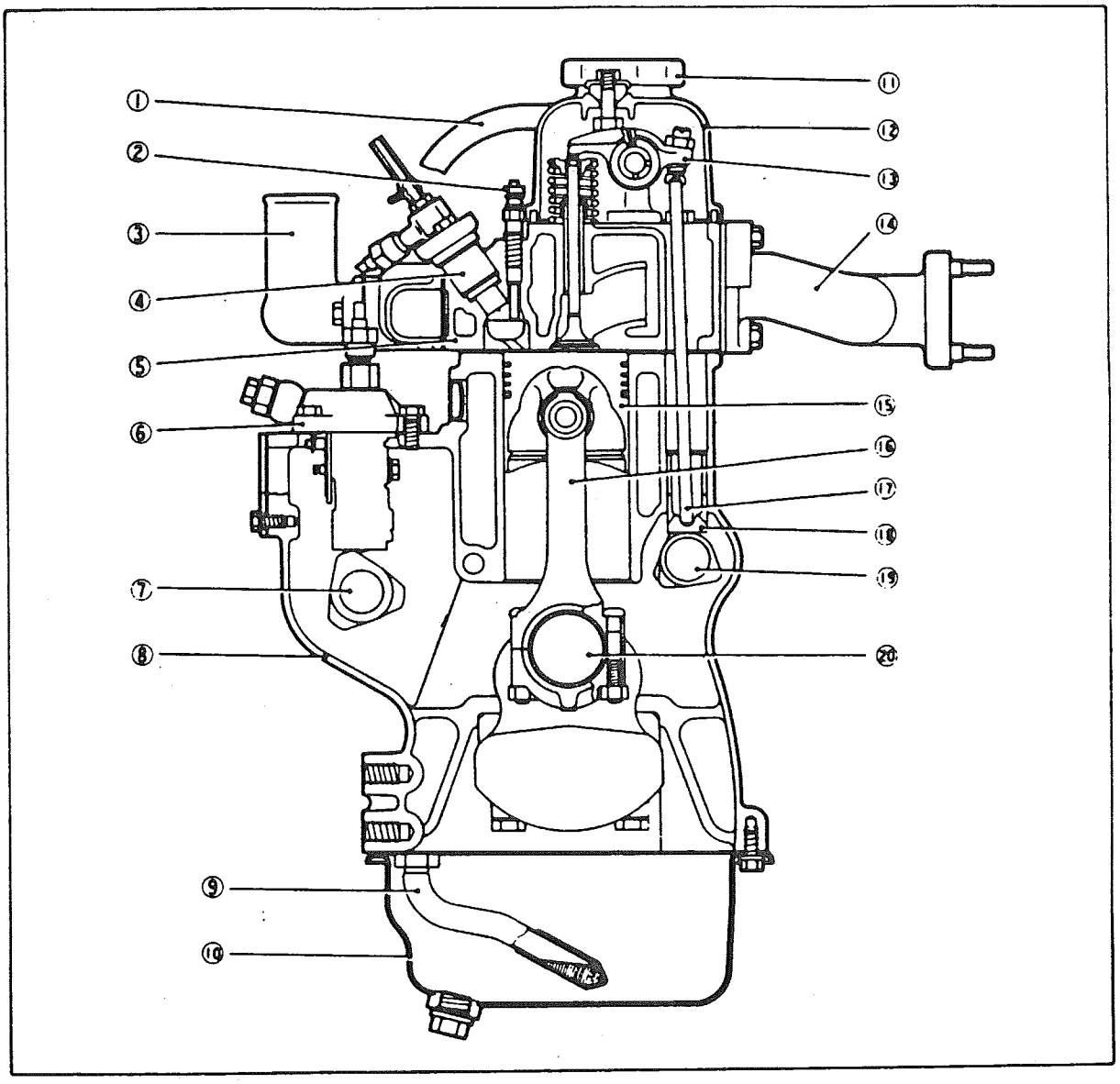
2. Sectional View of Engine

2-1 Longitudinal Sectional View



(1) Cooling fan
(2) Water outlet fitting
(3) Intake valve
(4) Exhaust valve
(5) Water pump pulley
(6) Water pump
(7) Piston
(8) Connecting rod
(9) Fan belt
(10) Crank pulley
(11) Crankshaft
(12) Gear case
(13) Oil pan
(14) Oil screen
(15) Oil filler cap
(16) Rocker cover
(17) Rocker arm
(18) Rocker shaft
(19) Cylinder head
(20) Cylinder block
(21) Push rod
(22) Tappet
(23) Camshaft
(24) Rear oil seal case
(25) Flywheel

2-2 Cross Sectional View



(1) Air breather pipe
(2) Glow plug
(3) Intake manifold
(4) Nozzle holder
(5) Cylinder head
(6) Injection pump
(7) Pump camshaft
(8) Cylinder block
(9) Oil screen
(10) Oil pan
(11) Oil filler cap
(12) Rocker cover
(13) Rocker arm
(14) Exhaust manifold
(15) Piston
(16) Connecting rod
(17) Push rod
(18) Tappet
(19) Camshaft
(20) Crankshaft

3. Major Specifications

Item \ Model	K3A	K3B	K3C	K3D	K3E
Type	4-cycle, water-cooled, vertical diesel engine				
Number of cylinders	3				
Bore x stroke	65 x 78 mm (2.559 x 3.071 in.)	68 x 78 mm (2.677 x 3.071 in.)	70 x 78 mm) (2.756 x 3.071 in.)	73 x 78 mm (2.874 x 3.071 in.)	76 x 78 mm (2.992 x 3.071 in.)
Total displacement	776 cc (47.38 cu.in.)	849 cc (51.85 cu.in.)	900 cc (54.96 cu.in.)	979 cc (59.77 cu.in.)	1,061 cc (64.78 cu.in.)
Combustion chamber	Swirl chamber				
Compression ratio	23				
Engine performance	See engine performance curves.				
Firing order	1–3–2				
Injection timing	(differs with specifications)				
Injection pump	Bosch M type				
Nozzle	Throttle type				
Governor	Centrifugal flyweight type				
Fuel	Diesel fuel				
Lubrication	Forced lubrication (trochoid pump)				
Oil filter	Filter paper (full flow type)				
Engine oil quantity					
Upper limit		3.0 lit. (0.79 U.S. gal)		* 4.0 lit (1.05 U.S. gal)	
Lower limit		1.8 lit. (0.48 U.S. gal)		* 2.8 lit. (0.74 U.S. gal)	
Water pump	Centrifugal type				
Coolant capacity	3.0 lit. (0.79 U.S. gal, expect radiator and hose)				
Starter motor	12V–1.6kW (12V-2kW: For K3D-61RG, TG)				
Alternator	*1				
Battery	12V–45AH or more		12V–60AH or more		
Stability angle	25° during continuous operaton 30° during short-time (less than 30 min.) operation				

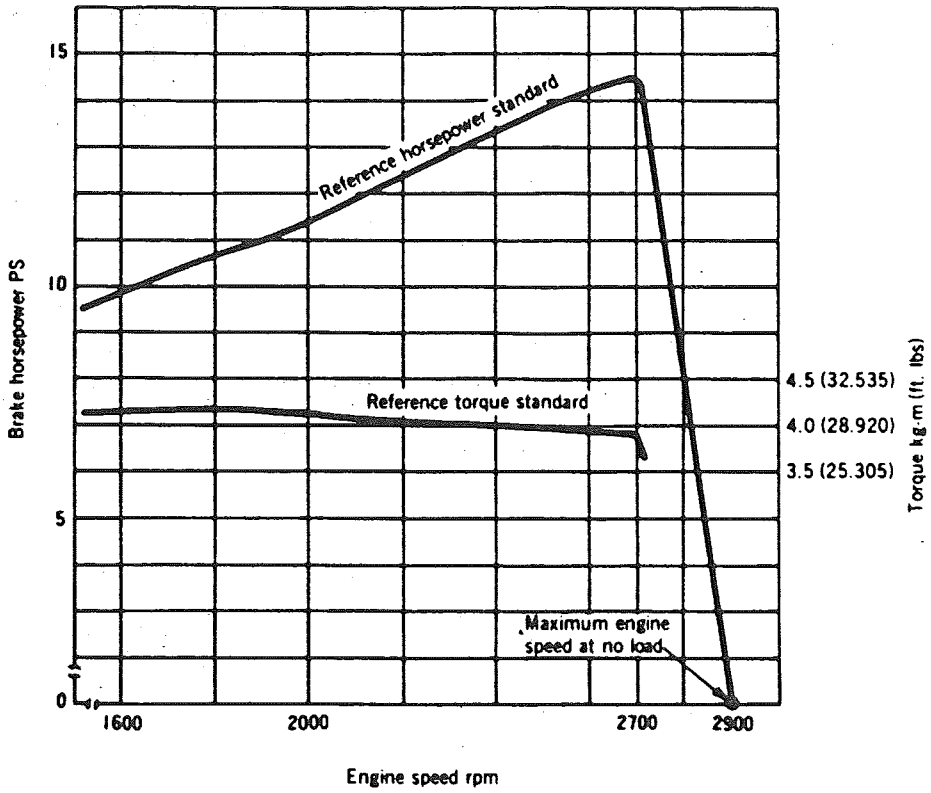
1. * mark applies to K3D, E-13R.
2. *1 marked alternator applies to the following engine models:

Alternator	Engine Model
12V–15A	K3A-11G, GE; K3B-11G, GE; K3C-11G, K3D-11G
12V–35A	K3A-11GT,13G; K3B-61A,11GT,13G,13R, K3C-13G,K3D-13R,61A,61RG,61TG; K3E-13R
12V–50A	K3D-61WM

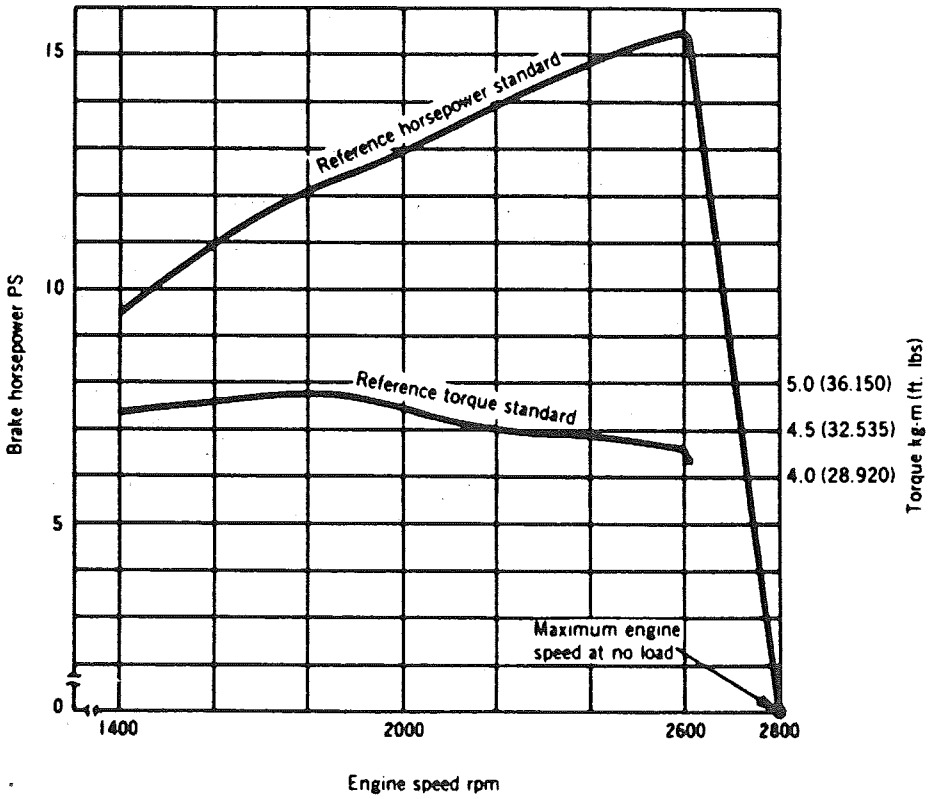
4. Performance Curves

4-1 Engines for Agricultural Use

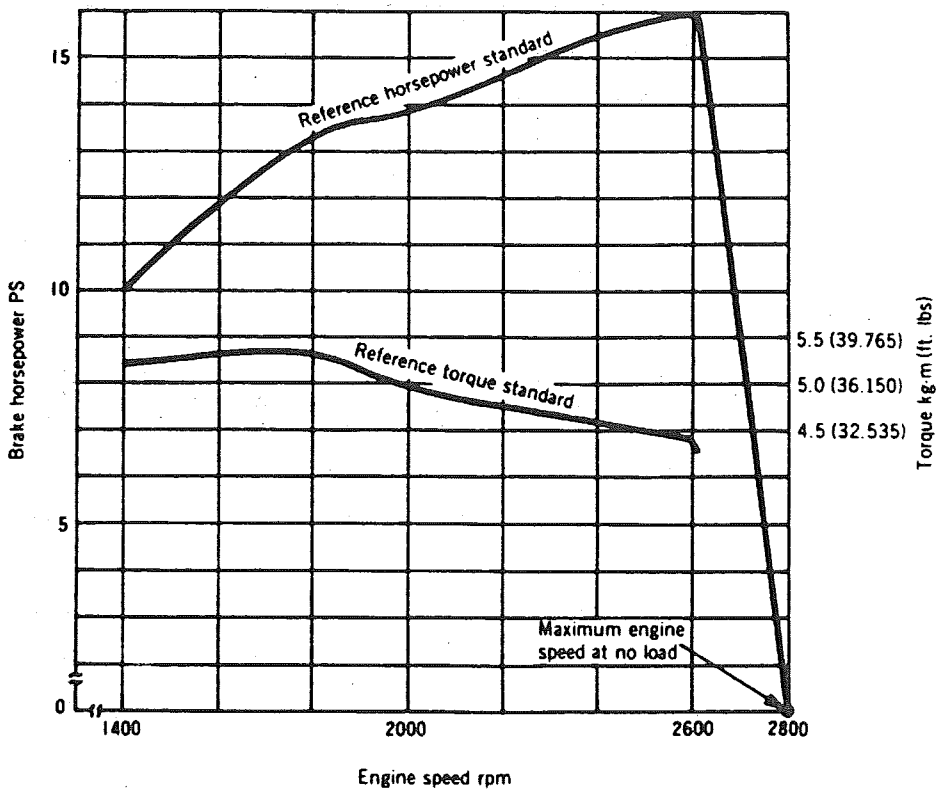
K3A-11 Models for Tractor



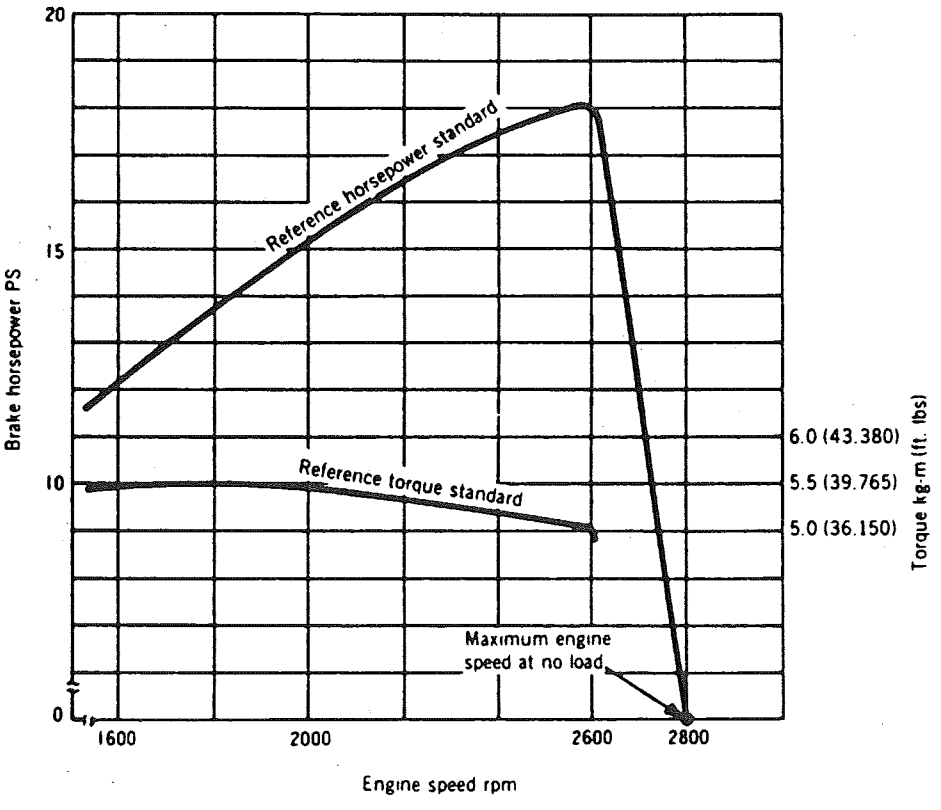
K3B-11 Models for Tractor



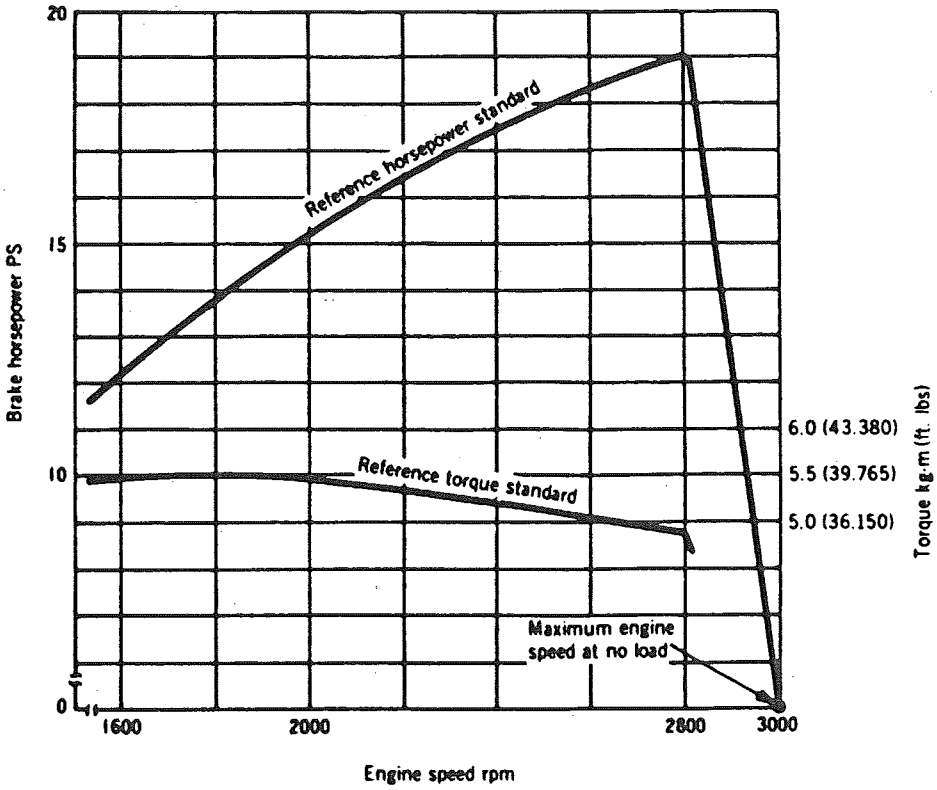
K3C-11 Models for Tractor



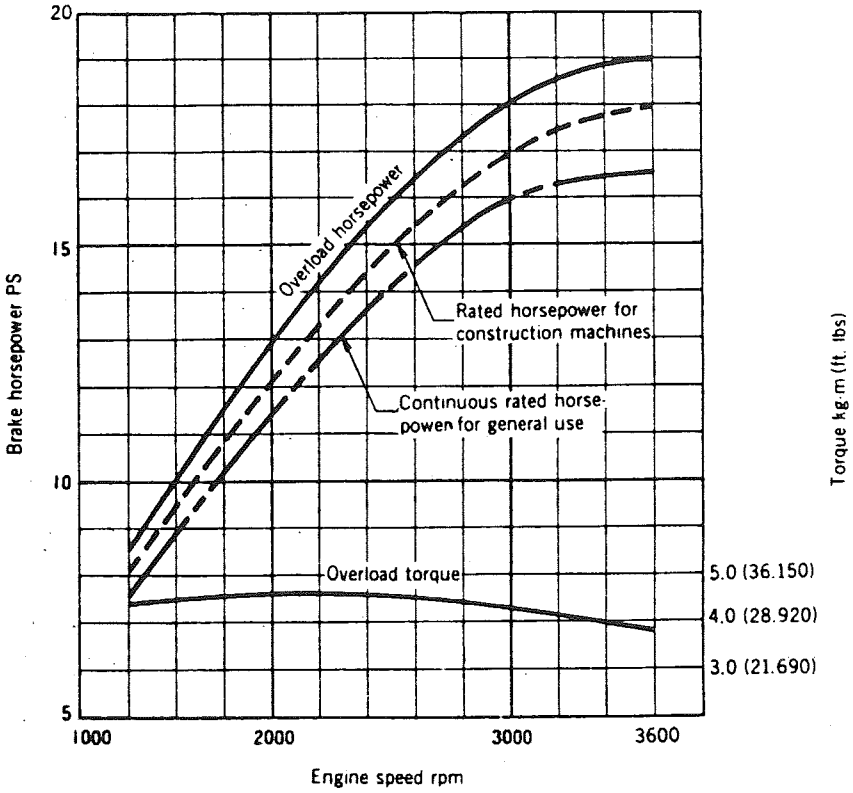
K3D-11 Models for Tractor



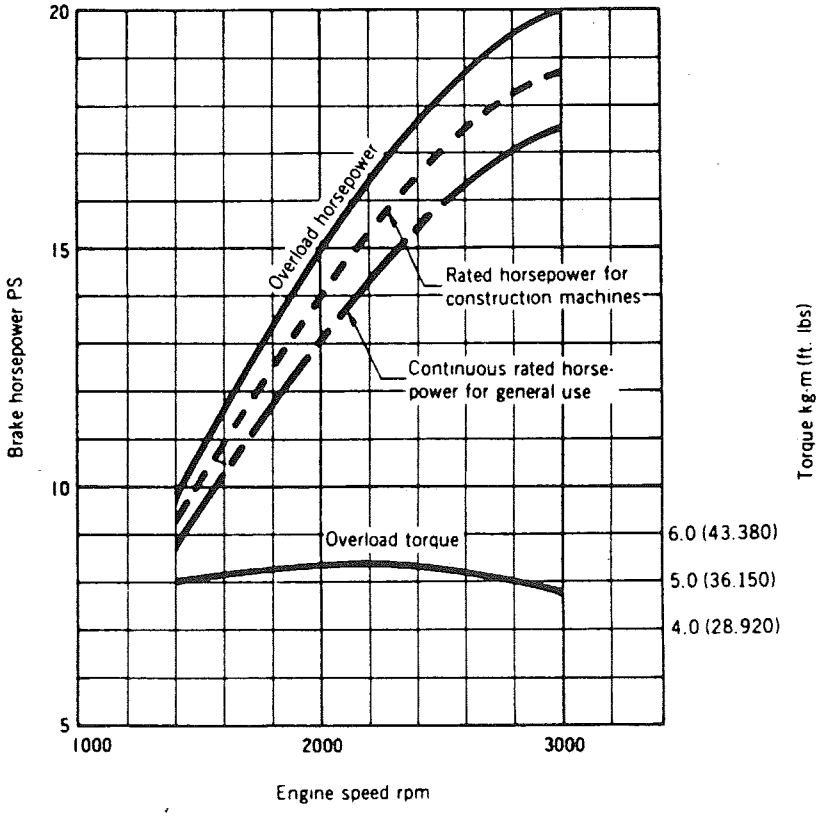
K3D-11C Models for Combine



K3B Models



K3D Models



5. Troubleshooting

Commonly encountered engine troubles, their causes and corrective actions are shown in the following table.

Symptoms and probable causes	Correction
Hard starting	
Low starting speed	
1. Engine oil viscosity too high	Replace engine oil with less viscous oil.
2. Run-down battery	Charge battery.
3. Worn battery	Replace battery.
4. Battery terminals loosely connected	Clean terminals and correct cables.
5. Defective starter	Disassemble and repair or replace starter.
6. Defective main drive section	Check clutch for disengagement.
Defective injection system	
1. Air trapped in fuel passage	Bleed air from fuel system.
2. Clogged fuel filter	Clean or replace filter.
3. Low injection pressure	Adjust injection pressure.
4. Inadequate spray	Clean or replace nozzle.
5. Injection pump delivering insufficient fuel	Disassemble and repair or replace injection pump.
6. Improper fuel	Replace with gas oil (JIS No. 2) (JIS No. 3 in very cold weather).
7. Injection too early	Adjust injection timing.
Engine body troubles	
1. Low compression	
a. Incorrect valve clearance	Adjust valve clearance.
b. Inadequate contact of valve seat	Lap valve.
c. Valve stem seizure	Replace valve and valve guide.
d. Broken valve spring	Replace valve spring.
e. Compression leaks through cylinder head gasket	Replace gasket.
f. Piston ring seizure	Replace piston and piston ring.
g. Worn piston ring and cylinder	Overhaul engine.
2. Burnt glow plug	Replace glow plug.
3. Faulty glow plug operation	Correct lead wire connection.
4. Incorrect governor lever position	Set lever to starting position.
5. Governor spring out of position	Adjust spring.
Low output	
Low compression	See "Hard starting" and "Low output".
Injection system out of adjustment	
1. Incorrect injection timing	Adjust injection timing.
2. Insufficient injection	Disassemble and repair or replace injection pump.
3. Low injection pressure	Check injection nozzle and adjust pressure.
Insufficient fuel	
1. Air trapped in fuel system	Check and retighten connector.
2. Clogged filter	Clean or replace filter.
3. Contaminated fuel tank	Clean tank.
Insufficient intake air	
1. Clogged air cleaner	Clean air cleaner or replace element.

Symptoms and probable causes	Correction
Overheating	
1. Low coolant level	Add coolant.
2. Loose V-belt	Adjust or replace.
3. Clogged or leaking condenser	Clean or replace.
4. Incorrect injection timing	Adjust injection timing.
5. Low engine oil level	Add engine oil.
Excessive oil consumption	
Oil leakage	
1. Defective oil seals	Replace oil seals.
2. Broken gear case gasket	Replace gasket.
3. Loose gear case attaching bolts	Retighten bolts.
4. Loose drain plug	Retighten plug.
5. Loose oil pipe connector	Retighten connector bolt.
6. Broken rocker cover gasket	Replace gasket.
7. Loose rocker cover attaching bolts	Retighten attaching bolts.
Oil working up	
1. Incorrectly positioned piston ring ends	Correct ring position.
2. Displaced or twisted connecting rod	Replace connecting rod.
3. Worn piston ring	Replace ring.
4. Worn piston or cylinder	Replace piston, and rebore cylinder.
Oil working down	
1. Defective stem seal	Replace stem seal.
2. Worn valve and/or valve guide	Replace valve and valve guide.
Abnormal sound or noise	
Crankshaft and main bearing	
1. Badly worn bearing	Replace bearing and grind crank.
2. Badly worn crank	Grind crank.
3. Melted bearing	Replace bearing and check oil system.
Connecting rod and connecting rod bearing	
1. Worn connecting rod big end bearing	Replace bearing.
2. Worn crankpin	Grind crank.
3. Bent connecting rod	Correct bend or replace.
Piston, piston pin and piston ring	
1. Worn cylinder	Grind cylinder to oversize or replace piston.
2. Worn piston pin	Replace piston.
3. Piston seizure	Replace piston.
4. Worn or broken piston ring	Replace piston ring.
Valve system, etc.	
1. Worn camshaft	Replace camshaft.
2. Excessive valve clearance	Adjust valve clearance.
3. Worn timing gear	Replace gear.
4. Worn fan pulley bearing	Replace bearing.
Unsmooth rotation	
Injection pump system	
1. Uneven injection	Adjust injection or replace part.
2. Control rack malfunctioning	Disassemble, check and correct injection pump.
3. Worn delivery valve	Replace delivery valve.
4. Inadequate injection nozzle spray	Replace injection nozzle.

Symptoms and probable causes	Correction
Governor system	
1. Governor lever malfunctioning	Check governor shaft and correct operation.
2. Sagging governor spring	Replace spring.

6. Adjustment

6-1 Adjustment of Valve Clearance

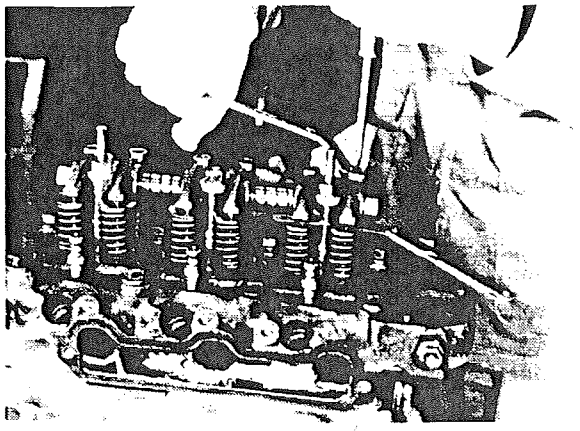
CAUTION:

- **Adjust the valve clearance when the engine is cold.**
- **Tighten the cylinder head bolts to the specified torque.**

1. Pull off the air breather pipe from the rocker cover, and then loosen off rocker cover bolts.

   Adjust the valve clearance at top dead center of compression stroke of each cylinder as described below.

2. Align the timing marks on the gear case and the crankshaft pulley as shown. In this position, No. 1 cylinder is in top dead center of its compression stroke. Check both intake and exhaust valve clearances of the cylinder. If the valves have no specified clearance, adjust by means of the adjusting screws. Remember to align the timing marks properly; if not, the valve will interfere with the piston because of wrong cam position.

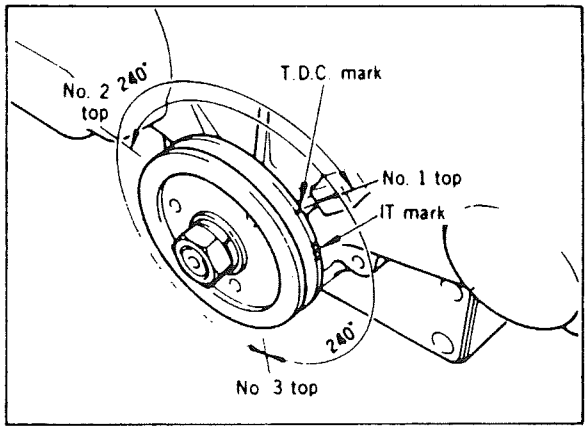


Adjustment of Valve Clearance

Description	Standard value
Valve clearance	
Intake valve	0.25 mm (0.0098 in.)
Exhaust valve	0.25 mm (0.0098 in.)

Description		Standard value
Cylinder head bolt tightening torque	10 mmϕ	7 to 8 kg·m (50.6 to 57.8 ft·lbs.)
	12 mmϕ	11 to 12 kg·m (79.5 to 86.8 ft·lbs.)

3. Next, the piston of No. 3 cylinder comes to top dead center. Turn the crankshaft 240° clockwise from the above position, aligning the timing mark of the crankshaft with that of the gear case. Then check and adjust the valve clearance.
4. To check No. 2 cylinder valve clearance, turn the crankshaft another 240° clockwise, then align the timing marks and check and adjust the valve clearance in a similar manner.



Timing Mark

6-2 Adjustment of Injection Timing

1. Incorrect fuel injection timing will result in hard engine starting and poor engine performance. Adjust the injection timing in the following manner. First remove No. 1 delivery valve holder. Pull off the delivery valve and spring. Install the delivery valve holder only. Subsequently turn the crankshaft, and find an instant when the fuel flowing out of the outlet port of the holder stops. This instant is the injection timing to be obtained. The injection timing differs with engine specifications; be sure to adjust the timing to specification.
2. When the specified injection timing cannot be obtained, adjust by increasing or decreasing the thickness of the injection pump mounting shim. Changing the shim thickness by 0.1 mm changes the injection timing by about 1°. If this adjustment cannot be made, adjust by the following method without removing the delivery valve and spring. First disconnect No. 1 injection pipe at the nozzle holder side. Then, using a wrench on the crankshaft pulley nut, gradually turn the nut. The instant the fuel in the forward end of the pipe expands is the injection timing. In this case, the injection timing takes place about 1° later than the specified.

CAUTION:
- **When the delivery valve is removed, use special care to prevent entry of foreign matter.**
- **Do not crank the engine with the delivery valve holder removed.**

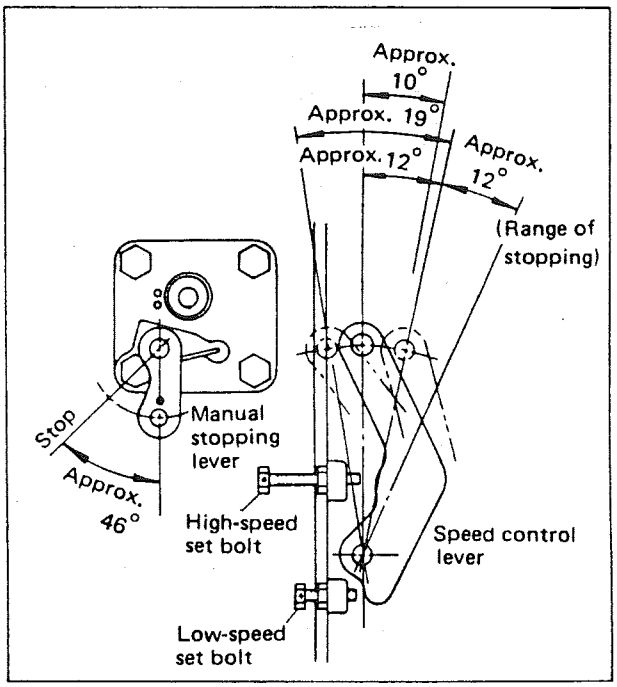
Model	Injection timing
K3A-11, K3B-11, K3C-11, K3B-13	19° BTDC
K3D-11, K3B-31, K3B-61 K3D-31, K3D-61, K3D-13, K3E-13	23° BTDC

6-3 Adjustment of High Speed

CAUTION:
Prior to adjustment operations, warm up the engine fully.

1. Engine without Damper Spring

   Set to a no-load high speed by the HIGH-SPEED set bolt and lock the set bolt. In engines of other models than the following, the set speed is otherwise specified in accordance with respective specifications.



High-Speed Adjustment

Model	Set speed (no-load)
K3A-11, K3B-11 K3C-11, K3D-11	$2,750^{+30}_{-10}$ rpm
K3D-61WM	$3,150^{+30}_{-10}$ rpm

2. Engine with Damper Spring

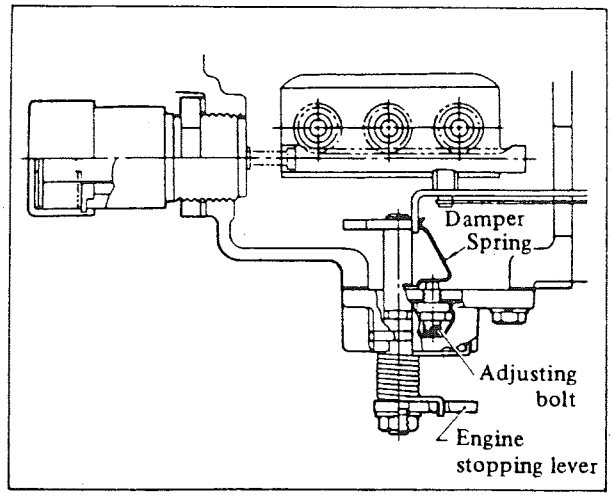
In the case of an engine with damper, adjust the HIGH-SPEED setting by the following procedure. In engines of other models than the following, the set speed is otherwise specified in accordance with respective specifications.

a. With the damper spring left free (with the adjusting bolt loosened), set the engine speed to "A" rpm shown at the right by means of the HIGH-SPEED set bolt, then lock the set bolt.

b. Tighten the damper spring adjusting bolt to adjust the engine speed to "A" + 40^{0}_{-15} rpm ("B" rpm shown at the right), then lock the adjusting bolt with a lock nut. (Apply Super Three-Bond #20 to the threads of the adjusting bolt.)

c. Seal the above-mentioned adjusting bolt with a sealing cap.

d. Seal the HIGH-SPEED set bolt by wire and sealing metal.



Adjusting Damper Spring

Model	Set speed "A"
K3A-11, K3B-11 K3C-11, K3D-11	$2{,}740^{0}_{-40}$ rpm
K3B-13R, K3D-13R	$2{,}840^{0}_{-40}$ rpm
K3E-13R	$2{,}940^{0}_{-40}$ rpm
K3D-61RG, K3D-61TG	$3{,}160^{0}_{-40}$ rpm

Model	Set speed "B"
K3A-11, K3B-11 K3C-11, K3D-11	$2{,}750^{+30}_{-25}$ rpm
K3D-13R	$2{,}850^{+30}_{-25}$ rpm
K3B-13R, K3E-13R	$2{,}950^{+30}_{-25}$ rpm
K3D-61RG, K3D-61TG	$3{,}170^{+30}_{-25}$ rpm

Model	Standard low speed
K3A, B, C, D	$1{,}000^{+30}_{-10}$ rpm
K3B, D, E, -13R	900^{+30}_{0} rpm

Adjustment of Low Speed

6-4 Adjustment of Low Speed

To adjust low speed, set the speed control lever to the specified low speed position with the LOW-SPEED set bolt shown in the figure on the preceding page.

6-5 Stopping the Engine

To stop the engine, pull the engine stopping lever shown in the figure at right. For the engine provided with the solenoid switch type stopping device, it can be stopped automatically only by turning the starting switch key to OFF.

1. Construction and Servicing of Cylinder Head

1-1 Construction

1. Cylinder Head

   a. The cylinder head is an overhead valve head produced from a high-rigidity special cast iron having an excellent cool-effect. Intake and exhaust ports are of a cross-flow type which insures good intake and exhaust efficiency: the intake ports are arranged on the right-hand side of the head and the exhaust ports, on the left-hand side.

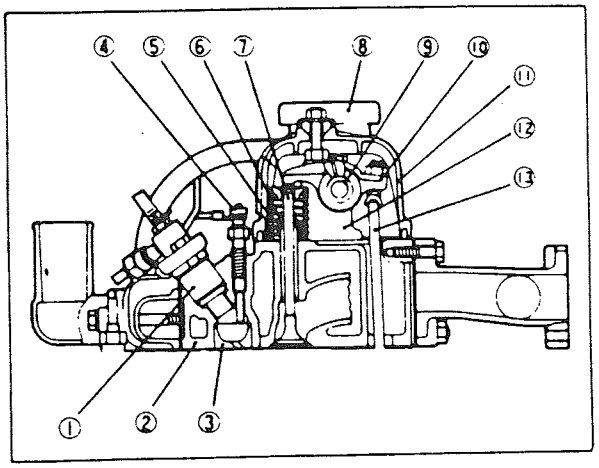
   b. The combustion chamber is a swirl chamber produced from heat-resisting steel and is press-fitted in the cylinder head. This chamber, therefore, requires no disassembly.

   c. Intake and exhaust valve guides are made of sintered alloy and are commonly usable in either ports. The valve guides are oil-impregnated to provide greater wear resistance.

   d. The valve seat is integral with the cylinder head, but, depending on specifications, the valve seat with a sintered alloy valve seat ring is used.

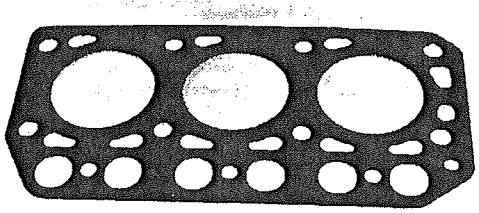
2. Cylinder Head Gasket

   The cylinder head gasket is a carbon graphite gasket and is fitted with stainless steel sheet grommets around the bores to provide greater heat and pressure resistance. The gasket requires no application of sealant for installation.



(1) Nozzle holder
(2) Cylinder head
(3) Mouthpiece
(4) Glow plug
(5) Valve spring
(6) Valve stem seal
(7) Valve
(8) Oil filler cap
(9) Rocker shaft
(10) Rocker arm
(11) Rocker cover
(12) Rocker shaft stay
(13) Push rod

Sectional View of Cylinder Head

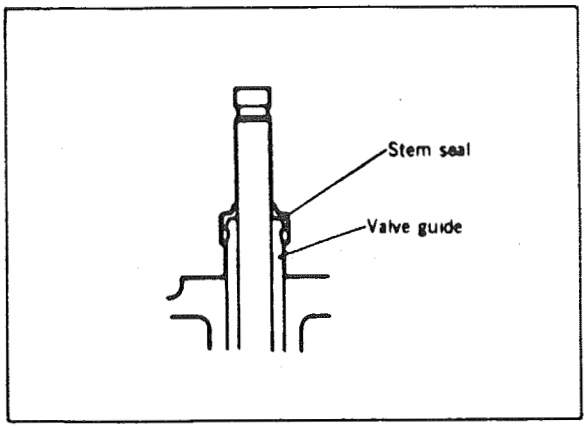


Cylinder Head Gasket

3. Valve and Valve Spring

The intake valve is a heat-resisting steel valve having a large-diameter head to provide great intake efficiency. The exhaust valve has a special heat-resisting steel head welded to the valve stem so the valve may have adequate resistance to high temperatures.

Valve springs are made of spring steel and are closed at the upper end. They carry a red enamel mark on the upper part (rocker arm side) for easy identification of the upper and lower ends. The retainer, retainer lock and valve guide are usable in common between intake and exhaust valves. In the top of the valve guide, a valve stem seal is fitted to prevent downward seepage of oil along the valve stem.



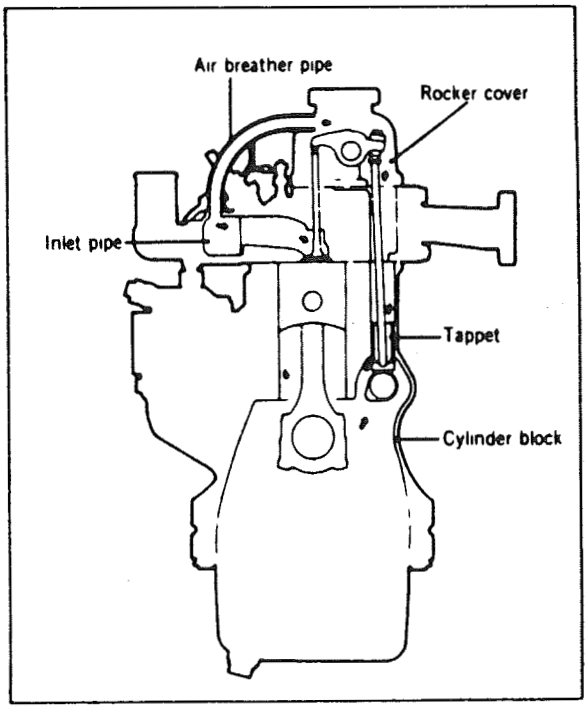
Valve Stem Seal

4. Rocker Arm, Rocker Shaft and Stay

Rocker arms are made of special cast iron and are gas-carburized on the entire surface. Some engines, depending on specifications, use aluminum alloy rocker arms having sintered alloy deposited on the surfaces contacting the valves. Each arm has an oil hole in the upper part. The rocker arm shaft is produced from a carbon steel tube, the interior of which forms a lubricant passage. The rocker arm area of the shaft is induction-hardened. The rocker shaft stay is an aluminum alloy casting. This engine uses three rocker shaft stays. The rear stay is provided with an oil hole into which the oil from the head flows for lubrication of the rocker shaft. The rear stay is identical to the front stay.

5. Crankcase Ventilating System

The crankcase ventilating system permits recirculation of blow-by fumes for recombustion without discharging into the atmosphere. The fumes in the cylinder block flow into the rocker cover through tappet holes then through push rod holes and further into the cylinders for recombustion through the air breather pipe (rubber pipe) and inlet pipe.



Crankcase Ventilating System

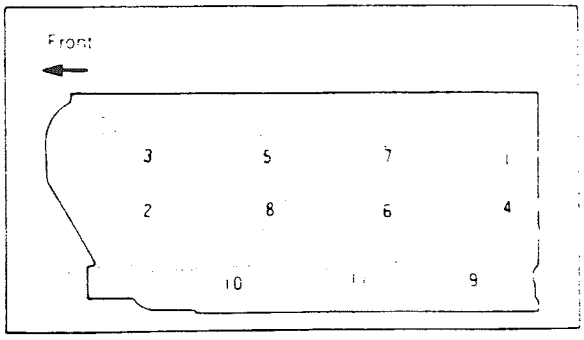
1-2 Servicing

1-2-1 Disassembly

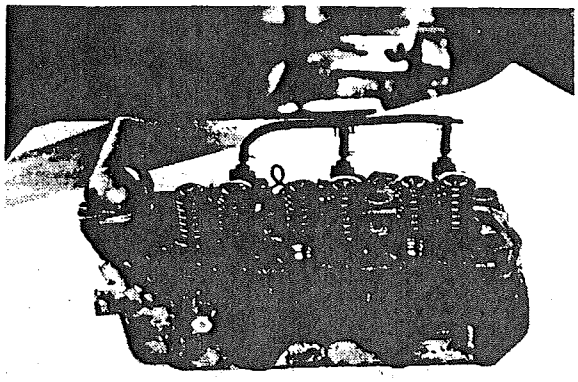
1. Disconnect the air breather pipe. Disconnect the water bypass hose when used.
2. Disconnect the fuel injection pipe.
3. Remove the inlet cover, inlet pipe and exhaust manifold.
4. Remove the rocker cover.
5. Remove the rocker arms and rocker shaft assembly.
6. Remove the push rods.
7. Remove the cylinder head assembly by loosening the head bolts in the sequence shown in the figure.
8. Remove the cylinder head gasket.
9. Partly disassemble the cylinder head assembly in the following manner.
   a. Remove the nozzle holder.
   b. Remove the glow plug lead wire, then remove the glow plug.
   c. Using a valve lifter, compress the spring. Remove the retainer lock, and then remove the retainer, spring, and valve. Place the removed valves and other parts in order by each cylinder.
   d. Remove the water outlet fitting in the case of an engine using the fitting and a thermostat.

1-2-2 Inspection

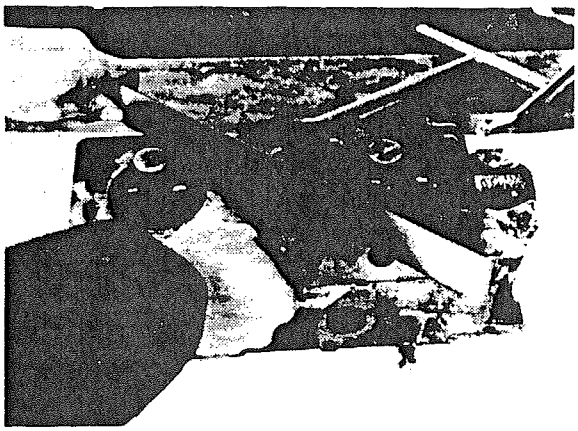
1. Cylinder Head
   a. Prior to washing the cylinder head, check for cracks, damage, and water leaks.
   b. Check to see if the oil passageway is clogged.
   c. Using a straight edge and a feeler gauge, check the lower surface of cylinder head for distortion as shown.



Cylinder Head Bolt Loosening Sequence



Cylinder Head Assembly



Checking Cylinder Head Distortion

Description	Standard value	Service limit
Cylinder head lower surface distortion	0.05 mm (0.0020 in.) max.	0.1 mm (0.0039 in.)

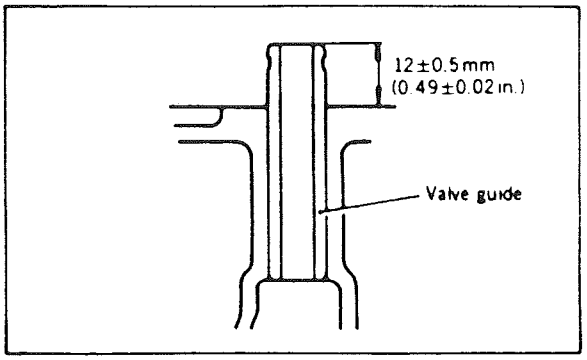
2. Valve Guide

a. Check a valve stem to guide clearance. If the clearance exceeds the service limit, replace the valve guide and valve.

b. To remove the existing guide, press it upward using a remover from under the cylinder head.

To install a new guide, press it in to the illustrated size using an installer from above the head.

After installing the valve guide, check the guide to stem clearance. If the clearance is smaller than the standard size, correct to the standard size by reaming.



Installing Valve Guide

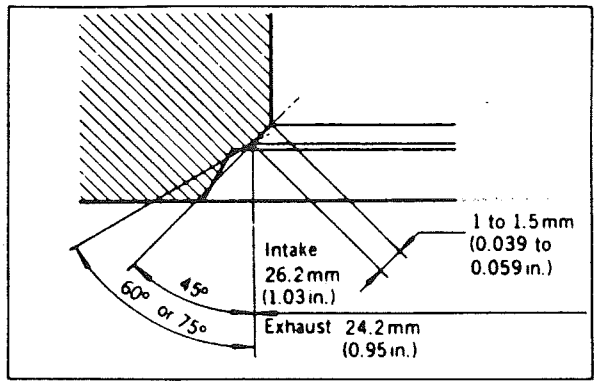
Description		Service limit
Valve guide to valve stem clearance	Intake valve	0.10 mm (0.0039 in.)
	Exhaust valve	0.15 mm (0.0059 in.)

3. Valve Seat

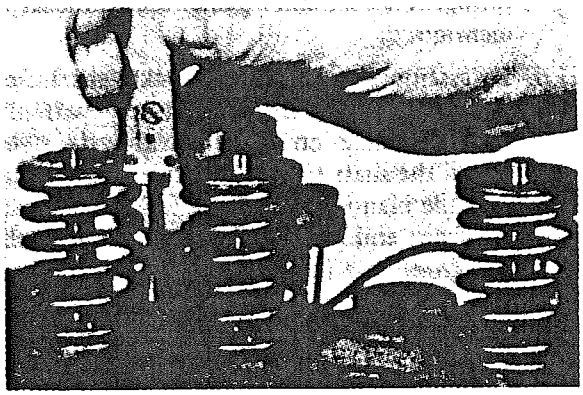
a. Check the valve seat for damage and incorrect contact. Correct as shown in defective. After correction, lap the seat using a lapping compound.

b. In case of excessive valve seat sinkage over the service limit, replace the cylinder head. If the seat rings are used, replace them.

c. Check the valve seat sinkage by measuring the installed length of the spring. When measuring the size up to the top of the valve spring retainer, include retainer thickness (at the collar) of $1.7^{+0.3}_{0}$ mm ($0.067^{+0.0118}_{-0}$ in.)



Correcting Valve Seat



Checking Installed Length of Valve Spring

4. Valve

a. Check the valve face and stem for excessive wear, damage and deformation. Correct or replace if defective.

b. If valve lip thickness (T) has decreased over the service limit, replace the valve.

c. Check the tip of the valve stem for wear and pitting. Correct if defective. Replace if the tip is worn over the service limit.

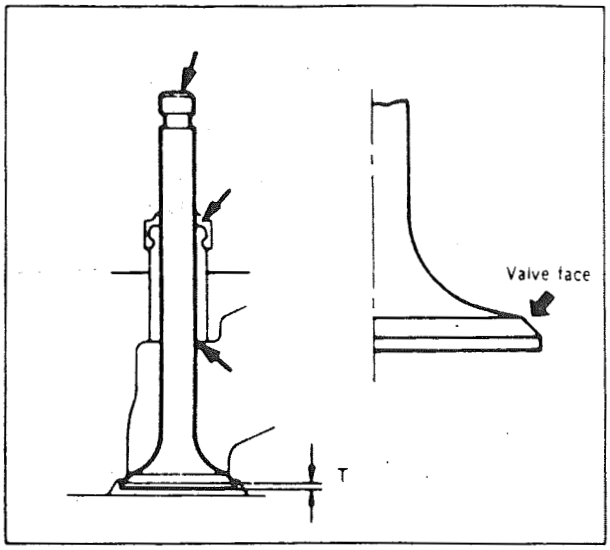
Description	Standard value	Service limit
Installed length of valve spring	37.1 mm (1.46 in.)	−15%
Valve lip thickness (T)	1.0 mm (0.039 in.)	0.5 mm (0.0197 in.)

5. Valve Spring
   a. Check for cracks and damage.
   b. Measure the free length and load of the spring. Replace if the spring is too much deteriorated.
   c. Check the squareness of the spring. Replace if it tilts too much.
6. Rocker Arm and Rocker Shaft
   a. Check the rocker arm face for wear and damage. Replace the rocker arm if excessively worn or damage. Also check the adjusting screw. If its push rod contact surface is worn or damaged, replace.
   b. Measure the rocker arm I.D. and shaft O.D. In the event of excessive clearance, replace the rocker arm.

1-2-3 Reassembly

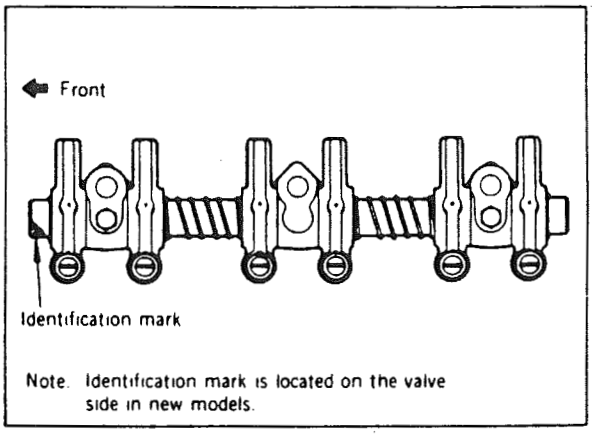
Reassembly can be done by reversing the order of disassembly. When reassembling keep in mind the following items.

1. Partial Assembly of Cylinder Head Assembly
   a. Press in the valve guide to the specified height. (For installation, see 2. Valve Guide in 1-2-2 Inspection.)
   b. Install the valve stem seal properly in the valve guide.
   c. Apply oil to the valve stem and insert the valve stem into the valve guide. Install the spring, retainer, and retainer lock in order of mention.
   d. To assemble rockers to the rocker shaft, first place the rocker shaft front stay with the attaching hole on the right (nozzle side). Install the shaft to this stay in such a manner that the identification mark (ϕ3 mm hole) at the front end of the shaft may come on the left front side (or on the right front side in new models) as shown. Install the front outside rocker arm, and retain it with a snap ring. In the similar manner, install other rocker arms in order backward. Install the rear snap ring. Then install to the cylinder head. When tightening the front and rear stays, be sure to install seat washers for bolts.
   e. Tighten the glow plug to a specified torque.
   f. Install the nozzle holder, then tighten the bolt evenly to a specified torque.



Checking Valve

Description	Standard value	Service limit
Valve spring free length	43 mm (1.6929 in.)	41.7 mm (1.6417 in.)
Squarness of valve spring	1.5°	3.0°

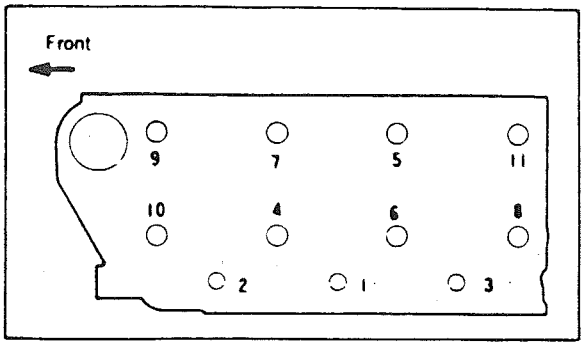


Assembling Rocker Arms to Rocker Shaft

Description	Service limit
Rocker arm to rocker shaft clearance	0.2 mm (0.0079 in.)

g. Install the glow plug lead wire. (The glow plug, being of a taper sealed type, requires no gasket.)

2. The cylinder head gasket must not be coated coated with the sealant.
3. Tighten cylinder head bolts to a specified torque in the illustrated sequence in two to three stages, first slightly and finally firmly to specification.
4. Replace gaskets and packings with new ones. Apply sealant to specified sealing points.
5. Adjust valve clearance. For adjustment procedures, see 6-1 Adjustment of Valve Clearance in 6. Adjustment.

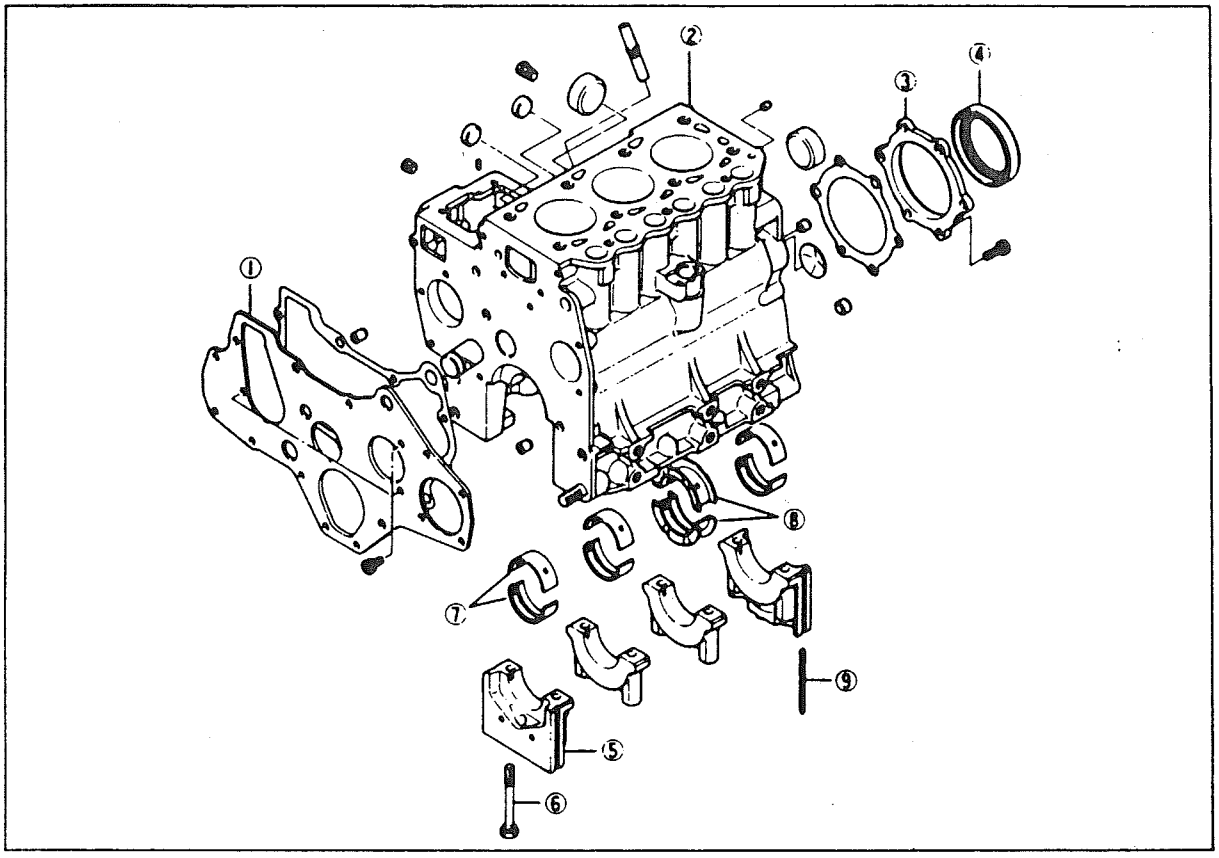


Cylinder Head Bolt Tightening Sequence

Description		Standard value
Cylinder head bolt tightening torque	10 mmϕ	7 to 8 kg.m (50.6 to 57.8 ft.lbs.)
	12 mmϕ	11 to 12 kg.m (79.5 to 86.8 ft.lbs.)
		12 to 13 kg.m:K3E only (86.8 to 94.0 ft. lbs.)

2. Construction and Servicing of Cylinder Block

2-1 Construction



(1) Front plate
(2) Cylinder block
(3) Oil seal case
(4) Oil seal
(5) Bearing cap (No. 1)
(6) Cap bolt
(7) Main bearing (No. 1)
(8) Main bearing (No.3 with flanges)
(9) Cap side seal

Disassembly of Cylinder Block

1. Cylinder Block

   a. The cylinder block is a special iron casting and is of a full jacket type formed integral with cylinder liners. The block has four main bearings to provide a greater rigidity and durability.

   b. Main bearings are metal-backed copper sintered alloy (kelmet) bearings and are coated with lead and tin alloy plating on the journal surface and flash-plated over the entire bearing surface to insure good run-in. Crankshaft thrust is received by No. 3 flanged bearing.

   c. On the front bearing area of the camshaft, a metal-backed special copper alloy rolled bushing is installed.

2. Crankshaft

   a. The crankshaft is a precision-forging of carbon steel and is supported on four bearings to provide great rigidity. Journals, pins and oil seal areas have been induction-hardened to improve wear resistance and durability.

3. Flywheel and Ring Gear

   a. The flywheel is produced from iron casting and is fitted with a ball bearing for the output shaft at the center.

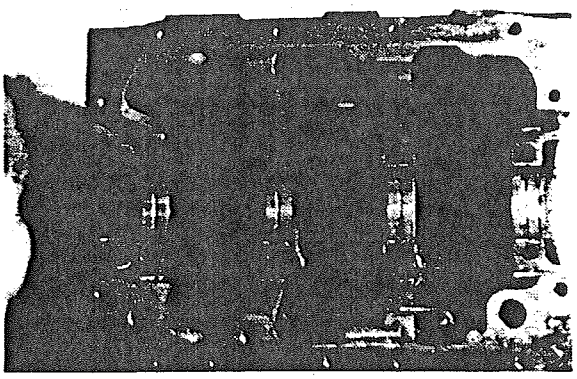
   b. The ring gear is produced from a carbon steel and shrinkage-fitted on the flywheel; the gear teeth are induction-hardened.

4. Piston, Pin and Piston Ring

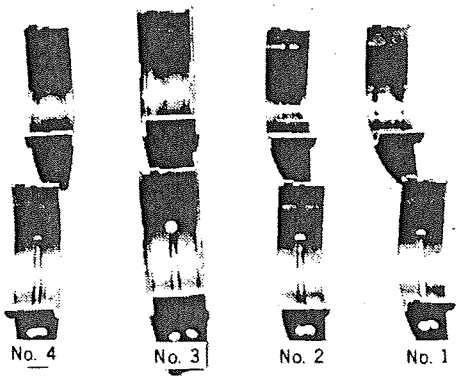
   a. The piston is made of aluminum alloy for less weight and less bearing load during high speed operation. Its external shape is cylindrical and tapered and its entire surface tin-plated, assuring optimum contact for the cylinder bore. In the K3D, a piston with a cavity in the top surface is used for better combustibility.

   b. The piston pin is a hollow, carburized forging, and retains the connecting rod small end to the piston by a semi-floating system. The piston pin is pressed in the rod. The exception is the full-float type for K3E engine, which uses a snap ring to retain the piston pin.

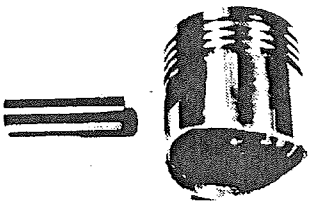
   c. Piston rings are made of a special cast iron. Each piston is provided with three compression rings (two for K3E only) and one oil ring. The outside surface of the top and oil rings are hard chrome-plated. The K3C,D and K3E engine alone uses a semi-keystone type top ring and an oil ring with coil expander.



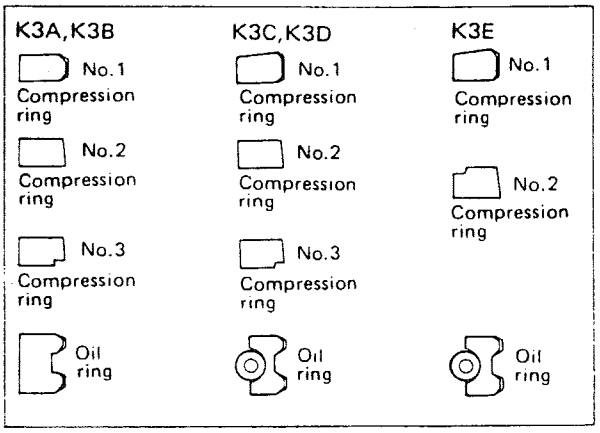
Cylinder Block



Journal Bearing

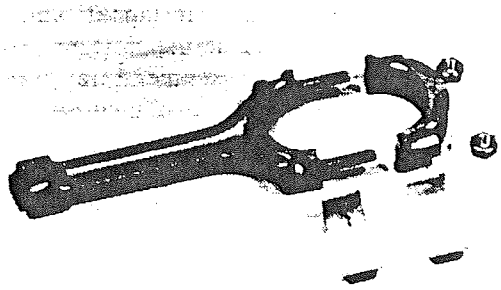


Piston and Piston Pin

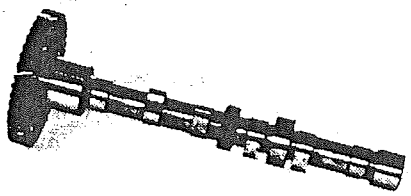


Shapes of Piston Rings

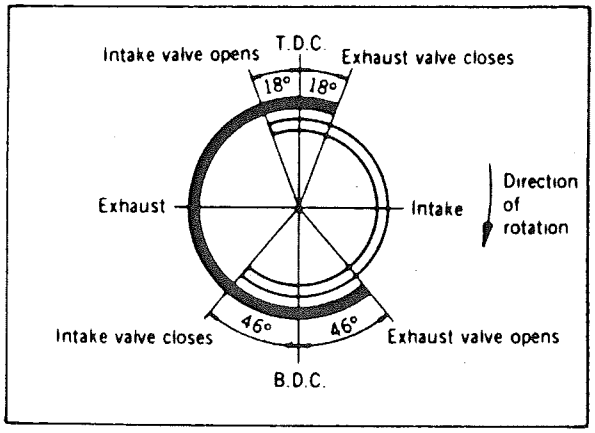
5. Connecting Rod
   a. The connecting rod is an I-beam section rod with a horizontal split-type big end to provide a great rigidity.
   b. The big end bearing is a metal-backed special copper alloy bearing and is flash-plated. An exception is the aluminum metal used for K3E engine.
6. Front Plate and Gear Case
   a. The front plate is a steel plate and positioned by a dowel pin located in the upper part of the camshaft gear and a dowel pin in the lower part of the injection pump gear. It is attached by bolts to the cylinder block. On the left end rear surface, the high-pressure pump gear bearing housing is installed together with the gear case.
   b. The gear case is an aluminum casting, and is attached on the front end of the cylinder block through the front plate. The case houses the high-pressure pump front bearing and related parts of the governor, and further serves as a camshaft and idle gear thrust stopper.
7. Camshaft and Timing Gear
   a. The camshaft is a high carbon steel forging. The cam surface and journals are induction-hardened to improve wear resistance. The shaft is supported on three bearings. Each journal is supported in a bore made in the cylinder block and is lubricated by a forced lubrication system. The camshaft rear journal has a slot to intermittently lubricate the rocker arms through the cylinder head. Further, the shaft has an oil escape hole at the rear end to let excess oil return to the oil pan.
   b. Timing gears are helical gears which have been finished by shaving and crowning to provide a greater durability and to reduce gear noise.
   c. The valve timing is as shown.
8. High-pressure Oil Pump Gear
   a. The high-pressure oil pump drive gear is mounted on the left end of the engine front gear case. The gearshaft has an Oldham's coupling groove in the rear end (except for some special engines which have a gearshaft with spline grooves). When the high-pressure pump is mounted, the pump cover is removed from the front place and the shaft is directly coupled to the bearing housing through this groove.



Connecting Rod



Camshaft

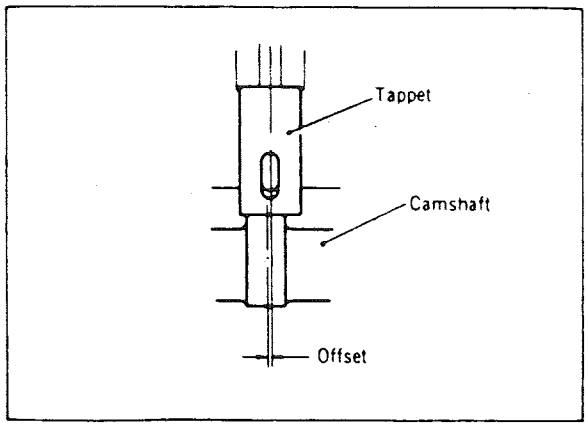


Valve Timing

9. Tappet and Push Rod

a. The tappet is a tubular tappet which has been chill-hardened at the bottom and gas-carburized at low temperature over the entire surface to provide a great wear resistance. The tappet is offset from the cam center to prevent uneven wear of the tappet bottom.

b. The push rod is produced from bar steel; both ends of the rod are flame-hardened.

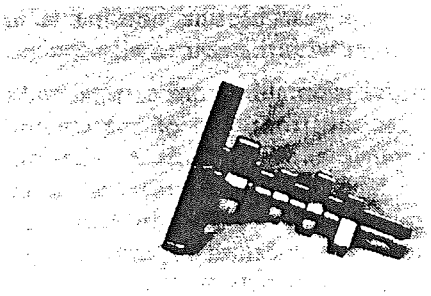


Offset of Tappet from Camshaft

10. Fuel Injection Pump Cam

a. The pump camshaft is produced from high carbon steel. Its cam surfaces are induction-hardened to provide great wear resistance.

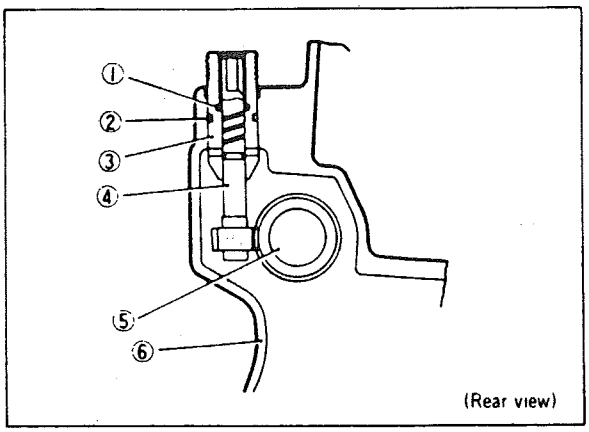
The front end of the shaft supported on a ball bearing has a provision for installation of governor weight and connection with the governor shaft. The rear end is provided with an Oldham's coupling groove for connecting with the oil pump drive shaft.



Fuel Injection Pump Cam

11. Speedometer Driven Gear Unit

a. A durable driven gear unit for high-speed passenger cars is adopted. It is mounted at left center of the cylinder block and is driven by the camshaft.

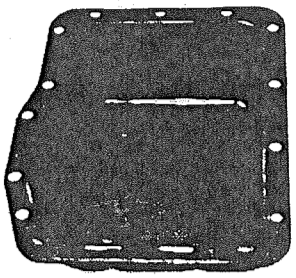


(1) O-ring (small)
(2) O-ring (large)
(3) Sleeve
(4) Driven gear shaft
(5) Camshaft
(6) Crankcase

Speedometer Driven Gear

12. Oil Pan

a. The oil pan is made of sheet metal and has a drain plug at the bottom.

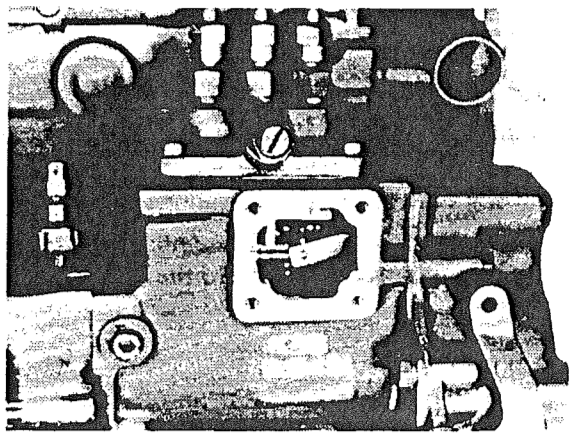


Oil Pan

2-2 Servicing

2-2-1 Disassembly

1. For the removal of the cylinder head and related parts, refer to Cylinder Head.
2. For the removal of the water pump and electrical equipment, refer to their respective items.
3. Pull off the push rod, then pull out the tappet upward.
4. Remove the fuel filter.
5. Remove the speedometer driven unit.
6. Loosen the crankshaft pulley nut, then take out the pulley and washer.
7. With flywheel bolts loosened, remove the flywheel.
8. Remove the rear plate and the rear oil seal case.
9. Place the engine upside down, then remove the oil pan and the oil screen.
10. Remove the high-pressure pump gear bearing housing. Remove the gear case. Remove the inspection window cover located at the right front (beside the injection pump) of the cylinder block, then the stopper spring and tie rod from the control rack of the pump prior to removal of the gear case.

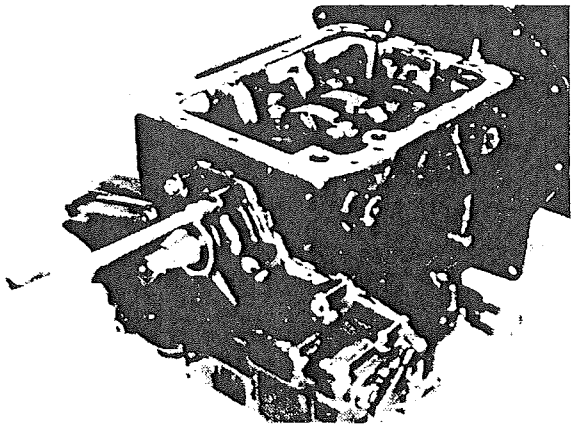


Removing Tie Rod

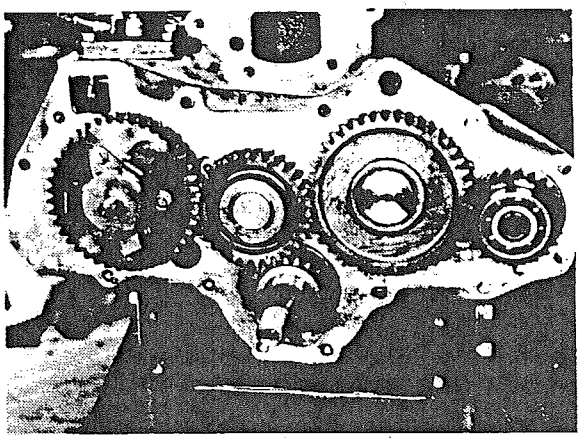
CAUTION:

- Prior to removing the gear case, be sure to separate the injection pump rack and tie rod.
- **The front plate is bolted to the cylinder block from inside the gear case; therefore be careful not to drive out the gear case together with the front plate. Also be careful not to impair the dowel pins.**

11. Remove the fuel injection pump.
12. Remove governor weight bolts, then remove the weight.
13. Remove the pump camshaft bolt.
14. Remove the oil filter and the oil pump assembly, and then draw out the pump camshaft.
15. Remove each gear. Remove the front plate.
16. Draw out the camshaft. Prior to removing the camshaft, remove the push rod, tappet and speedometer drive unit.



Removing Gear Case

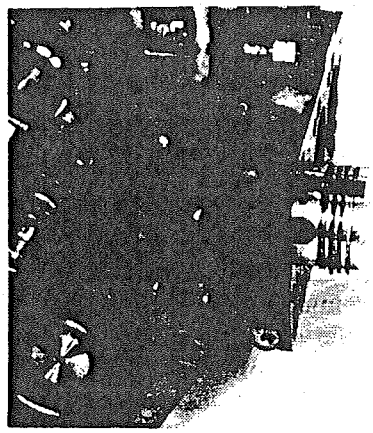


Removing Gears

17. Remove the connecting rod big end bolt nuts, then remove the bearing cap. Push the piston and connecting rod assembly upward out of the cylinder block. Arrange the removed parts by each cylinder. When pushing out the piston and connecting rod assembly, use a wooden block on the mating surface of cap so as not to impair the metal.

CAUTION:

- **Before the piston and rod assembly is removed, make the mating cylinder number on the top surface of the piston.**
- **When the piston and rod assembly is removed, use care to prevent damage to the metal, piston, etc.**



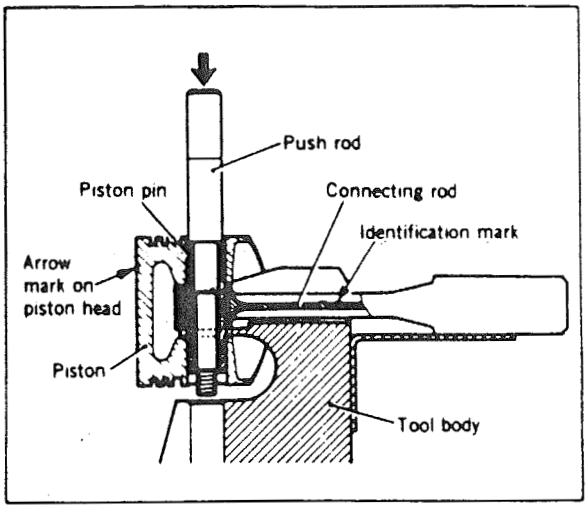
Removing Piston and Connecting Rod Assembly

18. When disassembling the piston and connecting rod assembly, use the following procedure. Keep the disassembled parts by each set. Be careful to prevent confusion, especially for each set of the piston and pin.
    (a)K3A ~ K3D
    1) Set the piston and connecting rod assembly on the special tool (Piston Pin Setting Tool) body.
    2) Insert the push rod of tool into the piston pin hole, and then press the pin out.

CAUTION:
- **Do not attempt to remove a piston pin by striking it with a hammer. A stuck piston pin which requires excessive pulling force should be replaced.**
- **Do not place a load of more than 3,000kg on the piston setting tool.**

    (b)K3E
    Remove the snap ring from each end of piston. Using a piston heater, heat the piston for about 5 minutes in an oil bath of 80°C. Take out the piston and pull out the piston pin.

19. Remove the main bearing caps. Arrange the removed caps and bearings by each cylinder. It is necessary to measure the crankshaft end play before removing the caps, (See the paragraph 4.Crankshaft of 2.2.2 Inspection.)
20. Remove the crankshaft.



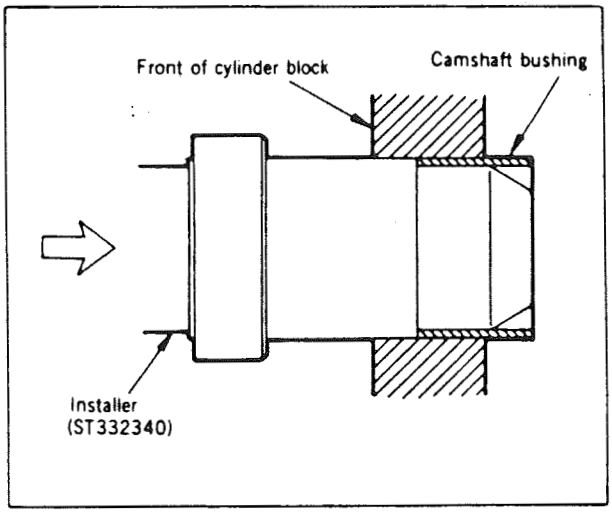
Removing Piston Pin

2-2-2 Inspection

1. Cylinder Block
    a. Check the cylinder block for cracks and damage. Replace if defective. Check the camshaft front journal bushing for wear and damage. If defective, replace using a special tool.

CAUTION:
- **Force out the bushing in the cylinder block and crush to take it out. Be careful not to damage the tappet hole.**

    b. Using a straight edge and a feeler gauge, check the top surface of the cylinder block for distortion (in the same manner as the distortion check of cylinder head lower surface). If the distortion is excessive, correct or replace the cylinder block.
    c. Check the water jacket for scales and rust. Correct if defective.



Removing Camshaft Bushing

Description	Standard value	Repair limit
Distortion of cylinder block top surface	0.05 mm (0.0020 in.) max.	0.10 mm (0.0039 in.)

d. Check the cylinder wall for scratches, damage and wear. If defective, correct the cylinder by honing or reboring. Measure the cylinder bore size at three levels in the directions of A and B.

e. In case of slight wear of cylinder bore and when only the piston rings require replacement, check the upper part of the cylinder for groove wear. If there exists a ridge wear, remove it by reaming and hone when necessary.

Description	Standard value	Repair limit	Service limit
Cylinder bore size	A: 65mm (2.5591 in.) B: 68 mm (2.6772 in.) C: 70 mm (2.7659 in.) D: 73 mm (2.8740 in.) E: 76 mm (2.9921 in.)	+0.2 mm (+0.0079 in.)	+0.95 mm (+0.0374 in.)
Taper of cylinder	0.01 mm (0.0004 in.) max.		

CAUTION:

- **The oversizes for reboring of cylinder are shown in the table of specifications and Service Standard in Section 7. In the rebored cylinder, assemble the piston and piston rings of the size corresponding to the oversize of cylinder.**

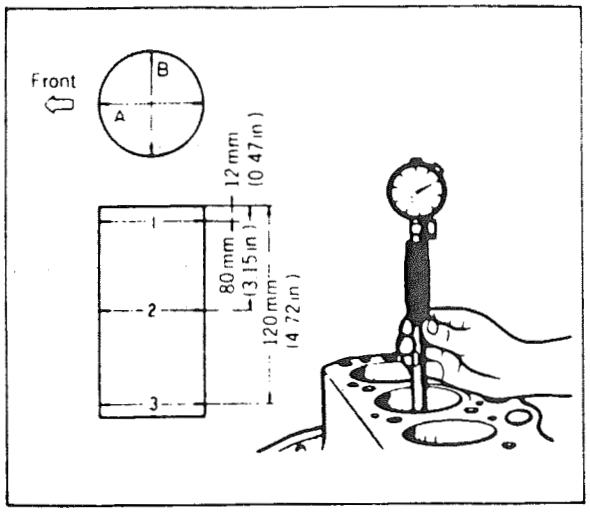
2. Piston, Pin and Rings

a. Check the piston for seizure, nicks and wear. Replace if defective.

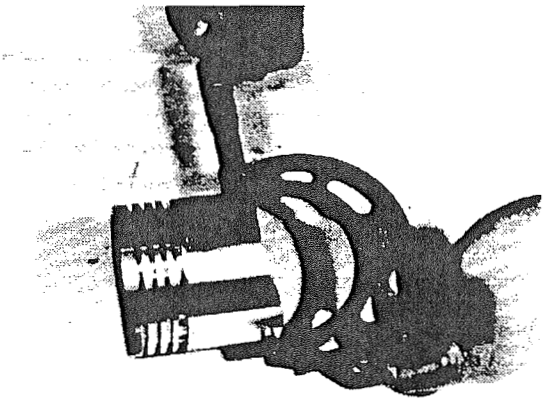
b. Measure the piston O.D. If the clearance between piston and cylinder exceeds the service limit, replace the piston. The piston O.D. should be measured at the lower end of the skirt, across the thrust faces (on the axis perpendicular to piston pin).

Description	Service limit
Piston to cylinder clearance (Piston O.D. as measured at skirt on axis perpendicular to piston pin)	0.3 mm (0.0118 in.)

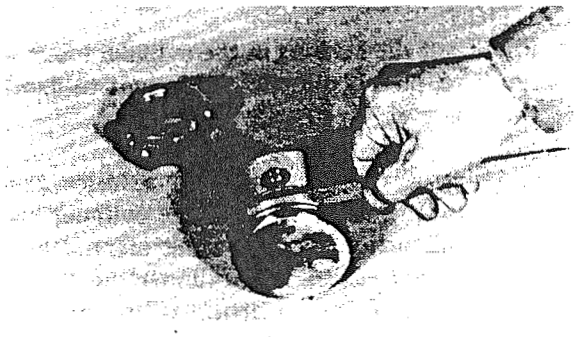
c. Measure the piston ring side clearance. Replace the ring if necessary. In the case of a taper ring (No. 1), measure the side clearance between the lower side of the ring and the ring groove with the ring outside surface held flush with the piston outside surface.



Checking Cylinder Bore Size



Measuring Piston O.D.



Measuring Piston Ring Side Clearance

Description		Standard value	Service limit
Piston ring side clearance	No. 1 compression ring	0.06 to 0.12 mm (0.0024 to 0.0047 in.)	0.3 mm (0.0118 in.)
	No. 2 compression ring	0.05 to 0.09 mm (0.0020 to 0.0035 in.)	0.2 mm (0.0079 in.)
	No. 3 compression ring	0.04 to 0.08 mm (0.0016 to 0.0031 in.)	0.2 mm (0.0079 in.)
	Oil ring	0.03 to 0.07 mm (0.0012 to 0.0028 in.)	0.2 mm (0.0079 in.)

d. Measure the piston ring gap clearance. Replace the ring if the gap is too large.

To measure, insert the ring into the least worn place of the cylinder bore (skirt) using a piston as shown, and measure the gap with a feeler gauge.

3. Connecting Rod

a. Using a connecting rod aligner, check bend and distortion of the rod. If excessive, correct or replace.

b. Measure the connecting rod thrust clearance with the rod assembled on the crankshaft. If the clearance is excessive, replace the rod assembly.

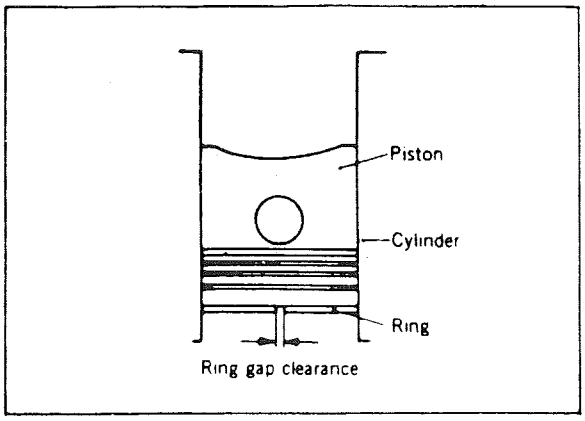
4. Crankshaft

a. Measure crankshaft bend. If excessive, repair or replace the crankshaft.

b. Check the journals and pins for damage, seizure and other faults. If the journals and pins are seriously worn or damaged, correct them to undersize.

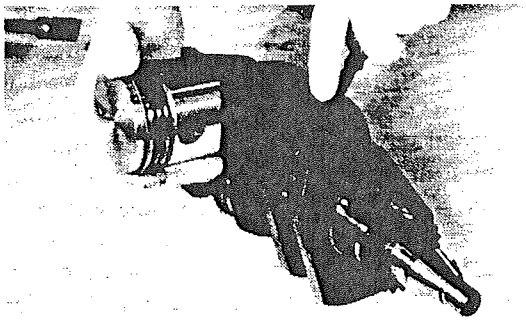
CAUTION:

- **Undersizes for correcting journals and pins are shown in the table of Specifications and Service Standard in Section 7.**
- **Finish each fillet of journal or pin to the radius of 2.5 mm (0.0984 in.).**



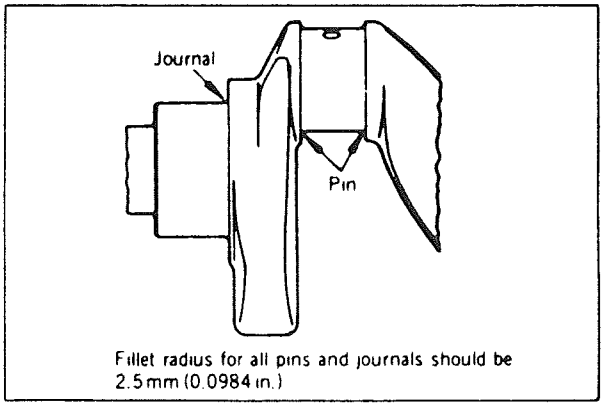
Measuring Piston Ring Gap Clearance

Description	Standard value	Service limit
Piston ring gap clearance	0.15 to 0.4 mm (0.0059 to 0.157 in.)	1.5 mm (0.0590 in.)



Measuring Connecting Rod Thrust Clearance

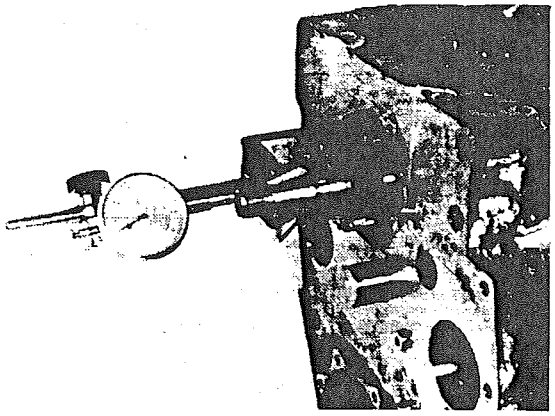
Description	Standard value	Service limit
Bend of connecting rod	0.05 mm (0.002 in.) max.	
Thrust clearance of connecting rod	0.1 to 0.35 mm (0.0039 to 0.0138 in.)	0.5 mm (0.0197 in.)



Fillet Radius

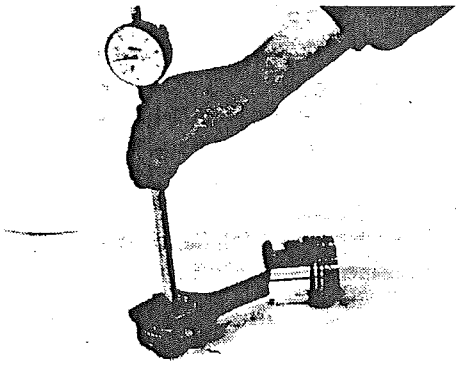
c. Check the crankshaft end play. If the end play exceeds the specified value, replace No. 3 main bearing. To check the end play, first install the main bearings, crankshaft, and main bearing caps, then tighten the cap bolts to the specified torque. Using a dial indicator on the forward end of the crankshaft, measure the end play.

Description	Standard value	Service limit
Bend of crankshaft	0.03 mm (0.0012 in.) max.	
End play of crankshaft	0.05 to 0.175 mm (0.0020 to 0.0069 in.)	0.3 mm (0.0118 in.)



Measuring Crankshaft End Play

5. Main Bearings and Connecting Rod Bearings
   a. Check the bearing surface for spalling, melt, seizure and incorrect contact. If defective, replace.
   b. Install the main bearings and connecting rod bearings to the cylinder block and connecting rod respectively. Measure the bearing I.D. Subsequently measure the crankshaft journal and pin O.D. to obtain an oil clearance. (A plastigauge may be used.) In case of too large oil clearance, replace the bearing. If the standard clearance cannot be obtained even after the replacement of the bearing, grind the crankshaft to undersize (refer to paragraph 4.b.) and install bearings of the same undersize.



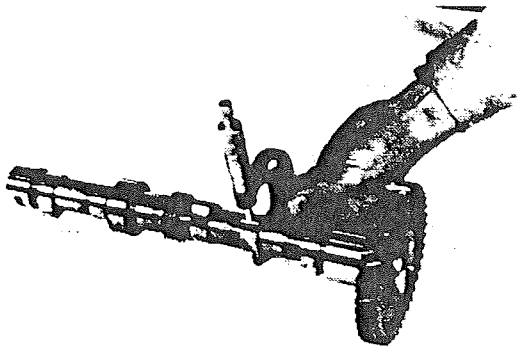
Measuring Connecting Rod Bearing I.D.

CAUTION:
Before measuring the I.D. of main bearing and connecting rod bearing, be sure to tighten their bolts to the specified torque.

Description	Standard value	Repair limit	Service limit
Journal O.D.	52 mm (2.0472 in.)	−0.15 mm (−0.0059 in.)	−0.95 mm (−0.0374 in.)
Pin O.D.	42 mm (1.6535 in.)	−0.15 mm (−0.0059 in.)	−0.95 mm (−0.0374 in.)

Description		Standard value
Crankshaft oil clearance	Journal	0.10 mm (0.0039 in.)
	Pin	0.15 mm (0.0059 in.)

6. Timing Gears and High-pressure Pump Gear
   a. Check each gear for incorrect tooth contact, wear and damage. Replace if defective. Also check the Oldham's coupling groove at the rear end of the high-pressure pump gear for faults.
7. Camshaft
   a. Measure a clearance between the camshaft journals and cylinder block. If the clearance is too large, replace the camshaft or the camshaft bushing.
   b. If the cam surface is damaged or the cam lobe is badly worn over the service limit, replace the camshaft.
8. Fuel Injection Pump Camshaft
   a. If the camshaft cam surface is badly worn or damaged, if the Oldham's coupling is damaged, or if the cams are worn in excess of service limit, replace the camshaft.

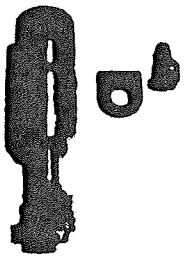


Measuring Camshaft Cam Lobe Height

Description	Standard value	Service limit
Clearance between each camshaft journal and cylinder block		0.15 mm (0.0059 in.)
Cam lobe height (for both intake and exhaust valves)	35.76 mm (1.4079 in.)	−1.0 mm (−0.0394 in.)
Injection pump cam lobe height	44 mm (1.7323 in.)	−1.0 mm (−0.0394 in.)

9. Tappet
   a. Check the bottom of tappets for wear, cracks, spalling and nicks. Replace a tappet if it is seriously defective.
   b. Check the tappet to cylinder block clearance. If the clearance exceeds the specified value, replace the tappet.
10. Push Rod
   a. Replace the push rod if its both ends are badly worn.
   b. With the push rod placed on a surface table, check for bend at the center. If the bend exceeds the specified value, correct or replace.
11. Speedometer Driven Unit
   a. Check the gear and shaft for wear and damage. Also check the O-ring for damage. If they are excessively damaged, replace.

Description	Standard value	Service limit
Tappet to cylinder block clearance		0.15 mm (0.0059 in.)
Bend of push rod	0.3 mm (0.0118 in.) max.	

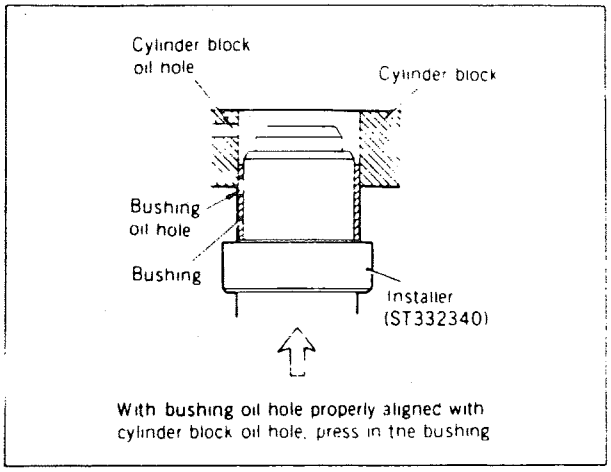


Speedometer Driven Unit

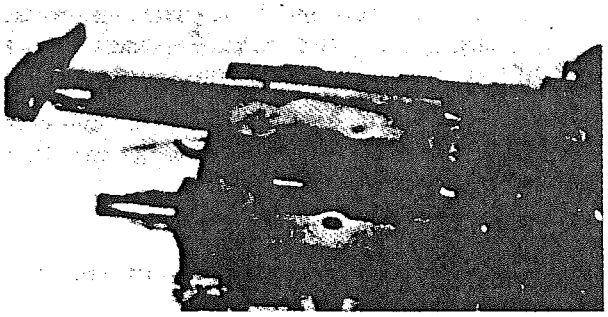
CAUTION:

- **Clean each part sufficiently. Clean oil holes, sliding surfaces and rotating parts specially carefully.**
- **Before assembling, apply engine oil to all sliding and rotating parts such as bearings and cylinder inner walls.**
- **Replace gaskets, packings and oil seals with new one. Reuse of these parts is not permitted.**
- **Apply sealant to gaskets and packings and to the specified sealing points.**
- **Observe tightening torque and sequence where specified. In other parts, tighten to the torque for ordinary screws.**
- **Check clearances and end plays when installing.**

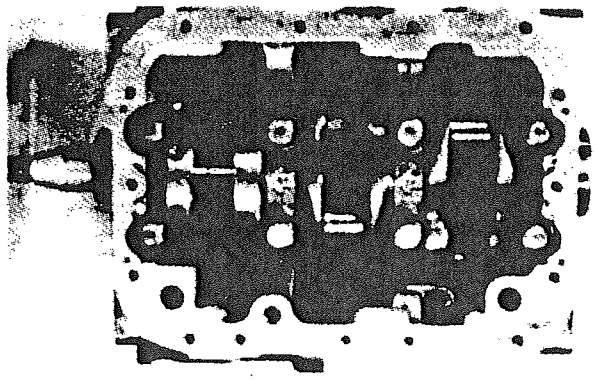
1. When the camshaft front bushing is pressed in, use the installer and align the bushing oil hole with that in the cylinder block as illustrated. After installing the bushing, make certain the oil holes are properly aligned.
2. Install the main bearings to the cylinder block and main bearing caps.
3. Install the crankshaft.



Installing Camshaft Bushing



Installing Main Bearing Caps

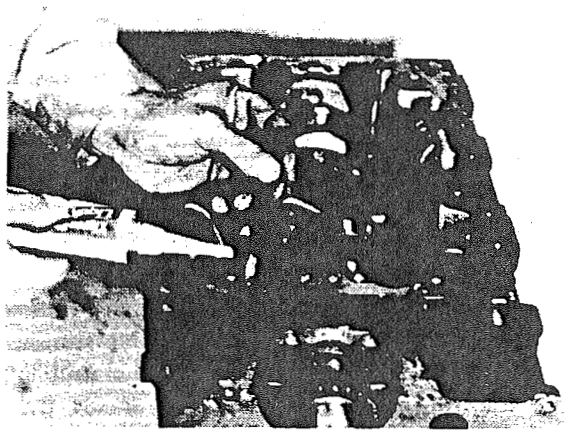


Arrow mark indicates the front of engine.

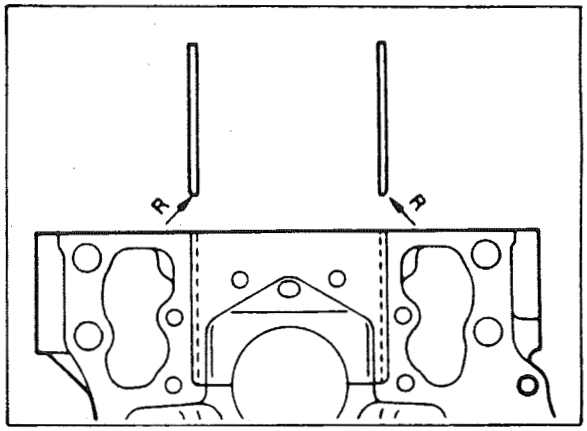
Installed Direction of Main Bearing Caps

4. Install the main bearing caps, then tighten cap bolts to the specified torque. Each cap carries an embossed arrow mark and numeral to prevent incorrect installation of the caps. When installing No. 1 and No. 4 caps, apply sealant to the upper surface (cylinder block mating surface).
5. Check the crankshaft end play.
6. Apply sealant to the outside surface of both side seals. Press the side seals into the front and rear caps, thus completing the reassembly of the crankshaft.

Description	Standard value
Main bearing cap bolt tightening torque	5 to 5.5 kg·m (36.2 to 39.8 ft·lbs.)



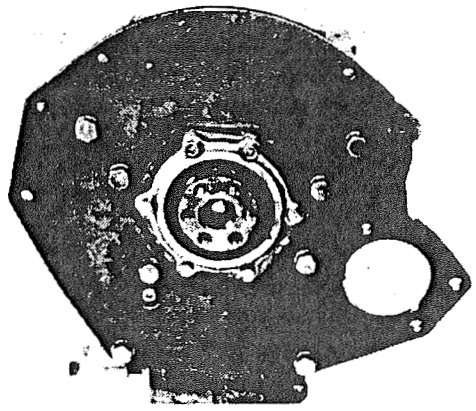
Installing Bearing Cap Side Seal



Direction of Side Seal Installation

7. Insert the oil seal into the crankshaft rear oil seal case, apply oil to the oil seal lip and install the seal case to the cylinder block. Remember to install the gasket.
8. Install the rear plate.
9. Install the flywheel. The bolts should be tightened to the specified torque.

Description	Standard value
Flywheel bolt tightening torque	11.5 to 12.5 kg·m (83.1 to 90.4 ft·lbs.)

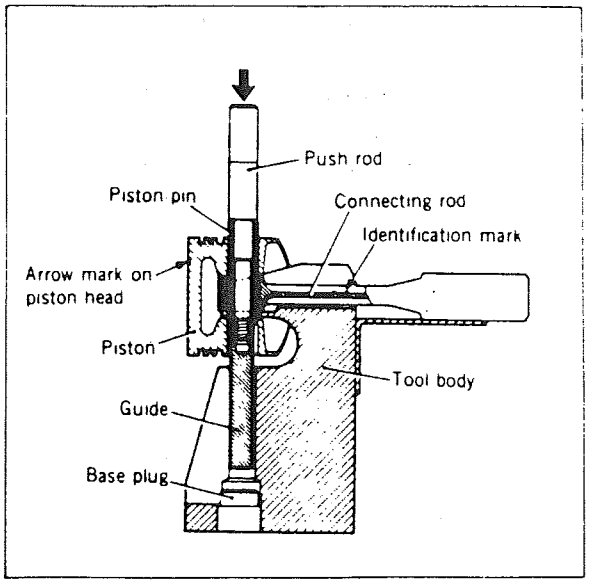


Installing Oil Seal Case

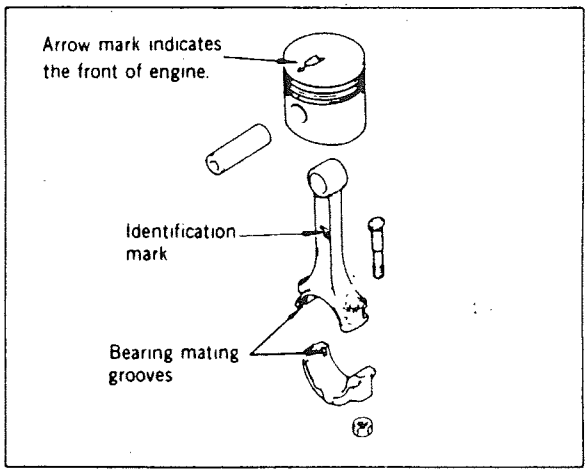
10. The piston and the connecting rod should be assembled as described below using Piston Pin Setting Tool. This does not apply to the K3E engine, pistons and connecting rods of which should be assembled according to step (10).
    a. Insert the piston pin into the push rod of the tool, then screw the guide fully into the push rod.
    b. Insert the assembled push rod, piston pin and guide into the piston pin hole from the guide side, and into the small end of the connecting rod. In this case, make certain the front mark (arrow) on the piston head and the identification mark on the connecting rod are on the same side, or face up. Before insertion, apply engine oil sufficiently to the piston pin O.D. and the connecting rod small end I.D.
    c. Set the piston, connecting rod and tool on the tool body. To set, insert the piston and connecting rod assembly and the tool into the tool body with the cut of the guide properly aligned with that of the tool body, and then turn the guide a 90° turn. After setting, make certain the small end of the connecting rod rests properly on the tool body. Also check to see if the front mark on the piston head and the connecting rod identification mark face up.
    d. Set the tool with piston to the press and press in the piston pin. If the press load required for fitting the pin is out of standard value, replace the connecting rod or the piston and piston pin assembly. The piston pin is pressed in to the specified position by the guide. After installation, turn the push rod 90° until the guide and tool body cuts match up, and then detach the piston and connecting rod assembly from the tool body.

CAUTION:

- **After assembling the piston and connecting rod, make certain the connecting rod small end is properly positioned at the center of the piston pin. In the event of excessive shift of the piston pin from its proper position, correct. In this case, check the special tool also.**
- **The piston and piston pin are matched parts and therefore must not be mixed with other parts. Pistons and piston pins to be used in one engine must be of the same size (same mark).**



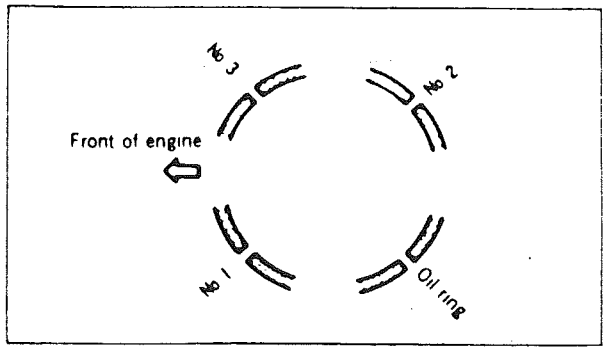
Pressing in Piston Pin



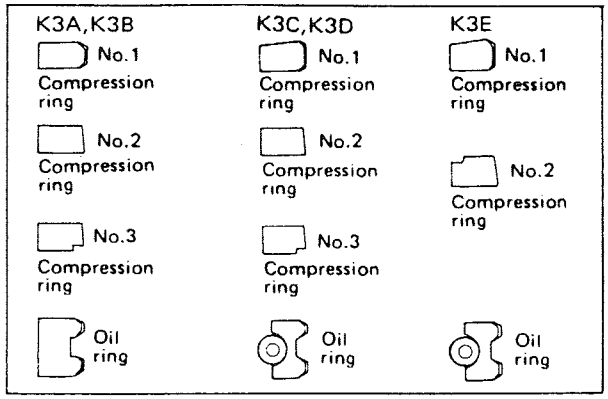
Installing Piston Rod

Description	Standard value
Press load for fitting piston pin into connecting rod	500 to 1,500 kg (1,102.29 to 3,306.88 lbs.)

11. When assembling the piston and connecting rod for the K3E engine, heat the piston at 80°C for about 5 minutes in oil using a piston heater. After installing the piston pin, lock with a snap ring at each end of the pin to prevent it from loosening.
12. The piston rings differ in shape from one another. Be careful to install them in proper positions and directions as illustrated. In the case of the oil ring with coil expander, the gap clearance of the ring should be positioned 180° away from the joint of the expander.



Piston Ring Gap Positions

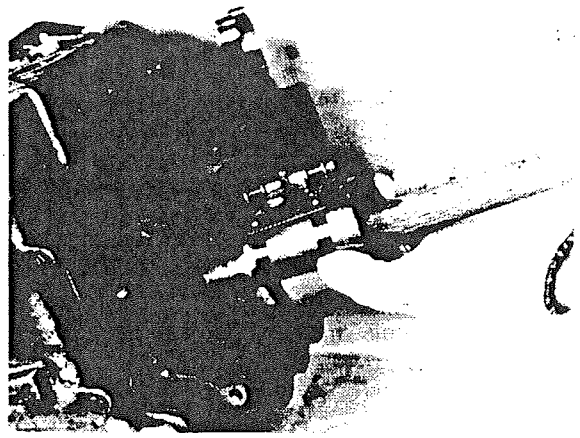


Shapes of Piston Rings

13. Insert the piston and connecting rod assembly from above into the cylinder block using a ring band. In this case, make certain the piston ring gaps are properly positioned. After insertion, properly install the connecting rod bearing metal and tighten rod cap bolts to the specified torque.

CAUTION:

- **Install the piston rings with the stamped manufacturer mark and size mark facing up.**
- **The arrow mark on the top surface of piston should be directed to the front of engine.**
- **The bearing assembly grooves of connecting rod caps should be on the same side when assembled.**



Installing Piston and Rod Assembly

14. Install the front plate. Remember to install the gasket and dowel pin.
15. Turn the crankshaft until No. 1 piston is in top dead center.
16. Drive the key into the crankshaft and then install the crankshaft gear onto the shaft.

Description	Standard value
Connecting rod cap nut tightening torque (Except K3E)	3.2 to 3.5 kg.m (23.1 to 25.3 ft.lbs.)
Connecting rod cap bolt tightening torque (For K3E)	5.5 to 6 kg.m (39.8 to 43.4 ft.lbs.)

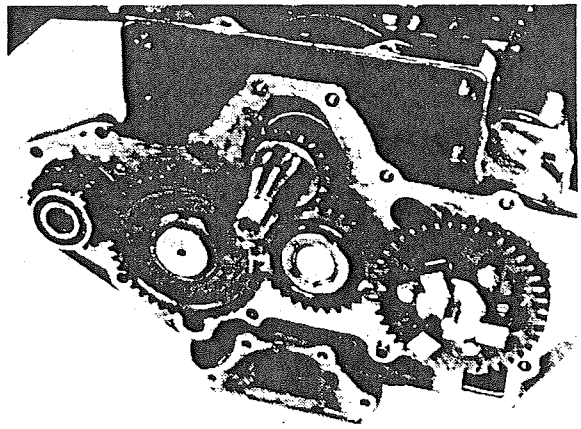
17. With the idle gear mating mark "1" properly aligned with the crankshaft mating mark "1", install the idle gear on to the idle shaft. When the crankshaft front bearing has already been installed, the mating mark "1" on the front side of the crankshaft is invisible. Align the idle gear mating mark "1" with a mark line on the side of the gear boss.

    Insert the camshaft and gear assembly into the cylinder block and align the idle gear mark "2" with the camshaft gear mating mark "2".

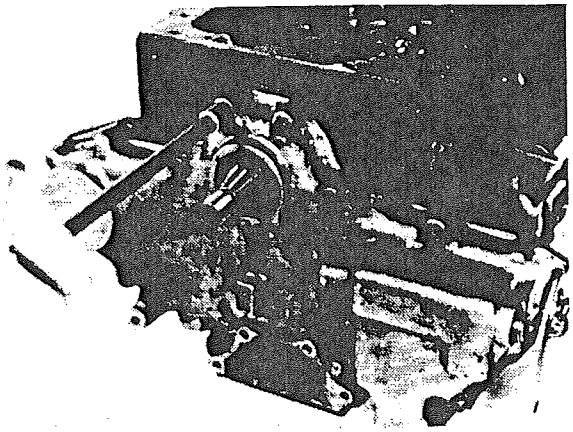
    Subsequently insert the injection pump camshaft assembly into the cylinder block and align the idle gear mating mark "3" with the pump gear mark "3". Finally install the high-pressure pump drive shaft gear assembly.

18. Install the governor weight assembly to the injection pump cam gear.

19. Install the gear case (after installing governor and related parts) and gasket. When installing the gear case, insert the tie rod and tie-rod stopper spring into a hole in the cylinder block.



Mating Marks of Gears



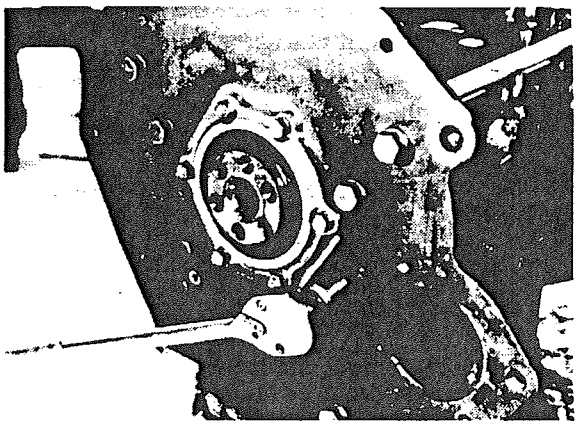
Installing Gear Case

20. Insert the crankshaft pulley. Install the washer and nut. Then tighten to the specified torque.

Description	Standard value
Crankshaft pulley nut tightening torque	20 to 25 kg·m (144.6 to 180.8 ft·lbs.)

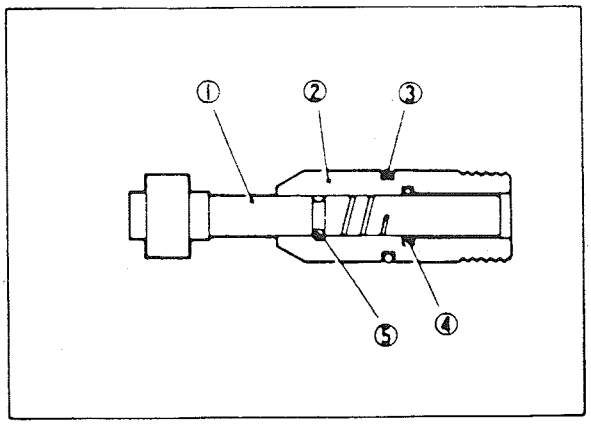
21. Install the rear plate. Be sure to install the gasket.

22. After installing the oil screen, install the oil pan.



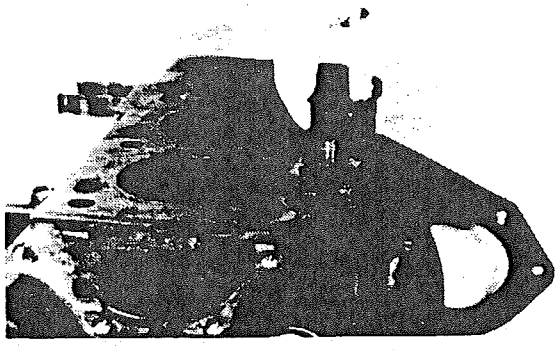
Installing Rear Plate

23. Place the engine upside down. Install the driven unit while turning the camshaft or the speedometer driven gear shaft. Install the O-ring properly. Apply a sealant "Three-Bond No. 2" to the outside surface of the sleeve beforehand. Assemble driven gear unit components in the following manner.
    a. Insert the O-ring properly into the O-ring groove in the driven gear sleeve.
    b. Apply Shell Albania grease #2 to the outside surface of driven gear shaft (specially to the O-ring area), and then insert the shaft into the sleeve.
    c. Keep the gear shaft and sleeve in position with a spring pin. The spring pin groove must be directed outward in relation to the shaft center. The pin end must not protrude out of the sleeve outside surface.
    d. Install the O-ring in the O-ring groove in the outside surface of the sleeve. After assembling, check to see if the gear shaft rotates smoothly.
24. Apply oil to the outside surface of tappet, and then insert the tappet into the cylinder block. Insert the push rod properly into the tappet hole. Check to see if the tappet lightly moves.
25. Install the cylinder head assembly. (Refer to "Reassembly of Cylinder Head".)



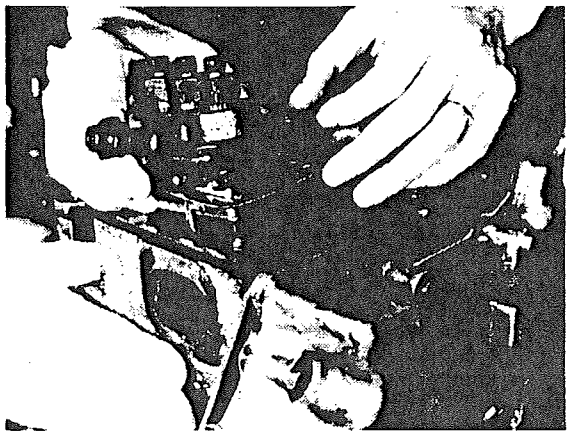
(1) Driven gear shaft
(2) Sleeve
(3) O-ring (big)
(4) O-ring (small)
(5) Spring pin

Driven Gear Unit Assembly



Inserting Tappet

26. Install the injection pump assembly. (Refer to FUEL SYSTEM.)
27. Install the oil pump and oil filter. (Refer to LUBRICATION SYSTEM.) When the oil pressure switch has not yet been installed, apply a sealant to its threaded portion and install the switch.
28. Install the fuel filter.
29. Install the water pump and cooling fan.
30. Install the starter and alternator. (Refer to ELECTRICAL SYSTEM.)



Installing Injection Pump

SECTION 2. LUBRICATION SYSTEM

1. Construction

The lubrication system is a full-force type using a trochoid gear pump fitted with a full-flow oil filter. The oil pump is driven through the Oldham's coupling at the rear end of the fuel injection pump camshaft. The oil from the oil pump flows into the cartridge type oil filter via the check valve. After being filtered by this filter, the oil passes through the oil hole in the cylinder block, being delivered to each part of the engine.

1. Engine Oil

a. Engine Oil

Use a heavy-duty (HD) engine oil of API Classification CC or better quality. Change the oil after the first 50 hours of operation and thereafter change every 100 hours of operation. Recommended oil viscosity is as shown at right bottom.

b. Changing Engine Oil

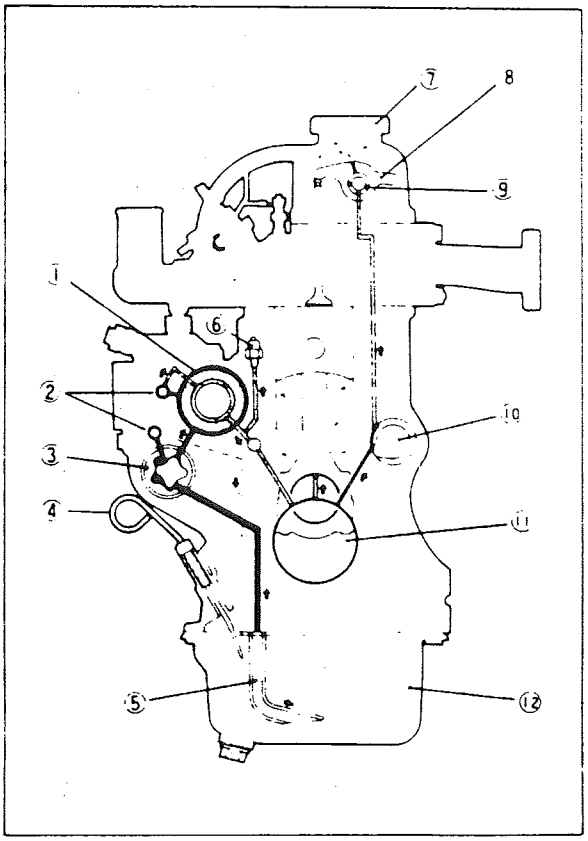
To change the engine oil, first warm up the engine and remove the oil pan bottom drain plug to let oil drain. Tighten the plug and put in new oil at the oil filler port located in the top of the rocker cover.

c. Checking and Refilling Engine Oil

Check the oil pan oil level. Refill up to the upper mark on the oil level gauge.

CAUTION:

- **When the oil has been added, wait for about one minute and check the oil level again by the level gauge.**



(1) Oil filter
(2) Check valve
(3) Oil pump
(4) Oil level gauge
(5) Oil screen
(6) Oil pressure switch
(7) Oil filler cap
(8) Rocker arm
(9) Rocker shaft
(10) Camshaft
(11) Crankshaft
(12) Oil pan

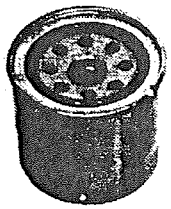
Lubricating System

Description		Recommended oil viscosity
Atmospheric temperature	Above 20°C (68°F)	SAE30 or 10W–30
	5 to 20°C (41 to 68°F)	SAE20 or 10W–30
	Below 5°C (41°F)	SAE10W–30

2. Oil Filter

The oil filter is of the cartridge type. The filter body is formed integral with the filter element to insure easy handling.

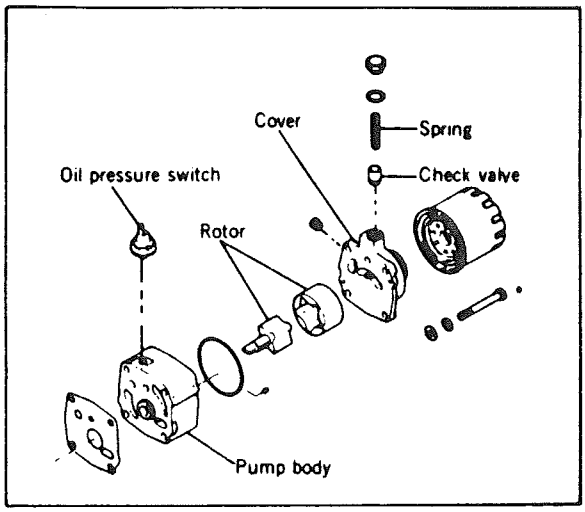
The oil from the oil pump is led into the filter element. When a pressure difference between before and after the element exceeds 1 kg/cm^2 (14.22 psi) due to excessive clogging of the element, the check valve in the element will open to allow the passage of the oil through the valve to each part of the engine. In this case, as the oil is not filtered, it is important to change the oil regularly. This oil filter does not require cleaning of the interior, but must be replaced after the first 50 hours of operation and thereafter every 100 hours of operation.



Oil Filter

3. Oil Pump

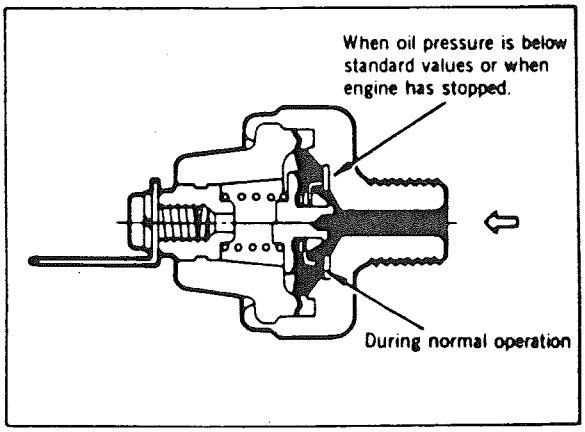
The oil pump is a trochoid gear type and is mounted at rear of the fuel injection pump on the right-hand side of the cylinder block. The oil pump houses a check valve, which, when the delivery pressure exceeds standard values, will open to let the oil flow into the oil pan, thus preventing oil pressure rise.



Disassembly of Oil Pump

4. Oil Pressure Switch

The oil pressure switch is located at the oil pump body. If the oil pressure decreases below standard values during normal operation, the switch operates to light up the lamp, giving a warning to the operator. When the light has been lit, stop the engine immediately and check for a cause of the trouble.



Oil Pressure Switch

Description		Standard value
Oil pump check valve opening pressure		4.0kg/cm^2 (56.9psi)
Oil pressure swich ON hydraulic pressure	(Mark : P25)	0.3–0.115 kg/cm^2 ($4.27^{0}_{-2.13}$psi)
	(Mark : P05)	0.5±0.1 kg/cm^2 (7.11±1.42psi)

2. Servicing

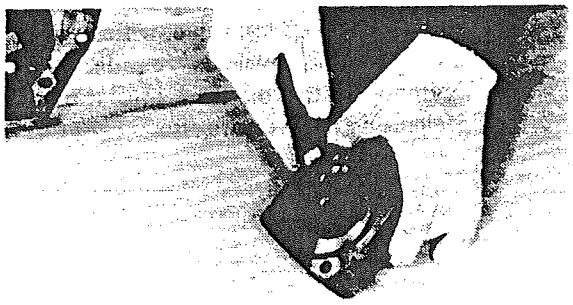
2-1 Disassembly

1. Oil Filter
   a. If the oil filter is stuck too hard to remove by hand, remove using a filter wrench (commercially obtainable).
2. Oil Pump
   a. Remove the oil filter.
   b. Remove the pump cover assembly, body, and gasket.

2-2 Inspection

1. Oil Pump
   a. Outer Rotor to Body Clearance

      Using a feeler gauge, check an outer rotor to body clearance. If excessive, replace the rotor assembly.

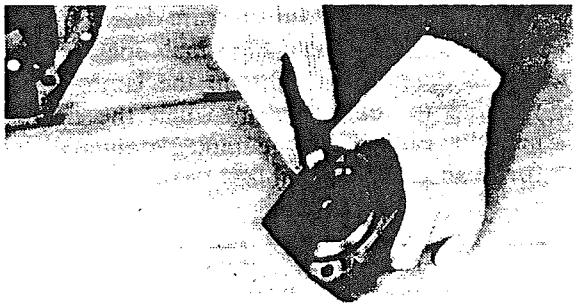


Checking Outer Rotor to Body Clearance

   b. Rotor Clearance

      Check an outer rotor to inner rotor clearance using the feeler gauge. If excessive, replace the rotor assembly.

      Check the Oldham's coupling of the inner rotor shaft for cracks and damage.



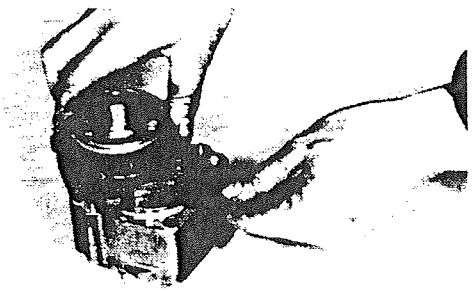
Checking Outer Rotor to Inner Rotor Clearance

c. Rotor to Cover Clearance

With the outer rotor inserted in the filter body, measure the clearance between the rotor and the straight edge using the feeler gauge. In case of excessive clearance, replace either the rotor or the body.

d. Pump Body O-ring

Check pump body O-ring for cracks and damage.

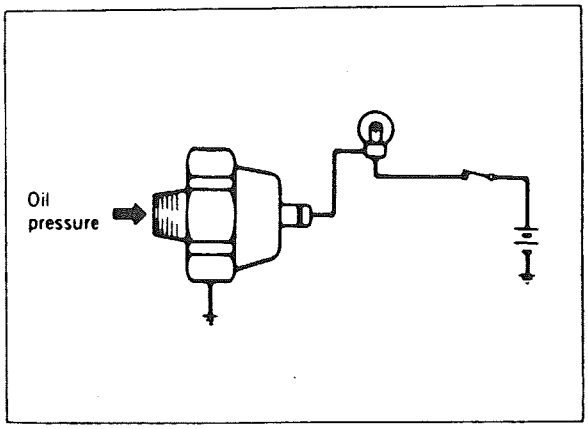


Checking Rotor to Cover Clearance

Description	Standard value	Service limit
Outer rotor to body clearance	0.15 to 0.2 mm (0.0059 to 0.0079 in.)	0.3 mm (0.0118 in.)
Outer rotor to inner rotor clearance	0.05 to 0.12 mm (0.0020 to 0.0047 in.)	0.25 mm (0.0098 in.)
Rotor to cover clearance	0.03 to 0.07 mm (0.0012 to 0.0028 in.)	0.20 mm (0.0079 in.)

2. Oil Pressure Switch

Check the oil pressure switch as illustrated. If the switch is defective, replace.



Checking Oil Pressure Switch

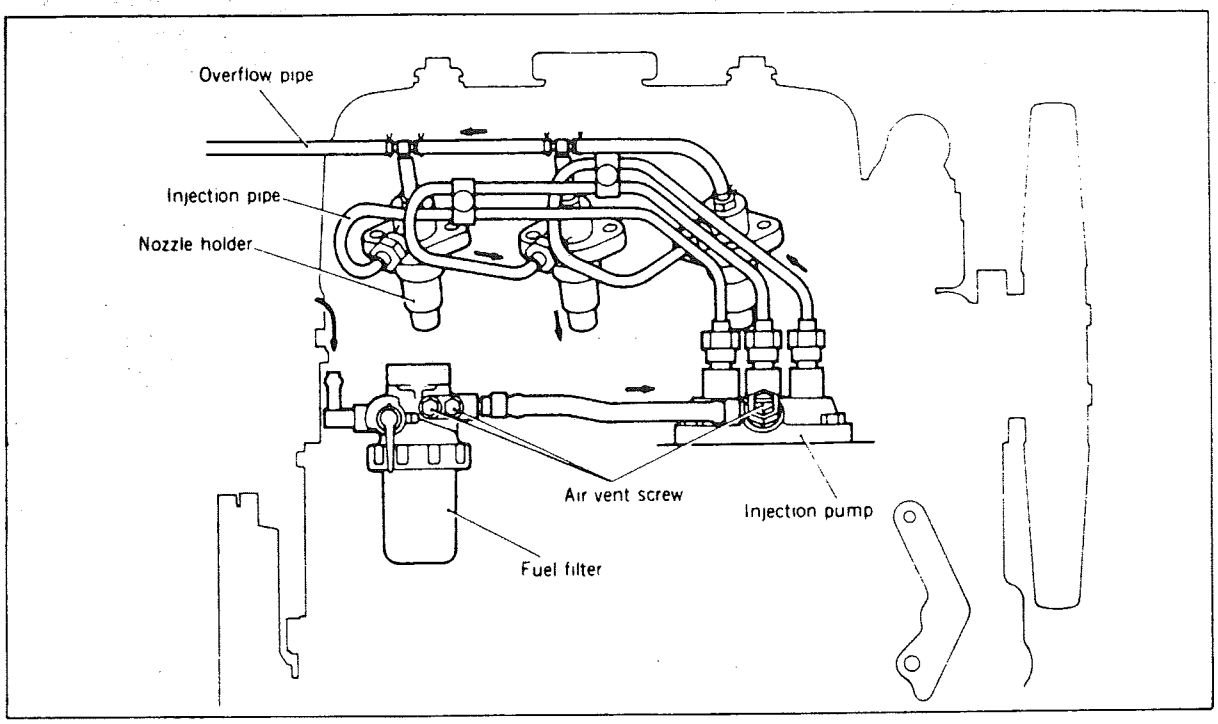
2-3 Reassembly

1. Oil Filter
   a. Install the filter and tighten fully by hand. (Reference: Tightening torque 1.1 to 1.3 kg-m (8.0 to 9.4 ft.lbs.). When installing, check to see if the O-ring is properly fitted in the O-ring groove. Apply a small amount of oil to the O-ring.
   b. Crank the engine and check for oil leaks.
2. Oil Pump

   Install the gasket. Install the pump body, O-ring, rotor assembly, and cover assembly in order of mention. Apply oil to rotating parts.
3. Oil Pressure Switch

   When installing the switch apply sealant to the threaded portion, and tighten so carefully that the oil hole will not be closed with the sealant.

1. Construction



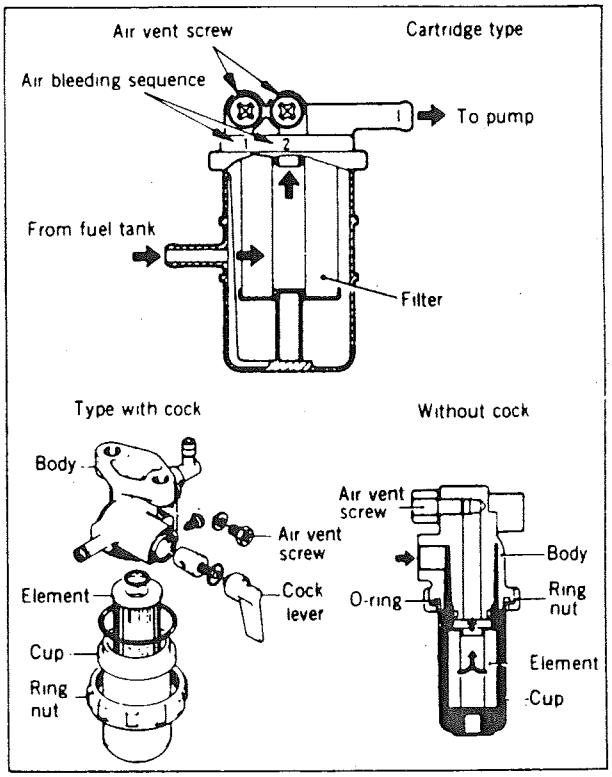
Fuel System

The fuel from the fuel tank is fed, after being filtered by the fuel filter, to the injection pump, where the fuel is pressurized by each plunger. Then the fuel thus pressurized is injected into the combustion chamber through the injection pipes and nozzles. The excess fuel is returned to the fuel tank through the fuel overflow pipe which is connected to the top of each nozzle holder.

1. Fuel Filter

The fuel filter employed is different with engine models and comes in two types: cartridge type and type with cock.

Both types of filters incorporate the filter paper type elements with high filtering efficiency and are provided with two each of air vent screws at their tops.



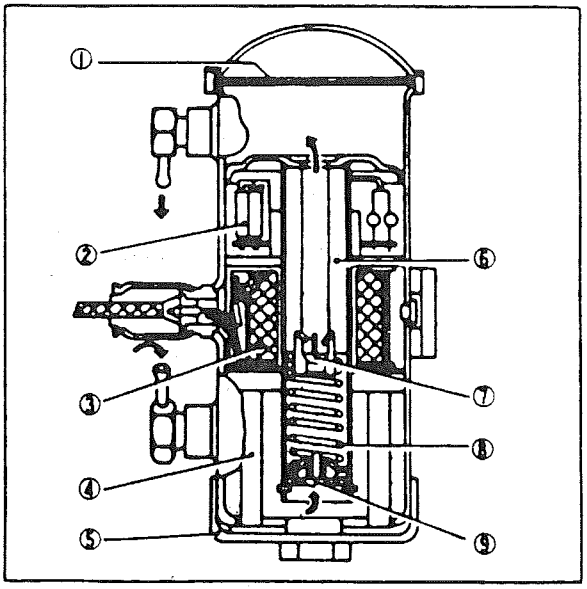
Fuel Filter

2. Fuel Pump (Option)

The electromagnetic type (transistor type) fuel pump performs the pumping function through the reciprocating motion of a plunger controlled by a transistor circuit.
The oscillator section contains a transistor, diode, resistor, etc.

When the transistor is driven to the ON state and the electromagnetic coil energized, an attractive force acts on the plunger and forces the plunger down against the spring. The fuel pushes the delivery valve up and flows into the plunger. When the transistor is forced to the OFF state, the plunger pushes the fuel out of the delivery port. At the same time, the suction valve opens and the fuel flows into the chamber under the plunger.

This fuel pump is provided as an option in engines other than those in which fuel is fed under its own weight.



(1) Diaphragm
(2) Oscillator section
(3) Electromagnetic coil
(4) Filter
(5) Filter cover
(6) Plunger
(7) Delivery valve
(8) Spring
(9) Suction valve

Fuel Pump

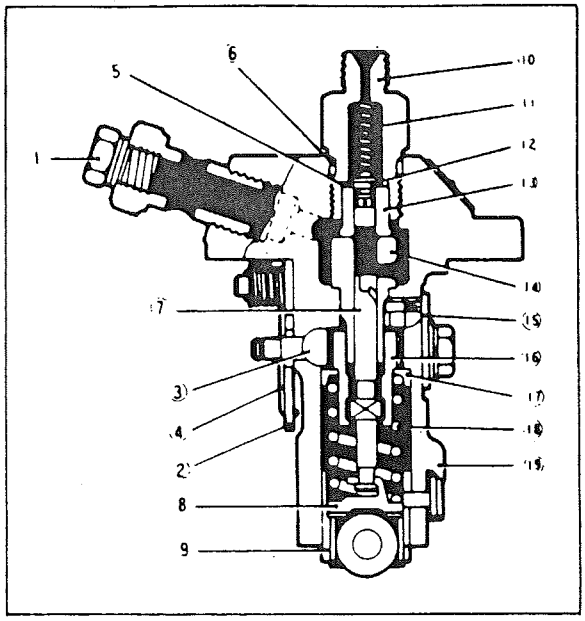
3. Fuel Injection Pump

A built-in type three-cylinder injection pump is mounted on the right-hand side of the cylinder block. It consists of a pump element (plunger assembly), a delivery valve, a tappet, and a smoke set unit. As the pump cam rotates, the plunger is moved up and down through a prescribed stroke, delivering fuel to engine cylinders. In some engines, depending on specifications, a fuel injection pump with a key operated stop system consisting of a control timer and solenoid interlocked with the pump is provided. (Refer to the wiring diagram in Electrical System section)

a. Fuel Injection Control

The fuel injection rate is controlled by changing the relative positions of the plunger lead and barrel. The plunger is rotated by the control pinion which is mounted on the plunger barrel. This pinion is in mesh with the plunger lower collar to directly turn the plunger.

As the engine turns, the injection pump camshaft rotates to move the control rack through the centrifugal type governor weight, governor sleeve, and lever. The control rack slides to turn this pinion. Rightward movement (STOP → mark) of the control rack decreases the fuel injection rate and leftward movement does the reverse.



(1) Air vent screw
(2) Stopper
(3) Control rack
(4) Return spring
(5) Gasket
(6) O-ring
(7) Plunger
(8) Lower seat
(9) Tappet
(10) Valve holder
(11) Spring
(12) Delivery valve
(13) Valve seat
(14) Plunger barrel
(15) Adjusting plate
(16) Control pinion
(17) Upper seat
(18) Plunger spring
(19) Pump housing

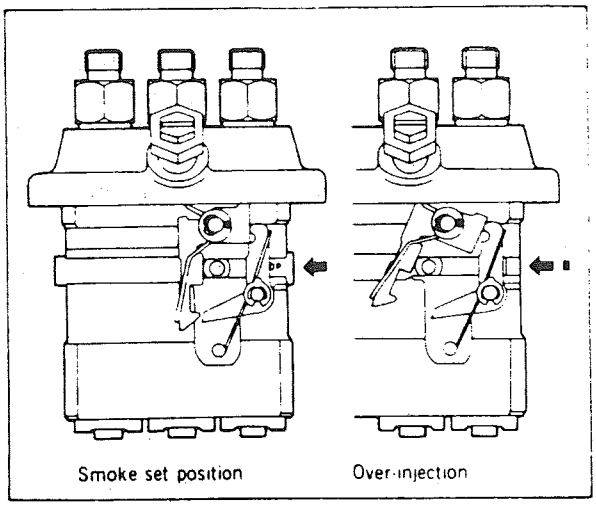
Fuel Injection Pump

b. Smoke Set Unit and Over-Injection

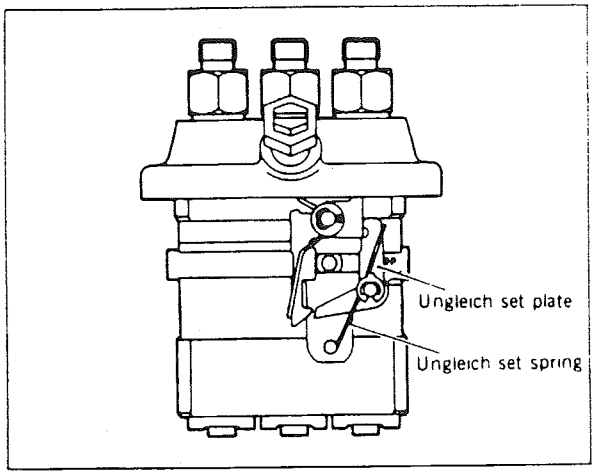
The smoke set unit restricts the maximum fuel injection rate from the injection pump and reduces the amount of exhaust smoke. The stopper is held by a spring in the illustrated position. This position is the smoke set position. When starting the engine, pull the speed control lever fully toward the maximum speed, and the tie rod (with the stopper spring) moves the control rack, which overcomes the spring force and moves in the direction of the arrow, thus allowing over-injection for easy engine starting. On engines with an ungleich device described under the following item c, however, the operations described under item d are required.

c. Ungleich Device

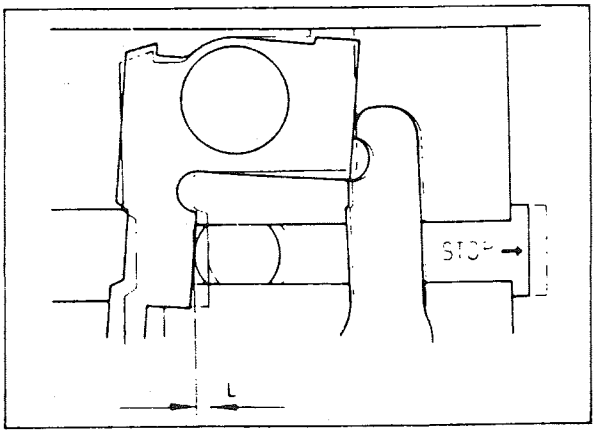
When an overload is imposed on the engine during operation, the engine speed falls and the function of the governor moves the speed control rack in the direction that fuel injection is increased against the smoke set spring to provide larger torque. To ensure an optimum increase of the injection during operation, the ungleich set plate which controls the motion of the smoke set stopper is provided. This injection increase characteristic (ungleich effect "L") provides proper torque performance suitable for the work machine between the maximum output point and maximum torque point.



Smoke Set Unit



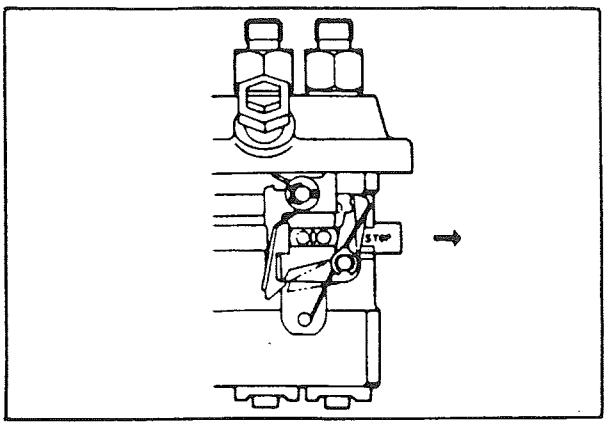
Ungleich Device



Ungleich Effect "L"

d. Resetting Ungleich Device and Starting Engine

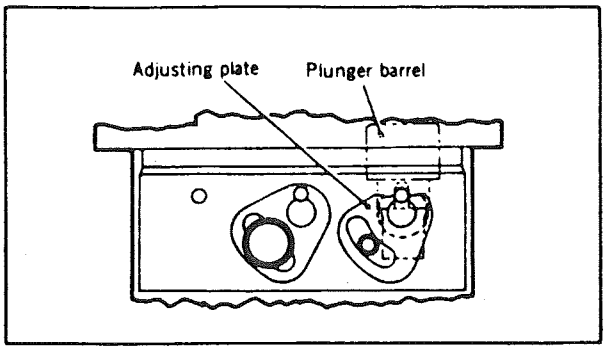
To start the engine, push the speed control lever in all the way in the stop direction and then move it to the fully opened position, and the ungleich set plate will be reset and an excessive injection state created.



Resetting Ungleich Device

e. Inter-cylinder Injection Control

Fuel injection control among three cylinders is performed by the adjusting plates (in two places) having a cam mechanism. These adjusting plates are located on the opposite side of the control rack and as these plates are turned, the plunger barrel is also turned, thus controlling the fuel injection.

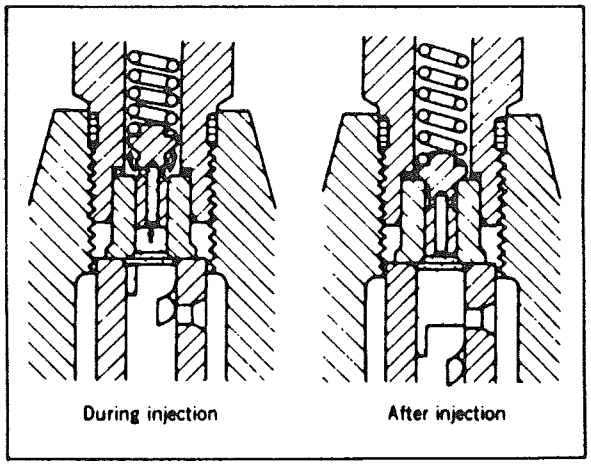


Adjustment of Injection Among Cylinders

f. Delivery Valve Operation

The delivery valve functions to deliver the fuel to the injection pipe after the fuel pressure has increased sufficiently high and also to prevent "after-drip" from the nozzle.

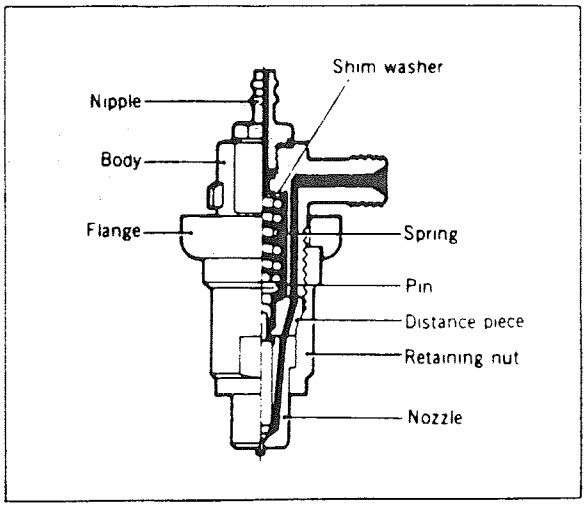
When the fuel pressure above the plunger has decreased after injection, the delivery valve closes the valve seat. At this time the compressed fuel remaining in the injection pipe drips from the nozzle. To prevent this "after-drip", the delivery valve bottom piston makes a stroke to draw back the fuel before the delivery valve reaches the seat, reducing the fuel pressure in the injection pipe to nearly zero. A standard type delivery valve is a Silt type while a special-specification delivery valve for use in a high-speed range is a Bosch type (having a flower petal type notch).



Operation of Delivery Valve

4. Nozzle and Nozzle Holder

The fuel from the fuel injection pump flows in the passageway in the nozzle holder body and is injected from the nozzle into the combustion chamber. Fuel overflowing from the nozzle flows in the nozzle holder, returning to the fuel tank via the upper nipple and overflow pipe.



Sectional View of Nozzle Holder

2. Servicing

2-1 Disassembly

CAUTION:

- **For the adjustment of pump delivery, a pump tester is needed. Where the pump tester is not available, do not remove the adjusting plate for fixing the plunger barrel.**
- **When disassembling the pump nozzle, put a small amount of clean gas oil in a vessel (vat or the like) and put disassembled parts in it to prevent rusting of these parts.**

1. Fuel Filter

Remove the retaining nut, then remove the O-ring and element. (In type with fuel cock only)

2. Fuel Pump

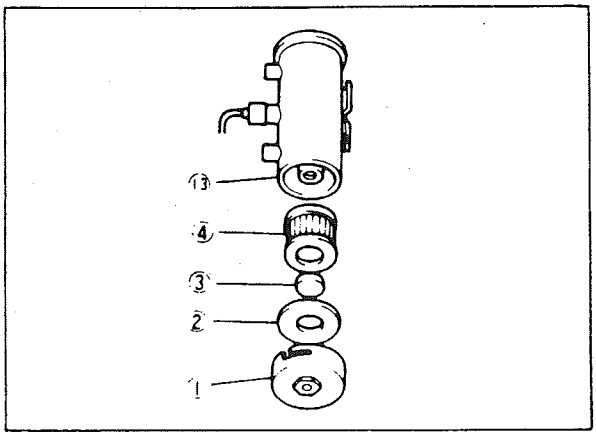
This transistor type fuel pump is a totally enclosed type.

No checks and adjustments are required except the cleaning of the cover, filter and plunger assembly.

a. Using a spanner 17 mm in side to side spacing, remove the cover (1) as shown in illustration at right. After the cover has been removed, the cover gasket (2), magnet (3) and filter (4) can be removed from the pump body.

Clean the filter in a cleaning oil (gas oil) and then blow away dust and the cleaning oil with compressed air. (A badly contaminated filter should be replaced.)

Check the cover gasket and replace if broken. Thoroughly clean the magnet and cover.



(1) Cover
(2) Cover gasket
(3) Magnet
(4) Filter
(13) Body

Removal of Filter

b. To remove the plunger, first remove the spring retainer (6) from the plunger tube (12).

Then remove the washer (7), O-ring seal (8), valve (9), plunger spring (10) and plunger (11) from inside the tube. Wash the above-mentioned parts in a cleaning oil and remove deposits with compressed air.

CAUTION:

- **In the above process, use care to make sure that the inside diameter of the tube is not deformed, as the tube (12) is very thin.**
- **Carefully handle the plunger and use care to prevent damage such as pounding.**

3. Fuel Injection Pump

a. Remove the injection pump.

b. With injection pump mounting bolts loosened, remove the pump assembly. Prior to removing the pump, remove the pump side cover and disconnect the tie rod from the rack.

c. Record the thickness and number of pump adjusting shims to facilitate adjustment at the time of reassembly.

d. Partly disassemble the fuel injection pump.

CAUTION:

- **Be sure not to confuse the delivery valve and delivery valve seat and the plunger and plunger barrel of one cylinder with those of another.**

i. Spread the lock plate of the tappet guide pin. Push the tappet slightly in and pull off the guide pin using a pincette. Then remove the tappet.

ii. Remove the plunger spring and upper seat.

iii. Remove the plunger.

iv. Remove the pinion.

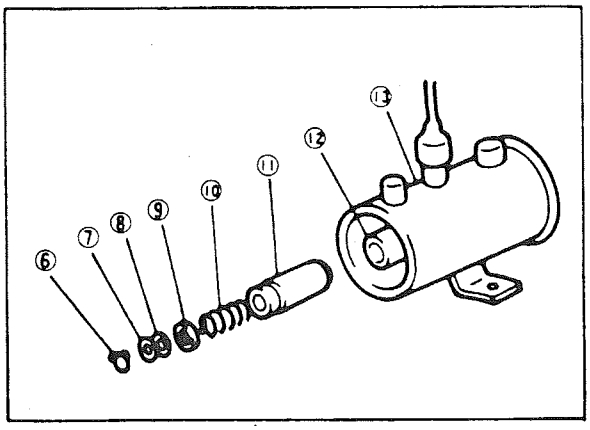
v. Pull out the plunger barrel upward from the pump housing.

vi. Remove the delivery valve holder.

vii. Take out the valve spring, valve, and O-ring.

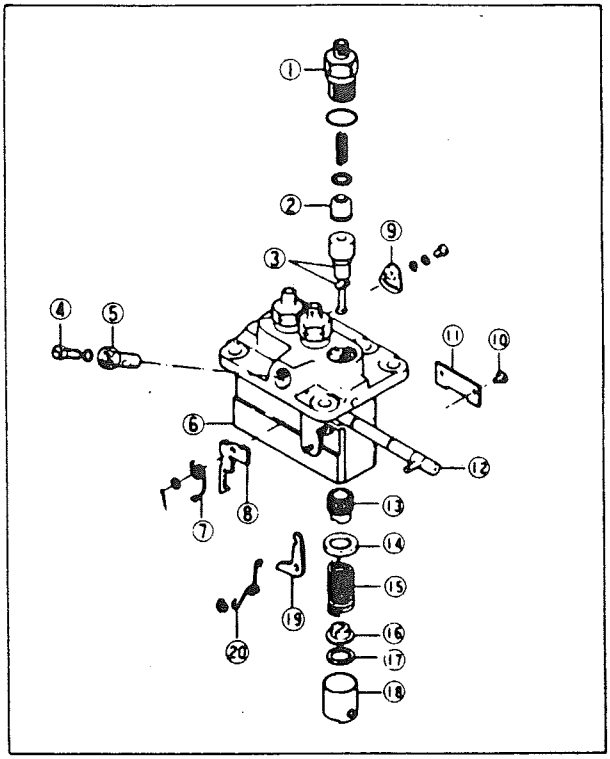
viii. Take out the gasket and valve seat.

ix. Remove the plunger barrels of the other cylinders by the same procedures and remove the control rack as required. In this case, perform (x) beforehand.



(6) Spring retainer
(7) Washer
(8) O-ring
(9) Valve
(10) Plunger spring
(11) Plunger
(12) Plunger tube
(13) Body

Removal of Plunger



(1) Valve holder
(2) Delivery valve
(3) Element
(4) Air vent screw
(5) Hollow screw
(6) Pump housing
(7) Return spring
(8) Stopper
(9) Adjusting plate
(10) Tappet guide pin
(11) Plate
(12) Control rack
(13) Control pinion
(14) Upper seat
(15) Plunger spring
(16) Lower seat
(17) Adjusting shim
(18) Tappet
(19) Ungleich set plate
(20) Ungleich set spring

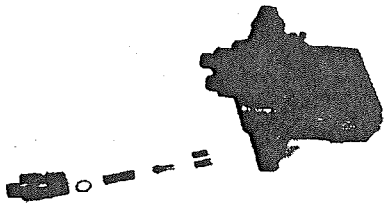
Disassembly of Injection Pump

x. Remove the snap ring of the ungleich set plate and remove the spring and plate as necessary.

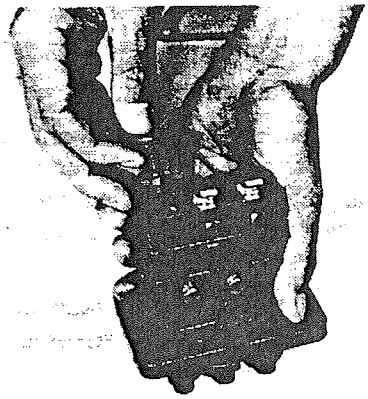
xi. Remove the split pin of the smoke set plate and remove the washer, return spring and smoke set stopper as necessary.

CAUTION:

- **Do not disassemble the inter-cylinder injection control adjusting plate. When this plate has been disassembled, it will become necessary to adjust the inter-cylinder injection by a tester. When this plate requires removal, remember to draw a mating mark across the pump body and plate.**



Removing Delivery Valve



Removing Plunger

4. Nozzle Holder

a. Disconnect the overflow pipe from the nozzle holder upper nipple.

b. Disconnect the fuel injection pipe from the nozzle holder.

c. Loosen nozzle holder attaching bolt, and remove the holder assembly.

d. Partly disassemble the nozzle holder assembly in the following manner.

i. Holding the retaining nut in a vice, remove the nozzle holder body using a spanner. When holding in the vice, be sure to use an aluminum or copper plate adapter.

ii. Remove the shim, pressure spring, flange, pressure pin, and distance piece.

iii. Take out the nozzle from the retainer nut. If the nozzle is hard to remove, remove it lightly tapping with a wooden block. Be careful not to impair the nozzle needle valve.

Disassembling Nozzle Holder

2-2 Inspection

1. Fuel Filter

   Check the element for clogging and dirtiness. Replace if it is seriously damaged.

2. Fuel Pump

   a. Filter and Valve

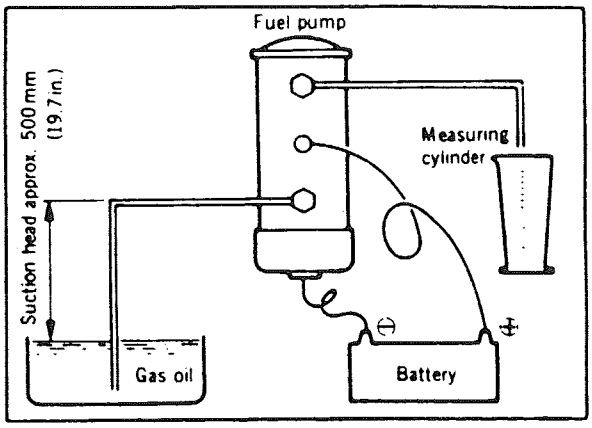
   Check the filter for clogging and contamination and check the valve plunger and spring for damage and contamination. Wash them in a clean gas oil.

   b. Inspection of Fuel Pump Operation

   Set the ignition switch to ON and check to ensure that the operating sound of the pump can be heard. If no operating sound is heard, connect 12V voltage directly to the fuel pump to check for operating sound. If no operating sound is still heard, replace the fuel pump assembly. If operating sound is heard, check the fuse, connector connections, electrical wiring, etc.

   c. Inspection of Fuel Pump Delivery

   Test the delivery of the pump by the procedures shown in illustration and check to ensure that the delivery of the pump has the standard value shown in the table at right.



Inspection of Delivery

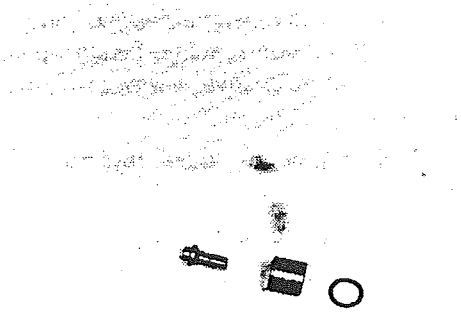
Description	Standard value
Delivery of fuel pump (15 sec.)	225 cc (13.73 cu.in.) min.

3. Fuel Injection Pump

   a. Delivery Valve Seat

   i. Check the contact surface of the delivery valve seat. Replace if defective.

   ii. Make sure that oil-tightness of the delivery valve meets specifications in the table on next page.



Delivery Valve

b. Plunger Barrel

i. Check the plunger for seizure, damage, and rust. Also check to see if the plunger slides smoothly when inserted into the barrel. If defective, do not repair it for reusing, but be sure to replace as a set with a new one.

ii. Make sure that oil-tightness of the plunger meets specifications in the table at right.

c. Control Rack and Pinion

If the rack and pinion have any worn or damaged teeth, replace.

d. Tappet

Check the tappet O.D., roller, and shaft for wear and damage. If defective, replace.

4. Nozzle

a. Check the nozzle for incorrect contact and damage. Replace the nozzle as an assembly if defective.

b. Check the pressure spring for damage.

2-3 Reassembly

1. Fuel Filter

a. Install the element and filter cup O-rings properly in position. Tighten the retaining nut securely. (only in the cock type)

b. Install the filter assembly to the support.

2. Fuel Pump

a. To reassemble, set the plunger, plunger spring, valve, O-ring and washer in position in that order, and as a final step, fit the retainer to prevent the above-mentioned parts from popping out of position. (See illustration in section on disassembly.)

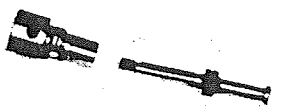
b. Put the filter in position and fit the magnet and gasket in the cover. Using a spanner 17 mm in side to side spacing, fasten up to the stopper portion in such a way as to prevent air leakage.

3. Partial Reassembly of Fuel Injection Pump Assembly

a. Install the smoke set stopper, control rack, and ungleich set plate if necessary.

b. Insert the plunger barrel with the adjusting plate dowel pins projecting in the pump housing aligned with the slots on the peripheral surface of the barrel.

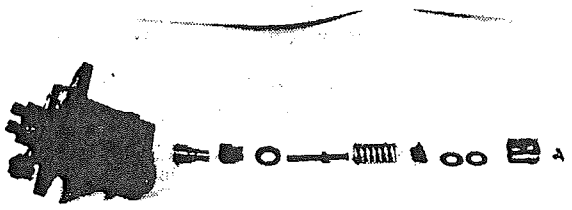
c. Install the O-ring to the valve holder.



Pump Element (Plunger Assembly)

Description	Standard value	Remarks
Oil tightness of delivery valve	5 sec. min.	Apply 150 kg/cm² (2,133 psi) oil pressure and check to ensure that no oil pressure drop occurs within period specified at left.
Oil tightness of plunger	6 sec. min.	Apply 300 kg/cm² (4,266 psi) oil pressure and check to ensure that period within which oil pressure falls from 200 kg/cm² (2,844 psi) to 100 kg/cm² (1,422 psi) is as specified at left.

* Special tester is required for above test.



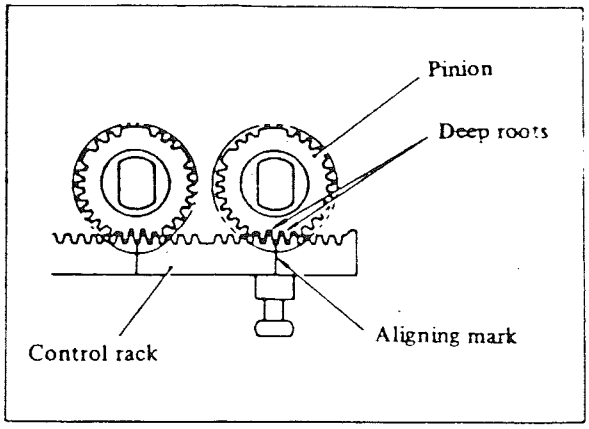
Reassembling Injection Pump

d. Install the spring seat gasket, and valve assembly to the holder, then tighten it to the pump housing. In this case, make certain the O-ring has been properly installed.

e. Install the pinion with its deep-root tooth aligned with an aligning mark on the rack.

f. Install the spring upper seat and spring.

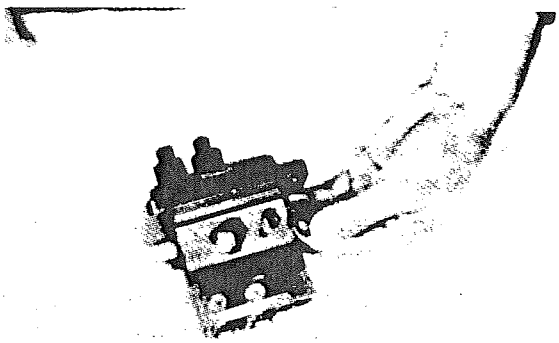
g. Assemble the spring lower seat to the plunger. Insert the mark "L" area of the plunger collar into the control rack side.



Assembling Rack and Pinion

h. Insert the tappet, using care not to drop the shim. Align the tappet guide hole with the dowel pin hole of the housing to insert the tappet guide pin. Before inserting the tappet guide pin, install the lock plate and insert the guide pin. Lock the pin by bending the plate.

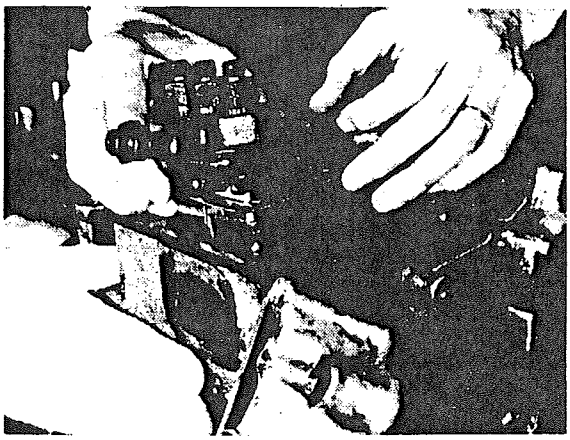
i. For other cylinders, use the same procedures as above for reassembly.



Assembling Tappet

4. Installation and Adjustment of Fuel Injection Pump

   a. When installing the pump assembly, select and install the adjusting shim. After installing the pump, tightly fit the tie rod connected with the governor lever and the tie rod spring to the control rack. There are nine types (thicknesses) of shims in 0.1 mm (0.0039 in.) increments from 0.2 mm (0.0079 in.) to 1.0 mm (0.039 in.).

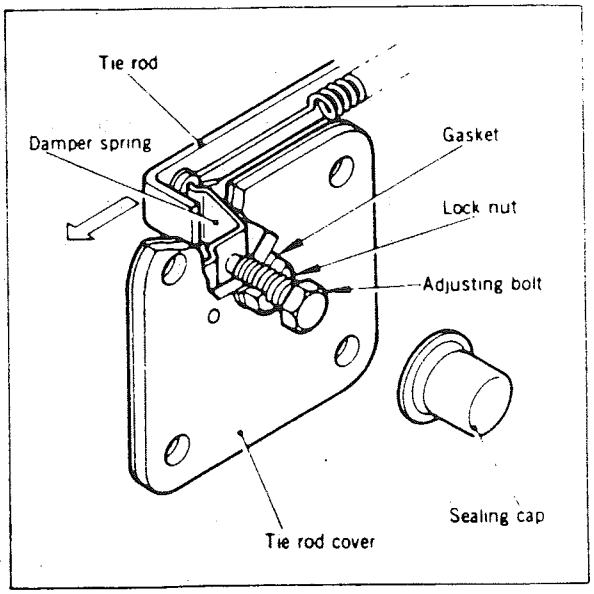


Installing Pump Assembly

b. After confirming the injection timing, install the tie-rod cover. In case of a damper spring-loaded cover of special specification, install the cover with the tie rod pressed toward High Speed side by the speed control lever as shown. For the adjustment of the damper spring, refer to "Adjustment" on page 13.

c. Connect the fuel feed hose. Loosen the injection pump air vent screw to remove the air.

d. Confirm the injection timing. For the adjustment of the injection timing, refer to "Adjustment" on page 12.



Installing Tie Rod Cover

5. Partial Reassembly of Nozzle and Nozzle Holder Assembly

a. Install the nozzle assembly, distance piece, and pressure pin to the retaining nut.

b. Install the shim, spring, and flange to the body, then tighten the retaining nut to the specified torque.

Description	Standard value
Nozzle holder body retaining nut tightening torque	6 to 8 kg·m (43.4 to 57.8 ft·lbs.)

CAUTION:

- **When using a vice to tighten the nut, be sure to hold the body side. Should the retaining nut be held, a deformed nozzle would result.**

c. Tighten the nipple gasket and nipple.

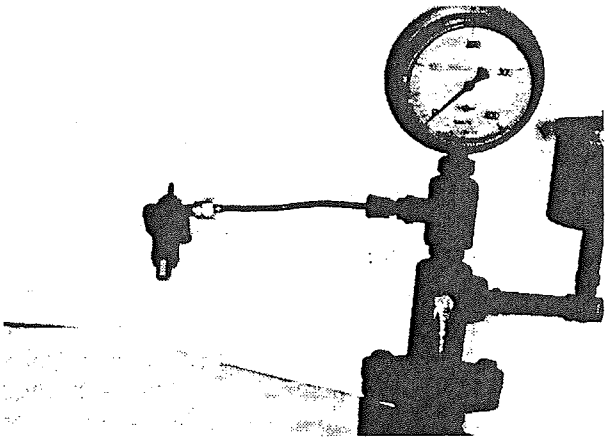
6. Installation and Adjustment of Nozzle Holder Assembly

a. Install the nozzle holder assembly to the cylinder head, then tighten bolts to the specified torque. Replace the nozzle holder gasket with a new one.

b. Injection Start Pressure Test

i. Using a nozzle tester, measure the injection start pressure. If the pressure is different from the standard value, adjust to the specified pressure by increasing or reducing the thickness of the adjusting shim.

ii. Increasing or reducing the thickness by 0.1 mm will vary the pressure by approximately 10 kg/cm² (142.25 psi).
When replacing the shim, hold the retaining nut in vice and remove the body with a spanner. Tighten the retaining nut to the specified torque.



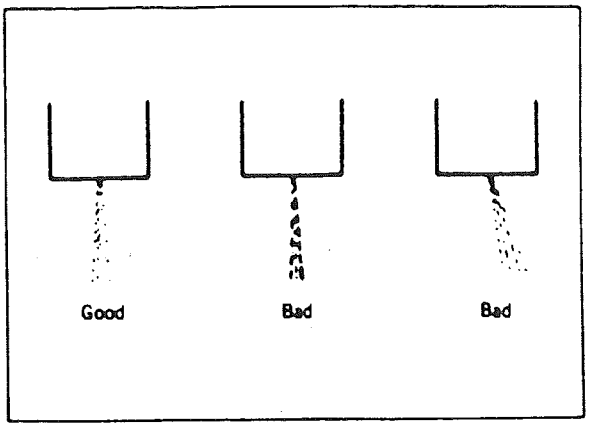
Injection Start Pressure Test

Description	Standard value	Repair limit
Nozzle injection start pressure	120 kg/cm² (1706.97 psi)	$120\ ^{+10}_{-0}$ kg/cm² ($1706.97\ ^{+142.25}_{-0}$ psi)

c. Injection Test

For the chattering test, operate the lever of the tester slowly. If the nozzle makes a spasm of injection, then the nozzle is good.

In this case, the nozzle should inject fuel straight in its axial direction. If it injects fuel in a wrong direction or injects fuel in several separate strips, it is defective. A spray in the form of particles is also defective.



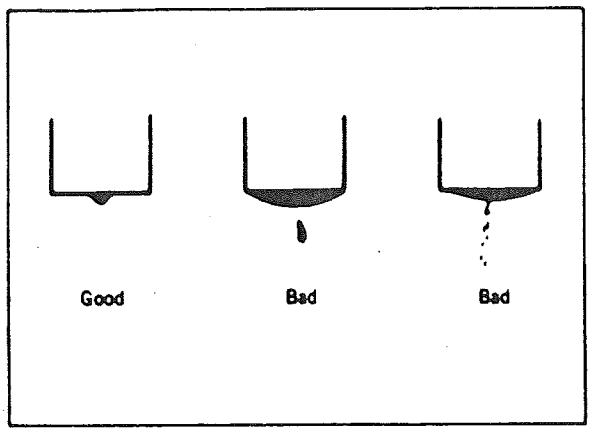
Chattering Test

d. After-injection Drip Test

If, after an injection in the chattering test, fuel is collected at the bottom surface of the nozzle and drips down, the nozzle is defective. Replace the nozzle. A very small amount of fuel will sometimes retain on the tip of the nozzle. This is due to chattering, and is not a sort of faulty nozzle.

e. Injecting Condition Test

Operate the tester lever quickly (at a rate of 800 strokes per minute). The nozzle should inject a fine atomized mist of fuel straight in its axial direction. A spray in the form of particles is cause for rejection.



After-injection Drip Test

SECTION 4. GOVERNOR SYSTEM

1. Construction

Operation of the governor maintains the engine speed constant as the centrifugal force acting on the governor weights, according to the engine speed, balances with the tension of the governor spring.

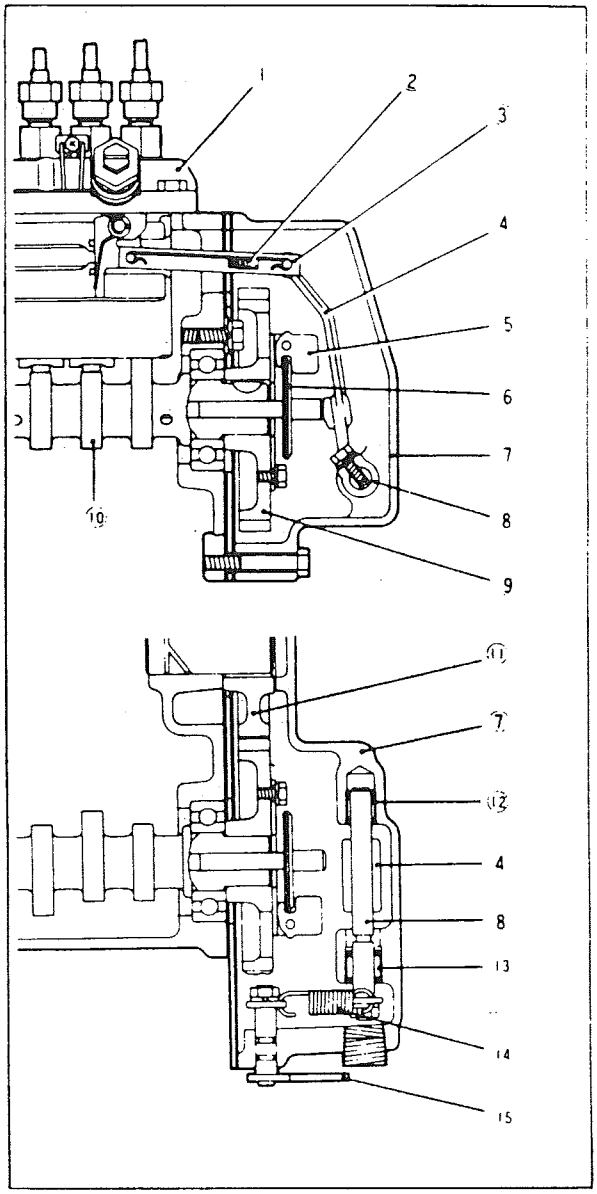
If the engine speed increases, the governor weights will open, forcing the sliding shaft forward to move via the governor lever the control rack of the injection pump in the direction that less fuel is injected. At the same time, the speed is maintained constant by the governor lever at a point where it achieves balance with the tension of the governor spring.

In engines of special specifications, a damper spring is installed to the tie rod cover to prevent the engine from stalling due to decreased fuel injection caused by sudden deceleration, etc. Additionally, provided on the tie-rod cover of some engines is lever for manually stopping the engine.

2. Servicing

2-1 Disassembly

1. Remove the fan belt. (Refer to COOLING SYSTEM).
2. Remove the crankshaft pulley nut, and then remove the pulley.
3. Remove the fuel injection pump. (Refer to "Fuel Injection Pump" on page 45.)
4. Remove gear case mounting bolts, then remove the gear case. (See CAUTION in "Removal" of cylinder block gear case on page 24.)
5. Remove the governor spring.
6. Remove the nut, washer, and lever C. Remove the speed control lever from the gear case.
7. Remove the nut, washer, and spring lever, then remove the governor lever set bolt. Remove the governor lever.
8. Remove the governor weight assembly and the sliding shaft from the pump camshaft.
9. Remove the tie rod and spring from the governor lever.



(1) Injection pump
(2) Stopper spring
(3) Tie rod
(4) Governor lever
(5) Governor weight
(6) Sliding shaft
(7) Gear case
(8) Governor shaft
(9) Pump gear
(10) Pump camshaft
(11) Idle gear
(12) Needle bearing
(13) Needle bearing
(14) Governor spring
(15) Speed control lever

Governor System

2-2 Inspection

1. Governor Assembly
   a. Check the governor weights for wear and damage. Replace if they are badly worn or damaged.
   b. Check the operating part of the sliding shaft for damage. Also check to see if the shaft operates smoothly. Replace if defective.
2. Governor Lever

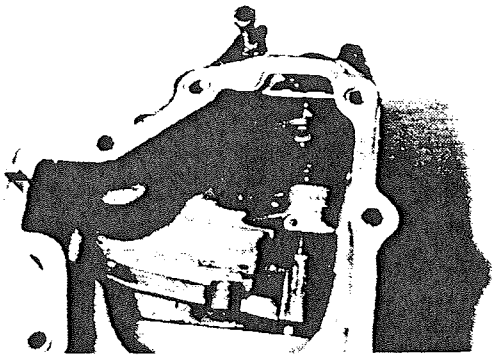
   Check the sliding shaft contact area of the governor lever, and tie rod and spring connecting the governor lever to the control rack; replace if defective.
3. Governor Spring

   Check the spring for deterioration and breakage. Replace if defective.
4. Needle Bearing

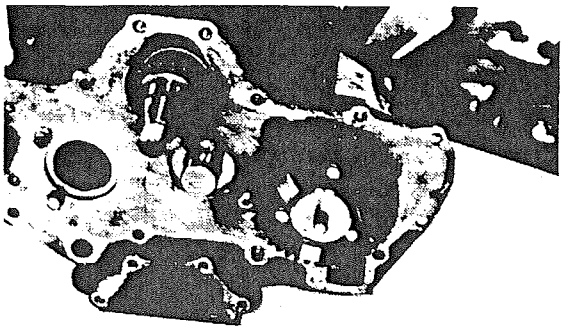
   Check the needle bearing supporting the governor lever shaft in the gear case for damage.

2-3 Reassembly

Reassembly is just the reverse of disassembly. After reassembly, confirm the operation.



Governor Lever Section



Governor Weight Assembly and Sliding Shaft

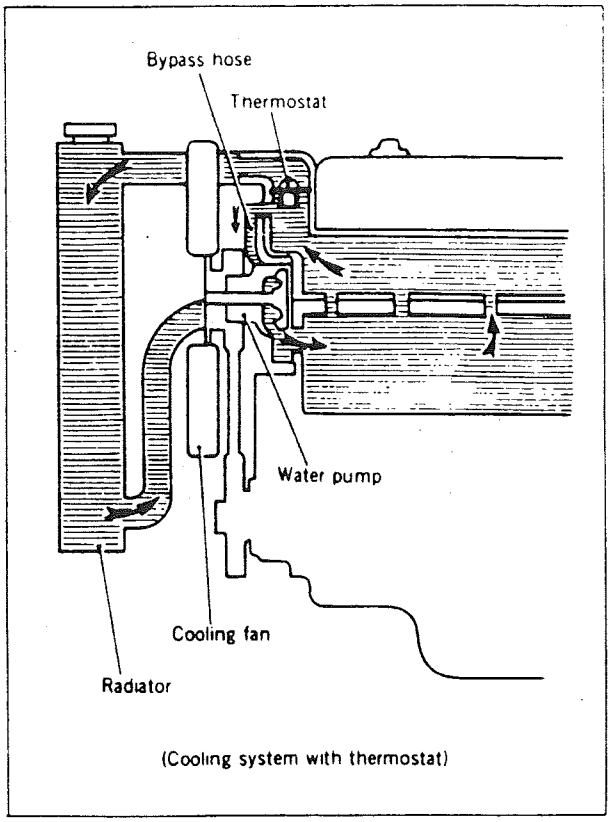
1. Construction

1. Water Pump

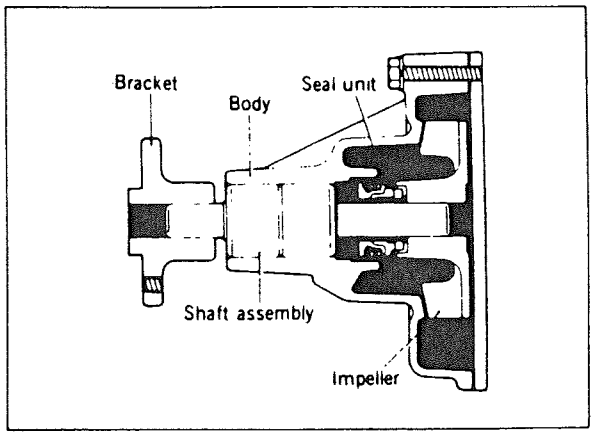
The water pump is a centrifugal impeller type and is mounted on the front upper part of the cylinder block. The pump shaft is supported on maintenance-free (grease-filled) double-row radial ball bearings.

2. Thermostat

A thermostat fitting is provided at the water outlet of the cylinder head, and a wax type thermostat mounted to the fitting. When the standard temperature is reached, the thermostat is operated and the valve opens. To uniformalize the temperature rise before operation of the thermostat, a bypass hose for circulation of the cooling water is provided between the thermostat fitting and water pump.



Cooling System



Sectional View of Water Pump

3. Thermoswitch

The thermoswitch is installed in the right front of the cylinder head. The switch operates when the cooling water temperature exceeds the standard temperature and at the same time a warning lamp is lit to give a warning to the operator. When the lamp is lit, check the cooling system.

4. Replacing Coolant

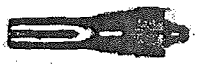
Over a long period of service, scale will be deposited and rust formation will occur in the water jacket and radiator, causing considerable deterioration in cooling efficiency. For this reason, flush the cooling system once or twice a year.

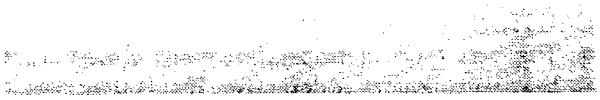
5. Antirust and Antifreeze

Add a well-known brand of antifreeze and antirust to the cooling water for protection of the cooling system.

CAUTION:

- **When adding an antifreeze and antirust, be sure to observe the mixing ratios shown on the containers.**





Thermoswitch

Description	Standard value
Thermoswitch closing (warning lamp lighting) temperature	111°C (232°F)
	108°C (226°F)

2. Servicing

2-1 Disassembly

1. Drain the cooling water. (The drain plug is located on the left-hand side of the cylinder block.)
2. Disconnect the water hoses.
3. Remove the fan belt.
4. Remove the cooling fan.
5. Disconnect a water bypass hose.
6. Remove the water pump assembly.

2-2 Inspection

1. Water Pump
   a. Check each part for cracks, damage and water leaks. Replace if defective.
   b. Check the rotating conditions of the impeller and shaft. If they produce noise or rotate defectively, replace.
   c. Check the fan for cracks and breakage. Replace if defective.

2. Fan Belt

Check the fan belt for elongation and cracks caused by deterioration. Replace if it is defective.

3. Thermostat

Check the thermostat for breakage. After this check, put it in water and raise water temperature to test its valve opening temperature. Replace if it is defective.

Description	Standard value
Thermostat valve opening temperature	
Valve opening temperature	82 ± 1.5°C (180 ± 2.7°F)
Wide-opening temperature	95°C (203°F)

CAUTION:

- **The wax-type thermostat remains closed if its heat-sensing part is defective. If this thermostat is left uncorrected, engine overheating will result.**

4. Water Bypass Hose

Check the bypass hose of the aforementioned specification for breakage and deterioration.

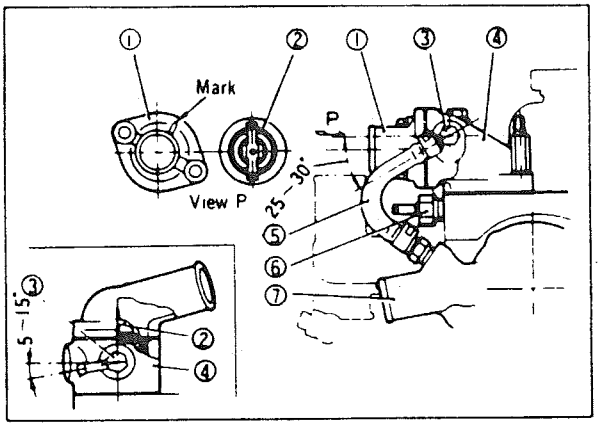
2-3 Reassembly

Reassembly is just the reverse of disassembly. For installation of thermostat and adjustment of fan belt, proceed as follows.

2-3-1 Installation of Thermostat

Securely install the thermostat fitting by two bolts, then install the thermostat in position. Install the water outlet fitting and its gasket with the arrow mark facing up. (The fitting, if installed in a wrong direction, will interfere with the thermostat, resulting in a broken thermostat.)

When installing a bypass nipple to the thermostat fitting, apply Three-Bond #4 to the nipple and screw it in.



(1) Water outlet fitting
(2) Thermostat
(3) Nipple
(4) Thermostat fitting
(5) Water bypass hose
(6) Thermoswitch
(7) Water pump

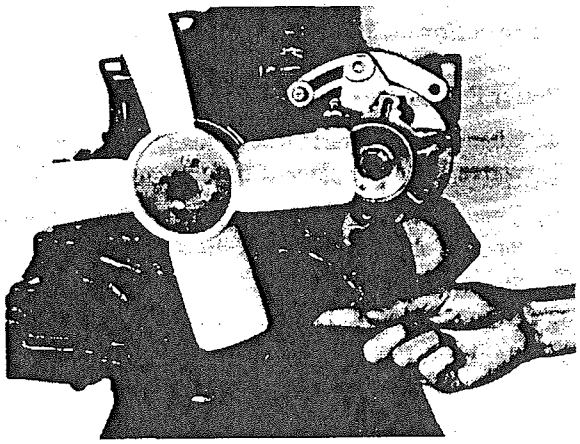
Installing Thermostat

2-3-2 Fan Belt Adjustment

Adjust the fan belt tension by moving the alternator so the belt may deflect 10 to 12 mm (0.39 to 0.47 in.) deep when depressed at a point midway between the alternator and crankshaft pulleys. After this adjustment, securely tighten the support bolt and brace bolt.

CAUTION:

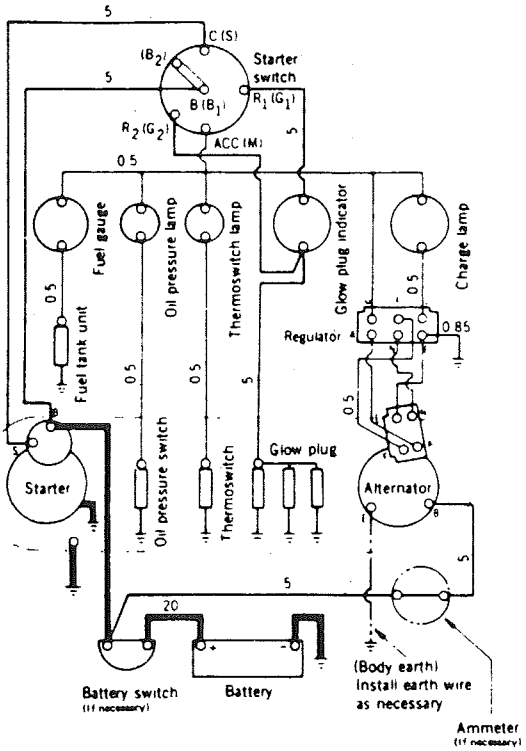
- **Check the installed conditions of the water bypass hose to see if the hose is interfering with the cooling fan.**



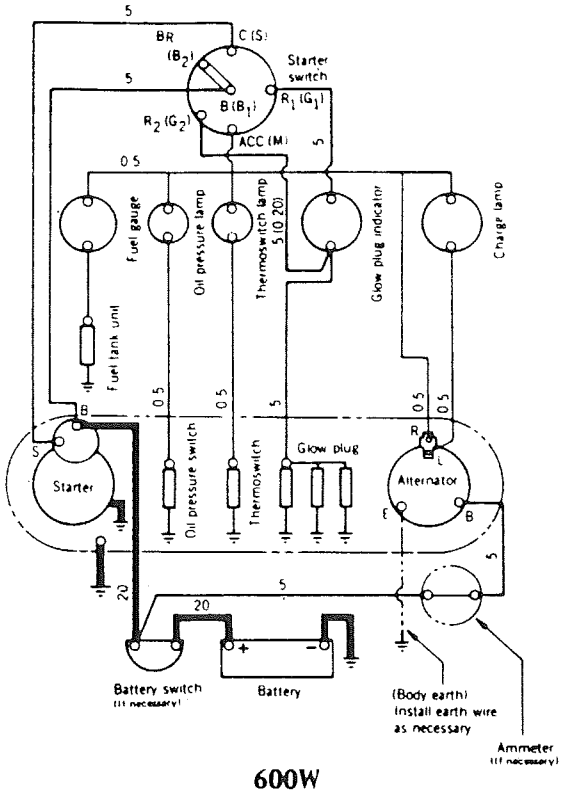
Adjusting Fan Belt Tension

1. Construction

1-1 Wiring Diagram



180W, 420W



600W

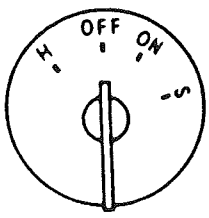
The numerals in the diagram indicate sectional areas of conductors. 1 mm^2=0.00155 in^2

The wiring of the standard 12-volt electrical system is arranged as illustrated at right. The system differs with engine models. When installing the wiring, carefully handle it and install in accordance with the wiring diagram on the working machine side. Numerals in parentheses in the wiring diagram at right are "nominal sizes" specified by JIS C3406 Low-voltage Electrical Wiring for Automobiles.

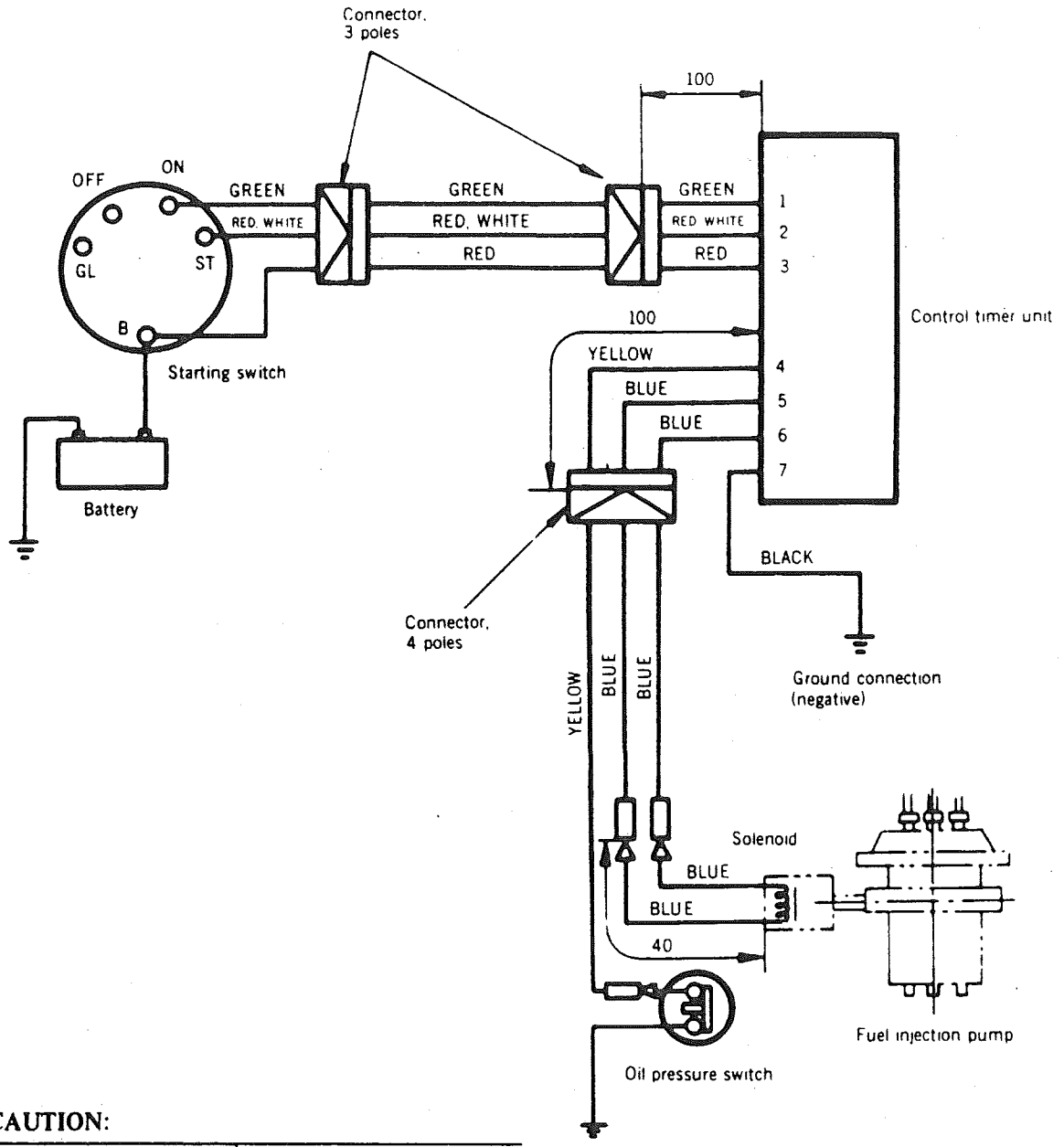
Starting switch connection

Terminal / Key position	B / B_a	R_1	R_2	C	ACC
	B_1 / B_a	G_1	G_2	S	M
H	O	O			
OFF	O				
ON	O				O
S	O		O	O	(O)

Note: (o) is only for M



1-2. Wiring Diagram of Electric Shut-off System (option)



CAUTION:

Description	Control timer unit and oil pressure switch
Ambient temperature	−30 to 80°C (−22 to 176°F)
Acceleration of VIB	10G (at 3,000 rpm)

1-2 Starter

The starter consists of the following sections:

a. A motor section which generates a drive power.

b. An overrunning clutch section which transmits an armature torque, preventing engine overrun after starting.

c. A switch section which is operated when actuating the overrunning clutch through a lever and which supplies a load current to the motor.

The starter used in this engine is a new type of small, light-weight starter called a high-speed internal-reduction starter. Its differences in construction from conventional starters are as follows.

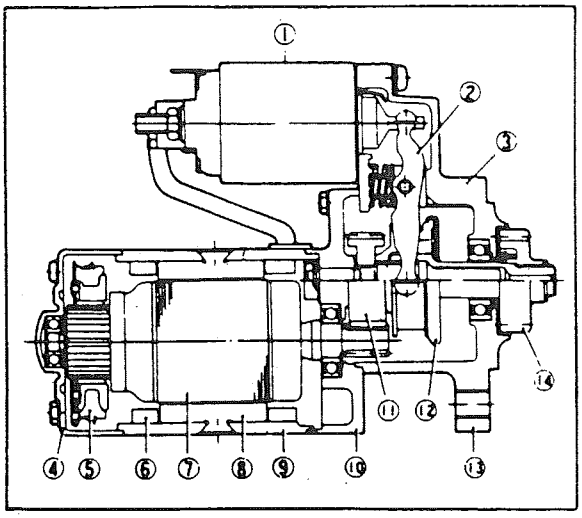
a. In conventional starters, the pinion slides on the motor shaft (armature shaft). In the new type of starter, however, the pinion shaft is separate from the motor shaft; the pinion slides only on the pinion shaft.

b. A reduction gear is installed between the motor shaft and a pinion shaft.

c. The pinion sliding part is not exposed out of the starter so the pinion may slide smoothly without being stuck hard with dust and grease.

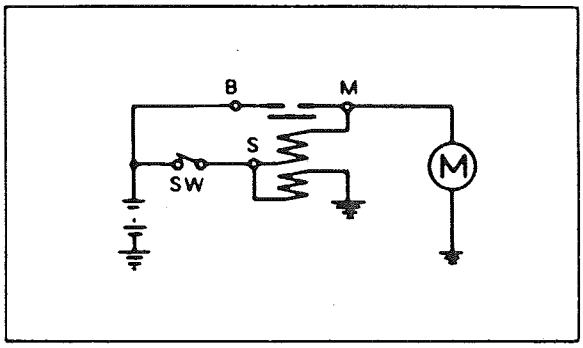
d. The motor shaft is supported at both ends on ball bearings. The lever mechanism, switch, and overrunning clutch inner circuit are identical to conventional ones.

e. The starter wiring is as shown.

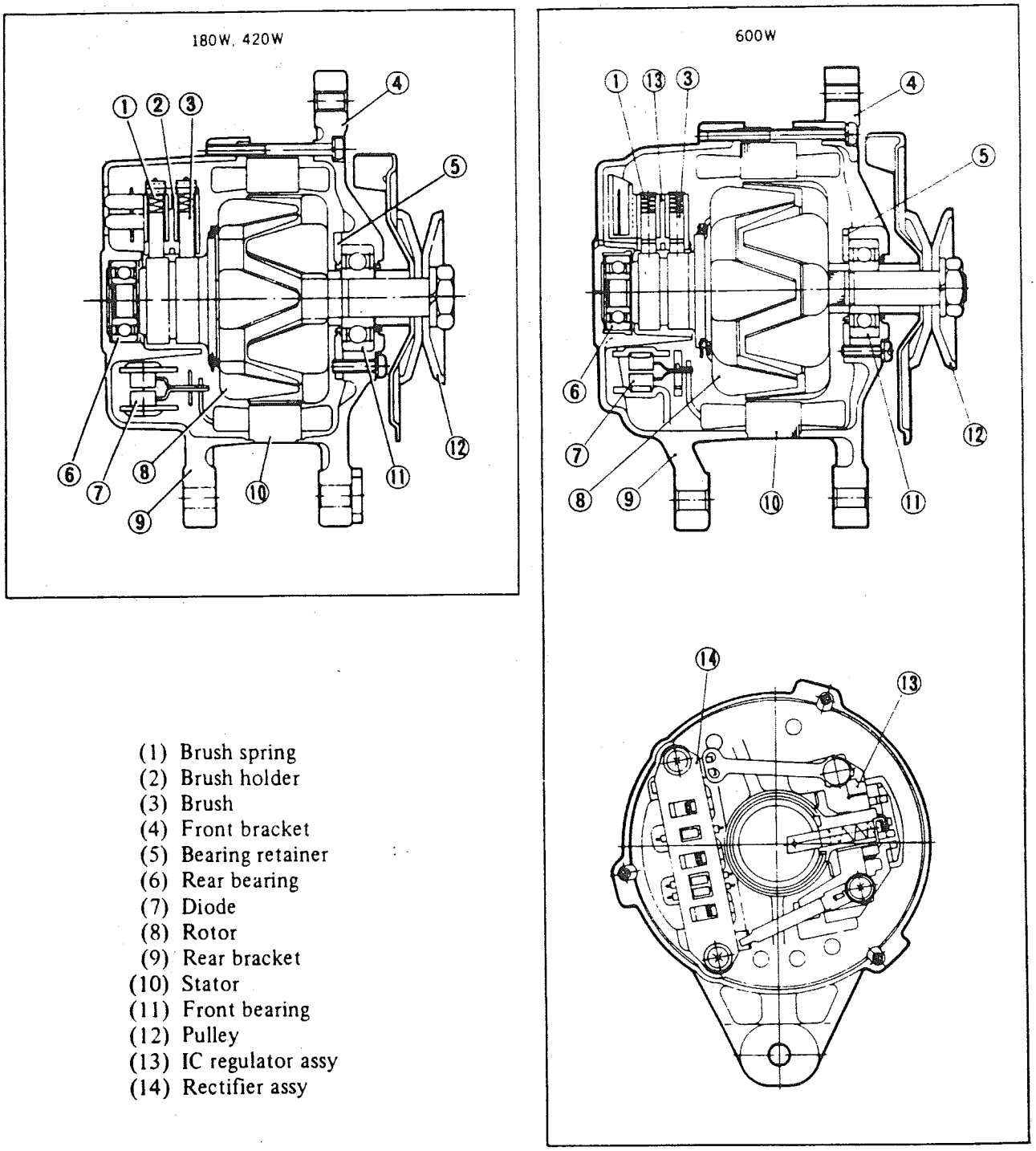


(1) Magnetic switch
(2) Shift lever
(3) Front bracket
(4) Rear bracket
(5) Brush
(6) Field coil
(7) Armature
(8) Pole piece
(9) Yoke
(10) Center bracket
(11) Gear
(12) Clutch
(13) Front bracket
(14) Pinion gear

Sectional View of Starter



Starter Wiring Diagram



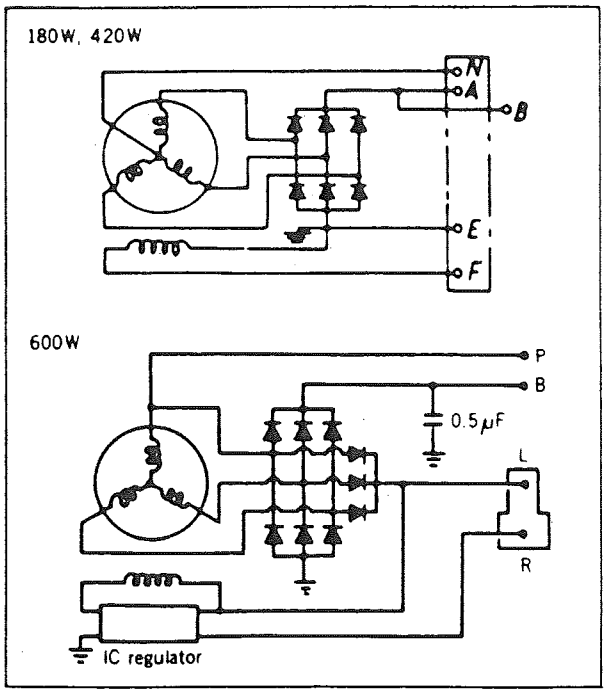
(1) Brush spring
(2) Brush holder
(3) Brush
(4) Front bracket
(5) Bearing retainer
(6) Rear bearing
(7) Diode
(8) Rotor
(9) Rear bracket
(10) Stator
(11) Front bearing
(12) Pulley
(13) IC regulator assy
(14) Rectifier assy

Sectional View of Alternator

The alternator is a three-phase AC generator with a diode rectifier and is driven by the crankshaft through a pulley and a V-belt.

It can be roughly divided into rotor and stator sections. The rotor section consists of a rotor, ball bearings, and pulley with a fan, while the stator section consists of an armature, front and rear brackets, fin complete, and brushes. Three diodes (+) and three diodes (−) are fixed on the fin complete (heat sink).

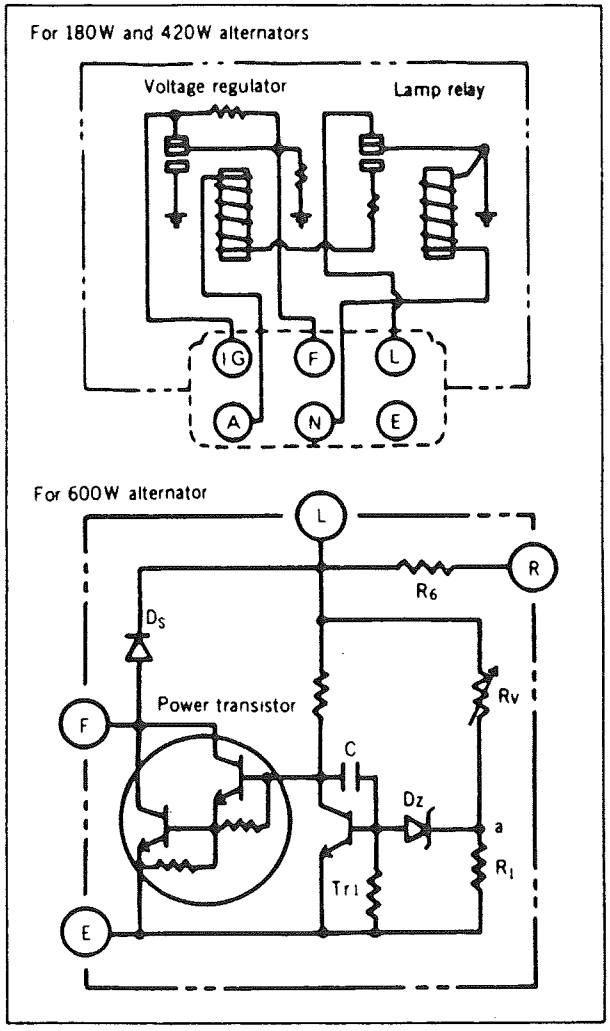
A 600W alternator has an I.C. regulator and three diodes (diode trio) for direct supply of field current. The 600W alternator, therefore, does not require a wire harness between the alternator and regulator. During operation current directly flows from the diode trio to the field coil, so no voltage drop due to the key switch or wiring occurs. The terminals are not four poles (A, E, F and N) but two poles (L and R). In addition, a terminal P is provided for detection of the engine speed.



Alternator Wiring Diagram

1-4 Regulator

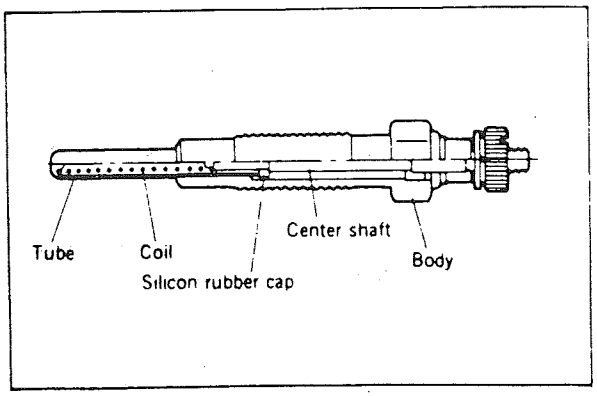
The regulator consists of a voltage regulator and a lamp relay; their wires are centralized in a connector. The voltage regulator is used to always maintain the alternator output constant regardless of the alternator speed of revolution and to cut off the flow of current to the field coil when necessary. The lamp relay is used to turn off the pilot lamp by utilizing the neutral point voltage (N terminal voltage) of the alternator; the lamp remains off while the alternator is producing the current.



Regulator Wiring Diagram

1-5 Glow Plug and Glow Plug Indicator

The glow plug employed is a sheathed type; its construction is as illustrated. The glow plug indicator lamp is lit when the glow plug glows red hot.



Sectional View of Glow Plug

1-6 Engine Stop System Using the Key Switch

This system uses a solenoid switch which acts, when the engine starting switch key is turned to OFF, on the fuel injection pump control rack to push it to the "non-injection" position to stop the engine. If necessary, the engine may be stopped by means of the manual stopping lever provided on the damp spring cover by the side of fuel injection pump. (See the figures on pages 12 for the location of the lever.)

1. Combinations of switch positions
   (refer to page 58 of Wiring diagram)

State of engine	Key switch	Oil pressure switch	Electro-magnetic solenoid	Fuel injection pump control rack	Function
Start	ON	ON	ON	STOP	MS resetting
	START	OFF	off	MS	Automatic increase of fuel injection quantity for engine start
Running	ON	OFF	OFF	(SS)	Normal operation
	ON	ON	ON	STOP	Emergency stop caused by an lowering of oil pressure
	OFF	OFF	ON	STOP	Stopping the engine with key switch turned to OFF

2. Function

(1) When starting the engine, turning the key switch to ON will close a circuit through which current flows to the oil pressure switch. This will cause transistors Tr5 and Tr4 to become conductive, thus allowing current to flow from terminal B of the key switch to transistors Tr3, Tr2 and Tr1. As the solenoid is excited, the control rack of fuel injection pump is placed in the MS reset position ..... MS resetting

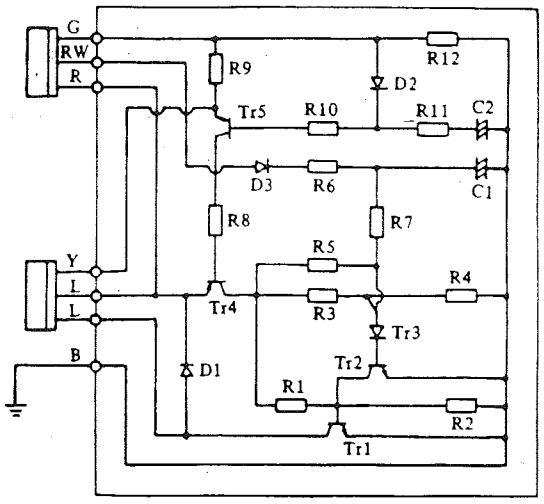
(2) When the engine starting key switch is turned to START, a short-circuit current will flow to the condenser C1 from ST terminal of the switch. Since the timer function is accelerated, the action of the solenoid will be terminated instantaneously and the fuel injection pump control rack will be set to the MS position automatically ..... Automatic increase of fuel injection quantity for engine start

(3) After the engine starts, increase of oil pressure will turn the oil pressure switch to OFF, thus opening the oil pressure switch circuit. Transistors Tr5 and Tr4 will become non-conductive (no current flows from the key switch terminal B to the transistors Tr3, Tr2 and Tr1), thus preventing the solenoid from acting ..... Normal engine operation

(4) When the key switch is turned to OFF, discharge current of the condenser C2 which has been charged during engine operation will make the transistors Tr5 and Tr4 conductive. Resulting current flow from terminal B of the key switch to the transistors Tr3, Tr2 and Tr1 will excite the solenoid to stop the engine ..... Stopping the engine with key switch turned to OFF

(5) If oil pressure lowers excessively during engine operation, the oil pressure switch will be turned on to close a circuit through which current flows from terminal B of the key switch to the transistors Tr3, Tr2 and Tr1. As the result, the solenoid will be excited to stop the engine ..... Emergency stop caused by an excessive lowering of oil pressure

(6) After the engine stops, all transistors are kept in non-conductive condition and no current flows in the timer circuit.



Reference:

Tr1 - Tr4	Transistors
D1 - D3	Diodes
C1 - C2	Condensers
R1 - R12	Resistors

Control Timer Circuit Diagram

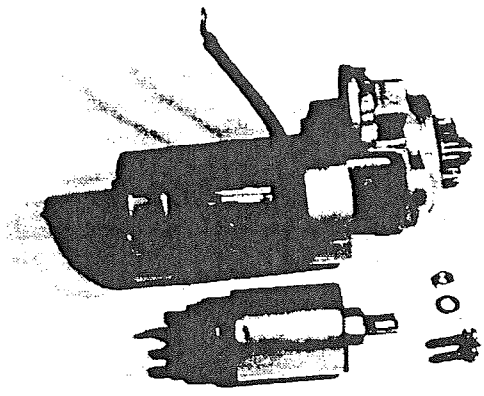
2. Servicing

CAUTION:

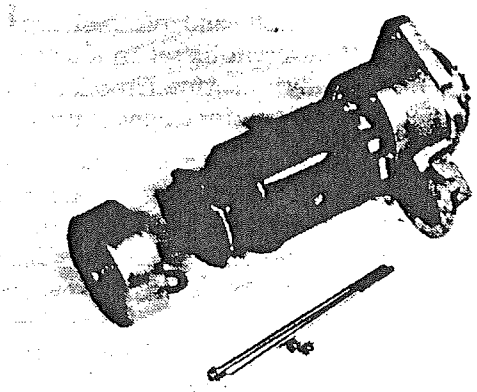
- **On electrical parts, water or high heat must be strictly avoided. If water is allowed to enter the starter and alternator when cleaned, a rusted brush or spring could cause faulty operation.**

2-1 Disassembly

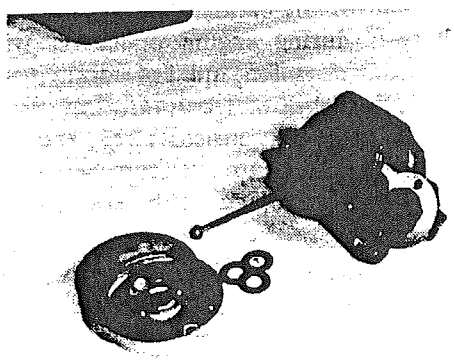
1. Starter
   a. Disconnect battery cables from battery terminals.
   b. Disconnect wiring from B and S terminals.
   c. Remove attaching nuts, then remove the starter.
2. Alternator
   a. Loosen the alternator brace bolts, then remove the belt.
   b. Remove alternator support bolts.



Removing Magnetic Switch



Removing Brush Assembly



Removing Center Bracket

2-2 Inspection and Servicing

2.2.1 Starter

CAUTION:

- **Hard engine starting is not necessarily caused by a starter trouble. A cause of trouble will sometimes exist in other part, for example in the starter switch or engine. In the event of hard starting, check the starter circuit with the starter left on the engine. If no abnormality has been found with the circuit, remove the starter from the engine and test it.**

(1) Starter Circuit

- Charged condition of battery
- Tightened condition of battery terminals
- Tightened condition of starter termianls
- Condition of wiring (Grounded or broken)
- Grounded condition of starter

(2) No-load Test

Connect the starter with the battery as illustrated and close the switch to turn the starter.

The starter must turn lightly at the current and speed shown at the right when the battery voltage is 11.5V.

If any abnormality has been found, make the following inspections.

(3) Brushes and Brush Holders

a. Check brushes. If the brushes are worn over the service limit, replace. (See "Service Standards.")

b. With the brush holders assembled to the commutator, check brush spring tension. If the spring tension has decreased over the service limit, replace.

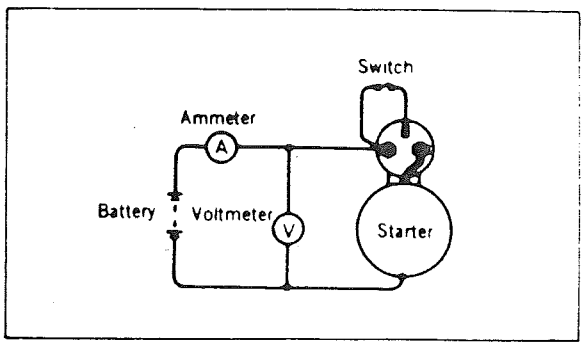
c. Check continuity between the positive brush holder and the brush holder base. In case of continuity, replace the holder assembly.

d. Check the brush holder caulk.

(4) Armature

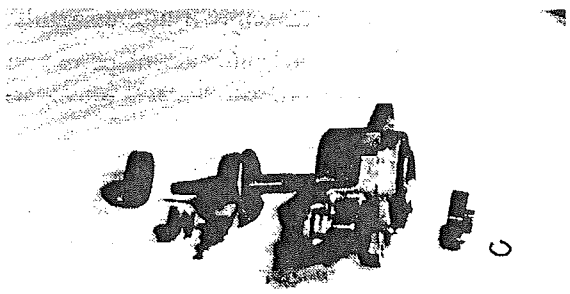
a. Check the armature coil using a growler tester. If the armature is shorted, replace.

Also check for continuity between the armature and the commutator shaft. Replace if defective.



No-load Test

Description		Standard value	
		Current	Speed
No-load characteristics of starter (Battery voltage: 11.5V)	1.6 kW	100A or less	3,000 rpm or more
	2.0 kW	180A or less	3,300 rpm or more

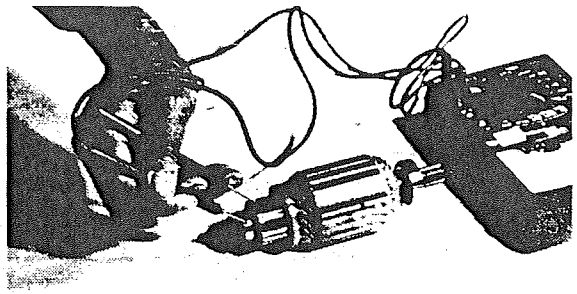


Disassembling Overrunning Clutch

Description		Standard value	Service limit
Brush spring tension	1.6 kW	1.5 kg (3.31 lbs.)	0.7 kg (1.54 lbs.)
	2.0 kW	3.0 kg (6.62 lbs.)	1.8 kg (3.97 lbs.)

Description	Standard value	Service limit
Brush length	1.7 mm (0.67 in.)	11.5 mm (0.45 in.)

b. Measure the commutator O.D. and the depth of undercut. Correct or replace the commutator if defective. Also check the commutator outside surface for dirtiness and roughness. Polish the commutator, if rough, with sand paper No. 300 to 400.



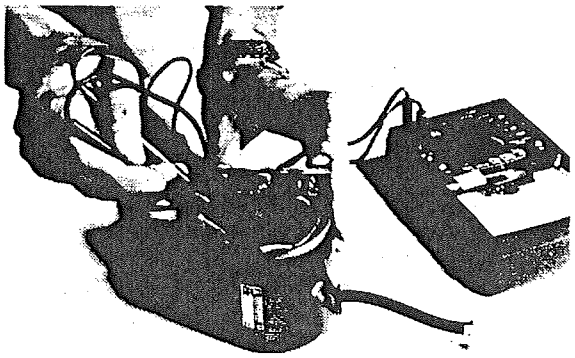
Checking Commutator

(5) Field Coil

a. Check for continuity at both ends of coil (between brushes). If no current is flowing, the coil is broken. Replace the yoke assembly.

b. Check for continuity between the connector and the yoke. If current is flowing, the coil is grounded. In this case, check the insulated condition and correct. Replace the yoke assembly if not repairable.

c. Check the staked condition of poles and check the coil and other parts for looseness.



Checking Field Coil

(6) Magnetic Switch

The magnetic switch must be conducting between S and M terminals and between S terminal and body.

(7) Overrunning Clutch

If the pinion is worn or damaged, replace.

(8) Reduction Gear

Replace the reduction gear if it is worn or damaged.

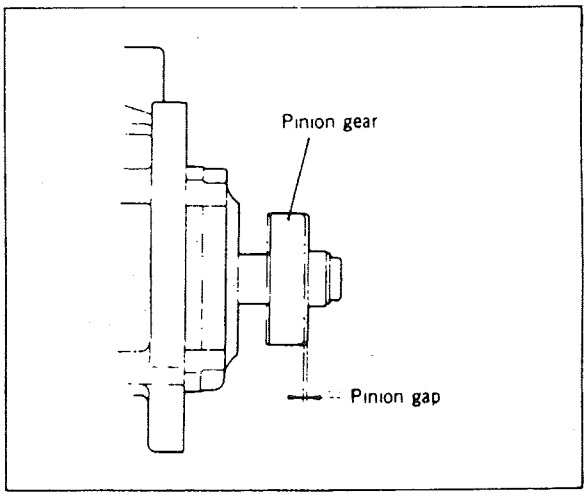
(9) Front Bracket

If the ball bearing or bushing is worn, replace the bracket assembly.

(10) Pinion Gap

a. Remove the connector from M terminal.

b. Insert the battery between the S terminal and the starter motor (connect the positive cable of battery to the S terminal), and the pinion moves out and stops. Lightly push the pinion back toward the armature to measure a pinion gap. If the pinion has no standard gap, adjust by increasing or reducing the adjusting washer between the magnet switch and the front bracket. Increasing the number of washers reduces the gap.



Checking Pinion Gap

Description		Standard value
Starter pinion gap	1.6 kW	0.5 to 2.0 mm (0.0197 to 0.0787 in.)
	2.0 kW	1 to 2.5 mm (0.0394 to 0.0984 in.)

CAUTION:

- **In this check, do not apply the current for over 20 seconds to prevent switch coil overheat.**
- **If the pinion does not move out, or if the pinion gap is too large or too small, the shift lever has been installed in a wrong direction or the magnet switch is defective.**

(11) Pinion Shaft Thrust Gap

A pinion shaft thrust gap is an axial play of the shaft. Adjust the gap to a value less than the standard value by the adjusting washer between the center bracket and the reduction gear.

a. When Pinion has been Removed

After installing the reduction gear to the pinion shaft, insert the pinion shaft into the center bracket, and then fix the pinion shaft with a washer and a snap ring. With the pinion shaft pressed to one side, measure the thrust gap and adjust by the adjusting shim.

b. When Pinion has not been Removed

Insert the pinion shaft and reduction gear between the front bracket and the center bracket and tighten the bolt. Move the pinion shaft to one side and measure the thrust gap.

CAUTION:

- **Prior to measuring the thrust gap in the above paragraph ii, remove the lever spring.**

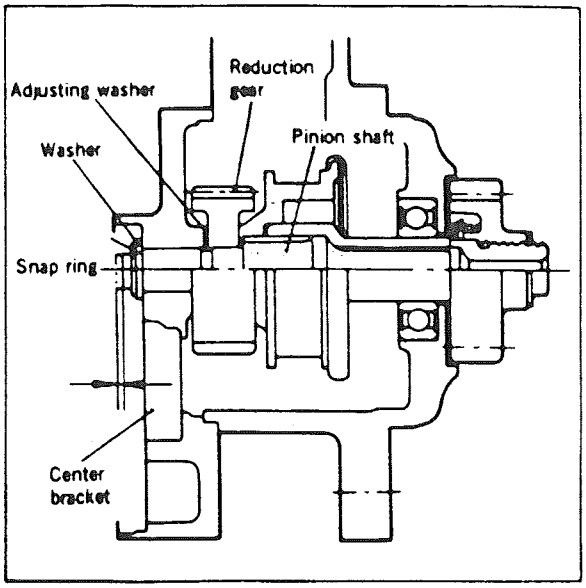
(12) Magnetic Switch

a. Attraction Test

Connect the battery between the S and M terminals of the magnetic switch. If the plunger is attracted and the pinion moves out, then the switch is good.

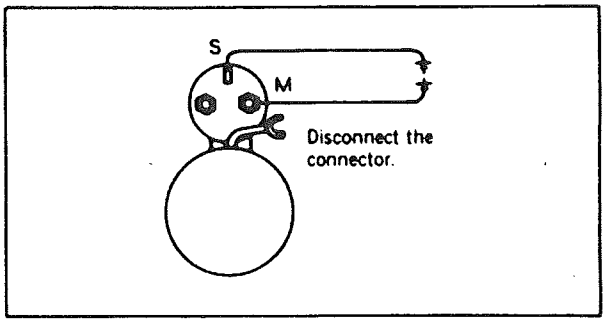
b. Holding Test

With the battery connected between the S terminal of the magnetic switch and the body, manually move the pinion out to the stopper position. If the pinion does not move back to its original position, the switch is good.

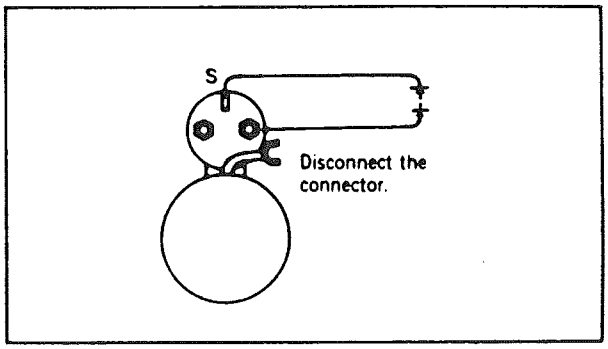


Checking Thrust Gap

Description	Standard value
Starter thrust gap	0.5 mm (0.0197 in.) max.



Attraction Test

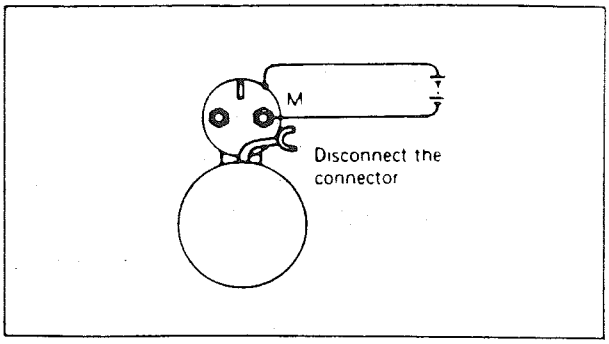


Holding Test

c. Return Test

With the battery connected between the M terminal of the magnetic switch and the body, manually move the pinion out to the stopper position. If the pinon returns to its original position as soon as it is released, the switch is good.

In the above tests of i, ii, and iii, do not supply current for more than 10 seconds.

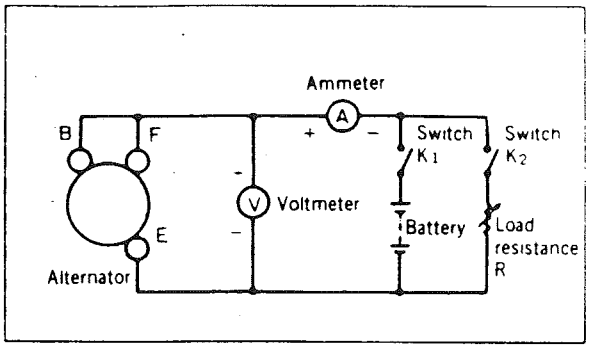


Return Test

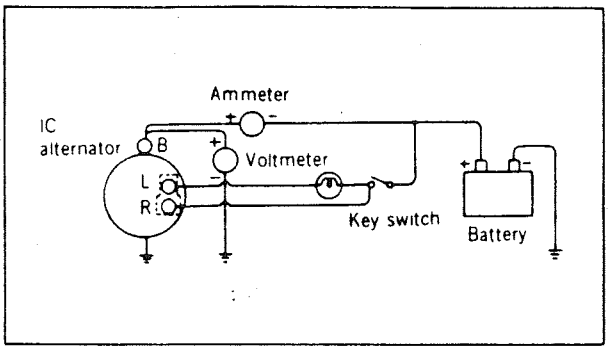
2-2-2 Alternator

CAUTION:

- **Do not use such a high-voltage tester as a megger, otherwise a damaged diode results.**
- **During high-speed operation of the engine, do not disconnect the positive or negative terminal of the battery from the (A) terminal of the regulator. If not, a surge voltage will occur to deteriorate diodes.**
- **Do not turn the engine with the lead disconnected from the (B) terminal of the alternator. The regulator voltage coil will be damaged.**
- **When making a rapid charge of battery using a quick charger, be sure to disconnect the battery terminals; otherwise damaged diodes result.**
- **When using a steam cleaner, be careful not to allow direct contact of steam with the alternator.**
- **Avoid to short the terminals B and L. If shorted, the diode trio will be burnt.**



Performance Test (180W, 420W)



Performance Test (600W)

(1) Performance Test

To make a performance test, remove the alternator from the engine, make connections as shown, and operate the alternator by the motor.

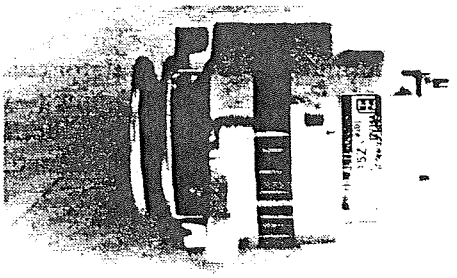
First close the switch K_1 to supply field current from the battery. In this state, increase the alternator speed gradually until there is no counter flow to the field coil or the ammeter registers zero. At this point, open the switch K_1 to let the alternator excite itself. In this condition, increase the alternator speed gradually until the voltmeter indicates the value shown at the right. Read the speed at that point. The reading is the no-load value.

Next, increase the load resistance R to a maximum so that practically no-load current will be flowing. In this condition, close the switches K_1 and K_2. While adjusting for a

Description		Standard value		
		Terminal voltage (V)	Current (A)	Speed (rpm)
No-load characteristics	180W	14	0	1,300 or less
	420W	14	0	1,100 or less
	600W	13.5	0	900 or less
Loaded characteristics	180W	14	15 or more	2,500 or less
	420W	14	30 or more	2,500 or less
	600W	13.5	50 or more	2,500 or less

constant terminal voltage, increase the alternator speed to 2,500 rpm and read the ammeter at that speed. The reading is the loaded value.

In the case of a 600W alternator, connect an ammeter and voltmeter as shown in picture at right. Run the engine and immediately operate the lamps, etc. If the standard value of output specified on page 66 is available when the engine speed is increased to the specified speed, the alternator is good.



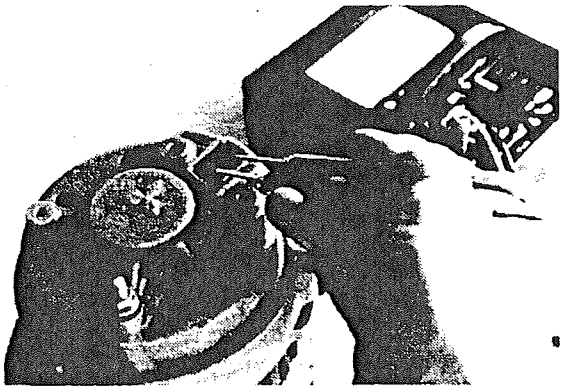
Alternator Assembly

(2) Rectifier Assembly (180W, 420W)

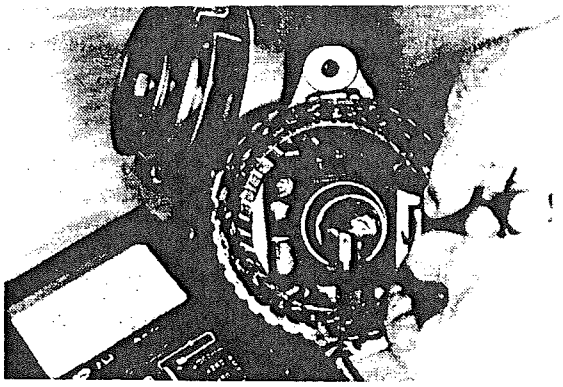
Diode troubles are open- and short-circuits. When the diode is open-circuited, no current flows. In a short-circuited diode, the current flows also in the reverse direction.

a. Checking Heat Sink

A short-circuit can easily be checked by checking for continuity between terminals without disassembling the alternator. For the (+) diodes, check continuity between the (A) and (N) terminals. If it is conducting in both directions of (A) → (N) and (N) → (A), the diode is shorted. For the (−) diodes, check continuity between (N) and (E) terminals as well. If not conducting in either direction, the three diodes are open-circuited though this is a very rare case. The diode, if not shorted, may be open-circuited. Disconnect the diode leads and check for continuity of each diode.



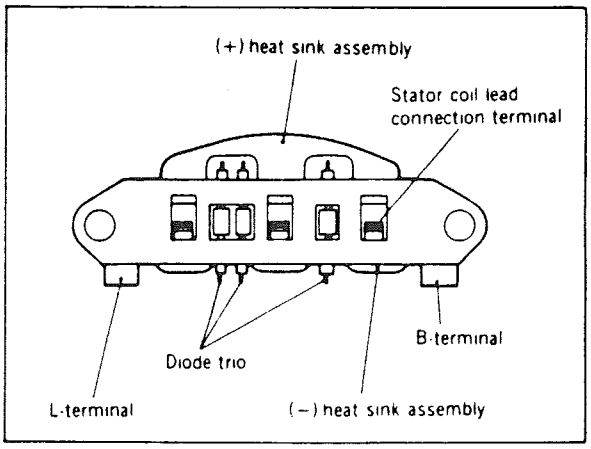
Checking for Short-circuit



Checking Diode

(3) Rectifier Assembly (600W)

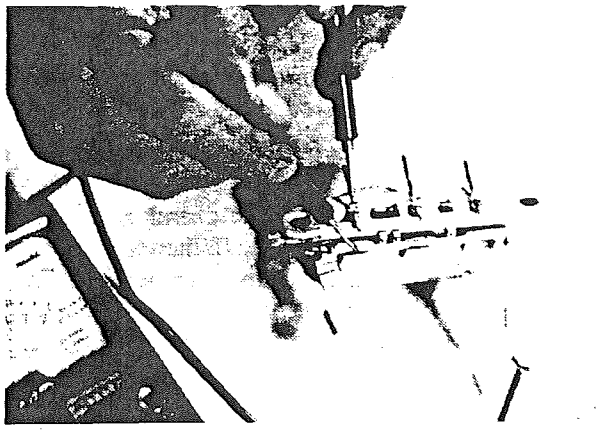
Remove the rectifier assembly from the main body and proceed as follows:



Rectifier Assembly (600W)

Heat Sink

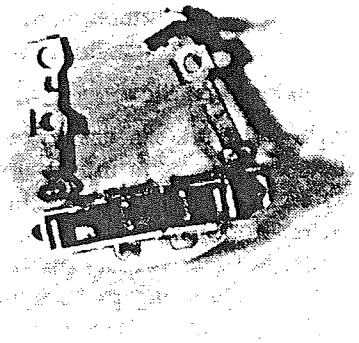
Check for continuity between the stator coil lead connection terminal and (+) and (–) heat sinks. If there is continuity in both directions, then the diode is short-circuited. Replace the rectifier assembly.



Heat Sink

Diode Trio

Check each of the three diodes for continuity across both ends. A diode short- or open-circuited in both direction is defective and should be replaced.



Diode Trio

(4) Stator

Disconnect coil stator leads, and then check for continuity between the three leads using a continuity tester. If the leads are not conducting, the stator loops are broken. Next, check for continuity between the leads and the core. If conducting, the stator is grounded. In this case, replace.

(5) Field Coil

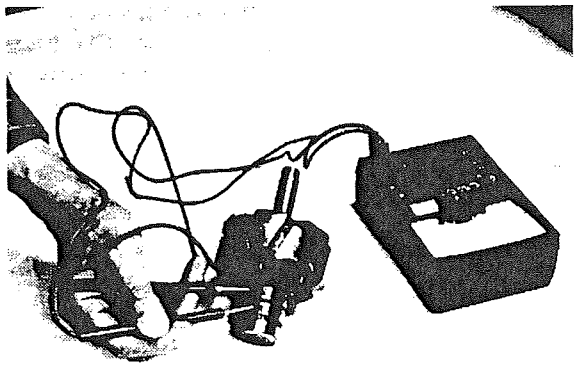
Check the continuity between slip rings. The resistance between slip rings should conform with the value shown at the right.

(6) Inspection of Brush and Brush Spring

Check the brushes and brush springs for wear and damage. If departures from the standard values shown at right are evident, replace.

(7) Inspection of Slip Ring

Check for wear and contact. A badly damaged slip ring should be replaced.



Checking Rotor

Description		Standard value
Field coil resistance	180W	7.12Ω ± 10%
	420W	3.88Ω ± 10%
	600W	3.87Ω ± 10%

Description	Standard value	Service limit
Brush spring pressure	370 gr (0.814 lb)	210 gr (0.462 lb)

2-2-3 Regulator

CAUTION:

- **The regulator is sealed. If this seal is destroyed during the warranty period, the regulator is no more covered by the warranty.**
- **Do not run the engine with the coupler of the regulator disconnected.**
- **Do not connect the capacitor to the (F) terminal.**
- **The regulator should be installed laterally and upright with the connector lead outlet facing down.**

(1) No-load Setting (180W, 420W)

a. Connect a voltmeter between the A and E terminals of the regulator.

b. With the engine running at idle, disconnect the wiring from the B terminal of the alternator to place the alternator at no-load.

c. If the standard value shown at the right is obtained when the alternator speed is increased to 4,000 rpm, the setting is correct.

(2) Inspection of No-load Regulated Voltage (600W)

a. Disconnect the (+) terminal of the battery and connect an ammeter (60A class).

b. Connect a voltmeter between the L terminal of the IC alternator and earth. The voltmeter reading should be 0. If the voltmeter shows a deflection, a defective IC alternator or wiring is suspected.

c. Operate the key switch a step, but do not start the engine. At that time, the voltmeter should deflect and register a value considerably lower than the battery voltage.

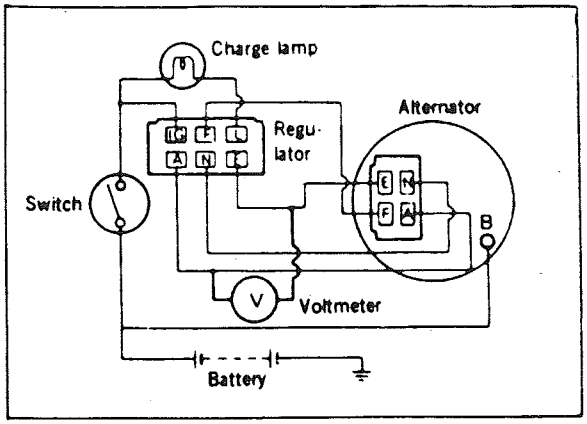
If the voltmeter indicates a value almost equivalent to the battery voltage, a defective IC alternator is suspected.

d. Short-circuit the ammeter terminals and start the engine.

Note:
When starting the engine, use care to make sure that the starter current does not flow to the ammeter.

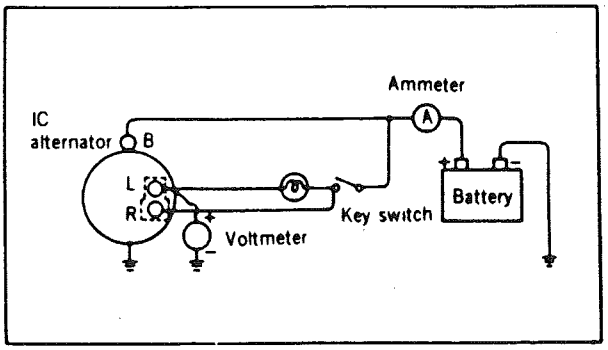
e. Immediately increase the engine speed to about 2,000 to 3,000 rpm and read the ammeter.

Description	Standard value	Service limit
Slip ring diameter	33 mm (1.299 in.)	32 mm (1.259 in.)
Brush length	18 mm (0.71 in.)	8 mm (0.31 in.)



Checking Regulator (180W, 420W)

Description		Standard value
Regulator no-load setting	180W	14.7 ± 0.3V
	420W	14.8 ± 0.3V
	600W	14.4 ± 0.3V



Checking Regulator (600W)

f. If the ammeter reading is less than 5A, read the voltmeter in the same condition (2,000 to 3,000 rpm engine speed). The reading is the regulated voltage.

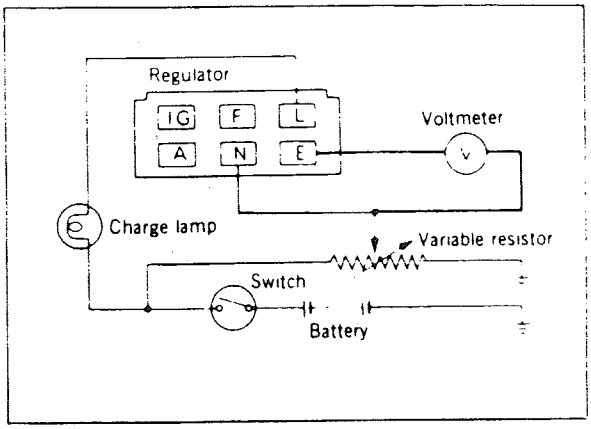
g. If the ammeter reading is over 5A, continue to charge the battery for a while and wait until the reading falls below 5A, or replace the battery with a fully charged one, or connect a 1/4Ω (25W) resistor in series with the battery to limit the charge current.

(3) Inspection of Pilot Lamp Voltage

a. Use a voltmeter and variable resistor and make connections as shown.

b. With the lamp ON, increase the voltage gradually until the lamp goes out, and measure the voltage at that point.

c. Reduce the voltage gradually until the lamp lights again, and measure the voltage at that point.



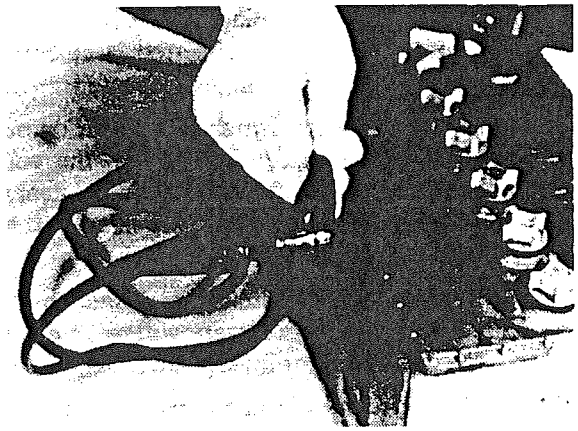
Checking Pilot Lamp Voltage

Description	Standard value
Pilot lamp voltage	
OFF	4.2 to 5.2V
ON	0.5 to 3.0V

2-2-4 Glow Plug and Glow Lamp

(1) When the positive cable of the battery is connected to the glow plug terminal and the negative cable to the body, the glow plug must glow red hot.

(2) With the glow plug installed to the engine, check to see if the glow plug takes much time to glow red hot. If the glow plug needs much time, any one of the three plugs is shorted. Check. Usually the glow lamp is lit within about 25 seconds.



Checking Glow Plug

2-2-5 Engine Stop System Using the Key Switch

(1) Checking the system for proper operation

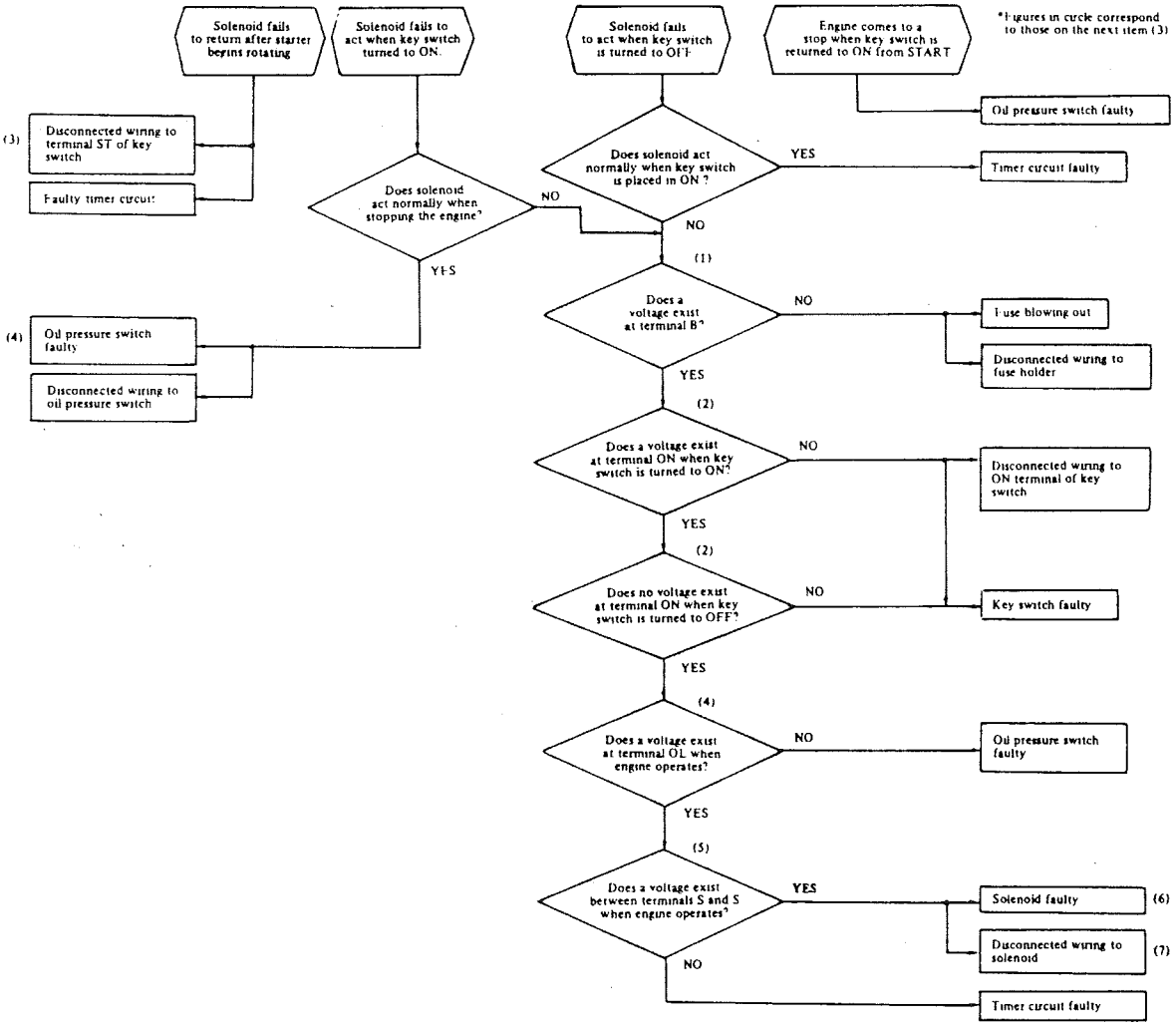
a. Make the wiring of this system in accordance to the wiring diagram shown in page 58.

b. Remove the tie-rod cover to give access to the fuel injection pump control rack. Turn the starting switch key to ON and check to see that the solenoid comes into action, causing the control rack to move accurately to the MS resetting position.

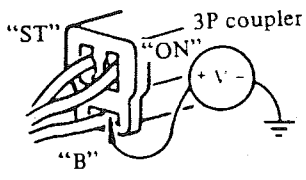
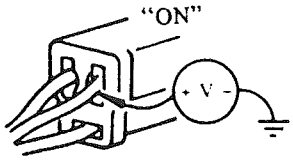
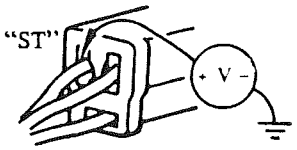
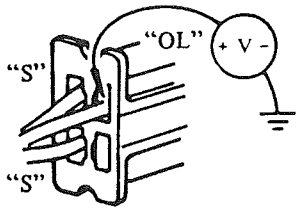
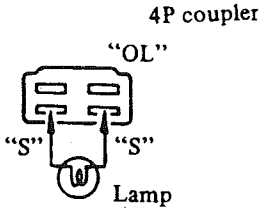
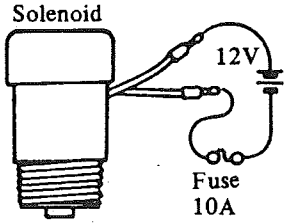
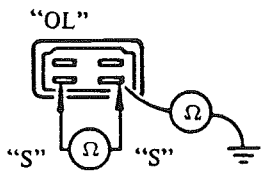
c. Turn the starting switch key to OFF and reinstall the tie-rod cover. Turn the key from OFF to START, through the ON position, and confirm that the solenoid comes into action at the ON position and the action stops at the START position.

(2) Troubleshooting

If the system becomes mal-functional, find out the cause of trouble using the diagnostic chart below.



(3) Testing procedures

No.	Check item	Sketch	Criterion	Testing tool
1	Voltage at terminal B (Lead wire: red)		Approx. 12V DC	Circuit tester
2	Voltage at terminal ON (Lead wire: green)		ON: Approx. 12V DC OFF: 0V	Circuit tester
3	Voltage at terminal ST (Lead wire: red/white)		ON: Approx. 12V DC OFF: 0V	Circuit tester
4	Voltage at terminal OL (Lead wire: yellow)		When stopped: 0V When operated: Approx. 12V	Circuit tester
5	Output of solenoid (Lead wire: blue)		Lamp lights for 7 to 15 seconds.	A lamp of 3W or lower rating
6	Action of solenoid		It is normal if plunger of solenoid is attracted.	Battery Fuse (10A)
7	Wiring to solenoid (Lead wire : blue)		Approx. 1.7 Ω Resistance to body: ∞	Circuit tester

Testing procedure
Connect voltmeter to terminal B of 3P coupler.
(1) Connect voltmeter to terminal ON of 3P coupler. (2) Read voltmeter each time when key switch is turned to ON and OFF.
(1) Connect voltmeter to terminal ST of 3P coupler. (2) Read voltmeter each time when starter is rotated and stopped.
(1) Connect voltmeter to terminal OL of 4P coupler. (2) Read voltmeter each time when engine is stopped and operated.
(1) Remove 4P coupler and connect lamp between terminals S and S. Keep terminal OL free from connection. (2) Turn key switch to ON and, after waiting for a few seconds, turn the switch to OFF. Lamp will go on and maintain lighting for 7 to 15 seconds.
Connect a battery to solenoid terminals and check for normal movement of plunger. Test should not be continued for more than 10 seconds.
(1) Remove 4P coupler and connect ohmmeter to terminals S and S to read resistance between terminals. Be sure to remove coupler without fail. (2) Measure resistance between ground and each terminals with ohmmeter.

2-3 Reassembly

2-3-1 Starter

CAUTION:

- **Prior to installation, clean the starter flange and crankcase mounting surface throughly by removing all oil, paint and rust.**
- **The starter performance largely depends on the quality of wiring. Use specified cords between the battery and the starter and fully tighten each terminal.**

2-3-2 Alternator

CAUTION:

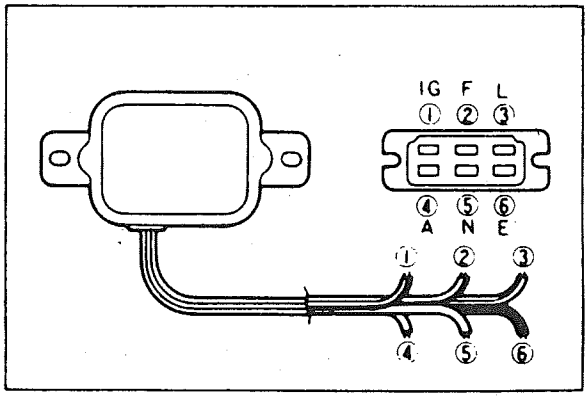
- **Connect the alternator, regulator and battery properly. Should the battery polarity be reversed, a tremendous current would flow from the battery into the alternator, damaging the diodes and wiring harness.**

a. Install the alternator to the left upper part of the gear case. Insert a distance piece between the rear end of the gear case and the rear bracket and adjust by a shim to provide no clearance. Temporarily tighten bolts.

b. Install the belt. Adjust the belt tension. Tighten the alternator brace, then tighten the gear case bolts.

2-3-3 Regulator

When the regulator needs replacement due to a broken connector, be sure to connect the wiring as colour-coded as shown.



(1) Red line on white ground
(2) Black line on white ground
(3) Yellow and green
(4) White
(5) Yellow
(6) Black

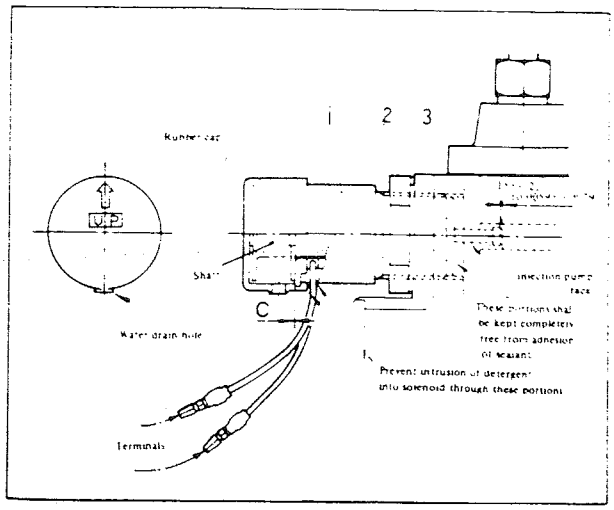
Colour Code for Standard Regulator Wiring

2-3-4 Solenoid Switch

CAUTION:

- **Be sure to prevent intrusion of detergent into the solenoid terminals and the inside of solenoid (cord and shaft).**

a. Temporarily install the solenoid (1), nut (2) and gasket (3) to the crankcase. (Coat the effective thread portion of the solenoid with Three-bond 1212 or 1211.)
b. Turn in the solenoid so that clearance "C" becomes zero at the injection pump rack position "zero."
c. Turn back the solenoid 30° to 45°. [The rack to shaft clearance will become 0.15 to 0.20 mm (0.0059 to 0.0079 in).] Lock the solenoid at that position with the nut. [Nut tightening torque: about 5 kg.m (36.2 ft.lb)]
d. Confirm that MS is reset securely when the shaft is pushed fully.
e. Finally, install the rubber cap with its arrow mark facing upward. (The water drain hole comes to the bottom of the cap.)



Installing Solenoid Switch

1. How to Judge Engine Disassembly Period

Generally when the engine should be disassembled is determined by lowered engine power, decreased compression pressure, and increased fuel and lubricating oil consumption.

The lowered engine power, in the case of diesel engines, is not necessarily due to a trouble of the engine itself but is sometimes caused by nozzle damage or injection pump maladjustment. It is most reasonable to judge by a decrease in compression pressure. The decrease in compression pressure is caused by many factors. It is, therefore, necessary to determine a cause or causes of the trouble on the basis of data of periodic inspection and maintenance.

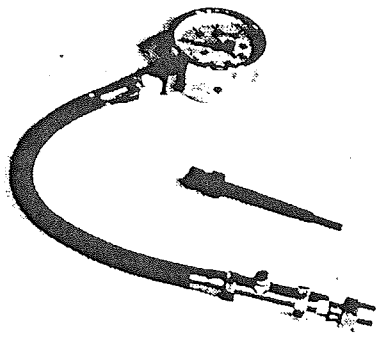
When the trouble is caused by a worn cylinder or piston ring, the following symptoms will occur.

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 noise in engine parts

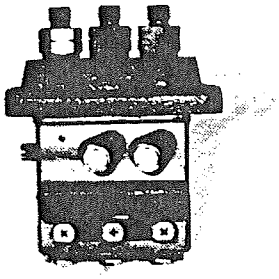
Actually these symptoms often appear together. The symptoms (2) and (4) result also from excessive fuel injection, improper injection timing, and wear of plunger and nozzle. Defective electrical parts, such as the battery, alternator, starter, and glow plug will become a major cause of engine trouble. Therefore, it is desirable to judge the period to overhaul the engine by the lowered compression pressure caused by worn cylinders and pistons plus increased oil consumption and other.

In diesel engines, satisfactory explosion is obtained when the air is compressed sufficiently. When the sufficient compression pressure is not obtained, incomplete combustion of fuel will take place if other parts of engine are operating properly.

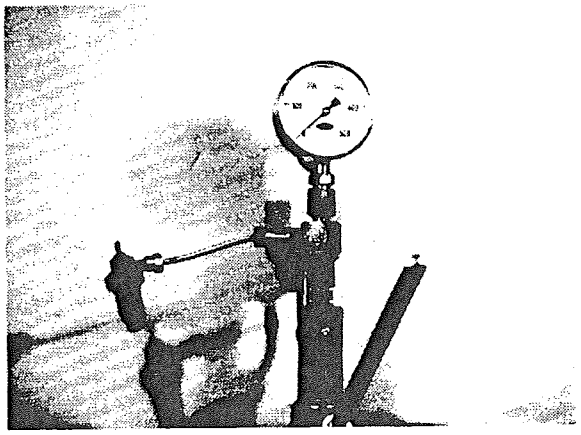
To judge the period of engine overhaul, it is important to measure the engine compression pressure regularly. Since the compression pressure varies with engine rpm, check the speed also. The engine rpm can be measured at the front end of the crankshaft.



Pressure Gauge Adapter and Pressure Gauge



Injection Pump



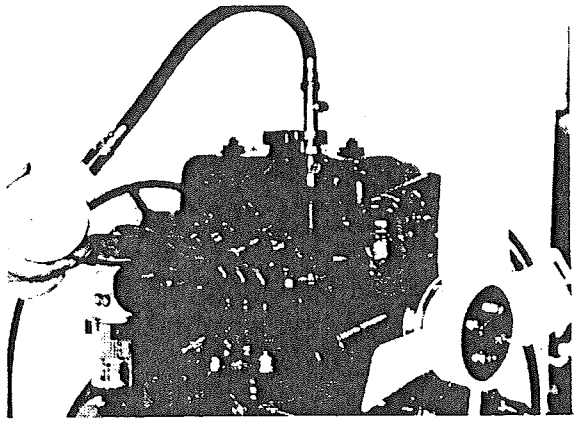
Nozzle Tester

1-1 How to Measure Compression Pressure

1. Remove the glow plug of cylinder to be measured.
2. Attach a pressure gauge adapter in the screw hole of the glow plug, and connect a pressure gauge.
3. Operate the starter. Read the engine rpm and pressure gauge when the pressure gauge pointer has become stable.
4. Measure the compression pressure of other cylinders in a similar manner.

CAUTION:

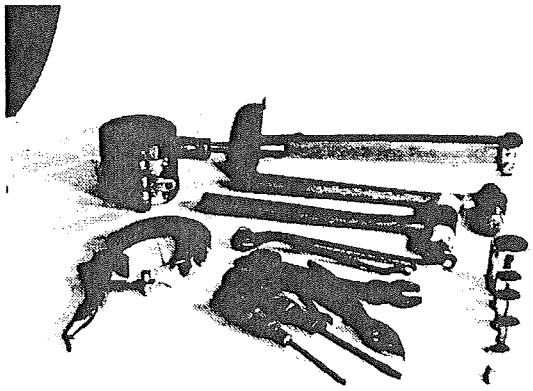
- **It is not a proper way to determine the conditions of the other cylinders from a result of measurements in one cylinder. Be sure to measure the compression pressure in three cylinders.**



Compression Pressure Measurement

1-2 Judgement of Engine Conditions by Compression Pressure

1. The compression pressure tends to increase a little in a new engine until piston rings and valve seats are broken in, and thereafter gradually decreases with the progress of wear of these parts.
2. If the compression pressure has decreased below the repair limit, overhaul the engine.



Tools

1-3 Increased Lubricating Oil Consumption

The engine requires overhaul when oil consumption has increased over about 150%.

1-4 Disassembling Cautions

When disassembling, keep in mind the following cautions. Note that the order of disassembly and reassembly will vary with change of specifications.

1. Before disassembly and cleaning, carefully check for defects which cannot be found after disassembly and cleaning.
2. Before disassembly, drain all drain water, oil and fuel. Check dirtiness of the oil.
3. Clean or wash the engine exterior.
4. Do not disassemble or remove the parts that require no disassembly.
5. Perform disassembly in a proper order using proper tools. Arrange disassembled parts in good order. Apply oil when necessary. Take special care to keep parts of the fuel system from dust.

1-5 Reassembling Cautions

1. Service all parts needed for reassembly.
2. Clean or wash the parts, and apply oil where specified.
3. Carefully check gaskets, packings and oil seals even if not specified to check. Replace with new ones if defective.
4. Be sure to install in proper directions and positions (see dowel pins, mating marks, and specified directions). Where tightening torque is not specified, tighten evenly to an ordinary torque. Apply a sealant where specified.
5. After completion of reassembly, re-check for abnormality. Prepare for starting the engine. Run the engine idle sufficiently for test run.

2. Periodic Service Chart

○ . . . Check, adjust or replenish □ . . . Clean ● . . . Replace △ . . . Drain

Check and service point \ Time to check or adjust	Before operation (on delivery)	After first 50 hours	Every 100 hours	Every 400 hours	Every 800 hours	Long-period storage	Remarks
Engine proper							
Loose, damaged and leaky points	○						
Exhaust fume, noise, and vibration	○						
Additional tightening of engine parts		○			○		
Valve clearance		○		○			
Engine idle speed		○	○				
Engine compression pressure					○		
Lubrication system							
Engine oil	○	●	●				
Oil filter		●	●				
Fuel system							
Fuel	○					△	
Fuel tank				□		□	
Fuel filter			□	●			Replace only the element for the type with cock
Fuel pump		□	□				Filter
Injection pump					○		Adjustment of fuel injection rate
Nozzle				○			
Intake system							
Air cleaner (filter paper type)			□	●			
Cooling system							
Cooling water	○	●			●	△	Unless anti-freeze is mixed, drain after each operation
Fan belt	○						
Electrical system							
Check of each instrument (pilot lamp)	○						
Starter motor, alternator, regulator				○	○*		* Adjustment of voltage and current
Glow plug				○			

3. Specifications and Service Standard

3-1 Engine Proper

All values in mm (in.) unless otherwise indicated

Description	Type	Standard value	Repair limit	Service limit
Compression pressure		32 kg/cm² (455.2 psi)/280 rpm	26 kg/cm² (369.8 psi)	Approx. 22 kg/cm² (312.9 psi)
Pressure difference between cylinders (max.)		2.5 kg/cm² (35.6 psi)		
Injection order		1–3–2		
Injection timing				
	K3A,B,C - 11,12,13, K3D-31H	19° B.T.D.C. (when started at smoke set position)	19° ± 2°	
	K3D-11,13, K3E-13, K3B, D-31, 61	23° B.T.D.C. (when started at smoke set position)	23° ± 2°	
Cylinder head				
Bottom surface flatness (distortion)		0.05 (0.0020) max.	0.1 (0.0039)	
Valve guide I.D. (both intake and exhaust valves)		6.6 (0.2598)		
Valve seat angle (both intake and exhaust valve)		45°		
Valve seat width (both intake and exhaust valves)		1.3 to 1.8 (0.0512 to 0.0709)	2.5 (0.0984)	
Valve seat sinkage				−1 (−0.0394)
Valve timing				
Intake valve opened		18° B.T.D.C.		
Intake valve closed		46° A.B.D.C.		
Exhaust valve opened		46° B.B.D.C.		
Exhaust valve closed		18° A.T.D.C.		
Valve clearance (both intake and exhaust valves)		0.25 (0.0098) (when engine is cold)		
Valve				
Valve head diameter				
Intake valve		27.2 (1.079)		
Exhaust valve		25.2 (0.9921)		
Overall length		114.5 (4.5079)		
Stem O.D.		6.6 (0.2598)		
Clearance between stem and guide				
Intake valve				0.10 (0.0039)
Exhaust valve				0.15 (0.0059)
Valve face angle		45°		
Valve head thickness (margin)		1.0 (0.0039)		0.5 (0.0197)
Valve spring				
Free length		43 (1.6929)		41.7 (1.6417)
Installed load/Installed length		11.8 kg ± 0.6 (26 lbs. ± 1.3)/ 37.1 (1.46)		−15%
Squareness		1.5°		3°

Description	Type	Standard value	Repair limit	Service limit
Rocker arm				
Rocker arm I.D.		18.9 (0.7441)		
Clearance between rocker arm and shaft				0.2 (0.0079)
Cylinder block				
Camshaft hole I.D.				
Front		45 (1.7716)		
Center		44 (1.7323)		
Rear		34 (1.3386)		
Cylinder bore				
	K3A	65 (2.5591)	+0.2 (+0.0079)	+0.95 (+0.0374)
	K3B	68 (2.6772)	+0.2 (+0.0079)	+0.95 (+0.0374)
	K3C	70 (2.7559)	+0.2 (+0.0079)	+0.95 (+0.0374)
	K3D	73 (2.8740)	+0.2 (+0.0079)	+0.95 (+0.0374)
	K3E	76 (2.9921)	+0.2 (+0.0079)	+0.95 (+0.0374)
Oversize finish tolerance		0 to 0.03 (0 to 0.0012)		
Taper of cylinder		0.01 (0.0004) max.		
Top surface flatness (distortion)		0.05 (0.0020) max.	0.1 (0.0039)	
Piston				
	Solid type			
Material	Aluminum alloy			
O.D. (skirt end)				
	K3A	65 (2.5591)		
	K3B	68 (2.6772)		
	K3C	70 (2.7559)		
	K3D	73 (2.8740)		
	K3E	76 (2.9921)		
Clearance between piston and cylinder				0.3 (0.0118)
Oversize		0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295)		
Piston pin				
Except K3E	Semi-floating type			
For K3E	Full floating type			
O.D.				
Except K3E		19 (0.7480)		
For K3E		23 (0.9055)		
Clearance between piston pin and piston				0.08 (0.0031)
Clearance between piston pin and connecting rod				
Except K3E		Press-fitting load: 500 to 1,500 kg (1,102.3 to 3,306.9 lbs.)		
For K3E				0.1 (0.0040)

Description	Type	Standard value	Repair limit	Service limit
Piston ring				
Type and number of rings		3 (2: only for K3E)		
Compression ring				
No. 1	Barrel type Semi-keystone type for K3C ~ E			
No. 2	Tapered ring			
No. 3	Tapered ring (Except K3E)			
Oil ring (K3C, K3D, K3E)	(Provided with coil expander)	1		
Ring width				
Compression ring				
No. 1 to No. 3		2.5 (0.0984)		
K3D: No.1 to No.3		2.0 (0.0787)		
Oil ring		4.0 (0.1575)		
Ring side clearance				
Compression ring				
No. 1		0.06 to 0.12 (0.0024 to 0.0047)		0.3 (0.0118)
No. 2		0.05 to 0.09 (0.0020 to 0.0035)		0.2 (0.0079)
No. 3		0.04 to 0.08 (0.0016 to 0.0031)		0.2 (0.0079)
Oil ring		0.03 to 0.07 (0.0012 to 0.0028)		0.2 (0.0079)
Ring end gap		0.15 to 0.40 (0.0059 to 0.0157)		1.5 (0.0590)
Connecting rod				
	Forged I-beam			
Bend and distortion		0.05 (0.0020) max.		
Big end thrust clearance		0.1 to 0.35 (0.0039 to 0.0138)		0.5 (0.0197)
Connecting rod bearing				
	Kelmet metal with backing metal (Aluminum metal for only K3E)			
Oil clearance				0.15 (0.0059)
Undersize		0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295)		
Crankshaft				
	Fully counterbalanced			
Bend		0.03 (0.0012) max.		
End play		0.05 to 0.175 (0.0020 to 0.0069)		0.3 (0.0118)
Journal O.D.			−0.15 (−0.0059)	(−0.0374)
Pin O.D.		42 (1.6535)	−0.15 (−0.0059)	−0.95 (−0.0374)
Undersize finish dimensions				
Journal				
	U.S. 0.25	51.735 to 51.750 (2.0368 to 2.0374)		
	U.S. 0.50	51.485 to 51.500 (2.0270 to 2.0276)		
	U.S. 0.75	51.235 to 51.250 (2.0171 to 2.0177)		

Description	Type	Standard value	Repair limits	Service limit
Crankshaft				
Pin				
	U.S. 0.25	41.700 to 41.715 (1.6417 to 1.6423)		
	U.S. 0.50	41.450 to 41.465 (1.6319 to 1.6325)		
	U.S. 0.75	41.200 to 41.215 (1.6220 to 1.6226)		
Main bearing				
	Kelmet metal with backing metal (flanged metal for center bearing) (Aluminum metal for only K3E)			
Oil clearance				0.10 (0.0039)
Undersize		0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295)		
Camshaft				
Driving system	Gear			
Clearance between journal and cylinder block hole or bushing (oil clearance)	Lead bronze alloy with backing metal			0.15 (0.0059)
Cam lobe height (for intake and exhaust valves)		35.76 (1.4079)		−1.0 (−0.0394)
Pump camshaft				
Driving system	Gear			
Bearing				
Front	Ball bearing			
Rear	Cylinder block			
Cam lobe height		44 (1.7323)		−1.0 (−0.0394)
Tappet				
O.D.		23 (0.9055)		
Clearance between tappet and cylinder block hole				0.15 (0.0059)
Push rod				
Bend		0.3 (0.0118) max.		

3-2 Lubrication System

Description	Type	Standard value	Repair limit	Service limit
Engine oil				
Engine oil (Except ... K3D-13, K3E... 13)		Upper limit: 3.0 lit. (0.79 gal), Lower limit: 1.8 lit. (0.48 gal): 0.5 lit. (0.13 gal) in oil filter not included		
(Only K3D-13R, K3E-13R)		Upper limit 4.0 lit (1.05 gal.) Lower limit 2.8 lit (0.74 gal.)		
Oil specification				
API classification		Class CC or higher		
Viscosity				
20°C (68°F) or higher		SAE 30 or 10W-30		
5 to 20°C (41 to 68°F)		SAE 20 or 10W-30		
5°C (41°F) or lower		SAE 10W-30		
Oil pump	Trochoid type			
Check valve opening pressure		4 kg/cm² (56.9 psi)		
Clearance between outer rotor and body		0.15 to 0.2 (0.0059 to 0.0079)		0.3 (0.0118)
Clearance between outer rotor and inner rotor		0.05 to 0.12 (0.0020 to 0.0047)		0.25 (0.0098)
Clearance between rotor and cover		0.03 to 0.07 (0.0012 to 0.0028)		0.2 (0.0079)
Oil pressure switch	(Mark : P25)	$0.3^{0}_{-0.15}$ kg/cm² ($4.27^{0}_{-2.13}$ psi)		
Contact closing pressure	(Mark : P05)	0.5±0.1 kg/cm² (7.11±1.42 psi)		

3-3 Fuel System

Description	Type	Standard value	Repair limit	Service limit
Fuel used		Gas oil		
Fuel filter	Filter paper type			
Fuel pump	Electromagnetic type			
Delivery		225 cc (13.73 cu.in.) min./15 sec. 12V		
Fuel injection pump	ND-PFR3M			
Fuel injection rate				
At smoke set (SS)				
	K3A-11GE, -11GT K3B-11GT K3B-13R	1,300 rpm: 20.5 ± 1.0 mm^3 (0.00125 ± 0.00006 cu.in.)/st.		
	K3B-11GE,	1,300 rpm: 22 ± 1.0 mm^3 (0.00134 ± 0.00006 cu.in.)/st.		
	K3B-61A	1,500 rpm: 25 ± 1.0 mm^3 (0.00153 ± 0.00006 cu.in.)/st.		
	K3D-13R			
	K3D-61WM, 61RG, 61TG K3E-13R	1,500 rpm: 28 ± 1.0 mm^3 (0.00170 ± 0.00006 cu.in.)/st.		
At start set (MS)				
	K3A-11GE, -11GT	150 rpm: 30 ± 5 mm^3 (0.00182 ± 0.00030 cu.in.)/st.		
	K3B-11GT, -13R			
	K3B-11GE, 61A	150 rpm: 33 ± 5 mm^3 (0.00201 ± 0.00030 cu.in.)/st.		
	K3D-13R			
	K3D-61WM, 61RG, 61TG K3E-13R	150 rpm: 37.5 ± 5 mm^3 (0.00228 ± 0.00030 cu.in.)/st.		
Difference from reference cylinder		2 mm^3 (0.00012 cu.in.)/rev. cyl.max.		
Prestroke		2.2 ± 0.1 (0.0866 ± 0.0039)		
Nozzle	Throttle type ND-DN4SD24			
Injection starting pressure		120 kg/cm^2 (1,706.97 psi)	120 $^{+10}_{0}$ kg/cm^2 (1,706.97 $^{+142.25}_{-0}$ psi)	

3-4 Governor System

Description	Type	Standard value	Repair limit	Service limit
Governor	Centrifugal weight type			
Engine stopping solenoid	Electromagnetic pull-out type			
Rated voltage [20°C (68°F)]		12V		
Current [20°C (68°F)]		7A max.		
Stroke		13.5 ± 0.5 (0.53 ± 0.02)		

3-5 Cooling System

Description	Type	Standard value	Repair limit	Service limit
Cooling fan				
K3A, B-11, 13R	4.N.S.	φ290mm (φ11.42 in.)		
K3B, D-61A	6.N.S.	φ325mm (φ12.80 in.)		
K3D-61TG; K3D,E-13R	5.N.S.	φ340mm (φ13.39 in.)		
Fan belt	HM type	939 (36.97)		
Water pump	Centrifugal impeller type			
Thermostat (Models equipped with thermostat only)	Wax type			
Valve opening temperature		82 ± 1.5°C (180 ± 2.7°F)		
Valve full-opening temperature		95°C (203°F)		
Valve lift		Approx. 8 (0.3)		
Thermoswitch				
Contact closing temperature	Bimetal switch type	108 to 114°C (227 to 238°F) 105 to 111°C (221 to 232°F)		

3-6 Electrical System

Description	Type	Standard value	Repair limit	Service limit
Starter (1.6 kW)	Electromagnetic push-in type M002T50381			
Output–voltage		1.6 kW–12V		
Rotating direction		Clockwise as viewed from pinion side		
No-load characteristics [20°C (68°F)]				
Terminal voltage		11.5V		
Current		100A or less		
Speed		3,000 rpm or more		

Description	Type	Standard value	Repair limit	Service limit
Brush length		17 (0.67)		11.5 (0.45)
Spring pressure		1.5 kg &3.31 lbs.)		0.7 kg(1.54 lbs.)
Pinion gap		0.5 to 2.0 (0.0197 to 0.0787)		
Thrust gap		0.5(0.0197) or less		
Starter (2 kW)	Electromagnetic push-in type M003T61171			
Output-voltage		2 kW – 12V		
Rotating direction		Clockwise viewed from pinion side		
No-load characteristics [20°C (68°F)]				
Terminal voltage		11V		
Current		180A or less		
Speed		3,300 rpm or more		
Brush length		17 (0.67)		11.5 (0.45)
Spring pressure		3.0 kg(6.61 lbs.)		1.8 kg(3.97 lbs.)
Pinion gap		1 to 2.5 (0.0394 tp 0.0984)		
Thrust gap		0.5 (0.0197) or less		

Description	Type	Standard value	Repair limit	Service limit
Alternator	AC type Model AR2115 Z_2			
Output – Voltage		12V – 15V		
Direction of rotation		Clockwise as viewed from pulley side		
No-load output characteristics 20°C (68°F)				
Terminal voltage		14V		
Current (Cold)		0A		
Speed (Alternator)		1300 rpm or less		
Load characteristics: 20°C(68°F)				
Terminal voltage		14V		
Current		15A or more		
Speed (Alternator)		2500 rpm		
Alternator	AC type Model AH2035M4			
Output-voltage		12V - 35A		
Direction of rotation		Clockwise as kewed from pulley side		
No load output				
Characteristics: 20°C (68°F)				
Terminal voltage		14V		
Current (Cold)		8A		
Speed (Alternator)		1300 rpm or less		
Load characteristics: 20°C (68°F)				
Terminal voltage		14V		
Current (cold)		30A or more		
Speed (Alternator)		2500 rpm		
Alternator	AC type Model A002T25271			
Output-voltage		12V - 50A		
Direction of rotation		Clockwise as viewed from pulley side		
No-load output				
Characteristics : 20°C(68°F)				
Terminal voltage		13.5V		
Current (cold)		24A		
Speed (Alternator)		1300 rpm		
Load characteristics: 20°C (68°F)				
Terminal voltage		13.5V		
Current (cold)		50A		
Speed (Alternator)		2500 rpm		

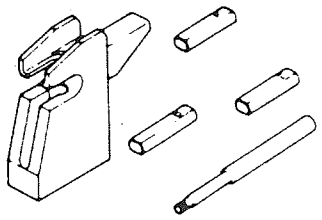
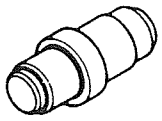
4. Tightening Torque Chart

Description	Tightening torque	
	kg-m	ft.lbs.
Cylinder head bolt { M12 screws 8	11 to 12	79.5 to 86.8
(K3E only)	12 to 13	86.3 to 94.0
M10 screws 3	7 to 8	50.6 to 57.8
Crank pulley nut	20 to 25	144.6 to 180.8
Main bearing cap bolt	5 to 5.5	36.2 to 39.8
Connecting rod cap nut (Except K3E)	3.2 to 3.5	23.1 to 25.3
Connecting rod cap bolt (K3E only)	5.5 to 6	39.8 to 43.4
Flywheel mounting bolt (8T)	11.5 to 12.5	83.1 to 90.4
Oil pan drain plug	5 to 6	36.2 to 43.4
Oil filter	1.1 to 1.3	8.0 to 9.4
Fuel injection pump		
Delivery valve holder	4 to 5	28.9 to 36.2
Nozzle holder		
Holder mounting bolt	1.5 to 2	10.8 to 14.5
Holder body and retaining nut	6 to 8	43.4 to 57.8
Glow plug	1.5 to 2	10.8 to 14.5
General screws		
M6	0.7	5.1
M8	1.7	12.3
M10	3.5	25.3
M12	6.4	46.3

5. Sealant Chart

Parts requiring sealant application	Surfaces requiring sealant application (Where to mount sealant-coated parts)	Sealant
Taper screw 1/2"	Thread portion (Gear case)	HERMESEAL H1
Taper screw 1/4"	Thread portion (Cylinder block right side, pump cover)	HERMESEAL H1
Taper screw 1/8"	Thread portion (Rear of cylinder head)	HERMESEAL H1
Oil pressure switch	Thread portion (Cylinder block right side)	HERMESEAL H1
Thermoswitch	Thread portion (Cylinder head side)	HERMESEAL H1
Joint gauge unit	Thread portion (Cylinder head side)	HERMESEAL H1
Side seal	Outside periphery (Main bearing caps No.1 and No.4)	SUPER THREE-BOND 20
Bearing cap No.1	Contact surface with cylinder block	SUPER THREE-BOND 20
Bearing cap No.4	Contact surface with cylinder block	SUPER THREE-BOND 20

6. Special Tools

Tool No.	Tool name	Sketch	Use
ST332301	Piston pin setting tools		Removal and installation of piston pin Guide D 92.5 mm (3.64 in.): for K3A Guide E 91 mm (3.58 in.): for K3B, K3C Guide F 89 mm (3.50 in.): for K3D
ST332340	Camshaft bushing installer		Removal and installation of camshaft front bushing
ST332230	Compression gauge adaptor		Measurement of compression pressure
MD998054	Oil pressure switch socket wrench (26)		Removal and installation of oil pressure switch

SUPPLEMENT

K3H, K3M, Models

INDEX

1. Engine Model and Engine Number . . (1)

1. Engine Mode

Model	Classification	Use
K3H, M	11, 12 series	For all types of agricultural
K3M	61A series	For exports and all types of agricultural and industrial machines

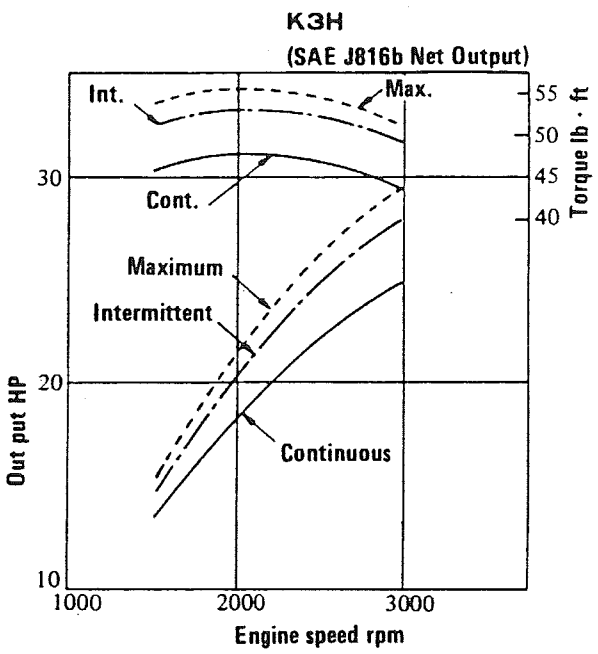
5. Stamped engine numbers are as shown below

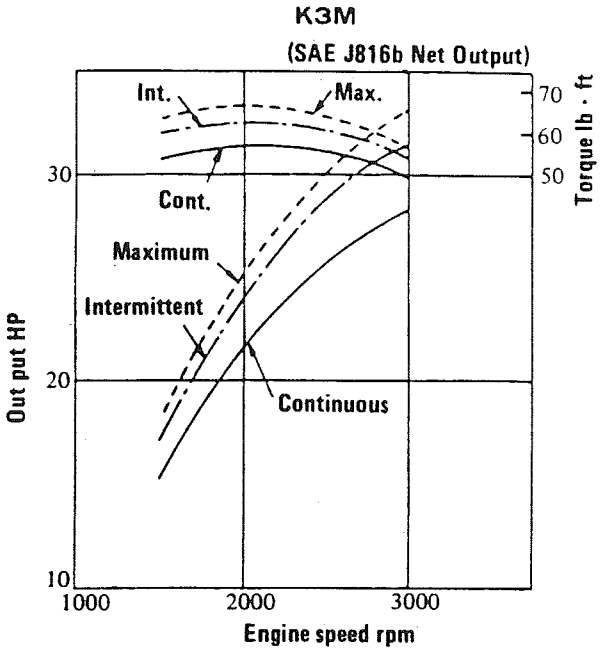
Model	Stamped number
K3H K3M	1001 ~

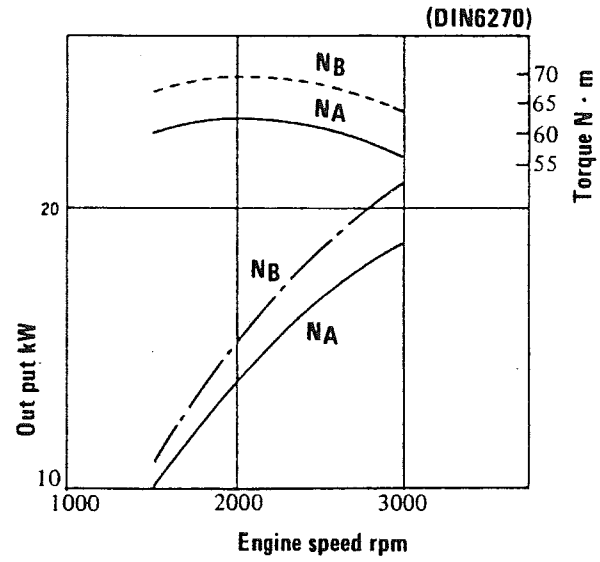
3. Major Specifications. . . . . .(4)

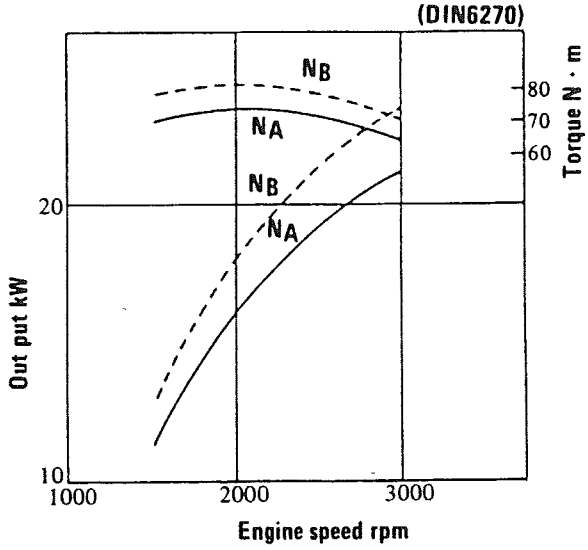
Item \ Model	K3H	K3M
Type	4-cycle, water-cooled, vertical diesel engine	
Number of cylinders	3	
Bore x stroke	78 x 90 mm (3.071 x 3.543 in.)	84 x 90 mm (3.307 x 3.543)
Total displacement	1290 cc (78.72 cu.in.)	1496 cc (91.29 cu.in.)
Combustion chamber	Swirl chamber	
Compression ratio	23	
Engine performance	See engine performance curves	
Firing order	1–3–2	
Injection timing	(differs with specifications)	
Injection pump	Bosch M type	
Nozzle	Throttle type	
Governor	Centrifugal flyweight type	
Fuel	Diesel fuel	
Lubrication	Forced lubrication (trochoid pump)	
Oil filter	Filter paper (full flow type)	
Engine oil quantity (excluding 0.5ℓ of oil filter) Upper limit - Lower limit	4.2 lit. (1.11 U.S.gal) – 2.7 lit. (0.71 U.S.gal)	
Water pump	Centrifugal type	
Coolant capacity	3.9 lit. (1.03 U.S.gal, except radiator and hose)	
Starter motor	12V–1.6kW (–11AE) or 12V–2kW (–11A, 12A, 61A)	
Alternator	12V-35A (AC)	
Battery	12V 70AH or more	
Stability angle	25° during continuous operation 30° during short-time (less than 30 min.) operation	

4. Performance Curves ..... (5)









Description	Standard value
Valve clearance Intake valve Exhaust valve	 0.25 mm (0.0098 in.) 0.25 mm (0.0098 in.)

Description		Standard value
Cylinder head bolt tightening torque	M14:8	15 ~ 16 kg·m (108.4 ~ 115.7 ft·lbs.)
	M14:3 (tappetside)	10 ~ 11 kg·m (72.3 ~ 79.5 ft·lbs.)

Model	Injection timing
K3H-11, 12 K3M-11	21° BTDC
K3M-61A	23° BTDC

2. Engine with Damper Spring

In the case of an engine with damper, adjust the HIGH-PSEED setting by the following procedure. In engines of other models than the following, the set speed is otherwise specified in accordance with respective specifications.

a. With the damper spring left free (with the adjusting bolt loosened), set the engine speed to "A" rpm shown at the right by means of the HIGH-SPEED set bolt, then lock the set bolt.

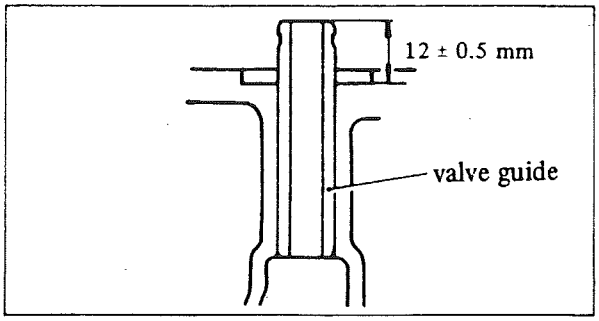
Model	Set speed "A" rpm
K3H-11, 12 K3M-11	2840^{0}_{-40}
K3M-61A	3140^{0}_{-40}

b. Tighten the damper spring adjusting bolt to adjust the engine speed to "A" $+40^{0}_{-15}$ rpm ("B" rpm shown at the right), then lock the adjusting bolt with a lock nut. (Apply Super Three-Bond #20 to the threads of the adjusting bolt.)

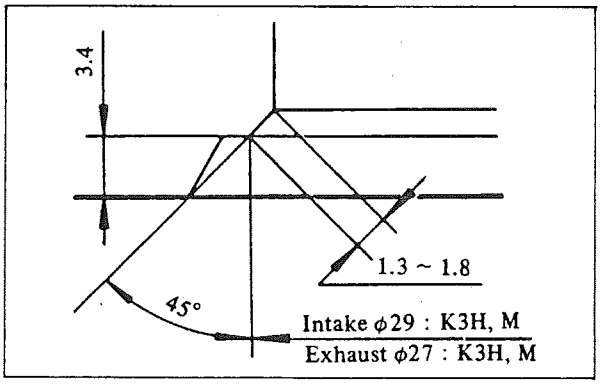
Model	Set speed "B" rpm
K3H-11, 12 K3M-11	2850^{+30}_{-25}
K3M-61A	3150^{+30}_{-25}

c. Seal the above-mentioned adjusting bolt with a sealing cap.

d. Seal the HIGH-SPEED set bolt by wire and sealing metal.



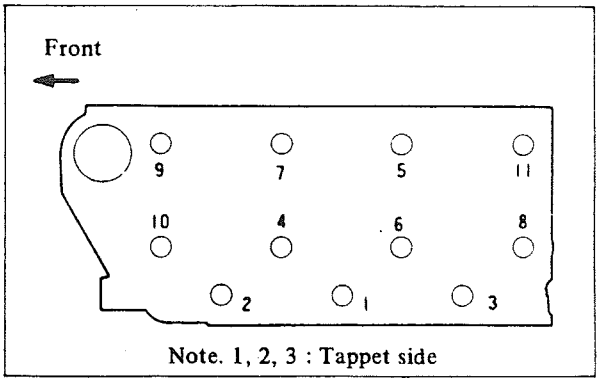
Installing Valve Guide



Correcting Valve Seat

Description	Standard value	Service limit
Valve lip thickness (T)	1.0 mm (0.039 in.).	0.5 mm (0.0197 in.)

Description	Standard value	Service limit
Valve spring free length	45.85 mm	44.5 mm
Installed load: /Installed length	27.9 ± 1.4 kg. /37.3 mm	−15%
Squarness of valve spring	1.5°	3.0°

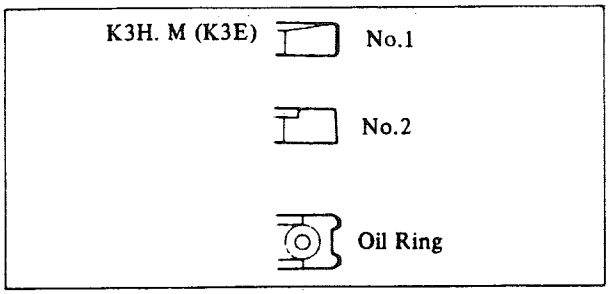


Note. 1, 2, 3 : Tappet side

Cylinder Head Bolt Tightening Sequence

Description		Standard value
Cylinder head bolt tightening torque	14 mmϕ	15 to 16 kg·m (108.4 ~ 115.7 ft·lbs.)
	14 mmϕ (tappet side)	10 to 11 kg·m (72.3 ~ 79.5 ft·lbs.)

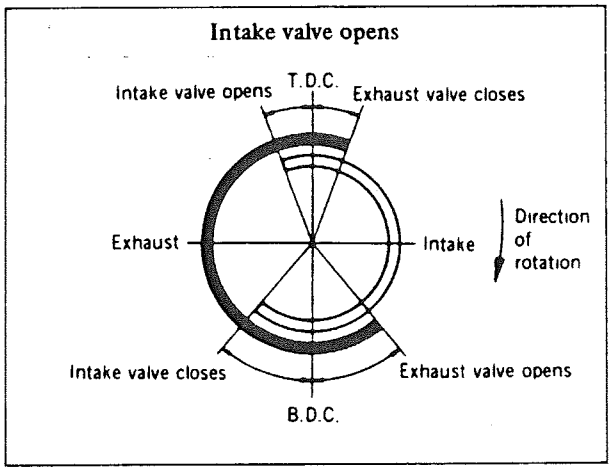
b. Main bearing are the aluminum metal.



Shapes of Piston Rings

The big end bearing is the aluminum metal.

c. The valve timing is shown.



Valve Timing (K3H, M)

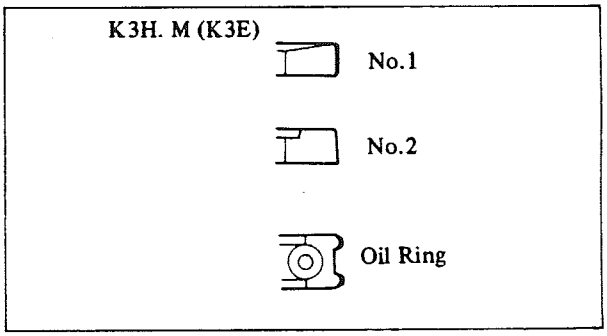
Remove the snap ring from each end of piston. Using a piston heater, heat the piston for about 5 minutes in an oil bath of 80°C.
Take out the piston and pull out the piston pin.

e. In case of slight wear of cylinder bore and when only the piston rings require replacement, check the upper part of the cylinder for groove wear. If there exists a ridge wear, remove it by reaming and hone when necessary.

Description	Standard value	Repair limit	Service limit
Cylinder bore size	K3H: 78mm (3.071 in.)	+0.2mm (+0.0374 in.)	+0.95mm (+0.0374 in.)
	K3M: 84mm (3.307 in.)		
Taper of Cylinder	0.01mm (0.0004 in.) max.		

11. When assembling the piston and connecting rod for the K3E, K3H and K3M engine, heat the piston at 80°C for about 5 minutes in oil using a piston heater. After installing the piston pin, lock with a snap ring at each end of the pin to prevent it from lossening.

12.



Shapes of Piston Rings

13. Connecting rod bot tightening

Description	Standard value
Connecting rod cap bolt tightening torque	5.5 to 6 kg•m (39.8 to 43.4 ft.lbs.)

SECTION 2. LUBRICATION SYSTEM

Description	Standard value
Oil pressure switch ON hydraulic pressure	0.15 to 0.3 kg/cm² (2.13 to 4.27 psi)

Note: all Models

SECTION 3. FUEL SYSTEM

Description	Standard value	Repair limit
Nozzle injection start pressure	160^{+10}_{-0} kg/cm² (2276^{+142}_{-0} psi)	160 ± 10kg/cm² (2276 ±142 psi)

SECTION 5. COOLING SYSTEM

Description	Standard value
Thermoswitch closing (warning lamp lighting) temperature	108 to 114°C (227 to 238°F)
Thermounit (K3M-11) Temperature/Resistance value	50°C (122°F)/ 350 ± 20Ω
	90°C (194°F)/ 81 ± 5Ω
	120°C (248°F)/ 36.2 ± 2.5Ω

SECTION 6. ELECTRICAL SYSTEM

1. Construction

(1) Type: M002T50381 . . . For k3H-11AE
Output-voltage: 1.6kW-12V

(2) Type: M002T56271 For K3H, M-11A,12A
Output-voltage: 2kW-12V

(3) Type: M002T56272 For K3H, M-11C, 61A
Output-voltage: 2kW-12V

Type: AH2035M_4
Output-voltage: 35A - 12V

SECTION 7. MAINTENANCE

3-1 Engine Proper

All values in mm (in.) unless otherwise indicated

Description	Type	Standard value	Repair limit	Service limit
Compression pressure		38 kg/cm² (540.5 psi)/280 rpm	30 kg/cm² (426.7 psi)	Approx. 27 kg/cm² (384.1 psi)
Pressure difference between cylinders (max.)		2.5 kg/cm² (35.6 psi)		
Injection order		1–3–2		
Injection timing	K3H, M-11, 12	21°B.T.D.C. (when started at smoke set position)	21° ± 2°	
	K3M-61A	23° B.T.D.C. (when started at smoke set position)	23° ± 2°	
Cylinder head				
Bottom surface flatness (distortion)		0.05 (0.0020) max.	0.1 (0.0039)	
Valve guide I.D. (both intake and exhaust valves)		8 (0.315)		
Valve seat angle (both intake and exhaust valve)		45°		
Valve seat width (both intake and exhaust valves)		1.3 to 1.8 (0.0512 to 0.0709)	2.5 (0.0984)	
Valve seat sinkage				–1(–0.0394)
Valve timing				
Intake valve opened		20° B.T.D.C.		
Intake valve opened		44° A.B.D.C.		
Exhaust valve opened		44° B.B.D.C.		
Exhaust valve closed		20° A.T.D.C.		
Valve celarance (both intake and exhaust valves)		0.25 (0.0098) (when engine is cold)		

Description	Type	Standard value	Repair limit	Service limit
Valve				
Valve head diameter				
Intake valve		30 (1.181)		
Exhaust valve		28 (1.102)		
Overall length		113 (4.449)		
Stem O.D.		8 (0.315)		
Clearance between stem and guide				
Intake valve				0.10(0.0039)
Exhaust valve				0.15(0.0059)
Valve face angle		45°		
Valve head thickness(margin)		1.5 (0.0591)		0.5 (0.0197)
Valve spring				
Free length		45.85 (1.8051)		44.5(1.7520)
Installed load/Installed length		13.2 ± 0.7 kg/41.8 (29.1 ± 1.5 lbs./1.65 in.)		−15%
Squareness		1.5°		3°
Rocker arm				
Rocker arm I.D.		18.9 (0.7441)		
Clearance between rocker arm and shaft				0.2 (0.0079)
Cylinder block				
Camshaft hole I.D.				
Front		45 (1.7716)		
Center		44 (1.7323)		
Rear		34 (1.3386)		
Cylinder bore				
	K3H	78 (3.0709)	+0.2 (+0.0079)	+0.95 (+0.0374)
	K3M	84 (3.3071)	+0.2 (+0.0079)	+0.95 (+0.0374)
Oversize finish tolerance		0 to 0.03 (0 to 0.0012)		
Taper of cylinder		0.01 (0.0004) max.		
Top surface flatness (distortion)		0.05 (0.0020) max.	0.1(0.0039)	
Piston				
Material	Solid type Aluminum alloy			
O.D. (skirt end)				
	K3H	78 (3.0709)		
	K3M	84 (3.3071)		
Clearance between piston and cylinder				0.3(0.0118)
Oversize		0.25(0.0098), 0.50(0.0197) 0.75(0.0295)		
Piston pin				
K3H, K3M, (K3E)	Full-floating type			
O.D.		23 (0.9055)		
Clearance between piston pin and piston				0.08(0.0031)
Clearance between piston pin and connecting rod				0.1 (0.0040)

Description	Type	Standard value	Repair limit	Service limit
Piston ring				
Type and number of rings		2		
Compression ring				
No.1	Semi-keystone type			
No.2	Tapered ring			
Oil ring	Provided with coil expander	1		
Ring width				
Compression ring				
No.1, No.2		2.0 (0.0787)		
Oil ring		4.0 (0.1575)		
Ring side clearance				
Compression ring				
No.1		0.06 to 0.12 (0.0024 to 0.0047)		0.3 (0.0118)
No.2		0.05 to 0.09 (0.0020 to 0.0035)		0.2 (0.0079)
Oil ring		0.03 to 0.07 (0.0012 to 0.0028)		0.2 (0.0079)
Ring end gap		0.15 to 0.40 (0.0059 to 0.0157)		1.5 (0.0590)
Connecting rod				
	Forged I-beam			
Bend and distortion		0.05 (0.0020) max.		
Big end thrust clearance		0.1 to 0.35 (0.0039 to 0.0138)		0.5 (0.0197)
Connecting rod bearing				
K3H:	Kelmet method			
K3M:	Aluminum metal			
Oil clearance				0.15(0.0059)
Undersize		0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295)		
Crankshaft				
	Fully counterbalanced			
Bend		0.03 (0.0012) max.		
End play		0.06 to 0.3 (0.0024 to 0.0118)		0.5 (0.0197)
Journal O.D.		57 (2.2441)	−0.15 (−0.0059)	−0.95 (−0.0374)
Pin O.D.		48 (1.8898)	−0.15) (−0.0059)	−0.95 (−0.0374)
Undersize finish dimensions				
Journal				
	U.S. 0.25	56.735 to 56.750 (2.2337 to 2.2342)		
	U.S. 0.50	56.485 to 56.500 (2.2238 to 2.2244)		
	U.S. 0.75	56.235 to 56.250 (2.2140 to 2.2146)		
Pin				
	U.S. 0.25	47.700 to 47.715 (1.8779 to 1.8785)		
	U.S. 0.50	47.450 to 47.465 (1.8681 to 1.8687)		
	U.S. 0.75	47.200 to 47.215 (1.8583 to 1.8589)		

Description	Type	Standard value	Repair limits	Service limit
Main bearing				
(flanged metal for center bearing) K3H:	Kelmet metal (Upper & lower common; without oil groove)			
Oil clearance K3M:	Aluminum metal (Upper side; with oil groove)			0.10 (0.0039)
Undersize		0.25 (0.0098), 0.50 (0.0197) 0.75 (0.0295)		
Camshaft				
Driving system	Gear			
Clearance between journal and cylinder block hole or bushing (oil clearance)	Lead bronze alloy with backing metal			0.15(0.0059)
Cam lobe height (for intake and exhaust valves)		35.76 (1.4079)		−1.0(−0.0394)
Pump camshaft				
Driving system	Gear			
Bearing				
Front	Ball bearing			
Rear	Cylinder block			
Cam lobe height		44 (1.7323)		−1.0(−0.0394)
Tappet				
O.D.		23 (0.9055)		
Clearance between tappet and cylinder block hole				0.15(0.0059)
Push rod				
Bend		0.3 (0.0118) max.		

3-2 Lubrication System. . . . . (86)

Description	Type	Standard value	Repair limits	Service limit
Engine oil				
Engine oil		Upper limit: 4.2 lit. (1.11 gal), Lower limit: 2.7 lit. (0.71 gal): 0.5 lit. (0.13 gal) in oil filter not included		
Oil specification				
API classification		Class CC or higher		
Viscosity				
Summer: 20°C (68°F) or higher		SAE 30 or 10W−30		
Spring and autumn: 5 to 20°C (41 to 68°F)		SAE 20 or 10W−30		
Winter: 5°C (41°F) or lower		SAE 10W−30		

Description	Type	Standard value	Repair limits	Service limit
Oil pump	Trochoid type			
Check valve opening pressure		4 kg/cm² (56.9 psi)		
Clearance between outer rotor and body		0.15 to 0.2 (0.0059 to 0.0079)		0.3(0.0118)
Clearance between outer rotor and inner rotor		0.05 to 0.12 (0.0020 to 0.0047)		0.25 (0.0098)
Clearance between rotor and cover		0.03 to 0.07 (0.0012 to 0.0028)		0.2 (0.0079)
Oil pressure switch				
Contact closing pressure		0.15 to 0.3 kg/cm² (2.13 to 4.27 psi)		

3-3 Fuel System . . . . . (87)

Description	Type	Standard value	Repair limits	Service limit
Fuel used		Diesel fuel		
Fuel filter	Filter paper type			
Fuel pump	Electromagnetic type			
Delivery		225cc (13.73 cu.in.) min./15 sec. 12V		
Fuel injection pump	ND-PFR3M			
Fuel injection rate				
At smoke set (SS)	K3H-11	1350 rpm: 30.5 ± 1.0 mm³/st		
	K3M-11A	1350 rpm: 33 ± 1.0 mm³/st		
	K3M-61A			
At start set (MS)	K3H-11	150 rpm: 53.5 ± 7.5 mm³/st		
	K3M-11	150 rpm : 66 ± 7.5mm³/st		
	K3M-61A			
Difference from reference cylinder		2 mm³ (0.00012 cu.in.) /rev. cyl. max.		
Prestroke		2.2 ± 0.1 (0.0866 ± 0.0039)		

Description	Type	Standard value	Repair limits	Service limit
Nozzle	Throttle type ND-DN4SD24			
Injection starting		$160\ ^{+10}_{-0}$ kg/cm² ($2276 \pm \ ^{142}_{0}$ psi)	160 ± 10 kg/cm² (2276 ± 142 psi)	

3-4 Governor System ..... (88)

Description	Type	Standard value	Repair limits	Service limit
Governor	Centrifugal weight type			

3-5 Cooling System ..... (88)

Description	Type	Standard value	Repair limits	Service limit
Cooling fan (K3H, M)	5-blade unequal pitch suction	340 (11.42)ϕ		
Fan belt	HM type (LL)	972 (38.27)		
Water pump	Centrifugal impeller type			
Thermostat (Models equipped with thermostat only)	Wax type			
o For K3H, M-11A, 12A				
Valve opening temperature		82 ± 1.5°C (180 ± 2.7°F)		
Temperature (Valve lift 8mm or more)		95°C (203°F)		
o For K3M-61A				
Valve opening temperature				
Temperature (Valve lift 8mm or more)				
Thermoswitch (K3H-11)				
Contact closing temperature		108 to 114°C (227 to 238°F)		
Thermo unit (K3M-11) Temperature/Resistance value		50°C (122°F)/350 ± 20Ω 90°C (194°F)/81 ± 5Ω 120°C (248°F)/36.2 ± 2.5Ω		
		76.5 ± 1.5°C (169.7 ± 2.7°F) 90°C (194°F)		

Description	Type	Standard value	Repair limits	Service limit
Starter (1.6kW) For K3H-11AE	Electromagnetic push-in type M0002T50381			
Output–voltage		1.6kW–12V		
Rotating direction		Clockwise as viewed from pinion side		
No-load characteristics [20°C(68°F)]				
Terminal voltage		11.5V		
Current		90A or less		
Speed		3,600 rpm or more		
Brush length		17 (0.67)		11.5 (0.45)
Spring pressure		1.5 kg (3.31 lbs.)		0.7 kg (1.54 lbs.)
Pinion gap		0.5 to 2.0 (0.0197 to 0.0787)		
Thrust gap		0.5 (0.0197) or less		
Starter (2kW)	Electromagnetic push-in type			
(For K3H, M-11A, 12A)	Model M002T56271			
(For K3M-61A)	Model M002T56272			
Output–voltage		2kW–12V		
Rotating direction		Clockwise as viewed from pinion side		
No-load characteristics [20°C(68°F)]				
Terminal voltage		11V		
Current		130A or less		
Speed		3,850 rpm or more		
Spring pressure		1.5 kg(3.31 lbs.)		0.7kg (1.54 lbs.)
Pinion gap		0.5 to 2.0 (0.0197 to 0.0787)		
Thrust gap		0.5 (0.0197) or less		
Alternator	AC type Model $AH2035M_4$			
Output–voltage		12V–35A		
Direction of rotation		Clockwise as kewed from pulley side		
No load output Characteristics 20°C(68°F)				
Terminal voltage		14V		
Current (Cold)		8A		
Speed (Alternator)		1300 rpm or less		
Load characteristics: 20°C(68°F)				
Terminal voltage		14V		
Current (Cold)		30A or more		
Speed (Alternator)		2500 rpm		
Regulator	Tirrill 2-element $RQB\ 2220D_4$			
Regulating voltage		14.8 ± 0.3V		
Pilot lamp OFF voltage		4.2 to 5.2V		
Pilot lamp ON voltage		0.5 to 3.0V		
Glow plug				
General type For K3H-11AE, (with circular nut) K3M-61A	Sheathed type Model: Y-110			
Voltage–current		10.5V–10A		
Resistance value		1 to 1.2Ω		

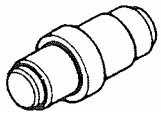
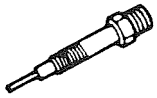
Description	Type	Standard value	Repair limits	Service limit
Quick-heat type For K3H, M (with hex. nut) −11A, 12A	Sheathed type Model: Y-114T			
Voltage−current		10.5V−9.7A		
Resistance value		0.16Ω		
Glow plug indicator (General type)	Red-hot type Model: X3856-007/114			
Rated current		30A		
Terminal voltage (at 30A)		0.9 to 1.1V		
Glow plug indicator (For quick-heat type)	Red-hot type Model: DH-139V−29			
Rated current		29A		
Terminal voltage (at 29A)		1.5 ~ 1.9V		

4. Tightening Torque Chart . . . . . (91)

Description	Tightening torque	
	kg-m	ft. lbs.
Cylinder head bolt M14 screws 8	15 to 16	108 to 116
Cylinder head bolt M14 screws 3 (tappet side)	10 to 11	72 to 80
Crank pulley nut	20 to 25	145 to 181
Main bearing cap bolt	5 to 5.5	36 to 40
Connecting rod cap nut	4 to 4.3	29 to 31
Flywheel mounting bolt (8T)	11.5 to 12.5	83 to 90
Oil pan drain plug	5 to 6	36 to 43
Oil filter	1.1 to 1.3	8 to 9
Fuel injection pump		
Delivery valve holder	4 to 5	29 to 36
Nozzle holder		
Holder mounting bolt	1.5 to 2	10.8 to 14.5
Holder body and retaining nut	6 to 8	43.4 to 57.8
Glow plug	1.5 to 2	10.8 to 14.5

General screws . . . . . Screw dia.	Head Mark (material)		
	4	7	10
M6	0.3−0.5 (2.2−3.6)	0.8−1.0 (5.8−7.2)	1.0−1.3 (7.2−9.4)
M8	1.0−1.3 (7.2−9.4)	1.5−2.2 (10.8−15.9)	2.5−3.5 (18.1−25.3)
M10	1.8−2.5 (13.0−18.1)	3.0−4.2 (21.7−30.4)	5.0−7.0 (36.2−50.6)
M12	3.0−4.2 (21.7−30.4)	5.5−7.5 (39.8−54.2)	9.5−12.0 (68.7−86.8)
M14	5.0−7.0 (36.2−50.6)	8.0−11.0 (57.9−79.6)	16.0−19.0 (115.7−137.4)

6. Special Tools . . . . . (92)

Tool No.	Tool name	Sketch	Use
ST332340	Camshaft bushing installer		Removal and installation of camshaft front bushing
ST332230	Compression gauge adaptor	 5/8-18 UNF (Gauge side)	Measurement of compression pressure
MD998054	Oil pressure switch socket wrench (26)		Removal and installation of oil pressure switch