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TO THE READER

This Workshop Manual has been prepared to provide servicing personnel with information on the mechanisms, service and maintenance of Universal Diesel Engines Models **12, 18 & 25**. The basic block is manufactured by Kubota to Universal specs. It is divided into two parts, "Mechanisms" and "Disassembly and Servicing."

■ Mechanisms

Information on construction and functions is included for each engine section. This part should be understood before proceeding to troubleshooting, disassembly or servicing.

■ Disassembly and Servicing

Under the heading "General" come general precautions, troubleshooting, lists of servicing specifications and periodic inspection items. For each engine section, there are "Checking and Adjustment," "Disassembly and Assembly," and "Servicing" which cover procedures, precautions, factory specifications and allowable limits.

All information, illustrations and specifications contained in this manual are based on the latest production information available at the time of publication. The right is reserved to make changes in all information at any time without notice.

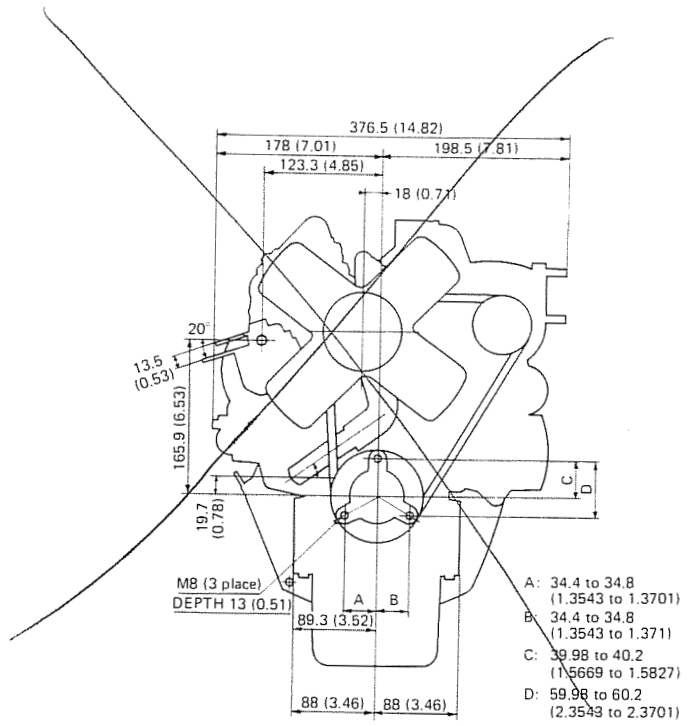
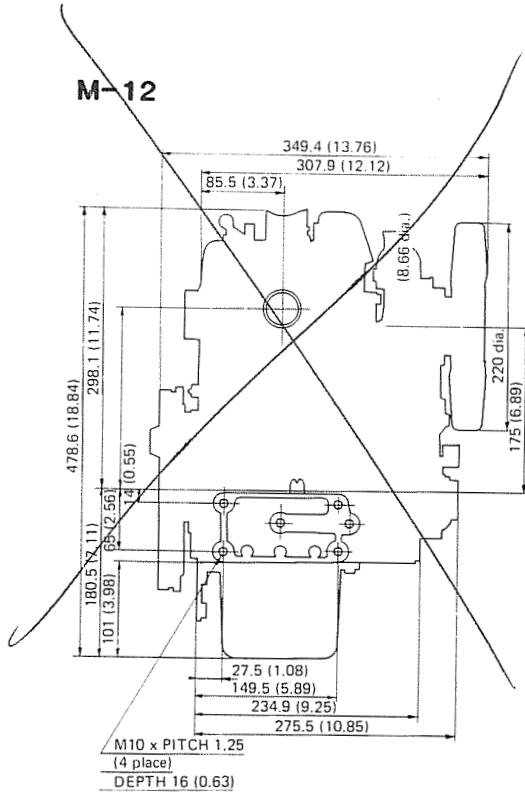
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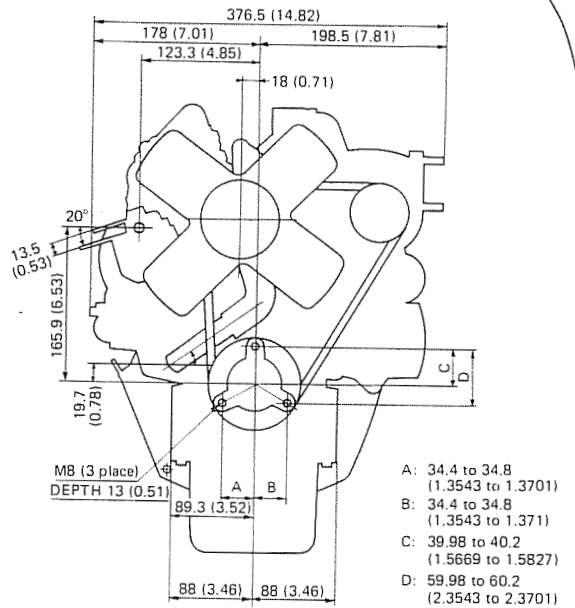
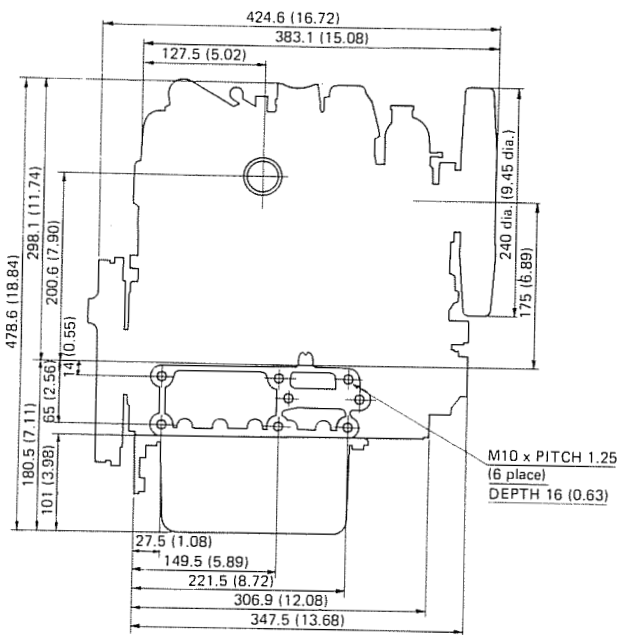
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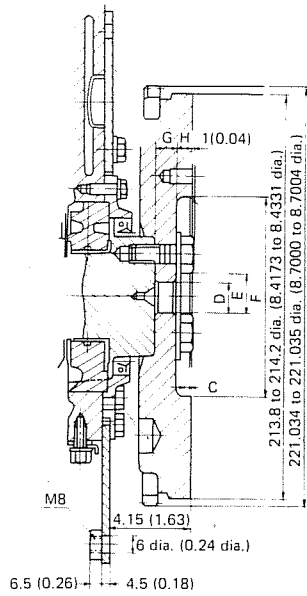
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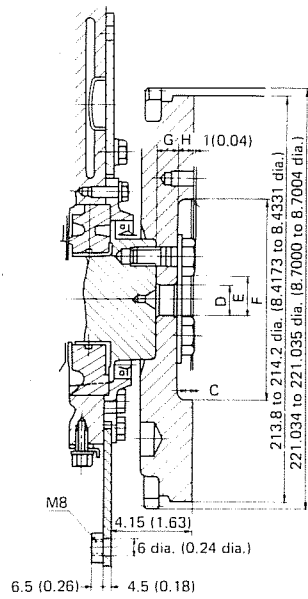
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- C: 4.00 to 4.05
(0.1575 to 0.1594)
- D: 16.000 H8 to 16.027 H8 dia.
(0.6299 H8 to 0.6310 H8 dia.)
- E: 25.4 dia.
(1.00 dia.)
- F: 106.000 H8 to 106.054 H8 dia.
(4.1732 H8 to 4.1754 H8 dia.)
- G: 12(0.47)
- H: 8(0.31)

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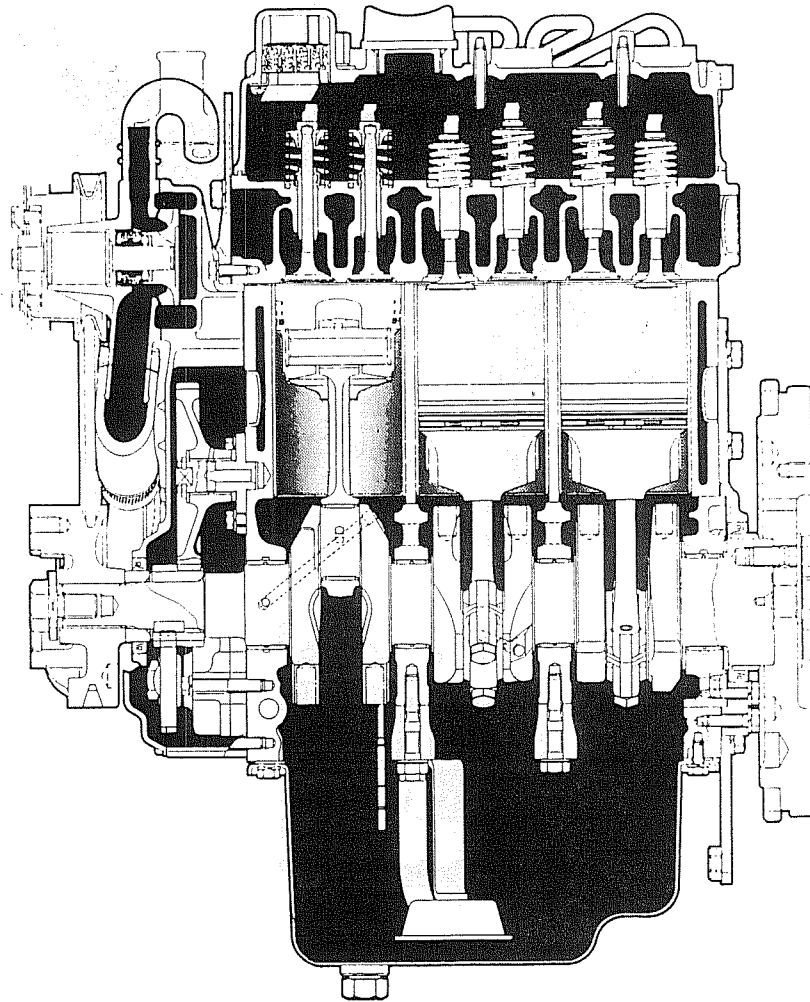


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- G: 12(0.47)
- H: 8(0.31)

Unit: mm (in.)

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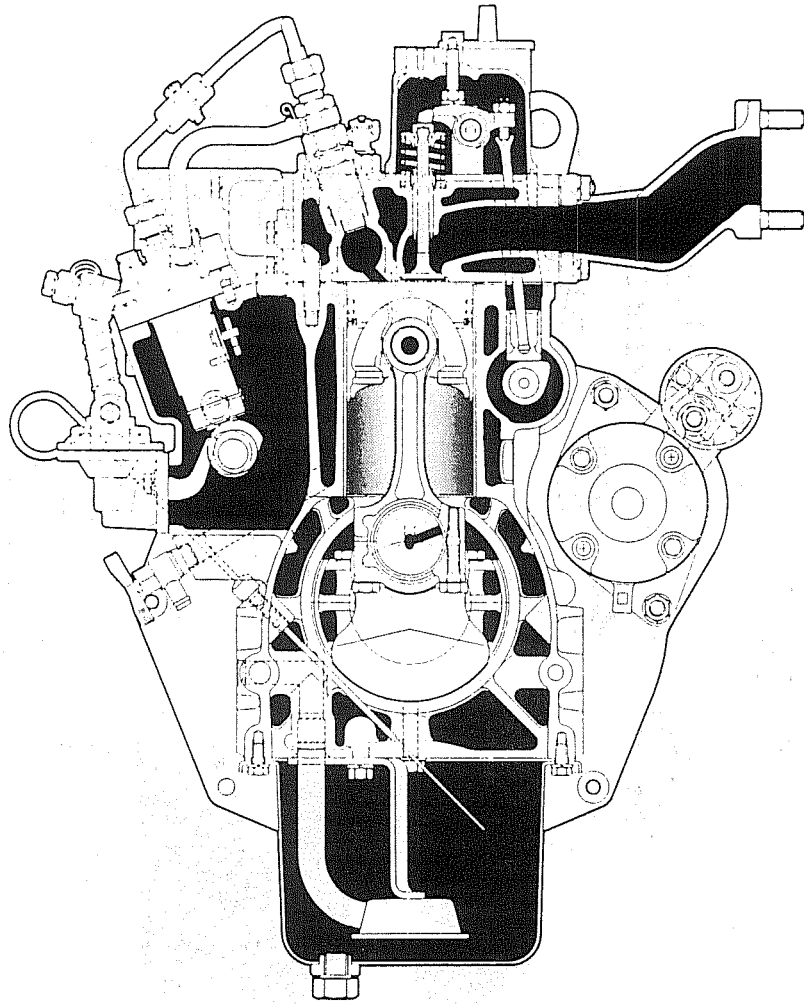
FEATURE



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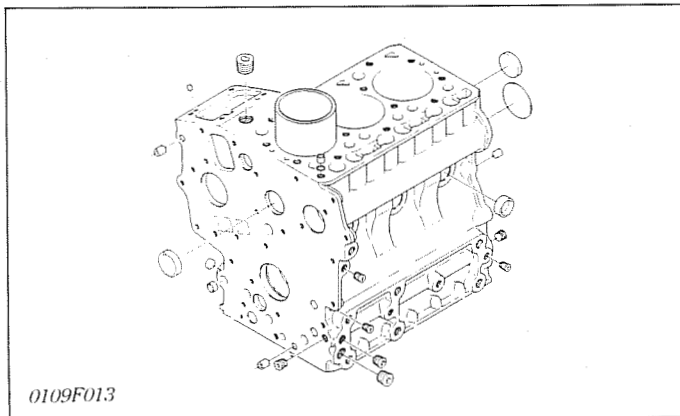
Models **12, 18 & 25** are vertical, water-cooled, 4-cycle diesel engines.

They incorporate UNIVERSAL'S foremost technologies. With UNIVERSAL'S spherical combustion chamber, well-known Bosch MD mini type injection pump and the well-balanced design, they give greater power, low fuel consumption, little vibration and quiet operation.



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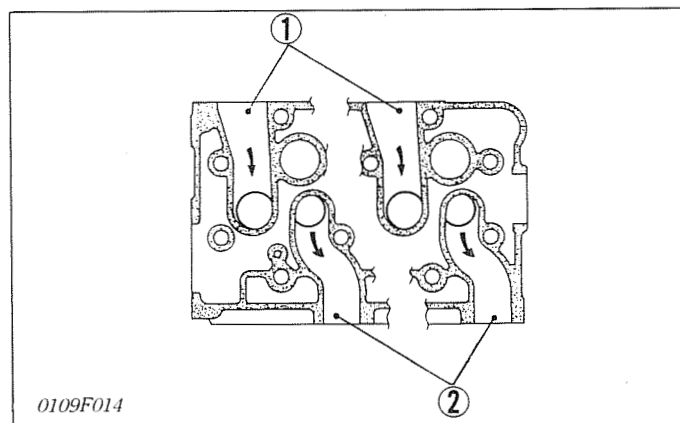
ENGINE BODY



[1] CYLINDER BLOCK

The engine has a highly durable tunnel-type cylinder block in which the bearings, pistons, crankshaft and camshafts are installed.

There are two types of cylinder block. One has dry-type cylinder liners and the other has no liners. The cylinder liners are pressure-fitted into the cylinder block.

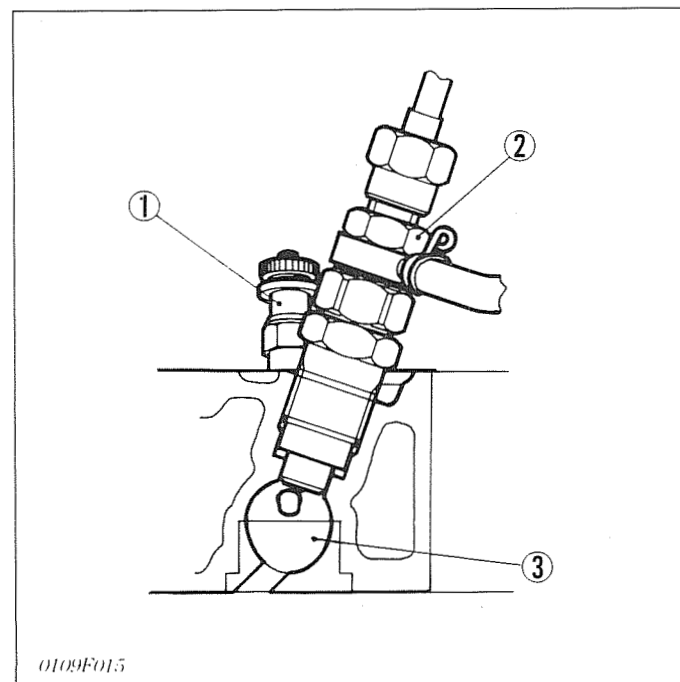


[2] CYLINDER HEAD

(1) Inlet and Outlet Port

The cylinder head has cross-flow type inlet/exhaust ports, which lower the heat conduction from the exhaust port to the inlet port. The low heat conduction keeps the inlet air from being heated and expanded by the exhaust gas.

- (1) Inlet Port
- (2) Outlet Port



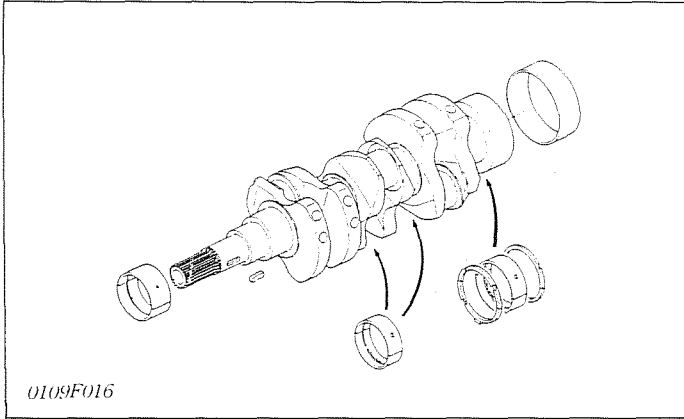
(2) Combustion System

Exclusive spherical combustion system – “TVCS” (Three Vortex Combustion System) – whirls the air and mixes it with the fuel effectively to accelerate combustion and reduce fuel consumption.

Sheathed type glow plugs are installed in the combustion chamber to ensure easy engine starting even at -15°C (5°F).

The injection nozzles are of the throttle type.

- (1) Glow Plug
- (2) Injection Nozzle
- (3) Combustion Chamber

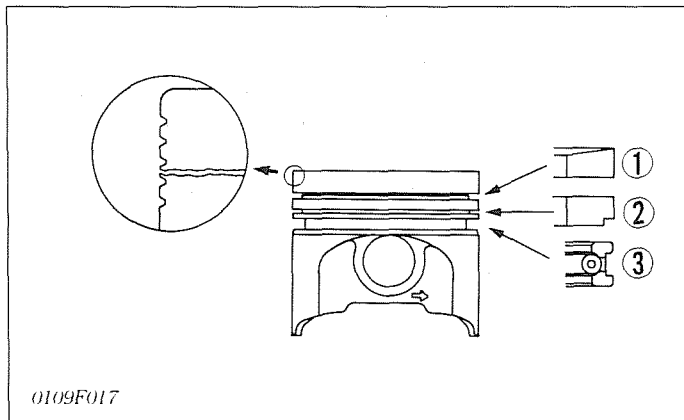


[3] CRANKSHAFT

The crankshaft with the connecting rod converts the reciprocating motion of the piston into rotating motion to driver the oil pump and camshafts.

The crankshaft has counterweights opposite the cranks to balance the weight of the offset cranks.

The crankshaft has oil passages drilled so that oil can flow from the main bearings to the connecting rod bearings. The front journal is supported by a sleeve type bearing, the intermediate journal by a split type, and the rear by a split type with a thrust bearing.



[4] PISTON AND PISTON RINGS

The piston has a slightly oval shape when cold (in consideration of thermal expansion) and a flat head.

Three rings are installed in grooves in the piston.

The top compression ring (1) is a keystone type, which can stand against heavy loads, and the barrel face on the ring fits well to the cylinder wall.

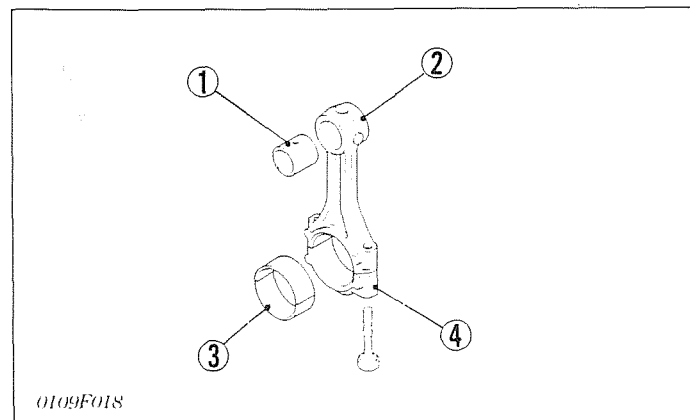
The second compression ring (2) is an undercut type, which effectively prevents the oil from being carried up.

The oil ring (3) has chamfered contact faces and an expander ring, which increase the pressure of the oil ring against the cylinder wall.

Several grooves are cut on the headland area to help heat dissipate and to prevent scuffing.

The piston pin is lightly offset from the centerline of the piston toward the major-thrust-face, so that it contacts the cylinder with minimized "piston slaps."

- (1) Top Compression Ring
- (2) Second Compression Ring
- (3) Oil Ring



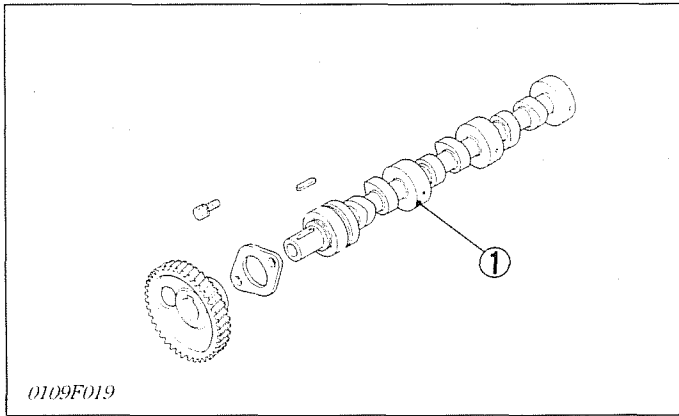
[5] CONNECTING ROD

The connecting rod (2) connects the piston and the crankshaft, and has bearings at both ends.

A solid type small end bushing (1) is installed between the piston pin and the rod.

Split type connecting rod bearing (3) is installed between the crankpin and the rod (2) and between the crankpin and the rod cap (4).

- (1) Small End Bushing
- (2) Connecting Rod
- (3) Connecting Rod Bearing
- (4) Rod Cap



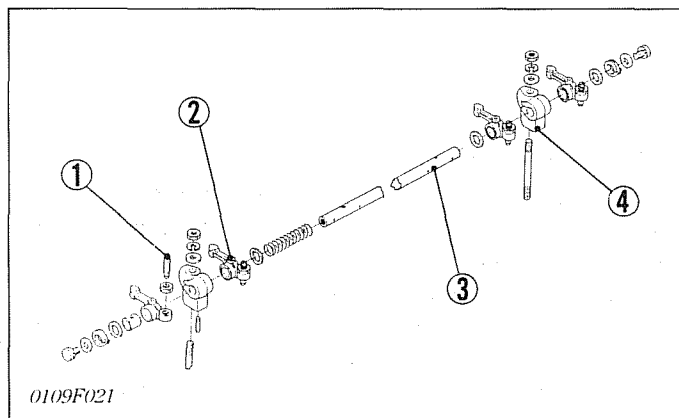
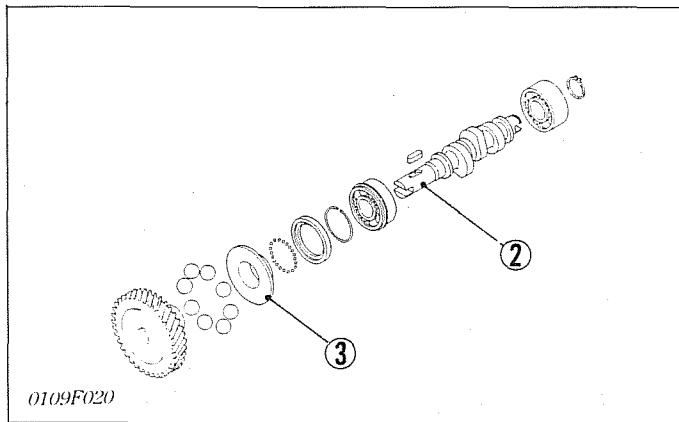
[6] CAMSHAFT AND FUEL CAMSHAFT

The cams on the camshaft (1) cause the inlet and exhaust valves to open as the camshaft rotates. The journals and the bearings are force-lubricated.

The cams on the fuel camshaft (2) cause the injection pump or the fuel pump to feed the fuel.

On the fuel camshaft, the governor sleeve (3) is installed.

- (1) Camshaft
- (2) Fuel Comshaft
- (3) Governor Sleeve



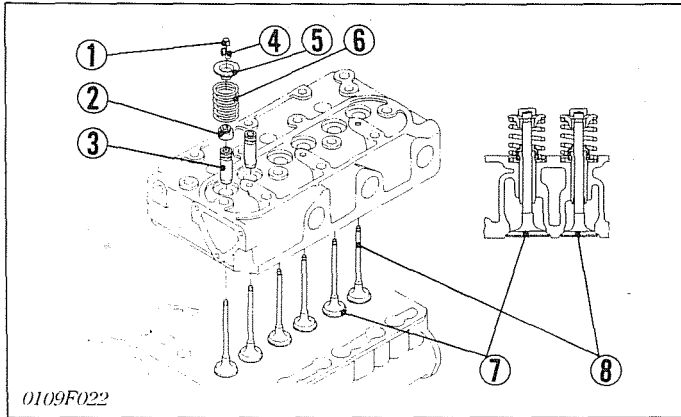
[7] ROCKER ARM ASSEMBLY

The rocker arm assembly includes the rocker arms (2) and an adjusting screw (1), the end of which rests on the push rod, rocker arm brackets (4) and rocker arm shaft (3).

The rocker arms swing and transmits the reciprocating motion of the push rods to the inlet and exhaust valves to open and close them.

Every bearing surface is lubricated through the drilled holes of the bracket and the rocker arm shaft.

- (1) Adjusting Screw
- (2) Rocker Arm
- (3) Rocker Arm Shaft
- (4) Rocker Arm Bracket

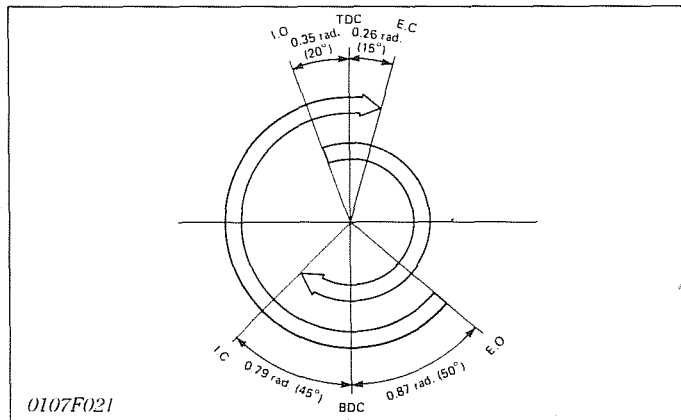


[8] INLET AND EXHAUST VALVES

The valve and its guide for the inlet are different from those for the exhaust.

Other parts, such as the spring (6), spring retainer (5), collet (4), stem seal (2) and cap (1) are the same for both the inlet and exhaust.

- (1) Cap
- (2) Stem Seal
- (3) Valve Guide
- (4) Collet
- (5) Spring Retainer
- (6) Spring
- (7) Inlet Valve
- (8) Exhaust Valve

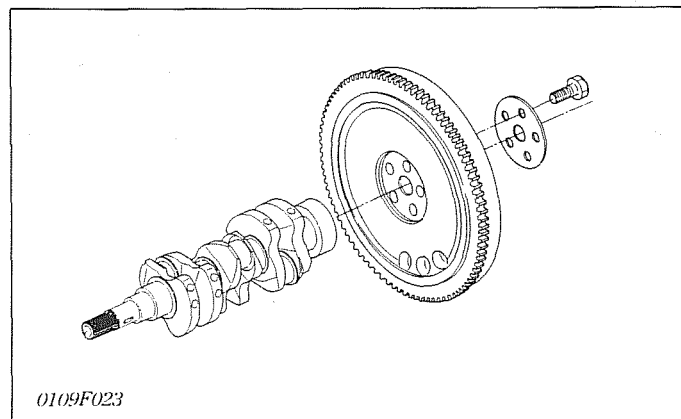


[9] VALVE TIMING

The timing for opening and closing the valve is extremely important to achieve effective air intake and sufficient gas exhaust.

The appropriate timing can be obtained by aligning the marks on the crank gear and the cam gear when assembling.

Inlet valve open (I.O)	0.35 rad. (20°) before T.D.C.
Inlet valve close (I.C)	0.79 rad. (45°) after B.D.C.
Exhaust valve open (E.O)	0.87 rad. (60°) before B.D.C.
Exhaust valve close (E.C)	0.26 rad. (15°) after T.D.C.



[10] FLYWHEEL

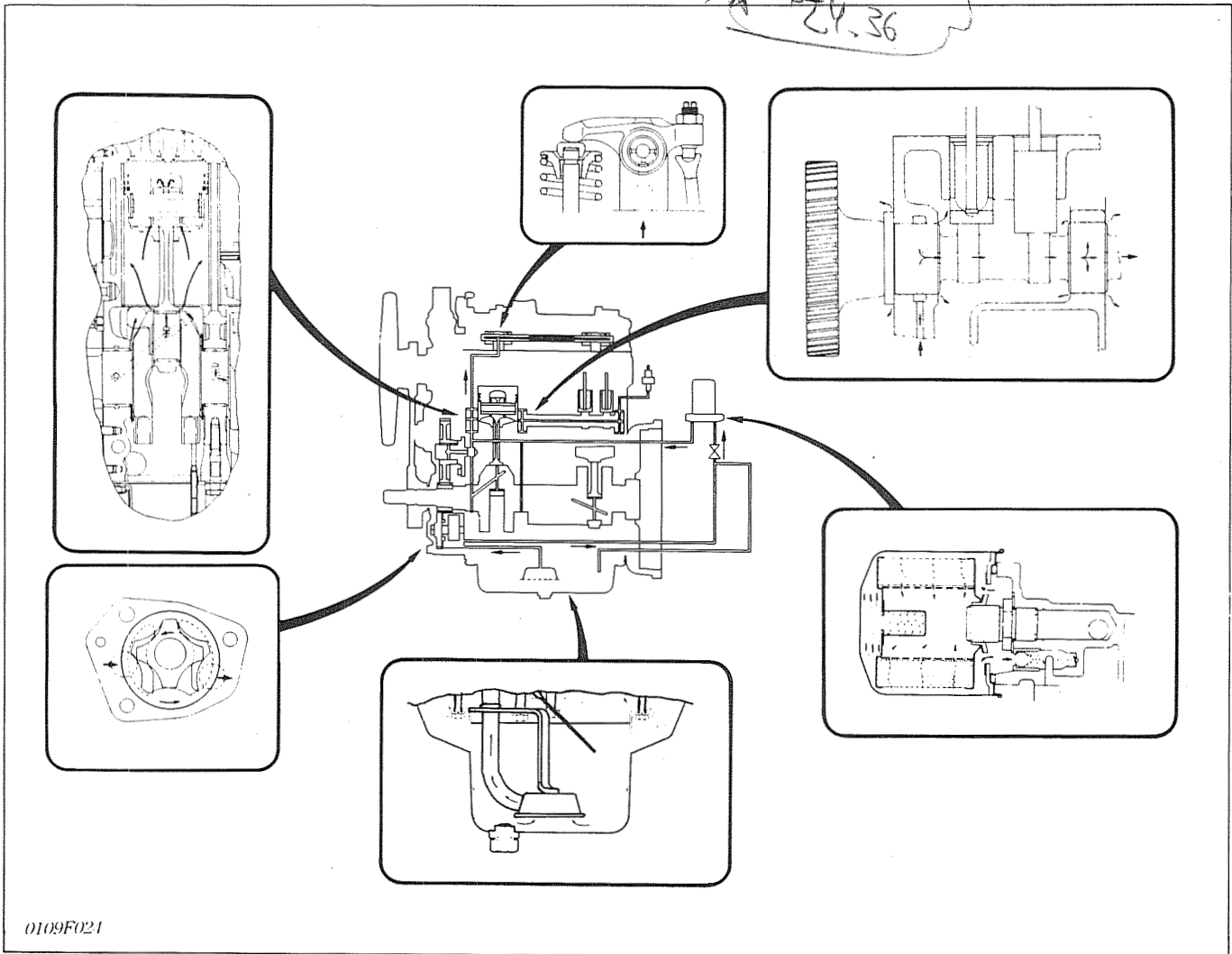
The flywheel is installed on the rear end of the crankshaft and its inertia tends to keep it turning at a constant speed, while the crankshaft tries to speed up during the power stroke and slow down during other strokes.

The flywheel has gear teeth around its outer rim, which mesh with the drive pinion of the starter.

The flywheel also has marks on its outer rim. Each must be aligned with the mark on the rear end plate to get the top dead centers and the injection timings.

LUBRICATING SYSTEM

299700 OIL MAXIP
 299964 OIL SENDOUT
 # 70.39
 24.36



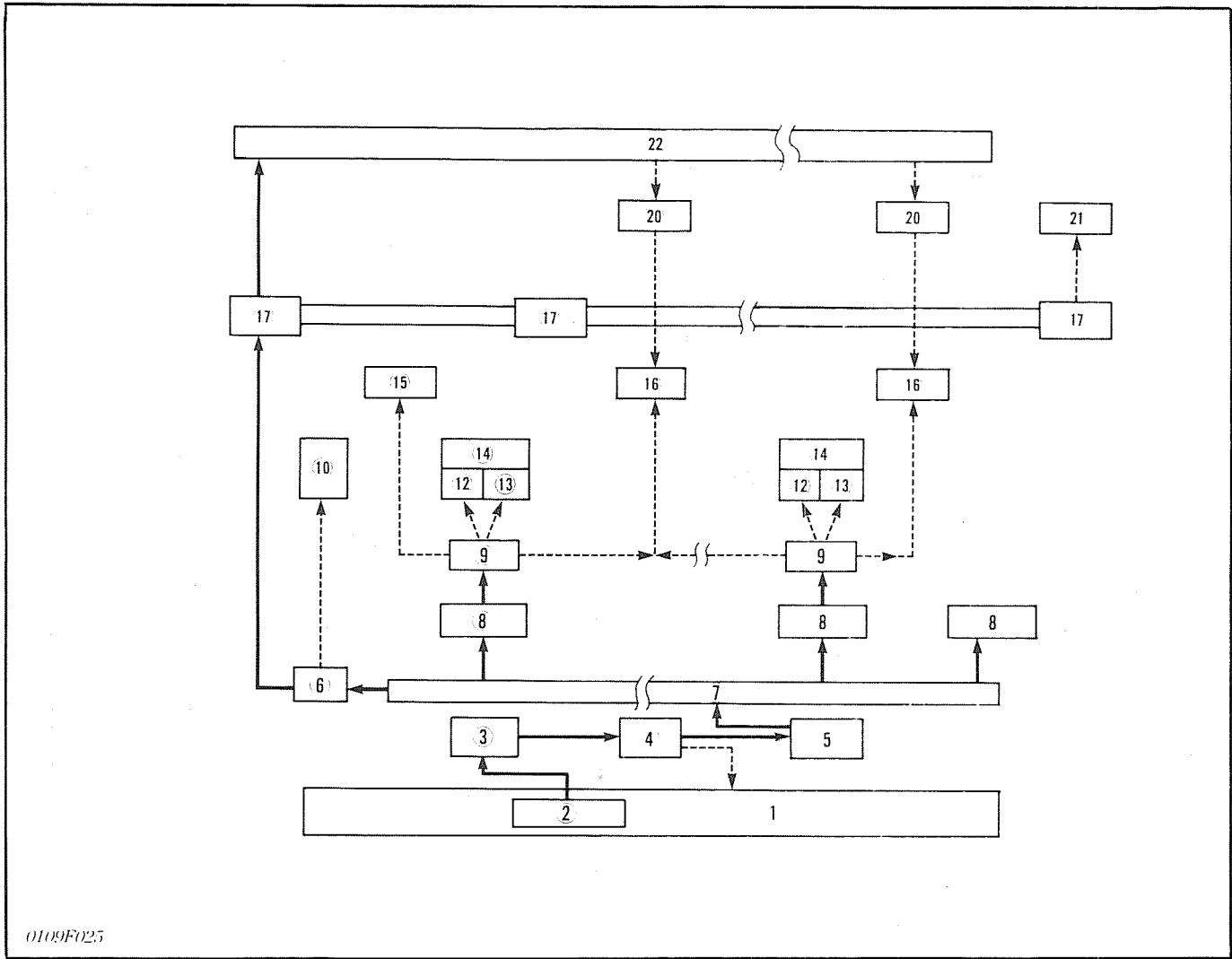
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The lubricating system consists of an oil strainer, an oil pump, a relief valve, an oil filter cartridge and an oil pressure switch. The oil pump sucks the lubricating oil in the oil pan through the strainer and sends it to the oil filter cartridge, where the oil is further filtered.

The filtered oil is forced to the crankshaft, the connecting rods, the idle gear, the camshaft and the rocker arm shaft through the oil passage in the crankcase and the shafts to lubricate the bearings.

Some oil, splashed by the crankshaft or thrown off from the bearings, lubricates other engine parts: the pistons, the cylinder walls, the piston pins, the tappets, the pushrods, the timing gears, and the inlet and exhaust valves.

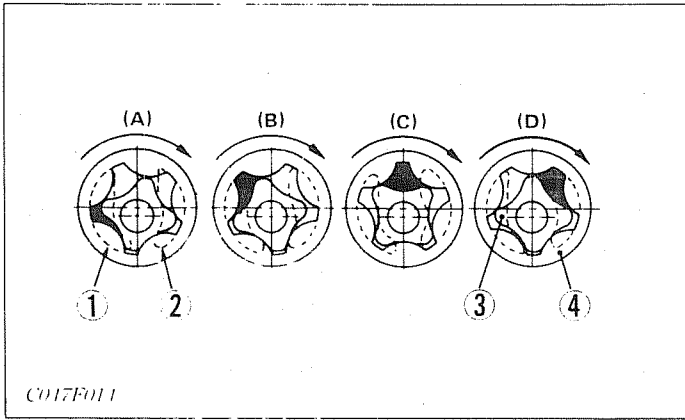
- [A] Piston
- [B] Oil Pump
- [C] Rocker Arm and Rocker Arm Shaft
- [D] Oil Strainer
- [E] Camshaft
- [F] Oil Filter Cartridge and Relief Valve



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Engine Oil Flow

- | | | | |
|--------------------------|----------------------|-----------------------|-----------------------|
| (1) Oil Pan | (7) Main Oil Gallery | (13) Small End | (19) Drain |
| (2) Oil Strainer | (8) Main Bearing | (14) Piston | (20) Rocker Arm |
| (3) Oil Pump | (9) Big End | (15) Fuel Camshaft | (21) Oil Switch |
| (4) Relief Valve | (10) Timing Gear | (16) Tappets | (22) Rocker Arm Shaft |
| (5) Oil Filter Cartridge | (11) Splash | (17) Camshaft Bearing | |
| (6) Idle Gear | (12) Cylinder | (18) Camshaft | |



[1] OIL PUMP

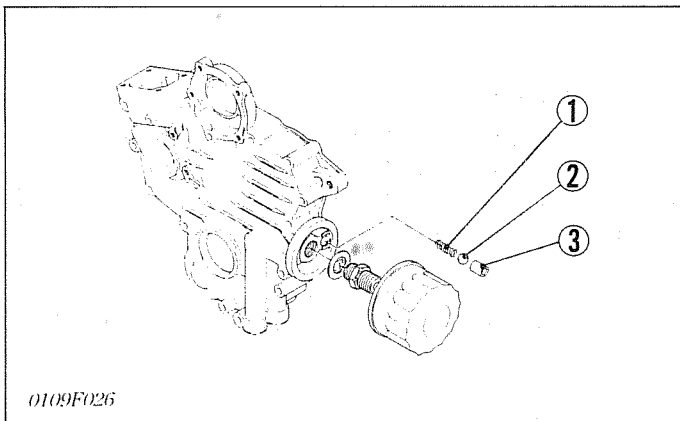
The oil pump is a gear pump, whose rotors have trochoid lobes. The inner rotor (3) has 4 lobes and the outer rotor (4) has 5 lobes, and they are eccentrically engaged with each other. The inner rotor, which is driven by the crankshaft through the gears, rotates the outer rotor in the same direction, varying the space between the lobes.

While the rotors rotate from (A) to (B), the space leading to the inlet port increases, which causes the vacuum to suck in the oil from the inlet port.

When the rotors rotate to (C), the connection to the space switches from the inlet port to the outlet port.

At (D), the space decreases and the sucked oil is discharged from the outlet port.

- (1) Inlet Port
- (2) Outlet Port
- (3) Inner Rotor
- (4) Outer Rotor



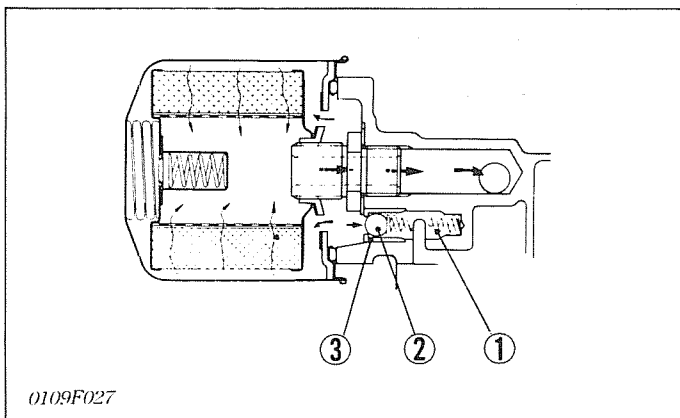
[2] RELIEF VALVE

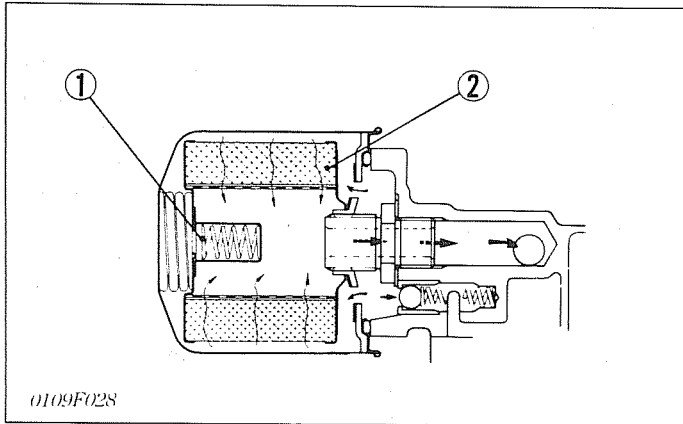
The relief valve prevents damage to the lubricating system due to the high pressure of the oil.

The relief valve is a ball type direct acting one, and is best suited for low pressures.

When the pressure of the oil, forced by the pump, exceeds the specified value, the oil pushes back the ball (3) and escapes to the oil pan.

- (1) Spring
- (2) Ball
- (3) Valve Seat



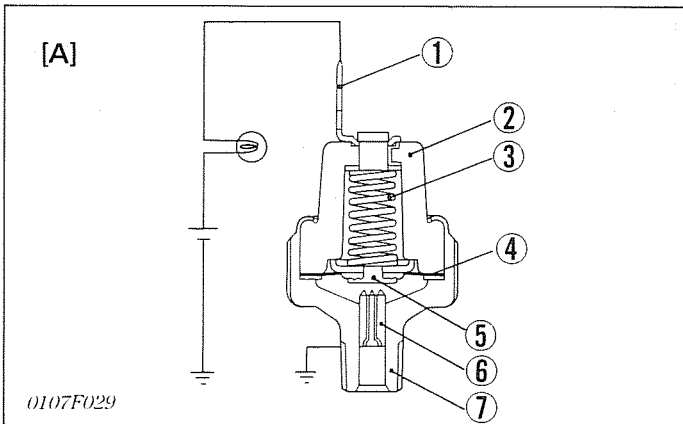
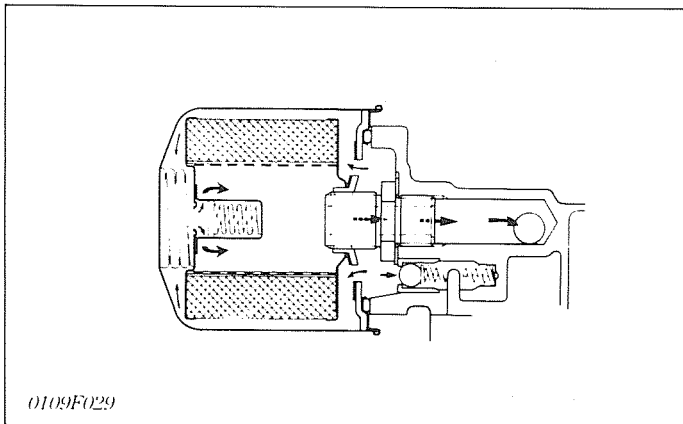


[3] OIL FILTER CARTRIDGE

After lubricating, the lubricating oil brings back various particles of grit and dirt to the oil pan. Those particles and the impurities in the lubricating oil can cause wear or seizure of the engine parts. It may also impair the physical and chemical properties of the oil itself.

The lubricating oil, which is force-fed by the pump, is filtered by the filter cartridge with the filter element (2). When the filter element accumulates on excessive amount of dirt and the oil pressure in the inlet line builds up by 98 kPa (1.0 kgf/cm², 14 psi) more than the outlet line, the bypass valve (1) opens to allow the oil to flow from the inlet into the outlet line, bypassing the filter element.

- (1) Bypass Valve
- (2) Filter Element

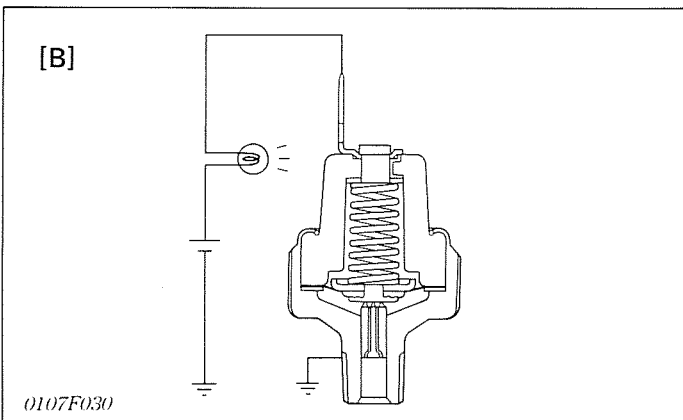


[4] OIL PRESSURE SWITCH

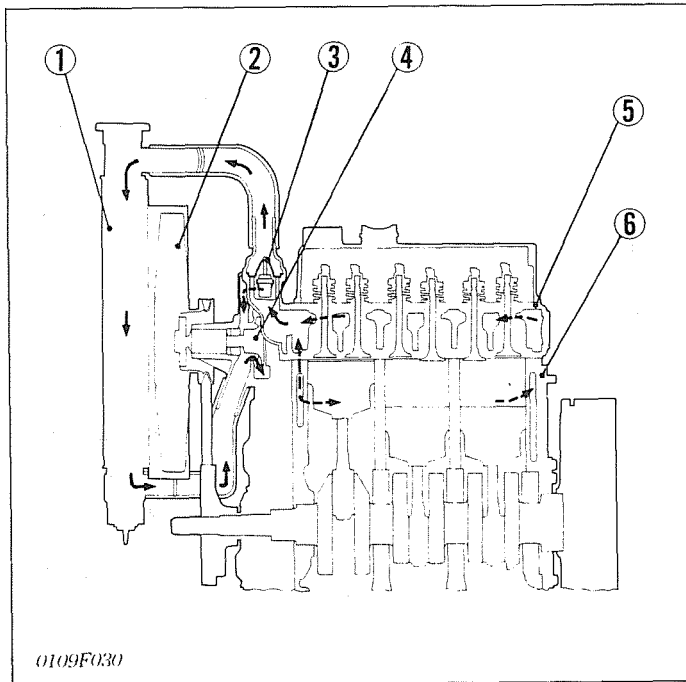
The oil pressure switch is mounted on the crankcase and is led to the lubricating oil passage.

When the oil pressure falls below the specified value, the oil pressure warning lamp lights.

- [A] At the proper oil pressure
- [B] At lower oil pressure, 49 kPa (0.5 kgf/cm², 7 psi) or less
- (1) Terminal
- (2) Insulator
- (3) Spring
- (4) Rubber Gasket
- (5) Contact Rivet
- (6) Contact
- (7) Oil Switch Body



COOLING SYSTEM



The cooling system consists of a radiator (1) (not included in a basic model), a centrifugal water pump (4), a suction fan (2) and a thermostat (3).

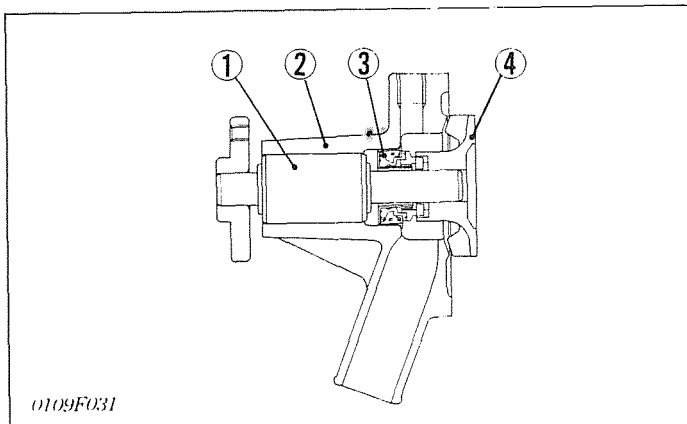
The water is cooled through the radiator core, and the fan behind the radiator pulls the cooling air through the core to improve cooling.

The water pump sucks the water from the radiator or from the cylinder block and forces it into the crankcase.

The thermostat opens or closes according to the water temperature, to allow the water to flow from the cylinder block to the radiator while open, or only to the water pump while closed.

Thermostat opening temperature	Approx. 82°C (180°F)
--------------------------------	----------------------

- (1) Radiator
- (2) Cooling Fan
- (3) Thermostat
- (4) Water Pump
- (5) Cylinder Head
- (6) Cylinder Block

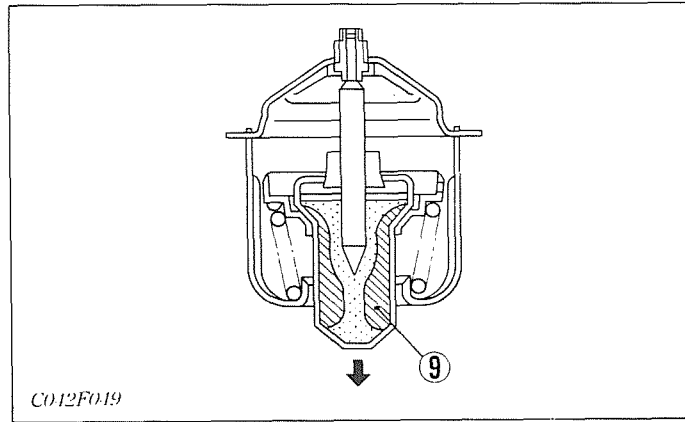
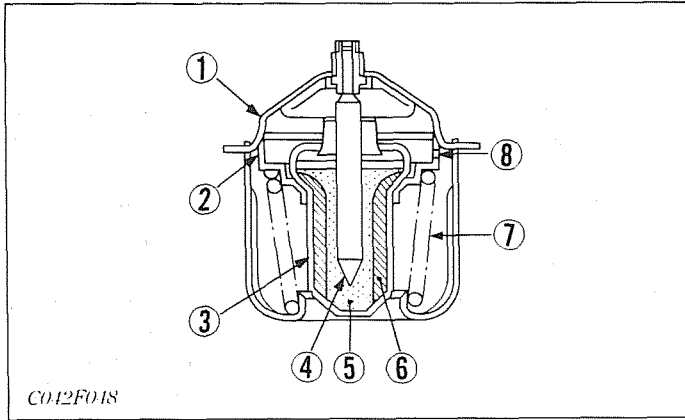


[1] WATER PUMP

The water pump is driven by the crankshaft and a V belt. The rotating impeller (4) in the water pump sucks the cooled water from the radiator and sends it into the water jacket in the crankcase.

The mechanical seal (3) prevents the water from entering the bearing unit (1).

- (1) Bearing Unit
- (2) Water Pump Body
- (3) Mechanical Seal
- (4) Water Pump Impeller



[2] THERMOSTAT

The thermostat is of the wax pellet type.

The thermostat controls the flow of the cooling water to the radiator to keep the proper temperature.

The case, which serves as a valve seat (1), has a spindle inserted in the pellet (3) which is installed to the valve (2). The spindle is covered with the synthetic rubber (5) in the pellet. The wax is charged between the pellet and the rubber.

■ At low temperatures (lower than 82° C (180° F))

The valve (2) is seated by the spring (7) and the cooling water circulates in the engine through the water return pipe without running into the radiator.

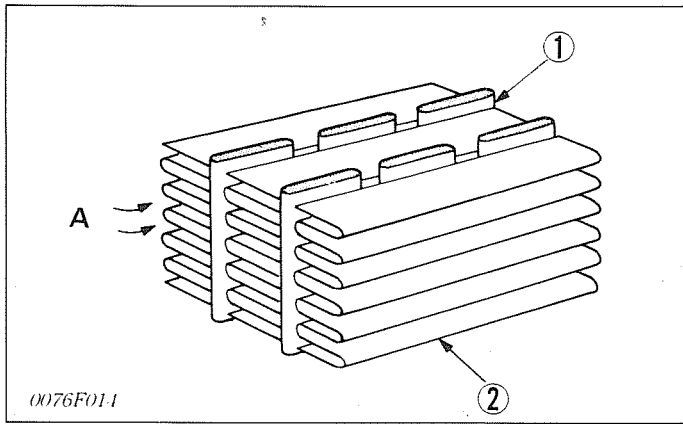
Only the air in the water jacket escapes to the radiator through the leak hole (8) on the thermostat.

■ At high temperature (higher than 82° C (180° F))

As the water temperature rises, the wax in the pellet (3) turns liquid and expands, repelling the spindle, which causes the pellet to lower.

The valve (2) opens to send the cooling water to the radiator.

- (1) Seat
- (2) Valve
- (3) Pellet
- (4) Spindle
- (5) Synthetic Rubber
- (6) Wax (solid)
- (7) Spring
- (8) Leak Hole
- (9) Wax (liquid)

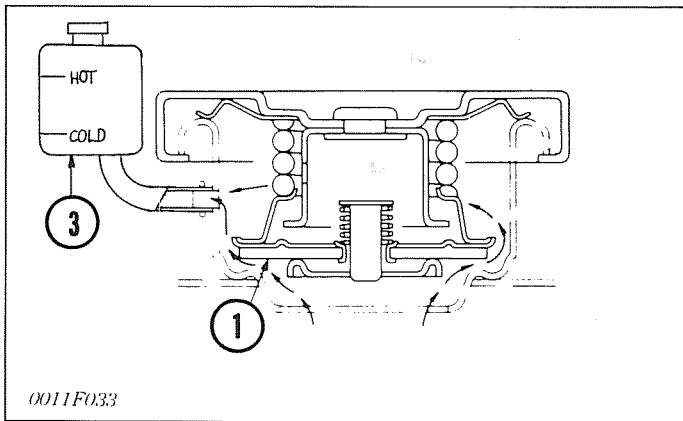
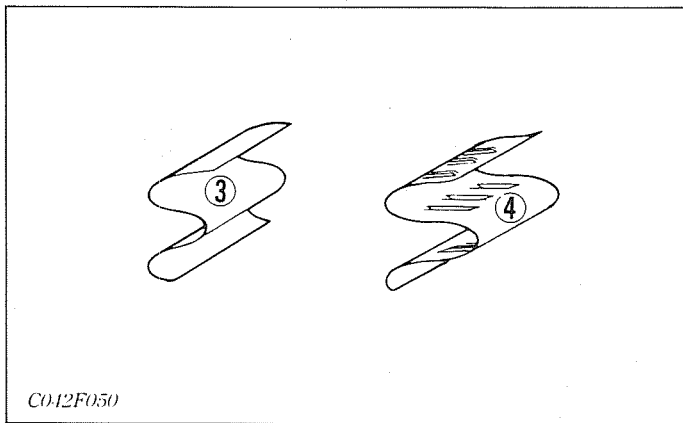


[3] RADIATOR

The radiator core consists of water carrying tubes (1) and fins (2) at a right angle to the tubes. The fin is a louverless, corrugated type which is light in weight, high in heat exchange ratio and less apt to clog.

The water in the tubes is cooled by the air flowing through the tube walls and fins.

- (A) Cooling Air
- (1) Tube
- (2) Fin
- (3) Louverless Corrugated Fin
- (4) Louvered Corrugated Fin

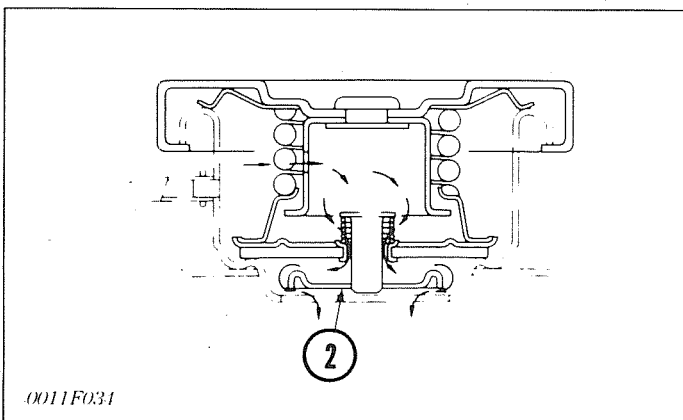


[4] RADIATOR CAP

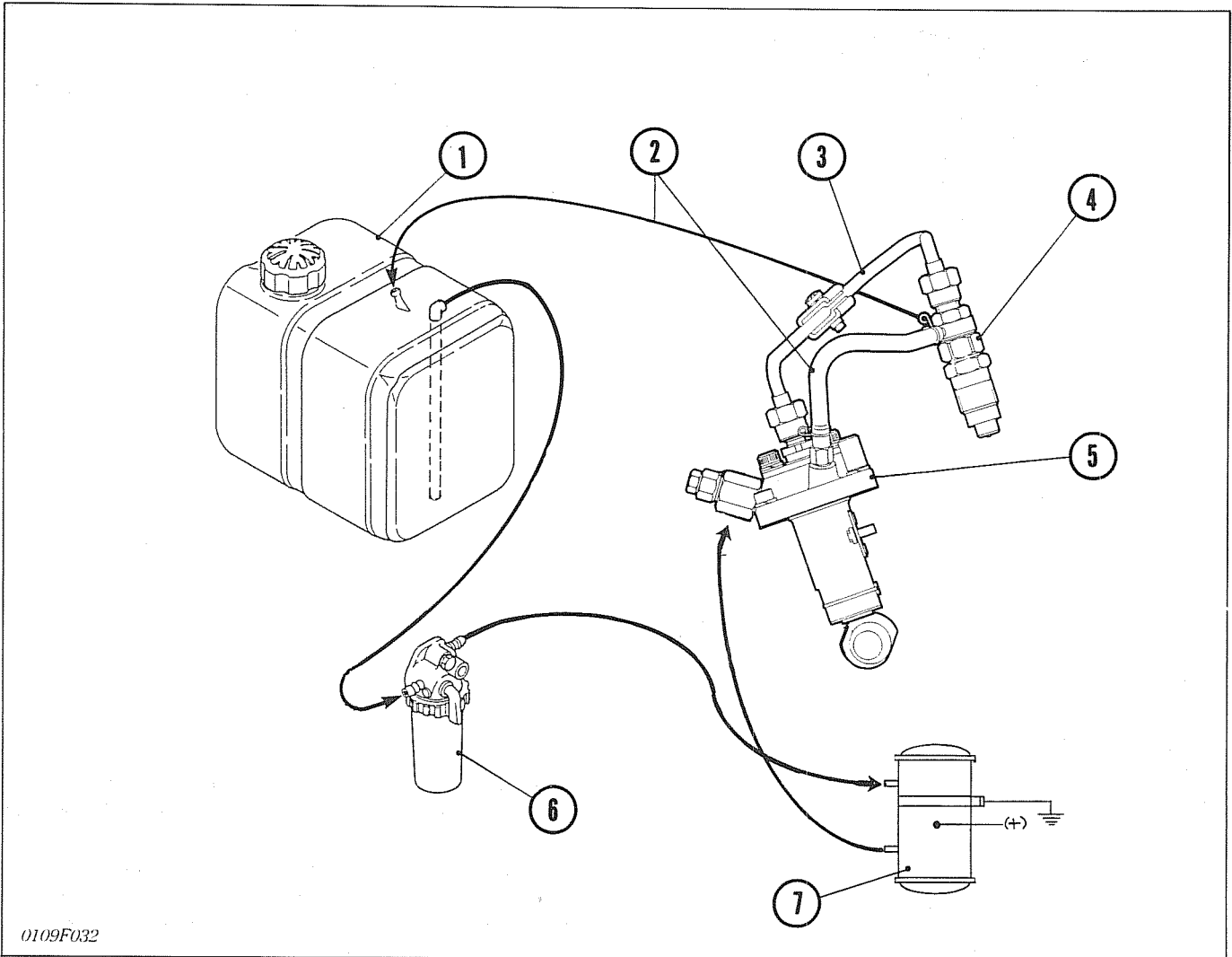
The pressure type radiator cap prevents differences in pressure between the inside and the outside of the radiator from deforming the radiator.

When the water temperature rises and the pressure in the radiator increases above the specified pressure, the pressure valve (1) opens to reduce the internal pressure. When the water temperature falls and a vacuum forms in the radiator, the vacuum valve (2) opens to introduce the coolant into the engine or radiator.

- (1) Pressure Valve
- (2) Vacuum Valve
- (3) Expansion Bottle



FUEL SYSTEM



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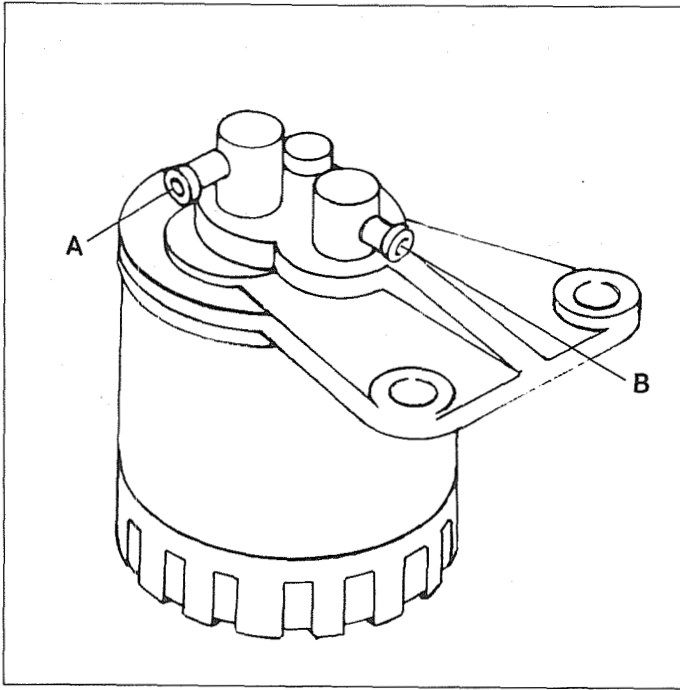
The fuel is fed from the fuel tank (1) (not included in the basic model) through the fuel filter (6) to the injection pump (5) by the fuel feed pump (7) (in the basic model). The injection pump force-feeds the fuel through the injection pipes (3) to the injection nozzles (4), which inject the fuel into the cylinders for combustion.

The excessive fuel in the injection pump and the injection nozzle is collected in the fuel overflow pipes (2) and returns to the fuel tank.

■ **NOTE:**

- Component marked * is not included in the basic model.
- Component marked ** is included only in the basic model.

- * (1) Fuel Tank
- (2) Fuel Overflow Pipe
- (3) Injection Pipe
- (4) Injection Nozzle
- (5) Injection Pump
- (6) Fuel Filter
- ** (7) Fuel Feed Pump (Elec.)

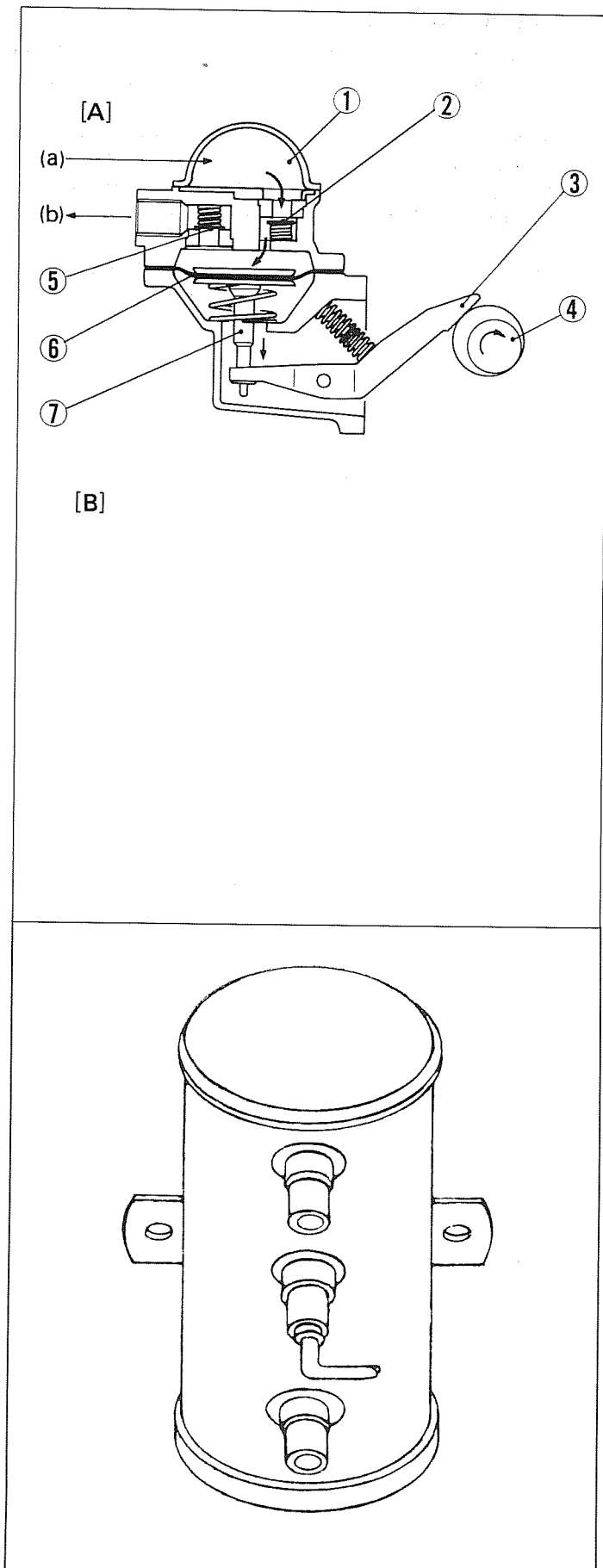


[1] FUEL FILTER

The fuel filter is installed in the fuel line from the fuel tank to the injection pump (between the tank and the feed pump in the basic model).

As the fuel from the inlet (A) of the cock body move through the filter element, the dirt and impurities in the fuel are filtered, allowing only clean fuel to enter the inside of the filter element. The cleaned fuel flows out from the outlet (B) of the cock body.

Before starting or after disassembling and reassembling, loosen the air vent plug (3) to bleed the air in the fuel line.



[2] FUEL FEED PUMP

The filtered fuel is fed to the injection pump by the fuel feed pump.

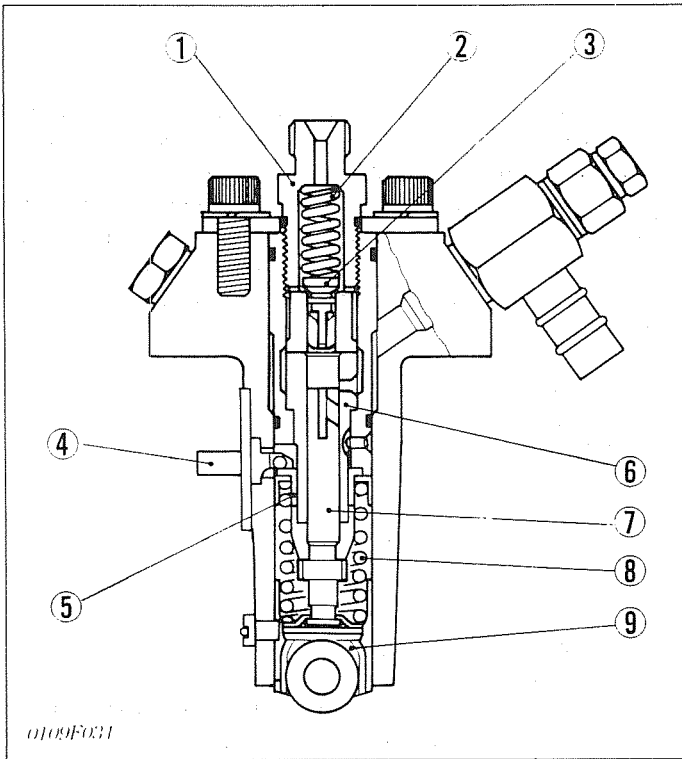
The chamber (1) is enclosed with the inlet valve (2), the outlet valve (5) and the diaphragm (6), which is linked to the rocker arm with the pull rod (7). The rocker arm is swung by the eccentric cam on the fuel camshaft (4).

When the diaphragm is pulled down, vacuum in the chamber (1) causes the outlet valve (5) to close and the atmospheric pressure in the fuel tank to force the fuel into the chamber, opening the inlet valve (2).

When the diaphragm is pushed up by the cam, the pressure in the chamber causes the inlet valve to close and forces out the fuel, opening the outlet valve.

- (A) Inlet Stroke
- (B) Discharge Stroke
- (a) from fuel filter
- (b) to injection pump
- (1) Chamber
- (2) Inlet Valve
- (3) Rocker Arm
- (4) Fuel Camshaft
- (5) Outlet Valve
- (6) Diaphragm
- (7) Pull Rod

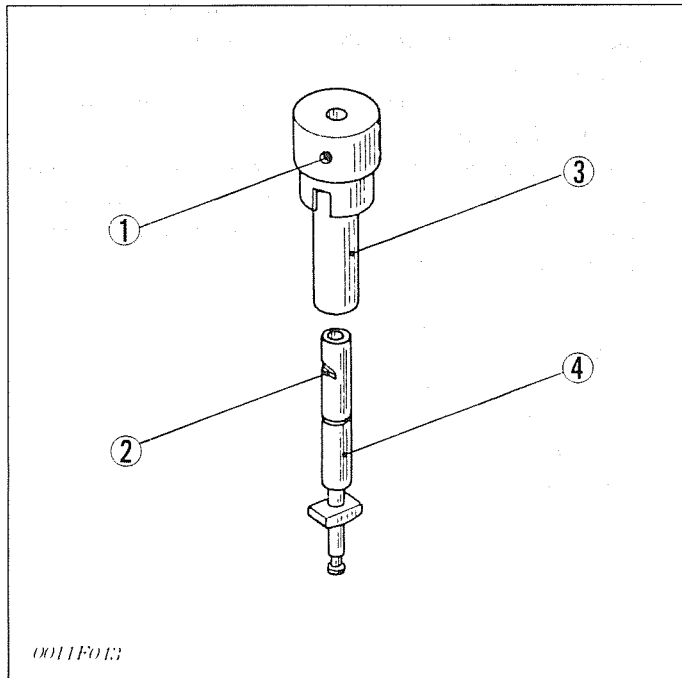
ELECTRIC FUEL PUMP



[3] FUEL INJECTION PUMP

The injection pump is a Bosch MD type mini-injection pump, which gives high injection quality even at low engine speeds. The plunger is reciprocated by the cam on the camshaft with the tappet and forces the fuel into the injection nozzle. The control rack (4) is pushed or pulled by the fork lever of the governor and rotates the control sleeve (5) and the plunger, which has a left-hand lead control groove, to vary the amount of fuel forced into the injection nozzle.

- (1) Delivery Valve Holder
- (2) Delivery Valve Spring
- (3) Delivery Valve
- (4) Control Rack
- (5) Control Sleeve
- (6) Cylinder
- (7) Plunger
- (8) Plunger Spring
- (9) Tappet



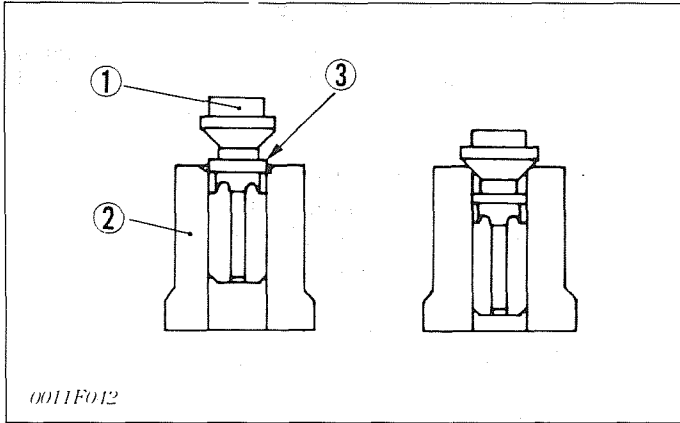
1) Pump Element

The pump element consists of the plunger (4) and cylinder (3), and their sliding surfaces are super precision-machined to maintain fueltightness.

The plunger fits in the control sleeve which is engaged with the control rack.

The plunger has a control groove of with a left-hand helix lead.

- (1) Feed Hole
- (2) Control Groove
- (3) Cylinder
- (4) Plunger



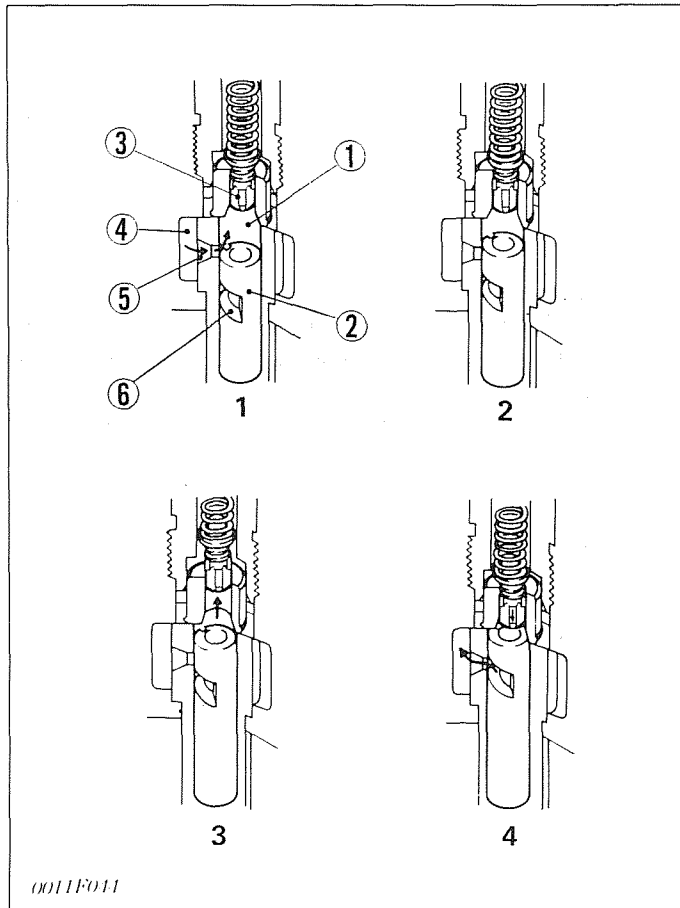
2) Delivery Valve

The delivery valve consists of the valve (1) and the Valve seat (2).

The delivery valve prevents the fuel from flowing back into the delivery chamber through the injection pipe. It also prevents the fuel from dribbling at the injection nozzle.

When the delivery stroke ends the relief plunger moves into the bore of the valve seat and seals the delivery line from the delivery chamber. The relief plunger lowers further until the valve seats suck back the fuel to prevent dribbling at the injection nozzle.

- (1) Valve
- (2) Valve Seat
- (3) Relief Plunger



3) Operation of Pump Element

1. Before delivery

As the tappet lowers, the plunger (2) also lowers and fuel is drawn into the delivery chamber (1) through the feed hole (5) from the fuel chamber (4).

2. Beginning of delivery

When the plunger is pushed up by the cam and the head of the plunger closes the feed hole, the pressure in the delivery chamber rises to push the relief plunger (3) open.

Fuel is then force-fed into the injection pipe.

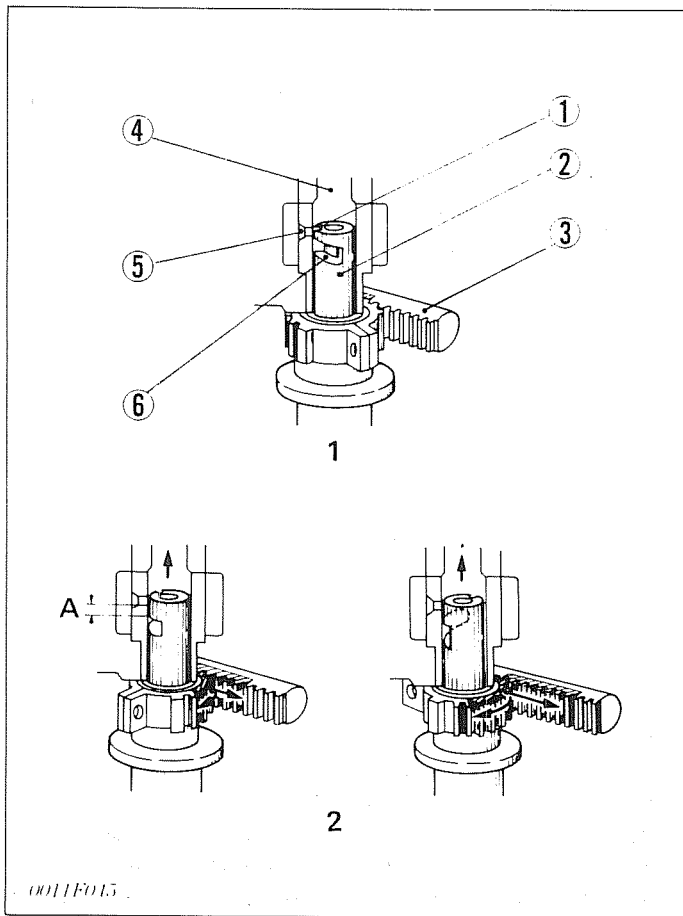
3. Delivery

While the plunger is rising, the delivery of fuel continues.

4. End of delivery

When the plunger rises further and the control groove (6) on its periphery meets the feed hole, the fuel returns to the fuel chamber from the delivery chamber through the control groove and the feed hole.

- (1) Delivery Chamber
- (2) Plunger
- (3) Relief Plunger
- (4) Fuel Chamber
- (5) Feed Hole
- (6) Control Groove



4) Plunger Position

1. No fuel delivery

At the engine stop position of the control rack (3), the lengthwise slot (1) on the plunger (2) aligns with the feed hole (5). And the delivery chamber (4) is led to the feed hole during the entire stroke of the plunger.

The pressure in the delivery chamber does not build up and no fuel can be forced to the injection nozzle.

2. Fuel delivery

The plunger is rotated (See figure) by the control rack. When the plunger is pushed up, the hole is closed. The pressure in the delivery chamber builds up and force-feeds the fuel to the injection nozzle until the control groove (6) meets the feed hole.

The amount of the fuel corresponds to the distance "A".

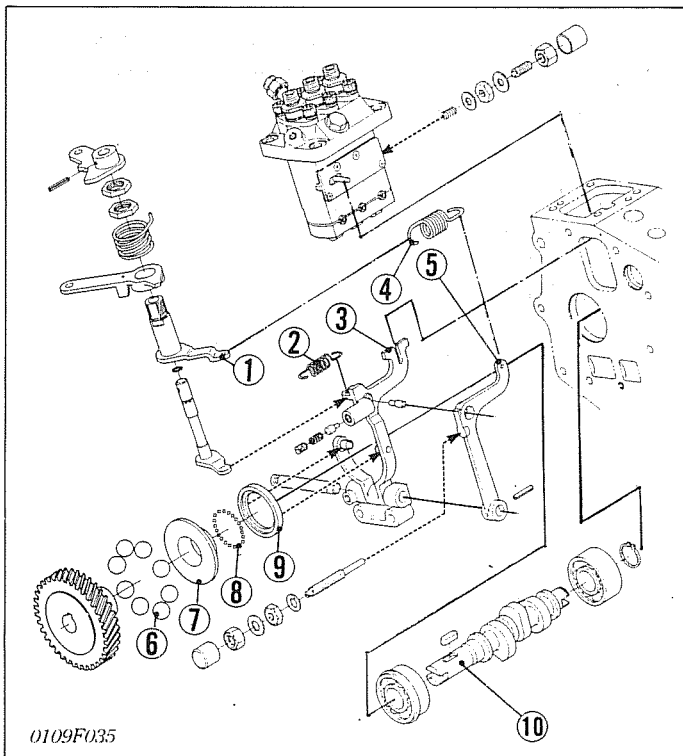
- (1) Slot
- (2) Plunger
- (3) Control Rack
- (4) Delivery Chamber
- (5) Feed Hole
- (6) Control Groove

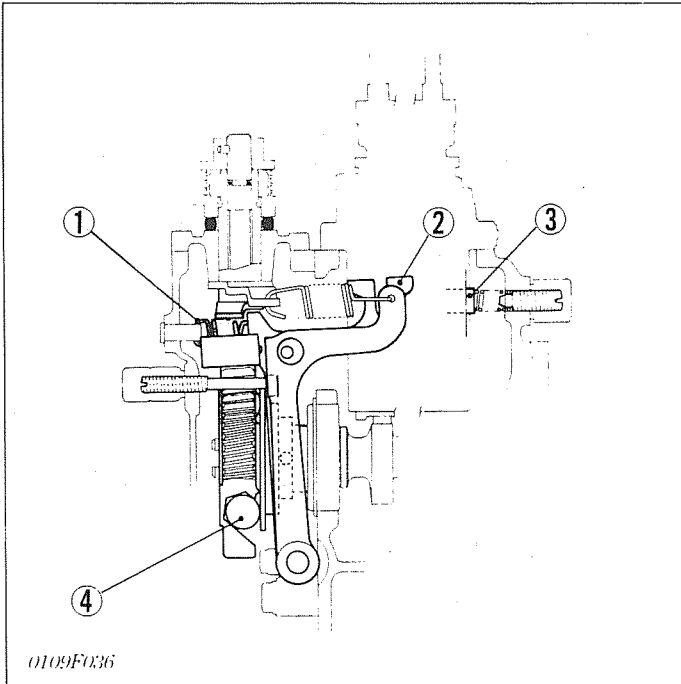
[4] GOVERNOR

The governor controls the amount of the fuel to be fed in the entire speed range to prevent the engine from changing its speed according to the load.

The fork lever 1 (3) is held where two forces on it are balanced. One is the force that fork lever 2 pushes, which is caused by the tension of the governor spring (4) between the governor lever (1) and fork lever 2 (5). Another is the component of the centrifugal force produced by the steel balls (6) which are rotated by the fuel camshaft (10).

- (1) Governor Lever
- (2) Start Spring
- (3) Fork Lever 1
- (4) Governor Spring
- (5) Fork Lever 2
- (6) Steel Ball
- (7) Governor Sleeve
- (8) Steel Ball
- (9) Governor Ball Case
- (10) Fuel Camshaft

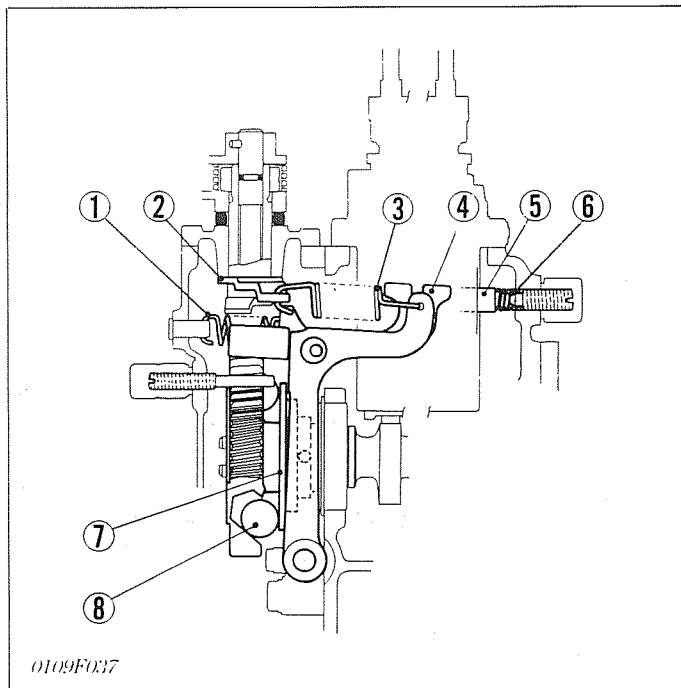




■ At start

The steel ball (4) has no centrifugal force. Fork lever 1 (2) is pulled by the start spring (1) and the control rack (3) moves to the maximum injection position for easy starting.

- (1) Start Spring
- (2) Fork Lever 1
- (3) Control Rack
- (4) Steel Ball



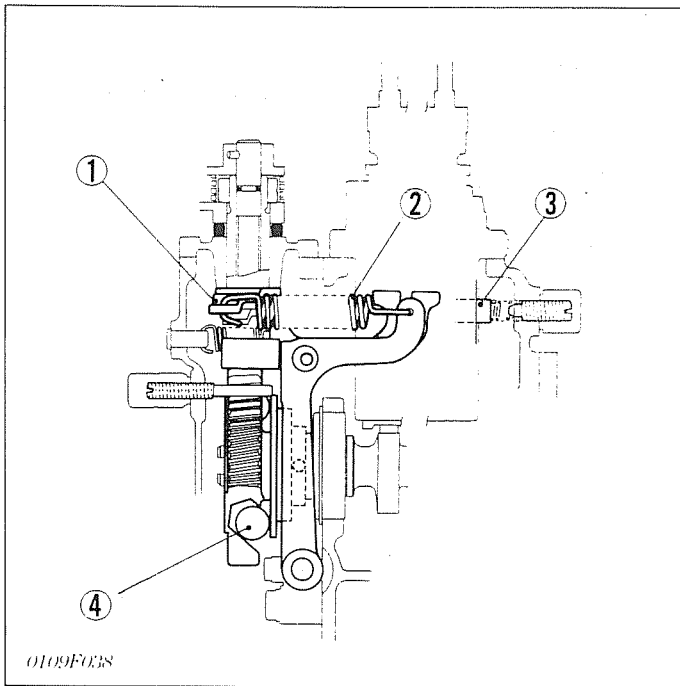
■ At idling

When the speed control lever (2) is set at the idling position, the governor spring (3) is pulled slightly.

As the camshaft rotates, the steel balls (8) increase their centrifugal force and push the governor sleeve (7). Fork lever 1 (4) pushed by the governor sleeve (7), pushes the control rack (5) and the control rack compresses, the idling adjust spring (6).

The control rack is kept at a position where the centrifugal force is balanced with the spring tension on the control rack, providing stable idling.

- (1) Start Spring
- (2) Speed Control Lever
- (3) Governor Spring
- (4) Fork Lever 1
- (5) Control Rack
- (6) Idling Adjust Spring
- (7) Governor Sleeve
- (8) Steel Ball



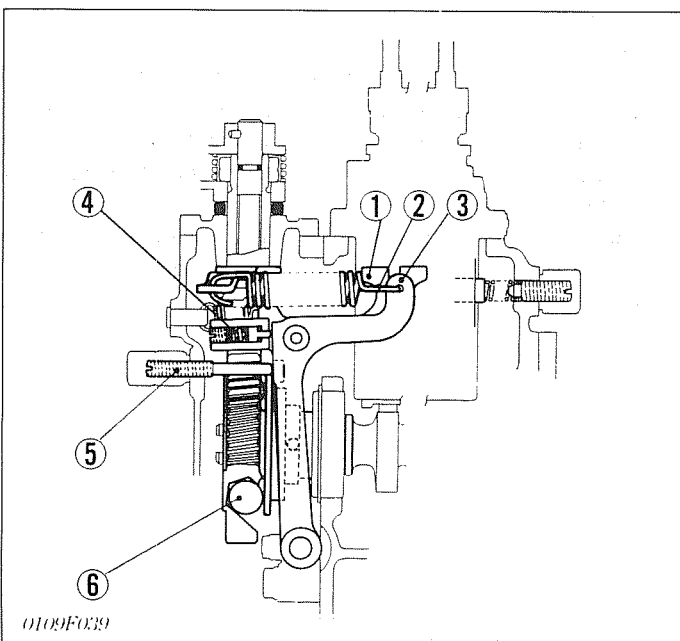
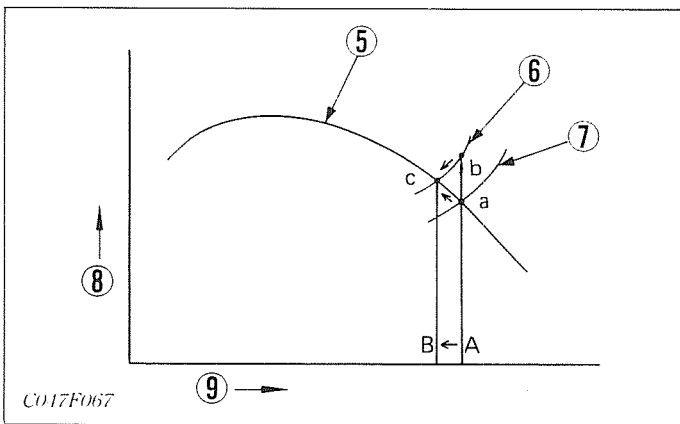
■ At medium or high speed running

When the speed control lever (1) is turned further, the governor spring (2) increases the tension and the control rack (3) is pulled to increase the engine speed.

The steel balls (4) increase their centrifugal force and the control rack is pushed, decreasing the engine speed, until the centrifugal force and the spring tension are balanced.

When the engine speed is dropped (A→B) with the increase of the load (a→b), the centrifugal force of the steel ball decreases and the control rack is pulled. The amount of the fuel to the injection nozzle is increased to produce a higher engine torque required for the load.

- (1) Speed Control Lever
- (2) Governor Spring
- (3) Control Rack
- (4) Steel Ball
- (5) Engine Torque Curve
- (6) Large Load Torque Curve
- (7) Small Load Torque Curve
- (8) Torque
- (9) Engine Speed



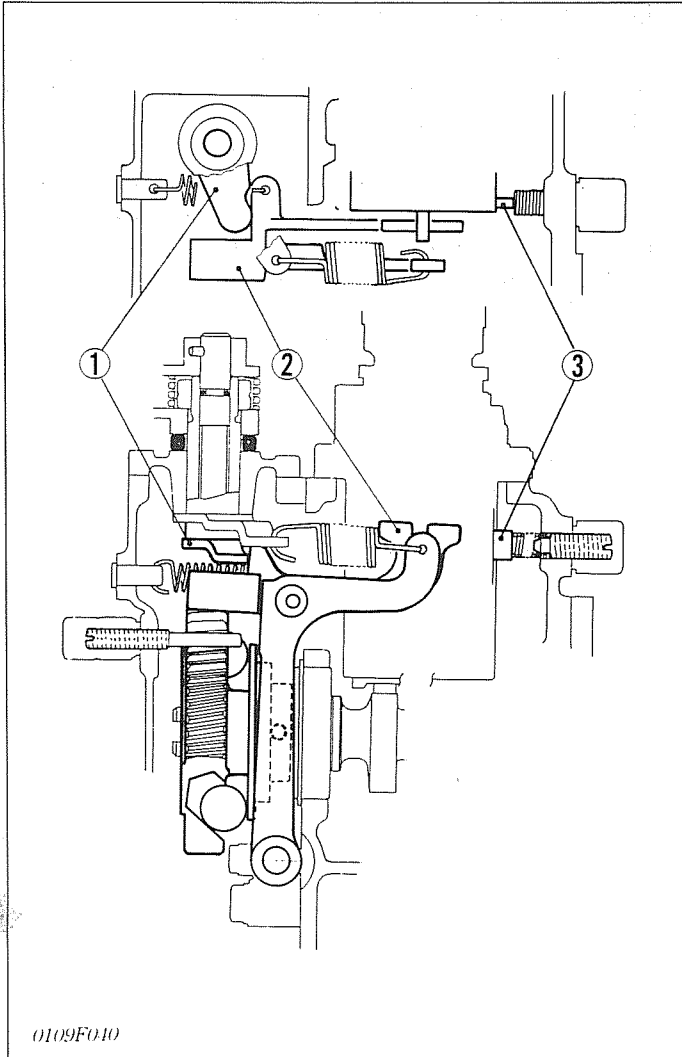
■ At maximum speed running with an overload

When the engine is overloaded at the high speeds and the engine speed drops, the centrifugal force of the steel balls (6) decreases and the governor spring (2) pulls fork lever 1 (1) and 2 (3).

When fork lever 2 contacts the adjusting screw (5), the spring (4) which is built in fork lever 2 begins to push the fork lever 1 to pull the control rack.

The fuel to the injection nozzle is increased to run the engine at high speed and torque.

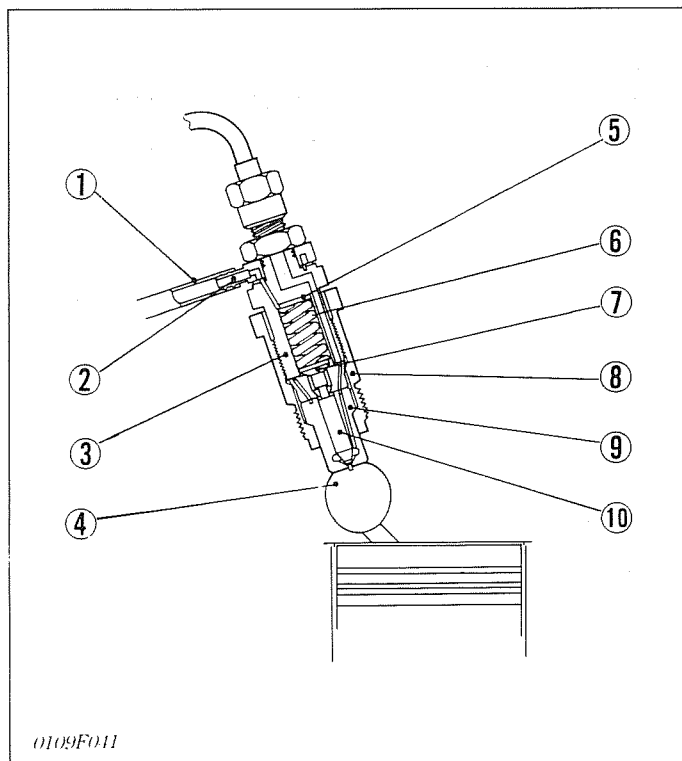
- (1) Fork Lever 1
- (2) Governor Spring
- (3) Fork Lever 2
- (4) Spring
- (5) Adjusting Screw
- (6) Steel Ball



■ To stop the engine

When the stop lever (1) is moved to the stop position, fork lever 1 (2) is pushed and the control rack (3) is moved to stop the fuel injection.

- (1) Stop Lever
- (2) Fork Lever 1
- (3) Control Rack



[5] Injection Nozzle

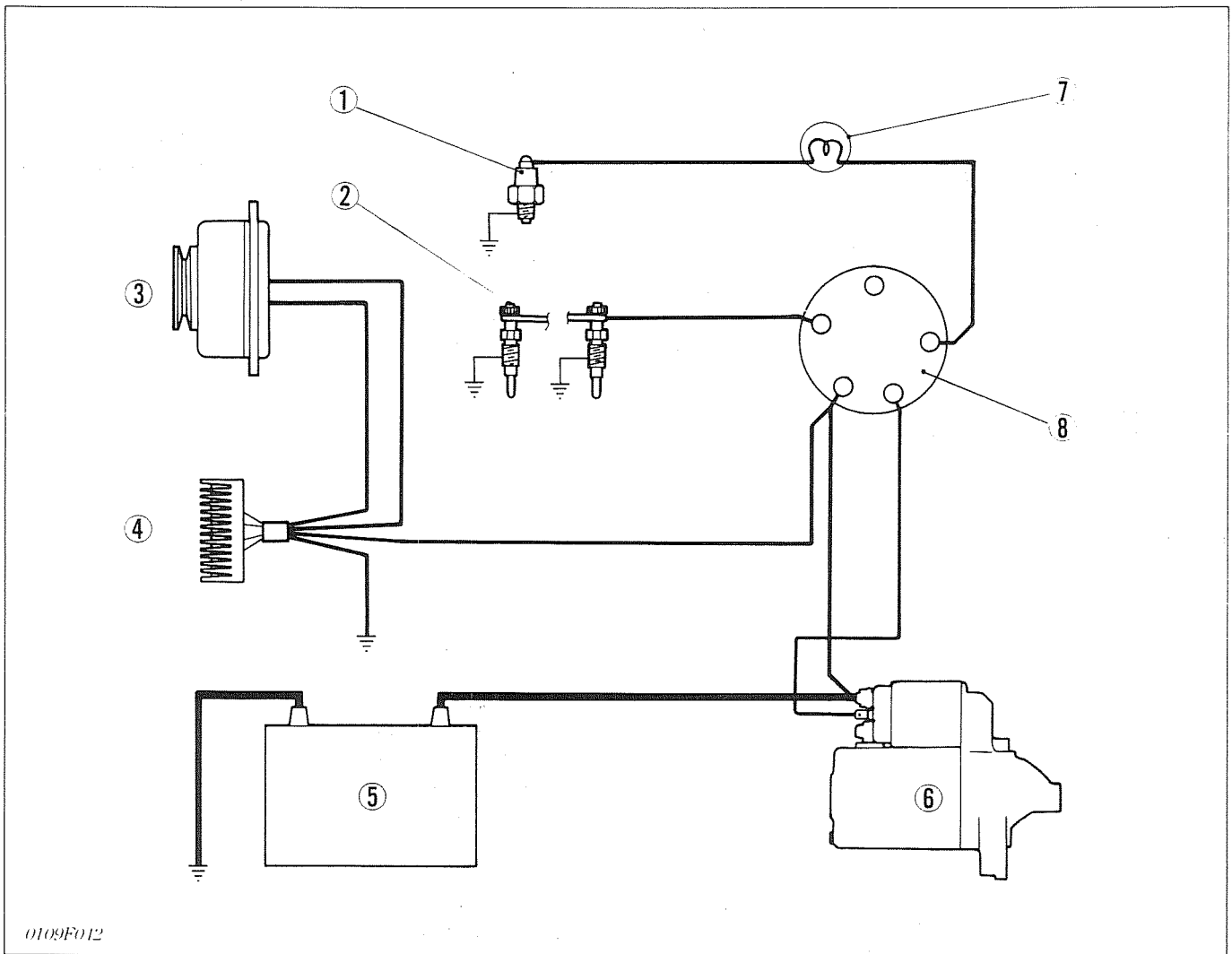
The nozzle is of the throttle type. The needle valve (10) is pushed against the nozzle body (9) by the nozzle spring (6) with the push rod (7).

The fuel forced from the injection pump pushes up the needle valve and is injected into the sub-combustion chamber (4). The excessive fuel which is not injected returns through the center chamber of the nozzle holder and the eye joint (2) to the fuel tank.

The injection pressure can be adjusted with the adjusting washer (5), from 13,73 to 14.71 MPa (140 to 150 kgf/cm², 1991 to 2133 psi).

- (1) Fuel Overflow Pipe
- (2) Eye Joint
- (3) Nozzle Holder Body
- (4) Sub-combustion Chamber
- (5) Adjusting Washer
- (6) Nozzle Spring
- (7) Push Rod
- (8) Retaining Nut
- (9) Nozzle Body
- (10) Needle Valve

ELECTRICAL SYSTEM

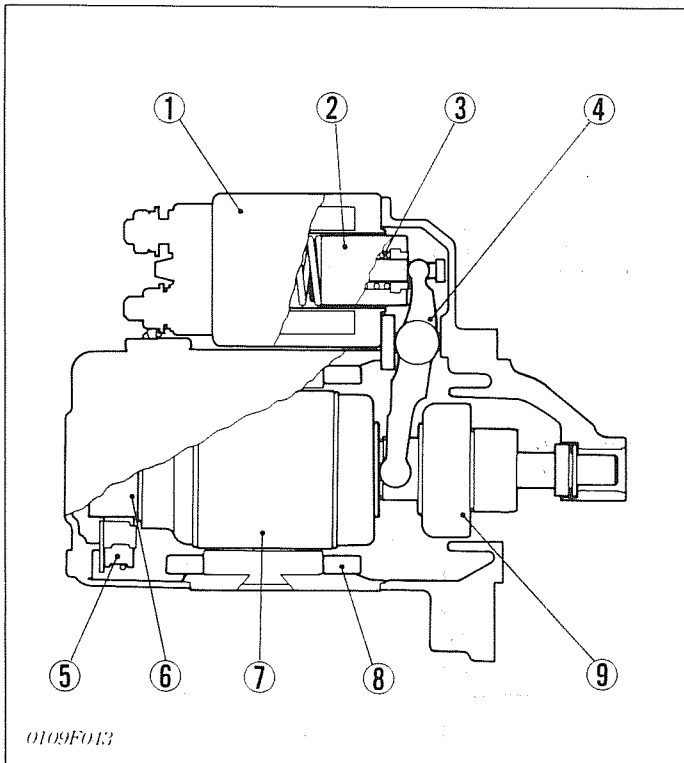


The electrical system of the engine consists of a starting system (including a starter, glow plugs and others), a charging system (including an AC dynamo, a regulator and others), a battery and an oil switch.

■ **NOTE:**

- Components marked * are not included in the basic model.

- (1) Oil Pressure Switch
- (2) Glow Plug
- (3) AC Dynamo
- (4) Regulator
- * (5) Battery
- (6) Starter
- * (7) Oil Lamp
- * (8) Key Switch



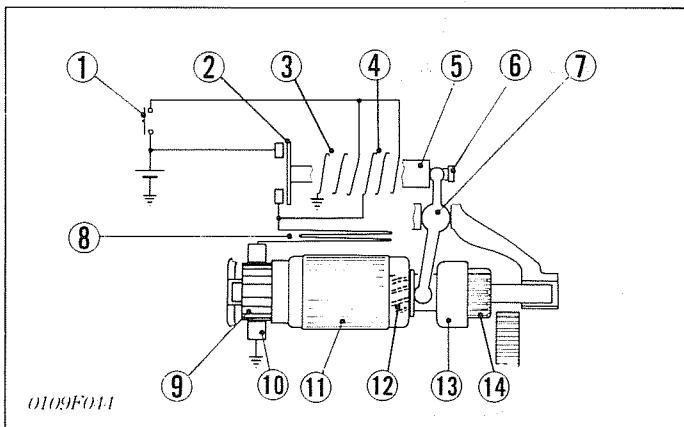
[1] STARTING SYSTEM

1) Starter

The starter is of the electromagnetic drive type.

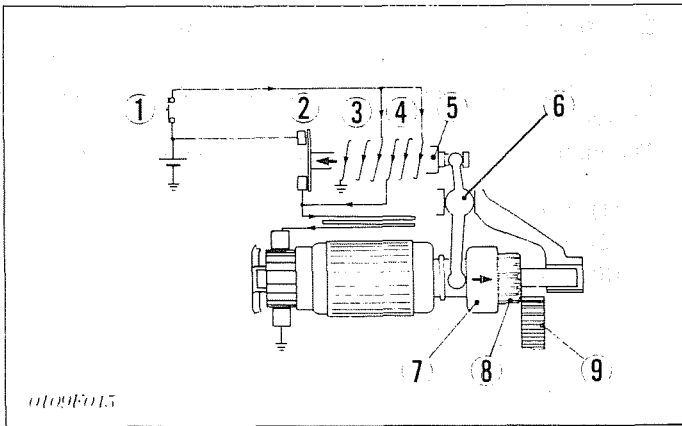
Type of motor	DC, Series, Electromagnetic drive
Supply Voltage	12V
Rated output	0.7 kW
Rate	Less than 30 seconds
Direction of rotation	Clockwise as viewed from pinion side

- (1) Solenoid Switch
- (2) Plunger
- (3) Spring
- (4) Shift Lever
- (5) Brush
- (6) Commutator
- (7) Armature
- (8) Field Coil
- (9) Overrunning Clutch



1. Schematic Circuit

- (1) Starting Switch
- (2) Magnetic Switch
- (3) Holding Coil
- (4) Pull-in Coil
- (5) Plunger
- (6) Rod
- (7) Shift Lever
- (8) Field Coil
- (9) Commutator
- (10) Brush
- (11) Armature
- (12) Spiral Spline
- (13) Overrunning Clutch
- (14) Pinion



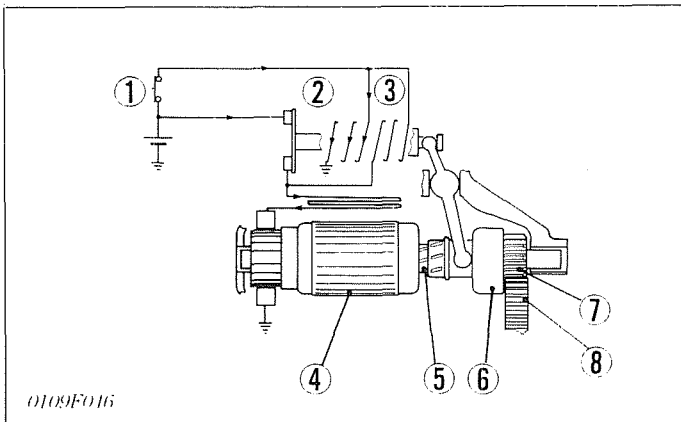
■ When the starting switch is turned on

The contacts of starting switch (1) close and the holding coil (3) is connected to the battery to pull the plunger (5).

The pull-in coil (4) and the starting motor are also connected to the battery.

The pinion (8) is pushed against the ring gear (9) with the overrunning clutch (7) by the shift lever (6) and the magnetic switch (2) is closed.

- (1) Starting Switch
- (2) Magnetic Switch
- (3) Holding Coil
- (4) Pull-in Coil
- (5) Plunger
- (6) Shift Lever
- (7) Overrunning Clutch
- (8) Pinion
- (9) Ring Gear



■ When the magnet switch is closed

The current from the battery flows through the magnetic switch (2) to the starting motor.

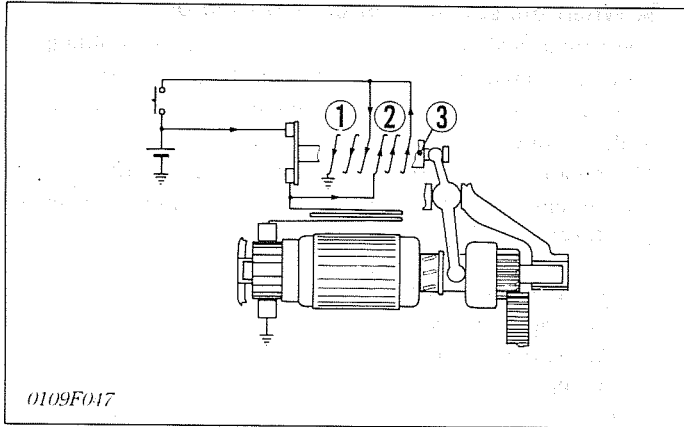
The pinion (7), which is pushed against the ring gear (8) and rotated along the spline (5), meshes with the ring gear to crank the engine.

The engine starts and increases its speed.

While the pinion spins faster than the armature, the overrunning clutch (6) allows the pinion to spin independently from the armature.

The pull-in coil (3) is short-circuited through the magnet switch (2) and the starting switch (1).

- (1) Starting Switch
- (2) Magnetic Switch
- (3) Pull-in Coil
- (4) Armature
- (5) Spline
- (6) Overrunning Clutch
- (7) Pinion
- (8) Ring Gear

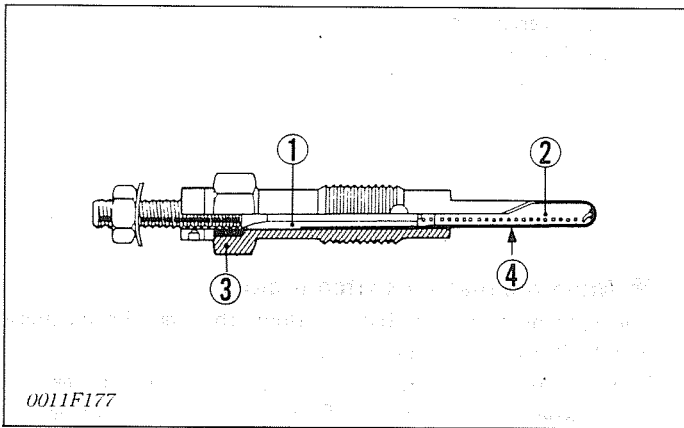


■ **When the starting switch is released**

The current from the battery flows to the holding coil (1) through the pull-in coil (2) to diminish the magnetism between them.

The plunger (3) is pushed by the spring to pull in the pinion.

- (1) Holding Coil
- (2) Pull-in Coil
- (3) Plunger

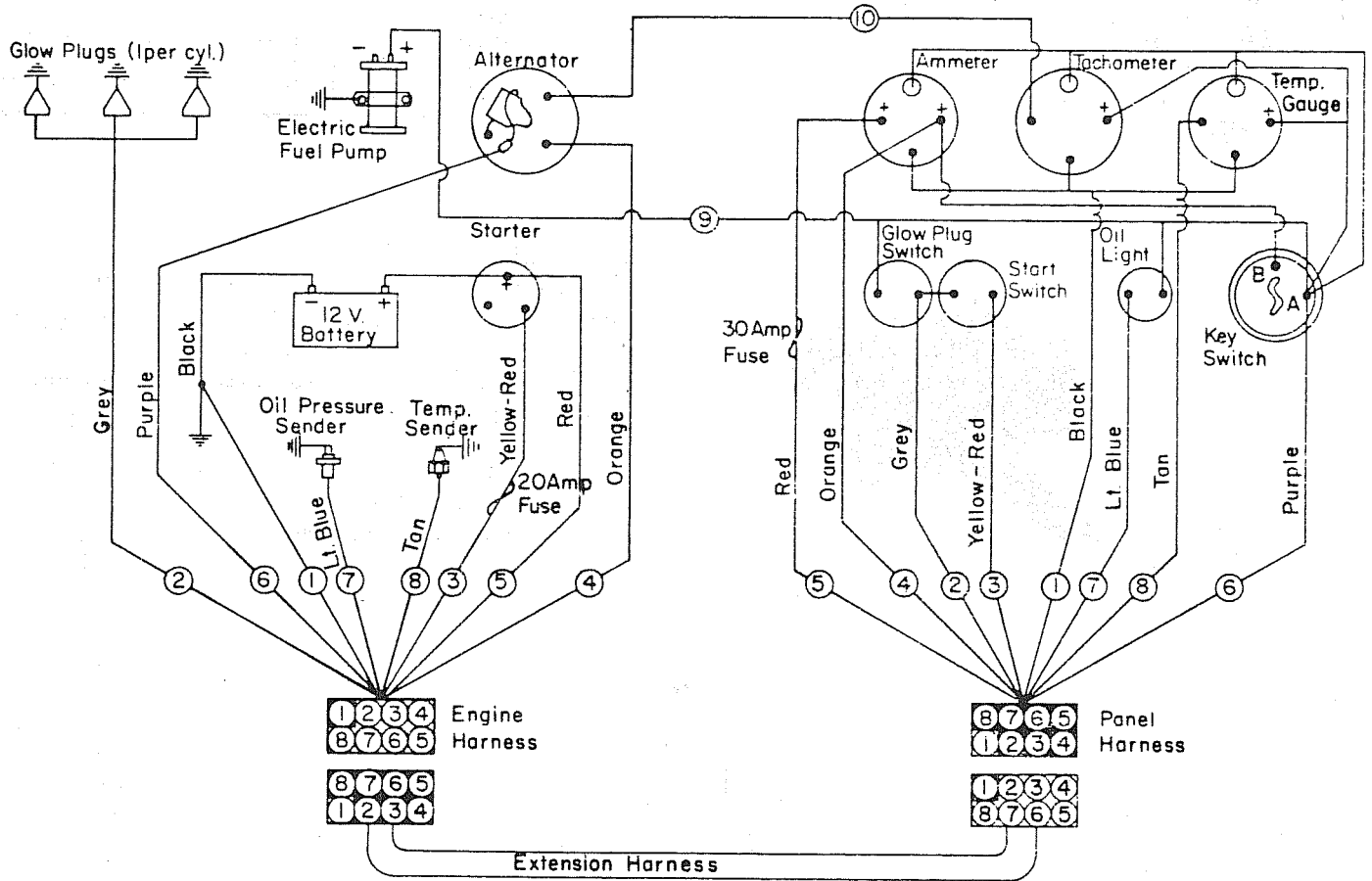


2) Glow Plug

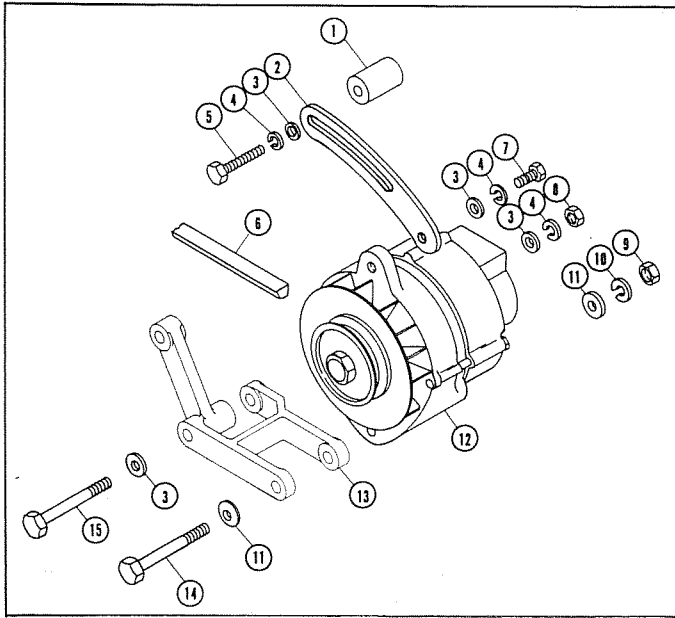
Each sub-combustion chamber has a glow plug for easy starting. The glow plug is of the quick-heating type.

- (1) Insulating Powder
- (2) Metal Tube
- (3) Housing
- (4) Heat Coil

WIRING DIAGRAM



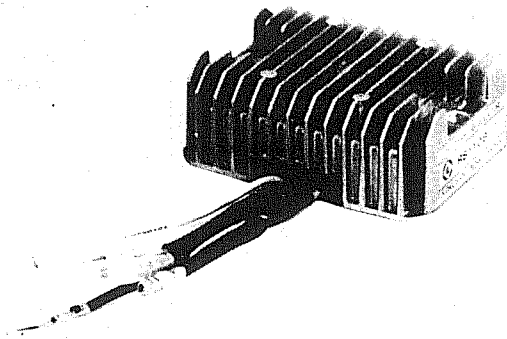
WIRE No.	COLOR	WIRE SIZE
1	Black	#10
2	Grey	10
3	Yellow-Red	16
4	Orange	10
5	Red	10
6	Purple	16
7	Lt. Blue	16
8	Tan	16
9	Open	14
10	Grey	16



1) ALTERNATOR

ALTERNATOR GROUP

Item	Part No.	Unit	Description
1	300105	1	Spacer - Alternator Arm
2	299809	1	Alternator Adjusting Arm
3	231875	4	Washer - 5/16 Plain
4	231891	3	Washer - Spring Lock 5/16
5	301019	1	Screw - Hex Head 5/16-18 x 3-1/4
6	300805	1	V-Belt
7	231057	1	Hex Head Cap Screw 5/16-18 x 3/4
8	230141	1	Hex Nut 5/16-18
9	230144	1	Hex Nut 3/8-16
10	231895	1	Washer - 3/8 Spring Lock
11	231876	2	Washer - 3/8 SAE
12	300800	1	Alternator
13	300950	1	Bracket - Alt. Mounting Assembly
14	231093	1	Hex Head Cap Screw 3/8-16 x 3-3/4
15	243061	1	Hex Head Cap Screw 5/16-18 x 4-1/2



2) Regulator

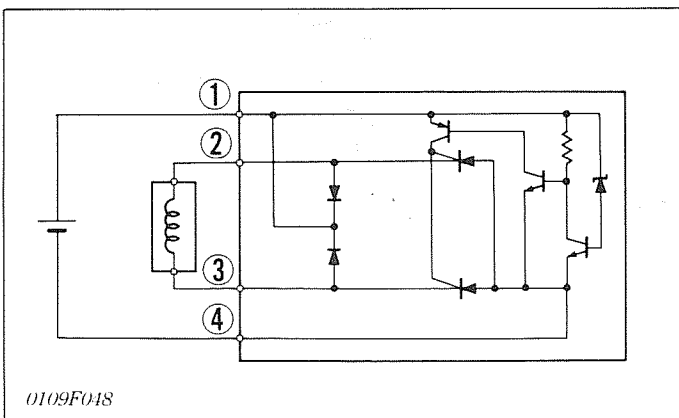
The regulator is a transistorised regulator with SCR.

When the battery voltage is low, SCRs turn on to charge the battery with the current from the generator.

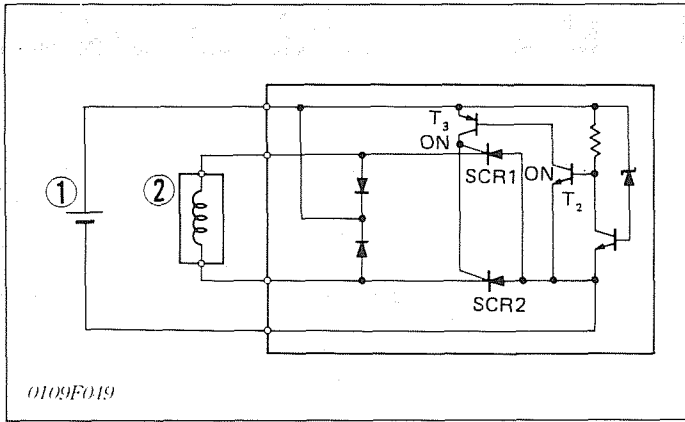
When the generated voltage excessively rises, they turn off to stop charging.

- (1) To AC Terminal of Key Switch (Red)
- (2) To Dynamo (Light Blue)
- (3) To Dynamo (Light Blue)
- (4) To Body (Black)

0109P001



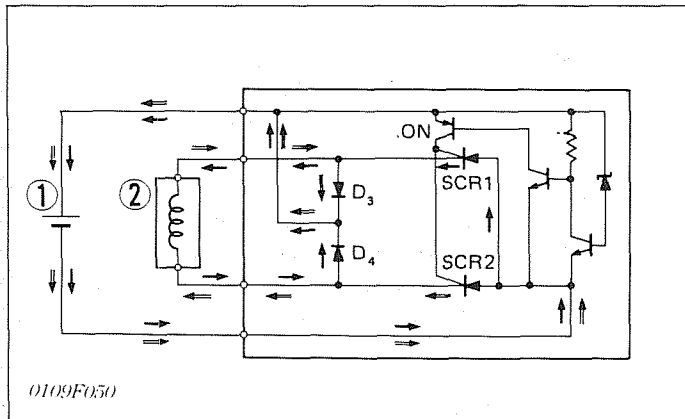
0109F048



■ **While the engine is stopped**

A small amount of current is applied to the base of transistor T2, and transistor T2 turns on, turning on transistor T3. Transistor T3 pulls up the gate voltage of the SCR's SCR1 and SCR2.

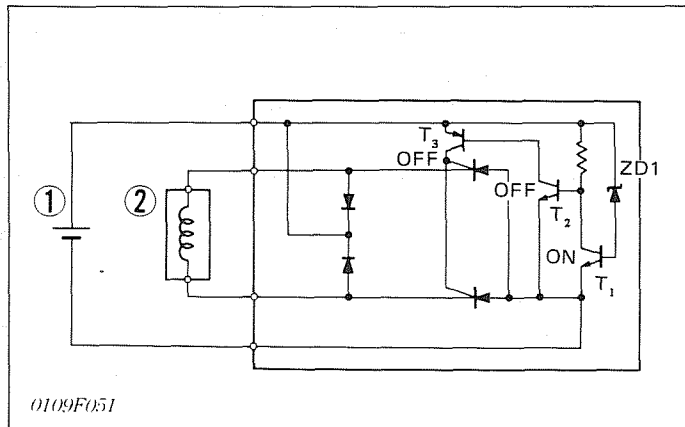
- (1) Battery
- (2) Dynamo Stator Coil



■ **When the engine starts**

The dynamo generates AC in the stator coils, and the current charges the battery through SCR1 and D4 (→ in figure) or SCR2 and D3 (← in figure).

- (1) Battery
- (2) Dynamo Stator Coil



■ **Overcharge prevention**

When the battery voltage rises and reaches a certain voltage determined by zener diode ZD1, the current begins to flow to the base of transistor T1 through ZD1. Transistor T1 turns on and turns off transistor T2. Transistor T3 turns off and stops applying the triggering current to the SCR's SCR1 and SCR2. The SCRs turn off and stop charging.

- (1) Battery
- (2) Dynamo Stator Coil

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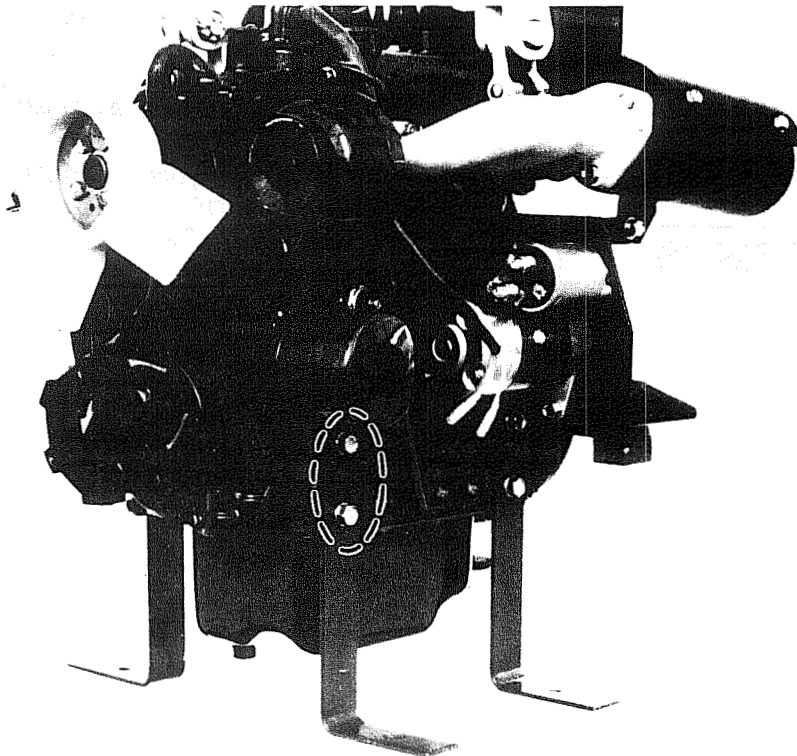
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GENERAL

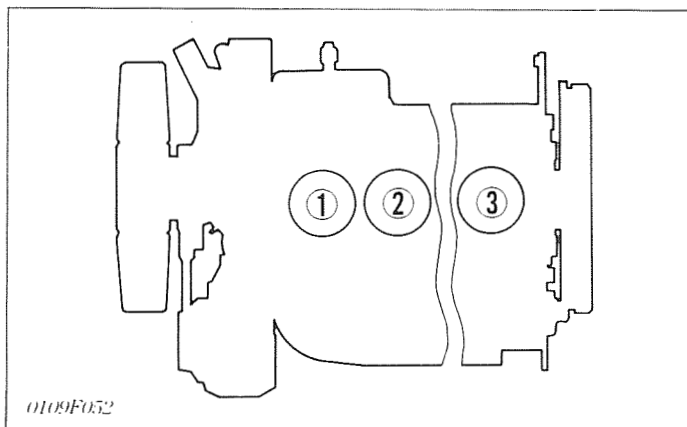
[1] ENGINE IDENTIFICATION



0109P002

When contacting your local UNIVERSAL distributor, always specify the engine serial number.

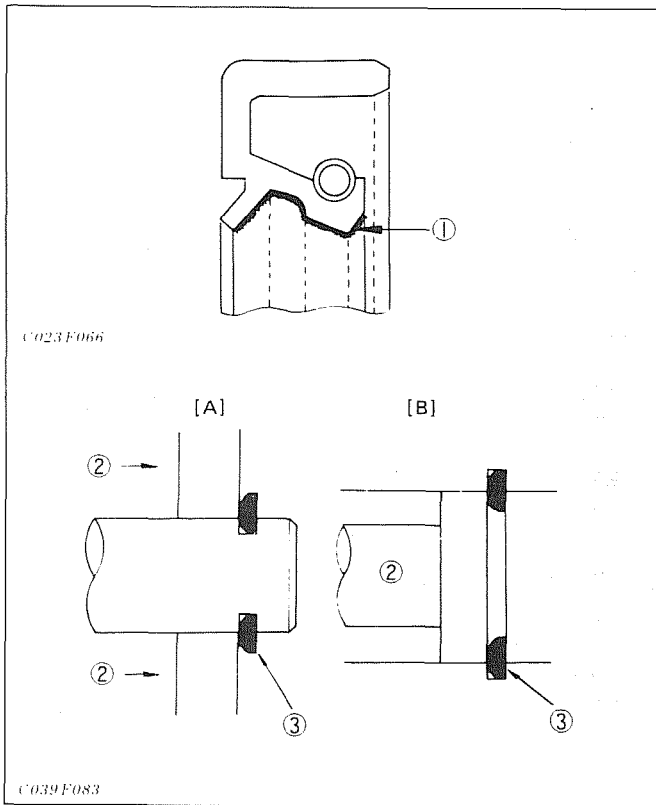
[2] CYLINDER NUMBER



0109F052

The cylinder numbers of the diesel engines are designated as shown in the figure. The sequence of cylinder side numbers is given as No. 1, starting from the gear case side.

[3] GENERAL PRECAUTIONS



- During disassembly, carefully arrange removed parts in a clean area to prevent confusion later. Screws, bolts and nuts should be replaced in their original position to prevent reassembly errors.
- When special tools are required, use Universal's genuine special tools. Special tools which are not frequently used should be made according to the drawings provided.
- Before disassembling or servicing live wires, make sure to always disconnect the grounding cable from the battery first.
- Remove oil and dirt from parts before measuring.
- Use only Universal genuine parts for parts replacement to maintain engine performance and to ensure safety.
- Gaskets and O-rings must be replaced during reassembly. Apply grease to new O-rings or oil seals before assembling.
- When reassembling external circlips or internal circlips, position them so that the sharp edge faces the direction from which force is applied.

(1) Grease

(2) Force

(3) Place the Sharp Edge against the Direction of Force

[A] External Circlip

[B] Internal Circlip

[4] TIGHTENING TORQUES

Screws, bolts and nuts must be tightened to the specified torque using a torque wrench. Several screws, bolts and nuts such as those used on the cylinder head must be tightened in proper sequence and at the proper torque.

1) Tightening torques for special use screws, bolts and nuts

Note:

- For "O" marked screws, bolts and nuts in the table, apply engine oil to their threads and seats before tightening.

Item	Size X Pitch	Tightening Torque		
		N·m	kgf·m	ft-lbs
O Head cover cap nuts	M6 x 1.0	3.9 to 5.9	0.4 to 0.6	2.9 to 4.3
O Head screws and nuts	M8 x 1.25	37.3 to 42.2	3.8 to 4.3	27.5 to 31.1
O Bearing case screws 1	M6 x 1.0	11.8 to 14.7	1.2 to 1.5	8.7 to 10.8
O Bearing case screws 2	M7 x 1.25	19.6 to 23.5	2.0 to 2.4	14.5 to 17.4
O Flywheel screws	M10 x 1.25	53.9 to 58.8	5.5 to 6.0	39.8 to 43.4
O Connecting rod screws	M6 x 0.75	14.7 to 18.6	1.5 to 1.9	10.8 to 13.7
O Rocker arm bracket nuts	M6 x 1.0	9.81 to 11.28	1.00 to 1.15	7.23 to 8.32
O Idle gear shaft screws	M6 x 1.0	9.81 to 11.28	1.00 to 1.15	7.23 to 8.32
Glow plugs	M10 x 1.25	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Drain plug	M12 x 1.25	32.4 to 37.3	3.3 to 3.8	23.9 to 27.5
Nozzle holders	M20 x 1.5	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6
Oil switch taper screw	PT 1/8	14.7 to 19.6	1.5 to 2.0	10.8 to 14.5
Fuel limit cap nut	M6 x 1.0	7.8 to 9.8	0.8 to 1.0	5.8 to 7.2
Injection pipe retaining nuts	M12 x 1.5	24.5 to 34.3	2.5 to 3.5	18.1 to 25.3
O Crankshaft screw	M12 x 1.5	98.1 to 107.9	10.0 to 11.0	72.3 to 79.6

2) Tightening Torques for general use screws, bolts and nuts

When the tightening torques are not specified, tighten the screws, bolts and nuts according to the table below.

Nominal Diameter	Material Grade	Standard Screw and Bolt			Special Screw and Bolt			Special Screw and Bolt		
		SS41, S20C			S43C, S48C			SCr435, SCM435		
		N·m	kgf·m	ft-lbs	N·m	kgf·m	ft-lbs	N·m	kgf·m	ft-lbs
M 6		7.85 to 9.32	0.80 to 0.95	5.79 to 6.87	9.81 to 11.28	1.00 to 1.15	7.23 to 8.32	12.26 to 14.22	1.25 to 1.45	9.04 to 10.49
M 8		17.7 to 20.6	1.8 to 2.1	13.0 to 15.2	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3	29.4 to 34.3	3.0 to 3.5	21.7 to 25.3
M10		39.2 to 45.1	4.0 to 4.6	28.9 to 33.3	48.1 to 55.9	4.9 to 5.7	35.4 to 41.2	60.8 to 70.6	6.2 to 7.2	44.8 to 52.1
M12		62.8 to 72.6	6.4 to 7.4	46.3 to 53.5	77.5 to 90.2	7.9 to 9.2	57.1 to 66.5	103.0 to 117.7	10.5 to 12.0	75.9 to 86.8
M14		107.9 to 125.5	11.0 to 12.8	79.6 to 92.6	123.6 to 147.1	12.6 to 15.0	91.1 to 108.5	166.7 to 196.1	17.0 to 20.0	123.0 to 144.7
M16		166.7 to 191.2	17.0 to 19.5	123.0 to 141.0	196.1 to 225.6	20.0 to 23.0	144.7 to 166.4	259.9 to 304.0	26.5 to 31.0	191.7 to 224.2
M18		245.2 to 284.4	25.0 to 29.0	180.8 to 209.8	274.6 to 318.7	28.0 to 32.5	202.5 to 235.1	343.2 to 402.1	35.0 to 41.0	253.2 to 296.6
M20		333.4 to 392.3	34.0 to 40.0	245.9 to 289.3	367.7 to 431.5	37.5 to 44.0	271.2 to 318.3	490.3 to 568.8	50.0 to 58.0	361.7 to 419.5

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below.

Punched Number	Screw and Bolt Material Grade
None	Standard Screw and Bolt SS41, S20C
7	Special Screw and Bolt S43C, S48C (Refined)
9	Special Screw and Bolt SCr435 SCM435 (Refined)

[5] TROUBLESHOOTING

Symptom	Probable Cause	Solution
<p>Engine does not start</p> <p>[Starter does not work]</p>	<ul style="list-style-type: none"> • No fuel • Air in the fuel system • Water in the fuel system • Fuel pipe clogged • Fuel filter clogged • Excessively high viscosity of fuel or engine oil at low temperature • Fuel with low cetane number • Fuel leak due to loose injection pipe retaining nut • Incorrect injection timing • Fuel cam shaft worn • Injection nozzle clogged • Injection pump malfunctioning • Fuel feed pump malfunctioning • Seizure of crankshaft, camshaft, piston, cylinder liner or bearing • Compression leak from cylinder • Improper valve seat alignment, valve spring broken, valve seized • Improper valve timing • Piston ring and liner worn • Excessive valve clearance • Battery discharged • Starter malfunctioning • Starter switch malfunctioning • Wiring disconnected 	<p>Replenish fuel</p> <p>Vent air</p> <p>Replace fuel and repair or replace fuel system</p> <p>Clean</p> <p>Clean or replace</p> <p>Use the specified fuel or engine oil</p> <p>Use the specified fuel</p> <p>Tighten nut</p> <p>Adjust</p> <p>Replace</p> <p>Clean</p> <p>Repair or replace</p> <p>Repair or replace</p> <p>Repair or replace</p> <p>Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder</p> <p>Repair or replace</p> <p>Correct or replace timing gear</p> <p>Replace</p> <p>Adjust</p> <p>Charge</p> <p>Repair or replace</p> <p>Repair or replace</p> <p>Connect</p>
Engine revolution is not smooth	<ul style="list-style-type: none"> • Fuel filter clogged or dirty • Air cleaner clogged • Fuel leak due to loose injection pipe retaining nut • Injection pump malfunctioning • Incorrect nozzle opening pressure • Injection nozzle stuck or clogged • Fuel over flow pipe clogged • Governor malfunctioning 	<p>Clean or replace</p> <p>Clean or replace</p> <p>Tighten nut</p> <p>Repair or replace</p> <p>Adjust</p> <p>Repair or replace</p> <p>Clean</p> <p>Repair</p>
Either white or blue exhaust gas is observed	<ul style="list-style-type: none"> • Excessive engine oil • Piston ring and liner worn or stuck • Incorrect injection timing • Deficient compression 	<p>Reduce to the specified level</p> <p>Repair or replace</p> <p>Adjust</p> <p>Adjust top clearance</p>
Either black or dark gray exhaust gas is observed	<ul style="list-style-type: none"> • Overload • Low grade fuel used • Fuel filter clogged • Air cleaner clogged 	<p>Lessen the load</p> <p>Use the specified fuel</p> <p>Clean or replace</p> <p>Clean or replace</p>
Deficient output	<ul style="list-style-type: none"> • Incorrect injection timing • Engine's moving parts seem to be seizing • Uneven fuel injection • Deficient nozzle injection • Compression leak 	<p>Adjust</p> <p>Repair or replace</p> <p>Repair or replace the injection pump</p> <p>Repair or replace the nozzle</p> <p>Replace head gasket, tighten cylinder head bolt, glow plug and nozzle holder</p>

Symptom	Probable Cause	Solution
Excessive lubricant oil consumption	<ul style="list-style-type: none"> • Piston ring's gap facing the same direction • Oil ring worn or stuck • Piston ring groove worn • Valve stem and guide worn • Crankshaft bearing, and crank pin bearing worn 	Shift ring gap direction Replace Replace the piston Replace Replace
Fuel mixed into lubricant oil	<ul style="list-style-type: none"> • Injection pump's plunger worn • Fuel feed pump broken 	Replace pump element or pump Replace
Water mixed into lubricant oil	<ul style="list-style-type: none"> • Head gasket defective • Crank case or cylinder head flawed 	Replace Replace
Low oil pressure	<ul style="list-style-type: none"> • Engine oil insufficient • Oil strainer clogged • Oil filter cartridge clogged • Relief valve stuck with dirt • Relief valve spring weaken or broken • Excessive oil clearance of crankshaft bearing • Excessive oil clearance of crank pin bearing • Excessive oil clearance of rocker arm bushing • Oil passage clogged • Different type of oil • Oil pump defective 	Replenish Clean Replace Clean Replace Replace Replace Replace Clean Use the specified type of oil Repair or replace
High oil pressure	<ul style="list-style-type: none"> • Different type of oil • Relief valve defective 	Use the specified type of oil Replace
Engine overheated	<ul style="list-style-type: none"> • Engine oil insufficient • Fan belt broken or tensioned improperly • Cooling water insufficient • Radiator net and radiator fin clogged with dust • Inside of radiator corroded • Cooling water flow route corroded • Radiator cap defective • Water pipe damaged • Thermostat defective • Water pump defective • Mechanical seal defective • Overload running • Head gasket defective • Incorrect injection timing • Unsuitable fuel used 	Replenish Replace or adjust Replenish Clean Clean or replace Clean or replace Replace Replace Replace Replace Replace Replace Loosen the load Replace Adjust Use the specified fuel
Battery quickly discharge	<ul style="list-style-type: none"> • Battery fluid insufficient • Fan belt slips • Wiring disconnected • Regulator defective • AC dynamo defective • Battery defective 	Replenish distilled water and charge Adjust belt tension or replace Connect Replace Replace Replace

[6] SERVICING SPECIFICATIONS

ENGINE BODY [Cylinder Head]

Item	Factory Specification		Allowable Limit	
Cylinder head surface flatness	—		0.05 mm per 100 mm (0.0019 in. per 3.94 in.)	
Top clearance	0.60 to 0.80 mm (0.0236 to 0.0315 in.)		—	
Gasket thickness	Free	1.15 to 1.30 mm (0.0453 to 0.0512 in.)	—	
	Tightened	1.05 to 1.15 mm (0.0413 to 0.0453 in.)	—	
Gasket shim thickness	0.2 mm (0.0079 in.)		—	
Compression pressure	3.09 MPa (31.5 kgf/cm ² , 448 psi)		2.32 MPa (23.7 kgf/cm ² , 337 psi)	
Variance among cylinders	—		10%	

[Valves (IN., EX.)]

Valve clearance (cold)	0.15 to 0.18 mm (0.0059 to 0.0071 in.)	—
Valve seat width	1.4 mm (0.055 in.)	—
Valve seat angle	0.785 rad. (45.0°)	—
Valve face angle	0.794 rad. (45.5°)	—
Valve recessing	0.75 to 0.95 mm (0.0295 to 0.0374 in.)	1.2 mm (0.047 in.)
Clearance between valve stem and guide	0.030 to 0.057 mm (0.00118 to 0.00224 in.)	0.10 mm (0.0039 in.)
Valve stem O.D.	5.968 to 5.980 mm (0.23496 to 0.23543 in.)	—
Valve guide I.D.	6.010 to 6.025 mm (0.23661 to 0.23721 in.)	—

[Valve Timing]

Inlet valve	Open	0.35 rad. (20°) before TDC	—
	Close	0.79 rad. (45°) after BDC	—
Exhaust valve	Open	0.87 rad. (50°) before BDC	—
	Close	0.26 rad. (15°) after TDC	—

[Valve Springs]

Free length	31.6 mm (1.244 in.)	28.4 mm (1.118 in.)
Tilt	—	1.2 mm (0.047 in.)
Tension	64.7 N/27 mm (6.6 kgf/27 mm, 14.6 lbs/1.063 in.)	54.9 N/27 mm (5.6 kgf/27 mm, 12.3 lbs/1.063 in.)

[Rocker Arm]

Item	Factory Specification		Allowable Limit
Clearance between rocker arm and bushing	0.016 to 0.068 mm (0.00063 to 0.00268 in.)		0.15 mm (0.0059 in.)
Rocker arm shaft O.D.	10.473 to 10.484 mm (0.41232 to 0.41276 in.)		—
Rocker arm bushing I.D.	10.500 to 10.541 mm (0.41339 to 0.41500 in.)		—

[Camshaft]

Camshaft alignment	0.01 mm (0.0004 in.)	0.08 mm (0.0031 in.)
Cam height (IN., EX.)	26.88 mm (1.0583 in.)	26.83 mm (1.0563 in.)
Oil clearance of camshaft	0.050 to 0.091 mm (0.00197 to 0.00358 in.)	0.15 mm (0.0059 in.)
Camshaft journal O.D.	32.934 to 32.950 mm (1.29662 to 1.29725 in.)	—
Camshaft bearing I.D.	33.000 to 33.025 mm (1.29921 to 1.30020 in.)	—

[Timing Gear]

Timing gear backlash	0.04 to 0.12 mm (0.0016 to 0.0047 in.)	0.15 mm (0.0059 in.)
Idle gear side clearance	0.20 to 0.51 mm (0.0079 to 0.0201 in.)	0.6 mm (0.024 in.)
Clearance between idle gear shaft and idle gear bushing	0.016 to 0.045 mm (0.00063 to 0.00177 in.)	0.05 mm (0.0020 in.)
Idle gear shaft O.D.	15.973 to 15.984 mm (0.62886 to 0.62929 in.)	—
Idle gear bushing I.D.	16.000 to 16.018 mm (0.62992 to 0.63063 in.)	—

[Cylinder (Liner)]

Cylinder (Liner) I.D.	64.000 to 64.019 mm (2.51969 to 2.52043 in.)	66.000 to 66.019 mm (2.59843 to 2.59917 in.)	0.15 mm (0.0059 in.) of wear
Oversize of cylinder liner	+0.5 mm (+0.020 in.)		—

[Piston/Piston Ring]

Piston pin hole I.D.	18.000 to 18.011 mm (0.79866 to 0.70910 in.)		18.05 mm (0.7106 in.)
Piston ring clearance	Compression ring 2	0.085 to 0.112 mm (0.00335 to 0.00441 in.)	0.15 mm (0.0059 in.)
	Oil ring	0.02 to 0.06 mm (0.0008 to 0.0024 in.)	0.15 mm (0.0059 in.)
Ring gap	Compression ring 1, 2	0.25 to 0.40 mm (0.0098 to 0.0157 in.)	1.25 mm (0.0492 in.)
	Oil ring	0.20 to 0.40 mm (0.0079 to 0.0157 in.)	1.25 mm (0.0492 in.)
Oversize of piston rings	+0.5 mm (+0.020 in.)		—

[Crankshaft]

Item		Factory Specification		Allowable Limit	
Crankshaft alignment		0.02 mm (0.0008 in.)		0.08 mm (0.0031 in.)	
Oil clearance between crankshaft journal and bearing		0.034 to 0.106 mm (0.00134 to 0.00417 in.)		0.20 mm (0.0079 in.)	
Journal O.D.	Front and intermediate	39.934 to 39.950 mm (1.57221 to 1.57284 in.)		-	
	Rear	43.934 to 43.950 mm (1.72969 to 1.73032 in.)		-	
Bearing I.D.	Front and intermediate	39.984 to 40.040 mm (1.57418 to 1.57638 in.)		-	
	Rear	43.984 to 44.040 mm (1.73166 to 1.73386 in.)		-	
Oil clearance between crank pin and bearing		0.019 to 0.081 mm (0.00075 to 0.00319 in.)		0.20 mm (0.0079 in.)	
Crank pin O.D.		33.959 to 33.975 mm (1.33697 to 1.33760 in.)		-	
Crank pin bearing I.D.		33.994 to 34.040 mm (1.33835 to 1.34016 in.)		-	
Crank shaft side clearance		0.15 to 0.31 mm (0.0059 to 0.0122 in.)		0.5 mm (0.020 in.)	
Under sizes of crankshaft bearing and crank pin bearing		-0.2 mm, -0.4 mm (-0.008 in., -0.016 in.)		-	
Oversizes of thrust bearing		+0.2 mm, +0.4 mm (+0.008 in., +0.016 in.)		-	

[Connecting Rod]

Connecting rod alignment	-	0.05 mm (0.0020 in.)
Oil clearance between piston pin and small end bushing	0.016 to 0.039 mm (0.00063 to 0.00154 in.)	0.15 mm (0.0059 in.)
Piston O.D.	18.001 to 18.009 mm (0.70870 to 0.70902 in.)	-
Small end bushing I.D. (fitting)	18.025 to 18.040 mm (0.70965 to 0.71024 in.)	-

LUBRICATING SYSTEM

Oil pressure	At idle speed	-	69 kPa (0.7 kgf/cm ² , 10 psi)
	At rated speed	196 to 441 kPa (2.0 to 4.5 kgf/cm ² , 28 to 64 psi)	-

[Oil Pump]

Rotor lobe clearance	-	0.25 mm (0.0098 in.)
Radial clearance between outer rotor and pump body	0.15 to 0.21 mm (0.0059 to 0.0083 in.)	0.30 mm (0.0118 in.)
End clearance between rotor and cover	0.08 to 0.13 mm (0.0031 to 0.0051 in.)	0.20 mm (0.0079 in.)

[Oil Filter]

Opening pressure of bypass valve	98 kPa (1.0 kgf/cm ² , 14.2 psi) of pressure difference	-
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COOLING SYSTEM

[Fan Belt]

Item	Factory Specification		Allowable Limit	
Belt deflection under load of 98 N (10 kgf, 21 lbs)	7 to 9 mm (0.28 to 0.35 in.)		-	

[Radiator] (not included with the basic model)

Radiator water tightness	Water tightness at specified pressure (137 kPa, 1.4 kgf/cm ² , 20 psi)	-
Radiator cap opening pressure	10 seconds or more of pressure falling time from 88 to 59 kPa (0.9 to 0.6 kgf/cm ² , 13 to 9 psi)	-

[Thermostat]

Thermostat's valve opening temperature	80.5 to 83.5°C (176.9 to 182.3°F)	-
Temperature at which thermostat completely opens	95°C (203°F) at 6mm (0.236 in.) of opening	-

FUEL SYSTEM

[Injection Pump]

Injection timing (static)	0.33 to 0.37 rad. (19° to 21°) before TDC	-
Fuel tightness of pump element	60 seconds or more of pressure falling time from 39.23 to 34.32 MPa	30 seconds or more of pressure falling time from 39.23 to 34.32 MPa
	(400 to 350 kgf/cm ² , 5689 to 4978 psi)	(400 to 350 kgf/cm ² , 5689 to 4978 psi)
Fuel tightness of delivery valve	10 seconds or more of pressure falling time from 21.57 to 20.59 MPa (220 to 210 kgf/cm ² , 3129 to 2987 psi)	5 seconds or more of pressure falling time from 21.57 to 20.59 MPa (220 to 210 kgf/cm ² , 3129 to 2987 psi)

[Injection Nozzle]

Fuel injection pressure	13.73 to 14.71 MPa (140 to 150 kgf/cm ² , 1991 to 2133 psi)	-
Fuel tightness of nozzle valve seat	No fuel leak at 12.75 MPa (130 kgf/cm ² , 1849 psi)	-

ELECTRICAL SYSTEM

[Starter]

Commutator O.D.	32 mm (1.26 in.)	31 mm (1.22 in.)
Variance	-	0.05 mm (0.0020 in.)
Mica undercut	-	0.2 mm (0.008 in.)
Brush length	17.0 mm (0.669 in.)	11.5 mm (0.453 in.)

[Glow Plug]

Resistance	approx. 1.6 ohm	-
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[AC dynamo]

No-load output	AC 20 volt or more at 5200 rpm	-
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[Regulator] (not included with the basic model)

Regulating voltage	14 to 15 volt	-
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[7] MAINTENANCE CHECK LIST

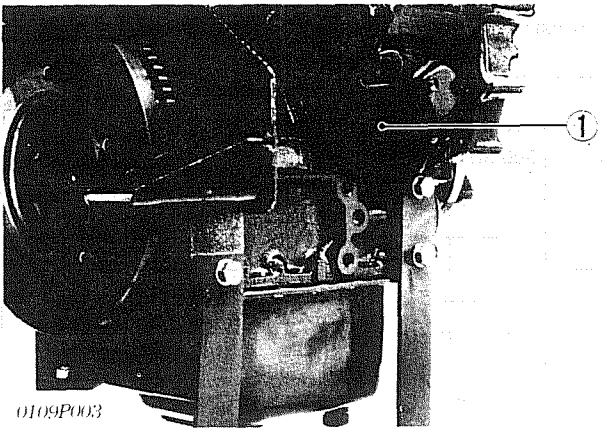
To maintain long-lasting and safe engine performance, make it a rule to carry out regular inspections by following the table below.

Item	Service interval									
	every 50 hrs.	every 100 hrs.	every 150 hrs.	every 200 hrs.	every 400 hrs.	every 500 hrs.	every one or two months	every three months	every one year	every two years
Checking fuel pipes and clamps	●									
Changing engine oil		●								
Cleaning air filter element		●								
Cleaning fuel filter		●								
Checking battery electrolyte level		●								
Checking fan belt tension and damage		●								
Checking oil or water leakage			●							
Checking water pipes and clamps			●							
Changing oil filter cartridge				●						
Changing fuel filter element					●					
Cleaning radiator interior						●				
Recharging battery							●			
Changing radiator cleaner and coolant								●		
Changing air filter element									● or every 6 cleanings	
Checking valve clearance									●	
Checking nozzle injection pressure									●	
Changing battery										●
Changing water pipes and clamps										●
Changing fuel pipes and clamps										●

CAUTION:

- When changing or inspecting, be sure to level and stop the engine.

[8] CHECK AND MAINTENANCE



0109P003

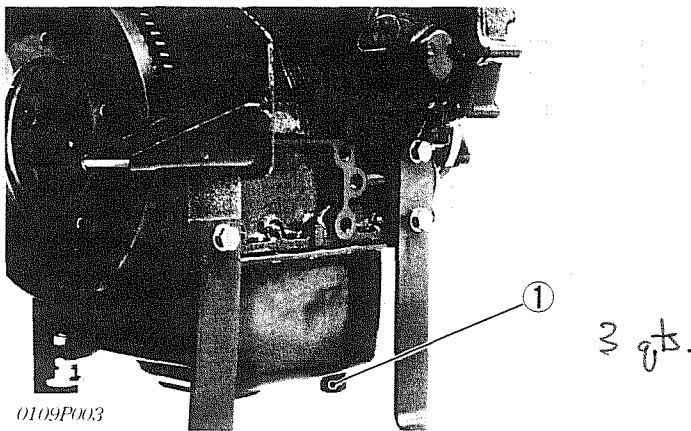
Checking Engine Oil Level

1. Level the engine.
2. To check the oil level, draw out the dipstick (1), wipe it clean, reinsert it, and draw it out again.
Check to see that the oil level lies between the two notches.
3. If the level is too low, add new oil to the specified level.
4. When using an oil of a different maker or viscosity from the previous one, remove all old oil. Never mix two different types of oil.

NOTE:

- Use the proper Engine Oil SAE according to the ambient temperatures.

(1) Dipstick



0109P003

Changing Engine Oil

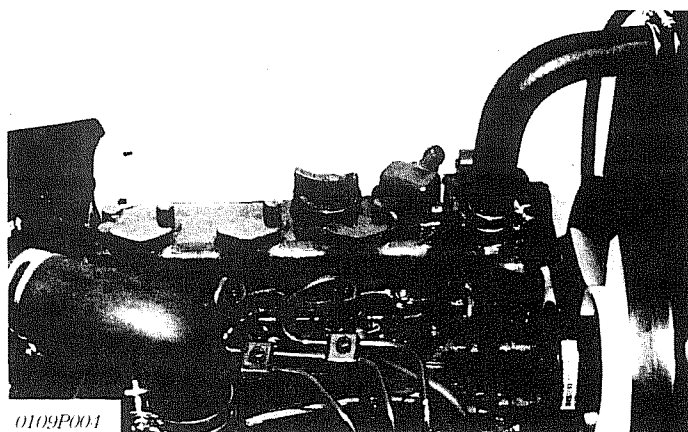
1. After warming up, stop the engine.
2. To change the used oil, remove the drain plug (1) at the bottom of the engine and drain off the oil completely.
3. Reinstall the drain plug.
4. Fill the new oil up to the upper notch on the dipstick.

Specified quantity	M-12	1.87 ℓ 0.494 U.S. gal 0.411 Imp. gal
	M-18,25	2.91 ℓ 0.769 U.S. gal 0.640 Imp. gal

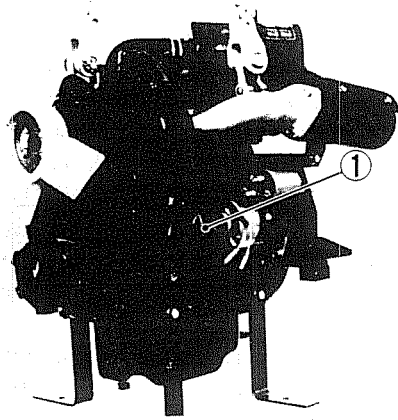
IMPORTANT:

- Engine oil should be MIL-L-46152/MIL-L-2104C or have properties of API classification CC/CD grades.
- Change the type of engine oil according to the ambient temperature.
 Above 25°C(77°F) SAE 30
 0°C to 25°C(32°F to 77°F)..... SAE 20
 Below 0°C(32°F) SAE10W or SAE10W-30

(1) Drain Plug



0109P004



0109P002

Changing Engine Oil Filter Cartridge

1. Remove the oil filter cartridge with a filter wrench.
2. Apply engine oil to the rubber gasket on the new cartridge.
3. Screw in the new cartridge in by hand.

NOTE:

- Over-tightening may cause deformation of the rubber gasket.
- After, the cartridge has been replaced, engine oil normally decreases a little.

Check the oil level and add new oil to the specified level.

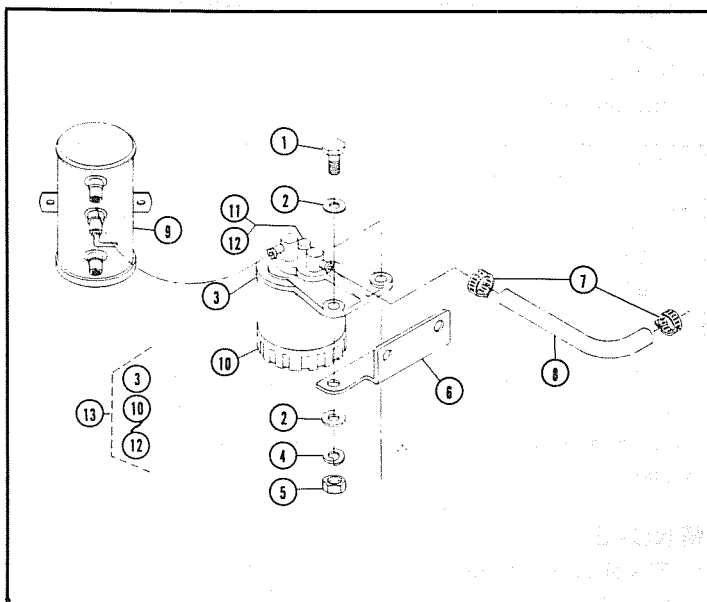
(1) Filter Cartridge

Bleeding Fuel System

1. Fill the fuel tank with fuel, and open the fuel cock.
2. Loosen the air vent plug of the fuel filter a few turns.
3. Screw back the plug when bubbles do not come up any more.
4. Open the air vent cock on top of the fuel injection pump.
5. Retighten the plug when bubbles do not come up any more.

NOTE:

- Always keep the air vent cock on the fuel injection pump closed except when air is vented, or it may cause the engine to stop.



Item	Part No.	Unit	Description
1	231059	2	Cap Screw
2	231875	4	Flat Washer
3	301602	1	Fuel Filter Cover
4	231906	2	Washer Lock
5	230141	2	Nut
6	300103	1	Bracket Fuel Filter
7	298605	2	Clamp Adjustable
8	298567	1	Fuel Hose
9	301385	1	Electric Fuel Pump
10	298854	1	Fuel Filter Element
11	299855	1	Bleed Screw
12	299856	1	O-Ring
13	298853	1	Fuel Filter Assembly

Checking Fuel Pipe

Check the fuel pipes every 50 hours of operation.

1. If the clamp is loose, apply oil to the threads and securely retighten it.
2. The fuel pipe is made of rubber and ages regardless of the period of service.
Change the fuel pipe together with the clamp every two years.
3. However, if the fuel pipe and clamp are found to be damaged or deteriorate earlier than two years, then change or remedy.
4. After the fuel pipe and the clamp have been changed, bleed the fuel system.

CAUTION:

- Stop the engine when attempting the check and change prescribed above.

Antifreeze

If the cooling water freezes, the engine cylinder block, cylinder head and radiator may crack. In cold weather before the temperature drops below 0°C (32°F), drain out the water after operating or add a proper amount of antifreeze.

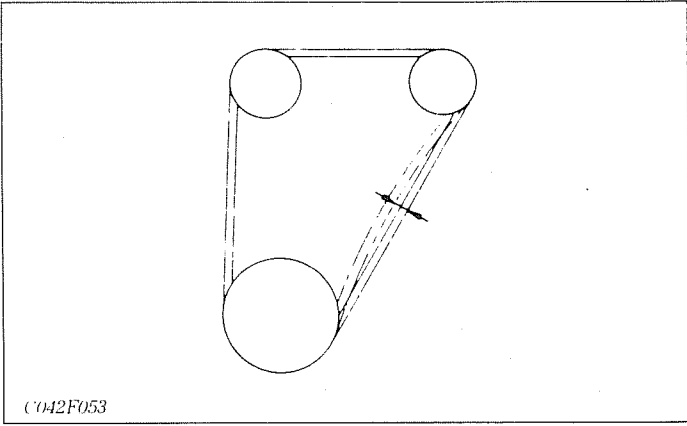
- There are two types of antifreeze solutions: permanent type (PT) and semi-permanent type (SPT). For the UNIVERSAL engines, be sure to use the permanent type.
- Do not use antifreeze during hot weather to keep the engine performance since the cooling water boiling point rises.
- When antifreeze is used for the first time, fill and drain clean water twice or three times so as to completely clean the inside of the radiator.
- The procedure for mixing water and antifreeze differs according to the make of the antifreeze and the ambient temperature. Basically, it should be referred to SAE J1034 standard, more specifically also to SAE J814c.
- Mix the antifreeze and water, then pour the mixture into the radiator.

Vol % antifreeze	Freezing point		Boiling point	
	°C	°F	°C	°F
40	-24	-12	106	222
50	-37	-34	108	226
60	-52	-62	111	232
70	-64	-84	114	238

*At 760mmHg pressure (atmospheric). A higher boiling point is obtained by using a radiator pressure cap which permits the development of pressure within the cooling system.

NOTE:

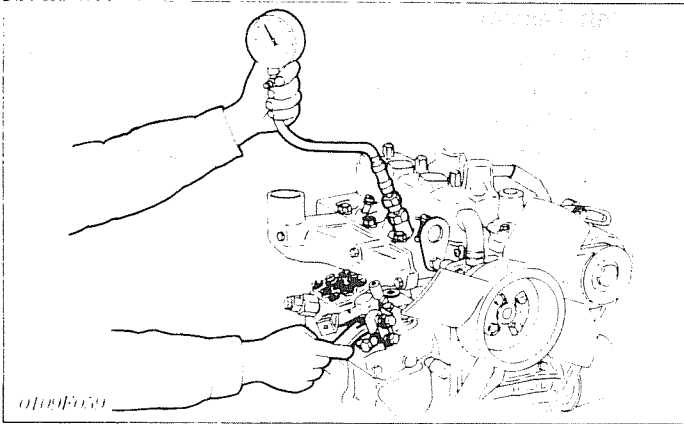
- The above data represents industrial standards that necessitate a minimum glycol content in the concentrated antifreeze.
- When the cooling water level drops due to evaporation, add water only. In case of leakage, add antifreeze and water in the specified mixing ratio.
- Antifreeze absorbs moisture. Keep unused antifreeze in a tightly sealed container.
- Do not use radiator cleaning agents when antifreeze has been added to the cooling water.
(Antifreeze contains an anticorrosive agent, which will react with the radiator cleaning agent forming sludge which will affect the engine parts.)



Belt Tension

- 1. Measure the deflection, depressing the belt halfway between the fan drive pulley and the AC dynamo pulley at 98 N (10 kgf, 22 lbs) of force.
- 2. If the measurement is not the specified value, loosen the bolts and the nuts, and relocate the AC dynamo to adjust.

Fan belt tension	Factory specification	approx. 10 mm 0.39 in.
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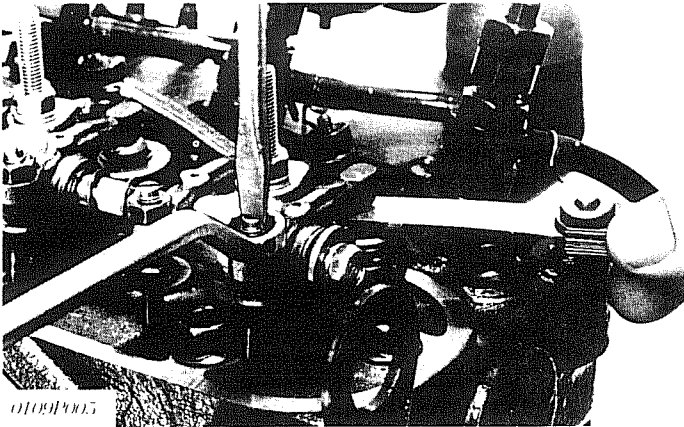
Checking Compression Pressure

1. Warm up the engine and stop it.
2. Remove the air cleaner and the muffler.
3. Remove the nozzle holders from all the cylinders.
4. Set a compression tester (Code No. 07909-30200) to the nozzle holder hole.
5. Cut the fuel (pull the stop lever), and run the engine for 5 to 10 seconds (at 200 to 300 rpm) and read the maximum pressure.
Execute the test at least twice.
6. If the compression pressure is less than the allowable limit, pour a small amount of engine oil through the nozzle holder hole and test again.
7. If the compression pressure reaches the allowable limit, check the cylinder liner and the piston rings. If not, check the top clearance, valve and cylinder head.

Compression pressure	Factory spec.	3.09 MPa 31.5 kgf/cm ² 448 psi
	Allowable limit	2.32 MPa 23.7 kgf/cm ² 337 psi

NOTE:

- For the test, use a fully charged battery and the specified valve clearance.
- Variances in cylinder compression values should be under 10%.



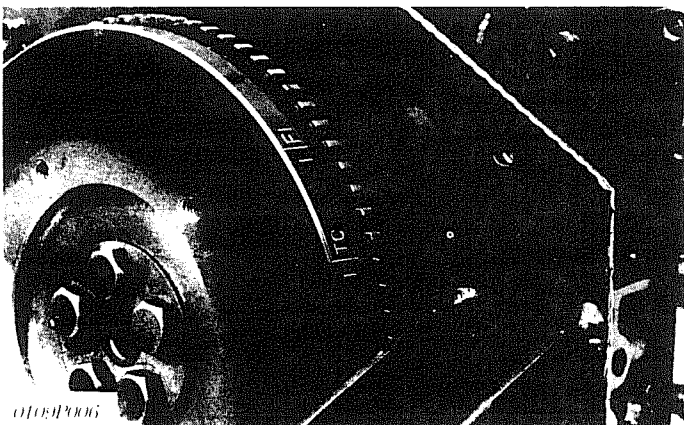
Valve Clearance

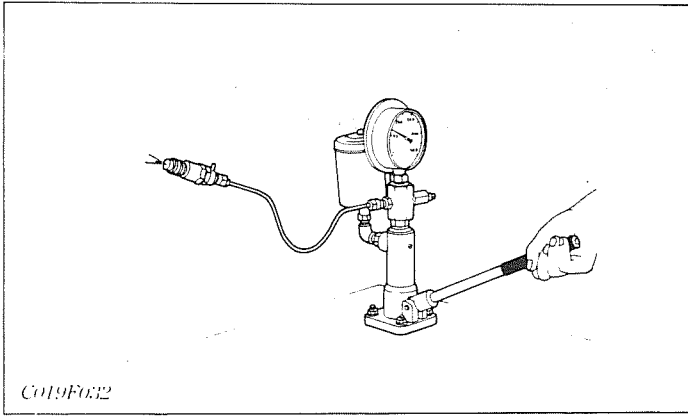
1. Loosen the lock nut and the adjusting screw on the rocker arm.
2. Turn the adjusting screw to adjust the valve clearance at the top dead center (T.D.C) during the compression stroke of the piston.
3. Tighten the lock nut and check the valve clearance again after several turns of the flywheel.

NOTE:

- To get T.D.C. of the piston, find its "TC" mark on the flywheel and align it to the punch mark on the rear end plate (See photo).

Valve clearance	Factory specification	0.15 to 0.18 mm, 0.0059 to 0.0071 in.
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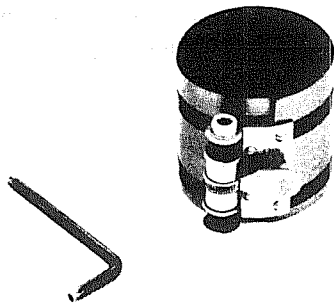
C019F032

Checking Fuel Injection Pressure

1. Set the injection nozzle to the nozzle tester.
2. Measure the injection pressure.
3. If the measurement is not within the factory specifications adjust with the adjusting washer inside the nozzle holder.

Fuel injection pressure	Factory spec.	13.73 to 14.71 MPa 140 to 150 kgf/cm ² 1991 to 2133 psi
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[9] SPECIAL TOOLS

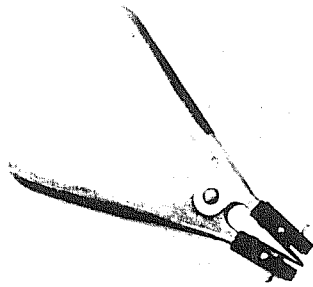


C056P008

Piston Ring Compressor

Code No.: 07909-32111

Application: Use exclusively for pushing in the piston with ease.

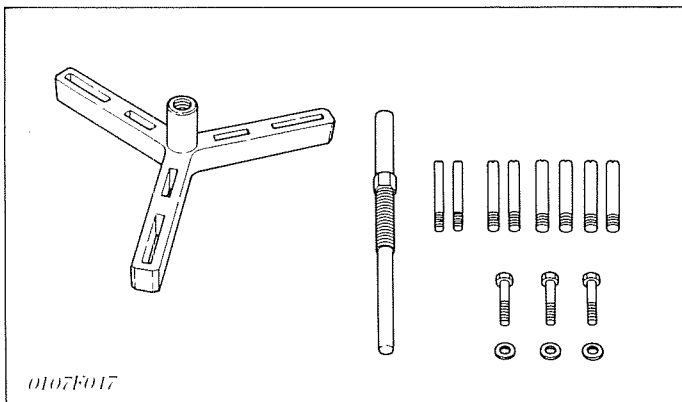


C056P009

Piston Ring Tool

Code No.: 07909-32121

Application: Use exclusively for removing or installing the piston ring with ease.

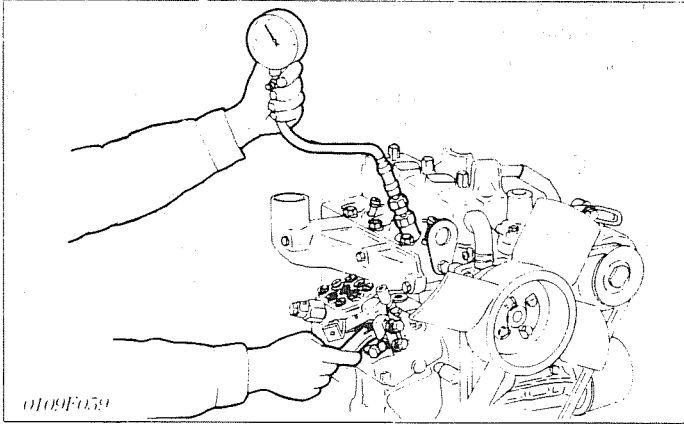


0107F017

Flywheel Puller (For vertical type diesel engines)

Code No.: 07916-32011

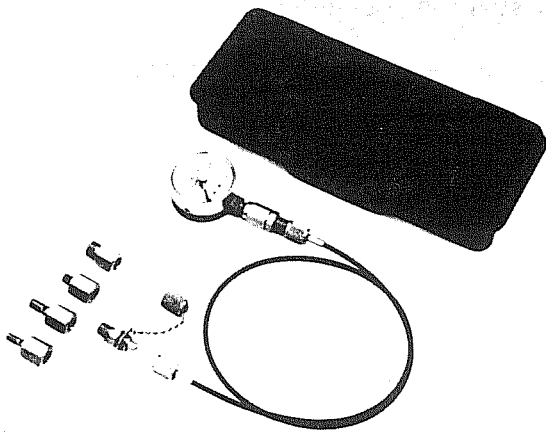
Application: Use exclusively to take off the flywheel of all vertical type diesel engines safely and easily.



Diesel Engine Compression Tester

Code No.: 07909-30200

Application: Use to measure diesel engine compression and to diagnose the engine for a major overhaul.

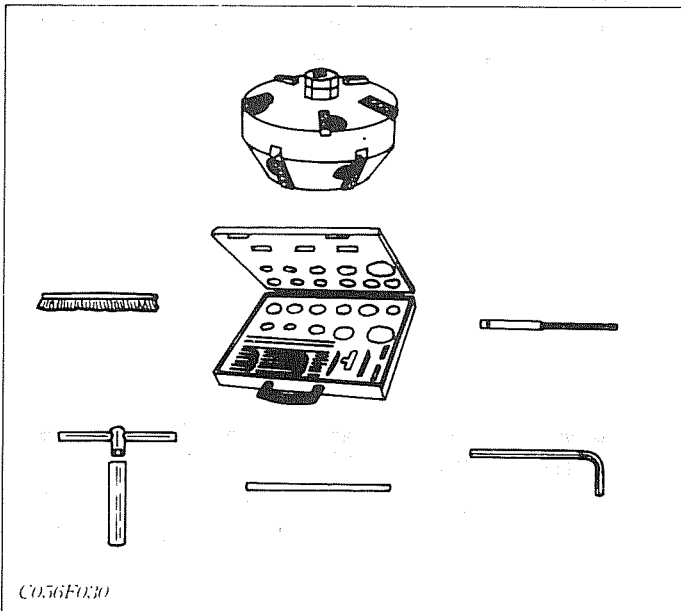


Oil Pressure Tester

Code No.: 07916-32031

Application: A tester to measure lubricating oil pressure for all kinds of diesel engines.

C017P068



Valve Seat Cutter

Code No.: 07909-33102

Application: Use to reseal valves.

Angle: 0.785 rad. (45°)

0.262 rad. (15°)

Diameter: 28.6 mm (1.126 in.)

31.6 mm (1.244 in.)

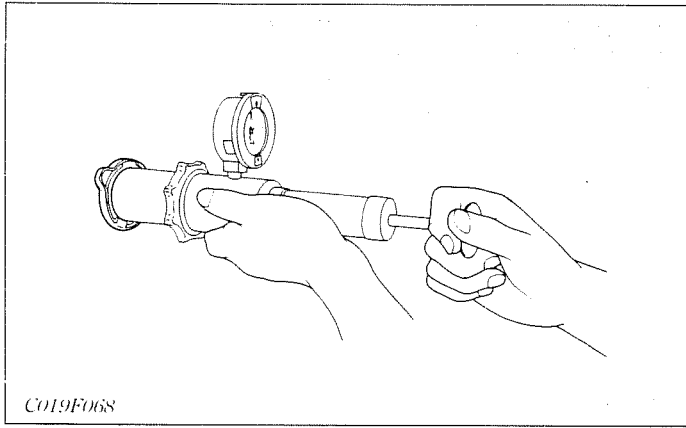
35.0 mm (1.378 in.)

38.0 mm (1.496 in.)

41.3 mm (1.626 in.)

50.8 mm (2.000 in.)

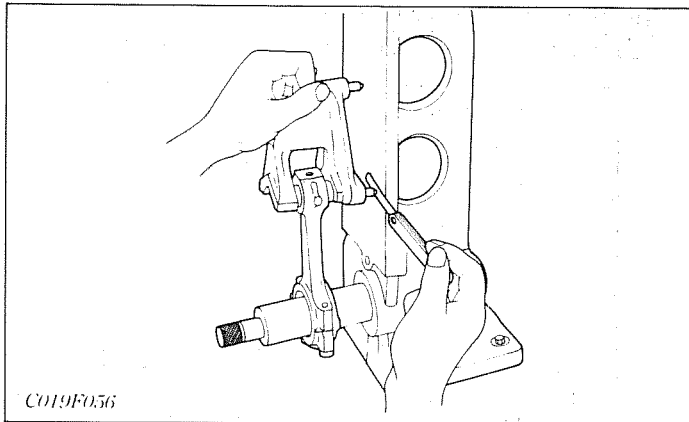
C056F030



Radiator Tester

Code No.: 07909-31551

Application: Use to check radiator cap pressure and leaks from cooling systems.

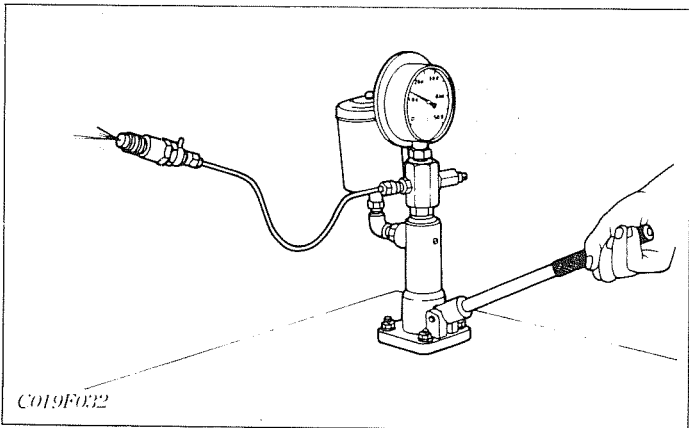


Connecting Rod Alignment Tool

Code No.: 07909-31661

Application: Use to check the connecting rod alignment.
 Applicable range: Connecting rod large end I.D. 30 to 75 mm
 (1.18 to 2.95 in dia.)

Connecting rod length
 65 to 330 mm (2.56 to 12.99 in.)

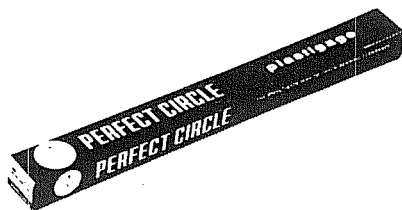


Nozzle Tester

Code No.: 07909-31361

Application: Use to check the fuel injection pressure and spraying condition of nozzle.

Measuring range: 0 to 49 MPa (0 to 500 kg/cm², 0 to 7112 psi)



Press Gauge

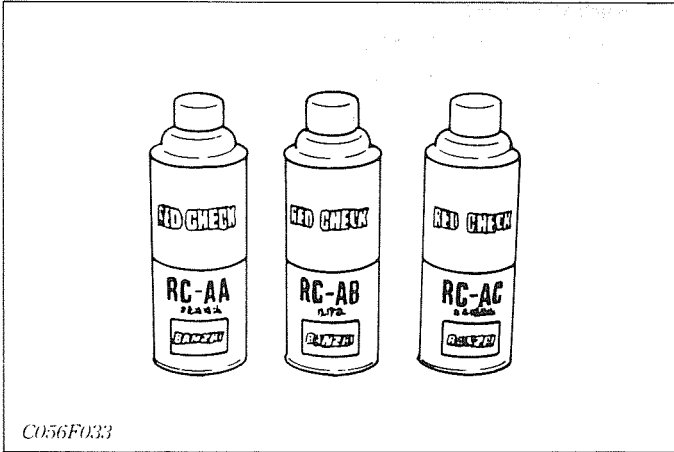
Code No.: 07909-30241

Application: Use to check the oil clearance between crankshaft and bearing, etc.

Measuring range: Green — 0.025 to 0.076 mm
 (0.01 to 0.03 in.)

Red — 0.051 to 0.152 mm
 (0.02 to 0.06 in.)

Blue — 0.102 to 0.229 mm
 (0.04 to 0.09 in.)



Red Check (Crack check liquid)

Code No.: 07909-31371

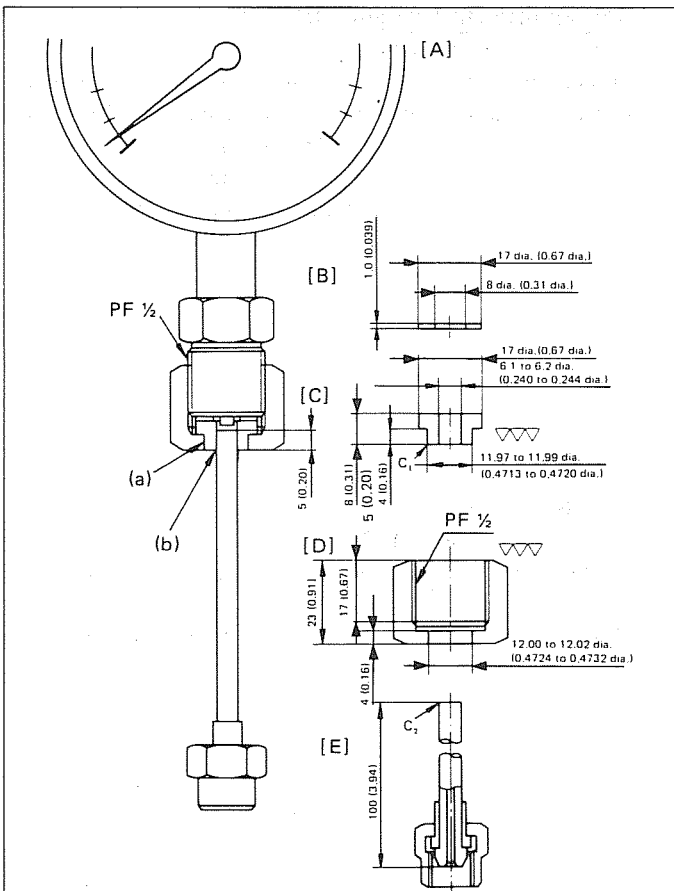
Application: Use to check cracks on cylinder heads, crank-cases, etc.

NOTE:

- The following special tools are not provided, so make them referring to the figures.

Injection Pump Pressure Tester

Application: Use to check fuel tightness of injection pumps.

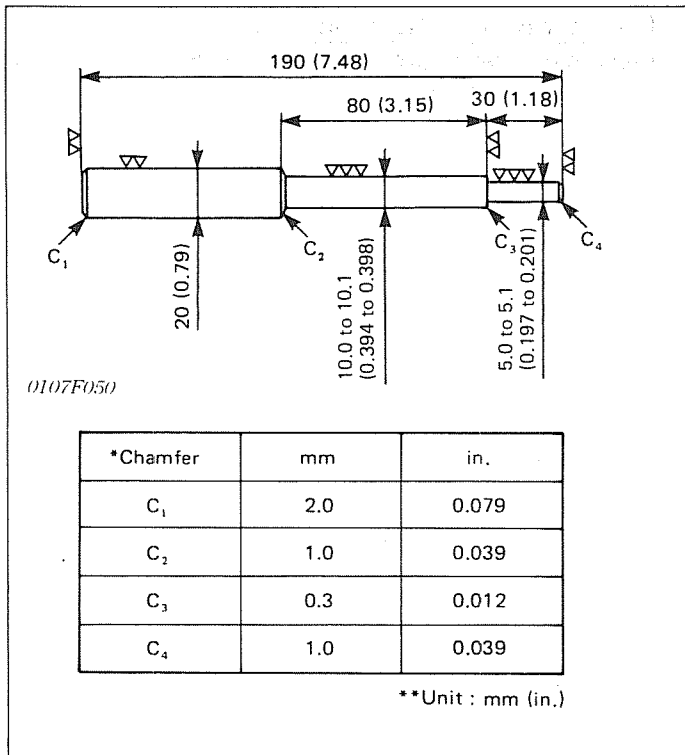


A	Pressure gauge [Full scale : More than 40 MPa, 400 kgf/cm ² , 6000 psi]
B	Copper gasket
C	Flange [Material : S45C]
D	Hex. nut 27 mm across the flat (1.06 in.) [Material : S45C]
E	Injection pipe

a	Adhesive application
b	Fillet welding on the enter circumference

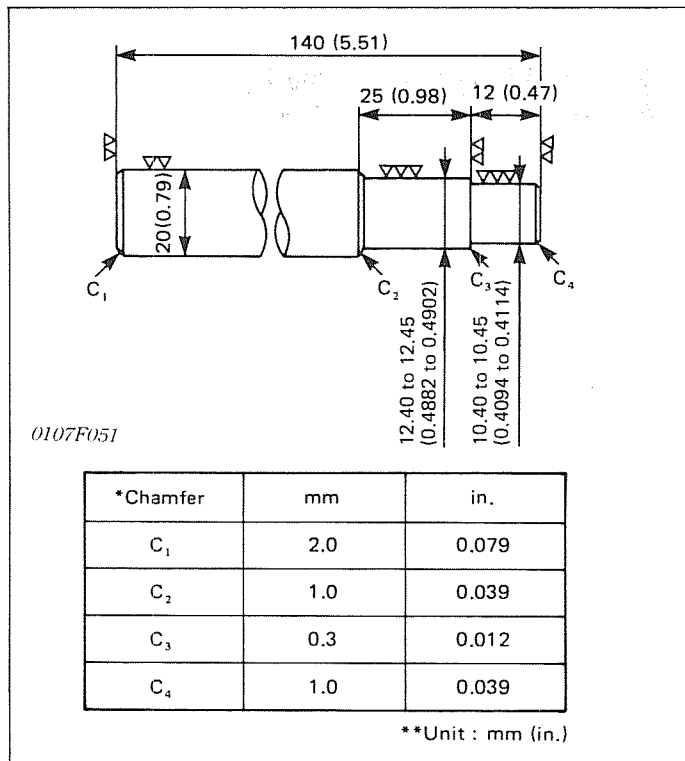
*Chamfer	mm	in.
C ₁	0.5	0.020
C ₂	0.5	0.020

**Unit: mm (in.)



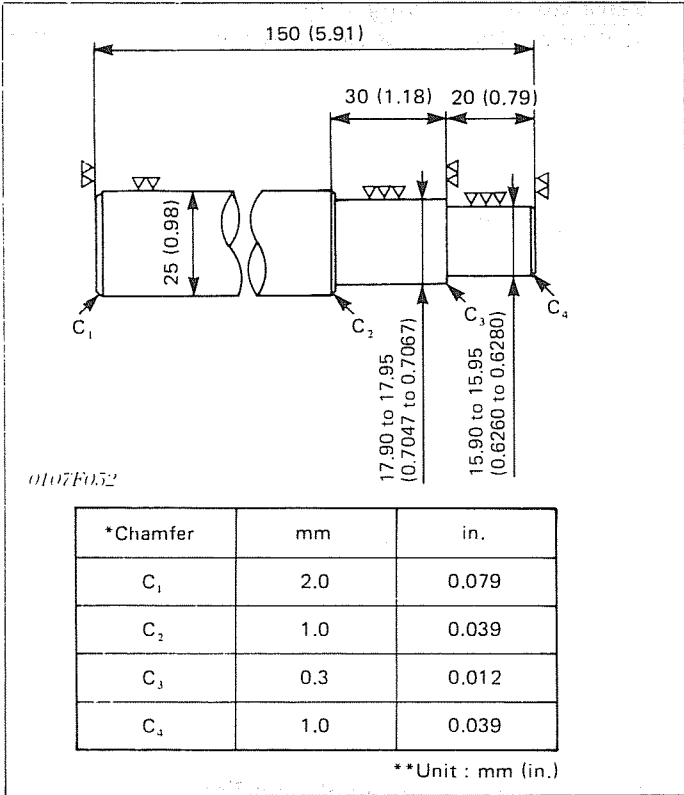
Valve Guide Replacing Tool

Application: Use to press out and to press fit the valve guide.



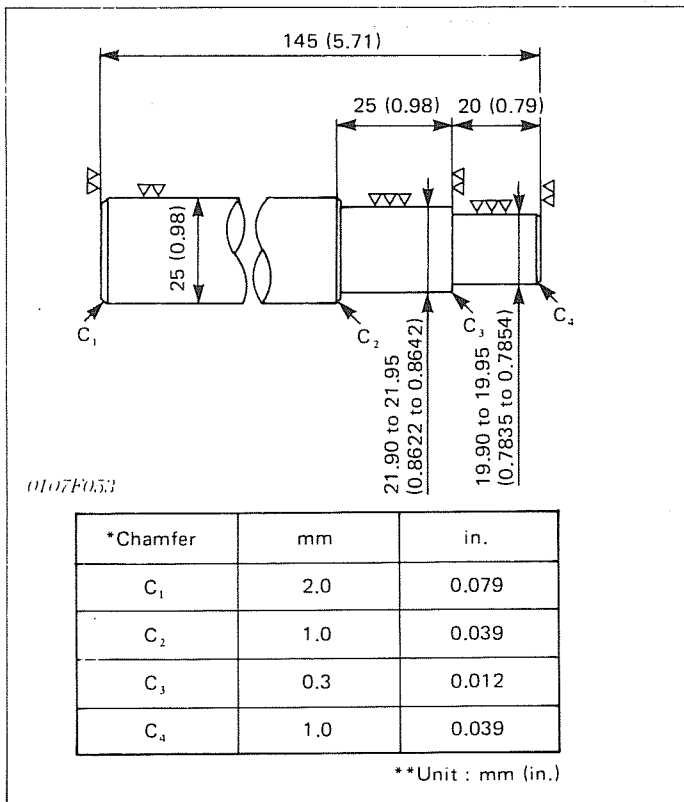
Rocker Arm Bushing Replacing Tool

Application: Use to press out and to press fit the rocker arm bushing.



Idle Gear Bushing Replacing Tool

Application: Use to press out and to press fit the idle gear bushing.

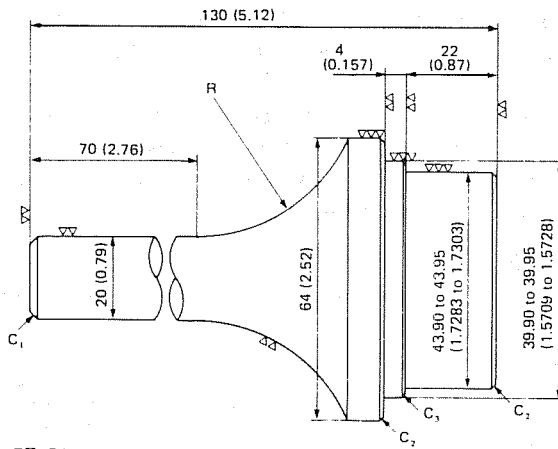
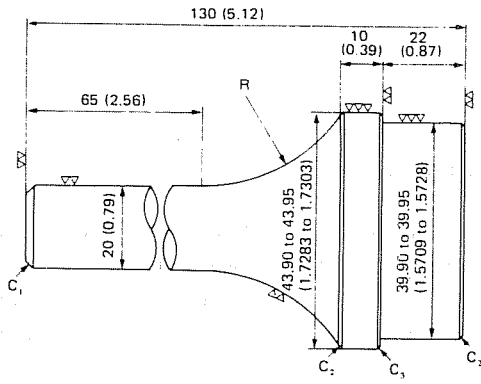


Small End Bushing Replacing Tool

Application: Use to press out and to press fit the small end bushing.

Crankshaft Bearing 1 Replacing Tool

Application: Use to press out and to press fit the crankshaft bearing 1.

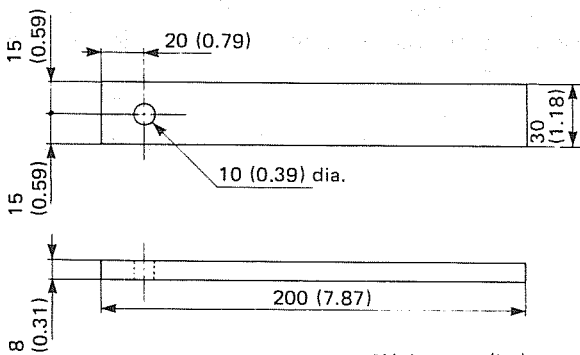


0107F054

*Chamfer	mm	in.
C ₁	2.0	0.079
C ₂	1.0	0.039
C ₃	0.3	0.012

**Radius	mm	in.
R	40	1.57

***Unit: mm (in.)



*Unit : mm (in.)

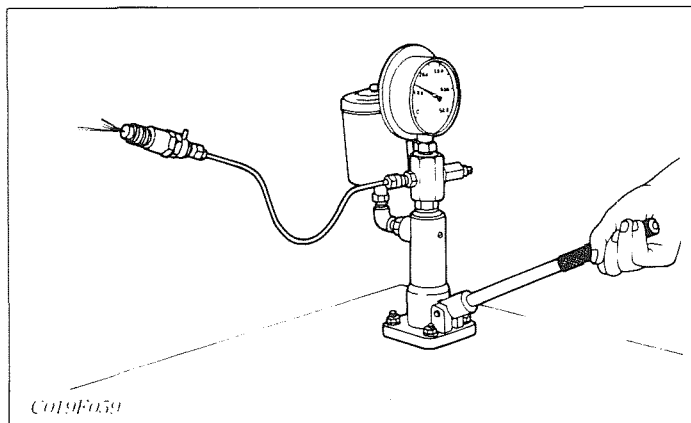
0107F055

Flywheel Stopper

Application: Use to loosen and tighten the flywheel screw.

ENGINE BODY

CHECKING AND ADJUSTMENT



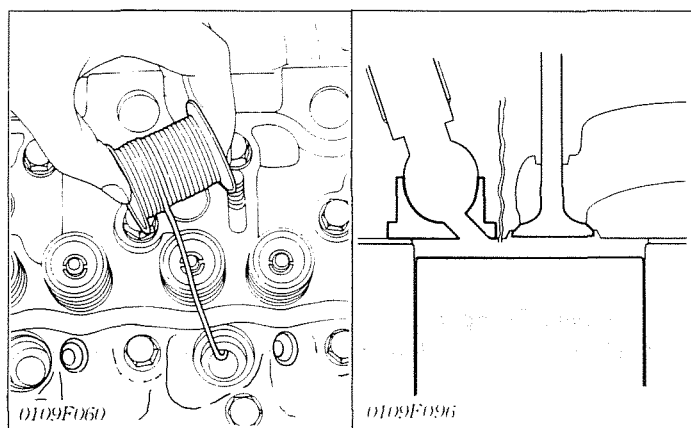
Compression Pressure

1. Run the engine until it is warmed up.
2. Stop the engine and remove the air cleaner, the muffler and all nozzle holders.
3. Set a compression tester (Code No.: 07909-30200) with the adaptor to the nozzle holder hole.
4. Run the engine with the starter at 200 to 300 rpm for 5 to 10 seconds and read the maximum compression pressure.
5. Measure the compression pressure several times.
6. If the measurement does not reach the allowable limit, apply a small amount of oil to the cylinder wall through the nozzle holder hole and measure the compression pressure again.
7. If the pressure is still less than the allowable limit, check the top clearance, valve and cylinder head.
8. If the pressure increases after applying oil, check the cylinder wall and piston rings.

NOTE:

- Check the compression pressure with the specified valve clearance (See page S-67).

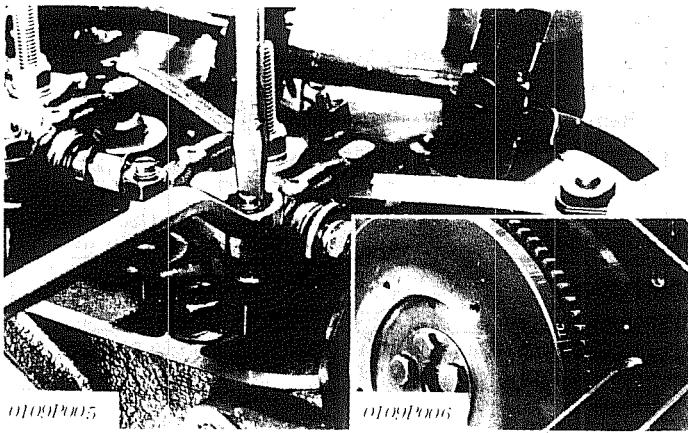
Compression pressure	Factory specification	3.09 MPa 31.5 kgf/cm ² 448 psi
	Allowable limit	2.32 MPa 23.7 kgf/cm ² 337 psi



Top Clearance

1. Remove the nozzle holder and lower the piston in the cylinder.
2. Insert a high-quality fuse from the nozzle holder hole on the piston [except where it faces the valve or the combustion chamber insert.]
3. Rotate the flywheel until the piston is raised and lowered again.
4. Take out the flattened fuse carefully and measure its thickness with vernier calipers.
5. If the measurement is not within the specified values, check the oil clearances of the crankpin journal and the piston pin.

Top clearance	Factory specification	0.60 to 0.80mm 0.0236 to 0.0315 in.
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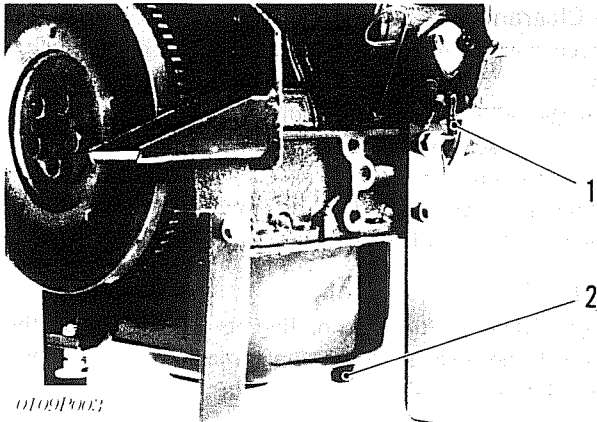
Valve Clearance

1. Loosen the lock nut and the adjusting screw on the rocker arm.
2. Turn the adjusting screw to adjust the valve clearance at the top dead center (T.D.C) during the compression stroke of the piston.
3. Tighten the lock nut and check the valve clearance again after several turns of the flywheel.

■ NOTE:

- To get T.D.C. of the piston, find its "TC" mark on the flywheel and align it to the punch mark on the rear end plate (See photo).

Valve clearance	Factory specification	0.15 to 0.18mm 0.0059 to 0.0071 in.
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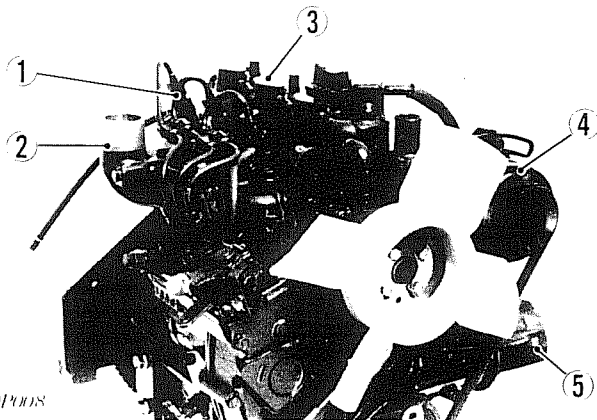
[1] External Components

Engine Oil and Cooling Water

1. Open the cock (1) and drain cooling water.
2. Remove the plug (2) and drain engine oil.

Capacity		M-12	M-18,25
Cooling water		1.9 ℓ, 2.0 USqts, 1.67 Imp. qts	2.1 ℓ, 2.3 USqts, 1.85 Imp. qts
Engine oil		2.0 ℓ, 2.1 USqts, 1.76 Imp. qts	3.0 ℓ, 3.2 USqts, 2.64 Imp. qts
Tightening torque	Drain plug	32.4 to 37.3 N·m, 3.3 to 3.8 kgf·m, 23.9 to 27.5 ft-lbs	

- (1) Drain Cock
- (2) Plug



[2] Cylinder Head

Injection Pipes, Inlet Manifold and Cylinder Head Cover

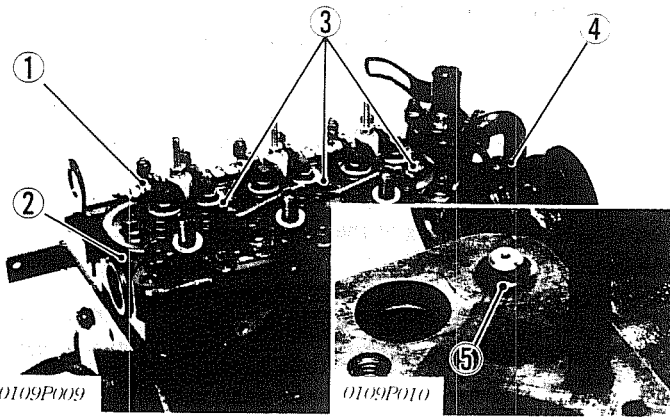
1. Remove the injection pipes, overflow pipes and the nozzle holders (1).
2. Remove the inlet manifold (2).
3. Remove the cylinder head cover (3).
4. Remove the dynamo (4) and the oil filter (5).

(When reassembling)

- Apply engine oil to the head cover nuts.

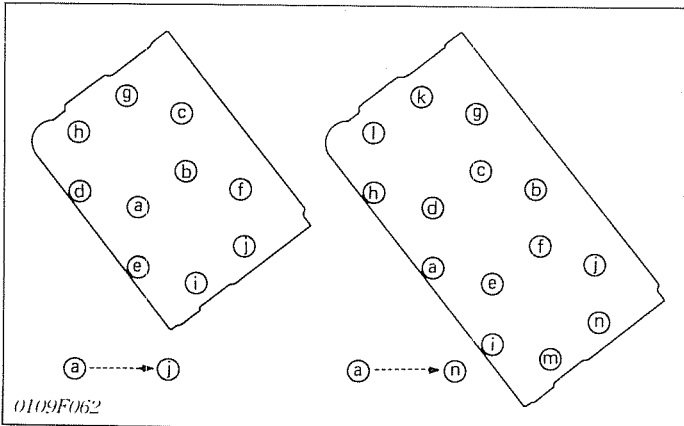
Tightening torque	Injection pipe nut	24.5 to 34.3 N·m 2.5 to 3.5kgf·m 18.1 to 25.3 ft-lbs
	Overflow pipe nut	19.6 to 25.3 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Head cover nut	3.9 to 5.9 N·m 0.4 to 0.6 kgf·m 2.9 to 4.3 ft-lbs
	Nozzle holder	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs

- (1) Nozzle Holder
- (2) Inlet Manifold
- (3) Cylinder Head Cover
- (4) Dynamo
- (5) Oil Filter



0109P009

0109P010



0109F062

Rocker Arm and Cylinder Head

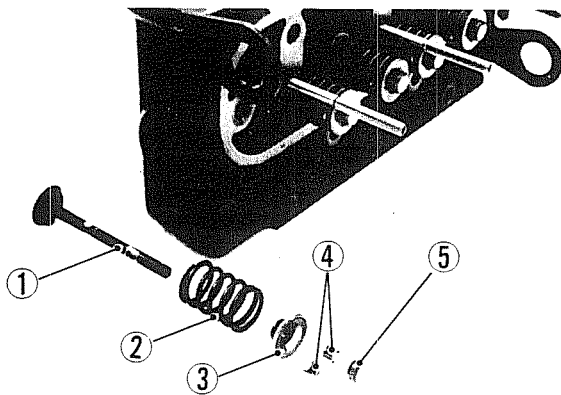
1. Remove the grow plugs (3).
2. Remove the rocker arms and shaft assembly (1).
3. Remove the push rods and tappets.
4. Loosen the hose clamp (4), and remove the screws, the nuts and the cylinder head (2).

(When reassembling)

- Be sure to place the O-ring (5) (See photo).
- Apply engine oil to the head screws and nuts, and tighten them in the specified sequence (See figure), in several steps and to the specified torque.
- After tightening all the screws and the nuts, run the engine until it warms up and tighten them again to the specified torque.

Tightening torque	Grow plug	19.4 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Rocker arm nut	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs
	Cylinder head stud	23.5 to 27.5 N·m 2.4 to 2.8 kgf·m 17.4 to 20.3 ft-lbs
	Cylinder head screw and nut	39.2 to 44.1 N·m 4.0 to 4.5 kgf·m 28.9 to 32.5 ft-lbs

- (1) Rocker Arm Shaft Assembly
- (2) Cylinder Head
- (3) Grow Plug
- (4) Hose Clamp
- (5) O-ring



0109P011

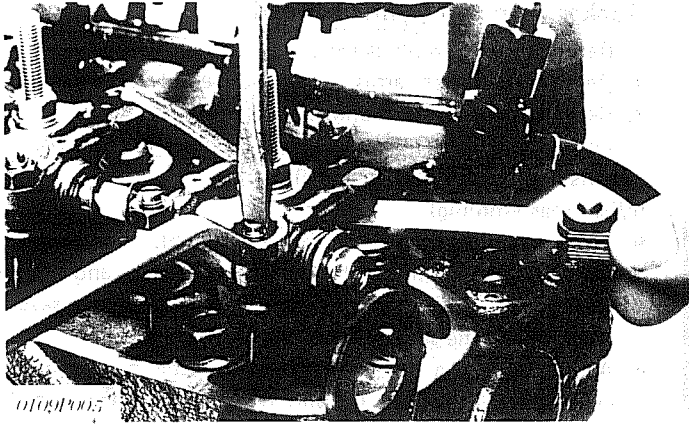
Valve

1. Remove the valve cap (5) and the valve spring collets (4), compressing the valve spring (2) with the valve spring retainer (3).
2. Remove the valve spring retainer (3) and the valve spring (2).

(When reassembling)

- Clean the valve stem and valve guide, and apply engine oil to them.
- Be sure to adjust the valve clearance after installing the valve.
- Be sure to lap the valve on its seat after replacing the valve, referring to "Correcting Valve and Seat".

- (1) Valve
- (2) Valve Spring
- (3) Valve Spring Retainer
- (4) Collet
- (5) Valve Cap

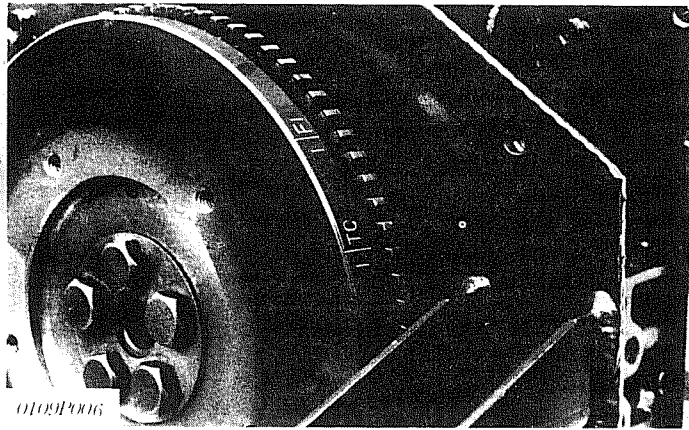


Adjusting Valve Clearance

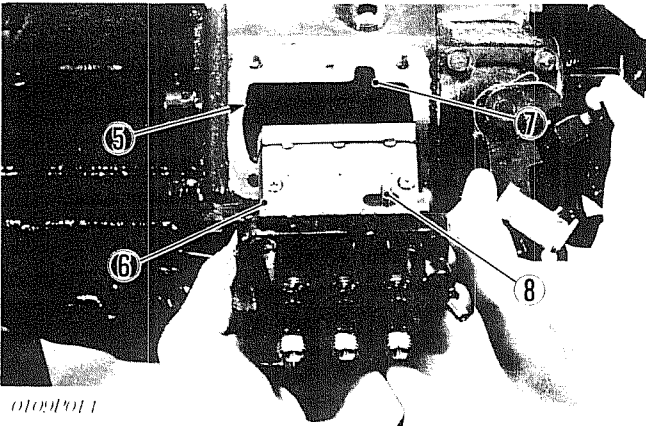
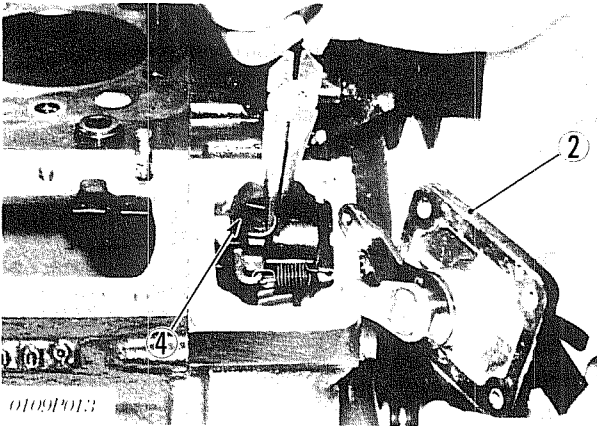
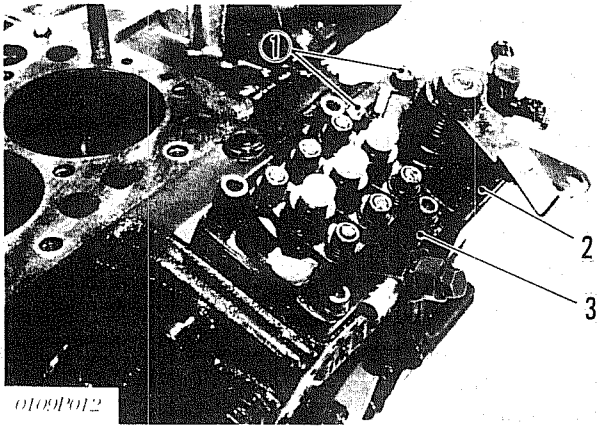
1. Loosen the lock nut and the adjusting screw on the rocker arm.
2. Turn the adjusting screw to adjust the valve clearance at the top dead center (T.D.C) during compression stroke of the piston.
3. Tighten the lock nut and check the valve clearance again after several turns of the flywheel.

■ **NOTE:**

- To get T.D.C. of piston, find its "TC" mark on the fly wheel and align it with the punch mark on the rear end plate (See photo).



Valve clearance	Factory specification	0.145 to 0.185 mm 0.00571 to 0.00728 in.
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[3] Injection Pump and Levers

Injection Pump and Speed Control Plate

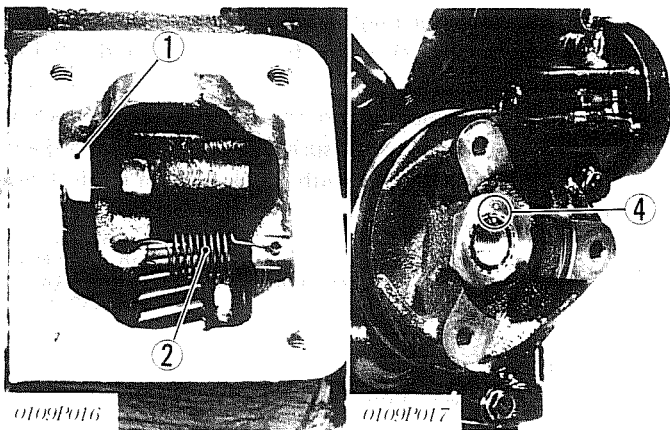
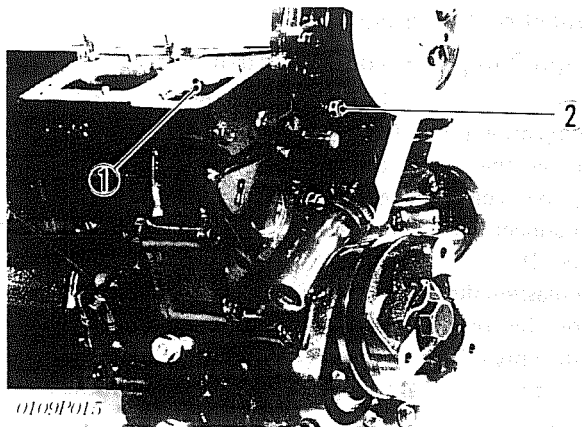
1. Remove the socket headed screws and nuts, and remove the injection pump (3).
2. Remove the screws and separate the speed control plate (2), taking care not to harm the spring (4).
3. Disconnect the spring (4) and remove the speed control plate (2).

(When reassembling)

- Hook the spring (4) to the lever first and install the speed control plate (2).
- Be sure to place the copper washers underneath the screws (1) (See photo).
- Slide the control rack (6) until its end is flush with the pump housing (See photo).
- Position the slot (7) on the fork lever just under the slot on the crankcase.
- Insert the injection pump so that the control rack (6) should be pushed by the spring (5) at its end and the pin (8) on the rack engages with the slot (7) on the fork lever (See photo).

Tightening torque	Injection pump	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 7.32 ft-lbs
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- (1) Screw
- (2) Speed Control Plate
- (3) Injection Pump
- (4) Spring
- (5) Spring
- (6) Control Rack
- (7) Slot
- (8) Pin



[4] Gear Case and Flywheel

Pulley and Gear Case

1. Prepare the stopper (See figure) and install it to the flywheel so that the crankshaft does not turn.
2. Flatten the metal lock and remove the lock screw and pull out the pulley with a puller.
3. Remove the screws and disconnect the spring, and remove the gear case.

■ NOTE:

- Be sure to remove the bolts behind the fan and inside the gear case, (1) and (2).

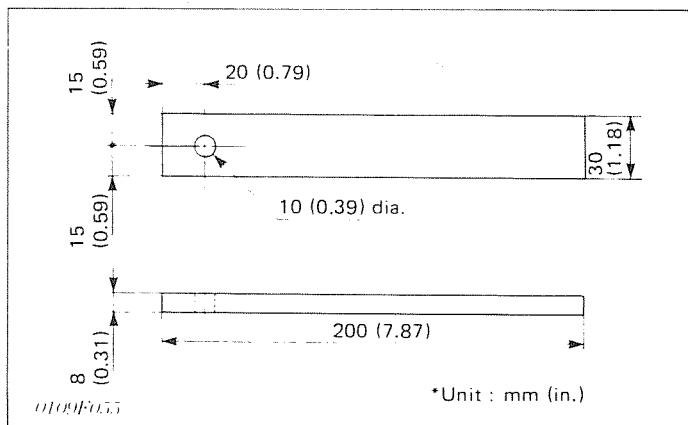
(When reassembling)

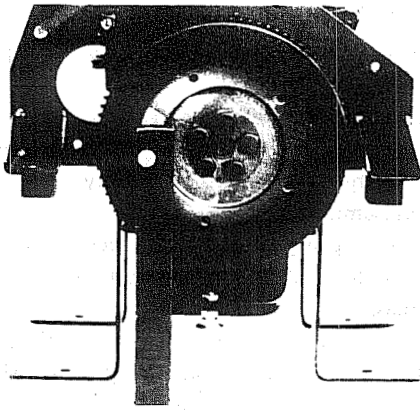
- Be sure to tighten the screws (1) and (2), and hook the spring (3).
- Install the pulley to the crankshaft, aligning the marks (4) on them.

Apply engine oil to the lock screw and tighten it to the specified torque.

Tightening torque	Lock screw	98.1 to 107.9 N·m 10.0 to 11.0 kgf·m 72.3 to 79.6 ft-lbs
	Gear case screw	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs

- (1) Screw
- (2) Screw
- (3) Spring
- (4) Aligning Mark





0109P018

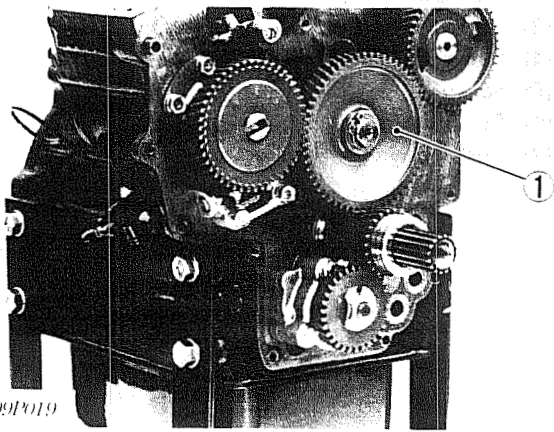
Flywheel

1. Install the stopper to the flywheel so that the flywheel does not turn.
2. Remove the screws and the flywheel.

(When reassembling)

- Place the flywheel washer on the flywheel and install them to the crankshaft, noting the location of the holes.

Tightening torque	Flywheel screw	53.9 to 58.8 N·m 5.5 to 6.0 kgf·m 39.8 to 43.4 ft-lbs
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0109P019

[5] Timing Gears and Camshafts

- If it is required to check the gear backlashes, measure them before disassembly.

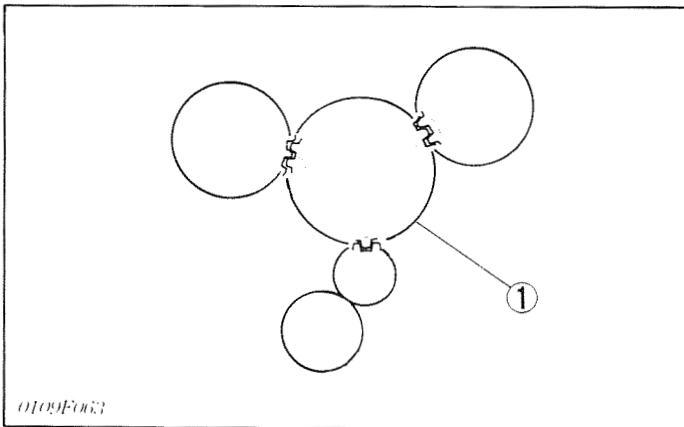
Idle Gear

1. Remove the retaining ring, the thrust washers and the idle gear (1).

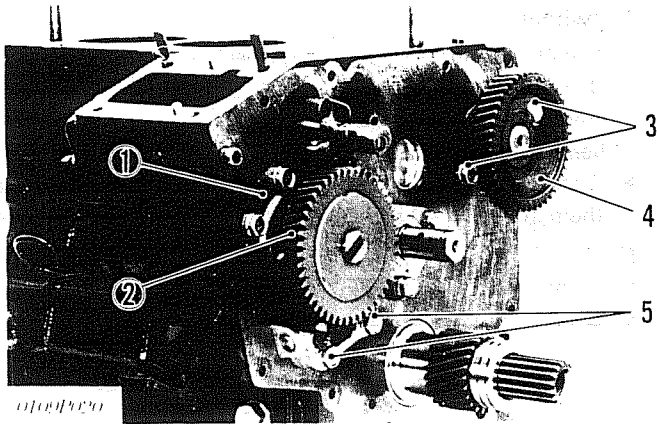
(When reassembling)

- Install the idle gear, aligning the marks on the gears referring to the figure.

(1) Idle Gear



0109F063

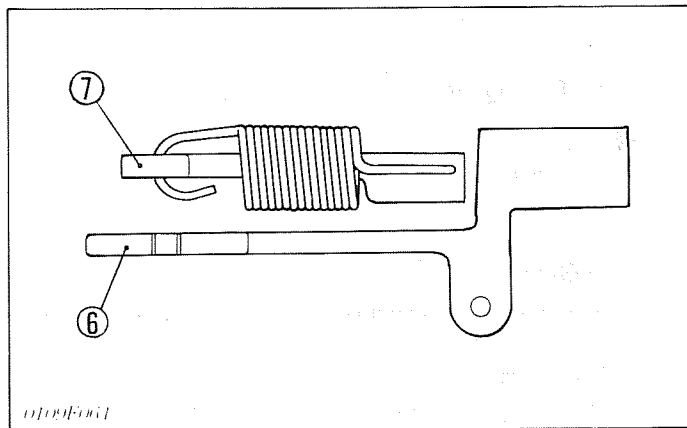


Gear and Camshaft

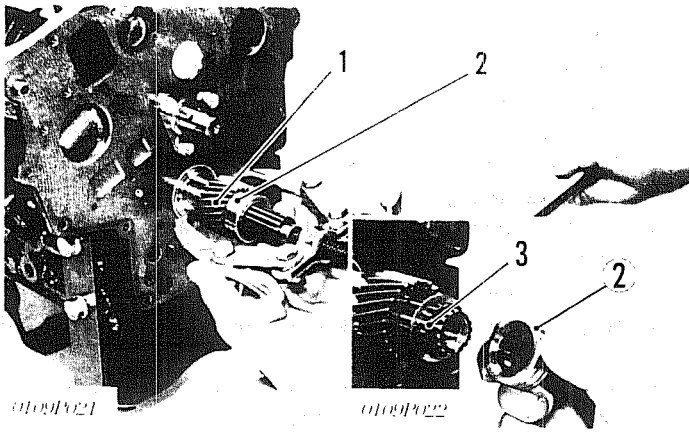
1. Remove the screws (3) and draw out the camshaft (4) with the gear on it.
2. Remove the retaining plate (1).
3. Remove the screws (5) and draw out the fuel camshaft (2) with the governor fork assembly.

(When reassembling)

- Hook the spring to the fork lever 1 (6) as shown in the figure before installing the fork lever assembly to the crankcase.
- Install the fork lever assembly so that the pins on the fork position evenly apart from the governor sleeve and make sure that the fork lever 1 is kept apart from the rack plate more than 1.5 mm (0.059 in.).



- (1) Retaining Plate
- (2) Fuel Camshaft
- (3) Screw
- (4) Camshaft
- (5) Screw
- (6) Fork Lever 1
- (7) Fork Lever 2



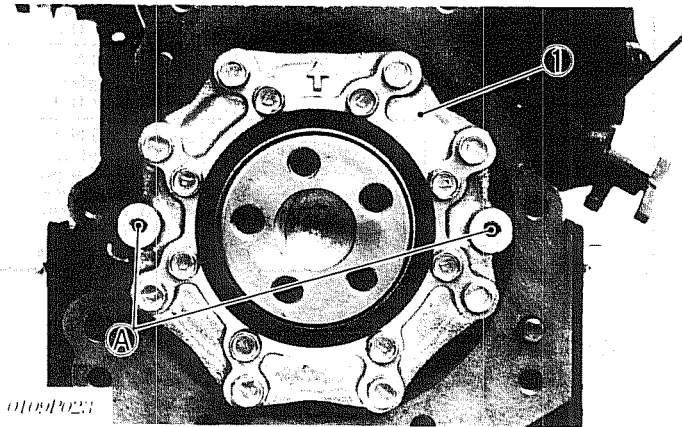
Oil Seal Sleeve and Gear

1. Pull out the oil seal sleeve (2) together with the gear (1) using a gear puller.

(When reassembling)

- Install the idle gear before installing the sleeve (See figure at "Idle Gear").
- Be sure to place the O-ring (3) before installing the sleeve (2).

- (1) Gear
- (2) Oil Seal Sleeve
- (3) O-ring



[6] Crankshaft and Piston

Main Bearing Case Cover

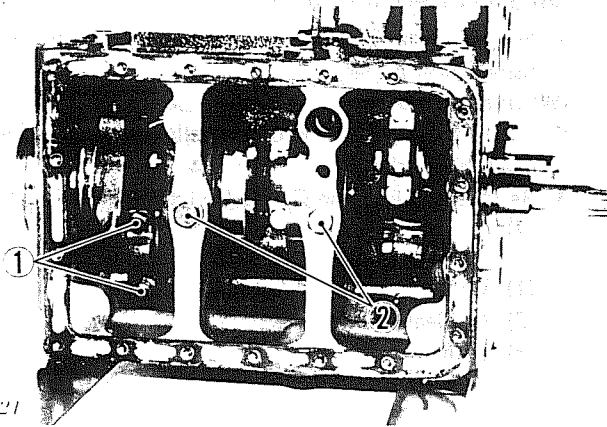
1. Remove the screws, and lift the cover (1) by screwing two screws (See photo) gradually and evenly.

(When reassembling)

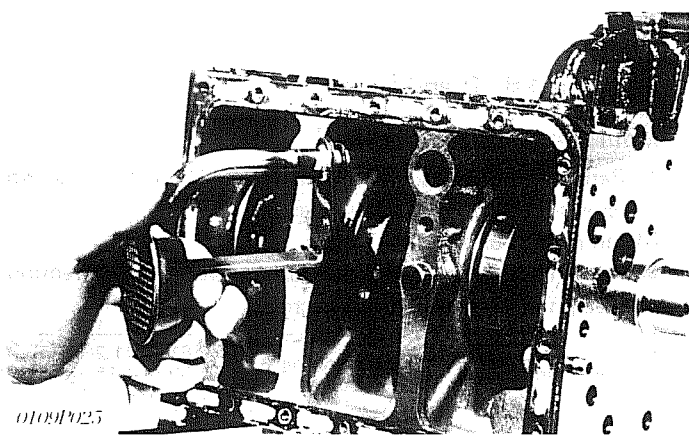
- Place the case cover and the gasket noting each direction (See photo), and tighten the screws.

Tightening torque	Main bearing case screw	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs
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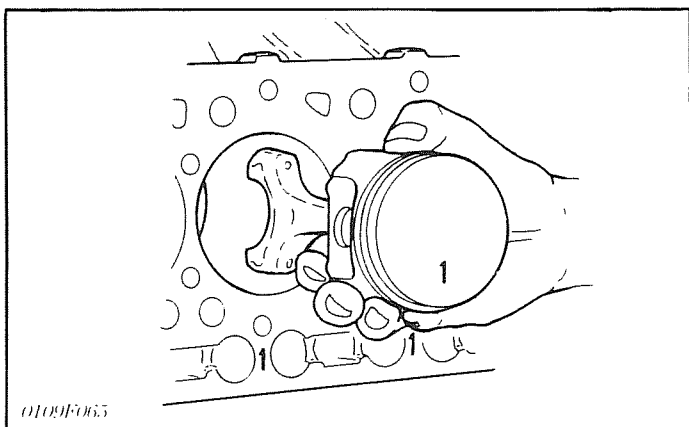
- (1) Main Bearing Case Cover
- (A) To lift the cover, screw in two screws.



0109P024



0109P025



0109F065

Crankshaft

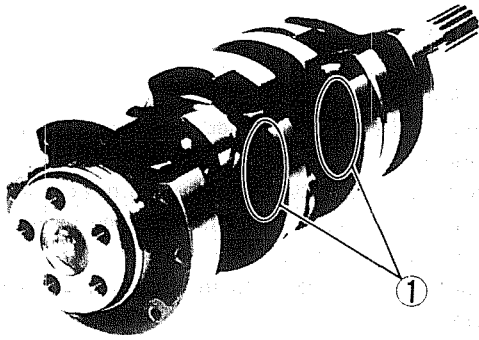
1. Remove the oil pan and the strainer.
2. Remove the screws (1) and the connecting rod caps, and push out the pistons.
3. Remove the screws (2) and pull out the crankshaft.

(When reassembling)

- Insert the piston in its cylinder in such a manner that the mark "1" on its head aligns with the mark "1" on the crankcase (See figure).
- Align the marks on the side of the connecting rod and cap.
- Apply engine oil to the bearing surface and the screws and tighten them to the specified torque.
- Be sure to install the O-ring on the pipe extending from the strainer (See photo).

Tightening torque	Oil pan screw	9.81 to 11.28 N·m 1.00 to 1.15 kgf·m 7.23 to 8.32 ft-lbs
	Connecting rod screw	14.7 to 18.6 N·m 1.5 to 1.9 kgf·m 10.8 to 13.7 ft-lbs
	Main bearing case screw	19.6 to 23.5 N·m 2.0 to 2.4 kgf·m 14.5 to 17.4 ft-lbs
	Oil pressure switch	14.7 to 19.6 N·m 1.5 to 2.0 kgf·m 10.8 to 14.5 ft-lbs

- (1) Screw
- (2) Screw



0109P026

Main Bearing Case

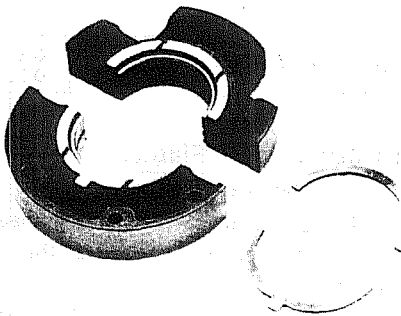
1. Remove the screws and separate the bearing case.

(When reassembling)

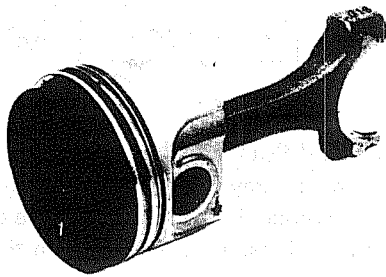
- Apply engine oil to the bearing surface and install the bearing case so that its casting mark "フライ" and "ホイール" (1) or the holes face the flywheel.
- Place washers with their round edge on the seat of the screws and apply engine oil to the screws and tighten them to the specified torque.
- Place the thrust washers with their oil groove outside.

Tightening torque	Main bearing case screw	14.7 to 19.6 N·m 1.2 to 1.5 kgf·m 10.8 to 14.5 ft-lbs
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(1) Casting Mark



0109P027



0109P028

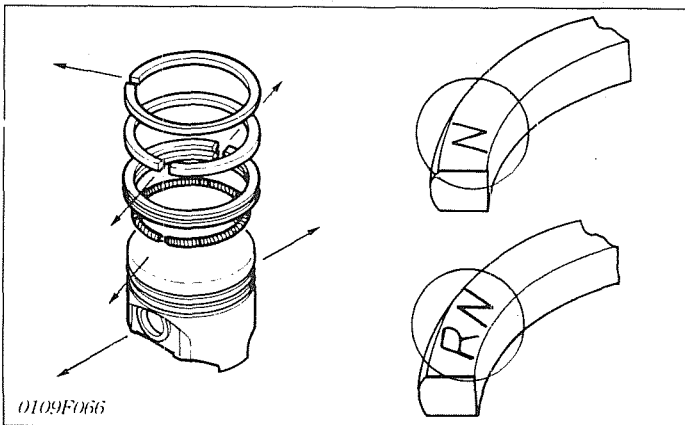
Piston and Connecting Rod

1. Remove the retaining ring and the piston pin.
2. Remove the piston rings using a piston ring tool (Code No.: 07909-32121).

(When reassembling)

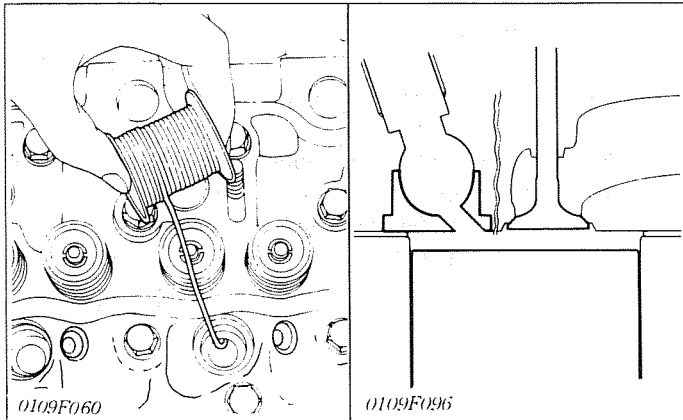
- Install the piston rings with their manufacturer's mark up and so that their gaps and the expander will not be positioned in line, referring to the figure.
- Apply engine oil to the piston pin and the bushing, and install the connecting rod so that the mark on its side is positioned opposite the mark "1" on the piston.
- When inserting the piston pin to the piston, heat the piston in oil (80°C, 176°F) for 10 to 15 minutes.

Fitted I.D. of the piston pin bushing	Factory specification	0.000 to 0.000 mm 0.0000 to 0.0000 in.
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0109F066

SERVICING

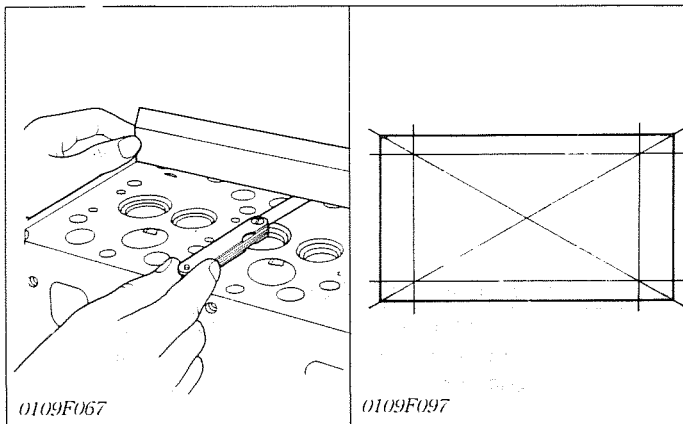


[1] Cylinder Head

Top Clearance

1. Remove the nozzle holder and lower the piston in the cylinder.
2. Insert a high-quality fuse from the nozzle holder hole on the piston except where it faces the valve or the combustion chamber insert.
3. Rotate the flywheel until the piston is raised and lowered again.
4. Take out the flattened fuse carefully and measure its thickness fuse with vernier calipers.
5. If the measurement is not within the specified values, check the oil clearances of the crankpin journal and the piston pin.

Top clearance	Factory specification	0.60 to 0.80 mm 0.0236 to 0.0315 in.
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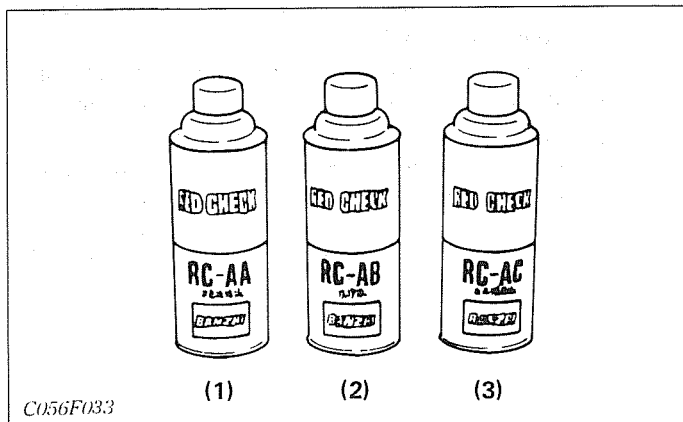
Cylinder Head Surface Flatness

1. Clean the cylinder head surface.
2. Place the straight edge on the cylinder head and measure the clearance with a feeler gauge at the positions shown in the figure.
3. If the measurement exceeds the allowable limit, correct it with a surface grinder.

NOTE:

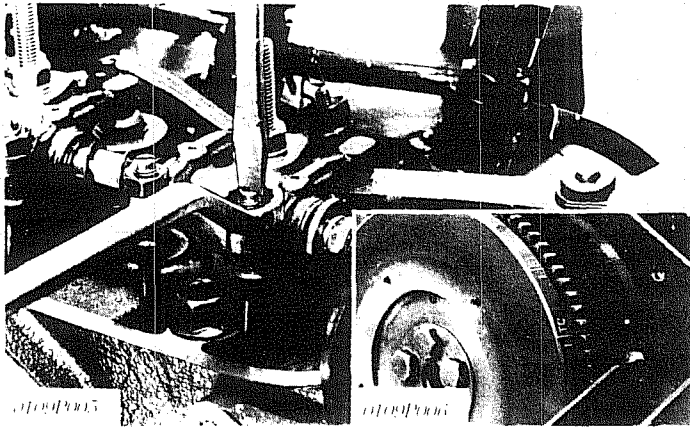
- Do not place a straight edge over the combustion chamber insert.

Flatness	Allowable limit	0.05 mm per 100 mm 0.0020 per 3.94 in.
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Cylinder Head Surface Flaw

1. Prepare an air spray red check (Code No.: 07909-31371).
2. Clean the cylinder head surface with the detergent (2).
3. Spray the cylinder head surface with the red permeative liquid (1).
4. Wash away the red permeative liquid on the cylinder head surface with the detergent (2).
5. Spray the cylinder head surface with the white developer (3).
6. If any flaw is found such as a red mark, replace the cylinder head.



[2] Valve and Rocker Arm

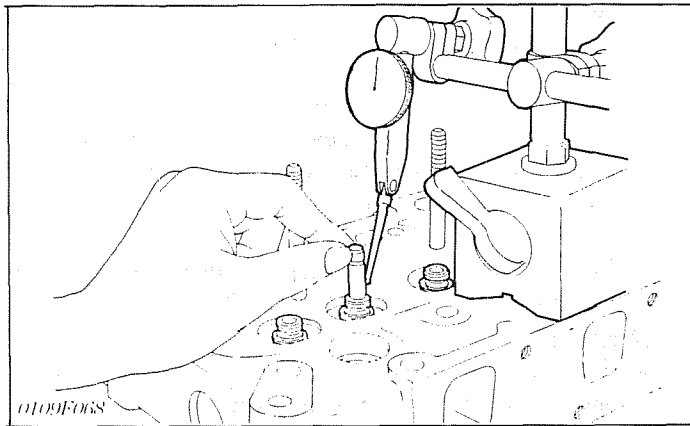
Valve Clearance

1. Loosen the lock nut and the adjusting screw on the rocker arm.
2. Turn the adjusting screw to adjust the valve clearance at the top dead center (T.D.C.) during compression stroke of the piston.
3. Tighten the lock nut and check the valve clearance again after several turns of the flywheel.

NOTE:

- To get T.D.C. of piston, find its "TC" mark on the flywheel and align it with the punch mark on the rear end plate (See photo).

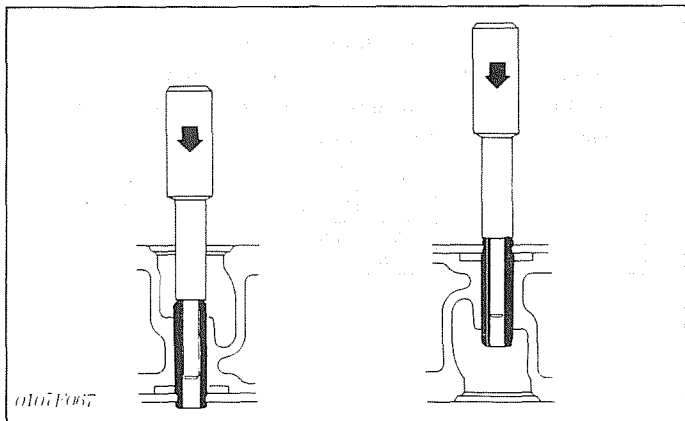
Valve clearance	Factory specification	0.15 to 0.18 mm 0.0059 to 0.0071 in.
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Valve Stem Clearance

1. Remove the carbon from the valve guide.
2. Make sure that the valve stem is straight and insert the valve into the valve guide.
3. Set the dial indicator with its tip on the stem near the end of the valve guide.
4. Measure the clearance, moving the valve sideways.
If the measurement exceeds the allowable limit, replace the valve guide or the valve.

Clearance between valve stem and valve guide	Factory specification	0.030 to 0.057 mm 0.00118 to 0.00224 in.
	Allowable limit	0.1 mm 0.004 in.
Valve guide bore I.D.	Factory specification	6.010 to 6.025 mm 0.23661 to 0.23721
Valve stem O.D.	Factory specification	5.969 to 5.980 mm 0.23496 to 0.23543



Replacing Valve Guide

(When removing)

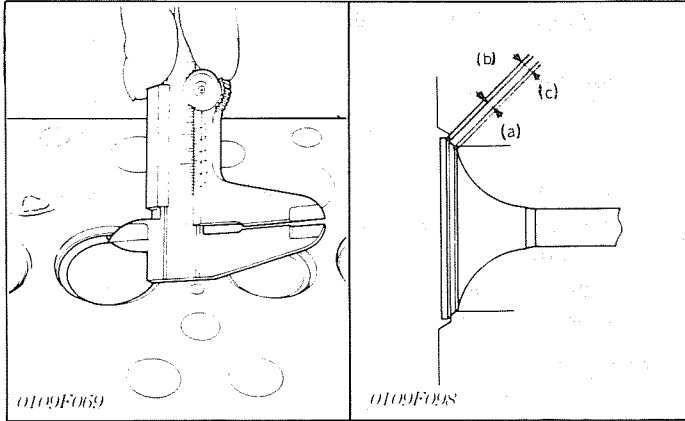
1. Press out the valve guide toward the head cover using a valve guide replacing tool

(When installing)

1. Clean the valve guide bore and apply engine oil to the bore, before installing the valve guide.
2. Press in the bushing so that its end comes flush with the cylinder block surface using a valve guide replacing tool.
3. Press in the valve guide until its end comes flush with the cylinder head surface.

IMPORTANT:

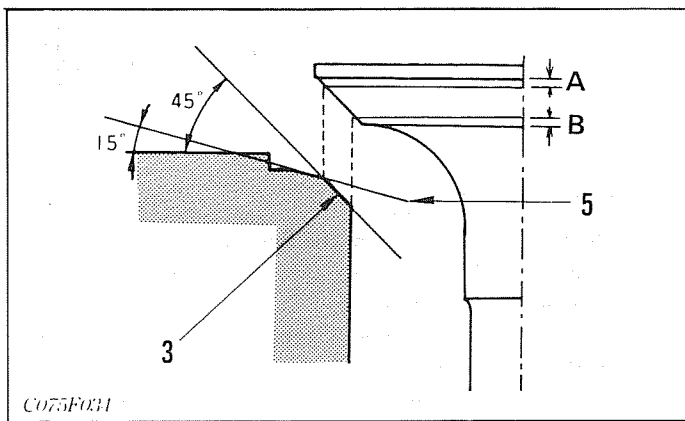
- Ream precisely the bore to the specified dimension shown in the figure, after installing the valve guide.



Valve Seat Width

1. Check the valve seat surface and the width.
2. If the seat width is not within the specified values or (b) is not equal to (c) (See Figure), correct the valve seat referring to "Correcting Valve and Seat".

Valve seat width	Factory specification	1.4 mm 0.055 in.
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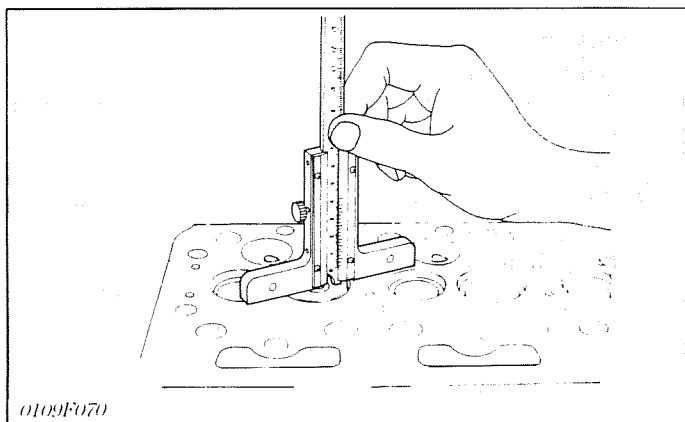


Correcting Valve and Seat

1. Correct the valve using a valve refacer.
2. Correct the valve seat surface using a valve seat cutter (Code No.: 07909-33102), following the steps below.
3. Cut the valve seat surface with a 0.75 rad (45°) valve seat cutter.
4. Check the seating surface on the valve face using a red lead.
5. Cut the valve seat surface with a 0.29 rad (15°) valve seat cutter so that the width A becomes equal to B (See figure).
6. Check the seating surface using a red lead. If needed, repeat the steps above from 3, until the valve contacts correctly.
7. Lap the valve onto its seat using lapping compound, until the valve contacts with its seat evenly.

NOTE:

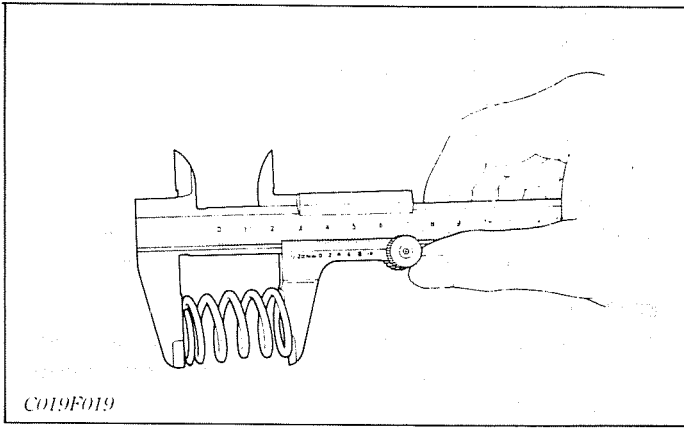
- Before correcting the valve and seat, check the valve stem and the valve guide, and repair them if necessary.



Valve Recessing

1. Clean the valve face and install it in its guide.
2. Measure the valve recessing with a depth gauge.
3. If the recessing exceeds the allowable limit, replace the valve, cylinder head or both.

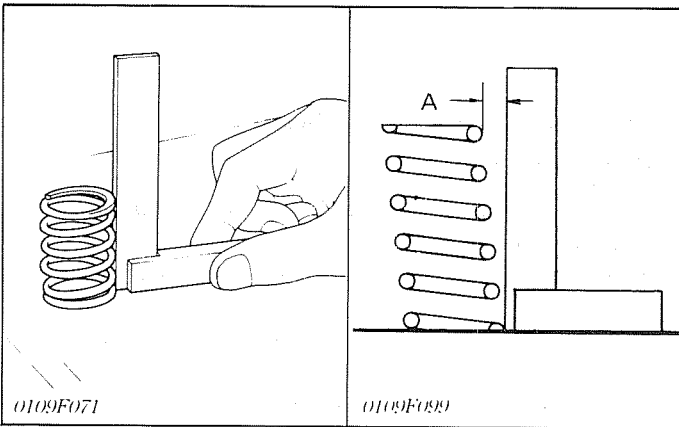
Valve recessing	Factory specification	0.75 to 0.95 mm 0.0295 to 0.0374 in.
	Allowable limit	1.2 mm 0.047 in.



Valve Spring Free Length and Tension

1. Measure the free length of the spring with vernier calipers.
2. Place the spring on a spring compression tester and compress to the specified length, and get the tension.
3. If the measurement is less than the allowable limit, replace the valve spring.

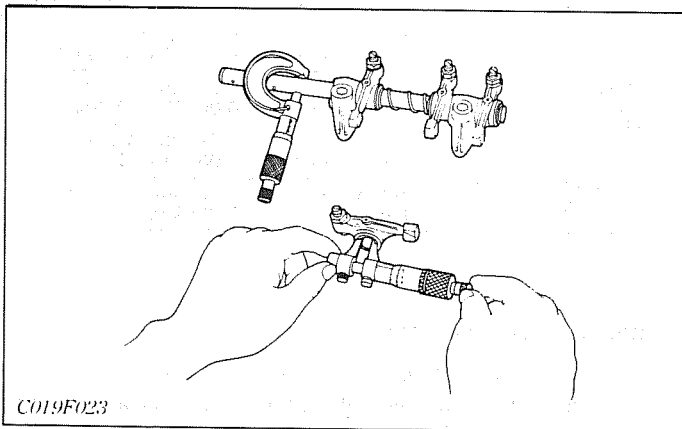
Free length	Factory specification	31.6 mm 1.244 in.
	Allowable limit	28.4 mm 1.118 in.
Spring tension	Factory specification	64.7 N (27.0 mm) 6.6 kgf (27.0 mm) 14.6 lbs (1.063 in.)
	Allowable limit	54.9 N (27.0 mm) 5.6 kgf (27.0 mm) 12.3 lbs (1.063 in.)



Valve Spring Squareness

1. Place the spring on the surface plate and a square at its side.
2. Measure the maximum distance A (See figure), rotating spring.

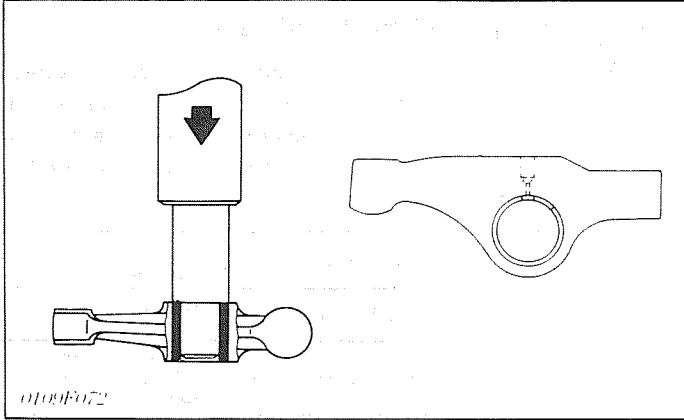
Valve spring squareness	Allowable limit	1.2 mm 0.047 in.
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Rocker Arm Bushing and Shaft Clearance

1. Measure the rocker arm bushing I.D. with an inside micrometer.
2. Measure the rocker arm shaft O.D. with an outside micrometer.
3. If the clearance exceeds the allowable limit, replace the bushing.
4. If the clearance still exceeds the allowable limit after replacing the bushing, replace the rocker arm shaft.

Rocker arm bushing and shaft clearance	Factory specification	0.016 to 0.068 mm 0.00063 to 0.00268 in.
	Allowable limit	0.15 mm 0.0059 in.
Bushings I.D. shaft O.D.	Factory specification	10.500 to 10.541 mm 0.41339 to 0.41500 in.
	Factory specification	10.473 to 10.484 mm 0.41232 to 0.41276 in.



Replacing Rocker Arm Bushing

(When removing)

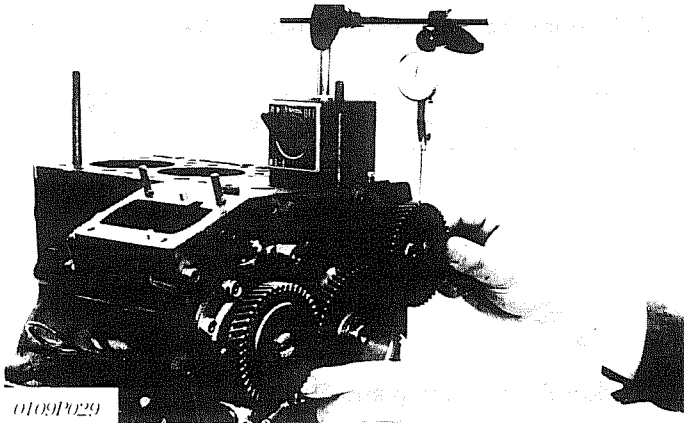
1. Press out the rocker arm bushing using a rocker arm bushing replacing tool.

(When installing)

1. Clean the rocker arm bushing and the bore, and apply engine oil to them.
2. Press in the bushing so that its end comes flush with the rocker arm, using a rocker arm bushing replacing tool.

■ IMPORTANT:

- Be sure to align the oil holes on the rocker arm and the bushing, and check that the seam of the bushing positions is as in figure.

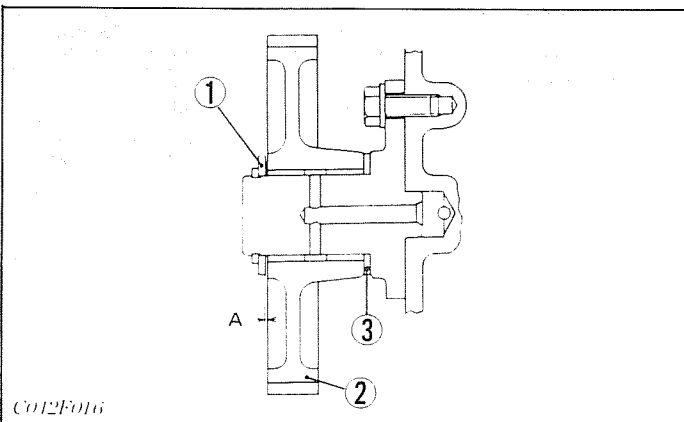


[3] Camshaft and Timing Gear

Gear Backlash

1. Set a dial indicator (lever type) with its indicator tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance is proper, replace the gear.

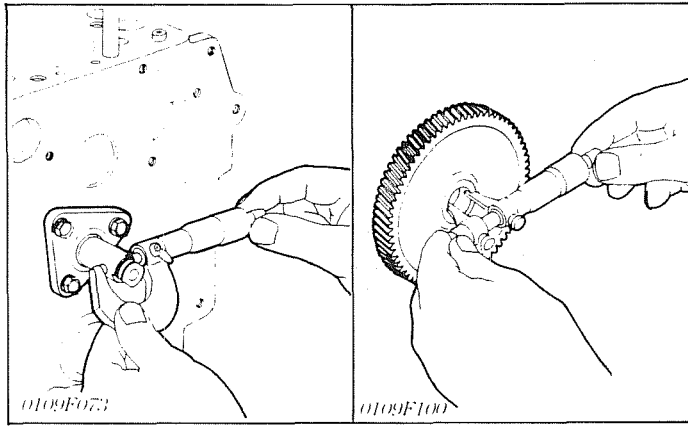
Oil pump gear to crank gear	Factory specification	0.041 to 0.123 mm 0.00161 to 0.00484 in.
Idler gear to crank gear	Factory specification	0.043 to 0.124 mm 0.00169 to 0.00488 in.
Idler gear to cam gear	Factory specification	0.047 to 0.123 mm 0.00185 to 0.00484 in.
Idler gear to injection pump gear Oil clearance	Factory specification	0.046 to 0.124 mm 0.00181 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.



Idle Gear Side Clearance

1. Pull the idle gear collar 2 and push the idle gear, and measure the clearance between the idle gear and the idle gear collar with a feeler gauge.
2. If the clearance exceeds the allowable limit, replace the idle gear collar 1.

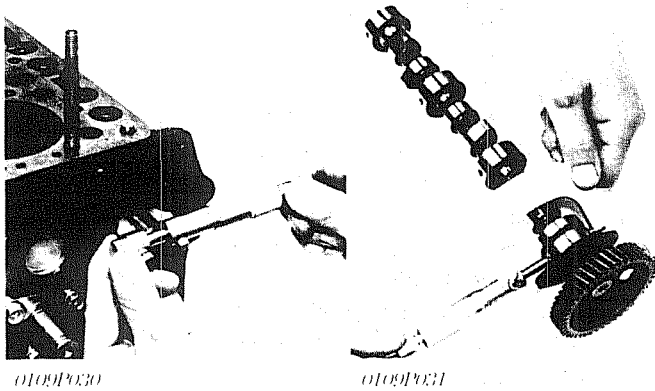
Side clearance	Factory specification	0.20 to 0.51 mm 0.0079 to 0.0201 in.
	Allowable limit	0.6 mm 0.024 in.



Idle Gear Oil Clearance

1. Measure the I.D. of the idle gear bushing with an inside micrometer.
2. Measure the O.D. of the idle gear shaft with an outside micrometer.
3. If the clearance exceeds the allowable limit, replace the bushing.

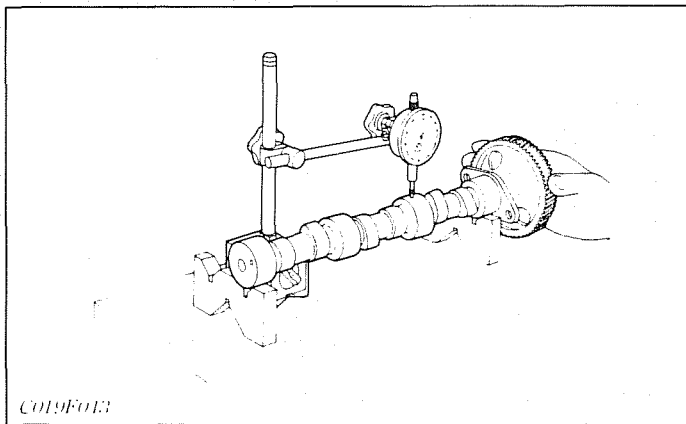
Oil clearance	Factory specification	0.016 to 0.045 mm 0.00063 to 0.00177 in.
	Allowable limit	0.05 mm 0.0020 in.
Bushing I.D.	Factory specification	16.000 to 16.018 mm 0.62992 to 0.63063 in.
Shaft O.D.	Factory specification	15.973 to 15.984 mm 0.62886 to 0.62929 in.



Camshaft Oil Clearance

1. Measure the I.D. of the camshaft bore on the crankcase with an inside micrometer.
2. Measure the O.D. of the camshaft journal.
3. If the clearance exceeds the allowable limit, replace the shaft.

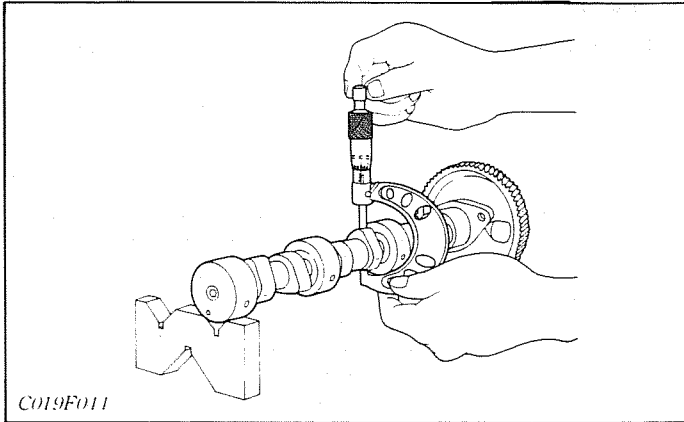
Oil clearance	Factory specification	0.050 to 0.091 mm 0.00197 to 0.00358 in.
	Allowable limit	0.15 mm 0.0059 in.
Camshaft bore I.D.	Factory specification	33.000 to 33.025 mm 1.29921 to 1.30020 in.
Camshaft journal O.D.	Factory specification	32.934 to 32.950 mm 1.29662 to 1.29725 in.



Camshaft Alignment

1. Place the camshaft on the V blocks and set a dial indicator with its indicator tip on the intermediate journal.
2. Rotate the camshaft in the V block and get the eccentricity (half of the measurement).
3. If the eccentricity exceeds the allowable limit, replace the camshaft.

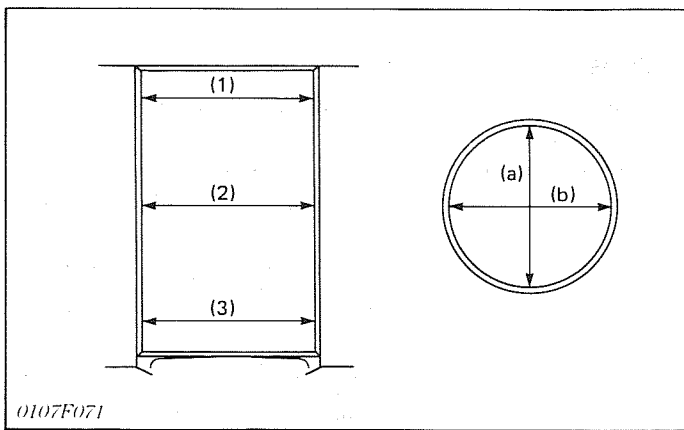
Eccentricity	Factory specification	0.01 mm 0.0004 in.
	Allowable limit	0.08 mm 0.0031 in.



Camshaft Lobes Height

1. Measure the height of the camshaft lobes at their largest O.D. with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

Cam height	Factory specification	26.88 mm, 1.0583 in.
	Allowable limit	26.83 mm, 1.0563 in.



[4] CYLINDER BLOCK

Cylinder Liner/Cylinder Wear

1. Measure the I.D. of the cylinder liner or the cylinder (linerless type) at six positions (See figure) with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Get the difference between the maximum and the minimum I.D.'s as the maximum wear.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension (Refer to the table) and replace the piston and the piston rings with the oversize ones.
4. When having been oversized and the wear exceeds the allowable limit, replace the cylinder liner or the cylinder. (linerless type).

Cylinder (liner) I.D.	Factory specification	M-12	64.000 to 64.019 mm, 2.51969 to 2.52043 in.
		M-18,25	66.000 to 66.019 mm, 2.59843 to 2.59917 in.
Maximum wear	Allowable limit	0,15 mm, 0.0059 in.	

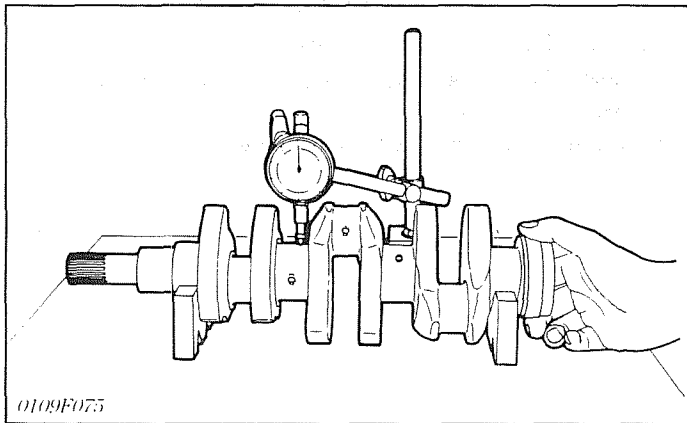
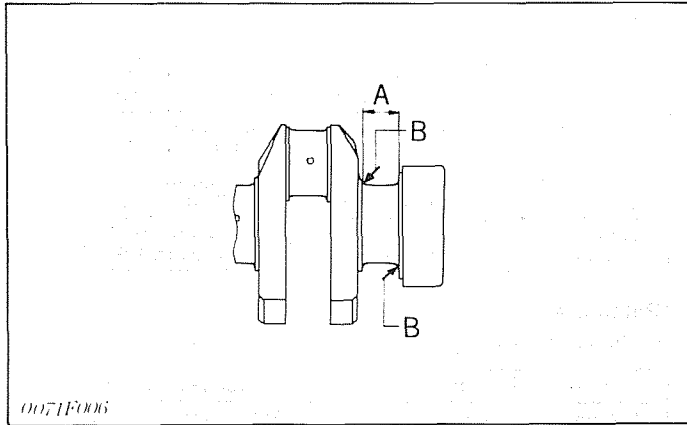
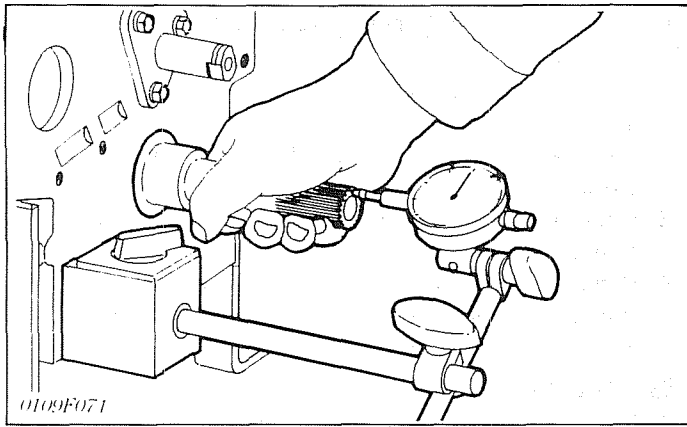
(Reference)

- Oversize dimension of cylinder:

Model	I.D.
M-12	64.500 to 64.519 mm, 2.53937 to 2.54012 in.
M-18,25	66.500 to 66.519 mm, 2.61811 to 2.61886 in. Hone to 1.2 to 2.0 μm max. 0.000047 to 0.000079 in.

- Oversize piston and piston rings:

Model	Name	Code Number	Marking
M-12	Piston 05	15841-21911	05 OS
	Piston ring 05 assembly	14601-21091	05 OS
M-18,25	Piston 05	15852-21911	05 OS
	Piston ring 05 assembly	14541-21091	05 OS



[5] Cranksahft

Crankshaft End Play

1. Set a dial indicator with its indicator tip touching the end of the crankshaft.
2. Measure the end play by moving the crankshaft to the front and rear.
3. If the play exceeds the allowable limit, replace the side bearing.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an oversize one referring to the table and the figure.

End play	Factory specification	0.15 to 0.31 mm, 0.0059 to 0.0122 in.
	Allowable limit	0.5 mm, 0.020 in.

(Reference)

- Oversize bearings:

Oversize	Bearing	Code Number	Marking
0.2 mm	Side bearing 1 02	15261-23951	020 OS
	Side bearing 2 02	15261-23971	020 OS
0.4 mm	Side bearing 1 04	15261-23961	040 OS
	Side bearing 2 04	15261-23981	040 OS

- Oversize dimensions of crankshaft:

Dimension

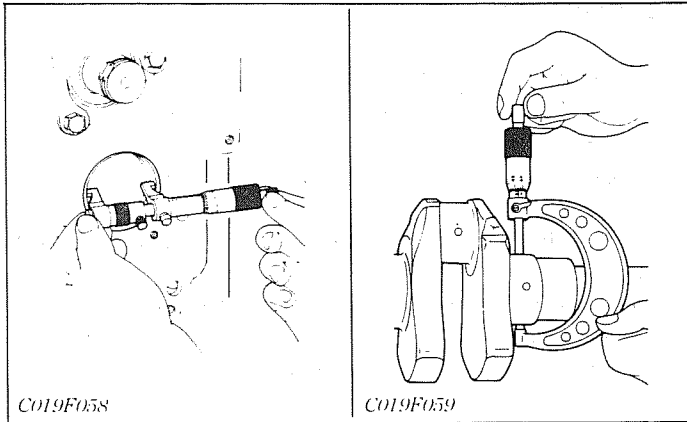
- (A) 0.2 mm Oversize 23.20 to 23.25 mm
(0.9134 to 0.9154 in.)
0.4 mm Oversize 23.40 to 23.45 mm
(0.9213 to 0.9232 in.)
- (B) 1.8 to 2.2 mm (0.071 to 0.087 in.)

- Finely finish the contact face to the bearing, to the higher than $\nabla\nabla\nabla\nabla$ (0.4S)

Crankshaft Alignment

1. Support the crankshaft with V blocks on the surface plate at both end journals.
2. Set a dial indicator with its indicator tip touching the intermediate journal.
3. Rotate the crankshaft on the V blocks and get the eccentricity (half of the measurement).
4. If the eccentricity exceeds the allowable limit, replace the camshaft.

Eccentricity	Factory specification	0.02 mm, 0.0008 in.
	Allowable limit	0.08 mm, 0.0031 in.



Oil Clearance between Crankshaft Journal and Bearing 1

1. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer.
2. Measure the O.D. of the crankshaft front journal with an outside micrometer.
3. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 1.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and the figure.

■ IMPORTANT:

- Install the bearing using a replacing tool, so that its seam directs toward the exhaust side in the crankcase (See figure).

Oil clearance	Factory specification	0.034 to 0.106 mm 0.00134 to 0.00417 in.
	Allowable limit	0.20 mm 0.0079 in.
Crankshaft bearing I.D.	Factory specification	39.984 to 40.040 mm 1.57418 to 1.57638 in.
Crankshaft journal O.D.	Factory specification	39.934 to 39.950 mm 1.57221 to 1.57284 in.

(Reference)

- Undersize bearings:

Undersize	Bearing	Code Number	Marking
0.2 mm	Bearing 1 02	15841-23921	020 US
0.4 mm	Bearing 1 04	15841-23921	040 US

- Undersize dimensions of crankshaft:

Dimension

(A) Oil hole 5 mm (0.2 in.) dia.

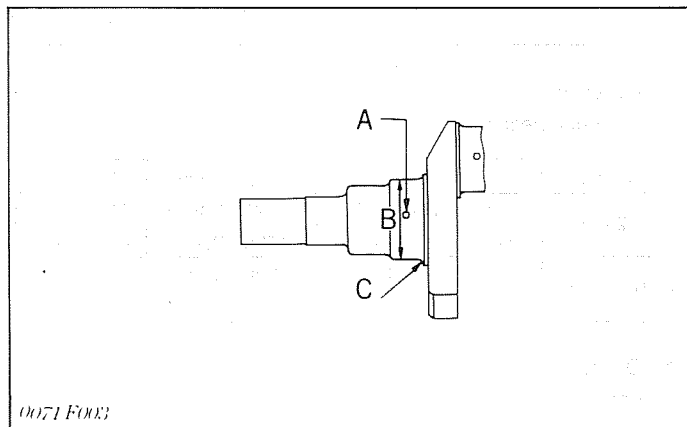
(B) 0.2 mm Undersize 39.734 to 39.750 mm
(1.56433 to 1.56496 in.)

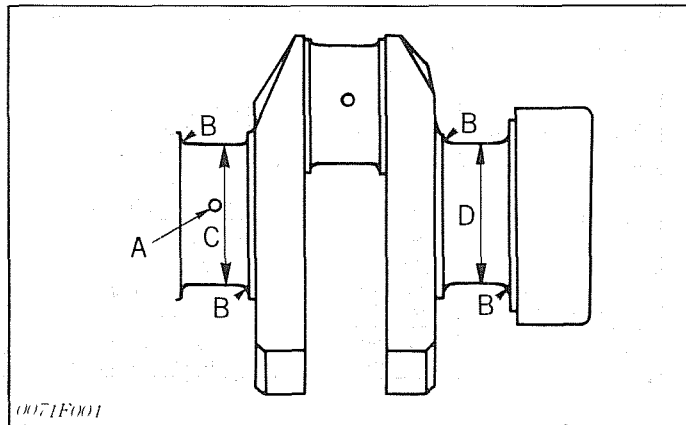
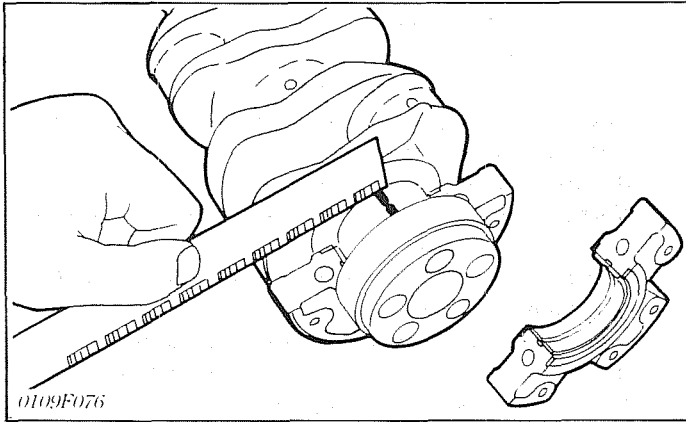
0.4 mm Undersize 39.534 to 39.550 mm
(1.55646 to 1.55709 in.)

(C) 1.8 to 2.2 mm (0.071 to 0.087 in.) R

- Finely finish the contact face to the bearing, to higher than $\nabla\nabla\nabla\nabla$ (0.4S).

- Chamfer the oil hole with an oilstone.





Oil Clearance between Crankshaft Journal and Bearings 2 and 3

1. Put a strip of Plastigage lengthwise in the center of the journal.
2. Install the bearing cap and tighten the screws to the specified torque, and remove the bearing cap.
3. Measure the amount of the flattening with the scale and get the oil clearance.
4. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing.
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and the figure.

Tightening torque	Bearing cap screw	11.8 to 14.7 N·m 1.2 to 1.5 kgf·m 8.7 to 10.8 ft-lbs
Oil clearance	Factory specification	0.034 to 0.092 mm 0.00134 to 0.00417 in.
	Allowable limit	0.20 mm 0.0079 in.

Rear

Bearing 2 I.D.	Factory specification	43.984 to 44.040 mm 1.73166 to 1.73386 in.
Crankshaft journal O.D.	Factory specification	43.934 to 43.950 mm 1.72969 to 1.73032 in.

Intermediate

Bearing 3 I.D.	Factory specification	39.984 to 40.026 mm 1.57418 to 1.57583 in.
Crankshaft journal O.D.	Factory specification	39.934 to 39.950 mm 1.57221 to 1.57284 in.

(Reference)

- Undersize bearings:

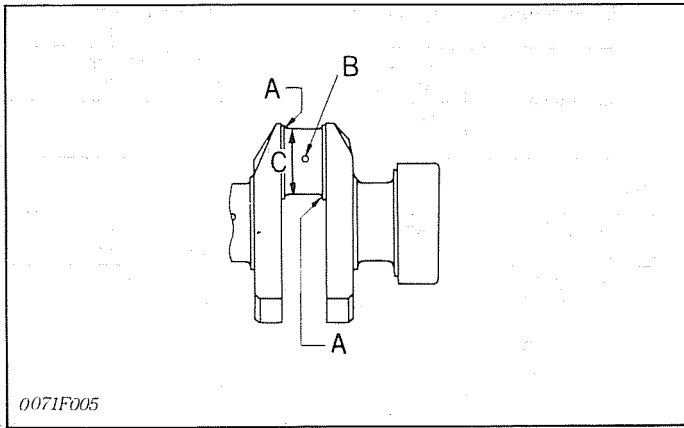
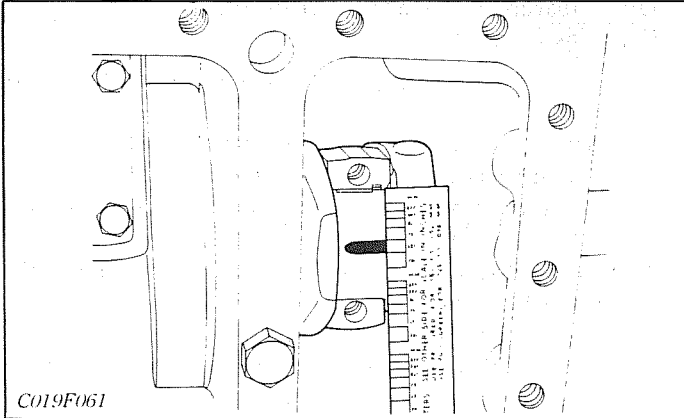
Undersize	Bearing	Code Number	Marking
0.2 mm	Bearing 2 02	15261-23931	020 US
	Bearing 3 02	15841-23861	020 US
0.4 mm	Bearing 2 04	15261-23941	040 US
	Bearing 3 04	15841-23871	040 US

- Undersize dimensions of crankshaft:

Dimension

- (A) Oil hole 3 mm (0.12 in.) dia.
- (B) 1.8 to 2.2 mm (0.071 to 0.087 in.) R
- (C) 0.2 mm Undersize 39.734 to 39.750 mm
(1.56433 to 1.56496 in.)
- 0.4 mm Undersize 39.534 to 39.550 mm
(1.55646 to 1.55709 in.)
- (D) 0.2 mm Undersize 43.734 to 43.750 mm
(1.72181 to 1.72244 in.)
- 0.4 mm Undersize 43.534 to 43.550 mm
(1.71394 to 1.71457 in.)

- Finely finish the contact face to the bearing, to higher than $\nabla\nabla\nabla\nabla$ (0.4S)



Oil Clearance between Crankpin and Connecting Rod Bearing

1. Put a strip of Plastigage lengthwise into the bearing cap.
2. Install the bearing cap noting that the gauge may not meet with the hole on the crank pin, tighten the screws to the specified torque, and remove the cap.
3. Measure the amount of the flattening with the scale and get the oil clearance.
4. If the clearance exceeds the allowable limit, replace the connecting rod bearing.
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and the figure.

NOTE:

- Be sure not to move the crankshaft while the bearing cap screws are tightened.

Tightening torque	Bearing cap screw	14.7 to 18.6 N·m 1.5 to 1.9 kgf·m 10.8 to 13.7 ft·lbs
Oil clearance	Factory specification	0.019 to 0.081 mm 0.00075 to 0.00319 in.
	Allowable limit	0.20 mm 0.0079 in.
Connecting rod bearing I.D.	Factory specification	33.994 to 34.040 mm 1.33835 to 1.34016 in.
Crankpin O.D.	Factory specification	33.959 to 33.975 mm 1.33697 to 1.33760 in.

(Reference)

- Undersize bearings:

Undersize	Bearing	Code Number	Marking
0.2 mm	Bearing 02	15841-22971	020 US
0.4 mm	Bearing 04	15841-22981	040 US

- Undersize dimensions of crankshaft:

Dimension

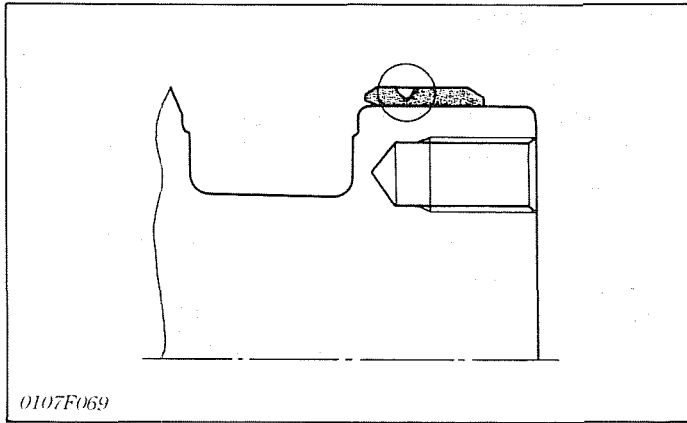
(A) 2.3 to 2.7 mm (0.091 to 0.106 in.) R

(B) Oil hole 4 mm (0.16 in.) dia.

(C) 0.2 mm Undersize 33.759 to 33.775 mm
(1.32910 to 1.32973 in.)

0.4 mm Undersize 33.559 to 33.575 mm
(1.32122 to 1.32185 in.)

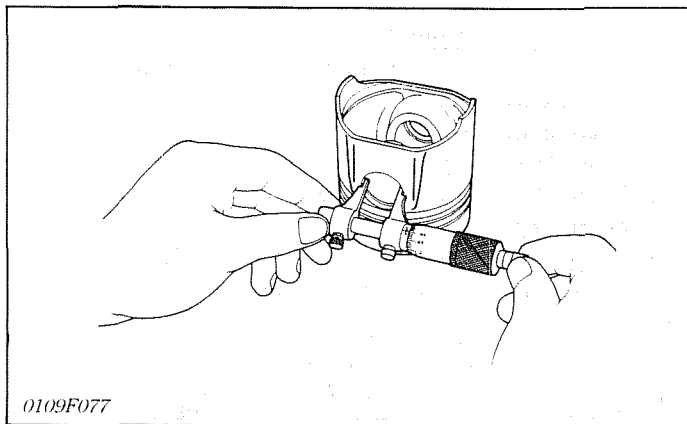
- Finely finish the contact face to the bearing, to higher than $\nabla\nabla\nabla$ (0.4S)



Crankshaft Sleeve

1. Check the wear on the crankshaft sleeve.
2. If the wear exceeds the allowable limit or when the engine oil leaks, replace the crankshaft sleeve.

Whear of sleeve	Allowable limit	0.1mm 0.004 in.
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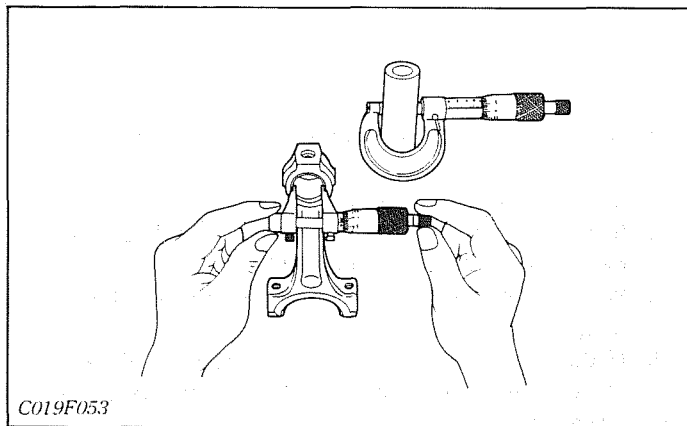


[6] Piston and Connecting Rod

Piston Pin Hole

1. Measure the I.D. of piston pin-hole lengthwise and width-wise of the piston with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

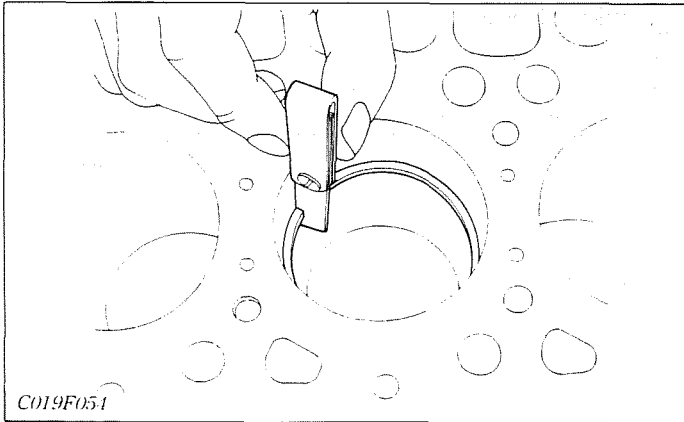
Piston pin hole I.D.	Factory specification	18.000 to 18.011 mm 0.70886 to 0.70910 in.
	Allowable limit	18.05 mm 0.7106 in.



Clearance between Piston Pin and Bushing

1. Measure the O.D. of the piston pin with an outside micrometer.
2. Measure the I.D. of the piston pin bushing with a cylinder gauge.
3. If the clearance exceeds the allowable limit, replace the bushing.
4. If the clearance still exceeds the allowable limit after replacing the bushing, replace the piston pin.

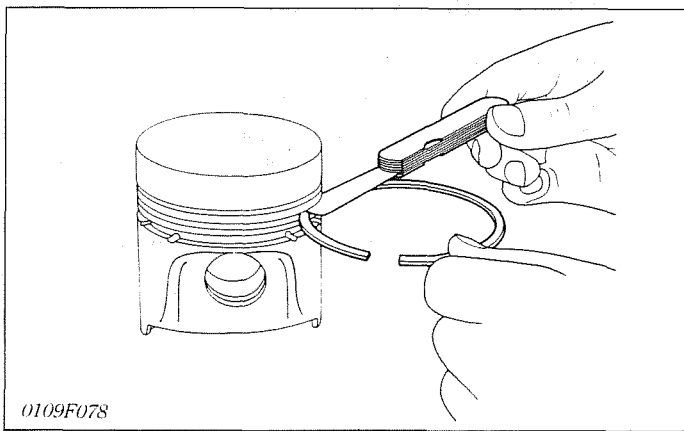
Clearance between	Factory specification	0.016 to 0.039 mm 0.00063 to 0.00154 in.
Piston pin and bushing	Allowable limit	0.15 mm 0.0059 in.
Piston pin bushing I.D.	Factory specification	18.025 to 18.040 mm 0.70965 to 0.71024 in.
Piston pin O.D.	Factory specification	18.001 to 18.009 mm 0.70870 to 0.70902 in.



Piston Ring Gap

1. Insert the piston ring into the cylinder and push down to the bottom, where the wear is least, using a piston head.
2. Measure the ring gap with a feeler gauge.
3. If the ring gap exceeds the allowable limit, replace the ring.

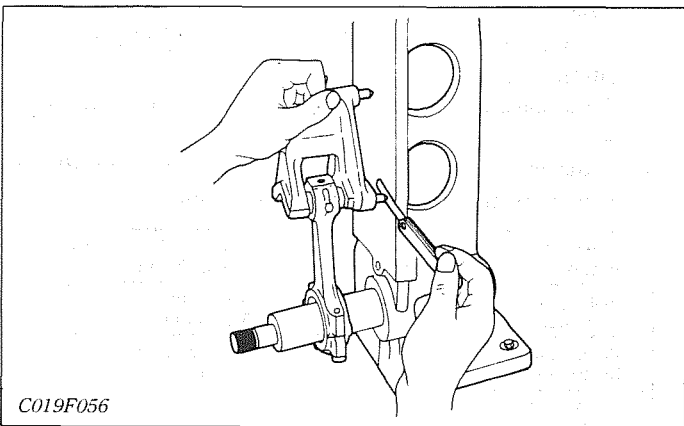
Piston Ring Gap	Second ring	Factory specification	0.25 to 0.40 mm 0.0098 to 0.0157 in.
	Oil ring	Factory specification	0.20 to 0.40 mm 0.0079 to 0.0157 in.
		Allowable limit	1.2 mm 0.047 in.



Piston Ring Clearance

1. Clean the rings and the ring grooves, and install each ring in its groove.
2. Measure the clearance between the ring and the groove with a feeler gauge.
3. If the clearance exceeds the allowable limit, replace the piston ring.
4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

Piston ring clearance	Second ring	Factory specification	0.085 to 0.112 mm 0.00335 to 0.00441 in.
	Oil ring	Factory specification	0.02 to 0.06 mm 0.0008 to 0.0024 in.
		Allowable limit	0.15 mm 0.0059 in.



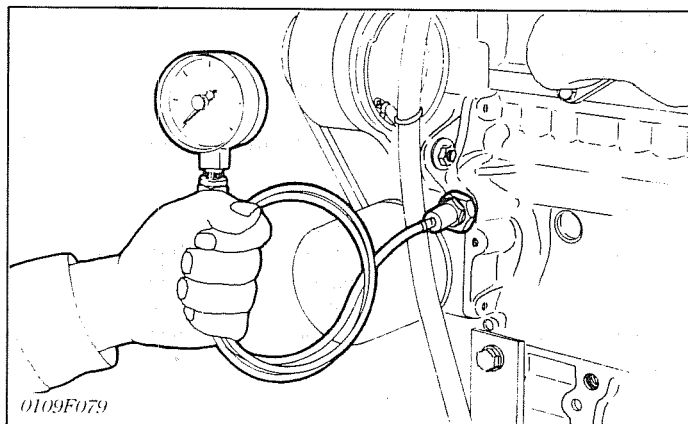
Connecting Rod Alignment

1. Remove the connecting rod bearing and install the bearing cap.
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool (Code No : 07909-31661).
4. Put a gauge over the piston pin and move it against the faceplate.
5. If the gauge does not fit squarely against the faceplate, measure the space between the pin of the gauge and the faceplate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.

Space between pin and face plate	Allowable limit	0.05 mm 0.0020 in. (gauge pin span at 100 mm, 3.94 in.)
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LUBRICATING SYSTEM

CHECKING



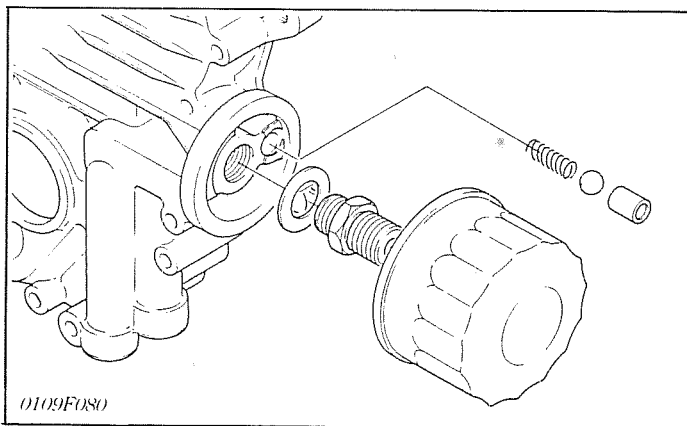
Engine Oil Pressure

1. Remove the oil pressure switch and install the oil pressure adaptor and the oil pressure tester (Code No.: 07916-32031).
2. Start the engine and run it until it is warmed up, and measure the oil pressure both at idling and rated speed.
3. If the oil pressure is less than the allowable limit, check and repair referring to the causes below.

- Engine oil insufficient
- Oil filter clogged
- Dirt in relief valve
- Oil gallery clogged
- Excessive oil clearance
- Oil pump defective

Tightening torque		Oil pressure switch	14.7 to 19.6 N·m 1.5 to 2.0 kgf·m 10.8 to 14.5 ft-lbs
Engine oil pressure	At idle speed	Factory specification	more than 69 kPa 0.7 kgf/cm ² 10 psi
	At rated speed	Factory specification	196 to 441 kPa 2.0 to 4.5 kgf/cm ² 28 to 64 psi
		Allowable limit	69 kPa 0.7 kgf/cm ² 10 psi

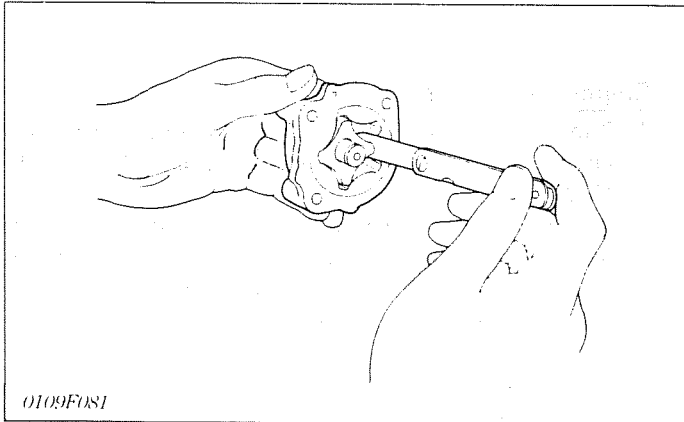
(The engine oil temperature at 90° to 95°C, 194° to 203°F)



Oil Filter and Relief Valve

1. Drain the engine oil.
2. Remove the oil filter and check it.
3. Check the relief valve for dirt.

SERVICING

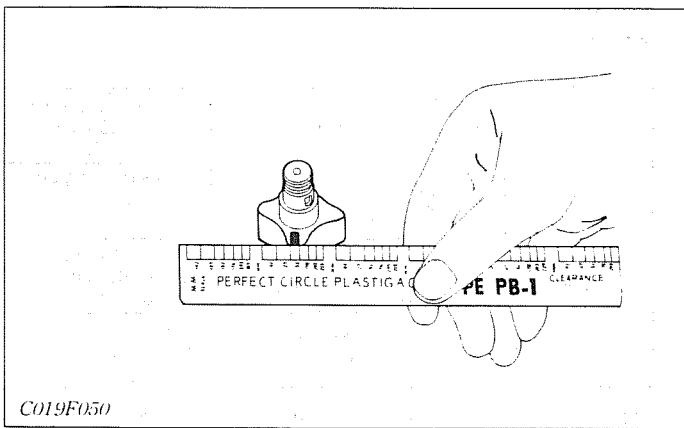


Pump Rotor and Lobe Clearance

1. Remove the oil pump from the crankcase.
2. Remove the screw and the port plate.
3. Measure the clearances between the outer rotor and the housing, and between the outer and inner rotor with a feeler gauge.

If the clearance exceeds the allowable limit, replace the pump.

Clearance between outer rotor and housing	Factory specification	0.15 to 0.21 mm 0.0059 to 0.0083 in.
	Allowable limit	0.30 mm 0.0118 in.
Clearance between outer and inner rotor	Allowable limit	0.25 mm 0.0098 in.



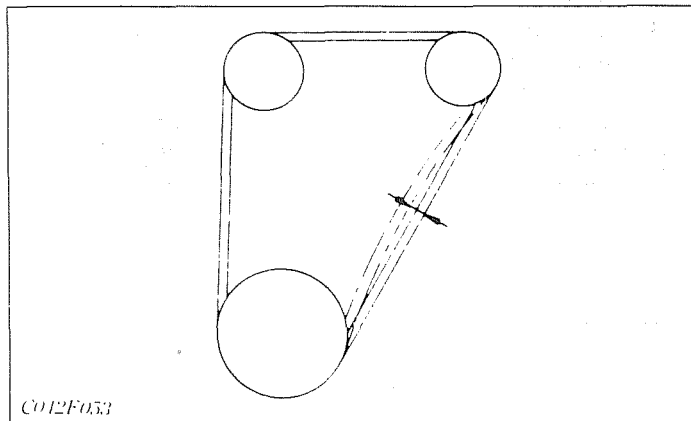
Rotor End Clearance

1. Put a strip of Plastigage on the rotor and install the pump to the crankcase with the port plate.
2. Remove the pump and the port plate.
3. Measure the amount of the flattening with the scale, and get the clearance.
4. If the clearance is not within the reference values, replace the pump.

End clearance	Factory specification	0.08 to 0.13 mm 0.0031 to 0.0051 in.
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COOLING SYSTEM

CHECKING

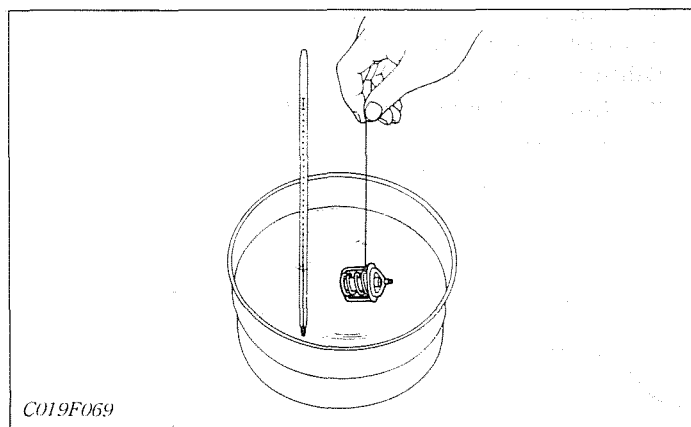


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Belt Tension

1. Measure the deflection, depressing the belt halfway between the fan drive pulley and the AC dynamo pulley at 98 N (10 kgf, 22 lbs) of force.
2. If the measurement is not the specified value, loosen the bolts and the nuts, and relocate the AC dynamo to adjust.

Fan belt tension	Factory specification	approx. 10 mm 0.39 in.
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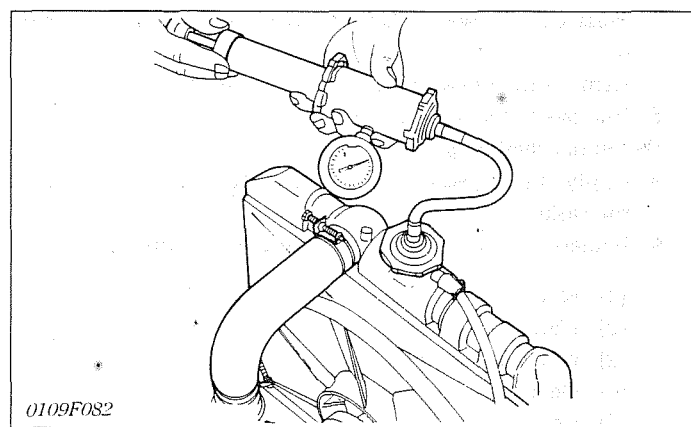


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Thermostat Valve Opening Temperature

1. Suspend the thermostat in the water by a string with its end inserted between the valve and the seat.
2. Heating the water gradually, read the temperature when the valve opens and leaves the string.
3. Continue heating and read the temperature when the valve opens approx. 6 mm (0.236 in.).
4. If the measurement is not within the specified values, replace the thermostat.

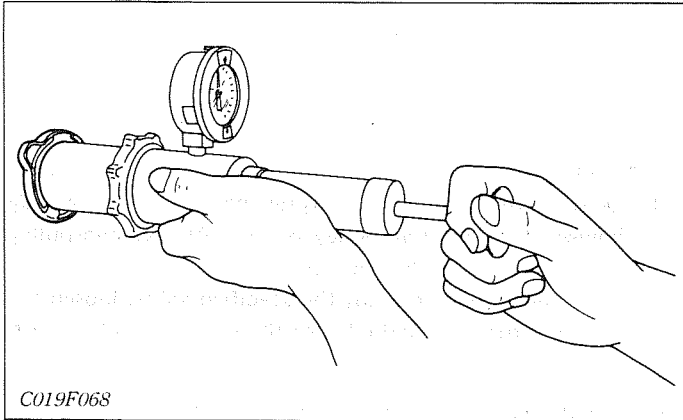
Opening temperature	Factory specification	80.5° to 83.5° C (176.9° to 182.3° F) at beginning below 95° C (203° F) at 6 mm (0.236 in.) of opening
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Radiator Water Tightness

1. Fill the radiator with water to the specified amount and warm up the engine.
2. Set a radiator tester and raise the water pressure to the 13.7 kPa (1.4 kgf/cm², 20 psi).
3. Check the radiator for water leaks.
4. For water leak from the pinhole, repair with the radiator cement, and for other leaks, replace the radiator.

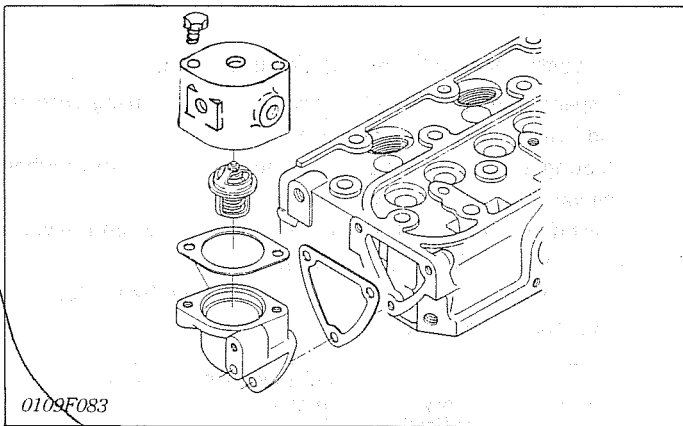


Radiator Cap Opening Pressure

1. Set a radiator tester on the radiator cap.
2. Apply the pressure of 88 kPa (0.9 kgf/cm², 13 psi) and measure the time for the pressure to fall to 59 kPa (0.6 kgf/cm², 9 psi).
3. If the measurement is less than the specified value, replace the radiator cap.

Pressure falling time	Factory specification	more than 10 seconds from 88 to 59 kPa (from 0.9 to 0.6 kgf/cm ² , from 13 to 9 psi)

DISASSEMBLY AND ASSEMBLY

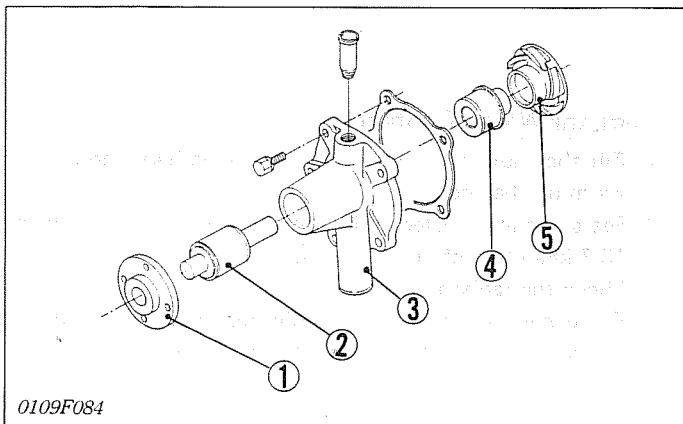


Thermostat

1. Remove the thermostat cover.
2. Remove the thermostat.

(When reassembling)

- Apply liquid gasket (Three Bond 1215 or equivalent) to the gasket.



Water Pump

1. Remove the water pump from the gear case cover.
2. Remove the fan, the pulley and the flange (1).
3. Press out the water pump shaft (2) with the impeller (5) on it.
4. Remove the impeller from the water shaft.
5. Remove the mechanical seal (4).

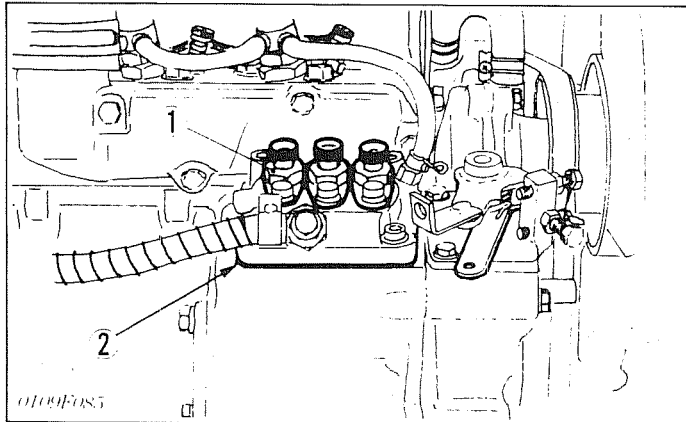
(When reassembling)

- Apply liquid gasket (Three Bond 1215 or equivalent) to the gasket.
- Replace the mechanical seal with the new one.

- (1) Water Pump Flange
- (2) Water Pump Shaft
- (3) Water Pump Body
- (4) Mechanical Seal
- (5) Impeller

FUEL SYSTEM

CHECKING AND ADJUSTMENT



[1] Injection Pump

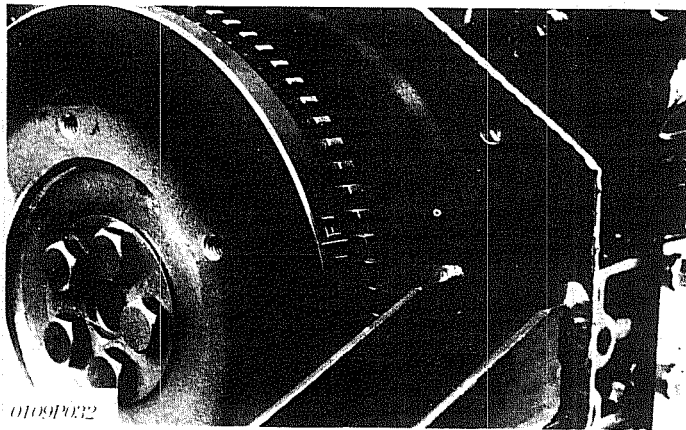
Injection Timing

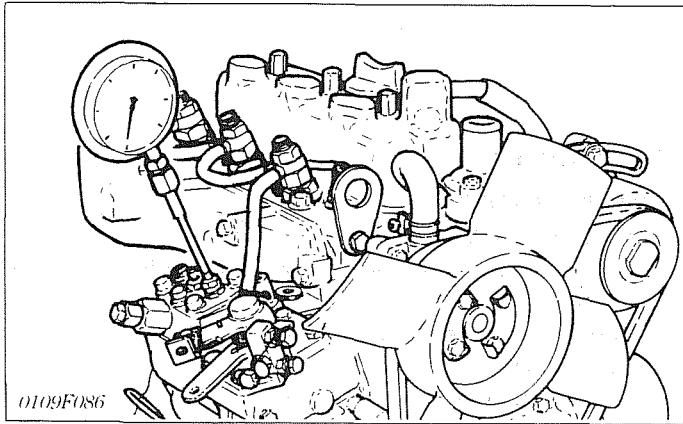
1. Remove the injection pipes.
2. Set the speed control lever to the maximum fuel discharge position.
3. Turn the flywheel until the fuel fills up to the hole of the delivery valve holder.
4. Turn the flywheel further and stop turning when the fuel begins to flow over again, to check the injection timing.
5. If the "FI" mark does not align with the punch mark on the rear plate, add or remove the shim (2) to adjust it.

(Reference)

- 0.026 to 0.035 rad. (1.5° to 2.0°) at flywheel
/0.15 mm (0.0059 in.) of shim

- (1) Injection Pump
- (2) Shim

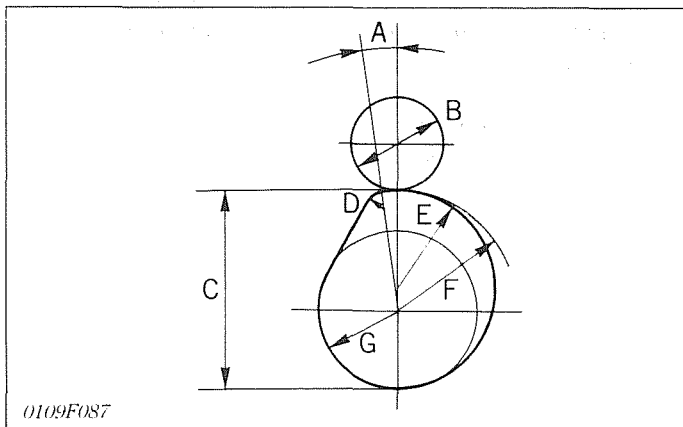




Pump Element Fuel Tightness

1. Install the pressure tester (See page S-51) to the fuel injection pump.
2. With the speed control lever at the maximum position of the fuel injection, rotate the flywheel to raise the fuel pressure to 39.23 MPa (400 kgf/cm², 5689 psi).
3. Measure the falling time of the fuel pressure from 39.23 to 34.32 MPa (from 400 to 350 kgf/cm², from 5689 to 4978 psi).
4. If the measurement is less than the allowable limit, replace the pump element or the injection pump assembly.

Pressure falling time	Factory specification	60 seconds or more
	Allowable limit	30 seconds



■ IMPORTANT:

- After replacing the pump element, adjust the amount of the fuel injection on the specified test bench.

(Reference)

- Test Bench:

Code No. 105760-0010 (50 Hz) / 105760-0020 (60 Hz)
[DIESEL KIKI CO. LTD]

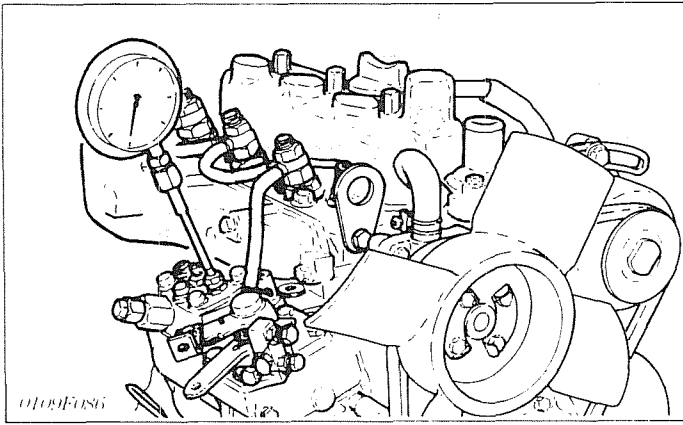
- Test Conditions:

Driving Stand	Code No. 10578-4160 [DIESEL KIKI CO. LTD]
Nozzle	DN12SD12T
Opening pressure	11.77 MPa, 120 kgf/cm ² , 1707 psi
Injection pipe	6 mm dia. x 2 mm dia. x 600 mm long, 0.24 in. dia. x 0.08 in. dia. x 23.62 in. long
Fuel feed pressure	49 kPa, 0.5 kgf/cm ² , 7 psi
Test fuel	Diesel fuel No.2-D
Pre-stroke	1.85 to 1.95 mm, 0.0728 to 0.0768 in. (with valve)
Cam profile	(See figure)

- (A) 0.12 rad (7°)
- (B) 14mm (0.55 in.)
- (C) 30mm (1.18 in.)
- (D) 3mm (0.12 in.)
- (E) 15mm (0.59 in.)
- (F) 18mm (0.71 in.)
- (G) 12mm (0.47 in.)

- Data for Adjustment

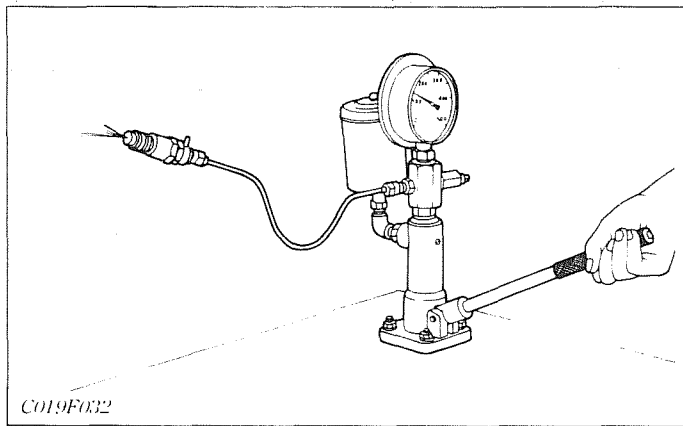
Control rack (from stop position)	Camshaft speed	Amount of fuel
4.5 mm, 0.177 in.	1800 rpm	1.17 to 1.23cc/100st, 0.0714 to 0.0751c. in./100st
1.0 mm, 0.039 in.	1800 rpm	less than 0.1cc/100st 0.006c. in./100st



Delivery Valves Fuel Tightness

1. Install the pressure tester (See page S-51) to the fuel injection pump.
2. With the speed control lever at the maximum position of the fuel injection, rotate the flywheel to raise the fuel pressure to 21.57 MPa (220 kgf/cm², 3129 psi).
3. Measure the falling time of the fuel pressure from 21.57 to 20.59 MPa (from 220 to 210 kgf/cm², from 3129 to 2987 psi).
4. If the measurement is less than the allowable limit, replace the pump element or the injection pump assembly.

Pressure falling time	Factory specification	10 seconds or more
	Allowable limit	5 seconds



[2] Injection Nozzle

⚠ CAUTION

- Never to contact with spraying diesel fuel under pressure, which can have sufficient force to penetrate the skin, causing serious personal injury.
- Be sure nobody is in the direction of the spray.

Fuel Injection Pressure

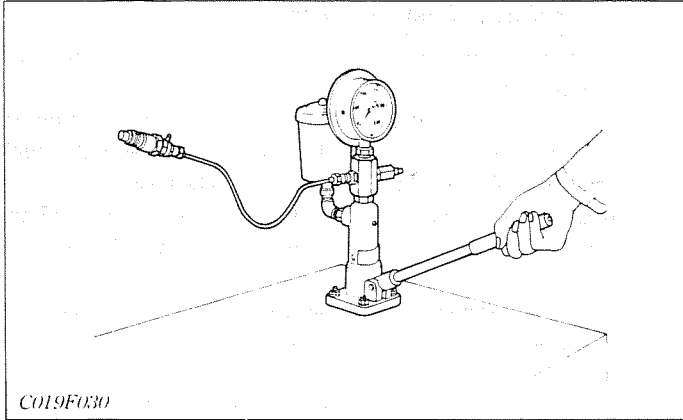
1. Set the injection nozzle to the nozzle tester.
2. Measure the injection pressure.
3. If the measurement is not within the specified values, replace the adjusting washer in the nozzle holder to adjust it.

Fuel injection pressure	Factory specification	13.73 to 14.71 MPa 140 to 150 kgf/cm ² 1991 to 2133 psi
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(Reference)

- Adjusting washer:
Assembly Code No. 15841-98101
(includes 43 sizes below)

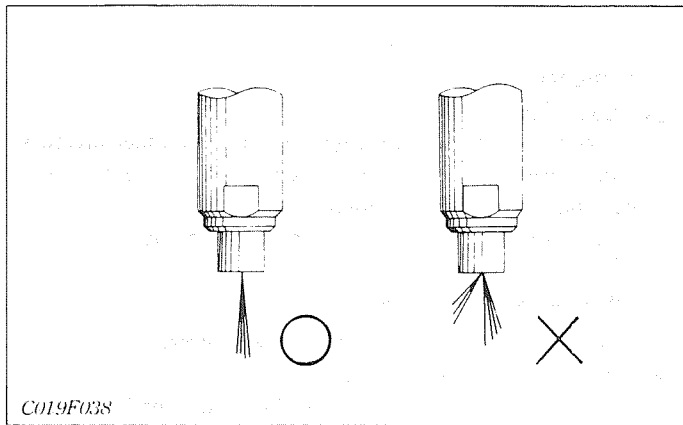
Adjusting washer	Thickness mm (in.)	Code Number	Adjusting washer	Thickness mm (in.)	Code Number
0900	0.900 (0.03543)	15481-98501	1200	1.200 (0.04724)	15481-98621
0925	0.925 (0.03642)	15481-98511	1225	1.225 (0.04823)	15481-98631
0950	0.950 (0.03740)	15481-98521	1250	1.250 (0.04921)	15481-98641
0975	0.975 (0.03839)	15481-98531	1275	1.275 (0.05020)	15481-98651
1000	1.000 (0.03937)	15481-98541	1300	1.300 (0.05118)	15481-98661
1025	1.025 (0.04035)	15481-98551	1325	1.325 (0.05217)	15481-98671
1050	1.050 (0.04134)	15481-98561	1350	1.350 (0.05315)	15481-98681
1075	1.075 (0.04232)	15481-98571	1375	1.375 (0.05413)	15481-98691
1100	1.100 (0.04331)	15481-98581	1400	1.400 (0.05512)	15481-98701
1125	1.125 (0.04429)	15481-98591	1425	1.425 (0.05610)	15481-98711
1150	1.150 (0.04528)	15481-98601	1450	1.450 (0.05709)	15481-98721
1175	1.175 (0.04626)	15481-98611	1475	1.475 (0.05807)	15481-98731



Valve Seat Tightness

1. Set the nozzle to a nozzle tester.
2. Raise the fuel pressure and keep at 12.75 MPa (130 kgf/cm², 1849 psi) for 10 seconds.
3. If any fuel leak is found, replace the nozzle piece.

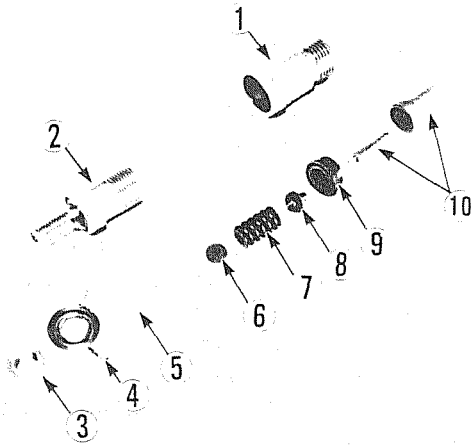
Valve seat tightness	Factory specification	No fuel leak at 12.75 MPa (130 kgf/cm ² , 1849 psi)
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Spraying Pattern

1. Set the nozzle to a nozzle tester and check the nozzle spraying pattern.
2. If the nozzle does not spray in a good pattern, replace the nozzle piece.

DISASSEMBLY AND ASSEMBLY



0075P015

[1] Injection Nozzle

Nozzle Holder

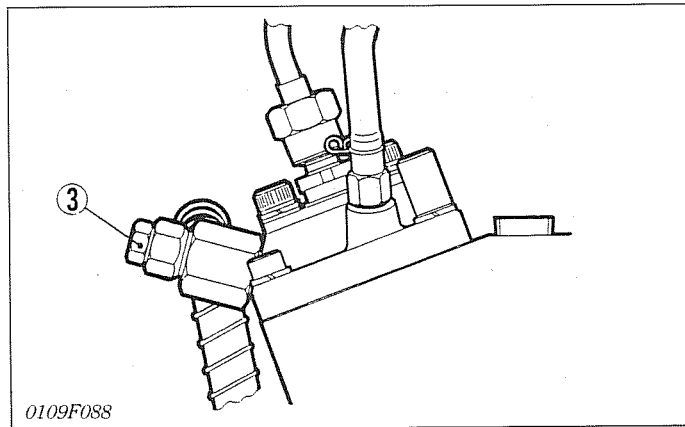
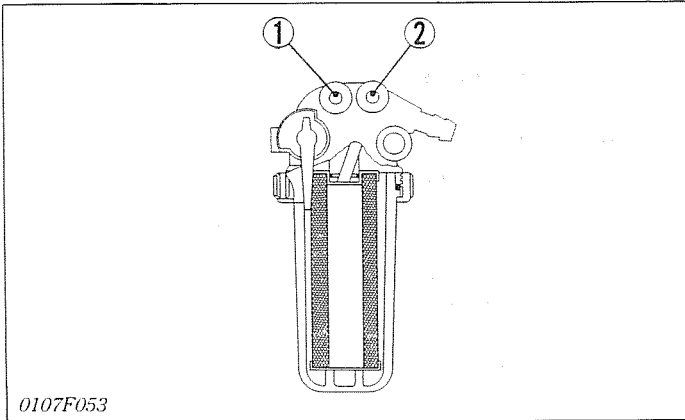
1. Secure the nozzle nut (1) in a vise.
2. Remove the nut (3), the eye joint (4) and the plain washer (5).
3. Remove the nozzle holder (2), and take out the parts. (When reassembling)
 - Assemble the nozzle in clean light oil.
 - Install the push rod (8), noting its direction.

Tightening torque	Nozzle holder	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs
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■ IMPORTANT:

- The nozzle piece is precisely finished. Do not use a piece of metal but a piece of wood to remove the carbon deposits.
- After assembling the nozzle, be sure to adjust the injection pressure. (See "Fuel Injection Pressure")

(1) Nozzle Nut	(6) Adjusting Washer
(2) Nozzle Holder	(7) Nozzle Spring
(3) Nut	(8) Push Rod
(4) Eye Joint	(9) Distance Piece
(5) Plain Washer	(10) Nozzle Piece



[2] Air Bleeding

Bleed the air from the fuel system before attempting to start the engine whenever:

- The fuel filter has been removed or the fuel system lines have been disconnected.
- The fuel tank has been empty.
- The engine has not been run for a long period of time.

CAUTION

- Never bleed the air while the engine is hot.
- Never contact with escaping diesel fuel under pressure, which can have sufficient force to penetrate the skin, causing serious personal injury.
- Be sure to relieve all pressure before disconnecting.
- Make sure that no fuel can escape from the system before applying pressure.
- Keep the engine stop lever at the "STOP" position to shut off the fuel, while bleeding the air.

Bleeding Fuel System

1. Replenish the fuel tank and open the fuel cock.
2. Loosen the bleeding screws (1), (2) at the top of the filter by two turns.
3. Keeping the engine stop lever at the "STOP" position, run the engine with the starter until the fuel without air flows from the loose screws.
4. Tighten the bleeding screw (1).
5. With the engine stop lever at the "STOP" position, run the engine with the starter again until the fuel without air flows from the loose screw.
6. Tighten the bleeding screw (2).

(Reference)

- If the engine will not start after the above bleeding, bleed the air further in the system, as follows.
- Loosen the plug (3).
- Run the engine with the starter, keeping the engine stop lever at the "STOP" position, until the fuel without air flows from the loose plug.
- Tighten the plug (3).

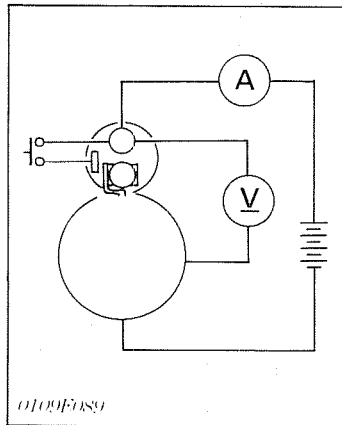
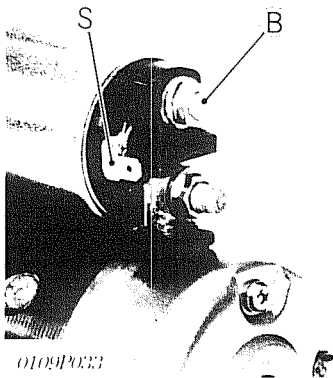
IMPORTANT:

- Do not run the engine with the starter continuously for more than 10 seconds.

ELECTRICAL SYSTEM

[1] Starter

CHECKING



No-load Test

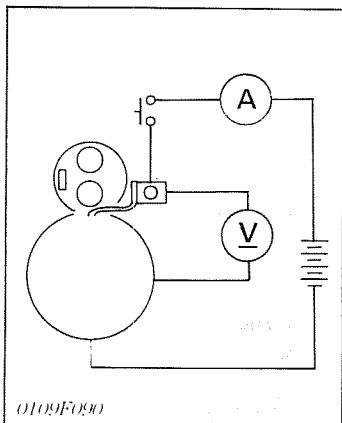
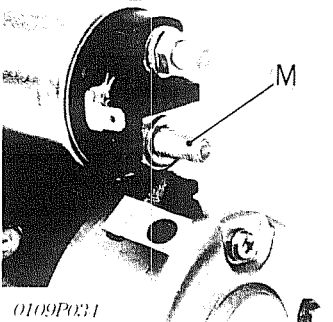
1. Connect a cable from the negative terminal of the battery to the body of the starter.
2. Connect a voltmeter across "B" terminal and the body of the starter, and an ammeter across the positive terminal of the battery and "B" terminal of the starter.
3. Connect a switch between "B" and "S" terminals of the starter, and run the starter.
4. The starter should run at the specified rate (See table).

(Reference)

Supply Voltage	11.5V
Current	Less than 53A
Speed	More than 7,000 rpm

NOTE:

- Test with a cable and an ammeter for large current, and a fully charged battery.

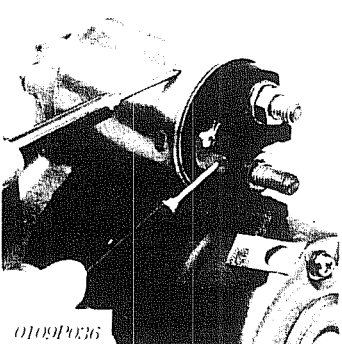
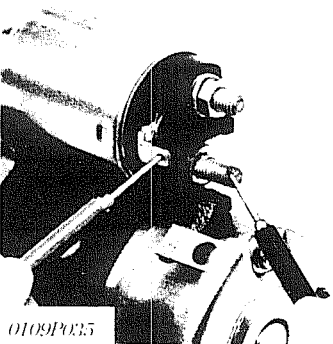


Motor Test

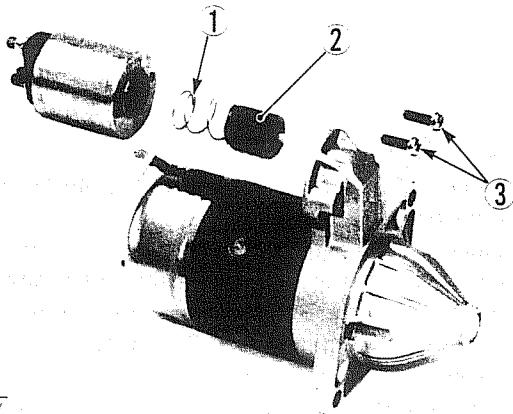
1. Disconnect the connecting lead to "M" terminal and connect a voltmeter across the lead and the body of the starter.
2. Connect a cable between the negative terminal of the battery and the starter body.
3. Connect an ammeter and a switch in series between the positive terminal of the battery and the connecting lead, and run the starter.
4. The starter should run at the specified rate (See "No-load test").

Solenoid Switch

1. Check the continuity across "S" and "M" terminals, and across "S" terminal and the body with an ohmmeter.
2. If not continuous, replace.



DISASSEMBLY AND ASSEMBLY

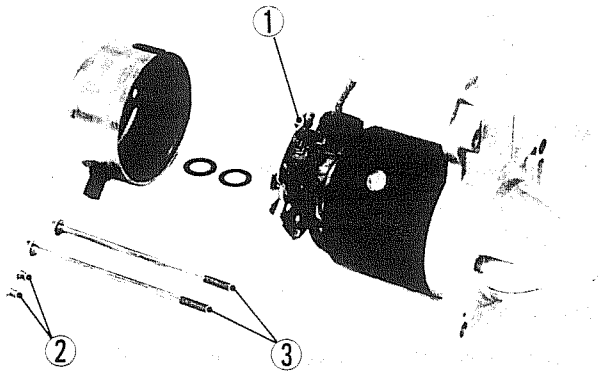


0109P037

Solenoid Switch

1. Remove the screws (3) to separate the solenoid switch.
2. Pull out the plunger (2) and the spring (1).

- (1) Spring
- (2) Plunger
- (3) Screw



0109P038

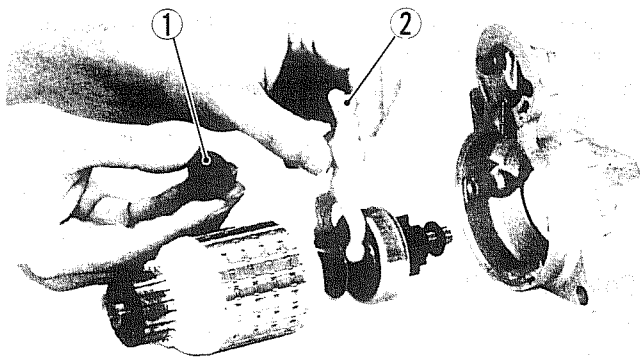
End Frame

1. Remove the through bolts (3) and the screw (2).
2. Remove the rear and frame.
3. Lift the brush and remove the brush holder (1).
4. Remove the yoke assembly.

■ NOTE:

- Do not miss the thrust washers behind the commutator.

- (1) Brush Hdder
- (2) Screw
- (3) Through Bolt



0109P039

Armature

1. Pull out the armature.
2. Remove the plate (1) and the lever (2).

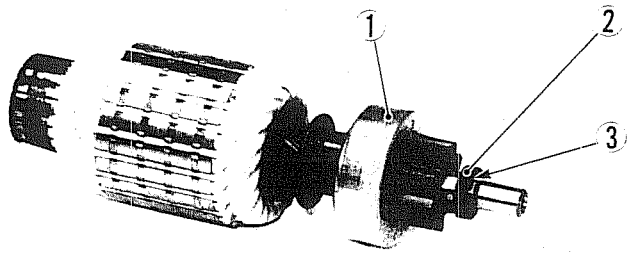
(When reassembling)

- Install the lever, noting its direction (See photo).

■ NOTE:

- Do not miss the thrust washers on the front of the armature shaft.

- (1) Plate
- (2) Lever



0109F010

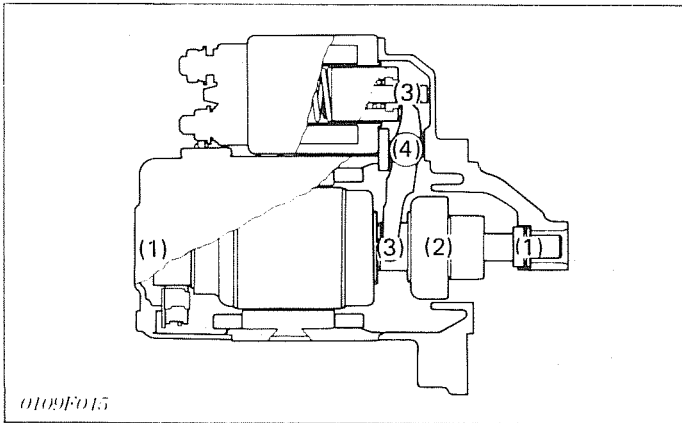
Overrunning Clutch

1. Tap in the stop ring (3).
2. Remove the retainer ring (2).
3. Remove the stop ring (3) and the overrunning clutch (1).

(When reassembling)

- Install the stop ring first, then the retainer ring, and then pull up the stop ring with a puller.

- (1) Overrunning Clutch
- (2) Retainer Ring
- (3) Stop Ring



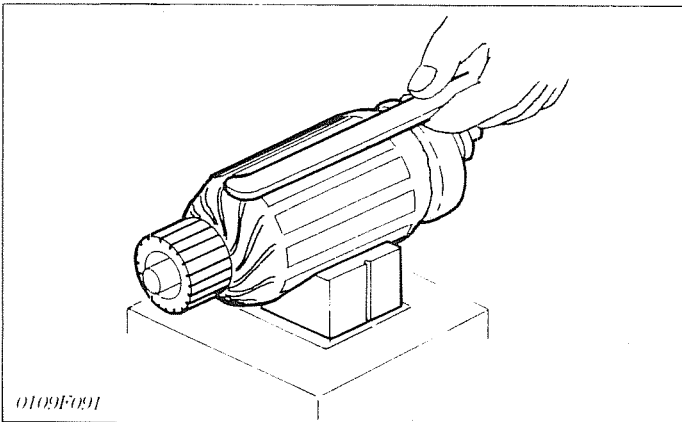
0109F015

Lubrication

Before reassembling, lubricate the following.

- (1) Bearings in the end frames and the washers.
- (2) Sliding surface between the armature shaft and overrunning clutch. (with low viscosity oil)
- (3) Shift lever where it engages with the plunger and the overrunning clutch.
- (4) Plunger where it contacts with solenoid housing.

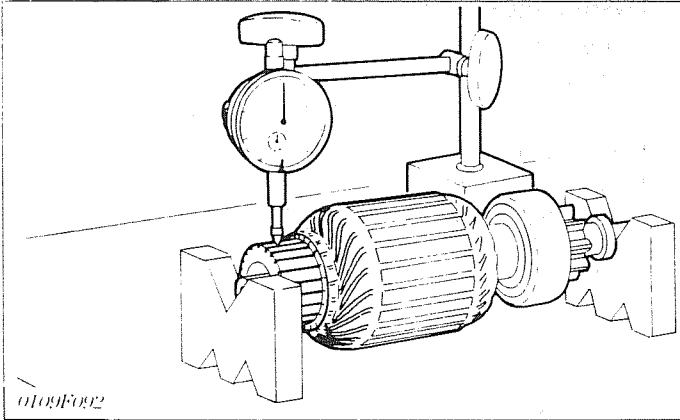
SERVICING



0109F091

Armature Coil

1. Place the armature on a growler to check for the short circuits, and slowly rotate the armature holding an iron piece above the core.
2. If the iron piece vibrates against the core, replace the armature.
3. Check the continuity across each segment of the commutator and the armature shaft.
4. If continuous, replace the armature.



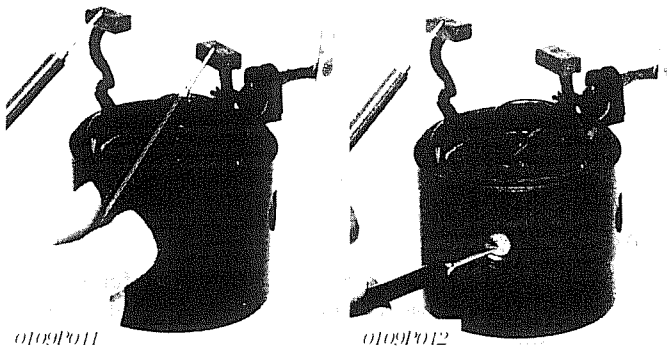
Commutator

1. Rotate the armature in V blocks to check out-of-roundness and run-out, setting a dial indicator with its tip on the commutator.
2. If the variance among the readings is more than the allowable limit, turn the armature in the lathe.
3. If the depth of undercut is less than the allowable limit, undercut with a hacksaw blade or an undercutter.
4. Sand off all burrs with sandpaper.

NOTE:

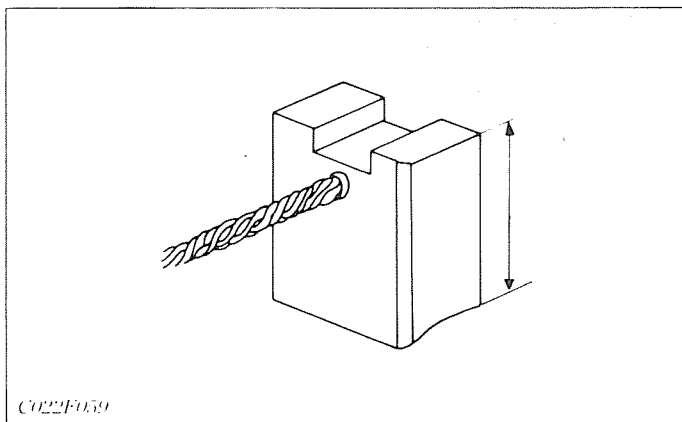
- When the smallest radius of the commutator is less than the allowable limit, replace the armature shaft.

Variance on commutator O.D.	Allowable limit	0.05 mm 0.0020 in.
Commutator O.D.	Allowable limit	31 mm 1.22 in.
Commutator undercut	Allowable limit	0.2 mm 0.008 in.



Field Coil

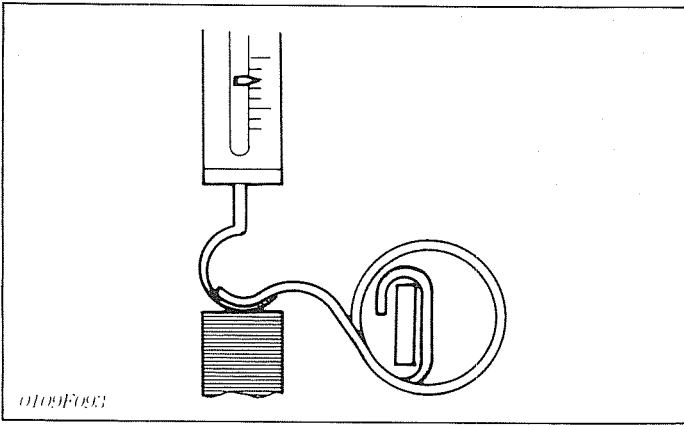
1. Check the continuity between the brushes.
2. If not continuous, replace the yoke assembly.
3. Check the continuity across the yoke and the brush or the connecting lead.
4. If continuous, check for the breakage of the insulation.
5. If not repairable, replace the yoke assembly.
6. Check that the pole and windings are not loose.



Brush

1. Clean off the brush and check for the wear.
2. If unevenly worn, correct.
3. If worn to less than the allowable limit, replace.
4. Check that the brushes move freely in the brush holder.

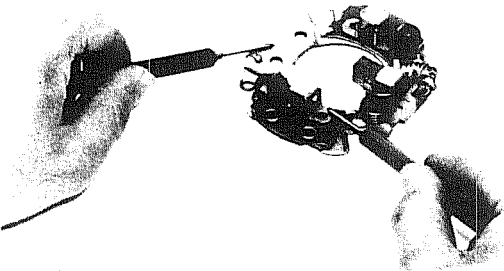
Brush length	Factory specification	17mm 0.67 in.
	Allowable limit	11.5 mm 0.453 in.



Brush Spring

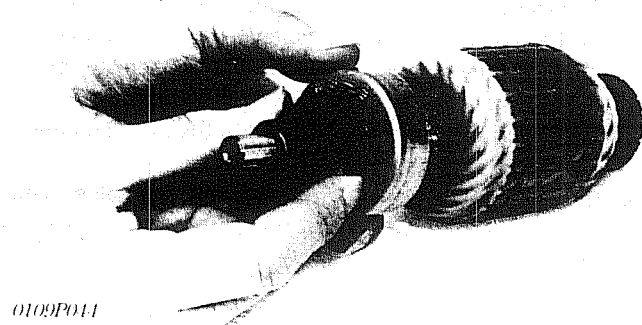
1. Pull the brush in the brush holder with a spring scale.
2. Measure the brush spring tension required to raise the spring from contact position with the commutator.
3. If the tension is less than the allowable limit, replace the spring.

Spring tension	Factory specification	13.7 to 25.5N 1.4 to 2.6 kgf 3.1 to 5.7 lbs
	Allowable limit	8.8 N 0.9 kgf 2.0 lbs



Brush Holder

1. Check the continuity across the insulated brush holder and the brush holder support.
2. If continuous, replace the brush holder assembly.

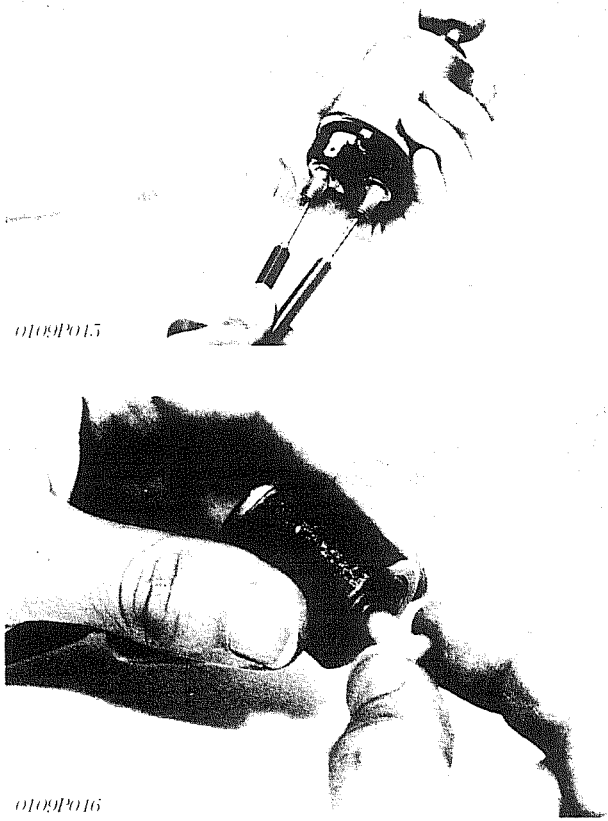


Overrun Clutch

1. Check the pinion and if worn or damaged, replace the clutch assembly.
2. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
3. If the pinion slips or does not turn in both directions, replace the overrunning clutch assembly.

■ NOTE:

- Do not wash off the grease in the overrunning clutch with the chemicals or oils.

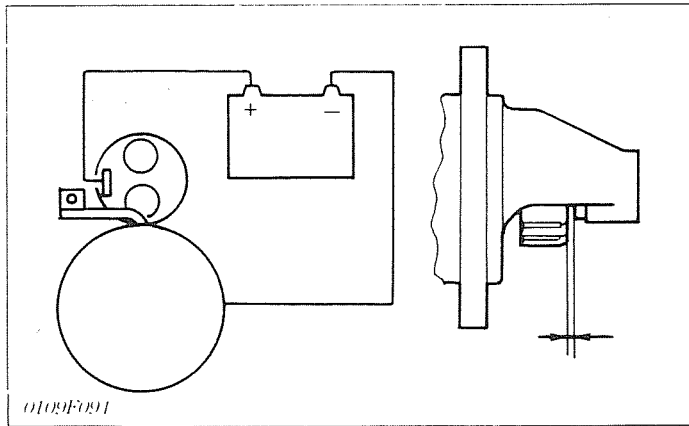


0109P015

0109P016

Solenoid Switch

1. Check the continuity across "B" and "M" terminals with an ohmmeter, pushing in the plunger.
2. If not continuous or if a certain value is indicated, replace the solenoid switch.
3. Pull the pull-rod to check the spring built in the plunger.



0109F091

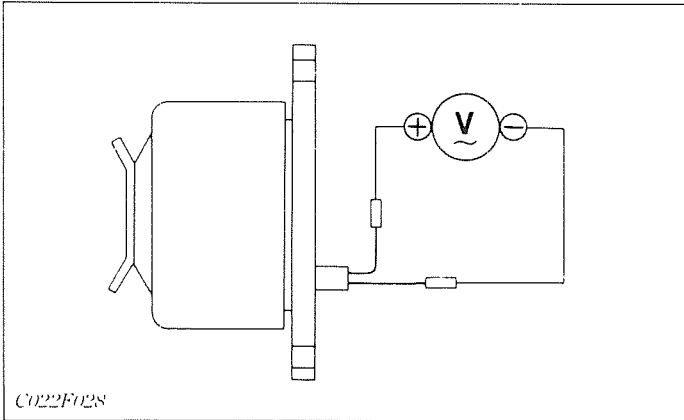
Pinion Clearance

1. Reassemble the starter with connecting leads unconnected.
2. Connect a cable from the negative terminal of the battery to the starter body and a cable from "S" terminal of the starter to the positive terminal of the battery to force out the pinion.
3. Push back the pinion slightly to kill the play, and measure the pinion clearance.
4. If the clearance is not within the specified values, add or remove the washer between the solenoid switch and front end frame.

Pinion clearance	Factory specification	0.5 to 2.0 mm 0.020 to 0.079 in.
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[2] AC Dynamo and Regulator

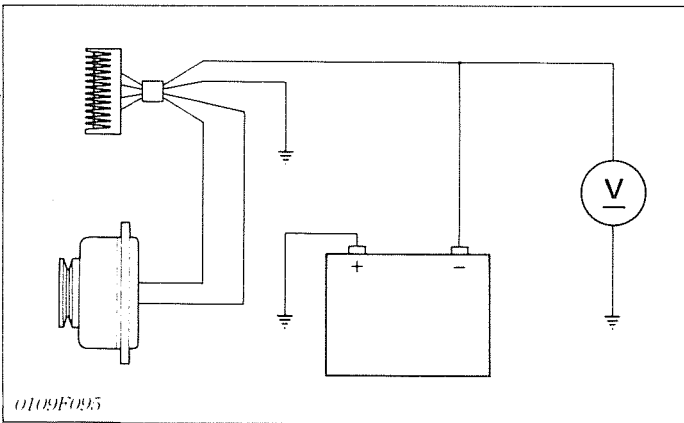
CHECKING



No-Load Dynamo Output

1. Disconnect the lead wires from the AC dynamo.
2. Start the engine and operate the AC dynamo at the specified speed.
3. Measure the output voltage with a volt meter.
If the measurement is not within the specified values, replace the AC dynamo.

No-load output	Factory specification	AC 20V or more at 5200 rpm
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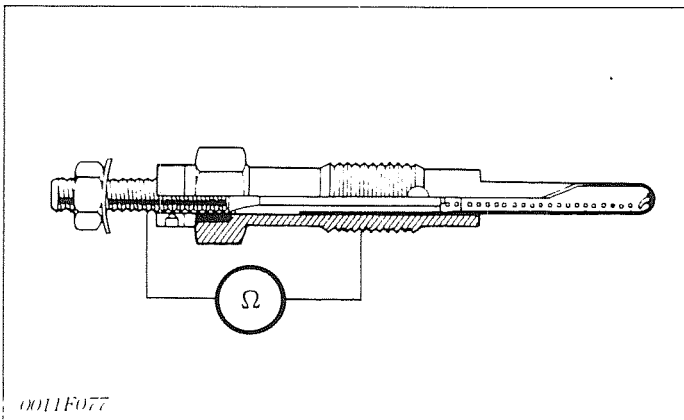
Regulating Voltage

1. Complete the charging circuit with a fully charged battery and operate the dynamo at the specified speed.
2. Measure the battery voltage with a volt meter.
3. If the measurement is not within the specified values, replace the regulator.

Regulating voltage	Factory specification	14 to 15V at 5200 rpm
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[3] Glow Plug

CHECKING



Heat Coil and Insulation

1. Disconnect the lead wires from the glow plug.
2. Check the continuity across the thread at the end of the glow plug and its housing or the engine body with an ohmmeter.
3. If the ohmmeter indicates 0 ohm or infinity, replace the glow plug.

Heat coil resistance	Factory specification	Approx. 1.6 ohm when cold
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