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Mitsubishi Tractor

Maintenance Manual

K3M, K4M

Mitsubishi Agricultural Machinery Co., Ltd.
Technical Service Dept.
K&T Saw Shop 606-678-9623 or 606-561-4983

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FOREWORD

This Service Manual, prepared for the benefit of service mechanics, describes the service procedures of the Mitsubishi K－series direct injection diesel engines.

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

All information contained in this manual is based on the products as of April 1, 1988. Therefore, this manual does not contain any subsequent changes of engine specifications and later improvements of products.

Other Service Manuals applicable to the swirl chamber type K－series diesel engines are :

KE70, K2－series Service Manual····· (MM201492)

K3－series Service Manual····· (MM201489)

KE150, K4－series Service Manual ····· (MM201488)

APRIL, 1988

Mitsubishi Heavy Industries, Ltd.

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MITSUBISHI DIESEL ENGINE
DIRECT INJECTON K3·K4 MODELS

CONTENTS

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Group 0 GENERAL INFORMATION

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■ Engine Model and Engine Number

(1) Engine model

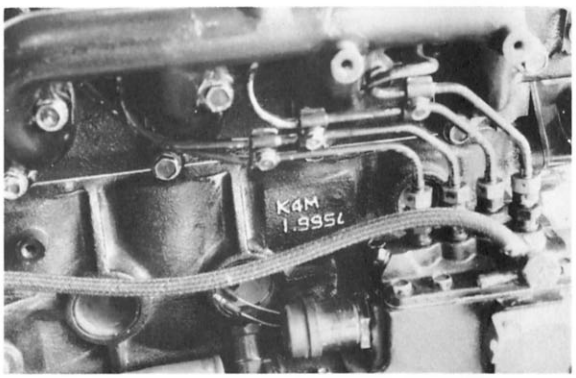
Model	Classification	Use
K3C K3D K3E	D11 〜 D14	For agricultural machines (tractors and combines)
K3F	D31	For domestic industrial machines
K4E K4F K4M	D61 〜	For exports

(2) Engine Model Designation

Example : K4M-D11C

K 4 M - D 1 1 C

- C — Subdivision of specification
  - A : for standard type tractor
  - C : for standard type combine
- 11 — Use
  - 11〜14 : for agricultural use
  - 31 : for industrial use
  - 61, 62 : for exports
- D — Direct Injection
- 4 — Cylinder bore size (84mm, 3.31in)
- 4 — Number of cylinders (4 : four cylinders)
- K — Manufacturing works (K : Kyoto)



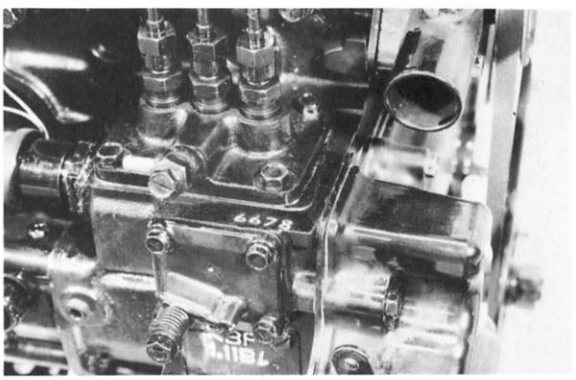
Engine Model and Total Displacement

(3) Engine Number

The engine number is stamped on the same location as the swirl chamber type as shown.

Model	Stamped number
K3C〜F K4F〜M	1001〜

(Note : Each model including the swirl chamber types are numbered serially.)



Location of Engine Number

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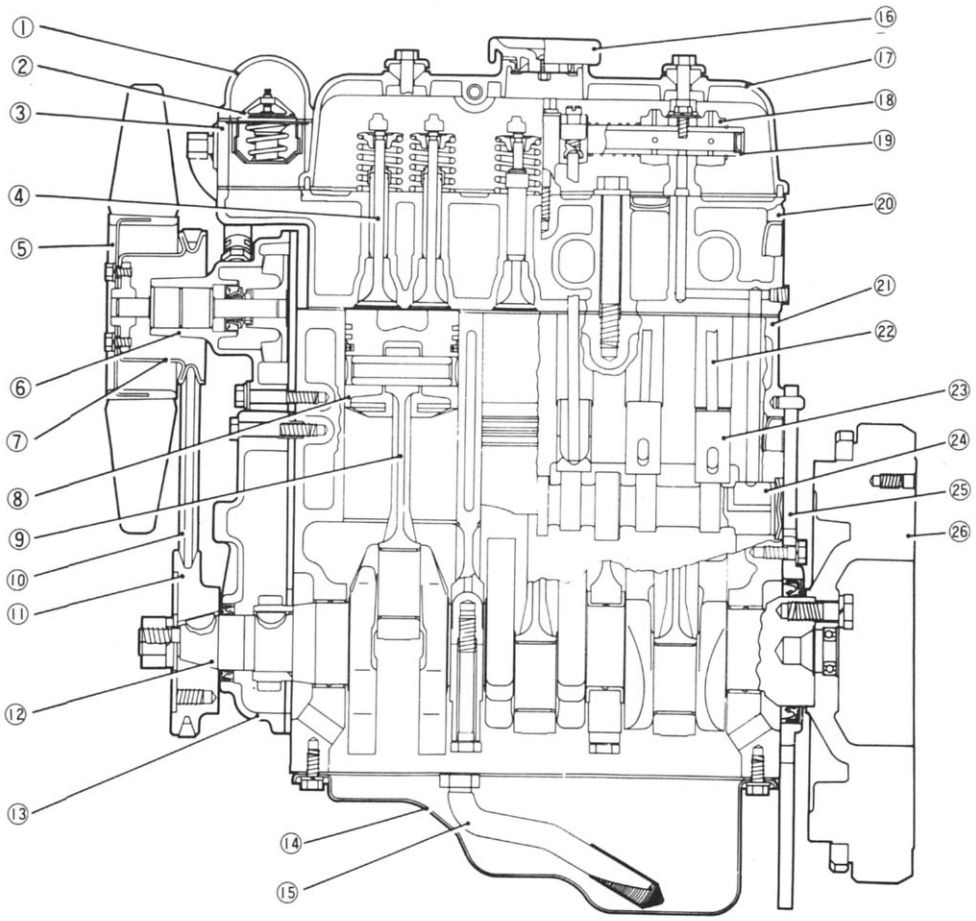

Longitudinal Sectional View of K3 Engine

① Water outlet fitting
② Thermostat
③ Thermostat fitting
④ Inlet valve
⑤ Cooling fan
⑥ Water pump
⑦ Water pump pulley
⑧ Piston
⑨ Connecting rod
⑩ Fan belt
⑪ Crankshaft pulley
⑫ Crankshaft
⑬ Gear case
⑭ Oil pan
⑮ Oil screen
⑯ Oil filler cap
⑰ Rocker cover
⑱ Rocker arm
⑲ Rocker shaft
⑳ Cylinder head
㉑ Cylinder block
㉒ Push rod
㉓ Tappet
㉔ Camshaft
㉕ Rear plate
㉖ Flywheel

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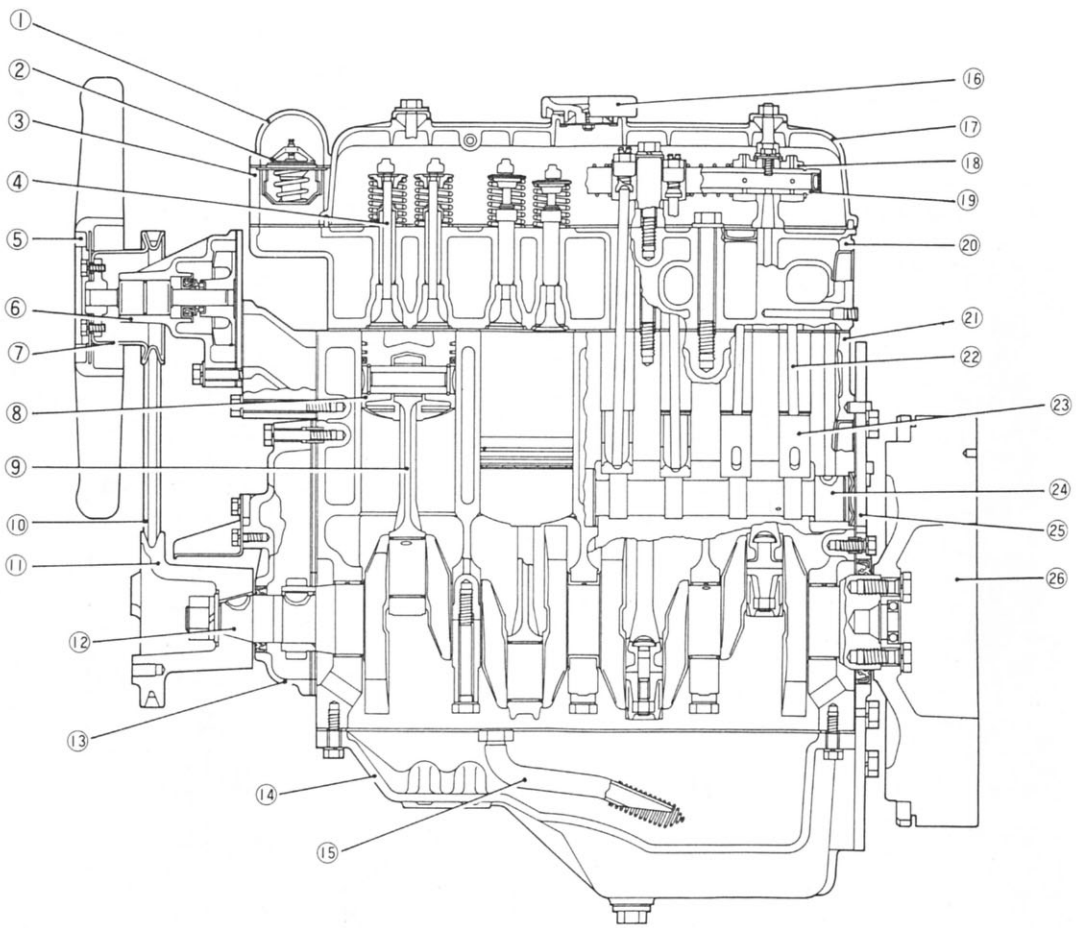

Longifudinal Section of K4 Engine

① Water outlet fitting
② Thermostat
③ Thermostat fitting
④ Inlet valve
⑤ Cooling fan
⑥ Water pump
⑦ Water pump pulley
⑧ Piston
⑨ Connecting rod
⑩ Fan belt
⑪ Crankshaft pulley
⑫ Crankshaft
⑬ Gear case
⑭ Oil pan
⑮ Oil screen
⑯ Oil filler cap
⑰ Rocker cover
⑱ Rocker arm
⑲ Rocker shaft
⑳ Cylinder head
㉑ Cylinder block
㉒ Push rod
㉓ Tappet
㉔ Camshaft
㉕ Rear plate
㉖ Flywheel

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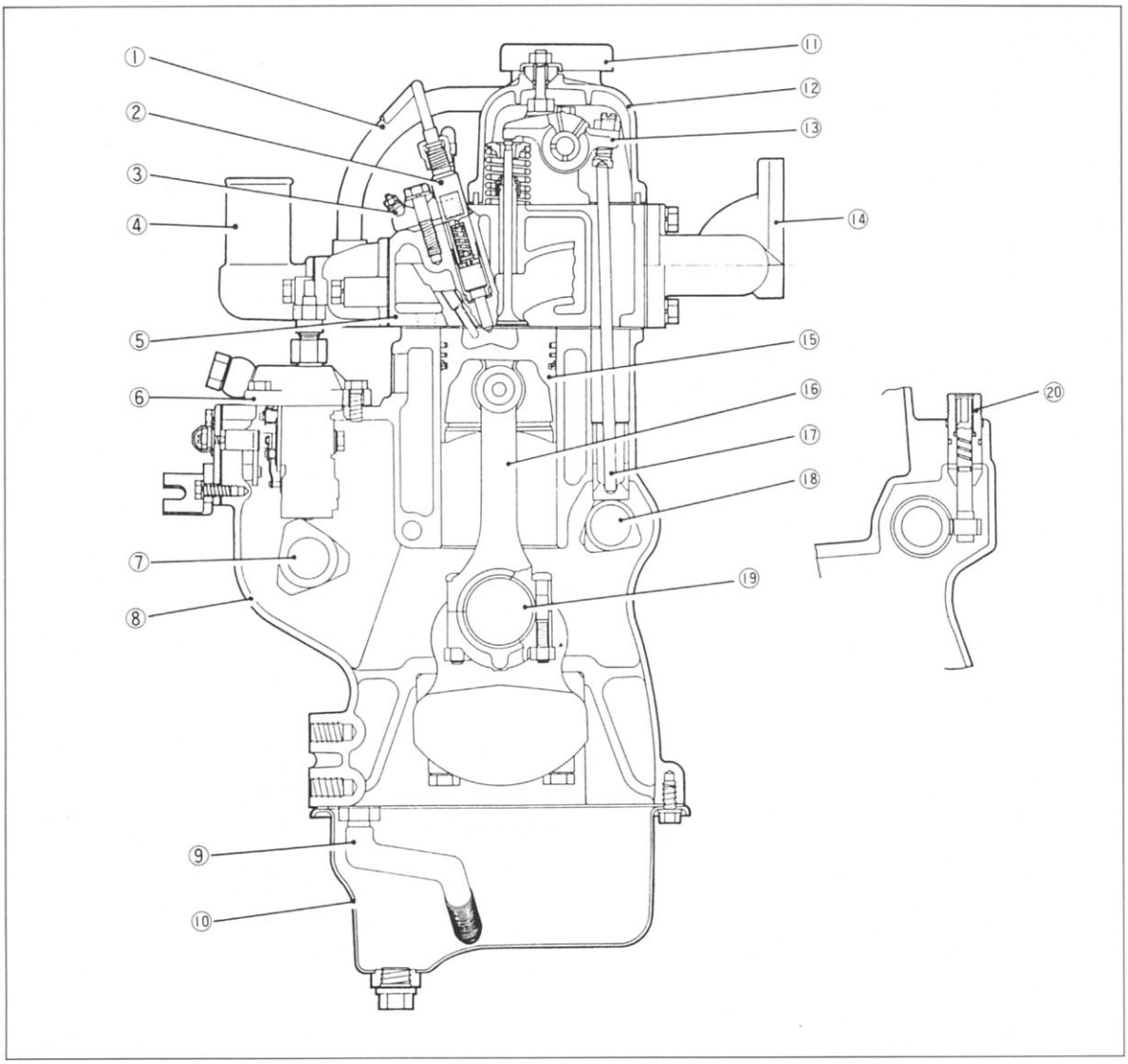

Cross Section of K3 and K4 Engines

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

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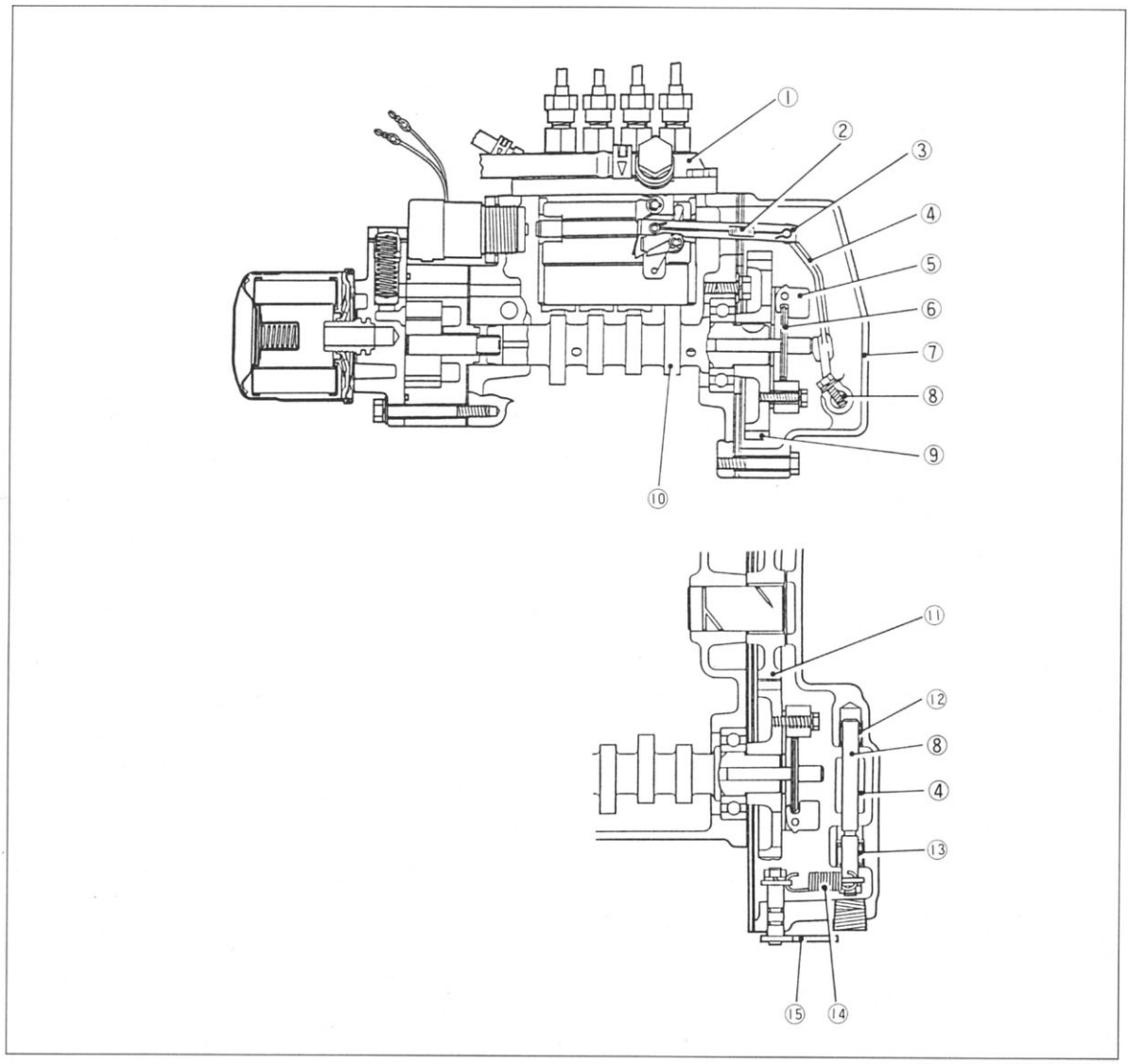

Governor System of K3 and K4 Engines

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

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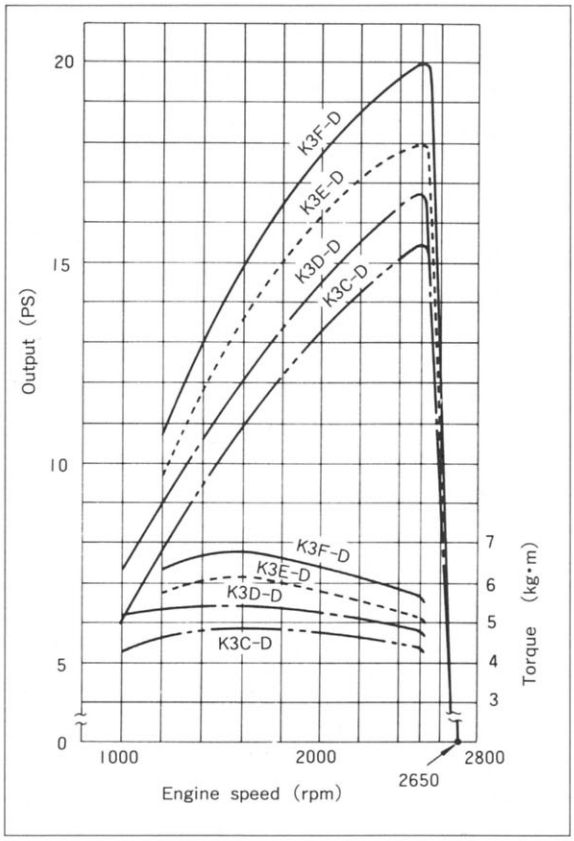
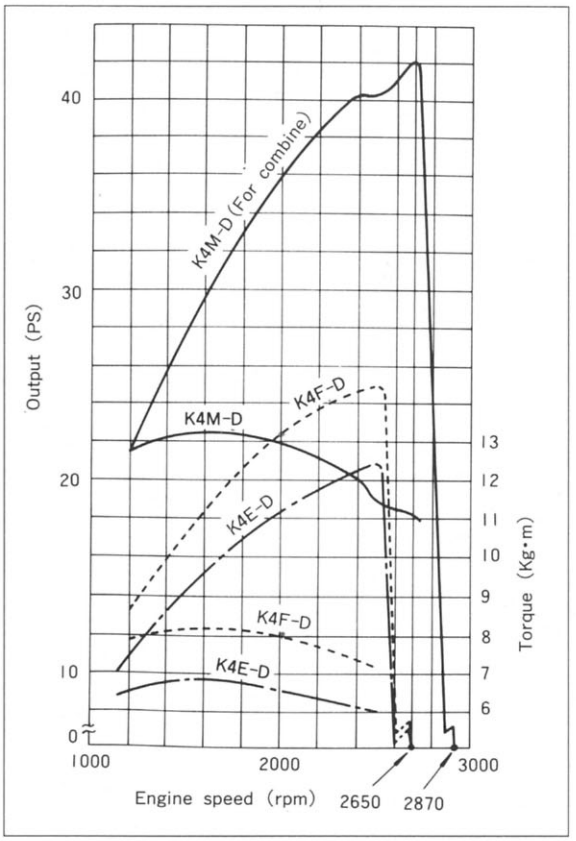
■ Engines for Agricultural Machines

(1) K3 Series



(2) K4 Series



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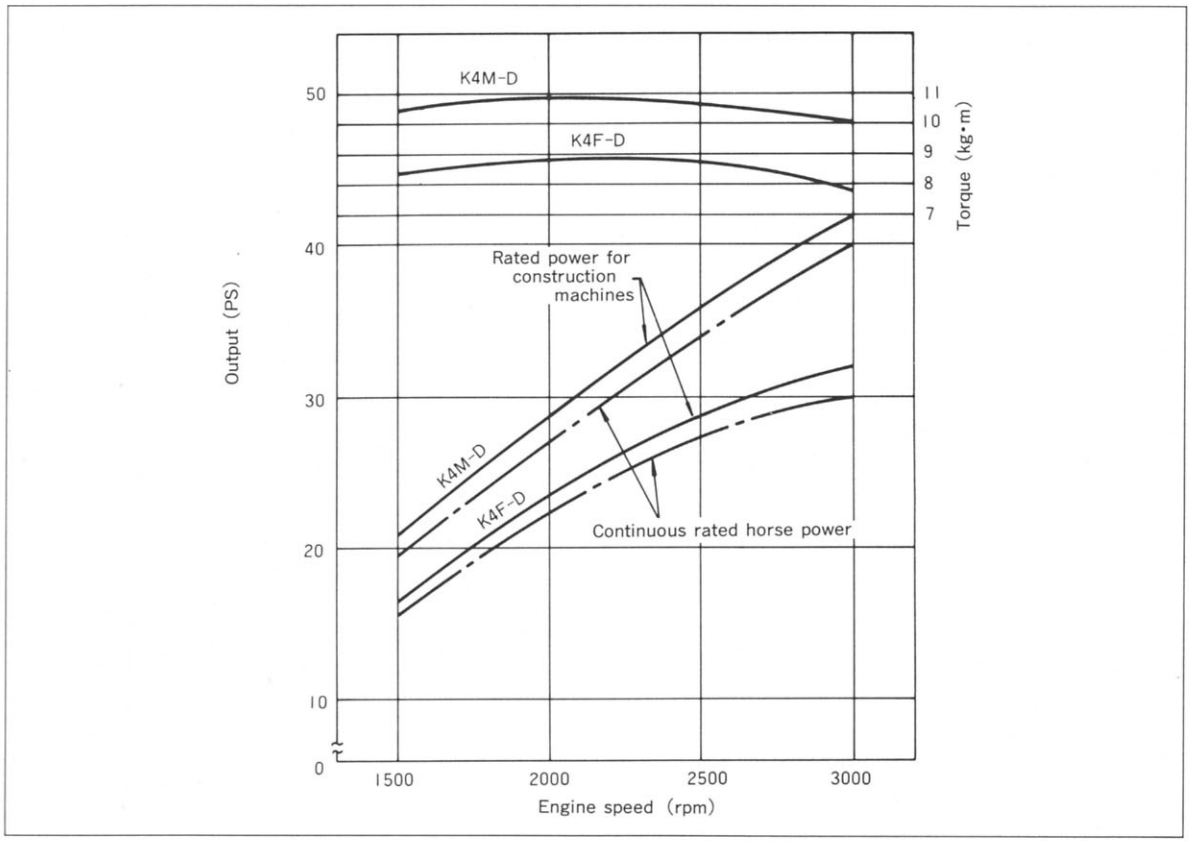
■ Engines for Industrial Use and for export



Engine output by purposes			Engine speed rpm	K4F-D	K4M-D
For general power sources	Continuous rated horsepower, PS		1500	16	21
			1800	20	24
			2400	26	33
			3000	29	40
For construction machines	Rated horsepower, PS		1500	17	20
			1800	21	25.5
			2400	28	35
			3000	31	42
For electric generators	Rated horsepower, long-time service type, PS(kW)	50Hz	1500	16(10)	21 (13.1)
			3000	29(18.1)	40 (25)
		60Hz	1800	20(12.5)	24 (15)
	Rated horsepower, ordinary service type, PS(kW)	50Hz	1500	17(10.6)	20 (12.5)
			3000	31(19.4)	42 (26.3)
		60Hz	1800	21(13.1)	25.5(15.9)

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Group No. 0-04

Item \ Model		K3C	K3D	K3E	K3F
General	Type	4−cycle, water−cooled, vertical diesel engine			
	Firing order	1−3−2			
	Compression ratio	18			
	Combustion chamber	Direct injection			
	Engine weight	134			
Cylinder	Number of cylinders	3			
	Bore x Stroke (mm)	70x78	73x78	76x78	78x78
	Total displacement (cc)	900	979	1061	1118
Performance	Max. horsepower (ps/rpm)	Specified in each separate specification			
	Max. torque (kgm/rpm)				
	No load max. speed (rpm)				
	Fuel consumption (g/ps−hr)	185			
Stability angle	Back and forth, right and left inclination (Lower limit of oil level)	25° during continuous operation, 30° during short−time (less than 30 minutes) operation			
Fuel system	Injection pump	Bosh M type			
	Nozzle	Hole type			
	Governor	Centrifugal flyweight type			
	Fuel	Diesel fuel			
Lubrication system	Type	Forced lubrication (trochoid pump)			
	Oil filter	Filter paper (full flow type)			
	Oil capacity : Standard type (ℓ)	Upper limit : 3.0, Lower limit : 1.8 (except 0.5 ℓ for oil filter)			
Cooling system	Type	Pressurized, forced recirculation with radiator			
	Coolant capacity (ℓ)	3.0 (except for radiator and hoses)			
Electrical system	Starter motor	12V−1.6kW			
	Alternator	12V−35A or 12V−40A			
	Battery	12V−60AH min.			

Note : Specifications for the standard type engines for agricultural use are shown.

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Item \ Model		K4E	K4F	K4M
General	Type	4−cycle, water−cooled, vertical diesel engine		
	Firing order	1−3−4−2		
	Compression ratio	18		
	Combustion chamber	Direct injection		
	Engine weight	177		188
Cylinder	Number of cylinders	4		
	Bore x Stroke (mm)	76x78	78x78	84x90
	Total displacement (cc)	1415	1490	1995
Performance	Max. horsepower (ps/rpm) Max. torque (kgm/rpm) No load max. speed (rpm)	Specified in each separate specification		
	Fuel consumption (g/ps−hr)	180		175
Stability angle	Back and forth, right and left inclination (Lower limit of oil level)	25° during continuous operation, 30° during short−time (less than 30 minutes) operation		
Fuel system	Injection pump	Bosh M type		
	Nozzle	Hole type		
	Governor	Centrifugal flyweight type		
	Fuel	Diesel fuel		
Lubrication system	Type	Forced lubrication (trochoid type)		
	Oil filter	Filter paper (full flow type)		
	Oil capacity : Standard type (ℓ)	Upper limit : 4.5, Lower limit : 3.0	Upper limit : 5.0, Lower limit : 3.0	
Cooling system	Type	Pressurized, forced recirculation with radiator		
	Coolant capacity (ℓ)	3.5 ℓ		3.7 ℓ
Electrical system	Starter motor	12V−2.0kW		
	Alternator	12V−40A		
	Battery	12V−70AH min.		

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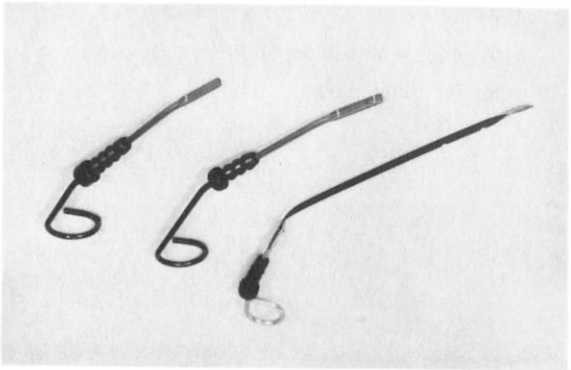
■ Engine Oil and Oil Filter

1. Engine Oil Level Check
   (1) Place the engine upright on level ground.
   (2) Check the oil level with the dipstick. Add the oil up to the upper level mark if the level is near the lower level mark.

CAUTION

- **Recheck the oil level after adding the oil.**
- **Add the same oil as which is used in the engine.**
- **If the engine is not used for long period, check the oil condition and level and replace or add if necessary. Operate the engine for several minutes and recheck the oil level.**



Oil Level Gauge

2. Oil Replacement Period
   Engine oil should be replaced after first 50 hours operation and every 100 hours operation.
   Replace the oil filter every 200 hours operation.

3. Engine Oil Recommendation
   Use engine oil certified to meet or exceed API service Classification CC and with the proper viscosity according to the ambient temperature as shown in the table.

API Service Classification	Ambient temperature	Oil viscosity SAE
CC or above	Above 20°C	30 or 10W−30
	5−20°C	20 or 10W−30
	Below 5°C	10W−30

Note : Use API CD coil when the engine is used under high load range and for engine with turbo-charger.

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4. Oil Filter

Use genuine Mitsubishi oil filter. Do not use a oil filter for other model.

5. Engine Oil Replacement

After warming up the engine, remove the drain plug and drain the engine completely. Install and tighten the drain plug and fill the engine with the recommended grade oil through the oil filler.

- Oil pan drain plug tightening torque :
  5~6 kgm
- Oil capacity : Oil capacities are different for respective engine models. Fill the engine upto the upper level on the oil dipstick of the engine. Oil capacity for the oil filter and oil line is approximately 0.5 liter.

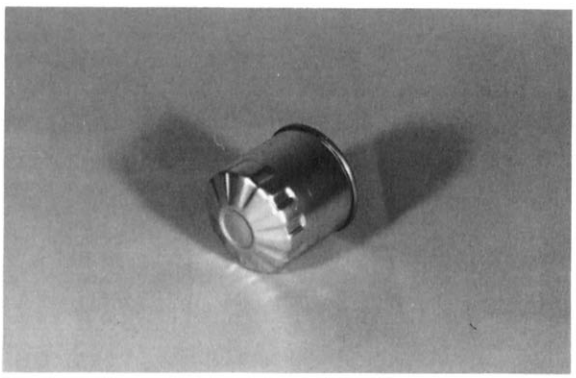
6. Oil Filter Replacement

(1) Remove the oil filter with an appropriate tool such as a filter wrench, etc.

(2) Clean the installation surface of the filter bracket before installing a new filter. Coat clean engine oil lightly to the O-ring of the oil filter and tighten the oil filter securely by hands. (Tightening torque : 1.1~1.3kgm)

CAUTION

- **Take care not to shift the O-ring.**



Oil Filter

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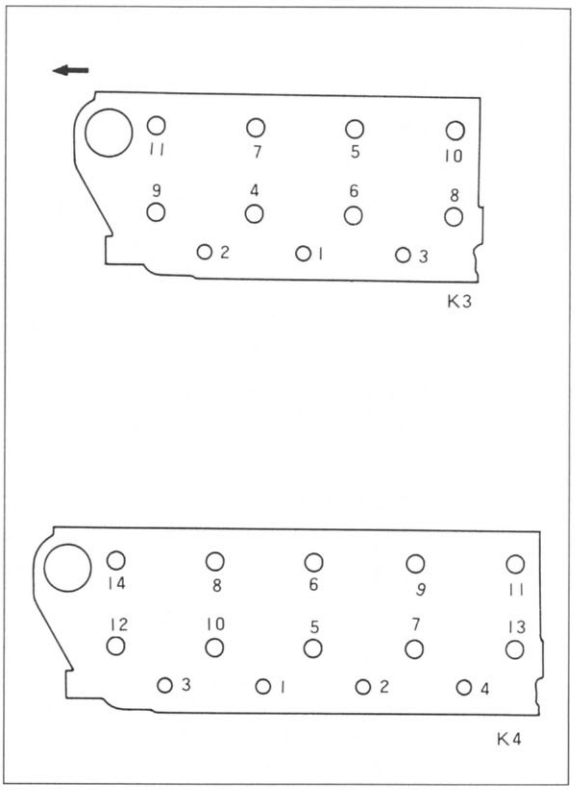
(3) Run the engine for several minutes and make sure that there is no oil leakage.
(4) Stop the engine, check the oil level and add engine oil if necessary.

■ Cylinder Head bolt Re−tightening

1. When re−tightening the cylinder head bolts, loosen the bolt slightly, then tighten to the specified torque.
   (1) Remove the rocker cover and air breather hose.
   (2) Remove the rocker shaft assembly.
   (3) Tighten the cylinder head bolts.
   - Cylinder head bolt tightening torque :
     Except K4M (M12) : 11.5∼12.5 kgm (Wet)
     Except K4M (M10) : 6.5∼8.0 kgm (Wet)
     K4M (M14) : 15∼16 kgm
     K4M (M10) : 10∼11 kgm



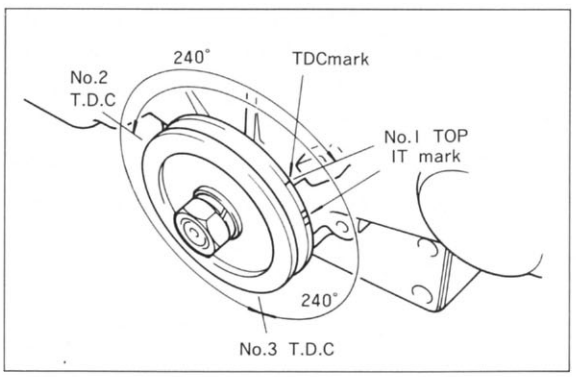
Cylinder Head Bolt Re−tightening

■ Valve Clearance Adjustment

CAUTION

- **Adjust valve clearance after re−tightening the cylinder head bolts.**

(1) **Adjust valve clearance with the piston at T. D. C. of the compression stroke.**
(2) **Measure the valve clearance with a feeler gauge. If adjustment is required, loosen the rocker arm nut and adjust by turning the adjusting screw.**
(3) **Hold the adjusting screw and tighten the lock nut.**



T. D. C. of Compression Stroke (K3, series)

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■ **Fan Belt Adjustment**

Push the fan belt midway between the alternator and crankshaft pulleys and measure the deflection. Adjust by moving the alternator so that the deflection may be 10～12 mm. Belt depression force : Approx. 10kg

■ **Fuel Injection Timing Adjustment**

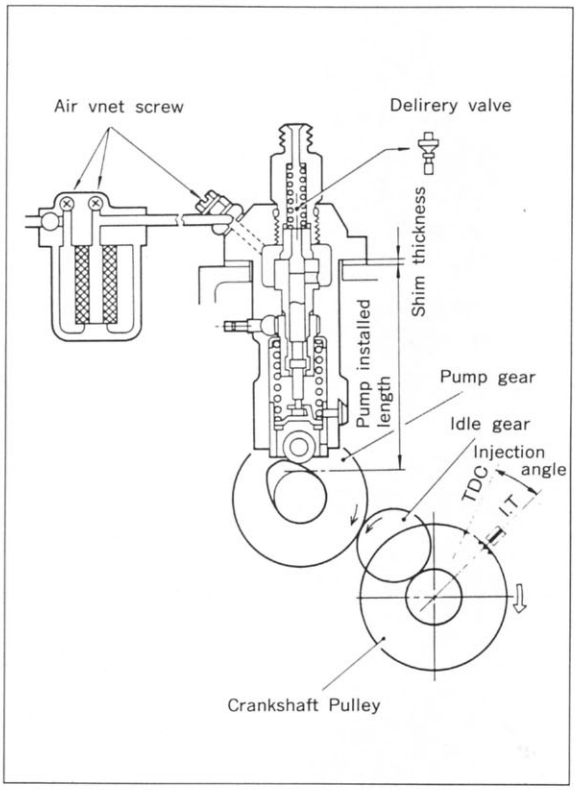
(1) Close the fuel filter cock.
(2) Remove the injection pipes.
(3) Remove the fuel pump No.1 delivery valve holder, delivery valve and delivery valve spring.
(4) Re－install the delivery valve holder and tighten it.
(5) Open the fuel filter cock.
(6) Turn the crankshaft pulley clockwise slowly until the fuel flow stops.

CAUTION

- **The control lever should be set in the midway.**

(7) The injection timing mark on the crankshaft pulley should align with the index mark on the gear case when the fuel flow stops.
Injection timing (B. T. D. C.)
For agricultural use : 19
For industrial use : 20
For exports : 20

(8) If injection timing is out of specification, adjust by increasing or decreasing the thickness of the fuel injection pump mounting shim after removing the pump.
To remove the fuel injection pump, remove the tie rod cover on the side of the cylinder block, tie rod connecting the control rack to the governor, and tie rod spring. Then, remove the fuel injection mounting bolts and the pump assembly.



Fuel Injection Timing Inspection by Removing the Delivery Valve

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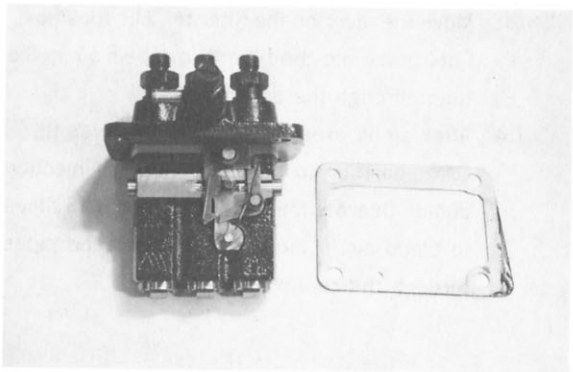
(9) Injection timing is changed by about 1° when thickness of the shim is changed by 0.1 mm.

Caution

- **Injection timing advances when shim thickness is increased, and retards when shim thickness is decreased.**

(10) Install the fuel injection pump in the reverse order of removal.

(11) If around the delivery valve is excessively dirty, check injection timing at the No. 1 injection pipe without removing the delivery valve.
Loosen the nozzle end of the No. 1 injection pipe.
Set the control lever at the middle and open the fuel cock.
Turn the crankshaft pulley clockwise slowly until the fuel at the end of the injection pipe just expands.
When the fuel just expands, injection timing is approximately 1° retarded from actual injection timing.



Injection Pump and Adjusting Shims

■ Fuel System Air Bleeding

(1) Loosen the air bleeder screw on the fuel filter.

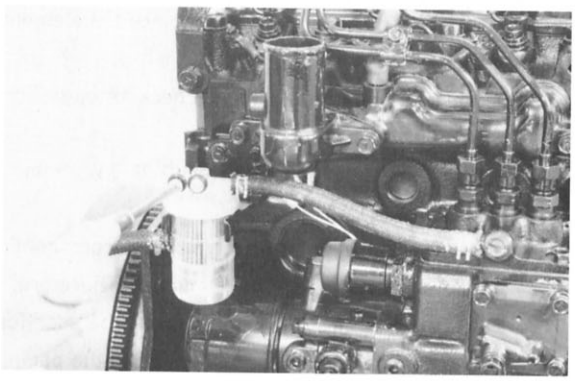
(2) On the drop type, fuel enters into the fuel filter by dropping itself naturally. Tighten the air bleeder screw on the fuel filter after weighting until fuel flows out of the screw.

(3) On the electromagnetic type, feed fuel by turning the key ON, loosen air bleeder screw on the fuel filter to bleed the air in the filter and tighten the screw.

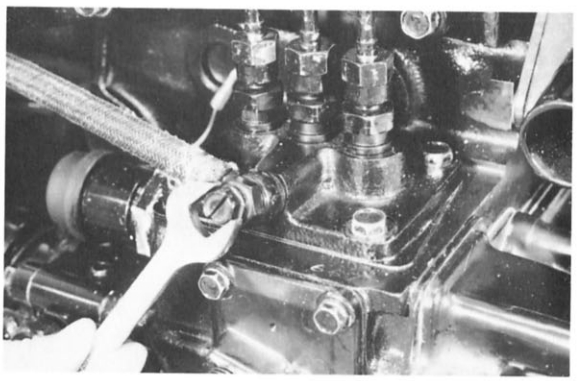
(4) Bleed air in the fuel pipes and injection pump by loosening the bleeder screw on the injection pump.

(5) Air in the injection pipes and nozzles is bled by cranking the engine.

(6) Bleed air from the filter with fuel (air bleeder) cock and with hand pump by the procedure as follows.



Air Bleeding from Fuel Filter



Air Bleeding from Injection Pump

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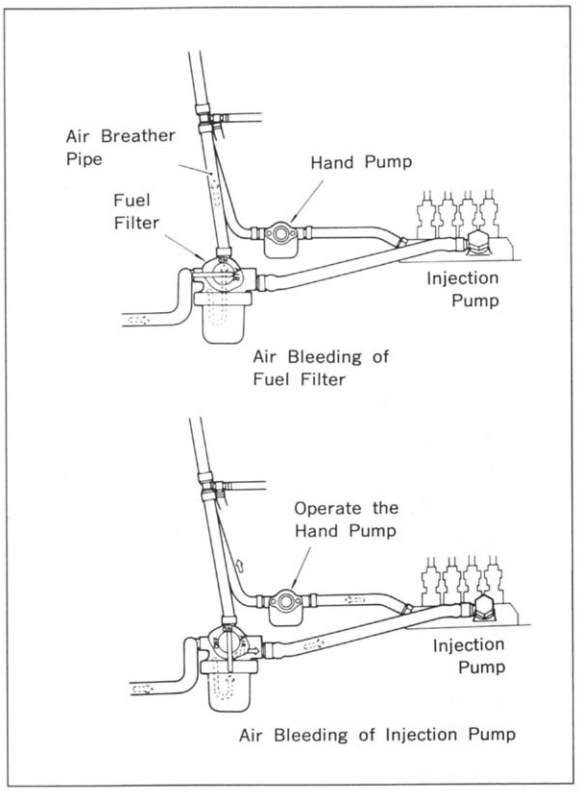
(a) Move the lever on the filter to "AIR" position. Fuel flows into the filter and expels air in the filter through the upper pipe.

(b) After air is expelled, move the lever to "ON" position to flow fuel into the injection pump. Operate the hand pump about 15 times to bleed air in the injection pump and pipes through the return pipe.



Air Bleeding of Injection Pump with Hand Pump

■ Fuel Filter Replacement

(1) Cartridge type
Replace the filter as an assembly if dust and water are accumulated in the element.
Replace the element every 400 operating hours.

(2) Filter with cock (Separate type)
Close the filter cock, loosen and remove the ring nut. Clean or replace the element.

(3) Electromagnetic pump filter (Plunger pump)
An element is installed on the electromagnetic pump. If this element is clogged, fuel feed will be restricted. Clean or replace the element same as the fuel filter.
After replacing the element, check for operation and fuel leakage.

- Electromagnetic pump delivery : 0.9 ℓ/min. at 20 ℃, 12 V

Reference : The diaphragm type electromagnetic pump has no fuel element. Therefore, a separate fuel filter should be used for cleaning before fuel is fed to the pump.

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■ Idle Speed Adjustment

Before adjustment, make sure of the following conditions :

(a) The engine has been warmed up until engine coolant temperature increases above 60°C.

(b) All of valve clearances, injection, timing, and injection nozzles are normal.

(1) Adjusting slow-idle speed

Loosen the slow-idle adjusting screw locknut. Turn the adjusting screw to set the slow-idle speed within specification.

Tighten the locknut to lock the adjusting screw at that position. For the slow-idle specification, see 9−02.

(2) Adjusting fast-idle speed

(a) Engines without damper spring or of damper-free specification-Loosen the fast-idle adjusting screw locknut.

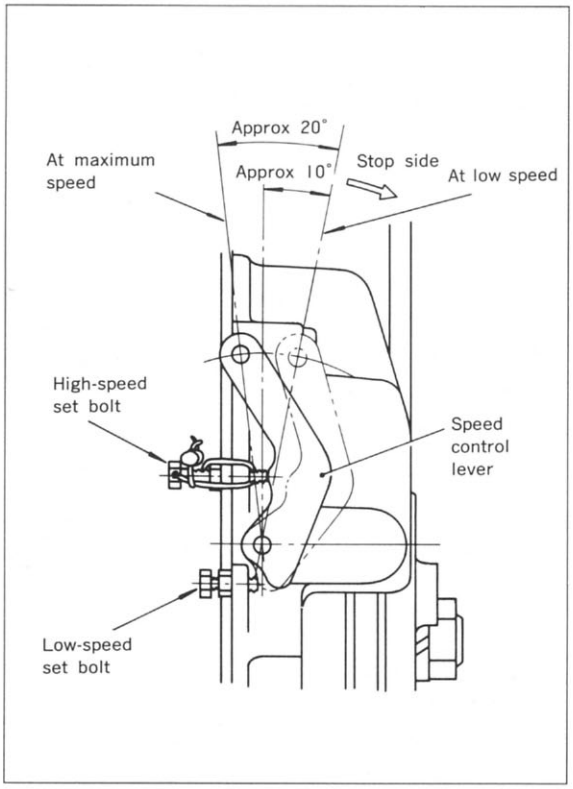
Turn the adjusting screw to set the fast-idle speed within specification. Tighten the locknut to lock the adjusting screw at that position. For the fast-idle specification, see 9−02.

(b) Engines with damper set-Follow the adjusting procedure described below. For the fast-idle specification, see 9−02.

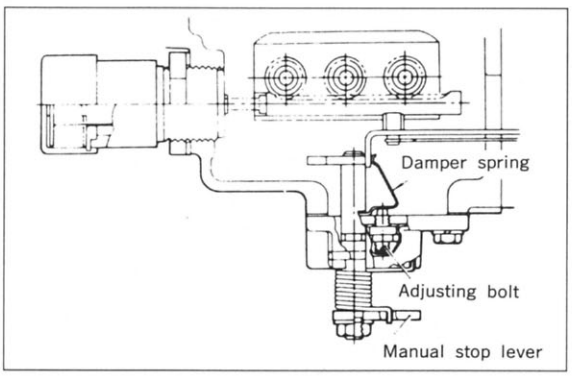
(1) Release the damper spring (by loosening the spring adjusting screw). Loosen the fast-idle adjusting screw locknut. Turn the adjusting screw to set the fast-idle speed at the specified "A" rpm. Tighten the locknut to lock the adjusting screw as that position.

(2) Turn in the damper spring adjusting screw to increase fast-idle speed to the extent of "A" +20±10rpm. Tighten the locknut to lock the spring adjusting screw at the position. (Coat the spring adjusting screw threads with SUPER THREE-BOND # 20.)

Check that engine speed is now within specification of "B" rpm.



Idle Speed Adjusting Screws



Adjusting Damper Spring

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(3) Seal the spring adjusting screw with the sealing cap.

Seal the fast-idle adjusting screw with the lock wire and sealing metal.

■ Nozzle Inspection

Perform the following inspection and repair or replace if necessary.

1. Injection Start Pressure Test

(1) Install the nozzle on the nozzle tester and bleed air from the nozzle by operating the handle up and down several times.

(2) Stroke the nozzle tester handle quickly (more than 60 strokes per minute) and read the pressure gauge.

Pressure should increase slowly and the indicator needle should swing during injection.

Injection start pressure is the reading at the needle just at the time of starting to swing.

(3) If injection start pressure is low, disassemble the nozzle and adjust by changing the shim thickness.

2. Chattering Test

(1) Stroke the tester handle slowly (1 stroke per minute).

- Needle valve

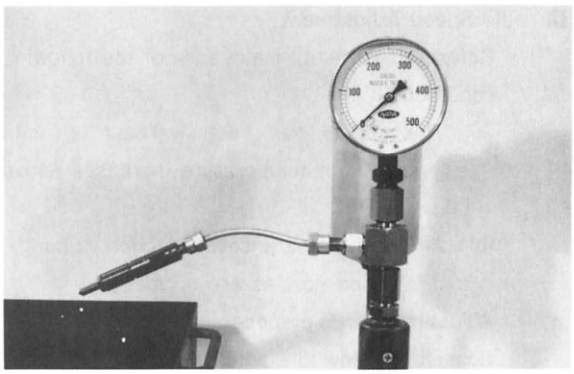
Injection should be done with peculiar snarl and vibration of the needle valve should be felt with the handle during stroking the handle.

- Spray form

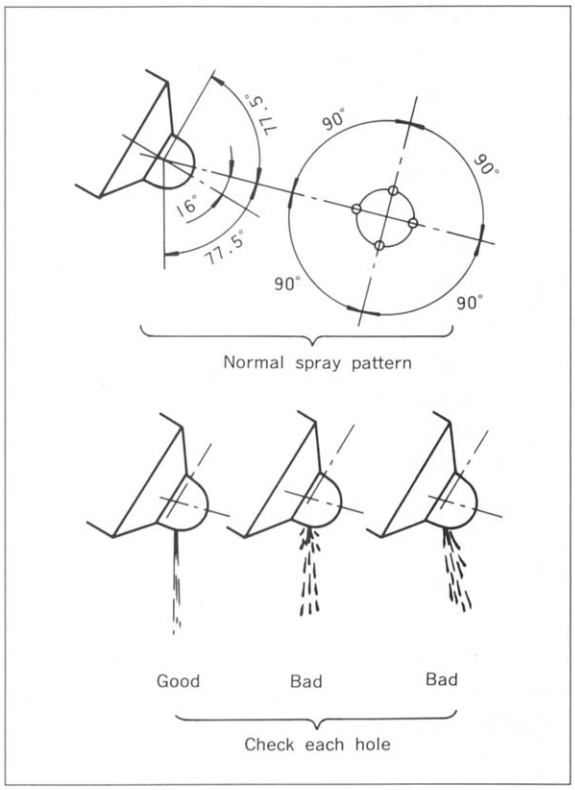
Spray form should be as shown in figure A. Other spray forms are not acceptable. In the case fuel is injected straight with coarse particles and remains at the holes after injection, this often occurs during this test and function of the nozzle will be normal.

(2) Stroke the tester handle quickly (4 to 6 strokes per second).

Fuel should be injected exactly equally from the four holes with fine spray.



Injection Start Pressure test



Chattering Test

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(3) Nozzle leak test

- Using the nozzle tester, pressurize the nozzle and maintain to 200～210 kg／cm². Check the nozzle tip for fuel leakage.
- Tightening torque of nozzle retaining nut : 3～4 kgm
- Tightening torque to the cylinder head : 2.0～2.5 kgm

■ Compression Pressure Test

1. Preparation of Test

Make sure the following condition before testing.

(1) Engine oil, air cleaner, starter and battery are in good condition.

(2) Engine should be warm (coolant temperature : above 50 ℃).

2. Test

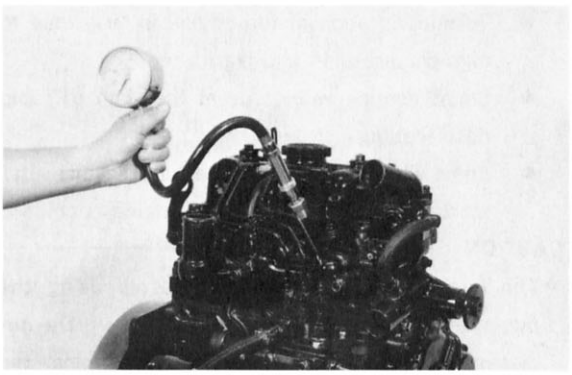
(1) Move the control lever to the stop position.

(2) Remove all glow plugs. Install the compression gauge adaptor and gauge to the cylinder.

(3) Crank the engine until the gauge reading stops rising and read the gauge.

(4) After measurement, remove the compression gauge and adaptor and install the glow plugs and glow plug wires.

- Glow plug tightening torque : 1.5～2.0 kgm



Compression Pressure Measurement

Item	Standard value
Engine speed	Exept K4M : 270 rpm K4M : 230 rpm
Compression pressure	29 kg／cm²
Difference between cylinders	3 kg／cm² max.

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■ Troubleshooting

I. Description

Troubles of the diesel engine occur usually as the result of plural causes which affect each other. Therefore, it is very difficult to diagnose the cause of the problem from the symptom. Careful consideration is necessary especially when diagnosing the problem concerned with the injection pump, nozzle and compression pressure because their faulty will fall into the same symptom.

For above reasons, the troubleshooting charts in this chapter start diagnosis from the items with high possibility or easy to check in order.

Perform the troubleshooting after fully understanding the following features of the diesel engine.

- The diesel engines produce combustion noise of their own (diesel knock) respectively under normal condition.
- Some black smoke will be exhausted under high loaded condition.
- Torque vibration of the engine is large due to high compression and high torque.
- Slight hunting will occur at the time of rapid deceleration.
- Some white smoke will be exhausted just after starting the engine when the engine is cold.

CAUTION

- **The injection pump must be adjusted using the pump tester after removing the pump. Do not disassemble or adjust when per— forming the troubleshooting.**
- **To check the combustion condition for each cylinder, loosen one of the injection pipes at a time to stop the injection for that cylinder and compare rpm drop with other cylinders.**

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2. Hard starting

(1) Check the following before diagnosing.

- Clogged air cleaner element
- Engine oil viscosity
- Improper fuel
- Low cranking speed

(2) Inspection

Is the glow system OK ? — No ⇨ Does the current flow to the glow plug operate properly just after the starter switch is turned ON ? — No ⇨ Control timer unit

⇩ Yes

Is the wiring OK ? (Does the fuel cut solenoid operate properly when the starter switch is turned ON ?) — No ⇨ Wiring or solenoid

⇩ Yes

Does fuel flow through the fuel line ? (Does the fuel pump operate while the starter switch is ON ?) — No ⇨ Fuel filter, fuel pipe or fuel tank.

⇩ Yes

Is the engine adjusted properly ? {Injection timing and valve clearance} — No ⇨ Engine adjustment

⇩ Yes

Is the injection nozzle OK ? (Spray form and injection start pressure) — No ⇨ Injection nozzle

⇩ Yes

Is compression pressure OK — No ⇨ Valve, piston ring or head gasket

⇩ Yes

Injection pump

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3. Knocking

The diesel engines produce combustion noise of their own respectively due to their combustion method. This knocking noise is normal unless it is excessive.

(1) Check the following before diagnosing.

- Clogged air cleaner
- Improper fuel

(2) Inspection

Is injection timing correct ? (Too advanced injection timing) → No ⇨ Injection timing adjustment

⇩ Yes

Is control lever normal ? (Solenoid switch) → No ⇨ Solenoid switch

⇩ Yes

Is injection nozzle OK ? (Low injection start pressure) → No ⇨ Injection nozzle adjustment

⇩ Yes

Is compression pressure OK ? → No ⇨ Valve, piston ring or head gasket

⇩ Yes

Injection pump

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4. Overheat

(1) Check the following before diagnosing.

- Coolant level and leakage
- Loosen fan belt
- Clogged radiator fins

(2) Inspection

Is the cooling system normal ? (Leaking head gasket, clogged water pump, water hoses or radiator, or faulty thermostat) → No ⇨ Cooling system

⇩ Yes

Is injection timing correct ? → No ⇨ Injection timing adjustment

⇩ Yes

Is the lubrication system normal ? (Oil level, oil filter, oil pump or oil screen) → No ⇨ Lubrication system

⇩ Yes

Is the control lever normal ? → No ⇨ Governor system or injection pump

⇩ Yes

Continuous high load operation

In many cases, overheat problems are caused by improper matching of the engine and the machine. Therefore, if the system overheats, measure coolant temperature and compare it with ambient temperature. If the temperature difference is more than 60°C, the cause should be investigated beside the engine.

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5. Excessive black smoke

(1) Check the following before diagnosing.

- Clogged air cleaner element
- Improper fuel

(2) Inspection

Is the engine adjusted correctly ? (Excessive valve clearance or advanced injection timing) → No ⇨ Engine adjustment

⇩ Yes

Is the injection nozzle normal ? (Spray form or high injection start pressure) → No ⇨ Injection nozzle

⇩ Yes

Is compression pressure normal ? → No ⇨ Valve, piston ring or head gasket

⇩ Yes

Injection pump

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6. Irregular idling

(1) Check the following before diagnosing.

- Engine control system
- Engine oil viscosity
- Improper fuel

(2) Inspection

Is the engine adjusted correctly ? (Valve clearance or injection timing) → No ⇨ Engine adjustment

⇩ Yes

Is injection nozzle normal ? (Spray form or uneven injection start pressure) → No ⇨ Injection nozzle

⇩ Yes

Is compression pressure OK ? (Difference between the cylinders) → No ⇨ Valve, piston ring or head gasket

⇩ Yes

Injection pump

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7. Poor performance

(1) Check the following before diagnosing.

- Seized engine
- Too high engine oil viscosity
- Improper fuel
- Clogged air cleaner element
- Clogged exhaust muffler
- Faulty power take off

(2) Inspection

Is the engine adjusted correctly? (Valve clearance or fuel injection timing) → No ⇨ Engine adjustment

⇩ Yes

Does fuel flow through the fuel line? (Does fuel pump operate when the key switch is turned ON?) → No ⇨ Fuel tank, fuel filter or fuel pipe

⇩ Yes

Is the control lever normal? → No ⇨ Governor system

⇩ Yes

Is injection nozzle normal? (Spray form or injection start spressure) → No ⇨ Injection nozzle

⇩ Yes

Is compression pressure OK? → No ⇨ Valve, piston ring or cylinder head gasket

⇩ Yes

Injection pump

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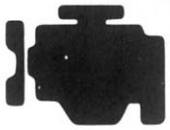
Group 1 ENGINE PROPER



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■ Specifications (K3)

Item \ Model		K3C	K3D	K3E	K3F
Cylinder head	Material Combustion chamber Intake and exhaust ports	Special cast iron Direct injection chamber type Cross flow type			
Rocker arm	Material Intake and exhaust	Special malleable cast iron Common to intake and exhaust (No mark)			
Valve	Face angle Identification mark : Intake : Exhaust	45° I E			
Valve spring	Type Identification color	Variable pitch Red (Upper side)			
Cylinder head gasket	Material	Grafoil			
Cylinder head bolt	Material	Special steel			
Cylinder block	Cylinder bore Cylinder liner Water jacket	70	73	76	78
		Monobloc casting Full jacket			
Crankshaft	Matelial Surface treatment Identification Journal dia. × pin dia.	Special steel Hardening Normal machined metal surface (glaze) 52 × 42			
Piston	Connection to connecting rod Piston — head shape	Semi — floating	Full floating		
		With cavity			
Piston ring	No. 1 No. 2 Oil	Semi — keystone Taper face | Taper face Under cut With coil expander			
Camshaft	Material Drive	Special steel Gear			
Oil pump	Type Drive	Trochoid type Directly connected to injection pump camshaft			

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■ Specifications (K4)

Item \ Model		K4E	K4F	K4M
Cylinder head	Material Combustion chamber Intake and exhaust ports	Special cast iron Direct injection chamber type Cross flow type		
Rocker arm	Material Intake and exhaust	Special malleable cast iron Common to intake and exhaust (No mark)		
Valve	Face angle Identification mark : Intake : Exhaust	45° I E		
Valve spring	Type Identification color	Variable pitch Red (Upper side)		
Cylinder head gasket	Material	Grafoil		
Cylinder head bolt	Material	Special steel		
Cylinder block	Cylinder bore Cylinder liner Water jacket	76 Monobloc casting (incl. dry liner—special type) Full jacket	78	80
Crankshaft	Material Surface treatment Identification Journal dia×pin dia.	Special steel Hardening (Induction hardening) Normal machined metal surface (glaze) K4E, F : 52×42, K4M : 57×48		
Piston	Connection to connecting rod Piston—head shape	Full floating With cavity		
Piston ring	No. 1 No. 2 Oil	Semi—keystone Taper face, Under cut With coil expander		
Camshaft	Material Drive	Special steel Gear		
Oil pump	Type Drive	Trochoid type Directly connected to injection pump camshaft		

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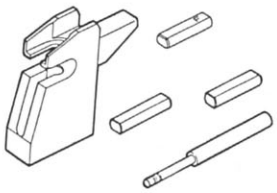
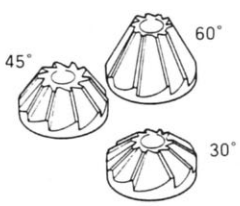
■ **Special Tools**

Use	Tool name	Sketch	Ref. page
Removing/pressing piston pin (For K3C and D)	Piston pin setting tool ST332301		Pages 58
Removing/pressing camshaft bushing	Camshaft bush installer ST332340		Page 70
Measuring cylinder compression	Compression gauge adaptor ST333060		Page 19
Removing/installing oil pressure switch	Oil pressure switch socket wrench MD998054		Page 72
Refacing valve seat	Valve seat cutter 45° (Seat cutting) 60° (interior cutting) 30° (Flat cutting) Valve seat cutter pilot ϕ6.6 (Except K4M) ϕ8.0 (For K4M)		Page 42

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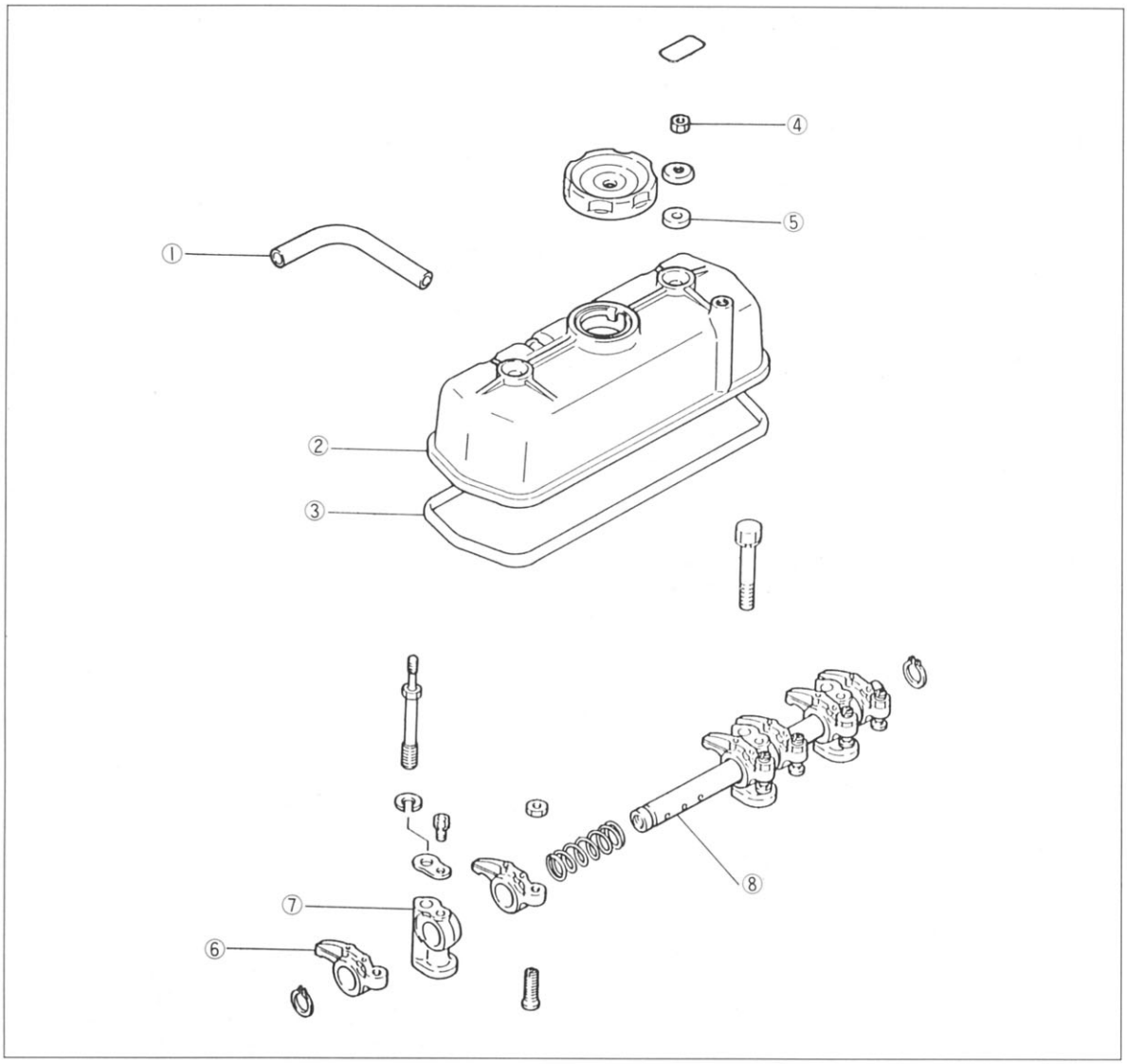
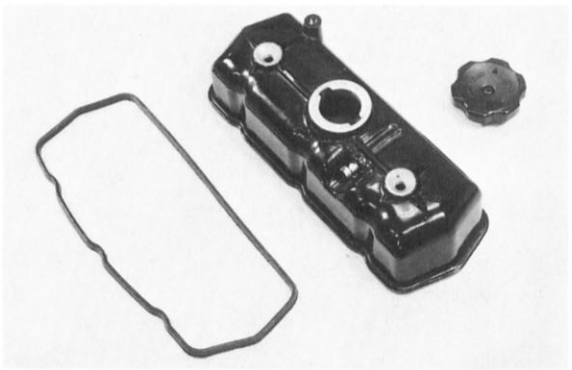
■ Components



① Breather hose
② Rocker cover
③ Rocker cover gasket
④ Nut
⑤ Seal
⑥ Rocker arm
⑦ Rocker stay
⑧ Rocker shaft



Rocker Cover

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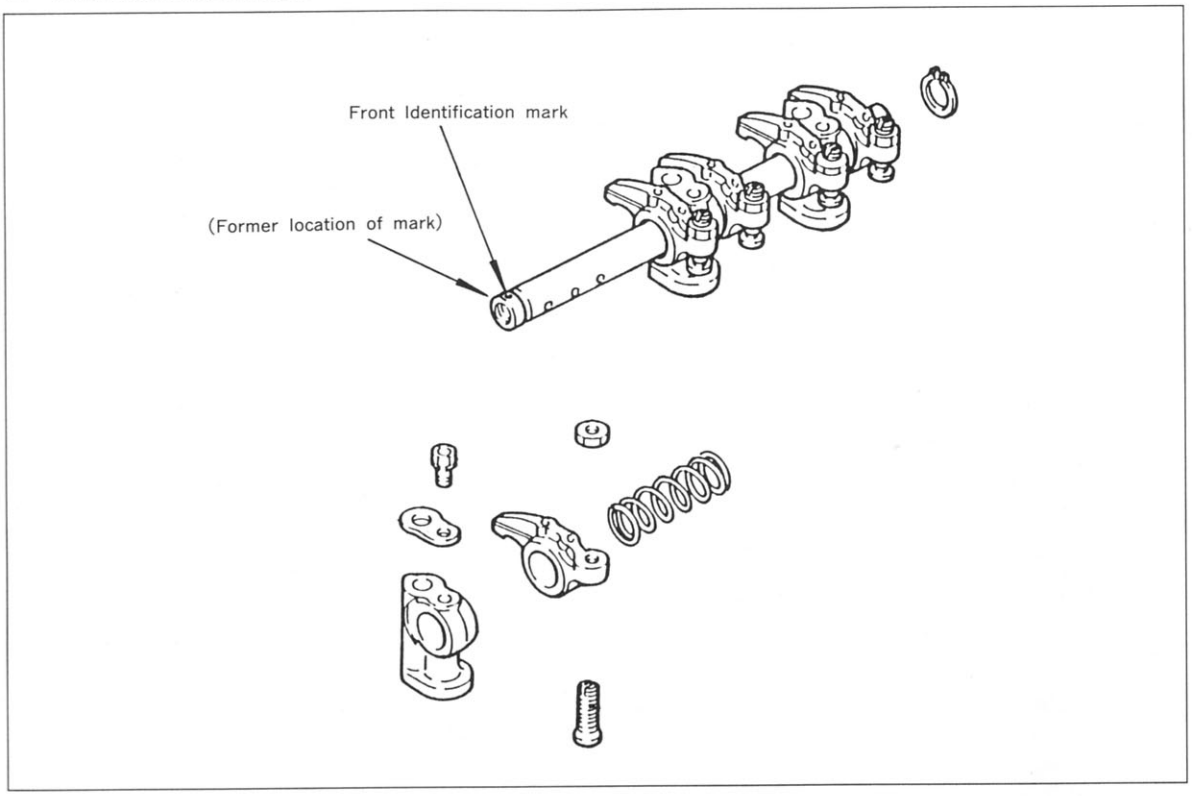
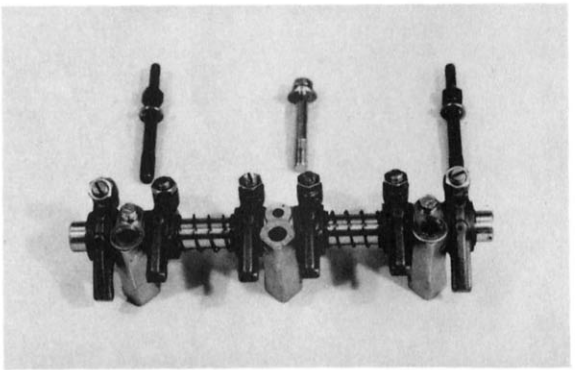
■ Removal and Installation



Rocker Arm Installation Direction

CAUTION

- **Before removing the rocker shaft assembly, turn the crankshaft to bring each cylinder to compression stroke as much as possible.**
- **After installation, always adjust valve clearance.**



Removing Rocker Shaft Assembly

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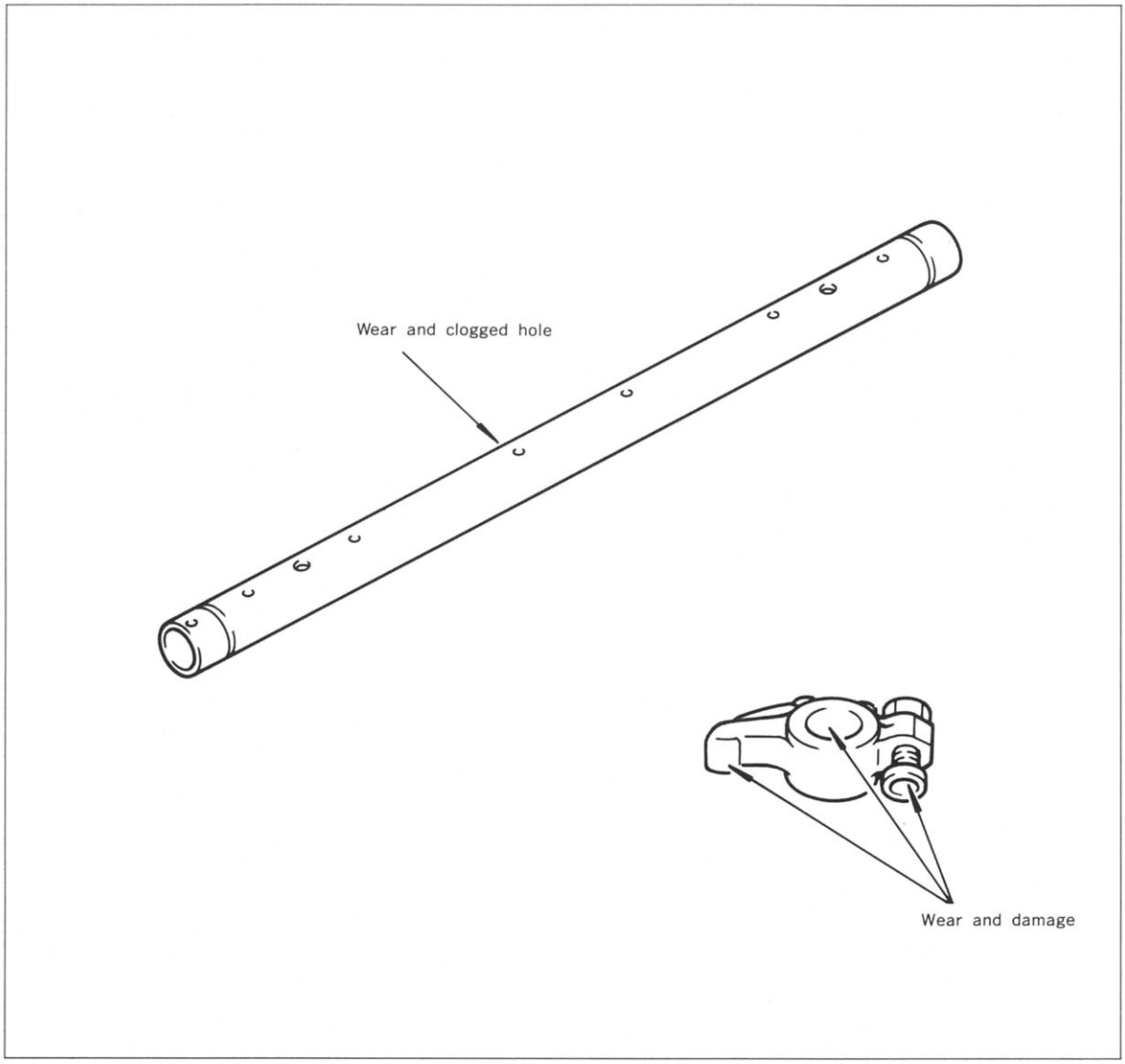
■ Inspection

Replace the parts if necessary.



Rocker Arm and Rocker Shaft Inspection

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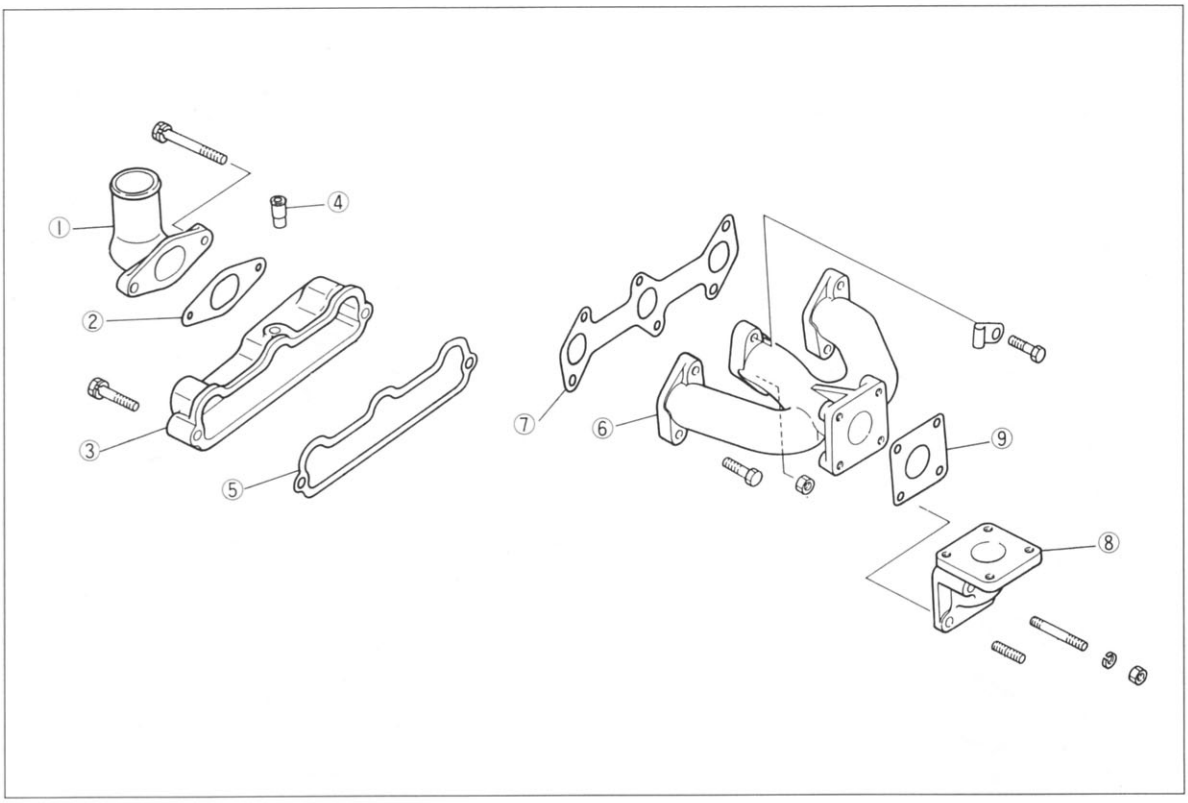
■ Components



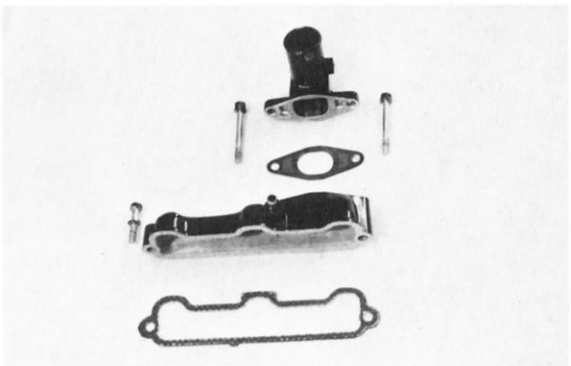
① Inlet pipe
② Inlet pipe gasket
③ Inlet manifold
④ Air breather nipple
⑤ Manifold gasket (IN)
⑥ Exhaust manifold
⑦ Manifold gasket (EX)
⑧ Exhaust elbow
⑨ Gasket

■ Inspection

Perform the following inspection and replace the parts if necessary.

(1) Check if warp of the mating surface to the cylinder head is less than 0.15mm.

(2) Check the manifolds for corrosion, cracks or damage.



Manifold Inspection

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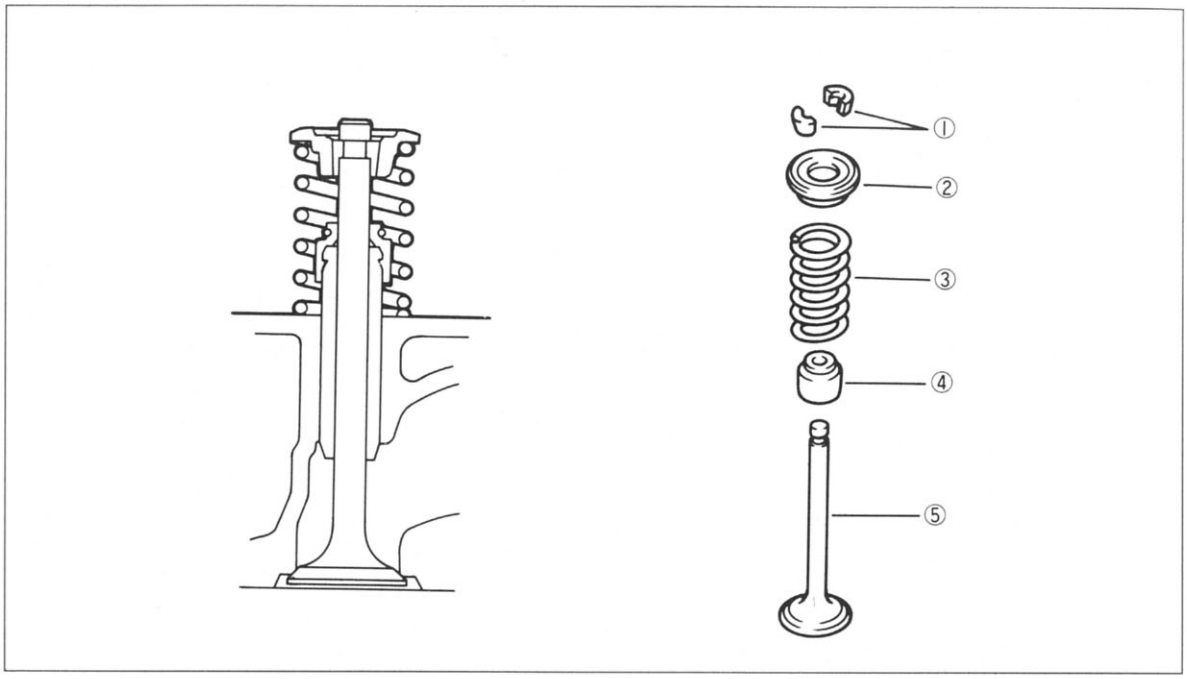
■ Components



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

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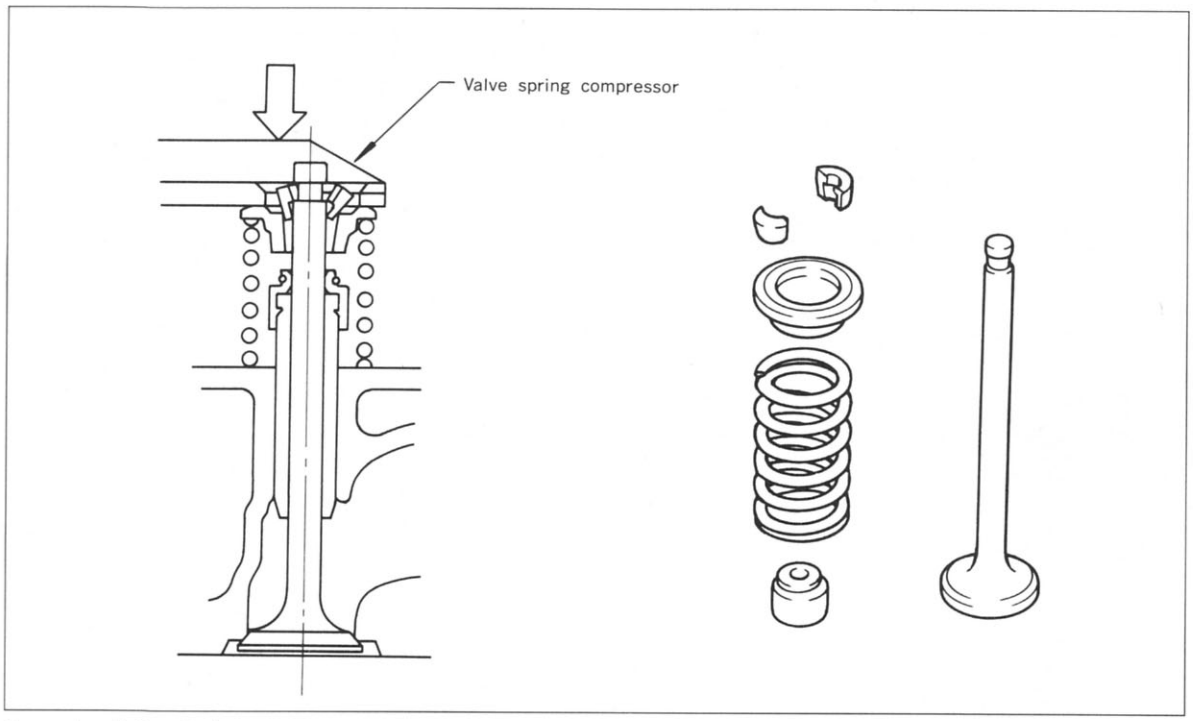
■ Removal

(1) Remove the cylinder head assembly.

(2) Remove each part as follows and put in order for each cylinder.



Removing Valve Spring

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■ Inspection and Repair

Repair or replace the parts if necessary.

(1) Valve refacing

If the valve face is worn, reface the face with a valve refacer. However, if the margin of the valve face exceeds the service limit after refacing, replace the valve.

Description	Standard value	Service limit
Margine	1.0	0.5

(2) Valve stem end refacing

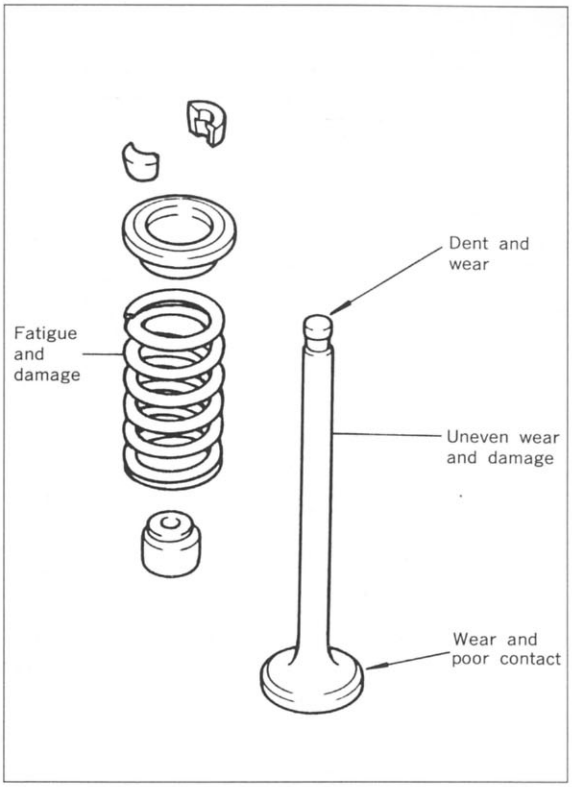
If the valve stem end is worn or pitting, the end should be ground with the valve refacer or an oil−stone. However, if the margin after such refacing exceeds the limitation, the valve should be replaced.

(3) Valve spring inspection

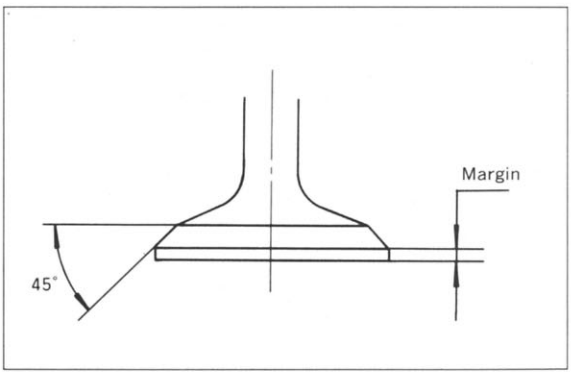
Check the valve spring for cracks or damage.

Measure the free length, tension and squareness of the valve spring.

Description		Standard value	Service limit
Free length (mm)	Except K4M	43	−1.0
	K4M	45.5	
Load (kg)	Except K4M	14±0.7 (at 36mm)	−15%
		29.8±2 (at 28mm)	
	K4M	15±0.8 (at 38mm)	
		30±2 (at 30.5mm)	
Squareness		2° or less	3°



Valve and Valve Spring Inspection



Valve Refacing

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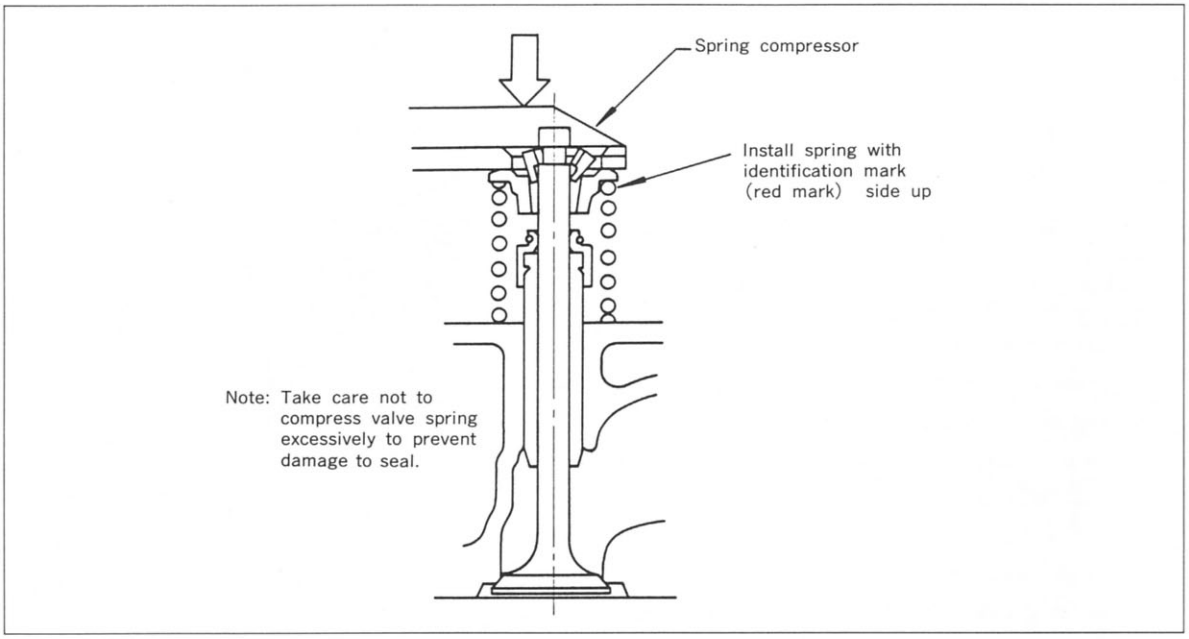
■ Installation

(1) Note the following items when installing the valves and valve springs.



(2) Install the cylinder head assembly.

(3) Install the rocker shaft assembly.

(4) Adjust the valve clearance.

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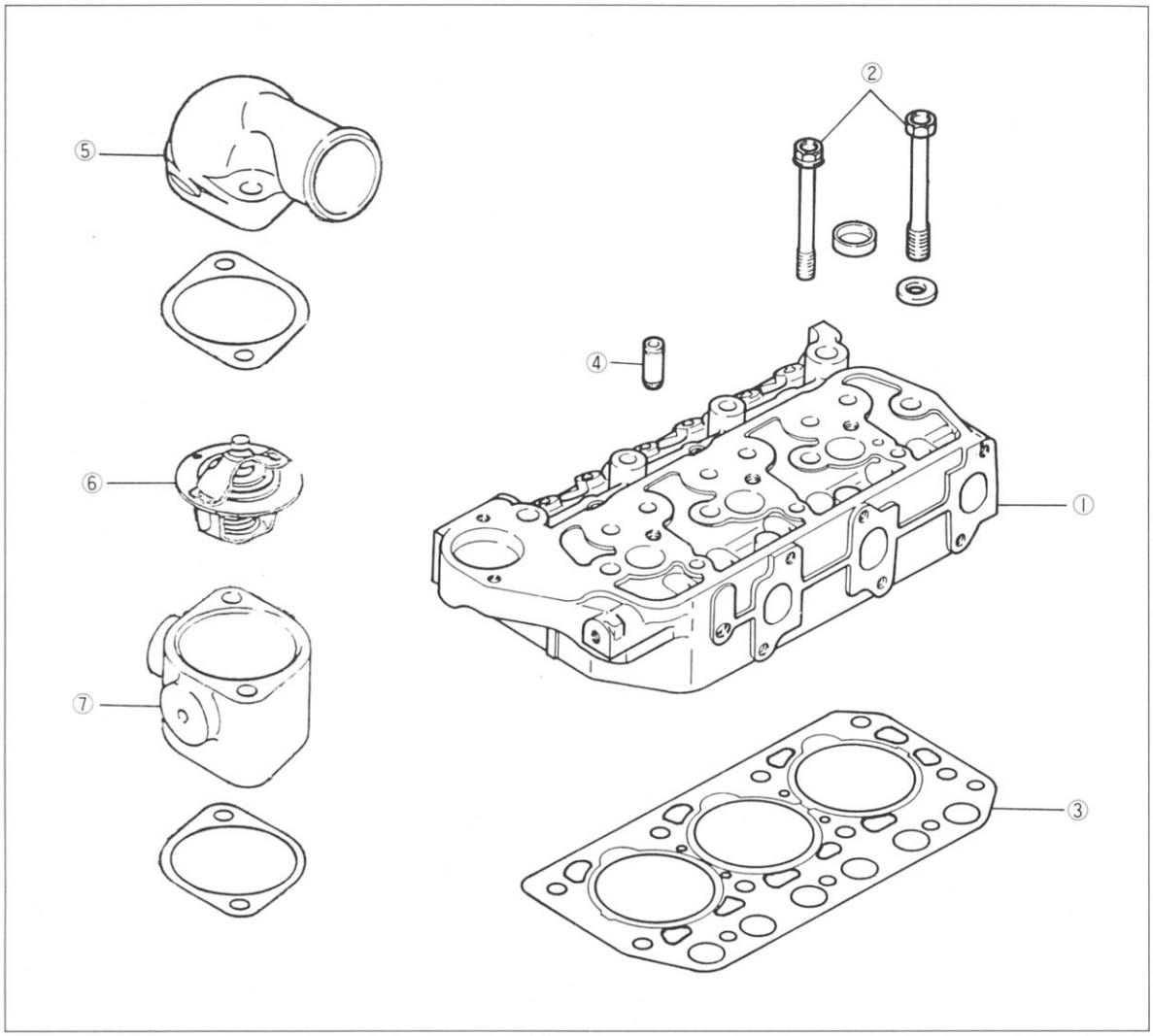
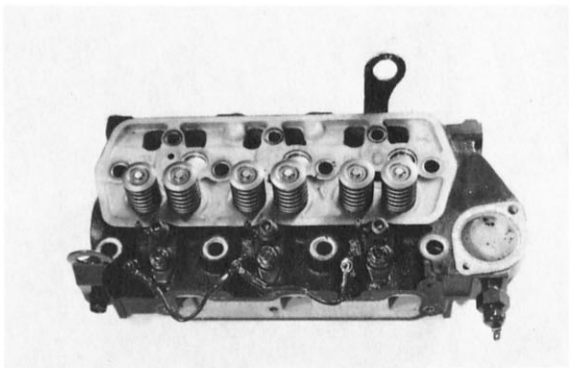
■ Components



① Cylinder head
② Cylinder head bolt
③ Cylinder head gasket
④ Valve guide
⑤ Water outlet fitting
⑥ Thermostat
⑦ Thermostat case



Cylinder Head Assembly (K3)

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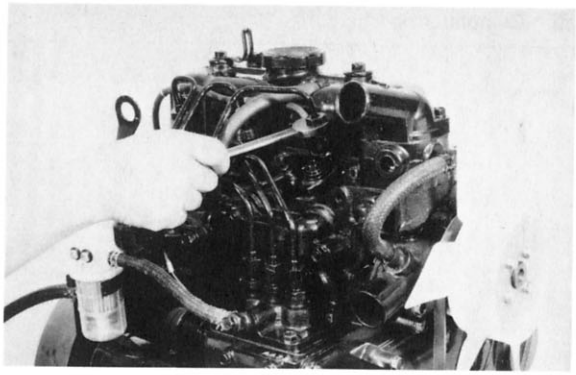
■ Removal

(1) Remove the injection pipe assembly.
When loosening the injection pipe nuts, counterhold the nozzle or delivery valve holder with a spanner.

Caution

- **After removing the injection pipes, plug the openings of the nozzle holders and delivery valve holders to prevent them from entering dust.**



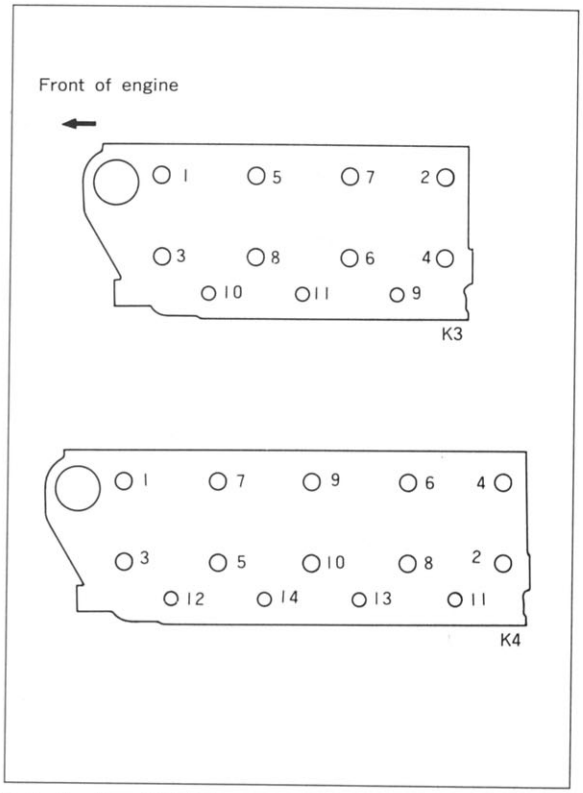
Removing Injection Pipe

(2) Remove the rocker cover, rocker shaft and push rods.
(3) Remove the alternator brace.
(4) Remove the water hose (outlet side).
(5) Remove the connectors on the intake and exhaust manifolds.
(6) Disconnect the wires from the glow plugs.
(7) Loosen and remove the cylinder head bolts.

Caution

- **Loosen the cylinder head bolts in the sequence shown in the figure in 2 to 3 steps.**

(8) Remove the cylinder head.
(9) Remove the cylinder head gasket.



Cylinder Head Bolt Loosening Sequence

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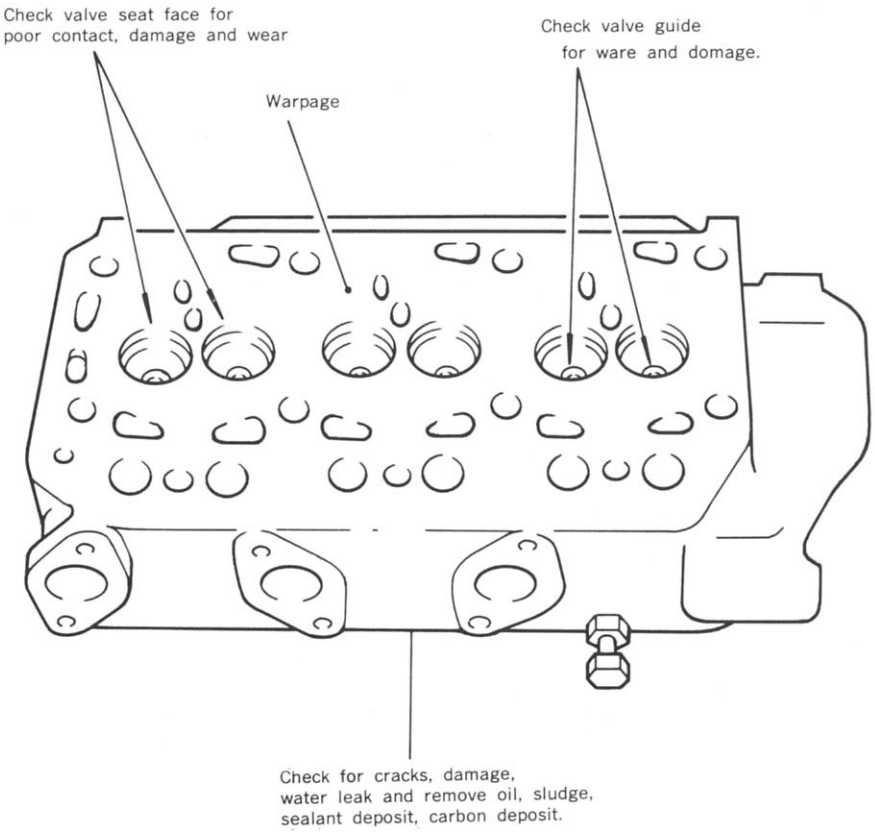
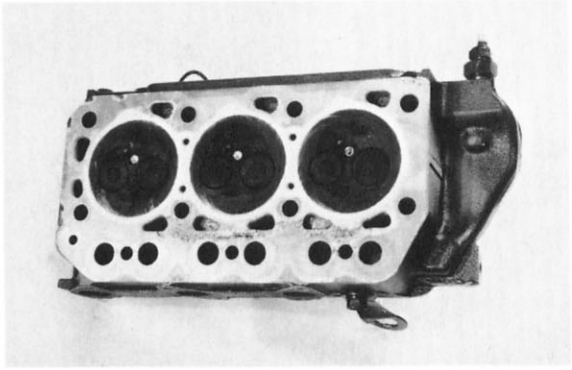
■ Inspection and Repair

Repair or replace the parts if necessary.





Cylinder Head Inspection (K3)

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■ Valve Guide Replacement

Replace the valve guide if it is worn or damaged.

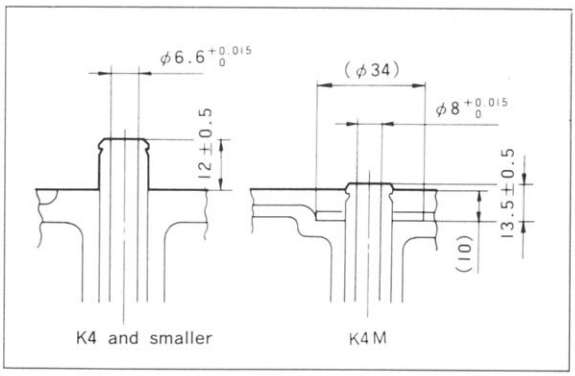
Remove the valve guide by pressing it from the upper side to the lower (seat) side with a press.

Description		Standard value
Valve guide pressing height (A)	Except K4M	12±0.5
	K4M	13.5±0.5

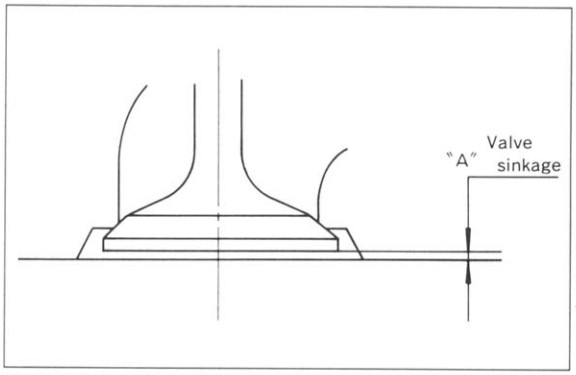
■ Valve Seat Refacing

Refer or replace the valve seat if necessary.

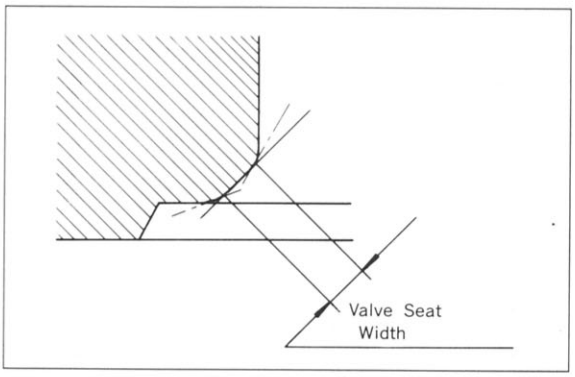
Description		Standard value	Service limit
Sinkage of valve (A)	Except K4M	0.5±0.35	1.5
	K4M	0.5±0.30	1.5



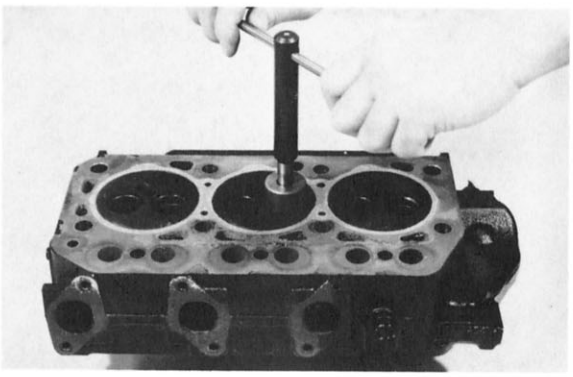
Valve Guide Pressing Height



Valve Head Depth



Valve Seat Width



Valve Seat Refacing

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Installation

Install the cylinder head in the reverse order of removal while following the items below.

(1) Use a new cylinder head gasket which is selected as described on the next page. Do not use a liquid sealant.

(2) Tighten the cylinder head bolts to the specified torque values in the sequence shown in 2 to 3 steps.

Tightening torque

Except K4M : (M10) 6.5 ~8.0 (Wet)

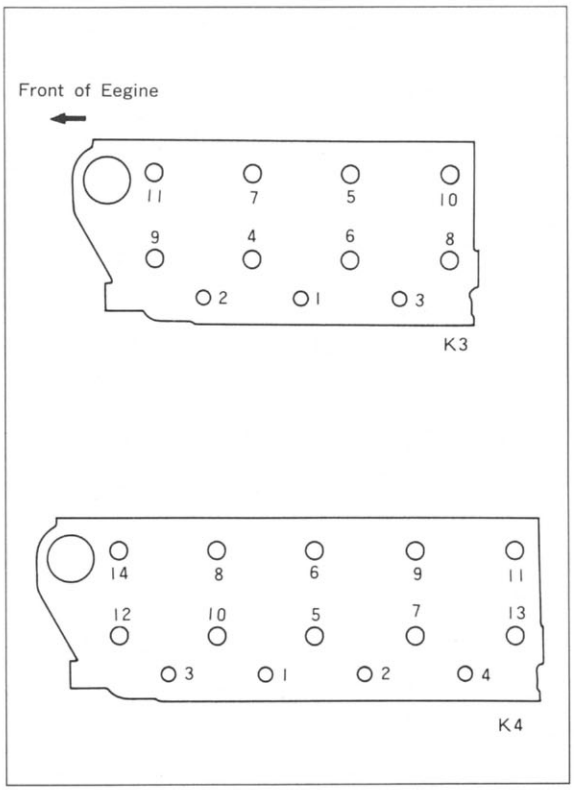
Except K4M : (M12) 11.5 ~12.5 (Wet)

K4M : (M10) 10 ~11

K4M : (M14) 15 ~16

(3) Loosen the injection pipe clamp and install the pipes. Take care not to allow dust to enter the fuel lines and passages.

(4) Install the push rods and rocker arm assembly and adjust the valve clearance.



Cylinder Head Bolt Tightening Sequence

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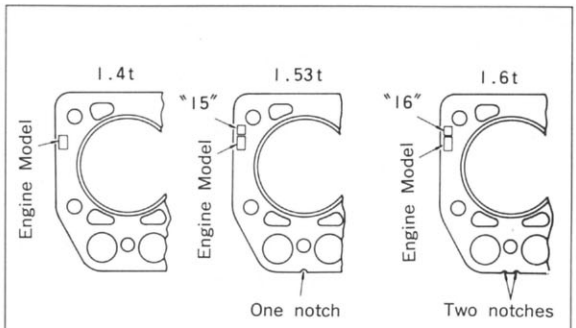
■ Cylinder Head Gasket Selection

Measure piston protruding (δ) from the cylinder block upper surface for all cylinders when the piston is at T. D. C. (Top Dead Center). Refer to the largest value (δ) and select the cylinder head gasket according to the table below.

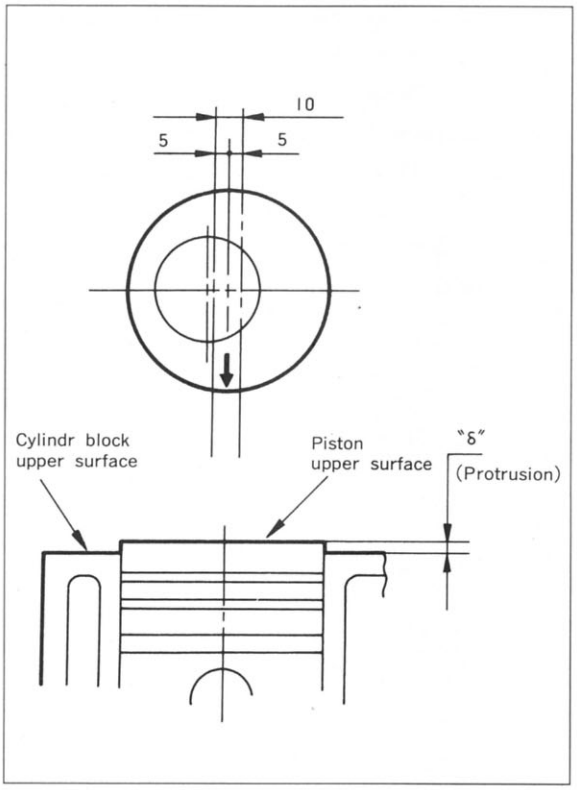
Gasket selection (δ = Piston protruding)		
Gasket thickness	t = 1.4	t = 1.6
δ / Model	(0.8 <) δ < 0.95	0.95 ≦ δ (< 1.15)
K3C − DI	MM408447	MM431966
K3D − DI	MM408453	MM431967
δ / Model	(0.77) < δ < 1.0	1.0 ≦ δ < 1.18
K4M-DI	MM432926	MM435312

Gasket	t = 1.4	t = 1.53	t = 1.6
δ / Model	(0.8 <) δ < 0.88	0.88 ≦ δ < 1.05	1.05 ≦ δ (< 1.15)
K3E-DI	MM409815	MM436598	MM435308
K3F-DI	MM430115	MM436599	MM435309
K4E-DI	MM408457	MM436600	MM435310
K4G-DI	MM436941	MM437314	MM436942

Note : The gasket number will be changed when it is modified.



Identification Number of Head Gasket



Measuring Postion of Piston Protruding (δ)

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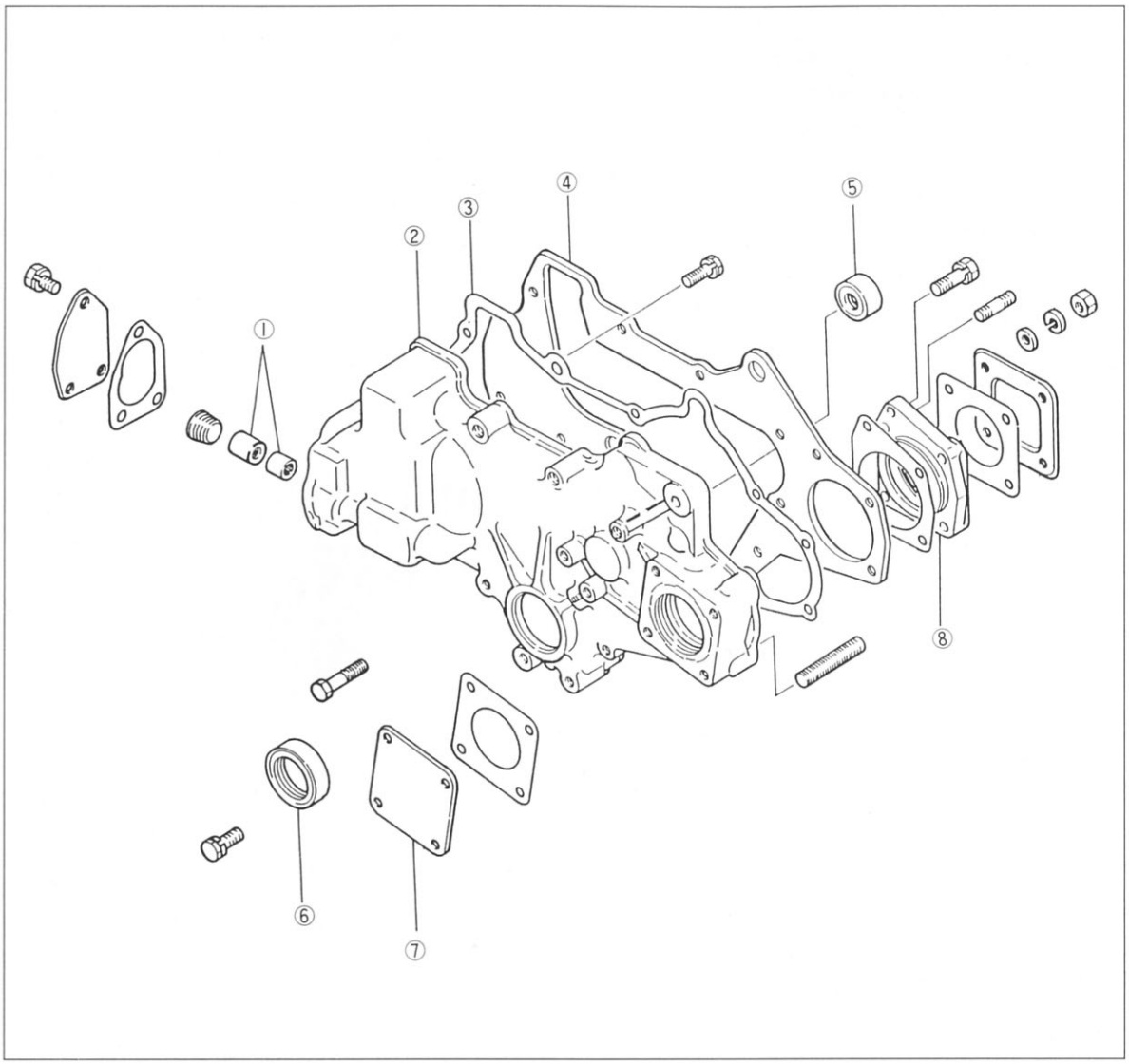
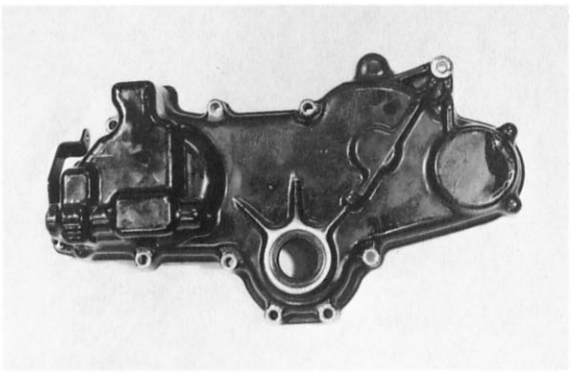
Components



① Needle bearing
② Gear case
③ Gear case gasket
④ Front plate
⑤ Thrust plug
⑥ Oil seal
⑦ Oil pump cover
⑧ Pump gear housing



Gear Case Assembly

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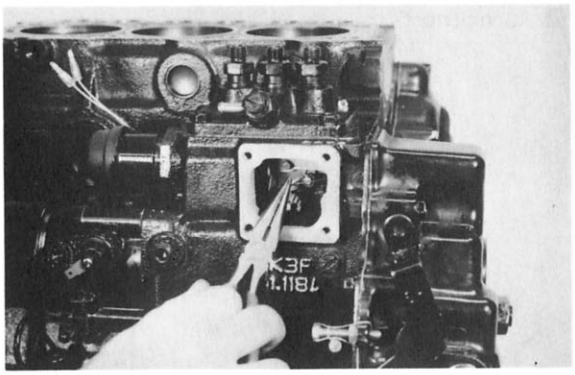
■ **Removal**

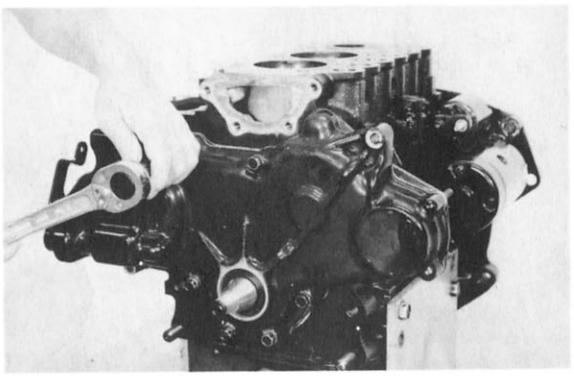
(1) Remove the fan belt.
(2) Remove the crankshaft pulley.
(3) Disconnect the adjusting rod if the engine is equipped with the speed control solenoid for the cooler unit system, etc.
(4) Remove the tie rod cover and disconnect the tie rod and tie rod spring which are connected to the injection pump control rack.
(4) Remove the high pressure pump of the machine side.
(6) Remove the alternator.
(7) Remove the gear case.

Caution

- **When removing the gear case, do not tap out the front plate together. The front plate is also bolted inside of the gear case.**



Tie Rod Removing


Gear Case Assembly Removing

K&T Saw Shop 606-678-9623 or 606-561-4983

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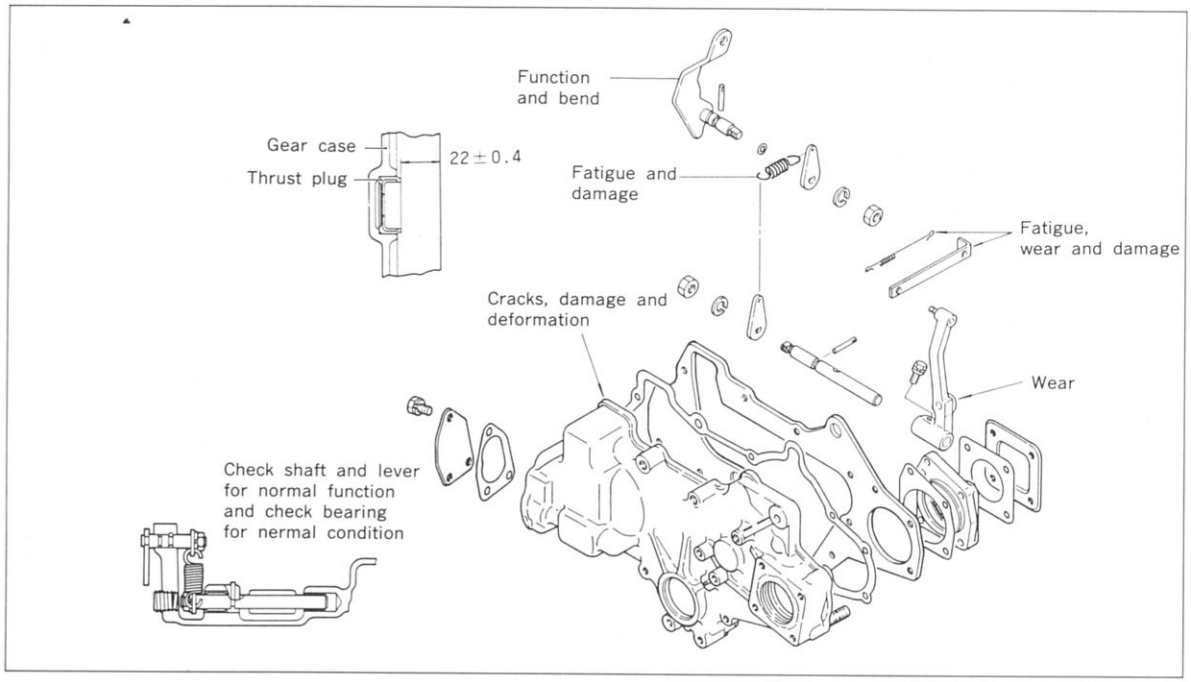
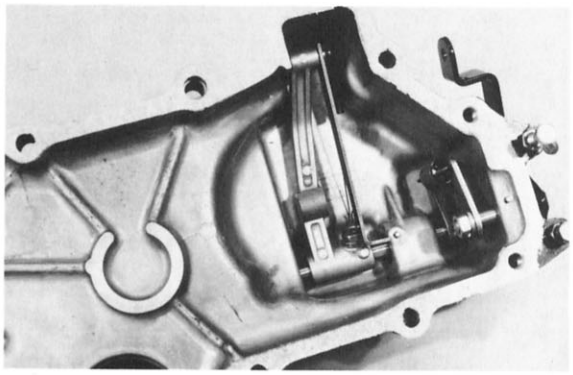
■ Inspection





Gear Case Inspection

■ Installation

Install the gear case in the reverse order of removal.

Caution

(1) Attach the gear case gasket with adhesive or sealant to prevent it from slipping off.

(2) Install the tie rod and tie rod spring by inserting them into the hole in the block.

(3) Apply engine oil or grease to the lip of the oil seal and install the seal taking care of not giving damage to the seal lip.

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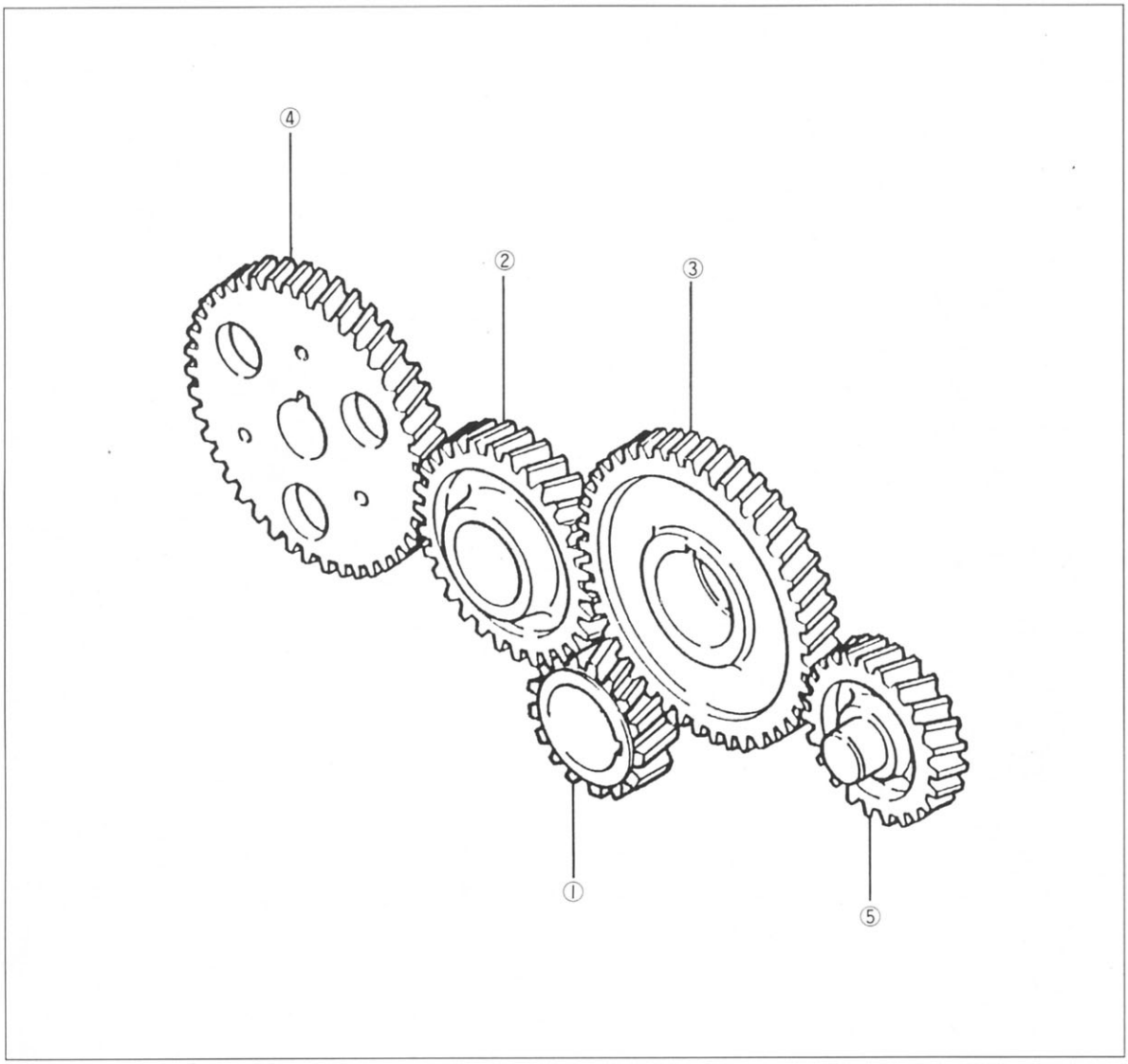
Components



① Crankshaft gear
② Idle gear
③ Camshaft gear
④ Injection pump gear
⑤ High pressure pump

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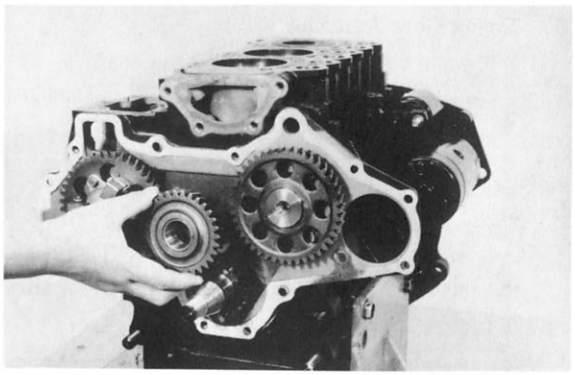
■ Removal

Remove the timing gears after removing the gear case, cylinder head, tappet, injection pump, etc.

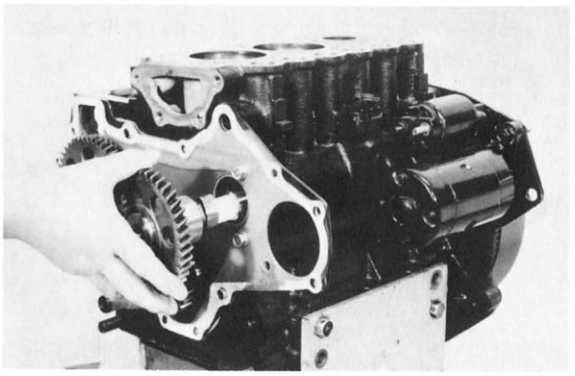
(1) Remove the snap ring and idle gear.

(2) Remove the camshaft gears (for valve and pump cams) after removing the camshaft assembly because the gears are press fitted.

(3) Remove the crankshaft gear after removing the crankshaft because it is also press fitted.



Idle Gear Removing



Camshaft Removing

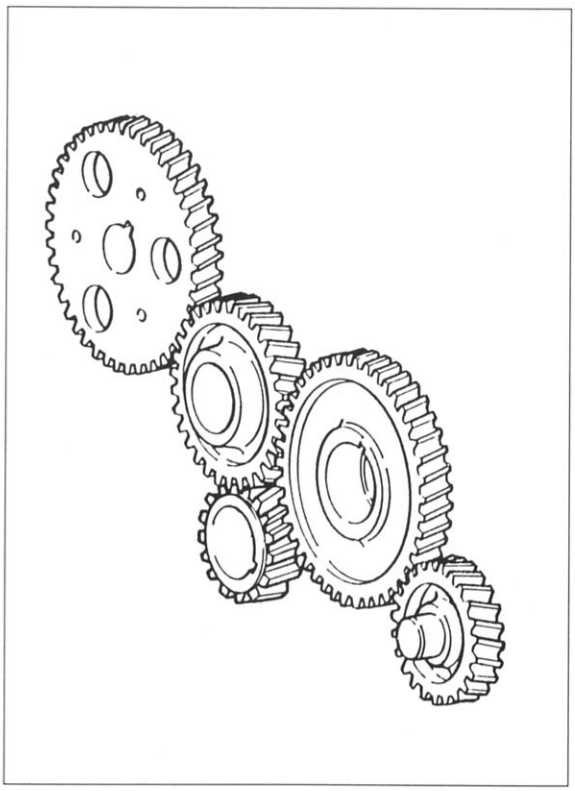
■ Inspection

Replace the gear if necessary.

Descrition	Standard value	Service limit
Idle gear bush—to—shaft clearance	0.03～0.07	0.2

Gear backlash after assembly

Description	Standard value	Service limit
Crankshaft—to—idle	0.01～0.14	0.3
Idle—to—valve cam		
Idle—to—injection pump cam		



Timing Gear Inspection

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■ Timing Gear Assembly

(1) Press the crankshaft gear on the shaft.

(2) Press the gears on the pump and valve camshafts.

(3) Install the gears in the following procedure.

(a) Turn the crankshaft until the No. I cylinder is T. D. C. of the compression stroke.

(b) Install the pump and valve camshaft assemblies.

(c) Install the idle gear while aligning the timing marks.

(d) Re—check the timing gear mark alignment.

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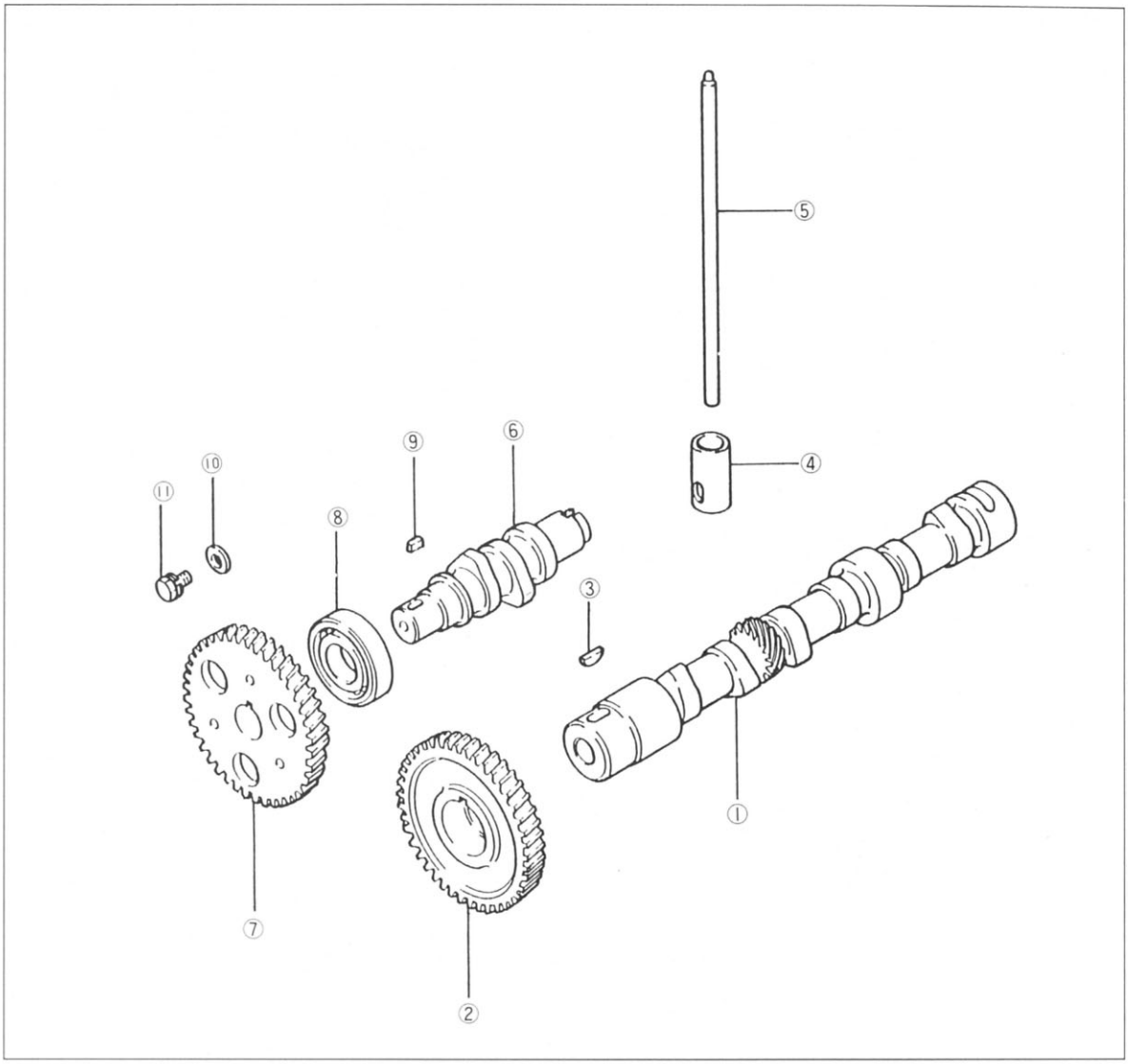
■ Components



① Camshaft (valve)
② Cam gear
③ Woodruff key
④ Tappet
⑤ Push rod
⑥ Camshaft (injection pump)
⑦ Pump cam gear
⑧ Ball bearing
⑨ Sunk key
⑩ Thrust stopper washer
⑪ Bolt

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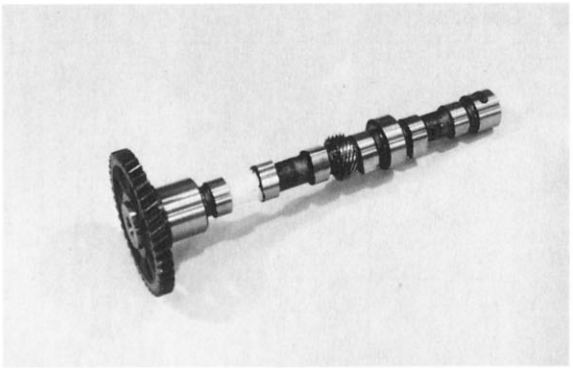
■ Valve Camshaft Removal

1. Valve Camshaft Removal
   (1) Remove the cylinder head assembly.
   (2) Remove the push rods.
   (3) Remove the tappets.
   (4) Remove the gear case assembly.
   (5) Remove the camshaft stopper bolt.
   (6) Remove the camshaft assembly.



Valve Camshaft Removal

2. Pump Camshaft Removal
   (1) Remove the injection pipes.
   (2) Remove the injection pump assembly.
   (3) Remove the gear case assembly.
   (4) Loosen and remove the stopper bolt.
   (5) Remove the camshaft from the front side.

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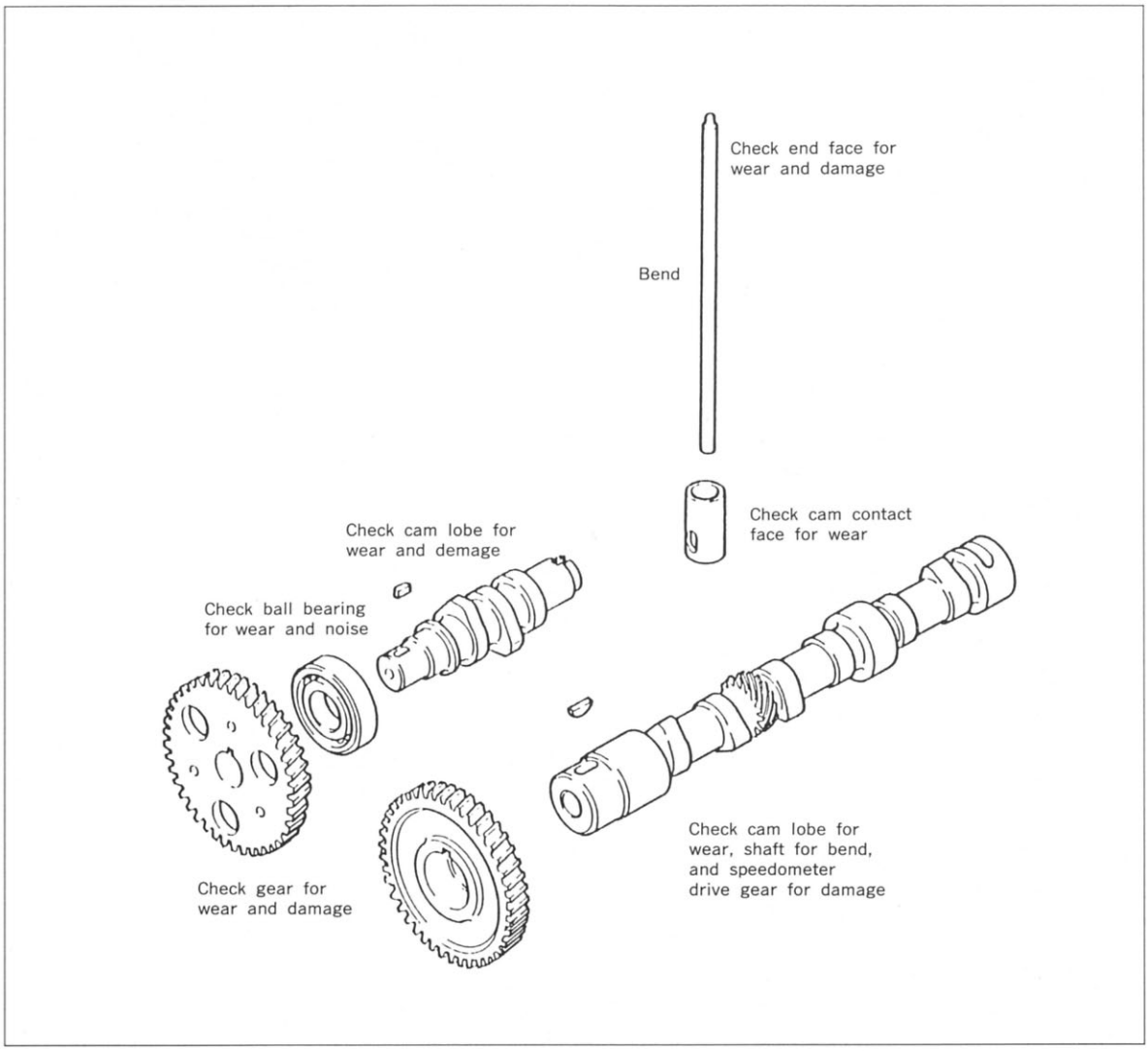
■ Inspection

Repair or replace the parts if necessary.



Valve camshaft			
Description		Standard value	Service limit
Front journal O. D.		45	
Center journal O. D.		44	
Rear journal O. D.	Except K4M	34	
	K4M	39	
Cam height (base O. D. + lift)		35.72	−1.0
	Former*	34.69	−1.0

Pump camshaft		
Description	Standard value	Service limit
Rear journal O. D.	25	
Coupling groove width	5	−0.5
Cam height (base O. D. + lift)	44	−1.0

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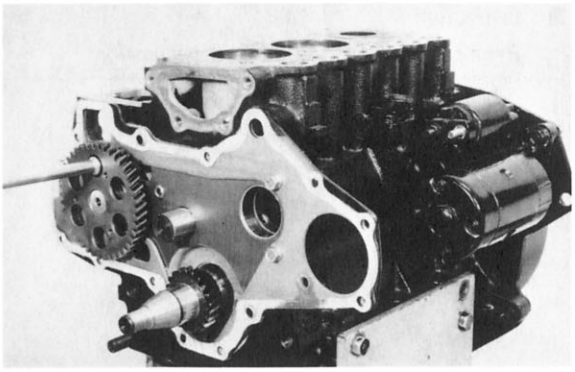
■ **Installation**

Install the camshaft while noting the following items.

(1) Apply engine oil to the all bearings and cams.
(2) Install the camshaft in the reverse order of removal.
(3) Re—check the timing marks.
(4) After installation, check and adjust the injection timing and valve clearance.



Installing Pump Camshaft

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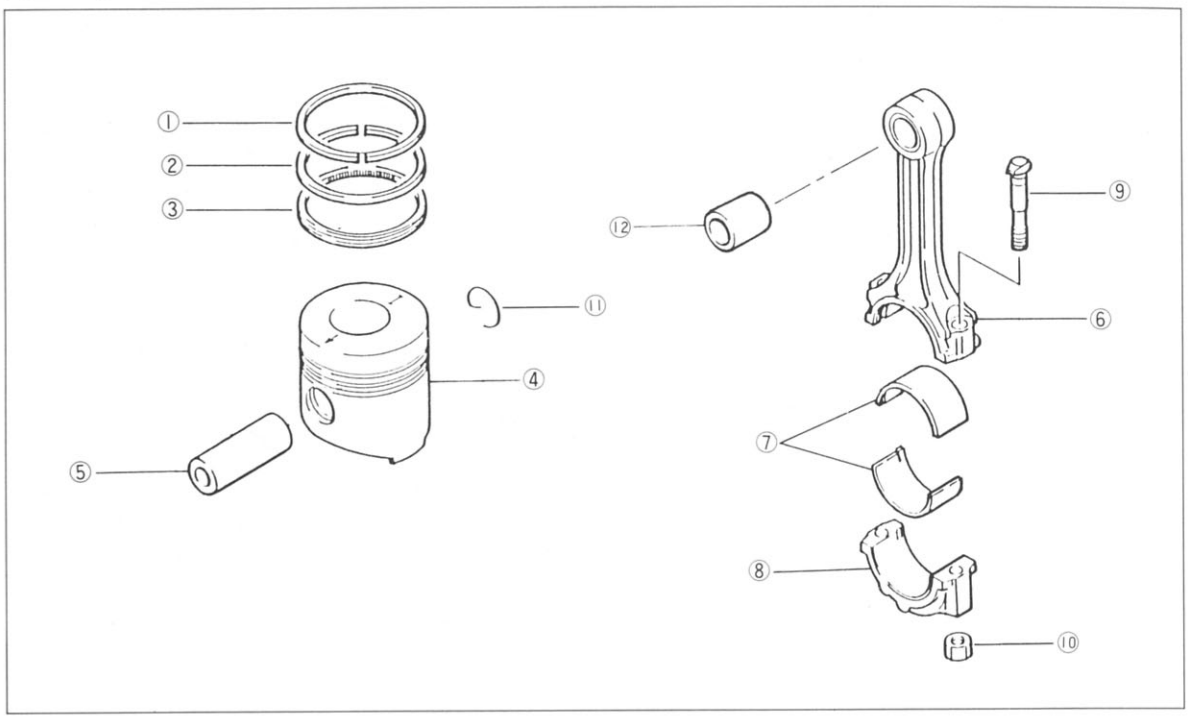
■ Components

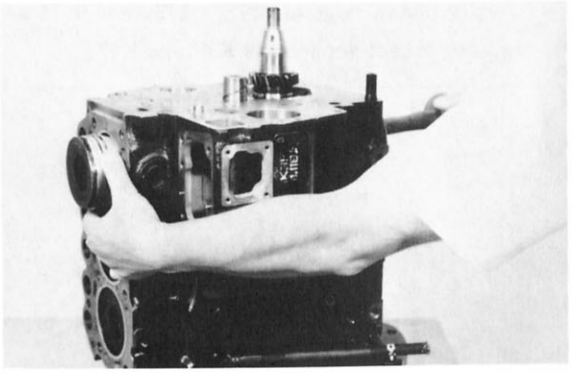


Piston and connecting rod components

① No. 1 piston ring	⑤ Piston pin	⑨ Connecting rod bolt
② No. 2 piston ring	⑥ Connecting rod	⑩ Connecting rod nut
③ Oil ring	⑦ Connecting rod bearing	⑪ Snap ring (Not used for K3C and D)
④ Piston	⑧ Connecting rod cap	⑫ Small end bush

■ Removal

(1) Remove the cylinder head assembly.
(2) Remove the oil pan and oil screen.
(3) Mark the cylinder number on the big end of the connecting rod.
(4) Remove the connecting rod cap and remove the piston and connecting rod assembly from the top of the cylinder block taking care of not giving damage to the cylinder and crankpin with the connecting rod.



Removing Piston and Connecting Rod Assembly

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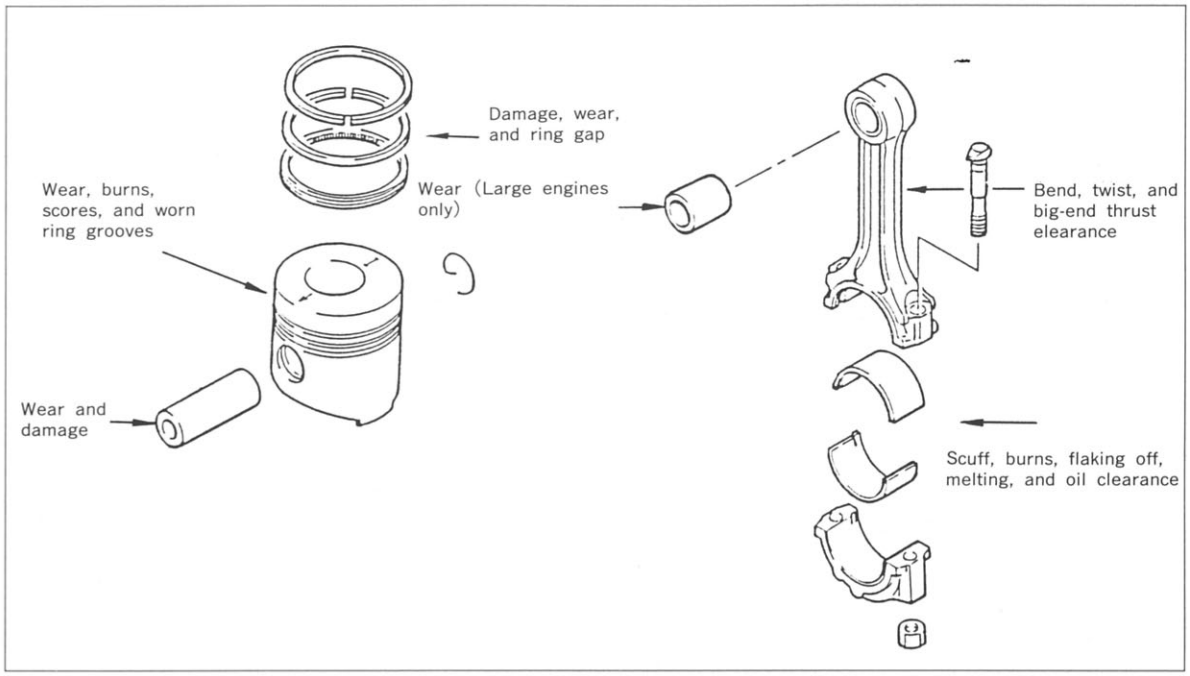
■ Inspection

Repair or replace the parts if necessary.

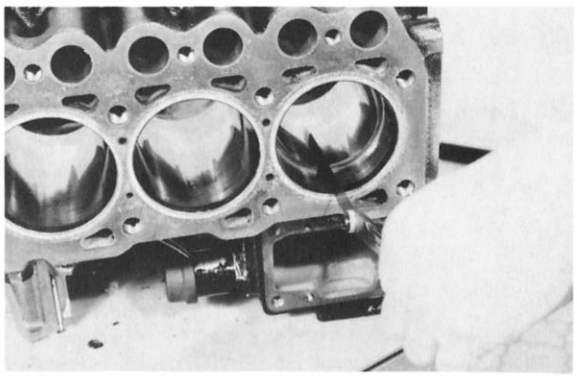


1. Piston Ring Gap Inspection

Using a piston, push the piston ring into the cylinder squarely and measure the ring gap with a feeler gauge. Replace the piston ring if the gap exceeds the service limit.

Caution

- **The ring must be fitted to the diameter at the lower limit of ring travel which has the minimum diameter.**
- **When replacing the rings, use correct sized new rings for the piston.**
- **Oversize piston rings of 0.25, 0.50 and 0.75 are available except for Models K3F and K4F.**



Piston Ring Gap

Piston ring gap		
Description	Standard value	Service limit
No. 1	0.2~0.4	1.5
No. 2		
Oil ring	0.3~0.45	

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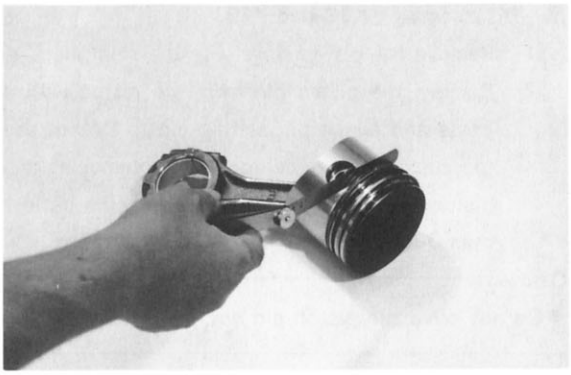
2. Piston Ring－to－Groove Clearance Inspection

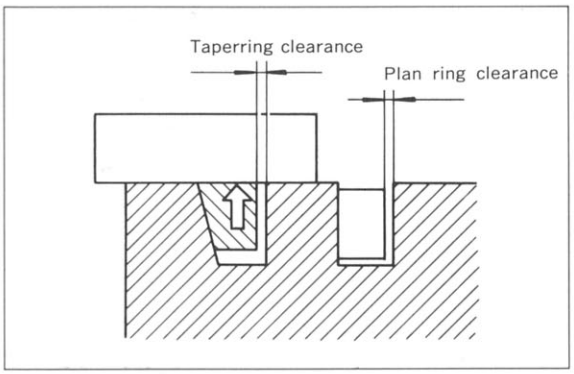
(1) Measure the piston ring－to－groove clearance. If the clearance exceeds the service limit, replace the ring with a new one and re－check the clearance.

(2) If the clearance still exceeds the service limit, replace the piston with a new one.

Piston ring－to－groove clearance		
Description	Standard value	Service limit
No.1	0.06	0.3
No.2	0.07	0.2
Oil ring	0.05	0.2



Measuring Piston Ring－to－Groove Clearance



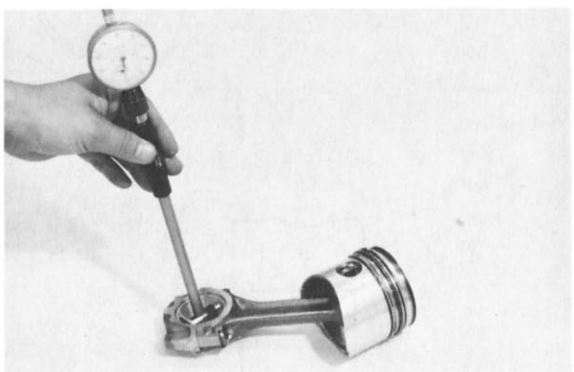
Measuring Semi－keystone Piston Ring－to－Groove Clearance

3. Connecting Rod Big End Bearing Inspection

Install the big end bearings and cap to the connecting rod, tighten the rod cap to the specified torque and measure the bearing I. D.

Caution

- **Oil clearance between the big end bearing and the crankpin can be measured with a plastic gauge.**
- **If the oil clearance does not fall within the service limit with new bearings, refer to the crankshaft chapter and use undersize bearings.**
- **Undersize bearings are available in the following sizes : 0.25, 0.50 and 0.75 US for all models**



Measuring Rod Big End Bearing I. D.

Description		Standard value	Service limit
Rod big end bearing I. D. (Standard)	Except K4M	42	+0.15
	K4M	48	+0.15
Rod big end bearing oil clearance	Except K4M	0.025～0.080	0.15
	K4M	0.035～0.090	0.15
Cap nut tightening torque (kgm)	Except K4M	3.2～3.5	
	K4M	4.0～4.3	

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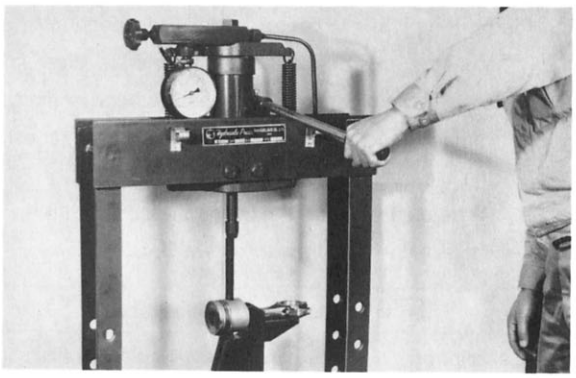
■ Disassembly (K3C and K3D)

(1) Remove the piston rings with the ring pliers.

(2) Remove the piston pin from the piston with a press and piston pin setting tool. Do not use the piston pin guide tool when removing the piston pin. The press out load should be less than 3 kg.

Caution

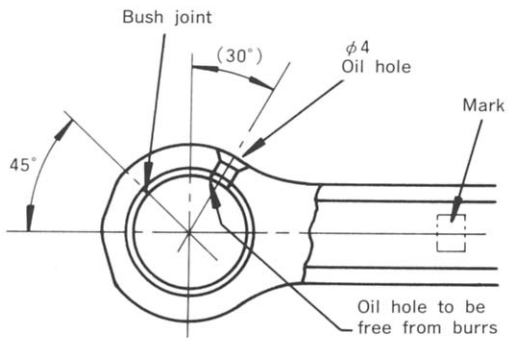
- **Do not drive the piston pin out.**

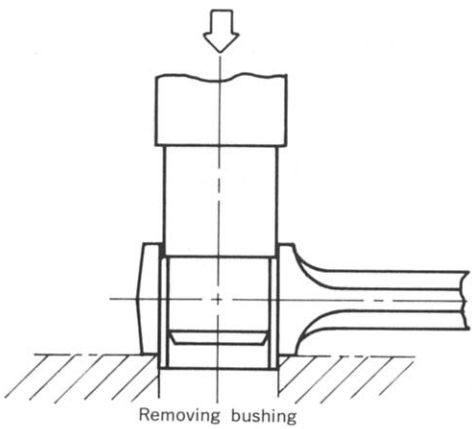


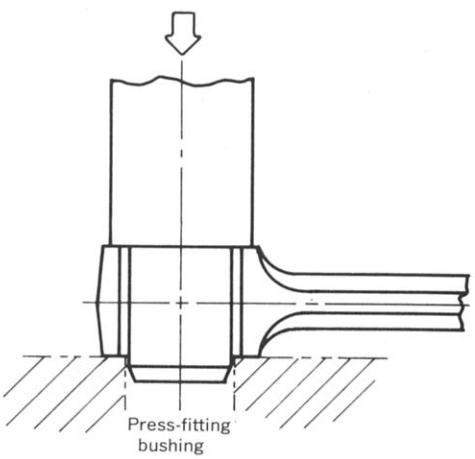
Removing the Piston Pin

■ Connecting Rod Small End Bush Replacement (Except K3E and K4E)

Replace the connecting rod small end bush in the following manner.







* If the bush I. D. is smaller than the standard value after pressing it in, ream the I. D. to the standard value with.

Description		Standard value
Rod small end bush I. D.	K3E, F K4E, F	$23^{+0.041}_{+0.005}$
	K4M	$27^{+0.041}_{+0.005}$

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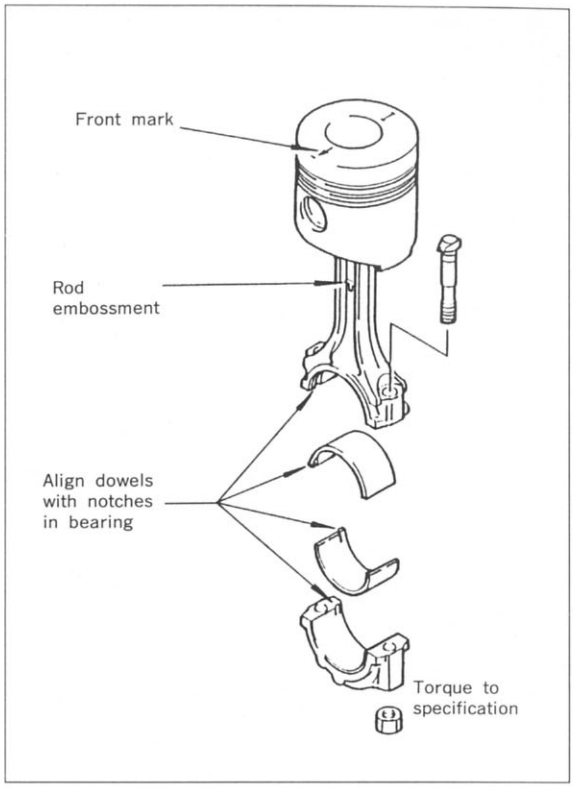
■ Installation

(1) Assemble the piston and connecting rod while noting the following items.

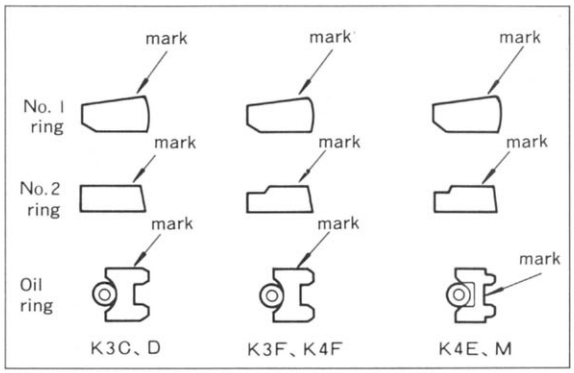
- K3C and D
  Press the piston pin by using the piston pin setting tool.
- Except K3E and K4E
  Apply oil to the snap ring groove and install the snap ring in the groove by the fingers securely.



Installation Direction of Piston and Connecting Rod

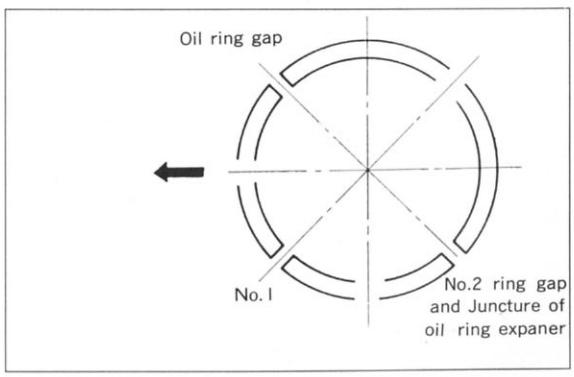
Description	Ring side I. D. NO.				Model
	STD	0.25	0.50	0.75	
Ring No. 1 and 2	—	25	50	75	All models
Oil ring					K3, K4F
Oil ring	No color	White	Blue	Black	K4E, M

Note : No oversize rings are available for K4M engines with cylinder liner and K3F engine serial Nos. up to 10922.



Piston Ring Installation Position

(2) Position the ring gaps as shown in the figure and apply engine oil to the piston and cylinder wall.



Piston Ring Gap Position

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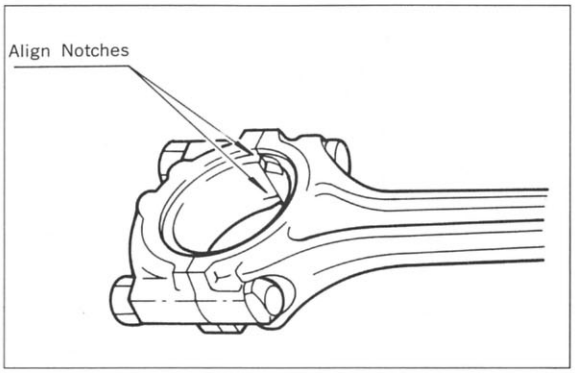
(3) Compress the piston rings with the piston band. Face the front marks on the piston and connecting rod to the front of the engine and insert the piston/connecting rod assembly into the cylinder from the top. Do not drive the piston head with too much blow to insert the piston for fear of possible ring breakage.

(4) Apply engine oil to the connecting rod cap bearing and install the cap aligning the cylinder numbers on the rod and cap marked at the time of disassembly. If the connecting rod is replaced with a new one, face the bearing stop notches to the same direction as shown in the figure.



Installing Connecting Rod Cap

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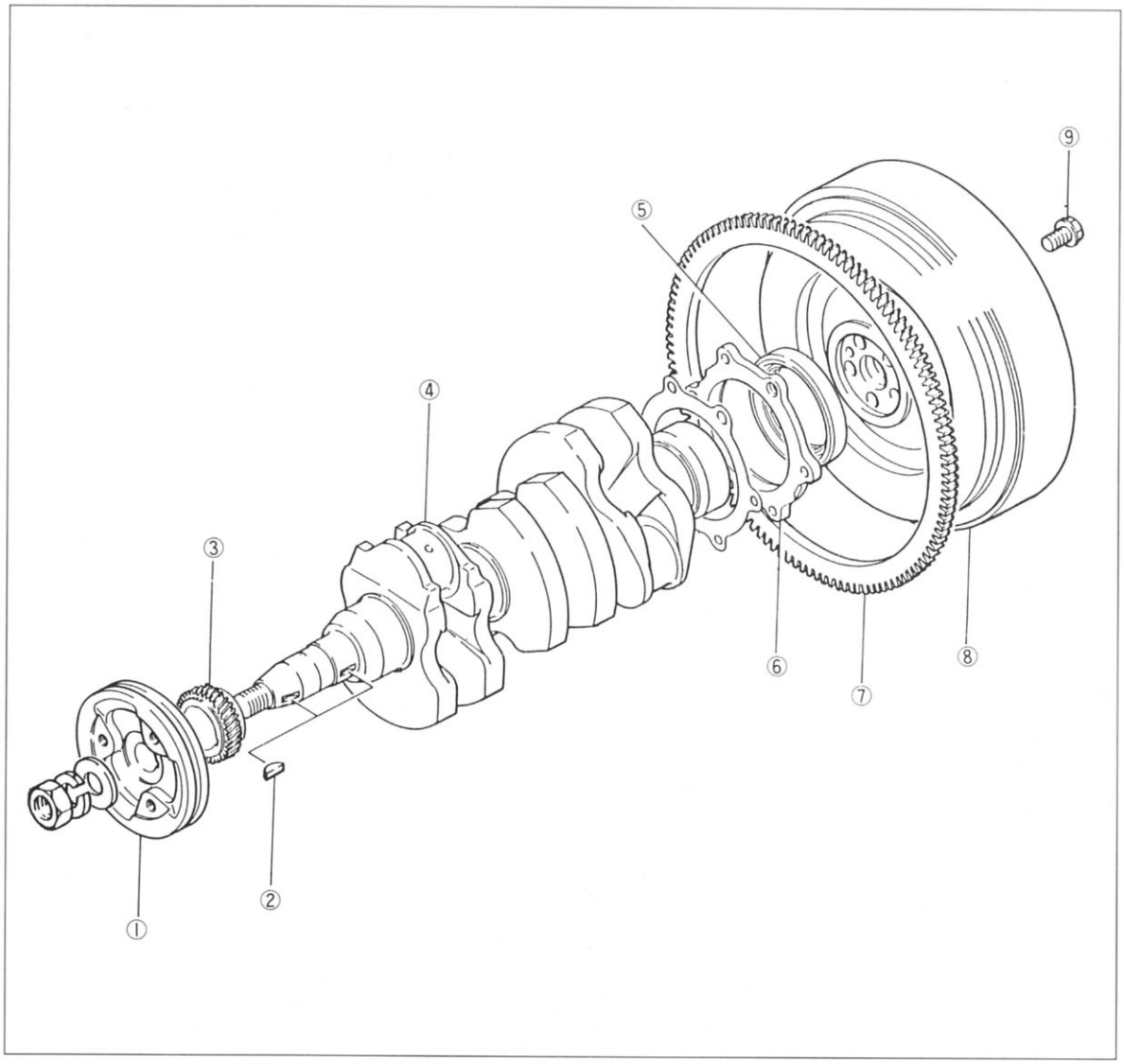
■Components



Crankshaft and flywheel components

① Crankshaft pulley	④ Crankshaft	⑦ Ring gear
② Key	⑤ Rear oil seal	⑧ Flywheel
③ Crankshaft gear	⑥ Rear oil seal case	⑨ Flywheel bolt

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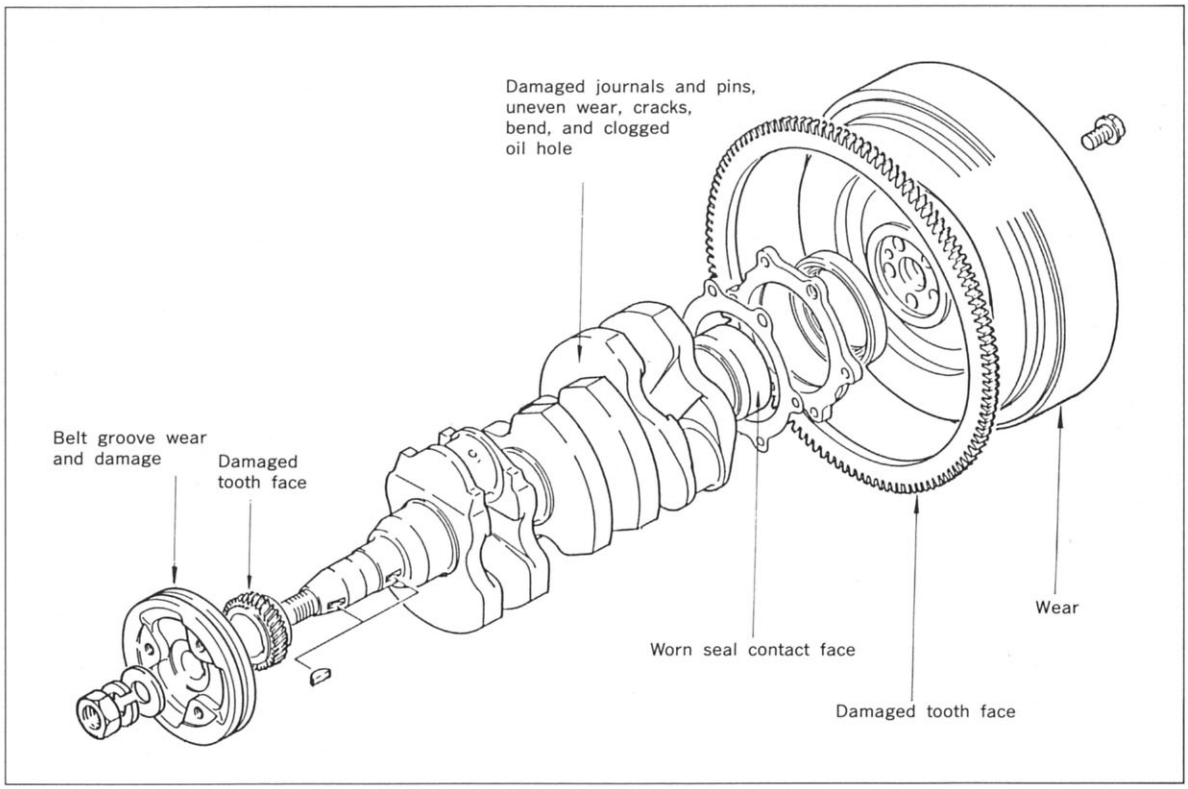
■Removal

Remove the cylinder head assembly, oil pan, pistons, connecting rods and gear case before removing the flywheel and crankshaft.

(1) Remove the flywheel mounting bolts and the flywheel.
(2) Remove the rear oil seal case.
(3) Remove the front plate.
(4) Remove the main bearing caps.
(5) Remove the crankshaft.

■Inspection

Repair or replace the parts if necessary.



Crankshaft and Flywheel Inspection

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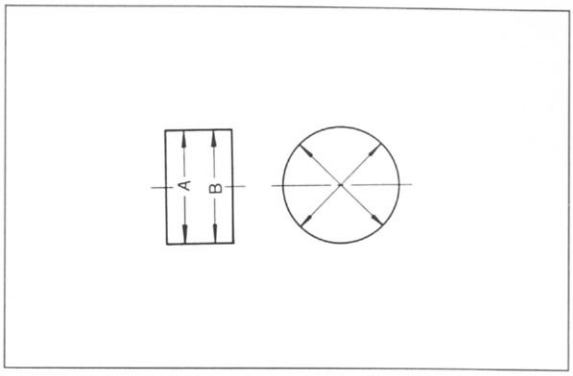
1. Crankshaft Wear Inspection

(1) Crankshaft journal and pin O. D. measurement
Measure the journal and pin O. D. at two places (front and rear) in A and B directions as shown in the figure. If the measured value exceeds the service limit, ground the crankshaft to the undersize.

CAUTION

- **If the crankshaft main or journal bearings are seized due to lacking of oil etc., the crankshaft can not be re-used.**



Measuring Crankshaft Journal O. D.

Description	Standard value		Service limit
	Except K4M	K4M	
Journal O. D. (standard)	52	57	−0.15
Pin O. D. (standard)	42	48	−0.15

(2) Grounding crankshaft to undersize
When grounding the crankshaft journals or pins to the undersize, finish them to the same size within the tolerance shown in the table. Also the fillet radii should be ground to 2.5R.

Description		Standard finished value	
		Except K4M	K4M
Journal O. D.	0.25US	$51.75_{-0.015}^{0}$	$56.75_{-0.055}^{-0.040}$
	0.55US	$51.50_{-0.015}^{0}$	$56.50_{-0.055}^{-0.040}$
	0.75US	$51.25_{-0.015}^{0}$	$56.25_{-0.055}^{-0.040}$
Pin O. D.	0.25US	$41.75_{-0.050}^{-0.035}$	$47.75_{-0.050}^{-0.035}$
	0.50US	$41.50_{-0.050}^{-0.035}$	$47.50_{-0.050}^{-0.035}$
	0.75US	$41.25_{-0.050}^{-0.035}$	$47.25_{-0.050}^{-0.035}$
Grounding limit (each)		−0.15	

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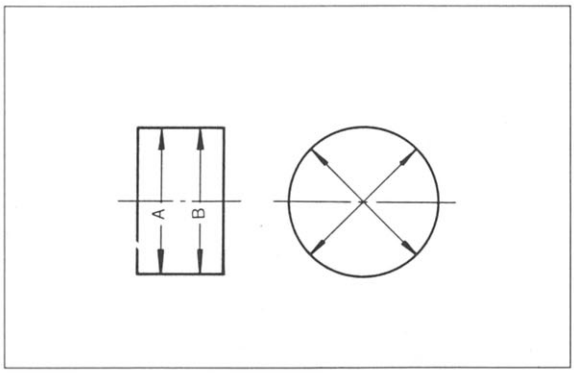
(3) Crankshaft oil clearance inspection
Measure the I. D. of the bearing at two places (front and rear) in A and B directions as shown in the figure.
Calculate the oil clearances of the journal and pin by subtracting the O. D. from the I. D. of the bearing.

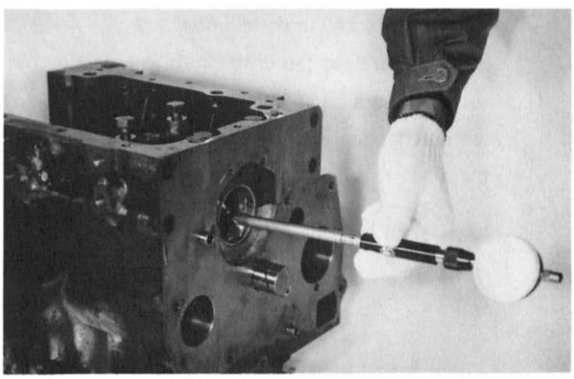


Measuring Bearing I. D.

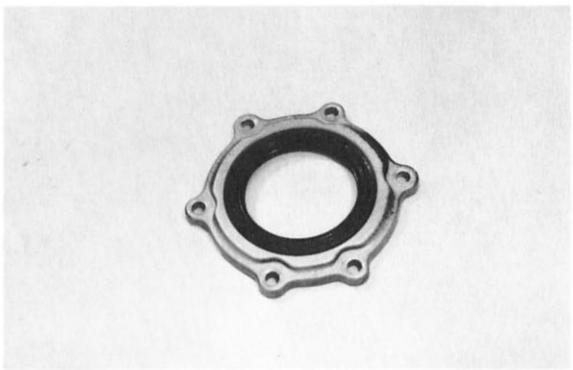
Oil clearance

Description	Standard value	Service limit
Main bearing	0.040~0.101	0.15
Rod bearing	(See Group 1-09.)	

(4) If the oil clearance still exceeds the service limit by using new bearings, grind the crankshaft to the undersize and use the undersize bearings.
Undersize bearings are available in the following sizes :
0.25, 0.50, and 0.75 US


Inspecting Main Bearing

(5) Crankshaft rear oil seal replacement
(a) Remove the oil seal.
(b) Drive a new oil seal squarely into the oil seal case.
Take care not to drive it in aslant.


Driving Oil Seal

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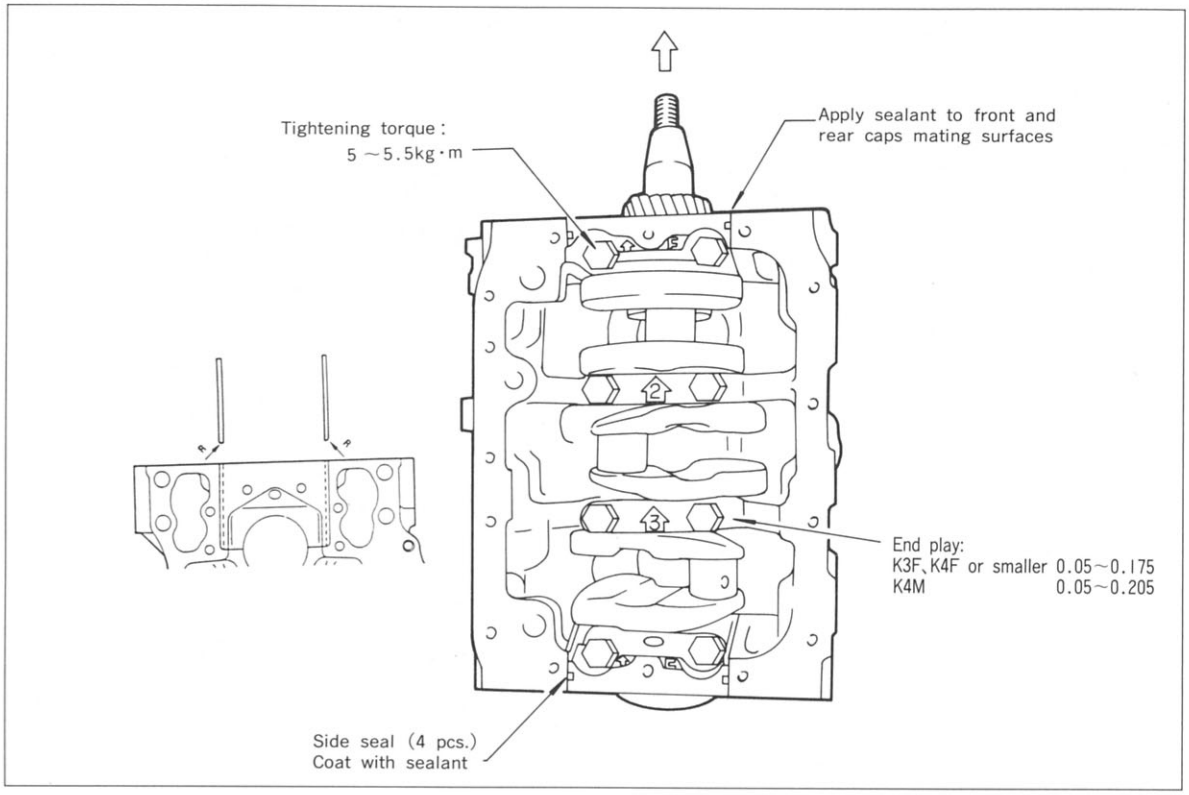
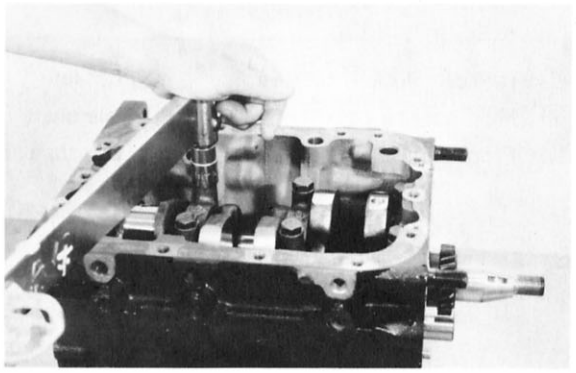
■ Installation

(1) Install the parts while noting the following items.



(2) Proper main bearing cap No. and direction of arrow (pointing the front of the engine) are shown in the figure.



Installing Crankshaft

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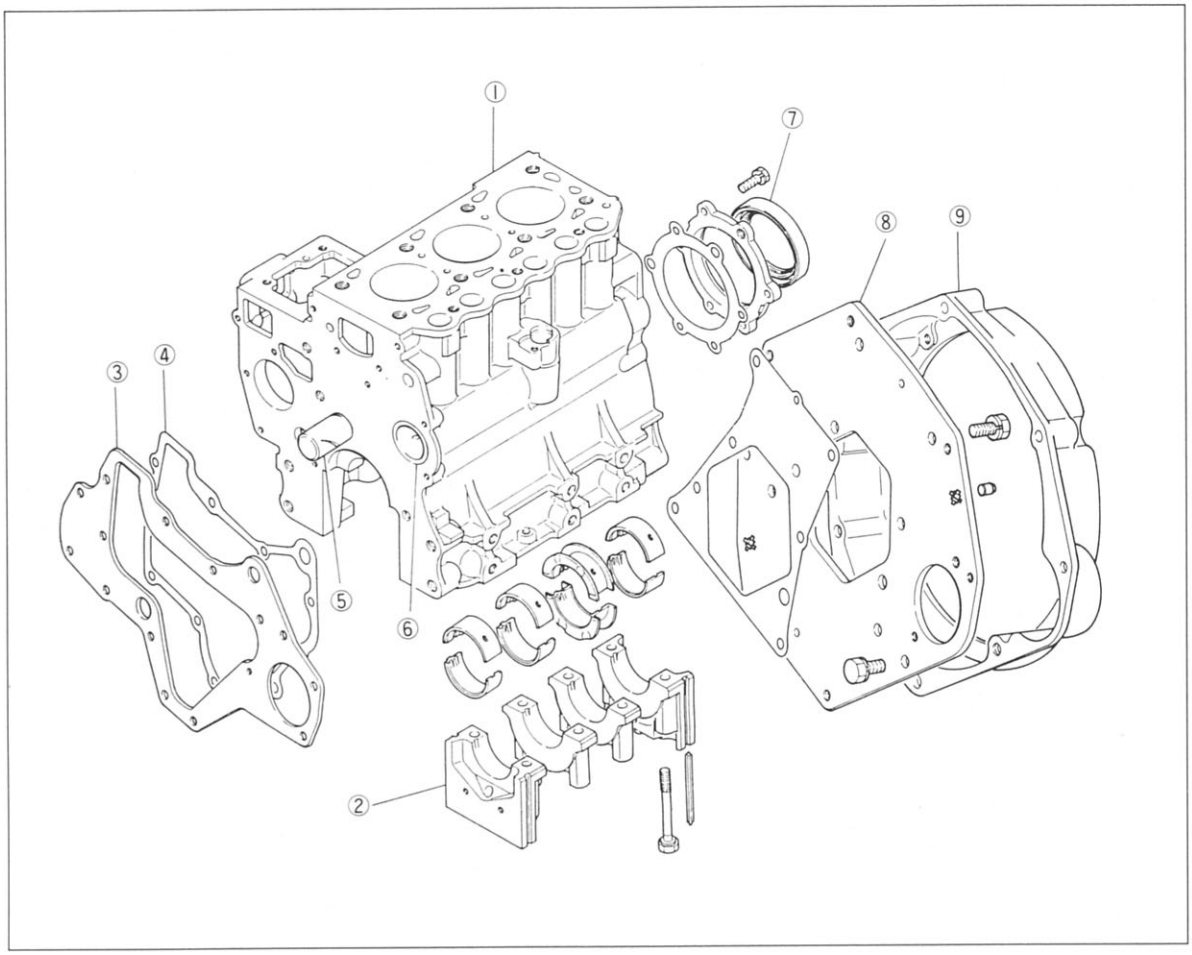
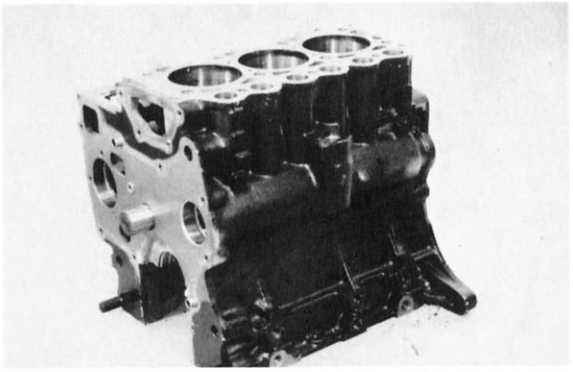
■ Components



① Cylinder block
② Main bearing cap
③ Front plate
④ Gasket
⑤ Idle shaft
⑥ Camshaft front bush
⑦ Rear oil seal
⑧ Rear plate
⑨ Flywheel housing



Cylinder Block Assembly

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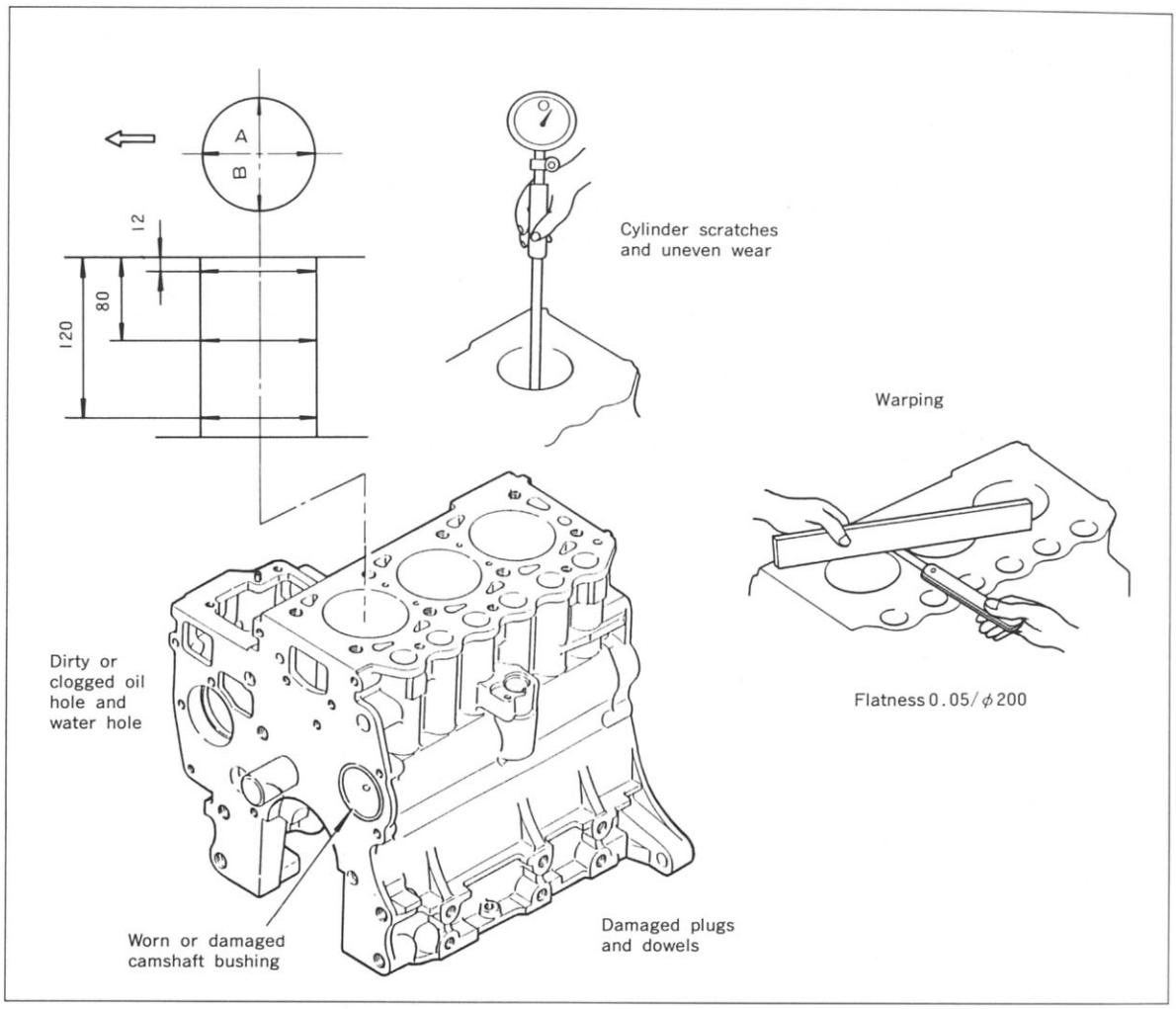
■ Inspection

Repair or replace the cylinder block if necessary.



CAUTION

- **No oversize cylinder liners are available for K3F engine serial Nos. up to 10922 and K4F engine serial Nos. up to 3634, and K4M engines with liner.**

Description		Standard value					Service limit
		K3C	K3D	K3E K4E	K3F K4F	K4M	
Cylinder I. D.	STD	70	73	76	78	84	−0.25
	0.25OS	70.25	73.25	76.25	—	84.25	
	0.50OS	70.50	73.50	76.50	—	84.50	
	0.75OS	70.75	73.75	76.75	—	84.75	
Camshaft front bush I. D.		45					
Camshaft front bush oil clearance		0.050~0.125					
Camshaft center bush I. D.		44					
Camshaft rear bush I. D.		34				39	

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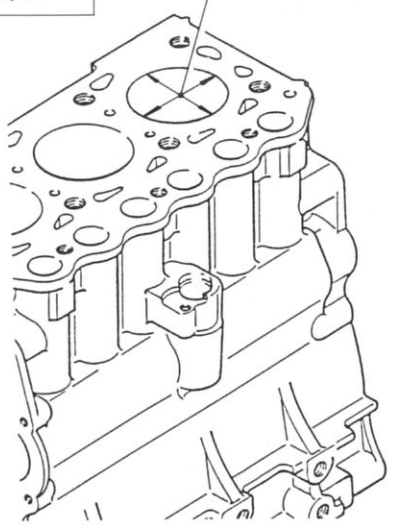
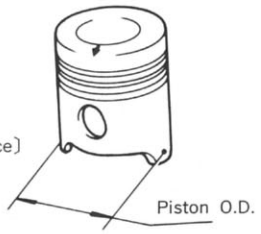
■ Honing Cylinders

Perform the honing in the following manner.
(K4M with the cylinder liners can not be honed.)

Oversize pistons

Size	Size mark
STD	Not available
OS 0.25	0.25
OS 0.55	0.50
OS 0.75	0.75





CAUTION

- **All cylinders should be honed to the same oversize.**

(1) Oversize pistons are available in the following size :
0.25, 0.50 and 0.75

(2) Honing allowance
The cylinder must be finished to the size called for by the piston to be installed within the tolerance shown below under consideration of 0.02 mm of honing allowance.

(3) Honing tolerance

Nominal dia.	Tolerance
Nominal dia. of oversize piston to be installed	+0.03 0

Example : 0.50 oversize for K4M
Nominal dia. =84.50 mm Tolerance=$84.50^{+0.03}_{0}$

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■ Cylinder Liner Replacement

If the cylinder liner is worn or damaged, select a new liner and replace.

(1) Remove the worn or damaged liner.

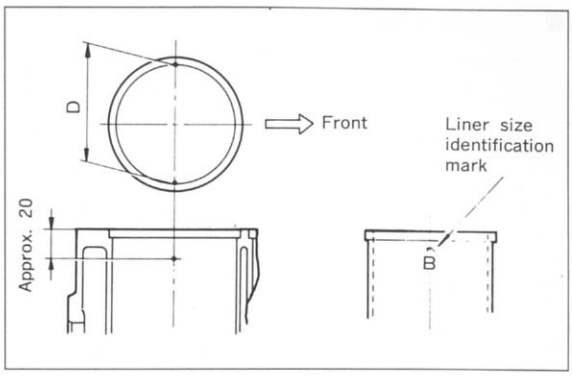
(2) Measure the cylinder clock I. D. (ϕD) as shown in the figure.

(3) Select a new liner from the three sizes in the table so that the cylinder block－to－liner clearance is 0.01～0.03

(4) After installing the liner, make sure that the liner protrusion is within the specification.

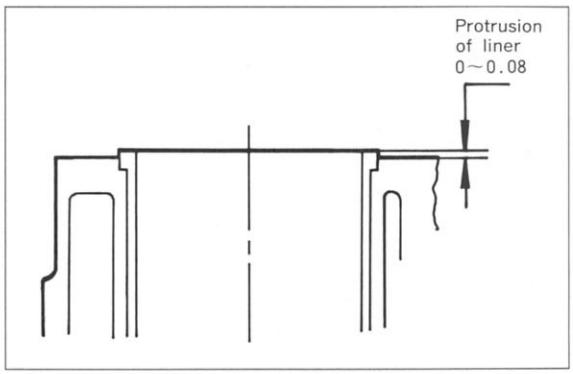
CAUTION

- **Clean the cylinder block bore thoroughly before installing the liner.**
- **Apply rust preventive oil NP－10－1 or NP－10－2 lightly to the outer surface of the liner.**
- **If the liner is selected properly, it can be inserted into the block by lightly pushing its flange with fingers. If the liner slips into the block with its dead load, re－check the I. D. of the block and the liner identification mark.**



Measring Locations and Directions for Block Bore

Liner identification mark	Liner O. D. (ϕD)
A	$\phi 88^{-0.011}_{-0.021}$
B	$\phi 88^{0}_{-0.010}$
C	$\phi 88^{+0.010}_{+0.001}$



Protrusion of liner

Description	Standard value
Cylinder liner protrusion	0～0.08

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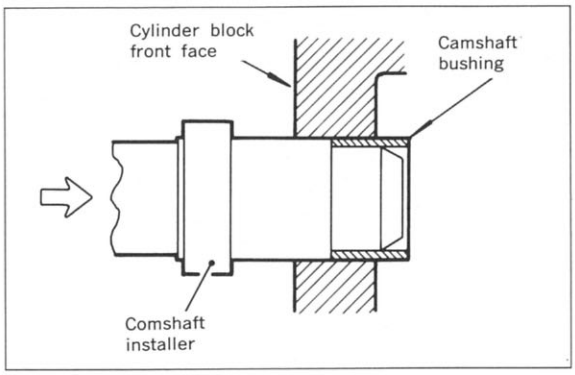
■ **Camshaft Front Bush Replacement**

Replace the camshaft bush with the special tool and press the bush in the location and direction as shown in the figure.

(1) Bush removal

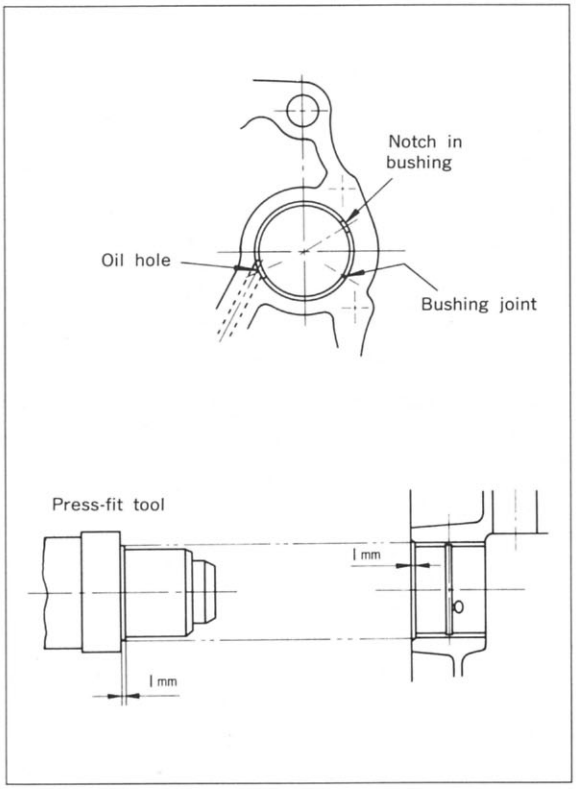
Use the drive outside of the tool and remove it into the inside of the block. Crush the bush to be taken out from the inside of the block with an enough care of not giving damage to the edge of the tappet hole.



Driving Camshaft Bush Out

(2) Pressing bush in

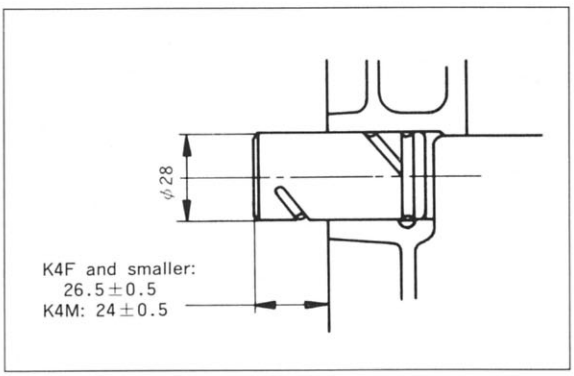
Press a new bush into proper location from the direction shown.



Pressing−in of Camshaft Bush

■ **Pressing−in of Idle Gear Shaft**

Pressing−in the idle gear shaft according to the dimension as shown in the figure.



Pressing−in of Idle Gear Shaft

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Group 2

LUBRICATION

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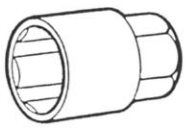
■ Specifications

Item	Specification
Lubrication and filtration	Forced lubrication, full-flow filtration type
Oil type	API service classification CC or severer
Oil capacity	3.0 or 7.0 (upper limit), oil filter oil capacity 0.5 or 0.7
Oil pump : Type Drive	Trochoid pump Driven by injection pump camshaft
Relief valve opening pressure	4.0 kg/cm^2
Oil pressure switch closing pressure	0.5 kg/cm^2
Oil filter	Paper-element cartridge type

■ Special Tools

Use	Tool name (Part number)	Sketch
Removing/installing oil pressure switch	Oil pressure switch wrench (26) MD998054	

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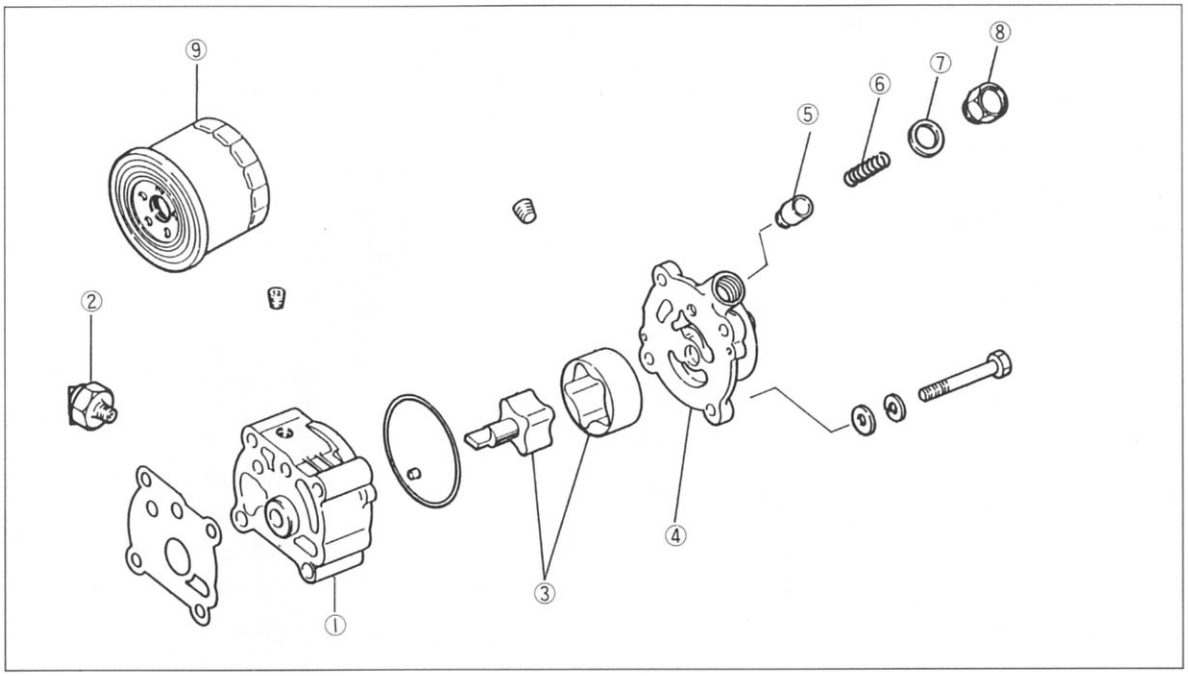
Group No. 2-02

■ Components



① Oil pump body	④ Oil pump cover	⑦ Gasket
② Oil pressure switch	⑤ Relief valve	⑧ Plug
③ Oil pump rotor	⑥ Relief valve spring	⑨ Oil filter

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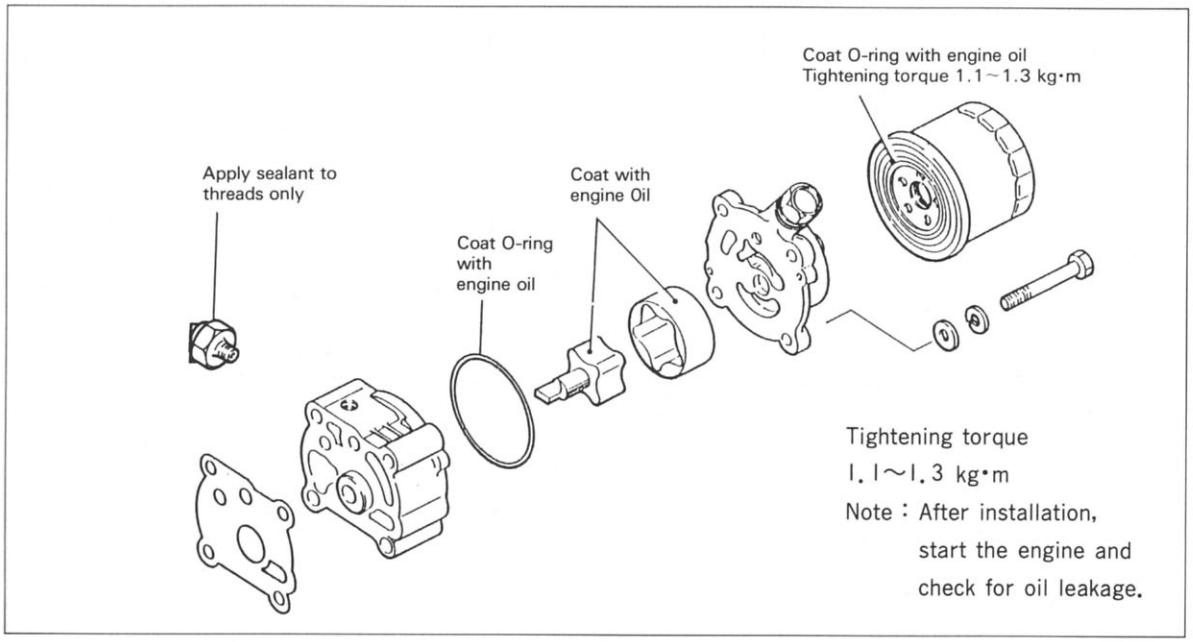
2-02 OIL PUMP AND OIL FILTER

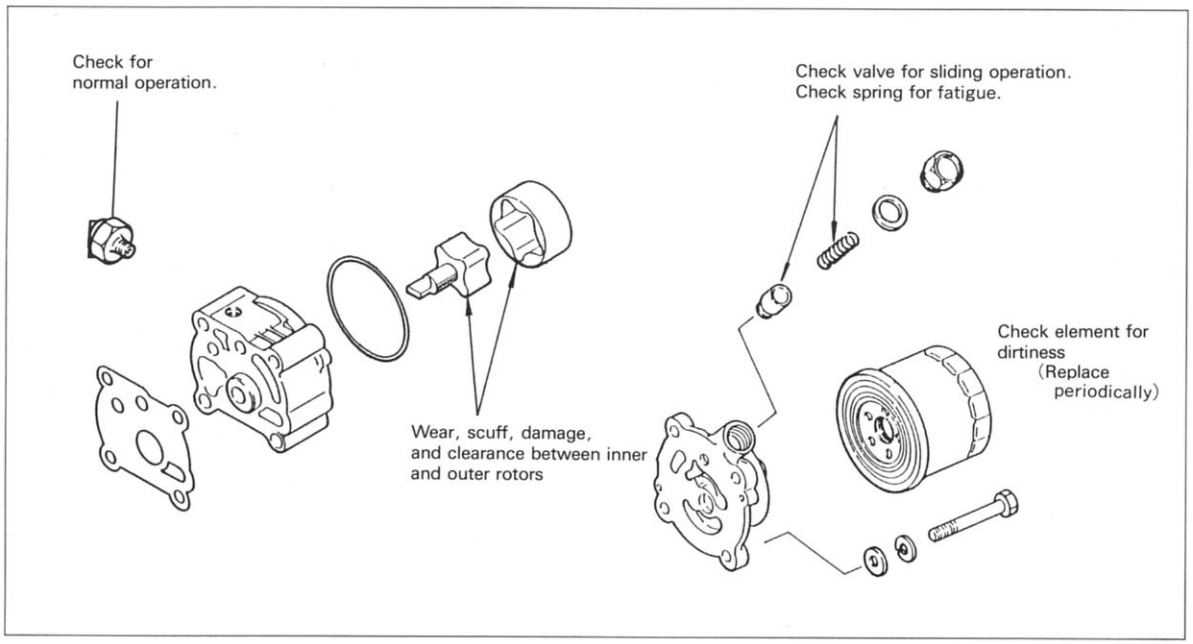
■ Removal／Installation

Follow the directions below for reassembly.



■ Inspection

Check the following parts for faulty condition. Replace if necessaly.



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Group 3 FUEL SYSTEM

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■ Specifications for K3 Series

Item	Model	K3C −DII, DI2	K3D −DIIA	K3D −DIIG, DI2G	K3D DI3G, DI4G	K3E −DIIA	K3F −DIIA
Injection Pump	Type	Bosch M type					
	Model	ND−PFR3M					
	Plunger dia.	φ6.5					φ7.0
	MS retard (Crank angle)	4°					
	Delivery valve	Silt type or Bosch					
	New device	With		Without		With	
	Air bleeder screw	Without					
	Injection amount	See group 9 Reference.					
Nozzle	Type	Hole type					
	Model	DLL−P					
	Nozzle opening pressure (kg/cm²)	220^{+10}_{0}					
	Nozzle hole dia.	φ0.20				φ0.22	
Fuel Filter	Type	Paper-element type					
	Element mesh	30μ					
	Filtration area	129cm² min.					
	Air bleeder screw	Without	With	Without		With	
Fuel Pump	Type	Electromagnetic diaphragm type	Without	Electromagnetic diaphragm type		Without	
	Pump delivery (at 12V DC, 20°C)	370cc/minute min.		370cc／minute min.			
	Filter element	Without		Without			

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■Specifications for K4 Series

Item	Model	K4E −D12, D13	K4E −D14	K4F −D11～	K4F −D31	K4M −D11	K4M −D31	K4M −D61, D62
Injection Pump	Type	Bosch M type						
	Model	ND−PFR4M						
	Plunger dia.	φ6.5		φ6.5		φ7.5		
	MS retard (Crank angle)	4°		4°		——		
	Delivery valve	Silt type or Bosch						
	New device	With						
	Air bleeder screw	Without	With (2screws)	Without	With (2screws)	With (1screw)	With (2screws)	
	Injection amount	See group 9 Reference.						
Nozzle	Type	Hole tyupe						
	Model	DLL−P						
	Nozzle opening pressure (kg/cm²)	220^{+10}_{0}						
	Nozzle hole dia.	φ0.20 or φ0.22				φ0.22		
Fuel Filter	Type	Paper-element type (with cock)			Paper-element type (cartridge type)	Paper-element type (with cock)		
	Element mesh	15μ	30μ	10～15μ	15μ	30μ		
	Filtration area (cm²)	260 min.	129 min.	260 min.	280 in.	900 min.		
	Air bleeder screw	Without			With	Without	With	
Fuel Pump	Type	Without		Compact electromagnetic plunger type	Electromagnetic plunger type	Electromagnetic diaphragm type	Electromagnetic plunger type	Without
	Pump delivery (at 12V DC, 20°C)			400cc /minute min.	900cc /minute min.	370cc /minute min.	900cc /minute min.	
	Filter element			Without	With	Without	With	
Hand Fuel Pump	Application	K4E−D12A	Not applied	K4F−D11A	Not applied			
	Type	Hand push type		Hand push type				
	Pump delivery (cc/stroke)	4.5		4.5				

Note : The compact electromagnetic plunger type fuel pump applies to K4F−D12A and−D13A.

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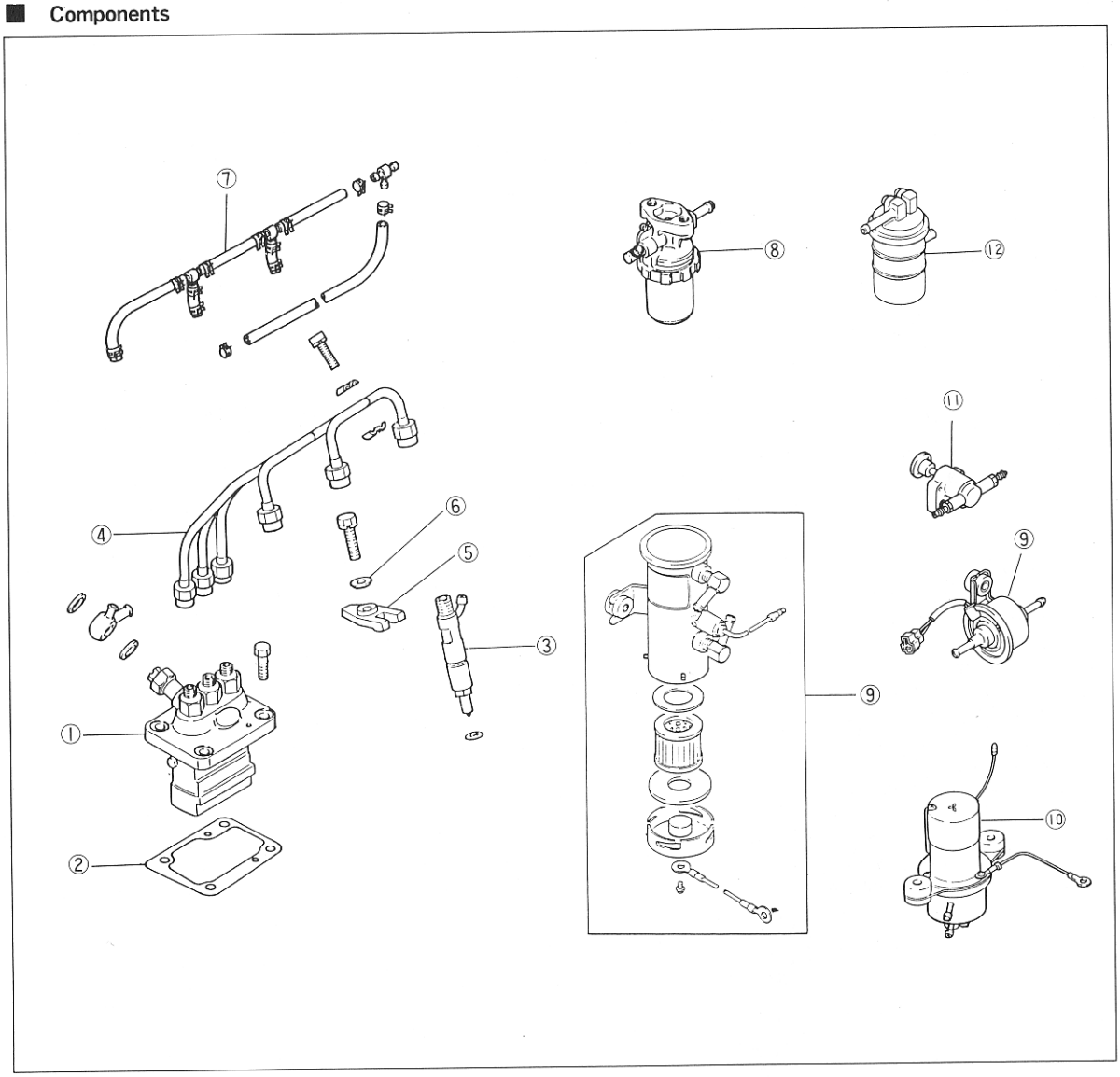
Components



① Fuel injection pump
② Shim
③ Nozzle holder assembly
④ Fuel injection pipes
⑤ Nozzle support
⑥ Special washer
⑦ Fuel return pipe
⑧ Fuel filter
⑨ Fuel pump (plunger type)
⑩ Fuel pump (diaphragm type)
⑪ Hand fuel pump
⑫ Fuel filter (cartridge type)

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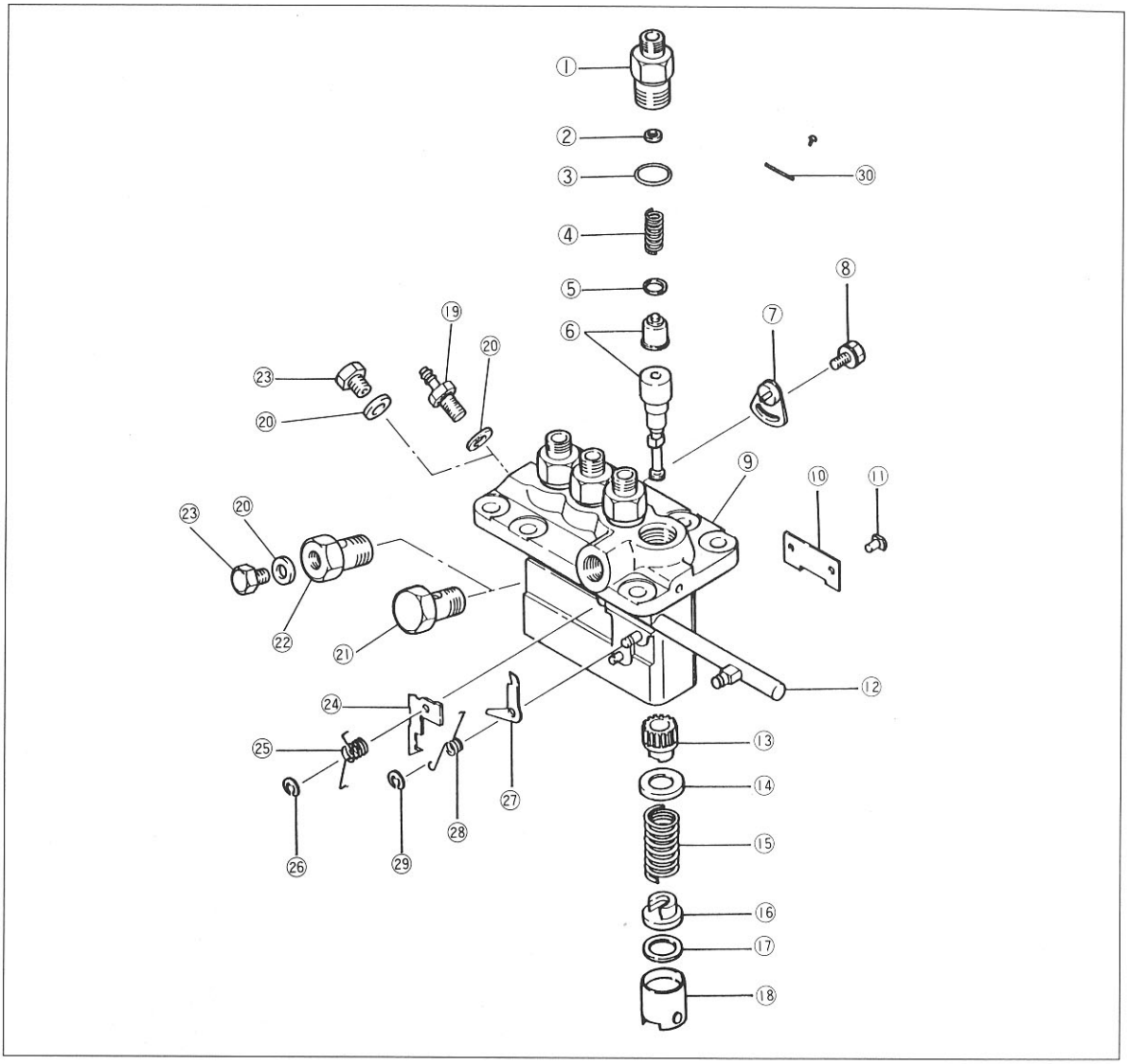
Components



① Delivery valve holder
② Shim washer
③ O-ring
④ Delivery valve spring
⑤ Delivery valve gasket
⑥ Plunger element assembly
⑦ Adjusting plate
⑧ Bolt
⑨ Pump body
⑩ Lock plate
⑪ Tappet guide pin
⑫ Rack
⑬ Sleeve
⑭ Spring upper seat
⑮ Plunger spring
⑯ Spring lower seat
⑰ Tappet adjusting shim
⑱ Tappet
⑲ Fuel leakage nipple
⑳ Washer
㉑ Hollow screw
㉒ Hollow screw (for air bleeder plug)
㉓ Air bleeder plug
㉔ Stopper
㉕ Return spring
㉖ E-ring
㉗ Ungleich set plate
㉘ Ungleich set spring
㉙ E-ring
㉚ Name plate

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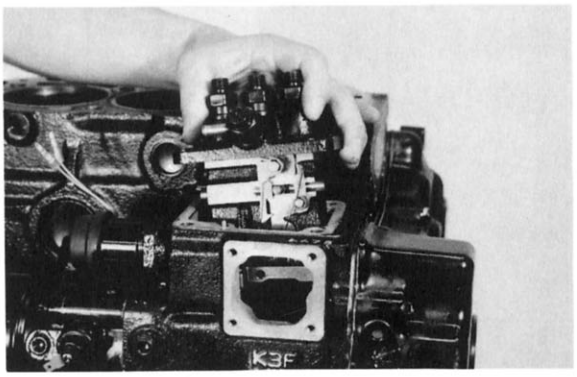
■ Inspection on the Engine

Do not try to disassemble the injection pump unnecessarily. It is recommended to replace the pump as an assembly when it is fault.

Item	Inspection	Criterion
Low idle speed	Measure engine rpm	Standard for agricultural engine : 970^{+30}_{0}rpm Standard for industrial and export engines : 935±25 rpm
Exhaust color	1) Accelerate the engine speed rapidly under no load and observe the exhaust color. 2) Apply load and observe the exhaust color.	Black smoke should not be excessively exhausted.
Nozzle injecting condition	Remove the nozzle assembly. Connect the nozzle to the injection pipe with its needle valve pointing the outside and make sure the injecting condition by cranking the engine with the starter.	Fuel spray should be good condition.

■ Removal

(1) Remove the fuel injection pipes.
(2) Remove the tie rod cover.
(3) Remove the tie rod and tie rod spring.
(4) Remove the injection pump assembly.



Removing Injection Pump

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■ Injection Pump Disassembly

Caution

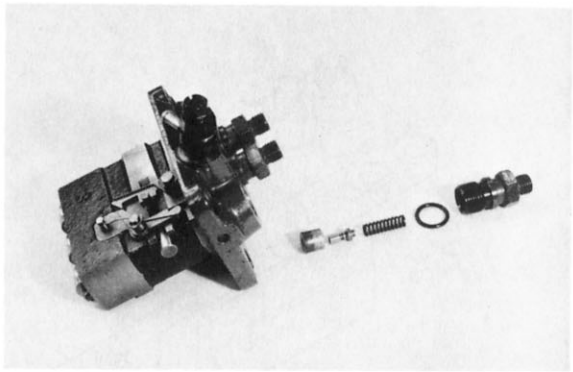
- **When replacing the plunger barrel, delivery valve, etc., do not loosen the adjusting plate between the cylinders.**
- **After these parts are replaced, measure injection amount with a pump tester cam box.**

■ Disassembly

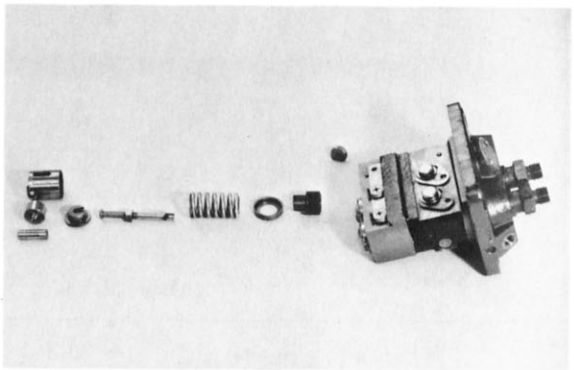
(1) Remove the delivery valve holders, delivery valves, and delivery valve springs.
(2) Remove the tappet roller stopper pins.
(3) Remove the tappet plunger springs, etc.
(4) Remove the plungers and plunger barrels.

Caution

- **All parts should be put in order for each cylinder and kept immersed in clean fuel oil.**



Removing Delivery Valve



Removing Tappet and Tappet Roller

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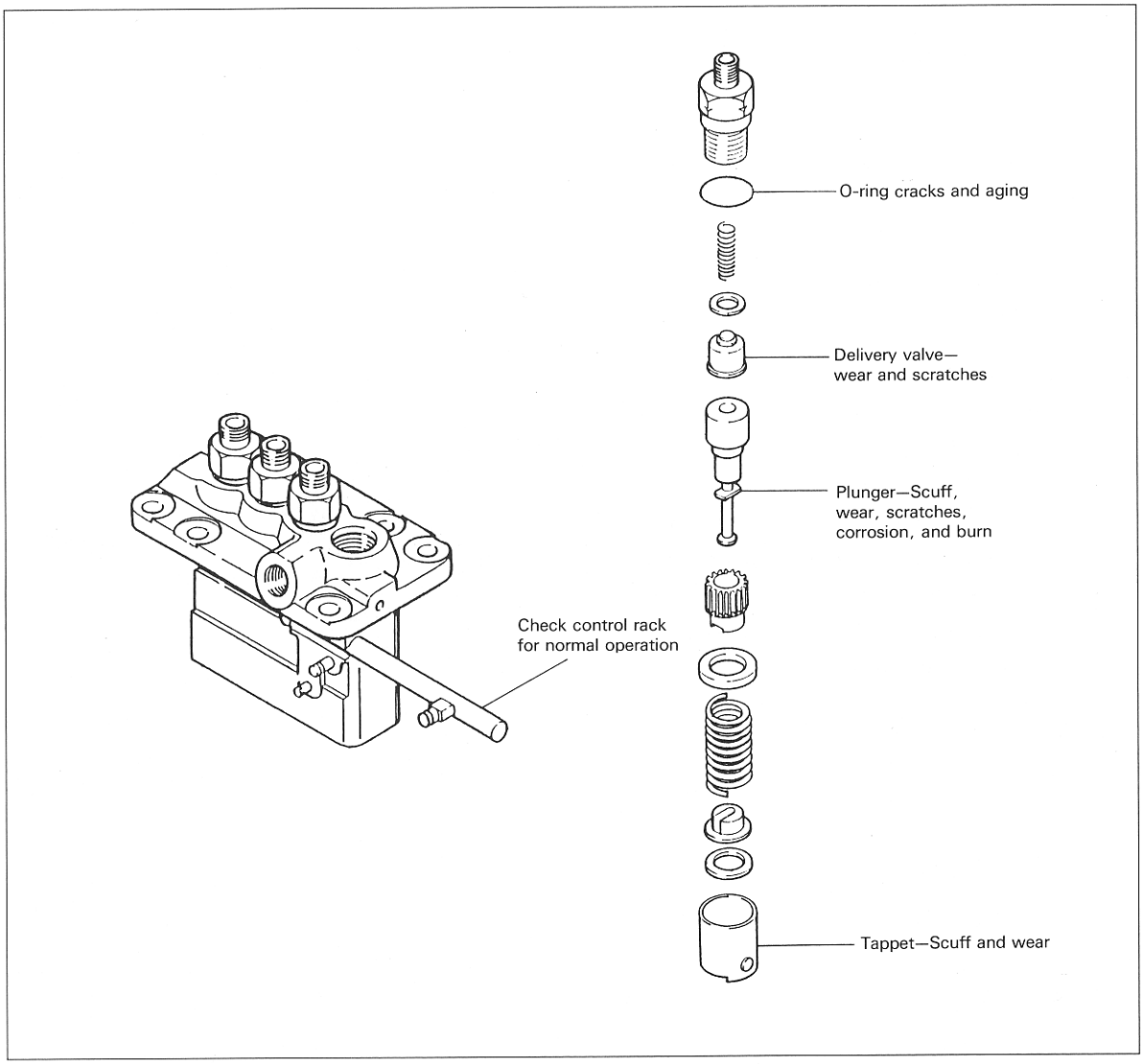
Inspection



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■ Assembly

(1) Insert the plunger barrels in the housing.

Caution

● Align the dowel pin with the groove in the barrel.

(2) Install the delivery valves and delivery valve springs and tighten the holders temporarily.

(3) Insert the control rack.

(4) Insert the control pinions. Align the alignment marks on the control racks and pinions.

(5) Install the plunger upper seats.

(6) Install the plunger springs.

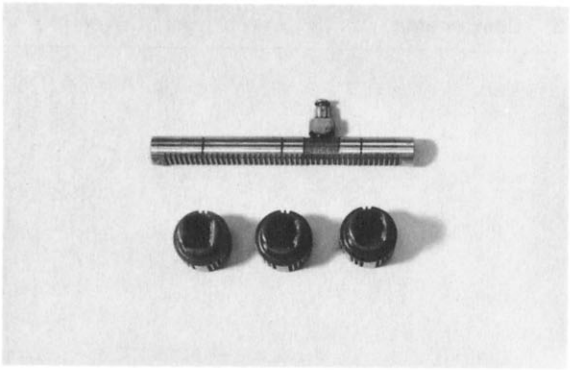
(7) Install the lower seats on the plungers and install them in the barrels.

Caution

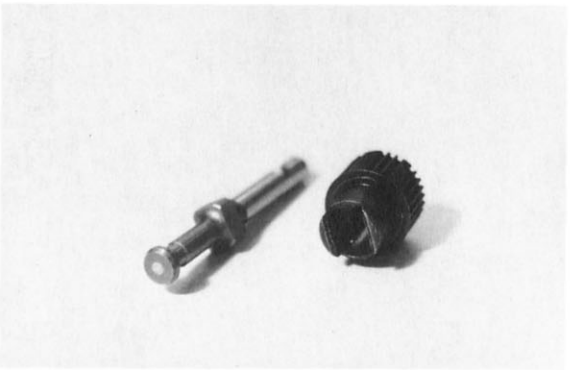
● Position the notch in the plunger flange oppositely to the control rack so that the feed hole faces the plunger lead.

(8) With the tappet roller assembly grasped, insert the stopper pin.

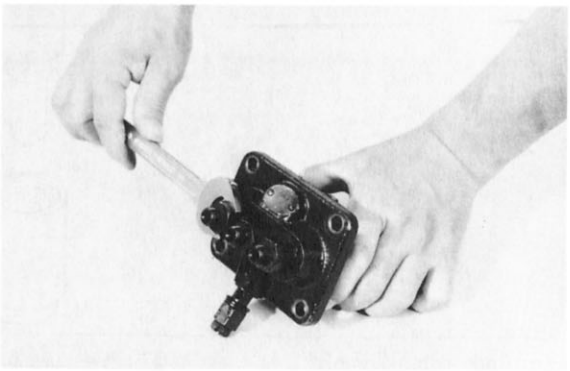
(9) Tighten the delivery holder.
Tightening torque : 4～5kg•m



Control Rack and Pinions



Plunger Installation Direction



Tightening Delivery Holder

■ Installation

Install the injection pump in the reverse order of removal.

Caution

● Check for injection timing after installation.

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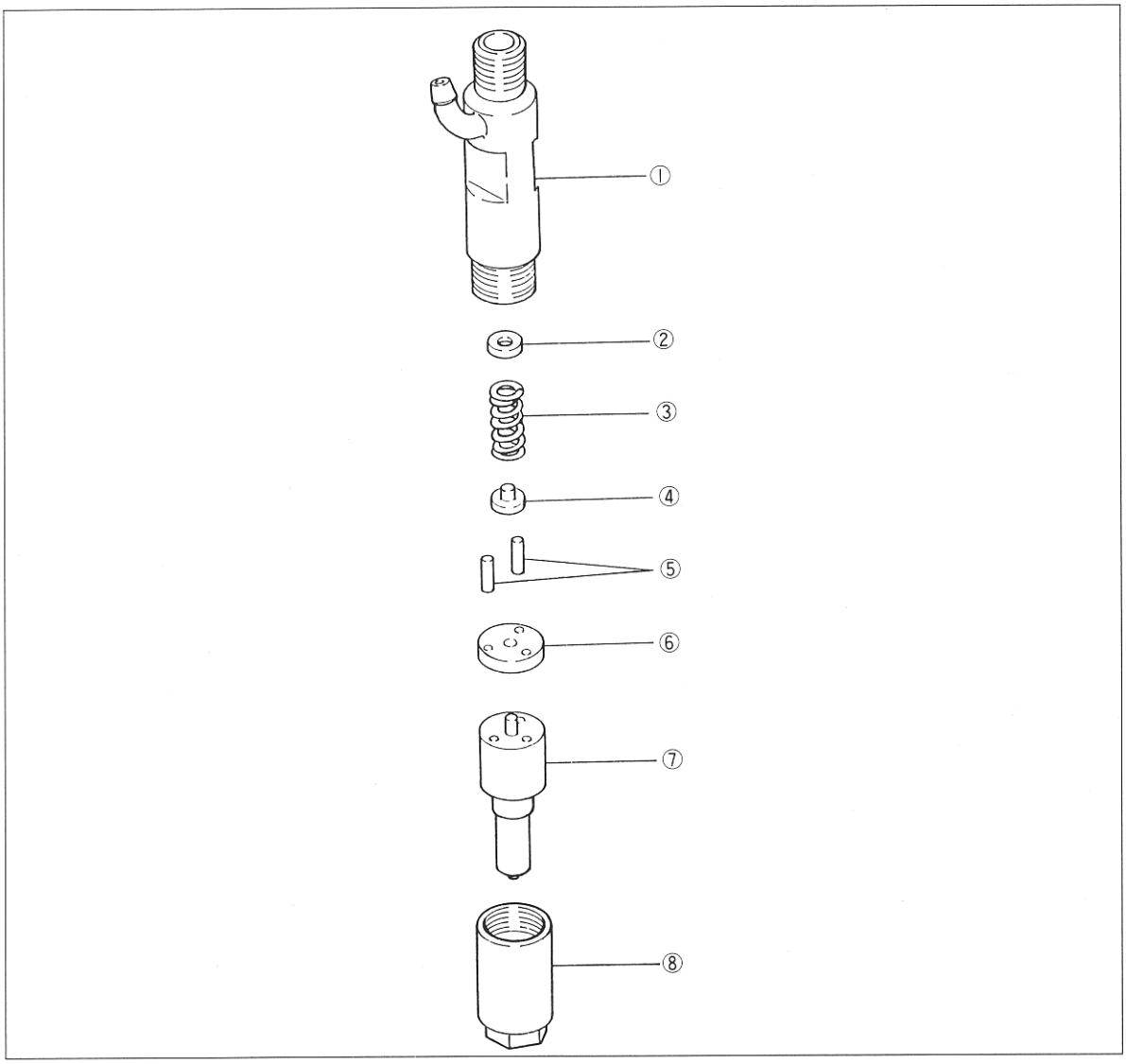
■ Components



① Body sub-assembly
② Washer
③ Spring
④ Pressure pin
⑤ Pin
⑥ Packing
⑦ Nozzle assembly
⑧ Retaining nut

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■ **Removal**

(1) Remove the injection pipe and fuel return pipe.

(2) Remove the injection nozzle assembly from the cylinder head.

Caution

- **Attach cylinder No. tags to the injection nozzles removed.**
- **Plug the fuel passages and combustion chambers to prevent dust, water or other foreign matter from entering there.**

■ **Disassembly**

If an injection nozzle is found by inspection to be out of order, disassemble it to repair or replace the faulty parts.

(1) Vise the nozzle holder body and loosen the retaining nut. Do not grip the retaining nut to prevent deformation of it.

(2) Remove the pressure spring, shim, distance piece and nozzle tip.

Caution

- **Remove carbon deposits from the nozzle parts with a wooden scraper and keep the parts immersed in clean fuel oil. Take special care not to damage the needle valve at the tip of the nozzle.**

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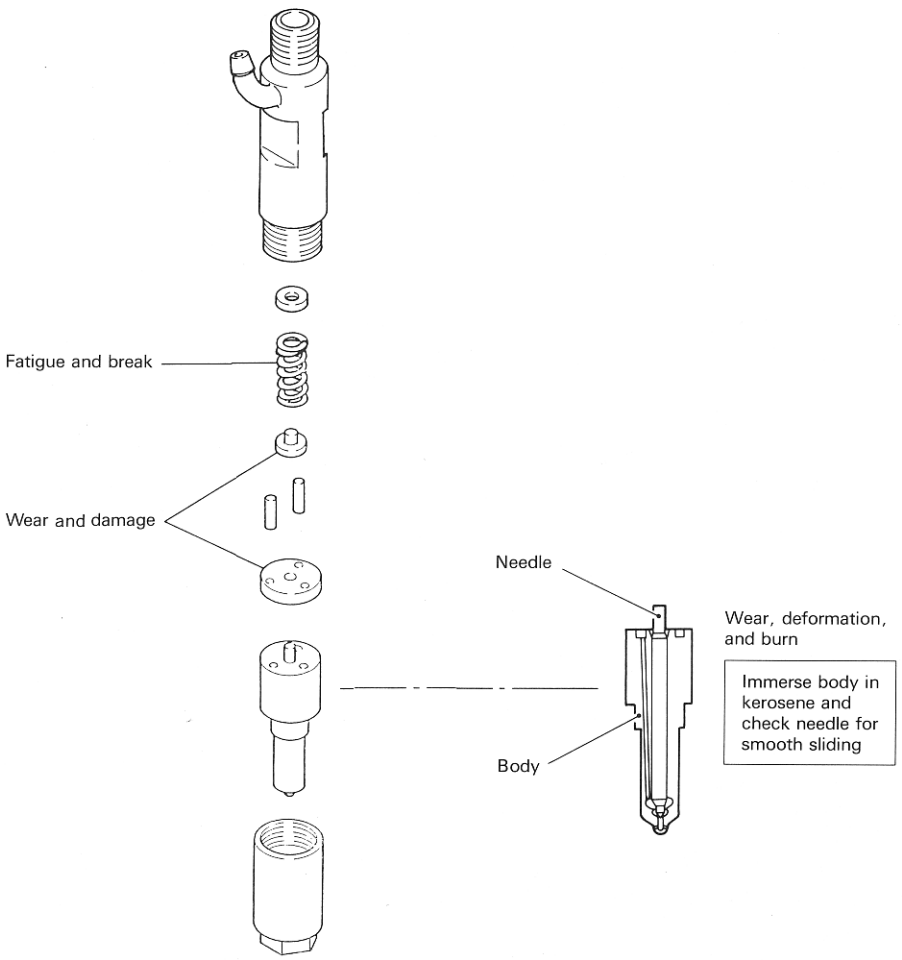
■ Inspection

Check the parts of disassembled nozzle for faulty condition.



■ Assembly

(1) Insert the nozzle tip into the retaining nut.
(2) Install the distance piece, retaining pins, pressure spring and shim.
(3) Tighten the nozzle holder body fully by hand.
(4) Grip the nozzle holder body in the vise and retighten the retaining nut.

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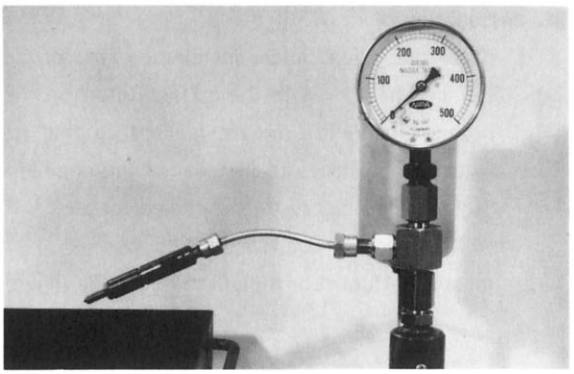
■ Adjustment

Adjust the injection starting pressure of the nozzle. The pressure varies 15 kg/cm² for every 0.1 mm increment in thickness of the shim.

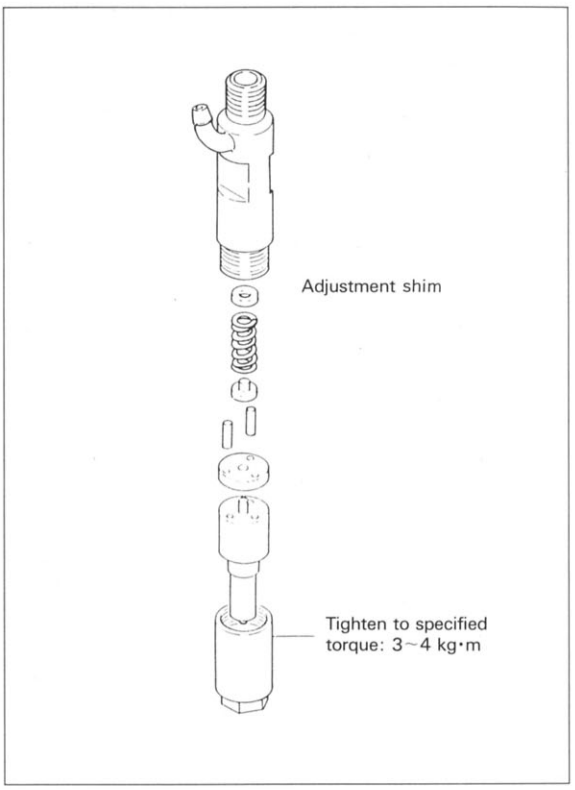
Shim thickness :

13 kinds of shims from 1.20 to 1.80 mm in 0.05 mm step are available. Refer to 0-05 Nozzle Inspection for detailed inspection and adjustment procedure.

Injection starting pressure	
Standard value	220^{+10}_{0} kg/cm²
Service limit	200 kg/cm² max.



Nozzle Injection Test



Installing Nozzle Holder

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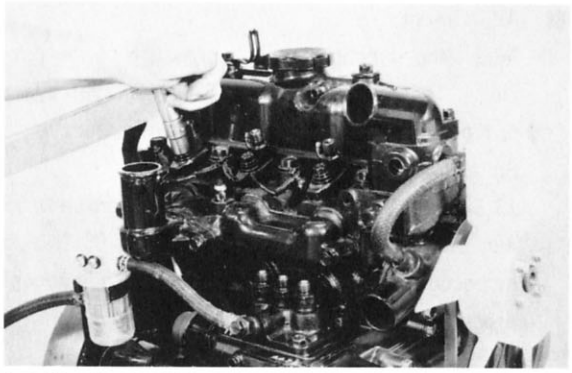
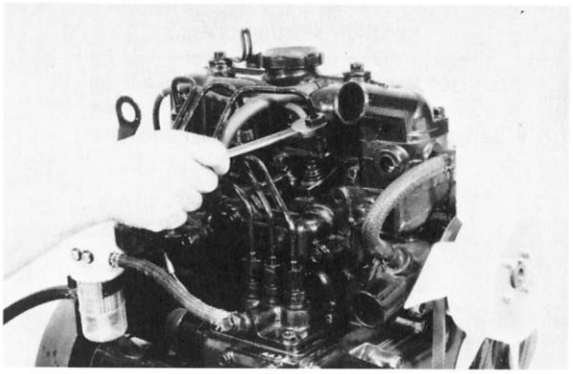
■ Installation

(1) Clean the nozzle holder installation area of the cylinder head. With the gasket fitted on the nozzle, install the nozzle holders so that its return nipple faces to the rear of the engine. Tighten the holders to a specified torque.
- ● Tightening torque : 2.0～2.5 kgm

(2) Install the fuel return pipe and injection pipes.



Installing Nozzle Holder



Installing Injection Pipe

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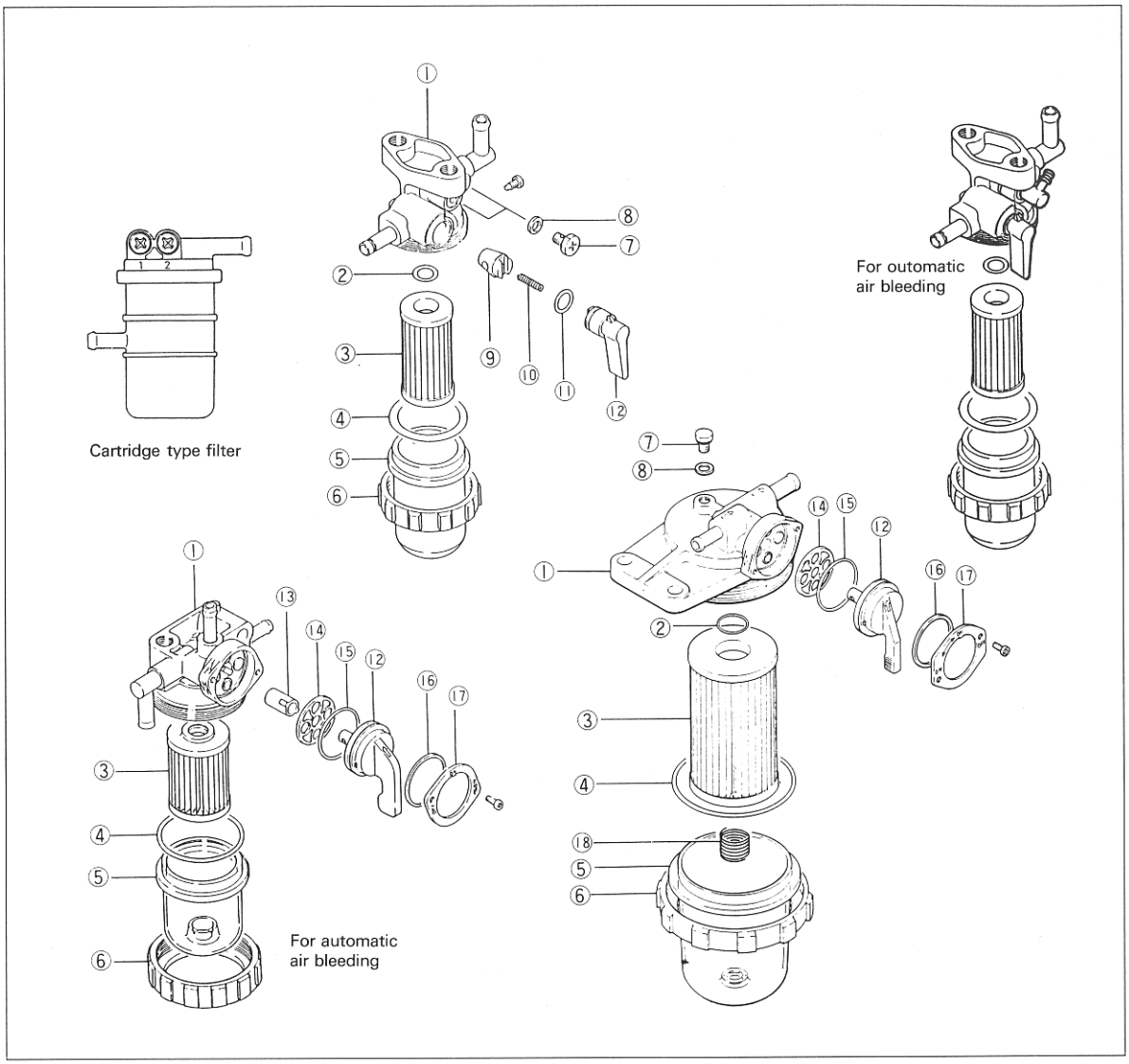
■ Components



① Filter body	⑦ Air vent screw	⑬ Valve seat
② O-ring	⑧ Packing	⑭ Valve packing
③ Element	⑨ Valve	⑮ O-ring
④ O-ring	⑩ Spring	⑯ Wave washer
⑤ Cup	⑪ O-ring	⑰ Lever plate
⑥ Retaining nut	⑫ Cock lever	⑱ Element spring

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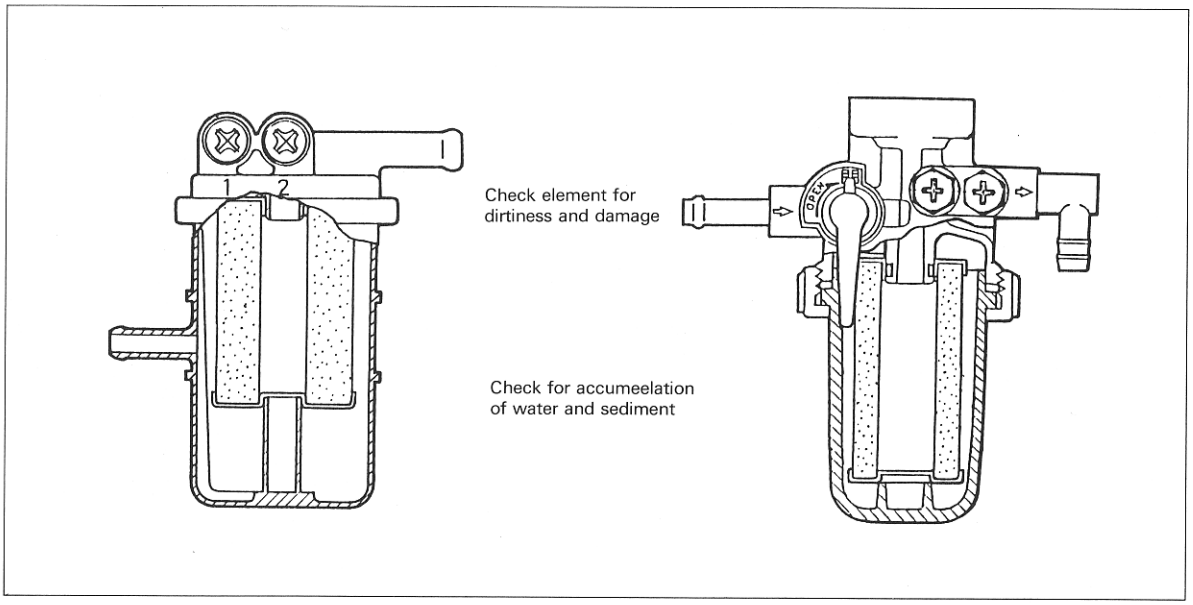
Inspection

Check the fuel filter for dirt or damage. For the disassemble-type filter, periodically remove and clean the element.



Precautions for Disassembly/Assembly

(1) Disassemble the filter only for removal of the element. Do not remove the cock lever unless it is necessary.

(2) Do not remove the fuel inlet, outlet and air bleeder nipple.

(3) When reinstalling the cock lever (the lever-plate installation type only) which has been removed for the purpose of cleaning, coat its O-ring with silicone and wave washer with grease.

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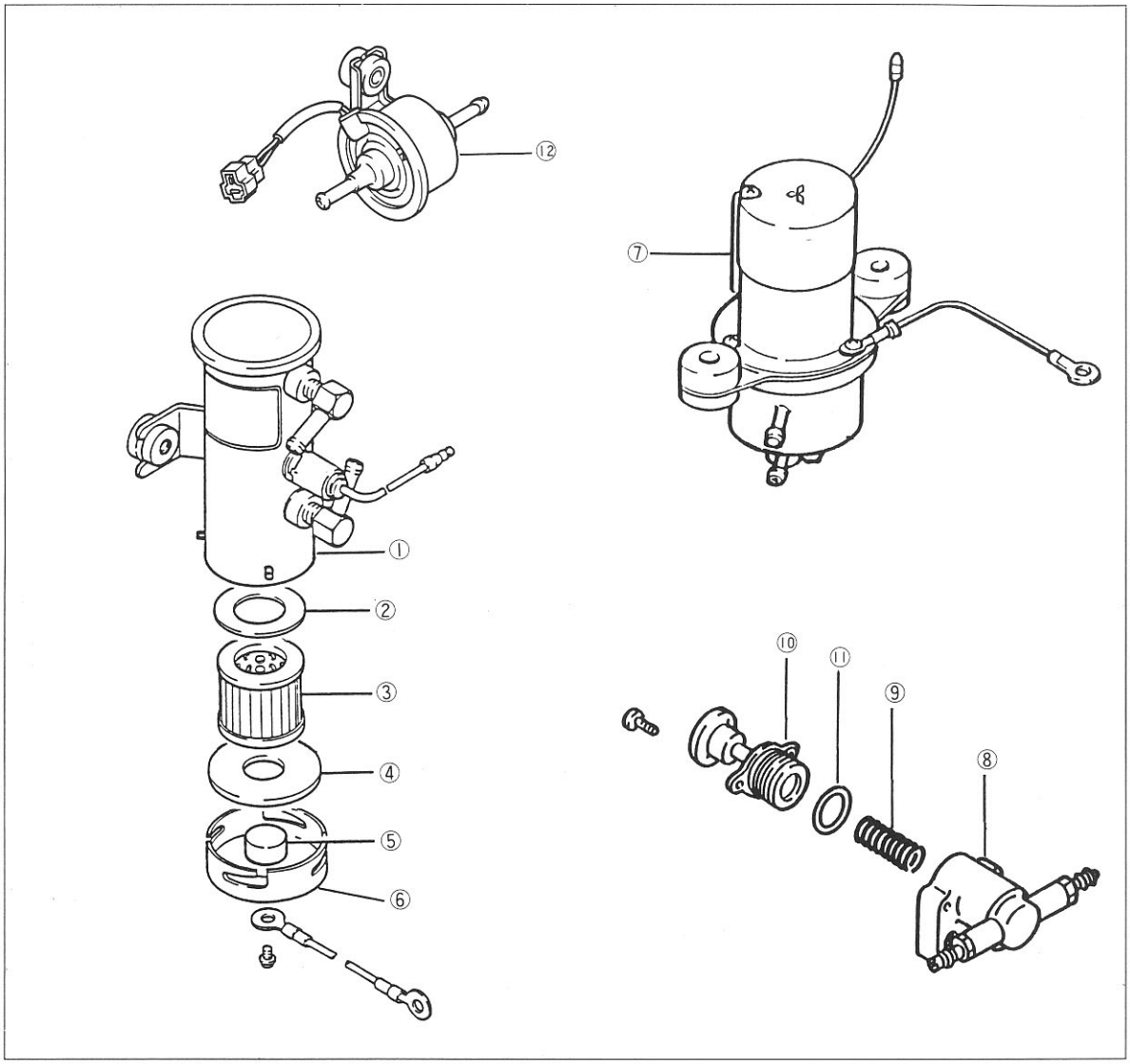
■ Components



① Pump body
② Packing (upper)
③ Element
④ Packing (lower)
⑤ Magnet
⑥ Cover
⑦ Diaphragm type pump
⑧ Hand pump body
⑨ Spring
⑩ Piston assembly
⑪ O-ring
⑫ Fuel pump (compact type)

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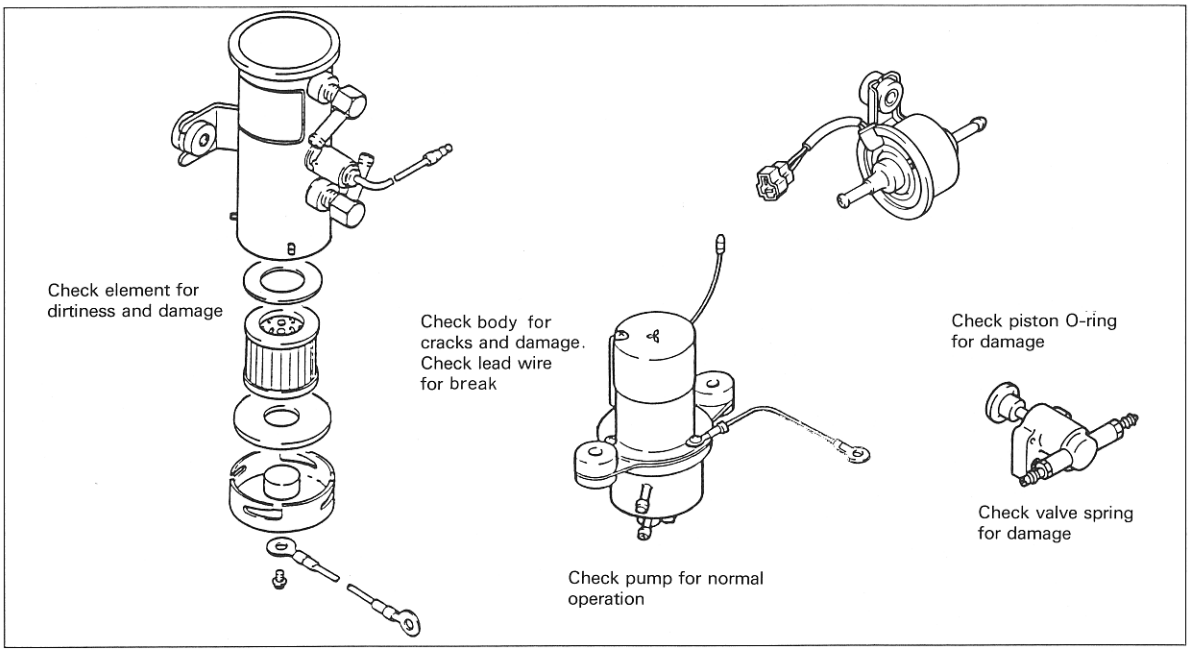
■ Inspection



Item	Standard value			
	Plunger type pump		Diaphragm type pump	Hand pump
	Normal type	Compact type		
Power source	12V DC	12V DC	12V DC	(Manual operation)
Delivery	900cc/minute min.	400cc/minute min.	370cc/minute min.	——
Delivery pressure at shut-off	$0.35^{0}_{-0.07}$kg/cm^2	0.35kg/cm^2 max.	$0.18^{0}_{-0.5}$kg/cm^2	——
Pump capacity	——		——	4.5cc/stroke

■ Precautions for Disassembly/Assembly

(1) Do not try to disassemble the diaphragm type pump. Check the pump for external damage and delivery function only.

(2) The plunger type pump has a filter element which can be replaced. Disassemble the pump only when replacement of the element is necessary.

(3) Do not disassemble the inlet and outlet nipples of the hand fuel pump.

(4) After reassembling a pump, make sure that no fuel leaks under pressure.

(5) Install the compact fuel pump for the models K4 F-D12A and D13A so that its wire leads face the fuel inlet side.

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Group 4 GOVERNOR SYSTEM

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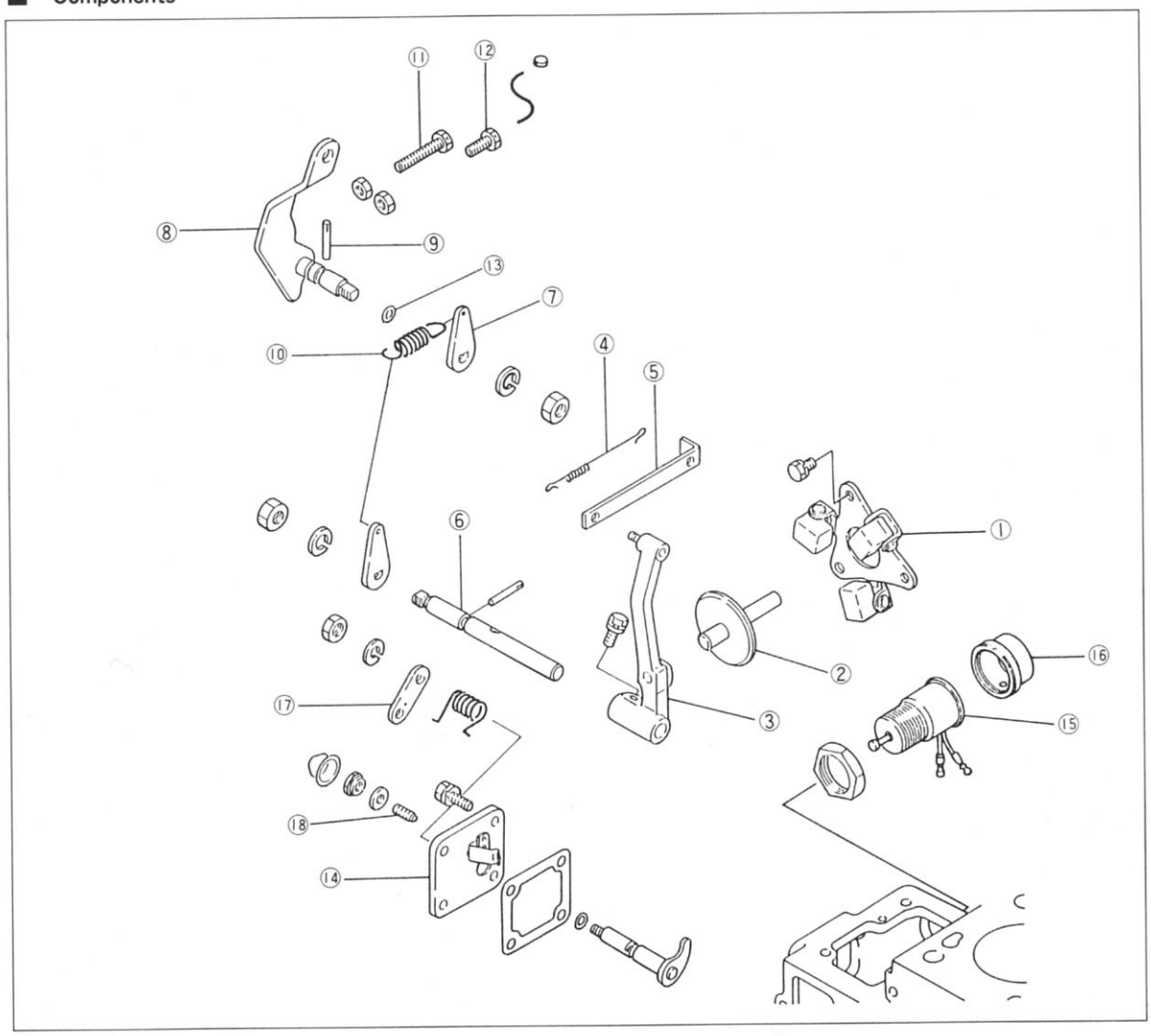
■ Specifications

Item	Specification
Governor type	Centrifugal weight type
Governor spring	One stage type (Except K4 series for tractor)
	Two stage type (K4 series for tractor)

■ Components



① Weight assembly
② Sliding shaft
③ Governor lever assembly
④ Tie rod spring
⑤ Tie rod
⑥ Governor shaft
⑦ Spring lever
⑧ Speed control lever
⑨ Pin
⑩ Governor spring
⑪ Speed set bolt (high)
⑫ Speed set bolt (low)
⑬ O-ring
⑭ Tie rod cover
⑮ Solenoid
⑯ Solenoid cap
⑰ Manual stop lever
⑱ Damper adjust screw

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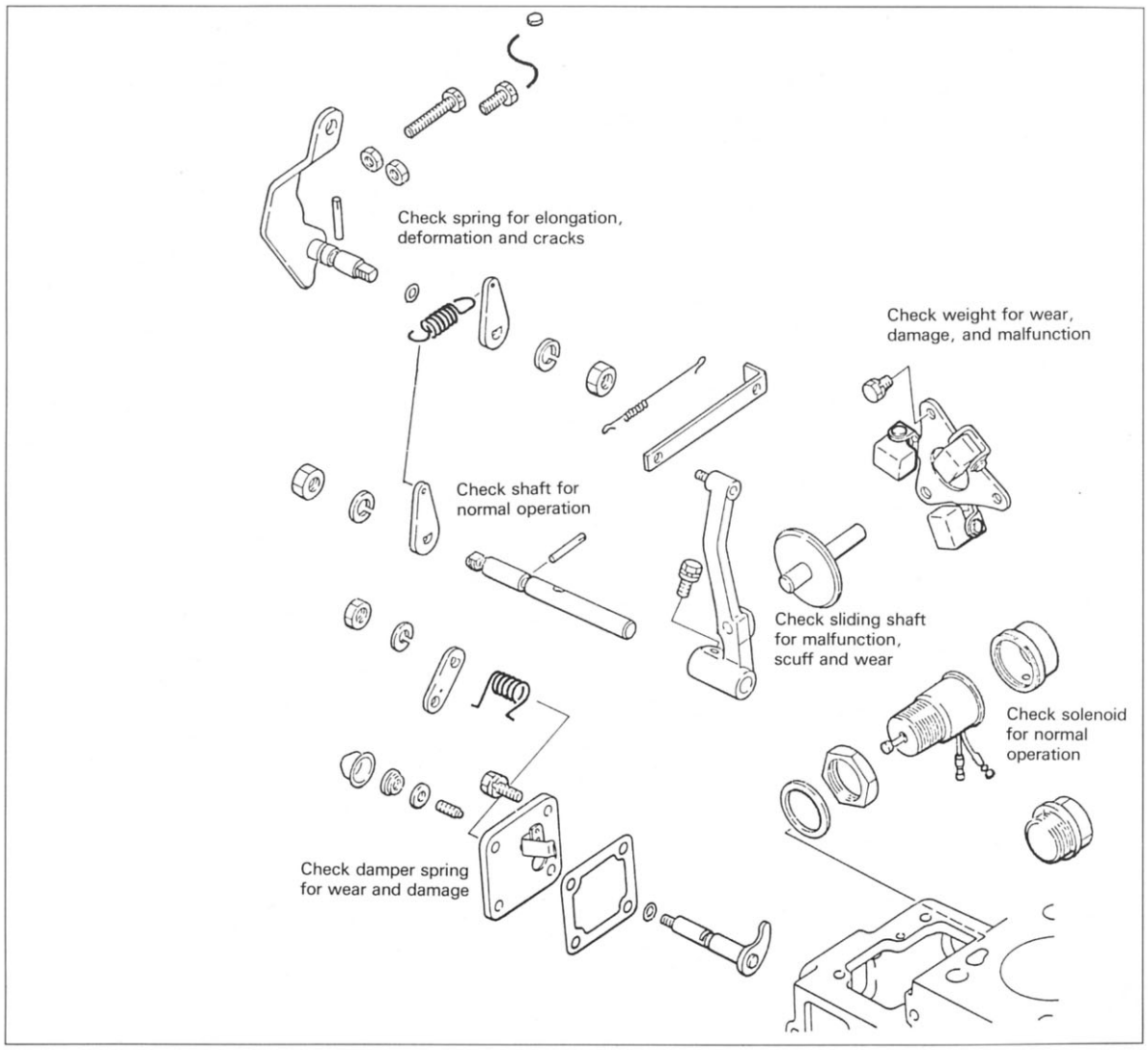
■ Inspection

Remove the gear case and inspect the governor parts. Before removing the gear case, remove the tie rod cover at the injection pump side and disconnect the tie rod from the rack. Refer to 0-06 Gear case for other information.

Check the governor parts in the following manner and replace the faulty parts.



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■ **Removal／Installation**

(Refer to the Engine Group I, Gear Case.)

■ **Removal**

(1) Lever removal

(a) Remove the grooved pins from the governor lever and speed control lever.

(b) Loosen bolts fastening the levers and shafts.

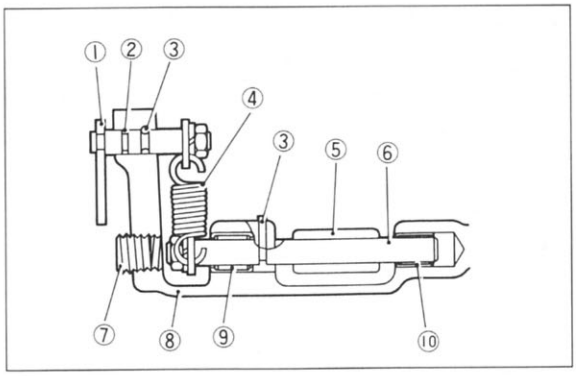
(c) Remove the shaft from the gear case.

(2) Installation

Install the governor parts while making sure that all levers and shafts operate smoothly.

Caution

- **Check shafts for smooth operation after driving in grooved pins.**
- **Apply oil to the O-rings when assembling.**
- **Do not slacken the governor spring when installation.**



Installing Governor Shaft

① Speed control lever
② O-ring
③ Pin
④ Governor spring
⑤ Governor lever
⑥ Governor shaft
⑦ Taper screw
⑧ Gear case
⑨ Needle bearing (large)
⑩ Needle bearing (small)

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Group 5

COOLING SYSTEM

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■ Specifications

Item		Specification
Fan belt	For agricultural and industrial engines	LL or HM type (Belt width 10.7, V angle 38°) Periphery length : 932, 940, 964, 980
Cooling fan	Suction type	5 blades : ϕ320 : ϕ340 6 blades : ϕ290 : ϕ310 7 blades : ϕ360
	Suction type	6 blades : ϕ360 : ϕ390
Water pump		Centrifugal impeller
Thermostat	82°C	Wax type Valve opening temperature : 82±1.5°C Full opening temperature : 90°C (at approx. 8 mm valve lift)
	76.5°C	Wax type Valve opening temperature : 76.5±1.5°C Full opening temperature : 90°C (at approx. 8 mm valve lift)
Thermo switch	111°C	Bimetal type Closing temperature : 111±3°C Resistance between terminals : 1.0±0.4Ω
	108°C	Bimetal type Closing temperature : 108±3°C Resistance between terminals : 1.0±0.4Ω
Thermo unit	More than 70°C	Thermistor type Temp./Resistance (°C/Ω) : 70/104±13.5, 115/23.8±2.5
	More than 50°C	Thermistor type Temp./Resistance (°C/Ω) : 50/350±20, 90/81±5, 120/36.2±2.5

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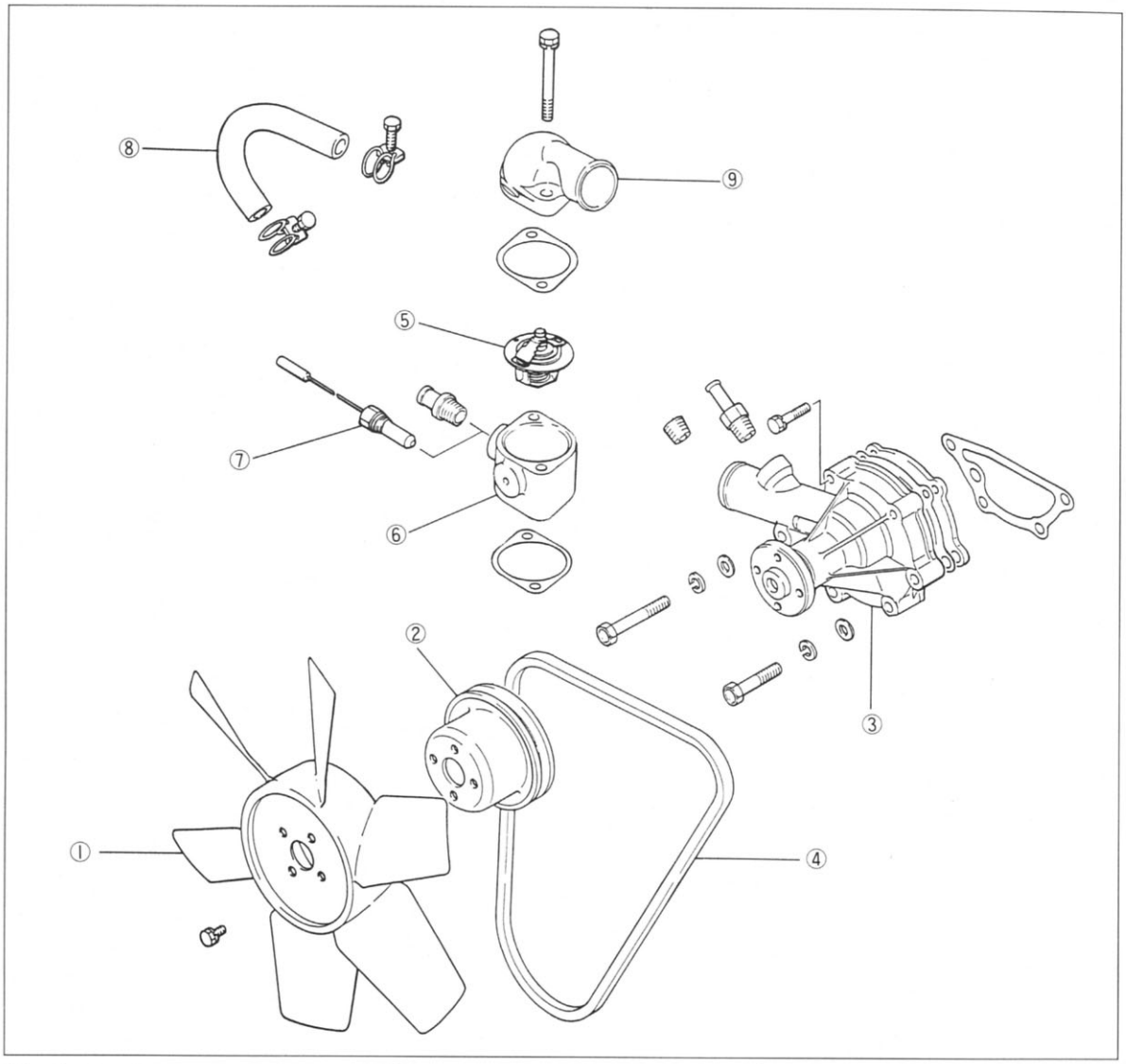
■ Components



① Cooling fan
② Water pump pulley
③ Water pump assembly
④ V-belt
⑤ Thermostat
⑥ Thermostat fitting
⑦ Thermo switch
⑧ Bypass hose
⑨ Water outlet fitting

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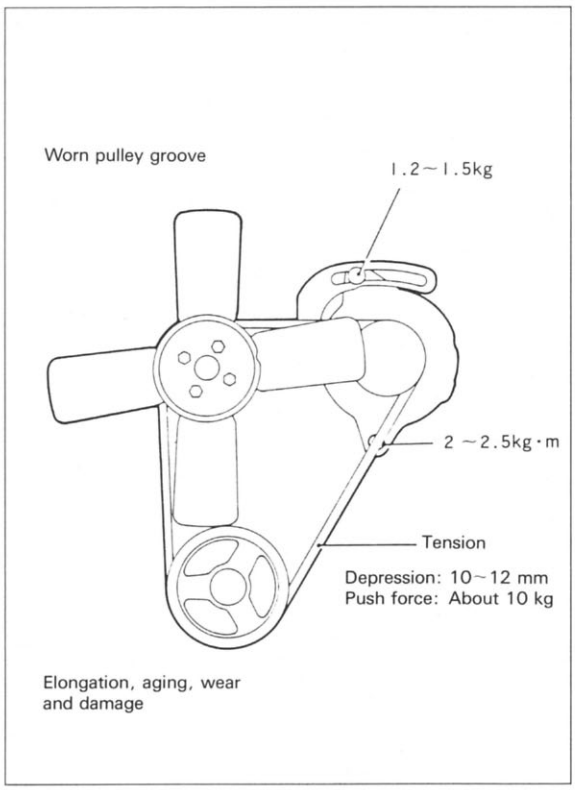
■ **Fan Belt Inspection**

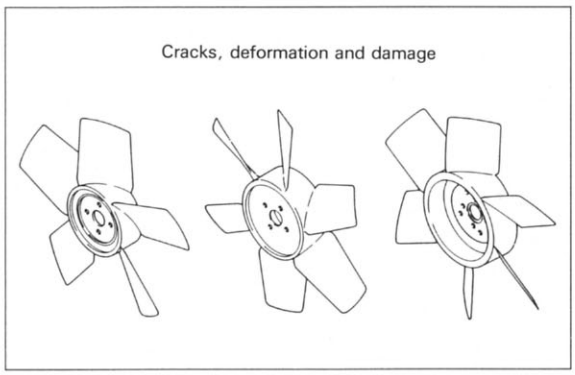
Refer to " Group 0, Maintenance" for fan belt tension.



Fan Belt Inspection

■ **Fan Inspection**

Check the fan for abnormality. It necessery, replace.



Fan Inspection

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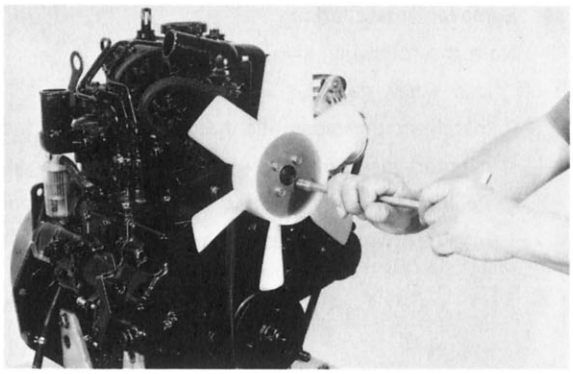
Group No. 5-03

■ Removal／Installation

(1) Remove the fan and fan belt.
(2) Remove the water pump.
(3) Install the water pump in the reverse order of removal.



Installing Fan

■ Inspection

Check the water pump for water leakage, irregular run, cracks, and other damage. Replace the water pump assembly if necessary.

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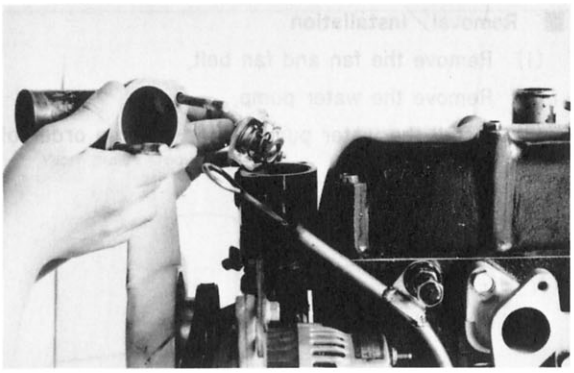
■ Removal／Installation

Note the following.

(1) Use a new gasket.

(2) Install the thermostat so that its flange seats the counter bore properly.

(3) Position the thermostat so that its stay does not interfere with the water temperature gauge.



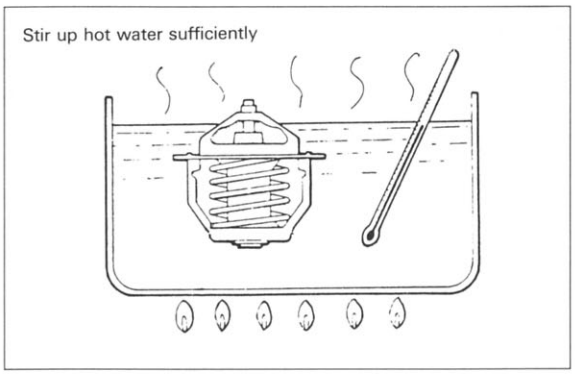
Installing Thermostat

■ Inspection

Replace the thermostat if it is faulty.

Start to open : 76.5 °C

Full open (at 8 mm lift) : 90 °C



Thermostat Inspection

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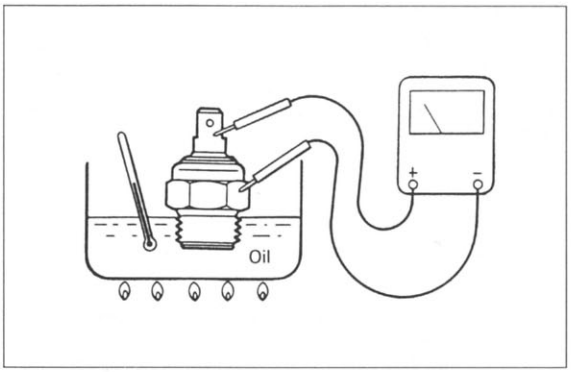
■ **Thermo Switch Inspection**

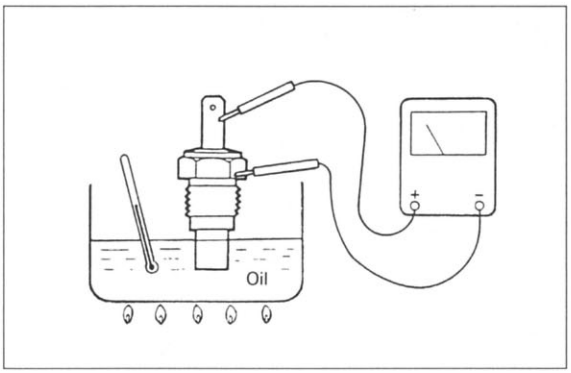
Replace the thermo switch if it is faulty.
Refer to the specification in this chapter for closing temperature and resistance between the terminals.



Thermo Switch Inspection

■ **Thermo Unit Inspection**

Refer to the specification in this chapter for the specified temperature/resistance.



Thermo Unit Inspection

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Group 6

AIR CLEANER

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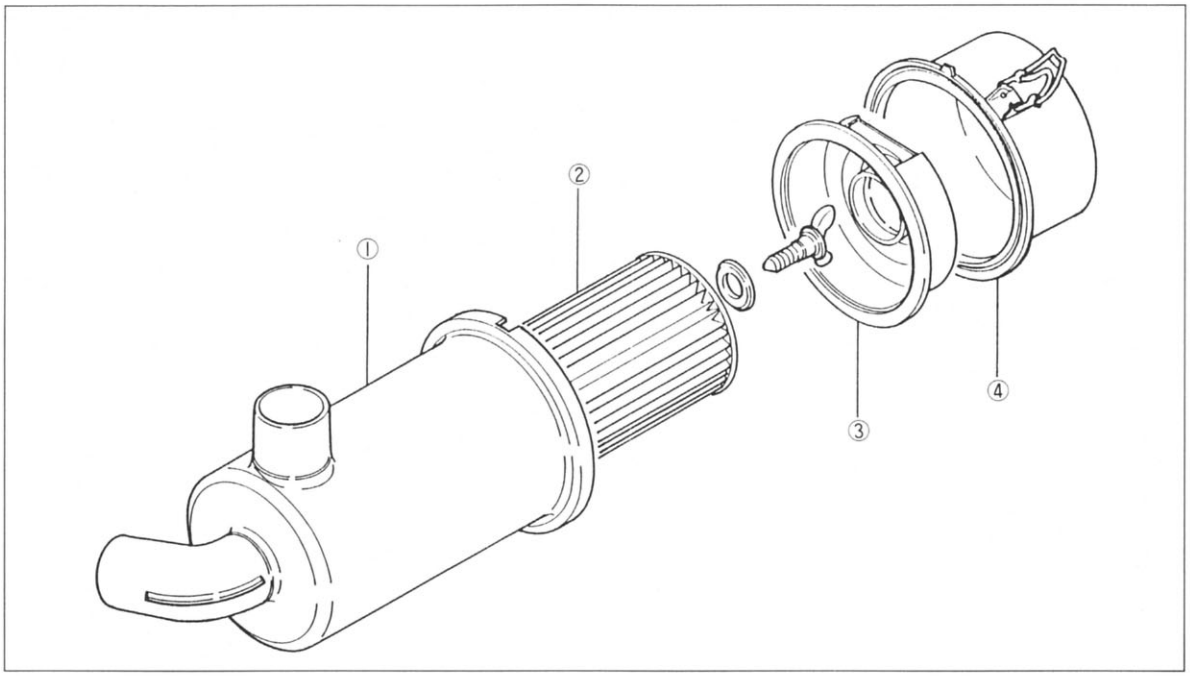
■ Components



① Body assembly
② Element assembly
③ Plate
④ Dust pan assembly

■ Inspection

(1) Check the body and cover for distortion, corrosion and damage. Repair or replace if necessary.
(2) If sealing of the body and cover is insufficient, dust will enter the engine and the cylinder and piston may be worn early. Check the inside of the body for traces of entering dust and repair if necessary.
(3) Check the element and packing for air leakage or damage and replace if necessary.
(4) Clean or replace the element if it is clogged or damaged.
(5) Check the intake hose for damage and cracks. Replace if necessary.

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Group 7 ELECTRICAL SYSTEM

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■ Specifications

Item				Specification		
Starter	Model			M2T50381	M2T56271	M2T56272
	Type			DC electromagnetic push-in type (with reduction gear)	←	←
	Output			12V-1.6kW	12V-2.0kW	←
	Performance (at 20°C)	No load characteristic	Terminal voltage	11.5V	11V	←
			Current	100A max.	130A max.	←
			Speed	3000 rpm min.	3850 rpm min.	←
Alternator	Model			AR2115Z_2	AH2035M_4	A0T25171 and A0T25271
	Type			AC (Separate regulator)	AC (Separate regulator)	AC (Built-in IC regulator)
	Output			12V-15A	12V-35A	12V-40A
	Performance (at 20°C)	With out	Terminal voltage	14V	←	
			Current	0A (at cold)	←	
			Speed	1300 rpm max.	←	
		With load	Terminal voltage	14V	←	13.5V
			Current	15A min. (at cold)	30A min. (at cold)	21A (at hot)
			Speed	2500 rpm max.	←	←
			Terminal voltage			13.5V
			Current			37A (at hot)
			Speed			5000 rpm max.
	Regulating voltage					14.7±0.3V
Regulator	Model			RQB2220D_4 (Separate type)		
	Type			Tirrill type 2-element		
	Regulating voltage			14.8V		
	Pilot lamp		Off voltage	4.2 ~ 5.2V		
			On voltage	0.5 ~ 3.0 V		
Glow plug	Model			Y-142T		
	Type			Sheathed type (immediately heating type)		
	Rated voltage			10.5V		
	Current			9.7A±1.0A (rated voltage applied for 30 seconds)		
	Resistance at normal temperature			0.16Ω		
Glow lamp	Model			DH-139V-29		Not applied to engines with glow relay
	Type			Red heat type (immediately heating type)		
	Rated current			29A		
	Voltage between terminals			1.7±0.2V		

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Item			Specification
Glow timer	Model		S8INJ
	Rated voltage		12V DC
	Initial characteristic		6 sec. (at normal temperature and humidity, Vcc = 12V)
Glow relay	Model		G71SP
	Rated voltage		12V DC
	Continuous rating		1 minute
	Coil resistance		13 Ω
Timer unit control	Model		YM-1B
	Input voltage range		9 ～ 15V DC
	Load		Solenoid (coil resistance 1.7 Ω min.)
Solenoid	Model		YMS-1
	Type		Push type
	Coil resistance		1.8 ± 10% (at 20°C)
	Stroke		13.5mm
	Voltage		10 ～ 15V DC
Electric service indicator	Model		REX00-8690
	Source voltage		12^{+4}_{-1}V DC
	Operating temperature range		−40°C～+80°C
	Adaptable load		12V DC, 3W (lamp)
	Operating resistance		Continuity at more than 508 mm H_2O
Battery	For standard	K3	12-60AH min.
		K4	12V-70A min.

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■ Wiring Diagram

1. The nominal size of the low voltage wire for automobile (JIS. C3406) is indicated on each wire lead.
2. The wiring diagrams for the standard, engines, the key-OFF stop engines, and the engines with glow timer are indicated. When modifying the electrical wiring for an engines-driven machine, the following should be taken into careful consideration.

CAUTION

- **The G and R wires for the control timer unit should be minimized in their wiring resistance to prevent influence noises (voltage variation, etc.) of other electrical equipment.**
- **Note the polarity of the diode between the key switch and the alternator L terminal. (If the diode is connected in the reverse polarity, the key-OFF stop will not operate.)**

3. Operating combination of the key-OFF stop system (solenoid)

Engine	Engine key	Oil pressure switch	Solenoid	Injection pump control rack	Function
Starting	ON	ON	ON	STOP	
	START	OFF	OFF	MS	Increase for starting
Running	ON	OFF	OFF	(SS)	Normal run
	ON	ON	ON	STOP	Emergency stop at abnormal oil pressure
	OFF	OFF	ON	STOP	Key-OFF engine stop

4. Key switch connection of key-OFF stop system (auto glow type)

Key switch	Connection	Remarks
OFF	B−OFF	
ON	B−ON	Current flows to glow circuit for a fixed period (6 sec.) when key is ON. (Lamp comes on)
ST	B−ST−ON	Current flows to glow circuit at starting. (Lamp comes on)

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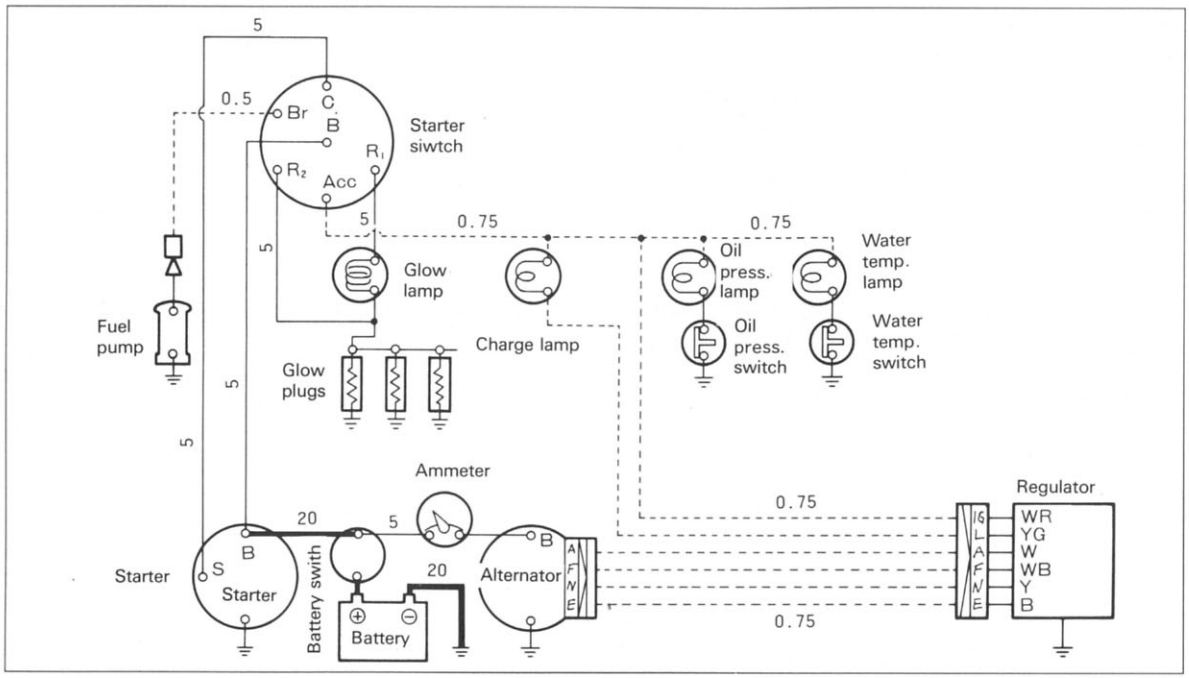
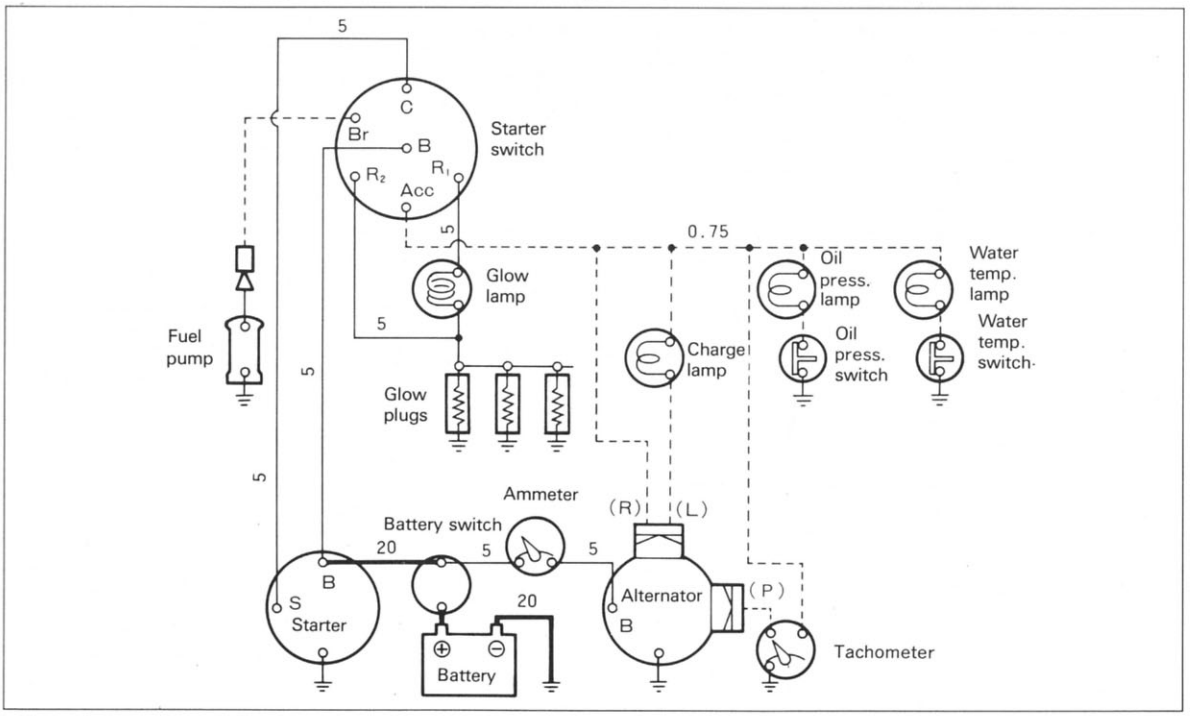
5. Wiring diagrams

(1) Standard type (Having alternator and separate regulator)



(2) Standard type (Having alternator with buit-in IC regulator)



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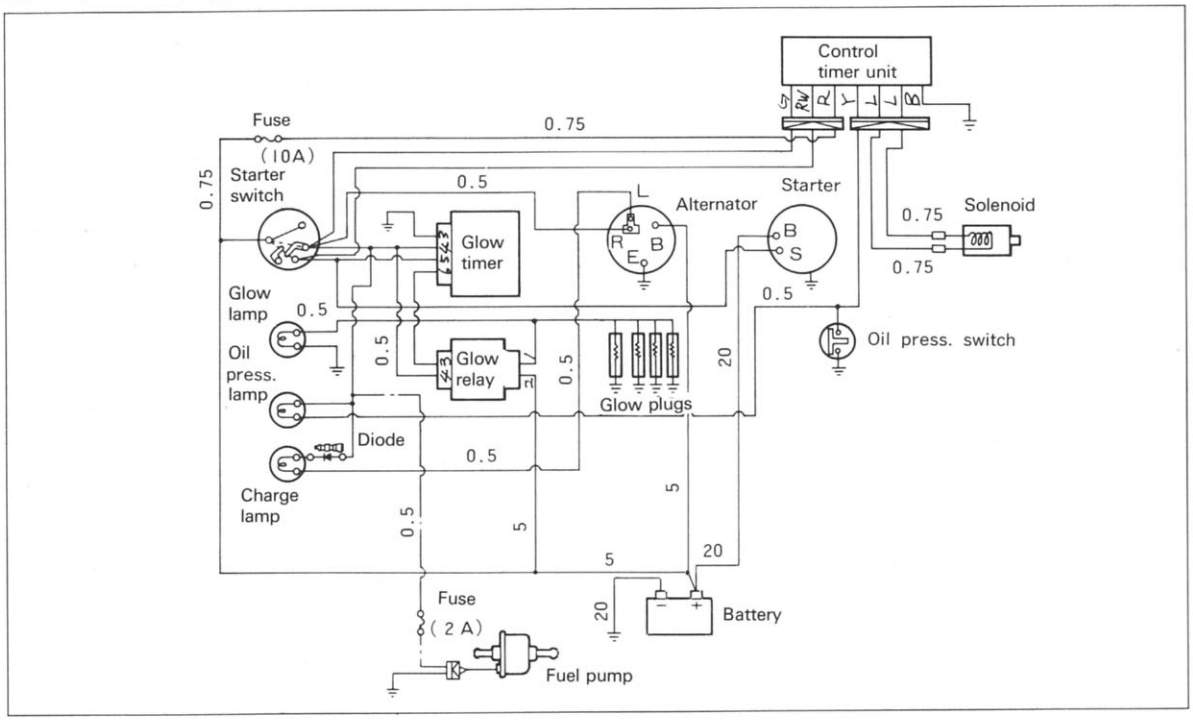
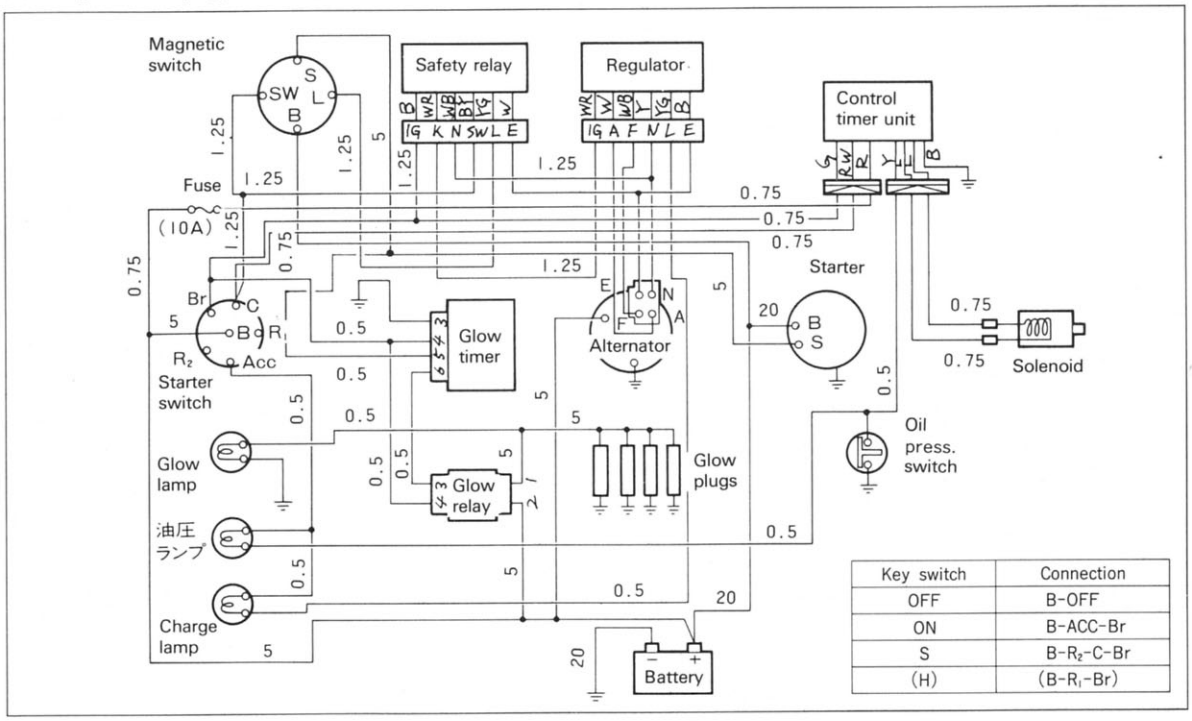
(3) Key-OFF stop type



(4) Key-OFF stop type with glow timer and safety relay



Key switch	Connection
OFF	B-OFF
ON	B-ACC-Br
S	B-R_2-C-Br
(H)	(B-R_1-Br)

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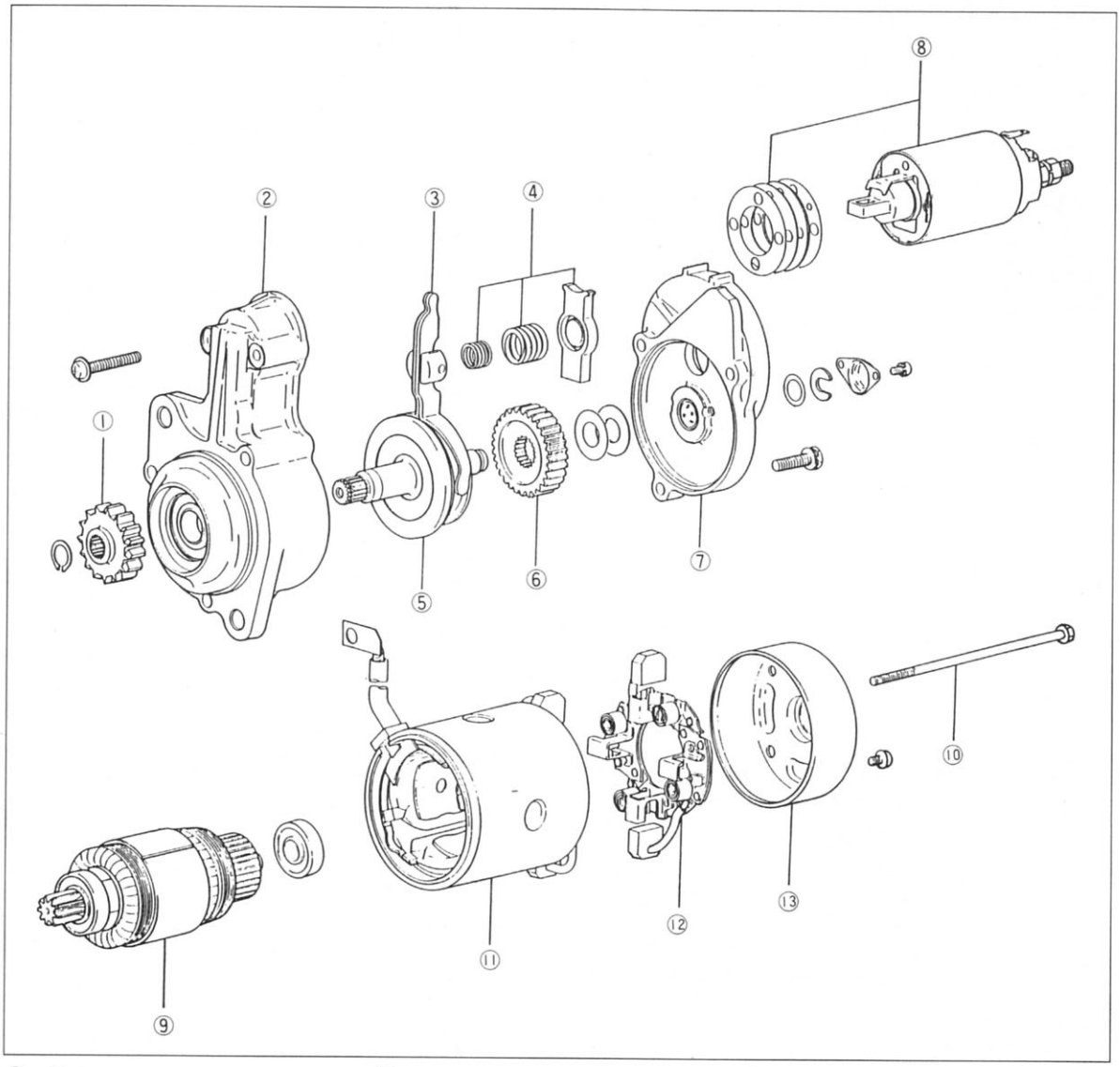
Components



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

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■ Starter Assembly Inspection

(1) Pinion gap

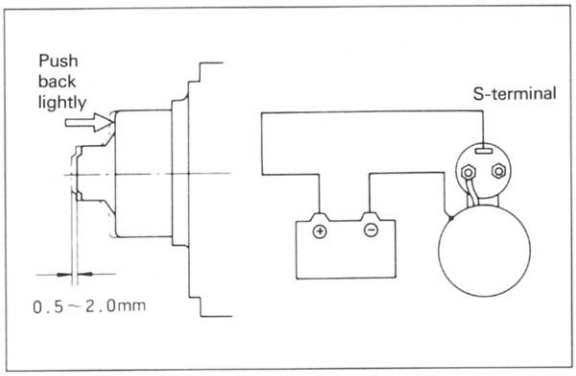
(a) Connect the S terminal of the starter to the positive (+) terminal of the 12V battery and the M terminal to the negative (−) terminal to slide out the pinion.

Caution

- **Do not apply voltage continuously for more than 10 seconds.**

(b) Push back the pinion with finger and measure this gap.

(c) If the gap is not within 0.5 ~ 2.0 mm, adjust it by increasing or decreasing the number of shims at the switch. Increasing of the number of shims will reduce the pinion gap.



Pinion Gap Inspection

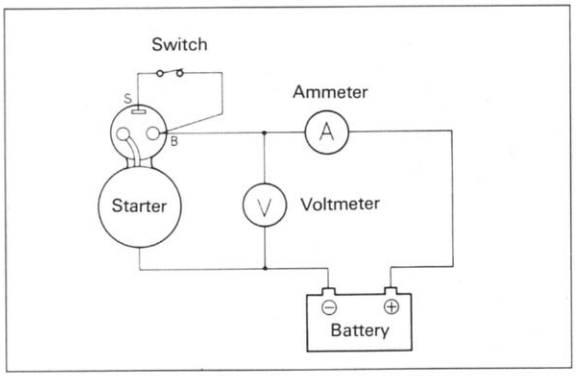
(2) No-load test

(a) Connect the ammeter, voltmeter and battery as shown in the figure.

(b) The pinion will be pushed out and starter turn smoothly at specified rpm or more when the switch is turned ON. If the current or rpm is not within specification, disassemble the starter and inspect it.

Caution

- **Use lines as thick as possible and tighten each terminal securely.**
- **Rotating noise of the reduction type starter may be loudly as compared with pinion direct driven type starter.**
- **In the case of measuring rpm at the end of the pinion, take care of protrusion of the pinion when the switch is turned ON.**



No-Load Test

Description		Standard value		
Starter model		M2T50381	M2T56271	M2T56272
Nominal output (V−kW)		12−1.6	12−2.0	12−2.0
No-load characteristic	Terminal voltage (V)	11.5	11	11
	Current (A)	100 max.	130 max.	130 max.
	Speed (rpm)	3000 min.	3850 min.	3850 min.

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(3) Magnetic switch

Disconnect the M terminal connector of the magnetic switch and perform the following inspection. Replace the magnetic switch assembly if it is faulty.

(a) Attraction test

The pinion must be pushed out when the battery is connected between the S and M terminals of the magnetic switch.

Caution

- **Do not connect the battery for more than ten seconds.**

(b) Holding test

Connect the battery between the S termial of the magnetic switch and the body and pull out the pinion fully by hand. The pinion must not return when it is released from the hand.

Caution

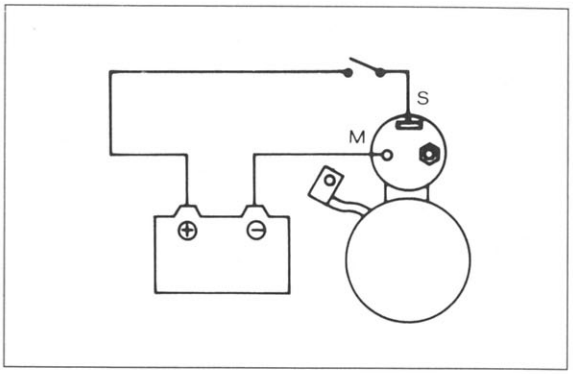
- **Do not connect the battery for more than ten seconds.**

(c) Return test

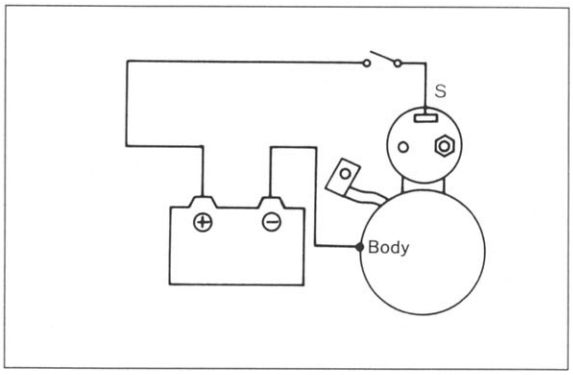
Connect the battery between the M terminal of the magnetic switch and the body and pull out the pinion fully by hand. The pinion must return immediately when it is released from the hand.

Caution

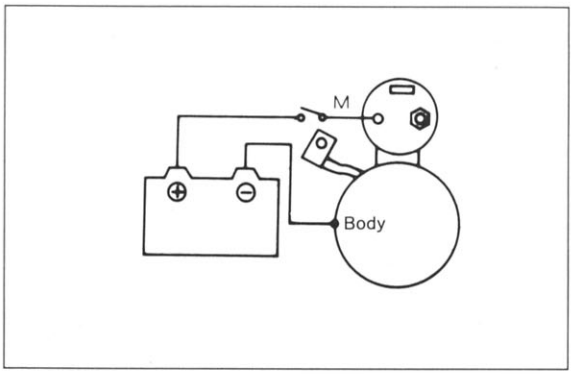
- **Do not connect the battery for more than ten seconds.**



Attraction Test



Holding Test



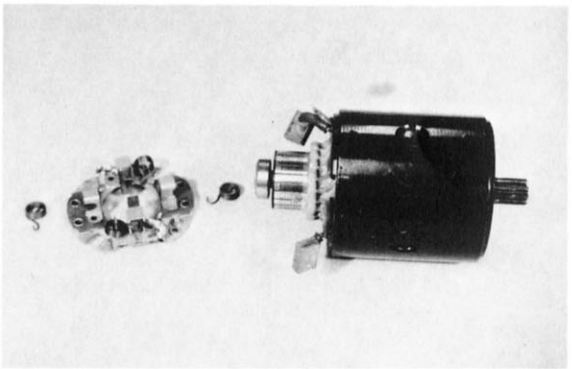
Return Test

■ Disassembly

(1) Loosen the nut on the M terminal and remove the connector.

(2) Remove the two screws attaching the magnetic switch. Remove the switch assembly.

(3) Remove the two through bolts, and two screws attaching the brush holder. Remove the rear bracket.



Removing Brush Holder Assembly

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(4) Remove the yoke and brush holder assembly while releasing the two brushes. Remove the armature.

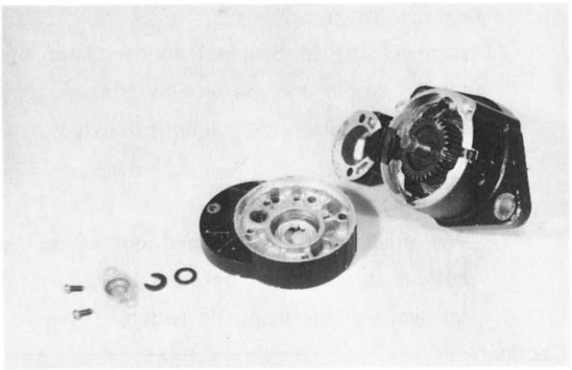
(5) Remove the cover, snap ring and washer.

(6) Remove the bolts and center bracket. Adjust the pinion shaft end play. Remove the snap ring to remove the end play adjusting washer.

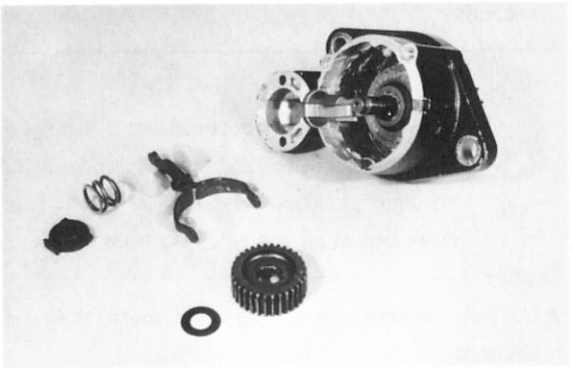
(7) Remove the reduction gear lever and the lever spring from the front bracket.

(8) Remove the snap ring from the pinion end. Remove the pinion and shaft.

(9) Remove the bearings from both ends of the armature using a bearing puller. The bearing pressd in the front bracket can not be replaced. Replace the front bracket assembly if the bearing is worn or damaged.



Removing Center Bracket



Removing Reduction Gear

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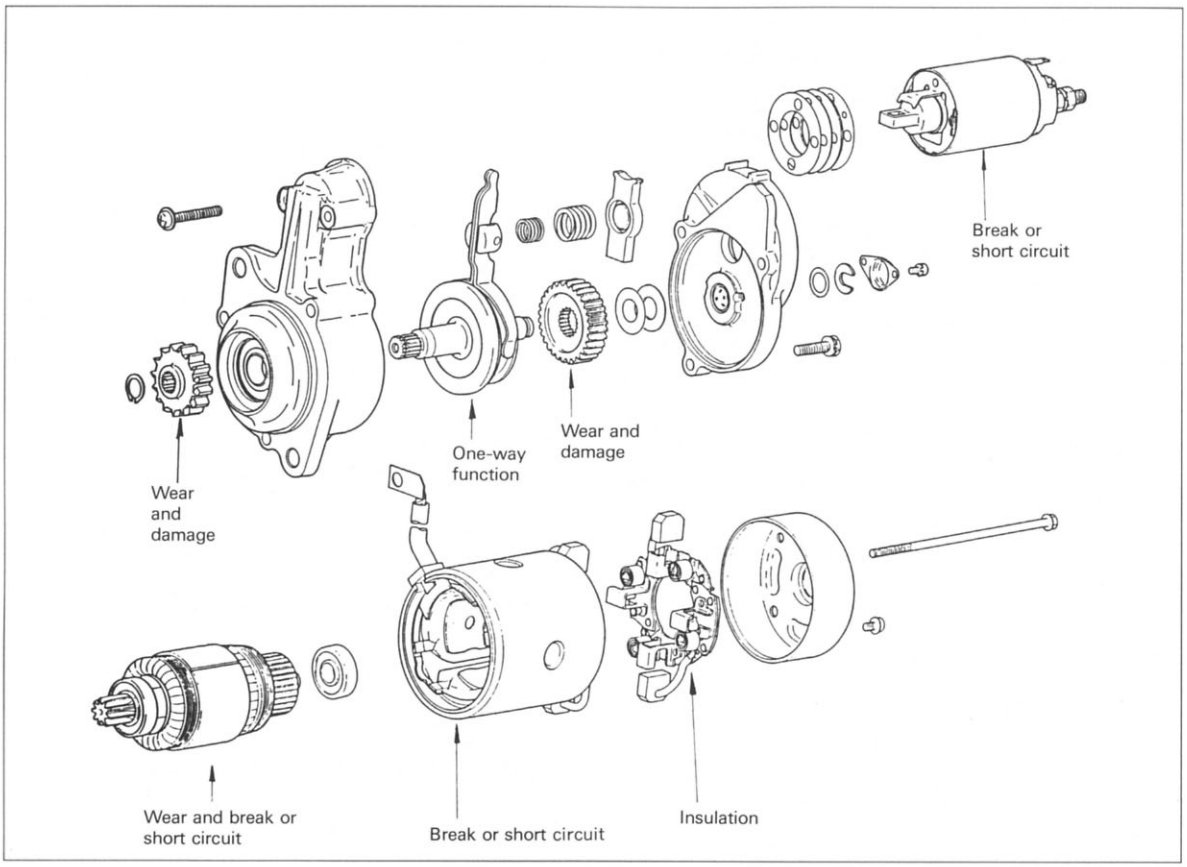
■ Inspection after Disassembly

Check the disassembled starter for faulty conditions.

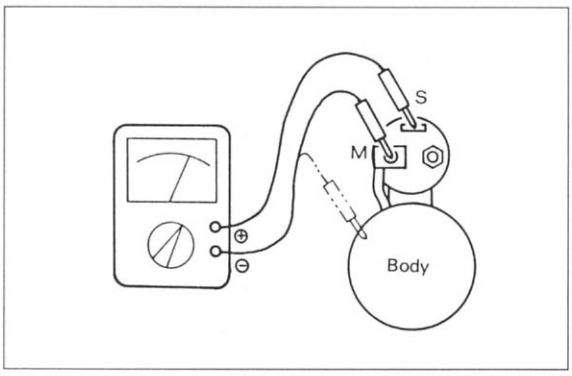


Armature		
Description	Standard value	Service limit
Undercut depth	0.5 mm	0.2 mm
O. D. of commutator	32 mm	−1.0 mm

Brush		
Description	Standard value	Service limit
Brush length	17 mm	6 mm
Spring force	3 kg	

(1) Magnetic switch inspection

Check for continuity between the S and M terminals, and the S terminal and body, respectively. If resistance is zero, it indicates short circuit and the magnetic switch should be replaced.



Magnetic Switch Inspection

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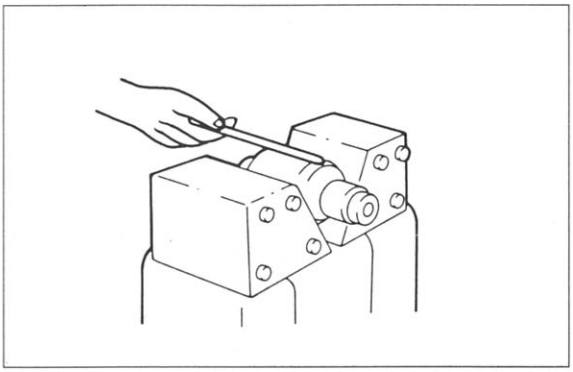
(2) Armature inspection

(a) Check the armature using a growler tester. Replace the armature if there is short circuit. Check for continuity between the commutator and the shaft. Replace if there is continuity.

(b) Measure the O. D. of the commutator and depth of undercut. Repair or replace if they exceed the service limit. If the commutator surface is roughened, polish with a fine sand paper.



Short-Circuit Test of Armature Coil

(3) Brush holder

(a) Check the brushes for wear. If they are worn to the wear limit line, replace with new ones.

(b) Check the brush spring tension. Replace the brush holder assembly if the tension is not correct.

(c) Check for continuity between the positive (+) side brush holder and the brush holder base. Replace the holder assembly if there is continuity. Also check the brush holder staked area for looseness.

(4) Field coil inspection

(a) Check for continuity between the coil end (brush) and the yoke. There must be no continuity.

(b) Check for continuity between the coil ends (brushes). There must be continuity.

(c) Check the pole piece and coil for looseness.

Field Coil Inspection

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■ Assembly and Adjustment

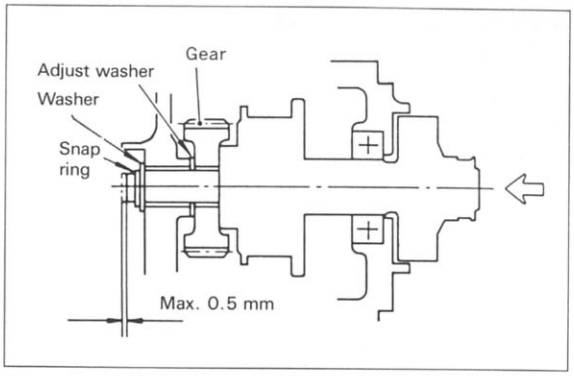
Assemble the starter in the reverse order of disassembly while noting the following items.

(1) Pinion shaft end play adjustment

Adjust the end play (thrust gap) to less than 0.5 mm by inserting the adjusting washer between the center bracket and the reduction gear.

(a) Install the pinion shaft, reduction gear washer and snap ring to the center bracket.

(b) Measure the end play by moving the pinion shaft in the axial direction. Adjust by adding the adjusting washer if the end play exceeds 0.5 mm.



Adjusting Thrust Gap

(2) Lubrication

Apply grease to the following friction surfaces, gears and bearings when the starter is overhauled.

- Armature shaft gear and reduction gear
- All bearings
- Washer and snap ring of the pinion shaft
- Bearing sleeve
- Pinion
- Friction surfaces of the lever

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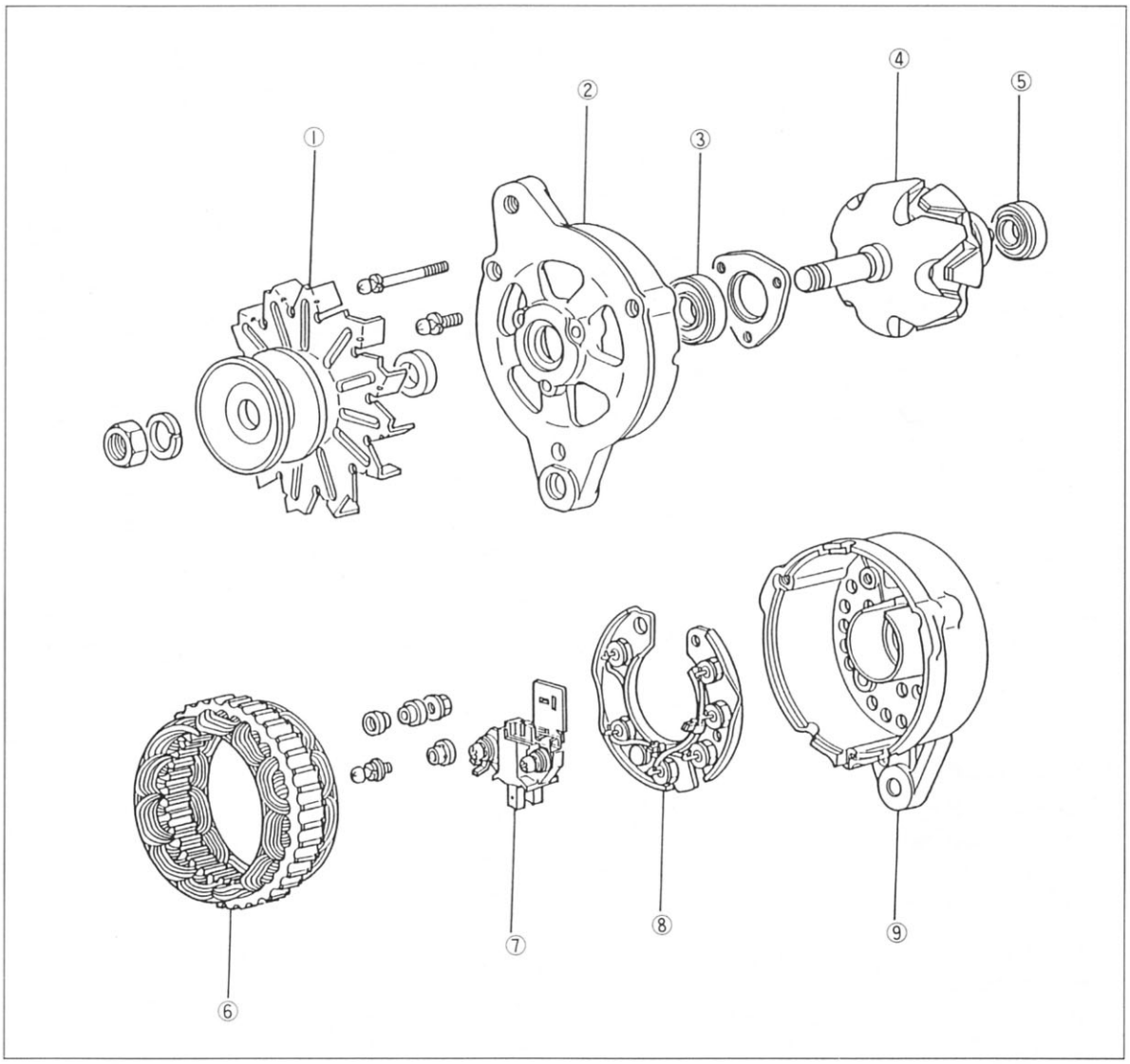
■ Components (Separate regulator type)



① Pulley
② Front bracket
③ Front bearing
④ Rotor assembly
⑤ Rear bearing
⑥ Stator
⑦ Brush holder assembly
⑧ Rectifier assembly
⑨ Rear bracket

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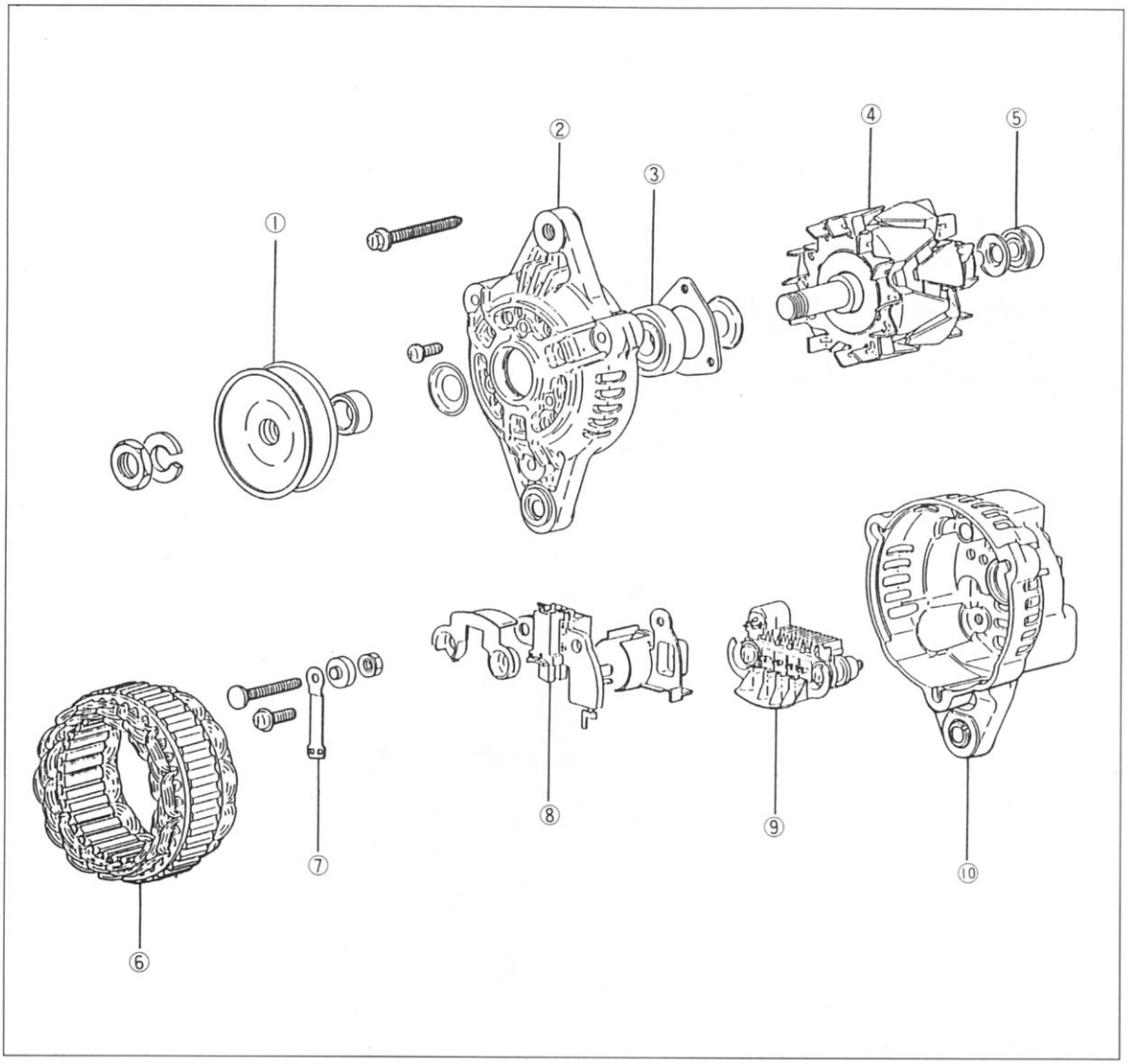
■ Components (Built-in IC regulator type)



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

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■ Inspection on Engine

1. Precautions for Inspection

Note the following precautions to prevent the alternator from damage or trouble.

(a) Do not connect the battery in reverse polarity. The negative (−) terminal should be connected to ground.

(b) Do not use a high voltage tester such as a megger.

(c) Disconnect the cables from the battery when recharging the battery.

(d) Do not disconnect the lead wire from the alternator B terminal when the engine is running.

(e) Do not ground the alternator B terminal because battery voltage is always applied to it.

(f) Take care not to short or ground the L terminal. (Built-in IC regulator type)

(g) When using a steam cleaner, take care not to apply steam directly to the alternator and other electrical parts.

2. Inspection

With the charging system parts left installed, check for faulty conditions such as shown in the table at right. Remove the questionable parts only when dismounting is necessary for inspection or repair.

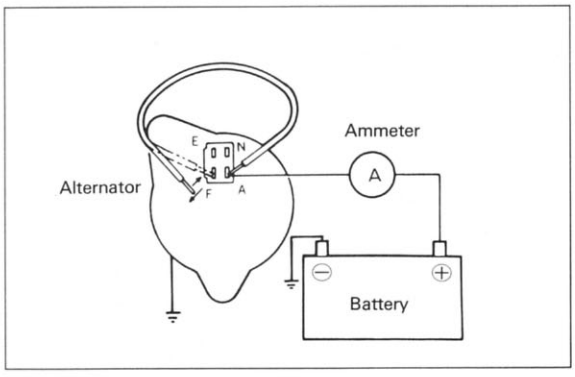
Over charge	Too high voltage relay set value
	Loose ground connection
	Faulty wiring
	Broken resistance or coil in series circuit
Discharge	Too low voltage relay set value
	Poor output of alternator
	Too much electric power consumption
	Use of improper load

(1) Inspection of alternator separate from regulator

(a) Diagnosis

Check to see whether the trouble is in the alternator or in the regulator by the following manner.

Connect an ammeter between the alternator A terminal and the battery positive (+) terminal. Run the engine at approximately 2000 rpm and observe the charging current.



Charging Performance Inspection

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Disconnect the connector between the alternator and regulator. Connect the alternator A and F terminals to each other for several seconds with a jumper wire.
If the charging current remains unvaried, the alternator is suspected to be defeetive. If the charging current increases, the regulator is suspected to be defective.

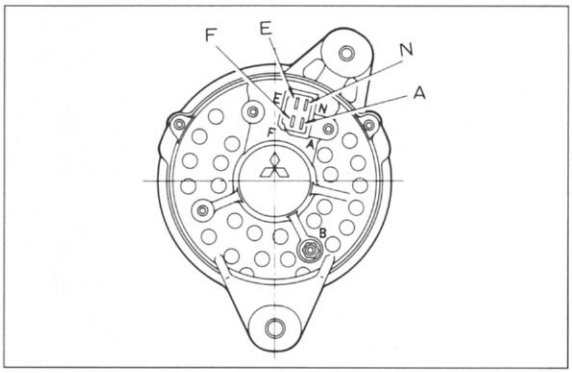
(b) Diode inspection

1) Check for continuity between the alternator terminals A and N, and E and N, respectively, with an ohmmeter. Reverse the ohmmeter polarity and recheck for continuity.

- The ohmmeter will indicate a large resistance in one direction and a small one in reverse direction.
- If resistance is small in both directions, a short circuit is suspected. If resistance is large in both directions, an open circuit suspected. Replace the rectifier assembly in both cases.

2) Perform the same inspection for the E and N terminals.

3) This testing method is not suited to check the diodes individually. Disassemble the alternator to check each diode.



Alternator Terminals

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(2) Regulating voltage inspection (Alternator with built-in regulator)

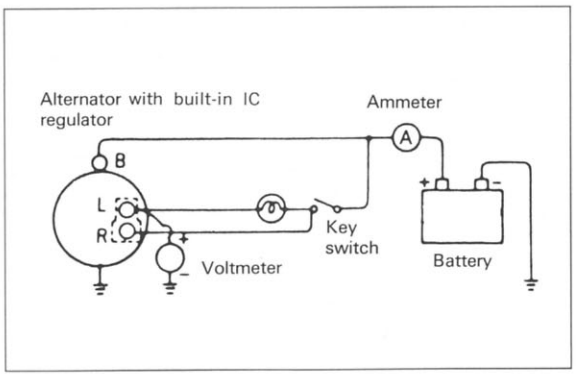
(a) Disconnect the battery cable from the positive (+) terminal and connect an ammeter between the cable and the terminal.

(b) Connect a voltmeter between the alternator L terminal and ground.

(c) The voltmeter must indicate zero when the starter switch is OFF and indicate a value somewhat below the battery voltage when the starter switch is ON (without engine running).

(d) Short-circuit the ammeter and start the engine.

(e) Measure regulating voltage (with the ammeter reading below 5A, engine speed at 1800 and 2500 rpm, and all lamp switches OFF). The regulating voltage varies with alternator temperature and has a tendency to indicate lower voltage as temperature increases.



Regulating Voltage Inspection

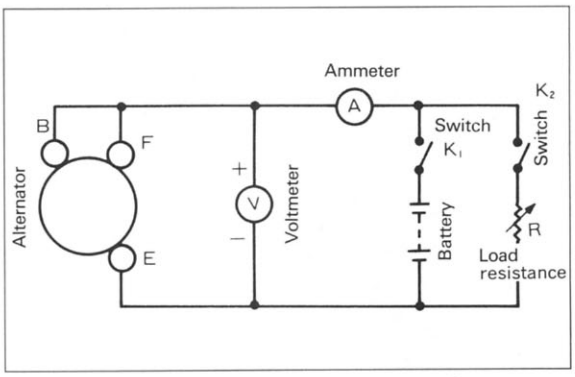
Description	Standard value
Regulating voltage (at 20°C)	14.7±0.3V

(3) Output inspection — I (Alternator separate from regulator)

Remove the alternator from the engine, connect the alternator as shown in the figure, and drive it with a motor.

Close switch KI to flow field current from the battery. Under this condition, increase the alternator speed gradually until current flow to the field coil stops, i. e. the ammeter indicates zero. Then, open switch KI to start self-exciting. Increase the speed gradually until the voltmeter indicates 14V and read the alternator rpm. This reading must satisfy the standard speed without load (1300 rpm max.)

Adjust the load resistance R to the maximum to minimize the load current flow and close switches KI and K2. While adjusting the terminal voltage to constant 14V, increase the alternator speed to 2500 rpm and read the indication of the ammeter. This reading must satisfy the standard speed with load.



Output Test Connection (Separate regulator type)

Output (Normal temperature)

Description	Model	Standard value	
		Terminal voltage/current	Speed
No-load output (at cold)	AR2115Z2	14V/0A	1300 rpm max.
	AH2035M4	14V/0A	1300 rpm max.
Loaded output (at cold)	AR2115Z2	14V/15A min.	2500 rpm max.
	AH2035M4	14V/30A min.	2500 rpm max.

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(4) Output inspection — 2 (Alternator with built-in IC regulator)

(a) Disconnect the battery ground cable.

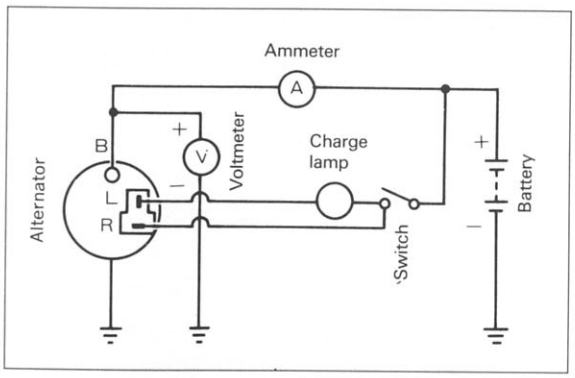
(b) Connect the ammeter between the alternator B terminal and battery. Connect the voltmeter between the B terminal and ground.

(c) Connect the battery ground cable.

(d) Start the engine.

(e) Turn all light switches ON.

(f) Increase the engine speed and read the ammeter at 13.5V of output voltage and specified alternator rpm. Ammeter reading must satisfy the standard value.



Output Test Connection (Built−in regulator type)

Output (normal temperature)

Description	Type	Standard value	
		Terminal voltage/current	Speed
Output (at hot)	A0T25171	13.5V/21A	2500 rpm max.
	A0T25271	13.5V/37A	5000 rpm max.

■ Removal

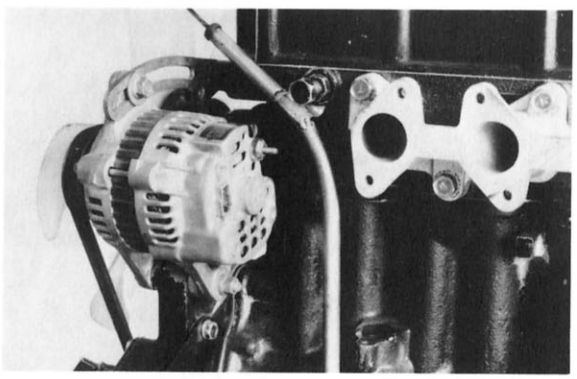
(1) Disconnect the battery cable.

(2) Disconnect the lead wire from the B terminal at the rear of the alternator.

(3) Disconnect the alternator connector.

(4) Loosen the alternator brace and support bolts and remove the fan belt by moving the alternator to the engine side.

(5) Remove the alternator.



Removing Alternator

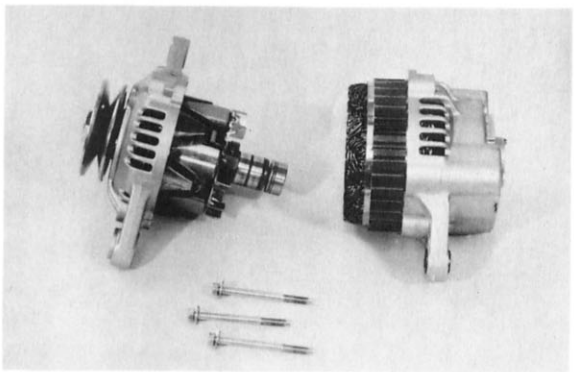
■ Disassembly

(1) Remove the three through bolts.

(2) Heat the rear bracket at the rear bearing to 50 ～ 60 ℃ with a soldering iron, etc. and separete the stator coil from the front bracket.

Caution

- **Pry the clearance between the stator core and the front bracket using the tip of a screwdriver.**
- **Do not insert the screwdriver excessively.**



Disassembling Stator

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(3) Hold the rotor in a vise and remove the pulley nut, pulley, fan and spacer in that order.

(4) Remove the rotor assembly from the front brakcet.

(5) Disconnect the soldered wire lead of the stator coil using a soldering iron and remove the stator assembly.

Caution

- **When disconnecting the lead wire, never heat the solder unnecessarily long to prevent the diodes from being damage by excessive heat.**

(6) Remove the capacitor from the B terminal.

(7) Remove the rectifier by removing the attaching screws.

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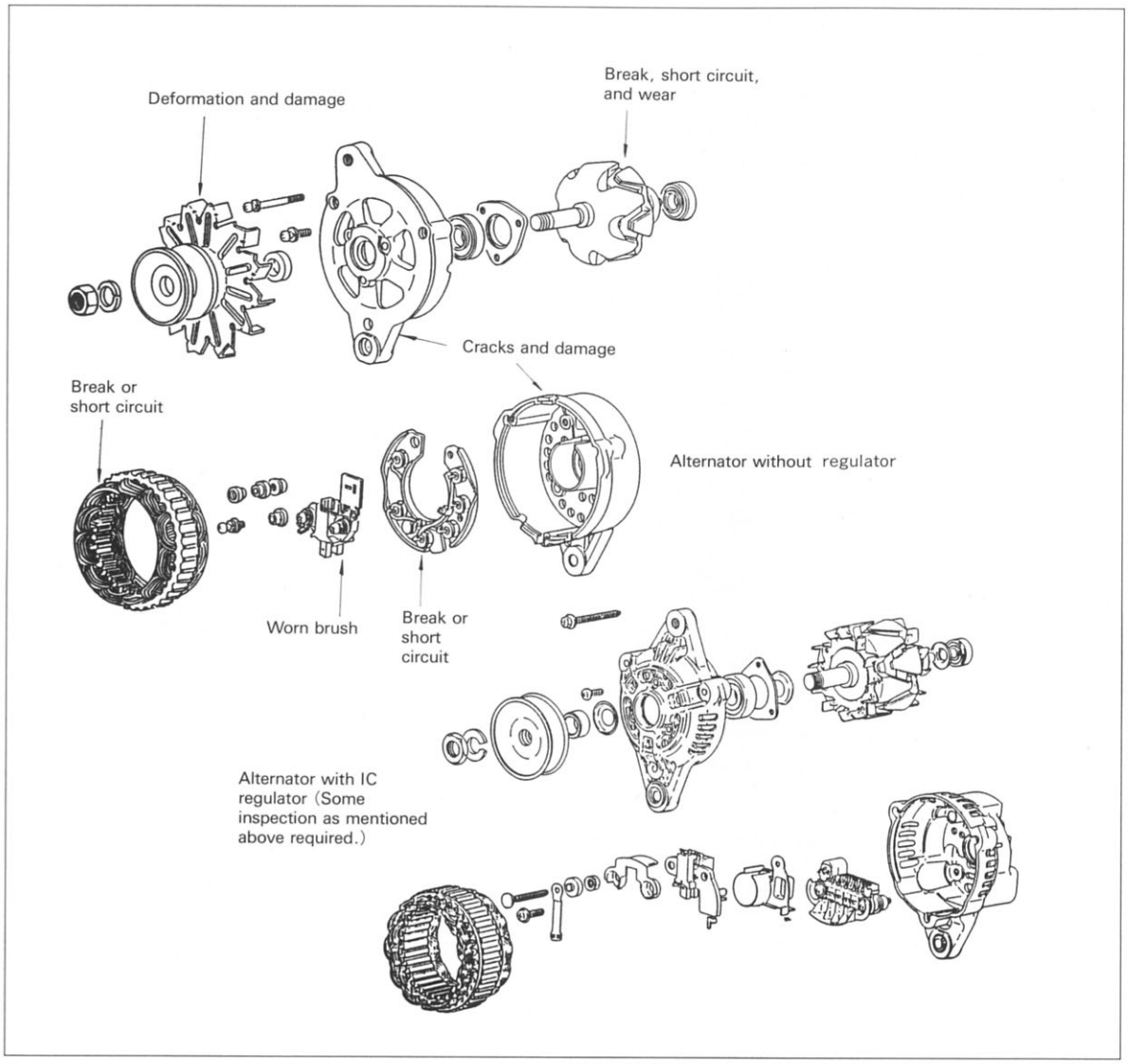
■ Inspection after Disassembly

Replace the parts if necessary.



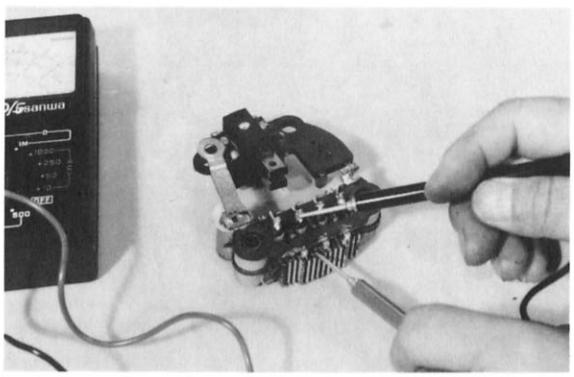
(1) Diode inspection

Check individual diodes assembled in the rectifier for continuity :

(a) Check for continuity between the lead wire from each diode and the diode case. Resistance must be large in one direction and small in reverse direction.

(b) If equal resistances are in both directions, replace the rectifier assembly.

(c) Check all diodes for continuity.



Diode Inspection

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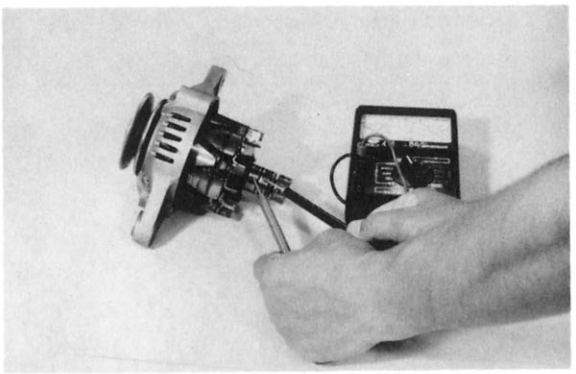
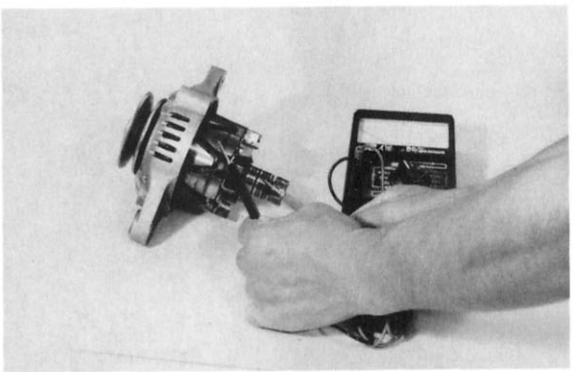
(2) Field coil inspection

(a) Check for continuity between the slip rings. If there is no continuity, the field coil is open and it should be replaced with a new one.

(b) Check for continuity between the slip ring and the shaft or the core. If there is continuity, the field coil is grounded and it should be replaced with a new one.



Continuity Test of Field Coil

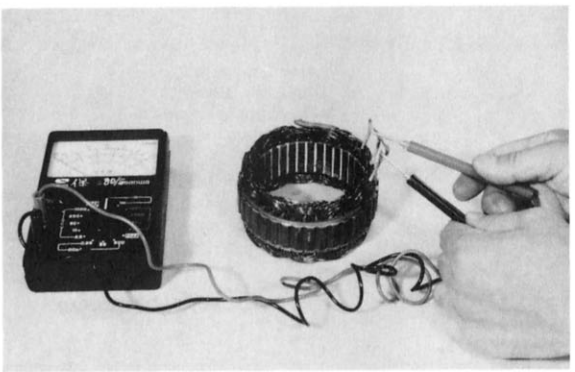


Insulation Test of Field Coil

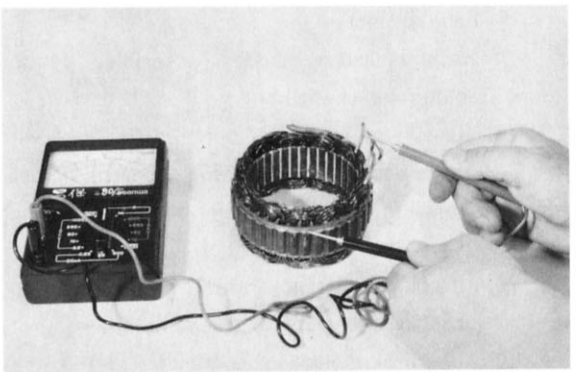
(3) Stator coil inspection

(a) Check the stator coil for continuity between each lead wire. If there is no continuity, the stator coil is open and it should be replaced with a new one.

(b) Check for continuity between each lead wire of the stator coil and the stator core. If there is continuity, the stator coil is grounded and it should be replaced with a new one.



Continuity Test of Stator Coil



Insulation Test of Stator Coil

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■ **Alternator Assembly**

Assemble the alternator in the reverse order of disassembly with care of the following :

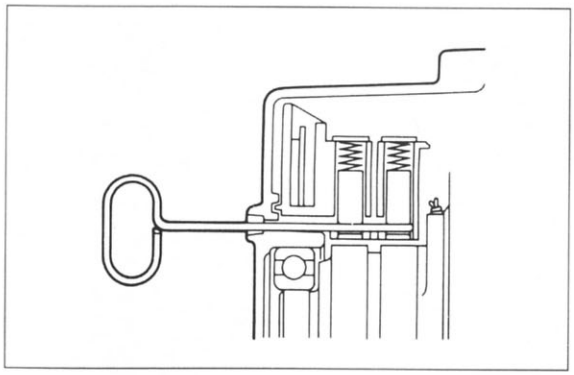
(1) Align the projection of the snap ring with the deepest portion of the eccentric groove in the rear bearing.

(2) When replacing the rear bearing, press-fit a new bearing so that its groove faces the slip ring.

(3) Heat the rear bracket when pressing the rear bearing into the rear bracket.

Caution

- **When fitting the rotor into the rear bracket, lift the brushes by inserting a wire through the small hole in the rear bracket.**



Lifting of Brushes

■ Installation

Install the alternator in the reverse order of removal.

(1) Spacer adjustment

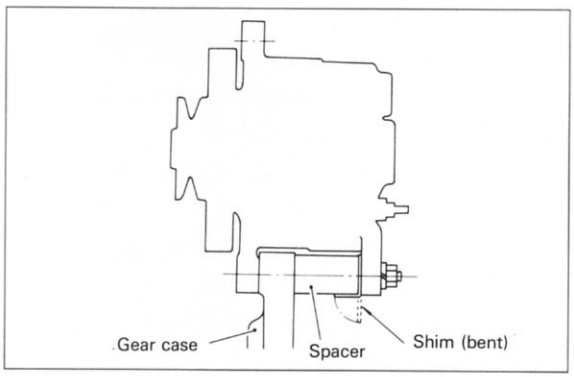
When installing the support bolt, insert the spacer as follows :

(a) Insert the support bolt to the specified position. (Do not install the nut yet.)

(b) Install the alternator and insert the spacer between the alternator rear bracket and the gear case bracket.

(c) Adjust the clearance between the rear bracket and the spacer to 0.2 mm or less by inserting the shims (0.198 mm thick each). Install the support bolt nut.

(d) Adjust the fan belt tension.



Inserting Spacer

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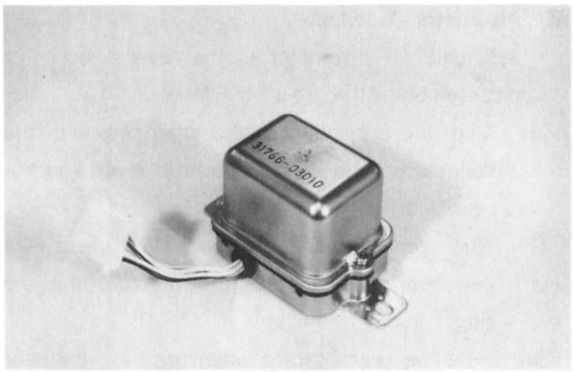
7-04 REGULATOR (Separate from Alternator)

■ Specifications

Description	Specification
Type	Tirrill type
Model	RQB2220D4
Regulating voltage	14.8V±0.3V
Pilot lamp ON voltage	4.2 ～ 5.2V
Pilot lamp OFF voltage	0.5 ～ 3.0V
Installation direction	Lead wire outlet side bottom



Regulator

■ Adjustment and Inspection

Caution

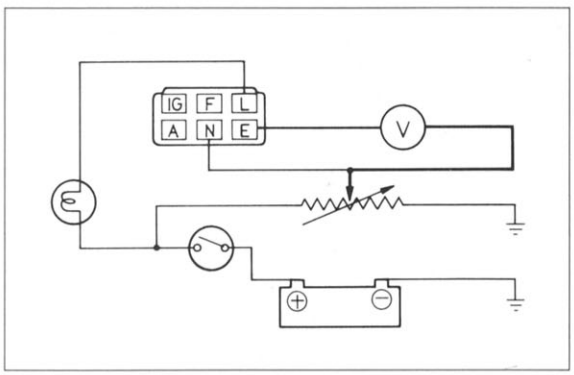
- **The regulator is sealed. Breaking the seal makes the regulator no more warranted.**
- **Do not operate the engine with the regulator coupler disconnected.**
- **Do not connect a capacitor to the F terminal of the regulator.**
- **The standard regulator (RQB2220D2) should be installed sideways so that its lead wire outlet faces downward.**

(1) No-load regulating voltage inspection

(a) Connect a voltmeter between the regulator A and E terminals.

(b) Start the engine and let it be idle. Disconnect the lead wire from the alternator B terminal to unload the alternator.

(c) The regulating voltage must be within specification when the alternator speed increases to 4000 rpm.



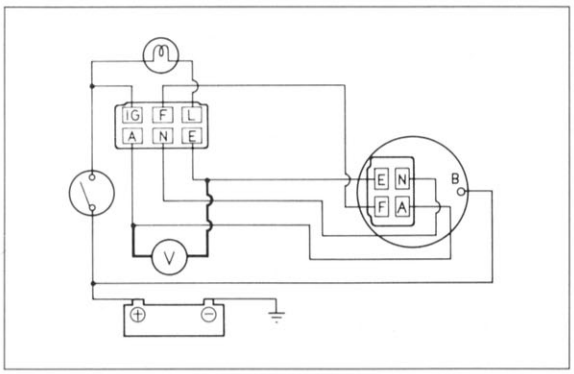
Regulator Inspection

(2) Pilot lamp voltage inspection

(a) Connect a voltmeter and variable resistor.

(b) With the pilot lamp lit, gradually increase voltage and read the voltage at which the lamp goes off.

(c) Decrease voltage gradually and read the voltage at which the lamp comes on again.



Pilot Lamp Voltage Inspection

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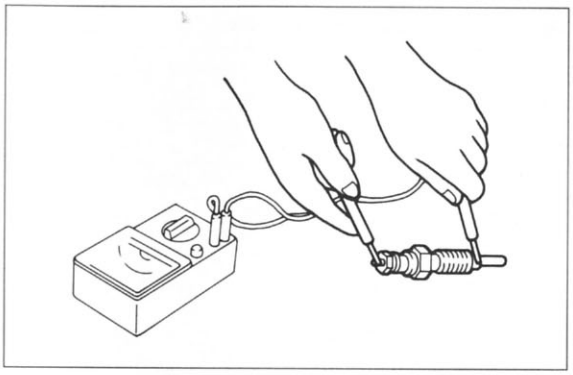
■ Removal／Installation

Glow plug tightening torque : 1.5 ～ 2.0 kgm

■ Inspection

Check the glow plug for continuity between the terminal and the body as shown. If there is no continuity or resistance is excessively high, replace the glow plug with a new one.

Description	Specification
Type	Y－142T
Rated voltage／current	10.5V／9.7A
Resistance	0.16Ω



Glow Plug Inspection

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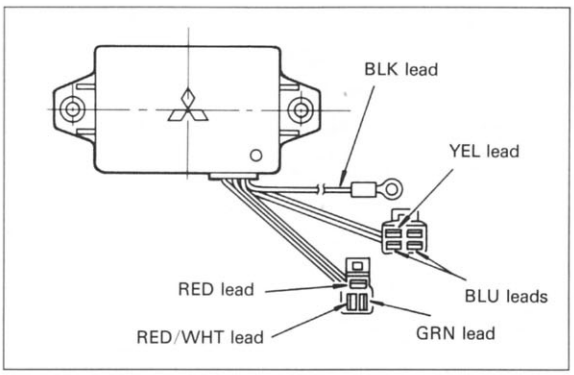
7-06 KEY-OFF STOP SYSTEM

■ General

This system stops the engine when the starter key is turned OFF, like the system used for ordinary autombile engines. Also, it incorporates with an oil pressure switch and a coolant temperature switch (if so specified) so that the engine is stopped urgently by the control-timer actuated solenid valve in case of abnormal oil pressure drop or coolant temperature increase.

■ Control Timer Specification

Description	Specification
Model	YM－I
Input voltage range	DC9 ～ I5V
Load	Solenoid (Coil resistance : I.7Ω min.)



Control Timer

■ Wire Identification Color

Code	Wire color	Connection
①	Blue	Solenoid
②	Blue	Solenoid
③	Red	Battery (key switch B)
④	Green	Key switch ON
⑤	Red, white	Starter (key switch, starter)
⑥	Yellow	Oil pressure switch
⑦	Black	Ground

■ Solenoid for Key-Off Stop

Description	Specification
Type	Pushing out type
Voltage	I0 ～ I5V DC
Coil resistance	I.8Ω±I0% (20 ℃)
Stroke	I3.5±0.5

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■ Solenoid Installation

(1) Temporarily install the solenoid ① and nut ② on the crankcase. (Apply THREE-BOND 1212 or 1211 to the effective threads of the solenoid.)

(2) Screw in the solenoid until clearance C is zero when the injection pump rack is at 0 position.

(3) From this position, turn back the solenoid by 30° to 45° (rack−to−shaft clearance is 0.15 ~ 0.2 mm in this condition) and tighten the locknut to 5.0 kgm.

(4) Start the engine and make sure that the engine stops when the solenoid shaft is fully pushed in.

(5) Install the rubber cap with its arrow pointing up (water drain hole pointing down) as shown.

Caution

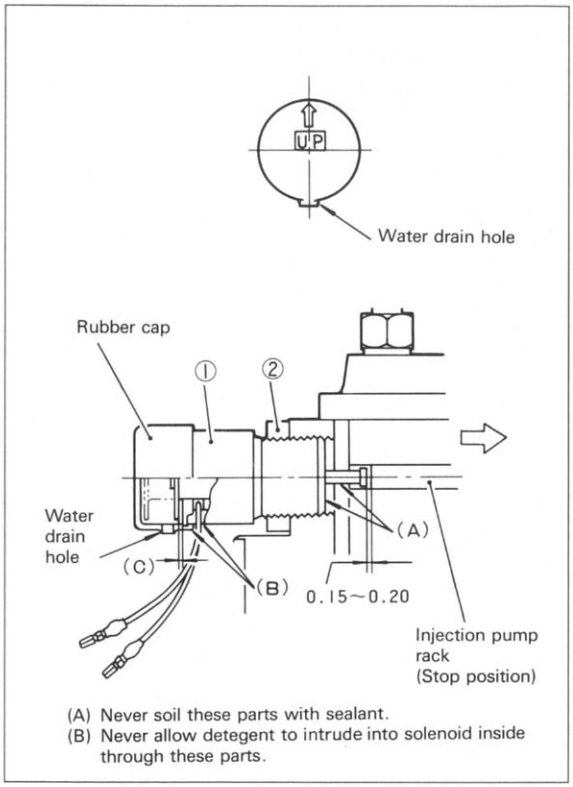
- **Take care not to allow the cleaning agent to enter the solenoid terminal and solenoid (at the lead wire and shaft) when cleaning the engine.**

(6) Precaution after engine assembly

(a) The wiring of the key-OFF stop system should follow the wiring diagram shown in this manual.

(b) Start the engine and make sure that the engine is stopped by means of the solenoid when the key is turned OFF.

(c) Start the engine and make sure that the engine stops when the oil pressure switch terminal is connected to the switch body with a jumper wire.



Installing Solenoid

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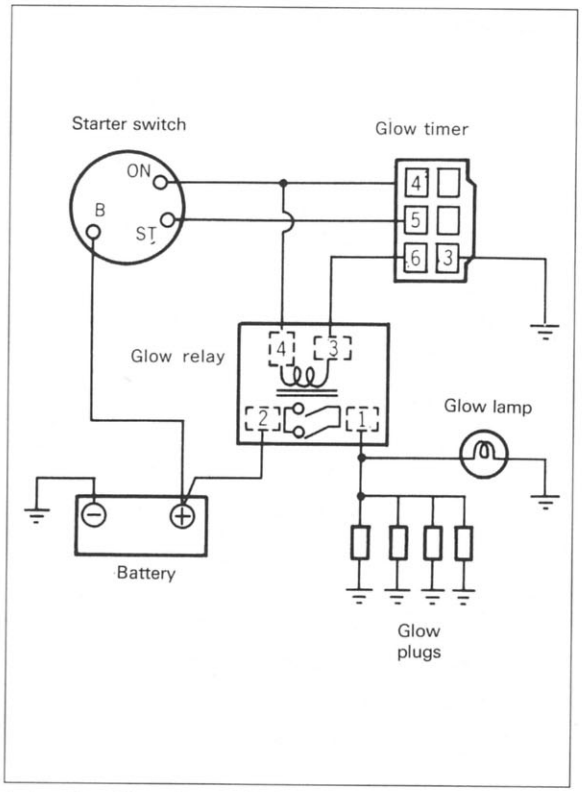
7-07 AUTO—GLOW TIMER SYSTEM

■ General

The glow plugs preheat the combustion chambers to facilitate the engine starting during cold weather. For the standard specification model, the starter key must be held in the glow position by hand for 20 ~ 30 seconds for preheating. The glow timer system eliminates this holding operation and shorten the glow time (approximately by 6 seconds) to make the glow operation simple. Take the utmost care not to allow the wiring to be made short because this system applies battery voltage to the glow plugs directly unlike the conventional system.

Note : After-glow specification

The after-glow specification provides the preheating function which is maintained for fixed time (4.5 sec) after the starter starts cranking the engine, in addition to the same pre-glow finction as provided by the ordinary glow timer specification.

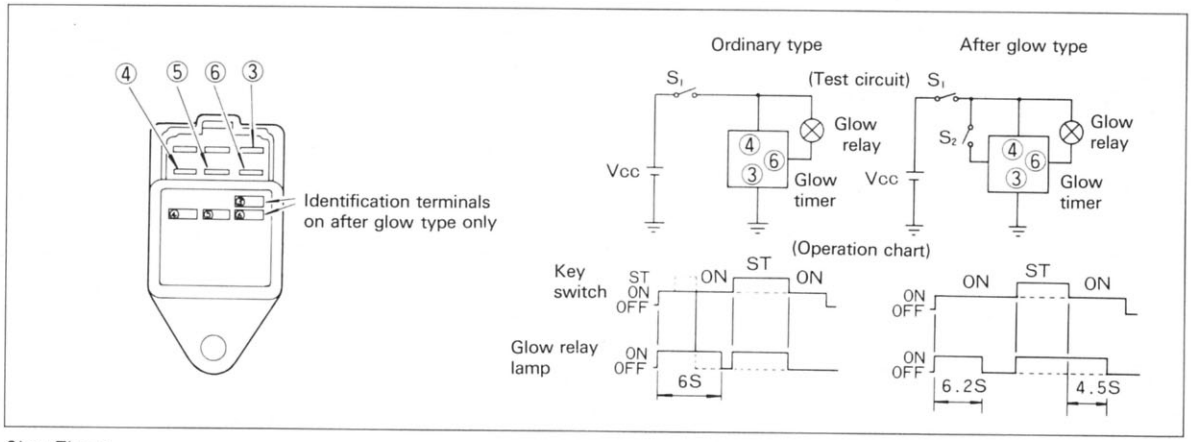


Auto—Glow Timer System Wiring

■ Glow Timer Specifications

Description	Specification
Model	S81NJ
Rated voltage	DC12V
Temperature range	−40 °C ~ 85 °C
Initial characteristic (Normal temperature and humidity, Vcc=12V)	6±0.7 sec. ＊1

Note : ＊1 Time passed until the glow relay is tripped to ON after switch S1 is turned ON in the test circuit.



Glow Timer

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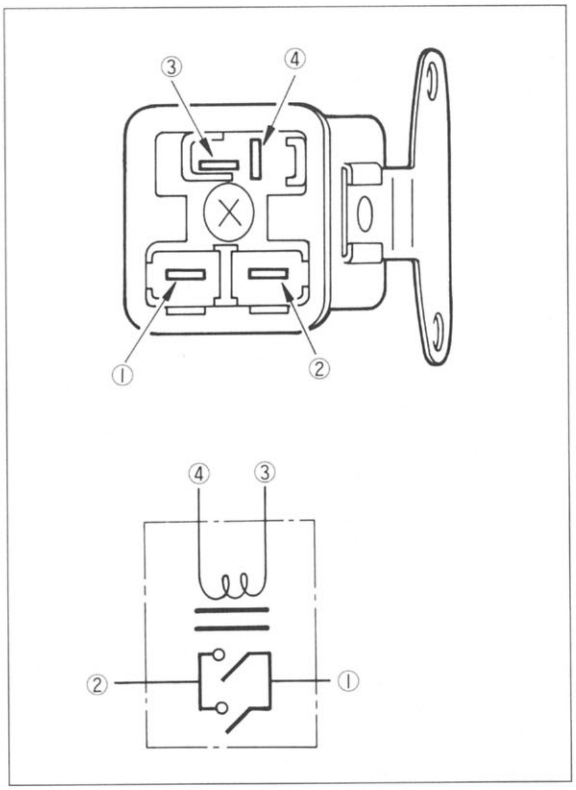
■ Glow Relay Specifications

Description	Specification
Model	G71SP
Rated voltage	DC12V
Continuous rating	1 minute
Coil resistance	13Ω
Inductance	24 mH (at 1 Hz)
Temperature range	−40 °C ～ 100 °C



Glow Relay

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Group 8

MAINTENANCE

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8-01 PERIODIC SERVICE CHART

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

Service item		Before operation	After first 50hours	Every 100hours	Every 400hours	Every 800hours	Long-period storage	Remarks
Engine	Loose, damaged and leaky points	○						
	Exhaust fume, noise, and vibration	○						
	Re-tightening engine parts		○			○		
	Valve clearance		○		○			
	Engine idle speed		○	○				
	Engine compression pressure					○		
Lubrication system	Engine oil	○	●	●				
	Oil filter (cartridge type)		●	●				
	Oil filter (disassemblable type)			□, ○	●			● : Replace element.
Fuel system	Fuel	○					△	
	Fuel tank				□		□	
	Fuel filter			□	●			For cock type, replace element only.
	Fuel pump		□	□				Filter (plunger type pump)
	Injection pump					○		Adjust fuel injection rate.
	Nozzle				○			
Intake system	Air cleaner (paper-element type)			□	●			
	Air cleaner (oil bath type)	○		□●				● : Replace oil.
Cooling system	Coolant	○	●			●	△	Unless antifreeze is used, drain after daily operation.
	Fan belt	○			○			
Electrical system	Gauges (incl. pilot lamps)	○						
	Starter motor, alternator, regulator				○	○*		* : Adjust voltage and current.
	Glow plug				○			
	Solenoid switch (key-OFF stop system)	○						Inspect switch operation.

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■ Engine

Unit : mm

Item	Standard value	Repair limit	Service limit
Compression pressure	29kg/cm² (K3, K4E, F : at 280 rpm) (K4M : at 240 rpm)	26 kg/cm²	Approximately 22kg/cm²
Pressure difference between cylinders (max.)	2.5 kg/cm²		
Injection order K3	1−3−2		
K4	1−3−4−2		
Injection timing (B.T.D.C.)			
K3, K4 : For agricultural use	19° (at SS starting)	19°±1.5°	
K3, K4 : For industrial use and export standard	20° (at SS starting) See page 156	20°±1.5°	
Cylinder head			
Bottom surface warpage	0.05 max.	0.1	
Valve seat width (intake and exhaust)	1.3〜1.8	2.5	
Valve seat sinkage			−1
Valve clearances (intake and exhaust)	0.25 (at cold)		
Valves			
Stem O.D. × dia. × length (intake) : K3	6.6×27.2×114.5		
K4E, F	6.6×32.2×114.5		
K4M	8×34×112.4		
(exhaust) : K3	6.6×25.2×114.5		
K4E, F	6.6×27.2×114.5		
K4M	8×29×112.4		
Stem-to-guide clearance			
(intake)			0.10
(exhaust)			0.15
Seat angle	45°		
Valve head thickness (margin width)	1.0		0.5
Valve spring			
Free length K3, K4E, F	43		−1
K4M	45.5		−1
Installation load/length K3, K4E, F	14±0.7/36		−15%
(kg/mm)	29.8±2/28		−15%
K4M	15±0.8/38		−15%
	30±2/30.5		−15%

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8-02 SPECIFICATIONS AND SERVICE STANDARD

Item		Standard value	Repair limit	Service limit
Squareness		2°		3°
Upper identification color		Red		
Rocker arms				
Rocker arm-to-shaft clearance				−0.2
Cylinder block				
Cylinder bore (Note : Exception of oversize specification. K3F : up to 10922 in serial No. K4F : up to 3634 in serial No. K4M : engines with liner)	K3C	70	+0.2	−0.2
	K3D	73	+0.2	+0.95
	K3E	76	+0.2	+0.95
	K3F	78	+0.2	(+0.85)
	K4E	76	+0.2	+0.95
	K4F	78	+0.2	(+0.95)
	K4M	84	+0.2	(+0.95)
Oversize finishing tolerances		0～0.03 for all oversizes		
Taper of cylinders		0.01 max.		
Cylinder liner O.D. :	A	$88^{-0.011}_{-0.020}$		
	B	$88^{0}_{-0.010}$		
	C	$88^{+0.010}_{+0.001}$		
Piston				
O.D. (skirt end) :	K3C	70		
	K3D	73		
	K3E, K4E	76		
	K3F, K4F	78		
	K4M	84		
Piston-to-cylinder clearance				0.3
Oversizes (Note : Excepting engines mentioned in Cylinder block columm.)		0.25, 0.50, 0.75		
Piston pins :	K3C, D	Semi-floating		
	K3E, F, K4E, F, M	Full-floating		
Piston pin-to-piston clearance		(Pressing force : 1000±500 kg)		0.08
Piston pin-to-connecting rod clearance :	K3C, D			Within standard
	K3E, F, K4E, F, M			0.1

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Item	Standard value	Repair limit	Service limit
Piston rings			
Number of rings			
Compression ring	2 (No. 1 : chrome, semi−keystone, No. 2 : taper ring)		
Oil ring	1 (Chrome plated, with coil expander)		
Side clearance			
Compression No. 1			0.3
Compression No. 2 and oil			0.2
Ring gap			1.5
Oversizes (Note : Excepting engines mentioned in Cylinder block columm.)	0.25, 0.50, 0.75		
Connecting rods			
Bend and twist			0.15max.
Big end thrust clearance	0.1～0.35		0.5
Small end bush I.D.	23 (K4M : 27)		
Big end bearing			
Oil clearance			0.15
Undersizes	0.25, 0.50, 0.75		
Crankshaft			
Bend			0.05
End play K3C～F, K4E, F	0.05～0.175		
K4M	0.05～0.205		
Journal O.D.			
K3C～F, K4E, F	52	−0.15	−0.95
K4M	57	−0.15	−0.95
Crankpin O.D. K4E, F	42	−0.15	−0.95
K4M	48	−0.15	−0.95
Undersizes (Pin and journal)	0.25, 0.50, 0.75		
Main bearings (with flange for No. 3)			
Oil clearance			0.10
Undersizes	0.25, 0.50, 0.75		
Camshaft			
Journal-to-cylinder block or bush clearance			0.15
Cam height (intake and exhaust)	35.72		−1.0

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Item	Standard value	Repair limit	Service limit
Pump camshaft			
Cam height	44		−1.0
Tappets			
Tappet-to-cylinder block hole clearance			0.15
Push rod			
Bend	0.3 max.		

■ **Lubrication System**

Unit : mm

Item	Standard value	Repair limit	Service limit
Oil pump (trochoid type)			
Check valve opening pressure	4 kg/cm²		
Outer rotor-to-body clearance	0.15～0.2	0.3	
Outer rotor-to-inner rotor clearance	0.05～0.12	0.25	
Oil pressure switch			
Contact closing pressure	0.5±0.1kg/cm²		

■ **Fuel System**

Unit : mm

Item	Standard value	Repair limit	Service limit
Fuel injection pump			
K3 : ND−PER3M			
K4 : ND−PER4M			
Fuel injection rate	Refer to Group 9.		
Difference from reference cylinder	2 mm²/rev., cylinder max.		
Nozzle (hole type)			
DLLA155			
Injection starting pressure	220^{+10}_{0} kg/cm²	220^{+10}_{10}kg/cm²	
Fuel filter			
Cartridge type fuel filter			
Model (Part No.)	3X05010 (MM435190)		
Filtration area	280 cm²		
Passing particles	Max. 15μ		
Air bleeding	Air bleeder plug (2 places)		

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■ Fuel System

Unit : mm

Item	Standard value	Repair limit	Service limit
Fuel filter width cock			
Model (Part No.)	MK_{34}100 (MM434476)		
Filtration area	129cm^2		
Passing particles	Max. 30μ		
Air bleeding	Air bleeder plug (2 places)		
Model (Part No.)	MK_{41}100 (MM435265)		
Filtration area	900cm$_2$		
Passing particles	Max. 30μ		
Air bleeding	Air bleeder plug (1 place)		
Model (Part No.)	MBK_{17}100A (MM435250)		
Filtration area	129cm^2		
Passing particles	Max. 30μ		
Air bleeding	Automatic type (with nipple)		
Model (Part No.)	MK_{33}100 (MM434448)		
Filtration area	260cm^2		
Passing particles	Max. 15μ		
Air bleeding	Automatic type (with nipple)		
Model (Part No.)	MK_{28}100 (MM434705)		
Filtration area	900cm^2		
Passing particles	Max. 30μ		
Air bleeding	Automatic type (with nipple)		
Fuel pump			
Electromagnetic diaphragm type pump			
Model (Part No.)	UC-S6 (MB052904)		
Power source	12V, DC (negative ground)		
Pump delivery	370cc／mm min. (at terminal voltage 12V, DC)		
Max. suction head (at dry)	150mmHg min.		
Closing delivery pressure	0.13～0.18kg／cm^2		
Installation direction	Cover side down		

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Item	Standard value	Repair limit	Service limit
Electromagnetic plunger type pump			
Model (Part No.)	378-02200 (MD025280)		
Power source	12V, DC (negative ground)		
Pump delivery	900cc/min. (at full pressure 0.18kg/cm^2)		
Dry suction pressure	−30mmHg max.		
Full pressure at closing	$0.35^{\ 0}_{-0.07}$kg/cm^2		
Installation direction	Filter side down		
Hand type fuel pump			
Model (Part No.)	$MK_3$100C (MM409571)		
Pump delivery	4.5cc/stroke (16mm)		
Load at pushing in the push button	5.9kg		
Inlet and outlet nipple O.D.	ϕ5.2		

■ **Cooling System**

Unit : mm

Item	Standard value	Repair limit	Service limit
Cooling fan			
Fan O.D. (Part No.)			
(Unequal 5-blade, suction)	ϕ320 (MD009015)		
	ϕ340 (MD009014)		
(Equal 6-blade, suction)	ϕ290 (MM409350)		
	ϕ310 (MM409351)		
(Equal 7-blade, suction)	ϕ360 (MM435279)		
(Equal 6-blade, pusher)	ϕ360 (MM435867)		
	ϕ390 (MM405431)		
Fan belt (HM, LL type)			
Periphery	932 ℓ (MD007528)		
	940 ℓ (MM409305)		
	964 ℓ (MD025523)		
	980 ℓ (MD088955)		
Water pump (centrifugal impeller type)			
Thermostat (wax type)			
82°C type	(MD001370)		
Valve opening temperature	82±1.5°C		
Fully open temperature at approx. 8mm valve lift	95°C		

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Item	Standard value	Repair limit	Service limit
76.5°C type	(K6516441)		
Valve opening temperature	76.5±1.5°C		
Fully open temperature at approx. 8mm valve lift	90°C		
Thermostat (thermistor)			
Model	A20-WEu (MD001380)		
Indicating specification (°C/Ω)	70/104±13.5, 115/23.8±2.5		
Installation thread dia.	M16		
Model	V495240 (MM409383)		
Indicating specification (°C/Ω)	50/350±20, 90/81±5, 120/36.2		
Installation thread dia.	PT3/8		
Thermo-switch (bimetal type)			
Model	071400-1190 (MM409381)		
Contact closing temperature	111±3°C		
Resistance between terminals	1.0±0.4Ω		
Installation thread dia.	PT3/8		
Model	071400-1180 (MM409380)		
Contact closing temperature	108±3°C		
Resistance between terminals	1.0±0.4Ω		
Installation thread dia.	PT3/8		

■ **Electrical System**

Unit : mm

Item	Standard value	Repair limit	Service limit
Starter (electromagnetic push-in type)			
Model	M2T50381 (MM409410)		
Nominal output	12V-1.6kW		
No load characteristic (20°C)			
Terminal voltage/current	11.5V/100A max.		
Speed	3000rpm min.		
Pinion gap	0.5~2.0		
Thrust gap	0.5 max.		
Rotating direction	Clockwise viewed from pinion side		
Model	M2T56271 (MM409412)		
Nominal output (V/kW)	12V-2.0kW		
No load characteristic (20°C)			

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Item	Standard value	Repair limit	Service limit
Terminal voltage/current	11V/130A max.		
Speed	3850rpm min.		
Pinion gap	0.5~2.0		
Thrust gap	0.5 max.		
Rotating direction	Clockwise viewed from pinion side		
Model	M2T56272 (MM409413)		
Nominal output	12V-2.0kW		
No load characteristic (20°C)			
Terminal voltage/current	11V/130A max.		
Speed	3850rpm min.		
Pinion gap	0.5~2.0		
Thrust gap	0.5 max.		
Rotating direction	Clockwise viewed from pinion side		
Alternator (separate from regulator, AC generator)			
Model	AH2035M (MD017645)		
Nominal output	12V-35A		
No-load characteristic (20°C, at cold)			
Terminal voltage/current	14V/0A		
Speed	1300rpm max.		
Load characteristic (20°C, at cold)			
Terminal voltage/current	14V/30A		
Speed	2500rpm		
Model	AR2115Z_2 (MM407671)		
Nominal output	12V/15A		
No-load characteristic (20°C, at cold)			
Terminal voltage/current	14V/0A		
Speed	1300rpm max.		
Load characteristic (20°C, at cold)			
Terminal voltage/current	14V/15A min.		
Speed	2500		
Alternator (with built-in IC regulator)			
Model	A0T25171 (MM432804)		

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Item	Standard value	Repair limit	Service limit
Nominal output	12V／40A		
Load characteristic (20°C, at hot)			
Terminal voltage／current	13.5V／21A		
Speed	2500rpm		
Terminal voltage／current	13.5V／37A		
Speed	5000rpm		
Regulating voltage	14.7±0.3V		
Capacitor capacity	0.5		
Model	A0T25271 (MM435081)		
Specifications and performance are same as above.			
Regulator (separate from alternator)			
Model	RQB2220D4 (MD001821)		
Type	Tirrill type 2-element		
Regulating voltage	14.8V		
Pilot lamp :			
Lamp on voltage	4.2～5.2V		
Lamp off voltage	0.5～3.0V		
Glow plugs (sheathed, immediately heating type)			
Model	Y-142T (MM431439)		
Rated voltage／current	10.5V／9.7A		
Resistance	0.16Ω		
Glow plug indicator			
Model	DH-139V-29 (MM409515)		
Type	Red heat type (immediately heating, for 3-cylinder engines)		
Rated current	29A		
Voltage between terminals	1.7±0.2V		
Model	DH-136V-39		
Type	Red heat type (immediately heating, for 4-cylinder engines)		
Rated current	39A		
Voltage between terminals	1.2±0.1V		
Glow timer			
Model	S81NJ (MM431762)		
Rated voltage	12V, DC		
Initial characteristic (normal temperature and humidity, Vcc : 12V)	6 seconds		

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Item	Standard value	Repair limit	Service limit
Temperature range	−40°C～85°C		
Glow timer (with after glow)			
Model	S83AD		
Rated voltage	DC12V		
Initial characteristics (normal temp・, normal humidity, Vcc＝12V)			
Pre-glow timer	6.2±0.7 seconds		
After-glow timer	4.5±0.7 seconds		
Glow relay			
Model	G71SP		
Rated voltage	12VDC		
Continuouse rating	1 minute		
Coil resistance	13Ω		
Temperature range	−40°C～100°C		
Control timer unit			
Model	YM-1B (MM435745)		
Input voltage range	9～15VDC		
Load	Solenoid (coil resistance : 1.7Ω min.)		
Temperature range	−30°C～80°C		
Solenoid (push type)			
Model	YMS-1 (MM431975)		
Coil resistance	1.8Ω±10% (20°C)		
Stroke	13.5±0.5mm		
Voltage	10～15VDC		
Attraction force (20°C)	4.2kgf min./9V (at 1mm stroke)		
Temperature range	YMS-1 (MM431975)		

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■ Tightening Torque

Description	Tightening torque (kgm)
Cylinder head bolts	
K3C ~ F, K4E, F { M12 main bolts	11.5 ~ 12.5 (Wet)
K3C ~ F, K4E, F { M10 sub bolts	6.5 ~ 8.0 (Wet)
K4M { M14 main bolts	15 ~ 16
K4M { M12 sub bolts	10 ~ 11
Rocker cover bolts (M8) standard	1.0 ~ 1.3
Rocker stay bolts (M10) standard	3.0 ~ 4.2
Thermo-switch (PT3/8) at cylinder head	2.0 ~ 3.0
Blind plug for gear case governor shaft hole (PT1/2), for both FC and A ℓ	4.0 ~ 5.0
Crankshaft pulley nut	
K3C ~ F, K4E, F (M18)	15 ~ 20
K4M (M20)	20 ~ 25
Main bearing cap bolts	5 ~ 5.5
Connecting rod cap nuts	
K3C ~ F, K4E, F	3.2 ~ 3.5
K3M	4.0 ~ 4.3
Flywheel mounting bolts	13 ~ 14
Oil pan drain plug (M18)	5 ~ 6
Oil relief plug (M18)	4.0 ~ 5.0
Oil filter	1.1 ~ 1.3
Fuel injection pipe nuts (M12)	2.5 ~ 3.5
Fuel injection pump	
Delivery valve holders	4 ~ 5
Nozzle holder	
Holder tightening bolts (M8)	2.0 ~ 2.5
Holder body retaining nuts	3 ~ 4
Glow plugs (M10)	1.5 ~ 2.0
Glow plug lead wire nuts (M4)	0.1 ~ 0.15
Key-OFF stop solenoid nuts (M30)	4.0 ~ 5.0

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8-03 TIGHTENING TORQUE AND SEALANT

Standard screws tightening torque

Thread dia.	Head mark		
	4	7	
M6	0.3 ~ 0.5	0.8 ~ 1.0	
M8	1.0 ~ 1.3	1.5 ~ 2.2	
M10	1.8 ~ 2.5	3.0 ~ 4.2	
M12	3.0 ~ 4.2	5.5 ~ 7.5	
M14	5.0 ~ 7.0	8.0 ~ 11.0	

Taper screws tightening torque

Size	To aluminum	To cast iron
NPTF 1/16	0.5 ~ 0.8	0.8 ~ 1.2
PT 1/8	0.8 ~ 1.2	1.5 ~ 2.2
PT 1/8, NPTF 1/4	2.0 ~ 3.0	3.5 ~ 4.5
PT 3/8	—	5.5 ~ 7.5

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■ Sealant

	Applied parts	Applied surface (location)	Sealant name
Thread parts	Taper screws 1/2″	Threads (gear case)	Hermeseal H1
	Taper screws 1/4″	Threads (right side of cylinder block, pump cover)	or ThreeBond 1104
	Taper screws 1/8″	Threads (rear surface of cylinder head)	
	Water drain plugs	Threads (right side and rear middle of cylinder block)	
	Oil pressure switch	Threads (right side surface of cylinder block)	
	Thermo−switch and thermo−senser	Threads (side surface of cylinder head or water outlet fitting)	
	Joint gauge unit	Threads (side surface of cylinder head)	
	Key-OFF solenoid	Threads	
Press-fit parts	Sealing caps	Press-fitting surface (cylinder head and block)	Hermeseal 52B
	Expansion plugs	Press-fitting surface (cylinder head and block)	
	Oil level gauge guide or guide retainer	Press-fitting surface (cylinder block)	
	Air breather hose nipples	Press-fitting surface (rocker cover and inlet manifold)	
Others	Side seals	Outer surface (main bearing cap No. 1 and No. 4)	ThreeBond 1212 or 1211
	Bearing cap front	Contact surface to cylinder block	ThreeBond 1212
	Bearing cap rear	Contact surface to cylinder block	

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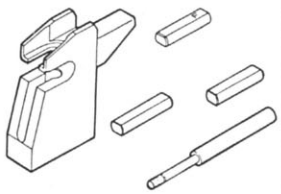
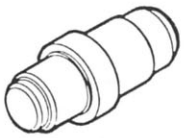
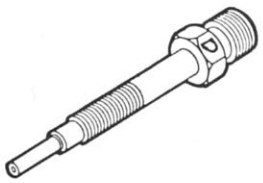
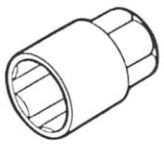
Tool No.	Tool name	Figure	Use
ST332301	Piston pin setting tool		Piston pin removal/installation Guide D (92.5 ℓ) : for K3A Guide E (91 ℓ) : for K3B, C Guide F (89 ℓ) : for K3D For K3D and smaller
ST332340	Camshaft bush installer		Camshaft front bush removal/installation
ST333060	Compression gauge adaptor		Compression measurement (for direct injection)
MD998054	Oil pressure switch socket wrench (26)		Oil pressure switch removing/installing

In addition to the above, commercially available bearing pullers, valve seat cutter, valve guide installer, oil filter wrench, etc. are required.

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Group 9

REFERENCE

Note :

Specifications given in this Group are as of April, 1988 and they are subject to change without notice.

In the maintenance of your engines, therefore, the oxlsting parts shoud be checked carefully for conformity to this manual. For new parts which this manual does not cover, refer to Service Bulletins applicable to the parts involved.

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COMPARISON BETWEEN SWIRL CHAMBER TYPE AND DIRECT INJECTIO

Item \ Type	Swirl chamber type	Direct injection type
Fuel consumption	Fuel consumption is bad as compared with the direct injection type due to following reasons. (1) Cooling loss is excessive because the combustion chamber (sub-chamber) is covered by the coolant. (2) Restriction loss is excessive because there is a restriction between the main and sub chambers. (3) Friction loss is excessive due to high compression ratio.	Opposition of the swirl chamber type
Exhaust fume	Good exhaust fume can be obtained in all range because forming of fuel-air mixture depends on strong swirl flow from the main chamber to sub-chamber.	Forming of fuel-air mixture depends on the swirl generated by the intake port. It is generally difficult to obtain good fume in all range because the swirl varies according to the engine speed. On the K series, however, exhaust fume equal to the swirl chamber type can be obtained as a result of thorough investigation of the best swirl and improvement of the combustion and injection systems.
Noise and vibration	It is generally quiet as compared with the direct injection type because its pressure increases slowly.	It is disadvantageous at noise and vibration because its pressure increases rapidly due to rapid combustion. On the K series, mild noise rather than the swirl chamber type can be obtained (at no load) as a result of lowered noise pressure level at high-frequency wave range by means of combustion and piston profile improvements.
Starting ability		
At hot	Ignitability is not good as compared with the direct injection.	Ignitability is good.
At cold	Combustion after ignition is good and start of revolution is rapidly raised because the combustion pressure is high and cold air does not enter the sub-chamber directly.	Determination of the optimum swirl is important to obtain smooth starting of revolution because the combustion tends to be disturbed due to cold air being sucked into the combustion chamber directly.
Blue and white exhaust fume		Blue or white exhaust fume or smell due to unburned fuel tends to generate immediately after starting the engine because the compression ratio is generally low. However, on the K series, blue or white fume, or smell is scarcely generated by complete combustion from immediately after starting the engine by means of thorough investigation of intake, combustion and injection systems.
Others		Less LOC and oil deterioration
Precautions		1. Always use the filtered diesel fuel. 2. Thoroughly clean all disassembled parts when overhauling the fuel system. Take care not to allow foreign matter or dust to enter the system, especially the nozzle injection holes because they are very precision.

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■ Fast Idle Speed

(1) Engines without damper spring

Engine		Fast idle speed setting (rpm)	Remarks
Model	Classification		
K3C K3D K3E K3F K4E	D11~D14	2650^{+30}_{-10}rpm	
K4F	D11, D12	2650^{+30}_{-10}	
K4F	D13	2750^{+30}_{-10}	
K4M	D11C, CT	2870^{+30}_{0}	
K4F	D31SS	2850^{+30}_{-10}	
K4M	D12CT	3070^{+30}_{0}	
K4F	D61A, D62DA	3150^{+30}_{-10}	Damper spring is set freely.
K4M	D61A, D62A, D62DA		

(2) Models with damper spring

Engine		Fast idle speed setting	
Model	Classification	A rpm	B rpm
K4F	D31BV, DS	2700^{0}_{-30}	2730^{0}_{-50}
K4M	D31DN, DS, DW	2750^{0}_{-30}	2780^{0}_{-50}

■ Slow Idle Speed

Engine		Slow Idle speed setting (rpm)
Model	Classification	
K3C K3D K3E K3F K4E K4F	D11~D14 (Except for Combines)	970^{+30}_{0}
K4F	D31BV, DS, SS D61, D62	935±25
K4M	D31DS, DN D31DW	1000±25
	D61A, 62A	935±25

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9-03 FUEL INJECTION TIMING TABLE

■ Injection timing

Injection timing B. T. D. C. (at SS)	Model	Use
19°±1.5°	K3C K3D K3E K3F K4E K4F K4M	D11~D14 (For agricultural use)
20°±1.5°	K4F	D31BV, DS, SS, D61A, D62A
	K4M	D61A, D62A, DA
17°±1.5°	K4M	D31DN, DS, DW

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Model		Pump part No.	At smoke setting (SS) NP／rpm： mm3／st	At start setting (MS) NP／rpm： mm3／st
K3C	D11, D12	MM431846	1250：23.6±1.0	150：41±5.0
K3D	D11G, D13G, GP	MM431847	1250：25.5±1.0	150：43±5.0
	D12G, D14G, GP	MM431848	1250：27±1.0	150：44±5.0
	D11A	MM433481	1250：27±1.0	150：44±5.0
K3E	D11A	MM433482	1250：26.1±1.0	150：43±5.0
K3F	D11A	MM433483	1250：28.7±1.0	150：43±5.0
K4E	D12A	MM434610	1250：22.9±1.0	150：41±5.0
	D13A	MM434611	1250：25.5±1.0	150：43.0±5.0
	D14A	MM434612	1250：20±1.0	150：39±5.0
K4F	D11A	MM436951	1250：25.8±1.0	150：43±5.0
	D12A	MM436457	1250：25.2±1.0	150：44±5.0
	D13A	MM436458	1300：28.0±1.0	150：47±5.0
	D31DS	MM437195	1250：25.2±1.0	150：44±5.0
	D31SS	MM435432	1350：41±1.0	——
	D61A, D62DA	MM435944	——	——
K4M	D11C, D11CT	MM434519	1350：39.6±1.0	150：73±7.5
	D12CT	MM437912	1450：37±1.0	150：62±7.5
	D61A, D62A, D62DA	MM436347	1350：39.4	150：83±7.5
	D31DS, D31DN, D31DW	MM435864	——	——

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TURBOCHARGERS

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INTRODUCTION

This Service Manual is written to familiarize you with the construction and maintenance of your Mitsubishi TD025, TD03, TD04, TD05 and TD06 Turbochargers.

Long life and efficient performance are the essential qualities required of the turbochargers if they are to fulfil their function of turbocharging the engines. These qualities depend to a great extent on the care exercised in maintenance of the turbochargers.

We hope you read this manual carefully, preferably referring to the separate parts catalogue, to get to know your new turbochargers and learn how to service them before starting disassembly, inspection, cleaning, repair and reassembly.

The description, illustrations and specifications contained in this manual were of the turbochargers manufactured at the time this manual was approved for printing.

Mitsubishi reserves the right to change specifications or design without notice and without incurring obligation.

HOW TO USE THIS MANUAL

1. The parts read in the texts or shown in the illustrations are numbered in the disassembling sequence prescribed for each system or assembly.
2. The items to be inspected during disassembly are indicated in ☐ in the disassembled view.
3. The maintenance standards to be referred to for inspection and reassembly are indicated in easy-to-refer passages of the texts and also in MAINTENANCE STANDARDS in a tabulated form.
4. The sequence in which the parts are to be reassembled are shown in the form of, for example, ⑤→②→④→③→①, below the assembled view.
5. The following marks are used in this manual:

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NOTES, CAUTIONS and WARNINGS

NOTES, CAUTIONS and WARNINGS are used in this manual to emphasize important and critical instructions. They are used for the following conditions:

NOTE ..... An operating procedure, condition, etc., which is essential to highlight.

CAUTION ..... Operating procedures, practices, etc., which if not strictly observed, will result in damage to or destruction of turbocharger.

WARNING .... Operating procedures, practices, etc., which if not correctly followed, will result in personal injury or loss of life.

DEFINITION OF TERMS

In this manual, the following terms are used in the dimensional and other specifications:

NOMINAL VALUE ..... Indicates the standard dimension of a part.

ASSEMBLY STANDARD ..... Indicates the dimension of a part, the dimension to be attained at the time of reassembly or the standard performance. Its value is rounded to the nearest whole number needed for inspection and is different from the design value.

STANDARD CLEARANCE ..... Indicates the clearance to be obtained between mating parts at the time of reassembly.

REPAIR LIMIT ..... A part which has reached this limit must be repaired.

SERVICE LIMIT ..... A part which has reached this limit must be replaced.

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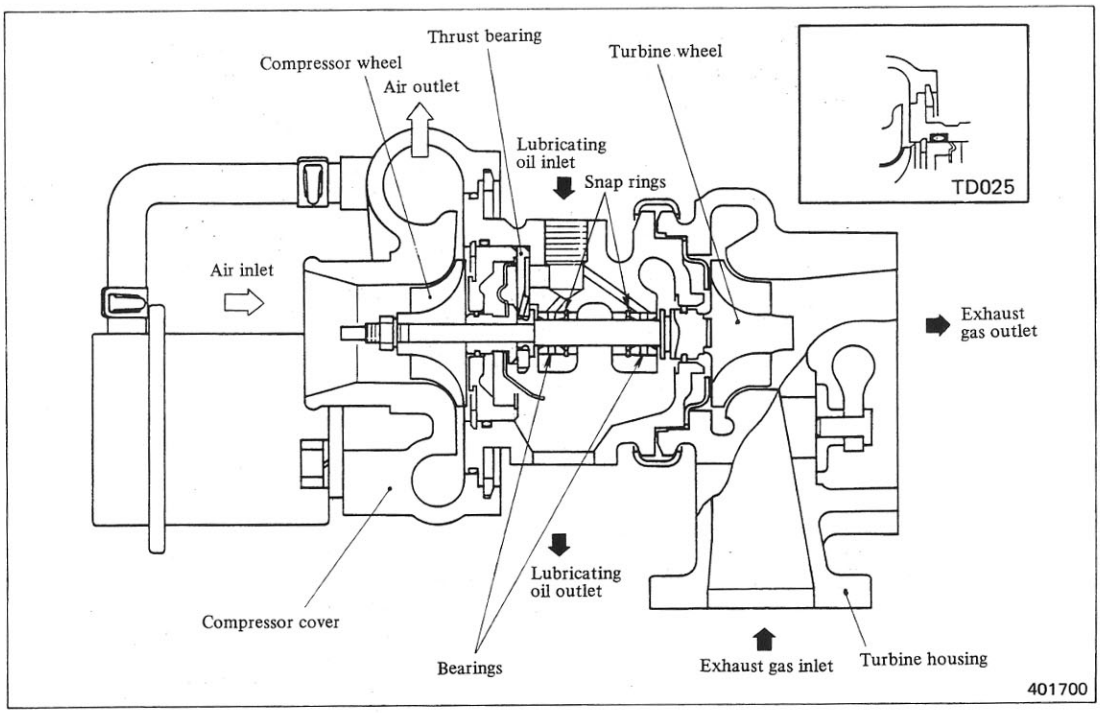
DESCRIPTION



The turbocharger consists of a mixed-flow turbine, driven by the exhaust gases coming from the engine, a centrifugal air compressor for pumping air toward the inlet manifold of the engine, and a shaft common to the turbine and compressor.

The turbocharger supplies a larger amount of inlet air to the engine than the amount it can draw in naturally aspirated condition.

For those diesel engine applications needing not so high "boost" (manifold) pressures, the larger amount of inlet air that turbocharging makes available eliminates sooty exhaust smoke, reduces the chances of engine overheating (by keeping down the cylinder temperature), improves fuel economy and does away with the need of engine derating at higher altitudes.

There are applications requiring more power from a given size of engine. For such applications, turbocharging meets the requirement by enabling the engine to convert more fuel into a large power output.

The high turbocharger technology of Mitsubishi is reflected in these turbochargers in terms of performance, reliability and durability. In comparison with other turbochargers, these five models feature separated-type bearings for supporting close to the ends of the shaft on which a greater part of rotary mass is concentrated during operation.

Other features are a shaft made slenderer to reduce the loss due to high-speed rotary friction and a separated-type turbine back plate designed to block more effectively the flow of heat from turbine side to bearing housing.

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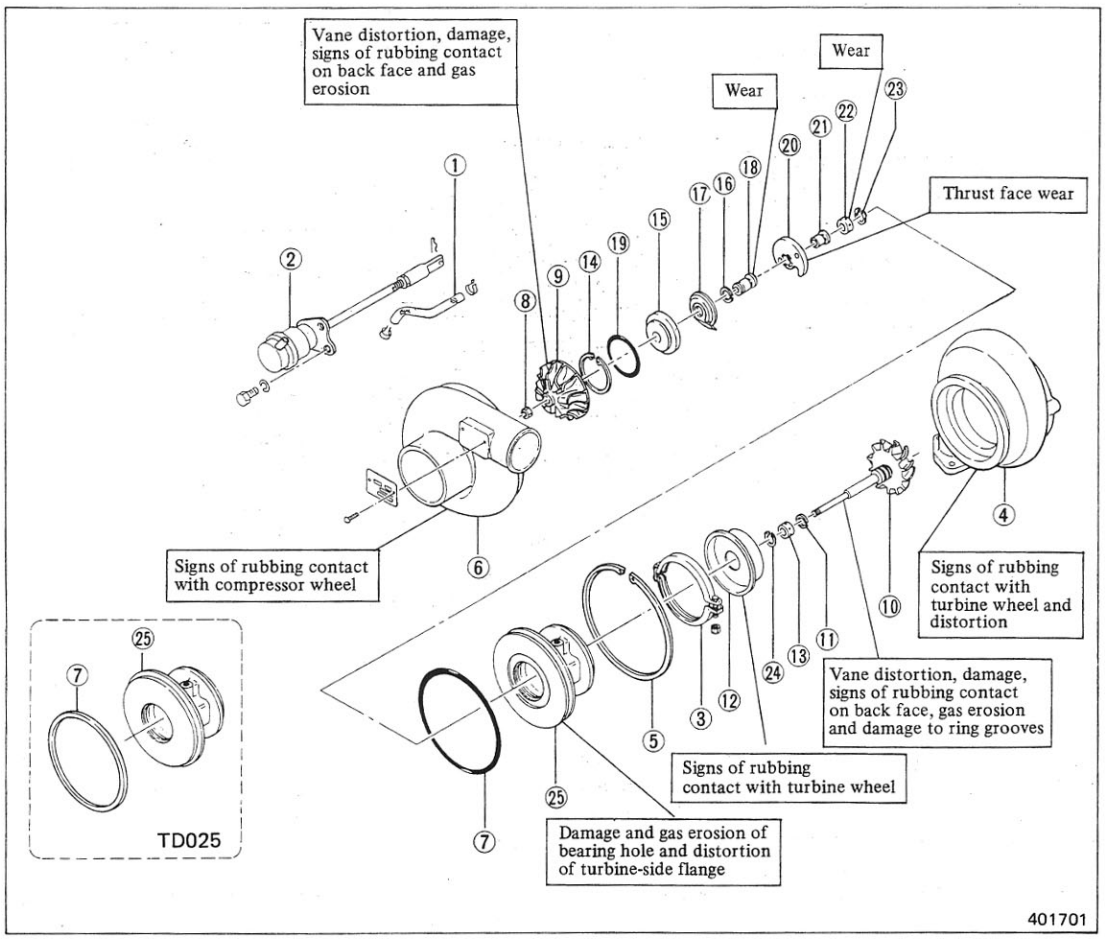
DISASSEMBLY



① Hose
② Actuator
③ Coupling assembly
④ Turbine housing
⑤ Snap ring
⑥ Compressor cover
⑦ O-ring
(shim for TD025)
⑧ Lock nut
⑨ Compressor wheel
⑩ Shaft & turbine wheel
⑪ Piston ring
⑫ Turbine back plate
⑬ Bearing
⑭ Snap ring
⑮ Insert
⑯ Piston ring
⑰ Oil deflector
⑱ Thrust sleeve
⑲ O-ring
⑳ Thrust bearing
㉑ Thrust ring
㉒ Bearing
㉓ Snap ring
㉔ Snap ring
㉕ Bearing housing

⚠ CAUTION

The vanes of compressor wheel and turbine wheel are not quite strong and can easily be distorted. When handling these wheels, be careful not to drop or shock them.

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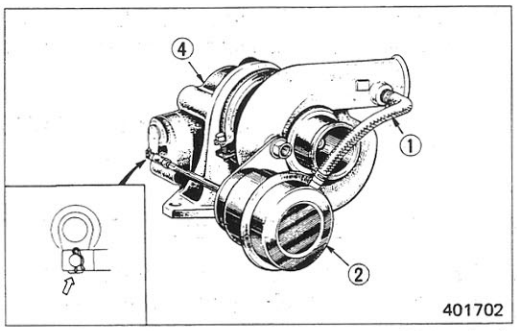
1. Removal of actuator

Disconnect hose (1) from actuator, and remove actuator (2).

NOTE

To disconnect the rod of actuator (2) from turbine housing (4), pull off snap pin at the lever joint.

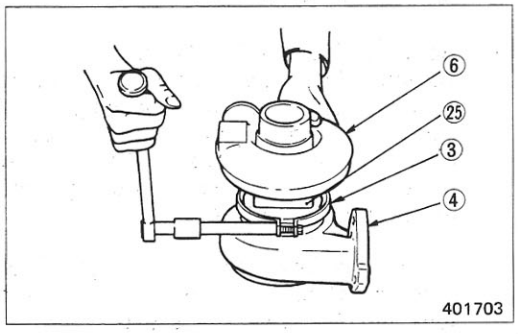


2. Removal of turbine housing

Loosen coupling assembly (3), as shown, and separate turbine housing (4) from bearing housing (25).

NOTE

Before separating the three enclosure parts, namely, compressor cover (6), bearing housing (25) and turbine housing (4), be sure to give match marks across each joint. A punch or quick-drying ink pen may be used.

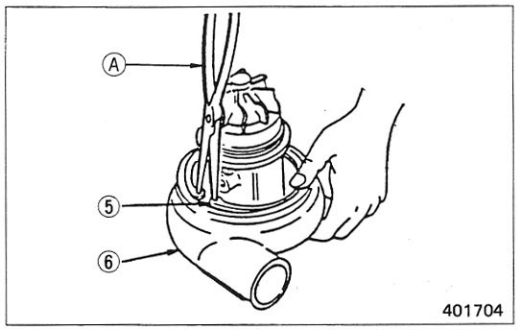


3. Removal of compressor cover

(1) Lay compressor cover (6) flat on the table, as shown. Using the snap ring pliers (A) (49160-90100), take off snap ring (5).

⚠ WARNING

Hold down the snap ring by hand while pinching the ring ends with the snap ring pliers, so that the ring will not fly off just in case the ring ends slip off the pliers.



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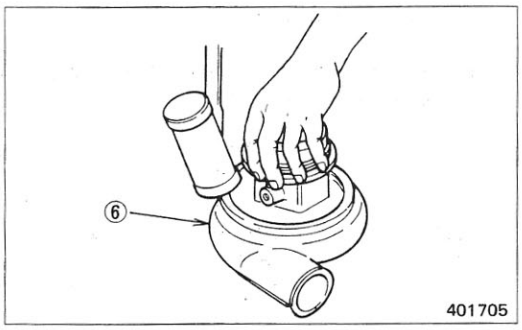
(2) Using a plastic hammer, lightly tap around on compressor cover (6) to remove the cover.

Remove the O-ring or shim (TD025) (7) from the bearing housing.



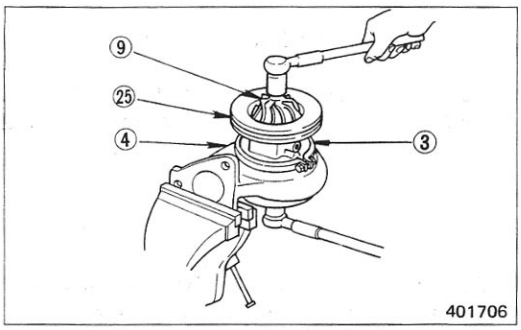
CAUTION

Be careful not to bump the compressor wheel against the cover.

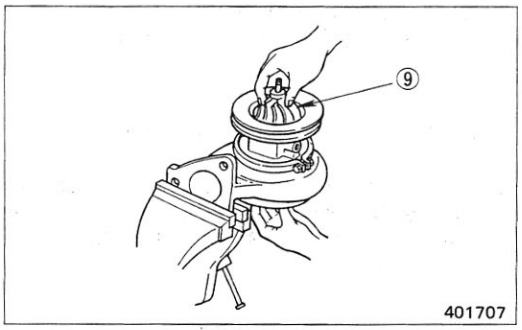
4. Removal of compressor wheel

(1) Hold turbine housing (4) in a vise, as shown. Fit the removed bearing housing (25) to the housing, and secure it temporarily with coupling. Shaft & turbine wheel (10) is now back in the turbine housing and compressor wheel (9) is on top.

While holding the boss part of turbine wheel as shown, loosen off lock nut (8) from the shaft.

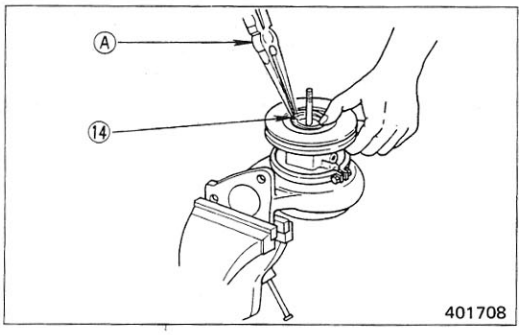


(2) Put your hand to the turbine wheel and, while holding this wheel, turn compressor wheel (9) back and forth with the other hand to lift it off the shaft.



5. Removal of snap ring

Using the snap ring pliers (A) (49160-90100), remove snap ring (14).



WARNING

Hold down the snap ring by hand while pinching the ring ends with the snap ring pliers, so that the ring will not fly off just in case the ring ends slip off the pliers.

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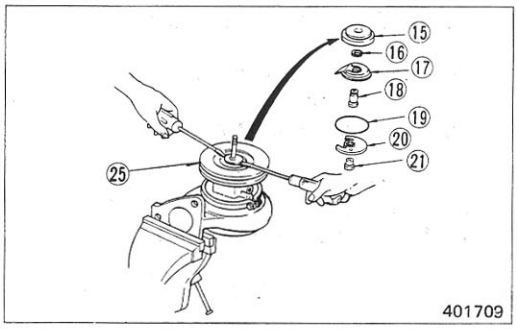
6. Removal of insert, oil deflector and others

Using two screwdrivers, gently lift insert (15) off bearing housing (25). Remove the following parts:

⑯ Piston ring
⑰ Oil deflector
⑱ Thrust sleeve
⑲ O-ring
⑳ Thrust bearing
㉑ Thrust ring

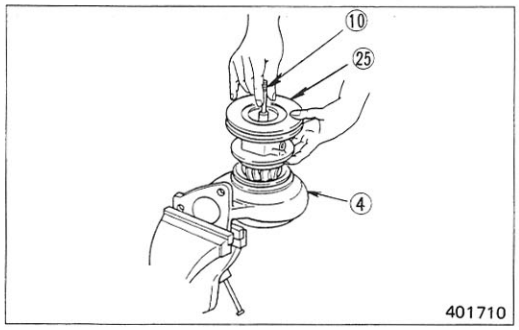


NOTE

In reassembling, position snap ring (14) with its flat side facing insert (15).

7. Removal of shaft & turbine wheel and bearing

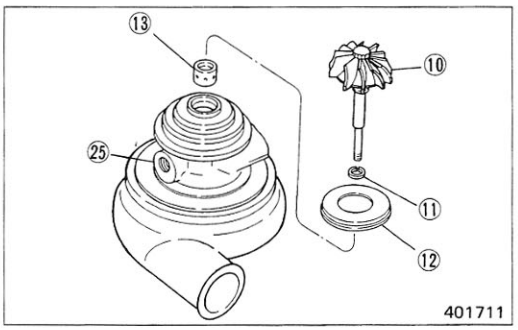
(1) Lift bearing housing (25) complete with shaft & turbine wheel (10) off turbine housing (4) held in the vise, with one hand holding the shaft and with the other hand holding the bearing housing (25). Be careful not to damage the vanes as the shaft & turbine wheel clears turbine housing (4).



(2) Turn bearing housing (25) upside down (with the turbine wheel up), and lay it on compressor cover. Under this condition, remove the following parts:

(To remove shaft & turbine wheel (10), lightly tap on its end with a hammer handle.)

⑩ Shaft & turbine wheel
⑪ Piston ring
⑫ Turbine back plate
⑬ Bearing (turbine side)



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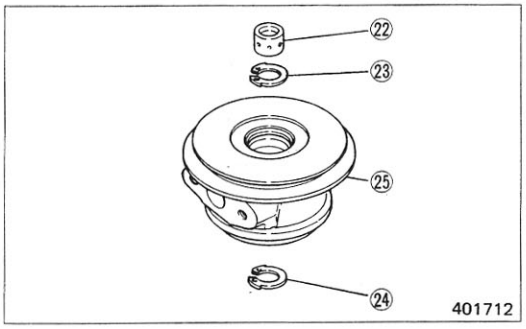
8. Removal of snap rings and bearing

Lay bearing housing (25) on the bench with the compressor side up, and remove the following parts:

㉒ Bearing
㉓ Snap ring } (compressor side)
㉔ Snap ring (turbine side)



NOTE

a) Use the snap ring pliers (49160-90200) to remove the snap rings.

b) When removing the snap ring, be careful not to damage the inside surface of bearing housing and sealing face (turbine side) of piston ring.

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CLEANING AND INSPECTION

1. Cleaning

Blasting equipment is used in the factory to clean turbochargers. At the dealer level, the following cleaning method, based on the use of a non-inflammable solvent (for which Die Cleaner T-30 of Daido Chemical make is recommendable), may be applied:

NOTE

Non-sudsing household detergent may be used instead of the solvent. In such a case, be sure to select one that is chemically neutral and does not attack metals.

(1) Visually inspect the parts to detect signs of burning and other mal-conditions in order to obtain as much information as possible before washing them.

(2) Immerse the parts in the washing pan filled with the solvent, and wash each clean, making it completely free of oily matter.

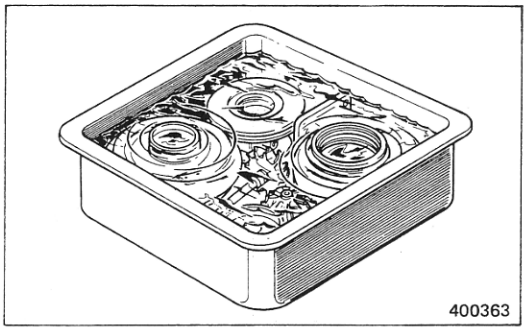
(3) Take out the washed parts and dry them by directing compressed air: blow off the solvent from every nook and corner of each part.

(4) Scale-like deposits, if any, must be removed by using a plastic scraper or bristle brush. After removing the deposits off, wash the part and dry it again as before.

⚠ CAUTION

When washing and drying the parts, handle them cautiously and avoid denting or nicking them.

(5) Protect the sliding surfaces of the cleaned parts against rusting by applying clean engine oil to them.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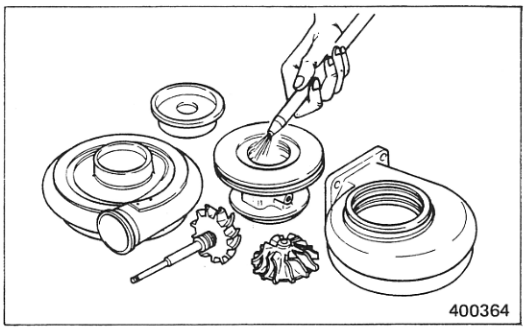
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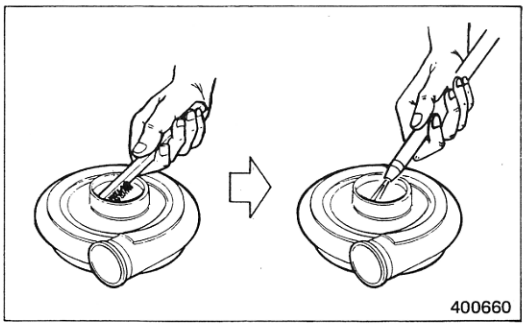
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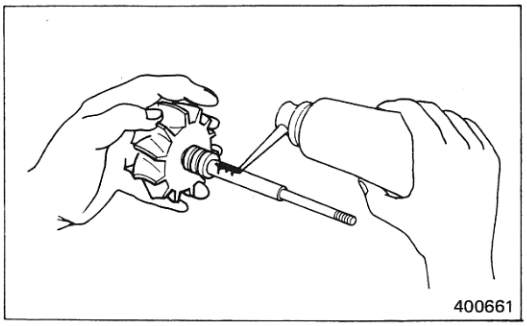
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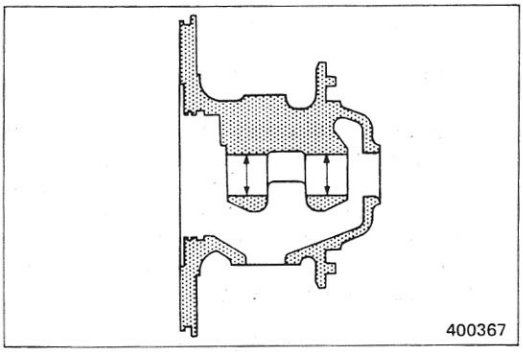
2. Inspection

(1) Bearing housing

Measure the inside diameter of bearing bores in the housing. If it exceeds the Service limit, replace the housing.

Unit: mm (in.)

Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Inside diameter of bearing bores in housing	11.006 (0.43331)	13.006 (0.51205)	15.686 (0.61756)

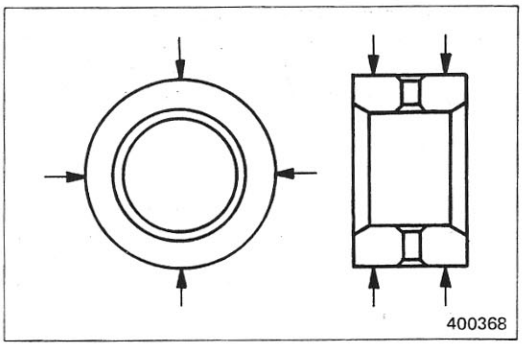


(2) Bearing

(a) Measure the outside diameter of the bearing. If it is less than the Service limit, replace the bearing.

Unit: mm (in.)

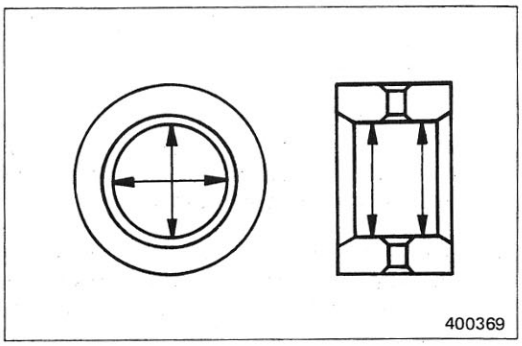
Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Outside diameter of bearing	10.924 (0.43008)	12.924 (0.50882)	15.574 (0.61315)



(b) Measure the inside diameter of the bearing. If it exceeds the Service limit, replace the bearing.

Unit: mm (in.)

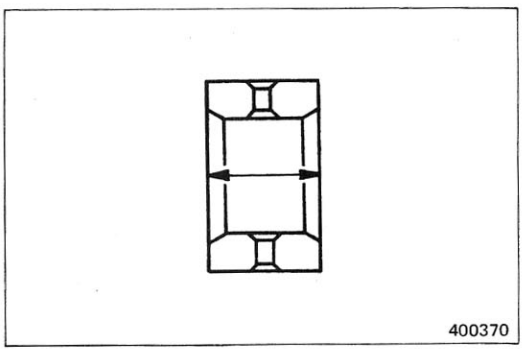
Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Inside diameter of bearing	6.029 (0.23736)	7.529 (0.29642)	9.040 (0.35590)



(c) Measure the length of the bearing. If it is less than the Service limit, replace the bearing.

Unit: mm (in.)

Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Length of bearing	6.94 (0.2732)	7.94 (0.3126)	9.34 (0.3677)



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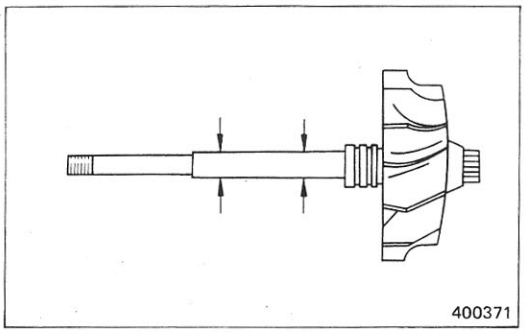
(3) Shaft & turbine wheel

(a) Measure the diameter of the shaft journals. If it is less than the Service limit, replace the shaft & turbine wheel and piston ring.

Unit: mm (in.)

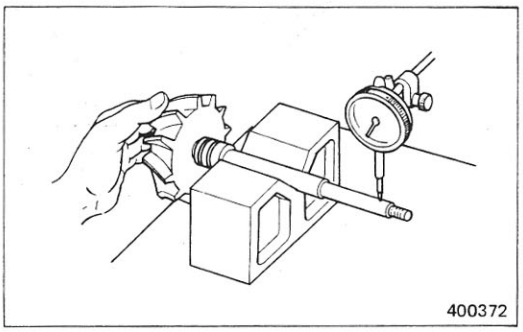
Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Diameter of shaft journals	5.996 (0.23606)	7.496 (0.29512)	8.994 (0.35410)



(b) Using a dial indicator and V-block, measure the runout of the shaft. If it exceeds the Service limit, replace the shaft & turbine wheel.

Unit: mm (in.)

Item	Service limit		
	TD025	TD03/TD04	TD05/TD06
Runout of shaft & turbine wheel	0.015 (0.00059)		



NOTE

Do not attempt to straighten a distorted shaft. Be sure to replace the shaft & turbine wheel with a new one when the shaft is distorted.

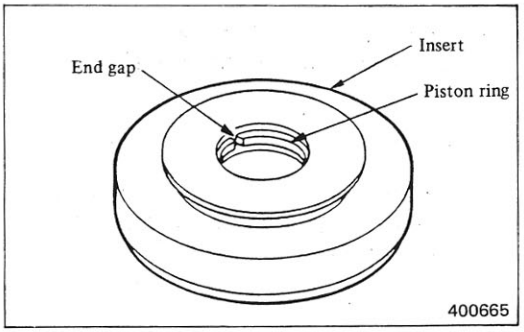
(c) Check the surfaces of shaft journals for condition. If they are roughened, hold the shaft on a lathe by tightening it in the chucks at its center, and turn it at 300 to 600 rpm to lightly polish the journals with #400 sandpaper and engine oil.

(4) Insert

Place a new piston ring in the groove in the insert, and measure the end gap of the ring. If the gap exceeds the Standard clearance, replace the insert.

Unit: mm (in.)

Item	Standard clearance		
	TD025	TD03/TD04	TD05/TD06
End gap of piston ring	0.05 – 0.15 (0.0020 – 0.0059)		



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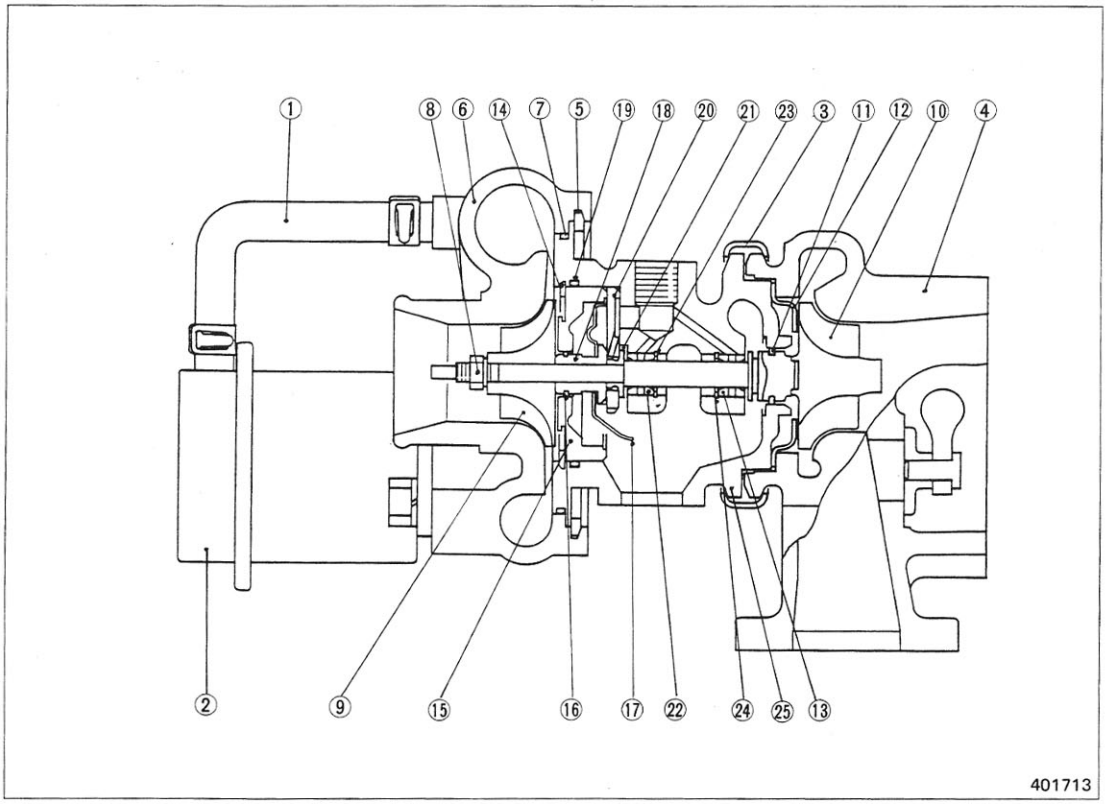
REASSEMBLY



Reassembling sequence

㉕→㉔→㉓→⑬→⑫→㉒→㉑→⑳→⑲→⑪→⑩→⑰→⑱→⑯→⑮→⑭→⑨→⑧→⑦→⑥→⑤→④→③→②→①

NOTE

a) Replace the following parts when reassembling the turbocharger:

⑪ Piston ring ⑲ O-ring
⑯ Piston ring ⑦ O-ring

b) After installing an overhauled turbocharger on the engine, crank the engine with the starter to permit the engine oil to flow to the turbocharger.

⚠ CAUTION

Replace the compressor wheel or shaft & turbine wheel if its vanes are badly distorted or cracked. A single blade having minor distortion or scratching is not the cause for replacement; in such a case, never attempt to re-shape the distorted vane.

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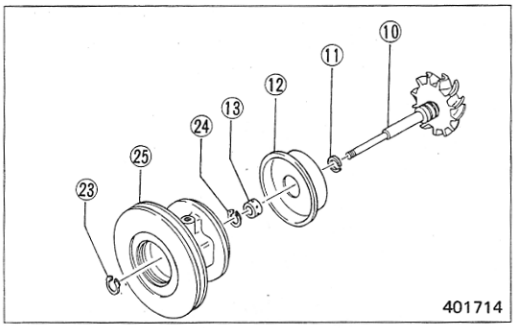
1. Installation of shaft & turbine wheel and bearings

(1) Reassemble the following parts:

㉕ Bearing housing
㉔ Snap ring
㉓ Snap ring
⑬ Bearing
⑪ Piston ring
⑩ Shaft & turbine wheel



⚠ CAUTION

a) Use the snap ring pliers (49160-90200) to install the snap rings. After installing the snap ring, make sure that it can be finger rotated freely.

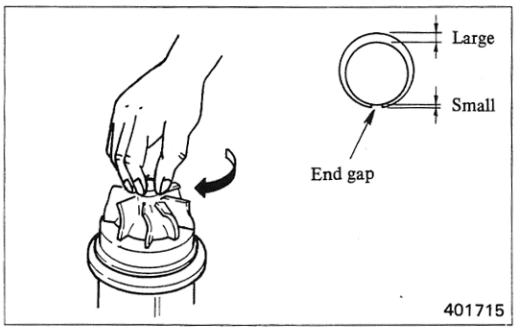
b) Apply engine oil to the inside and outside surfaces of bearing when installing the bearing to the shaft.

c) When installing the piston ring to the shaft & turbine wheel, be careful not to expand the ring more than is necessary for installation nor to twist it.

d) After installing the piston ring in its groove, apply Molykote to it.

Lay bearing housing (25) on compressor cover (6) and install turbine back plate (12).

(2) When installing shaft & turbine wheel complete with piston ring to the bearing housing, position the piston ring as shown, and insert the shaft & turbine wheel into the housing while rotating it back and forth.



⚠ CAUTION

Never force the shaft & turbine wheel unless it is in line with the turbine back plate and bearing housing.

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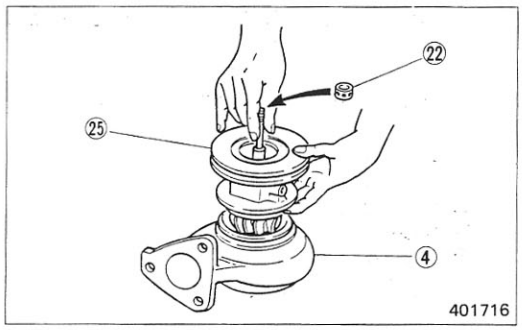
(3) After installing shaft & turbine wheel (10), hold the end of shaft by hand, and turn it upside down so that its compressor side is up. Then, install compressor-side bearing (22). Temporarily install bearing housing (25) to turbine housing (4), and install coupling assembly (3) by tightening its nut temporarily.

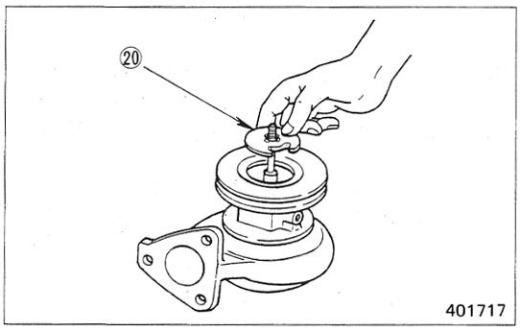


⚠ CAUTION

Hold the shaft by hand to prevent it from sliding out of position during installation.

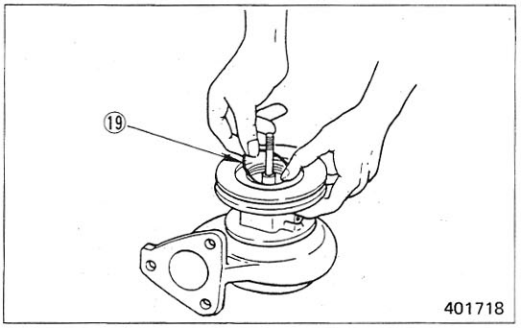
2. Installation of thrust bearing

Apply engine oil to the inside and outside surfaces of thrust ring (21) and thrust bearing (20), and install the ring and bearing in place.



3. Installation of O-ring

Apply engine oil to O-ring (19), and install it in place.



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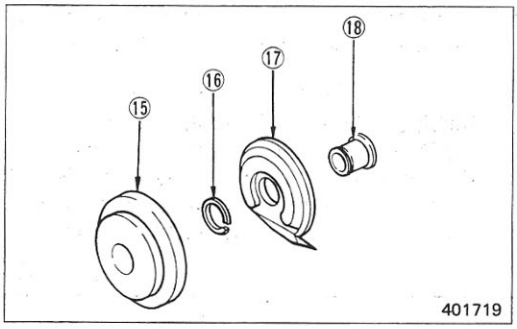
4. Reassembly of insert subassembly

(1) Reassemble the insert parts in the following sequence:

⑰ Oil deflector
⑱ Thrust sleeve
⑯ Piston ring
⑮ Insert



⚠ CAUTION

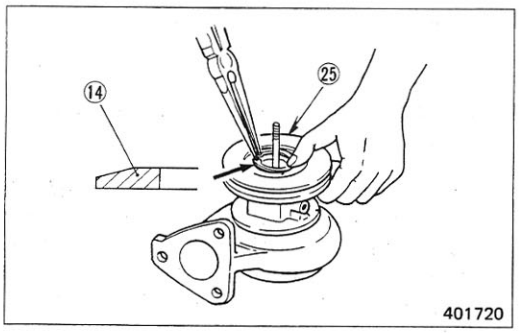
a) When installing the piston ring to the thrust sleeve, be careful neither to expand the ring more than is necessary for installation nor to twist its end gap.

b) Apply Molykote to the piston ring fitted to the thrust sleeve, and install the sleeve to the insert, taking care not to damage the ring.

(2) Install the insert subassembly to bearing housing (25).

5. Installation of snap ring

Using the snap ring pliers (49160-90100), install snap ring (14) to bearing housing (25), with its tapered side facing upward.

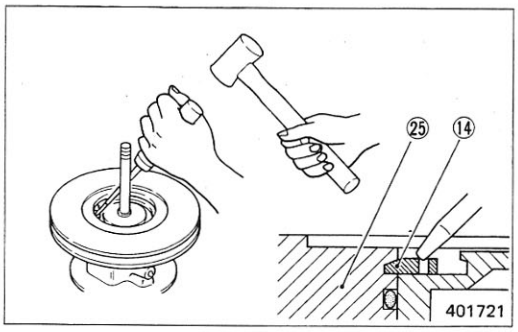


⚠ CAUTION

a) Be sure to position the snap ring as specified above when installing it.

b) Give light hammer blows to the ends of snap ring through a screwdriver to fit the ring in the groove in the bearing housing.

c) When giving hammer blows to the snap ring, be careful not to damage the bearing housing.



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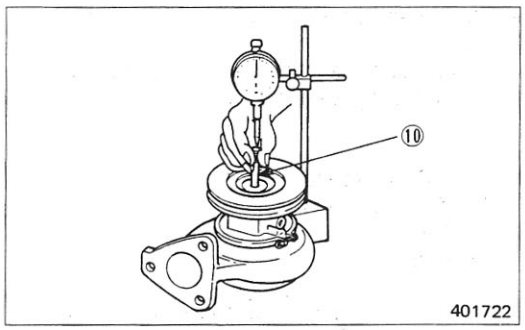
6. Measurement of clearance between turbine wheel and turbine housing

Set up a dial indicator on shaft & turbine wheel (10) as shown. Move the shaft in the axial direction to measure the clearance. If the clearance is out of the Standard clearance, disassemble the parts, and investigate for the cause.

Unit: mm (in.)

Item	Standard clearance		
	TD025	TD03/TD04	TD05/TD06
Clearance between shaft & turbine wheel and turbine housing	0.39 – 1.00 (0.0154 – 0.0394)	0.28 – 0.97 (0.0110 – 0.0382)	0.42 – 1.10 (0.0165 – 0.0433)

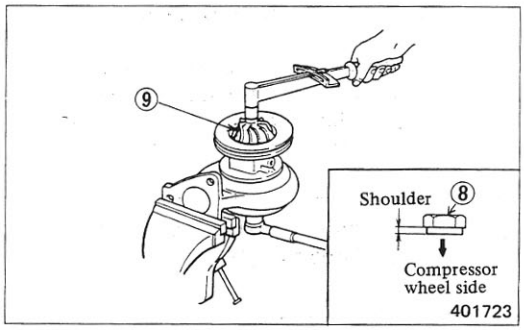


7. Installation of compressor wheel

Install compressor wheel (9), apply Molykote to the lock nut and tighten it to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Item	Tightening torque		
	TD025	TD03/TD04	TD05/TD06
Compressor wheel lock nut	0.15 – 0.25 (1.1 – 1.8) [1.5 – 2.5]	0.40 – 0.50 (2.9 – 3.6) [3.9 – 4.9]	0.80 – 0.90 (5.8 – 6.5) [7.8 – 8.8]

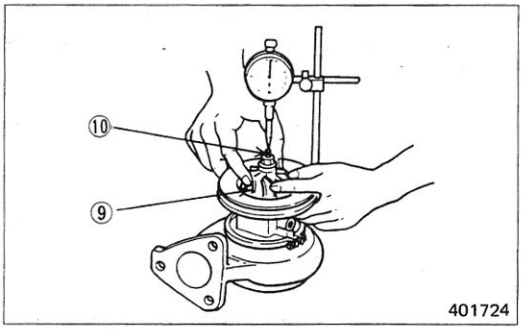


8. Measurement of axial play of shaft & turbine wheel

Set up a dial indicator on shaft & turbine wheel (10) as shown. Move compressor wheel (9) in the axial direction to measure the play. If the play is out of the Standard clearance, disassemble the parts, and investigate for the cause.

Unit: mm (in.)

Item	Standard clearance		
	TD025	TD03/TD04	TD05/TD06
Axial play of shaft & turbine wheel	0.057 – 0.103 (0.00224 – 0.00406)		



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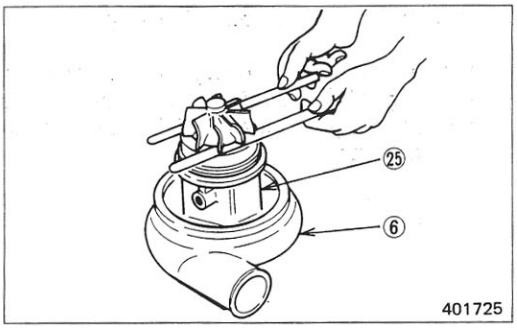
9. Measurement of clearance between turbine back plate and turbine wheel

Remove the turbine housing from bearing housing (25), and install compressor cover (6). Using filler gauges, measure the clearance between turbine back plate (12) and turbine wheel. If the clearance is out of the Standard clearance, disassemble the parts, and investigate for the cause.



NOTE

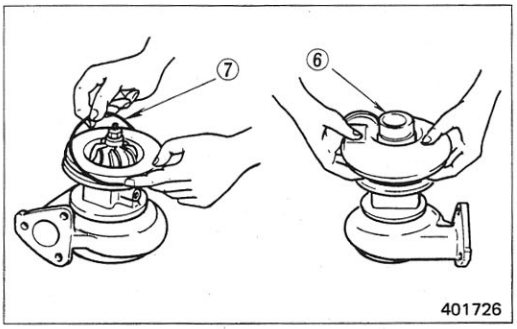
Measure the clearance at the tips of vanes with two feeler gauges.

Unit: mm (in.)

Item	Standard clearance		
	TD025	TD03/TD04	TD05/TD06
Clearance between turbine back plate and turbine wheel	0.88 – 1.32 (0.0346 – 0.0520)	0.39 – 0.83 (0.0154 – 0.0327)	0.37 – 0.85 (0.0146 – 0.0335)

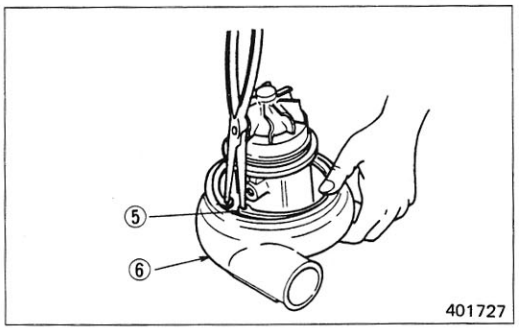
10. Installation of compressor cover

Install compressor cover (6), making sure that it is correctly positioned with respect to the turbine housing. Apply grease to O-ring (7) when installing it.



11. Installation of snap ring

Using the snap ring pliers (49160-90100), install snap ring (5) to compressor cover (6), with its tapered side facing upward.



NOTE

a) Be sure to position the snap ring as specified above when installing it.

b) Give light hammer blows to the ends of snap ring to fit the ring in the groove in the bearing housing.

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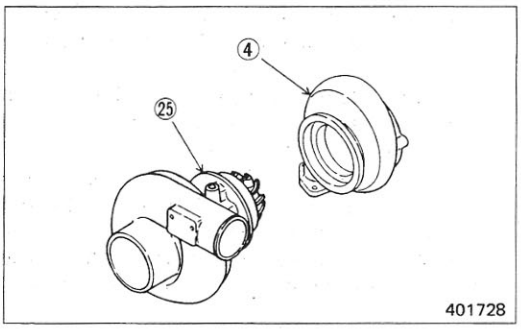
12. Installation of turbine housing

Install turbine housing (4) to bearing housing (25), making sure that it is correctly positioned with respect to the housing.

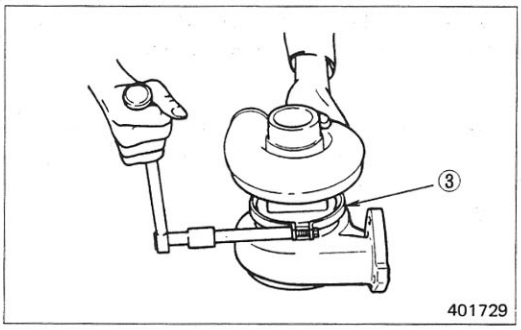


13. Installation of coupling assembly

Apply Molykote to the threads of nut of coupling assembly (3), and tighten the nut to the specified torque.

Unit: kgf·m (lbf·ft) [N·m]

Item	Tightening torque		
	TD025	TD03/TD04	TD05/TD06
Coupling assembly nut	0.15 – 0.25 (1.1 – 1.8) [1.5 – 2.5]	0.40 – 0.50 (2.9 – 3.6) [3.9 – 4.9]	0.40 – 0.50 (2.9 – 3.6) [3.9 – 4.9]

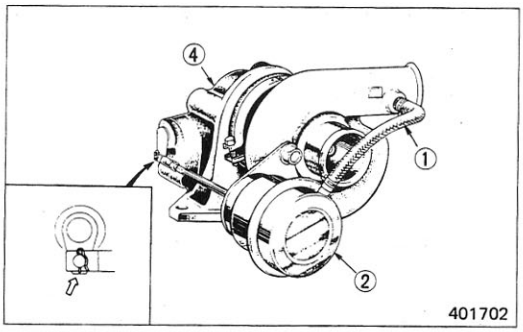


14. Installation of actuator

Install actuator (2) in place, and connect hose to actuator.

NOTE

After installing actuator body (2) to compressor cover (6), connect its rod to the lever of turbine housing (4) with snap pin.



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TROUBLESHOOTING

Symptom	Possible causes and remedy
Rough running (abnormal running noise or vibration)	(1) Bearing could be in faulty condition or rotating parts, particularly wheels, could be rubbing surrounding parts. This type of trouble is often caused by keeping a deteriorated lubricating oil in service, by inadequate oil supply due to a clogged oil pipe or broken or clogged oil filter, or by habitual quick cold starting or abrupt shutting down of a hot engine. (2) Evidence of rubbing contact on rotating parts indicates loss of balance in rotating mass or a distorted shaft, caused by a worn-down bearing or by an airborne or gasborne object impinging upon the compressor or turbine wheel to disturb its mass distribution. In either case, turbocharger must be taken down and inspected. Usually repair service is required.
Turbocharger appears to be in sound condition but engine lacks power.	(1) Exhaust gases could be leaking. Check exhaust gas line from engine manifold to turbocharger gas inlet. (2) Abnormally high back pressure to turbocharger's exhaust gas outlet could be the cause. Check muffler for clogging with carbon. (3) Boost air could be leaking or air cleaner could be in clogged condition. If clogged, clean or replace element. (4) Compressor interior could be dirty with excessive dust accumulation. If this happens to be the case, remove compressor cover and clean. (5) After shutting down engine, try to spin rotor by hand. If rotor will not spin, disassemble turbocharger and clean.

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Symptom	Possible causes and remedy
Oil leaks from exhaust gas outlet pipe or from inlet air pipe. Exhaust smoke tends to pick whitish color.	(1) A clogged air cleaner is liable to create a negative-pressure condition on suction side to draw in lubricating oil. Clean or replace element. (2) Inspect lubricating oil return pipe for damage. A dented or distorted pipe must be repaired or replaced. (3) See if piston ring is worn down or, because of its groove being worn down, loose in groove: if so, replace worn parts. (4) Keeping turbocharger in service with its bearing in faulty condition will damage piston ring in time, resulting in leakage of oil into both ends, that is, gas outlet pipe and inlet air pipe.

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MAINTENANCE STANDARDS

1. Maintenance standards

Unit: mm (in.)

Part or item			Nominal value	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remarks
Inside diameter of bearing bores in bearing housing		TD025	11.0 (0.433)			11.006 (0.43331)	
		TD03/TD04	13.0 (0.512)			13.006 (0.51205)	
		TD05/TD06	15.6 (0.614)			15.686 (0.61756)	
Bearing	Outside diameter	TD025				10.924 (0.43008)	
		TD03/TD04				12.924 (0.50882)	
		TD05/TD06				15.574 (0.61315)	
	Inside diameter	TD025				6.029 (0.23736)	
		TD03/TD04				7.529 (0.29642)	
		TD05/TD06				9.040 (0.35590)	
	Length	TD025				6.94 (0.2732)	
		TD03/TD04				7.94 (0.3126)	
		TD05/TD06				9.34 (0.3677)	
Shaft & turbine wheel	Diameter of shaft journals	TD025	6 (0.236)			5.996 (0.23606)	
		TD03/TD04	7.5 (0.295)			7.496 (0.29512)	
		TD05/TD06	9 (0.354)			8.994 (0.35410)	
	Runout of shaft					0.015 (0.00059)	
End gap of piston ring				0.05 – 0.15 [(0.0020 – 0.0059)]			With ring fitted in insert
Clearance between shaft & turbine wheel and turbine housing		TD025		0.39 – 1.00 [(0.0154 – 0.0394)]			
		TD03/TD04		0.28 – 0.97 [(0.0110 – 0.0382)]			
		TD05/TD06		0.42 – 1.10 [(0.0165 – 0.0433)]			
Axial play of shaft & turbine wheel				0.57 – 0.103 [(0.00224 – 0.00406)]			

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Unit: mm (in.)

Part or item		Nominal value	Assembly standard [Standard clearance]	Repair limit [Clearance]	Service limit [Clearance]	Remarks
Clearance between turbine back plate and turbine wheel	TD025		0.88 – 1.32 [(0.0346 – 0.0520)]			
	TD03/TD04		0.39 – 0.83 [(0.0154 – 0.0327)]			
	TD05/TD06		0.37 – 0.85 [(0.0146 – 0.0335)]			

2. Tightening torques

Secured part or component		Thread Diam. – pitch	Width across flats	Tightening torque			Remarks
				kgf·m	lbf·ft	N·m	
Compressor wheel lock nut	TD025	4 – 0.7 (0.16 – 0.03)	7 (0.28)	0.15 – 0.25	1.1 – 1.8	1.5 – 2.5	Apply Molykote to threads
	TD03/TD04	5 – 0.8 (0.20 – 0.03)	8 (0.31)	0.40 – 0.50	2.9 – 3.6	3.9 – 4.9	
	TD05/TD06	1/4-28UNF-3A	11 (0.43)	0.80 – 0.90	5.8 – 6.5	7.8 – 8.8	
Coupling assembly nut	TD025	5 – 0.8 (0.20 – 0.03)	8 (0.31)	0.15 – 0.25	1.1 – 1.8	1.5 – 2.5	Apply Molykote to threads
	TD03/TD04	6 – 1.0 (0.24 – 0.04)	10 (0.39)	0.40 – 0.50	2.9 – 3.6	3.9 – 4.9	
	TD05/TD06	6 – 1.0 (0.24 – 0.04)	10 (0.39)	0.40 – 0.50	2.9 – 3.6	3.9 – 4.9	

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