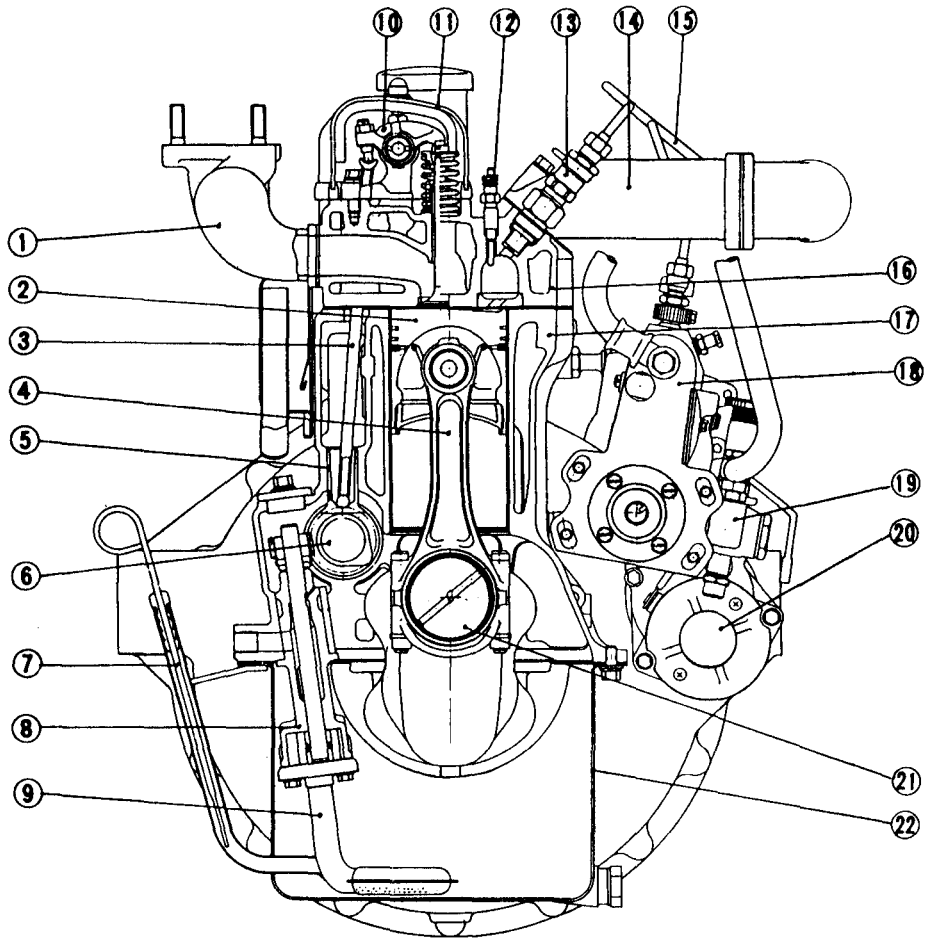
INDEX

1-4 Transverse sectional view



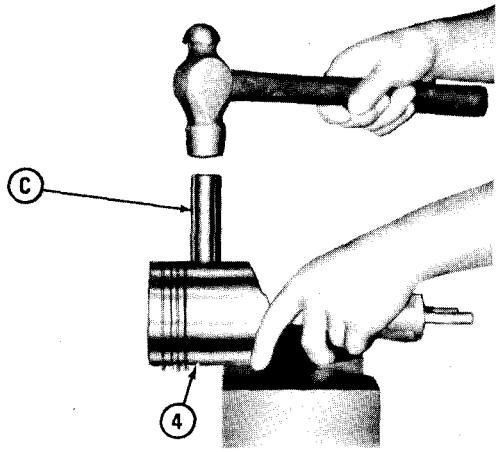
402503

1-Exhaust manifold
2-Piston
3-Valve push rod
4-Connecting rod
5-Tappet
6-Camshaft
7-Oil level gauge
8-Oil pump
9-Oil strainer
10-Rocker arm
11-Rocker cover
12-Glow plug
13-Fuel injection nozzle
14-Intake manifold
15-Fuel injection pipe
16-Cylinder head
17-Crankcase
18-Fuel injection pump
19-Fuel feed pump
20-Starter
21-Crankshaft
22-Oil pan

Engine model				4DQ5
Fuel system	Fuel injection nozzles	Type of nozzle tips		Bosch ND-DN0SD2 1
		Spray hole diam	mm (in.)	1 (0.04)
		Spray angle		0°
		Injection pressure	kg/cm² (psi)	$120\ ^{+10}_{0}$ ($1706\ ^{+142}_{0}$)
	Fuel filter			Paper-element type
Lubrication system	Oil pump	Type		Trochoid
		Speed ratio to crankshaft		1/2
		Capacity at oil temp. 50 ± 5°C (122 ± 9°F); pressure 3 kg/cm² (42.7 psi)	liter (cu in.)/ min/rpm	8.37 (510.8), min/1000 (pump rpm)
	Oil pressure	At duty run	kg/cm² (psi)	3 ~ 4 (42.7 ~ 56.9)
		At idling		1 ~ 2 (14.2 ~ 28.4)
	Oil filter			Paper-element type
	Relief valve	Type		Piston-valve
		Valve opening pressure	kg/cm² (psi)	3 ± 0.2 (42.7 ± 2.8)
	Refill capacity	Oil pan	liter (U.S. gal)	6.5 (1.7)
		Oil filter		0.7 (0.18)
	Oil bypass valve	Type		Piston-valve
		Valve opening pressure	kg/cm² (psi)	0.8 ~ 1.2 (11.4 ~ 17.1)
Cooling system	Water pump	Type		Centrifugal type
		Speed ratio to crankshaft		1.3
		Capacity	liter (cu in.)/ min/rpm	105 (6408)/3900 (pump rpm)
	Thermostat	Type		Wax
		Valve opening temperature		76.5 ± 2°C (169.7 ± 3.6°F)
		Valve lift temperature		90 ± 2°C (194 ± 3.6°F)
	Fan	Type		Circular-arc pusher type
		No. of blades		6
		Outside diameter	mm (in.)	380 (15)
		Ratio to crankshaft speed		1.3
	Drive belt	Type		Low-edge cog B
		No. of belts		1
	Refill capacity (engine water jacket)		liter (U.S. gal)	4.5 (1.2)

(d) Remove piston pin (4) by using drift (C).

(e) Remove piston pin bushing and connecting rod bearing (upper).



(25) Disassemble the rocker shaft assembly as follows:

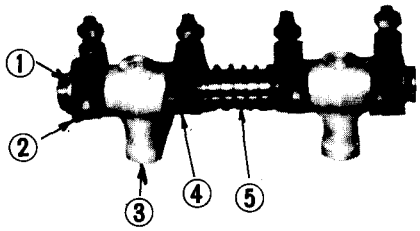
(a) Remove snap rings on both ends (1).

(b) Remove rocker assembly (2).

(c) Remove rocker bracket (3).

(d) Remove rocker assembly (4).

(e) Remove spring (5).



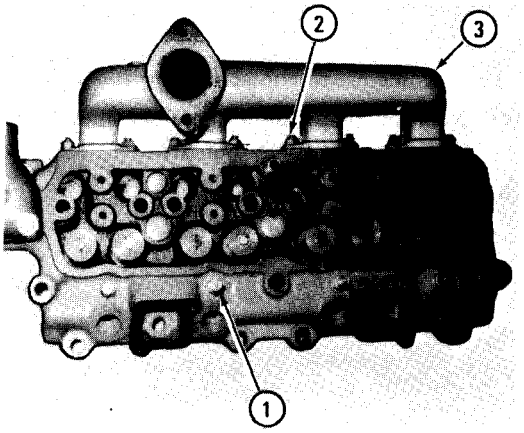
(26) Disassembly the cylinder head as follows:

(a) Remove nozzle holders.

(b) Remove glow plugs (1).

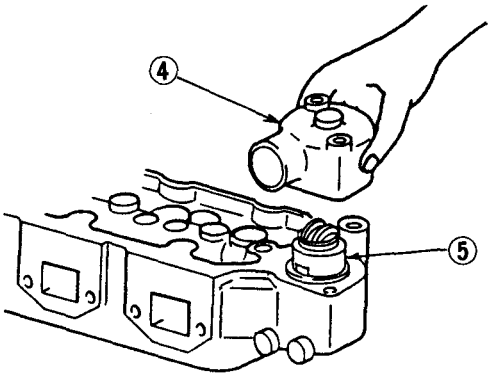
(c) Loosen bolts (2) securing exhaust and intake manifolds.

(d) Remove exhaust manifold (3).



(e) Loosen thermostat cover bolts and remove thermostat cover (4).

(f) Remove thermostat (5).



Cylinder sleeves

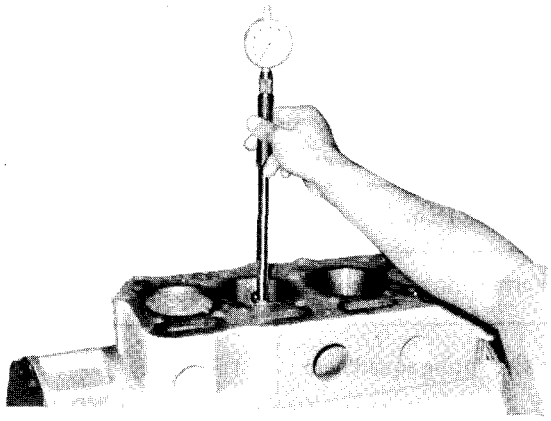
(1) Using a cylinder gauge, take ID measurements in two directions (parallel and transverse to crankshaft axis) on each cylinder sleeve, at three places indicated below.

If wear reaches the repair limit, rebore the sleeve to the next specified oversize.

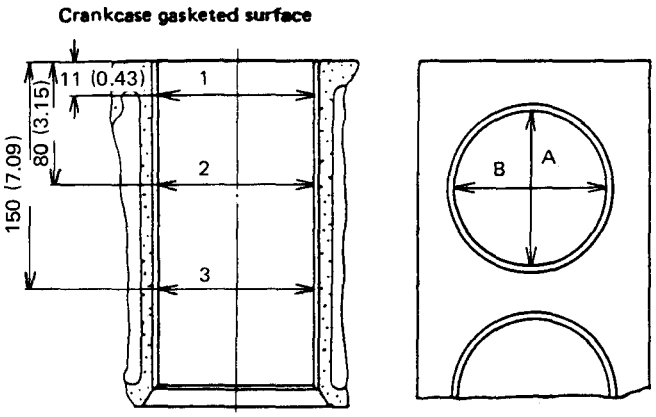
Specifications

Unit: mm (in.)

Item	Standard	Repair limit	Service limit
Cylinder sleeve ID	$84\,^{+0.035}_{0}$ $(3.307\,^{+0.00138}_{0})$	+0.20 (+0.008)	0.70 (0.0276)
Out of roundness	0.1 (0.004), max		
Taper	0.015 (0.0006), max		



Taking ID measurements on cylinder sleeves



Positions for checking sleeve bore diameter

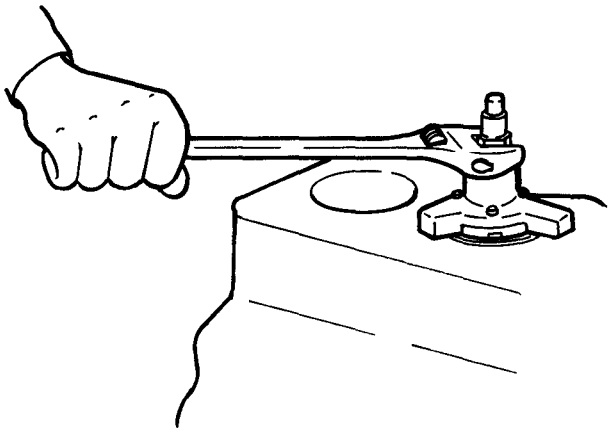
(2) There are three oversizes for cylinder sleeves, namely, +0.25 mm (0.0098 in.), +0.50 mm (0.0197 in.) and +0.75 mm (0.0295 in.). The tolerance to which the sleeves should be refinished by boring is 0 – 0.035 mm (0.0014 in.). When the sleeves are rebored, oversize pistons and piston rings should be used.

(3) An oversize to which any sleeve worn taper and/or out of round is to be rebored should be determined by relying on the most worn part of the sleeve. A cylinder sleeve whose abnormal wear is 0.4 mm (0.0157 in.) should be rebored to 1 mm (0.0394 in.) oversize, for example.

NOTE

a) All cylinders should be rebored to one and the same oversize.

b) When the sleeves are not worn beyond the repair limit, but the piston rings have to be renewed, correct stepped wear on the top part of the sleeve by using a ridge reamer and, if necessary, refinish the sleeves by honing.



Removing ridge with ridge reamer

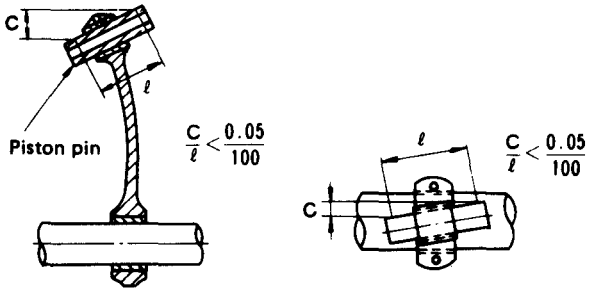
Connecting rod alignment and bearings

(1) Check the connecting rod for evidence of cracks, especially cracks in the fillets of its small and big ends. Replace the rod if any crack is noted in the fillets.

(2) Mount each connecting rod in the connecting rod aligner and check for bend and twist as shown below. In a twisted connecting rod, the bearing is not trued to the small end bushing. Such a rod must be corrected with the use of a press.

(3) If the connecting rod aligner is not available, the rod may be checked as follows:

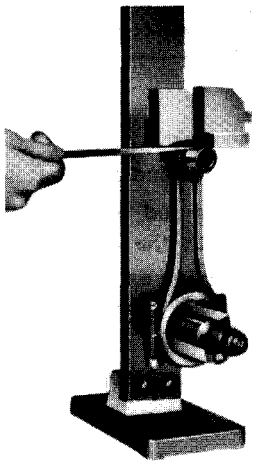
(a) To check the rod for bend, measure "C" and "ℓ" as shown in the figure "a." If the measurement at "C" is larger than 0.05 mm per 100 mm (0.00197 in. per 3.937 in.) of "ℓ," straighten the rod with the use of a press.



a. Checking the connecting rod for bend

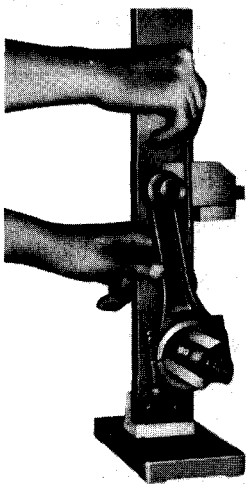
b. Checking the connecting rod for twist

Checking connecting rod



Checking connecting rod for bend

(b) To check the rod for twist, measure "C" as shown in the figure "b." If the measurement at "C" is larger than 0.05 mm per 100 mm (0.00197 in. per 3.937 in.) of "ℓ," correct the rod.



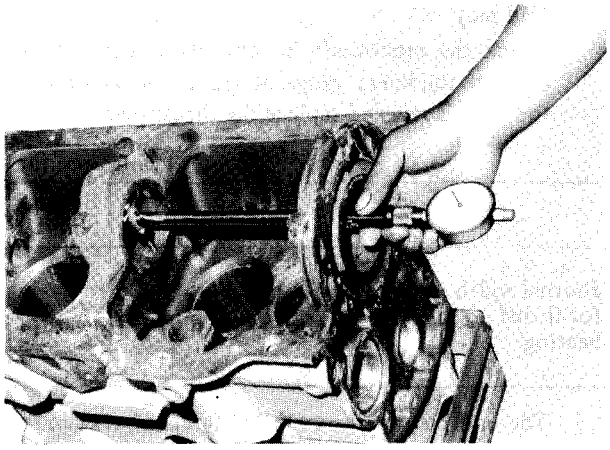
Checking connecting rod for twist

(5) **Main bearings**

Inspect each main bearing for evidence of wiping or fatigue failure, for scratches by dirt particles imbedded and for improper seating on the bore (bearing cap). On the basis of findings, determine whether the bearing should be replaced or not.

Check each main bearing to be used in engine reassembly to see whether it will provide the specified radial clearance. This can be accomplished in this manner.

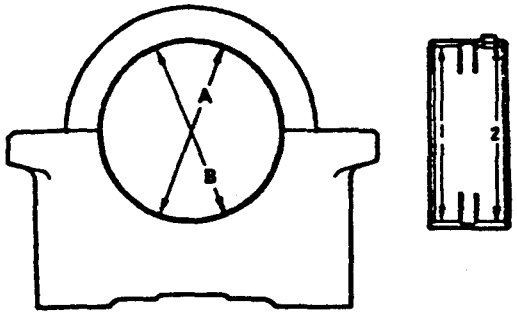
Install the main bearings on the crankcase, less the crankshaft, securing each bearing cap by tightening its bolts to 8.5 kg-m (61.5 lb-ft) and read the diameter in the two directions (A) (B), in indicated below. Mike the journal and, from these readings, compute the radial clearance.



Measuring main bearing ID

Specifications Unit: mm (in.)

Item	Standard	Repair limit
Fit of main bearings on journals	0.03 ~ 0.089 ((0.0012 ~ 0.00350)	0.200 (0.00787)



Positions for miking main bearing

Camshaft

(1) Check the camshaft end play as outlined for the timing gears. Where the end play exceeds the repair limit, replace the thrust plate with a new one.

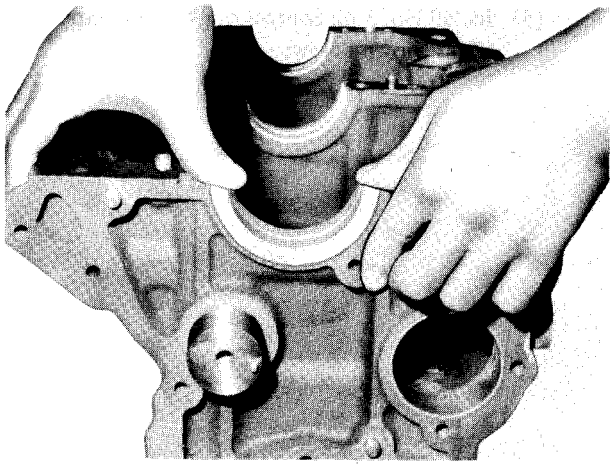
Specifications Unit: mm (in.)

Item	Nominal value	Standard	Repair limit
Camshaft end play	5.0 (0.197)	0.05 ~ 0.112 (0.00197 ~ 0.00441)	0.3 (0.012)

(2) **Inspect the camshaft journals for abnormal wear and damage; the camshaft must be replaced if any of its three journals is found in bad condition beyond repair.**

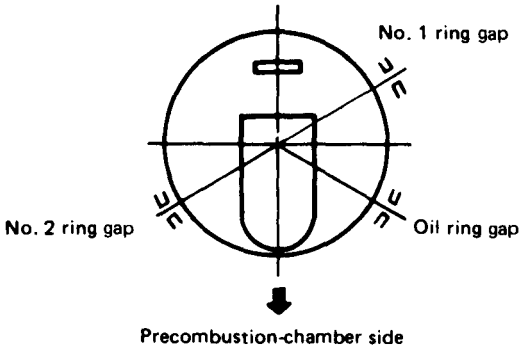
(3) **Mike each cam of the camshaft to read D_1 (cam height) and D_2 (diameter), and compute the difference between D_1 and D_2. If this difference is less than the service limit, replace the camshaft.**

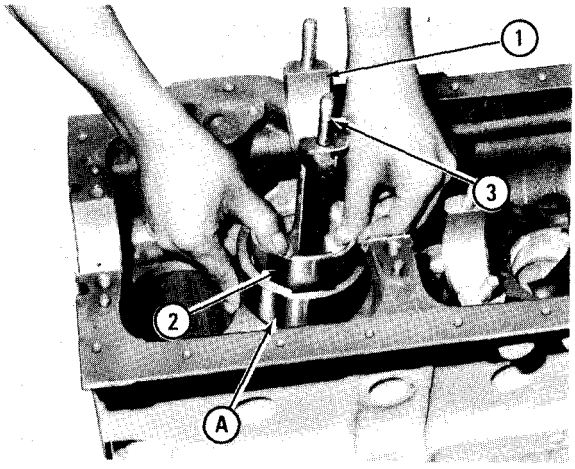
(c) Lightly apply engine oil to the crankpins and install main bearings (upper). Securely engage the bearings with the crankpins.



(3) Install the piston assembly as follows:

Install connecting rod bearing (upper) (1) into the big end of connecting rod. Apply engine oil in the internal surface of bearing and on the external periphery of piston. Position piston rings so that ring gaps are located 90°in respect with each other as shown, and then insert piston assembly (2) into crankcase. Alignment marks on the connecting rod must face the camshaft side. Put cap attaching bolts (3) into rod in advance. Insert piston assembly into crankcase by using piston guide (A).





(15) Install the push rods and rocker shafts as follows:

(a) Insert the push rods (1) into the tappets.

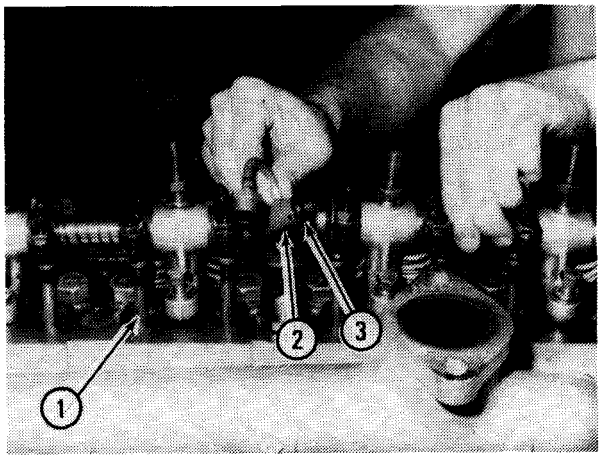
(b) Install rocker shaft assembly as follows:

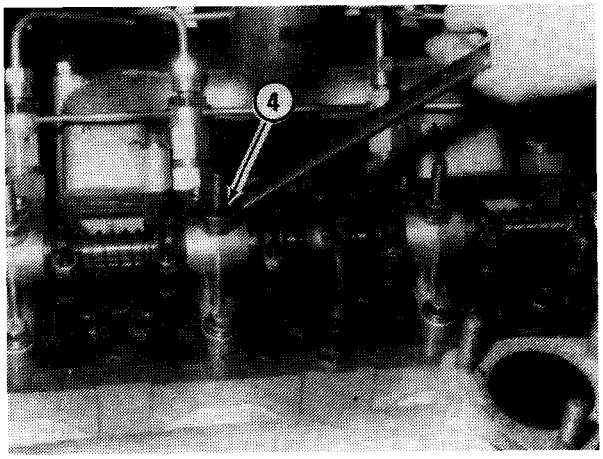
(c) Insert "O" rings (3) into oil pipe (2) and connect the oil pipe to the front and rear rocker shafts. Then temporarily install each bracket to the cylinder head.

(d) Temporarily tighten two or three threads on the oil pipe union nut and connector.

(e) Secure the preinstalled brackets by tightening four bolts at the front and rear sides uniformly to a torque of 1.5 kg-m (10.85 lb-ft). Tighten the long bolts (4) first.

(f) Connect oil pipe to connector securely. Then adjust the valve clearance to 0.25 mm (0.01 in.) for both intake and exhaust valves in cold setting.



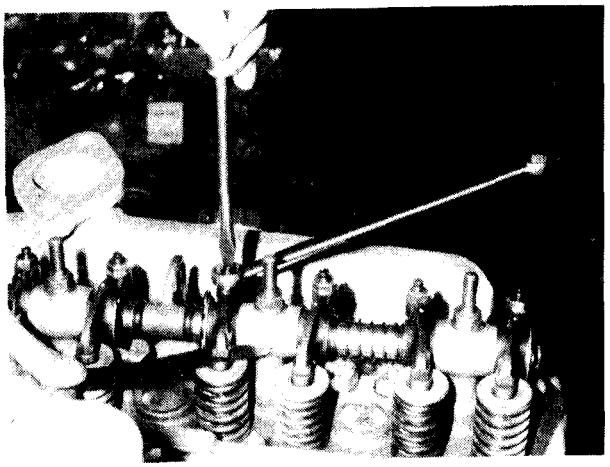


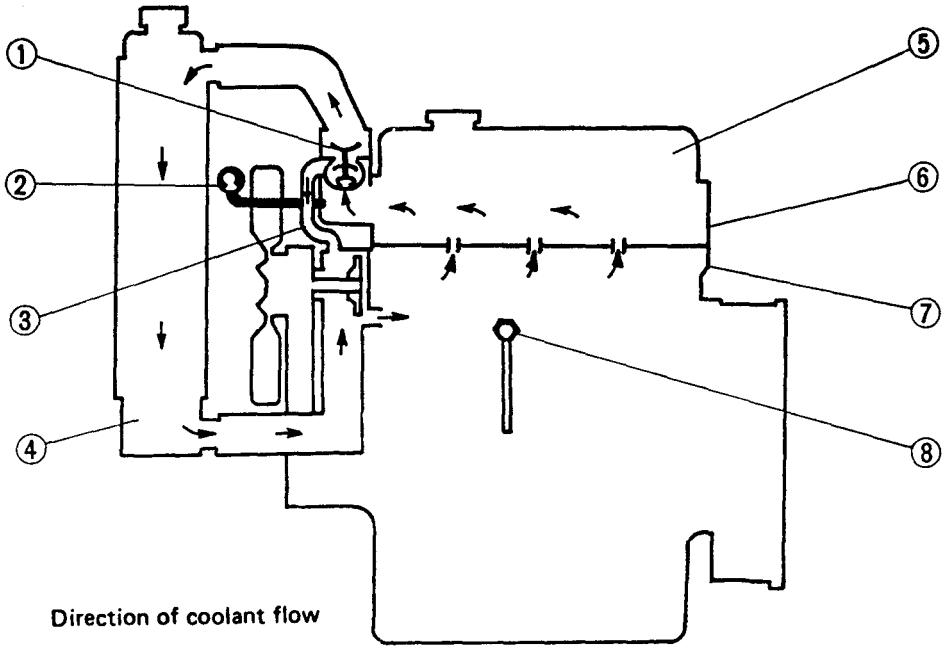
(16) Adjust valve clearance as follows:

The valve clearance specification for this engine is 0.25 mm (0.0098 in.) for both intake and exhaust valves. This value assumes that the engine is at normal temperature, there being no temperature difference throughout the body of the engine. The checking and adjusting procedure is as follows:

(a) Rotate the crankshaft slowly to bring the piston in No. 1 cylinder to Top Dead Center (TDC). This can be accomplished by observing rocker arms of No. 4 cylinder. As you turn the crankshaft, exhaust-valve rocker arm of this cylinder rises: stop turning the crankshaft just when intake-valve rocker arm begins to go down after exhaust valve rocker arm has come up all the way. Under this condition, adjust valve clearance in the usual manner on intake and exhaust valves of No. 1 cylinder, intake valve of No. 2 cylinder, and exhaust valve of No. 3 cylinder.

(b) Turn the crankshaft one complete rotation (360°), and hold it there. Adjust the clearance on intake and exhaust valves of No. 4 cylinder, exhaust valve of No. 2 cylinder, and intake valve of No. 3 cylinder.





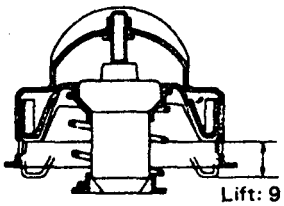
1. Coolant circuit

Referring to the diagram, above, the coolant is set in forced recirculation by the water pump, which is a centrifugal pump driven by cooling-fan belt. The pump draws coolant from the lower tank section of radiator ④ and forwards it to the water inlet of crankcase ⑦.

As the rising coolant temperature reaches 76.5°C (169.7°F), the thermostat valve begins to open increasingly wide and the coolant begins to flow to radiator ④ at a rising rate of flow, with a corresponding decreases in the amount of coolant being bypassed. As the temperature reaches 90°C (194°F), the valve becomes full open, shutting off the bypass passage.

2. Thermostat

The thermostat is of wax type, designed to start opening its valve at 76.5 ± 2°C (169.7 ± 3.6°F) of rising temperature and opens it fully at 90°C (194°F), lifting it off the seat by 9 mm (0.35 in.).



2-1 Disassembly

(1) Remove thermostat cover (2) by loosening bolts (1).

(2) Take out thermostat (3).

2. Priming the fuel system

(1) Unlock the priming pump by turning its knob counterclockwise.

(2) Loosen the air vent plugs, and operate the pump until overflowing fuel no longer carries air bubbles.

(3) Tighten the air vent plugs while pressing the pump knob downward.

(4) Lock the pump by turning the knob clockwise while pressing it downward.

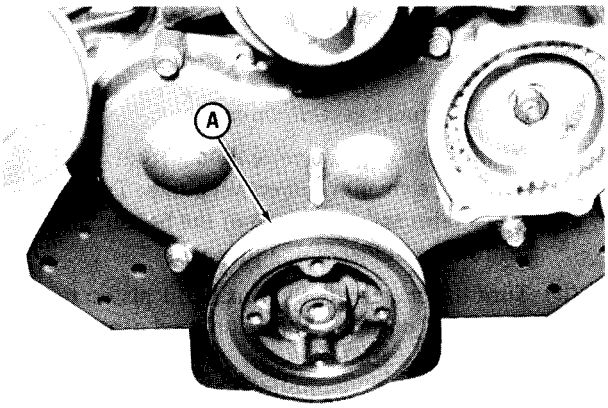
3. Adjusting the injection timing

The engine with RUV governor

(1) Alignment marks (line marks) are provided on the pump body and flange plate. Make sure that these marks are lined up. With the pump gear and idler properly positioned in their meshed condition inside the timing gear case, that is, the match marks on these gears indexed to each other, mount the injection pump unit on the engine front plate and secure it by tightening the mounting bolts.

(2) Install fuel feed pipes and lube oil pipe, and reconnect all but No. 1 fuel injection pipe.

(3) Crank the engine slowly until the plunger in No. 1 pumping element comes to the position for "beginning of injection." Check to be sure that the timing mark on crank pulley is matched to the pointer on the timing gear case; if not, adjust the mounted position of the pump in the following manner:

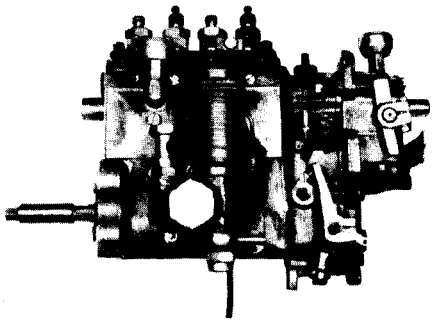


A-Timing mark on crankshaft pulley (TDC)

NOTE

Tilting the pump toward the engine advances the timing, and vice versa. Refer to the graduation marks provided on the edge face of the mounting flange: one division is equivalent to 6 deg. of crank angle.

(4) Having made sure that all timing marks are matched as prescribed and that the beginning of injection is correctly timed (in reference to No. 1 cylinder), reconnect the injection pipe (No. 1). Prime the fuel circuit in the manner previously described: make sure that no air remains trapped in any part of the circuit.

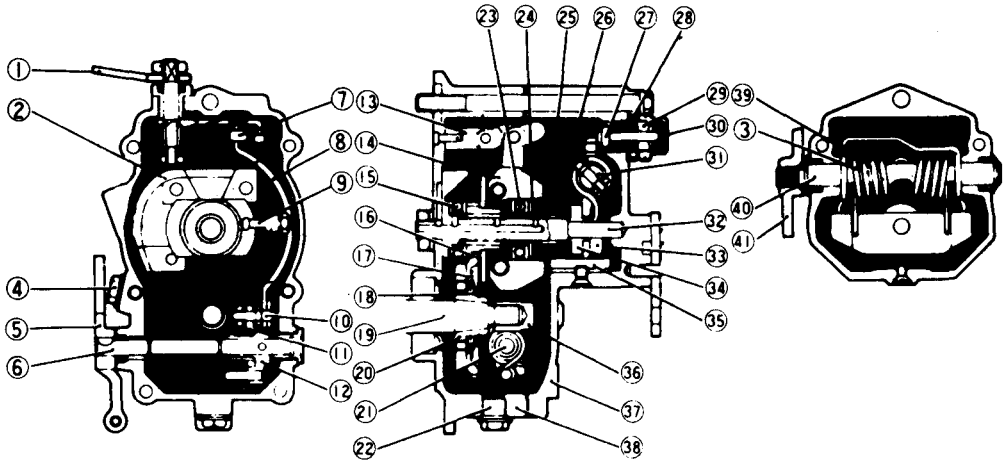


The delivery valve, through which a shot of fuel is forced out into the injection pipe by each upward motion of the plunger, is essentially a check valve having a special function of quickly reducing the line pressure the moment the plunger begins to descend. This quick relief of line pressure is necessary to prevent the injection nozzle from dribbling at the end of each injection. How this is accomplished will become clear.

Tabulated data

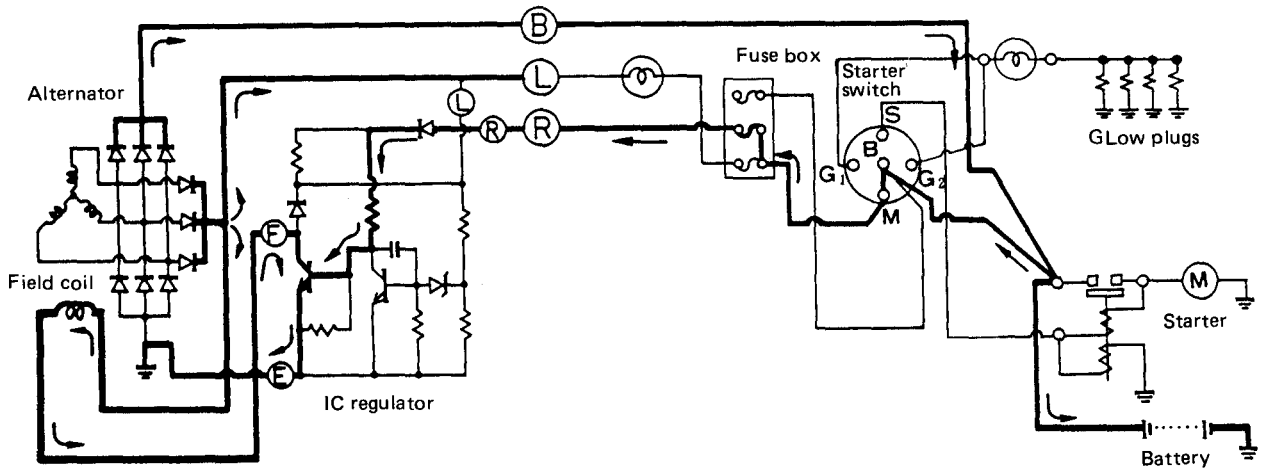
Cam lift	8 mm (0.315 in.)
Plunger diameter	6.5 mm (0.256 in.)
Delivery valve dia.	6 mm (0.236 in.); retraction volume 51 mm^3 (0.003 cu in.)/stroke
Injection order	1 – 3 – 4 – 2
Injection interval	90° ± 30′

8. Governor

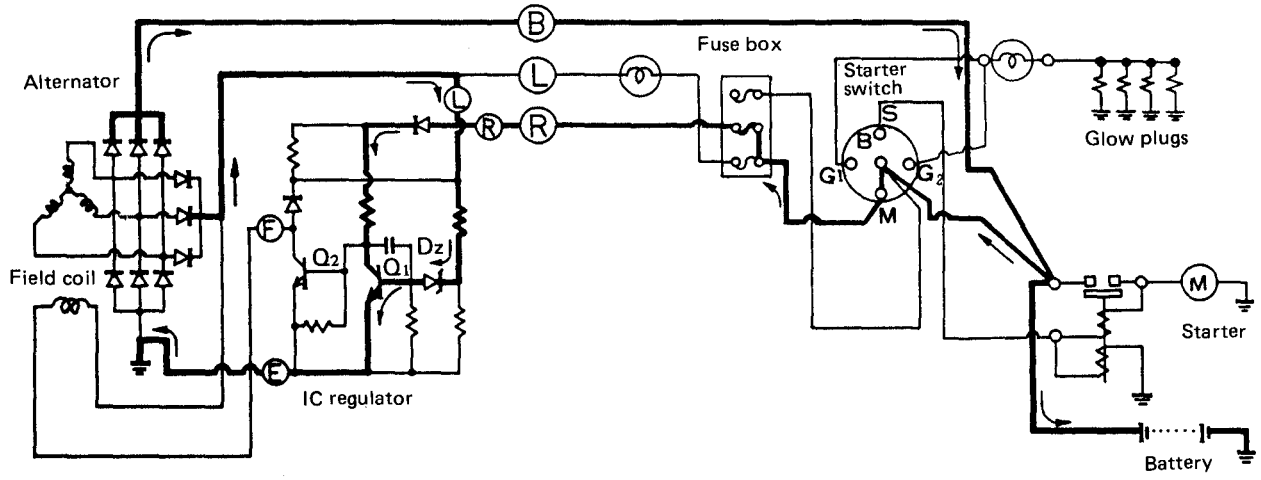


1-Stopper lever
2-Oil inlet
3-Control spring
4-Screw plug
5-Stopper
6-Control lever shaft
7-Shackle pin
8-Floating lever
9-Connecting pin
10-Connecting bolt
11-Supporting lever
12-Arm
13-Shackle
14-Flyweights
15-Bearing
16-Governor gear
17-Slip disc
18-Shim plate
19-Camshaft
20-Camshaft bushing
21-Control lever shaft
22-Drain plug
23-Bearing
24-Shim plate
25-Governor sleeve
26-Adaptor spring
27-Adaptor
28-Torque spring
29-Adjusting nut
30-Cap nut
31-Shaft
32-Governor shaft
33-Spring seat
34-Spring seat
35-Torque control lever
36-Round nut
37-Governor cover
38-Governor housing
39-Torque control lever
40-Shaft
41-Adjusting lever

(c) Engine starts and alternator charges battery



(d) Alternator charges battery excessively

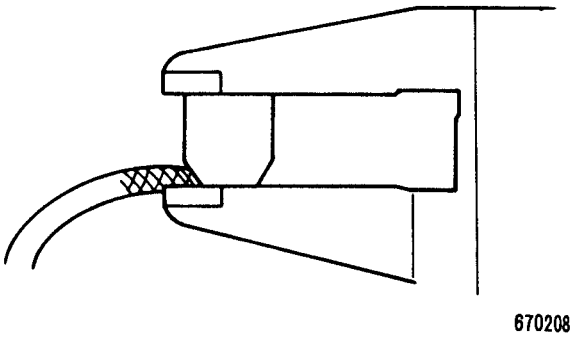


As alternator output voltage rises higher than the regulated voltage, zener diode DZ permits the current to flow to the base of transistor Q_1. As transistor Q_1 turns on, the current flows from the three diodes to transistor Q_1, causing transistor Q_2 to turn off. Under this condition, the field current is reduced to weaken excitation of the rotor and, consequently, output voltage begins to fall.

When output voltage has sufficiently dropped, zener diode DZ permits no current to flow. Now transistor Q_1 turns off and transistor Q_2 turns on and, consequently, the field current increases and output voltage rises again. This process is endlessly repeated to keep output voltage at a virtually constant level.

(d) Brushes and brush springs

1) Measure brush length. Replace brush if the length exceeds the service limit.

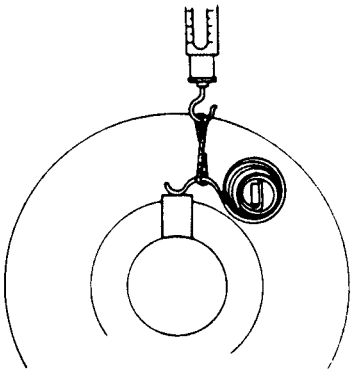


670208

Specifications Unit: mm (in.)

Item	Assembly standard	Service limit
Brush length	18 (0.71)	11 (0.43)

2) Using a spring balance and new brush, check spring pressure. Replace spring if the pressure is below the service limit.

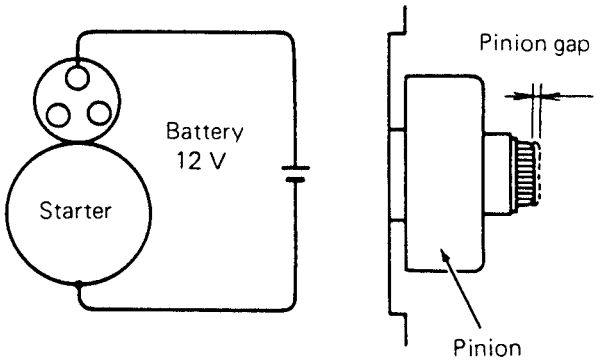


Specifications Unit: kg (lb)

Item	Assembly standard	Service limit
Spring pressure	3.5 (7.7)	2 (4.4)

(e) Pinion gap adjustment

Connect starter and battery as shown to allow pinion to shift against stopper. Under this condition, push pinion back, and measure gap.



Specifications Unit: mm (in.)

Item	Assembly standard
Pinion gap	0.5 ~ 2.0 (0.020 ~ 0.079)

NOTE

To adjust pinion gap, increase or decrease thickness of washers used between mating faces of magnetic switch and front bracket.

(f) No-load test

After adjusting pinion gap, connect starter and battery with an ammeter and voltmeter as shown, and test starter for performance.

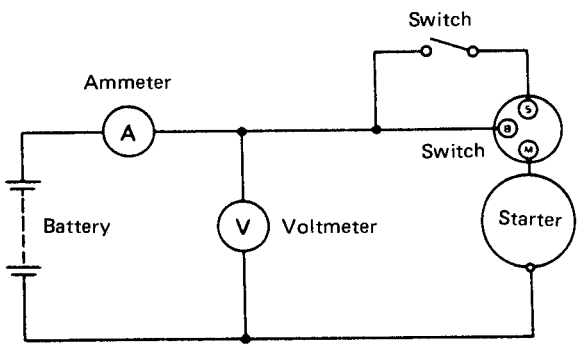
NOTE

Use thick wires and tighten terminal securely.

If current and speed meet the following specifications when battery voltage is 11 volts, starter is satisfactory:

Specifications

Current	Speed
130 (A), max.	4000 rpm, min.



BENCH TEST

When the engine is overhauled, it is advisable to conduct the bench tests for checking the engine performance. The purpose of bench tests is to make sure that each major component has been properly serviced.

1. Visual inspection

Couple the engine to the dynamometer and inspect as follows:

(1) Starting the engine

(a) Check the amounts of cooling water, lubricating oil and fuel oil. Bleed air out of the fuel system.

(b) Place the starter switch in PREHEAT position to preheat the combustion chambers. The glow plug indicator lamp will glow red within 20 seconds. If not, check the preheating system for condition.

(c) Place the starter switch in START position to start the engine. Do not move the governor control lever to INCREASE position.

(d) After starting the engine, manipulate the governor control lever to run the engine at idling speed.

(2) After starting the engine

Check the following items and repair if necessary.

(a) Abnormal oil pressure and oil leakage.

(b) Abnormal noise.

If knocking is heard while water temperature is low and the noise dies away as water temperature rises, the engine is in good condition.

(c) Color of exhaust gases.

(d) Leakage of cooling water.

(e) Leakage of fuel oil.

(f) Fuel injection.

(3) Running-in the engine

While running-in the engine, check the following items and repair if necessary.

(a) Oil pressure (3 ~ 4 kg/cm^2 or 42.7 ~ 56.9 psi).

(b) Temperature of cooling water (75 ~ 85°C or 167 ~ 185°F).

(c) Temperature of lubricating oil (60 ~ 70°C or 140 ~ 158°F in oil pan).

(d) Abnormal noise.

(e) Excessive blow-by, water leakage and oil leakage.

(f) The relationship between the load and running-in period is as follows:

After running-in the engine, check the valve clearance.

Engine speed rpm	Load PS	Time min
1000	0	30
1500	7.5	30
2000	15	60
2500	20	60

2. Performance tests

(1) Test condition

The engine must be equipped with the air cleaner and alternator.

(2) Test items

- No-load maximum speed test (governor set)
- Fuel injection quantity test (control rack set)
- No-load minimum speed test (idling speed set)

(3) Test procedures (with dynamometer pointer in OFF position)

(a) No-load maximum speed test (governor set)

While the temperatures of cooling water and oil are still high after engine running-in, set the no-load maximum speed.

(b) Fuel injection quantity test (control rack set)

The fuel injection quantity can be set by means of the governor fuel set lever. Loosening the set screw at the top of the fuel set lever will increase the fuel injection quantity, and vice versa.

(c) Move the control lever toward LOW SPEED position and adjust the stop screw to set the idling rpm to 650 to 700.

(d) Tune-up of engine output

The diesel engine output is based on the atmospheric pressure and temperature. Therefore, the output must be tuned up under standard conditions. Multiply the output measured by the factor. This factor can be computed by the following equation.