

TOYOTA

H ENGINE

REPAIR MANUAL

Diesel

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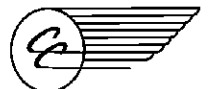


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FOREWORD

This manual describes the construction, operation, inspection, adjustment and repair procedures for servicing the H model Diesel Engine equipped on TOYOTA VEHICLES, and explanation is mainly composed of the H model Diesel Engine on TOYOTA DYNA and TOYOTA LAND CRUISER

In order to maintain full utilization of the high level performance of the H model Diesel Engine, we recommend that this manual be sufficiently utilized for the H model Diesel Engine maintenance reference.

For changes in specifications which may be incorporated in the production at a later date, please refer closely to the Service Bulletin.

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GENERAL

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CODES AND THEIR MEANINGS

For convenience, the following codes are used in this manual. Their meanings are as follows

Code	Translation	Definition
SST	Special Service Tool	These are tools that have been manufactured specially for the servicing of this vehicle. Their part numbers are shown in the text enclosed by []
STD	Standard	This is the dimension of the part used by the manufacturer in factory assembly
O/S	Over-size	When the fitting between the parts becomes loose due to wear by a long period of usage or to repeated disassembly and reassembly, replacing the piston with that of larger size will enable reusing the cylinder Size larger than STD is indicated as O/S
U/S	Under size	Similar to O/S, replacing the part that receives the insertion (such as bushing and bearing) with that having a smaller bore diameter will allow reusing the accompanying shaft, etc.
MP	Multi-purpose	Used in the case of multi-purpose grease.
w/ A	with A	
w/o A	without A	

GENERAL REPAIR INSTRUCTIONS

- 1 If during the disassembly and repair work or during inspection and adjustment, there is danger of soiling or damaging the body painted surface, interior trim, or seats, the work should be performed after placing fender cover, seat cover, etc.
- 2 In order not mix up the disassembled parts when overhauling the engine or other mechanism, keep the parts in a properly arranged order.
- 3 When servicing any place which is under power source voltage, be sure to disconnect the battery cable from the (+) terminal before starting work.
- 4 Use sealer at any place where it is required to prevent oil or water leakage
- 5 Bolts specified by Toyota must be installed at the specified places, and where required, they must be tightened to the specified torque with a torque wrench.
- 6 Gaskets, "O" rings, and similar parts should always be replaced with new parts whenever they are disassembled
- 7 In replacing parts at disassembly or repairs be sure to use genuine Toyota parts
Using imitation parts will not only hasten the deterioration of performance but will also be extremely dangerous from the point of safety
- 8 If the vehicle is to be jacked up only at the front or rear end, be sure to block the wheels in order to ensure safety
- 9 After the vehicle is jacked up, do not fail to support it on stands. It is extremely dangerous to do any work on the vehicle raised on a jack alone, even for a small job that can be finished quickly
- 10 In jacking up the vehicle and supporting it on stands, the front end should be supported at the lower suspension arm and the rear end at the rear axle housing
- 11 Use of the special service tool (SST) may be required depending upon the nature of the repair
Be sure to use the SST where specified portion
A list of the SST is shown in this manual

PRE-CAUTION OF PRE-DELIVERY SERVICE FOR ALTITUDE for HJ

Injection pumps on H engine is adjusted for sea level operation at the factory. When operating at higher altitude, the injection volume should be reduced proportionately to ensure complete combustion and a minimum of smoke emissions. It is to prevent excessive injection due to air density reduced at higher altitude. Also engine maximum speed is adjusted for sea level operation at the factory. When operating at higher altitude, the engine maximum revolutions should be readjusted by the maximum speed adjusting screw at the venturi of intake manifold. It is to prevent engine overrunning due to air density reduced at higher altitude. Maximum injection volume of fuel injection pump and engine maximum speed for vehicles operating at higher altitude, should be derated at pre delivery service or other service occasion, depending on the altitude at which the vehicle will operate.

I. Altitude Compensation for Maximum Injection Volume of Fuel Injection Pump

1. Mark the position of full stop capsule slit on the governor housing by punch to record calibrated sea level operation.
2. Break the sealed wire.
3. Loosen carefully the lock nut of full stop capsule, keeping the position of full stop capsule in place by a screw driver.
4. Screw in the full stop capsule according to Table 0-1.
5. Tighten securely the lock nut of full stop capsule.
6. Use a wire and a lead seal to seal the full stop capsule.
7. After completing the adjustment, identify the degree of adjustment by applying paint to the full stop capsule.

Example:

White paint = $5/24$ turn from standard position

Red paint = $5/12$ turn from standard position

Yellow paint = $15/24$ turn from standard position

Black paint = $5/6$ turn from standard position

Above example will help when readjustment is needed.

II. Altitude Compensation for Engine Maximum Speed

1. Break the sealed wire.
2. Loosen carefully the lock nut of maximum speed adjusting screw. Keeping the position of the maximum speed adjusting screw in place by a screw driver.
3. Screw in the maximum speed adjusting screw according to Table 0-1.
4. Tighten securely the lock nut of maximum speed adjusting screw.
5. Use a wire and a lead seal to seal the maximum speed adjusting screw.
6. If possible, check the engine revolutions at the altitude to which engine is adjusted.

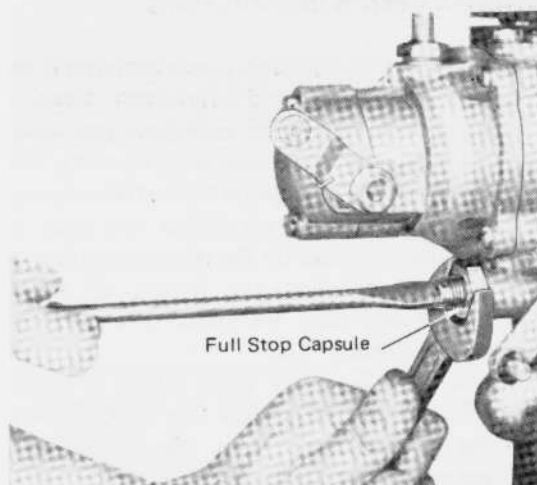


Fig. 0-1 Full Stop Capsule

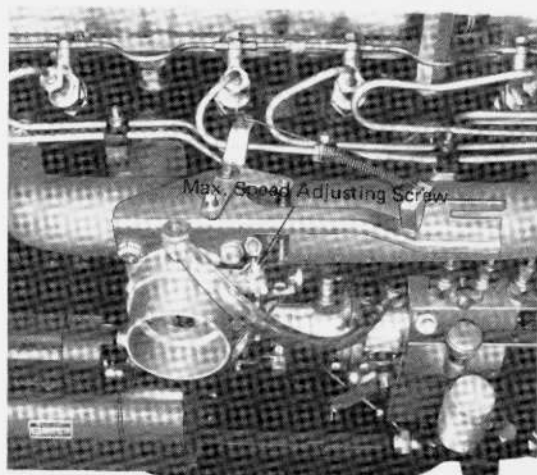


Fig. 0-2 Maximum Speed Adjusting Screw

Table 0-1 Screw in Amount of Screws

Altitude (m)	(for reference) Screw in amount of full stop capsule (Turn)	(for reference) Screw in amount of engine maximum speed adjusting screw (Turn)
1,000 (3,280ft.)	$5/24$	1
2,000 (6,560ft.)	$5/12$	1 $1/2$
3,000 (9,840ft.)	$15/24$	2
4,000 (13,120ft.)	$5/6$	2 $1/2$

ENGINE TUNE-UP

Engine Tune-up	1-2
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ENGINE TUNE-UP

Battery Inspection

1. Check for cracks in the battery case and see whether the liquid is up to the level indicator. If the liquid is insufficient, supply with distilled water.
2. Check for cracks and damage in head plugs of each cell and for clogage in the vent. Replace any defective ones.
3. Check the tightening part of terminal. Repair or replace if there is noticeable corrosion or damage.
4. Measure the specific gravity of the electrolyte and if the specific gravity is less than 1.200 (liquid temperature 20°C or 68°F), or if the difference in specific gravity between each cell exceeds 0.25 at 20°C (68°F), fully charge the battery.

The specific gravity of a fully charged battery – 1.260 at 20°C (68°F)

Caution

When measuring specific gravity, make sure that the float of hydrometer does not touch the inner wall of the outer case.

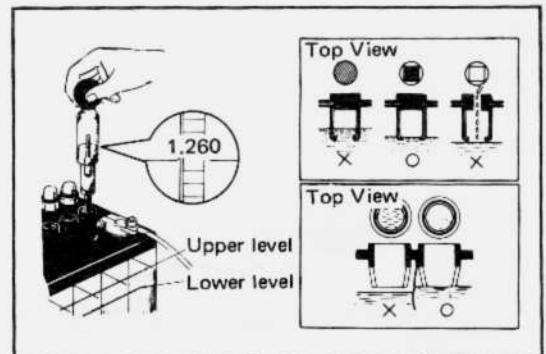


Fig. 1-1 Measuring Specific Gravity

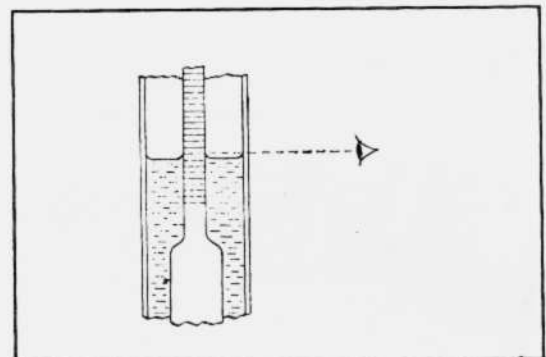


Fig. 1-2 How to Read Hydrometer

Cooling Water Inspection

Check the cooling water and if it is insufficient, supply with soft water. Replace if dirty.

Total cooling water capacity –

HU... 17.3 liters (18.3 US qts. 15.2 Imp. qts.)

HJ... 12.5 liters (13.2 US qts. 11.0 Imp. qts.)

Air Cleaner Element

1. Clean the dirt out inside the air cleaner element and case.
2. Check the air cleaner element and replace if there is considerable clogage.

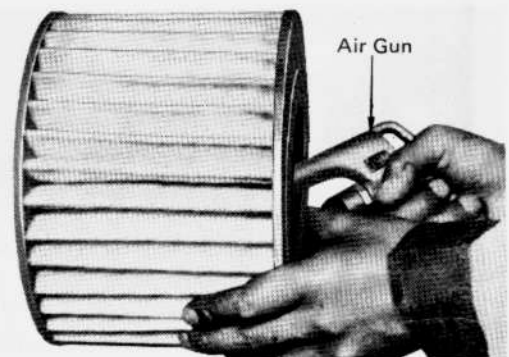


Fig. 1-3 Cleaning Air Cleaner Element

"V" Belt Inspection

1. Check the deflection by strongly depressing the middle part of the "V" belt and adjust if it is not within the specified deflection.

"V" belt deflection –

11 to 14 mm (0.4 to 0.6")

Pressing force, 10 kg (22 lbs)

Caution

Measure at midway, between the fan and alternator pulleys.

2. Replace when cracking, decay, excessive elongation and abrasion are found.

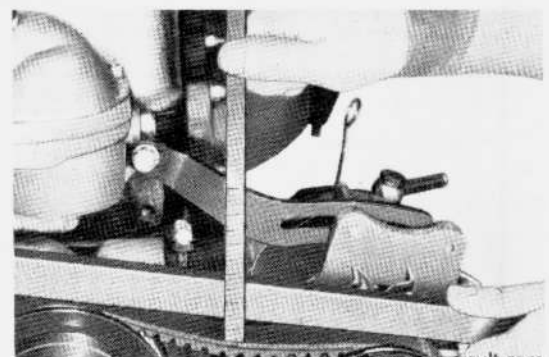


Fig. 1-4 "V" Belt Tension

Engine Oil

1. Measure the engine oil quantity with the level gauge and supply if necessary.
2. Check the engine oil for deterioration due to the intrusion of cooling water and fuel. If they are noticed, replace the oil after repairing the place that causes intrusion.
3. Replace the oil if dirty.

Engine oil total capacity —

HU ...9.1 liters (9.6 US qts., 8.0 Imp. qts.)

HJ8.6 liters (9.1 US qts., 7.6 Imp. qts.)

Injection Pump Cam Housing Oil Inspection

1. Check the oil quantity in the injection pump cam housing with a level gauge and replenish with diesel engine oil if necessary.
2. If an excessive quantity of fuel has mixed into the oil, remove the oil completely and replace with new oil.

Injection pump cam housing oil capacity —
150 cc (9.2 cu.in.)

Caution

When removing the oil, remove it from the drain in the lower part of injection pump body; pour in the oil by using a squirt.

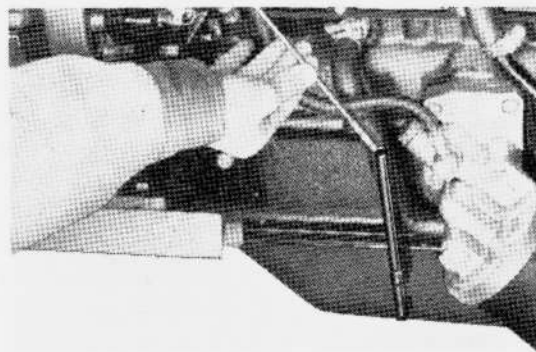


Fig. 1-5 Inspecting Engine Oil

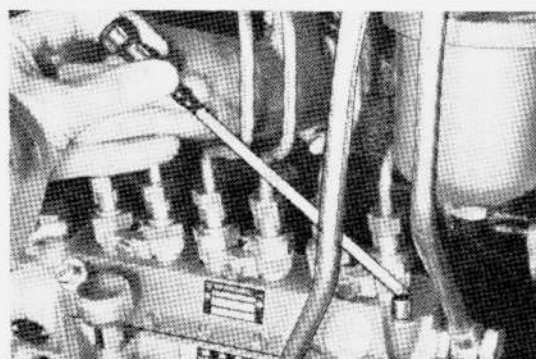


Fig. 1-6 Inspecting Pump Cam Housing Oil

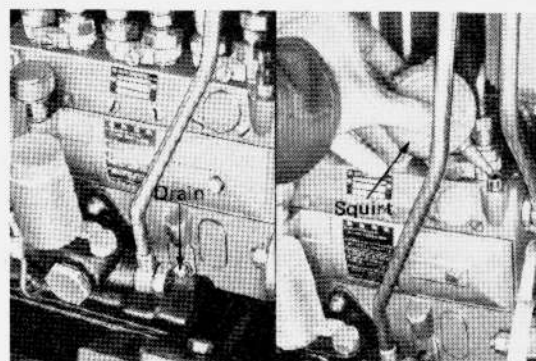


Fig. 1-7 Removing Injection Pump Cam Housing Oil

Pneumatic Governor

Remove the upper screw (for oil supply to the diaphragm) of governor housing sub-assembly and supply 2 to 4 drops of Diaphragm Oil to the diaphragm.



Fig. 1-8 Supplying Oil for Pneumatic Governor Diaphragm

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Fuel Filter Inspection

1. Inspect the fuel filter element and fuel element cylinder. Clean or replace if element is excessively clogged or if fuel leakage is found from the cylinder.
2. Check for fuel leakage from the connecting part of fuel pipe and fuel hose inside the engine room, for damage and decay of pipe and hose.
Repair or replace the defective ones.
3. Remove the feed pump fuel filter and clean it.

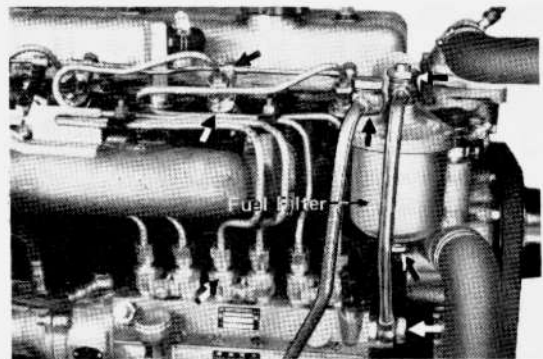


Fig. 1-9 Cleaning of Fuel Filter

Inspection and Adjustment of Injection Timing

Remove the No.1 injection pipe of the injection pump and install the pipe used for injection timing check. When the fuel surface inside the pipe begins to rise, check in the following order, whether the indicator is consistent with the marking line of crankshaft pulley.

1. Remove the injection pipe of No.1 cylinder and install the pipe used for checking injection timing to injection pump.
2. Rotate the engine using the starter till fuel sprays out of the pipe used for checking injection timing.
3. Rotate the crankshaft in the direction of rotation of the engine by using crankshaft pulley installing nuts (46 mm or 1.80") and stop the crankshaft rotation instantaneously when the fuel surface in the brim of pipe used for injection timing check swells.
4. At this time, check whether the timing pointer coincides with the marking of crankshaft pulley (front side of the direction of rotation).
5. When the injection timing is not proper, adjust by displacing the position of injection pump installation.

Note

If pump is rotated in the direction of crankshaft rotation, injection timing will be retarded.

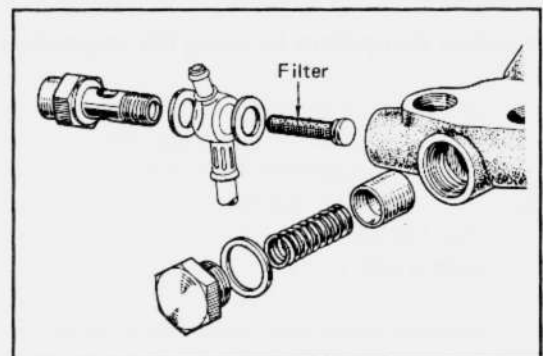


Fig. 1-10 Feed Pump Filter

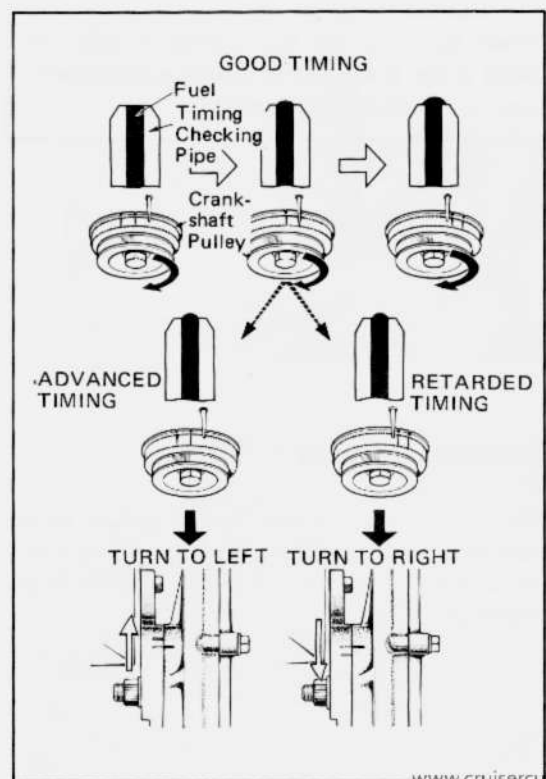


Fig. 1-11 Inspecting Injection Timing

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Glow Plug Inspection

1. It's O.K. if the glow plug controller glows 25 to 30 seconds after the starter switch is turned to "glow" position. Check the battery, wiring, glow plug connector, glow plug and others if the glow-time is longer than specified.

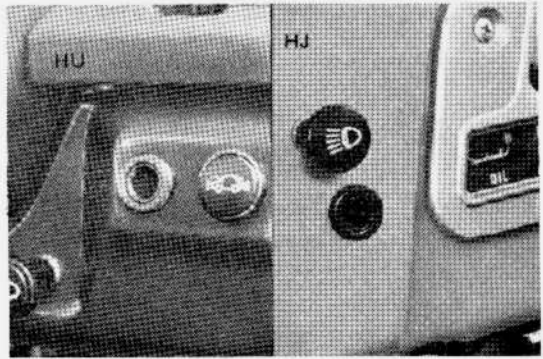


Fig. 1-12 Glow Plug Controller

2. Measure the current by using an ammeter (for 100 amperes) when starter switch is turned on (1) the preheating circuit and (2) the starting circuit. If the difference with the specified ampere is within 2A, it's O.K. (When the battery is fully charged.)

Specified amperes: **Current in glow-time**
 68 to 76A

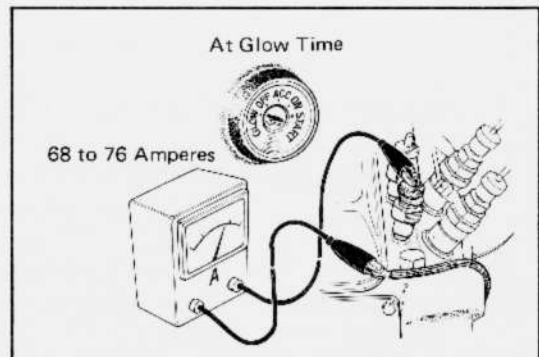


Fig. 1-13 Inspecting Current in Glow-time

Current in starting-time
55 to 63A

When the difference is large, check the battery, wiring, each terminal, glow plug relay and others.

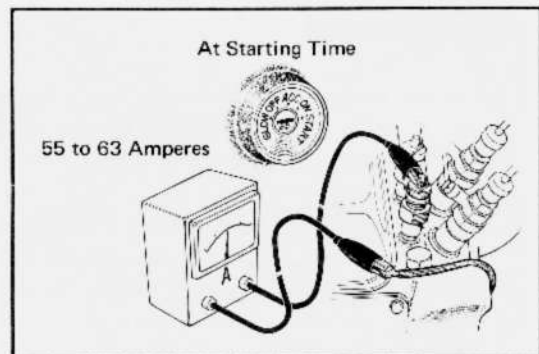


Fig. 1-14 Inspecting Current in Starting-time

Over Injection Magnet Inspection

1. Check matching condition of the magnet shaft groove and needle end when the starter switch is off the circuit.
2. Inspect for over injection due to operation of magnet when the starter switch is switched on to the motor rotation circuit.
3. If the operation is not satisfactory, set properly, loosening the wire lock nut setting to the mark.

Note

Be sure to return the stop button.

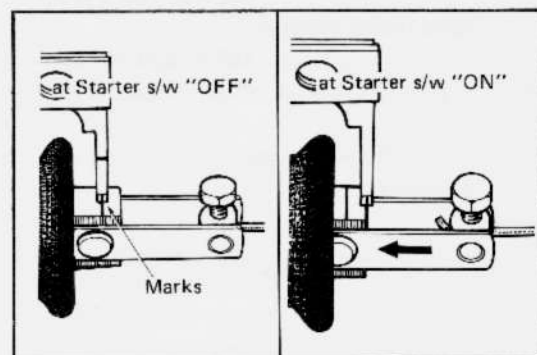


Fig. 1-15 Over Injection Magnet Setting

Inspection During Engine Warm Up

Inspect each of the following parts after warming up the engine till the temperature of cooling water rises to 75° to 85°C (167° to 185°F).

1. Check the oil pressure (warning lamp or oil pressure meter).
2. Check whether the battery is charged or not.
3. Check for oil and water leakage from each part of the engine.
4. In case a fuel pipe is contaminated with air;

(1) Evacuate air from air vent screw (1) of fuel filter and air bleeder screw (2) of injection pump, by operating the priming pump (3).

(2) Evacuate air from injection pipes concurrently with the judgement of nozzle quality by starting the engine.

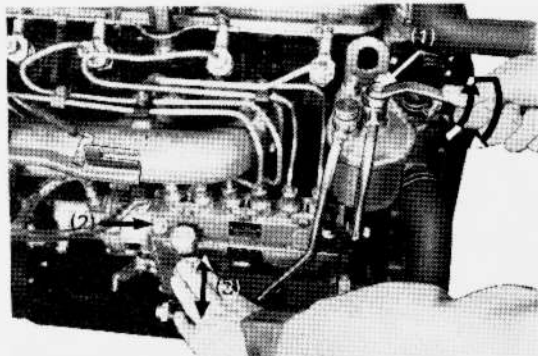


Fig. 1-16 Evacuating Air

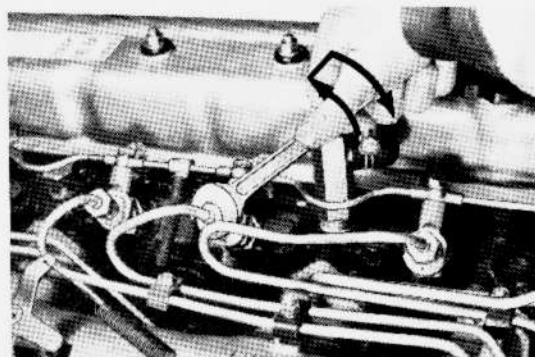


Fig. 1-17 Evacuating Air from Injection Pipe

Tappet Adjustment

1. Let the temperature of cooling water reach 75° to 85°C (167° to 185°F) by warming up the engine.
2. Before adjusting, retighten the cylinder head bolt, valve rocker support, installing bolt and nuts, etc. to the specified torque as necessary.

Tightening torque:

Cylinder head bolt 1280 to 1420 kg-cm
(92.6 to 102.7 ft-lb)

Valve rocker support

150 to 220 kg-cm
(10.9 to 15.9 ft-lb)

3. Adjust the valve clearance by using a thickness gauge.

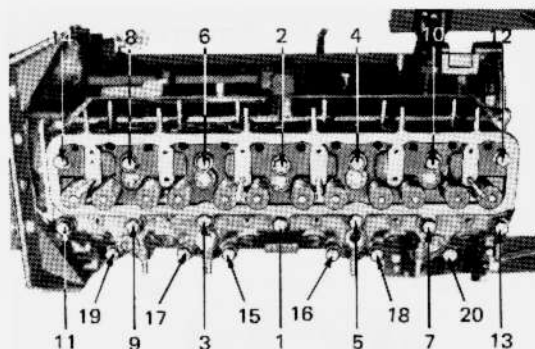


Fig. 1-18 Cylinder Head Bolt Tightening Oder

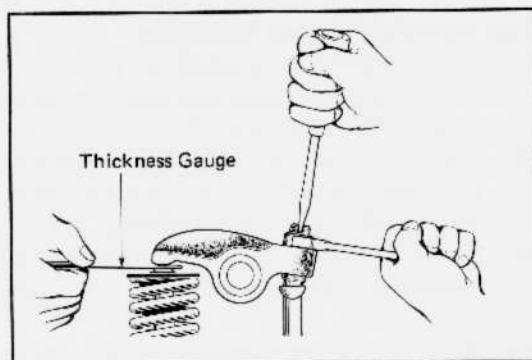


Fig. 1-19 Adjusting Valve

Specified clearance:

Intake	0.20 mm (0.008")
Exhaust	0.36 mm (0.014")

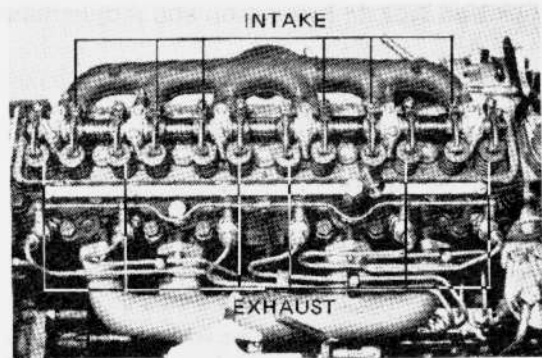


Fig. 1-20 Valve Arrangement

Compression Measurement

1. Perform when the temperature of cooling water does not get low after warming up the engine.
2. Disconnect the wiring (1) of glow plug, and remove the glow plug connector (2) and six glow plugs (3).

Note

Disconnected wiring terminal must be taped to prevent short.

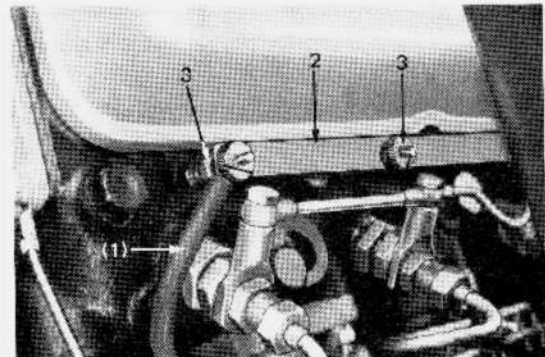


Fig. 1-21 Preparing for Compression Measurement

3. Install the SST [09992-00020] to the glow plug hole.
4. Pull out the stop button, and depress the accelerator pedal fully.
5. Rotate the engine using the starter and rotate it continuously till the indication in the gauge is stable, and read the maximum value.

Note

1. Engine rpm should be above 320 rpm.
2. Don't measure beyond necessity as the difference of gauge indication gets large because the rpm of engine is reduced due to the discharging of battery.

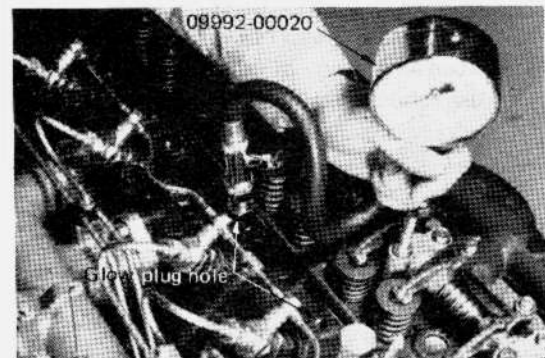


Fig. 1-22 Measuring Compression

Table 1-1 Engine Compression

Limit	20 kg/cm ² (285 psi.)
STD	Above 30 kg/cm ² (427 psi.)
Difference between cylinders	2 kg/cm ² (28 psi.)

6. When the measured maximum value or the difference between each cylinder is beyond the specified value, repair the defective places and re-check the compression.

Injection Nozzle Inspection and Adjustment

Check with nozzle hand tester. If defective, adjust or clean, replace if unadjustable.

Injection pressure.	100 to 110 kg/cm ² (1,420 to 1,560 psi)
Injection angle.	About 4°
Injection caliber.	1 mm (0.04")
Droplets.	No droplets should drip from the valve seat at an oil pressure of 90 kg/cm ² (1,280 psi).

Note

1. Use a hand tester for nozzle test and adjustment.
2. Adjust the injection pressure with the thickness of shim used for adjustment. There are twenty types of shims, with thicknesses ranging from 1.00 mm (0.04") to 19.5 mm (0.76") with the alternation of 0.05 mm (0.002"). With the change of 0.05 mm (0.002"), the injection pressure changes to 5 kg/cm² (70 psi).
3. In case the injection is sprayed as a cone of 4°, an atomization of circular form is obtainable if a white sheet of paper is kept 30 cm (11.8") apart from the nozzle.
4. At an oil pressure of 90 kg/cm² (1,280 psi), there should not be any leakage from nozzle valve seat and retaining nut.

Tightening torque:

Nozzle holder to Cylinder head
600 to 800 kg-cm (43.4 to 57.9 ft-lb)

Retaining nut to Nozzle holder
400 to 600 kg-cm (28.9 to 43.4 ft-lb)

Injection Nozzle Washing

Be sure to wash with new gasoline or light oil. Don't use the gasoline or light oil that was used for percolating the old things.

1. Elaborate washing is necessary not only for the old nozzle in action, but also for nozzle (1) packed with seal peel even though it is brand new.

Caution

New nozzle (2) with capsule packing can be used as it is.

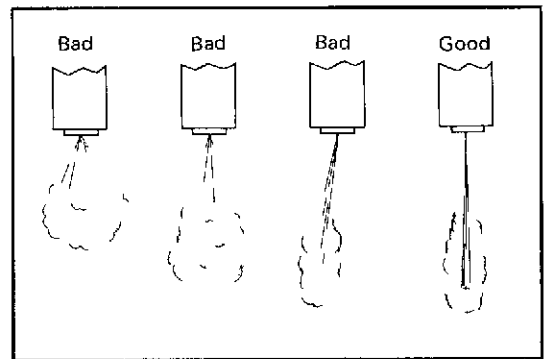


Fig. 1-23 Nozzle Spray Patterns

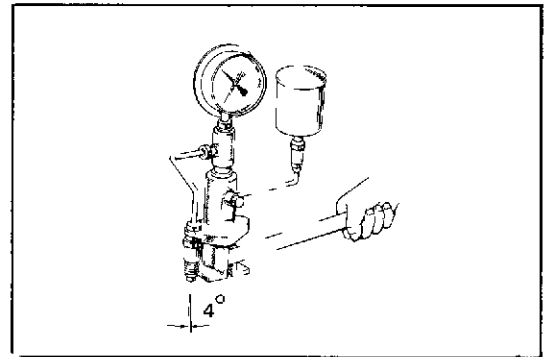


Fig. 1-24 Nozzle Test

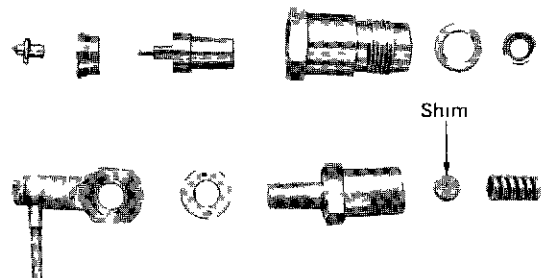


Fig. 1-25 Adjusting Shim Portion

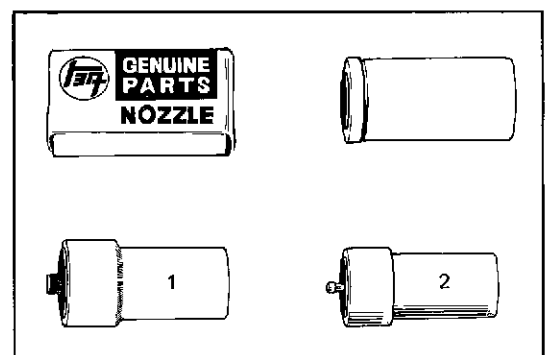


Fig. 1-26 Packing Mode of Nozzle

2. Use the nozzle cleaning kit for cleaning.
3. Clean the carbon attached to the edge of the nozzle needle using a wooden chip, and the nozzle seat part using a cleaning scraper.
4. Clean the injection opening of nozzle body using a cleaning needle, and the exterior of nozzle body using a brass brush.

Pneumatic Governor Adjustment

Idling Adjustment

1. Warm up the engine till the temperature of cooling water reaches 75 to 85°C (167 to 185°F).
2. Remove the governor connecting rod (1), and adjust the idling speed of the engine with the stop plate adjusting screw (3) located in the lower side of throttle valve housing (2).

Specified idling speed 625 to 675 rpm

3. Assemble after adjusting to a position where it can be naturally installed so that the idling rpm may not vary when the connecting rod (1), removed in item 2, is installed.

Maximum RPM Adjustment

1. Measure the maximum instantaneous rpm and the maximum created rpm after depressing the accelerator pedal fully at no load condition.
2. When the measured rpm is beyond the specified rpm, adjust to the specified rpm by opening the seal (5) of stop plate adjusting screw (4), located in the opposite side of the idling adjustment.

Specified rpm: Maximum instantaneous rpm
3950 rpm
Maximum created rpm
3900 rpm

Stop Plate Adjusting Screw Seal

Seal the stop plate adjusting screw by using a seal rod and seal wire.

Note

The screw (used for adjusting idling rpm) need not be sealed.

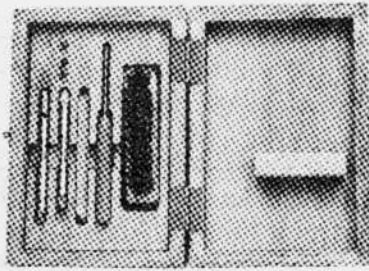


Fig. 1-27 Cleaning Kit

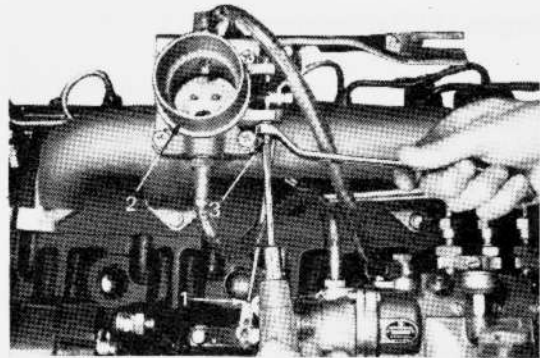


Fig. 1-28 Adjusting Idling

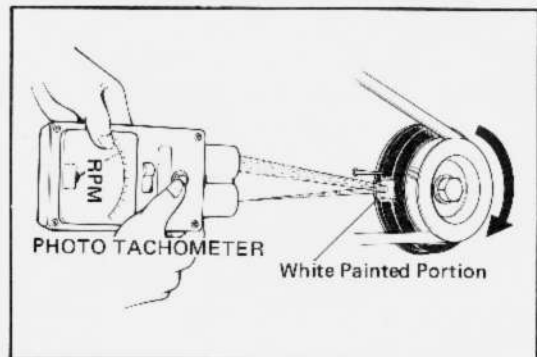


Fig. 1-29 Checking Idle Speed

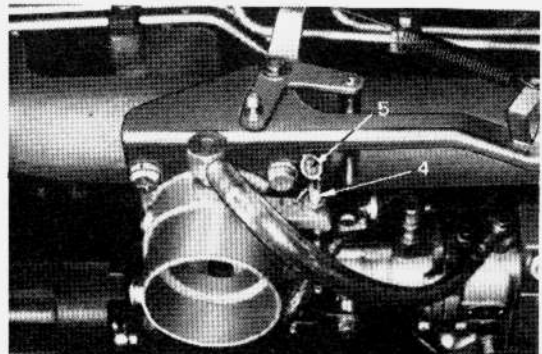


Fig. 1-30 Maximum RPM Adjustment

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Smoke Inspection

Visually check the color of exhaust discharged by the tail pipe and in case there is a good deal of black lead adjust the injection pump

Note

It is advisable to use a smoke meter to ascertain the rate of black lead.

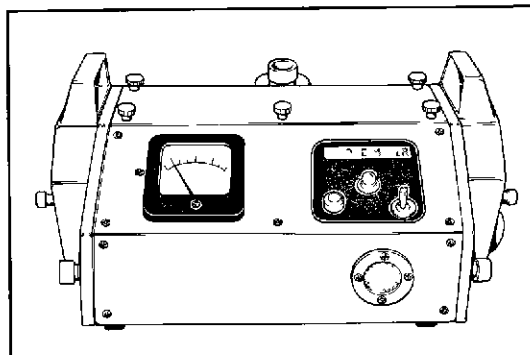


Fig 1 31 Smoke Meter

Engine Oil Replacement

- 1 Remove the oil pan drain plug to drain out the oil
2. Remove the oil cleaner drain plug to drain the oil out of the case.
- 3 Replace the gasket and pour in engine oil after installing the removed drain plugs

Specified oil

Summer

Winter

Diesel Oil

SAE 30

10W-30 (special)

Total oil capacity

HU ...9.1 liters (9.6 US. qts., 8.0 Imp. qts.)

HJ ...8.6 liters (9.1 US. qts., 7.6 Imp. qts.)

Oil pan

HU ...8.1 liters (8.6 US. qts. 7.1 Imp. qts.)

HJ ...7.6 liters (8.0 US qts. 6.7 Imp. qts.)

ENGINE

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Disassembly	2-8
Inspection & Repair	2-15
Engine Assembly	2-31



GENERAL

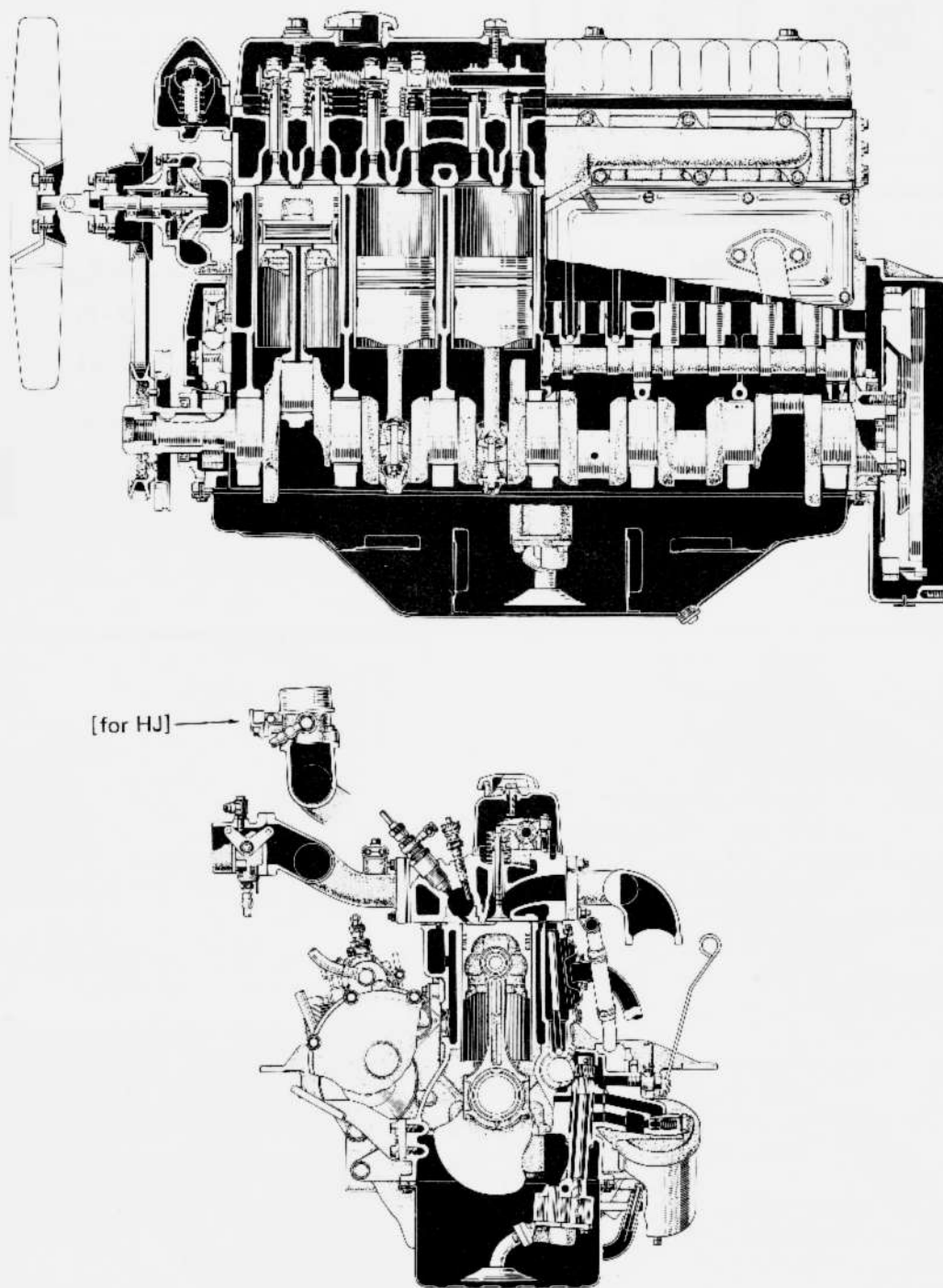


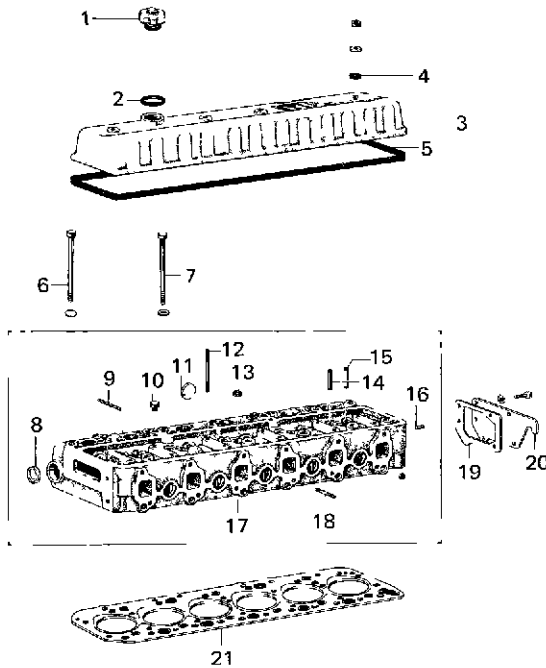
Fig. 2-1 Sectional Views of Engine

GENERAL SPECIFICATION

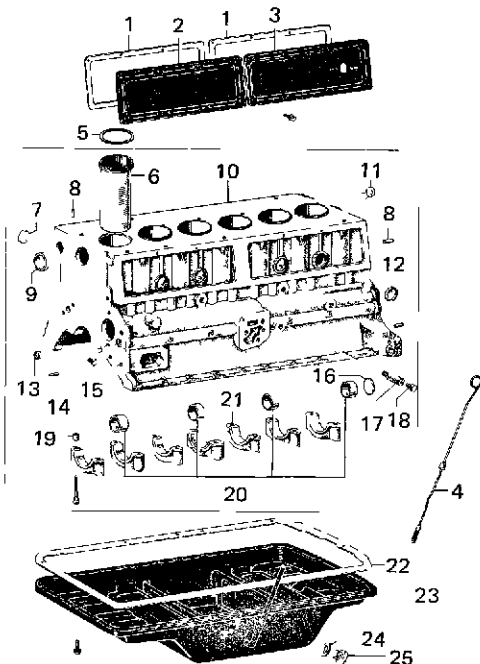
Table 2-1 Engine Specifications

ITEM			HU	HJ
Engine model			H	←
Type			Diesel	←
Cooling system			Water cooled	←
Nos. of cylinder and order			6, in-line	←
Cycles,			4	←
Valve arrangement			Overhead valve	←
Combustion chamber type			Whirl flow chamber	←
Cylinder liner type			Dry type	←
Bore x stroke			88 x 98mm (3.5 x 3.9")	←
Total displacement			3,576cc (218 cu.in.)	←
Compression ratio			19.5	←
Compression pressure			30kg/cm ² (427psi/320rpm)	←
Piston rings	Compression		2	←
	Oil		1	←
Valve timing	Intake	Open	16° BTDC	←
		Close	52° ABDC	←
	Exhaust	Open	52° BBDC	←
		Close	14° ATDC	←
Valve clearance	Intake (hot)		0.20mm (0.008")	←
	Exhaust (hot)		0.36mm (0.014")	←
Fuel injection order			1-4-2-6-3-5	←
Injection timing			12° BTDC	←
Injection pump type			Bosch A	←
Governor type			Mechanical RU type	Pneumatic MN type
Timer type			Centrifugal type	←
Lubrication system			All forced-feed Full flow	←
Total lubricating oil			9.1 liters (9.6 US.qts., 8.0 Imp.qts.)	8.6 liters (9.1 US.qts., 7.6 Imp.qts.)
Coolant capacities w/o heater			17.3 liters (18.3 US.qts., 15.2 Imp.qts.)	12.5 liters (13.2 US.qts., 11.0 Imp.qts.)

COMPONENT PARTS

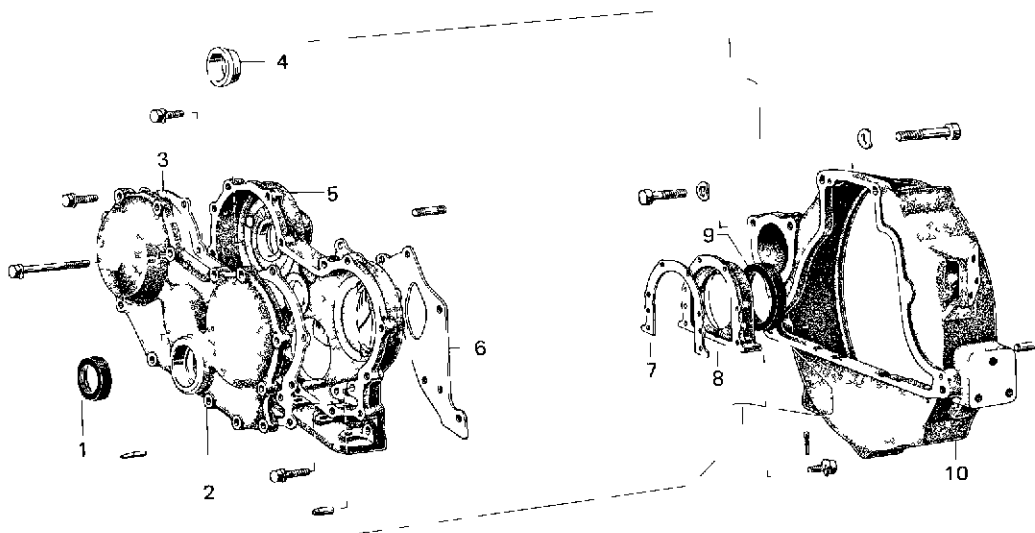


- 1 Oil filler cap
- 2 Gasket
- 3 Cylinder head cover
- 4 Seal washer
- 5 Cylinder head cover gasket
- 6 Bolt
- 7 Bolt
- 8 Tight plug
- 9 Stud bolt
- 10 With head taper screw plug
- 11 Tight plug
- 12 Stud bolt
- 13 Tight plug
- 14 Valve guide intake bushing
- 15 Valve guide exhaust bushing
- 16 Straight plug
- 17 Cylinder head
- 18 Stud bolt
- 19 Cylinder head rear plate gasket
- 20 Cylinder head rear plate
- 21 Cylinder head gasket



- 1 Valve push rod cover gasket
- 2 Valve push rod cover No 1
- 3 Valve push rod cover No.2
- 4 Oil level gauge
- 5 Cylinder liner shim
- 6 Cylinder liner
- 7 Tight plug
- 8 Straight pin
- 9 Tight plug
- 10 Cylinder block
- 11 Tight plug
- 12 Tight plug
- 13 Expansion plug
- 14 Straight pin
- 15 Intake manifold suction hole plug
- 16 Tight plug
- 17 Union
- 18 Oil delivery pipe union bolt
- 19 Ring pin
- 20 Camshaft bearing
- 21 Crankshaft bearing cap
- 22 Oil pan gasket
- 23 Oil pan
- 24 Filler plug gasket
- 25 Oil pan drain plug

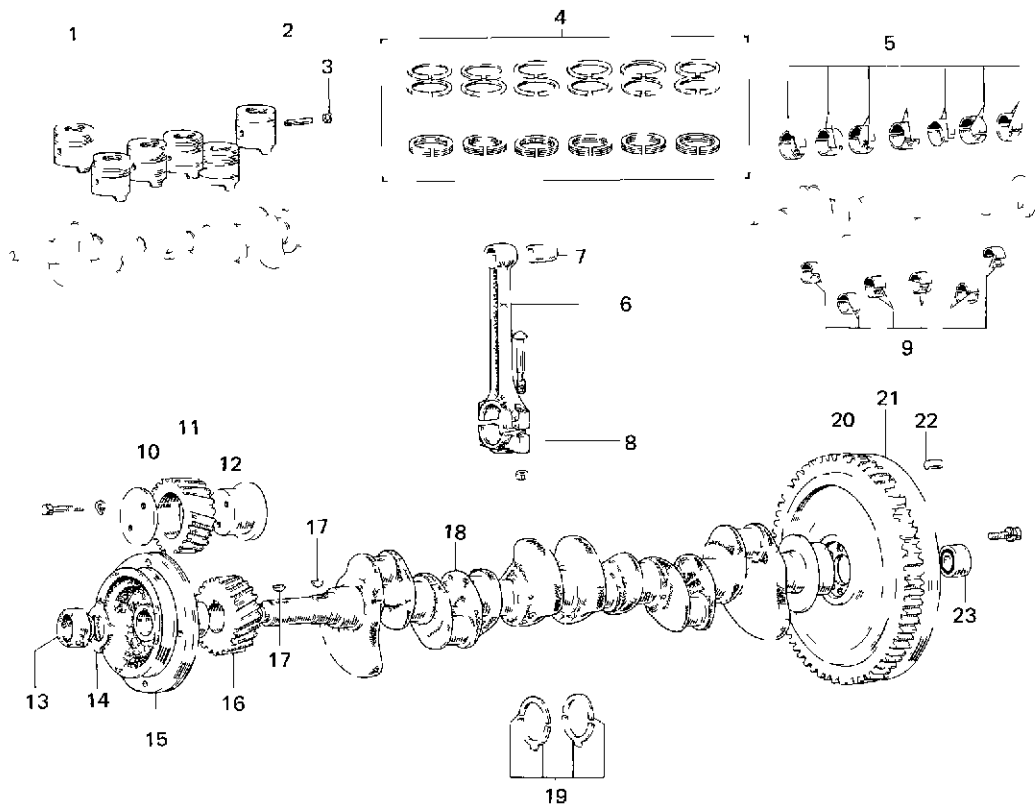
Fig. 2-2 Cylinder Head & Cylinder Block Component Parts



- 1 Type 'T' oil seal
- 2 Timing gear cover
- 3 Timing gear cover gasket
- 4 Bearing
- 5 Timing gear case

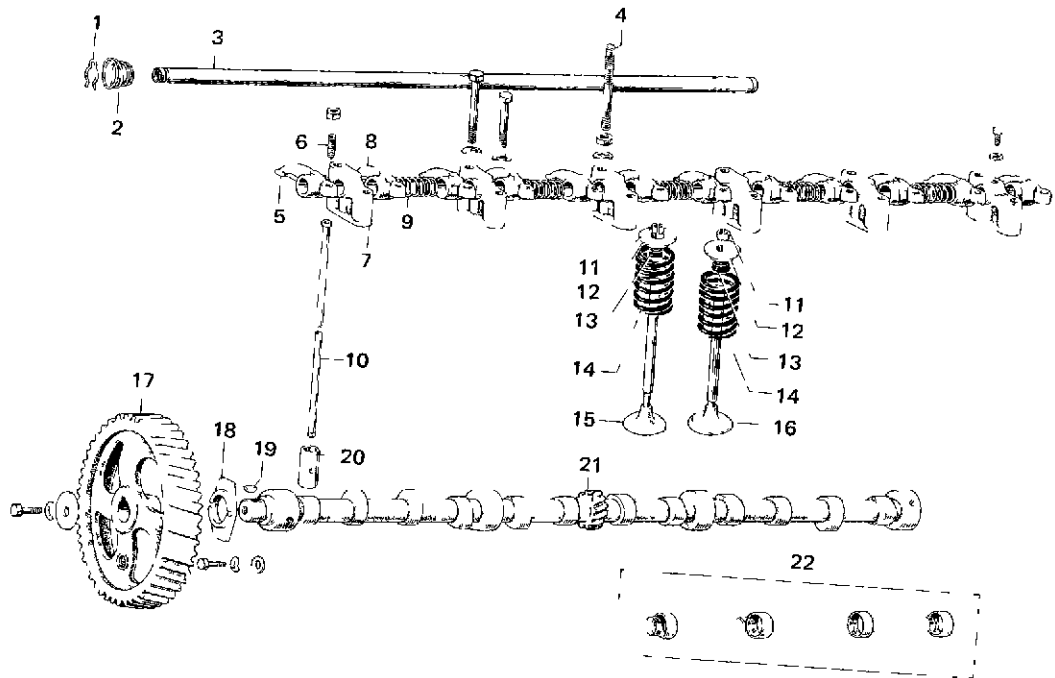
- 6 Gasket
- 7 Oil seal gasket
- 8 Oil seal retainer
- 9 Type 'T' oil seal
- 10 Flywheel housing

Fig 2-3 Timing Gear Cover & Flywheel Housing Component Parts



- | | | | |
|----|------------------------|----|---------------------------|
| 1 | Piston | 13 | Crankshaft claw |
| 2 | Piston pin | 14 | Crankshaft pulley lock |
| 3 | Hole snap ring | 15 | Crankshaft pulley |
| 4 | Piston ring | 16 | Crankshaft timing gear |
| 5 | Crankshaft bearing | 17 | Key |
| 6 | Connecting rod | 18 | Crankshaft |
| 7 | Bushing | 19 | Crankshaft thrust bearing |
| 8 | Connecting rod cap | 20 | Flywheel ring gear |
| 9 | Connecting rod bearing | 21 | Flywheel |
| 10 | Idle gear thrust plate | 22 | Ring pin |
| 11 | Idle gear | 23 | Bearing |
| 12 | Idle gear shaft | | |

Fig. 2-4 Crankshaft & Connecting Rod Components Parts



- | | | | |
|----|-----------------------------------|-----|-----------------------|
| 1 | Retainer spring | 12. | Valve spring retainer |
| 2 | Valve rocker shaft tension spring | 13 | Valve stem oil seal |
| 3 | Valve rocker shaft | 14 | Compression spring |
| 4 | Stud bolt | 15 | Exhaust valve |
| 5 | Valve rocker arm (EX) | 16 | Intake valve |
| 6 | Valve adjusting screw | 17 | Camshaft timing gear |
| 7 | Valve rocker support No.2 | 18 | Camshaft thrust plate |
| 8 | Valve rocker arm (IN) | 19 | Key |
| 9 | Compression spring | 20 | Valve lifter |
| 10 | Valve push rod | 21 | Camshaft |
| 11 | Valve spring retainer lock | 22 | Camshaft bearing |

Fig. 2-5 Camshaft & Valve Components Parts

DISASSEMBLY

Remove the following parts in numerical order.

1. Drain the engine oil.
2. Valve rocker cover
3. Injection pipes
4. Starter
5. Over injection magnet
6. Fuel pipes
7. Fuel filter with engine hanger

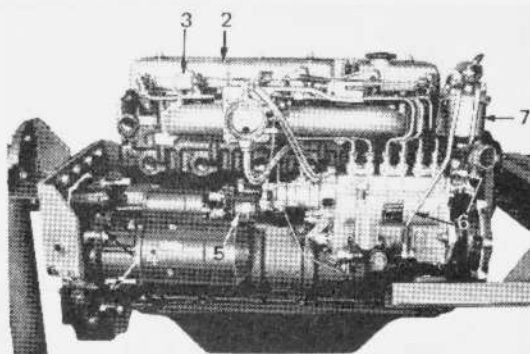


Fig. 2-6 Removing External Parts

8. Vacuum hoses
9. Connecting rod
10. Intake manifold with venturi

Caution

When loosening the nuts, loosen from outside gradually and alternately to prevent warpage.

11. Overflow pipe
12. Injection pump

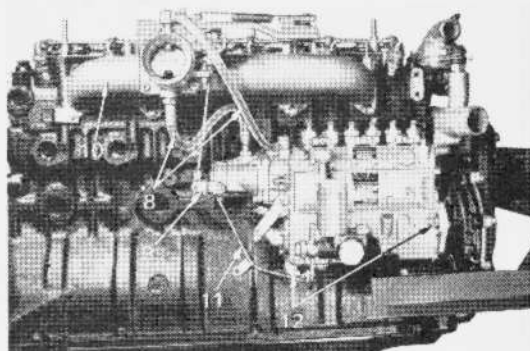


Fig. 2-7 Removing External Parts

13. Oil level gauge
14. Oil hoses
15. "V" belt and alternator
16. Oil filter
17. Oil cooler, hose and pipe (HU)
18. Exhaust manifold
19. Ventilation tube and push rod cover
20. Oil pressure sender gauge

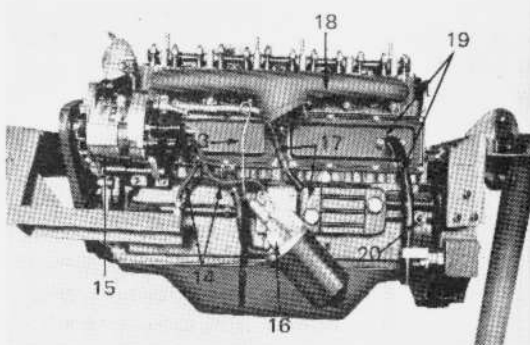


Fig. 2-8 Removing External Parts

21. Water by-pass hose
22. Water outlet
23. Water pump

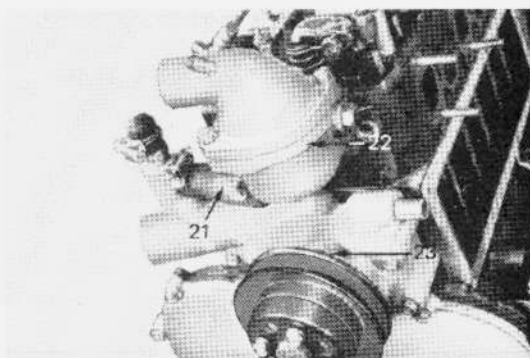


Fig. 2-9 Removing External Parts

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24.
25.
26.

27.
28.
29.

30. (C)
31. (C)

32. V

When
outside
shaft

- 24. Heater union
- 25. Linkage pipe
- 26. Packing rings

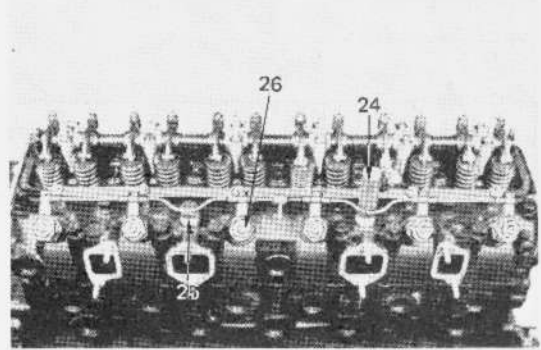


Fig. 2-10 Removing Pipe & Ring

- 27. Nozzle holders
SST [09268-46011]
- 28. Nozzle seats
- 29. Nozzle gaskets

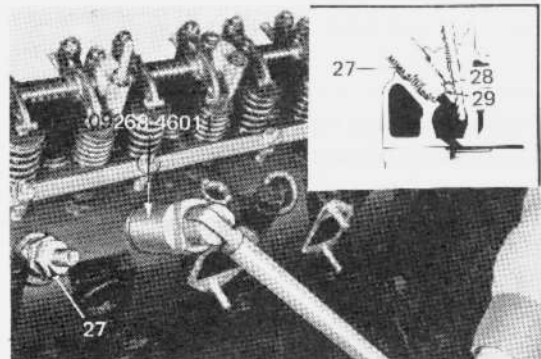


Fig. 2-11 Removing Nozzle

- 30. Glow plug connector
- 31. Glow plugs

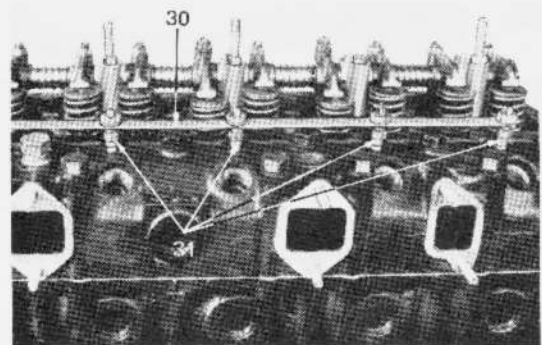


Fig. 2-12 Removing Glow Plug

- 32. Valve rocker shaft assembly

Caution

When loosening nuts and bolts, loosen from outside gradually and alternately to protect shaft and rocker support from warpage.

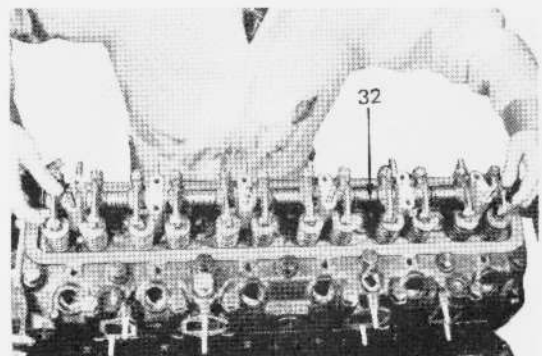


Fig. 2-13 Removing Valve Rocker Shaft

- 33. Push rods
- 34. Valve lifters

Caution

Keep the drawn out push rods and valve lifters in correct order.

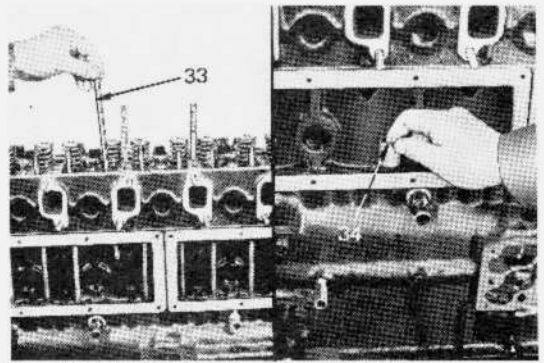


Fig. 2-14 Removing Push Rod & Lifter

- 35. Cylinder head and gasket

Caution

When loosening set bolts, loosen little by little and evenly, according to the specified order, to prevent cylinder head warpage.

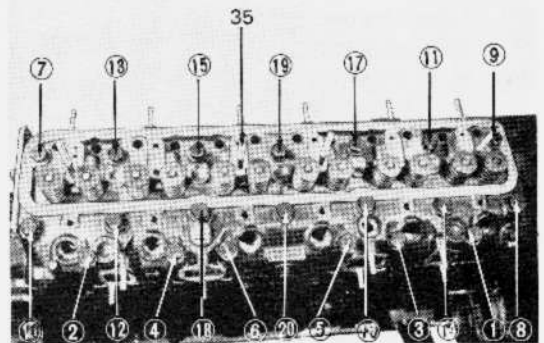


Fig. 2-15 Bolt Loosening Order

- 36. Oil pan and gasket

Caution

Remove carefully so that the oil pan may not be deformed or installing surface may not get damaged.

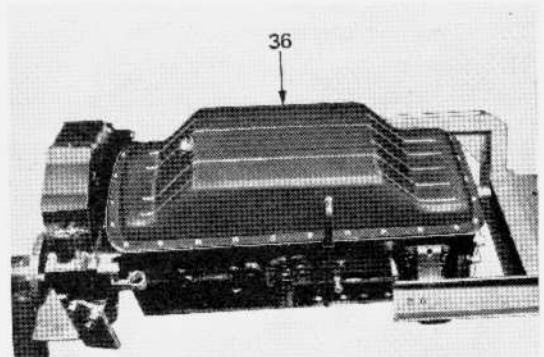


Fig. 2-16 Removing Oil Pan

- 37. Oil pump assembly

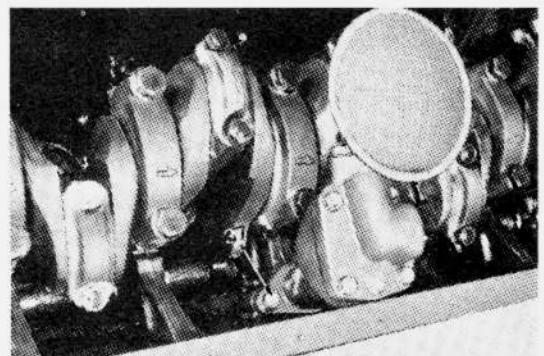


Fig. 2-17 Removing Oil Pump

38. Crankshaft pulley lock nut

Note

1. Remove calking of crank pulley lock plate (39) by using chisel and the like.
2. Remove crank pulley installing nut with 46mm (1-13/16") Box Wrench.

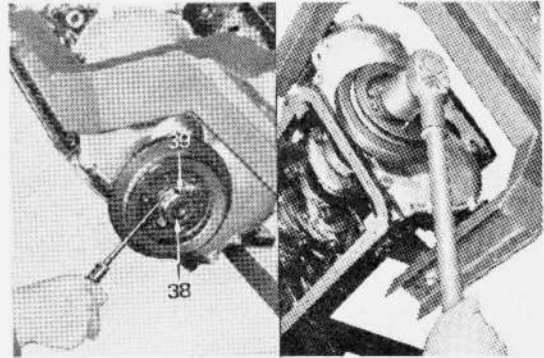


Fig. 2-18 Removing Lock Nut

40. Crankshaft pulley

SST : [09213-31020 or 09213-60014]

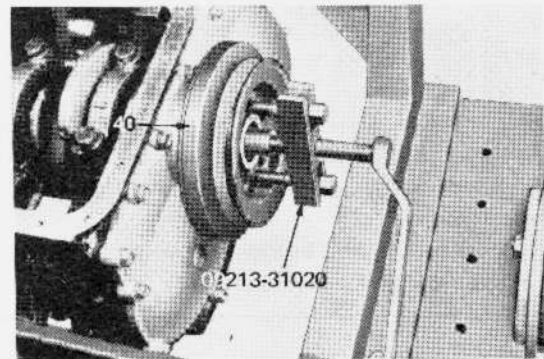


Fig. 2-19 Pulling Pulley

41. Timing gear cover w/automatic timer and gasket.

Caution

Perform the job carefully so that oil seal, installing surfaces and so on may not get damaged.

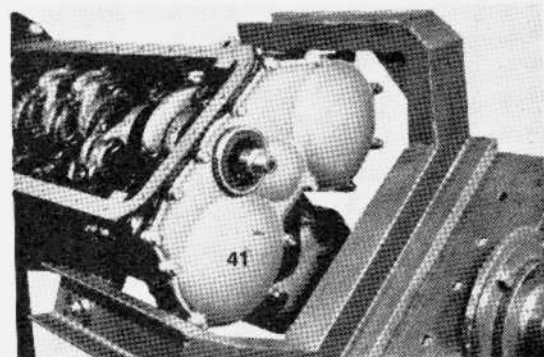


Fig. 2-20 Timing Gear Cover

42. Camshaft w/camshaft timing gear

Caution

When pulling out camshaft, do not use force, otherwise the bearing may be damaged.

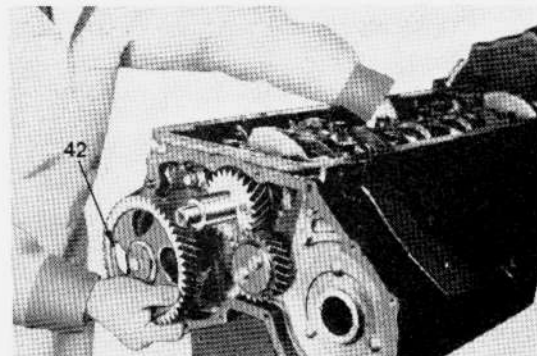


Fig. 2-21 Removing Camshaft

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- 43. Idle gear
- 44. Idle gear shaft
- 45. Timing gear case and gasket

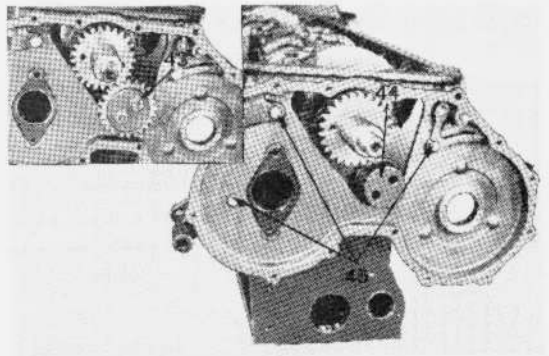


Fig. 2-22 Removing Gear Case

- 46. Connecting rod caps
- 47. Pistons w/connecting rod

Caution

Temporarily assemble rod and cap so that connecting rod and cap combination may not be changed.

As connecting rod bearings are common parts, do not change the combination.

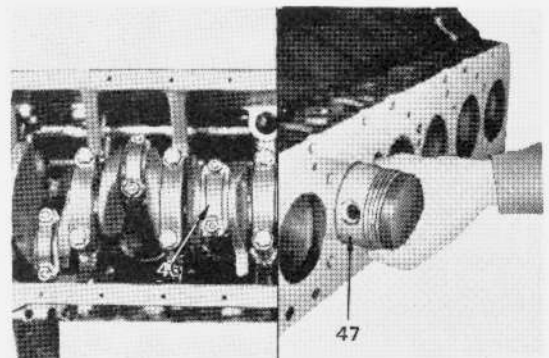


Fig. 2-23 Removing Piston

- 48. Flywheel
- 49. Clutch housing

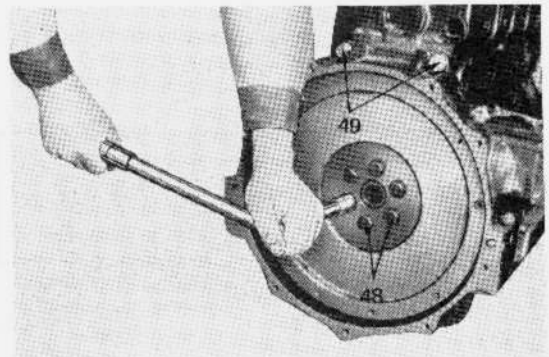


Fig. 2-24 Removing Flywheel

- 50. Crankshaft rear oil seal retainer and gasket

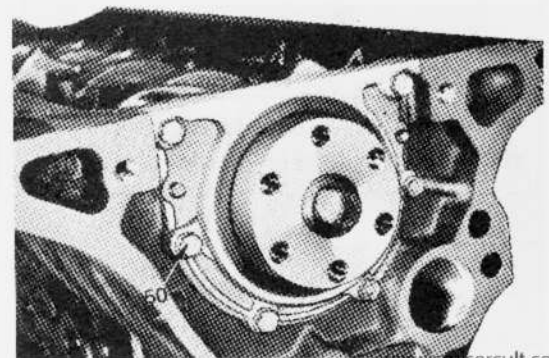


Fig. 2-25 Removing Retainer

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51. Crankshaft bearing caps

Caution

1. When loosening set bolts, loosen little by little and evenly, according to the specified order to prevent crankshaft bend.
2. Do not change crankshaft bearings.

52. Crankshaft

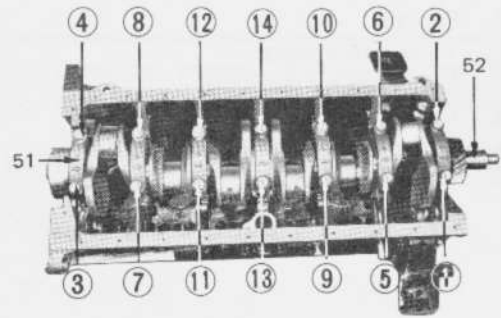


Fig. 2-26 Loosening Order

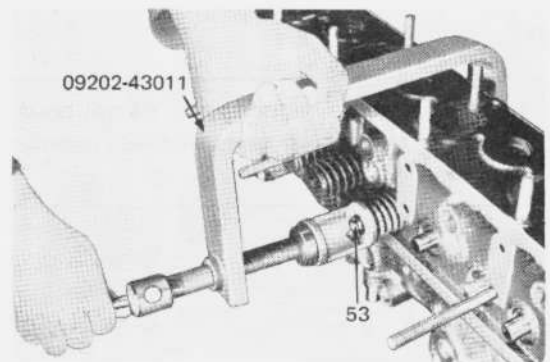
53. Valve spring retainer locks
SST [09202-43011]

Fig. 2-27 Removing Retainer Lock

54. Valve spring retainers

55. Valve springs

56. Oil seals

Note

Before pulling oil seal, cover the valve stem end with tape to prevent oil seal damage. (In the case of reused only)

57. Valves

Caution

Stamp marks upon valves, and keep in order.

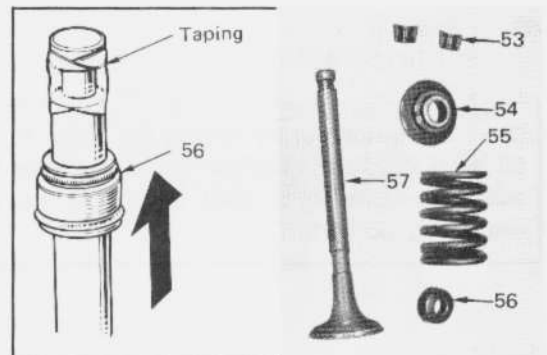
58. Combustion chamber
SST [09208-48010]

Fig. 2-28 Removing Valve

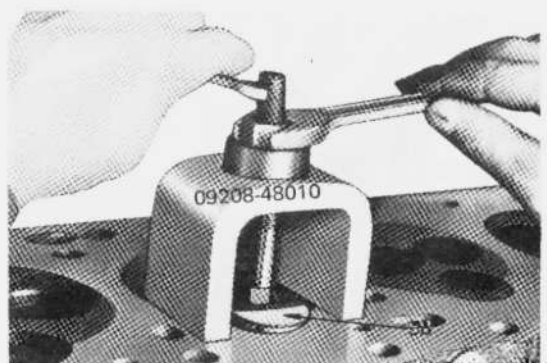


Fig. 2-29 Removing Combustion Chamber

- 59 Spring retainers
- 60 Springs
- 61 Valve rocker arms
- 62 Bolt (only for rear end)
- 63 Valve rocker supports
- 64 Springs
- 65 Valve rocker shaft

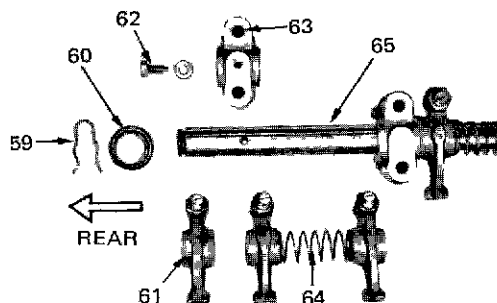


Fig 2-30 Disassembling Rocker Shaft

- 66 Piston rings

Caution

If the rings are to be used again, do not break them, and also keep the removed rings in order to prevent mixing.

- 67 Hole snap rings

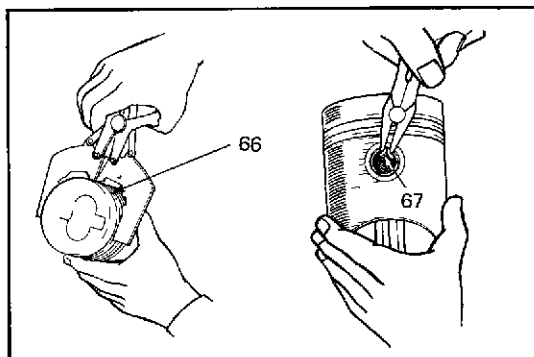


Fig. 2 31 Disassembling Piston

- 68 Piston pin
SST [09221 46010]

Note

Draw out piston pin by heating the piston to 50 to 60°C (122 to 140°F) with a piston heater and disassemble piston (69), piston pin and connecting rod (70).

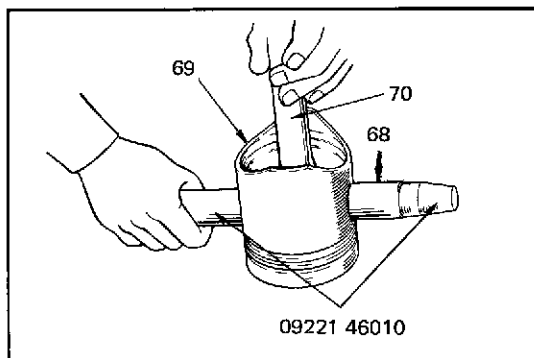


Fig 2 32 Removing Piston Pin

INSPECTION & REPAIR

Caution

1. Before inspection and repair, wash the parts, and remove the dirt, oil, carbon and water scale.
2. Inspect the cylinder block and cylinder head for water leakage and damage before washing.
3. Blow the oil passages with compressed air, and remove the adhering dirt, and confirm that no clogage is present.
4. Carefully remove the carbon on the pistons, cylinder head and valves without damaging the parts.
5. Keep the parts in order which have a fixed order of connection.
Do not allow them to get mixed up.

Cylinder Head

1. Besides visual inspection, use the Magnaflux to inspect for cracks and damages.
2. Measure the cylinder head lower surface for warpage by using a straight-edge and feeler gauge. If the warpage exceeds the limit, correct using a surface grinder, or replace.

Warpage limit **0.2mm (0.008")**

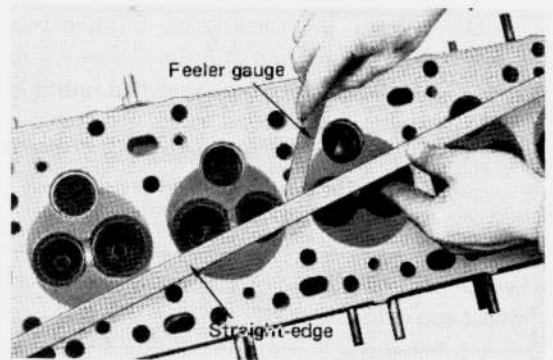


Fig. 2-33 Measuring Cylinder Head Warpage

Note

Measure the cylinder head lower surface warpage at square and diagonal positions as illustrated in Fig. 2-34.

3. Measure the manifold installing surface for warpage.

Warpage limit **0.2mm (0.008")**

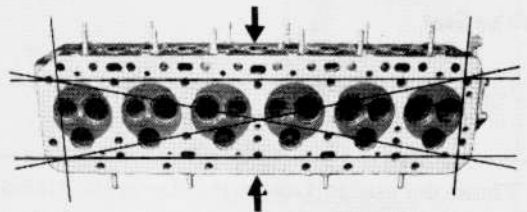


Fig. 2-34 Measuring Positions of Lower Surface

Valve Guide Bushing

1. Measure the valve stem to the guide bushing clearance, and if the clearance exceeds the limit, replace the valve together with valve guide bushing.

Clearance limit: Intake 0.10mm (0.0039")
Exhaust 0.12mm (0.0047")

Specified clearance:

Intake	0.021 to 0.057mm (0.00083 to 0.00224")
Exhaust	0.040 to 0.076mm (0.00157 to 0.00299")

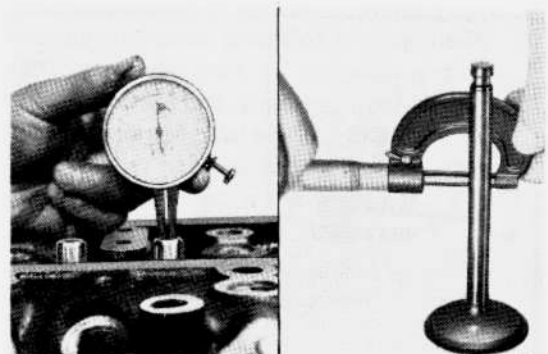


Fig. 2-35 Measuring Valve Stem & Bushing Clearance

2. Valve guide bushing replacement
 - a) Drive out the valve guide towards the cylinder head lower part by using SST [09201-40010].
 - b) Drive in the guide bushing from the upper part of cylinder head until a protrusion of 17mm (0.67") from the upper surface of cylinder head is developed, by using SST [09201-40010].
 - c) Finish the valve guide bushing bore using a reamer according to necessity.
Guide bushing bore specified finishing measurements:
 9.01 to 0.03mm (0.354 to 0.355")
 for both intake and exhaust

Note

Length of valve guide bushing differs for intake and exhaust.

Total length :

Intake	56mm (2.21")
Exhaust	60mm (2.36")

Valve Seat

1. Correct or replace cylinder head if the valve seat has poor contact or damages.

Caution

Finish the seat surface in the size as illustrated in Fig. 2-38 by using a seat cutter, and after running-out with compound, confirm the seat surface contact by using red lead.

2. There are the following general methods of cutting valve seat by using valve seat cutter.
 - a) After correcting the seat contacting surface of valve by valve refacer, check the contacting position with the seat and make this a standard for applying seat cutter,

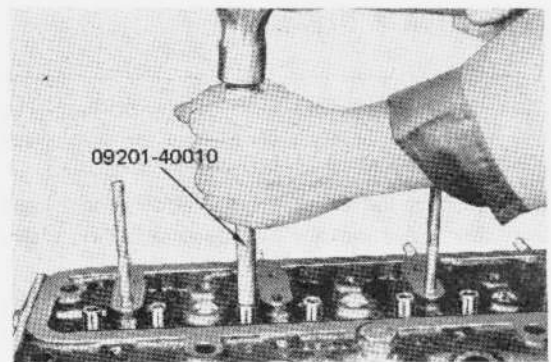


Fig. 2-36 Replacing Valve Guide Bushing

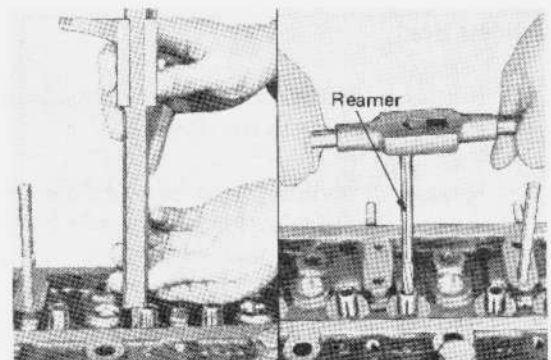


Fig. 2-37 Protrusion & Reaming

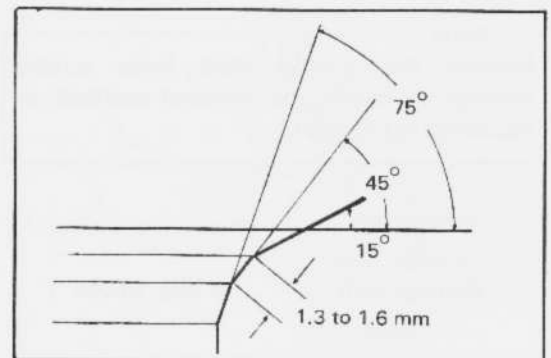


Fig. 2-38 Valve Seat Correction Size

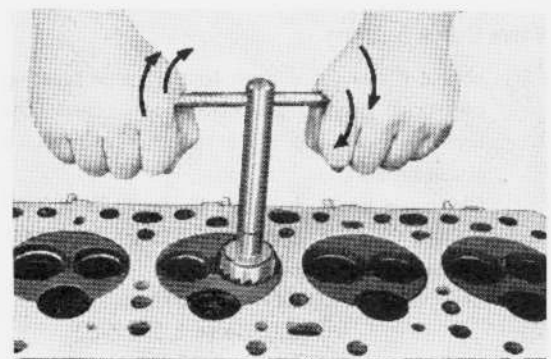


Fig. 2-39 Correcting Valve Seat

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- b) The order of applying seat cutter is illustrated in Fig 2.40. First apply 15° cutter, next 75° cutter and finally correct the contacting surface width by applying lightly the 45° cutter.

Contact width :

Intake	1.3 to 1.6mm (0.05 to 0.06")
Exhaust	1.3 to 1.6mm (0.05 to 0.06")

- c) It is desirable that the contact position of valve and seat is in the middle of the seat contact surface of the valve. Accordingly, when applying cutters of 15° and 75° due attention should be paid to the seat contact position of valve.

Note

Use only the cutters of 15° and 45° to correct, when the valve lower part is in contact, and only 75° and 45° cutters when the valve upper part is in contact.

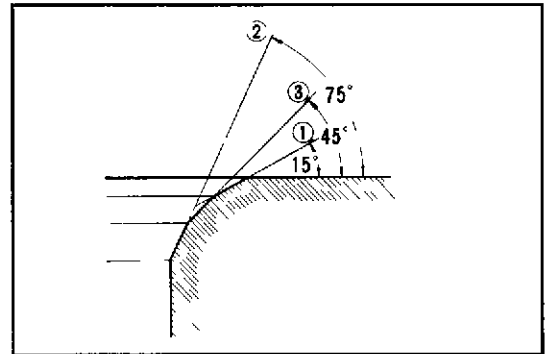


Fig 2.40 Seat Parts Correction Order

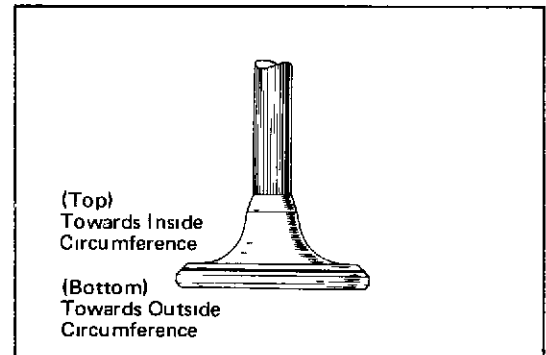


Fig. 2.41 Contact Position with Seat

Valve

1. Inspect the valve and stem parts of intake and exhaust valves, and replace those which are excessively worn, burnt and deformed.
2. Replace the valve if the valve head thickness is less than below

Thickness limit:

Intake	0.9mm (0.035")
Exhaust side	1.0mm (0.039")

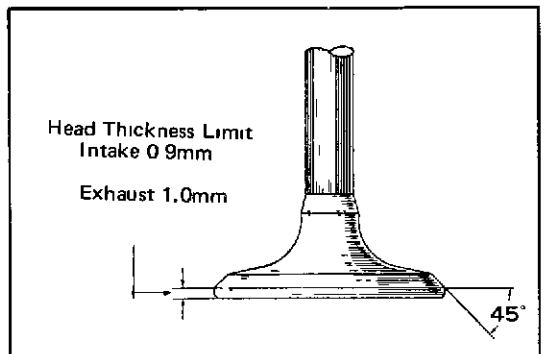


Fig. 2.42 Valve Head Thickness Limit

3. Correct the valve seat contact parts and its contact surface with rocker arm using a valve refacer.

Seat contact surface correction angle : 45°

Valve stem edge surface correction limit:
0.5mm (0.02")

Valve total length:

Intake side	120.6mm (4.748")
Exhaust side	120.4mm (4.740")

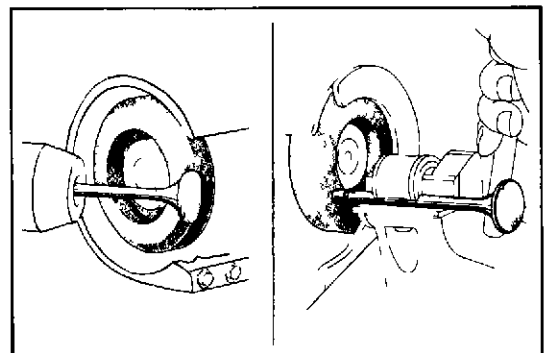


Fig 2.43 Correcting Valve

Compression Spring (for valve use)

1. Free length
Measure the free length of each spring.
Specified length 45.1mm (1.776")
2. Spring tension
Measure the spring tension by using a spring tester and replace if the tension is less than the limit.

Note

When measuring the tension, make the installing length as the standard one.

Table 2-2 Spring Specifications

Installing Length	40.0 mm (1.575")
Installing Tension Limit	18.5 kg (40.8 lb)
Specified Installing Tension	21.7 kg (47.8 lb)

3. Squareness
Measure the squareness on a surface plate with a steel square, and replace if the inclination at the top exceeds the following.
Squareness limit 1.6mm (0.063")

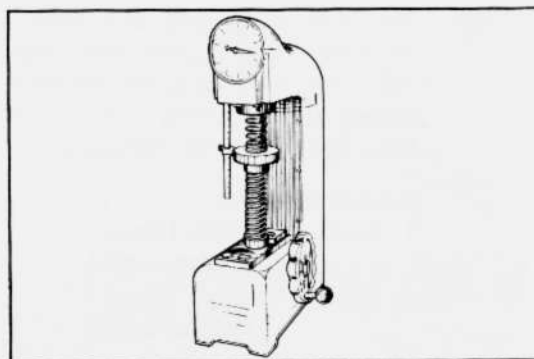


Fig. 2-44 Measuring Spring Tension

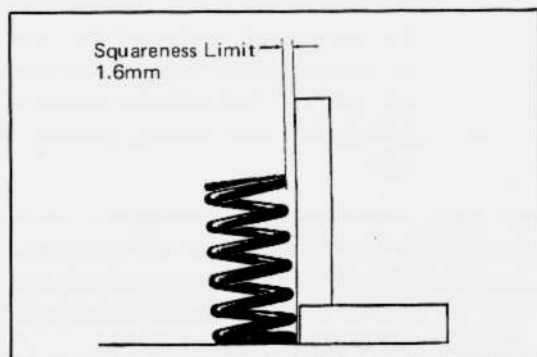


Fig. 2-45 Measuring Spring Squareness

Valve Rocker Arm, Shaft

1. Inspect the valve rocker arm and shaft, and replace the rocker arm or shaft if remarkably worn.

Note

To measure the rocker arm to shaft clearance, measure the inner and outer diameters of rocker arm by using a micrometer and dial gauge, and then subtract, to find out the clearance.

Clearance limit 0.1mm (0.004")
Specified clearance 0.007 to 0.049mm
(0.00028 to 0.00193")

2. Replace the rocker arm if the valve stem contact surface of valve rocker arm is remarkably worn.
Correct with valve refacer in case of a little step wear.
3. Replace the rocker shaft spring if damaged.

Push Rod

Replace the push rod if bent or if both ends are worn and damaged.

Bend limit 0.5mm (0.020")

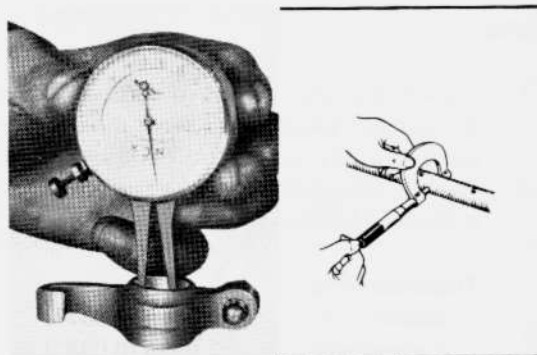


Fig. 2-46 Measuring Clearance

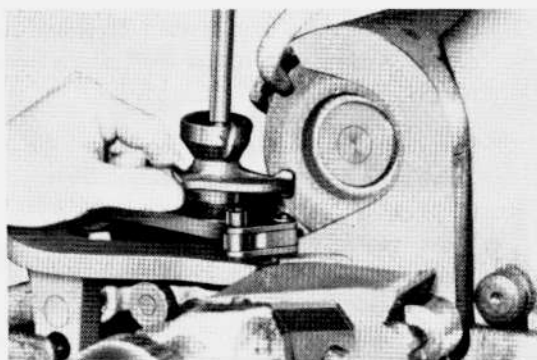


Fig. 2-47 Correcting Valve Rocker Arm

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Valve Lifter

1. Check the lifter for wear and damage, and replace if defective.
2. Measure the lifter bores of cylinder block and if the clearance with lifter is more than 0.1mm (0.004"), reface and correct the lifter bores to normal clearance by using oversize (0.05mm or 0.002") lifter.

Clearance limit **0.1mm (0.004")**
Specified clearance **0.010 to 0.051mm**
(0.00039 to 0.00201")

Table 2-3 Valve Lifter Specifications

Size	Lifter Diameter mm (in)	Lifter Bore Diameter mm (in)
STD	22.170 to 22.190 (0.87283 to 0.87362)	22.200 to 22.220 (0.87401 to 0.87480)
O/S 0.05	22.220 to 22.235 (0.87480 to 0.87539)	22.250 to 22.270 (0.87598 to 0.87677)

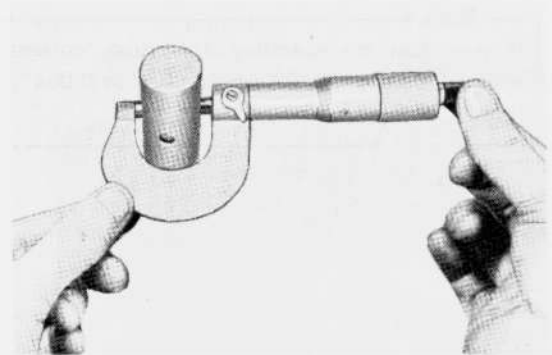


Fig. 2-48 Measuring Valve Lifter Outer Diameter

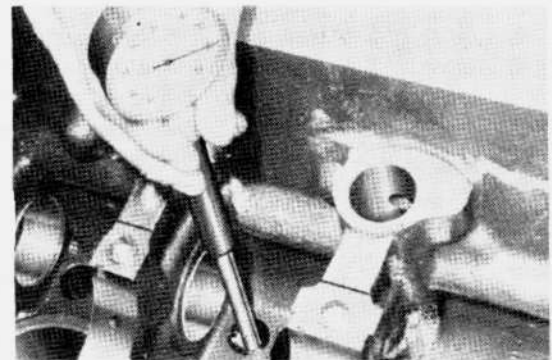


Fig. 2-49 Measuring Valve Lifter Bore

Cylinder Block

1. Crack and damage inspection
Besides visual inspection, use Magna-flux to inspect for cracks and damage, and if defective, correct or replace.
2. Block upper surface warpage
Inspect the block upper surface for warpage in the similar manner as the cylinder head, and if warpage exceeds the limit, grind for correction.

Warpage limit **0.15mm (0.0059")**

3. Cylinder liner protrusion size
Cylinder liner is a bit protruded over the block upper surface.

Specified protrusion **0.03 to 0.12mm**
(0.0012 to 0.0047")

Caution

Do not grind the block upper surface with oil stone.

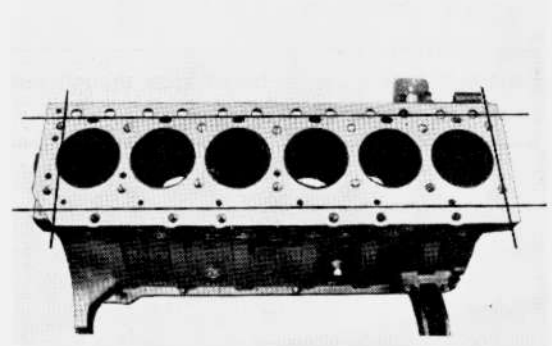


Fig. 2-50 Measuring Positions of Surface

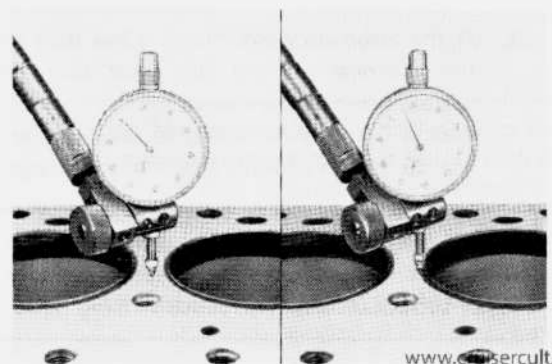


Fig. 2-51 Measuring Liner Protrusion

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Note

If less than the specified dimension, correct with a 0.05mm or a 0.1mm (0.002" or 0.004") shim.

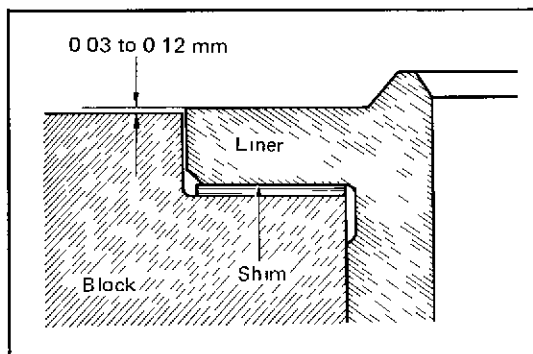


Fig. 2-52 Liner Protrusion

4. Measuring cylinder bore diameter
Measure the cylinder bores with a cylinder bore gauge (inside dial gauge) at six locations as illustrated in Fig. 2-54 and correct if the wear and taper exceed the limit

Wear limit **0.6mm (0.024")**

Cylinder bore (STD)

88.00 to 88.03mm

(3.4646 to 3.4657")

5. If the wear in cylinder bore exceeds the limit or if the cylinder walls are damaged or burnt, perform boring of the cylinders and use oversize piston

Caution

All cylinders must be bored even though one cylinder requires boring.

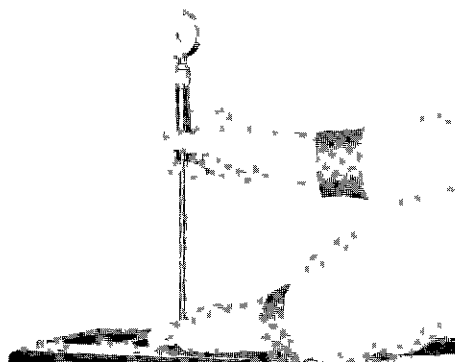


Fig. 2-53 Measuring Cylinder Bore

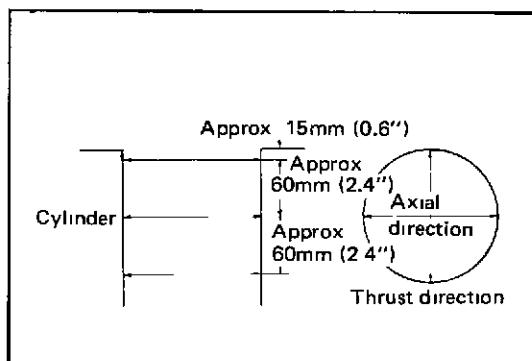


Fig. 2-54 Measuring Locations of Cylinder Bore

6. If the wear in cylinder bore is less than the limit, scrape off the step wear in upper surface using a ridge reamer.
Perform honing according to necessity, and use the piston of same size or slightly larger

Caution

If only the piston ring is replaced with new one without scraping off the step wear in cylinder upper surface, this may produce striking noise.

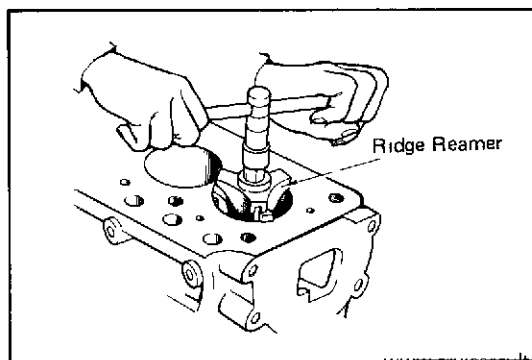


Fig. 2-55 Removing Step Wear

Table 2-4 Standard Piston Outer Diameter

Size	Marks	Piston Outer Diameter mm (in)	Bore Finishing Inner Diameter mm (in)
STD	1	87.81 to 87.82 (3.4571 to 3.4575)	88.00 to 88.01 (3.4646 to 3.4650)
	2	87.82 to 87.83 (3.4575 to 3.4579)	88.01 to 88.02 (3.4650 to 3.4653)
	3	87.83 to 87.84 (3.4579 to 3.4583)	88.02 to 88.03 (3.4653 to 3.4657)

Note

The marks of bore inner diameter finishing size are stamped on the left front side of valve push rod cover installing surface of cylinder block. Pistons are also of the same marks.

Cylinder Boring

When boring after measuring oversize piston, select the cylinder having largest bore to determine the oversize piston.

1. Boring

- a) Measure the outer diameter of selected piston with a micrometer correctly at the piston skirt (thrust surface).

Oversize piston outer diameter size

**O/S 1.00 88.81 to 88.84 mm
(3.4964 to 3.4976")**

Note

The measuring point should be at 6mm (0.24") from the oil groove at 20°C (68°F).

- b) After measuring the selected piston, use the following formula to calculate the finishing inner diameter of the boring.

Finishing inner diameter (mm or in) =
 $P + C - H \pm E$ where

P; Piston outer diameter (mm or in)

C; Piston clearance 0.18 to 0.20 mm
(0.0071 to 0.0079") at 20°C or 68°F

H; Honing allowance Below
0.02mm (0.0008")

E; Boring machine error (mm or in)

Caution

- When mounting the boring machine, take out 2 knock pins over the block upper surface.
- As the liner protrudes 0.03 to 0.12mm (0.0012 to 0.0047") from the block upper surface, insert a thickness gauge of about 0.20mm (0.008") in the gap with the boring machine lower surface to perform cylinder boring securely.

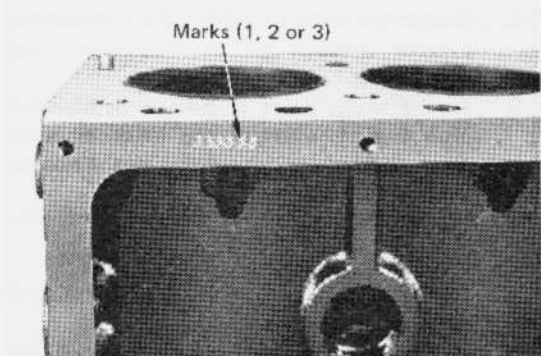


Fig. 2-56 Cylinder Bore Finishing Size & Mating Marks

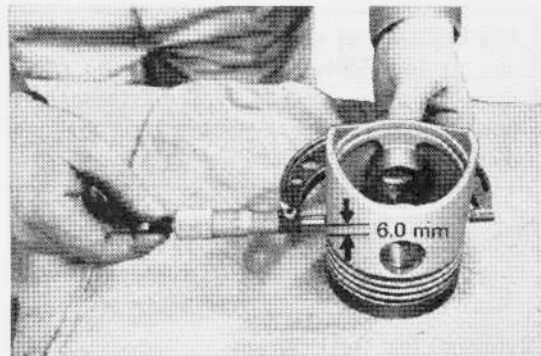


Fig. 2-57 Cylinder Boring Preparation

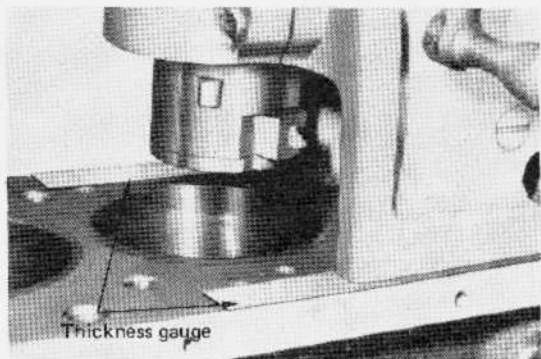


Fig. 2-58 Cylinder Boring

- If the boring machine mechanical error is not known, perform the first boring with 0 error, and then determine the mechanical error according to the result of boring.
- When boring, do not file much at a time, rather do it in 2 or 3 times. The filing allowance for one time is 0.05mm (0.002").

5. Bore in the order of 1-3-6-4-2-5 cylinders to prevent warpage due to temperature rise upon filing.
6. As the temperature of cylinder is high just after boring, measure the inner diameter when the temperature drops to the normal value 20°C (68°F).

2. Honing

After boring, perform honing to finish the cylinder inner surface.

Honing allowance **Less than 0.02mm**
 (0.008")

Caution

The objective of honing is to remove the bites due to boring. Hence care should be taken, since finishing accuracy will be lowered, if honing times are increased to enlarge the inner diameter.

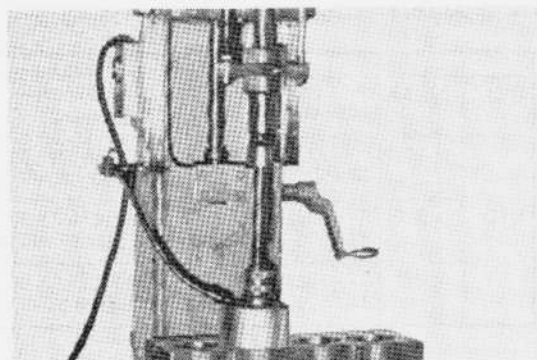


Fig. 2-59 Cylinder Honing

3. Cylinder bore inspection

Taper elliptic degree

Less than 0.02mm (0.008")

Difference of each cylinder inner diameter

Less than 0.02mm (0.008")

4. Cylinder to piston clearance

Measure the cylinder to piston clearance.

Clearance **0.23 to 0.25mm**
 (0.0091 to 0.0098")

Cylinder Liner Replacement

If the cylinder bores are remarkably damaged or worn so that the O/S 1.00mm size pistons cannot be used, replace the cylinder liner.

1. Use SST [09218-46010] to remove the liners.
2. Determine the liner by mark or measurement so that the installation tightening allowance of the selected liners matches with specified allowance.

Table 2-5 Cylinder Liner Sizes

Mark	Cylinder Block Diameter mm (in)	Liner Outer Diameter mm (in)	Tightening Allowance mm (in)
A	93.000 to 93.0175 (3.6614 to 3.6621)	93.055 to 93.075 (3.6636 to 3.6644)	0.0375 to 0.075 (0.0015 to 0.0030)
B	93.0175 to 93.035 (3.6621 to 3.6628)	93.075 to 93.095 (3.6644 to 3.6652)	0.040 to 0.0775 (0.0016 to 0.0031)

3. Coat the outer circumference of liners with engine oil lubricants and use press to install.
Pressing load — 3,000 to 5,000kg
(6,614 to 11,023 lb)

Note

The final pressure for insertion is about 5,000kg (11,023 lbs).

4. After installation, the liner upper surface is 0.03 to 0.12mm (0.0012 to 0.0047") protruding from the cylinder upper surface.

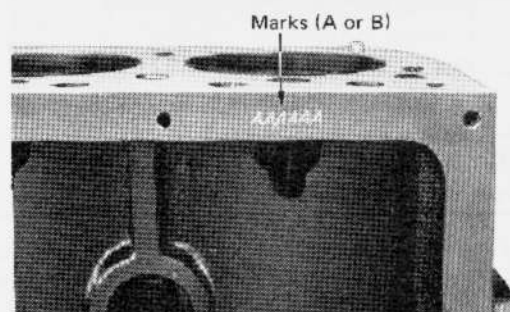


Fig. 2-60 Lower Hole Size and Mark for Liners

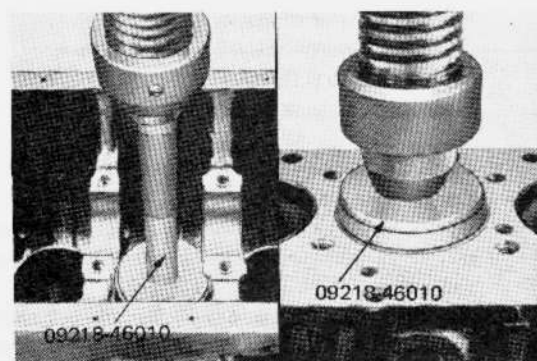


Fig. 2-61 Cylinder Liner Replacement

5. After pressing in, bore and hone to fit the STD piston.

Piston, Piston Pin & Piston Rings

Replace the pistons if the piston ring grooves are worn, damaged or if there are other troubles. Inspect the pistons and piston pins for fitting.

Note

1. The fitting of the piston pin into the piston should be possible with the thumb pressure when the piston is heated to 50 to 60°C (122 to 140°F).
2. Front mark (1), cylinder number (2), piston outer diameter mark (3) and piston pin inner diameter mark (4) are stamped on the piston top surface.
3. When the piston rings are broken, damaged or remarkably worn, or when the pistons are to be replaced, select the rings of same size of the pistons to be used.
4. Insert the piston ring into cylinder bore, and measure the end gap by using a thickness gauge.

Specified end gaps:

Compression rings No.1, No.2

0.25 to 0.45mm (0.0098 to 0.0177")

Oil ring

0.20 to 0.40mm (0.0079 to 0.0157")

Caution

Measure the end gap at the lower part of the cylinder where the wear is minimum.

5. Measure the ring to ring groove clearance, and replace the piston if the clearance is defective.

Specified ring to groove clearance:

Compression ring No.1

0.01 to 0.06mm (0.0004 to 0.0024")

Compression ring No.2

0.05 to 0.09mm (0.0020 to 0.0035")

Oil ring

0.03 to 0.07mm (0.0012 to 0.0028")

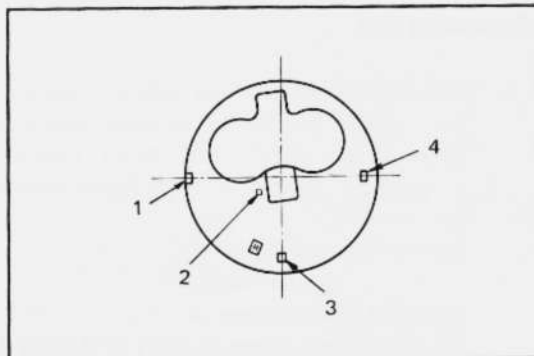


Fig. 2-62 Piston Top Surface Marks

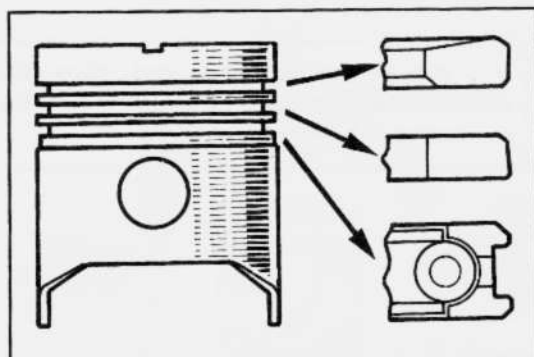


Fig. 2-63 Piston Ring Shapes

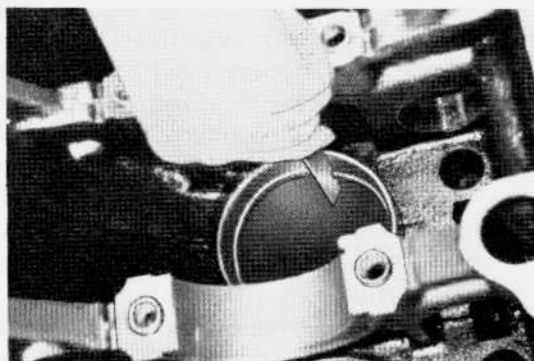


Fig. 2-64 Measuring Piston Ring End Gap



Fig. 2-65 Measuring Piston Ring to Groove Clearance

Connecting Rod

1. Assemble the connecting rods to crank pins, and measure the thrust clearance; replace the connecting rods if the thrust clearance exceeds the limit or if both thrust surfaces are damaged.

Thrust clearance limit

0.3mm (0.012")

Specified thrust clearance

0.08 to 0.16mm (0.0031 to 0.0063")

Caution

If a new connecting rod is used, stamp the corresponding cylinder number on the connecting rod.

2. Measure for bend and twist by using a connecting rod aligner, and if the bend or twist exceeds the limit, correct so that the "V" block will contact the face plate correctly at three points, or replace as necessary.

Bend limit

0.05mm per 100mm (0.0020" per 3.9")

Twist limit

0.15mm per 100mm (0.0059" per 3.9")

3. Replace the connecting rod bushing if worn or damaged using SST [09222-40011].

Oil clearance limit

0.05mm (0.002")

Specified oil clearance

0.004 to 0.012mm (0.0002 to 0.0005")

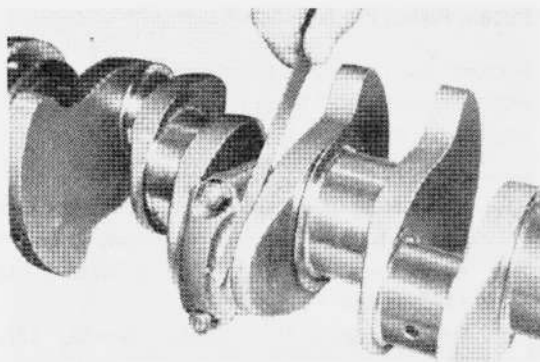


Fig. 2-66 Measuring Thrust Clearance

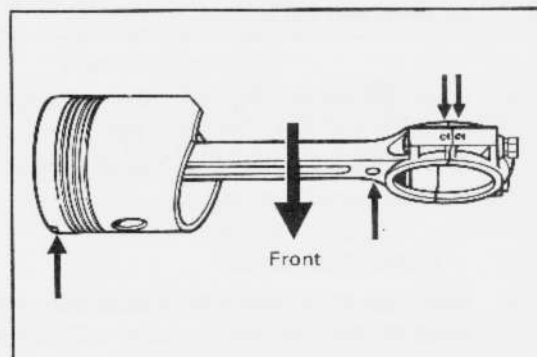


Fig. 2-67 Marks

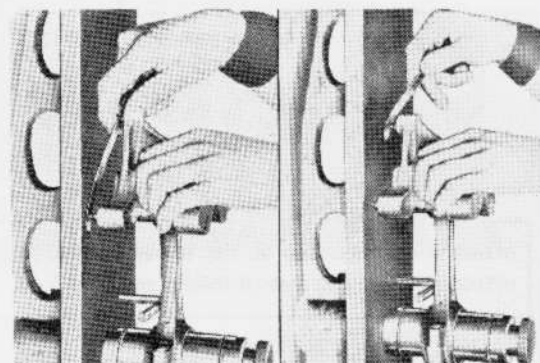


Fig. 2-68 Measuring Connecting Rod Bend & Twist



Fig. 2-69 Replacing Connecting Rod Bushing

4. After installing the bushing, finish the bushing with a pin hole honing machine or reamer in accordance with the piston pin inner diameter.

Specified oil clearance

0.004 to 0.012mm (0.0002 to 0.0005")

Note

The fitting of bushing with the pin should be possible with the thumb pressure after applying engine oil to the pin, when the piston is heated to a normal temperature.

Connecting Rod Bearing

1. Inspect for peeling, melt, burnt and condition of contact surface, and replace if defective.

Caution

1. Never do shim adjusting and scraping.
2. Never scrape off the bearing with sand paper.
3. Be sure to measure the oil clearance and confirm that the clearance is within the specified oil clearance.

2. Measure the oil clearance using a plastigage.
 - a) Cut the plastigage to the width of the bearing, and place the plastigage on the crank pin parallel to the crankshaft, avoiding the oil hole.
 - b) Assemble the connecting rod bearing and bearing cap, and tighten to specified torque.
- During this operation, do not rotate the connecting rod.

Tightening torque

650 to 750kg-cm (47.0 to 54.3ft-lb)

- c) Remove the cap, and measure the plastigage width with the scale printed on the cover.
- d) Measure the widest portion of the gage, and also watch for the difference of size in both ends of the gage.

Oil clearance limit

0.10mm (0.0039")

Specified oil clearance

0.030 to 0.070mm
(0.0012 to 0.0028")

3. As a result of inspection, if the oil clearance is over the limit, replace the bearing in accordance with Table 2-6.

Caution

1. When assembling new crankshaft, use the bearing of STD size.
2. If the specified oil clearance is not obtained

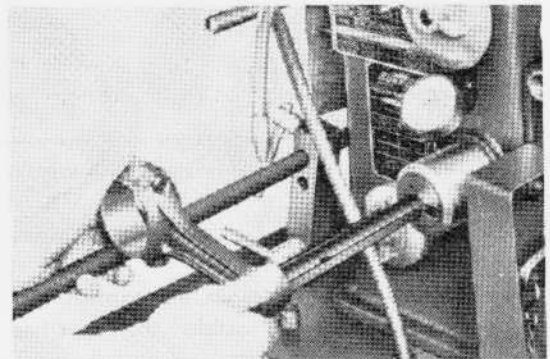


Fig. 2-70 Finishing Connecting Rod Bushing

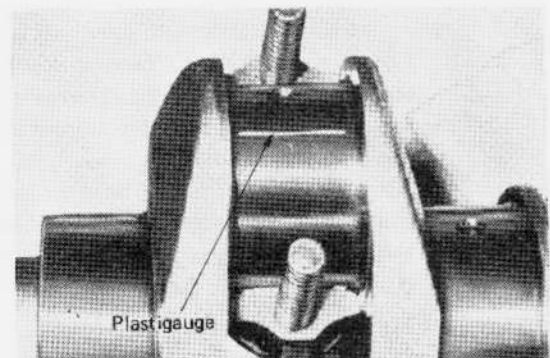


Fig. 2-71 Preparing for Crank Pin Oil Clearance Measurement

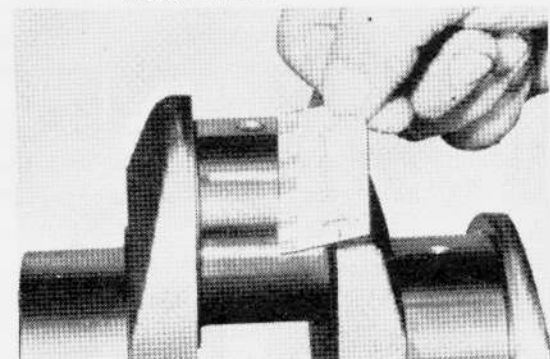


Fig. 2-72 Measuring Crank Pin Oil Clearance

Table 2-6 Connecting Rod Bearing

Bearing Size	Crank Pin Finished Diameter mm (in)
STD	54.98 to 55.00 (2.1646 to 2.1654)
U/S 0.05	54.94 to 54.95 (2.1630 to 2.1634)
U/S 0.25	54.74 to 54.75 (2.1551 to 2.1555)
U/S 0.50	54.49 to 54.50 (2.1453 to 2.1457)
U/S 0.75	54.24 to 54.25 (2.1354 to 2.1358)
U/S 1.00	53.99 to 54.00 (2.1256 to 2.1260)

even when using U/S 0.05 bearing, use the bearings below U/S 0.25 size after grinding the crank pins.

Crankshaft Bearing

1. Inspect the peeling, melting, burning and contact conditions, and replace if defective.

Caution

1. Do not adjust with shims or finish with a scraper.
2. Do not dress the bearing with an emery cloth.
3. Measure the oil clearance, and confirm that the clearance is within the specified clearance.

2. Measure the oil clearance with the Plastigage.
 - a. Cut the plastigage to bearing width, and place it onto the crankshaft journal parallel with the crankshaft avoiding the oil hole.
 - b. Assemble the crankshaft bearings and bearing cap, and tighten to specified torque. At this time, do not rotate the crankshaft.

Tightening torque

**980 to 1120 kg-cm
(70.9 to 81.0 ft-lb)**

- c. Remove the cap, measure the widest portion of the Plastigage with the scale on the gauge cover.
- d. Measuring must be performed at widest compressed portion, but the gauge ends must also be checked carefully.

Oil clearance limit

0.10 mm (0.004")

Specified oil clearance

**0.030 to 0.072 mm
(0.0012 to 0.0028")**

3. Upon inspection, if the oil clearance is not within the specified clearance, replace the bearings in accordance with the following list.

Caution

- a. If a new crankshaft is utilized, use the STD size bearing.
- b. If the specified oil clearance is not obtained

even utilizing the U/S-0.05 (0.002") bearing, grind the crankshaft journals, and utilize the bearing of less than U/S-0.25 (0.0098")

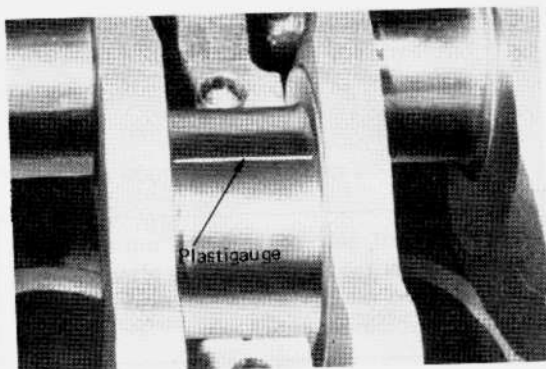


Fig. 2-73 Position of Plastigage

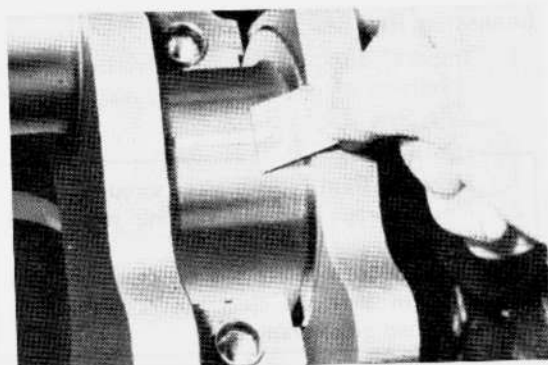


Fig. 2-74 Measuring Crankshaft Oil Clearance

Table 2-7 Crank Journal Outer Diameter Finishing Size

Bearing Size	Crank Journal Outer Diameter Finishing Size mm (in)
STD	69.98 to 70.00 (2.7551 to 2.7559)
U/S 0.05	69.89 to 69.90 (2.7516 to 2.7520)
U/S 0.25	69.74 to 69.75 (2.7457 to 2.7461)
U/S 0.50	69.49 to 69.50 (2.7358 to 2.7362)
U/S 0.75	69.24 to 69.25 (2.7260 to 2.7264)
U/S 1.00	68.99 to 69.00 (2.7161 to 2.7165)

Crankshaft

1. Measure the crankshaft for bend, and if it exceeds the limit, correct or replace.

Bend limit **0.04mm (0.0016")**

Note

Place the dial gauge to the center bearing journal part to measure the run-out as illustrated in Fig. 2-75, and then rotate the crankshaft one revolution, and read 1/2 of maximum gauge reading difference.

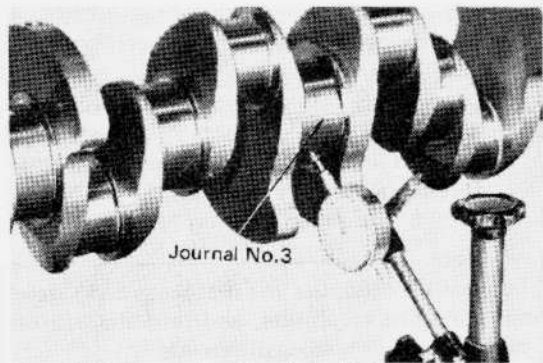


Fig. 2-75 Measuring Crankshaft Bend

2. Inspect the crankpin journals and crankshaft journals for damage, and abnormal wear (out-of-round, tapered), and if defective, grind the crankpin journals and crankshaft journals for correction, or replace.

Tapered limit **0.05mm (0.0020")**

Out-of-round limit **0.02mm (0.0008")**

Caution

When grinding crankshaft journal and pin parts, finish according to the selected bearings as illustrated in Table 2-6 or in Table 2-7.

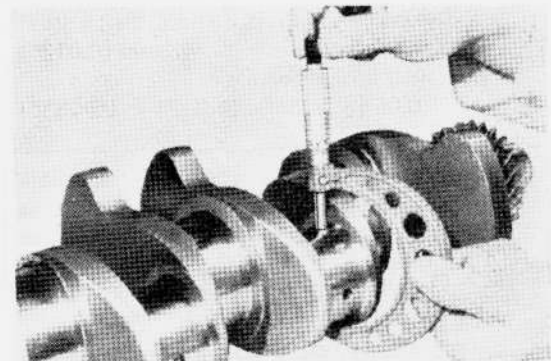


Fig. 2-76 Measuring Taper and Run-out

3. Measure the thrust clearance of crankshaft at crankshaft center bearing part.

Thrust clearance limit **0.3mm (0.012")**

Specified thrust clearance

0.04 to 0.24mm (0.0016 to 0.0095")

Caution

Upon assembling the thrust washer, position the oil groove toward the crankshaft thrust surface (outside).

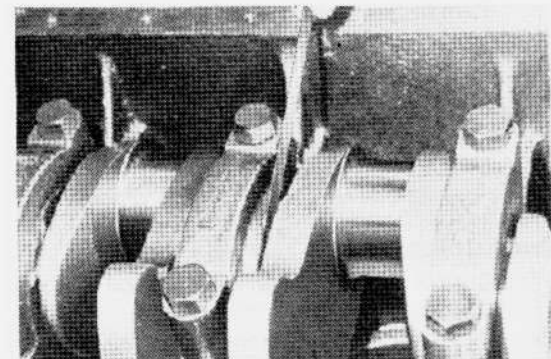


Fig. 2-77 Measuring Crankshaft Thrust Clearance

4. If the crankshaft thrust clearance exceeds the limit, replace the thrust washer with the oversize thrust washer according to the Table 2-8.

Table 2-8 Thrust Washers

Size	Thrust Washer Thickness mm (in)
STD	2.930 to 2.980 (0.1154 to 0.1173)
O/S 0.125	2.993 to 3.043 (0.1173 to 0.1198)
O/S 0.250	3.055 to 3.105 (0.1203 to 0.1222)

Camshaft

1. Inspect the camshaft for bend and the journal parts for damage and wear. Correct or replace if excessively out-of-round, damaged or worn.

Run-out limit 0.03mm (0.0012")

Out-of-round and tapered limit

Less than 0.02mm (0.0008")

Note

To measure bend, use the dial gauge and rotate the shaft one revolution, and read the 1/2 of maximum gauge reading difference.

2. Measure the camshaft thrust clearance, and if it exceeds the limit, replace the camshaft.

Thrust clearance limit 0.3mm (0.012")

Specified thrust clearance

0.06 to 0.13mm (0.0024 to 0.0051")

Caution

When measuring thrust clearance, assemble thrust plate and timing gear to camshaft as illustrated in Fig. 2-79, and tighten the bolt to specified torque.

Tightening torque

300 to 450kg-cm (21.7 to 32.6ft-lb)

3. Measure the cam height of camshaft, and replace if it is less than the limit.

Cam height limit:

Intake 38.92mm (1.5323")

Exhaust 38.91mm (1.5319")

Specified cam height:

Intake 39.467 to 39.557mm
(1.5538 to 1.5574")

Exhaust 39.465 to 39.555mm
(1.5538 to 1.5573")

Camshaft Bearing

1. Inspect the bearing, and replace if poor contact, melting or scored.
2. Measure the oil clearance, and replace if it exceeds the limit.

Oil clearance limit 0.1mm (0.004")

Specified thrust clearance

0.025 to 0.066mm (0.0010 to 0.0026")

Note

To measure the oil clearance, find out the clearance by subtracting the journal outer diameter and bearing inner diameter measurements.

3. If the oil clearance exceeds the limit, finish the camshaft in accordance with Table 2-8, using undersize bearing.
4. To remove the bearings, follow the methods as illustrated in Fig. 2-80.
 - a) Remove the rear side tight plug.

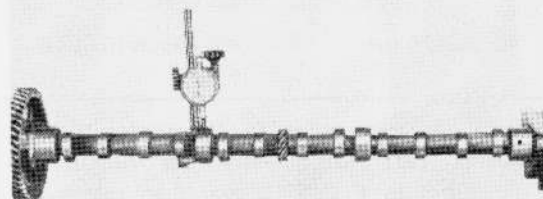


Fig. 2-78 Measuring Camshaft Bend

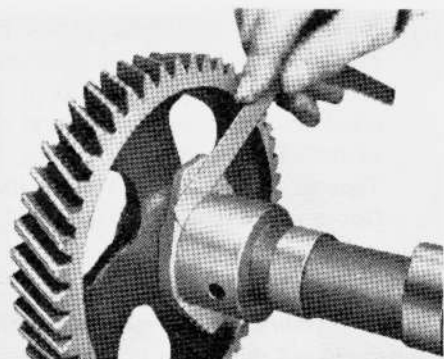


Fig. 2-79 Measuring Camshaft Thrust Clearance

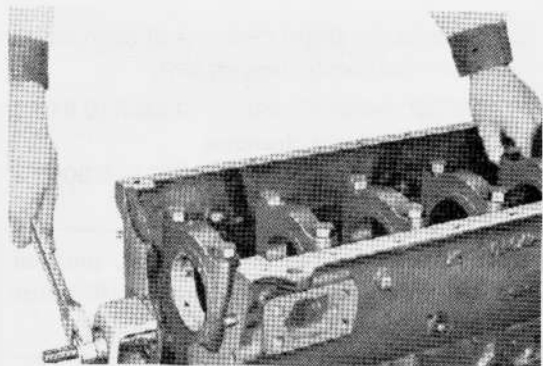


Fig. 2-80 Removing Camshaft Bearing

- b) Remove the camshaft bearing, using Camshaft Bearing Remover and Replacer (suitable tool).
- c) Assemble the undersize camshaft bearing to cylinder block, using the suitable tool.

Note

Mate the oil holes of bearing and cylinder block, and insert one by one carefully.

5. Insert the camshaft into the bearings, and assemble the new tight plug to the block after applying the seal packing.

Table 2-9 Camshaft Journal Outer Diameter Finishing Sizes

Bearing Sizes	Camshaft Journal Outer Diameter Finishing Sizes mm (in)			
	Journal No.1	Journal No.2	Journal No.3	Journal No.4
STD	47.159 to 47.175 (1.8566 to 1.8573)	46.959 to 46.975 (1.8488 to 1.8494)	46.759 to 46.775 (1.8409 to 1.8415)	46.559 to 46.575 (1.8330 to 1.8337)
U/S 0.125	47.025 to 47.035 (1.8514 to 1.8518)	46.825 to 46.835 (1.8435 to 1.8439)	46.625 to 46.635 (1.8356 to 1.8360)	46.425 to 46.435 (1.8278 to 1.8281)
U/S 0.250	46.900 to 46.910 (1.8465 to 1.8468)	46.700 to 46.710 (1.8386 to 1.8390)	46.500 to 46.510 (1.8307 to 1.8311)	46.300 to 46.310 (1.8228 to 1.8232)
U/S 0.500	46.650 to 46.660 (1.8366 to 1.8370)	46.450 to 46.460 (1.8287 to 1.8291)	46.250 to 46.260 (1.8209 to 1.8213)	46.050 to 46.060 (1.8130 to 1.8134)

Camshaft Timing Gear

1. Inspect the gear, and replace if fitting parts and teeth surface are damaged or worn.

2. Backlash

Measure the backlash with crankshaft timing gear, and if the backlash exceeds the limit, remove together with crankshaft timing gear.

Backlash limit **0.3mm (0.012")**

Specified backlash **0.1mm (0.004")**

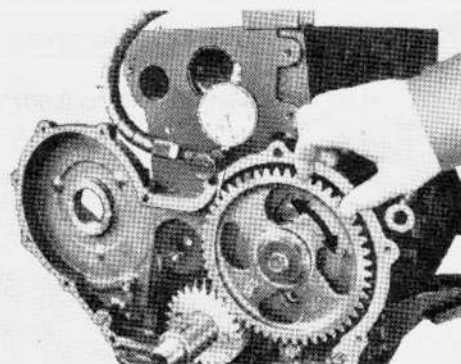


Fig. 2-81 Measuring Camshaft Gear Backlash

3. Camshaft timing gear replacement

- a) Remove the bolts (for timing gear set) and plates.
- b) Support the camshaft at thrust plate position, and remove the gear using a press.

Caution

Take care so that gear key may not damage the thrust plate.

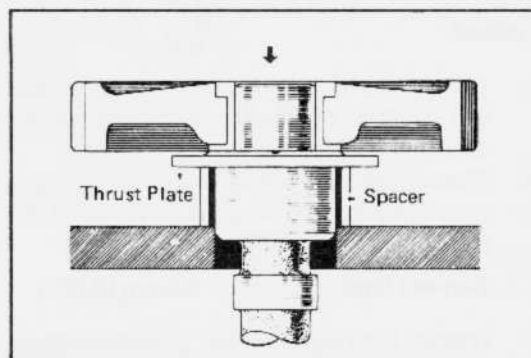


Fig. 2-82 Removing Camshaft Timing Gear

- c) Assembling new thrust plate and key, install by pressing the gear with a press.
- d) Apply engine oil onto the bolt and tighten it.

Tightening torque:

300 to 450kg-cm (21.7 to 32.6ft-lb)

4. Crankshaft timing gear replacement

- a) Remove using SST [09213-60014] using attachment to crankshaft edges.
- b) When installing crankshaft timing gear, use SST [09214-60010] to install with a press.

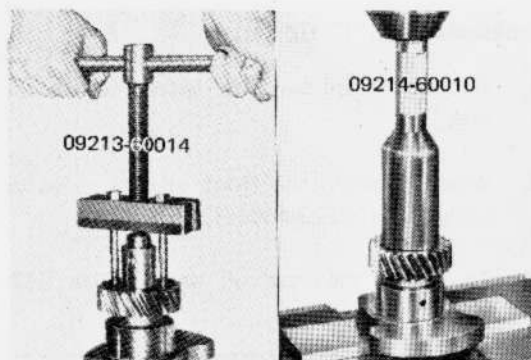


Fig. 2-83 Replacing Crankshaft Timing Gear

Idle Gear

1. Inspect the idle gear and idle gear shaft, and replace if the clearance between the gear and shaft exceeds 0.3mm (0.0118").

Idle gear inner diameter

50.00 to 50.03mm (1.9685 to 1.9697")

Idle gear shaft outer diameter

49.94 to 49.96mm (1.9661 to 1.9669")

Clearance

0.04 to 0.09mm (0.0016 to 0.0035")

2. Measure the backlashes of idle gear and crankshaft timing gear, and if they exceed 0.3mm (0.0118"), replace both gears.

Specified backlash 0.1mm (0.004")

3. Check the idle gear thrust clearance.

Specified clearance:

0.08 to 0.18mm (0.0032 to 0.0071")

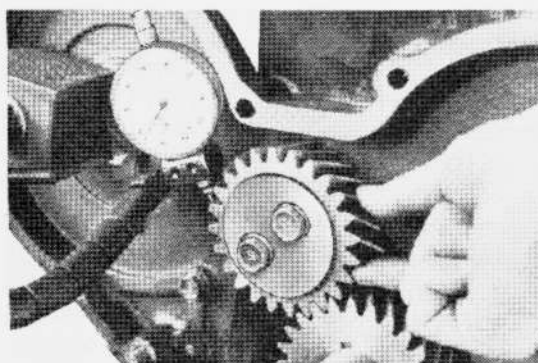


Fig. 2-84 Measuring Idle Gear Backlash

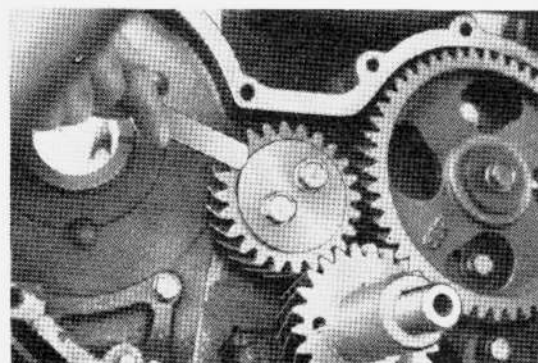


Fig. 2-85 Checking Thrust Clearance

Flywheel

1. Inspect the clutch disc contacting surface, and correct or replace according to the degree of damage and wear.
2. Measure the clutch disc run-out according to contacting surface wear, and replace if the run-out exceeds the limit.

Run-out limit

0.5mm (0.02")

3. Inspect the ring gear, and if it is damaged, cracked or worn, replace the ring gear.

Crankshaft Type "T" Oil Seal

1. Replace the oil seal if oil leaks from the oil seal.
2. When installing the front oil seal, drive in using SST [09223-46010].
3. To install the rear oil seal, utilize SST [09223-56010].



Fig. 2-86 Assembling Crankshaft Front Oil Seal



Fig. 2-87 Assembling Crankshaft Rear Oil Seal

ASSEMBLY

Caution

1. The assembling parts should be thoroughly cleaned.
2. Apply new engine oil upon assembly to the sliding and rotation parts.
3. Always replace the gaskets and "O" rings with new parts.
4. To prevent water and oil leakages, always apply liquid packing
5. Assemble while checking oil clearance and thrust clearances.
6. Do not mistake each of the installing bolts, nuts and washers, and tighten the bolts and nuts to the specified torques. Especially, do not tighten aluminium alloy parts too much.
7. If marks have been stamped during disassembly, follow those marks for assembling, and make sure not to make a mistake when mating the parts such as bearings and pistons, of which the combinations due to clearances are specified

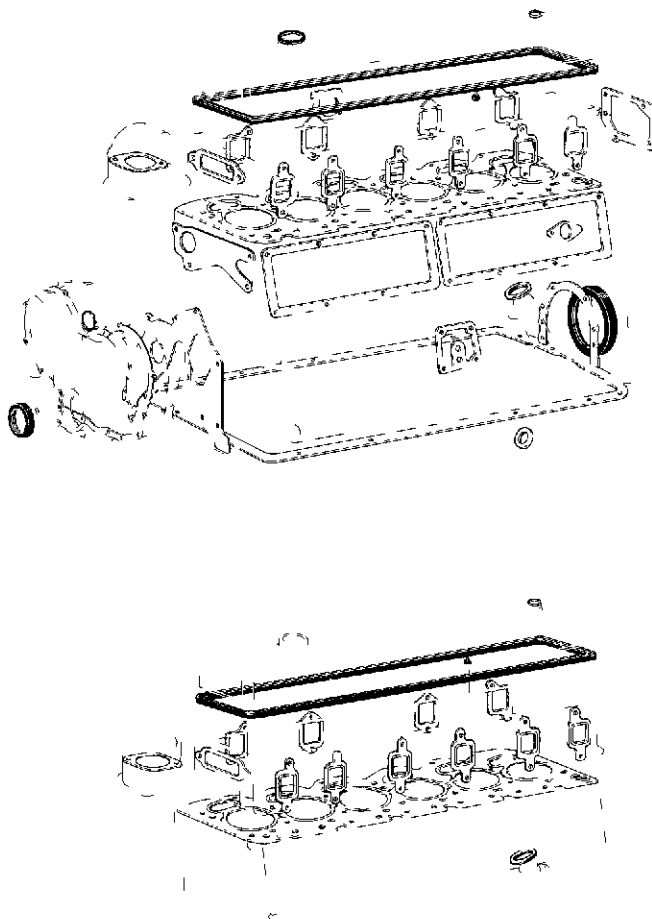


Fig 2 88 Engine Overhaul Gasket Kit Components

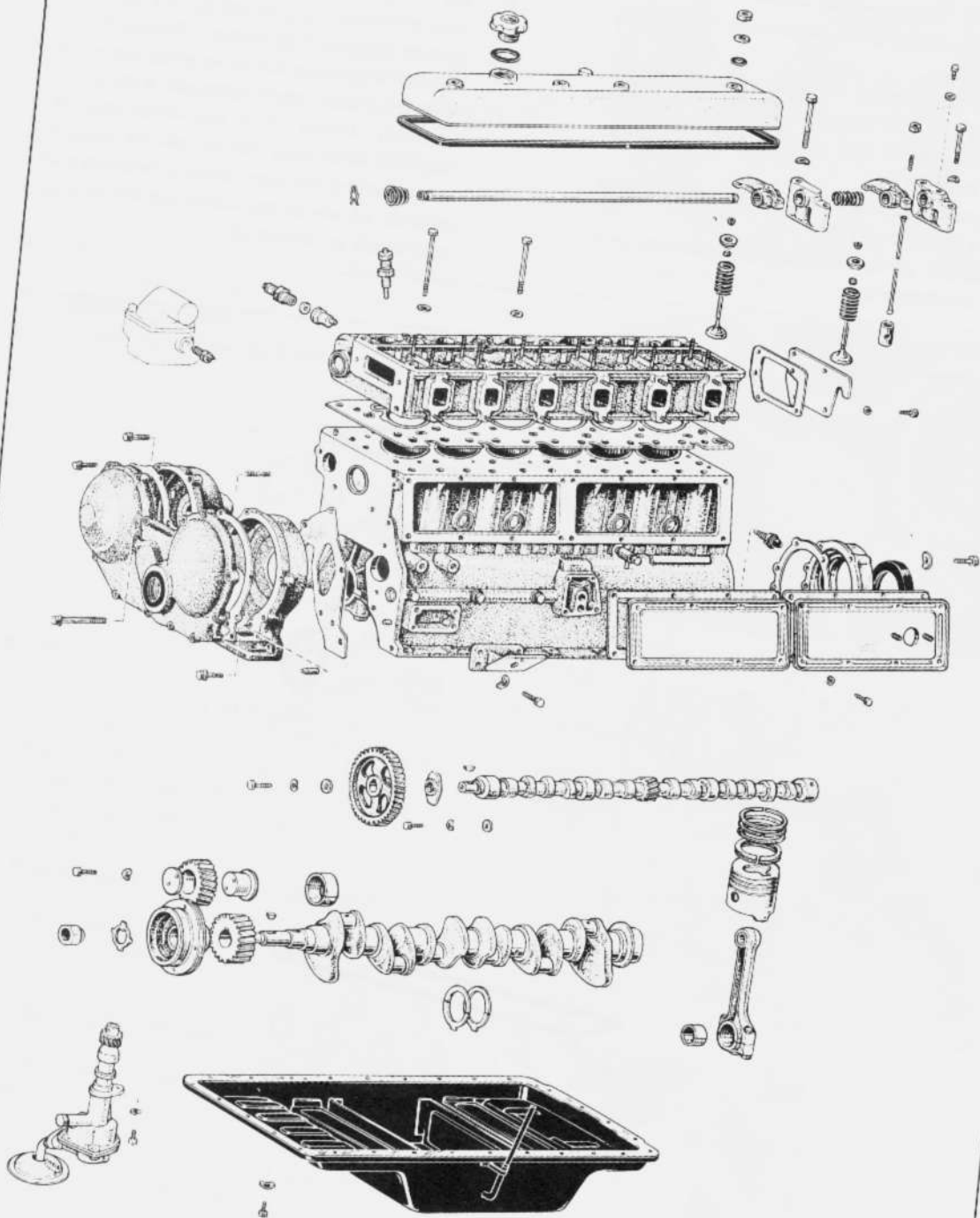


Fig. 2-89 Partial Engine Assembly Components

Assembling Piston Components

Caution

When assembling the connecting rod to the piston, the notch in the top of piston and the ↑ mark in the middle of connecting rod must be on the same side as illustrated

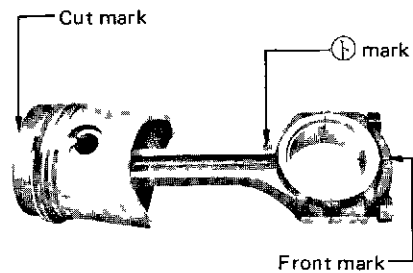


Fig. 2-90 Piston and Connecting Rod Mating Marks

- 1 Warm the piston to 50 to 60°C (122 to 140°F) using a piston heater and assemble the piston and connecting rod to piston pin using SST [09221-46010]

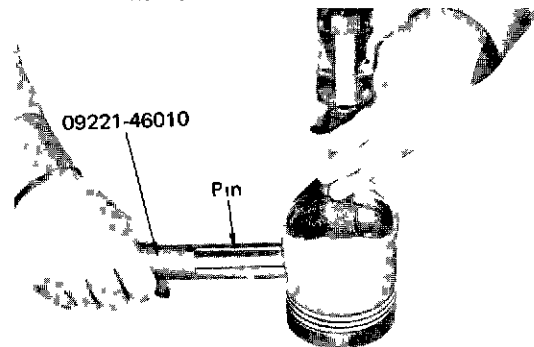


Fig. 2-91 Assembling Piston Pin

- 2 Install the hole snap ring

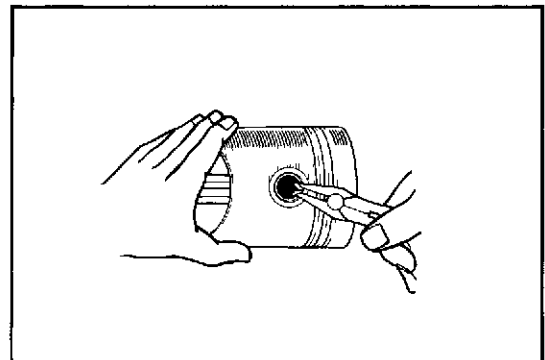


Fig. 2-92 Assembling Snap Ring

Assemble the piston ring as illustrated in Fig 2-93 to 95.

Caution

The piston ring has marks and assembling numbers on its surface, and assembles in the order of steel wire, oil ring, No. 2, 1, facing these marks upward.

- 4 Clean the connecting rod bearing installing surface and temporarily assemble the bearing

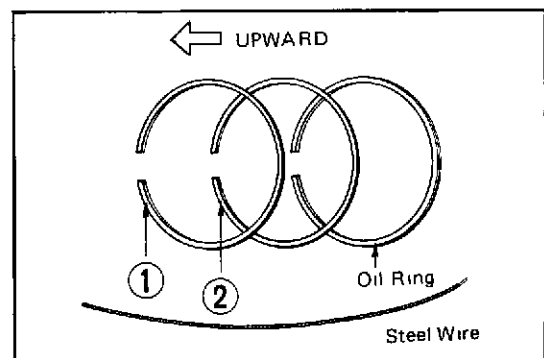


Fig. 2-93 Piston Ring Up & Downward Direction

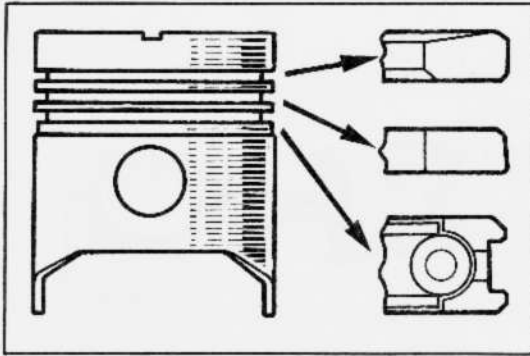


Fig. 2-94 Piston Ring Cross Section

Assembling Cylinder Head Components

1. Apply engine oil onto the valve stem.
2. Insert the valve (1) into the cylinder head.
3. Assemble valve stem oil seal (2) from the opposite side.

Note

1. Longer seal is for intake valve.
2. After taping on the stem end, assemble the oil seal the prevent damage.

4. Install in the following order spring (3), spring retainer (4), and use SST [09202-43011] to assemble spring retainer lock (5).

5. Install the combustion chambers on the head.

Note

Align the dowel pin against the slot and install by tapping in lightly with a wooden mallet.

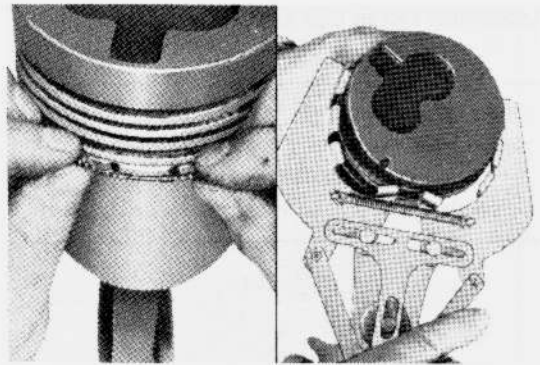


Fig. 2-95 Assembling Ring

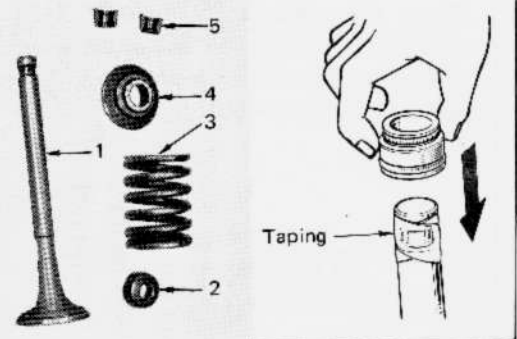


Fig. 2-96 Assembling Valve Parts

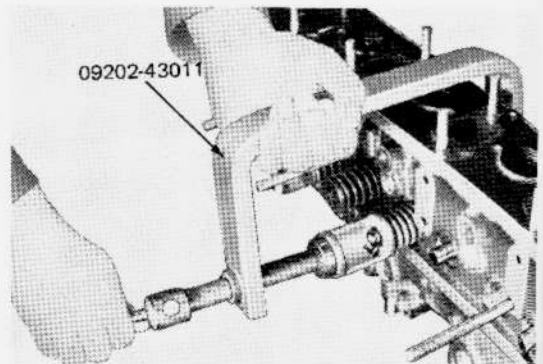


Fig. 2-97 Assembling Spring Retainer Lock

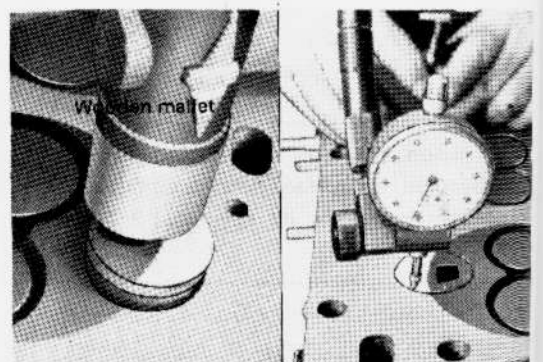


Fig. 2-98 Installing Chamber

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Amount of protrusion	0 to 0.1 mm (0 to 0.004")
Tightening allowance	0.01 to 0.06 mm (0.004" to 0.0024")

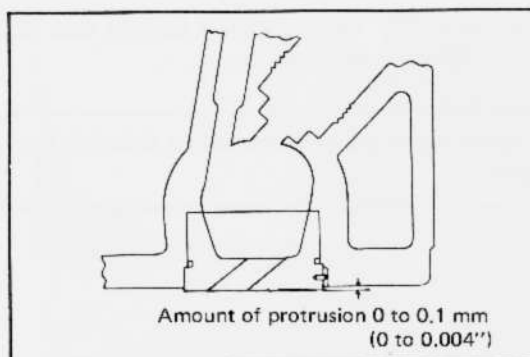


Fig. 2-99 Installing Combustion Chamber

Assembling Valve Rocker Shaft Components

1. Insert valve rocker support (1) from the rear side of valve rocker shaft, and fitting to the shaft hole, fix with bolt (2).
2. Insert in the following order valve rocker arm, tension spring from the back side of valve rocker shaft, and prevent them from slipping-off with a spring retainer.
3. Insert in the following order: valve rocker arm, compression spring, valve rocker arm, valve rocker support from the front side of valve rocker shaft, install tension spring and secure with a spring retainer.

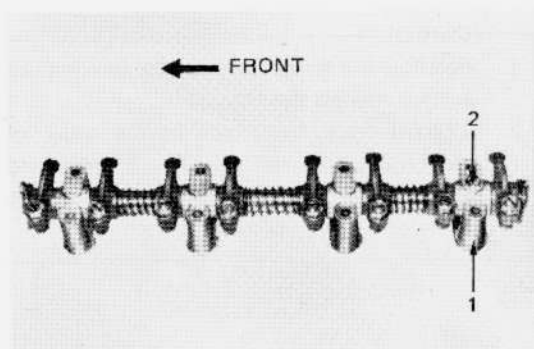


Fig. 2-100 Assembling Valve Rocker

Assembling Engine Interior Components

1. Assemble crankshaft bearings onto cylinder block and onto bearing caps.

Caution

1. Assemble after cleaning the bearings and bearing installing parts thoroughly.
2. Apply engine oil onto the bearings.

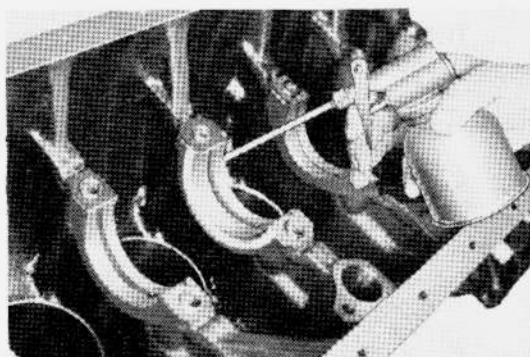


Fig. 2-101 Applying Engine Oil

2. Install crankshaft onto the cylinder block.
3. Assemble the crankshaft upper thrust washer.

Caution

When assembling, the washer oil groove should face toward the crankshaft thrust surface.

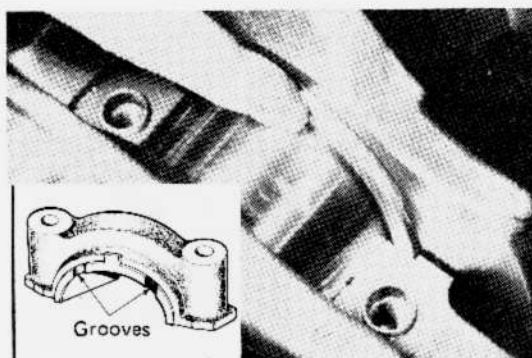


Fig. 2-102 Installing Thrust Washer

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4. Assemble the crankshaft bearing cap, and tighten to specified torque.

Note

Apply engine oil onto the bolt as shown in Fig. 2-103.

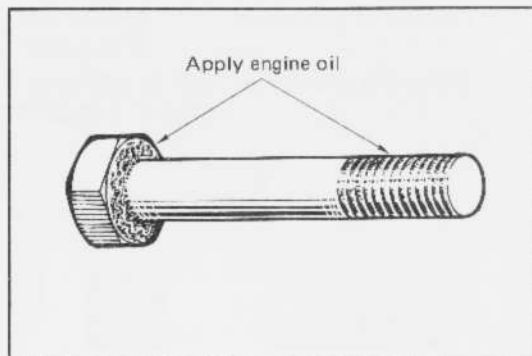


Fig. 2-103 Cap Bolt

Caution

1. Position the arrow mark on the bearing cap surface toward the front side.
2. Tighten from front side in the order of No.4,5,3,6,2,7, and 1 in 2 to 3 times, and at the same time, rotate the crankshaft to check the tightness while tightening.

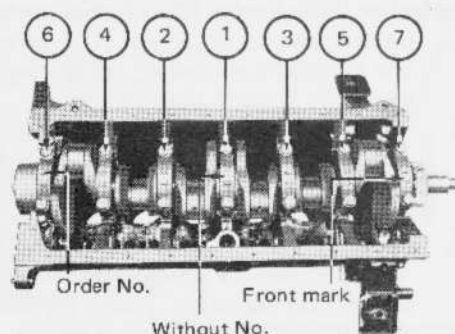


Fig. 2-104 Tightening Order

Tightening torque:

980 to 1120 kg-cm (70.9 to 81.0 ft-lb)

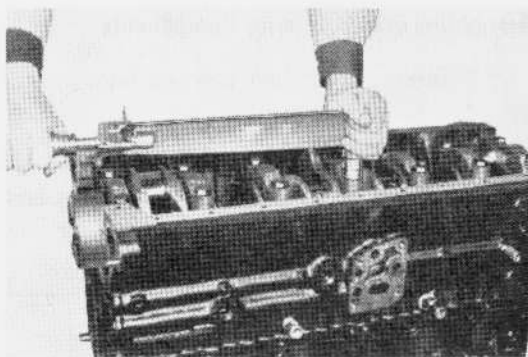


Fig. 2-105 Tightening Bolts

5. Install the rear oil seal retainer over the gasket.

Tightening torque:

150 to 220 kg-cm (10.9 to 15.9 ft-lb)

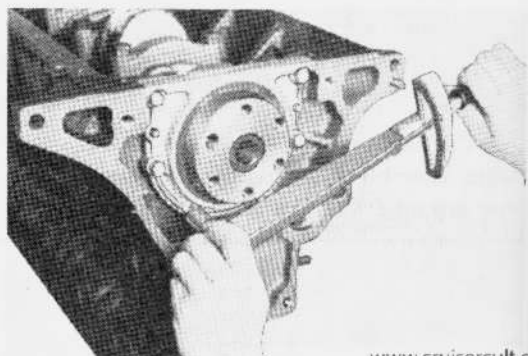


Fig. 2-106 Installing Retainer

6. Install the fly-wheel housing and fly-wheel.
Tightening torque (fly-wheel):
 1150 to 1250 kg-cm (83.2 to 90.4 ft-lb)

Note

Apply engine oil onto the threads of bolts.

7. Install the cylinder block onto the engine stand.

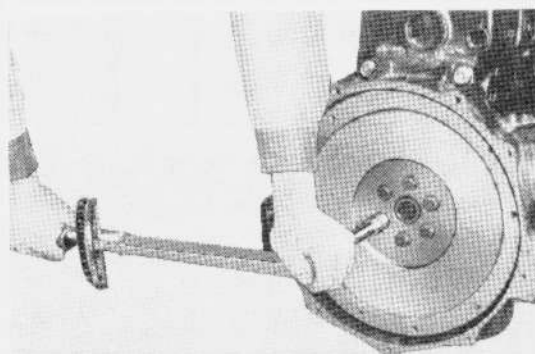


Fig. 2-107 Installing Fly-wheel

8. Apply engine oil onto the piston, inner surface of cylinder, crank pin, connecting rod bearings, connecting rod bolts and nuts. (Fig. 2-108, 2-109.)

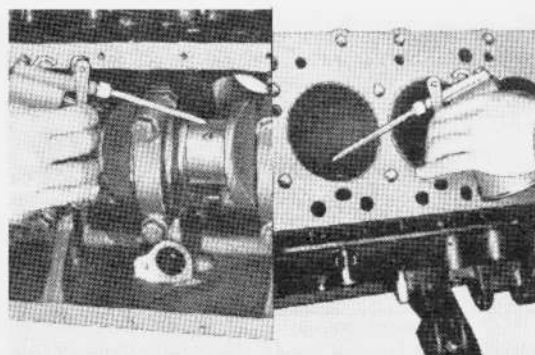


Fig. 2-108 Applying Engine Oil

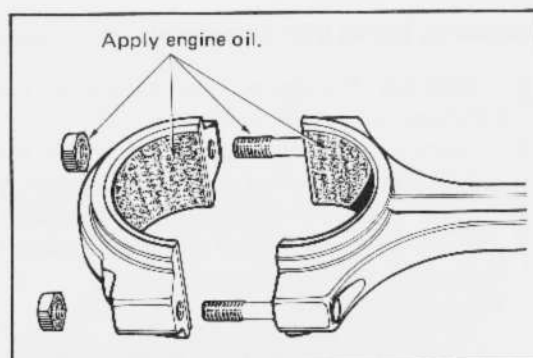


Fig. 2-109 Applying Engine Oil

9. Insert the piston into the cylinder block using a piston ring compressor.

Caution

1. Position the piston ring ends as illustrated in Fig. 2-110.
2. Position the piston head cut toward the front side of the engine.
3. Insert the cylinder number mark on the top of the piston, fitting it into the cylinder.

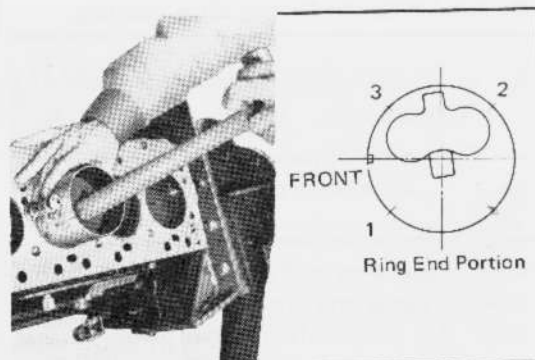


Fig. 2-110 Installing Piston

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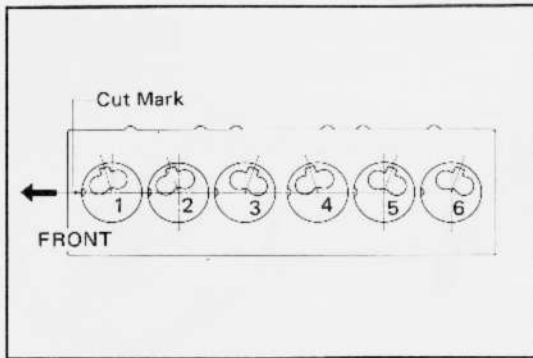


Fig. 2-111 Piston Assembly Locations

10. Assemble the connecting rod bearing cap, and tighten the hexagon nut to specified torque.

Tightening torque

650 to 750 kg-cm (47.0 to 54.3 ft-lb)

Caution

The mating marks stamped on connecting rod and cap should match.

11. Install the oil pump onto the cylinder block.

Assembling Timing Gear Components

1. Assemble the timing gear case onto the cylinder block with the gasket.
2. Insert camshaft with gear attached, to the cylinder block so that the timing gear mating marks ("O") of crankshaft and camshaft match each other, and then fix the camshaft thrust plate with the installing bolts.

Tightening torque

150 to 220 kg-cm (10.9 to 15.9 ft-lb)

Caution

Do not damage the bearing when inserting.

3. Install the oil pan with the gasket onto the cylinder block.

Tightening torque:

35 to 65 kg-cm (30 to 56 in-lb)

Caution

When assembling, apply liquid sealer onto the cylinder block and timing gear case and also onto the crankshaft rear oil seal retainer connection.

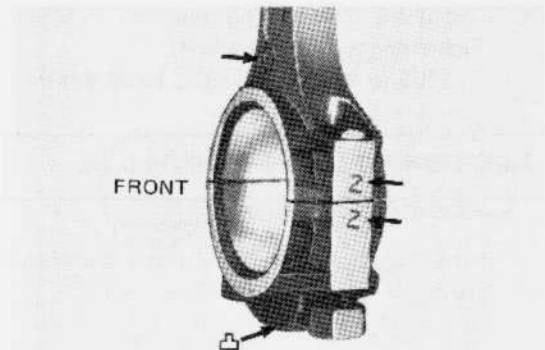


Fig. 2-112 Cap direction

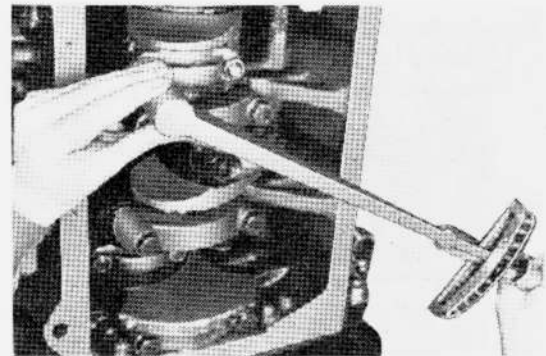


Fig. 2-113 Tightening Cap

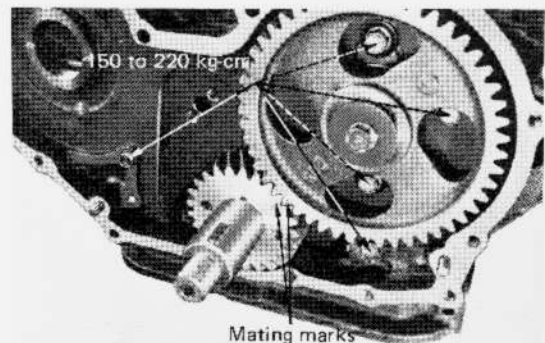


Fig. 2-114 Crankshaft Gear & Camshaft Gear Mating Marks

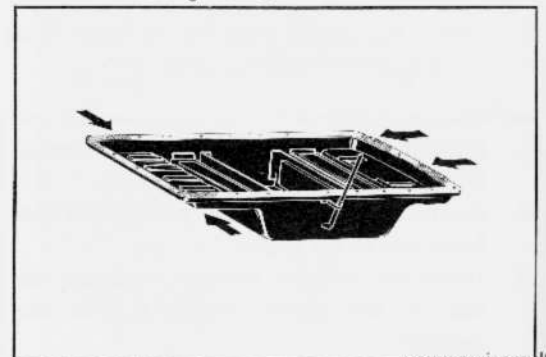


Fig. 2-115 Sealer Applying Portion

Assembling Engine Upper Components

1. Install the cylinder head with the cylinder head gasket.

Tightening torque

1280 to 1420 kg-cm (92.6 to 102.7 ft-lb)

Caution

1. When mounting cylinder head over cylinder block, do not damage the cylinder head lower surface with straight pin.
 2. When tightening cylinder head bolts, tighten in specified order and in 3 to 4 times, and then finally to the specified torque.
2. Apply engine oil onto the valve lifters and push rod ends, insert the valve lifters and push rods into the cylinder block.

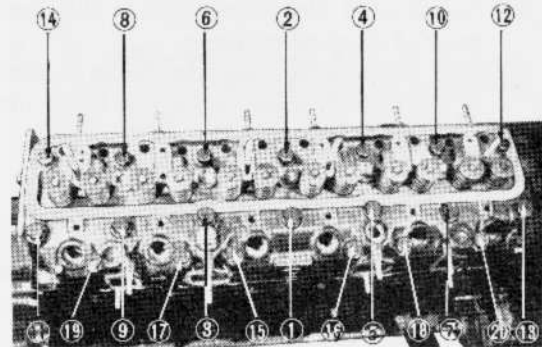


Fig. 2-116 Tightening Order

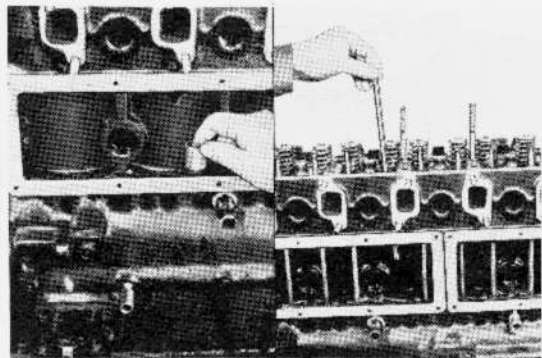


Fig. 2-117 Installing Lifter & Push Rod

3. Install the valve rocker shaft assembly.
 - a) Loosening the adjusting screw lock nut loosen the adjusting screw about 2 revolutions.
 - b) Tighten the rocker support installing bolts and nuts.

Caution

When tightening rocker supports bolts and nuts, tighten in specified order and in 3 to 4 times, and then finally to the specified torque.

Tightening torque:

150 to 220 kg-cm (10.9 to 15.9 ft-lb)

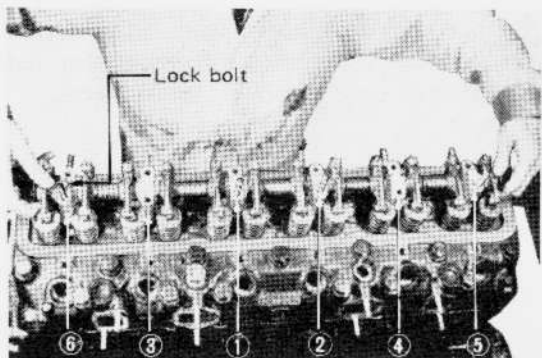


Fig. 2-118 Installing Rocker Shaft and Tightening Order

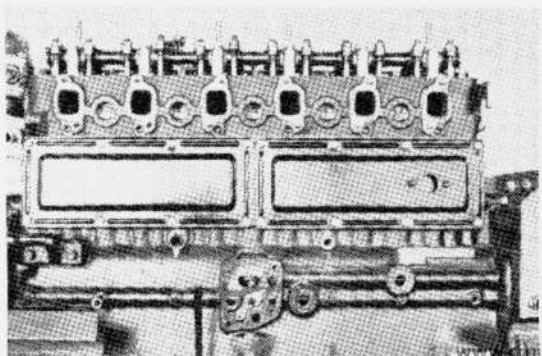


Fig. 2-119 Installed Push Rod Cover

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5. Adjust valve clearances, using a thickness gauge of specified thickness.

- a) Position No.1 cylinder piston at TDC of compression stroke, and adjust the following valve clearances.

Counting from engine front side

No. 1, 2, 3, 5, 7, 9

- b) Rotate the crankshaft one revolution in the direction of rotation, and adjust the following valve clearances.

Counting from engine front side

No. 4, 6, 8, 10, 11, 12

Valve clearances:

Intake	0.20 mm (0.008")
Exhaust	0.36 mm (0.014")

Note

After installing engine onto vehicle, valve clearance must be readjusted in warmed up engine condition.
(75 to 85°C or 167 to 185°F Temp.)

6. Install glow plugs and glow plug connectors, fix the connector with connecting nuts through plate washer and spring washer.

7. Insert the gasket (1) and seal (2) into the nozzle hole, install the injection nozzle holder assembly (3) onto the cylinder head. SST [09268-46011]

Tightening torque:

600 to 800 kg-cm (43.4 to 57.9 ft-lb)

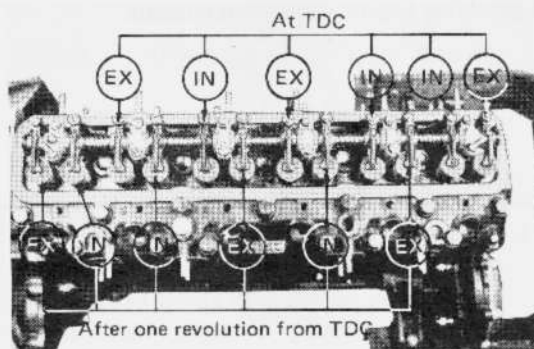


Fig. 2-120 Valve Arrangement

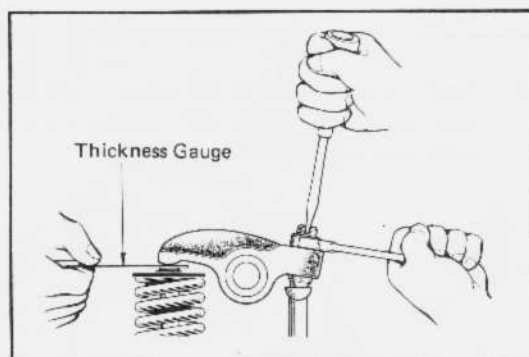


Fig. 2-121 Adjusting Valve Clearance

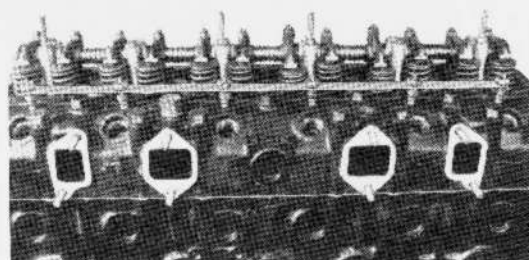


Fig. 2-122 Installing Glow Plug

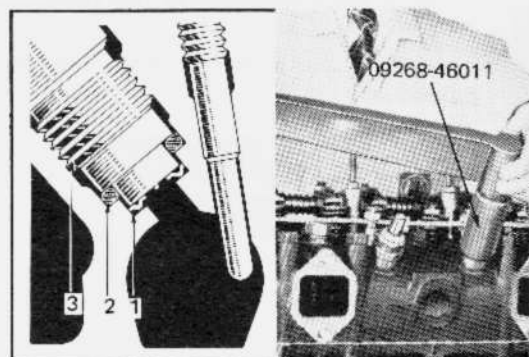


Fig. 2-123 Installing Nozzle Holder

8. Install the nozzle linkage pipe (1) over the packing ring (2) and gaskets.
9. Install the water union (3).
10. Assemble the intake manifold (4) with venturi attached through the gasket.

Tightening torque:

150 to 220 kg-cm (10.9 to 15.9 ft-lb)

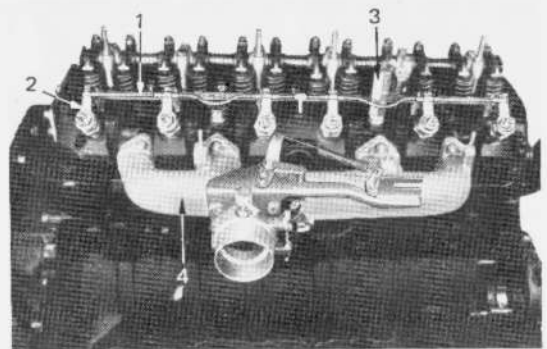


Fig. 2-124 Installing Intake Manifold

Assembling Engine Right and Front Side Components

1. Install the over injection magnet (1) and starter (2).

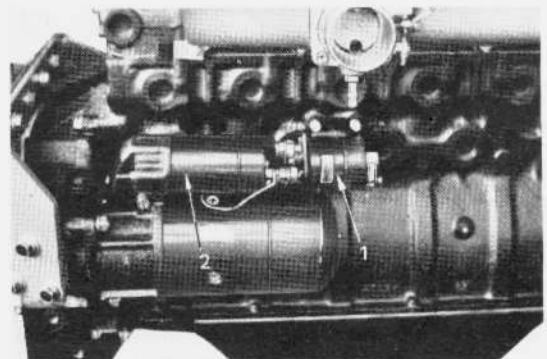


Fig. 2-125 Installing Magnet & Starter

2. Install the injection pump.
 - (1) Set the mating marks of injection pump spline shaft and flange.
 - (2) Removing injection pump rear cover, use cover installing bolt hole and camshaft key groove to install SST [09284-46010], and then stop the pump spline shaft by turning.

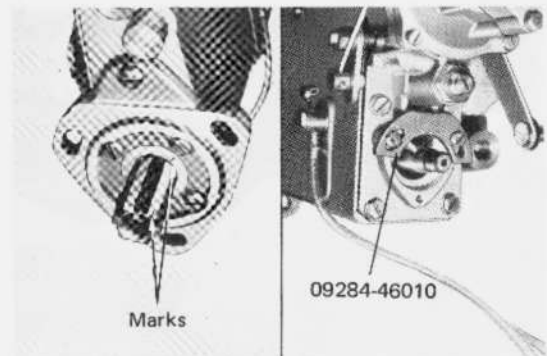


Fig. 2-126 Setting Camshaft

- (3) Install the injection pump to the engine temporarily, matching the marks of pump hub to engine.

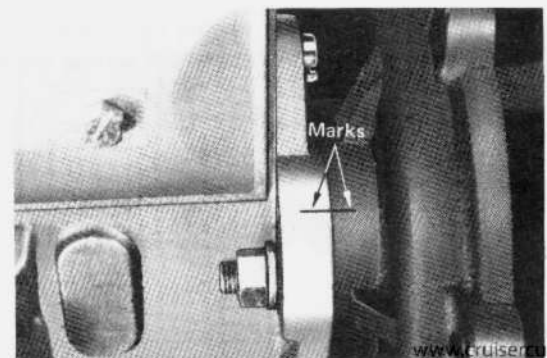


Fig. 2-127 Installing Pump

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3. Match the mating marks ("O") on the crankshaft gear and camshaft gear.
4. Install the idle gear shaft,

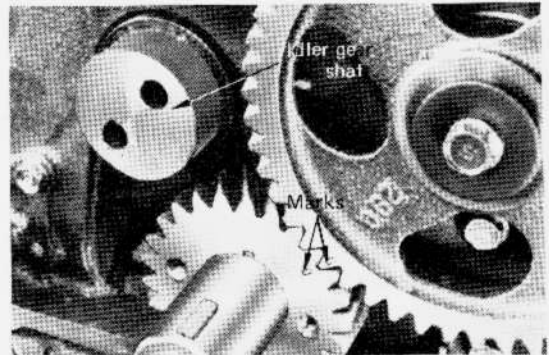


Fig. 2-128 Installing Idle Gear Shaft

5. Apply engine oil onto the idle gear shaft, install the idle gear onto the shaft with thrust plate, matching the marks ("1") on the crankshaft gear and idle gear.

Tightening torque:

300 to 450 kg-cm (21.7 to 32.6 ft-lb)

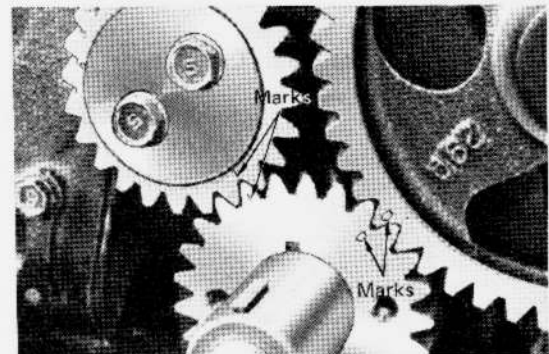


Fig. 2-129 Installing Idle Gear

6. Matching the marks on the spline shaft and timer hub, and also marks ("2") on the idle gear and timer gear, install the timer onto the spline shaft.
7. Remove the SST [09284-46010], and install the camshaft cover.

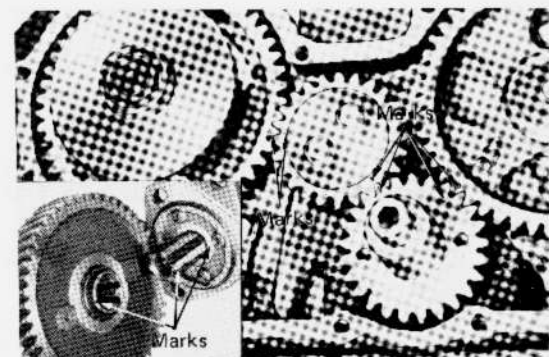


Fig. 2-130 Installing Timer

8. Recheck the marks on the pump hub and engine, and tighten the pump setting bolts firmly.
9. Install the woodruff key onto the crankshaft.

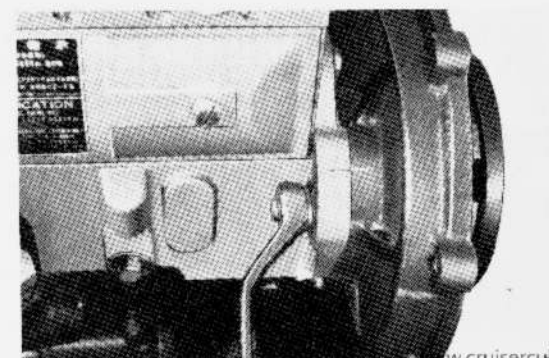


Fig. 2-131 Retighten Pump

10. Heating the timing gear cover with heater to 60°C (140°F), install the timing gear cover through the new gasket.

Note

1. Coat MP Grease thoroughly on timer hub bearings and drive gear spline.
2. Apply liquid sealer onto both sides of new gasket.

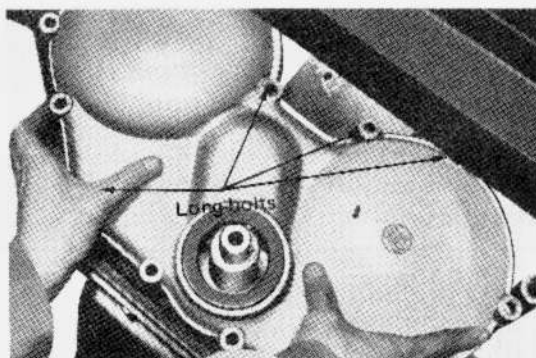


Fig. 2-132 Installing Timing Gear Cover

11. Apply MP grease onto the lips of crankshaft oil seal.
12. Drive in the pulley onto the crankshaft using SST [09214-60010].

Caution

Drive in by fitting the crankshaft key and pulley side key groove.

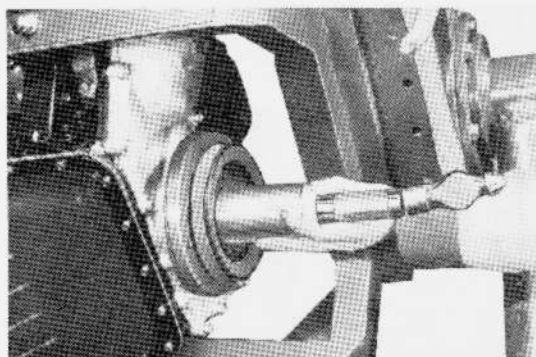


Fig. 2-133 Driving Crankshaft Pulley

13. After tightening the pulley with nuts through crankshaft pulley lock, calk at pulley lock. (Nut side 46mm)

Tightening Torque:

1600 to 2000 kg-cm (115.7 to 144.7 ft-lb)



Fig. 2-134 Calking Pulley Lock

14. Connect the over-injection wire. Adjust the lever length by setting the mating marks, lock the wire.

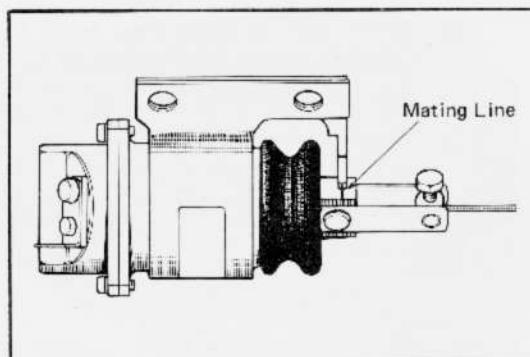


Fig. 2-135 Matching Marks

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15. Install the following parts in numerical order.

- (1) Over-flow pipe and hose
- (2) Connecting rod

Note

Assemble the rod where it can be naturally installed so that the idling rpm may not vary.

- (3) Hoses
- (4) Engine hanger
- (5) Fuel filter
- (6) Fuel pipes

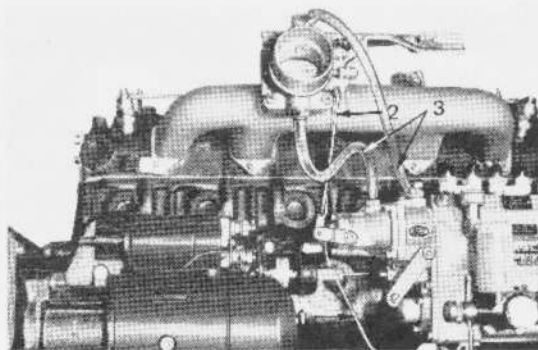


Fig. 2-136 Installing RH Parts

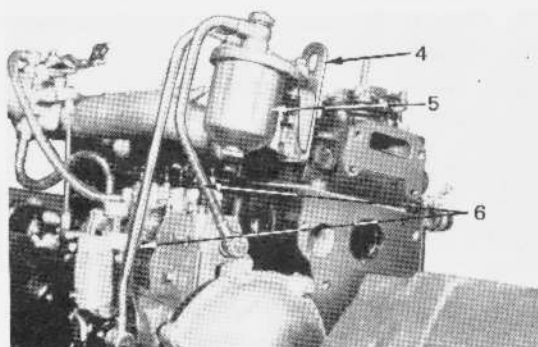


Fig. 2-137 Installing Fuel Filter

16. Adjust the injection timing

- (1) Supply fuel to the fuel pump and, operating the priming pump, evacuate air from fuel filter and pump.

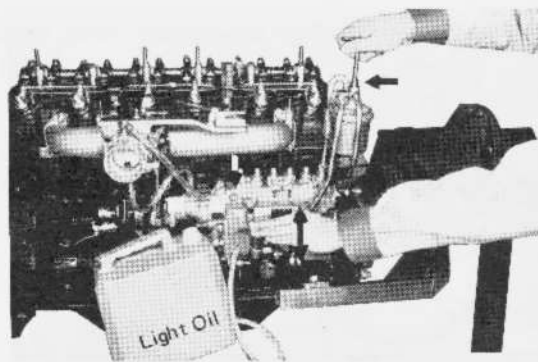


Fig. 2-138 Evacuating Air

- (2) Install the checking pipe (used for injection timing check) onto the No.1 delivery valve holder.

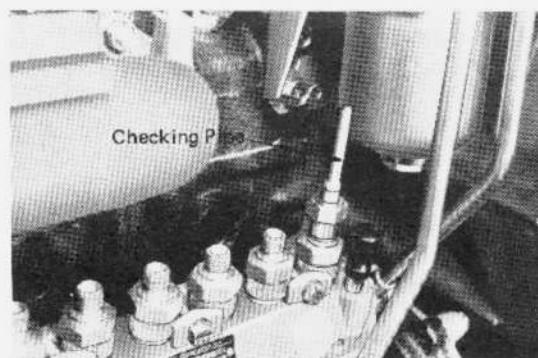


Fig. 2-139 Setting Checking Pipe

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- (3) Crank the engine at crankshaft pulley portion till the fuel appears at the end of the pipe.

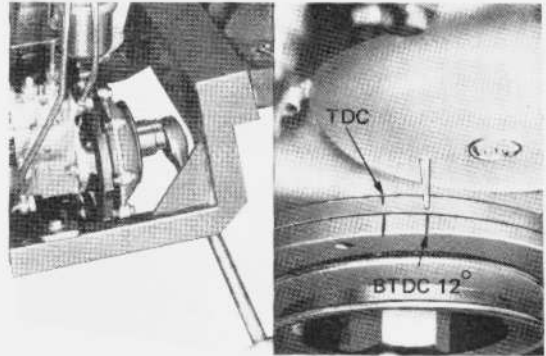


Fig. 2-140 Cranking Crankshaft

- (4) Gently crank the engine and adjust the injection pump body by tilting left and right so that oil surface rising start time in the test pipe comes to the position 12° before the top dead center.

Note

1. If pump is rotated in the direction of crankshaft rotation, injection timing will be retarded.
2. Adjustment of injection timing by means of a test pipe should be repeated 3 to 4 times to prevent error.

- (5) Remove the checking pipe and fuel hose with tank for supplying.

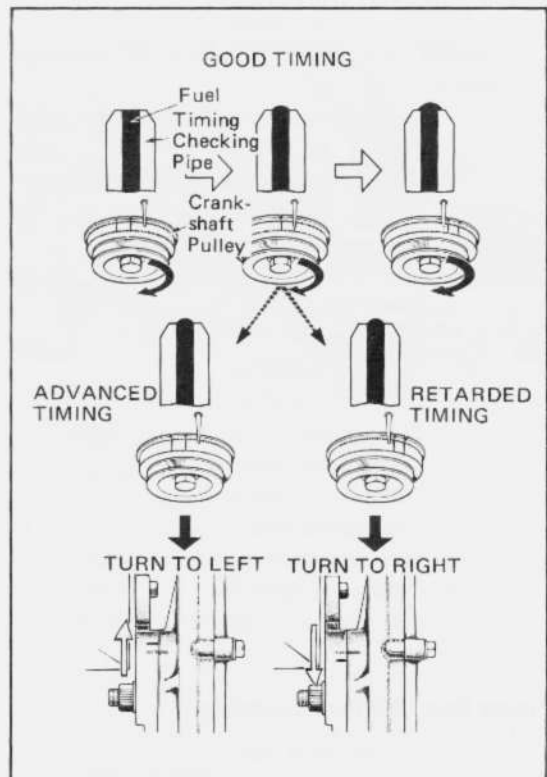


Fig. 2-141 Checking & Adjusting Injection Timing

17. Install the injection pipes and clamps.

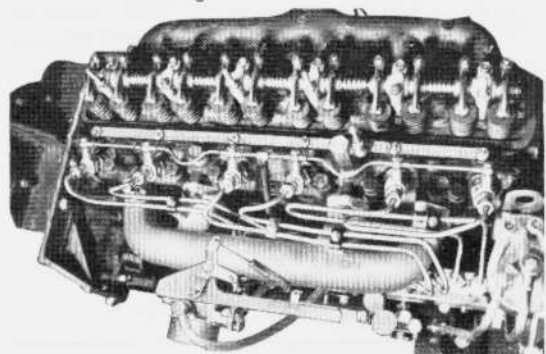


Fig. 2-142 Installing Pipes

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18. Install the water pump (1) over a gasket, by-pass hose (2) and water outlet (3) w/thermostat over a gasket.

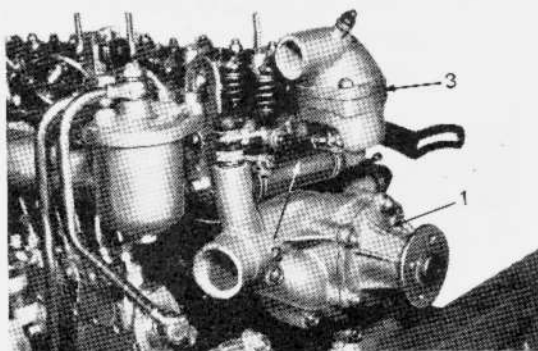


Fig. 2-143 Installing Water Pump

Engine Left Side Parts Assembly

1. Install the following parts in numerical order.

- (1) Exhaust manifold w/gaskets and water pipe

Tightening torque:

150 to 220 kg-cm

(10.9 to 15.9 ft-lb)

- (2) Oil cooler w/"O" ring and gasket (Only for RU)
- (3) Water hose
- (4) Oil filter w/gasket
- (5) Alternator and adjusting lever
- (6) Water pump pulley and fan belt
- (7) Oil hoses w/gaskets
- (8) Oil pressure sender gauge
- (9) Ventilation tube
- (10) Water drain plug
- (11) Oil level gauge
- (12) Valve rocker cover

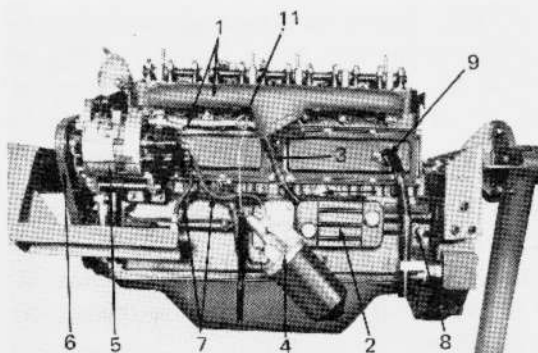


Fig. 2-144 Installing LH Parts

Engine Rear Side Parts Assembly

1. Install clutch cover assembly.
 - a) Install clutch disc and cover by using SST [09301-55022].
 - b) Tighten 6 pieces of cover installing bolts to specified torque, and take out the above Guide Tool.

Tightening torque:

150 to 220 kg-cm

(10.9 to 15.9 ft-lb)

- c) Adjust clutch pressure lever height by using SST [09302-25010].

Specified height:

HU ... 16.2 mm (0.638")

HJ ... 14.2 mm (0.559")

Caution

Be sure to tighten the lock nuts after adjustment.

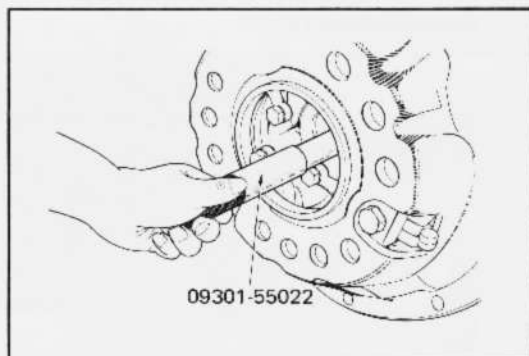


Fig. 2-145 Installing Clutch

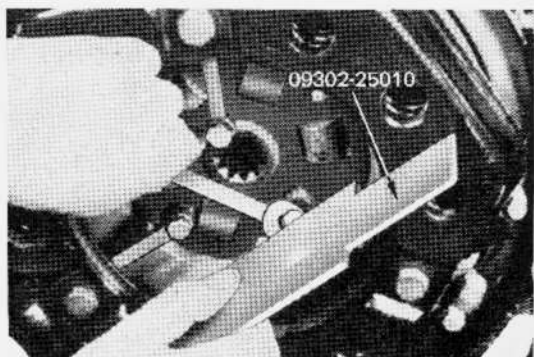


Fig. 2-146 Adjusting Clutch Pressure Lever

Inspection and Starting After Installing Engine

1. After installing the engine to the vehicle, install each part and wirings, and fill in cooling water and engine oil.

Caution

Always use diesel engine oil

Table 2-10 Capacities of Oil

	HU liters (US qt. Imp. qt.)	HJ liters (US qt. Imp. qt.)
Cooling water	17.3 (18.3, 15.2)	12.5 (13.2, 11.0)
Total oil	9.1 (9.6, 8.0)	8.6 (9.1, 7.6)
Injection pump housing oil	150cc (9.2cu.in.)	150cc (9.2cu.in.)
Mechanical Governor oil	170cc (10.4cu.in.)	—
Diaphragm oil	—	2 to 4 Drops

2. Using the fuel pump priming pump (1), bleed the fuel system to remove air from fuel hoses, fuel filter (2), and injection pump (3).
3. Loosen the injection pipe nuts (at all nozzle holders), depress the accelerator pedal fully, switch on the starter, and check the operation of over-injection magnet by cranking the engine until fuel starts to come out from the injection pipes.
4. Tighten the injection pipe nuts (at all nozzle holders).
5. Check whether or not the glow plug controller glows 25 to 30 seconds after the starter switch is turned on glow.
6. Start the engine and check as noted below. If any defect appears, stop the engine immediately.

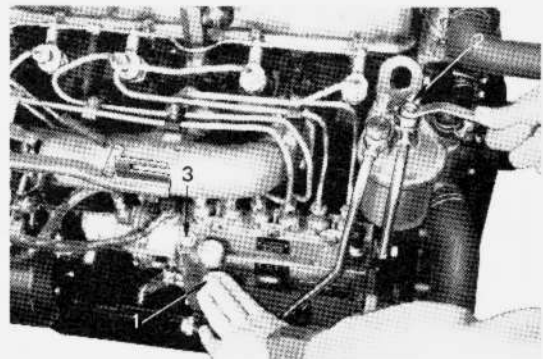


Fig. 2-147 Air Evacuating Locations

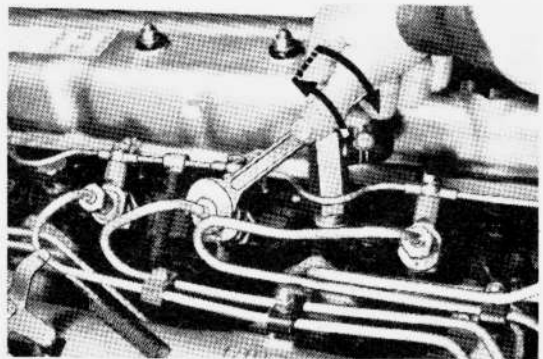


Fig. 2-148 Air Bleeding Injection Pipes

Note

1. Set the engine revolution at around 1,000 rpm.
 2. Check for water and oil leakages.
 3. Check the oil pressure and charging state.
 4. Check for abnormal or knocking noise inside the engine.
7. Warm up the engine until cooling water temperatures reach 75 to 85°C (167 to 185°F) and adjust the valve clearances.

Valve clearance:

Intake	0.20 mm (0.008")
Exhaust	0.36 mm (0.014")

FUEL SYSTEM

General	3-2
Fuel Feed Pump	3-3
Fuel Filter	3-6
Nozzle & Nozzle Holder	3-7
Automatic Timer	3-11
Injection Pump	3-15
Mechanical Governor (RU Type)	3-50



GENERAL

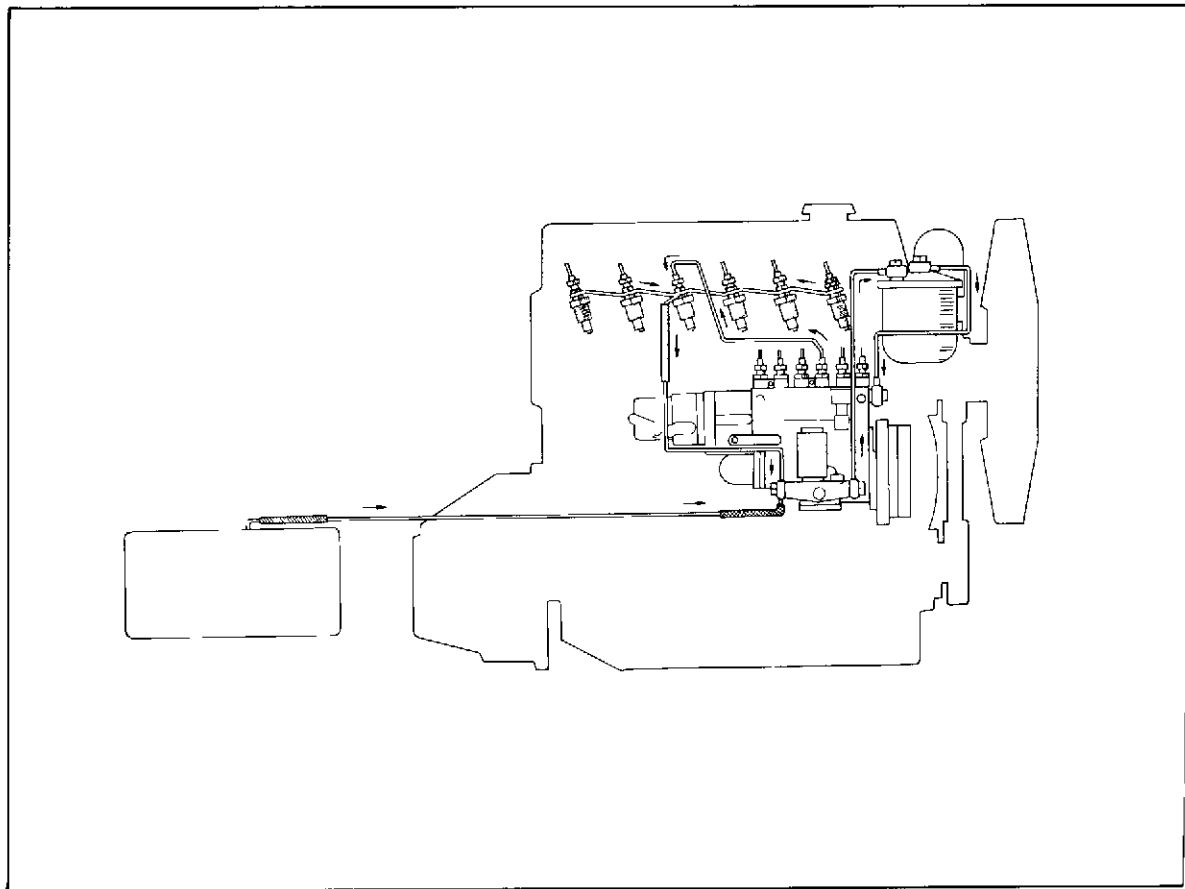


Fig 3.1 Fuel System

The fuel system of the diesel engine is manufactured to extremely high precision to make it capable of maintaining adequate performance under high pressure. If by chance any minute particle of dirt or water should enter in the fuel, the longevity of the most important parts of the diesel engine – the injection pump and injection nozzles – could be extremely shortened. Thus diesel fuel must be sufficiently filtered and cleaned, and for this purpose, a fuel strainer of high filtering performance is equipped on the

engine. Of course, the fuel filled in the fuel tank must also be clean. The fuel in the fuel tank is drawn out by the fuel feed pump and passes through the pump filter located just in front of the feed pump. It then passes through the fuel pump and fuel filter and enters the injection pump for injection into the combustion chambers through the injection nozzles.

The fuel that leaks out from the nozzles passes through the leakage pipe and returns to the feed pump inlet.

FUEL FEED PUMP

DESCRIPTION

The fuel feed pump is made up of the feed pump and priming pump. The feed pump is driven by the injection pump camshaft while the priming pump is operated by hand.

Sufficient fuel must always be kept in the injection pump fuel chamber making it necessary to feed the fuel to the injection pump under pressure since the pump element is not capable of supplying sufficient fuel at high speed. Therefore, the discharge pressure is regulated at from 1.8 to 2.2 kg/cm^2 (26.6 to 31.1 psi) by the piston spring. The priming pump is used to bleed the fuel system for air removal.

The priming pump is operated by unlocking the knob at pump top (by turning it counter-clockwise) and then moving it up and down. After

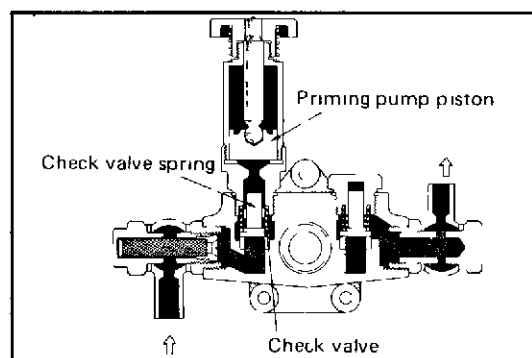


Fig. 3-2 Fuel Feed Pump Construction

using the priming pump, the knob must be locked (by turning it clockwise). Failure to lock the knob might cause the feed pump to leak.

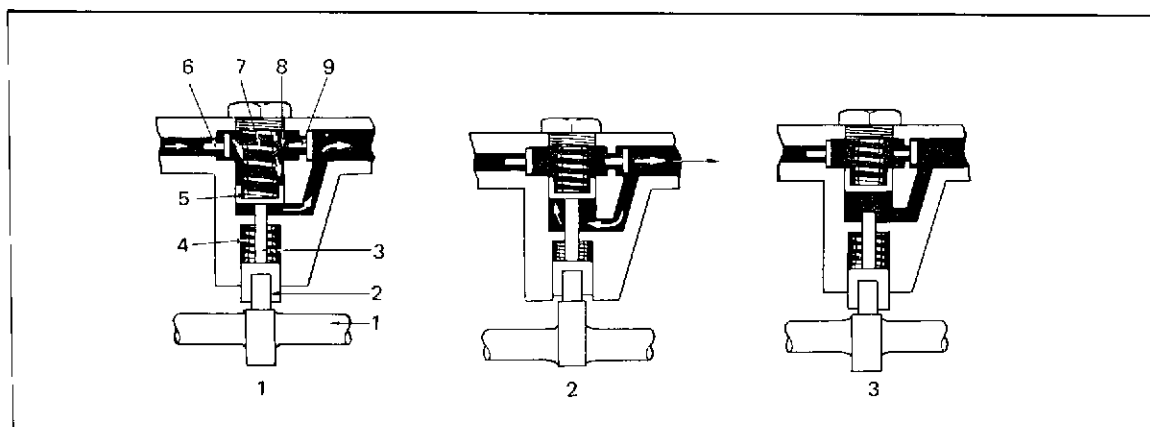


Fig. 3-3 Feed Pump Operating Diagram

OPERATION

The feed pump is operated by the injection pump camshaft which imparts reciprocating motion to the piston to suck in and discharge the fuel under pressure.

After the camshaft (1) is not pushing against the tappet roller (2), the piston (5) is pressed on the push rod (3) by the tension of spring (7), to increase the volume of pressure chamber (8). Thus the inlet valve (6) opens to draw in fuel.

The camshaft, on turning, allows the cam to push the piston through the tappet roller and push

rod. The rising of the piston compresses the fuel in the pressure chamber, causing the inlet valve to close and the outlet valve to open and discharge the fuel under pressure. A part of the discharged fuel enters in the pressure chamber (10) at underside of piston. If the fuel pressure at underside of piston that is the discharge pressure rises above 1.8 to 2.2 kg/cm^2 , the tension of spring is insufficient to lower the piston so that the piston no longer reciprocates causing the pump to stop functioning.

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Table 3 1 Fuel Pump Specifications

Fuel Pump	Housing to piston clearance	0.009 to 0.013 mm (0.0004 to 0.0005")
	Housing to push rod clearance	0.003 to 0.006 mm (0.0001 to 0.0002")
	Feed pump tappet operation stroke	8 mm (0.31")
	Priming pump stroke	25 mm (0.98")
	Discharge pressure	1.8 to 2.2 kg/cm (26 to 31 psi)

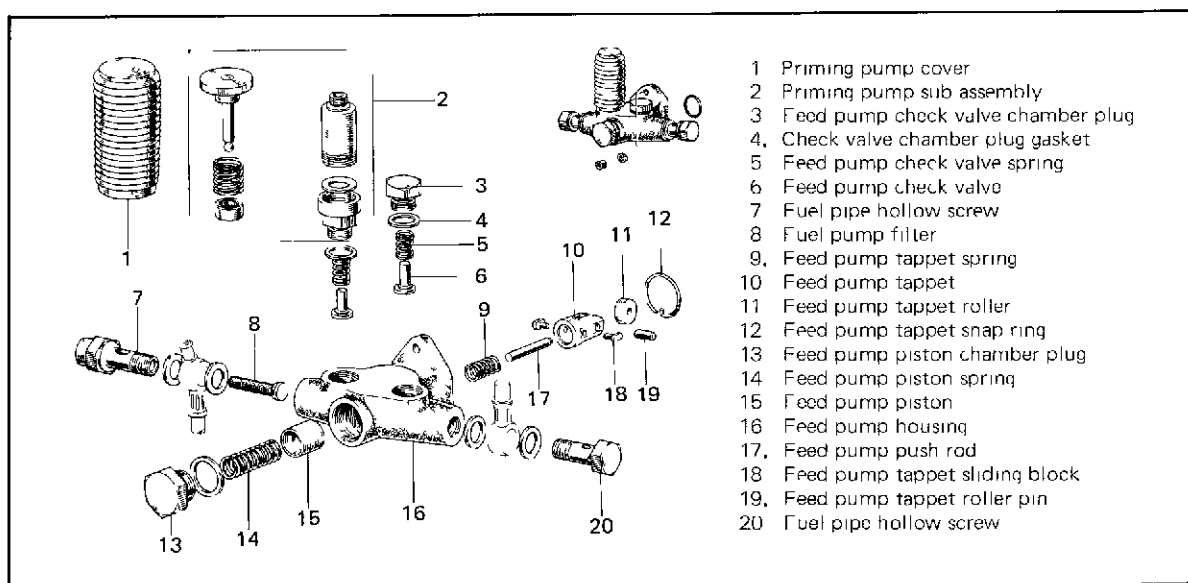


Fig. 3-4 Fuel Pump Component Parts

DISASSEMBLY

- 1 Removing fuel pipe hollow screw (1), take out fuel filter (2)
- 2 Remove piston chamber plug (3) using SST[09333-5b011] to remove piston spring (4) and piston (5).
- 3 Remove priming pump cover (6) to pull out priming pump (7), spring (8) and valve (9)
- 4 Removing check valve chamber plug (10), pull out spring (11) and check valve (12)
- 5 Removing tappet snap ring (13) take out feed pump tappet (14).
- 6 Pull out feed pump push rod (15)

Caution

Since push rod is closely fitted with feed pump housing (20), do not remove this unless necessary. If removed, confirm the assembly direction and remember

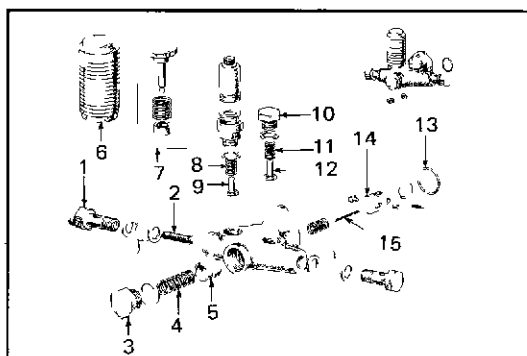


Fig. 3-5 Disassembling Fuel Pump

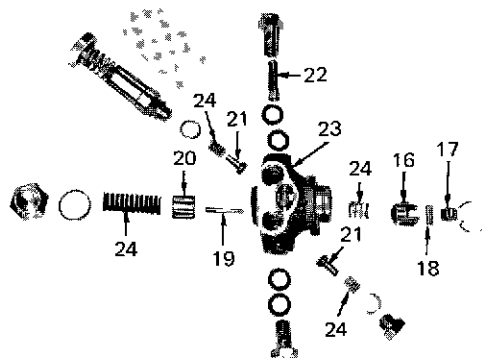


Fig. 3-6 Inspecting Fuel Pump

INSPECTION AND REPAIR

Wash each part with clean gasoline, and inspect.
Replace the defective parts

- 1 Inspect the tappet (16), roller (17) roller pin (18), push rod (19), piston (20) check pin (18), push valve (21), fuel strainer (22) and pump housing (23) for cracks, damages and wear springs (24) for weakness
- 2 Inspect the priming pump operation.

ASSEMBLY

- 1 Follow the disassembly procedures in the reverse order.
- 2 Perform pump test after assembly is completed
(Refer to Pump Test Page 3-47)

FUEL FILTER

DISASSEMBLY

1. Remove the fuel filter center bolt.
2. Take out the filter element, washer, and spring

INSPECTION

Inspect the fuel filter body and element for damage and deformation, and replace if found defective.

Note

Clean the element with a soft brush.

ASSEMBLY

Perform the disassembly procedures in reverse order.

Note

Be sure to use new gaskets.

EVACUATING AIR

1. When removing air by operating the priming pump and bleeding out through the bleeder plug, check also for fuel leakage.
2. Tighten the plug after locking the priming pump.

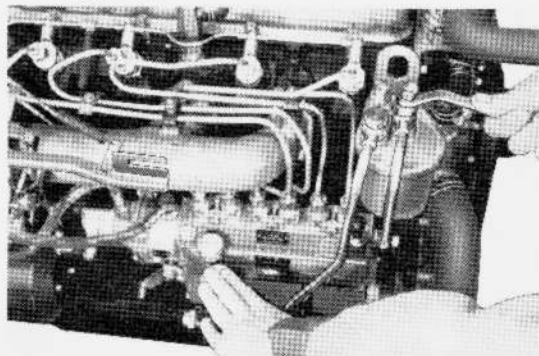


Fig. 3-9 Evacuating Air

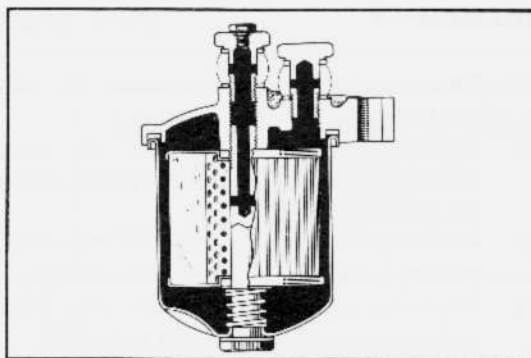


Fig. 3-7 Sectional View of Fuel Filter

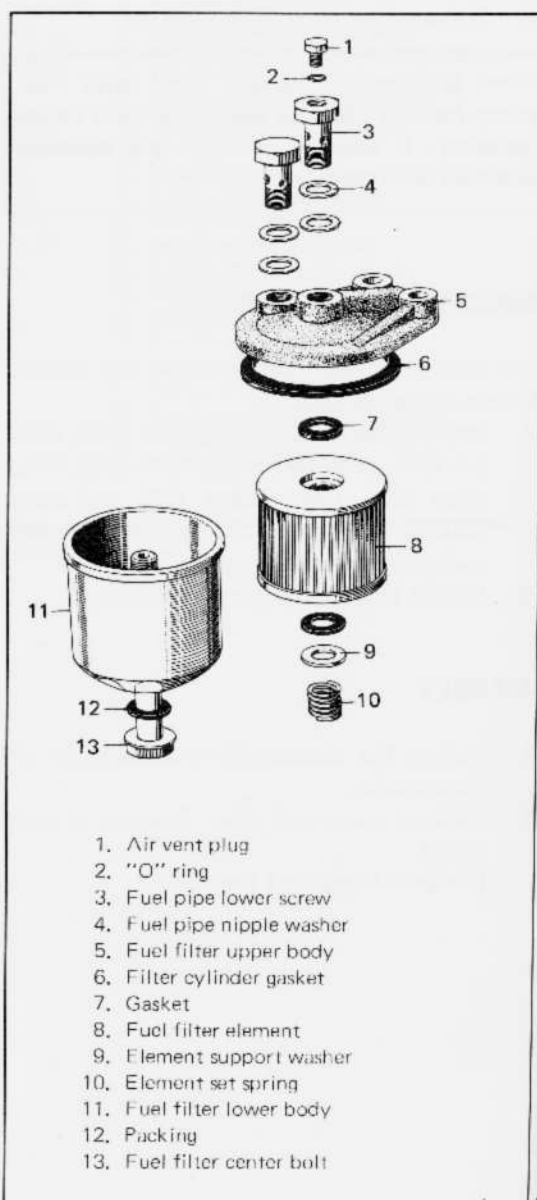


Fig. 3-8 Fuel Filter Parts

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NOZZLE & NOZZLE HOLDER

DESCRIPTION

The fuel pressure fed by injection pump reaches the nozzle holder through an injection pipe and through the small hole of nozzle holder body and passing through the ring groove of the distance where the fuel flows into the pressure chamber after moving through 3 feed holes ring groove of nozzle body and 2 feed holes. When the oil pressure inside pressure chamber reaches 100 to 110 kg/cm^2 (1,429 to 1,571 psi) due to injection pump plunger action, the nozzle needle pressed by pressure spring through pressure pin is lifted up so that the fuel is injected into the pre chamber. When the pressure feeding due to injection pump plunger ends the oil pressure inside pressure chamber is lowered, due to pumping-back action of deliver valve, and due to the pressure spring the nozzle needle closely sticks to the seat to stop the fuel injection.

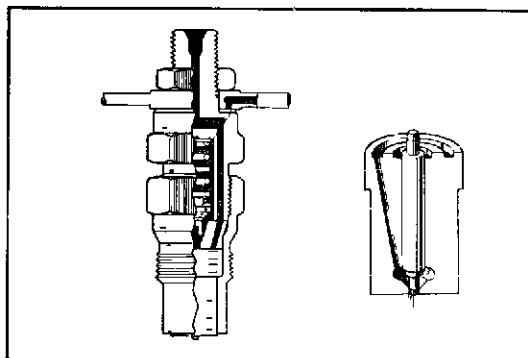


Fig. 3-10 Cross Sectional View of Nozzle and Nozzle Holder

The fuel in the nozzle pressure chamber is under high pressure so that there is minute leakage of fuel between the nozzle body and needle. This leakage fuel lubricates the nozzle and needle sliding surfaces and then passes out from the nozzle holder and flows through the leakage pipe to return to the fuel pump inlet side.

SPECIFICATIONS

Table 3.2 Nozzle & Nozzle Holder Specifications

Nozzle	Type Valve opening pressure Injection bore Injection angle	Throttle 100 to 110 kg/cm^2 (1,422 to 1,565 psi) 1 mm (0.0394") Approx. 4°
Nozzle Holder Pressure Spring	Free length Installing length Installing load	22.1 mm (0.8700") 21.5 mm (0.8465") 15.0 kg (33.1 lbs)
Adjust washer thickness (used for nozzle valve opening pressure adjustment)		1.0, 1.05, 1.10 . . . 1.95 mm (0.0394, 0.0413, 0.0433 . . . 0.076") (20 types in 0.05 mm (0.0020") variation)

COMPONENTS

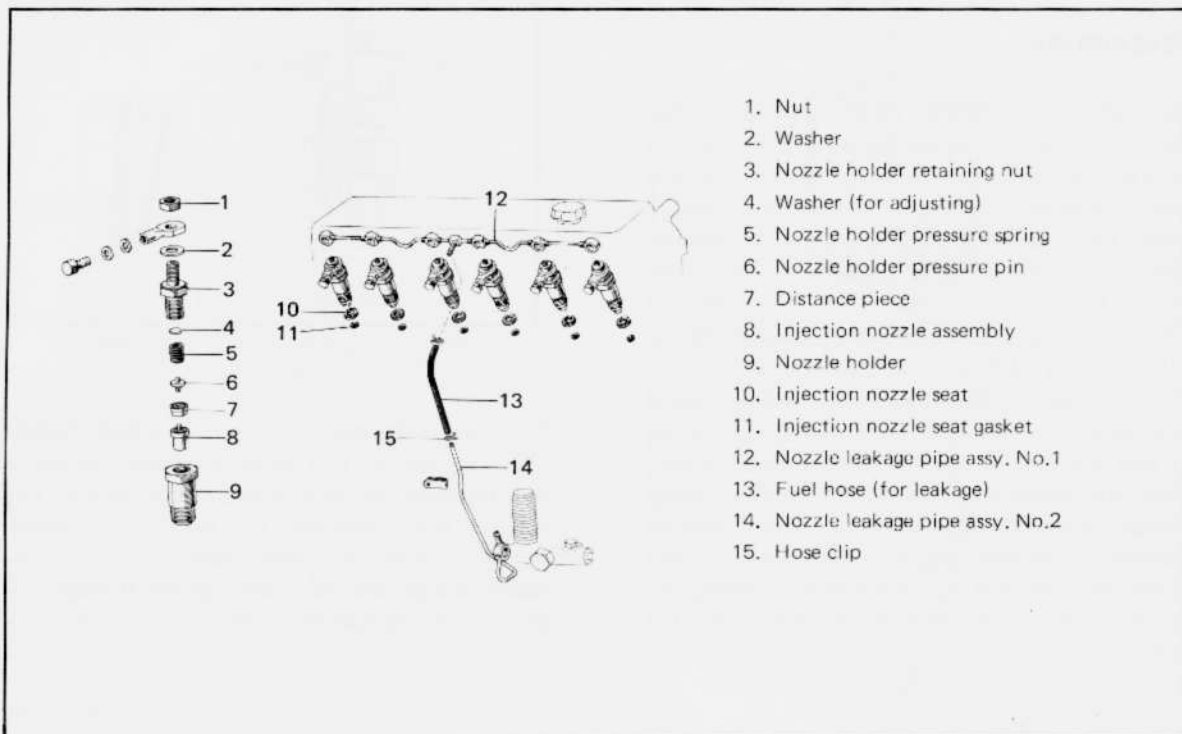


Fig. 3-11 Nozzle and Nozzle Holder Parts

DISASSEMBLY

Note

Similar to injection pump disassembly, perform the nozzle holder disassembly in a clean place.

Fixing

Fixing SST[09268-46011] into the vise, and inserting nozzle holder assembly, disassemble nozzle holder body (2) and retaining nut (1) by using SST [09268-46021], and take out pressure spring (3), washer (4), pressure pin (5), distance piece (6) and nozzle assembly (7).

Caution

1. When disassembling nozzle holder, do not drop the inner parts on the floor.
2. When nozzle body is stuck to retaining nut with carbon, extrude with a stiff wood.

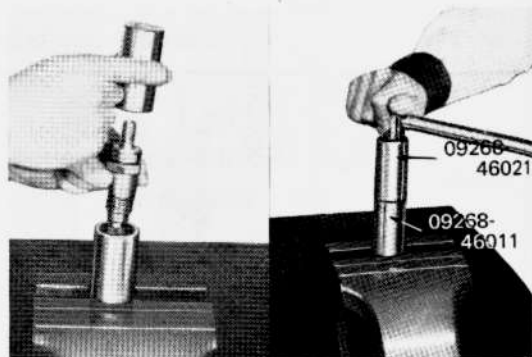


Fig. 3-12 Disassembling Nozzle & Nozzle Holder

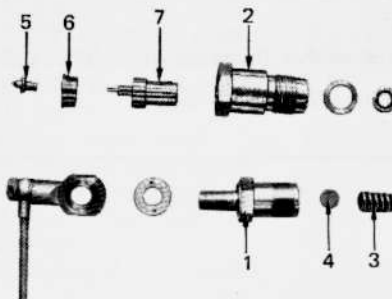


Fig. 3-13 Disassembling Nozzle Holder

INSPECTION, REPAIR & WASHING

- 1 After washing the disassembled parts, check for wear and damage, and replace if defective
- 2 After washing the exteriors, always use gasoline or light oil to wash the nozzle and nozzle holder

Caution

Do not use the oil that has been used for sedimenting and filtering old parts.

- 3 Use Nozzle Cleaning Kit to wash the nozzle in clean light oil
- 4 Clean the carbon attached in nozzle needle end with a piece of wood

Caution

Wash the nozzle needle part with nylon brush, and do not use any shop towel. To prevent corrosion, do not touch the lapped surface with the fingers, but hold the every end of the journal

- 5 Clean the nozzle seat with cleaning scraper.

Caution

When using chrome oxide as an abrasive, coat slightly avoiding deep coating at a time, and carefully clean after repair.

- 6 Clean the nozzle body injection hole with a cleaning needle
- 7 Clean the carbon from the nozzle body exterior (except wrapping angle) with a brass brush

SINKING TEST

Wash the body and needle in clean light oil. Pull out the needle about half way from body and then release it. The needle should sink down into the body extremely smoothly by its own weight. Repeat this test rotating the needle slightly after each test. If the needle fails to sink smoothly at any place, replace the needle and body as a set.

ASSEMBLY

1. With the retaining nut (1) lower side facing upward, assemble into the nut in the following order: pressure spring washer (2), pressure spring (3), pressure pin (4) and distance piece (5) and manually assemble the nozzle holder body (7) with the nozzle assembly (6) being installed to the distance piece.

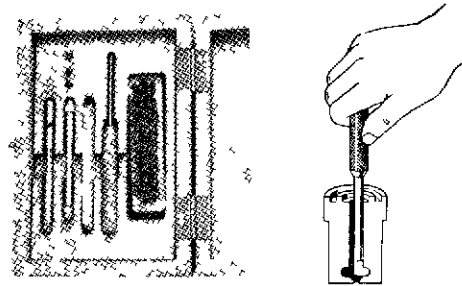


Fig 3-14 Cleaning Kit & Cleaning Pressure Chamber

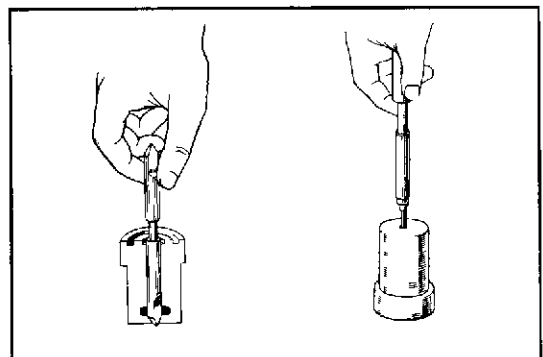


Fig 3-15 Cleaning Nozzle Body

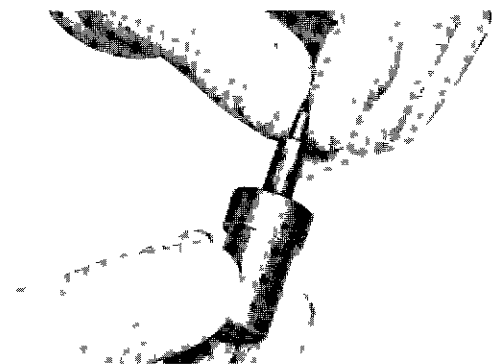


Fig 3-16 Nozzle Sinking Test

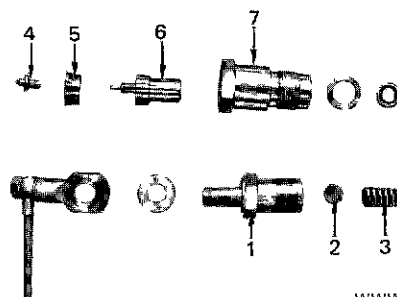


Fig 3-17 Assembling Nozzle

- 2 Install the nozzle holder into SST[09268-46011] fixed to the vise, and tighten with SST[09268-46021]

Caution

Be careful not to allow the nozzle needle to drop out while assembling.

Tightening torque .

400 to 600 kg-cm (28.9 to 43.4 ft-lb)

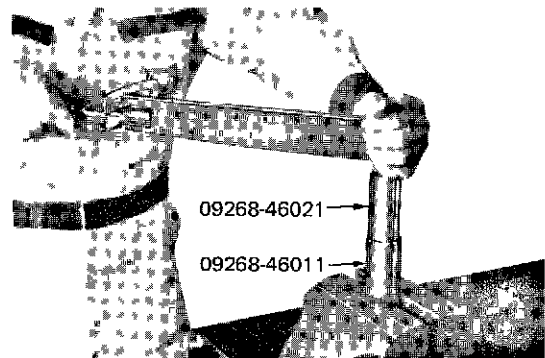


Fig 3-18 Tightening Nozzle Holder

SPRAY TEST

- 1 Generally use Hand Tester to test and adjust the nozzle
Injection pressure 100 to 110 kg/cm² (1,422 to 1,564 psi)
- 2 To adjust the injection pressure perform with the washer at the top of pressure spring

Note

There are 20 types of washer ranging from 1.00 mm to 1.95 mm (0.0394 to 0.0768"), one for each 0.05 mm. The adjustment of injection pressure will increase 5 kg/cm² (71.1 psi) with the increase of 0.05 mm (0.0020") adjusting washer thickness.

- 3 Evacuating air from pipe line of tester.
- 4 Slowly operate the tester lever when adjusting injection pressure.

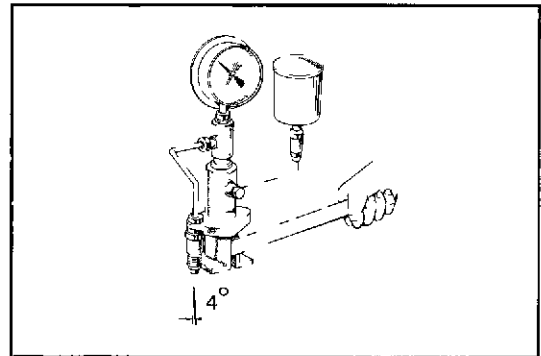


Fig 3-19 Testing Injection Nozzle

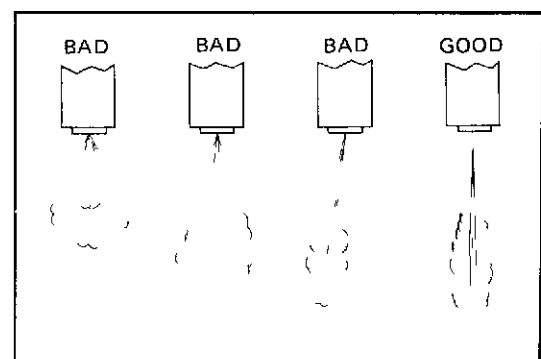


Fig 3-20 Spray Condition

- 5 Spray condition
 - (1) Including the nozzle center line the spray should come out in 4° conical form
 - (2) A round circular form of injection should be obtained in a white sheet of paper, placed 30 cm (11.8") away from the nozzle
 - (3) Dripping should not occur
 - (4) Leakage test.
 Oil should not leak from nozzle valve seat and retaining nut at the oil pressure of 90 kg/cm² (1,286 psi)

AUTOMATIC TIMER

DESCRIPTION

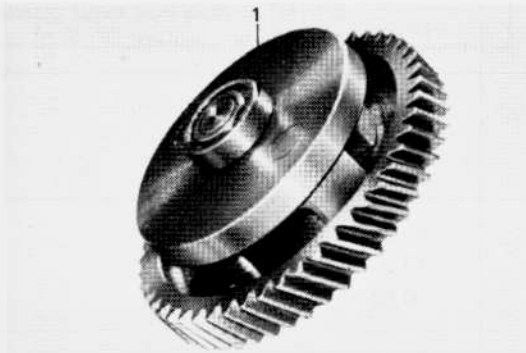


Fig. 3-21 Automatic Timer Assembly

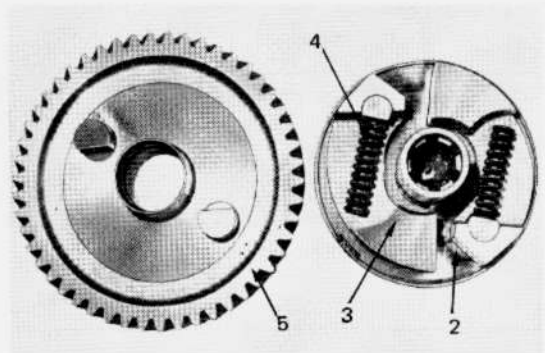


Fig. 3-22 Automatic Timer Construction

In H-model engine, the automatic timer is adopted to obtain the correct injection timing according to the increase in engine speed. The automatic timer automatically adjusts the injection timing making use of the centrifugal force due to rotation. The

timer is composed of bearing (1), hub (2), weight (3), spring (4) and drive gear (5), and is driven by the engine rotational force through the idle gear.

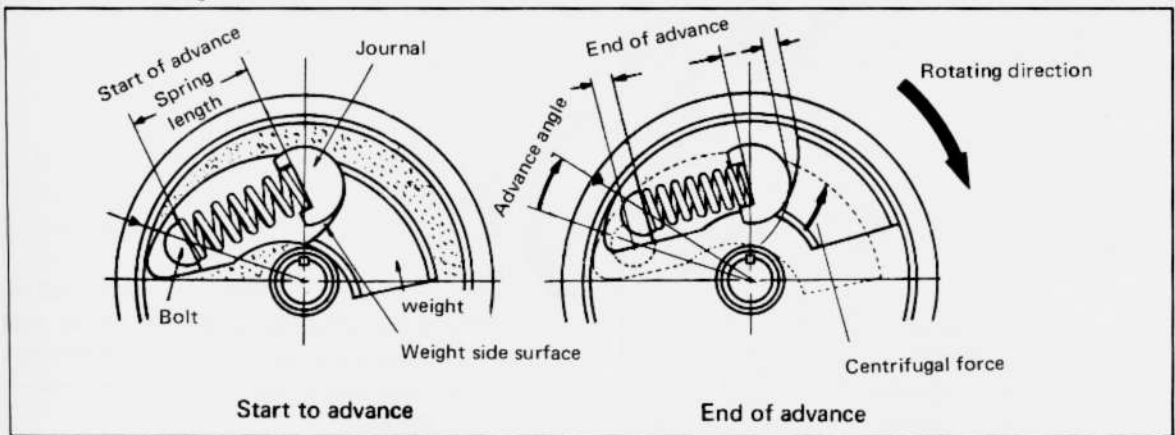


Fig. 3-23 Automatic Timer Operation

OPERATION

The automatic advance angle adjustment of the automatic timer is performed as follows. As the RPM increases, the weight moves outward due to centrifugal force. At this time, the weight curved surface, made according to required advance angle, slides along the drive gear journal. Therefore, the drive gear and hub can relatively rotate up to the advance angle.

Forces of the weight to move outward due to the centrifugal force overcomes the spring tension and the friction of weight curved surface at hub bolt, causing the hub to increase the advance angle against the drive gear, as RPM increases. Since the timer hub is connected to injection pump spline shaft, injection timing is also quickened.

Table 3.3 Automatic Timer Specifications

Timer Advance Angle (2-step bending)	450 to 550 rpm (Timer rpm)	Advance Angle Begins
	800 rpm "	2.5 to 3.5°
	1 050 rpm "	5 to 6°
	1 800 rpm "	7 to 8° (Maximum)
Main Spring	Free length	50 mm (1.97")
	Installing length	48.5 mm (1.91")
	Installing load	7.8 kg(17.4 lb)
Sub spring	Free length	43.5 mm (1.71")
	Installing length	43.5 mm (1.71")
	Installing load	0 kg
Timer Spring Adjust Washer Thickness (Small and large)		0.1, 0.2, 0.5 mm (0.004, 0.008, 0.020)

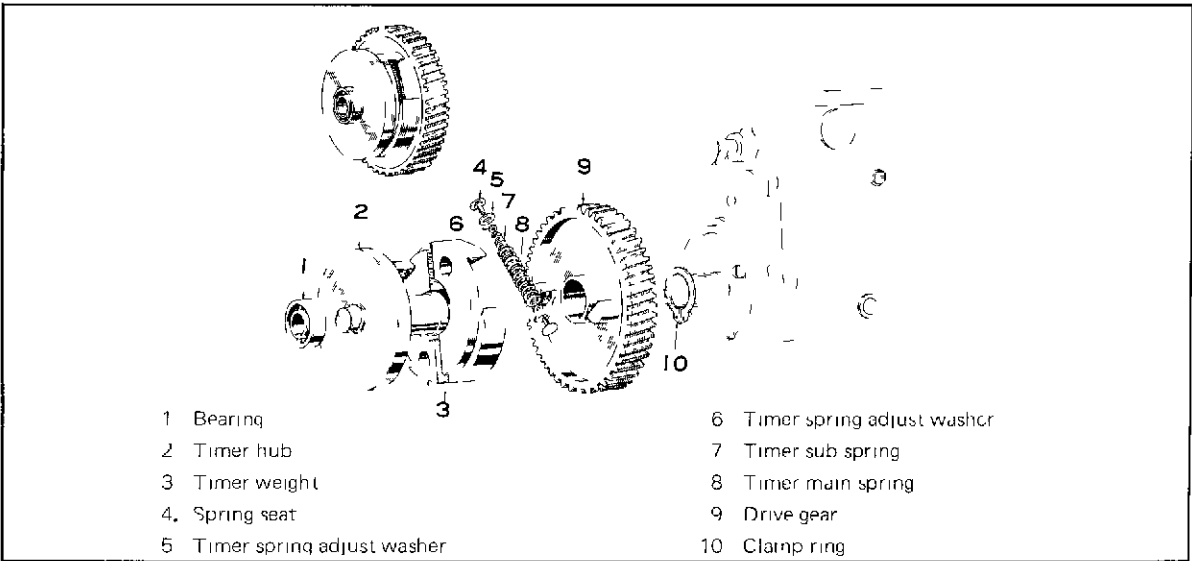


Fig 3.24 Automatic Timer Component

DISASSEMBLY

- 1 Warm the injection gear cover to 60°C (140°F) with heater, and remove the timer from the cover

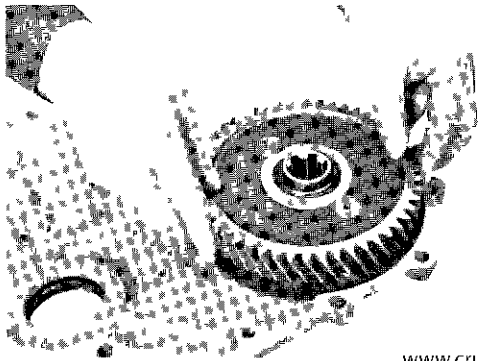


Fig 3.25 Disassembling Timer

2. Mark the mating marks onto the timer hub and drive gear.

Caution

To avoid damage, use a rag or vise sleeve when meshing timer hub with a vise.

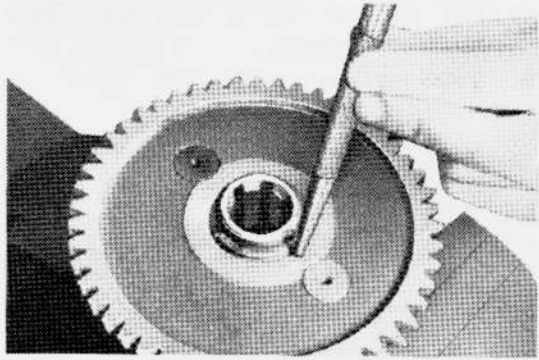


Fig. 3-26 Marking Mating Marks

3. Remove clamp ring (3), that is fixing timer hub (1) and drive gear (2).

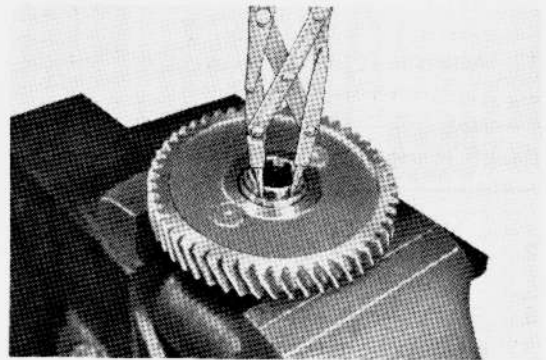


Fig. 3-27 Disassembling Clamp Ring

4. Pulling up the drive gear with both hands, disassemble in the following order: drive gear, timer spring (4), spring adjust washer (5) and timer weight (6).

Caution

When pulling the drive gear, do not let the spring and washer come out.

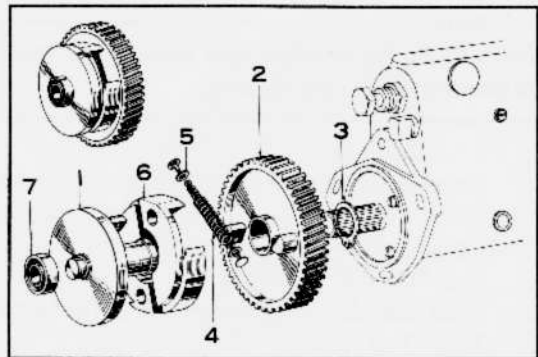


Fig. 3-28 Disassembling & Inspecting Automatic Timer

INSPECTION & REPAIR

After cleaning disassembled parts in clean light oil, check for damage and wear, and replace if defective.

1. Inspect drive gear (2), timer weight (6) and timer hub (1) for damage and wear.
2. Inspect timer spring (4) for breakage and weakening.
3. Inspect bearing (7) for damage and wear.

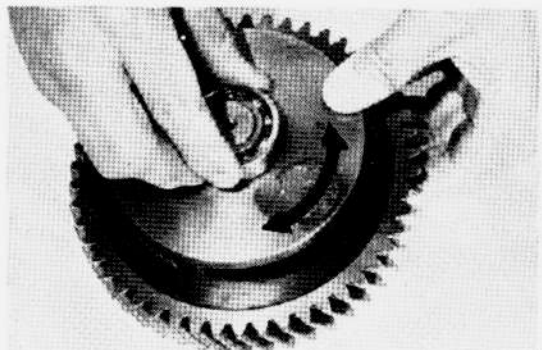


Fig. 3-29 Bearing Inspection

4. Pull out the bearing using SST[09602-35011], if necessary.
5. Install the bearing with a press.

ASSEMBLY

1. Assemble the weights to timer hub and clamp on a vise.

Note

Be sure to use a rag or vise sleeves.

2. Install adjust washer and spring, using SST[09280-76010].
3. Gently insert drive gear from upside, and after confirming that spring is housed in to the drive gear journal, pull out the Spring Holder.

Note

Pull out Spring Holders after holding the gear to prevent spring jumping out.

4. Assemble drive gear to the hub by rotating it with both hands in the directional rotation (spring compressing direction).
5. Assemble the clamp ring.
6. After assembling perform the test. (Refer to Timer Test Item.)



Fig. 3-30 Bearing Replacement

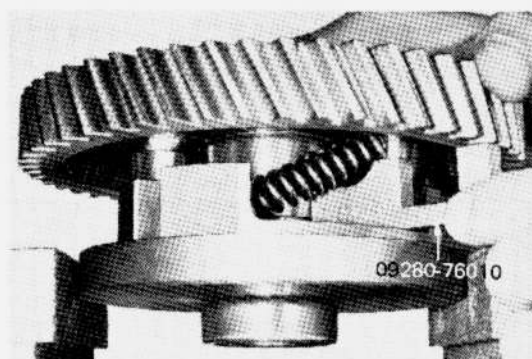


Fig. 3-31 Using Spring Holder

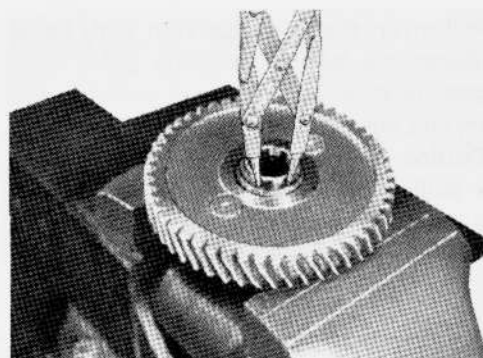


Fig. 3-32 Assembling Clamp Ring

INJECTION PUMP

DESCRIPTION

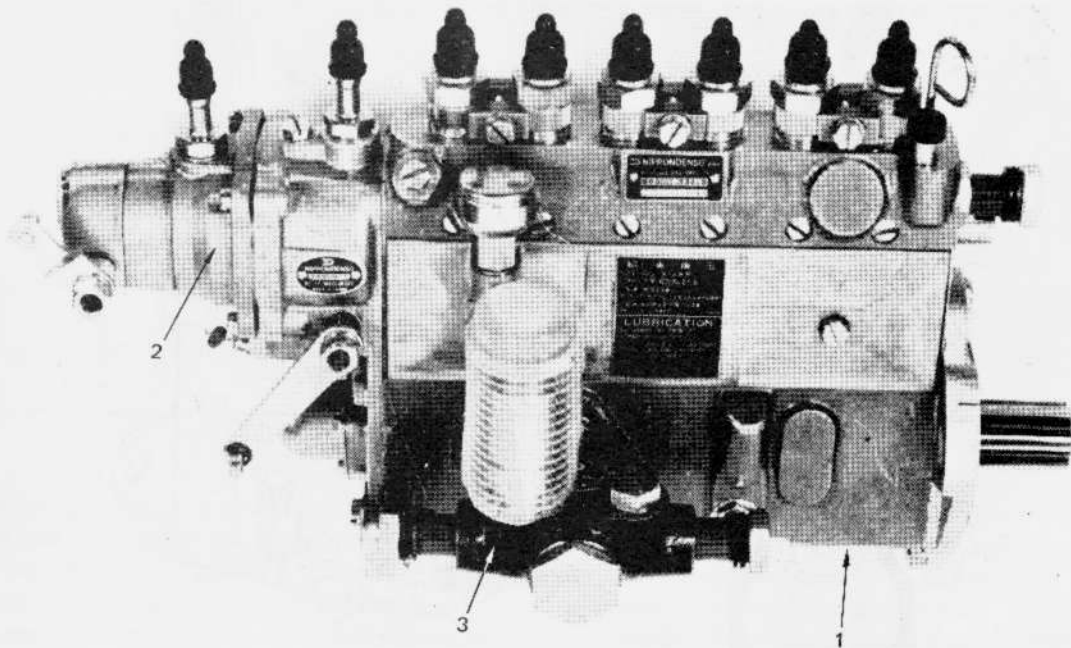


Fig. 3-33 Injection Pump Assembly

Bosch A type injection pump is used in model H-engine. It continually always supplies suitable fuel under any sort of operational conditions such as starting, idling, acceleration, high speed, economical running, and high load.

This injection pump is composed of an injection pump body (1), pneumatic governor (2) or mechanical governor fuel pump (3) and automatic timer (4). The pump body possesses the same number of cylinders and plungers as the engine. The fuel control is conducted by MN-type Pneumatic Governor (HJ series) and RU-type Mechanical Governor (HU series). The fuel pump is composed of feed pump and priming pump. The air bleeding of fuel line is performed with priming pump before engine start.

The automatic timer is equipped with timer weights that serve to advance the injection period in accordance with the variations in engine speed, and functions independent of the engine load. This automatic timer is located inside the timing cover and driven by engine idle gear. The timer is fitted on the injection pump on splines, and rotates at one-half the engine speed.

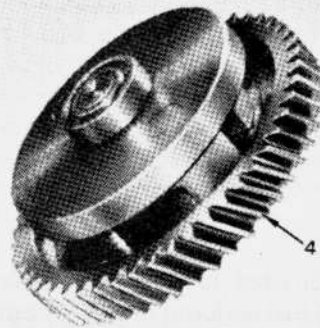


Fig. 3-34 Automatic Timer

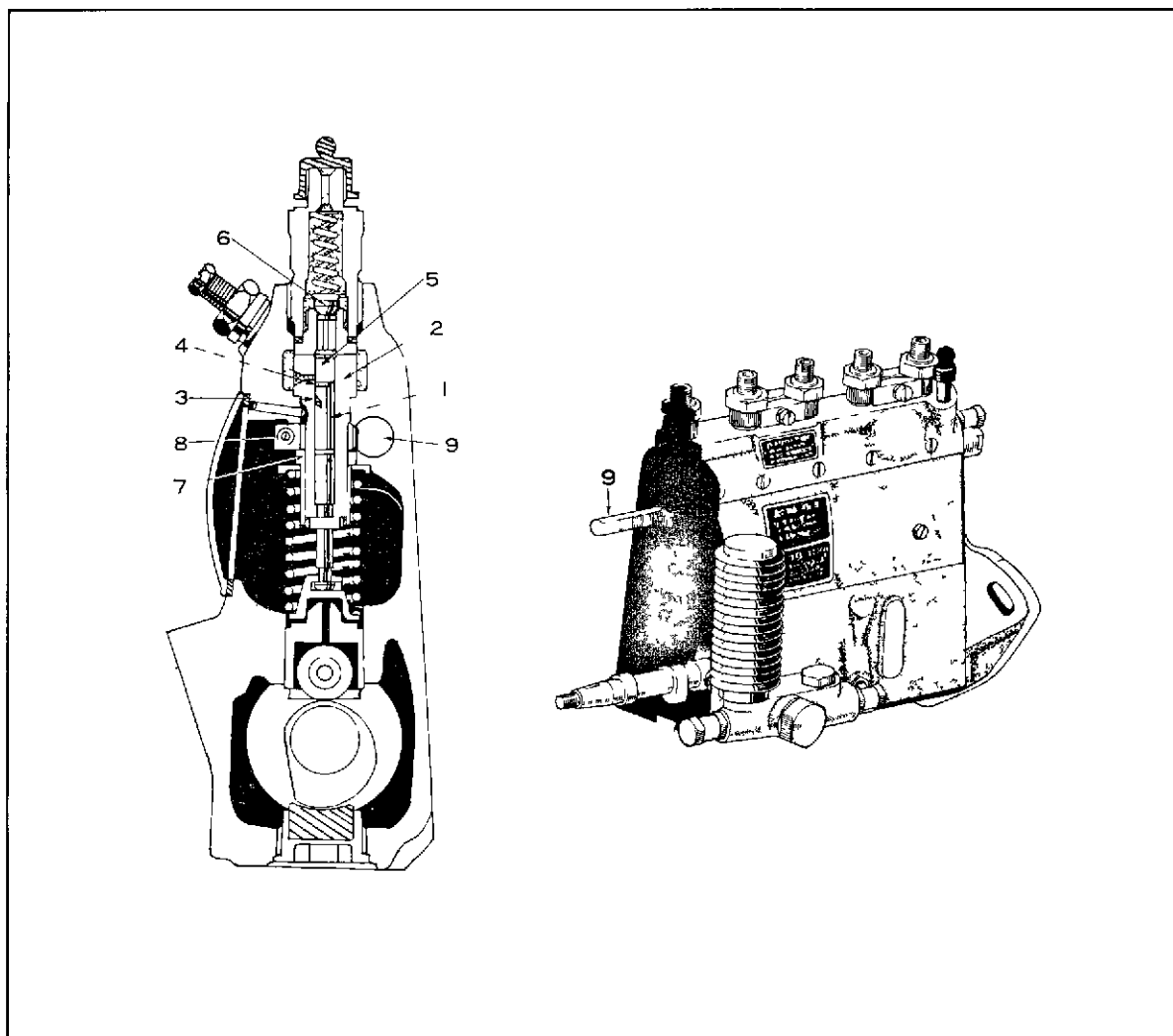


Fig 3-35 Injection Pump Unit Construction

Fuel is force-fed to the injection pump by a plunger (1) that performs the reciprocating motion with a constant stroke. As the plunger is wrapped and super accurately fitted into cylinder (2) replacement is possible only as a set of plunger and cylinder. On the plunger cylindrical surface, there is an oblique groove called control groove (3), and hole, which connects this groove and the plunger head and which lies in the middle of the plunger. There is one feed hole (4) in the cylinder, and the fuel passing through this hole, flows into cylinder delivery chamber (5) to open the delivery valve (6)

located at the top of the chamber. Through the delivery valve, the fuel moves to the injection nozzle passing through injection pipe, and is then injected into the precombustion chamber.

The cylinder is covered by plunger control sleeve (7), at the upper end of which there is a control pinion (8) and, 2 slits are cut lengthwise to serve as guides for the plunger driving face in the lower end of the sleeve. The control pinion meshes in the control rack (9). Thus the rack, by turning the plunger can vary the fuel injection amount continuously from zero to maximum.

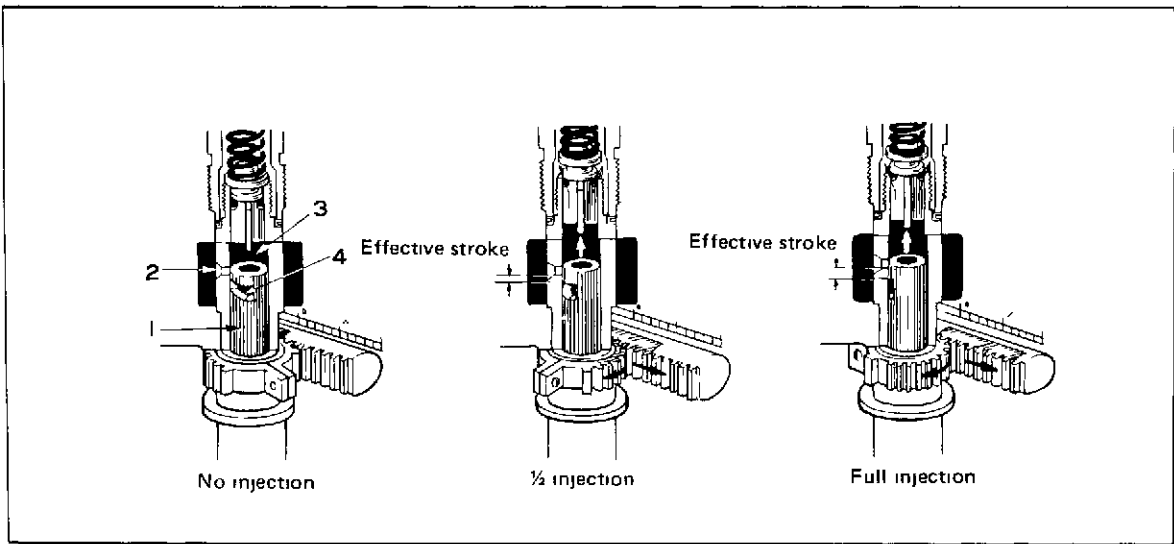


Fig. 3-36 Fuel Control System

When plunger (1) is at the lowest position, the fuel from feed hole (2) fills the delivery chamber (3) at the top of plunger, and with the rising of the plunger, the plunger shuts out the feed hole to increase oil pressure inside the delivery chamber, causing the delivery valve to open so that the fuel is led to injection pipe. Further, when the plunger pushed by tappet is raised up, the oil pressure between delivery chamber and nozzle reaches about 100 to 110 kg/cm² (1 429 to 1 571 psi), causing the nozzle to open so that the fuel is injected into the precombustion chamber. However, continuous rising of plunger causes the control groove (4) and feed hole (2) to face each other so that the high pressure fuel inside the

delivery chamber flows through the hole at the center of plunger, and passing through the control groove and feed hole, it is pushed back to the suction chamber, stopping fuel feed.

With the above operation, plunger is rotated due to control rack and when feed hole and control groove upper end part face each other, the feed hole is put through control groove before being closed by plunger so that there is no fuel feeding and the injection quantity is zero. At this time the control rack is just in governor side termination, and when it comes to timer side termination in the opposite side, the injection quantity becomes maximum.

Delivery Valve Operation

When delivery valve is pushed back by valve spring because oil feeding pressure of the fuel is lowered down as the above said feed hole is put through the control groove. At first, relief valve (5) shuts off the injection pipe and delivery chamber. The fuel volume from delivery valve to nozzle at the cutting off moment is further increased by valve spring until it contracts with the delivery valve seat.

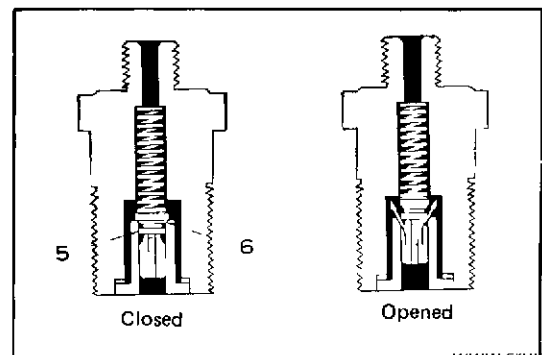


Fig. 3-37 Delivery Valve Operation

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surface; however, as fuel is not supplied even though the fuel volume is increased, the fuel pressure correspondingly decreases. Due to this pressure drop, the nozzle needle is quickly locked out and the dripping fuel is sucked back. Thus the delivery valve has two purposes: preventing fuel counter flow and sucking-back action.

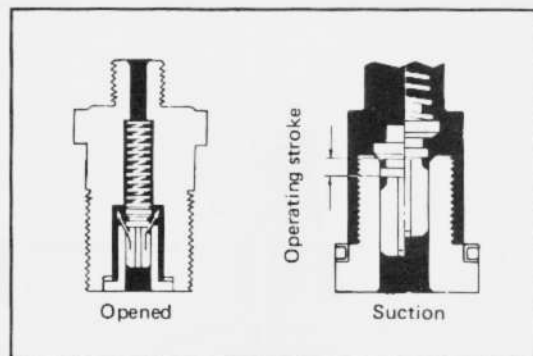


Fig. 3-38 Delivery Valve Operation

Pneumatic Governor

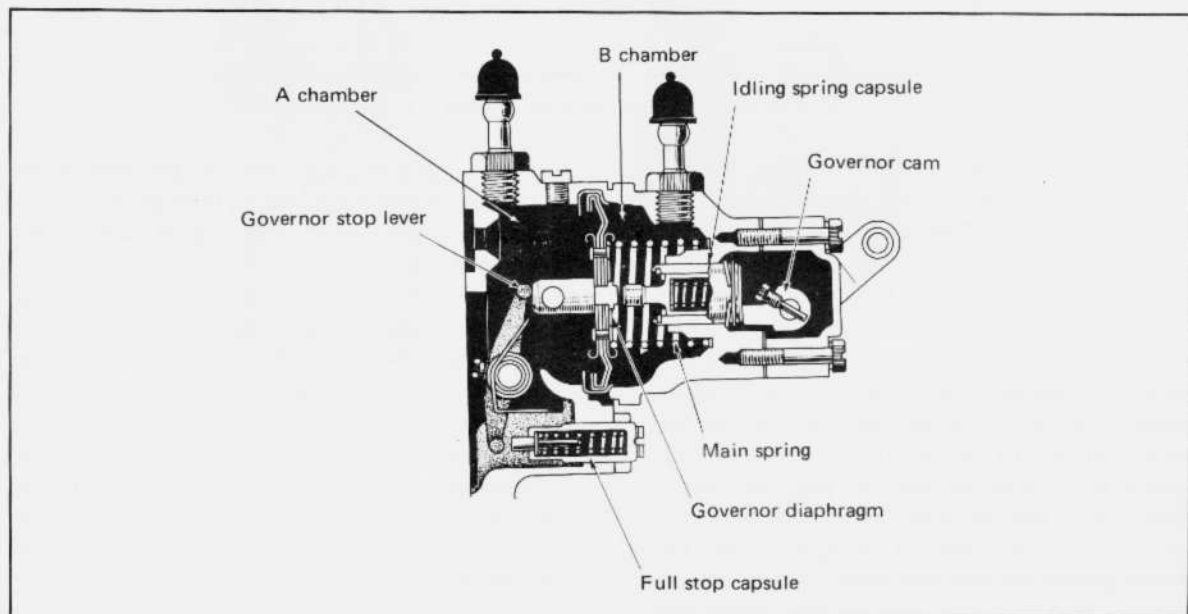


Fig. 3-39 Cross Sectional View of Pneumatic Governor

Many demands are made on the engine depending of the operating condition. In the Model H-engine, the MN type governor is used. This governor is of the pneumatic type utilizing intake manifold vacuum and has specially good low speed stability. The MN type pneumatic governor is installed on the rear side of injection pump. As illustrated above, the governor is separated into two chambers by a diaphragm, with the A chamber connected by hose to the venturi and led to the air cleaner (air horn) by throttle valve, and the B

chamber connected by hose to the manifold side of throttle valve (auxiliary venturi). The diaphragm is linked to one end of the control rack and is always kept pushed by the main spring toward maximum injection side. When the engine is in operation, the diaphragm is moved by the difference in pressure between the vacuum created by air flow and the pressure in the air cleaner, and fuel control effected by the balance between the diaphragm and main spring.

Purpose of the Venturi

The venturi is installed between the air cleaner and intake manifold and is actuated by the vacuum variation in relation to the throttle opening and closing which operates the governor and controls the fuel required for the engine.

The venturi vacuum port is provided with an auxiliary venturi and is installed at the side of the throttle valve.

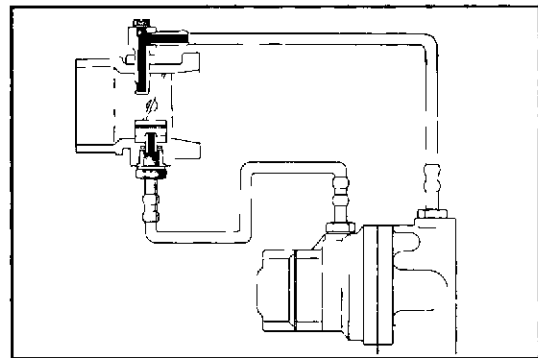


Fig. 3-40 Venturi Cross Sectional View

Governor Operation

During Idling

During idling as the throttle valve is in almost fully closed condition, it results in creating a strong vacuum in the vacuum chamber. By this vacuum, the rack is pulled to idling position by the balancing of the governor main spring and idle spring. If in case the engine revolution increases by the load variation, this causes vacuum actuated in the vacuum chamber to increase and the rack will move in relation with the movement of the diaphragm toward the injection volume decreasing direction which will extremely reduce the engine revolution.

Suppose the engine revolution reduces, and the vacuum in the diaphragm chamber decreases the diaphragm will move the rack toward the injection volume increasing direction, thus the engine revolution is increased.

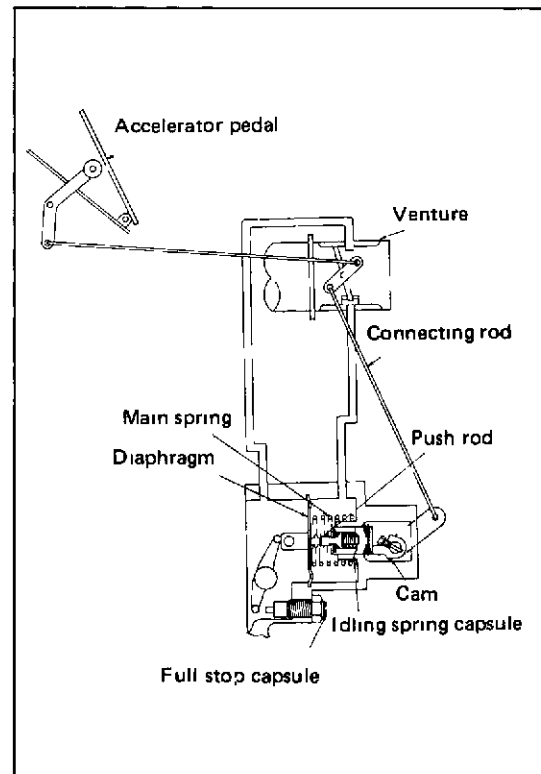


Fig. 3-41 Pneumatic Governor Link Mechanism

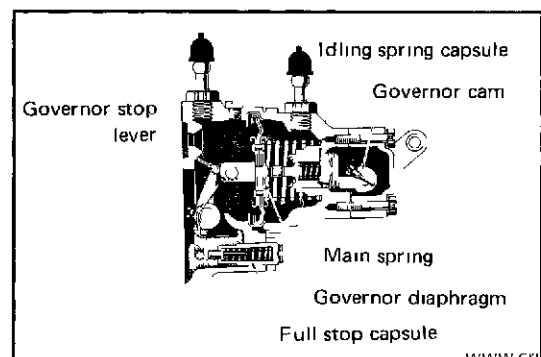


Fig. 3-42 Model MN Governor Cross Sectional View

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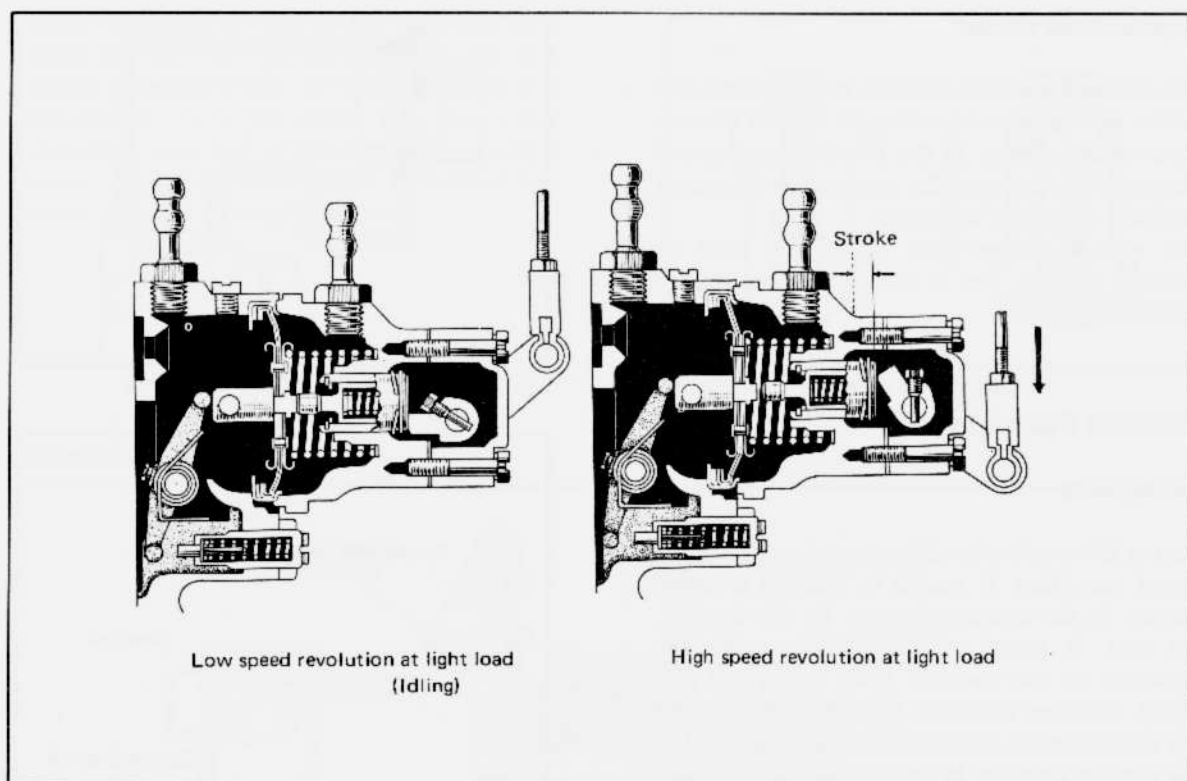


Fig. 3-43 Pneumatic Governor Operation

On the model MN, the idling spring and accelerator pedal are connected, and the diaphragm movement is prevented in idling condition and only in close idling condition. The governor idling spring lever free position is maintained by the linkage when the idling spring is fully pushed by the cam, and also when the push rod is in fully raised position. This condition is idling condition when the idling spring operates the diaphragm to maintain steady engine idling.

At Maximum Revolution

If the accelerator is suddenly depressed all the way to the floor, the governor cam pulls away from the idling spring capsule, ceasing interference with the diaphragm. Since the venturi negative pressure is low at this time, the control spring moves to the maximum fuel injection position (contacting position of governor stop lever and full stop capsule) under action of the main spring. The venturi negative pressure then builds up together with engine revolution. When the engine reaches the maximum permissible revolution, the

venturi negative pressure, using the main spring force, moves the control rack into the injection low range. In this way, the control rack moves to a position in terms of the load and thereby maintains the maximum permissible revolution. Should there be engine overload, however, the engine can not attain maximum permissible revolution.

Stopping the Engine

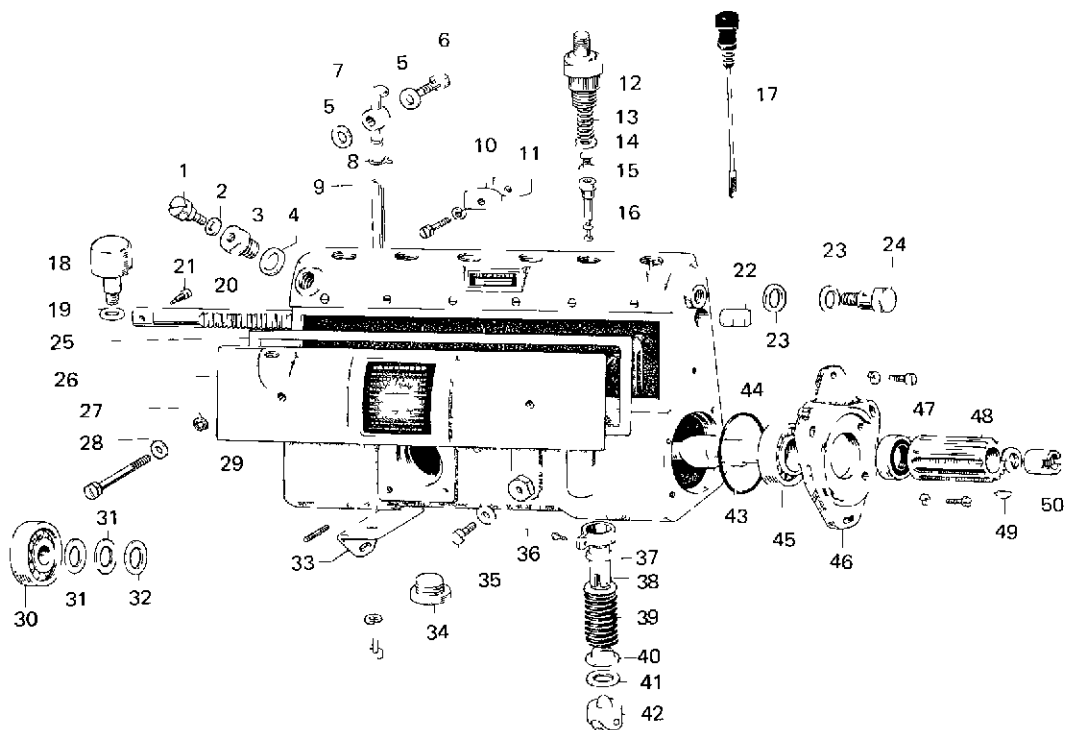
When the stop button in the driver's compartment is pulled out, the control wire connecting the stop button and injection pump is pulled, and the control rack will move toward the injection volume zero direction. Thus, the engine stops.

INJECTION PUMP SPECIFICATIONS

Rotational direction		Clockwise as seen from driving side
Cam lift		6 mm (0.24")
Pump element	Bore diameter	7 mm or 0.28" (Left reed)
	Type	Increased injection at start
Injection order		1 4 2 6 3 5
Control rack	Pump stopped	Less than 160 g (5.3 oz)
sliding resistance	Pump at 1,000 rpm	Less than 50 g (1.8 oz)
Pre stroke		1.9 to 2.0 mm (0.075 to 0.079")
Injection interval angle		59°30' to 60°30'
Tapolet clearance		More than 0.2 mm (0.008")
Tapolet adjusting shim plate thickness		0.1, 0.2, 0.3, 1.4 mm (14 species) (0.0039, 0.0079, 0.0118, 0.0551")
Camshaft thrust clearance		0.03 to 0.05 mm (0.0012 to 0.0020")
Camshaft shim plate thickness		0.10, 0.12, 0.14, 0.16, 0.18, 0.50 mm (0.0039, 0.0047, 0.0055, 0.0063, 0.0071, 0.0197")
Plunger spring	Free length	49.4 mm (1.945")
	Load at 44 mm (1.732")	15.1 kg (33.3 lb)
	Load at 36 mm (1.417")	37.5 kg (82.7 lb)
Pneumatic governor	Type	Vacuum type
	Main spring free length	105.0 mm (4.134")
	Adjusting shim thickness	0.5, 1.0, 2.0, 3.0 mm (0.020, 0.039, 0.079, 0.118")

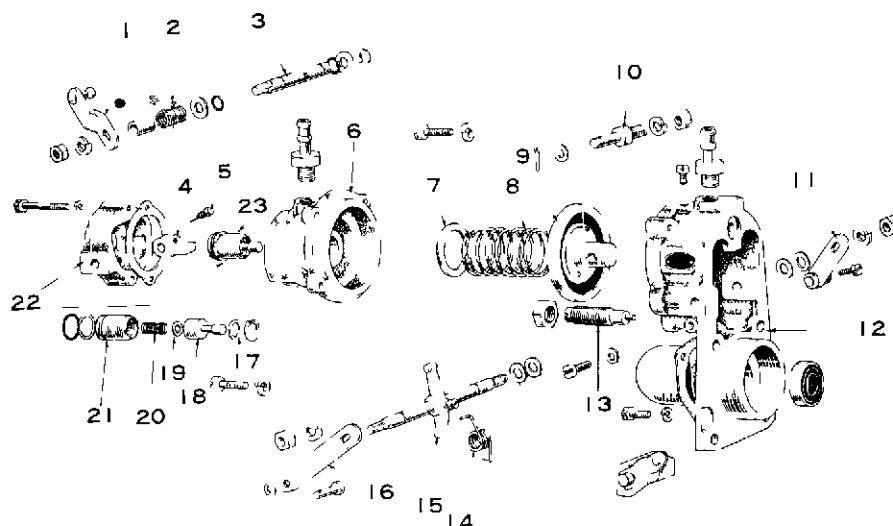
INJECTION PIPE SPECIFICATIONS

Total length	528 to 538 mm (20.78 to 21.18)
Outer diameter	6 mm (0.24")
Inner diameter	2.0 mm (0.08")



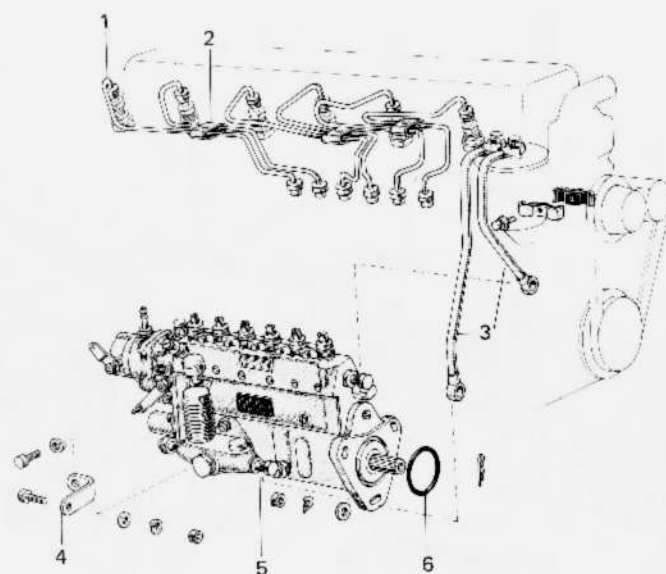
- | | |
|---|--|
| 1 Air bleeder screw | 26 Injection pump cover sub assembly |
| 2 Air bleeder screw packing | 27 E ring |
| 3 Air bleeder nipple | 28 Air bleeder screw packing |
| 4 Air bleeder nipple washer | 29 Injection pump housing sub assembly |
| 5 Injection pump drain union washer | 30 Bearing |
| 6 Nipple | 31 Camshaft shim |
| 7 Overflow nipple | 32 Camshaft adjust ring |
| 8 Clip | 33 Injection pump body stay |
| 9 Overflow pipe | 34 Injection pump felt plate plug |
| 10 Delivery valve holder front lock plate | 35 Drain screw |
| 11 Delivery Valve holder rear lock plate | 36 Drain screw washer |
| 12 Delivery valve holder | 37 Plunger control pinion |
| 13 Delivery valve spring | 38 Plunger control sleeve |
| 14 Delivery valve gasket | 39 Pump plunger spring |
| 15 Injection pump delivery valve sub assembly | 40 Spring lower seat |
| 16 Injection pump element sub assembly | 41 Tappet adjusting shim |
| 17 Injection pump oil level gauge | 42 Injection pump tappet assembly |
| 18 Injection pump cleaner | 43 Injection pump camshaft |
| 19 Air bleeder nipple washer | 44 O ring |
| 20 Control rack | 45 Bearing |
| 21 Rack guide screw | 46 Injection pump flange |
| 22 Control rack cover | 47 Oil seal |
| 23 Fuel pipe union washer | 48 Spline shaft |
| 24 Fuel pipe hollow screw | 49 Key |
| 25 Injection pump cover plate gasket | 50 Timing round nut |

Fig 3-44 Injection Pump Unit Components



- | | |
|--------------------------------------|---------------------------------------|
| 1 Injection pump lever sub assembly | 13 Full stop capsule |
| 2 Spring | 14 Diaphragm stop lever return spring |
| 3 Governor shaft | 15 Governor stop lever w/shaft |
| 4 Cam | 16 Injection pump lever sub-assembly |
| 5 Screw | 17 Adjust washer |
| 6 Governor diaphragm housing | 18 Push rod |
| 7 Main spring shim | 19 Adjusting washer |
| 8 Governor main spring | 20 Return spring |
| 9 Governor diaphragm sub assembly | 21 Idling spring sleeve |
| 10 Diaphragm connecting bolt | 22 Lever housing |
| 11 Injection pump lever sub assembly | 23 Idling spring capsule |
| 12 Governor housing sub assembly | |

Fig. 3-45 Pneumatic Governor Component Parts



1. Injection pipe sub-assembly
2. Injection pipe clamp
3. Fuel pipe sub-assembly

4. Injection pump stay
5. Fuel pipe hollow screw
6. "O" ring

Fig. 3-46 Injection Pump Assembly & Pipe Component Parts

DISASSEMBLY

Note

1. When disassembling and adjusting injection pump, be sure to test before disassembling and adjusting except for some case when testing is impossible, and record the disassembling and adjusting.
2. Use 2 sets of SST [09260-46011], [09260-76014] for disassembly and assembly.
3. Disassemble and assemble in a clean place, and use Disassembly Pan with light oil to keep each cylinder part in order.

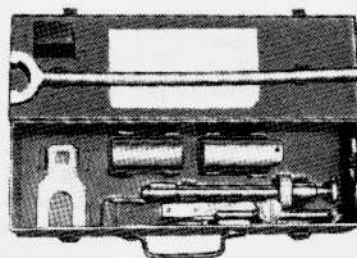


Fig. 3-47 Injection Pump Tool Set
SST [09260-46011]

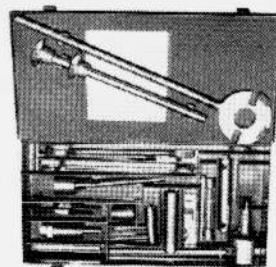


Fig. 3-48 Injection Pump Tool Set
SST [09260-76014]

1. Remove the following parts in numerical order.

Drain out injection cam chamber oil.

- (1) Drain plug.
- (2) Fuel pump SST [09276-76010].
- (3) No.2 delivery valve holder SST [09270-76010].
- (4) Vacuum hose union.
- (5) Pump lower bracket.
- (6) Overflow pipe.

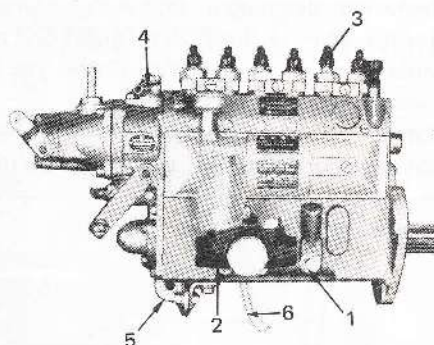


Fig. 3-49 Removing External Parts

2. Use SST [09245-46010] (1) and SST [09241-76010] (2) to install injection pump to the stand.

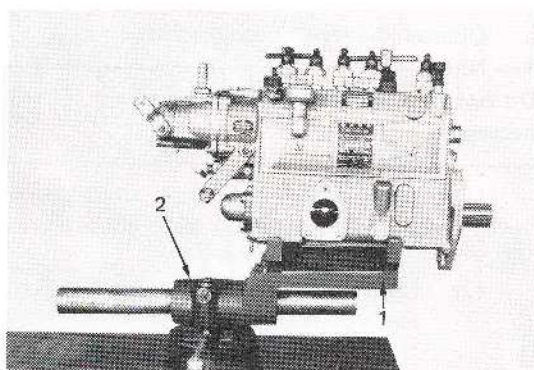


Fig. 3-50 Installing Injection Pump to Stand

3. Cut off the seal to remove lever housing sub-assembly (1) and idling capsule sub-assembly (2).

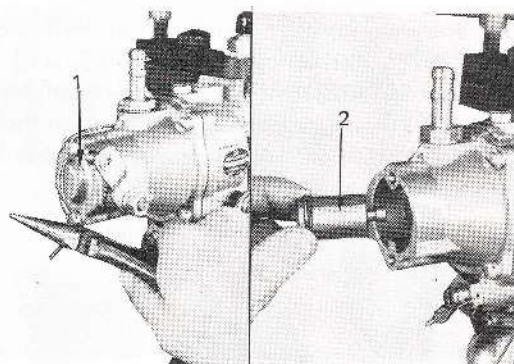


Fig. 3-51 Removing Lever Housing & Idling Capsule

4. Cut off the seal, and remove governor diaphragm housing (1) to take out main spring shims (2) and main spring (3).

Note

When a number of main spring shims are used, keep them securely to prevent any from being lost or getting mixed up.

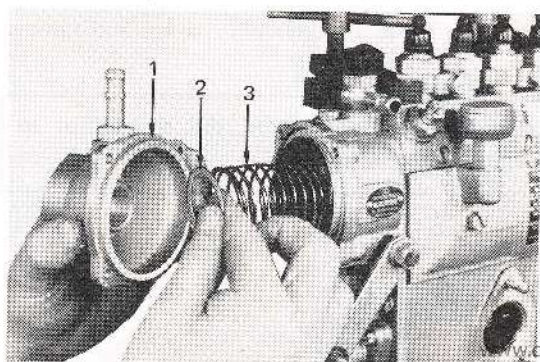


Fig. 3-52 Removing Diaphragm Housing

5. Removing diaphragm (1) from governor housing, remove diaphragm connecting bolt cotter pin (2) and washer (3) to remove governor diaphragm.

Note

Keep the governor diaphragm away from the oil.

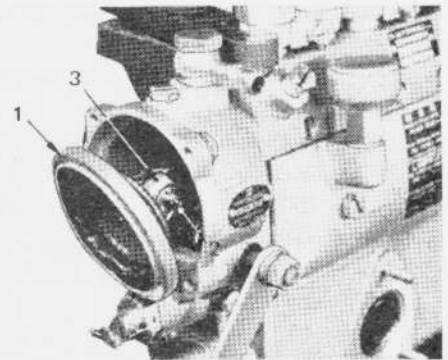


Fig. 3-53 Removing Governor Diaphragm

6. Disassemble lever housing sub-assembly.

Note

Do not disassemble lever housing except when necessary.

- (1) Remove injection pump lever, springs and bushings from lever housing sub-assembly.
- (2) Unscrew cam installing screws to remove shaft and cam.

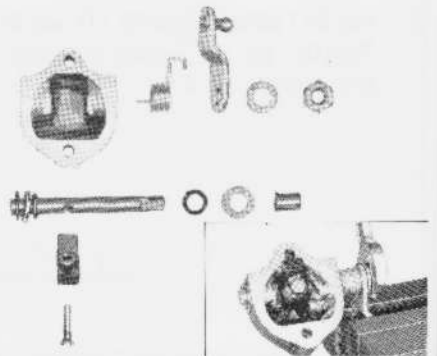


Fig. 3-54 Disassembling Lever Housing

7. Remove injection pump cover with SST [09276-76010].
8. Use SST [09278-46010] to rotate camshaft, and keeping tappet in raised position insert SST [09274-46010] into tappet service holes in order.

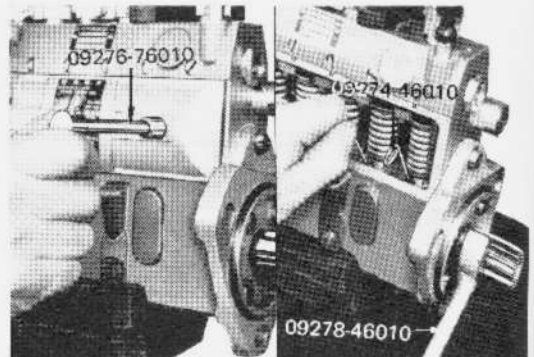


Fig. 3-55 Inserting Tappet Inserts

9. Lay aside the injection pump, and remove the felt plate plug.

Note

Remove the pump from the stand arm to remove the plug No.2.

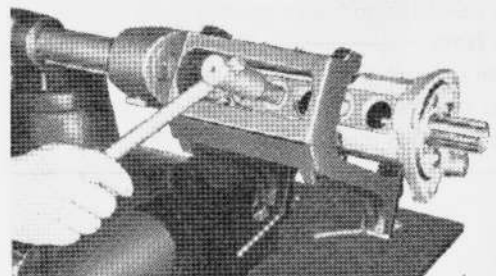


Fig. 3-56 Removing Felt Plate Plug

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10. Remove the round nut using SST[09278-46010] and SST[09266-46011].

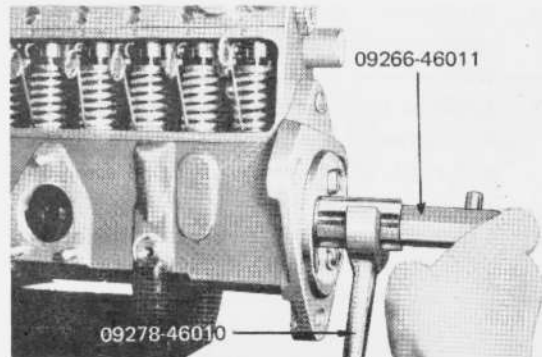


Fig. 3-57 Removing Timer Round Nut

11. Remove spline shaft using SST[09286-46011].

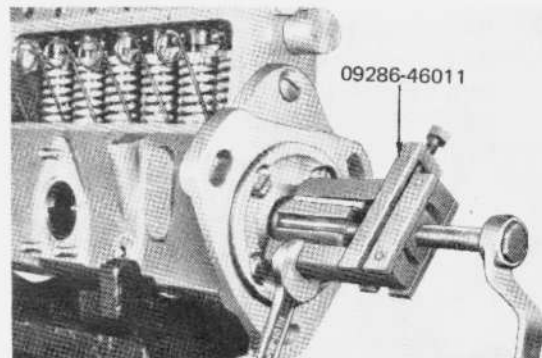


Fig. 3-58 Removing Spline Shaft

12. Unscrewing injection pump flange screw, remove pump flange together with "O" ring.
13. Remove camshaft.

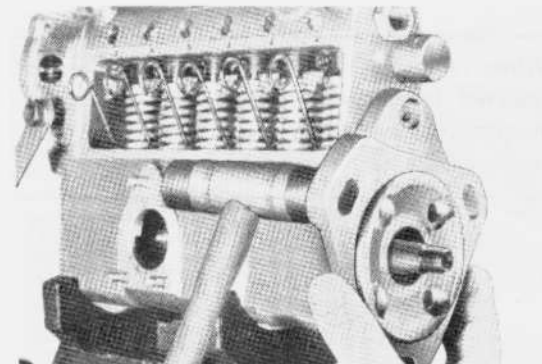


Fig. 3-59 Removing Pump Flange

14. After assembling No.2 delivery valve, inspect control rack sliding resistance.

Specified resistance Less than 150g
(5.3 oz) at pump rpm 0

Caution

Remove carefully the tappet and control sleeves for inspection, when control rack movement is not smooth.

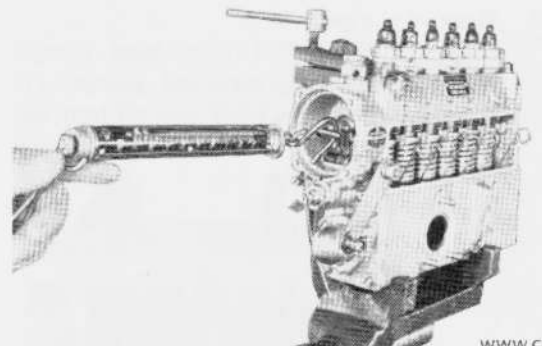


Fig. 3-60 Measuring Control Rack Sliding Resistance

15. Bring down the pump housing so that its upper part comes down a bit below the level.

Note

1. Confirm the control pinion stop position by moving the control rack fully to left and right, to prevent error upon assembling.
2. From now on, keep all parts in the order of each cylinder in disassembly pan.

16. Using SST[09272-76011], lift the tappet to remove SST[09274-46010].

17. Remove tappet.
Hold the tappet inside camshaft chamber with SST[09272-76011] and take out that tappet from camshaft bearing hole, using SST[09273-76011].

Note

When removing tappet adjusting shim plates inserted in tappet upper surface, place the number of sheets and types in the order of each cylinder.

18. Remove plunger.
Use SST[09275-46010] to hold plunger spring lower seat, take out plunger (1) together with spring lower seat (2) from felt plate plug hole.



Fig. 3-61 Removing Tappet Insert

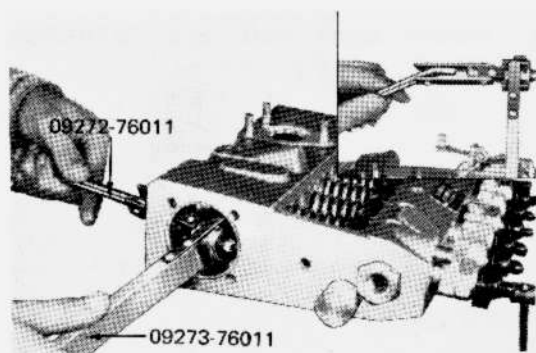


Fig. 3-62 Removing Tappet

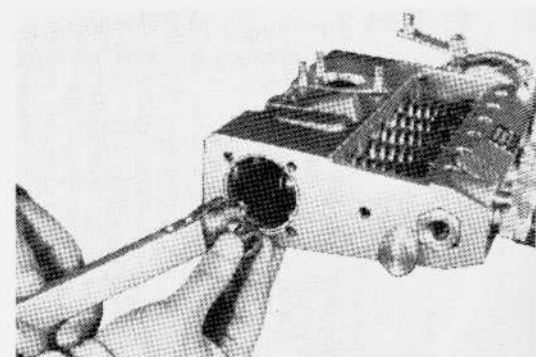


Fig. 3-63 Removing Tappet & Shim



Fig. 3-64 Removing Plunger

19. Take out plunger spring (1).
20. Remove upper spring seat (2) and control sleeve (3) with pinion (4) attached.

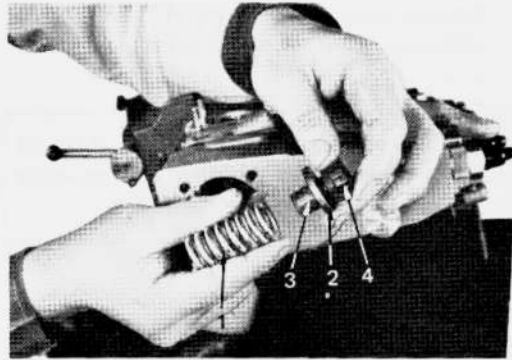


Fig. 3-65 Removing Control Sleeve

21. Loosen rack guide screw to draw out control rack.

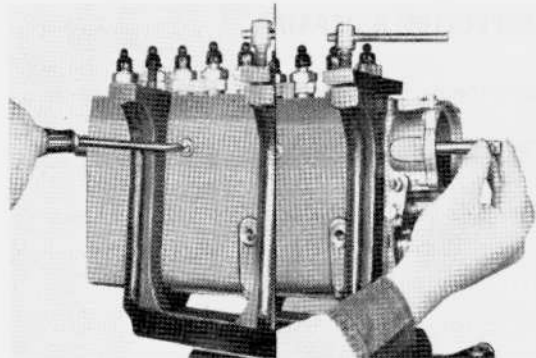


Fig. 3-66 Removing Control Rack

22. Remove delivery valve holder lock plate.
23. Remove delivery valve holder (1) with SST [09270-76010].
24. Remove delivery valve spring (2).

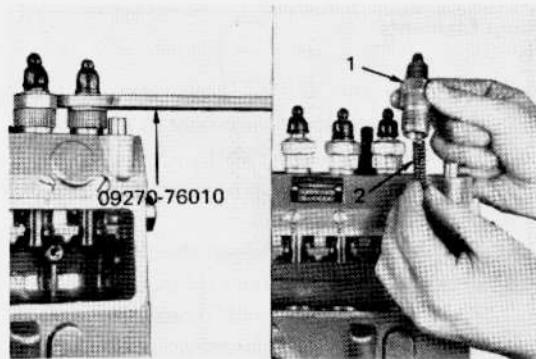


Fig. 3-67 Removing Delivery Valve Holder

25. Remove the delivery valves.
 - (1) Turn the handle at upper part of SST [09271-76011] and screw the tool into the valve seat service screw.
 - (2) Using the handle as lever, pull off the delivery valve seat and gasket as a set.

Caution

Do not screw the tool too far into the seat service screw.

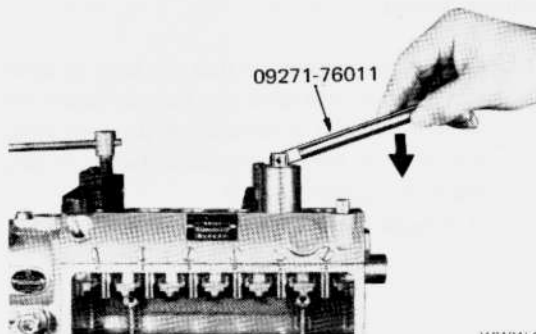


Fig. 3-68 Removing Delivery Valve Seat

26. Remove pump cylinder (1).
27. Remove governor housing sub-assembly.

Caution

Disassemble governor housing only for oil leakage between pump housing and governor housing, and when replacing oil seals.

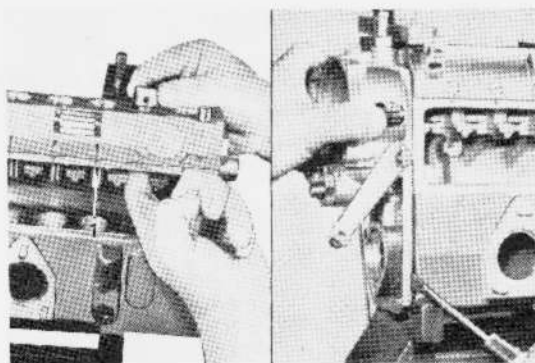


Fig. 3-69 Removing Pump Cylinder & Governor Housing

INSPECTION & REPAIR

Wash the parts in clean light oil before inspecting.

Notes

1. Be careful not to touch the sliding surfaces of the pump elements and delivery valves with your hand when handling them.
2. Wash and clean the outer surfaces of the housings with a soft brush, and blow out the tapped holes with compressed air.
3. Wipe the diaphragm with cloth. Do not allow gasoline, light oil or other petroleum products to get on the diaphragm.

Pump Elements

1. Examine the sliding parts and if found damaged, replace the element as a set.
2. Test the fit. (Sinking test).

Tilt the cylinder slightly and pull out the plunger.

The plunger when released should drop down smoothly in the cylinder by its own weight. Turn the plunger and repeat the test at various places. If defective at any place, replace the element as a set.

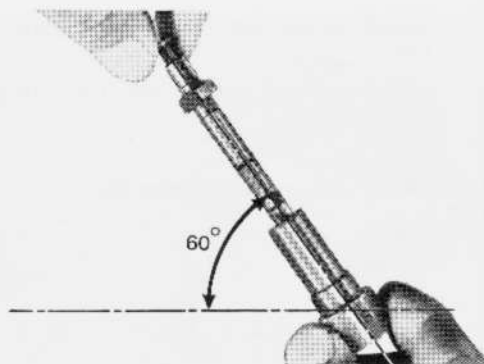


Fig. 3-70 Element Sinking Test

Delivery Valves

1. Pull up the valve and close the hole at valve seat bottom end with the thumb. When the valve is released, it should sink down quickly and stop at the place where the relief ring closes the valve seat hole. If defective, replace the valve as a set.



Fig. 3-71 Testing Delivery Valve

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2. Close the hole at valve seat bottom end with the thumb.
Insert the valve into the valve seat and press down with finger. When the finger is released, the valve should rise back to its former position. Replace if defective.
3. Release the thumb closing the valve seat hole. The valve should close completely by its own weight. Replace if defective.

Note

Before using a new valve set, wash off the rust preventive compound with light oil or gasoline. Then re-wash with light oil and perform the above tests.

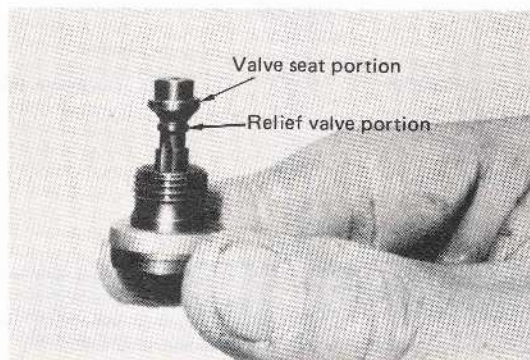


Fig. 3-72 Testing Delivery Valve

Control Rack, Pinion

1. Inspect tooth faces and sliding surfaces of rack, and replace if damaged or otherwise defective.
2. Inspect pinion tooth faces for damage and abnormal wear, and replace if defective.

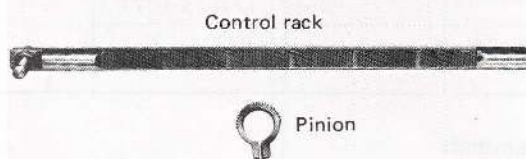


Fig. 3-73 Inspecting Rack & Pinion

Spring

1. Inspect springs for damage, decay and rust, replace the defective one(s).

Table 3-4 Spring Specifications

Spring Items	Plunger Spring	Delivery Valve Spring	Governor Main Spring	Governor Idling Spring
Free length mm (in)	49.4 (1.945")	37.0 (1.457")	105.0 (4.134")	23.7 (0.933")
Total Wind- ing Number	8.5	16.0	10.5	7.9
Installing Length mm (in)	44.0 (1.732")	25.9 (1.020")	36.0 (1.417")	23.7
Installing Load kg (lb)	15.1 (33.3)	4.42 (9.6)	1.04 (2.3)	0 (at 20 mm)

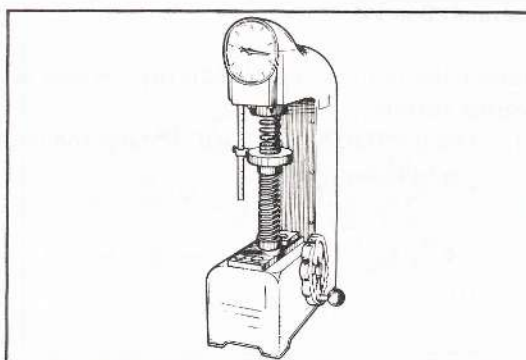


Fig. 3-74 Inspecting Spring

Tappet

Inspect tappet (1), tappet roller (2), bushing (3) and pin (4) for wear, and replace if defective.

Wear limit 0.1 mm (0.004")

Table 3-5 Tappet Specifications

Parts Nomen.	Parts	Specified Value mm (in)	Oil Clearance Limit
Tappet Roller	Outer Diameter	17,0 (0,669")	0.3 mm (0,012")
	Inner Diameter	11,050 to 11,077 (0,435 to 0,436")	
Tappet Bushing	Outer Diameter	11,0 (0,433")	0.3 mm (0,012")
	Inner Diameter	7,02 to 7,05 (0,276 to 0,278)	
Roller Pin	Outer Diameter	6,972 to 6,987 (0,274 to 0,275)	

Camshaft

Inspect oil seal contact surface (1) and cam surface (2), replace if excessively worn and damaged.

Camshaft Bearing

Inspect the bearing, and if defective, replace as a bearing assembly.

1. Using SST[09950-20010], remove the bearing from camshaft.
2. Using SST[09286-76011], remove the bearing outer race from bearing cover.

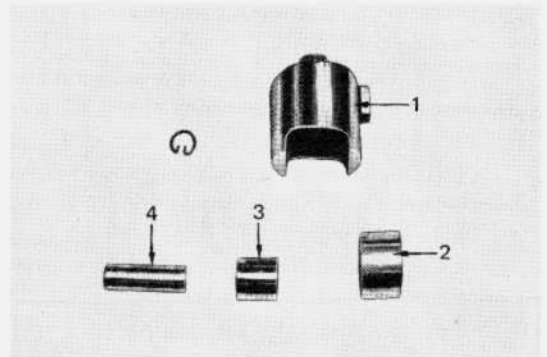


Fig. 3-75 Inspecting Tappet

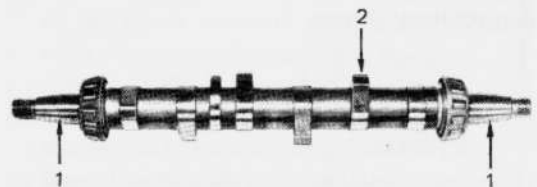


Fig. 3-76 Inspecting Camshaft

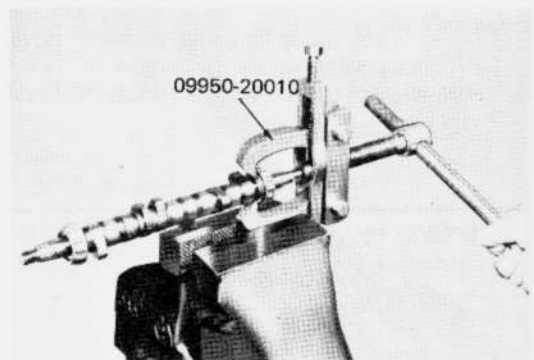


Fig. 3-77 Removing Bearing

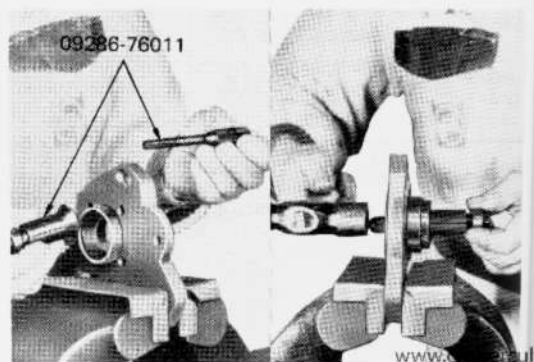


Fig. 3-78 Removing Bearing Outer Race

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- 3 Press the new bearing outer race into bearing cover

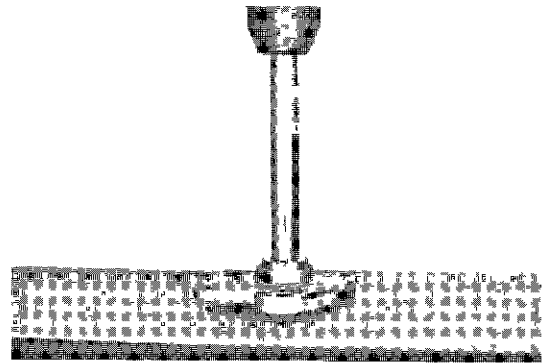


Fig 3-79 Assembling Bearing Outer Race

- 4 Use SST [09285-76010] to assemble adjusting shim plate and bearing cone into cam shaft and install with a press

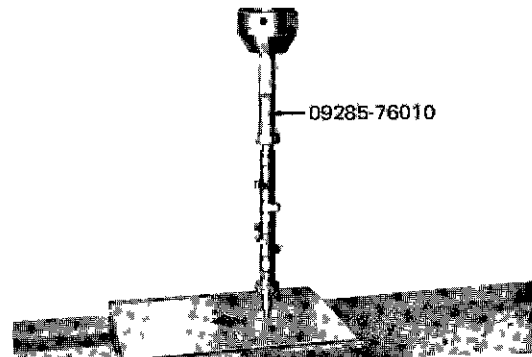


Fig 3-80 Assembling Bearing

Pneumatic Governor

Inspect pneumatic governor component parts and replace if defective

- 1 Diaphragm (1) for damage and tear
- 2 Main spring (2) for damage and decay.
- 3 Governor stop lever with shaft (3) governor (4) and other shaft for damage, bend and wear conditions
- 4 Fill stop capsule (5) and idling spring capsule (6) for operating condition and spring for decay and damage
- 5 Cam (7) and levers for damage wear and deformation
- 6 Housing (8), (9), (10) for damage, cracks and installing surfaces for damage and deformation
- 7 "O" ring (11), return spring (12) and air hoses for damage, decay and tear

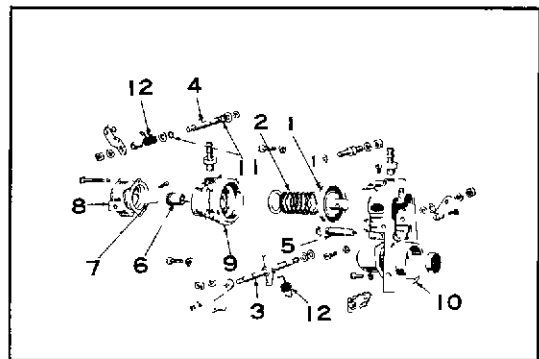


Fig 3-81 Inspection Pneumatic Governor

ASSEMBLY

Caution

1. Separate the replaced and utilizing parts after and wash and keep them in order.
2. Replace gaskets and packings with new parts.

1. Mount pump housing onto pump stand using SST[09245-46010] and SST[09241-76010].

2. Assemble governor housing sub-assembly onto pump housing sub-assembly.

Caution

1. Coat adhesive on the governor housing and pump housing installing surfaces before installation.
2. When assembling injection pump, use a wooden or plastic hammer.

3. Assemble the control rack, and install guide screw.

Note

Confirm that rack moves smoothly.

4. Keep the pump cylinder in line with pump housing knock pin and pump cylinder notch to assemble cylinder.

Caution

Never drive in the cylinder with a wooden or plastic hammer, always install securely with your finger.

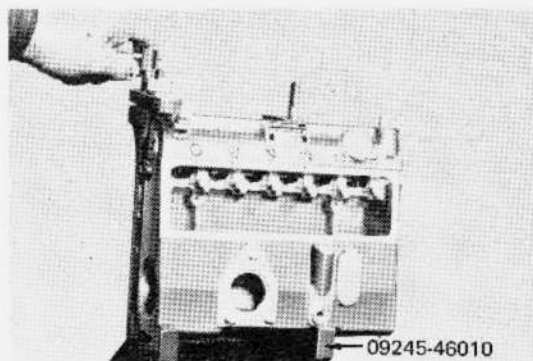


Fig. 3-82 Installing Pump Body into Stand

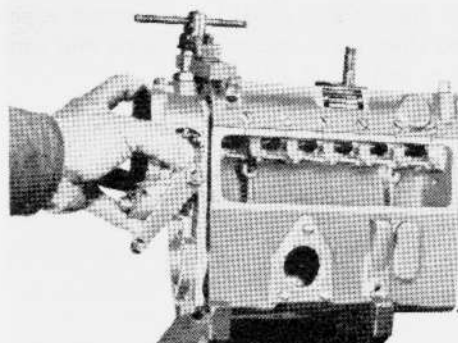


Fig. 3-83 Assembling Governor Housing

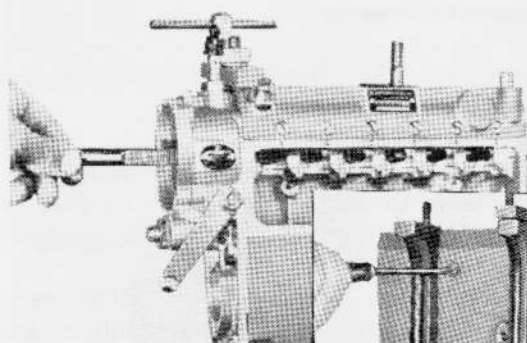


Fig. 3-84 Assembling Control Rack

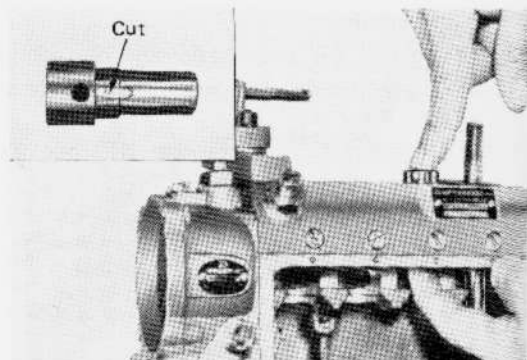


Fig. 3-85 Assembling Pump Cylinder

5. Fitting gasket into delivery valve seat, assemble together with valve, and using SST [09262-76010], drive in lightly with a wooden or plastic hammer.

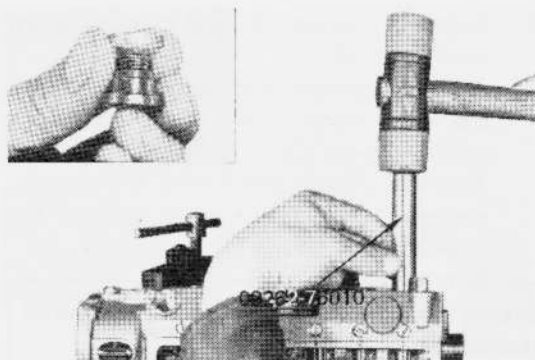


Fig. 3-86 Assembling Delivery Valve

6. Installing delivery valve (1) and spring (2), temporarily tighten delivery valve holders (3) with SST [09270-76010].

Note

When tightening holders using Torque Wrench, inspect control rack sliding after plunger is assembled.

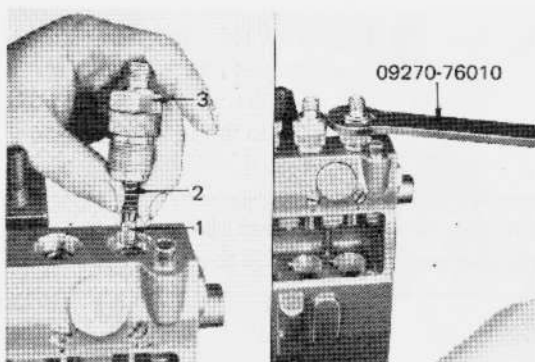


Fig. 3-87 Assembling Delivery Valve Holders

7. Bring down pump housing so that its upper part comes down a bit below the level.
8. Assemble plunger control sleeve and control pinion into pump cylinder.

Note

1. When assembling pinion into control sleeve, place the control sleeve adjusting groove (4) facing toward pinion clamp screw (5).
2. Assemble so that the pinion can evenly swing left and right when rack is moved to right and left.
3. When assembling the sleeves, inspect fitting condition by moving the rack.

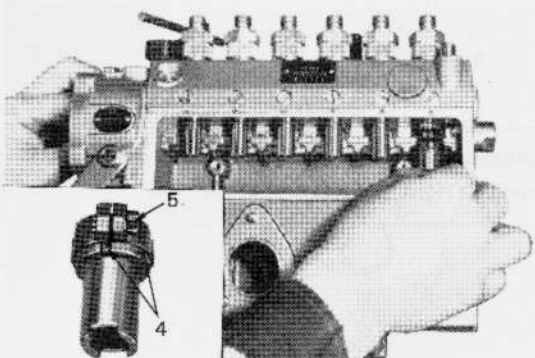


Fig. 3-88 Assembling Control Sleeve

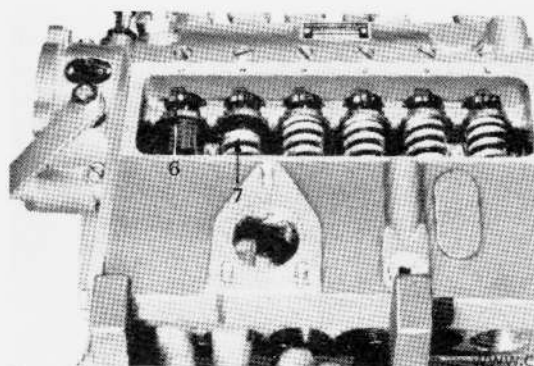


Fig. 3-89 Assembling Plunger Spring

9. Assemble upper spring seat (6) and plunger spring (7).

10. Assemble plunger (8) and plunger spring lower seat (9).

Assemble plunger and spring lower seat, and then insert into cylinder by using SST[09275-46010].

Assemble, facing the driving face marked number upward (cover plate side) and the lower seat notch parts to the opposite side.

Note

Driving face marked number is at control groove side.

11. Use SST[09273-76011] and SST[09272-76011] to insert tappet into the housing. Setting the plunger driving face and control sleeve groove, press in the tappet and hold it by SST[09274-46010].

Note

Fit the driving face into groove facing its number marks to the pump cover side.

12. When all tappets are inserted, tighten delivery valve holders using a Torque Wrench.

Tightening torque

250 to 350 kg-cm (18.1 to 25.3 ft-lb)

Caution

When one place is tightened, move control rack to right and left and inspect rack tightness.

13. Measure control rack sliding resistance with a spring scale, and confirm that the resistance is less than 150 g (5.3 oz) and rack moves smoothly.

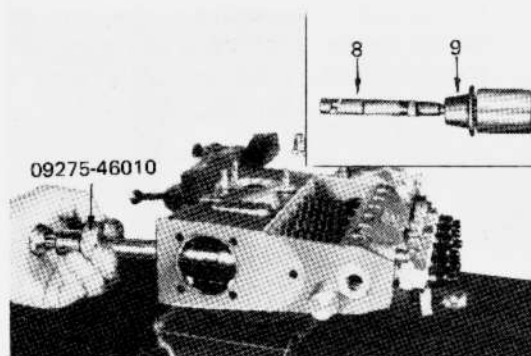


Fig. 3-90 Assembling Plunger Lower Seat

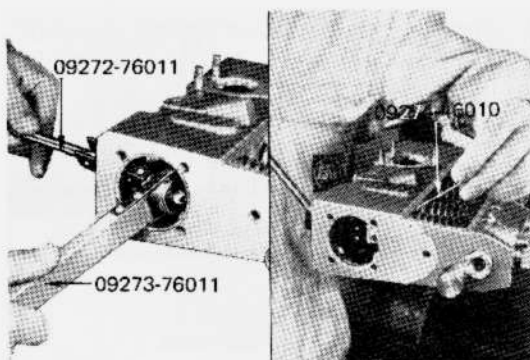


Fig. 3-91 Assembling Tappet

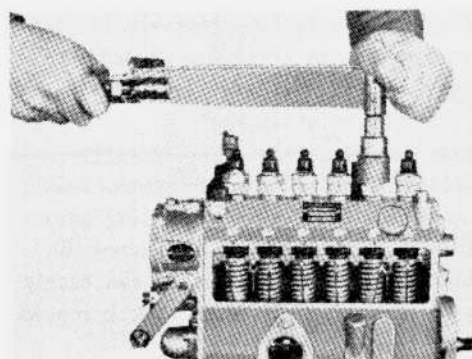


Fig. 3-92 Tightening Delivery Valve

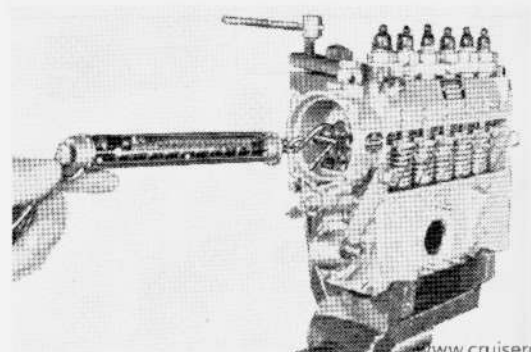


Fig. 3-93 Measuring Control Rack Sliding Resistance

14. Lubricate camshaft bearing with engine oil, and assemble the camshaft.

Note

To assemble the camshaft, position the mark on the camshaft end toward the governor side.

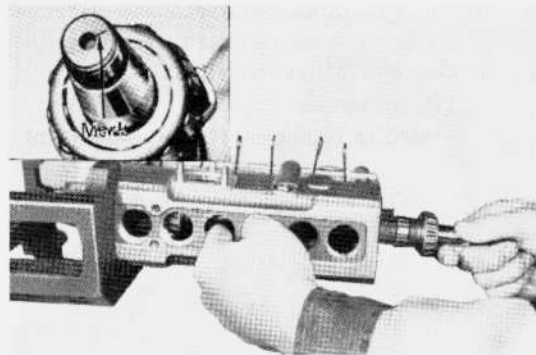


Fig. 3-94 Assembling Camshaft

15. Install injection pump flange, and measure camshaft play in axial direction by using SST [09287-76010].

- (1) Clean the surface of pump flange.
- (2) Loosen the outer dial of SST.
- (3) Tighten the SST handle to camshaft.
- (4) Pushing SST handle toward the pump, contact the outer dial to flange lightly.
- (5) Memorize the scale of SST, strike the rear of camshaft.

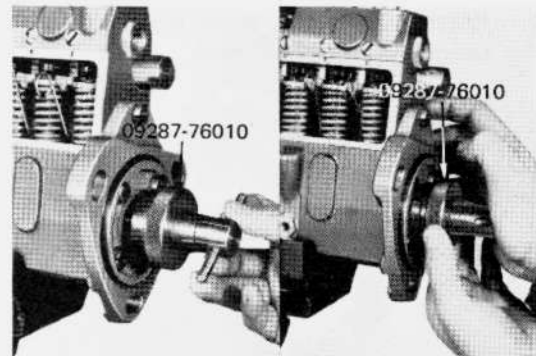


Fig. 3-95 Measuring Thrust Play

- (6) Tighten the outer dial firmly by hand, read the scale of SST.
The screwing distance from dial contact with pump flange is the camshaft play in axial direction.

Specified play:

0.03 to 0.05 mm (0.0012 to 0.0020")

To adjust, increase or decrease camshaft adjusting ring.

Ring thickness: 0.10, 0.12, 0.14, 0.16, 0.18, 0.50 mm

(0.0039, 0.0057, 0.0055, 0.0063, 0.0071, 0.0197")

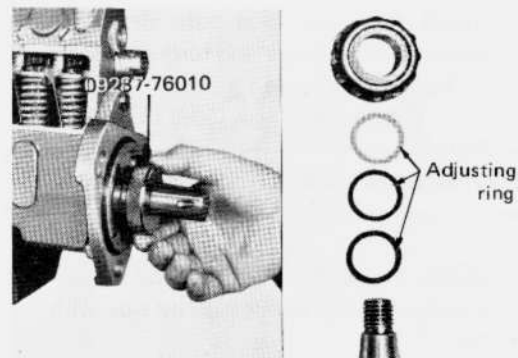


Fig. 3-96 Measuring Thrust Play

- (7) After adjustment, slightly coat liquid sealer on installing surface, and install injection pump flange through "O" ring.

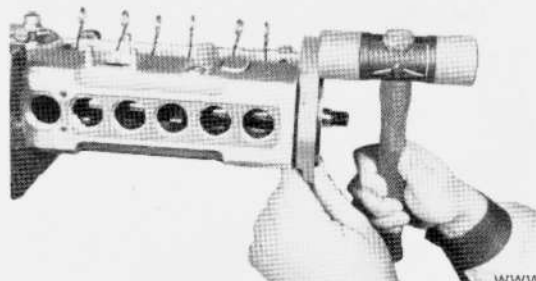


Fig. 3-97 Installing Pump Flange

16. Install key onto camshaft, and assemble spline shaft onto camshaft by using SST [09278-46010] and [09266-46011].

Tighten torque :

600 to 700 kg-cm (43.4 to 50.6 ft-lb)

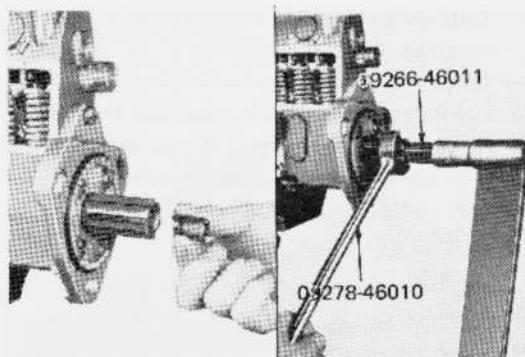


Fig. 3-98 Installing Spline Shaft

17. Rotate camshaft by above Holding Tool to remove SST [09274-46010].

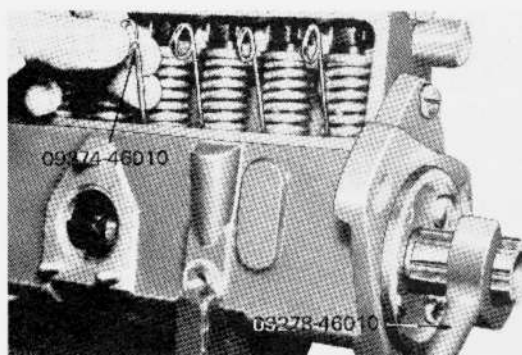


Fig. 3-99 Removing SST [09274-46010]

18. Install the lower plug onto the pump by using a extension bar and torque wrench.

Tightening torque :

550 to 750 kg-cm (39.8 to 54.2 ft-lb)

Note

Apply MP grease onto the plug screw threads.

19. Perform pump test in this condition and assemble the governor side by side with the test.

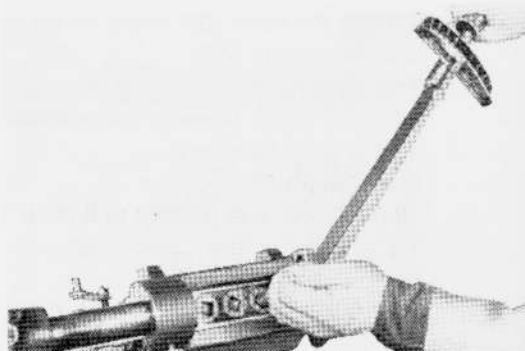


Fig. 3-100 Installing Lower Plug

20. Install the diaphragm with connecting bolt (1), plate washer (2) and cotter pin (3) onto the rack.

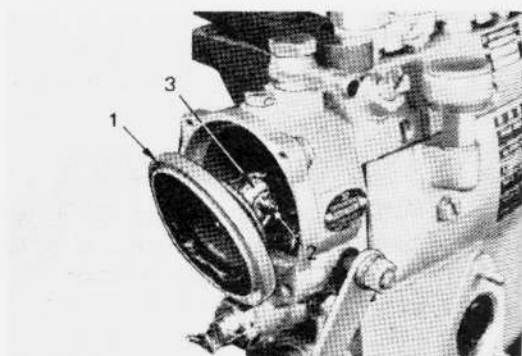


Fig. 3-101 Installing Diaphragm

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21. Install the main spring (1), spring shim (2) and diaphragm housing (3) onto the governor housing.

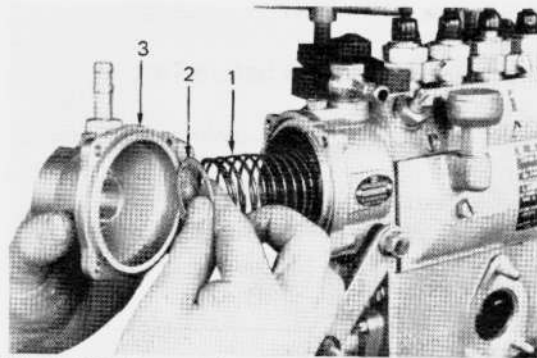


Fig. 3-102 Assembling Diaphragm Housing

22. Install the idling capsule (1) and lever housing (2).

Note

When assembling, coat shaft, cam and inside of lever housing with MP grease.

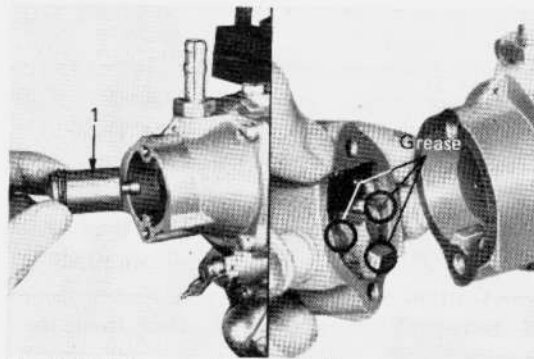


Fig. 3-103 Assembling Lever Housing

23. Install the delivery valve holder lock plates (1).
24. Assemble fuel pump assembly (2) with "O" ring.
25. Lubricate pump housing with diesel oil and diaphragm with diaphragm oil.

Oil quantity: Pump housing — 150 cc
(0.2 cu.in.)

Diaphragm 2 to 4 drops

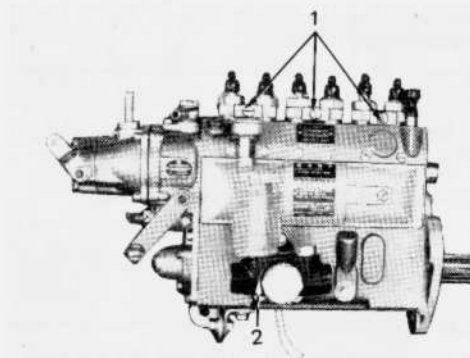


Fig. 3-104 Installing Fuel Pump

26. Remove injection pump from pump stand.

INJECTION PUMP TEST

Check & Preparations before Test

1. Test nozzle and nozzle holder specifications:

Nozzle 4 SD-24
 Nozzle holder valve-opening pressure
 100 to 110 kg/cm²
 (1,422 to 1,565 psi)

Caution

Re-adjust the valve-opening pressure after each after each 20 hours use.

2. The following items must be utilized for injection pipes.

Outer diameter 6 mm (0.24")
 Inner diameter 1.6 mm (0.06")
 Length — 600 mm (23.62")
 Minimum bending radius — More than
 25 mm (0.98")

Caution

If tested or adjusted with other than the specified pipe, specified injection adjustment may not be satisfactory, and after assembling into engine, excessive smoke and defective fuel consumption may occur.

3. Oil feeding pressure to injection pump should be 0.5 kg/cm² (7.1 psi)
4. Remove fuel pump.
5. Be sure to measure the injection of each cylinder at the specified measuring cylinder.

Note

Topple the measuring cylinder for 30 seconds for light oil to gush out, and after that raise the cylinder to measure.

6. Correct the tachometer after every 2 months.

Accuracy At 2,000 rpm $\pm$ 1%

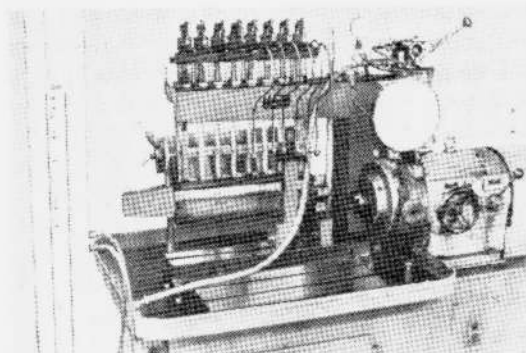


Fig. 3-105 Inspecting Pump Tester

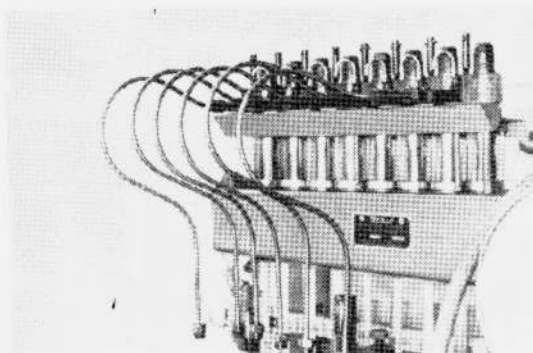


Fig. 3-106 Inspecting Test Injection Pipe

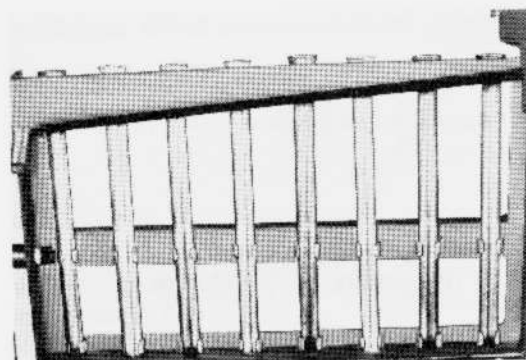


Fig. 3-107 Inspecting Measuring Cylinder

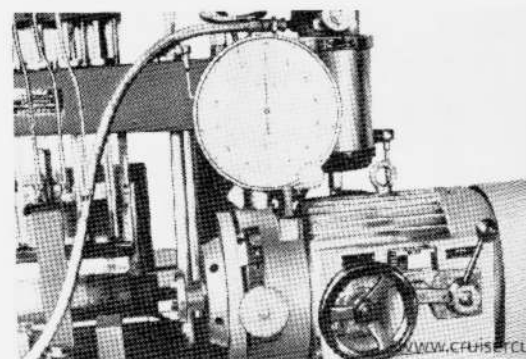


Fig. 3-108 Inspecting Tachometer

7. U-tube for measuring vacuum pressure
Observe water column at zero point and at adjusting points, and correct if necessary.

Note

Recording of adjusting points on graph paper is not accurate since the error due to graph paper expansion is quite large.

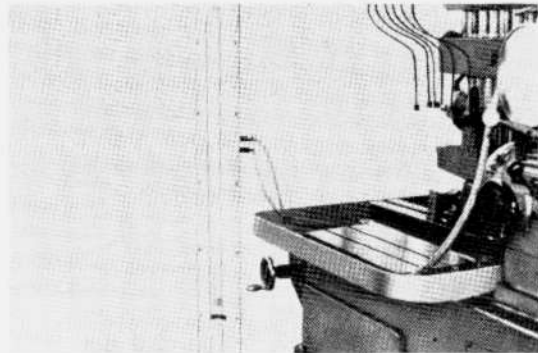


Fig. 3-109 Inspecting U-Tube

8. Insert spline shaft flange into spline shaft, and install injection pump into pump tester.

Note

It is better if there is a little of thrust play between pump and tester.

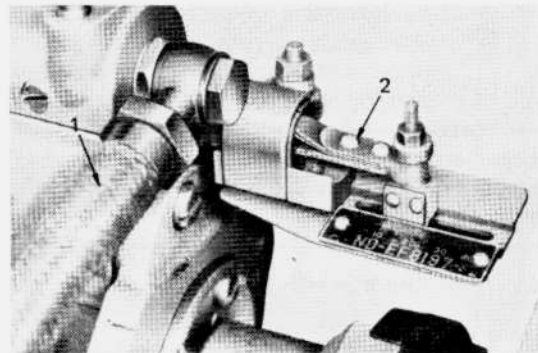


Fig. 3-110 Installing Rack Scale

9. Remove control rack cover and install device joint bolt. Then install fuel hose (1), rack scale (2) and injection pipes.

Note

Install the rack scale so that its zero point will be at the position where the control rack is pushed fully toward the governor side, and set it to allow easiest reading of scale graduations.

10. Check oil level in the pump housing, and replenish if necessary.
11. Using SST [09276-76010], loosen the air bleed plug and bleed outair.

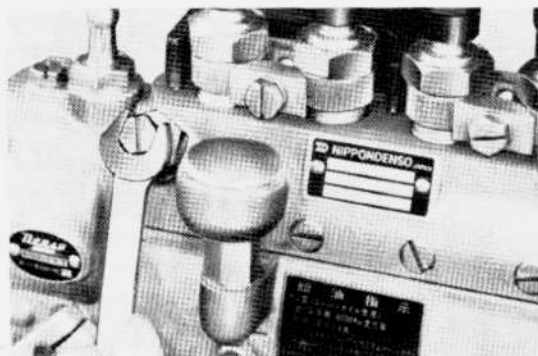


Fig. 3-111 Air Bleed Pump

Tests

Measuring Control Rack Sliding Resistance

Measure control rack weight with the spring scale (spring balancer).

Table 3-6 Control Racks Sliding Resistance

Pump revolution	Sliding Resistance
0 rpm	Less than 150 g (5.3 oz)
1,000 rpm	Less than 50 g (1.8 oz)

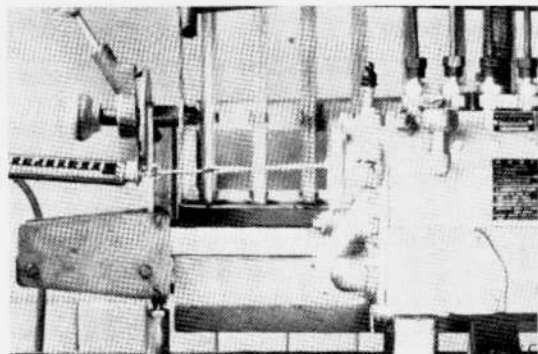


Fig. 3-112 Measuring Rack Sliding Resistance

Injection Timing Adjustment

1. Measuring Pre-stroke.
 - a) Set the control rack position at 11 mm (0.433")
 - b) Use dial gauge and SST [09283-46010] to measure the lift (pre-stroke) of No.1 cylinder when the plunger moves from bottom dead center position to injection starting time (till the fuel flowing to overflow pipe just stops).

Adjusting valve 1.9 to 2.0 mm
(0.075 to 0.079")

- c) For beyond the adjusting valve, adjust by increasing or decreasing adjusting shim plate, located between tappet upper surface and plunger spring lower seat, by using SST [09280-46010].

Note

There are 14 adjusting shim plate thickness types, ranging from 0.1 mm to 1.4 mm with alternation of 0.1 mm.

2. Measuring Injection Intervals.
 - a) Supposing No.1 cylinder injection starting time position as a standard one, inspect and adjust injection starting angle in the order of injection.

Table 3-7 Injection Starting Angle

Cylinder No.	1	4	2	6	3	5
Injection Starting Angle	0	59°30' to 60°30'	119°30' to 120°30'	179°30' to 180°30'	239°30' to 240°30'	299°30' to 300°30'

- b) Follow the similar procedures as in the case of pre-stroke adjustment, if injection starting angle is beyond adjusting value.

Note

With the increase or decrease of 0.1 mm of the adjusting shim plate, the injection starting angle will vary by 30'.

3. Measuring Tappet Clearance
 - a) Use SST [09280-46010] to insert 0.2 mm (0.008") of the SST [09288-46011] into the tappet clearance, and GENTLY rotate the camshaft BY HAND; it is satisfactory if camshaft rotates without a large amount of rotating resistance.

Adjusting value: More than 0.2 mm (0.008")

Caution

At this time, do not rotate motor of tester.

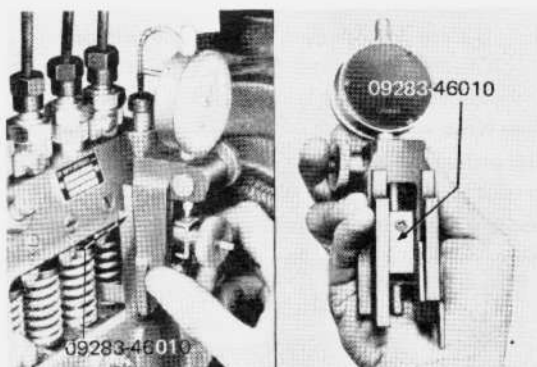


Fig. 3-113 Measuring Pre-stroke

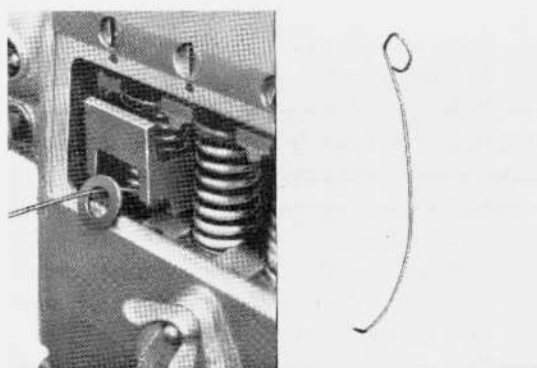


Fig. 3-114 Shim Adjustment

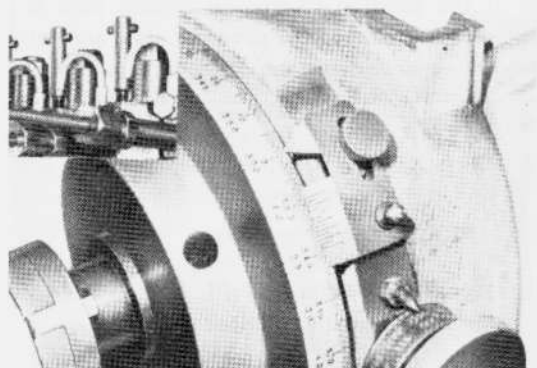


Fig. 3-115 Adjusting Injection Gap

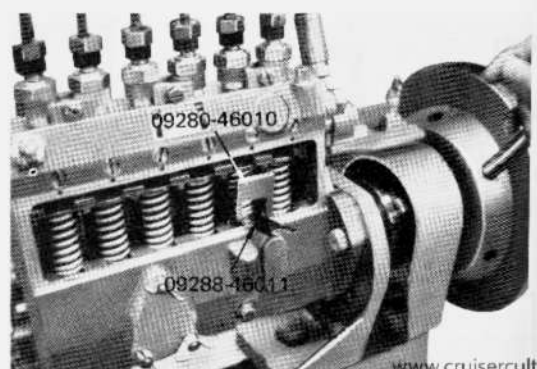


Fig. 3-116 Measuring Tappet Clearance

- b) If defective, repeat the inspection and adjustment from the item of pre-stroke adjustment.

Note

If pre-stroke and injection interval adjustments are correct, the clearance will certainly be more than 0.2 mm (0.008") and so tappet clearance adjustment will be unnecessary.

Injection Volume Adjustment

To adjust the injection, loosen pinion clamp screws and rotate the control sleeve.

Table 3-8 Injection Volume Adjusting Value

Pump revolution rpm	Rack Position mm (in)	Stroke	Injection Limit cc (cu.in.)	Uneven Quantity cc (cu.in.)
1000	10.5 (0.413)	200	8.2 to 8.8 (0.502 to 0.539)	0.4 (0.024)
1000	8.0 (0.315)	200	4.3 to 5.1 (0.263 to 0.312)	0.4 (0.024)
300	6.5 (0.256)	500	2.5 to 4.5 (0.153 to 0.275)	1.0 (0.061)
100	16.0 (0.630)	100	7.0 to 8.0 (0.428 to 0.490)	0.6 (0.037)

Plunger, Delivery Valve Test

1. Plunger test

- a) Install the pressure gauge on delivery valve holder of the cylinder, for test.

Note

Pressure gauge maximum reading

300 to 400 kg/cm² (4,267 to 5,689 psi)

Injection pipe length Approx. 50 mm (1.97")

- b) Fix the control rack with rack scale at 7 mm (0.276"), the position of engine no-load.
- c) Measure the maximum pressure with pump rpm at 200 rpm.

Pressure Above 150 kg/cm² (2,143 psi)

Note

Delivery valve should be in good condition.

2. Delivery valve test

- a) Follow the same procedures as in the case of plunger test, stop pump revolution when the pressure gauge reading exceeds 150 kg/cm² (2,133 psi), and keep the control rack position at zero.
- b) Measure the time required by valve holder to lower its pressure by 10 kg/cm² (143 psi).

Time required for lowering down
10 kg/cm² (143 psi)
More than 5 seconds

- c) If faulty, replace both the plunger and delivery valve.

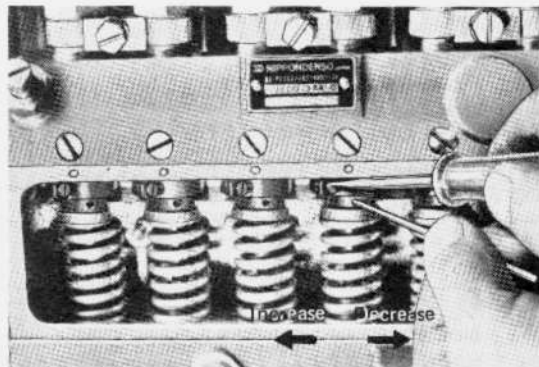


Fig. 3-117 Adjusting Injection Volume

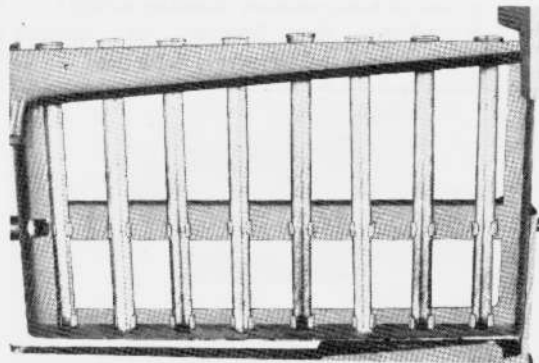


Fig. 3-118 Measuring Injection Volume

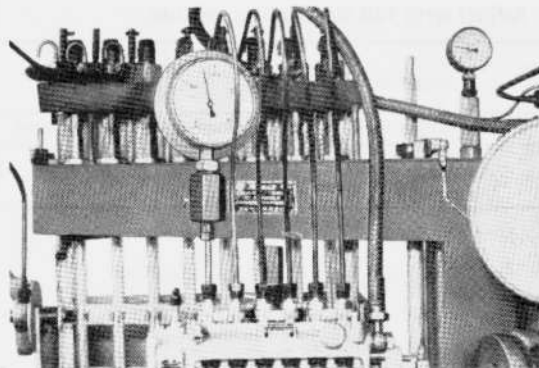


Fig. 3-119 Testing Plunger

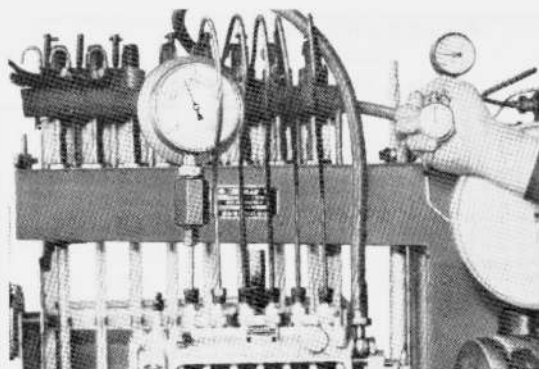


Fig. 3-120 Testing Delivery Valve

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Pneumatic Governor Adjustment

1. Assemble the governor, and perform air-tightness test.

Table 3-9 Airtightness Test

Vacuum Loss	Time
From 500 mm Aq to 480 mm Aq (19.69" to 18.90" Aq)	More than 10 seconds

Notes

1. When assembling the governor, coat diaphragm housing and idling capsule with grease to keep vacuum chamber airtight.
2. Retighten the housing or inspect diaphragm if the airtight is defective.

2. Adjust the initial set of control rack.

Note

Adjust with full load spring capsule.

Table 3-10 Initial Set Adjustment

Pump revolution	Negative Pressure	Rack Position
600 rpm	500 mm Aq (19-11/16")	10,1 mm (0.398")

3. Adjust the main spring

Table 3-11 Main Spring Adjustment

Pump revolution	Vacuum mm Aq. (in Aq.)	Rack Position mm
600 rpm	550 (21.85)	6.5 to 8.2 (0.256 to 0.323")
	600 (23.62)	4.0 to 5.5 (0.157 to 0.217")
	510 (20.08)	9.8 to 10.1 (0.386 to 0.398")
	500 (19.69)	10,1 (0.398") (Initial Setting)

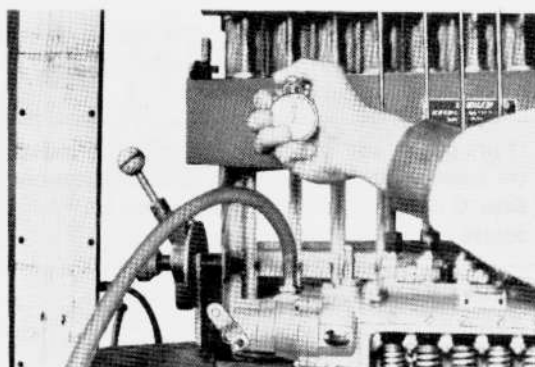


Fig. 3-121 Testing Governor Airtightness

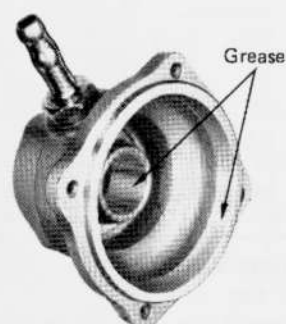


Fig. 3-122 Diaphragm Housing

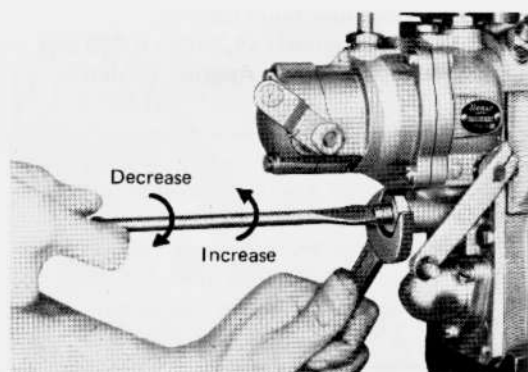


Fig. 3-123 Adjusting Full Stop Capsule

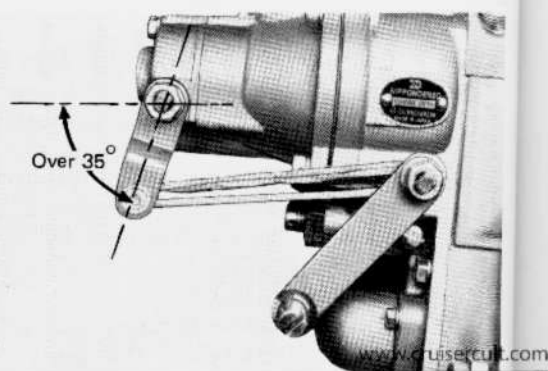


Fig. 3-124 Adjusting Main Spring

Notes

1. Adjust by increasing or decreasing the number of main spring shim.
2. Place cam lever at more than -35° from the level (Fig. 3-124).
3. After finishing adjustment, reconfirm the initial setting.

Table 3-12 Main Spring and Shim

Main Spring	Free Length mm (in)	105 0 (4 134)
	Total Winding Numbers	10 5 Windings
Shim Thickness mm (in)		0 5 1 0 2 0 3 0 (0 02 0 04, 0 08 0 12)

4. Adjust the idling speed

Notes

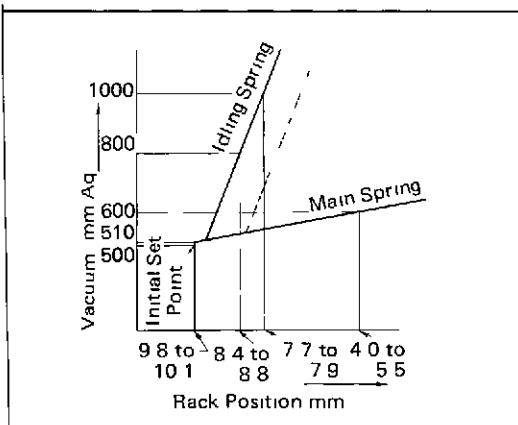
1. Loosening the cam lever, place it in idling position (35° from the level).
2. Adjust with shim and washer inside the idling spring capsule.
3. To adjust the push rod protrusion if shim is thick, the washer should be thinned to the same degree to keep specified push rod clearance. The reverse case is also similar.

Push rod clearance More than 0.3 mm
(0.012")

Table 3-13 Idling Spring Adjustment

Pump revolution	Vacuum (mm Aq)	Rack Position mm (in)
600 rpm	600 (23 62)	9.2 to 9.6 (0.362 to 0.378)
	1 000 (39 37)	7.7 to 7.9 (0.303 to 0.311)

- o There are 4 types in capsule sub-assembly shim and washer: 0.1, 0.2, 0.5, 1.0 mm (0.004, 0.008, 0.020, 0.04")



Governor Spring Characteristic

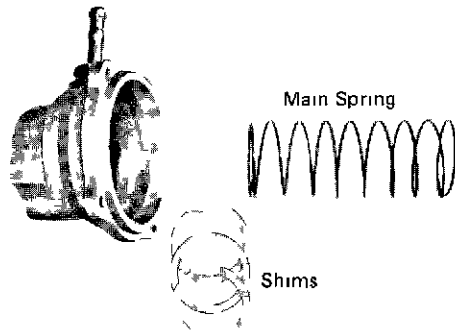


Fig. 3-125 Main Spring & Shim

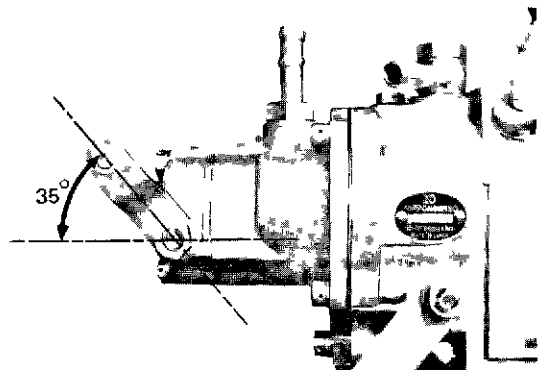


Fig. 3-126 Cam Lever Idling Position

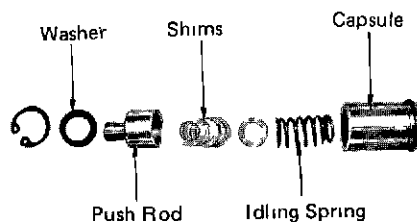


Fig. 3-127 Idling Spring Capsule Components

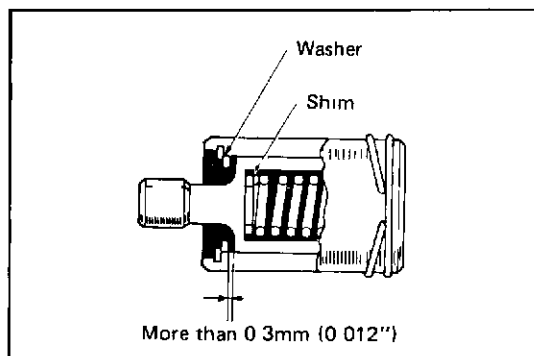


Fig. 3-128 Push Rod Clearance

6. Adjust the total injection.

Table 3-14 Total Injection Adjustment

Pump revolution	Vacuum	Injection Volume (6 cylinder)
1,100 rpm	150 mm Aq (6-7/8")	115.5 to 121.5 cc at 500 strokes 7.04 to 7.41 cu.in. at 500 strokes

Caution

Adjust with the full stop capsule if the injection volume is not within the above value.

7. Seal diaphragm housing (1), lever housing (2) and full stop capsule (3).

8. Set No.1 cylinder at injection start, and confirm the injection start mark of spline shaft.

If not matching, mark again the mating mark on to the flange matching to spline shaft mark.

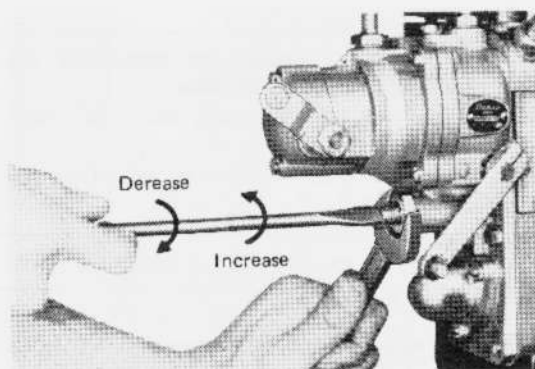


Fig. 3-129 Adjusting Total Injection Volume

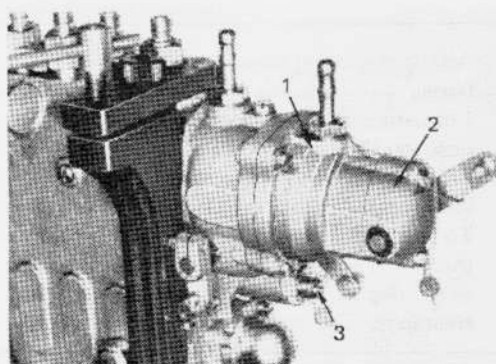


Fig. 3-130 Sealing Governor & Confirming

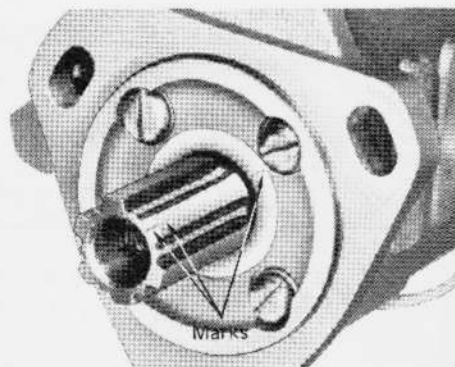


Fig. 3-131 Checking Marks

Automatic Timer Advance Angle Adjustment

1. Assembling automatic timer onto pump spline shaft, install timer flange and then mount onto pump tester.
2. Remove camshaft cover to install timer breaker, and use the stroboscope.

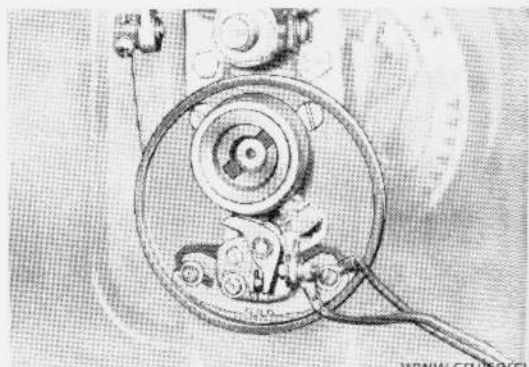


Fig. 3-132 Installing Timer Breaker

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Table 3-15 Automatic Timer Advance Angle

Pump revolution	Advance Angle
450 ~550 rpm	Advancing starts
800 rpm	2.5 to 3.5°
1,050 rpm	5 to 6°
1,800 rpm	7 to 8°Maximum

3. If the advance angle is outside the specified range, adjust by using timer spring adjust washer. These are available in following sizes:

0.1, 0.2, 0.5, 1.0, 1.5 mm
(0.004, 0.008, 0.020, 0.039, 0.059")

Fuel Pump Test

Mount the fuel pump according to the respective pump tester types and perform the tests described below.

1. Suction capacity test

— **Note** —

Suction pipes should be of following sizes.

Pipe inner diameter	8 mm (0.31")
Pipe length	2 m (78.7")
Suction height	1 m (39.4")

- a) Operate the priming pump for one minute at 60 cycles with full stroke.

Suction Capacity

Fuel must discharge within 25 cycles.

- b) If the fuel does not discharge within the specified cycles, check for air entry and then correct or replace the defective parts.
- c) Set the feed pump tester at 150 rpm and test the feed pump suction capacity.

Suction capacity

Fuel must discharge within 40 seconds.

- d) If the fuel does not discharge within the specified time, check for air entry and then correct or replace the defective parts.

2. Discharge Performance Test

- a) Connect the pressure gauge onto the feed pump discharge side.
- b) Operate the feed pump at 600 rpm.

Discharge pressure

More than 1.8 to 2.2 kg/cm
(25.6 to 31.3 psi)

- c) If discharge pressure is insufficient, replace the check valve, feed pump piston and piston spring.

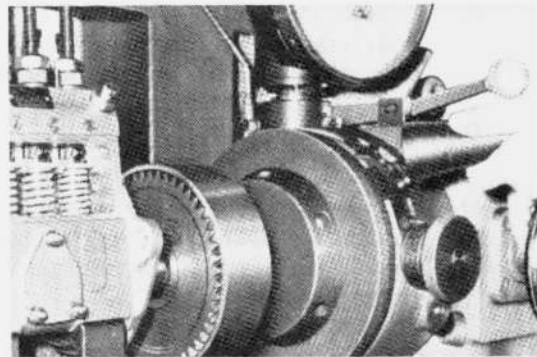


Fig. 3-133 Inspecting Timer Advance Angle

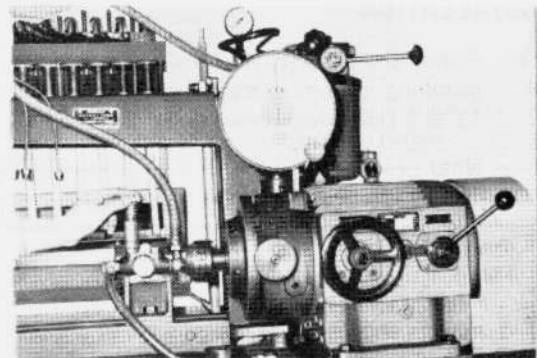


Fig. 3-134 Priming Pump Test

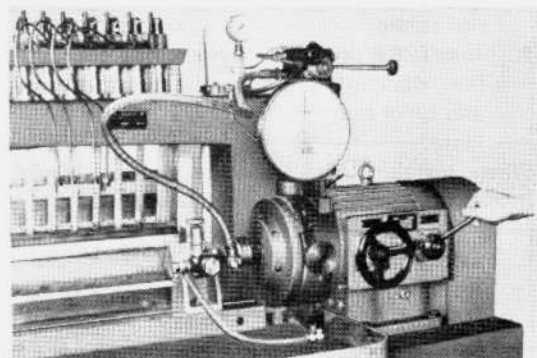


Fig. 3-135 Suction Capacity Test

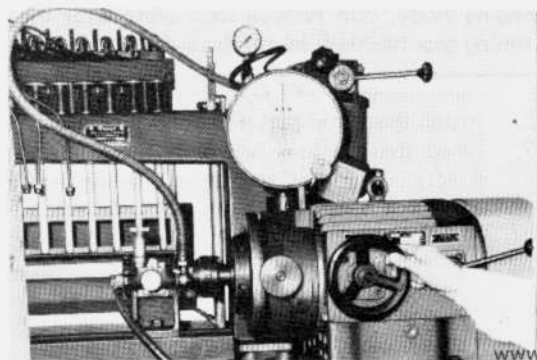


Fig. 3-136 Discharge Pressure Test

- d) Operate the feed pump at 1,000 rpm, and measure the discharge volume from discharge side nozzle of 1.54 mm (0.060") diameter.

Discharge volume capacity

More than 900 cc (54.9 cu.in.)/min.

- e) If discharge volume is insufficient, correct the air entering location or replace the check valve, feed pump piston, piston spring.

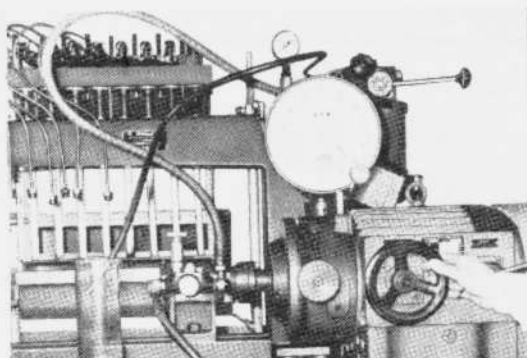


Fig. 3-137 Discharge Volume Test

INSTALLATION

1. Rotate the crankshaft by using crank pulley installing nut and place the No.1 cylinder at 12° B.T.D.C. of compression stroke.

Note

Confirm by removing the valve rocker cover.

2. Align the injection pump spline shaft and pump flange marks.
3. Remove the rear cover to install SST [09284-46010] into camshaft key groove, and after confirming that spline shaft does not rotate.
4. Insert the injection pump into the timer hub, matching the marks of the spline shaft and timer hub.

Note

When installing the injection pumps, apply multipurpose grease on the spline section.

5. Temporarily tighten the injection pump installing bolts and nuts, and remove SST [0928-46010]

Note

Gently pull with your hand the injection pump upper part toward the reverse direction of the engine body, and remove lock plate with the timing gear backlash in eliminated state.

6. Install the pump fuel pipes and the hoses.
7. Bleed the air from fuel pipe, fuel filter and injection pump by operating priming pump.

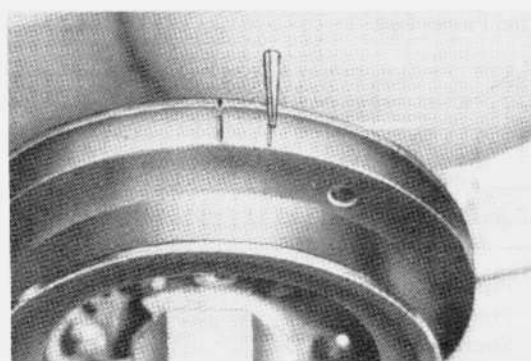


Fig. 3-138 Crank Pulley Mark

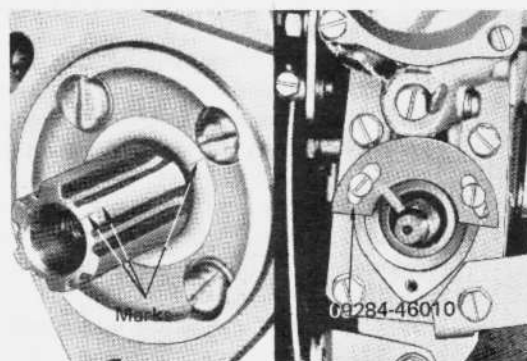


Fig. 3-139 Installing Injection Pump



Fig. 3-140 Mating Marks

8. Install injection timing test pipe in No.1 delivery valve holder, and rotate the crankshaft with crankshaft pulley until fuel starts injection
9. Gently rotate the crankshaft, and adjust slowly tilting the injection pump body to right and left so that the oil surface rising time comes to the position of 12° B.T.D C

Notes

When adjusting injection timing with injection timing test pipe, since there are individual errors and mistakes, it is necessary to repeat the adjustment 3 to 4 times.

- 0 Fully tighten the temporarily tightened injection pump installing nuts and bolts

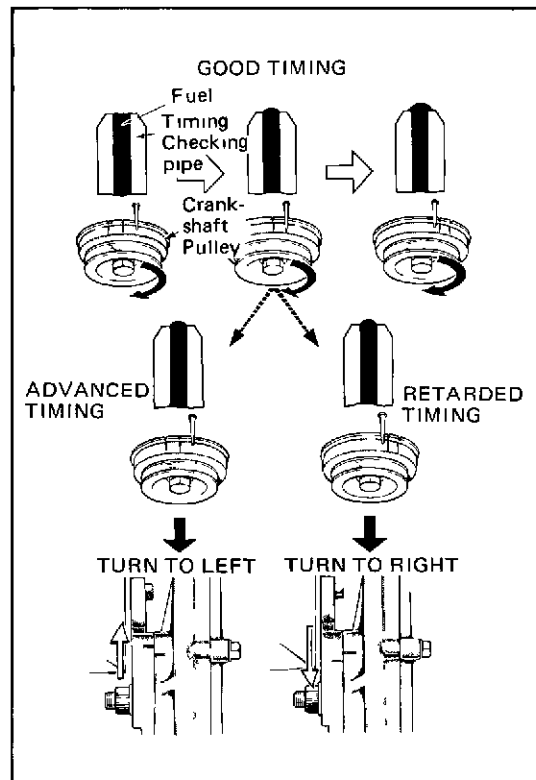


Fig. 3-141 Check and Adjusting Injection Timing

- 1 Install the removed parts

Note

Match the mating mark when installing over injection magnet.

- 12 Crank the engine while depressing the accelerator, and bleed the air within the injection pipes.
- 13 After inspecting the engine while warming, inspect and adjust the idling and maximum revolution.

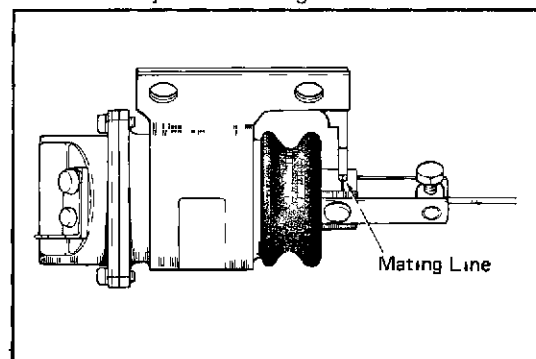


Fig. 3-142 Matching Over-Injection Magnet Marks

MECHANICAL GOVERNOR (RU Type)

GENERAL

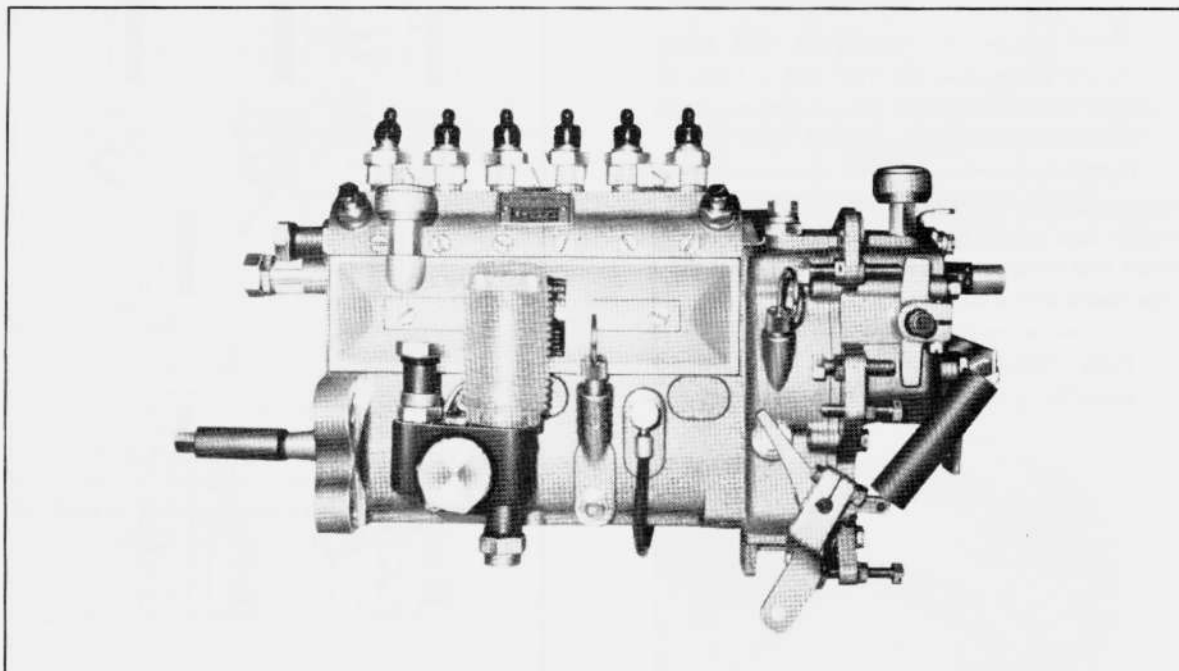


Fig. 3-143 Injection Pump Assembly

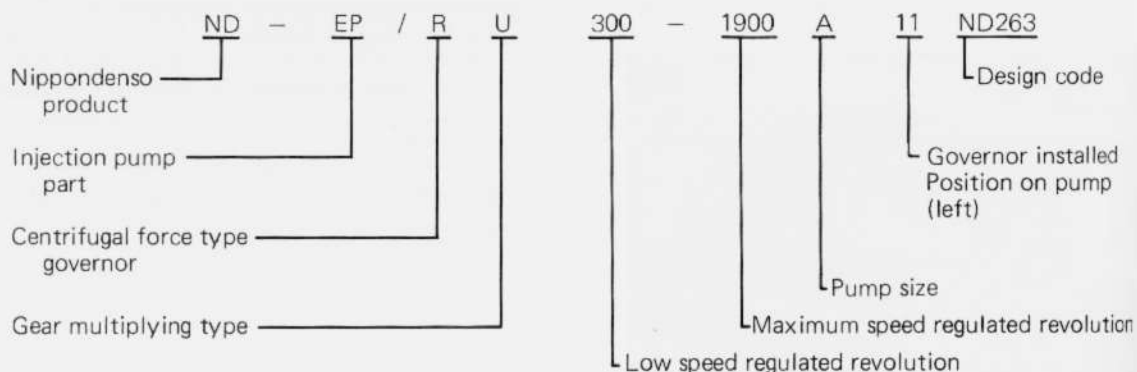
The RU type governor equipped on the Toyota HU series vehicles is of the mechanical type using centrifugal force, and serves to control automatically only the maximum and minimum engine speeds.

Therefore, within the maximum and minimum speed limits, the governor remains inoperative, the speed being controlled by the driver through manipulating the accelerator pedal.

The fuel quantity injected into the engine by the injection pump is varied by the control rack, with the governor performing the control by shifting the control rack in accordance with the engine speed.

In any case, drawing the control rack toward the governor decreases the injection quantity, and pushing the control rack toward the pump increases the injection quantity.

1. Type Number Classification



2. Precautions Upon Handling

When handling the RU type governor care should be given to the following matters

a Oil replenishment

The governor oil capacity should be inspected at every specified mileage or operating hours with the oil level gauge and if it is insufficient remove the breather on the top of the governor or remove the oil level gauge, and replenish from either hole

The oil level gauge is provided with two graduations, and the top graduation indicates the maximum capacity while the lower graduation indicates the minimum. The oil level must always be between these two graduations

Also, at every specified mileage or operating hours, the drain plug installed underneath the governor should be removed, and the oil should be replaced with SAE30 high quality engine oil. (Oil capacity is about 1/0 cc)

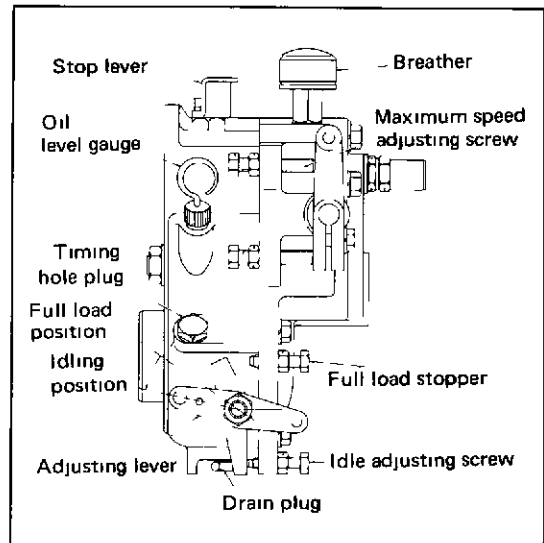


Fig. 3 144 Governor Outside View

Especially, as the RU type governor is of gear mesh type upon driving, and also as the flyweight rotates on the governor shaft with multiplying speed the oil replenishment is essential. If replenishment is insufficient trouble may be encountered due to insufficient lubrication. Thus attention should be given to oil replenishment.

- b Do not open the seals on the full load stopper and maximum speed adjusting screw and carelessly alter the setting positions. (Refer to Fig. 3 144).
- 1) If the setting position of the full load stopper is altered, the fuel delivery quantity during full load will alter and insufficient power and incomplete combustion (blackening of exhaust gas) will be encountered
 - 2) If the maximum speed adjusting screw position is altered, the maximum speed regulated revolution will alter and insufficient power and improper revolution will be encountered
- c The manipulation of the stopper lever should only be performed during engine idling (when the governor adjusting lever is at idling position). If the stopper lever is manipulated when the engine revolution is above low speed revolution the engine will not stop only but may damage the floating lever and shackle within the governor due to extreme force application on these items therefore, carefully manipulate the stopper lever. (Refer to engine stopping paragraph)
- c Pertaining to disassembly and assembly of the governor carefully refer to disassembly and assembly procedures and care should be taken not to encounter incorrect assembly. Especially on the installation of the retainer ring onto the governor gear complete and on the assembly of the governor sleeve and spring seat, perform with care

CONSTRUCTION & OPERATION

1. Construction

The Fig. 3 145 is a cross-sectional view of the RU type governor while the Fig. 3 148 is an exploded view of the components

The governor gear assy (103) (disassembled itm number of Fig. 3-148) on the injection pump camshaft is secured with the round (sleeve) nut (96). The gear installed onto the flyweight (86) is meshed with this governor gear assy. Thus, the flyweight rotates with multiple revolution on the governor shaft (88) which is secured onto the governor housing (77) as a pivot, and this multiple revolution ratio is 2.43 times. Due to this, oil hole is provided in the interior of the governor shaft to lubricate the rotating and sliding components.

The governor gear assy is composed of the camshaft bushing (102) inserted with the governor gear (101) and slip disk (100), and it is secured with the retainer ring (98) by installing it into the groove. This slip disk functions as a plate spring, and performs as a damper to prevent the abnormal wear of the governor gear caused from torque variation encountered during variation of engine revolution.

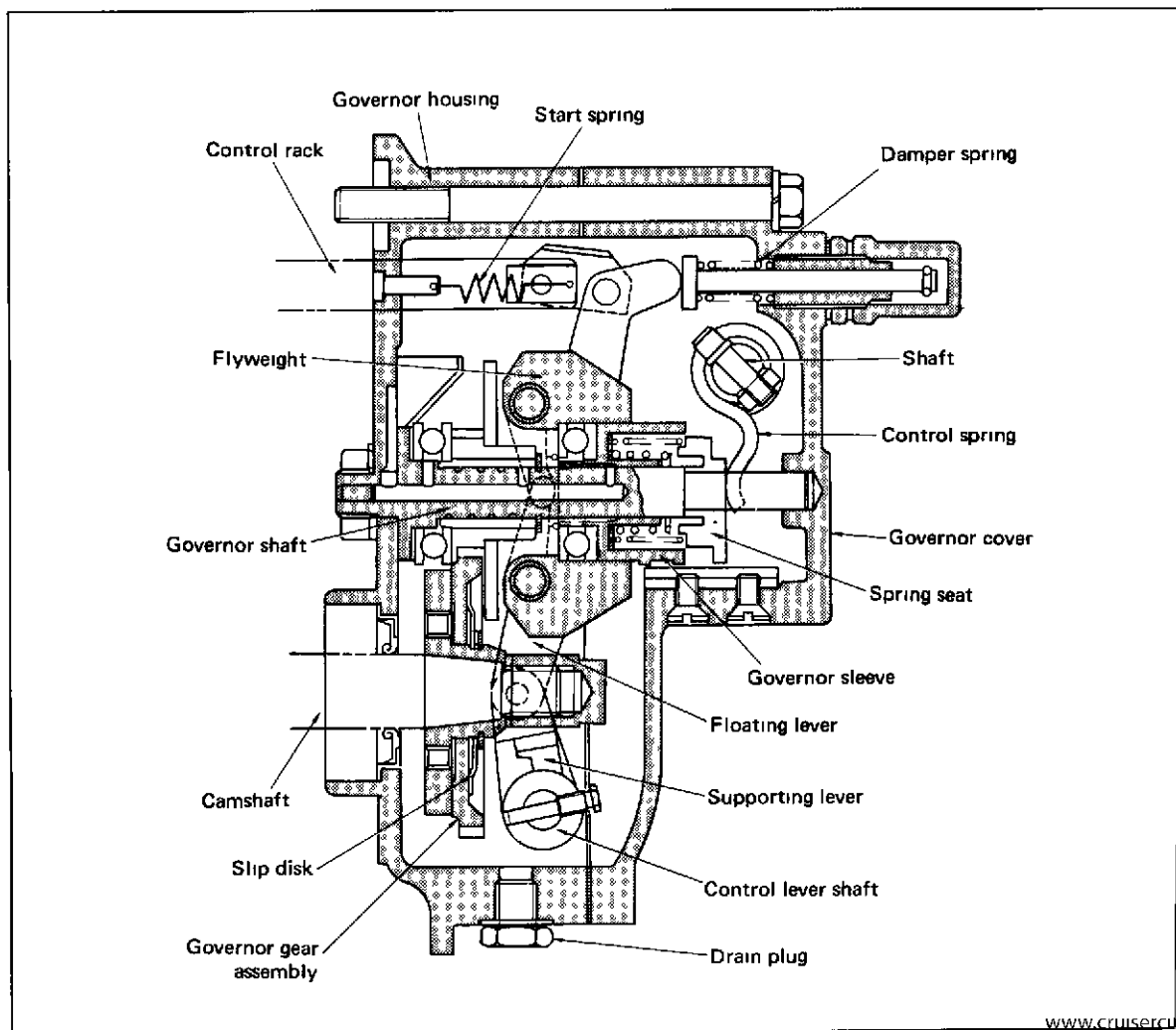


Fig 3-145 Governor Structure

When the flyweight opens externally the arm ends will push the Flyweight sleeve assy (83) thrust bearing shoulder toward the thrust direction.

In the interior of the governor sleeve the idling spring inner (79) and idling spring outer (80) are inserted. The control spring (3) is installed onto the shaft (6) of the governor cover (28), and by this spring tension, the spring seat (78) is pushed against the step cut portion of the governor shaft.

The lower end of the floating lever (68) is connected onto the connecting pin (6) of the supporting lever (40) while the upper end is connected onto the control rack through the shackle (54). The floating lever middle is inserted into the governor sleeve groove, and interlocks with the governor sleeve.

Also the adjusting lever (49) which is installed onto the control lever shaft (41) is connected onto the accelerator pedal. Due to this, when this adjusting lever (49) is moved, the supporting lever (40) moves, thus, the floating lever moves at this middle point as a pivot, and moves the control rack.

Between the control rack connecting arm (55) and governor housing, the start spring (63) is installed, and the fuel delivery quantity is increased during engine starting. If the engine is suddenly accelerated during idling, there is a possibility of stalling the engine.

To prevent this, damper spring (32) is installed on the upper portion of the governor cover.

The stop lever (67) is provided on the governor housing side, and the control rack is pulled back up to the stopping position by the arm (71) which is installed on the same shaft. Also when the hand is released the stop lever will automatically return to driving position by the return spring (73). (Refer to Fig 3-146)

On the RU type governor, as illustrated in Fig 3-147, timing mark is provided on the periphery of the governor gear assy which is installed onto the camshaft while the timing pointer is installed on the governor housing for timing alignment. This facilitates the timing setting of the engine with the mechanical governor on the PES type pump.

Remove the timing hole plug (93) on the governor housing, rotate the injection pump camshaft, and when the timing pointer aligns with the timing mark provided on the periphery of the governor gear assy, No 1 cylinder injection starting position will be obtained.

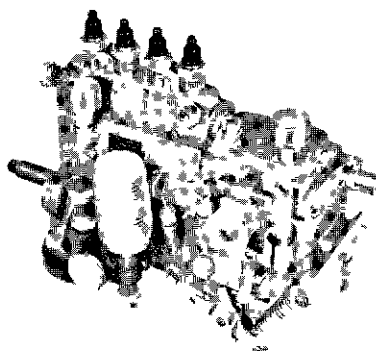


Fig 3-146 Stop Lever

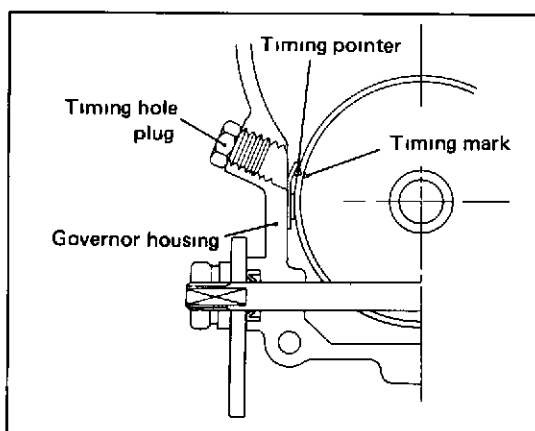


Fig 3-147 Timing Alignment

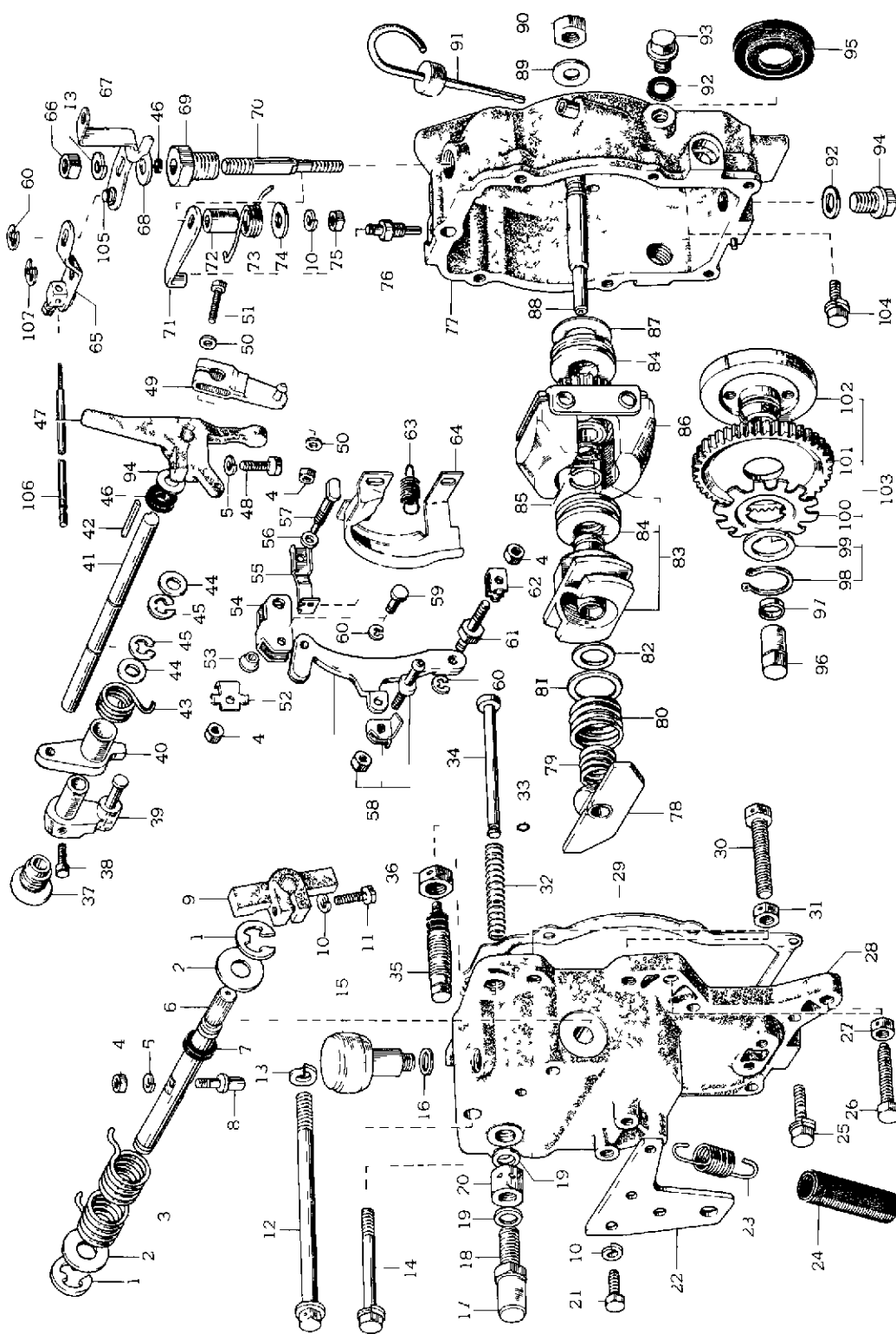


Fig 3 148 Mechanical Governor Components (RU)

3	Governor main spring	47	Stopper	81	Outer washer
6	Shaft	49	Adjusting lever	82	Inner washer
8	Stop screw	54	Shackle	83	Flyweight sleeve
9	Adjusting lever	53	Bushing	84	Bearing
15	Bleeder	55	Spring arm	85	Snap ring
17	Cap nut	56	Bushing	86	Fly weight
18	Adapter capsule	57	Connecting pin	87	Washer
20	Lock nut	58	Floating lever sub-assembly	88	Governor shaft
23	Return spring	59	Shackle pin	91	Oil level gauge
26	Idle adjusting screw	61	Connecting bolt	93	Timing hole plug
	Full load stopper	63	Short spring	94	Drain plug
28	Governor cover	64	Oil guide	95	Oil seal
29	Gasket	65	Adjusting lever	96	Round nut
30	Stopper	67	Stop lever	97	Spring washer
	Maximum speed adjusting screw	69	Bearing bushing	98	Retainer ring
32	Damper spring	71	Arm	99	Shim plate
34	Adapter	73	Return spring	100	Slip disk
35	Spring capsule	76	Stop screw	101	Governor gear
39	Arm	77	Housing	102	Camshaft bushing
40	Supporting lever	78	Spring seat	103	Gear assembly
41	Mechanical governor control shaft	79	Idling inner spring	106	Over injection wire
43	Safety spring	80	Idling outer spring		

2. During Starting

During starting, when the adjusting lever is moved toward the full position, the control rack and floating lever will move toward the direction to increase the fuel delivery quantity, and the governor sleeve will move up to the full closing position of the flyweight.

As the control rack is pushed out up to the position exceeding the full load position to inject required fuel delivery quantity, the engine starting is facilitated (Refer to Fig. 3-149)

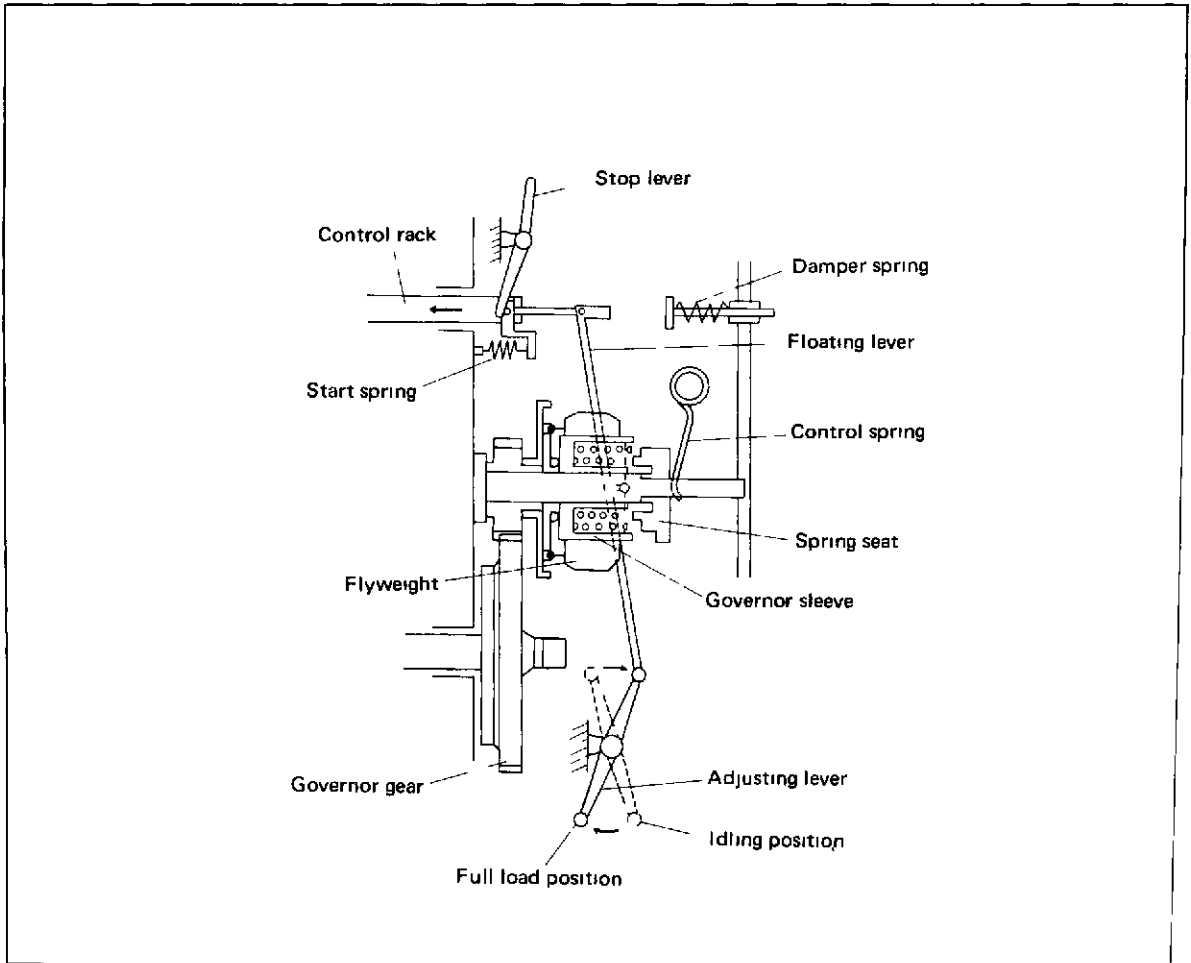


Fig. 3-149 During Starting

3. Idling Control

Once the engine is started, the adjusting lever returns to idling position. In this condition, the centrifugal force of the flyweight is comparatively weak, thus, smooth idling is mainly maintained by the balancing of the sum of the idling spring outer and start spring tension. Also, if the engine revolution exceeds the specified idling, the centrifugal force of the flyweight becomes stronger, thus, the floating lever is moved toward the rear by compressing the idling spring, and as a result, the control rack is moved toward the fuel decreasing direction. Also when the engine revolution reduces, reverse to above will function, thus, constant idling is maintained (Refer to Fig. 3-150)

The damper spring will not contact with the floating lever when the idling is constant, but, when sudden engine acceleration is performed, and when the control rack exceeds the idling position toward the decreasing direction, it will function to prevent the engine from stalling

4. During Intermediate Speed

When the adjusting lever is gradually moved toward the full load side from idling position, as illustrated in Fig. 3 150, the floating lever will move toward the fuel increasing direction at A point as a pivot, and in relation to the increase of revolution, the governor sleeve will move toward the right direction, thus, the speed control is functioned by the idling spring inner and outer which are installed within the governor sleeve until the governor sleeve contacts the spring seat.

When the governor sleeve contacts the spring seat, the pivot A point becomes stationary (as spring seat is pushed against the step cut portion of the governor shaft by the strong spring tension of the control spring), the fuel injection adjustment is maintained without the movement of the adjusting lever, thus, in relation with the load, the operator must adjust accordingly. At this time, the governor does not function the regulation

5. Maximum Speed Control

When the engine exceeds the specified maximum revolution due to reduction of load, the centrifugal force of the flyweight becomes stronger than the control spring tension, thus, the governor sleeve moves together with the spring seat toward the right direction. At this time the floating lever with B point as a pivot will pull back the control rack toward the fuel decreasing direction, and functions not to exceed the specified maximum revolution.

(Refer to Fig. 3 151)

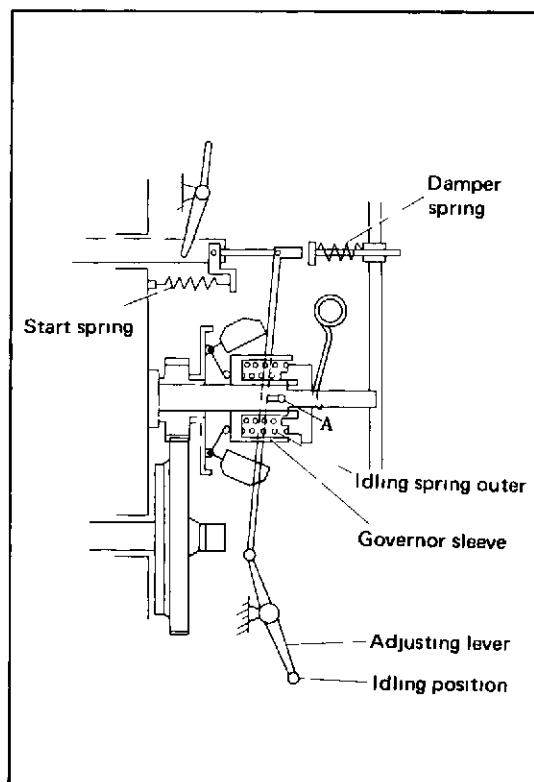


Fig. 3-150 During Idling

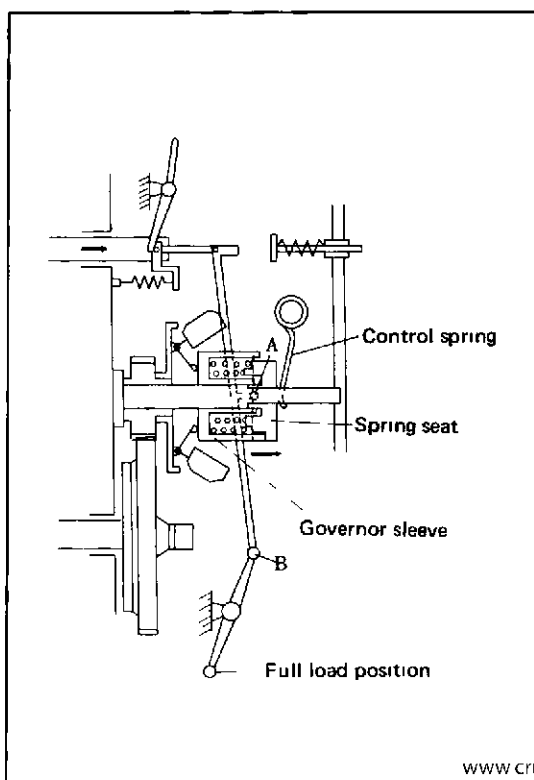


Fig 3 151 Maximum Speed Control

6. During Steep Grade Descent

When descending a grade, the automobile utilizes the engine brake, thus, reversely drives the engine. At this time, the adjusting lever is at idling position, and if the engine revolution becomes higher, the control rack will be pulled back almost to zero position.

When the engine revolution increases and exceeds the no-load maximum revolution, the centrifugal force of the flyweight increases, and the control rack is further pulled back from zero position. As the control rack cannot return further due to being contacted with the rack guide screw, over force will be applied onto the floating lever and shackle. To absorb this over force, the following lever mechanism is provided.

When this type of force is actuated, as illustrated in Fig 3 152, the supporting lever which is secured by the connecting bolt, will move the spring arm toward the rear while compressing the safety spring.

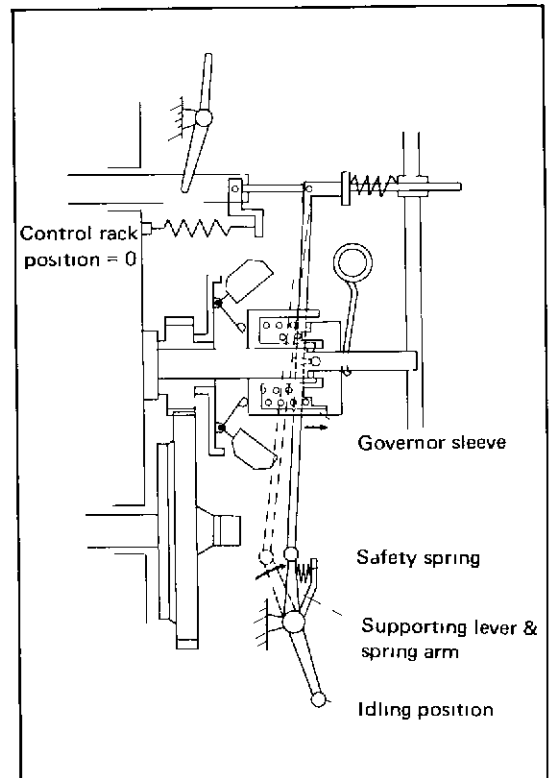


Fig. 3 152 During Steep Grade Descent

7. During Engine Stopping

Set the adjusting lever to idling position, and when the stop lever is manipulated, the control rack will be pulled toward the fuel decreasing direction by the stop lever arm counteracting the damper spring. On the other hand, the floating lever will move the governor sleeve toward the right direction from idling position until it contacts the spring seat.

For this reason, when stopping the engine, the four springs, namely, the start spring, damper spring, idling spring inner and outer are compressed. Thus, the control rack will move almost to zero position from idling position.

If the engine revolution exceeds the specified minimum revolution, the engine stopping cannot be performed even though the stop lever is manipulated. In this case, the governor sleeve is contacting the spring seat, and the spring seat is pushed by the strong tension of the control spring. Due to this, the floating lever middle cannot move toward the right direction at a point, thus, the control rack will not move.

(Refer to Fig 3-153)

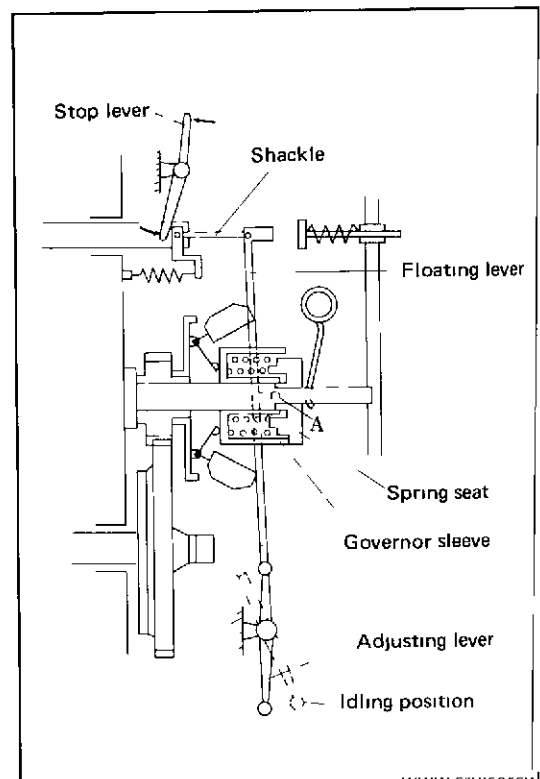


Fig 3 153 When Engine Stopping Cannot be Performed

If the stop lever is manipulated unreasonably, over force will be brought to bear onto the floating lever and shackle, and may cause bending of the lever therefore, it is essential that the stop lever is manipulated only during engine idling

8. Governor Characteristic Curves

The Fig 3 154 is the characteristic curve diagram of the RU type governor. The lines A, B, C indicate the control rack positions in relation to the revolution when the revolution is gradually increased by tilting the governor adjusting lever until it contacts the full load stopper. A-B indicates the full load rack position when the governor sleeve contacts the spring seat. The B point is the starting point of maximum revolution control, and C point is the position when the rack is pulled back reaching almost up to no load by increasing the revolution. Next, the lines E, F, G, H, J indicate the rack positions when the revolution is varied by setting the adjusting lever at idling position. E-F indicates the rack pushed out condition when the start spring functions at very low revolution, and F-G indicates the condition when the sum of the idling spring outer and start spring tension actuates against the centri-fugal force of the flyweight. G-H indicates the condition in which the sum of idling spring outer and inner and start spring tension actuates, and between H-J indicates the condition when the governor sleeve contacts the spring seat by compressing the interior idling spring due to strong centrifugal force. The I point is the specified idling position, and if the damper spring is installed, it will be as per dotted line.

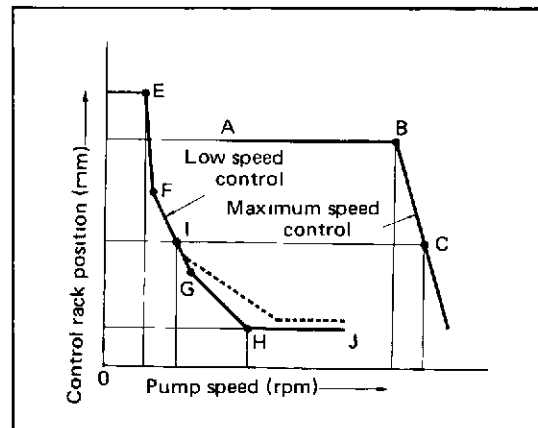


Fig. 3-154 Governor Characteristic Curves

9. Limit Spring

Pertaining to RU type governor, excessive smoking may be produced during full load low speed due to increase of fuel delivery quantity. Fig. 3-156 indicates the characteristic curves of the RU type governor. At low speed revolution, the centrifugal force of the flyweight decreases, and the rack will move toward the fuel increasing direction exceeding the full load position as indicated by a and b in Fig. 3-156

For this reason, the limit spring is installed to regulate the increase of fuel at low speed, and to automatically increase the fuel during starting. This is installed at the end of the control rack on the pump driving side, and the construction is as per Fig. 3-155

The limit spring is assembled with constant load setting, and at intermediate speed, the rack end is separated with A clearance, thus, it is adjusted by rotating the adjusting screw. When the revolution decreases, first, the rack will move toward the increasing direction of A clearance, and will contact the rod. This point is C point of Fig. 3-156

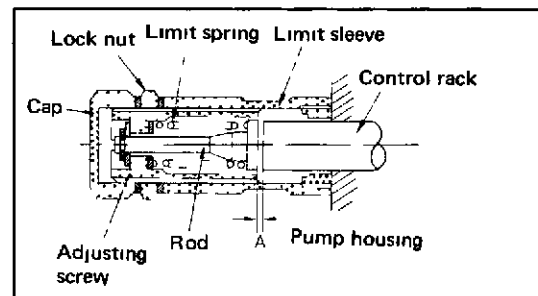


Fig. 3 155 Limit Spring Structure

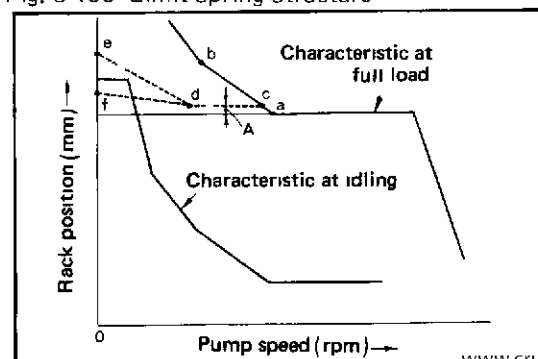


Fig. 3-156 Governor Characteristic Curves

Even when the revolution is decreased slightly more, the rack cannot move until the sum of the tensional load of idling spring and start spring counteracts this limit spring. This condition is between c-d, and regulates the smoking at low speed.

Further, when the revolution is decreased, the rack will compress the limit spring, and will move toward fuel increasing direction. This condition is indicated with d-e, and due to this, increase of fuel is obtained during starting.

10. Spring Capsule

This spring capsule is installed to regulate the increase of fuel at full load low speed revolution of the engine.

The Fig. 3-158 illustrates of this, but, if the spring capsule is not installed, the arm which is installed onto the stop lever shaft will return completely up to the surface of the governor housing, by the return spring as shown with the dotted line.

In the interior of the spring capsule, a spring with a constant setting is inserted.

(This spring as shown in Fig. 3-158 is stronger than the return spring tension.)

By installing this spring capsule, the stop lever, namely; the arm is set at the actual line position. In other words, even when the revolution is decreased, the control rack cannot move until the sum of the idling spring and start spring tension counteracts the interior spring set load of the spring capsule. This condition exists between c-d of Fig. 3-156, and reduces the smoking at low speed.

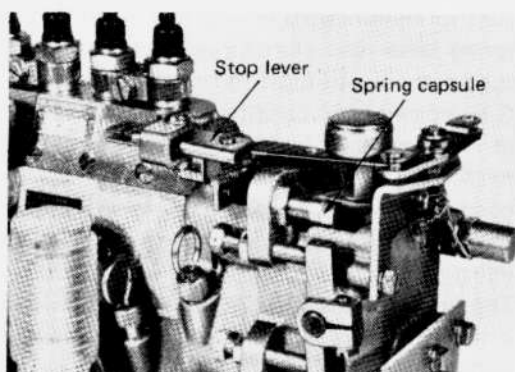


Fig. 3-157 Spring Capsule

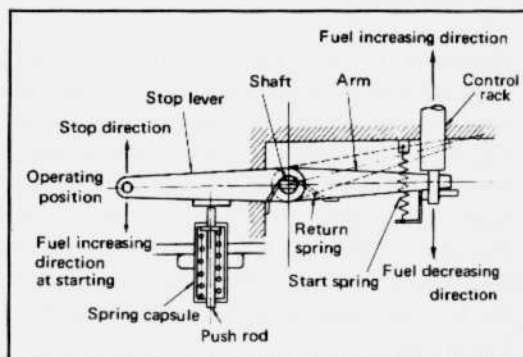


Fig. 3-158 Spring Capsule Action

When the revolution is further decreased, it will be as d-f, but, as this is besides the engine operating revolution, there is no problem. During engine stopping, the stop lever will push in the spring capsule pull rod, and will move toward the fuel increasing direction. As the arm end will separate from the rack, the rack will move toward the fuel increasing direction by the start spring.

DISASSEMBLY & ASSEMBLY

1. Disassembly

When performing the disassembly and assembly of the RU type governor, the following tools are required.

1. Tool set for disassembling and assembling the injection pump.
2. Puller (for pulling out the governor gear).
Nippondenso No. 95907-01020
3. Slip torque measuring tool.
Nippondenso No. 95907-01030
4. Torque wrench (small size of 0 to 120 kg-cm will be adequate).
5. Retainer ring removing pliers.
6. Screwdriver and open-end wrenches of common tools.

Before disassembling the governor, thoroughly wash the pump exterior, and mount the pump onto the work stand as illustrated in Fig. 3-160. Remove the drain plug underneath the governor, and drain the oil.

a. Governor cover removal.

(The figure, indicated in parentheses are disassembled numbers of Fig. 3-148.)

- 1) Remove the return spring (23) of adjusting lever (49), loosen the lock nut of the maximum speed adjusting screw (30), and by loosening this, release the control spring tension within the governor.
- 2) Loosen the six 6 mm and one 8 mm bolts securing the governor cover (28), and remove the governor cover completely by pulling toward the rear as illustrated in Fig. 3-161.

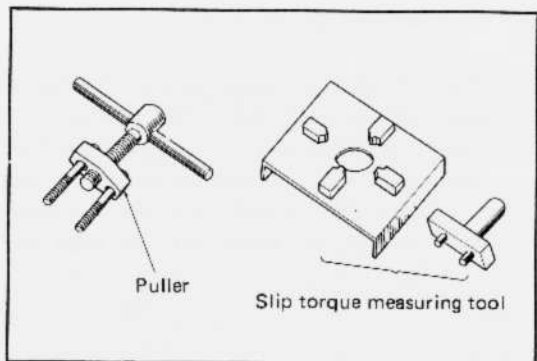


Fig. 3-159 Special Service Tools

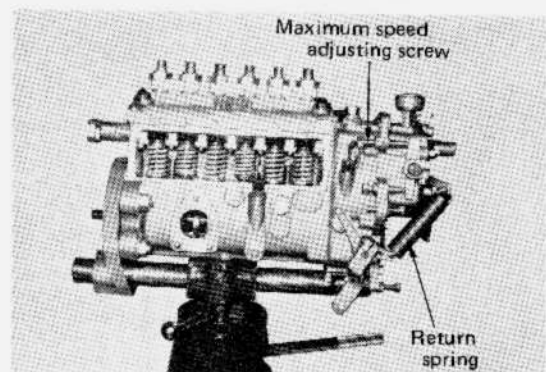


Fig. 3-160 Injection Pump Mount

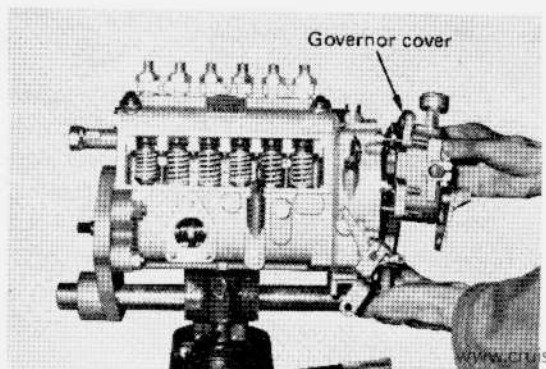


Fig. 3-161 Governor Cover Removal

b. Governor sleeve removal.

Next, remove the spring seat (78) and governor sleeve (83) from the governor shaft.

When the governor sleeve is slightly rotated as shown in Fig. 3-162, the floating lever connection will disengage. Thus, pull out at this position.

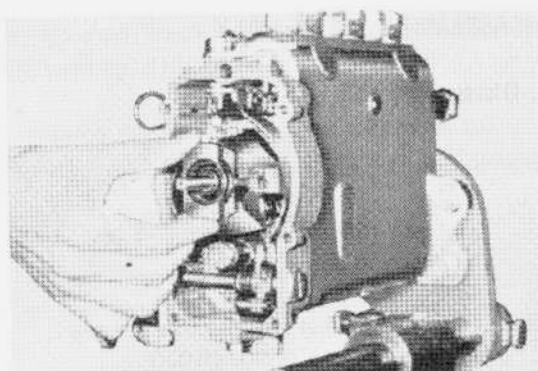


Fig. 3-162 Governor Sleeve Removal

c. Floating lever top removal.

Remove the start spring (63) at the top of the floating lever (58) with a long nose pliers, and open the lock washer (52), then remove the nut. Remove the connecting pin (57) from the control rack. At this time, care should be taken not to drop the bushing.

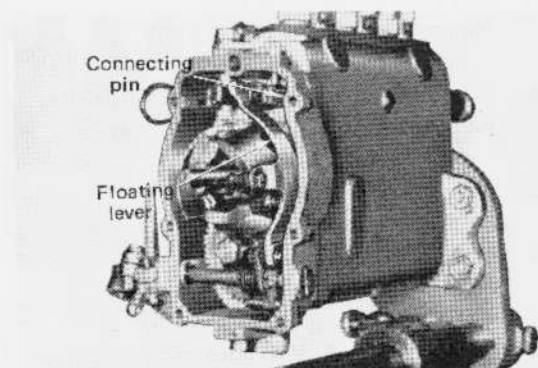


Fig. 3-163 Floating Lever Removal

d. Flyweight removal.

Remove the snap washer (85) securing the flyweight as per Fig. 3-164, and pull out the flyweight (86).

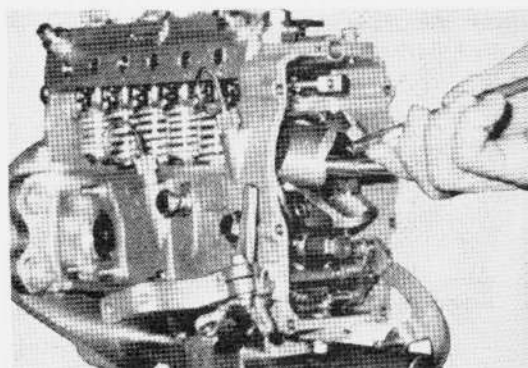


Fig. 3-164 Snap Washer Removal

e. Control lever shaft removal.

Remove the snap washer (45) installed onto the control lever shaft (41). Next, as per Fig. 3-165, loosen and remove the stopper bolt (38) (taper bolt), and remove the floating lever from the arm portion. Then, pull out the control lever shaft toward the side.

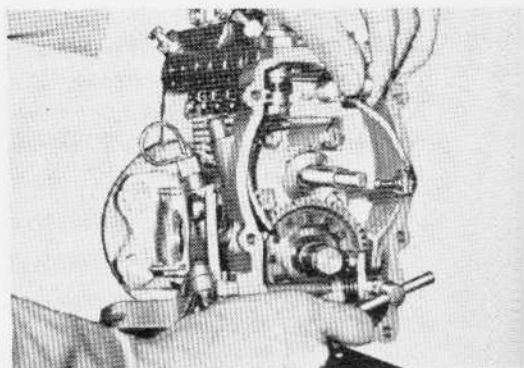


Fig. 3-165 Control Lever Shaft Removal

f. Gear Assy removal.

- 1) Loosen the hexagon round (sleeve) nut (96). Remove the retainer ring (98) of gear assy, and remove the shim plate (99), slip disk (100) and governor gear (101).
- 2) Next, insert the two bolts of the special tool puller (No. 95907-01020) into the 6 mm holes in the camshaft bushing (102), and pull out the camshaft bushing from the camshaft as per Fig. 3-166.

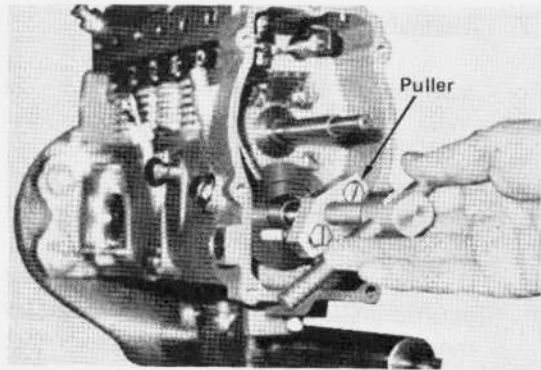


Fig. 3-166 Gear Assy Removal

g. Governor housing removal.

Insert the tappet inserts of the special tool onto the pump unit tappets, and by removing the six screws securing the governor as per Fig. 3-167, the governor housing (77) can be removed from the pump body.

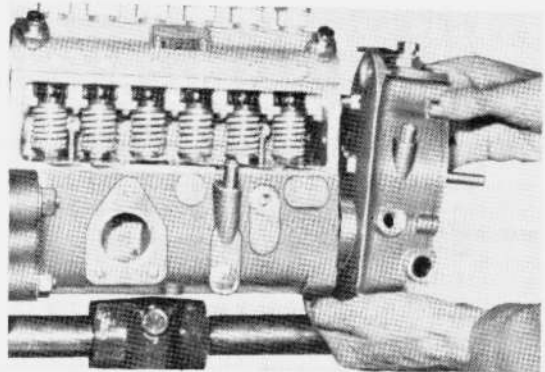


Fig. 3-167 Governor Housing Removal

h. Governor shaft removal.

As per Fig. 3-168, loosen the lock nut (90) on the back of the governor housing, and remove the governor shaft (88).

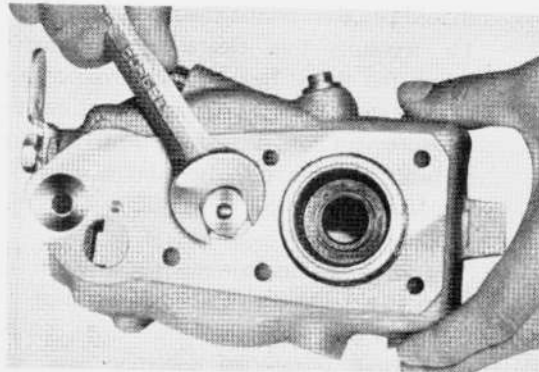


Fig. 3-168 Governor Shaft Removal

i. Control spring removal.

Remove the snap washer (1) at the opposite side of the lever. Next, as per Fig. 3-169, loosen the lock nut (4), remove the stop screw (8), and pull out the shaft (6) toward the side of the governor cover, then, the control spring (3) can be removed.

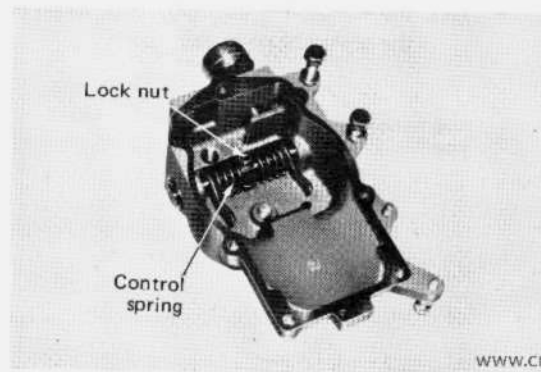


Fig. 3-169 Control Spring Removal

2. Assembly

For assembling the governor, follow the disassembly procedures in the reverse order, but, the following points must be kept in mind.

- a. As illustrated in Fig. 3-170, the oil hole in the governor shaft must always face upward upon assembly.
If this oil hole is faced downward, insufficient lubrication of the flyweight and thrust bearing will be encountered, thus, care should be taken on this matter.
- b. Install the lock nut securing the governor shaft after applying adhesive cement onto the shaft thread, and always properly tighten to 180 to 260 kg-cm (13.0 to 18.8 ft-lbs) torque.
- c. To maintain the clearance between the thrust bearing and gear of 0.35 to 0.85 mm (0.0137 to 0.0336") as per Fig. 3-170, adjust by increasing the shim plates.
If this clearance is excessive, the rear of the flyweight will contact with the retainer ring of the gear assy, and if the clearance is small, there is a possibility that the gear assy may contact with the thrust bearing. Thus, care should be taken on the clearance.

To measure this clearance, temporarily install the thrust bearing and governor gear assy as per Fig. 3-170, and measure the measurement of A and B from the end surface of the governor housing. It is satisfactory if $A - B = 5.85 - 6.35$ mm (0.23 - 0.25").

This value is C measurement-gear width 5.5 mm (2.17") added to specified clearance.

- d. Governor gear assembly
 - 1) First, install the governor gear, slip disk, shim plate and retainer ring onto the camshaft bushing, and assemble the governor gear assy

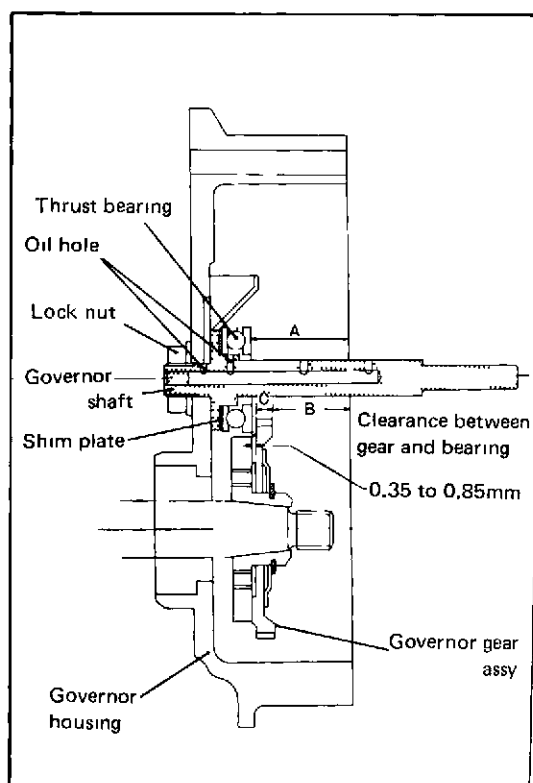


Fig. 3-170 Governor Shaft Installation

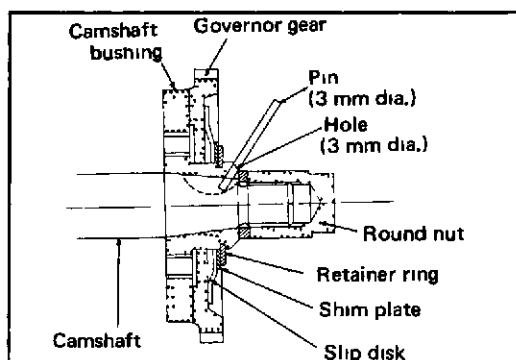


Fig. 3-171 Governor Gear Assembly

2) Retainer ring installation

As per Fig 3-172, the retainer ring must be assembled with the chamfered side always facing toward the interior.

This is due to the force being applied onto the retainer ring from the arrow direction. Thus, the side opposite to sharp edge side must face toward the exterior, to properly insert the retainer ring into the camshaft bushing groove.

First, contact the retainer ring with a screwdriver, lightly tap with a hammer, and insert it into the camshaft bushing groove. Then, close both ends of the retainer ring from exterior, and properly insert it into the groove.

At this time, as per Fig 3-172, the A measurement should be less than 2 mm (0.079"). Also, always replace the retainer ring with new part, and assemble. If this retainer ring disengages, the governor gear will slip, and the governor speed adjusting performance will be much reduced. Thus, care should be taken as this may cause engine over run.

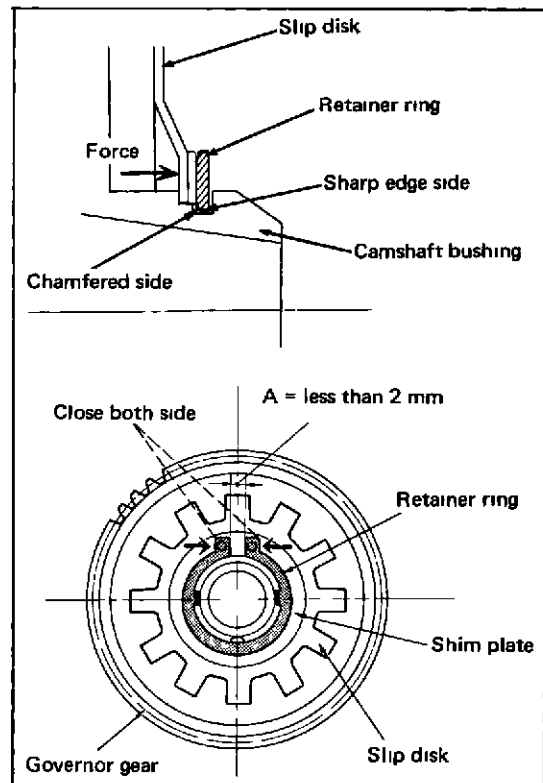


Fig 3-172 Governor Gear Assembly

3) Slip torque adjustment.

To obtain the slip starting torque of 40 to 60 kg-cm (34.7 to 52.1 in-lbs) between the camshaft bushing and governor gear of governor gear assy, adjust by increasing the shim plates.

The serviceable limit of this slip torque is 25 kg cm (21.7 in-lbs), but, if it is below this, re adjustment is required.

For measurement, place the governor gear assy onto the stand of the slip torque measuring tool as per Fig 3-173, and measure while meshing the governor gear assy teeth with the stand. Insert the handle into the two 6 mm (0.236") holes in the governor shaft bushing, and measure the slip starting torque with a small size torque wrench.

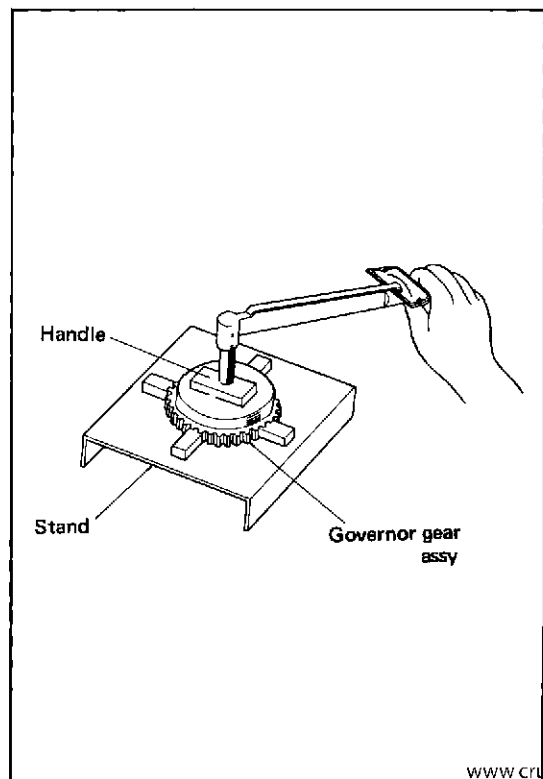


Fig 3-173 Slip Torque Measurement

e. Governor gear installation.

For installation onto the camshaft, as illustrated in Fig 3-171, insert the 3 mm (0.118") pin into the 3 mm (0.118") hole in the camshaft bushing, and install while aligning with the camshaft key groove. Properly tighten the round (sleeve) nut, securing the governor gear at 200 to 300 kg cm (14.5 to 21.7 ft-lbs) torque.

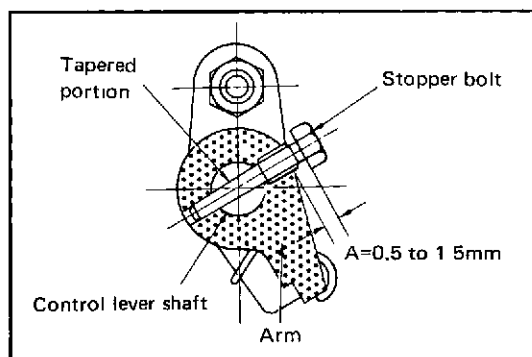


Fig 3-174 Arm Installation

f. As illustrated in Fig. 3-174, the arm is installed onto the control lever shaft with the stopper bolt (tapered). When tightening the stopper bolt, the A clearance should be 0.5 to 1.5 mm (0.0197 to 0.059") as per Fig. 3-164. (Lock washer is not utilized at this portion, and is secured by the taper.)

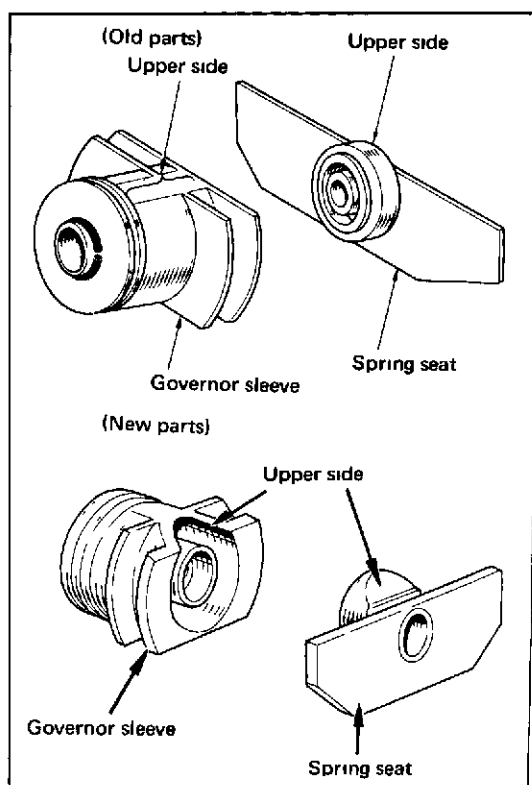


Fig. 3-175 Governor Sleeve & Spring Seat

g. When installing the governor sleeve assy and spring seat onto the governor shaft, assemble as per Fig 3-175, but do not mistake the vertical positions.

If the vertical positions of these are assembled reversely, it will cause contact with the control spring, and defective speed adjustment of the governor will result.

h. Floating lever assembly.

1) First, assemble the shackle (54) onto the control rack.

As illustrated in Fig 3-176, for connection of both, install the bushings on both sides of the shackle, and install the spring arm (55) together with the connecting pin (57) and lock washer (52) (at this time, do not bend it), then temporarily tighten the nut.

The two bushings installed on both sides of the shackle differ in shape. The bushing (53) provided with the flange should be installed on the outside of the governor (not installed side), and confirm the shackle movement for smoothness.

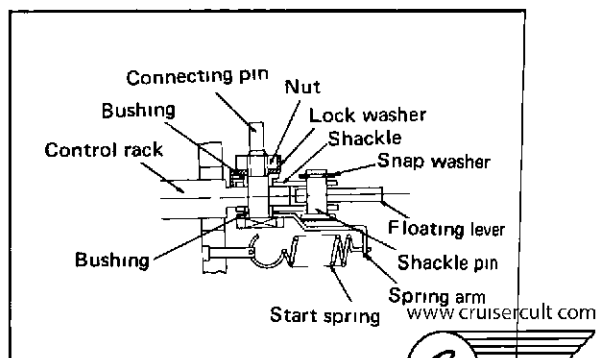


Fig 3-176 Floating Lever Assembly

- 2) Next, insert the connecting bolt (61) through the lower side of the floating lever (58), and install the snap washer.
 - 3) Then, connect the floating lever top onto the shackle. At this time, as illustrated in Fig. 3-176, assemble the shackle pin (59) so that the head will be at the interior side. The shackle pin should be inserted lightly.
 - 4) Move the floating lever top fully toward the front and rear of control rack stroke, and inspect the floating lever for smooth movement. Finally, tighten the connecting pin (57) nut properly, and bend the lock washer to secure the nut from loosening.
- i. Confirm the snap washers and retainer rings of the governor for proper insertion.
 - j. To assemble the governor cover, correctly place the governor sleeve and spring seat lower flange onto the governor cover assembly guide, and assemble.

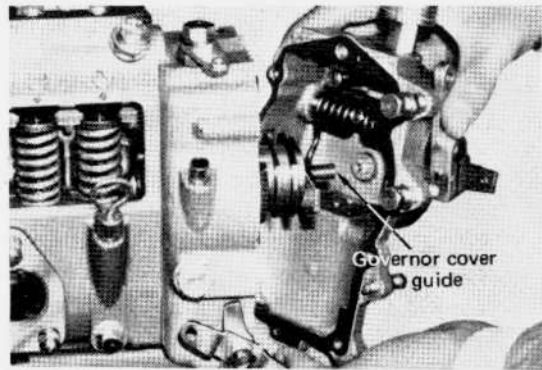


Fig. 3-177 Governor Cover Assembly

Tightening torque:

Lock nut of governor shaft
Round nut of governor gear
Governor gear — Slip torque

180 to 260 kg-cm (13.0 to 18.8 ft-lbs)
200 to 300 kg-cm (14.5 to 21.7 ft-lbs)
Specified upon assembly
40 to 60 kg-cm (34.7 to 52.1 in-lbs)
Serviceable limit — 25 kg-cm (21.7 in-lbs)

ADJUSTMENT

After completing the governor assembly, the following adjustments must be performed. These must be adjusted in accordance with adjustment standard procedures.

- a. Preparation.
- b. Low speed control adjustment.
- c. Maximum speed control adjustment.
- d. Damper spring adjustment.
- e. Adjustment to conform with engine.

1. Preparation

- a. Zero position setting of control rack.
Completely loosen the idle adjusting screw of the governor, and without securing the adjusting lever, set the rack position at 0 mm of measuring tool while pushing in the control rack to full position. Also, loosen the lock nut, and remove the damper spring.
- b. Tighten the maximum speed adjusting screw to some extent to provide stronger tension of the control spring.
- c. Fill the governor chamber with specified volume (170 cc) of high quality engine oil. To perform the governor adjustment and fuel delivery quantity adjustment, always perform the test after filling the governor with oil as the injection pump must be rotated for test.

2. Low Speed Control Adjustment

The adjustment procedures will be described in accordance with the governor characteristic curve diagram illustrated in Fig. 3-179.

- a. Rotate the pump at 800 rpm revolution, and slightly incline the adjusting lever. With the rack position at 2.0 mm (0.079") position, turn the idle adjusting screw as per Fig. 3-180, and secure the lever by tightening the lock nut.
- b. Next, at 300 rpm revolution, remove the governor cover, and adjust so that the rack position will be at 6.8 mm (0.268") by increasing the governor sleeve interior idling spring outer shim plates. (Refer to Fig. 3-181)

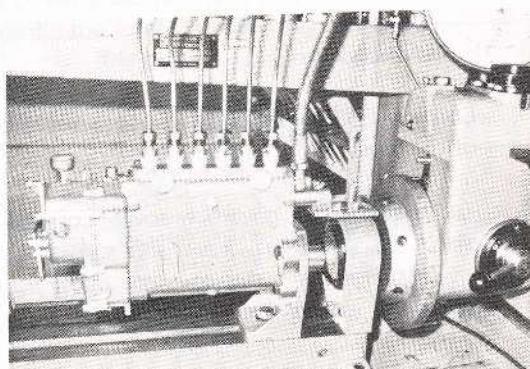


Fig. 3-178 Zero Position Setting

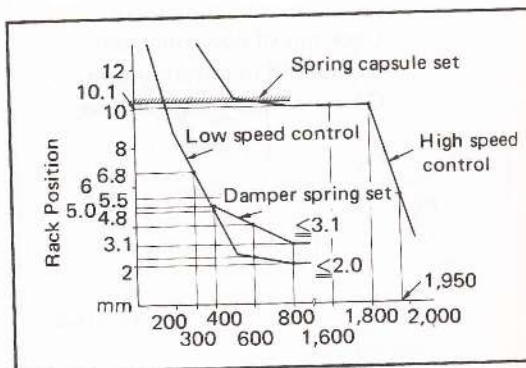


Fig. 3-179 Governor Characteristic Curves

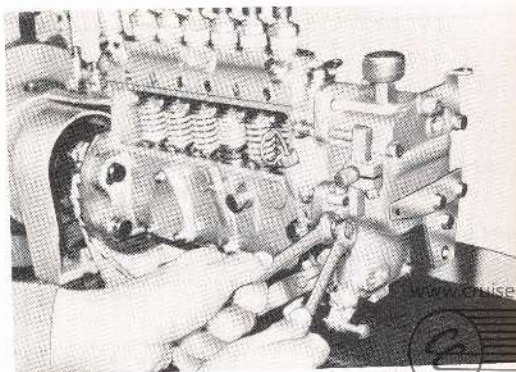


Fig. 3-180 Idle Adjusting Screw Tight

- c. Set the revolution at 600 rpm, and adjust so that the rack position will be at 2.4 mm (0.094") with the governor sleeve interior idling spring inner shim plates. (Refer to Fig. 3-181)
- d. Confirm whether the rack position will exceed 11.0 mm (0.433") when the revolution is at 100 rpm.
- e. When performing the governor adjustment, the rack positions may slightly differ at the same revolution during revolution increase and during revolution decrease. This is called hysteresis. During this low speed control, confirm that the hysteresis is within the specified range (0.3 mm).

Table 3-16 Low Speed Control Adjustment

Adjusting lever angle	Pump speed rpm	Rack Position mm (in)
$+23^{\circ} \pm 7^{\circ}$	100	More than 11 (0.433)
	300	6.6 to 7.0 (0.260 to 0.276)
	400	4.6 to 5.0 (0.181 to 0.197)
	600	2.2 to 2.6 (0.086 to 0.102)
	800	Less than 2.0 (0.079)

3. Maximum Speed Control Adjustment

- a. Set the revolution at 1,600 rpm, incline the adjusting lever at specified lever angle (-9°), and adjust by turning the full load stopper so that the rack position will be at 10.1 mm (0.398"). Then, secure with the lock nut. (Refer to Fig. 3-182)
- b. Next, at 1,800 rpm revolution, adjust by turning the maximum speed adjusting screw so that the control rack starts pulling, and secure with the lock nut. When this maximum speed adjusting screw is tightened (inclining toward the rear), the maximum controlled revolution will increase, and reversely, when it is loosened, the revolution will decrease. When the revolution is increased to 1,950 rpm, check whether the rack is at specified rack position of 5.5 mm (0.217") maximum.
- c. During maximum speed control, confirm that the hysteresis is within the specified range. (Pump speed at 1,800 rpm, rack position less than 1.0 mm (0.039").

Table 3-17 Maximum Speed Control Adjustment

Adjusting lever angle	Pump speed rpm	Rack Position mm (in)
$-9^{\circ} \pm 7^{\circ}$	1,600	10.1 (0.398)
	1,800	10.0 to 10.1 (0.394 to 0.398)
	1,950	Less than 5.5 (0.217)

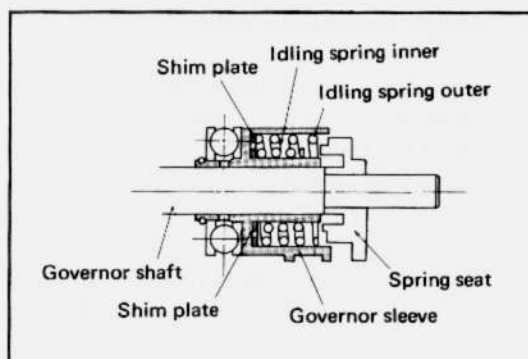


Fig. 3-181 Idling Spring

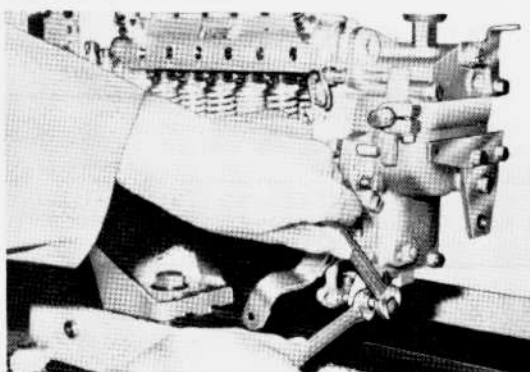


Fig. 3-182 Full Load Stopper Adjustment

4. Damper Spring Adjustment

- Set the adjusting lever angle similar to low speed control, and at 400 rpm revolution, adjust by turning the damper spring as per Fig. 3-183, so that the rack position will be at 5.0 mm (0.197"); then, secure with the lock nut.
- Next, at 800 rpm revolution, confirm that the rack position is at less than 3.1 mm (0.122").

In this case, carefully check whether the damper spring rod movement is satisfactory or not.

Table 3-18 Damper Spring Adjustment

Adjusting lever angle	Pump speed rpm	Rack position mm (in)
$+23^{\circ} \pm 7^{\circ}$	400	4.8 to 5.2 (0.189 to 0.207)
	600	3.8 to 4.2 (0.150 to 0.268)
	800	Less than 3.1 (0.122)

5. Adjustment to Conform with Engine

- When the governor adjustment is finalized, perform the minute adjustment in accordance with adjustment standard, utilizing the graduated cylinder (500 cc), and measure the fuel delivery quantity as per Fig. 3-184, and readjust by full load stopper.

Table 3-19 Overall Injection Quantity Adjustment

Adjusting lever angle	Pump speed rpm	Measure strokes	Injection quantity cc (cu.in) at 6 cylinder
$-9^{\circ} \pm 7^{\circ}$	1,100	500	115.5 to 121.5 (7.05 to 7.41)

- With spring capsule.
Install the spring capsule, and adjust by turning the spring capsule to obtain the specified rack position at specified revolution as per Fig. 3-185; then, secure with the lock nut.

Table 3-20 Spring Capsule Adjustment

Adjusting lever angle	Pump speed rpm	Rack position
$-9^{\circ} \pm 7^{\circ}$	500	10.3 mm (0.406") Adjust the rack position 0.2 mm (0.008") more than its specified position (Table 3-19) with spring capsule.

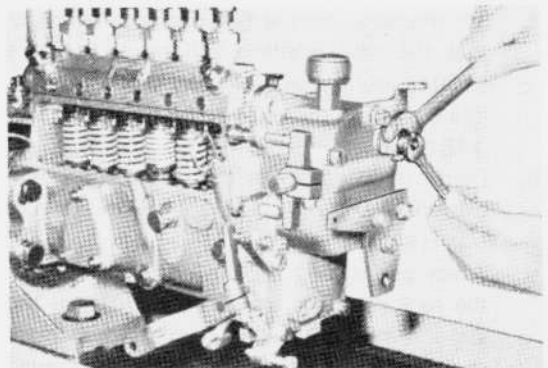


Fig. 3-183 Damper Spring Adjustment

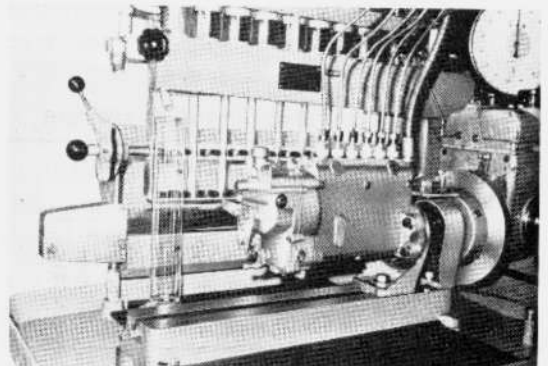


Fig. 3-184 Fuel Delivery Quantity Measurement

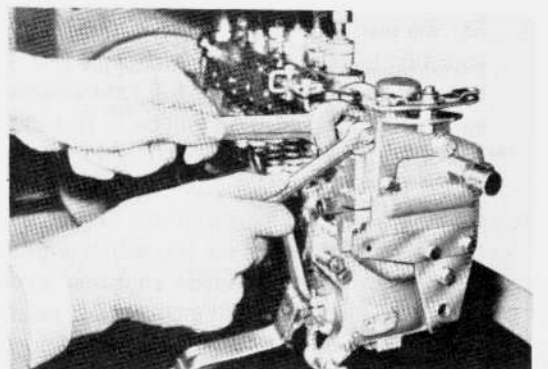


Fig. 3-185 Spring Capsule Adjustment

LUBRICATING SYSTEM

Description	4-2
Oil Pump	4-3
Oil Filter	4-7



DESCRIPTION

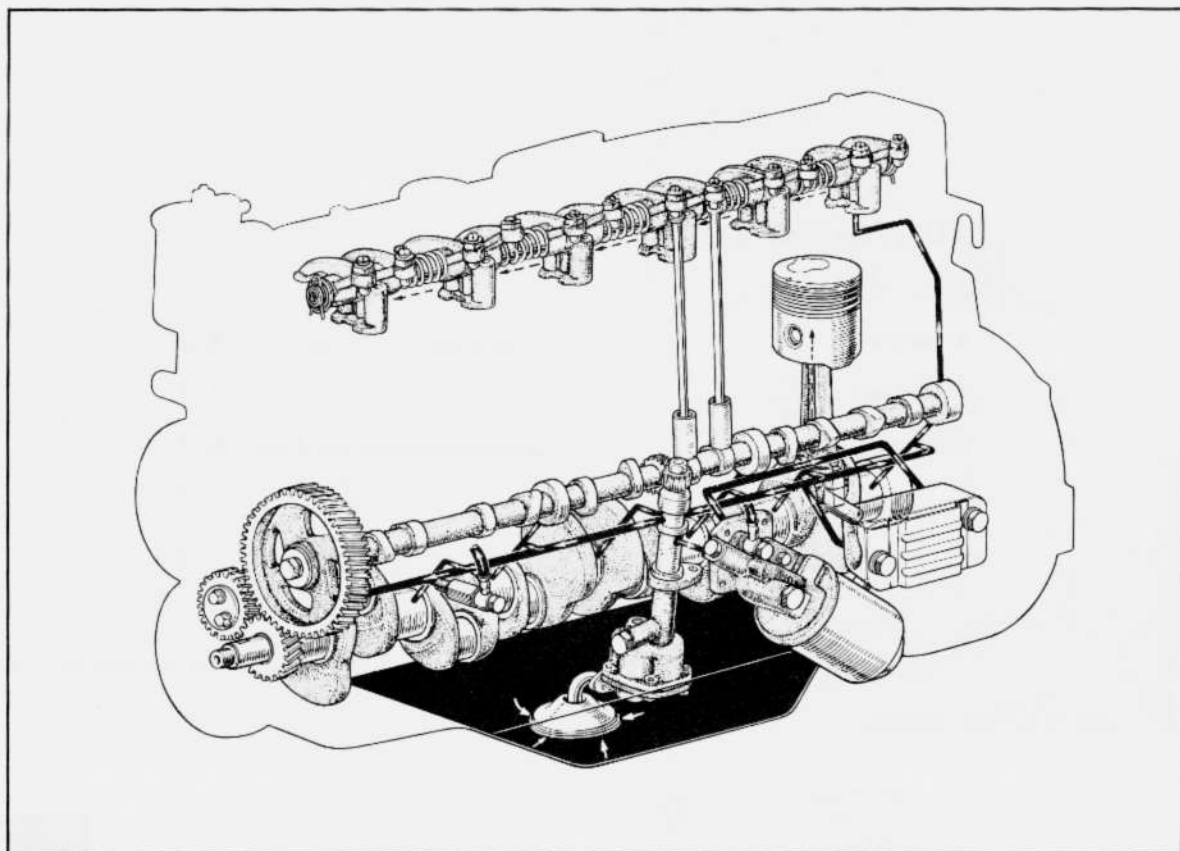


Fig. 4-1 Engine Lubrication System (HU)

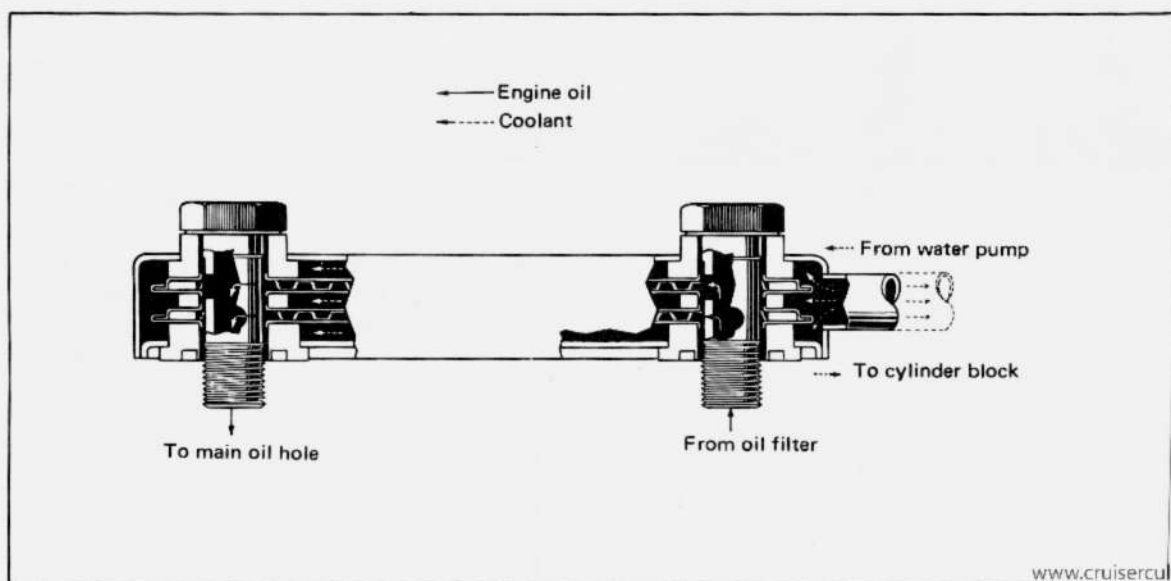


Fig. 4-2 Cross-sectional View of Oil Cooler (HU)

OIL PUMP

COMPONENTS PARTS

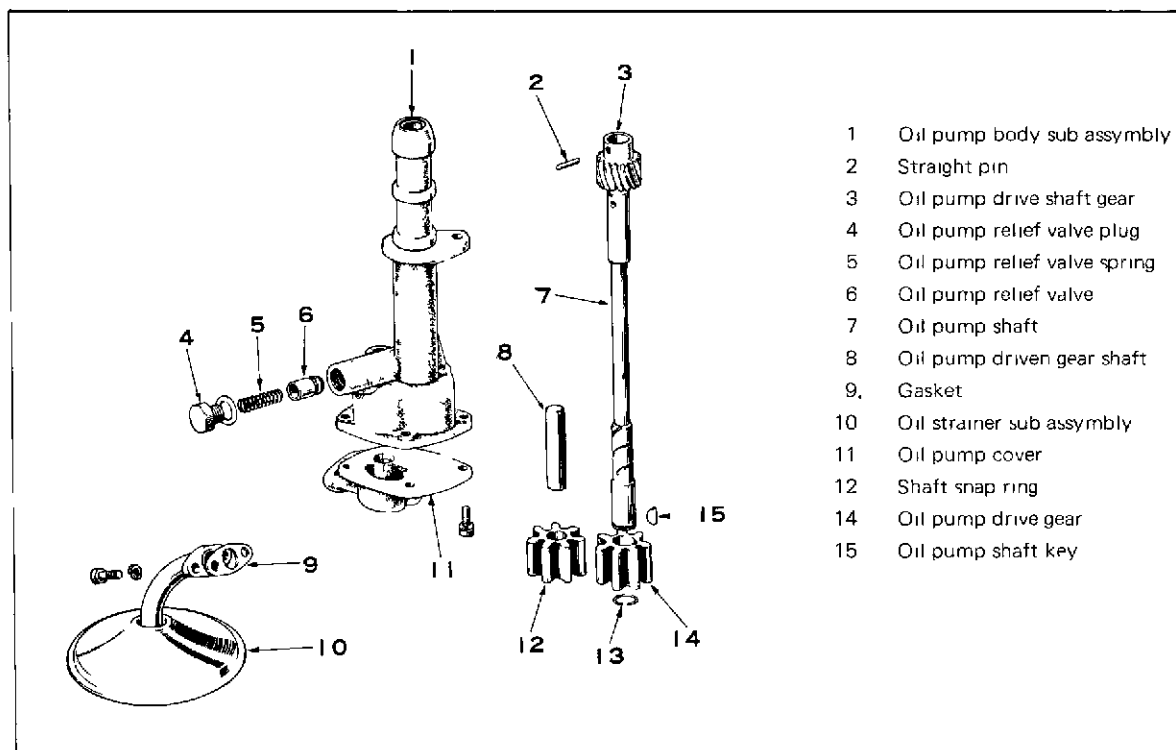


Fig 4-3 Oil Pump Component Parts

SPECIFICATIONS

Table 4-1 Oil Pump Specifications

Type			Gear Type	
Pump Performance	Discharge	Discharge	More than 40 liters (10.6 US gal, 8.8 Imp gal)/min	
		Pump speed	1,800 rpm	
		Oil temperature	98 to 102°C (208 to 216°F)	
		Discharge pressure	3kg/cm ² (42.7 psi)	
Pump Shaft Outer Diameter		Drive	12.453 to 12.471 mm (0.4868 to 0.4875")	
		Driven	13.961 to 13.968 mm (0.5458 to 0.5461")	
Oil Clearance		Drive shaft	0.013 to 0.051 mm (0.00051 to 0.00200")	
		Driven shaft	0.014 to 0.042 mm (0.00055 to 0.00165")	
Tip Clearance		Limit	0.2 mm (0.008")	
		Specified	0.025 to 0.105 mm (0.0010 to 0.0041")	
Side Clearance		Limit	0.2 mm (0.008")	
		Specified	0.03 to 0.09 mm (0.0012 to 0.0035")	
Relief Valve	Spring	Free length	59.8 mm (2.36")	
		Installing length	47.9 mm (1.88")	
		Installing load	5.60 to 5.64 kg (12.35 to 12.43 lb)	
	Valve opening pressure		3.0 to 4.5 kg/cm ² (42.7 to 64.0 psi)	
		Piston to body clearance	0.032 to 0.068 mm (0.0013 to 0.0027")	

DISASSEMBLY

1. Remove oil strainer (1), gasket (2) and pump cover (3).
2. Draw out pump driven gear (4).

Caution

Before drawing out the driven gear, check the tip clearance (gear teeth tip to body clearance), side clearance (gear side surface to pump cover clearance) and drive gear to driven gear clearance. (Refer to Inspection and Repair section)

3. Removing relief valve plug (5), take out valve spring (6) and relief valve (7).

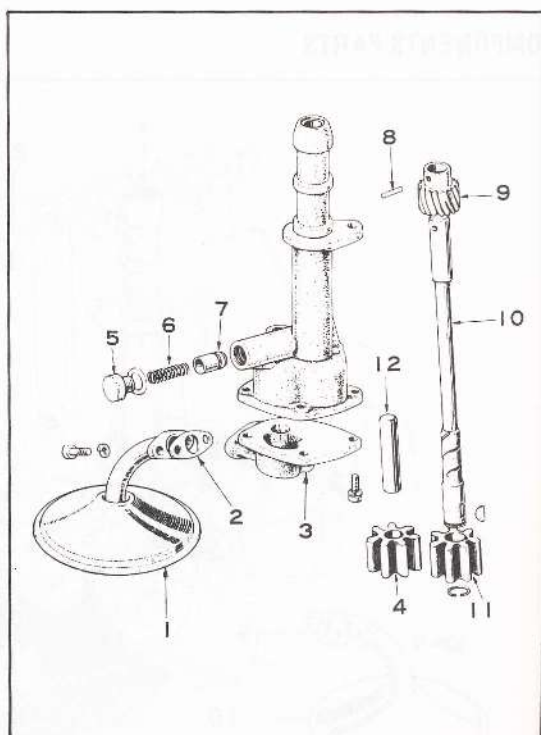


Fig. 4-4 Disassembling Oil Pump

4. Fix the pump drive shaft gear end in a vise. Using a drill (approx. 5mm), remove the calking of the straight pin (8) which fixes gear into the shaft. Then drive out the straight pin.

Caution

1. Always install the sleeve when fixing in a vise. Do not directly fit the gear teeth part.
2. When removing straight pin calking with drill, do not damage gear and shaft.

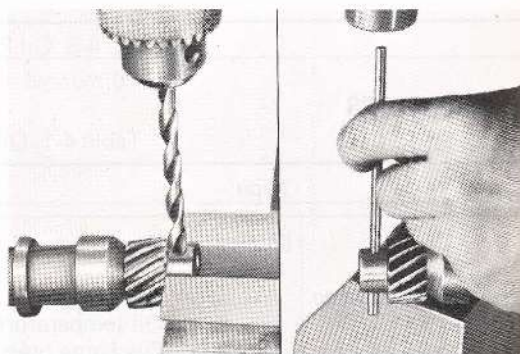


Fig. 4-5 Driving Out Straight Pin

5. Drawing out drive shaft gear (9) from the pump shaft (10), take out the shaft from body with the drive gear (11) attached.
6. Warm up the pump body at from 80 to 100°C (176 to 212°F) with oil heater, then pull the driven gear shaft (12) toward the cover side.

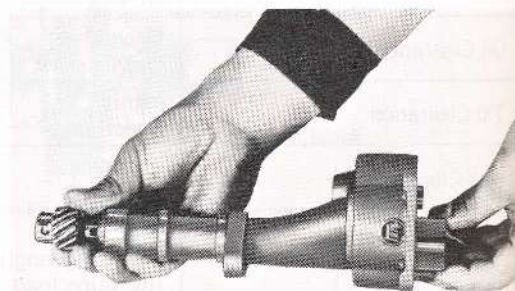


Fig. 4-6 Removing Drive Shaft Gear

7. Separate oil pump shaft and drive gear.
 - a) Take out the drive gear approx. 10mm (0.4") toward drive shaft gear side of the pump shaft.
 - b) Remove the snap ring from pump shaft.
 - c) Take out drive gear from pump shaft toward snap ring side.

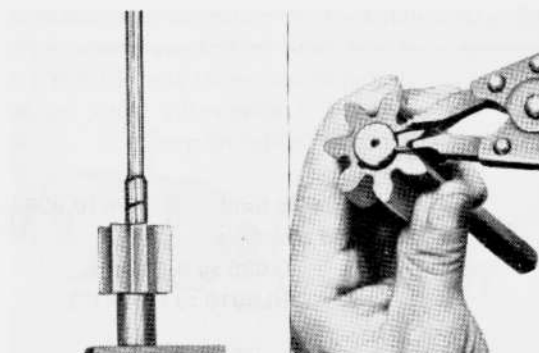


Fig. 4-7 Removing Shaft & Drive Gear

INSPECTION & REPAIR

After washing each of the disassembled parts, inspect and then replace the defective parts.

1. Oil strainer (1) for damage, deformation and tears.
2. Oil pump cover (2) for damage, warpage, cracks and wear.
3. Valve spring (3) for weakness and breakage.
4. Pump body (4) for damage, crack and wear.
5. Drive gear (5), driven gear (6) and drive shaft gear (7) for damage and wear.
6. Pump shaft (8) and driven gear shaft for damage, bend and wear.
7. Relief valve (9) for damage and wear.
8. Inspect the driven shaft, and replace if excessively worn and damaged.

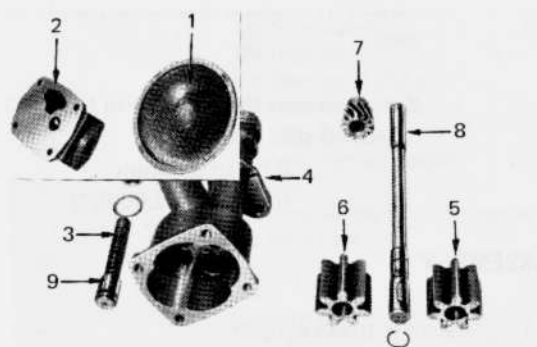


Fig. 4-8 Inspecting Oil Pump Parts

Specified oil clearance 0.014 to 0.042mm
(0.00055 to 0.00165")

Caution

1. When replacing driven shaft, heat the pump body reach 80 to 100°C (176 to 212°F) with piston heaters, and use a press.
2. Install the shaft so that shaft end surface come to a position 37mm (1.4567") from the body installing surface.

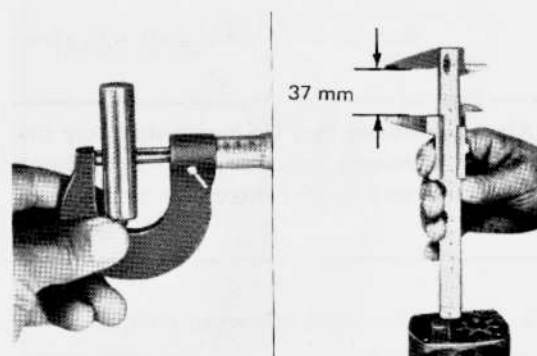


Fig. 4-9 Inspecting Driven Shaft

9. Measure the pump shaft outer diameter, and replace if excessively worn and damaged.

Specified oil clearance
0.0130 to 0.051mm
(0.00051 to 0.00200")

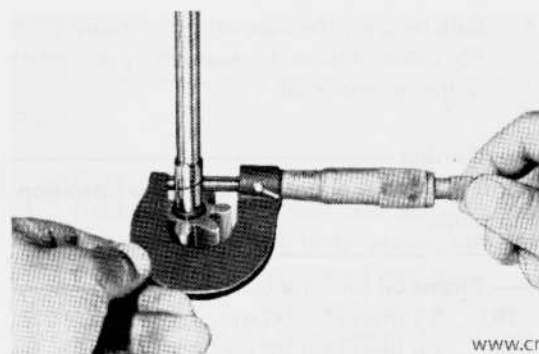


Fig. 4-10 Inspecting Pump Shaft Wear

10. Oil pump drive gear and driven gear clearances
- If gear teeth tip to body clearance (tip clearance) exceeds 0.2mm (0.008") or the gear is abnormally worn, replace the cover, body and gear.

Tip clearance limit 0.2mm (0.008")

Specified clearance

0.025 to 0.105mm
(0.0010 to 0.0041")

- Measure the gear to cover clearance (side clearance). If it exceeds 0.2mm (0.008"), replace the cover, body or gear.

Side clearance limit 0.2mm (0.008")

Specified side clearance

0.03 to 0.09mm
(0.0012 to 0.0035")

ASSEMBLY

- Assemble the drive gear.
 - Install pump shaft key into pump shaft.
 - Assemble snap ring in pump shaft.
 - Install the drive gear from drive shaft gear side of oil pump shaft with a press.

Caution

After confirming that the pump shaft key fits in the drive gear groove, install until pump shaft end surface and drive gear end surface match.

- Insert the above assembled pump shaft into pump body.
- Assemble drive shaft gear onto the shaft, and drive in the straight pin.
- Calk securely the inserted straight pin.
- For others, follow the disassembly procedures in the reverse order.

Caution

Confirm whether or not the relief valve operation is smooth.

Engine oil capacity (oil pan)

HU ... 8.1 liters (8.6 US.qts., 7.1 Imp.qts.)

HJ ... 7.6 liters (8.0 US.qts., 6.7 Imp.qts.)

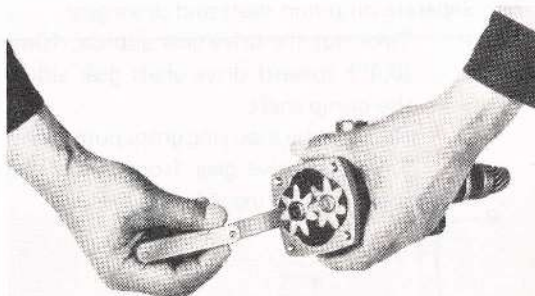


Fig. 4-11 Measuring Tip Clearance

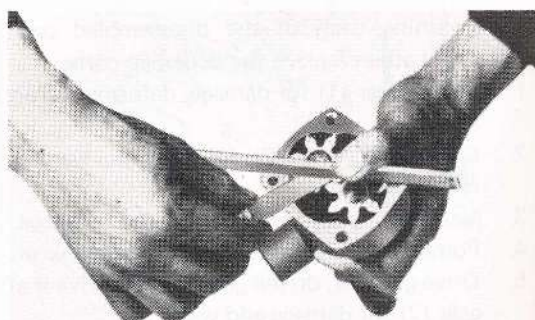


Fig. 4-12 Measuring Side Clearance

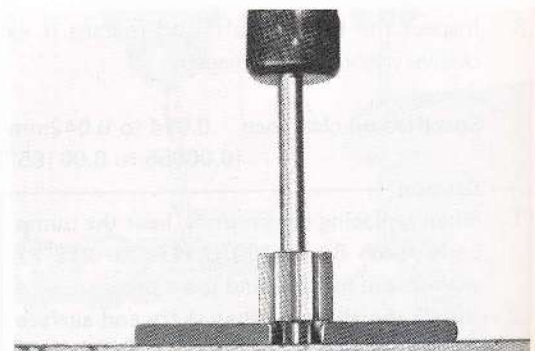


Fig. 4-13 Assembling Drive Gear

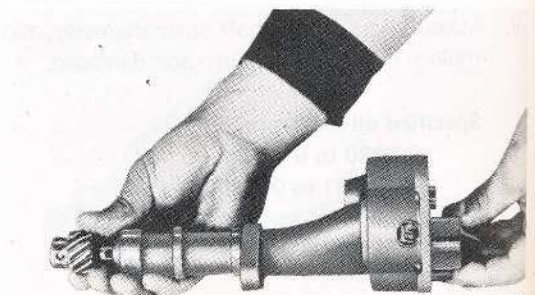


Fig. 4-14 Assembling Drive Shaft

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OIL FILTER

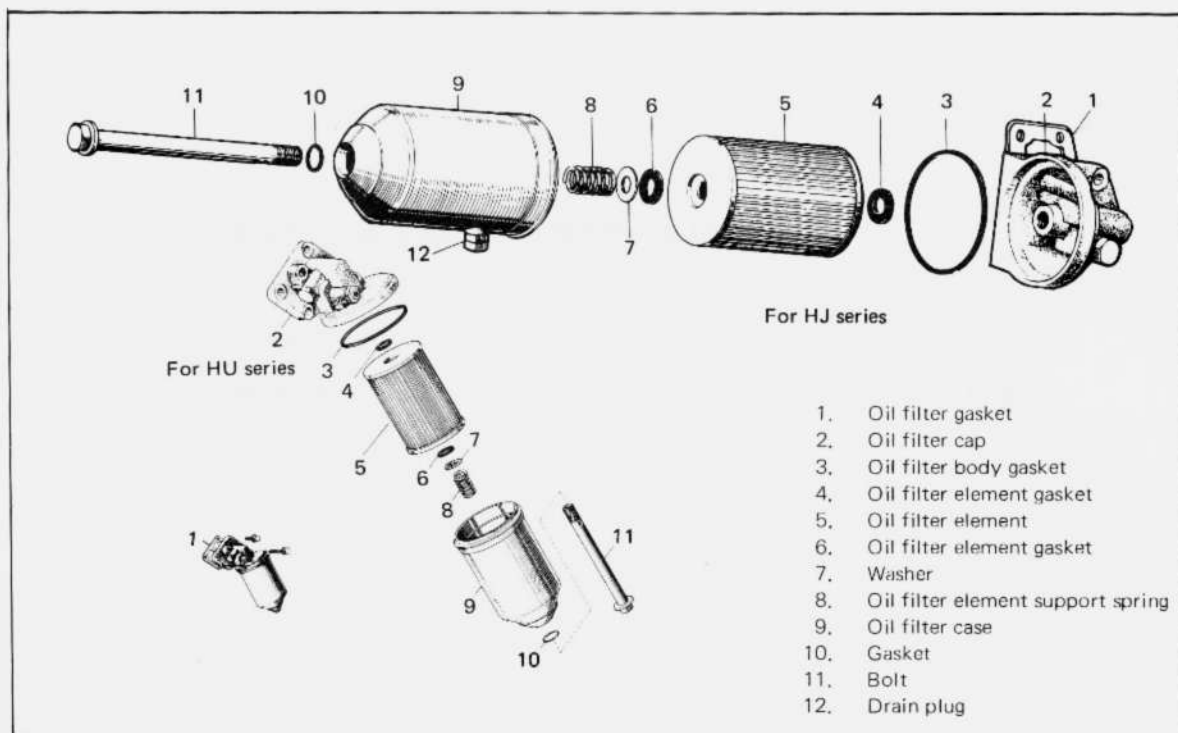


Fig. 4-15 Oil Filter Components

SPECIFICATIONS

Table 4-2 Oil Filter Specifications

Type	Paper Element
Filter Valve Opening Pressure	0.8 to 1.2 kg/cm ² (11.4 to 17.1 psi)
Oil Capacity	1.0 liters (1.06 US qts., 0.88 Imp. qts.)

DISASSEMBLY (Refer to Fig. 4-15)

1. Remove the bolt (11) (for oil filter case set).
2. Disassemble oil filter cap (2), oil filter element (5) and oil filter case (9).

INSPECTION

1. Replace the oil filter element if excessively dirtied or damaged.
2. Replace the filter cap and case if deformed and damaged.
3. Replace the filter valves for poor fitting, damage in sliding surface and defect in operation.
4. Inspect filter valve spring for deformation and weakness and replace if defective.

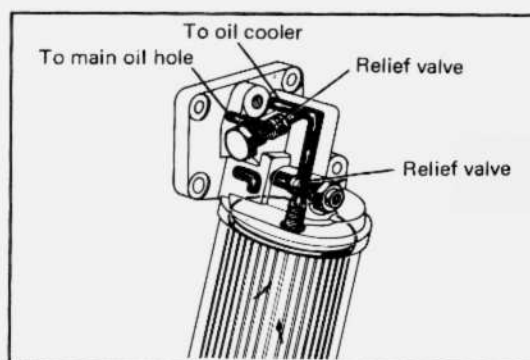


Fig. 4-16 Oil Filter Valve Operation (HU)

ASSEMBLY

Follow the disassembly procedures in the reverse order.

Note

1. Replace the gaskets with new parts.
2. Assemble the filter body gasket with the rounded side facing upward (cap side).
3. Assemble the filter case so that bolt positions (for oil filter drain) face downward.

INTAKE & EXHAUST MANIFOLDS

Venturi	5-2
Manifolds	5-3



VENTURI

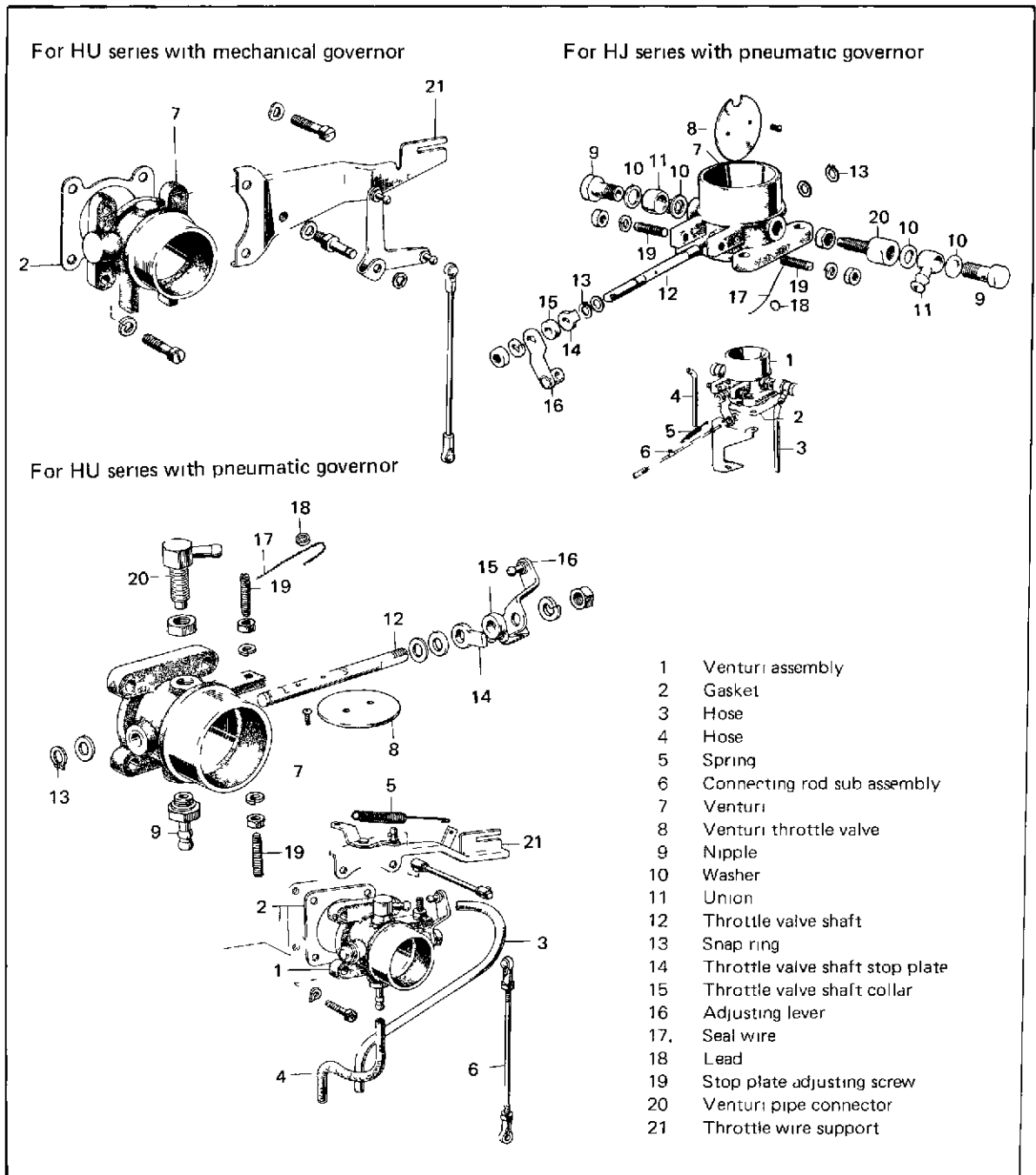


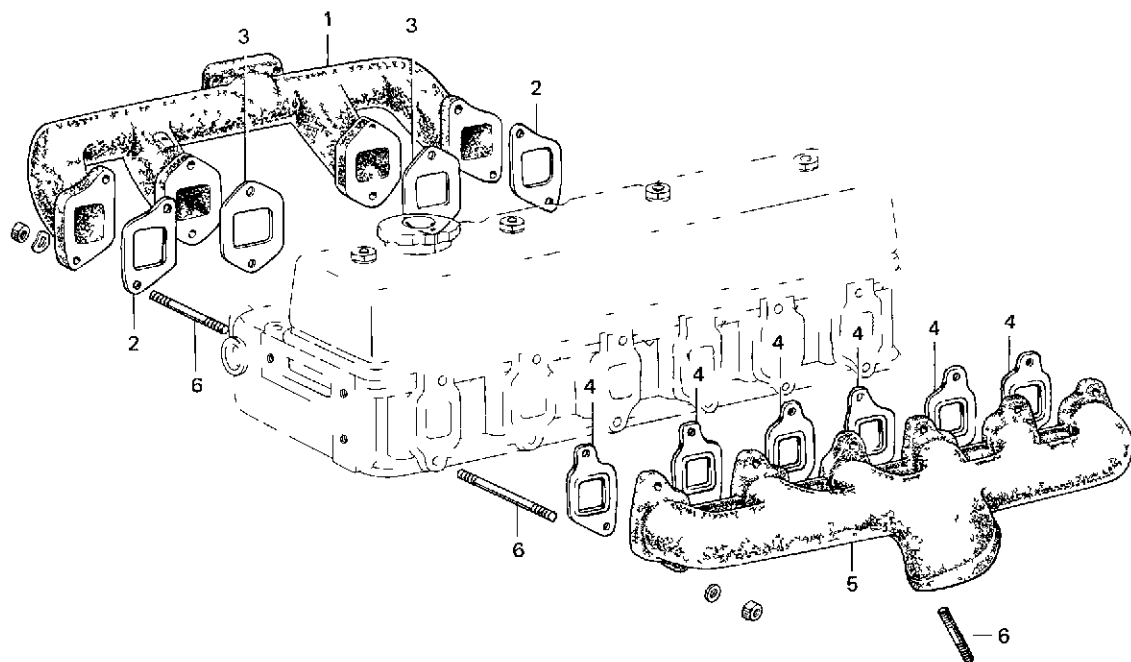
Fig 5-1 Venturi Components

INSPECTION & REPAIR

Inspect for cracks, damage on installing surfaces, wear in throttle valve shaft sliding parts,

deformation of throttle valve, shaft runout damage in screw parts, deformation and damage in small venturi parts, and replace the defective parts.

MANIFOLDS



- | | | | |
|---|-----------------------------|---|-------------------------|
| 1 | Intake manifold | 4 | Exhaust manifold gasket |
| 2 | Intake manifold gasket No 2 | 5 | Exhaust manifold |
| 3 | Intake manifold gasket No 1 | 6 | Stud bolt |

Fig 5-2 Manifold Component Parts

INSPECTION & REPAIR

- 1 Inspect each part for corrosion, damage and cracking, and replace the defective parts

Caution

Also check the stud bolts used for installing manifolds and exhaust pipes.

- 2 Inspect the cylinder head installing surface of the manifold for warpage, and if it exceeds the limit, correct or replace

Warpage limit: Intake 0.3 mm (0.012")
Exhaust 0.5 mm (0.020")

Note

Replace the gaskets with new ones.

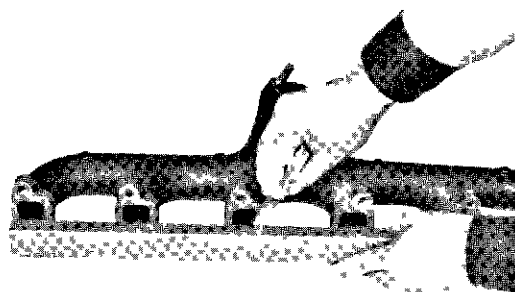


Fig. 5-3 Checking Manifold Warpage

Stud bolt (for manifold set)

Tightening torque: 150 to 220 kg-cm
(10.9 to 15.9 ft-lb)

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COOLING SYSTEM

Description	6-2
Water Pump	6-2
Thermostat	6-6
Radiator, Fan & Fan Drive Shaft	6-7
Hoses & Pipes	6-9



DESCRIPTION

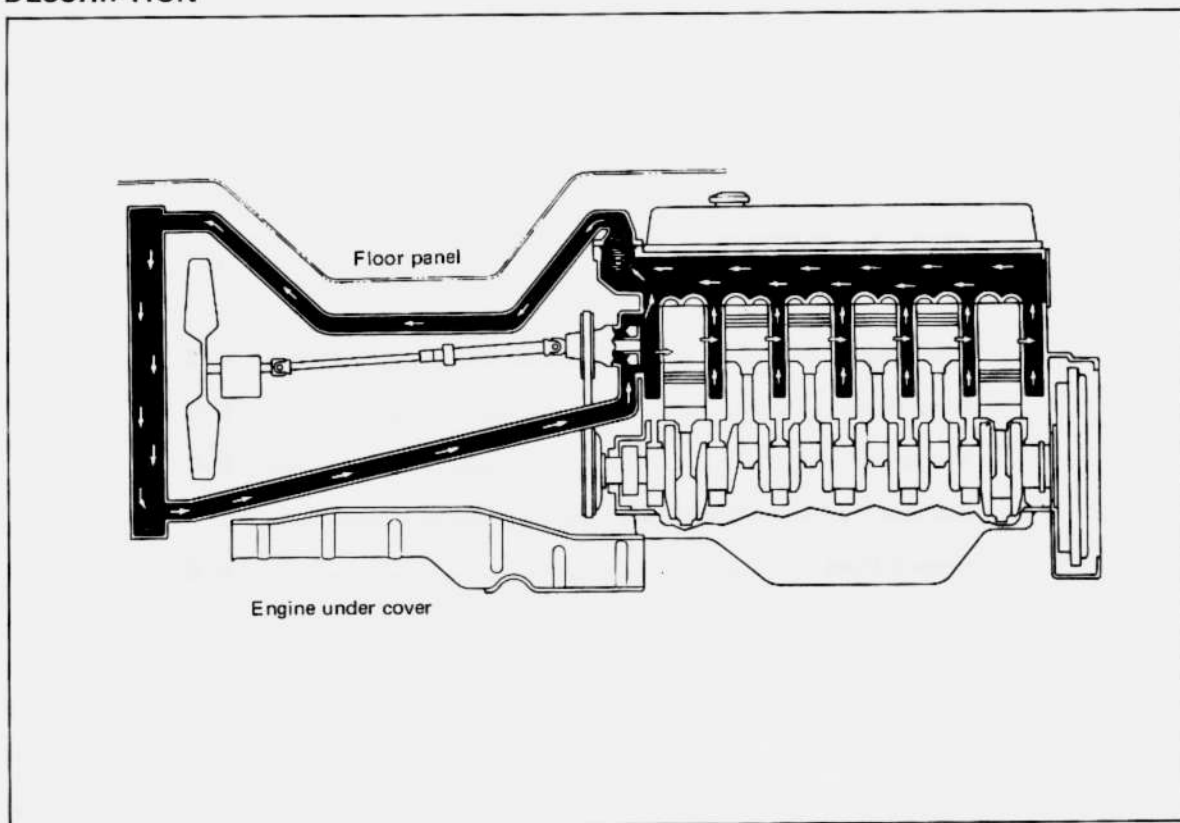


Fig. 6-1 Engine Cooling System

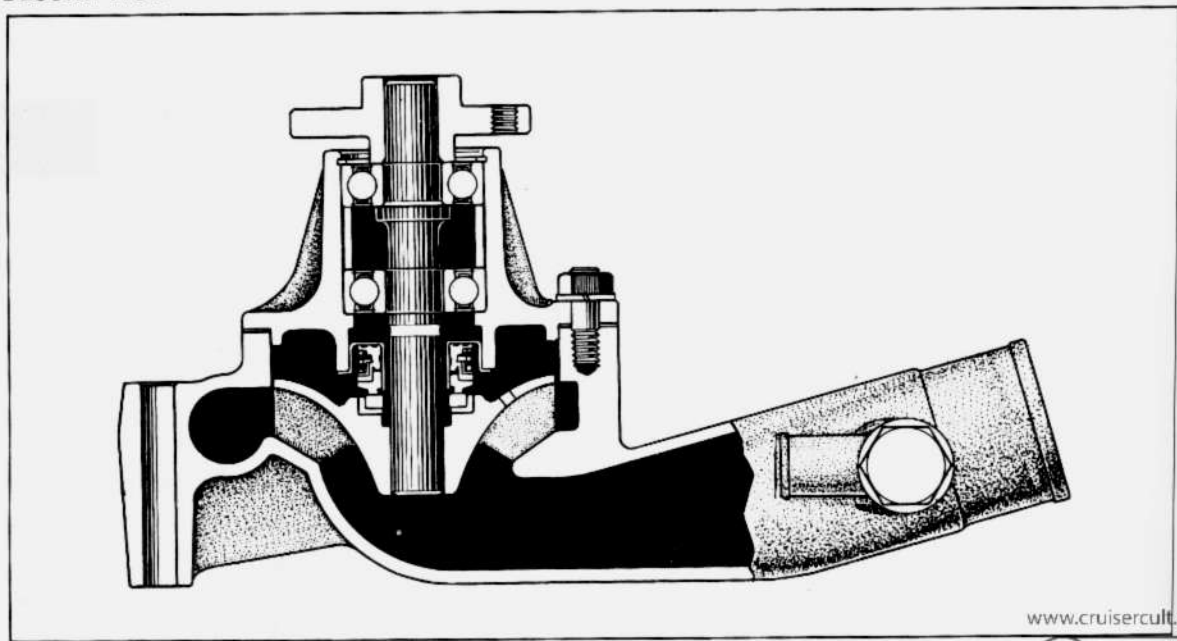
WATER PUMP
DESCRIPTION

Fig. 6-2 Water Pump Cross Sectional View

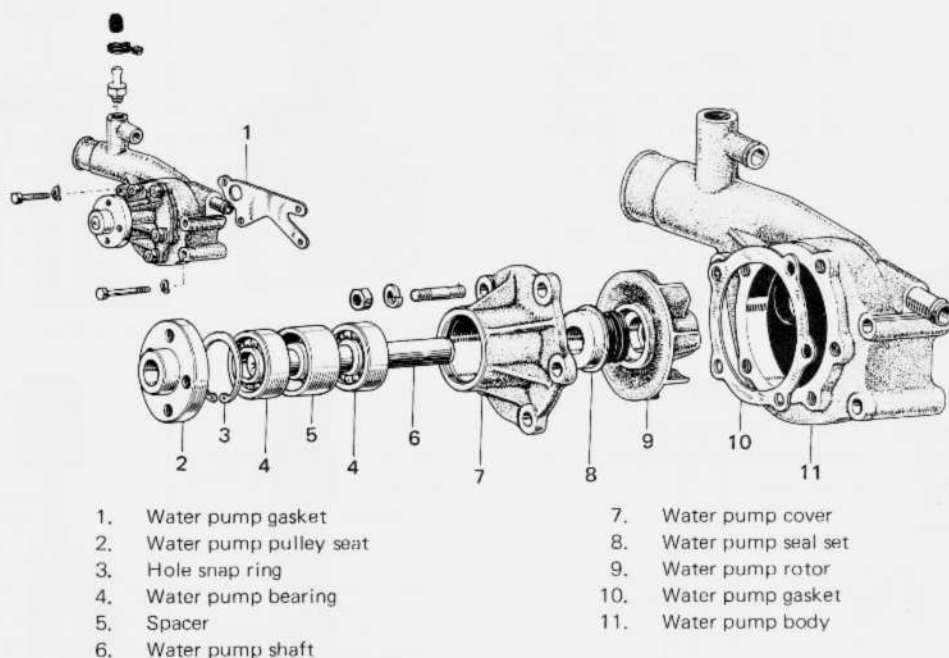


Fig. 6-3 Water Pump Component Parts

DISASSEMBLY

1. Remove the cover from water pump body.
2. Remove the pulley seat, using SST [09235-60010].

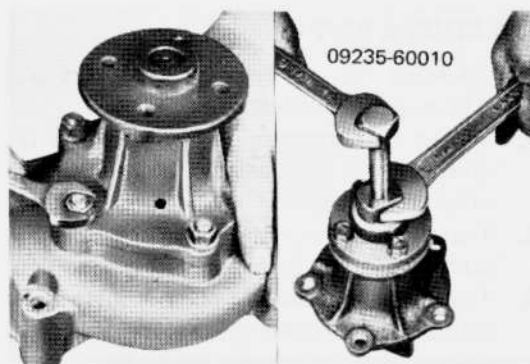


Fig. 6-4 Removing Cover & Pulley Seat

3. Pull out water pump rotor with a press by using SST [09239-40010] or suitable steel sheet.
4. Remove the pump seal set from water pump rotor side and pump cover side.

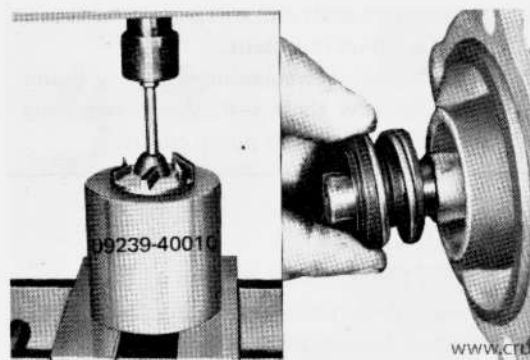


Fig. 6-5 Disassembling Rotor & Seal Set

5. Remove the snap ring from pulley seat side of water pump cover.
6. After heating the water pump cover to 80°C(176°F) with hot water, pull out the shaft together with the bearing from pump cover toward the pulley seat with a press and using SST [09238-47010].

Caution

Never remove the bearing except for replacement.

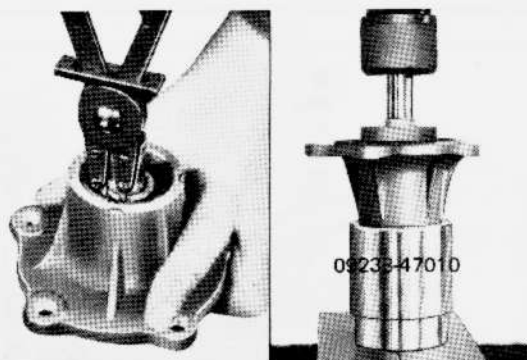


Fig. 6-6 Removing Snap Ring & Shaft

7. Use SST [09238-47010] to remove the pulley seat side bearing from the shaft.
8. Pull out the bearing in the other side toward rotor side in a similar manner.

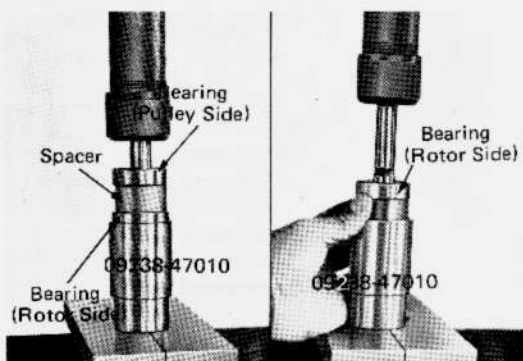


Fig. 6-7 Removing Bearings

INSPECTION & REPAIR

After cleaning the dirt, inspect each part and correct or replace the defective parts.

1. Inspect the water pump body (1), cover (2) and rotor (3) for damage, deformation and cracks.
2. Inspect the water pump shaft (4) for damage and the bearing (5) for operating condition.
3. Inspect the water pump shaft seal component parts (6) for damage, deformation, poor contact and wear.

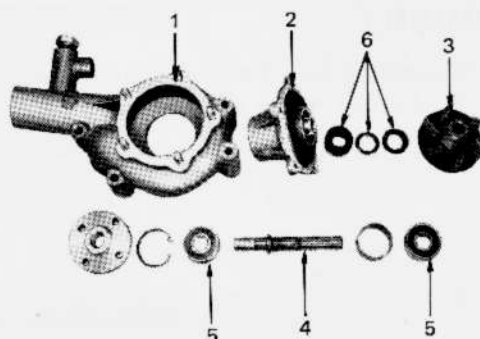


Fig. 6-8 Inspecting Water Pump Components

Notes

1. Replace the shaft seal component parts as a set, if a defect is present.
2. At the time of replacement, apply liquid sealer on the shaft seal cover contacting surface toward water pump cover.

ASSEMBLY

1. Use SST [09238-47010] and a press to press the pulley seat side bearing into shaft until it stops at the stepped shaft.

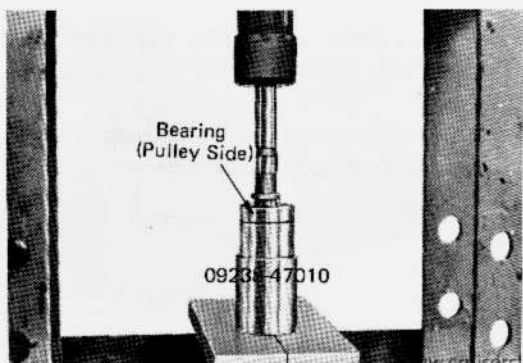


Fig. 6-9 Assembling Bearing

2. After installing the spacer, use SST [09238-47010] and a press to press in the rotor side bearing until the spacer ceases to play.

Caution

Perform the centering carefully so that the spacer ceases its play when it touches the outer races of 2 bearings.

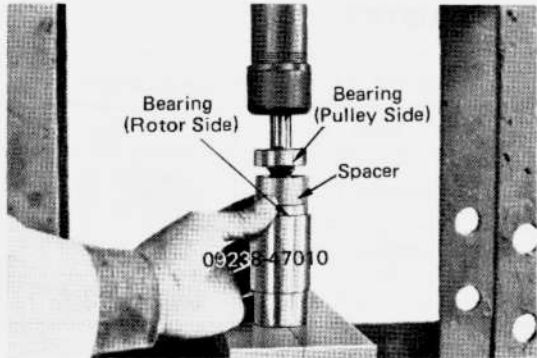


Fig. 6-10 Assembling Spacer & Bearing

3. After heating the water pump cover to 80°C (176°F) with hot water, use SST [09238-47010] and a press to press the bearing together with shaft from the front side of pump cover.

Note

1. Never fit in by pressing the shaft and bearing inner race.
2. Press in until the rear bearing outer race side surface touches the pump cover.

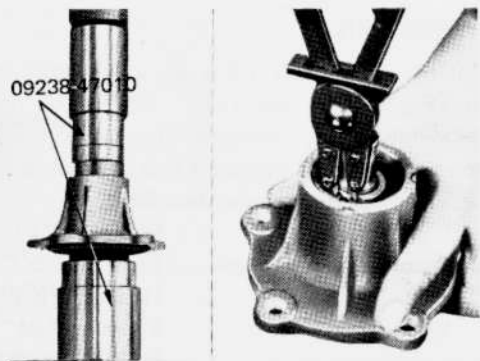


Fig. 6-11 Assembling Bearing & Snap Ring

4. Assemble the snap ring.
5. After assembling seal component parts into pump cover and rotor sides, press in the rotor from rear side until its end surface is flush with the shaft.

Note

When assembling the seal set, coat the frictional positions of seal with a small amount of silicone oil.

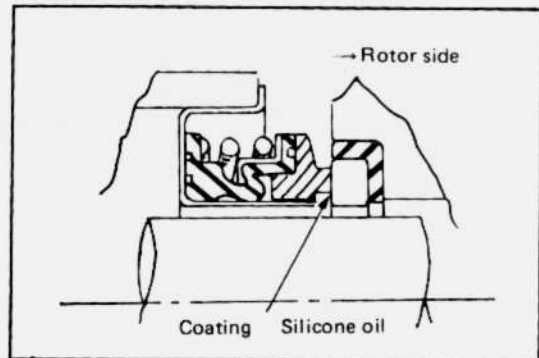


Fig. 6-12 Seal Set Assembly Order

6. Press in the pulley seat until it touches the bearing inner race.
7. Assemble the cover and body so that the drain hole of water pump cover faces down-ward.

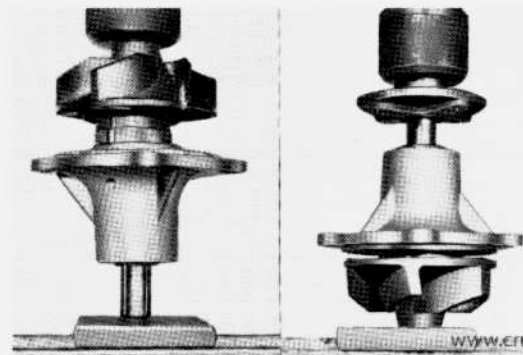


Fig. 6-13 Assembling Rotor and Pulley Seat

THERMOSTAT

Table 6 1 Thermostat Specifications

Type	Wax
Valve Opening Temp	74.5 to 78.5°C (166 to 173°F)
Fully Opening Temp.	90°C (194°F)
Valve Opening Travel	10 mm (0.39")

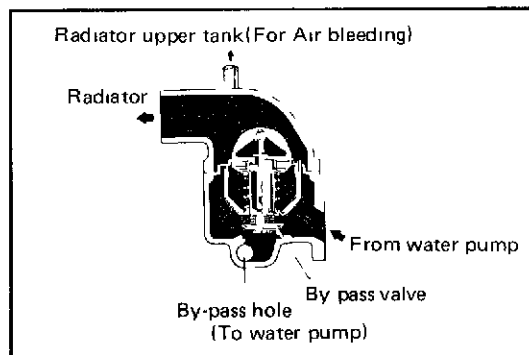


Fig 6-14 Thermostat Cross Sectional View

INSPECTION

Put the thermostat inside the water as illustrated in Fig 6 15, and test the valve opening temperature by gradually increasing the water temperature, and replace if it is less than the limit.

Valve opening temperature limit

55°C (131°F)

Specified temperature

74.5 to 78.5°C
(166 to 173°F)

Valve travel limit

6 mm or 0.24"
(at 83°C or 181°F)

Specified valve opening travel

10 mm or 0.39" (at 90°C or 194°F)

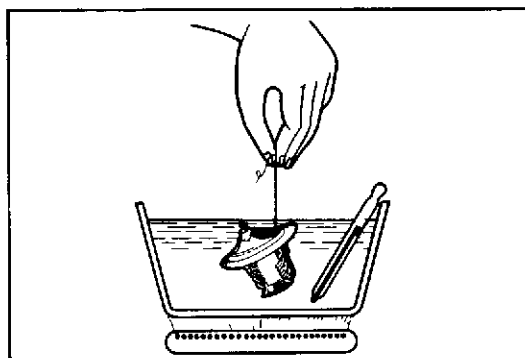


Fig 6 15 Inspecting Thermostat

RADIATOR, FAN & FAN DRIVE SHAFT

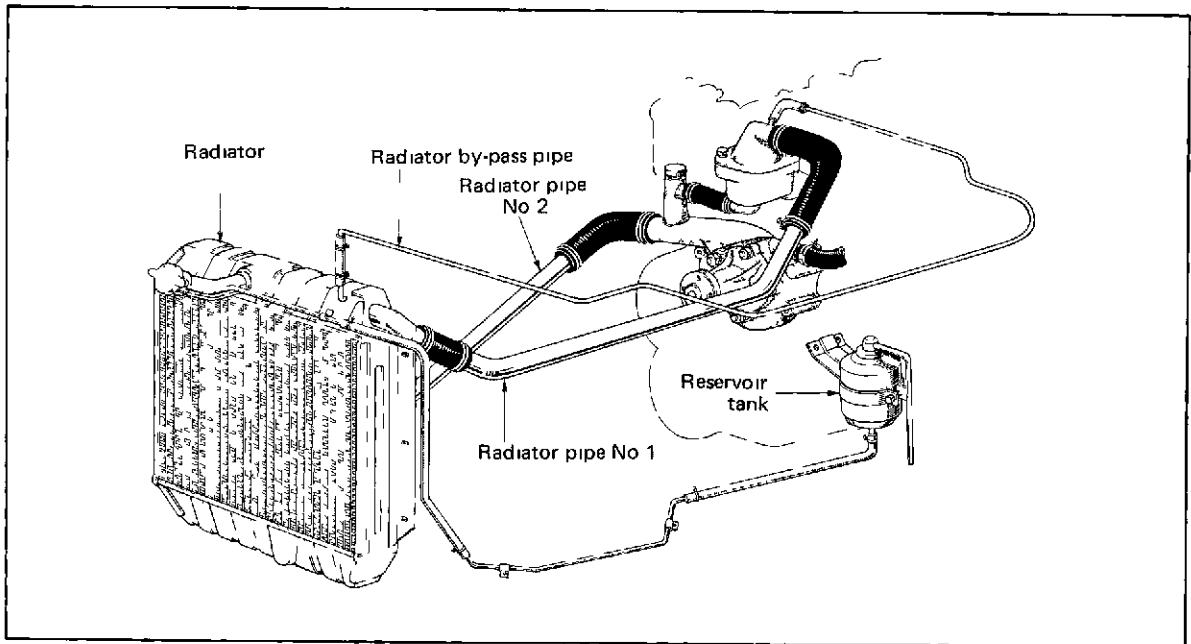


Fig 6-16 Radiator Component Diagram (HU)

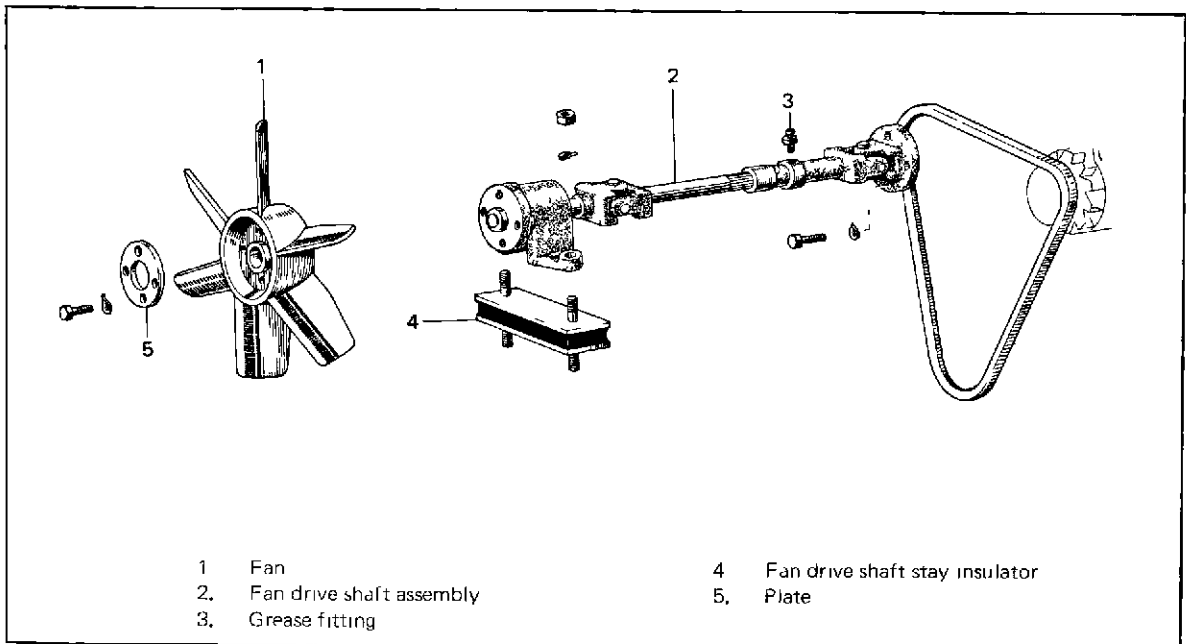
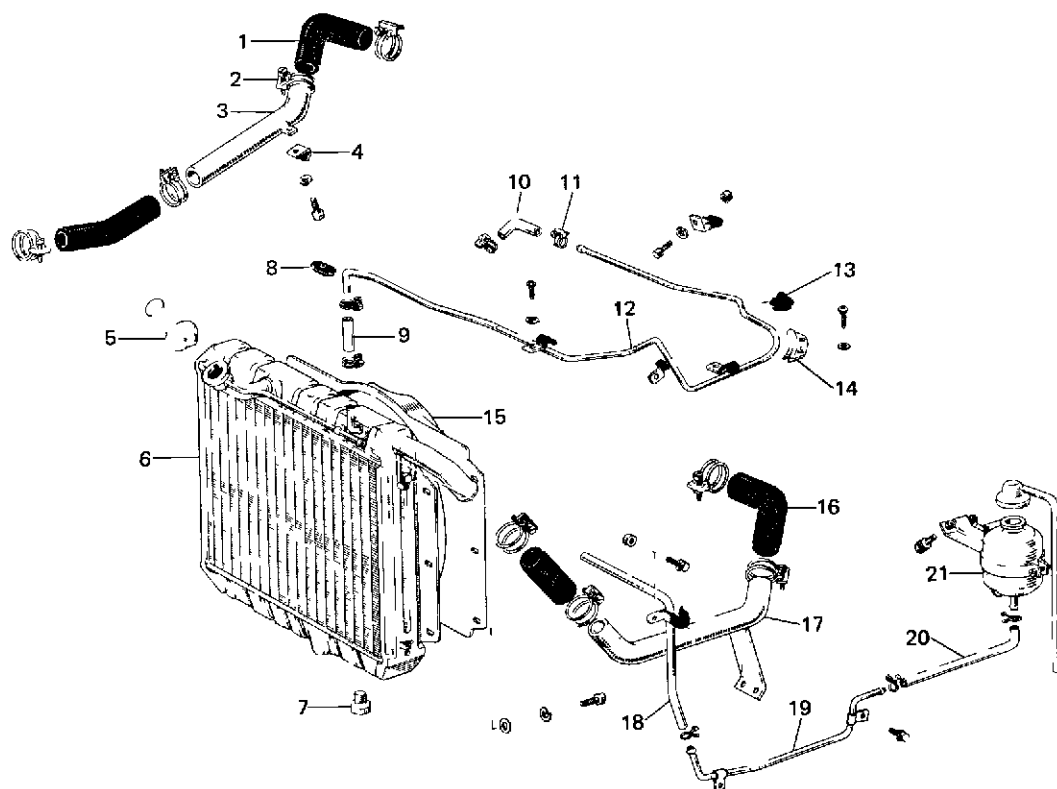


Fig. 6-17 Fan and Fan Drive Shaft Component (HU)

Table 6 2 Radiator Specifications

Coolant Capacity (Radiator)	3.5 liter (3.7 US qts 3.1 Imp. qts)
(Total)	17.3 liter (18.3 US qts 15.2 Imp. qts.)
	12.5 liter (13.2 US qts 11.0 Imp. qts.)
Valve Opening Pressure	0.9 kg/cm ² (12.8 psi)



- | | | | |
|----|----------------------------|----|-----------------------------|
| 1 | Radiator hose | 12 | Radiator by pass pipe |
| 2 | Hose clamp | 13 | Grommet |
| 3 | Radiator pipe sub assembly | 14 | Radiator by pass pipe clamp |
| 4 | Pipe clamp stay | 15 | Fan shroud |
| 5 | Radiator cap | 16 | Radiator hose |
| 6 | Radiator | 17 | Radiator pipe No 1 |
| 7 | Drain cock | 18 | Reservoir tank hose |
| 8 | Grommet | 19 | Reservoir tank pipe |
| 9 | Hose | 20 | Reservoir tank hose |
| 10 | Hose | 21 | Reservoir tank |
| 11 | Hose clamp | | |

Fig 6 18 Radiator Component Parts (HU)

INSPECTION & REPAIR

Disassemble the fan and drive shaft, radiator and fan shroud to clean each of the parts, then inspect following.

1. Fan for damage, crack and deformation.
2. Fan drive shaft for damage and run-out, and the bearing, universal joint and spline for their operating condition.

Note

When replacing, replace as an assembly with bearings attached even though only one part is defective.

3. Radiator for leakage, fin for damage and clogging, and oil cooler parts for leakage and clogging.

Note

1. Correct damaged fins as illustrated in Fig. 6-19.
2. To test water leakage, apply an atmospheric pressure of 0.9 kg/cm^2 (12.8 psi) and soak in a water tank, and then test by checking for air leakage.

4. Inspect the spring tension and airtight condition of radiator cap pressure adjusting valve and negative pressure valve, and replace if the valve opens at a pressure less than the limit.

Specified valve opening pressure
 0.9 kg/cm^2 (12.8 psi)

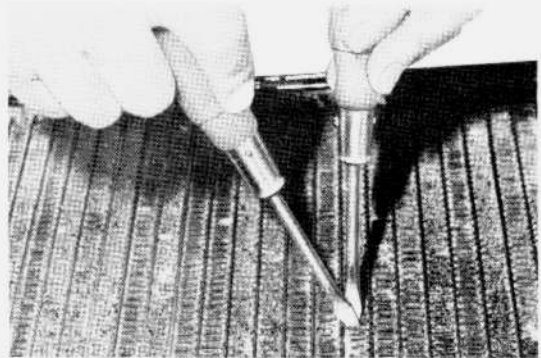


Fig. 6-19 Repairing Radiator Fins

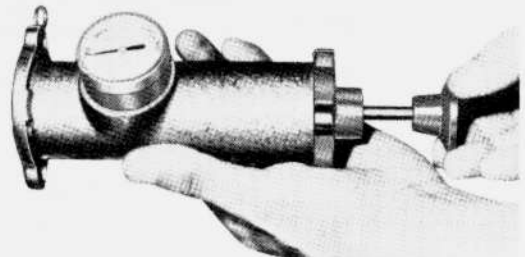


Fig. 6-20 Testing Radiator Cap

HOSES & PIPES

INSPECTION

Inspect each hose and pipe for damage, deformation, weakness and rust.

If defective, repair or replace the part involved.

ENGINE ELECTRICAL

General	7-2
Starter	7-3
Alternator	7-13
Generator Regulator	7-35
Preheating System	7-37
Over Injection Magnet	7-40

GENERAL

The electrical components of the Model H engine can be roughly divided into starting parts, pre heating parts over injection parts, and

charging parts, all of which are electrically connected as shown in Fig 7 1 and 7 2

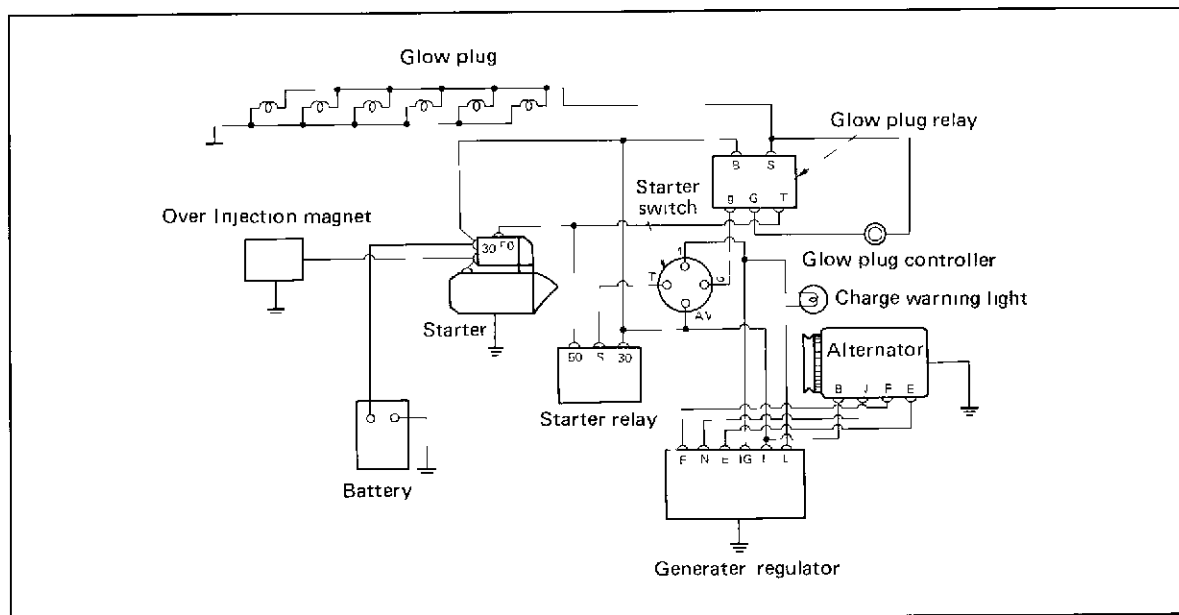


Fig 7 1 Engine Electrical Connection Diagram (HU)

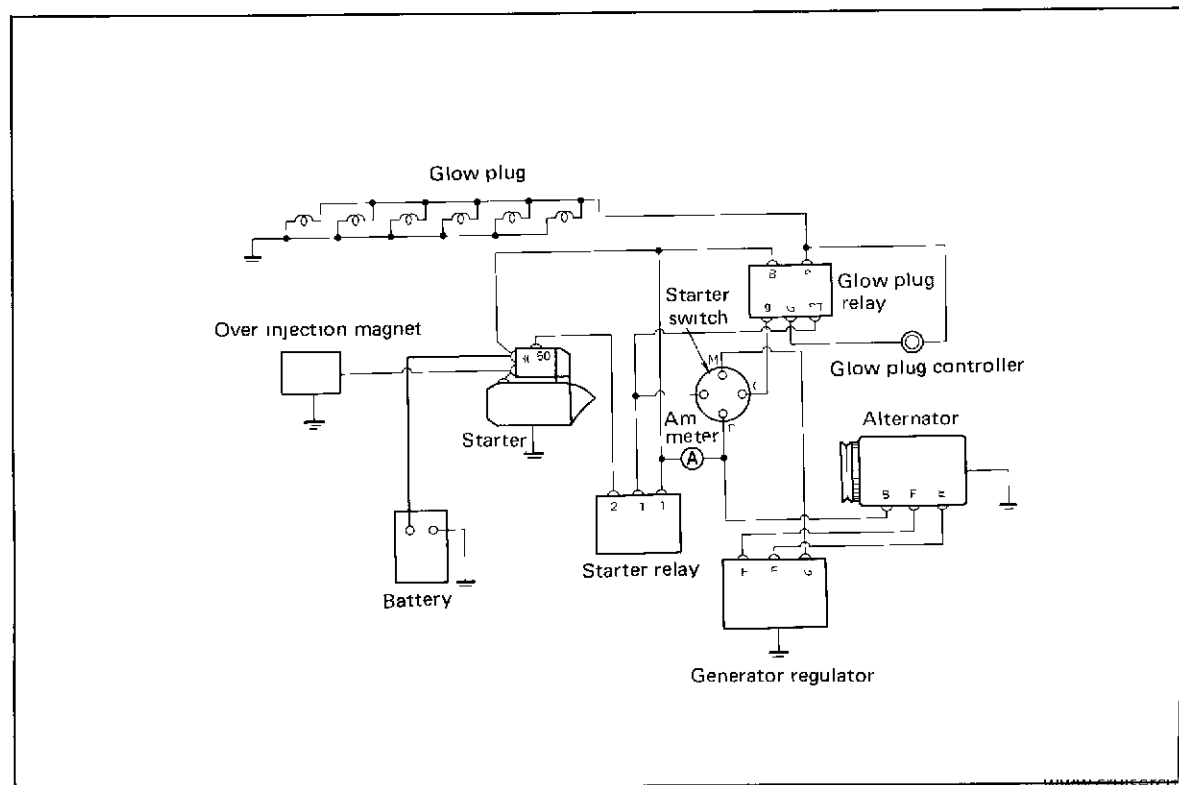


Fig 7-2 Engine Electrical Connection Diagram (HJ)

STARTER

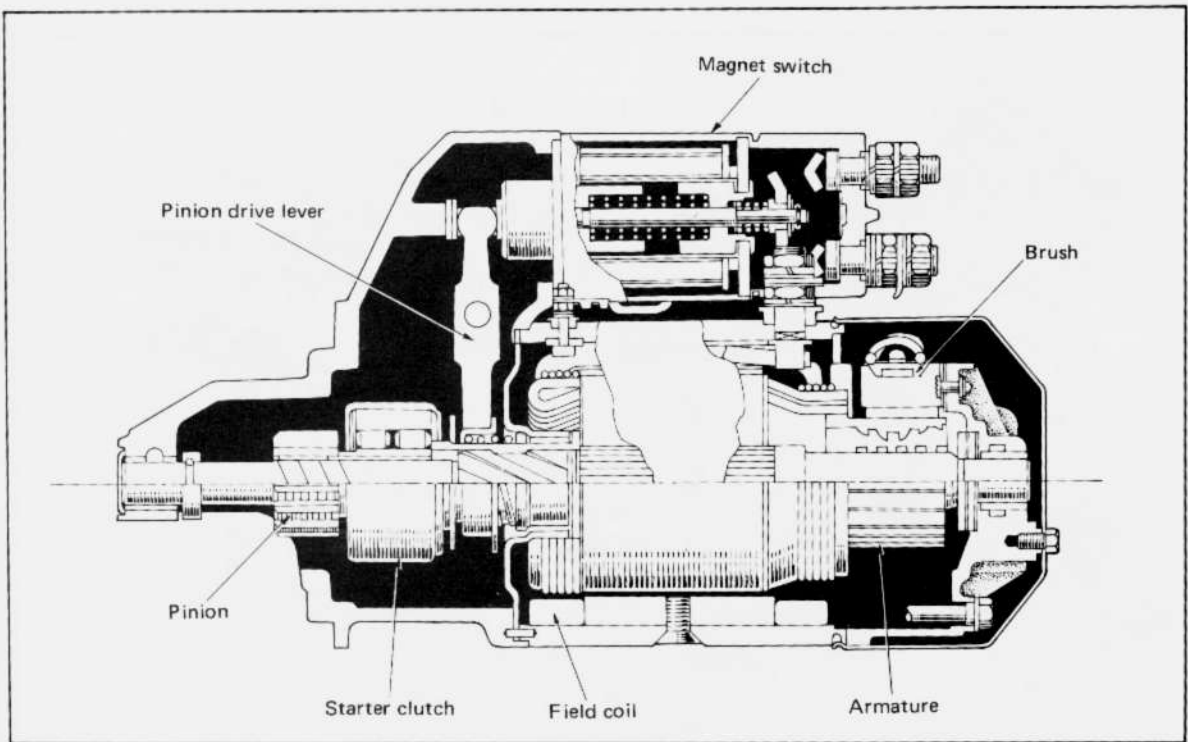


Fig. 7-3 Starter Cross Sectional View

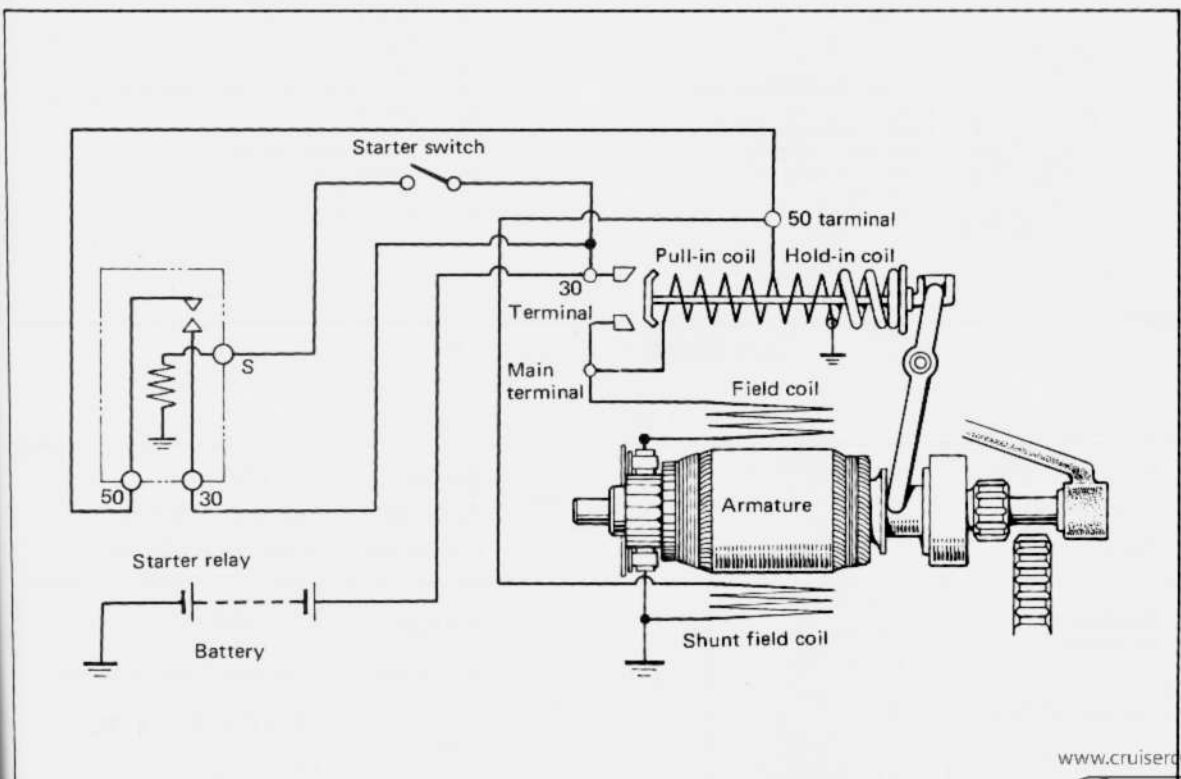


Fig. 7-4 Starter Operational Diagram

COMPONENTS

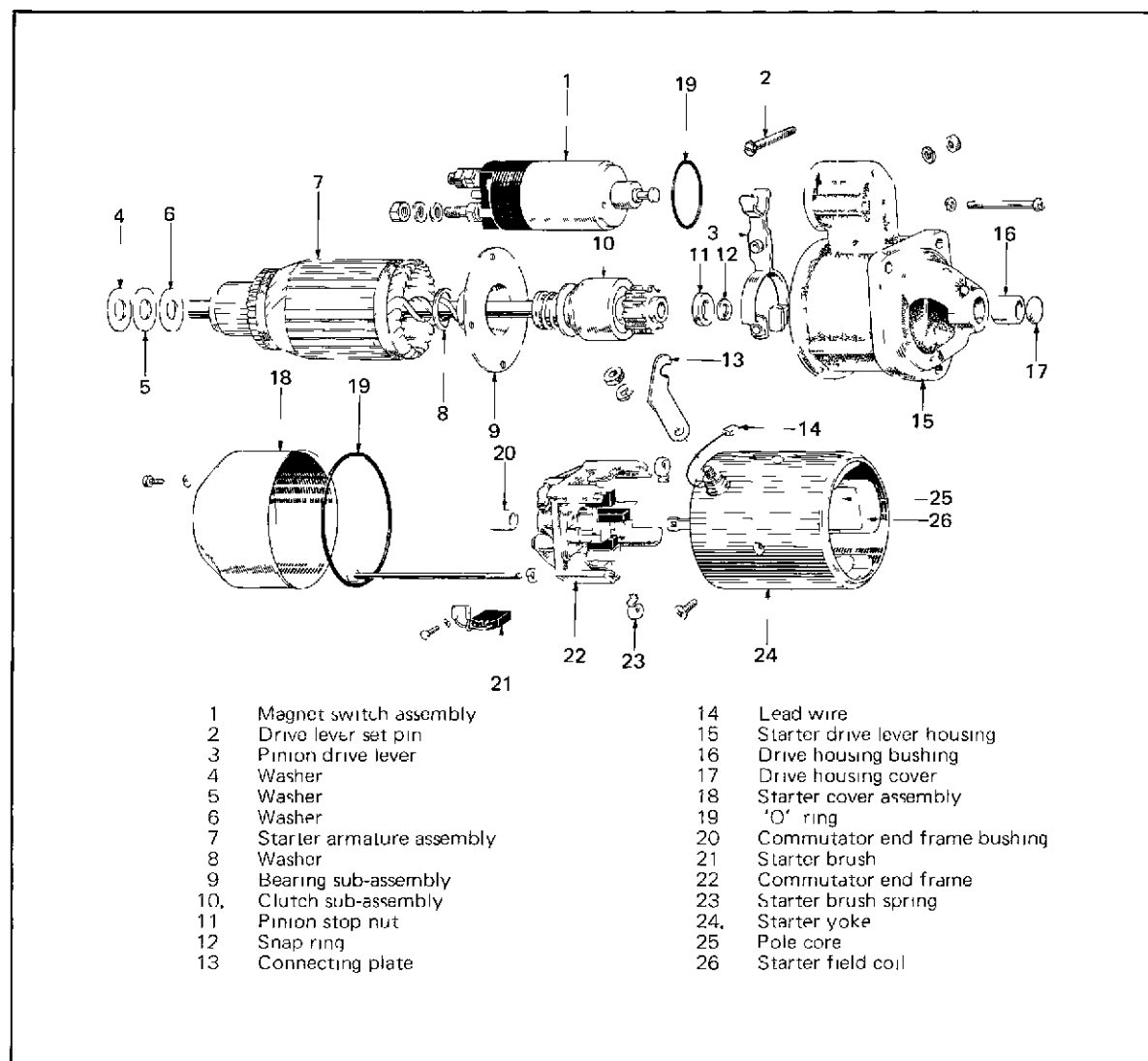


Fig. 7-5 Starter Component Parts

Table 7-1 Starter Specifications

Nominal Voltage	12 volts	No Load Characteristics	Voltage	At 11,5 volts
Output Power	2.5 KW		Amperage	Less than 100 amperes
Rated Time	30 seconds		Revolution	More than 4,000 rpm
Rotational Direction	Clockwise (as seen from pinion side)	Lock characteristics	Voltage	At 5 volts
Number of Poles	4		Amperage	Less than 1,800 amperes
Number of Pinion Teeth	11		Torque	More than 3.5 kg m (25.3 ft lb)

DISASSEMBLY

1. Remove the nuts underneath the magnetic switch main terminal, then remove the connecting plate (1) and the lead wire of the shunt field coil (2).
2. Remove the magnetic switch (3).

Note

Unscrew the two set screws, then hooking up the magnetic switch, disengage it from the pinion drive lever to remove the magnetic switch.

3. Remove the starter cover (4) and "O" ring.
4. Disconnect the field coil and shunt field coil terminals from the brush.
5. Remove the commutator end frame.
6. Remove the starter yoke.

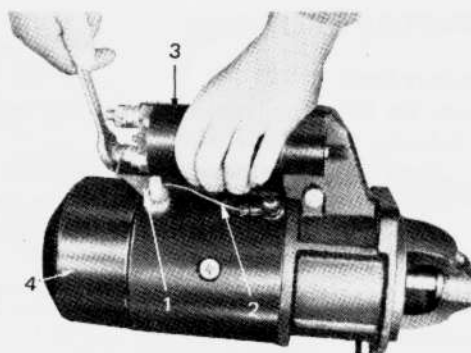


Fig. 7-6 Removing Magnetic Switch

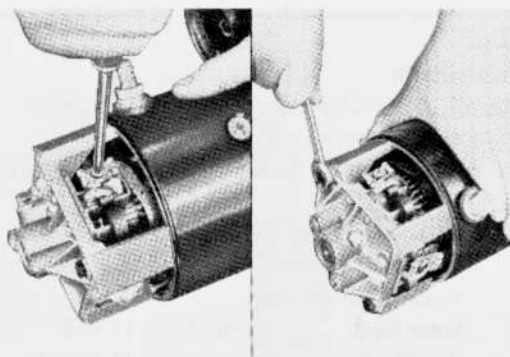


Fig. 7-7 Removing End Frame

7. Remove the drive lever set pin (1), then remove then armature (2) together with the drive lever (3) as illustrated in Fig. 7-8.

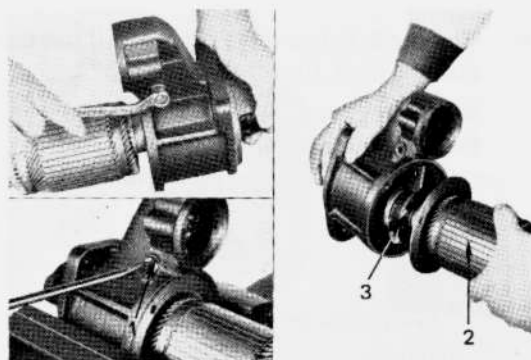


Fig. 7-8 Removing Armature

8. Pull out the starter clutch.
 - (1) Use the tool as illustrated in Fig. 7-9 to drive out the pinion stop nut towards the clutch, first.
 - (2) Remove the snap ring to pull out the clutch together with stop nut.

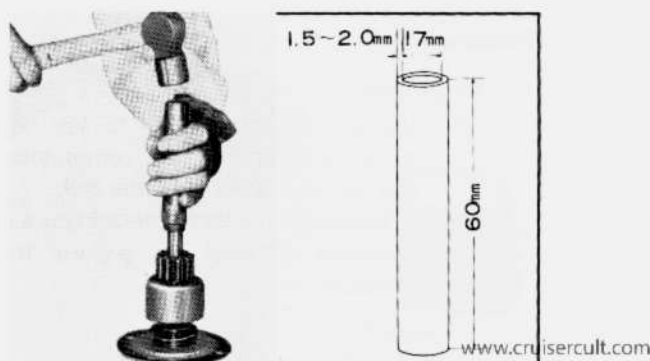


Fig. 7-9 Removing Starter Clutch

INSPECTION & REPAIR

Armature Shaft

Inspect the following items, and correct or replace the defective parts.

1. Shaft to bushing clearance: if it exceeds the limit, replace the bearing. (Refer to Table 7-2)

Table 7-2 Shaft to Bushing Clearance Limit

Housing Side	0.2 mm (0.008")
Pinion Side	0.2 mm (0.008")
Center Side	0.3 mm (0.012")
End Frame Side	0.2 mm (0.008")

Commutator

Inspect the following items, and correct or replace the defective parts.

1. Stains and burns over the surface: clean with sand paper.
2. Abnormal wear: dress with a lathe.
3. Diameter wear: if it is less than the limit, replace the armature.

Wear limit 46.2 mm (1.819")

Specified wear 48.2 mm (1.898")

4. Mica depth between the segments: if it is less than the limit, file off the mica.

Mica depth limit 0.2 mm (0.008")

Specified mica depth 0.5 to 0.8 mm
(0.020 to 0.032")

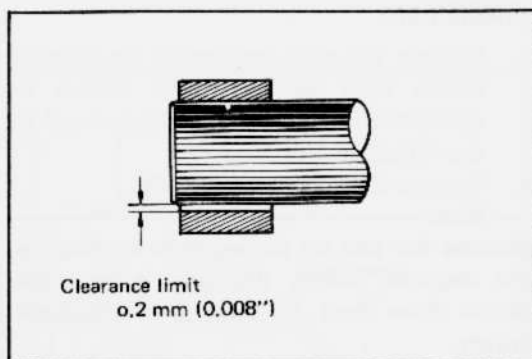


Fig. 7-10 Shaft & Bushing Inspection

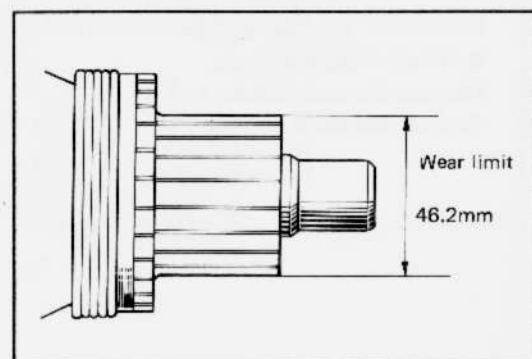


Fig. 7-11 Commutator Wear Limit

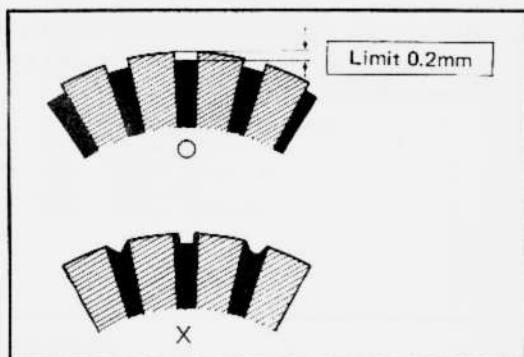


Fig. 7-12 Mica Depth

Armature Coil

1. Ground test
 - (1) Use an armature tester to test the continuity between the commutator and the core of the armature coil.
 - (2) If the pilot lamp lights, the armature is grounded. Correct or replace the armature coil.

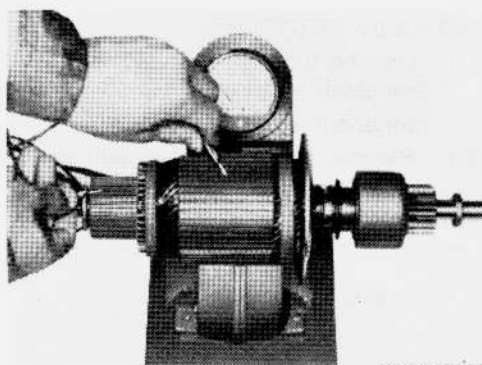


Fig. 7-13 Testing Armature Coil for Ground

2. Short circuit test

- (1) Place the armature on the armature tester, and hold a hacksaw blade over the core while rotating the armature, and test whether or not the hacksaw blade pulls in or vibrates.
- (2) If the hacksaw blade pulls in or vibrates, the armature coil is shorted. Repair or replace the armature.

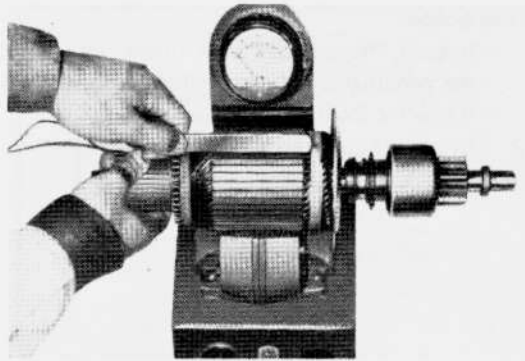


Fig. 7-14 Testing Armature Coil for Short

3. Open circuit test

- (1) Check the armature coil for open circuit by placing on the armature tester, and connect the two segments to test the open circuit.
- (2) If the pilot light does not glow even at one location, it indicates open circuit; therefore, correct or replace.

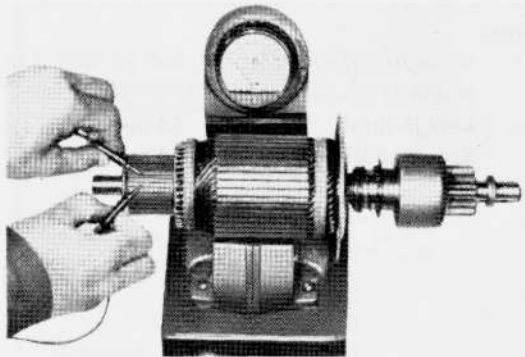


Fig. 7-15 Testing Armature Coil for Open Circuit

Field Coil

1. Open circuit test

- (1) Perform continuity test between the connecting lead terminals and the field coil and shunt field coil terminals.
- (2) If the continuity is defective, the field coil has an open circuit.



Fig. 7-16 Testing Field Coil for Open Circuit

2. Ground test

- (1) Test the continuity between the yoke and each of the field coil and shunt field coil terminals.
- (2) If there is continuity, remove the pole cores in order and find out the grounded places to repair.



Fig. 7-17 Testing Field Coil for Ground

Brush holder

1. Inspect the positive side brush holder and the negative side brush holder; also, the end frame for insulation.
2. In case of continuity, repair or replace.

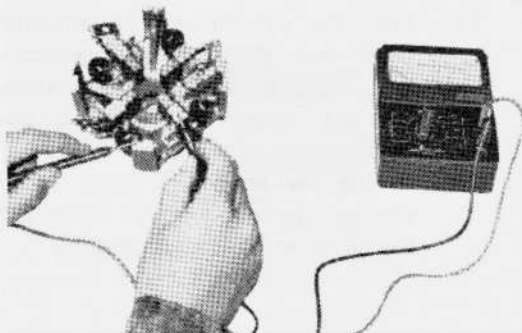


Fig. 7-18 Inspecting Brush Holder Insulation

Brush

1. Measure the brush length, and replace if the length is less than the limit.

Length limit 13 mm (0.51")

Specified length 20 mm (0.79")

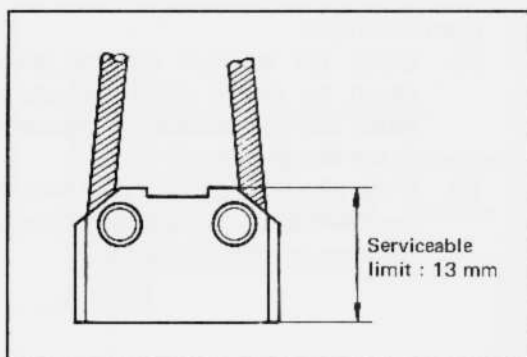


Fig. 7-19 Brush Length Inspection

2. When the brush is replaced, dress the brush with sand paper to obtain proper contact.

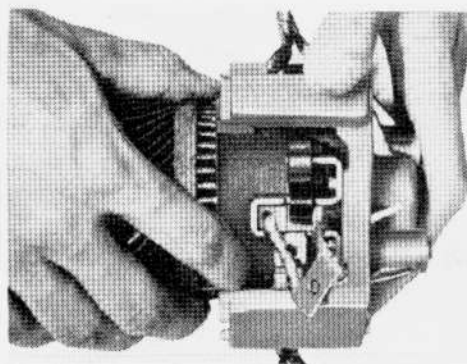


Fig. 7-20 Dressing Brush

3. Measure the brush spring installing load with a spring balancer.

- (1) The spring balancer should be read just when the brush spring leaves the brush.

- (2) If the load is less than the limit, replace the spring.

Load (Tension) limit 1200 g (2.6 lbs)

Specified Load

1700 to 2400 g (59.8 to 84.5 oz)

Starter Clutch

1. Check the pinion teeth surface for wear and damage and replace if defective.
2. Replace the starter clutch if it does not rotate freely or is slipping in the driving direction.

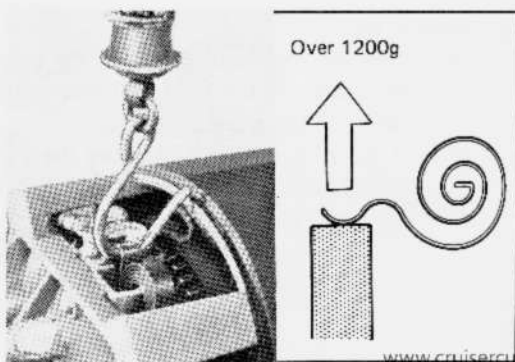


Fig. 7-21 Inspecting Brush Spring Tension

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Magnetic Switch

Caution

1. Inspect the magnetic switch with starter assembled. If inspected separately, the main contact may be deformed.
2. If the connecting plate of the lower main terminal field coil is removed, the starter does not rotate.
3. Disconnect the lead wire of the shunt field coil.

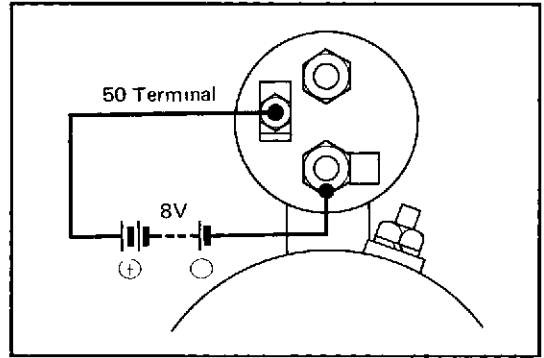


Fig. 7-22 Pull in Coil Test

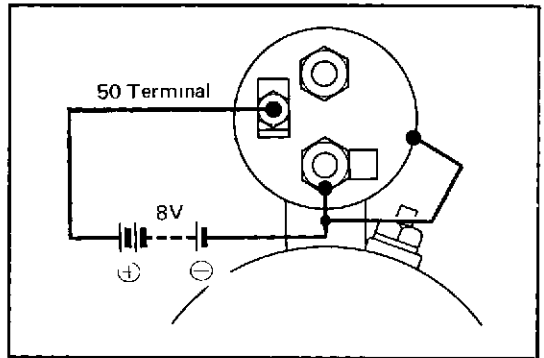


Fig. 7-23 Hold in Coil Test (1)

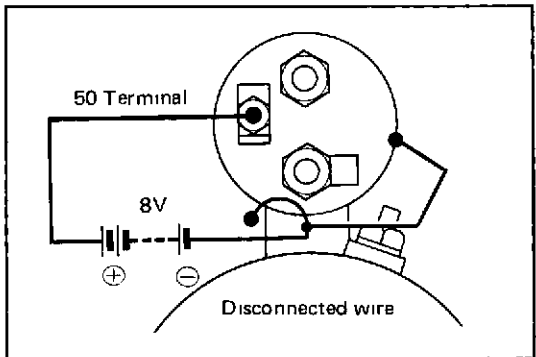


Fig. 7-24 Hold-in Coil Holding Test (2)

3. Return test
 - (1) Impress 12V between the lower main terminal and magnetic switch body
 - (2) Push in the plunger and then release the plunger.
The plunger should return quickly to its stop position

Caution

The ⊕ terminal of battery must be connected to main terminal.

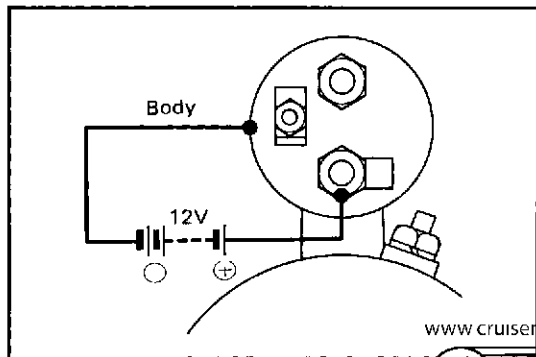


Fig. 7-25 Starter Switch Returning Test

ASSEMBLY

1. Upon assembling, coat the housing bushings, armature shaft splines, starter clutch drive ring, the magnetic switch retaining parts of pinion drive lever, the engaging parts to drive ring, hinges and the magnetic switch plunger with grease.

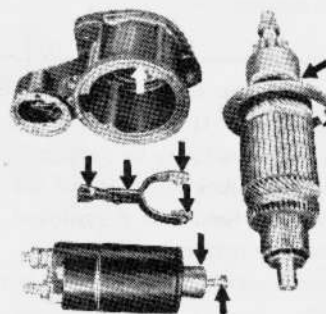


Fig. 7-26 Grease Coating Parts

2. Assemble the starter clutch.
 - (1) Assemble in the following order the washer, center bearing and the starter clutch into the armature shaft.
 - (2) Calk the pinion stop nut with a punch at four places.

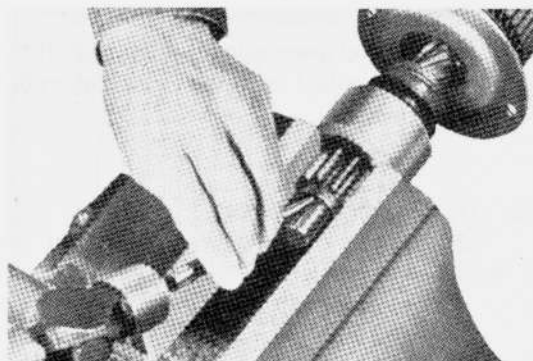


Fig. 7-27 Calking Stop Nut

3. Assemble the drive lever into the clutch, and after assembling the armature (1) with the drive lever (2) into the housing, fix the drive lever with the set pin.

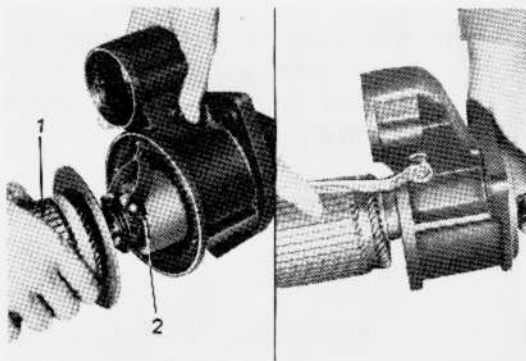


Fig. 7-28 Assembling Armature and Drive Lever

4. When assembling the yoke, assemble by fitting the knock pin of the yoke into the center bearing and housing holes.

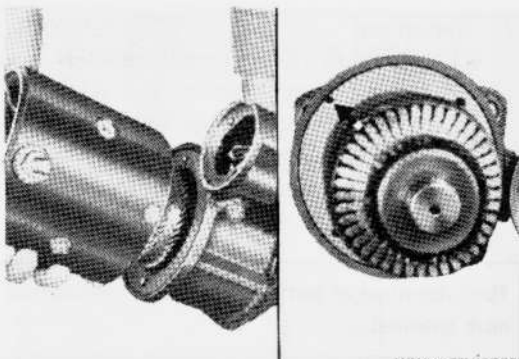


Fig. 7-29 Assembling Yoke

5. Assemble the commutator end frame.
 - (1) Insert one piece of Bakelite-made thrust washer and two pieces of Iron-made thrust washer into the armature shaft in order.

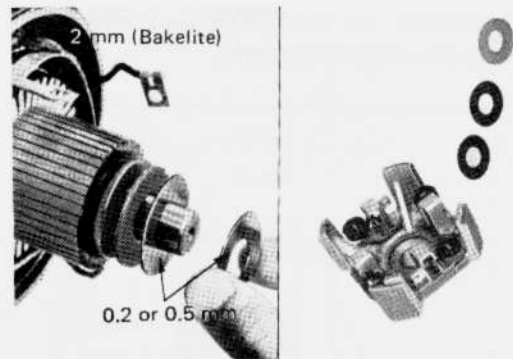


Fig. 7-30 Adjusting Armature Shaft Thrust

- (2) Mate the end frame notches with the yoke concave parts (oil inlet port (1) and terminal (2) should face in the same direction) to assemble, and then inspect the thrust of armature shaft.
- (3) When the thrust clearance is beyond the specified clearance, select the thrust washer and adjust.

Specified thrust clearance

0.05 to 0.35 mm
(0.002 to 0.014")

Thrust clearance limit

0.8 mm (0.032")

Note

After assembling the end frame, pour engine oil into the bearing oil inlet port.

6. Assemble the brushes.
7. Assemble the "O" ring and the end frame cover.

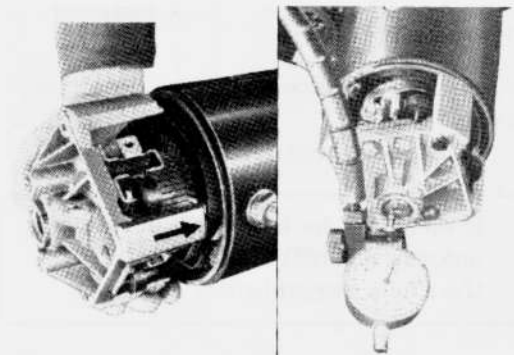


Fig. 7-31 Assembling End Frame

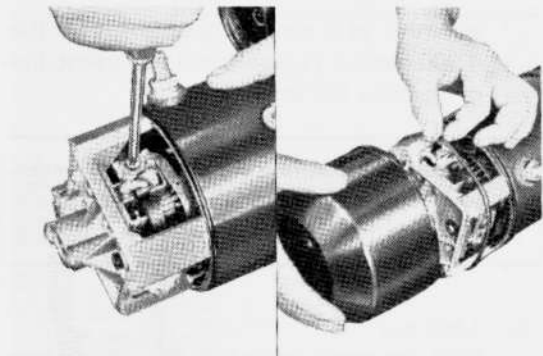


Fig. 7-32 Assembling Brushes & Cover

8. Assemble the "O" ring and magnetic switch.

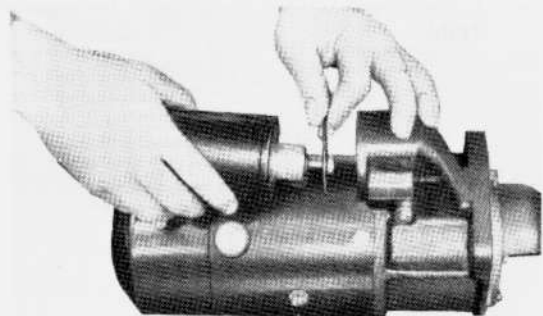


Fig. 7-33 Assembling Magnetic Switch

9. Connect the connecting lead wire of the shunt coil, and the plate.

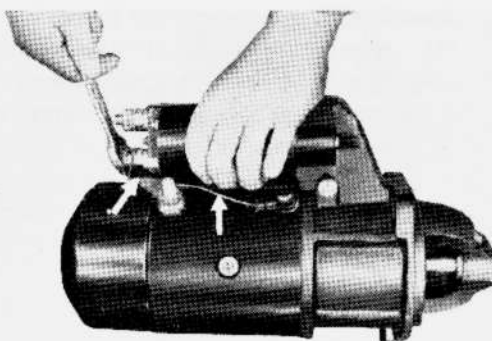


Fig. 7-34 Connecting Wire & Plate

Performance Tests

Perform the following tests upon the starter assembly.

- (1) No-load test, (2) Lock test

Notes

1. If equipment for lock test is not available, make the no-load test only.
2. Use a fully charged battery of 12 volts.

1. No-load test

The starter is satisfactory if it rotates smoothly at a constant speed of more than 4,000 rpm at 11.5 volts with a current draw of less than 100 amperes.

Note

To perform the test in a simple method, make the connections as shown in Fig. 7-36 and apply 12 volts directly.

2. Lock test

With the armature locked, the current draw should be less than 1,800 amperes at 5 volts producing a torque of over 3.5 kg-m (25.3 ft-lb).

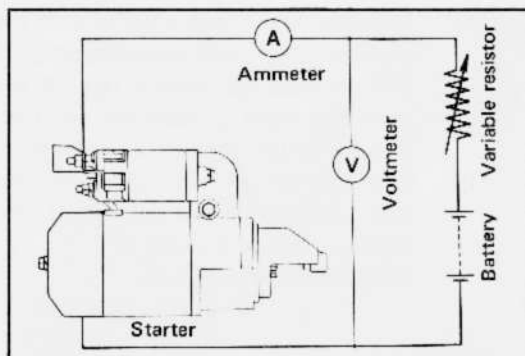


Fig. 7-35 Starter No-load Test

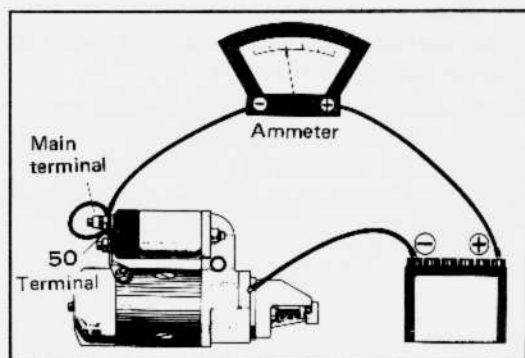


Fig. 7-36 Starter No-load Test

ALTERNATOR

DESCRIPTION

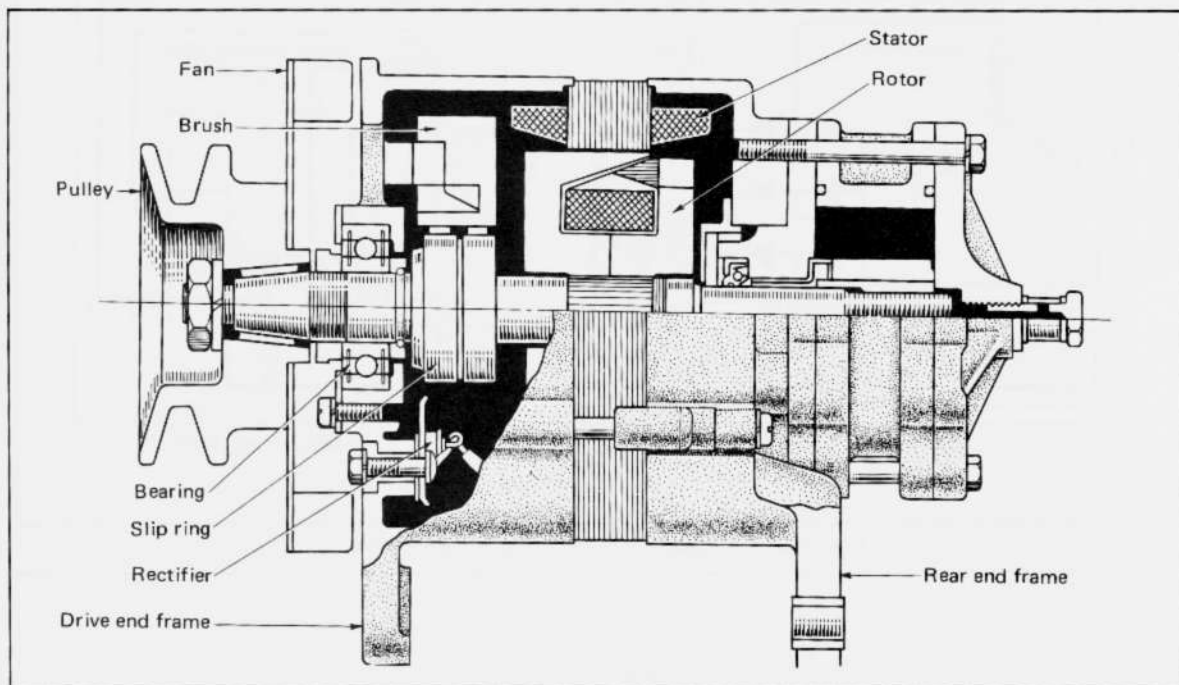


Fig. 7-37 Alternator Cross Sectional View (HU)

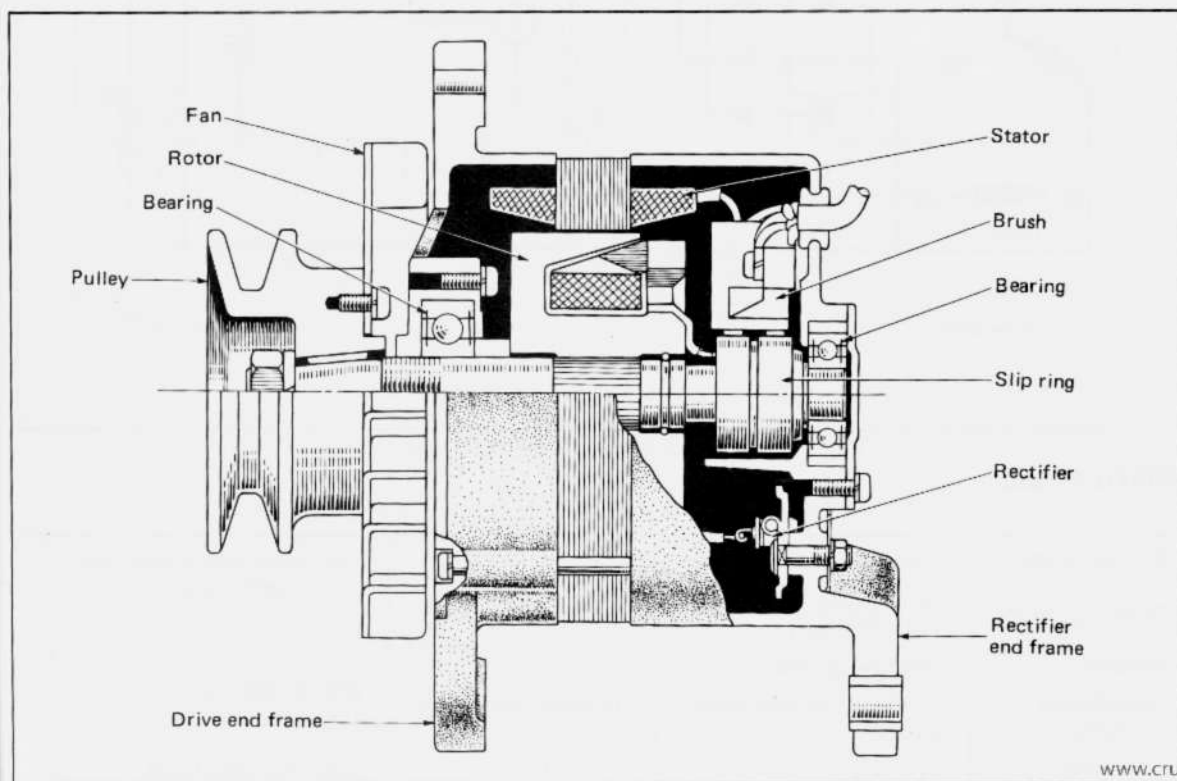


Fig. 7-38 Alternator Cross Sectional View (HJ)

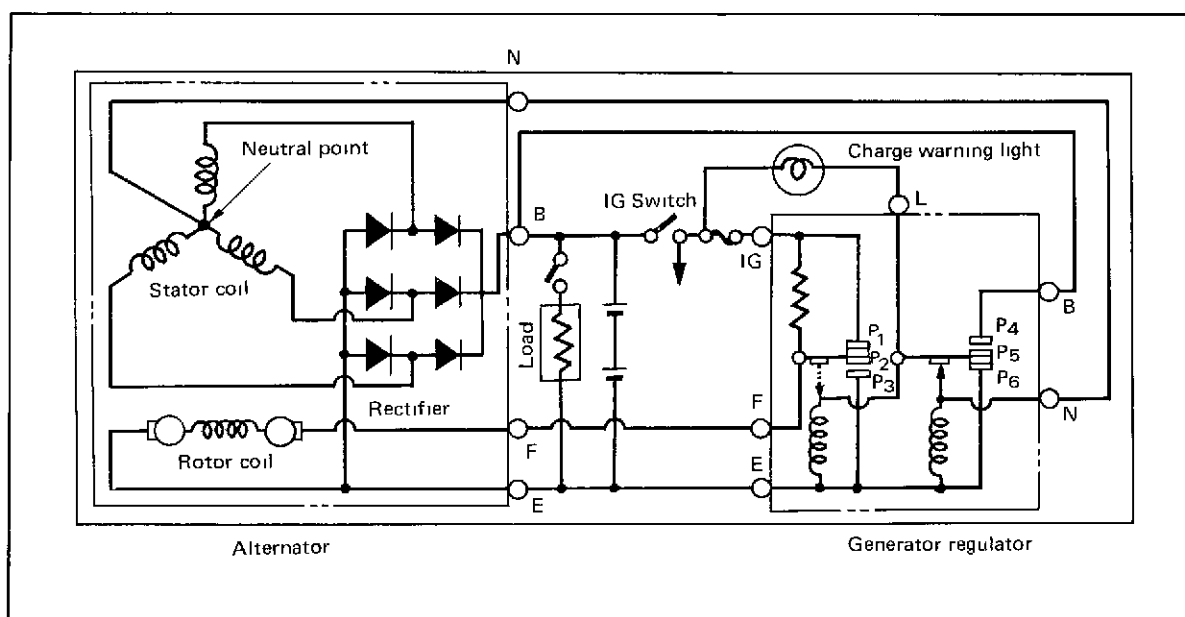


Fig. 7-39 Charging System Wiring Diagram (HU)

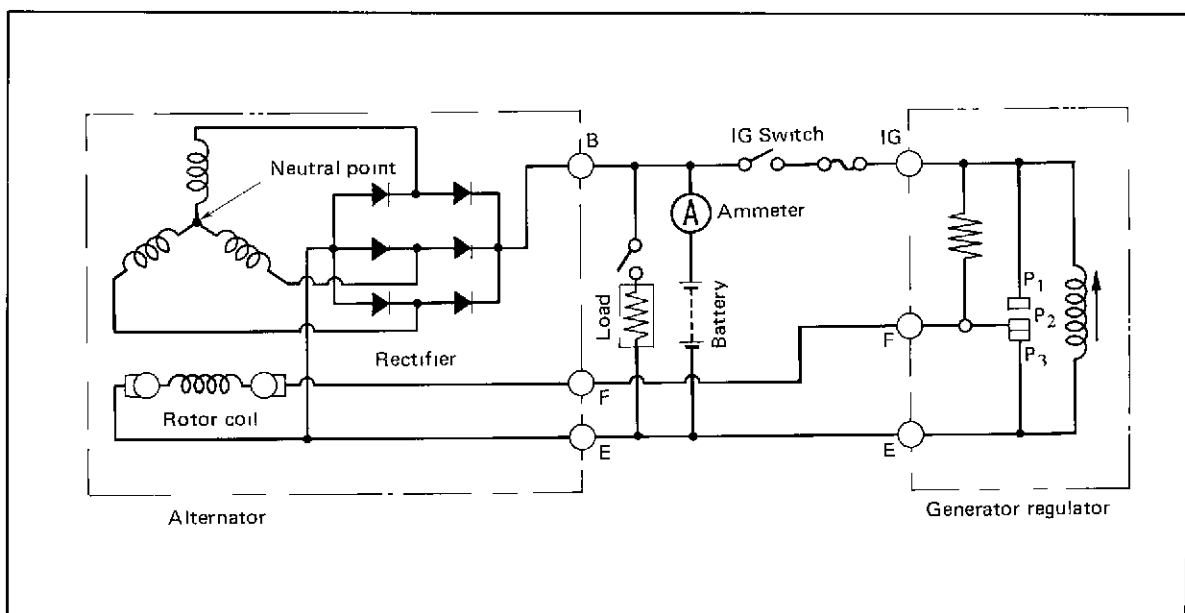


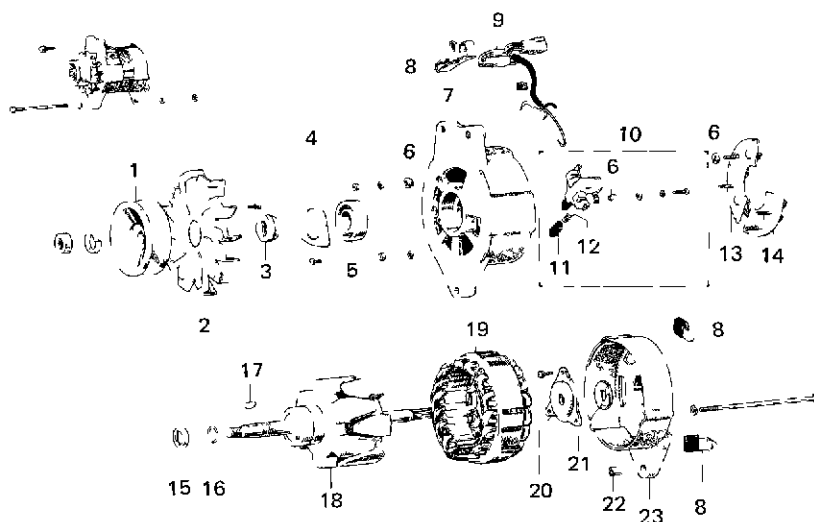
Fig. 7-40 Charging System Wiring Diagram (HJ)

SPECIFICATIONS

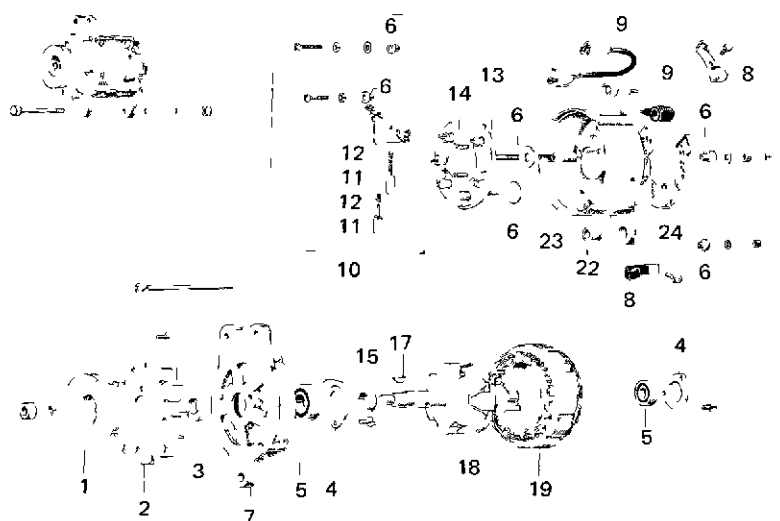
Table 7-3 Alternator Specifications (HU & HJ)

Rating voltage	12 volts	Rectification	Full wave rectification by six integral silicon diodes
Output current	35 amperes (14 volts, hot)	No load revolution	650 to 950 rpm (14 volts, 0 amperes)
Polarity	Negative grounded	Output power revolution	Less than 3500 rpm (14 volts, 35 amperes)
Direction of revolution	Clockwise as seen from pulley		
Generator connection	Three phase, Y Type		

HU Series



HJ Series



- | | |
|------------------------------|--------------------------------|
| 1 Pulley | 13. Holder with (C) rectifiers |
| 2 Fan | 14 Holder with (D) rectifiers |
| 3 Lock nut | 15 Spacer ring |
| 4 Retainer plate | 16 Snap ring |
| 5. Bearing | 17 Key |
| 6. Terminal insulator | 18 Rotor assembly |
| 7 Drive end frame | 19. Stator assembly |
| 8 Clamp | 20 Rear end cover |
| 9. Lead wire | 21. Felt washer |
| 10 Brush holder sub assembly | 22. Bushing |
| 11 Brush | 23. Rear end frame |
| 12 Brush spring | 24. Rear end cover |

Fig 7-41 Alternator Component Parts

Precautions on Alternator

1. When working on the alternator, be sure to keep in mind that its terminal B is always under voltage from the battery plus side, and that turning on the ignition switch will also impress battery voltage on the F terminal
2. Carefully note the battery polarity. Never make any connections with the polarity reversed.
Reversed connection allow large current to flow from the battery and damage the rectifiers and wiring.
3. In charging the battery with quick charger, be sure to have the battery terminals disconnected.
Use of the quick charger with the alternator connected to the battery will damage the rectifiers.
4. Never the engine with the lead wire disconnected from the alternator B terminal
This might cause the N terminal voltage to rise excessively and burn out the regulator voltage relay coil. If required to have the B terminal open, also have the F terminal disconnected.
5. In adjusting the regulator, be sure that the socket connection is pulled out beforehand
Attempting to adjusting regulator while in connected state might short the contacts and fuse them together.
6. When washing the car, use care not to direct the water hose directly on the alternator.
Presence of water on the rectifier surface will lower rectifier performance.
7. Do not rotate the alternator by itself.

Circuit Tester Polarity

The following precaution should be observed when testing continuity with circuit tester. The current flows from the tester (–) terminal to its (+) terminal. The tester (+) terminal becomes (–) polarity and tester (–) terminal becomes (+) polarity, and these differ from polarities obtained in voltage and current measurements. Therefore if the semiconductor being tested shows the same polarity, this indicates continuity. If reverse, this indicates no continuity. This point should be specially kept in mind when checking rectifiers

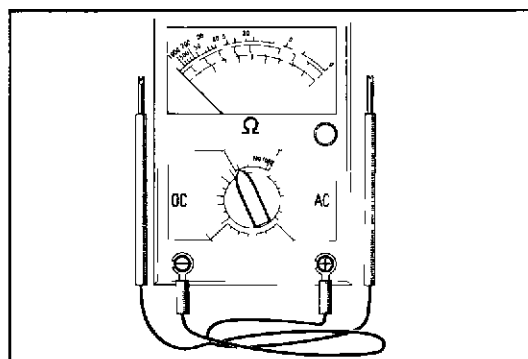


Fig 7 42 Circuit Tester

ALTERNATOR (HU)

DISASSEMBLY

1. Remove the vacuum pump.
 - (1) Remove the three through bolts attaching the rear end frame, and take off the rear end frame with vacuum pump attached.

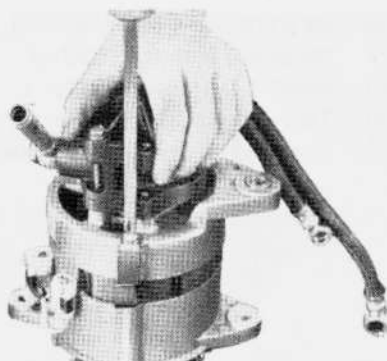


Fig. 7-43 Rear End Frame Removal

- (2) Remove the oil hoses and vacuum pipe.
- (3) Remove the three screws from rear end frame and take off the rear end cover and felt.

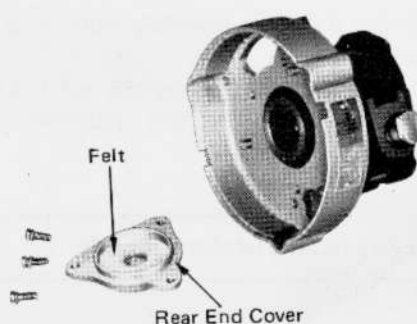


Fig. 7-44 Rear End Frame Removed

- (4) Remove the three through bolts mounting the vacuum pump and take off the vacuum pump assembly by lightly tapping the pump drive end frame with plastic hammer.

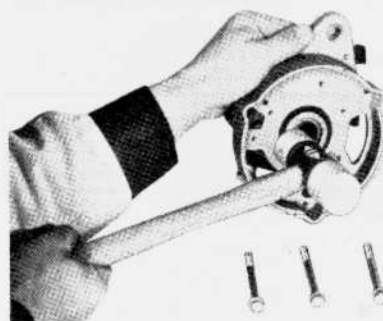


Fig. 7-45 Removing Vacuum Pump

Caution

Take means to prevent dirt from entering the vacuum pump.

2. Remove the pulley with fan attached.
 - (1) Remove the pulley lock nut. Hold SST [09841-56010] in a vise and have the rotor core locked into the alternator stand.

Note

1. Do not attempt to remove the lock nut by holding the rotor shaft in a vise.
2. Clamp the SST [09841-56010] in the vise so that the stator coil will not be contacting the vise.

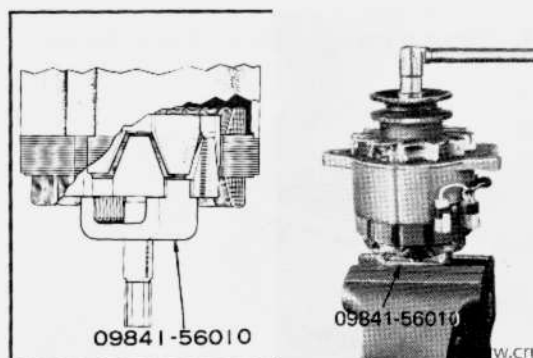


Fig. 7-46 Removing Pulley Lock Nut

- (2) By using SST [09950-20010], remove the pulley with fan attached.
- (3) Remove the woodruff key.
- (4) Take off the bearing retainer plate by removing three attaching screws.

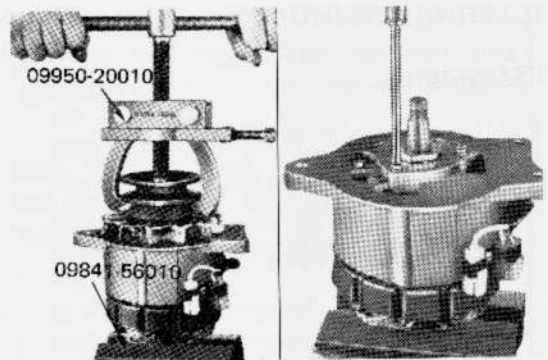


Fig. 7-47 Removing Pulley & Plate

3. Remove the rotor assembly from drive end plate.

- (1) Remove the bearing lock nut. Use SST [09841-56010] and [09333-55011] 32 mm wrench.

Caution

Bearing lock nut has left-hand threads.



Fig. 7-48 Removing Bearing Lock Nut

- (2) Using SST [09950-20010], draw out the rotor assembly.

Note

Hook on the universal puller so that it will not contact the stator coil.

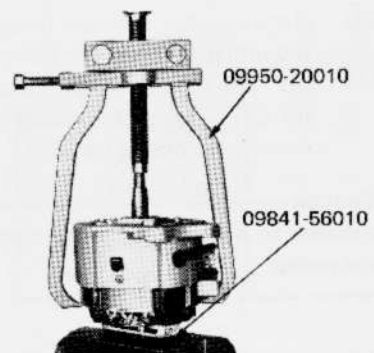


Fig. 7-49 Removing Rotor Assembly

4. Remove the bearing from drive end plate.

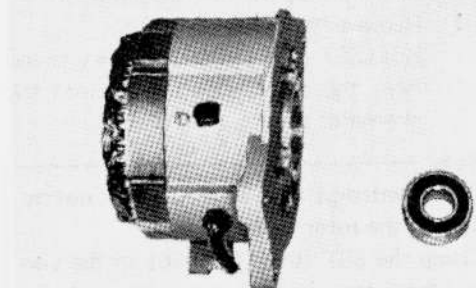


Fig. 7-50 Bearing Removed

5. Pull out the stator coil with brush holders and rectifiers complete from the drive end frame.

- (1) Remove the brush holder mounting screws (1) from the inner side of drive end frame.

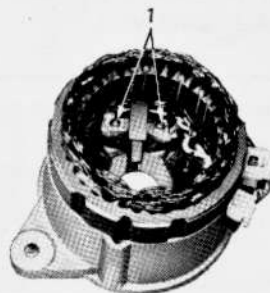


Fig. 7-51 Brush Holder Removal

- (2) Remove the rectifier mounting nuts (1), washers (2), and (+) side insulators (3) from front side of drive end frame.
 - (3) Remove the socket mounting clamp (4) from the frame by removing one screw.

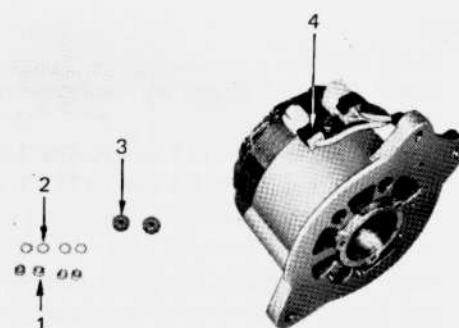


Fig. 7-52 Rectifier Removal

- (4) Take out the stator coil with brush holder with rectifiers complete from the drive end frame.

Note

1. Rectifiers at (+) side are provided with insulation washers (1).
2. Tuck in the wiring harness from socket when drawing out the stator coil.

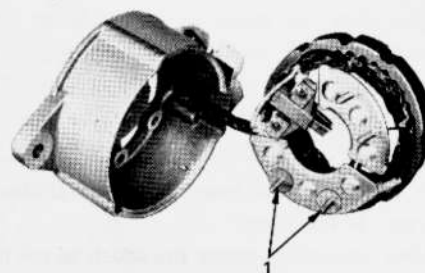


Fig. 7-53 Stator Coil Drawn Out

6. Unsolder the rectifier and brush holder leads by using soldering iron.

Note

1. Do not remove the rectifier unless found necessary to do so.
2. In unsoldering the rectifier, hold its lead wire with long nose pliers to prevent overheating and melt off the solder quickly.

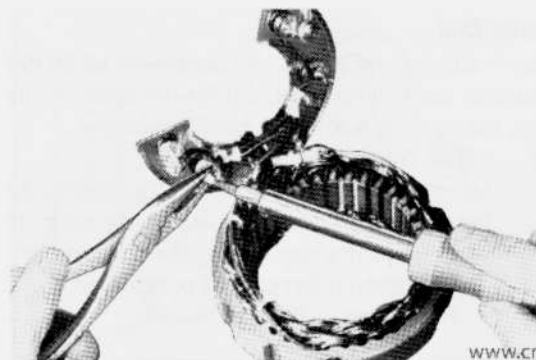


Fig. 7-54 Removing Rectifier

- 7 Remove the spacer ring (1) and snap ring (2) from rotor assembly

Note

Do not disassemble unless found necessary to do so.

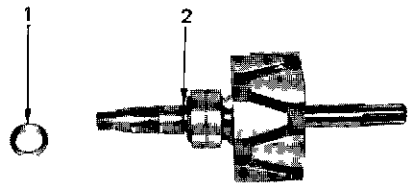


Fig 7 55 Rotor Disassembled

INSPECTION**Brushes**

- 1 Brush length
Check the brush length and replace if worn over the limit
Standard length 12.5 mm (0.492")
Service limit 5.5 mm (0.217")
- 2 Check the brushes to see if they move freely in the brush holders. Also check for continuity between the brush holders and end frame, if continuity is indicated the insulation is defective, necessitating replacement
- 3 Brush replacement
Insert the new brush in the holder so that it protrudes out about 12.5 mm (0.5") and then solder on the brush lead wire. After soldering, cut off the surplus wire

Note

1. In replacing the brush, do not solder it drawn in too deep.
2. After soldering, check the brush to see if it moves freely in the holder.

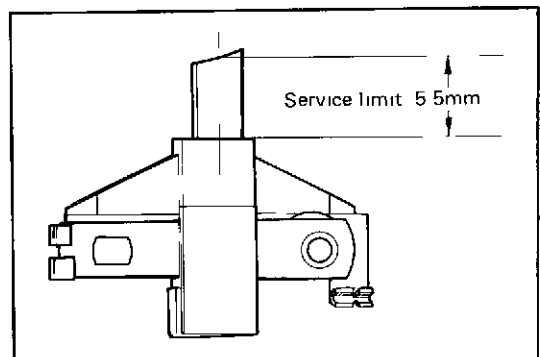


Fig 7 56 Brush Length

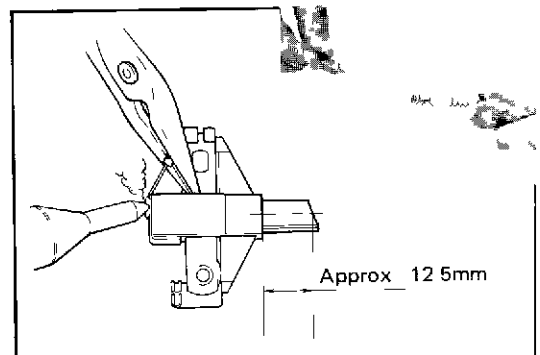


Fig 7 57 Replacing Brush

Stator Coil

Stator coil ground test can be performed while the rectifiers are still installed but for the open-circuit test, the rectifier leads must be disconnected.

- 1 Stator coil ground test
Using a circuit tester, check the continuity between the stator coil and stator core. If tester indicates continuity, the coil is grounded and should be repaired or replaced.

Resistance Infinity

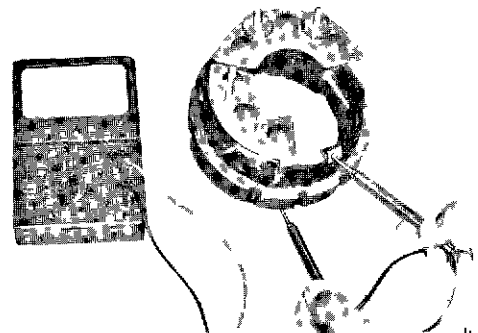


Fig 7-58 Stator Coil Ground Test

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2 Stator coil open-circuit test

Check the continuity between the stator coil four leads. If tester does not indicate continuity, the coil has open circuit and should be repaired or replaced

Resistance 0

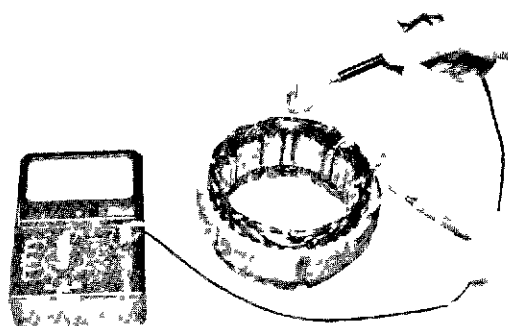


Fig 7-59 Stator Coil Open Circuit Test

Rectifiers

Rectifier short-circuit test can be performed between the N and B or E terminals but for the open circuit test, the rectifier must be disconnected from stator coil. In case of defect, the entire assembly must be replaced

1 Short circuit test

(1) Plus side rectifiers

Touch the B terminal with tester (-) probe and stator coil N terminal with tester (+) probe

Resistance Infinity . Normal
Close to 0 Ω . Shorted

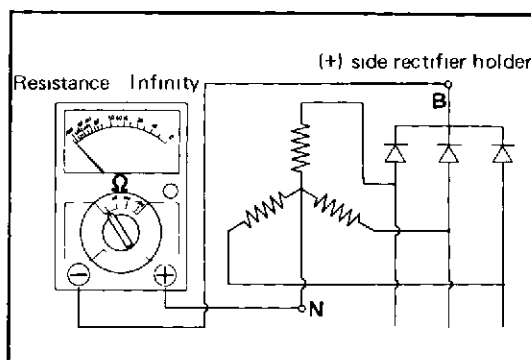


Fig. 7 60 (+) Rectifier Short-Circuit Test

(2) Minus side rectifiers

Touch the E terminal with tester (+) probe and stator coil N terminal with tester (-) probe.

Resistance Infinity : Normal
Close to 0 Ω . Shorted

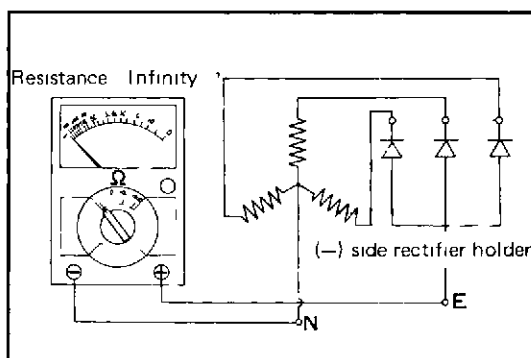


Fig 7-61 (-) Rectifier Short Circuit Test

2 Open circuit test

(1) Plus side rectifiers

Touch the plus side holder with tester (+) probe and rectifier lead wire with tester (-) probe.

Resistance Close to 0 Ω : Normal
Infinity . Open

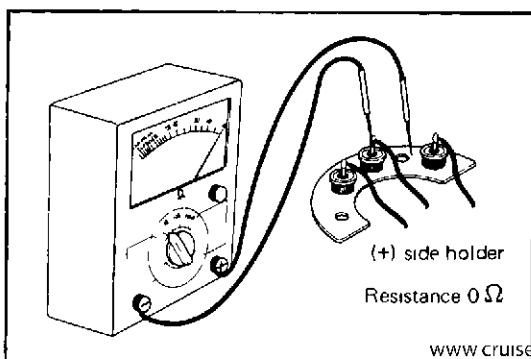


Fig. 7 62 (+) Rectifier Open-Circuit Test

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(2) Minus side rectifiers

Touch the minus side holder with tester (-) probe and rectifier lead wire with tester (+) probe

Resistance **Close to 0 Ω** **Normal**
 Infinity **Open**

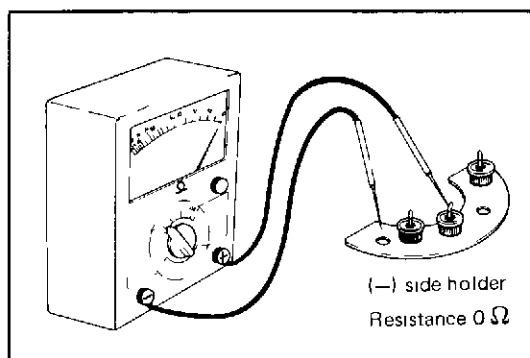


Fig 7 63 (-) Rectifier Open Circuit Test

Rotor Coil

1. Rotor coil open circuit test

Check the continuity between the two slip rings. If there is no continuity, the coil is open-circuited and should be replaced.

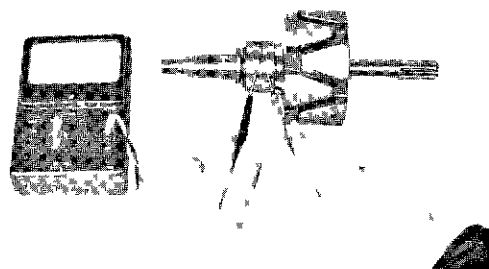


Fig 7 64 Rotor Coil Open-Circuit Test

2. Rotor coil ground test

Check the continuity between the slip ring and rotor shaft. If continuity is indicated, the insulation between the slip ring and rotor coil is defective, necessitating replacement.

Resistance **Infinity**

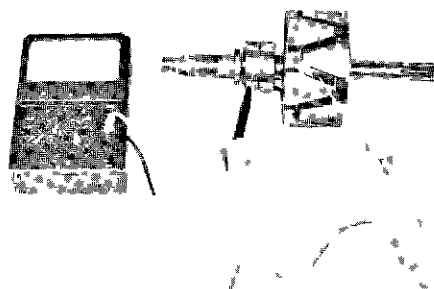


Fig. 7 65 Rotor Coil Ground Test

Bearing

Inspect the ball bearing and replace if found defective.

Rear End Frame and Vacuum Pump

1. Inspect the rear end cover (1), felt washer (2), and rear end frame (3)

Note

If dirty with oil or grease, check the vacuum pump oil seal and bearing.

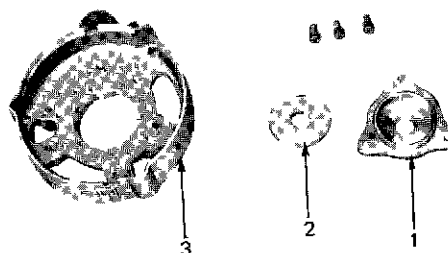


Fig. 7 66 Felt Washer & Rear End Frame Inspection

2. The vacuum pump oil seal should be inserted in fully as shown in Fig. 7-67.
3. Measure the vacuum pump bearing inside diameter.

Limit	16.14 mm (0.6354")
Standard	16.04 to 16.06 (0.6315 to 0.6323")

Note

If over the limit, replace the vacuum pump assembly.

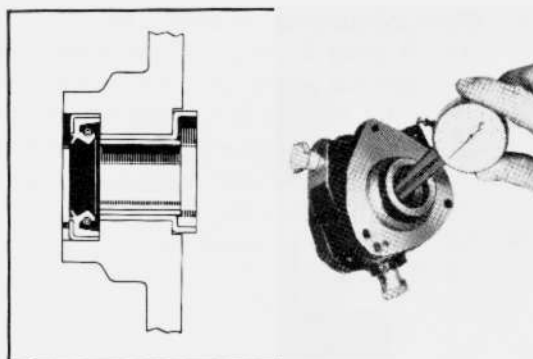


Fig. 7-67 Oil Seal & Bearing Inspection

ASSEMBLY

1. Solder on the rectifier lead wires to the stator coil.

Note

Solder by holding the rectifier lead wire with long nose plier and applying the soldering iron quickly to prevent overheating.

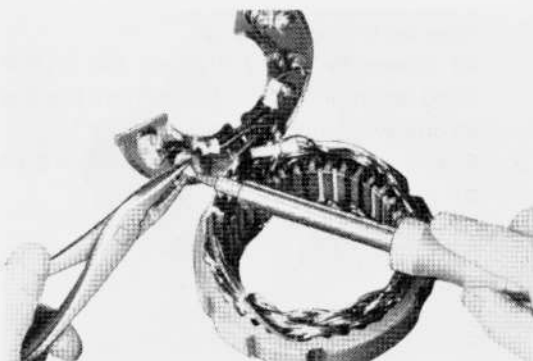


Fig. 7-68 Soldering Rectifier to Stator Coil

2. Assemble the brushes into the brush holders. (Refer to P. 7-20)
 - (1) Solder the F terminal to brush holder.
 - (2) Connect the E terminal to the F terminal side over terminal insulation washer.
 - (3) Solder the N terminal socket side together with N terminal stator side onto the terminal plate, and push them in to the brush holder over terminal insulator.

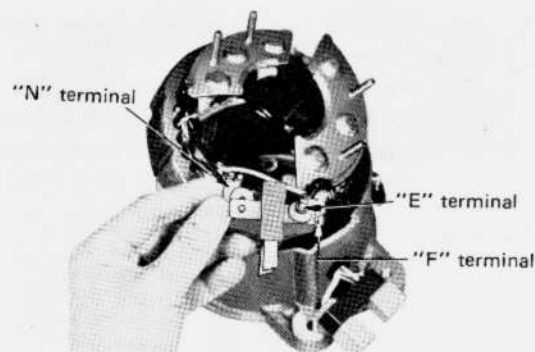


Fig. 7-69 Assembling Brush Holder

3. Assemble the rectifier holders, brush holders, and stator coil in to drive end frame.
 - (1) Insert insulation washers (1) between the (+) side rectifier holder and end frame.
 - (2) Attach the brush holder with two screws.
 - (3) Bolt on the (+) side rectifier holder over terminal insulation washers (2) and lock washer.

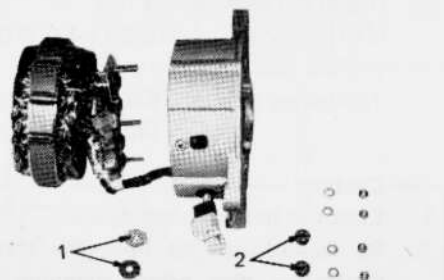


Fig. 7-70 Assembling Stator Coil

4. Check the stator coil installed state.
 - (1) If there is danger of the stator coil terminal wiring contacting on frame or rotor, correct by bending the wiring.
 - (2) Check the position of stator coil notch for alignment with end frame through bolt hole position.
 - (3) Install the socket clamp.

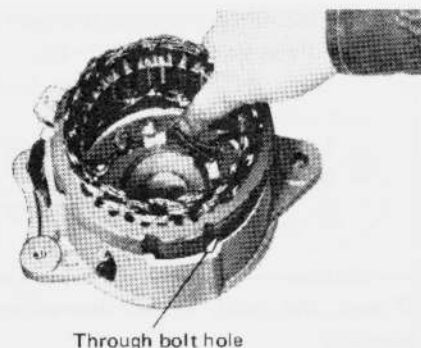


Fig. 7-71 Checking Stator Coil Installed State

5. Have the brushes lifted up.
As shown in Fig. 7-72, have the brushes lifted up from the end frame front side and secured with wire or other means.
6. Assemble the snap ring and spacer ring on the rotor shaft.

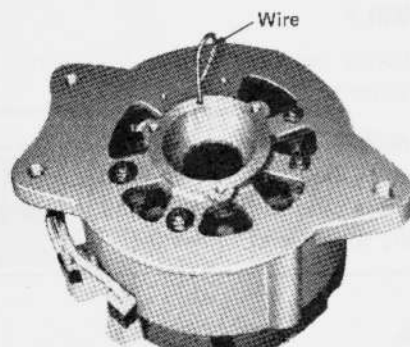


Fig. 7-72 Lifting Up Brushes

7. Insert bearing into drive end frame, and install the rotor assembly.
 - (1) Hold the rotor with SST [09841-56010] and using the tool illustrated in Fig. 7-73, at the bearing side, press the end frame onto rotor.

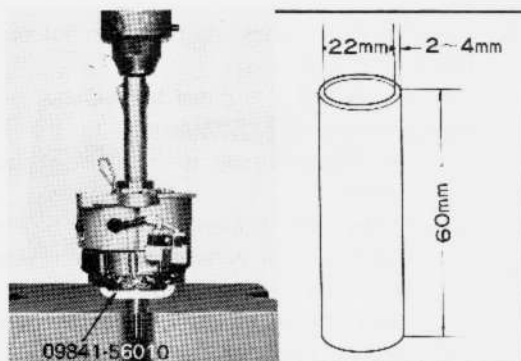


Fig. 7-73 Installing Rotor Assembly

8. Install the bearing lock nut.
Utilize SST [09841-56010] and [09333-55011] 32 mm wrench.
**Tightening torque: 5.6 to 8.0 kg-cm
(40.5 to 57.9 ft-lb)**

Caution

1. Lock nut has left-hand thread.
2. Be careful not to have the stator coil contacting vise when clamping on the alternator stand in vise.

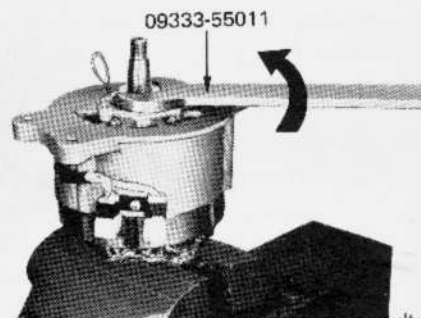


Fig. 7-74 Tightening Bearing Lock Nut

9. Remove the wires holding up the brushes and install the bearing plate retainer with three screws.
10. Install the pulley with fan attached.
 - (1) Install the fan on the pulley with three screws.
 - (2) Fit the key into the rotor shaft, and after aligning the key-way, install the pulley, washer and nut on the shaft.

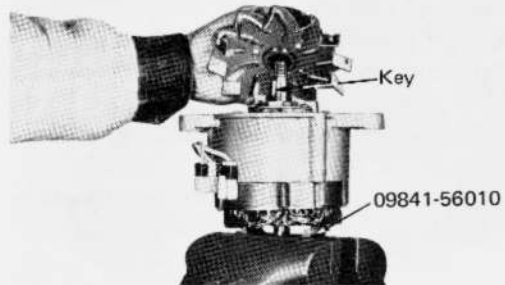


Fig. 7-75 Installing Pulley with Fan

11. Mount the vacuum pump on the rear end frame with three through bolts.

Note

Coat the oil seal lightly with grease.

12. Insert the felt washer in the rear end frame and install the rear end cover with three screws.
13. Connect the oil hoses and vacuum pipe.



Fig. 7-76 Installing Felt Washer

14. Bolt together the rear end frame and drive end frame with three through bolts.

Note

Align the vacuum pump rotor spline hole against the rear cover hole and then fit in the alternator rotor shaft spline.

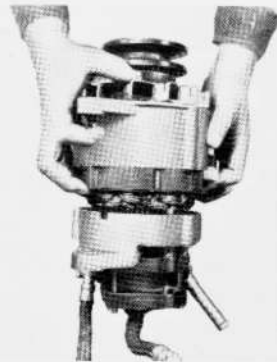


Fig. 7-77 Installing Rear End Frame to Drive End Frame

PERFORMANCE TESTS

In case the alternator performance is conducted on bench tester, make sure that the vacuum pump is attached to the alternator. Then, connect the oil pipes as shown in Fig. 7-78.

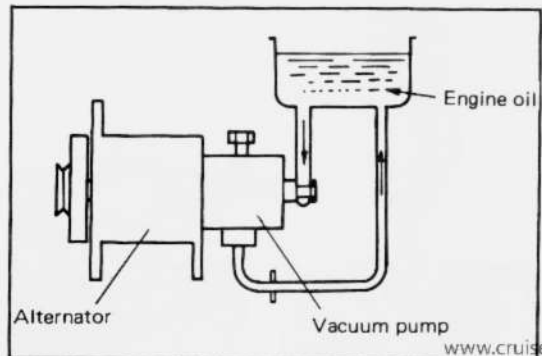


Fig. 7-78 Alternator Performance Test

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Conduct the performance tests by hooking up the alternator as shown in Fig 7-79

1 No-load test

For this test, have the switch S_2 open. Drive the alternator with the variable speed motor and after closing the switch S_1 , speed up the alternator gradually from low speed and read the rpm at 14V.

The alternator speed at this time should be 650 to 950 rpm (cold).

2 Output test

Maintain the output voltage at constant 14V by adjusting the variable resistance. At output current of 35A the alternator speed should be less than 3,500 rpm (cold).

Note

Fully charged battery should be used for the tests.

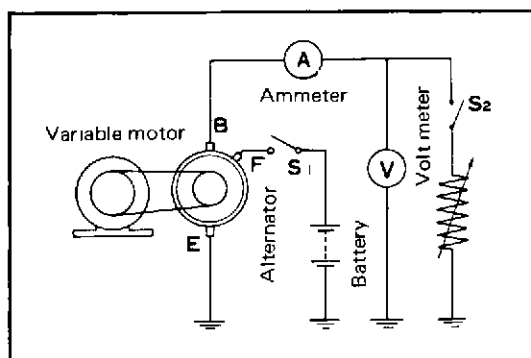


Fig 7-79 No Load Test

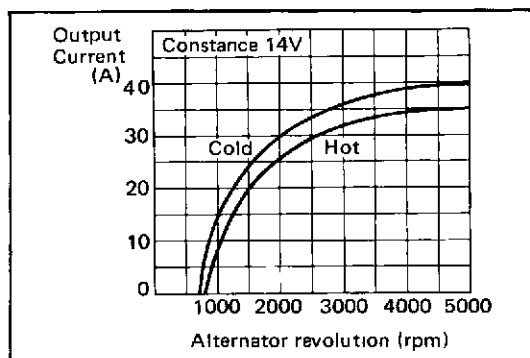


Fig. 7-80 Alternator Output Characteristics

ALTERNATOR (HJ)**DISASSEMBLY**

1. Remove the three screws on the drive end frame.
2. Remove the wiring clamp (1) and rear end plate (2).

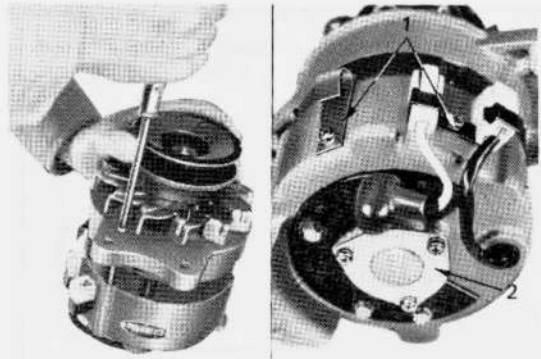


Fig. 7-81 Removing Screws & Plate

3. Remove the rotor w/drive end frame from the rear end frame pressing the rotor shaft and using a socket wrench (9 mm or 11/32").

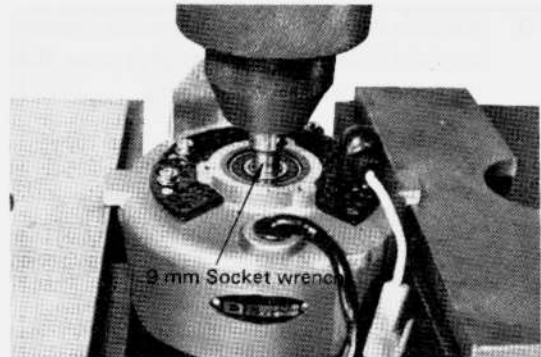


Fig. 7-82 Separating Front and Rear

4. Secure the rotor core in a vise, remove the pulley attaching nut and spring washer.

Caution

When securing the rotor core in the vise, it is necessary to install wooden blocks or copper plates to prevent the core from damaging.

5. By using SST [09950-20010], remove the pulley with fan attached.
6. Remove the woodruff key.

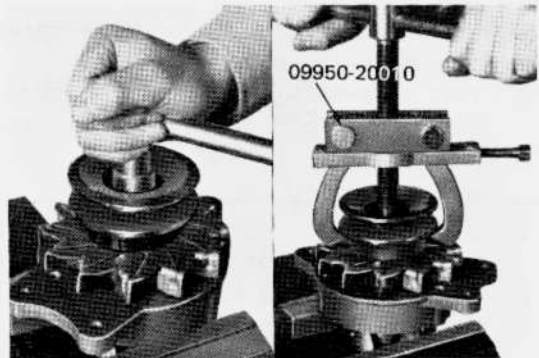


Fig. 7-83 Removing Pulley with Fan

7. Remove the bearing lock nut using SST [09333-55011] or 32 mm wrench. Then remove the rotor from the drive end frame using a press.
8. Remove the spacer ring from the rotor shaft.

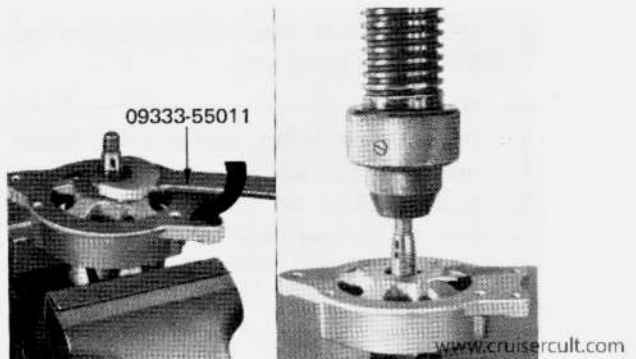


Fig. 7-84 Removing Rotor Assembly

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9. Remove the front bearing retainer and bearing from the drive end frame.

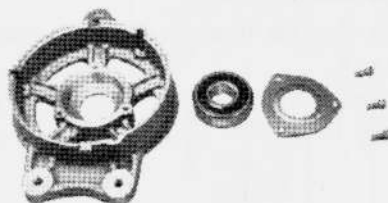


Fig. 7-85 Removing Front Bearing

10. Remove the nuts, wiring connector, washers, terminal insulators and rear end cover from the rear end frame.

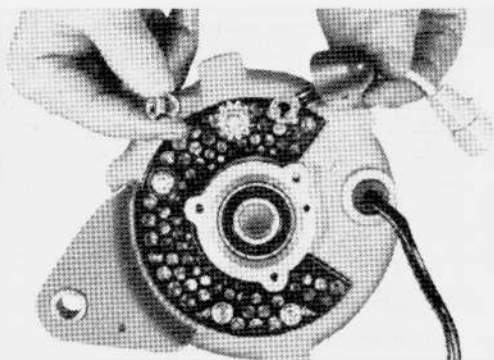


Fig. 7-86 Removing Rear End Cover

11. Remove the brush holder mounting screws from the rear end frame.
12. Take out the stator coil with brush holder and rectifier holders from the rear end frame.

Note

1. Rectifiers at (+) side are provided with insulation washers (1).
2. Tuck in the wiring harness from socket when drawing out the stator coil.

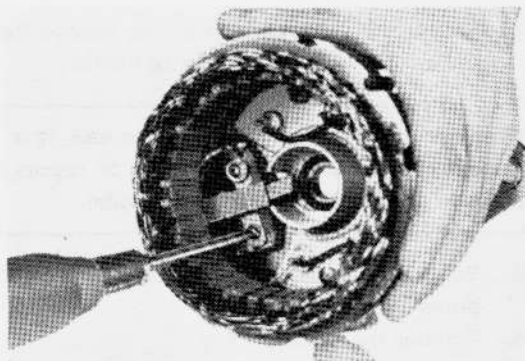


Fig. 7-87 Removing Brush Holder

13. Unsolder the rectifier and brush holder leads by using soldering iron.

Note

1. Do not remove the rectifier unless found necessary to do so.
2. In unsoldering the rectifier, hold its lead wire with long nose pliers to prevent overheating and melt off the solder quickly.

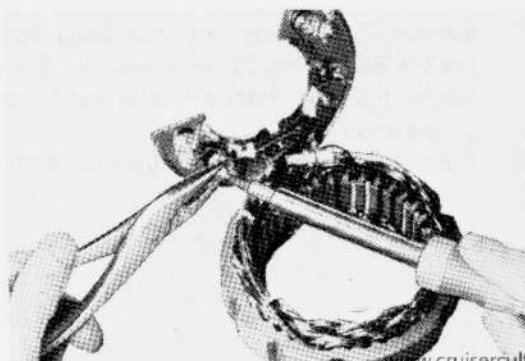


Fig. 7-88 Removing Rectifier

INSPECTION

Brushes

1. Brush length
Check the brush length and replace if worn over the limit.
Standard length 12.5 mm (0.492")
Service limit 5.5 mm (0.217")
2. Check the brushes to see if they move freely in the brush holders. Also check for continuity between the brush holders and end frame. If continuity is indicated, the insulation is defective, necessitating replacement.
3. Brush replacement
Insert the new brush in the holder so that it protrudes out about 12.5 mm (0.5") and then solder on the brush lead wire. After soldering, cut off the surplus wire.

Note

1. In replacing the brush, do not solder it drawn in too deep.
2. After soldering, check the brush to see if it moves freely in the holder.

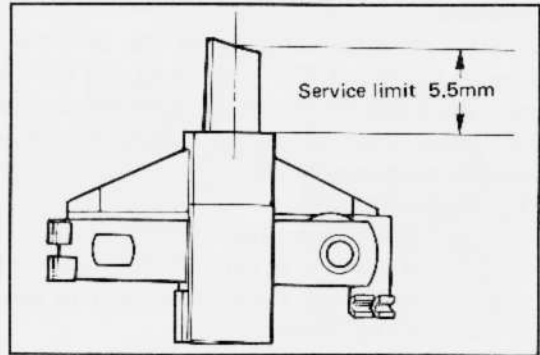


Fig. 7-89 Brush Length

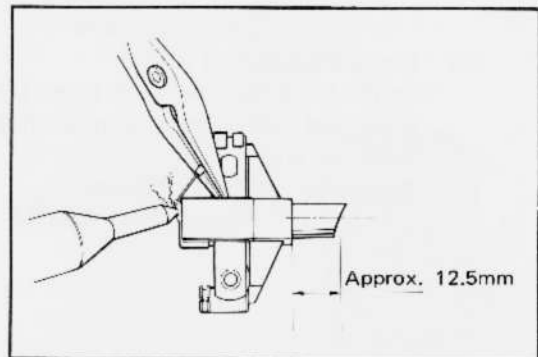


Fig. 7-90 Brush Replacement

Stator Coil

Stator coil ground test can be performed while the rectifiers are still installed, but for the open-circuit test, the rectifier leads must be disconnected.

1. Stator coil ground test
Using a circuit tester, check the continuity between the stator coil and stator core. If tester indicates continuity, the coil is grounded and should be repaired or replaced.

Resistance Infinity

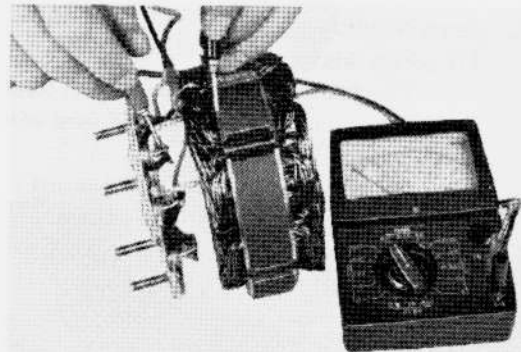


Fig. 7-91 Stator Coil Ground Test

2. Stator coil open-circuit test
Check the continuity between the stator coil four leads. If tester does not indicate continuity, the coil has open-circuit and should be repaired or replaced.

Resistance 0

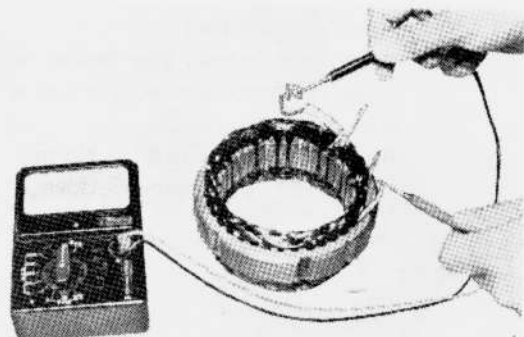


Fig. 7-92 Stator Coil Open Circuit Test

Rectifiers

Rectifier short circuit test can be performed between the N and B or E terminals, but for the open-circuit test the rectifier must be disconnected from stator coil. In case of defect the entire assembly must be replaced

1 Short circuit test

(1) Plus side rectifiers

Touch the B terminal with tester () probe and stator coil N terminal with tester (+) probe

Resistance **Infinity : Normal**
Close to 0 Ω : Shorted

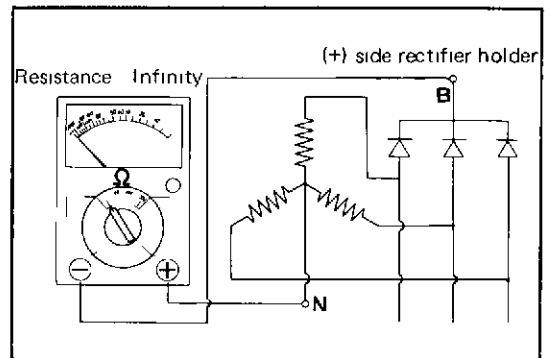


Fig 7-93 (+) Rectifier Short Circuit Test

(2) Minus side rectifiers

Touch the E terminal with tester (+) probe and stator coil N terminal with tester (–) probe.

Resistance **Infinity : Normal**
Close to 0 Ω : Shorted

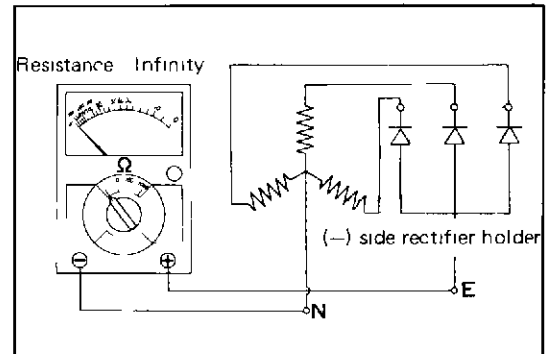


Fig 7-94 (–) Rectifier Short Circuit Test

2 Open circuit test

(1) Plus side rectifiers

Touch the plus side holder with tester (+) probe and rectifier lead wire with tester (–) probe.

Resistance **Close to 0 Ω : Normal**
Infinity : Open

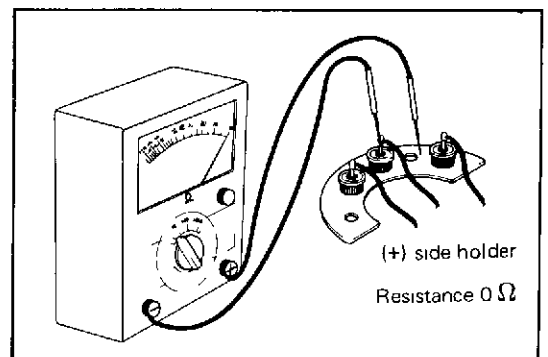


Fig 7-95 (+) Rectifier Open Circuit Test

(2) Minus side rectifiers

Touch the minus side holder with tester (–) probe and rectifier lead wire with tester (+) probe

Resistance **Close to 0 Ω : Normal**
Infinity : Open

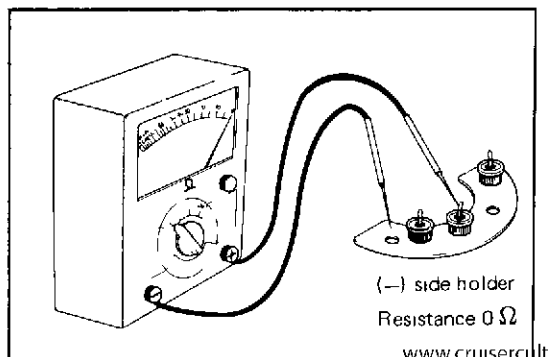


Fig 7-96 (–) Rectifier Open Circuit Test

Rotor Coil**1. Rotor coil open-circuit test**

Check the continuity between the two slip rings. If there is no continuity, the coil is open-circuited and should be replaced.

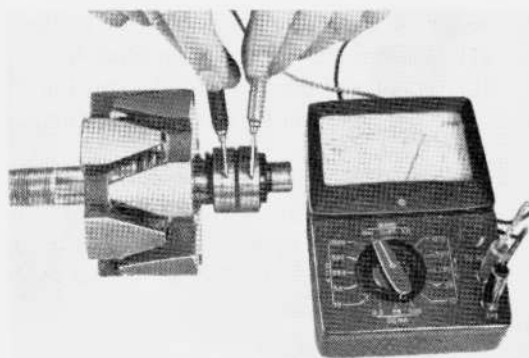


Fig. 7-97 Testing Rotor Coil for Open Circuit

2. Rotor coil ground test

Check the continuity between the slip ring and rotor shaft. If continuity is indicated, the insulation between the slip ring and rotor coil is defective, necessitating replacement.

Resistance Infinity

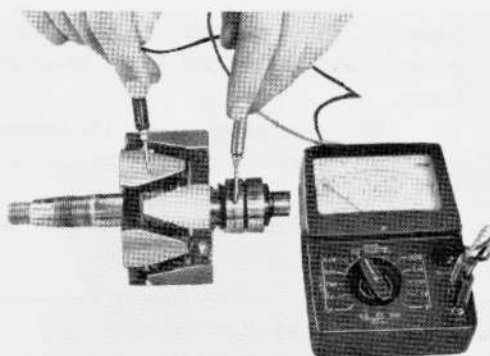


Fig. 7-98 Testing Rotor Coil for Ground

Rear Bearing

Inspect the ball bearing and replace if found defective.

Note

Do not disassembly unless found necessary to do so.

1. Strike out the bearing toward the rear.
2. Install the bearing into the rear end frame using a socket wrench (24 mm or 1.0 in.) and a press.

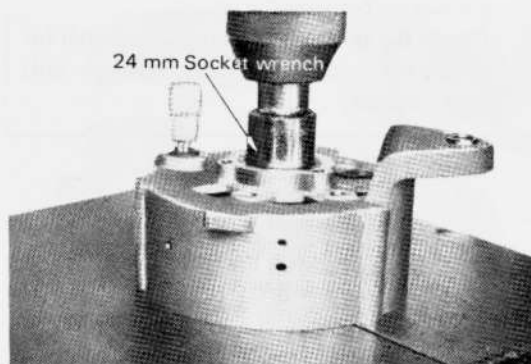


Fig. 7-99 Installing Rear Bearing

ASSEMBLY

1. Solder on the rectifier lead wires to the stator coil.

Note

Solder by holding the rectifier lead wire with long nose plier and applying the soldering iron quickly to prevent overheating.

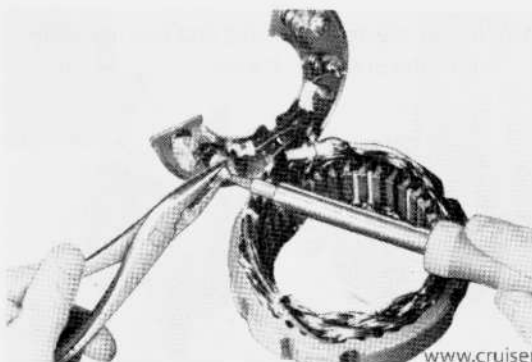


Fig. 7-100 Soldering Rectifier to Stator Coil

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2. Assemble the brushes into the brush holders.
 - (1) Solder the F terminal to brush holder.
 - (2) Connect the E terminal to the F terminal side over terminal insulation washer.
 - (3) Solder the N terminal socket side together with N terminal stator side onto the terminal plate, and push them into the brush holder over terminal insulator.

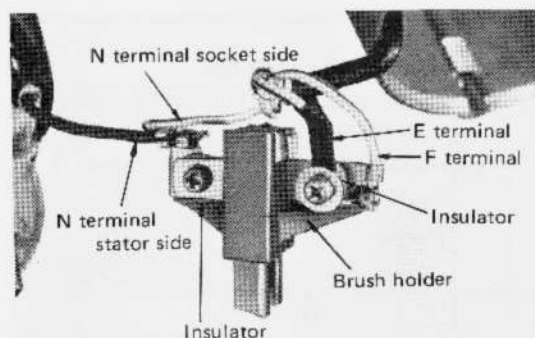


Fig. 7-101 Assembling Brush Holder

3. Assemble the rectifier holders, brush holders, and stator coil in to drive end frame.
 - (1) Insert insulation washers (1) between the (+) side rectifier holder (2) and end frame.
 - (2) Attach the brush holder with two screws (3).

Note

Check the stator coil installed state.

- (1) If there is danger of the stator coil terminal wiring contacting the frame or rotor, correct by bending the wiring.
- (2) Check the position of stator coil notch for alignment with end frame through bolt hole position.

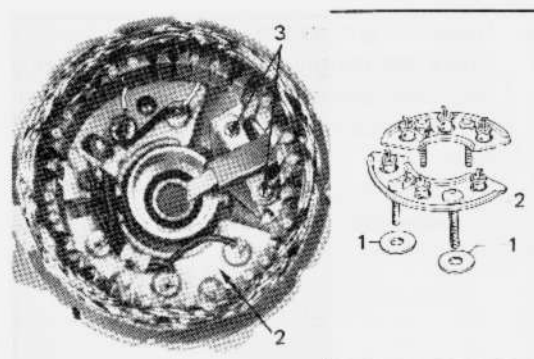


Fig. 7-102 Assembling Stator Coil

- (3) Install the rear end cover (4).
- (4) Bolt on the (+) side rectifier holder over terminal insulation washers (5), lock washer and nut.
- (5) Install the B terminal wire (6), washers, nuts (7) and clamps (8).

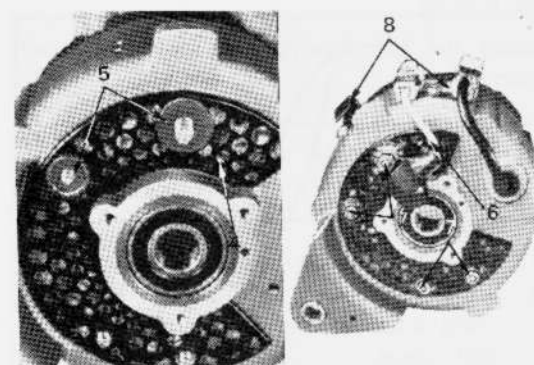


Fig. 7-103 Assembling Rear End

4. Install the front bearing and bearing retainer onto the drive end frame.

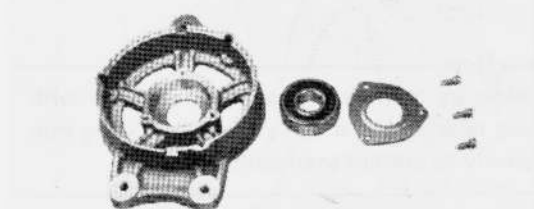


Fig. 7-104 Installing Front Bearing

5. Assemble the spacer ring onto the rotor shaft, press the rotor shaft into the drive end frame,

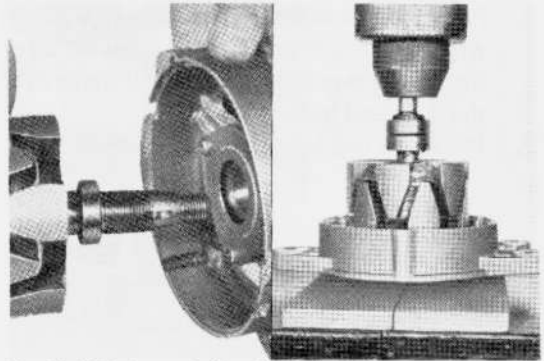


Fig. 7-105 Assembling Drive End Frame

6. Secure the rotor core in a vise and install the bearing lock nut using SST [09333-55011].

**Tightening torque: 560 to 800 kg-cm
(40.5 to 57.9 ft-lb)**

Caution

When securing the rotor core in the vise, it is necessary to install wooden blocks or copper plates to prevent the core from damaging.



Fig. 7-106 Tightening Nut

7. Install the woodruff key, pulley with fan, washer and nut onto the rotor shaft.
8. Remove the rotor core from the vise.

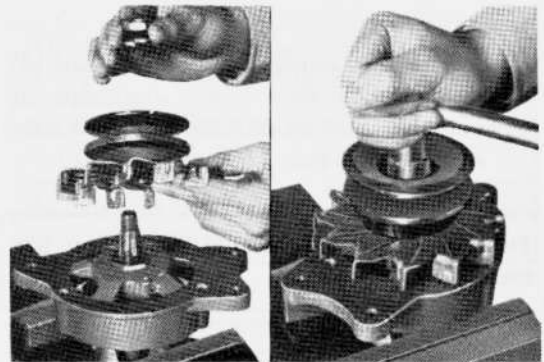


Fig. 7-107 Installing Pulley

9. Have the brushes lifted up.
10. Assemble the front parts into the rear end frame.

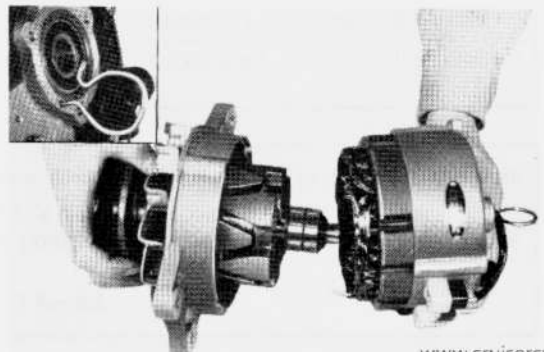


Fig. 7-108 Assembling Front & Rear Parts

11. Press the rear bearing inner race with socket wrench (17 mm or 11/16"), screw th three through screws onto the rear end frame over the drive end frame.
12. Install the rear bearing cover.

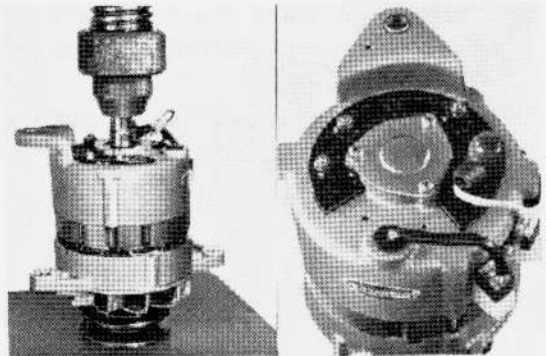


Fig. 7-109 Assembling Front & Rear

Conduct the performance tests by hooking up the alternator as shown in Fig. 7-110.

1. No-load test

For this test, have the switch S_2 open. Drive the alternator with the variable speed motor and after closing the switch S_1 , speed up the alternator gradually from low speed and read the rpm at 14V.

The alternator speed at this time should be 650 to 950 rpm (cold).

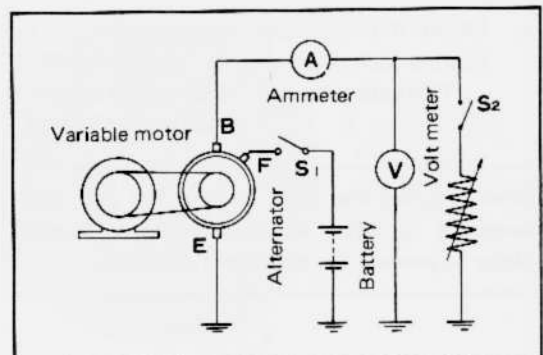


Fig. 7-110 No-Load Test

2. Output test

Maintain the output voltage at constant 14V by adjusting the variable resistance. At output current of 35A the alternator speed should be less than 3,500 rpm (cold).

Note

Fully charged battery should be used for the tests.

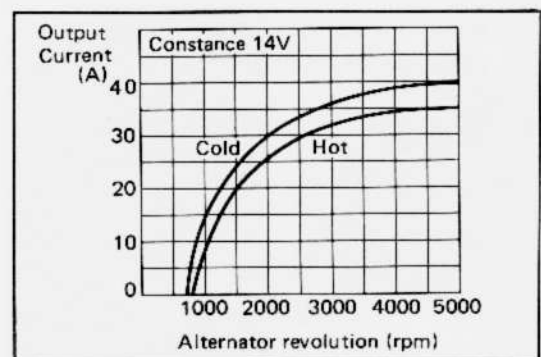


Fig. 7-111 Alternator Output Characteristics

GENERATOR REGULATOR

RESISTANCE TEST (USING CIRCUIT TESTER)

Inspect the generator regulator internal conditions by methods outlined in the following table.

Caution

1. If point surfaces are dirty, polish with paper of post card hardness.
2. If point surfaces are burnt or excessively injured, replace regulator.

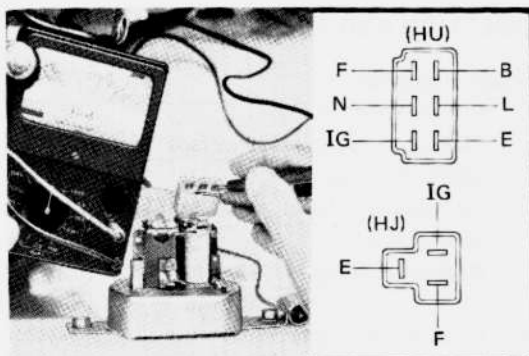


Fig. 7-112 Measuring Resistance

Table 7-4 Resistance Test (for HU)

Terminals Measured	Voltage Relay	Voltage Regulator	Normal Resistance (Ω)	Symptoms and Probable Causes
IG-F	—	Static	0	If more than 0 is indicated, defective contact at low speed point P_1 in voltage regulator.
	—	Pulled-in	Approx. 11	If infinity is indicated, open circuit in control resistor.
L-E	Static	—	0	If more than 0 is indicated, defective contact at points P_4 in voltage relay.
	Pulled-in	—	Approx. 100	If 0 is indicated, voltage relay points P_4 fused. If infinity is indicated, voltage coil opened.
N-E	—	—	Approx. 23	If 0 is indicated, pressure coil shorted. If infinity is indicated, pressure coil opened.
B-E	Static	—	Infinity	If infinity not indicated, voltage relay points P_6 fused.
B-L	Pulled-in	—	0	If more than 0 is indicated, defective contact at voltage relay points P_6 .

Table 7-5 Resistance Test (for HJ)

Terminals Measured	Voltage Regulator	Normal Resistance (Ω)	Symptoms and Probable Causes
IG-F	Static	0	If more than 0 is indicated, defective contact at low speed point P_1 in voltage regulator.
	Pulled-in	Approx. 2.8	If infinity is indicated, open circuit in control resistor.

Note

1. Pulled-in is the condition when the applicable armature is pressed with finger so that the armature point will be contacting the high speed point P_3 or point P_6 .
2. Static is the condition where the applicable armature point is contacting the low speed point P_1 or point P_4 .
3. Refer to Fig. 7-113 and Fig. 7-114 for HU and Fig. 7-113 for HJ.

INSPECTION AND ADJUSTMENT

Voltage Regulator

1. Electrical adjustment
Check the regulated voltage regulator and adjust if faulty.
To adjust, bend the voltage regulator adjusting arm.
Regulated voltage **13.8 to 14.8 V (for HU)**
 13.6 to 14.6 V (for HJ)
2. Mechanical adjustments
Check on the following items, and adjust or replace if defective

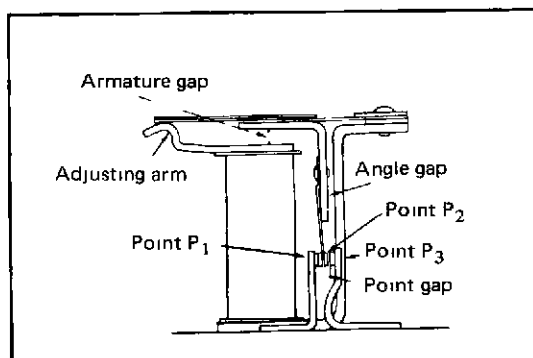


Fig 7-113 Names of Regulator Parts

Check Items	Standard	Adjustment Place
Armature gap	0.3 mm (0.012 in.) min.	Low speed point P ₁
Point gap	0.30 to 0.45 mm (0.0118 to 0.0177 in.)	High speed point P ₃
Contact Spring Deflection	0.2 to 0.6 mm (Pulled-in) (0.008 to 0.024 in.)	High speed point P ₃
Angle gap	0.2 mm (0.008 in.) min	High speed point P ₃

Voltage Relay (only for HU)

1. Electrical adjustment
Check the actuating voltage of voltage relay and adjust if faulty.
Check the relay points to see if they are open when the engine is stopped, and if they are closed when the engine is idling.
Relay actuating voltage
4.5 to 5.8 V (Reference only)
2. Mechanical adjustment
Check on the following items, and adjust or replace if defective

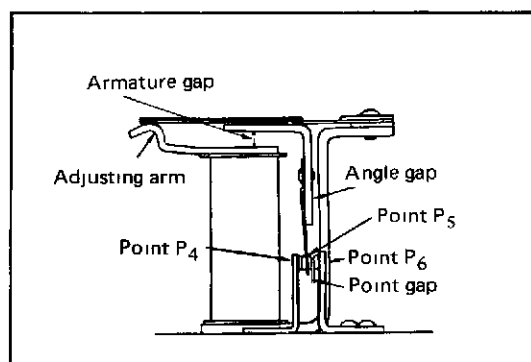


Fig 7-114 Names of Relay Parts

Check Items	Standard	Adjustment Place
Armature gap	0 (Pulled in)	Point P ₆ holder
Contact spring deflection	0.2 to 0.6 mm (pulled-in) (0.008 to 0.024 in.)	Point P ₆ holder
Point gap	0.4 to 1.2 mm (0.016 to 0.047 in.)	Point P ₄ holder

Caution

1. **Pulled-in** is the condition where the armature is pressed with finger so that the armature point (P₂ or P₅) will be contacting the high speed point P₃ or point P₆.
2. Always be sure to have the regulator connector pulled out when inspecting or adjusting.

PREHEATING SYSTEM

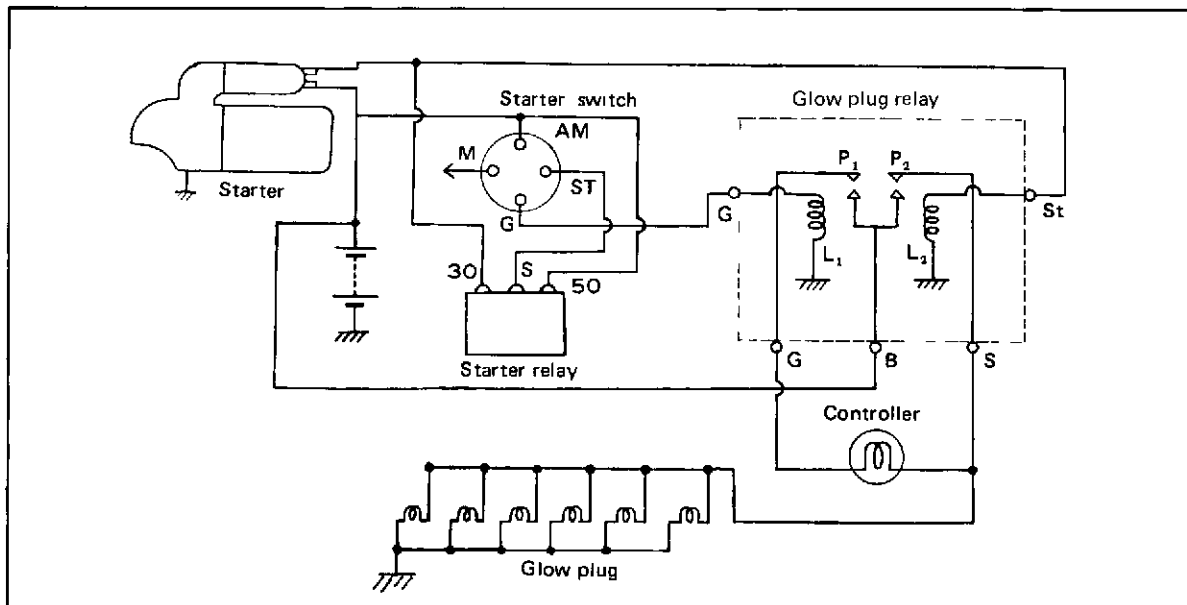


Fig. 7 115 Preheating Circuit Connection Diagram

Glow Plugs

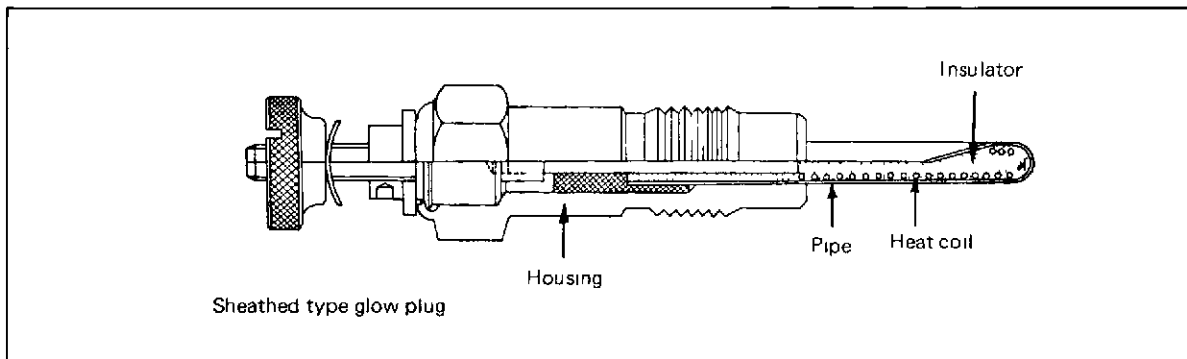


Fig. 7 116 Glow Plug Construction

Table 7-6 Glow Plug Specifications

Rated Voltage	8 volts
Rated Amperage	11.1 to 13.5 amperes

INSPECTION

1. Clean the glow plug pipes.

Caution

Be careful not to mar the glow plug pipes. This might cause open circuit or shorten the plug life.

2. Measure the resistance.
Measure the resistance between the glow plug terminal and pipe.

Resistance 0.6 to 0.7 Ω (12 V type)

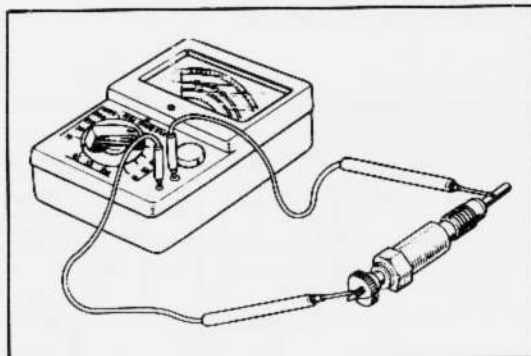


Fig. 7-117 Measuring Glow Plug Resistance

Note

1. Do not wet with oil and gasoline when cleaning the glow plug.
2. At the time of inspection, be sure to wipe oil off glow plug terminals and bakelite

washer by using a dry cloth.

3. Do not damage the pipes of the heat generating part. If damaged, this may cause disconnection or shorten life.

Glow Plug Controller**INSPECTION**

Turn the starter switch onto glow; it is normal if the controller glows after 25 to 30 seconds.

Table 7-7 Controller Specifications

Rated Voltage	0.3 to 0.38 volts
Rated Amperage	74 amperes

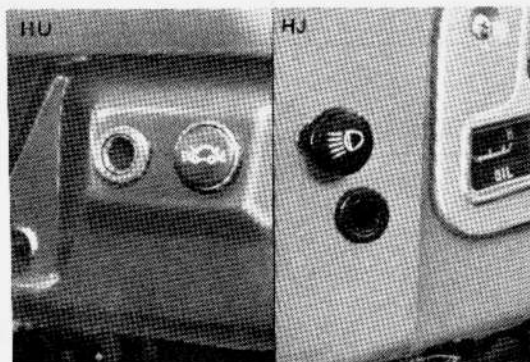


Fig. 7-118 Glow Plug Controller

Glow Plug Relay

Table 7-8 Glow Plug Relay Specifications

Rated Voltage	12 volts
Rated Coil Amperage	0.8 to 1.2 amperes
Maximum Amperage	80 amperes
Contact Pressure	More than 500 g (17.6 oz)

INSPECTION AND ADJUSTMENT

1. Check the point faces for burning.
2. Point gap
Measure the point gap, and if not within the specified value, correct by bending the point holder.
Point gap standard 1.1 to 1.5 mm (0.043 to 0.059")
3. Adjust contact pressure
Hook a spring scale on the contact, and measure the pressure to open the point.
Contact pressure 500 g (17.6 oz) minimum
4. Operational inspection
Impress battery voltage ST and 9 terminal respectively.
The contacts should close strongly.
If contacts fail to be pulled in, check continuity between the coils and terminals, and repair or replace as found necessary.

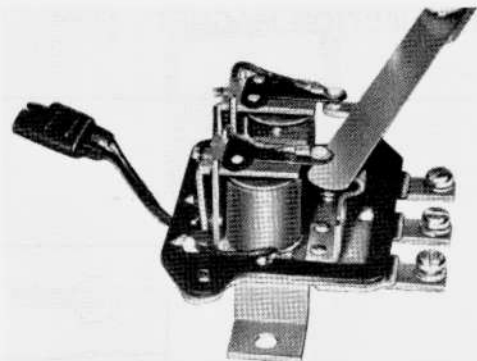


Fig. 7-119 Checking Point Gap

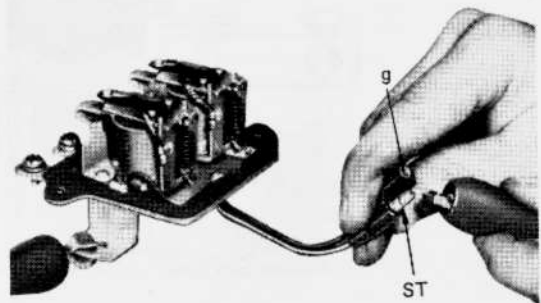


Fig. 7-120 Testing Relay Operation

OVER INJECTION MAGNET

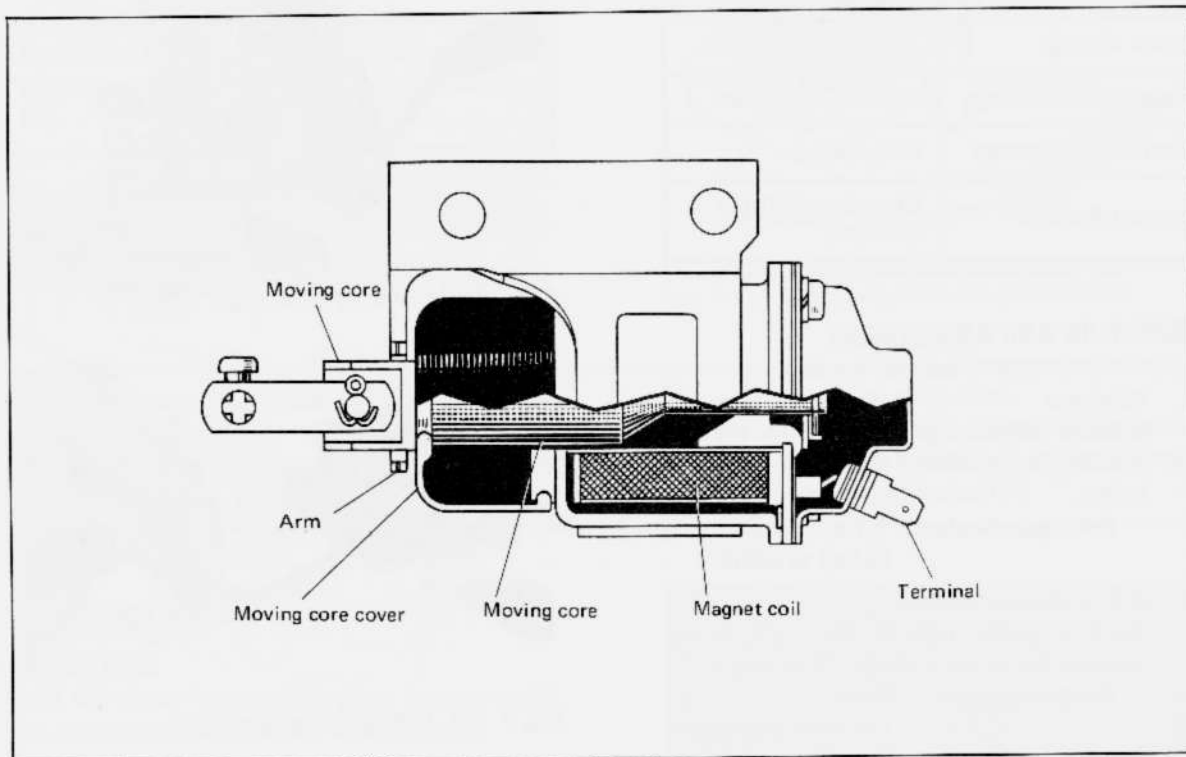


Fig. 7-121 Over Injection Magnet Construction

Table 7-9 Over Injection Magnet Specifications

Parts Number		22560-47030 (HU)	22560-47020 (HJ)
Type		12V	←
Rated voltage		12V	←
Current		20A max.	←
Time rating		30 Second	←
Pull-in force	At 2.7 mm (0.106") gap (marks aligned)	5 kg (11.0 lb) min.	7.5 kg (16.5 lb) min. 8.5 kg (18.7 lb) min.
	At 4.7 mm (0.185") gap (marks aligned)		
	At 0 gap	12 kg (26.5 lb) min.	
Stroke		14 to 17 mm (0.55 to 0.67")	←

INSPECTION

1. Continuity test

Check the continuity of the magnet coils by using a circuit tester, and if there is no continuity, the coils are opened, so replace.

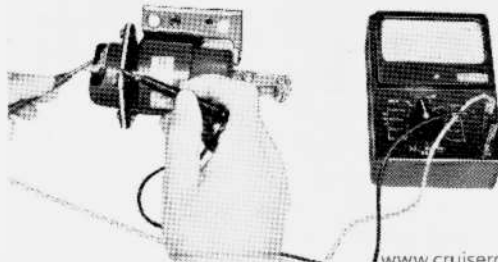


Fig. 7-122 Testing Magnet for Open Circuit

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2. Pull-in force test

Connect an ammeter and apply 12 volts onto the magnet coil terminals. At this time, if the moving core is strongly pulled at an amperage of 20 amperes, the pull-in force is satisfactory

Pull-in force:

Gap at 2.7 mm (0.106")

More than 5.0 kg (11.0 lb) – HU

Gap at 4.7 mm (0.185")

More than 7.5 kg (16.5 lb) – HJ

Gap at 0

More than 12.0 kg (26.5 lb) – HU

Gap at 0

More than 8.5 kg (18.7 lb) – HJ

Note

The gap is 4.7 mm (0.19") or 2.7 mm (0.106") at a position where the mark of moving core matches with that of the arm. The position where the moving core is fully pushed is the zero gap position.

Notes

1. Set the over injection wire at a position where the moving core mark and the arm mark mate with each other, keeping the injection pump stop lever in a free state.
2. After installation, confirm that it returns to its original set position.

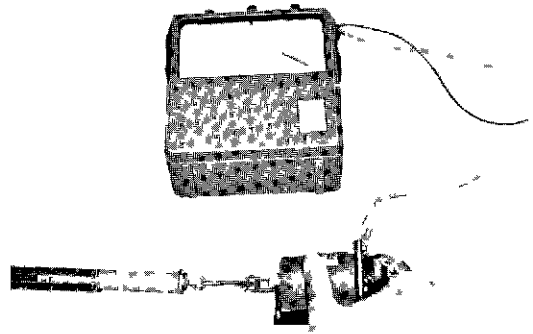


Fig 7-123 Magnet Pull-in Force Test

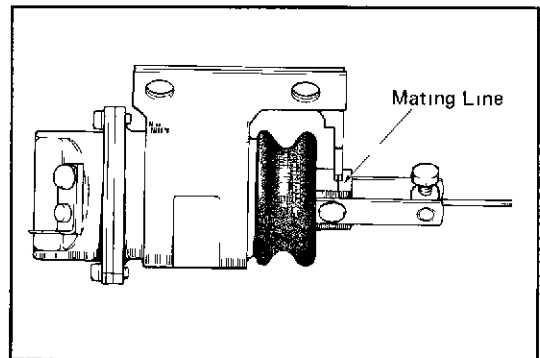


Fig 7-124 Adjusting Magnet

BATTERY INSPECTION

1. Check the battery in accordance with the following chart.

Inspection Points	Inspection Items	Remedies
Battery case Filler plugs Terminals Cables	Dirty exterior, cracks Cracks fluid leakage Corrosion, fusing, deformation	Wash off dirt with warm water. For other defects, repair or replace Fog light corrosion. Wash with warm water and clean with wire brush or sandpaper For other defects, replace
Voltage	Above 12 volts	Recharge
Electrolyte level	10 to 25 mm (0.4" to 1") above plates	Replenish with purified water
Specific gravity	All cells over 1,200 (20°C) Difference between cells 0.025 maximum	After full charge, adjust specific gravity

2. Electrolyte Specific Gravity

- (1) Measure the specific gravity with a hydrometer

The electrolyte level rises slightly on the float due to surface tension, but read the raised part

- (2) If the electrolyte level is low so that specific gravity measurements cannot be made, replenish with purified water and measure after the water has completely diffused in the electrolyte
- (3) The specific gravity changes with the electrolyte temperature so that its value at 20°C has been taken as the standard. In order to know the true charged state, the measured value should be corrected to that for 20°C.
- (4) The standard specific gravity of the electrolyte is that at 20°C

The specific gravity decreases 0.0007 for every 1°C rise in electrolyte temperature, and increases 0.0007 for every 1°C drop in temperature

If the electrolyte temperature is $t^{\circ}\text{C}$ and specific gravity S_t when measured, the correction to specific gravity S_{20} at standard condition (20°C) can be calculated by the following equation

$$S_{20} = S_t + 0.0007 (t - 20)$$

- (5) The relationship between the electrolyte specific gravity and the remaining capacity is as shown in Table 7.10.

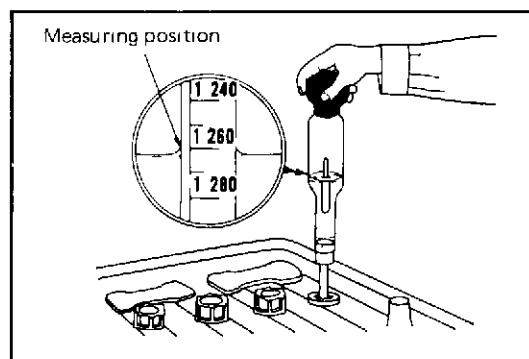


Fig. 7.125 Measuring Specific Gravity

Table 7.10 Electrolyte Sp. Gr. and Remaining Capacity

Electrolyte Sp. Gr. (20°C)	Remaining Capacity (%)
1.260	100
1.210	75
1.160	50
1.110	25
1.060	0 (fully discharged)

CHARGING

Precautions before Charging

1. If a quick charger is to be employed in charging the battery, be sure to disconnect the battery-to-ground cable from the battery minus terminal in order to prevent high voltage from being impressed on the alternator and damaging its rectifiers.
2. Be sure to have all filler plugs removed while charging.
3. If electrolyte heats up above 45°C, stop charging temporarily.
4. Flammable gas will be produced while charging, making it extremely dangerous to have open flame or sparking nearby.

1. Constant current charging method

- (1) Connect the charger (+) and (-) leads to the respective battery (+) and (-) terminals, and charge while maintaining the charging current constantly at the following value.

Charging current

7A (70 Ah capacity) – HJ

10A (100 Ah capacity) – HU

- (2) The voltage and specific gravity gradually rise as the charging progresses until they reach maximum values. If these values remain nearly unchanged for over an hour and all cells are gassing vigorously, it can be

assumed that charging has been completed

2. Constant voltage charging method

- (1) Connect the charger (+) and (-) leads to the respective battery (+) and (-) terminals, and charge while maintaining the charging voltage constantly within the following values

Charging voltage 14.0 to 14.8 V

- (2) After the charging starts, the current gradually decreases and when it reaches nearly zero, the charging is considered as completed.
- (3) Unlike the constant current charging method, there is no gassing as completion of charge

3. Quick charging method

- (1) This is a method in which the discharged battery is charged with large current to restore the capacity as much as possible in a short time. This method is usually employed as a temporary measure when the engine cannot be started due to battery having been over-discharged
- (2) In this method, a quick charger is used, and there is no necessity of removing the battery from the vehicle
- (3) For charging procedures, refer to the instruction manual for the charger employed

SPECIFIC GRAVITY ADJUSTMENT

If the specific gravity differs from the standard value after completing the charge, make the adjustments as follows

Specific gravity standard

1.250 to 1.270 (20°C)

Difference between cells

0.025 max.

1. If above the standard value . Add purified water.
2. If below the standard value . Add dilute sulfuric acid of less than 1.400 (20°C) specific gravity.

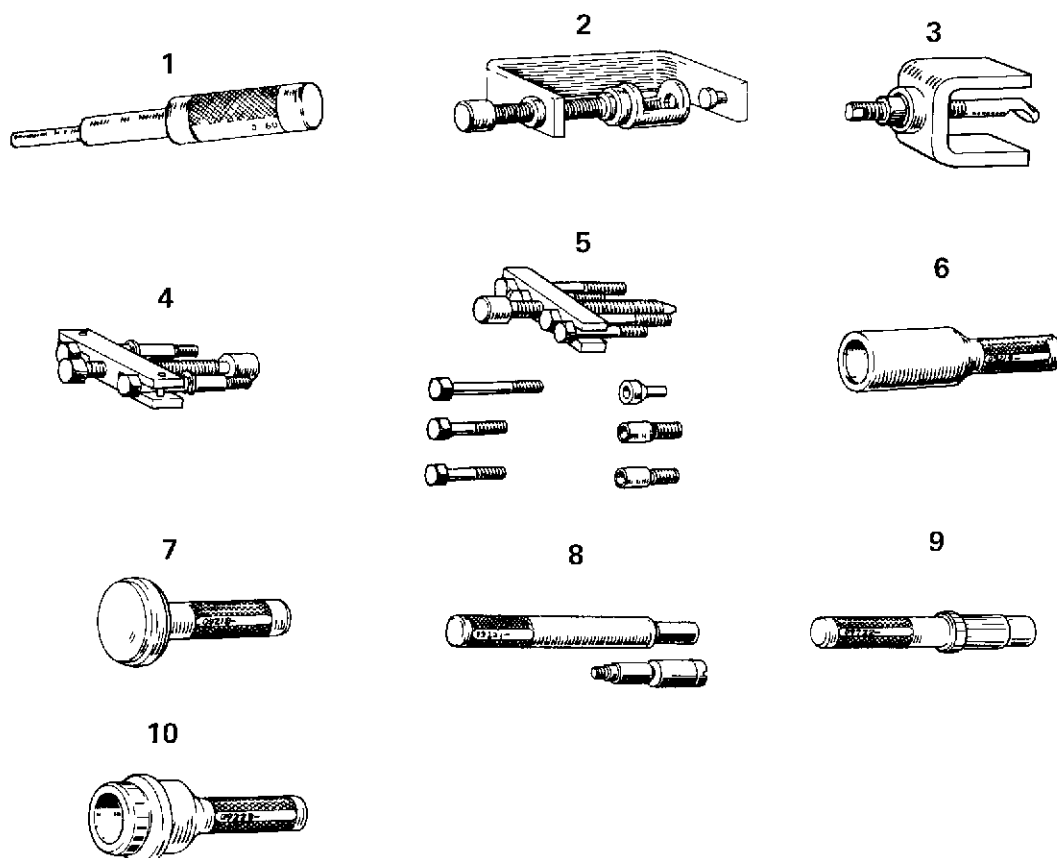
SST & SERVICE SPECIFICATIONS

Special Service Tool	8-2
Standard Bolt Classification	8-8
Standard Bolt Tightening Torque	8-8
Main Parts Tightening Torque	8-10
Service Specification	8-11



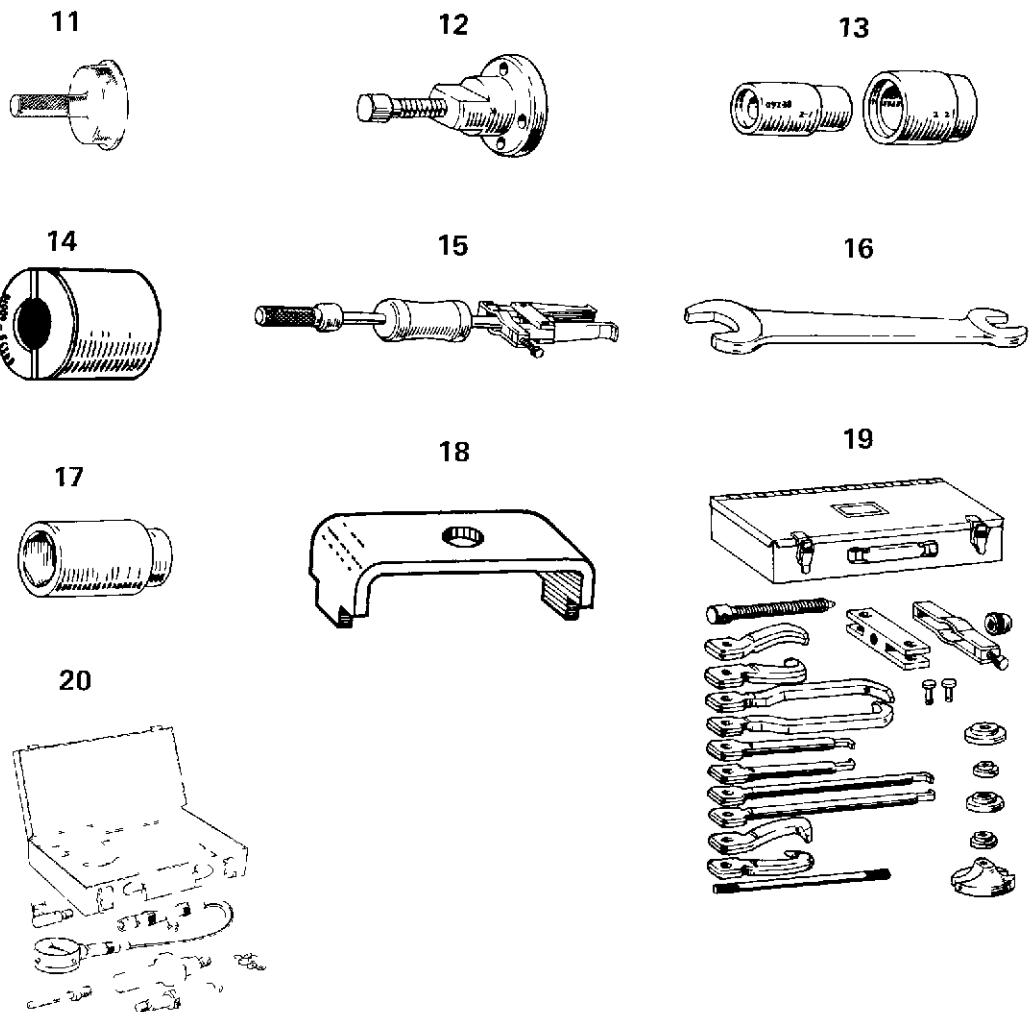
SPECIAL SERVICE TOOL

Engine (1)



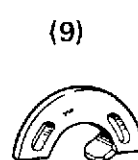
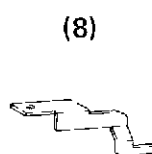
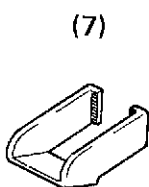
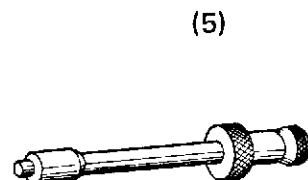
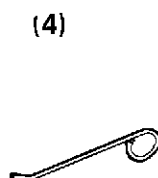
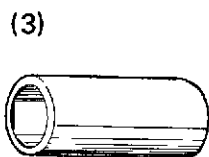
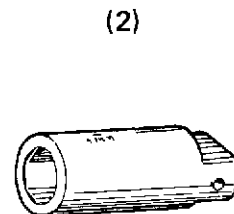
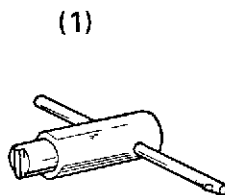
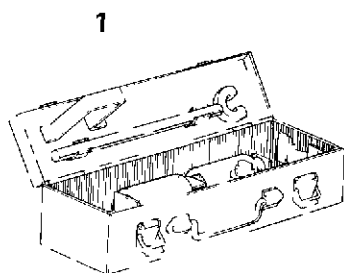
1.	09201 40010	Valve guide bushing remover & replacer
2.	09202 43011	Valve spring Compressor
3.	09208-48010	Combustion chamber remover
4.	09213 31020	Crankshaft pulley puller
5.	09213-60014	Crankshaft pulley & gear puller
6.	09214-60010	Crankshaft pulley & gear replacer
7.	09218-46010	Cylinder liner remover & replacer
8.	09221 46010	Piston pin remover & replacer
9.	09222-40011	Connecting rod bushing remover & replacer
10.	09223 46010	Crankshaft front oil seal replacer

Engine (2)



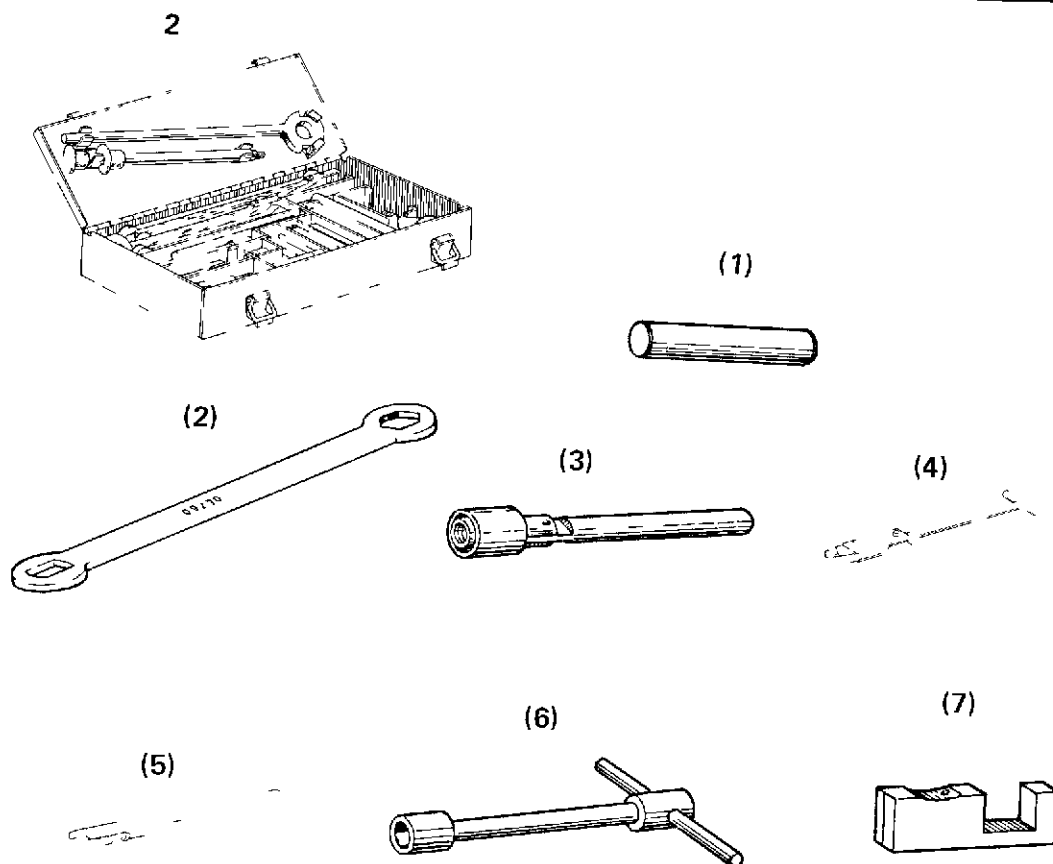
11	09223-56010	Crankshaft rear oil seal replacer
12	09235-60010	Water pump pulley seat puller
13	09238 47010	Water pump bearing remover & replacer
14	09239-40010	Water pump rotor puller
15	09308-00010	Oil seal puller
16.	09333-65011	Wrench 55 x 32 mm
17	09816-30010	Oil pressure switch socket
18	09841-56010	Alternator stand
19.	09950 20010	Universal puller
20	09992 00020	Compression check gauge set

Injection Pump (1)



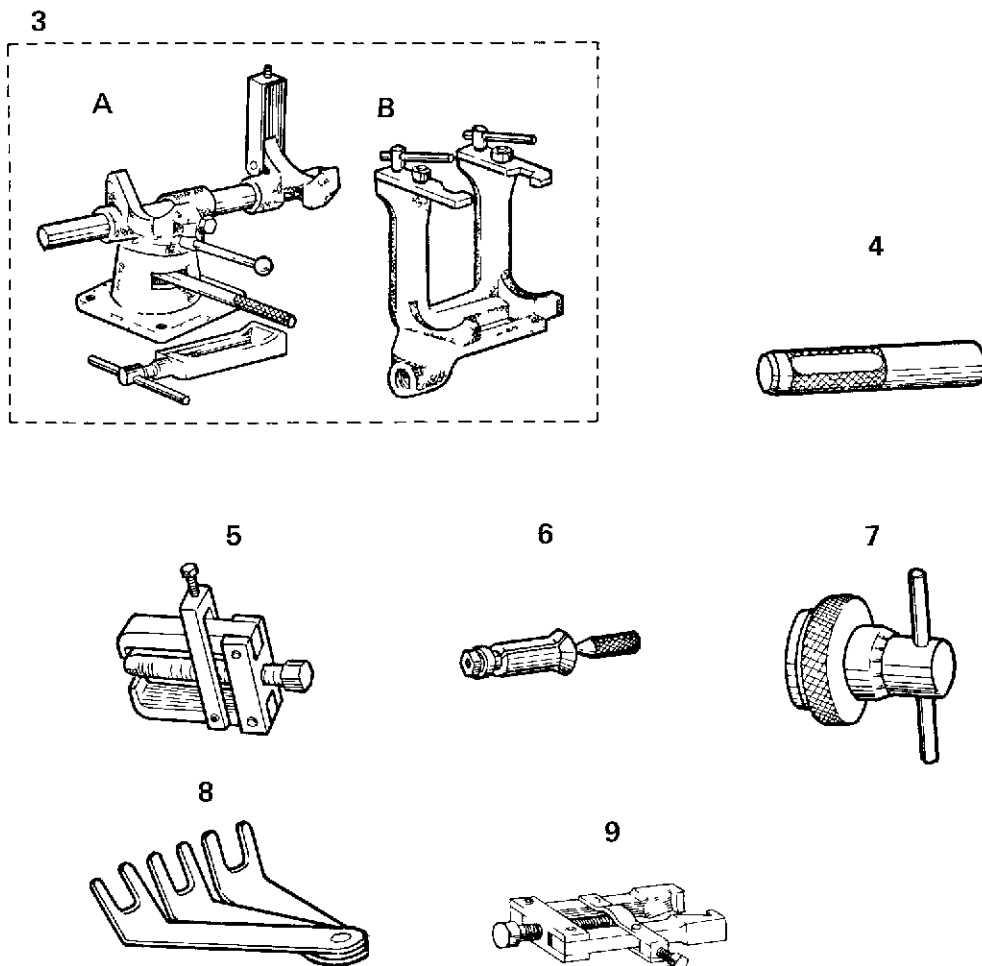
1	09260-46011	Injection pump tool set
(1)	09266 46011	Round nut wrench
(2)	09268 46011	Nozzle holder body wrench
(3)	09268-46021	Nozzle holder retaining nut wrench
(4)	09274-46010	Tappet insert
(5)	09275-46010	Plunger clamp
(6)	09278-46010	Spline shaft holding tool
(7)	09280 46010	Plunger spring holder
(8)	09283-46010	Tappet gauge holder attachment
(9)	09284-46010	Camshaft lock plate

Injection Pump (2)



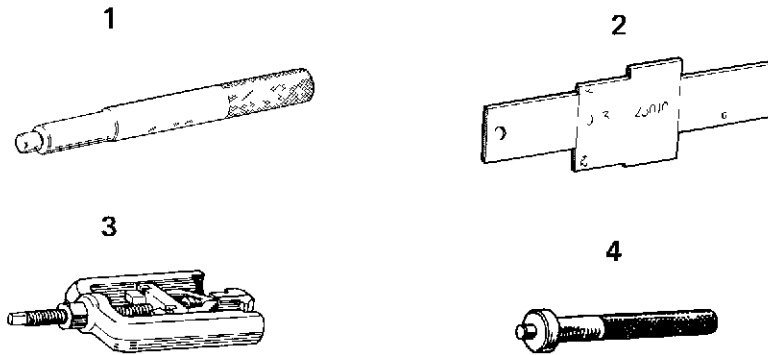
2	09260-76014	Injection pump tool set
(1)	09262-76010	Delivery valve gasket replacer
(2)	09270-76010	Delivery valve holder wrench
(3)	09271-76011	Delivery valve extractor
(4)	09272-76011	Tappet roller clamp
(5)	09273-76011	Tappet clamp
(6)	09276-76010	"T" type box wrench (10 mm)
(7)	09280-76010	Automatic timer spring holder

Injection Pump (3)



3	09241 76020	Injection pump stand set
(A)	09241-76010	Injection pump stand
(B)	09245-46010	Injection pump stand arm
4.	09285-76010	Injection pump camshaft bearing cone replacer
5	09286-46011	Injection pump spline shaft puller
6.	09286 76011	Injection pump camshaft bearing cup puller
7	09287 76010	Injection pump camshaft end play micrometer
8	09288-46011	Tappet adjust gauge
9.	09602-35011	Front axle inner bearing puller (for Timer Bearing)

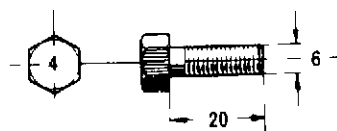
Clutch



- | | | |
|----|-------------|------------------------------------|
| 1 | 09301-55022 | Clutch guide tool |
| 2 | 09302-25010 | Clutch pressure lever height gauge |
| 3. | 09303-55010 | Input shaft front bearing puller |
| 4 | 09304 47010 | Input shaft front bearing replacer |

STANDARD BOLT CLASSIFICATION

91111-40620 – Parts Number
 Length of Bolt 20 mm
 Basic Major Dia of Thread 6 mm
 Bolt Head Mark*



*Bolt Head Mark has the following indications

Fig 8-1 Bolt

Mark on head of bolt	4	5	7
Toyota Standard Classification	4T	5T	7T
Tensile Strength (kg/mm ²)	more than 42	more than 55	more than 75
Brinell Hardness Number	121 to 209	147 to 227	227 to 271
Rockwell Hardness Number	B70 to 95	B89 to 98	C20 to 28
Yield Point (kg/mm ²)	more than 30	more than 45	more than 60

STANDARD BOLT TIGHTENING TORQUE

Class	Basic Dia	Pitch	Standard Torque kg-cm (ft-lb)	Torque Limit kg-cm (ft-lb)
4T	6	1	47 (3.4)	40 to 70 (2.9 to 5.0)
	8	1.25	111 (8.0)	100 to 160 (7.3 to 11.6)
	10	1.25	225 (16.3)	190 to 310 (13.7 to 22.4)
	10	1.5	214 (15.5)	180 to 300 (13.0 to 21.7)
	12	1.25 (ISO)	440 (31.8)	350 to 550 (25.3 to 39.8)
	12	1.5	389 (28.1)	350 to 550 (25.3 to 39.8)
	12	1.75	374 (27.0)	300 to 500 (21.7 to 36.2)
	13	1.5	508 (36.8)	450 to 700 (32.5 to 50.6)
	14	1.5	633 (45.8)	500 to 800 (36.2 to 57.8)
	14	2	593 (42.8)	470 to 770 (34.0 to 55.7)
	16	1.5	957 (69.2)	750 to 1100 (54.2 to 79.6)
	16	2	910 (65.8)	710 to 1060 (51.3 to 76.7)
5T	6	1	71 (5.1)	60 to 90 (4.4 to 6.5)
	8	1.25	166 (12.0)	150 to 220 (10.9 to 15.9)
	10	1.25	334 (24.1)	300 to 450 (21.7 to 32.5)
	10	1.5	322 (23.3)	270 to 420 (19.5 to 30.4)
	12	1.25 (ISO)	660 (47.7)	500 to 800 (36.2 to 57.8)
	12	1.5	584 (42.2)	500 to 700 (36.2 to 50.6)
	12	1.75	561 (40.6)	480 to 680 (34.7 to 49.2)
	13	1.5	763 (55.2)	650 to 900 (47.0 to 65.1)
	14	1.5	890 (65.3)	750 to 1100 (54.2 to 79.6)
	14	2	950 (68.7)	700 to 1050 (50.6 to 75.9)
	16	1.5	1436 (103.8)	1200 to 1700 (86.8 to 123.0)
	16	2	1358 (98.1)	1150 to 1650 (83.2 to 119.2)

STANDARD BOLT TIGHTENING TORQUE (Cont'd)

Class	Basic Dia	Pitch	Standard Torque		Torque Limit	
			kg-cm	(ft lb)	kg cm	(ft lb)
7T	6	1	95	(6.9)	80 to 120	(5.8 to 8.6)
	8	1.25	221	(16.1)	200 to 300	(14.5 to 21.7)
	10	1.25	449	(32.5)	400 to 550	(28.9 to 39.8)
	10	1.5	429	(31.0)	370 to 520	(26.8 to 37.6)
	12	1.25	880	(63.5)	750 to 1050	(54.1 to 75.8)
	12	1.5	778	(56.2)	700 to 900	(50.6 to 65.1)
	12	1.75	748	(54.1)	600 to 850	(43.3 to 61.4)
	13	1.5	1017	(73.5)	800 to 1200	(57.8 to 86.8)
	14	1.5	1267	(91.6)	1000 to 1500	(72.3 to 108.5)
	14	2	1186	(85.8)	950 to 1400	(68.7 to 101.2)
	16	1.5	1915	(138.5)	1500 to 2300	(108.5 to 166.2)
	16	2	1811	(131.0)	1400 to 2200	(101.2 to 159.0)

Note: The above specified tightening torque is applicable only for female threads cut into a steel material.

If the female threads are cut in other materials than steel, and also tightening surfaces are encountered to heat or vibrations, these specified tightening torques must be reconsidered.

MAIN PARTS TIGHTENING TORQUES

Tightening Locations			Torque kg cm (ft lb)	
Flywheel	x	Crankshaft	1150 to 1250	(83.2 to 90.4)
Crankshaft bearing cap	x	Cylinder block	980 to 1120	(70.9 to 81.0)
Connecting rod cap	x	Connecting rod	650 to 750	(47.0 to 54.3)
Camshaft	x	Camshaft gear	300 to 450	(21.7 to 32.6)
Camshaft thrust plate	x	Cylinder block	150 to 220	(10.9 to 15.9)
Crankshaft pulley	x	Crankshaft	1600 to 2000	(115.7 to 144.7)
Idle gear shaft	x	Cylinder block	300 to 450	(21.7 to 32.6)
Timing gear cover	x	Cylinder block	150 to 220	(10.9 to 15.9)
Cylinder head	x	Cylinder block	1280 to 1420	(92.6 to 102.7)
Valve rocker support	x	Cylinder head	150 to 220	(10.9 to 15.9)
Manifold	x	Cylinder head	150 to 220	(10.9 to 15.9)
Oil pump set bolt	x	Cylinder block	150 to 220	(10.9 to 15.9)
Oil pan	x	Cylinder block	30 to 60	(2.2 to 4.3)
Glow plug	x	Cylinder head	100 to 160	(7.2 to 11.6)
Nozzle holder	x	Cylinder head	600 to 800	(43.4 to 57.9)
Nozzle retaining nut	x	Nozzle holder	400 to 600	(28.9 to 43.4)
Injection pipe	x	Injection pump	230 to 370	(16.6 to 26.8)
Delivery valve holder	x	Injection pump housing	250 to 350	(18.1 to 25.3)
Clutch cover	x	Flywheel	150 to 220	(10.9 to 15.9)
Mechanical governor				
Lock nut	x	Governor shaft	180 to 260	(13.0 to 18.8)
Round nut	x	Governor gear	200 to 300	(14.5 to 21.7)

SERVICE SPECIFICATION

Periodical Service

Battery	Electrolyte level Specific gravity Capacity	10 to 25 mm (0.4 to 1.0") (above plates) 1,260 (at 20°C) 70AH or 100AH
Cooling water capacity (w/o heater)		17.3 liters (18.3 USqt. 15.2 Imp qt.) HU 12.5 liters (13.2 USqt. 11.0 Imp qt.) HJ
Radiator cap valve opening pressure		0.9 kg/cm ² (12.8 psi)
"V" belt deflection (Water pump X alternator)		11 to 14 mm (0.4 to 0.6") at 10 kg (22 lb) pressure
Injection timing		12° BTDC (stationary)
Idling speed		625 to 675 rpm
Maximum no load speed	Momentary At 3rd speed	3950 rpm 55 km/H
Compression	Limit Standard Variation limit between cylinders	20 kg/cm ² (284 psi) at 320 rpm 30 kg/cm ² (427 psi) at 320 rpm 2.0 kg/cm ² (28 psi)
Valve clearance (Hot)	Intake Exhaust	0.20 mm (0.008") 0.36 mm (0.014")
Engine oil capacity	Total	9.1 liter (9.6 USqts. 8.0 Imp qts.) HU 8.6 liter (9.1 USqts. 7.6 Imp qts.) HJ
	Oil pan	8.1 liter (8.6 USqts. 7.1 Imp qts.) HU 7.6 liter (8.0 USqts. 6.7 Imp qts.) HJ

Engine**Cylinder Head**

Underside surface warpage limit		0.2 mm	(0.008")
Manifold mounting surface warpage limit		0.20 mm	(0.008")
Valve seat	Seating width	1.3 to 1.6 mm	(0.051 to 0.063")
	Seating angle	45°	
	Refacing angles	15° 75°	

Valve Guide Bushing

Overall length	Intake Exhaust		56 mm 60 mm	(2.21") (2.36")
Outside diameter Protrusion above head upper surface (From valve spring contact surface)			14.02 to 14.04 mm 17.0 mm	(0.5520 to 0.5528") (0.669")
Valve stem to guide bushing clearance	Limit	Intake	0.10 mm	(0.0039")
		Exhaust	0.12 mm	(0.0047")
	Standard	Intake	0.021 to 0.057 mm	(0.00083 to 0.00224")
		Exhaust	0.040 to 0.076 mm	(0.00157 to 0.00299")

Valve

Head outside diameter	Intake	40.3 to 40.7 mm	(1.587 to 1.602")
	Exhaust	33.3 to 33.7 mm	(1.311 to 1.327")
Overall length	Intake	120.6 mm	(4.748")
	Exhaust	120.4 mm	(4.740")
Stem outside diameter	Intake	8.97 to 8.99 mm	(0.3531 to 0.3539")
	Exhaust	8.95 to 8.97 mm	(0.3523 to 0.3531")
Valve seating angle		45°	
Stem end refacing limit		0.5 mm	(0.020")
Head thickness limit	Intake	0.9 mm	(0.035")
	Exhaust	1.0 mm	(0.039")

Compression Spring (Valve)

Free height	45.1 mm	(1.776")
Installed height	40.0 mm	(1.575")
Installed load limit	18.5 kg	(40.8 lb)
Installed load	21.7 kg	(47.8 lb)
Squareness limit	1.6 mm	(0.063")

Valve Rocker Shaft and Arm

Shaft diameter limit		18.44 mm	(0.7260")
Rocker arm bore limit		18.60 mm	(0.7323")
Rocker arm bushing to shaft oil clearance	Limit	0.1 mm	(0.004")
	Standard	0.007 to 0.049 mm	(0.00028 to 0.00193")

Valve Lifter and Push Rod

Lifter diameter	STD	22.170 to 22.190 mm (0.87283 to 0.87362")	
Lifter to block bore clearance	Limit	0.1 mm	(0.004")
	Standard	0.010 to 0.051 mm	(0.00039 to 0.00201")
Push rod bend limit		0.5 mm	(0.020")

Manifold

Cylinder head mounting surface warpage limit	Intake	0.3 mm	(0.012")
	Exhaust	0.5 mm	(0.020")

Cylinder Block

Block upper surface warpage limit		0.15 mm	(0.0059")
Valve lifter bore limit	STD	22.20 to 22.22 mm	(0.8740 to 0.8748")
Cylinder bore	STD	88.00 to 88.03 mm	(3.4646 to 3.4657")
Liner	Max wear limit	0.6 mm	(0.024")
	Protrusion	0.03 to 0.12 mm	(0.0012 to 0.0047")

Crankshaft

Bend limit			0.04 mm	(0.0016")
Thrust clearance		Limit	0.3 mm	(0.012")
		Standard	0.04 to 0.24 mm	(0.0016 to 0.0095")
Main Journal	Diameter	STD	69.98 to 70.00 mm	(2.7551 to 2.7559")
		U/S 0.05	69.89 to 69.90 mm	(2.7516 to 2.7520")
		U/S 0.25	69.74 to 69.75 mm	(2.7457 to 2.7461")
		U/S 0.50	69.49 to 69.50 mm	(2.7358 to 2.7362")
		U/S 0.75	69.24 to 69.25 mm	(2.7260 to 2.7264")
		U/S 1.00	68.99 to 69.00 mm	(2.7161 to 2.7165")
Journal and Crankpin	Tapered limit		0.05 mm	(0.0020")
	Out-of-round limit		0.02 mm	(0.0008")
Crank pin Journal	Diameter	STD	54.98 to 55.00 mm	(2.1646 to 2.1654")
		U/S 0.05	54.94 to 54.95 mm	(2.1630 to 2.1634")
		U/S 0.25	54.74 to 54.75 mm	(2.1551 to 2.1555")

		U/S 0.50	54.49 to 54.50 mm	(2.1453 to 2.1457")
		U/S 0.75	54.24 to 54.25 mm	(2.1354 to 2.1358")
		U/S 1.00	53.99 to 54.00 mm	(2.1256 to 2.1260")
Main Journal	Oil Clearance	Limit Standard	0.1 mm 0.030 to 0.072 mm	(0.004") (0.0012 to 0.0028")

Flywheel

Run out limit	0.5 mm	(0.020")
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Connecting Rod

Bend limit [per 100 mm (3.9")]		0.05 mm	(0.0020")
Twist limit [per 100 mm (3.9")]		0.15 mm	(0.0059")
Thrust clearance	Limit Standard	0.3 mm 0.08 to 0.16 mm	(0.012") (0.0031 to 0.0063")
Solid bushing to pin clearance	Limit Standard	0.05 mm 0.004 to 0.012 mm	(0.0020") (0.0002 to 0.0005")
Connecting rod bearing	Oil clearance limit Oil clearance std	0.10 mm 0.030 to 0.070 mm	(0.0039") (0.0012 to 0.0028")

Piston and Piston Ring

Piston	Diameter		STD O/S 1.00	87.81 to 87.84 mm 88.81 to 88.84 mm	(3.4571 to 3.4583") (3.4964 to 3.4976")
	Piston to cylinder clearance			0.18 to 0.20 mm	(0.0071 to 0.0079")
Piston ring	Pin diameter			27.00 to 27.012 mm	(1.0630 to 1.0635")
	Pin fitting temperature			60°C	(140°F)
	End gap	Compression ring	No.1 No.2	0.25 to 0.45 mm 0.25 to 0.45 mm	(0.0098 to 0.0177") (0.0098 to 0.0177")
		Oil ring	No.1	0.20 to 0.40 mm	(0.0079 to 0.0157")
	Ring to groove clearance	Compression ring	No.1 No.2	0.01 to 0.06 mm 0.05 to 0.09 mm	(0.0004 to 0.0024") (0.0020 to 0.0035")
		Oil ring	No.1	0.03 to 0.07 mm	(0.0012 to 0.0028")

Timing and Idle Gear

Gear backlash	Idler gear to timer drive gear	Limit Standard	0.3 mm 0.1 mm	(0.012") (0.004")
	Crankshaft gear to idler gear & cam gear	Limit Standard	0.3 mm 0.1 mm	(0.012") (0.004")
Idle gear thrust clearance		Limit Standard	0.25 mm 0.08 to 0.18 mm	(0.01") (0.0032 to 0.0071")
Idle gear oil clearance		Limit Standard	0.15 mm 0.04 to 0.09 mm	(0.0059") (0.0016 to 0.0035")
Idle gear bore			50.00 to 50.03 mm	(1.9685 to 1.9697")
Idle gear shaft diameter		Limit Standard	49.90 mm 49.94 to 49.96 mm	(1.9646") (1.9661 to 1.9669")

Camshaft and Bearing

Bend limit			0.03 mm	(0.0012")
Thrust clearance	Limit		0.3 mm	(0.012")
	Standard		0.06 to 0.13 mm	(0.0024 to 0.0051")
Oil clearance	Limit		0.1 mm	(0.004")
	Standard		0.025 to 0.066 mm	(0.0010 to 0.0026)
Cam height limit	Intake		38.92 mm	(1.5323")
	Exhaust		38.91 mm	(1.5319")
Cam height standard	Intake		39.467 to 39.557 mm	(1.5538 to 1.5574")
	Exhaust		39.465 to 39.555 mm	(1.5537 to 1.5573")
Journal diameter (STD)	No.1		47.159 to 47.175 mm	(1.8566 to 1.8573")
	No.2		46.959 to 46.975 mm	(1.8488 to 1.8494")
	No.3		46.759 to 46.775 mm	(1.8409 to 1.8415")
	No.4		46.559 to 46.575 mm	(1.8330 to 1.8337")
Journal Bearing U/S			0.125, 0.50, 0.500	

Fuel System

Fuel Pump (Part Number 22510-48010)

Fuel pump	Housing to piston clearance	0,009 to 0 013 mm	(0,0004 to 0 005 ")
	Housing to push rod clearance	0,003 to 0 006 mm	(0,0001 to 0 0002 ")
	Feed pump tappet stroke	8 mm	(0 31 ") approx
	Priming pump stroke	25 mm	(0,98 ") approx

Fuel Pump Performance Test (Part Number 22510-48010)

Test Item	Conditions	Performance
Suction test	Suction pipe spec. Inside dia 8 mm (0 31 ") Length 2 m (78 7 ") Height 1 m (39,4 ")	Feed pump Start discharge within 40 seconds at 150 rpm Priming pump Start discharge within 25-strokes when pumped at 60 stroke/min
	600 rpm	Discharge pressure 1 8 to 2 2 kg/cm ² (25,6 to 31 3 psi)
Discharge test	1000 rpm	Discharge quantity More than 900 cc/min (54 9 cu in) (Discharge nozzle diameter 1,54 mm (0 0606 ")

Injection Pump (Part Number 22100-47042-HJ) (Part Number 22100-47032-HU)

Direction of rotation Cam lift		Clockwise as seen from drive side 6 mm (0 24 ")
Pump element	Bore Shape	7 mm (0,28 ") Lift hand lead
Injection order		1-4-2-6-3-5
Control rack sliding resistance	Pump stopped Pump at 1,000 rpm	Less than 150g (5 3 oz) Less than 50g (1 8 oz)
Pre-stroke Injection interval angle Tappet clearance Camshaft thrust clearance Camshaft shim plate thickness		1 9 to 2 0 mm (0 075 to 0 079 ") 59 5 to 60 5 degrees More than 0,2 mm (0 008 ") 0 03 to 0 05 mm (0 0012 to 0 0020 ") 0 10, 0 12, 0 14, 0 16, 0 18, 0 50 mm (0,0039, 0,0047, 0 0055, 0 0063, 0 0071, 0 0197 ")

Plunger spring	Free length		49.4 mm	(1.945")	
	Installed length		44.0 mm	(1.732")	
	Installed load		15.1 kg	(33.3 lb)	
Delivery valve spring	Free length		37.0 mm	(1.457")	
	Installed length		25.9 mm	(1.020")	
	Installed load		4.42 kg	(9.7 lb)	
Pneumatic governor (HJ)	Model and Type		Model MN, vacuum type		
	Main spring	Free length	105.0 mm	(4.134")	
		Installed length	36.0 mm	(1.417")	
		Installed load	1.04 kg	(2.3 lb)	
	Adjust shim thickness		0.5, 1.0, 2.0, 3.0 mm (0.020, 0.039, 0.079, 0.118")		
	Idling spring	Free length	23.7 mm	(0.933")	
Shim & washer thickness (for idling capsule)		0.1, 0.2, 0.5, 1.0 mm (0.004, 0.008, 0.020, 0.039")			
Mechanical governor (HU)	Governor gear	Slip torque limit	0.25 kg-m	(1.81 ft-lb)	
			0.4 to 0.6 kg-m	(2.9 to 4.3 ft-lb)	
	Governor gear to thrust bearing clearance		0.35 to 0.85 mm	(0.0138 to 0.0335")	
	Idling spring	Inner	Free length	12.53 mm	(0.4933")
			Shim thickness	0.1 mm	(0.004")
	Outer	Free length	14.7 mm	(0.5787")	
		Shim thickness	0.1, 0.3 mm	(0.004, 0.012")	

Injection Pipe

Overall length	528 to 538 mm	(10.78 to 21.28")
Outside diameter	6 mm	(0.24")
Inside diameter	2 mm	(0.08")

Nozzle and Nozzle Holder (Part Number 23600-48010)

Nozzle holder model		KCA
Nozzle	Type	Throttle
	Opening pressure	100 to 110 kg/cm ² (1422 to 1564 psi)
	Injection angle	Approx. 4 degrees
Adjust washer thickness (For adjusting nozzle opening pressure)		1.00 to 1.95 mm (0.0394 to 0.0768") 20 sizes in 0.05 mm (0.0020") increments

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Automatic Timer (Part Number 22610-47010)

Timer advance angles	450 to 550 rpm (timer speed) 800 rpm (timer speed) 1050 rpm (timer speed) 1800 rpm (timer speed)	0 degree 2.5 to 3.5 degree 5 to 6 degree 7 to 8 degree (max)
Timer spring adjust washer thicknesses	0.1, 0.2, 0.5, 1.0, 1.5 mm (0.004, 0.008, 0.020, 0.039, 1.059")	

Injection Pump Adjustment and Test

Pressure Test

Plunger pressure	More than 150 kg/cm ² (2133 psi) (Pump speed at 200 rpm, Rack position at 7 mm)
Delivery valve pressure	More than 5 seconds for holder internal pressure to drop 10 kg/cm ² (142 psi) [Holder internal pressure more than 150 kg/cm ² (2133 psi), Rack position at 0 mm]

Injection Quantity Adjustment (Part Number 22100-47042)

Rack Position mm (in)	Pump Speed (rpm)	Measured Strokes (stroke)	Injection Quantity cc (cu in)	Variation Limit cc (cu in)	Remarks Test Bench
10.5 (0.398)	1,000	200	8.2 to 8.8 (0.502 to 0.539)	0.4 (0.024)	Nozzle opening pressure 100 kg/cm ² (1422 psi)
8.0 (0.315)	1,000	200	4.3 to 5.1 (0.263 to 0.312)	0.4 (0.024)	Delivery pressure 0.5 kg/cm ² (7.1 psi)
6.5 (0.256)	300	500	2.5 to 4.5 (0.153 to 0.275)	1.0 (0.061)	Nozzle high pressure pipe O.D. 6 mm (0.24")
16.0 (0.630)	100	100	7.0 to 8.0 (0.428 to 0.490)	0.6 (0.037)	I.D. 1.6 mm (0.063") Length 600 mm (23.62")

Governor Adjustment (Pneumatic Type) (Part Number 22310-47042)

Test & Adjustment	Pump Speed (rpm)	Vacuum mm (in) Aq	Rack Position mm (in)	Time (Second)	Remarks
Governor air tightness	—	500 → 480 (19.69 → 18.90)	—	10 minimum	—
Main spring adjustment	600	500 (19.69) 510 (20.08) 550 (21.85) 600 (23.62)	10.1 (0.398) 9.8 to 10.1 (0.386 to 0.398) 6.5 to 8.2 (0.256 to 0.323) 4.0 to 5.5 (0.157 to 0.217)	—	Initial rack set 10.1 mm at 500 mm Aq (0.398" at 19.69 in Aq)
Idling spring adjustment	600	600 (23.62) 1000 (39.37)	9.2 to 9.6 (0.362 to 0.378) 7.7 to 7.9 (0.303 to 0.311)	—	Lever positioned at idling state (cam actuation)

Governor Adjustment (Mechanical Type) (Part Number 22410-47032)

Test & Adjustments	Adjusting Lever Angle	Pump Speed (rpm)	Rack Position mm (in)
Low speed control adjustment	$23^{\circ} \pm 7^{\circ}$	100	11 (0.433) Min
		300	6.6 to 7.0 (0.260 to 0.276)
		400	4.6 to 5.0 (0.181 to 0.197)
		600	2.2 to 2.6 (0.087 to 0.102)
		800	2.0 (0.079) Max
High speed control adjustment	$-9^{\circ} \pm 7^{\circ}$	1600	10.1 (0.398)
		1800	10.0 to 10.1 (0.394 to 0.398)
		1950	5.5 (0.217) Max
Damper spring control	$23^{\circ} \pm 7^{\circ}$	400	4.8 to 5.2 (0.189 to 0.205)
		600	3.8 to 4.2 (0.150 to 0.165)
		800	3.1 (0.122) Max

Overall Injection Quantity Adjustment (Pneumatic Type) (Part Number 22310-47042)

Pump Speed (rpm)	Vacuum mm (in) Aq	Measure Strokes (stroke)	Injection Quantity cc (cu in)/6 cyl.
1,100	150 (5.91)	500	115.5 to 121.5 (7.04 to 7.41)

Overall Injection Quantity Adjustment (Mechanical Type) (Part Number 22410-47032)

Pump Speed (rpm)	Adjusting Lever Angle	Measure Strokes (stroke)	Injection Quantity cc (cu.in)/6 cyl
1,100	$9^{\circ} \pm 7^{\circ}$	500	115.5 to 121.5 (7.05 to 7.41)

Lubricating System

Oil Pump and Oil Cleaner

Type		Gear pump	
Discharge	Oil temperature	98 to 102°C	(208 to 216°F)
	Discharge pressure	3 kg/cm ²	(42.7 psi)
	Discharge quantity	40 liters/min.	(10.6 US or 8.8 Imp. gal)
	Speed	1800 rpm	
Oil clearance	Drive shaft	0.013 to 0.051 mm	(0.00051 to 0.00200)
	Driven shaft	0.014 to 0.042 mm	(0.00055 to 0.00165)
Tip clearance	Limit	0.2 mm	(0.008")
	Standard	0.025 to 0.105 mm	(0.0010 to 0.0041")
Side clearance	Limit	0.2 mm	(0.008")
	Standard	0.03 to 0.09 mm	(0.0012 to 0.0035")
Relief valve	Valve opening pressure	3.0 to 4.5 kg/cm ²	(42.7 to 64.0 psi)
Filter valve	Valve opening pressure	0.8 to 1.2 kg/cm ²	(11.4 to 17.1 psi)

Cooling System

Radiator

	HU	HJ
Overall cooling water capacity w/o heater	17.3 liters (18.3 USqts.) (15.2 Imp qts.)	12.5 liters (13.2 USqts.) (11.0 Imp qts.)
Cooling water capacity	3.6 liters (3.8 USqts.) (3.2 Imp qts.)	3.2 liters (3.4 USqts.) (2.8 USqts.)
Radiator cap valve opening pressure	0.9 kg/cm ² (12.8 psi)	←

Water Pump

Discharge capacity (liter/min.)	220 liter (58 US gal. 48 Imp. gal.)
Pump speed	4300 rpm

Thermostat

Type	Wax	
Full open temperature	90°C	(194°F)
Valve opening temperature	74.5 to 78.5°C	166 to 173°F
Valve lift	10 mm Min.	(0.39")

Engine Electrical System

Starter (Part Number 28100-47020)

Type	12 V type			
Rated output	2.5 kW			
Performance	No load characteristics		100 A max, and 4000 rpm min at 11.5V	
	Locked characteristics		1800 A max and 3.5 kg m (25.3 ft lb) min at 5V	
Armature shaft	Shaft to bushing clearance	Housing side	Standard 0.05 mm (0.0020")	Limit 0.2 mm (0.008")
		Pinion side	0.1 mm (0.004")	0.2 mm (0.008")
		Center part	0.05 mm (0.0020")	0.3 mm (0.012")
		End frame part	0.05 mm (0.0020")	0.2 mm (0.008")
	Thrust clearance	Standard Limit	0.05 to 0.35 mm 0.8 mm	(0.002 to 0.014") (0.032")
Thrust washer thickness			0.2, 0.5, 1.0, 2.0 mm	(0.008, 0.020, 0.039, 0.079")
Commutator	Outside diameter	Limit	46.2 mm	(1.819")
		Standard	48.2 mm	(1.898")
	Mica depth	Limit	0.2 mm	(0.008")
		Standard	0.5 to 0.8 mm	(0.020 to 0.032")
Brush	Length	Limit	13 mm	(0.51")
		Standard	20 mm	(0.79")
	Spring pressure		1,700 to 2,400 g	(59.8 to 84.5 oz)
Magnetic switch	Pull in voltage		8 V max	
	Holding voltage		8 V	

Alternator (Part Number 27020-47033 (HU) 27020-47041 (HJ))

Type	12 V	
Nominal voltage	12 V	
Maximum output	35 A	
No load speed	800 rpm	(14V hot)
Output speed	3,500 rpm Max	(14V 35A)
No load speed	650 to 950 rpm	

Brush length	Limit	5.5 mm	(0.217")
	Standard	12.5 mm	(0.492")

Generator Regulator

Part Number		27700-36010 (HU)	27700-60080 (HJ)
Regulating voltage		13.8 to 14.8 V	13.6 to 14.6 V
Relay actuating voltage		4.5 to 5.8V	
Voltage regulator	Armature gap	0.3 mm (0.012") min (actuated)	←
	Point gap	0.3 to 0.45 mm (0.012 to 0.0177")	←
	Angle gap	0.2 mm (0.008") min (actuated)	←
	Contact pressure	180 g (6.3 oz) min	←
Voltage relay	Point gap	0.4 to 1.2 mm (0.016 to 0.047")	
	Contact pressure	100 g (3.5 oz) min	
	Contact spring deflection	0.2 to 0.6 mm (0.008 to 0.024") actuated	

Overinjection Magnet

Part Number		22560-47030 (HU)	22560-47020 (HJ)
Type		12V	←
Rated voltage		12V	←
Current		20A max	←
Time rating		30 seconds	←
Pull in force	At 2.7 mm (0.106") gap (marks aligned)	5 kg (11.0 lb) min	
	At 4.7 mm (0.185") gap (marks aligned)		7.5 kg (16.5 lb) min
	At 0 gap	12 kg (26.5 lb) min	8.5 kg (18.7 lb) min
Stroke		14 to 17 mm (0.55 to 0.67")	←

Glow Plug (Part Number 19850-56020)

Type	12V
Rated voltage	8V
Maximum allowable voltage	9V
Rated current	11.1 to 13.5A
Heater temperature (after 90 sec.)	970 to 1070°C (1778 to 1958°F)

Glow Plug Controller (Part Number 28550-47020)

Type	12V
Rated current	74A
Rated voltage	0,30 to 0 38V
Heater temperature	930 to 1030°C (1706 to 1886°F)
Time required to glow (normal state)	90 secd

Glow Plug Relay (Part Number 28610-47010)

Type	12V Type
Rated voltage	12V
Rated coil current	0 8 to 1 2A
Maximum current capacity	80A

Battery

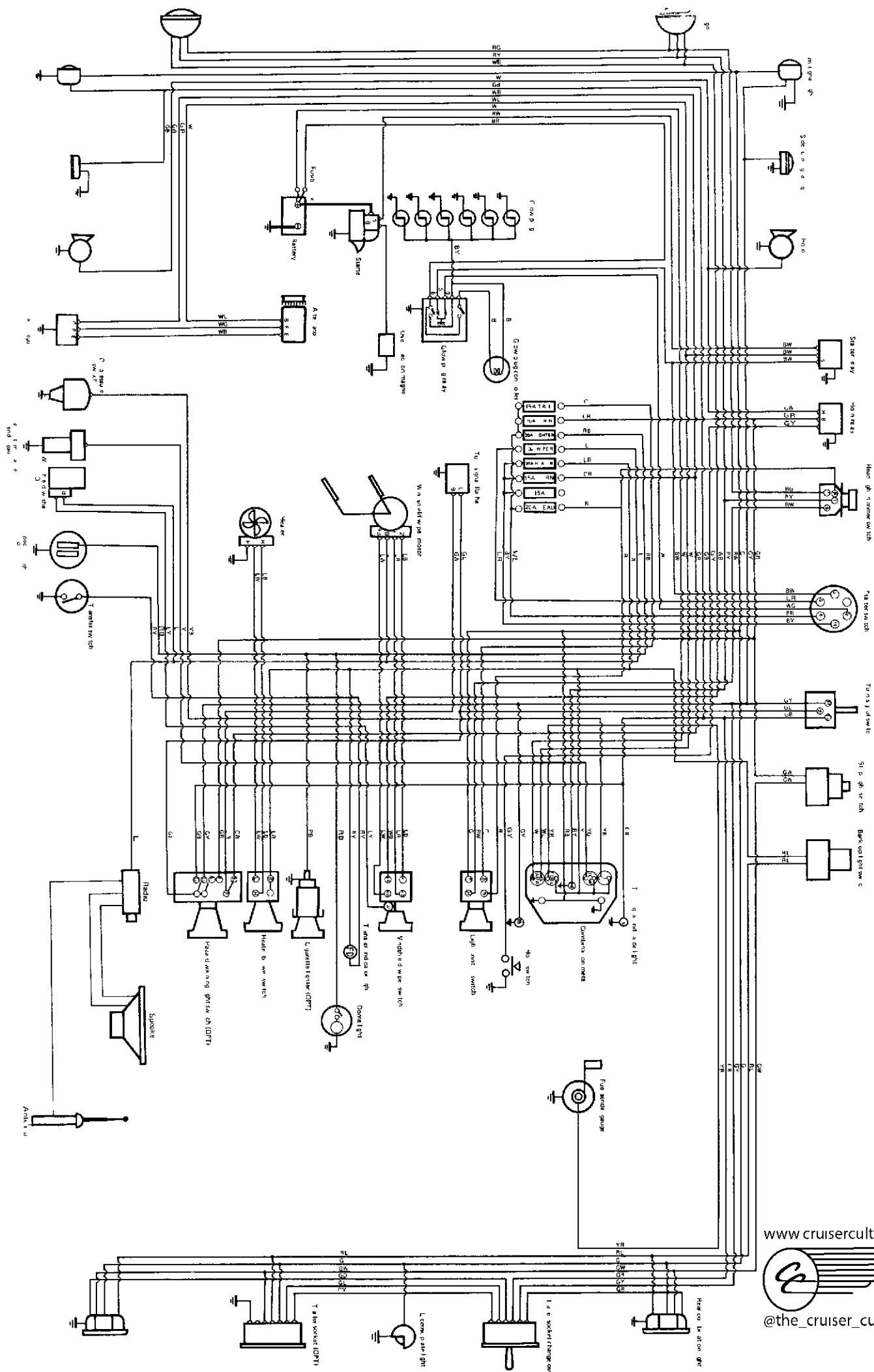
Nominal voltage	12V
Capacity	70 AH (20HR) for HJ series 100 AH (20HR) for HU series
Electrolyte level (above plates)	10 to 25 mm (0 4 to 1 0'')
Electrolyte specific gravity	1.260 (at 20°C) (at 68°F)
Specific gravity difference of cells	0 025

Clutch

Clutch release lever height	14 2 mm (0 559'') for HJ 16 2 mm (0 638'') for HU
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