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PART 2

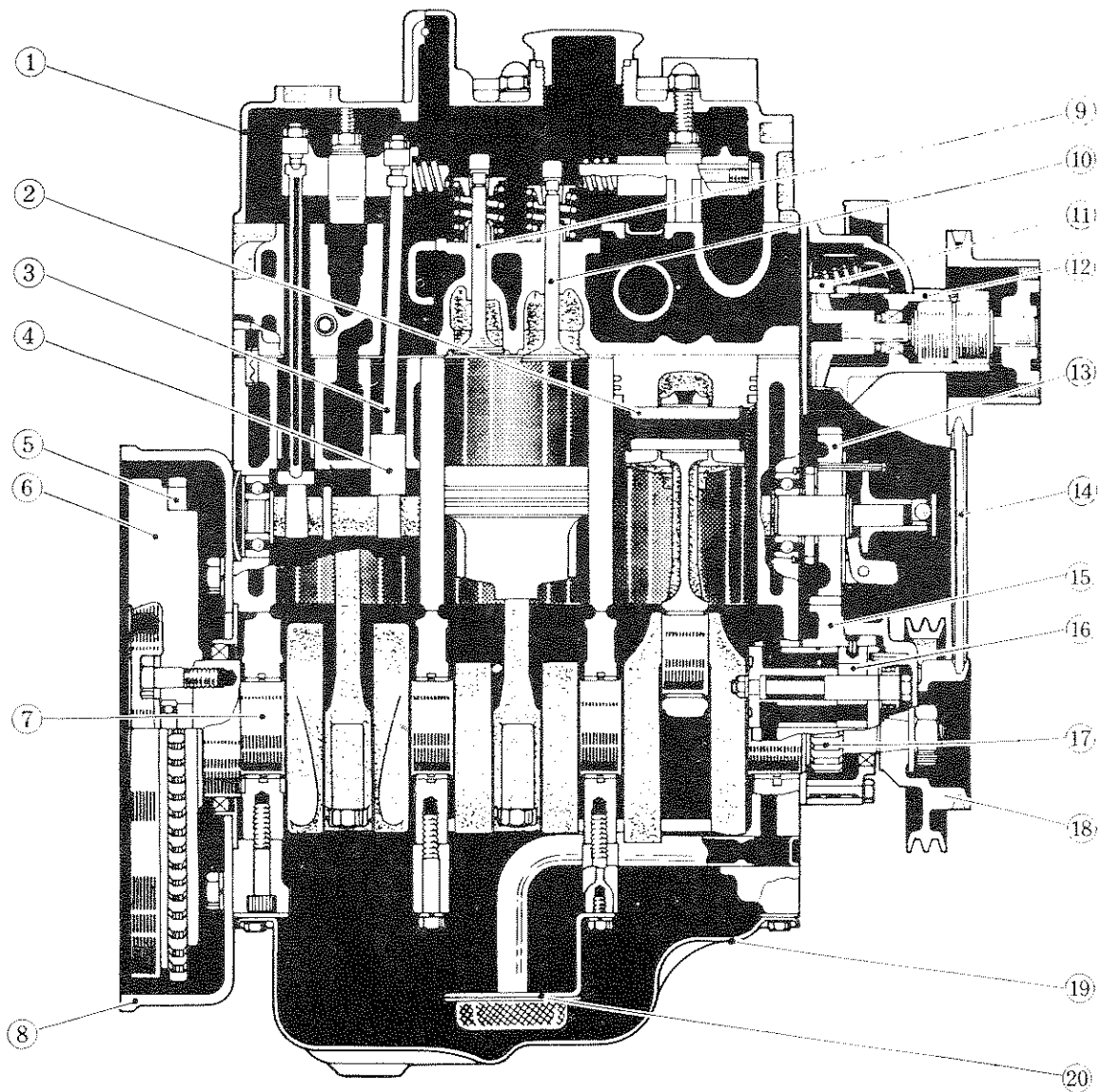
ENGINE

MECHANICAL

Section 2.4- ENGINE REASSEMBLY

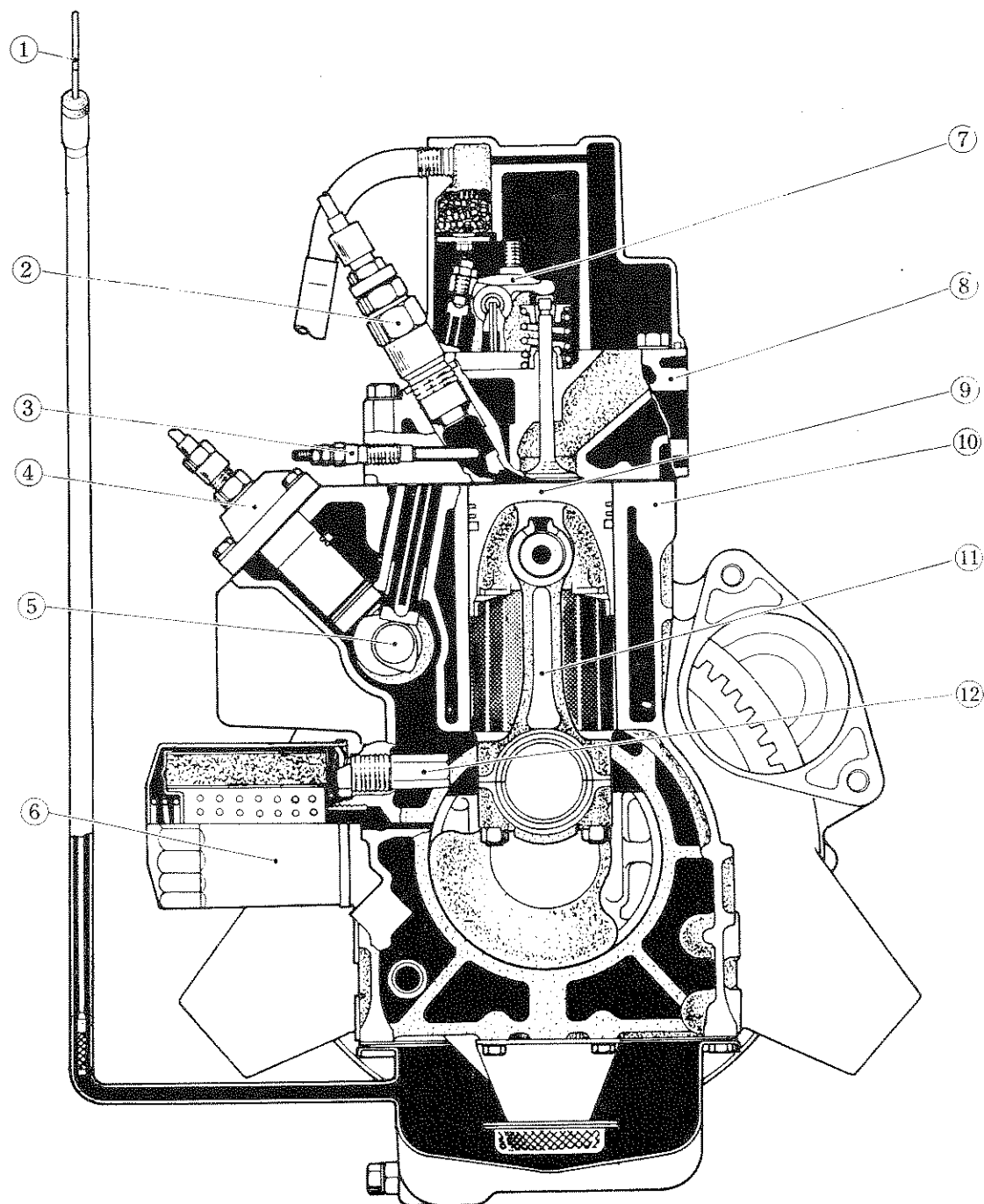
- 2.4.1- Relief Valve Assembly
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- 2.4.18- Complete the Assembly

ENGINE CROSS SECTION



- | | |
|--------------------|-----------------------|
| 1. Head cover | 11. Thermostat |
| 2. Piston pin | 12. Water pump |
| 3. Push rod | 13. Camshaft gear |
| 4. Tappet | 14. V belt |
| 5. Ring gear | 15. Idle gear |
| 6. Fly wheel | 16. Oil pump |
| 7. Crank shaft | 17. Crankshaft gear |
| 8. Fly wheel cover | 18. Crankshaft pulley |
| 9. Exhaust valve | 19. Oil pan |
| 10. Intake valve | 20. Suction filter |

ENGINE CROSS SECTION



- | | |
|----------------------|--------------------|
| 1. Level gauge | 7. Rocker arm |
| 2. Nozzle and holder | 8. Cylinder head |
| 3. Glow plug | 9. Piston |
| 4. Injection pump | 10. Cylinder block |
| 5. Camshaft | 11. Connecting rod |
| 6. Oil filter | 12. Relief valve |

GENERAL ENGINE SPECIFICATIONS

Type of Engine 4-Cycle Diesel
 Cooling Method Water Cooled
 Cylinder Arrangement Vertical In-Line
 Combustion Chamber Special Swirl Type
 No. of Cylinders 3
 Bore x Stroke
 In Inches 2.95 x 2.83
 In millimeters 75 x 72
 Total Displacement 954 cc
 Compression Ratio 23 to 1
 Fuel Injection Pump Bosch Type
 Injection Nozzle Throttle Type
 Recommended Fuel JIS No. 2D Diesel Fuel

Oil Pump Trochoid Type
 Oil Filter Full Flow Spin-On
 Crankcase Oil Capacity
 With Filter Change 4 U.S. quarts
 Without Oil Filter Change 3.7 U.S. quarts
 Oil Pressure 28-71 psi (196-490 kPa)
 Cooling System Heat Exchanger Type
 Captive Water Pump Flow Rate 121.5 U.S. Gal./Minute
 Captive Water Cooling System
 Capacity 2.5 U.S. Quarts
 Sea Water Pump Flow Rate 7.0 U.S. Gal./Minute
 Sea Water Pump Maximum Lift
 Dry 10 feet
 Wet 20 feet
 Pre-Heat Method Glow Plugs

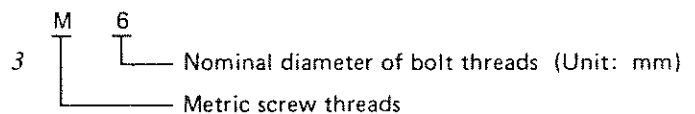
TORQUE VALUES FOR METRIC BOLTS

Grade	Bolt or nut size	Bolt or nut diameter* mm	Pitch mm	Tightening torque		
				N·m	kg·m	ft·lb
4T	M6	6.0	1.0	3 - 4	0.3 - 0.4	2.2 - 2.9
	M8	8.0	1.25	8 - 11	0.8 - 1.1	5.8 - 8.0
			1.0	8 - 11	0.8 - 1.1	5.8 - 8.0
	M10	10.0	1.5	16 - 22	1.6 - 2.2	12 - 16
			1.25	16 - 22	1.6 - 2.2	12 - 16
	M12	12.0	1.75	26 - 36	2.7 - 3.7	20 - 27
			1.25	30 - 40	3.1 - 4.1	22 - 30
M14	14.0	1.5	46 - 62	4.7 - 6.3	34 - 46	
7T	M6	6.0	1.0	6 - 7	0.6 - 0.7	4.3 - 5.1
	M8	8.0	1.25	14 - 18	1.4 - 1.8	10 - 13
			1.0	14 - 18	1.4 - 1.8	10 - 13
	M10	10.0	1.5	25 - 35	2.6 - 3.6	19 - 26
			1.25	26 - 36	2.7 - 3.7	20 - 27
	M12	12.0	1.75	45 - 61	4.6 - 6.2	33 - 45
			1.25	50 - 68	5.1 - 6.9	37 - 50
M14	14.0	1.5	76 - 103	7.7 - 10.5	56 - 76	
9T	M6	6.0	1.0	8 - 11	0.8 - 1.1	5.8 - 8.0
	M8	8.0	1.25	19 - 25	1.9 - 2.5	14 - 18
			1.0	20 - 27	2.0 - 2.8	14 - 20
	M10	10.0	1.5	36 - 50	3.7 - 5.1	27 - 37
			1.25	39 - 51	4.0 - 5.2	29 - 38
	M12	12.0	1.75	65 - 88	6.6 - 9.0	48 - 65
			1.25	72 - 97	7.3 - 9.9	53 - 72
M14	14.0	1.5	109 - 147	11.1 - 15.0	80 - 108	

- Special parts are excluded.
- This standard is applicable to bolts having the following marks embossed on the bolt head.

*: Nominal diameter

Grade	Mark
4T	4
7T	7
9T	9



ENGINE TOLERANCES AND FITS

CYLINDER HEAD

Compression Pressure

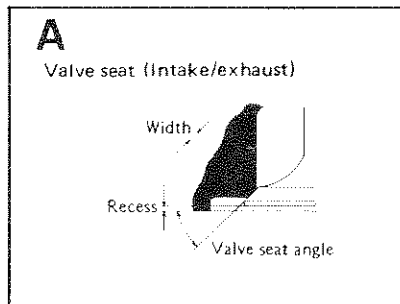
Standard Value.....More than 426.6 psi
Repair Required ifLess than 284.4 psi
Check Pressure at.....200 rpm

Maximum Cylinder Head Face Distortion

Standard Value.....Less than 0.0020 inch
Repair If.....More than 0.005 inch

A Valve Seat (Intake and Exhaust)

Standard Recess.....0.033 inch
Repair if Greater than.....0.070 inch
Valve Seat Standard Width.....0.047-0.059 inch
Repair Width if Greater Than.....0.079 inch
Valve Seat Angle.....45°



Tightening Torque of Cylinder Head

Torque Value.....32.5-36.0 ft.-lbs.

CYLINDER BLOCK

TypeWet, Single Piece

Cylinder Block Bore

Standard Dimension.....2.95 inches
Standard Value.....2.9527-2.9535 inch
Repair if More Than.....2.9606 inch
Allowable Limits3.0000 inch
Oversize0.020, 0.040 inch

Max. Distortion of Cylinder Block Upper Face

Standard Value.....0.0020 inch
Repair if More Than.....0.005 inch

MAIN REVOLVING SYSTEM

Piston Skirt Max. Diameter

Standard Dimension.....2.9527 inch
Standard Value.....2.9134 inch
Allowable Limit2.9409 inch
Oversize0.020, 0.040 inch

Clearance to Cylinder

Standard Value0.003-0.004 inch
Allowable Limit0.010 inch
Measure at20° C.

Inside Diameter of Piston Pin

Standard Dimension0.827 inch
Standard Value0.80.8267-0.8269 inch

Piston Pin Hole to Pin Clearance

Standard Value-0.00008- +0.0003 inch
Allowable Limit0.0008 inch

Piston Pin Outer Diameter

Standard Dimension0.8268 inch
Standard Value0.8266-0.8268 inch
Allowable Limit0.8260 inch

Small End Bushing to Pin Oil Clearance

Standard Value0.0006-0.0012 inch
Allowable Limit0.003 inch

Piston Ring Gap

No. 1 Ring Standard Value0.008-0.014 inch
No. 2 Ring Standard Value0.006-0.012 inch
Oil Ring Standard Value0.008-0.014 inch
Allowable Limit (All Rings)0.039 inch

Piston Ring Groove to Ring Clearance

No. 1 Ring Standard Value0.002-0.004 inch
No. 2 Ring Standard Value0.002-0.012 inch
Oil Ring Standard Clearance0.002-0.004 inch
Allowable Limit (No. 1 & No. 2)0.001 inch
Allowable Limit (Oil Ring)0.006 inch

Piston Ring Width

No. 1 Ring Standard Dimension0.079 inch
No. 1 Ring Standard Value0.0776-0.0783 inch
No. 2 Ring Standard Dimension0.059 inch
No. 2 Ring Standard Value0.0579-0.0587 inch
Oil Ring Standard Dimension.....0.1575 inch
Oil Ring Standard Value0.1563-0.1571 inch
Oversize Rings Available.....0.020 & 0.040 inch

Connecting Rod

Allowable Twist Between small
& large end Holes (per 3.94 inches)
Not to Exceed0.008 inch
Front to Rear Play Between Connecting Rod
and Crankpin Allowable Limit.....0.028 inch
Connecting Rod to Crankpin
Oil Clearance Allowable Limit0.008 inch
Connecting Rod Bolt Torque.....22-25 ft.-lbs.

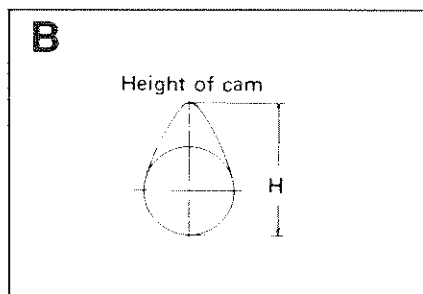
Crankshaft

Standard Diameter of Main Journal.....	1.8110 inch
Standard Tolerance of Main Journal.....	1.8096-1.8100 inch
Allowable Limit of Main Journal.....	1.7874 inch
Main Journal Undersize.....	0.010, 0.020 inch
Crankpin Standard Diameter.....	1.5354 inch
Crankpin Standard Tolerance.....	1.5340-1.5344 inch
Allowable Crankpin Limit.....	1.5118 inch
Crankpin Undersize.....	0.010, 0.020 inch
Standard Crankshaft Deflection.....	Less than 0.001 inch
Max. Allowable Crankshaft Deflection.....	0.002 inch
Standard Axial Crankshaft Play.....	0.002 inch
Max. Allowable Axial Crankshaft Play.....	0.020 inch
Standard Thickness of Thrust Washer.....	0.079 inch
Standard Tolerance of Thrust Washer.....	0.077-0.079 inch
Minimum Allowable Thickness of Thrust Washer.....	0.071 inch
Tolerance of Oil Clearance between Crankshaft Journal and Center Bearing.....	0.0015-0.0036 inch
Maximum Allowable Oil Clearance between Crankshaft Journal and Center Bearing.....	0.0078 inch

VALVE SYSTEM

B Camshaft

Standard Height of Cam	
Tolerance for Intake/Exhaust.....	1.0413-1.0433 inch
Minimum Allowable Cam Height for Intake/Exhaust.....	1.0276 inch
Standard Cam Height for Injection Pump.....	0.9425-0.9472 inch
Minimum Allowable Injection Pump Cam Height.....	0.9370 inch
Standard Cam Height for Feed Pump.....	1.0590-1.0630 inch
Minimum Allowable Cam Height for Feed Pump.....	1.0236 inch
Standard Cam Gear Backlash.....	0.003 inch
Maximum Cam Gear Backlash.....	0.012 inch



C Valves

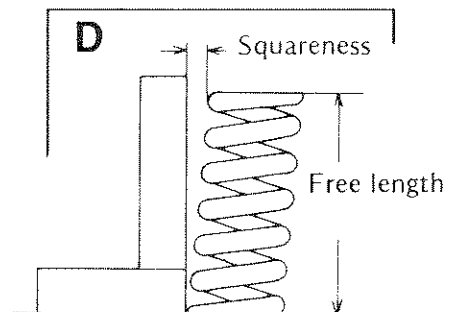
Standard Diameter of Intake Valve Stem.....	0.2744-0.2738 inch
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C Valves (Cont'd)

Minimum Allowable Diameter of Intake Valve Stem.....	0.2713 inch
Standard Diameter of Exhaust Valve Stem.....	0.2740-0.2736 inch
Minimum Allowable Diameter of Exhaust Valve Stem.....	0.2693 inch
Standard Clearance Between Intake Valve Stem and Valve Guide.....	0.001-0.002 inch
Maximum Clearance Between Intake Valve Stem and Guide.....	0.0079 inch
Standard Clearance Between Exhaust Valve Stem and Guide.....	0.0016-0.0026 inch
Maximum Clearance-Exhaust Valve Stem to Guide.....	0.010 inch
Valve Standard Thickness.....	0.039 inch
Valve Thickness Standard Tolerance.....	0.036-0.042 inch
Minimum Allowable Valve Thickness.....	0.020 inch
Valve Clearance- Intake/Exhaust (When Cold).....	0.008-0.020 inch

Valve Springs

Force Required to Compress Spring to Length of 1.197 inch.....	17.86 lbs.
Valve Spring Standard Free Length.....	1.3779 inch
Valve Spring Minimum Free Length.....	1.3189 inch
Standard Valve Spring Squareness.....	Less than 0.047 inch
Replace Spring if Out-of-Square More Than.....	0.079 inch



Valve Timing

Intake Valve	
Open.....	13° BTDC
Closed.....	43° BTDC
Exhaust Valve	
Open.....	43° BTDC
Closed.....	13° BTDC

Push Rods

Standard Overall Length.....	5.181 inch
Overall Length Standard Tolerance.....	5.173-5.189 inch
Push Rod Outer Diameter.....	0.248 inch

Rocker Arm

Rocker Arm Standard Diameter0.459 inch
Rocker Arm Standard Tolerance.....0.4586-0.4594 inch
Maximum Allowable Wear.....0.4555 inch

LUBRICATION SYSTEM

Oil Pump

Discharge VolumeΔ
Quarts Over 10.57 per Minute
Liters Over 10.00 per Minute
Relief Pressure.....43-71 psi
Pump Rotor to Vane Tip Clearance
(Standard Tolerance)0.0004-0.0059 inch
Pump Rotor to Vane Maximum
Allowable Tip Clearance0.010 inch
Pump Rotor to Cover Side
Clearance (Standard Tolerance)0.004-0.006 inch
Rotor to Cover Maximum
Side Clearance.....0.008 inch

FUEL SYSTEM

Injection Pump

Diameter of Pump Plunger.....0.1969 inch
Pump Plunger Stroke.....0.2362 inch
Fuel Injection Timing.....20°-21° BTDC

Injection Nozzle

Injection Pressure 1706.4-1848.6 psi
Angle of Injection 12°

SPECIAL TORQUE VALUES

Connecting Rod Bearing Cap

Foot-Pounds 22-25
m-kg 3.0-3.5

Main Bearing Holders

Foot-Pounds 18-22
m-kg 2.5-3.0

Flywheel Cover

Foot-Pounds 34-40
m-kg 4.7-5.5

Flywheel

Foot-Pounds 43-51
m-kg1 6.0-7.0

Suction Filter

Foot-Pounds 7.0-9.0
m-kg 0.9-1.3

Camshaft Plate

Foot-Pounds 7-9
m-kg 0.9-1.3

Crankshaft Pulley

Foot-Pounds 72-80
m-kg 10-11

Oil Pipe Eyebolts

Foot-Pounds 7-9
m-kg 1.0-1.3

Cylinder Head

Foot-Pounds 33-36
m-kg 4.5-5.0

Rocker Arm Assembly

Foot-Pounds 15-18
m-kg 2.0-2.5

Cylinder Head Cover

Foot-Pounds 6-8
m-kg 0.8-1.2

Fuel Injection Pipes

Foot-Pounds 18-22
m-kg 2.5-3.0

Injection Nozzle Holders

Foot-Pounds 58-61
m-kg 8.0-8.5

SECTION 2.1 - GENERAL INFORMATION

This section contains valuable tips pertaining to the repair and/or replacement of engine parts. Read this section carefully before attempting to repair the engine.

2.1.1- When is Major Engine Maintenance Required

The necessity for major engine repairs is usually a result of excessive cylinder, piston, ring and valve wear. Data gathered from periodic maintenance and inspection will usually indicate the need for major maintenance. Occurrence of one or more of the following will indicate a need for major engine repairs:

1. Loss of engine compression pressure below the stated limit.
2. Increased engine oil consumption.
3. Increased fuel consumption.
4. Engine starts with difficulty (starts hard).
5. Loss of engine power.
6. Rough or noisy engine operation.
7. Excessive "blowby" of combustion gases through the engine breather.

The main causes of the symptoms listed above are:

1. Weak battery or malfunctioning starter motor.
2. Excessive cylinder, piston or piston ring wear.
3. Insufficient or excessive valve clearance.
4. Fuel injection pump malfunction.
5. Incorrect fuel injection timing.
6. Fuel injection nozzle malfunction.

2.1.2- General Rules for Engine Repair

The following general rules should be strictly complied with when performing engine maintenance:

1. The work area should be neat and uncluttered. Arrange the work table(s), engine stands, parts bins, etc., in a logical sequence of disassembly.
2. Prior to disassembly of engine parts, locate any alignment or reassembly marks on the parts to be disassembled. If alignment marks cannot be found, place your own alignment marks on the parts.
3. Pay close attention to all parts during disassembly. Many defects will be evident prior to the actual disassembly of parts.
4. Use the proper tool for each job.
5. Use new gaskets, o-rings and seals during reassembly.
6. Use a torque wrench to ensure that all fasteners are properly tightened. Some components require a special torque value, which is given in the reassembly sequence in this Manual. Parts not requiring a special torque value should be tightened to the value recommended in TORQUE VALUES FOR METRIC BOLTS (Page 3).

SECTION 2.2 - DISASSEMBLY OF ENGINE

The engine disassembly procedure covers complete disassembly. You may wish to disassemble the engine only to the extent needed to effect needed repairs. Most engine disassembly is a matter of common sense and simple logic.

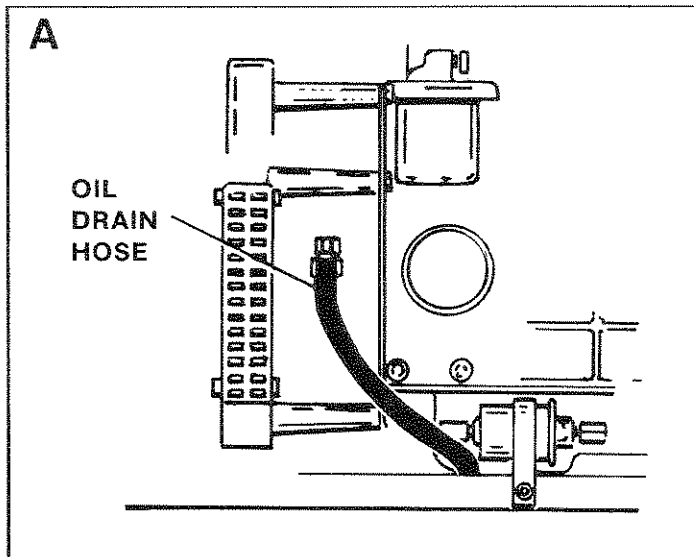
2.2.1- Disassemble the a-c Generator

Disassemble the a-c generator and remove generator parts from engine. See Sections 1.6 and 1.7.

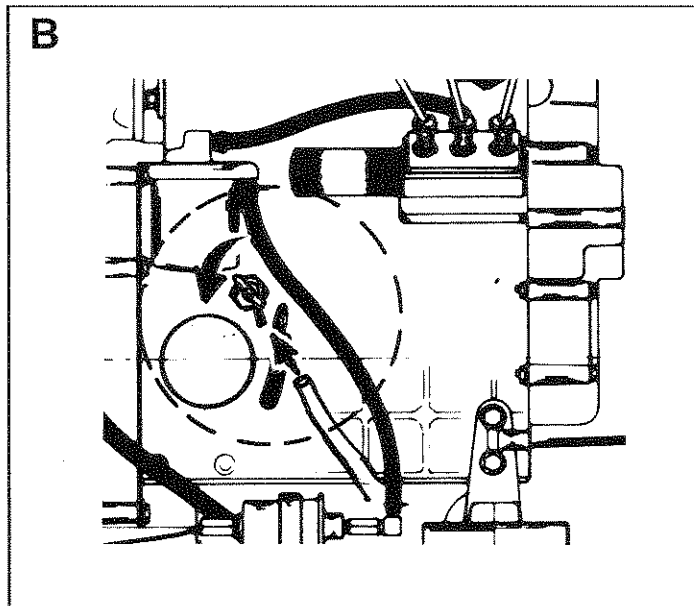
2.2.2- Drain Engine Fluids

Prior to engine disassembly, drain all engine fluids from the engine block.

A Drain oil completely from the engine crankcase. If complete disassembly is required, remove the engine oil filter.



B Completely drain the engine's captive water system.

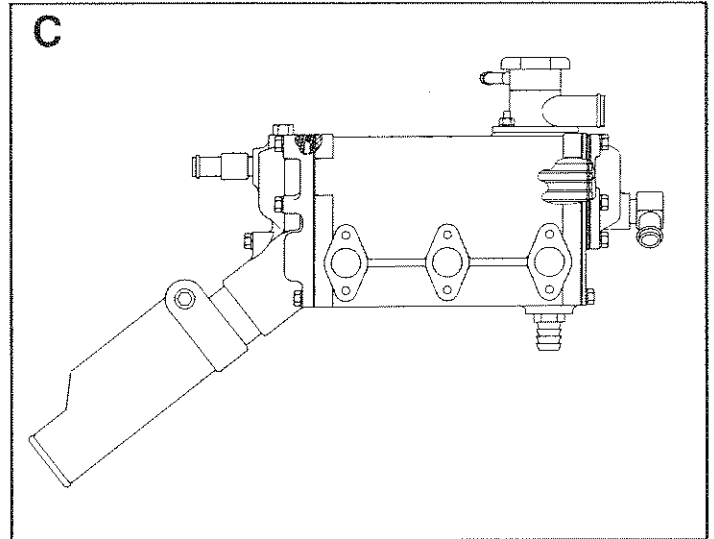


2.2.2- Remove Cooling and Fuel System Hoses

Remove cooling system and fuel system hoses, if complete disassembly is to be performed.

2.2.3- Remove Heat Exchanger

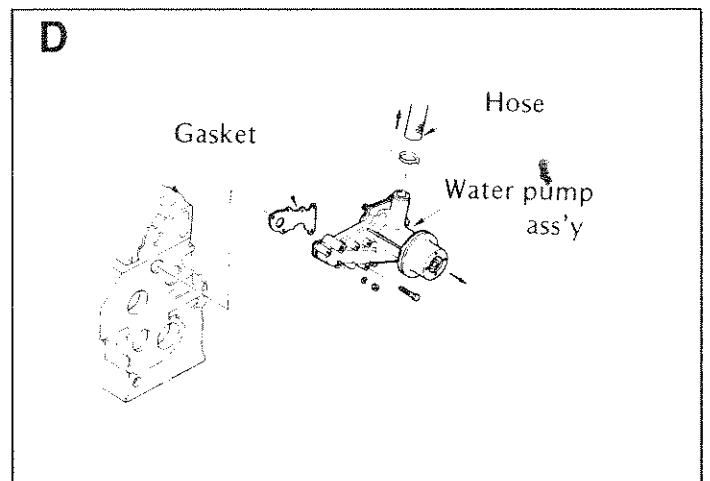
C The cooling system Heat Exchanger also serves as the engine Exhaust Manifold. Remove the Heat Exchanger from the engine.



2.2.4- Miscellaneous Parts

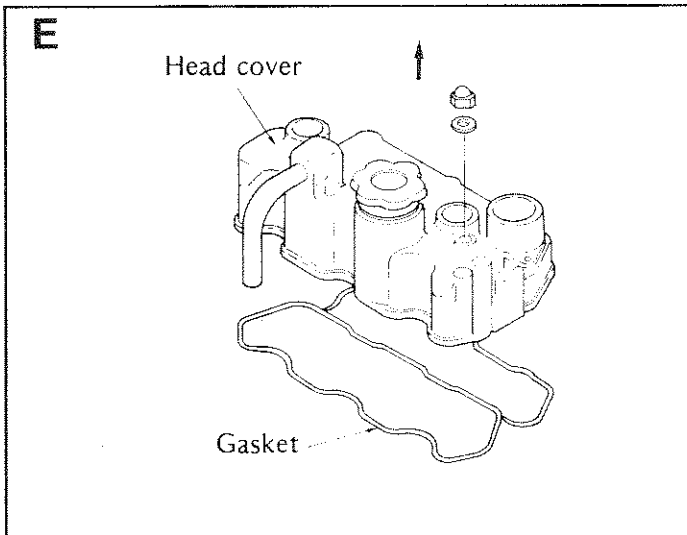
1. Remove the engine Fuel Filter.
2. Remove the Oil Dipstick Tube and Oil Dipstick.
3. Remove engine V-belt(s).
4. Remove Fuel Injection hoses, pipes and return pipes.
5. Remove the Fuel Injection Nozzle and Nozzle Holders.

D Remove the engine Water Pump assembly and gasket.



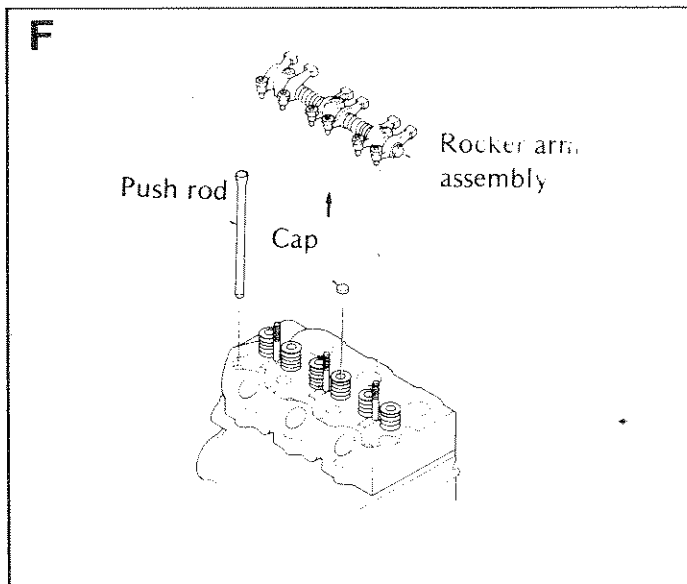
2.2.5- Remove the Head Cover

E Remove the Cylinder Head Cover.



2.2.6- Rocker Arm Assembly, Push Rod and Cap

F Remove the Rocker Arm Assembly and Push Rods. Remove Caps from the Intake and Exhaust Valves. Store all parts together in a safe place.

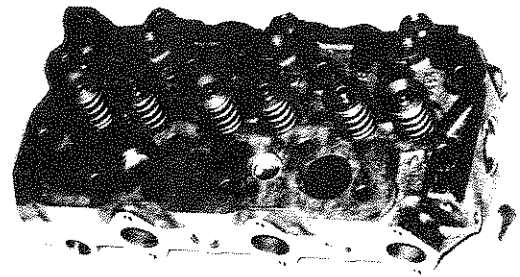


2.2.7- Cylinder Head Assembly

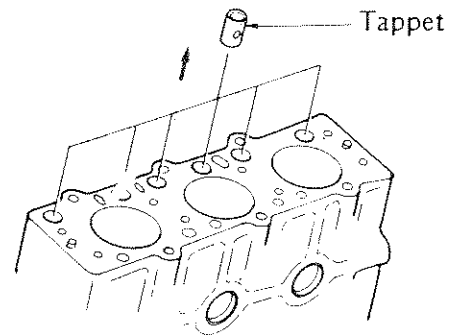
G Remove the Oil Pipe eye bolts (head side). To remove the bolts, loosen them in about two to three increments. Finally, remove the Glow Plugs.

H Remove Tappets by pulling them up from the Cylinder Block.

G

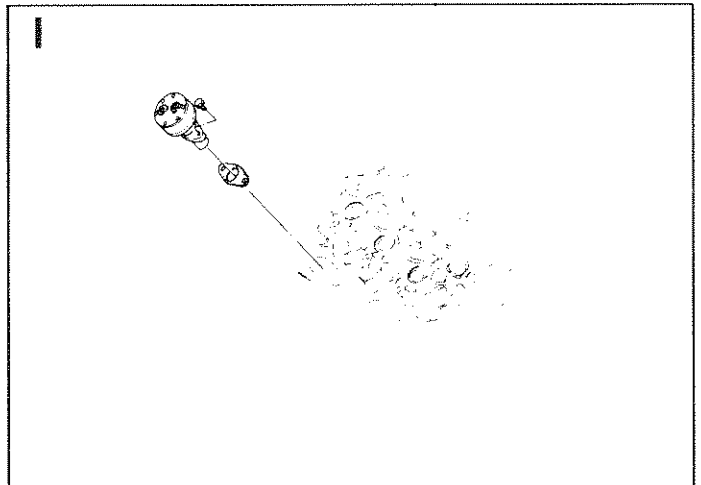


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2.2.8- Feed Pump Assembly

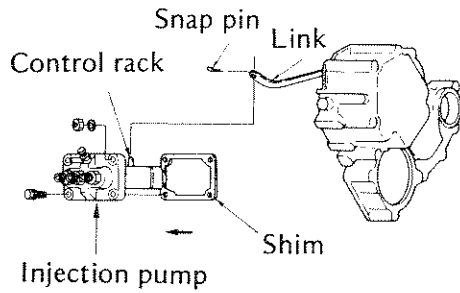
I Remove the Feed Pump assembly.



2.2.9- Fuel Injection Pump Assembly

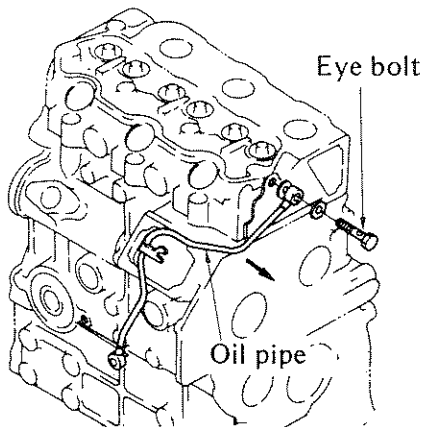
J Remove bolts and nuts that retain the Fuel Injection Pump. Move the Injection Pump straight up and pull out the Snap Pin. Remove the Link from the Pump Control Rack. Finally, remove the Pump.

NOTE: Injection timing is determined by SHIMS at the Pump mounting face. Be sure to check and record the thickness and number of shims to ensure proper re-installation of the Pump.

J

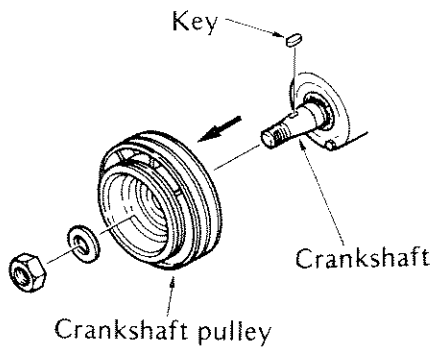
2.2.10- Oil Pipe

K Loosen EYE BOLT and remove the Oil Pipe.

K

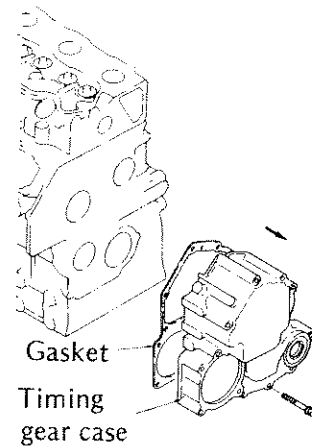
2.2.11- Crankshaft Pulley

L Remove CRANKSHAFT PULLEY.

L

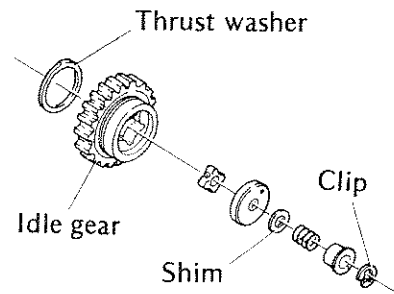
2.2.12- Timing Gear Assembly

M Remove TIMING GEAR CASE and GASKET.

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2.2.13- Idler Gear and Oil Pump Assembly

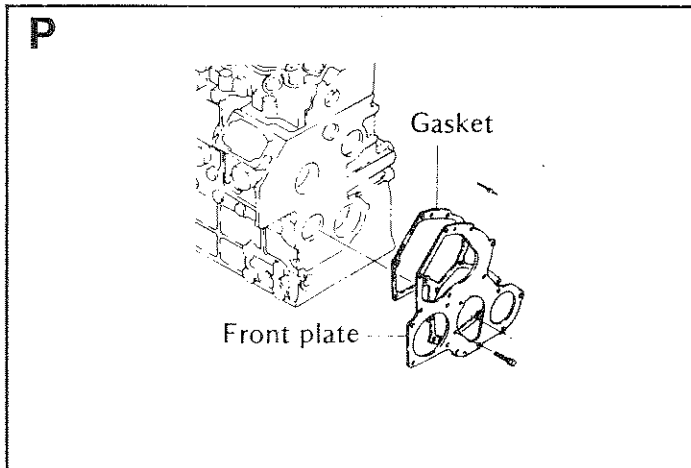
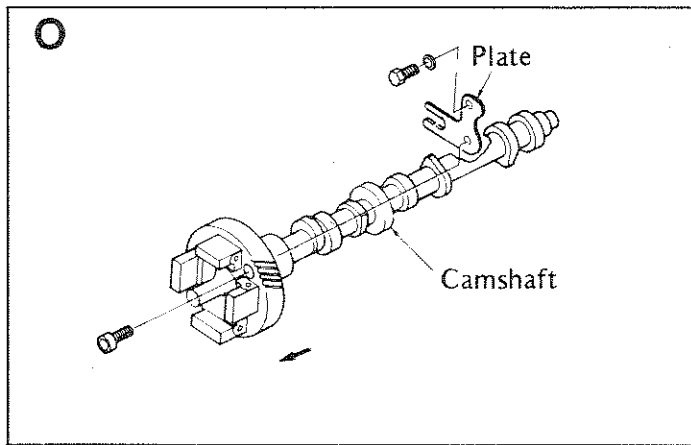
N Remove the CLIP, then remove the OIL PUMP and IDLE GEAR.

N

2.2.14- Camshaft Assembly and Plate

O Remove two Bolts which retain the PLATE. Remove the CAMSHAFT and the PLATE.

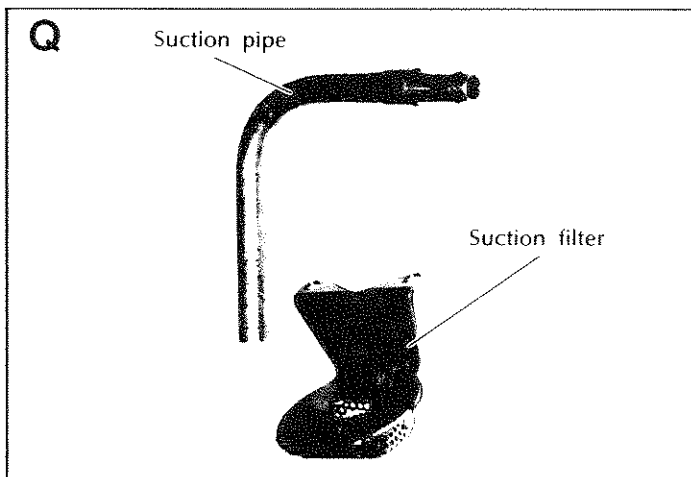
P Remove the FRONT PLATE and GASKET.



2.2.15- Remove the Oil Pan

Remove Oil Pan screws and remove Oil Pan.

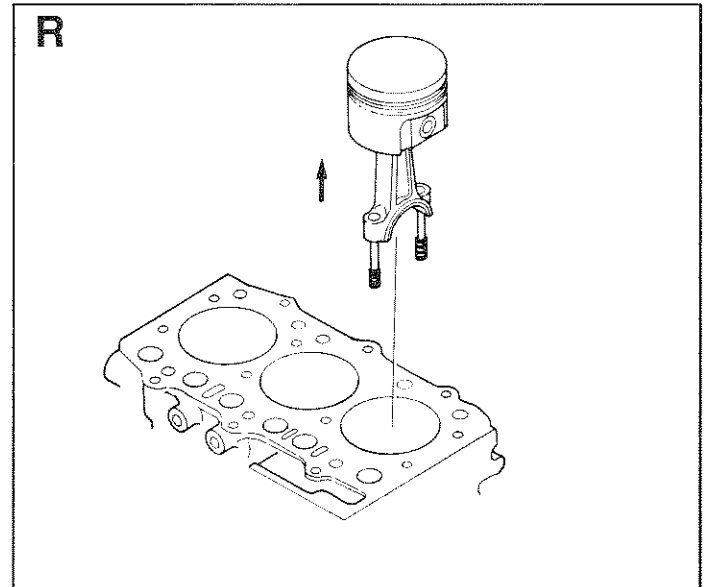
Q Remove the SUCTION FILTER and SUCTION PIPE.



2.2.16- Connecting Rods and Pistons

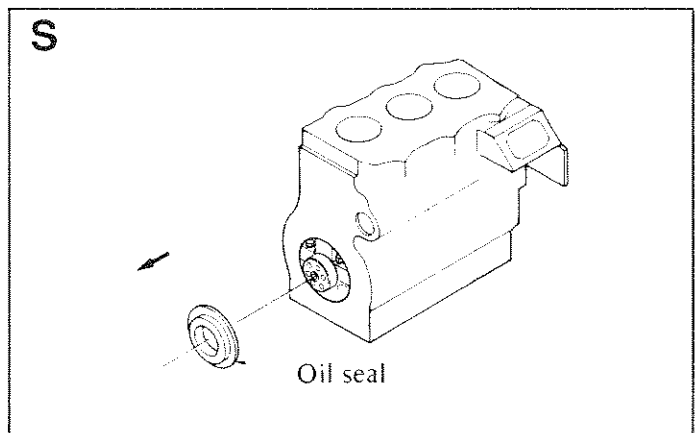
IMPORTANT: Clean carbon from upper part of cylinder before removing Piston. Mark connecting rods, cap and bearings with cylinder number upon removal.

R Loosen connecting rod cap nuts and remove. Pull piston, with connecting rod, from each cylinder.



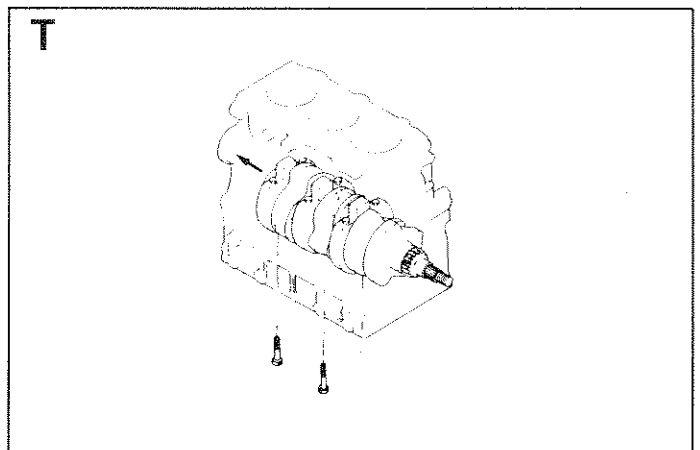
2.2.17- Flywheel Cover

S Remove Flywheel Cover, then remove OIL SEAL.



2.2.18- Crankshaft and Bearing Holder

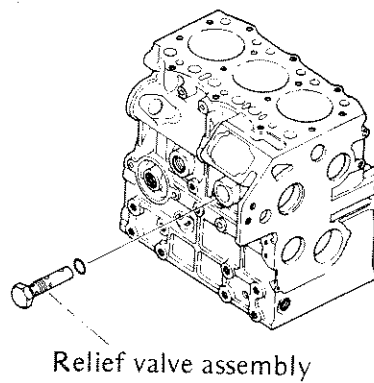
T Remove the bolts that retain the Bearing Holder. Remove Crankshaft and Bearing Holder by pulling out, toward the flywheel.



2.2.19- Relief Valve Assembly

U Remove the RELIEF VALVE ASSEMBLY.

U



SECTION 2.3 - DISASSEMBLY, INSPECTION AND REASSEMBLY

This section provides instructions for the disassembly, inspection and reassembly of major engine parts. Follow the instructions carefully.

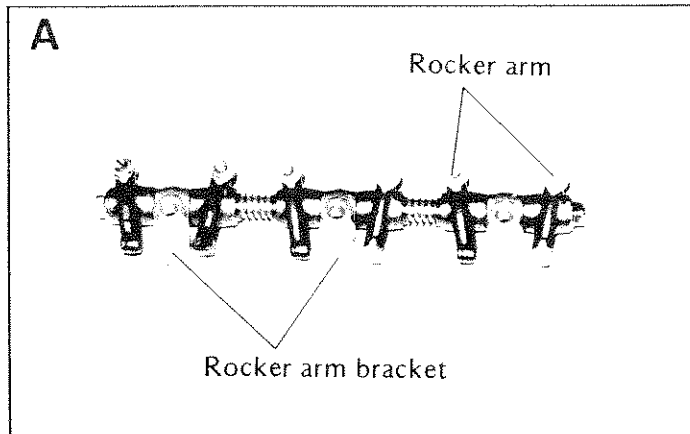
2.3.1- General

Before starting the disassembly and inspection procedure, check the following:

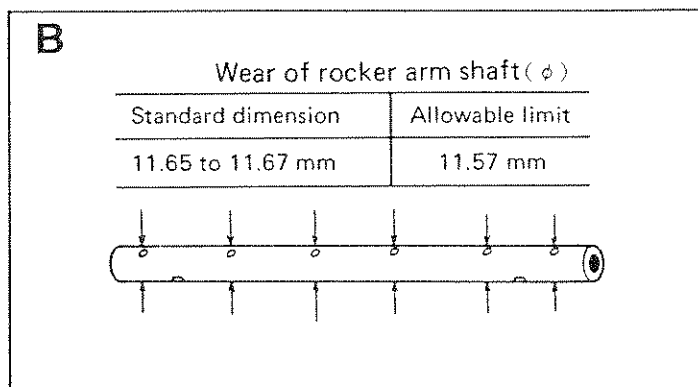
1. Carefully inspect the cylinder block and cylinder head for damage and evidence of water leakage.
2. Use pressure air to blow out all oil holes. Check that no oil hole is plugged.
3. Wash all parts to remove dirt, dust, dirty oil and carbon deposits.
4. Clean all carbon deposits from the piston, cylinder head and valves. Make sure these parts are not damaged. Pay special attention to aluminum alloy parts.
5. Place match marks on all mating parts for correct reassembly.

2.3.2- Rocker Arm Assembly

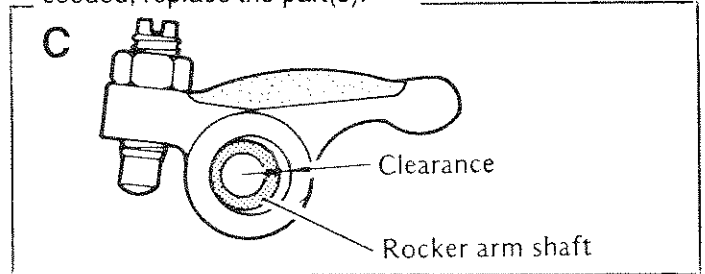
A Remove bolt at end of rocker arm shaft, then remove **ROCKER ARM**, **ROCKER ARM BRACKET** and **SPRINGS**. Pull out the Spring Pin from the No. 1 Cylinder **ROCKER ARM BRACKET**. Remove **ROCKER ARMS**, **SPRINGS** and **BRACKETS**.



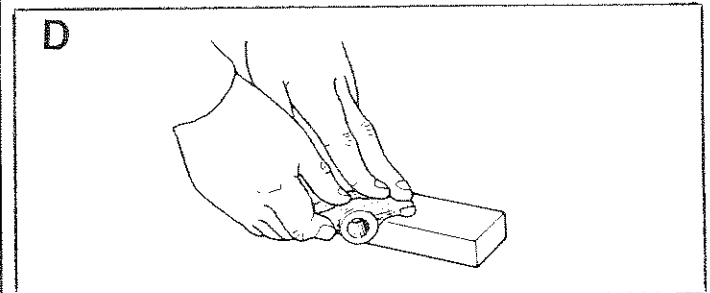
B Use a micrometer to check outside diameter of the Rocker Arm Shaft. If allowable limits are exceeded, replace the Rocker Arm Shaft.



C Measure the inside diameter of the **ROCKER ARM**. Calculate the clearance between the Rocker Arm and the Rocker Arm Shaft. If allowable limits are exceeded, replace the part(s).

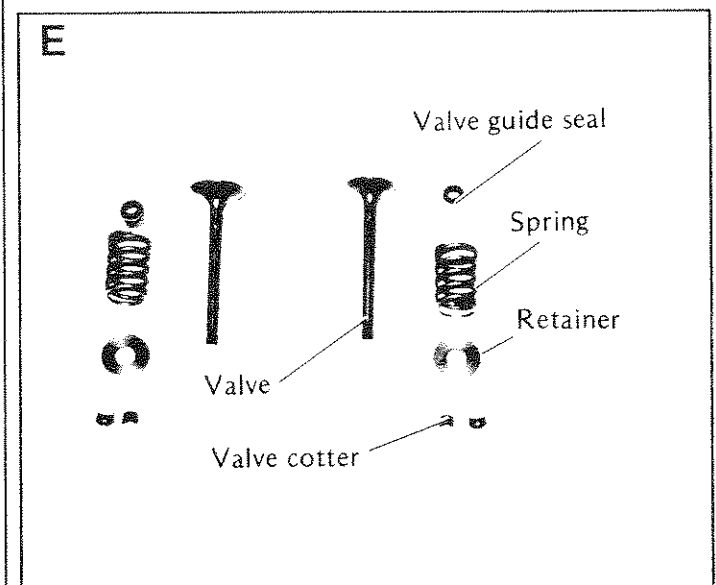


D Check the Valve Stem Face for step wear or scoring. Slight wear or scoring may be corrected using an oil stone or grinder.

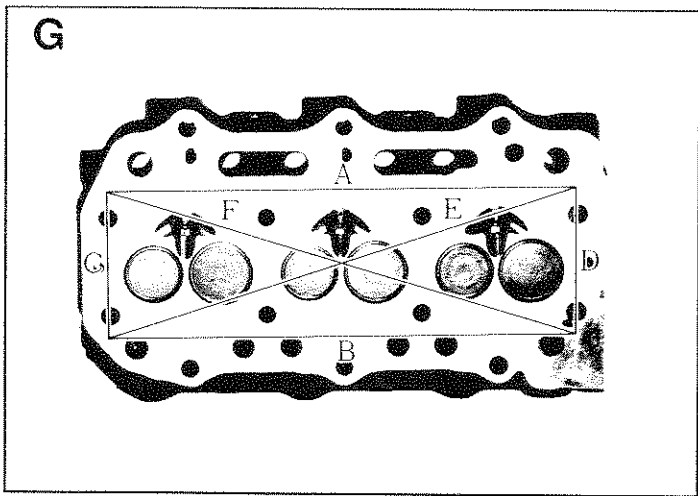
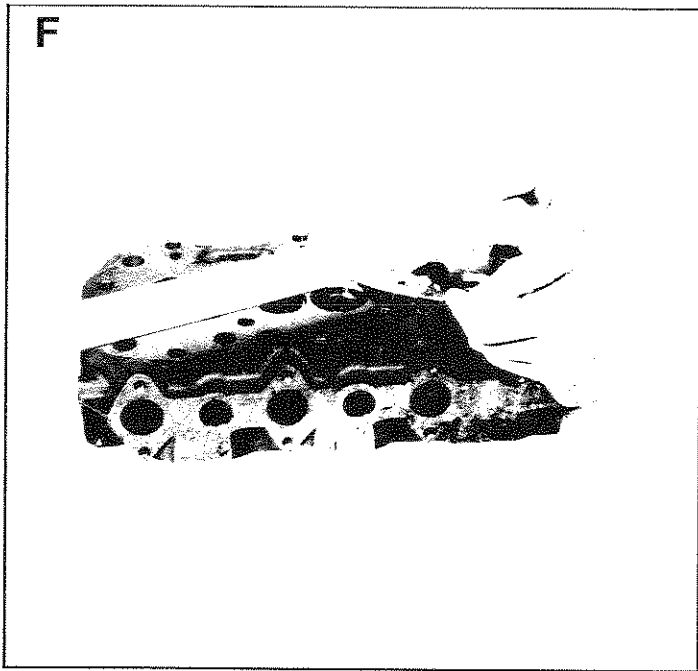


2.3.3- Cylinder Head Assembly

E Use a Valve Spring compressor to compress valve springs. Then, remove the **VALVE COTTER**, **RETAINER**, **SPRING** and **VALVE**. Remove the **VALVE GUIDE SEAL**.



F, G Use a straight edge and a thickness gauge to check warp of the cylinder head lower face. Check with straight edge at six positions, as shown in Illustration G. If warped excessively, correct with a surface grinder.



H Check the Valve Stem for damage, excessive wear. Replace if damaged or worn excessively. Use a micrometer to check valve stem diameters at locations I, II and III. If stem is worn beyond limits, replace Valve. Check valve head thickness, replace if worn excessively.

I Check the clearance between the valve and the Valve Guide. If beyond limits, replace parts.

J Always check for wear in the Valve Guide before making any corrections in Valve Seat. Use cutters of 15°, 45° and 75° to correct the Valve Seat.

H

Wear of valve stem

Intake valve	
Standard diameter	Allowable limit
6.955 to 6.97 mm	6.09 mm

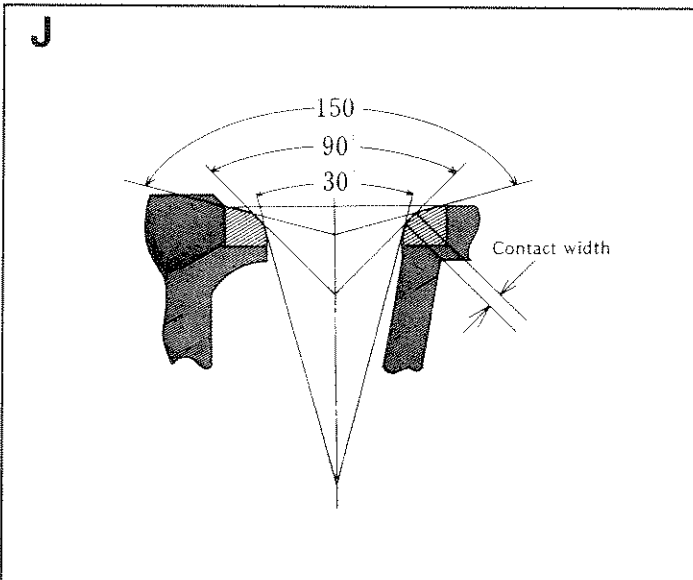
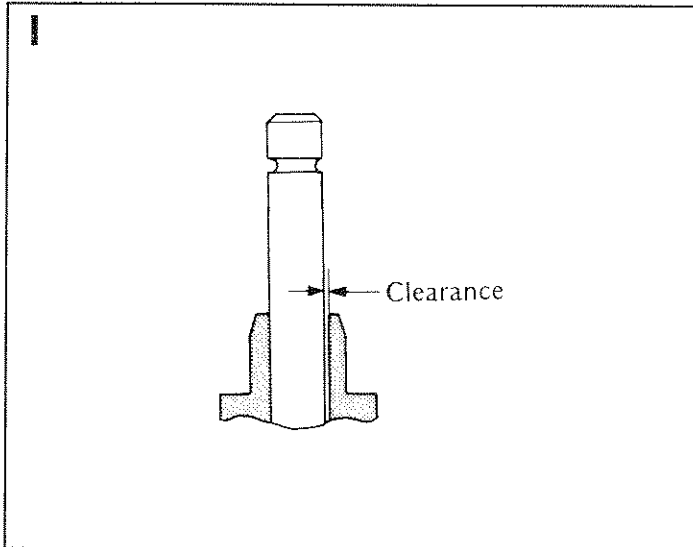
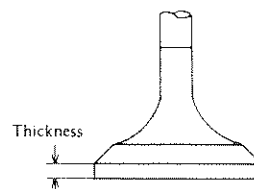
Exhaust valve

Standard diameter	Allowable limit
6.95 to 6.96 mm	6.84 mm



Thickness of valve head

Standard thickness	Allowable limit
0.925 to 1.075 mm	0.5 mm



K If the Valve RECESS exceeds allowable limits, replace the VALVE SEAT.

k

Recess of valve seat	
Standard recess	Allowable limit
0.85 to 1.15 mm	1.8 mm

Recess

L Grind the Valve Seat with a valve seat grinder and valve grinding compound. Check the valve contact face for correct contact and positioning.

NOTE: When installing a new cylinder head, use the valve seat cutter to obtain correct seat contact with recess of seat. Then, use lapping compound to lap the valve in.

L

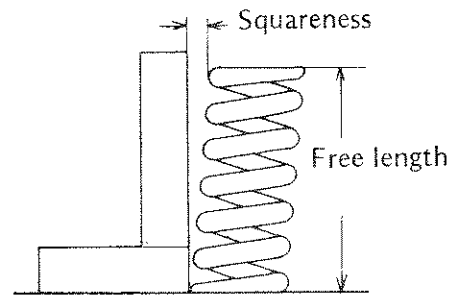
Valve lapper

M Visually inspect the Valve Spring for damage. Check spring squareness. If allowable limits are exceeded, replace the spring. Use a spring force tester, to test for correct spring force and free length.

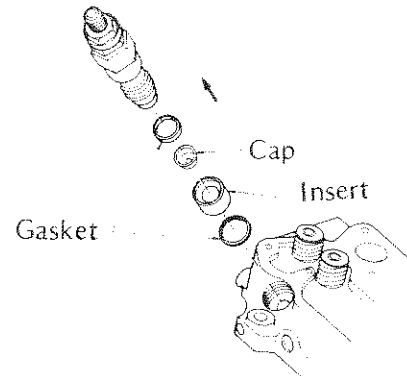
N Pull out the CAP and INSERT from the Cylinder. Inspect and clean the combustion chamber.

Reassemble all parts in the reverse order of disassembly. When assembling the VALVE SPRING, RETAINER and COTTER, use care to avoid damage to the VALVE GUIDE SEAL.

M



N



2.3.4- Cylinder Block

Inspect the cylinder block top face for damage, cracks, and warping. Use the same method that was used for the cylinder head.

CYLINDER BLOCK UPPER FACE WARP

Standard Value Less than 0.002 inch (0.05mm)

Allowable Limit 0.005 inch (0.12mm)

O Visually inspect the Cylinder Bore. There should be no scoring, rust or corrosion. Measure the cylinder bore at its upper, middle and lower areas, at positions A and B. If bore diameter exceeds limits, rebore to the correct oversize dimension.

NOTE: In SLIDE RANGE OF PISTON RING, the upper area corresponds to top ring when piston is at top dead center (about 10mm below block top surface). Lower area corresponds to oil ring with piston at bottom dead center (about 100mm from top face).

Use a cylinder (inside diameter) gauge to check cylinder bore.

P After boring, hone the cylinder in two stages, to obtain a diamond or "cross hatch" finish. The following specifications apply:

‡Use a rough finishing stone as follows: Tokyo DIA, SD120/140, N100M (bronze series).

‡Use finishing stone GC600JB

‡Use a grinding stone 100mm long by 4mm wide.

‡ Drill speed should be 162 rpm.

‡ Feed should be 13m per minute.

‡ Rough finishing gauge pressure should be 15kg/cm².

‡ Finishing pressure should be 5kg/cm²

‡ Perform finishing stroke 9 times.

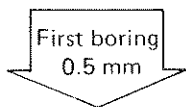
‡ Honing depth should be 0.04mm (diameter).

‡ Cross hatch angle should be 40°.

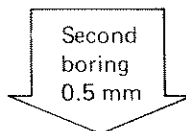
‡ Surface roughness should be 2-4μ

P

Standard bore	Allowable limit
φ 75 ~ 75.019	φ 75.2



Standard bore	Allowable limit
φ 75.5 ~ 75.519	φ 75.7



Standard bore	Allowable limit
φ 76 ~ 76.019	φ 76.2



Replace the block

2.3.5- Piston and Piston Rings

Q Use a ring compressor to remove piston rings. Remove one SNAP RING and remove PISTON PIN.

R Inspect Piston. Replace if damaged, cracked, scored, burned, etc.

Check the diameter of the piston skirt, about 0.394 inch (10mm) from bottom. Also check the inside diameter of the cylinder. Then, calculate the piston to cylinder clearance. If the clearance exceeds allowable limits, or if piston diameter

is less than the allowable limit, replace the piston. When a cylinder is oversized, use a correspondingly oversize piston.

PISTON SIZE	LARGEST DIAMETER	
	PART NO.	OF PISTON SKIRT
Standard	810261	2.9488-2.9500 in.
0.5mm O.S.	810262	2.9685-2.9697 in.
1.0mm O.S.	810263	2.9882-2.9894 in.

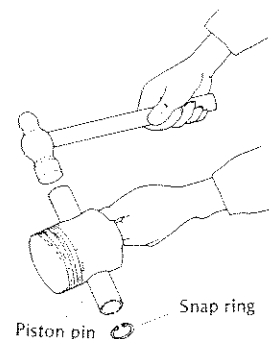
Standard piston to cylinder clearance is 0.003-0.005 inch (0.070-0.119mm); allowable limit is 0.010 inch (0.25mm).

Standard largest diameter of the piston skirt is 2.9488-2.9500 inch (74.900-74.930mm). Allowable limit is 2.9409 inch (74.7mm).

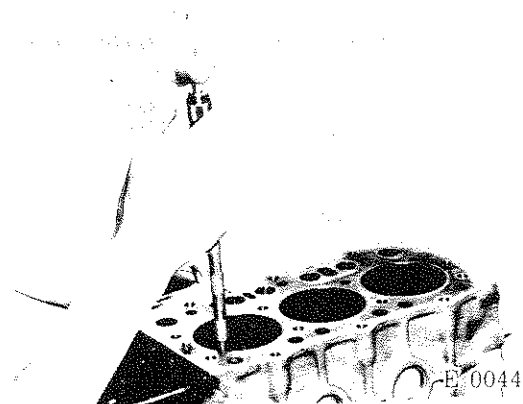
Check the diameter of the piston pin hole and the outside diameter of the piston pin. Calculate the clearance between them. If clearance is more than the allowable limit, replace the piston.

Standard Piston Pin Hole to Pin clearance is -0.00008-+0.0003 inch (-0.002 to +0.008mm). Allowable limit is 0.0008 in. (0.02mm).

Q



R



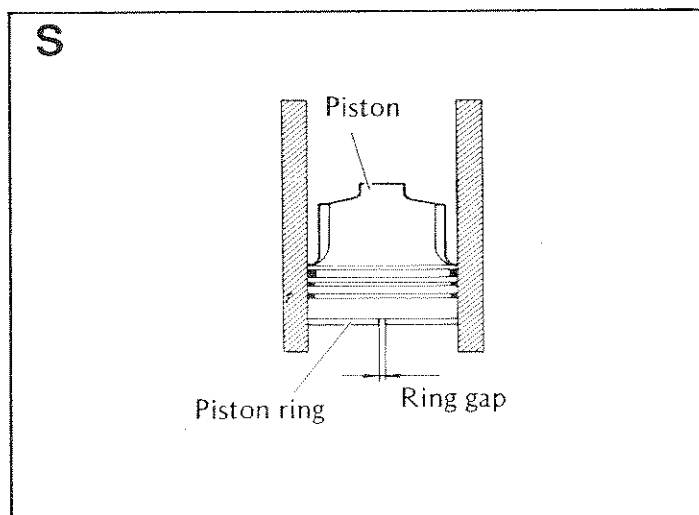
S Inspect piston rings, replace if worn or damaged. Install the rings into the cylinder skirt and measure the ring gaps with a feeler gauge. If allowable limits are exceeded, replace rings.

Standard Gap of No. 1 Ring = 0.008-0.014 inch (0.2-0.35mm)

Standard Gap of No. 2 Ring = 0.006-0.012 inch (0.15-0.3mm)

Oil Ring Standard Gap = 0.008-0.01 inch (0.2-0.35mm)

Allowable Limit (All Rings) = 0.039 inch (1.0mm)



Measure the clearance between the piston ring groove and the ring. If allowable limits are exceeded, replace the ring.

No. 1 Ring Standard Clearance = 0.002-0.004 inch (0.06-0.1mm)

No. 2 Ring Standard Clearance = 0.002-0.0035 inch (0.05-0.09mm)

No. 1 & 2 Ring Allowable Limit = 0.010 inch (0.25mm)

Oil Ring Standard Clearance = 0.0008-0.006 inch (0.02-0.06mm)

Oil Ring Allowable Limit = 0.006 inch (0.15mm)

If the cylinder is oversized, use an oversize piston ring set.

PISTON RING SIZE	PART NO.
STANDARD	810258
0.5 mm OVERSIZE	810259
1.0 mm OVERSIZE	810260

T When installing the Piston Rings, install them as shown in the illustration.

2.3.6- Connecting Rod

U Check the connecting rod for bending with a rod bending gauge. If allowable limit is exceeded, replace the connecting rod.

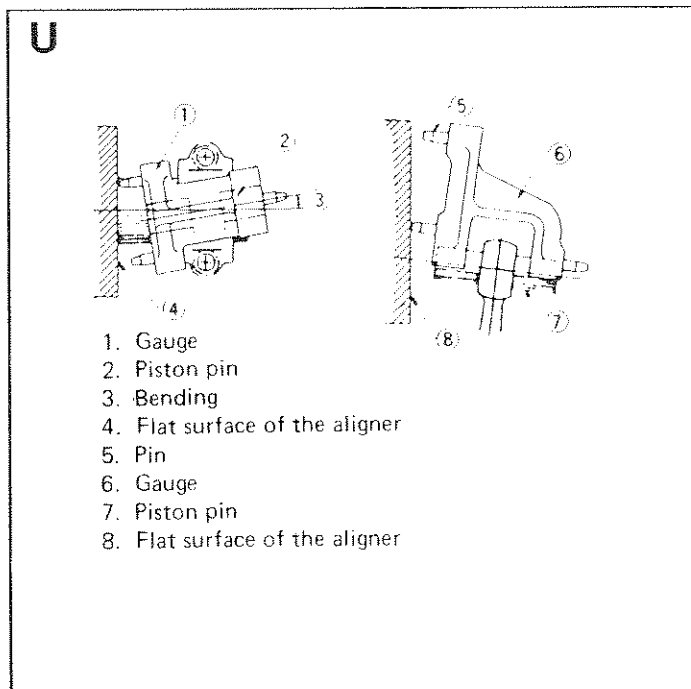
Standard Bending Value* = Less than 0.003 inch (0.08mm)

Allowable Bending Limit = 0.008 inch (0.2mm)

Parallelism Standard Value* = Less than 0.002 inch (0.05mm)

Allowable Parallelism Limit* = 0.006 inch (0.15mm)

*Per 3.94 inches (100mm)



1. Gauge
2. Piston pin
3. Bending
4. Flat surface of the aligner
5. Pin
6. Gauge
7. Piston pin
8. Flat surface of the aligner

Measure the diameter of the connecting rod small end bore. If the piston pin to bore clearance exceeds allowable limits, replace the rod. Standard rod bore to piston pin clearance and allowable limit are as follows:

Standard Clearance 0.0006-0.0012 inch (0.015-0.03mm)

Allowable Limit..... 0.003 inch (0.08mm)

Assemble the connecting rod to the crankshaft. Then, measure the end play (in direction of shaft). If play exceeds allowable limit, replace the connecting rod.

Standard Play 0.004-0.012 inch (0.1 to 0.3mm)

Allowable Limit..... 0.0275 inch (0.7mm)

V Inspect the connecting rod bearing for peeling, cracks, etc. Replace, if defective. Use plastigauge to check bearing oil clearance, as follows:

1. Remove oil and dirt from the rod bearing and from the crankpin.
2. Cut a length of plastigauge to the same length as the width of the bearing. Place it on the crankpin, parallel with the crankshaft. DO NOT PLACE OVER OIL HOLE.

3. Assemble the connecting rod bearing and cap to the crankpin. Tighten to 22-25 foot-pounds (3.0-3.5 m·kg).

IMPORTANT: NEVER ROTATE THE CONNECTING ROD OR CRANKSHAFT WHILE PLASTIGAUGE IS INSTALLED.

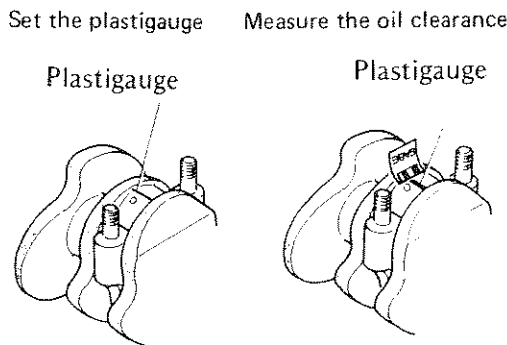
4. Remove the connecting rod cap and bearing. Measure the oil clearance, using the plastigauge scale (measure the widest area).

Standard Clearance.....0.001-0.003 inch
(0.035-0.083mm)
Allowable Limit.....0.008 inch (0.7mm)

5. If oil clearance exceeds the allowable limit, replace the bearing or grind the crankshaft pin and use the next undersize.

CRANKPIN BEARING SIZE	BEARING PART NO.	CRANKPIN O.D.
Standard	810270	1.5340-1.5344 inch (38.964-38.975mm)
0.25mm U.S.	810271	1.5242-1.5246 inch (38.714-38.725mm)
0.50mm U.S.	810272	1.5143-1.5148 inch (38.464-38.475mm)

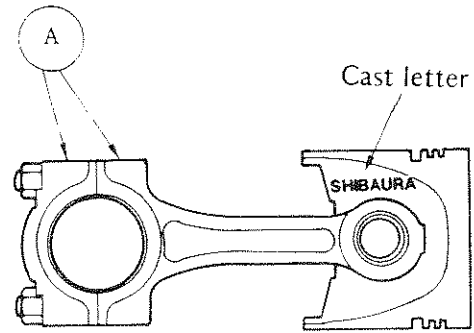
V



W Heat the piston to approximately 100° C. (212° F.). Then, assemble the piston to the connecting rod by aligning the match marks as shown in "A". Install rings onto piston with scribed mark at ring ends facing upward.

IMPORTANT: The difference in weight between cylinders of the assembled piston, piston pin, connecting rod and rings should not be more than 0.35 ounces (10 grams).

W



2.3.7- Main Bearing Holders

X Remove the bearing holder and inspect for peeling, cracking, wear, etc. Replace if defective. Use plastigauge to measure the oil clearance between the crankshaft center journal and the bearing. If oil clearance exceeds allowable limits, replace the bearing or grind the crankshaft center journal and use an undersize bearing.

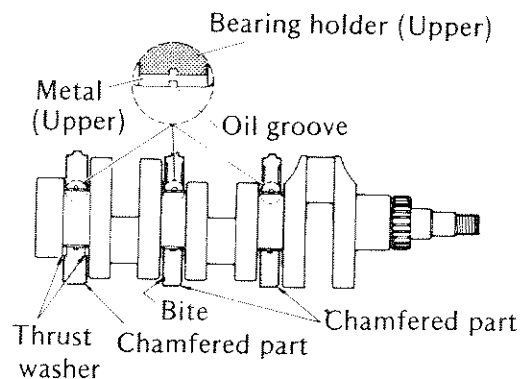
Standard Oil Clearance0.0015-0.0036 inch
(0.039-0.092mm)
Allowable Limit.....0.0078 inch (0.2mm)

BEARING SIZE	BEARING PART NO.	CRANKSHAFT JOURNAL DIA.
Standard	810249	1.8096-1.8100 inch (45.964-45.975mm)
0.25mm U.S.	810250	1.7998-1.8002 inch (45.714-45.725mm)
0.50mm U.S.	810251	1.7899-1.7903 inch (45.464-45.475mm)
	810254	(45.464-45.475mm)

Carefully inspect THRUST WASHER for wear, poor contact, burning and other defects. Replace washer if damaged or defective.

Standard Thickness of Thrust Washer.....0.077-0.079 inch
(1.95-2.0mm)
Allowable Limit.....0.071 inch (1.8mm)

X



Reassembly of Bearing Holder, Center Bearing and Thrust Washer:

1. Face the chamfered part of the Bearing Holder toward the front. Install the Bearing Holder which has reference bite at its center. Then, install the Bearing Holer which is to be mounted at the flywheel side.
2. Install Thrust Washer. Face its oil groove toward thrust face of crankshaft.

Tightening torque of Bearing Holder is 18-22 ft.-lbs. (2.5-3.0 m·kg).

3. Place the bearing with oil groove at the upper side and the bearing without oil groove at the lower side.

2.3.8- Crankshaft Bearing

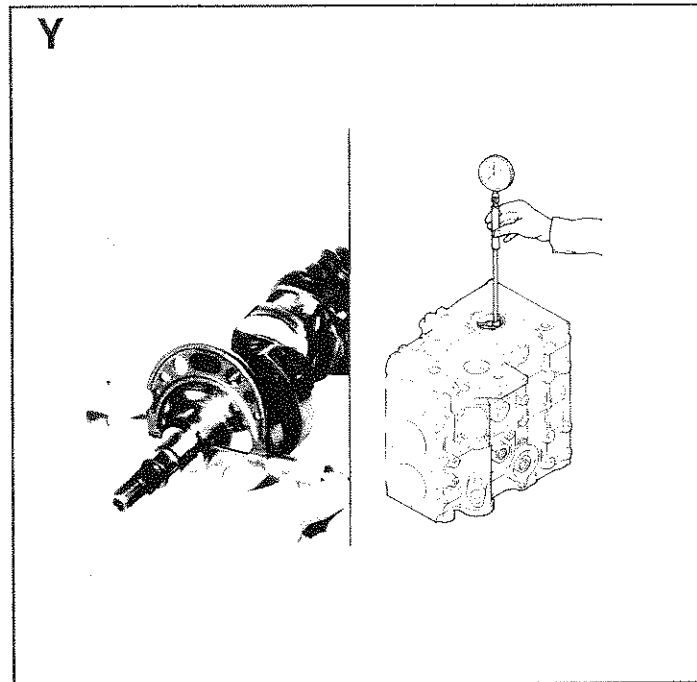
Y Inspection

1. Check bearings for peeling, weld cracks, burning, poor contact. Replace bearing, if defective.
2. Use a cylinder gauge and micrometer to measure oil clearance between the bearing and the crankshaft journal.
3. If oil clearance exceeds the allowable limit, replace the bearing or grind the crankshaft journal and use an undersize bearing.

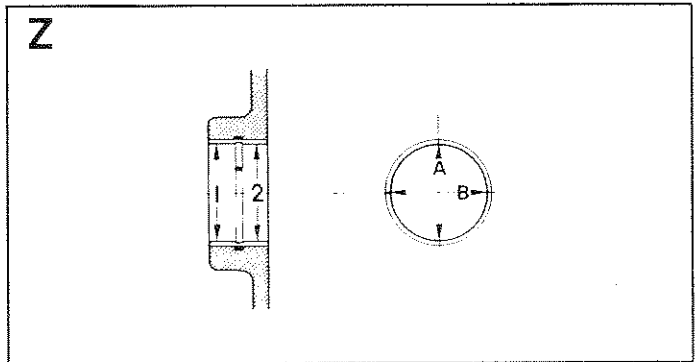
Standard Oil Clearance 0.0015-0.0042 inch (0.039-0.106mm)

Allowable Limit 0.0079 inch (0.2mm)

BEARING SIZE	PART NO.	O.D. OF CRANK JOURNAL
Standard	810249	1.8096-1.8100 inch (45.964-45.975mm)
0.25mm U.S.	810250	1.7998-1.8002 inch (45.714-45.725mm)
0.50mm U.S.	810251	1.7899-1.7903 inch (45.464-45.475mm)



Z Measure inside diameters at positions 1 and 2. At each position, measure in directions A and B as shown. When changing the bushing, press fit using a press. If crankshaft journal has been ground, check oil clearance before installing crankshaft.



2.3.9- Crankshaft

AA Support the crankshaft with a V-Block. Position a dial indicator on the crankshaft center journal, then turn the crankshaft slowly one full turn. If the gauge reading exceeds the allowable limit, replace the crankshaft. Be sure to check the oil seal contact face for damage or wear. Also check for clogged oil holes.

Standard Deflection 0.0012 (0.03mm) or less
Allowable Limit 0.0024 inch (0.06mm)

BB Inspect crankshaft journal and pin sections for damage, uneven abrasion, out-of-roundness, and axle diameter. Take measurements as shown in the illustration, at points 1 and 2 and in the directions A-A and B-B. Avoid the oil holes when measuring.

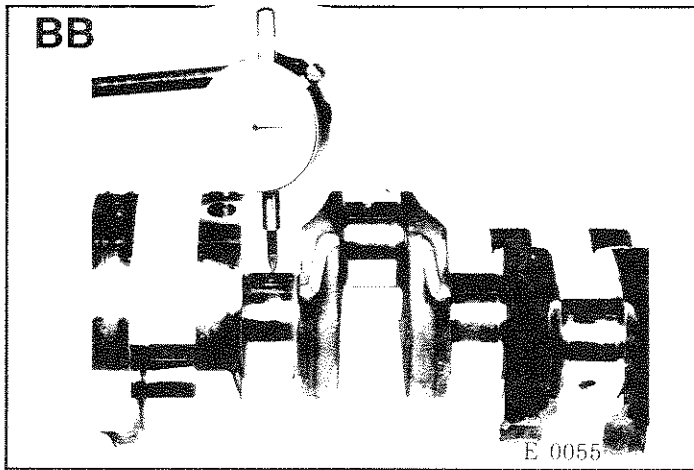
Shaft Diameter of Crankshaft Journal:

BEARING SIZE	STANDARD DIAMETER	ALLOWABLE LIMIT
Standard	1.8096-1.8100 in. (45.964-45.975mm)	1.8070 in. (45.9mm)
0.25mm U.S.	1.7998-1.8002 in. (45.714-5.725mm)	1.7972 in. (45.65mm)
0.50mm U.S.	1.7899-1.7903 in. (45.464-45.475mm)	1.7874 in.* (45.4mm*)

Shaft Diameter of Crankshaft Pin:

BEARING SIZE	STANDARD DIAMETER	ALLOWABLE LIMIT
Standard	1.5340-1.5344 in. (38.964-38.975mm)	1.5315 in. (38.90mm)
0.25mm U.S.	1.5242-1.5246 in. (38.714-38.725mm)	1.5216 in. (38.65mm)
0.50mm U.S.	1.5143-1.5148 in. (38.464-38.475mm)	1.5118 in. (38.40mm)*

* If crankshaft journal or pin diameter is less than this value, replace the crankshaft.



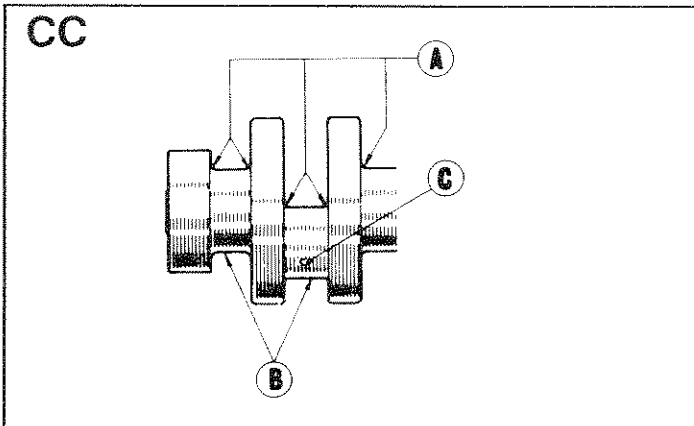
CC When grinding the crankshaft, comply with the following specifications:

A Radius at Pin/Journal= 3mm + 0.1mm

B Finish precision 1.6Z (▽▽▽)

C Radius around oil hole = 2mm max; 0.5mm min.

Use No. 400 sandpaper for final polishing.



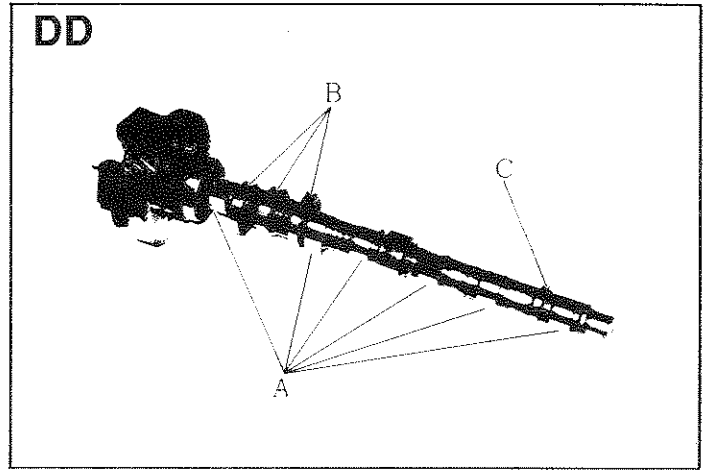
2.3.10- Camshaft Assembly

DD Inspect the journals and cams for wear and damage. Replace camshaft assembly if allowable limits are exceeded.

A Cam Height- Intake & Exhaust Valve Cams:
 Standard Value.....1.0413-1.0433 inch
 (26.45-26.50mm)
 Allowable Limit1.0275 in. (26.1mm)

B Injection Pump Cam Height
 Standard Value.....0.9425-0.9472 inch
 (23.94-24.06mm)

C Fuel Feed Pump Cam Height
 Standard Value.....1.0590-1.0630 inch
 (26.9-27.0mm)
 Allowable Limit1.0236 inch (26.0mm)

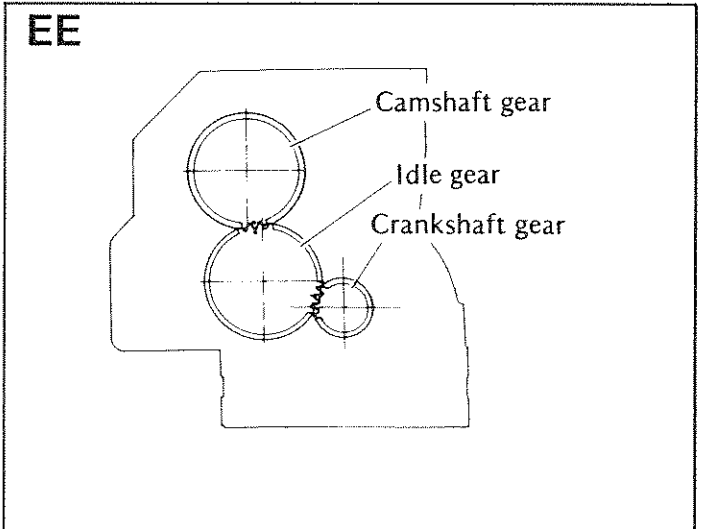


2.3.11- Timing Gear

EE Inspect timing gears for wear or damage at their engaging areas. Replace if damaged or worn excessively. Use a thickness gauge or a dial indicator to measure gear backlash. If allowable limit is exceeded, replace the timing gears as a set.

Back Lash of Timing Gears:

Standard Back Lash.....0.003 inch (0.08mm)
 Allowable Limit0.010 inch (0.25mm)



2.3.12- Other Components

A. Oil Pump and Filter- See Part 3, ENGINE LUBRICATION AND COOLING SYSTEM.

B. Water Pump & Thermostat- See Part 3, ENGINE LUBRICATION AND COOLING SYSTEM.

C. Heat Exchanger- See Part 3, ENGINE LUBRICATION AND COOLING SYSTEM.

D. Fuel Filter- See Part 4, ENGINE FUEL AND SPEED CONTROL SYSTEM.

E. Fuel Feed Pump Assembly- See Part 4.

F. Governor, Nozzle & Holder, Injection Pump- See Part 4.

SECTION 2.4 - ENGINE REASSEMBLY

This section provides instructions for the reassembly of the engine. Be sure to wash all parts prior to reassembly. Also be sure to coat all sliding and rotating surfaces with fresh, clean, new engine oil (as cylinder bores, pistons, bearings, bearing surfaces, etc.). Use new gaskets, seals and o-rings. And finally, always tighten bolts to the specified torque value. Never overtighten any fasteners that thread into aluminum.

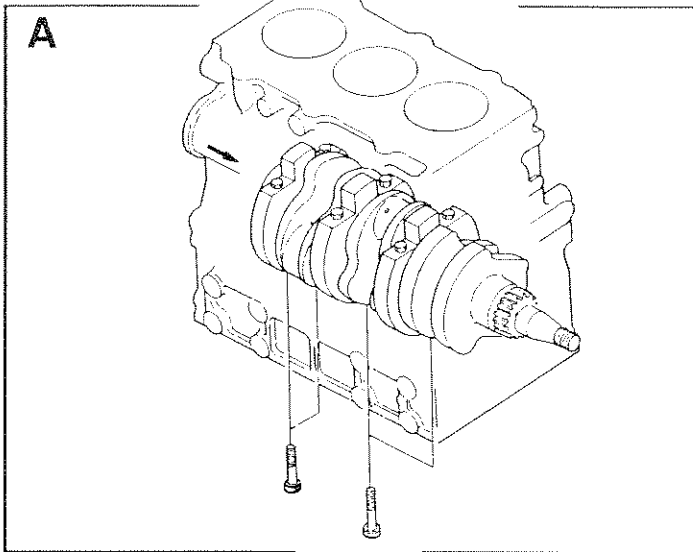
2.4.1- Relief Valve Assembly

Install a new o-ring onto the relief valve assembly. Install the relief valve and tighten to 43-51 ft.-lbs. (6-7 m-kg).

2.4.2- Crankshaft and Bearing Holder Assembly

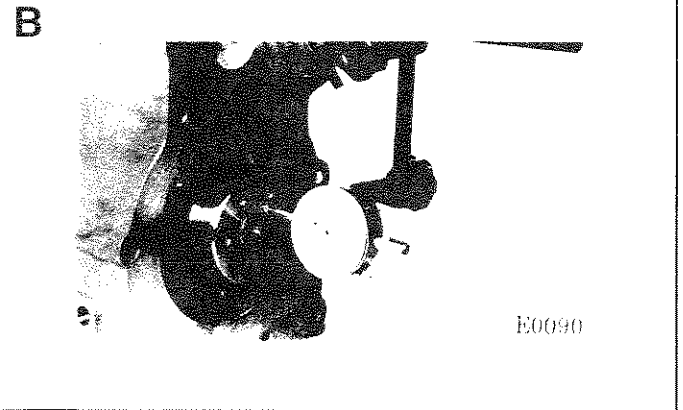
A Install Bearing Holder onto Crankshaft and into bushing at front end of cylinder block. Align bolt holes at lower part of cylinder block with threaded holes on Bearing Holder and tighten with bolts. Use hex bolts at flywheel side.

Bearing Holder tightening torque is 18-22 ft.-lbs. (2.5-3.0 m-kg).

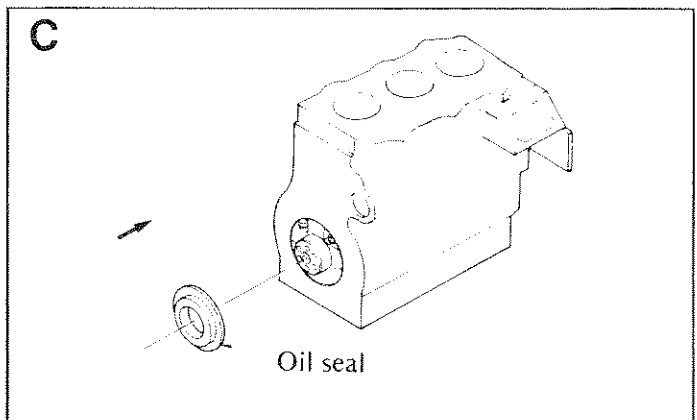


B Measure the crankshaft end play, in the direction of the crankshaft.

Standard Play0.0020-0.0118 inch
(0.05-0.3mm)
Allowable Limit0.020 inch (0.5mm)

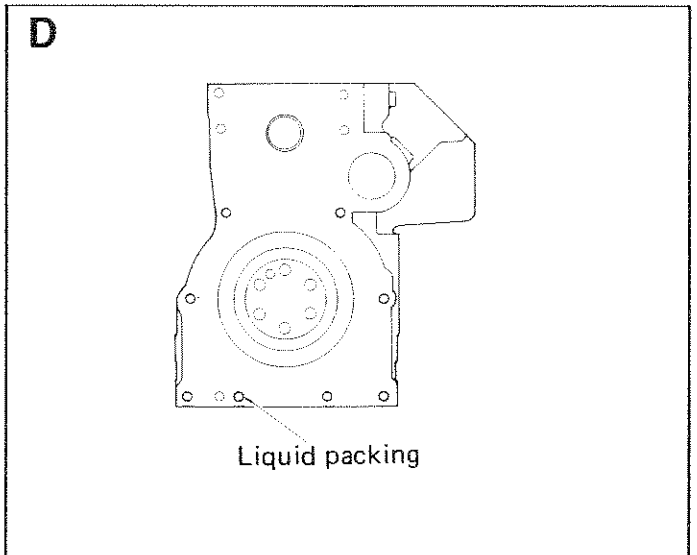


C Install Oil Seal at flywheel end of crankshaft.



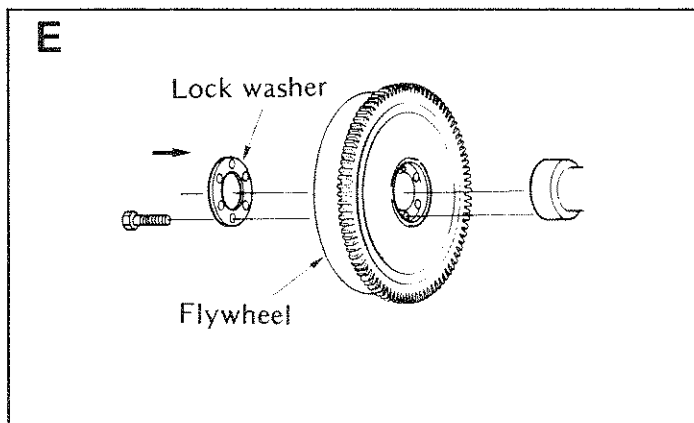
D Install Flywheel Cover. Spread liquid packing over the M10 screw hole of the cylinder block flywheel cover face, then fit flywheel over it.

Flywheel Cover Tightening Torque = 34-40 ft.-lbs. (4.7-5.5 m-kg)



E Install Flywheel. Pay close attention to location of the alignment pin. Retain Flywheel with bolts and locking.

Flywheel Tightening Torque = 43-51 ft.-lbs. (6-7 m-kp)

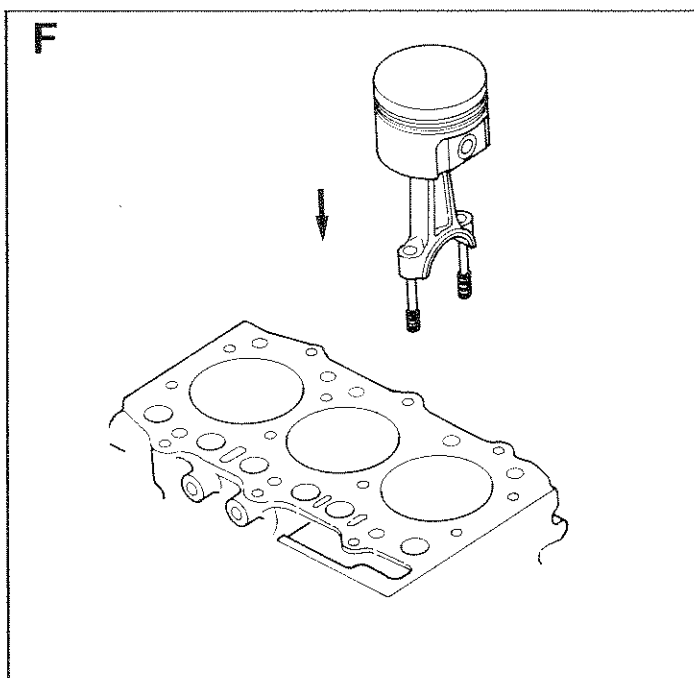


2.4.3- Piston and Connecting Rod

F Coat parts with clean engine oil. Move the piston rings to provide plenty of oil in the ring grooves. Set ring gaps 90° apart from each other. However, do not place the gaps toward the piston pin or at right angles to the piston pin. Use a ring compressor to compress the rings around the piston. Face the alignment mark on the connecting rod toward the injection pump. Install the parts starting at the front and moving toward the rear. Tighten the connecting rod caps to their specified torque. Check the play in the direction of the crankshaft.

Tighten connecting rod caps to 22-25ft.-lbs. (3.0-3.5 m-kp).

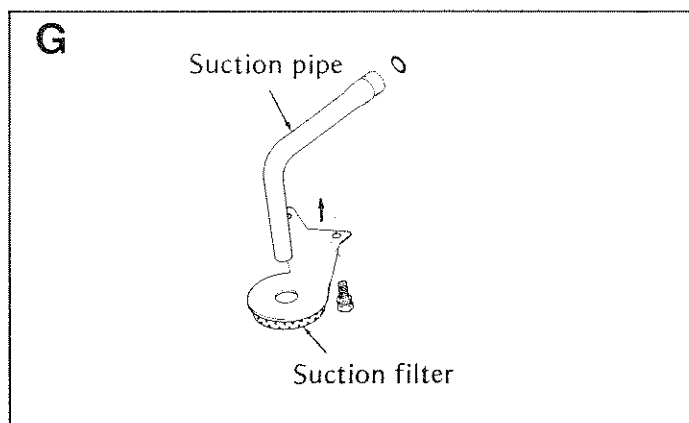
After installation, check that the crankshaft moves about 0.004-0.012 inch (0.1-0.3mm).



2.4.4- Suction Pipe and Filter

G Install an o-ring onto the suction pipe. Install the pipe into the cylinder block. Install the suction filter.

Suction filter torque = 7-9 ft.-lbs. (0.9-1.3 m-kp).

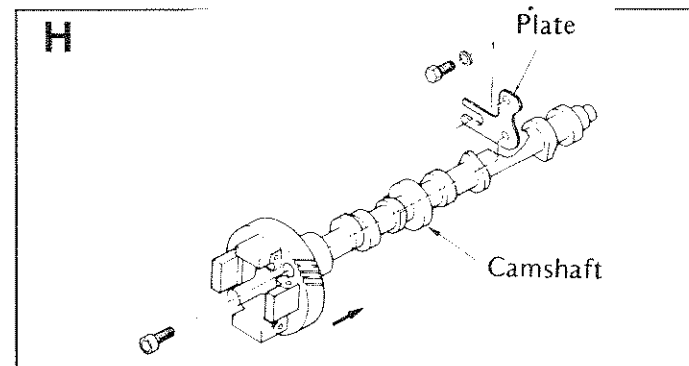


2.4.5- Oil Pan

Tighten Oil Pan bolts evenly and in diagonal increments. Install the Front Plate.

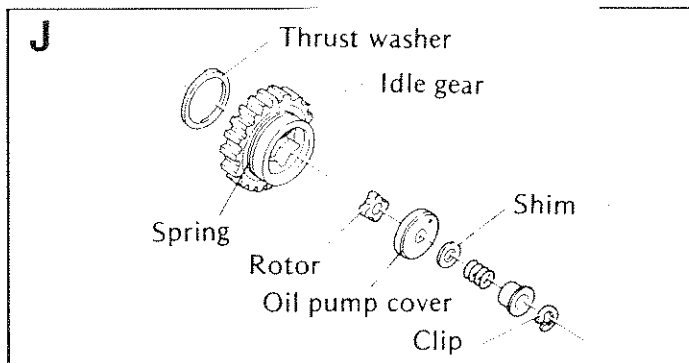
2.4.6- Camshaft Assembly

H Install the camshaft assembly and plate. Plate tightening torque is 7-9 ft.-lbs. (0.9-1.3 m-kp).

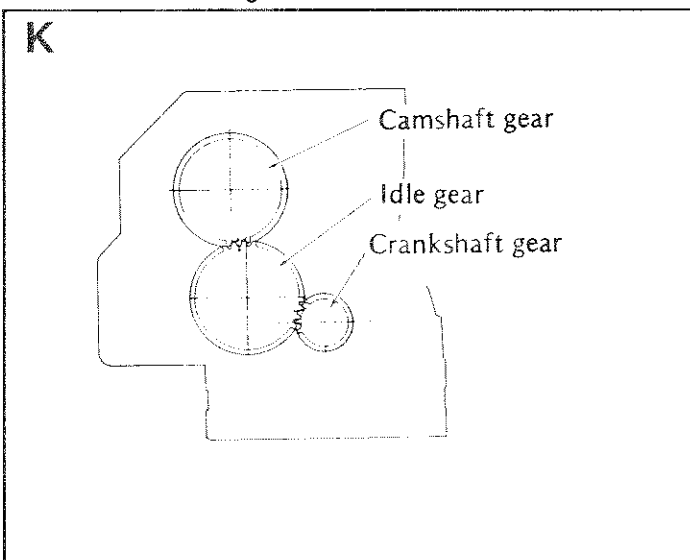


2.4.7- Idler Gear and Oil Pump

J Install Thrust Washer onto Idler Gear shaft. Assemble vane, knock pin and spring to the Idler Gear.



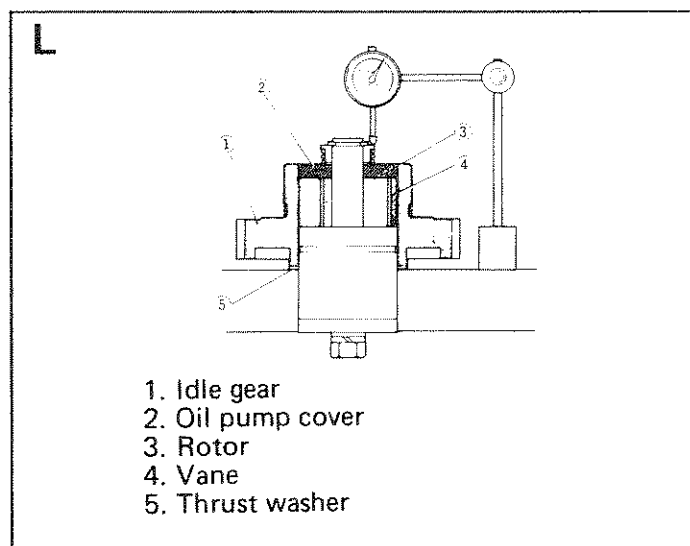
K Align the timing marks of the Idler Gear, Crankshaft Gear and camshaft gear.



L Install the Oil Pump Rotor. Install the Oil Pump cover, shim, spring and collar. Retain with a snap ring. Adjust with shim so that side clearance between pump, rotor and vane is 0.004-0.006 inch (0.1-0.15mm).

IMPORTANT: Coat both faces of the rotor and vane with grease prior to assembly. DO NOT ROTATE CRANKSHAFT UNTIL THE TIMING GEAR CASE IS MOUNTED.

Rotate the oil pump cover to place the spring pin insert hole in the center position. Then, assemble the Gear Case.

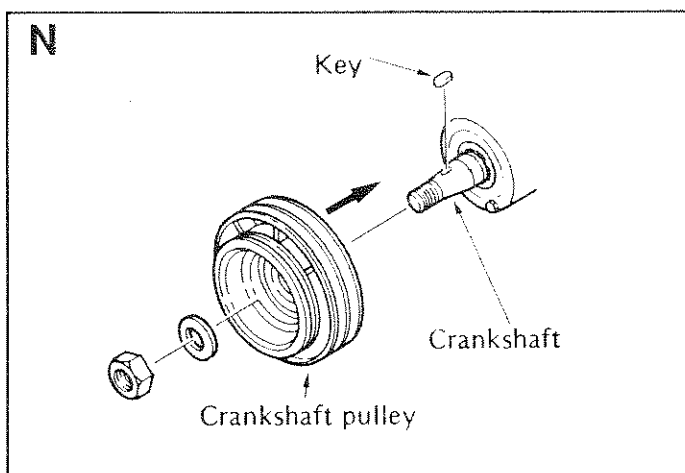
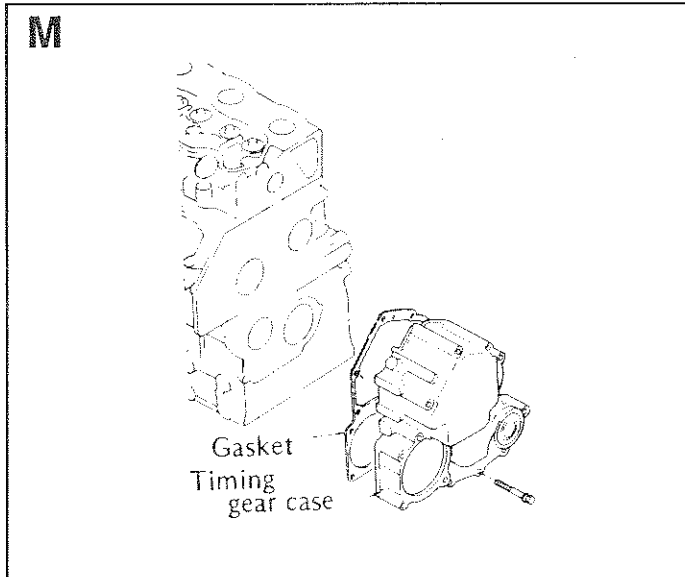


2.4.8- Timing Gear Case

M Install the start spring. Install the link to cylinder block hole. Install the gasket and the timing gear case.

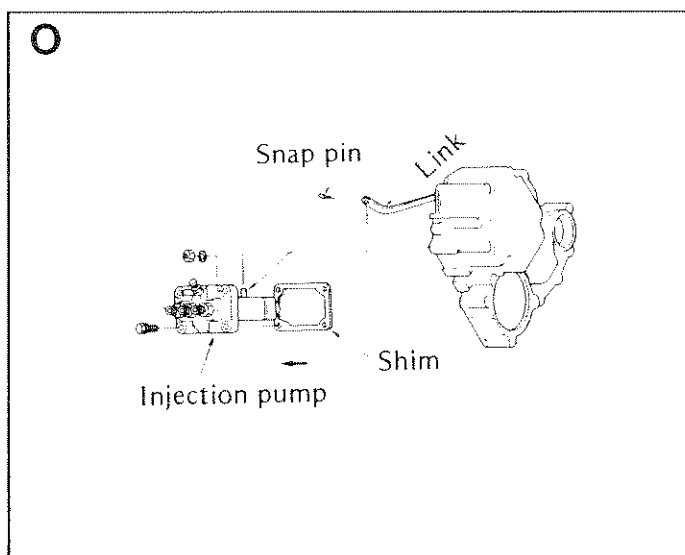
2.4.9- Crankshaft Pulley

N Align pulley with key and install. Tighten to 72-80 ft.-lbs. (10-11 m-kg).



2.4.10- Injection Pump Assembly

O Install the Injection Pump, using the same shims that were removed during disassembly. Connect control rack of pump with link and retain with snap pin. Retain pump with bolts and nuts.



2.4.11- Adjust Fuel Injection Timing

P When the same injection pump is reinstalled, always use the same shims that were removed. If a new injection pump, camshaft or cylinder block is used, adjust injection timing as follows:

1. Install the injection pump, using a shim that is 0.5mm (0.020 inch) thick.
2. Remove the delivery valve holder at the front of the injection pump.
3. Remove the delivery valve (IN). Reinstall the spring and delivery valve holder.

IMPORTANT: When reassembling the delivery holder, adjust the location of the delivery valve (OUT) to its proper position using a wire.

4. Move the governor control lever to its FULL INCREASE position, to deliver fuel with No. 1 piston at around 25° BTDC of its compression stroke. Fuel will flow from the delivery holder at this time.

5. Slowly turn the crankshaft clockwise until fuel stops coming from the delivery holder. Check the piston position at this point.

If the piston position is LATER than 16.5° BTDC, use a thinner shim.

If the piston position is earlier than 17.5° BTDC, use a thicker shim.

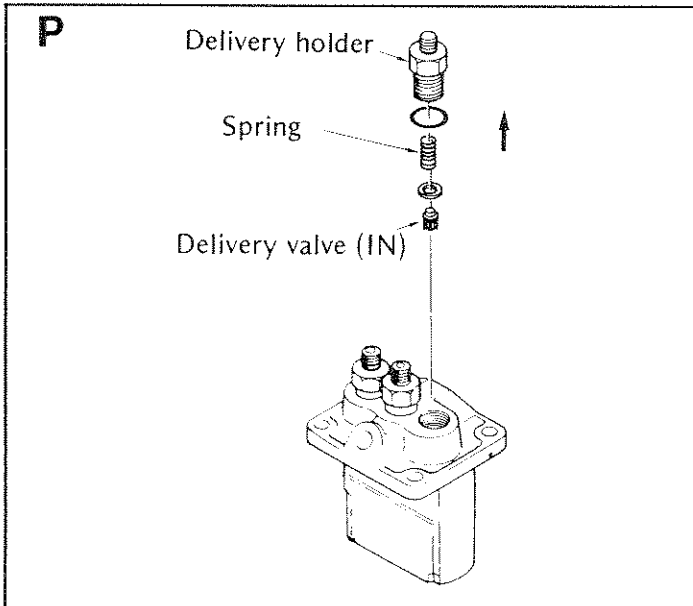
Injection Timing in ° BTDC: 16.5° to 17.5° BTDC

Piston Position: 0.077-0.086 inch (1.95-2.19mm) BTDC

IMPORTANT: When a shim is not required, use liquid packing to assemble the injection pump.

6. Assemble the delivery valve (IN). Delivery holder tightening torque is 29-33 ft.-lbs. (4.0-4.5 m-kg).

Injection Timing Adjusting Shims are available in the following thicknesses:- 0.2mm- 0.3mm- 0.5mm- 1.0mm.



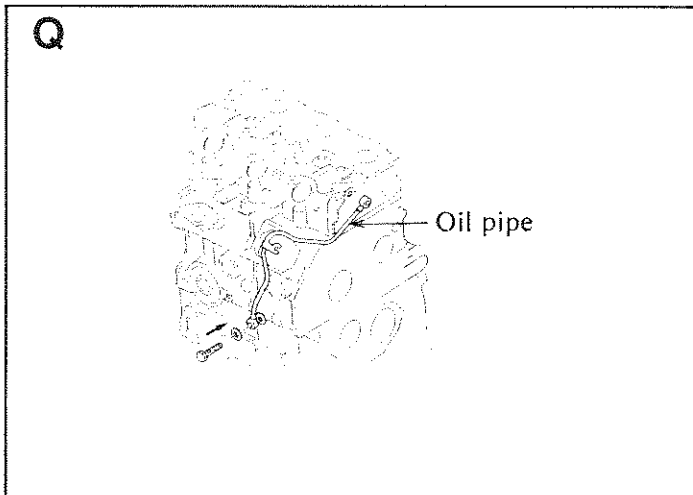
2.4.12- Oil Filter, Oil Pipe, Feed Pump and Tappets

Coat oil filter mounting face with light film of oil and install. Tighten by hand.

Install the feed pump assembly, using two bolts.

Coat tappets with oil and assemble.

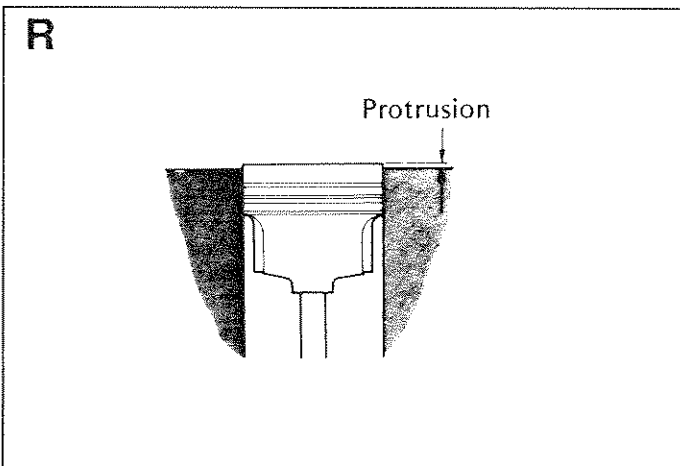
Q Install the Oil Pipe. Eyebolt tightening torque is 7-9 ft.-lbs. (1.0-1.3 m-kg).



2.4.13- Cylinder Head Assembly

R Set pistons at top dead center (TDC) one at a time. With each piston at TDC, measure their protrusion above the cylinder block with a depth gauge or a dial indicator. Measure the protrusion of all 3 pistons. Use the largest protrusion as a reference. Select the correct cylinder head gasket based on the largest protrusion.

PROTRUSION	GASKET PART NO.	GASKET THICKNESS
0.018-0.021 inch (0.45-0.55mm)		1.1mm
0.022-0.026 inch (0.55-0.65mm)	810205	1.2mm
0.026-0.029 inch (0.65-0.75mm)	810206	1.3mm

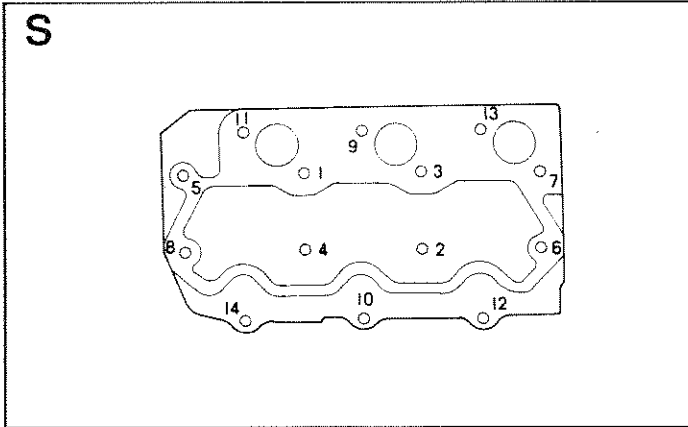


Install the Glow Plugs.

NOTE: The thickness of the head gasket, when tightened, is stamped at top of gasket (as .1, .2, .3).

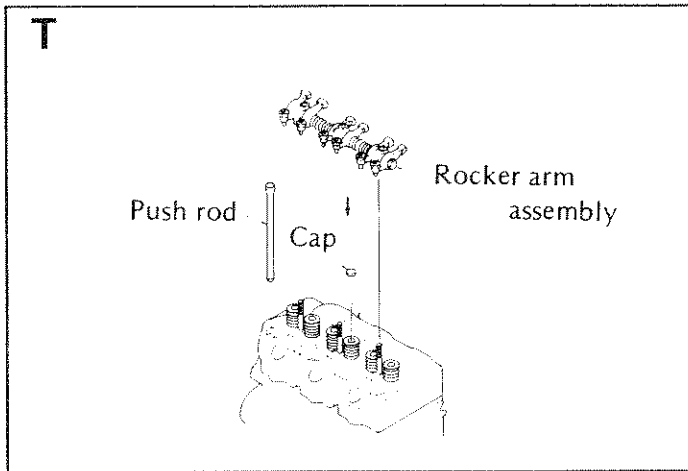
S Tighten the cylinder head bolts in 3 phases and in the sequence shown in the illustration. Alignment pins are provided for proper positioning. Coat all bolt threads with molybdenum disulphide base grease.

Cylinder Head final tightening torque = 33-36 ft.-lbs. (4.5 to 5.0 m-kg)



T Install caps on ends of valve stems. Install the push rods and rocker arm assembly.

Rocker Arm Assembly Tightening Torque=15-18 ft.-lbs. (2.0-2.5 m-kg).

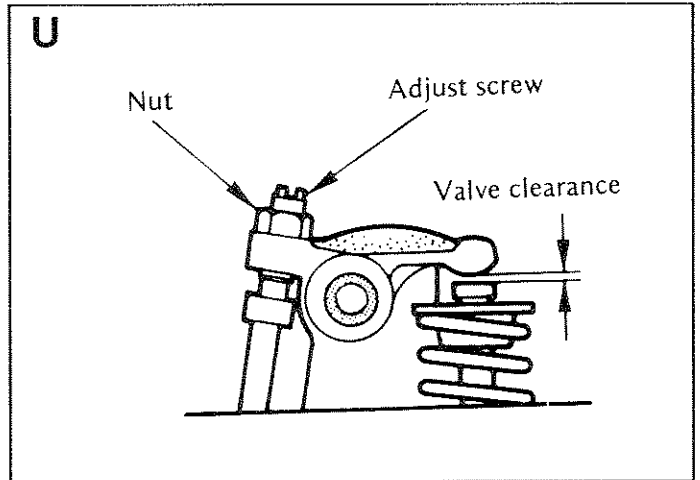


2.4.14- Valve Clearance Adjustment

U Loosen the nut and adjust intake and exhaust valve clearance to 0.008 inch (0.2mm) by turning the adjust screw. Use the following procedure:

1. Adjust with engine cold.
2. Set No. 1 piston at top dead center (TDC), then adjust No. 1 cylinder intake/exhaust valves and the exhaust valve of No. 2 cylinder.
3. Turn the crankshaft 240° counterclockwise (as viewed from the front).

4. Adjust No. 2 cylinder intake valve and No. 3 cylinder intake and exhaust valves.

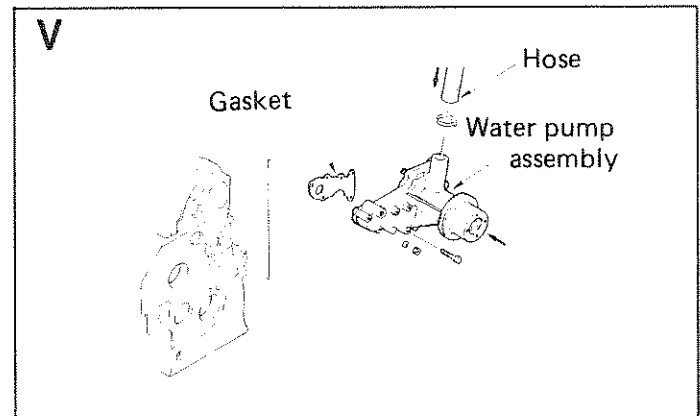


2.4.15- Cylinder Head Cover

Install cover gasket and cover. Tighten cylinder head cover evenly to 6-8 ft.-lbs. (0.8-1.2 m-kg).

2.4.16- Water Pump Assembly

V Install water pump assembly, gasket and hose.



2.4.17- Nozzles and Nozzle Holders

Install caps and gaskets. Install nozzle holders, tighten to 58-61 ft.-lbs. (8.0-8.5 m-kg). Finally, install the return pipe, and injection pipes. Injection pipe tightening torque is 18-22 ft.-lbs. (2.5-3.0 m-kg).

2.4.19- Complete the Assembly

Install remaining engine components.

ENGINE LUBRICATION & COOLING SYSTEM

Section 3.1 - ENGINE LUBRICATION SYSTEM

- 3.1.1- Oil Pump Removal
- 3.1.2- Oil Pump Inspection and Reassembly
- 3.1.3- Idle Gear and Oil Pump Assembly
- 3.1.4- Oil Filter
- 3.1.5- Automatic Low Oil Pressure Shutdown

Section 3.2- WATER PUMP AND THERMOSTAT

- 3.2.1- Water Pump Removal
- 3.2.2- Water Pump Disassembly
- 3.2.3- Water Pump Reassembly
- 3.2.4- Thermostat Testing

Section 3.3- HEAT EXCHANGER AND EXHAUST OUTLET

- 3.3.1- General
- 3.3.2- Radiator Cap
- 3.3.3- Zinc Anode

Section 3.4- THE SEA WATER SYSTEM

- 3.4.1- Description
- 3.4.2- Sea Water System Rules
- 3.4.3- Sea Water Pump Specifications

Section 3.5 - COOLING SYSTEM PERIODIC MAINTENANCE

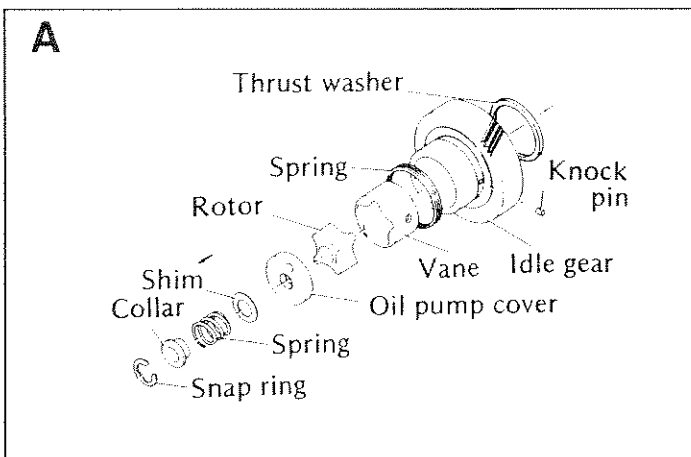
- 3.5.1- Sea Water Pump Operation
- 3.5.2- Freezing Temperature Operation
- 3.5.3- Recommended Coolant Mixture
- 3.5.4- Checking Captive Coolant Level

Heat Exchanger and Exhaust Outlet	Page 5
Cooling Circuit	Page 6
Exploded View of Sea Water Pump	Page 8
Sectional View of Sea Water Pump	Page 9

SECTION 3.1 - ENGINE LUBRICATION SYSTEM

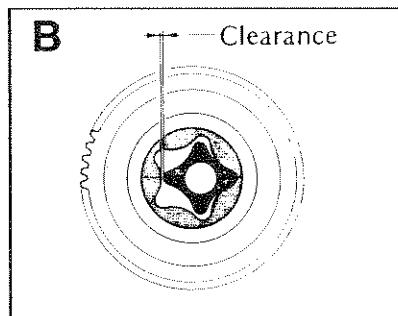
3.1.1- Oil Pump Removal

A Remove the snap ring. Remove the collar, spring and shim. Remove the idle gear, vane and oil pump as a unit. Remove the rotor and thrust washer. Remove the oil pump cover. Remove spring from idle gear. Remove vane.



3.1.2- Oil Pump Inspection and Reassembly

B Inspect oil pump cover, rotor and vane for wear. Replace, if worn or damaged. Check the clearance between rotor and vane. If clearance is excessive, replace worn part(s). Reassemble oil pump in the reverse order of disassembly. Be sure to align the marks on the crankshaft gear and the idle gear during assembly. Also, adjust the side clearance between the rotor and vane to 0.1-0.15mm (see Paragraph 3.1.3).

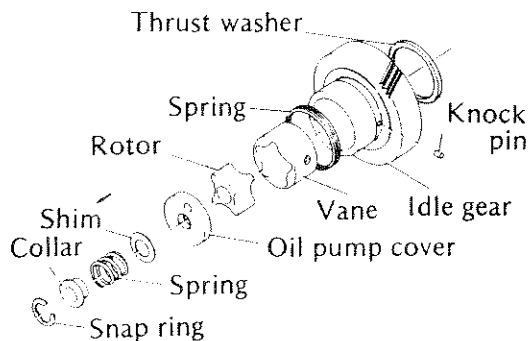


3.1.3- Idle Gear and Oil Pump Assembly

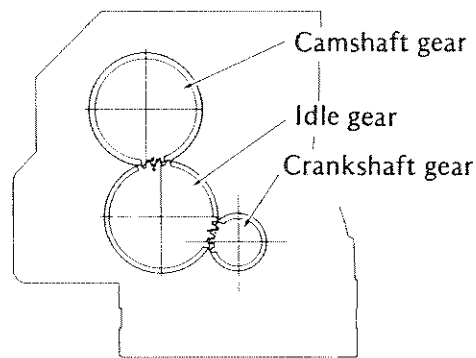
C Install thrust washer onto idle gear shaft. Assemble the vane, knock pin and spring to the idle gear.

D Align the aligning marks on idle gear, crankshaft gear and camshaft gear. Then, assemble to the idle gear shaft. Install the rotor. Install the pump cover, shim, spring and collar. Retain with snap ring. Coat both sides of rotor and vane with grease before assembly. **DO NOT TURN CRANKSHAFT UNTIL TIMING GEAR CASE IS INSTALLED.**

C



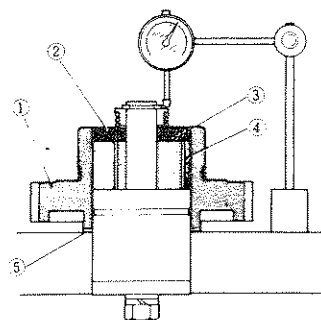
D



E Use shim to adjust side clearance between pump, rotor and vane to 0.004-0.006 inch (0.1-0.15mm).

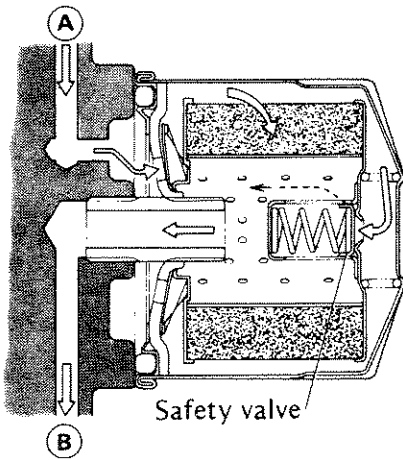
E

1. Idle gear
2. Oil pump cover
3. Rotor
4. Vane
5. Thrust washer



3.1.4- Oil Filter

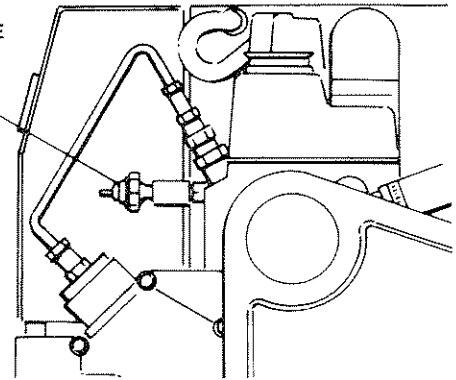
F The oil filter is a cartridge type. If the filter clogs, a SAFETY VALVE will open to permit oil to bypass the filter and flow to all parts of the engine. Oil enters the filter at "A", flows through the filter, and exits at "B". Replace oil filter every 200 hours of operation.

F

To test the oil pressure shutdown feature, start engine and let it run at no-load (electrical loads disconnected). Remove wire from switch terminal. Hold wire against a clean frame ground. Engine should shut down.

G

LOW OIL
PRESSURE
SWITCH



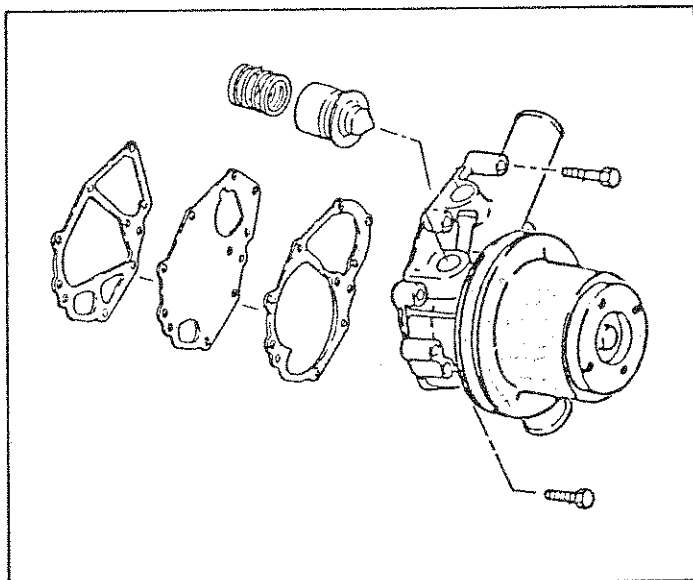
3.1.5- Automatic Low Oil Pressure Shutdown

G Should engine oil pressure drop below approximately 15 psi, an engine shutdown will occur. The oil pressure switch senses oil pressure in the engine's main oil gallery. The switch is normally-closed (N.C.), is held open by engine oil pressure during startup and operation.

SECTION 3.2 WATER PUMP AND THERMOSTAT

3.2.1 Water Pump Removal

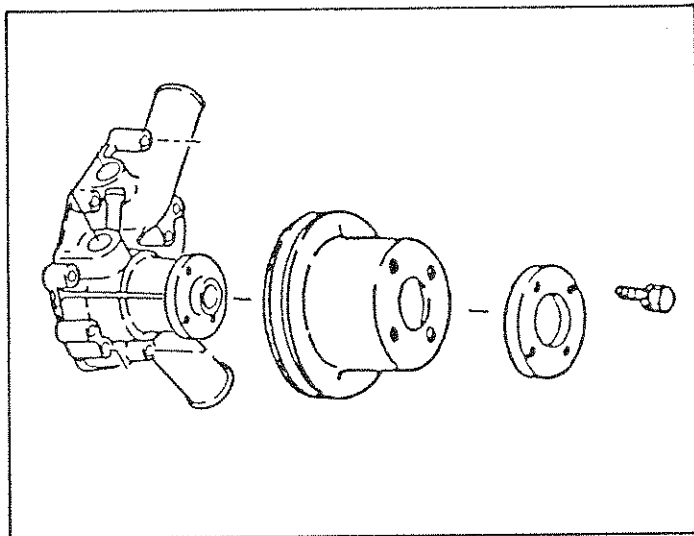
A Remove water pump bolts, nut, water pump and gaskets, thermostat and spring.



B The water pump is a non-repairable unit and must be replaced as a unit if defective.

3.2.2 Water Pump Disassembly

C Remove pulley retaining bolts, washer and pulley and retain for installation onto the new pump.



3.2.3 Water Pump Assembly

D Install pulley and washer onto new water pump. Secure pulley with mounting bolts.

3.2.4 Thermostat Testing

E Place thermostat in water. Raise the water temperature. Thermostat starts to open at 157 to 163F (69.5-72.5c). Fully open at 185F (85c) Valve lift at 185F (85c) should be 0.315 in. (8.0mm).

PART 4

**FUEL
SYSTEM**

Section 4.1 - FUEL SYSTEM

4.1.1- General

4.1.2- Fuel Recommendations

4.1.3- Fuel System Components

Section 4.2 - FUEL PUMP

4.2.1- General

4.2.2- Fuel Pump Testing

Section 4.3 - GOVERNOR

4.3.1- General

4.3.2- Governor Adjustment

Section 4.4- INJECTION PUMP

4.4.1- Removal, Replacement

Section 4.5 - NOZZLES AND HOLDERS

4.5.1- General

4.5.2- Specifications

4.5.3- Check Injection Pressure

Timing Gear Case and Governor... Page 4
Injection Pump Assembly..... Page 5
Injector Assembly..... Page 7
Injector Pump and Injectors Page 8

SECTION 4.1 - FUEL SYSTEM

4.1.1- General

A diesel engine does not require an electrical ignition system or spark plugs. The diesel fuel is ignited by the extremely high pressures present in the combustion chambers during the compression stroke. The compression ratio of this engine is rated at 23 to 1, to provide a cylinder compression pressure of nearly 340 psi.

4.1.2- Fuel Recommendations

Diesel fuels are less volatile than gasoline and, for that reason, are considered safer than gasoline. Because diesel fuels are relatively safe, careless practices often result which can lead to serious problems with marine generator performance and reliability. To maintain the generator in good working order, comply with the following:

- * **Recommended Fuel:** Use CLEAN, FRESH, No. 2D diesel fuel having a cetane number of at least 40. Where the vessel is equipped with a diesel engine, that engine's fuel tank may also supply fuel to the marine generator.

- * **Keep Diesel Fuel Clean:** Dirt or water in the fuel system is the major cause of diesel engine, injection pump or injection nozzle failure.

- * **Do Not Alter the Installation:** When installed, the diesel fuel system was in full compliance with applicable codes, standards and regulations. Do not make any changes that might render the system unsafe or in non-compliance with such codes, standards and regulations.

- * **Check for Leaks Periodically:** Fuel lines must not leak and fittings must be kept tight. An improperly tightened fuel line may show no evidence of leakage, but may permit air to be drawn into the system. Any air that is drawn into the system will cause hard starting and rough engine operation.

NOTE: The diesel fuel system is self-bleeding and should never require hand priming or bleeding.

4.1.3- Fuel System Components

A During engine operation, fuel is pumped from the FUEL TANK, through a 12 volts d-c electric FUEL PUMP, through a FUEL FILTER, the INJECTION PUMP, INJECTION NOZZLES, and into the combustion chambers.

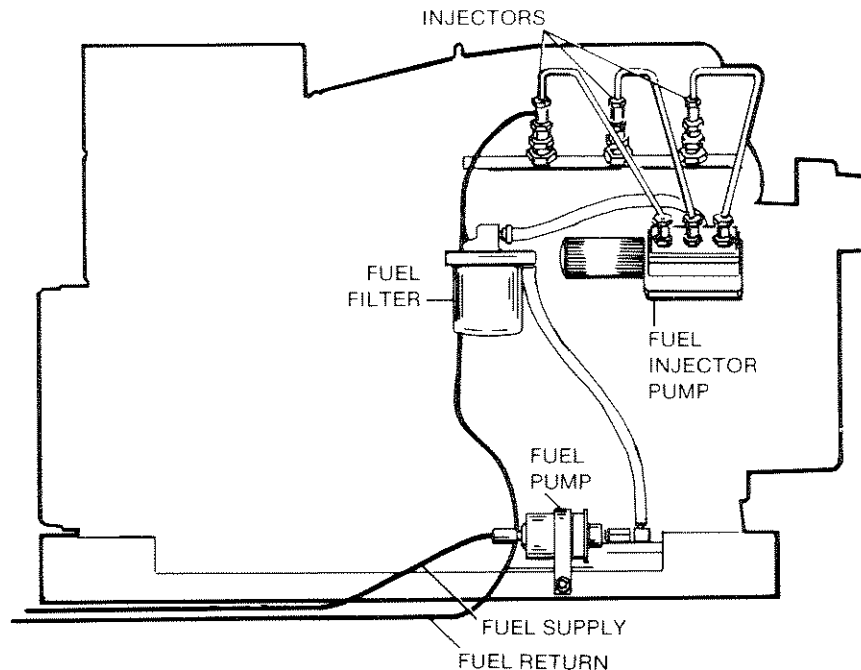
The Injection Pump must be properly timed, to deliver the required amount of fuel to each cylinder at the precise moment the fuel is required. Firing order of the engine cylinders is 1-2-3. Fuel injection is set to occur at 20°-21° BTDC.

Injection pressure is approximately 1707 psi (11,769 kPa).

Electric fuel pump lift is approximately 9-10 feet (200mm of Hg).

Excess fuel from the system is returned to the Fuel Tank, via one or more return lines.

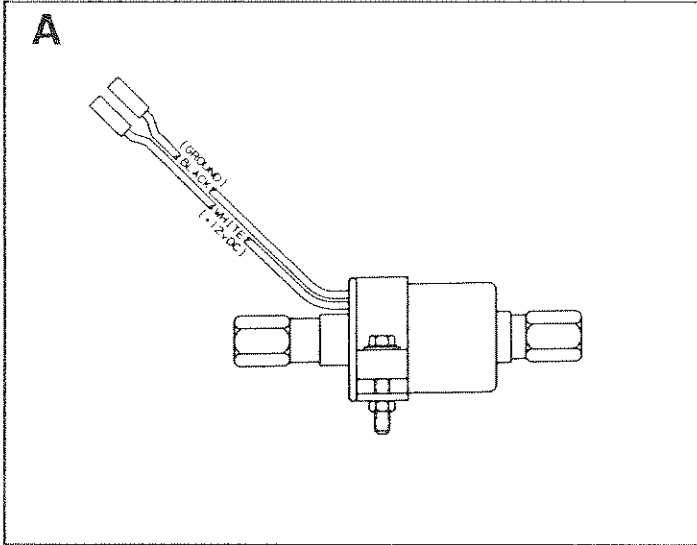
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SECTION 4.2 - FUEL PUMP

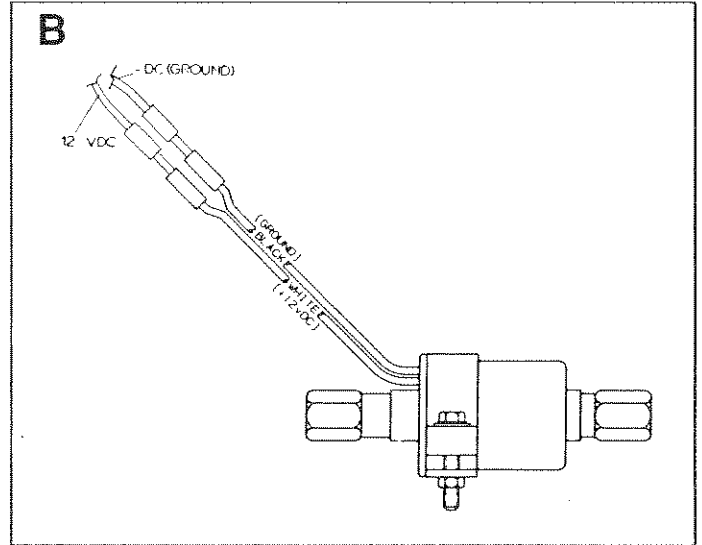
4.2.1- General

A The 12 volts d-c electric Fuel Pump is activated by action of an Engine Control circuit board during startup and operation. Power for pump operation is supplied via Wire #14, which is electrically hot only during engine running condition. Wire #14 also delivers power to a Fuel Solenoid (FS), which then opens to supply fuel to the Injection Pump. A Pre-Heat Contactor is also energized, to energize the engine combustion chamber Glow Plugs and pre-heat the combustion chambers.



4.2.2- Fuel Pump Testing

B An ohmmeter may be used to test Pump windings for continuity. To perform an operational test, disconnect outlet line from the pump and connect inlet line to a fuel supply. Connect a +12 volts d-c power supply to the WHITE Fuel Pump wire, a negative (-) 12 volts d-c power source to the BLACK wire. Pump should operate and pump fuel, if not replace the Pump.



SECTION 4.3 - GOVERNOR

4.3.1- General

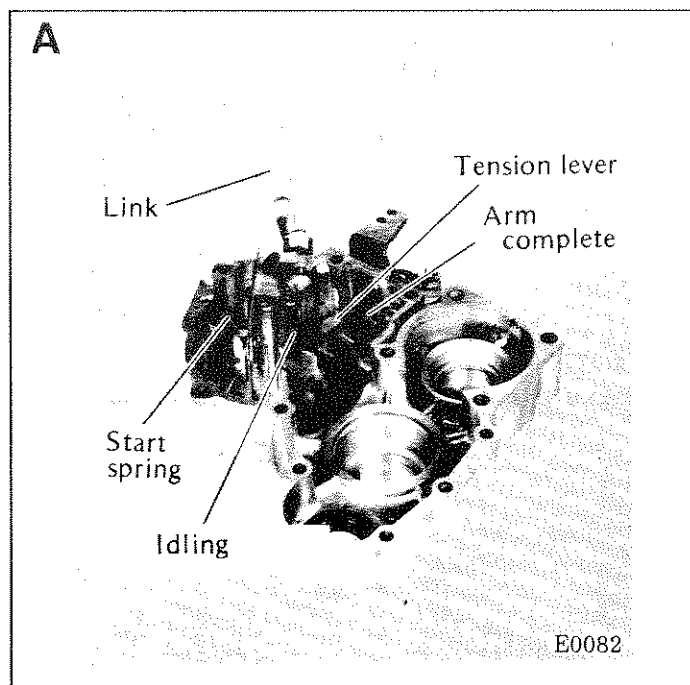
The governor is a mechanical, fixed speed type. It is housed in the engine Gear Case.

A A flyweight assembly is mounted on the camshaft. Flyweight movement is transmitted to the injection pump control rack by means of a slider, control lever, and LINK. A spring, connected to the ARM COMPLETE and to the TENSION LEVER, regulates flyweight movement. Governed speed is regulated by changing the angle of the governor lever, which changes the spring tension.

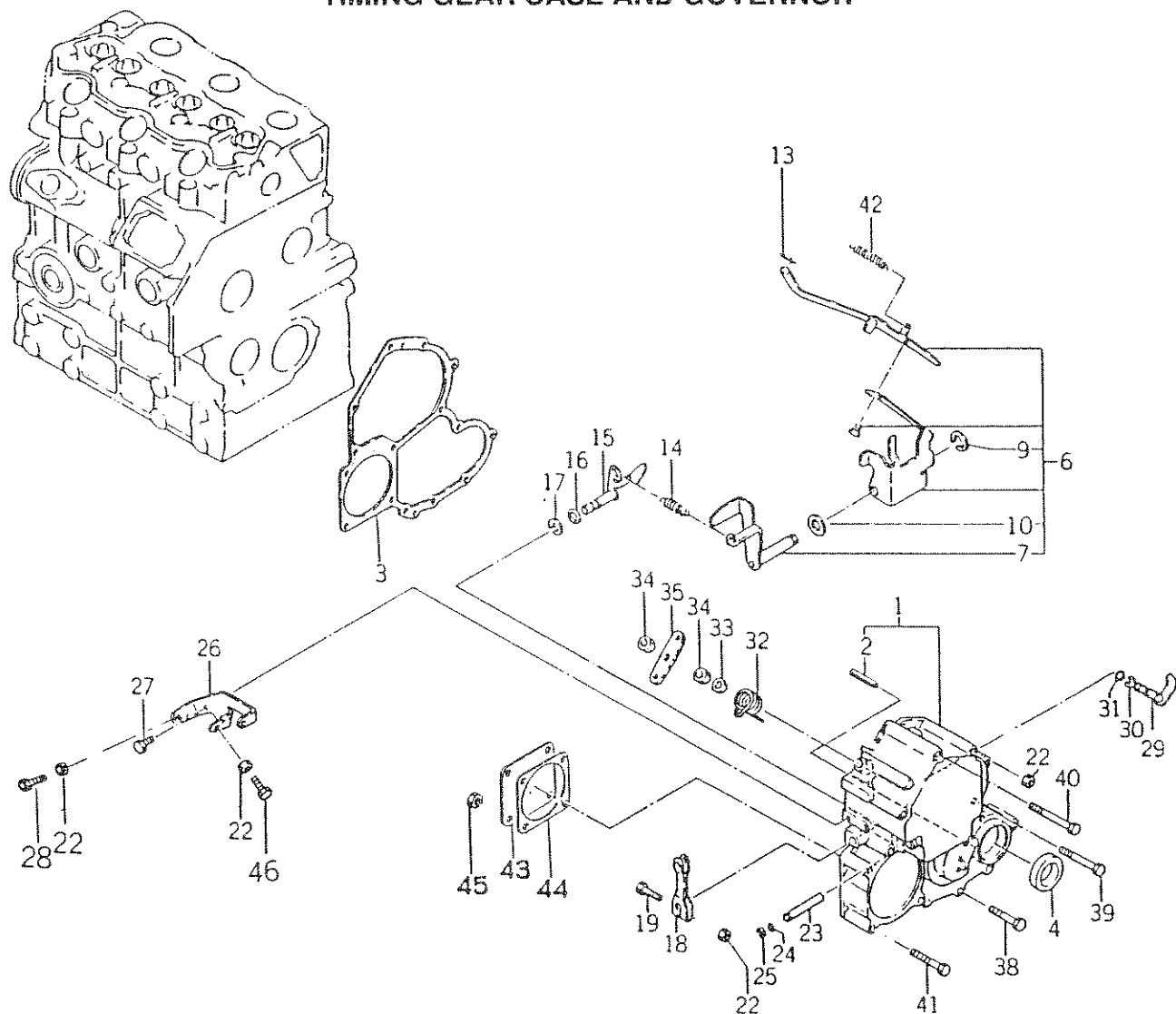
A START SPRING is placed between the gear case and LINK. The START SPRING functions to increase the amount of injected fuel during startup. An IDLING spring in the gear case stabilizes idle speed.

4.3.2- Governor Adjustment

Refer to Section 1.5, ADJUSTMENTS.



TIMING GEAR CASE AND GOVERNOR



ITEM	DESCRIPTION	QTY
1	TIMING GEAR CASE- COMPLETE	1
2	SPRING PIN	1
3	GASKET	1
4	OIL SEAL	1
6	GOVERNOR LEVER ASSY	1
7	TENSION LEVER ASSY	1
9	SNAP RING	1
10	WASHER	1
13	SNAP PIN	1
14	SPRING	1
15	ARM- COMPLETE	1
16	O-RING	1
17	SNAP RING	1
18	GOVERNOR LEVER	1
19	BOLT	1
22	NUT	4

ITEM	DESCRIPTION	QTY
23	SHAFT	1
24	O-RING	1
25	SNAP RING	1
26	STAY	1
27	BOLT	3
28	BOLT	2
29	ARM- COMPLETE	1
30	SNAP RING	1
31	O-RING	1
32	SPRING	1
33	WASHER	1
34	NUT	2
35	STOP LEVER	1
40	BOLT	5
41	BOLT	4
42	START SPRING	1
43	COVER	1
44	GASKET	1
45	NUT	4

SECTION 4.4 - INJECTION PUMP

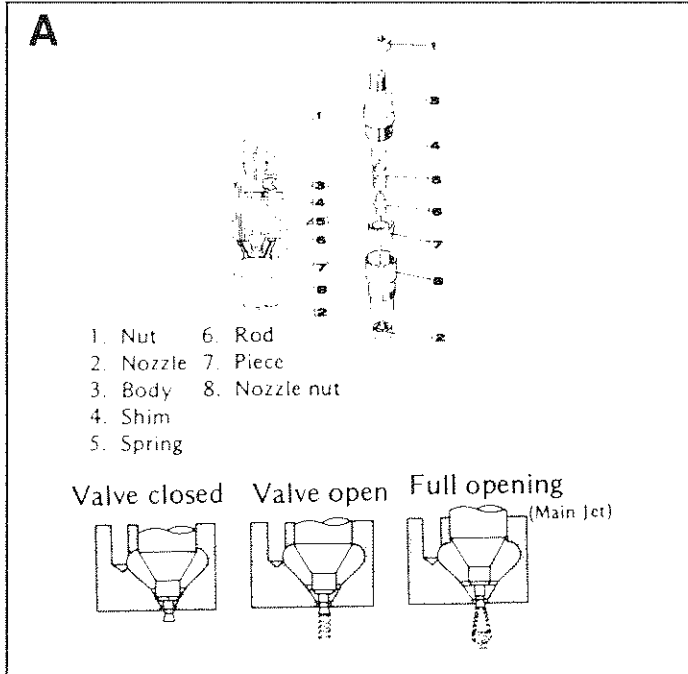
4.4.1- Removal, Replacement

If a failure of the injection pump should occur, remove and replace the entire assembly. The injection pump should be disassembled only by a fuel injection pump repair facility.

SECTION 4.5 - NOZZLES AND HOLDERS

4.5.1- General

A Fuel, supplied from the Injection Pump, is delivered to the nozzle HOLDER and to the nozzle BODY. When fuel pressure is sufficient to compress the SPRING, fuel is sprayed from the NOZZLE into the engine combustion chamber.



4.5.2- Specifications

Needle Valve Diameter0.236 inch (6mm)
Pintle Diameter.....0.039 inch (1mm)
Valve Opening Pressure1636-1778 psi
(115-125 kg/cm²)
Adjusting Pressure1778-1849 psi
(125-130 kg/cm²)
Spraying Angle.....12°

4.5.3- Check Injection Pressure

Use a NOZZLE TESTER to check injection pressure. Adjust the pressure at which injection occurs by using shims, so that injection begins at 1707 psi (120 kg/cm²).

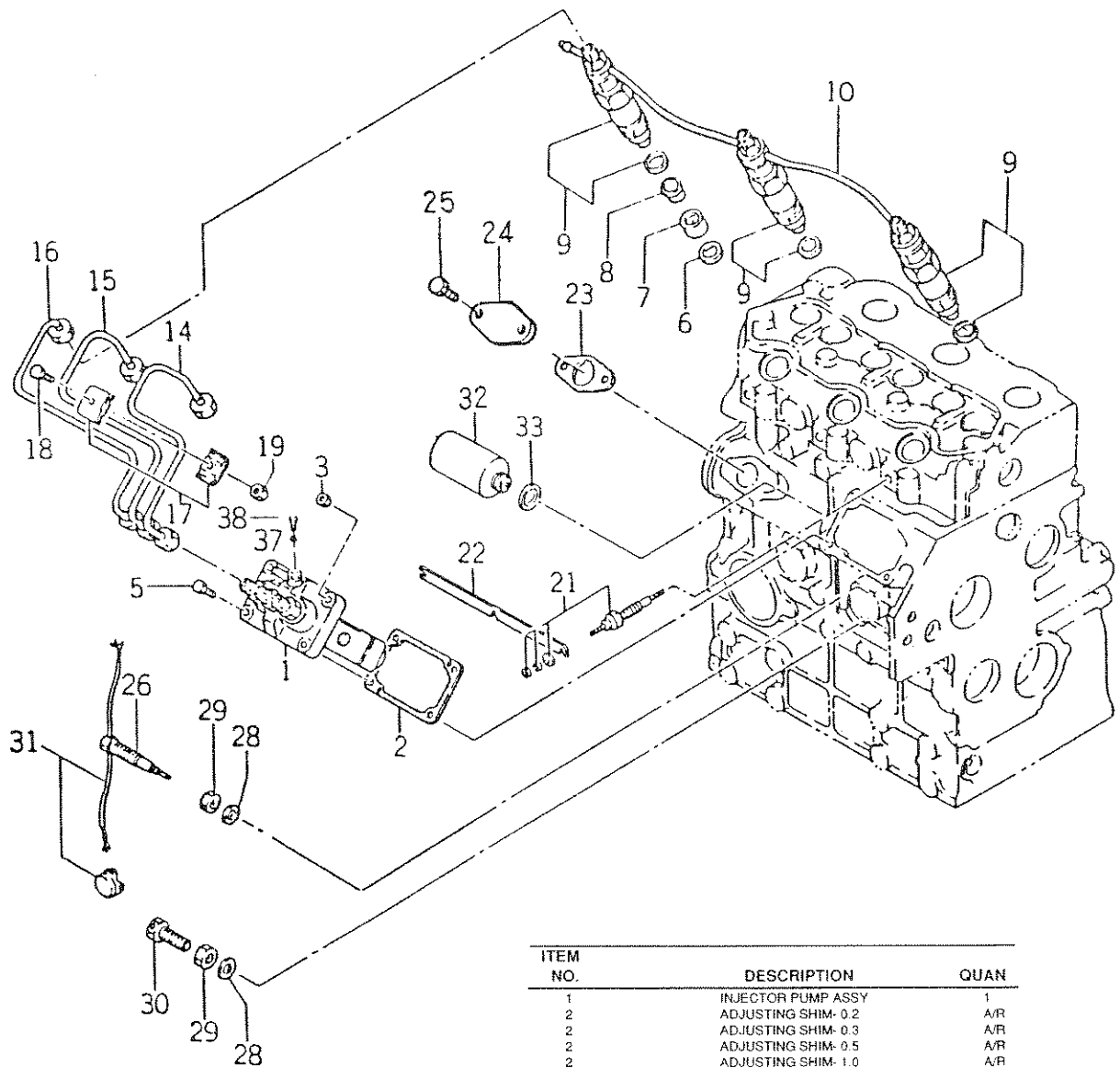
NOTE: Injection pressure increases or decreases about 142.23 psi (10 kg/cm²) for a shim 0.1mm thick.

Using the Nozzle Tester, check the spray pattern as follows:

1. There should be no fuel droplets in the spray.
2. The spray pattern should be of a conical shape, with respect to the nozzle axis.
3. When sprayed at a distance of 11-12 inches (30cm) from a sheet of white paper, spray pattern should be of a circular shape.

Use the Nozzle Tester to bring Nozzle pressure up to 1422 psi (100 kg/cm²). At that pressure, there should be no leakage from the Nozzle tip.

INJECTOR PUMP AND INJECTORS



ITEM NO.	DESCRIPTION	QUAN
1	INJECTOR PUMP ASSY	1
2	ADJUSTING SHIM- 0.2	A/R
2	ADJUSTING SHIM- 0.3	A/R
2	ADJUSTING SHIM- 0.5	A/R
2	ADJUSTING SHIM- 1.0	A/R
3	NUT	2
5	BOLT	2
6	GASKET	3
7	INSERT	3
8	CAP	3
9	INJECTOR ASSY	3
10	RETURN PIPE	1
14	INJECTION PIPE	1
15	INJECTION PIPE	1
16	INJECTION PIPE	1
17	CLAMP	4
18	BOLT	2
19	NUT	2
21	GLOW PLUG	3
22	CONNECTOR	1
23	GASKET	1
24	COVER	1
25	BOLT	2
26	SMOKE SET	1
28	SEAL WASHER	2
29	NUT	2
30	BOLT	1
31	LOCK WIRE	1
32	SOLENOID	1
33	SEAL WASHER	1
37	SEAL WASHER	1
838	SCREW	1

**ENGINE
ELECTRICAL
SYSTEM**

Section 5.1 - BATTERY CHARGE SYSTEM

- 5.1.1- Battery Charge System Components
- 5.1.2- The Alternator
- 5.1.3- Voltage Regulator

Section 5.2 - ENGINE CRANKING SYSTEM

- 5.2.1- Components
- 5.2.2- Operation
- 5.2.3- Battery Capacity Test
- 5.2.4- Starter Relay
- 5.2.5- Starter Motor Servicing

Section 5.3 - ENGINE PRE-HEAT CIRCUIT

- 5.3.1- Circuit Description
- 5.3.2- Glow Plug Construction
- 5.3.3- Glow Plug Testing

Section 5.4 - ENGINE SAFETY SHUTDOWN SYSTEM

- 5.4.1- General
- 5.4.2- Low Oil Pressure Switch
- 5.4.3- High Coolant Temperature Switch
- 5.4.4- High Exhaust Temperature Switch
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- 5.4.6- Testing the High Coolant and High Exhaust Temperature Switches
- 5.4.7- Overspeed Shutdown

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SECTION 5.1 - BATTERY CHARGE SYSTEM

5.1.1- Battery Charge System Components

A An a-c ALTERNATOR delivers a charging voltage to the battery during engine operation, as controlled by a d-c VOLTAGE REGULATOR. The circuit is protected against overload by a 30 amp FUSE. The ALTERNATOR delivers its a-c output to the REGULATOR, via Wires 48 and 49. The REGULATOR rectifies the alternating current and, based on a battery voltage signal from Wire 15 input, delivers a regulated battery charge output to the BATTERY, via Wire 13A, 30 amp FUSE, and Wire 13.

5.1.2- The Alternator

A belt driven, permanent magnet type alternator is used. Alternator maintenance is limited to the replacement of parts.

5.1.3- Voltage Regulator

B The solid state Voltage Regulator is housed in an aluminum heat sink. All parts are covered with an epoxy resin, making the unit non-repairable. Regulator connector pins are numbered from left to right, as follows:

Pin #1: Charging output to battery (12.5-14.5 volts d-c)

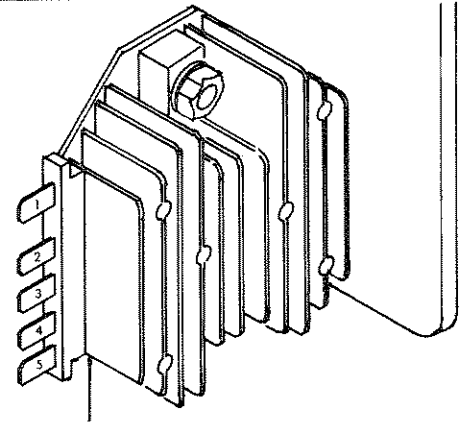
Pin #2: Wire 48, Input from Alternator

Pin #3: Wire 49, Input from Alternator

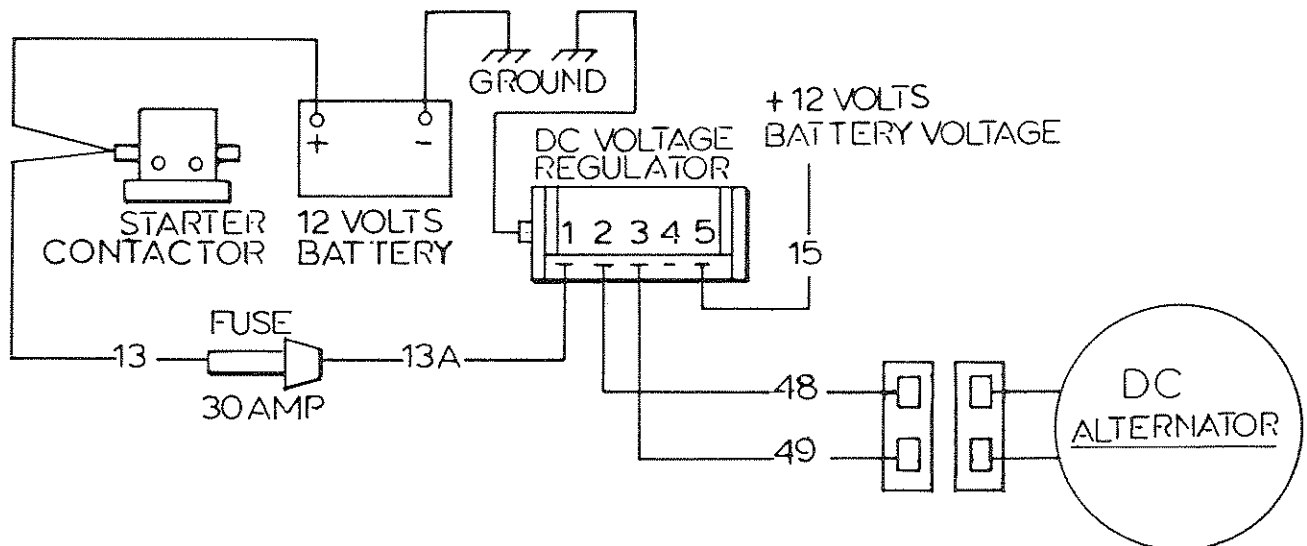
Pin #4: Not Used (Charge indicating light connection)

Pin #5: Wire 15, sensing input from battery

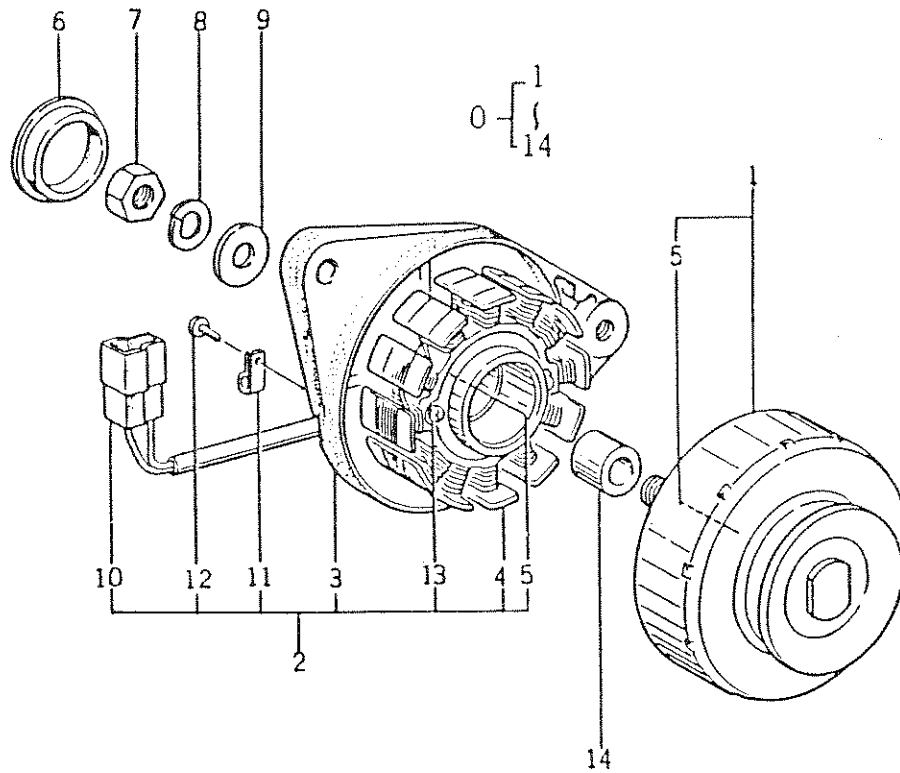
B



A



ALTERNATOR ASSEMBLY EXPLODED VIEW



ITEM NO.	DESCRIPTION	QUAN
---	ALTERNATOR ASSY	1
1	FLYWHEEL- COMPLETE	1
2	PLATE- COMPLETE	1
3	PLATE	1
4	STATOR- COMPLETE	1
5	BEARING	2
6	CAP	1
7	NUT	1
8	SPRING WASHER	1
9	WASHER	1
10	COUPLER	1
11	CLAMP	1
12	SCREW	1
13	SCREW	2
14	COLLAR	1

SECTION 5.2 - ENGINE CRANKING SYSTEM

5.2.1- Components

A The engine cranking system consists of the following major components:

1. Engine-Start/Stop Switch
2. Engine Controller circuit board
3. 10 amp Circuit Breaker
4. Starter Relay
5. Starter Assembly
6. 12 volts Battery
7. Interconnecting wires and battery cables

5.2.2- Operation

A When the Engine-Start/Stop switch is held at its START position, Wire 17 from the Engine Control circuit board is connected to frame ground. Circuit board action then delivers battery +d-c output (available to the circuit board via Wire 15) to the Starter Relay (SR), via Wire 56A. The Starter Relay energizes and +d-c voltage is delivered to the Starter Contactor (SC) via wire 56. The Starter Contactor energizes and Battery voltage is delivered to the Starter (S) from Wire 13. The engine cranks.

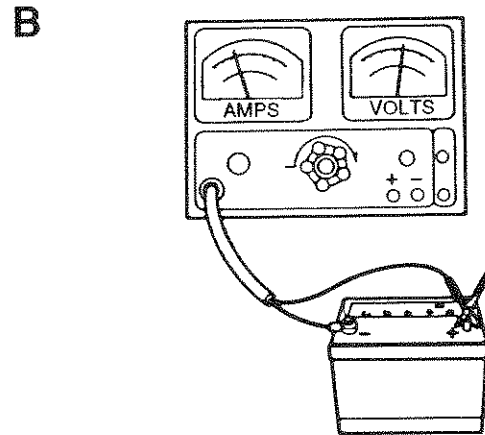
5.2.3- Battery Capacity Test

B To test the Battery, proceed as follows:

1. With Battery connected to tester as shown, turn the load knob until a current draw equal to 3 times the battery rating is selected. For example, if battery is rated 60 amp-hours, set the load to 180 amp draw.

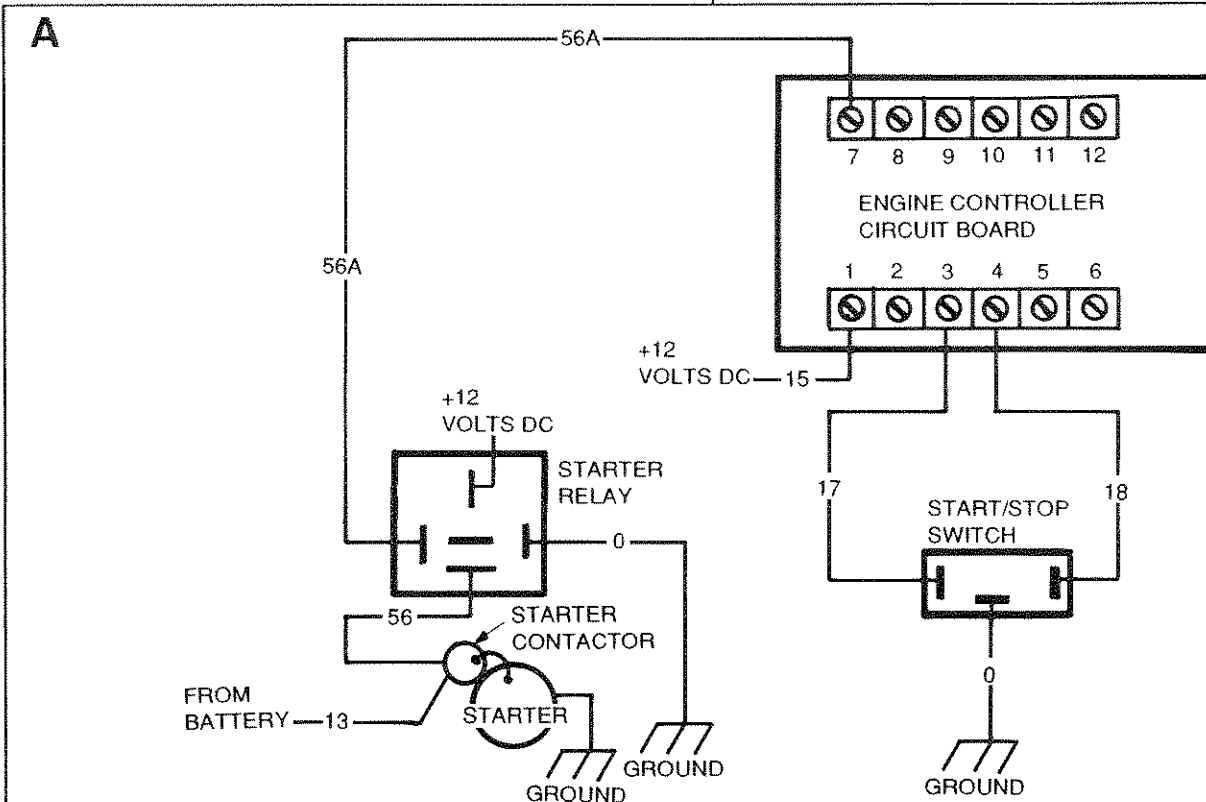
2. Hold the current draw for 15 seconds. Then, observe battery voltage. If voltage remains at 9.6 volts or more, battery is good. If battery voltage drops below 9.6, go to Step 3.

3. Connect the battery to a charger and set charger to its fast charge rate. DO NOT EXCEED 40 AMPS. After 3 minutes, check the voltmeter reading. If reading is more than 16.5 volts, replace the battery.



5.2.4- Starter Relay

C The Starter Relay (SR) is shown pictorially and schematically in the illustration.



5.2.5- Starter Motor Servicing

Rated Voltage: The Starter Motor is rated 12 volts d-c. Never apply more than the rated voltage or magnets may become demagnetized.

Inspection: Check for excessive wear on all bearings, gears, shafts, etc. Inspect shift lever assembly for wear or damage, replace with new shift lever kit if necessary.

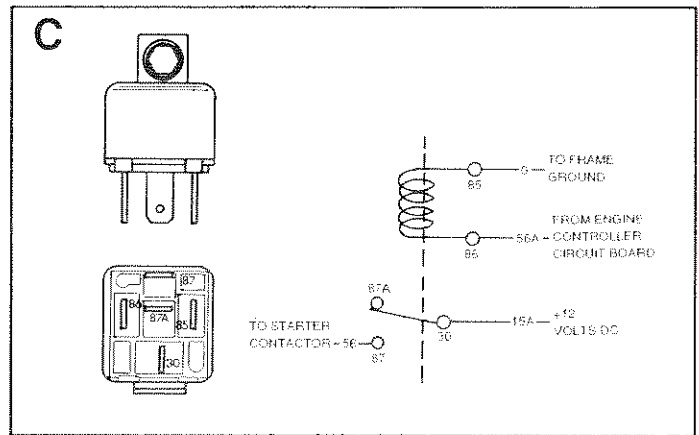
Thru-Bolts: Tighten Thru-Bolts to 75 inch-pounds.

Brushes and Brush Holder Assembly: Replace brushes and brush springs at each overhaul. Replace any brush that is worn excessively or that has been in contact with grease, oil or cleaning fluid. Make sure the brushes are riding properly on the armature when reassembling.

Armature: Check the armature for a ground, open or shorted condition with a growler. Apply a thin film of Quick-silver non-conducting grease to the commutator end of the armature shaft and to the portions of the shaft the contact the bearings.

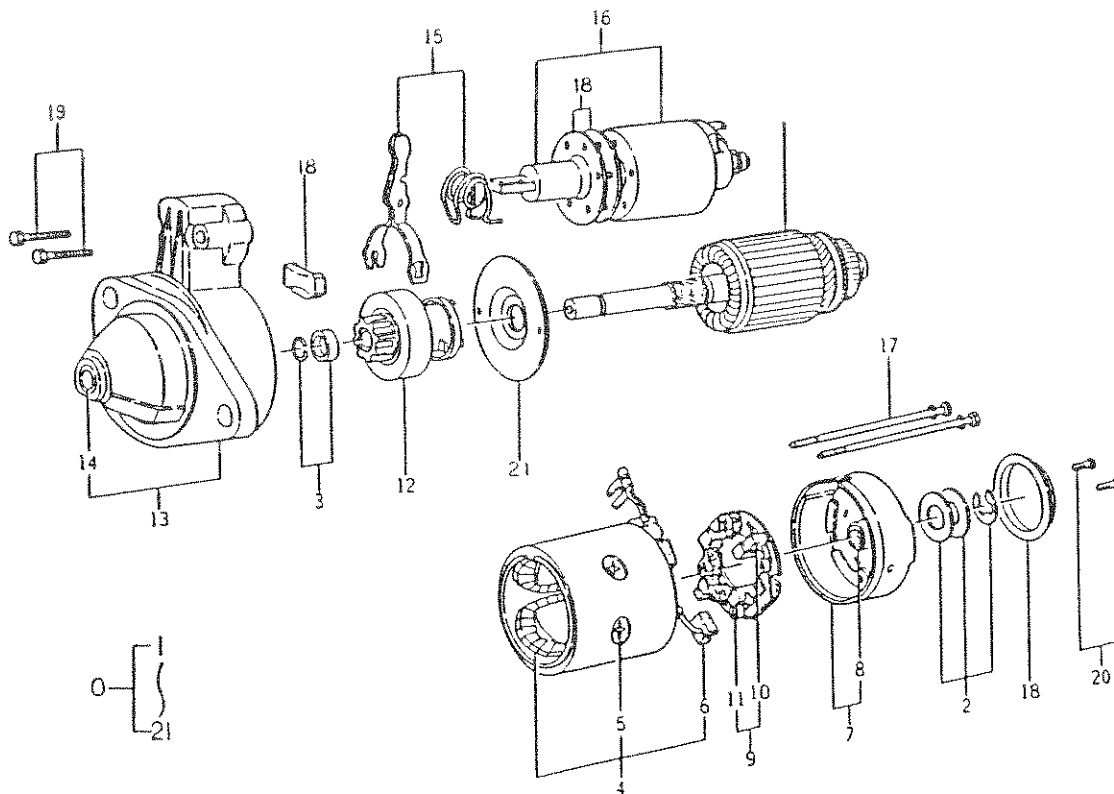
5.2.6- Starter Performance Test

Use a fully charged 12 volts battery to test the starter motor. DO NOT OPERATE THE STARTER CONTINUOUSLY FOR LONGER THAN 30 SECONDS.



Connect the positive (+) battery terminal to the starter solenoid input stud. Connect the negative (-) battery terminal to the Wire 56 terminal stud on starter solenoid. Use a No. 10 (or larger) cable, not over 6 feet long. Maximum current draw should be 17 amps at 6000-7200 rpm.

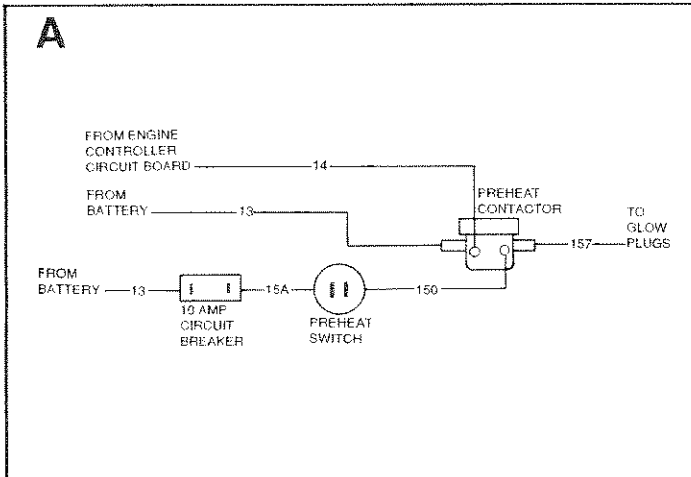
EXPLODED VIEW OF STARTER ASSEMBLY



SECTION 5.3 - ENGINE PRE-HEAT CIRCUIT

5.3.1- Circuit Description

A When the Pre-Heat Switch (SW1) is actuated, fused +d-c voltage is delivered to the Pre-Heat Contactor (PHC). The Contactor energizes and Battery voltage is delivered to the engine Glow Plugs. The glow plugs warm up their respective combustion chambers, to provide easier and quicker starts in cold weather.



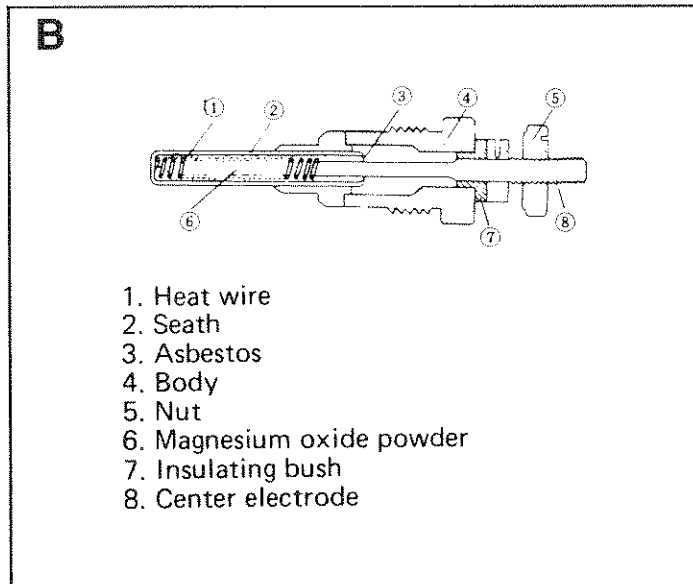
5.3.3- Glow Plug Testing

Glow Plugs are connected in parallel. For that reason, if one plug is open other Glow Plugs will continue to operate. However, loss of one Plug will increase the possibility of the Heat Wire melting in the remaining plugs.

To test each Glow Plug, remove the connector. Check each Glow Plug for continuity between the Plug terminal and metal. If continuity is indicated, replace the Plug.

5.3.2- Glow Plug Construction

B A thin, coiled HEAT WIRE is encased in sintered magnesium oxide powder and enclosed by a stainless steel SHEATH. One end of the wire is welded to the SHEATH, the other end to the CENTER ELECTRODE. When pre-heat circuit voltage is applied to the HEAT WIRE, the wire heats the air in the engine combustion chamber.



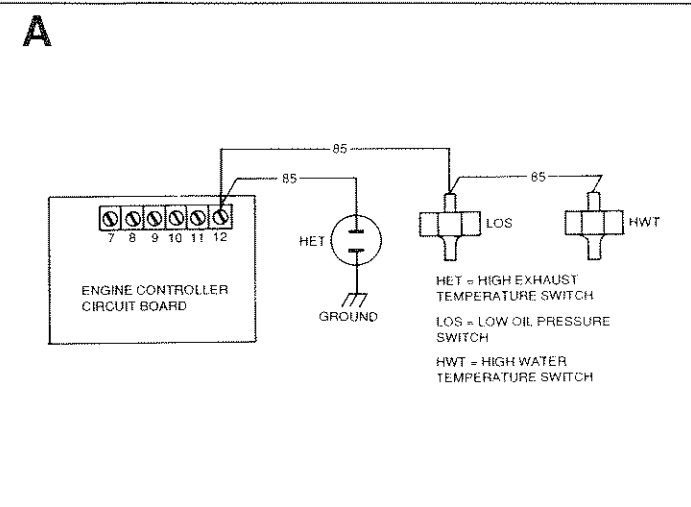
SECTION 5.4 - ENGINE SAFETY SHUTDOWN SYSTEM

5.4.1- General

The engine will shut down automatically in the event of one or more of the following:

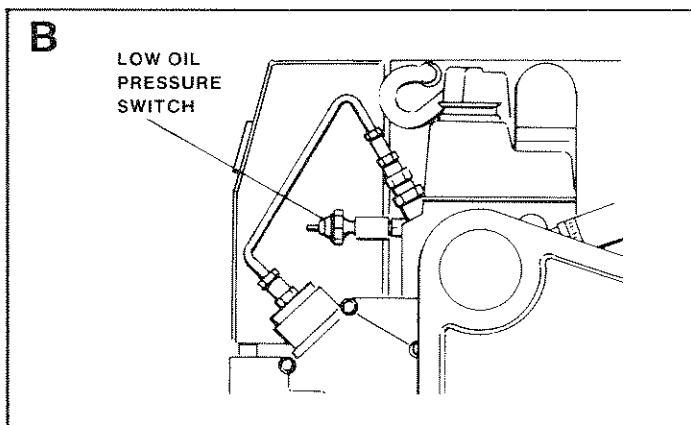
1. High Exhaust Temperature
2. High Captive Coolant Temperature
3. Low Engine Oil Pressure
4. Overspeed

A The engine mounts a Low Oil Pressure Switch (LOS) and a High Water Temperature Switch (HWT). A High Exhaust Temperature Switch (HET) is located on the Heat Exchanger exhaust outlet. These switches are normally-open (N.O.) except for the Oil Pressure Switch, and are connected to Terminal 12 of the Engine Controller circuit board via Wires 85. On closure of one or more of the switch contacts, Wire 85 and circuit board Terminal 12 will be connected to frame ground to effect an automatic shutdown (in the same manner as setting the Engine-Start/Stop switch to STOP).



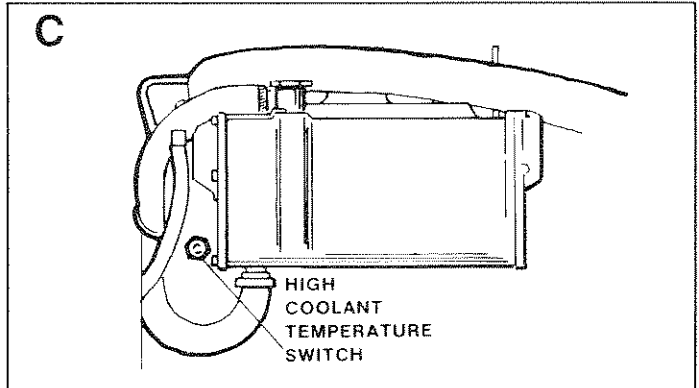
5.4.2- Low Oil Pressure Switch

B Switch is normally-closed, is held open by engine oil pressure during cranking and operation. Switch contacts closure will occur when oil pressure drops below approximately 15-17 psi (104-117 kPa).



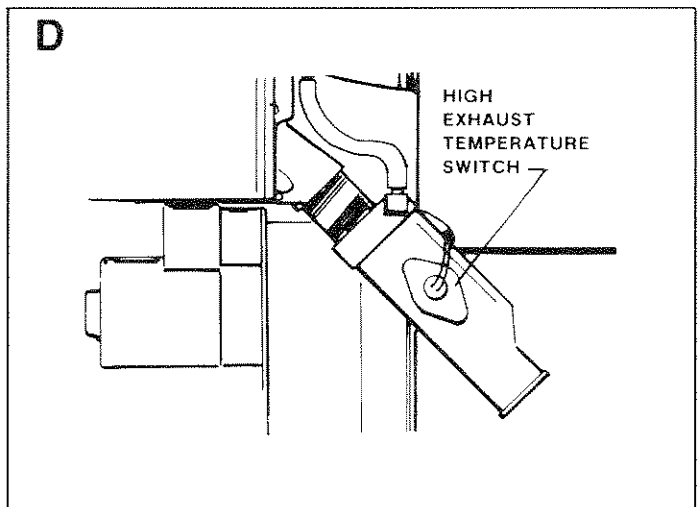
5.4.3- High Coolant Temperature Switch

C This normally-open thermostatic switch has a sensing tip which is immersed in captive engine coolant. Should captive coolant temperature exceed approximately 230° F. (110° C.), the switch contacts will close and effect an engine shutdown.



5.4.4- High Exhaust Temperature Switch

D Engine exhaust outlet piping and hoses are cooled by sea water, pumped through the system by a Sea Water Pump. Without adequate sea water flow, excessive heat will quickly damage the exhaust system hoses. This protective switch helps prevent damage to the exhaust system. Switch closure and resultant engine shutdown will occur if exhaust outlet temperature exceeds approximately 246°-266° F. (119°-130° C.).



5.4.5- Testing the Low Oil Pressure Switch

With engine shut down, disconnect Wire 85 from the switch terminal. Set a VOM to its Rx1 scale and zero the meter. Connect one VOM test probe to the switch terminal, the

other to a clean frame ground. The VOM needle should swing upscale and indicate continuity.

Now, start the engine. Again, connect the VOM across the switch terminal and frame ground. The VOM should indicate infinity.

With the engine running at no-load, connect the terminal end of Wire 85 (previously disconnected from switch terminal) to a clean frame ground. The engine should shut down.

5.4.6- Testing the High Coolant and High Exhaust Temperature Switches

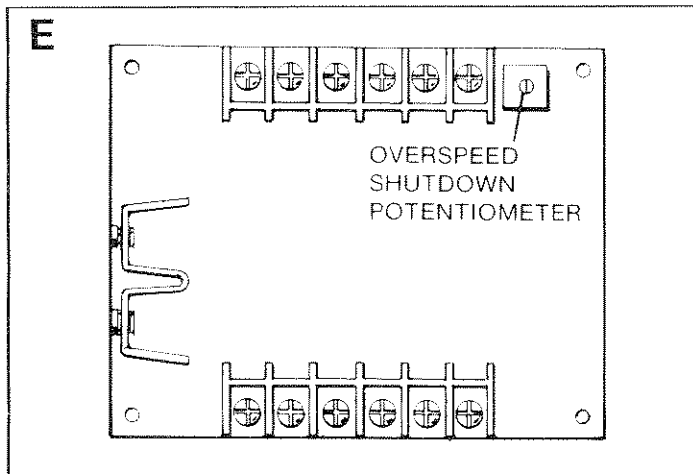
Set a VOM to its Rx1 scale and zero the meter. Disconnect Wire 85 from the switch terminal. Connect the VOM test probes to the switch terminal and to a clean frame ground. VOM needle should indicate continuity.

With engine running at no-load, connect terminal end of Wire 85 to a clean frame ground. Engine should shut down.

Switches may be tested by removing them and immersing their sensing probes in water. Heat the water and check the temperature at which the switch contacts close.

5.4.7- Overspeed Shutdown

E Engine speed (a-c frequency) signals are delivered to Engine Controller circuit board terminals 5 and 6, via Wires 11 and 22. Should engine speed exceed approximately 69-71 Hz (2070-2130 rpm), an engine shutdown will occur after about 4 seconds.



To test overspeed shutdown, proceed as follows:

1. Connect an accurate a-c FREQUENCY METER to circuit board terminals 5 and 6 (Wires 11 and 22).
2. Start the engine, let it stabilize and warm up at no-load. DO NOT CONNECT ANY ELECTRICAL LOADS DURING THE TEST.
3. Slowly increase engine speed until the frequency meter reads approximately 69 Hz. Then, slowly increase engine speed to just slightly more than 71 Hz. After a 4 second delay, engine should shut down.

To adjust overspeed shutdown, proceed as follows:

1. Turn the slotted adjustment on the Engine Controller circuit board all the way clockwise against its stop.
2. Start the engine, let it stabilize and warm up at no-load.
3. Connect an a-c frequency meter across circuit board terminals 5 and 6 (Wires 11 and 22).
4. Slowly increase engine speed until the frequency meter reads approximately 70 Hz. Hold that setting and slowly turn the slotted OVERSPEED adjustment counterclockwise in very small increments. Wait about 4 seconds between each incremental adjustment. When engine shuts down, adjustment is correct.

