

YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

4JHE

4JH-TE

4JH-HTE

4JH-DTE

FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by its applicability to the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions—such as installation on the hull and suitability of the ship's piping and propeller—and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

Models **4JH(B)E • 4JH-T(B)E** **4JH-HT(B)E • 4JH-DT(B)E**

CHAPTER 1 GENERAL

1. Exterior Views	1-1
2. Specifications	1-4
3. Construction	1-5
4. Performance Curves	1-6
5. Engine Cross Section	1-10
6. Dimensions	1-11
7. Piping Diagrams	1-15
8. Parts Interchangeability	1-18

CHAPTER 2 BASIC ENGINE PARTS

1. Cylinder Block	2-1
2. Cylinder Liners	2-4
3. Cylinder Head	2-6
4. Piston and Piston Pins	2-13
5. Connecting Rod	2-17
6. Crankshaft and Main Bearing	2-20
7. Camshaft and Tappets	2-23
8. Timing Gear	2-26
9. Flywheel and Housing	2-28

CHAPTER 3 FUEL INJECTION EQUIPMENT

1. Fuel Supply System	3-1
2. Disassembly, Reassembly and Inspection of Governor	3-9
3. Disassembly, Reassembly and Inspection of Fuel Injection Pump	3-18
4. Adjustment of Fuel Injection Pump and Governor	3-28
5. Automatic Advancing Timer	3-34
6. Fuel Feed Pump	3-36
7. Fuel Injection Nozzle	3-38
8. Troubleshooting	3-42
9. Fuel Injection Pump Service Data	3-44
10. Tools	3-45
11. Fuel Filter	3-47
12. Fuel Tank (Optional)	3-48
13. Design Change of Fuel Piping Line	3-49

CHAPTER 4 INTAKE AND EXHAUST SYSTEM

1. Intake and Exhaust System	4-1
2. Intake Silencer	4-4
3. Intake Manifold	4-5
4. Turbocharger	4-6
5. Mixing Elbow	4-21
6. Breather	4-22

CHAPTER 5 LUBRICATION SYSTEM

1. Lubrication System	5-1
2. Lube Oil Pump	5-3
3. Lube Oil Filter	5-6
4. Oil Pressure Control Valve	5-8
5. Lube Oil Cooler	5-9
6. Piston Cooling Nozzle	5-11
7. Rotary Waste Oil Pump (Optional)	5-12

CHAPTER 6 COOLING WATER SYSTEM

1. Cooling Water System	6-1
2. Sea Water Pump	6-4
3. Fresh Water Pump	6-7
4. Heat Exchanger	6-10
5. Pressure Cap and Sub Tank	6-12
6. Thermostat	6-14
7. Kingston Cock (Optional)	6-16
8. Sea Water Filter (Optional)	6-17
9. Bilge Pump and Bilge Strainer (Optional)	6-18

CHAPTER 7 REDUCTION AND REVERSING GEAR

Marine gear model KBW 20 and 21

1. Construction	7-1
2. Installation	7-6
3. Inspection and Servicing	7-7
4. Operation and Maintenance	7-8
5. Disassembly	7-13
6. Reassembly	7-17
7. Special Tools	7-23

Marine gear model KM4A, (Angle drive)

1. Construction	7-24
2. Shifting Device	7-28
3. Inspection and Servicing	7-33
4. Special Tools	7-43
5. Disassembly	7-45
6. Reassembly	7-53

CHAPTER 8 REMOTE CONTROL

1. Remote Control System	8-1
2. Remote Control Installation	8-2
3. Remote Control Inspection	8-5
4. Remote Control Adjustment	8-6

CHAPTER 9 ELECTRICAL SYSTEM

1. Electrical System	9-1
2. Battery	9-6
3. Starter Motor	9-9
4. Alternator	9-20
5. Instrument Panel and Wiring Codes	9-30
6. Warning Devices	9-35
7. Air Heater (Optional)	9-38
8. Electric Type Engine Stop Device (Optional)	9-39
9. Tachometer	9-41
10. Alternator 12V/80A (Optional)	9-44

CHAPTER 10 DISASSEMBLY AND REASSEMBLY

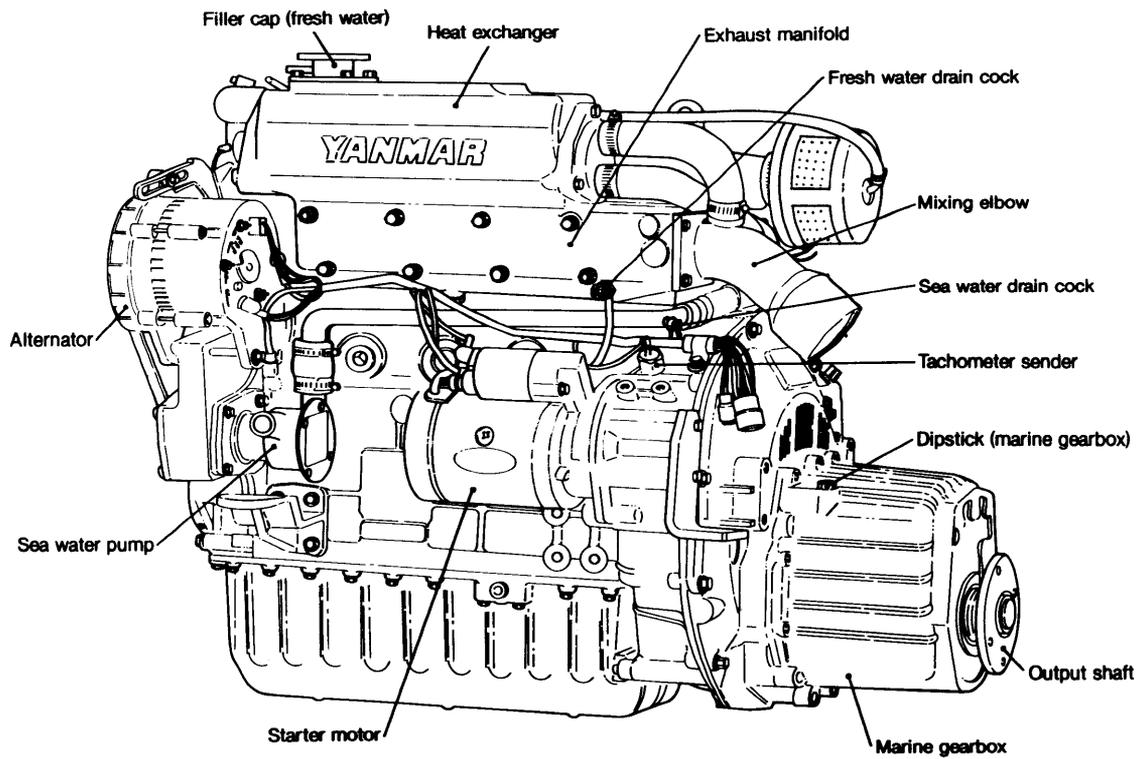
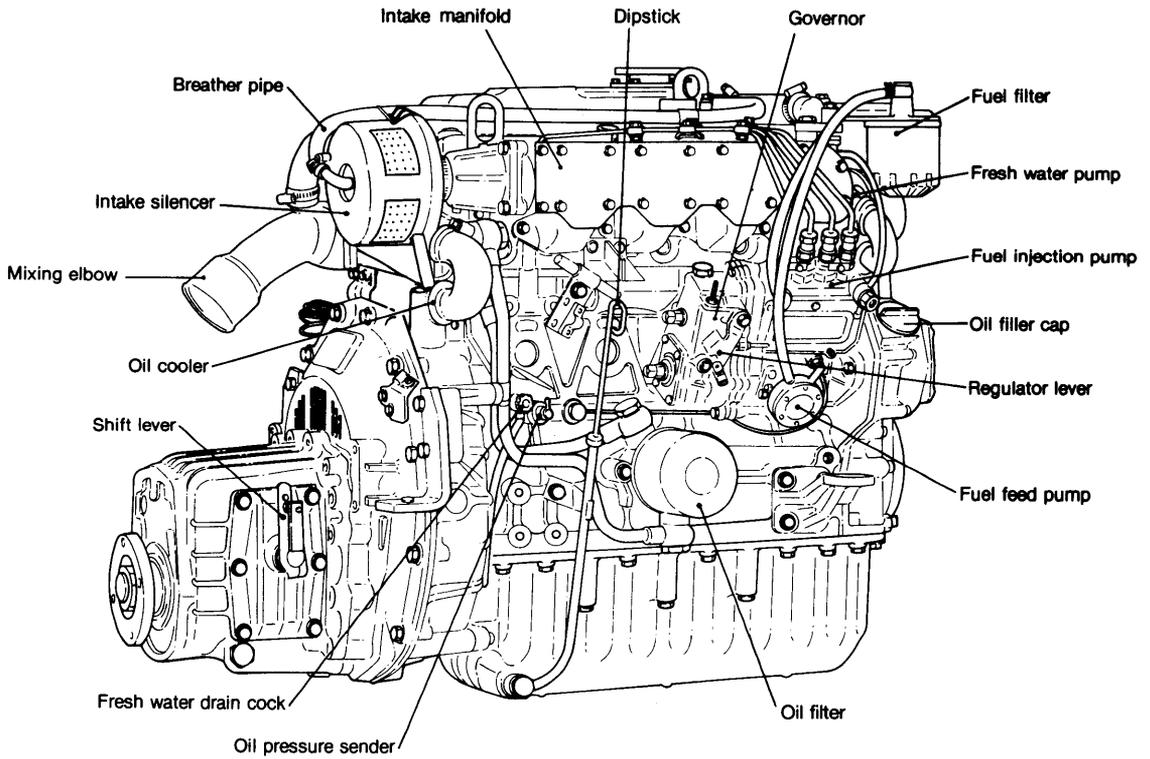
1. Disassembly and Reassembly Precautions	10-1
2. Disassembly and Reassembly Tools	10-2
3. Disassembly and Reassembly	10-9
4. Bolt/nut Tightening Torque	10-32
5. Test Running	10-33

CHAPTER 1
GENERAL

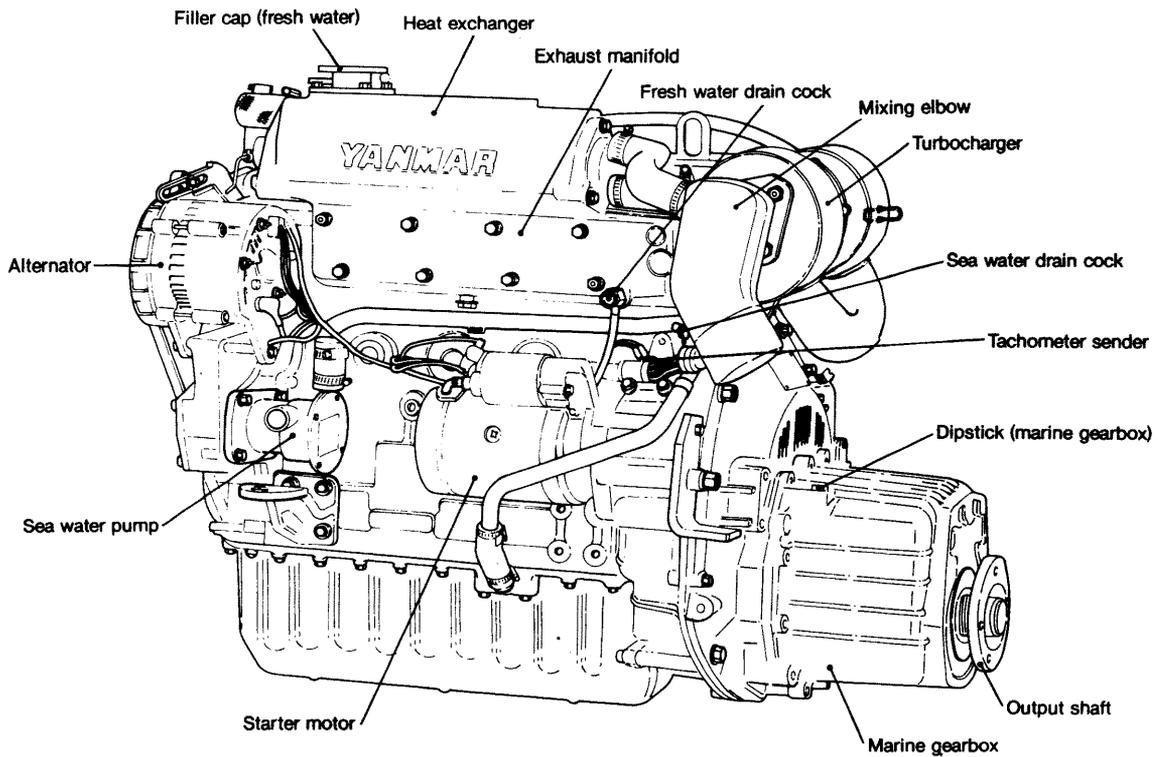
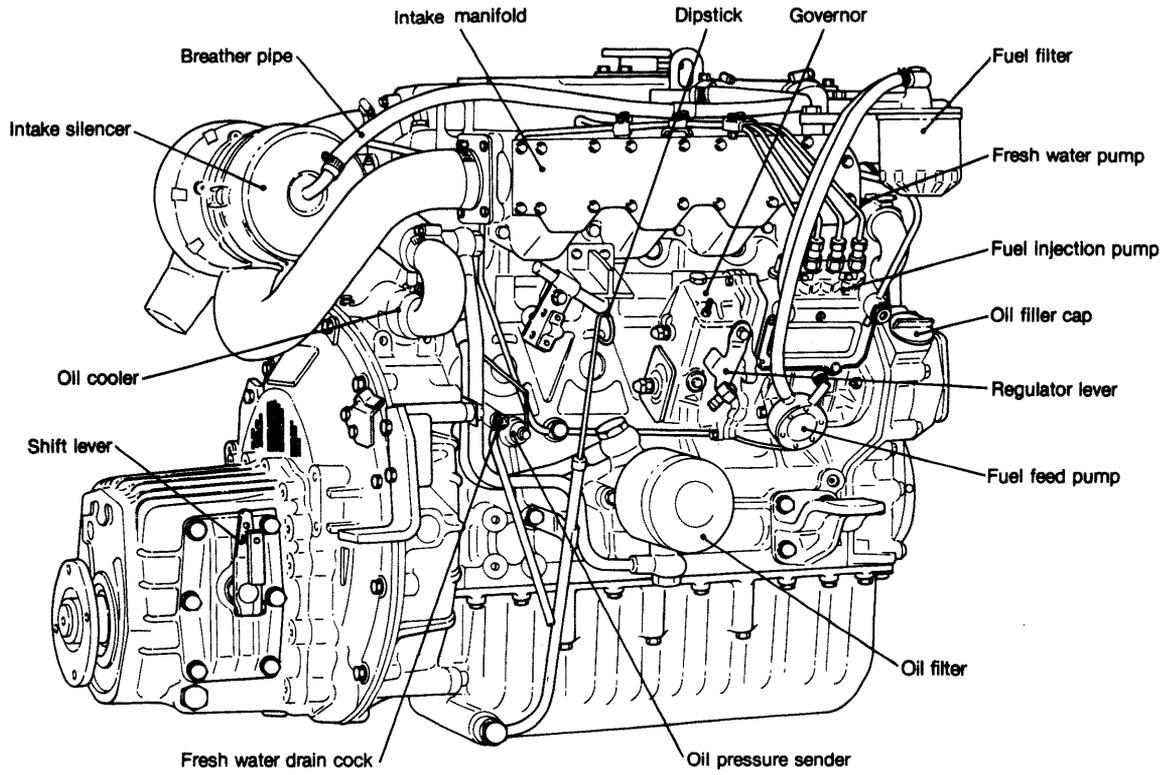
1. Exterior Views	1-1
2. Specifications	1-4
3. Construction	1-5
4. Performance Curves	1-6
5. Engine Cross Section	1-10
6. Dimensions	1-11
7. Piping Diagrams	1-15
8. Parts Interchangeability	1-18

1. Exterior Views

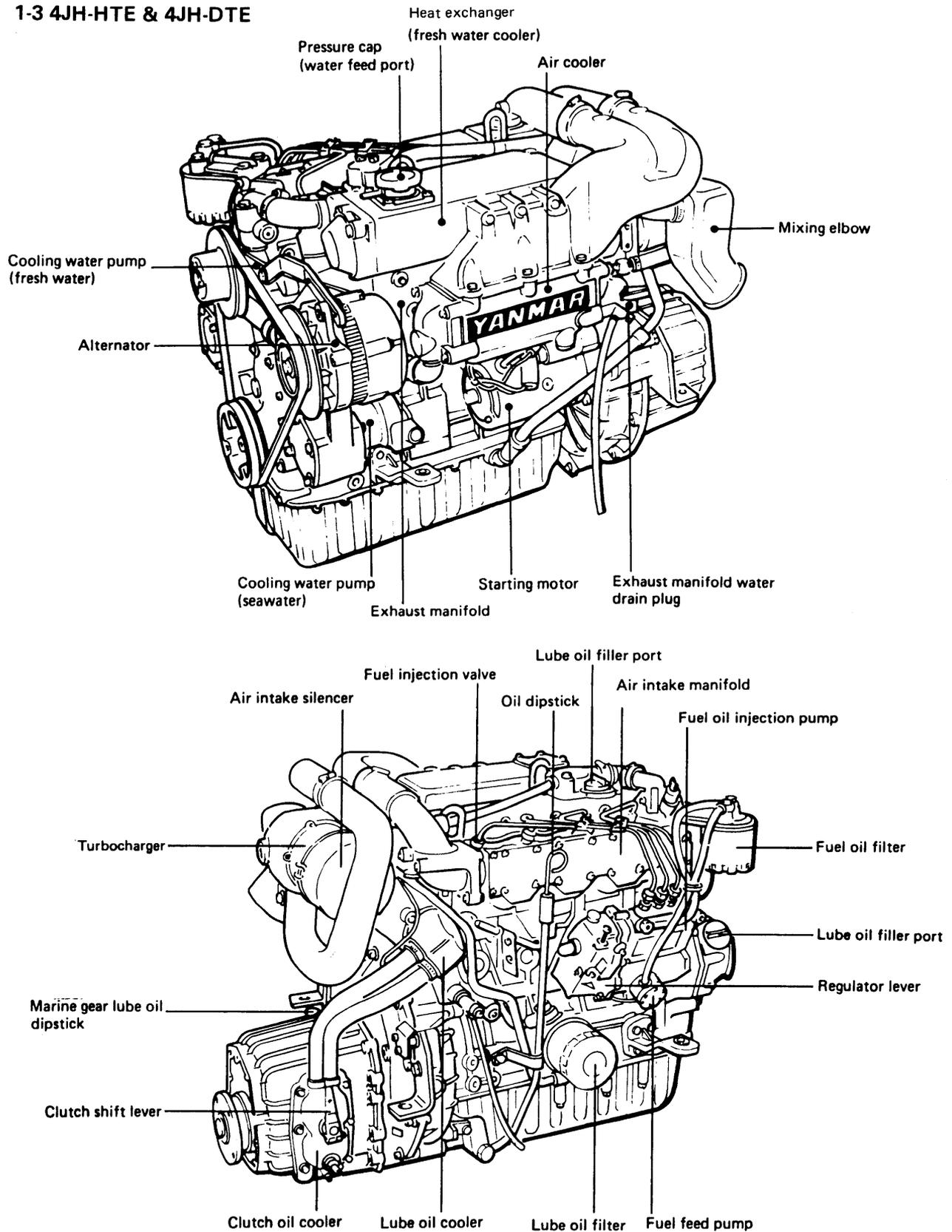
1-1 4JHE



1-2 4JH-TE



1-3 4JH-HTE & 4JH-DTE



2. Specifications

Model		4JHE	4JH-TE	4JH-HTE	4JH-DTE	
Type		Vertical 4-cycle water cooled diesel engine				
Combustion system		Direct injection				
Aspiration		Normal aspiration	Exhaust gas turbine turbocharger	Exhaust gas turbine turbocharger with intercooler		
Number of cylinders		4				
Bore x stroke		mm (in.) 78 x 86 (3.07 x 3.39)				
Displacement		ℓ (cu.in.) 1.644 (100.33)				
One hour rating output (DIN6270B)	Output/crankshaft speed	HP/rpm (kW/rpm)	44/3600 (32.4/3600)	55/3600 (40.5/3600)	66/3600 (48.6/3600)	77/3600 (56.7/3600)
	Brake mean effective pressure	Kg/cm ² (lb./in. ²)	6.69 (95.15)	8.36 (118.91)	10.0 (142.20)	11.7 (166.37)
	Piston speed	m/sec. (ft./sec.)	10.3 (33.79)	10.3 (33.79)	10.3 (33.79)	10.3 (33.79)
Continuous rating output (DIN6270A)	Output/crankshaft speed	HP/rpm (kW/rpm)	40/3500 (29.5/3500)	50/3500 (36.8/3500)	60/3500 (44.2/3500)	70/3500 (51.5/3500)
	Brake mean effective pressure	kg/cm ² (lb./in. ²)	6.26 (89.04)	7.82 (111.23)	9.39 (133.53)	11.0 (156.42)
	Piston speed	m/sec. (ft./sec.)	10.0 (32.81)	10.0 (32.81)	10.0 (32.81)	10.0 (32.81)
Compression ratio		17.8	16.2	15.9	15.9	
Fire order		180° 180° 180° 180° 1 - 3 - 4 - 2 - 1				
Fuel injection pump		Bosch in-line type YPES-CL				
Fuel injection timing (FID)		degree	12° ± 1° (*9° ± 1°) bTDC	12° ± 1° bTDC	12° ± 1° bTDC	12° ± 1° bTDC
Fuel injection pressure		kg/cm ² (lb./in. ²)	200 ± 5 (2844 ± 71)			
Fuel injection nozzles		Hole type				
Direction of rotation	Crankshaft	Counter-clockwise viewed from stern				
	Propeller shaft (Forward)	Clockwise viewed from stern				
Power take off		At flywheel side				
Cooling system		Constant high temperature fresh water cooling Fresh water: Centrifugal pump Sea water: Rubber impeller pump				
Lubrication system		Forced lubrication with trochoid pump				
Starting system	Starting motor	DC 12V, 1.8kW				
	AC generator	12V, 55A				
Turbocharger	Type		RHB52 (IHI)	RHB52HW (IHI)		
	Model		MY29	MY31	MY34	
	Cooling system		Air cooling	Water cooling		
Air cooler system	Type			Sea-water cooled, Plate fin type	Sea-water cooled, Corrugated fin type	
	Radiation area	m ² (in. ²)		0.76 (1178)	0.67 (1038)	
Clutch	Model		KBW20	KBW21	KBW21	
	Type		Constant mesh gear with multiple friction disc clutch			
	Reduction ratio (Forward/Reverse)		2.17/3.06, 2.62/3.06, 3.28/3.06		2.17/3.06, 2.62/3.06	
	Propeller speed DIN6270A rating (Forward/Reverse)		1615/1145, 1336/1145, 1068/1145		1615/1145, 1336/1145	
	Lubricating oil capacity Effect/max	ℓ (cu.in.)	0.15/1.2 (9.15/73.22)			
	Clutch weight	kg (lb.)	26 (57.33)	30 (66.15)	30 (66.15)	
Dimensions	Overall length	mm (in.)	906.3 (35.68)	906.3 (35.68)	906.3 (35.68)	
	Overall width	mm (in.)	561 (22.09)	561 (22.09)	561 (22.09)	
	Overall height	mm (in.)	659 (25.94)	668 (26.30)	668 (26.30)	
Engine weight with clutch (dry)		kg (lb.)	226 (498)	232 (511)	246 (542)	246 (542)
Lubricating oil capacity Effect/max.		ℓ (cu.in.)	3.0/6.5 (183.06/396.63)			
Cooling water capacity (Fresh water)	Fresh water tank	ℓ (cu.in.)	6.0 (366.12)			
	Sub tank	ℓ (cu.in.)	0.8 (48.82)			

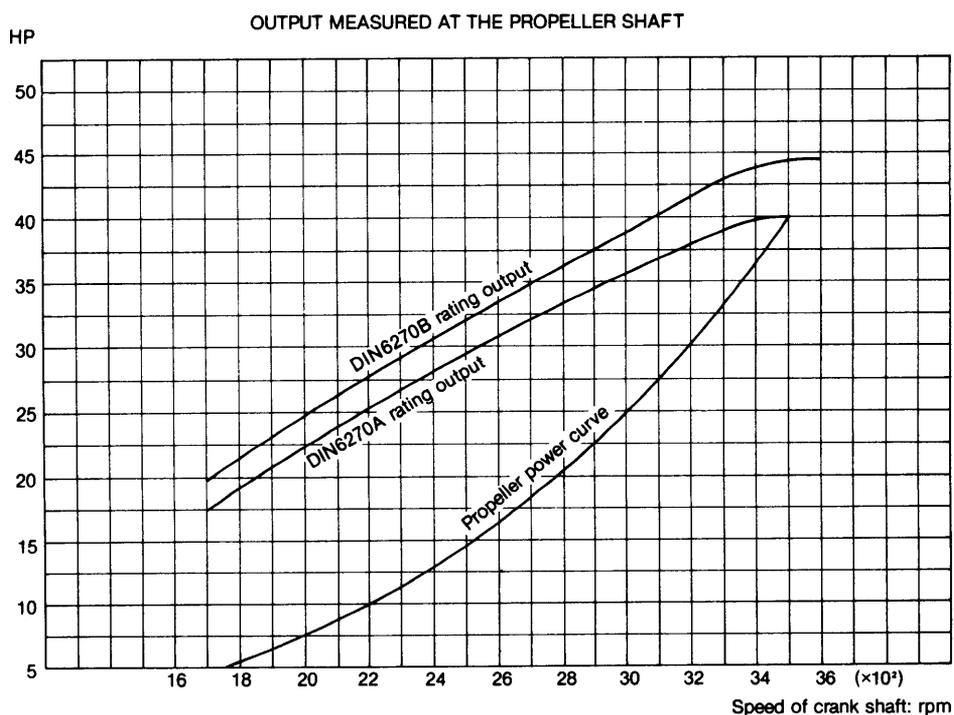
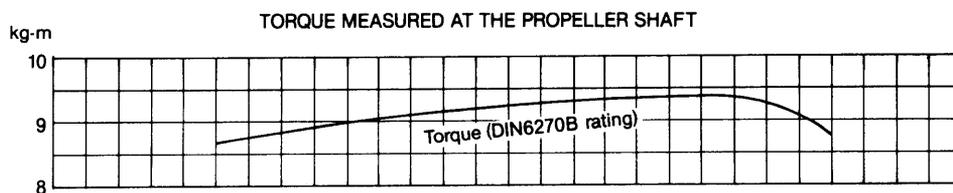
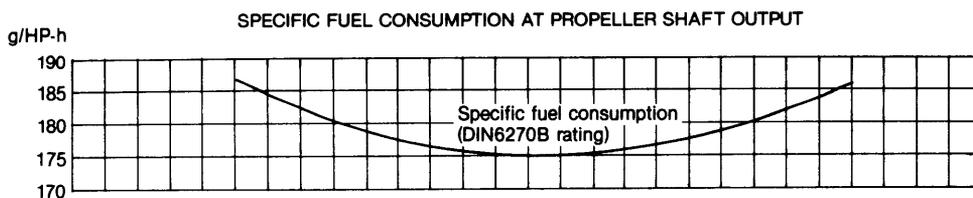
Note: * Applicable engine number #/E 00101 ~ 00574

3. Construction

ENGINE MODEL		4JH	4JH-TE	4JH-HTE	4JH-DTE
Group	Part	Construction			
Engine Proper	Cylinder block	Integrally-cast water jacket and crankcase			
	Cylinder liner	Dry sleeve			
	Timing gear case	Cast aluminum			
	Oil sump	Cast aluminum, oil pan			
	Main bearings	Hanger-type bearings supports			
	Engine feet	Cylinder block and Flywheel mounting side			
Intake/Exhaust, Valve Drive	Cylinder head	Integrally-cast type, jet cooling between valves, Intake/exhaust valve seat inserts			
	Intake/exhaust valves	Mushroom shaped, seat angle: Intake: 120° Exhaust: 90°			
	Intake manifold	Aluminum diecast integral			
	Exhaust manifold	Water cooled integral with water tank			
	Air cooler			Plate fin type	Corrugated fin type
	Turbocharger	—	IHI RHB52 exhaust gas turbo	IHI RHB52HW exhaust gas turbo, Water cooled type.	
	Valve drive	Overhead valve push rod rocker arm system			
	Timing gear	Helical gear			
Main Moving Parts	Crankshaft	Stamped forging			
	Flywheel	Cast iron static balance with ring gear			
	Pistons	Cast aluminum, oval type			
	Piston rings	2 compression rings, 1 oil ring			
	Piston pin	Floating type			
	Connecting rod	Forged steel			
	Crank pin bushings	Aluminum bushings			
Lube Oil System	Lube oil pump	Trochoid type			
	Oil filter	Full flow paper element cartridge type			
	Oil cooler	Sea water cooled pipe type	Sea water cooled multi-pipe type		
	Control valve	Cylindrical type with external adjusting shims			
Cooling Water System	Fresh water pump	V-pulley driven, centrifugal type			
	Sea water pump	Gear driven, rubber impeller type			
	Thermostat	Wax pellet type			
	Fresh water cooler	Multi-tube type integral with exhaust manifold			
Bilge	Bilge pump	Electric			
Fuel Injection Equipment	Fuel injection pump	YANMAR YPES-CL type integral with governor			
	Fuel injection nozzles	Hole type			
	Fuel feed pump	Diaphragm type			
	Fuel filter	Paper element cartridge type			
Governor	Governor	Centrifugal all-speed mechanical type			
Remote Control Equipment	Engine speed & marine gearbox	Single control lever type with push-pull cable			
Starting Equipment	Electric starter	DC 12V, 1.8kW starter motor			
	Generator	12V, 55A with built-in IC regulator			
Marine Gearbox	Clutch	Multi-disc mechanical wet type			
	Reduction gear	Helical gear constant mesh type			

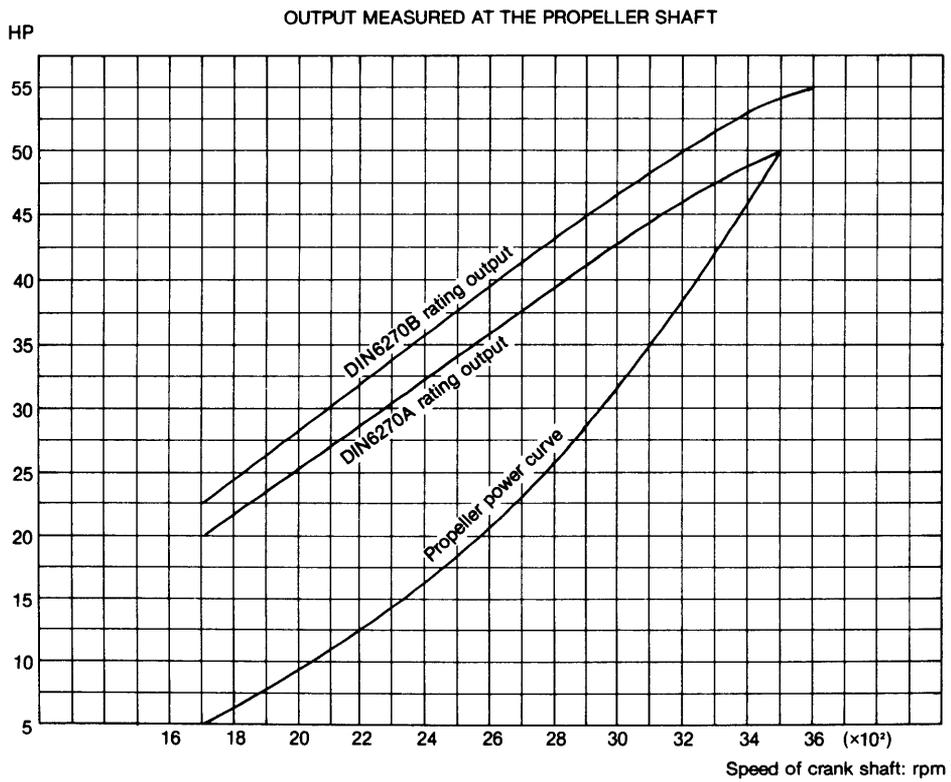
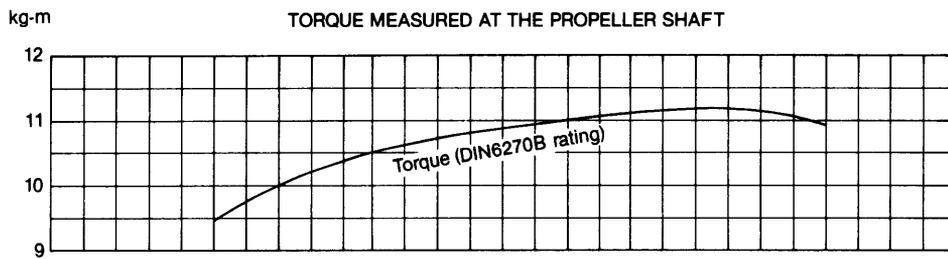
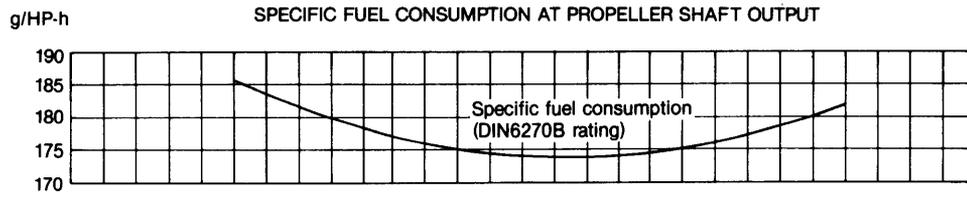
4. Performance Curves

4-1 4JHE



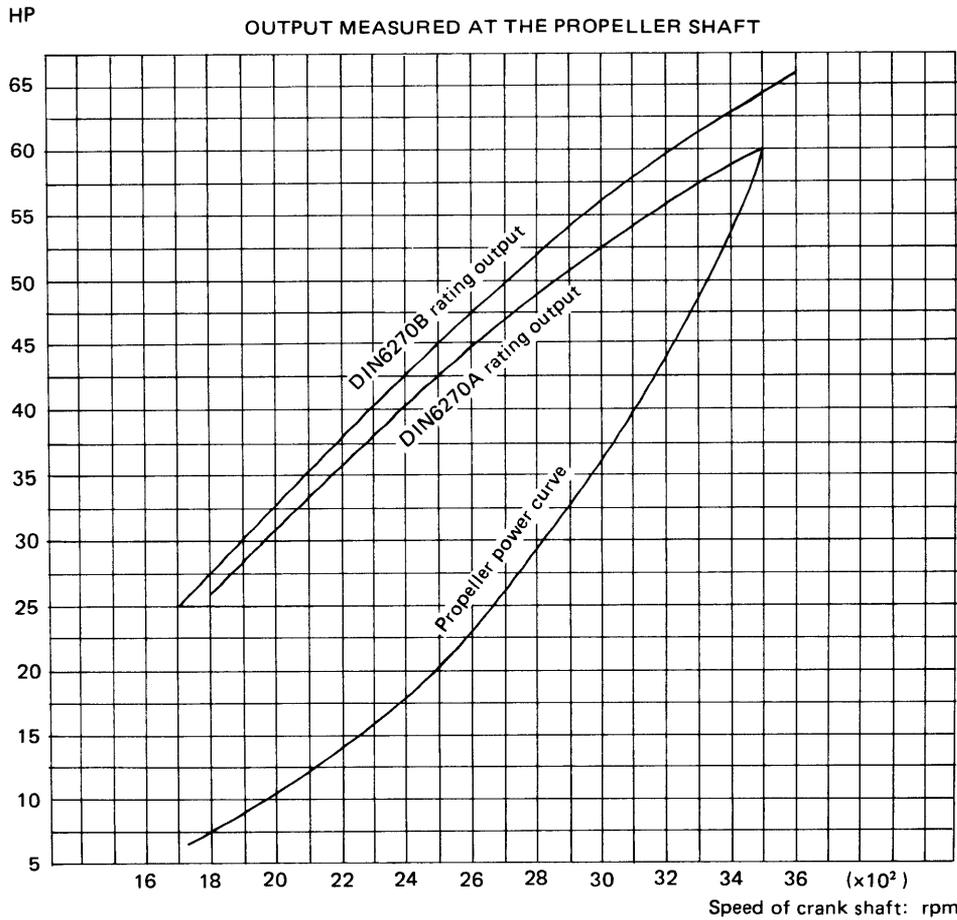
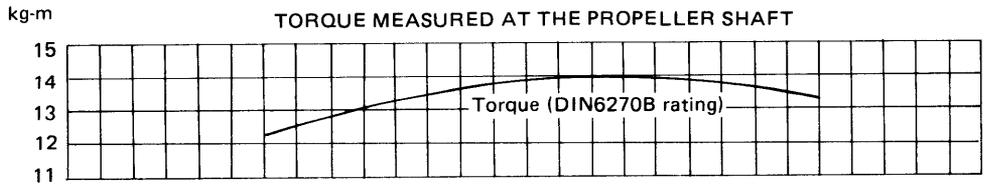
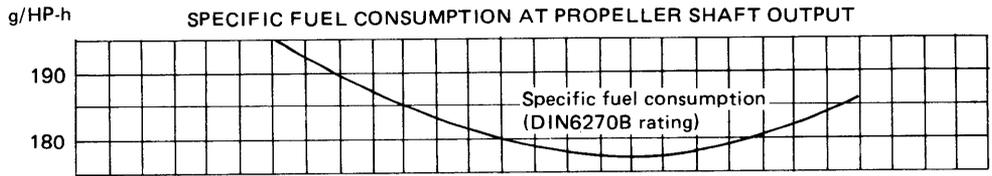
THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER

4-2 4JH-TE



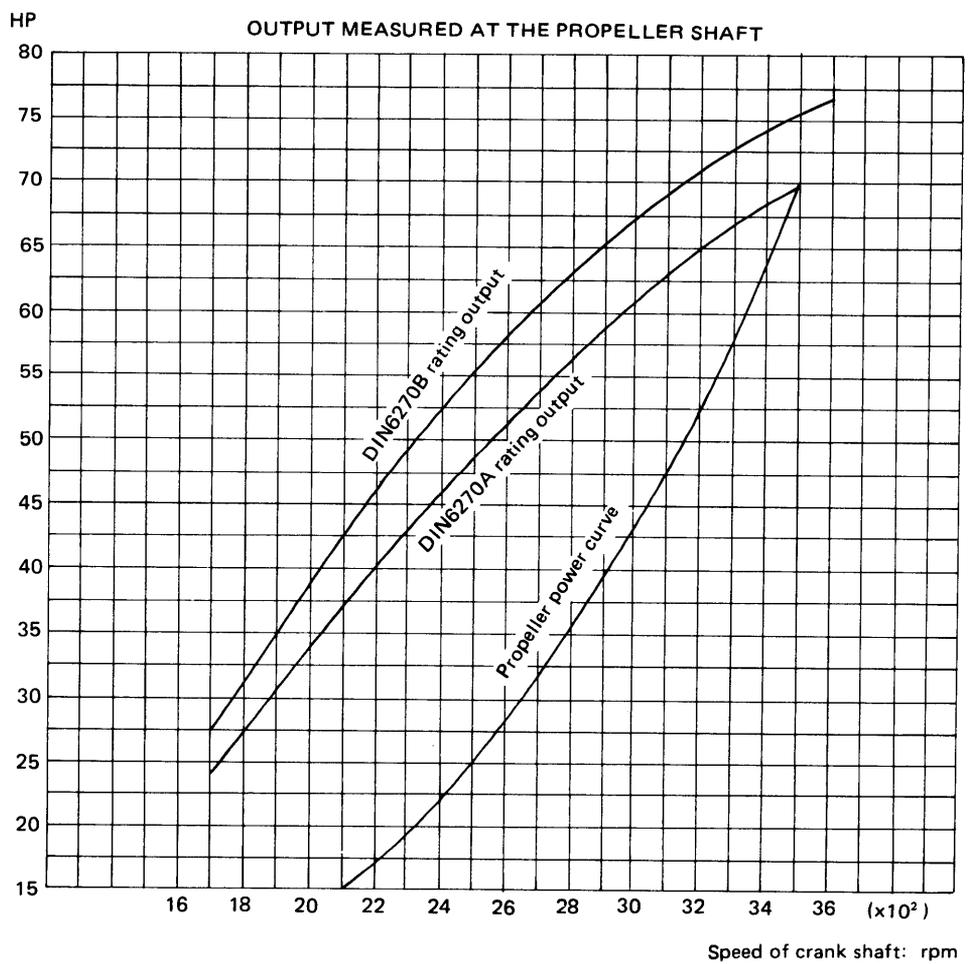
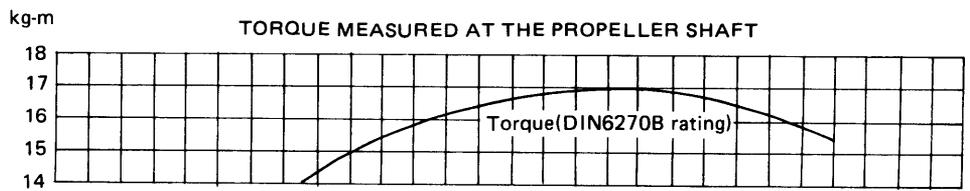
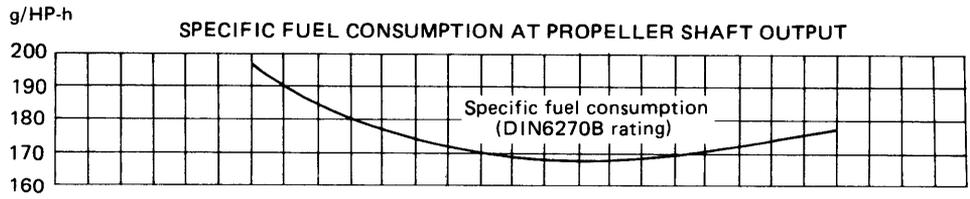
THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER

4-3 4JH-HTE



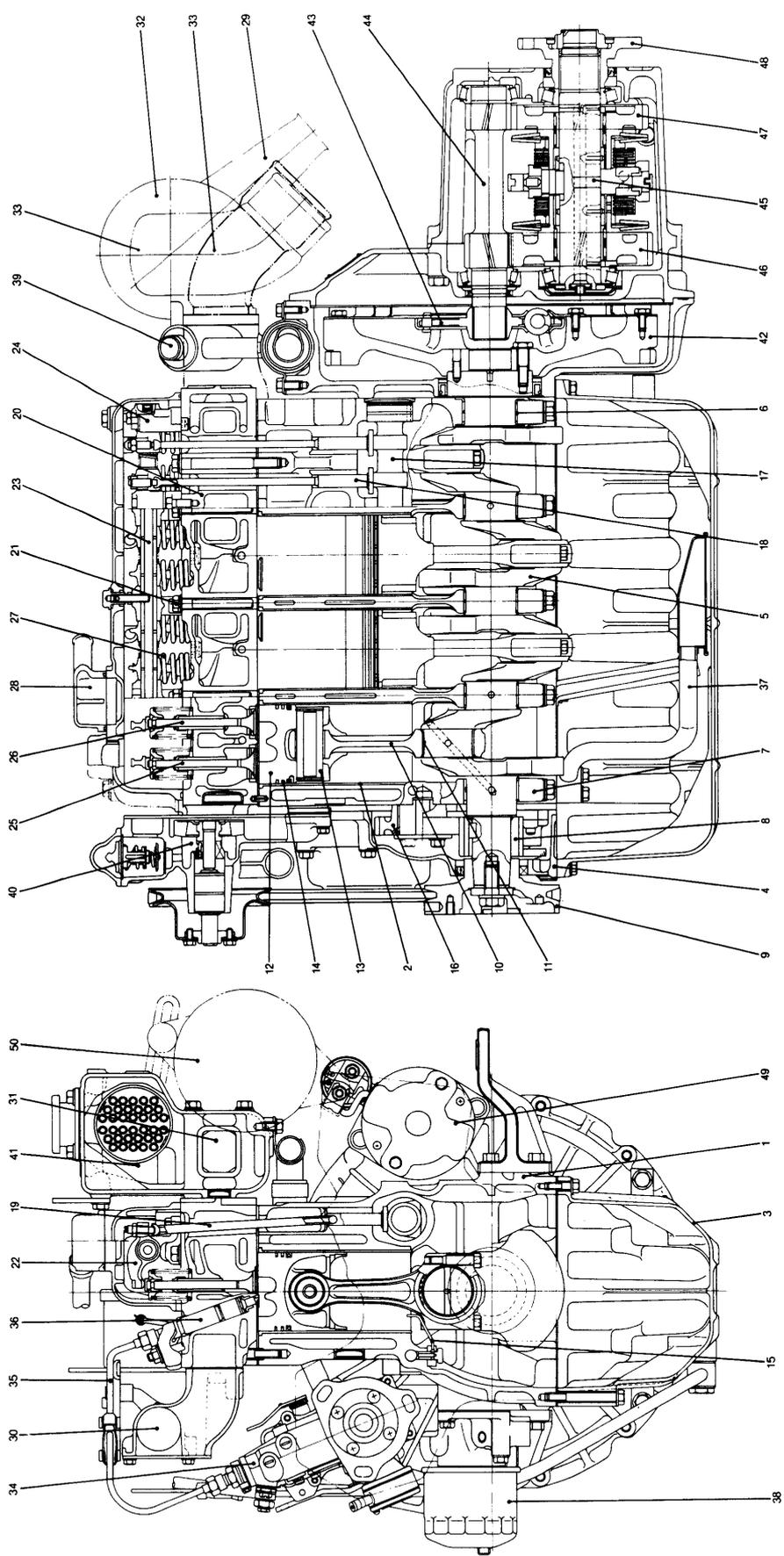
THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER.

4-4 4JH-DTE

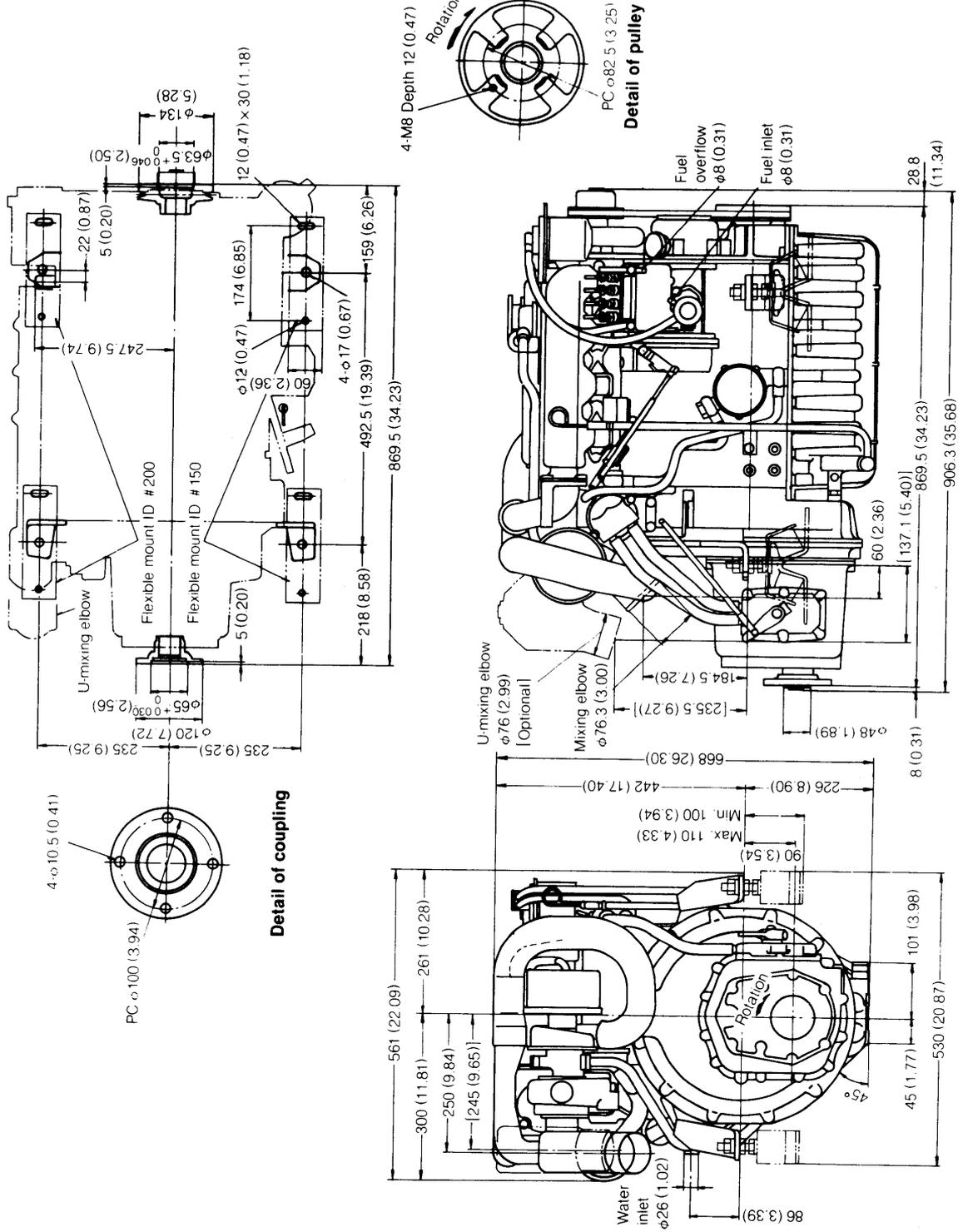


THE ENGINE FLYWHEEL OUTPUT IS APPROX. 3% HIGHER.

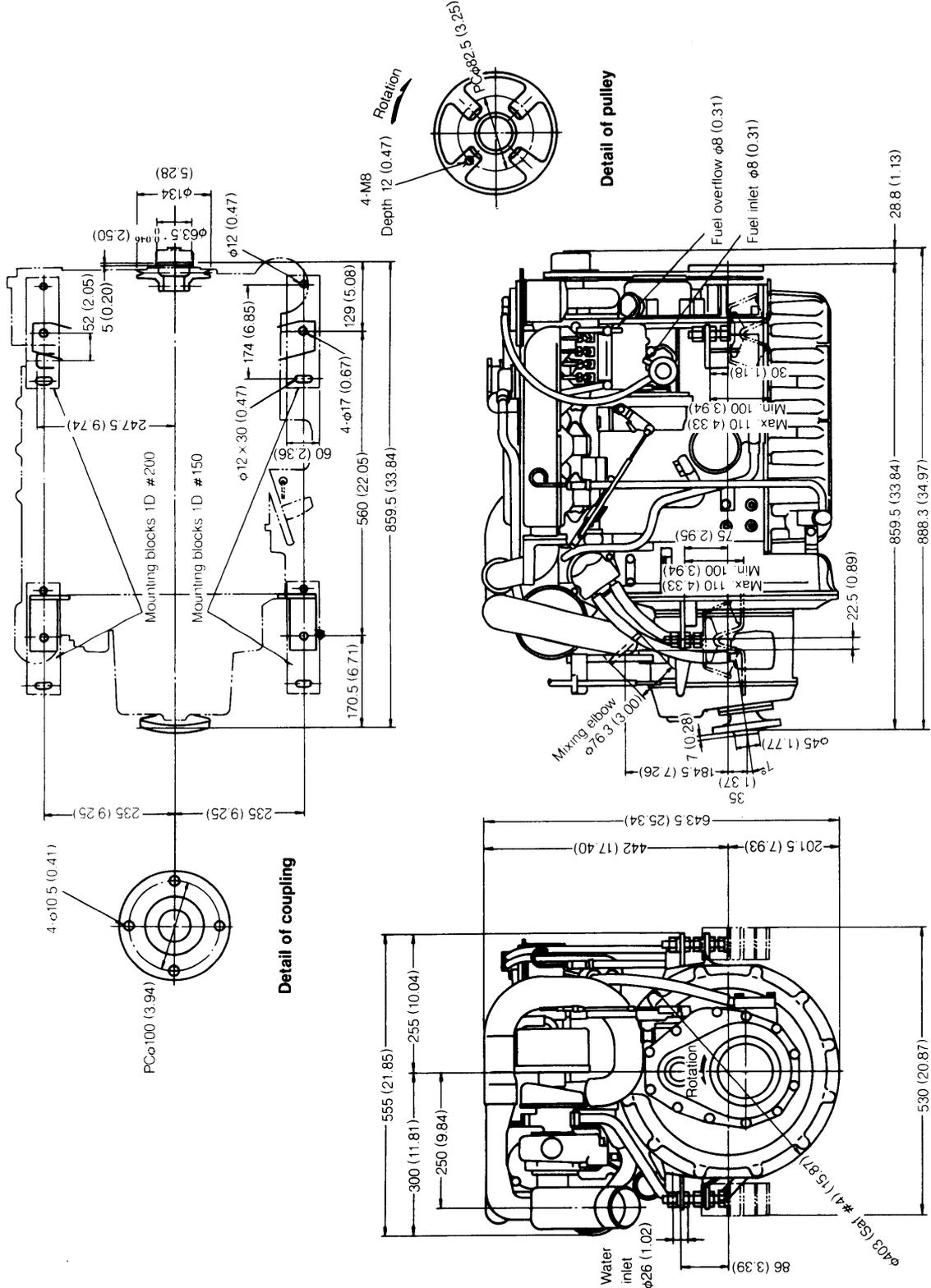
5. Engine Cross Section



- 1. Cylinder block
- 2. Cylinder liner
- 3. Oil pan
- 4. Timing gear case
- 5. Crankshaft
- 6. Main bearing bushing
- 7. Main bearing cap
- 8. Crank gear
- 9. Crankshaft V-pulley
- 10. Connecting rod
- 11. Crank pin bushing
- 12. Piston
- 13. Piston ring
- 14. Piston pin
- 15. Piston pin lock
- 16. Piston pin lock pin
- 17. Piston pin lock nut
- 18. Piston pin lock washer
- 19. Piston pin lock cap
- 20. Piston pin lock cap nut
- 21. Piston pin lock cap washer
- 22. Piston pin lock cap lock pin
- 23. Piston pin lock cap lock nut
- 24. Piston pin lock cap lock washer
- 25. Piston pin lock cap lock pin lock
- 26. Piston pin lock cap lock pin lock nut
- 27. Piston pin lock cap lock pin lock washer
- 28. Piston pin lock cap lock pin lock lock
- 29. Piston pin lock cap lock pin lock lock nut
- 30. Piston pin lock cap lock pin lock lock washer
- 31. Piston pin lock cap lock pin lock lock lock
- 32. Piston pin lock cap lock pin lock lock lock
- 33. Piston pin lock cap lock pin lock lock lock nut
- 34. Piston pin lock cap lock pin lock lock lock washer
- 35. Piston pin lock cap lock pin lock lock lock lock
- 36. Piston pin lock cap lock pin lock lock lock lock nut
- 37. Piston pin lock cap lock pin lock lock lock lock washer
- 38. Piston pin lock cap lock pin lock lock lock lock lock
- 39. Piston pin lock cap lock pin lock lock lock lock lock nut
- 40. Piston pin lock cap lock pin lock lock lock lock lock washer
- 41. Piston pin lock cap lock pin lock lock lock lock lock lock
- 42. Piston pin lock cap lock pin lock lock lock lock lock lock nut
- 43. Piston pin lock cap lock pin lock lock lock lock lock lock washer
- 44. Piston pin lock cap lock pin lock lock lock lock lock lock lock
- 45. Piston pin lock cap lock pin lock lock lock lock lock lock lock nut
- 46. Piston pin lock cap lock pin lock lock lock lock lock lock lock washer
- 47. Piston pin lock cap lock pin lock lock lock lock lock lock lock lock
- 48. Piston pin lock cap lock pin lock lock lock lock lock lock lock lock nut
- 49. Piston pin lock cap lock pin lock lock lock lock lock lock lock lock washer
- 50. Piston pin lock cap lock pin lock lock lock lock lock lock lock lock lock

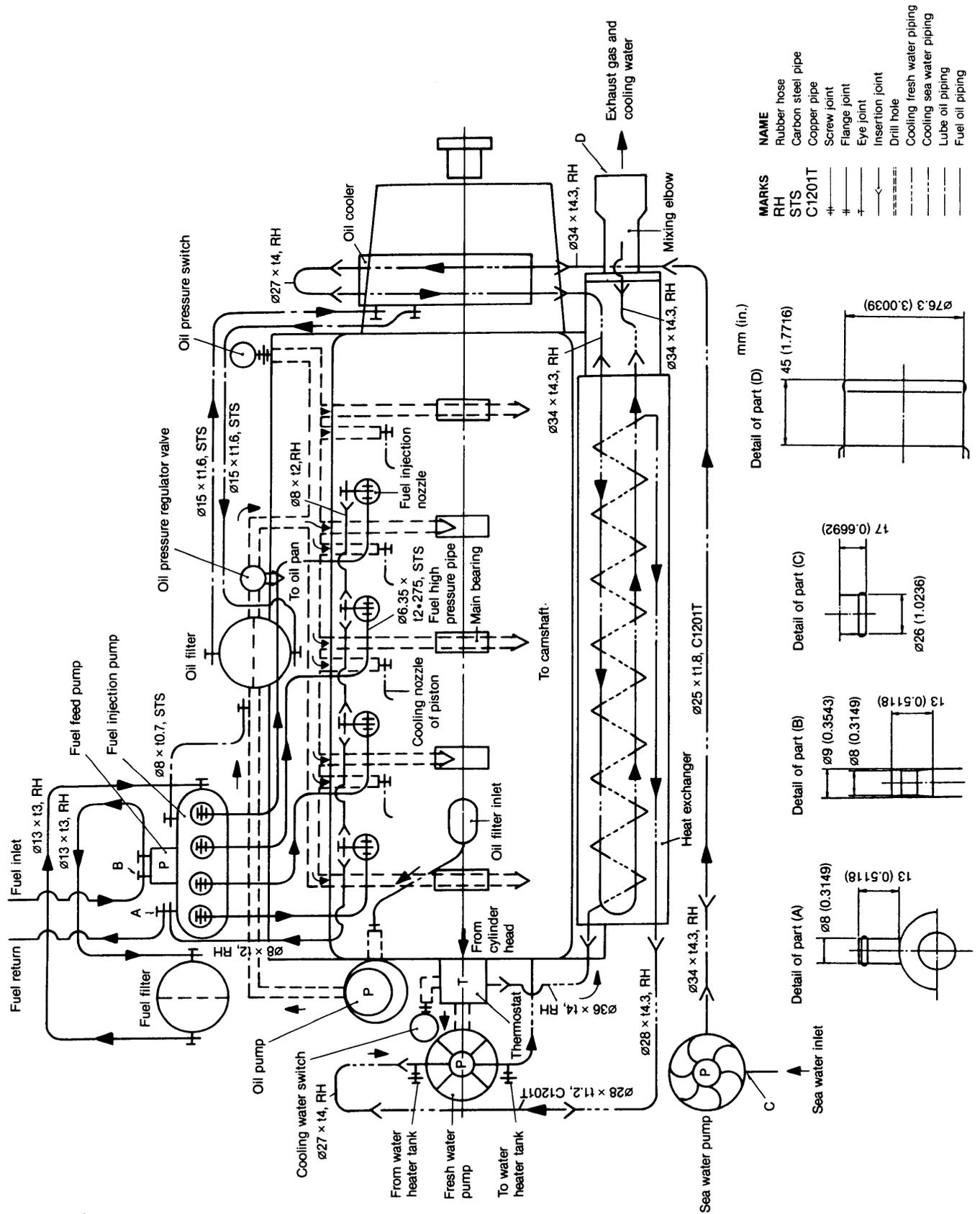


6-4 4JH-DTE

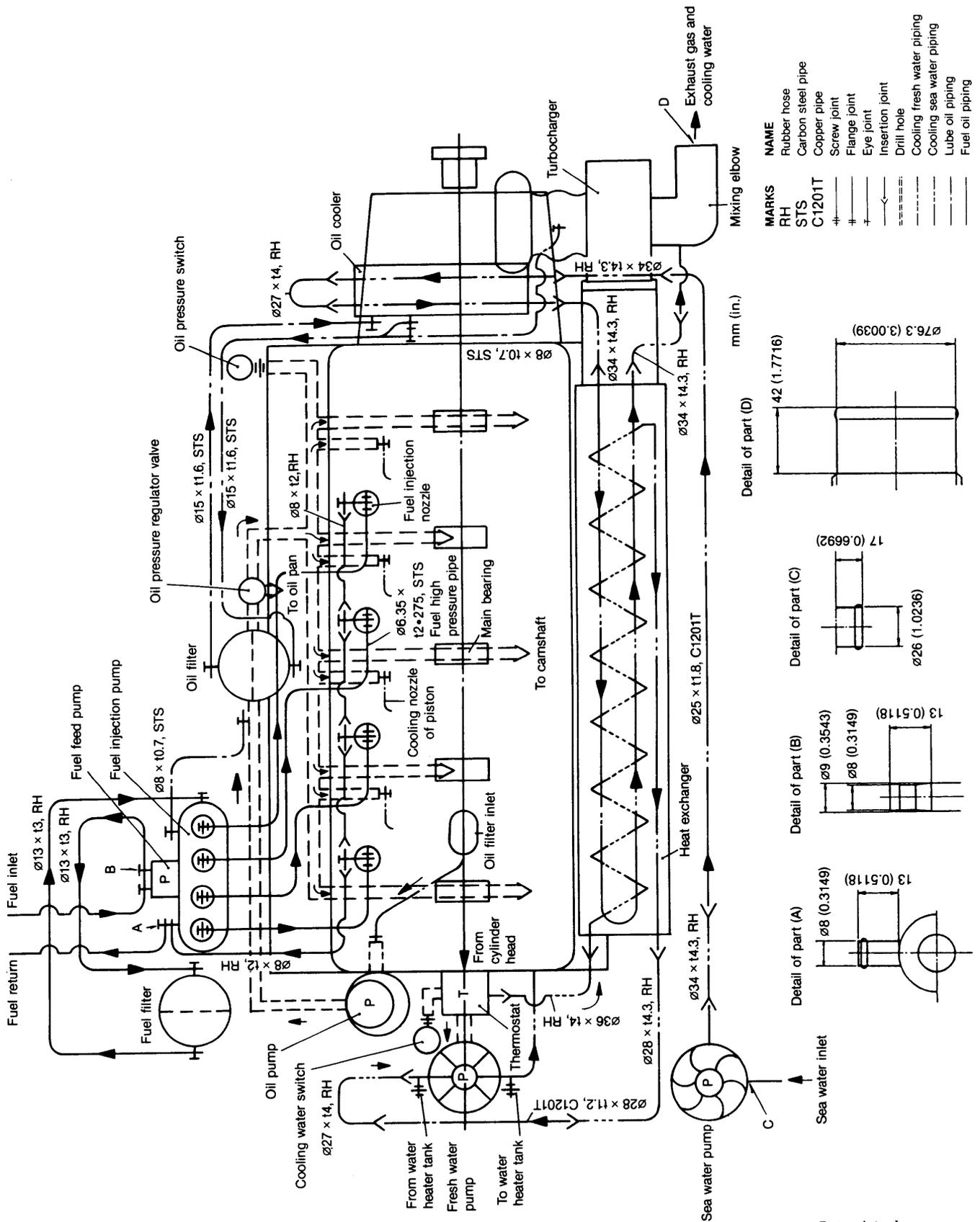


7. Piping Diagrams

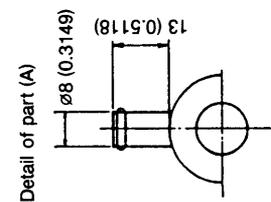
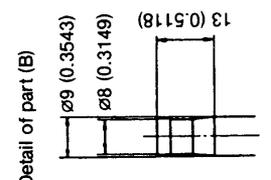
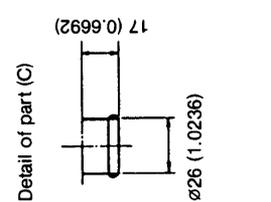
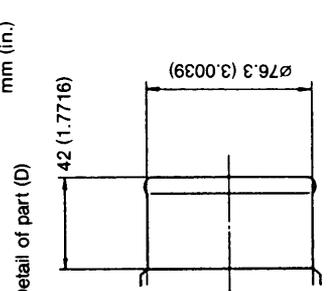
7-1 4JHE



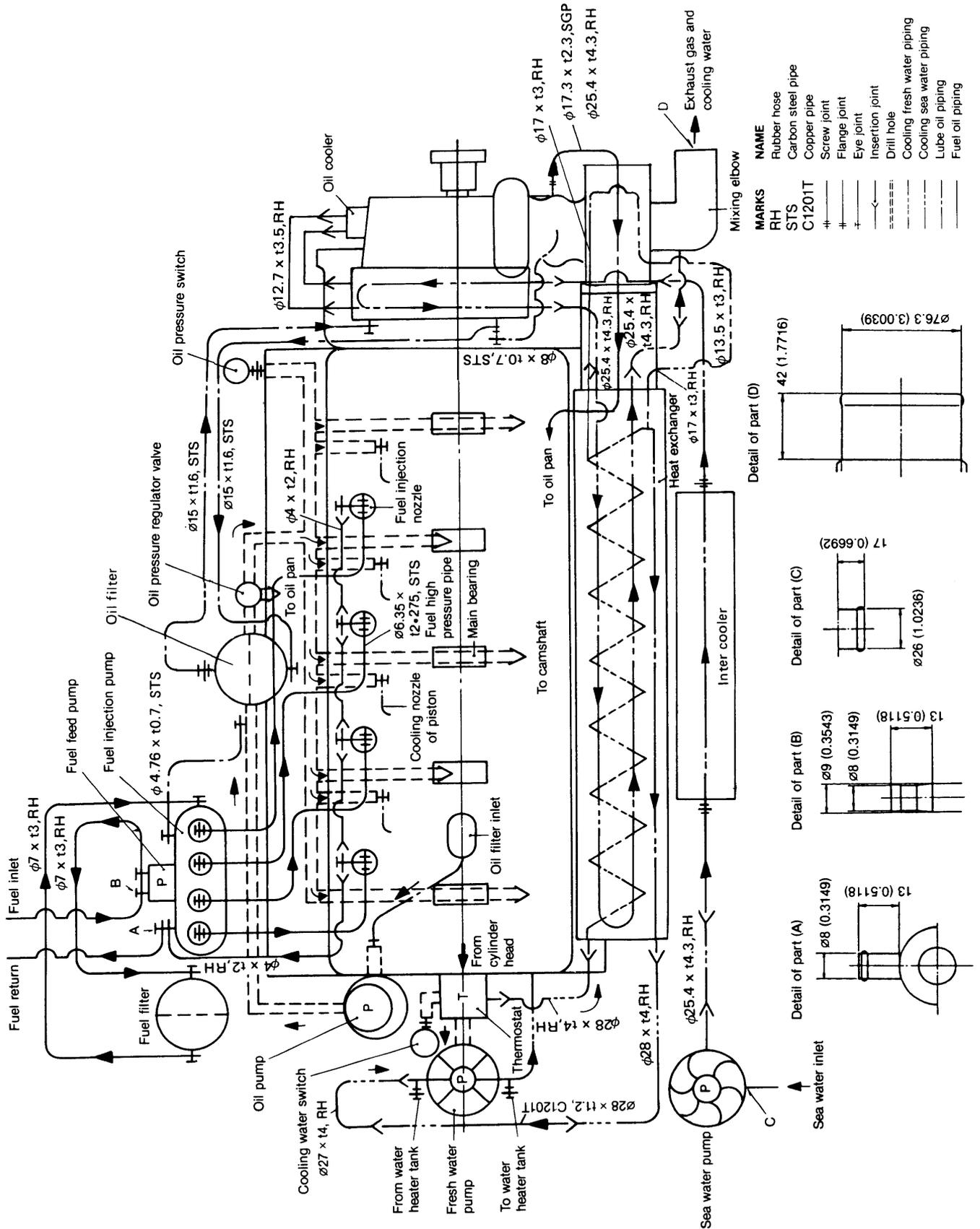
7-2 4JH-TE



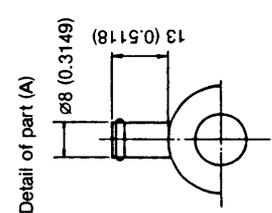
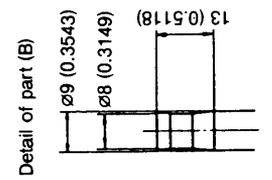
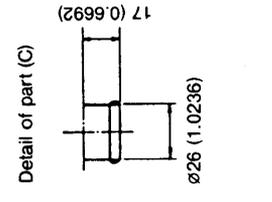
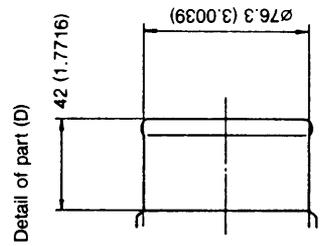
MARKS	NAME
RH	Rubber hose
STS	Carbon steel pipe
C1201T	Copper pipe
+	Screw joint
+	Flange joint
+	Eye joint
+	Insertion joint
+	Drill hole
---	Cooling fresh water piping
---	Cooling sea water piping
---	Lube oil piping
---	Fuel oil piping



7-3 4JH-HTE & 4JH-DT(B)E



MARKS	NAME
RH	Rubber hose
STS	Carbon steel pipe
C1201T	Copper pipe
+	Screw joint
#	Flange joint
*	Eye joint
— —	Insertion joint
—•—	Drill hole
---	Cooling fresh water piping
----	Cooling sea water piping
.....	Lube oil piping
-----	Fuel oil piping

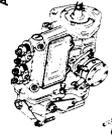
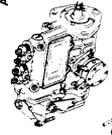
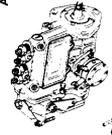
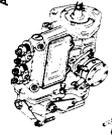
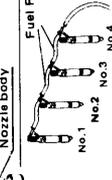
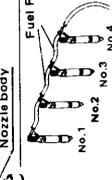
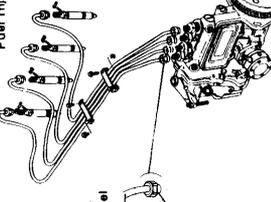
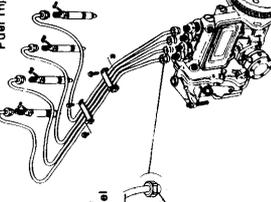


8. Parts Interchangeability

4JH-Series Parts Interchangeability (Cylinder Head Assembly, Piston and FIE)

IMPORTANT:

There is no interchangeability between the old type and the new type parts.
To ensure the parts interchangeability among the 4JH series engines, be sure to change all the relative parts as follows.

CHANGE PARTS		ENGINE MODEL	4JHE	4JH-TE	4JH-HTE	4JH-DTE	Note.
1) Cylinder Head Ass'y	Old type	Part code: Swirl ratio: Identification mark:	729470-11700 2.25 1	□	729474-11700 2.0 5	□	Applicable ENG. model I.D. mark 
	New type	Part code: Swirl ratio: Identification mark:	729470-11701 2.8 SL	729474-11701 2.0 SG	□	□	Applicable ENG. model I.D. mark 
2) Piston	Old type	Part code: Identification mark:	129400-22020 1	129472-22010 2	129474-22010 5	□	Applicable ENG. model I.D. mark 
	New type	Part code: Identification mark:	129400-22021 A	129472-22011 B	129474-22010 C (only changed I.D. mark)	□	Applicable ENG. model I.D. mark 
3) - 1 Automatic Timer Ass'y (Automatic Advancing Timer)	Old type	Part code: Advanced angle: Cam. deg. Identification mark:	729470-54101 5.5 JH-A1	729472-54100 3.5 JH-B0	729499-54100 2.5 JH-C0	□	Applicable ENG. model I.D. mark 
	New type	Part code: Advanced angle: Cam. deg. Identification mark:	729100-54100 4 TN-A0	729499-54100 2.5 JH-C0	□	□	Applicable ENG. model I.D. mark 
3) - 2 Fuel Injection Nozzle Ass'y	Old type	Part code: Identification mark: Nozzle identification mark:	729470-53101 E 155P244J1	729472-53100 B 150P284J0	729499-53100 D 145P265J1	□	Applicable ENG. model I.D. mark   
	New type	Part code: Identification mark: Nozzle identification mark:	129470-53102 F 155P244J2	729499-53102 G 140P255J2	□	□	Applicable ENG. model I.D. mark   
3) - 3 Fuel Return Pipe	Old type	Part code: Length:	129470-59550 90mm	□	□	□	Applicable ENG. model I.D. mark 
	New type	Part code: Length:	121250-59550 120mm	□	□	□	Applicable ENG. model I.D. mark 
3) - 4 Fuel Injection Pipe (Pump to Nozzle)	Old type	Part code: (No. 1. Cylinder) (No. 2. Cylinder) (No. 3. Cylinder) (No. 4. Cylinder) Size: Inner dia, Length, Identification mark:	129470-59810 129470-59820 129470-59830 129470-59840 φ1.8 400mm None	□	129499-59810 129499-59820 129499-59830 129499-59840 φ2.0 400mm None	□	Applicable ENG. model I.D. mark 
	New type	Part code: (No. 1. Cylinder) (No. 2. Cylinder) (No. 3. Cylinder) (No. 4. Cylinder) Size: Inner dia, Length, Identification mark:	129470-59811 129470-59821 129470-59831 129470-59841 φ1.8 400mm 18	□	129499-59811 129499-59821 129499-59831 129499-59841 φ2.0 400mm 20	□	Applicable ENG. model I.D. mark 

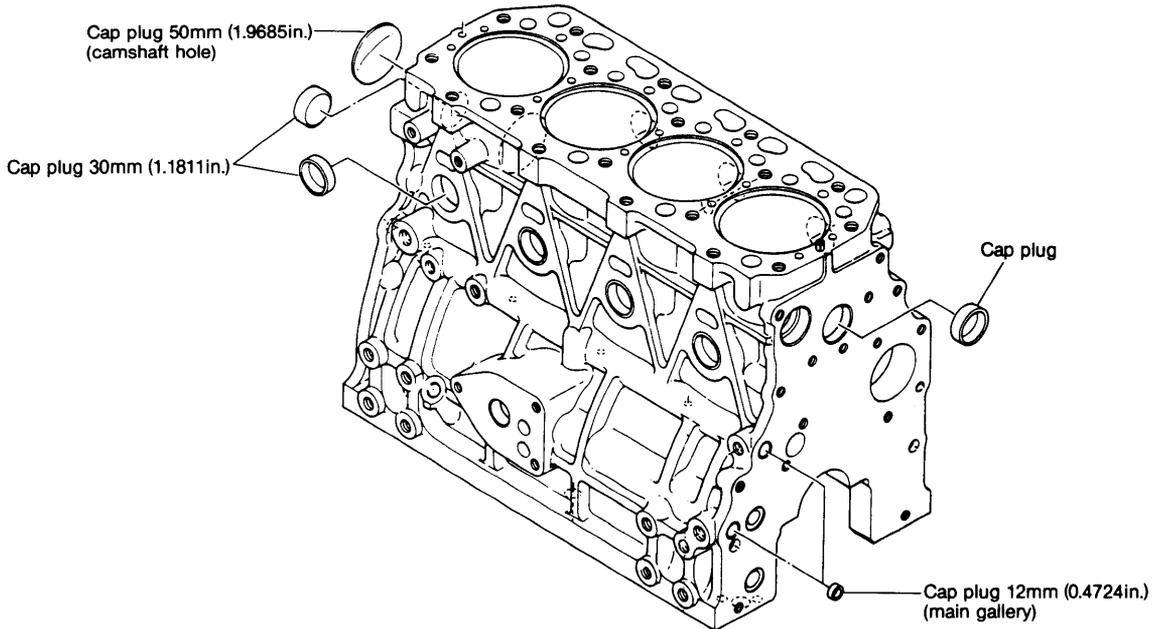
Applicable Engine Model and Engine Number:
4JHE, E/#01001 and after (Jun., '85 YANMAR Plant)
4JH-TE, E/#11001 and after (Jun., '85 YANMAR Plant)
4JH-HTE, E/#21001 and after (Jun., '85 YANMAR Plant)
4JH-DTE, E/#30101 and after (Jun., '85 YANMAR Plant)

INSPECTION AND SERVICING OF BASIC ENGINE PARTS

1. Cylinder Block	2-1
2. Cylinder Liners	2-4
3. Cylinder Head	2-6
4. Piston and Piston Pins	2-13
5. Connecting Rod	2-17
6. Crankshaft and Main Bearing	2-20
7. Camshaft and Tappets	2-23
8. Timing Gear	2-26
9. Flywheel and Housing	2-28

1. Cylinder Block

The cylinder block is thin-skinned, (low-weight), short skirt type with rationally placed ribs. The side walls are wave shaped to maximize rigidity for strength and low noise.



1-1 Inspection of parts

Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

1-2 Cleaning of oil holes

Clean all oil holes, making sure that none are clogged up and the blind plugs do not come off.

Color check kit
Part code No. 97550-004560

	Quantity
Penetrant	1
Developer	2
Cleaner	3

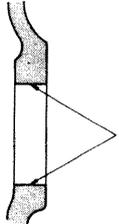


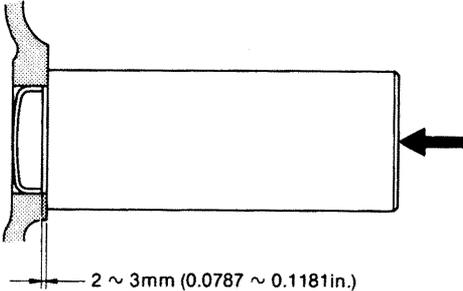
1-3 Color check procedure

- (1) Clean the area to be inspected.
- (2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.
- (3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
- (4) Spray on red penetrant
After cleaning, spray on the red penetrant and allow 5 ~ 10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.
- (5) Spray on developer
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.
Hold the developer 300 ~ 400mm (11.8110 ~ 15.7480in.) away from the area being inspected when spraying, making sure to coat the surface uniformly.
- (6) Clean the surface with the cleaner.

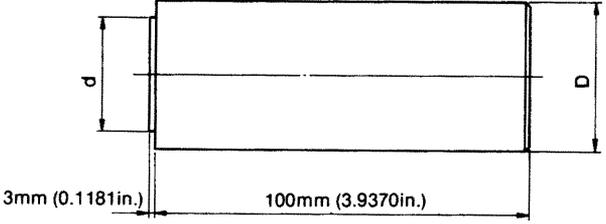
NOTE: Without fail, read the instructions for the color check kit before use.

1-4 Replacement of cup plugs

Step No.	Description	Procedure	Tool or material used
1.	Clean and remove grease from the hole into which the cup plug is to be driven. (Remove scale and sealing material previously applied.)	 <p>Remove foreign materials with a screw driver or saw blade.</p>	<ul style="list-style-type: none"> •Screw driver or saw blade •Thinner
2.	Remove grease from the cup plug.	Visually check the nick around the plug.	•Thinner
3.	Apply Threebond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	•Threebond No. 4
4.	Insert the plug into the hole.	Insert the plug so that it sits correctly.	
5.	Place a driving tool on the cup plug and drive it in using a hammer.	Drive in the plug parallel to the seating surface.	<ul style="list-style-type: none"> •Driving tool •Hammer



2 ~ 3mm (0.0787 ~ 0.1181in.)



3mm (0.1181in.) 100mm (3.9370in.)

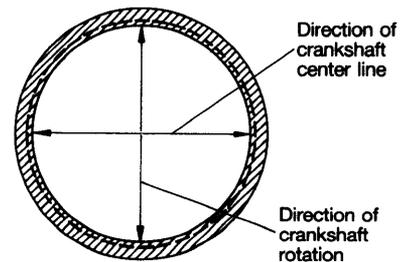
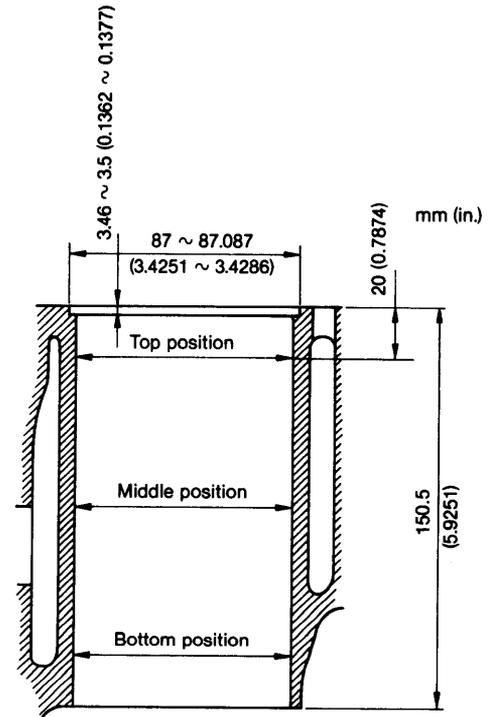
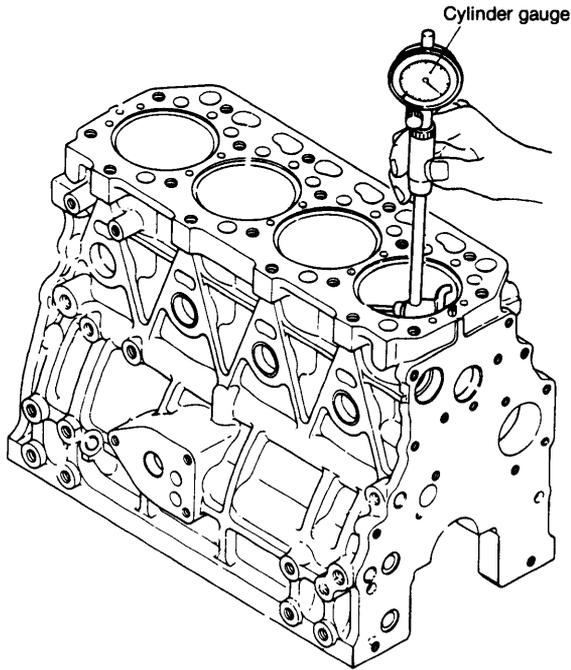
Plug dia.	mm (in.)	
	d	D
ø12	ø11.9 ~ 12.0 (ø0.4685 ~ 0.4724)	ø20 (ø0.7874)
ø30	ø29.9 ~ 30.0 (ø1.1770 ~ 1.8110)	ø40 (ø1.5748)

*Using the special tool, drive the cup plug to a depth where the edge of the plug is 2mm (0.0787in.) below the cylinder surface.

1-5 Cylinder bore measurement

Measure the bore diameter with a cylinder gauge at the positions shown in the figure.

Replace the cylinder bore when the measured value exceeds the wear limit. Measurement must be done at least at 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions along the crankshaft rotation and crankshaft center lines.

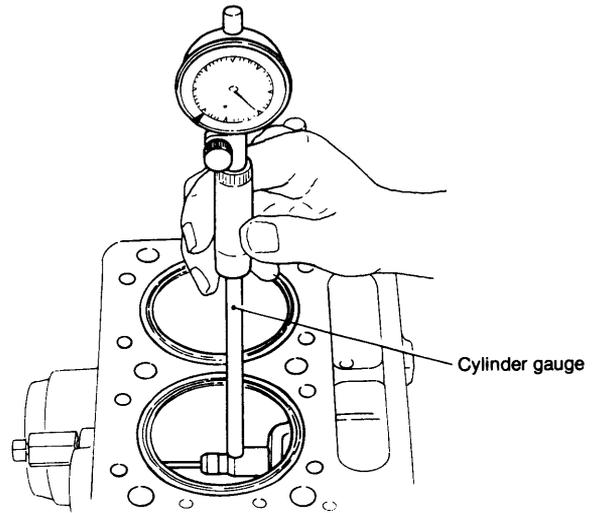
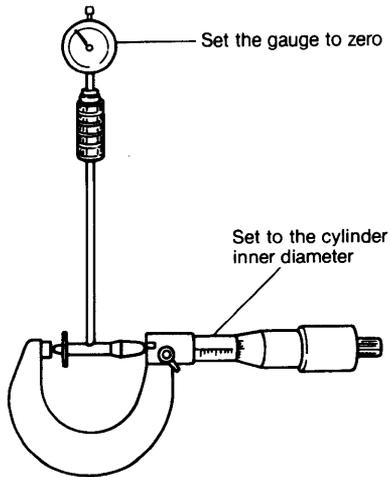


	mm (in.)	
	Standard	Wear limit
Cylinder bore dia.	ø82.00 ~ 82.03 (3.2283 ~ 3.2295)	ø82.06 (3.2307)
Cylinder roundness	0 ~ 0.01 (0 ~ 0.0004)	0.02 (0.0008)

2. Cylinder Liners

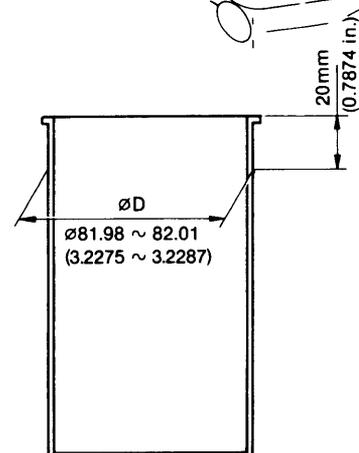
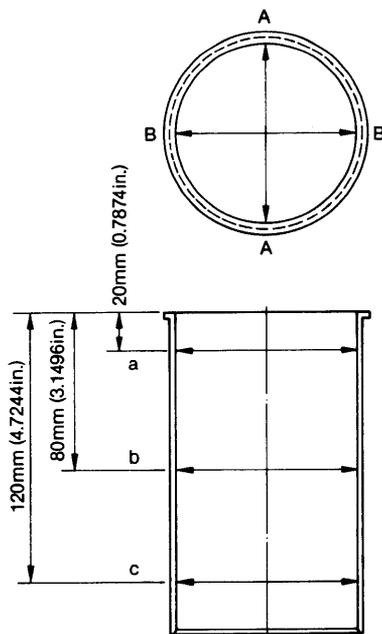
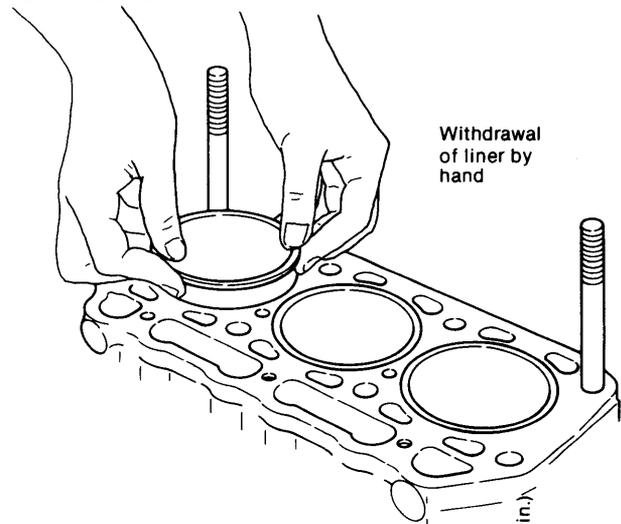
2-1 Measuring cylinder liners

Measure the inner diameter of each cylinder with a cylinder gauge and replace the cylinder liner if it exceeds the wear limit.



2-2 Inserting cylinder liners

Coat the outside of the liner with oil, and insert lightly by hand. Do not tap with a wooden hammer as this may deform the liner.

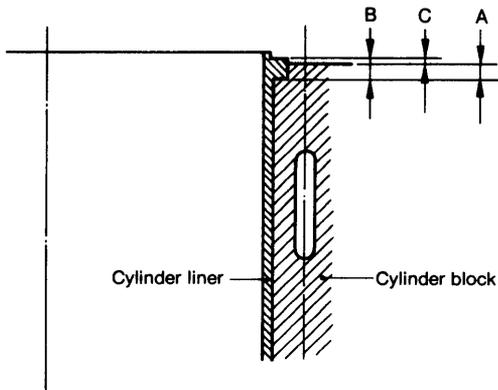


	mm (in.)	
	Standard	Wear limit
Cylinder liner	$\varnothing 78.00 \sim 78.03$ ($\varnothing 3.0708 \sim 3.0720$)	$\varnothing 78.12$ ($\varnothing 3.0755$)

NOTE: Be sure to measure A-A, B-B and a, b and c

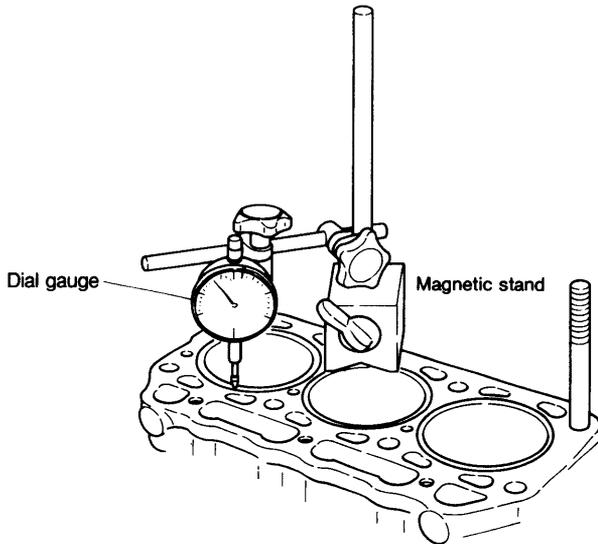
2-3 Measuring cylinder liner projection

Make sure the cylinder liner flange projects only slightly above the block.



	mm (in.)
A	3.46 ~ 3.50 (0.1362 ~ 0.1378)
B	3.53 ~ 3.55 (0.1390 ~ 0.1398)
C	0.03 ~ 0.09 (0.0011 ~ 0.0035)

NOTE: Excessive cylinder liner projection is frequently caused by incomplete removal of the rust on the ledge (Part D of figure) of the cylinder block.

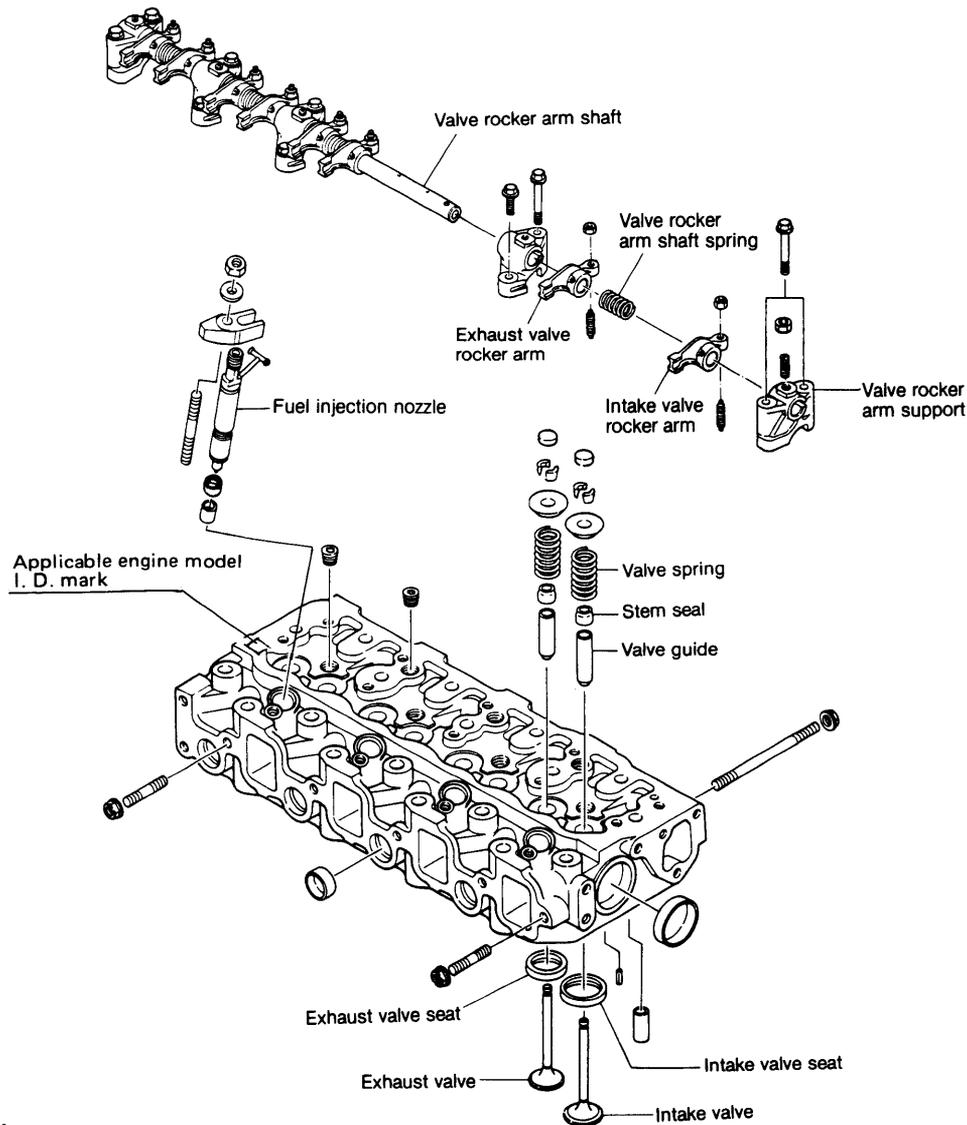


3. Cylinder Head

The cylinder head is of 4-cylinder integral construction, mounted with 18 bolts. Special alloy stellite with superior resistance to heat and wear is fitted on the seats, and the area between the valves is cooled by a water jet.

IMPORTANT:

Cylinder head assembly differs among engine models. If an incorrect cylinder head is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the cylinder head assembly to insure use of the correct part.



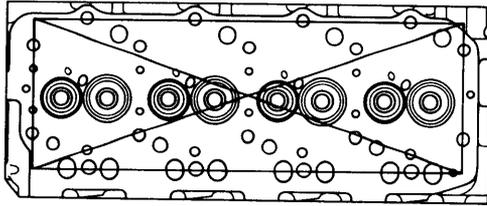
Cylinder Head Ass'y

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	1	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	SL	4JHE	E/#01001 and after
	SG	4JH-TE	E/#11001 and after
	SG	4JH-HTE	E/#21001 and after
	SG	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

3-1 Inspecting the cylinder head

The cylinder head is subjected to very severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.

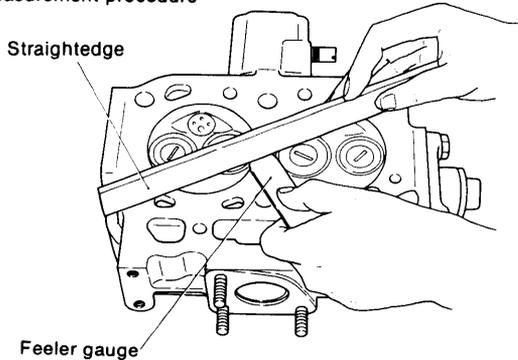


3-1.1 Distortion of the combustion surface

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

- (1) Clean the cylinder head surface.
- (2) Place a straight-edge along each of the four sides and each diagonal. Measure the clearance between the straight-edge and combustion surface with a feeler gauge.

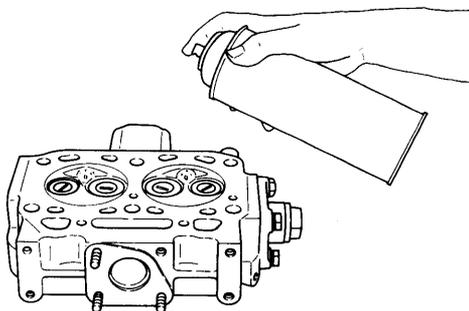
Measurement procedure



	mm (in.)	
	Standard	Wear limit
Cylinder head distortion	0.05 (0.0019) or less	0.15 (0.0059)

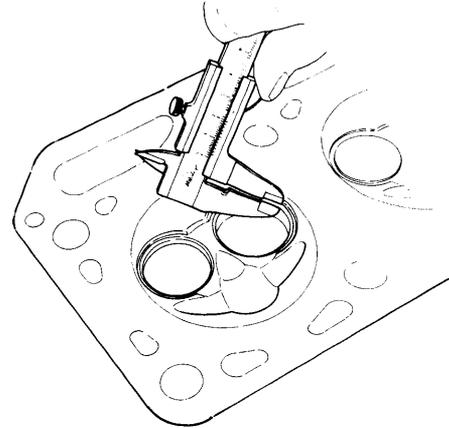
3-1.2 Checking for cracks in the combustion surface

Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.



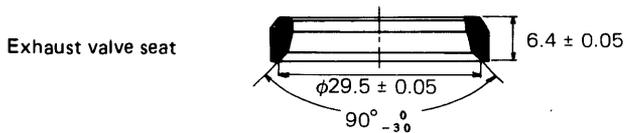
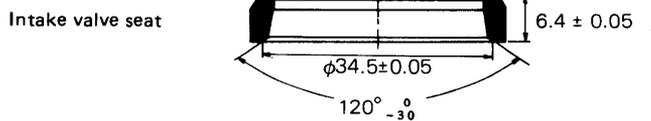
3-1.3 Checking the intake and exhaust valve seats

Check the surface and width of the valve seats. If they are too wide, or if the surfaces are rough, correct to the following standards:

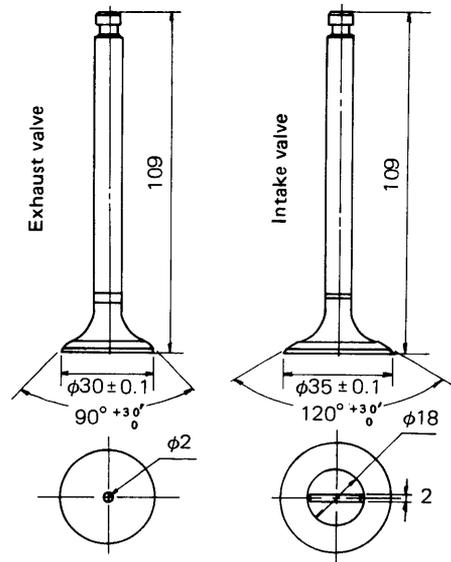


Seat angle	Intake	120°
	Exhaust	90°

mm (in.)		
Seat width	Standard	Wear limit
Intake	1.28 (0.0504)	1.78 (0.0700)
Exhaust	1.77 (0.0697)	2.27 (0.0894)



Standard dimension

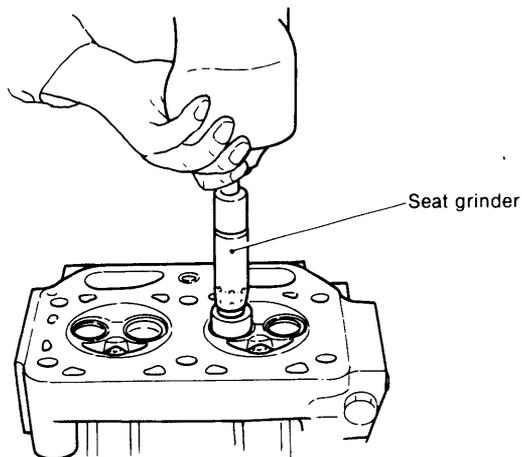


3-2 Valve seat correction procedure

The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

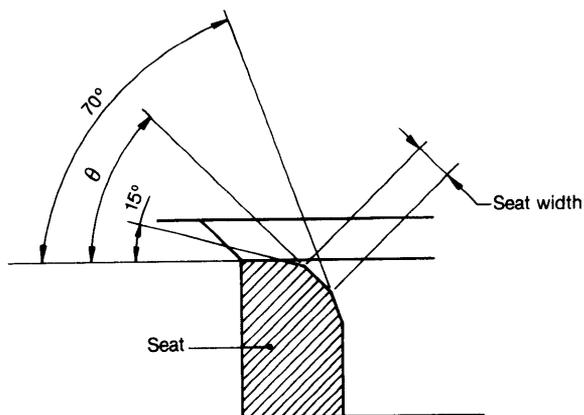
(1) Use a seat grinder to make the surface even.

As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder.

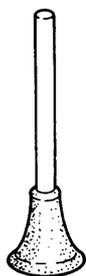


Seat grinder	Intake valve	30°
	Exhaust valve	45°

NOTE: When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.

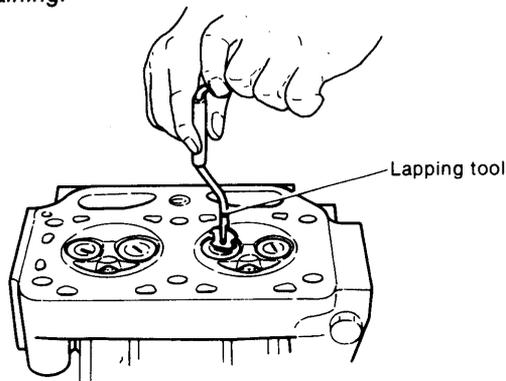


- (2) Knead valve compound with oil and finish the valve seat with a lapping tool.
- (3) Final finishing should be done with oil only.



Lapping tool
Use a rubber cap type lapping tool for cylinders without a lapping tool groove slit.

NOTE: Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed, and make sure that there are no grindings remaining.

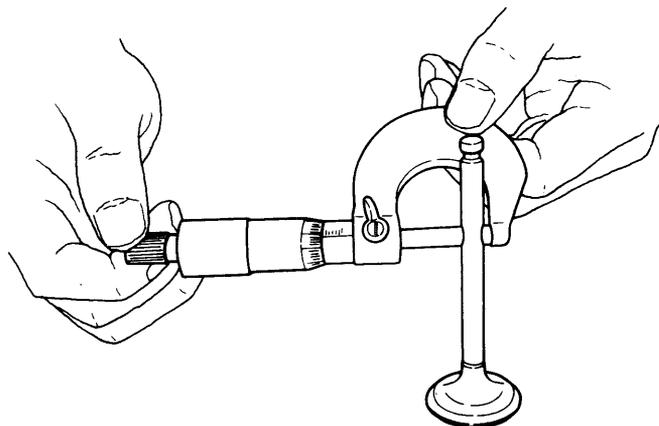
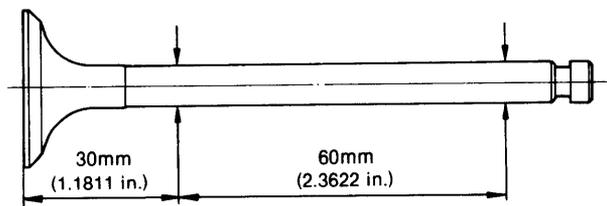


- NOTE: 1. Insert adjusting shims between the valve spring and cylinder head when seats have been re-finished with a seat grinder.
2. Measure valve distortion after valve seat re-finishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

3-3 Intake/exhaust valves, valve guides

3-3.1 Wearing and corrosion of valve stem

Replace the valve if the valve stem is excessively worn or corroded.



Valve stem outside dia.	Standard	Wear limit
Intake	ø7.960 ~ 7.975 (ø0.3134 ~ 0.3140)	-0.13 (-0.0051)
Exhaust	ø7.955 ~ 7.970 (ø0.3132 ~ 0.3138)	-0.13 (-0.0051)

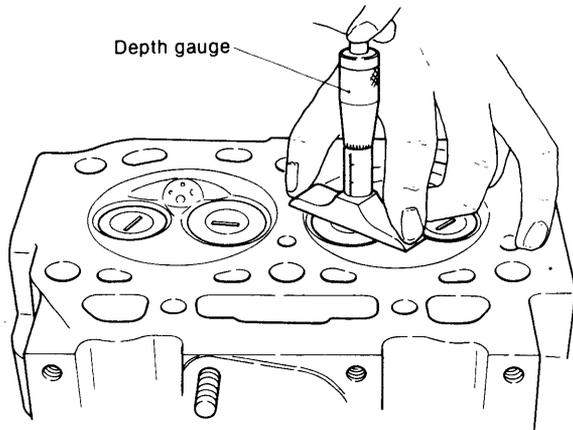
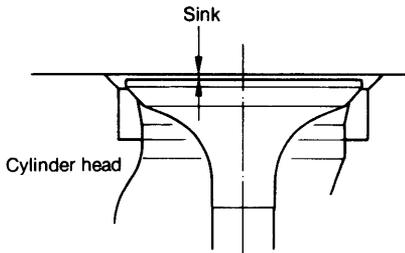
3-3.2 Inspection of valve seat wear and contact surface

Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

NOTE: Keep in mind the fact that the intake and discharge valve have different diameters.

3-3.3 Valve sinking

Over long periods of use and repeated lappings, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.



	mm (in.)	
	Standard	Wear limit
Valve sink	0.4 ~ 0.6 (0.0157 ~ 0.0236)	1.5 (0.0590)

3-3.4 Valve guide

(1) Measuring inner diameter of valve guide.

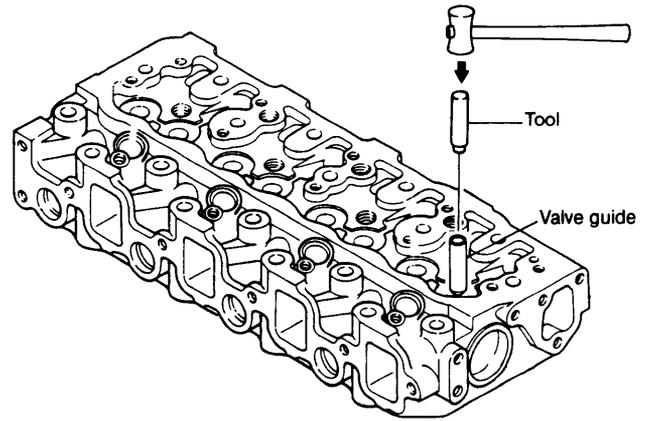
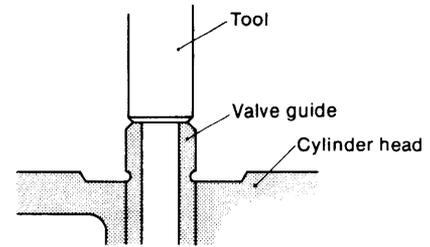
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

		mm (in.)	
		Standard	Wear limit
Valve guide inside dia.	Intake	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)
	Exhaust	ø8.015 ~ 8.030 (ø0.3156 ~ 0.3161)	+0.2 (0.0079)

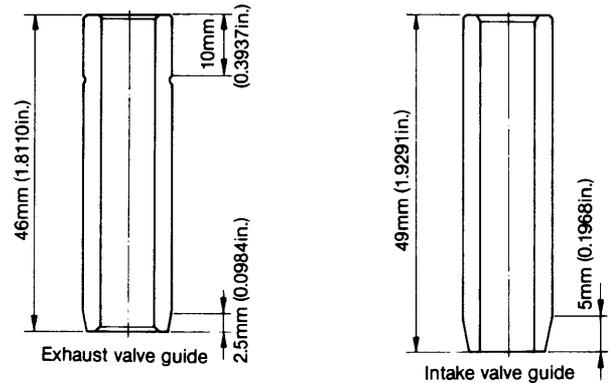
NOTE: The inner diameter standard dimensions assume a pressure fit.

(2) Replacing the valve guide

Use the insertion tool and tap in the guide with a mallet.

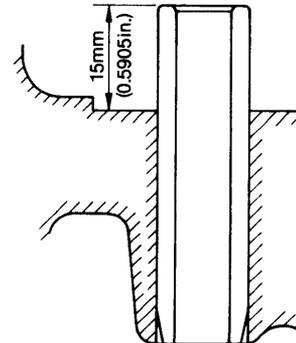


The intake valve guide and exhaust valve guide are of different shapes/dimensions. The one with a groove around it is the exhaust valve guide and the one without is the intake valve guide.



(3) Valve guide projection

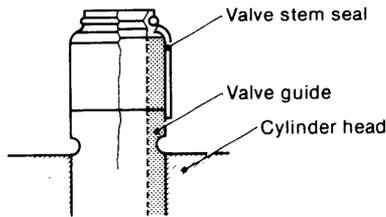
The valve guide should project 15mm from the top of the cylinder head.



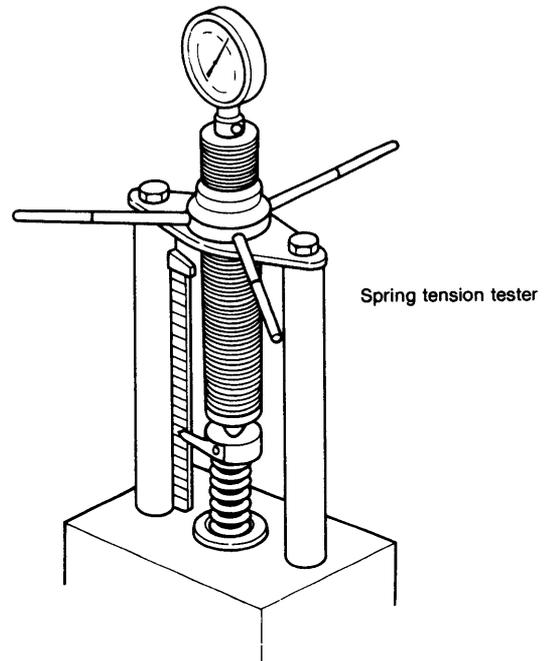
(4) Valve stem seals

The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed—be sure to replace them.

When assembling the intake/exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting them.



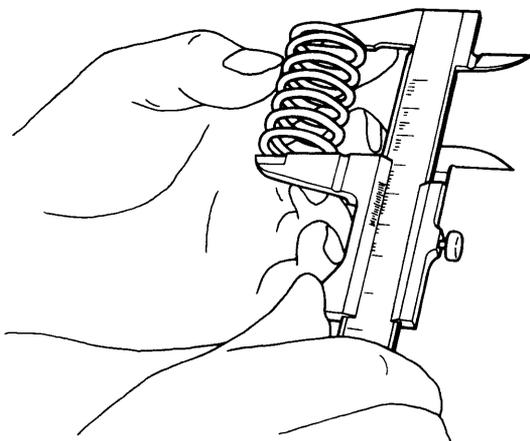
(4) Measure spring tension.



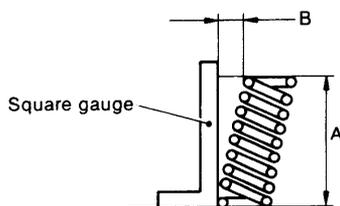
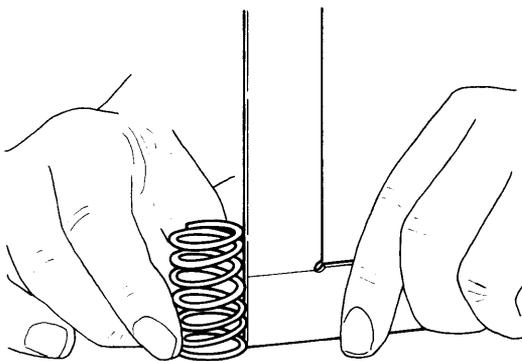
3-4 Valve springs

3-4.1 Checking valve springs

- (1) Check the spring for scratches or corrosion.
- (2) Measure the free length of the spring.



(3) Measure inclination.

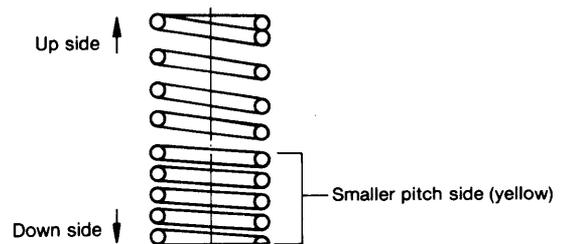


mm (in.)

Valve spring	Standard	Wear limit
Free length	44.4 (1.7480)	43 (1.6929)
Length when attached	40 (1.5748)	—
Load when attached	12kg (26.46 lb.)	10kg (22.05 lb.)

Assembling valve springs

The side with the smaller pitch (painted yellow) should face down (cylinder head).



NOTE: The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

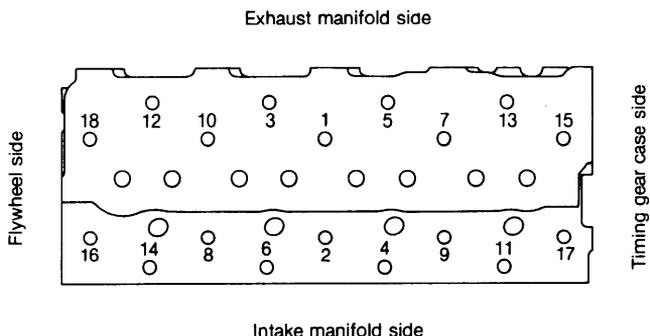
(5) Spring retainer and spring cotter

Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less than 70%, or when the spring cotter has been recessed because of wear.

3-5 Assembling the cylinder head

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful that head does not get distorted.

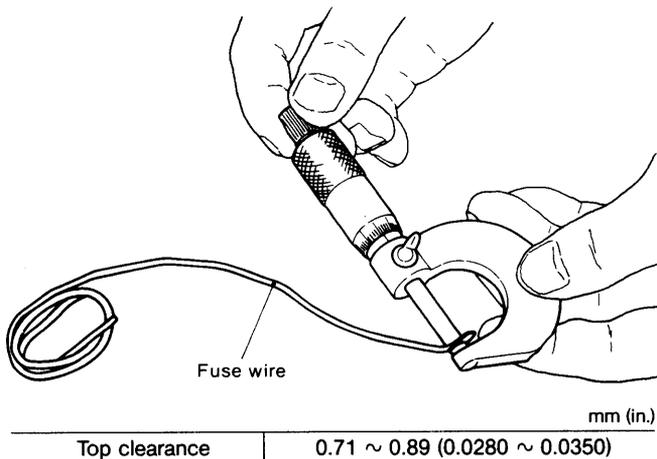
- (1) Clean out the cylinder head bolt holes.
- (2) Check for foreign matter on the cylinder head surface that comes in contact with the block.
- (3) Coat the head bolt threads and nut seats with lube oil.
- (4) Use the positioning pins to line up the head gasket with the cylinder block.
- (5) Match up the cylinder head with the head gasket and mount.



	kg-m (ft-lb)	
	First	Second
Tightening torque	3.5 ~ 4.5 (25.32 ~ 32.55)	7.5 ~ 8.5 (54.25 ~ 61.48)

3-6 Measuring top clearance

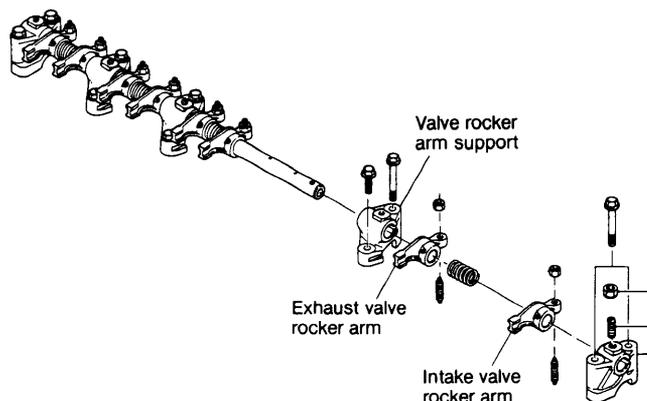
- (1) Place a high quality fuse (ø1.5mm (0.0591in.), 10mm (0.3937in.) long) in three positions on the flat part of the piston head.
- (2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
- (3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
- (4) Remove the head and take out the broken fuse.
- (5) Measure the three positions where each fuse is broken and calculate the average.
(0.71 ~ 0.75mm (0.0280 ~ 0.0295in.) is ideal)



	mm (in.)
Top clearance	0.71 ~ 0.89 (0.0280 ~ 0.0350)

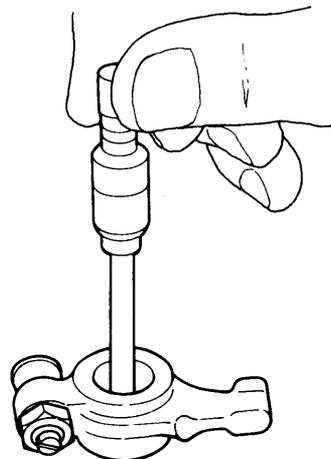
3-7 Intake and exhaust valve arms

Valve arm and valve arm bushing wear may change opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



(1) Valve arm shaft and valve arm bushing

Measure the outer diameter of the shaft and the inner diameter of the bearing, and replace if wear exceeds the limit.



		mm (in.)	
		Standard	Wear limit
Intake and exhaust valve rocker arm shaft outside dia.	A	15.966 ~ 15.984 (0.6285 ~ 0.6292)	15.955 (0.6281)
Intake and exhaust valve rocker arm bushing inside dia. (assembled)	B	16.000 ~ 16.018 (0.6299 ~ 0.6306)	16.090 (0.6334)
Valve rocker arm shaft and bushing clearance at assembly		0.016 ~ 0.052 (0.0006 ~ 0.0020)	0.135 (0.0053)

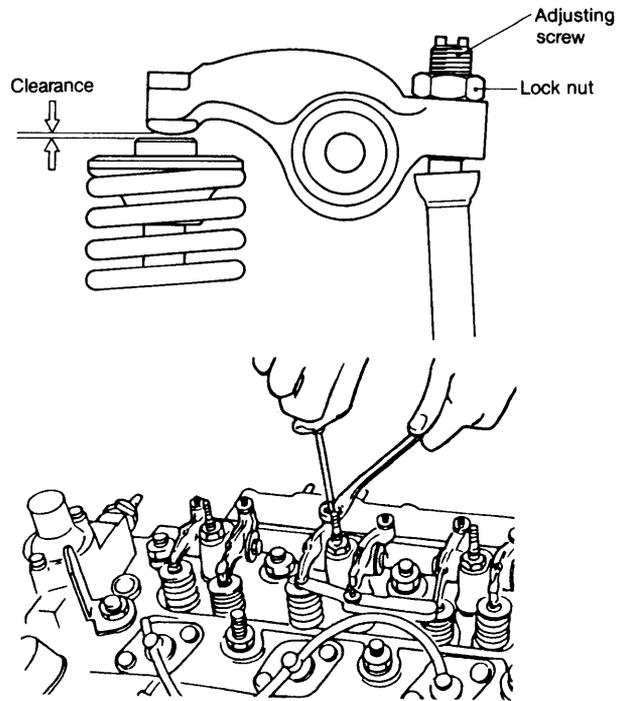
Replace the valve arm shaft bushing if it moves and replace the entire valve arm if there is no tightening clearance.

- (2) Valve arm spring
Check the valve arm spring and replace it if it is corroded or worn.
- (3) Valve arm and valve top retainer wear
Inspect the contact surface of the valve arm and replace it if there is abnormal wear or flaking.
- (4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.

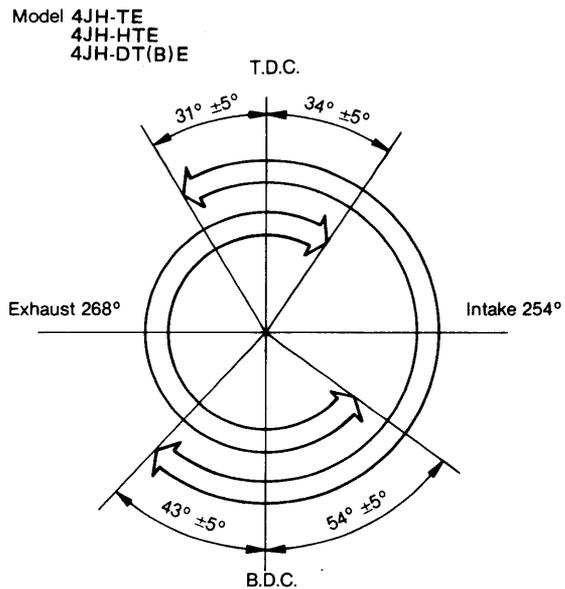
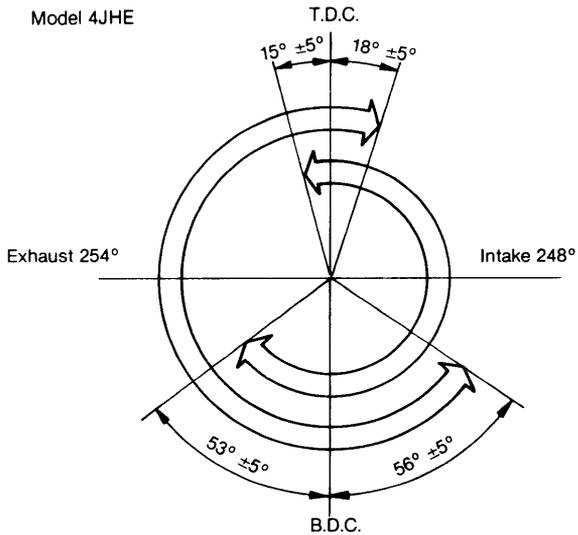
3-8 Adjustment of valve head clearance

- (1) Make adjustments when the engine is cool.

	mm (in.)
Intake and exhaust head clearance	0.2 (0.0079)



- (2) Be sure that the opening and closing angles for both the intake and the exhaust valves are checked when the timing gear is disassembled (The gauge on the flywheel is read when the push rod turns the flywheel).



		4JHE	4JH-TE 4JH-HTE 4JH-DT(B)E
Intake valve open	b. TDC	10° ~ 20°	26° ~ 36°
Intake valve closed	a. BDC	48° ~ 58°	38° ~ 48°
Exhaust valve open	b. BDC	51° ~ 61°	49° ~ 59°
Exhaust valve closed	a. TDC	13° ~ 23°	29° ~ 39°

4. Pistons and Piston Pins

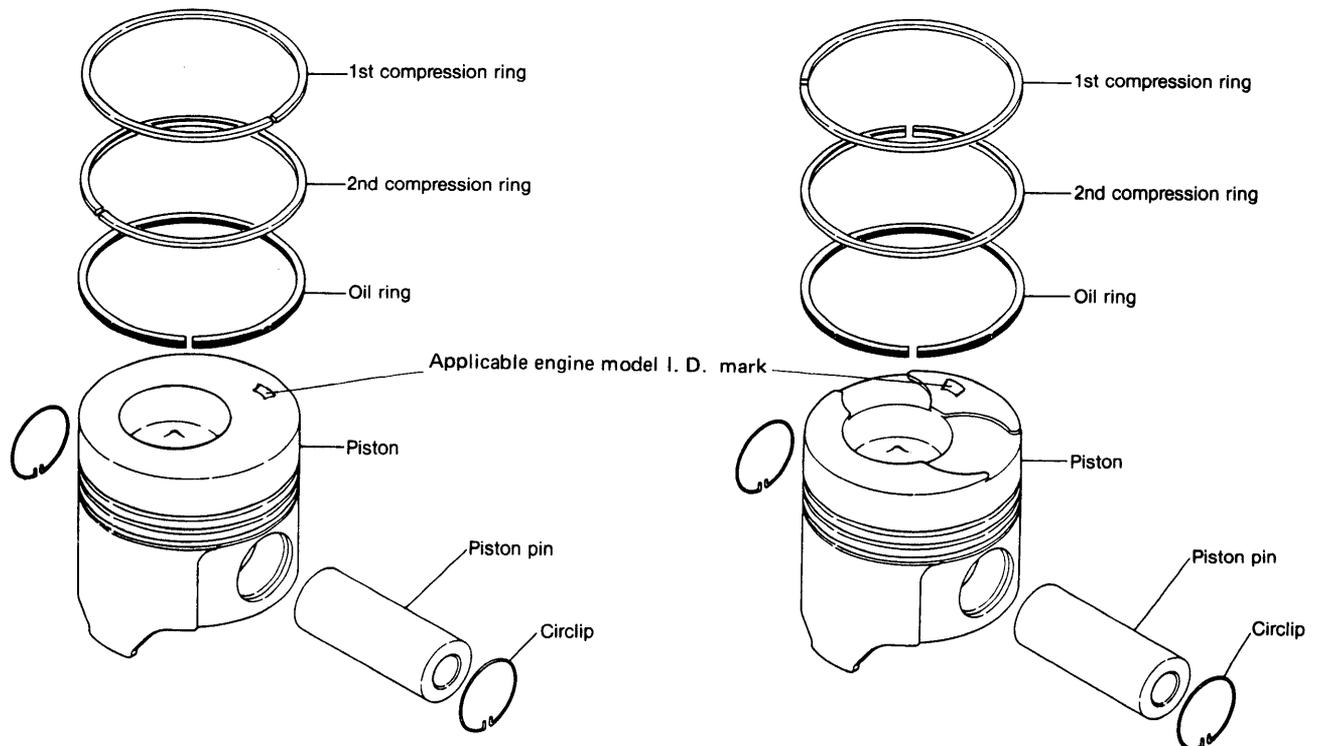
Pistons are made of a special light alloy with superior thermal expansion characteristics, and the top of the piston forms a swirl type toroidal combustion chamber. The opposite face of the piston combustion surface is oil-jet cooled.

Pistons for engines with superchargers have a valve recess for the intake and exhaust valves.

The clearance between the piston and cylinder liner is kept at the proper value by the piston and cylinder liner property fit effected during assembly at the Yanmar factory.

IMPORTANT:

Piston shape differs among engine models. If an incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the piston to insure use of the correct part.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

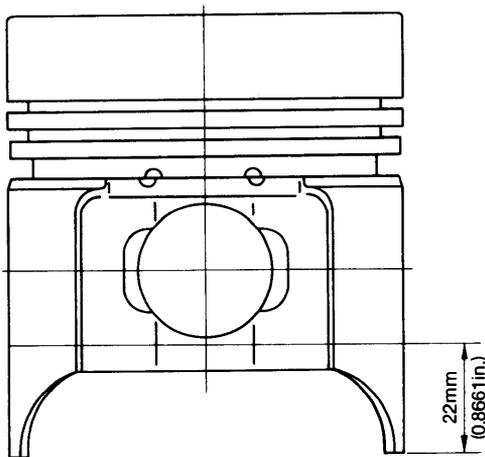
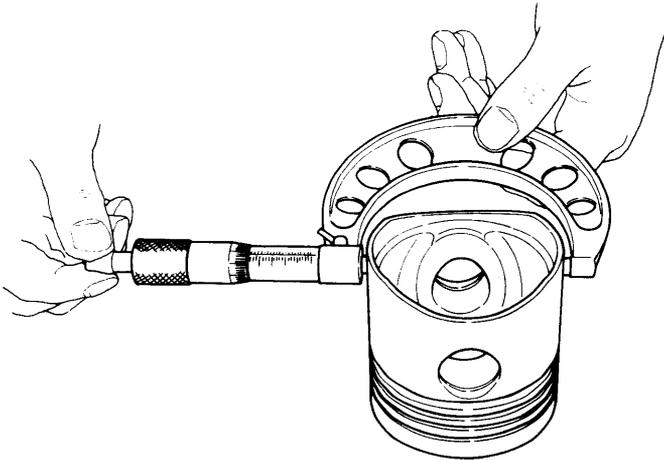
4-1 Piston

4-1.1 Piston head and combustion surface

Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.

4-1.2 Measurement of piston outside diameter/inspection

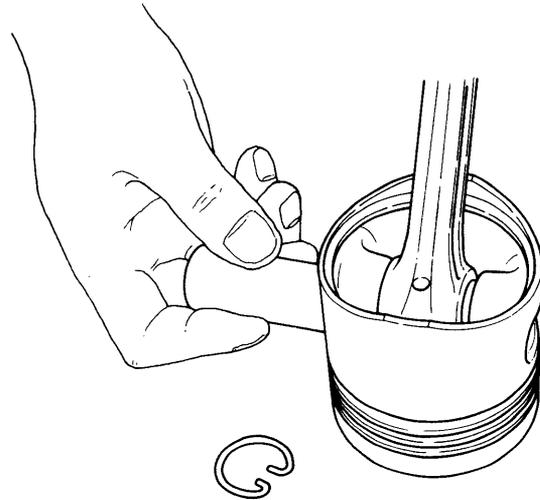
- (1) Replace the piston if the outsides of the piston or ring grooves are worn.
- (2) Measure the piston 22mm (0.8661in.) from the bottom at right angles to the piston pin.



mm (in.)	
Standard	Wear limit
77.91 ~ 77.94 (3.0673 ~ 3.0685)	77.81 (3.0633)

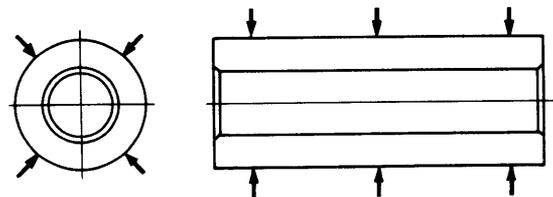
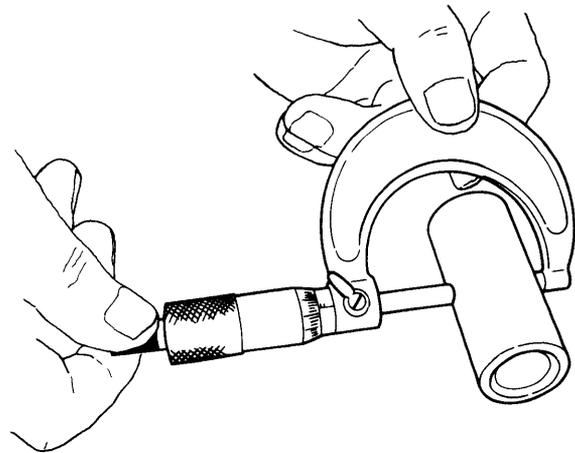
4-1.3 Replacing the piston

A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



4-2 Piston pin

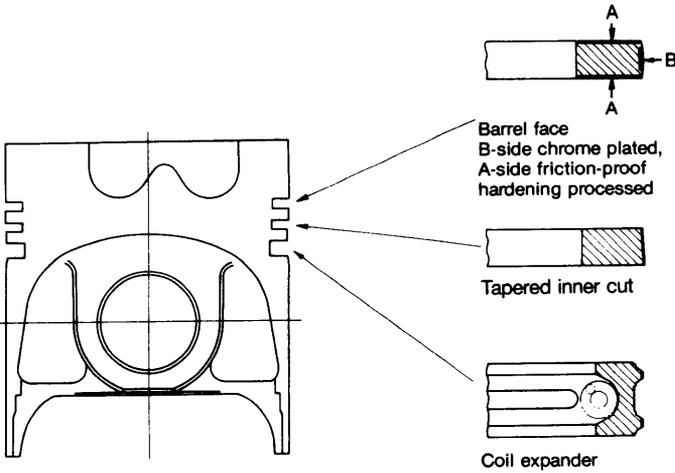
Measure the outer diameter and replace the pin if it is excessively worn.



	mm (in.)	
	Standard	Wear limit
Piston pin insert hole dia.	ø26.000 ~ 26.009 (ø1.0236 ~ 1.0240)	+0.020 (0.0008)
Piston pin outside dia.	ø25.987 ~ 26.000 (ø1.0231 ~ 1.0236)	-0.025 (0.0009)
Standard clearance	0 ~ 0.022 (0 ~ 0.0009)	0.045 (0.0018)

4-3 Piston rings

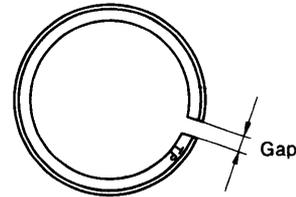
There are 2 compression rings and 1 oil ring.
The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.



		mm (in.)	
		Standard	Wear limit
First piston ring	Groove width	2.060 ~ 2.075 (0.0811 ~ 0.0816)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.070 ~ 0.100 (0.0027 ~ 0.0039)	0.2 (0.0078)
Second piston ring	Groove width	2.025 ~ 2.040 (0.0797 ~ 0.0803)	—
	Ring width	1.975 ~ 1.990 (0.0777 ~ 0.0783)	—
	Groove and ring clearance	0.035 ~ 0.065 (0.0013 ~ 0.0025)	0.2 (0.0078)
Oil ring	Groove width	4.020 ~ 4.035 (0.1582 ~ 0.1588)	—
	Ring width	3.975 ~ 3.990 (0.1564 ~ 0.1570)	—
	Groove and ring clearance	0.030 ~ 0.060 (0.0011 ~ 0.0023)	0.2 (0.0078)

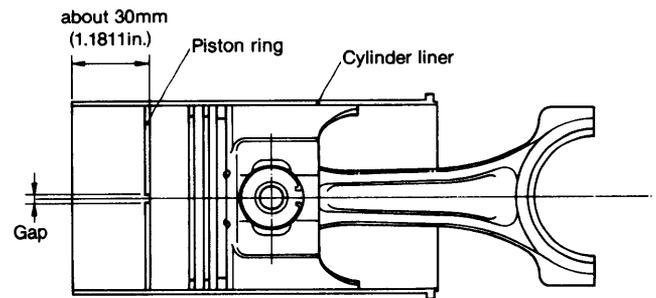
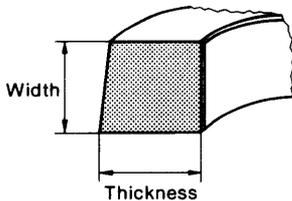
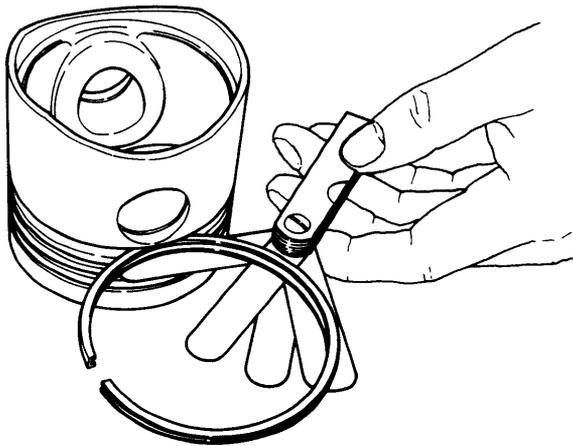
4-3.2 Measuring piston ring gap

Press the piston ring onto a piston liner and measure the piston ring gap with a gauge. Press on the ring about 30mm (1.811 in.) from the bottom of the liner.



4-3.1 Measuring the rings

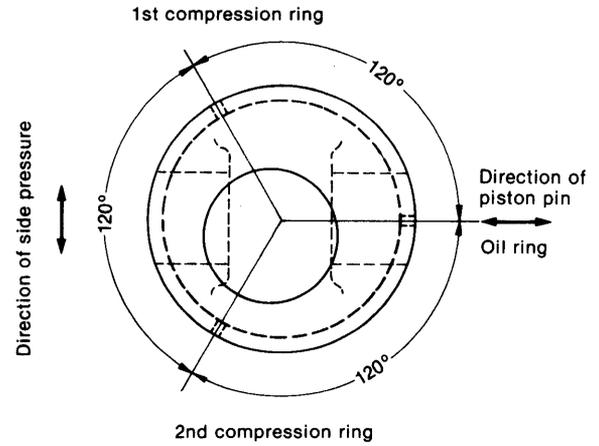
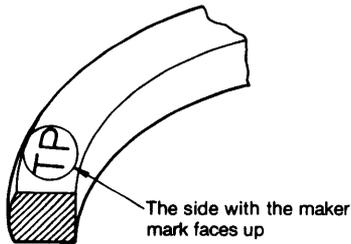
Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



		mm (in.)	
		Standard	Wear limit
First piston ring gap		0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Second piston ring gap		0.25 ~ 0.40 (0.0098 ~ 0.0157)	1.5 (0.0590)
Oil ring gap		0.20 ~ 0.40 (0.0078 ~ 0.0157)	1.5 (0.0590)

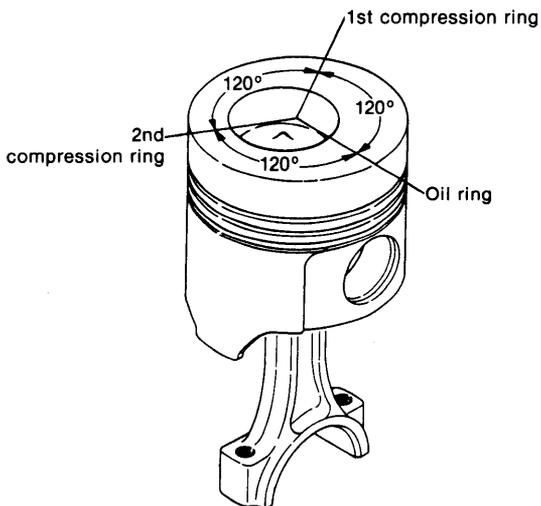
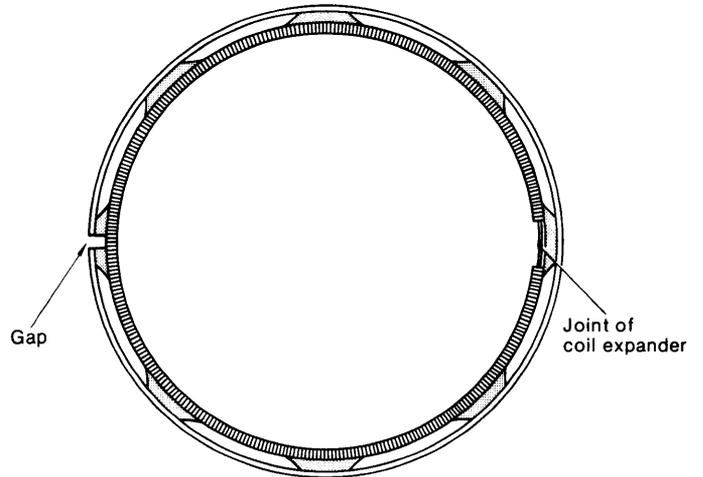
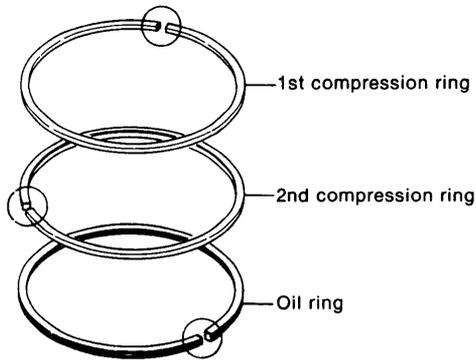
4-3.3 Replacing the piston rings

- (1) Thoroughly clean the ring grooves when replacing piston rings.
- (2) The side with the manufacturer's mark (near piston ring gap) should face up.



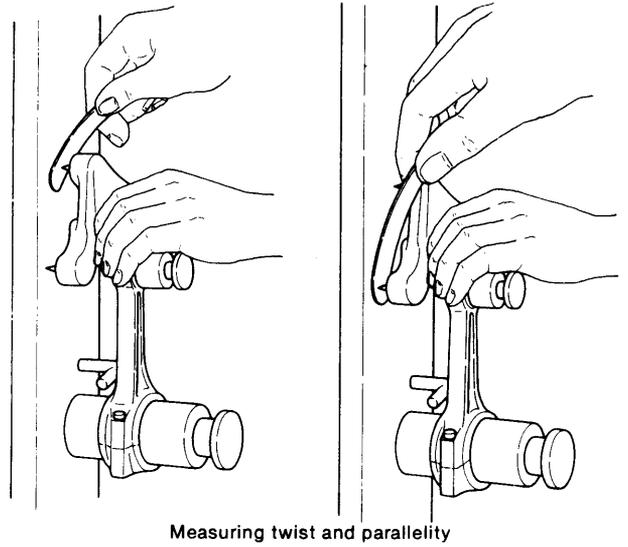
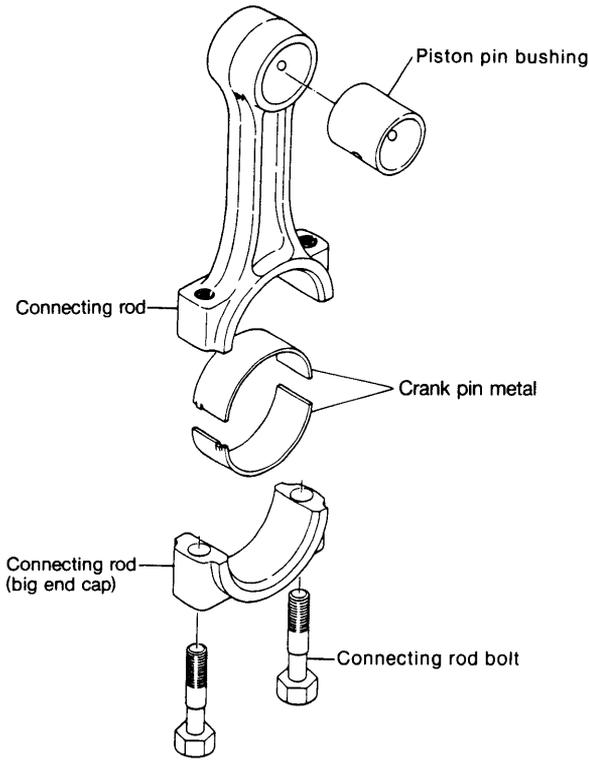
- (3) After fitting the piston ring, make sure it moves easily and smoothly.
- (4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.

- (5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



5. Connecting Rod

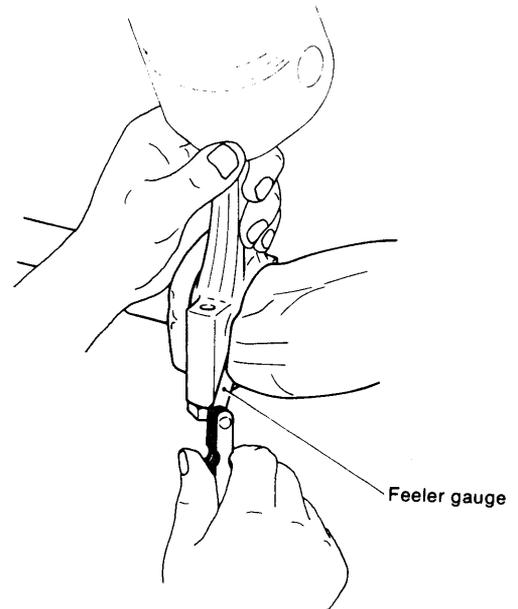
The connecting rod is made of high-strength forged carbon steel.
The large end with the 3-layer kelmet can be separated into two and the small end has a 2-layer copper alloy coil bushing.



	mm (in.)	
	Standard	Wear limit
Connecting rod twist and parallelity	0.05 (0.0019)	0.07 (0.0027)

5-1.2 Checking thrust clearance

Fit the respective crank pins to the connecting rod and check to make sure that the clearance in the crankshaft direction is correct.

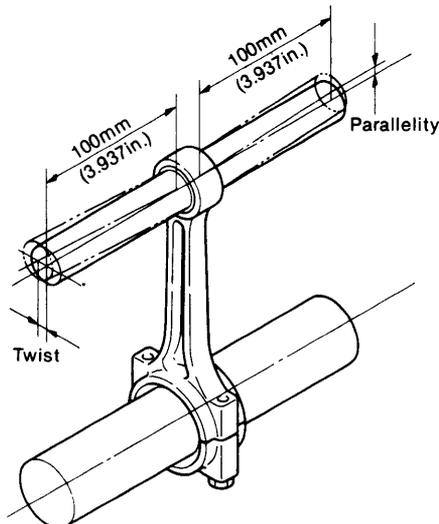


	mm (in.)	
	Standard	Wear limit
Connecting rod side clearance	0.20 ~ 0.40 (0.0078 ~ 0.0157)	0.55 (0.0216)

5-1 Inspecting the connection rod

5-1.1 Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.



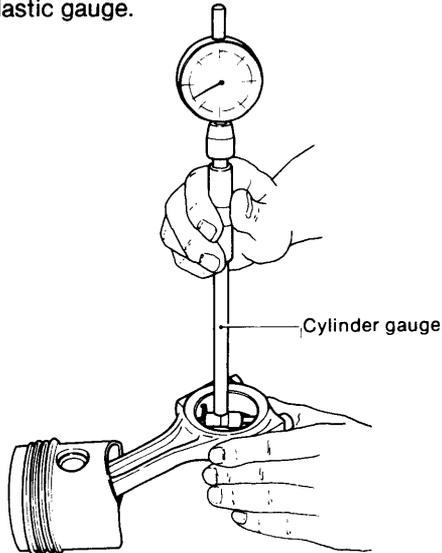
5-2 Crank pin bushing

5-2.1 Checking crank pin bushing

Check for flaking, melting or seizure on the contact surface.

5-2.2 Measuring crank pin oil clearance

Use a plastic gauge.

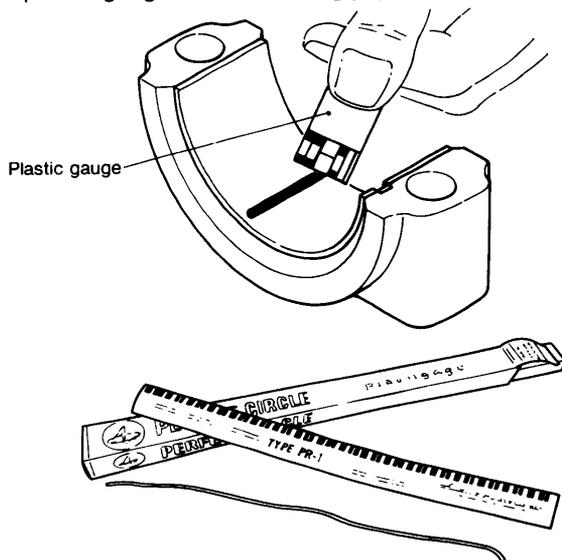


Procedure

- (1) Use the press gauge (Plastigage) for measuring oil clearance in the crank pin.
- (2) Mount the connecting rod on the crank pin (tighten to specified torque).

Connecting rod tightening torque	4.5 ~ 5.0 kg-m (32.5 ~ 36.1 ft-lb)
----------------------------------	---------------------------------------

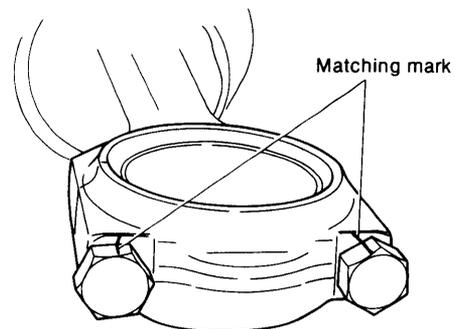
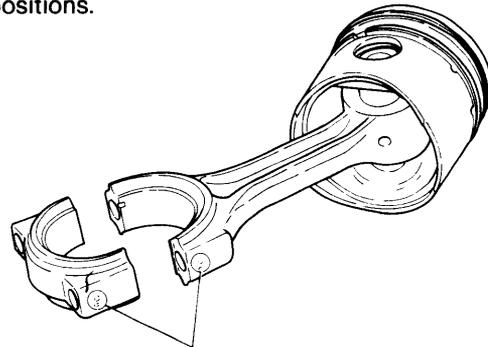
- (3) Remove the connecting rod and measure the broken plastic gauge with measuring paper.



5-2.3 Precautions on replacement of crank pin bushing

- (1) Wash the crank pin bushing.
- (2) Wash the large end cap, mount the crank pin bushing and make sure that it fits tightly on the large end cap.
- (3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.

If a torque wrench is not available, make match marks on the bolt heads and large end cap (to indicate the proper torque position) and retighten the bolts to those positions.

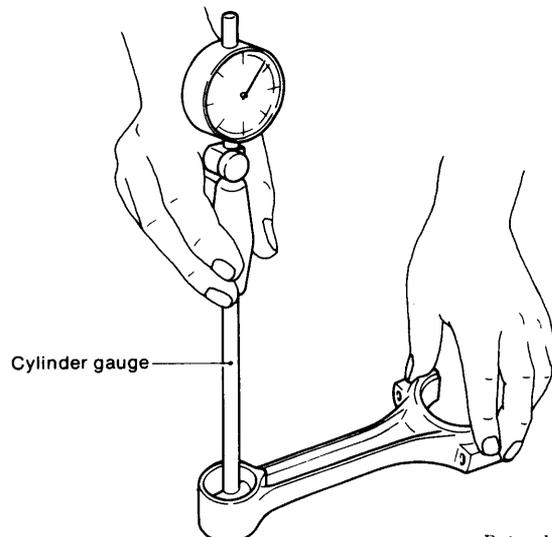


- (4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

5-3 Piston pin bushing

(1) Measuring piston pin clearance

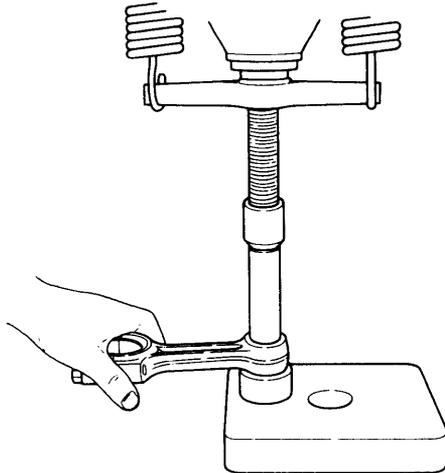
Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself.



	mm (in.)	
	Standard	Wear limit
Piston pin bushing inside dia.	26.025 ~ 26.038 (1.0246 ~ 1.0251)	26.1 (1.0275)
Piston pin and bushing oil clearance	0.025 ~ 0.051 (0.0009 ~ 0.002)	0.11 (0.0043)

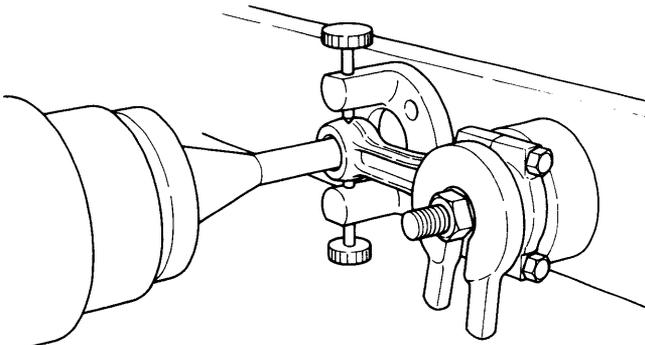
(2) Replacing piston pin bushing

- 1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.



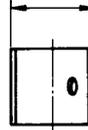
NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

- 2) After forcing the piston pin bushing into position, finish the inner surface of the bushing by using a pin honing machine or reamer so that it fits the piston pin to be used.

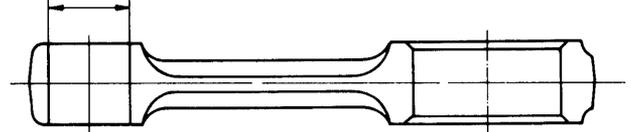


NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.

29.08 ~ 29.12mm
(1.1448 ~ 1.1464in.)

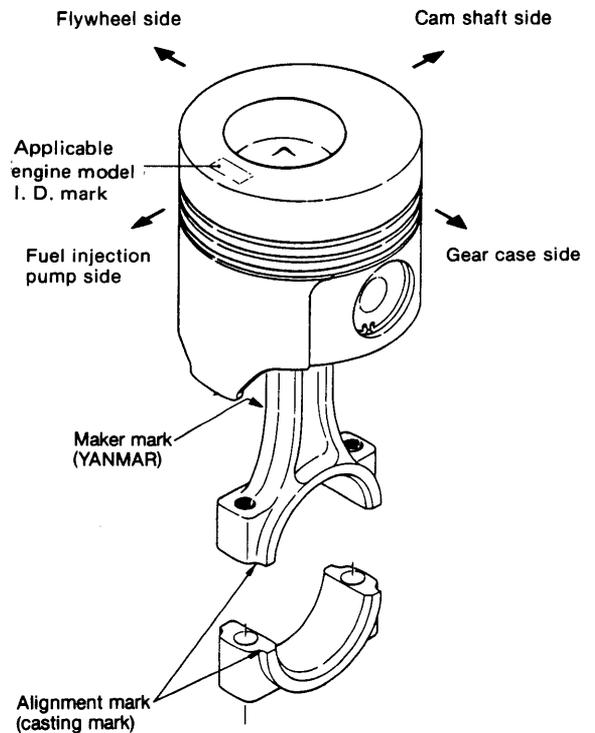


29.0 ~ 29.021mm
(1.1417 ~ 1.1425in.)



5-4 Assembling piston and connecting rod

The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faces the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.



I. D. Mark for Piston

	I.D. Mark	Applicable Engine Model & E/#	
Old type	1	4JHE	E/#01000 and before
	2	4JH-TE	E/#11000 and before
	5	4JH-HTE	E/#21000 and before
New type	A	4JHE	E/#01001 and after
	B	4JH-TE	E/#11001 and after
	C	4JH-HTE	E/#21001 and after
	C	4JH-DTE	E/#30101 and after

*Engines produced at YANMAR plant on and after June 21, 1985

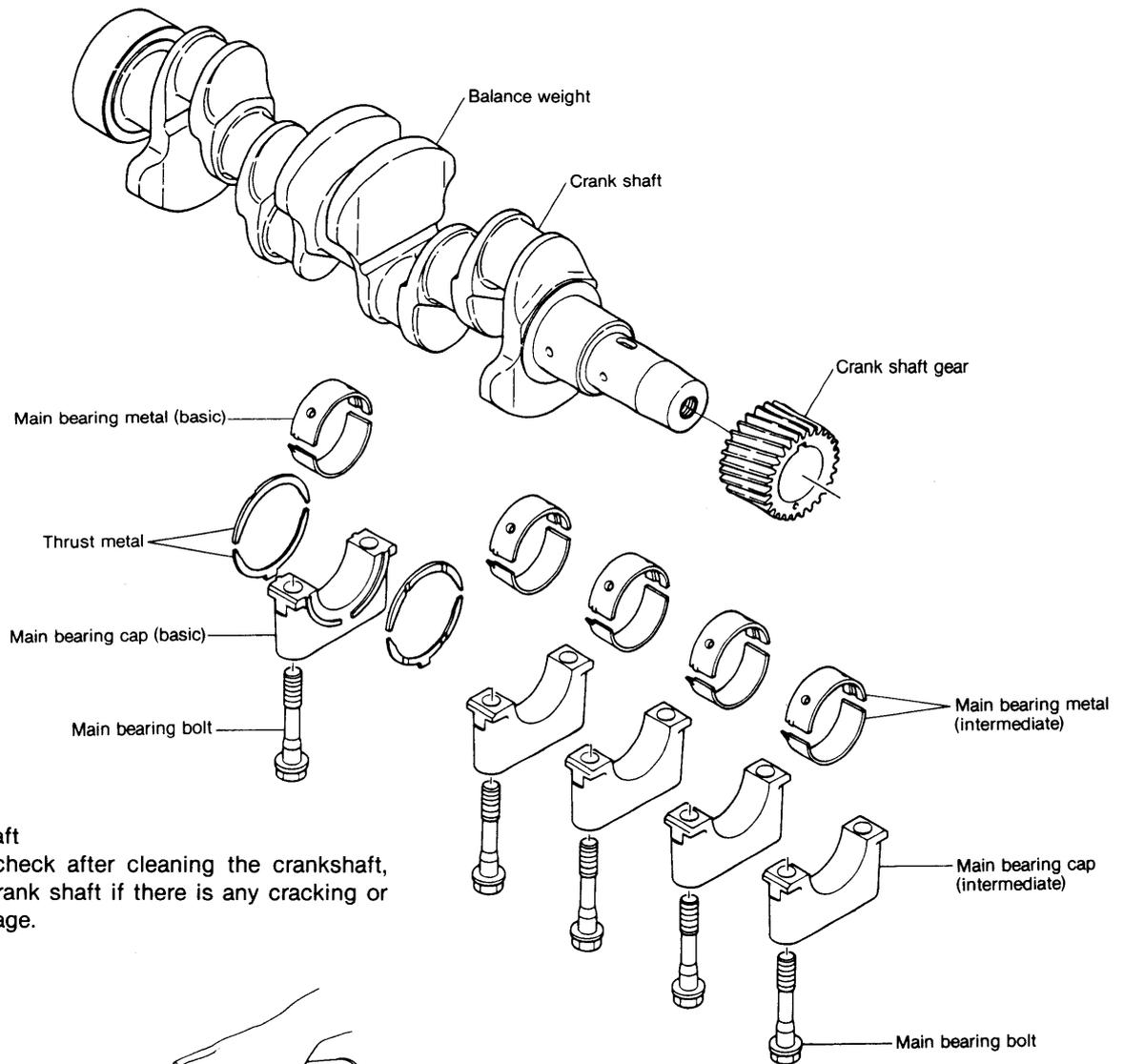
6. Crankshaft and Main Bearing

The crank pin and crank journal have been induction hardened for superior durability, and the crankshaft is provided with four balance weights for optional balance. The crankshaft main bearing is of the hanger type. The upper metal (cylinder block side) is provided with an oil groove. There is no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.

IMPORTANT:

Although the size is identical, the crankshaft material of models 4JHE and 4JH-TE differ from that used in models 4JH-HTE and 4JH-DTE.

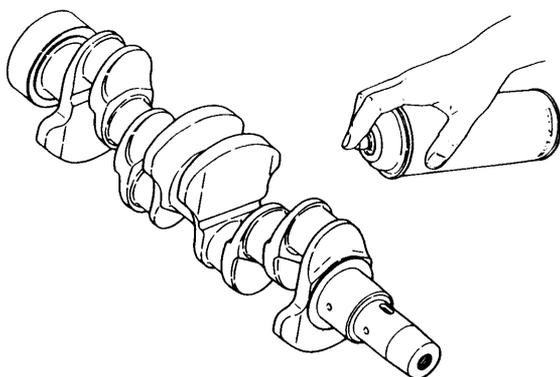
Please note that the crankshaft for models 4JHE and 4JH-TE cannot be used for models 4JH-HTE and 4JH-DTE since the crankshaft is not durable enough.



6-1 Crankshaft

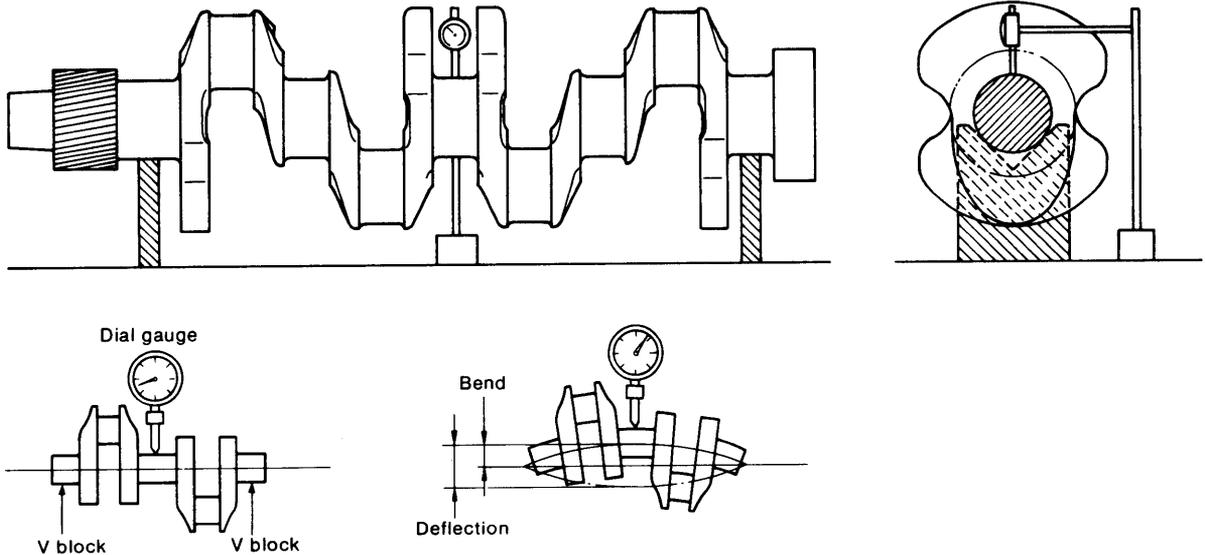
(1) Color check of shaft

Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.



(2) Bending of the crankshaft

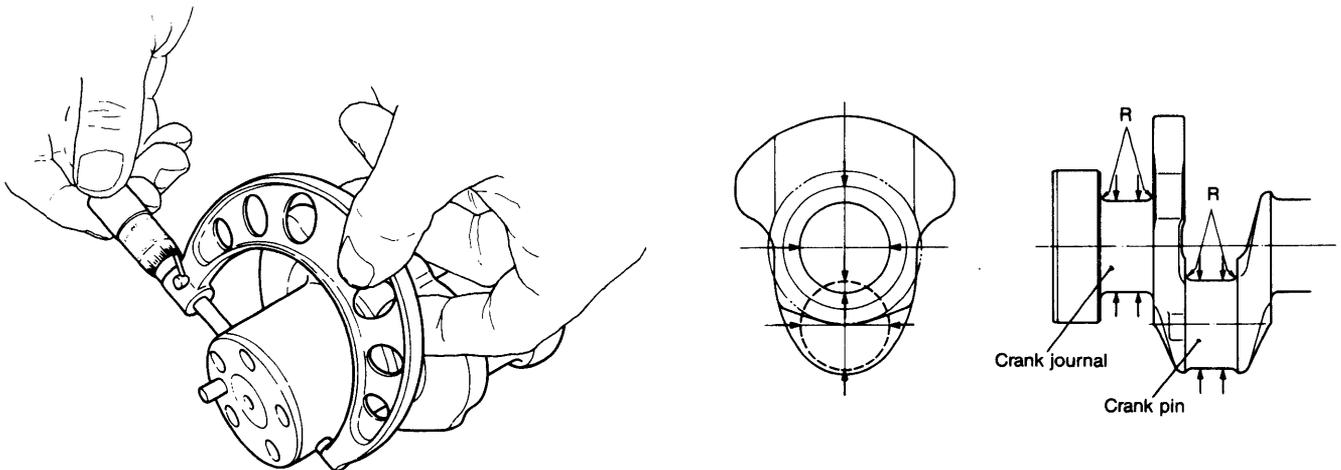
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



Crankshaft bend	Less than 0.02mm (0.0007 in.)
-----------------	-------------------------------

(3) Measuring the crank pin and journal

Measure the extent of journal wear (roundness, taper). Grind it to the proper shape if it is within the outer diameter limit, and replace if not.



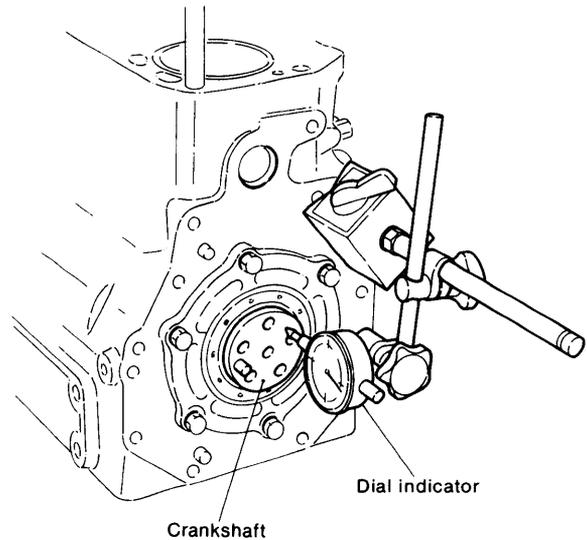
		mm (in.)	
		Standard	Wear limit
Crank pin	Outside dia.	47.952 ~ 47.962 (1.8878 ~ 1.8882)	47.75 (1.8799)
	Bushing inside dia.	48.000 ~ 48.045 (1.8897 ~ 1.8915)	48.10 (1.8937)
	Crank pin and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Crank journal	Outside dia.	49.952 ~ 49.962 (1.9666 ~ 1.9670)	49.75 (1.9586)
	Bushing inside dia.	50.000 ~ 50.045 (1.9685 ~ 1.9702)	50.10 (1.9724)
	Crank journal and bushing oil clearance	0.038 ~ 0.093 (0.0014 ~ 0.0036)	0.25 (0.0098)
Fillet rounding of crank pin and journal		3.500 ~ 3.800 (0.1377 ~ 0.1496)	

(4) Checking side clearance of the crankshaft

After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

This measurement can also be effected by inserting the gauge directly into the clearance between the thrust bearing and crankshaft thrust surface.

Replace the thrust bearing if it is worn beyond the limit.



	mm (in.)	
	Standard	Wear limit
Crankshaft side gap	0.090 ~ 0.271 (0.0035 ~ 0.0106)	0.30 (0.0118)

6-2 Main bearing

(1) Inspecting the main bearing

Check for flaking, seizure or burning of the contact surface and replace if necessary.

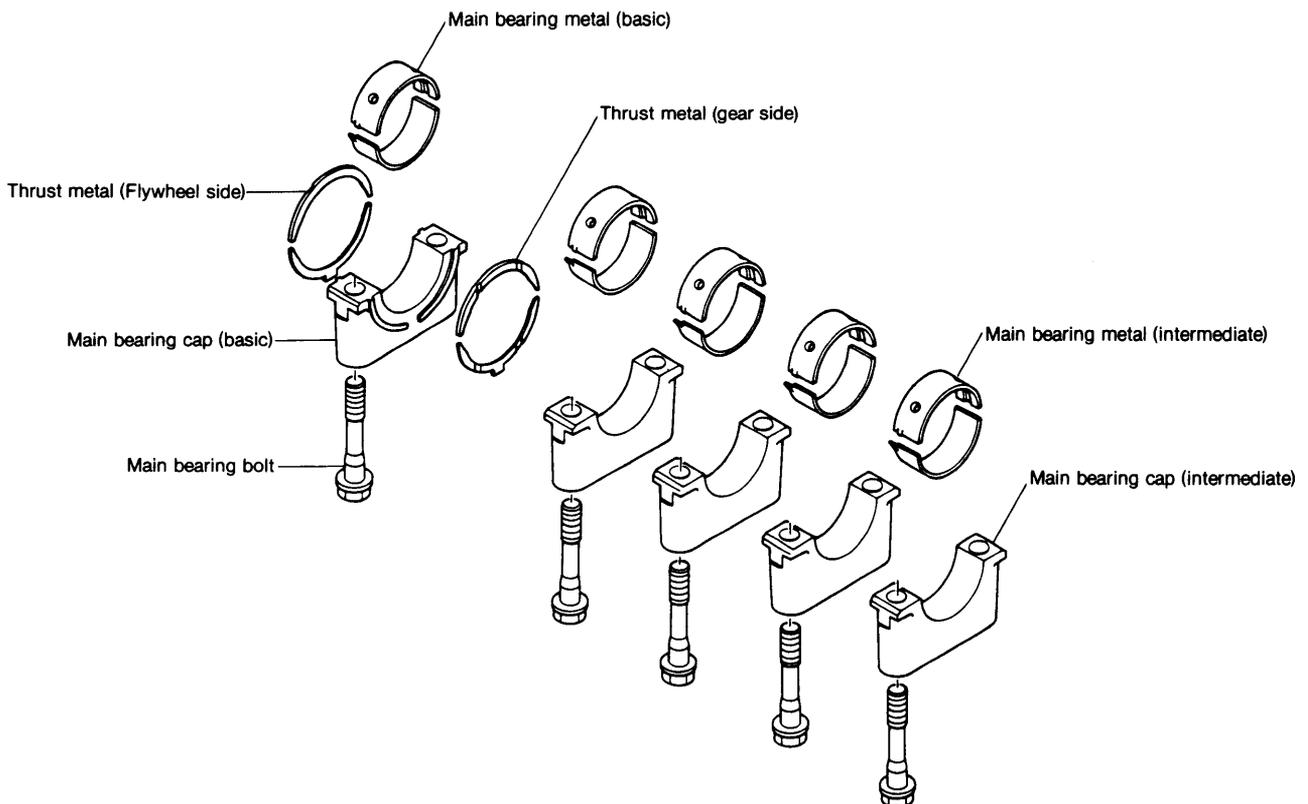
(2) Measuring the inner diameter of metal

Tighten the cap to the specified torque and measure the inner diameter of the metal.

NOTE: When assembling the bearing cap, keep the following in mind.

- 1) The lower metal (cap side) has no oil groove.
- 2) The upper metal (cylinder block side) has an oil groove.
- 3) Check the cylinder block alignment No.
- 4) The "FW" on the cap lies on the flywheel side.

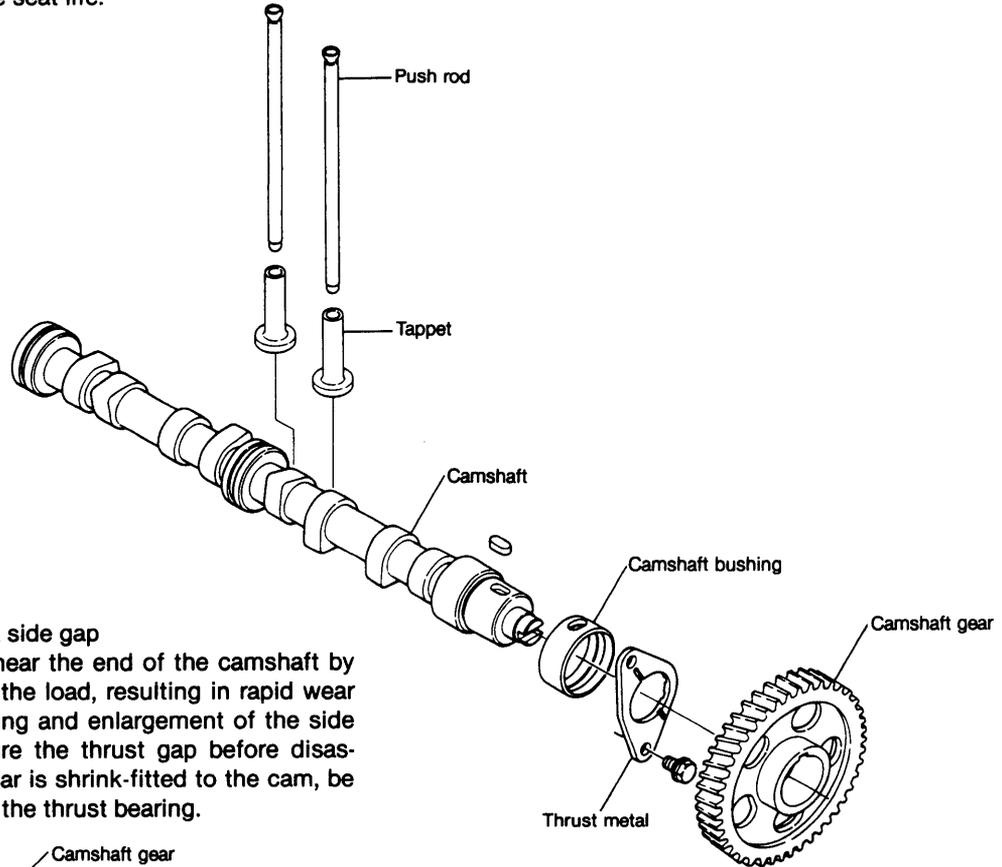
Bearing cap bolt tightening torque	9.5 ~ 10.5 kg-m (68.71 ~ 75.84 ft-lb)
------------------------------------	--



7. Camshaft and Tappets

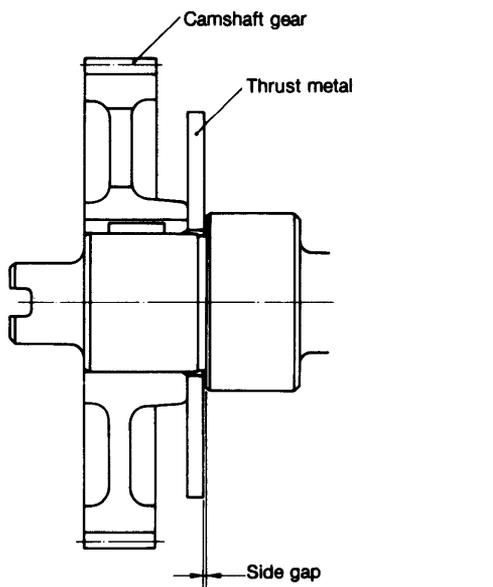
7-1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimizes the repeated shock on the valve seats and maximizes valve seat life.



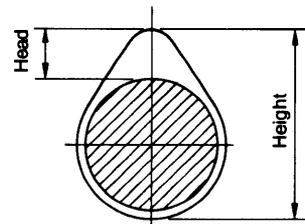
(1) Checking the camshaft side gap

The standard bearing near the end of the camshaft by the cam gear receives the load, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.



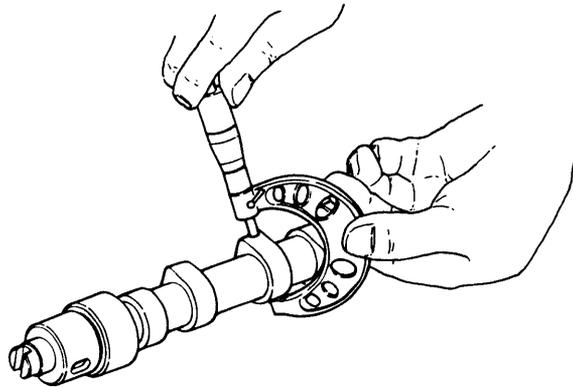
	mm (in.)	
	Standard	Wear limit
Camshaft side gap	0.05 ~ 0.25 (0.0019 ~ 0.0098)	0.4 (0.0157)

(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.



Camshaft height		mm (in.)	
Engine model		Standard	Wear limit
4JHE	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
	Exhaust cam		
4JH-TE	Intake cam	38.66 ~ 38.74 (1.5220 ~ 1.5251)	38.4 (1.5118)
4JH-HTE			
4JH-DT(B)S	Exhaust cam	38.86 ~ 38.94 (1.5299 ~ 1.5330)	38.6 (1.5196)

- (3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.

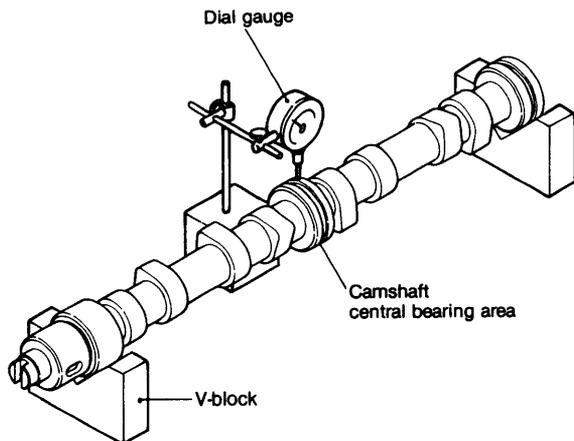


mm (in.)

	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.910 ~ 44.935 (1.7681 ~ 1.7690)	44.925 ~ 44.950 (1.7687 ~ 1.7696)	44.8 (1.7637)
Camshaft journal bushing inside dia.	44.990 ~ 45.050 (1.7712 ~ 1.7736)	—	—	—
Cylinder block bearing inside dia.	—	45.000 ~ 45.025 (1.7716 ~ 1.7726)	45.000 ~ 45.025 (1.7716 ~ 1.7726)	—
Oil clearance	0.040 ~ 0.130 (0.0015 ~ 0.0050)	0.065 ~ 0.115 (0.0025 ~ 0.0045)	0.050 ~ 0.100 (0.0019 ~ 0.0039)	0.2 (0.0078)

- (4) Bending of the crankshaft

Support both ends of the crankshaft with V-blocks, place a dial gauge against the central bearing areas and measure bending. Replace if excessive.



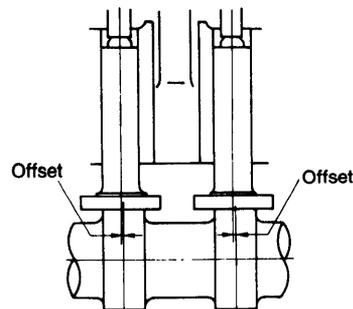
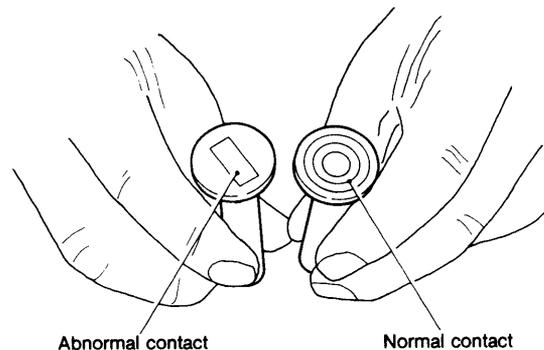
NOTE: The reading on the dial gauge is divided by two to obtain the extent of bending.

mm (in.)

	Wear limit
Camshaft deflection	0.02 (0.0007)

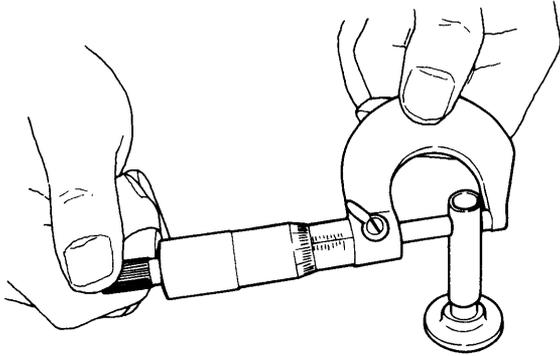
7-2 Tappets

- (1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.



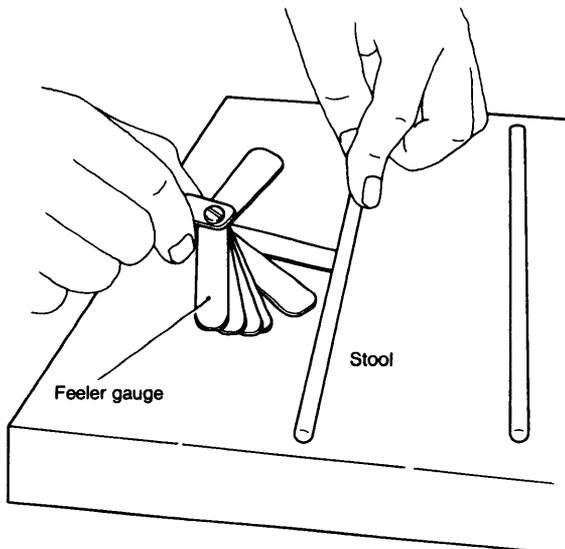
NOTE: When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

- (2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



	mm (in.)	
	Standard	Wear limit
Tappet stem outside dia.	11.975 ~ 11.990 (0.4714 ~ 0.4720)	11.93 (0.4696)
Tappet guide hole inside dia. (cylinder block)	12.000 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Tappet stem and guide hole oil clearance	0.010 ~ 0.043 (0.0003 ~ 0.0016)	0.10 (0.0039)

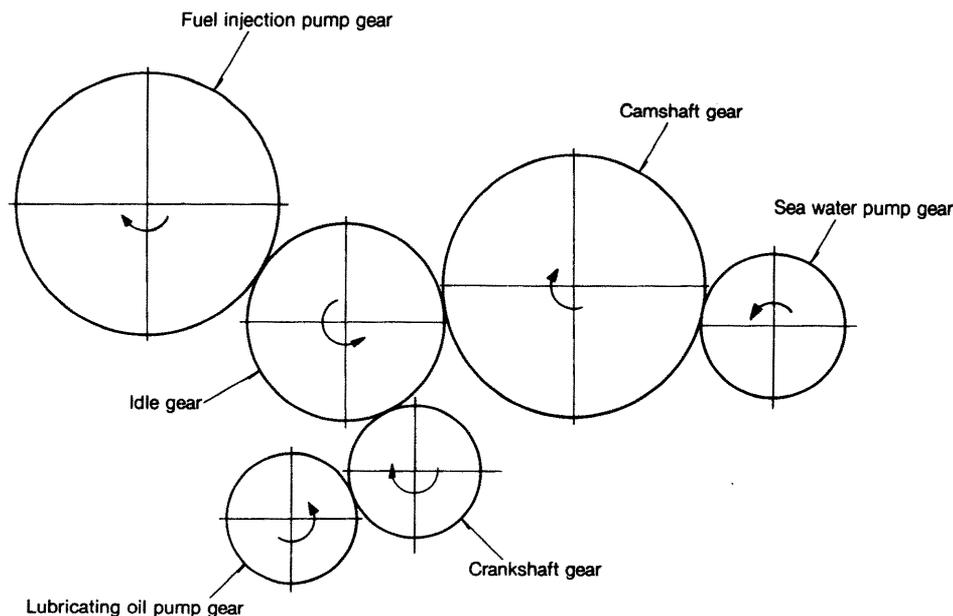
- (3) Measuring push rods.
Measure the length and bending of the push rods.



	mm (in.)	
	Standard	Wear limit
Push rod length	178.25 ~ 178.75 (7.0177 ~ 7.0374)	—
Push rod bend	Less than 0.03 (0.0011)	0.3 (0.0118)
Push rod dia.	8 (0.3149)	—

8. Timing Gear

The timing gear is helical type for minimum noise and specially treated for high durability.



mm (in.)						
	No. of teeth	Face width	Spiral angle	Center distance	Back lash	Back lash Wear limit
Sea water pump gear	31	12.0	right	92.544 ~ 92.592 (3.6434 ~ 3.6453)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Camshaft gear	56	18.0	left	105.318 ~ 105.380 (4.1463 ~ 4.1488)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Idle gear	43	18.0	right	75.525 ~ 75.573 (2.9734 ~ 2.9753)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Crankshaft gear	28	40.0	left	60.629 ~ 60.677 (2.3869 ~ 2.3888)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Lubricating oil pump gear	29	8.0	right			
Idle gear	43	18.0	right	105.254 ~ 105.316 (4.1438 ~ 4.1462)	0.04 ~ 0.12 (0.0015 ~ 0.0047)	0.2 (0.0078)
Fuel injection pump gear	56	10.0	left			

8-1 Inspecting the gears

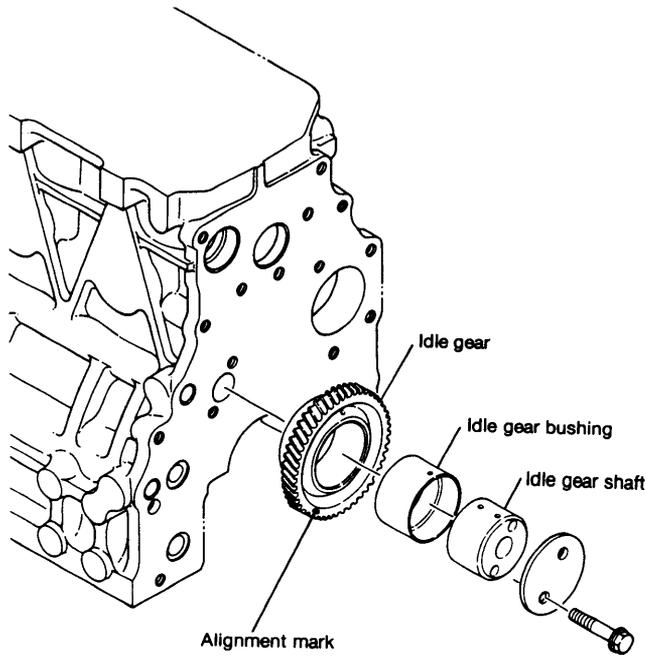
- (1) Inspect the gears and replace if the teeth are damaged or worn.
- (2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

NOTE: If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

(3) Idling gear

The bushing is pressure fitted into the idling gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.

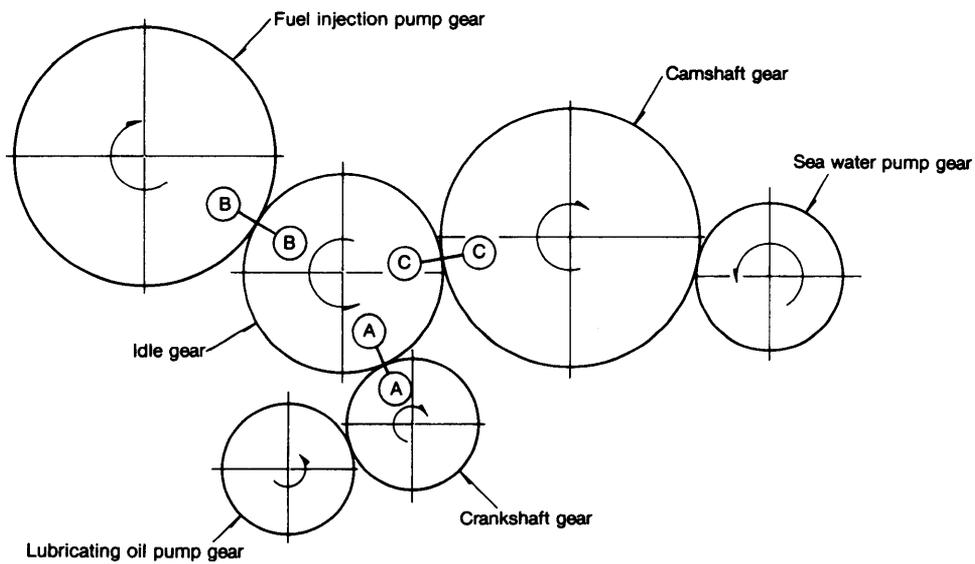
A, B and C are inscribed on the end of the idling gear. When assembling, these marks should align with those on the cylinder block.



	mm (in.)	
	Standard	Wear limit
Idle shaft dia.	45.950 ~ 45.975 (1.8090 ~ 1.8100)	45.88 (1.8062)
Idle shaft bushing inside dia.	46.000 ~ 46.025 (1.8110 ~ 1.8120)	—
Idle shaft and bushing oil clearance	0.025 ~ 0.075 (0.0009 ~ 0.0029)	0.15 (0.0059)

8-2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).



9. Flywheel and Housing

The function of the flywheel is, through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.

The flywheel is mounted and secured by 6 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.

On the crankshaft side of the flywheel is the fitting surface for the damper disc, through which the rotation of the crankshaft is transmitted to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.

The flywheels unbalanced force on the shaft center must

be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed. To achieve this, the balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.

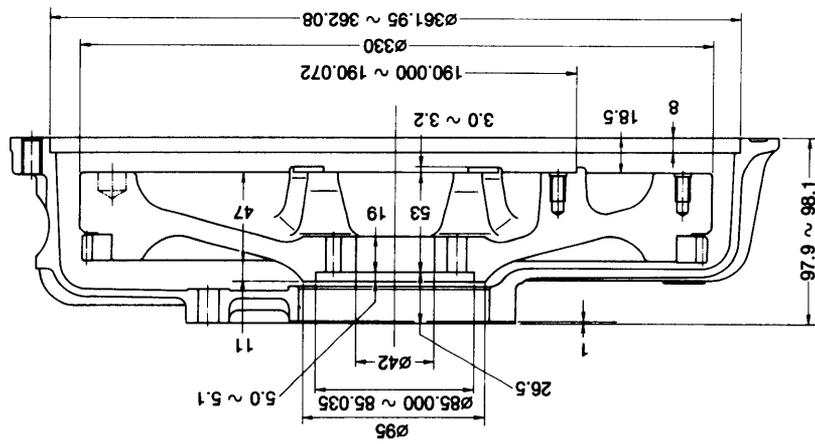
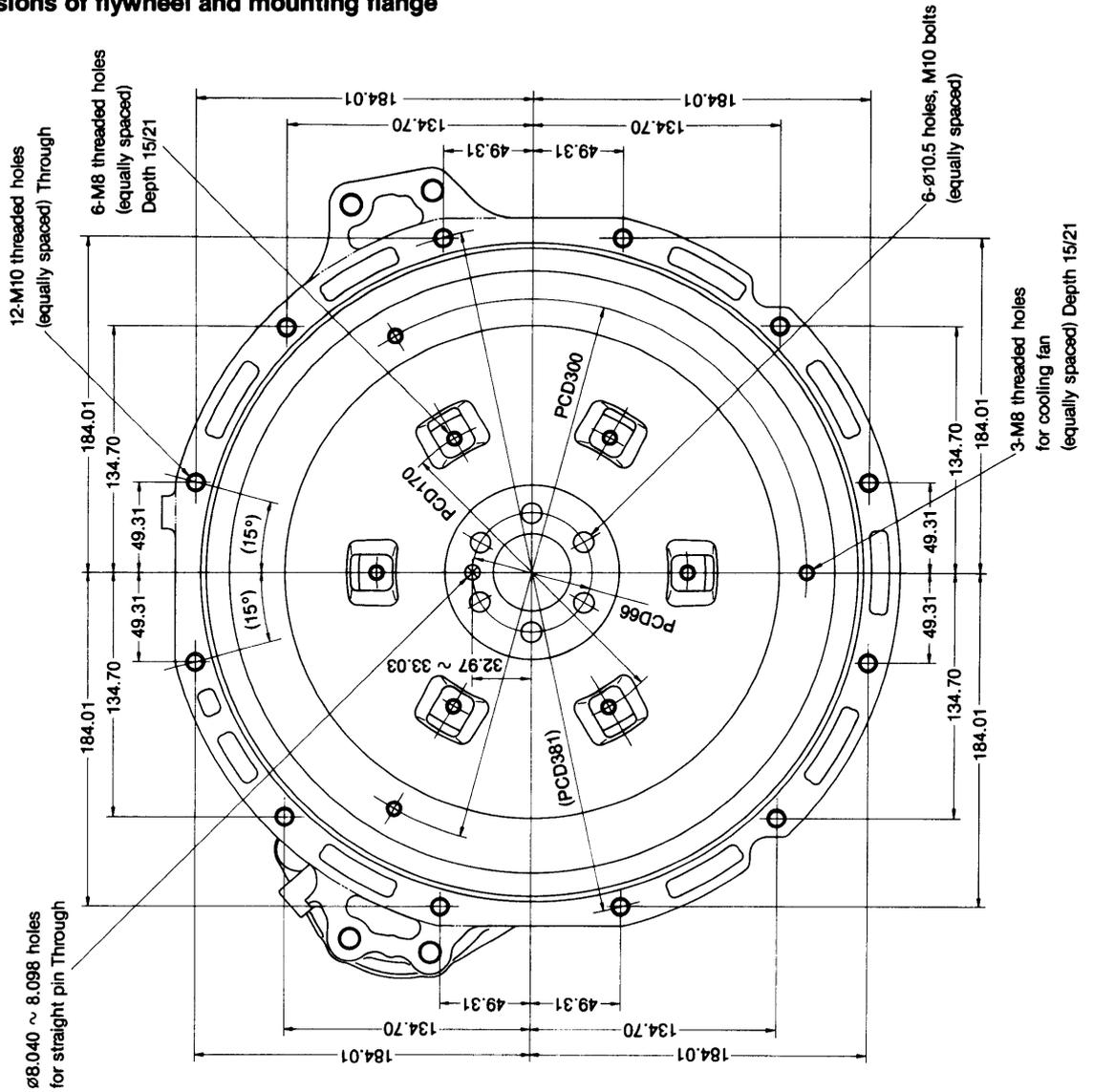
The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.

The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

9-1 Specifications of flywheel

Outside dia. of flywheel	mm	ø330	
Width of flywheel	mm	47	
Weight of flywheel (including ring gear)	kg	13.17	
GD ² value	kg·m ²	1.10	
Circumferential speed	m/s	62.2 (3600rpm)	
Speed fluctuation rate	δ	1/346 (3600rpm)	
Allowable amount of unbalance	g·cm	22	
Fixing part of damper disc	Pitch circle dia. of bolts	mm	170
	No. of bolts × bolt dia.		6-M8 thread equally spaced
Fixing part of crankshaft	Pitch circle dia. of bolts	mm	66
	No. of thread holes	mm	6-M10
	Fit joint dia.		ø85.000 ~ 85.035
Model of reduction and reversing gear			KBW-20 & KBW-21
Mounting flange No.			SAE No.4 (in metric unit)
Ring gear	Center dia.	mm	322.58
	No of teeth		127

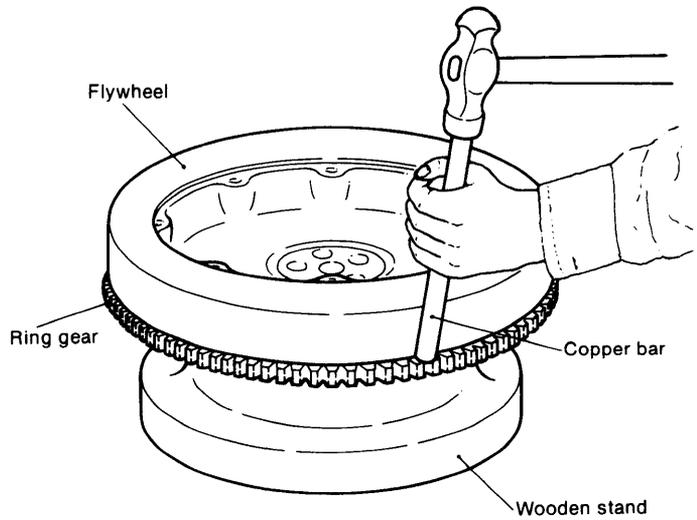
9-2 Dimensions of flywheel and mounting flange



9-3 Ring gear

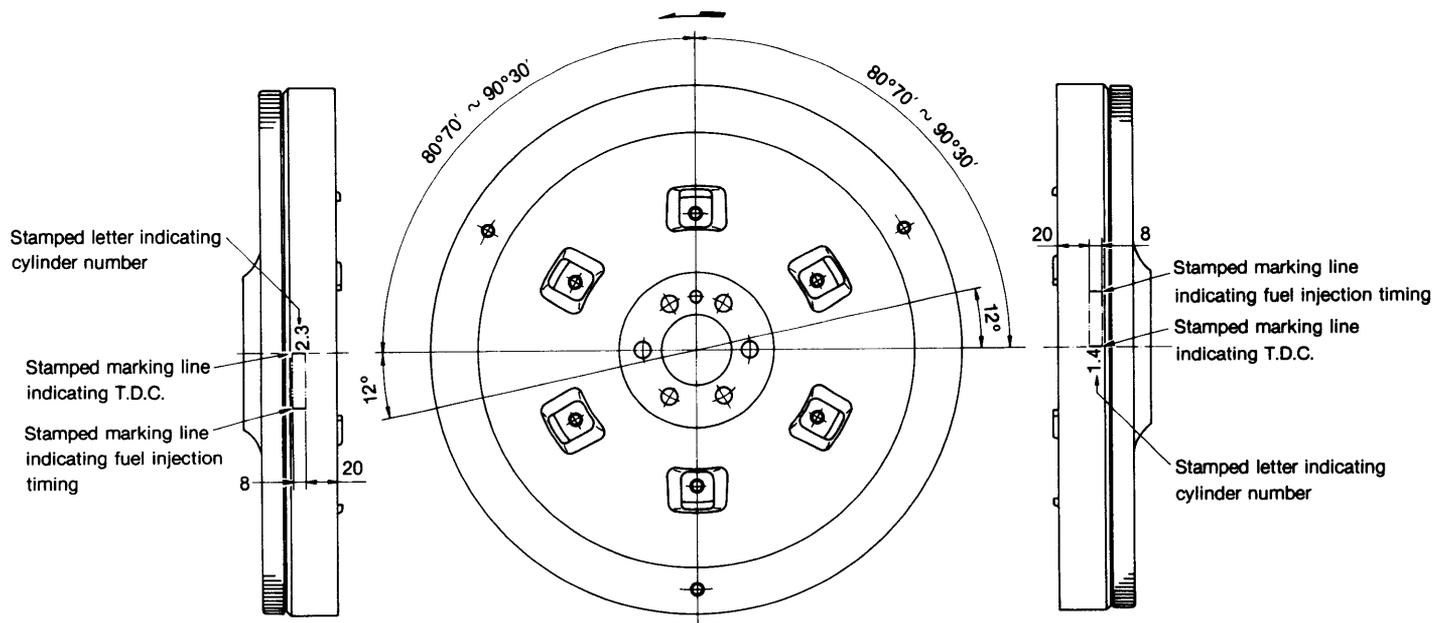
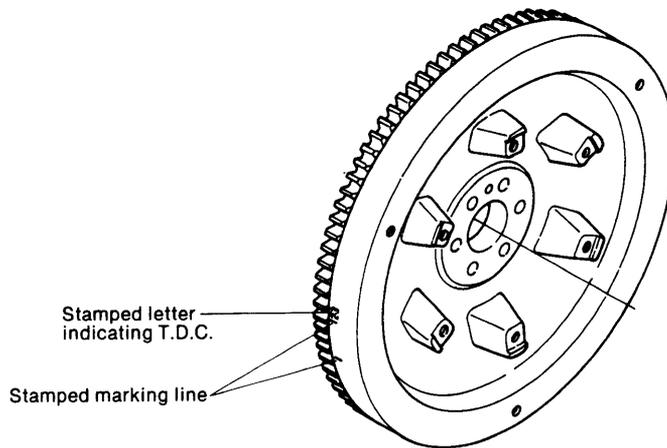
When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer, a copper bar or something similar around the whole circumference.

	mm (in.)
Interference of ring gear	0.158 ~ 0.250 (0.0062 ~ 0.0098)

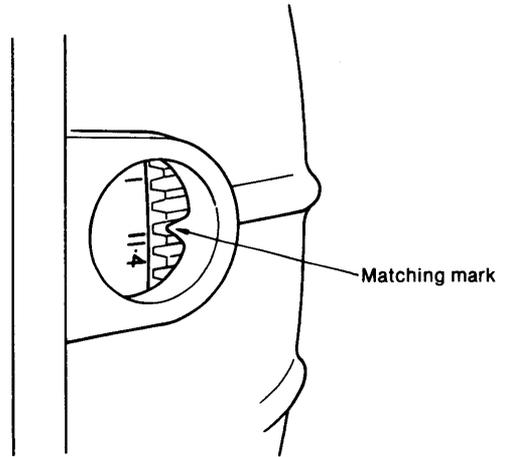
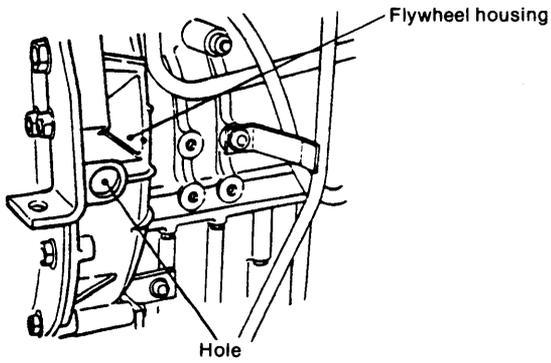


9-4 Position of top dead center and fuel injection timing

(1) Marking

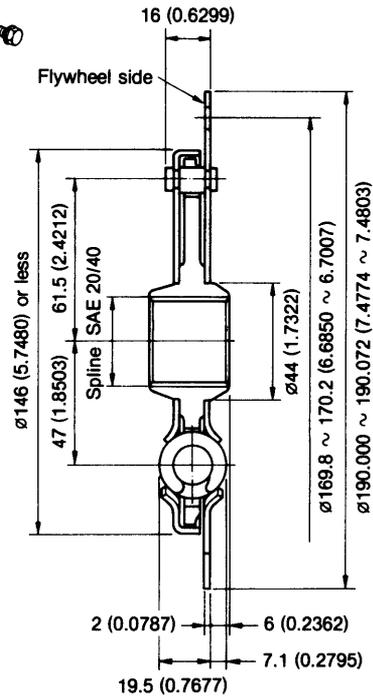
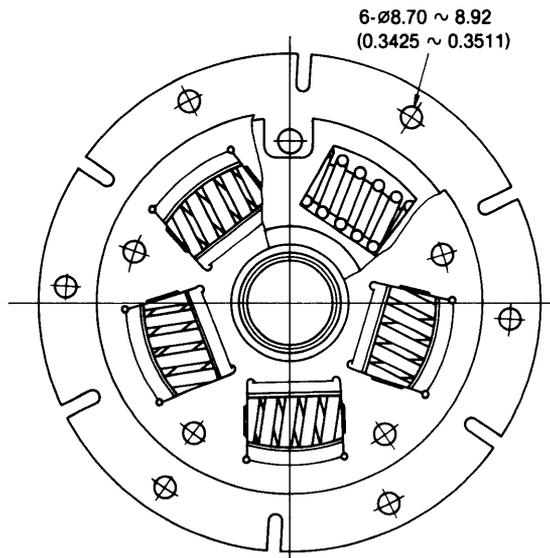
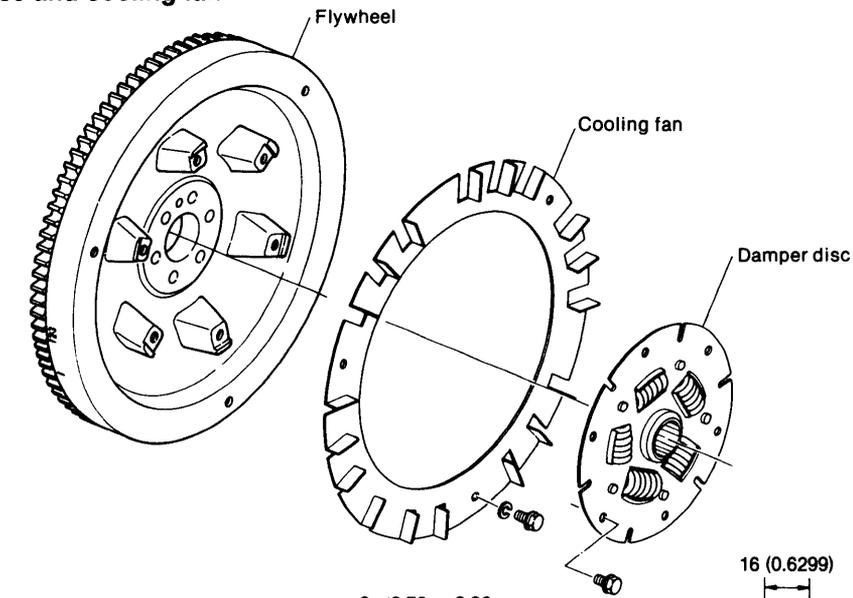


(2) Matching mark



The matching mark is made at the hole of the flywheel housing.

9-5 Damper disc and cooling fan



mm (in.)

Torsional rigidity	421 kg /rad (928.3 lb/rad)
Max. angle of torsion	7.3×10^{-2} rad
Stopper torque	37.7 kg-m (272.68 ft-lb)

FUEL INJECTION EQUIPMENT

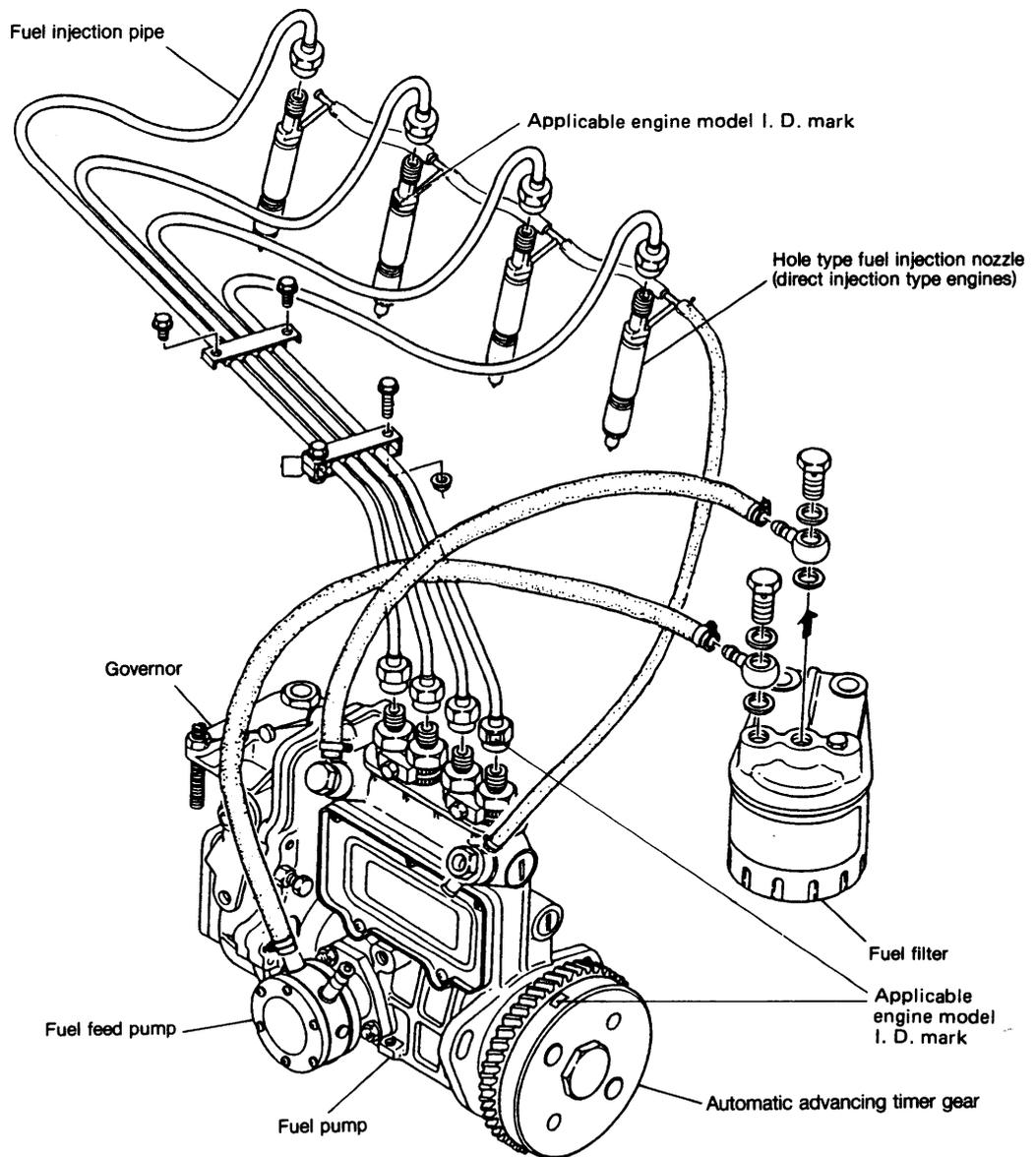
1. Fuel Supply System	3-1
2. Disassembly, Reassembly and Inspection of Governor	3-9
3. Disassembly, Reassembly and Inspection of Fuel Injection Pump	3-18
4. Adjustment of Fuel Injection Pump and Governor	3-28
5. Automatic Advancing Timer	3-34
6. Fuel Feed Pump	3-36
7. Fuel Injection Nozzle	3-38
8. Troubleshooting	3-42
9. Fuel Injection Pump Service Data	3-44
10. Tools	3-45
11. Fuel Filter	3-47
12. Fuel Tank (Optional)	3-48
13. Design Change of Fuel Piping Line	3-49

1. Fuel Supply System

The Yanmar fuel injection pump is Bosch cluster type, the cam shaft of which is driven by the engine gears through the timing gear. The feed pump, driven by the cam shaft, pumps fuel oil from the fuel tank to the fuel filter at a pressure of 0.3kg/cm². The filtered fuel is supplied to the reservoir in the pump housing, the plunger increases the pressure, and the fuel goes through the injection pipe to be injected into each cylinder by the fuel injection nozzles.

IMPORTANT:

Automatic timer assembly, fuel injection nozzle assembly and injection pipe differ among engine models. When incorrect parts are installed, engine performance will drop. Be sure to check the applicable engine model identification marks (I. D. Marks) provided on each part to insure use of the correct part.



I. D. Marks for Automatic Timer Assembly

Automatic Timer Ass'y (Automatic Advancing Timer)	Old type	I. D. Mark	Applicable Engine Model & E/#	
		JH-A0	4JHE	E/# 00101 ~ 00574
		JH-A1	4JHE	E/# 01000 and before
		JH-B0	4JH-TE	E/# 11000 and before
		JH-C0	4JH-HTE	E/# 21000 and before
	New type	TN-A0	4JHE	E/# 01001 and after
			4JH-TE	E/# 11001 and after
		JH-C0	4JH-HTE	E/# 21001 and after
			4JH-DTE	E/# 30101 and after

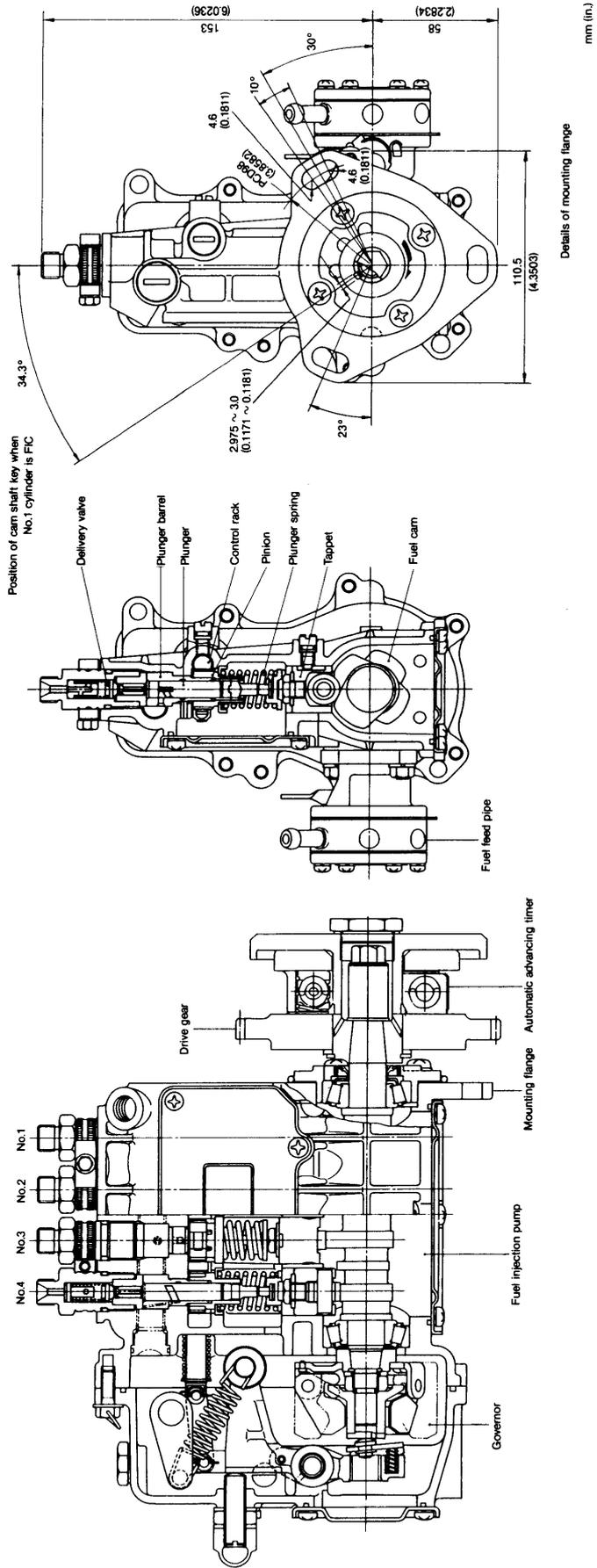
I. D. Marks for Fuel Injection Nozzle Assembly and Fuel Injection Pipe

Fuel injection nozzle ass'y	Old type	I. D. Mark	Applicable Engine Model & E/#		Nozzle I. D. Mark
		A	4JHE	E/# 00101 ~ 00574	
		E	4JHE	E/# 01000 and before	155P244J1
		B	4JH-TE	E/# 11000 and before	150P284J0
		D	4JH-HTE	E/# 21000 and before	145P265J1
	New type	F	4JHE	E/# 01001 and after	155P244J2
			4JH-TE	E/# 11001 and after	140P255J2
		G	4JH-HTE	E/# 21001 and after	
			4JH-DTE	E/# 30101 and after	

I. D. Marks for Fuel Injection Pipe

Fuel Injection Pipe (Pump to Nozzle)	Old type	I. D. Mark	Applicable Engine Model & E/#		Pipe Inner Dia
		None	4JHE	E/# 01000 and before	φ1.8
	4JH-TE	E/# 11000 and before			
		None	4JH-HTE	E/# 21000 and before	φ2.0
	New type	18	4JHE	E/# 01001 and after	φ1.8
			4JH-TE	E/# 11001 and after	
		20	4JH-HTE	E/# 21001 and after	φ2.0
				4JH-DTE	

1-1 Fuel injection pump construction



The Yanmar Model YPES Bosch type fuel injection pump is an in-line cluster type pump with a governor and timer incorporated.

A cam shaft is built into the fuel injection pump, which has a drive cam for the fuel supply pump and a tappet drive cam for the plunger. A timing gear and drive gear are mounted on the drive side of the cam shaft, and a governor weight on the opposite side.

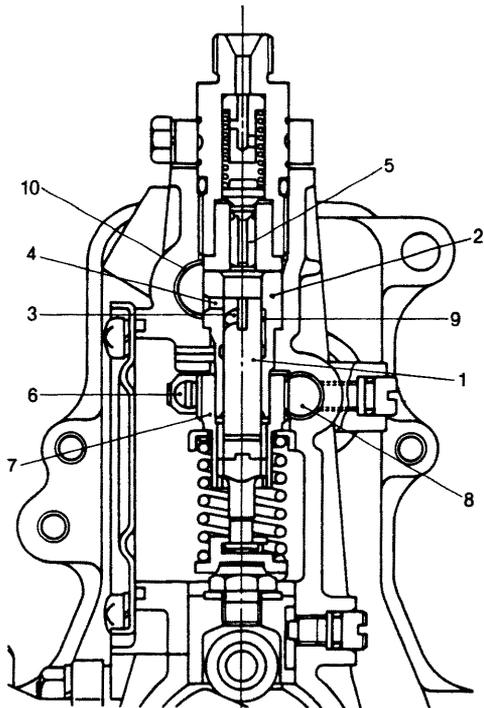
As the plunger rises, the fuel oil opens the delivery valve and goes through the high pressure pipe to the fuel injection nozzles.

When the control rack connected to the governor lever moves, the pinion turns the plunger. This changes the fuel discharge and intake positions and in turn controls the amount of fuel injected.

1-2 Fuel injection pump specifications

Type		YPES-CL
No of cylinders		4
Plunger dia.	mm (in.)	8 (0.3149)
Cam lift	mm (in.)	7 (0.2755)
Max. fuel injection volume	mm ³ /st	65 (0.0039)
Max. fuel injection press.	kg/cm ² (lb/in. ²)	450 (6399)
Max. cam shaft	rpm	2200
Direction of revolution		right (looking from drive side)

1-3 Functioning of fuel injection pump



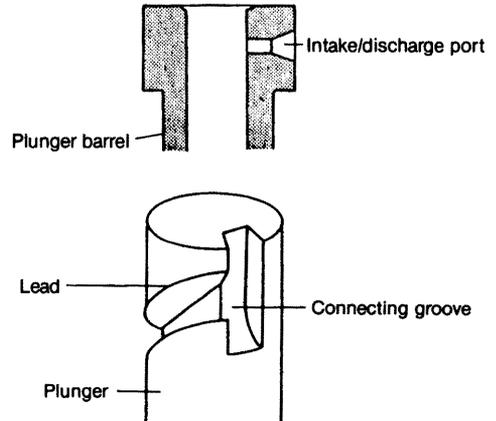
- 1. Plunger
- 2. Plunger barrel
- 3. Lead groove
- 4. Intake port
- 5. Delivery valve
- 6. Control sleeve
- 7. Control pinion
- 8. Control rack
- 9. Fuel leak return groove
- 10. Protector

The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel through a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which goes to the top of the plunger.

There is a port in the plunger barrel which serves as both an intake and discharge port. The fuel comes through this port into the plunger chamber, is pressurized by the plunger, opens the delivery valve, flows to the fuel injection nozzle through the fuel injection pipe and is injected into the combustion chamber. Fuel injection terminates after the pressurized fuel has been discharged. This happens when the lead groove lines up with the discharge groove as the plunger rises and the pressure in the fuel injection pipe drops.

The control sleeve groove is fitted to the plunger flange. The control sleeve is secured to the control pinion and the pinion teeth and rack gear teeth are engaged.

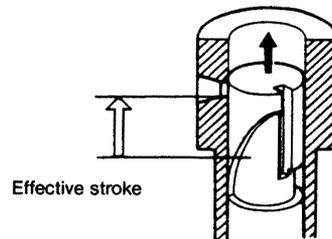
The plunger is controlled by the rack, enabling continuous changing of the volume of fuel injected from zero to maximum. A fuel leak return hole is provided in the plunger barrel. This returns fuel leaking from the gap between the plunger and the barrel to the fuel lines. This prevents dilution of the lubricant in the cam chamber.



1-4 Injection volume control

(1) Full injection volume position

When the rack is set at the maximum setting, fuel injection starts earlier. It occurs when the widest part of the lead groove on the upper part of plunger lines up with the intake port in the barrel. At this time, the nar-

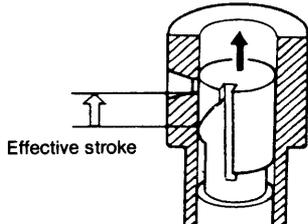


lowest part of the lower lead groove lines up with the discharge port, prolonging the length of injection and increasing the volume of fuel injected.

This setting is normally used for starting and max. output operation.

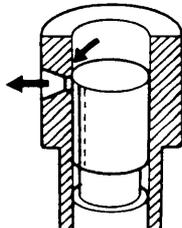
(2) Half injection volume position

When the rack is returned towards zero from the maximum setting, discharge starts later and ends earlier, decreasing the volume of fuel injected.



(3) No fuel injection

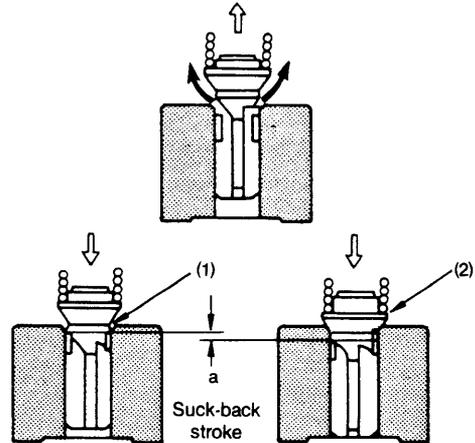
When the rack is set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized (even though the plunger continues to reciprocate).



The delivery valve at the top of the plunger prevents fuel in the fuel injection pipe from flowing back to the

plunger and sucks up fuel from the nozzle valve to prevent after drip.

When the plunger lead lines up with the discharge port of the plunger barrel, the injection pressure drops, and the delivery valve is brought down by the delivery valve spring.



At this time, the suck-back collar (1) blocks off the fuel injection pipe and the delivery chamber, and the valve continues to descend until the seat (2) comes in contact with the barrel. The fuel oil pressure in the fuel injection pipe decreases proportionately with the lowering of the valve (due to increased volume).

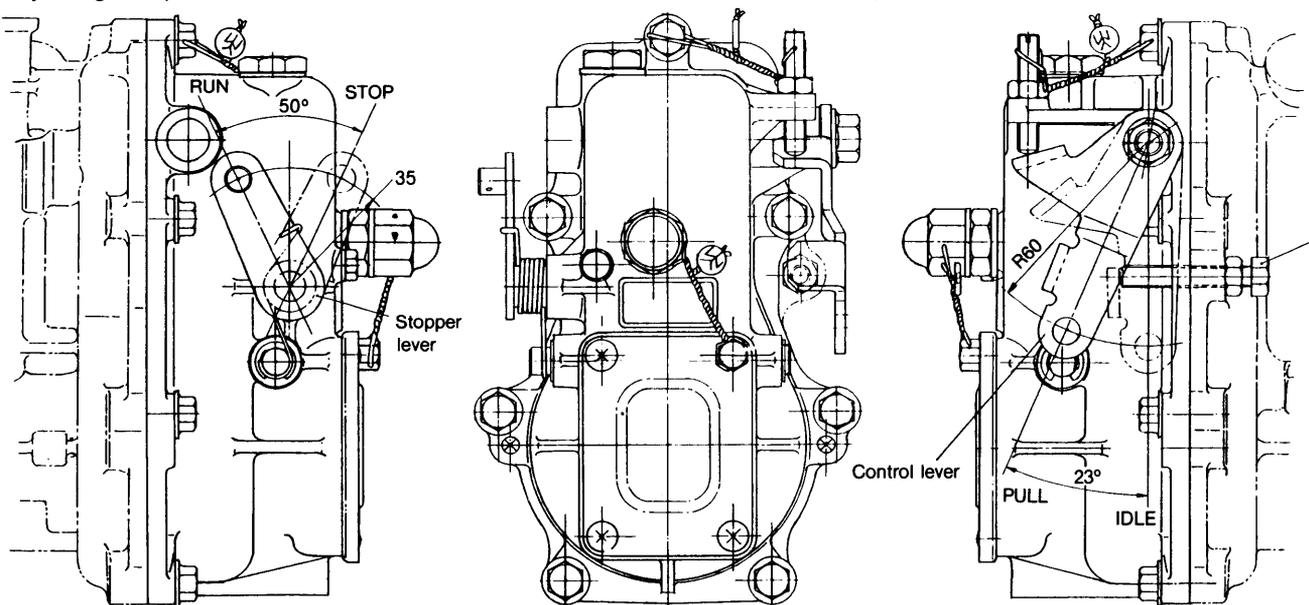
This accelerates closing of the nozzle valve, and sucks up fuel from the nozzle to prevent it from dripping.

This increases nozzle life and improves combustion efficiency.

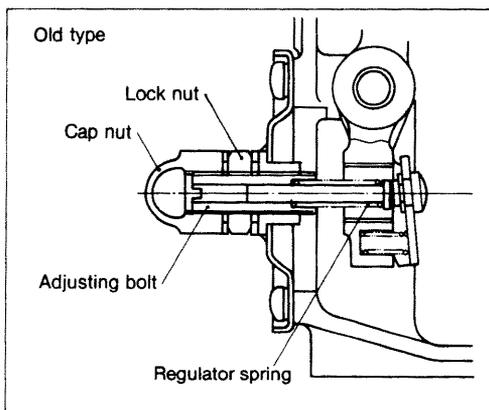
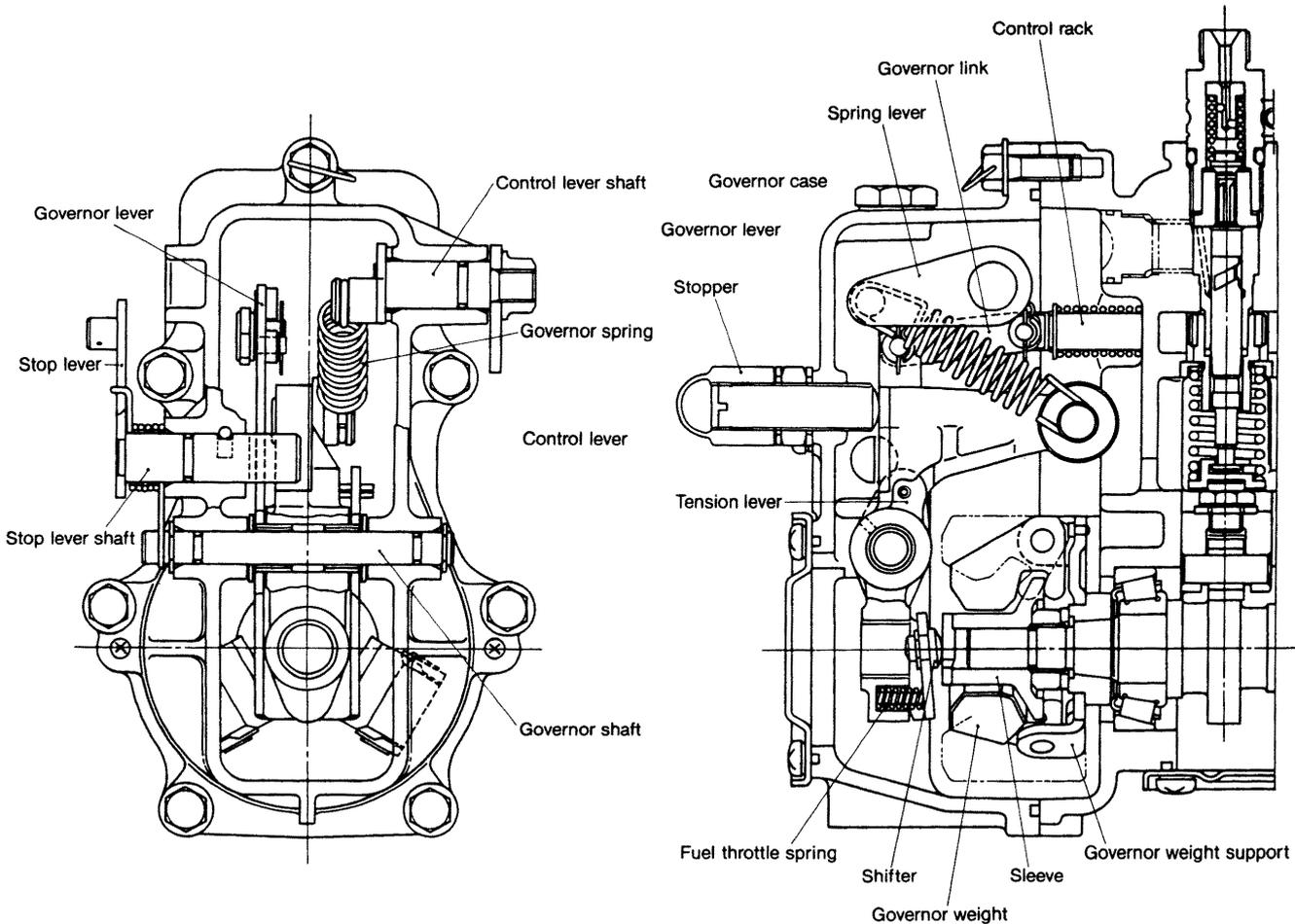
1-5 Governor construction

Usage conditions of diesel engines are extremely varied, with a wide range of loads and rpms. The governor plays an important role in the operation of the engine by quickly adjusting the position of the control rack to control the

amount of fuel injected according to changes in rpm. It also automatically controls the engine to prevent engine rpm from exceeding the maximum, and keeps the engine from stopping.



(1) A-type governor (without angleich spring)



This governor is all-speed, directly connected to the YPES-CL fuel injection pump. The construction will be explained with the cutaway views.

The governor weight mounted on the end of the fuel injection pump cam shaft rotates around the governor support pin, driven by the cam shaft, and is forced outwards by the centrifugal force acting on the weight.

The thrust force acting on the cam shaft due to this centrifugal force acts on the lower part of the tension lever through the sleeve. A starting throttle spring is mounted on the bottom of the tension lever.

One end of the governor spring is hooked to the right upper end of the tension bar, and the other end to the spring lever of the control lever shaft.

As the spring lever and control lever are mounted on the same shaft, when the control lever is turned towards full, the governor spring is pulled and the load gradually increases.

As the lever is turned, the spring force acting on the upper end of the tension lever and the thrust force acting on the lower end of the tension lever come into equilibrium, to obtain the specified rpm.

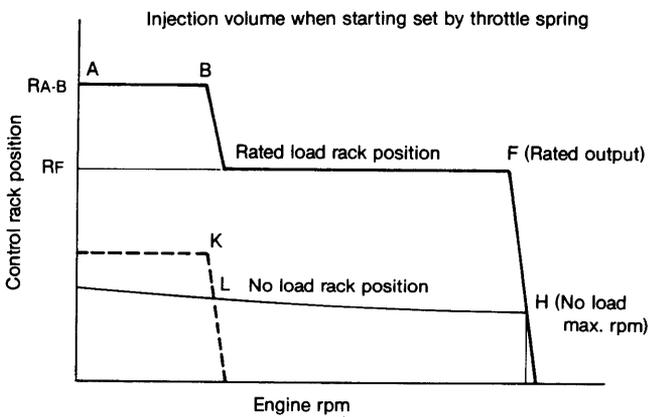
Since the tension bar can move freely around the governor shaft on the player bearing, as rpm increases and the shifter is pushed to the left, the tension bar rotates clockwise, and when rpm decreases, the tension bar rotates counterclockwise.

The governor lever rotates smoothly on the same governor shaft. The bottom part of this lever is in contact with the sleeve through the shifter, which is in contact with the bottom of the tension lever through the throttle spring. It therefore moves with the tension lever according to increases/decreases in engine rpm.

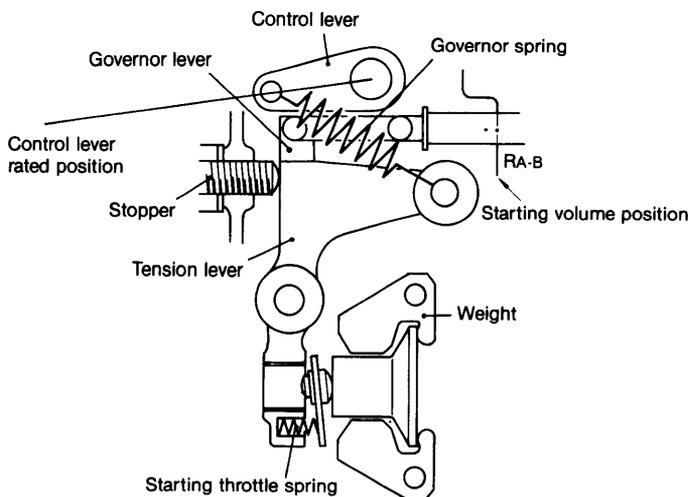
The top of the governor is connected to the fuel pump control rack by a link. The movement of the lever controls the volume of fuel injected by the pump. When rpm increases the lever rotates clockwise to cause the control rack to reduce fuel, and when rpm decreases the lever rotates counterclockwise to cause the control rack to increase fuel, thus controlling engine rpm.

The top of the tension bar comes in contact with the stopper built into the top of the governor case to limit the maximum fuel injection volume.

**Function of governor
(on 4JH Series)**



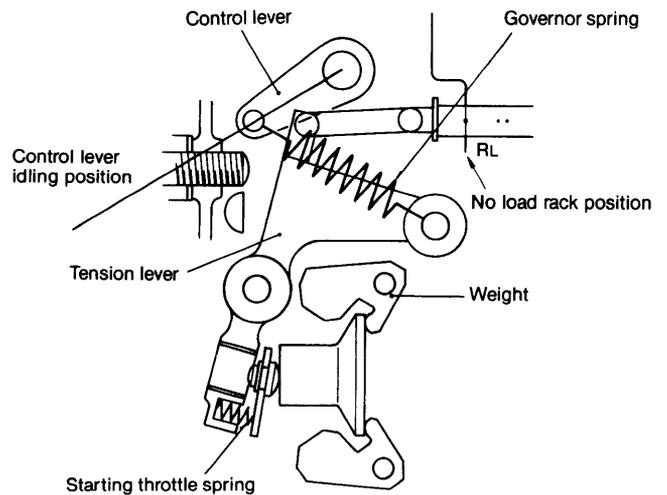
(1) Starting control



The control lever is set at the max. rpm position. The tension lever connected to the control lever is pulled as far as the stopper. The starting throttle spring mounted inbetween the tension lever and governor lever increases the governor weight thrust load, and the control rack is set at the max. injection volume position, to attain the starting volume.

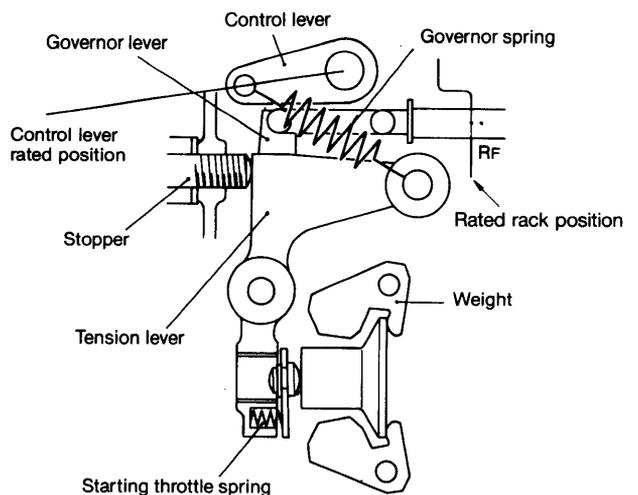
(2) Idling control

Idling control is effected by the governor spring as this engine is not provided with an idling spring. When the control lever is returned to the idling position after starting, almost no tension acts on the governor spring. The thrust force of the governor weight, and the starting throttle spring and governor spring load, come into equilibrium, effecting idling speed control.



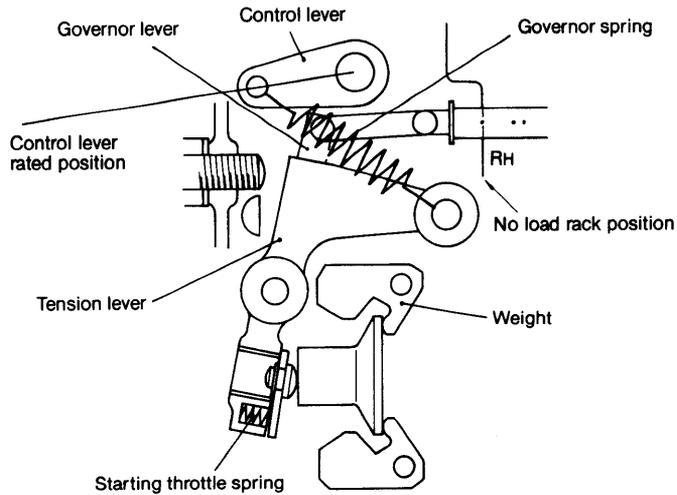
(3) Rated load max. rpm control

At rated load, the thrust load of the governor weight and the governor spring load are in equilibrium. The tension lever and governor lever come together and are limited by the stopper. The control rack is maintained at the position necessary for the rated load.



(4) No load max. rpm control

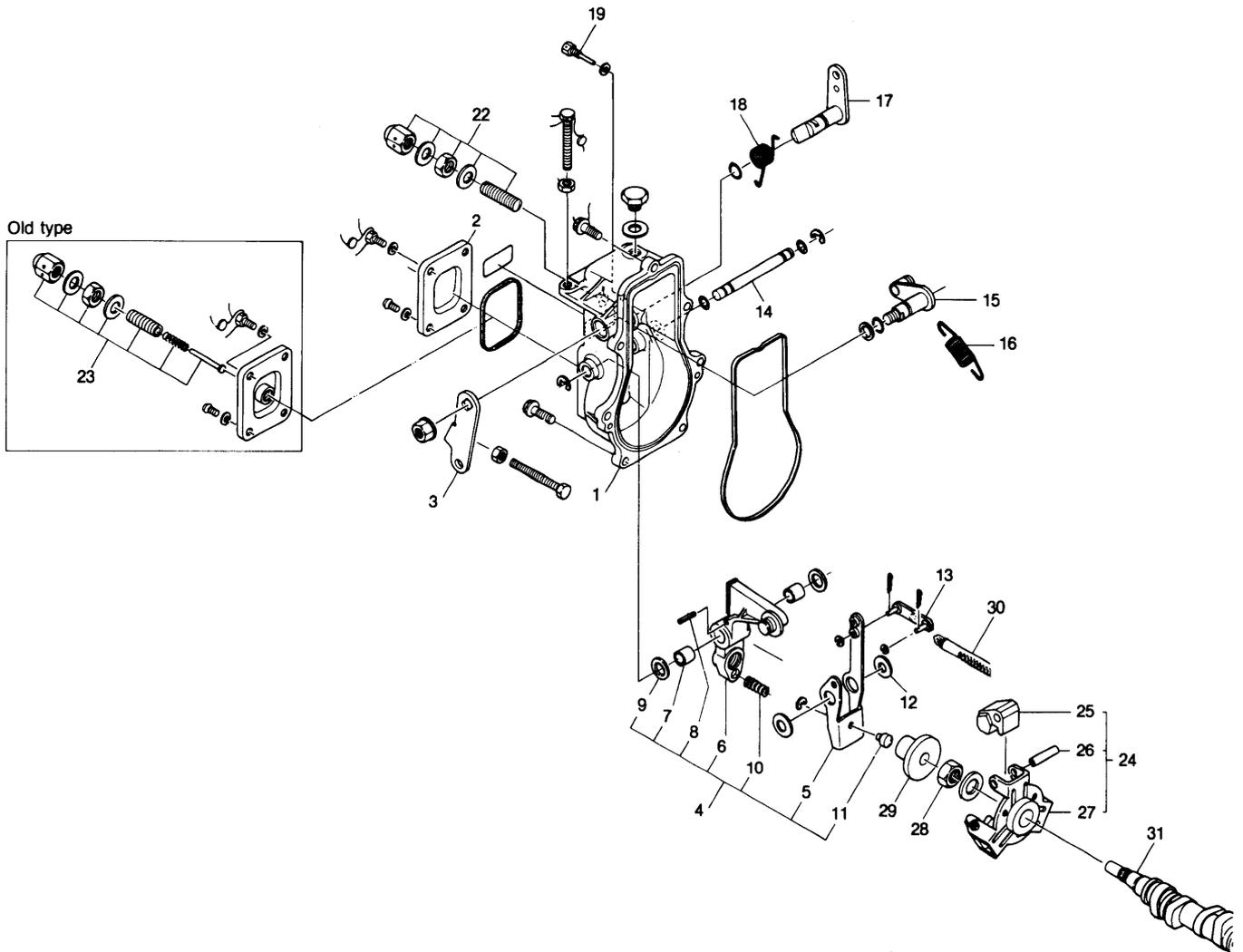
When rpm increases further from the max. load rpm control position, the thrust load of the governor weight exceeds that of the governor spring load, and causes the control rack to decrease injection volume through the tension lever and governor lever.



(5) Stopping engine

When you turn the stop handle, the governor causes the rack to decrease injection volume and stop the engine, regardless of the governor spring load.

2. Disassembly, Reassembly and Inspection of Governor



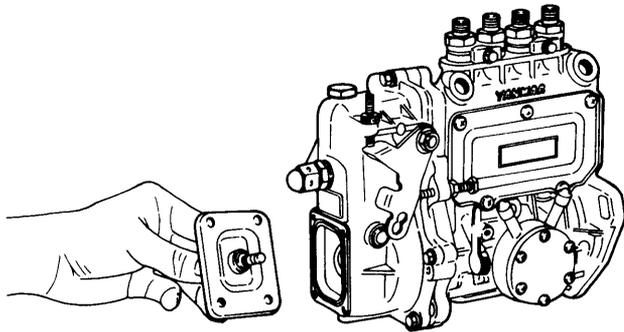
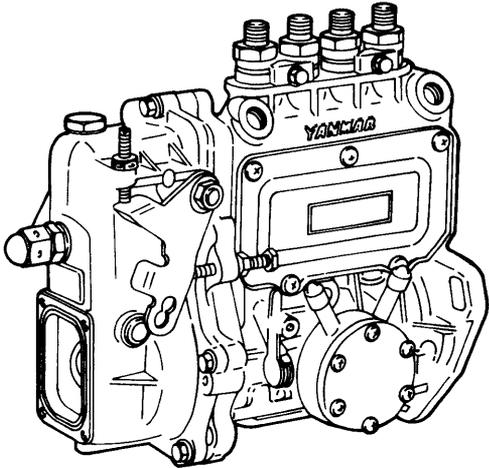
- 1. Governor case
- 2. Governor case cover
- 3. Control lever
- 4. Governor lever assembly
- 5. Governor lever
- 6. Tension lever
- 7. Bushing
- 8. Spring pin
- 9. Shim
- 10. Throttle spring
- 11. Shifter

- 12. Washer
- 13. Governor link
- 14. Governor shaft
- 15. Control lever shaft
- 16. Governor spring
- 17. Stop lever
- 18. Stop lever return spring
- 19. Stop lever stop pin
- 22. Fuel stopper (limit bolt) assembly
- 23. Adjusting spring assembly

- 24. Governor weight
- 25. Governor weight
- 26. Pin
- 27. Governor weight support
- 28. Governor weight nut
- 29. Governor sleeve
- 30. Control rack
- 31. Fuel pump cam shaft

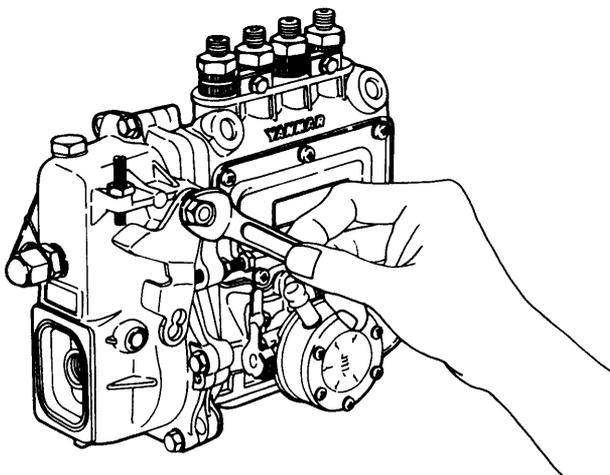
2-1 Governor disassembly

(1) Remove the governor case.

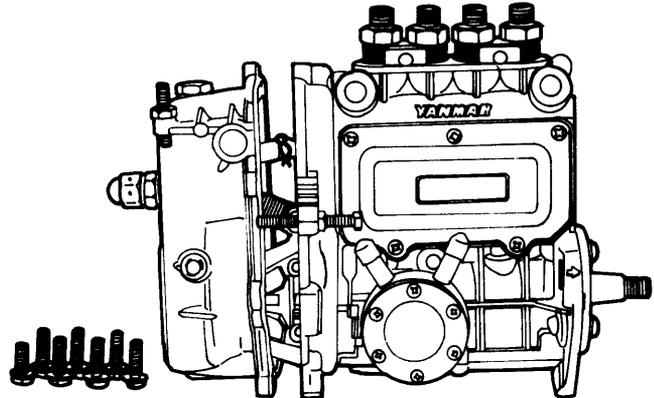


NOTE: Loosen the hex bolt on models with an angleich spring.

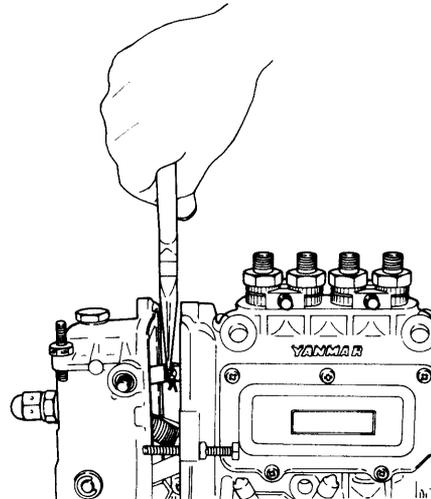
(2) Remove the control lever hex nut, and pull out the control lever from the control lever shaft.



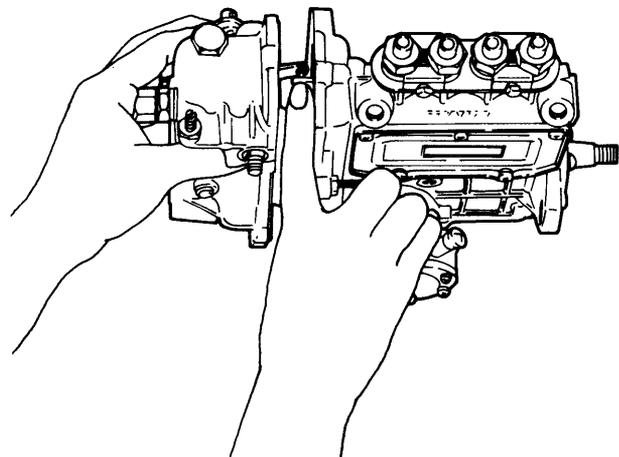
(3) Remove the governor case bolt. Remove the governor case (parallel pin) from the fuel pump unit while lightly tapping the governor case with a wood hammer. Create a gap between the governor case and fuel pump by moving only the moving parts of the governor lever.

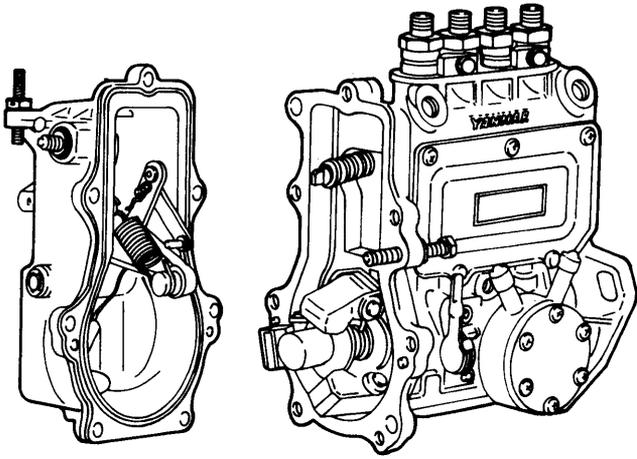


(4) Pull out the governor link snap pin by inserting needle nosed pliers between the fuel pump and governor case.

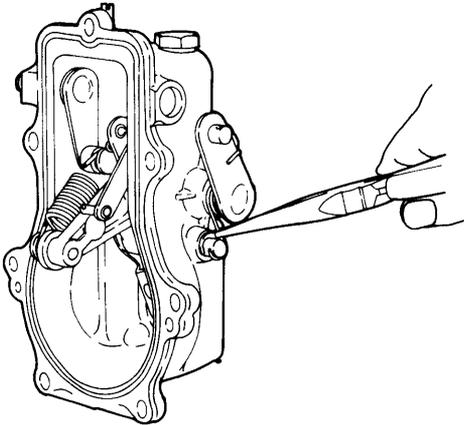


(5) The governor and fuel pump come apart by sliding the governor case and fuel pump apart and pulling out the link pin of the fuel control rack.

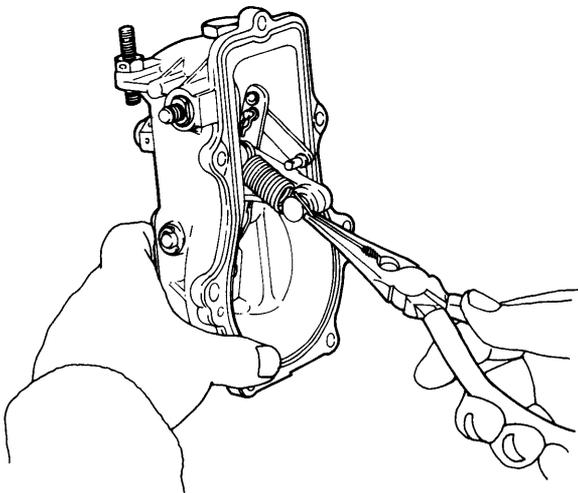




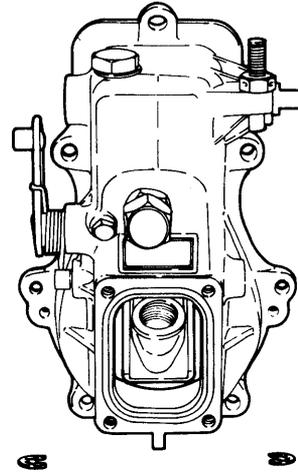
(6) Remove the stop lever return spring from the governor lever shaft.



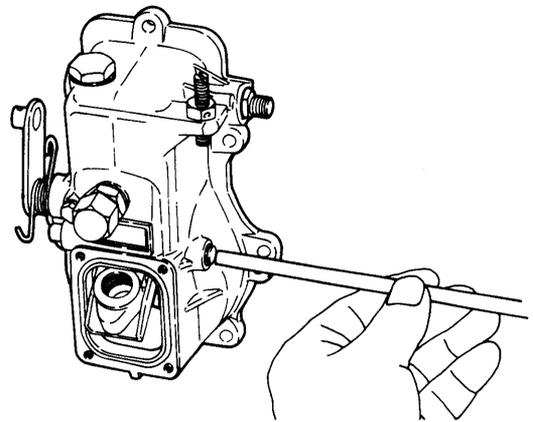
(7) Use needle nose pliers to unhook the governor spring from the tension lever and control lever shaft.



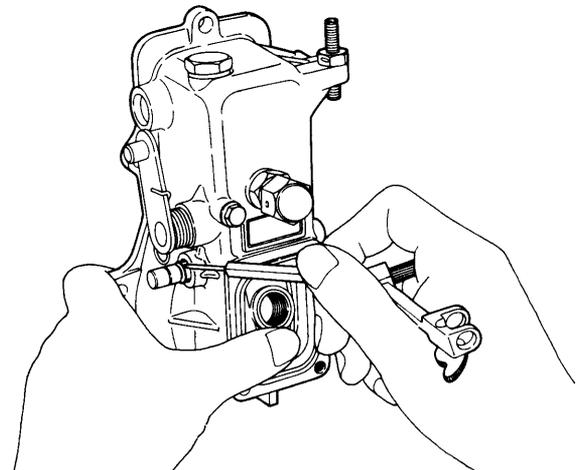
(8) Remove the snap-rings on both ends of the governor lever shaft.

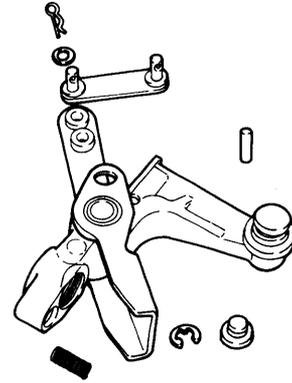
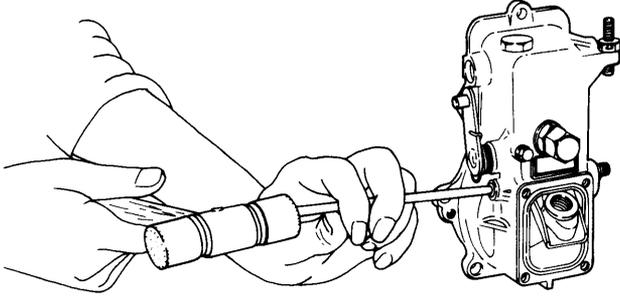


(9) Put a rod 8mm (0.3150in.) in dia. or less in one end of the governor lever shaft, and tap the governor shaft until the O-ring comes out the other side of the governor case.



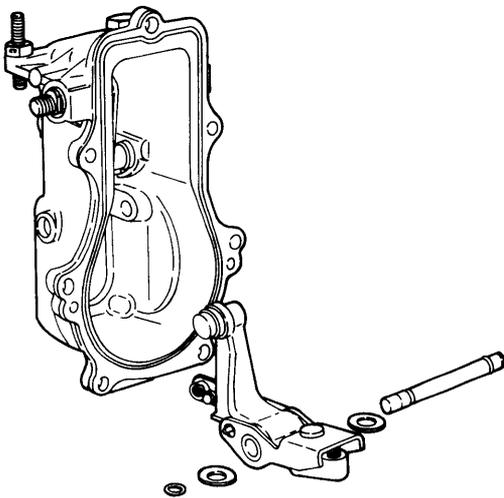
(10) After you remove the O-ring, lightly tap the end of the shaft that you removed the O-ring from, and remove the governor lever shaft. Then remove the governor shaft assembly and washer.



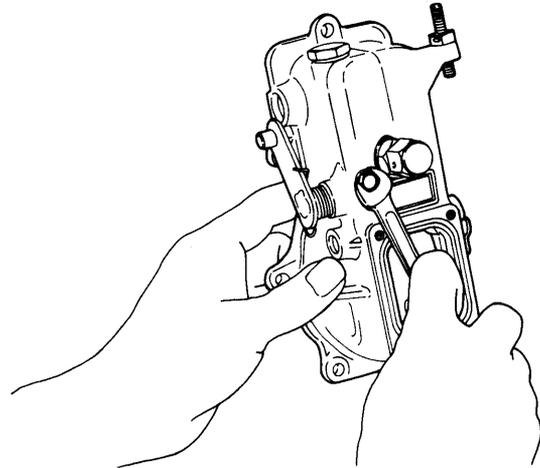


NOTE: The governor assembly consists of the governor lever, tension bar, bushing, throttle spring and shifter, and is normally not disassembled. The spring pin is removed when you replace the shifter or throttle spring.

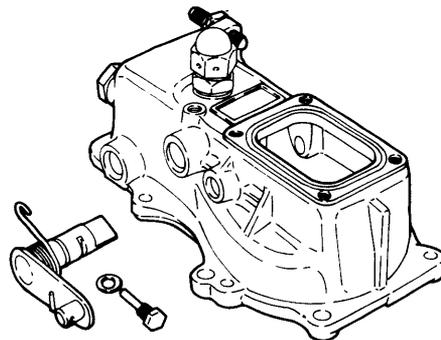
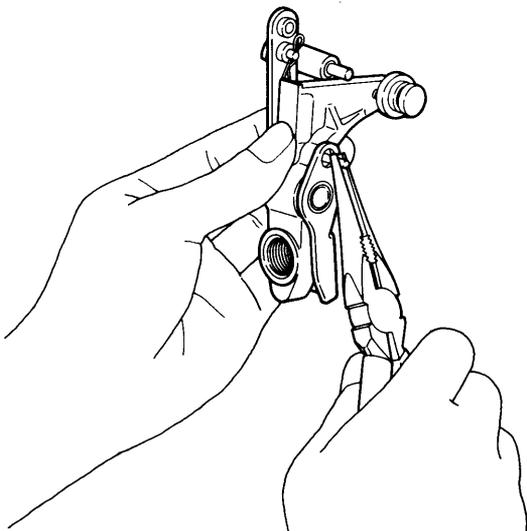
(12) When you need to pull out the stop lever, remove the stop lever shaft stop pin, and lightly tap the inside of the governor case.



(11) Remove the governor link from the governor lever.

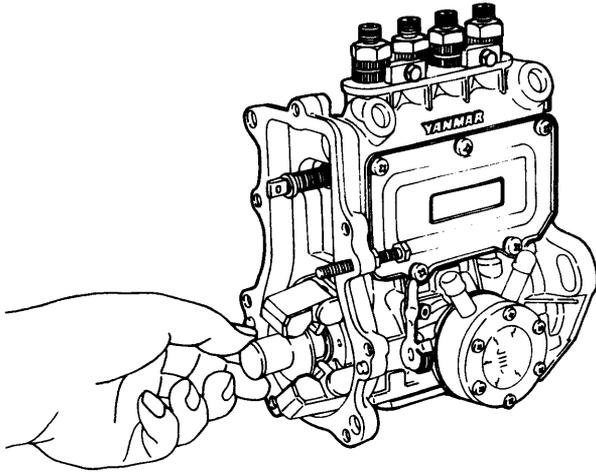


(13) When you need to pull out the control lever shaft, tap the end of the shaft with a wood hammer.

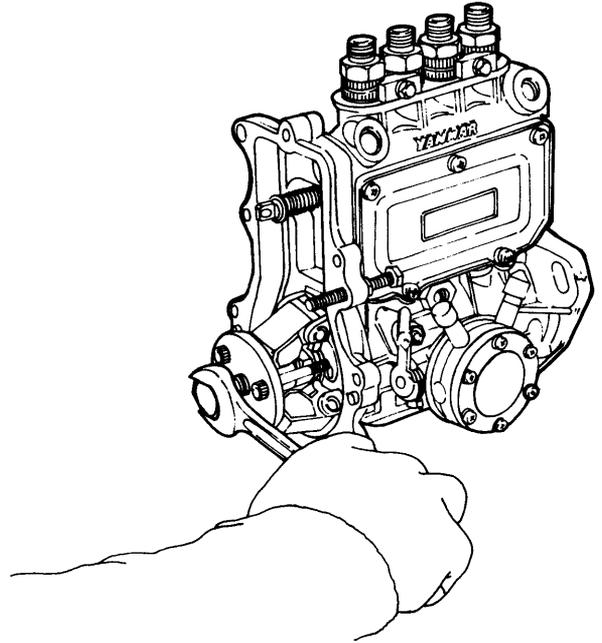


NOTE: 1. Do not remove the fuel limit nut from the governor case unless necessary.

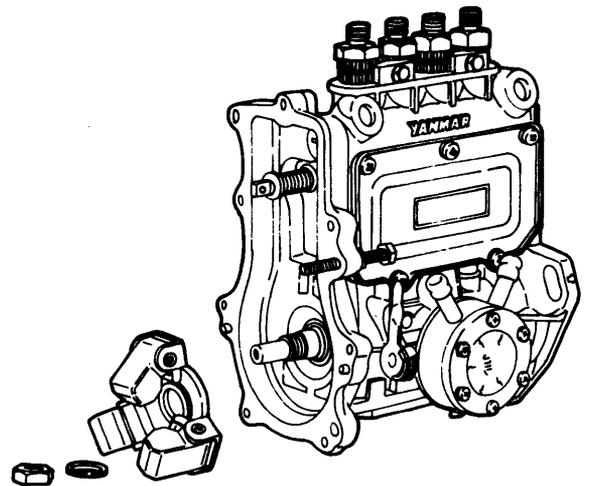
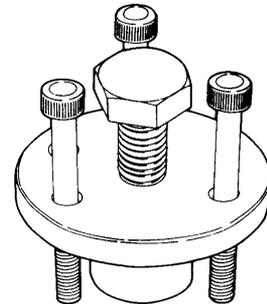
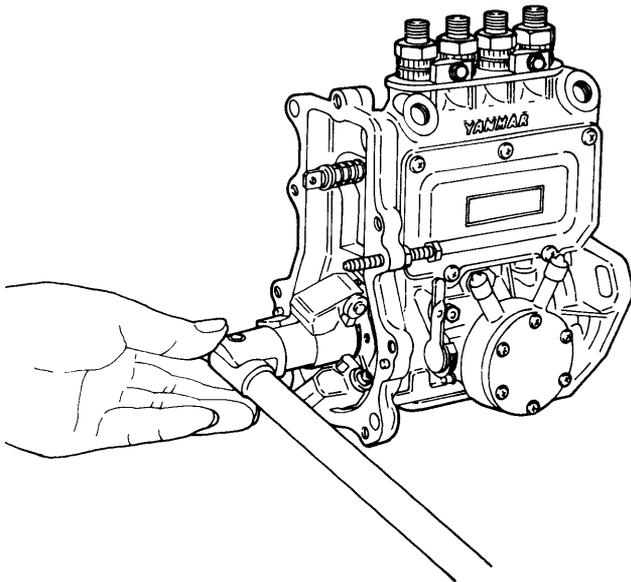
(14) Pull out the governor sleeve on the end of the fuel camshaft by hand.



(16) Remove the governor weight assembly from the fuel pump cam using the governor weight pulling tools.



(15) Turn the governor weight with a box spanner two or three times to loosen it, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise.



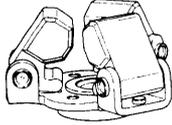
NOTE: When the taper fit comes apart after you have removed the nut, the governor weight may fly out — Be Careful.

NOTE: The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.

2-2 Inspection of governor

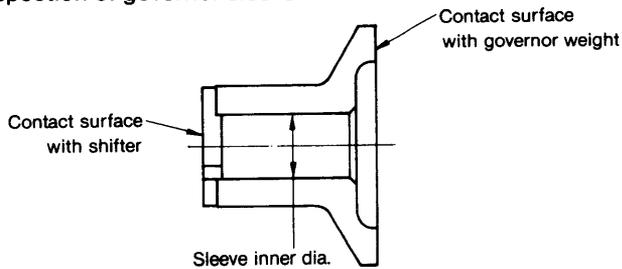
Inspection of governor weight assembly

- (1) Replace the governor weight if it does not open and close smoothly.



- (2) Replace the governor weight if the contact surface with governor sleeve is extremely worn.
- (3) Replace if there is governor weight support/pin wear or the caulking is loose.
- (4) Replace if the governor weight support stopper is excessively worn.

Inspection of governor sleeve



- (1) Replace the governor sleeve if the contact surface with governor weight is worn or there is pitching.
- (2) Replace the governor sleeve if the contact surface with shifter is considerably worn or there is pitching.
- (3) If the governor sleeve does not move smoothly above the cam shaft due to governor sleeve inner dia. wear or other reasons, replace.

Inspection of governor shaft assembly

- (1) Measure the clearance between the governor shaft and bushing, and replace if it exceeds the limit.

	Standard Dimension	Standard Clearance	Limit
Governor shaft outer dia.	7.986 ~ 7.995 (0.3144 ~ 0.3147)	0.065 ~ 0.124 (0.0025 ~ 0.0048)	0.5 (0.0196)
Bushing inner dia.	8.060 ~ 8.110 (0.3173 ~ 0.3192)		

- (2) Inspect the shifter contact surface, and replace the shifter (always by removing the pin to disassemble) if it is worn or scorched.
- (3) Disassemble and replace throttle springs that are settled, broken or corroded by pulling the spring pin.
- (4) Check link parts for bends or kinks that will cause malfunctioning, and replace any parts as necessary.

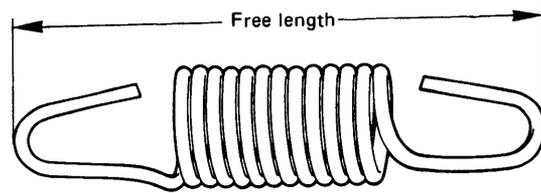
NOTE: 1. Side gap on top of governor lever shaft.

	Standard side gap
	0.4 (0.0157)

2. Replace the governor lever, tension bar, bushing, shifter and throttle spring as an assembly.

(5) Inspection of springs

- 1) Check the governor spring and other springs and replace if they are broken, settled or corroded.
- 2) Measure the free length of the governor spring, and replace if it exceeds the limit.
See service data sheet for free length of governor spring.



Governor spring spec. table

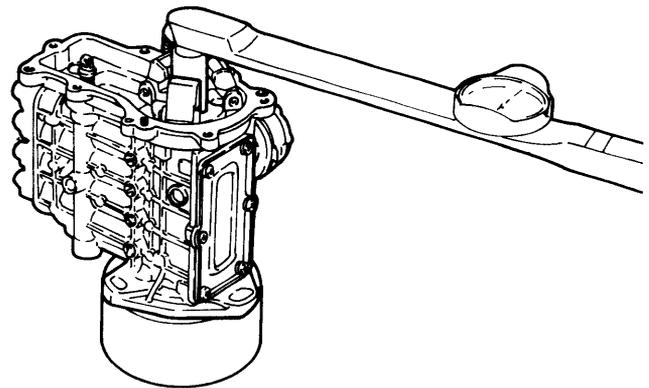
Engine model	4JHE, 4JH-TE	4JH-HTE, 4JH-DTE
Part No.	129470-61700	129473-61700
Spring constant	kg/mm 0.479	0.431
Free length	mm 54.0	52.5

2-3 Assembling governor

Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean new parts and parts to be reused, and put them in order.

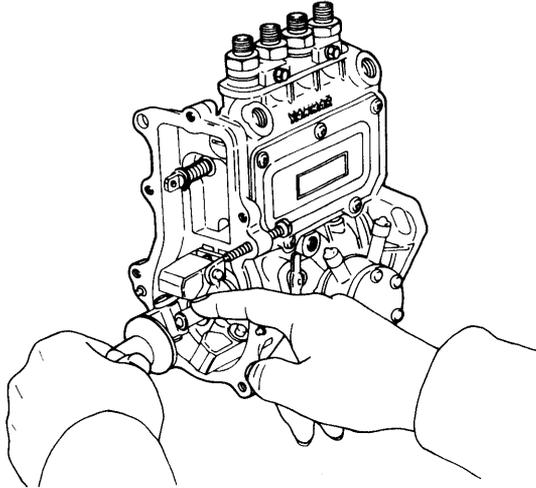
Make sure to readjust the unit after reassembly to obtain the specified performance.

- (1) Insert the governor weight assembly in the taper portion at the end of the fuel pump camshaft, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise, mount the rest, and tighten the governor weight nut.



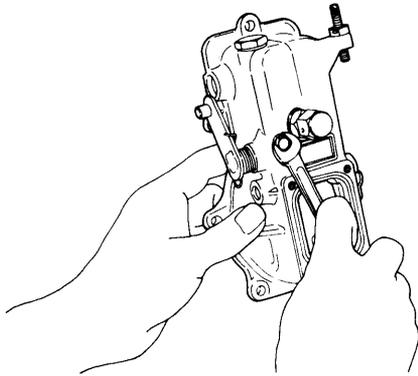
	kg-m (ft-lb)
Governor weight nut tightening torque	4.5 ~ 5.0 (32.54 ~ 36.16)

- (2) Open the governor weight to the outside, and insert the sleeve in the end of the fuel pump camshaft.



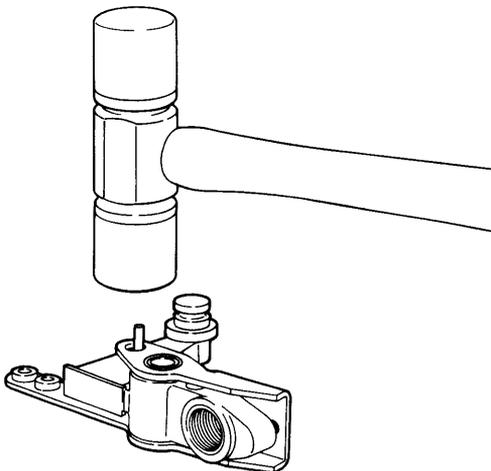
NOTE: Make sure that the sleeve moves smoothly after inserting it.

- (3) When the stop lever has been disassembled, mount the stop lever return spring on the stop lever, tap the stop lever lightly with a wooden hammer to insert it, and tighten the stop lever stop pin.

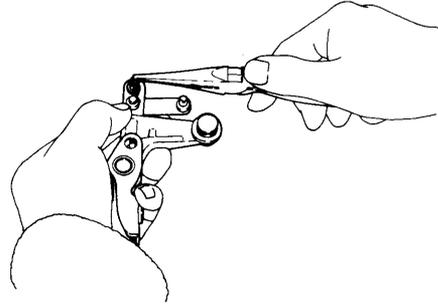


- (4) When the control lever shaft has been removed, lightly tap the control lever shaft and washer from inside the governor case, using an appropriate plate.

- (5) If the governor has been disassembled, tap in the spring pin.



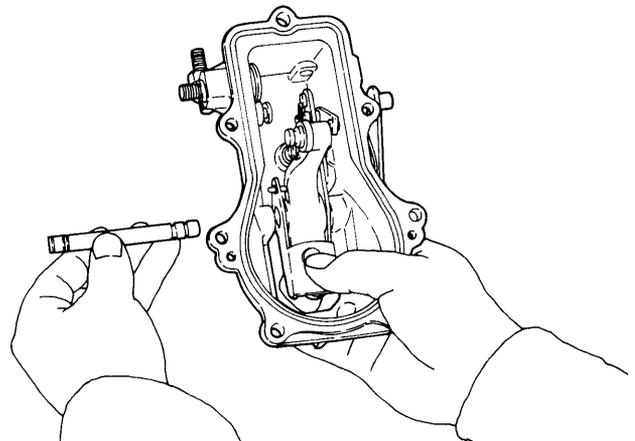
- (6) Mount the governor lever assembly to the governor link.



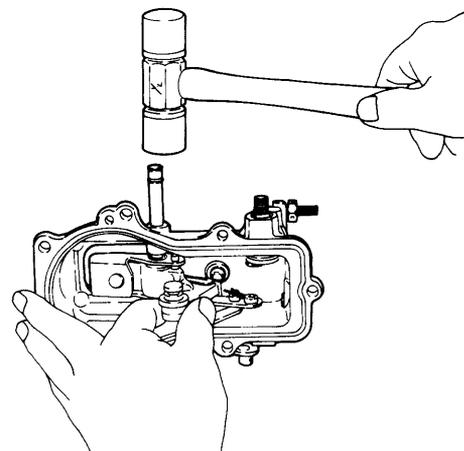
NOTE: 1. Make sure that the correct governor link mounting holes are used, and that it is mounted in the correct direction.

2. Make sure that the governor link moves smoothly.

- (7) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft, and tap it in until the O-ring groove comes out the opposite side of the governor case.

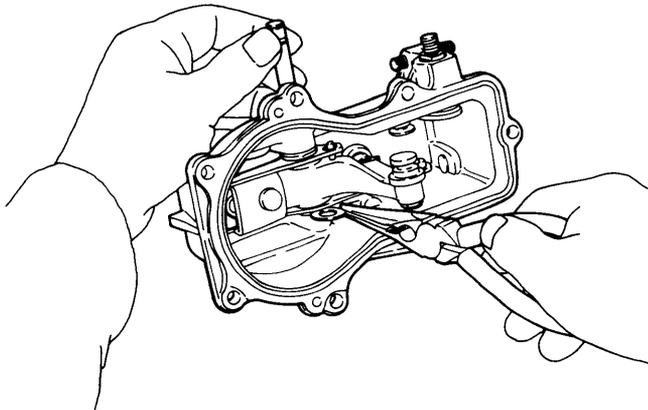


NOTE: 1. Fit the O-ring to the side you have tapped in.

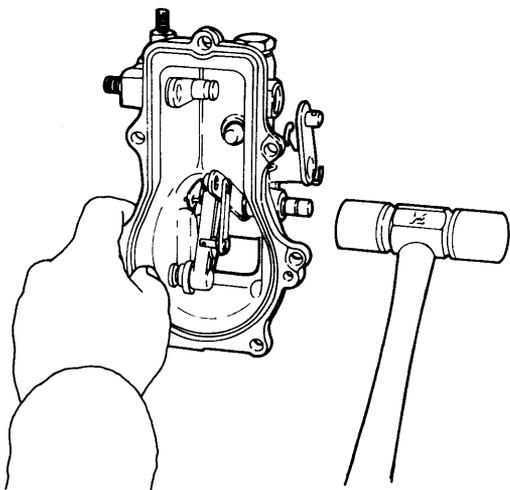
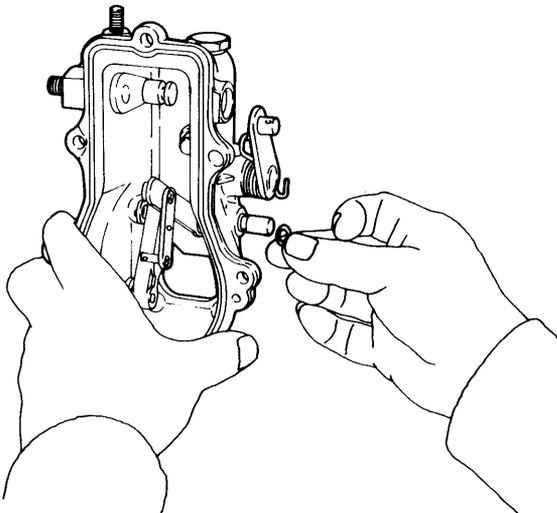


2. Make sure to insert the governor lever shaft in the correct direction.

3. Don't forget to mount the washers to both sides of the governor lever.

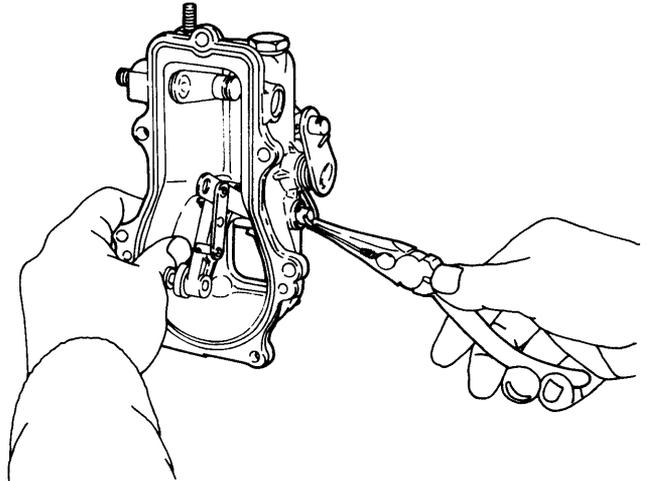


(8) After you have mounted the O-ring, tape the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.

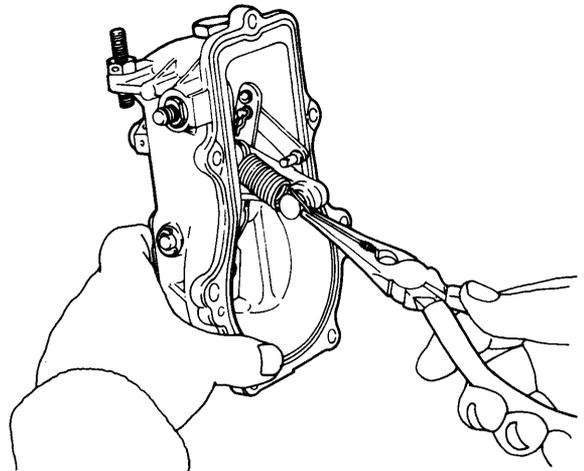


NOTE: After mounting the governor lever assembly, make sure the governor lever assembly moves smoothly.

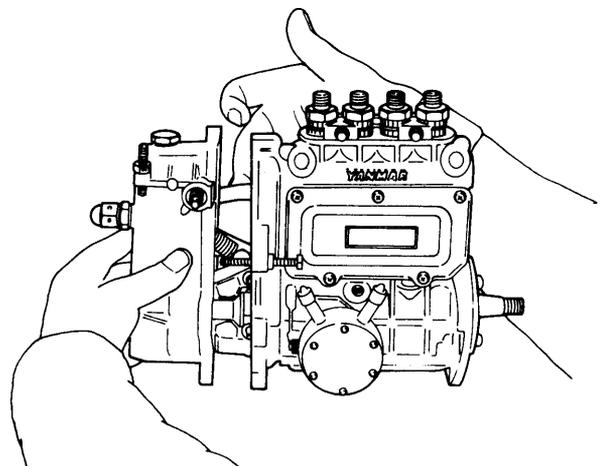
(9) Fit the stop lever return spring to the end of the governor lever shaft.



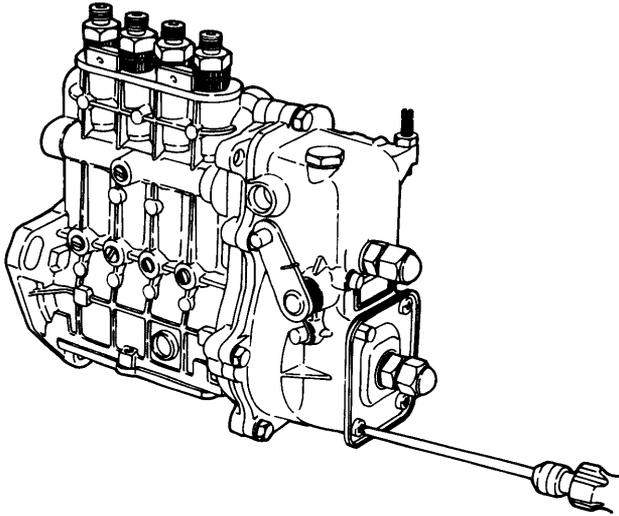
(10) Hook the governor spring on the control lever shaft and tension lever hook with radio pliers.



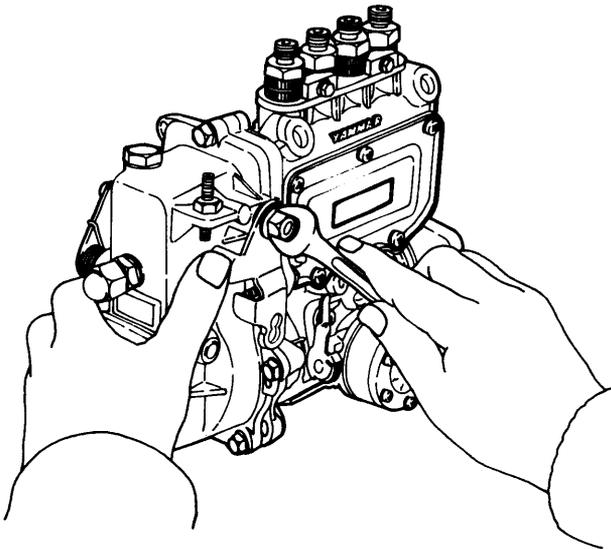
(11) Pull the governor link as far as possible towards the governor case mounting surface, insert the governor link pin in the fuel control rack pin hole and fit the snap pin on it.



- (12) Mount the governor case to the fuel pump unit while lightly tapping it with a wooden hammer, and tighten the bolts.
- (13) Place the adjusting spring and adjusting rod on the governor case cover adjusting bolt, and mount the governor case cover.

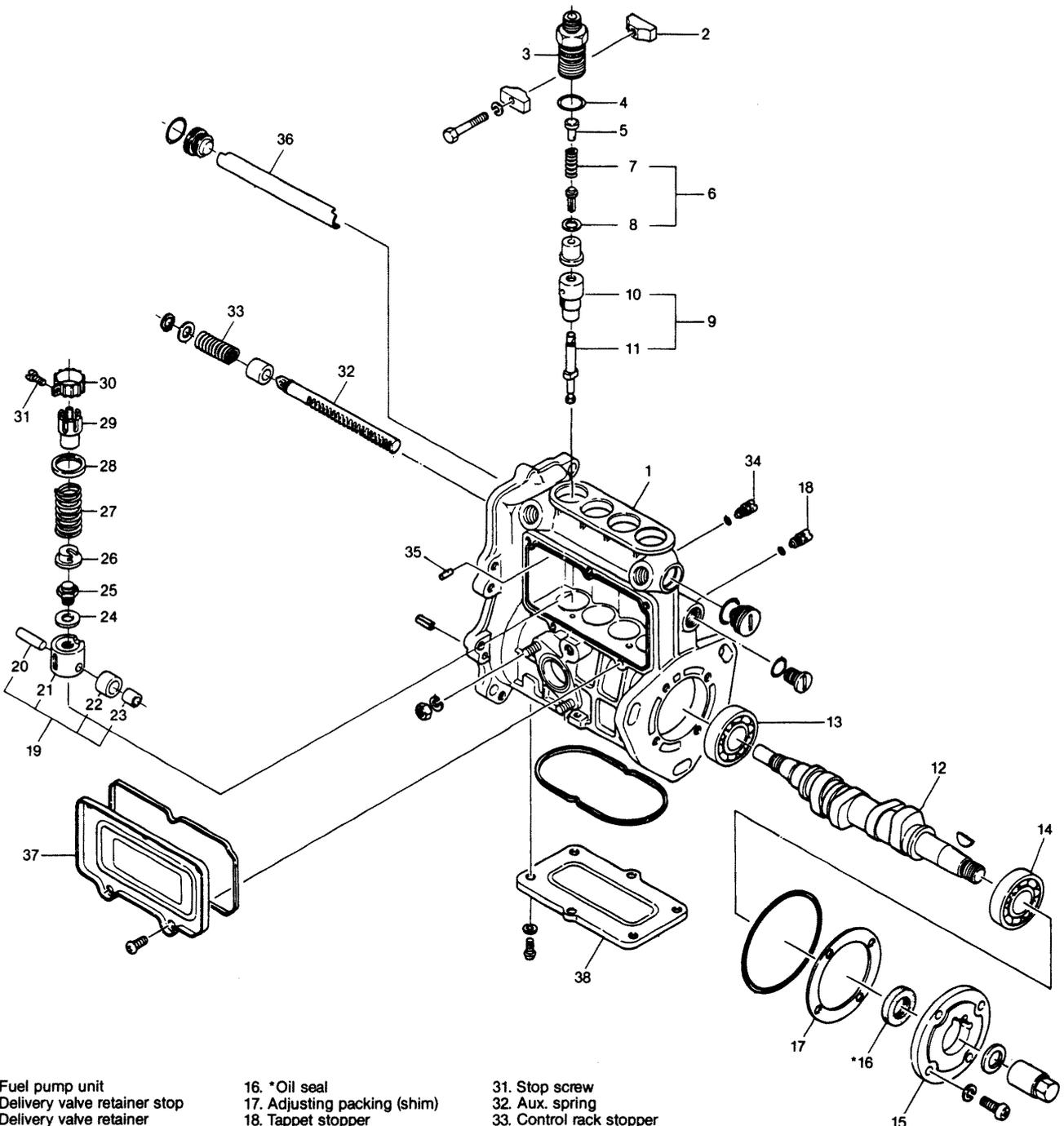


- (14) Insert the control lever in the control lever shaft, and tighten the nut.



NOTE: Move the control lever back and forth to make sure that the entire link moves smoothly.

3. Disassembly, Reassembly and Inspection of Fuel Injection Pump



- | | | |
|---------------------------------|-------------------------------------|----------------------------|
| 1. Fuel pump unit | 16. *Oil seal | 31. Stop screw |
| 2. Delivery valve retainer stop | 17. Adjusting packing (shim) | 32. Aux. spring |
| 3. Delivery valve retainer | 18. Tappet stopper | 33. Control rack stopper |
| 4. Delivery valve stopper | 19. Tappet assembly | 34. Plunger barrel stopper |
| 5. Delivery valve spring | 20. Pin | 35. Deflector |
| 6. Delivery valve assembly | 21. Roller guide | 36. Pump side cover |
| 7. Delivery valve | 22. Roller (outer) | 37. Pump bottom cover |
| 8. Delivery valve seat | 23. Roller (inner) | |
| 9. Plunger assembly | 24. Adjusting shim | |
| 10. Plunger barrel | 25. Adjusting bolt | |
| 11. Plunger | 26. Plunger spring rest B | |
| 12. Fuel pump camshaft | 27. Plunger spring | |
| 13. Bearing | 28. Plunger spring rest A | |
| 14. Bearing | 29. Control sleeve (reduction ring) | |
| 15. Bearing holder | 30. Control pinion B | |

NOTE: 1. Some models are equipped with ball bearings and some with taper roller bearings.

2. *Oil seal: Some models are equipped with oil seals and some are not. The shape of the bearing holder differs for models with and without oil seals.

3-1 Disassembly of fuel injection pump

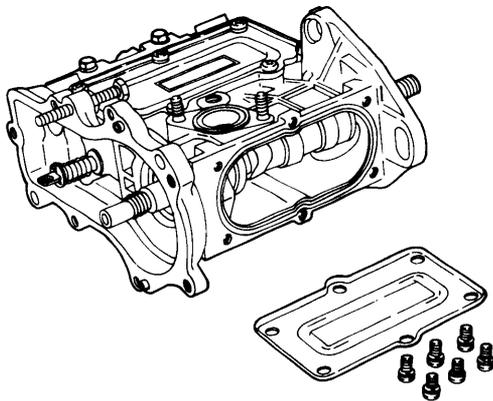
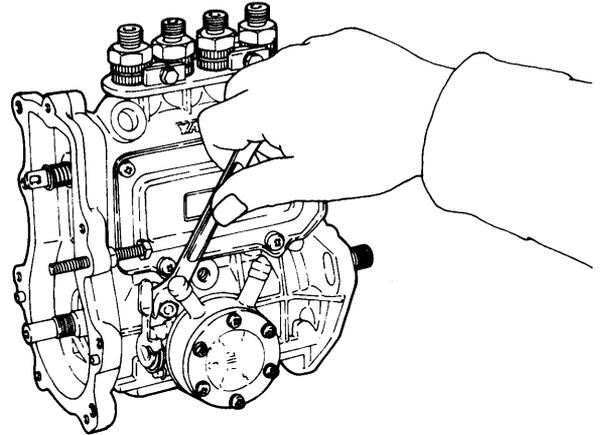
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up. Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept with that assembly and put back in the same cylinder).

Preparation

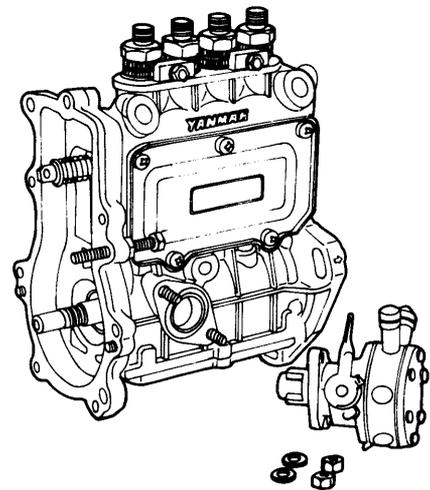
1. Wash off the dirt and grease on the outside of the pump with cleaning oil (kerosene or diesel oil) before disassembly.
2. Perform work in a clean area.
3. Take off the fuel pump bottom cover and remove lubricant oil.
4. Turn the fuel pump upside down to drain fuel oil.

(2) Remove the fuel feed pump.

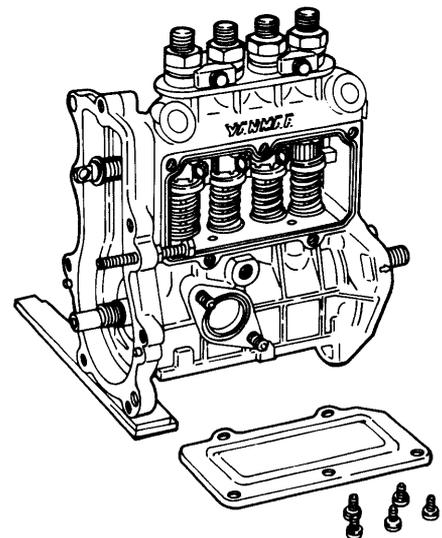
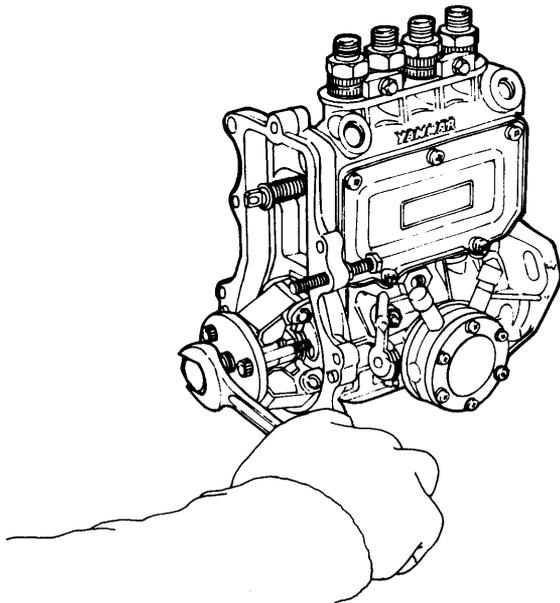
NOTE: Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.



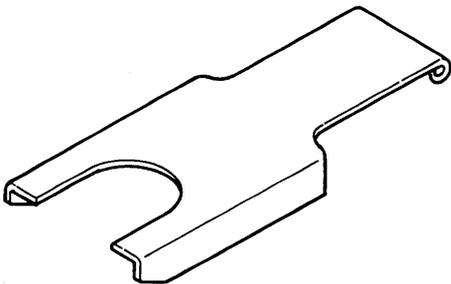
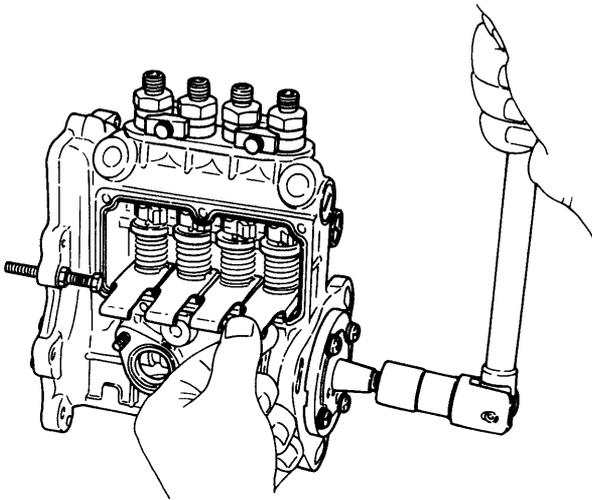
(1) Loosen the nut with a box spanner and take it off, holding it with the hole in the fuel coupling ring or holding the coupling with a vise and take out the governor weight assembly.



(3) Remove the fuel pump side cover.



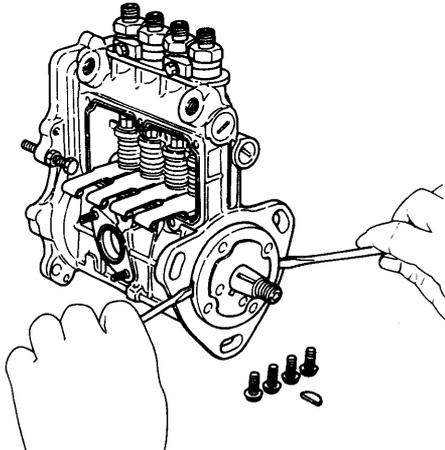
- (4) Turn the camshaft until the roller guide is at the maximum head, and insert the plunger spring support plate in between the plunger spring washer B (lower side) and fuel pump unit.



Plunger spring support plate

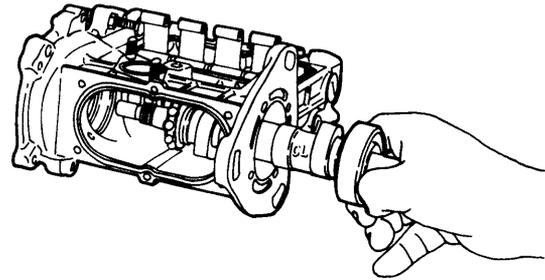
NOTE: If the camshaft does not turn, put double nuts on the end of the cam shaft or remove the coupling.

- (5) Remove the camshaft wood ruff key.
 (6) Put a screwdriver in the two grooves on the camshaft bearing holder mounting surface, and pull out the camshaft bearing holder.

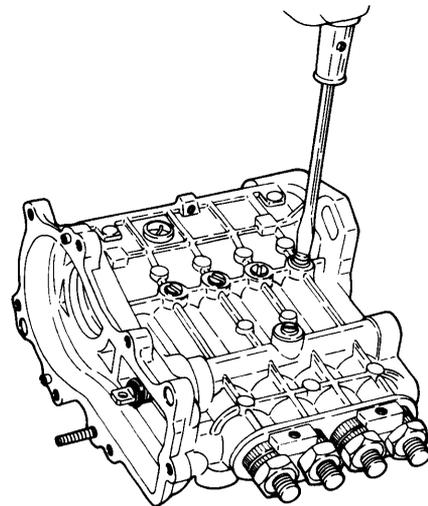


NOTE: 1. Make sure not to damage the oil seal with the threaded part of the camshaft.
 2. Be careful not to loose the shims in between the pump and bearing holder.

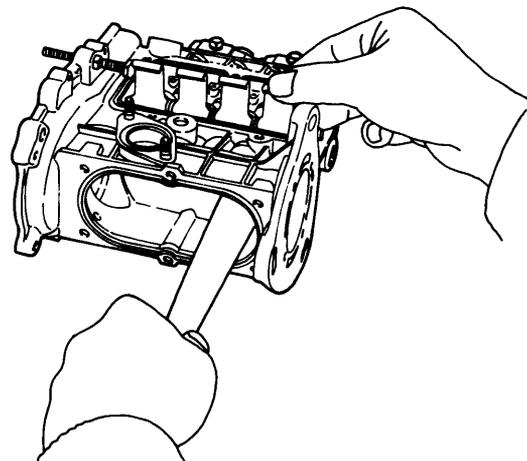
- (7) Turn the fuel pump upside down, move all the roller guides to the plunger side, and then put the pump on its side. Turn the camshaft to a position so that none of the cylinder cams hit the tappets.
 (8) Put a plate against the governor end side of the camshaft and lightly tap it, and pull out the camshaft and drive side bearing.



- (9) Remove the roller guide stop.

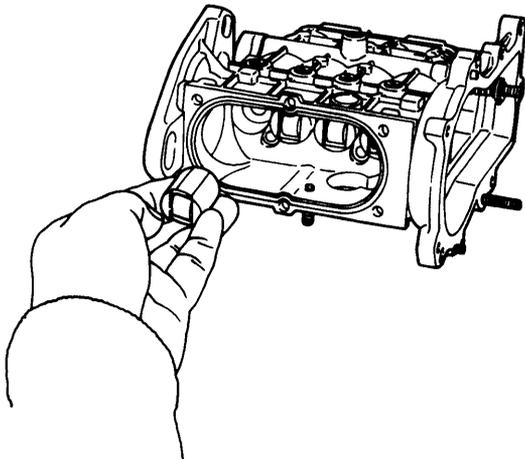


- (10) Use a hammer handle or the like to push up the roller guide from the bottom of the pump, and remove the plunger spring support plate.

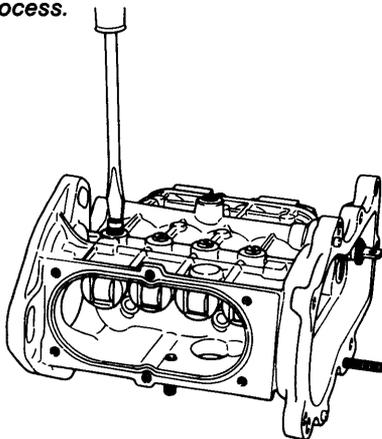


NOTE: The plunger spring may make the roller guide and plunger, etc. fly out when the plunger support plate is removed.

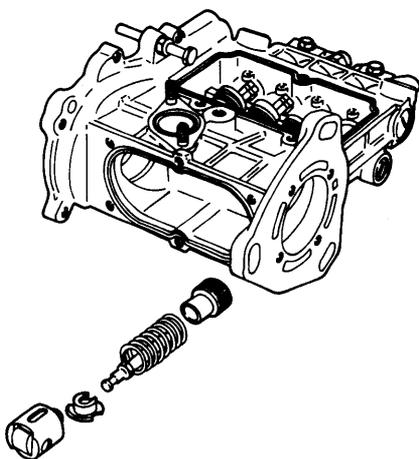
(11) Remove the roller guide.



NOTE: When you stand the fuel pump up, all of the roller guides drop out at one time. Therefore, first remove the stop bolt for one cylinder at a time, and then the roller guide for each cylinder—continue this process.

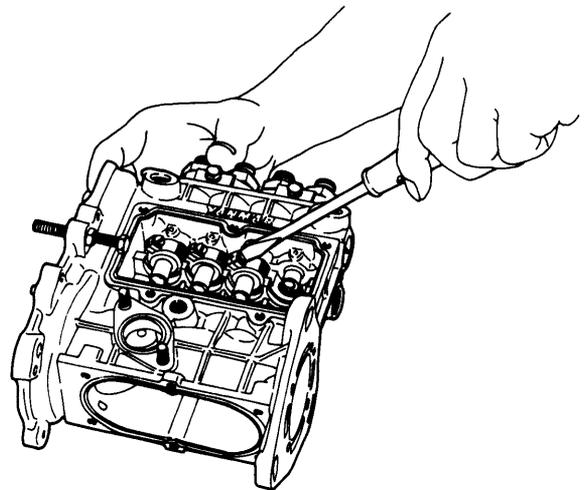


(12) Remove the plunger, plunger spring and lower washer from the lower part of the pump.

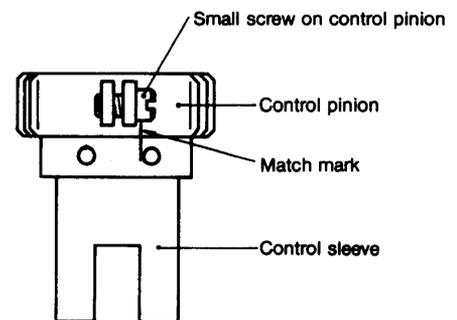


NOTE: Keep the parts separate for each cylinder.

(13) Loosen the small screw on control pinion.

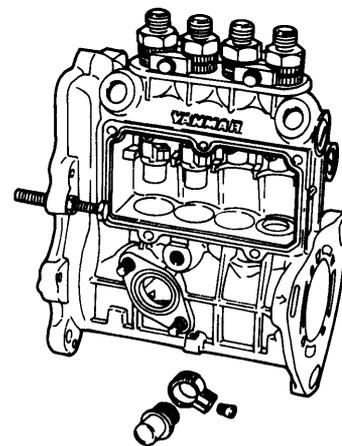


NOTE: 1. Check to make sure the match marks on the pinion/sleeve are correct before loosening the small screw on the control pinion, as the pinion and sleeve come apart when the screw is loosened. If the mark is hard to read or off center, lightly inscribe a new mark. This will serve as a guide when adjusting injection volume later.



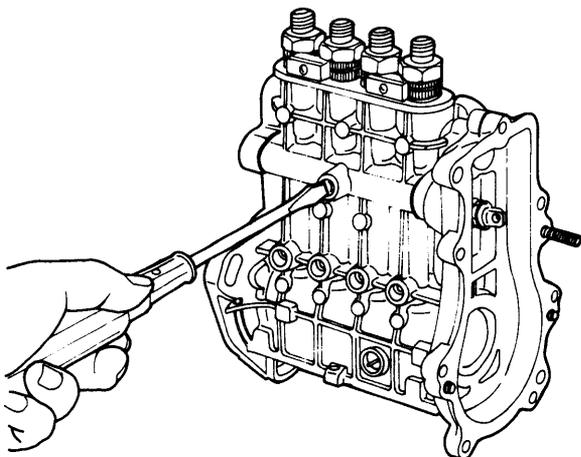
2. Keep parts separate for each cylinder.

(14) Remove the control pinion, sleeve and upper rest.

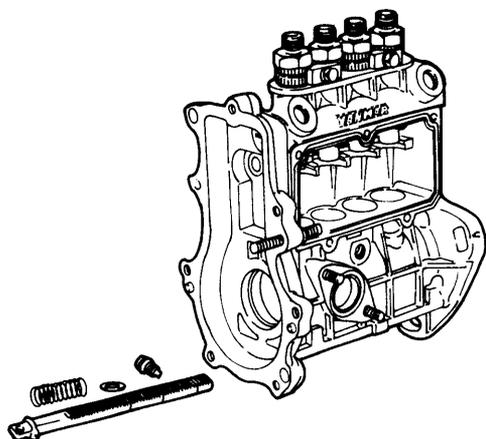


NOTE: Keep parts separate for each cylinder.

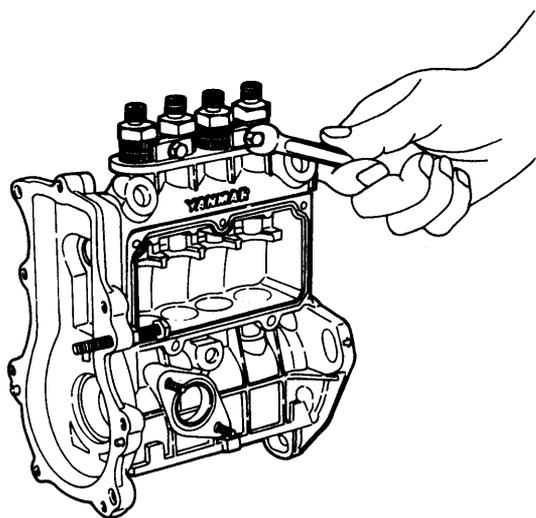
(15) Remove the control rack stop bolt and remove the rack.



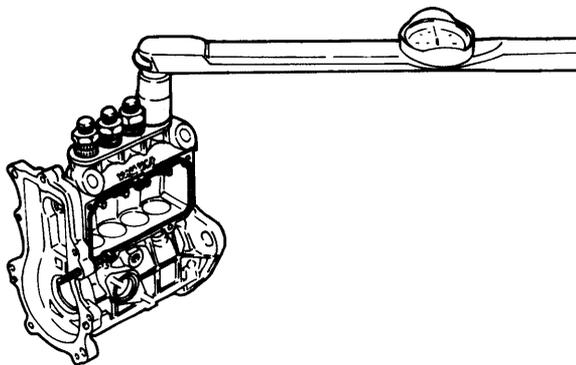
NOTE: Be careful not to lose the spring or rest on the control rack.



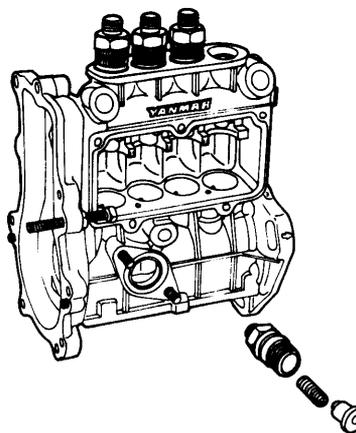
(16) Loosen the delivery valve retainer stop bolt, and remove the delivery valve holder stop.



(17) Remove the delivery valve holder.



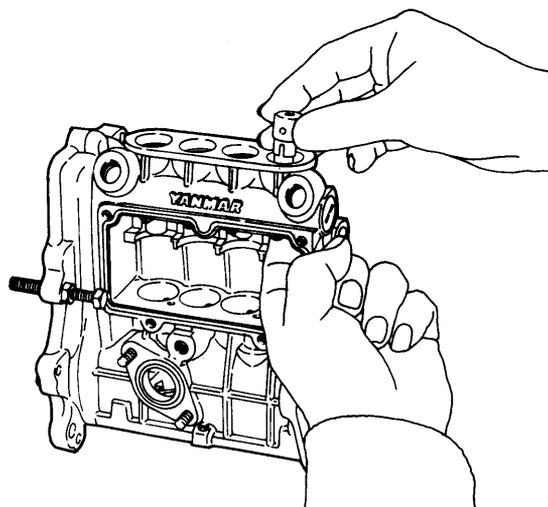
(18) Remove the delivery valve assembly.



NOTE: 1. Be careful not to lose the delivery valve packing, delivery valve spring, delivery valve stopper or other small parts.

2. Keep the delivery valve assemblies for each cylinder clearly separated.

(19) Take the plunger barrel out from the top of pump.

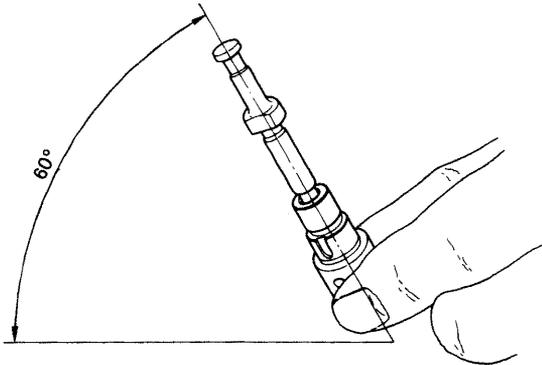


NOTE: Keep it as a set with the plunger that was removed earlier.

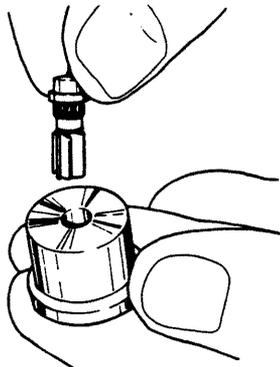
3-2 Inspection of fuel injection pump

(1) Inspection of plunger

- 1) Thoroughly wash the plungers, and replace plungers that have scratches on the plunger lead or are discolored.
- 2) The plunger is in good condition if it slides down smoothly when it is tilted about 60°. Repeat this several times while turning the plunger. Repair or replace if it slides down too quickly or if it stops part way.



(2) Inspection of delivery valve



- 1) Replace as a set if the delivery valve suck-back collar or seat are scratched, scored, scuffed, worn, etc.
- 2) The valve is in good condition if it returns when released after being pushed it down with your finger (while the holes in the bottom of the delivery guide seat are covered). Replace if necessary.
- 3) Likewise, the valve should completely close by its own weight when you take your finger off the holes in the bottom of the delivery guide sheet.

NOTE: When fitting new parts, wash with diesel oil and perform the above inspection.

(3) Inspection of pump

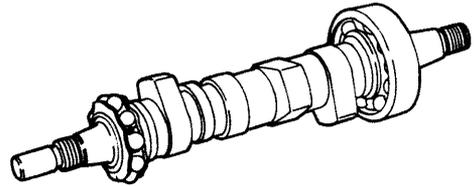
- 1) Inspect for extreme wear of roller guide sliding surface. Scratches on the roller pin sliding surface are not a problem.
- 2) Inspect the plunger barrel seat. If there are burrs or discoloration, repair or replace as this will lead to dilution of the lubricant.
- (4) Inspection of fuel camshaft and bearings
 - 1) Fuel camshaft

Inspect for scratches or wear of camshaft, deformation

of key grooves and deformation of screws on both ends, and replace if necessary.

2) Bearings

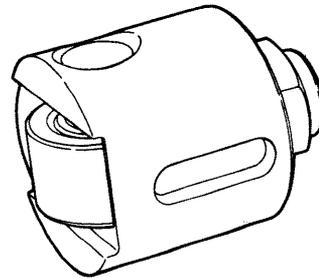
Replace if the taper rollers or outer race surface is flaked or worn.



NOTE: Replace fuel camshafts and bearings together.

(5) Inspection of roller guide assembly

1) Roller



Replace if the surface is worn or flaked.

2) Roller Guide

Replace if the outer roller pin hole is extensively worn or there are many scratches.

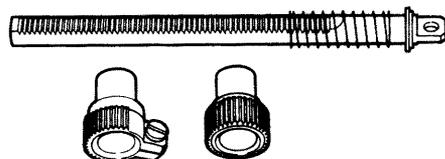
3) Replace if the play of the roller guide assembly pin/roller is 0.2mm (0.0078in.) or more.

4) Injection timing adjustment bolt

Replace if the surface in contact with the plunger side is unevenly or excessively worn.

(6) Inspection of rack and pinion

1) Rack



Inspect for bending of rack and wear or deformation of fit with pinion.

2) Pinion

Inspect for wear or deformation of fit with rack.

NOTE: If the tooth surface or sliding surface is not in good working order, rack resistance increases, affecting the condition of the engine (rough rpm, over running, etc.).

(7) Inspection of plunger spring and delivery spring
Inspect springs for scratches, cracks, breakage, uneven wear and rust.

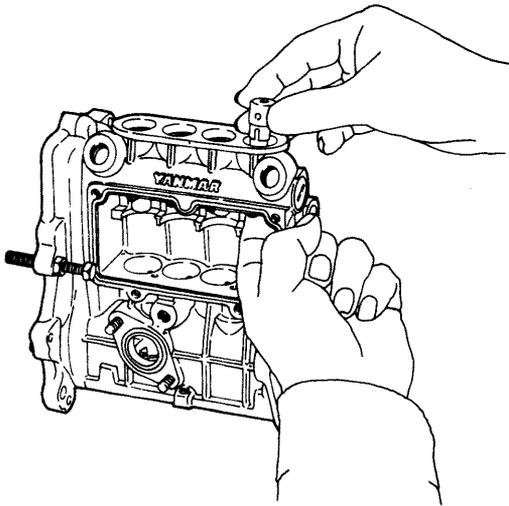
- (8) Inspection of oil seals
Inspect oil seals to see if they are burred or scratched.
- (9) Inspection of roller guide stop
Inspect the side of the tip, replace if excessively worn.
- (10) Inspection of O-rings
Inspect and replace if they are burred or cracked.

3-3 Reassembly of fuel injection pump

Preparation

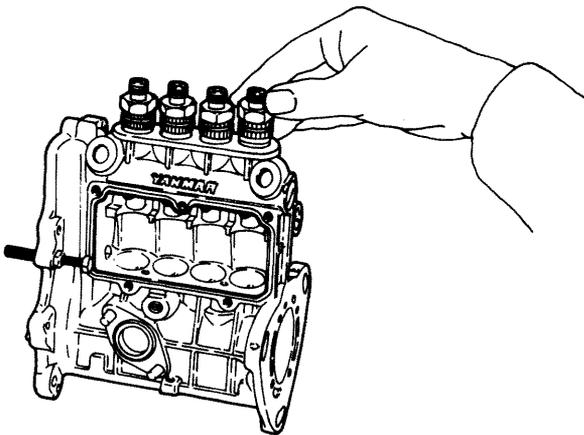
After inspection, put all parts in order and clean.
See Inspection of Fuel Pump for inspection procedure.

- (1) Put in the plunger barrel from the top of pump.



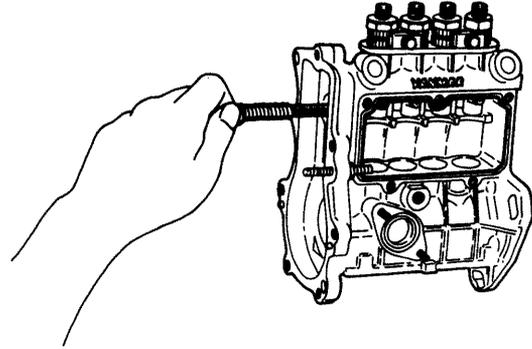
NOTE: Make sure the barrel key groove is fitted properly to the barrel stop pin.

- (2) Place the delivery valve assembly, packing, spring and stopper from the top of the pump, in this order.



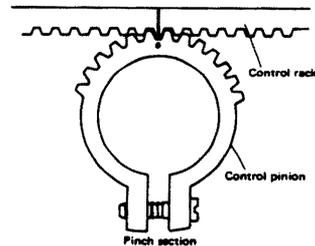
NOTE: Replace the delivery valve packing and O-ring.

- (3) Place the control rack, and tighten the control rack stop bolt.

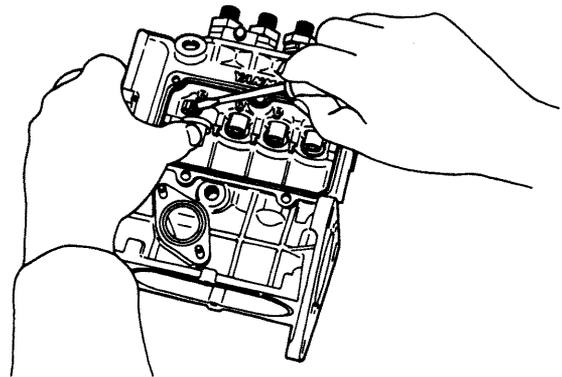


NOTE: 1. Do not forget the rack aux. spring.
2. Make sure the rack moves smoothly through a full cycle.

- (4) Place the rack set screw (using the special tool) in the rack stop bolt screw hole to fix the rack.
- (5) Looking from the bottom of pump, align the match marks on the rack and pinion.

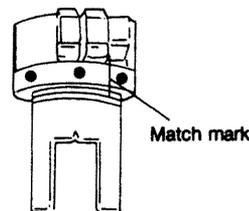


- (6) While holding the pinion with one hand and keeping it aligned with the match mark, fit in the sleeve, and lightly tighten the small pinion screw.

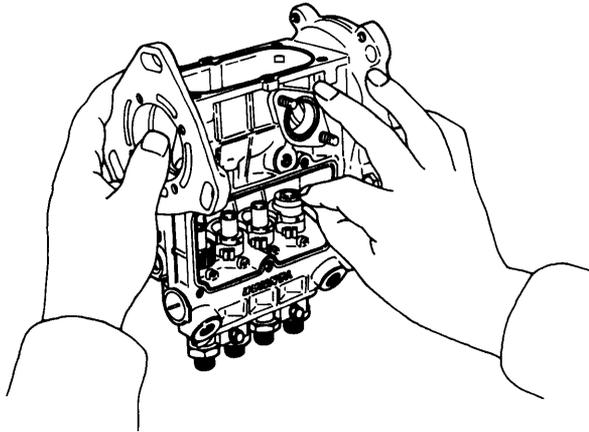


NOTE: Fitting of sleeve; Face towards small pinion screws and align with match mark.

Pinion/sleeve match mark



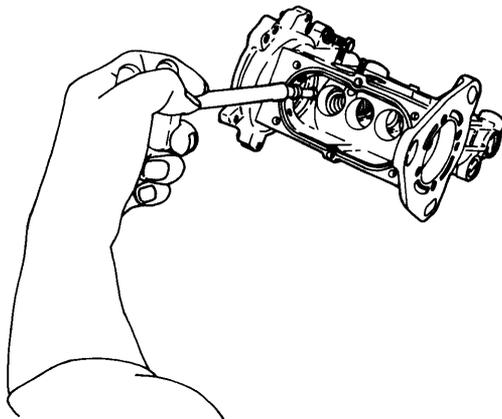
(7) Mount the plunger spring upper rest.



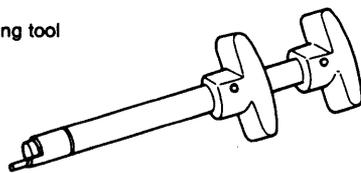
NOTE: 1. Make sure to mount the upper rest with the hollow side facing down.
2. Recheck to make sure that the rack moves easily.

(8) Mount the plunger spring.

(9) Mount the lower rest on the head of the plunger, and fit the plunger in the lower part of pump while aligning the match marks on the plunger flange and the sleeve.

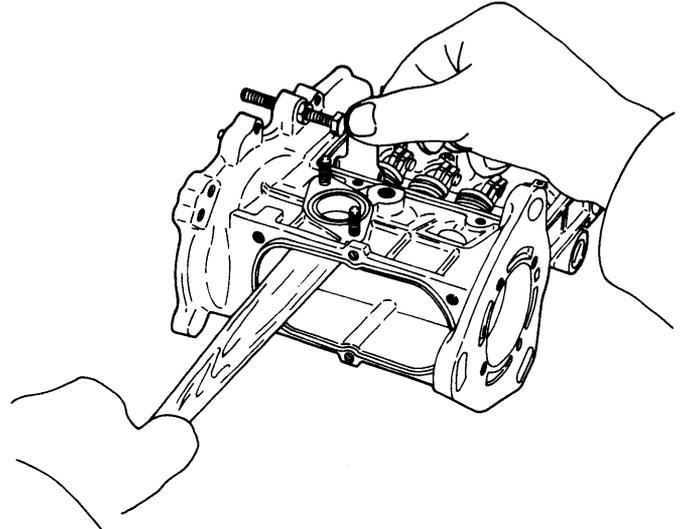


Plunger inserting tool

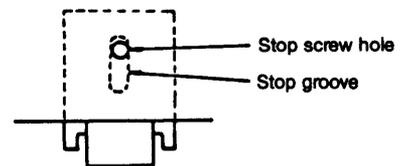


NOTE: If the plunger is mounted in the opposite direction, the injection volume will increase abnormally and cannot be adjusted.

(10) Insert the plunger spring support plate between the plunger spring seat B (lower) and fuel pump, by putting the handle of a hammer in the lower part of pump and pushing the roller guide up.



NOTE: 1. Face the roller guide stop groove up, and align with stop screw hole on pump.

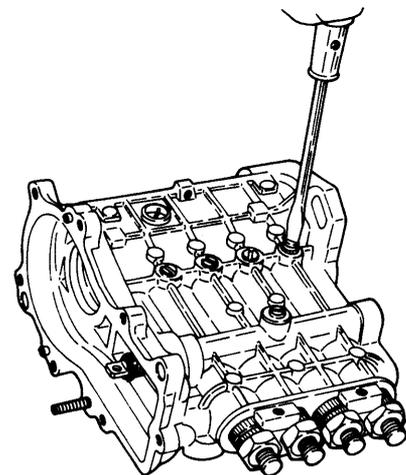


2. Check movement of rack. The plunger spring may be out of place if movement is heavy—insert a screwdriver and bring to correct position.

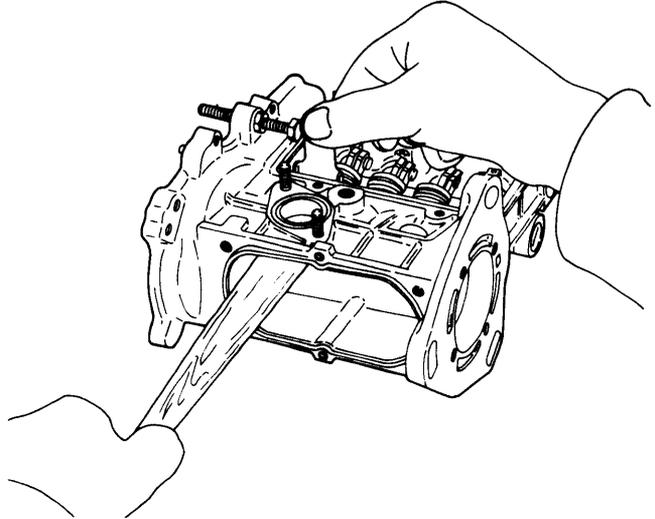
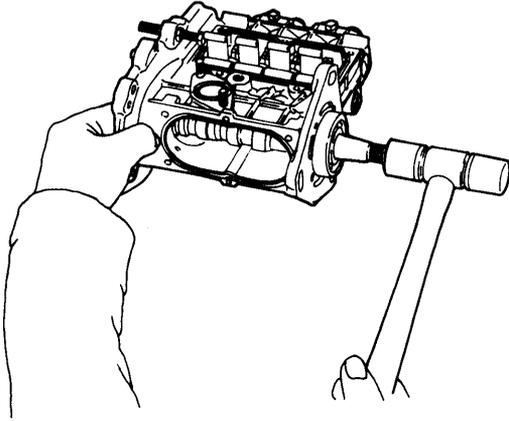
3. When replacing the roller guide assembly, fit shims and lightly tighten:

Standard shim thickness	1.2 mm (0.0472 in.)
Part code number	129155-51600

(11) Make sure that roller guide stop groove is in correct position, and tighten roller guide stop bolt.



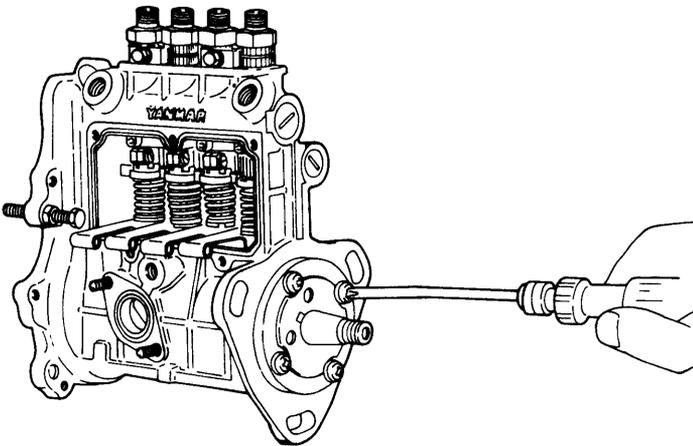
- (12) Fit the bearings to both ends of the camshaft, and insert from drive side by lightly tapping.



NOTE: Turn pump upside down, and tap camshaft in while moving roller guide to plunger spring side.

- (13) Fit the oil seal on the inside of the bearing retainer and mount the bearing retainer.

- (15) Mount the fuel pump side cover.
 (16) Tap in the camshaft wood ruff key.
 (17) Turn the camshaft, and pull out the plunger spring support plate.



NOTE: Coat the camshaft and oil seal with oil to prevent the oil seal from being scratched.

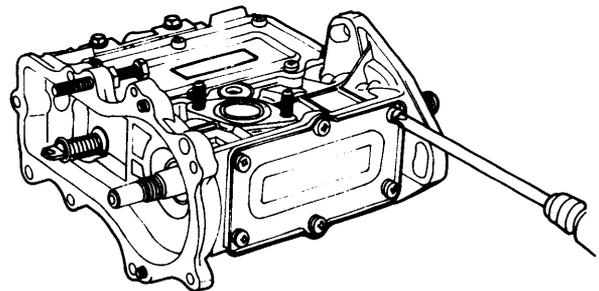
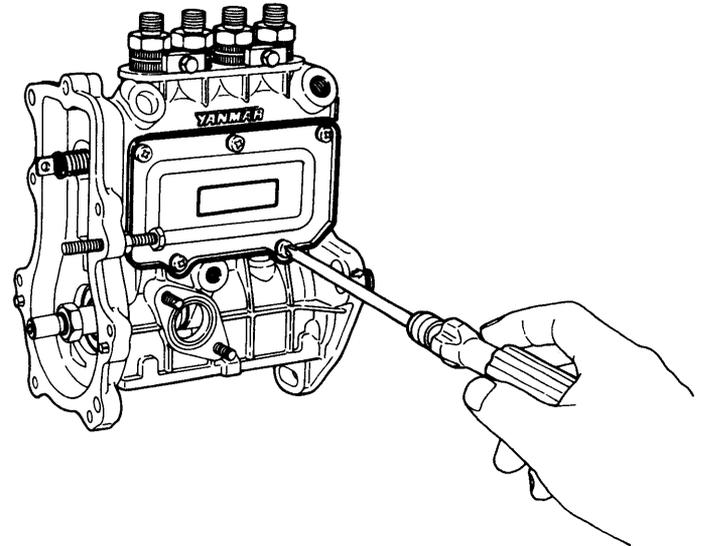
- (14) Fix the pump, lightly tap both ends of the cam shaft with a wood hammer, and adjust the cam shaft side clearance with the adjustment shims while checking with side clearance gauge.

	mm (in.)
Camshaft side clearance	0.02 ~ 0.05 (0.0007 ~ 0.0019)

Adjusting

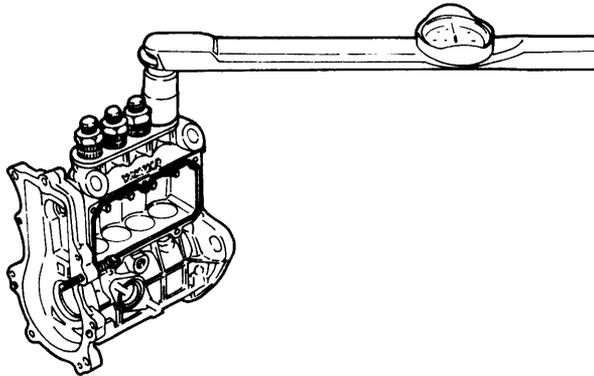
Pull out adjusting shims if clearance is too small, and add adjusting shims if it is too large.

	mm (in.)
Adjusting shim thickness	0.50 (0.0196)
	0.40 (0.0157)
	0.30 (0.0118)
	0.15 (0.0059)



NOTE: Fit double nuts to turn the camshaft.

(18) Tighten delivery valve retainer.

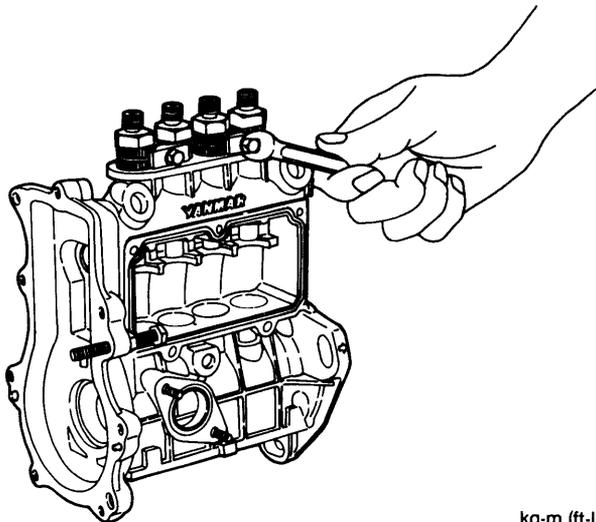


	kg-m (ft-lb)
Tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

NOTE: 1. Tighten the retainer as far as possible by hand— if the bolt gets hard to turn part way, the packing or delivery valve are out of place. Remove, correct, and start tightening again.

2. Overtightening can result in malfunctioning of the rack.

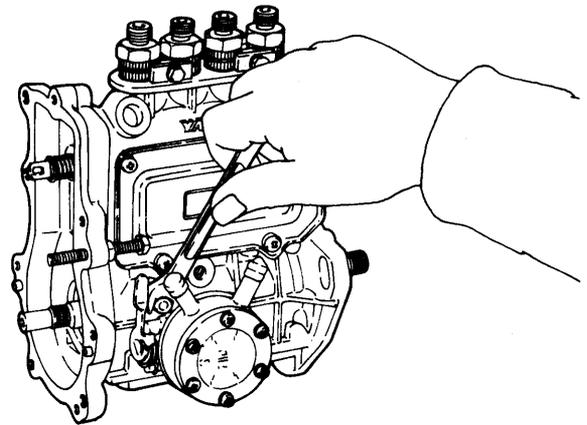
(19) Fit the delivery retainer stop and tighten the stop bolt.



	kg-m (ft-lb)
Tightening torque	0.3 (2.16)

NOTE: Overtightening can upset the delivery retainer and cause oil leakage.

(20) Mount the fuel feed pump



NOTE: See the item explaining reassembly of the fuel feed pump.

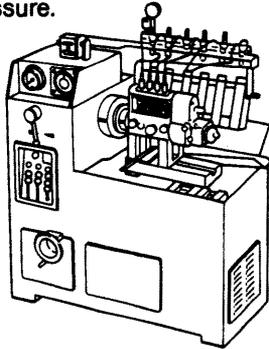
4. Adjustment of Fuel Injection Pump and Governor

Adjust the fuel injection pump after you have completed reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, roller guide assembly, fuel camshaft, etc. Procure a pump tester like the one illustrated below.

4-1 Preparations

Prepare for adjustment of the fuel injection pump as follows:

(1) Adjusting nozzle assembly and inspection of injection starting pressure.

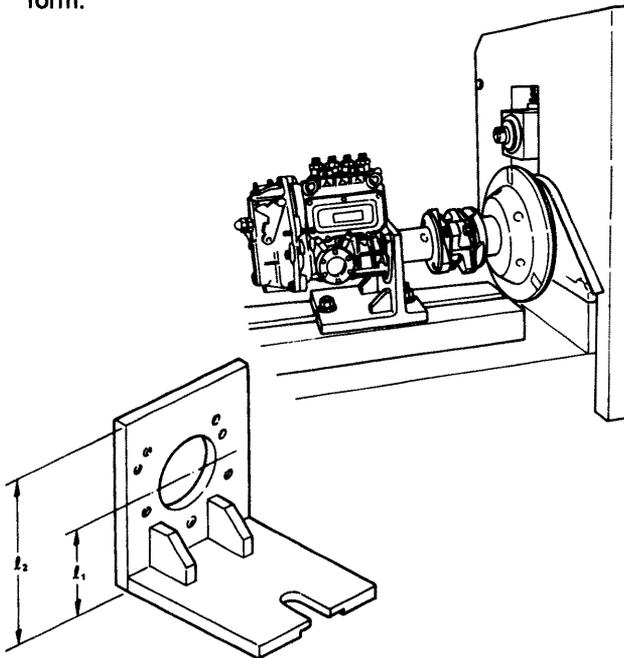


	kg/cm ² (lb/in. ²)
Adjusting nozzle type	YDN-12SD12
Injection starting pressure	165 ~ 175 (2346.85 ~ 2489.08)

(2) Adjusting injection pipe.

	mm (in.)
Inner dia./outer dia. × length	2.0/6.0 × 600 (0.0787/0.2362 × 23.6220)
Minimum bending radius	25 (0.9842)

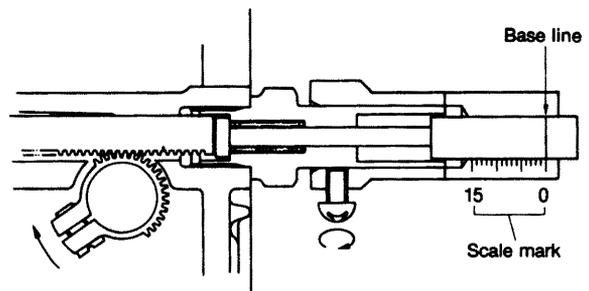
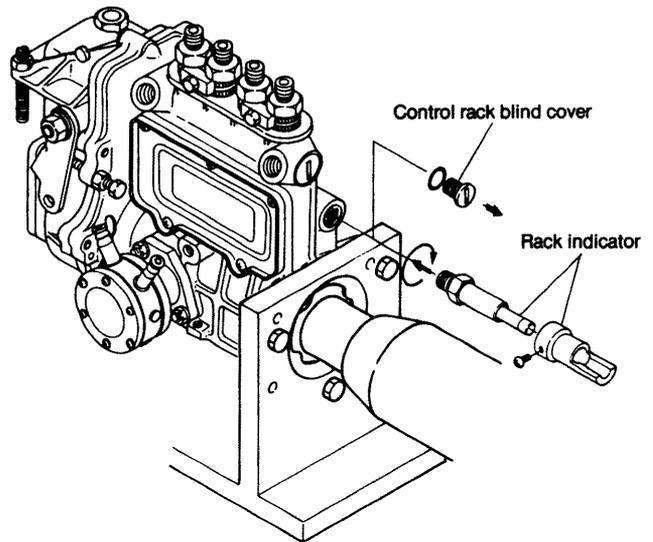
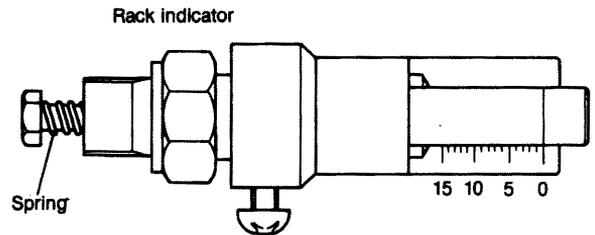
(3) Mount the fuel injection pump on the pump tester platform.



	mm (in.)		
Tester used	l_1	l_2	Part code number
Yanmar	110 (4.3307)	150 (5.9055)	158090-51010
Robert Bosch	125 (4.9212)	165 (6.4960)	158090-51020

(4) Remove the control rack blind cover and fit the rack indicator.

Next, turn the pinion from the side of the pump until the control rack is at the maximum drive side position, and set it to the rack indicator scale standard position. Then make sure that the control rack and rack indicator slide smoothly.

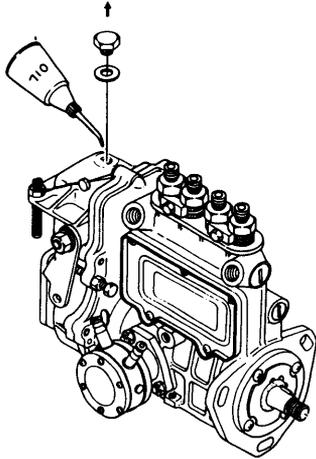


Part code number	158090-51500
------------------	--------------

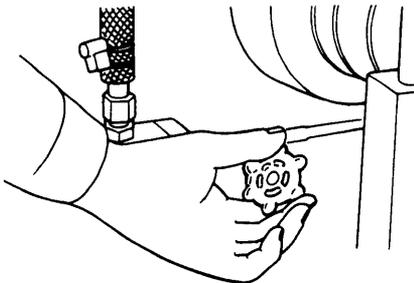
- (5) Check control rack stroke
 Make sure the rack position is at 11.5 ~ 12.5mm (0.4527 ~ 0.4921in.) on the indicator scale when the governor control lever is set at the maximum operating position. If it is not at this value, change the link connecting the governor and control rack to adjust it.

NOTE: Links are available in 1mm (0.0394in.) increments.

- (6) Remove the plug in the oil fill hole on the top of the governor case, and fill the pump with about 200cc of pump oil or engine oil.

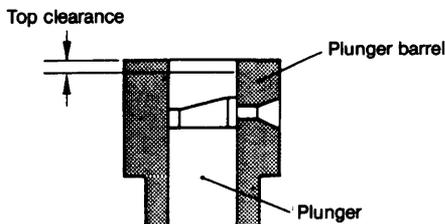


- (7) Complete fuel oil piping and operate the pump tester to purge the line of air.
 (8) Set the pressure of oil fed from pump tester to injection pump at 0.2 ~ 0.3kg/cm² (2.84 ~ 4.26 lb/in.²).



4-2 Adjustment of top clearance

Adjust the top clearance (clearance between top of plunger and top of barrel with cam at top dead point) of each cylinder plunger to bring it to the specified value by changing the thickness of the shims.



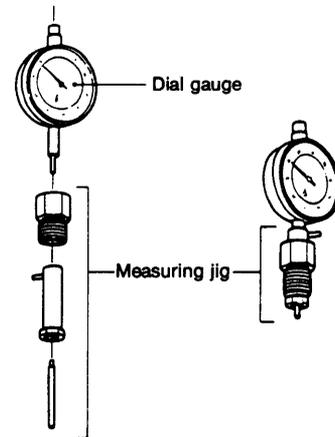
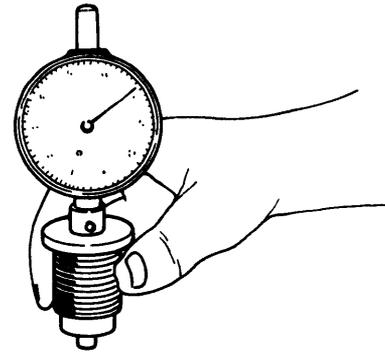
	mm (in.)
Top clearance	0.95-1.05 (0.0374-0.0413)
Pre-stroke	2.5 (0.0984)
Standard shim thickness	1.2 (0.0472)

Relation between top clearance, standard shim thickness and pre-stroke.

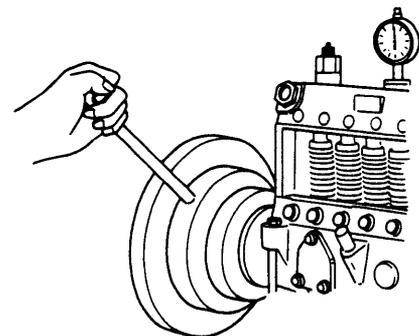
Adjusting shim thickness	mm (in.)
1.0	0.0394
1.2	0.0472
1.3	0.0512
1.4	0.0551
1.5	0.0591
1.6	0.0630

Part Code No.	129155-51600
---------------	--------------

- (1) Place the top clearance gauge on a level surface and set the gauge to zero.

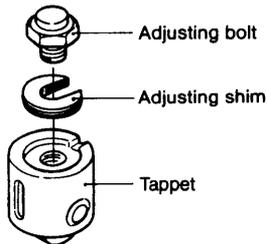


- (2) Remove the injection pump delivery retainer, take out the delivery valve assembly, insert the top clearance gauge and tighten by hand.

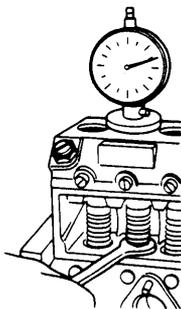


- (3) Turn the camshaft, and bring cam to top dead point while watching gauge needle.

- (4) Read the gauge at this position, and adjust until the clearance is at the specified value by changing adjusting shims. Tighten the adjusting screw after completing adjustment.



(Greater shim thickness decreases top clearance and smaller shim thickness increases top clearance).



NOTE: Adjust while watching gauge, and then tighten.

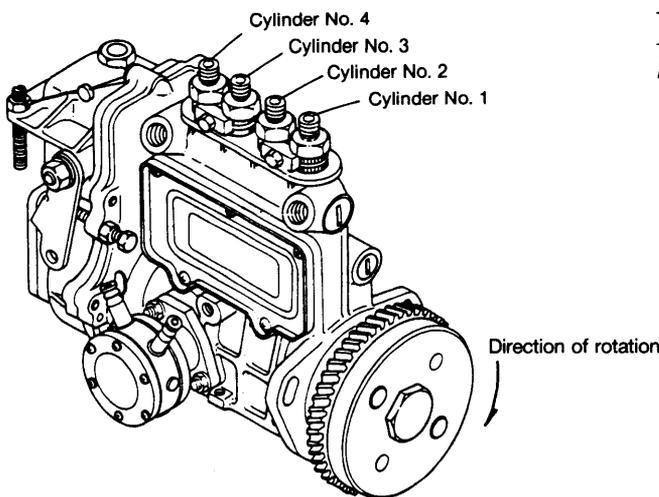
- (5) After adjustment is completed, insert the delivery valve assembly and tighten the delivery retainer.

	kg-m (ft-lb)
Delivery retainer tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

Repeat the above procedure to adjust the top clearance of each cylinder.

4-3 Adjusting of injection timing

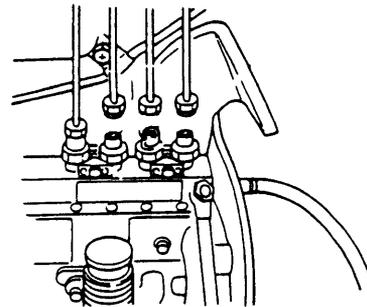
After adjusting the top clearance for all cylinders, check/adjust the injection timing.



- (1) Set the governor control lever to the operating position and fix (bring plunger to the effective injection range), turn the camshaft clockwise, and check the injection starting time (FID) of cylinder No.1 (start of discharge of fuel from the delivery retainer).

Cylinder no.	Count from the drive side
Direction of rotation	Right looking from drive side

- (2) In the above state, set the tester needle to a position easy to read on the flywheel scale, and check the injection timing several times by reading the flywheel scale, according to the injection order.



Injection order	1-3-4-2-1
Injection timing	90°
Allowable deviation	±30'

- (3) Readjust the top clearance of cylinders that are not within the allowable deviation (increasing adjusting shim thickness makes injection timing faster, and decreasing makes it slower).

The change in injection timing effected by adjusting shims is as follows:

Change in shim thickness	Change in injection timing	
	Cam angle	Crank angle
0.1mm (0.0039in.)	0.5°	1.0°

- (4) When you have readjusted top clearance, make sure it is within allowable values after completing adjustment.

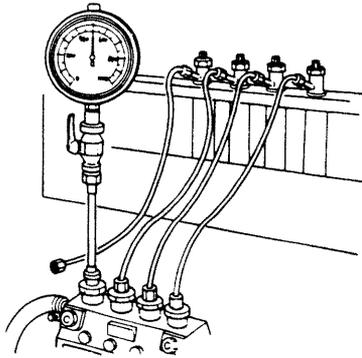
Allowable top clearance	0.3 (0.0118)
-------------------------	--------------

NOTE: 1. All cylinders must be readjusted if one shows less than the allowable value.

2. If the top clearance is less than the allowable value, the plunger will hit the delivery valve or the plunger flange will hit the plunger barrel.

4-4 Plunger pressure test

- (1) Mount the pressure gauge to the delivery retainer of the cylinder to be tested.



Max. pressure gauge reading	1000 kg/cm ² (14223 lb/in. ²)
Connecting screw dimensions	M12 × 1.5

- (2) Set the governor control lever to the stop position, operate the injection pump at about 200 rpm, and make sure that the pressure gauge reading is 500 kg/cm² (7110 lb/in.²) or more while lightly moving the control pinion gear towards full throttle (drive side) from the pump.

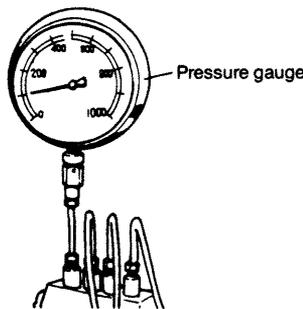
Replace the plunger if the pressure does not reach this value.

- (3) Immediately release the gear after pressure rises to stop injection.

At the same time, check to see that oil is not leaking from the delivery retainer or fuel injection piping, and that there is no extreme drop in pressure.

4-5 Delivery valve pressure test

- (1) Perform the plunger pressure test in the same way, bringing the pressure to about 120 kg/cm² (1706 lb/in.²), and then stopping injection.



- (2) After pressure rises to the above value, measure the time it takes to drop from 100 ~ 90 kg/cm² (1422 ~ 2702 lb/in.²).

100 → 90 kg/cm ² (1422 ~ 1280 lb/in. ²)	5 seconds (to drop 10 kg/cm ² (142 lb/in. ²))
---	---

If the pressure drops faster than this, wash the delivery valve, and retest. Replace the delivery valve if the pressure continues to drop rapidly.

4-6 Adjusting injection volume (uniformity of each cylinder)

The injection volume is determined by the fuel injection pump rpm and rack position. Check and adjust to bring to specified value.

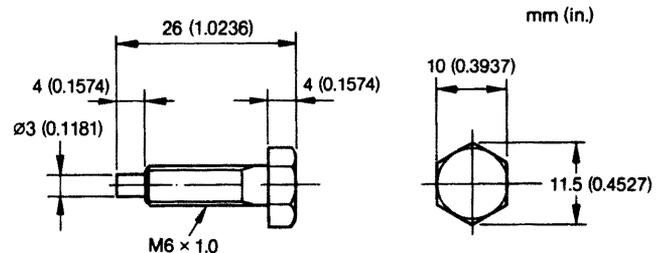
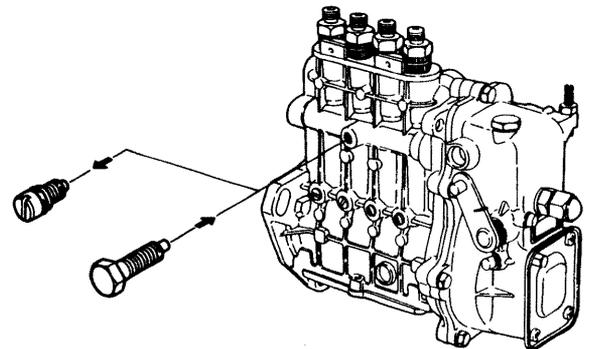
4-6.1 Measuring injection volume

- (1) Preparation

Set the pump rpm, rack position and measuring stroke to the specified value and measure:

Pump RPM	1800 rpm
Pump rotating direction	Right looking from drive side
Rack indicator scale reading	7mm (0.2756 in)

Remove the rack stop bolt behind the pump and screw in the rack fixing bolt to fix rack.



Part Code No.	158090-51510
---------------	--------------

- (2) Measuring injection volume

Measure the injection volume at the standard stroke, and adjust as follows if it is not within the specified value.

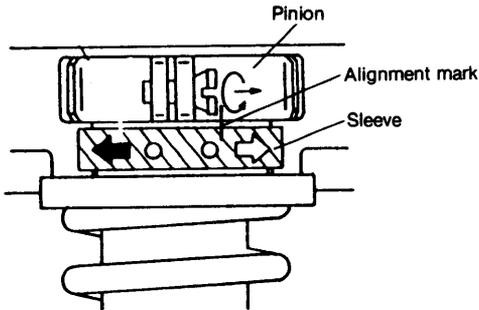
Measuring stroke	1,000 st
Specified injection volume at standard rack position	See injection pump service data
Nonuniformity of cylinders	±3%

4-6.2 Adjustment of injection volume

Compare the injection volume collected in measuring cylinders for each cylinder, and adjust if necessary to obtain specified value.

- (1) Push the control rack all the way to the drive side, stop with rack fixing bolt, and loosen the pinion/sleeve fixing bolt 1/3 revolution.

- (2) When the control sleeve is turned to the right or left, the plunger is turned through the same angle to increase or decrease injection volume. The injection volume is increased when the control sleeve is turned in the direction of the → and is decreased when turned in the direction of the ← on the following figure.



- (3) Measure the injection volume of each cylinder again. Repeat this process until the injection volume for every cylinder is the same (within specified limit).
 (4) Next, measure the injection volumes under different conditions, and make sure the injection volume for every cylinder is within specifications. Replace the plunger if the injection volume is not within specifications.

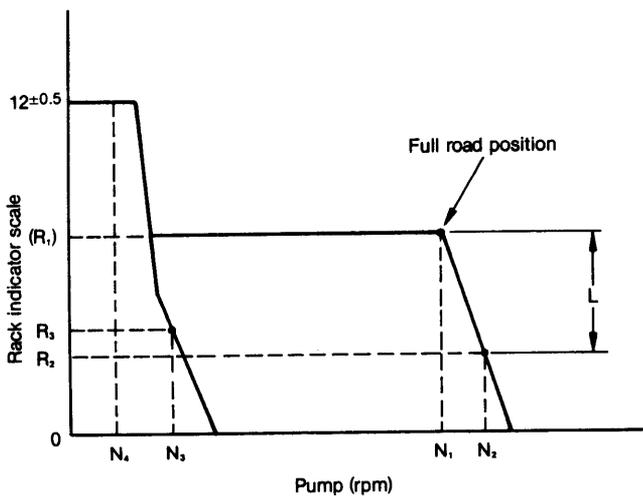
NOTE: See adjustment data for the specified injection volume value at other measuring points.

- (5) After completing measurement, firmly tighten the piston/sleeve fixing screw.
 (6) If not aligned with match mark, make a new match mark.

4-7 Adjustment of governor

4-7.1 Adjusting fuel limit bolt

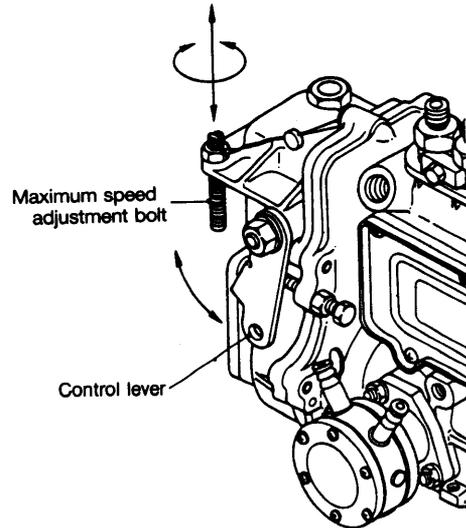
- (1) Adjust the tightness of the fuel limit bolt to bring the rack position to the specified value (R₁) with the governor control lever all the way down towards the fuel increase position, while keeping the pump at rated rpm N₁.



- (2) Measure fuel injection volume at rack position (R₁). Tightening of fuel limit bolt.
 (3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut at that position.

4-7.2 Adjusting RPM limit bolt

- (1) Gradually loosen the governor control lever while keeping the pump drive condition in the same condition as when the fuel limit bolt was adjusted, and adjust the tightness of the RPM limit bolt to the point where the rack position just exceeds the specified value (R₁).

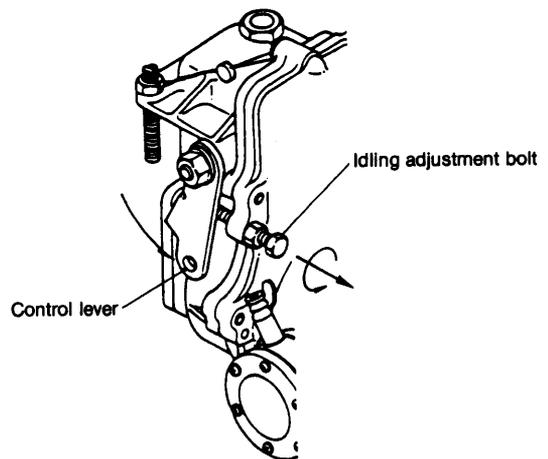


- (2) Check maximum RPM at no load. Further increase rpm, and make sure that rack position (R₂ = R₁ - L) corresponding to maximum rpm at no load is within specified value (N₂).

No load max. RPM (Pump RPM)	1950 rpm
-----------------------------	----------

4-7.3 Adjusting idling

- (1) Maintain the pump rpm at specified rpm (N₃).



Idling rpm (Pump RPM)	325 rpm
-----------------------	---------

- (2) Measure the injection volume while lowering the governor control lever to the idling position, and adjust the position of the control lever with the idling adjustment bolt to bring it to specified value.

Measuring stroke	1000 st
Idling injection volume	See injection pump service data

4-7.4 Check injection volume when starting

- (1) Make sure the control rack moves smoothly while gradually reducing idling rpm.
- (2) Next, fix the governor control lever at full load position with the pump at specified rpm (N_4). Make sure that control rack is at maximum rack position (11.05 ~ 12.05).

Measure the injection volume and check to make sure it is within the specified value.

Pump rpm (N_4)	200 rpm
Rack indicator scale	11.5~12.5mm(0.4527~0.4921 in.)
Measuring stroke	1000 st
Injection volume	See injection pump service data

Check injection stop

Drive the pump at rated rpm (N_1) and standard rack position (R_1) with governor control lever at full load position, operate the stop lever on the back of the governor case, and make sure that injection to all cylinders is stopped.

NOTE: Be sure to remove the rack fixing bolt when doing this.

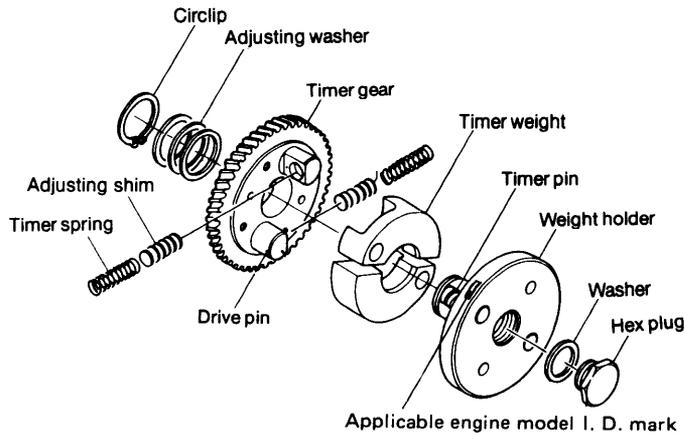
5. Automatic Timer (Automatic Advancing Timer)

5-1 Timer construction

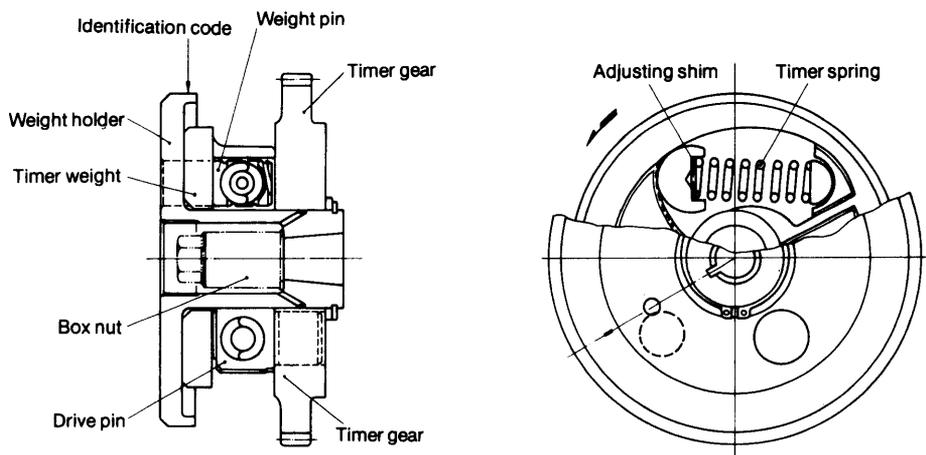
The faster the engine rpm, the larger the crank angle is during ignition delay. This results in a delay in ignition time and thus a decrease in engine output.

When an engine is used from low to high rpm, the injection timing must be changed according to engine rpm to maintain it at the optimum timing.

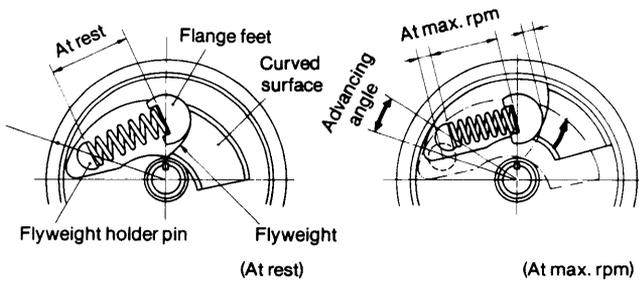
The automatic timer uses centrifugal force to automatically adjust injection timing.



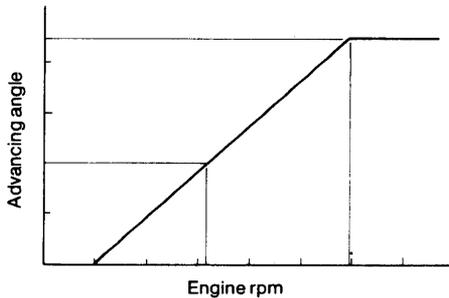
Automatic Timer Ass'y (Automatic Advancing Timer)	I. D. Mark	Applicable Engine Model & E/#		Advanced angle
		Old type	JH-A0	4JHE
JH-A1	4JHE		E/# 01000 and before	5.5°
JH-B0	4JH-TE		E/# 11000 and before	3.5°
JH-C0	4JH-HTE		E/# 21000 and before	2.5°
New type	TN-A0	4JHE	E/# 01001 and after	4°
	JH-CO	4JH-TE	E/# 11001 and after	2.5°
		4JH-HTE	E/# 21001 and after	
4JH-DTE		E/# 30101 and after		



5-2 Functioning and characteristics of timer

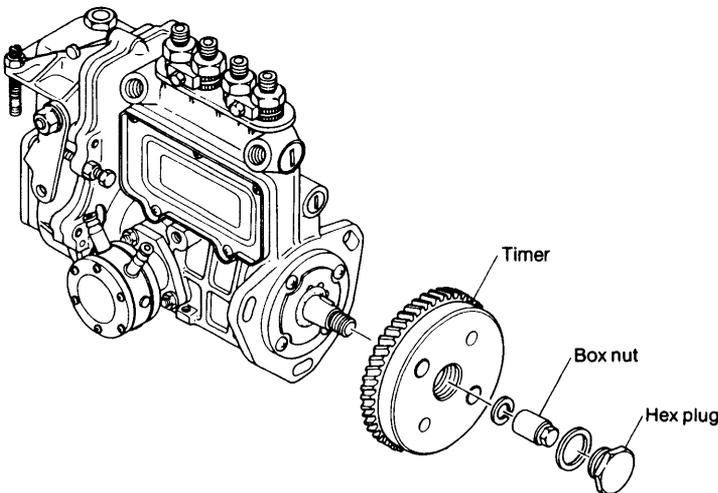


The spring is pressed against the center of the flyweight. As rpm increases, the centrifugal force of the two flyweights increases, compresses the timer spring, and the position of the weight holder and flange changes due to the movement of the curved surface of the weight, changing the injection timing. Accordingly, as the spring is compressed (according to the rise in rpm advancing the timing), the advancing angle remains proportional to rpm.



The advancing characteristics can be changed by changing the profile of the side of the weight and the spring constant of the spring.

5-3 Timer disassembly



- (1) Remove the hex plugs from both ends of timer.
- (2) Use a box spanner to remove the cam shaft box nut.
- (3) Use a gear pulling tool to remove the timer assembly.
- (4) The spring, shim and weight can be removed when you take off the gear circlip and separate the timer and weight holder.

NOTE: As the advancing angle has been set at the factory, do not disassemble the timer unless necessary.

5-4 Timer inspection

- (1) Inspect the timer ring, and replace if there is excessive settling or corrosion.
- (2) Inspect the curved surface of the timer weight and the portion of drive pin it comes in contact with, and replace if wear is excessive or movement is not smooth.

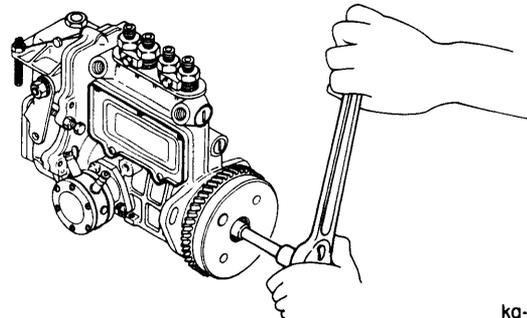
NOTE: 1. Recheck advancing angle when replacing weight or spring, and readjust as necessary with adjusting shims.

2. If you change weight holders, measure the shaft side clearance, and adjust with washers.

	mm (in.)
Standard side clearance	0.02 ~ 0.10 (0.0007 ~ 0.0039)

5-5 Timer reassembly

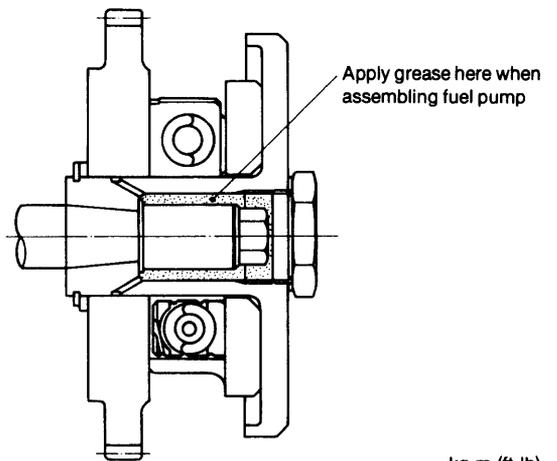
- (1) Mount the timer assembly on the fuel injection pump camshaft, and tighten the box nut with a box spanner.



	kg-m (ft-lb)
Tightening torque	6 ~ 7 (43.3 ~ 50.6)

NOTE: The box nut is tightened by turning it right looking from the drive side.

- (2) Apply grease around the box nut, and tighten the hex plug.

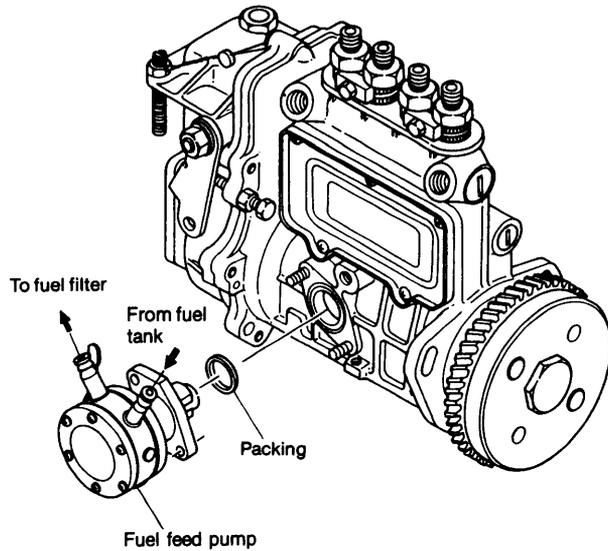


	kg-m (ft-lb)
Tightening torque	0.8 ~ 1.20 (1.30 ~ 8.67)

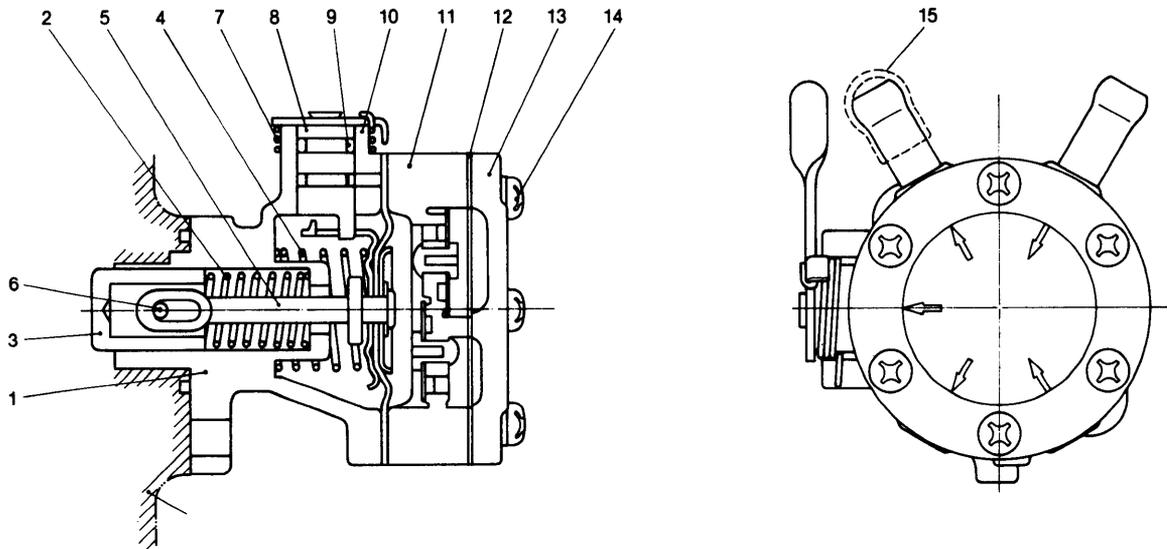
6. Fuel Feed Pump

The fuel feed pump pumps fuel from the fuel tank, passes it through the fuel filter element, and supplies it to the fuel injection pump.

The fuel feed pump is mounted on the side of this engine and is driven by the (eccentric) cam of the fuel pump camshaft. It is provided with a manual priming lever so that fuel can be supplied when the engine is stopped.



6-1 Construction of fuel feed pump



- | | | |
|-----------------------|------------------------|-----------------------|
| 1. Bottom body | 6. Pin | 11. Top body assembly |
| 2. Piston spring | 7. Lever return spring | 12. Packing |
| 3. Piston | 8. Lever assembly | 13. Cover |
| 4. Diaphragm spring | 9. O-ring | 14. Small screw |
| 5. Diaphragm assembly | 10. Stop pin | 15. Cap |

6-2 Fuel feed pump specifications

Head	1m (3.28 ft)
Discharge volume	230 cc/min (14.03 in. ³ /min) at 1500 cam rpm, discharge pressure of 0.2 kg/cm ² (2.84 lb/in. ²)
Closed off pressure	0.3 kg/cm ² (4.26 lb/in. ²) or more (at 400 cam rpm)

6-3 Disassembly and reassembly of fuel feed pump

6-3.1 Disassembly

- (1) Remove the fuel feed pump mounting nut, and take the fuel feed pump off the fuel injection pump.
- (2) Clean the fuel feed pump assembly with fuel oil.
- (3) After checking the orientation of the arrow on the cover, make match marks on the upper body and cover, remove the small screw, and disassemble the cover, upper body and lower body.

6-3.2 Reassembly

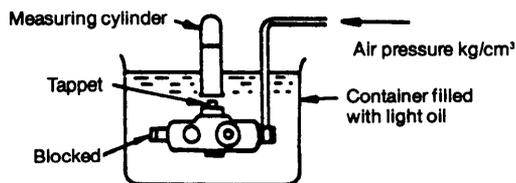
- (1) Clean all parts with fuel oil, inspect, and replace any defective parts.
- (2) Replace any packings on parts that have been disassembled.
- (3) Make sure that the intake valve and discharge valve on upper body are mounted in the proper direction, and that you don't forget the valve packing.
- (4) Assemble the diaphragm into the body, making sure the diaphragm mounting holes are lined up (do not force).
- (5) Align the match marks on the upper body of the pump and cover, and tighten the small screws evenly.

kg-cm (ft-lb)

Tightening torque	15 ~ 25 (1.08 ~ 1.80)
-------------------	-----------------------

6-4 Fuel feed pump inspection

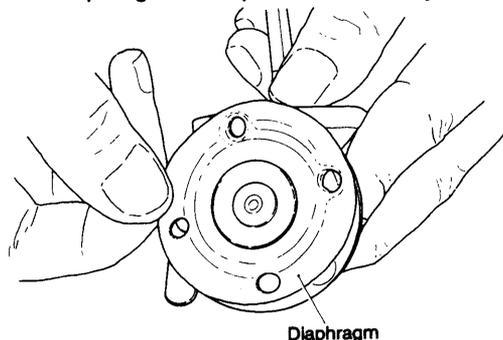
- (1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



- (2) Attach a vinyl hose to the fuel feed pump intake, keep the pump at the specified depth from the fuel oil surface, move the priming lever by hand and check for sudden spurts of fuel oil from the discharge port. If oil is not spurting out, inspect the diaphragm and diaphragm spring and repair/replace as necessary.

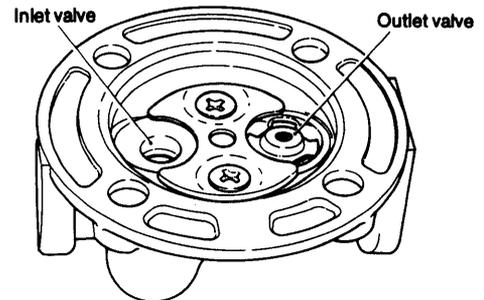
(3) Diaphragm inspection

Parts of the diaphragm that are repeatedly burned will become thinner or deteriorate over a long period of time. Check diaphragm and replace if necessary.



(4) Valve contact/mounting

Clean the valve seat and valve with air to remove any foreign matter.



- (5) Inspect the diaphragm spring and piston spring for settling and the piston for wear, and replace as necessary.

NOTE: Replace parts as an assembly.

7. Fuel Injection Nozzle

When fuel oil pumped by the fuel injection pump reaches the injection nozzle, it pushes up the nozzle valve (held down by spring), and is injected into the combustion chamber at high pressure.

The fuel is atomized by the nozzle to mix uniformly with the air in the combustion chamber. How well the fuel is mixed with high temperature air directly affects combustion efficiency, engine performance and fuel economy.

Accordingly, the fuel injection nozzles must be kept in top condition to maintain performance and operating efficiency.

7-1 Functioning of fuel injection nozzle

Fuel from the fuel injection pump passes through the oil port in the nozzle holder, and enters the nozzle body reservoir.

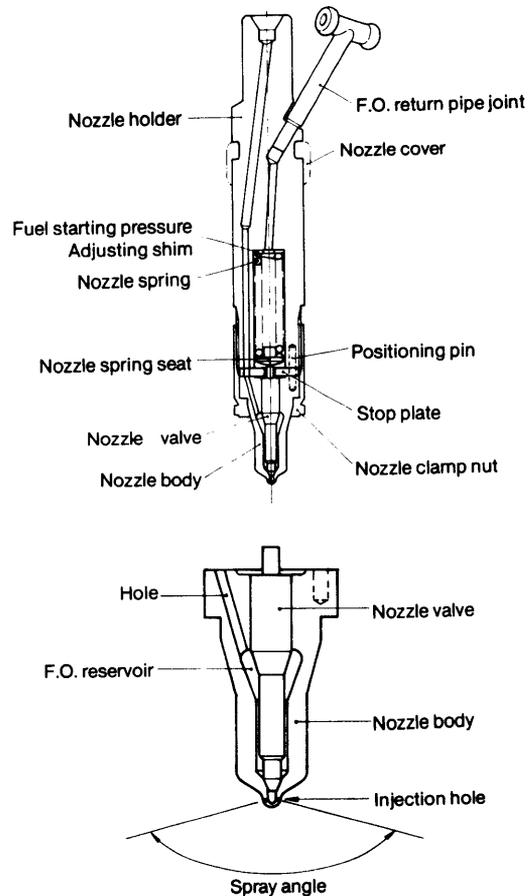
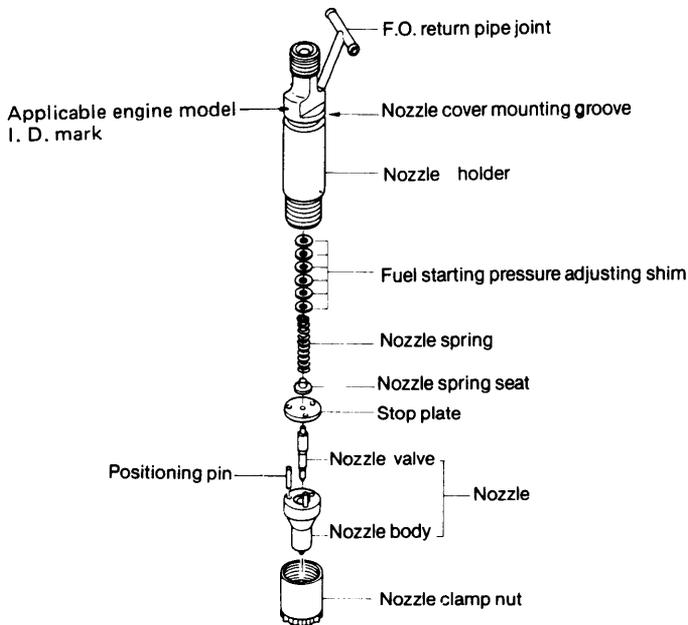
When oil reaches the specified pressure, it pushes up the nozzle valve (held by the nozzle spring), and is injected through the small hole on the tip of the nozzle body.

The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.

Oil that leaks from between the nozzle valve and nozzle body goes from the hole on top of the nozzle spring through the oil leakage fitting and back into the fuel tank.

Adjustment of injection starting pressure is effected with the adjusting shims.

(1) Hole type fuel injection nozzle

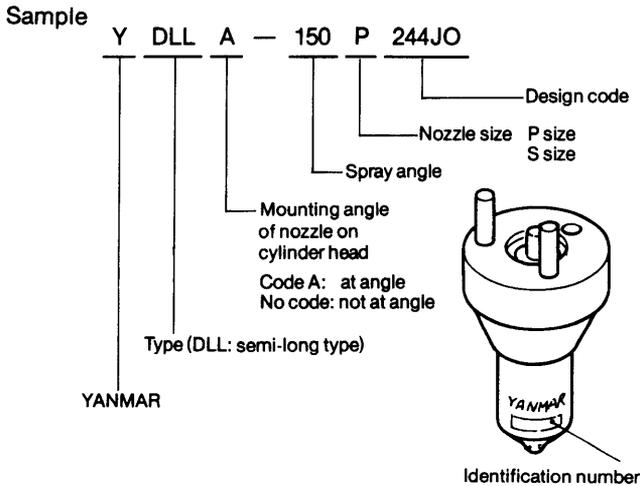


Fuel Injection Nozzle Ass'y I. D. Mark	A	E	B	D	F	G		
Spray angle	150°	155°	150°	145°	155°	140°		
Nozzle opening pressure	195 ~ 205 kg/cm ² (2,773 ~ 2,915 lb/in. ²)							
No. of injection hole x dia	4 x 0.24mm (0.0094 in.)		4 x 0.28mm (0.0110 in.)	5 x 0.26mm (0.0102 in.)	4 x 0.24mm (0.0094 in.)	5 x 0.25mm (0.0098 in.)		
Nozzle I. D. mark	150P244J0	155P244J1	150P284J0	145P265J1	155P265J1	140P255J2		
Applicable engine model	4JHE		4JH-TE	4JH-HTE	4JHE	4JH-TE	4JH-HTE	4JH-DTE
Applicable engine No.	#00101 ~ 00574	#00575 ~ 01000	#00101 ~ 11000	#20101 ~ 21000	#01001 and after	#11001 and after	#21001 and after	#30101 and after

(3) Nozzle body identification number

The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

1) Hole type fuel injection nozzles

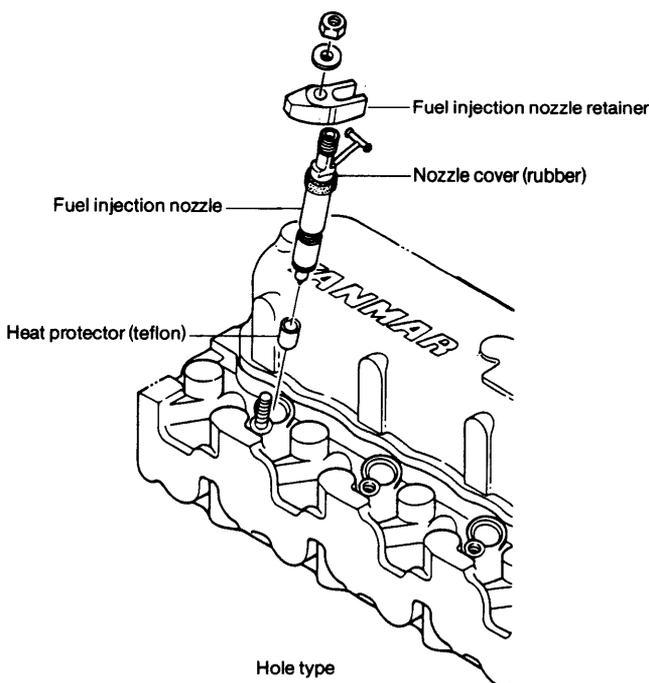


7-3 Fuel injection nozzle disassembly

NOTE: 1. Disassemble fuel injection nozzle in a clean area as for fuel injection pump.

2. When disassembling more than one fuel injection nozzle, keep the parts for each injection nozzle separate for each cylinder (i.e. the nozzle for cylinder 1 must be remounted in cylinder 1).

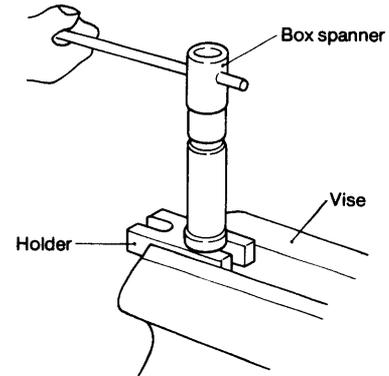
(1) When removing the injection nozzle from the cylinder head, remove the high pressure fuel pipe, fuel leakage pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.



(2) Put the nozzle in a vise

NOTE: Use the special nozzle holder for the hole type injection nozzle so that the high pressure mounting threads are not damaged.

(3) Remove the nozzle nut



NOTE: Use a special box spanner for the hole type (the thickness of the two nozzle nuts is 15mm (0.5906in.)).

(4) Remove the inner parts

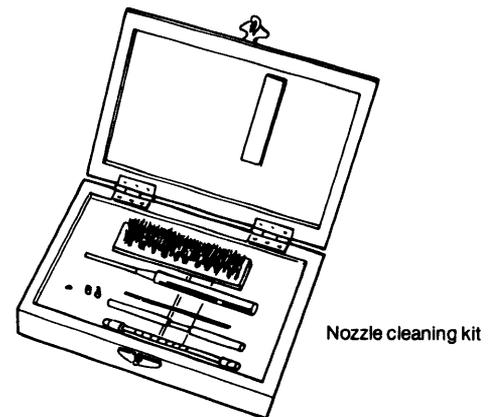
NOTE: Be careful not to loosen the spring seat, adjusting shims or other small parts.

7-4 Fuel injection nozzle inspection

7-4.1 Washing

(1) Make sure to use new diesel oil to wash the fuel injection nozzle parts.

(2) Wash the nozzle in clean diesel oil with the nozzle cleaning kit.



1) Diesel Kiki nozzle cleaning kit:

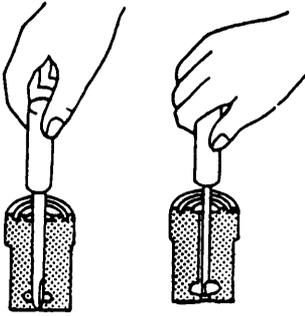
Type NP-8486B No. 5789-001

2) Anzen Jidosha Co., Ltd. nozzle cleaning kit:

Type NCK-001

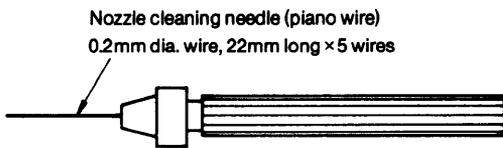
(3) Clean off the carbon on the outside of the nozzle body with a brass brush.

(4) Clean the nozzle seat with cleaning spray.



(5) Clean off the carbon on the tip of nozzle with a piece of wood.

(6) Clean hole type nozzles with a nozzle cleaning needle.



Part code no.	28210-000010
---------------	--------------

7-4. 2 Nozzle Inspection

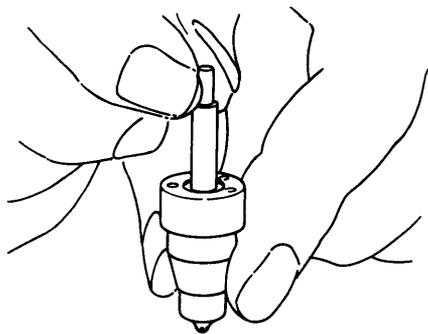
(1) Inspect for scratches/wear

Inspect oil seals for abnormal scratches or wear and replace nozzle if the nozzle sliding surface or seat are scratched or abnormally worn.

(2) Check nozzle sliding

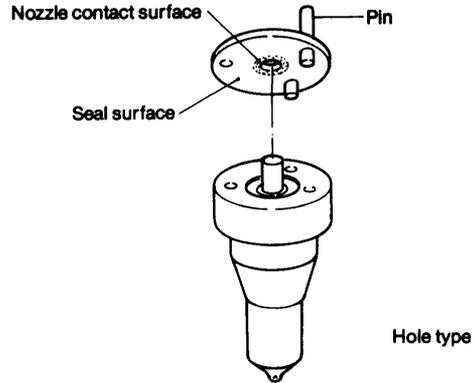
Wash the nozzle and nozzle body in clean diesel oil, and make sure that when the nozzle is pulled out about half way from the body, it slides down by itself when released.

Rotate the nozzle a little; replace nozzle/nozzle body as a set if there are some places where it does not slide smoothly.



(3) Inspecting stop plate (inter-piece)

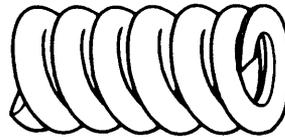
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if stop plate is excessively worn.



mm (in.)	
Nozzle contact surface wear limit	0.1 (0.0039)

(4) Inspecting nozzle spring

Replace the nozzle spring if it is extremely bent, or the surface is scratched or rusted.



(5) Nozzle holder

Check oil seal surface for scratches/wear; replace if wear is excessive.

7-5 Fuel injection nozzle reassembly

The fuel injection nozzle is reassembled in the opposite order to disassembly.

(1) Insert the adjusting shims, nozzle spring and nozzle spring seat in the nozzle holder, mount the stop plate with the pin, insert the nozzle body/nozzle set and tighten the nut.

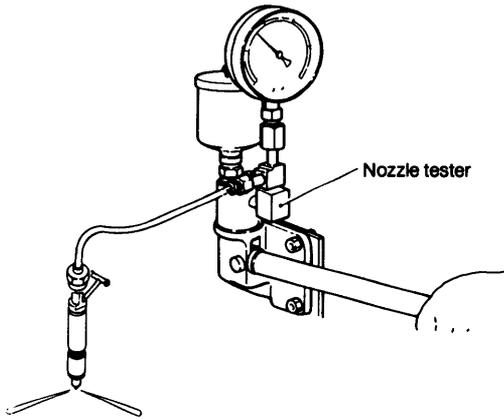
(2) Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

Nozzle nut tightening torque		kg-m (ft-lb)
Hole type nozzle	4 ~ 4.5	(28.9 ~ 32.5)

7-6 Adjusting fuel injection nozzle

7-6. 1 Adjusting opening pressure

Mount the fuel injection nozzle on the nozzle tester and use the handle to measure injection starting pressure. If it is not at specified pressure, use the adjusting shims to increase/decrease pressure (both hole and pintle types).



Injection starting pressure

	kg/cm ² (lb/in. ²)
Injection starting pressure	195 ~ 205 (2773 ~ 2915)

7-6. 2 Injection test

After adjusting the nozzle to the specified starting pressure, check the fuel spray condition and seat oil tightness.

(1) Check seat oil tightness

After two or three injections, gradually increase the pressure up to 20 kg/cm² (284 lb/in.²) before reading the starting pressure, maintain the pressure for 5 seconds, and make sure that no oil is dripping from the tip of the nozzle.

Test the injection with a nozzle tester; retighten and test again if there is excessive oil leakage from the overflow coupling.

Replace the nozzle as a set if oil leakage is still excessive.

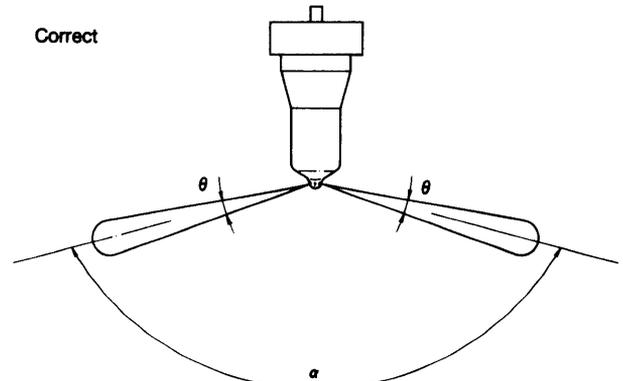
(2) Injection spray condition

Operate the nozzle tester lever once to twice a second and check for abnormal injection.

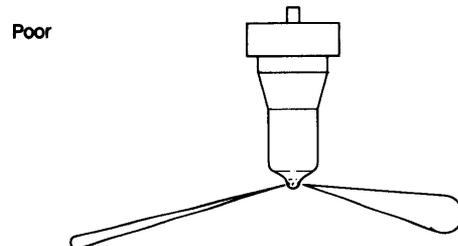
1) Hole type nozzles

Replace hole type nozzles that do not satisfy the following conditions:

- Proper spray angle (θ)
- Correct injection angle (α)
- Complete atomization of fuel
- Prompt starting/stopping of injection



Spray from each nozzle hole is uniform



- Excessive difference in spray angle (θ)
- Excessive difference in injection angle (α)
- Incomplete atomization
- Sluggish starting/stopping of injection

8. Troubleshooting

1. Troubleshooting of fuel injection pump

Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

Basic check points

- Check for breaks or oil leaks throughout the fuel system, from the fuel tank to the nozzle.
- Check the injection timings for all cylinders. Are they correctly adjusted? Are they too fast or too slow?
- Check the nozzle spray.
- Check the fuel delivery. Is it in good condition? Loosen the fuel pipe connection at the injection pump inlet, and test operate the fuel feed pump.

2. Major faults and troubleshooting

Fault		Cause	Remedy
1. Engine won't start.	Fuel not delivered to injection pump.	(1) No fuel in the fuel tank. (2) Fuel tank cock is closed. (3) Fuel pipe system is clogged. (4) Fuel filter element is clogged. (5) Air is sucked into the fuel due to defective connections in the piping from the fuel tank to the fuel pump. (6) Defective valve contact of feed pump (7) Piston spring of feed pump is broken. (8) Inter-spindle or tappets of feed pump are stuck.	Resupply Open Clean Disassemble and clean, or replace element Repair Repair or replace. Replace Repair or replace
	Fuel delivered to injection pump.	(1) Defective connection of control lever and accel. rod of injection pump. (2) Plunger is worn out or stuck. (3) Delivery valve is stuck. (4) Control rack doesn't move. (5) Injection pump coupling is damaged, or the key is broken.	Repair or adjust Repair or replace Repair or replace Repair or replace Replace
	Nozzle doesn't work.	(1) Nozzle valve doesn't open or close normally. (2) Nozzle seat is defective. (3) Case nut is loose. (4) Injection nozzle starting pressure is too low. (5) Nozzle spring is broken. (6) Fuel oil filter is clogged. (7) Excessive oil leaks from the nozzle sliding area.	Repair or replace Repair or replace Inspect and tighten Adjust Replace Repair or replace Replace the nozzle assembly
	Injection timing is defective.	(1) Injection timing is retarded due to failure of the coupling. (2) Camshaft is excessively worn. (3) Roller guide incorrectly adjusted or excessively worn. (4) Plunger is excessively worn.	Adjust Replace camshaft Adjust or replace Replace plunger assembly
2. Engine starts, but immediately stops.		(1) Fuel pipe is clogged. (2) Fuel filter is clogged. (3) Improper air-tightness of the fuel pipe connection, or pipe is broken and air is being sucked in. (4) Insufficient fuel delivery from the feed pump.	Clean Disassemble and clean, or replace the element. Replace packing; repair pipe Repair or replace

Fault		Cause	Remedy
3. Engine's output is insufficient.	Defective injection timing, and other failures.	(1) Knocking sounds caused by improper (too fast) injection timing. (2) Engine overheats or emits large amount of smoke due to improper (too slow) injection timing. (3) Insufficient fuel delivery from feed pump.	Inspect and adjust Inspect and adjust Repair or replace
	Nozzle movements is defective	(1) Case nut loose. (2) Defective injection nozzle performance. (3) Nozzle spring is broken. (4) Excessive oil leaks from nozzle.	Inspect and retighten Repair or replace nozzle Replace Replace nozzle assembly
	Injection pump is defective.	(1) Max. delivery limit bolt is screwed in too far. (2) Plunger is worn. (3) Injection amount is not uniform. (4) Injection timings are not even. (5) The 1st and 2nd levers of the governor and the control rack of the injection pump are improperly lined up. (6) Delivery stopper is loose. (7) Delivery packing is defective. (8) Delivery valve seat is defective. (9) Delivery spring is broken.	Adjust Replace Adjust Adjust Repair Inspect and retighten Replace packing Repair or replace Replace
4. Idling is rough.		(1) Movement of control rack is defective. 1) Stiff plunger movement or sticking. 2) Rack and pinion fitting is defective. 3) Movement of governor is improper. 4) Delivery stopper is too tight. (2) Uneven injection volume. (3) Injection timing is defective. (4) Plunger is worn and fuel injection adjustment is difficult. (5) Governor spring is too weak. (6) Feed pump can't feed oil at low speeds. (7) Fuel supply is insufficient at low speeds due to clogging of fuel filter.	Repair or replace Repair Repair Inspect and adjust Adjust Adjust Replace Replace Repair or replace Disassemble and clean, or replace element
5. Engine runs at high speeds, but cuts out at low speeds.		(1) The wire or rod of the accel. is caught. (2) Control rack is caught and can't be moved.	Inspect and repair Inspect and repair
6. Engine doesn't reach max. rpm.		(1) Governor spring is broken or excessively worn. (2) Injection performance of nozzle is poor.	Replace Repair or replace
7. Loud knocking.		(1) Injection timing is too fast or too slow. (2) Injection from nozzle is improper. Fuel drips after each injection. (3) Injection nozzle starting pressure is too high. (4) Uneven injection. (5) Engine overheats, or insufficient compression.	Adjust Adjust Adjust Adjust Repair
8. Engine exhausts too much smoke.	When exhaust smoke is black:	(1) Injection timing is too fast. (2) Air volume intake is insufficient. (3) The amount of injection is uneven. (4) Injection from nozzle is improper.	Adjust Inspect and repair Adjust Repair or replace
	When exhaust smoke is white:	(1) Injection timing is too slow. (2) Water is mixed in fuel. (3) Shortage of lube oil in the engine. (4) Engine is over-cooled.	Adjust Inspect fuel system, and clean Repair Inspect

9. Fuel Injection Pump Service Data

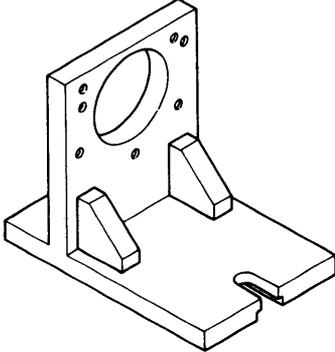
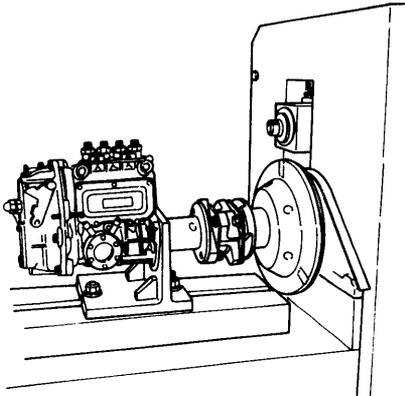
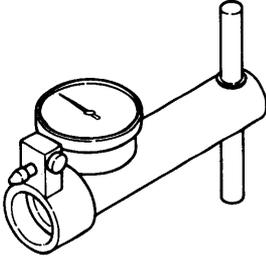
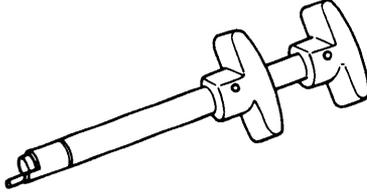
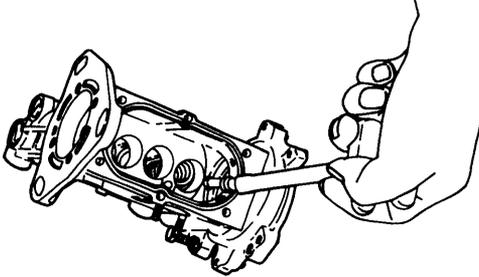
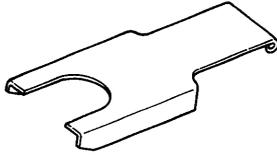
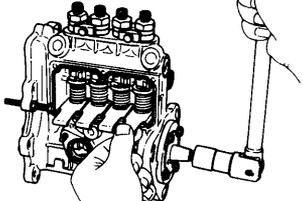
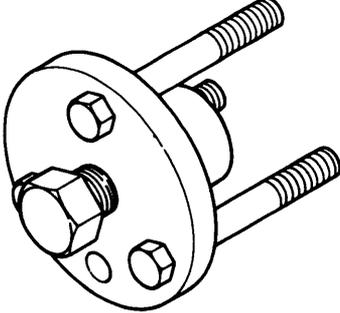
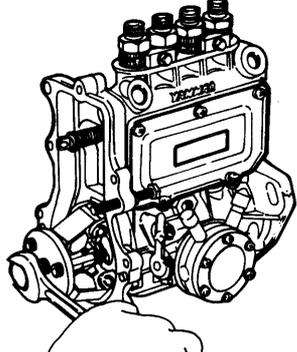
July 18 '85

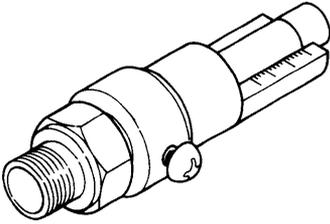
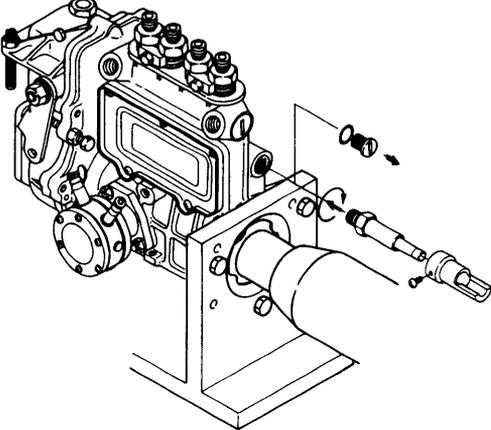
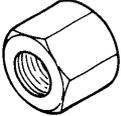
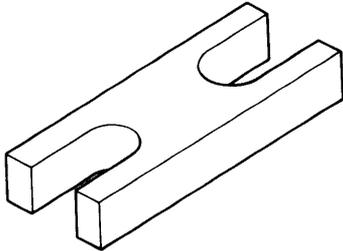
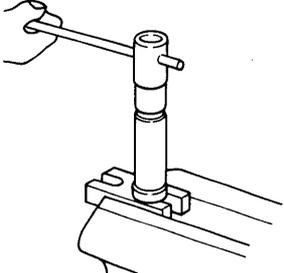
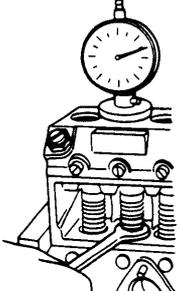
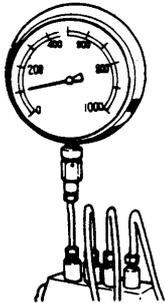
Adjustment Item	4JHE		4JH-TE		4JH-HTE		4JH-DTE	
	Engine model	729470 - 51300	729472 - 51300	729474 - 51300	729473 - 51300	729473 - 51300	729473 - 51300	
Assemble cord	Part No.	8300		8303		8384		
Adjustment specs.	I.D. mark	Engine specs.	Calibration specs.	Engine specs.	Calibration specs.	Engine specs.	Calibration specs.	
4-1-(1)	Nozzle type	150P744J0/**155P244J1/**155P244J2	DIN-12SD12	150P728J0/**140P255J2	DIN-12SD12	140P255J2	DIN-12SD12	
	Injection starting pressure	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	195 ~ 205 (2,773 ~ 2,915)	165 ~ 175 (2,346 ~ 2,489)	
4-1-(2)	Fuel injection pipe OD ϕ / ID ϕ x L	ϕ 6 / ϕ 1.8 x 400 (0.2362/0.0787 x 15.748)	ϕ 6 / ϕ 2 x 600 (0.2362/0.0787 x 23.622)	ϕ 6 / ϕ 1.8 x 400 (0.2362/0.0787 x 15.748)	ϕ 6 / ϕ 2 x 600 (0.2362/0.0787 x 23.622)	ϕ 6 / ϕ 2 x 400 (0.2362/0.0787 x 15.748)	ϕ 6 / ϕ 2 x 600 (0.2362/0.0787 x 23.622)	
4-2	Top clearance /prestroke	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	0.95 ~ 1.05/2.5 (0.0374 ~ 0.0413/0.0984)	
4-7-1	Pump rpm: N1	1,800	1,800	1,800	1,800	1,800	1,800	
	Rack position: R1	7 (0.2756)	7 (0.2756)	7 (0.2756)	7 (0.2756)	7 (0.2756)	7 (0.2756)	
	Measuring stroke	St	1,000	1,000	1,000	1,000	1,000	
	Injection volume	cc	25	26.5	31	32	33	34
	Nonuniformity	%	\pm 3	\pm 3	\pm 3	\pm 3	\pm 3	\pm 3
4-7-2	Pump rpm: N2	1,950	1,950	1,950	1,950	1,950	1,950	
	Rack position: R2	mm(in.)						
4-7-3	Pump rpm: N3	325	325	325	325	325	325	
	Measuring stroke	St	1,000	1,000	1,000	1,000	1,000	
4-7-4	Injection volume	cc	7 ~ 8	9 ~ 10	10 ~ 11	9 ~ 10	10 ~ 11	
	Nonuniformity	%	\pm 10	\pm 10	\pm 10	\pm 10	\pm 10	
	Pump rpm: N4	rpm	200	200	200	200	200	
Starting	Rack position	mm(in.)	11.5 ~ 12.5 (0.4527 ~ 0.4921)	11.5 ~ 12.5 (0.4527 ~ 0.4921)	11.5 ~ 12.5 (0.4527 ~ 0.4921)	11.5 ~ 12.5 (0.4527 ~ 0.4921)	11.5 ~ 12.5 (0.4527 ~ 0.4921)	
	Measuring stroke	St	1,000	1,000	1,000	1,000	1,000	
	Injection volume	cc	60~70	55~65, **65~75	60~70	55~65, **65~75	60~70	55~65, **65~75

NOTE 1: * Applicable engine number: # 00575 and after (Engine model 4JHE)
4JH-TE # 11001 and after

NOTE 2: ** Applicable engine model and engine number: 4JH-HTE # 21001 and after
4JHE # 01001 and after

10. Tools

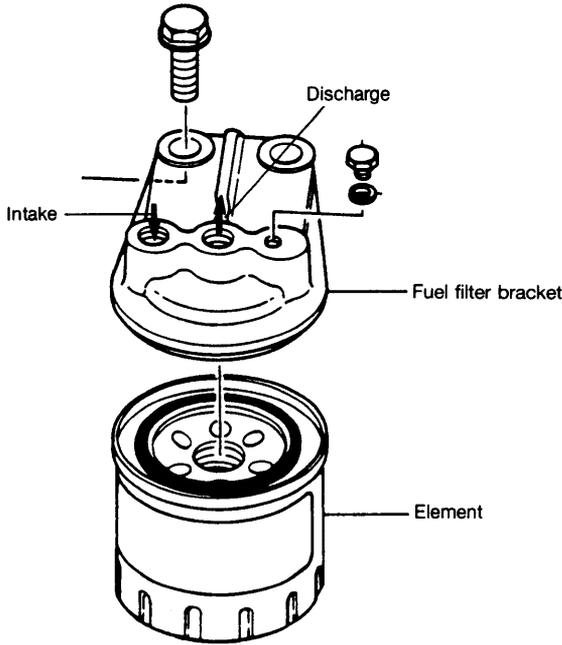
Name of tool	Shape and size	Application
<p>Pump mounting scale for Yanmar tester 158090-51010 for Bosch (tester) 158090-51020</p>		
<p>Measuring device (cam backlash) 158090-51050</p>		
<p>Plunger insert 158090-51100</p>		
<p>Tappet holder 158090-51200</p>		
<p>Weight extractor 158090-51400</p>		

Name of tool	Shape and size	Application
Rack indicator 158090-51500		
Rack lock screw 158090-51010		
Dummy nut 158090-51520		
Nozzle plate 158090-51700		
Plunger gauge 121820-92540		
Top clearance gauge 158090-51300		
Timer extraction tool		

11. Fuel Filter

The fuel filter is installed between the fuel feed pump and fuel injection pump, and removes dirt/foreign matter from the fuel pumped from the fuel tank.

The fuel filter element must be changed periodically. The fuel pumped by the fuel feed pump goes around the element, is fed through the pores in the filter and discharged from the center of the cover. Dirt and foreign matter in the fuel is deposited in the element.



11-1 Fuel filter specifications

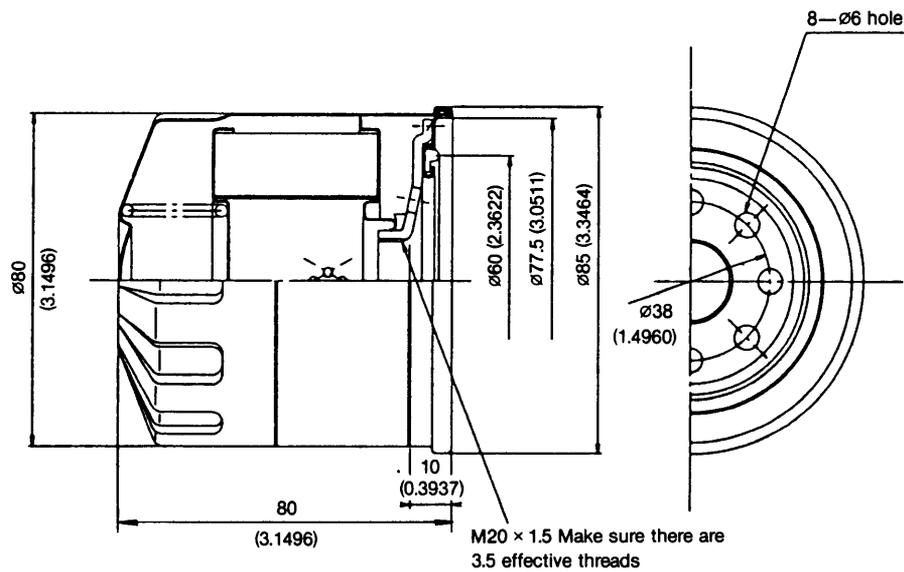
Filtering method	filter paper
Filtering area	840cm ² (130.20in. ²)
Maximum flow	0.25 l/min (15.25 in. ³ /min)
Pressure loss	100mm (3.9370in.) Hg or less
Max. dia. of unfiltered particle	5μ

11-2 Fuel filter inspection

The fuel strainer must be cleaned occasionally. If there is water or foreign matter in the strainer bowl, disassemble the strainer and wash with clean fuel oil to completely remove foreign matter. Replace the element every 300 hours of operation.

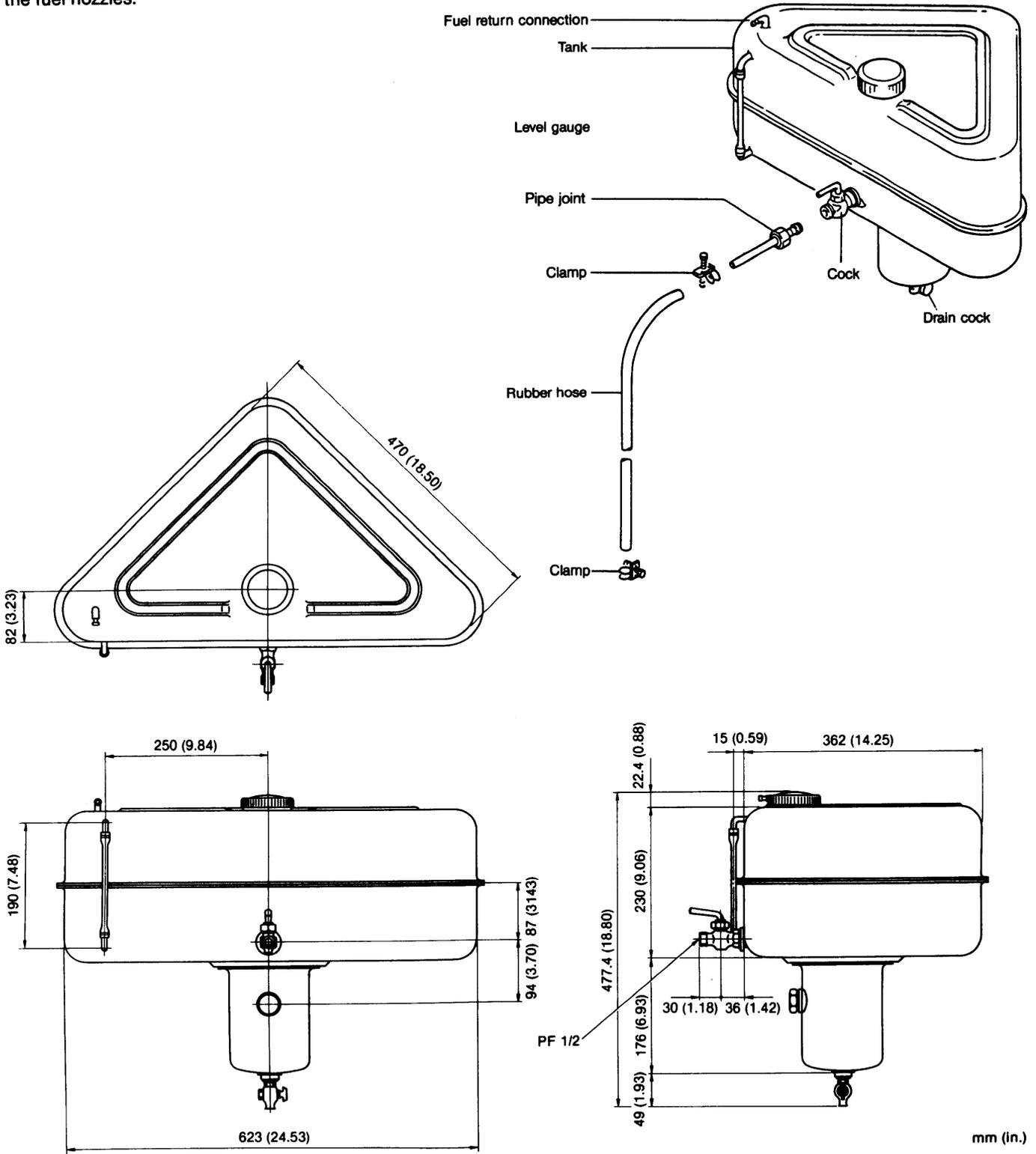
Replace the filter prior to this if the filter is very dirty, deformed or damaged.

Element changes	every 300 hours
Element part code number	129470-55700



12. Fuel Tank

A triangular 30 liter fuel tank with a 2000mm (78.7402in.) rubber fuel hose to fit all models is available as an option. A fuel return connection is provided on top of the tank to which a rubber hose can be connected to return fuel from the fuel nozzles.

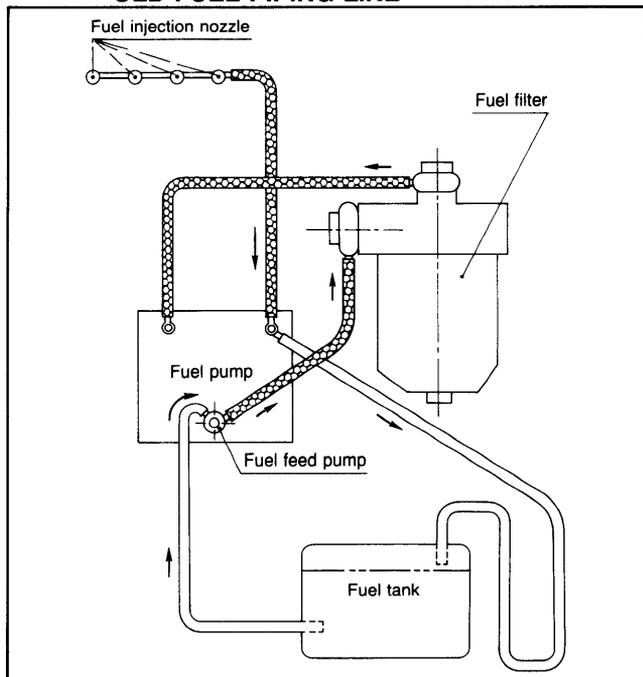


13. Design Change of Fuel Piping Line

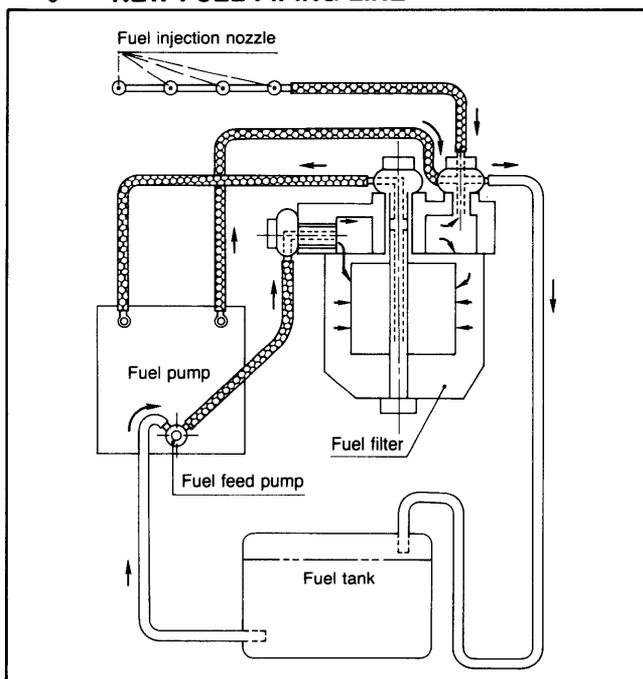
To facility easy servicing, following design modifications will be made on the marine diesel engine model 4JH-series. Through the change of fuel piping line, air-bleeding will be done more easily.

13-1 Modification of fuel piping line.

OLD FUEL PIPING LINE



NEW FUEL PIPING LINE



13-2 Applicable engine models and serial numbers.

Engine Model	Serial Number	Plant Production
4JH(B)E	#01179 and thereafter	From Dec., 1985
4JH-T(B)E	#11201 and thereafter	
4JH-HT(B)E	#21226 and thereafter	
4JH-DT(B)E	#30312 and thereafter	

NOTE: Air-bleeding of the following engines with the modified fuel piping require the equivalent procedure as in the engine with the former fuel piping.

Engine Model	Serial Number
4JH(B)E	#01109 – 01178
4JH-T(B)E	#11143 – 11200
4JH-HT(B)E	#21180 – 21225
4JH-DT(B)E	#30256 – 30311

INTAKE AND EXHAUST SYSTEM

1. Intake and Exhaust System	4-1
2. Intake Silencer	4-4
3. Intake Manifold	4-5
4. Turbocharger	4-6
5. Mixing Elbow	4-21
6. Breather	4-22

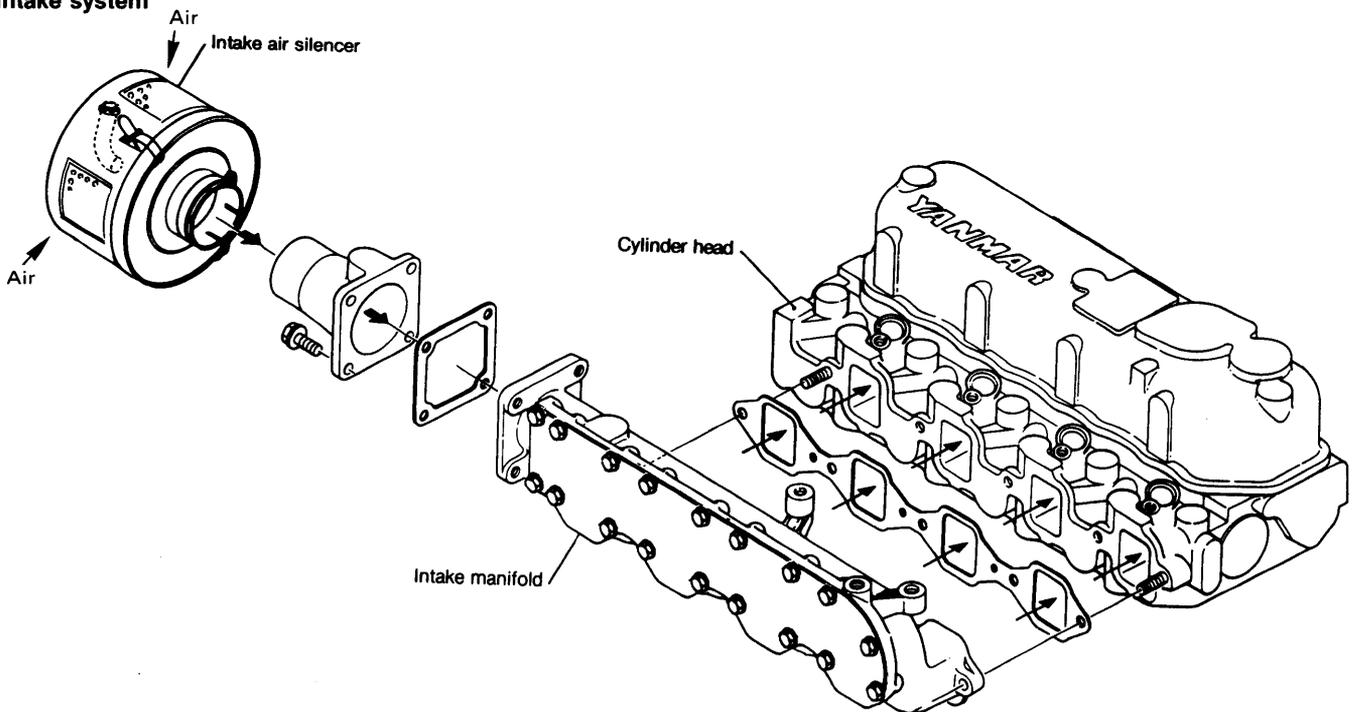
1. Intake and Exhaust System

1-1 4JHE engine

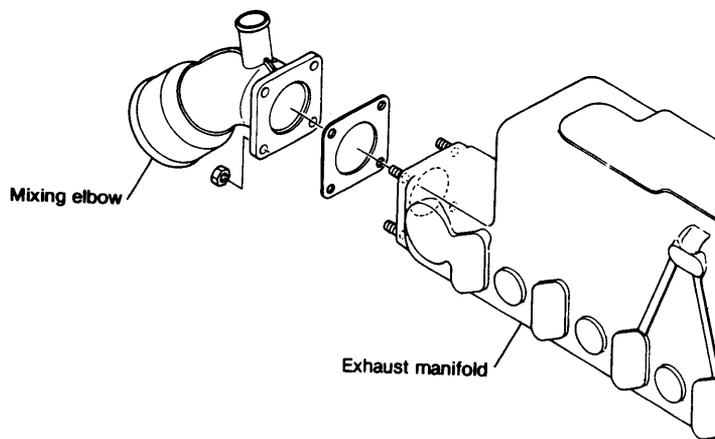
Air enters in the intake silencer mounted at the end of the intake manifold, is fed to the intake manifold and then on to each cylinder.

Exhaust gas goes into the exhaust manifold (in the fresh water tank) mounted on the cylinder head discharge. After cooling it enters the mixing elbow which is directly connected with the exhaust manifold, and is discharged from the ship along with waste cooling water.

Intake system

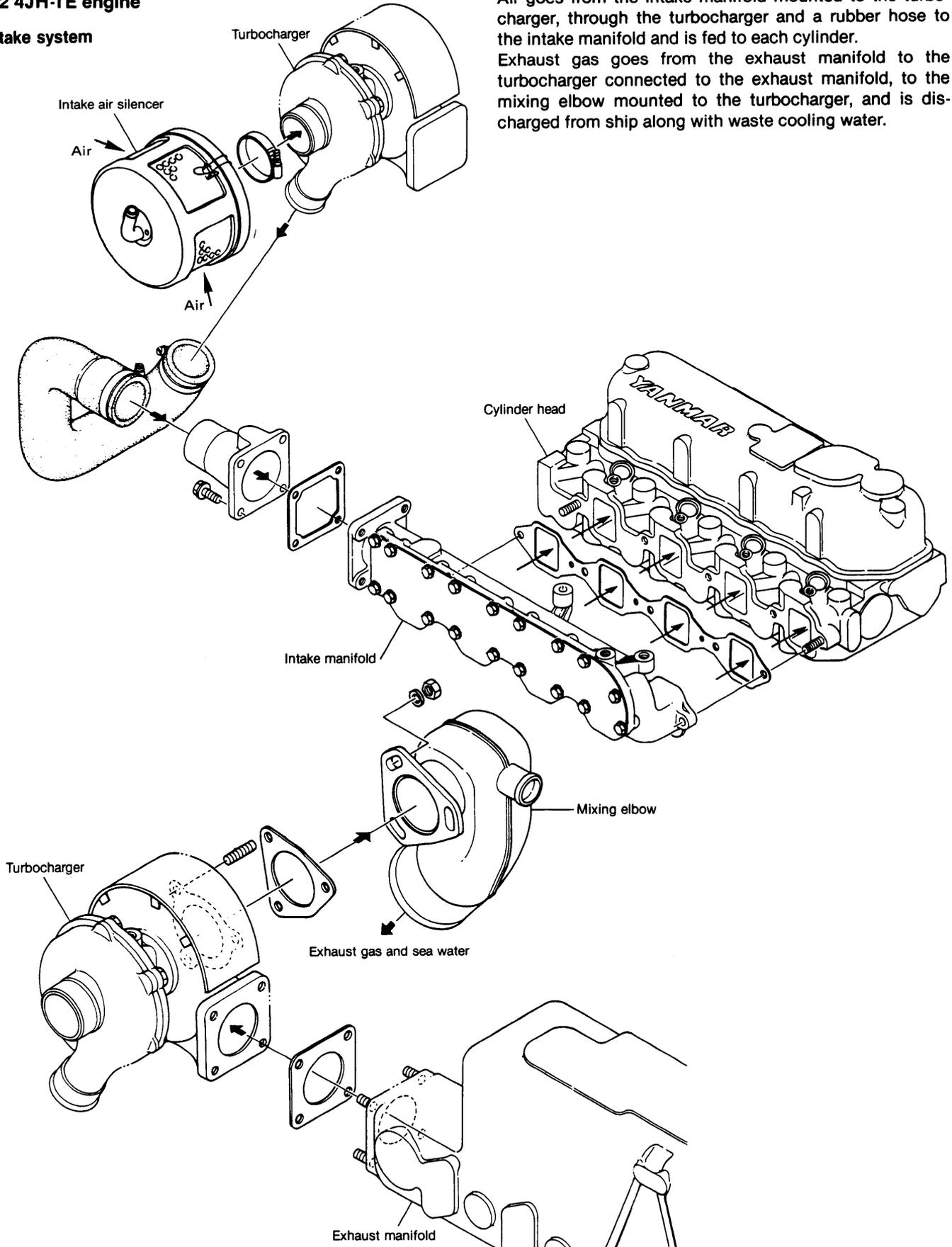


Exhaust system



1-2 4JH-TE engine

Intake system



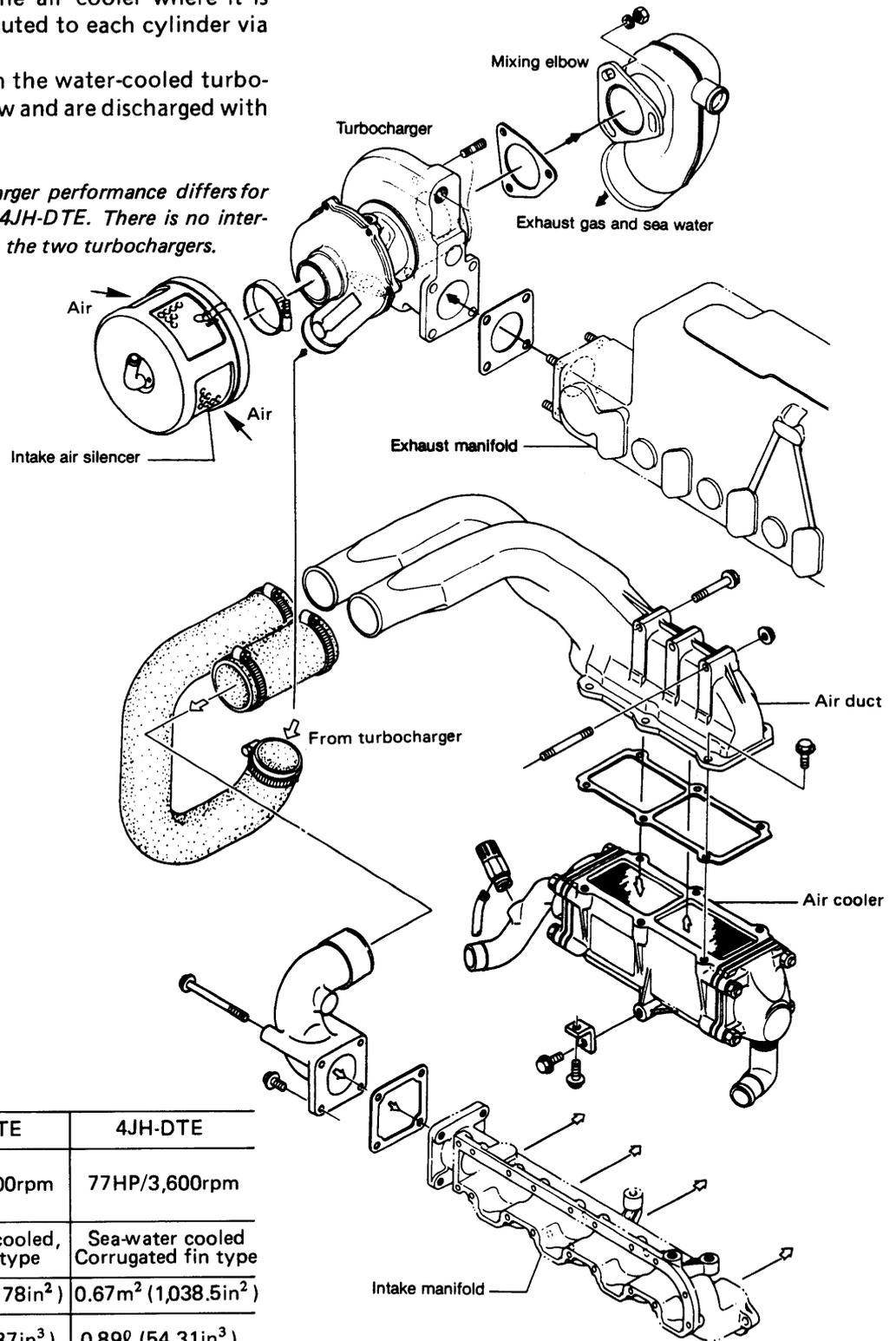
Air goes from the intake manifold mounted to the turbocharger, through the turbocharger and a rubber hose to the intake manifold and is fed to each cylinder. Exhaust gas goes from the exhaust manifold to the turbocharger connected to the exhaust manifold, to the mixing elbow mounted to the turbocharger, and is discharged from ship along with waste cooling water.

Air Cooler for Models 4JH-HTE and 4JH-DTE

Air introduced from the intake air silencer passes through the air duct to the air cooler where it is cooled, and is then distributed to each cylinder via the intake manifold.

Exhaust gases pass through the water-cooled turbocharger to the mixing elbow and are discharged with the sea water.

NOTE: Water-cooled turbocharger performance differs for models 4JH-HTE and 4JH-DTE. There is no interchangeability between the two turbochargers.



Air Cooler Specifications

Engine model	4JH-HTE	4JH-DTE
Output Din6270B Rating	66HP/3,600rpm	77HP/3,600rpm
Type	Sea-water cooled, Plate fin type	Sea-water cooled Corrugated fin type
Radiation area	0.76m ² (1,178in ²)	0.67m ² (1,038.5in ²)
Sea-water capacity	0.85ℓ (51.87in ³)	0.89ℓ (54.31in ³)

NOTE: ⇒ Charging Air
 ⇒ Exhaust gas and Sea-water

2. Intake Silencer

2-1 Construction

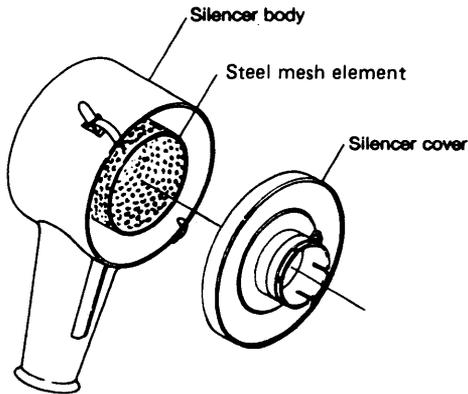
The intake silencer has a steel plate element with holes to reduce noise.

The silencer is provided with a mist breather pipe joint from which mist is taken in.

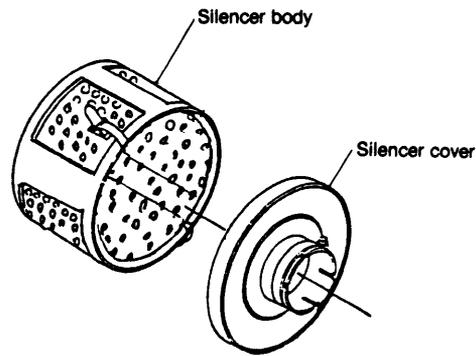
2-2 Intake silencer inspection

- (1) Sometimes disassemble the silencer and clean the inside. If welds are cracked or corroded, repair or replace as necessary.
- (2) Inspect the mist pipe joint, remove any dirt and thoroughly clean.

Old type (Part No. 129495-12500)



New type (Part No. 129470-12300)



			4JHE	4JH-TE	4JH-HTE	4JH-DTE
Rating air discharge volume		m ³ /min (ft ³ /min)	2.5 (88.27)	3.7 (130.64)	4.7 (165.96)	5.6 (197.74)
Ventilation resistance	Old type	mmAq (in.Aq)	120 (4.72)	150 (5.90)	—	—
	New type	mmAq (in.Aq)	35 (1.38)	70 (2.76)	100 (3.94)	125 (4.92)

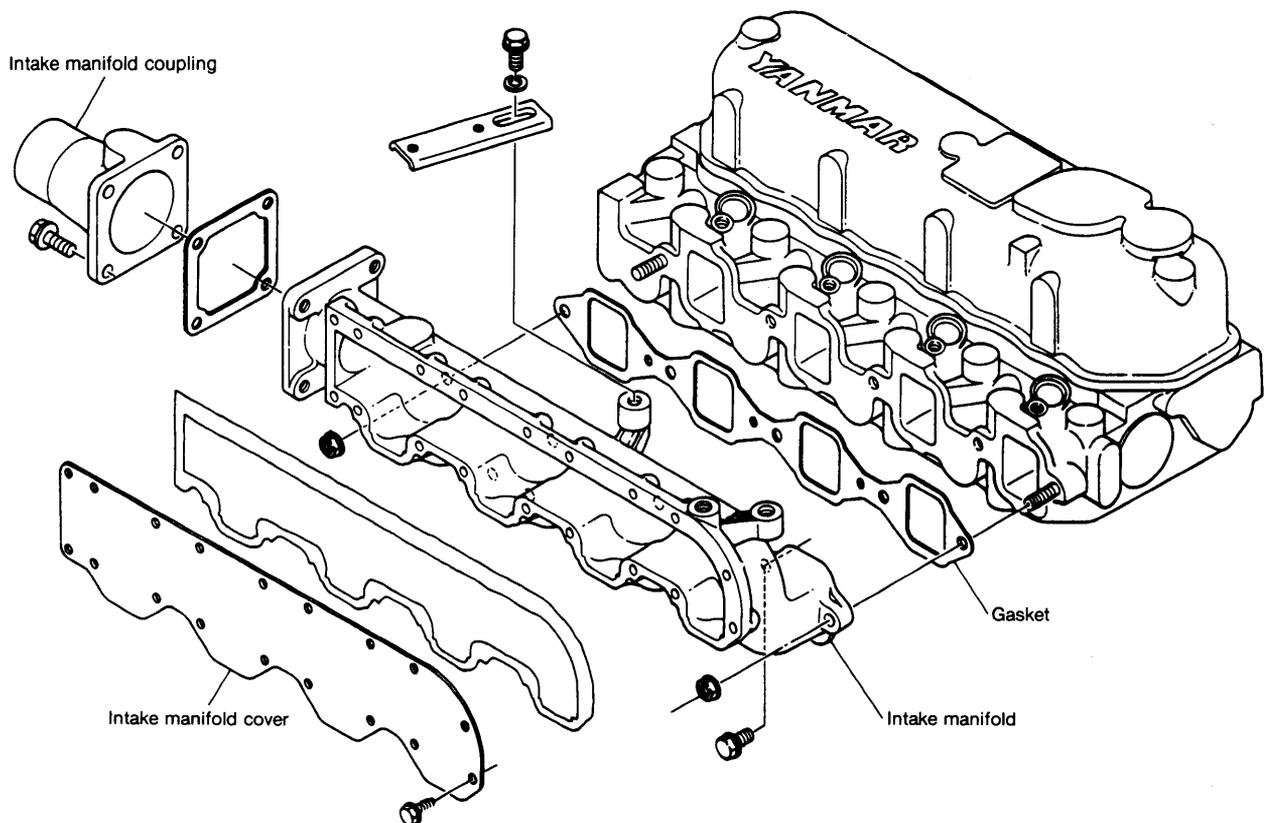
3. Intake Manifold

3-1 Construction

The intake manifold consists of the manifold and the cover, but the cover should not be disassembled without a special reason as it is coated with adhesive and bolted. If it is disassembled, recoat with adhesive and tighten to specified torque. (It can only be disassembled three times).

3-2 Inspection

- (1) Make sure that air flows through smoothly and clean out any dirt. Replace if it is excessively corroded, cracked or otherwise damaged.
- (2) Inspect the gasket packings and replace if damaged.
- (3) On models equipped with an air heater between the manifold and coupling, inspect the nickel-chrome wires for breakage, damaged contacts, etc.,



Intake manifold cover set bolts tightening torque	0.7 kg-m (5.06 ft-lb)
--	-----------------------

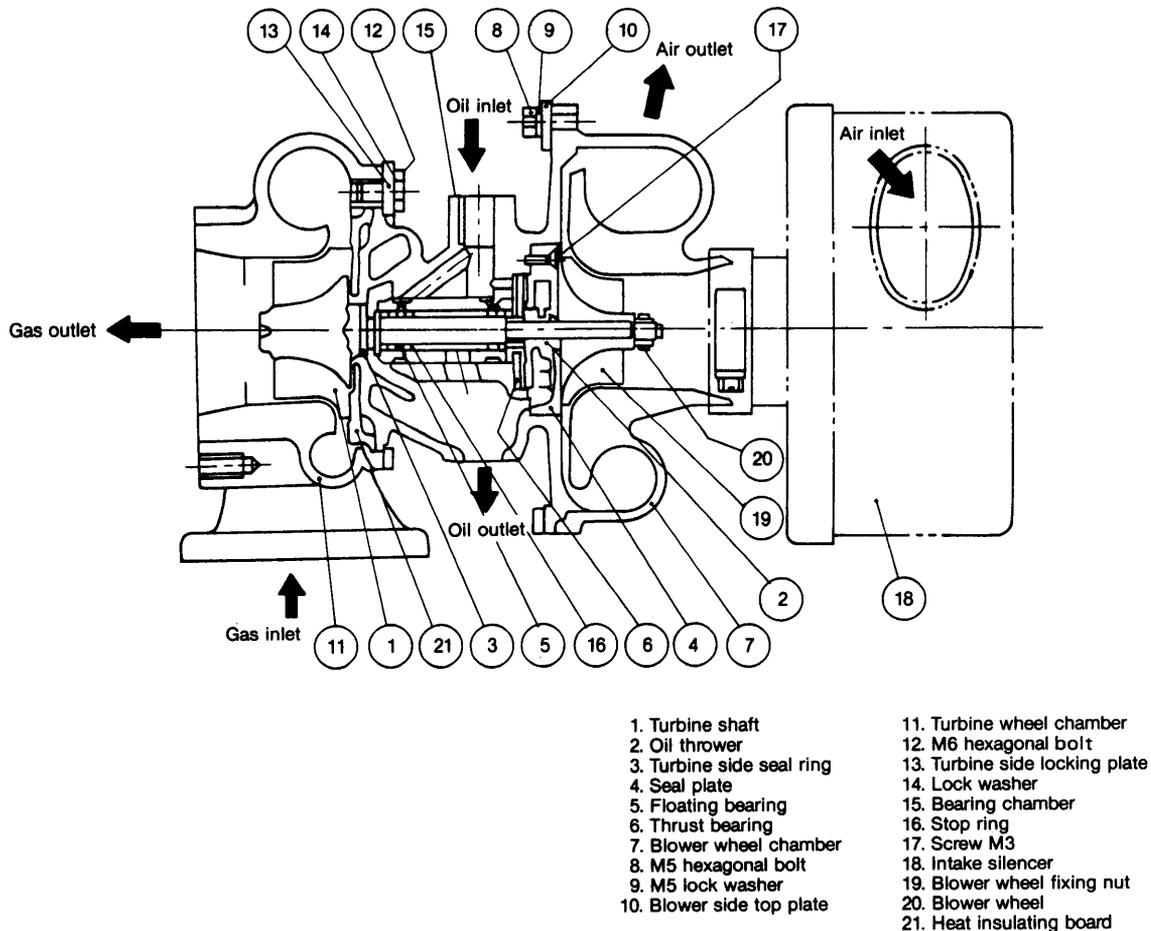
4. Turbocharger

4-1 Specifications

Turbocharger maker	ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIAL CO.,LTD. (I H I)		
Turbine type	Radial flow		
Blower type	Centrifugal		
Bearing type	Full floating		
Lubrication method	Outer lubrication		
Cooling method	Air cooled	Water cooled	
Continuous rated rpm	140,000	160,000	170,000
Max. gas inlet temp. (continuous allowable)	700°C		
Dry weight, approx.	4.2kg (9.26 lb.)		
Turbocharger model	MY20	*MY29	MY31 MY34
Applicable engine model	4JH-TE		4JH-HTE 4JH-DTE

NOTE: *MY29 is equipped on models 4JH-TE produced at Yanmar plants since Nov., 21.1984

4-2 Construction

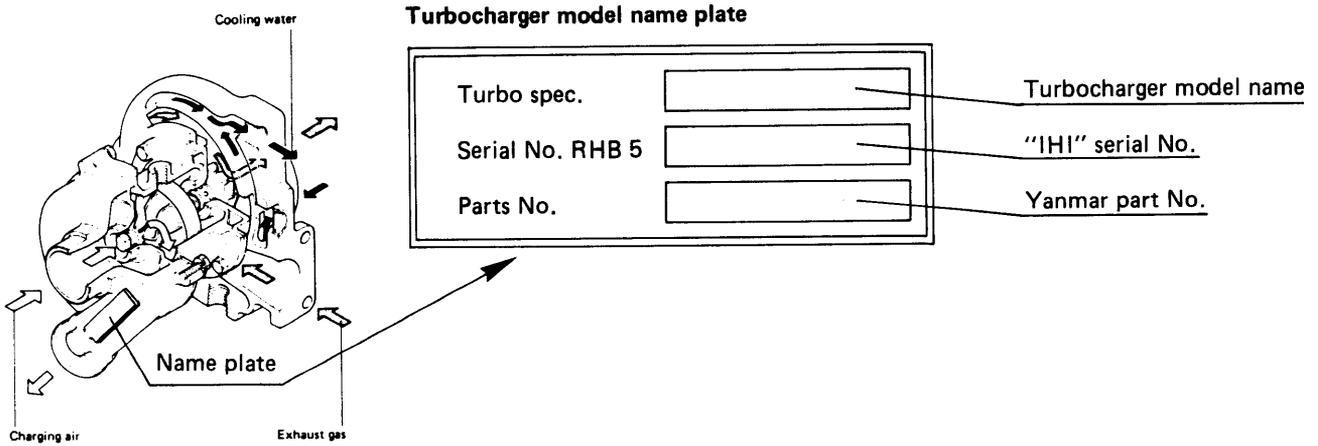


- | | |
|---------------------------|--------------------------------|
| 1. Turbine shaft | 11. Turbine wheel chamber |
| 2. Oil thrower | 12. M6 hexagonal bolt |
| 3. Turbine side seal ring | 13. Turbine side locking plate |
| 4. Seal plate | 14. Lock washer |
| 5. Floating bearing | 15. Bearing chamber |
| 6. Thrust bearing | 16. Stop ring |
| 7. Blower wheel chamber | 17. Screw M3 |
| 8. M5 hexagonal bolt | 18. Intake silencer |
| 9. M5 lock washer | 19. Blower wheel fixing nut |
| 10. Blower side top plate | 20. Blower wheel |
| | 21. Heat insulating board |

4-4 Interchangeability of turbochargers

The IHI-make turbocharger used for the 4JH serieses differ according to the engine model. Care should therefore be taken to assemble only components for the turbocharger used in

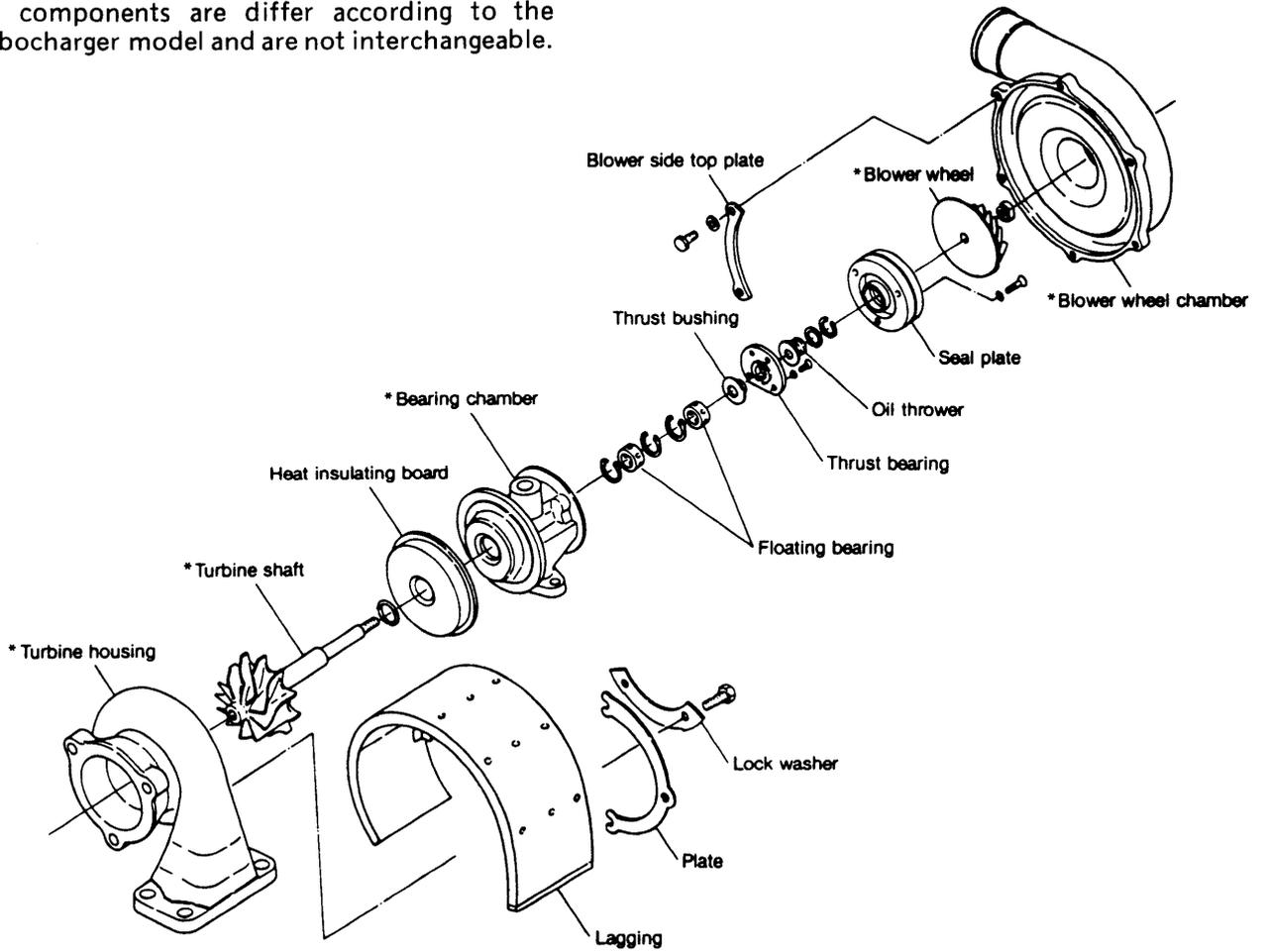
your engine when replacing parts. The use of incorrect turbocharger components will detract from the performance of the engine. Turbocharger models can be distinguished by their name plates.



Engine model	Turbocharger model (spec.)	Yanmar parts No.	Note.
4JH - TE	MY20	129492 - 18000	Design changed from MY29
	MY29	129497 - 18000	Yanmar production start Nov., 21. 1984
4JH - HTE	MY31	129474 - 18000	
4JH - HTE	MY34	129473 - 18000	

4-5 Interchangeability of turbocharger components

The inspection procedures and adjustment standard are identical for all turbocharger models. Please note, however, that the asterisked (*) components are different according to the turbocharger model and are not interchangeable.

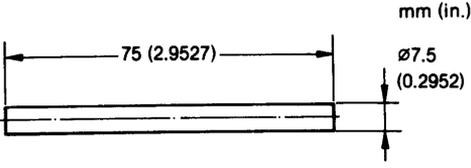
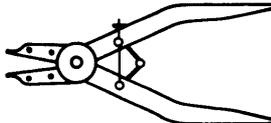
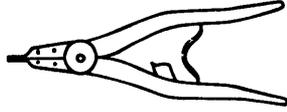
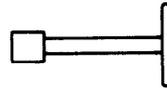
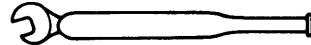
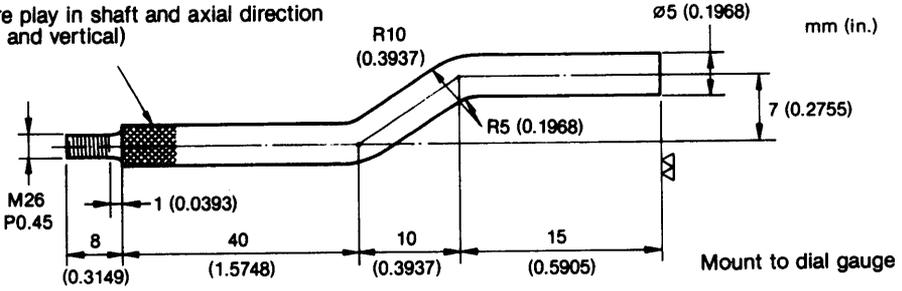


Part name	Part No.	Turbocharger model	Engine model
Turbine housing	X-N138892	MY20	4JH-TE
	X-N138872	MY29	
	X-N139452	MY31	4JH-HTE
	X-N139402	MY34	4JH-DTE
Bearing chamber	X-N133422	MY20	4JH-TE
	X-N133432	MY29, MY31	4JH-TE, 4JH-HTE
	X-N133442	MY34	4JH-DTE
Turbine shaft	X-N131502	MY20, MY29, MY34	4JH-TE, 4JH-DTE
	X-N131572	MY31	4JH-HTE
Blower wheel	X-N136504	MY20, MY29, MY31	4JH-TE, 4JH-HTE
	X-N136606	MY34	4JH-DTE
Blower wheel chamber	X-N134072	MY20, MY29, MY31,	4JH-TE, 4JH-HTE
	X-N134092	MY34	4JH-DTE

4-6 Disassembly, assembly

4-6.1 Preparations for disassembly

The following special tools are required for disassembly of the turbocharger, in addition to the standard tools.

Name of tool	Use	Illustration
Bar	To remove thrust metal and thrust bushings	 <p>mm (in.) 75 (2.9527) ø7.5 (0.2952)</p> <p>Material: Copper or brass</p>
Pliers	To remove floating bushing stop ring	
Pliers	To remove seal ring	
Torque driver (Phillips) 5 ~ 50kg/cm ² (71.11 ~ 711.16 lb/in. ²)	To mount thrust metal and seal plate (+)	 <p>Standard Model</p>
Box wrench	To tighten turbine shaft 10mm (0.3937 in.) × 12 square	 <p>Box only may be used</p>
Torque wrench	For following bolts M6: 10mm (0.3937 in.) 110kg/cm ² (1564.56 lb/in. ²) M5: 8mm (0.3149 in.) 45 kg/cm ² (64.005 lb/in. ²) M5: 8mm (0.3149 in.) 20 kg/cm ² (284.46 lb/in. ²)	
Gauge wire	To measure play in shaft and axial direction (horizontal and vertical)	 <p>mm (in.) ø5 (0.1968) 7 (0.2755) R10 (0.3937) R5 (0.1968) 15 (0.5905) 10 (0.3937) 40 (1.5748) 8 (0.3149) 1 (0.0393) M26 P0.45</p> <p>Mount to dial gauge</p>

4-6.2 Inspection prior to disassembly

- (1) Make sure that the turbine and blower blades are not in contact and that the rotor rotates smoothly.
- (2) Measuring rotor play.

	mm (in.)	
	Standard	Wear limit
Rotor play in direction of shaft	0.03 ~ 0.06 (0.0011 ~ 0.0023)	0.09 (0.0035)
Rotor play in axial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.17 (0.0066)

4-6.3 Disassembly

Make match marks before disassembling the turbocharger to show how the super charger is mounted on the engine. This determines the angle at which the turbine chamber, bearing chamber and blower chamber are mounted.

- (1) Removing blower chamber
 - 1) Remove the M5 mounting bolts, spring washers and blower side retaining plate.
 - 2) Remove the blower chamber.

NOTE: 1. The blower chamber and bearing chamber mounting surfaces are coated with a liquid gasket.
 2. Be careful not to scratch the blower blade when disassembling the blower chamber.

- (2) Removing blower blade
 - 1) Fit a box wrench (10mm (0.3937in.)) to the end of the turbine side of the turbine shaft and remove the shaft end nut.

NOTE: The box end nut has left handed threads.

- 2) Remove the blower blade.
- (3) Removing turbine chamber, lagging.
 - 1) Remove the turbine chamber mounting bolts and the turbine side retaining plate for lagging.
 - 2) Remove the lagging and turbine chamber.
- (4) Pulling the turbine shaft
 - 1) Lightly hold the heat shield by the hand and pull out the turbine shaft.

NOTE: If the turbine shaft is hard to pull out, lightly tap the blower side end of the shaft with a wood mallet.

- 2) Remove the heat shield.

NOTE: If the heat shield is hard to remove, tap it lightly with a caulking chisel.

- (5) Removing the seal plate
 - 1) Loosen the M3 flat seal plate mounting screws with a plus screwdriver and remove them along with double grip (tooth) washers.
 - 2) Remove the seal plate.

NOTE: The seal plate and bearing chamber mounting surfaces are coated with a liquid gasket.

- 3) Remove the oil ring seal from the seal plate.
- (6) Removing the thrust metal and thrust bushing.
 - 1) Loosen the M3 flat seal plate mounting screws with a plus screwdriver and remove them along with the double grip washers.
 - 2) Use a copper rod to remove the thrust metal and thrust bushing.

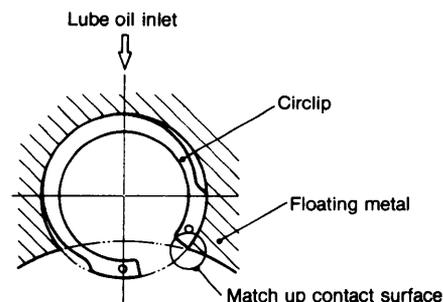
- (7) Removing the floating metal (bushing)
 - 1) Remove the round R stop ring from the bearing chamber with stop ring pliers.
 - 2) Remove the floating metal from the bearing chamber.
- (8) Removing seal ring
 - 1) Remove the turbine side seal ring from the turbine shaft.
 - 2) Remove the large and small blower side seal rings from the oil seal.

4-6.4 Preparations for reassembly

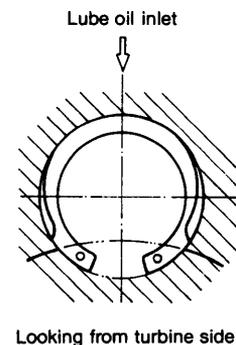
- (1) When the turbocharger is reassembled, special tools, liquid gasket (Three Bond No.1207S or Three Bond No.1215) and burning preventative agent are needed in addition to the standard tools.
- (2) Always replace the following with new parts when reassembling the turbocharger:

- Turbine side seal rings
- Blower side seal rings (large)
- Blower side seal rings (small)
- M3 flat screws
- Bent washers
- Double grip washers

Near the turbine



All other cases



4-6.5 Reassembly

- (1) Reassembly of floating metal
- 1) Mount the inside round R stop ring in the bearing chamber with stop ring pliers.
 - 2) Fit the floating metal in the bearing chamber.
 - 3) Mount the outside round R stop ring in the bearing chamber.

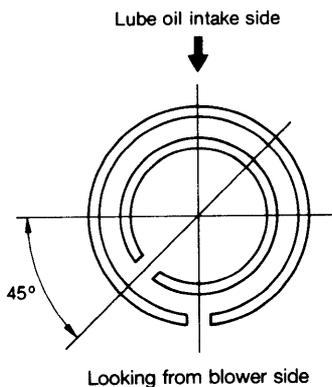
NOTE: 1. The round R stop ring opening should be mounted as shown in the illustration. The round part of the stop ring should be mounted on the metal.

2. When mounting, coat the floating metal with engine oil.

- (2) Reassembly of the turbine shaft
- 1) Insert the seal ring in the turbine shaft.
 - 2) Mount the heat shield on the turbine side bearing chamber.
 - 3) Coat the journal of the turbine shaft with engine oil and insert from the turbine side of the bearing chamber.

NOTE: Take adequate care not to scratch the floating metal with the turbine shaft. The seal ring opening should face the oil intake and be inserted aligned with the turbine shaft center.

- (3) Reassembly of the thrust metal
- 1) Insert the thrust bushing in the turbine shaft.
 - 2) Coat the thrust metal with engine oil and mount it in the bearing chamber.
 - 3) Put the double grip washers on the thrust metal mounting M3 flat screws and tighten with the torque driver.

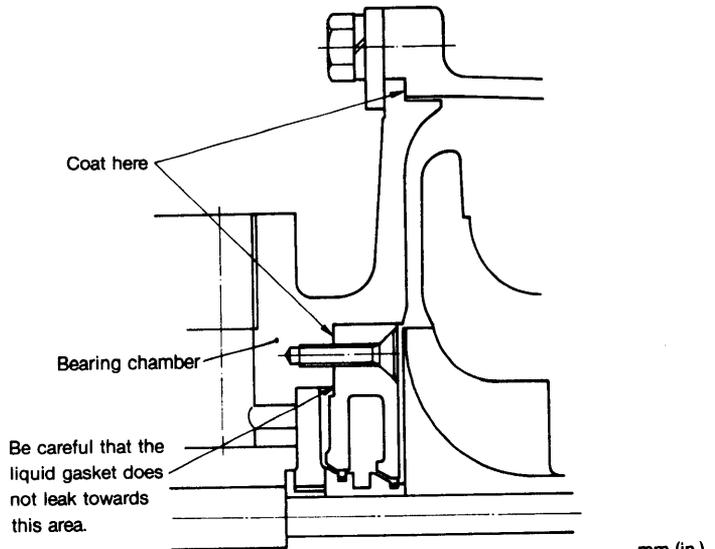


	kg-cm (ft-lb)
Tightening torque	12 ~ 14 (0.86 ~ 1.01)

- (4) Mounting seal plate
- 1) Insert the seal ring in the oil drain.
 - 2) Insert the seal plate in the oil drain.

NOTE: The seal ring opening should face the direction indicated in the upper right illustration.

- 3) Coat the blower side seal plate mounting surface of the bearing chamber (20) with the liquid gasket (Three Bond No.1207S or Three Bond No.1215).



	mm (in.)
Coating thickness	0.1 ~ 0.2 (0.0039 ~ 0.0078)

NOTE: See the illustration for where to coat it.

- 4) Mount the sealing plate on the bearing chamber.
- 5) Put the double grip washers on the sealing plate mounting M3 flat screws and tighten with the torque driver.

	kg-cm (ft-lb)
Tightening torque	12 ~ 14 (0.86 ~ 1.01)

- (5) Mounting blower blade
- 1) Put the blower blade on the turbine shaft.
 - 2) Tighten the turbine side shaft end nut of the turbine shaft with a box wrench (10mm (0.3937in.)).

NOTE: The shaft end nut has a left handed thread.

	kg-cm (ft-lb)
Tightening torque	18 ~ 22 (1.30 ~ 1.59)

- (6) Mounting turbine chamber
- 1) Mount the turbine chamber, aligned with the match marks made before disassembly.

NOTE: When replacing parts, mount after checking the oil intake/discharge and exhaust gas intake positions.

- 2) Lugging
Put on the turbine side retainer plate for lugging and the bent washer, and tighten with the M6 hex bolt. Make sure to bend the washer after tightening the M6 hex bolt.

	kg-cm (ft-lb)
Tightening torque	105 ~ 115 (7.59 ~ 8.31)

- (7) Mounting blower chamber
- 1) Coat the blower side flange surface of the seal plate with the liquid gasket (Three Bond No.1207S or Three Bond No.1215).

NOTE: Refer to page (21) for where to coat.

	mm (in.)
Coating thickness	0.1 ~ 0.2 (0.0039 ~ 0.0078)

- 2) Align the match marks made before disassembly and mount the seal plate in the blower chamber.

NOTE: When replacing parts, mount only after checking oil intake/discharge and air discharge positions.

- 3) Replace on the blower side retaining plate and spring washer and tighten with the M5 hex bolt.

	kg-cm (ft-lb)
Tightening torque	40 ~ 50 (2.89 ~ 3.61)

(8) Measuring rotor play

See item 3-2 on inspection procedure—the measuring procedure is the same.

Rotor play above the standard is usually due to improper assembly or use of the wrong part—reassemble.

	mm (in.)
	Standard
Rotor play in direction of shaft	0.03 ~ 0.06 (0.0011 ~ 0.0023)
Rotor play in axial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)

4-6.6 Disassembly/reassembly precautions

Observe the following during and after mounting the turbocharger on the engine.

Be especially careful to prevent the entrance of foreign matter into the turbocharger.

- (1) Precautions on mounting the turbocharger.

Lube oil system

- 1) Run new engine oil through the oil intake holes before mounting on the engine, turn the turbine shaft by hand and lubricate the journal metal (bushings) and thrust metal.
- 2) Wash the engine oil intake pipe and oil discharge pipe, check for damage and make sure it is not clogged up with dirt or other foreign matter.
- 3) Make sure that there is no oil leakage from the oil pipes and joints after assembly.

Intake system

- 1) Make sure that there is no dirt or other foreign matter in the air intake system.
- 2) Make sure that there is no air leakage from the air supply duct/air cleaner connections.

Exhaust system

- 1) Make sure that there is no dirt or other foreign matter in the exhaust gas system.
- 2) Make sure not to mix up the special heat resistant bolts and nuts with the regular bolts when mounting the parts. Coat the bolts, nuts, etc. with burning preventive agent.
(Heat resistant hex bolts are used for the turbine chamber.)
- 3) Make sure that there is no gas leakage from exhaust piping/connections.

4-7 Inspection and maintenance

4-7.1 Washing

- (1) Inspection prior to washing

Make a visual inspection of disassembled parts before washing to check for burning, wear, foreign matter and carbon build-up. Make an especially thorough inspection in case of breakdowns as a step towards determining the cause of the breakdown.

Major items

Inspection	Location
Carbon build-up	<ol style="list-style-type: none"> 1) Turbine shaft turbine side seal ring and back of blade. 2) Around the heat shield mounting of the bearing chamber and the inside wall of the bearing chamber.
Lubrication (wear, burning, discoloration)	<ol style="list-style-type: none"> 1) Turbine shaft journal, thrust bushing, oil drain. 2) Floating metal and thrust metal. 3) Around the inner bearing race of the bearing chamber.
Oil leakage	<ol style="list-style-type: none"> 1) Inside wall of the turbine chamber. 2) Outer circumference of the bearing chamber and around the heat shield mounting. 3) Turbine side seal ring of the turbine shaft and the back of the blade. 4) Inside wall of the blower chamber. 5) Back of the blower blade. 6) Back of the seal plate and portion where the seal ring is inserted.

(2) Washing procedure

Keep the following in mind when washing the parts.

Item	Tools/Cleaning Agent	Procedure
(1) Turbine shaft	1. Tools (1) Bucket (500 × 500) (2) Heat source steam or gas burner (3) Brush 2. Cleaning agent Standard carbon removing agent	(1) Boil the turbine shaft in the washing bucket. Do not hit the blade to remove the carbon. (2) Soak in the cleaning agent until the carbon and other materials adhering to the surface become soft. (3) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. (4) Be very careful not to scratch the turbine shaft bearing surface or the seal ring grooves. (5) Any foreign matter will unbalance the turbine shaft, so be sure to clean it well. Do not use a wire brush.
(2) Turbine chamber	1. Tools same as for turbine shaft 2. Cleaning agent same as for turbine shaft	(1) Boil the turbine chamber in the washing bucket. (2) Soak in the cleaning agent until all the material adhering to the surface becomes soft. (3) Use a plastic scrubber or hard hair brush to remove the foreign matter.
(3) Blower blade, blower chamber	1. Tools (1) Bucket (500 × 500) (2) Brush 2. Cleaning agent	(1) Soak in the cleaning agent until the foreign matter adhering to the surface becomes soft. (2) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. Do not use a wire brush.
(4) Other parts	(1) Wash all other parts with diesel oil. (2) Clean all lube oil lines with compressed air. (3) Be careful not to scratch parts or allow them to rust.	

4-7.2 Inspection procedure

(1) Blower chamber

Inspect for scratches caused by contact with the blower blade, scratches in the mounting surface, any galling or cracks.
Replace if necessary.

(2) Turbine chamber

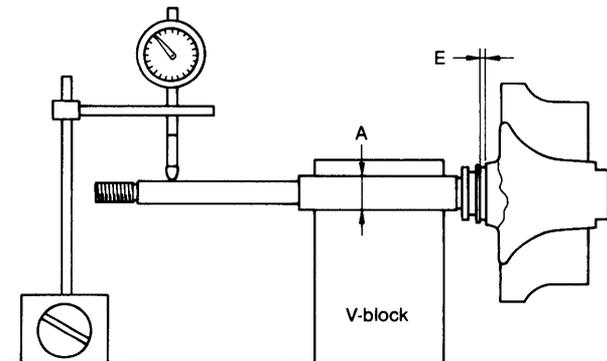
Inspect for scratches caused by contact with the turbine blade, flaking due to oxidation of the skin, and deformation due to heat or cracks.
Replace if necessary.

(3) Blower blade

Inspect for scratches caused by contact, and for breakage, corrosion or deformation.
Replace if necessary.

(4) Turbine shaft

- 1) Inspect the portion around the turbine blade for scratches, breakage, discoloration or deformation, and inspect the shaft for bending, discoloration of journal, abnormal wear, seal ring groove scratches or wear.
Replace if necessary.
- 2) Measure the outer diameter of turbine shaft journal (A) and seal ring groove width (E), and replace if beyond the wear limit.



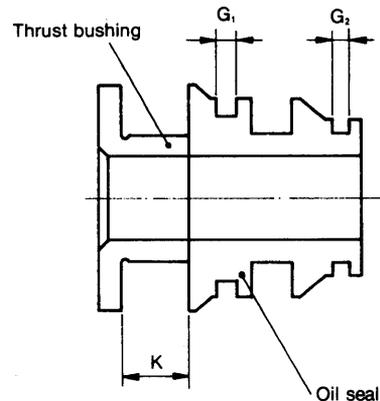
		mm (in.)
		Wear limit
Journal outer dia.	A	7.98 (0.3141)
Seal ring groove width	B	1.29 (0.0507)

3) Measure turbine shaft undulation and replace if it exceeds 0.011mm (0.0004in.).

(5) Head shield

Inspect for scratches due to contact, deformation due to heat, and corrosion.
Replace if necessary.

(6) Thrust bushing, oil seal and thrust metal. Inspect for wear, scratches, discoloration, etc., and replace if necessary, even if they remain within the wear limit.



1) Thrust bush

Measure the thrust bush groove clearance (K), and replace if it exceeds the wear limit.

		mm (in.)
		Wear limit
Thrust bush groove clearance	K	4.07 (0.1602)

2) Oil ring

Measure the seal ring groove width (G₁), (G₂) and replace if it exceeds the wear limit.

		mm (in.)
		Wear limit
Seal ring groove width	G ₁	1.31 (0.0515)
	G ₂	1.11 (0.0437)

3) Thrust metal

Measure the thrust metal width (J), and replace if it exceeds the wear limit.

		mm (in.)
		Wear limit
Thrust metal width	J	3.98 (0.1566)

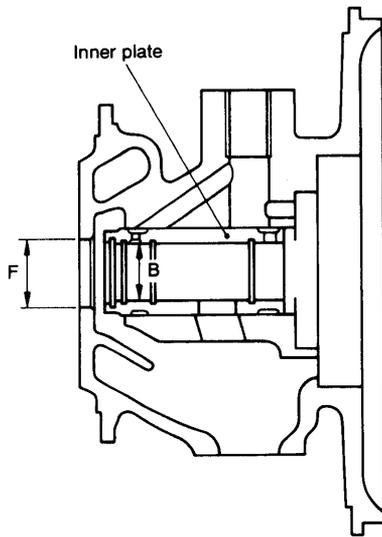
(7) Floating metal

- 1) Inspect for abnormal wear, discoloration, scratches, etc., and replace if necessary.
- 2) Measure the inner diameter (C) and outer diameter (D) of the metal, and replace if either exceeds the wear limit.

		mm (in.)
		Wear limit
Floating metal outer dia.	C	12.31 (0.4846)
Floating metal inner dia.	D	8.04 (0.3165)

(8) Bearing chamber

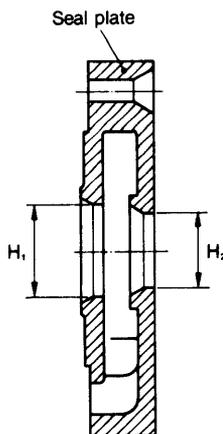
- 1) Inspect for flaking due to oxidation of the skin, galling and scratches, and replace if necessary.
- 2) Inspect the round R stop ring for breakage or cracks and replace if necessary.
- 3) Measure the (B) and (F) dimensions of the bearing chamber as shown in the illustration on the right, and replace if either exceeds the wear limit.



		mm (in.)
		Wear limit
Bearing chamber inner dia.	B	12.42 (0.4889)
Turbine side seal ring area inner dia.	F	15.05 (0.5925)

(9) Seal plate

- 1) Inspect for scratches due to contact, scratches in mounting surface, galling and cracks and replace if necessary.
- 2) Measure the blower side seal ring area (H_1 , H_2) and replace if either exceeds the wear limit.



		mm (in.)
		Wear limit
Blower side seal ring area inner dia.	H_1	12.45 (0.4901)
	H_2	10.05 (0.3956)

(10) Seal ring

Inspect for wear or deformation and replace if necessary.

- (11) Inspect retaining plates, bolts and spring washers for deformation and replace if necessary. Always replace the M3 flat screw bend washer and grip washer.

4-7.3 Periodic inspection

- (1) Periodically inspect the overall condition of supercharger and the amount of dirt build-up. Inspect at the intervals specified in the following chart.

Item	Interval		
	3 months or 1500 hours	6 months or 3000 hours	12 months or 6000 hours
Rotation of rotor	○		
Rotor play		○	
Disassembly, cleaning and inspection of entire unit			○
Cleaning and inspection of air filter	Every 300 hours		

(2) Inspection Procedure

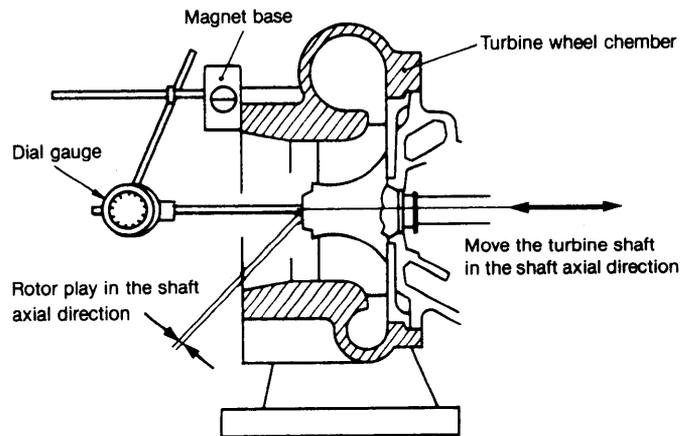
1) Rotation of rotor

The rotation of the rotor is checked by listening for any abnormal noise when it is rotating. Use a listening bar, placing the tip of the bar firmly against the turbocharger and gradually increasing engine rpm. If a loud noise is emitted every 2 or 3 seconds, rotation is abnormal. The turbocharger should be replaced or repaired as something may be wrong with the metal or rotor.

2) Rotor play

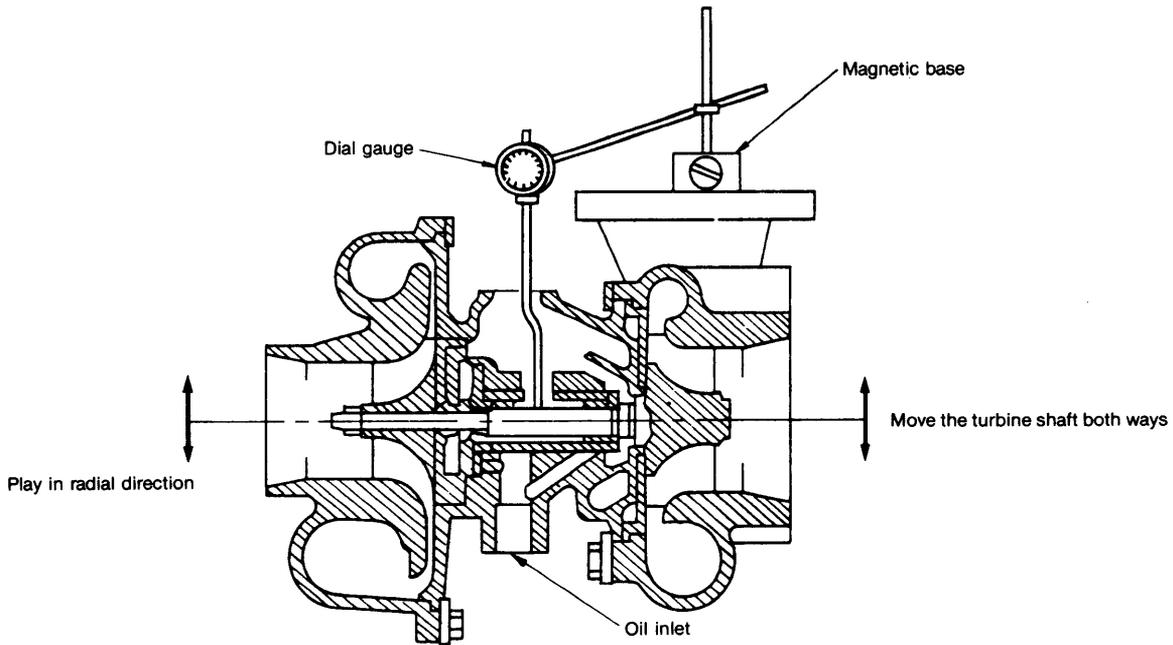
Remove the turbocharger from the engine and check the play in the shaft axial and radial directions as shown below.

3) Rotor play in the shaft axial direction.

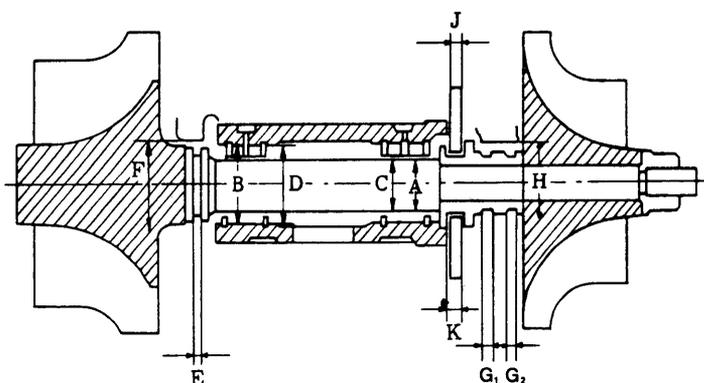


		mm (in.)
		Standard
		Wear limit
Rotor play in shaft axial direction		0.03 ~ 0.06 (0.0018 ~ 0.0023)
		0.09 (0.0035)

4) Rotor play in shaft radial direction.



	mm (in.)	
	Standard	Wear limit
Rotor play in the shaft radial direction	0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.17 (0.0066)



mm (in.)

	Items to check	Standard	Wear limit
Turbine shaft	Turbine shaft journal outer dia. (A)	7.99 ~ 8.00 (0.3145 ~ 0.3149)	7.980 (0.3141)
	Turbine side seal ring groove width (E)	1.25 ~ 1.28 (0.0492 ~ 0.0503)	1.210 (0.0476)
	Blower side seal ring groove width (G ₁)	1.22 ~ 1.23 (0.0480 ~ 0.0484)	1.310 (0.0515)
	Blower side seal ring groove width (G ₂)	1.02 ~ 1.03 (0.0401 ~ 0.0405)	1.110 (0.0437)
	Turbine shaft play	0.01 (0.0003)	0.011 (0.0004)
Bearing	Floating bearing inner dia. (C)	8.01 ~ 8.03 (0.3153 ~ 0.3161)	8.040 (0.3165)
	Floating bearing inner dia. (D)	12.32 ~ 12.33 (0.4850 ~ 0.4854)	12.310 (0.4846)
	Bearing set ring inner dia. (B)	12.40 ~ 12.41 (0.4881 ~ 0.4885)	12.420 (0.4889)
Thrust bearing	Thrust bearing width (J)	3.99 ~ 4.01 (0.1570 ~ 0.1578)	3.980 (0.1566)
	Thrust bushing groove dimension (K)	4.04 ~ 4.05 (0.1590 ~ 0.1594)	4.070 (0.1602)
Seal ring fixing area	Turbine side (bearing wheel chamber) (F)	15.00 ~ 15.02 (0.5905 ~ 0.5913)	15.050 (0.5925)
	Blower side (seal plate) (H ₁)	12.40 ~ 12.42 (0.4881 ~ 0.4889)	12.450 (0.4901)
	Blower side (seal plate) (H ₂)	10.00 ~ 10.02 (0.3937 ~ 0.3944)	10.050 (0.3956)
Play of rotor in shaft axial direction		0.03 ~ 0.06 (0.0011 ~ 0.0023)	0.090 (0.0035)
Play of rotor in radial direction		0.08 ~ 0.13 (0.0031 ~ 0.0051)	0.170 (0.0066)

Tightening torque

	Screw dia. mm	Tightening torque kg-cm (ft-lb)
Turbine chamber set bolt	M6	105 ~ 115 (7.59 ~ 8.31)
Blower chamber set bolt	M5	40 ~ 45 (2.89 ~ 3.25)
Thrust metal set screw	M3	12 ~ 14 (0.86 ~ 1.01)
Seal plate set screw	M3	12 ~ 14 (0.86 ~ 1.01)
Blower blade nut	left hand screw M5	18 ~ 22 (1.30 ~ 1.59)

4-8 Troubleshooting

The engine will not produce the required output if the turbocharger breaks down. If the engine output drops, first check the engine to see if anything is wrong, and then check the turbocharger according to the following procedure if there is nothing wrong with the engine.

4-8.1 Excessive smoke

(1) Insufficient air intake

Cause	Remedy
<ol style="list-style-type: none"> 1) Air cleaner is clogged up. 2) Air intake is closed. 3) Leakage from air intake system connections. 	<ul style="list-style-type: none"> • Replace or wash the element. • Open to proper position. • Inspect and repair

(2) Turbocharger does not rotate

Cause	Remedy
<ol style="list-style-type: none"> 1) Build-up of foreign matter in oil on seals inhibiting turbine shaft rotation. 2) Burned metal <ul style="list-style-type: none"> • Insufficient oil or clogging up of supply pipe. • Oil temperature too high. Rotating parts are out of balance. • Insufficient warming up or sharp stopping. 3) Turbine or blower blade knocking something or broken. <ul style="list-style-type: none"> • Excessive rpm • Excessive exhaust gas temperature rise. • Entrance of foreign matter. • Worn metal (bushings) • Improper reassembly 	<ul style="list-style-type: none"> • Disassemble and clean turbocharger and change engine oil. • Disassemble turbocharger and repair. • Inspect engine oil supply system, repair any parts as necessary and change the engine oil. • Wash or replace rotating parts. • Read operation manual and operate engine accordingly. • Inspect engine parts and adjust. • Disassemble and thoroughly remove any foreign matter, inspect the air cleaner, and engine parts, and repair as necessary. • Disassemble turbocharger and repair. • Reassemble

(3) Excessive exhaust gas drag (resistance)

Cause	Remedy
<ol style="list-style-type: none"> 1) Insufficient turbocharger rpm due to leakage of exhaust gas before entry into turbocharger. 2) Insufficient turbocharger rpm due to deformation of exhaust system piping. 	<ul style="list-style-type: none"> • Inspect fittings and repair. • Repair

4-8.2 White exhaust smoke

Cause	Remedy
<ol style="list-style-type: none"> 1) Oil leaking on blower side or turbine side due to clogging or deformation of return piping. 2) Seal ring excessively worn or broken due to excessive metal wear. 	<ul style="list-style-type: none"> • Repair or replace pipe. • Disassemble turbocharger and repair.

4-8.3 Excessive oil consumption

Cause	Remedy
<ol style="list-style-type: none"> 1) Seal ring excessively worn or broken due to excessive metal wear. 	<ul style="list-style-type: none"> • Disassemble turbocharger and repair.

4-8.4 Decrease in (engine) output

Cause	Remedy
<ol style="list-style-type: none"> 1) Gas leakage from exhaust gas system. 2) Air leakage from blower side discharge. 3) Air cleaner element clogged up. 4) Turbocharger dirty or damaged. 	<ul style="list-style-type: none"> • Inspect parts and repair. • Clean or replace element. • Disassemble turbocharger and repair, or replace.

4-8.5 Poor (slow) turbocharger responsiveness (starting)

Cause	Remedy
1) Carbon build-up on turbine side (blade seal) inhibiting turbine shaft rotation.	• Disassemble and wash turbocharger and replace engine oil.
2) Incomplete combustion.	• Inspect engine fuel system and improve combustion efficiency.

4-8.6 Abnormal noise or vibration

(1) Abnormal noise

Cause	Remedy
1) Blower discharge air flows back (surges) when the gas line area is considerably reduced due to closing of the turbine chamber nozzle or during acceleration.	• Disassemble and clean turbocharger.
2) Rotating parts knocking something.	• Disassemble turbocharger and repair or replace.

(2) Vibration

Cause	Remedy
1) Fittings connecting turbocharger and exhaust gas piping/oil pipe have become loose.	• Inspect fittings and retighten/repair as necessary.
2) Rotating parts making contact with surrounding parts because of metal failure, or turbine blade or blower blade damaged due to entrance of foreign matter.	• Disassemble turbocharger and repair or replace. Thoroughly remove any foreign matter.
3) Rotating parts out of balance.	• Repair or replace rotating parts.

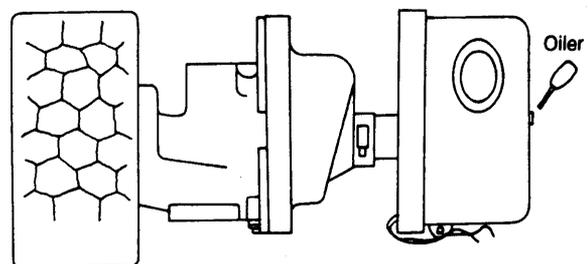
4-9 Turbocharger blower washing procedure

4-9.1 General

- (1) Use "Blower Wash" and clean water to wash the blower.
- (2) Make it a general practice to wash the turbocharger blower when the air supply pressure has decreased by about 10 percent. The frequency of this will differ greatly depending on working conditions, but about once a week is generally sufficient.
- (3) This procedure cannot be used for cleaning the entire turbocharger. It must be periodically disassembled and cleaned.
- (4) Only remove the inlet cap when washing the blower—it must not be removed under any other circumstances.

4-9.2 Procedure

- (1) Run the engine at normal load (3/4 ~ 4/4 load) and apply Blower Wash for 4 ~ 5 seconds with a 20cc standard oiler.
- (2) 3 ~ 5 minutes after application of the Blower Wash the dirt will be loosened up. Slowly put in 20cc of water (over about 4 ~ 10 seconds).
- (3) Use a vinyl container to feed in the cleaning agent or water. If too much cleaning agent or water enters suddenly there might be a breakdown or breakage of the blower blade. Be sure to feed in the cleaning agent or water at the correct speed.
- (4) If there is no change in the air supply pressure or exhaust gas temperature after washing, repeat the washing after about 10 minutes.
No change after washing the blower 3 ~ 4 times indicates that either the blower is extremely dirty or something else is out of order. Disassemble and clean the washer, and take any other action as necessary.
- (5) Run the engine under load to dry for at least 15 minutes after feeding in the agent or water.



Clean the blower: Every 150 hours

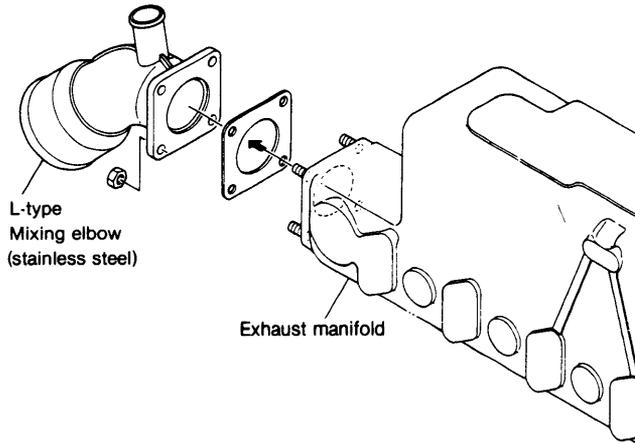
5. Mixing Elbow

5-1 Construction

There are two types of mixing elbows for the 4JHE engine: the L and U types. Both types are bolted to the exhaust manifold.

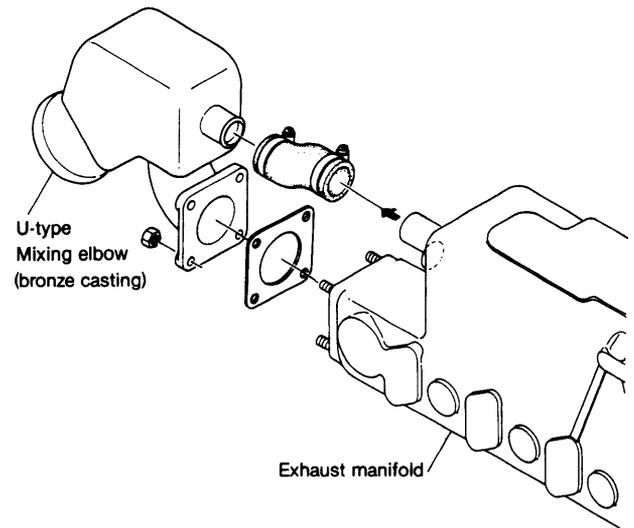
There are also L and U types for the 4JH-TE, 4JH-HTE and 4JH-DTE engines. Both are mounted on the turbocharger discharge.

For model 4JHE

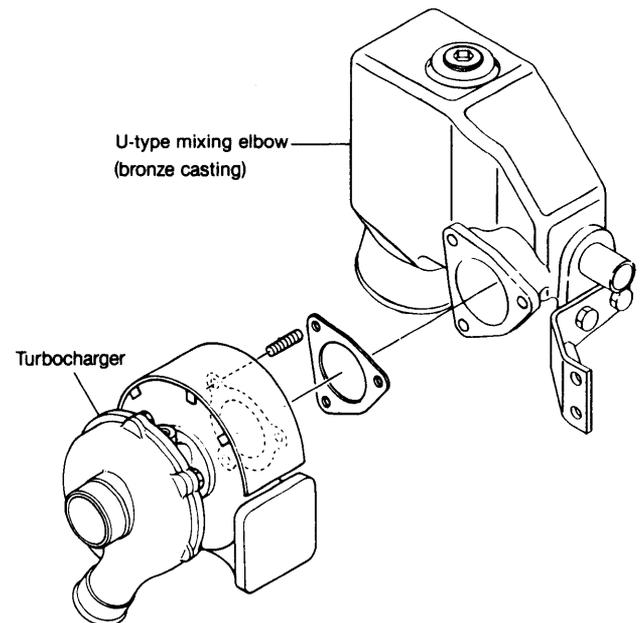
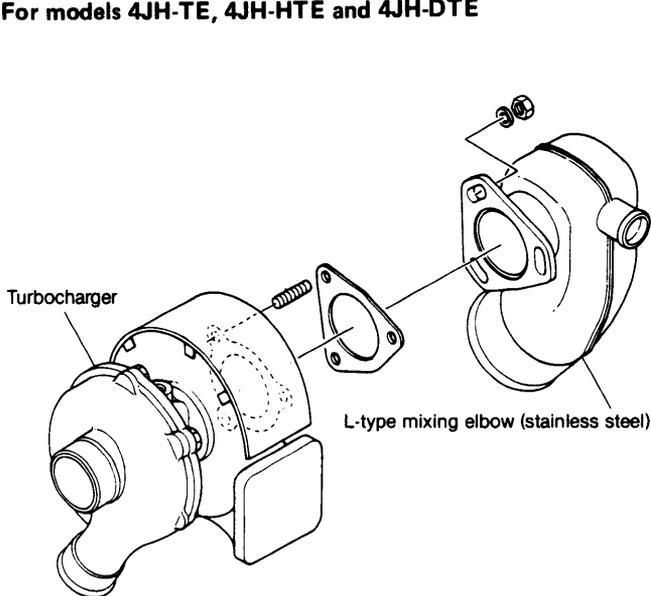


5-2 Mixing elbow inspection

- (1) Clean dirt and scale out of the air and cooling water lines.
- (2) Repair cracks or damage to welds, or replace.
- (3) Inspect the gasket packing and replace as necessary.



For models 4JH-TE, 4JH-HTE and 4JH-DTE



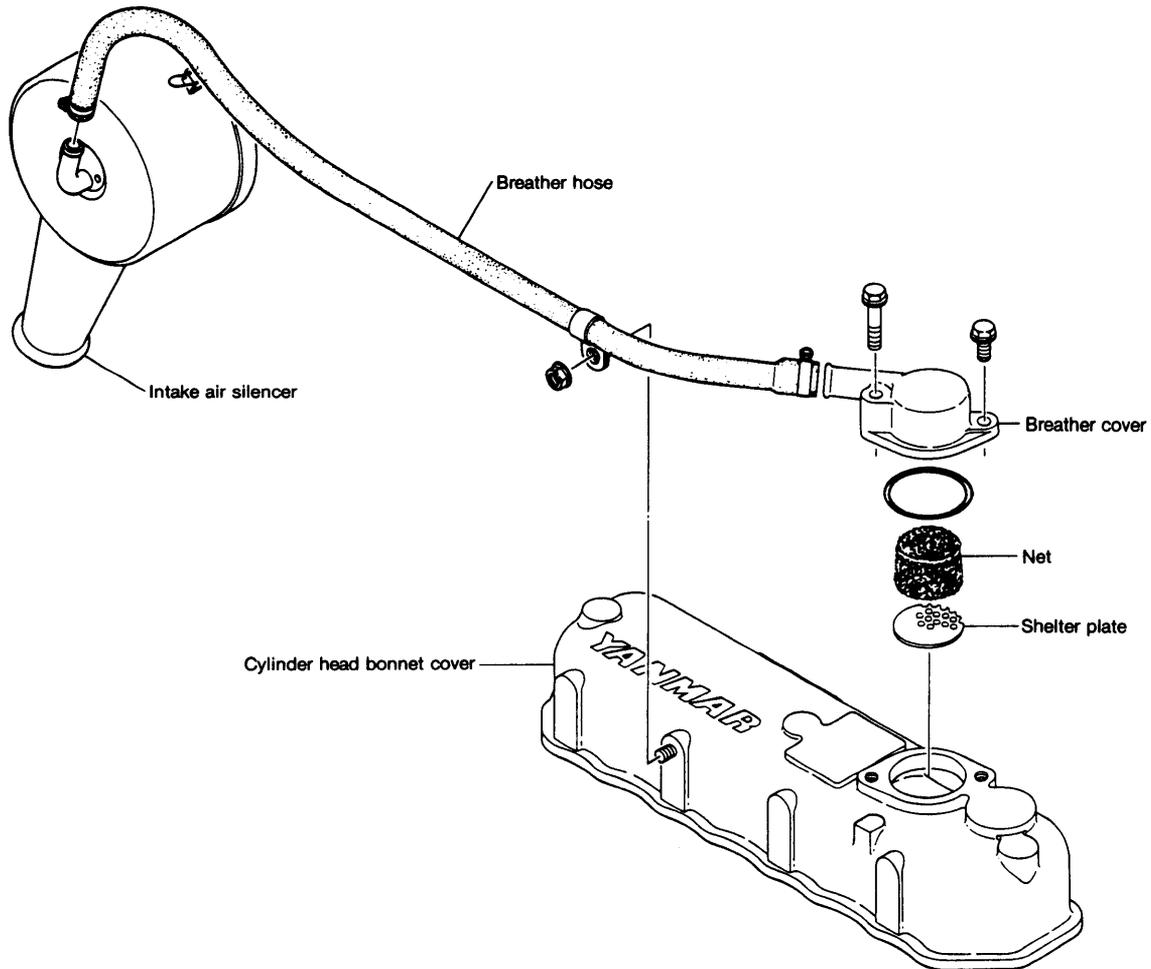
6. Breather

6-1 Construction

The mist in the crank chamber goes past the tappets in the cylinder block to the valve arm chamber, through the breather in the bonnet (head) cover, into the intake silencer through the mist (removal) pipe, and is sucked in together with the intake air.

6-2 Breather inspection

- (1) Remove the breather cover and clean the wire element.
- (2) Check to see whether the breather pipe is clogged up, and clean if necessary. Replace the pipe if damaged or cracked.
- (3) Inspect the O-ring(s) and replace as necessary.



CHAPTER 5

LUBRICATION SYSTEM

1. Lubrication System	5-1
2. Lube Oil Pump	5-3
3. Lube Oil Filter	5-6
4. Oil Pressure Control Valve	5-8
5. Lube Oil Cooler	5-9
6. Piston Cooling Nozzle	5-11
7. Rotary Waste Oil Pump (Optional)	5-12

1. Lubrication System

The lube oil in the oil pan is pumped up through the intake filter and intake piping by the lube oil pump, through the holes in the cylinder body and on to the discharge filter.

The lube oil which flows from the holes in the cylinder body through the bracket to the oil element is filtered and sent to the oil cooler. It returns from the oil cooler to the bracket, the pressure is regulated, and it is fed back to main gallery in cylinder body.

The lube oil which flows in the main gallery goes to the crankshaft journal, lubricates the crank pin from the crankshaft journal, and a portion of the oil is fed to the camshaft bearings.

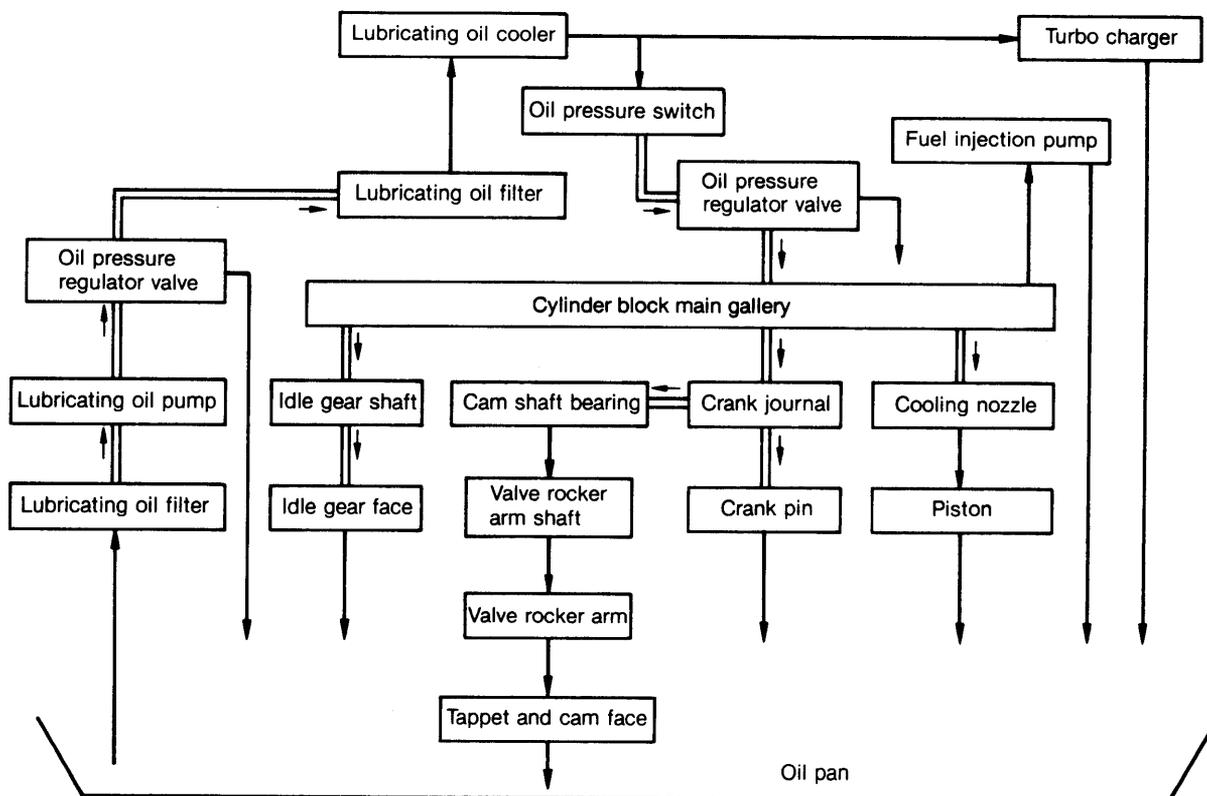
Oil is sent from the gear case camshaft bearings through

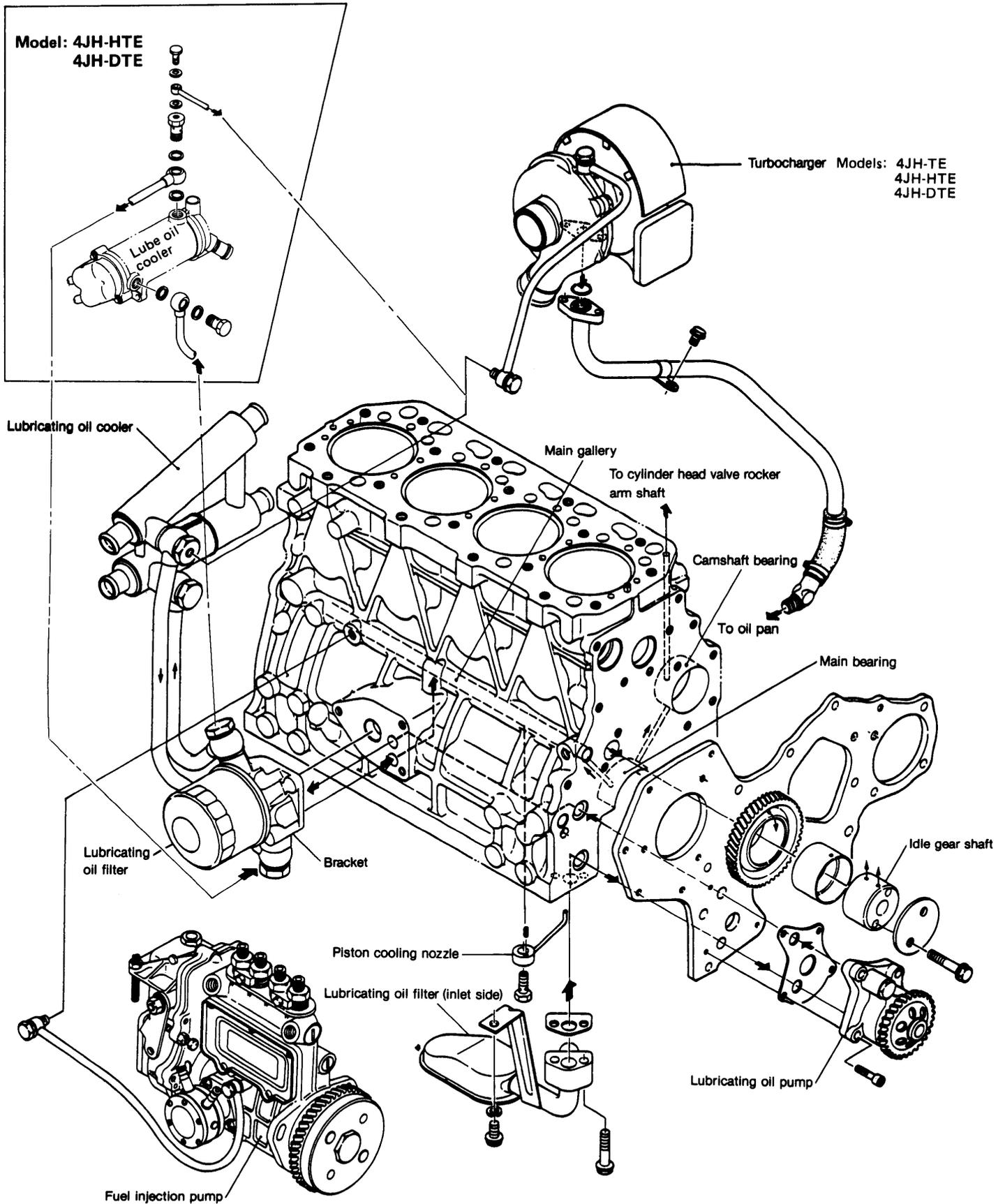
the holes in the cylinder body and cylinder head to the valve arm shaft to lubricate the valve arm and valves.

Oil is also sent from the main gallery to the piston cooling nozzle to cool the piston surface, and is sent through the intermediate gear bearing (oil) holes to lubricate the intermediate gear bearings and respective gears.

Lube oil for the fuel injection pump is sent by pipe from the main gallery to the fuel injection pump.

Part of the lube oil is sent from the oil cooler discharge to the supercharger in engines fitted with one, and is then piped back from the supercharger to the oil pan.





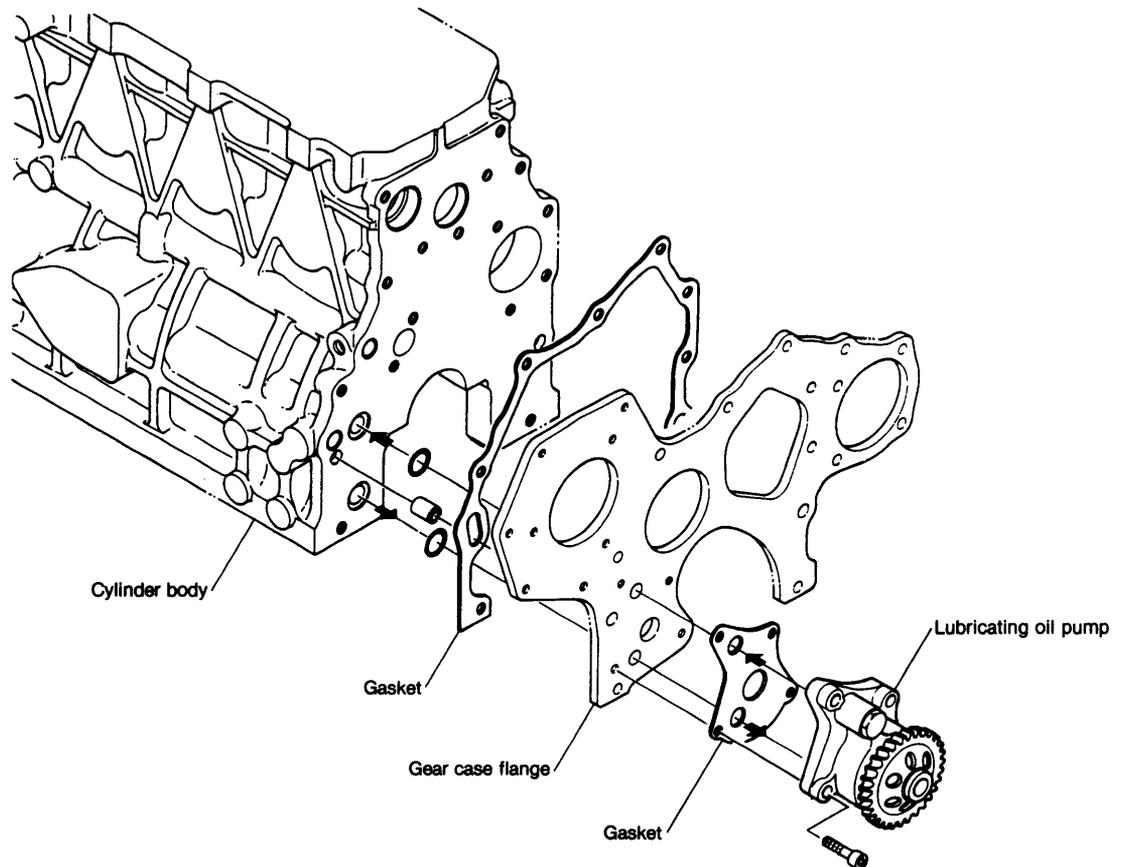
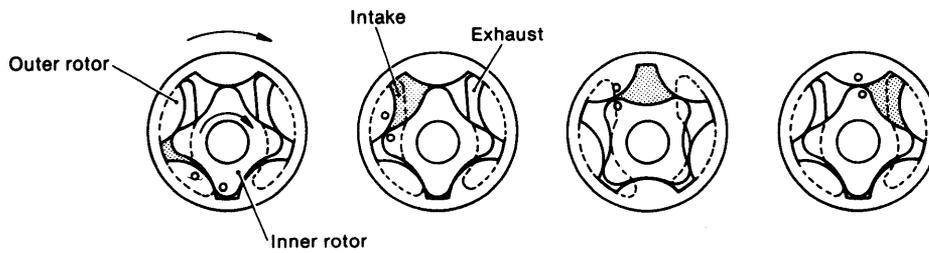
2. Lube Oil Pump

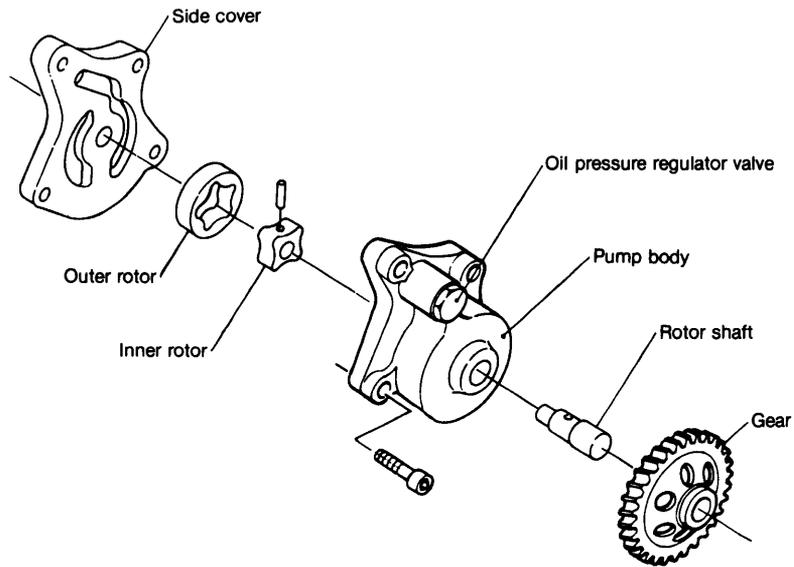
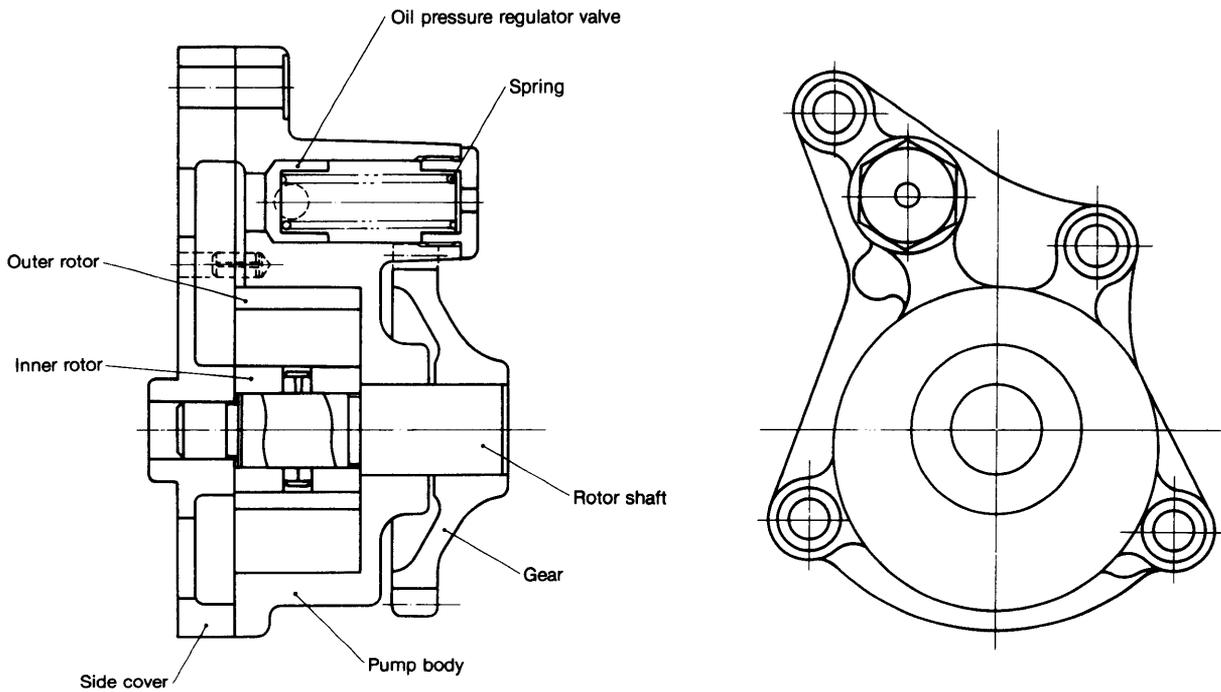
2-1 Lube oil pump construction

The trochoid type lube oil pump is mounted on the gear case side engine plate, and the rotor shaft gear is driven by the crankshaft gear.

The lube oil flows from the intake filter mounted on the bottom of the cylinder body through the holes in the cylinder body and engine plate, and out from the holes in the engine plate and cylinder body to the discharge filter.

The lube oil pump is fitted with a pressure regulating valve which maintains the discharge pressure at 3kg/cm².





2-2 Specifications of lube oil pump

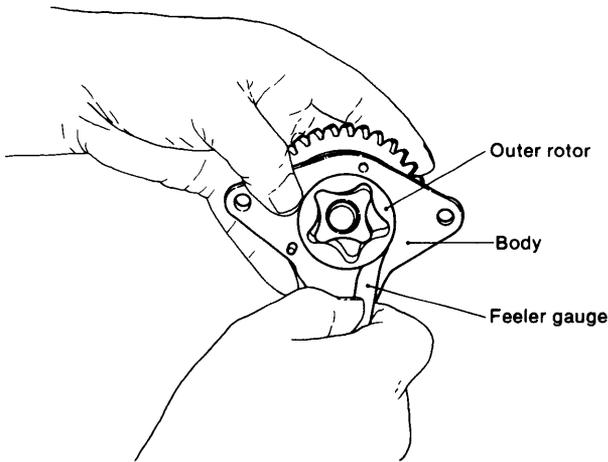
Engine speed	3600 rpm
Gear ratio (crank gear/pump gear)	28/29
Pump speed	3477 rpm
Discharge volume	36 l/min (2196 in. ³ /min)
Discharge pressure	3 kg/cm ² (42.66 lb/in. ²)

2-3 Lube oil pump disassembly

- (1) Remove the lube oil pump assembly from the engine plate.
- (2) The lube oil pump cover may be disassembled, but do not disassemble the rotor, rotor shaft or drive gear. The oil pressure regulating valve plug is coated with adhesive and screwed in, so it cannot be disassembled. These parts cannot be reused after disassembly. Replace if necessary as an assembly.

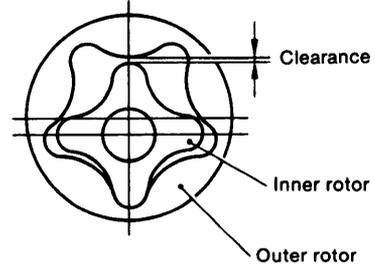
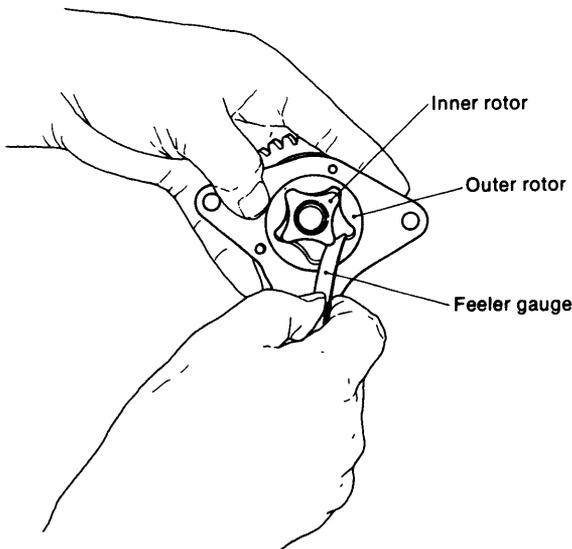
2-4 Lube oil pump inspection

- (1) Clearance between outer rotor and pump body
Insert a feeler gauge between the outer rotor and pump body to measure the clearance, and replace if it exceeds the limit.



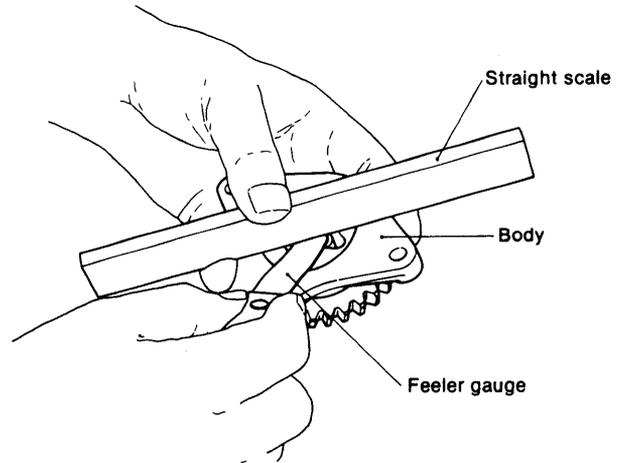
	mm (in.)	
	Standard	Wear limit
Outer rotor and pump body clearance	0.100 ~ 0.170 (0.0039 ~ 0.0066)	0.25 (0.0098)

- (2) Clearance between outer rotor and inner rotor
To measure clearance, insert a feeler gauge between the top of the inner rotor tooth and the top of the outer rotor tooth, and replace if it exceeds the limit.



	mm (in.)	
	Standard	Wear limit
Outer rotor and inner rotor clearance	0.050 ~ 0.105 (0.0019 ~ 0.0041)	0.15 (0.0059)

- (3) Clearance between pump body and inner rotor side of outer rotor
Place a straight-edge against the end of the pump body and insert a feeler gauge between the straight-edge and the rotor to measure side clearance. Replace the assembly if the clearance exceeds the limit.



	mm (in.)	
	Standard	Wear limit
Pump body and inner rotor, outer rotor clearance	0.03 ~ 0.09 (0.0011 ~ 0.0035)	0.13 (0.0051)

- (4) Clearance between rotor shaft and side cover
Measure the rotor shaft outer diameter and the side cover hole diameter, and replace the entire assembly if the clearance exceeds the limit.

	mm (in.)	
	Standard	Wear limit
Rotor shaft and body clearance	0.013 ~ 0.043 (0.0005 ~ 0.0016)	0.2 (0.0078)

- (5) Check for looseness of driver gear/rotor shaft fitting, and replace the entire assembly if loose or wobbly.
- (6) Push the oil pressure regulating valve piston from the oil hole side, and replace the assembly if the piston does not return due to spring breakage, etc.
- (7) Make sure that the rotor shaft rotates smoothly and easily when the drive gear is rotated.

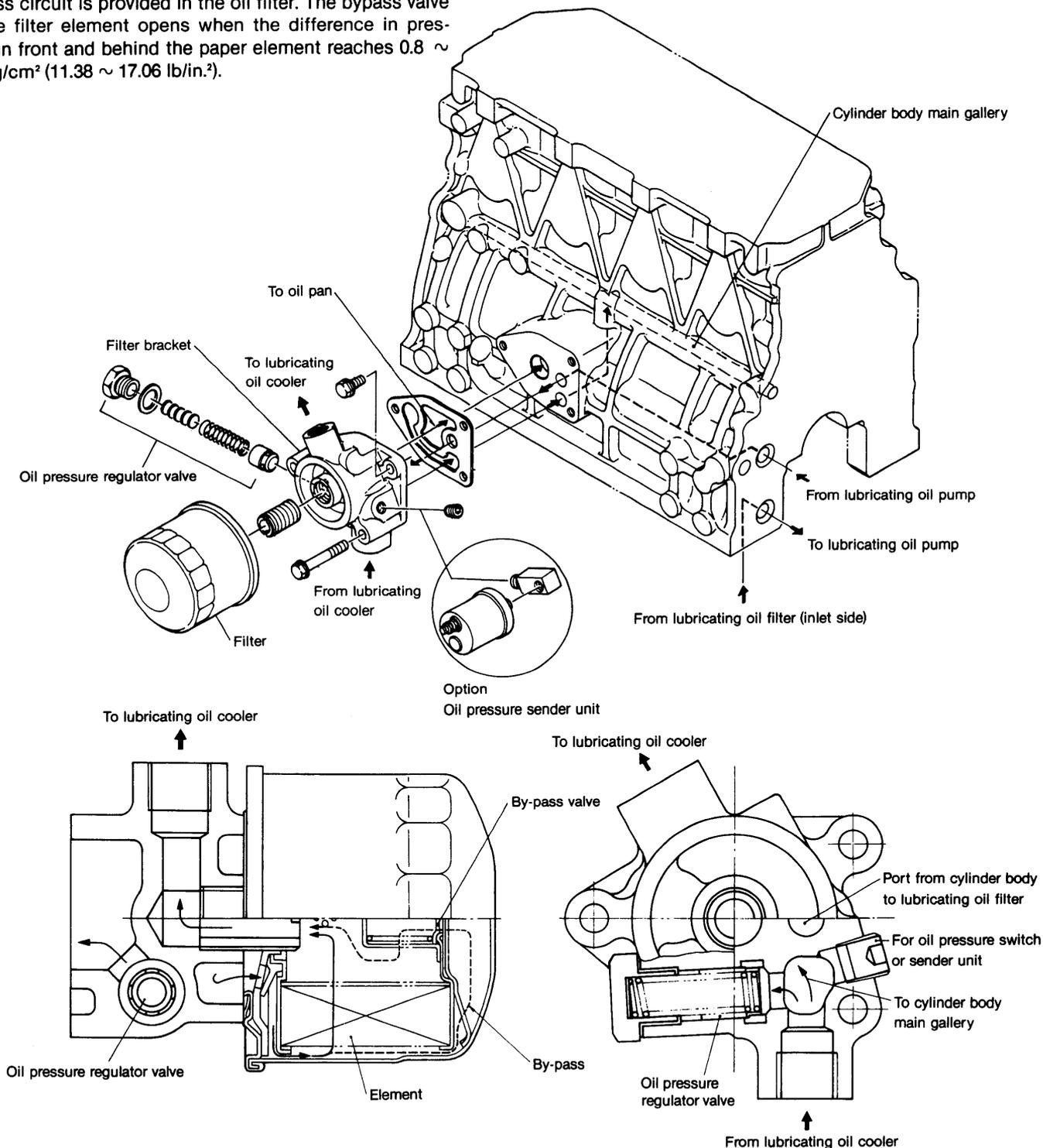
Turning torque	less than 1.5 kg-cm (0.108 ft-lb)
----------------	-----------------------------------

3. Lube Oil Filter

3-1 Lube oil filter construction

The lube oil filter is a full-flow paper element type, mounted to the side of the cylinder body with the filter bracket. It is an easy to remove cartridge type filter.

To prevent seizure in the event of the filter clogging up, a bypass circuit is provided in the oil filter. The bypass valve in the filter element opens when the difference in pressure in front and behind the paper element reaches $0.8 \sim 1.2 \text{ kg/cm}^2$ ($11.38 \sim 17.06 \text{ lb/in.}^2$).



Type	Full flow, paper element
Filtration area	0.10m ² (155 in. ²)
Discharge volume	30 ℓ/min (1830 in. ³ /min)
Pressure loss	0.3 ~ 0.5 kg/cm ² (4.26 ~ 7.11 lb/in. ²)
By-pass valve regulating pressure	0.8 ~ 1.2 kg/cm ² (11.37 ~ 17.06 lb/in. ²)

3-2 Lube oil filter replacement

(1) Period

The paper element will get clogged up with dirt after long hours of usage, and eventually unfiltered oil will be fed to the engine through the bypass circuit. Replace the filter according to the following standard, as the dirt in unfiltered oil will of course have a detrimental affect on the engine.

Oil filter replacement period	Every 300 hours of engine operation
-------------------------------	-------------------------------------

(2) Replacement

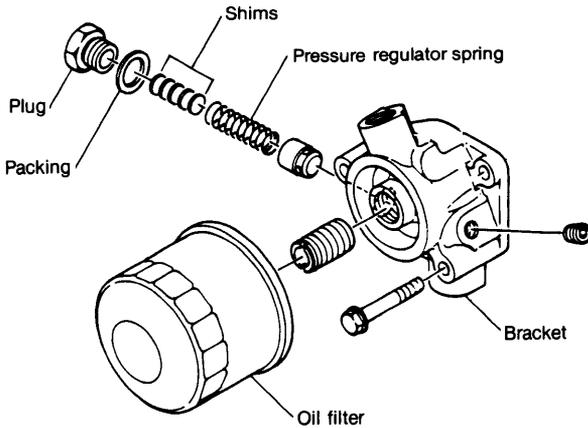
- 1) Remove the lube oil filter with the special tool.
- 2) Clean the filter mounting surface on the filter bracket and mounting screws.
- 3) Coat the filter rubber packing with lube oil.
- 4) Screw in the filter until the rubber packing comes in contact with the bracket mounting surface, and then 2 ~ 3 turns more.
- 5) Run the engine after mounting the filter, and make sure that there is no oil leakage.

4. Oil Pressure Control Valve

4-1 Oil pressure control valve construction

The oil pressure control valve built into the oil filter bracket controls the oil pressure from the time the lube oil leaves the filter and is cooled in the lube oil cooler until just before it enters the cylinder body main gallery.

When the pressure of lube oil entering the cylinder body main gallery exceeds the setting, the control valve piston opens the bypass hole and lube oil flows back into the oil pan.



Regulating pressure	3.5 ~ 4.5 kg/cm ² (49.78 ~ 64.00 lb/in. ²)
---------------------	--

4-2 Oil pressure control valve replacement

The control valve has been adjusted and assembled at the factory, so it should not be disassembled without good reason.

If the oil pressure control valve is disassembled due to spring trouble, etc., mount a pressure gauge on the oil pressure sender unit mounting washer, and adjust the pressure with adjustment shims until it is at the specified value.

Shim thickness	Shim part No.
0.2mm (0.0078 in.)	121850-35210
0.5mm (0.0196 in.)	121850-35220
1.0mm (0.0393 in.)	121850-35230

4-3 Vibration preventing damper

The filter bracket hydraulic (oil pressure) sender unit mount is constructed so that a vibration preventing damper can be mounted on it.

The hydraulic sender unit is mounted on the damper.

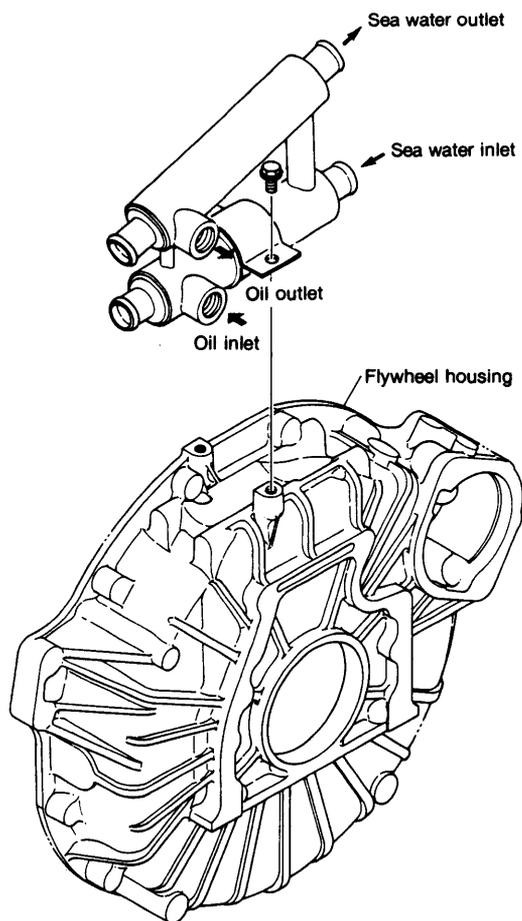
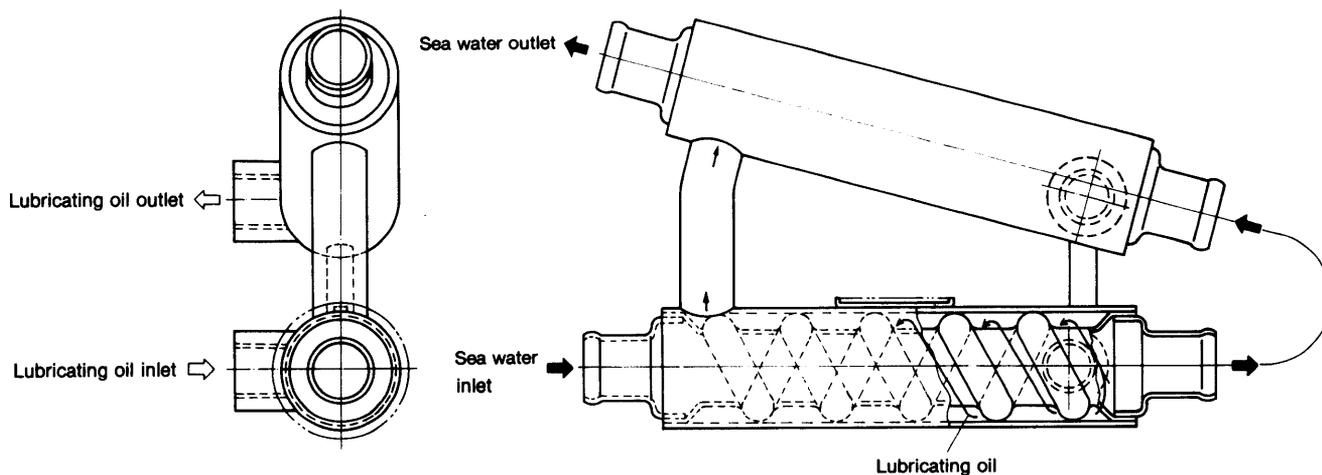
5. Lube Oil Cooler [Applicable Engine Model 4JHE & 4JH-TE]

5-1 Lube oil cooler construction

The spiral thread of the inner pipe is in contact with the inner surface of the outer pipe. This forms a spiral passageway.

The lube oil flows through this passageway and is cooled by the cooling water (sea water) flowing through the inner pipe.

There are two such pipes, connected side by side, designed so that the lube oil and sea water flow in the opposite directions.



Cooling area	0.0192m ² (29.76 in. ²)
Cooling water discharge volume	3773 l/hr (230228 in. ³ /h)
Lubricating oil discharge volume	2160 l/hr (131803 in. ³ /h)
Lubricating oil temperature at 40°C room air	Model 4JHE: 110°C or below Model 4JH-TE: 115°C or below

5-2 Inspecting the lube oil cooler

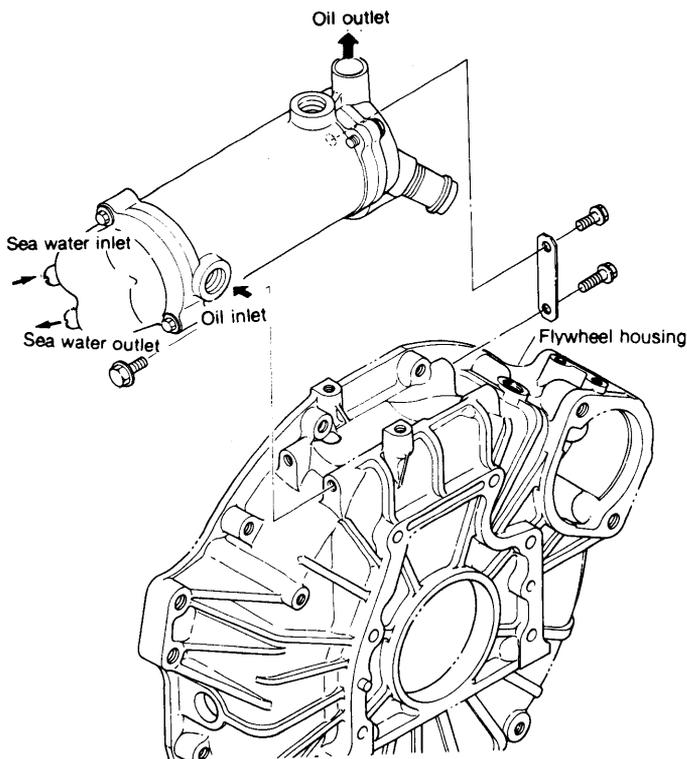
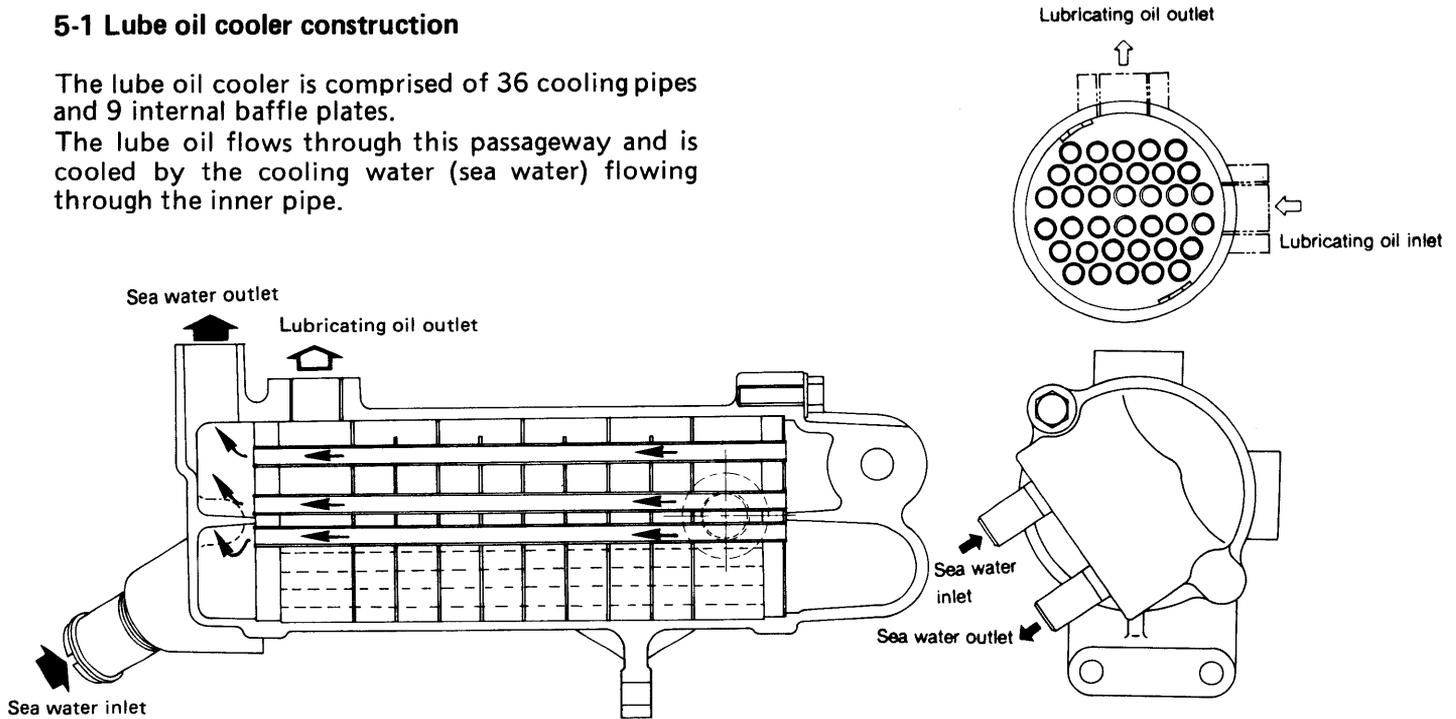
- (1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
- (2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
- (3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace the cooler if there are any leaks.

	Test pressure
Lubricating oil circuit	8 kg/cm ² (113.78 lb/in. ²)
Sea water circuit	4 kg/cm ² (56.89 lb/in. ²)

Lube Oil Cooler [Applicable Engine Model 4JH-HTE & 4JH-DTE]

5-1 Lube oil cooler construction

The lube oil cooler is comprised of 36 cooling pipes and 9 internal baffle plates. The lube oil flows through this passageway and is cooled by the cooling water (sea water) flowing through the inner pipe.



Cooling area	0.165m ² (255.75 in. ²)
Cooling water discharge volume	3500ℓ/hr (213570 in ³ /h)
Lubricating oil discharge volume	2160 ℓ/hr (131803 in. ³ /h)
Lubricating oil temperature at 40°C room temperature	100°C or below

5-2 Inspecting the lube oil cooler

- (1) Clean the inside of the sea water pipes with a wire brush to prevent the build-up of scale.
- (2) If the rubber hose connection or welds are corroded, repair or replace the cooler.
- (3) Apply the following water pressures to the sea water and lube oil lines to check for any leakage. Repair or replace the cooler if there are any leaks.

	Test pressure
Lubricating oil circuit	15kg/cm ² (213.30 lb/in. ²)
Sea water circuit	4 kg/cm ² (56.89 lb/in. ²)

6. Piston Cooling Nozzle

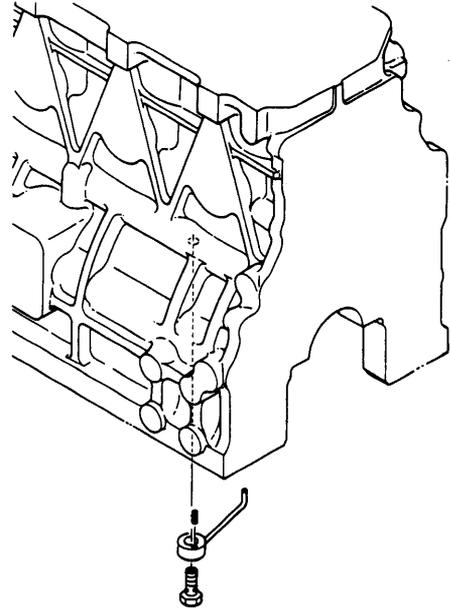
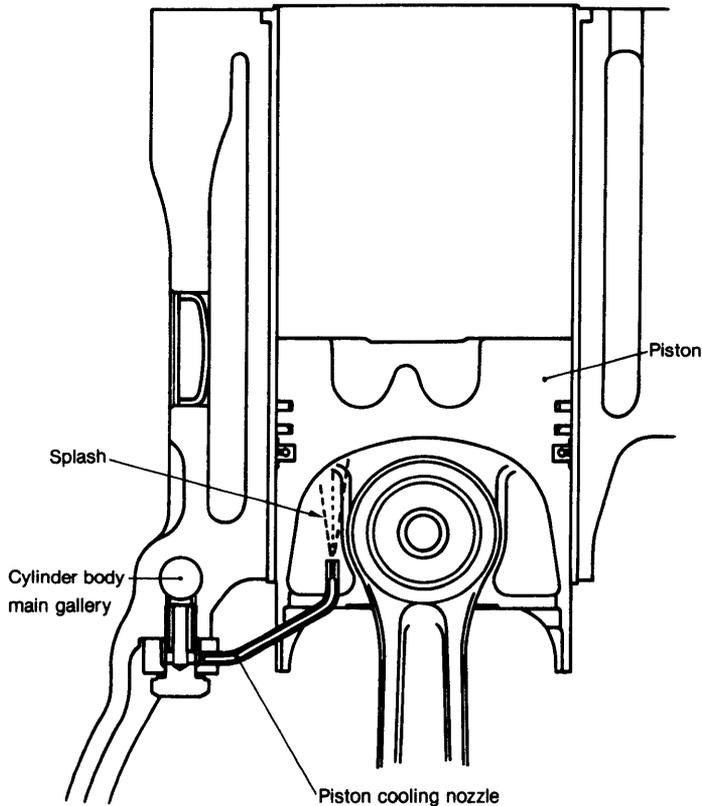
6-1 Piston cooling nozzle construction

A nozzle made from steel piping is mounted on the lower part of cylinder body main gallery. Lube oil from the main gallery is sprayed out in a jet from the steel tip ($\varnothing 1.77\text{mm}$ (0.0697in.)) of this pipe.

This jet spray cools the piston surface when the piston goes down.

6-2 Inspection of piston cooling nozzle

- (1) Check the nozzle tip hole to see if it is clogged up with dirt or other foreign matter, and clean.
- (2) Inspect the pipe mounting to see if it is or may become loose or come off due to vibration, etc., and replace if necessary.

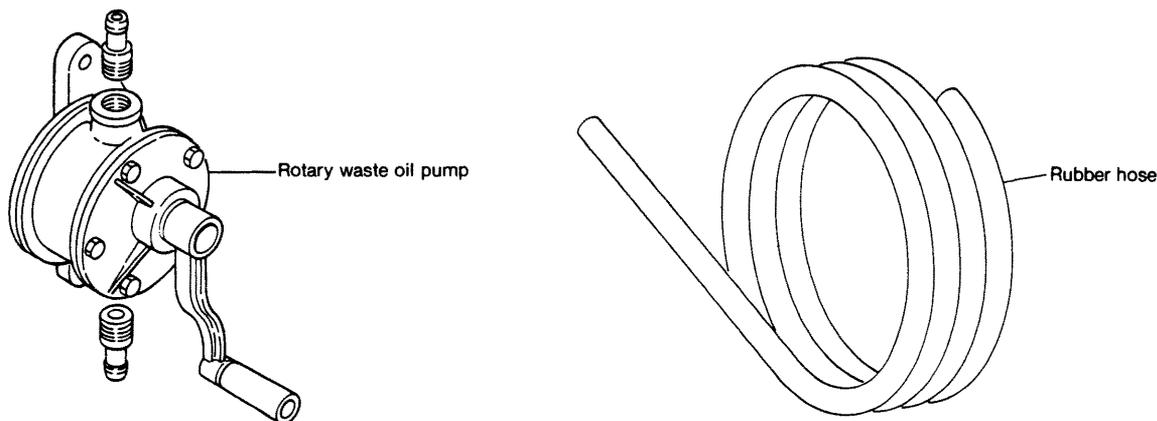


Oil injection volume	1.3 l/min. (79.32 in. ³ /min)
Oil injection pressure	3.5 kg/cm ² (49.78 lb/in. ²)

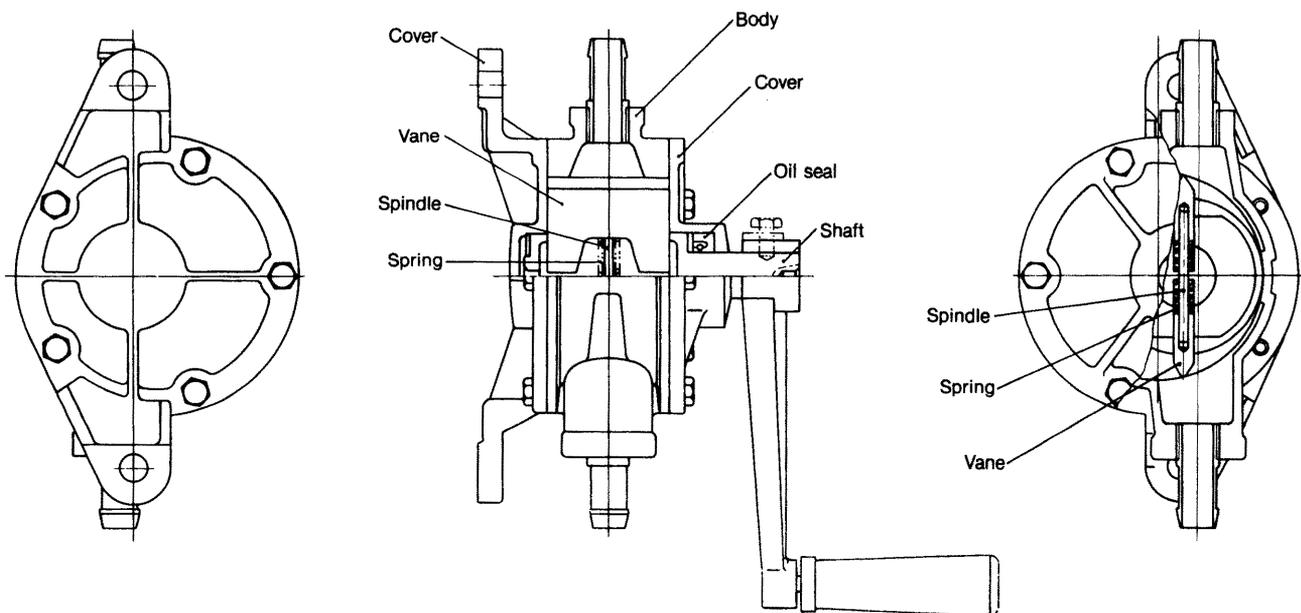
7. Rotary Waste Oil Pump (Optional)

A rotary waste oil pump to pump out waste oil during oil changing is available as an option.

This is a vane type pump. Turning the handle rotates the vanes and pumps out lube oil.



7-1 Construction



Rotary waste oil pump

Delivery capacity of one stroke	0.13ℓ (7.93 in. ³)
Delivery pressure	1.5 kg/cm ² (21.33 lb/in. ²) or below
Suction head	less than 1m (39.37 in.)
Part No.	43600-002311

Rubber hose

Inner dia. × length	∅12 × 1000mm (0.4724 × 39.37 in.)
Part No. of rubber hose	43720-001220

7-2 Inspecting the waste oil pump

- (1) Disassemble the waste oil pump and check for spring breakage or vane damage when there is an extreme drop in discharge volume, and replace if necessary.
- (2) Replace the oil seal if there is excessive oil leakage from the handle shaft.
- (3) Replace the impeller if there is an excessive gap between the impeller and the covers on both sides of casing. This will cause a drop in discharge volume.
- (4) The hose coupling is coated with adhesive and screwed in. It therefore cannot be disassembled.

CHAPTER 6

COOLING WATER SYSTEM

1. Cooling Water System6-1
2. Sea Water Pump6-4
3. Fresh Water Pump6-7
4. Heat Exchanger6-10
5. Pressure Cap and Sub Tank6-12
6. Thermostat6-14
7. Kingston Cock (Optional)6-16
8. Sea Water Filter (Optional)6-17
9. Bilge Pump and Bilge Strainer (Optional)6-18

1. Cooling Water System

The cooling water system is of the indirect sea water cooled, fresh water circulation type. The cylinders, cylinder heads, turbocharger (only 4JH-HTE & 4JH-DTE) and exhaust manifold are cooled with fresh water, and the lube oil cooler air cooler (only 4JH-HTE & 4JH-DTE) and fresh water cooler (heat exchanger) use sea water.

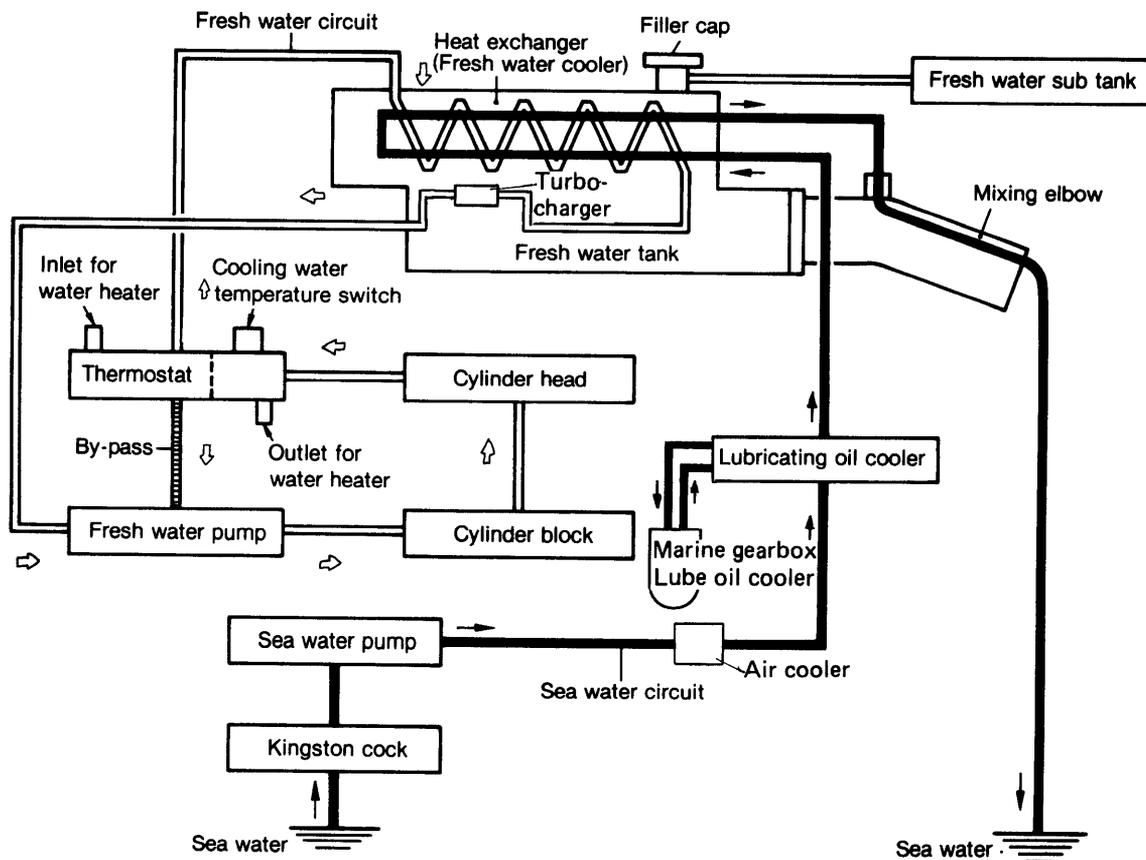
Sea water pumped in from the sea by the sea water pump cools the lube oil in the lube oil cooler and then goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.

Fresh water is pumped by the fresh water pump from the fresh water tank to the cylinder jacket to cool the cylinders, turbocharger and then the cyl-

inder head. The fresh water pump body also serves as a discharge passageway (line) at the cylinder head outlet, and is fitted with a thermostat.

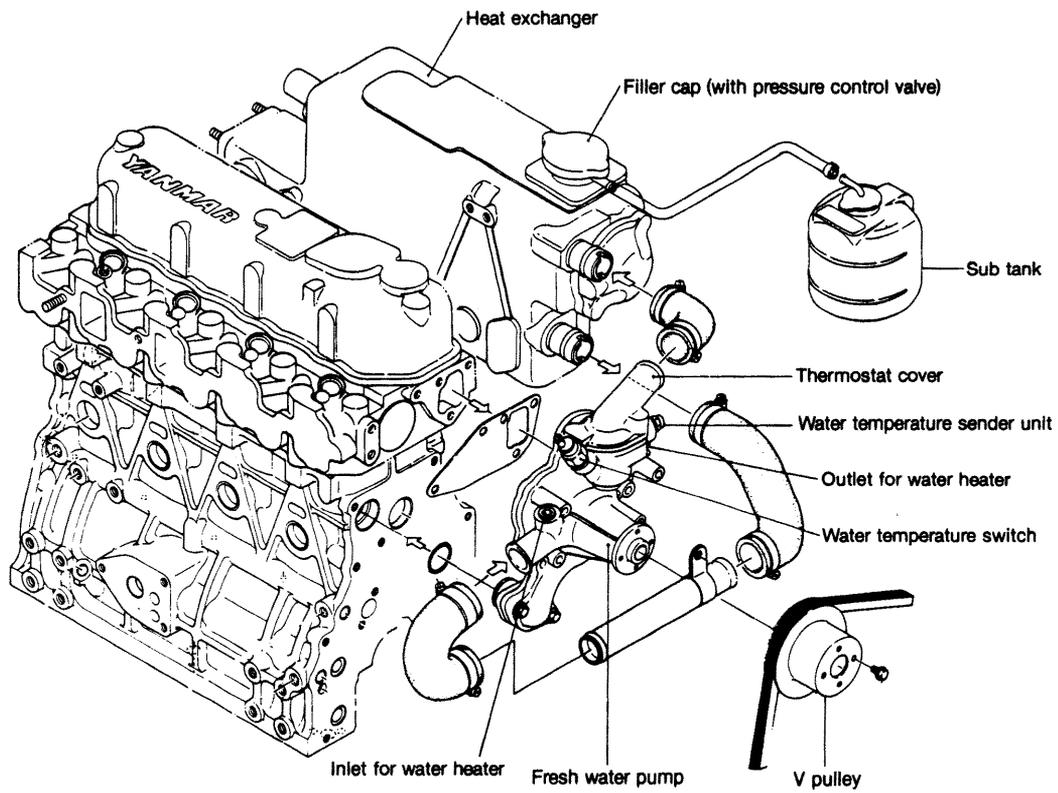
The thermostat is closed when the fresh water temperature is low, immediately after the engine is started and during low load operation, etc. Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine without passing through the heat exchanger.

When the temperature of the fresh water rises, the thermostat opens, fresh water flows to the heat exchanger, and it is then cooled by the sea water in the tubes as it flows through the cooling pipe. The temperature of the fresh water is thus kept within a constant range by the thermostat.

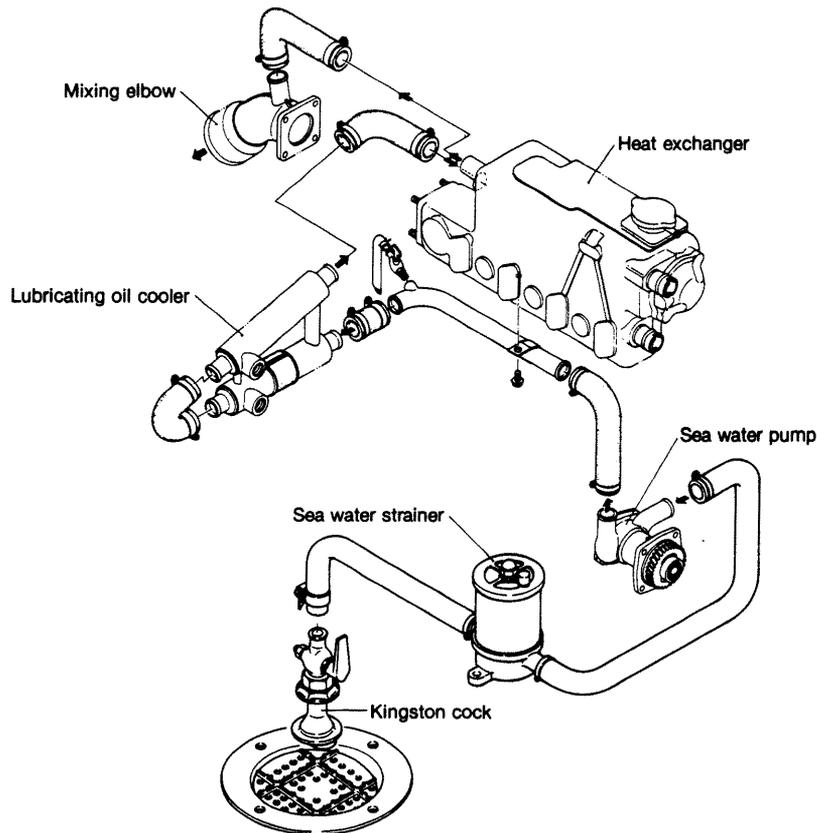


NOTE: Air cooler, marine gear box, lube oil cooler, and water-cooled turbocharger are only for models 4JH-HTE and 4JH-DTE.

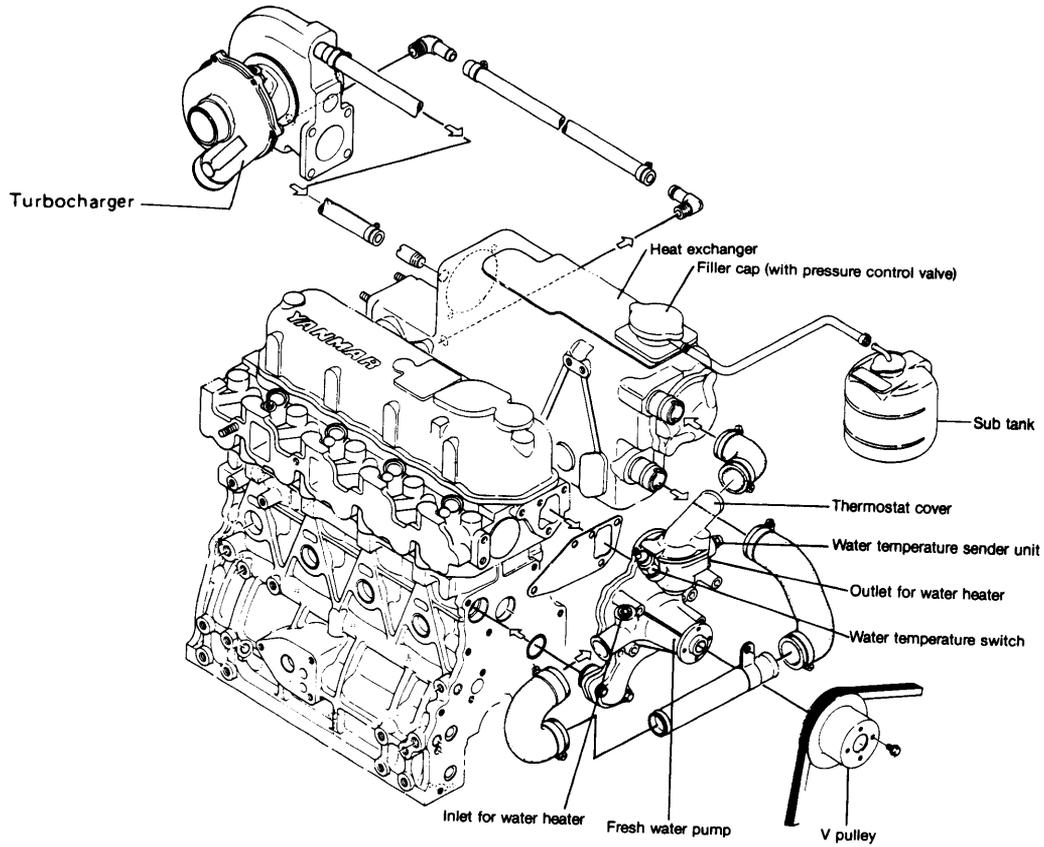
Fresh water line [ENGINE MODEL: 4JHE & 4JH-TE]



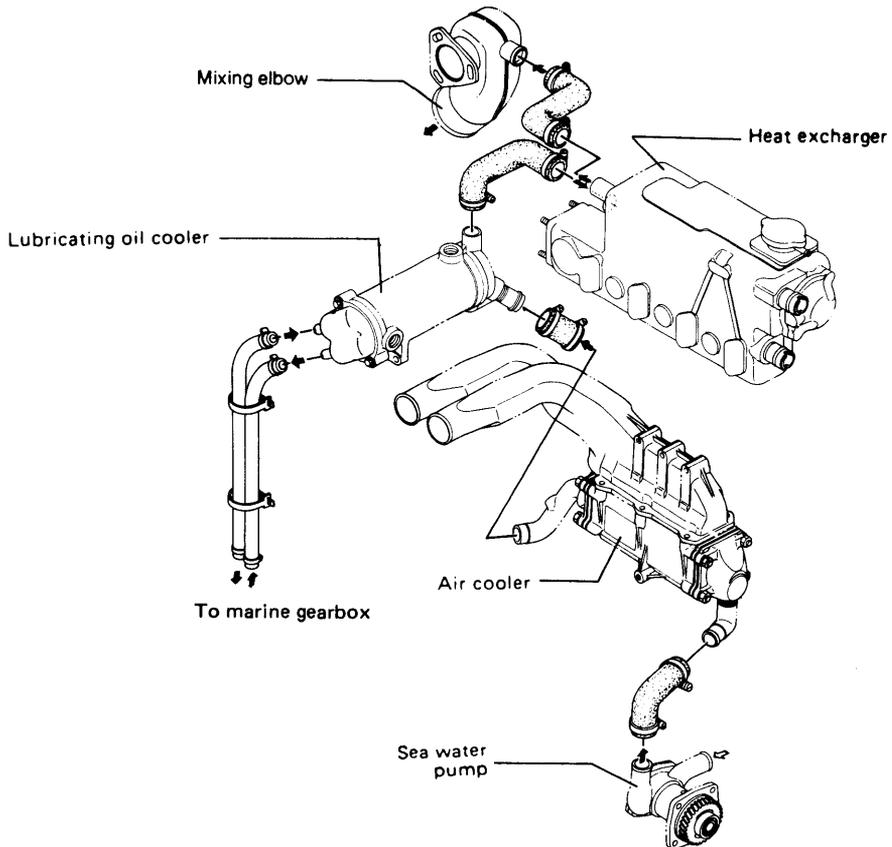
Sea water line [ENGINE MODEL: 4JHE & 4JH-TE]



Fresh water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]



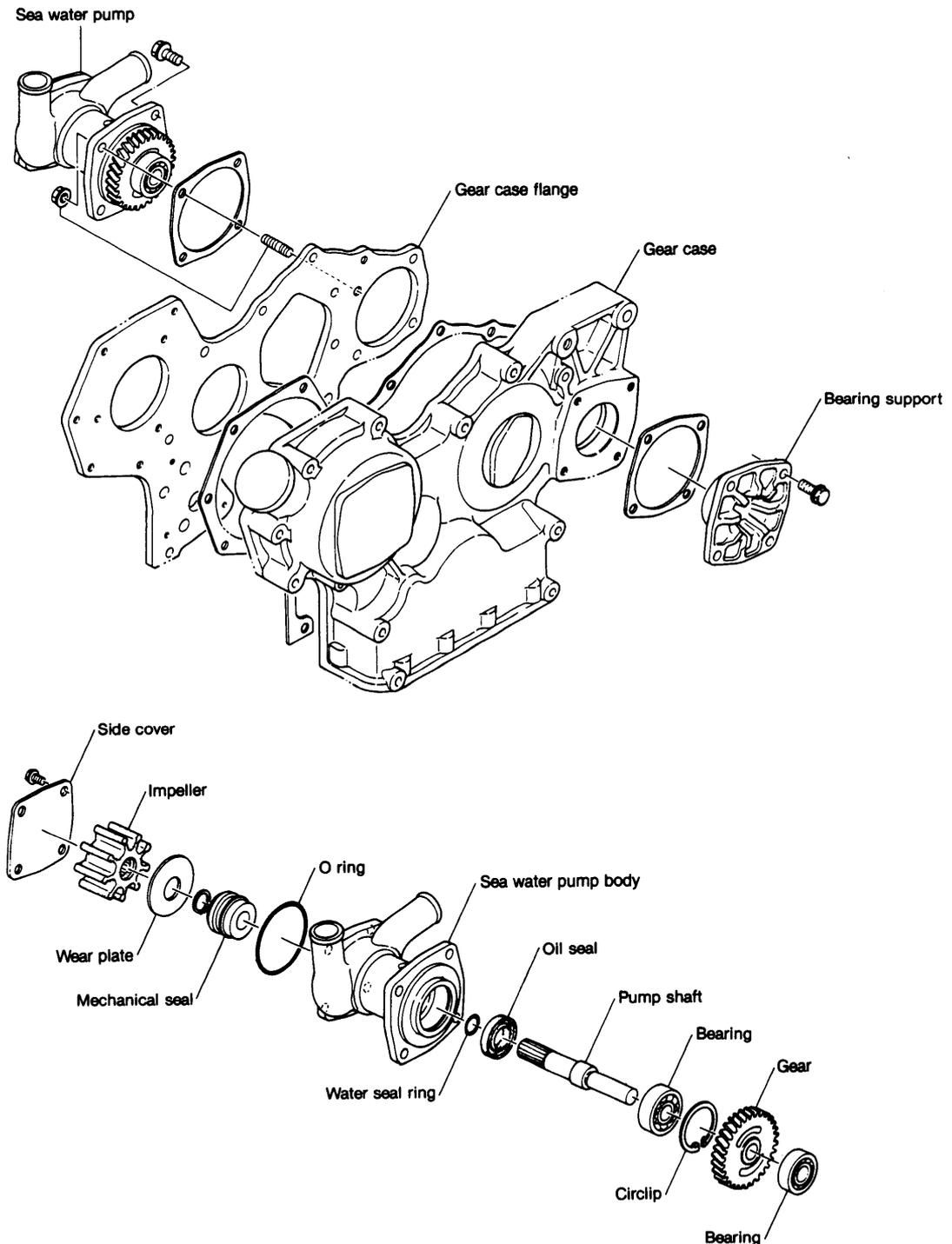
Sea water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]

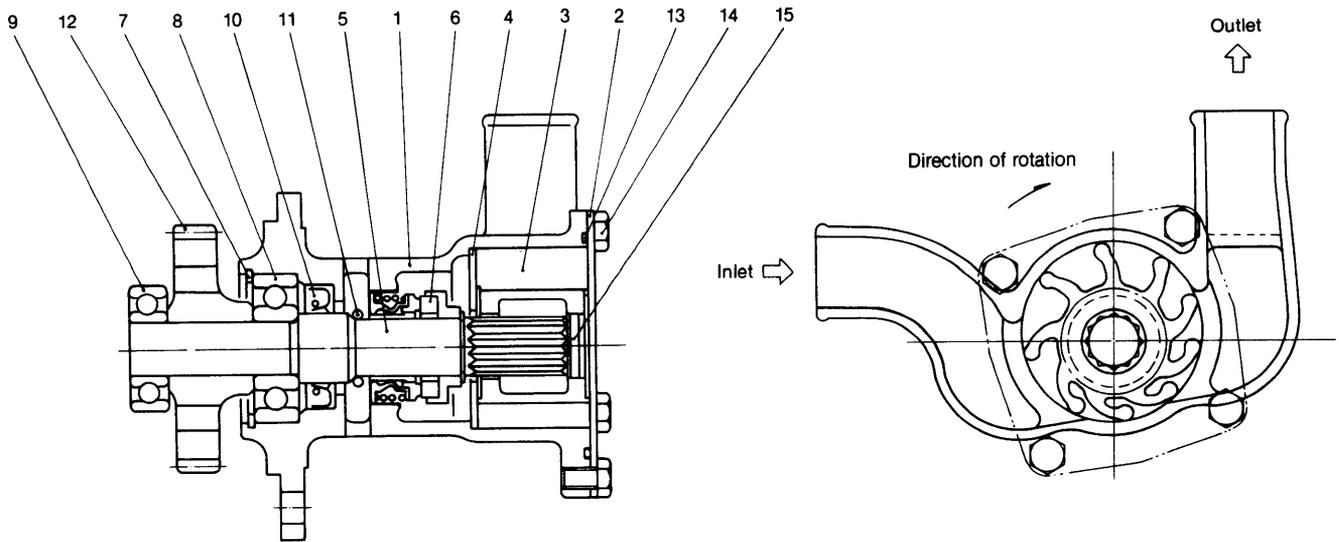


2. Sea Water Pump

2-1 Sea water pump construction and functioning

The sea water pump has a rubber impeller. The sea water pump is mounted to the gear case, and the drive gear on the end of the sea water pump shaft meshes with the camshaft gear to drive the pump.





- | | | |
|------------------------|--------------------|--------------------------|
| 1. Sea water pump body | 6. Mechanical seal | 11. Water seal ring |
| 2. Side cover | 7. Circlip | 12. Gear |
| 3. Impeller (C-type) | 8. Bearing | 13. O ring |
| 4. Wear plate | 9. Bearing | 14. Hexagonal bolt |
| 5. Pump shaft | 10. Oil seal | 15. Impeller blind cover |

2-2 Specifications of sea water pump

Engine speed (max.)	3600 rpm
Gear ratio (crank gear/pump gear)	28/31
Pump speed	3252 rpm
Suction head	0.5m (1.66 ft)
Total head	9.5m (31.16 ft)
Delivery capacity	3250 l/h (198315 in. ³ /h)

2-3 Sea water pump disassembly

- (1) Remove the rubber hose from the sea water pump outlet and then the sea water pump assembly from the gear case.
- (2) Remove the sea water pump cover and take out the O-ring, impeller and wear plate.
- (3) Remove the mechanical seal side stop ring.
- (4) Insert pliers from the drive gear long hole and remove the stop ring that holds the bearings.
- (5) Lightly tap the pump shaft from the impeller side and

- remove the pump shaft, bearings, and drive gear as a set.
- (6) Remove the oil seal and mechanical seal if necessary.

2-4 Sea water pump inspection

- (1) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.

	Standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	31.6 ~ 31.8 (1.2440 ~ 1.2519)	0 ~ 0.3 (0 ~ 0.0118)	0.8 (0.0314)	31.3 (1.2322)
Wear plate thickness	2 (0.0787)			1.8 (0.0708)
Housing width	33.8 ~ 33.9 (1.3307 ~ 1.3346)			—
Side plate thickness	2 (0.0787)			1.8 (0.0708)

- (3) Inspect the mechanical seal and replace if the spring is damaged, or the seal is corroded. Also replace the mechanical seal if there is considerable water leakage during operation.

Cooling water leakage	less than 3 cc/h (0.18 in. ³ /h)
Parts No. of oil seal	129795-42670

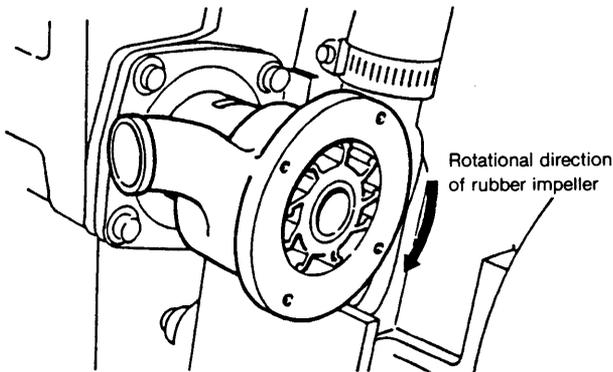
- (4) Make sure the ball bearings rotate smoothly. Replace if there is excessive play.

2-5 Sea water pump reassembly

- (1) When replacing the mechanical seal, coat the No.1101 oil seal and pressure fit. Coat the sliding surface with a good quality silicon oil, taking sufficient care not to cause any scratches.
- (2) When replacing the oil seal, coat with grease and insert.
- (3) Mount the pump shaft, ball bearing and gear assembly to the pump unit and fit the bearing stop ring. Be sure not to forget the water O-ring when doing this.

NOTE: Coat the shaft with grease.

- (4) After inserting the mechanical seal stop ring, mount the wear plate and impeller.



- NOTE: 1. When inserting the impeller in the pump, make sure that the impeller lies in the proper direction.
2. Coat the inside of pump body impeller housing with grease.*

- (5) Mount the O-ring side cover.

NOTE: Replace the O-ring.

3. Fresh Water Pump

3-1 Fresh water pump construction

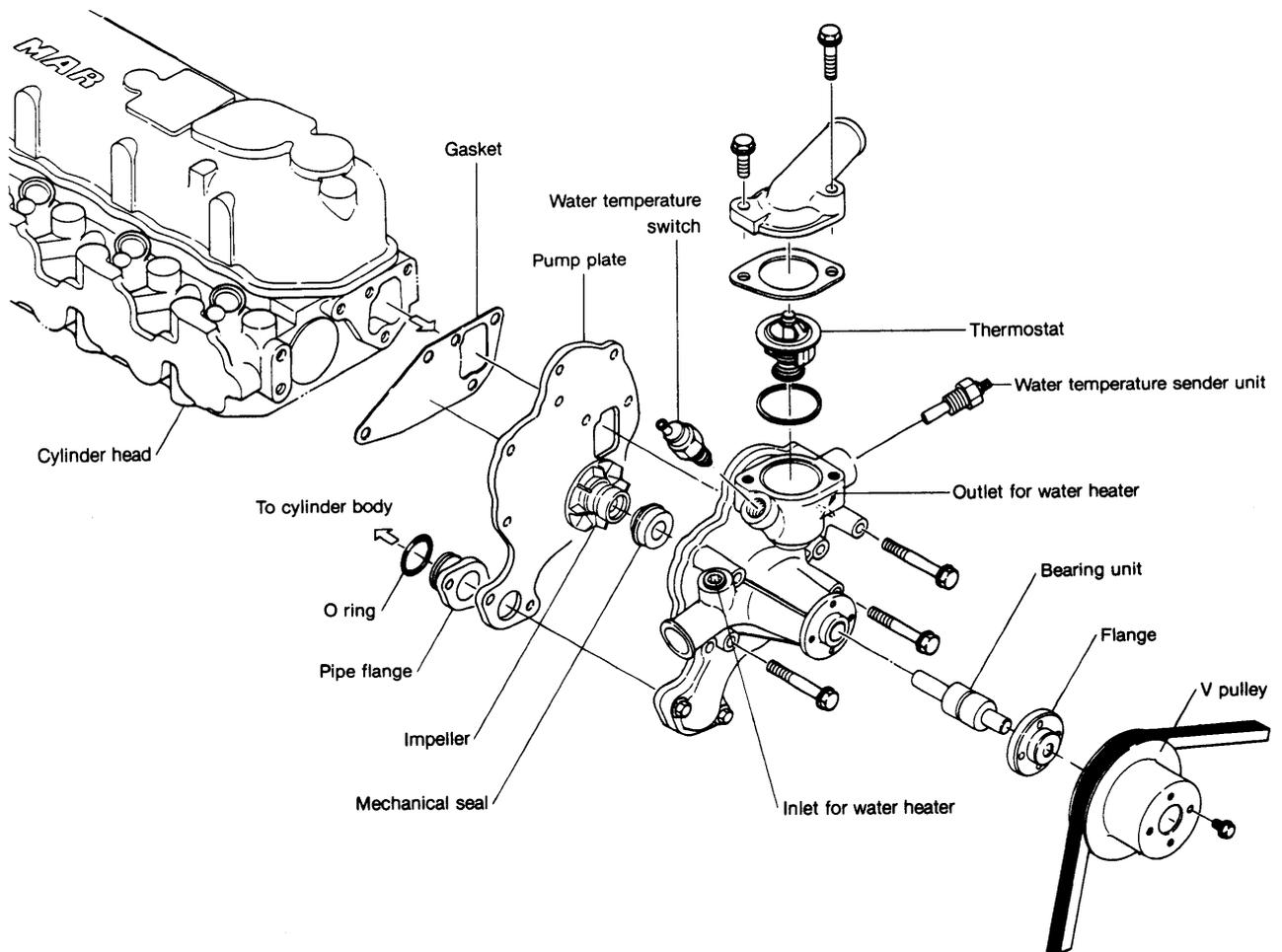
The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinders and cylinder head.

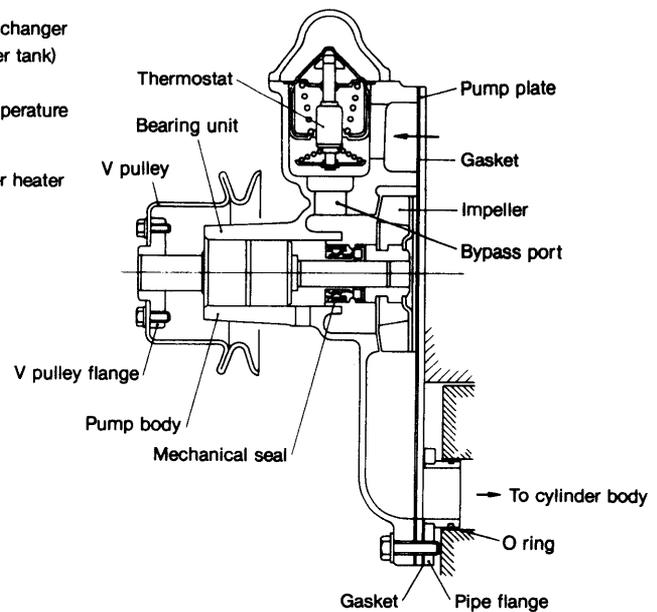
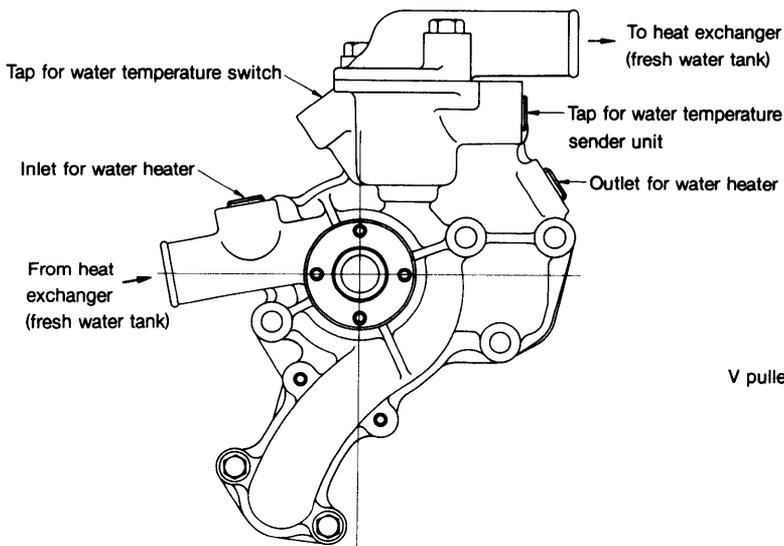
The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V pulley on the end of the pump shaft is driven by a V belt from the crankshaft.

The bearing unit assembled in the pump shaft uses grease

lubricated ball bearings and cannot be disassembled. The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.

As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.





3-2 Specifications of fresh water pump

Crank shaft speed (max.)	3600 rpm
Pulley ratio (crank shaft/pump shaft)	∅134/∅120
Pump shaft speed	4020 rpm
Delivery capacity	86.6 l/min (5284 in. ³ /min)
Total head	4m (13.12 ft)

3-3 Fresh water pump disassembly

- (1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble.
- (2) When removing the fresh water pipe as an assembly from the cylinder and cylinder head, replace the cylinder intake pipe O-ring.
- (3) When the fresh water pump body and cylinder intake flange and/or fresh water pump and pump plate are disassembled, retighten to the specified torque.

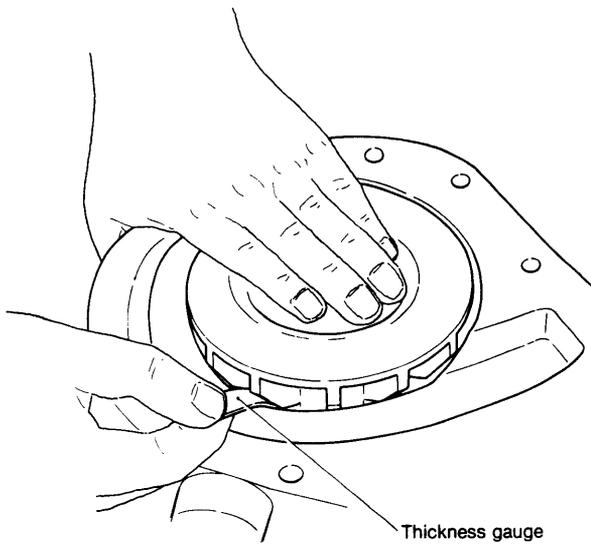
Tightening torque for pump setting bolts	70 ~ 110 kg-cm (5.06 ~ 7.94 ft-lb)
--	---------------------------------------

3-4 Fresh water pump inspection

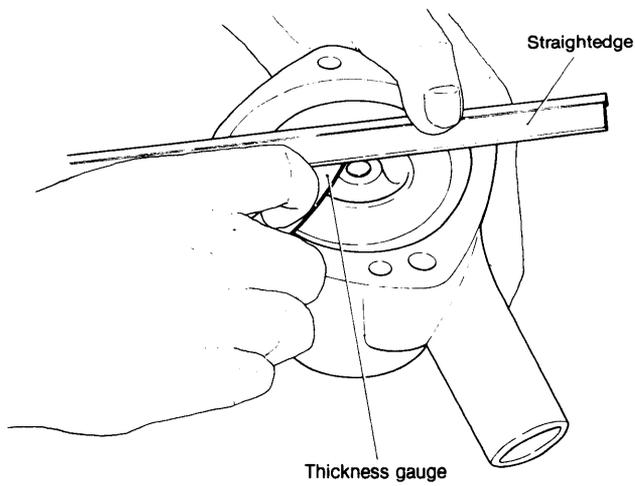
- (1) Bearing unit inspection
Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is heard due to excessive bearing play or contact with other parts, replace the pump as an assembly.
- (2) Impeller inspection
Check the impeller blade, and replace if damaged or corroded, or if the impeller blade is worn due to contact with pump body.

- (3) Check the holes in the cooling water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.
- (4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.
- (5) Inspect the fresh water pump body and flange, clean off scale and rust, and replace if corroded.
- (6) Measure the clearance between the impeller and the pump body, and the impeller and the plate.
Measure the clearance between the impeller and the pump body by pushing the impeller all the way towards the body, and inserting a thickness gauge diagonally between the impeller and the body.
Measure the clearance between the impeller and the plate (pump body bracket) by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

Measuring clearance between impeller and pump body.



Measuring clearance between impeller and pump body bracket.



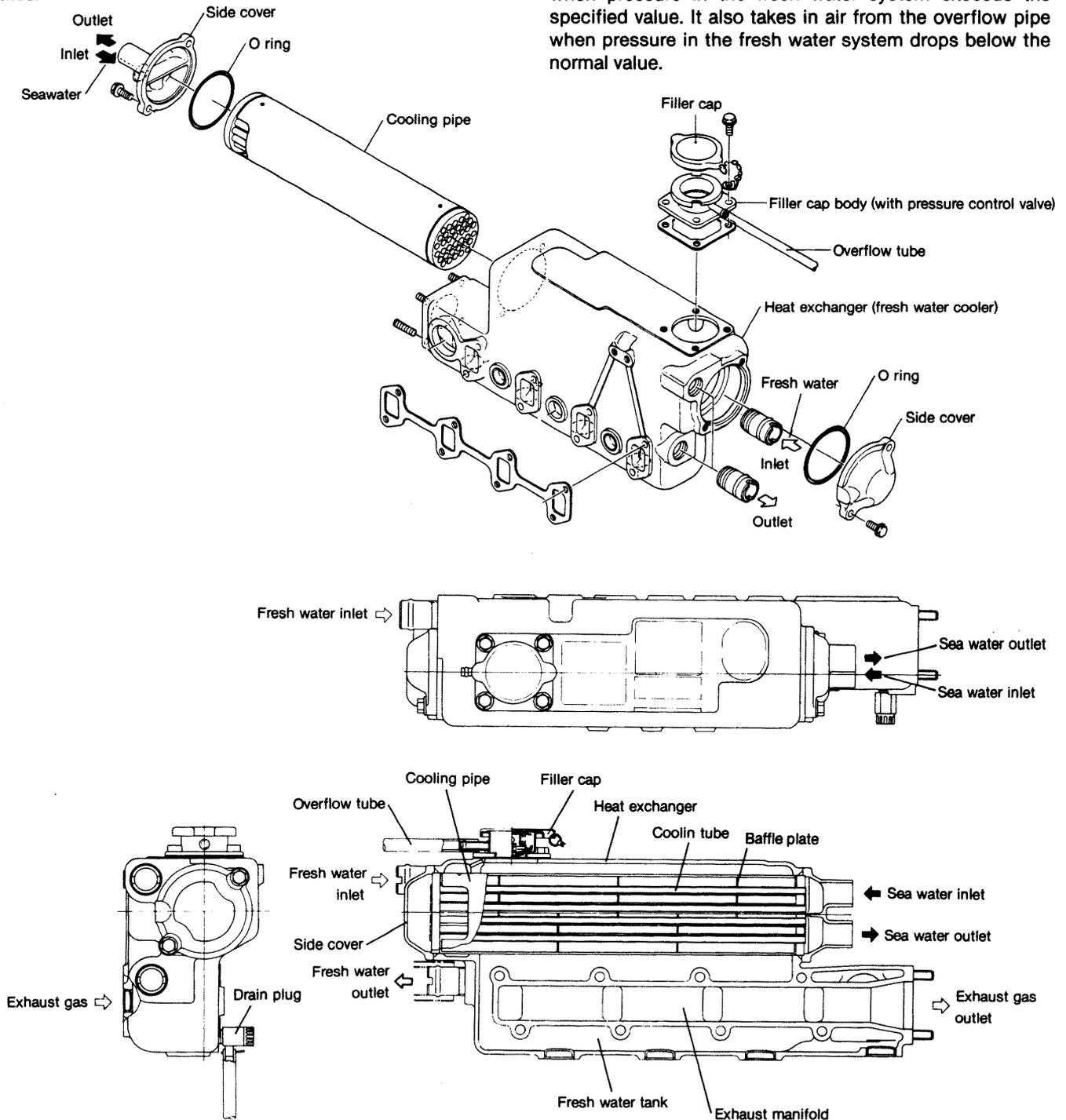
	mm (in.)	
	Standard	Wear limit
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)	1.5 (0.0590)
Clearance between impeller and plate	1.5 (0.0590)	—

4. Heat Exchanger

4-1 Heat exchanger construction

The heat exchanger cools the hot fresh water that has cooled the inside of the engine with sea water. The inside of the heat exchanger cooling pipe consists of 36 small dia. tubes and baffle plates. The sea water flows through the small dia. tubes and the fresh water flows through the maze formed by the baffle plates.

There is a reservoir at the bottom of the cooling pipe which serves as the fresh water tank. There is an exhaust water passageway (line) in the reservoir which forms a water cooled exhaust gas manifold. The filler cap on top of the heat exchanger has a pressure valve, which lets off steam through the overflow pipe when pressure in the fresh water system exceeds the specified value. It also takes in air from the overflow pipe when pressure in the fresh water system drops below the normal value.



4-2 Specifications of heat exchanger

Model of engine		4JHE	4JH-TE	4JH-HTE	4JH-DTE
Output (DIN6270 B rating)	HP/rpm	44/3600	55/3600	66/3600	77/3600
Pipe dia. x pieces	mm(in.)	$\phi 6.4/\phi 8$ (0.2519/0.3149) ^{x 36}			
Radiation area	m ² (in. ²)	0.298 (461.9)			
Radiation area/HP	m ² /HP(in. ² /HP)	0.00677(10.493)	0.00542(8.401)	0.00452(7.006)	0.00387(6.000)
Fresh water discharged volume	ℓ/hr (in. ³ /hr)	5562 (339393)			
Sea water discharged volume	ℓ/hr (in. ³ /hr)	3773 (230228)			3200(195264)
Fresh water flow speed in cooling pipe	m/s (ft/s)	1.74 (5.71)			1.54 (5.05)
Sea water flow speed in cooling tube	m/s (ft/s)	1.81 (5.94)			
Fresh water capacity	ℓ (in. ³)	6.5 (396.6)			

4-3 Disassembly and reassembly of the heat exchanger

(1) Remove the covers on both sides and take out the cooling pipe and O-ring(s).

NOTE: Replace the O-ring(s) when you have removed the cooling pipe.

(2) Remove the filler assembly.

4-4 Heat exchanger inspection

(1) Cooling pipe inspection

1) Inspect the inside of the tubes for rust or scale build-up from sea water, and clean with a wire brush if necessary.

NOTE: Disassemble and wash when the cooling water temperature reaches 85°C.

2) Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.

3) Check tubes and replace if leaking.

4) Clean any scale or rust off the outside of the tubes.

(2) Heat exchanger body inspection

1) Check heat exchanger body and side cover for dirt and corrosion. Replace if excessively corroded, or cracked.

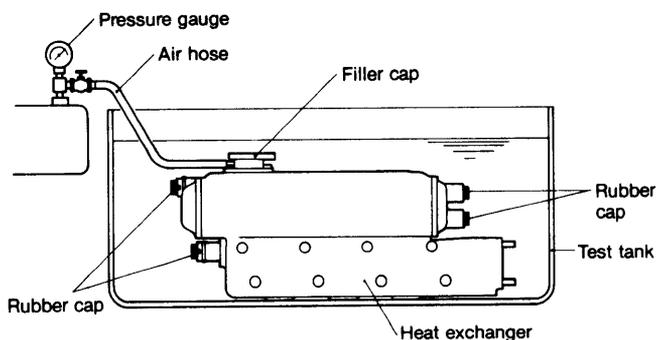
2) Inspect sea water and fresh water inlets and outlets, retighten any joints as necessary and clean the insides of the pipes.

3) Check the exhaust gas intake flange and line, and replace if corroded or cracked.

(3) Heat exchanger body water leakage test

1) Compressed air/water tank test

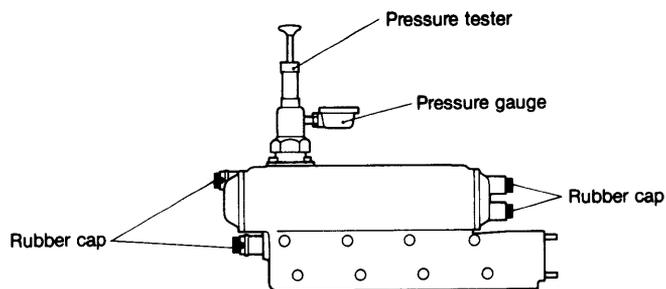
Fit rubber covers on the fresh water and sea water inlets and outlets. Place the heat exchanger in a water tank, feed in compressed air from the overflow pipe and check for any (water) leakage, (air bubbles).



Test pressure	2 kg/cm ² (28.44 lb/in. ²)
---------------	---

2) Use of the tester

Fit the fresh and sea water inlets and outlets with rubber covers and fill the fresh water tank with fresh water. Fit a pressure cap tester in place of the pressure cap, operate the pump for one minute and set the pressure at 1.5kg/cm² (21.33lb/in.²). If there are any leaks the pressure will not rise. If there are no leaks the pressure will not fall.



5. Pressure Cap and Sub Tank

5-1 Pressure cap construction

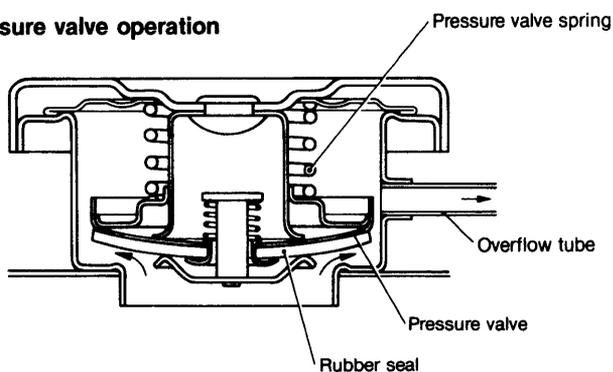
The pressure cap mounted on the fresh water filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cam by placing it on the rocking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.

5-2 Pressure cap pressure control

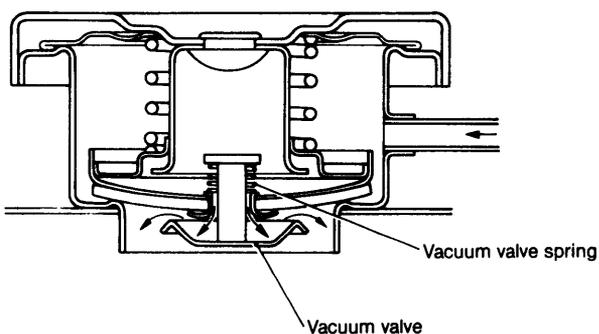
The pressure valve and vacuum seal both seal the valve seat when the pressure in the fresh water system is within the specified value of 0.9kg/cm² (12.80lb/in.²). This seals the fresh water system.

When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe. When the fresh water is cooled and the pressure within the fresh water system drops below the normal value, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

Pressure valve operation



Vacuum valve operation



The sub tank, (which will be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

Action of pressure control valve

Pressure valve	Open at 0.9 kg/cm ² G (12.80 lb/in. ²)
Vacuum valve	Open at 0.05 kg/cm ² G (0.71 lb/in. ²) or below

5-3 Pressure cap inspection

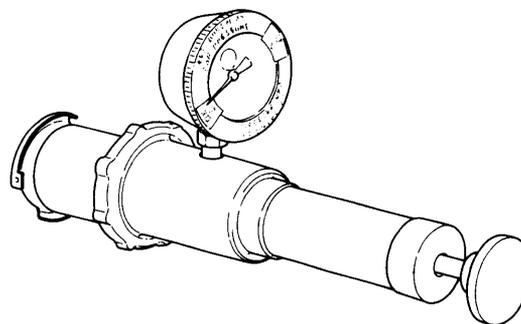
Precautions

Do not open the pressure cap while the engine is running or right after stopping because high temperature steam will be blown out. Remove the cap only after the water has had a chance to cool down.

- (1) Remove scale and rust, check the seat and seat valve, etc. for scratches or wear, and the spring for corrosion or settling. Replace if necessary.

NOTE: Clean the pressure cap with fresh water as it will not close completely if it is dirty.

- (2) Fit the adapter on the tester to the pressure cap. Pump until the pressure gauge is within the specified pressure range (0.75 ~ 1.05kg/cm² (10.67 ~ 14.91lb/in.²)) and note the gauge reading. The cap is normal if the pressure holds for six seconds. If the pressure does not rise, or drops immediately, inspect the cap and repair or replace as necessary.



Parts No. of cap tester

120445-44600

5-4 Function of the sub tank

The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds 0.9kg/cm² (12.80lb/in.²).

This consumes water. The sub tank maintains the water level by preventing this discharge of water.

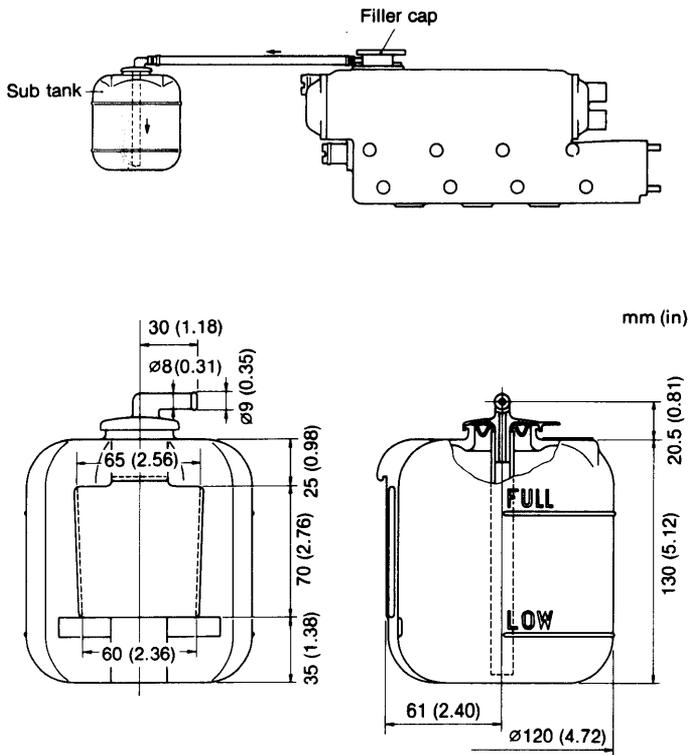
The steam discharged into the sub tank condenses into water, and the water level in the sub tank rises.

When the pressure in the fresh water system drops below the normal value, the water in the sub tank is sucked back into the fresh water tank to raise the water back to its original level.

The sub tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.

5-7 Precautions on usage of the sub tank

- (1) Check the sub tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.
- (2) Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged up.

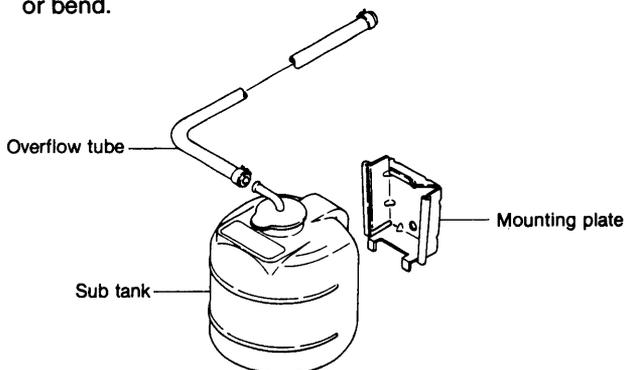


5-5 Specifications of sub tank

Subtank capacity	Overall capacity	1.25l (76.27 in. ³)
	Full-scale position	0.8l (48.81 in. ³)
	Low-scale position	0.2l (12.20 in. ³)
Part No. of subtank	120445-44530	

5-6 Mounting the sub tank

- (1) The sub tank is mounted at approximately the same height as the heat exchanger (fresh water tank). (allowable difference in height: 300mm (11.8110in.) or less)
- (2) The overflow pipe should be less than 1000mm (39.3701in.) long, and mounted so that it does not sag or bend.



NOTE: Make sure that the overflow pipe of the sub tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the water is being cooled.

6. Thermostat

6-1 Functioning of thermostat

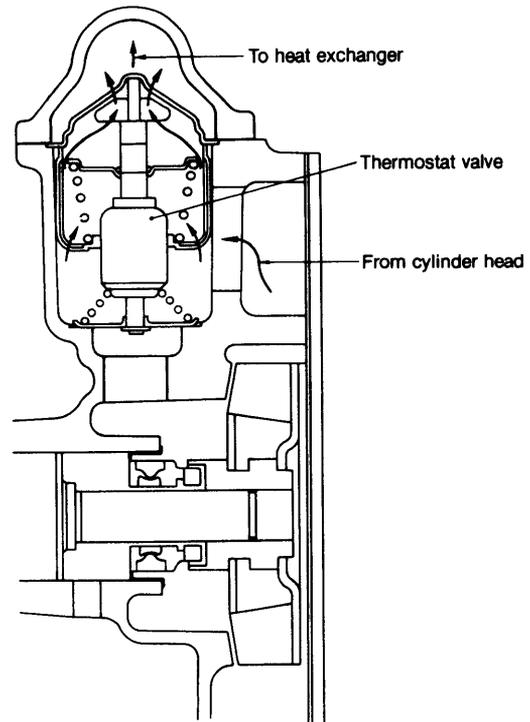
The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.

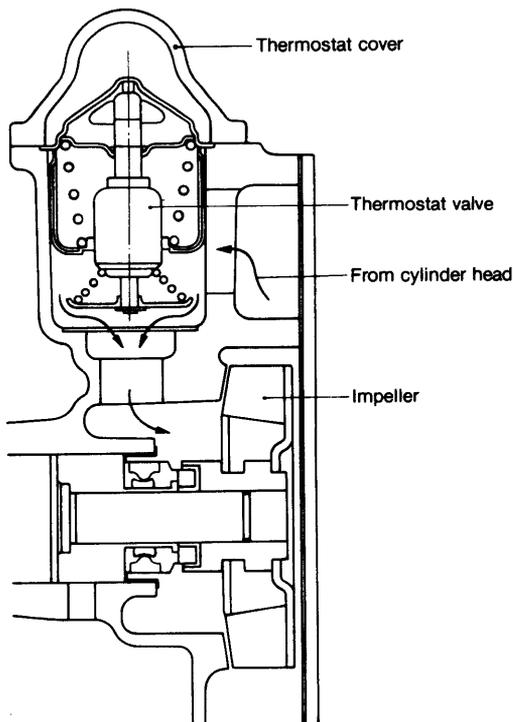
When the fresh water temperature is low (75.0 ~ 78.0°C or less), the thermostat is closed, and fresh water goes from the bypass line to the fresh water pump intake and circulates in the engine.

When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by sea water, the other portion going from the bypass line to the fresh water pump intake.

The bypass line is closed off as the thermostat valve opens, and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4mm (0.1575in.)), sending all of the water to the heat exchanger.



When valve is opened (by-pass passage is closed)



When valve is closed (by-pass passage is opened)

6-2 Thermostat construction

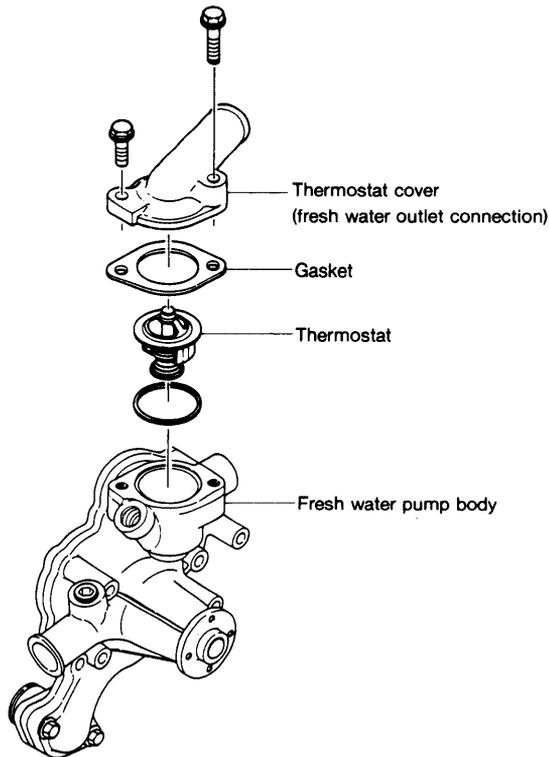
The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber. When the temperature of the cooling water rises, the wax melts and increases in volume. This expansion and contraction is used to open and close the valve.

6-3 Characteristics of thermostat

Opening temperature	75 ~ 78°C (167 ~ 174°F)
Full open temperature	90° (194°F)
Valve lift at full open	8mm (0.3149 in.)
By-pass valve lift	3.7mm (0.1456 in.)
By-pass valve close temperature	81.5°C (178°F)

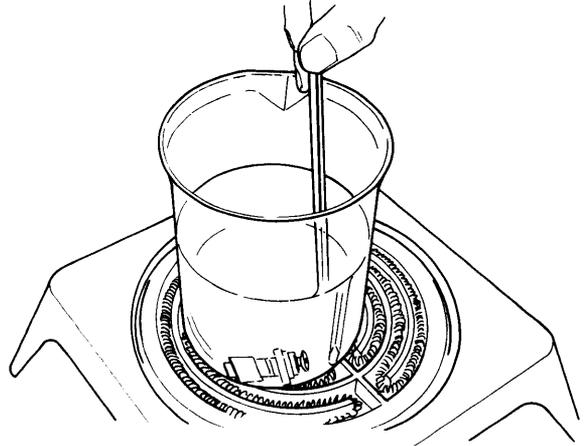
6-4 Thermostat inspection

Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.



6-5 Testing the thermostat

- (1) Put the thermostat in a beaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75 ~ 78°C, and opens 8mm (0.3150in.) or more at 90°C. Replace the thermostat if it is not functioning normally.
- (2) Normally, the thermostat should be inspected every 500 hours of operation, but, it should be inspected before this if the cooling temperature rises abnormally or white smoke is emitted for a long time after engine starting.
- (3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).



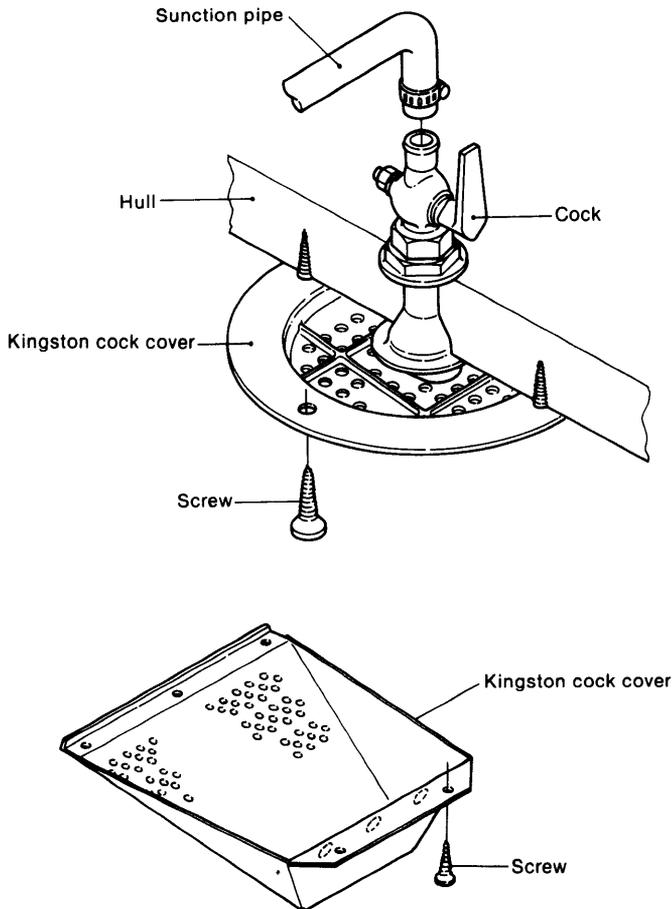
Part No. of thermostat	129470-49800
------------------------	--------------

7. Kingston Cock (Optional)

7-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock serves to filter the water so that mud, sand, and other foreign matter in the water does not enter the water pump.

Numerous holes are drilled in the water side of the Kingston cock, and a scoop strainer is installed to prevent the sucking in of vinyl, etc.



7-2 Handling precautions

Caution the user to always close the Kingston cock after each day of use and to confirm that it is open before beginning operation.

If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.

On the other hand, if the engine is operated with the Kingston cock closed, cooling water will not be able to get in, resulting in engine and pump trouble.

7-3 Inspection

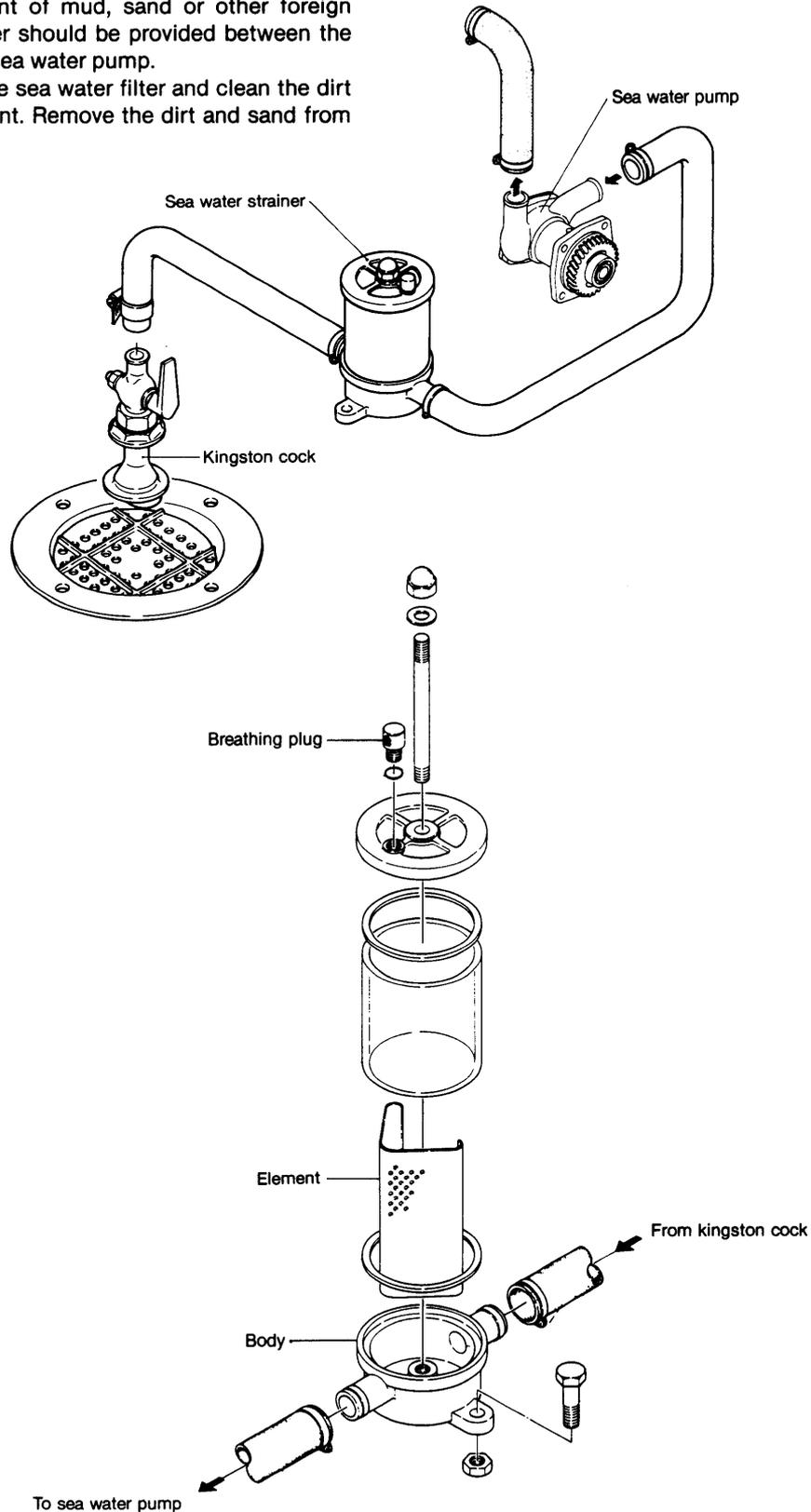
When the cooling water volume has dropped and the pump is normal, remove the vessel from the water and check for clogging of the Kingston cock.

If water leaks from the cock, disassemble the cock and inspect it for wear, and repair or replace it.

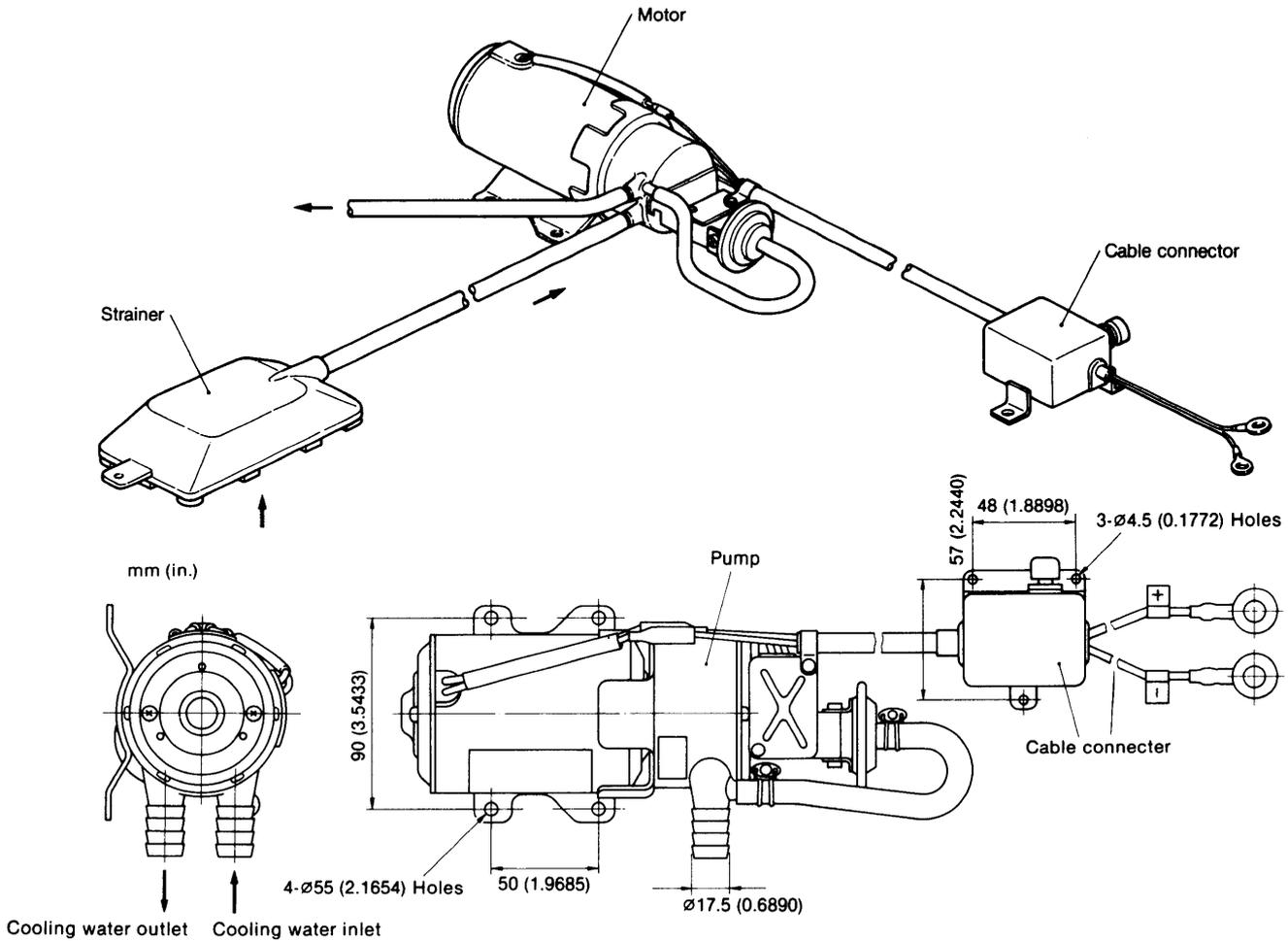
8. Sea Water Filter (Optional)

When operating the engine in areas where the sea water contains a large amount of mud, sand or other foreign matter, a sea water filter should be provided between the kingston cock and the sea water pump.

Occasionally inspect the sea water filter and clean the dirt and scale off the element. Remove the dirt and sand from the bottom of the filter.



9. Bilge Pump and Bilge Strainer (Optional)



9-1 Bilge pump

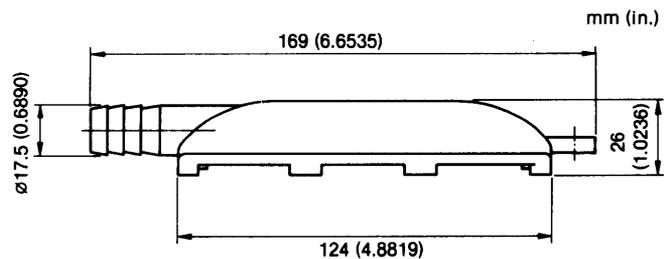
9-1.1 Specifications

Code No.	120345-46010 (with strainer)
Model No.	BP190-10
Rating	60 min.
Voltage	12V
Output	90W
Weight	3.0kg (6.6 lb)

9-1.2 Performance of pump (in pure water)

Suction performance	Voltage	11.5V
	Max. suction lift	1.2m (3.94 ft)
	Suction time	4 sec.
Pumping lift performance	Voltage	11.5V
	Current	8A
	Total lift	1m (3.28 ft)
	Lifting volume of water	17 l/min

9-2 Bilge strainer



CHAPTER 7

REDUCTION AND REVERSING GEAR

Marine gear model KBW 20 and 21

1. Construction	7-1
2. Installation	7-6
3. Operation and Maintenance	7-7
4. Inspection and Servicing	7-8
5. Disassembly	7-13
6. Reassembly	7-17
7. Special Tools	7-23

Marine gear model KM4A, (Angle drive)

1. Construction	7-24
2. Shifting Device	7-28
3. Inspection and Servicing	7-33
4. Special Tools	7-43
5. Disassembly	7-45
6. Reassembly	7-53

1. Construction

1-1 Construction

The Kanzaki-Carl Hurth KBW20 and KBW21 reduction reversing gears were developed jointly by Kanzaki Precision Machine Co., Ltd., a subsidiary of Yanmar and one of Japan's leading gear manufacturers, and Carl Hurth Co.

The KBW20 and KBW21 consist of a multi-disc clutch and reduction gear housed in a single case. It is small, light, simply constructed and extremely reliable.

*The force required to shift between forward and reverse can be controlled by a cable type remote

control system much smaller and simpler than other types of reduction reversing gears.

*The friction discs are durable sinter plates, and the surface of the steel plates are corrugated in a sine curve shape to ensure positive engagement and disengagement and minimum loss of transmission force.

*Because of the special construction of this gear, the optimum pressure is automatically applied to the clutch plate in direct proportion to the input shaft torque.

1-2 Specifications

Engine model		4JHE			4JH-TE		
Marine gear model		KBW20					
Reduction system		One-stage reduction, helical gear					
Reversing system		Constant mesh gear					
Clutch		Wet type multi-disc, mechanically operated					
Reduction ratio	Forward	2.17	2.62	3.28	2.17	2.62	3.28
	Reverse	3.06			3.06		
Direction of rotation	Input shaft	Counterclockwise as viewed from stern					
	Output shaft	Forward	Clockwise as viewed from stern				
Reverse		Counterclockwise as viewed from stern					
Lubricating oil		DEXRON, ATF					
Lubricating oil capacity		1.2ℓ					

Engine model		4JH-HTE			4JH-DTE		
Marine gear model		KBW21					
Reduction system		One-stage reduction, helical gear					
Reversing system		Constant mesh gear					
Clutch system		Wet type multi-disc, mechanically operated					
Reduction ratio	Forward	2.17	2.62	3.28	2.17	2.62	
	Reverse	3.06			3.06		
Direction of rotation	Input shaft	Counterclockwise as viewed from stern					
	Output shaft	Forward	Clockwise as viewed from stern				
Reverse		Counterclockwise as viewed from stern					
Lubricating oil		DEXRON, ATF					
Lubricating oil capacity		1.2ℓ					
Lube oil cooler		Sea-water cooling					

IMPORTANT:

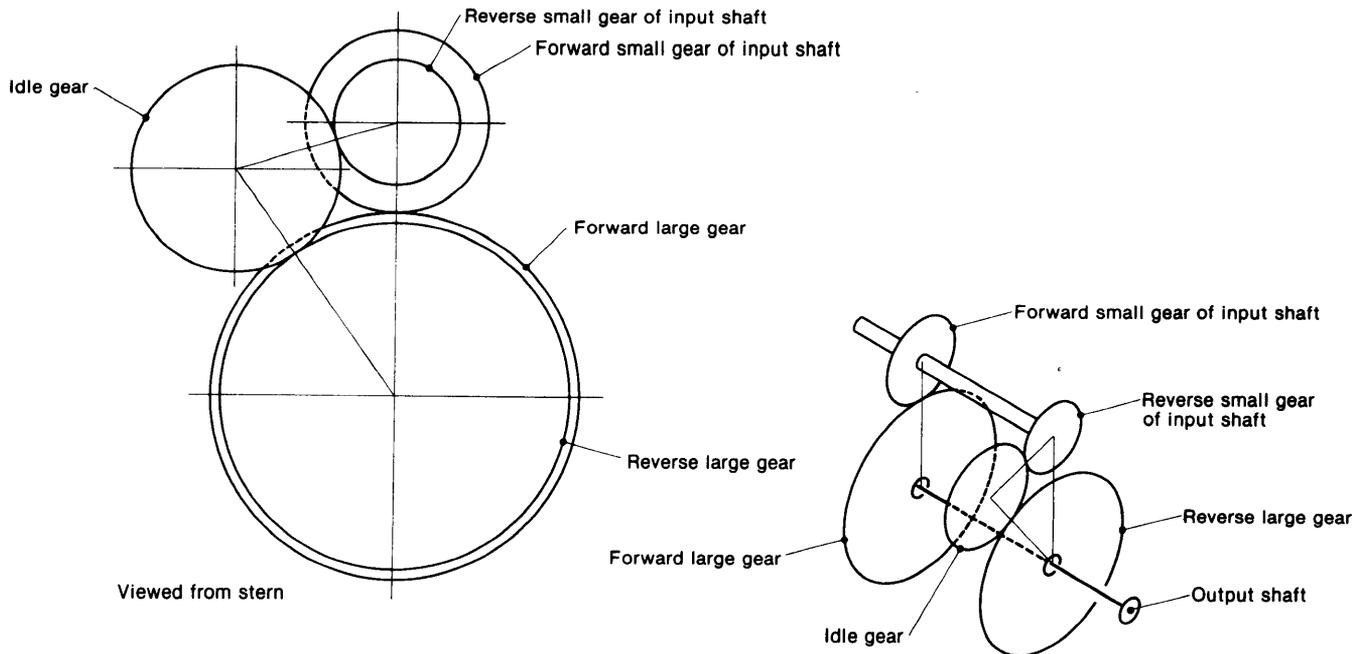
Differences between Marine Gear Models KBW20 and KBW21

KBW 21 is provided with a lube oil cooler (of side cover monoblock construction).

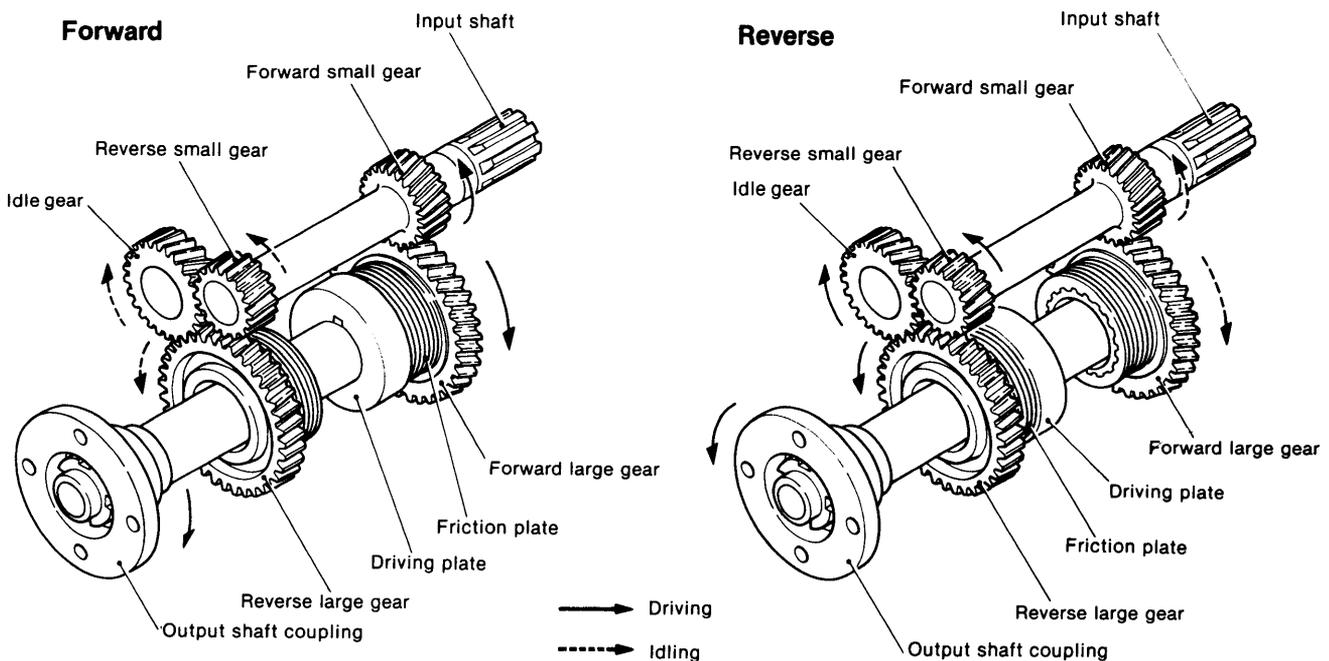
The dimensions of all KBW21 internal marine gear box components are identical to those of KBW20. However, all KBW21 gears are provided with higher strength through a gear teeth hardening process.

Accordingly, KBW21 can be used both for models 4JHE and 4JH-TE, however, KBW20 cannot be used for models 4JH-HTE and 4JH-DTE since KBW20 is not durable enough for these engine models.

1-3 Power transmission system

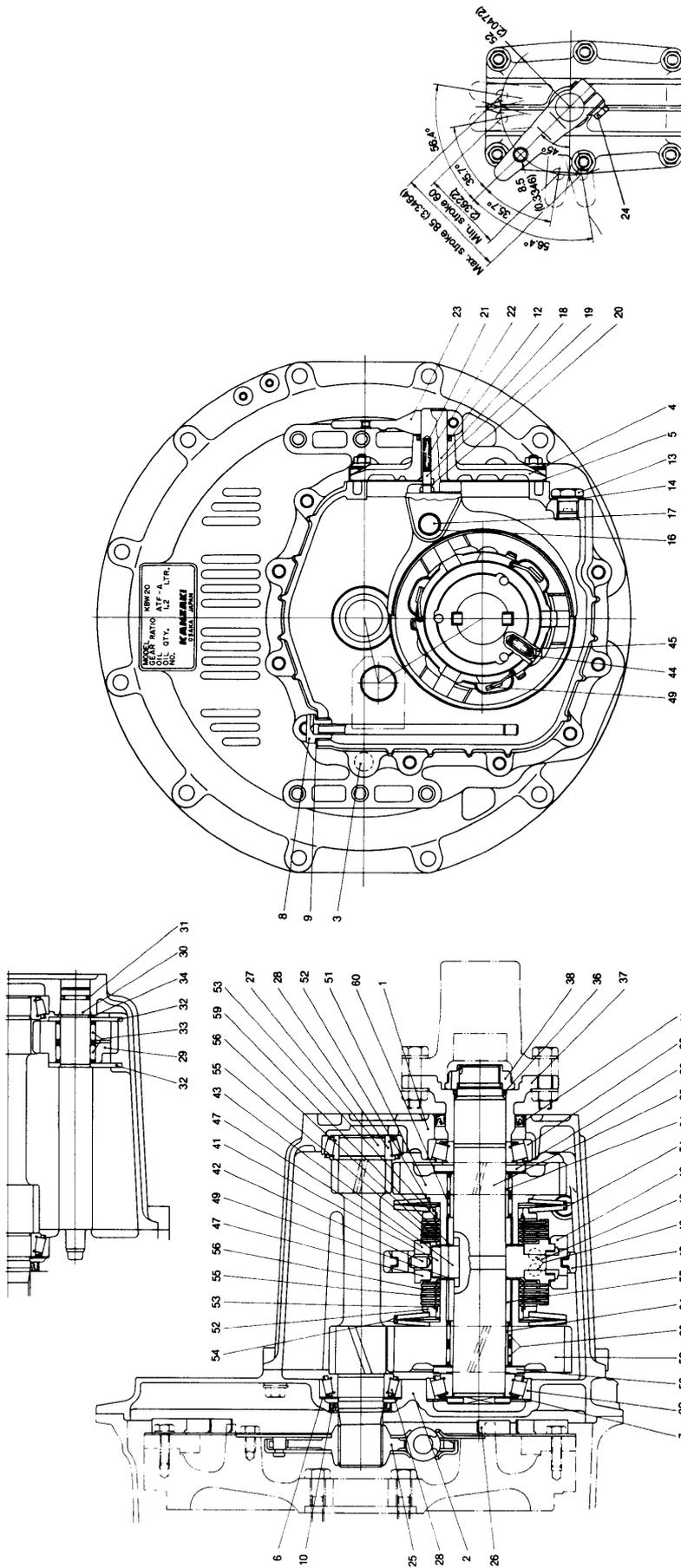


Forward			Reverse			
Number of teeth		Reduction ratio	Number of teeth			Reduction ratio
Forward small gear of input shaft	Forward large gear		Reverse small gear of input shaft	Idle gear	Reverse large gear	
24	52	$52/24 = 2.17$	18	25	55	$55/18 = 3.06$
21	55	$55/21 = 2.62$				
18	59	$59/18 = 3.28$				



1-5 Cross section

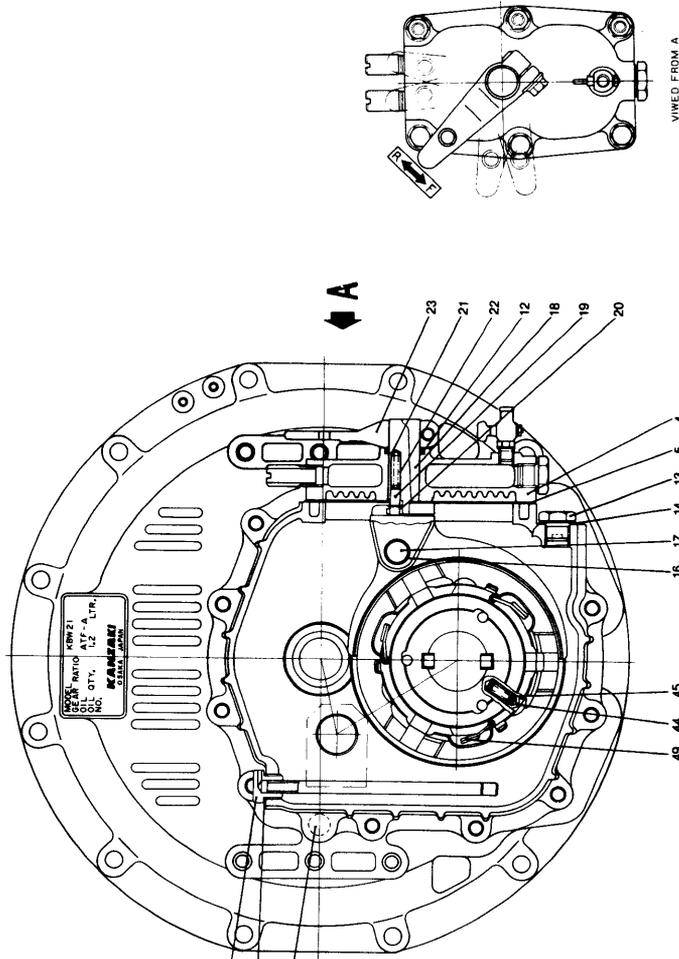
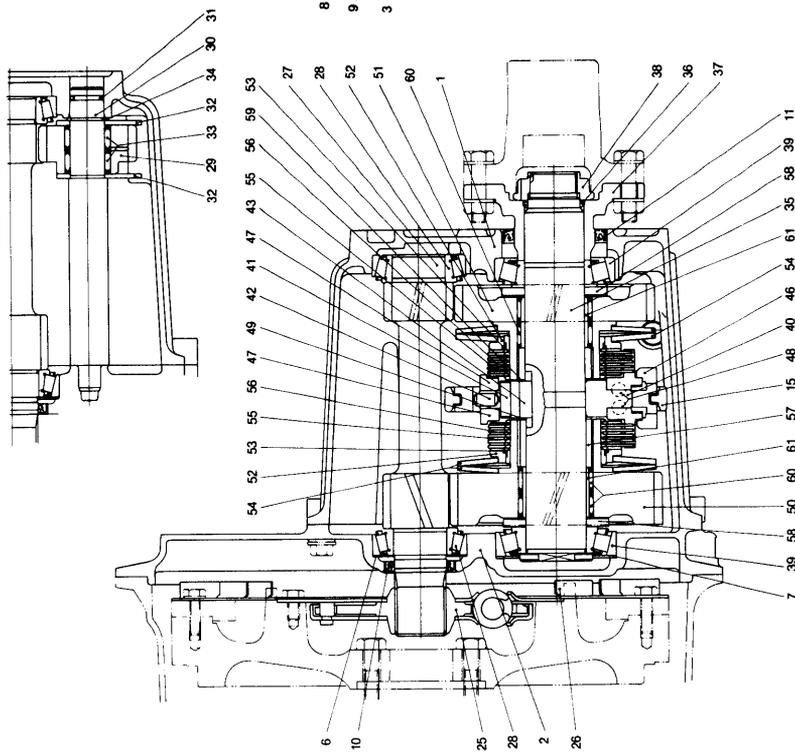
Model: KBW20



- | | | | |
|-----------------------------|---------------------|---------------------------|-------------------------|
| 1. Clutch housing | 16. Dry bearing | 31. O-ring | 46. Shift ring |
| 2. Mounting flange | 17. Shift bar | 32. Thrust washer | 47. Pressure plate |
| 3. Parallel pin | 18. Shift cam | 33. Needle bearing | 48. Steel ball |
| 4. Side cover | 19. Pin | 34. Circlip | 49. Return spring |
| 5. Packing | 20. Circlip | 35. Output shaft | 50. Forward gear |
| 6. Shim (input shaft) | 21. Spring | 36. O-ring | 51. Reverse gear |
| 7. Shim (output shaft) | 22. Spring | 37. Retainer | 52. Retainer |
| 8. Disc | 23. Shift lever | 38. Output shaft coupling | 53. Retainer |
| 9. Packing | 24. Bolt | 39. Roller bearing | 54. Plate |
| 10. Oil seal (input shaft) | 25. Damper disc | 40. Driving plate | 55. Friction disc |
| 11. Oil seal (output shaft) | 26. Fan | 41. Parallel pin | 56. Steel plate |
| 12. Oil seal (shift cam) | 27. Input shaft | 42. Parallel pin | 57. Spacer |
| 13. Plug | 28. Roller bearing | 43. Key | 58. Thrust washer |
| 14. Packing | 29. Idle gear | 44. Pin | 59. Shim (output shaft) |
| 15. Shift fork | 30. Idle gear shaft | 45. Spring | 60. Needle bearing |
| | | | 61. Inner race |

Cross section

Model: KBW21



MODEL: KBW21
RATIO: A1F-A
G.O. QTY: 12 LTR.
MITSUBISHI
CORPORATION

- | | | | |
|-----------------------------|---------------------|---------------------------|-------------------------|
| 1. Clutch bearing | 16. Dry bearing | 31. O-ring | 46. Shift ring |
| 2. Mating flange | 17. Shift bar | 32. Thrust washer | 47. Pressure plate |
| 3. Parallel pin | 18. Shift cam | 33. Needle bearing | 48. Steel ball |
| 4. Side cover | 19. Pin | 34. Circlip | 49. Return spring |
| 5. Packing | 20. Circlip | 35. Output shaft | 50. Forward gear |
| 6. Shim (input shaft) | 21. Spring | 36. O-ring | 51. Reverse gear |
| 7. Shim (output shaft) | 22. Spring | 37. Output shaft coupling | 52. Retainer |
| 8. Dipstick | 23. Shift lever | 38. Roller bearing | 53. Plate spring |
| 9. Oil seal (input shaft) | 24. Bolt | 39. Drive plate | 54. Friction disc |
| 10. Oil seal (output shaft) | 25. Damper disc | 40. Driving plate | 55. Friction plate |
| 11. Oil seal (shift cam) | 26. Fan | 41. Parallel pin | 56. Steel plate |
| 12. Plug | 27. Input shaft | 42. Parallel pin | 57. Spacer |
| 13. Plug | 28. Roller bearing | 43. Key | 58. Thrust washer |
| 14. Packing | 29. Idle gear | 44. Pin | 59. Shim (output shaft) |
| 15. Shift fork | 30. Idle gear shaft | 45. Spring | 60. Needle bearing |
| | | | 61. Inner race |

2. Installation

2-1 Installation angle

During operation the angular inclination of the gearbox in the longitudinal direction must be less than 20° relative to the water line.

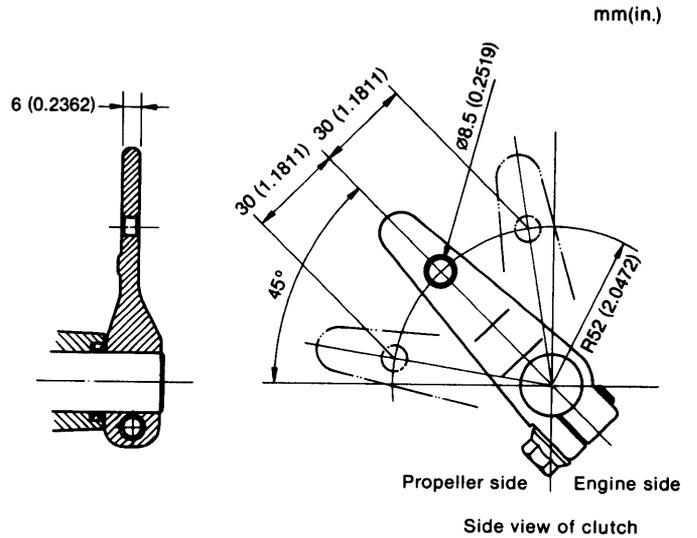
2-2 Remote control unit

This marine gearbox is designed for single lever control to permit reversing at full engine speed (e.g. to avoid danger, etc.). Normally, Morse or Teleflex single lever control is employed. During installation, make sure that the remote control lever and shift lever on the marine gearbox are coordinated. Shifting the lever toward the propeller side produces forward movement, while moving the lever toward the engine side causes the vessel to move in the reverse direction.

To connect the linkage, the operating cable must be positioned at right angles to the shift lever when the shift lever is in the neutral position.

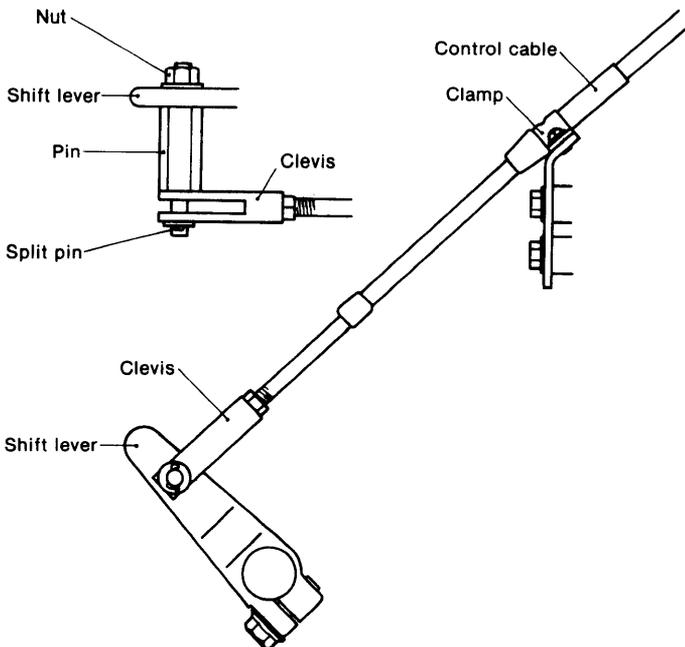
The shift play, measured at the pivot point of the shift lever, must be at least 30mm (1.1811in.) on each side (reverse and forward) of the neutral position. Greater shift play has no adverse effect on the marine gearbox. After connecting the linkage, confirm that the remote control and the shift lever on the marine gearbox work properly.

A typical linkage arrangement is illustrated in the figure below.



2-3 Clutch operation force (reference value)

Operation position	Operation lever position at 52mm (2.0472in.)	Remarks
Engaging stroke	Approx. 9.5kg (20.94 lb)	Engine speed at 1000 rpm
Disengaging stroke	Approx. 11.5kg (25.35 lb)	

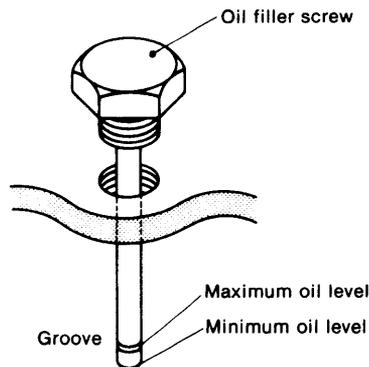


3. Operation and Maintenance

3-1 Lube oil

(1) Oil level

The oil level should be checked each month and must be maintained between the groove and the end of the dipstick. The groove indicates the maximum oil level and the end of the dipstick is the minimum oil level. When checking the oil level with the dipstick, do not screw in the oil filler screw; it should rest on top of the oil filler hole.



(2) Oil change

Change the oil after the first 50 hours of operation, and every 150 hours of operation thereafter. When adding oil between oil changes, always use the same type of oil as is in the marine gearbox.

(3) Recommended brands of lube oil

Supplier	Brand name
SHELL	SHELL DEXRON
CALTEX	TEXAMATIC FLUID (DEXRON)
ESSO	ESSO ATF
MOBIL	MOBIL ATF220
B.P. (British Petroleum)	B.P. AUTRAN DX

3-2 Precautions

Do not stop the shift lever halfway between the neutral and forward or reverse positions. The lever must be set to the neutral position or shifted into forward or reverse in a single motion.

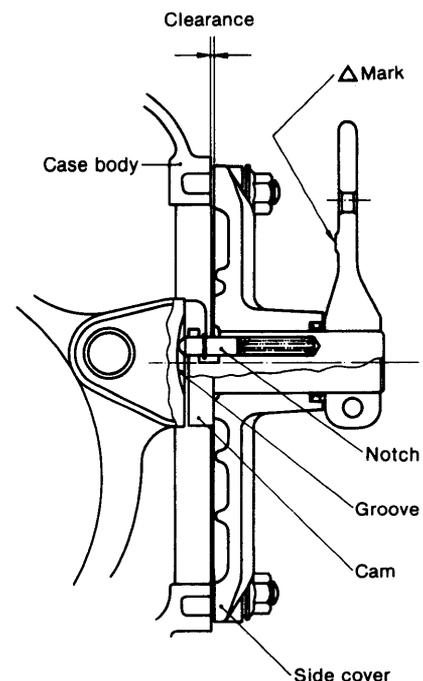
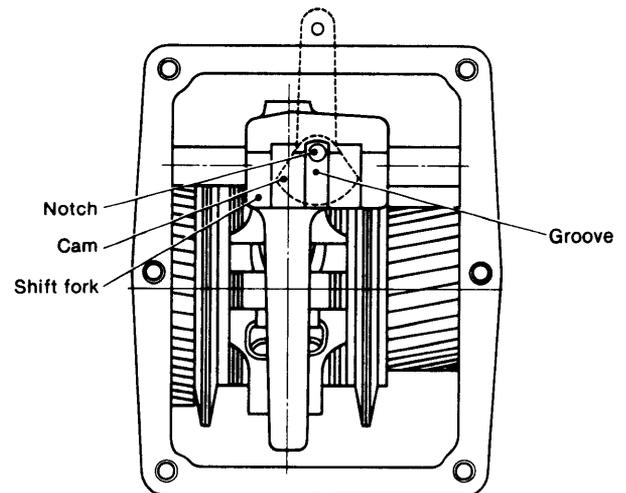
3-3 Side cover

The internal shifting mechanism has been carefully aligned at the factory. Improper removal of the side cover can cause misalignment. If the side cover must be removed, proceed as follows:

- Before removing the cover, put alignment marks on the side cover and the case to facilitate accurate installation.
- When installing the side cover, put the shift lever in neutral so that the cam lobe on the shift lever engages the groove on the internal shift mechanism. When the cam

lobe and groove are engaged properly there will be no clearance between the body and the side cover. Use packing when installing the side cover.

—After making sure that the cam lobe and notches are aligned properly, securely tighten all the bolts. After tightening the bolts, move the lever back and forth. Positive contact should be felt and a click should be clearly audible as the gears shift; otherwise, the cam and notch are not properly engaged, and the cover must be loosened and readjusted until proper engagement is achieved.



4. Inspection and Servicing

4-1 Clutch case

- (1) Check the clutch case for cracking with a test hammer. Perform a color check when required. If the case is cracked, replace it.
- (2) Check for staining on the inside surface of the bearing section. Also, measure the inside diameter of the case. Replace the case if it is worn beyond the wear limit.

4-2 Bearing

- (1) Rusting and damage
If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly. If rotation is not smooth, if there is any binding, or if an abnormal sound is heard, replace the bearing.

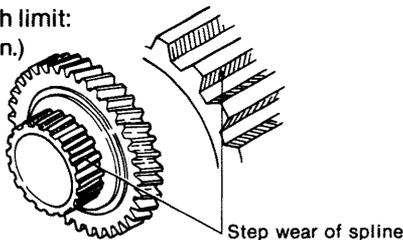
4-3 Gear

- (1) Tooth surface wear
Check the tooth surface for pitching, abnormal wear, dents, and cracks. Repair lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact
Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash
Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.

	mm (in.)	
	Standard	Wear limit
Input shaft forward gear and output shaft forward gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	0.3 (0.0118)
Input shaft reverse gear and intermediate gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	0.3 (0.0118)
Intermediate gear and output shaft reverse gear	0.1 ~ 0.2 (0.0039 ~ 0.0078)	0.3 (0.0118)

(4) Forward/reverse gear spline

- 1) Check the spline for damage and cracking.
- 2) Step wear of spline
Step wear depth limit:
0.1mm (0.0040in.)



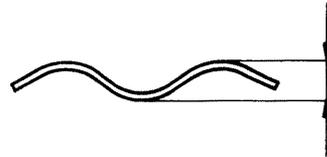
(5) Forward/reverse gear needle bearing

When an abnormal sound is produced at the needle bearing, visually inspect the rollers; replace the bearing if the rollers are faulty.



4-4 Steel plate

- (1) Burning, scratching, cracking
Replace any steel plates that are discolored or cracked.
- (2) Warping measurement



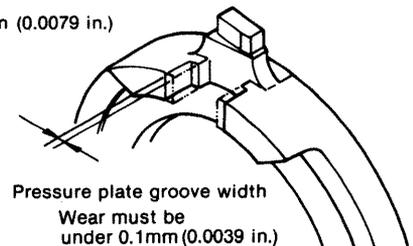
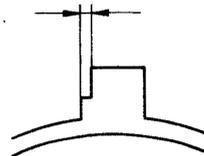
	mm (in.)	
	Standard	Wear limit
Warping	1.49 ~ 1.70 (0.0586 ~ 0.0669)	1.4 (0.0551)

(3) Steel plate pawl width measurement



Measure the width of the steel plate pawl and the width of the pressure plate; replace the plate when the clearance exceeds the wear limit.

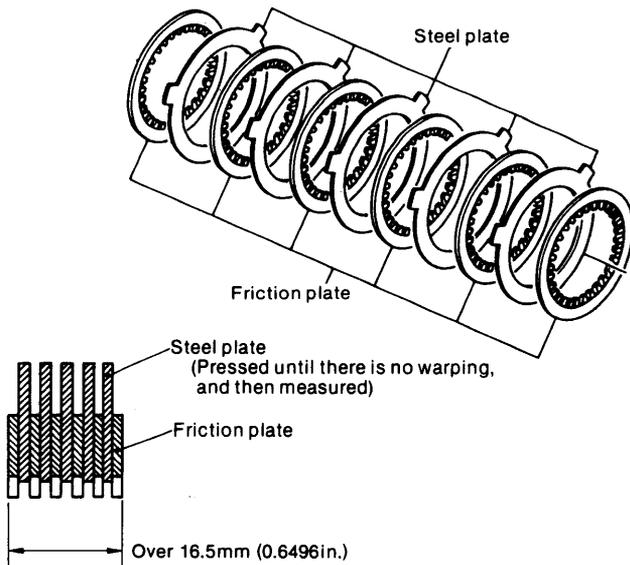
Steel plate width
Wear must be under 0.2mm (0.0079 in.)



	mm (in.)	
	Standard	Wear limit
Steel plate width	11.8 ~ 12.0 (0.4645 ~ 0.4724)	Worn 0.2 (0.0078)
Pressure plate groove	12.0 ~ 12.1 (0.4724 ~ 0.4763)	Worn 0.1 (0.0039)
Clearance	0 ~ 0.3 (0 ~ 0.0118)	0.3 ~ 0.6 (0.0118 ~ 0.0236)

4-5 Friction plate

- (1) Check the friction plate for burning, scoring, or cracking. Repair the plate when the damage is light and replace the plate if the damage is heavy.
- (2) Friction surface wear
Measure the thickness of the friction plate, and replace the plate when it is worn beyond the wear limit.



	mm (in.)	
	Standard	Wear limit
Friction plate thickness	1.65 ~ 1.70 (0.0649 ~ 0.0669)	1.5 (0.0590)

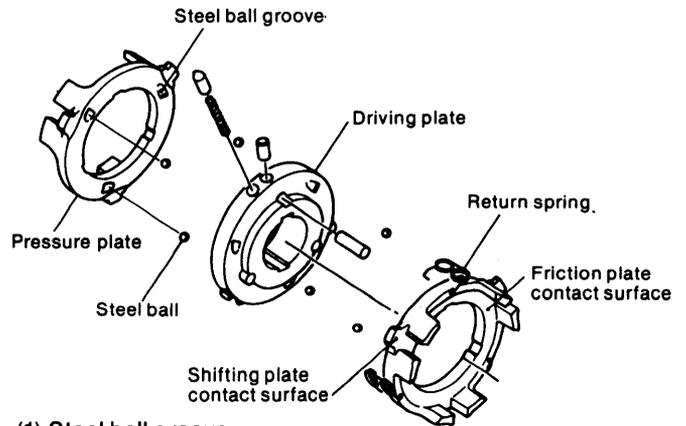
The assembled friction plate and steel plate dimensions must be over 16.5mm (0.6496in.).

Both sides of the friction plate have a 0.35mm (0.0138in.) copper sintered layer. Replace the friction plate when this layer is worn more than 0.2mm (0.0079in.) on one side (standard thickness 1.65 ~ 1.70 (0.0650 ~ 0.0670in.)). However, the sum of the wear of the six friction plates must not exceed 1.2mm (0.0472in.). When this value is exceeded, replace all friction plates. In unavoidable circumstances, it is permissible to replace only the friction plate with the greatest amount of wear.

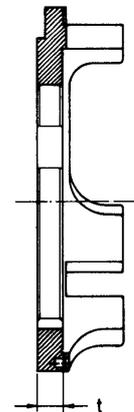
- (3) Friction plate and gear spline back clearance
Measure the clearance between the friction plate spline collar and the output shaft gear spline, and replace the plate or spline when they are worn beyond the wear limit.

	mm (in.)	
	Standard	Wear limit
Standard backlash	0.20 ~ 0.61 (0.0078 ~ 0.0240)	0.9 (0.0354)

4-6 Pressure plate

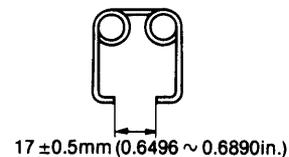


- (1) Steel ball groove
Check the steel ball groove for stains and wear. Replace the pressure plate if the groove is noticeably worn.
- (2) Friction plate contact surface
Check the contact face for stains and damage.
- (3) Shifting plate contact surface
- (4) Worn parts measurement

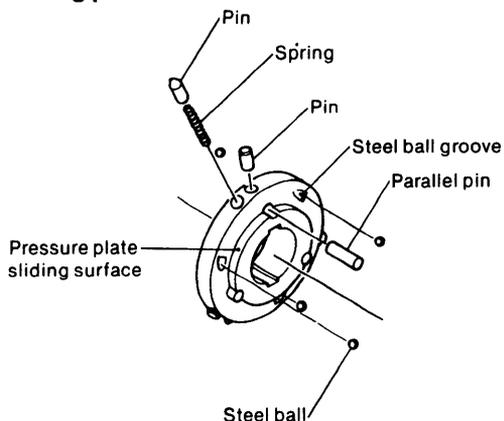


	mm (in.)	
	Standard	Wear limit
Thickness: t	8.0 ~ 8.1 (0.3149 ~ 0.3188)	7.9 (0.3110)

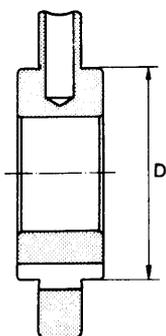
- (5) Return spring permanent strain.
Make sure the length (free length) is within the values specified in the figure.



4-7 Driving plate



- (1) Check the key groove for scoring and cracking, and the output shaft fitting section for burning. Repair if the damage is light and replace the driving plate if the damage is heavy.
- (2) Outside diameter of pressure plate sliding part; others



	mm (in.)	
	Standard	Wear limit
Outside diameter: D	ø68.366 ~ 68.440 (2.6915 ~ 2.6944)	ø68.3 (2.6889)

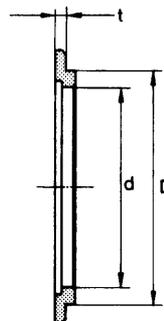
- (3) Steel ball groove wear and stains.
- (4) Determine the amount of wear and play of both the axial and circumferential direction pins.
- (5) Permanent spring strain.

	mm (in.)	
	Standard	Wear limit
Spring free length	32.85 (1.2933)	32 (1.2598)

- (6) Pin end wear.

4-8 Retainer

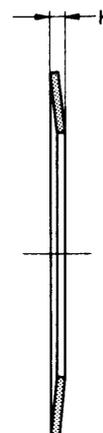
- (1) Check for stains and damage on the friction plate contact surface.
- (2) Check for wear and cracking on the plate spring contact surface.
- (3) Measurement of dimensions



	mm (in.)	
	Standard	Wear limit
d	ø67.060 ~ 67.106 (2.6401 ~ 2.6419)	ø67.3 (2.6496)
D	ø75.9 ~ 76.0 (2.9881 ~ 2.9921)	ø75.7 (2.9803)
t	4.95 ~ 5.05 (0.1948 ~ 0.1988)	4.8 (0.1889)

4-9 Plate spring

- (1) Permanent strain

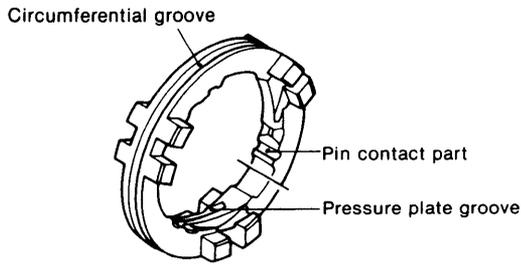


	mm (in.)	
	Standard	Wear limit
H: when plate spring is free	7.2 ~ 7.6 (0.2834 ~ 0.2992)	7.05 (0.2775)

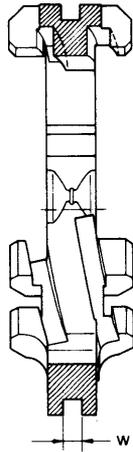
4-10 Thrust collar

The gear side of the thrust washer has a 0.3mm (0.0118in.) copper sintered layer. Replace the thrust collar when the thickness is less than 5.75mm (0.2263in.) (Standard thickness: 5.9 ~ 6.0mm (0.2322 ~ 0.2362)).

4-11 Shift ring



(1) Circumferential groove wear.

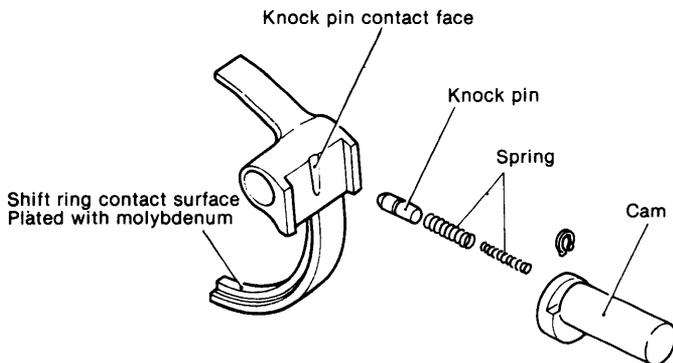


mm (in.)

	Standard	Wear limit
Shifting groove: w	6.0 ~ 6.1 (0.2362 ~ 0.2401)	6.3 (0.2480)

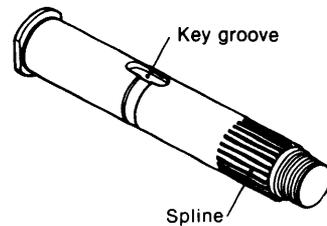
- (2) Pressure plate groove wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Parallel pin contact part wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-12 Shift fork and shift lever



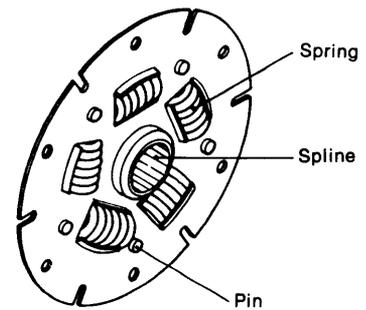
- (1) End wear.
The shift ring contact surface of the shift fork is plated with molybdenum (thickness: 0.04 ~ 0.05mm (0.0016 ~ 0.0020in.)). If this plating is peeled or worn to such an extent that the base metal of the shift fork is exposed, replace the shift fork.
- (2) Cam surface wear and stains.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin part play.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (4) Notch end wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-13 Output shaft



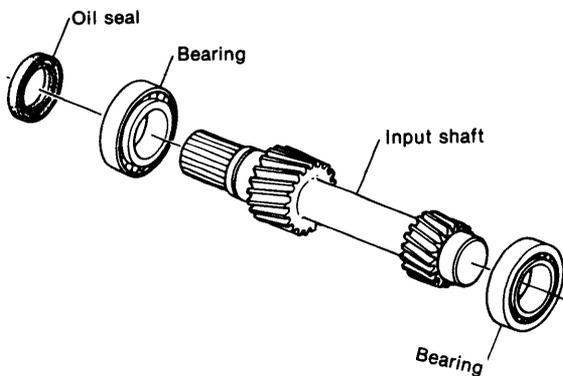
- (1) Key groove.
Whenever uneven cracks and/or stains are found, replace with a new part.

4-14 Damper disc



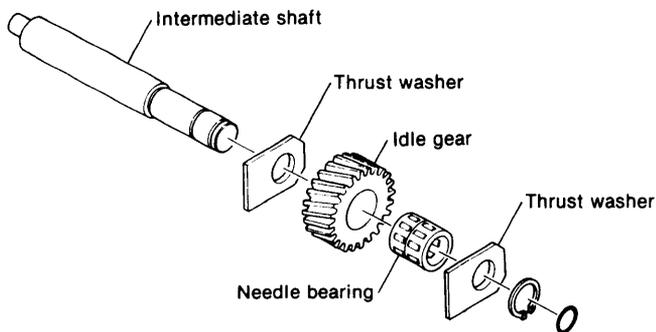
- (1) Spline part
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Spring.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin wear.
Whenever uneven wear and/or scratches are found, replace with a new part.

4-15 Input shaft



- (1) Spline part
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Surface of oil seal.
If the sealing surface of the oil seal is worn or scratched, replace.

4-16 Intermediate shaft

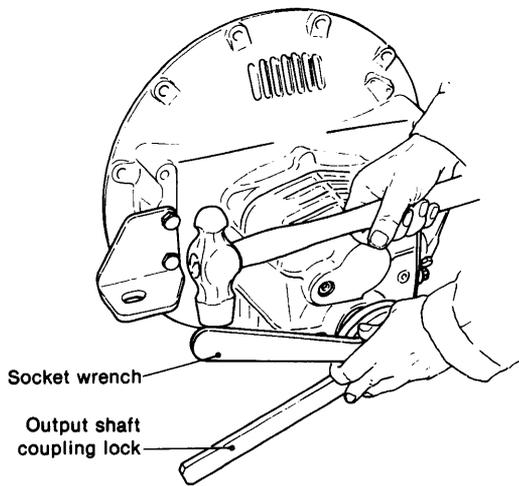
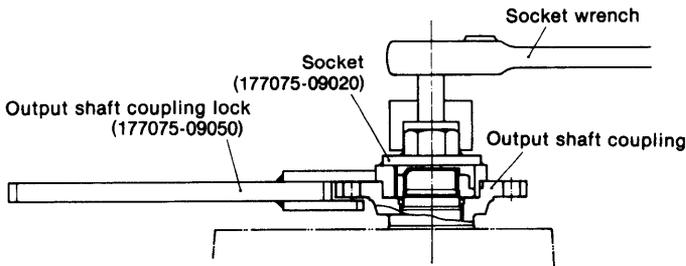


- (1) Needle bearing dimensions, staining.
Check the surface of the roller to see whether the needle bearing sticks or is damaged. Replace if necessary.

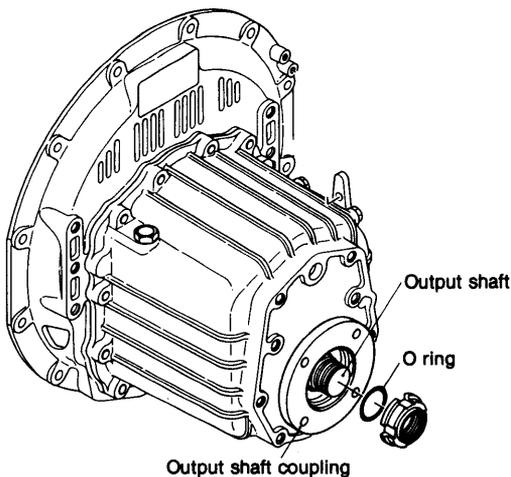
5. Disassembly

5-1 Disassembling the clutch and accessories

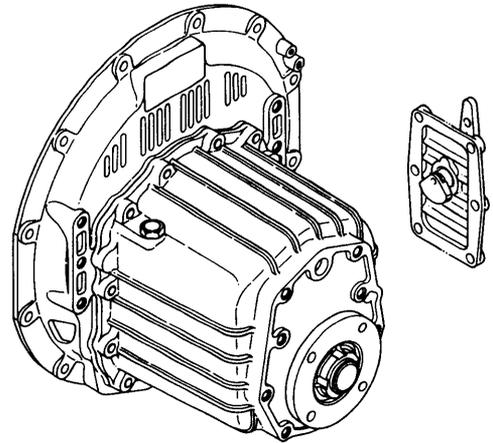
- (1) Remove the drain plug and packing, and drain the oil from the clutch.
- (2) Uncaulk the output shaft lock nut, and remove the nut using a disassembly tool.



- (3) Remove the output coupling with O-ring.

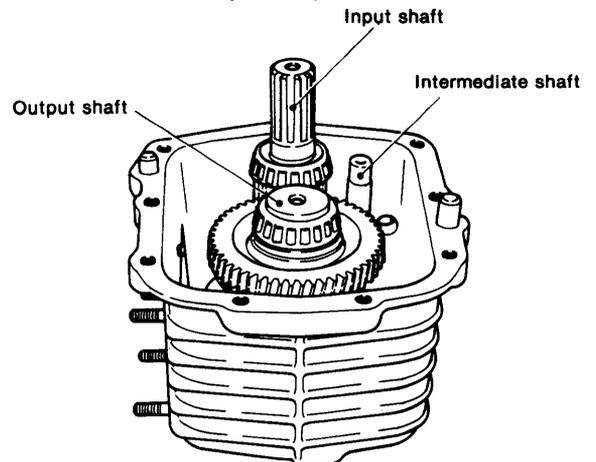


- (4) Remove the dipstick and packing.
- (5) Remove the case cover M8 nut and M8 bolt; remove the case cover, with the operating lever, shift cam, etc. in position.



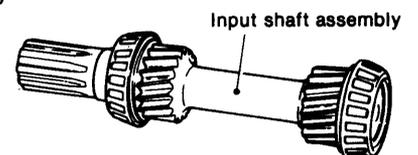
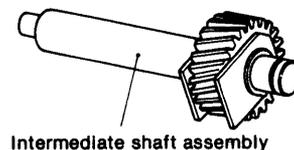
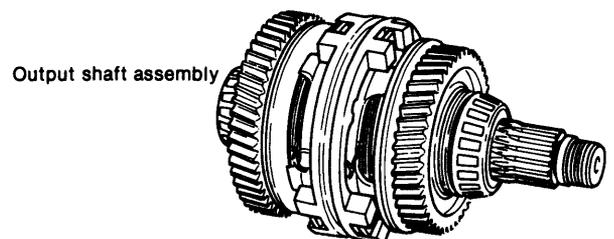
- (6) Remove the M10 bolt and super lock washer on the mounting flange.

- (7) Screw the M10 bolt into the M10 pulling bolt hole of the mounting flange, and remove the mounting flange. Do not remove the parallel pin.



- (8) Remove the output shaft, intermediate shaft, and input shaft from the case, in that order.

- (9) Remove the shift bar from the moving flange side.



- (10) Heat the case body to about 100°C and remove the outer race of the input shaft and output shaft bearings. If the outer races are difficult to remove, tap them out with a plastic hammer from the rear of the case, or pull them by using the pulling groove in the case at the rear of the races.
- (11) Remove the outer race of the bearing from the mounting flange as described in step (11) above.
- (12) Remove the input shaft and output shaft adjusting plates.

NOTE: If the following parts are not replaced, the adjusting plates may be reused without readjustment. However, if even one part is replaced, readjustment is necessary.

Input shaft part: 24-2, 24-31

Output shaft part: 26-6, 26-9, 26-26, 26-27, 26-28, 26-30

- (13) Pull the oil seal from the case.
- (14) Pull the oil seal from the mounting flange.

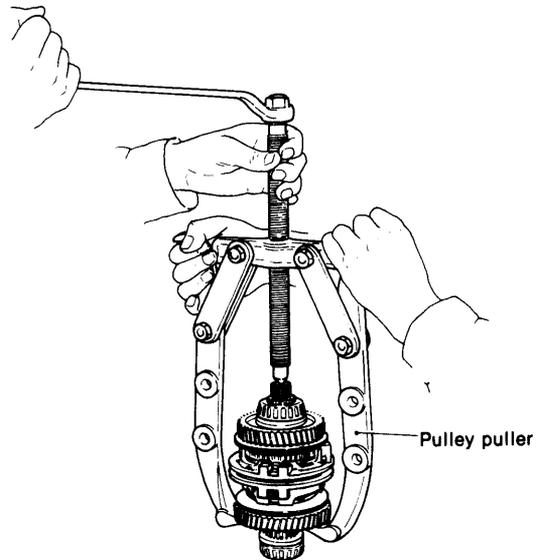
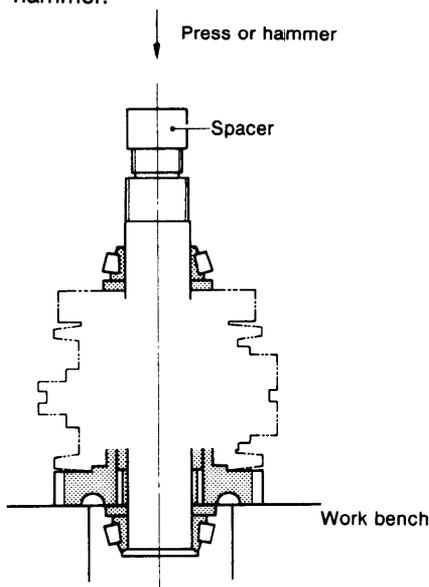
5-2 Disassembling the input shaft

Pull the bearing from the input shaft.

NOTE: Do not disassemble unless the input shaft parts are damaged.

5-3 Disassembling the output shaft

- (1) Remove the O-ring.
- (2) Remove the output shaft by pressing the threaded end of the output shaft with a press, or tapping it with a hammer.

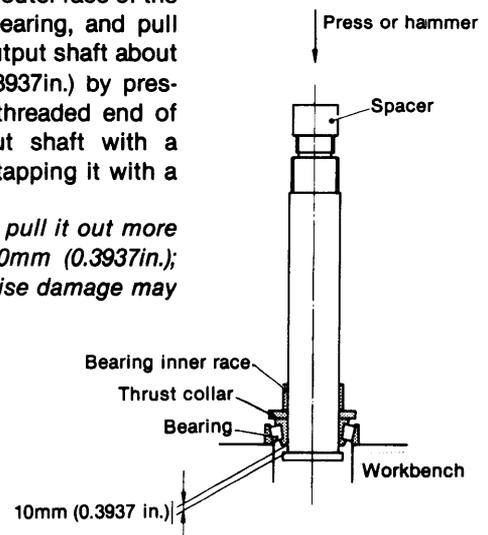


NOTE 1: When removing the shaft, place spacers between the shaft and the press to prevent damage.

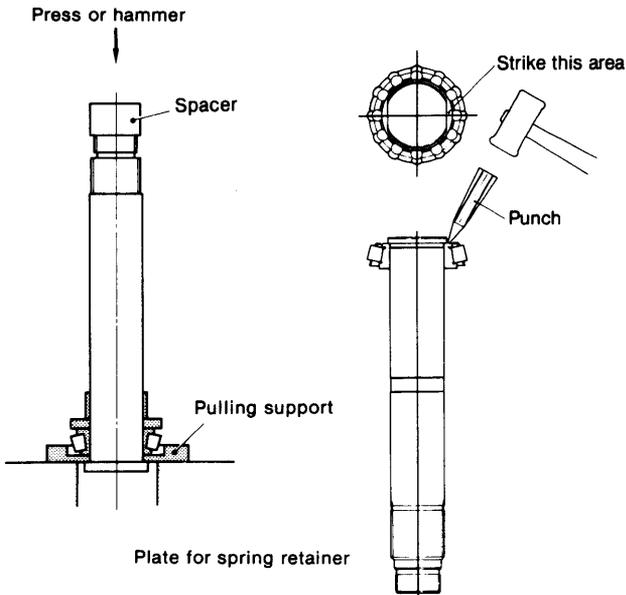
NOTE 2: Make sure that the forward large gear parts and reverse large gear parts are not mixed together once they are removed.

- (3) Remove the adjusting plate.
NOTE: Record the thickness of the adjusting plate to facilitate reassembly. If the parts are not replaced, the adjusting plate may be reused without readjustment. However, if even one part is replaced, readjustment is required.
- (4) Remove the key.
To facilitate removal, clamp the key with a vise.
- (5) Remove the adjusting plate.
NOTE: Record the thickness of the adjusting plate to facilitate reassembly. If the parts are not replaced, the adjusting plate may be reused without adjustment. However, if even one part is replaced, readjustment is required.
- (6) Remove the spacer and needle bearing.
- (7) Cover the outer race of the forward bearing, and pull out the output shaft about 10mm (0.3937in.) by pressing the threaded end of the output shaft with a press, or tapping it with a hammer.

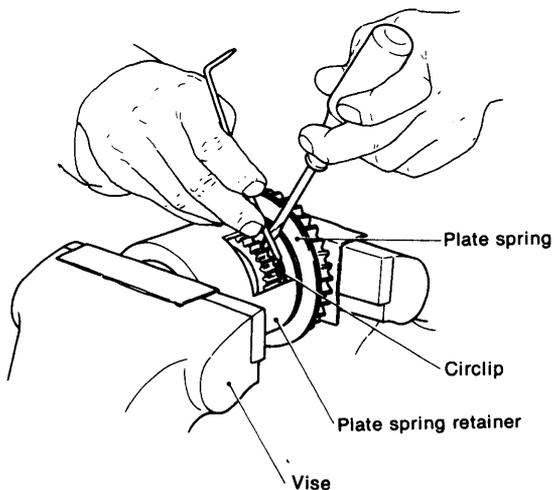
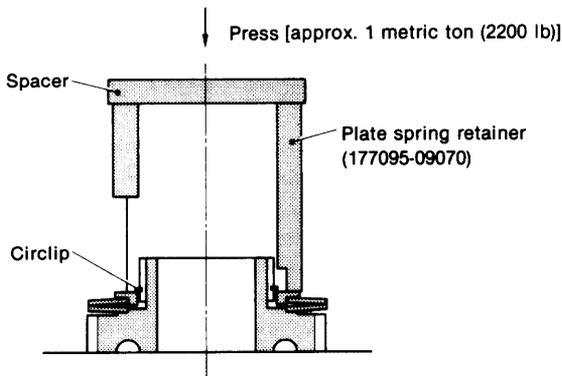
NOTE: Do not pull it out more than 10mm (0.3937in.); otherwise damage may result.



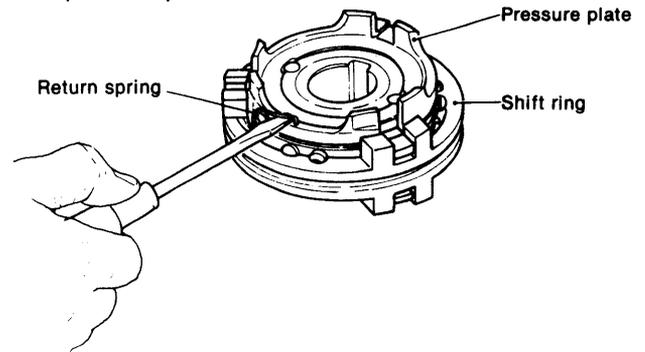
- (8) Insert the disassembly tool between the collar of the output shaft and the bearing; next remove the bearing inner race, thrust collar, and bearing from the output shaft with a press or hammer.



- (9) Remove the friction plates and steel plates from the forward large gear.
(10) Using a disassembly tool, compress the plate spring and remove the circlip from the forward large gear.



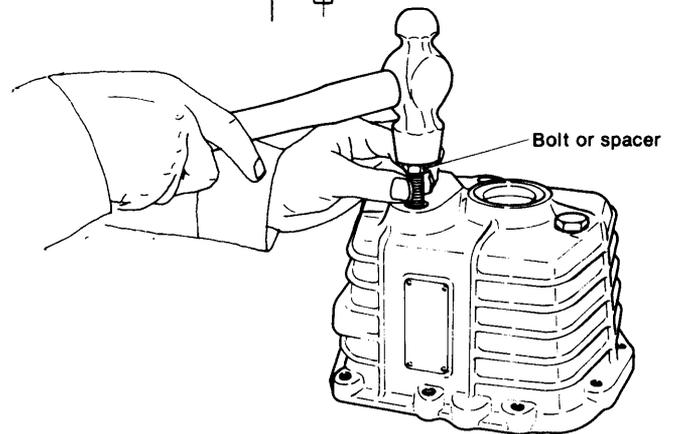
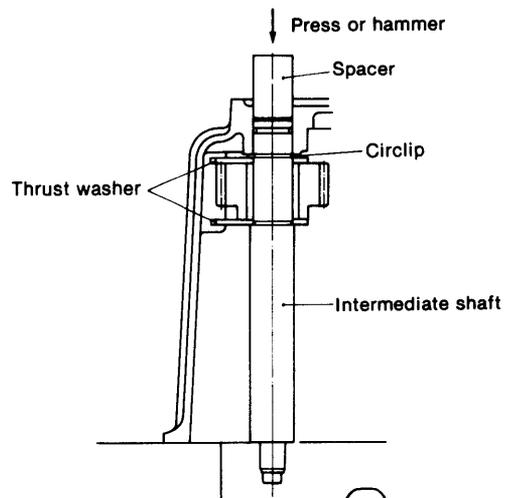
- (11) Remove the retainer and plate spring.
(12) Remove the parts from the reverse large gear as described in steps (9)—(11) above.
(13) Remove the pressure plate return spring; remove the pressure plate and steel ball.



- (14) Remove the shift ring.
To disassemble, remove the three knock pins. When disassembling the shift ring, cover it with a cloth to prevent it being lost.
(15) Remove the knock pin and spring from the driving plate.

5-4 Disassembling the intermediate shaft

- (1) Place a spacer against the case side end of the intermediate shaft and remove the shaft from the case by tapping the spacer with a hammer.



- (2) Remove the O-ring, and then remove the circlip.
- (3) Remove the idle gear, needle bearing, and thrust washer.

5-5 Disassembling the operating system

- (1) Loosen the M8 bolt of the shift lever; remove the shift lever.
- (2) Pull the shift cam.
- (3) Push in the knock pin and remove the circlip.
- (4) Remove the knock pin and spring.
- (5) Pull the oil seal from the case side cover.

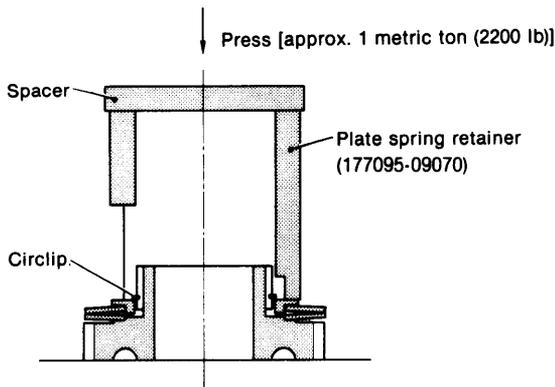
6. Reassembly

6-1 Reassembly precautions

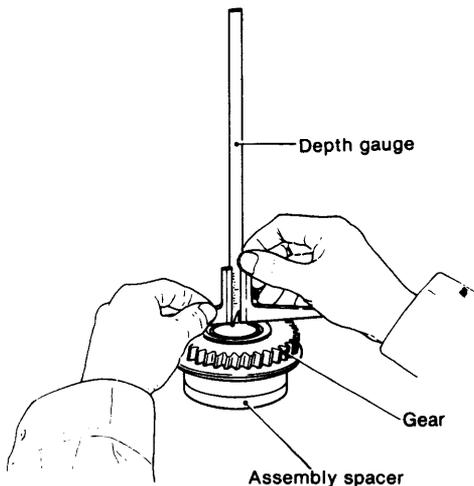
- (1) Before reassembling, clean all parts in washing oil, and replace any damaged or worn parts. Remove non-dry packing agent from the mating surface with a blunt knife.
- (2) Pack the oil seal and O-ring parts with grease.
- (3) Coat the mating surfaces of the case with wet packing.

6-2 Reassembling the output shaft

- (1) Reassembling forward large gear and plate spring
 - 1) Insert the two plate springs of the forward large gear so that their large diameter sides are opposite each other.
 - 2) Insert the retainer and install the circlip.
 - 3) Compress the plate spring, using the disassembly tool, and snap the circlip into the groove on the outside of the spline of the forward large gear.

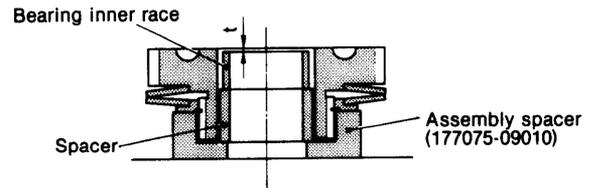


- (2) Reassemble the reverse large gear and plate spring retainer, and circlip as described in step (1) above.
- (3) Determining the forward adjusting plate thickness



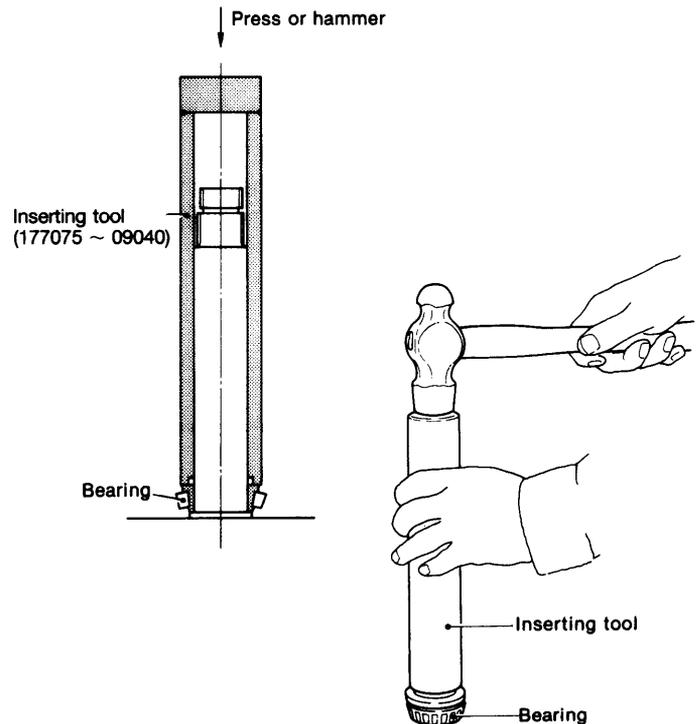
NOTE: As mentioned in section 5-3. (5), if no parts need to be replaced, the adjusting plate can be reused without adjustment.

- 1) Position the assembled large gear on the assembly tool so that the spline part is on the bottom; insert the spacer and bearing inner race into the gear.

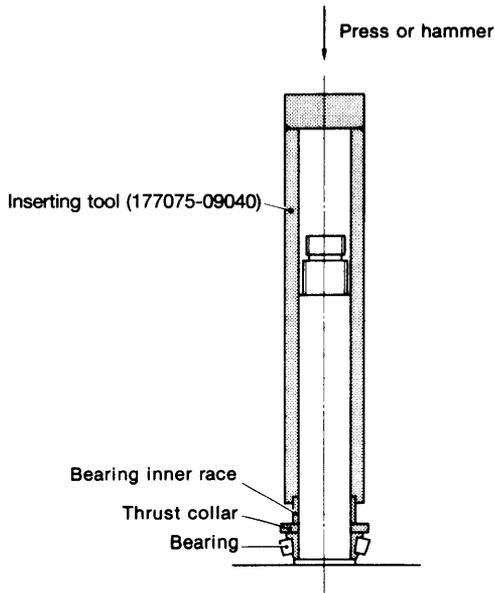


- 2) Three adjustment plates of 0.5mm (0.0196in.), 0.4mm (0.0157in.) and 0.3mm (0.0118in.) are available.
- 3) Measure the "t" dimension. Combine these plates to obtain a dimension from (t-0.5)mm to (t+0.5)mm.
- (4) Determine the thickness of the reverse adjusting plate by following the procedure described in step(3)above.
- (5) First, insert a friction plate into the spline part of the forward large gear; next insert steel plates and friction plates alternately. Finally, insert a friction plate (six friction plates and five steel plates).
- (6) Insert the friction plates and steel plates into the spline part of the reverse large gear in the same manner as described in step (5) above (six friction plates and five steel plates).
- (7) Press the inner race of the bearing onto the output shaft up to the collar, using an assembly tool.

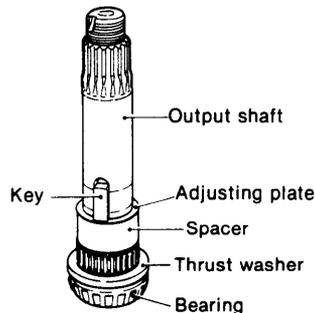
NOTE: The inner race can be installed easily by preheating it to approximately 100°C.



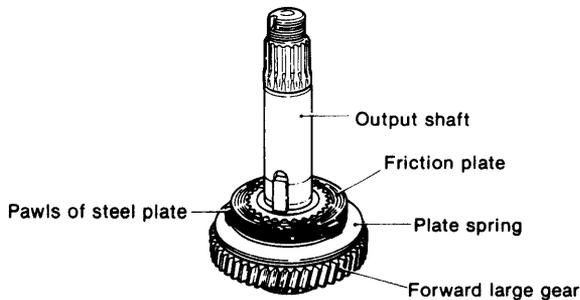
- (8) Insert the thrust collar, with the sintered surface (brown surface) facing the gear side.
- (9) Press the bearing inner race onto the output shaft, using an assembly tool.



- (10) Insert the needle bearing.
- (11) Insert the spacer and adjusting plate.
- (12) Fit the key so that the fillet side is facing the threaded part of the output shaft.



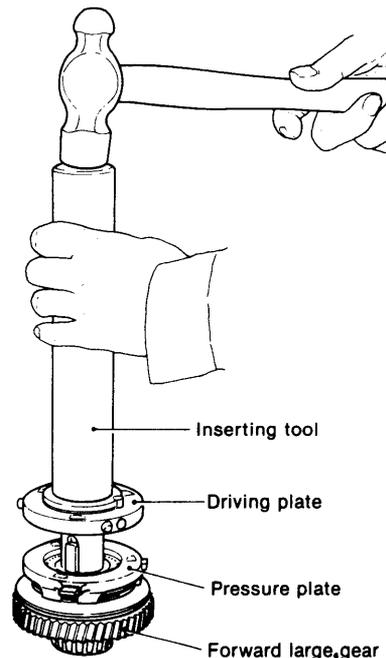
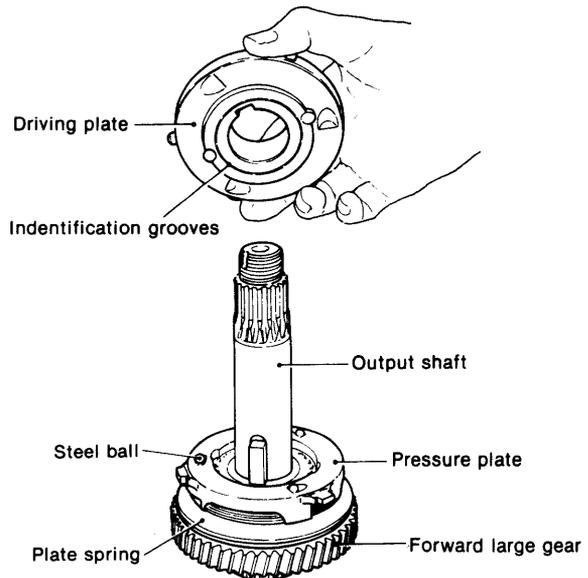
- (13) Insert the forward large gear, together with the friction plates and steel plates. At this time, align the three pawls on the outside of the steel plates.



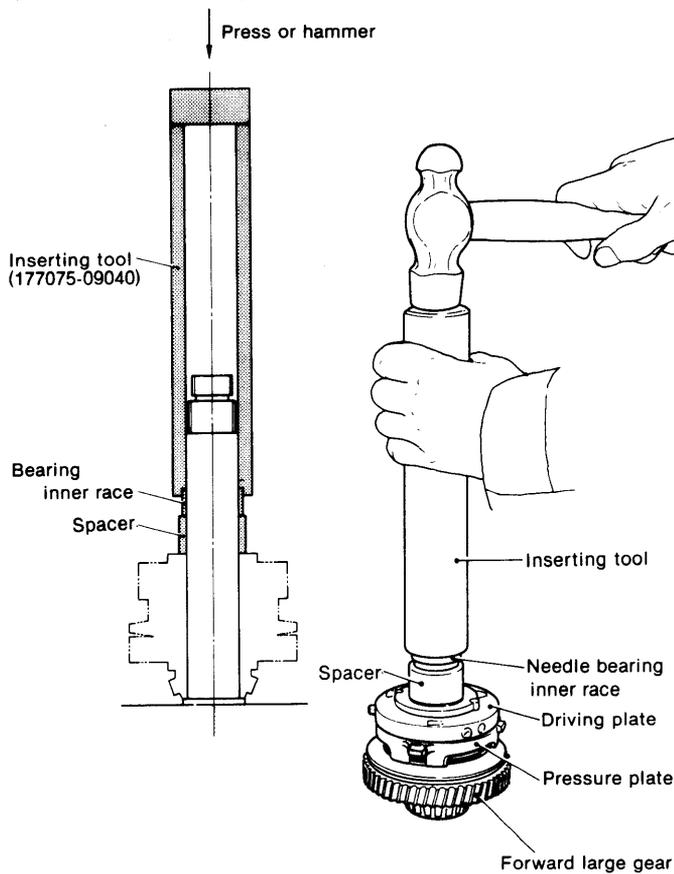
- (14) Cover the friction plates and steel plates with the pressure plate so that the pawls of the steel plate fit into the three notches on the pressure plate.
- (15) Insert the three steel balls into the three grooves in the pressure plate.

- (16) Insert the drive plate into the output shaft so that the side with the identification groove faces the forward large gear side.

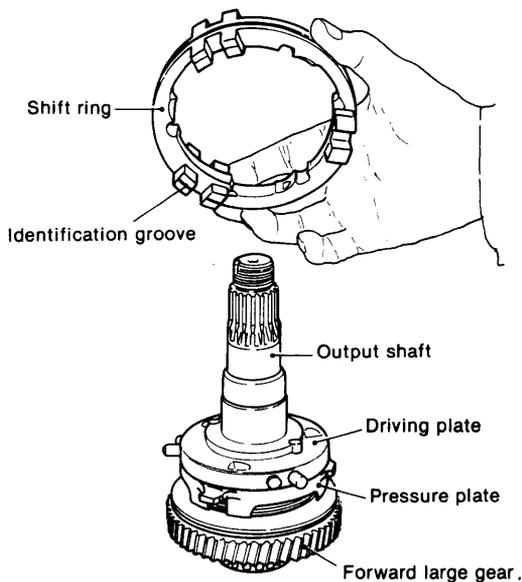
NOTE: Make sure that the three steel balls are in the three grooves of the driving plate. At the same time, make sure that the pin for the driving plate fits into the groove of the torque limiter for the pressure plate.



- (17) Insert the adjusting plate and spacer.
(18) Press the bearing inner race, using an assembly tool.

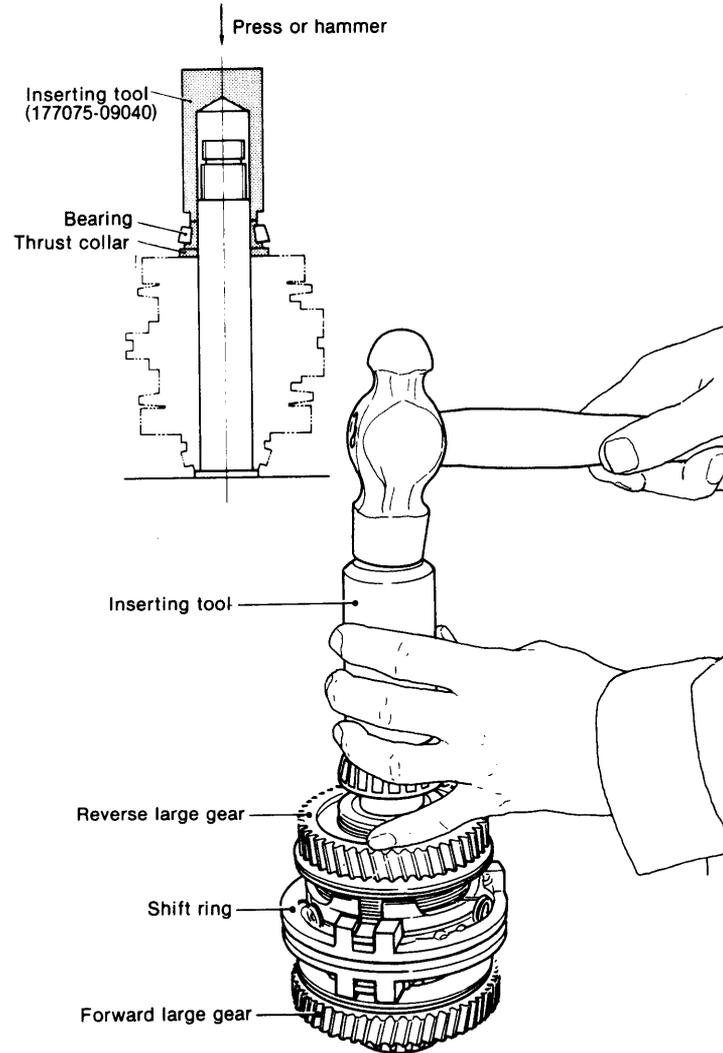


- (19) Insert the knock pins and springs into the three holes around the circumference of the driving plate.
(20) Cover the driving plate with the shift ring so that the side with the identification groove faces the forward large gear side; install the ring so that the knock pins are pushed in.



- (21) Insert the three steel balls into the three grooves in the driving plate.
(22) Place the pressure plate onto the driving plate so that the steel balls enter the three grooves of the pressure plate.
(23) Insert the three pressure plate return springs between the shift ring and the driving plate, and attach them to the small holes in the side of the pressure plate.
(24) Insert the reverse large gear [see step (6)] so that the three pawls of the steel plates enter the notches around the circumference of the pressure plate.
(25) Insert the needle bearing.
(26) Insert the thrust washer so that the sintered side (brown side) faces the gear side.
(27) Press the inner race of the bearing, using an assembly tool. At this time, make sure that the direction of the bearing is correct.

NOTE: The bearing inner race can be installed easily by preheating it to approximately 100°C.



- Insert the O-ring.
(28) With the shift ring in the reverse position, check the forward large gear to make sure it rotates smoothly. Next, with the shift ring in the forward position, check the reverse large gear to make sure it rotates smoothly.

6-3 Reassembling the input shaft

Press the inner race of the bearing onto the input shaft. At this time, make sure that the direction of the bearing is correct.

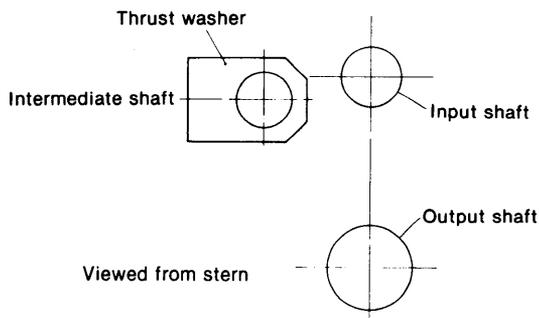
NOTE: The bearing inner race can be easily installed by preheating it to approximately 100°C.

6-4 Reassembling the intermediate shaft

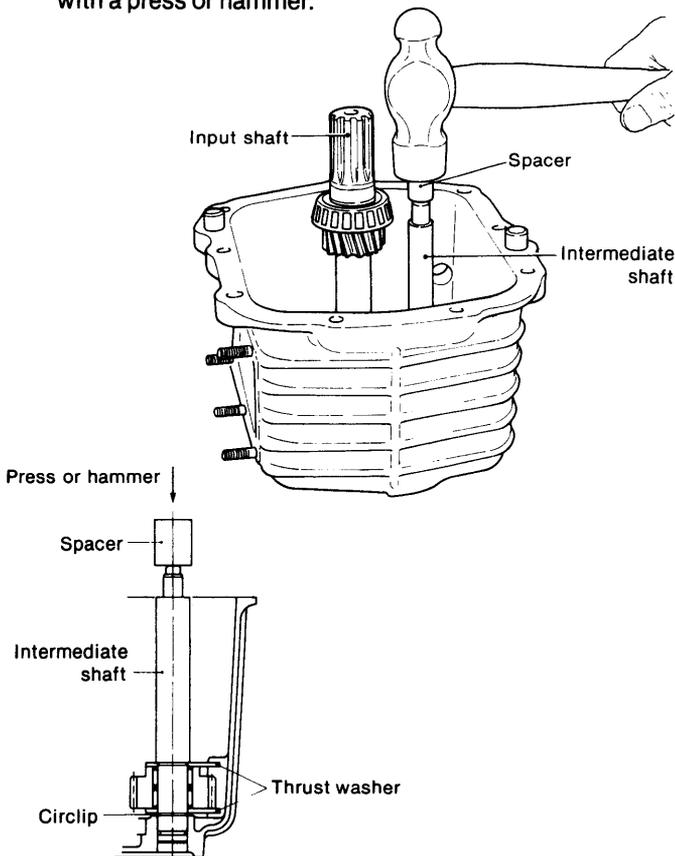
NOTE: Assemble the intermediate shaft as described in section 6-5. (5).

- (1) Insert the thrust washer the needle bearing and idle gear on the intermediate shaft. Then insert the thrust washer.

NOTE: Pay careful attention to the assembling direction of the thrust washer.



- (2) Insert the circlip on the intermediate shaft, and then insert the O-ring.
- (3) Press the assembled intermediate shaft into the case with a press or hammer.



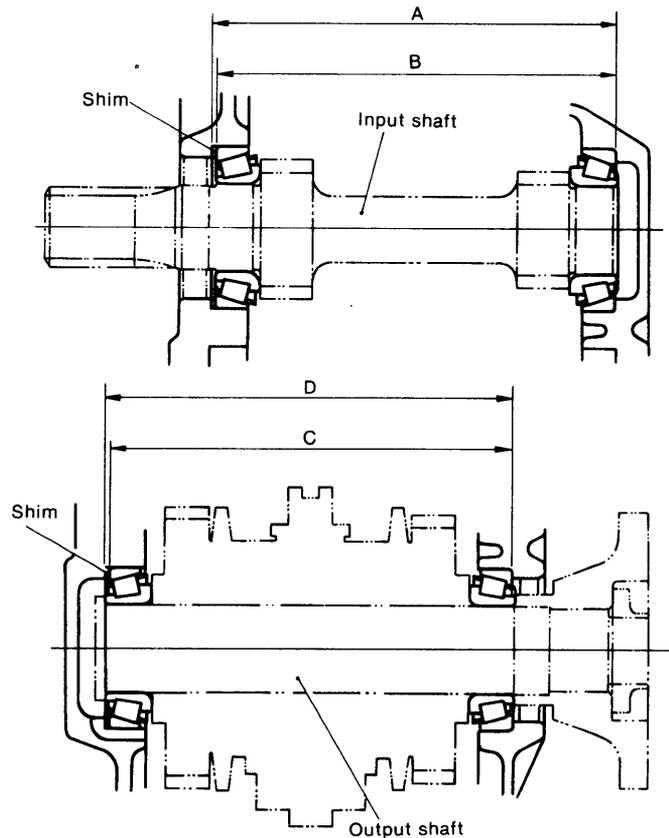
- (4) Make sure that the idle gear rotates smoothly.

6-5 Installing the input shaft and output shaft

- (1) Determining the thickness of the input shaft adjusting plate and output shaft adjusting plate

NOTE: As mentioned in section 5-1. (13), when none of the parts are replaced the adjusting plate can be reused without readjustment.

- 1) Measure length "A" "D" between the cases of each shaft of the case body and mounting flange.
- 2) Cover each bearing with the bearing outer race, and measure length "B" "C" between the bearings.



- 3) Adjust the input shaft adjusting plate thickness so that the clearance or tightening allowance is less than 0.05mm (0.0020in.).

- 4) Adjust the output shaft adjusting plate thickness so that the tightening allowance is within 0 ~ 0.1mm (0 ~ 0.0040in.).

- 5) Three adjustment plates of 0.5mm (0.0196in.), 0.4mm (0.0157in.) and 0.3mm (0.0118in.) are available.

Combine these plates to obtain the desired adjusting plate measurement.

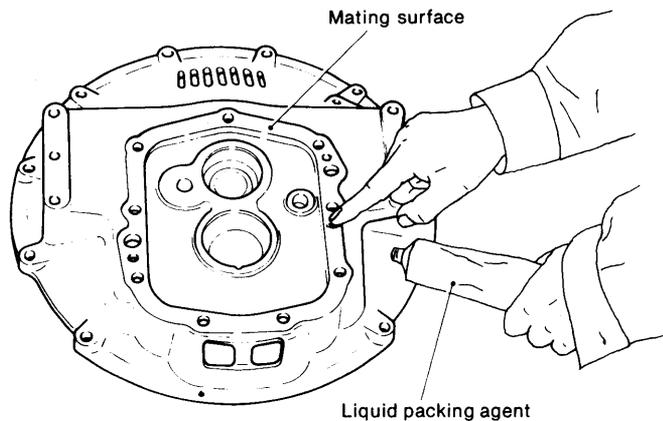
- (2) Insert the adjusting plate into the mounting flange, and press the outer race of the bearing.

Also, press the outer race of the bearing into the case.

NOTE: The outer race can be installed easily by heating the mounting flange and case to approximately 100°C, or by cooling the bearing outer race with liquid nitrogen, etc.

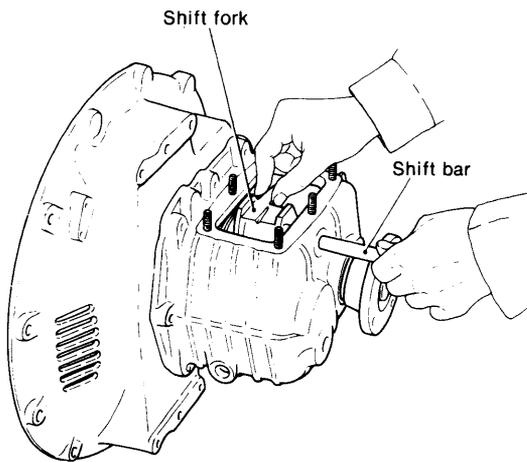
- (3) Coat the circumference of the oil seal with a liquid packing agent, and press it onto the mounting flange and case so that the spring part of the oil seal is inside the case.

- (4) Coat the mating surfaces of the mounting flange and case with a liquid packing agent. Wipe off oil and dirt on the mating surface of the case and coat with a thin film of liquid packing agent.

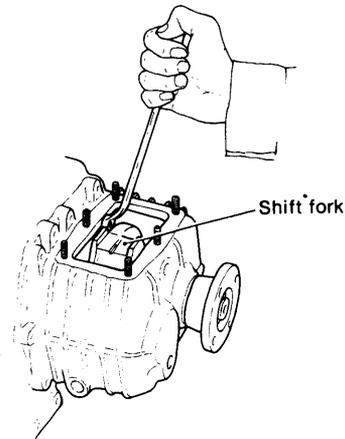


- (5) Insert the input shaft into the case, assemble the intermediate shaft as described in section 6-4 and then insert the output shaft into the case, mounted with shift fork and shift ring.
 (6) Align the mounting flange with the case, and insert the parallel pin by tapping the mounting flange with a plastic hammer.
 (7) Insert the super lock washer and tighten the M10 bolt.
 (8) Install the dipstick and packing.
 (9) Install the drain plug and packing.

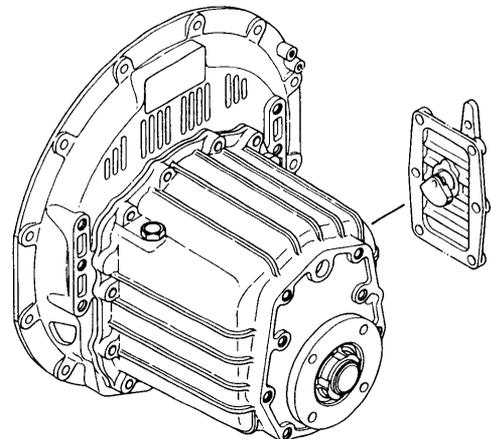
6-6 Reassembling and installing the operating system



- (1) Put the shift fork into neutral before installing.



- (3) Coat the circumference of the oil seal with a liquid packing agent and press the seal against the case cover.
 (4) Insert the spring into the shift cam.
 (5) Insert the knock pin into the shift cam from the front end, and lock with the circlip.
 (6) Insert the assembled shift cam into the case cover.



- (7) Fit the shift lever to the shift cam, and tighten the M8 bolt.

NOTE: The shift cam must rotate smoothly.

- (8) Replace the packing if it is damaged.
 (9) Attach the case side cover with operating system in the case body.

At this time, make sure that the shift cam is fitted to the shift fork, and that the shift lever is in neutral.

NOTE: Put the shift fork into neutral before installing.

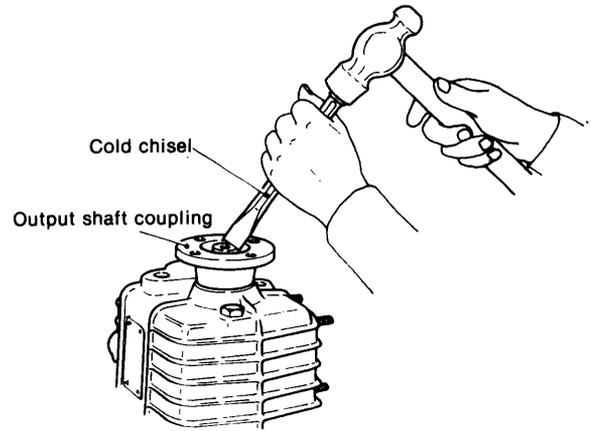
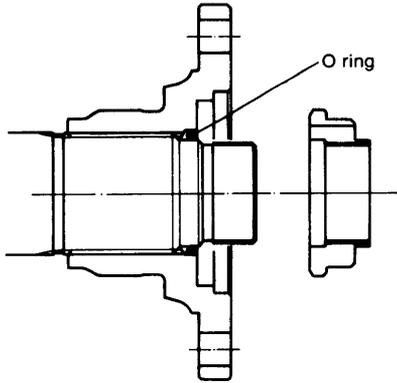
- (10) Insert the super lock washer, and tighten the M8 nut.
 (11) Shift the shift lever to forward and reverse to make sure that the lever operates normally.

If the lever does not operate normally, loosen the M8 nut, slide the case side cover forward, backward, and to the left and right, then re-tighten with the M8 nut in the position at which the lever operates normally.

NOTE: If the lever operates normally a click will be heard when it is put into forward and reverse.

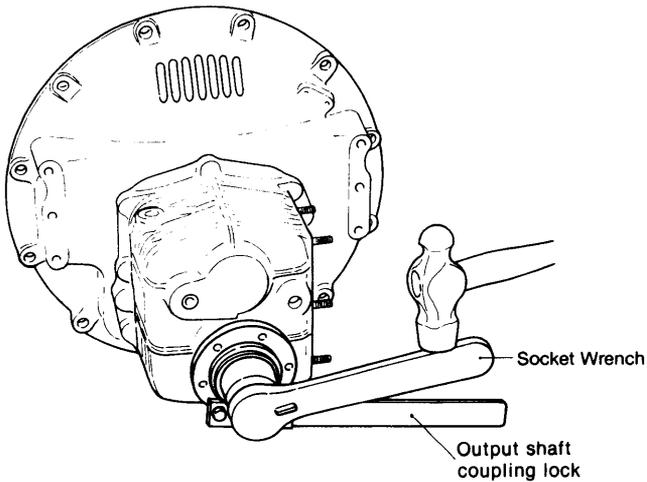
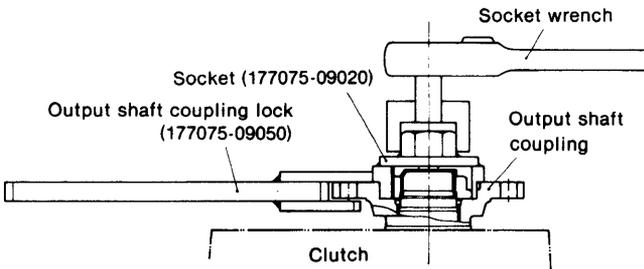
6-7 Installing the output shaft coupling

- (1) Install the output shaft coupling on the output shaft and then insert the O-ring in the groove between the output shaft and the output shaft coupling.

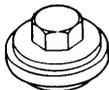
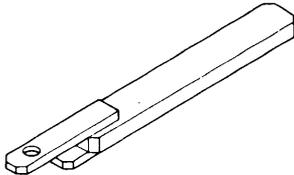
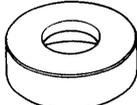
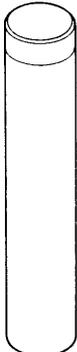


- (2) Tighten and caulk the output shaft lock nut, using the assembly tool.
Tightening torque....., 15kg-m (108.5ft-lb)

- (3) Shift the shift lever to the neutral position and make sure the clutch engages when the shift lever is put into forward and reverse.
The input/output shafts will not rotate smoothly if the side gap of the bearing is too small in relation to the thickness of the adjusting plate.



7. Special Tools

Name of tool	Part number	Illustration	Application
Socket	177075-09020		For removing and tightening the output shaft nuts.
Output shaft coupling lock	177075-09050		For removing and tightening the output shaft nut.
Plate for spring retainer	177095-09070		For removing and installing the plate spring, retainer and circlip of the large gear (forward and reverse).
Assembly spacer	177075-09010		For determining the thickness of adjusting plate.
Inserting tool	177075-09040		For installing the spacer and needle bearing inner race of the output shaft (reverse small gear side).
Inserting tool	177075-09030		For installing the thrust bearing of the input shaft.

Marine Gear Model

KM4A

for Engine Models 4JH-BE, 4JH-TBE, 4JH-HTBE and 4JH-DTBE

1. Construction

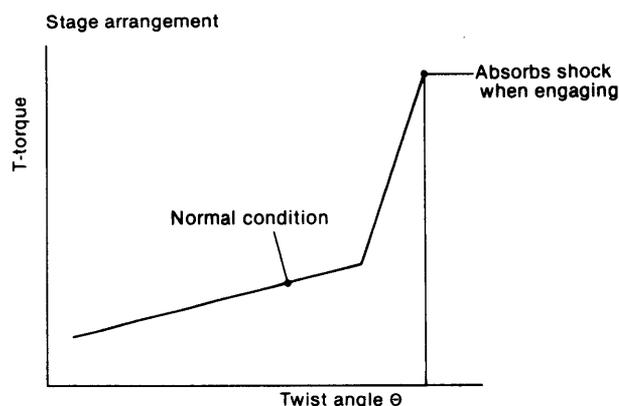
1-1 Construction

The clutch is a cone-type, mechanically operated clutch. When the drive cone (which is connected to the clutch shaft by the lead spline) is moved forward or backward, its taper contacts with the clutch gear and transfers power to the output shaft.

The construction is simple when compared with other types of clutch and it serves to reduce the number of components, making for a lighter, more compact unit which can be operated smoothly. Although it is small, the power transmission efficiency is high even under a heavy load. It is also durable and reliable because high grade materials are used for the shaft and gear, and a taper roller bearing is incorporated. Power transmission is smooth because connection with the engine is made through the damper disc.

- The drive cone is made from special aluminum bronze which has high wear-resistance and durability. The drive cone is connected with the clutch shaft. The taper angle, diameter of the drive cone, twist angle, and diameter of the involute spline, are designed to give the greatest efficiency, thus ensuring that the drive cone can be readily engaged or disengaged.
- Helical gears are used for greater strength. The intermediate shaft is supported at 2 points to reduce deflection and gear noise.
- The clutch case and mounting flange are made from an aluminum alloy of special composition to reduce weight. This is non-corrosive in seawater.
- The damper disc is fitted to the input shaft, so power can be transmitted smoothly. Springs of different strengths are used for the damper disc so that two stages of torque and twist angle are applied. That is, in the first stage, only the weak spring is used, and the strong spring comes into action for a torque higher than a predetermined value.

This prevents gear noise due to torsional vibration, as well as absorbing shock when engaging.



There is a small clearance between the dipstick and the inside of the dipstick tube. A small hole in the dipstick works as a breather.

- When the load on the propeller is removed, the engagement of the drive cone and the clutch gear is maintained by the shifter and V-groove of the drive cone. Even when the drive cone's tapered area and V-groove are worn, this engagement is maintained by the shift lever device. Accordingly no adjustment of the remote control cable is required.
- The cup spring on the rear of the clutch gear absorbs rotational fluctuations and stabilizes the engagement of the drive cone and the clutch gear. Thus, the durability of the cone against wear is enhanced.

- A torque limiter is built into the input shaft gear to prevent damage caused by excessive torque.
- The lube oil temperature can be controlled because in addition to the input shaft gear which functions as a centrifugal pump, an oil cooler is also equipped.
- The oil cooler is equipped with a cooling water drain cock to prevent cracks caused by freezing in cold weather. It is therefore easy to drain the water.
- The propeller shaft can rotate in both counter clockwise (C.C.W.) and clockwise (C.W.) directions.

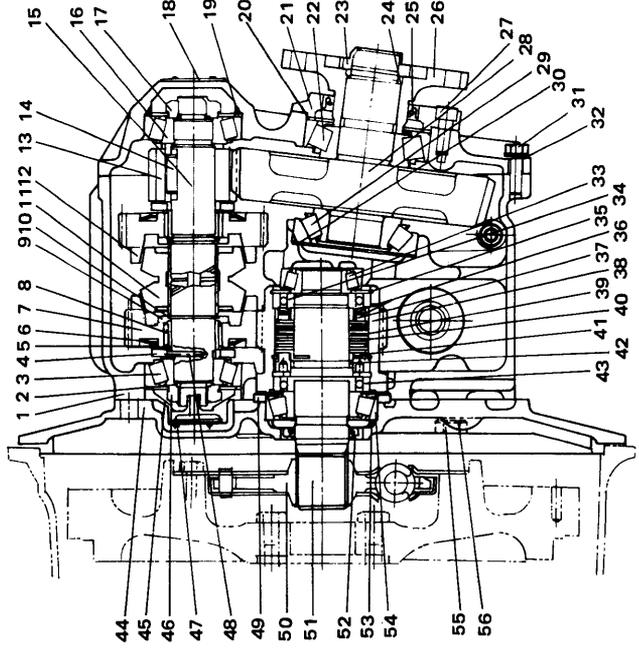
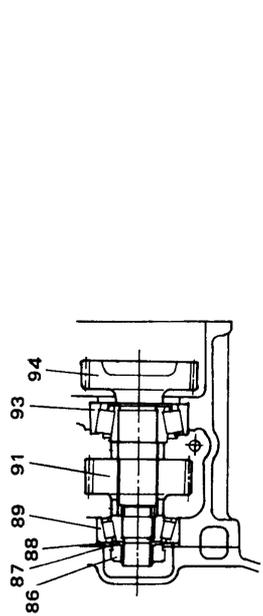
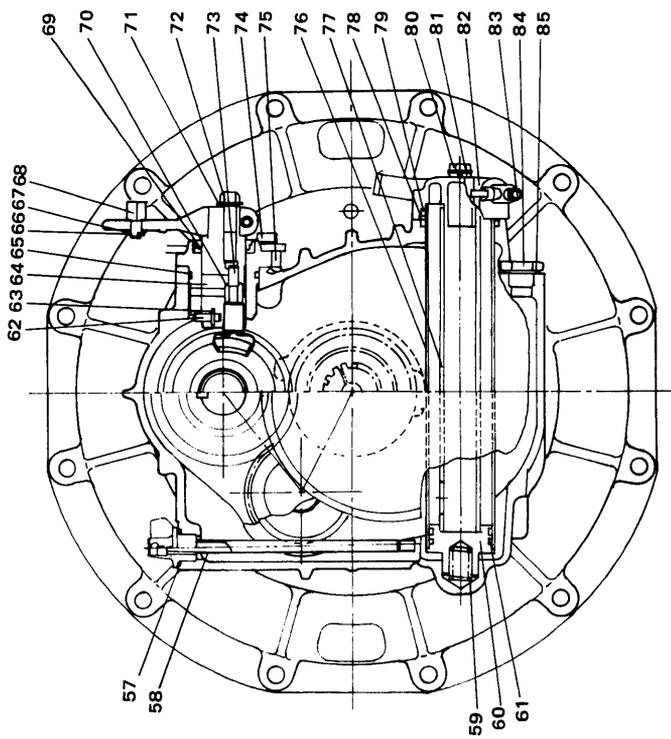
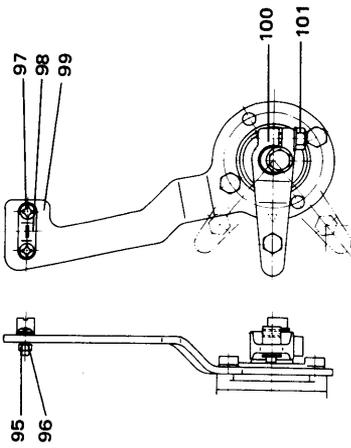
NOTE: Since the difference in reduction gear ratio between C.C.W. and C.W. rotations is within 0.07%, no problem occurs in operation.

1-2 Specifications of Angle Drive Marine Gear

Model		KM4A		
For engine models		4JH-BE, 4JH-TBE, 4JH-HTBE, 4JH-DTBE		
Down angle		7 degree		
Clutch		Constant mesh gear with servo cone clutch (wet type)		
Direction of rotation	Input shaft	Counter-clockwise, viewed from stern.		
	Output shaft	Bi-rotation		
Reduction ratio		3.30	2.63	2.14
Propeller shaft rpm at cont. rating		1062	1332	1637
Remote control	Control head	Single lever control		
	Cable	Morse, 33-C (Cable travel 76.2mm or 3 in.)		
	Clamp	YANMAR Made, standard accessory		
	Cable connector	YANMAR Made, standard accessory		
Output shaft coupling	Outer diameter	φ120mm (4.72")		
	Pitch circle diameter	φ100mm (3.93")		
	Connecting bolt holes	4-φ10.5mm (4-φ0.41")		
Position of shift lever		Right side, viewed from stern		
Lubricating oil		Same as Engine lube oil		
Lubricating oil capacity		1.3ℓ		
Lube oil cooler		Sea-water cooling		

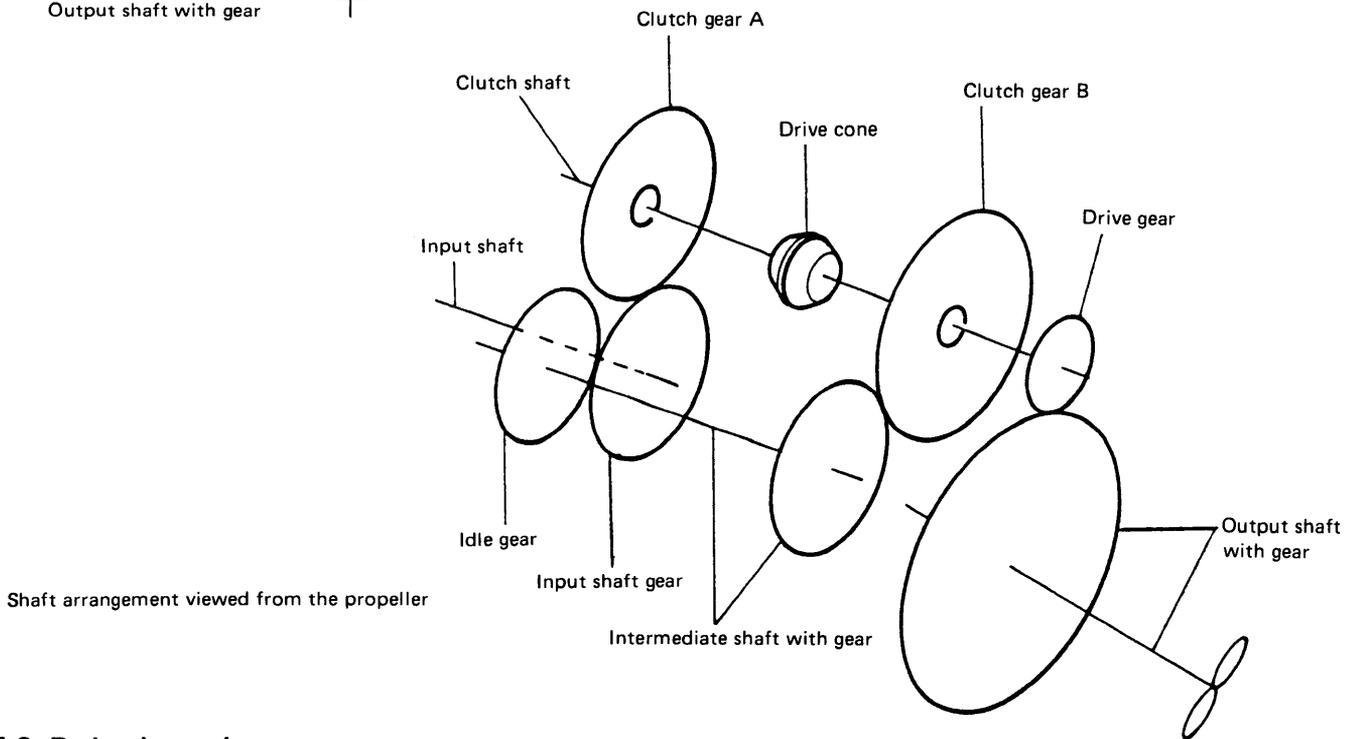
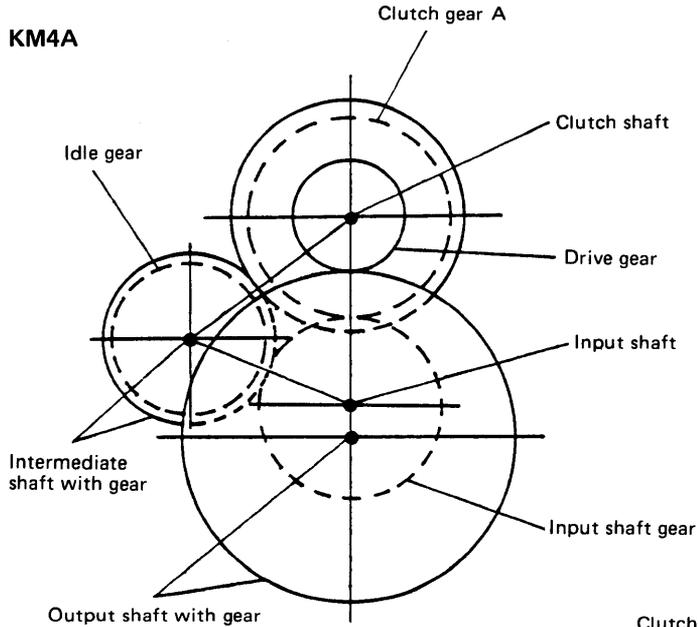
1-3 KM4A Sectional View

- 1 Clutch case
- 2 Shim
- 3 Bearing
- 4 Thrust collar (A)
- 5 Spring retainer
- 6 Cup spring
- 7 Clutch gear (A)
- 8 Needle bearing
- 9 Thrust collar (B)
- 10 Snap ring
- 11 Drive cone
- 12 Clutch gear B
- 13 Driving gear
- 14 Key
- 15 Clutch shaft
- 16 Bearing
- 17 End nut
- 18 Name plate
- 19 Shim
- 20 Shim
- 21 Output shaft cover
- 22 Bearing
- 23 End nut
- 24 O-ring
- 25 Oil seal
- 26 Output shaft coupling
- 27 Bolt
- 28 Output shaft
- 29 Bearing
- 30 Shim
- 31 Bolt
- 32 Washer
- 33 Bearing
- 34 Ball bearing
- 35 Snap ring
- 36 Cup spring
- 37 Spacer
- 38 Input shaft gear
- 39 Plate (A)
- 40 Plate (B)
- 41 Lock nut
- 42 O-ring
- 43 Ball bearing
- 44 Mounting flange
- 45 Lube oil filter case
- 46 End nut
- 47 Lube oil filter
- 48 Pin
- 49 Centering bush
- 50 Dumper disk
- 51 Input shaft
- 52 Oil seal
- 53 Shim
- 54 Bearing
- 55 Nut
- 56 Washer
- 57 O-ring
- 58 Dip stick
- 59 Spring
- 60 Cover
- 61 O-ring
- 62 Location pin
- 63 Spring pin
- 64 Shift lever shaft
- 65 O-ring
- 66 Washer
- 67 Split space pin
- 68 Pivot
- 69 Oil seal
- 70 Spring
- 71 Shim
- 72 Stopper bolt
- 73 Shifter
- 74 Bolt (M8 x 30)
- 75 Side cover
- 76 Oil-cooler body
- 77 Pipe
- 78 Shim
- 79 O-ring
- 80 Bolt
- 81 Washer
- 82 Cooler
- 83 Cock
- 84 Drain plug
- 85 Washer
- 86 End nut
- 87 Washer
- 88 Shim
- 89 Bearing
- 90
- 91 Idle gear
- 92
- 93 Bearing
- 94 Intermediate shaft gear
- 95 Washer
- 96 Lock nut
- 97 Bolt
- 98 Cable clamp
- 99 Cable bracket
- 100 Shift lever
- 101 Bolt (M8 x 25)



1-4 Power Transmission System

1-4-1 Arrangement of shafts and gear

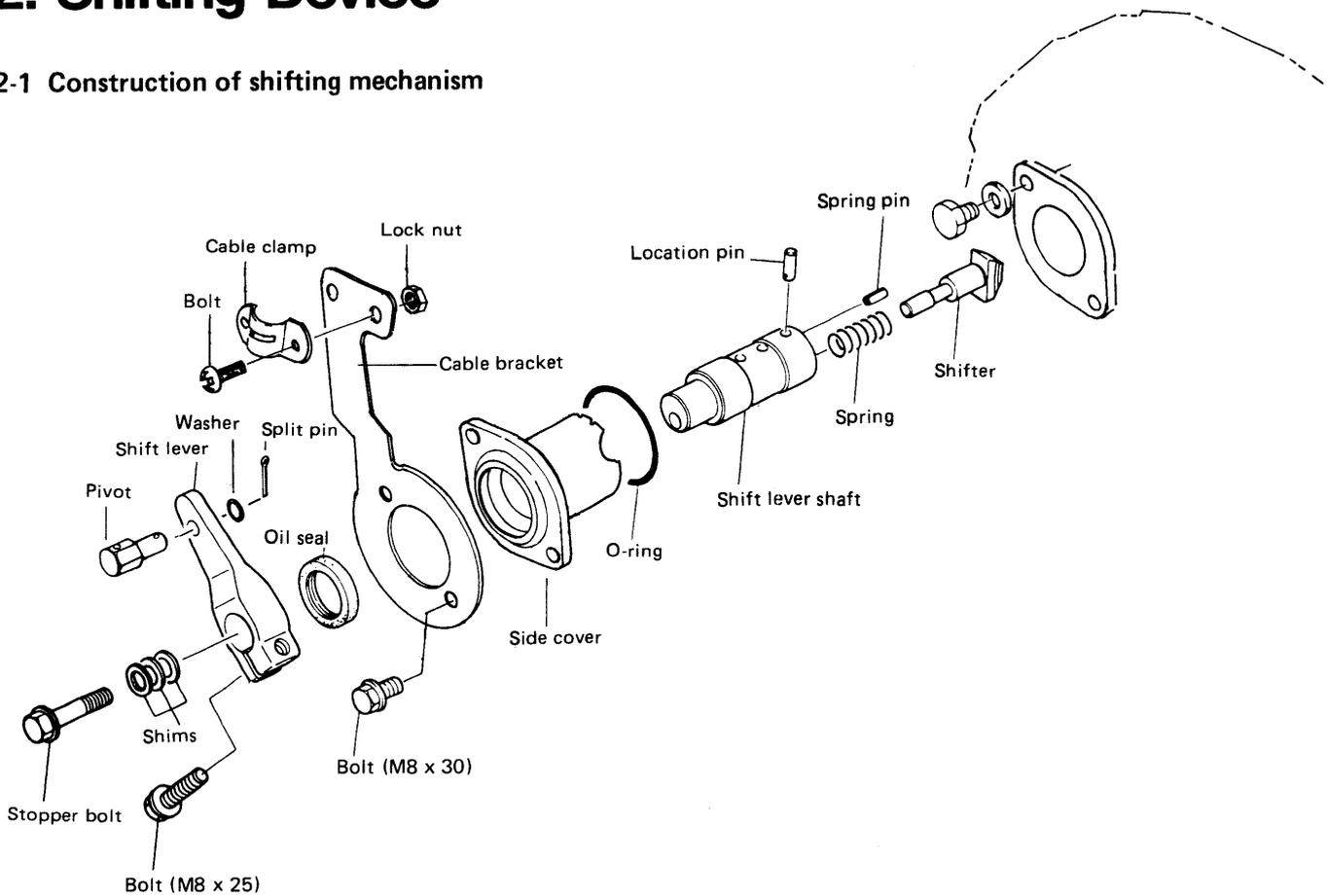


1-4-2 Reduction ratio

Input shaft gear	Clutch gear		Intermediate shaft		Drive gear	Output shaft with gear	Reduction ratio
	A	B	Idle gear	Shaft gear			
39	41	45	31	34	30	61	2.14
					26	65	2.63
					22	69	3.30

2. Shifting Device

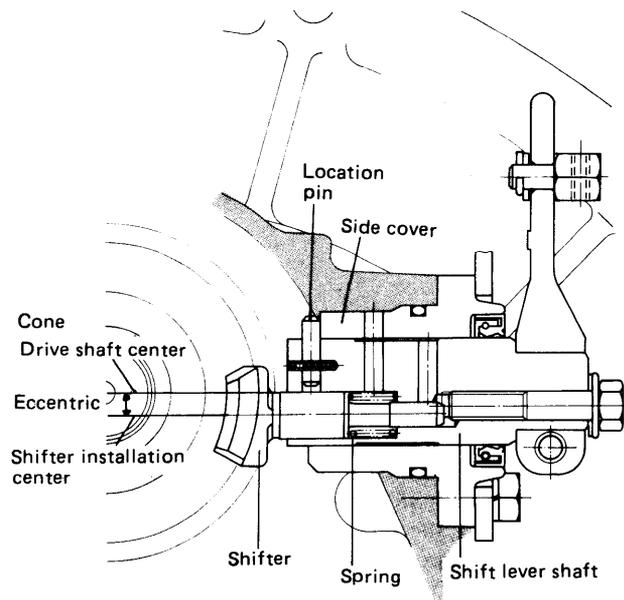
2-1 Construction of shifting mechanism



The shift lever shaft is installed on the side cover with neutral, clutch gear (A) and clutch gear (B) positions provided on the cover. The neutral, clutch gear (A) and clutch gear (B) location pins of the shift lever shaft are constantly inserted into their respective grooves on the shift lever by the tension of the shifter spring. The shifter is set on the eccentric hole of the shift lever shaft and moves the drive cone in the neutral position either to the clutch gear (A) or clutch gear (B) positions, and then back to the neutral position. (The shift lever shaft moves slightly to the shift lever (or drive cone) side when the shift lever is placed in the clutch gear (A) or clutch gear (B) positions.)

NOTE:1 Clutch gear (A) position: clockwise propeller rotation viewed from propeller side (C.C.W.)

NOTE:2 Clutch gear (B) position: Counterclockwise propeller rotation viewed from propeller side (C.W.)



2-2 Clutch gear (A) and clutch gear (B) operation (Neutral ⇒ clutch gear (A), Neutral ⇒ clutch gear (B))

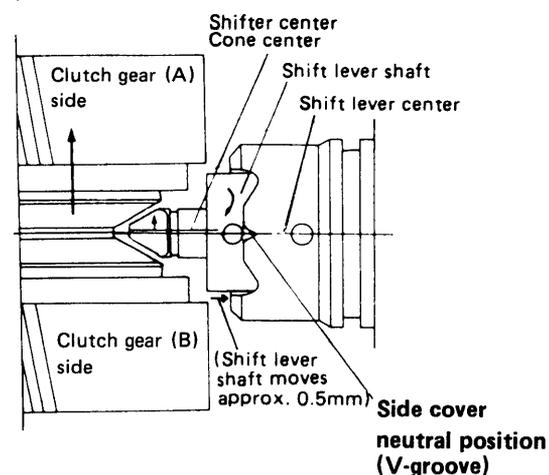
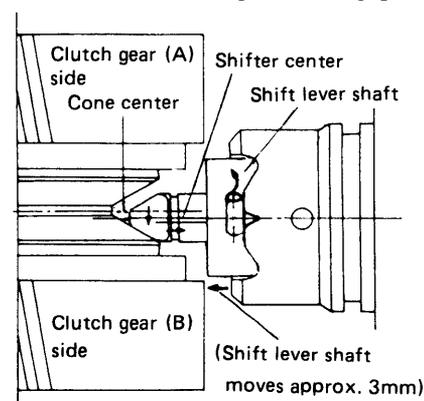
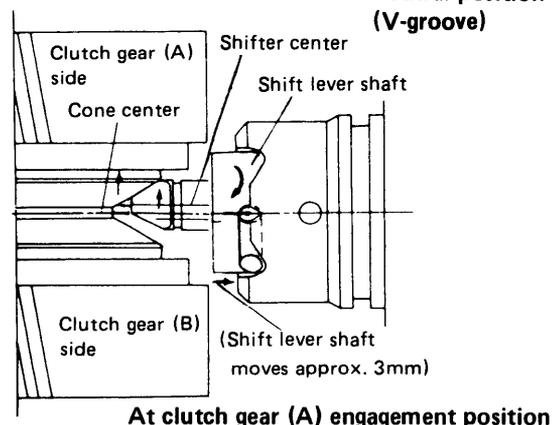
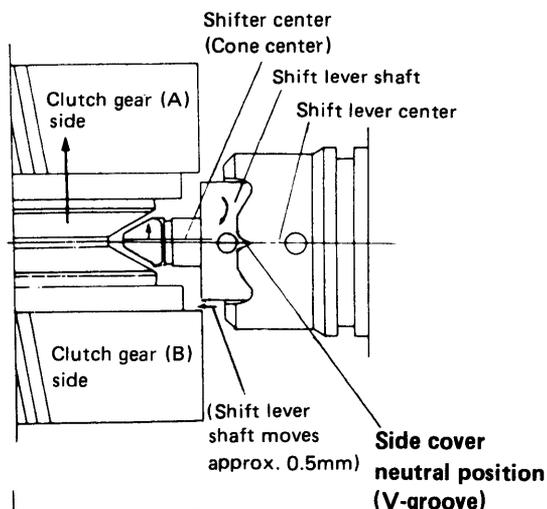
When the shift lever is moved to the clutch gear (A) position from the neutral position, the shift lever shaft starts to revolve, and the location pin disengages from the neutral V-groove position of the side cover. (Shift lever moves approx. 0.5mm to the drive cone side.) At this time the shifter, which is set on the eccentric hole of the shift lever shaft, moves the drive cone's V-groove to the clutch gear (A).

When the location pin of the shift lever shaft falls into the clutch gear (A) position groove on the side cover, the shift lever shaft moves approx. 3mm to the shift lever side, and the shifter starts to press the drive cone V-groove to the clutch gear (A) side by spring force.

2-3 Engagement and disengagement of clutch (Clutch gear (A) ⇒ Neutral, Clutch gear (B) ⇒ Neutral)

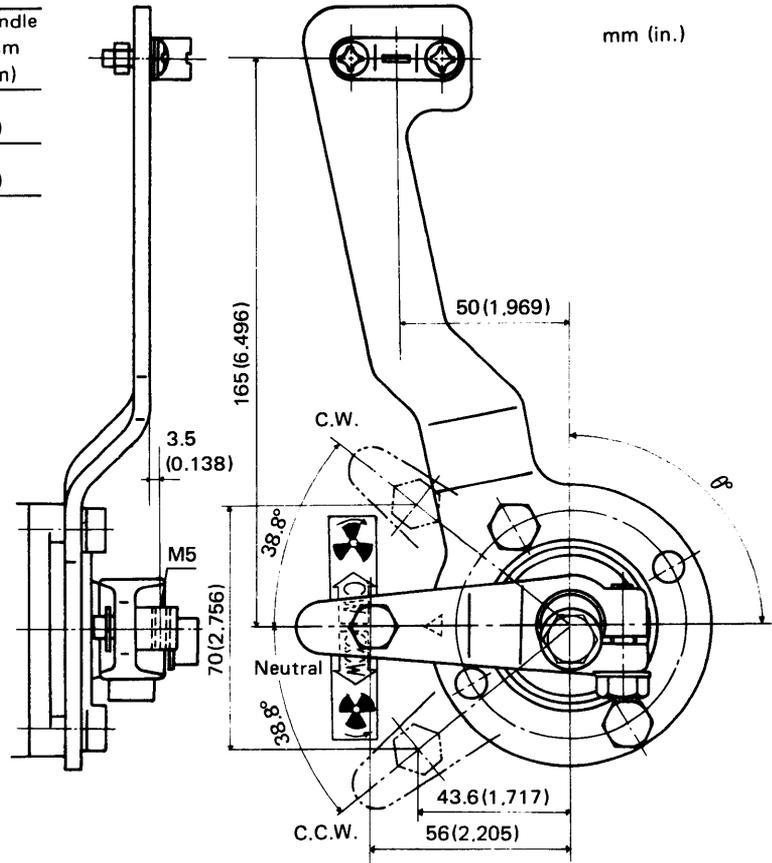
When the shift lever is moved to the clutch gear (A) position from the neutral position, the shift lever shaft starts to revolve, and the location pin disengages from the clutch gear (A) position groove on the side cover. (The shift lever shaft moves approx. 3mm to the drive cone side.) At this time, the shifter which is set on the eccentric hole of the shift lever shaft, is moved to the neutral side (clutch gear (B) side). The drive cone, however, is engaged with the clutch gear (A) as the torque force produced by the revolving centrifugal force.

Further, when the shift lever shaft starts to revolve, and the positioning pin falls into the neutral V-groove position of the side cover (the shift lever shaft travels approx. 5mm to the shift lever side), the shifter moves to the shift lever side (to the spring side) while moving the V-groove of the drive cone to the clutch gear (B) side. The movement of the shifter to the shift lever side, however, is stopped when the shifter end contacts the stopper bolt. The shifter only works to press the V-groove of the drive cone to the clutch gear (B) side. Thus, the drive cone is disengaged from the clutch gear (A). After this disengagement, the transmission torque of the drive cone is decreased to zero and the shift lever is returned to the neutral position by spring force.



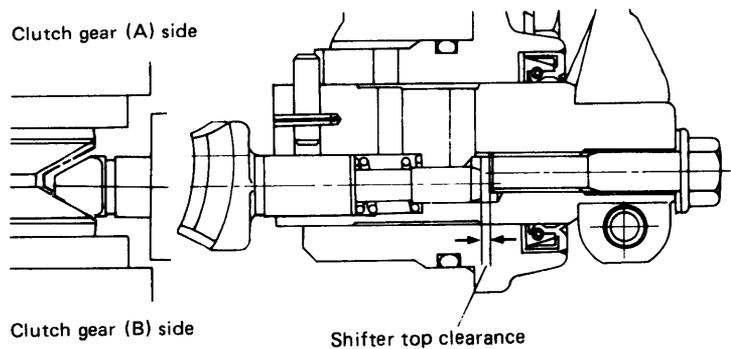
2-4 Clutch shifting force

Shifting position Shifting direction	Shift lever position at 56mm	Remote control handle position at 170mm (Cable length, 4m)
Engaging force at 1000 rpm	3 ~ 4 kg (6.6 ~ 8.8 lbs)	4 ~ 5 kg (8.8 ~ 11.0 lbs)
Disengaging force at 1000 rpm	3.5 ~ 5 kg (7.7 ~ 11.0 lbs)	4 ~ 6 kg (8.8 ~ 13.2 lbs)



2-5 Adjustment of shifting device

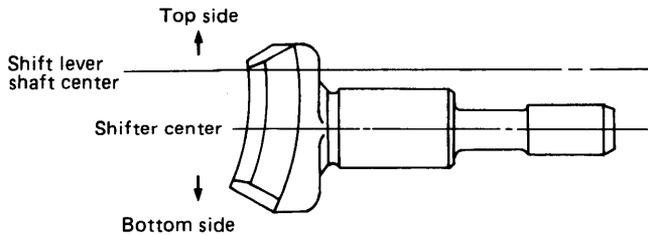
Whenever the side cover, shift lever shaft, shifter, stopper bolt or drive cone is replaced, be sure to adjust the clearance between the shifter end and the stopper bolt with shims. When the adjustment of this clearance is inadequate, the drive cone may not connect properly when the shift lever is moved to the neutral position, either from the clutch gear (A) or clutch gear (B) position.



2-5-1 Measurement and adjustment of clearance

(1) Assemble the shifting mechanism (without installing the stopper bolt of the shifter) to the marine gear case.

NOTE: Ensure the correct alignment of the shifter before assembly.



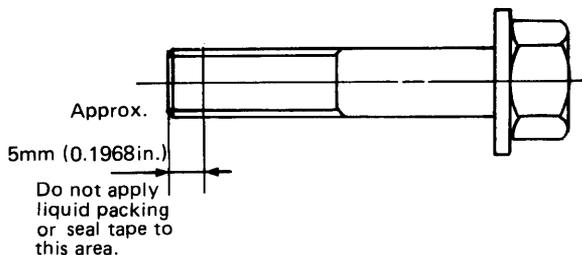
- (2) Turn the shift lever 10 ~ 15 degrees either to the clutch gear (A) or clutch gear (B) position from the neutral position.
- (3) Measure the L-distance between the shift lever shaft end surface and the shifter end.
- (4) Measure the H-distance (the distance from the neck of the stopper bolt to its end).
- (5) Obtain the shim thickness "T" by the following formula.

$$T = (H - L + 1.25) \pm 0.1\text{mm} (0.0039\text{in.})$$

NOTE: Shim set includes one each of 1mm, 0.4mm, 0.3mm, 0.25mm shims.
(YANMAR Part No. 177088-06380)

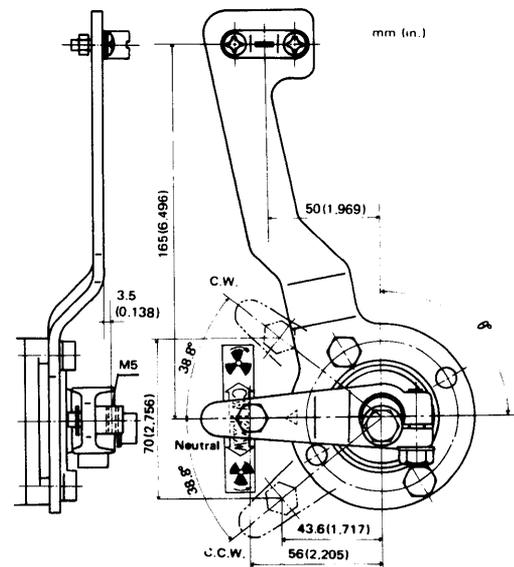
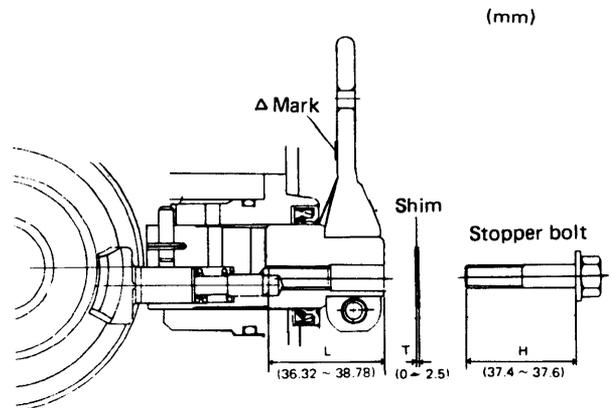
(6) Insert shim (s) of proper thickness to the stopper bolt side and tighten to the shift lever shaft.

NOTE: When tightening the stopper bolt, apply either a non-drying type liquid packing (THREE BOND No.1215), or a seal tape around the bolt threads.



2-5-2 Inspect for the following points (to be inspected every 2-3 months)

- (1) Looseness at the connection of the cable connector and the remote control cable.
- (2) Looseness of the attaching nut of the cable connector and the shift lever.

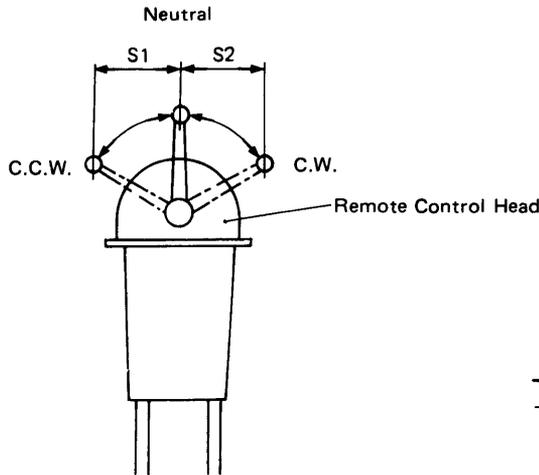


NOTE. Shift lever must be installed in the direction of the Δ-mark ensuring the specified installation angle (θ).

$$\theta = 90^\circ$$

2-6 Adjustment of the remote control head Marine gearbox control side

(1) Equal distribution of the control lever stroke.

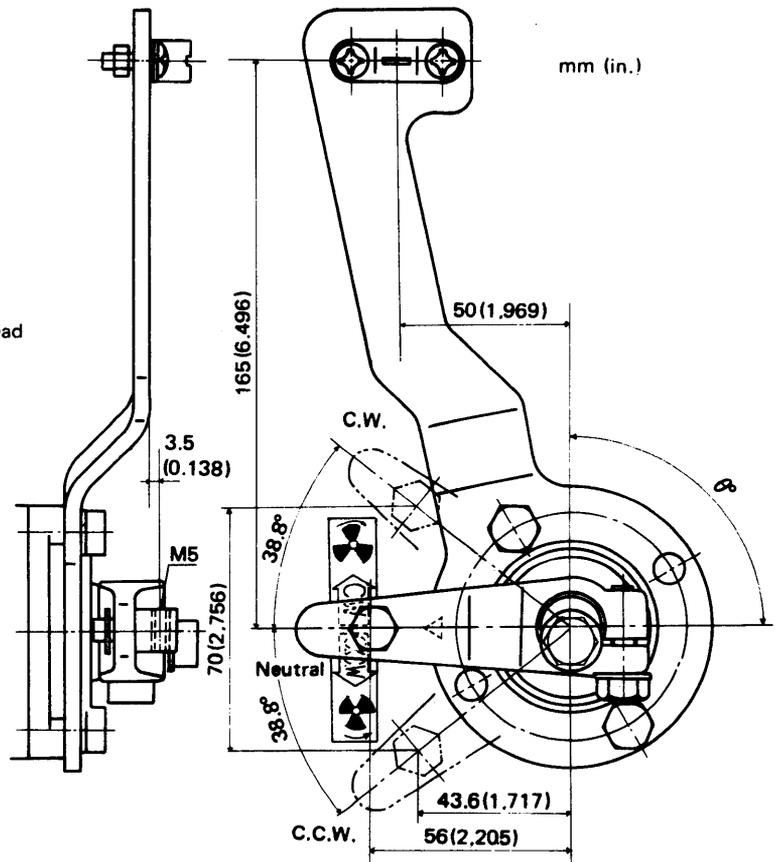
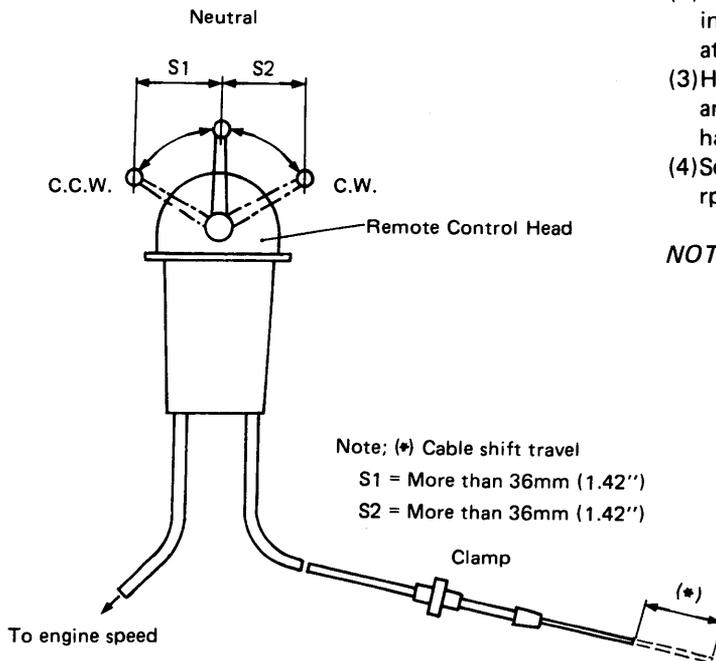


The stroke between the neutral position → C.W. position (S2), and the neutral position → C.C.W. position (S1) must be equalized.

When either stroke is too short, clutch engagement becomes faulty.

(2) Equalizing the travel distance of the control cable.

After ensuring the equal distribution of the stroke described in (1), connect the cable to the control head. Adjust so that the cable shift travel of the S1 and S2 control lever strokes becomes identical.



2-7 Cautions

- (1) Always stop the engine when attaching, adjusting, and inspecting.
- (2) When conducting inspection immediately after stopping the engine, do not touch the clutch. The oil temperature is often raised to around 90°C (194°F).
- (3) Half-clutch operation is not possible with this design and construction. Do not use with the shift lever halfway to the engaged position.
- (4) Set the idling engine speed at between 800 and 850 rpm.

NOTE: The dual (Two) lever remote control device cannot be used.

3. Inspection and Servicing

3-1 Clutch case and cover

- (1) Check the clutch case and cover for cracking with a test hammer.
Perform a color check when required.
If the case and cover are cracked, replace those together.
- (2) Check for staining on the inside surface of the bearing section.
Also, measure the inside diameter of the case and cover.
Replace the case and cover if these are worn beyond the wear limit.

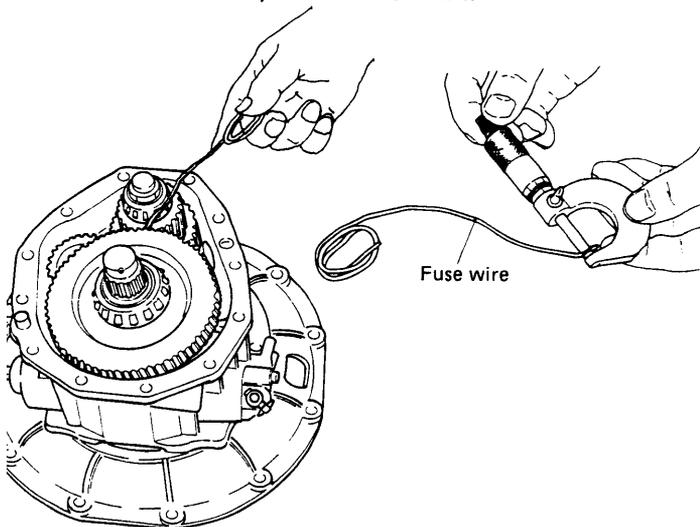
3-2 Bearing

- (1) Rusting and damage.
If the bearing is rusted or the taper roller retainer is damaged, replace the bearing.
- (2) Make sure that the bearings rotate smoothly.
If rotation is not smooth, if there is any binding, or if any abnormal sound is evident, replace the bearing.

3-3 Gear

Check the surface, tooth face conditions and backlash of each gear. Replace any defective part.

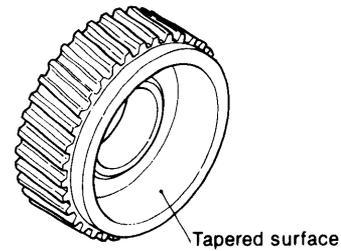
- (1) Tooth surface wear.
Check the tooth surface for pitting, abnormal wear, dents, and cracks. Repair the lightly damaged gears and replace heavily damaged gears.
- (2) Tooth surface contact.
Check the tooth surface contact. The amount of tooth surface contact between the tooth crest and tooth flank must be at least 70% of the tooth width.
- (3) Backlash.
Measure the backlash of each gear, and replace the gear when it is worn beyond the wear limit.



	mm (in.)	
	Maintenance Standard	Wear limit
All gears	0.08 ~ 0.16 (0.0031 ~ 0.0063)	0.3 (0.0118)

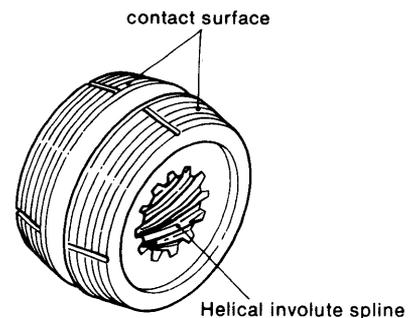
3-4 Clutch gear (A) and (B)

- (1) Contact surface with drive cone.
Visually inspect the tapered surface of the clutch gears (A) and (B) where they make contact with the drive cone to check if there is any abnormal condition or sign of overheating.
If any defect is found, replace the gear.



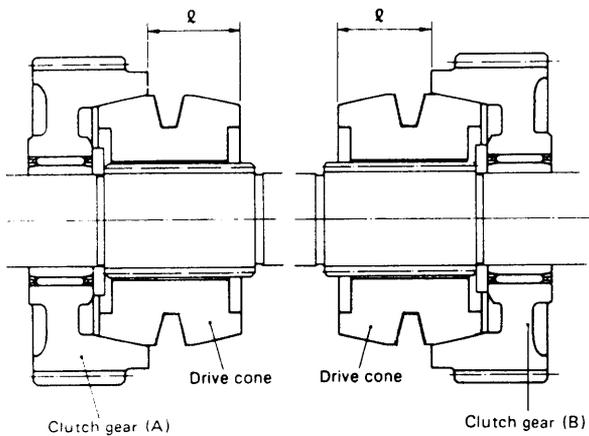
3-5 Drive cone

- (1) Visually inspect that part of the surface that comes into contact with the circumferential triangular slot to check for signs of scoring, overheating or wear. If deep scoring or signs of overheating are found, replace the cone.



- (2) Check the helical involute spline for any abnormal condition on the tooth surface, and repair or replace the part should any defect be found.

(3) Measure the amount of wear on the tapered contact surface of the drive cone, and replace the cone when the wear exceeds the specified limit.

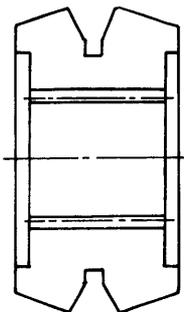


mm(in.)

	Standard dimensions	Limited dimensions
Dimensions l	29.2 ~ 29.8 (1.1496 ~ 1.1732)	28.1 (1.1063)

NOTE: When dismantled, the forward or reverse direction of the drive cone must be clearly identified.

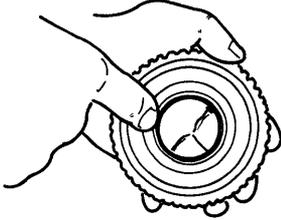
(4) If the wear of the V-groove of the drive cone is excessive, replace the part.



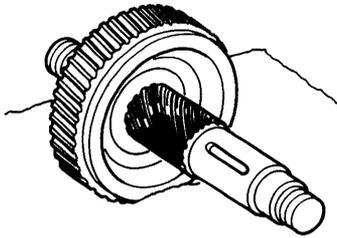
NOTE: When replacing the drive cone, the drive cone and clutch gears (A) and (B) must be lapped prior to assembly.
The lapping procedure is described below.

3-5-1 Lapping Procedure for Drive Cone

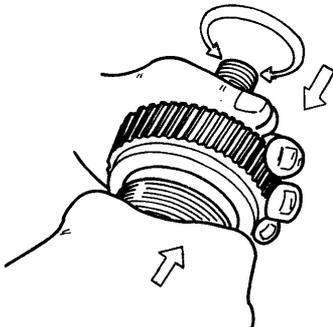
(1) Coat the lapping powder onto the cave of the clutch gear (Lapping powder: 67 micron silicon carbide #280)



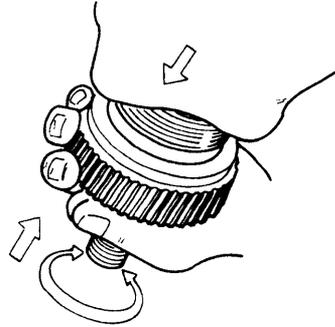
(2) Set the clutch gear on the clutch shaft with a needle bearing and then set the drive cone on the clutch shaft



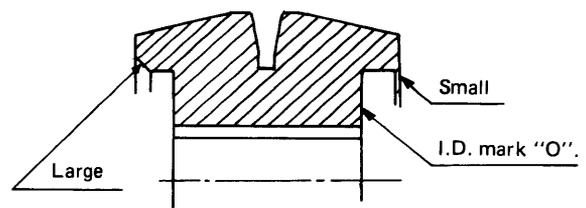
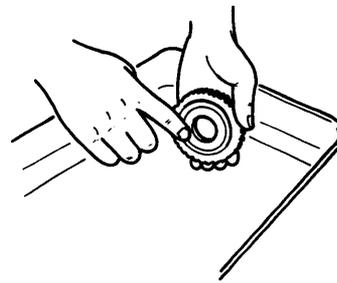
(3) Lap the clutch gear's cave and drive cone, pushing them together by hand



(4) Push and turn the clutch gear about 5 times both clockwise and counter-clockwise.

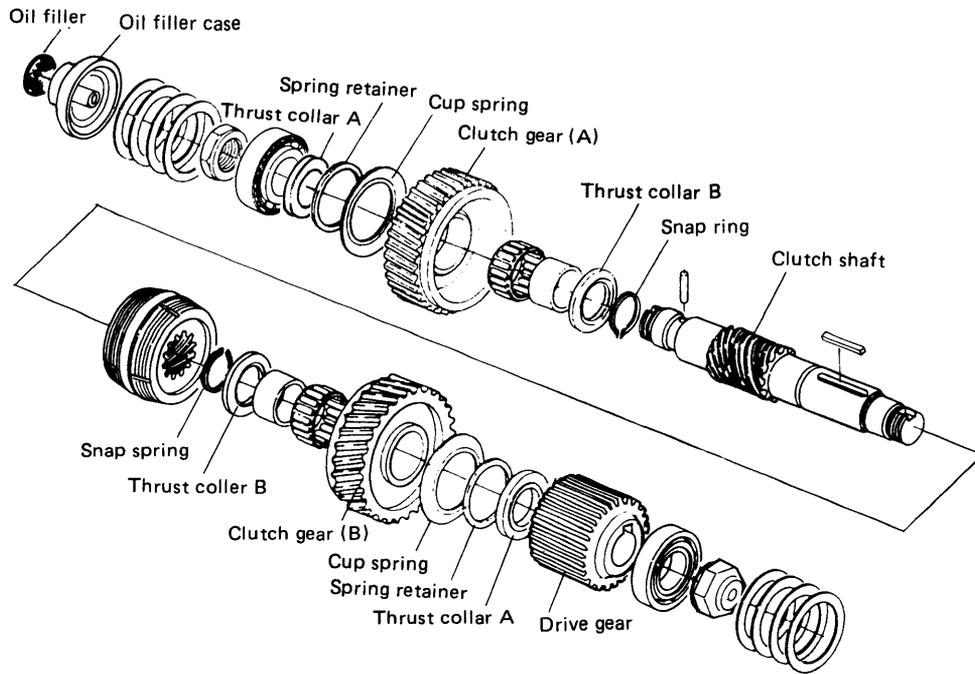


(5) After lapping them, wash them with washing oil. The lapped parts should be cleaned completely.



NOTE: Do not mix the combination of the lapped parts. The washing oil should be changed frequently in order to prevent residual powder being left on the parts. When assembling the drive cone, be sure to check its alignment. The larger chamfering face should be on the clutch gear (A) side.

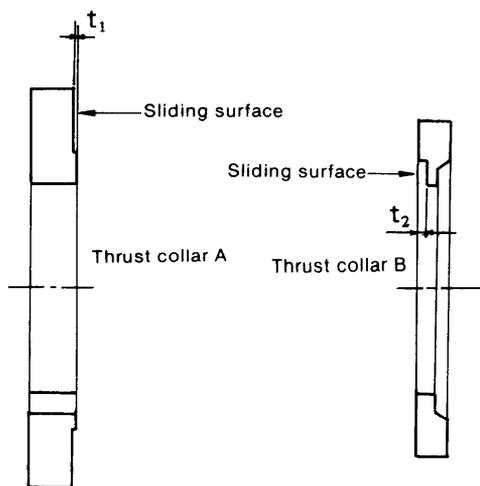
3-6 Thrust collar A and B for clutch shaft



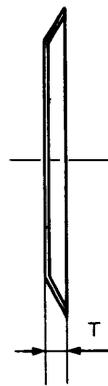
- (1) Visually inspect the sliding surface of thrust collar A or B to check for signs of overheating, scoring, or cracks. Replace the collar if any abnormal condition is found.
- (2) Measure the thickness of thrust collar A or B, and replace it when the dimension exceeds the specified limit.

3-7 Cup spring and spring retainer

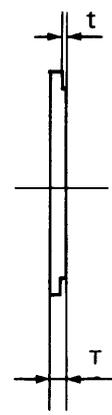
- (1) Check for cracks and damage to the cup spring and spring retainer. Replace the part if defective.
- (2) Measure the free length of the cup spring and the thickness of the spring retainer. If the length or the thickness deviates from the standard size, replace the part.



Cup spring



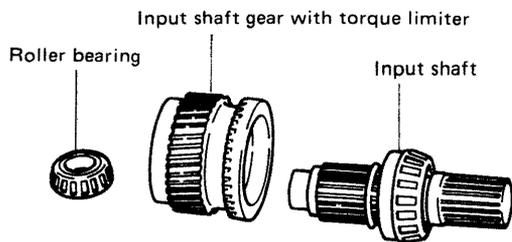
Spring retainer



Stepped wear	mm (in.)	
	Standard	Limit
Thrust collar A, t_1	t_1 0.1 (0.0039)	0.05 (0.0020)
Thrust collar B, t_2	t_2 1.0 (0.0394)	0.20 (0.0079)

	mm (in.)	
	Standard	Limit
Cup spring, T	2.8 ~ 3.1 (0.1102 ~ 0.1220)	2.6 (0.1024)
Spring retainer, T	2.92 ~ 3.08 (0.1150 ~ 0.1213)	2.8 (0.1102)
Spring retainer, t	—	0.1 (0.0039)

3-8 Input shaft



(1) Spline part.

Whenever uneven wear and/or scratches are found, replace with a new part.

(2) Surface of oil seal.

If the sealing surface of the oil seal is worn or scratched, replace.

(3) Torque limiter parts.

If the torque limiter has slipped due to excessive torque, measure the size of the inner parts listed top right. If the parts are excessively damaged replace.

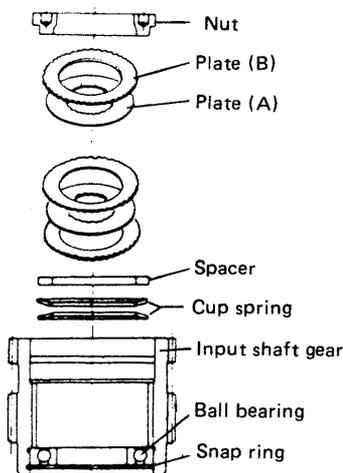
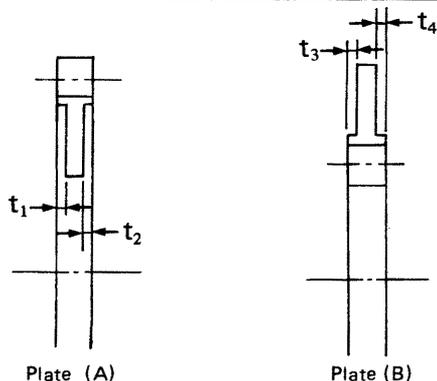
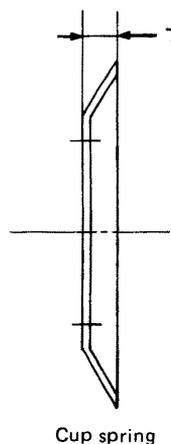


Plate (A) and (B) mm(in.)

Stepped wear	Standard	Limit	Q'ty/unit
Plate (A) ($t_1 + t_2$)	0.95 ~ 1.05 (0.0374 ~ 0.0413)	0.92 (0.0362)	15
Plate (B) ($t_3 + t_4$)	0.35 ~ 0.45 (0.0138 ~ 0.0177)	0.32 (0.0126)	16

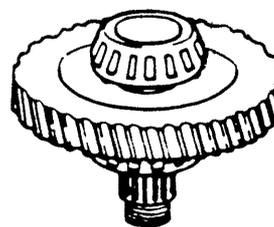


	mm(in.)	
	Standard	Limit
Cup spring, T	2.75 ~ 3.05 (0.1083 ~ 0.120)	2.6 (0.1024)



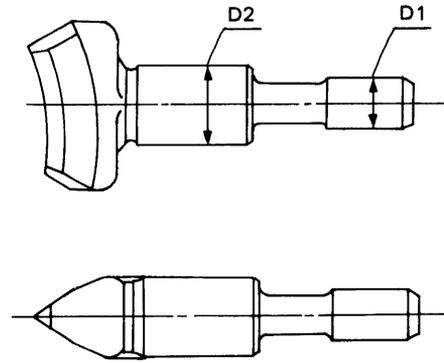
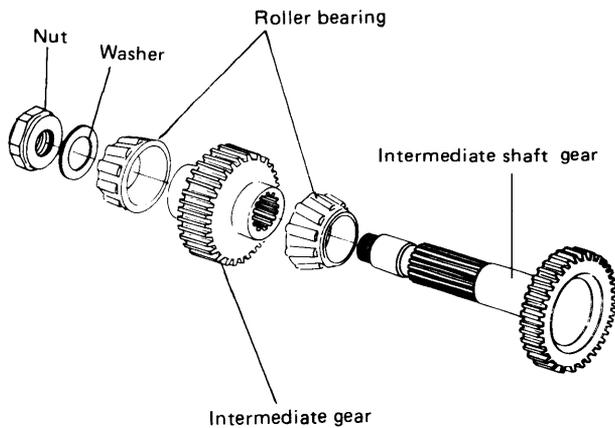
Cup spring

3-9 Output shaft



(1) Visually inspect the spline, oil seal and O-ring, and repair or replace a part when any abnormal condition is found on its surface.

3-10 Intermediate shaft

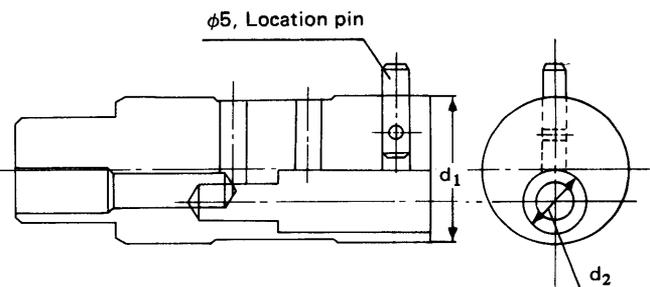
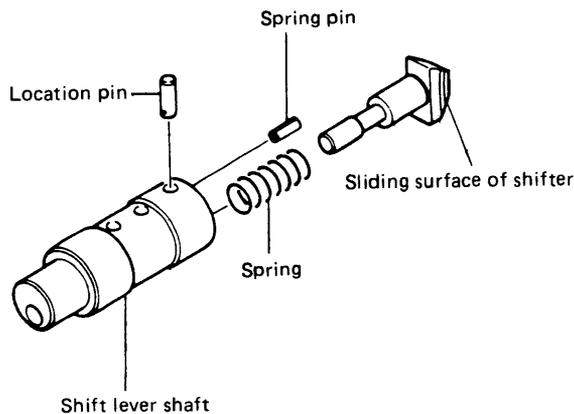


	Standard	mm (in.) Limit
D1	6.69 ~ 6.70 (0.2634 ~ 0.2638)	6.50 (0.2559)
D2	11.966 ~ 11.984 (0.4711 ~ 0.4718)	11.95 (0.4705)
Shift lever shaft, Shifter insertion hole	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)

(1) Visually inspect the spline and repair or replace a part when any abnormal condition is found on its surface.

3-11 Shifting device

3-11-1 Shifter



	Standard	mm (in.) Limit
d ₁	27.959 ~ 27.98 (1.1001 ~ 1.1016)	27.90 (1.0984)
d ₂	12.0 ~ 12.018 (0.4724 ~ 0.4731)	12.05 (0.4744)
Side cover, Shift insertion hole	28.0 ~ 28.021 (1.1024 ~ 1.1032)	28.08 (1.1055)

- (1) Visually inspect the surface which contacts with the drive cone, and replace the shifter when signs of over-heating, damage or wear are found.
- (2) Measure the shaft diameter of the shifter. Replace the shaft if the size deviates from the standard.

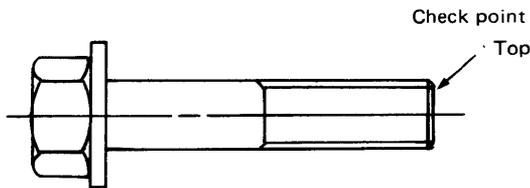
3-11-3 Shifter spring

- (1) Check the spring for scratches or corrosion.
- (2) Measure the free length of the spring.

Shifter spring	Standard	Limit
Free length	22.6 mm (0.890in.)	19.8 mm (0.780in.)
Spring constant	0.854 kg/mm (1.88 lbs/0.04in.)	—
Length when attached	14.35 mm (0.5650 in.)	—
Load when attached	7.046 kg (15.54 lbs)	6.08 kg (13.41 lbs)

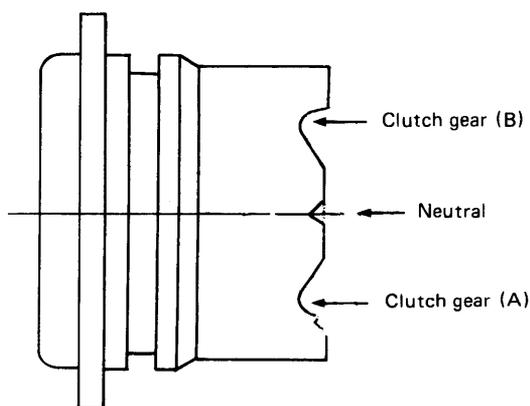
3-11-4 Stopper bolt

Check the stopper bolt. If it is worn or stepped, replace.

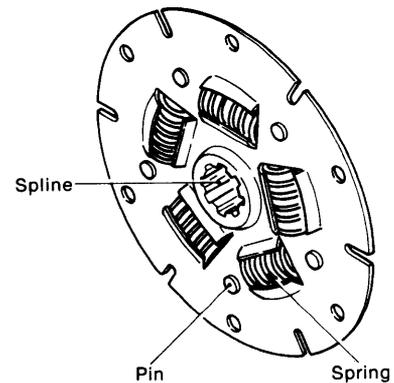


3-11-5 Side cover and oil seal

- (1) Check the neutral, clutch gear (A) and clutch gear (B) position grooves. Replace if the grooves are worn.
- (2) Measure the insertion hole of the shift lever shaft. Replace if the size deviates from the standard value.
- (3) Check the oil seal and the O-ring for damage. Replace if the part is defective.



3-12 Damper disc



- (1) Spline part.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (2) Spring.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (3) Pin wear.
Whenever uneven wear and/or scratches are found, replace with a new part.
- (4) Whenever a crack or damage to the spring slot is found replace the defective part with a new one.

3-13 Shim adjustment for output and input shafts

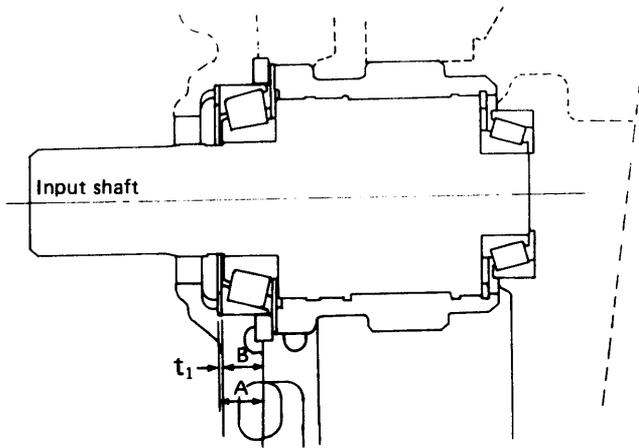
Check the thickness of the shims for the intermediate, clutch, input and output shafts. When the component parts are not replaced after dismantling, the same shims can be reused. When the clutch case, mounting flange and clutch case cover or any one of the following parts is replaced the shim thickness must be determined in the following manner.

- For input shaft parts : input shaft, bearing.
- For output shaft parts: output shaft, bearing.
- For intermediate shaft parts : intermediate shaft, spacer, gear bearing.
- For clutch shaft parts : clutch shaft, thrust collar (A), (B), gear, bearing.

(1) Input Shaft

Measure the distance A and B.
Thickness of Shim t_1

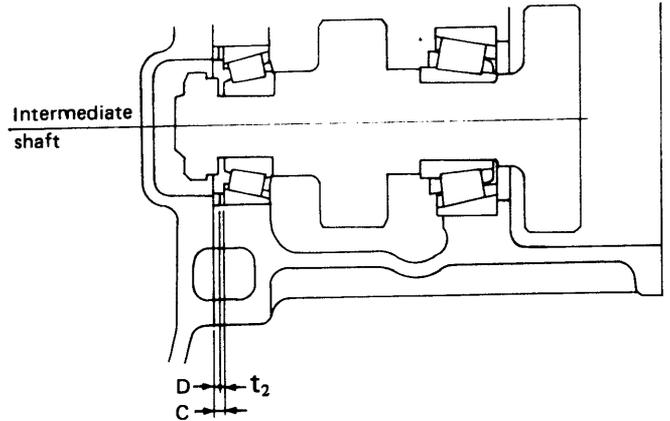
$$t_1 = (A - B) \pm 0.05$$



(2) Intermediate Shaft

Measure the distance C and thickness D

$$t_2 = (C - D) \pm 0.05$$



(3) Clutch Shaft

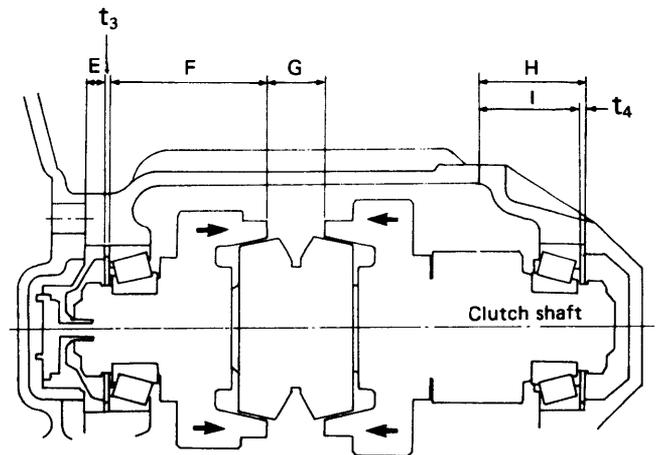
Measure the distance E, F and G.

$$t_3 = \left(78 - E - F - \frac{G}{2}\right) \pm 0.05$$

NOTE: When measuring the distances F and G, the clutch gears must be pushed in the direction of the drive cone.

Then measure distances H and I.

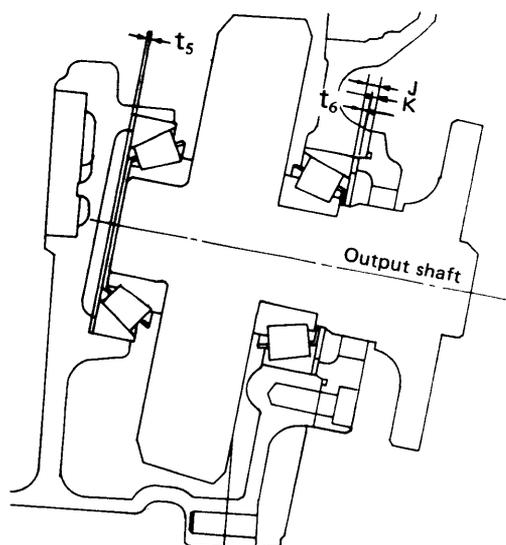
$$t_4 = (H - I) \pm 0.05$$



(4) Output Shaft

Adjust the thickness of Shim t_5 to make the backlash of gear at 0.08~0.16mm (0.0032~0.0063in).
Then measure the distances J and K.

$$t_6 = (J - K) \begin{matrix} +0 \\ -0.1 \end{matrix}$$



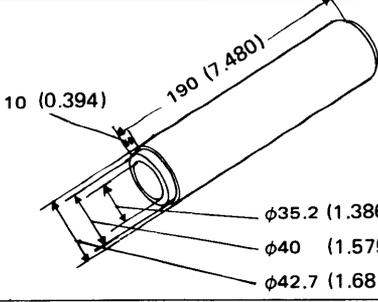
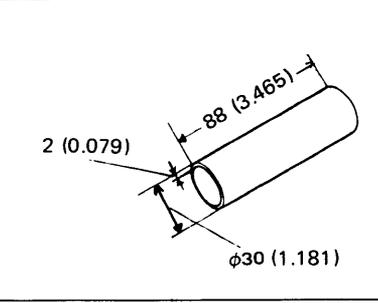
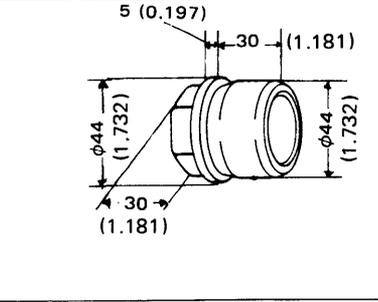
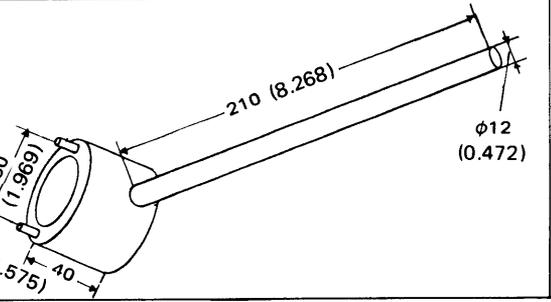
(5) Standard size of parts

											mm (in.)
A	B	C	D	E	F	G	H	I	J	K	Drive cone neutral center position
14.0 ~ 14.2 (0.551 ~ 0.559)	11.4 ~ 12.9 (0.449 ~ 0.508)	2.3 ~ 3.7 (0.091 ~ 0.146)	1.9 ~ 2.1 (0.075 ~ 0.083)	7.4 ~ 7.5 (0.291 ~ 0.295)	57.8 ~ 58.7 (2.276 ~ 2.311)	20.3 ~ 21.2 (0.799 ~ 0.835)	39.9 ~ 40.3 (1.571 ~ 1.587)	37.7 ~ 39.5 (1.484 ~ 1.555)	3.6 ~ 4.7 (0.142 ~ 0.185)	2.4 ~ 2.6 (0.094 ~ 0.102)	78 (3.071)

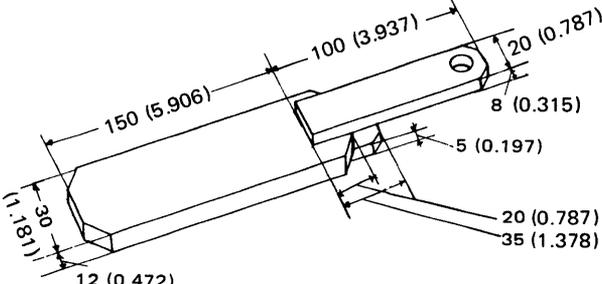
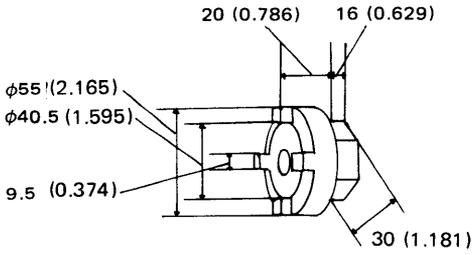
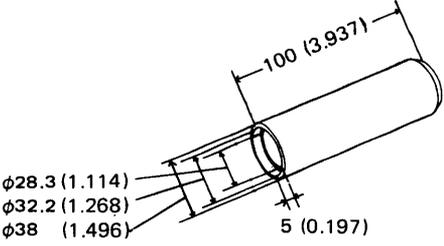
NOTE: Compare your measurements with the above standard size. If your measurements differ greatly from the standard sizes, the measurements may not be correct. Check and measure again.

Adjusting point	Part No.	Thickness. mm (in.)	No. of shims
t1	177095-02150	0.1 (0.0039)	2
		0.3 (0.0118)	1
		0.5 (0.0197)	2
		1.0 (0.0394)	1
t2	177090-02250	0.1 (0.0039)	2
		0.3 (0.0118)	1
		0.5 (0.0197)	1
		1.0 (0.0394)	1
t3 & t4	177075-02150	0.3 (0.0118)	4
		0.4 (0.0157)	4
		0.5 (0.0197)	4
t5 & t6	177090-02310	0.1 (0.0039)	4
		0.3 (0.0118)	2
		0.5 (0.0197)	2
		1.0 (0.0394)	2

4.Special Tools

Name of tool	Shape and size mm(in.)	Application
Inserting tool Part No. 177075-09030		For installing input and output shaft bearings.
Inserting tool Part No. 177088-09150		For installing intermediate shaft and clutch shaft bearings.
Spline socket Part No. 177073-09020		For checking limiter torque of the torque limiter
Ring nut wrench Part No. 177073-09010		For removing and tightening the torque limiter

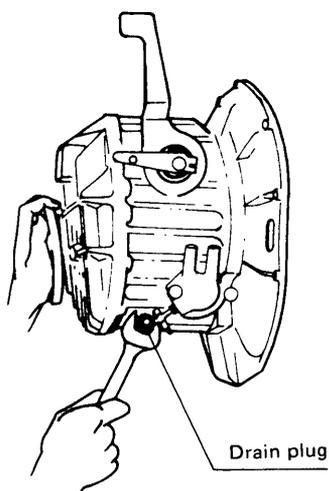
Special tools

Name of tool	Shape and size mm (in.)	Application
<p>Output shaft coupling lock</p> <p>Part No. 177075-09050</p>		<p>For removing and tightening the output shaft nut.</p>
<p>Socket</p> <p>Part No. 177073-00050</p>		<p>For removing and tightening output shaft nut.</p>
<p>Inserting tool</p> <p>Part No. 177073-09030</p>		<p>For installing the clutch shaft bearing</p>

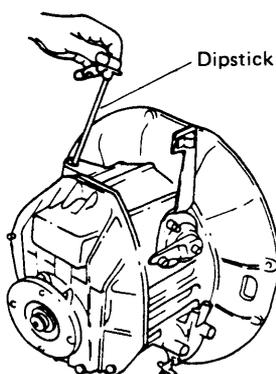
5. Disassembly

5-1 Disassembling the clutch and accessories.

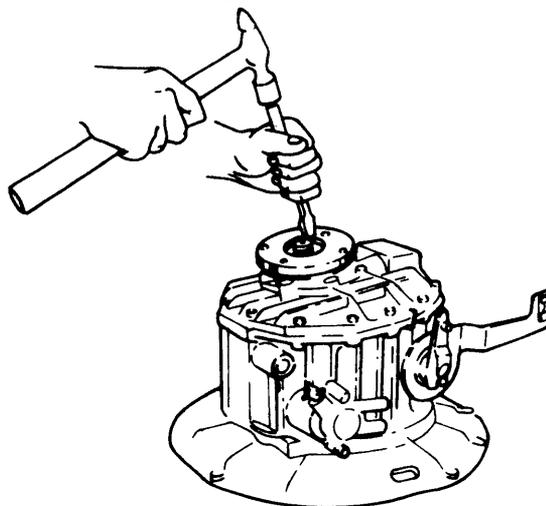
- (1) Remove the remote-control cable and the C.W. hose of L.O. cooler.
- (2) Dismount the clutch main body from the mounting flange.
- (3) Drain the lubricating oil
Drain the lubricating oil by loosening the plug at the bottom of the clutch case. Also remove the dipstick from the clutch case at the same time.
- (4) Remove the drain plug and pull out the L.O.



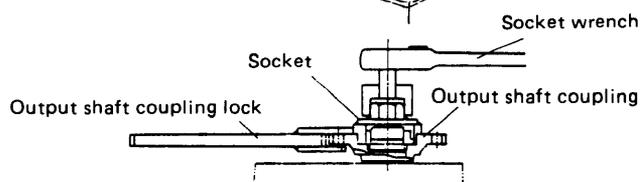
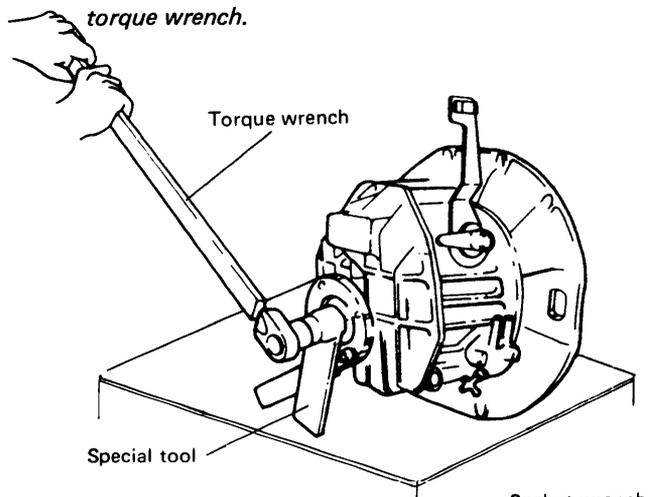
- (5) Remove the dipstick.



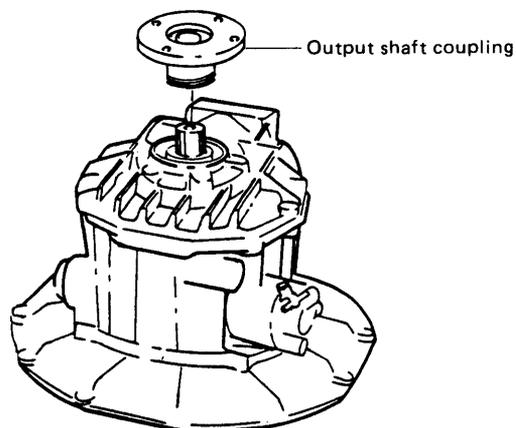
- (6) Remove the end nut and output shaft coupling
1) Loosen the calking of the endnut.



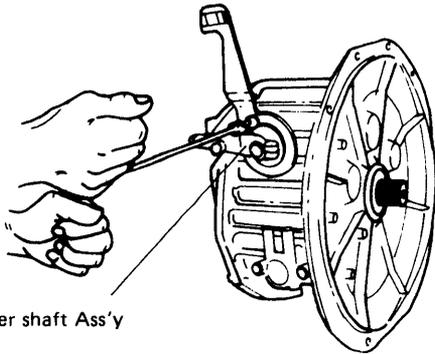
NOTE: Loosen the endnut with the special tool and a torque wrench.



- 2) Remove the output shaft coupling



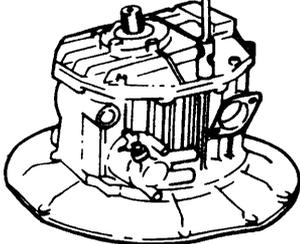
(7) Remove the fixing bolts on the side cover of clutch case, and also remove the shift lever shaft assembly.



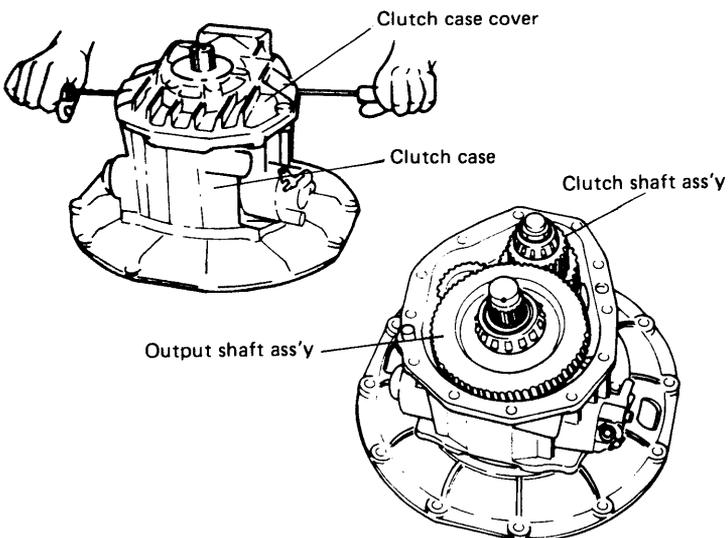
Shift lever shaft Ass'y

(8) Remove the clutch case cover.

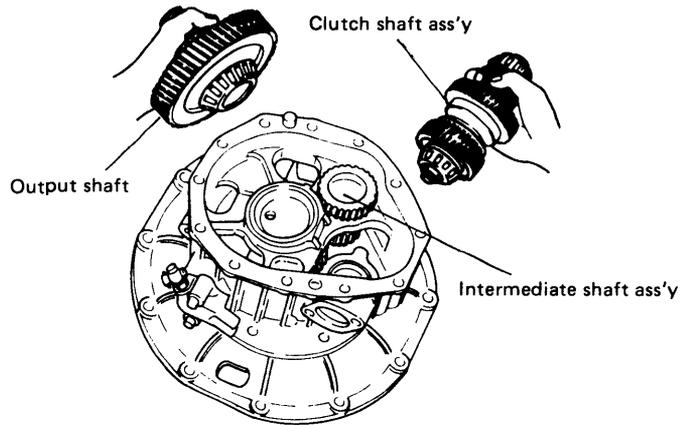
1) Remove the bolt of the clutch case cover



2) Remove the clutch case cover from the clutch case.

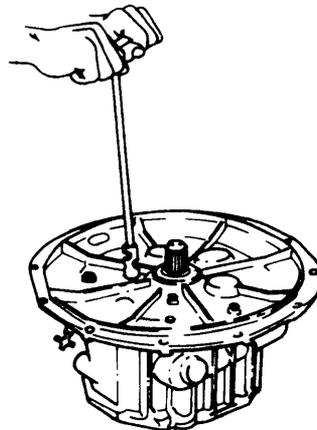


(9) Removing the output shaft assembly and clutch shaft assembly.



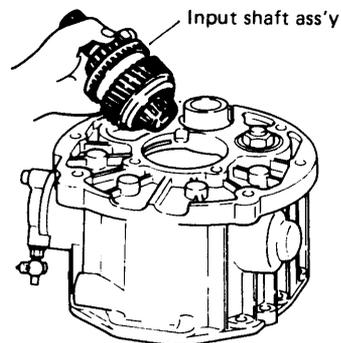
(10) Removing the mounting flange

Remove the fastening bolt of the mounting flange and then remove the mounting flange.



(11) Removing the input shaft assembly.

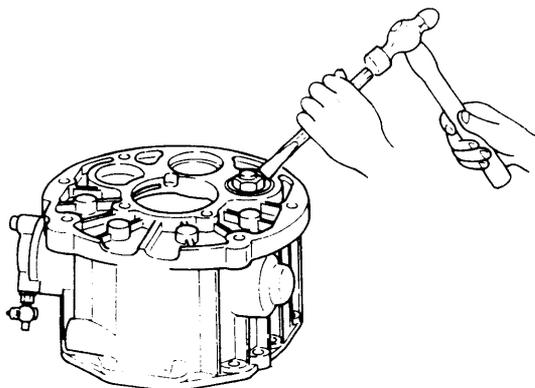
Draw out from the mounting flange side of the case.



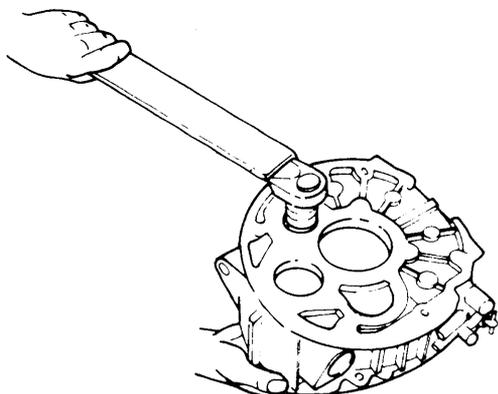
NOTE: To remove the case cover and the case, insert two drivers into the two depressed points at the joint between the case cover and the case. This makes removal easy.

(12) Removing the intermediate shaft.

- 1) Loosen the calking of locknut of the intermediate shaft.

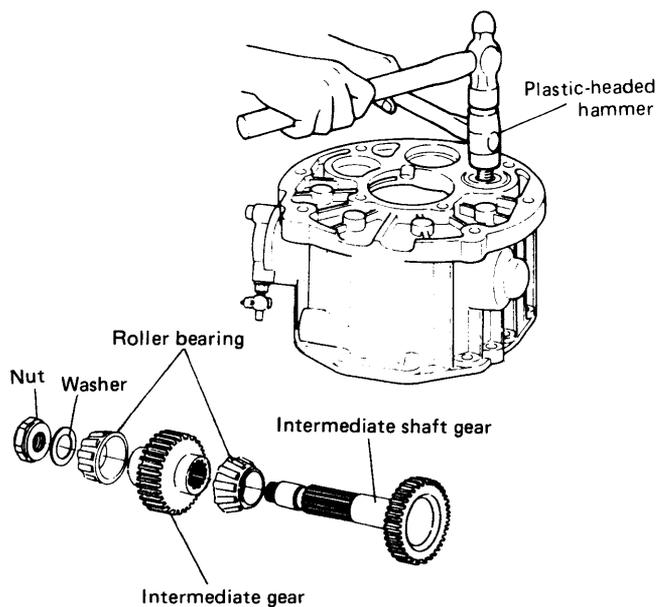


- 2) Remove the locknut.

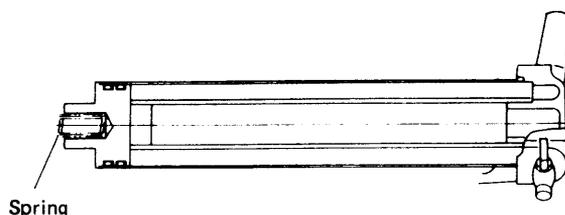
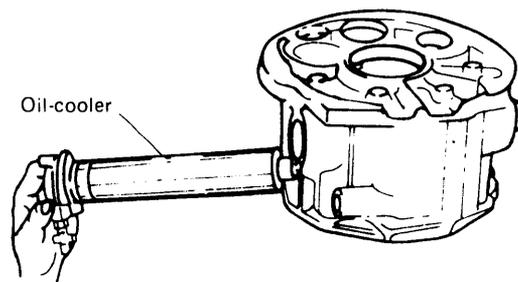


NOTE: Thread of the locknut is left-handed.

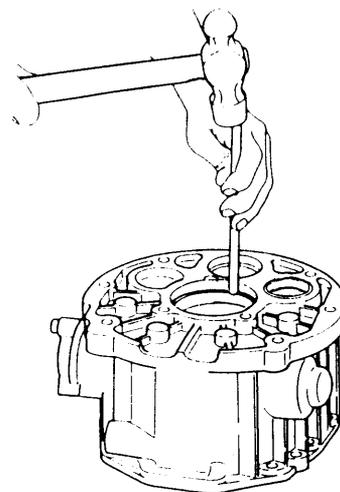
- 3) Draw out the intermediate shaft tapping to the case cover side with a plastic-headed hammer.



(11) Removing the oil-cooler.

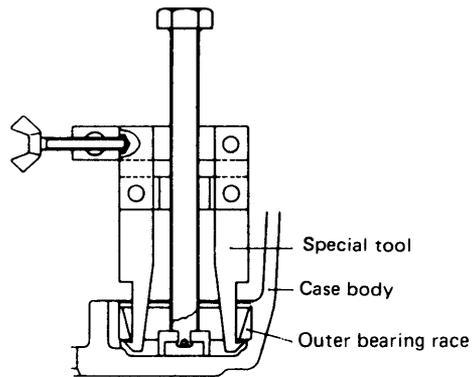


(14) Draw out the outer bearing races.

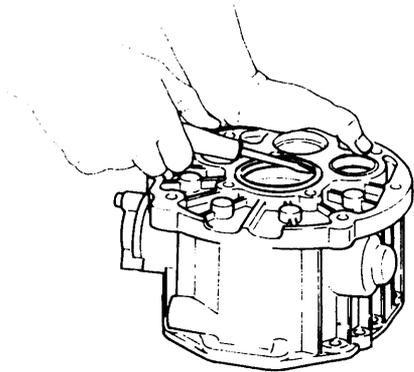


- 1) Remove the outer bearing races of the mounting flange, the case cover and the case.

NOTE: Remove the outer bearing races with a special tool.



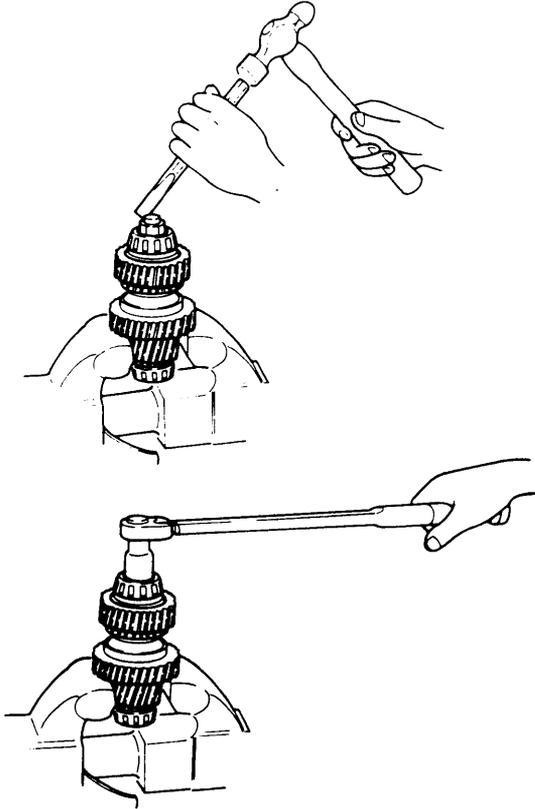
- (15) Remove the oil seals of the mounting flange and the case cover.



5-2 Disassembling the clutch shaft.

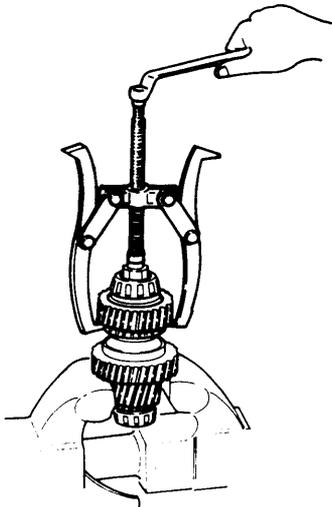
5-2-1 Clutch gear (A) side

- (1) Loosen the calking of the end nut and remove the nut. Remove the nut by a torque wrench, fixing the clutch shaft in a vice.

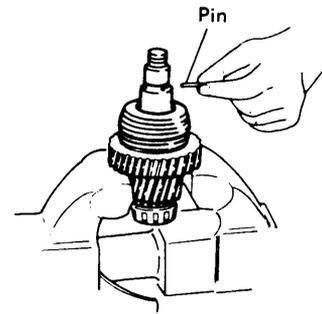


NOTE: Remember that the nut has a left-handed thread.

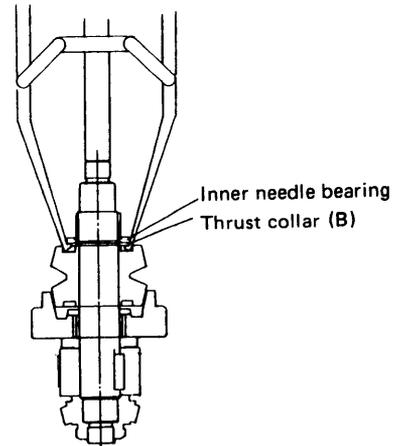
- (2) Take out the clutch gear (A), Thrust collar (A), cup spring, spring retainer and inner bearing trace. The clutch gear (A) must be withdrawn using a pulley extractor, with the clutch shaft fixed in a vice.



- (3) Remove the pin

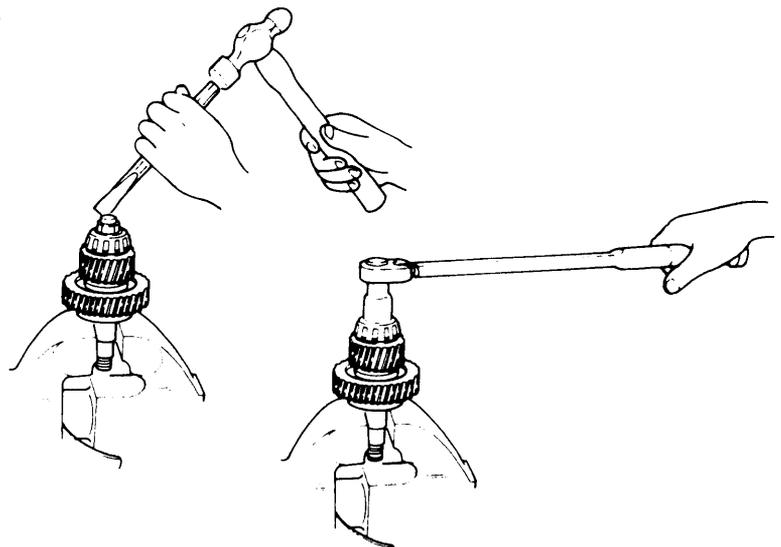


- (4) Withdraw the thrust collar (B), inner needle bearing by pulley extractor.



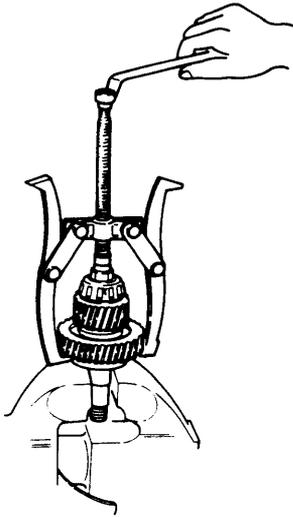
5-2-2 Clutch gear (B) side

- (1) Loosen the calking of the end nut and remove the nut. Remove the nut by a torque wrench, with the clutch shaft fixed in a vice.

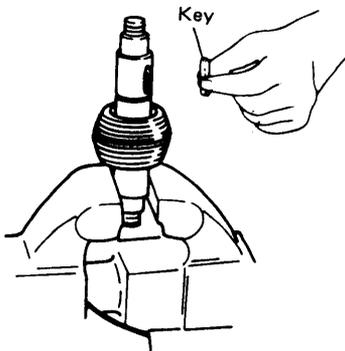


NOTE: Remember that as the nut has a left-handed thread.

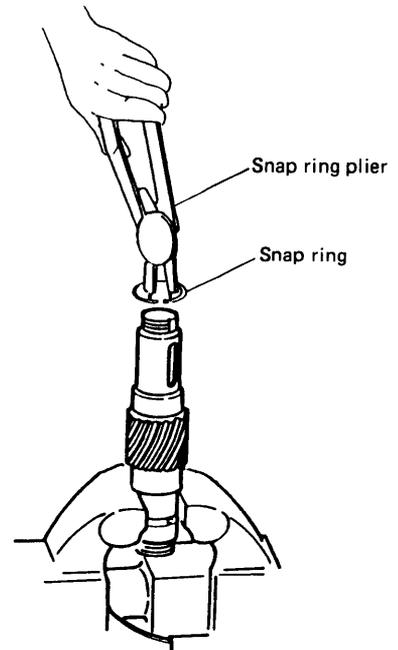
(2) Withdraw the large gear (B), thrust collar (A), cup-spring, spring retainer, drive gear and inner bearing race.
Use a pulley extractor, with the clutch shaft fixed in a vice.



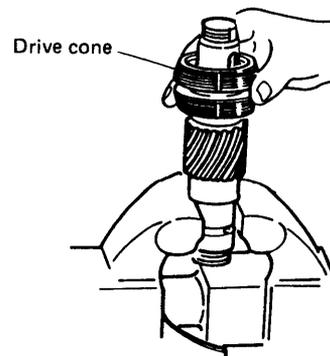
(3) Remove the key



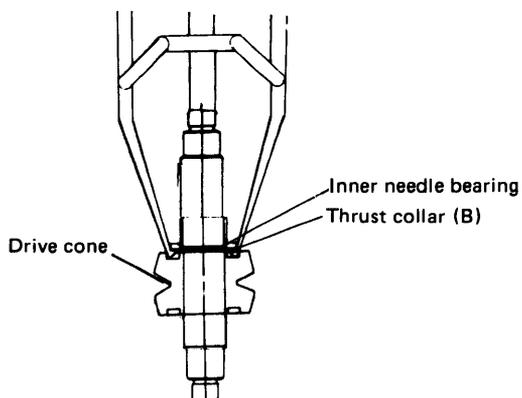
(5) Remove the snap rings



(6) Draw out the drive cone.

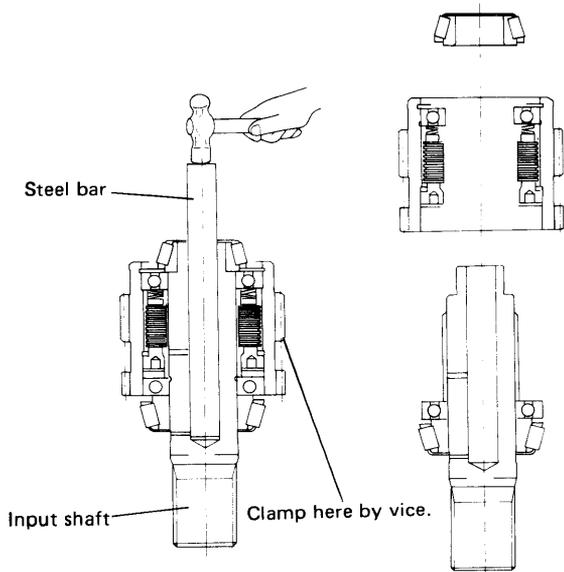


(4) Withdraw the thrust collar (B) and inner needle bearing race with the pulley extractor.



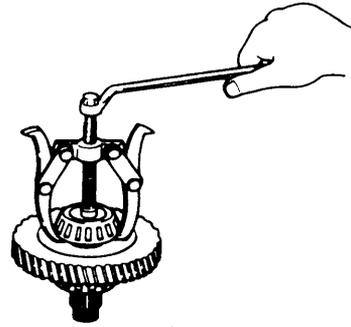
5-3 Disassembling the input shaft.

- (1) Draw out the input shaft tapping to the small roller bearing side with a steel bar.

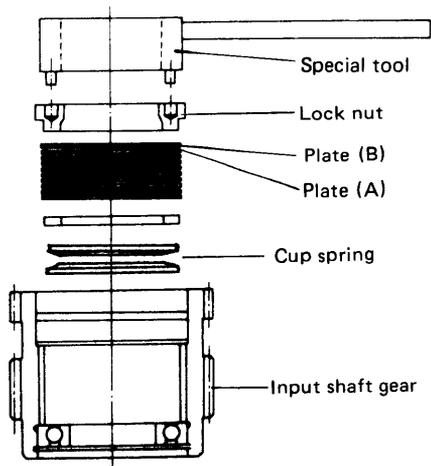


5-4 Disassembling the output shaft

- (1) Remove the bearing inner race from the output shaft. Use a pulley extractor, fixing the output shaft in a vice.

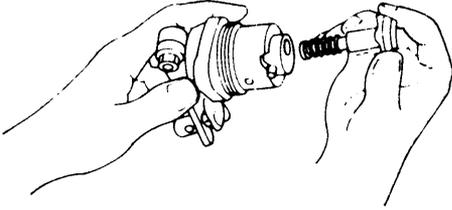


- (2) Fix the input shaft gear in a vice, and remove the lock nut with a special tool.

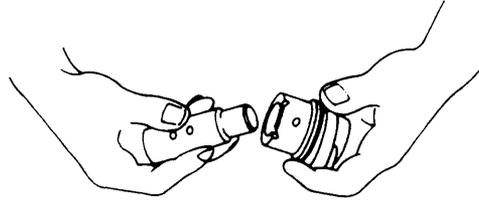


5-5 Disassembling the shifting device

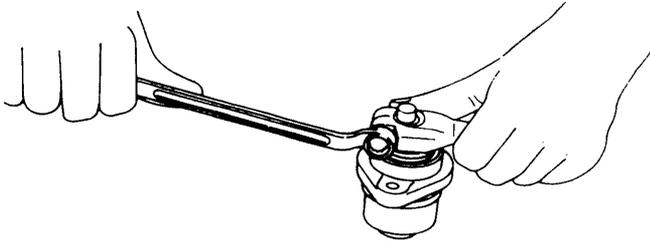
(1) Take out the shifter and shifter spring



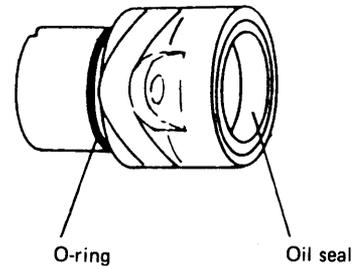
(4) Remove the shift lever to the anti-shift lever side.



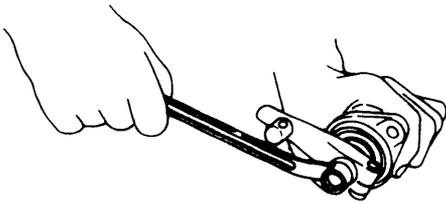
(2) Remove the stopper bolt of the shifter and shim.



(5) Remove the oil-seal and O-ring.



(3) Loosen the belt of the shift lever and remove the shift lever and cable bracket

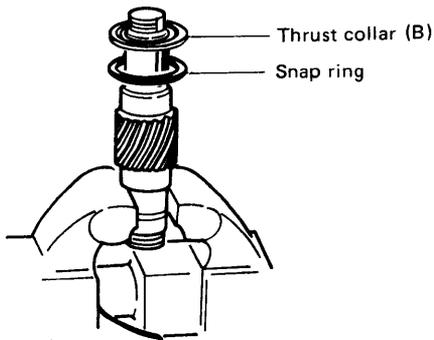


6.Reassembly

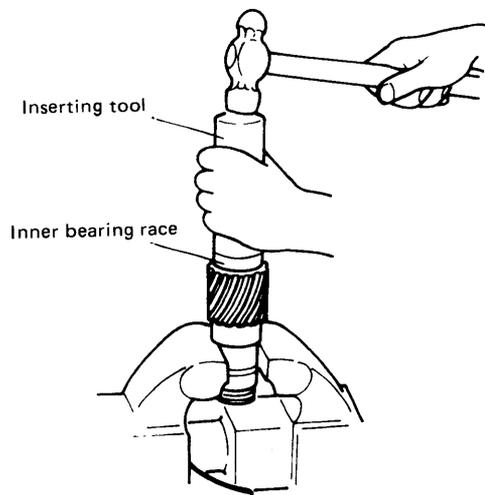
6-1 Reassembly of clutch shaft

6-1-1 Clutch gear (B) side

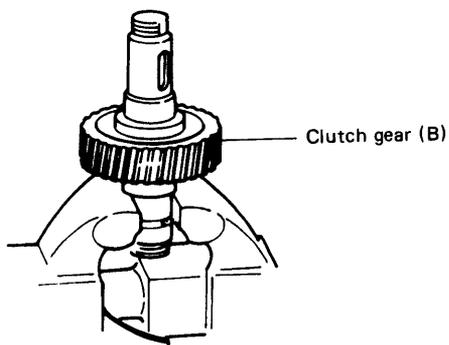
(1)Fit the clutch gear (B) side snap ring and thrust collar (B) onto the shaft.



(2)Drive in the inner needle bearing race using the inserting tool.

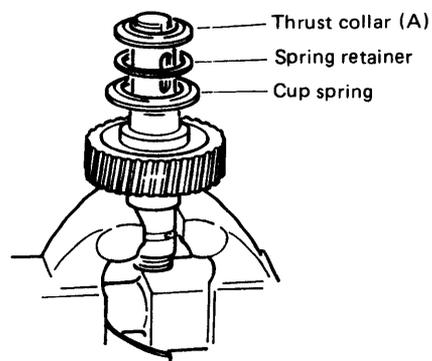


(3)Assemble the needle bearing and clutch gear (B)



NOTE: Check that the clutch gear (B) rotates smoothly.

(4)Fit the cup spring, spring retainer, thrust collar (A).

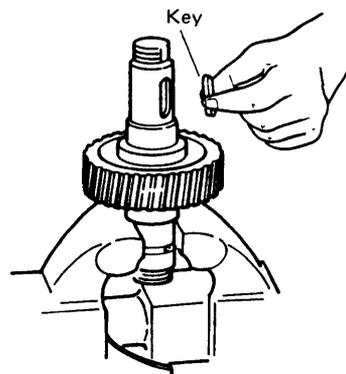


NOTE: 1) Drive in with a plastic headed hammer. Do not hit hard.

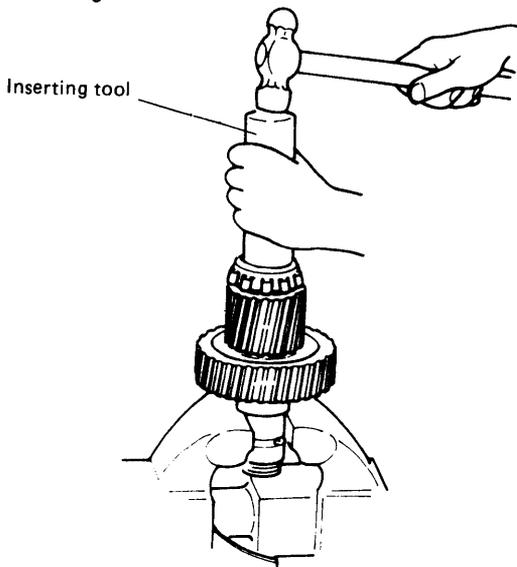
2) When fitting the thrust collar (A), note the fitting direction. Fit it keeping the stepped surface toward the drive gear side.

3) Check that the clutch gear (B) rotates smoothly.

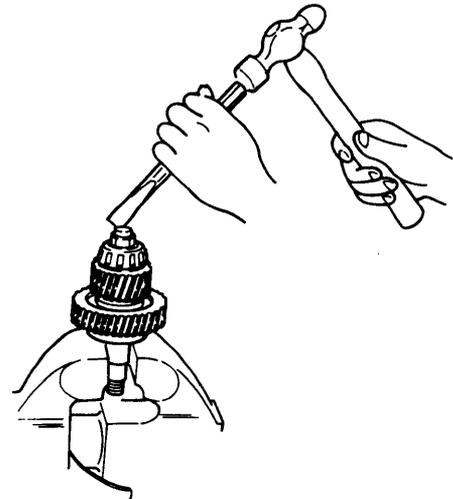
(5)Fit the key



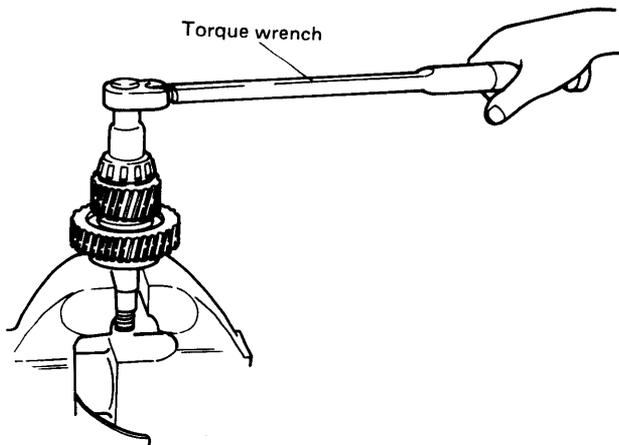
(6) Drive in the driving gear and inner bearing race using the inserting tool.



(8) Calking the end nut and clutch shaft.

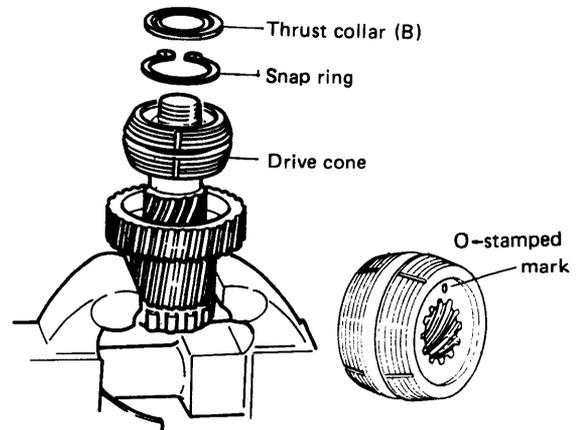


(7) Set and tighten the clutch gear (B) end nut. Fit the clutch shaft in a vice, and tighten the nut with a torque wrench.



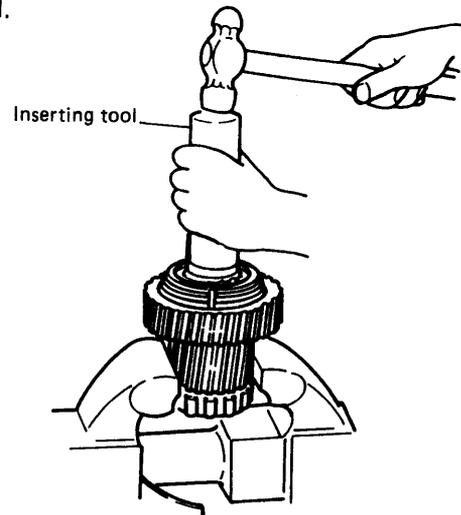
6-1-2 Clutch gear (A) side

(1) Insert the drive cone, snap ring and thrust collar (B).



NOTE: Insert it keeping the O-stamped make surface toward the clutch gear (B) side.

(2) Drive in the inner needle bearing race, using an inserting tool.

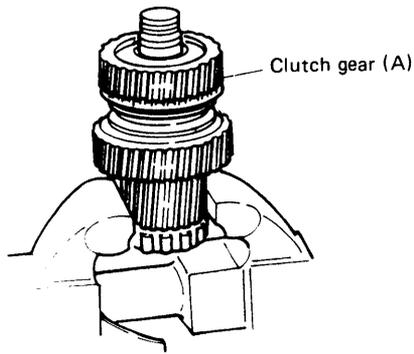


Tightening torque	8.5 – 11.5 kg-m (61.5 – 83.2 ft-lb)
-------------------	--

NOTE: 1) Remember it is a left-handed thread.

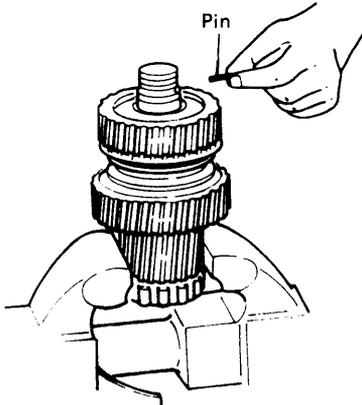
2) Use the clutch gear (A) side nut which is used before dismantling for the clutch gear (B) end nut. This is not to make the calked portion to the same point.

(3) Assemble the needle bearing and clutch gear (A)

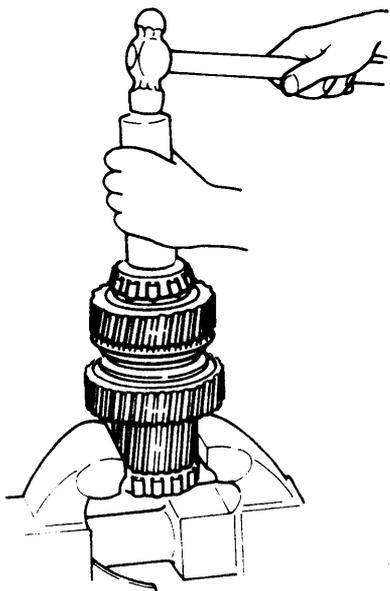


NOTE: Check that the clutch gear (A) rotates smoothly.

(4) Insert the pin.



(5) Fit the cup spring, spring retainer and thrust collar (A) and drive in the inner bearing race using the inserting tool.

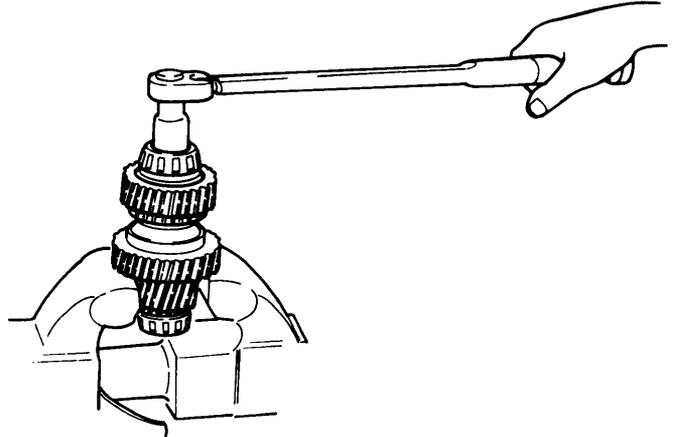


NOTE: 1) When fitting the thrust collar (A), note the fitting direction. Fit it keeping the stepped surface toward the roller bearing side.

2) The pin cannot be fitted after the inner bearing race has been driven in.

3) Check that the large gear (B) rotates smoothly.

(6) Set and tighten the clutch gear (A) end nut. Fix the clutch shaft in a vice and tighten the nut with a torque wrench.

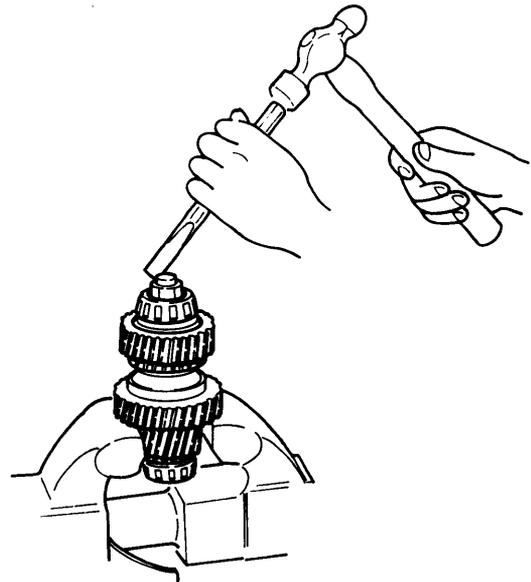


Tightening torque

8.5 – 11.5 kg-m
(61.5 – 83.2 ft-lb)

NOTE: 1) Remember it is a left-handed thread.

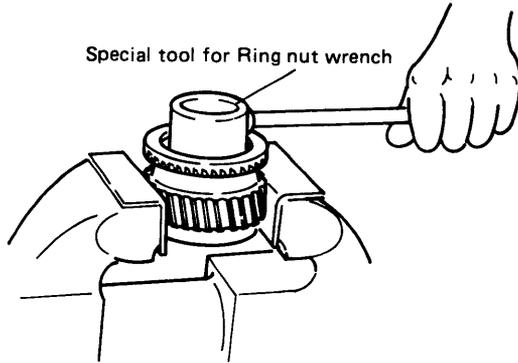
(7) Calk the end nut and clutch shaft.



NOTE: Use the clutch gear (A) side nut which is used before dismounting for the clutch gear (B) end nut. This not to make the calked portion to the same point.

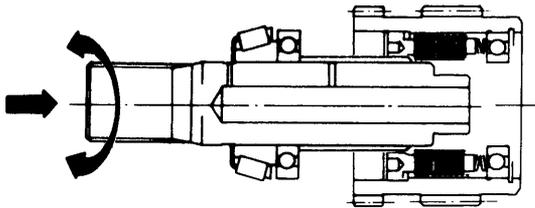
6-2 Reassembly of input shaft

- (1) Drive in the ball bearing and fit the snap ring into the input shaft gear.
- (2) Insert the cup springs, spacer, plates (A) and plates (B) and temporarily lock the lock nut.

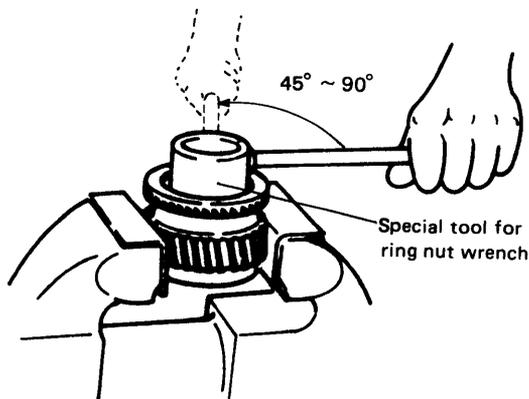


NOTE: Apply lube oil to each insert parts.

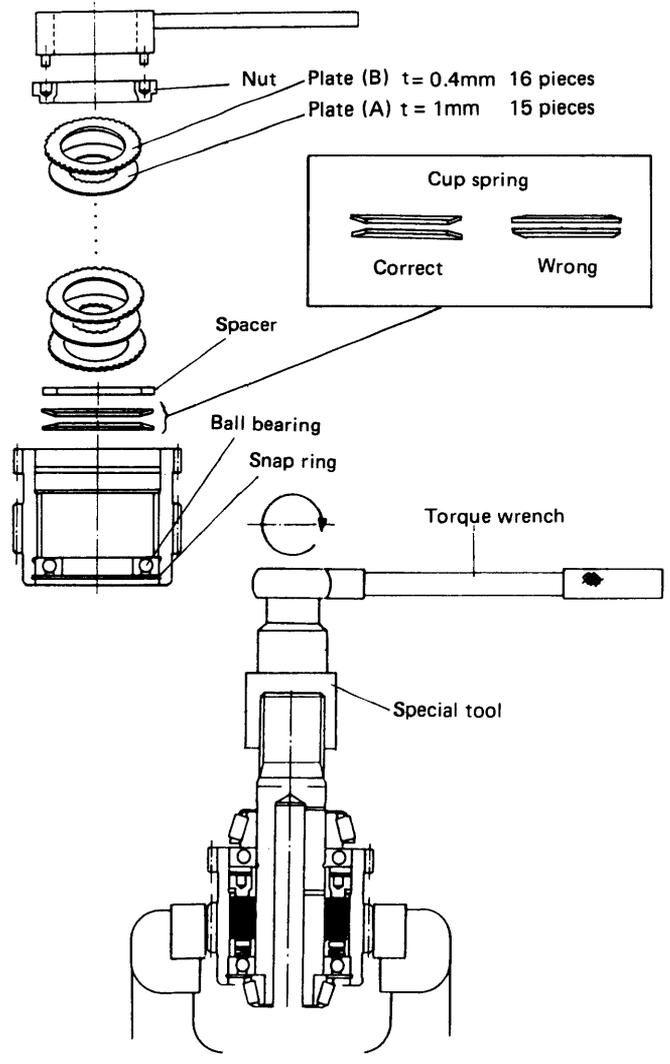
- (3) Fit the O-ring onto the input shaft.
- (4) Drive the ball bearing and the inner bearing race using a inserting tool.
- (5) Insert the input shaft into the plate (A).



- (6) Take out the input shaft again.
- (7) Tighten the nut firmly by using a special tool, then return the nut to 45 – 90 degrees.



- (8) Insert the input shaft, then measure the torque of the input shaft using a torque wrench.

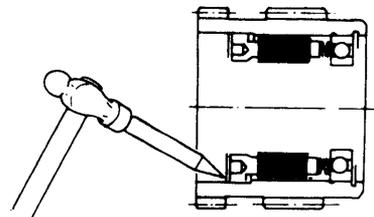


Torque:

55 – 60 kg-m
(398 – 434 ft-lb.)

NOTE: Match up the teeth of plate (A).

- (9) Take out the input shaft and calking the lock nut end of the thread.

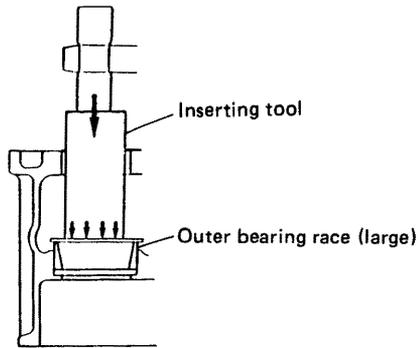


- (10) Insert the input shaft into the input gear assembly.
- (11) Drive in the inner bearing race onto the input shaft end.

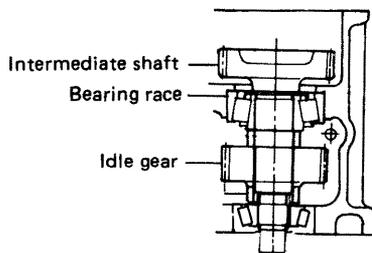
6-3 Reassembly of the clutch case

6-3-1 Reassembly of the intermediate shaft

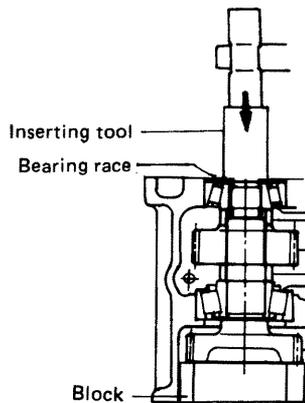
(1) Drive in the outer bearing race (large) into the clutch case.



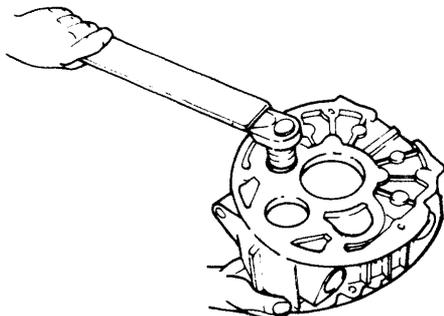
(2) Insert the inner bearing races and idle gear and drive in the intermediate shaft



(3) Drive the outer bearing race into the clutch case.



(4) Insert the washer and tighten the end nut using a torque wrench.

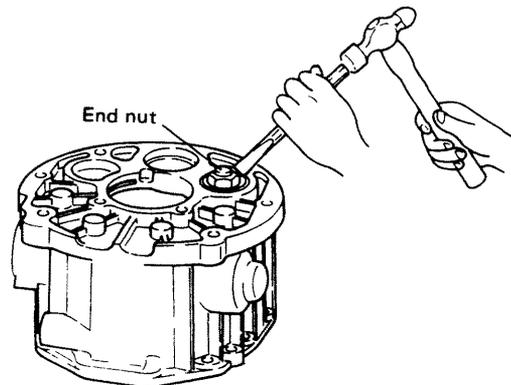


Tightening torque

8.5 ~ 11.5 kg-m
(61.5 ~ 83.2 ft-lb)

NOTE: Remember it is a left-handed thread

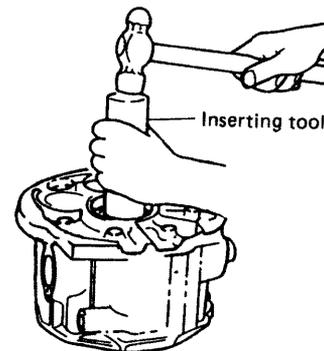
(5) Calk the end nut



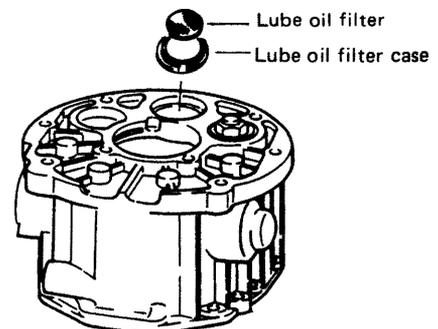
(6) Insert the shims into the clutch case.

6-3-2 Reassembly of the bearing outer races and shims in the clutch case

(1) Drive the input shaft outer bearing race and clutch shaft outer bearing race into the clutch case.

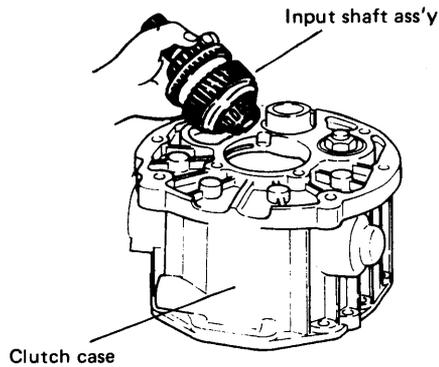


(2) Insert the clutch shaft shim, Lube oil filter case and filter into the clutch case.

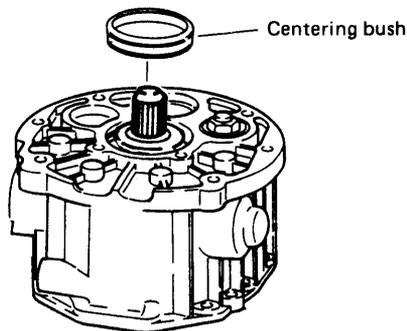


6-3-3 Reassembly of the input shaft

(1) Insert the input shaft assembly into the clutch case.



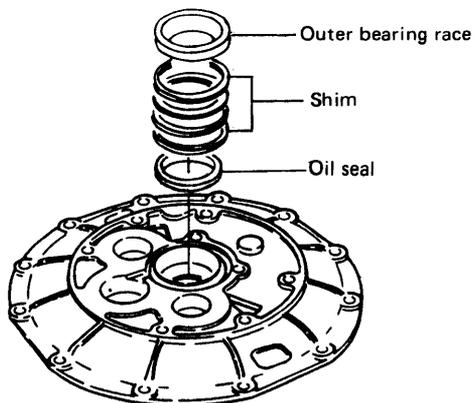
(2) Drive the centering bush into the clutch case.



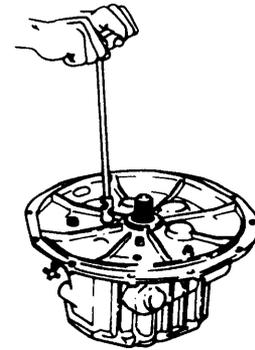
6-3-4 Reassembly of the mounting flange

(1) Insert the oil seal and the shim into the mounting flange.

(2) Drive the outer bearing race into the mounting flange.

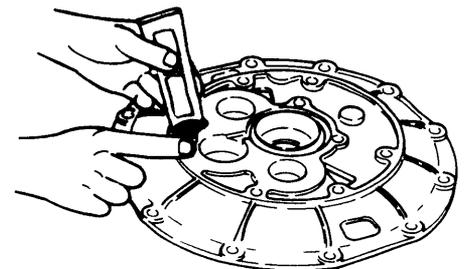
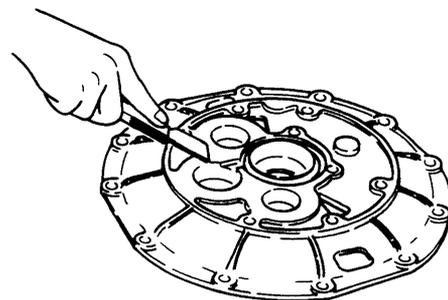


(3) Fit the mounting flange onto the clutch case, and tighten the bolt.



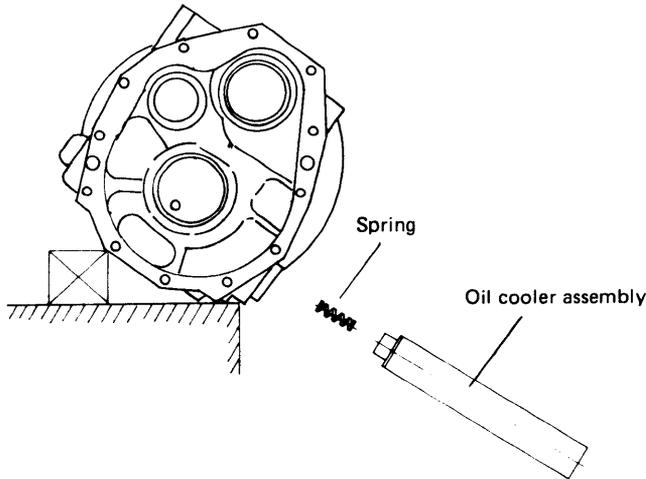
Tightening torque	5 – 6 kg-m (36.2 – 43.4 ft-lb)
-------------------	-----------------------------------

NOTE: Apply non-drying liquid packing to the machining surface of the mounting flange and the clutch case.

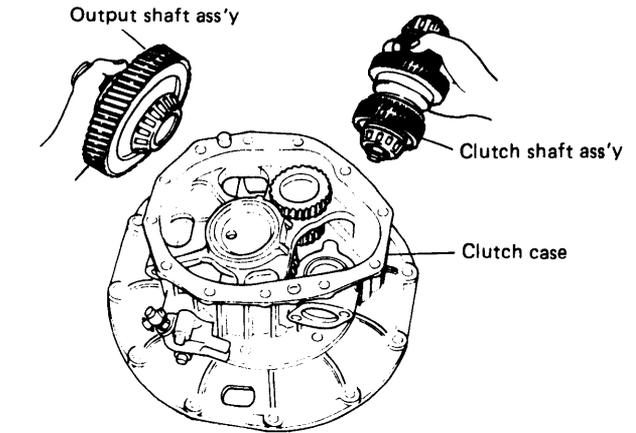


6-3-5 Reassembly of the oil cooler

NOTE: Fasten taking care not to allow the spring at the tip of oil cooler to drop out.

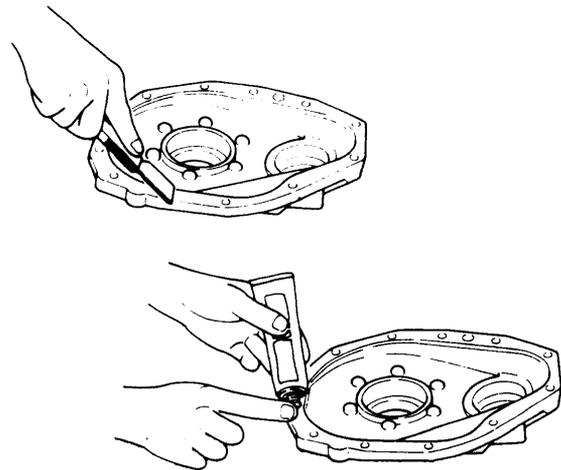
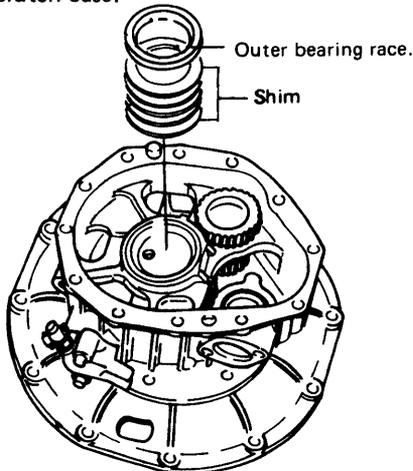


(3) Insert the clutch shaft assembly and the output shaft into the clutch case.



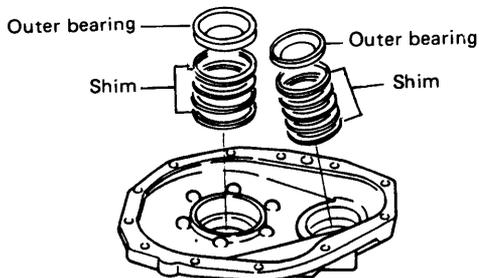
6-3-6 Reassembly of the clutch case cover.

(1) Drive the output shaft shim and the outer bearing race into the clutch case.

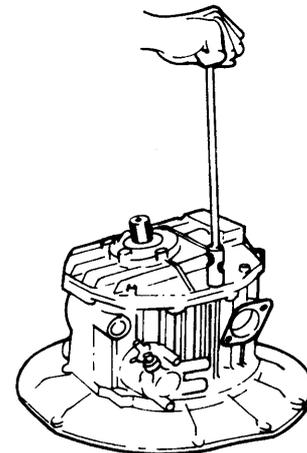


NOTE: Apply non-drying liquid packing to the matching surface of the clutch case cover and the clutch case.

(2) Drive the shims and the outer bearing races into the clutch case cover

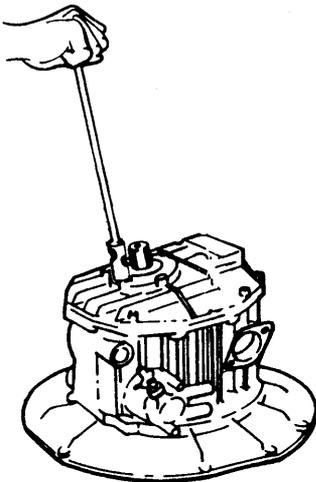


(4) Fit the clutch case cover on the clutch case, and tighten the bolt.



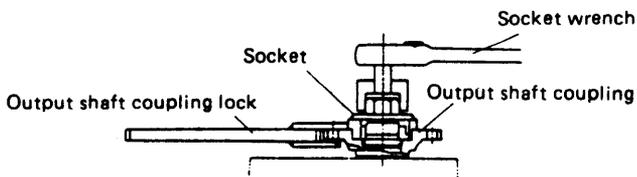
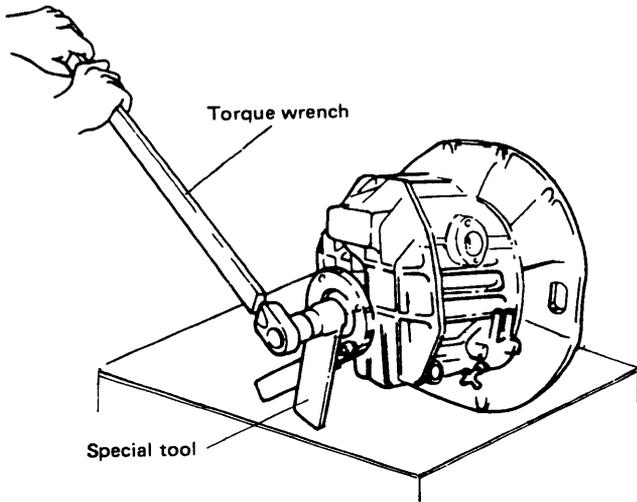
Tightening torque	2.3 – 2.8 kg-m (16.6 – 20.3 ft-lb)
-------------------	---------------------------------------

(5) Insert the outer bearing race, shim and the output shaft cover, and tighten the bolt.



(6) Insert the oil seal, output shaft coupling, O-ring and the end nut into the output shaft.

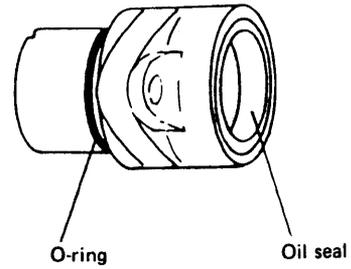
(7) Tighten the end nut with the special tool and a torque wrench, then calk it.



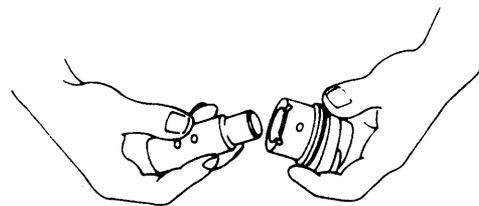
Tightening torque	54 – 56 kg-m (391 – 405 ft-lb)
-------------------	-----------------------------------

6-3-7 Reassembly of the shifting device

(1) Fit the oil seal and O-ring to the side cover

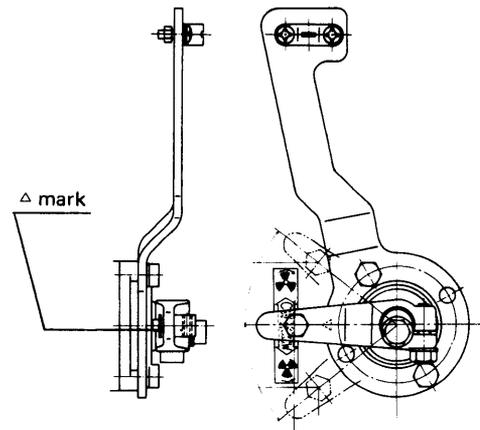


(2) Insert the shift lever shaft to the side cover

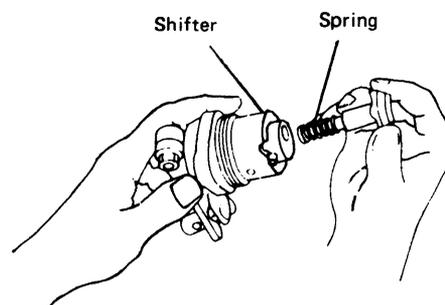


(3) Fit the shift lever to the shift lever shaft

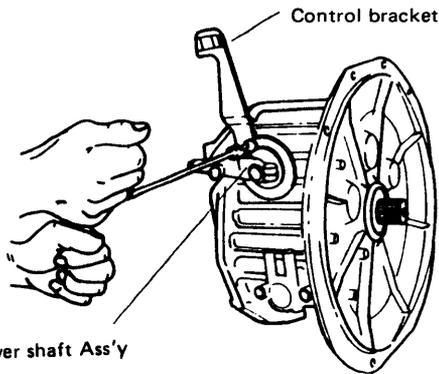
NOTE: Check the direction of the shift lever Δ mark.



(4) Insert the shifter spring and shifter to the shift lever shaft



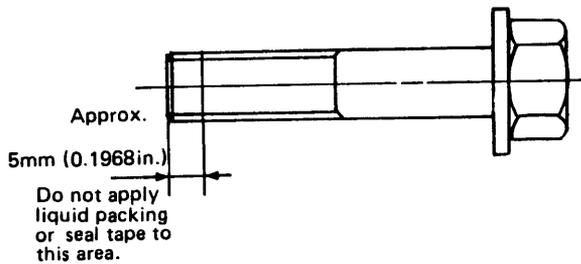
(5) Fit the side cover assembly and the remote control bracket to the clutch case.



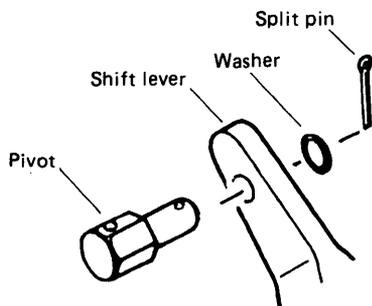
NOTE: 1) Check the direction of the shifter (Top and bottom side)
2) The shift lever may not turn smoothly if the clutch case is not filled with lubricating oil.

(6) Fit the shim and stopper bolt to the shift lever shaft.

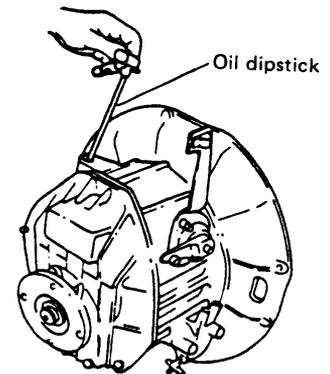
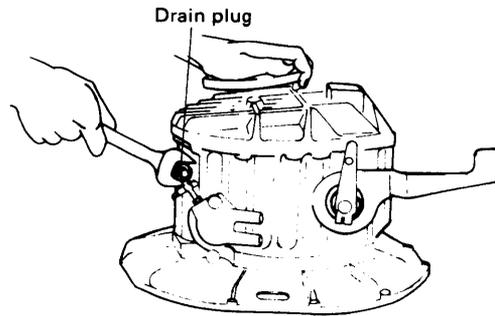
NOTE: Apply non-drying liquid packing or seal tape to the thread of the stopper bolt.



(7) Fit the pivot to the shift lever.



6-3-8 Reassembly of the lube oil drain plug and the dipstick



REMOTE CONTROL (OPTIONAL)

1. Remote Control System	8-1
2. Remote Control Installation	8-2
3. Remote Control Inspection	8-5
4. Remote Control Adjustment	8-6

1. Remote Control System

1-1 Construction of remote control system

The remote control permits one handed control of the engine speed, changing from forward to reverse, and stopping.

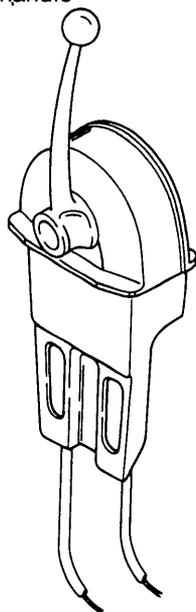
Fittings which allow for easy connection of the remote control cables with the fuel injection pump and transmission are provided with the remote control set.

The use of Morse remote control cables, clamps and a remote control head, are also provided for. The device to stop the engine is electric and will be explained under the section on electrical equipment.

1-2 Remote control device components

	Morse description	Yanmar Part No.
Remote control head	Morse MT2 top mounting single lever	41730-000680
	Morse MV side mounting single lever	128170-86500
Remote control cable	Morse 33C x 4m (13.12ft.)	41710-000360
	Morse 33C x 7m (23.00ft.)	129470-86500
Engine stop cable	Yanmar 4m (13.12ft)	129470-67550
	Yanmar 7m (22.96ft)	129470-67560

(1) Remote control handle

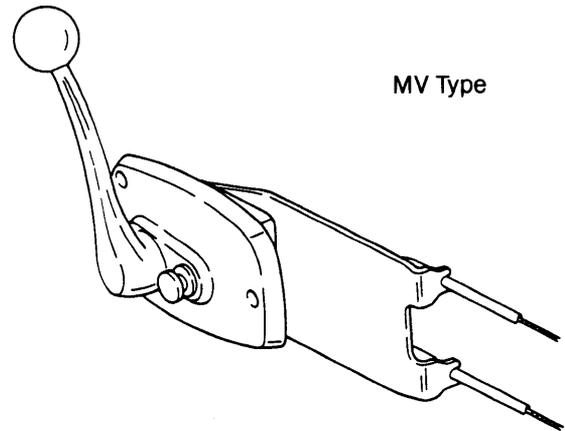


MT-2 Type

The model MT-2 remote control has been designed so that operation of the clutch (shift) and governor (throttle) can be effected with one lever.

Two cables are required for the MT-2 single, one for the clutch and the other for the governor.

When warming up the engine, to freely control the governor separately from the clutch put the lever in neutral, the central position, and pull the knob in the center of the control lever. When the lever is returned to the neutral position, the knob automatically returns to its original position, and the clutch is free. The governor can then be freely operated.

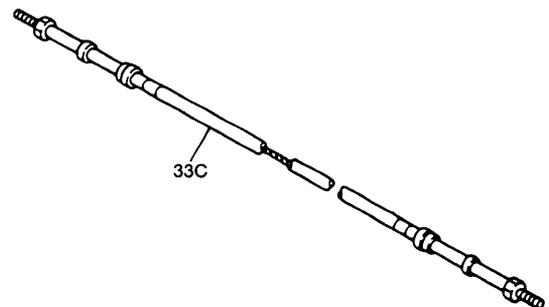


MV Type

The MV type controller has been designed so that operation of the clutch and throttle can be effected with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the neutral position so that the throttle can be opened all the way and warm up the engine.

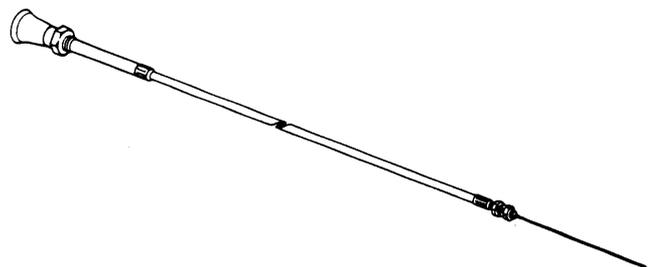
When the engine is warmed up, return the handle to the central position and push the button back in. Control of the clutch and throttle is thus effected with one handle.

(2) Remote control cable



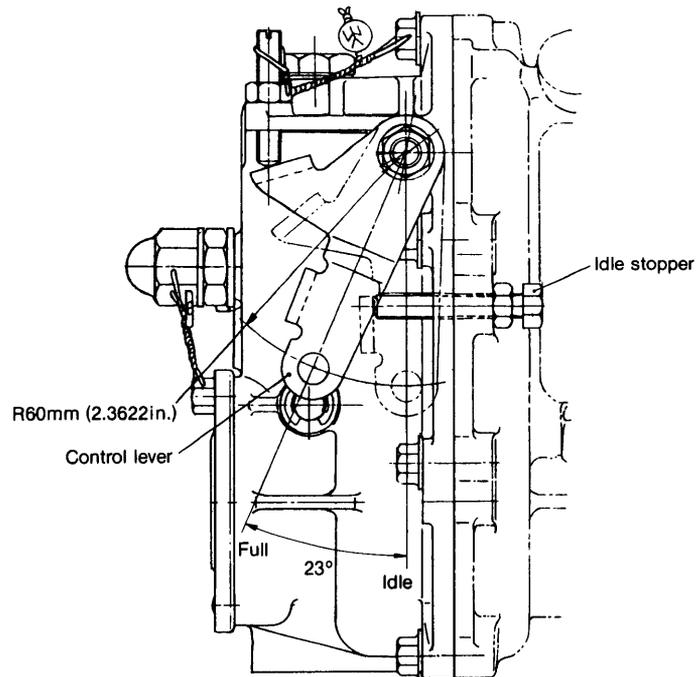
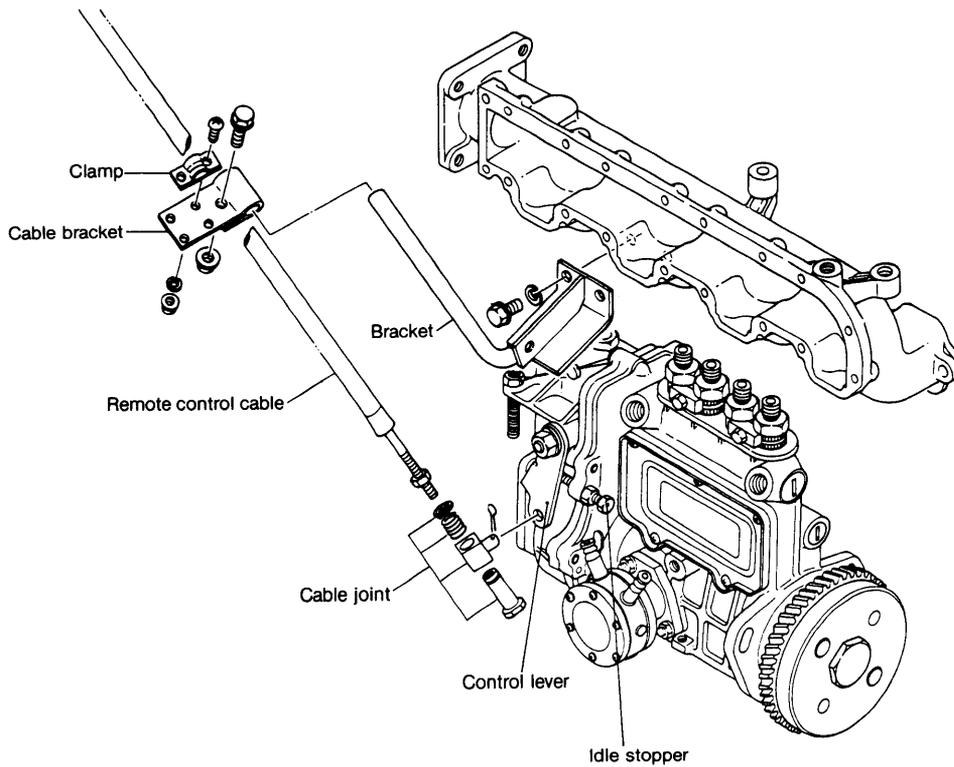
Use only Super-Responsive Morse Control Cables. These are designed specifically for use with Morse control heads. This engineered system of Morse cables, control head and engine connection kits ensures dependable, smooth operation with an absolute minimum of backlash.

(3) Engine stop cable

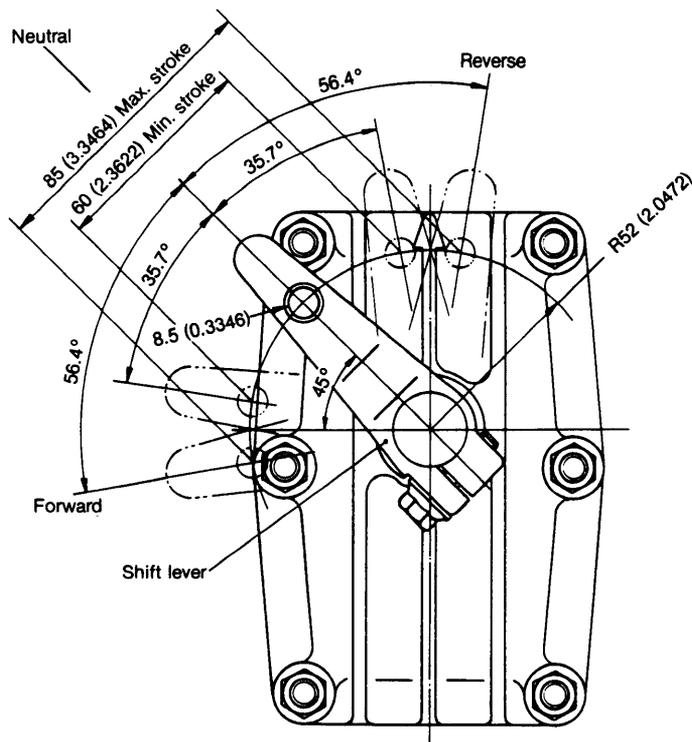
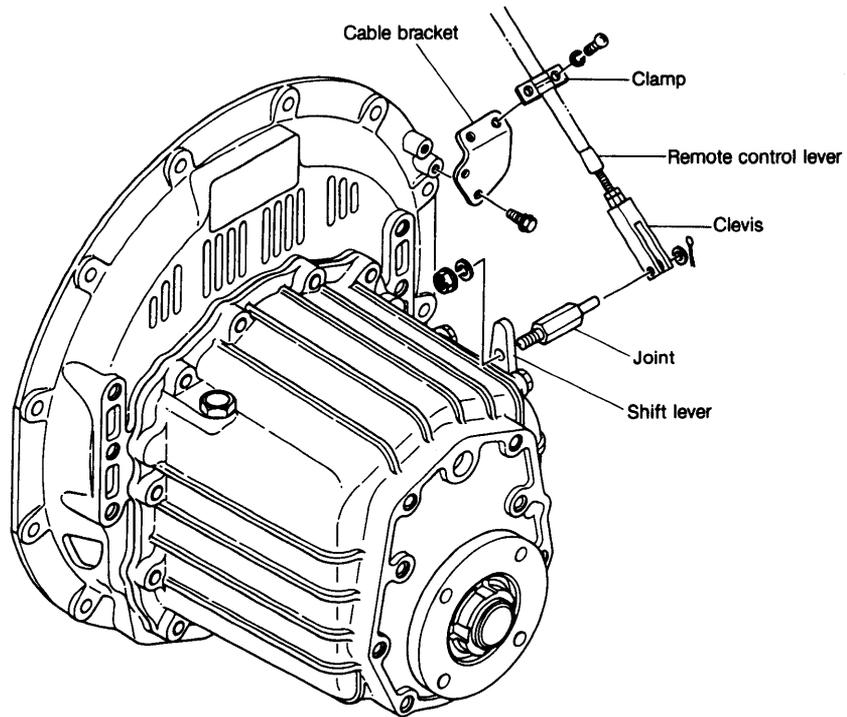


2. Remote Control Installation

2-1 Speed control

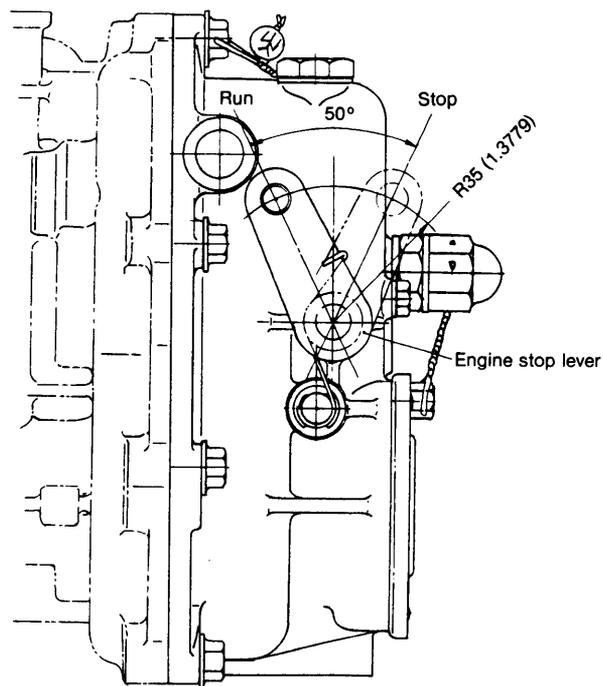
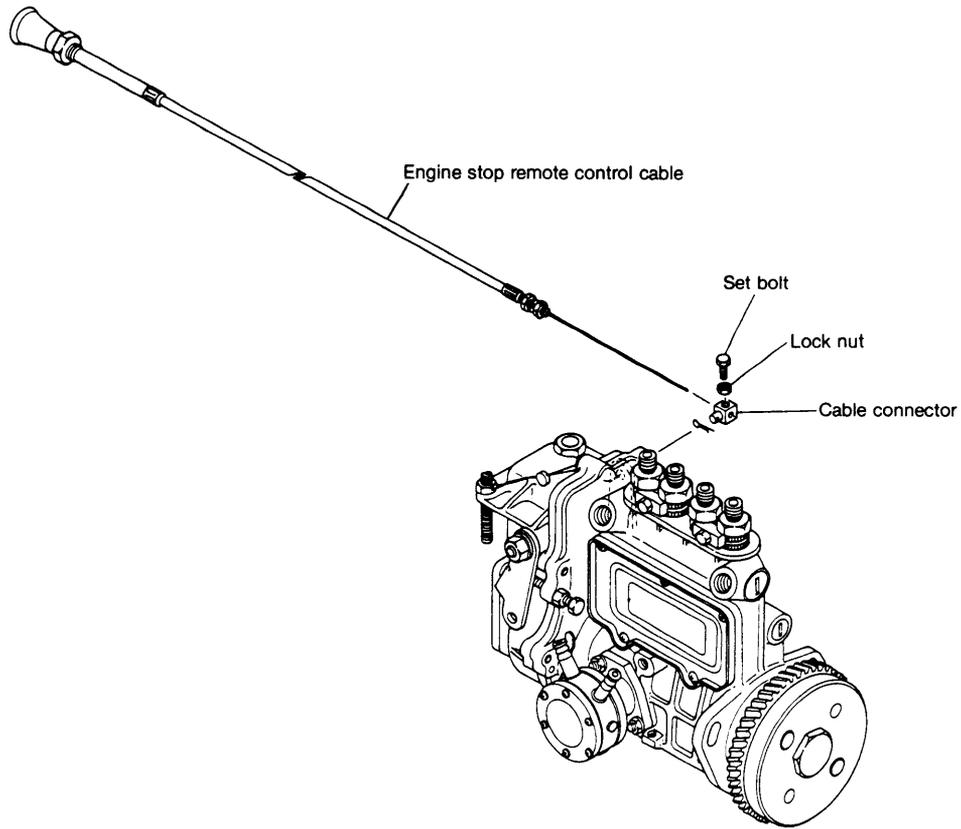


2-2 Clutch control



mm (in.)

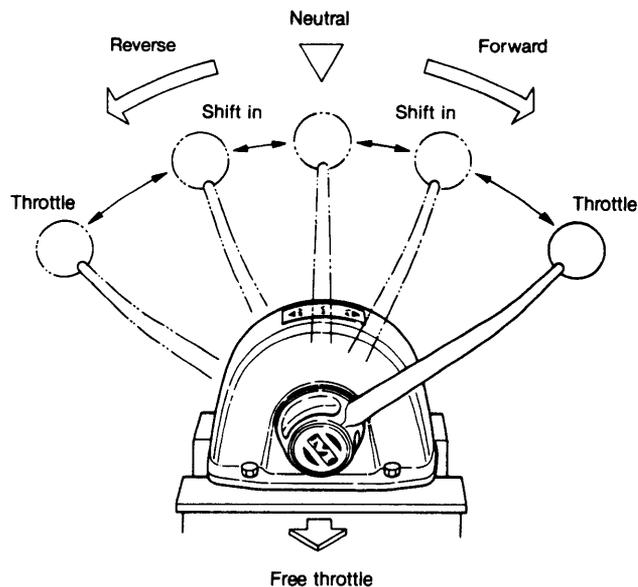
2-3 Engine stop



mm (in.)

3. Remote Control Inspection

- (1) When the control lever movement does not coincide with operation of the engine, check the cable end stop nut to see whether or not it is loose, and readjust/retighten when necessary.



- (2) Too many bends (turns) in the cable or bends at too extreme an angle will make it difficult to turn the handle. Reroute the cable to reduce the number of bends or enlarge the bending radius as much as possible (to 200mm or more).
- (3) Check for loose cable bracket/clamp bolts or nuts and retighten as necessary.
- (4) Check cable connection screwheads, cable sleeves and other metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

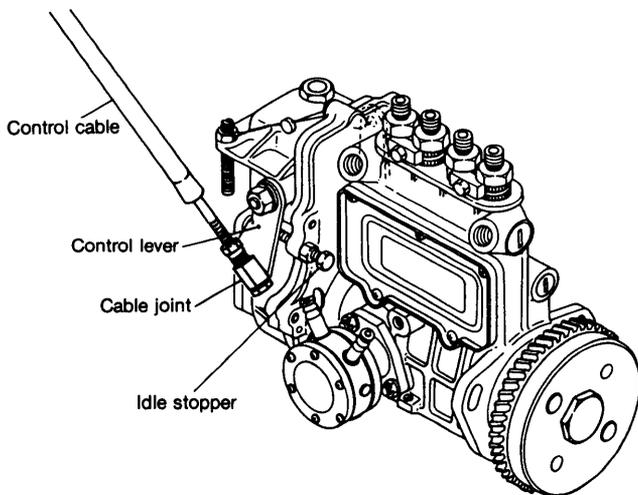
4. Remote Control Adjustment

(1) Shift lever adjustment

Move the lever several times—the movement of the clutch lever on the engine from forward, neutral and reverse must coincide with the forward, neutral and reverse on the control lever. If they do not coincide, adjust the fittings as necessary (first engine side, then controller side).

(2) Throttle lever adjustment

Move the control lever all the way to full throttle several times, and then return. The throttle lever on the engine must lightly push against the idle switch when it is returned. If it is properly adjusted, the knob can be easily pulled out when the lever is in the neutral position, and will automatically return when the control lever is brought back to the neutral position. If the control lever presses too hard against the knob, it may not return automatically, in which case the cable end must be adjusted as explained for the clutch. The knob cannot be pulled out when the lever is not in the neutral (central) position.



CHAPTER 9

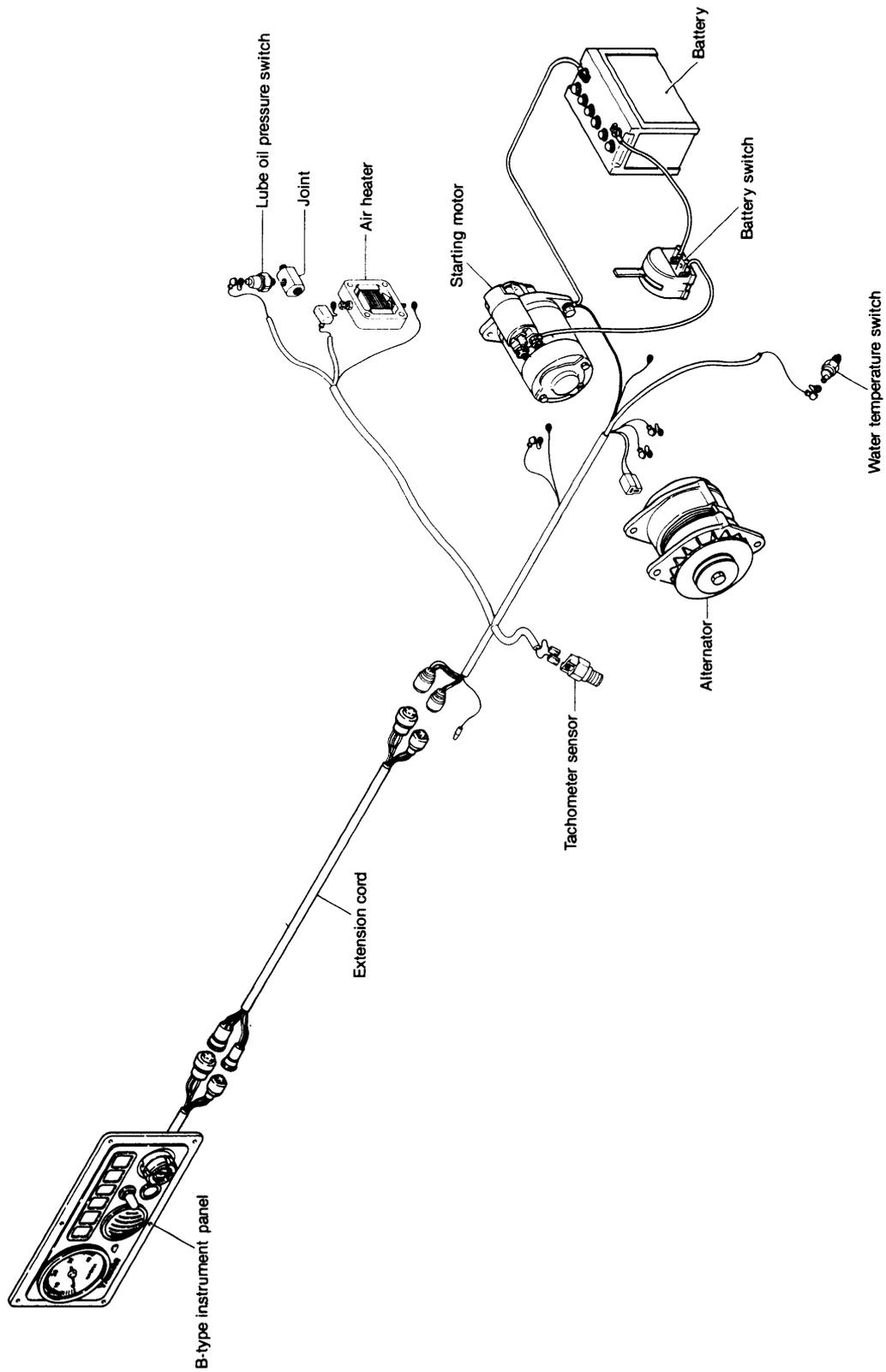
ELECTRICAL SYSTEM

1. Electrical System	9-1
2. Battery	9-6
3. Starter Motor	9-9
4. Alternator	9-20
5. Instrument Panel and Wiring Codes	9-30
6. Warning Devices.	9-35
7. Air Heater (Optional)	9-38
8. Electric Type Engine Stop Device (Optional).	9-39
9. Tachometer	9-41
10. Alternator 12V/80 A (Optional)	9-44

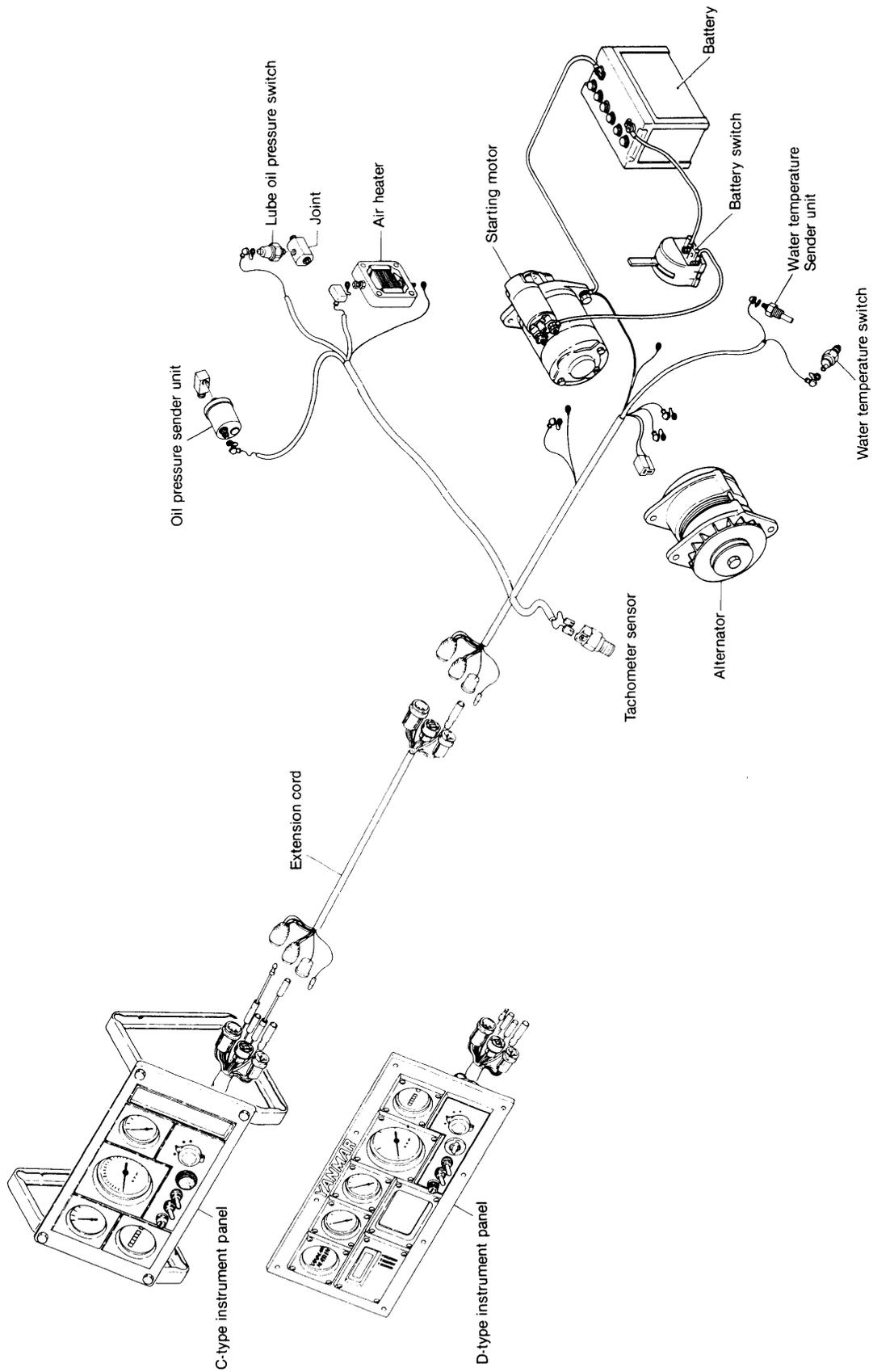
1. Electrical System

1-1 System diagrams of electric parts

1-1.1 B-type instrument panel

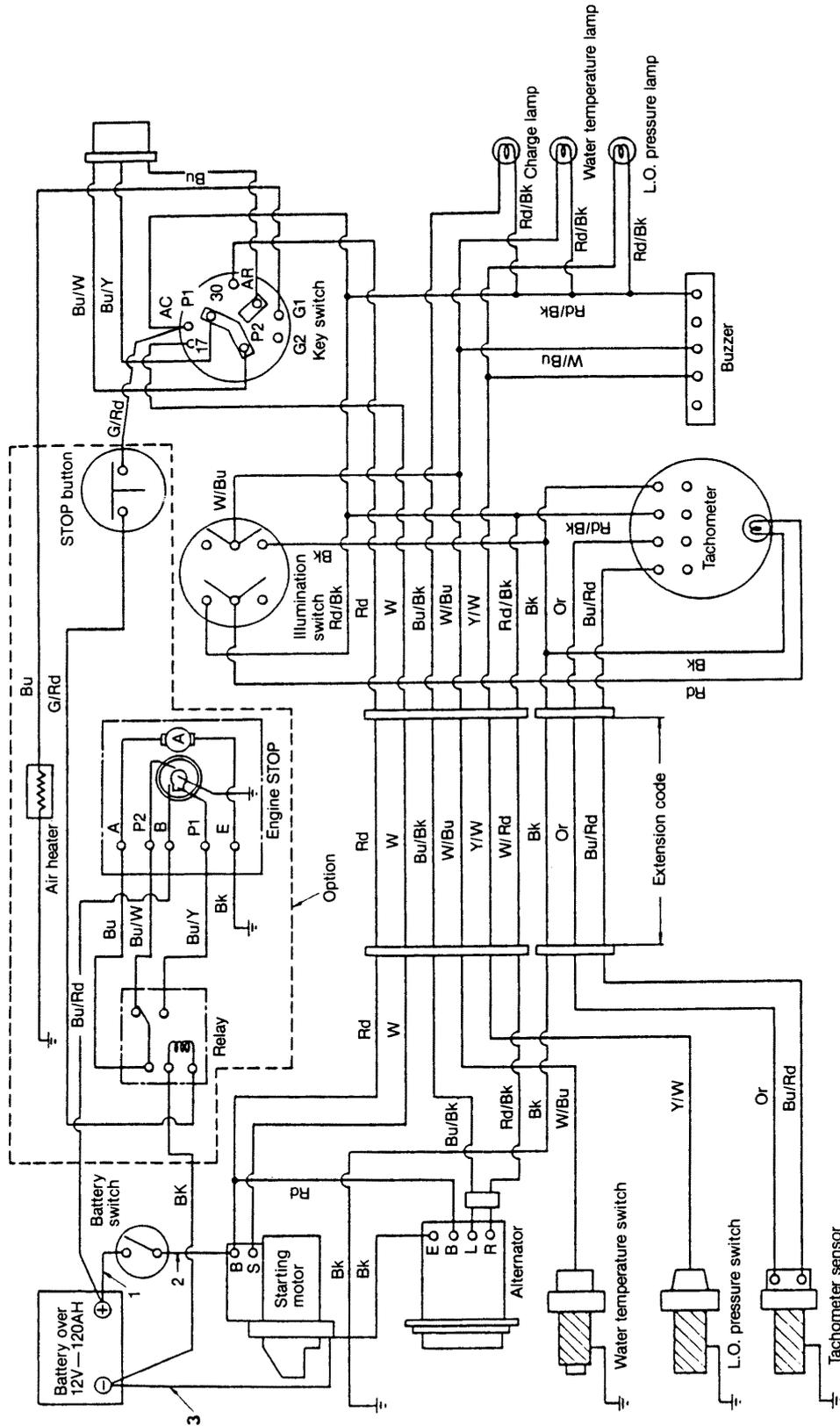


1-1.2 C-type and D-type instrument panel



1-2 Wiring diagram

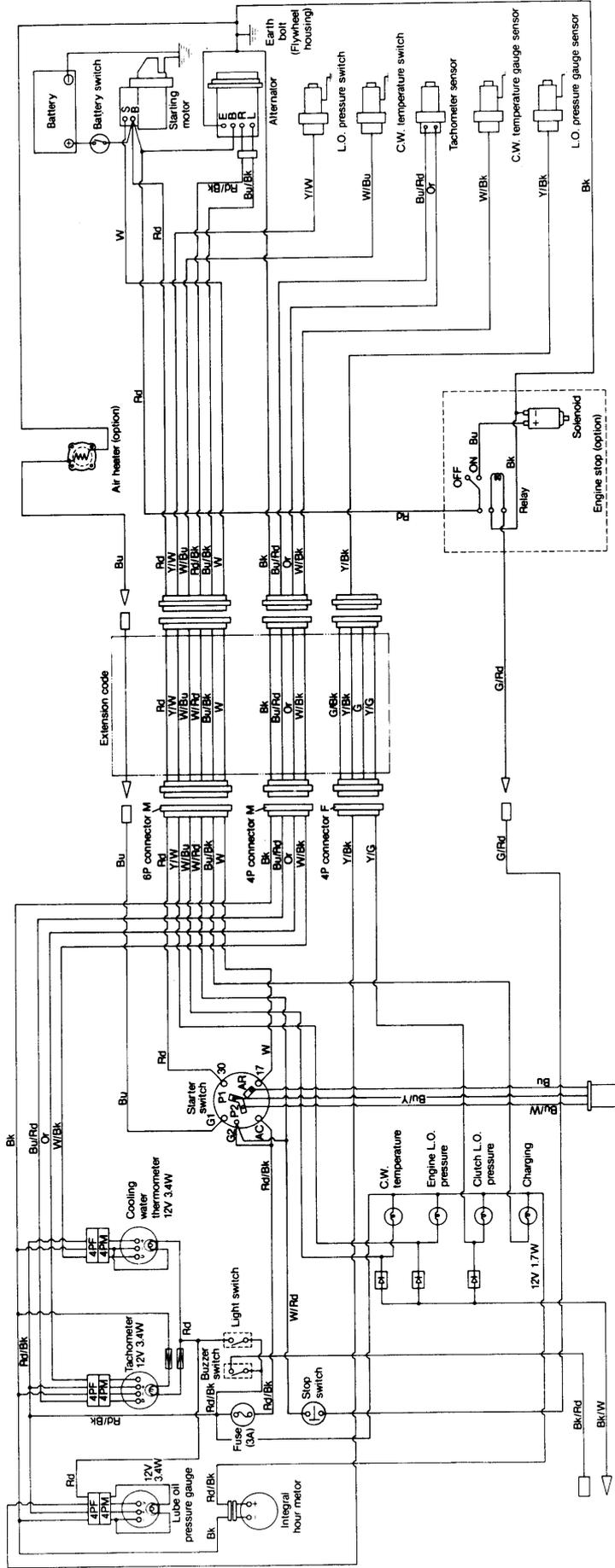
1-2.1 For B-type instrument panel



- Rd: Red
- W: White
- Bk: Black
- Bu: Blue
- Y: Yellow
- Or: Orange
- G: Green

Note: 1 + 2 + 3 < 2.8m → 40mm² (cross sectional area)

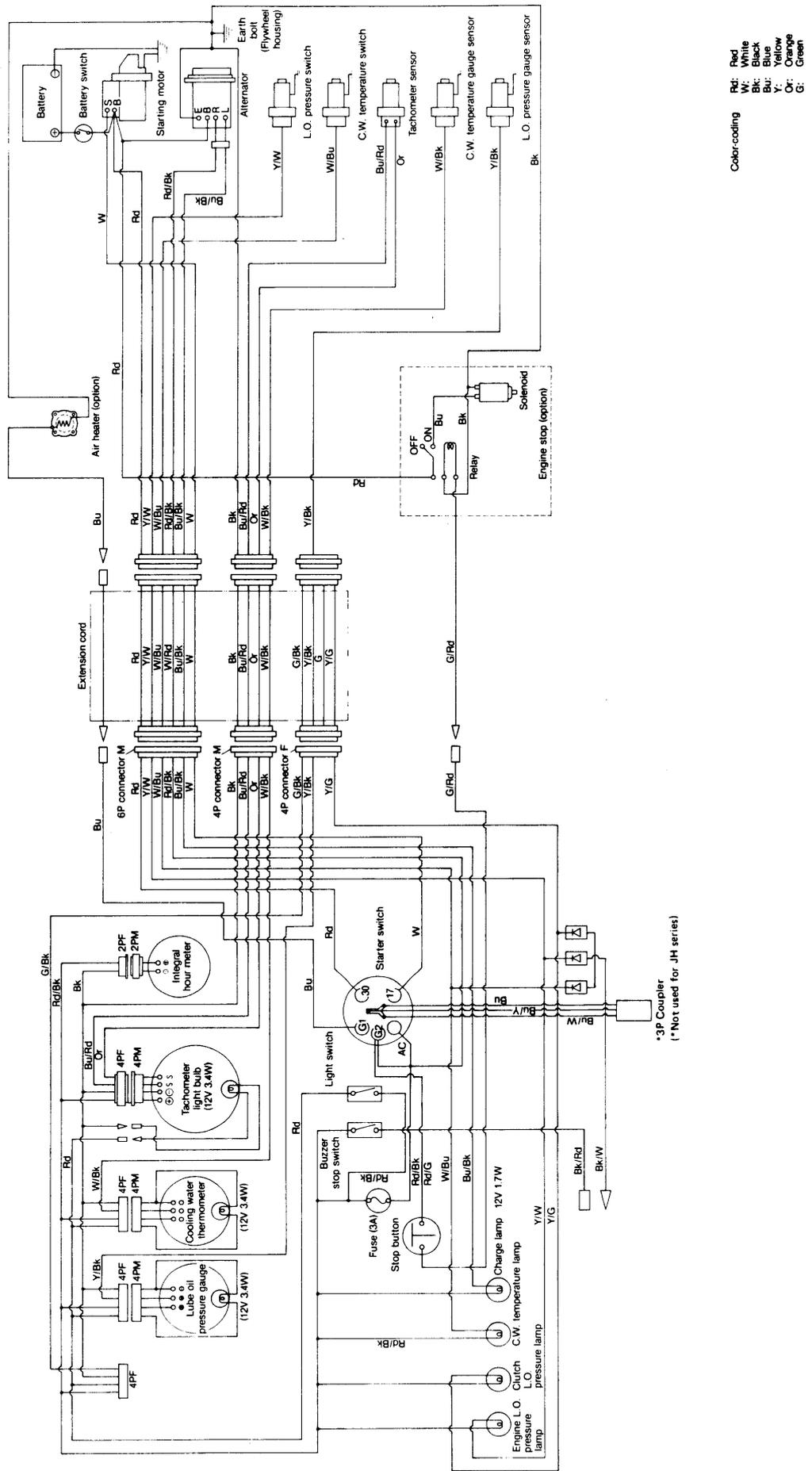
1-2.2 For C-type instrument panel



Color-coding
 Rd: Red
 W: White
 Bk: Black
 Bu: Blue
 Y: Yellow
 Or: Orange
 G: Green

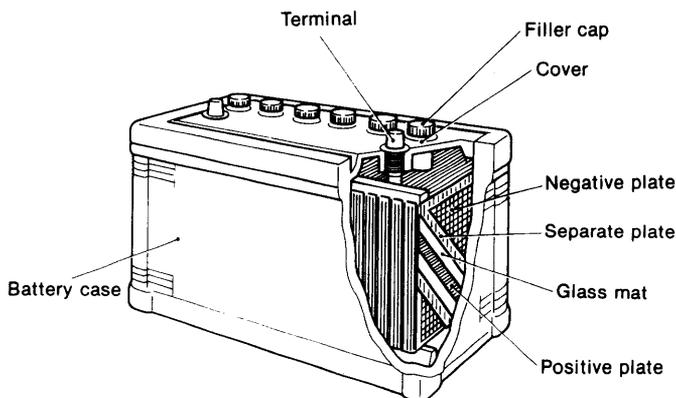
*3P Coupler
 (** Not used for JH series)

1-2.3 For D-type instrument pannel



2. Battery

2-1 Construction



The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.

As shown in the figure, a nonconductive container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive plates and lead dioxide negative plates separated by glass mats are stacked alternately in the electrolyte. The positive and negative plates are connected to their respective terminals.

Power is removed from the battery by connecting the load across these two terminals.

When the battery is discharging, an electric current flows from the positive plates to the negative plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

2-2 Battery capacity and battery cables

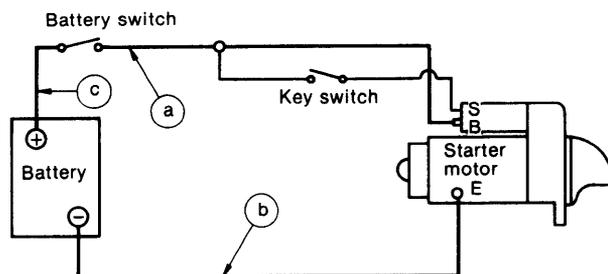
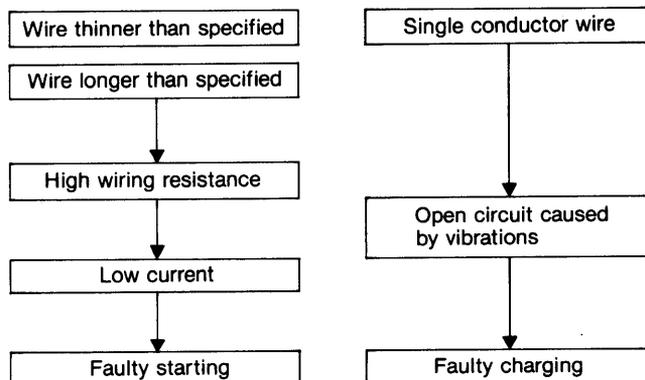
2-2.1 Battery capacity

Since the battery has a minimum capacity of 12V, 70AH, it can be used for 100 ~ 150AH.

Battery capacity	minimum	12V — 100AH
	standard	12V — 120AH
	cold weather	12V — 150AH
Full charged specific gravity		1.26

2-2.2 Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter, (soft automotive low-voltage wire [AV wire]). Using wire other than that specified may cause the following troubles:



The overall lengths of the wire between the battery (+) terminal and the starter (B) terminal, and between the battery (-) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage system	Allowable wiring voltage drop	Conductor cross-section area	a + b + c allowable length
12V	0.2V or less/100A	20mm ² (0.0311 in. ²)	Up to 2.5m (98.43 in.)
		40mm ² (0.062 in. ²)	Up to 5m (196.87 in.)

Note: Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.

2-3 Inspection

The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to ensure that it functions perfectly at all times.

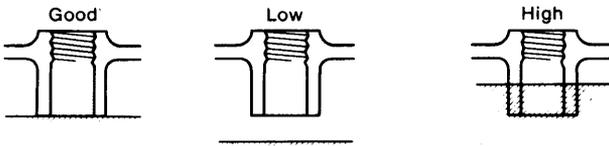
2-3.1 Visual inspection

- (1) Inspect the case for cracks, damage and electrolyte leakage.
- (2) Inspect the battery holder for tightness, corrosion, and damage.
- (3) Inspect the terminals for rusting and corrosion, and check the cables for damage.
- (4) Inspect the caps for cracking, electrolyte leakage and clogged vent holes.

Correct any abnormal conditions found. Clean off rusted terminals with a wire brush before reconnecting the battery cable.

2-3.2 Checking the electrolyte

(1) Electrolyte level

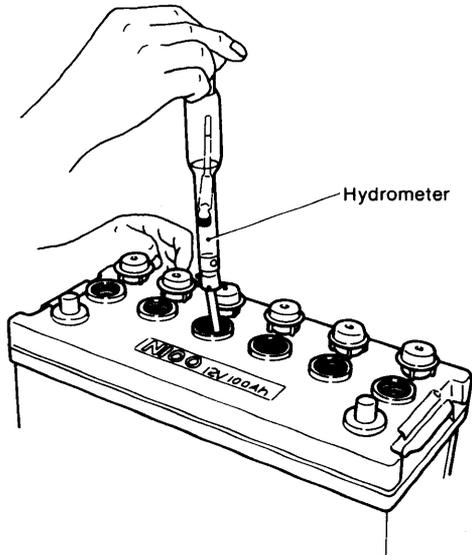


Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 ~ 20mm (0.3937 ~ 0.7874in.) over the top of the plates.

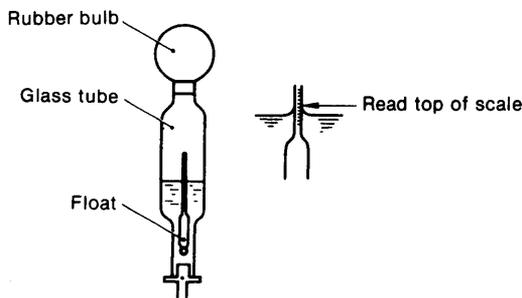
- NOTES: 1. The "LEVEL" line on a transparent plastic battery case indicates the height of the electrolyte.
 2. Always use distilled water to bring up the electrolyte level.
 3. When the electrolyte has leaked out, add dilute sulfuric acid with the same specific gravity as the electrolyte.

(2) Measuring the specific gravity of the electrolyte

- 1) Draw some of the electrolyte up into a hydrometer.



- 2) Take the specific gravity reading at the top of the scale of the hydrometer.



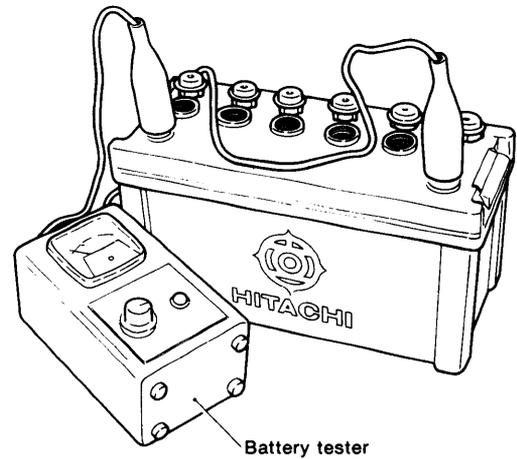
- 3) The battery is fully charged if the specific gravity is 1.260 at an electrolyte temperature of 20°C. The battery is discharged if the specific gravity is 1.200

(50%). If the specific gravity is below 1.200, recharge the battery.

- 4) If the difference in the specific gravity among the cells of the battery is ± 0.01 , the battery is OK.
 5) Measure the temperature of the electrolyte. Since the specific gravity changes with the temperature, 20°C is used as the reference temperature.
 Reading the specific gravity at 20°C
 $S_{20} = S_t + 0.0007(t - 20)$
 S_{20} : Specific gravity at the standard temperature of 20°C
 S_t : Specific gravity of the electrolyte at t°C
 0.0007: Specific gravity change per 1°C
 t: Temperature of electrolyte

2-3.3 Voltage test

Using a battery tester, the amount of discharge can be determined by measuring the voltage drop which occurs while the battery is being discharged with a large current.



- (1) Connect the tester to the battery.
 12V battery tester
 Adjust the current (A).
 (2) Connect the (+) lead of the tester to the (+) battery terminal, and the (-) tester lead to the (-) battery terminal.
 (3) Push the TEST button, wait 5 seconds, and then read the meter.
 • Repeat the test twice to make sure that the meter indication remains the same.

2-3.4 Washing the battery

- (1) Wash the outside of the battery with a brush while running cold or warm water over the battery. (Make sure that no water gets into the battery.)
 (2) When the terminals or other metal parts are corroded due to exposure to electrolyte leakage, wash off all the acid.
 (3) Check the vent holes of the caps and clean if clogged.
 (4) After washing the battery, dry it with compressed air, connect the battery cable, and coat the terminals with grease. Since the grease acts as an insulator, do not coat the terminals before connecting the cables.

2-4 Charging

2-4.1 Charging methods

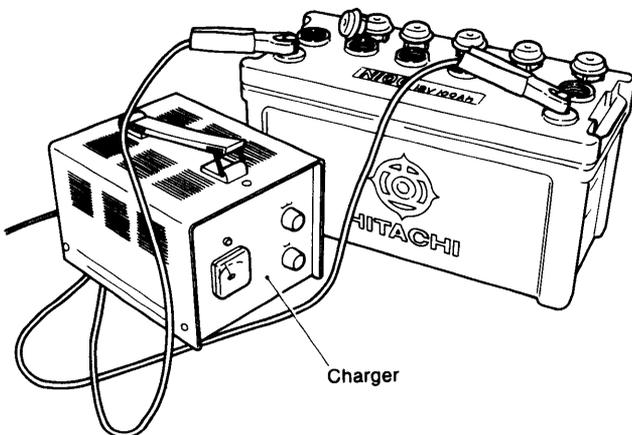
There are two methods of charging a battery: normal and rapid.

Rapid charging should only be used in emergencies.

- Normal charging... Should be conducted at a current of 1/10 or less of the indicated battery capacity (10A or less for a 100AH battery).
- Rapid charging... Rapid charging is done over a short period of time at a current of 1/5 ~ 1/2 the indicated battery capacity (20A ~ 50A for a 100AH battery). However, since rapid charging causes the electrolyte temperature to rise too high, special care must be exercised.

2-4.2 Charging procedure

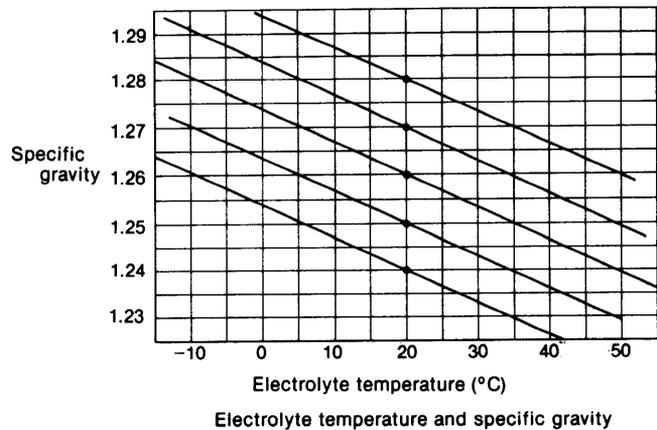
- (1) Check the specific gravity and adjust the electrolyte level.
- (2) Disconnect the battery cables.
- (3) Connect the red clip of the charger to the (+) battery terminal and connect the black clip to the (-) terminal.



- (4) Set the current to 1/10 ~ 1/5 of the capacity indicated on the outside of the battery.
- (5) Periodically measure the specific gravity during charging to make sure that the specific gravity remains at a high fixed value. Also check whether gas is being generated.

2-4.3 Charging precautions

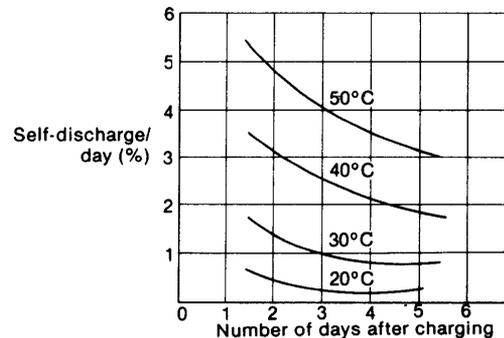
- (1) Remove the battery caps to vent the gas during charging.
- (2) While charging, ventilate the room and prohibit smoking, welding, etc.
- (3) The electrolyte temperature should not exceed 45°C during charging.
- (4) Since an alternator is used on this engine, when charging with a charger, always disconnect the battery (+) cable to prevent destruction of the diodes. (Before disconnecting the (+) battery cable, disconnect the (-) battery cable [ground side].)



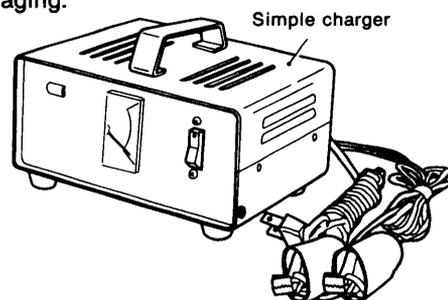
2-5 Battery storage precautions

The life of a battery depends considerably on how it is handled. Generally speaking, however, after about two years its performance will deteriorate, starting will become difficult, and the battery will not fully recover its original charge even after recharging. Then it must be replaced.

- (1) Since the battery will self-discharge about 0.5%/day even when not in use, it must be charged 1 or 2 times a month when it is being stored.



- (2) If charging by the engine alternator is insufficient because of frequent starts and stops, the battery will rapidly lose power. Charge the battery as soon as possible after it is used under these conditions.
- (3) An easy-to-use battery charger that permits home charging is available from Yanmar. Take proper care of the battery by using the charger as a set with a hydrometer. When the specific gravity has dropped to about 1.16 and the engine will not start, charge the battery up to a specific gravity of 1.26 (24 hours).
- (4) Before putting the battery in storage for long periods, charge it for about 8 hours to prevent rapid aging.



3. Starter Motor

The starter motor is installed on the flywheel housing. When the starting button is pushed, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.

After the engine starts, the pinion automatically returns to its initial position when the starting button is released. Once the engine starts, the starting button should be released immediately. Otherwise, the starter motor may be damaged or burned out.

3-1 Specifications and Performance.

Engine model	4JHE, 4JH-TE 4JH-HTE, 4JH-DT(B)E	
Model	S12-77A	
Rating (sec.)	30	
Output (kW)	1.8	
Direction of rotation (viewed from pinion side)	Clockwise	
Weight kg (lb.)	9.3 (20.5)	
Clutch system	Overrunning	
Engagement system	Magnetic shift	
No. of pinion teeth	15	
Pinion flyout voltage (V)	8 or less	
No-load	Terminal voltage (V)	12
	Current (A)	90 or less
	Speed (rpm)	4000 or greater
Loaded characteristics	Terminal voltage (V)	8.5
	Current (A)	420
	Torque kg-m (ft.-lb.)	1.35 (9.76) or greater

3-2 Construction

The starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.

The starter motor is composed of three major parts, as follows:

(1) Magnetic switch

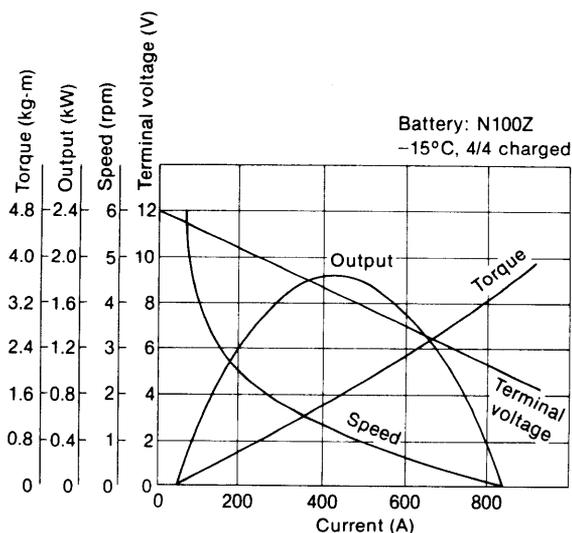
Moves plunger to engage and disengage pinion and, through the engagement lever, opens and closes the main contact (moving contact) to stop the starter motor.

(2) Motor

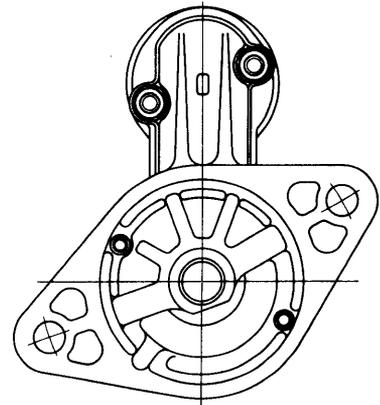
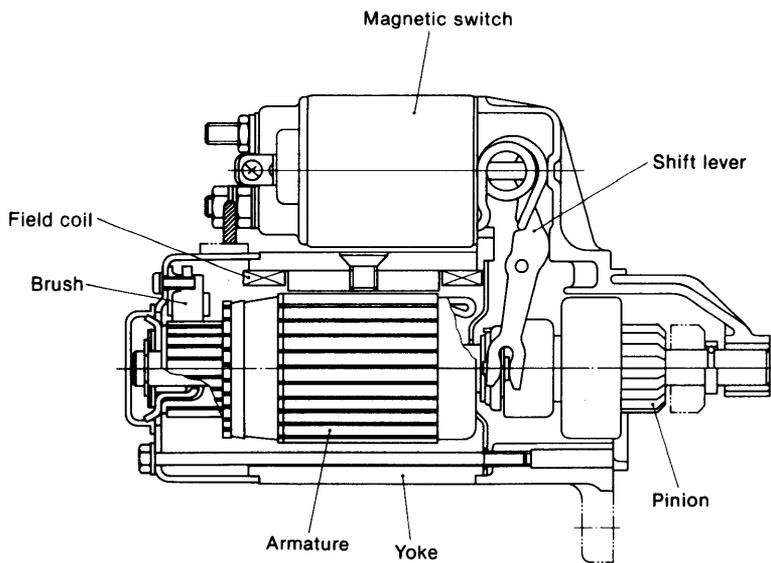
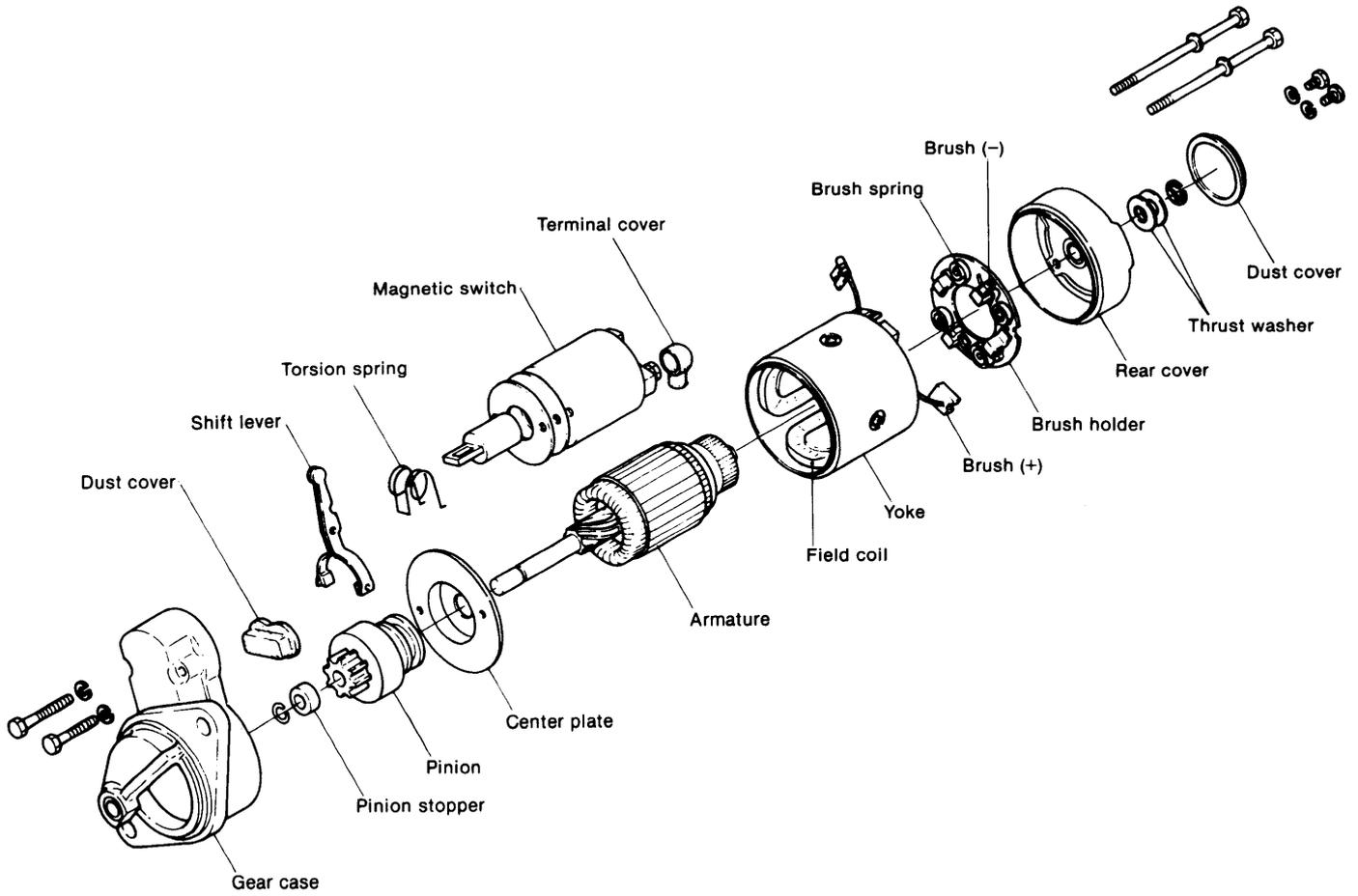
A continuous current series motor which generates rotational drive power.

(3) Pinion

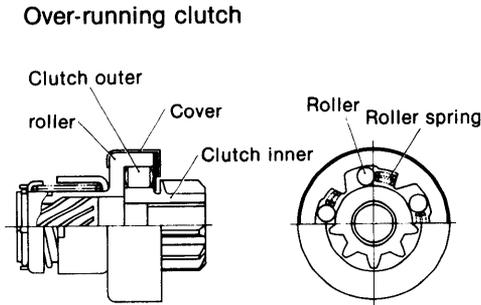
Transfers driving power from motor to ring gear. An over-speed clutch is employed to prevent damage if the engine should run too fast.



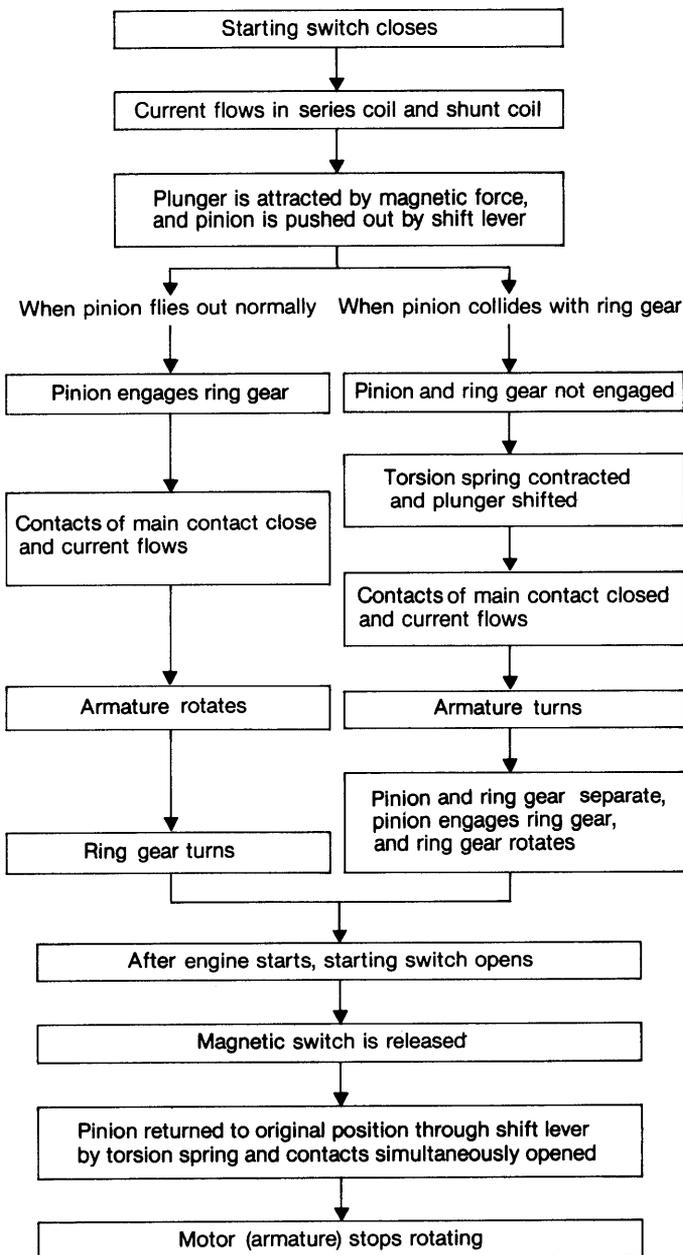
S12-77A Performance curves



To prevent the motor receiving a shock when the engine starts and over-runs, the starter motor has an over-running clutch.



3-3 Operation

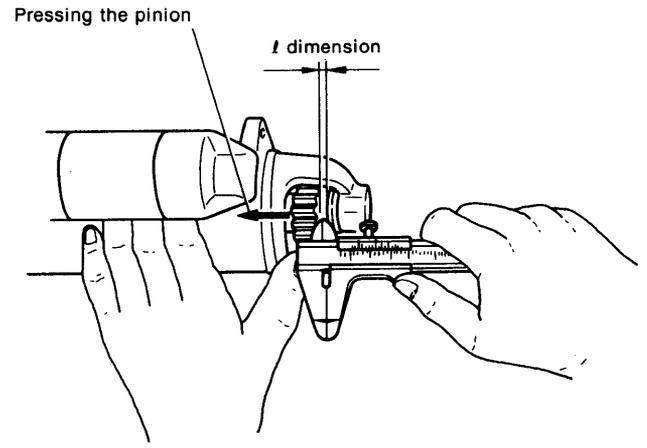


3-4 Adjustment and performance test

3-4.1 L-size measurement (gap between pinion and pinion stopper)

When the pinion is at the projected position, measure gap between pinion and pinion stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

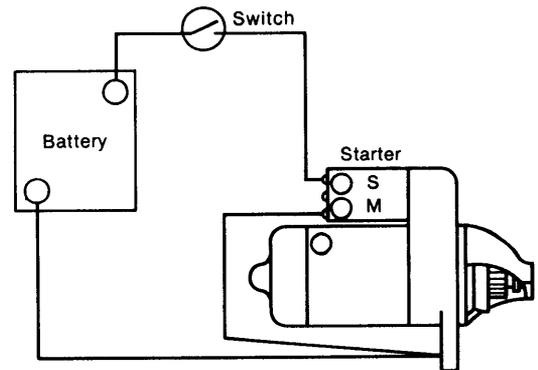
	Starter motor	l dimension mm (in.)
	S12-77A	0.2 ~ 1.5 (0.0079 ~ 0.0591)



Measuring of l dimension

3-4.2 Pinion movement

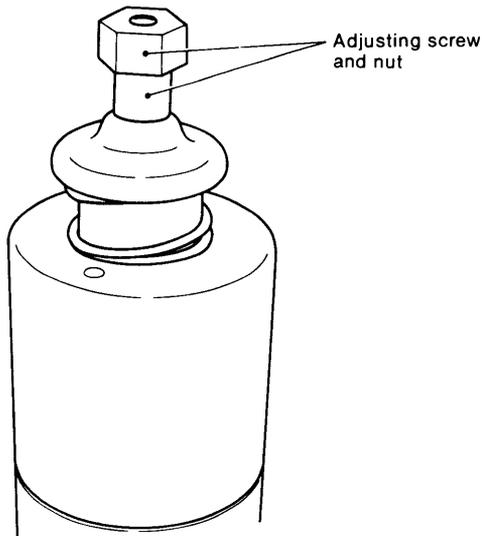
After complete assembly of the starter motor, connect up the motor as in Fig.



3-4.3 Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.

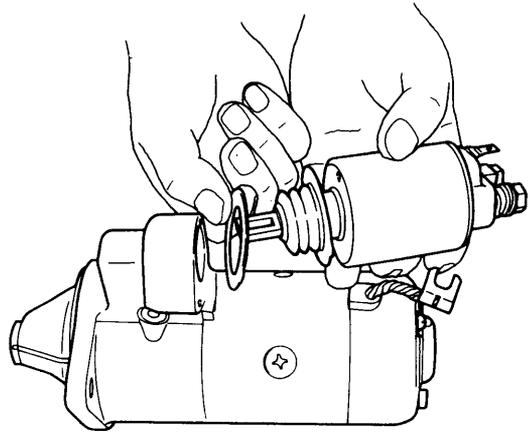
Adjust the *l*-dimension by adjusting screw and nut.



3-5 Disassembly

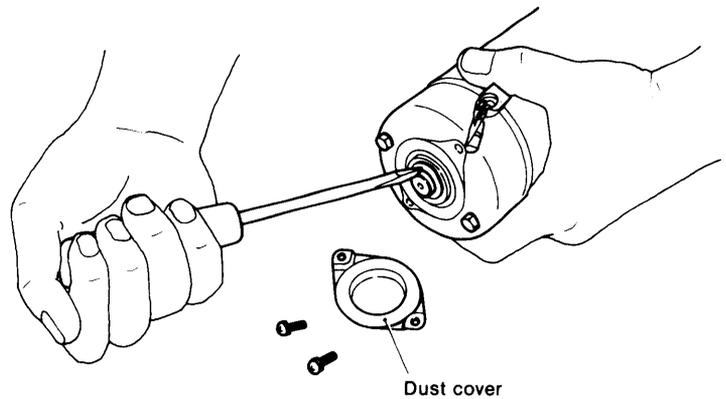
3-5.1 Magnetic switch

- (1) Disconnect magnetic switch wiring.
- (2) Remove through bolt mounting magnetic switch.
- (3) Remove magnetic switch.

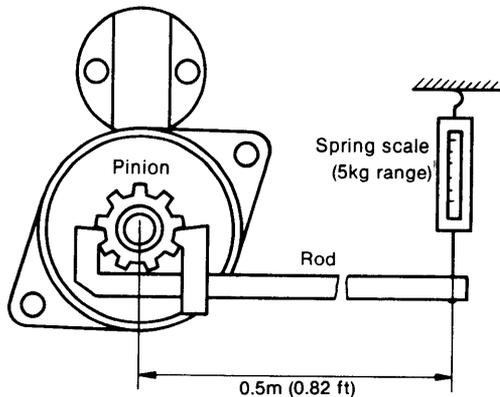


3-5.2 Rear cover

- (1) Remove dust cover.

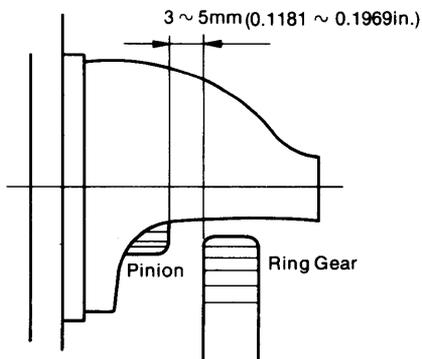


3-4.4 Pinion lock torque measurement

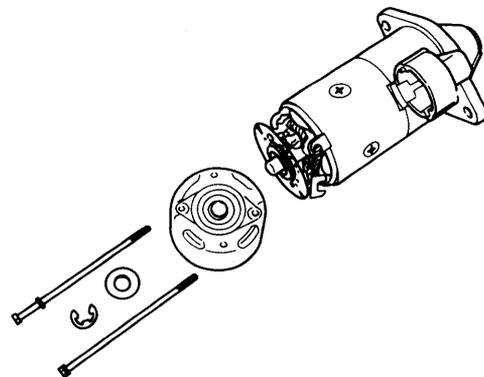


3-4.5 Mesh clearance

Mesh clearance is the distance between the flywheel ring gear and starter motor pinion in the rest position. This clearance should be between 3mm (0.1181in.) to 5mm (0.1969in.).

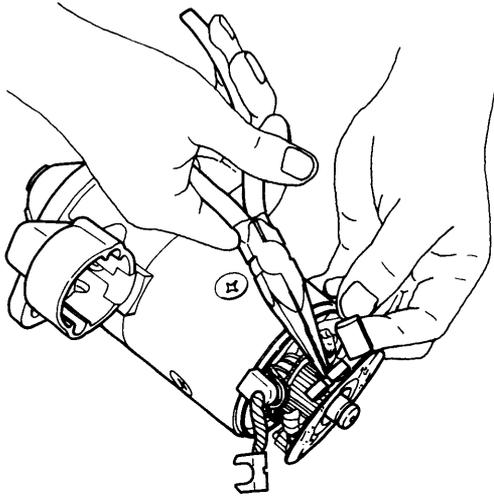


- (2) Remove E-ring, and remove thrust washer (be careful not to lose the washer and shim).
- (3) Remove the two through bolts holding the rear cover and the two screws holding the brush holder.
- (4) Remove rear cover.



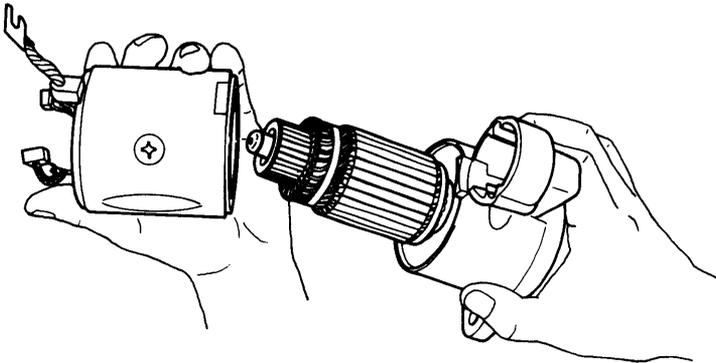
3-5.3 Brush holder

- (1) Float (-)brush from the commutator.
- (2) Remove (+)brush from the brush holder.
- (3) Remove brush holder.



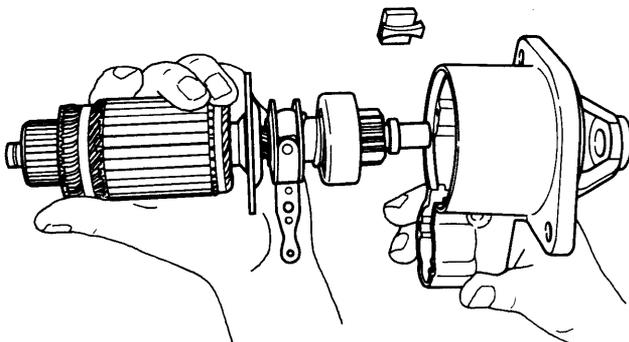
3-5.4 Yoke

- (1) Remove yoke. Pull it out slowly so that it does not strike against other parts.



3-5.5 Armature

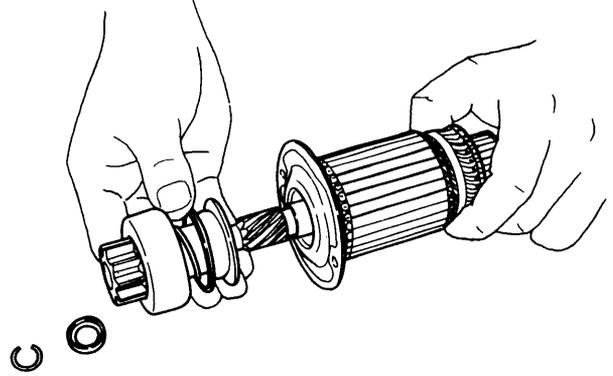
- (1) Slide pinion stopper to pinion side.



- (2) Remove the pinion stopper clip.

3-5.6 Pinion

- (1) Slide the pinion stopper to the pinion side.
- (2) Remove the pinion stopper clip.
- (3) Remove the pinion from the armature.

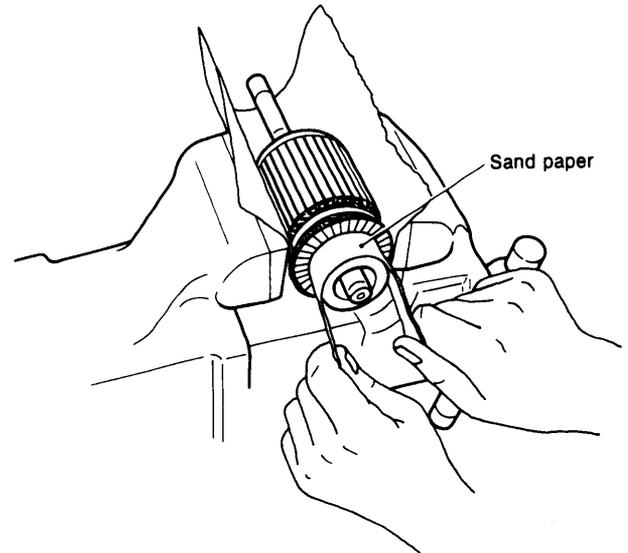


3-6 Inspection

3-6.1 Armature

- (1) Commutator

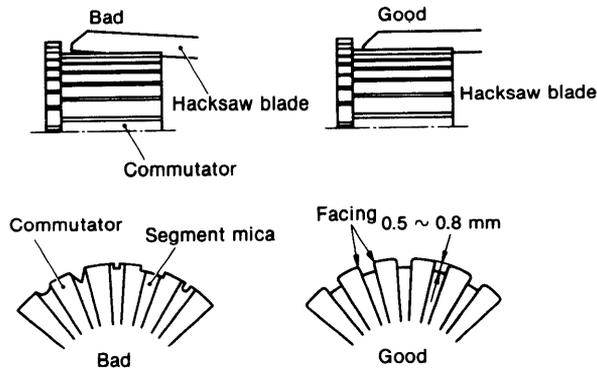
Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. If the commutator is severely pitted, grind it to within a surface roughness of at least 0.4 by turning it on a lathe. Replace the commutator if damage is irreparable.



	S12-77A	
	Maintenance standard	Wear limit
Commutator outside diameter	ø43 (1.693)	ø40 (1.575)
Commutator run-out	Within 0.03 (0.0012)	0.2 (0.0079)
Difference between maximum diameter and minimum diameter	Repair limit 0.4 (0.0157)	Repair accuracy 0.05 (0.002)

(2) Mica undercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.



mm (in.)

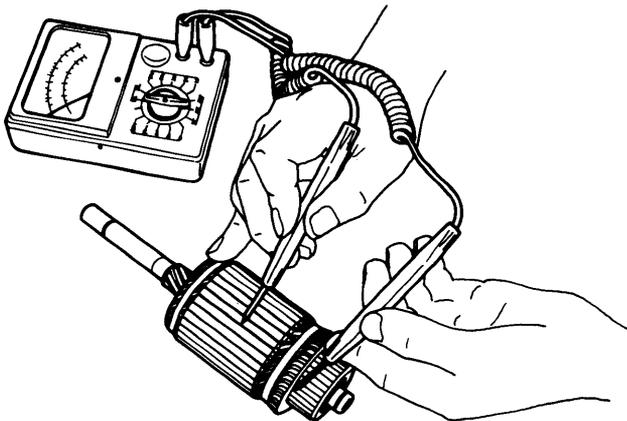
	Maintenance standard	Repair limit
Mica undercut	0.2 (0.0079)	0.5 ~ 0.8 (0.0197 ~ 0.0315)

(3) Armature coil ground test

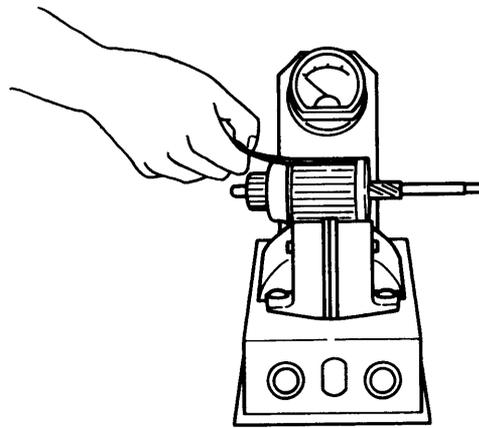
Using a tester, check for continuity between the commutator and the shaft (or armature core). Continuity indicates that these points are grounded and that the armature must be replaced.

- 1) Short test...existence of broken or disconnected coil.
- 2) Insulation test...between commutator and armature core or distortion shaft.

Checking commutator for insulation defects.



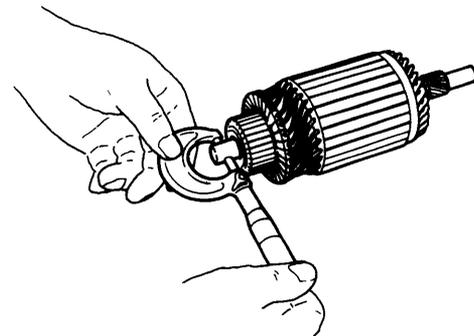
Checking armature windings for insulation faults.



(4) Armature shaft outside diameter

Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn.

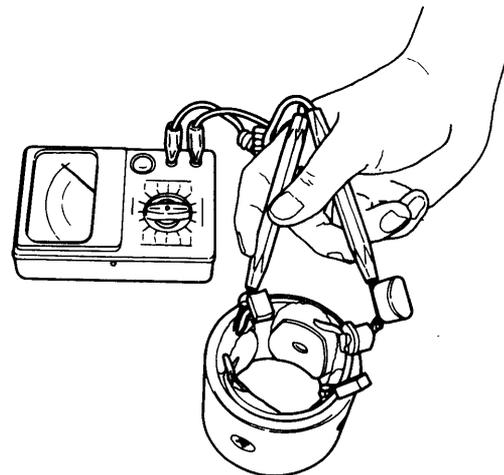
Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



3-6.2 Field coil

(1) Open test

Check for continuity between the terminals connecting the field coil brushes. Continuity indicates the coil is open and must be replaced.



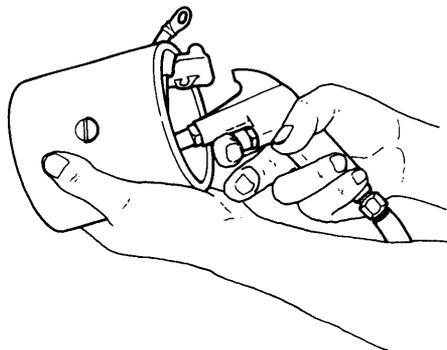
(2) Short test

Check for continuity between the yoke and any field coil terminal. Continuity indicates that the coil is shorted and it must be replaced.

(3) Cleaning the inside of the yoke

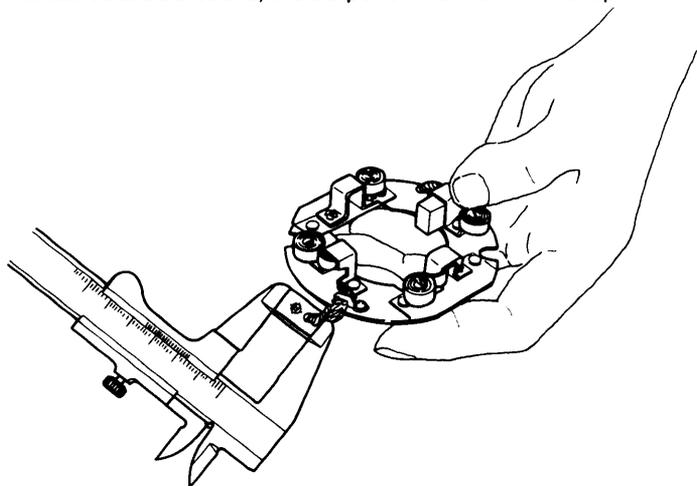
If any carbon powder or rust has collected on the inside of the yoke, blow the yoke out with dry compressed air.

*Do not remove the field coil from the yoke.



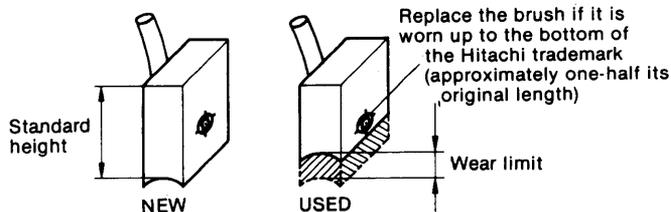
3-6.3 Brush

The brushes are quickly worn down by the motor. When the brushes are defective, the output of the motor will drop.



(1) Brush dimensions

Replace brushes which have been worn beyond the specified wear limit.



	S12-77A
Brush standard height	22 (0.8661)
Wear limit	8 (0.3150)

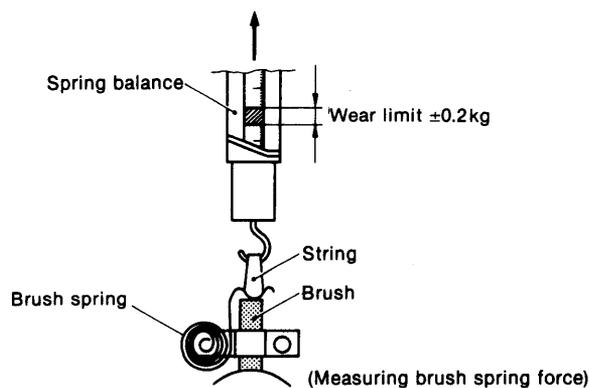
mm (in.)

(2) Brush appearance and movement in brush holder

If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

(3) Brush spring

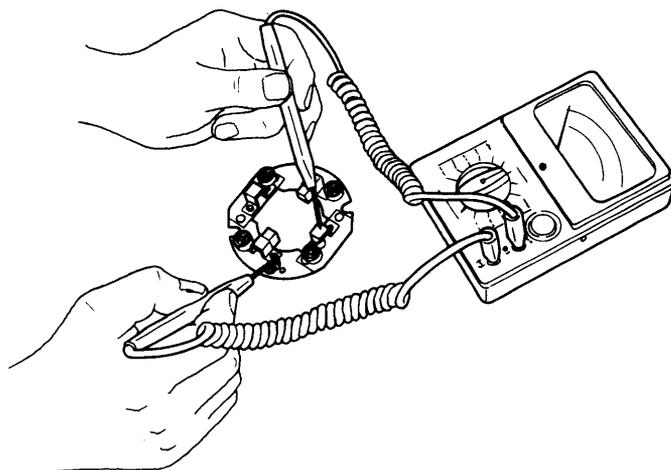
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds $\pm 0.2\text{kg}$.



	S12-77A
Standard spring load	0.85kg (1.8737 lb)

(4) Brush holder ground test

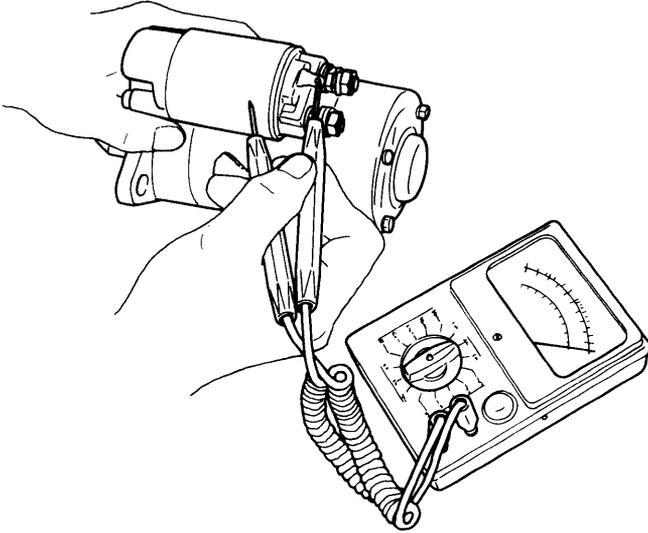
Check for continuity between the insulated brush holder and the base of the brush holder assembly. Continuity indicates that these two points are grounded and that the holder must be replaced.



3-6.4 Magnetic switch

(1) Shunt coil continuity test

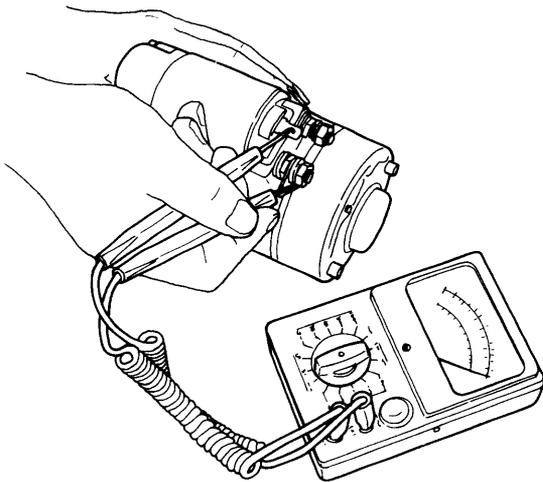
Check for continuity between the S terminal and the magnetic switch body (metal part). Continuity indicates that the coil is open and that the switch must be replaced.



	S12-77A
Coil resistance (at 20°C)	0.590Ω

(2) Series coil continuity test

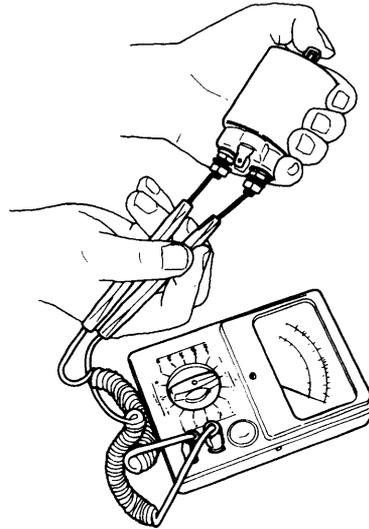
Check for continuity between the S terminal and M terminal. Continuity indicates that the coil is open and that it must be replaced.



	S12-77A
Resistance value (at 20°C)	0.267Ω

(3) Contactor contact test

Push the plunger with your finger and check for continuity between the M terminal and B terminal. Continuity indicates that the contact is faulty and that the contactor must be replaced.



3-6.5 Pinion

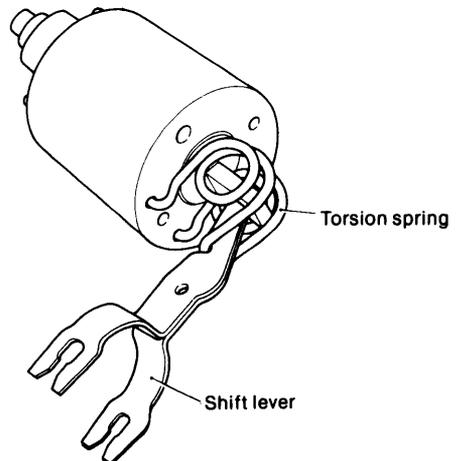
- (1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
- (2) Check if the pinion slides smoothly; replace the pinion if faulty.
- (3) Inspect the springs and replace if faulty.
- (4) Replace the clutch if it slips or seizes.

3-7 Reassembly precautions

Reassemble the starter motor in the reverse order of disassembly, paying particular attention to the following:

(1) Torsion spring and shift lever

Hook the torsion spring into the hole in the magnetic switch and insert the shift lever into the notch in the plunger of the magnetic switch (through the torsion spring).

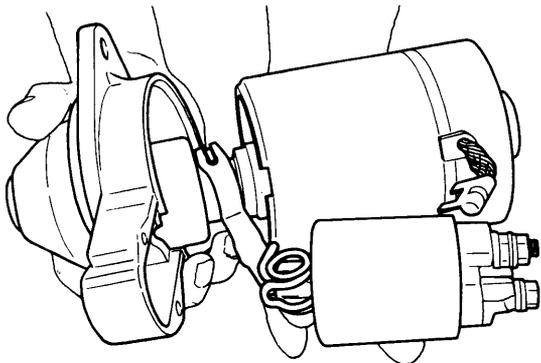


(2) Mounting the magnetic switch

Attach the shift lever to the pinion; assemble the gear case as shown below.

Do not forget to install the dust cover before assembling the gear case.

After reassembly, check by conducting no-load operation.



(3) Lubrication

Lubricate each bearing and spline (points indicated in the figure below) with high quality "Hitachi Electrical Equipment Grease A"

The following lubricants may be used in place of Hitachi Electrical Equipment Grease A.

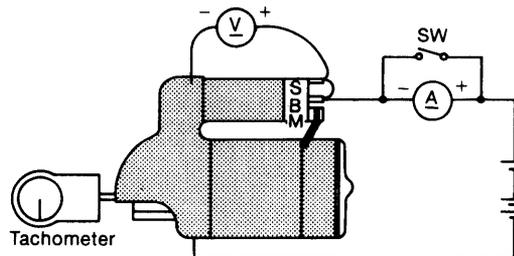
Magnetic switch plunger	Shell	Aeroshell No. 7
Bearing and spline	Shell	Albania Grease No. 2

3-8 Testing

3-8.1 No load test

Test procedure

- (1) Connect the positive side of the ammeter (A) to the positive terminal of the battery, and connect the negative side of the ammeter to the B terminal of the starter.



- (2) Connect the negative terminal of the battery to the body of the starter.
- (3) Connect the positive side of the voltmeter (V) to the B terminal of the starter, and connect the negative side of the voltmeter to the body of the starter.
- (4) Attach the tachometer.
- (5) Connect the B terminal of the starter to the S terminal of the magnetic switch.

- The magnetic switch should begin operation, and the speed, current, and voltage should be at the prescribed values.
- A fully charged battery must be used.
- Since a large current flows when the starter is operated, close the protection circuit switch before initial operation, then open the switch and measure the current after the starter reaches a constant speed.

3-9 Maintenance standard

			S12-77A
Brush	Standard spring load	kg (lb)	0.85 (1.8737)
	Standard height	mm (in.)	22 (0.8661)
	Wear limit	mm (in.)	8 (0.3150)
Magnetic switch	Series coil resistance	Ω	0.267
	Shunt coil resistance	Ω	0.590
Commutator	Outside diameter	Maintenance standard	mm (in.) ∅43 (1.193)
		Wear limit	mm (in.) ∅40 (1.575)
	Difference between maximum diameter and maximum diameter	Repair limit	mm (in.) 0.4 (0.0157)
		Repair accuracy	mm (in.) 0.05 (0.002)
	Mica undercut	Maintenance standard	mm (in.) 0.2 (0.0079)
		Repair limit	mm (in.) 0.5 ~ 0.8 (0.0197 ~ 0.0315)
Standard dimension	Rear side bearing	Shaft diameter	14.950 ~ 14.968 (0.5886 ~ 0.5893)
		Bearing inside diameter	15.000 ~ 15.018 (0.5906 ~ 0.5913)
	Intermediate bearing	Shaft diameter	20.350 ~ 20.368 (0.7972 ~ 0.7980)
		Bearing inside diameter	20.500 ~ 20.518 (0.8071 ~ 0.8080)
	Pinion sliding section	Shaft diameter	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Pinion inside diameter	14.030 ~ 14.050 (0.5524 ~ 0.5531)
	Pinion side bearing	Shaft diameter	13.950 ~ 13.968 (0.5492 ~ 0.5499)
		Bearing inside diameter	14.000 ~ 14.018 (0.5512 ~ 0.5519)

3-10 Various problems and their remedies

(1) Pinion fails to advance when the starting switch is closed

Problem	Cause	Corrective action
Wiring	Open or loose battery or switch terminal	Repair or retighten
Starting switch	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Repair contacts, or replace switch
Starter motor	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Replace
Magnetic switch	Plunger of magnetic switch malfunctioning or coil shorted	Repair or replace

(2) Pinion is engaged and motor rotates, but rotation is not transmitted to the engine

Problem	Cause	Corrective action
Starting motor	Overrunning clutch faulty	Replace

(3) Motor rotates at full power before pinion engages ring gear

Problem	Cause	Corrective action
Starter motor	Torsion spring permanently strained	Replace

(4) Pinion engages ring gear, but starter motor fails to rotate

Problem	Cause	Corrective action
Wiring	Wires connecting battery and magnetic switch open or wire connecting ground, magnetic switch and motor terminals loose	Repair, retighten, or replace wire
Starter motor	Pinion and ring gear engagement faulty Motor mounting faulty Brush worn or contacting brush spring faulty Commutator dirty Armature, field coil faulty Field coil and brush connection loose	Replace Remount Replace Repair Repair or replace Retighten
Magnetic switch	Contactors contact faulty Contactors contacts pitted	Replace Replace

(5) Motor fails to stop when starting switch is opened after engine starts

Problem	Cause	Corrective action
Starting switch	Switch faulty	Replace
Magnetic switch	Switch faulty	Replace

4. Alternator Standard, 12V/55A

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V-belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keep the generated voltage constant even when the engine speed changes.

4-1 Features

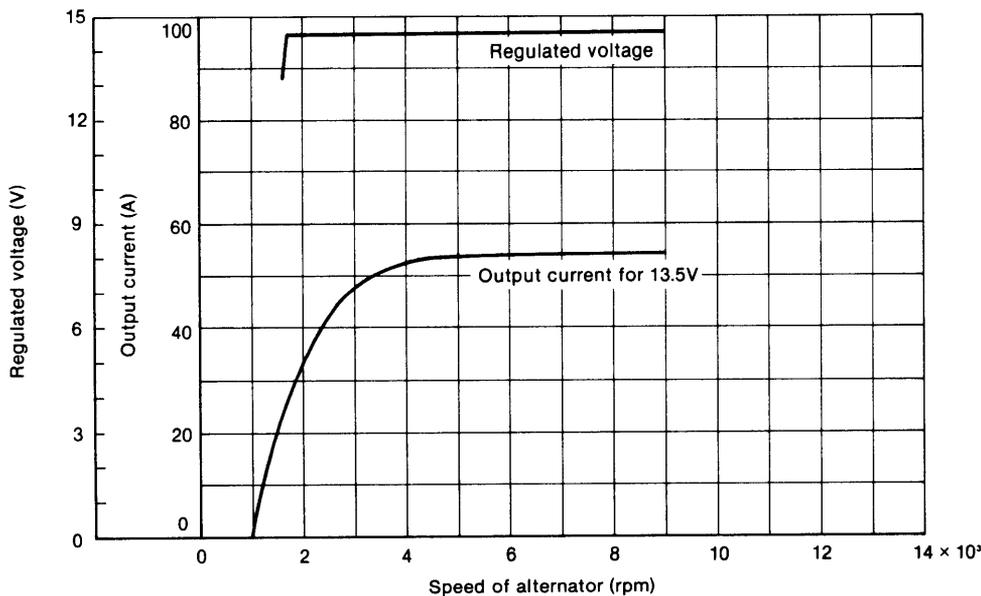
The alternator contains a regulator using an IC, and has the following features.

- (1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). It therefore has superior features such as freedom from vibration, no fluctuation of voltage during use, and no need for readjustment.
Also, it is of the over-heating compensation type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.
- (2) The regulator is integrated within the alternator to simplify external wiring.
- (3) It is an alternator designed for compactness, lightness of weight, and high output.
- (4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.
- (5) As the alternator is to be installed on board, the following measures are taken to provide salt-proofing.
 - 1) The front and rear covers are salt-proofed.
 - 2) Salt-proof paint is applied to the diode.
 - 3) The terminal, where the inboard harness is connected to the alternator, is nickel plated.

4-2 Specifications

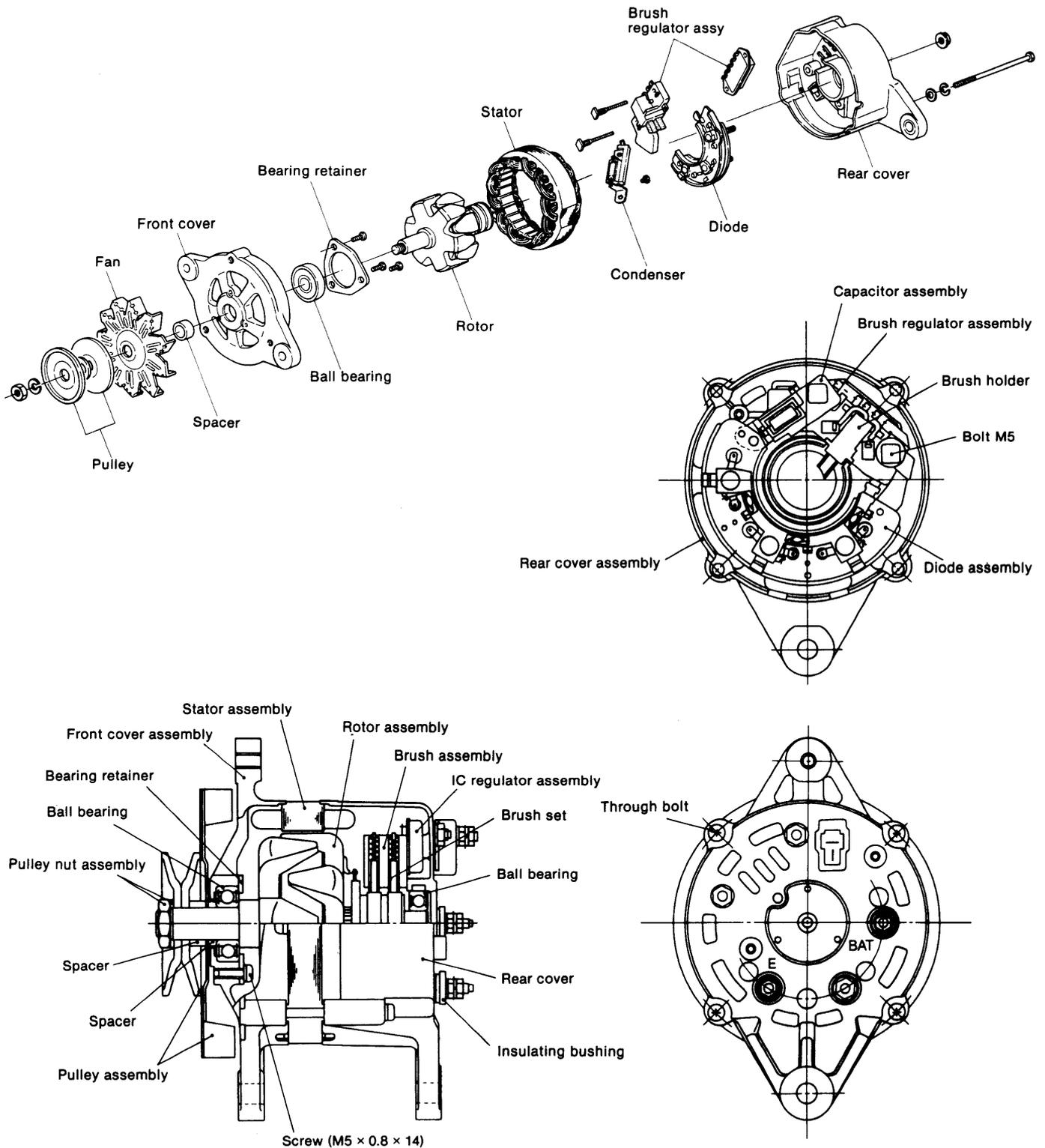
Model of alternator	LR155-20 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/55A
Earth polarity	Negative earth (⊖)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	4.3kg (9.5lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 53A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, -0.01/°C)

4-3 Characteristics



4-4 Construction

This is a standard rotating field type three-phase alternator. It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.



4-5 Alternator functioning

(1) IC regulator

The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.

When the output voltage of the generator is within the standard value, the transistor (Tr_1) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor (Tr_1) turns off.

With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

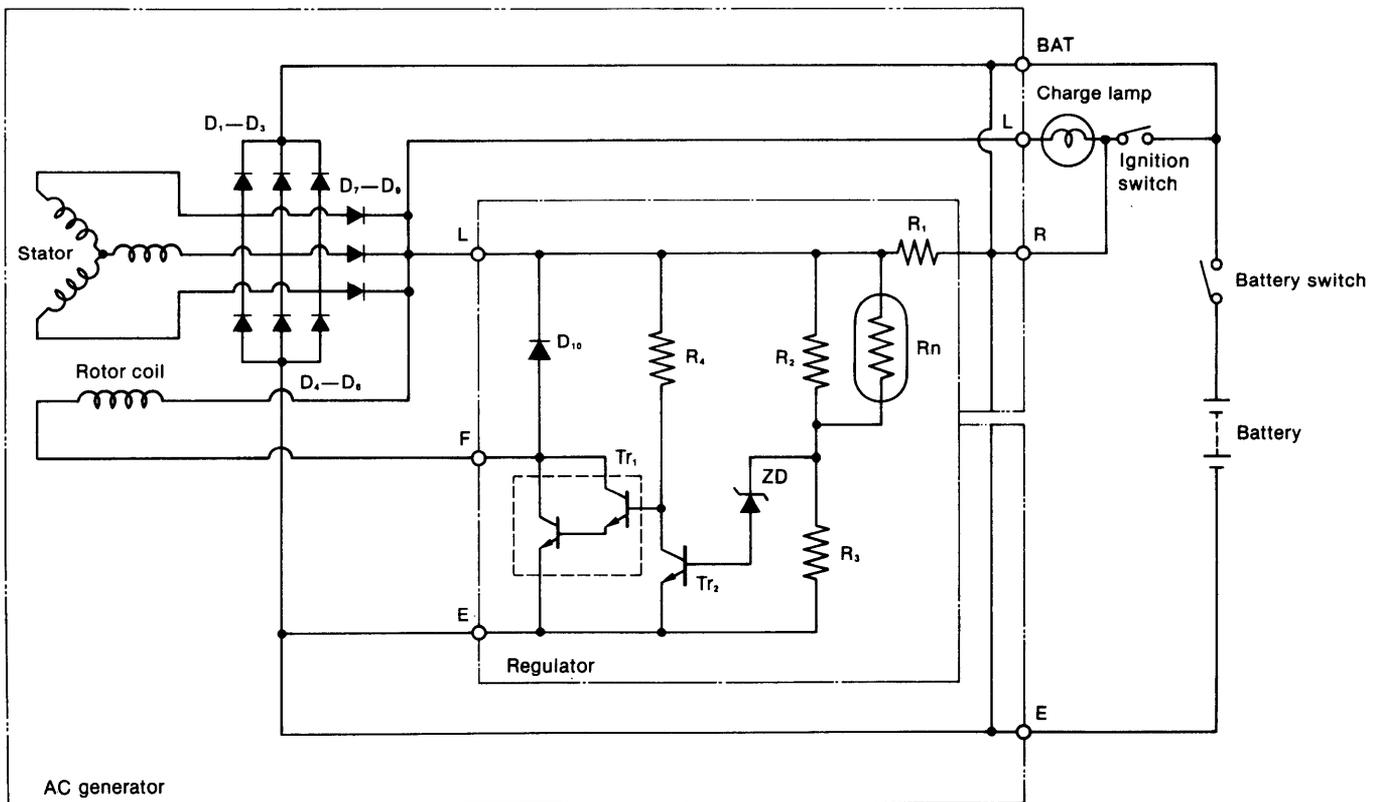
(2) Charge lamp

When the transistor (Tr_1) is on, the charge lamp key switch is turned to ON, and current flows to R_1 , R_4 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

(3) Circuit diagram

4-6 Handling precautions

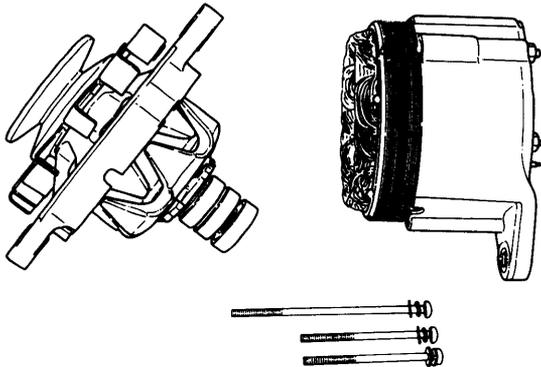
- (1) Be careful of the battery's polarity (+, - terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode. In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.
- (2) Make sure of the correct connection of each terminal.
- (3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.
- (4) Do not short-circuit the terminals.
- (5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



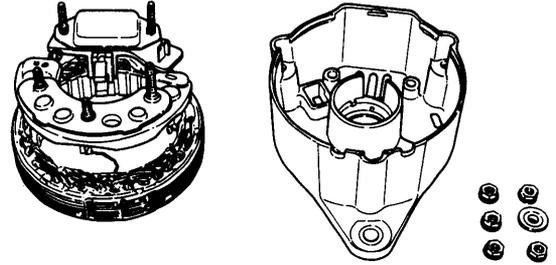
BAT:	Generator output terminal	D_1-D_6 :	Output commutation diode
D_{10} :	IC protecting diode	R_1-R_4 :	Resistor
L:	Charge lamp terminal	D_7-D_8 :	Charging lamp switching diode
ZD:	Zener diode	F:	To supply current to rotor coil
E:	Earth	R_n :	Thermistor (Temperature gradient resistance)
Tr_1, Tr_2 :	Transistor		

4-7 Disassembling the alternator

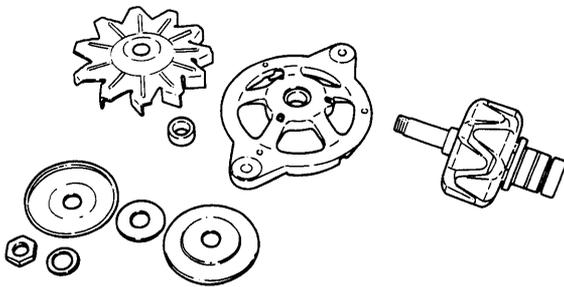
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



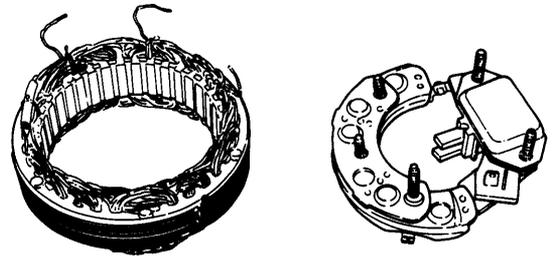
(4) Remove the nut, the brush-holder, and diode fixing nut at the BAT, and the terminal screws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).



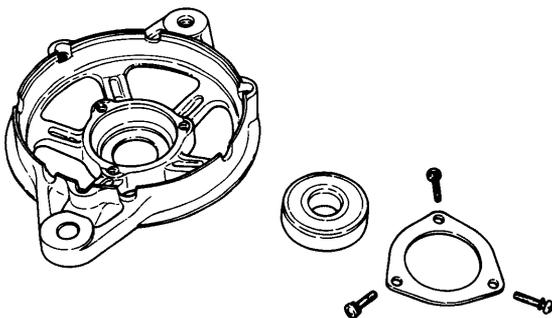
(2) Remove the pulley nut, and pull out the rotor from the front cover.



(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

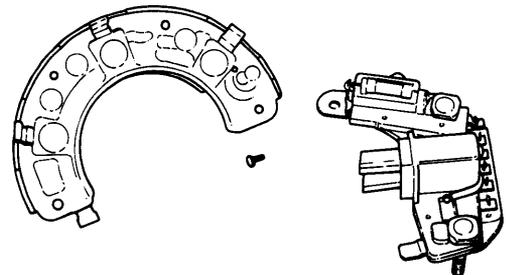


(3) Remove the $\varnothing 5\text{mm}$ ($\varnothing 0.1969\text{in.}$) screw from the front cover, and then remove the ball bearing.

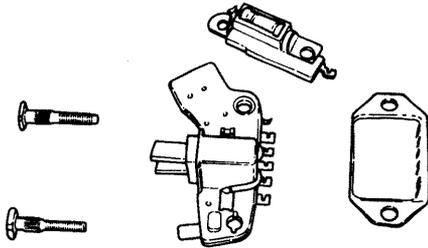


(6) Separating the regulator

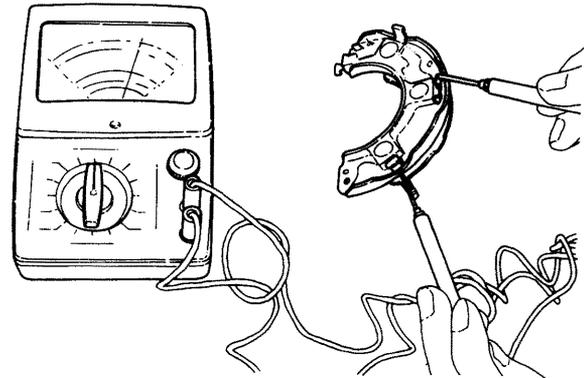
1) To separate the regulator, remove the $\varnothing 3\text{mm}$ ($\varnothing 0.1181\text{in.}$) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.



After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



4-8 Inspection and adjustment

(1) Diode

Between terminals		BAT (+ side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	Continuity	No continuity
	- side		

Between terminals		E (- side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	No continuity	Continuity
	- side		

CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(2) Rotor

Inspect the slip ring surface, rotor coil continuity and insulation.

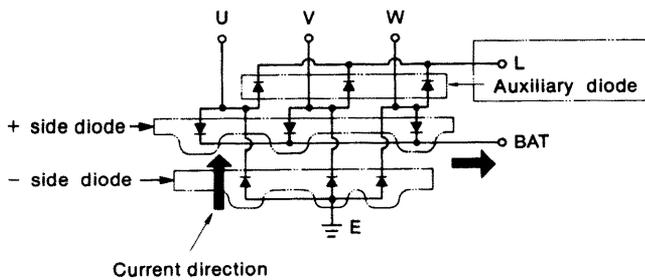
1) Inspecting the slip ring surface

Check if the surface of the slip ring is sufficiently smooth. If the surface is rough, grind the surface with No. 500—600 sand paper. If it is contaminated with oil, etc., wipe the surface clean with alcohol.

Slip ring outer dia.	Standard	Wear limit
	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

2) Rotor coil continuity test

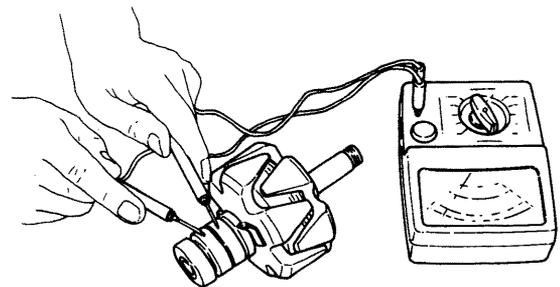
Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.



U.V.W.: terminal from the stator coil

Current flows only in one direction in the diode as shown in Fig. 181. Accordingly, when there is continuity between each terminal (e.g. BAT and U), the diode is in normal condition (photo). When there is no continuity, the diode is defective.

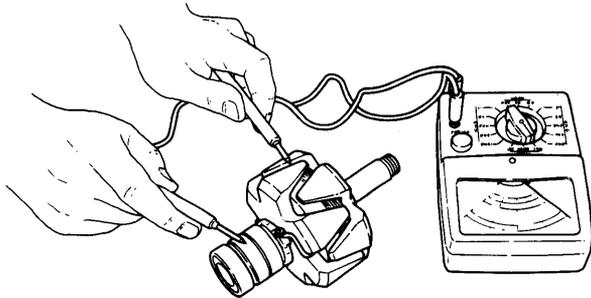
When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.



Resistance value	Approx. 3.34Ω at 20°C
------------------	-----------------------

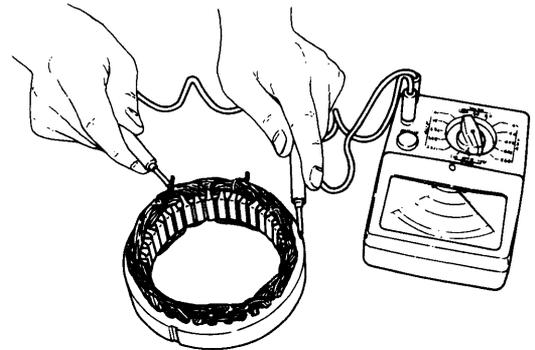
3) Rotor coil insulation test

Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.

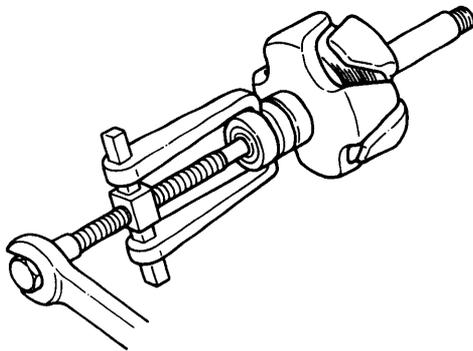


2) Stator coil insulation test

Check the continuity between the terminals and the stator core. If there is continuity, insulation of the stator coil is defective. This will cause a short-circuit with the earth core. Replace the stator coil.

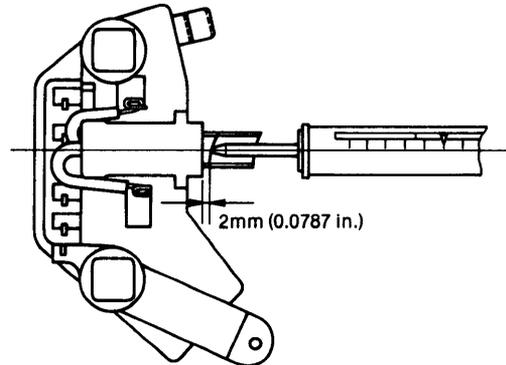


4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



(4) Brush

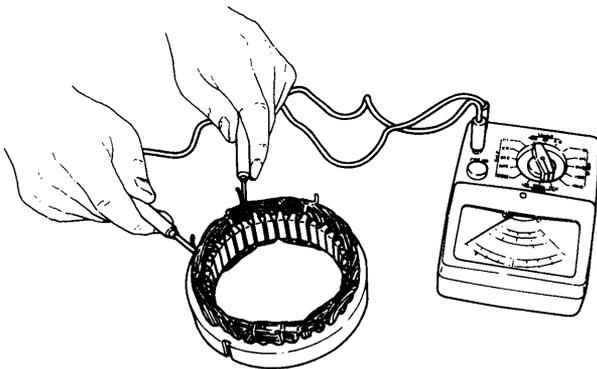
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring. To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



(3) Stator

1) Stator coil continuity test

Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.

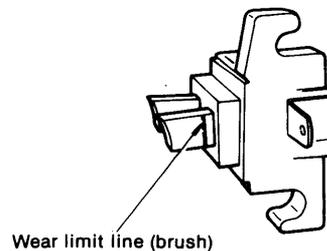


Brush spring strength	255—345g (0.56 ~ 0.76lb.)
-----------------------	---------------------------

(5) Brush wear

Check the brush length.

The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



Resistance value	Approx. 0.077Ω at 20°C 1-phase resistance
------------------	--

	mm (in.)	
	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

(6) IC regulator

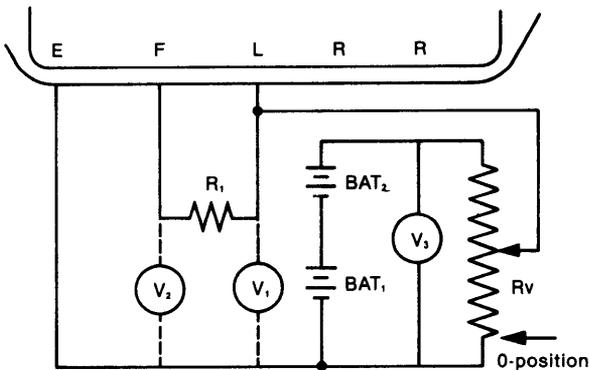
Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

- Resistor (R₁) 100Ω, 2W, 1pc.
- Variable resistor (R_v) 0—300Ω, 12W, 1pc.
- Battery (BAT₁, BAT₂) 12V, 2pcs.
- DC voltmeter 0—30V, 0.5 class 1pc.
(measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.

- a) Check V₃ (BAT₁ + BAT₂ voltage). If the voltage is 20—26V, both BAT₁ and BAT₂ are normal.
- b) While measuring V₂ (F-E terminal voltage), move R_v gradually from the 0-position. Check if there is a point where the V₂ voltage rises sharply from below 2.0V to over 2.0V. If there is no such point, the regulator is defective. Replace the regulator. If there is a sharp voltage rise when testing, return the R_v to the 0-position, and connect the voltmeter to the V₁ position.
- c) While measuring V₁ (voltage between L-E terminals), move R_v gradually from the 0-position. There should be a point where the voltage of V₁ rises sharply by 2—6V. Measure the voltage of V₁ just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V₁ is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.



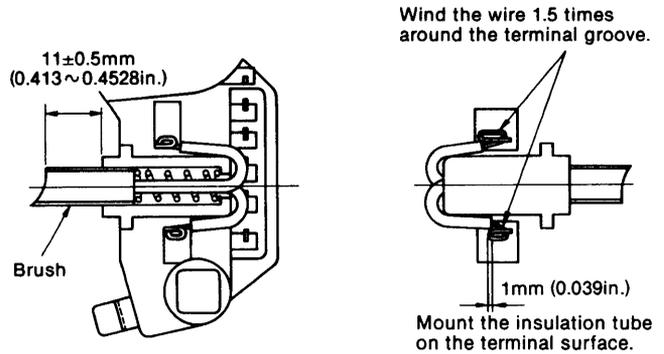
4-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4—7 disassembling alternator).

(1) Assembling the brush regulator

1) Solder the brush.

Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).

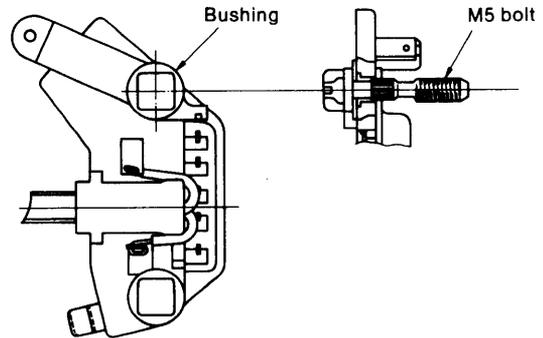


NOTES: 1. Use non-acid type paste.

2. The soldering iron temperature is 300 ~ 350°C.

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.

(If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)

2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

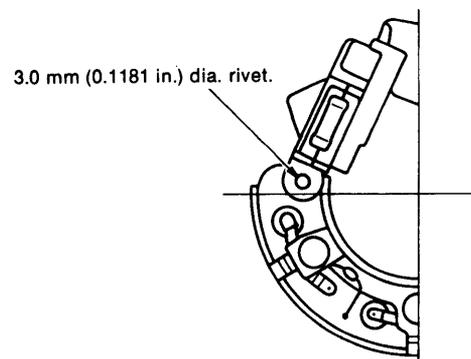
1) Check the rivets

Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500kg (1102 lbs.)
----------------	-------------------

2) Connect the brush to the diode.

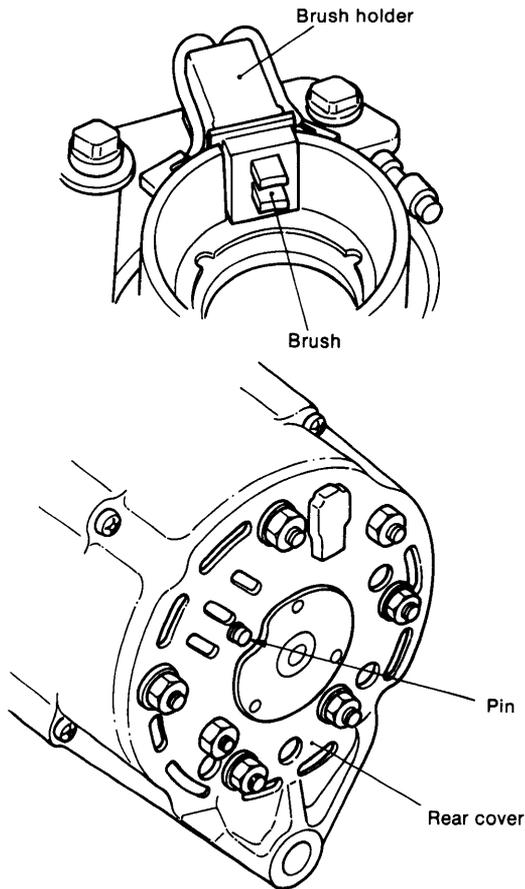
Insert the brush side terminal into the diode terminal, calk it, and then solder into place.



Rivetting pressure	500kg (1102 lbs.)
--------------------	-------------------

(3) Assembling the rear cover

Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.

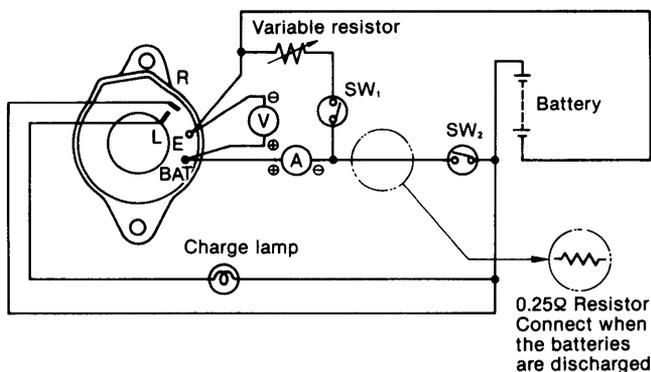


(4) Tightening torques

Positions	Tightening torque kg-cm (ft-lb)
Brush holder fixing	32—40 (2.31 ~ 2.89)
Diode fixing	32—40 (2.31 ~ 2.89)
Bearing retainer fixing	32—40 (2.31 ~ 2.89)
Pulley nut tightening	400—600 (28.93 ~ 43.40)
Through-bolt tightening	32—40 (2.31 ~ 2.89)

4-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.



(1) Measuring devices

DC voltmeter	0—15V or 0—30V, 0.5 Class, 1pc.
DC ammeter	0—100A, 1.0 Class, 1pc.
Variable resistor	0—0.25Ω, 1kW, 1pc.
Lamp	12V, 3W
100Ω resistor	3W
0.25Ω resistor	25W

(2) Measuring the regulating voltage

- 1) When measuring devices are connected in the performance test circuit as shown above, the charge lamp lights.
- 2) Close SW₂ while keeping SW₁ open and run the AC generator. When the revolutions of the generator are gradually raised, the charge lamp goes off.
- 3) Raise the revolutions of the AC generator, and read the voltmeter gauge when the revolutions reach about 5,000 rpms.

NOTES: 1. Make sure that the ammeter indication at this time is less than 5A. If the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.

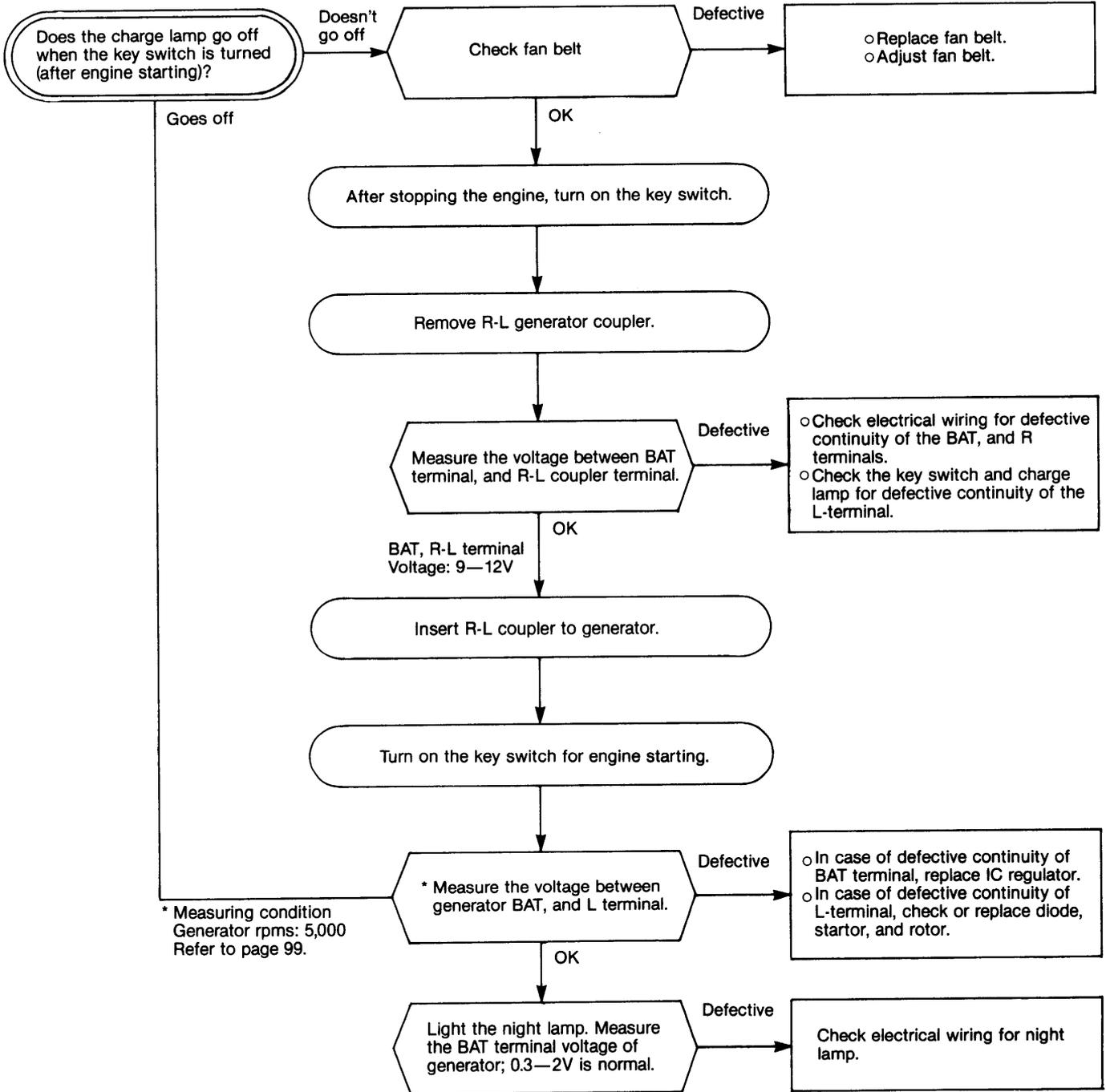
2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

(3) Precautions for measuring the regulating voltage

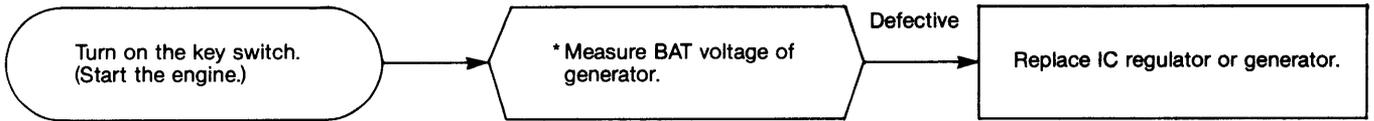
- 1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
- 2) Use a fully charged battery.
- 3) Measure the voltage quickly.
- 4) Keep SW₁ open for measurement.

4-11 Troubleshooting

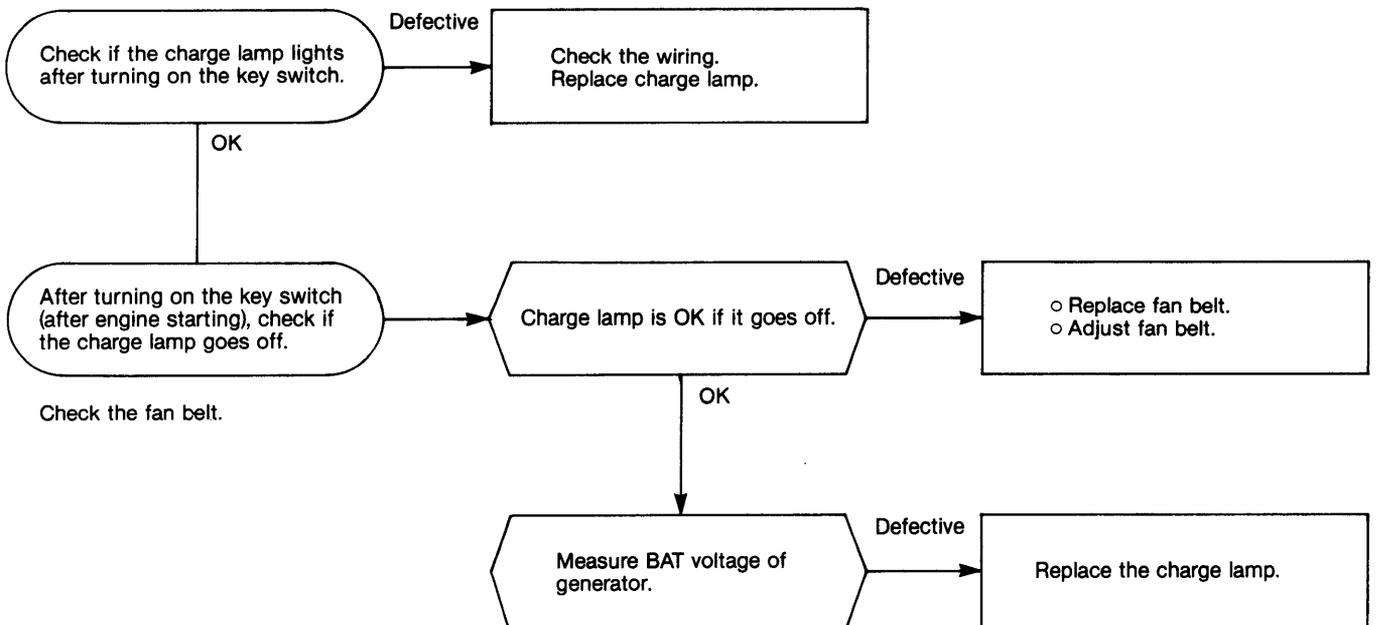
(1) Charging failure



(2) Overcharging



(3) Charge lamp failure



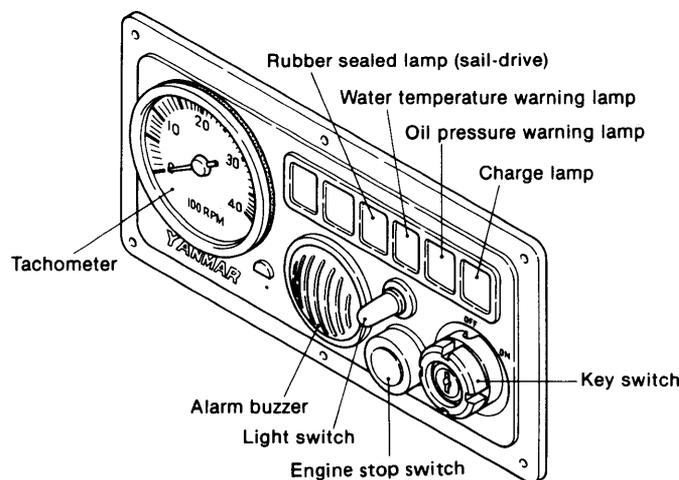
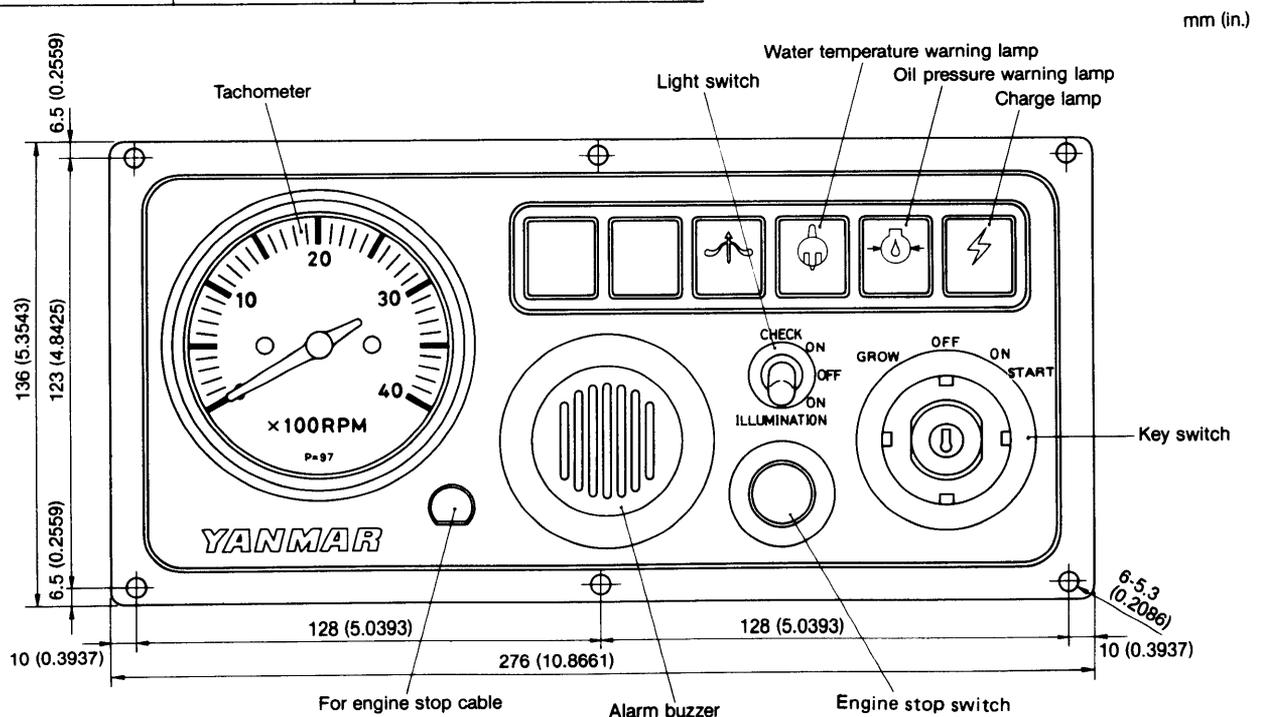
5. Instrument panel and wiring codes

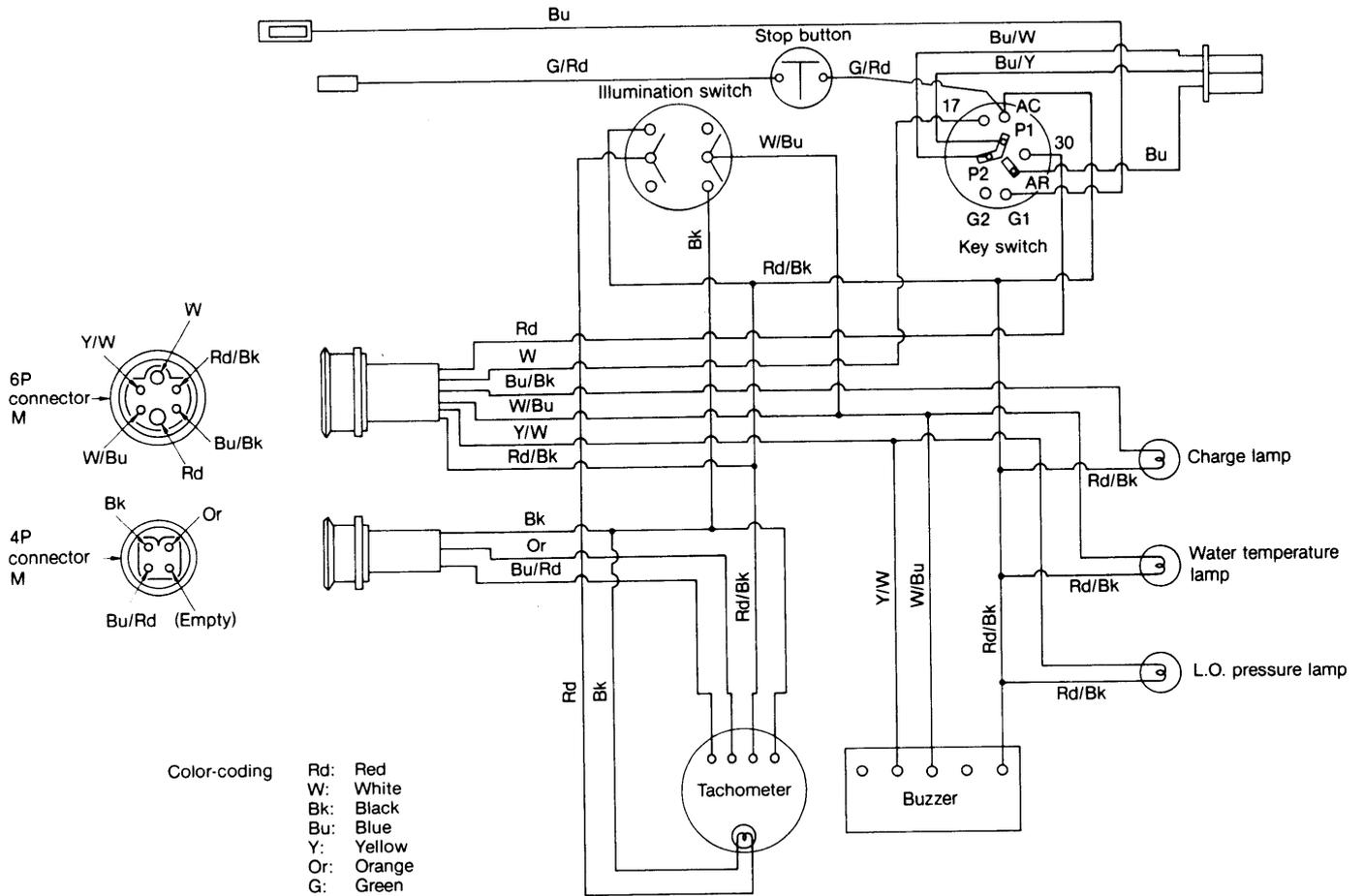
There are three types of instrument panels and wire harnesses and expansion (extension) cords as follows:
 Make sure to use the correct parts when making replacements.

5-1 B-type instrument panel and wire harness

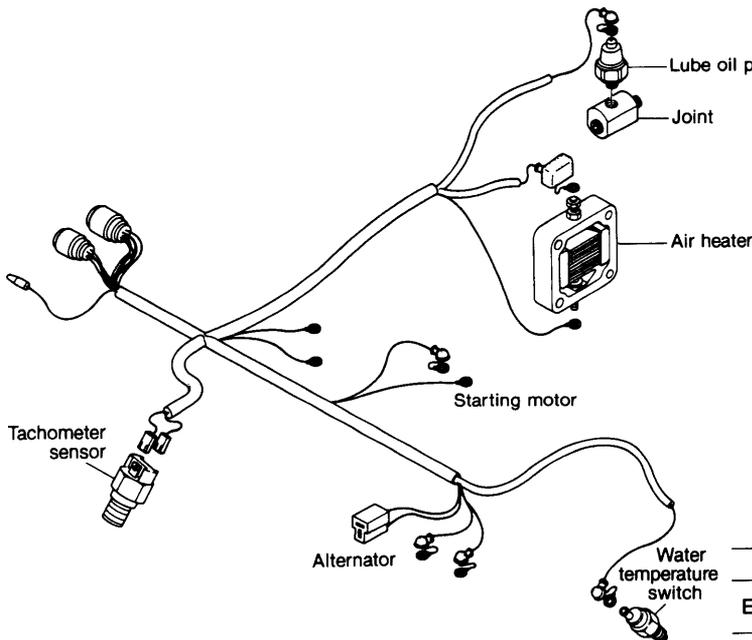
5-1.1 B-type instrument panel

Type	B-type	C-type	D-type
Instrument panel	124411-91190	129470-91100	124411-91180
Wire harness	129470-77920	129470-77930	
Extension cord 4M	129772-77500	129470-77500	
Extension cord 2M	129470-77510	129470-77520	
Extension cord 6M	129470-77530	129470-77540	

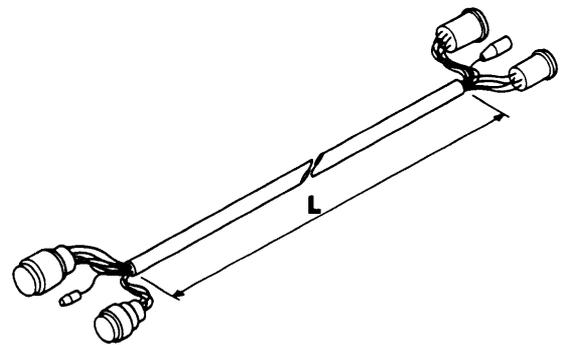




5-1.2 Wire harness for B-type instrument panel



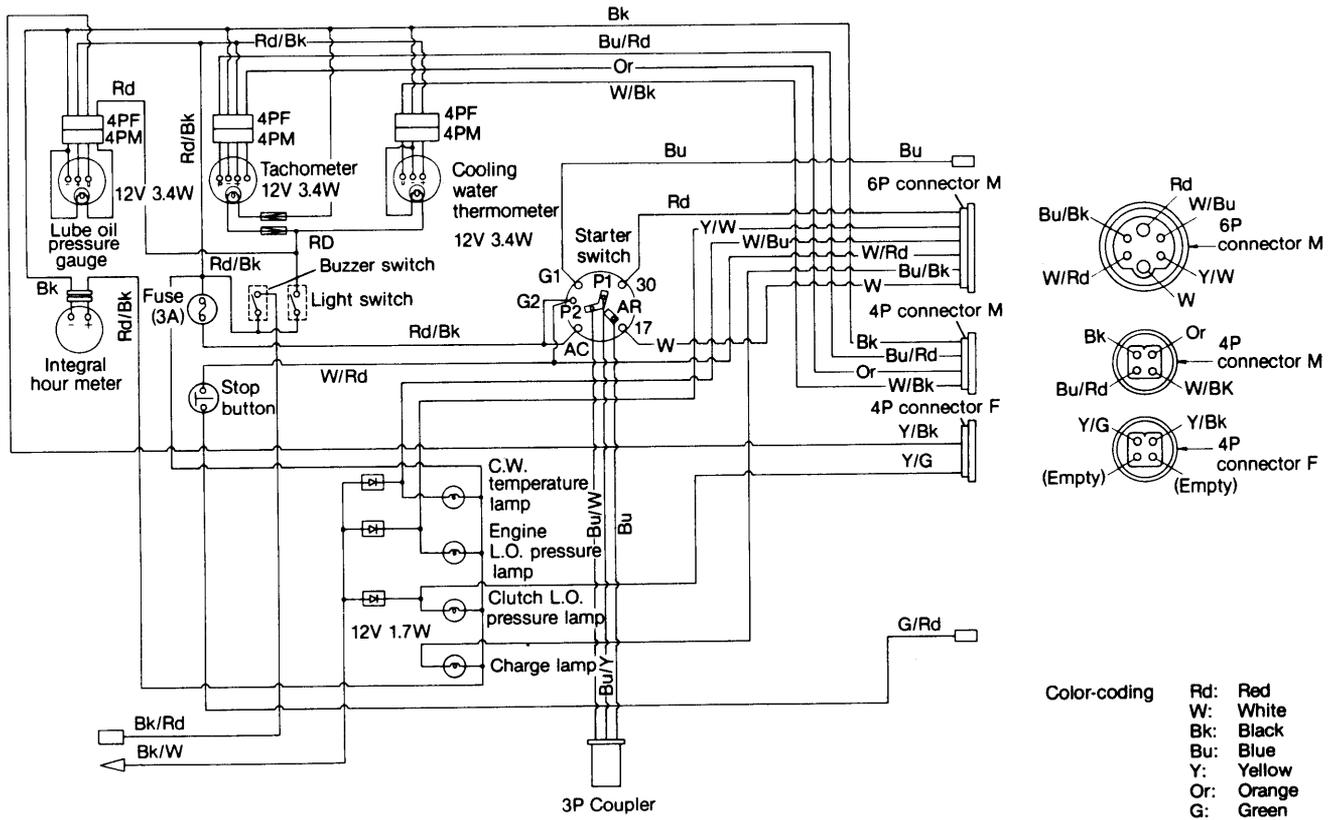
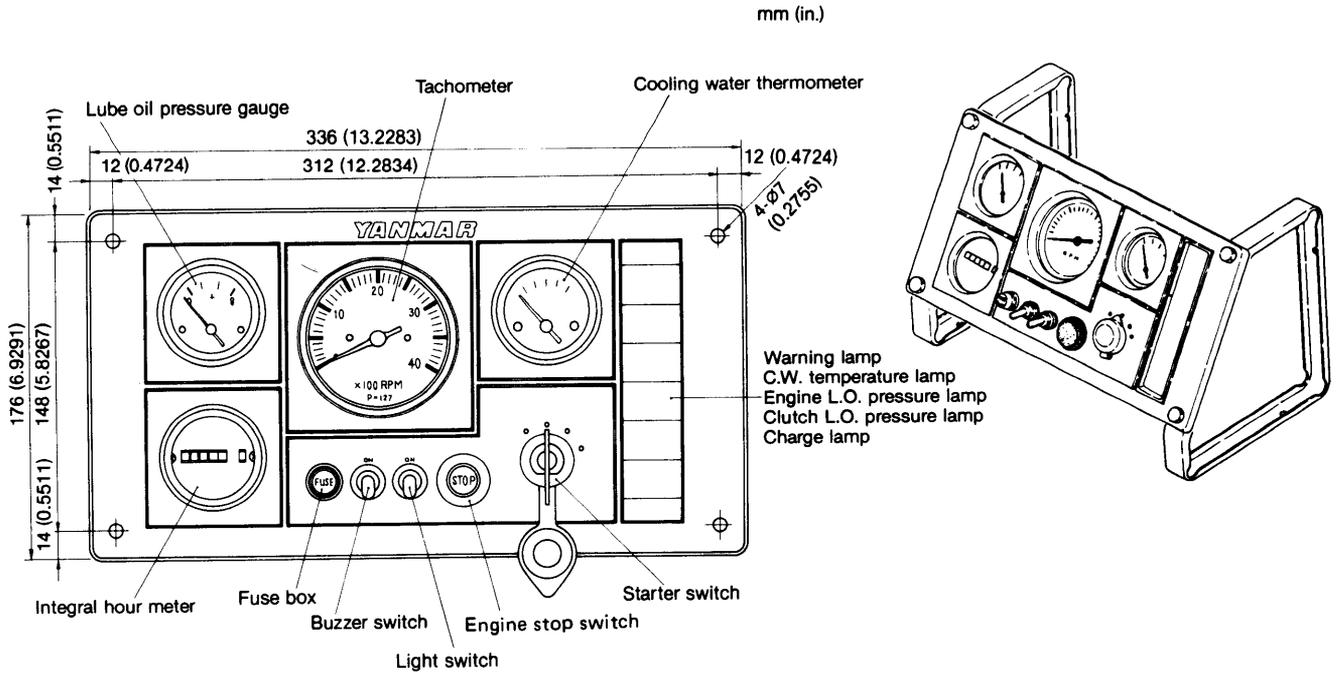
5-1.3 Extension cord for B-type instrument panel



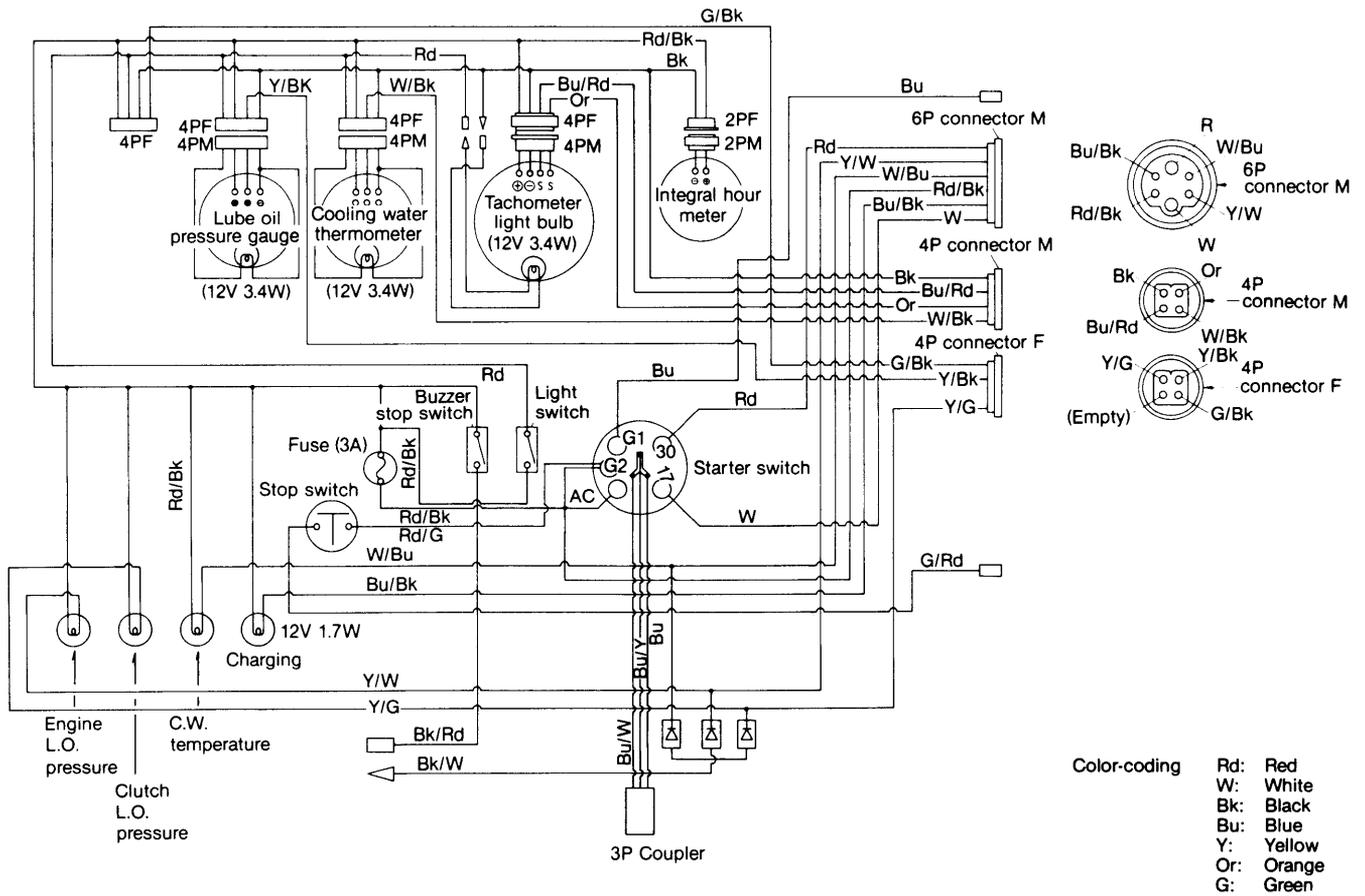
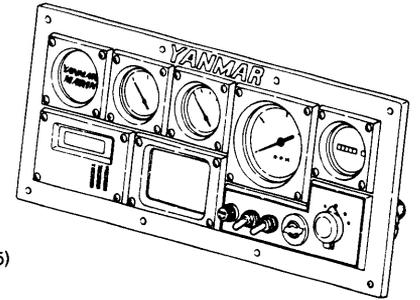
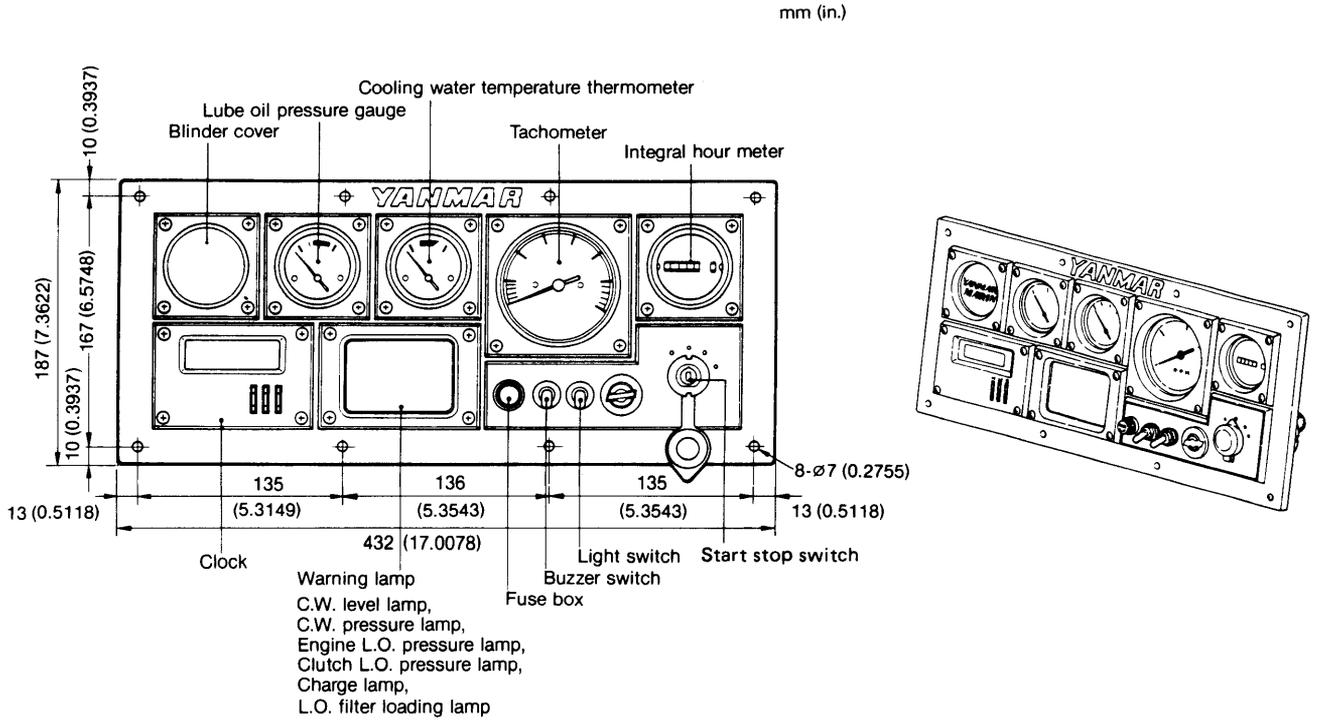
	Part code No.	L mm (in.)
Extension cord 4M	129772-77500	3750 ~ 3850 (147.63 ~ 151.57)
Extension cord 2M	129470-77510	1750 ~ 1850 (68.89 ~ 72.83)
Extension cord 6M	129470-77530	5750 ~ 5850 (226.38 ~ 230.31)

5-2 C-type, D-type instrument panel and wire harness

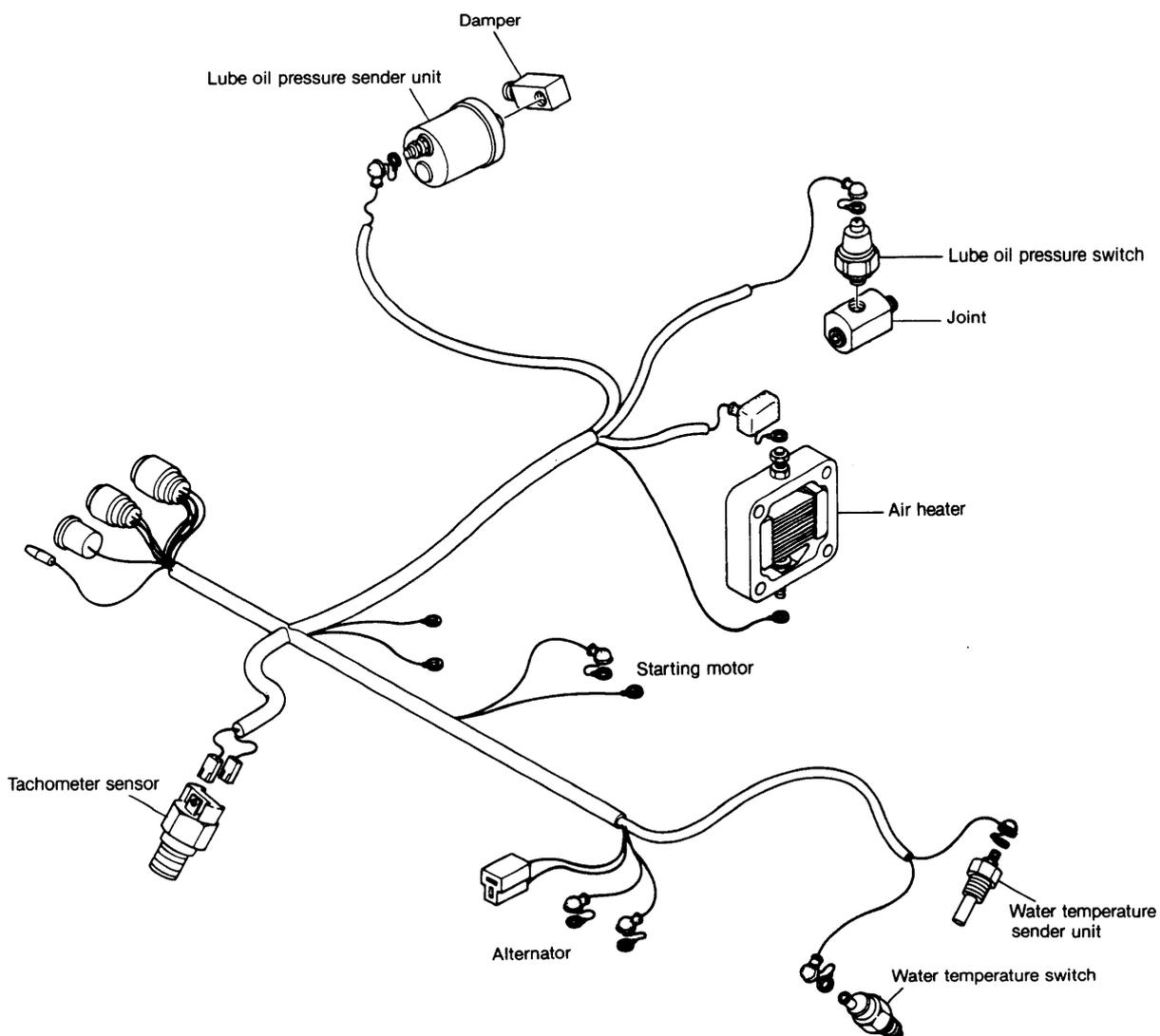
5-2.1 C-type instrument panel



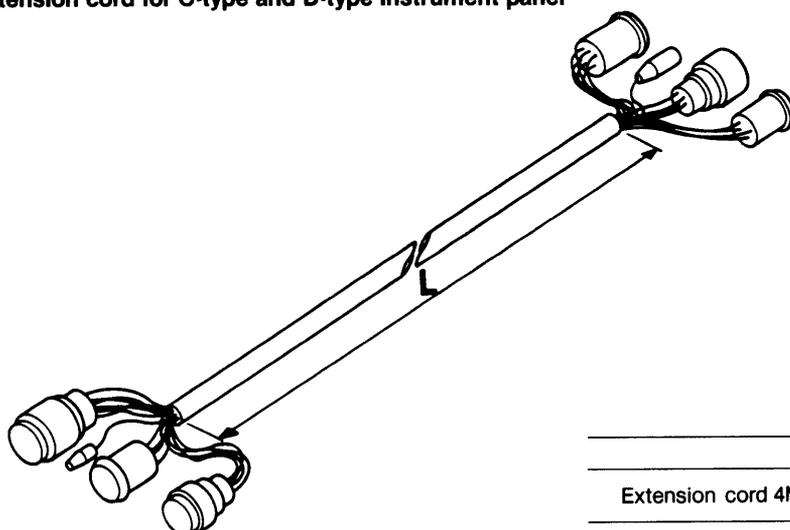
5-2.2 D-type instrument panel



5-2.3 Wire harness for C-type and D-type instrument panel



5-2.4 Extension cord for C-type and D-type instrument panel

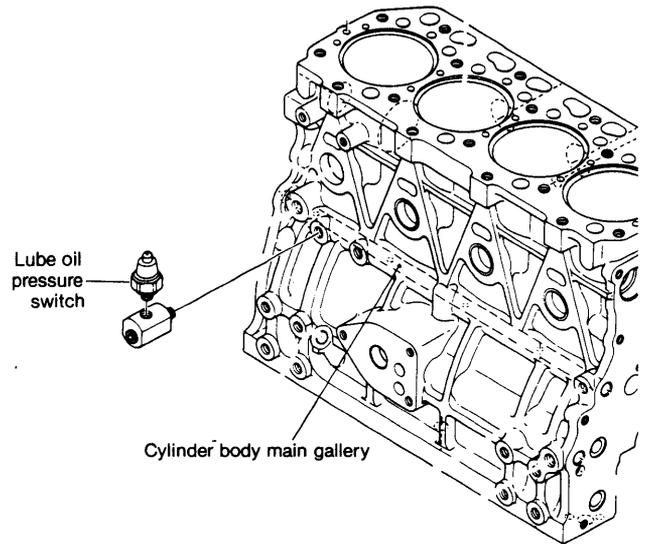
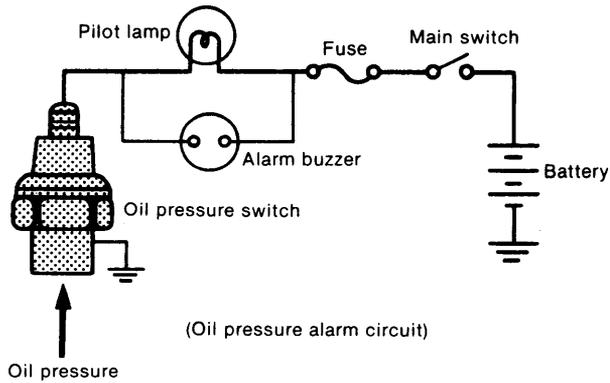


	Part code No.	L mm (in.)
Extension cord 4M	129470-77930	3750 ~ 3850 (147.63 ~ 151.57)
Extension cord 2M	129470-77520	1750 ~ 1850 (68.89 ~ 72.83)
Extension cord 6M	129470-77540	5750 ~ 5850 (226.38 ~ 230.31)

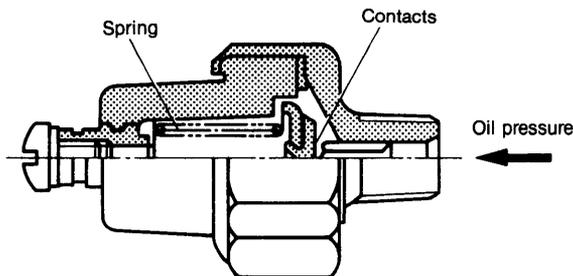
6. Warning Devices

6-1 Oil pressure alarm

If the engine oil pressure is below 0.1 ~ 0.3 kg/cm² (1.42 ~ 4.26 lb/in.²), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring, and the lamp is illuminated through lamp → oil pressure switch → ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.



Oil pressure switch



Part No.	124060-39451
Rated voltage	12V
Operation pressure	0.1 ~ 0.3kg/cm ² (1.422 ~ 4.266lb/in. ²)
Lamp capacity	5W

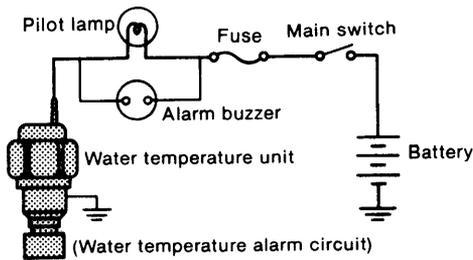
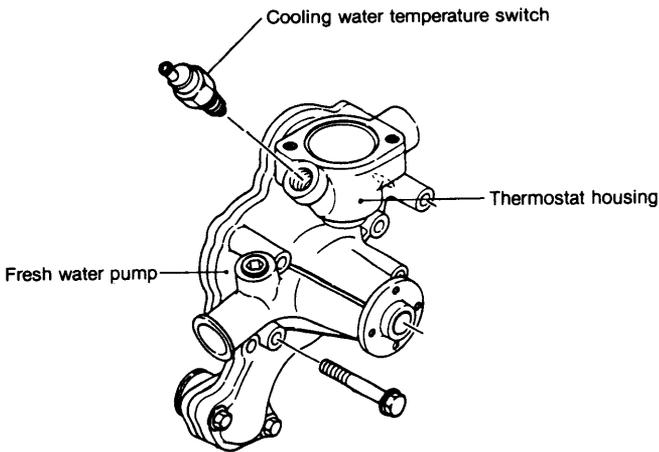
Inspection

Problem	Inspection item	Inspection method	Corrective action
Lamp not illuminated when main switch set to ON	1. Oil pressure lamp blown out	(1) Visual inspection (2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded	Replace lamp
	2. Operation of oil pressure switch	Lamp illuminated when checked as described in (2) above	Replace oil pressure switch
Lamp not extinguished while engine running	1. Oil level low	Stop engine and check oil level with dipstick	Add oil
	2. Oil pressure low	Measure oil pressure	Repair bearing wear and adjust regulator valve
	3. Oil pressure faulty	Switch faulty if abnormal at (1) and (2) above	Replace oil pressure switch
	4. Wiring between lamp and oil pressure switch faulty	Cut the wiring between the lamp and switch and wire with separate wire	Repair wiring harness

6-2 Cooling water temperature alarm

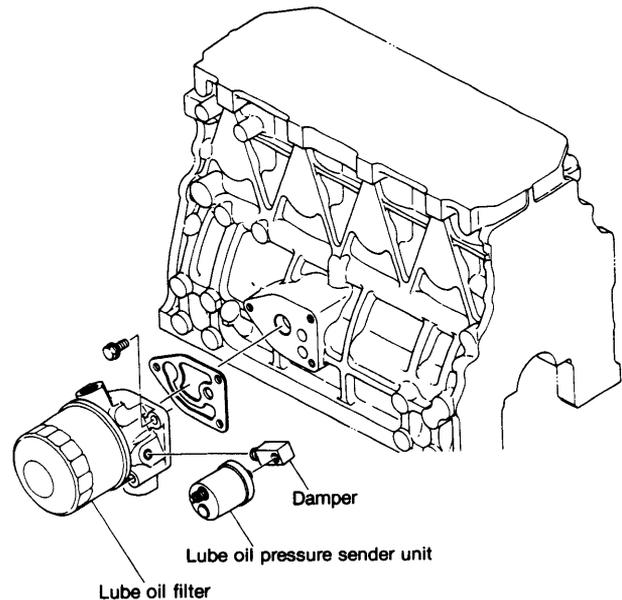
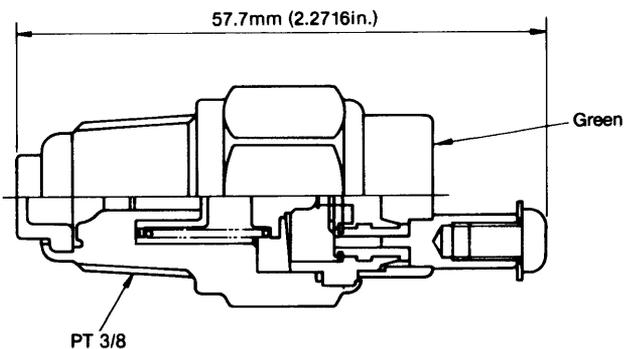
A water temperature lamp and water temperature gauge, backed up by an alarm in the instrument panel, are used to monitor the temperature of the engine cooling water. A high thermal expansion material is set on the end of the water temperature unit. When the cooling water temperature reaches a specified high temperature, the contacts are closed, and an alarm lamp and buzzer are activated at the instrument panel.

Operating temperature	ON	93 ~ 97°C (199 ~ 206°F)
	OFF	88°C (190°F) or high
Electric capacity	DC 12V, 1A	
Response time	within 60 sec.	
Indication color	Green	
Part code No.	127610-91350	
Tightening torque	2.40 ~ 3.20kg-m (17.35 ~ 23.14ft-lb)	

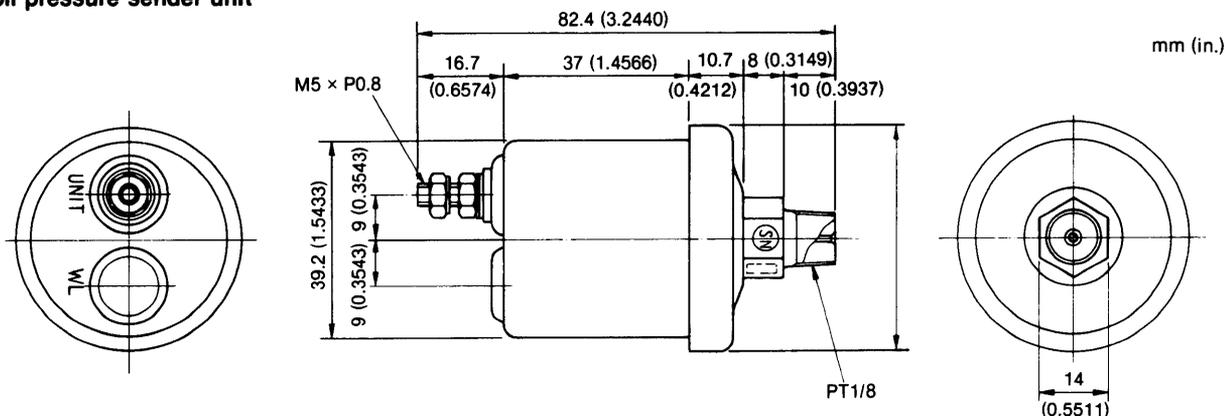


6-3 Sender unit for lube oil pressure gauge

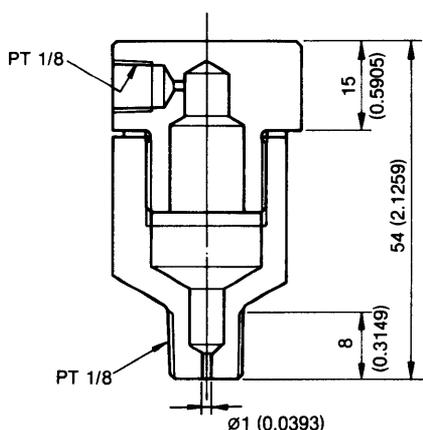
The sender unit for the lube oil pressure gauge has a mounting seat for mounting on the lube oil filter bracket. Oil pressure is measured when the oil enters into the main gallery after being fed from the lube oil cooler and passing through oil pressure control valve. Make sure to mount a vibration damper when mounting the oil pressure sender unit.



Lube oil pressure sender unit



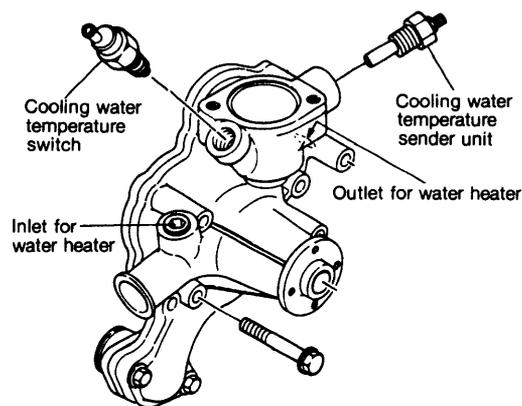
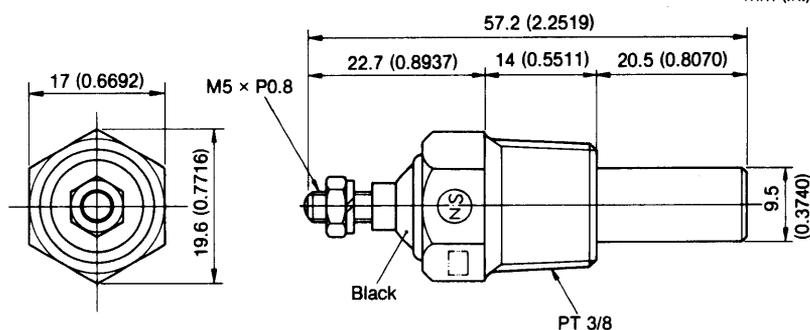
Damper



Type	Resistance switch
Rated voltage	DC 12/DC 24
Max. operating pressure	8kg/cm ² (113.76 lb/in. ²)
Part code No.	144626-91560

6-4 Sender unit for the cooling water temperature gauge

The water temperature sender unit has a mounting seat for mounting on the fresh water pump unit. Water temperature is measured when the cooling water flows into the thermostat housing after leaving the cylinder head.

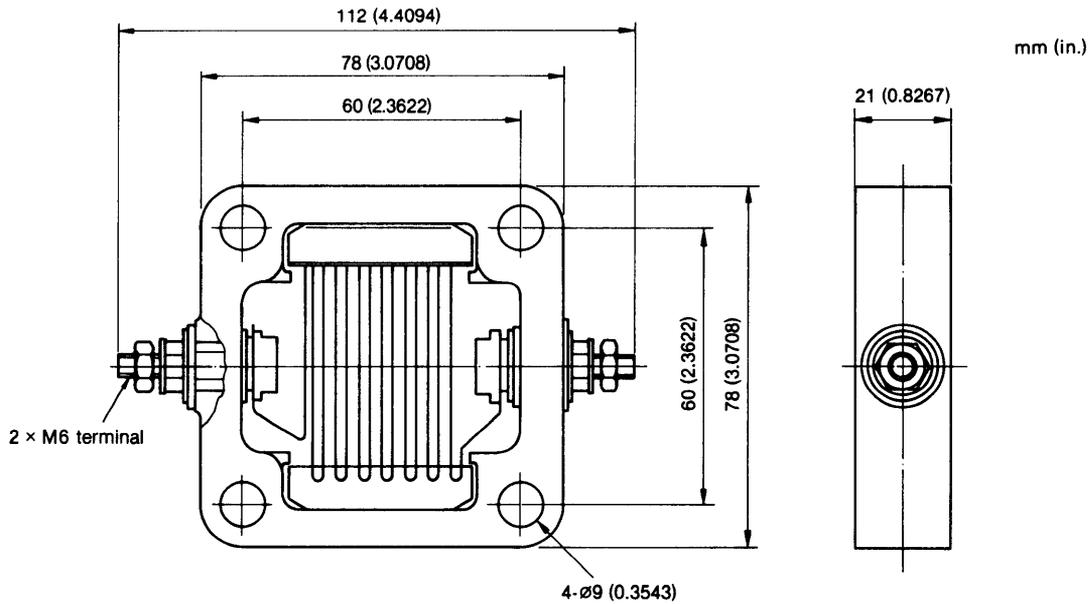
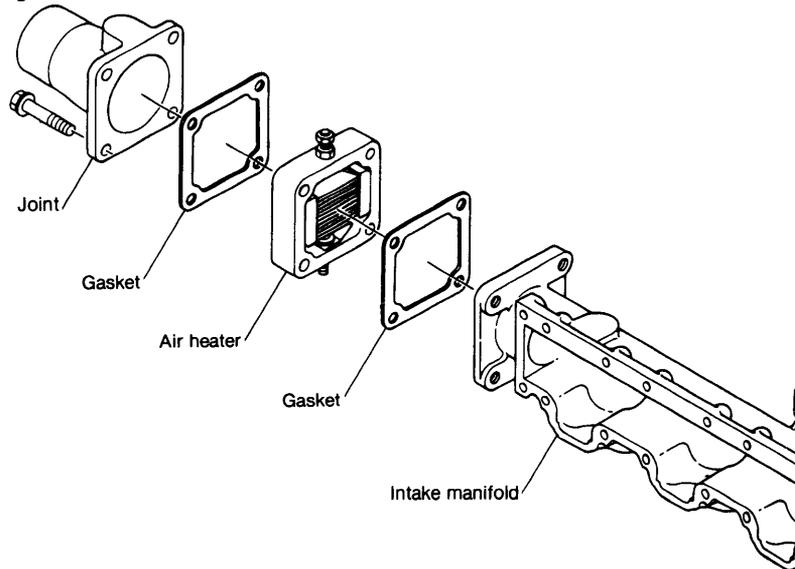


Type	Thermistor switch
Rated voltage	12V/24V
Part code No.	144626-91570

7. Air Heater (Optional)

An air heater is available for warming intake air during starting in cold areas during winter. The air heater is mounted between the intake manifold and intake manifold coupling.

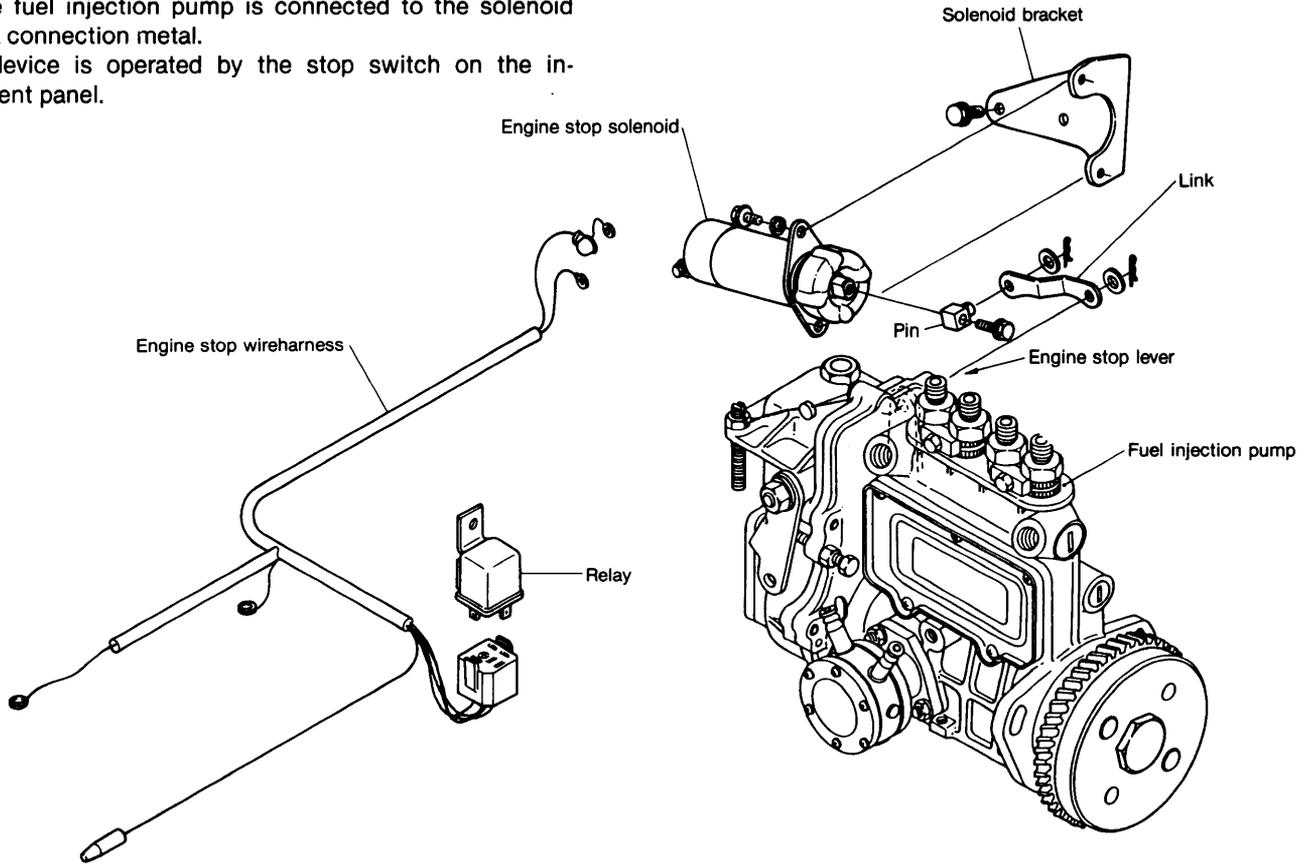
The device is operated by the glow switch on the instrument panel.



Rated output	400W
Rated current	33.3A
Rated voltage	DC 12V
Rated operating time	Engine operation: 60 sec. Engine stop: 30 sec.
Range of operating temperature	+50°C ~ 30°C (122°F ~ -22°F)
Part code No.	129400-77500

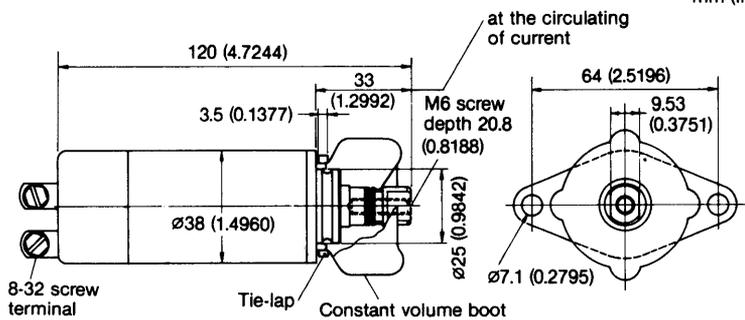
8. Electric type Engine Stopping Device (Optional)

To employ the electric engine stop device, the stop lever of the fuel injection pump is connected to the solenoid with a connection metal.
 The device is operated by the stop switch on the instrument panel.

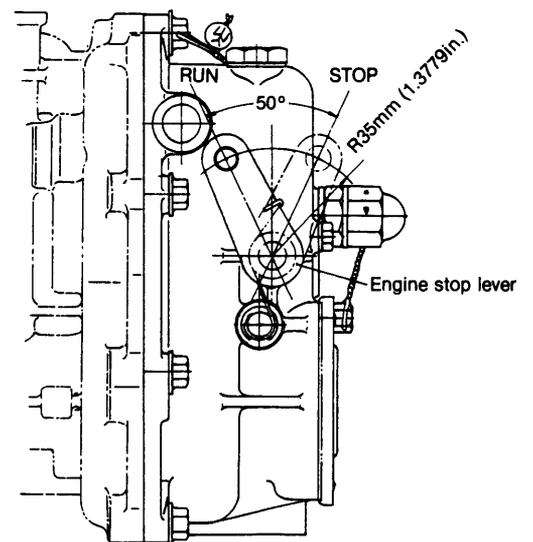


8-1 Solenoid

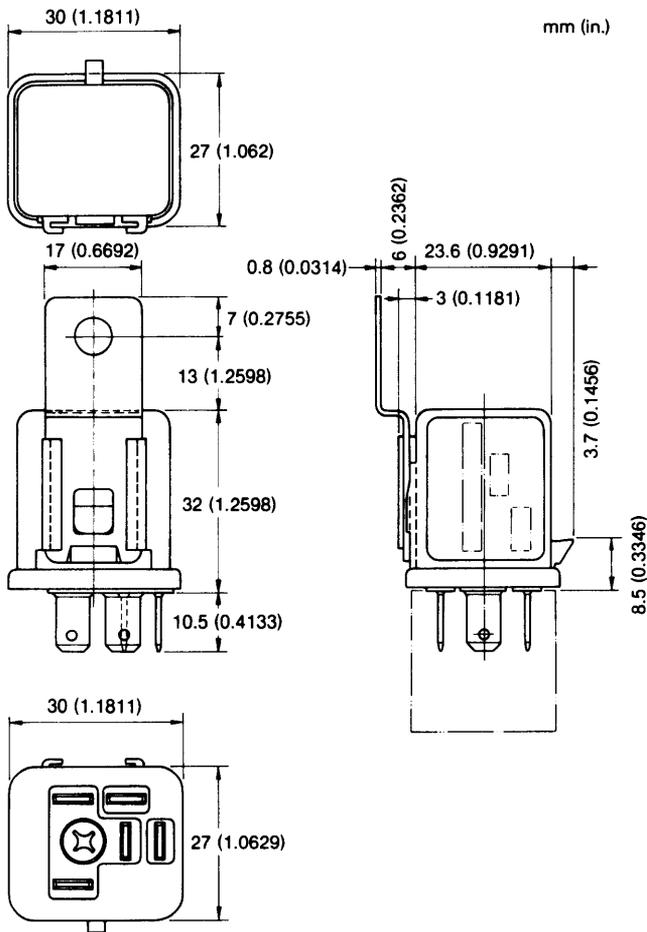
Solenoid model	1502-12A7U1B
Rated voltage	12V
Loaded current	30A
Loaded force	9kg (19.84lb)
No-load current	0.7A
No-load force	4kg (8.82lb)



mm (in.)

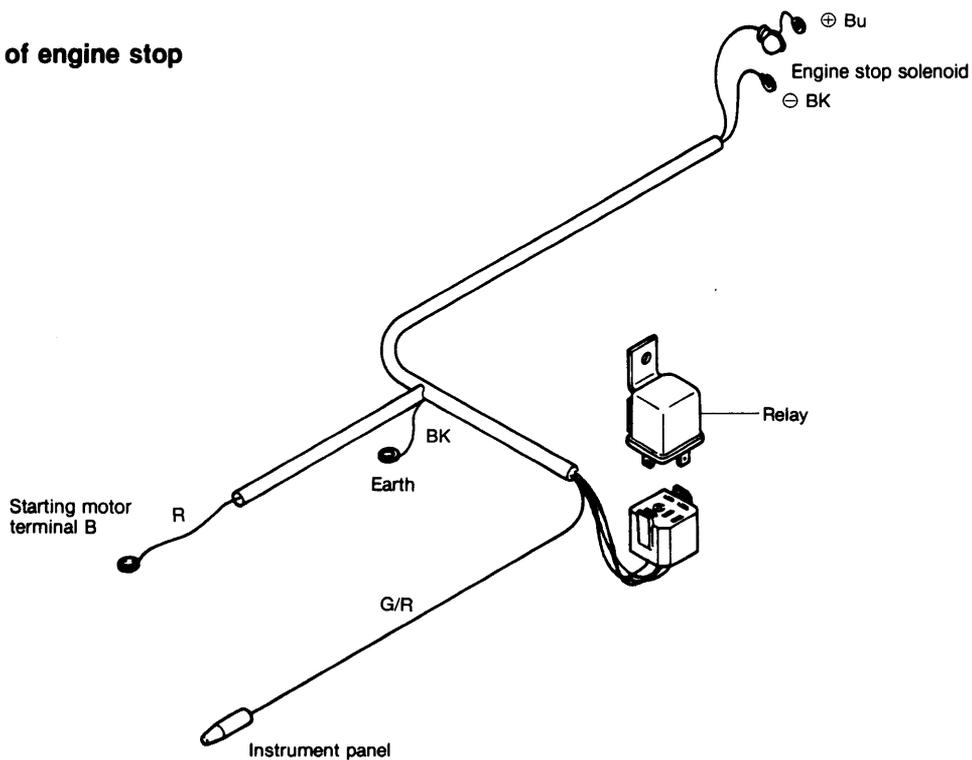


8-2 Relay



Rated voltage	12V
Contact current	Lamp: 20A, extra-lamp: 25A
Range of operation	-30°C ~ +90°C (-22°F ~ 194°F)
Part code No.	124617-91850

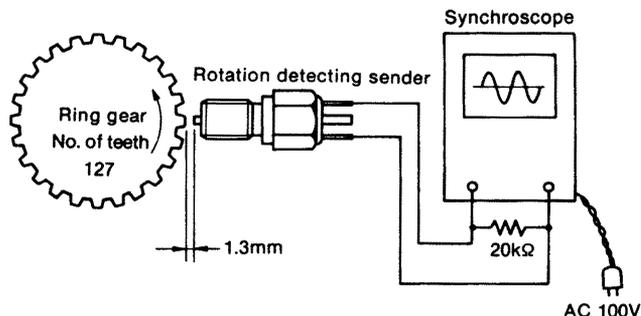
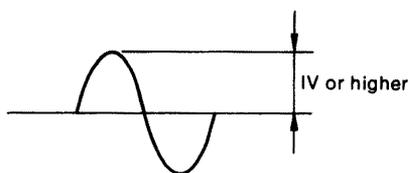
8-3 Wire harness of engine stop



9-3 Measurement of sensor unit characteristics

(1) Measurement of output voltage

Output voltage	1.0V or higher
----------------	----------------



* Check the output wave pattern and number of pulses when carrying out the output voltage measurement.

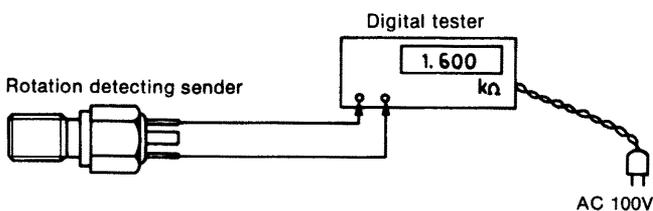
Measuring conditions

Number of teeth of ring gear	127
Gap between the ring gear and sender	1.3mm (0.0511 in.)
Resistance	20kΩ
Speed of ring gear	500 rpm (approx. 800Hz)
Measuring temperature	20°C (68°F)
Measuring instrument	Synchroscope

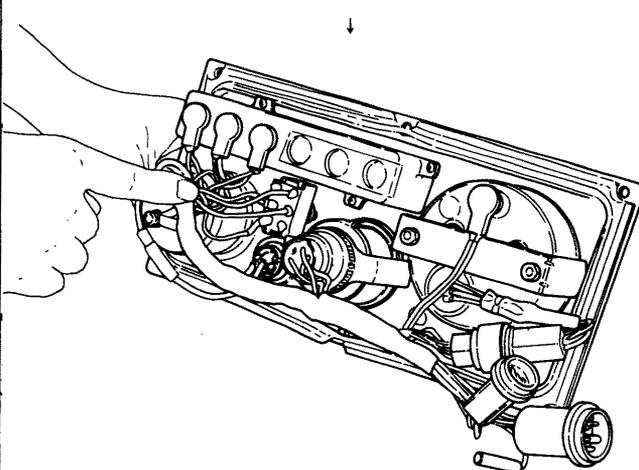
(2) Measurement of internal resistance

Measuring conditions

Measuring temperature	20°C (68°F)
Measuring instrument	Digital tester



9-4

Fault	Diagnosis	Remedy
Does not function well. 1) Pointer does not move. 2) Functions intermittently.	Check if there is an open-circuit cable connection at the rear of the meter, a loose or disconnected terminal, or bad continuity due to corrosion. 	Yes Make good the connection.
	Disconnect at the instrument terminals, and measure the voltage between the cable terminals. (To be 10 ~ 16V) ↓ Satisfactory	No If the input voltage is abnormal, check the cause. (e.g. short-circuit, disconnection, or blown fuse, etc.)

	Check if the sender is loosely fitted. ↓ No	Yes Fix the sender securely.
	Measure the internal resistance of the sender. (To be $1.6 \pm 0.1k\Omega$ at $20^{\circ}C$) ↓	No Replace the sender.
	Measure the output voltage of the sender. (To be 1V or higher at $20^{\circ}C$)	No Replace the sender.

10. Alternator 12V/80A (OPTIONAL)

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V-belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keeps the generated voltage constant even when the engine speed changes.

10-1 Features

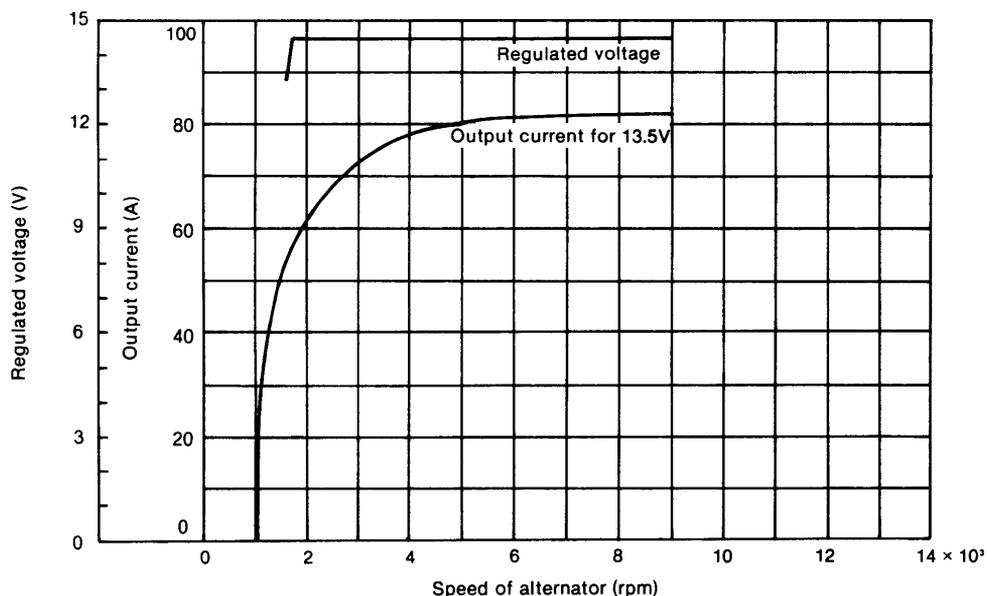
The alternator contains a regulator using an IC, and has the following features.

- (1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). It therefore has superior features such as freedom from vibration, no fluctuation of voltage during use, and no need for readjustment.
 Also, it is of the over-heating compensation type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.
- (2) The regulator is integrated within the alternator to simplify external wiring.
- (3) It is an alternator designed for compactness, lightness of weight, and high output.
- (4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.
- (5) As the alternator is to be installed on board, the following measures are taken to provide salt-proofing.
 - 1) The front and rear covers are salt-proofed.
 - 2) Salt-proof paint is applied to the diode.
 - 3) The terminal, where the inboard harness is connected to the alternator, is nickel plated.

10-2 Specifications

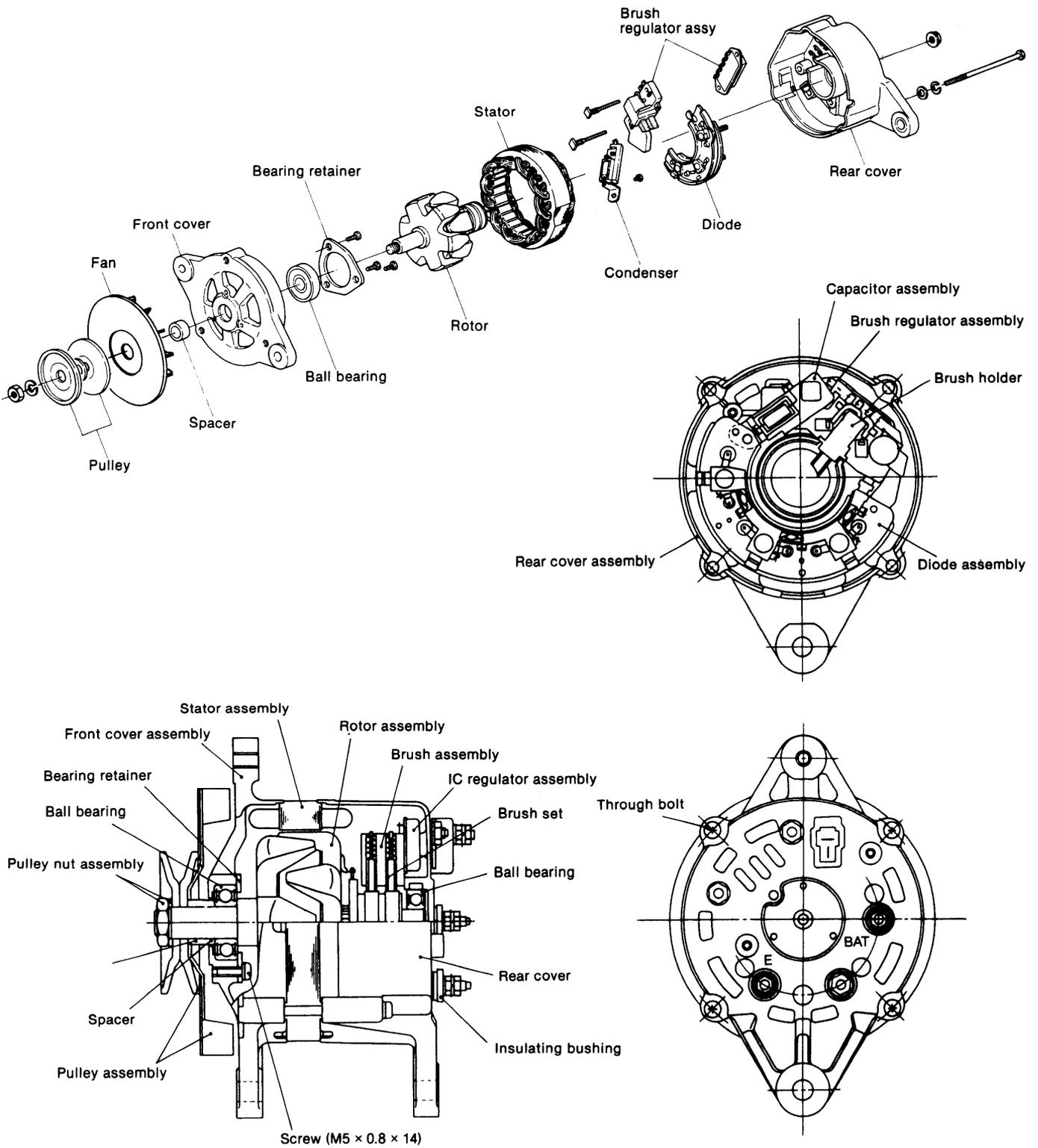
Model of alternator	LR180-03 (HITACHI)
Model of IC regulator	TRIZ-63 (HITACHI)
Battery voltage	12V
Nominal output	12V/80A
Earth polarity	Negative earth (⊖)
Direction of rotation (viewed from pulley end)	Clockwise
Weight	5.8kg (12.8lb.)
Rated speed	5000 rpm
Operating speed	1000 ~ 9000
Speed for 13.5V	1000 or less
Output current at 20°C	over 78A/5000 rpm
Regulated voltage	14.5 ±0.3V (Standard temperature voltage gradient, -0.01/°C)

10-3 Characteristics



10-4 Construction

This is a standard rotating field type three-phase alternator. It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.



10-5 Alternator functioning

(1) IC regulator

The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.

When the output voltage of the generator is within the standard value, the transistor (Tr_1) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor (Tr_1) turns off.

With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

(2) Charge lamp

When the transistor (Tr_1) is on, the charge lamp key switch is turned to ON, and current flows to R_1 , R_2 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

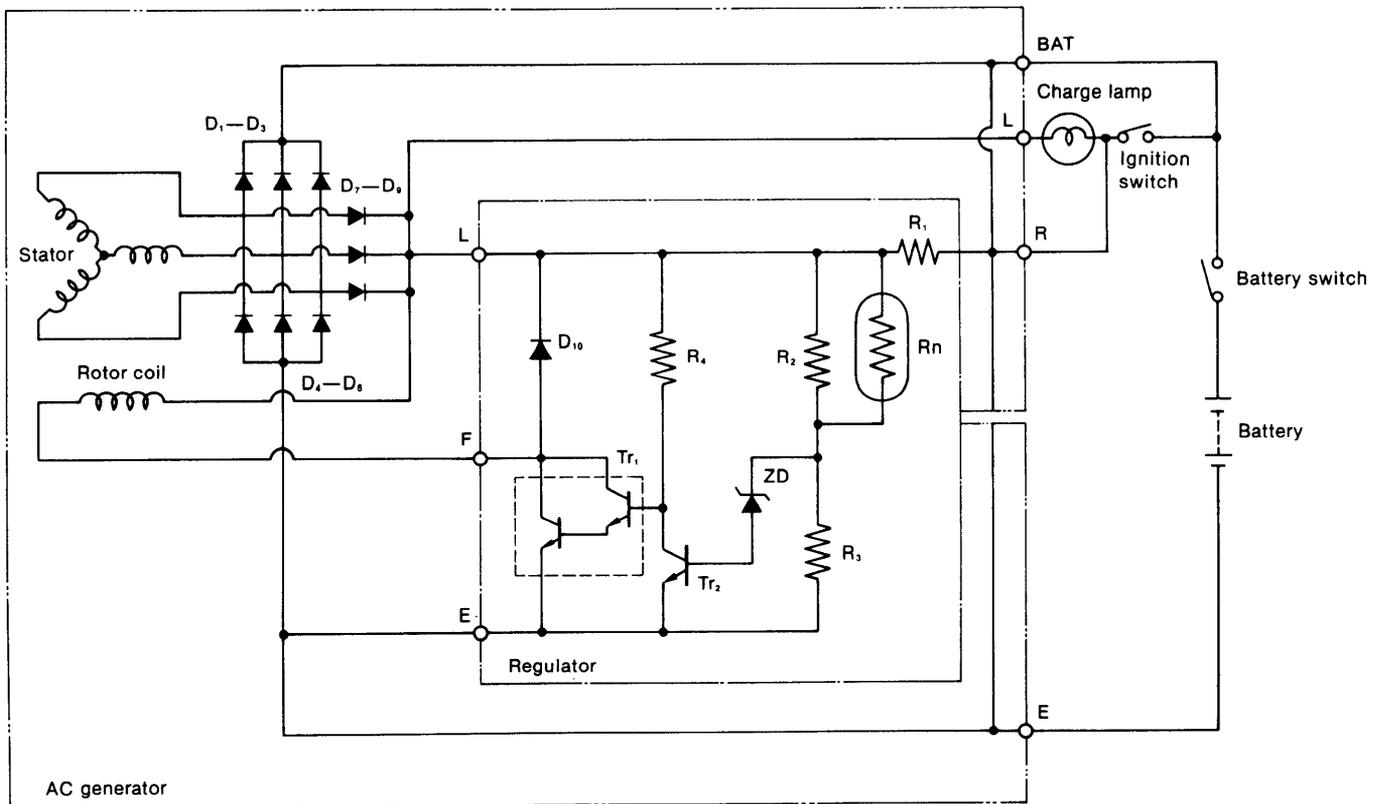
(3) Circuit diagram

10-6 Handling precautions

(1) Be careful of the battery's polarity (+, - terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.

In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

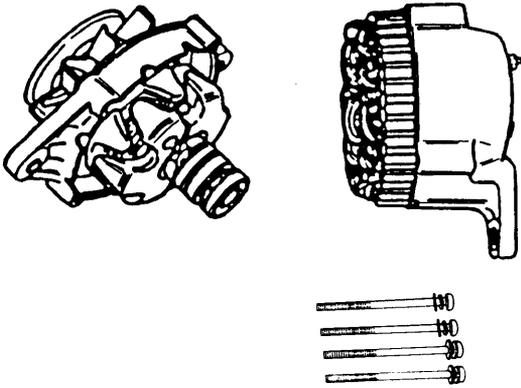
- (2) Make sure of the correct connection of each terminal.
- (3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.
- (4) Do not short-circuit the terminals.
- (5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



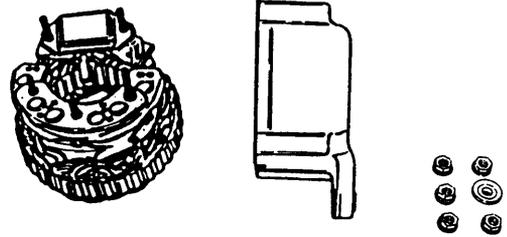
- | | | | |
|----------------|---------------------------|-------------|--|
| BAT: | Generator output terminal | D_1-D_6 : | Output commutation diode |
| D_{10} : | IC protecting diode | R_1-R_4 : | Resistor |
| L: | Charge lamp terminal | D_7-D_8 : | Charging lamp switching diode |
| ZD: | Zener diode | F: | To supply current to rotor coil |
| E: | Earth | Rn: | Thermistor (Temperature gradient resistance) |
| Tr_1, Tr_2 : | Transistor | | |

10-7 Disassembling the alternator

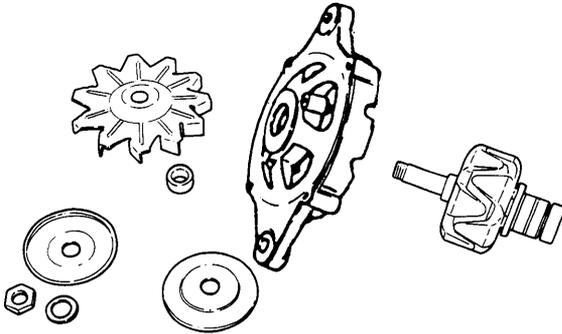
- (1) Remove the through-bolt, and separate the front assembly from the rear assembly.



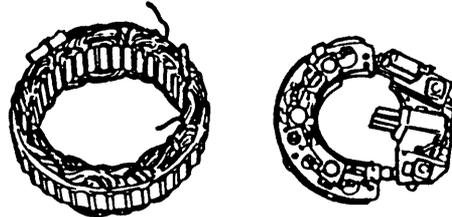
- (4) Remove the nut, the brush-holder, and diode fixing nut at the BAT, and the terminal screws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).



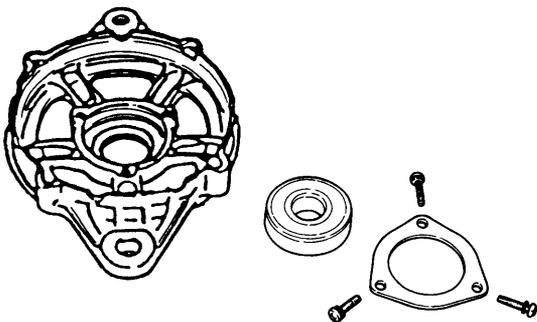
- (2) Remove the pulley nut, and pull out the rotor from the front cover.



- (5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

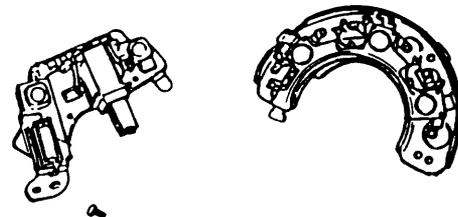


- (3) Remove the $\varnothing 5\text{mm}$ ($\varnothing 0.1969\text{in.}$) screw from the front cover, and then remove the ball bearing.

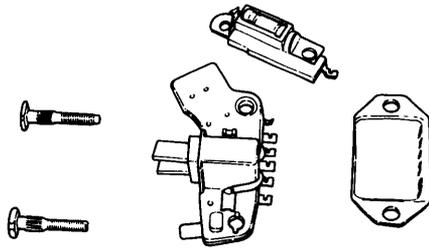


- (6) Separating the regulator

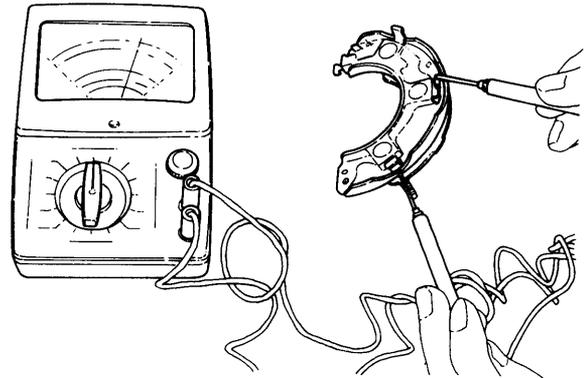
- 1) To separate the regulator, remove the $\varnothing 3\text{mm}$ ($\varnothing 0.1181\text{in.}$) rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.



After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



10-8 Inspection and adjustment

(1) Diode

Between terminals		BAT (+ side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	/	
	- side		

Between terminals		E (- side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	/	
	- side		

CAUTION: Do not use high tensile insulation resistance such as meggers, etc. for testing. The diode may burn out.

(2) Rotor

Inspect the slip ring surface, rotor coil continuity and insulation.

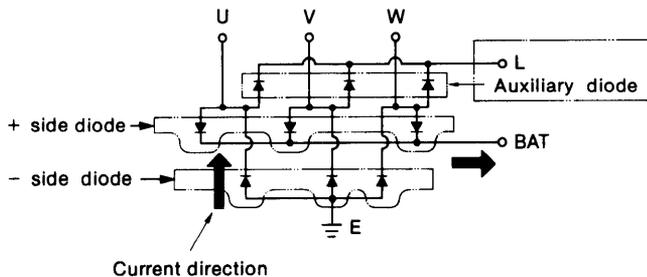
1) Inspecting the slip ring surface

Check if the surface of the slip ring is sufficiently smooth. If the surface is rough, grind the surface with No. 500—600 sand paper. If it is contaminated with oil, etc., wipe the surface clean with alcohol.

Slip ring outer dia.	Standard	Wear limit
	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

2) Rotor coil continuity test

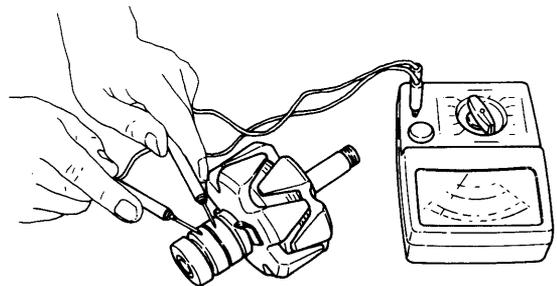
Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.



U.V.W.: terminal from the stator coil

Current flows only in one direction in the diode as shown in Fig. 181. Accordingly, when there is continuity between each terminal (e.g. BAT and U), the diode is in normal condition. When there is no continuity, the diode is defective.

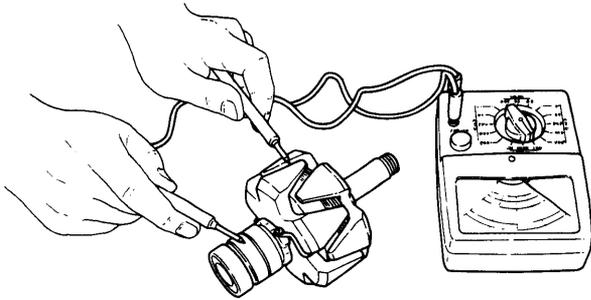
When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.



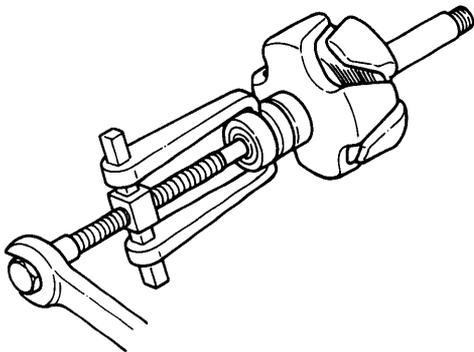
Resistance value	Approx. 2.58Ω at 20° C
------------------	------------------------

3) Rotor coil insulation test

Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



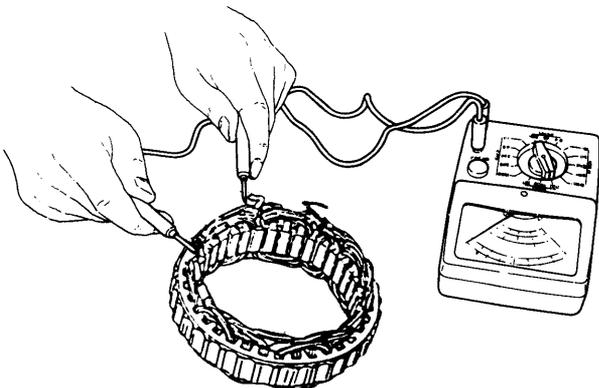
4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



(3) Stator

1) Stator coil continuity test

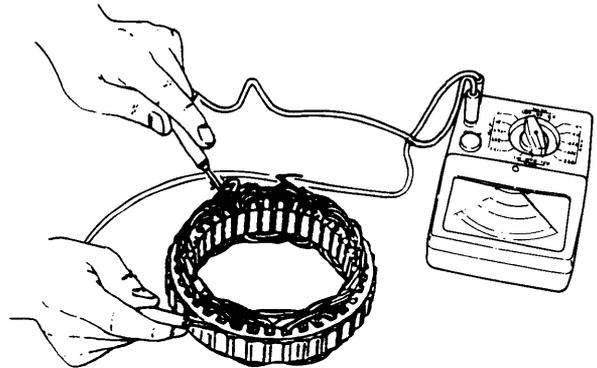
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.



Resistance value	Approx. 0.041Ω at 20° C u, v-phase resistance
	Approx. 0.036Ω at 20° C w-phase resistance

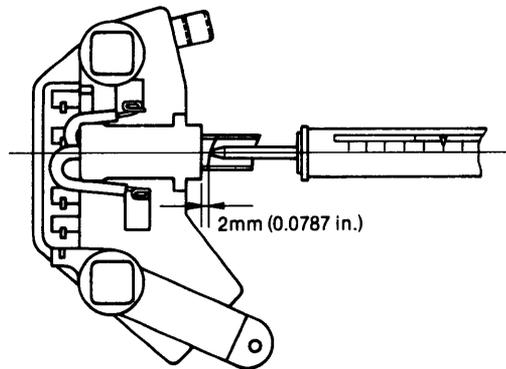
2) Stator coil insulation test

Check the continuity between the terminals and the stator core. If there is continuity, insulation of the stator coil is defective. This will cause a short-circuit with the earth core. Replace the stator coil.



(4) Brush

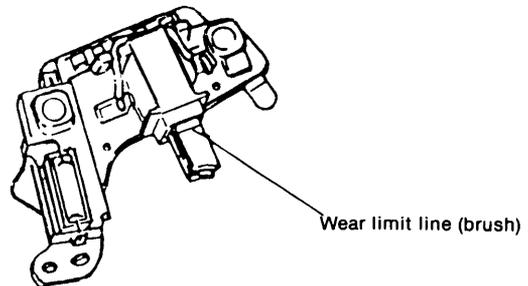
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring. To check, push the spring down to 2mm (0.0787in.) from the end surface of the brush holder, and read the gauge.



Brush spring strength	255—345g (0.56 ~ 0.76lb.)
-----------------------	---------------------------

(5) Brush wear

Check the brush length. The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



	mm (in.)	
	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

(6) IC regulator

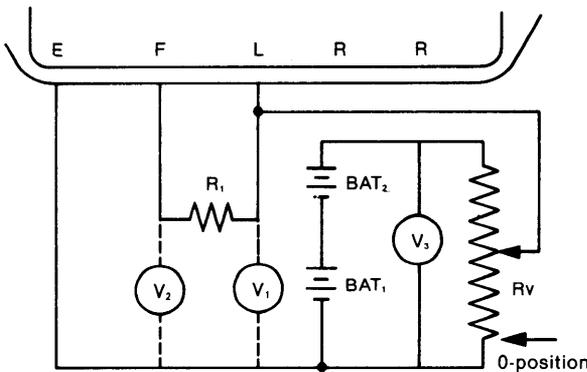
Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the diagram.

1) Use the following measuring devices.

- Resistor (R₁) 100Ω, 2W, 1pc.
- Variable resistor (R_v) 0—300Ω, 12W, 1pc.
- Battery (BAT₁, BAT₂) 12V, 2pcs.
- DC voltmeter 0—30V, 0.5 class 1pc.
(measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.

- a) Check V₃ (BAT₁ + BAT₂ voltage). If the voltage is 20—26V, both BAT₁ and BAT₂ are normal.
- b) While measuring V₂ (F-E terminal voltage), move R_v gradually from the 0-position. Check if there is a point where the V₂ voltage rises sharply from below 2.0V to over 2.0V. If there is no such point, the regulator is defective. Replace the regulator. If there is a sharp voltage rise when testing, return the R_v to the 0-position, and connect the voltmeter to the V₁ position.
- c) While measuring V₁ (voltage between L-E terminals), move R_v gradually from the 0-position. There should be a point where the voltage of V₁ rises sharply by 2—6V. Measure the voltage of V₁ just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V₁ is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.



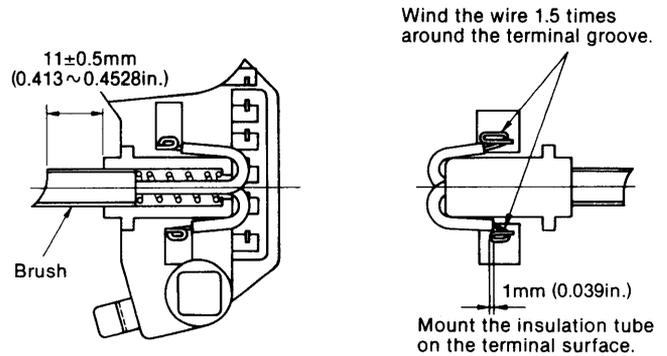
10-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 4—7 disassembling alternator).

(1) Assembling the brush regulator

1) Solder the brush.

Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).

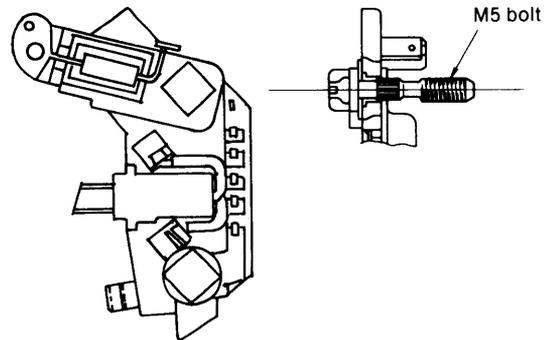


NOTES: 1. Use non-acid type paste.

2. The soldering iron temperature is 300 ~ 350°C.

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.

(If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)

2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

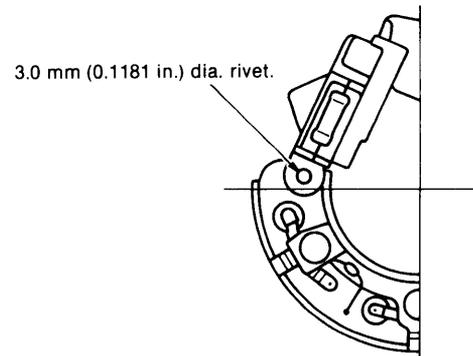
1) Check the rivets

Place the rivets as shown in the figure, and then calk them using the calking tool.

Calking torque	500kg (1102 lbs.)
----------------	-------------------

2) Connect the brush to the diode.

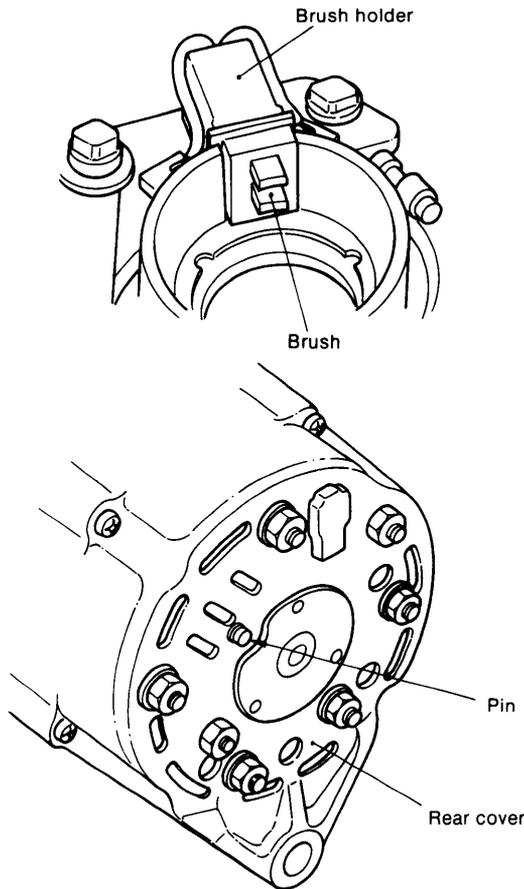
Insert the brush side terminal into the diode terminal, calk it, and then solder into place.



Rivetting pressure	500kg (1102 lbs.)
--------------------	-------------------

(3) Assembling the rear cover

Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.



(1) Measuring devices

DC voltmeter	0—15V or 0—30V, 0.5 Class, 1pc.
DC ammeter	0—100A, 1.0 Class, 1pc.
Variable resistor	0—0.25Ω, 1kW, 1pc.
Lamp	12V, 3W
100Ω resistor	3W
0.25Ω resistor	25W

(2) Measuring the regulating voltage

- 1) When measuring devices are connected in the performance test circuit as shown above, the charge lamp lights.
- 2) Close SW₂, while keeping SW₁ open and run the AC generator. When the revolutions of the generator are gradually raised, the charge lamp goes off.
- 3) Raise the revolutions of the AC generator, and read the voltmeter gauge when the revolutions reach about 5,000 rpm.

NOTES: 1. Make sure that the ammeter indication at this time is less than 5A. If the indication is over 5A, connect the 0.25Ω resistor. The voltmeter indication at this time must be within the prescribed regulating voltage value.

2. Raise the AC generator revolutions high to make sure the regulating voltage does not fluctuate along with changes in the revolution speed.

(3) Precautions for measuring the regulating voltage

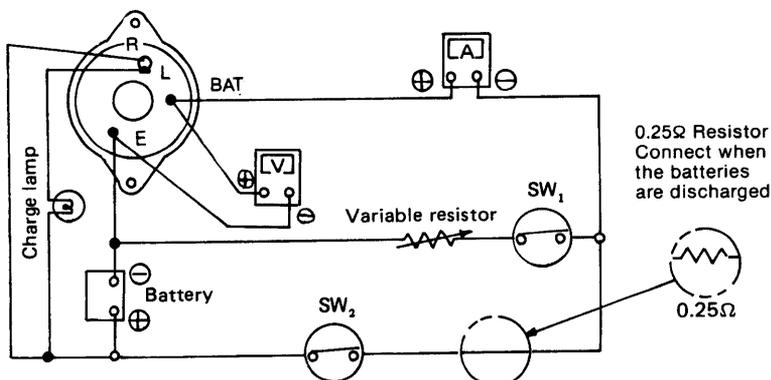
- 1) When measuring the voltage, measure the voltage between the AC generator BAT terminal, or Battery + terminal, and AC generator E-terminal.
- 2) Use a fully charged battery.
- 3) Measure the voltage quickly.
- 4) Keep SW, open for measurement.

(4) Tightening torques

Positions	Tightening torque kg-cm (ft-lb)
Brush holder fixing	32—40 (2.31~2.89)
Diode fixing	60—70 (4.33~5.05)
Bearing retainer fixing	32—40 (2.31~2.89)
Pulley nut tightening	400—600 (28.93~43.40)
Through-bolt tightening	32—40 (2.31~2.89)

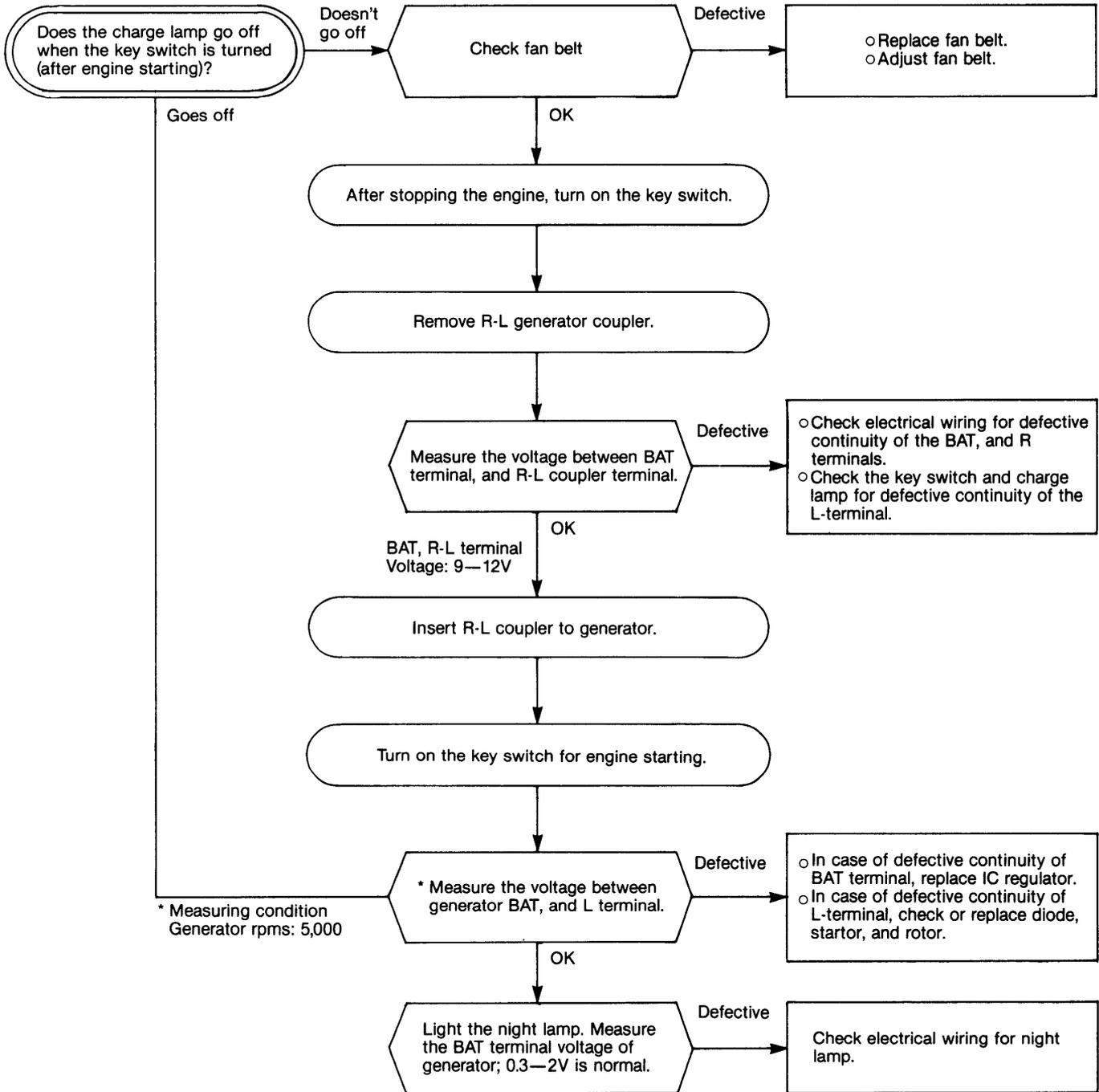
10-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.

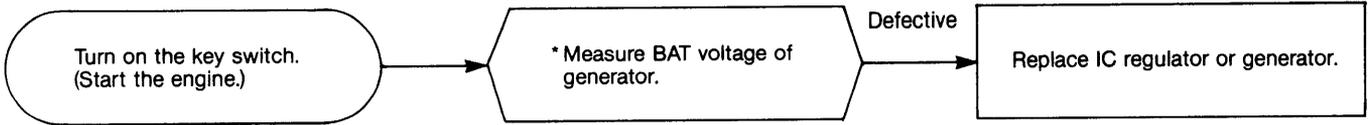


10-11 Troubleshooting

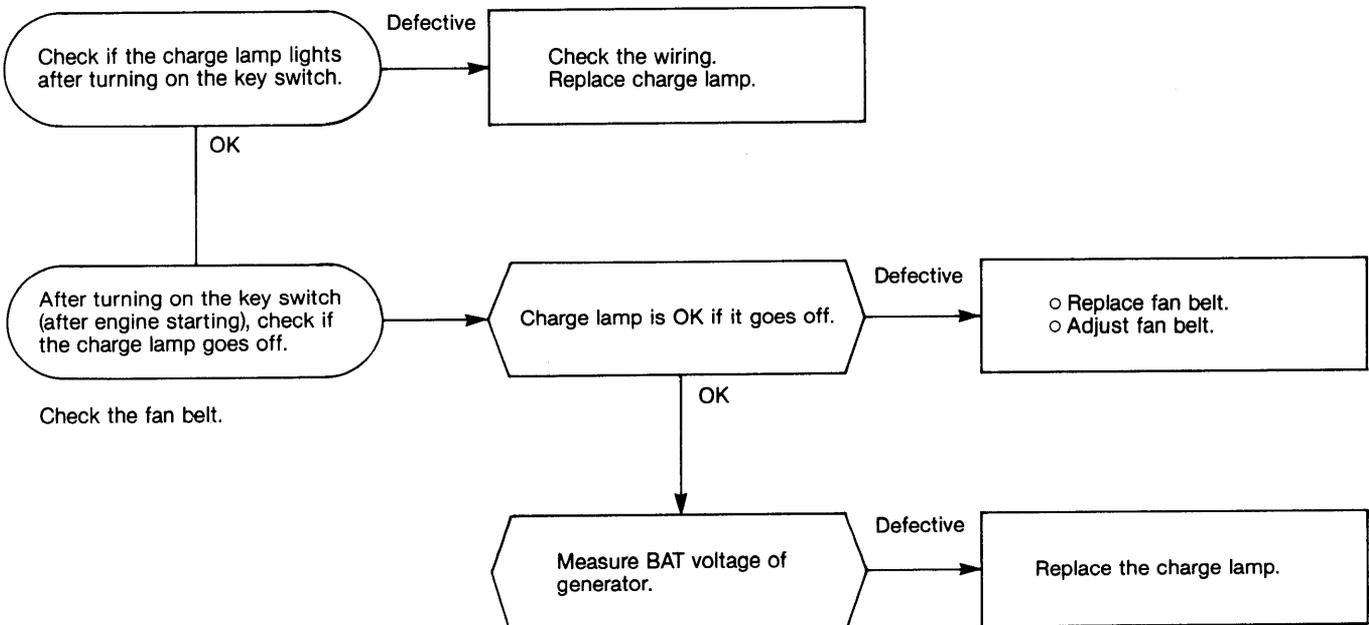
(1) Charging failure



(2) Overcharging



(3) Charge lamp failure



CHAPTER 10

DISASSEMBLY AND REASSEMBLY

1. Disassembly and Reassembly Precautions	10-1
2. Disassembly and Reassembly Tools	10-2
3. Disassembly and Reassembly	10-9
4. Bolt/nut Tightening Torque	10-32
5. Test Running	10-33

1. Disassembly and Reassembly Precautions

(1) Disassembly

- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.
- Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare container(s).
- Drain cooling water (sea water, fresh water) and lube oil.
- Close the Kingston cock.

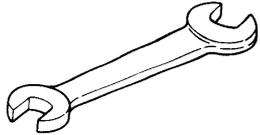
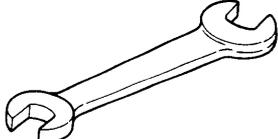
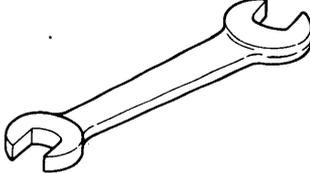
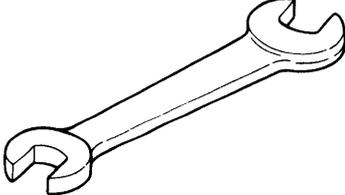
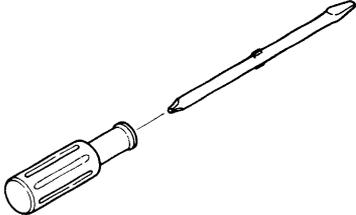
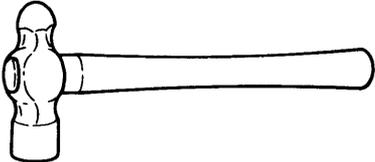
(2) Reassembly

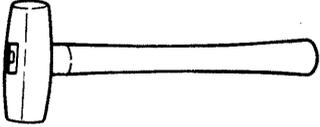
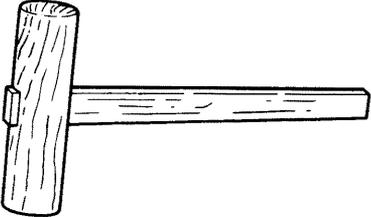
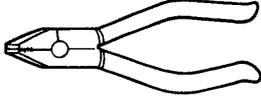
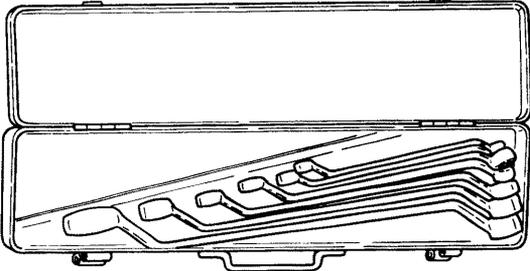
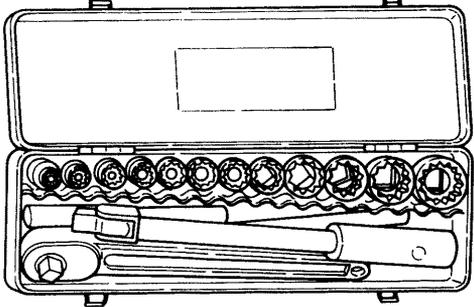
- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check oil and thrust clearances, etc. of parts when assembling.
- Make sure you use the correct bolt/nut/washer. Tighten main bolts/nuts to specified torque. Be especially careful not to overtighten the aluminum alloy part mounting bolts.
- Align match mark (if any) when assembling. Make sure that the correct set of parts is used for bearings, pistons, and other parts for which a property fit is used.

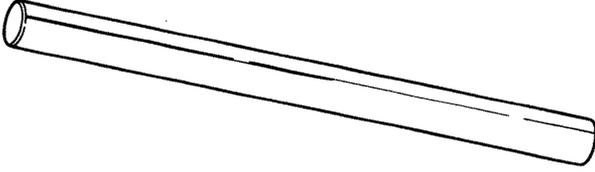
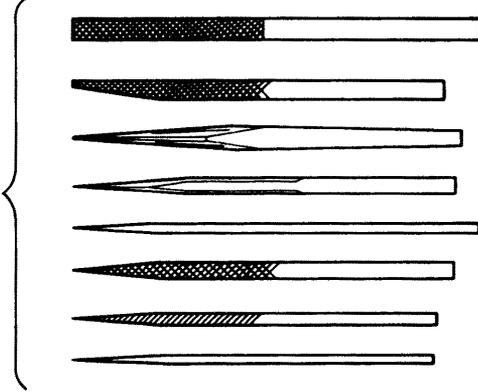
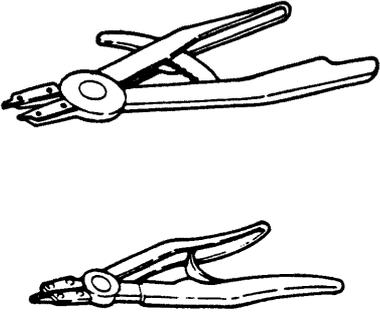
2. Disassembly and Reassembly Tools

The following tools are required when disassembling and reassembling the engine.
 Please use them as instructed.

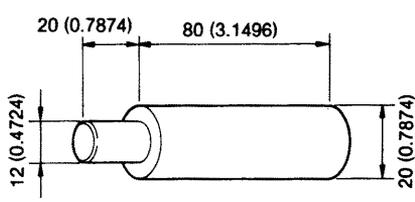
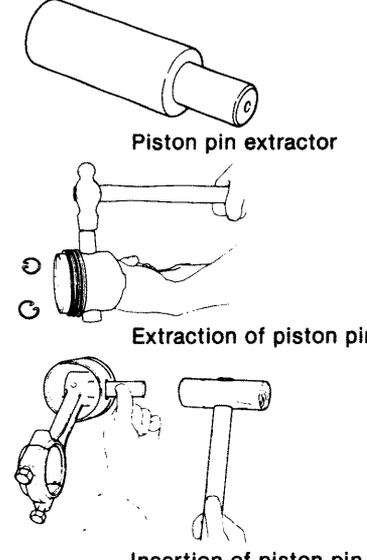
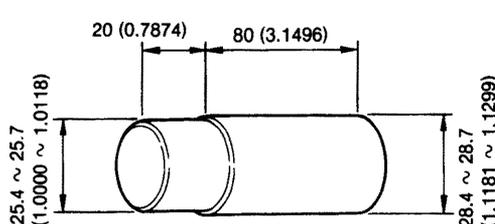
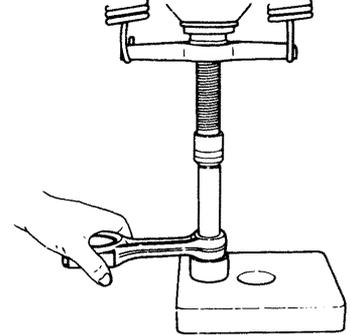
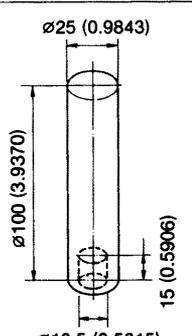
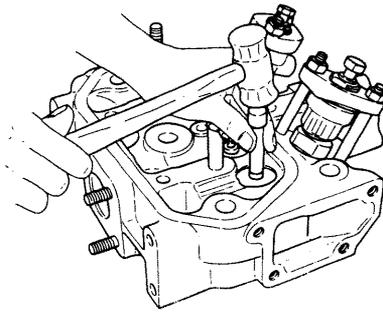
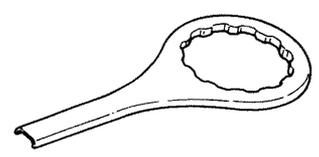
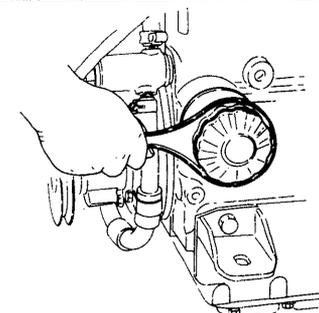
2-1. General Handtools

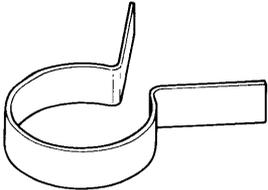
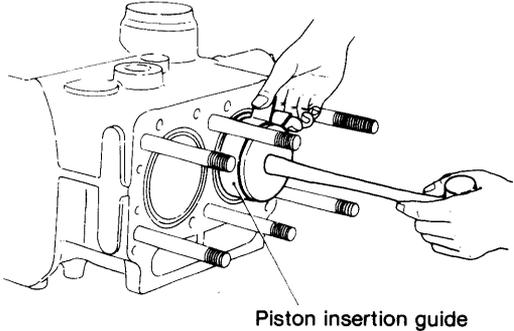
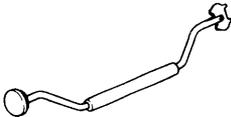
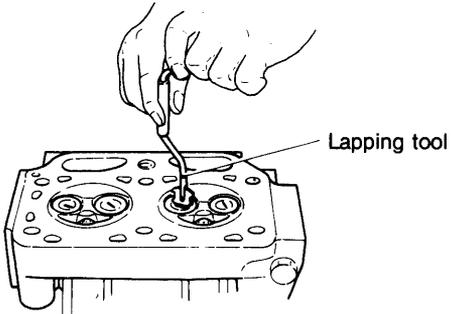
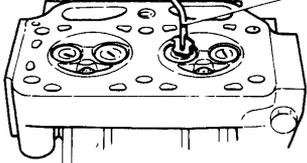
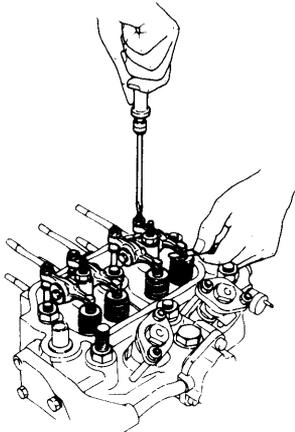
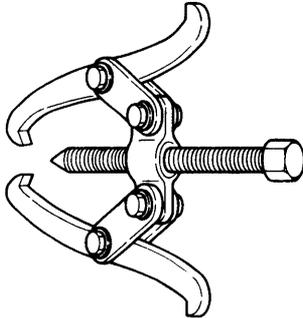
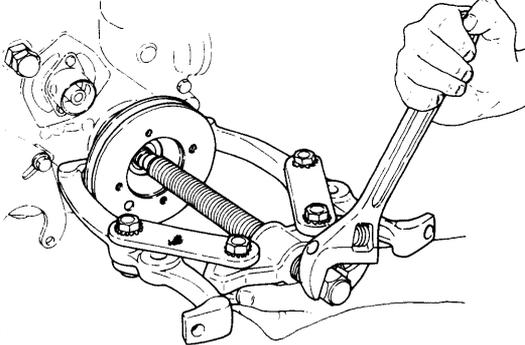
Name of tool	Illustration	Remarks
Wrench		Size: 10 × 13
Wrench		Size: 12 × 14
Wrench		Size: 17 × 19
Wrench		Size: 22 × 24
Screwdriver		
Steel hammer		Local supply

Name of tool	Illustration	Remarks
Copper hammer		Local supply
Mallet		Local supply
Nippers		Local supply
Pliers		Local supply
Offset wrench		Local supply 1 set
Box spanner		Local supply 1 set
Scraper		Local supply

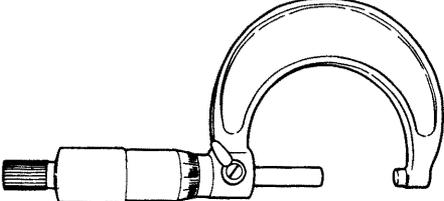
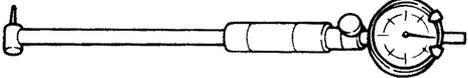
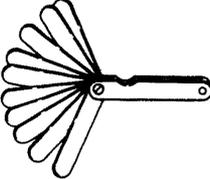
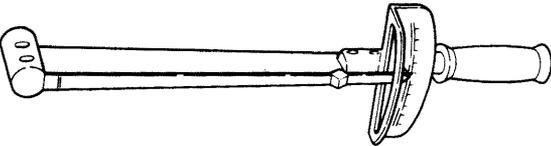
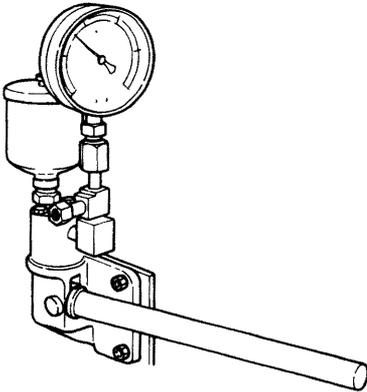
Name of tool	Illustration	Remarks
Lead rod		Local supply
File		Local supply 1 set
Rod spanner for hexagon socket head screws		Local supply Size: 6mm (0.2362in.) 8mm (0.3150in.) 10mm (0.3937in.)
Starling Pliers Hole type Shaft type	 <p data-bbox="895 1218 951 1240">S—0</p> <p data-bbox="895 1429 983 1451">H4 ~ H8</p> <p data-bbox="895 1570 1062 1615">S = Hole type H = Shaft type</p>	Local supply

2-2 Special Handtools

Name of tool	Shape and size	Application
Piston pin insertion/ extraction tool	<p style="text-align: right;">mm (in.)</p>  <p style="text-align: center;">Part No. 128670-92260</p>	 <p style="text-align: center;">Piston pin extractor</p> <p style="text-align: center;">Extraction of piston pin</p> <p style="text-align: center;">Insertion of piston pin</p>
Connecting rod small end bushing insertion/ extraction tool	<p style="text-align: right;">mm (in.)</p> 	 <p style="text-align: center;">Extraction</p>
Intake and exhaust valve insertion/ extraction tool	<p style="text-align: right;">mm (in.)</p> 	
Lubricating oil No.2 filter case remover		

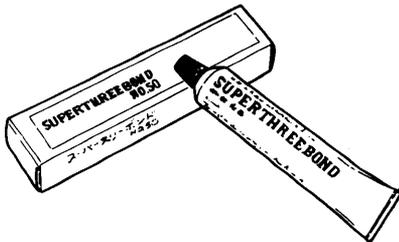
Name of tool	Shape and size	Application
Piston ring compressor		 <p>Piston insertion guide</p>
Valve lapping handle		 <p>Lapping tool</p>
Valve lapping powder		
Feeler gauge		
Pulley puller	 <p>Local supply</p>	 <p>Removing the coupling</p>

2-3 Measuring Instruments

Name of tool	Shape and size	Application
Vernier calipers		0.05mm (0.0020in.), 0 ~ 150mm (0 ~ 5.9055in.)
Micrometer		0.01mm (0.0004in.) 0 ~ 25mm (0 ~ 0.9843in.), 25 ~ 50mm (0.9843 ~ 1.9685in.), 50 ~ 75mm (1.9685 ~ 2.9528in.), 75 ~ 100mm (2.9528 ~ 3.9370in.), 100 ~ 125mm (3.9370 ~ 4.9213in.), 125 ~ 150mm (4.9213 ~ 5.9055in.)
Cylinder gauge		0.01mm (0.0004in.), 18 ~ 35mm (0.7087 ~ 1.3780in.), 35 ~ 60mm (1.3780 ~ 2.3622in.), 50 ~ 100mm (1.9685 ~ 3.9370in.)
Thickness gauge		0.05 ~ 2mm (0.0020 ~ 0.0787in.)
Torque wrench		0 ~ 13kg-m. (0 ~ 94ft-lb)
Nozzle tester		0 ~ 500kg/cm ² (0 ~ 7111.7lb/in. ²)

2-4 Other

Supplementary packing agent

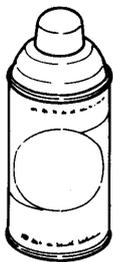


Type	Use
“Three Bond 3B8-005”	White. Since “Three Bond 3B8-005” is a nonorganic solvent, it does not penetrate asbestos sheets made principally or completely of asbestos. Always use it with grey asbestos sheet packing for complete oil tightness. When “Three Bond 3B8-005” is difficult to obtain, use silicon nonsolvent type “Three Bond No. 50.”
“Three Bond No. 50”	Grey. Silicon nonsolvent type liquid packing. Semidry type packing agent coated on mating faces to prevent oil and gas leakage. Does not penetrate asbestos sheet and assures complete oil tightness.
“Three Bond No. 1”	Reddish brown. Paste type wet viscous liquid packing. Ideal for mating faces which are removed but reinstalled. Particularly used to prevent water leakage and to prevent seizing of bolts and nuts.

The surface to be coated must be thoroughly cleaned with thinner or benzene and completely dry. Moreover, coating must be thin and uniform.

Products of Three Bond Co., Ltd.

Paint



Color spray

Only Metallic Ecol Silver is used on this engine.

Wipe the surface to be painted with thinner or benzene, shake the spray can well, push the button at the top of the can and spray the paint onto the surface from a distance of 30 ~ 40 cm.

Paint

Type

White paint
(Mixed oil paint)

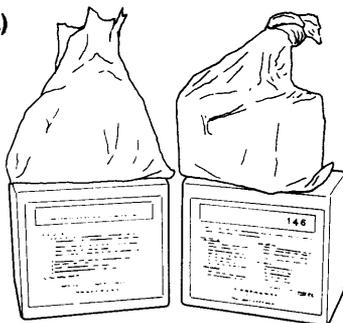
Usage point

Cylinder liner
insertion hole

Use

Paint parts that contact with the cylinder body when inserting the cylinder liner to prevent rusting and water leakage.

Yanmar cleaner (Ref.)



Cooling passage cleaner is mixed by adding one part “Unicon 146” to about 16 parts water (specific gravity ratio). To use, drain the water from the cooling system, fill the system with cleaner, allowing it to stand overnight (10 ~ 15 hours). Then drain out the cleaner, refill the system with water, and operate the engine for at least one hour.

NEJI LOCK SUPER 203M: a locking agent for screws (Ref.)



For coating on screws and bolts to prevent loosening, rusting, and leaking. To use, wipe off all oil and water on the threads of studs, coat the threads with screw lock, tighten the stud bolt, and allow them to stand until the screw lock hardens. Use screw lock on the oil intake pipe threads, oil pressure switch threads, fuel injection timing shim faces, and front axle bracket mounting bolts.

3. Disassembly and Reassembly

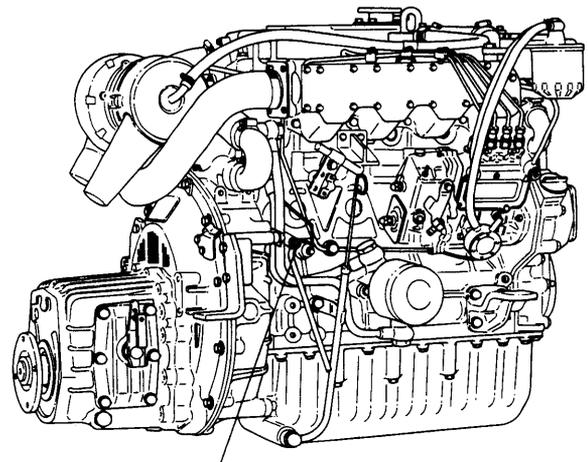
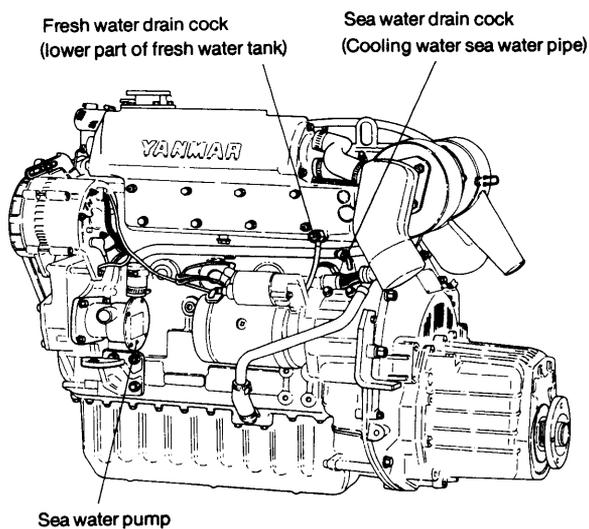
3-1 Disassembly

For engines mounted in an engine room, remove the piping and wiring connecting them to the ship.

- (1) Remove the remote control cable (from engine and marine gearbox).
- (2) Unplug the extension cord for the instrument panel from the engine.
- (3) Remove the wiring between the starting motor and the battery.
- (4) Remove the exhaust rubber hose from the mixing elbow.
- (5) Remove the fresh water sub-tank rubber hose from the filler cap.
- (6) Remove the cooling water (sea water) pump sea water intake hose (after making sure the Kingston cock is closed).
- (7) Remove the fuel oil intake rubber hose from the fuel feed pump.
- (8) Remove the body fit (reamer) bolts and disassemble the propeller shaft coupling and thrust shaft coupling.
- (9) If a driven coupling is mounted to the front drive coupling, disassemble.
- (10) Remove the flexible mount nut, lift the engine, and remove it from the engine base.
(Leave the flexible mount attached to the engine base.)

3-1.1 Drain cooling water

- (1) Open the sea water drain cock between the sea water pump and lube oil cooler to drain the sea water.
- (2) Open the cylinder body drain cock to drain the fresh water from the cylinder head and cylinder body.
- (3) Open the fresh water drain cock on the lower part of the fresh water tank to drain the fresh water.



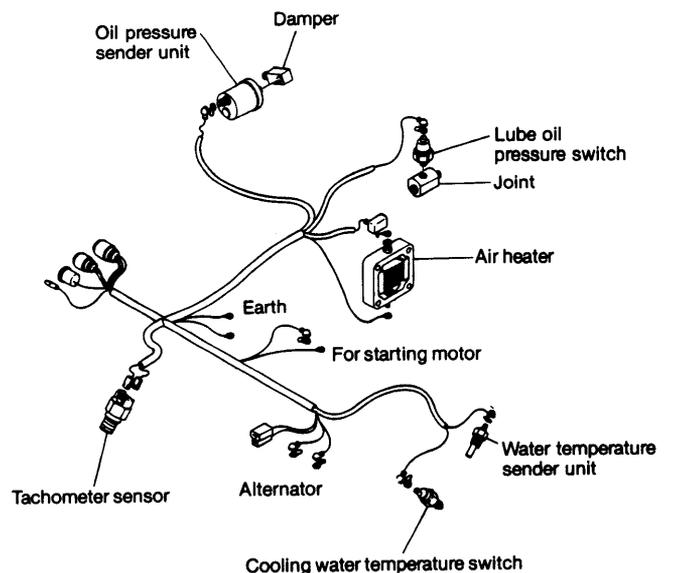
3-1.2 Drain lube oil

- (1) Remove the pipe coupling bolt which holds the lube oil dip stick guide, and drain the lube oil from the engine.
- (2) Remove the drain plug on the lower part of the crank case control side, and drain the lube oil from the marine gearbox.

NOTE: If a lube oil supply/discharge pump is used for the engine, the intake hose is placed in the dip stick guide, and for the clutch side (gearbox) it is placed in the oil hole on top of the case.

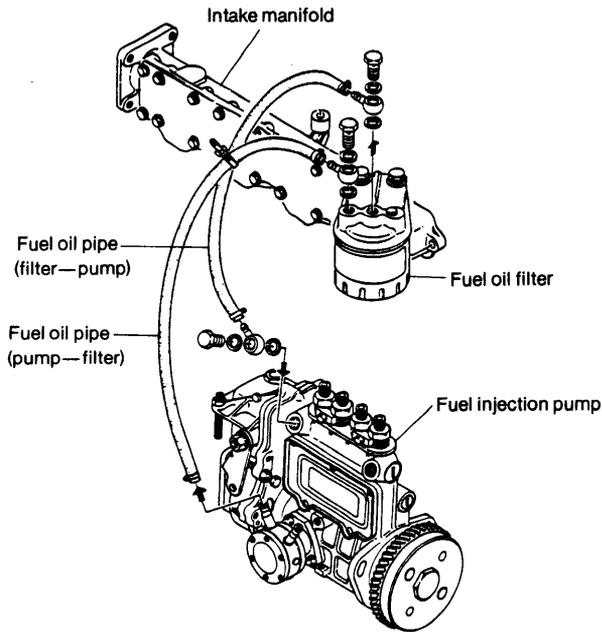
3-1.3 Removing (electrical) wiring

Remove the wiring from the engine.



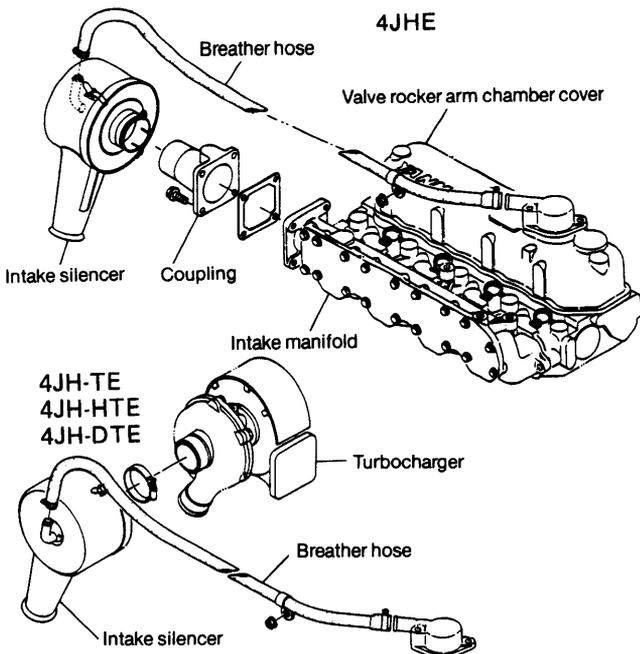
3-1.4 Removing the fuel oil filter & fuel oil pipe

- (1) Remove the fuel oil pipe (fuel oil filter—fuel feed pump, fuel oil filter—fuel injection pump).
- (2) Remove the fuel oil filter (with bracket) from the intake manifold.



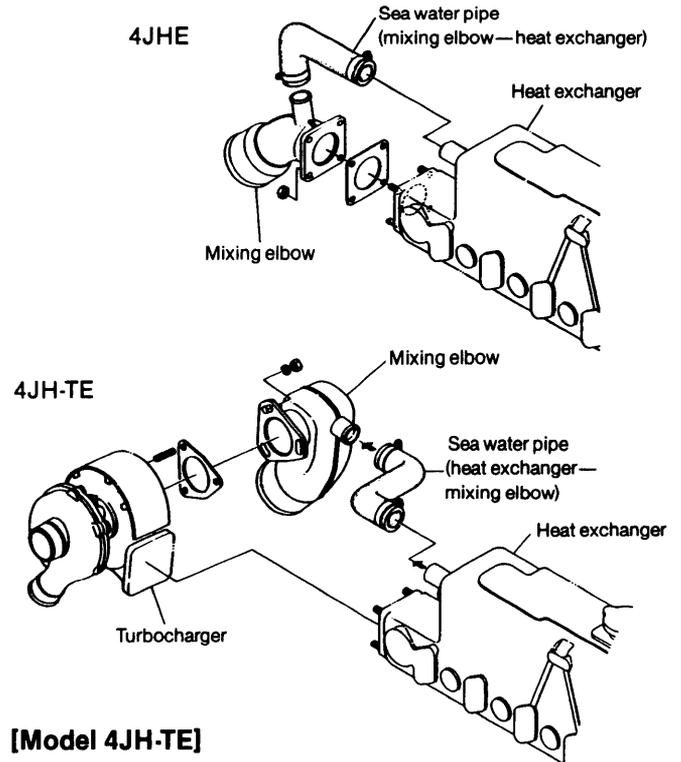
3-1.5 Removing the intake silencer

- (1) Remove the breather hose attached to the intake silencer—valve rocker arm chamber cover.
- (2) Remove the intake silencer
 4JHE: from the intake manifold intake coupling
 4JHE, 4JH-HTE, 4JH-DTE: from the blower side of the turbocharger



3-1.6 Removing the mixing elbow

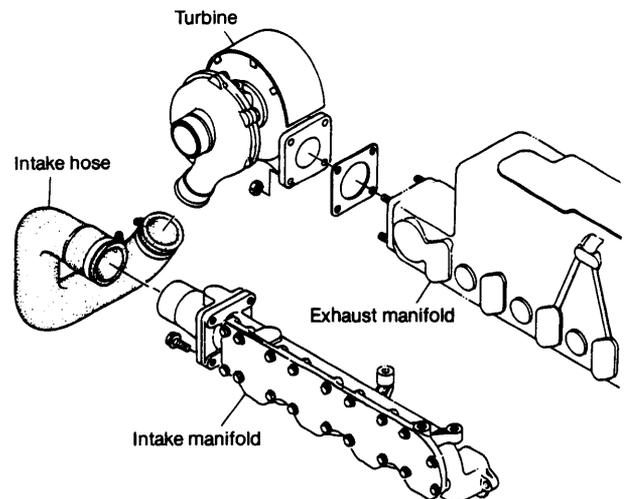
- (1) Remove cooling water (sea water) pipe rubber hose (heat exchanger—mixing elbow).
- (2) Remove the mixing elbow
 4JHE: from exhaust manifold outlet
 4JH-TE: from turbocharger outlet

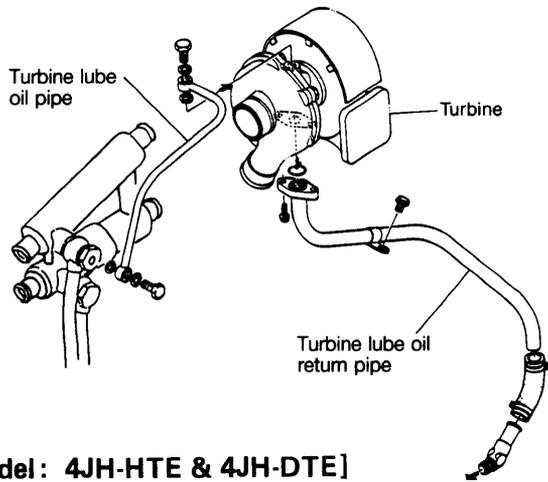


[Model 4JH-TE]

3-1.7 Removing the turbine

- (1) Remove the intake rubber hose (turbine—intake manifold).
- (2) Remove the oil pan side rubber hose for the turbine lube oil return pipe from the oil pan, and the vibration stop from the flywheel housing.
- (3) Remove the turbine lube oil pipe (lube oil cooler—turbine).
- (4) Remove the turbine from the exhaust manifold.



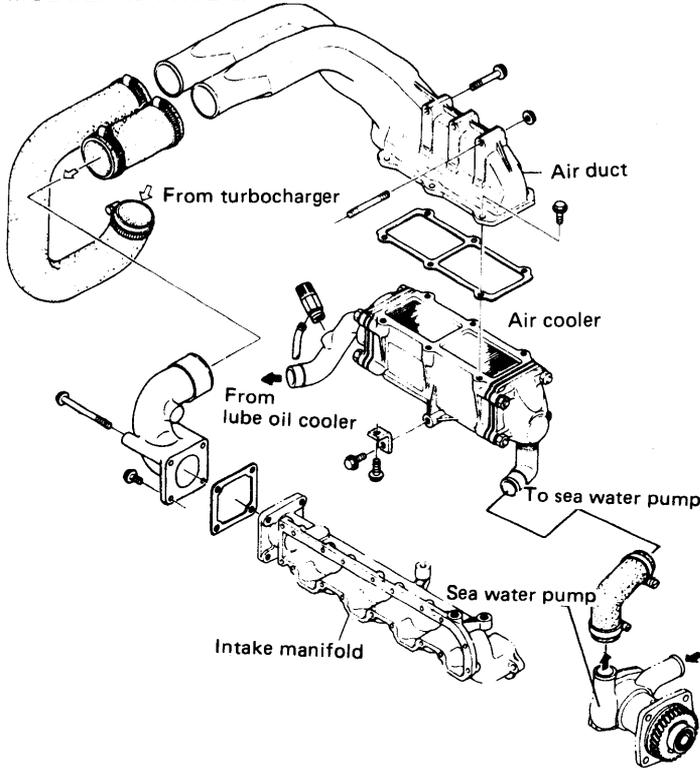


[Model: 4JH-HTE & 4JH-DTE]

Removing the air cooler

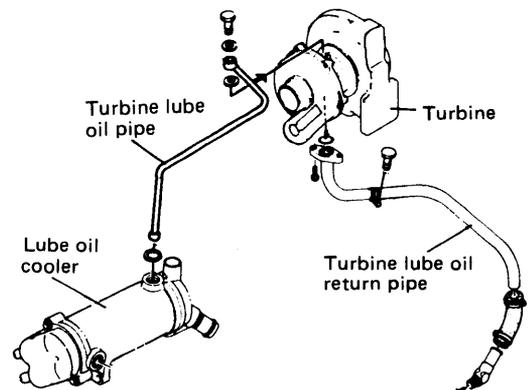
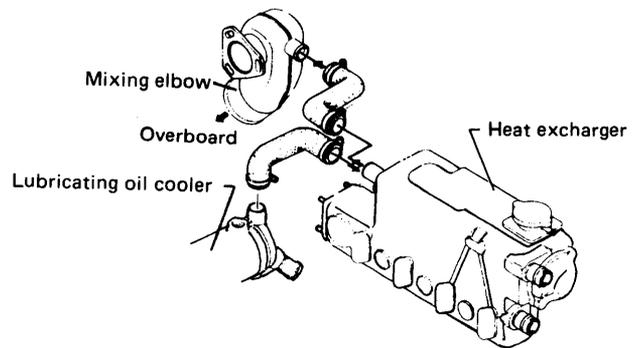
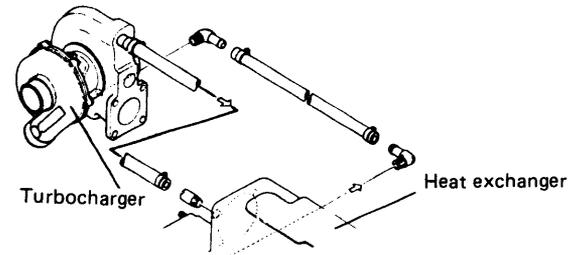
- (1) Remove the intake rubber hoses.
(Air duct-intake manifold, and turbocharger)
- (2) Remove the sea-water rubber hoses.
(Sea water pump — Air cooler — Lube oil cooler)
- (3) Remove the air cooler from the heat exchanger, and cylinder block.

MODEL: 4JH-HTE & 4JH-DTE



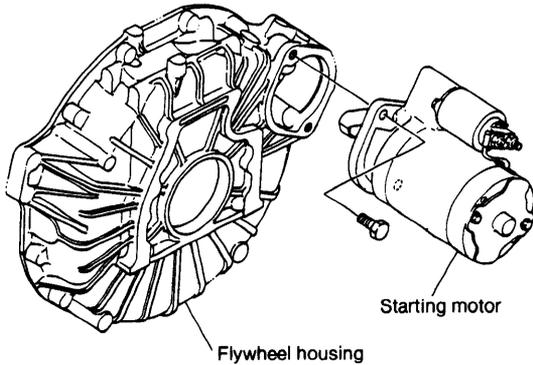
Removing the mixing elbow and the turbocharger.

- (1) Remove the fresh water hoses.
(Turbocharger — heat exchanger)
- (2) Remove the lube oil pipes.
(Lube oil cooler—Turbocharger—Lube oil pump)
- (3) Remove the sea water hose.
(Mixing elbow — heat exchanger)
- (4) Remove the mixing elbow from turbocharger.
- (5) Remove the air duct rubber hose.
(Air duct — Turbocharger)
- (6) Remove the turbocharger from exhaust manifold.



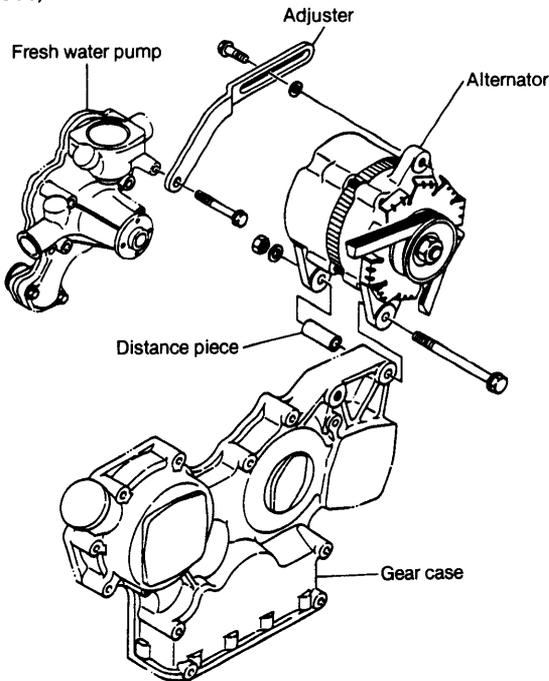
3-1.8 Removing the starting motor

Remove the starting motor from the flywheel housing.



3-1.9 Removing the alternator

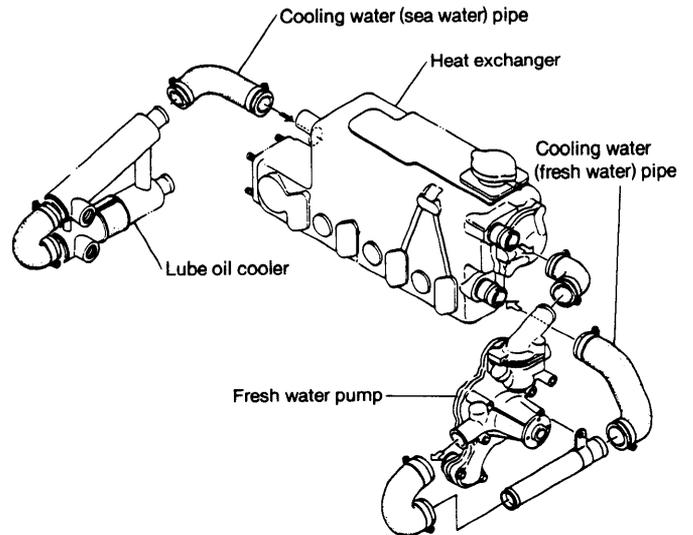
- (1) Loosen the alternator adjuster bolt and remove the V-belt.
- (2) Remove the adjuster from the fresh water pump, and remove the alternator from the gear case (with distance piece).



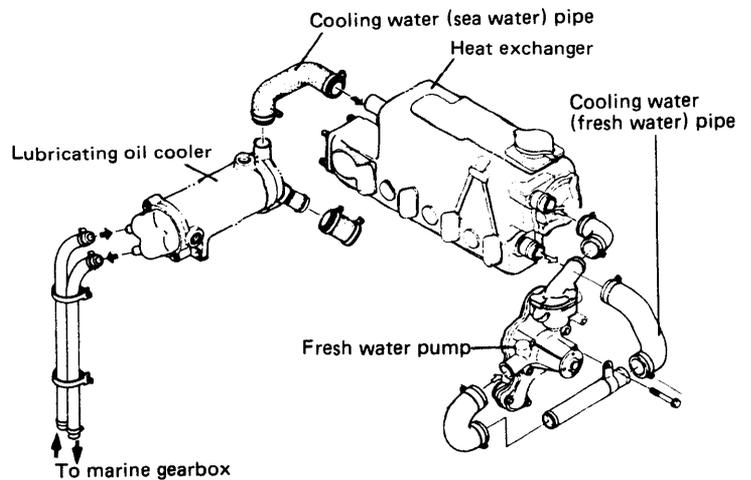
3-1.10 Removing the cooling water pipe

- (1) Remove the cooling water (sea water) pipe (lube oil cooler — heat exchanger).
- (2) Remove the cooling water (fresh water) pipe (heat exchanger — fresh water pump, fresh water pump — fresh water tank).
- (3) Remove the cooling water pipe (lube oil cooler — marine gearbox)

[Model: 4JHE, 4JH-TE]

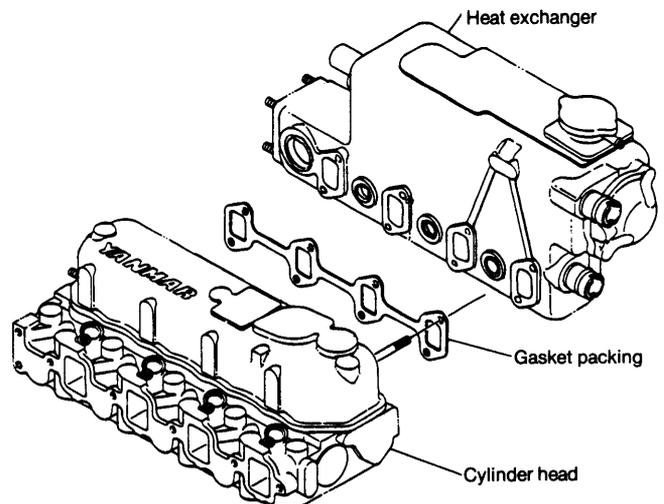


[Model: 4JH-HTE, 4JH-DTE]

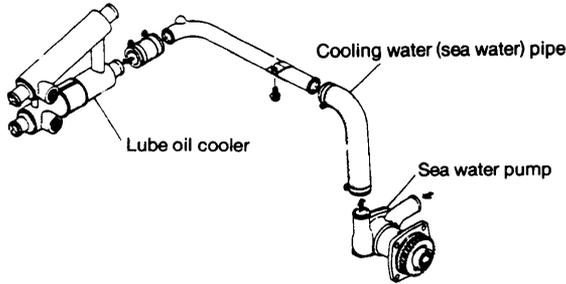


3-1.11 Removing the heat exchanger (exhaust manifold, fresh water tank unit)

Remove the heat exchanger and gasket packing.

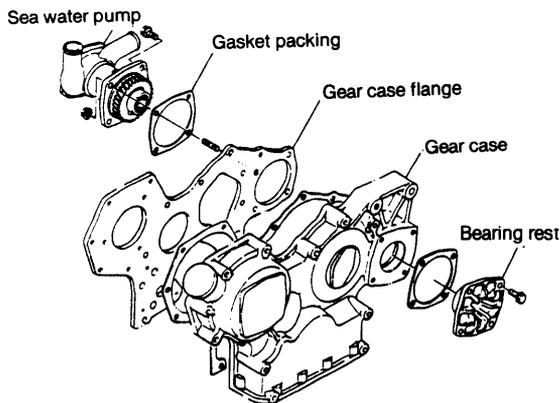


3-1.12 Removing the cooling water (sea water) pipe (sea water pump—lube oil cooler).



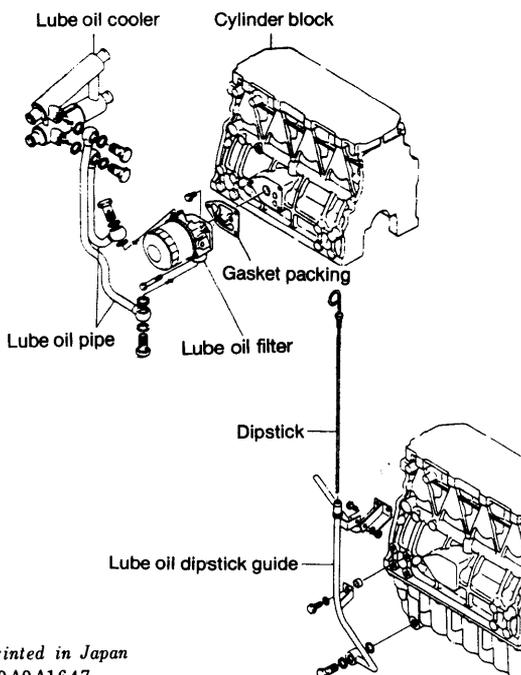
3-1.13 Removing the sea water pump

- (1) Pull out the bearing mounts, receptacles from the sea water pump mounting side and from the opposite side of the gear case.
- (2) Remove the sea water pump.



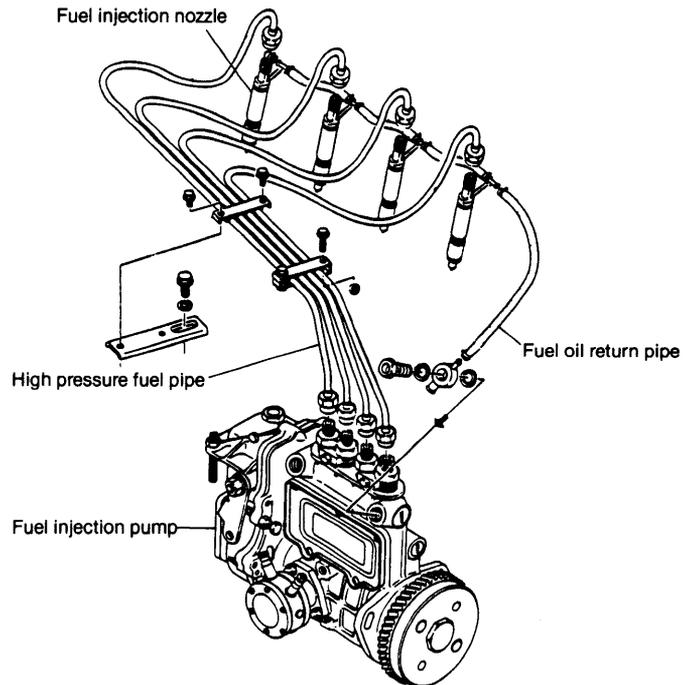
3-1.14 Removing the lube oil filter

- (1) Remove the lube oil pipe (lube oil cooler—filter bracket, filter bracket—lube oil cooler).
- (2) Remove the filter bracket (with lube oil filter element) from the cylinder block.
- (3) Remove the lube oil pipe (cylinder block—fuel injection pump).
- (4) Remove the lube oil dipstick and guide.



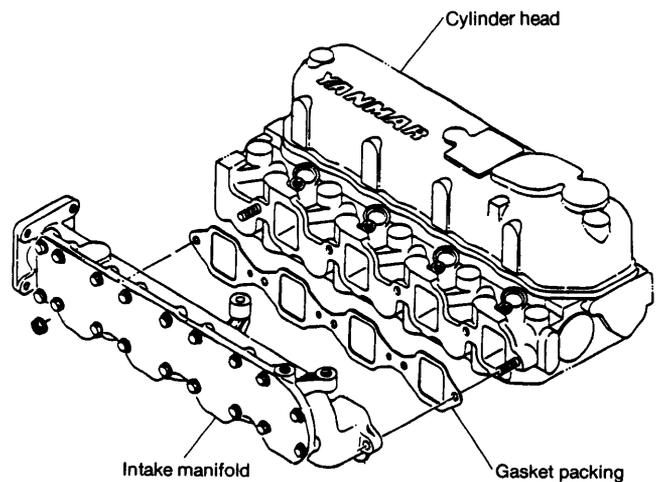
3-1.15 Removing the high pressure fuel pipe

- (1) Remove the high pressure fuel pipe vibration stop from the intake manifold.
- (2) Loosen the box nuts on both ends of the high pressure fuel pipe and remove the high pressure fuel pipe.
- (3) Remove the fuel oil return pipe (fuel injection nozzle—fuel injection pump).



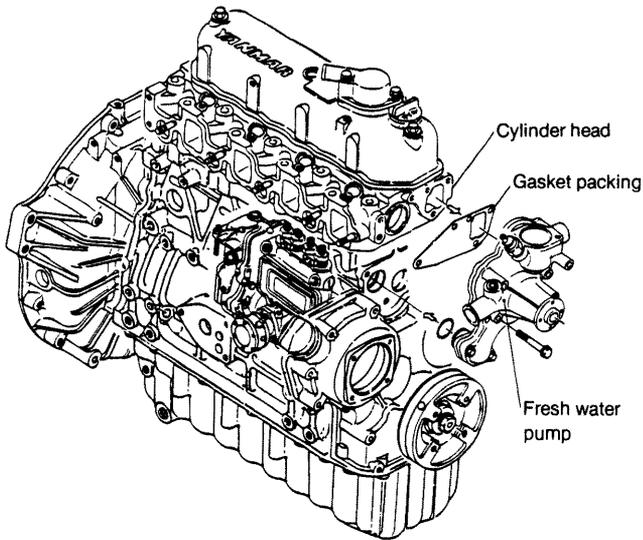
3-1.16 Removing the intake manifold

- (1) Remove the governor speed remote control bracket.
- (2) Remove the intake manifold and gasket packing.



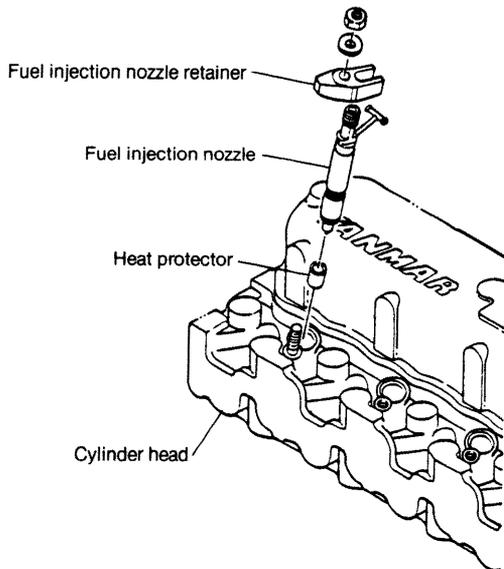
3-1.17 Removing the fresh water pump

Remove the fresh water pump, gasket packing and O-ring.



3-1.18 Removing the fuel injection nozzles

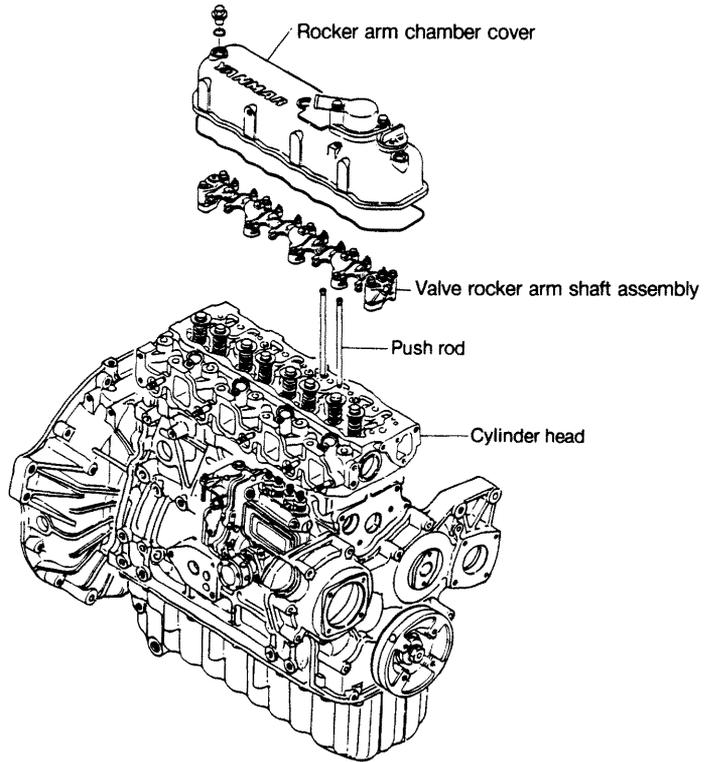
Remove the fuel injection nozzle retainer nut, and pull out the fuel injection nozzle retainer and fuel injection nozzle.



NOTE: If the heat protector stays in the cylinder head, make a note of the cylinder no. and be sure to remove it when you disassemble the cylinder head.

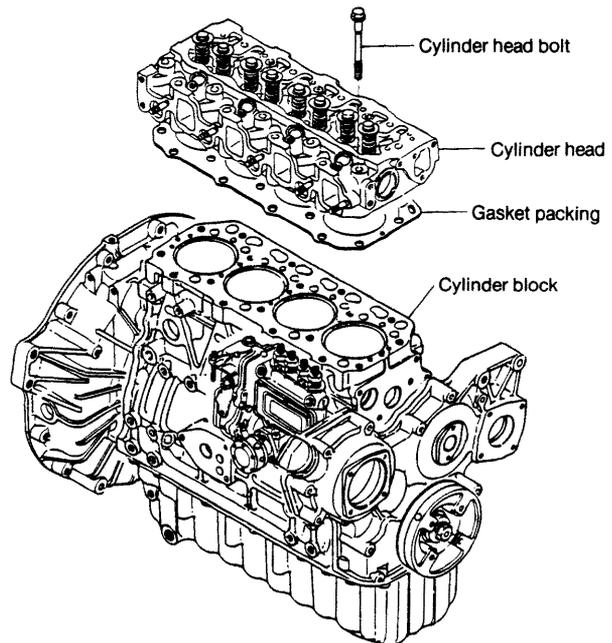
3-1.19 Removing the valve elbow shaft assembly

- (1) Remove the valve elbow chamber cover.
- (2) Remove the valve elbow shaft support mounting bolts(s), and remove the entire valve elbow shaft assembly.
- (3) Pull out the push rods.



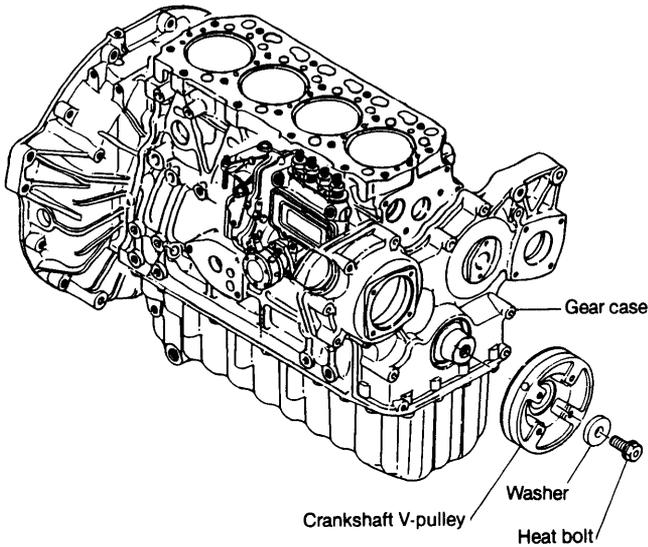
3-1.20 Removing the cylinder head

- (1) Remove the cylinder head bolts with a torque wrench, and remove the cylinder head.
- (2) Remove the cylinder gasket packing.



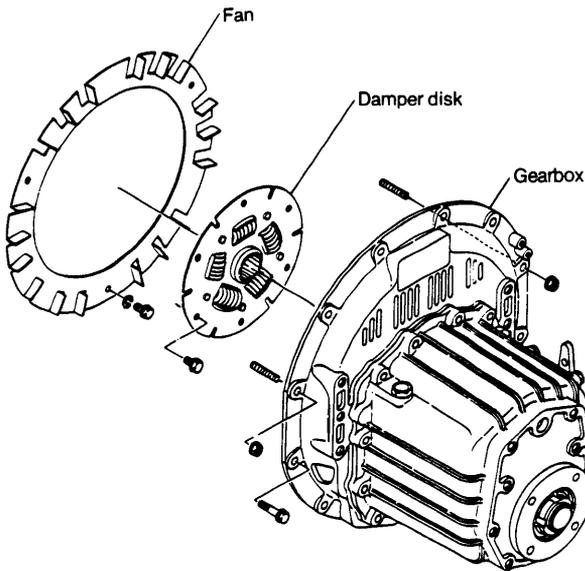
3-1.21 Removing the crankshaft V-pulley

Remove the hex bolts holding the crankshaft V-pulley, and remove the crankshaft V-pulley with an extraction tool.



3-1.22 Removing the marine gearbox

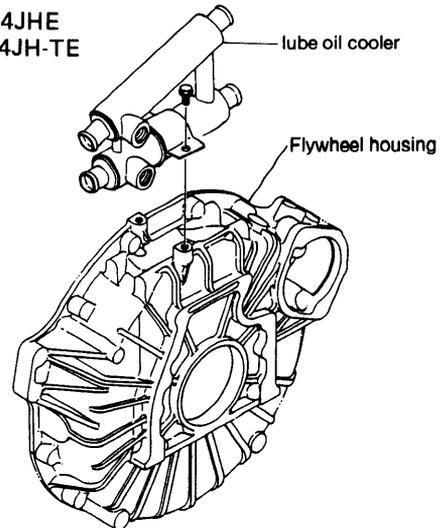
- (1) Remove the hex bolts from the clutch case flange, and remove the gearbox assembly.
- (2) Remove the damper disk from the flywheel.
- (3) Remove the fan from the flywheel.



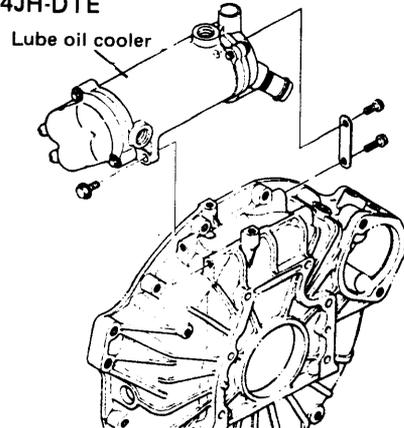
3-1.23 Removing the lube oil cooler

Remove the lube oil cooler from the upper part of the flywheel housing.

MODEL: 4JHE
4JH-TE

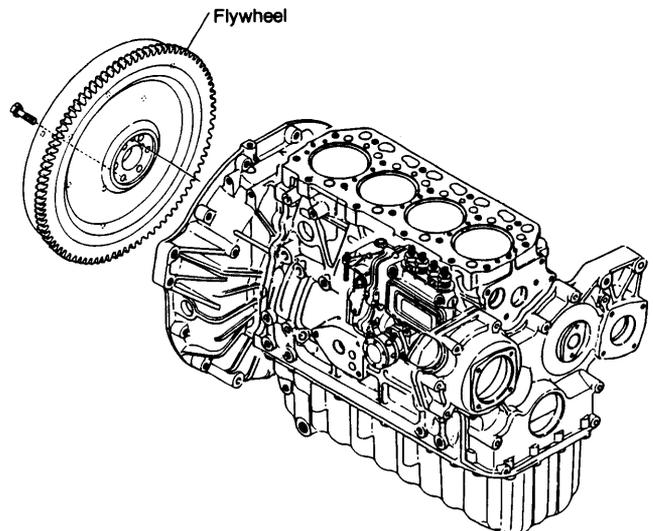


MODEL: 4JH-HTE
4JH-DTE



3-1.24 Removing the flywheel

Remove the flywheel mounting bolts and then the flywheel.



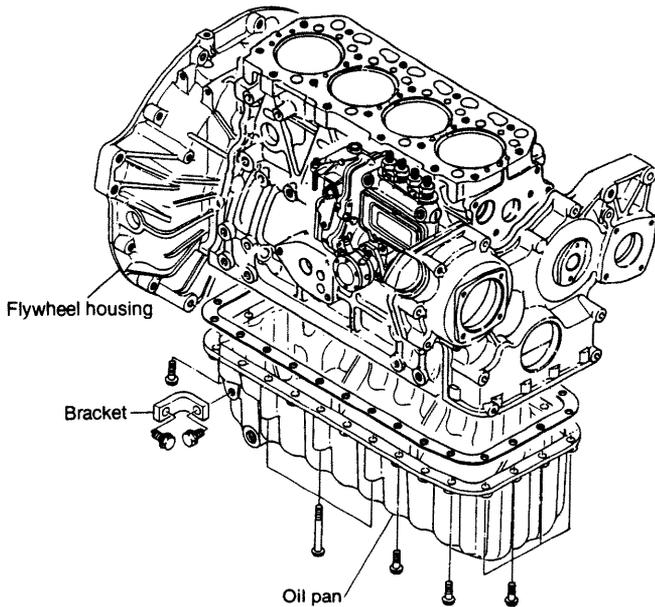
NOTE: Be careful not to scratch the ring gear.

3-1.25 Turning the engine over

- (1) Place a wood block of appropriate size on the floor, and stand up the engine on the flywheel housing.
- (2) Remove the engine mounting feet.

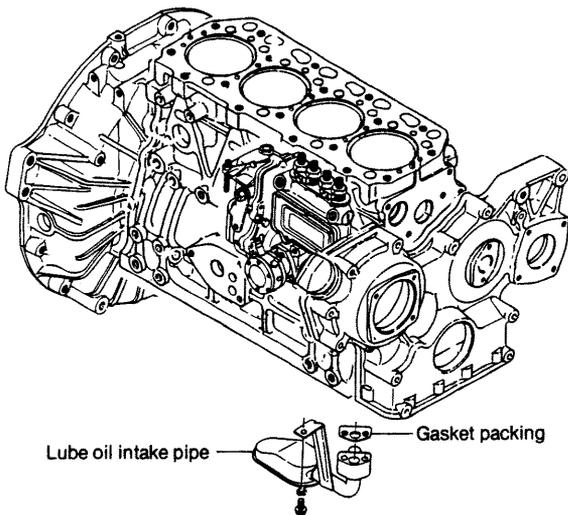
3-1.26 Removing the oil pan

- (1) Remove the bracket holding the oil pan and clutch housing.
- (2) Remove the oil pan and gasket packing.



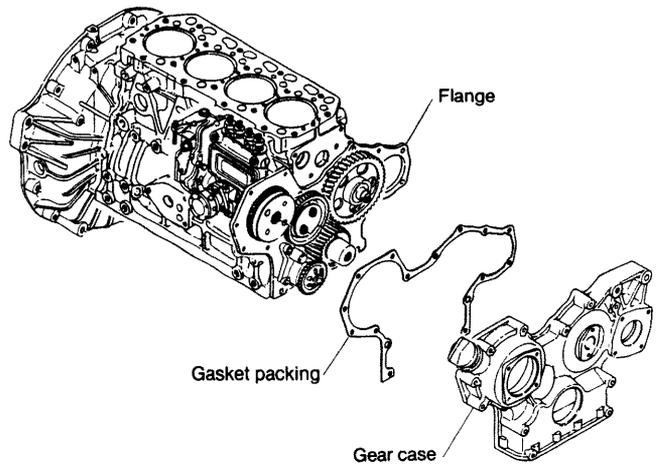
3-1.27 Removing the lube oil intake pipe

Remove the lube oil intake pipe and gasket packing.



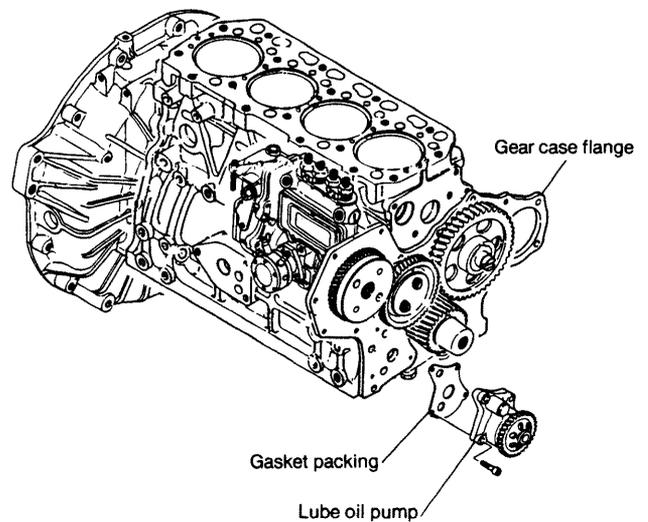
3-1.28 Removing the gear case

Remove the gear case mounting bolts, and remove the gear case from the cylinder block.



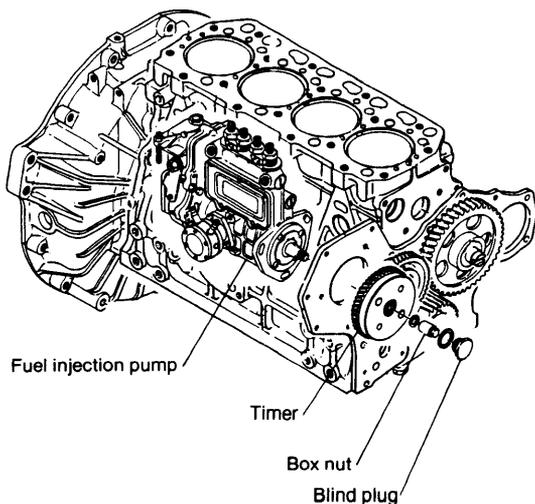
3-1.29 Removing the lube oil pump

Remove the lube oil pump and gasket packing from the gear case flange.



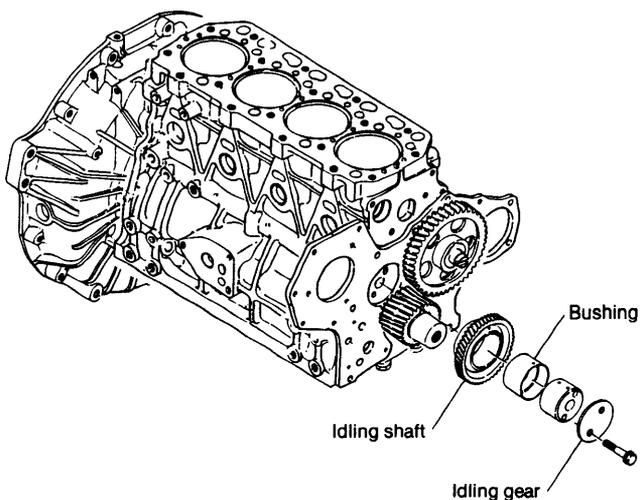
3-1.30 Remove the fuel injection pump

- (1) Remove the blind plug mounted to the hub of the automatic advancing timer.
- (2) Remove the box nut, and pull out the fuel oil pump drive gear/automatic advancing timer assembly with an extraction tool.
- (3) Remove the fuel injection pump and O-ring from the gear case flange.



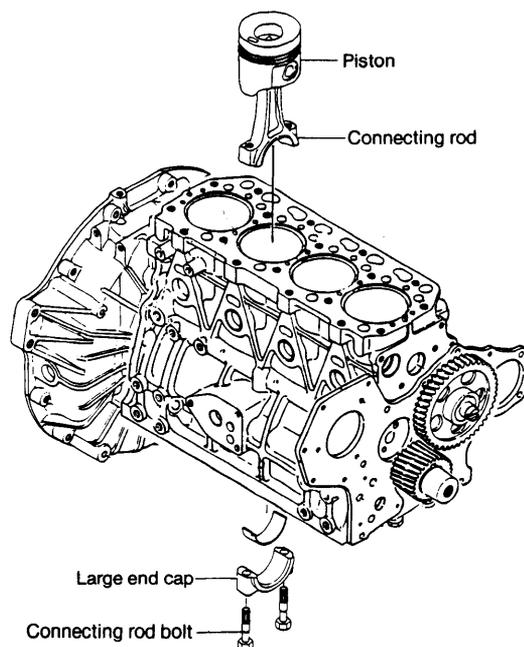
3-1.31 Removing the idling gear

Remove the two hex bolts holding the idling shaft, and pull out the idling gear and idling shaft.



3-1.32 Removing the pistons and connecting rods

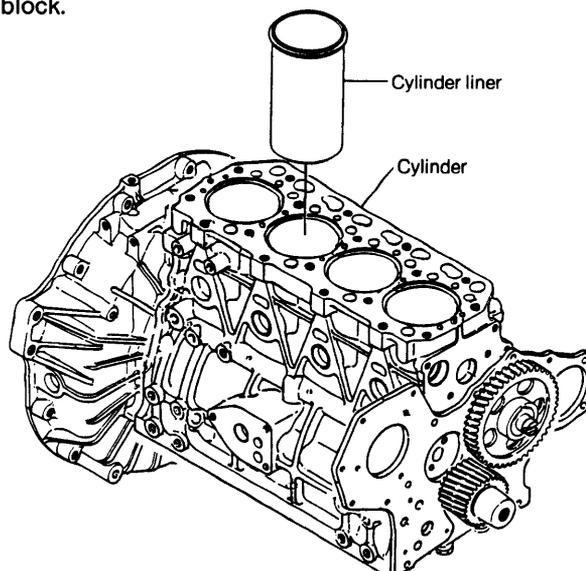
- (1) Remove the connecting rod bolt and the large end cap.
- (2) Push the connecting rod from the bottom and pull out the piston connecting rod assembly.



NOTE: Place a tool against the piston cooling nozzle to make sure the nozzle position does not change and it doesn't get scratches.

3-1.33 Removing the cylinder liner

Remove the cylinder liner from the top of the cylinder block.



NOTE: If it is difficult to pull out the liner, tap the bottom of the liner with a plastic hammer.

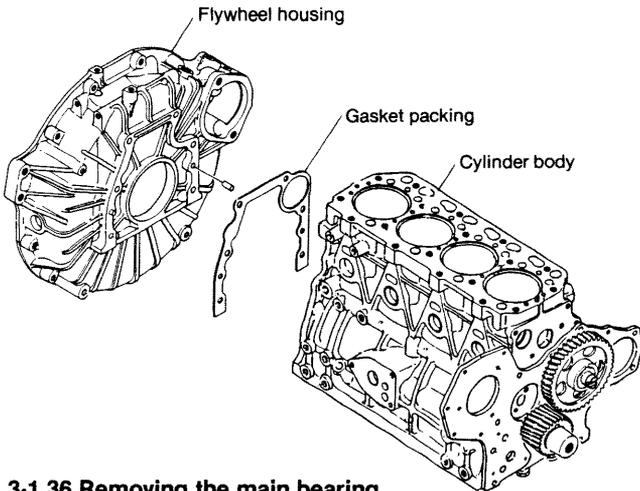
3-1.34 Turning the engine over

Place a wood block of suitable size on the floor and turn the engine over, with the cylinder head mounting surface facing down.

NOTE: Make sure that the cylinder head positioning pins on the cylinder block do not come in contact with the wood block.

3-1.35 Removing the flywheel housing

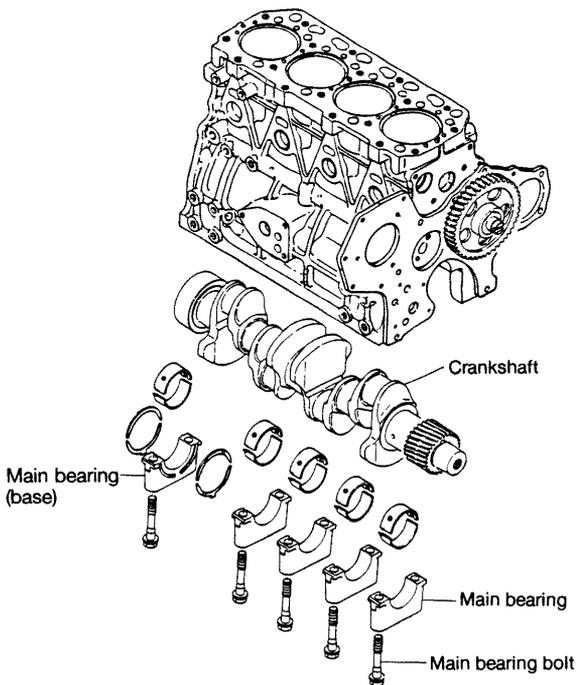
Remove the flywheel housing from the cylinder block.



3-1.36 Removing the main bearing

- (1) Remove the main bearing bolts.
- (2) Remove the main bearing cap and lower main bearing metal.

NOTE: The thrust metal (lower) is mounted to the standard main bearing cap. Be sure to differentiate between mounting surfaces.



3-1.37 Removing the crankshaft

- (1) Remove the crankshaft

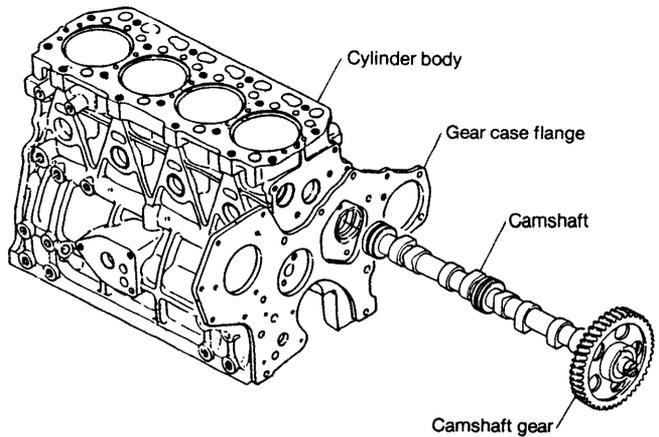
NOTE: 1. The thrust metal (upper) is mounted to the standard main bearing. However, in some cases the thrust metal (upper) may be mounted to the crankshaft.

2. Remove the main bearing metal (upper) from the cylinder block.

3-1.38 Removing the camshaft

- (1) Loosen the thrust rest mounting bolts out of the holes in the camshaft gear, and remove.
- (2) Pull out the camshaft gear and camshaft assembly from the cylinder block.

NOTE: The camshaft gear and camshaft are shrunk fit. They must be heated to 180—200°C to disassemble.

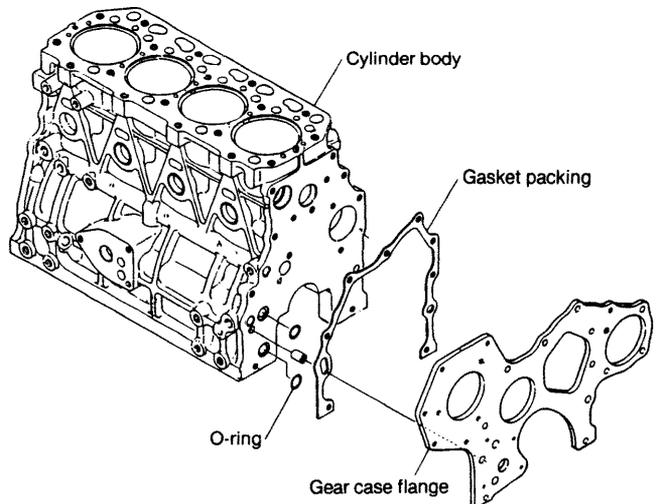


3-1.39 Removing the tappets

Remove the tappets from the tappet holes in the cylinder block.

3-1.40 Removing the gear case flange

- (1) Remove the gear case flange from the cylinder block.
- (2) Remove the two O-rings from the lube oil passage.



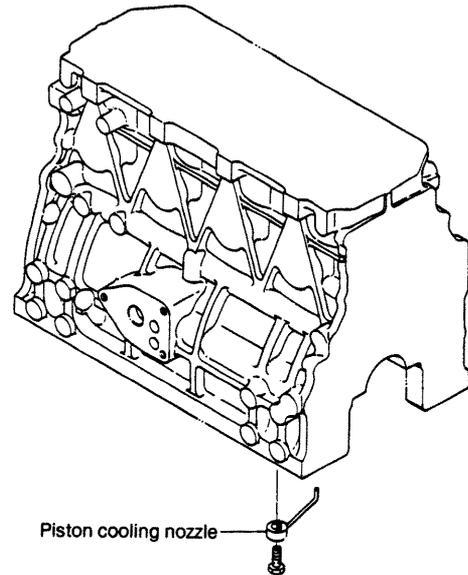
3-1.41 Removing the piston cooling nozzle

Remove the piston cooling nozzle mounting nut and then the piston cooling nozzle from the cylinder block.

3-2 Reassembly

3-2.1 Mounting the piston cooling nozzle

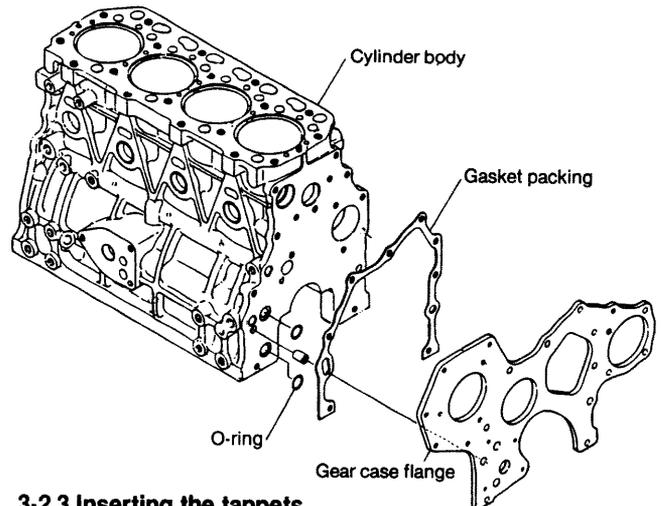
Turn the cylinder block upside down and place it on appropriate wood blocks. Mount the piston cooling nozzles.



3-2.2 Mounting the gear case flange

Mount the gear case flange, gasket packing and lube oil line O-ring onto the cylinder block.

NOTE: 1. When mounting the gear case flange, match up the two cylinder block pipe knock pins.
2. Be sure to coat the cylinder block lube oil line O-ring with grease when assembling, so that it does not get out of place.



3-2.3 Inserting the tappets

Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, and insert the tappets in the cylinder block.

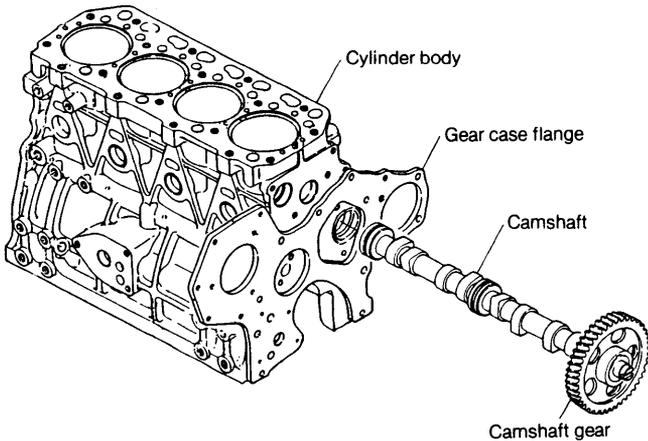
NOTE: Separate the tappets to make sure that they are reassembled in the same cylinder, intake/exhaust manifold as they came from.

3-2.4 Mounting the camshaft

- (1) If the camshaft and camshaft gear have been disassembled, shrink fit the camshaft and camshaft gear [heat the camshaft gear to 180—200°C (356—392°F) in the hot oil and press fit].

NOTE: When mounting the camshaft and camshaft gear, be sure not to forget assembly of the thrust rest. Also make sure they are assembled with the correct orientation.

- (2) Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block, and mount the thrust rest with the bolt.



- (3) Measure the camshaft side gap.

	mm (in.)
Camshaft side gap	0.05 ~ 0.25 (0.0020 ~ 0.0098in.)

- (4) Make sure that the camshaft rotates smoothly.

3-2.5 Mounting the crankshaft

- (1) The crankshaft and crankshaft gear are shrink fitted. If the crankshaft and crankshaft gear have been disassembled, they have to be shrink fitted [heat the crank shaft gear to 180°—200°C (356—392°F) in the hot oil and press fit].

- (2) Coat the cylinder block crank journal holes and upper part of the main bearing metal with oil and fit the upper main bearing metal onto the cylinder block.

NOTE: 1. Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.

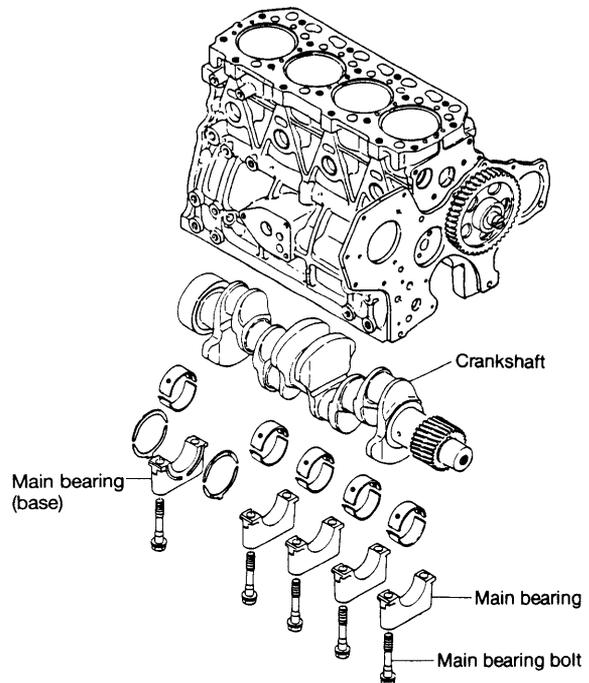
2. When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, (crankshaft side).

- (3) Coat the crank pin and crank journal with engine oil and place them on top of the main bearing metal.

NOTE: 1. Align the crankshaft gear and camshaft gear with the "A" match mark.

2. Position so that the crankshaft gear is on the gear case side.

3. Be careful not to let the thrust metal drop.



3-2.6 Mounting the main bearing metal with engine oil, and mounting the main bearing cap.

NOTE: 1. The lower main bearing metal does not have an oil groove.

2. The standard bearing thrust metal is fitted with the oil groove slit facing outwards.

- (2) Coat the main bearing cap bolt washer contact surface and threads with engine oil, place them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.

	kg-m (ft-lb)
Main bearing bolt tightening torque	9.5 ~ 10.5 (68.7 ~ 75.9)

NOTE: 1. The main bearing cap should be fitted with the arrow near the embossed letters "FW" on the cap pointing towards the flywheel.

2. Make sure you have the correct cylinder alignment no.

- (3) Measure the crankshaft side clearance.

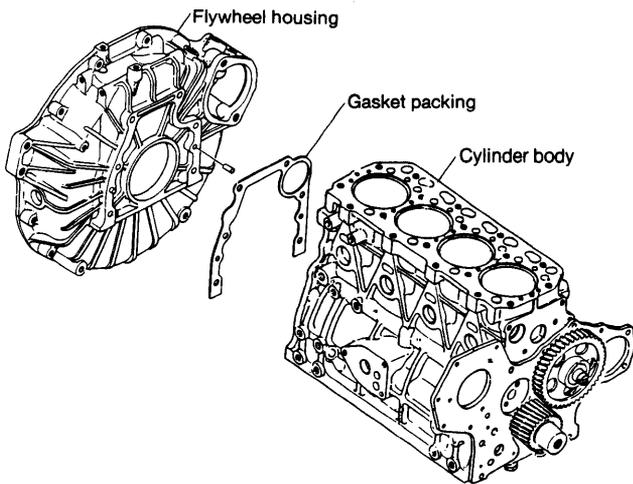
	mm (in.)
Crankshaft side clearance	0.090 ~ 0.271 (0.0035 ~ 0.0107)

- (4) Make sure that the crankshaft rotates smoothly and easily.

3-2.7 Mounting the flywheel housing

- (1) Press fit the oil seal in the flywheel housing, and coat the lip of the oil seal with engine oil.
- (2) Mount the flywheel housing and gasket packing, matching them up with the cylinder block positioning pins.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.

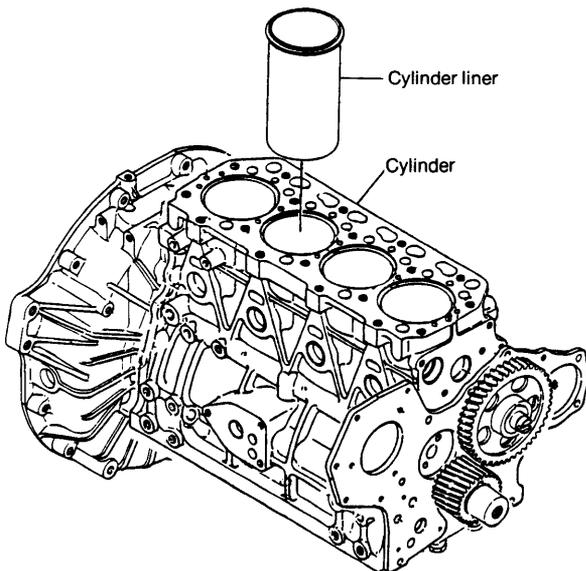


3-2.8 Stand up the cylinder block

On wood blocks, with the flywheel housing facing down. Take care that the gearbox mounting surface does not get scratched.

3-2.9 Inserting the cylinder liners

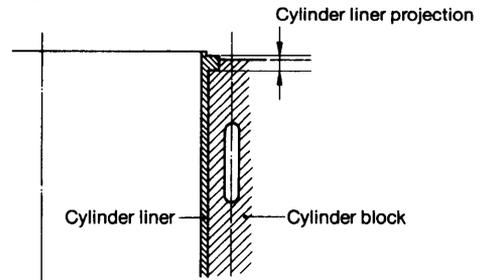
- (1) Thoroughly clean the cylinder block mounting holes and contact surfaces.
- (2) After thoroughly cleaning the outside of the cylinder liner, carefully insert it in to the cylinder block by hand (do not force).



NOTE: 1. Make sure that each liner is put back into its original cylinder.

2. Do not turn over the engine (with the cylinder head mounting surface facing down) after the liners have been inserted.

(3) Measuring cylinder liner projection



mm (in.)	
Cylinder liner projection	0.03 ~ 0.09 (0.0012 ~ 0.0035)

(4) Measuring cylinder liner inner dia.

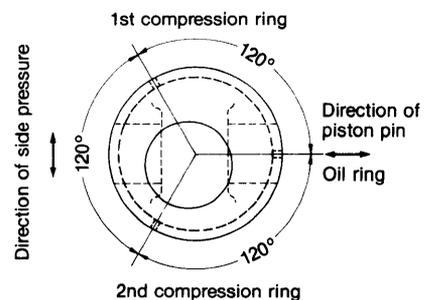
Cylinder liner distortion after insertion	0.03mm or less (0.0012in. or less)
---	---------------------------------------

3-2.10 Mounting the piston and connecting rod

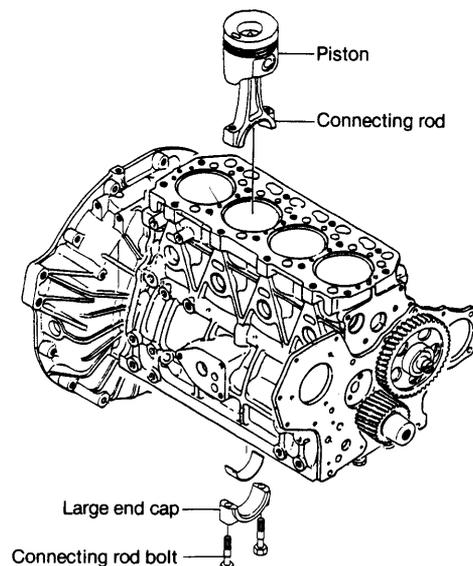
- (1) Reassemble the piston and connecting rod.

NOTE: When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.

- (2) Each ring opening (piston/oil rings) should be staggered at gaps of 120°.



- (3) Coat the outside of the piston and the inside of the connecting rod crank pin metal with engine oil and insert the piston with the piston insertion tool.



- NOTE:** 1. Insert the piston so that the match mark on the large end of the connecting rod faces the fuel feed pump, and the manufacturer's mark on the stem points toward the flywheel.
 2. After inserting the piston, make sure the combustion chamber hollow is facing the fuel feed pump, looking from the top of the piston.

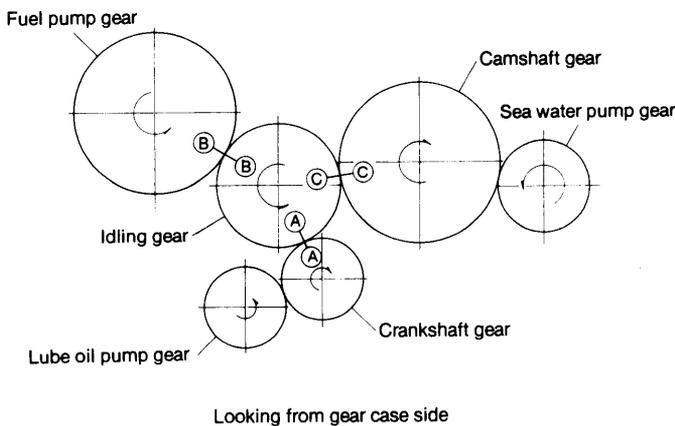
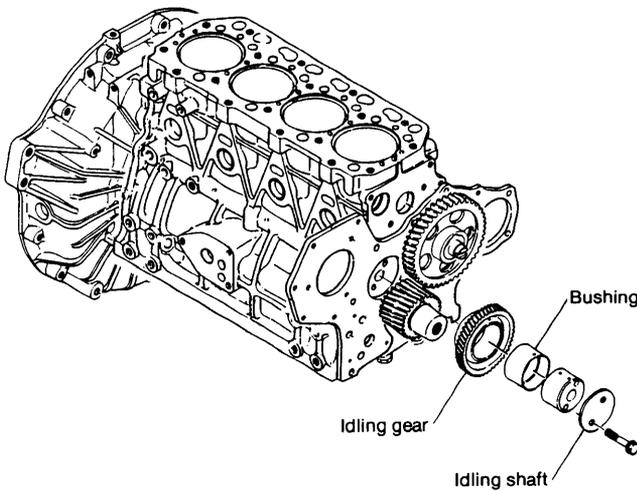
(4) Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

	kg-m (ft-lb)
Connecting rod bolt tightening torque	4.5 ~ 5.0 (32.5 ~ 36.2)

NOTE: If a torque wrench is not available, match up with the mark made before disassembly.

3-2.11 Mounting the idling gear

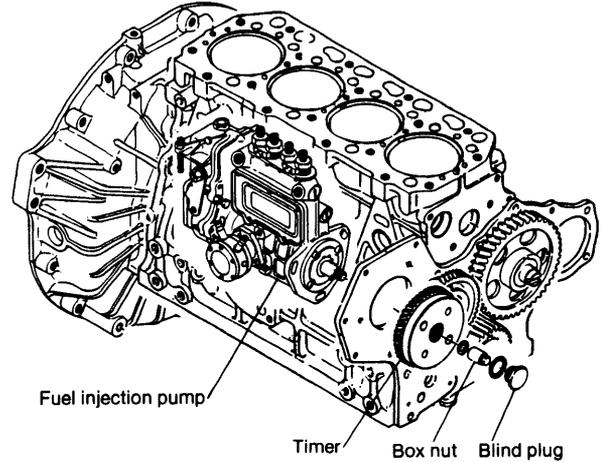
- Fit the idling gear so that the side of the idling shaft with two oil holes faces up.
- Align the "A" and "C" camshaft gear and crankshaft gear match marks, match up with idling shaft retaining plate, and tighten the bolts.
- Measure the idling gear, camshaft gear and crankshaft gear backlash.



3-2.12 Mounting the fuel injection pump

Lightly fit the fuel injection pump on the gear case.

- NOTE:** 1. Be careful not to scratch the O-ring between the fuel injection pump and gear case flange.
 2. Tighten the fuel injection pump all the way after adjusting injection timing.



3-2.13 Mounting the fuel feed pump drive gear and automatic advancing timer.

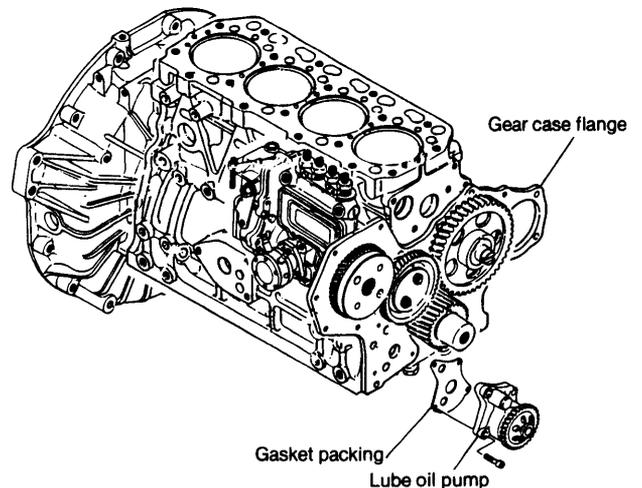
- When the drive gear and automatic advancing timer have been disassembled, coat all sliding parts in both assemblies with grease.
- Align the "B" match marks on the fuel pump drive gear and idling gear.
- Tighten all box nuts holding the fuel feed pump to the specified torque.

	kg-m (ft-lb)
Box nut tightening torque	6 ~ 7 (43.4 ~ 50.6)

- Grease parts around the box nuts (lithium grease) and tighten the blind plug.
- Measure the backlash of the fuel feed pump drive gear.

3-2.14 Mounting the lube oil pump

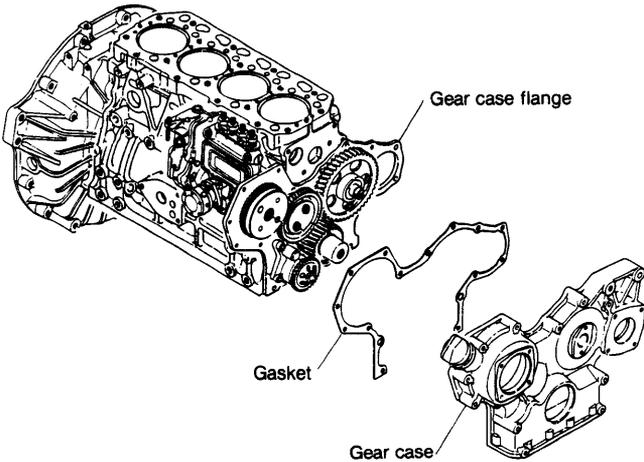
- Mount the lube oil pump on the gear case flange.
- Measure the backlash of the lube oil pump drive gear.



3-2.15 Mounting the gear case

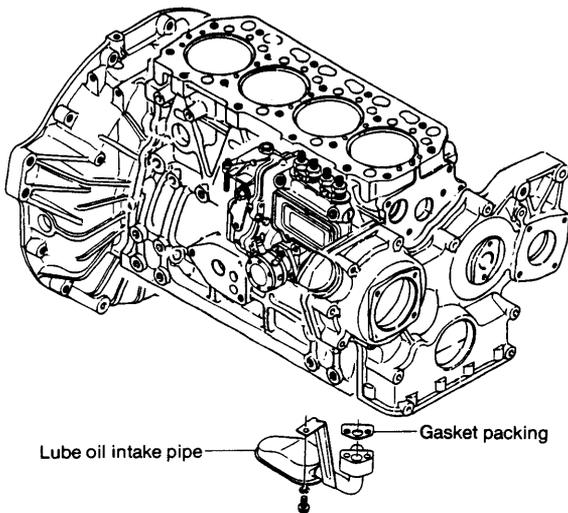
- (1) Coat the inside and outside of the oil seals with engine oil, and press fit them into the gear case.
- (2) Position the two pipe knock pins, and tighten the bolts holding the gear case and gasket packing.

NOTE: Trim the gasket packing if it protrudes onto the oil pan mounting surface.



3-2.16 Mounting the lube oil intake pipe

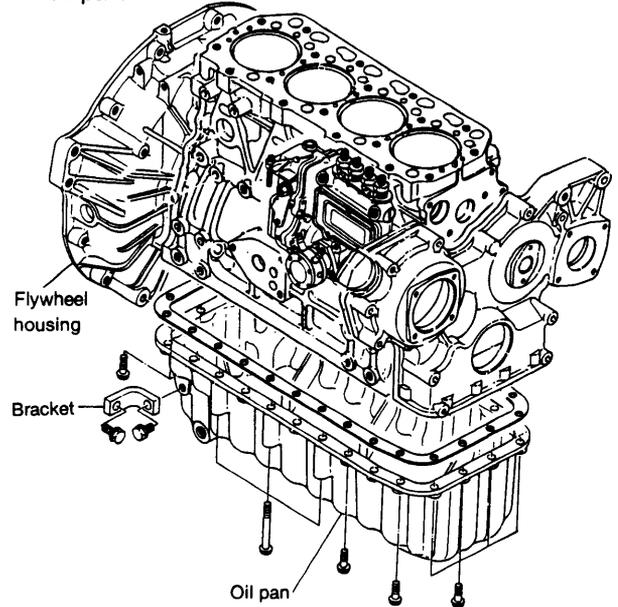
Mount the lube oil intake pipe on the bottom of the cylinder block, using new packing.



	kg-m (ft-lb)
lube oil intake pipe tightening torque	2.6 (18.8)

3-2.17 Mounting the oil pan

- (1) Coat with three bond (3B-1114) the surfaces of the gear case, gear case flange and flywheel that contact with the cylinder block.
- (2) Tighten the gasket packing/oil pan bolts.
- (3) Mount the bracket that connects the flywheel with the oil pan.

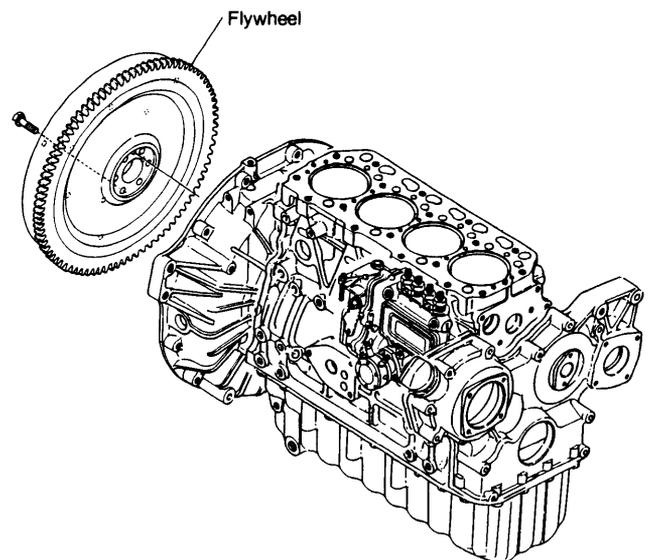


3-2.18 Mounting the engine mounting feet and turning the engine upright.

Place suitable wood blocks below the oil pan and turn the engine upright.

3-2.19 Mounting the flywheel

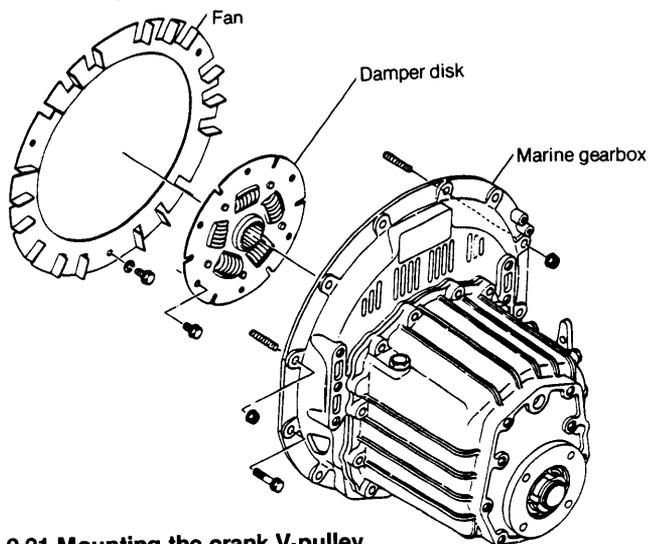
- (1) Coat the flywheel mounting bolt threads with engine oil.
- (2) Align the positioning pins, and tighten the flywheel bolts to the specified torque.



	kg-m (ft-lb)
Flywheel mounting bolt tightening torque	7.0 ~ 8.0 (50.6 ~ 57.9)

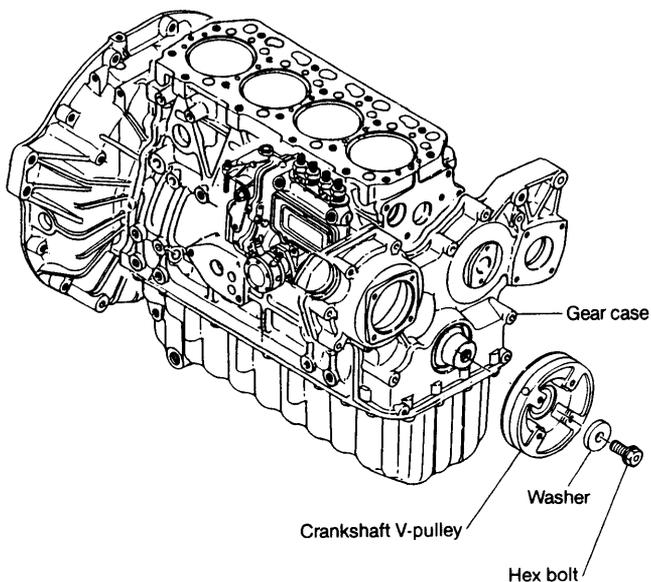
3-2.20 Mounting the marine gearbox

- (1) Mount the fan and damper disk to the flywheel.
- (2) Align the damper disk with the input shaft spline and insert. Tighten the flywheel housing and flange.



3-2.21 Mounting the crank V-pulley

- (1) Coat the oil seal and the section of the shaft with which it comes in contact with oil.
- (2) Tighten to the specified torque.



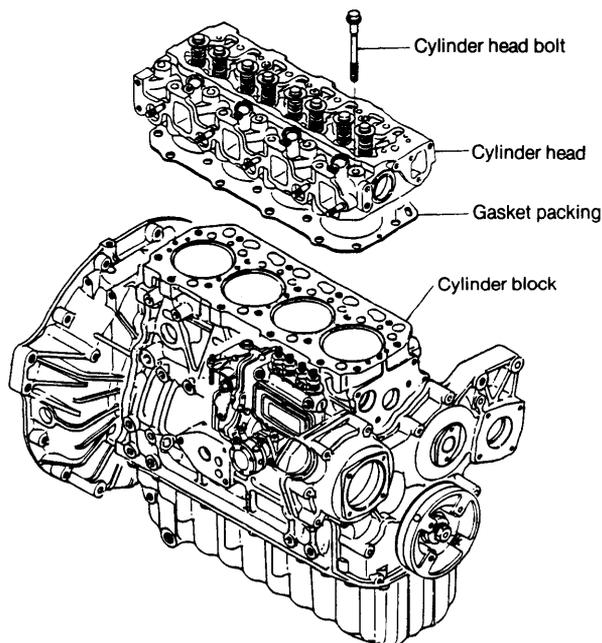
	kg-m (ft-lb)
V-pulley tightening torque	11.5 ~ 12.5 (83.2 ~ 90.4)

3-2.22 Mounting the cylinder head

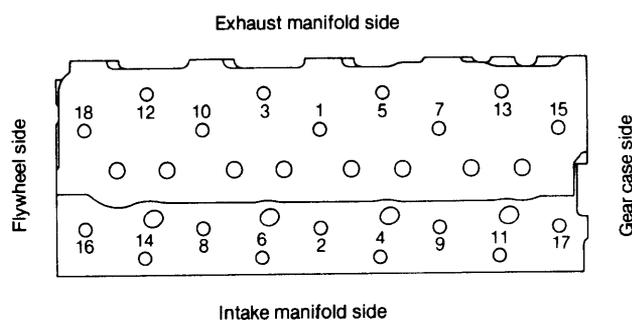
- (1) Fit the gasket packing against the cylinder block, aligning it with the cylinder block positioning pins.

NOTE: The side on which the engine model is inscribed should face up (cylinder head side).

- (2) Lift the cylinder head horizontally and mount, aligning with the cylinder head gasket.
- (3) Coat the mounting bolt washers and threads with engine oil, and lightly tighten the bolts in the specified order. Then tighten completely, in the same order.



Tightening order



	kg-m (ft-lb)	
	Partial	Complete
Cylinder bolt tightening torque	3.5 ~ 4.5 (25.3 ~ 32.5)	7.5 ~ 8.5 (54.2 ~ 61.5)

- (4) Measure the top clearance.

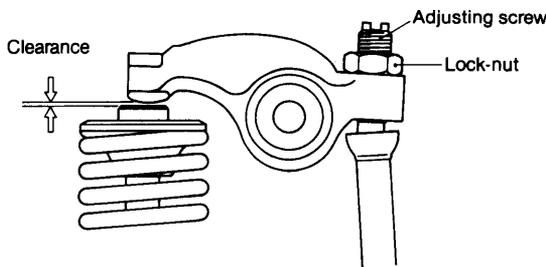
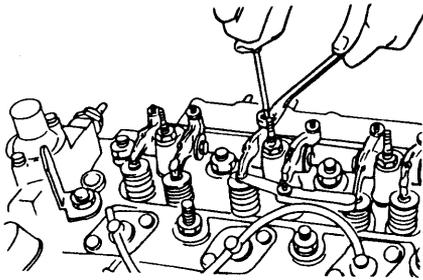
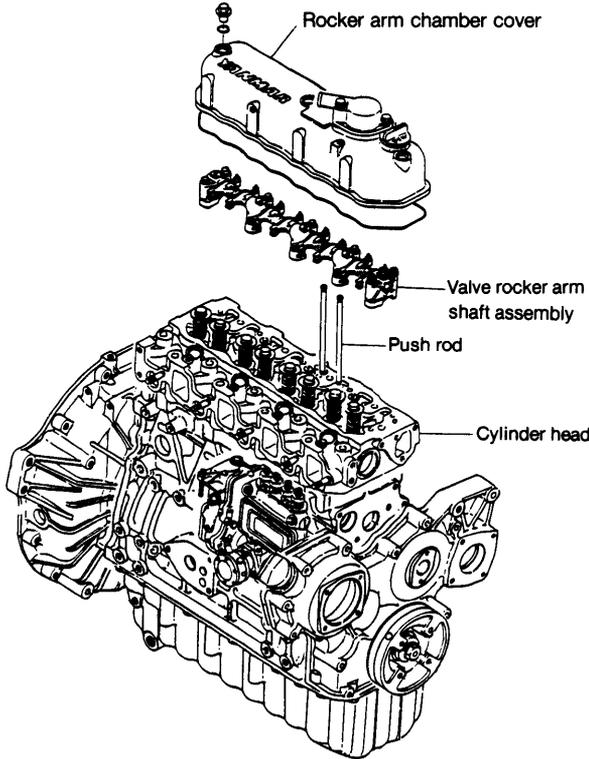
	mm (in.)
Top clearance	0.71 ~ 0.89 (0.0279 ~ 0.0350)

3-2.23 Mounting the valve rocker arm shaft assembly pushrod

- (1) Fit the pushrod to the tappet.
- (2) Mount the valve rocker arm shaft assembly.

	kg-m (ft-lb)
Valve rocker arm shaft support tightening torque	2.4 ~ 2.8 (17.4 ~ 20.4)

- (3) Adjust valve clearance.

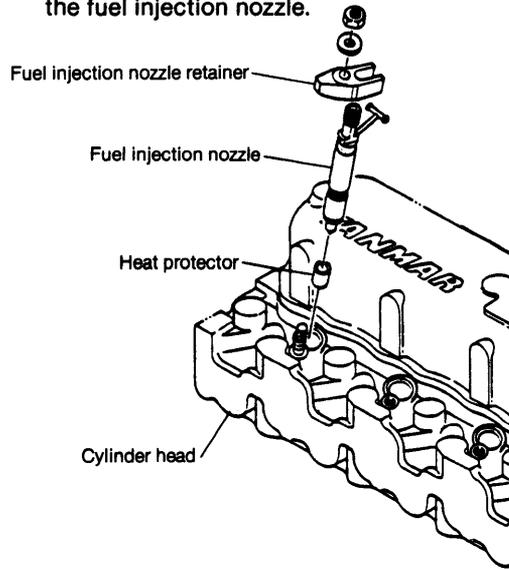


	mm (in.)
Intake/discharge valve clearance	0.2 (0.0079)

- (4) Coat the valve rocker arm and valve spring with engine oil, and mount the valve rocker arm chamber cover.

3-2.24 Mounting the fuel injection nozzle

- (1) Mount the injection nozzle tip heat protector, and then the fuel injection nozzle.

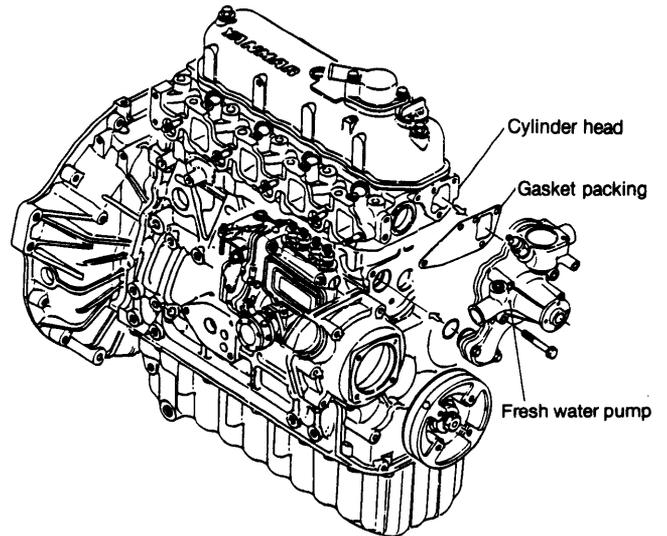


- (2) Tighten the fuel injection nozzle retainer nut to the specified torque.

	kg-m (ft-lb)
Fuel injection nozzle retainer tightening torque	2.0 ~ 3.0 (14.5 ~ 21.7)

3-2.25 Mounting the fresh water pump

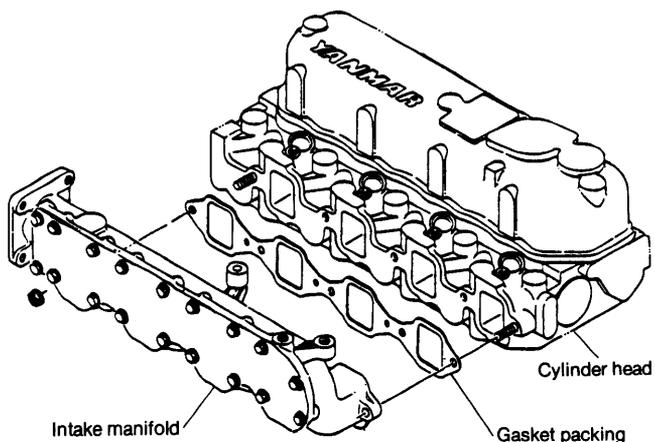
- (1) Thoroughly coat both sides of the packing with adhesive.
- (2) Replace the O-ring for the connecting pipe which is inserted in the cylinder block, and tighten the fresh water pump to the specified torque.



	kg-m (ft-lb)
Fresh water pump tightening torque	0.7 ~ 1.1 (5.0 ~ 8.0)

3-2.26 Mounting the intake manifold

- (1) Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.
- (2) Mount the governor remote control bracket.

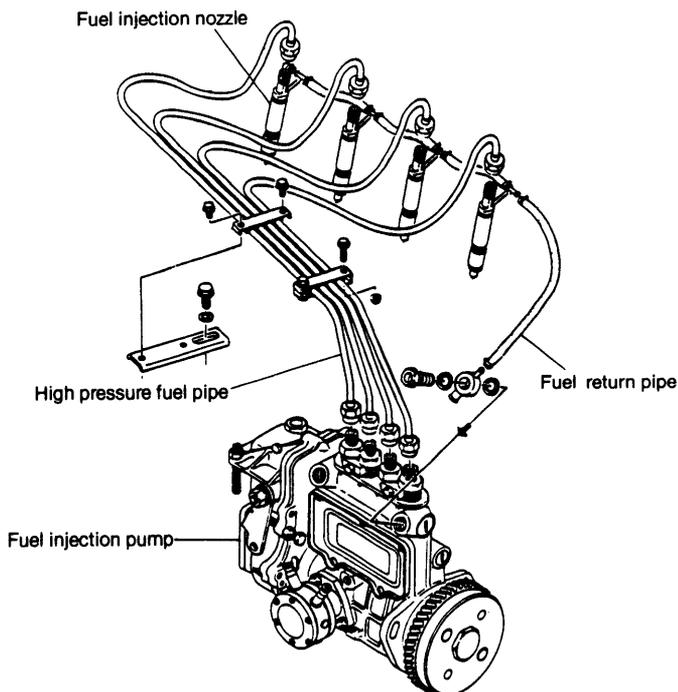


3-2.27 Mounting the high pressure fuel pipe and fuel oil return pipe

- (1) Mount the high pressure fuel pipe and then the high pressure fuel pipe vibration stop.

NOTE: Lightly tighten the box nuts on both ends of the high pressure fuel pipe. Completely tighten after adjusting the injection timing.

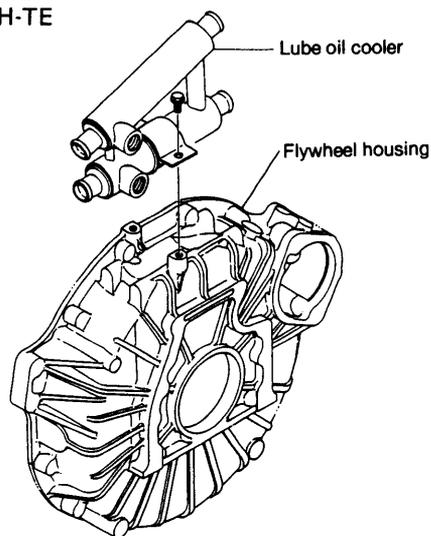
- (2) Mount the fuel oil return pipe with the hose clamp (fuel injection nozzle—fuel injection pump)



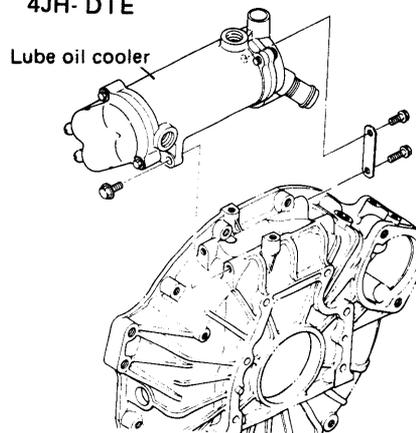
3-2.28 Mounting the lube oil cooler

Mount the lube oil cooler to the top of the flywheel housing with the bracket.

MODEL: 4JHE
4JH-TE

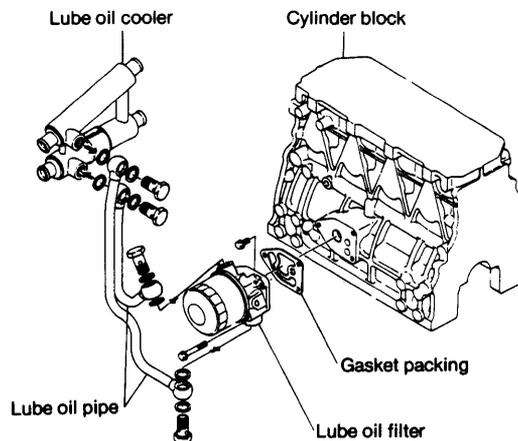


MODEL: 4JH-HTE
4JH-DTE



3-2.29 Mounting the lube oil filter

- (1) Mount the filter bracket and packing on the cylinder block.
- (2) Mount the filter element with the filter remover mounting tool.

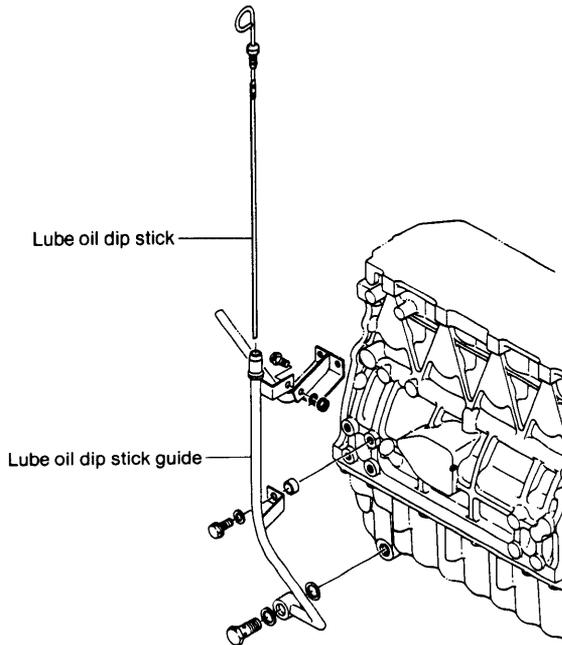


3-2.30 Mounting the lube oil pipe

- (1) Mount the lube oil pipe (filter—lube oil cooler, lube oil cooler—filter).
- (2) Mount the lube oil pipe (cylinder block—fuel injection pump).

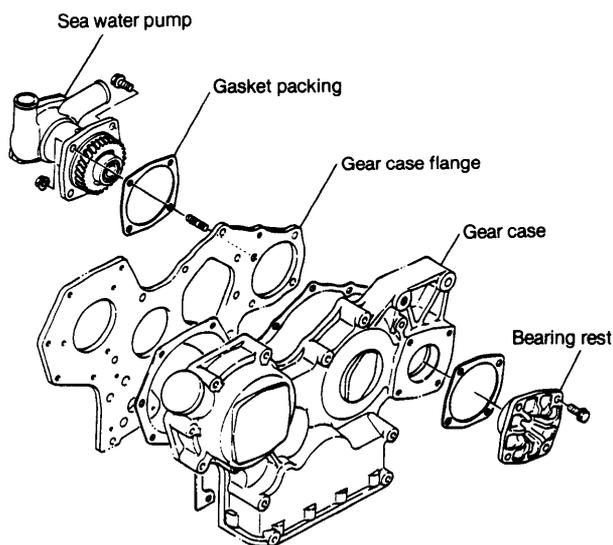
3-2.31 Mounting the dipstick guide

Mount the dipstick and dipstick guide.



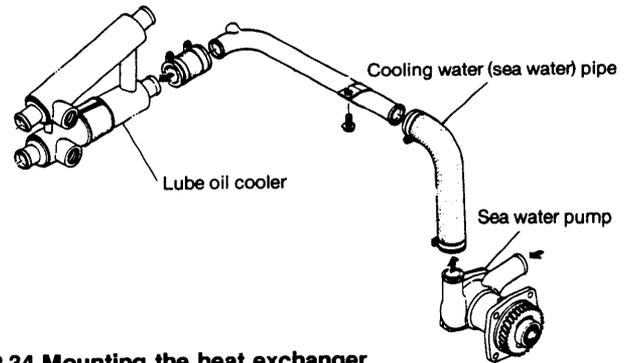
3-2.32 Mounting the sea water pump

- (1) Mount the sea water pump assembly to the gear case flange.
- (2) Lightly tap the gear case side bearing rest with a wood hammer, and tighten the mounting bolts.



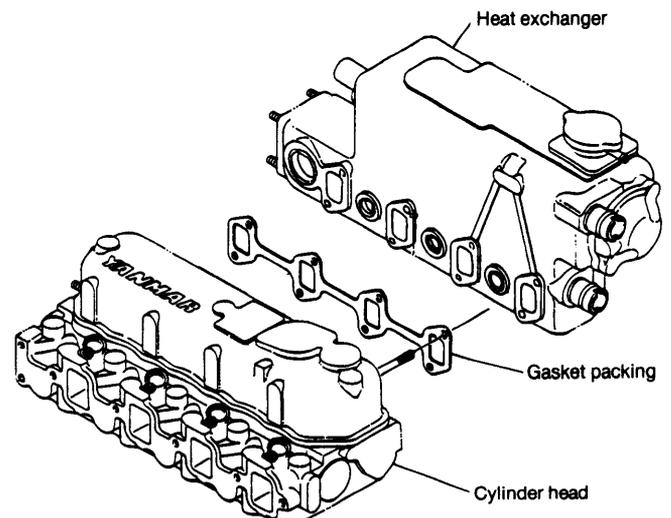
3-2.33 Mounting the cooling sea water pipe

Mount the cooling water pipe with the hose clamp (sea water pump—lube oil cooler).



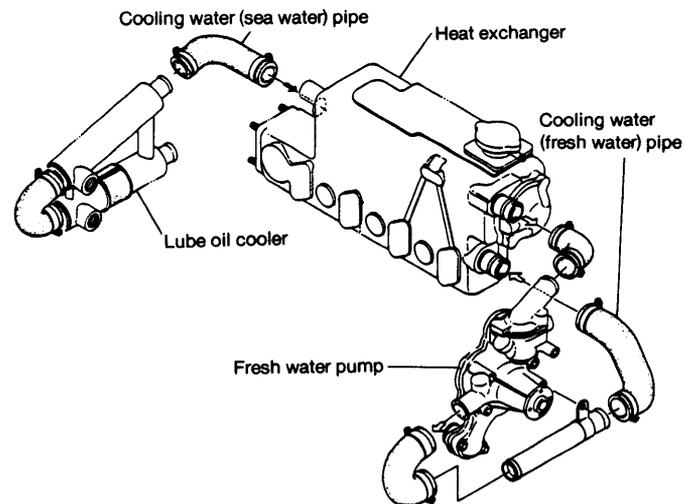
3-2.34 Mounting the heat exchanger (exhaust manifold, fresh water tank unit).

Mount the gasket packing and exhaust manifold.

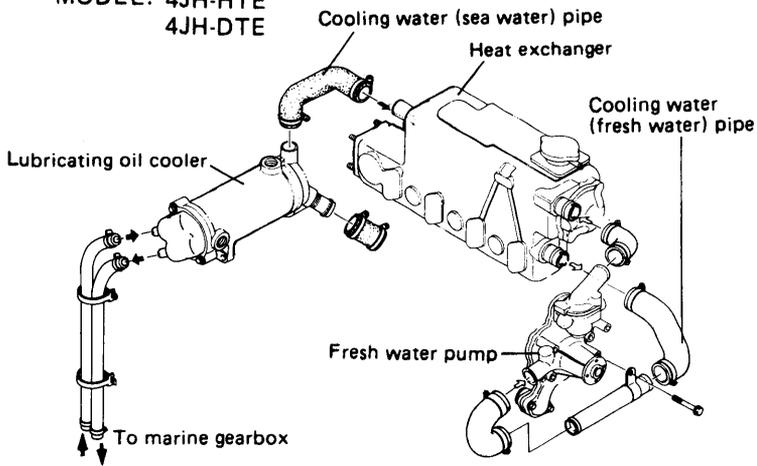


3-2.35 Mounting the cooling water pipe

- (1) Mount the cooling fresh water pipe with the hose clamp (fresh water tank — fresh water pump, fresh water pump—heat exchanger).
- (2) Mount the cooling sea water pipe with the hose clamp (lube oil cooler — heat exchanger).
- (3) Mount the cooling sea water pipe with the hose clamp (lube oil cooler — marine gearbox).

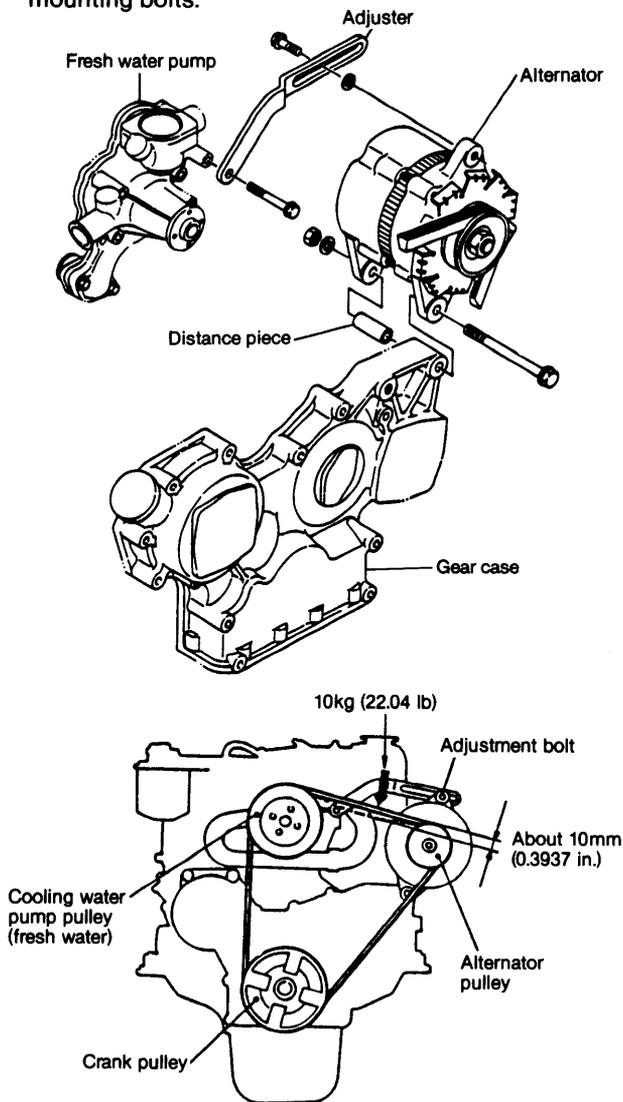


MODEL: 4JH-HTE
 4JH-DTE



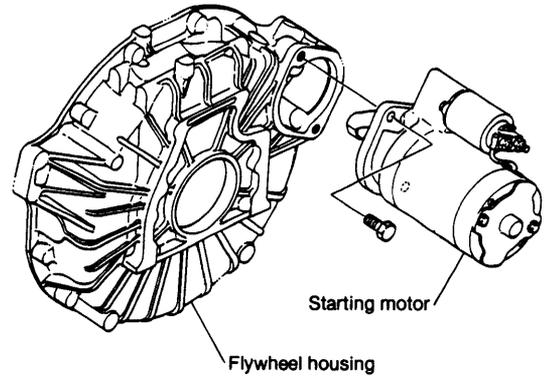
3-2.36 Mounting the alternator

- (1) Mount the adjuster on the fresh water pump, the distance piece on the gear case, and then the alternator.
- (2) Adjust V-belt tension with the adjuster, and tighten the mounting bolts.



3-2.37 Mounting the starting motor

Fit the starting motor in the flywheel housing.



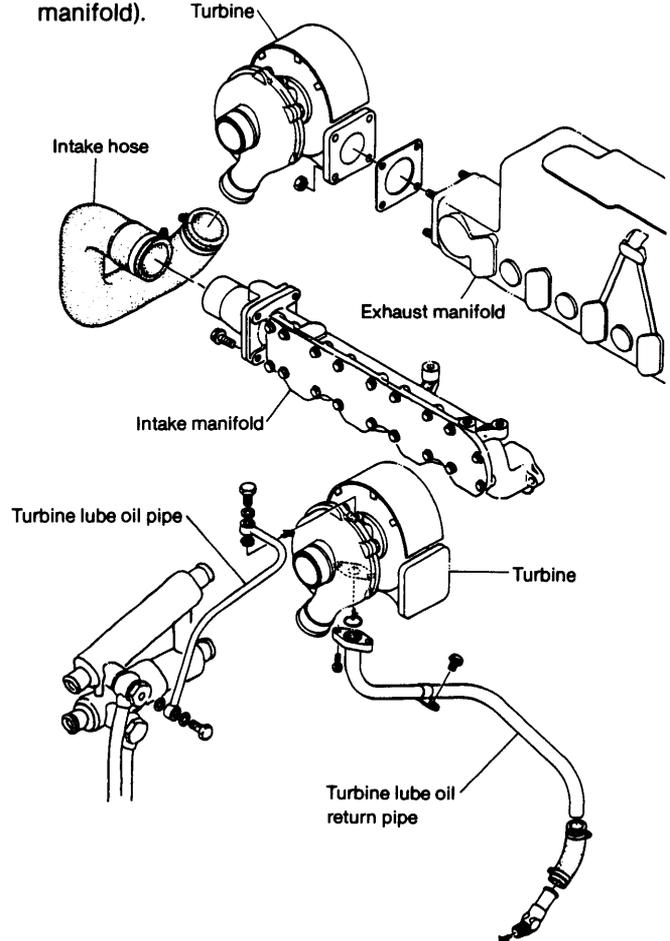
[Model 4JH-TE]

3-2.38 Mounting the turbine

- (1) Mount the turbine on the exhaust manifold.

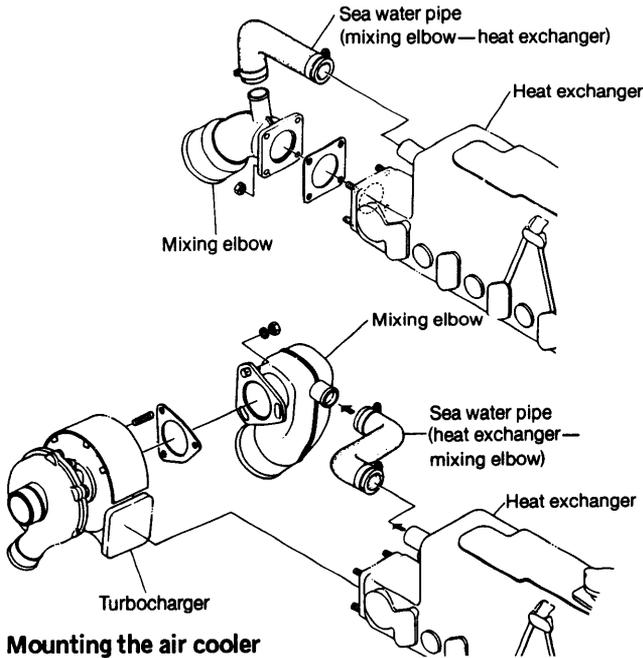
NOTE: First make sure to tighten the turbine lube oil return pipe.

- (2) Mount the lube oil pipe (lube oil cooler—turbine).
- (3) Insert the rubber hose at the end of the lube oil return pipe (turbine—oil pan) into the elbow on the oil pan, and mount with the hose grip.
- (4) Mount the intake rubber hose (turbine—intake manifold).



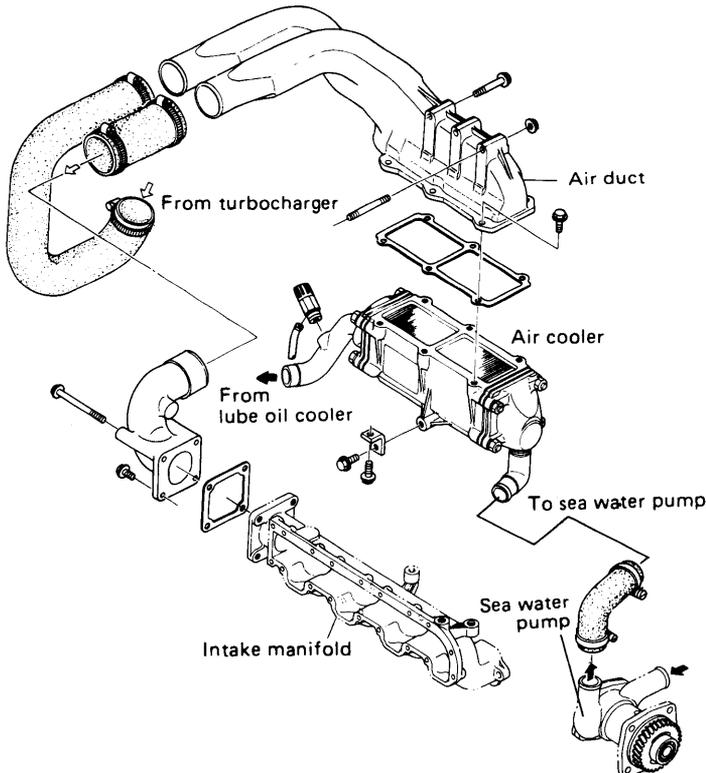
3-2.39 Mounting the mixing elbow

- (1) Mount the mixing elbow on the exhaust manifold outlet for model 4JHE, and on the turbocharger outlet for model 4JE-TE.
- (2) Mount the cooling sea water pipe rubber hose with the hose grip (heat exchanger—mixing elbow).



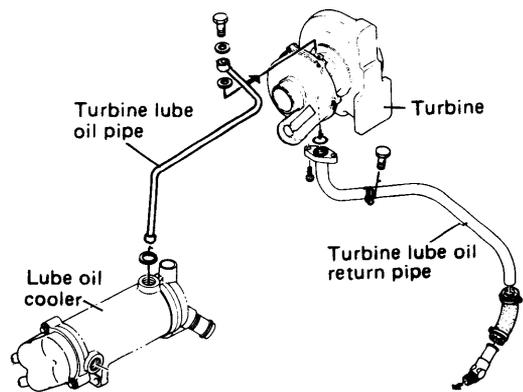
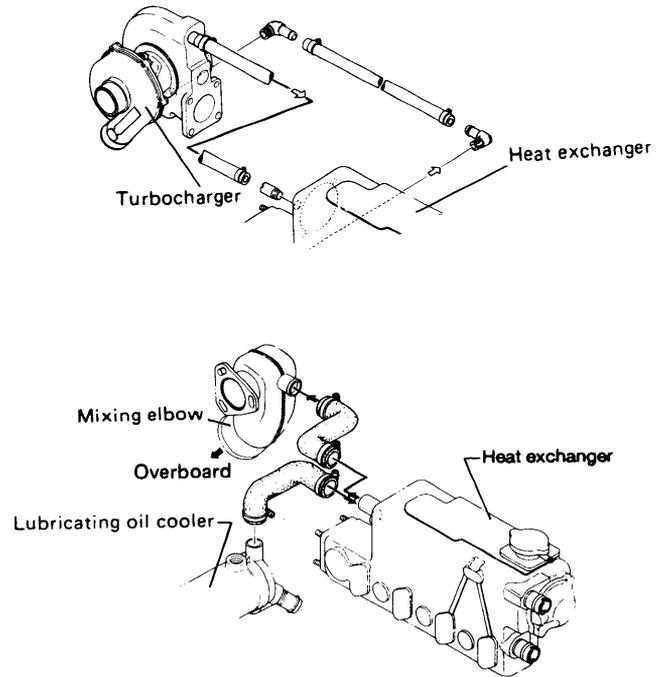
Mounting the air cooler

- (1) Mount the air cooler on the heat exchanger, and cylinder block.
- (2) Mount the sea-water rubber hoses. (Lube oil cooler — Air cooler — Sea water pump)
- (3) Mount the intake rubber hoses (Intake manifold, and turbocharger — Air duct)



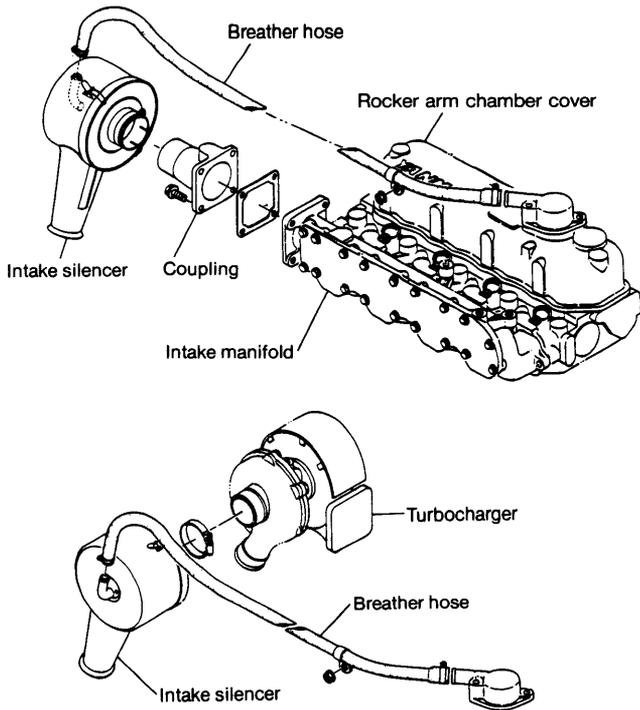
Mounting the mixing elbow and the turbocharger

- (1) Mount the turbocharger on the exhaust manifold.
- (2) Mount the air duct rubber hose. (Turbocharger — Air duct)
- (3) Mount the mixing elbow on the turbocharger.
- (4) Mount the sea water hose. (Heat exchanger — Mixing elbow)
- (5) Mount the lube oil pipes. (Lube oil pump — Turbocharger — Lube oil cooler)
- (6) Mount the fresh water hoses. (Heat exchanger — Turbocharger)



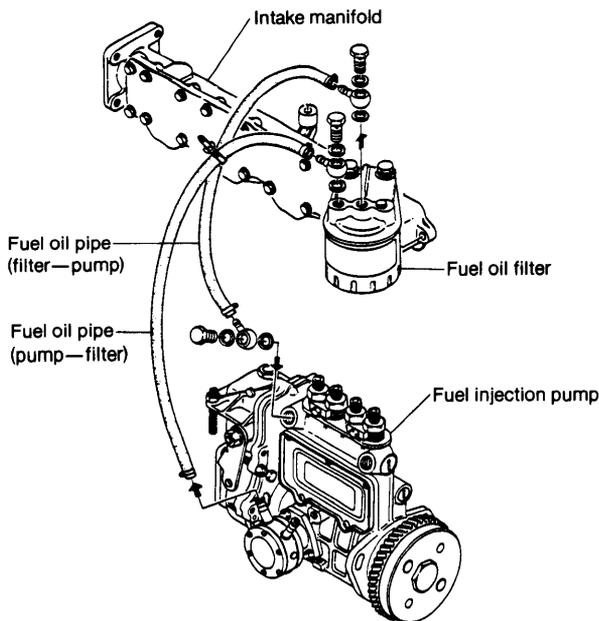
3-2.40 Mounting the intake silencer

- (1) Mount the intake silencer on the intake manifold inlet coupling for model 4JHE, and on the turbocharger blower side for model 4JH-TE.
- (2) Mount the breather hose with the hoe clamp (intake silencer—valve rocker arm chamber cover).



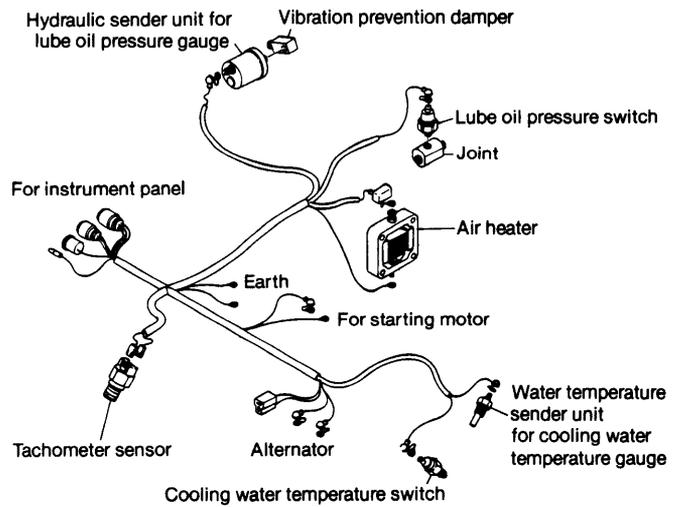
3-2.41 Mounting the fuel filter and fuel oil pipe

- (1) Mount the fuel filter.
- (2) Mount the fuel oil pipe (fuel feed pump—fuel filter, fuel filter—fuel injection pump).



3-2.42 Electrical Wiring

Connect the wiring to the proper terminals, observing the color coding to make sure the connections are correct.



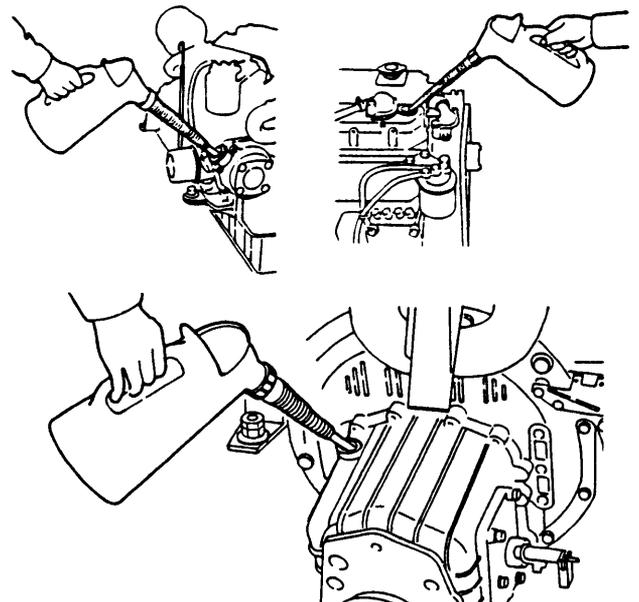
3-2.43 Installation in the ship and completion of the piping and wiring

Mount the engine in the ship after all engine assembly has been completed. Connect the cooling water, fuel oil and other piping on the ship and the exhaust hoses. Connect the battery, instrument panel, remote control and other wiring.

3-2.44 Filling with lube oil

Fill the engine with lube oil from the supply port on top of the gear case and the marine gearbox supply port on top of the clutch case.

		ℓ (in. ³)
Lube oil capacity	Engine	6.5 (396.63)
	Gearbox	1.2 (73.22)



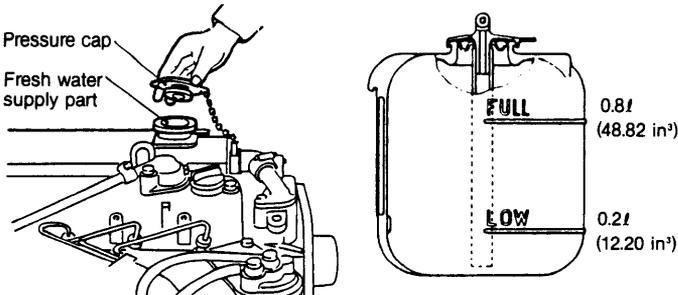
3-2.45 Filling with cooling water

(1) Open the fresh water tank cap and fill with water.

		ℓ (in. ³)
Fresh water tank capacity	6.0	(366.12)

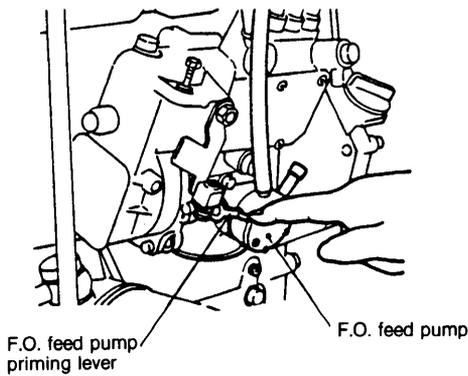
(2) Fill with water until the level in the sub-tank is between the full and low marks.

		ℓ (in. ³)
Sub-tank capacity	Full	0.8 (48.82)
	Low	0.2 (12.20)

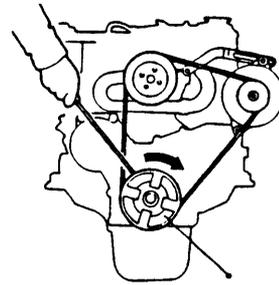
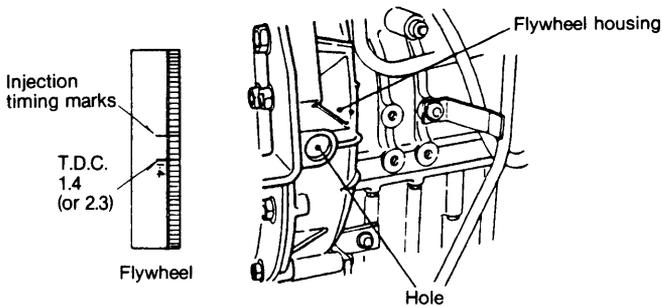


3-2.46 Check fuel injection timing

(1) Open the fuel tank cock and shift the fuel feed pump priming lever for air bleeding.

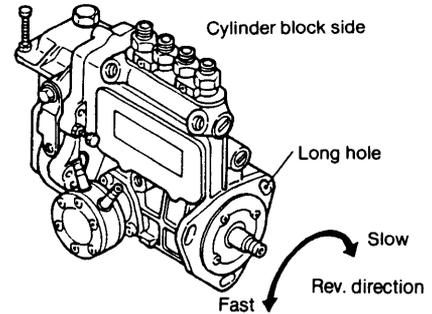


(2) Check injection timing by turning the flywheel and looking through the inspection hole in the flywheel housing.



(3) If injection timing is off, change the mounting position using the long hole in the injection pump mounting flange. Turning the fuel feed pump towards the cylinder block slows timing down, while movement in the other direction makes it faster.

Fuel injection timing (FID)	4JH-E	E/#00101 ~ 00574, b.TDC 8 ~ 10° E/#00575 and after, b.TDC 11 ~ 13°
	4JH-TE 4JH-HTE 4JH-DTE	b.TDC 11 ~ 13°



4. Bolt/nut tightening torque

Engine

Description	Thread dia. × pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in.)
Cylinder head bolts	M10 × 1.25	7.5 ~ 8.5 (54.24 ~ 61.48)	14 (0.5512)
Connecting rod bolts	M9 × 1.0	4.5 ~ 5.0 (32.54 ~ 36.16)	13 (0.5118)
Flywheel bolts	M10 × 1.25	7.0 ~ 8.0 (50.63 ~ 57.86)	17 (0.6693)
Crankshaft V-pulley bolts	M14 × 1.5	11.5 ~ 12.5 (83.17 ~ 90.41)	22 (0.8661)
Main bearing bolts	M12 × 1.5	9.5 ~ 10.5 (68.71 ~ 75.94)	17 (0.6693)
Fuel pump automatic timer box nuts	M12 × 1.75	6.0 ~ 7.0 (43.39 ~ 50.63)	13 (0.5112)

Turbocharger (RHB52)

Description	Thread dia. × pitch mm	Tightening torque kg-m (ft-lb)	Wrench mm (in.)
Turbine chamber bolts	M6	10.0 ~ 11.0 (72.33 ~ 79.56)	10 (0.3937)
Blower chamber bolts	M5	3.5 ~ 4.5 (25.31 ~ 32.54)	8 (0.3150)
Thrust metal bolts	M3	0.7 ~ 0.9 (5.06 ~ 6.50)	—
Seal plate screws	M3	0.7 ~ 0.8 (5.06 ~ 5.78)	—
Blower blade nuts	M5	1.8 ~ 2.2 (13.01 ~ 15.91)	8 (0.3150)

5. Test running

5-1. Preliminary Precautions

Before making a test run, make sure of the following points.

- (1) Warm the engine up.
- (2) Remove any precipitation from the F.O. filter, water separator, and F.O. tank.
- (3) Use only lube oil recommended by Yanmar.
- (4) Be sure to add Yanmar anti-rust agent to fresh cooling water.
- (5) During cold weather, add Yanmar anti-freeze to the cooling water.
- (6) Provide good ventilation in the engine room

5-2 Check Points and Precautions During Running

Step	Item	Instructions	Precautions
1	Checks before operation	<ol style="list-style-type: none"> 1) Make sure that the Kingston Cock is open. 2) Make sure there is enough lube oil and (fresh) cooling water. 3) Operate the remote control handle and check if the devices connected to the engine side work properly. 	<ol style="list-style-type: none"> 3) Lamp should go off when engine is running.
2	No load operation; warm up operation	<ol style="list-style-type: none"> 1) Glow plug is provided to aid engine starts. When the lube oil temperature is raised to allow the engine to start, the pilot lamp goes off. 2) When the engine is started, check the following: <ul style="list-style-type: none"> • there is no water and no oil leakage. • gas does not leak when the engine is started. • there are no abnormal indications on the instrument panel. • there is no abnormality in cooling water discharge, engine vibrations, or engine sounds. 3) To warm up the engine, operate at low revolutions for about 5 minutes, then raise the revolutions to the rated rpms and then to max. rpms. 	<ol style="list-style-type: none"> 1) Even if one glow plug should break, the remaining plug works. 2) <ul style="list-style-type: none"> • Fix leaks if any. • Check the intake/exhaust valves, F.O. injection valve, and cylinder head. 3) Do not raise the engine revolutions abruptly.
3	Cruising (load) operation	<ol style="list-style-type: none"> 1) Do not operate the engine at full load yet, but raise the rpms gradually for about 10 minutes until they reach rated rpms. 2) Make sure that exhaust color and temperature are normal. 3) Check the instrument panel and see if the water temperature and oil pressure are normal. 	
4	Stopping the engine	<ol style="list-style-type: none"> 1) Before stopping the engine, operate it at 650—700 rpms for about 5 minutes. 2) Raise engine rpms to 1,800 just before stopping the engine and idle the engine for about 3—4 seconds. 	<ol style="list-style-type: none"> 1) Stopping the engine suddenly during high speed operation increases the temperature of engine parts. 2) This procedure prevents carbon from being deposited on the valve seats, etc.
5	Checks after stopping the engine	<ol style="list-style-type: none"> 1) Check again for water and oil leaks. 2) Make sure that no nuts and bolts are loose. 3) Close the Kingston and fuel cocks. 4) When the temperature is expected to fall below freezing, drain the cooling water (sea water). 5) Turn off the battery switch. 	<ol style="list-style-type: none"> 1) Check the oil seal area. 2) Especially the engine installation bolts. 4) Drain from the sea water pump.



YANMAR DIESEL ENGINE CO.,LTD.

OVERSEAS OPERATIONS DIVISION
Telex: 0222-4733 Telephone: 03-3275-1111

1-1, 2-chome, Yaesu, Chuo-ku, Tokyo 104, Japan
Facsimile: 03-3272-0687 Cable: YANMAR TOKYO

Printed in Japan
0000A0A1647