



# WORKSHOP MANUAL

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## HINO MOTORS, LTD.

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# CHAPTER GI

## GENERAL INTRODUCTION

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## GENERAL PRECAUTIONS

Some recommended and standard maintenance services for your engine are mentioned in this section.

When performing maintenance on your engine be careful not to get injured by improper work.

Improper or incomplete work can cause a malfunction of the engine which may result in personal injury and/or property damage.

### WARNING

When working on your engine, observe the following general precautions to prevent personal injury and/or property damage in addition to the particular NOTES or WARNINGS.

Most threaded fasteners are metric.

Be careful not to mix with threaded fasteners using the inch system.

- Always wear safety glasses or goggles to protect your eyes.
- Remove rings, watches, ties, loose hanging jewelry and loose clothing before starting work on the engine.
- Bind long hair securely behind the head.
- To avoid serious burns, keep yourself away from hot metal parts such as the engine, exhaust manifold, radiator, muffler, exhaust pipe and tail pipe.
- Keep yourself, your clothing and your tools away from moving parts such as the cooling fan and V-belts when the engine is running.
- Always stop the engine by pulling out the engine stop knob. Leave the knob pulled out as long as the engine is stopped. And turn off the starter switch, unless the operation requires the engine running. Removing the key from the switch is recommended.
- Run the engine only in a well-ventilated area to avoid inhaling of carbon monoxide.
- Do not smoke while working on the engine since fuel and gases from the battery are flammable.
- Take utmost care when working on the battery. It contains corrosive sulfuric acid.
- Large electric current flows through the battery cable and starter cable. Be careful not to cause a short which can result in personal injury and/or property damage.
- Be careful not to leave any tool in the engine compartment. The tool may be hit by moving parts and can cause personal injury.

HOW TO USE THIS WORKSHOP MANUAL.

This workshop manual is designed as a guide for servicing engine.

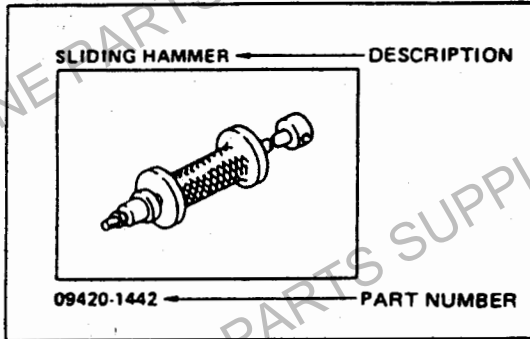
An INDEX is provided on the first page of each chapter.

TROUBLESHOOTING is dealt with each chapter.

When beginning operations, refer to the sections on for guide to appropriate diagnoses.

SPECIAL TOOLS are dealt with in each chapter.

When ordering a special tool, make sure that the parts number is correct.

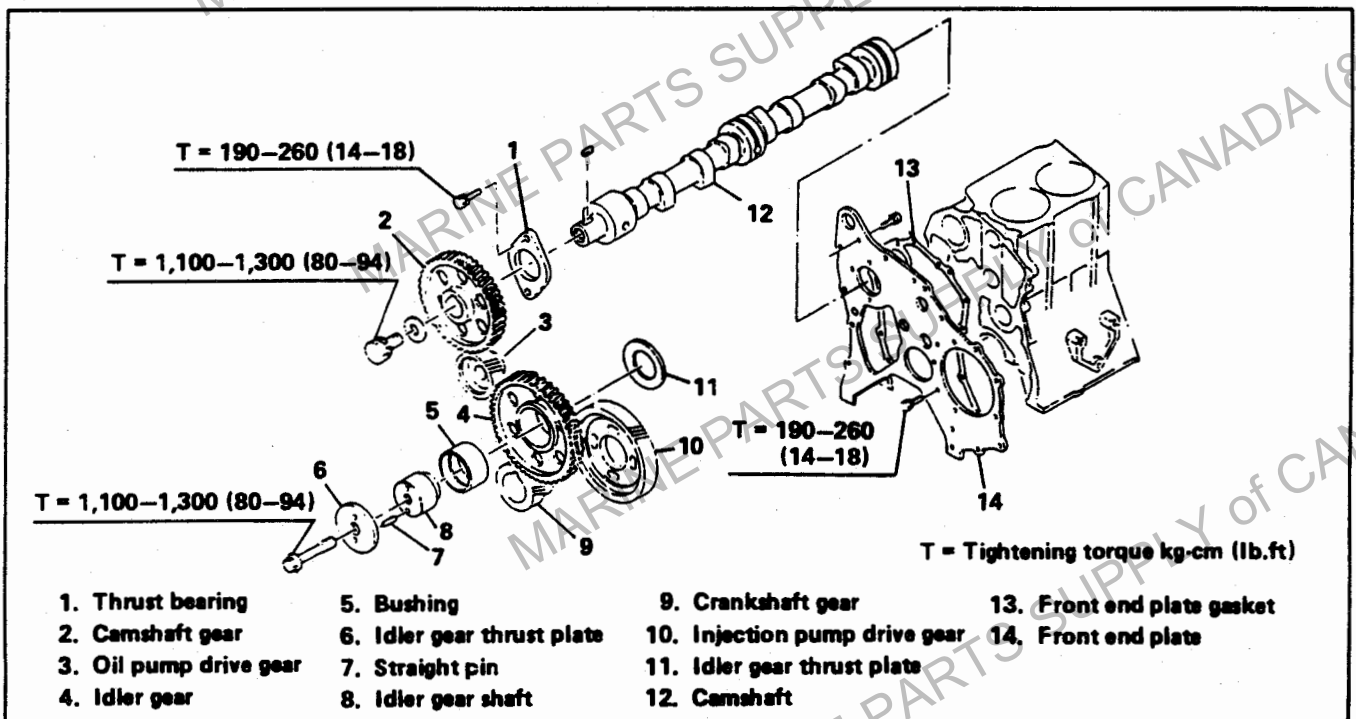


REPAIR PROCEDURES

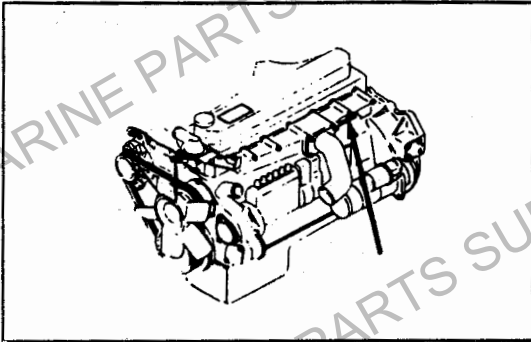
Repair procedures which are self-explanatory such as simple installation and removal of parts have been omitted. Illustrations such as the one below have been provided to make such simple procedures clear. Only essential procedures requiring directions have been dealt with explicitly.

EXAMPLE:

TIMING GEAR AND CAMSHAFT



In some cases, illustrations may be of parts which differ in some nonessential way from the parts found on your particular engine. In such cases, however, the principle or procedure being illustrated applies regardless of such non-essential differences.



#### IDENTIFICATION INFORMATION

##### ENGINE SERIAL NUMBERS

Please quote these numbers when ordering spare parts or reporting technical matter as they will give you prompt service attention.

The engine serial number is engraved on the engine cylinder block.

SPECIFICATIONS  
DIESEL ENGINE FOR MARINE USE

**HINO****W06D-T1**

5.759 liters, 4-cycle,  
6-cyl., water-cooled,  
turbocharged and intercooled

● ENGINE DESCRIPTION

- |  |   |
|--|---|
| 1. Max. output, pleasure craft                 | 187 kW (250 HP)/3,000 rpm                                       |
| 2. Max. output, work boat<br>(light duty)      | 164 kW (220 HP)/3,000 rpm                                       |
| 3. Type  | Diesel, 4-cycle, 6-cyl., in-line, over-head valve, water-cooled |
| 4. Aspiration                                  | Turbocharged and intercooled                                    |
| 5. Combustion system                           | Direct injection  |
| 6. Cylinder<br>Bore x Stroke                   | 104 x 113 mm (4.09 x 4.45 in.)                                  |
| 7. Piston displacement                         | 5.759 liter (351.5 cu.in.)                                      |
| 8. Compression ratio                           | 16.5  |
| 9. Direction of rotation                       | Counter-clockwise viewed from flywheel                          |
| 10. Dimensions with marine<br>gear (L x W x H) | Approx. 1,401 x 835 x 866 mm<br>(55.2 x 32.9 x 34.1 in.)        |
| 11. Dry weight with marine<br>gear             | Approx. 600 kg (1,323 lb)                                       |

● FEATURES

- |                     |  |
|---------------------|--|
| 1. Cylinder block   | Mono block cast iron with replaceable dry liner  |
| 2. Cylinder head    | Single piece cast iron   |
| 3. Crankshaft       | Induction hardened die forged special steel with counter weights   |
| 4. Piston and rings | Heat resistance aluminum alloy<br>Two compression rings, chrome plated<br>One oil ring, chrome plated with coil expander |
| 5. Camshaft         | Induction hardened carbon steel  |
| 6. Valves           | Heat resistance steel  |

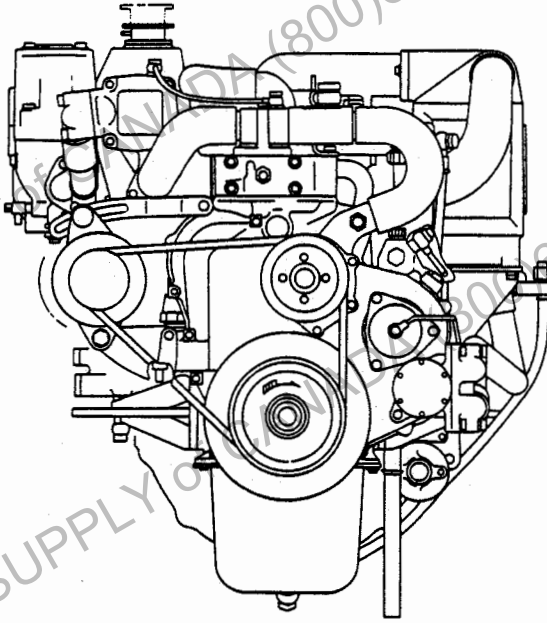
- **EQUIPMENT**

- **ENGINE**

- |                          |  |
|--------------------------|--|
| 1. Flywheel housing      | SAE No. 3  |
| 2. Flywheel              | SAE 11½  |
| 3. Fuel injection pump   | BOSCH "A" type with all speed governor   |
| 4. Fuel filter           | Paper element type   |
| 5. Water separator       | Equipped   |
| 6. Lube oil pump         | Full forced pressure feed by gear pump   |
| 7. Lube oil filter       | Paper element type (Full flow)   |
| 8. Lube oil cooler       | Multi plate type, Fresh water cooled   |
| 9. Fresh water pump      | Forced-circulation by volute pump  |
| 10. Raw water pump       | Self priming, Rubber impeller type   |
| 11. Intake manifold      | Inlet position at rear   |
| 12. Exhaust manifold     | Fresh water-cooled exhaust manifold, integrated heat exchanger with expansion tank |
| 13. Turbocharger         | Cooled by fresh water, with air cleaner  |
| 14. Intercooler          | Cooled by raw water  |
| 15. Starter              | 12V, 2.5 KW  |
| 16. Alternator           | 12V, 80A, with built-in voltage regulator  |
| 17. Engine stop solenoid | Equipped   |
| 18. Emergency stop relay | Equipped   |
| 19. Starter block relay  | Equipped   |
| 20. Glow plug            | Equipped   |
| 21. Rigid mount bracket  | Equipped   |
| 22. Exhaust riser        | Cooled by raw water  |
| 23. Marine gear          | Equipped   |

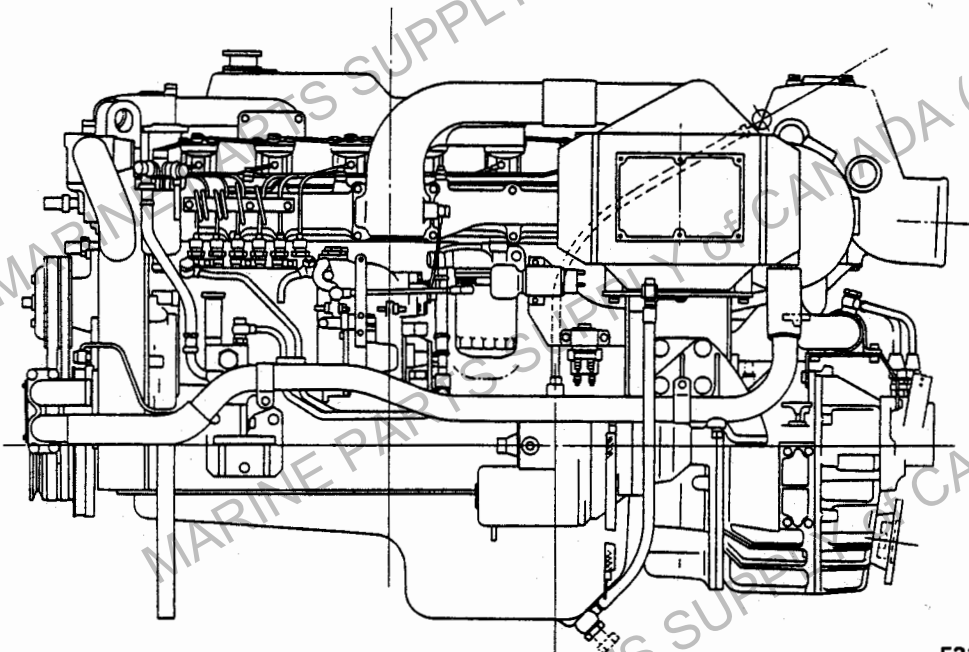
- **INSTRUMENT PANEL**

1. Battery switch
2. Starter switch with key
3. Instrument panel lamp switch
4. Tachometer with hourmeter
5. Coolant temperature gauge
6. Oil pressure gauge
7. Fuel gauge
8. Volt meter
9. Pre-heater indicator lamp
10. Coolant temperature warning lamp
11. Charge warning lamp
12. Oil pressure warning lamp



FRONT VIEW

F230



LEFT SIDE VIEW

F231

NOTE: These specifications are subject to change without notice.

**Hino** HINO MOTORS, LTD.

TOKYO, JAPAN

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fax (250) 754-9471

**TIGHTENING TORQUE OF STANDARD BOLT**

Unit: kg-cm (lb.ft)

Bolt identification	Bolt diameter (mm)	Tightening conditions											
		4	6	8	10	12	14	16	18	20	22	24	
4	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	10 - 15 (0.8 - 1.0)	36 - 53 (2.7 - 3.8)	88 - 128 (7 - 9)	174 - 255 (13 - 18)	304 - 445 (22 - 32)	486 - 712 (36 - 51)	758 - 1,110 (55 - 80)	1,040 - 1,530 (76 - 110)	1,480 - 2,170 (108 - 156)	2,030 - 2,980 (147 - 215)	2,580 - 3,750 (186 - 271)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	14 - 20 (1.1 - 1.4)	48 - 71 (3.5 - 5.1)	117 - 172 (9 - 12)	232 - 340 (17 - 24)	405 - 592 (30 - 42)	647 - 960 (47 - 66)	1,010 - 1,480 (74 - 107)	1,380 - 2,040 (101 - 147)	1,970 - 2,900 (143 - 209)	2,700 - 3,970 (196 - 287)	3,410 - 5,000 (247 - 361)	
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	17 - 25 (1.3 - 1.8)	60 - 88 (4.4 - 6.3)	146 - 214 (11 - 15)	290 - 425 (21 - 30)	506 - 742 (37 - 53)	809 - 1,180 (59 - 85)	1,260 - 1,850 (92 - 133)	1,740 - 2,540 (126 - 183)	2,460 - 3,620 (178 - 261)	3,380 - 4,950 (245 - 358)	4,260 - 6,250 (309 - 452)	
5	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	16 - 24 (1.2 - 1.7)	58 - 83 (4.2 - 6.0)	138 - 201 (10 - 14)	273 - 400 (20 - 28)	477 - 700 (35 - 50)	784 - 1,120 (58 - 81)	1,190 - 1,750 (87 - 126)	1,640 - 2,400 (119 - 173)	2,320 - 3,410 (168 - 246)	3,180 - 4,680 (231 - 338)	4,020 - 5,380 (291 - 387)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	22 - 32 (1.6 - 2.3)	75 - 110 (5.5 - 7.9)	183 - 270 (14 - 19)	364 - 533 (27 - 38)	636 - 932 (47 - 67)	1,020 - 1,500 (74 - 108)	1,590 - 2,330 (116 - 168)	2,180 - 3,200 (158 - 231)	3,100 - 4,550 (225 - 329)	4,250 - 6,210 (308 - 449)	5,360 - 7,850 (388 - 567)	
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	27 - 40 (2.0 - 2.8)	94 - 138 (6.8 - 9.9)	229 - 336 (17 - 24)	455 - 667 (33 - 48)	795 - 1,165 (58 - 84)	1,270 - 1,870 (92 - 135)	1,890 - 2,920 (144 - 211)	2,730 - 4,000 (198 - 289)	3,870 - 5,680 (280 - 410)	5,310 - 7,800 (385 - 564)	6,700 - 9,850 (485 - 712)	
6	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 - 32 (1.8 - 2.3)	82 - 110 (6.0 - 7.9)	200 - 267 (15 - 19)	397 - 574 (29 - 41)	694 - 925 (51 - 66)	1,010 - 1,480 (74 - 107)	1,730 - 2,310 (126 - 167)	2,380 - 3,170 (173 - 229)	3,380 - 4,510 (244 - 326)	4,630 - 6,170 (335 - 448)	5,850 - 7,790 (424 - 563)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	32 - 42 (2.4 - 3.0)	110 - 146 (8.0 - 10.5)	287 - 356 (19 - 25)	529 - 706 (39 - 51)	925 - 1,230 (67 - 88)	1,480 - 1,970 (108 - 142)	2,310 - 3,080 (168 - 222)	3,170 - 4,230 (230 - 305)	4,510 - 6,010 (327 - 434)	6,170 - 8,230 (447 - 595)	7,790 - 10,390 (564 - 751)	
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	40 - 53 (2.9 - 3.8)	137 - 183 (10.0 - 13.2)	334 - 445 (25 - 32)	662 - 882 (48 - 63)	1,180 - 1,540 (84 - 111)	1,850 - 2,470 (134 - 178)	2,890 - 3,850 (210 - 278)	3,970 - 5,290 (288 - 382)	5,640 - 7,510 (408 - 543)	7,720 - 10,290 (559 - 744)	9,740 - 12,990 (705 - 939)	
7	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 - 32 (1.8 - 2.3)	82 - 110 (6.0 - 7.9)	200 - 267 (15 - 19)	397 - 574 (29 - 41)	694 - 925 (51 - 66)	1,010 - 1,480 (74 - 107)	1,730 - 2,310 (126 - 167)	2,380 - 3,170 (173 - 229)	3,380 - 4,510 (244 - 326)	4,630 - 6,170 (335 - 448)	5,850 - 7,790 (424 - 563)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	32 - 42 (2.4 - 3.0)	110 - 146 (8.0 - 10.5)	287 - 356 (19 - 25)	529 - 706 (39 - 51)	925 - 1,230 (67 - 88)	1,480 - 1,970 (108 - 142)	2,310 - 3,080 (168 - 222)	3,170 - 4,230 (230 - 305)	4,510 - 6,010 (327 - 434)	6,170 - 8,230 (447 - 595)	7,790 - 10,390 (564 - 751)	
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	40 - 53 (2.9 - 3.8)	137 - 183 (10.0 - 13.2)	334 - 445 (25 - 32)	662 - 882 (48 - 63)	1,180 - 1,540 (84 - 111)	1,850 - 2,470 (134 - 178)	2,890 - 3,850 (210 - 278)	3,970 - 5,290 (288 - 382)	5,640 - 7,510 (408 - 543)	7,720 - 10,290 (559 - 744)	9,740 - 12,990 (705 - 939)	
8	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 - 32 (1.8 - 2.3)	82 - 110 (6.0 - 7.9)	200 - 267 (15 - 19)	397 - 574 (29 - 41)	694 - 925 (51 - 66)	1,010 - 1,480 (74 - 107)	1,730 - 2,310 (126 - 167)	2,380 - 3,170 (173 - 229)	3,380 - 4,510 (244 - 326)	4,630 - 6,170 (335 - 448)	5,850 - 7,790 (424 - 563)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	32 - 42 (2.4 - 3.0)	110 - 146 (8.0 - 10.5)	287 - 356 (19 - 25)	529 - 706 (39 - 51)	925 - 1,230 (67 - 88)	1,480 - 1,970 (108 - 142)	2,310 - 3,080 (168 - 222)	3,170 - 4,230 (230 - 305)	4,510 - 6,010 (327 - 434)	6,170 - 8,230 (447 - 595)	7,790 - 10,390 (564 - 751)	
	Tightening area having black coarse surface. Rusty. Naked bolt or lubricant unavailable. Poor tightening conditions.	40 - 53 (2.9 - 3.8)	137 - 183 (10.0 - 13.2)	334 - 445 (25 - 32)	662 - 882 (48 - 63)	1,180 - 1,540 (84 - 111)	1,850 - 2,470 (134 - 178)	2,890 - 3,850 (210 - 278)	3,970 - 5,290 (288 - 382)	5,640 - 7,510 (408 - 543)	7,720 - 10,290 (559 - 744)	9,740 - 12,990 (705 - 939)	
9	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 - 32 (1.8 - 2.3)	82 - 110 (6.0 - 7.9)	200 - 267 (15 - 19)	397 - 574 (29 - 41)	694 - 925 (51 - 66)	1,010 - 1,480 (74 - 107)	1,730 - 2,310 (126 - 167)	2,380 - 3,170 (173 - 229)	3,380 - 4,510 (244 - 326)	4,630 - 6,170 (335 - 448)	5,850 - 7,790 (424 - 563)	
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11	Even tightening area. Bolt nut, coating, naked bolt, lubricant, etc. Optimum conditions.	24 - 32 (1.8 - 2.3)	82 - 110 (6.0 - 7.9)	200 - 267 (15 - 19)	397 - 574 (29 - 41)	694 - 925 (51 - 66)	1,010 - 1,480 (74 - 107)	1,730 - 2,310 (126 - 167)	2,380 - 3,170 (173 - 229)	3,380 - 4,510 (244 - 326)	4,630 - 6,170 (335 - 448)	5,850 - 7,790 (424 - 563)	
	Cast iron or aluminum tightening surface. Washers. Medium conditions.	32 - 42 (2.4 - 3.0)	110 - 146 (8.0 - 10.5)	287 - 356 (19 - 25)	529 - 706 (39 - 51)	925 - 1,230 (67 - 88)	1,480 - 1,970 (108 - 142)	2,310 - 3,080 (168 - 222)	3,170 - 4,230 (230 - 305)	4,510 - 6,010 (327 - 434)	6,170 - 8,230 (447 - 595)	7,790 - 10,390 (564 - 751)	
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NOTE: The torque values given in this table should be applied where bolt torque is not specified.



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## RECOMMENDED LUBRICANTS FOR ALL HINO ENGINE

HINO MOTORS, LTD.  
OVERSEAS OPERATIONS  
SERVICE DIV.  
TOKYO, JAPAN

LUBRICANTS	POSITIONS	ATMOS- PHERIC TEMP.	S. A. E. NO.	BP	CALTEX	CASTROL	ESSO	GULF	MOBIL	SHELL	TOTAL
ENGINE OIL (A P1 CD) Previous Classification (A P1 DS) (MIL-L-2104C) (MIL-L-45199B)	Cylinder Block Injection Pump Air Cleaner	Above 32°C (90°F)	40	Vanellus C-3 40	RPM DELO 400 Oil SAE 40 or 15W/40 RPM DELO 300 Oil SAE 40	Castrol or Deusol CRD 40, Turbomas Castrol or Deusol RX Super 40 15W-40	Essolube D-3 40, XD-3 40	Gulf Super Duty Motor Oil 40, 15W-40	Mobil Delvac 1340 Mobil Delvac Super 15W-40	Myrna Oil 40, 20W-40, 15W-40 Rimula X Oil 40 Rimula CT 40	TOTAL Rube S 40 TOTAL Rube TM 15W40
		32° - 0°C (90° - 32°F)	30	Vanellus C 3 30	RPM DELO 400 Oil SAE 30 or 15W/40 RPM DELO 300 Oil SAE 30	Castrol or Deusol CRD 30 Castrol or Deusol RX Super 30, 15W-40	Essolube D-3 30, XD-3 30	Gulf Super Duty Motor Oil 30 15W-40	Mobil Delvac 1330 Mobil Delvac Super 15W-40	Myrna Oil 30, 20W-40, 15W-40 Rimula X Oil 30, 10W-30 Rimula CT30	TOTAL Rube S 30 TOTAL Rube TM 15W40
		0° - -12°C (32° - 10°F)	20	Vanellus C-3 20W	RPM DELO 400 Oil SAE 20/20W, 15W/40 RPM DELO 300 Oil SAE 20/20W	Castrol or Deusol CRO 20W/20 Castrol or Deusol RX Super 20W, 20 15W-40	Essolube D-3 20W, XD-3 15W-40	Gulf Super Duty Motor Oil 20, 15W-40	Mobil Delvac 1310 Mobil Delvac Super 15W-40	Myrna Oil 20, 20W-40, 15W-40 Rimula X Oil 20 Rimula CT20	TOTAL Rube S 20 TOTAL Rube TM 15W40
ENGINE OIL (A P1 CC) Previous Classification (A P1 DM) (MIL-L-46152) (MIL-L-2104B)		Above 32°C (90°F)	40	Vanellus M 40	RPM DELO 200 Oil SAE 40 RPM DELO 100 Oil SAE 40	Castrol or Deusol CRX 40 Castrol or Deusol RX Super 40, 15W-40	Essolube HDX 40, HDX Plus 40	Gulfube Motor Oil XHD 40, 15W-40	Mobil Delvac 1240 Mobil Delvac 1140	Rotella TX40, 20W-50 Rotella SX Oil 40, 20W-40	TOTAL Rube H 40
		32° - 0°C (90° - 32°F)	30	Vanellus M 30	RPM DELO 200 Oil SAE 30 RPM DELO 100 Oil SAE 30	Castrol or Deusol CRX 30 Castrol or Deusol RX Super 30, 15W-40	Essolube HDX 30, HDX Plus 30	Gulfube Motor Oil XHD 30, 15W-40	Mobil Delvac 1230 Mobil Delvac 1130	Rotella TX30, 20W-50 Rotella SX Oil 30, 20W-40	TOTAL Rube H 30
		0° - -12°C (32° - 10°F)	20	Vanellus M 20W	RPM DELO 200 Oil SAE 20/20W RPM DELO 100 Oil SAE 20/20W	Castrol or Deusol CRX 20W 20 Castrol or Deusol RX Super 20W 20, 15W-40	Essolube HDX 20 HDX Plus 20W 20	Gulfube Motor Oil XHD 20, 15W-40	Mobil Delvac 1220 Mobil Delvac 1120	Rotella TX20, 20W-50 Rotella SX Oil 20/20W, 20W-40	TOTAL Rube H 20
COOLANT PUMP BEARING GREASE (MIL-G-10924B)	Coolant Pump Bearing			Energrease L 2	Marlak Multipurpose 2 or Marlak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP.77, MS	Retrax A Avalara Grease R2	TOTAL MULTIS 2
STARTER GREASE	Bushing, Clutch, Drive Shaft, Pinion Shaft Lever & Reduction Gear			---	Molytex Grease EP2	---	---	---	Mobilgrease 29	Aero Shell Grease 17	---
GENERATOR & STARTER BEARING GREASE	Generator Bearing Starter Bearing			Energrease LT 2	RPM Grease SRI 2	---	---	---	Mobilgrease 28	Aero Shell Grease 7	---
INJECTION PUMP TIMER GREASE (MIL-G-10924B)	Injection Pump Timer			Energrease L-2	Marlak Multipurpose 2 or Marlak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP.77, MS	Retrax A Avalara Grease R2	TOTAL Multis EP 1
ANTI FREEZE (MIL-H-5559A)	Engine, Radiator			Anti Frost	AF Engine Coolant	Castrol Anti-Freeze Castrol Long Life Coolant	Esso Anti Freeze Coolant	Cruise Master Antifreeze And Summer Coolant	Mobil Permazone	Shellzonal(U.S.A.) Glycoshell Plus (European Countries) Shellzonal Anti-Freeze P281 Coolguard	TOTAL ANTIGEL,

Note: Lubricants were amended according to new classification by A P I (American Petroleum Institute)

82-12-200 (T S D 8)

GENERAL INTRODUCTION

(K.P.)

**Marine  
Parts  
Supply  
of Canada**  
1520 Stewart Ave  
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# CHAPTER EN

## ENGINE

Model W06D-TI

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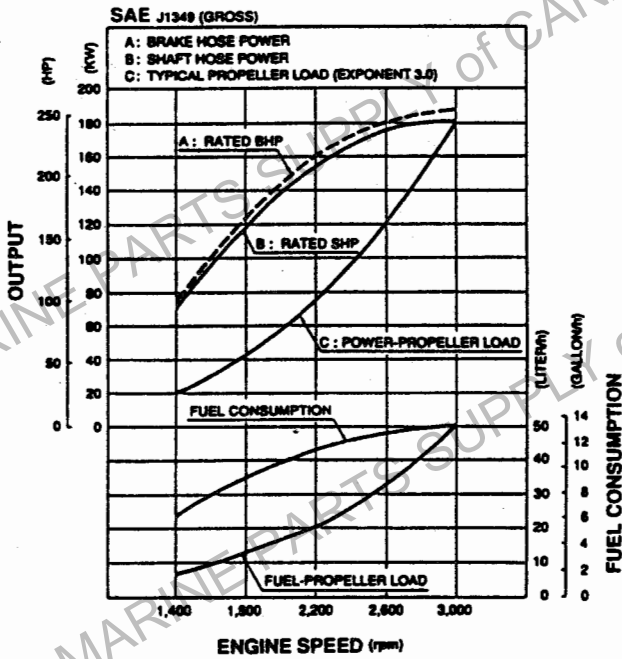
## DATA AND SPECIFICATIONS

Model .....	HINO W06D-T1
Type .....	Diesel, 4-cycle, vertical, 6-cylinder, in-line, overhead valve, water-cooled
Aspiration .....	Turbocharged and intercooled
Combustion system .....	Direct injection
Bore and stroke .....	104 x 113 mm (4.09 x 4.45 in)
Piston displacement .....	5.759 liters (351.4 cu.in)
Firing order .....	1-4-2-6-3-5
	(A number of a cylinder is to be counted in order from the timing gear side.)
Direction of rotation .....	Counter-clockwise viewed from flywheel
Compression ratio .....	16.5 : 1
Maximum speed .....	3,000 rpm
Idling speed .....	700-750 rpm
Dry weight with marine transmission .....	Approx. 600 kg (1,323 lb)
Valve timing (flywheel travel)	
Intake opens .....	16° before top dead center
Intake closes .....	40° after bottom dead center
Exhaust opens .....	55° before bottom dead center
Exhaust closes .....	13° after top dead center
Valve clearance (when cold)	
Intake .....	0.35 mm (0.0138 in)
Exhaust .....	0.50 mm (0.0197 in)
Injection nozzle opening pressure .....	220 kg/cm <sup>2</sup> (3,129 lb/sq.in)
Injection timing .....	20° before top dead center for No. 1 cylinder on compression stroke

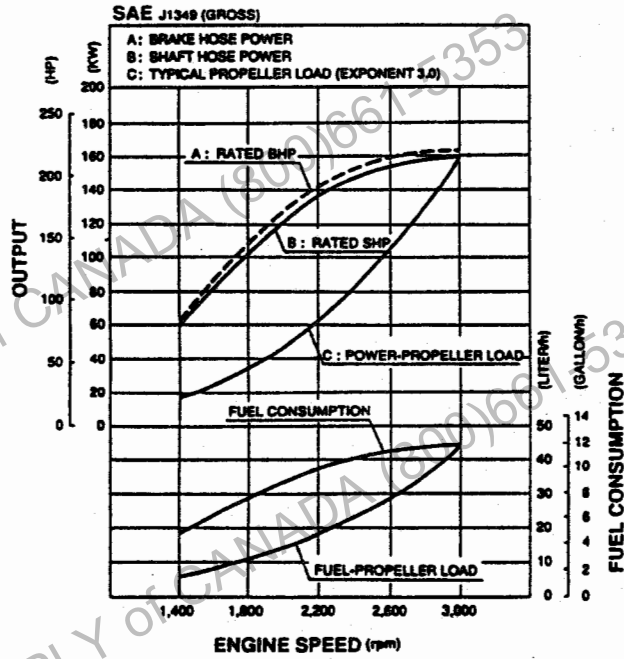
PERFORMANCE CURBE

PLEASURE CRAFT RATING

LIGHT DUTY RATING



DHF-219

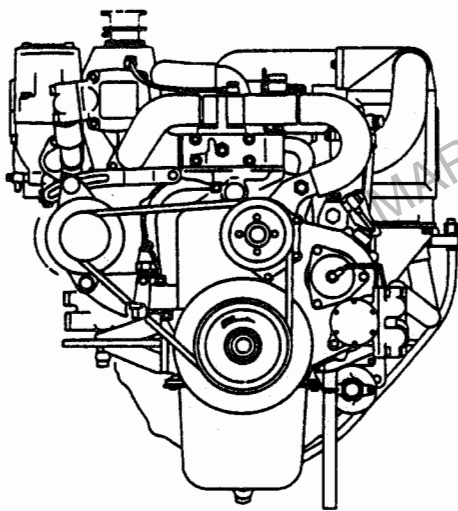


DHF-220

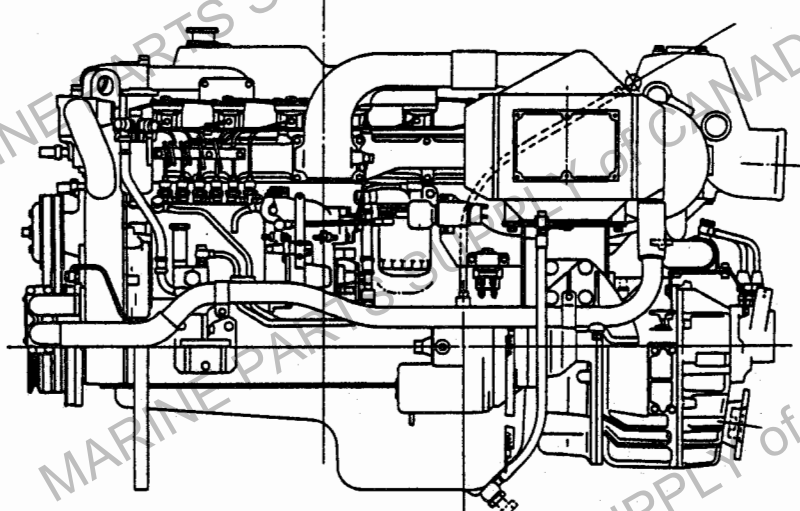
NOTE:

Engine performance at SAE standard J1349 conditions of 90m (300ft) altitude (100 kPa [29.61 in.Hg] barometric pressure), 25°C (77°F) air intake temperature, and 1 kPa (0.30 in.Hg) water vapor pressure with No.2 diesel fuel will be within 5% of that shown at the time of engine shipment. Actual performance may vary with different ambient conditions.

DESCRIPTION



DHF-230



DHF-231

# TROUBLESHOOTING

**Symptom**

**Possible cause**

**Remedy/Prevention**

Engine overheating

**Coolant**

- Insufficient coolant . . . . . Add coolant.
- Defective thermostat . . . . . Replace the thermostat.
- Overflow of coolant due to leakage of exhaust into cooling system . . . . . Repair.
- Coolant leakage from cylinder head gasket . . . . . Replace gasket.
- Defective coolant pump . . . . . Repair or replace.

**Heat Exchanger**

- Clogged with rust and scale . . . . . Clean heat exchanger.
- Clogged with iron oxide due to leakage of exhaust into cooling system . . . . . Clean coolant passage and correct exhaust leakage.
- Clogged or corroded heat exchanger due to mud or other debris . . . . . Clean or replace heat exchanger.
- Defective heat exchanger cap pressure valve . . . . . Replace heat exchanger cap.

**Abnormal combustion**

- Incorrect injection timing . . . . . Adjust injection timing.
- Reduced injection pressure . . . . . Adjust injection pressure.
- Poor fuel . . . . . Use good quality fuel.
- Poor nozzle spray . . . . . Adjust or replace nozzle.
- Unsatisfactory automatic timer advance angle . . . . . Repair or replace timer.

**Other problems**

- Defective or deteriorated engine oil . . . . . Change engine oil.
- Unsatisfactory operation of oil pump . . . . . Replace or repair.
- Insufficient oil . . . . . Add oil.
- Brake drag . . . . . Repair or adjust.

**Cooling system**

- Defective sea water pump . . . . . Repair or replace.
- Loose or slipping V-belt . . . . . Adjust V-belt tension or replace.
- Closed sea water intake valve (Seacock) . . . . . Open intake valve.
- Clogged sea water strainer . . . . . Clean strainer.

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**Symptom**

**Possible cause**

**Remedy/Prevention**

Excessive oil consumption

**Pistons, cylinder liners, and piston rings**

- Wear of piston ring and cylinder liner . . . . . Replace piston rings and cylinder liner.
- Worn, sticking or broken piston rings . . . . . Replace piston rings and cylinder liner.
- Insufficient tension on piston rings . . . . . Replace piston rings and cylinder liner.
- Unsatisfactory break-in of piston rings . . . . . Replace piston rings and cylinder liner.
- Unsuitable oil (viscosity too low) . . . . . Change oil as required and replace piston rings and cylinder liners.
- Incorrectly fitted piston rings (upside down) . . . . . Replace piston rings.
- Gaps of piston rings in line with each other . . . . . Reassemble piston rings.

**Valve and valve guides**

- Worn valve stem . . . . . Replace valve and valve guide.
- Worn valve guide . . . . . Replace valve guide.
- Incorrectly fitted valve stem seal . . . . . Replace the stem seal.
- Excessive lubricant on rocker arm . . . . . Check clearance of rocker arm and shaft.

**Excess oil feed**

- Defective oil level gauge . . . . . Replace oil level gauge.
- Oil level too high . . . . . Drain excess oil.

**Cooling system**

- Overcooled engine (low temperature wear) . . . . . Warm up engine before moving boat.  
Check cooling system.

**Other problems**

- Oil leakage from miscellaneous parts . . . . . Repair.

Piston seizure

**Operation**

- Abrupt stoppage of engine after running at highspeed . . . . . Operate engine properly.

Symptom	Possible cause	Remedy/Prevention	
Piston seizure	<b>Oil</b>		
	● Insufficient oil	Add oil.	
	● Dirty oil	Change oil.	
	● Poor quality oil	Replace with proper engine oil.	
	● High oil temperature	Repair.	
	● Low oil pressure	Repair.	
	● Defective oil pump	Repair oil pump.	
	● Reduced performance due to worn oil pump	Replace oil pump.	
	● Suction strainer sucking air	Add oil and/or repair strainer.	
		<b>Abnormal combustion</b>	See Symptom: "Engine overheating."
	<b>Coolant</b>	See Symptom: "Engine overheating."	
Lack of power	<b>Injection pump</b>	Refer to CHAPTER IP, FUEL INJECTION PUMP.	
	<b>Intake</b>		
	● Clogged air cleaner	Clean element or replace element.	
	<b>Overheating</b>	See Symptom: "Engine overheating."	
	<b>Fuel and nozzle</b>		
	● Poor nozzle spray	Adjust or replace injection nozzle.	
	● Clogged nozzle with carbon	Clean nozzle.	
	● Wear or seizure of nozzle	Replace nozzle.	
	● Air in fuel system	Repair and bleed air from fuel system.	
	● Clogged fuel filter	Replace element.	
	● Use of poor fuel	Use good quality fuel.	
		<b>Abnormal combustion</b>	See Symptom: "Engine overheating."
		<b>Piston, cylinder liners, and piston rings</b>	See Symptom "Engine overheating."
	<b>Other problems</b>		
	● Breakage of turbine or blower	Replace the turbine or blower or turbocharger.	

<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>	
Difficulty starting engine	<b>Electrical system</b>		
	● Discharged battery	Charge battery.	
	● Defective wiring in starter circuit	Repair wiring of starter.	
	● Loose or open-circuit battery cable	Tighten battery terminal connections or replace battery cable.	
	● Breakdown of starter	Replace starter.	
	● Break of glow plug or intake air heater (If so equipped)	Replace	
	<b>Injection pump</b>	Refer to CHAPTER IP, FUEL INJECTION PUMP.	
	<b>Air cleaner</b>		
	● Clogged element	Clean the element or replace the element.	
	<b>Fuel system</b>		
	● No fuel in tank	Supply fuel and bleed air from fuel system.	
	● Clogged fuel line	Clean fuel line.	
	● Air sucked into fuel system through fuel line connections	Tighten fuel line connections.	
	● Clogged fuel filter	Replace element.	
	● Loose connection in high-pressure line	Tighten sleeve nut of high pressure line.	
	● Water in fuel	Drain and clean fuel system	
	Difficulty starting engine	<b>Nozzles</b>	
		● Seized nozzle	Replace nozzle.
● Broken or fatigued nozzle spring		Replace spring.	
<b>Oil system</b>			
● Oil viscosity too high		Use proper viscosity oil, or install an oil immersion heater and warm up oil.	
<b>Other problems</b>			
● Seized piston		Replace piston, piston rings, and liner.	
● Seized bearing		Replace bearing and/or crankshaft.	
● Reduced compression pressure		Overhaul engine.	
● Ring gear damaged or worn		Replace the ring gear and/or starter pinion.	
● Improperly adjusted or broken accelerator cable	Adjust or replace the accelerator cable.		

Symptom	Possible cause	Remedy/Prevention
Rough idling	<b>Injection pump</b>	Refer to CHAPTER IP, FUEL INJECTION PUMP.
	<b>Nozzles</b>	
	• Uneven injection pressure	Adjust.
	• Poor nozzle spray	Adjust or replace nozzle.
	• Carbon deposit on nozzle tip	Remove carbon.
	• Seized needle valve	Replace nozzle.
	<b>Engine proper</b>	
	• Improper valve clearance	Adjust valve clearance.
	• Improper contact of valve seat	Replace or repair valve and valve seat.
	• Idling speed too low	Adjust idling speed.
	• Coolant temperature too low	Warm up engine.
	• Compression pressure of cylinders markedly different from one another	Overhaul engine.
Leakage of exhaust	<b>Cylinder head gasket</b>	
	• Fatigued gasket (aging)	Replace gasket.
	• Damage	Replace gasket.
	• Improper installation	Replace gasket.
	<b>Cylinder head bolts</b>	
	• Loose bolts	Tighten bolt.
	• Elongated bolts	Replace bolt.
	• Improper tightening torque or tightening sequence	Tighten properly.
	<b>Cylinder block</b>	
	• Cracking	Replace cylinder block.
	• Surface distortion	Repair or replace.
	• Fretting of cylinder liner insertion portion (insufficient projection of cylinder liner)	Replace cylinder liner or cylinder block.
	<b>Cylinder head</b>	
	• Cracking	Replace cylinder head.
	• Surface distortion	Repair or replace.

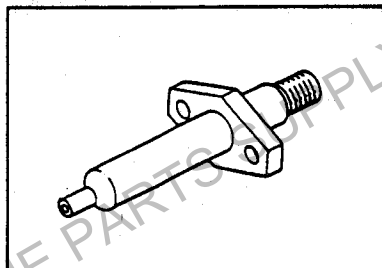
<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>	
Leakage of exhaust	<b>Cylinder liners</b>		
	● Cracking . . . . .	Replace cylinder liner.	
	● Corrosion . . . . .	Replace cylinder liner.	
	● Insufficient projection of cylinder liner . . . . .	Replace cylinder liner.	
	<b>Other problems</b>		
	● Incorrect injection timing . . . . .	Adjust injection timing.	
Seawater discharge is not sufficient	<b>Seawater pump</b>		
	● Sucking air . . . . .	Supply seawater and bleed air from cooling system.	
	● Damaged impeller . . . . .	Replace impeller.	
Abnormal noise or vibration	<b>Seawater pump</b>	● Clogging of suction pipe and/or seawater strainer . . . . .	Clean suction pipe and strainer.
		● Worn bearing . . . . .	Replace bearing.
		● Foreign material in the pump . . . . .	Repair or replace.
		● Incomplete mounting . . . . .	Mount completely.
Bearing wears frequently	<b>Seawater pump</b>	● Too tight V-belt tension . . . . .	Adjust V-belt tension.
Damage of impeller	<b>Seawater pump</b>	● When it has been operated for a long period . . . . .	Replace impeller.
		● When it has been operated without seawater . . . . .	Replace impeller.
		● When it has been operated at higher RPM . . . . .	Replace impeller and operate at normal RPM.
		● Too high or low water temperature . . . . .	Replace impeller and operate at normal temperature.
		● When it has not been operated for an extended period . . . . .	Replace impeller.
		● Foreign material in the pump . . . . .	Repair or replace.

# ENGINE OVERHAUL CRITERIA

## SPECIAL TOOL

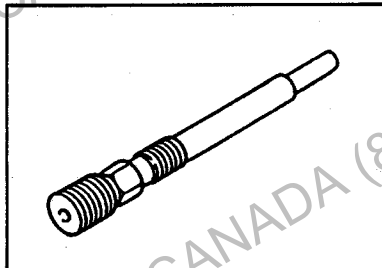
Prior to starting an engine overhaul, it is necessary to have these special tools.

### COMPRESSION GAUGE ADAPTOR (NOZZLE HOLDER)



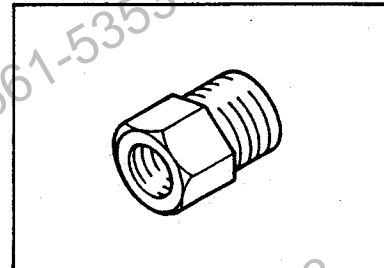
09408-1041

### COMPRESSION GAUGE ADAPTOR (GLOW PLUG)



09552-1051

### COMPRESSION GAUGE ADAPTOR



09552-1070

## FACTORS WHICH DETERMINE WHEN AN ENGINE OVERHAUL IS NEEDED.

1. Lowered compression pressure
  - a. Before the measurement
    - a) Correct the valve clearance.
    - b) Warm up engine [Bring the coolant temperature to about 80°C (176°F)].
    - c) Charge the battery fully.
    - d) Remove the air cleaner.
  - b. Measurement
    - 1) Measure at nozzle holder hole.
      - a) Remove the nozzle holders.
      - b) Install the gauge adapter in the nozzle holder hole.

Special Tool: Compression Gauge Adapter (09408-1041)  
(09552-1070)

- 2) Measure at glow plug hole.
  - a) Remove the glow plug.
  - b) Install the gauge adapter in the glow plug hole.

Special Tool: Compression Gauge Adapter (09552-1051)  
(09552-1070)

- c) Connect a compression gauge to the gauge adapter.
- d) Drive the engine with the starter and read the compression pressure.

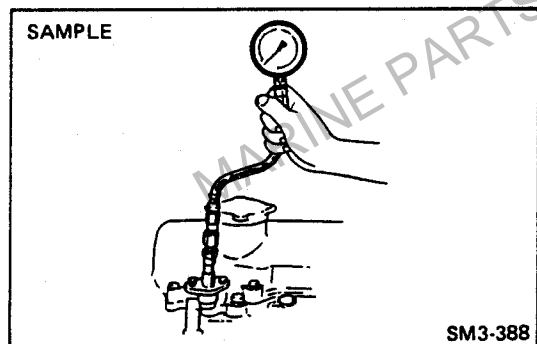
**NOTE:** Do not continuously operate the starter for more than 15 seconds at a time.

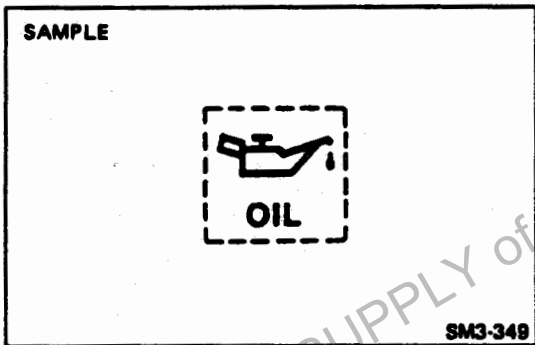
- e) Measure the compression pressure for each cylinder. If the compression pressure is low, be sure to repeat the measuring.

**NOTE:** Be sure not to leak through sealing face.

Unit: kg/cm<sup>2</sup> (lb/sq.in)

Engine model	Compression pressure		Difference between each cylinder	Engine speed (rpm)
	Standard	Limit		
W04D W04C-T	33-36 (469-511)	25 (356)	Less than 3 (43)	350
W04C-TI	30-33 (427-469)	22 (313)		
W06D W06E	33-36 (469-511)	25 (356)		
W06D-TI	30-33 (427-469)	22 (313)		280





S.A.E. GRADE	ATMOSPHERIC TEMPERATURE							°F	°C
	-10	0	32	50	70	90	100		
	-23	-18	0	10	21	32	39		
40									
30									
20W/20									
15W/40									

2. **Decreased oil pressure**  
Check the oil pressure warning lamp when the oil and coolant temperature is hot [about 80°C (176°F)].
  - a. If the warning lamp is lighted, check the oil level.
  - b. Check oil deterioration.  
If oil quality is poor, replace with a suitable grade oil.
  - c. Remove the oil pressure switch and install the oil pressure gauge.
  - d. Measure the oil pressure at coolant temperature 80°C (176°F) or more.

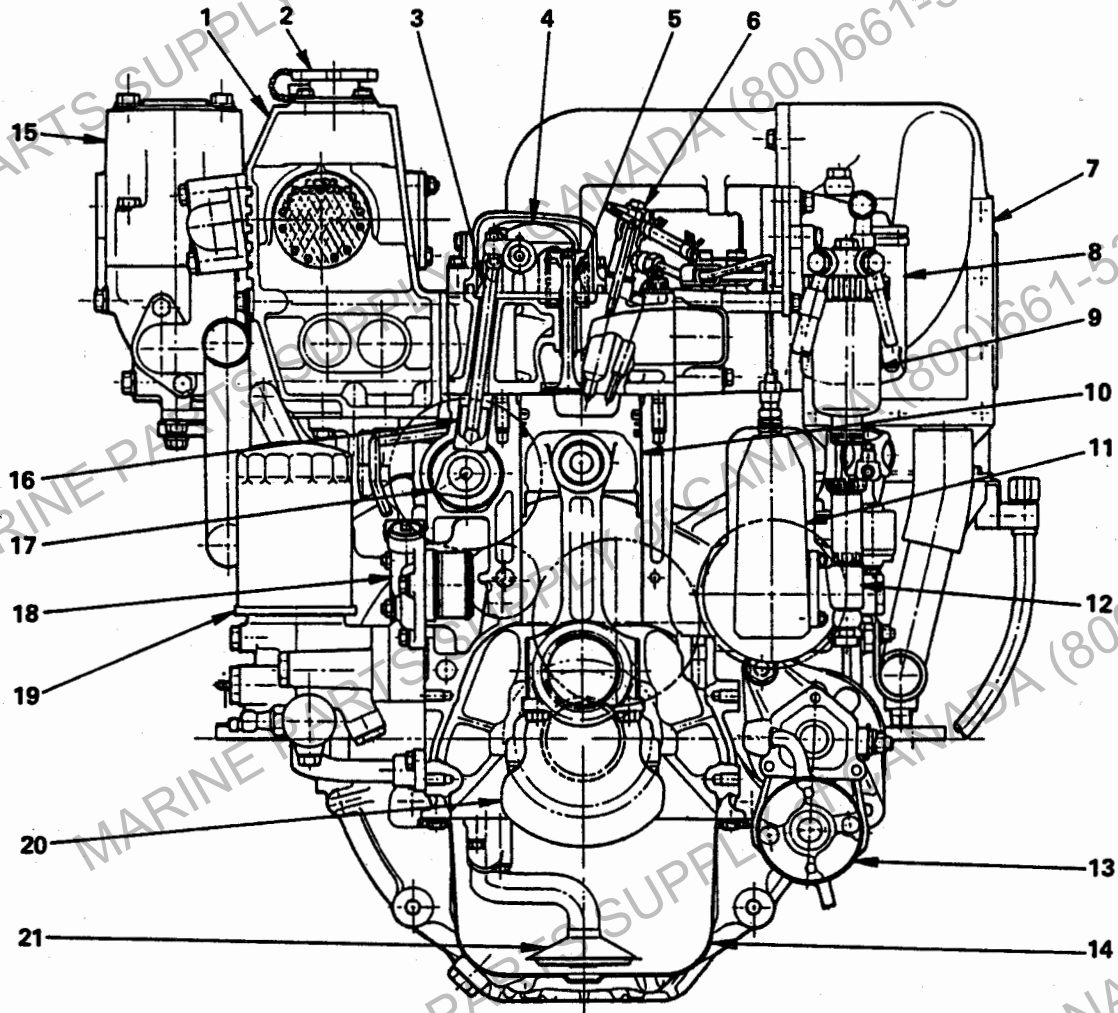
Standard oil pressure: 0.5–5.0 kg/cm<sup>2</sup> (7.11–71.10 lb/sq.in)  
Service limit: Less than 0.5 kg/cm<sup>2</sup> (7.11 lb/sq.in)

3. **Other factors**
  - a. The blow-by gas increases.
  - b. The engine does not start easily.
  - c. Engine output decreases.
  - d. Fuel consumption increases.
  - e. Engine makes greater noise.
  - f. Excessive oil consumption.

## ENGINE MOVING PARTS

## DESCRIPTION

Representative engine model W06D-T1



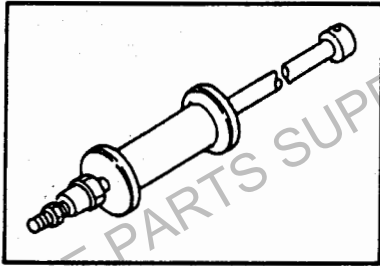
SM3-1921

- |   |                         |
|---|-------------------------|
| 1. Heat exchanger<br>(Exhaust manifold) | 11. Fuel injection pump |
| 2. Coolant filler cap                   | 12. Fuel feed pump      |
| 3. Push rod                             | 13. Starter             |
| 4. Rocker arm                           | 14. Oil pan             |
| 5. Valve                                | 15. Exhaust pipe        |
| 6. Fuel injection nozzle                | 16. Tappet              |
| 7. Intercooler                          | 17. Camshaft            |
| 8. Fuel filter                          | 18. Oil cooler          |
| 9. Water separator                      | 19. Oil filter          |
| 10. Piston                              | 20. Crankshaft          |
|   | 21. Oil strainer        |

**SPECIAL TOOL**

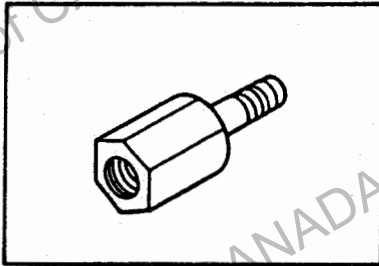
Prior to starting an engine overhaul, it is necessary to have the following.

**SLIDING HAMMER  
(For nozzle holder)**



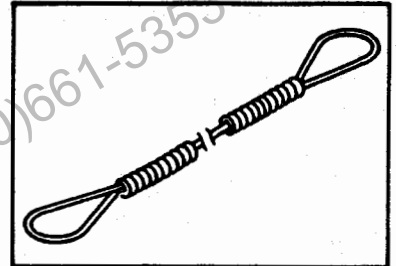
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**ADAPTOR**



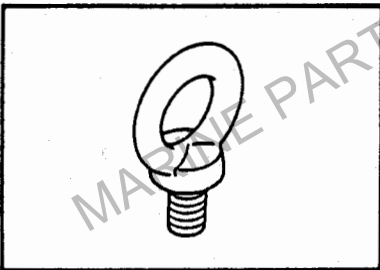
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(Used with 09420-1442)

**WIRE**



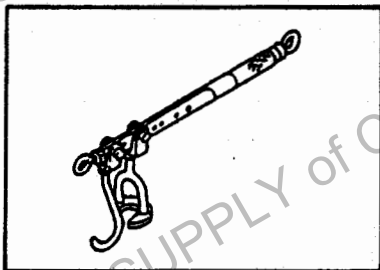
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**EYE BOLT  
(For cylinder head)**



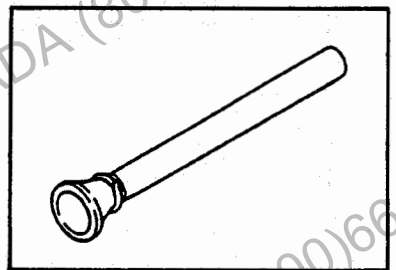
09433-1070  
(Used with 09491-1010)

**VALVE SPRING PRESS**



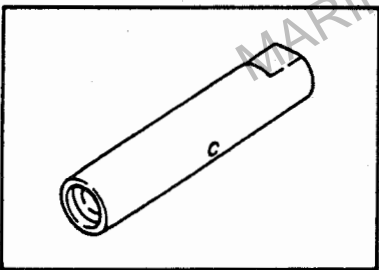
09470-1022

**VALVE LAPPING TOOL**



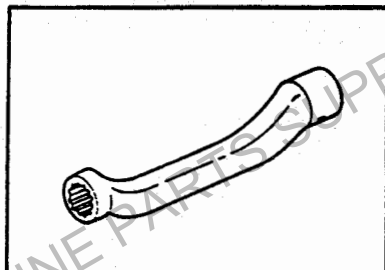
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**VALVE STEM SEAL PRESS**



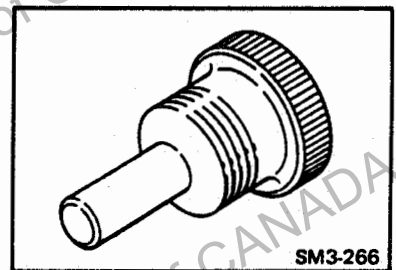
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**CYLINDER HEAD BOLT WRENCH**



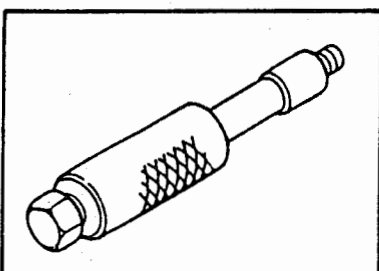
09411-1260

**TIMER SETTING TOOL**



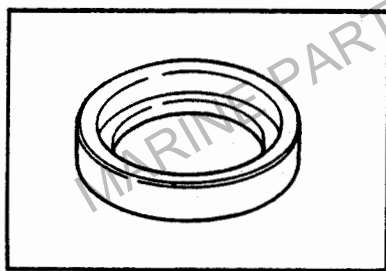
09512-2100  
SM3-266

**SLIDING HAMMER  
(For idle gear shaft)**



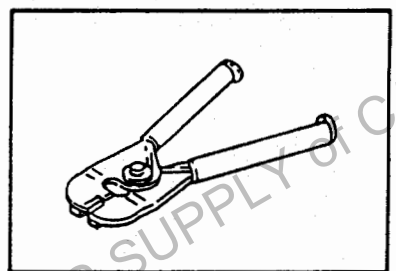
09420-1100

**TIMING GEAR CASE OIL SEAL PRESS**



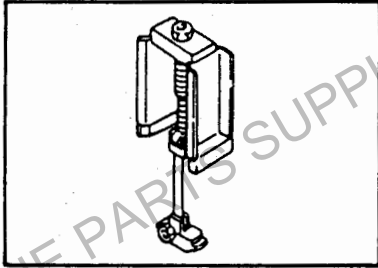
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**PISTON RING EXPANDER**



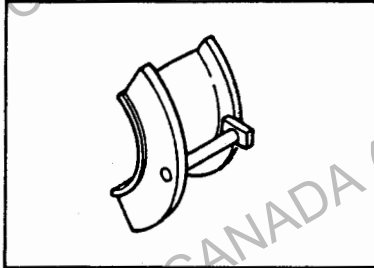
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CYLINDER LINER PULLER



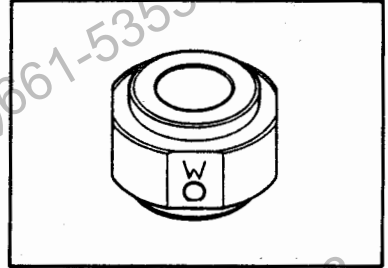
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CYLINDER LINER GUIDE



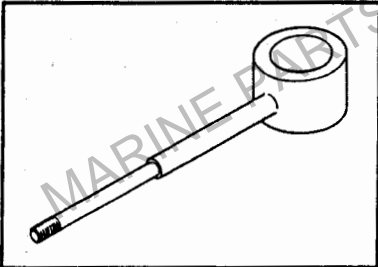
09480-1120

GUIDE  
(For piston pin bushing)



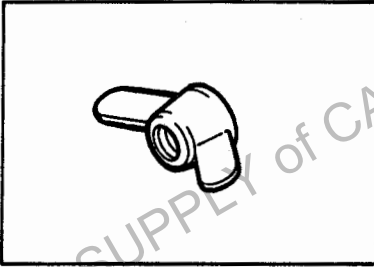
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PRESS SUBASSEMBLY  
(For piston pin bushing)



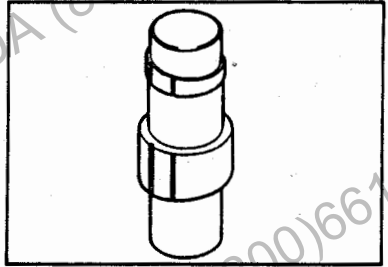
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WING NUT  
(For piston pin bushing)



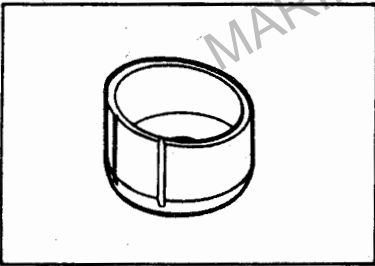
9233-10360

SPINDLE  
(For piston pin bushing)



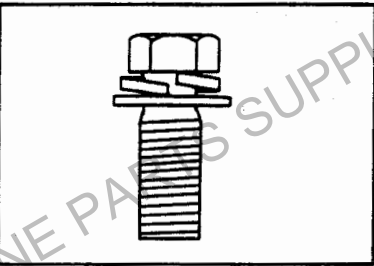
09402-1460

GUIDE  
(For piston pin bushing)



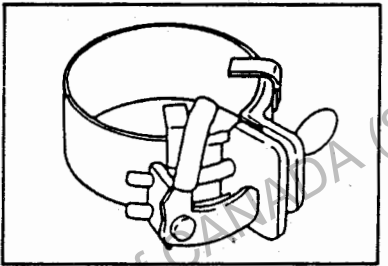
09481-1140

BOLT  
(For piston pin bushing)



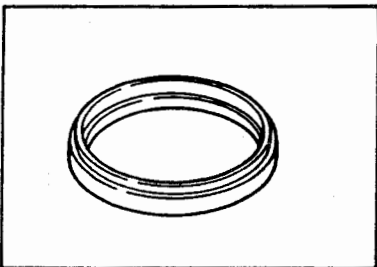
9191-08252

PISTON RING HOLDER



09441-1260

FLY WHEEL HOUSING OIL SEAL  
PRESS

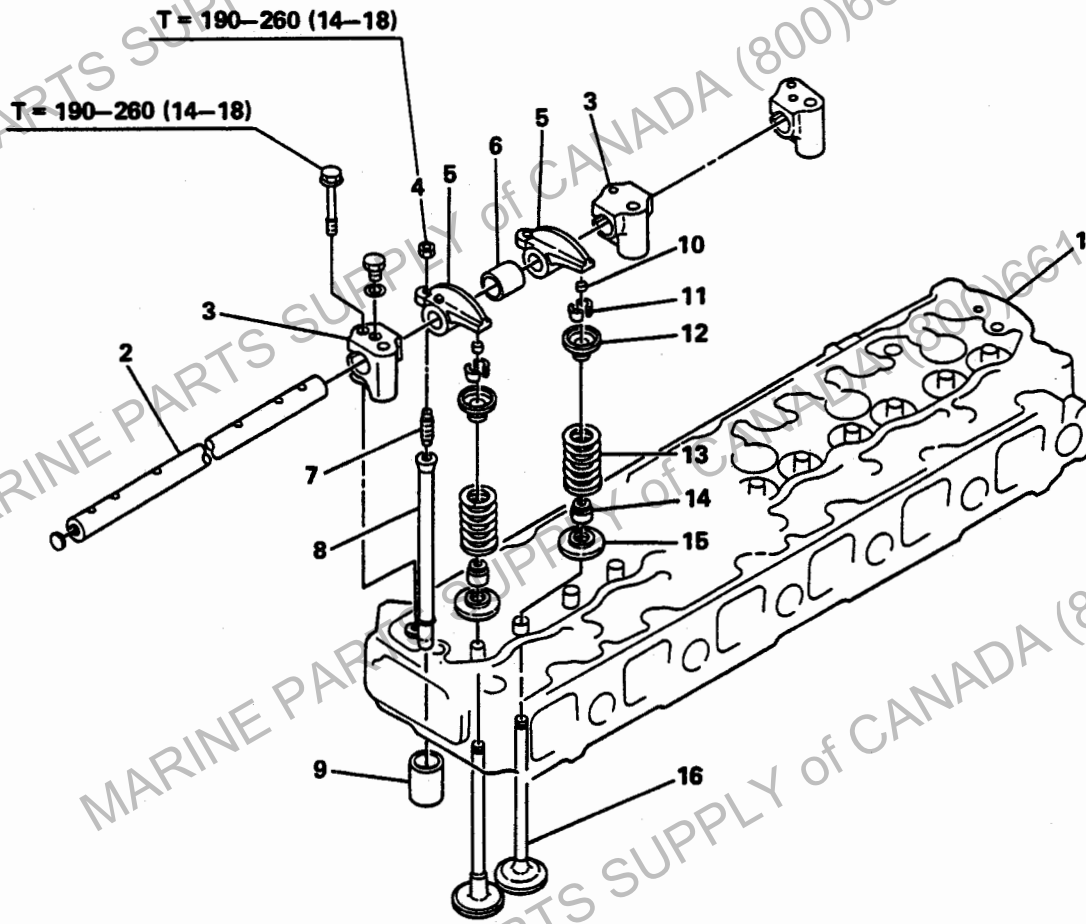


09482-1540

CYLINDER HEAD

OVERHAUL

HE11-059-00X00 (1310)



SM3-1926

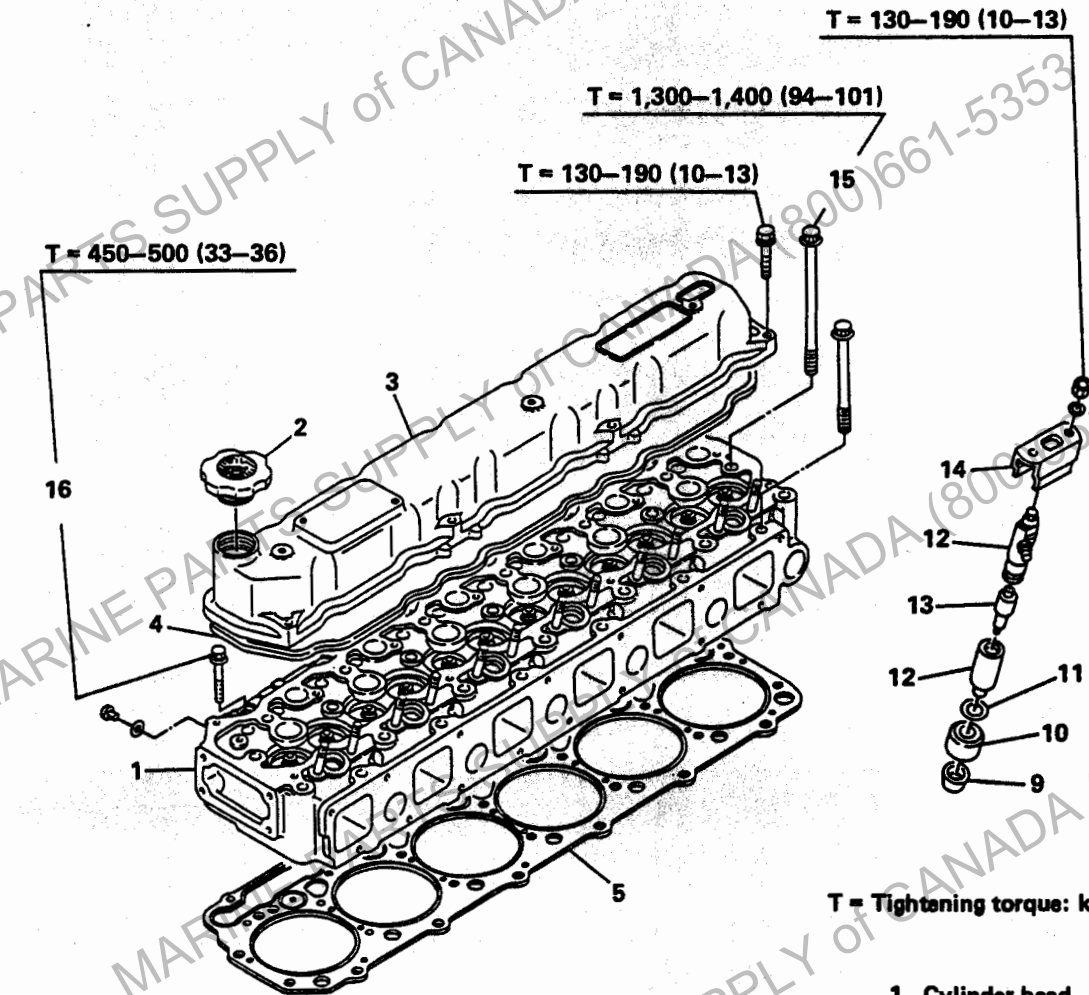
T = Tightening torque: kg-cm (lb.ft)

- 1. Cylinder head
- 2. Rocker arm shaft
- 3. Rocker arm support
- 4. Adjusting screw lock nut
- 5. Rocker arm
- 6. Bushing

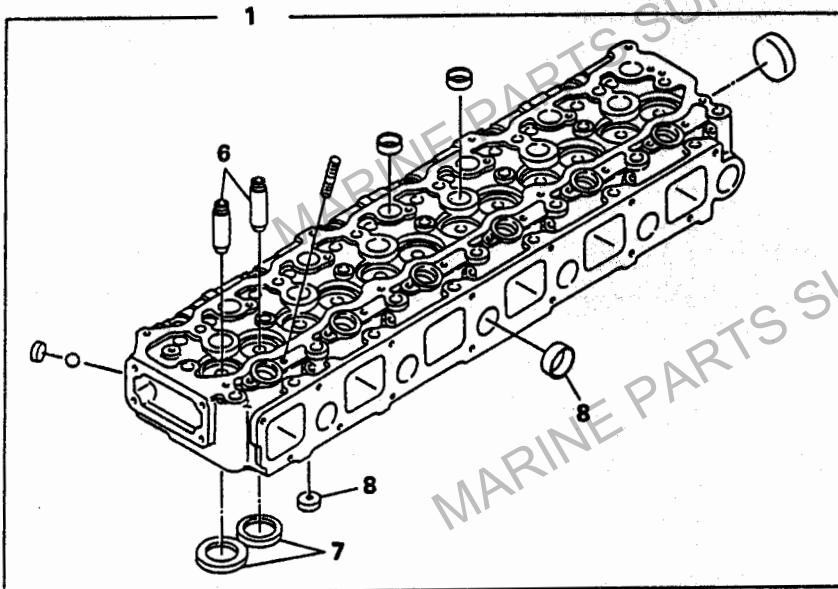
- 7. Valve clearance adjusting screw
- 8. Push rod
- 9. Tappet
- 10. Valve stem cap
- 11. Cotter key
- 12. Valve spring upper seat

- 13. Valve spring
- 14. Valve stem oil seal
- 15. Valve spring lower seat
- 16. Valve

OVERHAUL

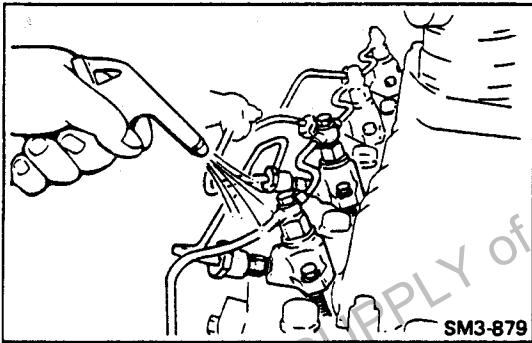


T = Tightening torque: kg-cm (lb.ft)



1. Cylinder head
2. Oil filler cap
3. Cylinder head cover
4. Cylinder head cover gasket
5. Cylinder head gasket
6. Valve guide
7. Valve seat
8. Expansion plug
9. Nozzle holder gasket
10. Packing ring
11. Shim
12. Nozzle holder
13. Nozzle
14. Nozzle holder adapter
15. Cylinder head bolt
16. Cylinder head additional bolt

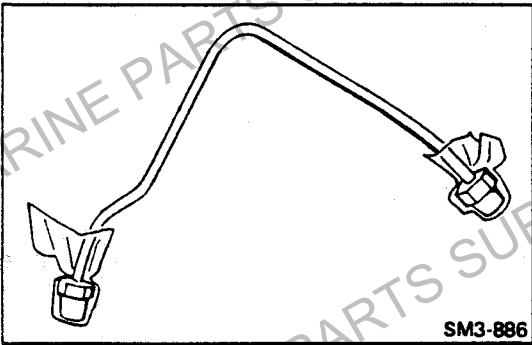
SM3-1927



**IMPORTANT POINTS — DISASSEMBLY**

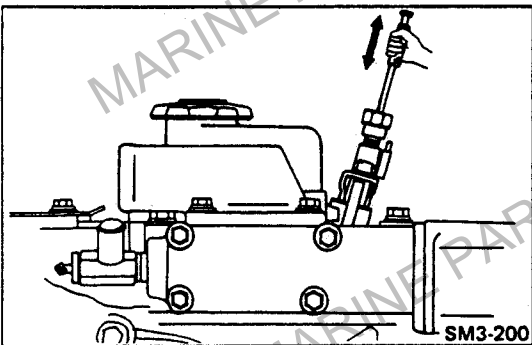
**CLEAN OFF SURROUNDING AREA OF THE INJECTION NOZZLE HOLDERS AND THE FUEL LINE CONNECTORS.**

**NOTE:** If foreign matter is allowed to enter the combustion chamber, engine trouble may result.



**REMOVE THE INJECTION PIPES.**

**NOTE:** Cover open ends of the pipes and fuel injection pump to prevent entry of dirt.

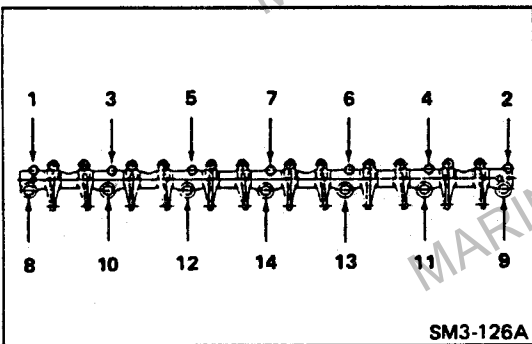


**REMOVE THE INJECTION NOZZLE HOLDERS.**

Using a special tool, if the nozzle holder is difficult to remove by hand.

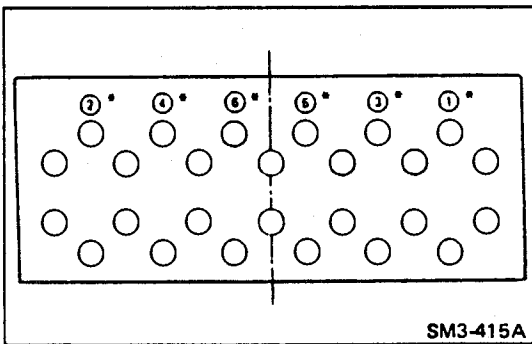
**Special Tool:** Sliding Hammer (09420-1442)  
Adapter (09462-1130)

**NOTE:** ○ After removal of the nozzle holder, cover the nozzle holder with cloth. Also cover the cylinder head with a cloth to prevent dust from getting in.



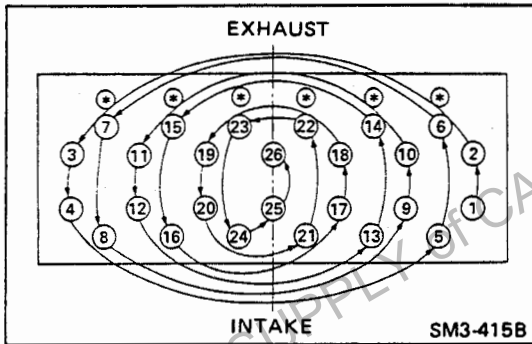
**REMOVE THE ROCKER ARM ASSEMBLY.**

Loosen the rocker arm support bolts and cylinder head bolt little by little in three stages and in the numerical order shown.

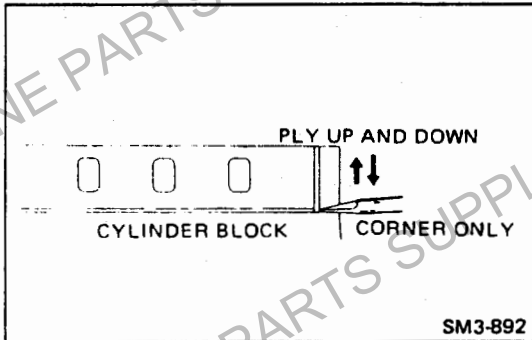


**LOOSEN THE CYLINDER HEAD BOLTS AND REMOVE THEM.**

Loosen the cylinder head additional bolts in the numerical order shown.



Loosen the cylinder head bolts little by little in three stages and in the numerical order shown.

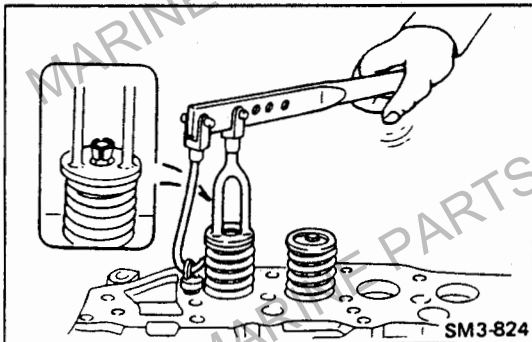


LIFT THE CYLINDER HEAD FROM THE DOWELS ON THE CYLINDER BLOCK AND PLACE IT ON WOODEN BLOCKS.

1. Remove the valve stem cotters, upper valve seats, and valve springs from cylinder head.

**NOTE:** Do not damage the machined surface of the head or block when removing the cylinder head.

**Special Tool:** Eye Bolt (09433-1070)  
Wire (09491-1010)

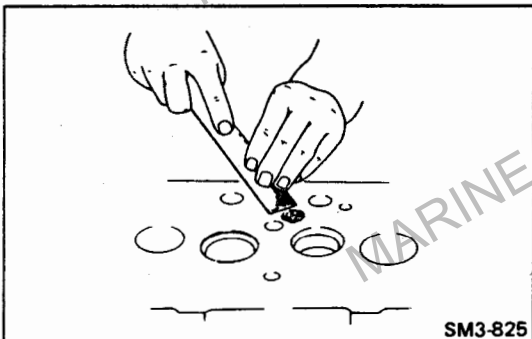


REMOVE THE VALVE SPRINGS.

1. Remove the valve stem cotters, upper valve seats, and valve springs from cylinder head.

**Special Tool:** Valve Spring Press (09470-1022)

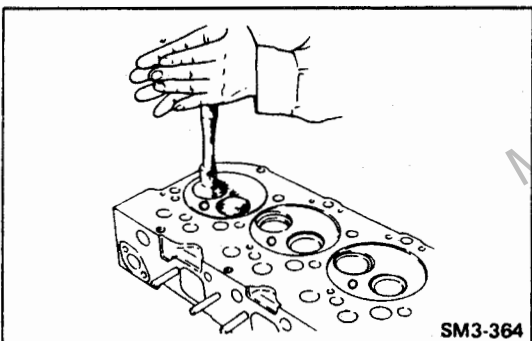
2. Remove the intake and exhaust valves.
3. Tag valves to identify their cylinder numbers and to eliminate valve lapping.



IMPORTANT POINTS – ASSEMBLY

CLEAN THE CYLINDER HEAD THOROUGHLY WITH A SUITABLE SOLVENT.

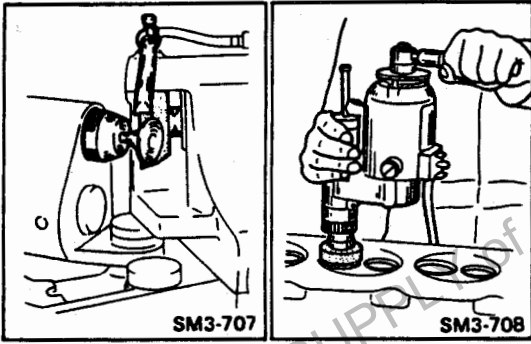
**NOTE:** Be careful not to damage the cylinder head surface.



IF NECESSARY, HAND-LAP THE VALVE AND VALVE SEAT.

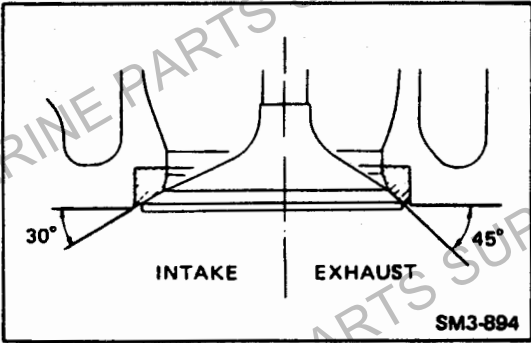
Lightly apply lapping compound to the valve face. Install the valve with a special tool, tap and rotate the valve against the seat.

**Special Tool:** Valve Lapping Tool (09431-1010)



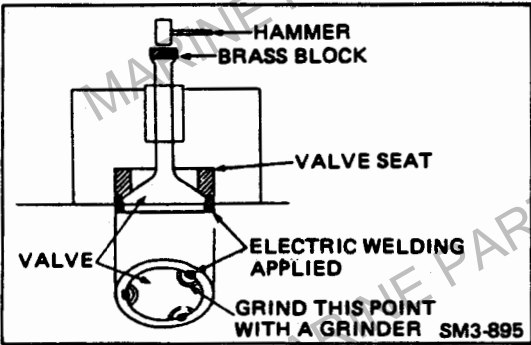
IF NECESSARY, GRIND THE VALVES AND VALVE SEATS.

- NOTE:
- Grinding of valves and valve seats should only be performed when hand-lapping does not result in proper seating.
  - After grinding, always recheck the valve sink.



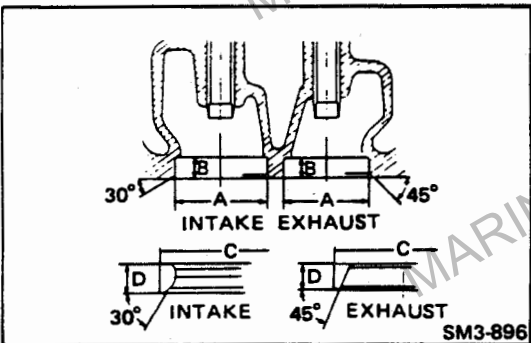
Standard:

- Valve Seat (Intake) : 30° - 30°30'
- Valve Face (Intake) : 29°45' - 30°15'
- Valve Seat (Exhaust) : 45° - 45°30'
- Valve Face (Exhaust) : 44°45' - 45°15'



IF NECESSARY, REPLACE THE VALVE SEAT.

1. Cut the circumference of a valve head at three places with a grinder and install it into the seat as shown and weld the valve to the seat. Then drive the valve and the seat out with a hammer and a brass block.

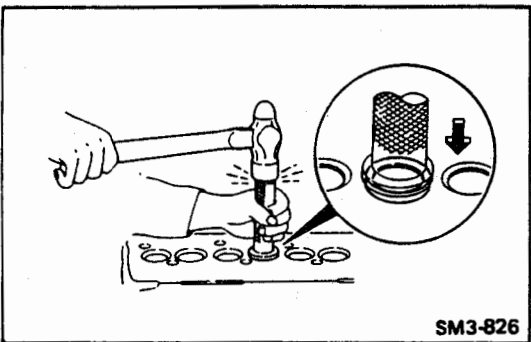


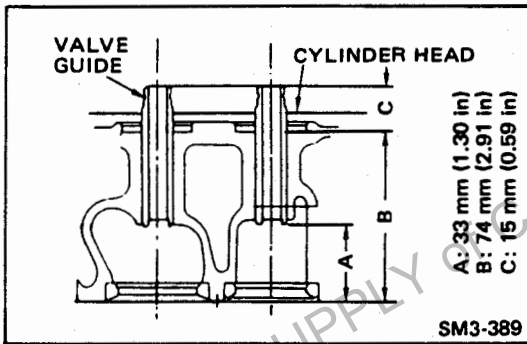
2. Valve seat section machining specifications. Unit: mm (in)

		Intake	Exhaust
Cylinder head dimension	A	46.500-46.516 (1.8308-1.8313)	41.000-41.016 (1.6142-1.6148)
	B	8.8-9.0 (0.3465-0.3543)	7.2-7.4 (0.2835-0.2913)
Valve seat dimension	C	46.585-46.600 (1.8341-1.8346)	41.130-41.145 (1.6193-1.6198)
	D	7.5-7.7 (0.2953-0.3031)	6.0-6.2 (0.2363-0.2440)

3. Valve seat installation

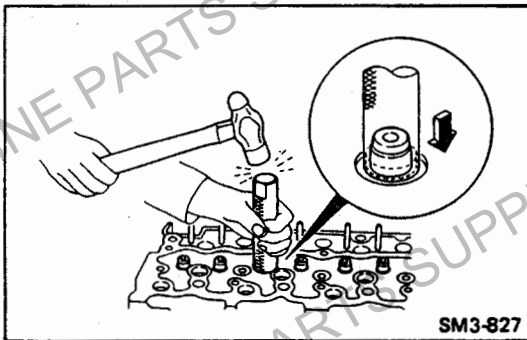
Heat the cylinder head to about 80° - 100°C (176 - 212°F) with hot water. On the other hand, cool the valve seat with dry ice or liquid nitrogen for about 30 minutes. Hold the seat with pincers and place it into the heated cylinder head.



**IF NECESSARY, REPLACE THE VALVE GUIDE.**

1. Remove the valve stem seal.
2. Using a brass rod and hammer, drive out the valve guide.
3. Install the valve guide.

**NOTE:** Apply engine oil lightly to the valve guide outer circumference before installation.

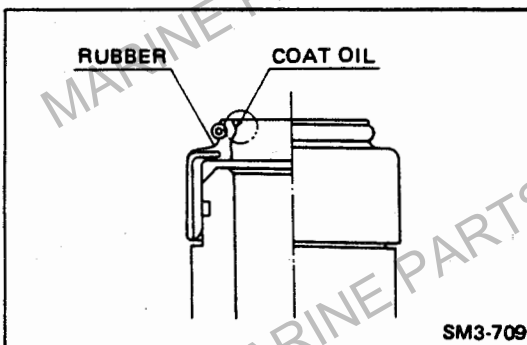
**IF NECESSARY, REPLACE THE VALVE STEM SEAL.**

1. Remove the valve stem seal.
2. Install the valve stem seal.

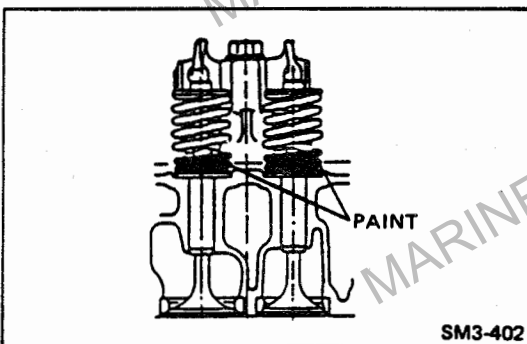
First, install the lower spring seat (for stopper of special tool) and valve. Then apply engine oil to the lip of the stem seal and drive the special tool until it hits the lower spring seat.

**Special Tool:** Stem Seal Press (09472-1650)

- NOTE:**
- After installing stem seal, make sure that check the rubber position for cracks or any other damage.
  - Do not use the special tool if its tip (surface contacting lower spring seat) is worn or deformed.

**ASSEMBLE THE CYLINDER HEAD.**

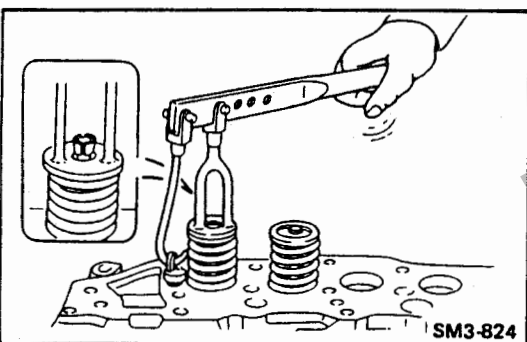
- NOTE:**
- Apply engine oil to contact surfaces of all parts.
  - Make sure that the valves are installed in the correct cylinders.
  - Install the valve springs with their painted side down, since they have variable pitches.

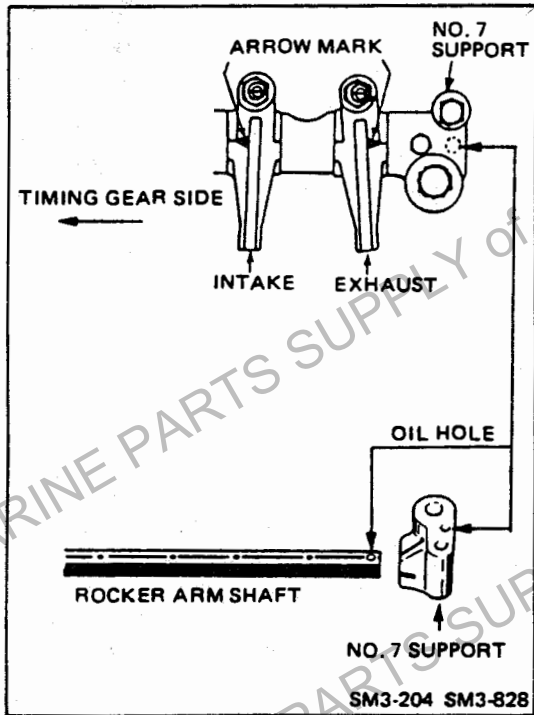


Press upper spring seats and install the valve stem keys securely in the upper spring seats.

**Special Tool:** Valve Spring Press (09470-1022)

- NOTE:**
- When pressing with the valve spring press, be careful not to damage the stem seals by contacting the upper seats.
  - Drive the valve stem lightly with a hammer to assure proper fit the valve stem key.





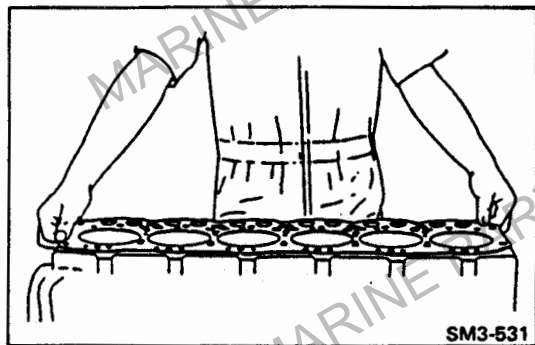
**ASSEMBLE THE ROCKER ARM.**

Lubricate the rocker arm shaft and bushing.

**NOTE:** Confirm that oil hole of rocker arm assembly No. 7 support aligns with shaft oil hole. Improper installation will result in burning of the entire valve assembly.

**INSTALL THE TAPPETS IN THE CYLINDER BLOCK IN CORRECT ORDER.**

**NOTE:** Apply engine oil to the tappet faces and tappet guide when installing them in the cylinder block.

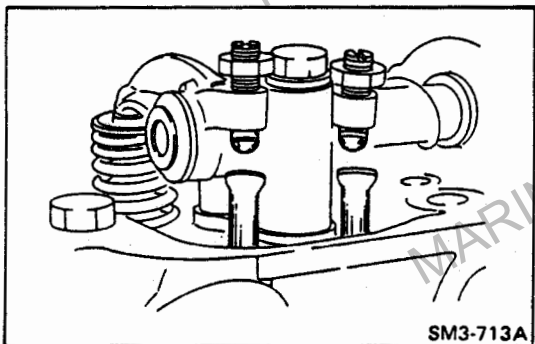


**INSTALL THE CYLINDER HEAD AND ROCKER ARM ASSEMBLY.**

1. Install the cylinder head gasket.

**NOTE:** Always use new cylinder head gasket after cleaning the surfaces of the cylinder head, cylinder block and head gasket free of all dirt, water and grease.

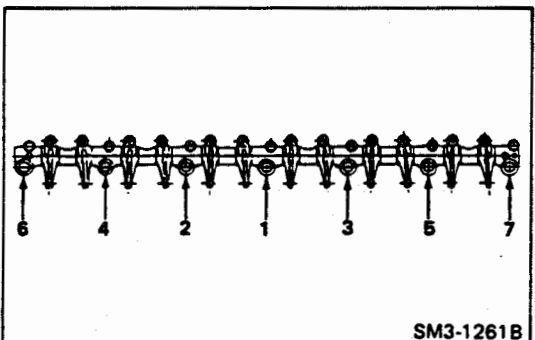
2. Install the cylinder head over the dowels on the cylinder block.



3. Insert the push rods in correct order, after applying engine oil to both ends.

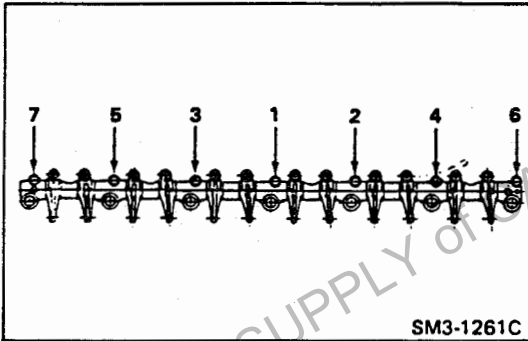
4. Mount the rocker arm assembly on the cylinder head, make sure that the push rods interlock with the adjusting screws.

**NOTE:** Always loosen the lock nut and raise the adjusting screws fully to the top.

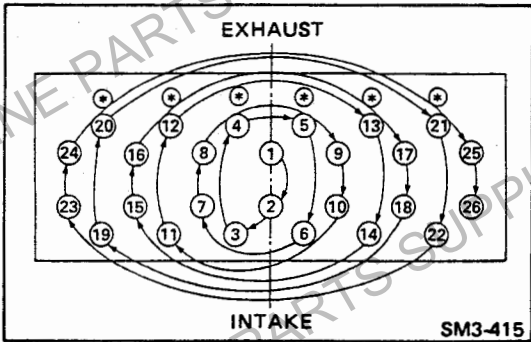


5. Tighten the cylinder head bolts and rocker arm support bolts provisionally.

**Tightening order: 1-2-3-4-5-6-7**



Tightening order: 1-2-3-4-5-6-7



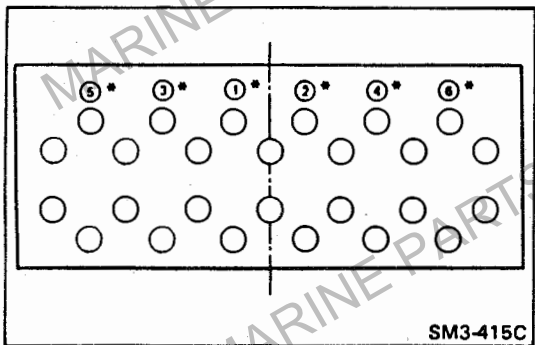
6. Tighten the cylinder head bolts in three stages following the tightening order shown.

Tighten the bolts  $\phi 12$  mm to the specified torque.

**NOTE:** Apply engine oil to the bolt threads and under the bolt head.

\* Mark bolts (cylinder head additional bolt):  $\phi 10$  mm (0.39 in)  
 No. 1 - No. 26 Bolts (Cylinder head bolt):  $\phi 12$  mm (0.47 in)

Special tool: Wrench (09411-1260)



7. Tighten the cylinder head additional bolts and rocker arm support bolts in three stages following the tightening order.

Tighten the bolts to the specified torque.

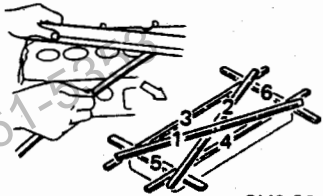
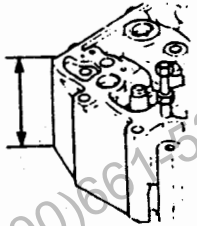

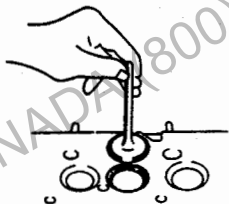
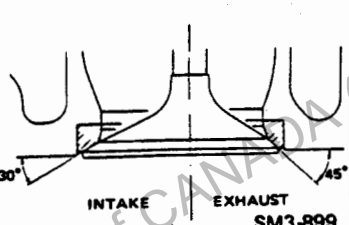
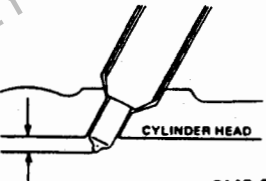
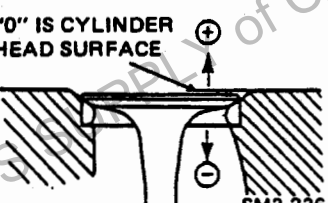
Tightening order: 1-2-3-4-5-6

8. Retighten the cylinder head bolts.

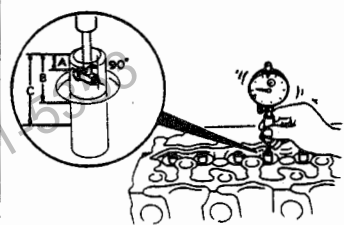
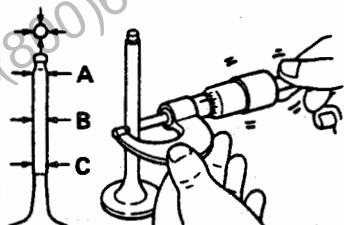
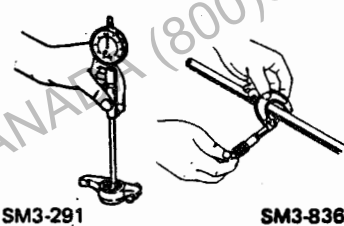
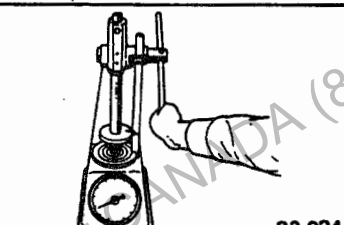
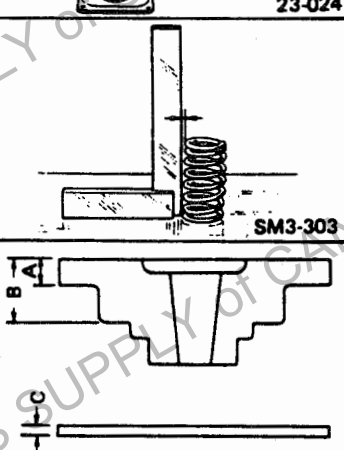
**NOTE:** Refer to section ENGINE TUNE-UP.

INSPECTION AND REPAIR

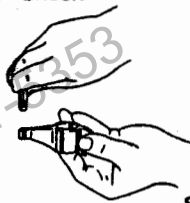

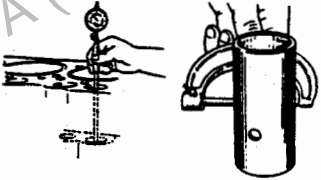
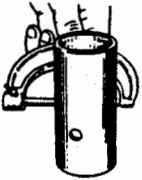
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Cylinder Head Flatness	Less than 0.05 (0.0019)	0.1 (0.0039)	Regrind or replace	 SM3-831
Cylinder Head Height	87.0 (3.425)	86.8 (3.417)	Replace	 SM3-887
Cylinder Head Cracks and Damage * Using a Dye Penetrant	-	-	Replace, if necessary	 SM3-832
Valve Seating Condition * Using Red Lead Marking Compound	There should be good contact around entire circumference of valve head.	-	Hand-lap with lapping compound	 SM3-833
Valve Seat Angle	Intake	30°-30°30'	Regrind or replace valve and/or valve seat	 SM3-899
	Exhaust	45°-45°30'		
Valve Angle	Intake	29°45'-30°15'		
	Exhaust	44°45'-45°15'		
Nozzle Protrusion from Cylinder Head Surface	2.75-3.25 (0.1083-0.1279)	-	Replace nozzle gasket	 SM3-391
Intake Valve Sink	-0.05- -0.35 (-0.0020- -0.0138)	-0.55 (-0.0216)	Replace valve and/or valve seat	 SM3-236
Exhaust Valve Sink	-0.47- -0.77 (0.0185- -0.0303)	-0.87 (-0.0342)		

Unit: mm (in)

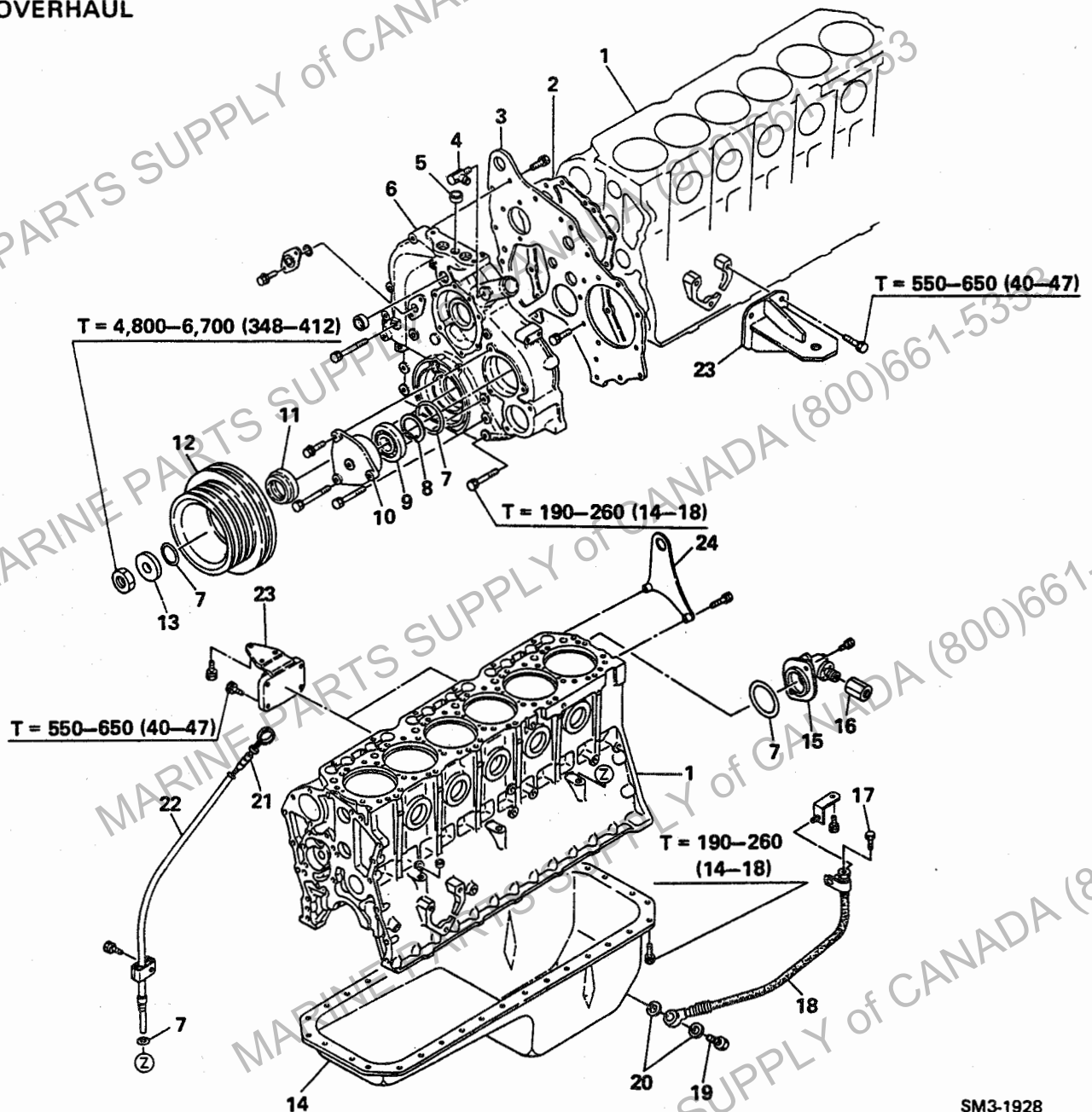
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Intake Valve Stem Diameter	8.95–8.97 (0.3524–0.3531)	8.90 (0.3503)	Replace valve guide and/or valve	 <p>A: 5 (0.197) SM3-834 B: 25 (0.984) C: 45 (1.771)</p>
Exhaust Valve Stem Diameter	8.93–8.95 (0.3516–0.3524)	8.80 (0.3464)		
Intake and Exhaust Valve Guide Diameter	9.000–9.015 (0.3544–0.3549)	A & B: 9.05 (0.3562) C: 9.10 (0.3582)		
Clearance between Valve Stem and Valve Guide (Intake)	0.035–0.068 (0.0014–0.0026)	A & B: 0.10 (0.0040) C: 0.18 (0.0071)		
Clearance between Valve Stem and Valve Guide (Exhaust)	0.050–0.083 (0.0020–0.0032)	A & B: 0.12 (0.0047) C: 0.2 (0.0078)		
Rocker Arm Shaft Diameter	18.97–18.98 (0.7469–0.7472)	18.95 (0.7461)	Replace rocker arm bushing and/or shaft	 <p>SM3-835</p>
Clearance between Rocker Arm Shaft and Rocker Arm Bushing	0.036–0.079 (0.0014–0.0031)	0.1 (0.0039)		
Valve Spring Setting Load	27.4 kg (60.4 lb) at 45.5 (1.79)	25.5 kg (56.2 lb)	Replace	 <p>SM3-291 SM3-836</p>
Valve Spring Straightness	-	2.0 (0.0787)	Replace	 <p>SM3-303</p>
Valve Spring Seat for Wear	A: 2.5 (0.0984) B: 5.0 (0.1969) C: 1.0 (0.0394)	-	Replace	 <p>SM3-909</p>

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Valve Stem Tip Surface for Wear	-	-	Resurface or replace	Visual Check 
Valve Stem Contact Surface of Rocker Arm for Wear				SM3-837
Push Rod Bend	-	0.3 (0.0118)	Replace	 SM3-292
Tappet Diameter	26.95–26.97 (1.0611–1.0618)	-	Replace tappet	 SM3-420
Tappet Guide Inside Diameter	27.00–27.02 (1.0630–1.0637)	-		
Clearance between Tappet and Tappet Guide	0.025–0.071 (0.0010–0.0027)	0.1 (0.0039)		
Tappet for Wear	Should not be worn unevenly.	-	Replace, if necessary	Visual Check  SM3-293

## TIMING GEAR, CAMSHAFT AND OIL PAN

## OVERHAUL



SM3-1928

T = Tightening torque: kg-cm (lb.ft)

- |                      |                               |                             |
|----------------------|-------------------------------|-----------------------------|
| 1. Cylinder block    | 9. Ball bearing               | 17. Oil drain plug          |
| 2. Gasket            | 10. Bearing holder case       | 18. Oil drain hose          |
| 3. Timing gear plate | 11. Oil seal                  | 19. Connector bolt          |
| 4. Connector         | 12. Crankshaft pulley         | 20. Soft washer             |
| 5. Expansion plug    | 13. Plain washer              | 21. Oil level gauge         |
| 6. Timing gear cover | 14. Oil pan                   | 22. Oil level gauge guide   |
| 7. O-ring            | 15. Tachometer drive assembly | 23. Engine mounting bracket |
| 8. Retainer ring     | 16. Connector                 | 24. Engine hanger bracket   |

OVERHAUL

T = 1,100-1,300 (80-94)

T = 190-260 (14-18)

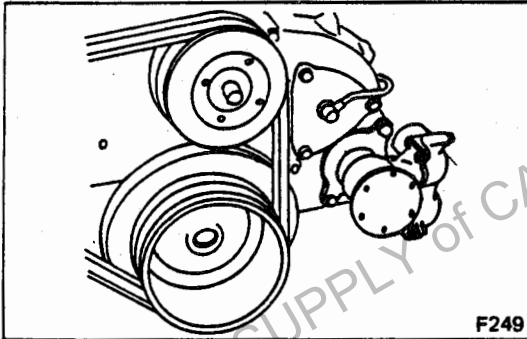
T = 190-260 (14-18)

T = 1,100-1,300 (80-94)

T = 300-350 (22-25)

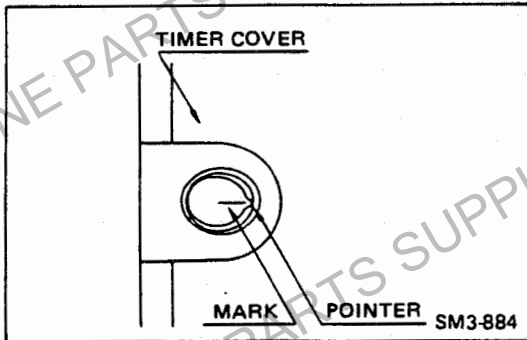
T = Tightening torque: kg-cm (lb.ft)

- |                        |                            |                               |
|------------------------|----------------------------|-------------------------------|
| 1. Camshaft            | 7. Idler gear thrust plate | 13. Injection pump drive gear |
| 2. Key                 | 8. Straight pin            | 14. Coupling flange           |
| 3. Thrust bearing      | 9. Idler gear shaft        | 15. O-ring                    |
| 4. Camshaft gear       | 10. Bearing                | 16. Timer cover               |
| 5. Thrust washer       | 11. Idler gear             | 17. Soft washer               |
| 6. Oil pump drive gear | 12. Crankshaft gear        | 18. Plug                      |

**IMPORTANT POINTS – DISASSEMBLY****REMOVE THE FUEL INJECTION PUMP ASSEMBLY.**

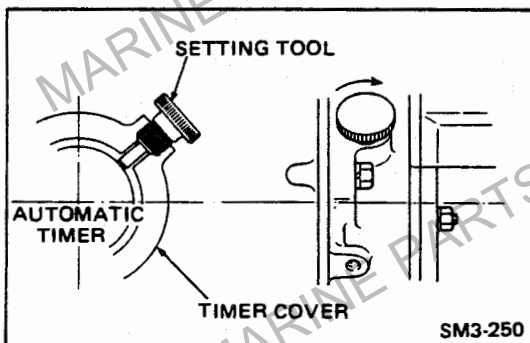
1. Remove the bearing holder case.

**NOTE:** Do not loosen the injection pump drive gear fitting bolts.



2. Remove the plug of the timer cover.

3. Turn the crankshaft counter-clockwise viewed from the flywheel to align the injection timing mark with pointer.

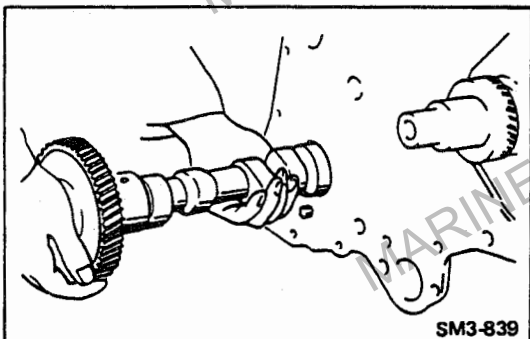


4. Install the setting tool.

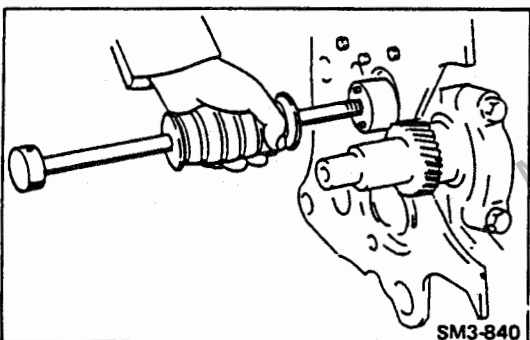
**Special Tool:** Timer Setting Tool (09512-2100)

5. Loosen the timer cover fitting bolts and remove the fuel injection pump with timer cover.

**NOTE:** Do not loosen the fuel injection pump body fitting nuts.

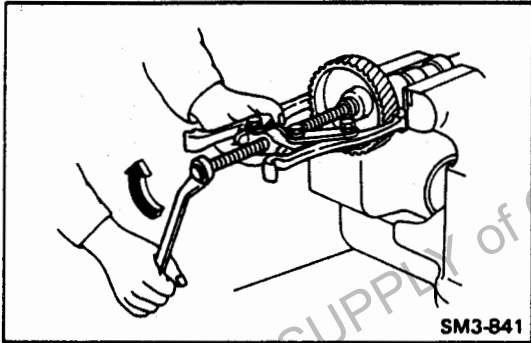
**REMOVE THE CAMSHAFT WITH GEAR.**

- NOTE:**
- Remove the tappets above the camshaft.
  - Pull out the camshaft, slowly turning it so as not damage the bearings.

**REMOVE THE IDLER GEAR SHAFT.**

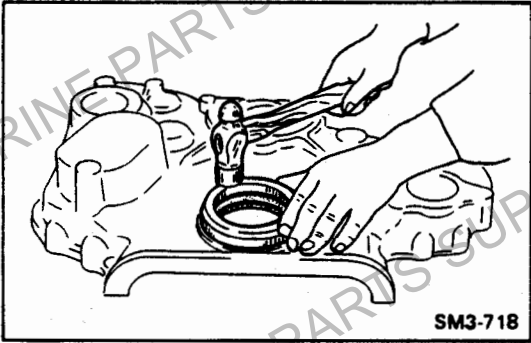
Using a special tool, remove the idler gear shaft.

**Special Tool:** Sliding Hammer (09420-1100)



**IF NECESSARY, REMOVE THE CAMSHAFT GEAR.**

1. Hold the camshaft with a vice through wooden plates.
2. Remove the bolt and plain washer, then using a gear puller, remove the gear.

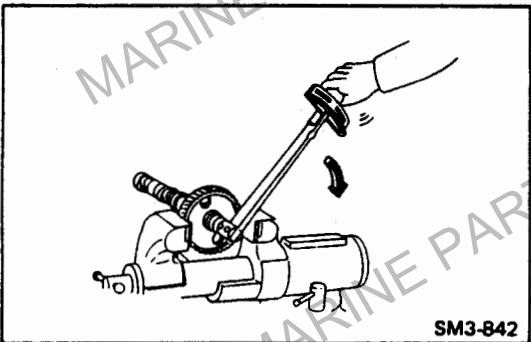


**IMPORTANT POINTS – ASSEMBLY**

**IF NECESSARY, REPLACE THE TIMING GEAR COVER OIL SEAL.**

1. Using a screwdriver, remove the oil seal.
2. Using a special tool, install the new oil seal.

**Special Tool:** Press (09482-1530)

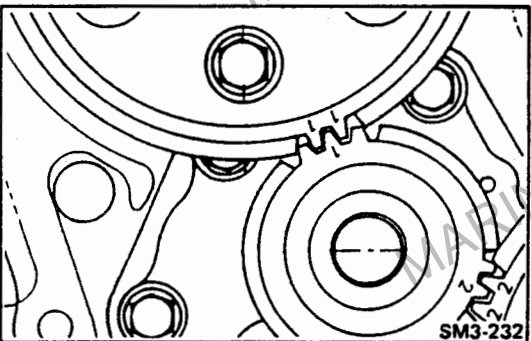


**ASSEMBLE THE CAMSHAFT GEAR AND SHAFT.**

Install the camshaft gear with thrust bearing.

**NOTE:** When installing the gear to the camshaft:

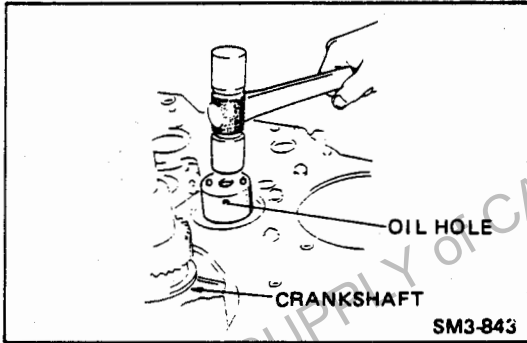
- Heat the gear in hot water [Approx. 100°C (212°F)], then install the gear to the camshaft by using a press.
- When tightening the bolt, apply engine oil to the threads and plate surface of the bolt.



**INSTALL THE CAMSHAFT.**

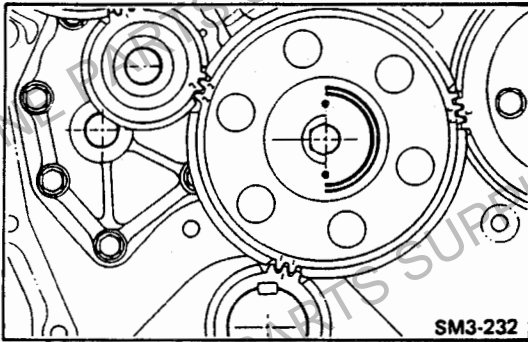
Lubricate all journals of the camshaft and insert the camshaft assembly into the cylinder block.

- NOTE:**
- Insert the camshaft, slowly turning while inserting so that the bearing will not be damaged.
  - When installing the camshaft, be sure that the match marks of the oil pump drive gear and camshaft gear are aligned correctly.

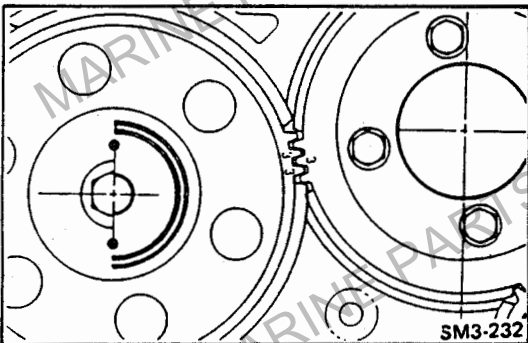
**INSTALL THE IDLER GEAR SHAFT.**

Install the idler gear shaft with thrust plate using a plastic hammer.

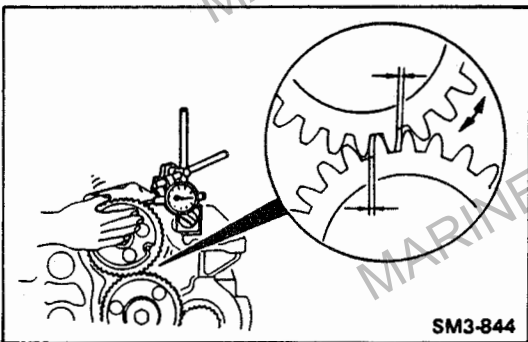
**NOTE:** Be sure that the oil hole is downward, if installed the wrong way, damage to the idler gear shaft and bushing can result.

**INSTALL THE IDLER GEAR.**

**NOTE:** When installing the idler gear, be sure that the matching marks of the crankshaft gear, oil pump drive gear and idler gear are aligned correctly.

**INSTALL THE INJECTION PUMP TEMPORARILY.**

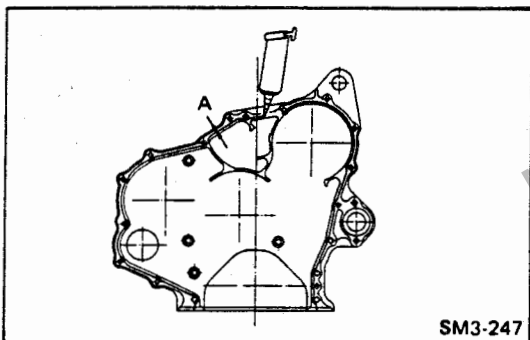
**NOTE:** When installing the injection pump, be sure that the match marks of the idler gear and injection pump drive gear are aligned correctly.

**MEASURE THE GEAR BACKLASH.**

Measure the backlash of each gear using a dial indicator.

Replace the gear if necessary.

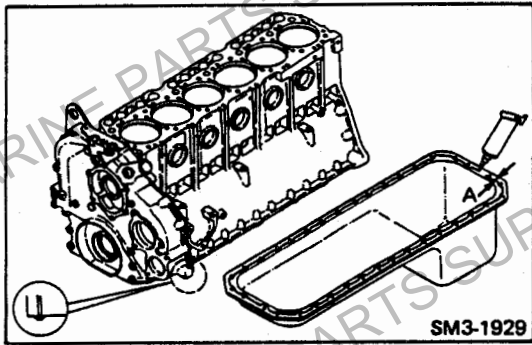
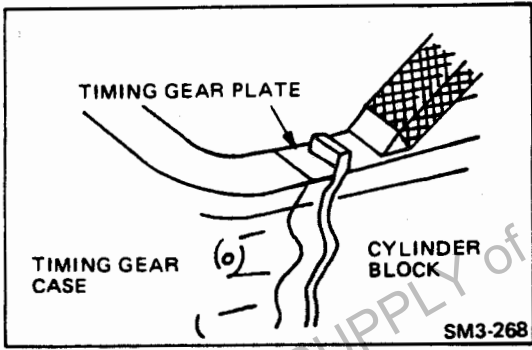
Refer to INSPECTION AND REPAIR.

**INSTALL THE TIMING GEAR CASE.**

1. Clean the faces.
2. Apply the liquid gasket as shown and install the timing gear cover within 20 minutes.

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

Coating Width (A): 1.5 – 2.5 mm (0.06 – 0.10 in)



**INSTALL THE OIL STRAINER.**

Refer to Section LUBRICATING SYSTEM.

**INSTALL THE OIL PAN.**

1. Cut the protrusion of the timing gear plate gasket from the oil pan mounting surface.
2. Clean the faces.
3. Apply the liquid gasket as shown and install the timing gear cover within 20 minutes.

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

Coating Width (A): Approx. 3—4 mm (0.12—0.15 in)

**TIGHTEN THE CRANKSHAFT PULLY.**

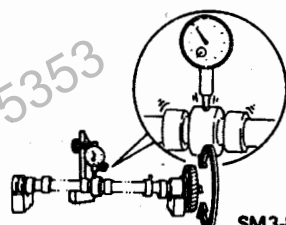
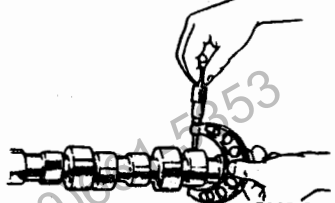
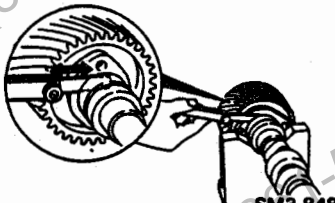
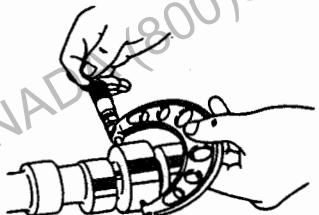
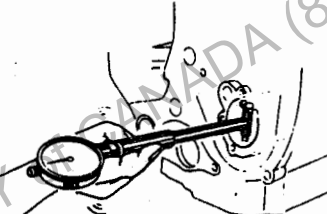
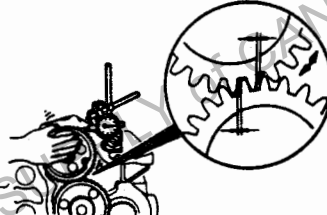
**NOTE:** Apply engine oil to the nut threads.

**INSPECTION AND REPAIR**

Unit: mm (in)

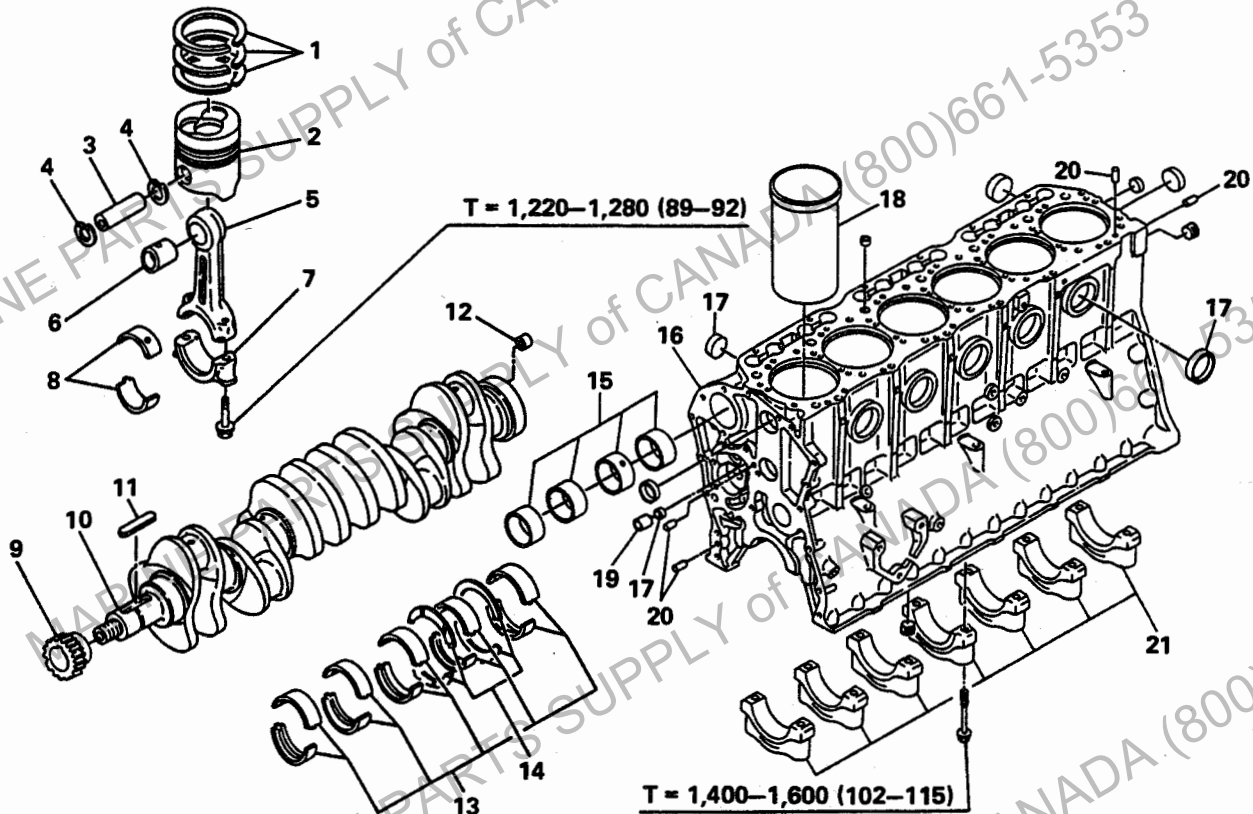
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Gear Teeth for Pitting or Wear	-	-	Replace, if necessary	Visual check  SM3-845
Idler Gear Shaft Diameter	49.95—49.97 (1.9666—1.9673)	49.93 (1.9657)	Replace bushing and/or shaft	 SM3-846
Idler Gear Bushing Inside Diameter	50.00—50.03 (1.9685—1.9696)	50.05 (1.9705)		 SM3-847
Oil Clearance between Idler Gear Shaft and Gear Bushing	0.03—0.08 (0.0018—0.0031)	0.1 (0.0039)		
Idler Gear end Play	0.04—0.10 (0.0016—0.0039)	0.15 (0.0059)	Replace thrust plate	 SM3-421

Unit: mm (in)

Inspection Item		Standard	Limit	Remedy	Inspection Procedure
Camshaft Bend			0.05 (0.0019)	Replace	 SM3-858
Camshaft Cam Height	Intake	49.44 (1.9465)	48.44 (1.9071)	Replace	 SM3-374
	Exhaust	49.50 (1.9488)	48.50 (1.9095)		
Camshaft End Play		0.10—0.18 (0.0040—0.0070)	0.30 (0.0118)	Replace thrust plate	 SM3-848
Camshaft Journal Diameter	No. 1	57.0 (2.2441)	56.85 (2.2383)	Replace shaft and/or bearing	 SM3-849
	No. 2	56.8 (2.2362)	56.65 (2.2303)		
	No. 3	56.6 (2.2283)	56.45 (2.2224)		
	No. 4	56.4 (2.2205)	56.25 (2.2145)		
Camshaft Journal Bearing Inside Diameter	No. 1	57.0 (2.2441)	57.15 (2.2500)		 SM3-850
	No. 2	56.8 (2.2362)	56.95 (2.2421)		
	No. 3	56.6 (2.2283)	56.75 (2.2342)		
	No. 4	56.4 (2.2204)	56.55 (2.2263)		
Oil Clearance between Camshaft Journal and Bearing		0.03—0.12 (0.0012—0.0047)	0.15 (0.0059)		
Timing gear backlash	Crankshaft Gear — Idler Gear	0.068—0.194 (0.0027—0.0076)	0.30 (0.0118)	Replace gear, if necessary.	 SM3-844
	Idler Gear — Oil Pump Gear	0.065—0.182 (0.0026—0.0071)			
	Idler Gear — Injection Pump Gear	0.065—0.182 (0.0026—0.0071)			
	Oil Pump Gear — Camshaft Gear	0.065—0.182 (0.0026—0.0071)			

# PISTON, CRANKSHAFT, CYLINDER BLOCK AND FLYWHEEL HOUSING

## OVERHAUL

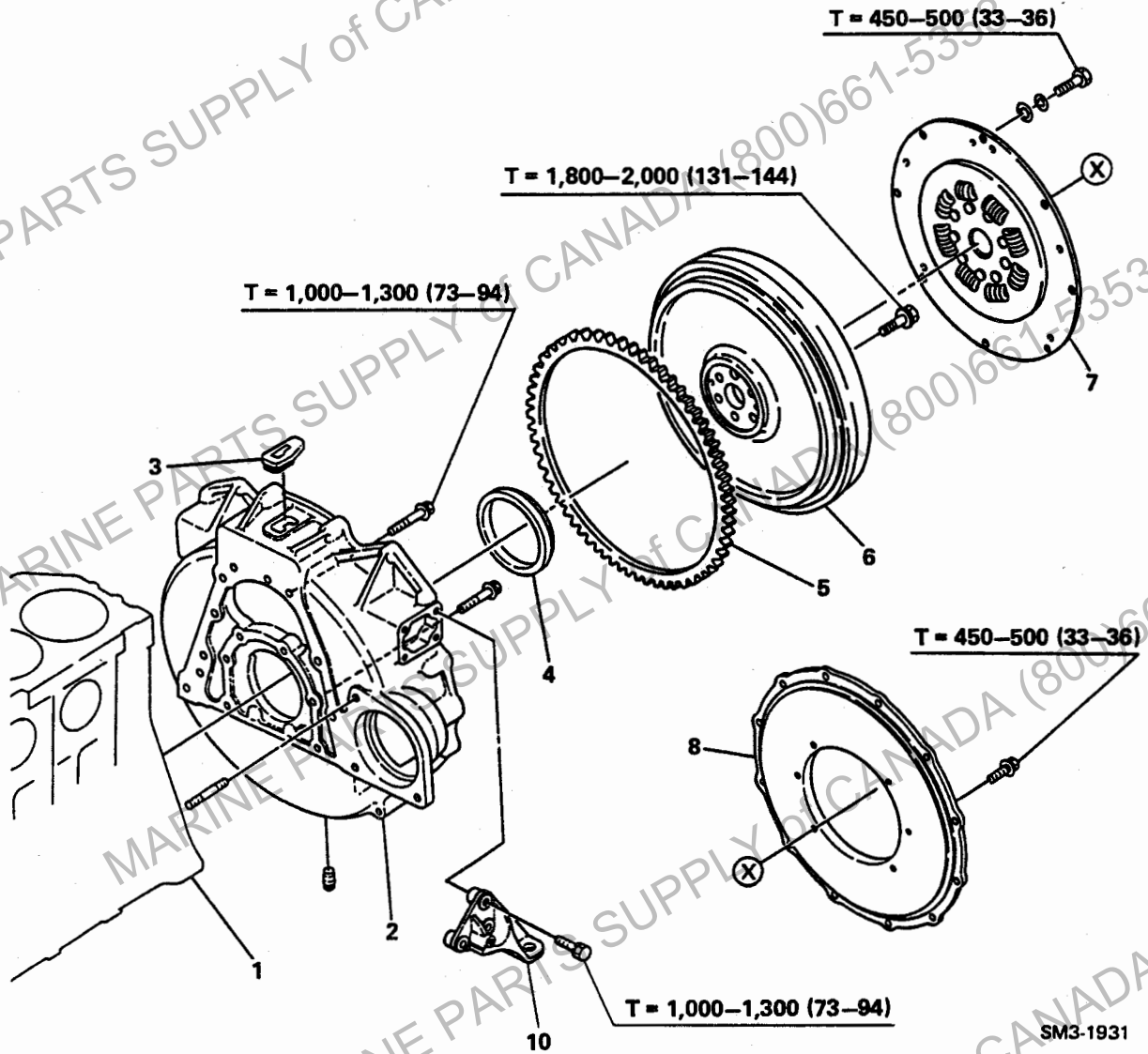


SM3-1930

T = Tightening torque kg-cm (lb.ft)

- |                           |                               |                                  |
|---------------------------|-------------------------------|----------------------------------|
| 1. Piston ring            | 9. Crankshaft gear            | 17. Expansion plug               |
| 2. Piston                 | 10. Crankshaft                | 18. Cylinder liner               |
| 3. Piston pin             | 11. Key                       | 19. Oil pump drive shaft bearing |
| 4. Retainer ring          | 12. Collar                    | 20. Straight pin                 |
| 5. Connecting rod         | 13. Main bearing              | 21. Main bearing cap             |
| 6. Piston pin bushing     | 14. Crankshaft thrust bearing |                                  |
| 7. Connecting rod cap     | 15. Camshaft bearing          |                                  |
| 8. Connecting rod bearing | 16. Cylinder block            |                                  |

OVERHAUL



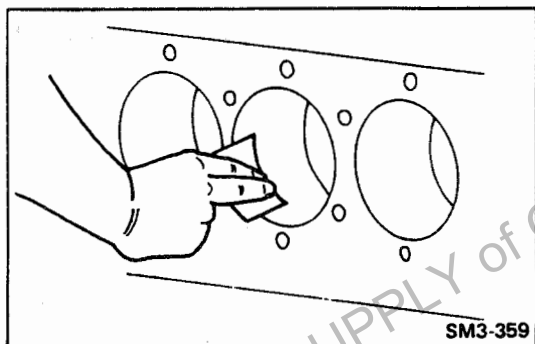
- 1. Cylinder block
- 2. Flywheel housing
- 3. Timing port cover
- 4. Oil seal

- 5. Ring gear
- 6. Flywheel
- 7. Torsion-elastic coupling
- 8. Spacer

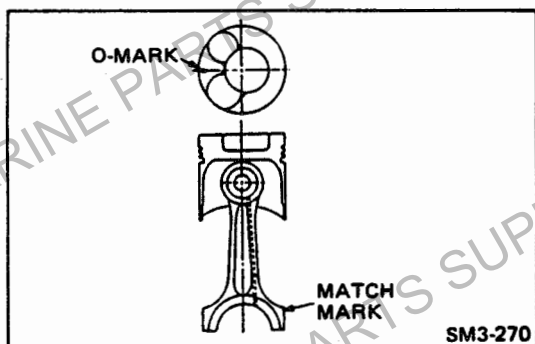
- 9. Intermediate flange
- 10. Bracket

T = Tightening torque: kg-cm (lb.ft)

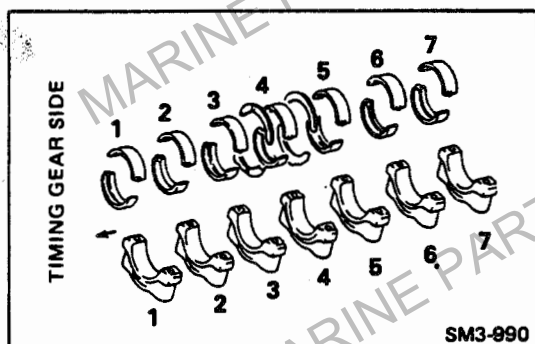
SM3-1931



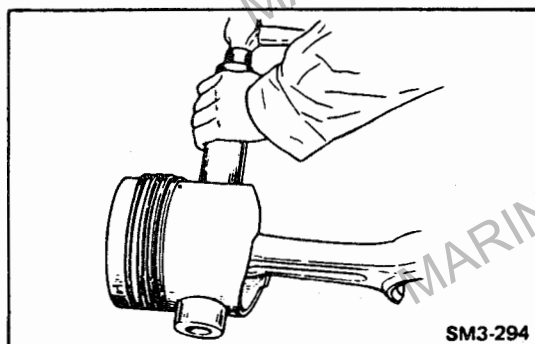
SM3-359



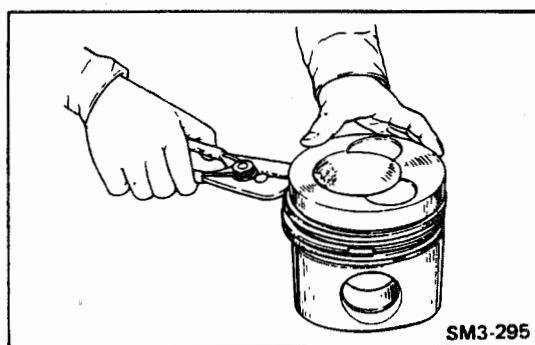
SM3-270



SM3-890



SM3-294



SM3-295

## IMPORTANT POINTS – DISASSEMBLY

### REMOVE THE PISTONS WITH CONNECTING RODS.

1. Remove the carbon from the upper end of the cylinder liner with a scraper or emery paper (recommended: No. 150) in a circular direction.

2. Extract the piston and connecting rod assembly out through the top of the cylinder.

**NOTE:** ○ Arrange the piston and connecting rod caps in order.

### REMOVE THE CRANKSHAFT.

**NOTE:** Arrange the caps, main bearings and thrust bearings in order.

### DISASSEMBLE THE CONNECTING ROD AND PISTON.

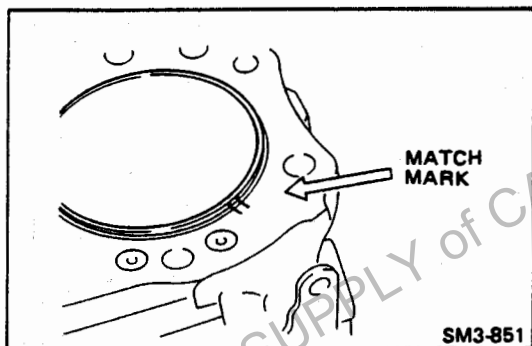
1. Remove the retainer ring installed on both ends of the piston pin, by means of retainer ring pliers.
2. Apply a metal pad to the pin and strike out the pin with a hammer.

**NOTE:** Warm up the piston first in hot water 80–90°C (176–194°F) for about 5 minutes before removing the pin.

### REMOVE THE PISTON RINGS.

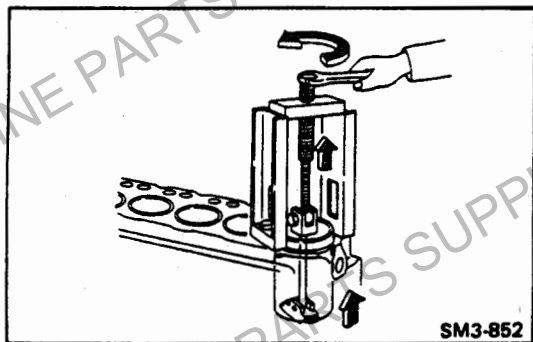
**Special Tool:** Piston Ring Expander (09442-1180)

- NOTE:** ○ Handle the piston rings carefully because they are made of a special casting which is easily broken.
- Keep the rings for each cylinder separate.

**REMOVE THE CYLINDER LINER.**

1. Place the match marks with a pen on the cylinder block and liner flange, before removing the cylinder liners.

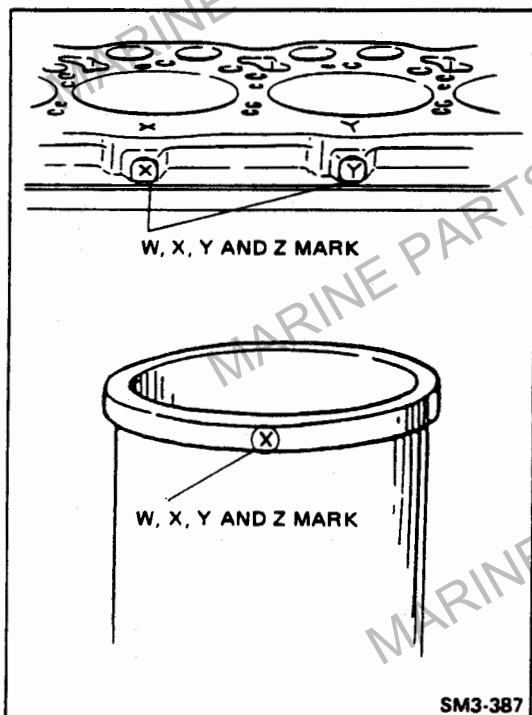
**NOTE:** Do not put the match marks with a punch.



2. Using a special tool, remove the cylinder liners.

**Special Tool:** Cylinder Liner Puller (09420-1460)

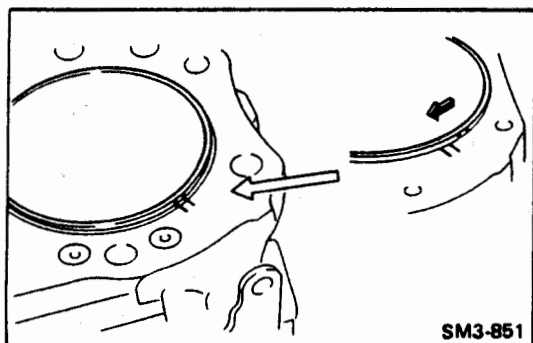
**NOTE:** After removing the cylinder liners, put numbers on their periphery or arrange them in sequence.

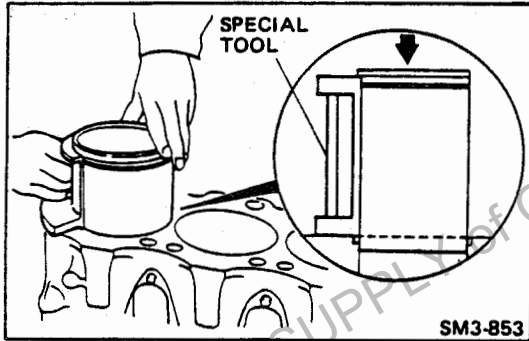
**IMPORTANT POINTS – ASSEMBLY****INSERT THE CYLINDER LINER INTO THE CYLINDER BLOCK.**

1. When a new cylinder liner is used, make sure that the liner has the same mark as the mark on the cylinder block.

**NOTE:** ○ There are 4 different liner and cylinder block matches. The flange section of each liner has a marking any, W, X, Y, Z, or indicating the size of the outer diameter of the liner on which it is stamped. The markings W, X, Y and Z, indicating the inner diameter of the cylinder bore supporting the liner on the sides and top of the cylinder block (the boss section for attaching the coolant gallery cover), are inscribed on each cylinder.

2. When reusing a liner, insert the liner its original position aligning the marking marked before disassembly.

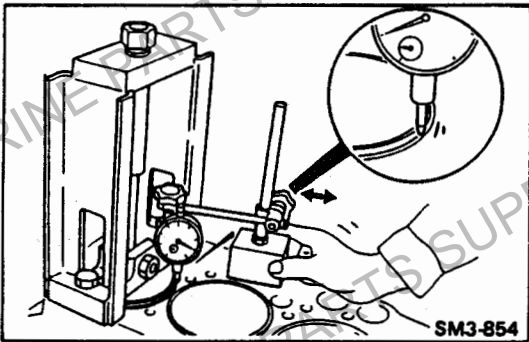




Apply a small amount of fresh engine oil on the outer periphery of the liner, and apply pressure on the entire flange section of the liner. If insertion by hand is difficult, use a cylinder guide, and the cylinder liner will easily be pushed in.

**Special Tool:** Cylinder Liner Guide (09480-1120)

- NOTE:**
- Do not use a liner that has been dropped.
  - Take extra care when handling the liner since the liner is easily deformed.



**MEASURE THE PROJECTION OF THE CYLINDER LINER.**

Tighten a special tool with a tightening torque of 100 kg-cm (7.23 lb-ft) and measure the amount of projection of the top end of the liner from the cylinder block with a dial gauge or straight edge and a thickness gauge.

**Special Tool:** Cylinder Liner Puller (09420-1460)

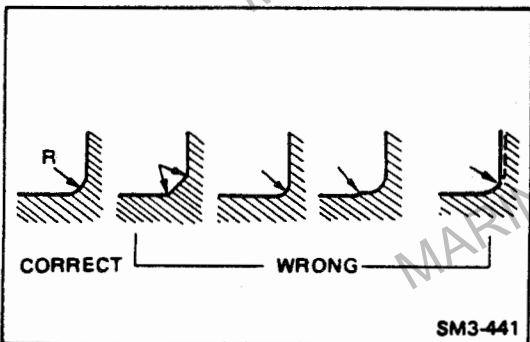
**Tightening Torque:** 100 kg-cm (7.23 lb.ft)

**Assembly Standard:** 0.01–0.08 mm (0.0004–0.0031 in)

Unit: mm (in)

Under size	Outside diameter	
	Crankpin	Journal
0.25	61.69–61.71 (2.4288–2.4295)	72.69–72.71 (2.8619–2.8625)
0.50	61.44–61.46 (2.4189–2.4196)	72.44–72.46 (2.8520–2.8527)
0.75	61.19–61.21 (2.4091–2.4098)	72.19–72.21 (2.8422–2.8429)
1.00	60.94–60.96 (2.3992–2.4000)	71.94–71.96 (2.823–2.8330)

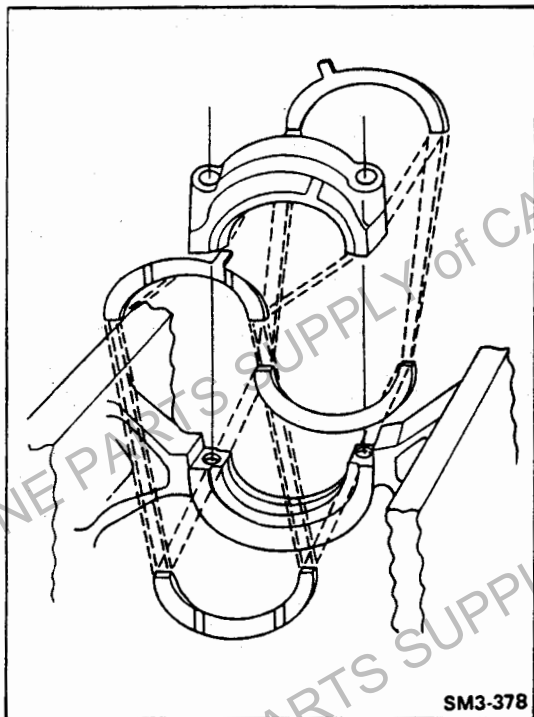
**IF NECESSARY, GRIND THE CRANKSHAFT AND USE UNDER SIZE BEARINGS.**



**Dimension of Fillet R:**

**Crank pin:** 3.50 – 4.00 mm (0.1378 – 0.1574 in)

**Journal:** 3.05 – 3.50 mm (0.1201 – 0.1377 in)

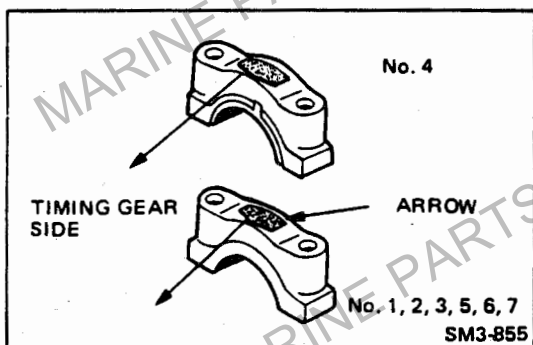
**INSTALL THE CRANKSHAFT.**

1. Install the crankshaft bearings on the cylinder block and bearing cap.

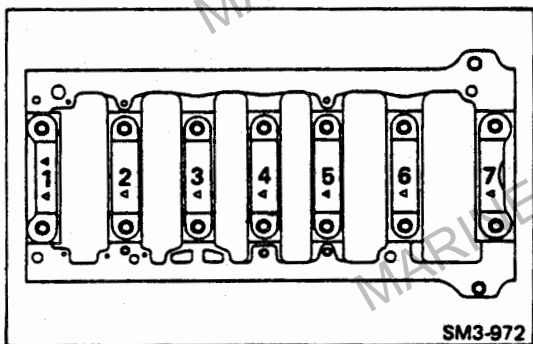
**NOTE:** Apply new engine oil to each bearing surface.

2. Install the crankshaft on the cylinder block.
3. Insert the crankshaft thrust bearings along the groove of the cylinder block.
4. Install the thrust bearings on the No. 4 bearing cap sides.

**NOTE:** Apply new engine oil to each thrust bearing surface.



5. Install the crankshaft bearing caps. Install the bearing caps in numbered order from timing gear side with the arrow point toward the timing gear side.

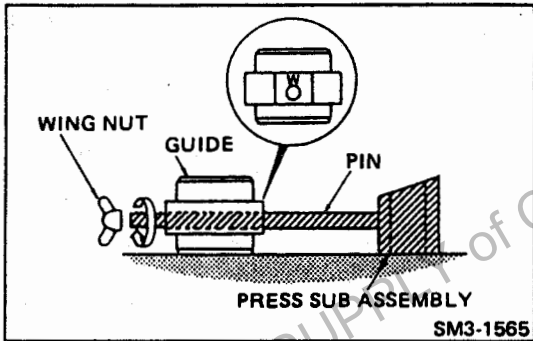


6. Tighten the cap bolts in three stages following the tightening order.

**NOTE:** Apply engine oil to the bolt threads and under the bolt head.

Tightening order: 4-3-5-2-6-1-7

- NOTE:**
- Make sure that the crankshaft rotates smoothly.
  - Inspect the crankshaft end play.



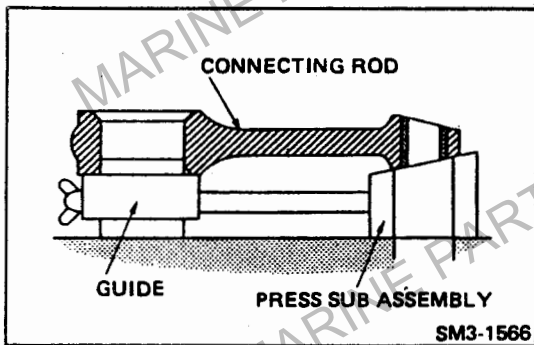
**IF NECESSARY, REPLACE THE PISTON PIN BUSHING.**

1. Prepare the special tools.

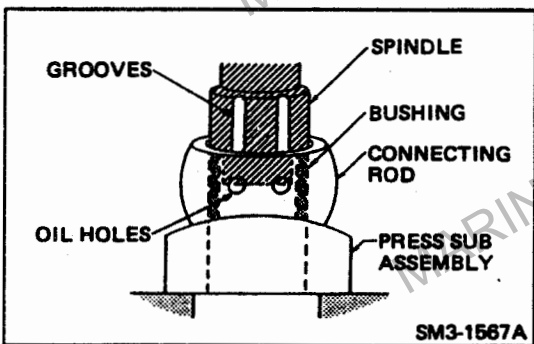
Assemble the guide and press sub assembly inserting its pin into the guide, then secure them with the wing nut.

**Special tools:** Guide (09481-1130)  
 Press subassembly (09402-1450)  
 Wing nut (9233-10360)

**NOTE:** ○ Bring letter "W" punched on the guide above the pin.  
 ○ Make sure to align both supporting surface of the guide and press sub assembly flush on a flat plane.



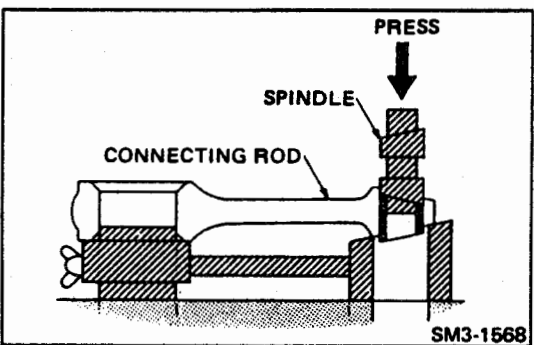
2. Using a special tool, remove the piston pin bushing.
  - a. Set the connecting rod assembled without crank pin bore bearing on the guide and press subassembly.



- b. Install the spindle on the bushing.
 

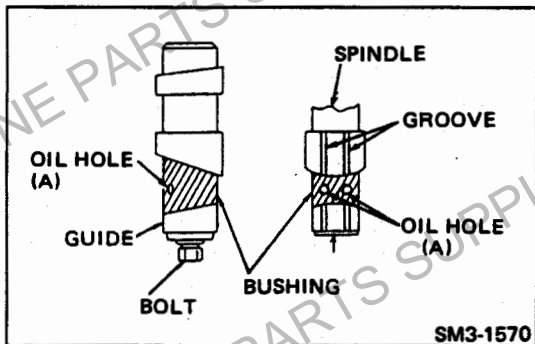
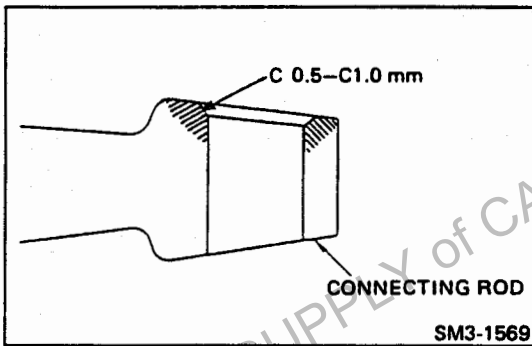
**Special tool:** Spindle (09402-1470)

**NOTE:** Align the grooving of the spindle with the oil hole of the bushing.



- c. Using a hydraulic press, remove the bushing.
 

**NOTE:** Always operate the press slowly and smoothly.



3. Assemble the piston pin bushing.  
Chamfer one edge of the bushing hole at the small end of the connecting rod uniformly by C 0.5–1.0 mm (0.0196–0.0393 in).

**NOTE:**

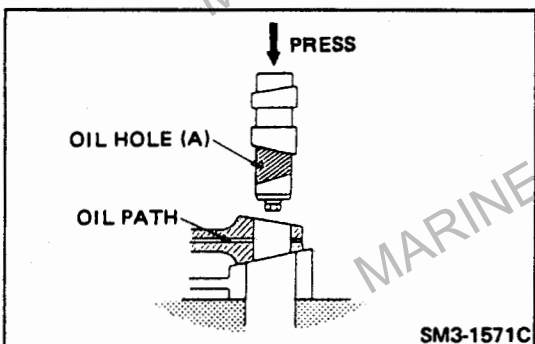
- Irregular chamfering can cause out-of-roundness of the pressed bushing, which may result in jamming during insertion.
- Remove dust from the inner surface of the small-end hole.

4. Mount the bushing on the spindle.
- a. Set the bushing and guide on the spindle aligning oil hole (A) in the bushing the grooves on the both the spindle and guide.
  - b. Secure the bushing and guide with the bolt.

**Special Tool:** Spindle (09402-1470)  
Guide (09481-1140)  
Bolt (9191-08252)

**NOTE:**

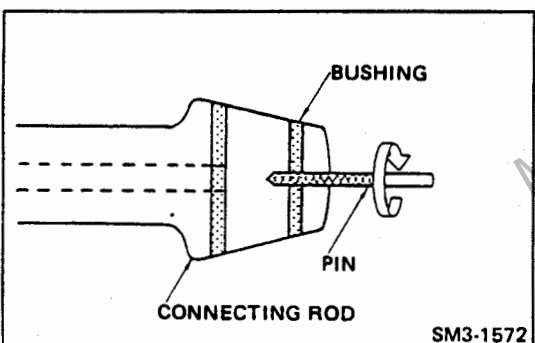
- Be sure to slip the bushing over the spindle in the proper direction so that oil hole (A) will later align with the oil path in the connecting rod.
- Apply fresh engine oil to the bushing and guide.



5. Install the bushing in the connecting rod.  
Position the bushing—special tool assembly so that oil hole (A) align with the oil path through the connecting rod.

**NOTE:**

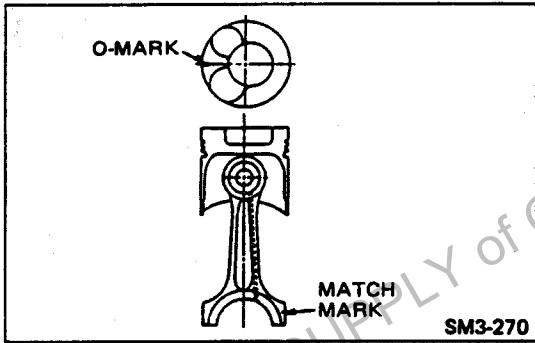
- Fully coat the bore in the connecting rod with fresh engine oil.
- Always operate the press slowly and smoothly.



6. Inspect the bushing position after installation.

**NOTE:**

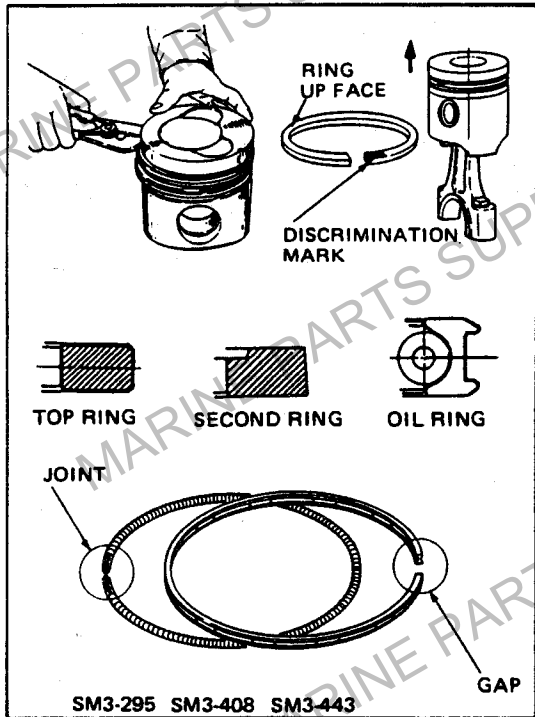
- Make sure that the oil holes of the bushing and connecting rod are aligned.
- Insert a pin of 3.0 mm (0.1181 in) dia. into an hole at the end of the connecting rod, and make sure that the pin fully penetrates.  
If there is any deviation in the alignment of the oil holes correct it with a drill of 3.0 mm (0.1181 in) dia.
- Misalignment of the oil holes leads to insufficient lubrication, which may result in seizure.
- Insert a new piston pin and rotate it slowly to make sure that there is no rattling.



**ASSEMBLE THE PISTON AND CONNECTING ROD.**

Make sure that the O-mark at the top of the piston and the connecting rod match mark in opposite directions.

- NOTE:**
- Use the new retainer rings.
  - Heat the piston to about 80 – 90°C (176 – 194°F) in hot water about 5 minutes.



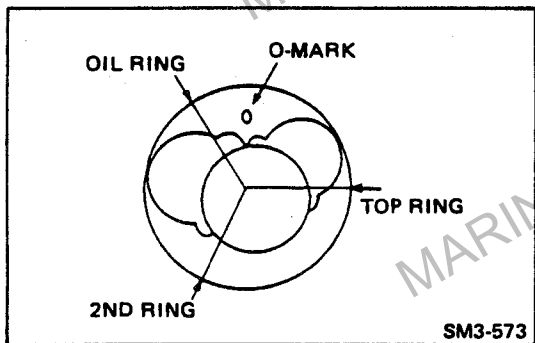
**INSTALL THE PISTON RING.**

1. Install the piston rings in the sequence oil ring, second ring and top ring with the identification mark at the top of the ring facing up.

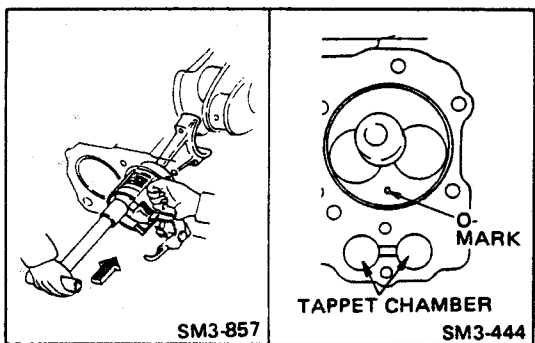
- NOTE:**
- Identification mark of second ring and oil ring is applied with gold paint.
  - Apply oil to the piston pin.

**Special Tool:** Piston Ring Expander (09442-1180)

2. Connect the ends of the coil expander and then fit the coil inside the piston ring after ensuring that the gap of the piston ring is 180° away from the joint of the coil.



3. Arrange the piston rings so that their gaps are equally spaced.

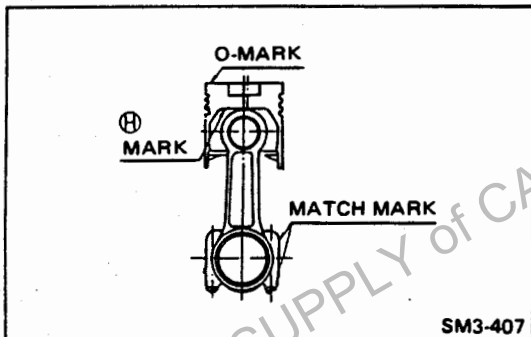


**INSTALL THE PISTON IN THE CYLINDER LINER.**

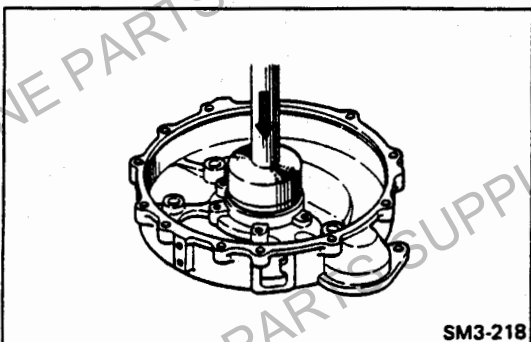
Apply engine oil to the piston, cylinder liner and connecting rod bearing surface.

- NOTE:** Check the piston that the O-mark on the top is on the tappet chamber side.

**Special Tool:** Piston Ring Holder (09441-1260)

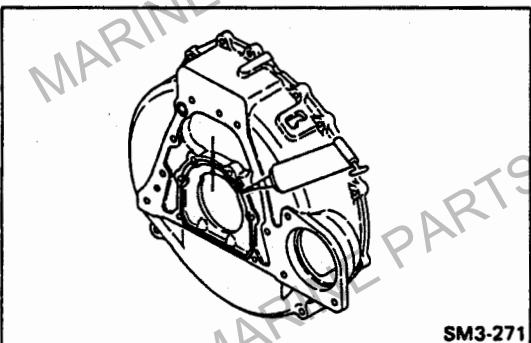
**INSTALL THE CONNECTING ROD.**

1. Apply engine oil to the cap bearing surface.
2. Align the matching marks on the connecting rod and cap.
3. Apply engine oil to the bolt threads and under the bolt head.
4. Tighten the cap bolt in three stages.

**IF NECESSARY, REPLACE THE FLYWHEEL HOUSING OIL SEAL.**

1. Using a screwdriver, remove the oil seal.
2. Install the new oil seal.

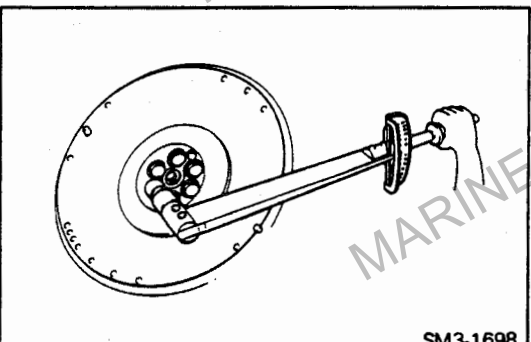
**Special Tool: Flywheel Housing Oil Seal Press (09482-1540)**

**INSTALL THE FLYWHEEL HOUSING.**

1. Clean the faces.
2. Apply the liquid gasket as shown and install the flywheel housing within 20 minutes.

**NOTE: If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.**

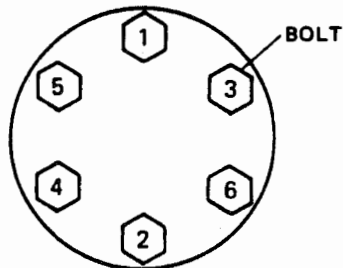
**Coating Width: 1.5–2.5 mm (0.06–0.10 in)**

**INSTALL THE FLYWHEEL.**

Install the flywheel and tighten the bolts through several repetitions of the tightening order so as to reach specified torque evenly and gradually, then slacken and tighten them one by one to the specified torque.

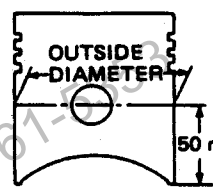
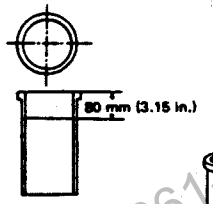
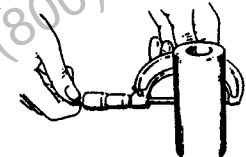
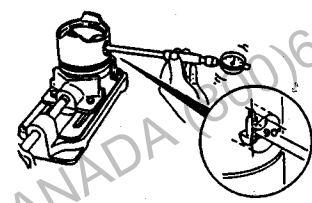
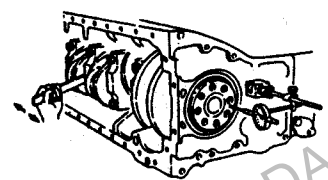
- NOTE:**
- Align the "O" mark on the flywheel and crankshaft collar knock-in.
  - When tightening the bolt, apply engine oil to the threads and flywheel surface of the bolts.

**TIGHTENING ORDER**

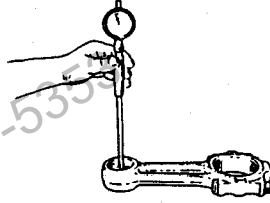
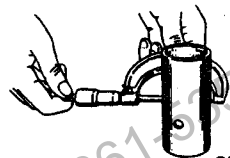
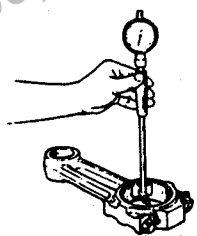
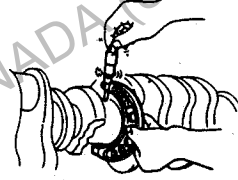
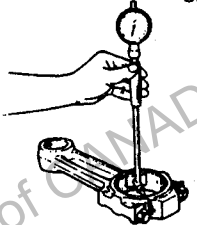
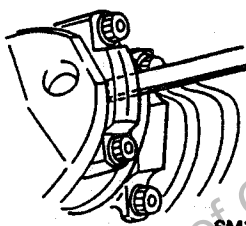


INSPECTION AND REPAIR

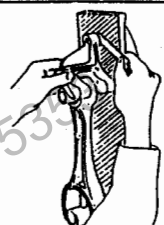
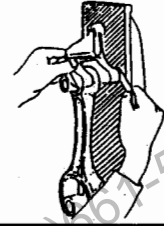
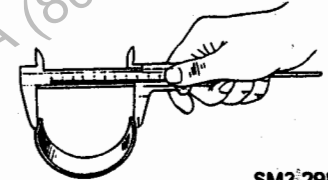
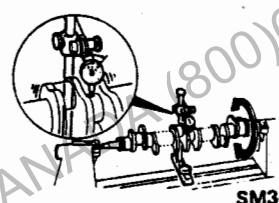
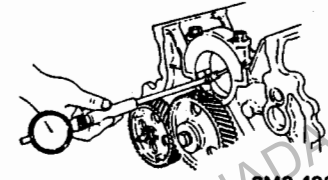
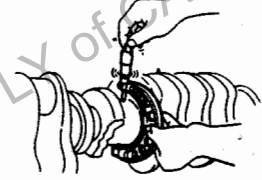
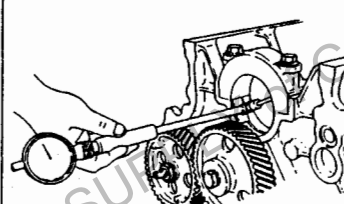
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Piston Diameter	103.852–103.884 (4.0887–4.0899)	–	Replace piston and/or liner	  SM3-202 SM3-432 SM3-313
Cylinder Liner Inside Diameter	104.008–104.040 (4.0949–4.0960)	104.15 (4.1003)		
Clearance between Piston and Cylinder Liner	0.140–0.172 (0.0056–0.0067)	–		
Piston Pin Diameter	36.987–37.003 (1.4562–1.4568)	36.98 (1.4559)	Replace piston and/or piston pin	 SM3-859
Piston Pin Hole Inside Diameter	36.987–37.003 (1.4562–1.4568)	37.02 (1.4575)		
Clearance between Piston Pin and Piston Pin Hole	0.013T–0.014L (0.00052T–0.00055L) T : Tight, L: Loose	0.03 (0.0011)		 SM3-1585
Crankshaft end Play	0.05–0.22 (0.0020–0.0086)	0.4 (0.0157)	Replace thrust bearing	 SM3-362

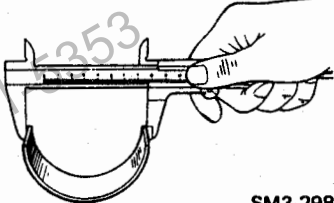
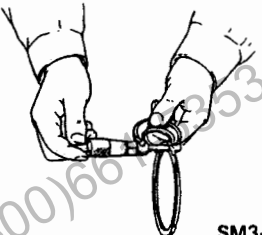
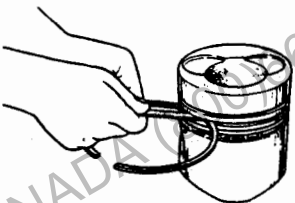
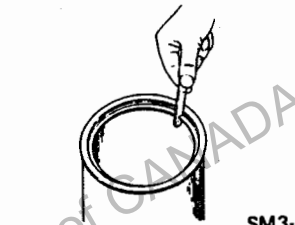

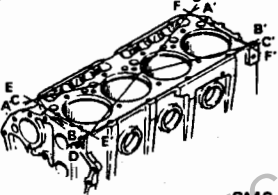
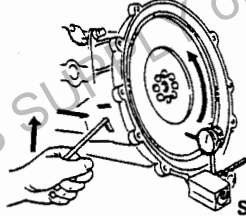
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Connecting Rod Small End Bushing Inside Diameter	37.015–37.025 (1.4573–1.4577)	37.07 (1.4594)	Replace bushing and/or piston pin	 SM3-296
Piston Pin Diameter	36.987–37.003 (1.4562–1.4568)	36.98 (1.4559)		 SM3-297
Clearance between Piston Pin And Connecting Rod Small End Bushing	0.015–0.036 (0.0006–0.0014)	0.08 (0.0031)		
Connecting Rod Big end Inside Diameter without Bearing	65.985–66.000 (2.5979–2.5984)	–	Replace connecting rod assembly	 SM3-300
Crank Pin Diameter	61.94–61.96 (2.4386–2.4393)	–0.20 (–0.0078)	Regrind and use undersize bearing	 SM3-860
		60.76 (2.3921)	Replace crankshaft	
Clearance between Connecting Rod and Crank Pin	0.031–0.082 (0.0013–0.0032)	0.12 (0.0047)	Replace bearing	 SM3-300
Connecting Rod end Play	0.20–0.52 (0.0079–0.0204)	0.6 (0.0236)	Replace the connecting rod.	 SM3-862

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Connecting Rod Straightness	-	0.1 (0.0039) Par 200 (7.874)	Replace	 SM3-541
Connecting Rod Twist	-	0.1 (0.0039) Par 200 (7.874)	Replace	 SM3-542
Connecting Rod Bearing Spread Dimension	67.05-67.55 (2.6398-2.6594)	-	Replace	 SM3-298
Crankshaft Bend	-	0.04 (0.0015)	Repair or replace	 SM3-861
Crankshaft Main Bearing Cap Inside Diameter Without Bearing	77.985-78.000 (3.0703-3.0709)	-	Replace	 SM3-436
Crankshaft Journal Diameter	72.94-72.96 (2.8717-2.8724)	-0.20 (-0.0078)	Regrind and use undersize bearing	 SM3-860
		71.76 (2.8252)	Replace crankshaft	
Clearance between Crankshaft Journal and Main Bearing	0.039-0.090 (0.0016-0.0035)	0.13 (0.0051)	Replace bearing	 SM3-436

Unit: mm (in)


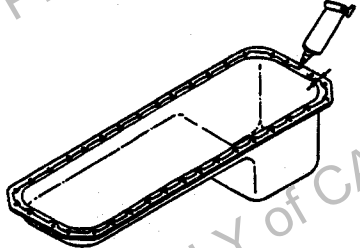
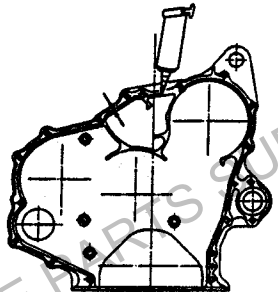
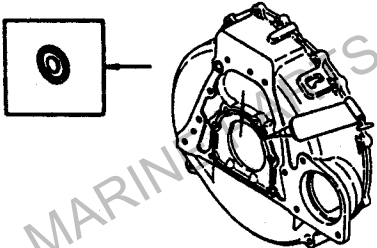
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Crankshaft Main Bearing Spread Dimension	79.00–79.60 (3.1103–3.1338)	-	Replace	 SM3-298
Piston Ring Breadth Ring No.:	Top: Not easily measured		Replace	 SM3-379
	2nd: 2.47–2.49 (0.0972–0.0980)	2.32 (0.0913)		
	Oil: 4.97–4.99 (0.1957–0.1964)	4.95 (0.1949)		
Piston Ring Groove Breadth Ring No.:	Top: Not easily measured		Replace piston ring and/or piston	 SM3-301
	2nd: 2.53–2.55 (0.0996–0.1004)	2.14 (0.0842)		
	Oil: 5.01–5.03 (0.1973–0.1980)	5.08 (0.2000)		
Clearance between Piston Ring and Piston Ring Breadth Ring No.:	Top: Not easily measured		Replace	 SM3-302
	2nd: 0.04–0.08 (0.0015–0.0032)	0.30 (0.0118)		
	Oil: 0.02–0.06 (0.0008–0.0023)	0.08 (0.0031)		
Piston Ring Gap All Rings: • Insert the Piston Rings Where the Wear of the Liner is Small.	Top: 0.3–0.45 (0.0119–0.0177)	1.2 (0.0472)	Replace	 SM3-216
	2nd: 0.3–0.45 (0.0119–0.0177)			
	Oil: 0.3–0.45 (0.0119–0.0177)			
Cylinder Block Flatness	Less than 0.05 (0.0019)	0.1 (0.0039)	Regrind and/or replace	 SM3-216
Flywheel Face Alignment	-	0.15 (0.0059)	Regrind and/or replace	 SM3-908

# LIQUID GASKET AND APPLICATION POINTS

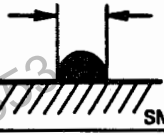
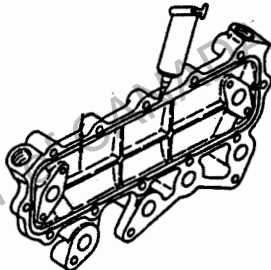
The W06D-T1 type engine use liquid gasket (Three Bond TB1207C, 04132-1207).  
Apply liquid gasket, therefore, taking the following items into account.

## 1. LIQUID GASKET APPLICATION POINTS AND COATING WIDTH

Unit: mm (in)

Parts name	Application point	Coating width  SM3-1932
(a) Oil pan	<p>Flange face which mates with cylinder block and timing gear cover</p>  <p>SM3-1929</p>	<p>3 – 4 (0.12 – 0.16)</p>
(b) Timing gear cover	<p>Face which mates with timing gear plate (flange face, boss face)</p>  <p>SM3-247</p>	<p>1.5 – 2.5 (0.06 – 0.10)</p>
(c) Flywheel housing	<p>Faces which mates with cylinder block (flange face, boss face)</p>  <p>SM3-271</p>	<p>1.5 – 2.5 (0.06 – 0.10)</p>

Unit: mm (in)

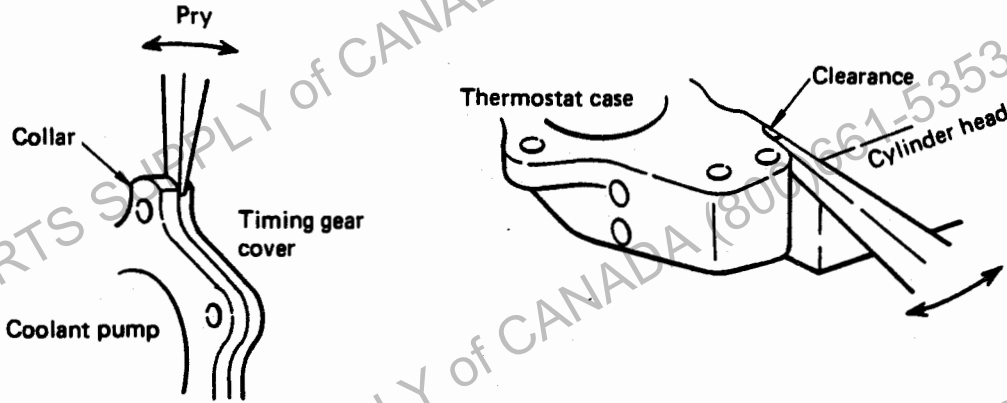
Parts name	Application point	Coating width  SM3-1932
(d) Oil cooler	Flange face which mates with cylinder block  SM3-269	1.5 – 2.5 (0.06 – 0.10)
(e) Coolant pump	Flange face which mates with timing gear cover	1.5 – 2.5 (0.06 – 0.10)
(f) Thermostat case	Flange face which mates with cylinder head	1.5 – 2.5 (0.06 – 0.10)
(g) Intake manifold	Flange face which mates with cylinder head	1.5 – 2.5 (0.06 – 0.10)
(h) Intake pipe	Flange face which mates with intake manifold	1.5 – 2.5 (0.06 – 0.10)

## 2. COATING LIQUID GASKET AND PARTS ASSEMBLY PROCEDURE

- (1) Completely remove old liquid gasket from each part and the respective mating part, and remove oil, water, and dirt using a cloth.
- (2) Be careful not to apply excessive or insufficient liquid gasket. Also, be sure to overlap the start and end of each coating.
- (3) When assembling coated parts, be careful that there is no misalignment between mating parts. If there is any misalignment, coat the parts again.
- (4) Assemble the various parts within 20 minutes after applying liquid gasket. If more than 20 minutes have elapsed, remove the liquid gasket and apply it again.
- (5) After assembling the various parts, wait for at least 15 minutes before starting the engine.

**3. REMOVING PARTS**

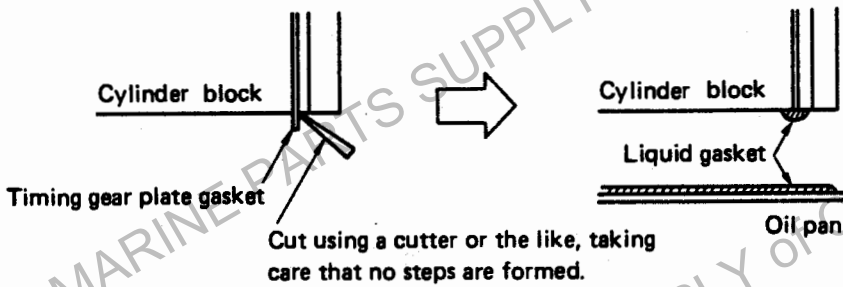
When removing each part, do not attempt to pry one portion of the flange alone but use the flange collar or clearance to pry the flange at several points alternately.



SM3-1933

**4. TIMING GEAR PLATE GASKET**

When replacing the timing gear plate gasket, cut it so that no steps are formed in it, then liberally apply liquid gasket to the cut face and assembly the oil pan.



Cut using a cutter or the like, taking care that no steps are formed.

SM3-1932

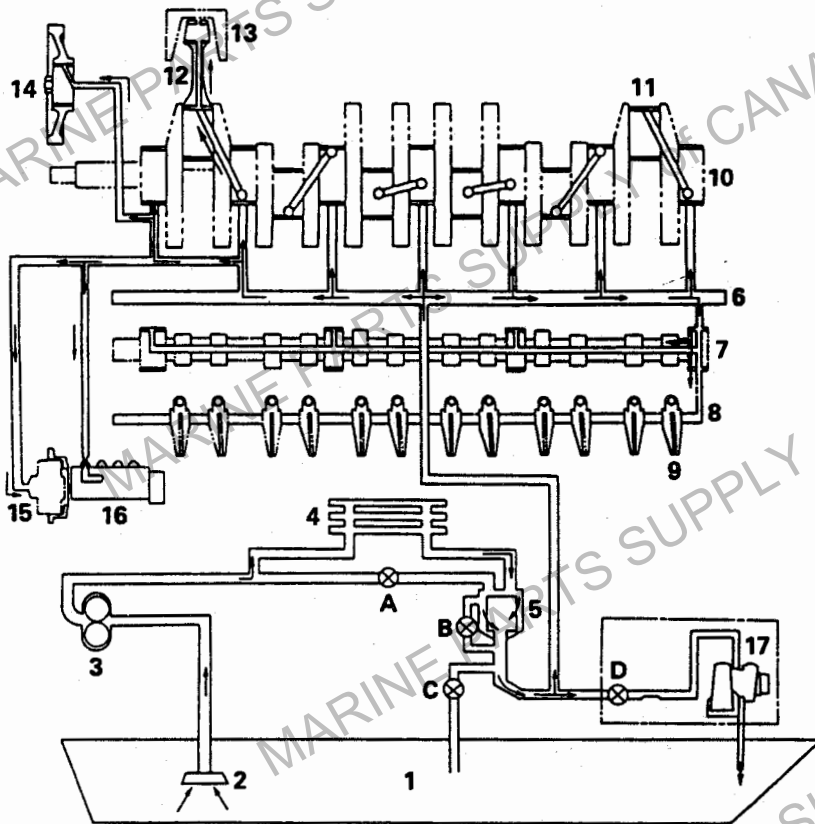
**NOTE:** The flange of the oil pan may sometimes become deformed preventing it from being reused. To prevent this, therefore, first insert plates with a thin edge at several points around the periphery of the oil pan, then remove the oil pan using a screwdriver.

# LUBRICATING SYSTEM

## DATA AND SPECIFICATIONS

Oil pump	
Type .....	Full forced pressure feed by gear pump
Drive .....	By gear
Oil cooler	
Type .....	Multi plates type, water-cooled

## LUBRICATING SYSTEM DIAGRAM

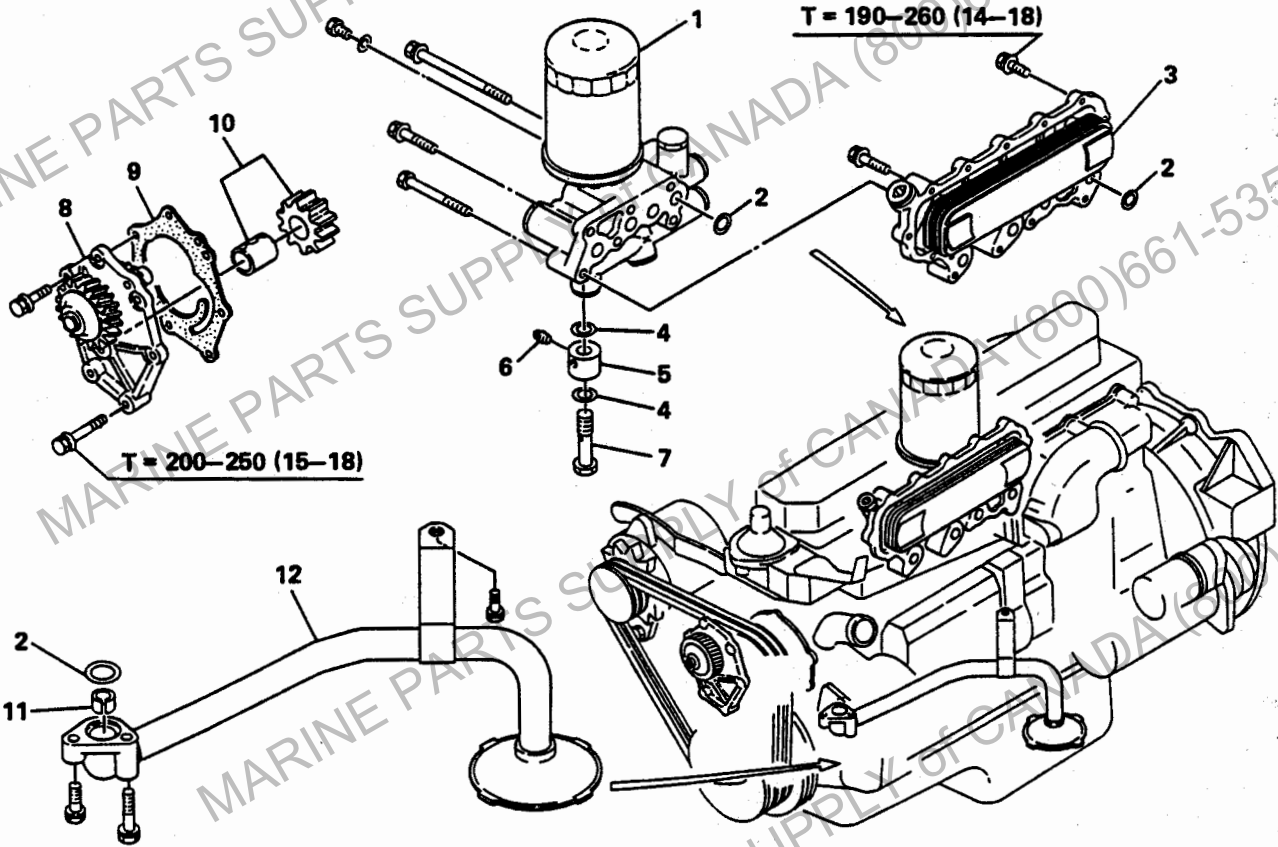


1. Oil pan
2. Oil strainer
3. Oil pump
4. Oil cooler
5. Oil filter
6. Main oil hole
7. Camshaft
8. Rocker arm shaft
9. Rocker arm
10. Crankshaft journal
11. Crankshaft pin
12. Connecting rod
13. Piston
14. Idler gear
15. Fuel injection pump drive gear
16. Fuel injection pump
17. Turbocharger
- A. Oil cooler safety valve
- B. Oil filter safety valve
- C. Regulator valve
- D. Check valve

SM3-1922

**OVERHAUL**

HE11-059-00X00~03  
(1400)

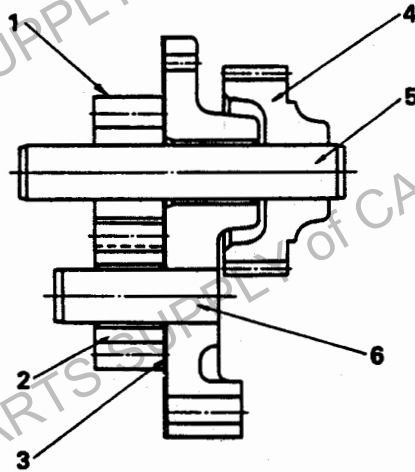


T = Tightening torque: kg-cm (lb.ft)

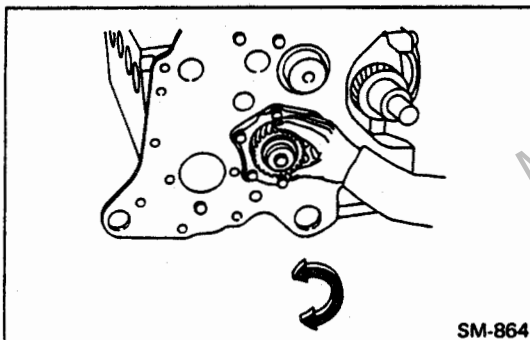
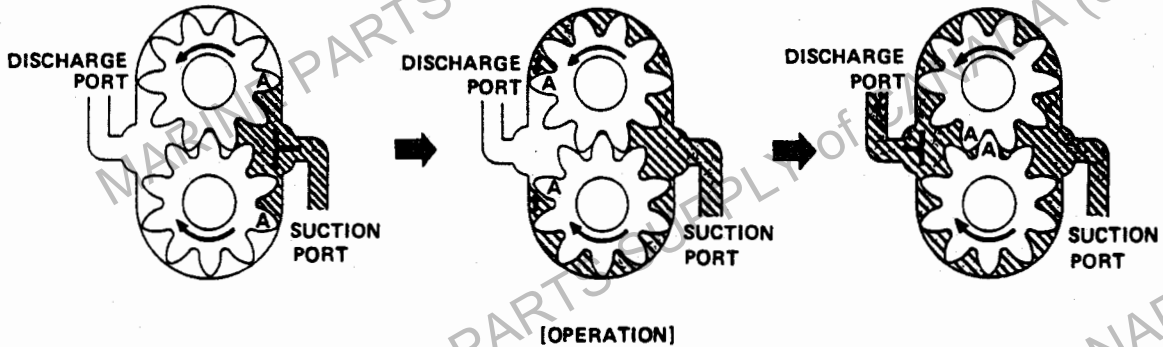
- |                   |                               |                  |
|-------------------|-------------------------------|------------------|
| 1. Oil filter     | 6. Plug                       | 11. O-ring guide |
| 2. O-ring         | 7. Connector bolt             | 12. Oil strainer |
| 3. Oil cooler     | 8. Oil pump cover subassembly |                  |
| 4. Soft washer    | 9. Gasket                     |                  |
| 5. Connector pipe | 10. Oil pump driven gear      |                  |

OIL PUMP

DESCRIPTION



- 1. Drive gear (Inside)
- 2. Driven gear
- 3. Gasket
- 4. Drive gear (Outside)
- 5. Drive shaft
- 6. Driven shaft



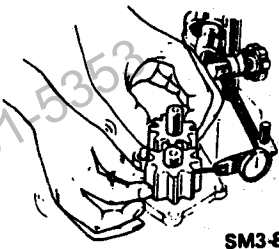
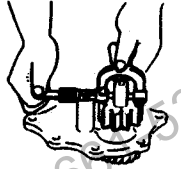
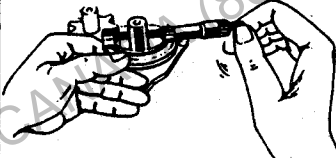
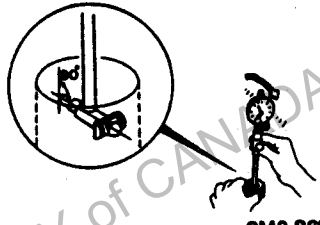

IMPORTANT POINT – MOUNTING

INSTALL THE OIL PUMP.

- 1. Apply oil liberally to cylinder block pump case and bearing before installing oil pump.
- 2. Confirm smooth rotation of oil pump after tightening bolts.

INSPECTION AND REPAIR

Unit: mm (in)

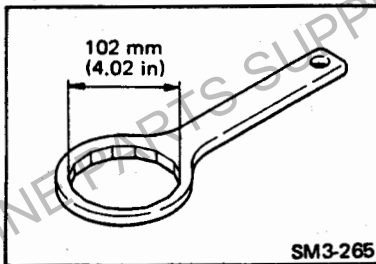
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Gear Backlash	0.09–0.21 (0.0036–0.0082)	0.30 (0.0118)	Replace gear	 SM3-867
Drive Gear Shaft Diameter	18.088–18.106 (0.7122–0.7128)	18.060 (0.7110)	Replace	 SM3-870
Drive Shaft Bearing Inside Diameter	18.146–18.173 (0.7145–0.7154)	18.20 (0.7165)	Replace	
Clearance between Drive Shaft and Bearing	0.040–0.085 (0.0080–0.0033)	0.1 (0.0039)	Replace bearing and/or shaft	
Driven Gear Shaft Diameter	17.979–17.997 (0.7079–0.7085)	17.970 (0.7074)	Replace	 SM3-868
Driven Gear Inside Diameter	18.037–18.054 (0.7102–0.7107)	18.070 (0.7114)	Replace	 SM3-869
Clearance between Driven Gear and Shaft	0.040–0.075 (0.0080–0.0023)	0.1 (0.0039)	Replace bearing and/or shaft	
Gear Teeth Pitting or Wear	-	-	Replace, if necessary	Visual check  SM3-845

## OIL COOLER AND OIL FILTER

## SPECIAL TOOL

Prior to starting an engine overhaul, it is necessary to have these special tools.

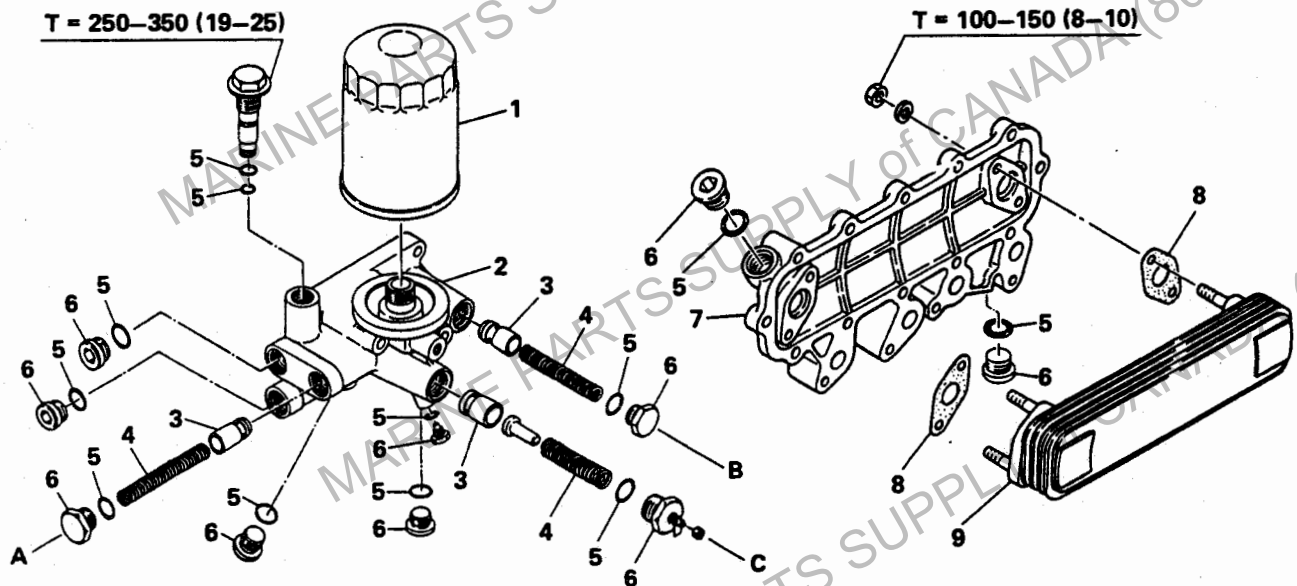
## WRENCH



09553-1010

For spin-on type oil filter

## OVERHAUL

1419M  
I-No.211425G  
I-No. 20

T = Tightening torque: kg-cm (lb.ft)

1. Oil filter
2. Oil filter cover
3. Valve
4. Spring
5. O-ring
6. Plug

7. Oil cooler case
8. Gasket
9. Oil cooler element

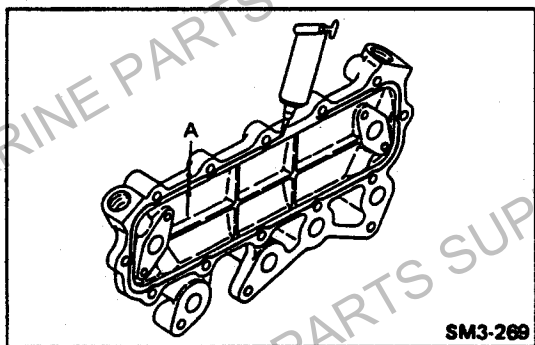
- A. Oil filter safety valve  
1.3 kg/cm<sup>2</sup> (18.5 lb/sq.in)
- B. Oil cooler safety valve  
4.0 kg/cm<sup>2</sup> (56.9 lb/sq.in)
- C. Regulator valve  
4.0 kg/cm<sup>2</sup> (56.9 lb/sq.in)

**IMPORTANT POINT – DISMOUNTING**

**REMOVE THE SPIN-ON TYPE OIL FILTER.**

Using a special tool, unscrew the oil filter.

Special Tool: Wrench (09553-1010)



SM3-269

**IMPORTANT POINTS – MOUNTING**

**INSTALL THE OIL COOLER.**

1. Clean the faces.
2. Apply the liquid gasket as shown and install the oil cooler within 20 minutes.

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

Coating Width (A): 1.5–2.5 mm (0.06–0.10 in)

**INSTALL THE SPIN-ON TYPE OIL FILTER.**

1. Apply a slight amount of engine oil to the gasket of the new filter.
2. Tighten the new filter by hand until the gasket touches the cover and the tighten another 3/4 to 1 full turn with a special tool.

Special Tool: Wrench (09553-1010)

**INSPECTION AND REPAIR**

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Valve and Springs of Oil Filter. Wear or Damage.	—	—	Replace, if necessary.	Visual check

# FUEL SYSTEM

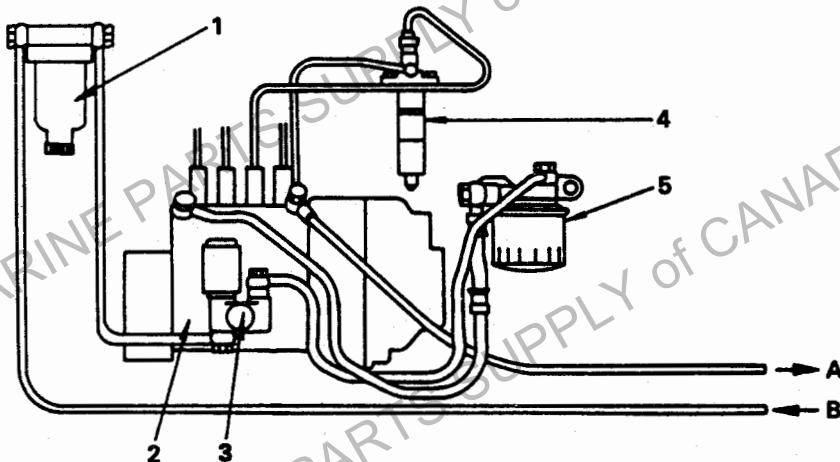
## DATA AND SPECIFICATIONS

**Injection nozzle**

Type ..... Multi-hole nozzle type

Opening pressure ..... 220 kg/cm<sup>2</sup> (3,129 lb/sq.in)

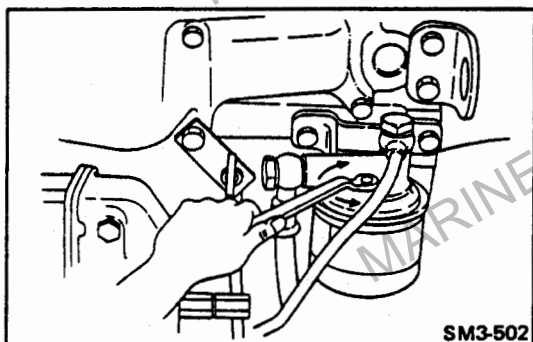
## FUEL SYSTEM DIAGRAM



- 1. Water separator (if so equipped)
- 2. Fuel injection pump
- 3. Fuel feed pump
- 4. Injection nozzle
- 5. Fuel filter
- A. To fuel tank
- B. From fuel tank

NOTE: Figure illustrates 4-cylinder engine.

SM3-227A



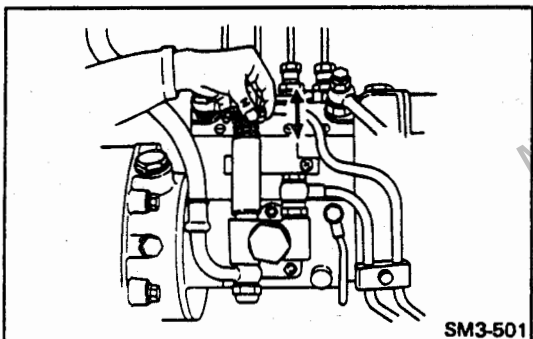
SM3-502

### AIR BLEEDING FROM FUEL SYSTEM.

1. Loosen the bleeder plug on the fuel filter.
2. Loosen the priming pump knob.
3. Operate the priming pump knob until the air will not come out from the bleeder plug.
4. Tighten the bleeder plug.

Tightening Torque: 40–60 kg-cm (3–4 lb.ft)

NOTE: The bleeder plug should be tightened while the priming pump knob is operated.



SM3-501

5. Once again, operate the priming pump knob several times.
6. Push back the priming pump knob and tighten it.

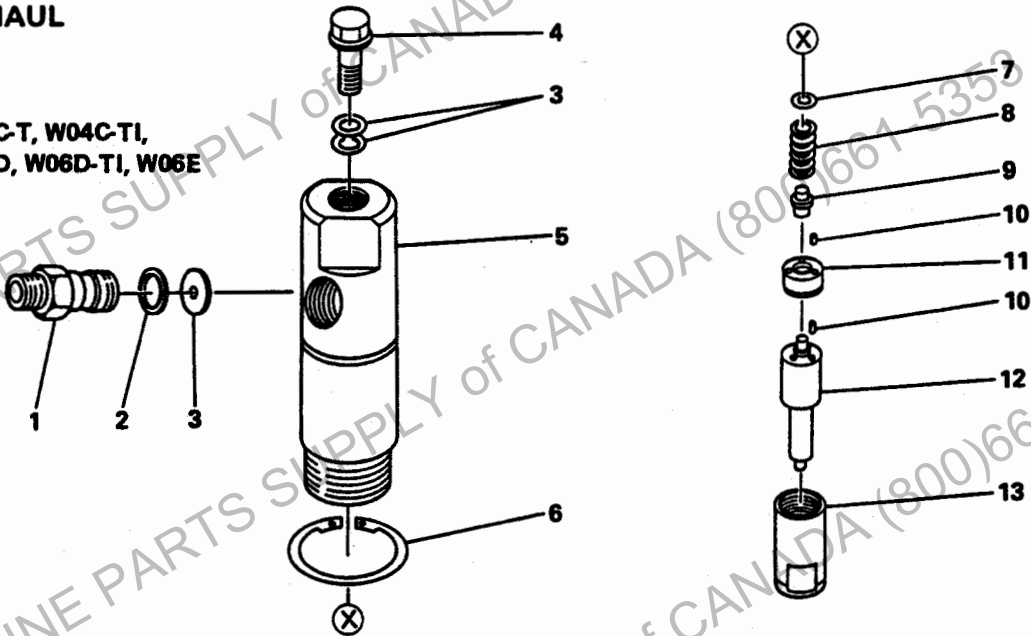
NOTE: Wipe off any splashed fuel.

# INJECTION NOZZLE

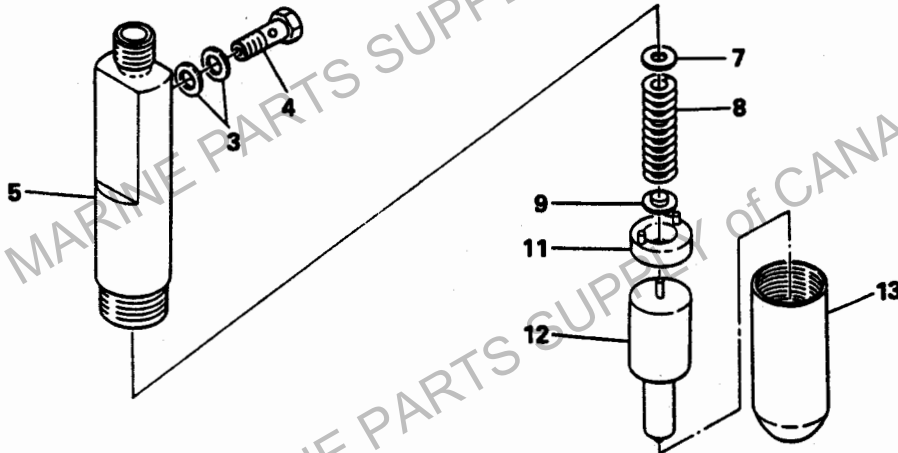
## OVERHAUL

1530V  
I-No. 20

For W04C-T, W04C-TI,  
W06D, W06D-TI, W06E



For W04D



SM3-1238A

- |                  |                               |                          |
|------------------|-------------------------------|--------------------------|
| 1. Connector     | 6. Retainer ring              | 11. Distance piece       |
| 2. Packing ring  | 7. Shim                       | 12. Nozzle               |
| 3. Gasket        | 8. Spring                     | 13. Nozzle retaining nut |
| 4. Joint bolt    | 9. Nozzle holder pressure pin |                          |
| 5. Nozzle holder | 10. Pin                       |                          |

### IMPORTANT POINTS – DISMOUNTING

REMOVE THE NOZZLE HOLDER ASSEMBLY.

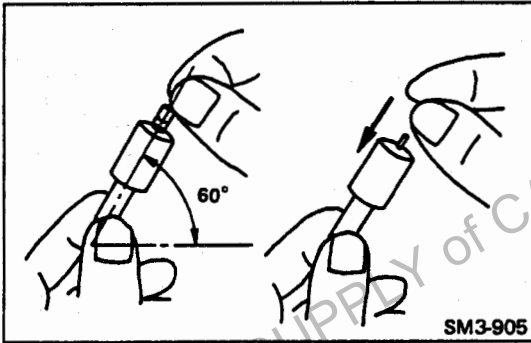
Refer to Section ENGINE MOVING PARTS.

**IMPORTANT POINTS – ASSEMBLY**

**TEST THE NOZZLE SKINKING.**

Wash the nozzle proper with diesel fuel oil, then immerse it in diesel fuel oil.

Next slide the needle inside the nozzle proper and ensure that it move smoothly. The needle valve should fall under its own weight when withdrawn vertically about 1/3 and released. If its motion is sluggish, replace the nozzle with a new one.



SM3-905

**ADJUST THE INJECTION PRESSURE.**

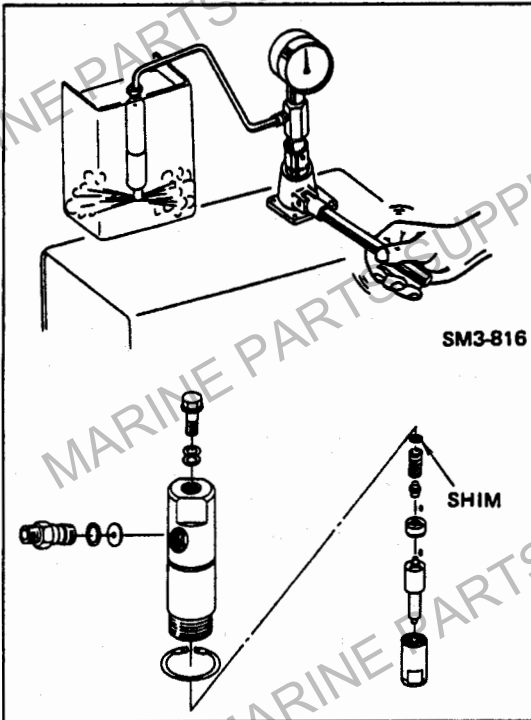
1. Connect the nozzle holder with a nozzle tester and move the lever at the rate of about 50 to 60 times per minute.

Injection Pressure: 220 kg/cm<sup>2</sup> (3,129 lb/sq.in)

**WARNING**

- Diesel fuel is flammable. This nozzle adjusting should be done a well ventilated room and away from any open flames or electric spark.
- The spray must always be covered. Keep your face and body away from the spray. This is because of the risk of fuel oil getting in your eyes or passing into your body.

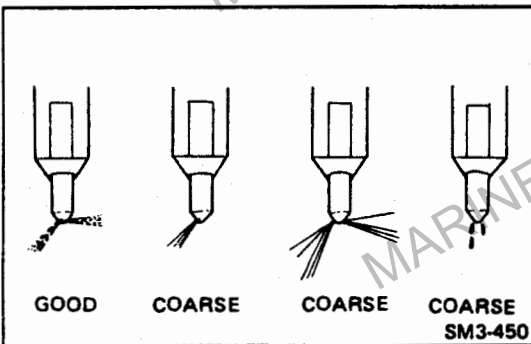
2. If the injection pressure is not within specification, change the shim.



SM3-816

**TEST THE SPRAY PROFILE.**

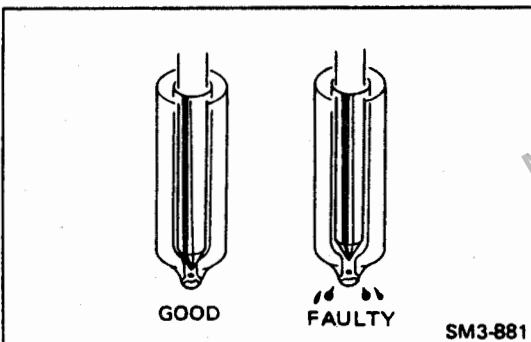
In the case of the new nozzle, operate the lever at the rate of 30 to 60 strokes per minute, and for a used nozzle, operate the lever at the rate of 15 to 60 strokes per minute.



SM3-450

**TEST THE FUEL LEAKAGE.**

When checking for fuel leakage from the nozzle, apply a pressure of about 10 to 20 kg/cm<sup>2</sup> (142–284 lb/sq.in) lower than the correct injection pressure to the nozzle by means of the nozzle tester. If there is no fuel leakage, the nozzle is normal.



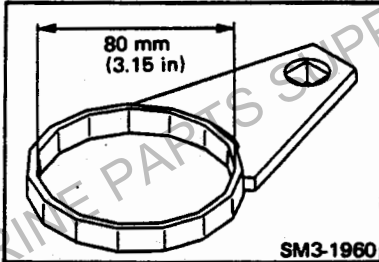
SM3-881

# FUEL FILTER

## SPECIAL TOOL

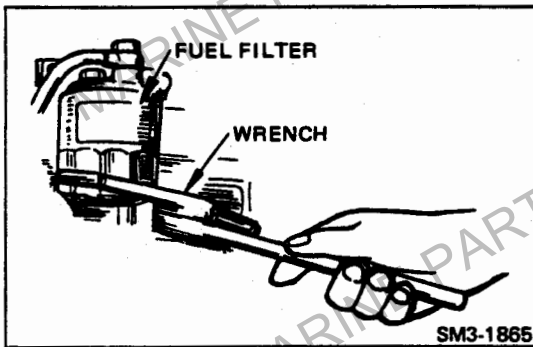
Prior to starting an engine overhaul, it is necessary to have these special tools.

### WRENCH



**09503-1040**

For spin-on type fuel filter



### IMPORTANT POINT – DISMOUNTING

#### REMOVE THE SPIN ON TYPE FUEL FILTER.

Using a special tool, unscrew the fuel filter.

- NOTE:**
- Be careful not to spill diesel fuel.
  - When removing the fuel filter for W04C-TI and W06D-TI, use a suitable wrench.

**Special Tool:** Wrench (09503-1040) for W04D, W04C-T, W06E

### IMPORTANT POINT – MOUNTING

#### INSTALL THE SPIN-ON TYPE FUEL FILTER.

1. Apply a small amount of diesel fuel to the gasket of a new fuel filter.
2. Manually tighten the new fuel filter until its gasket touches the cover and then tighten another 2/3 turn with a special tool.

**NOTE:** When installing the fuel filter for W04C-TI and W06D-TI, use a suitable wrench.

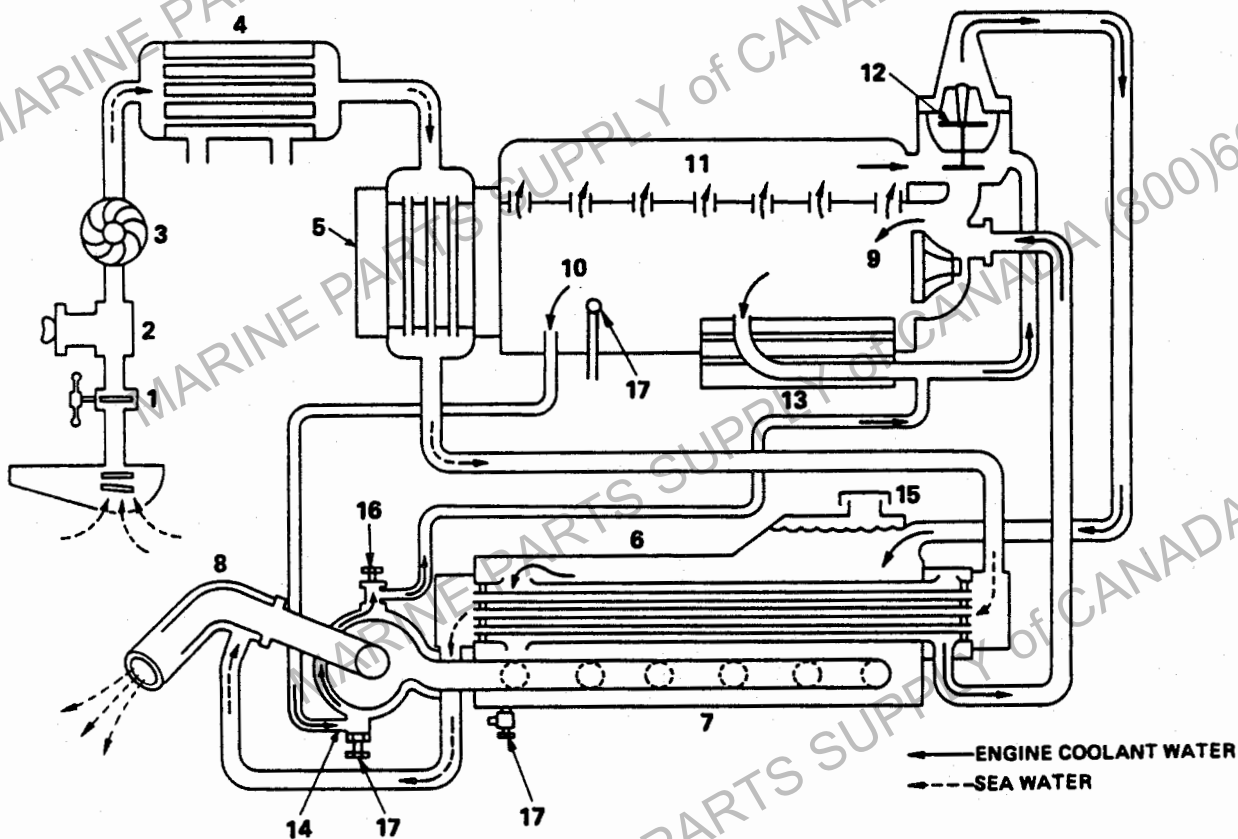
**Special Tool:** Wrench (09503-1040) for W04D, W04C-T, W06E

# COOLING SYSTEM

## DATA AND SPECIFICATIONS

<b>Coolant pump</b>	
Type .....	Forced circulation by volute pump
Drive .....	By V-belt
<b>Seawater pump</b>	
Type .....	Self priming type (Flexible impeller pump)
Drive .....	By gear
<b>Thermostat</b>	
Type .....	Wax type, bottom bypass system
Valve opening temperature .....	76,5°C (170°F)

## COOLING SYSTEM DIAGRAM

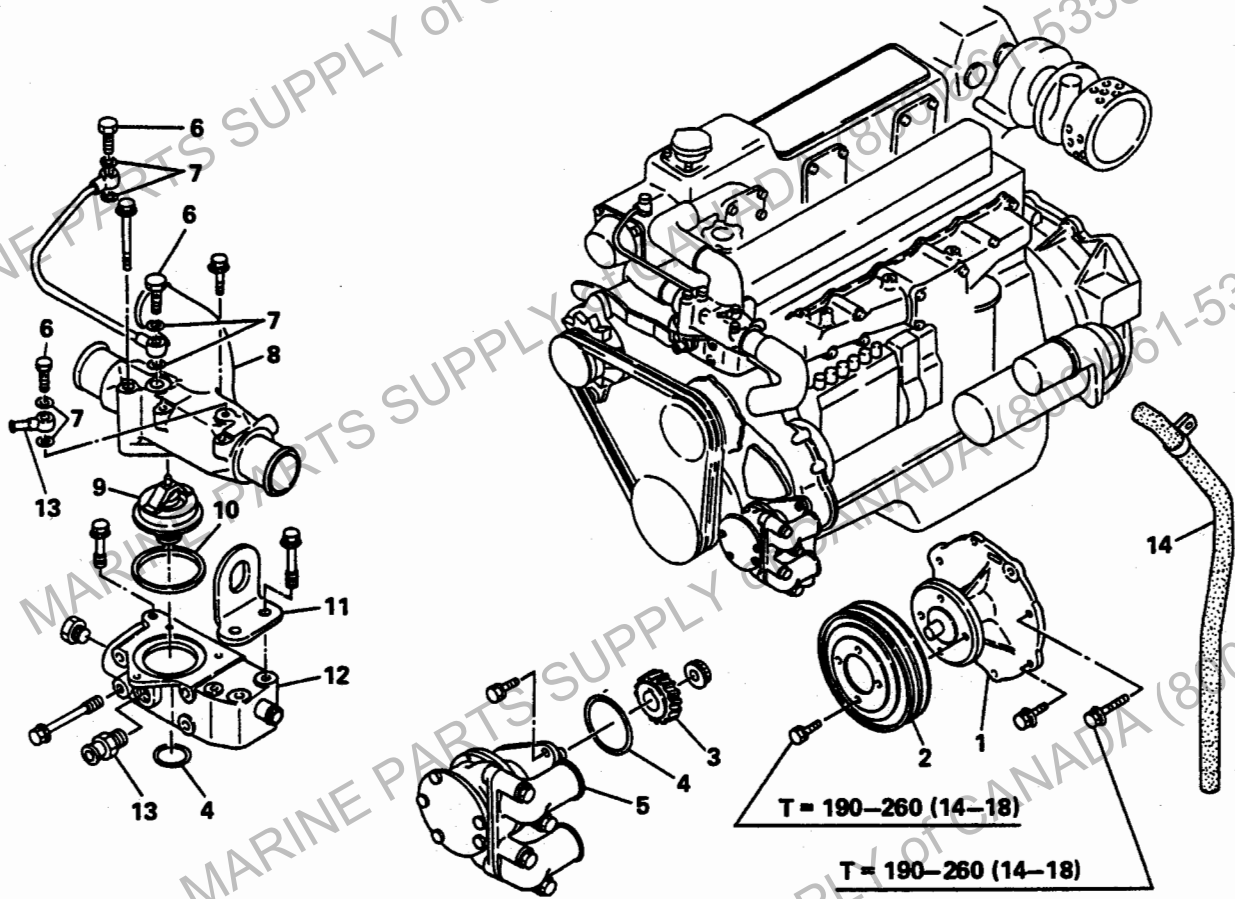


SM3-1793

- |                                    |                                  |                               |
|------------------------------------|----------------------------------|-------------------------------|
| 1. Seawater intake valve (Seacock) | 7. Water cooled exhaust manifold | 13. Engine oil cooler         |
| 2. Seawater filter                 | 8. Exhaust pipe                  | 14. Water cooled turbocharger |
| 3. Seawater pump                   | 9. Coolant pump                  | 15. Coolant filler cap        |
| 4. Intercooler                     | 10. Cylinder block               | 16. Air bleeder plug          |
| 5. Transmission fluid cooler       | 11. Cylinder head                | 17. Coolant drain plug        |
| 6. Heat exchanger                  | 12. Thermostat                   |                               |

**OVERHAUL**

HE11-059-00X01



SM3-1934

T = Tightening torque: kg-cm (lb.ft)

- 1. Coolant pump
- 2. Coolant pump pulley
- 3. Seawater pump drive gear
- 4. O-ring
- 5. Seawater pump

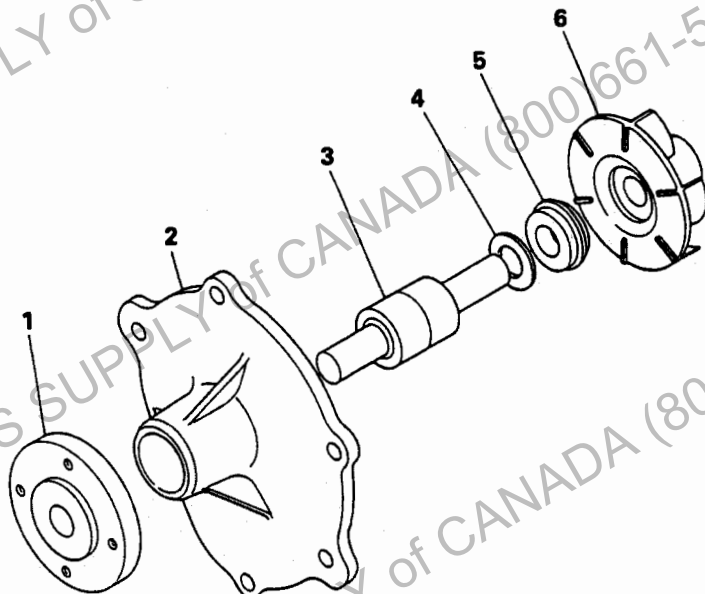
- 6. Connector bolt
- 7. Soft washer
- 8. Coolant manifold
- 9. Thermostat
- 10. Thermostat gasket

- 11. Engine hanger
- 12. Thermostat case
- 13. Connector
- 14. Hose

# COOLANT PUMP

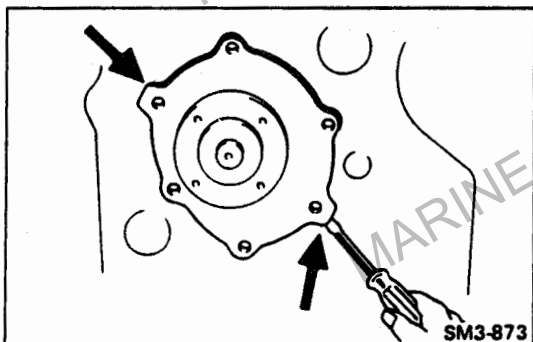
## OVERHAUL

1659N  
I—No. 21



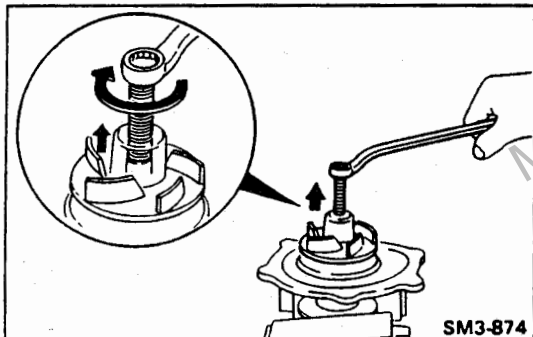
- 1. Pulley center
- 2. Pump case
- 3. Shaft subassembly

- 4. Slinger
- 5. Coolant seal
- 6. Vane



### IMPORTANT POINT – DISMOUNTING

REMOVE BY PRYING LOOSE WITH SCREWDRIVER AT THE 2 POINTS ON THE FLANGE.



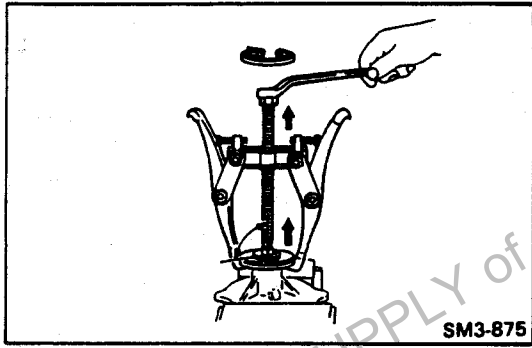
### IMPORTANT POINTS – DISASSEMBLY

REMOVE VANE FROM SHAFT BY SCREWING IN A BOLT.

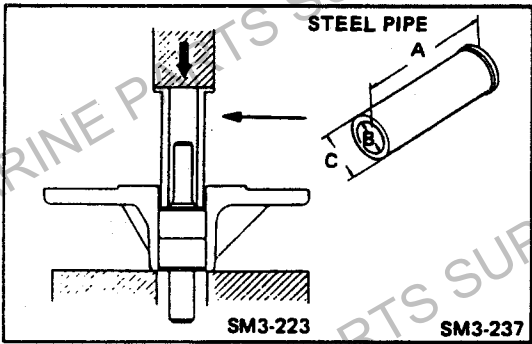
Bolt Size;

Diameter: 10 mm (0.394 in)

Pitch: 1.5 mm (0.059 in)

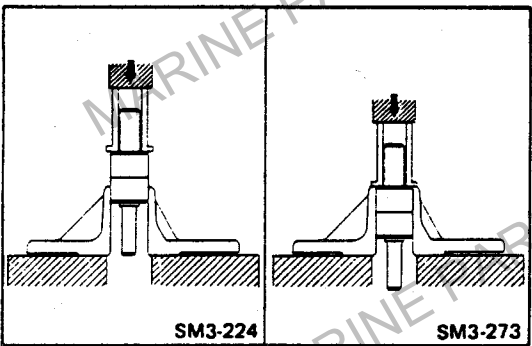


USING A PULLER, REMOVE THE PULLY CENTER FROM THE SHAFT.



USING A STEEL PIPE AND PRESS, REMOVE THE SHAFT FROM BODY.

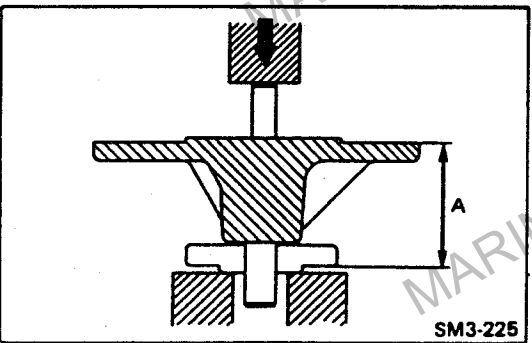
Steel Pipe Dimention: A: More than 57 mm (2.244 in)  
 B: 18 – 21 mm (0.7087 – 0.8267 in)  
 C: Less than 29.5 mm (1.161 in)



**IMPORTANT POINTS – ASSEMBLY**

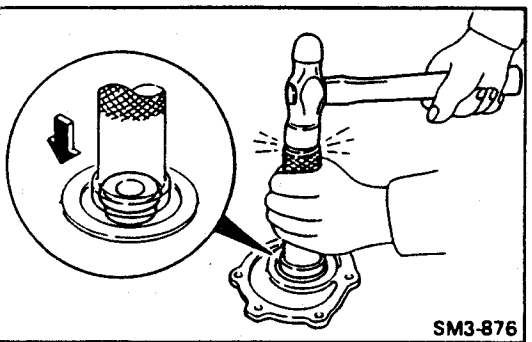
USING A STEEL PIPE AND PRESS, INSTALL THE SHAFT TO THE CASE.

NOTE: Bearing face must be aligned with edge of body.



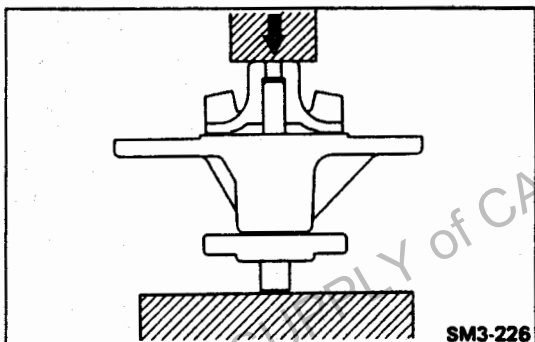
USING A PRESS, INSTALL THE PULLEY CENTER.

DIMENSION (A): 90 mm (3.543 in)



**INSTALL THE NEW COOLANT SEAL.**

1. Apply a little liquid sealer to the coolant seal outer circumference and coolant pump body.
2. Install the slinger and coolant seal.

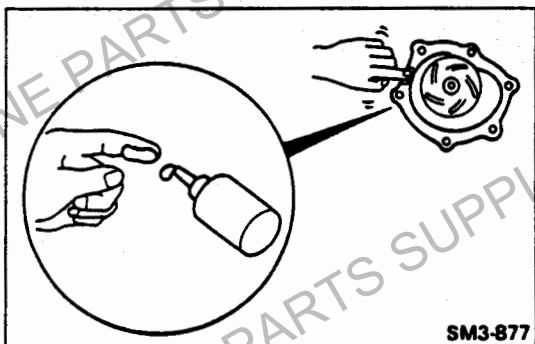


SM3-226

**USING A PRESS, INSTALL THE VANE TO THE SHAFT.**

**NOTE:** Apply a little engine oil to the coolant seal face.

**AFTER THE COOLANT PUMP HAS BEEN ASSEMBLED, CHECK THAT THE SHAFT ROTATES SMOOTHLY.**



SM3-877

#### IMPORTANT POINT – MOUNTING

**INSTALL THE COOLANT PUMP TO THE TIMING GEAR COVER.**

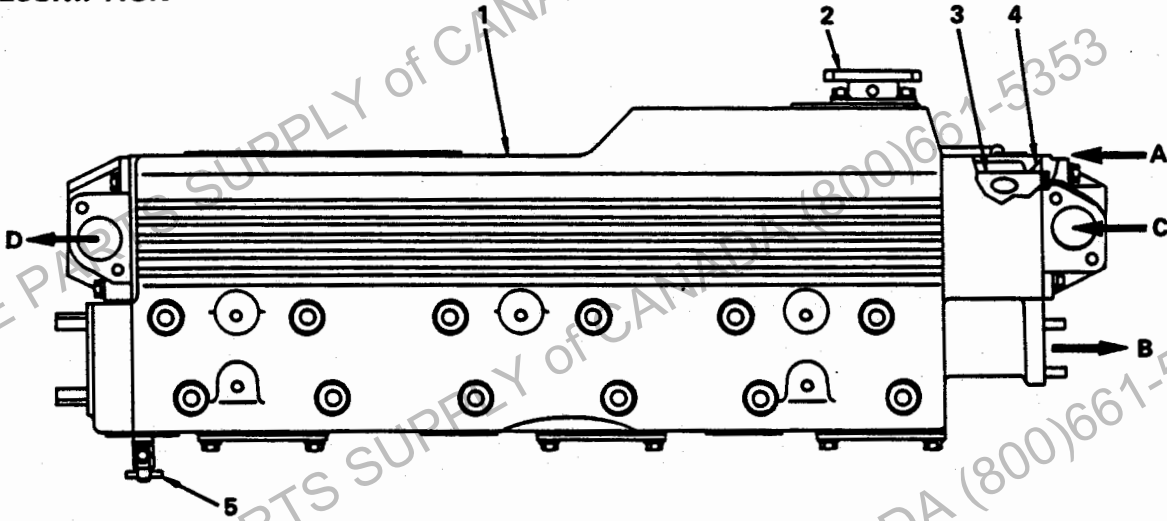
1. Clean the contacting surface of the coolant pump and timing gear cover free of old sealer, water and oil.
2. Apply the liquid gasket as shown and install the coolant pump within 20 minutes.

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

**Coating Width:** 1.5–2.5 mm (0.06–0.10 in)

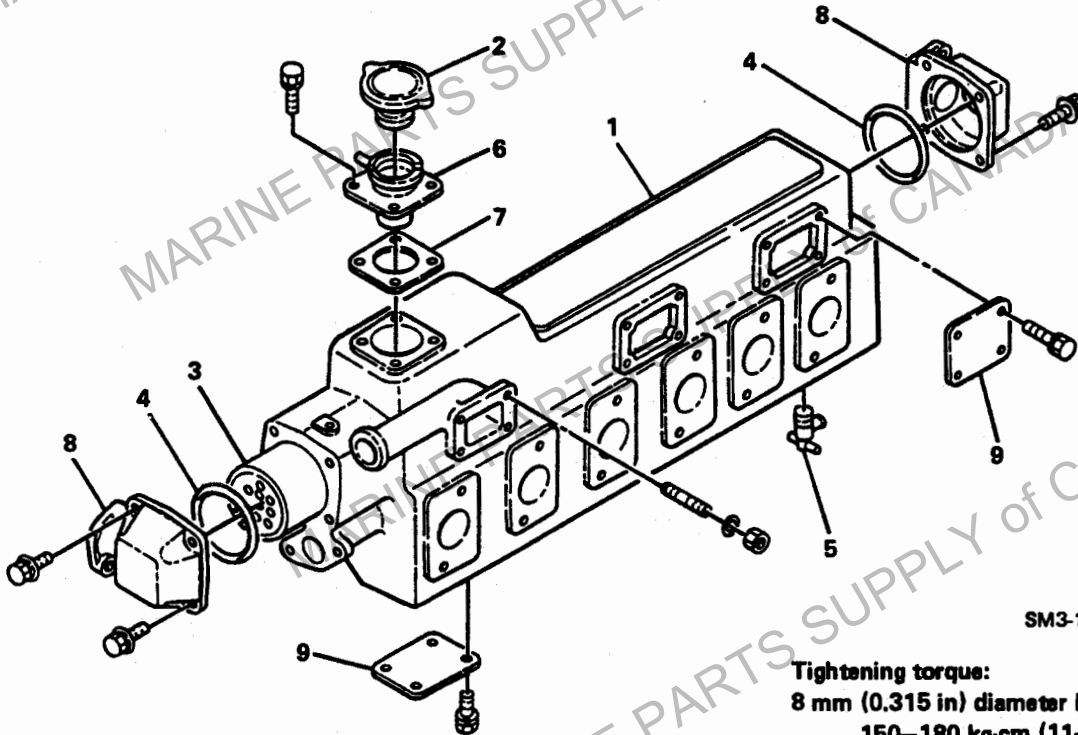
HEAT EXCHANGER

DESCRIPTION



SM3-1935

OVERHAUL



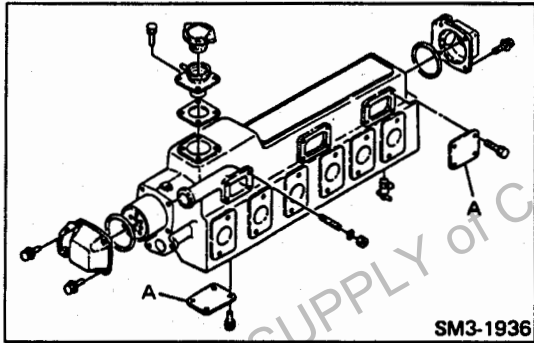
SM3-1936

Tightening torque:  
8 mm (0.315 in) diameter bolt and nut  
150-180 kg-cm (11-13 lb.ft)

- 1. Housing
- 2. Coolant filler cap
- 3. Element
- 4. O-ring
- 5. Engine coolant drain cock

- 6. Filler pipe seat
- 7. Gasket
- 8. Water gallery cover
- 9. Plate

- A. Engine coolant inlet
- B. Engine coolant outlet
- C. Seawater inlet
- D. Seawater outlet



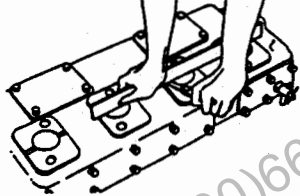

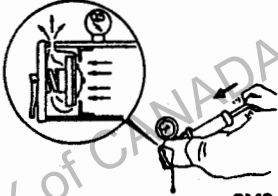
**IMPORTANT POINTS – ASSEMBLY**

**ASSEMBLE THE HEAT EXCHANGER.**

- NOTE:**
- Replace the O-rings and gasket with new ones.
  - Before installing the plates "A", apply sealing compound (Three Bond No. TB-1207C or equivalent).

**INSPECTION AND REPAIR**

Unit: mm (in)

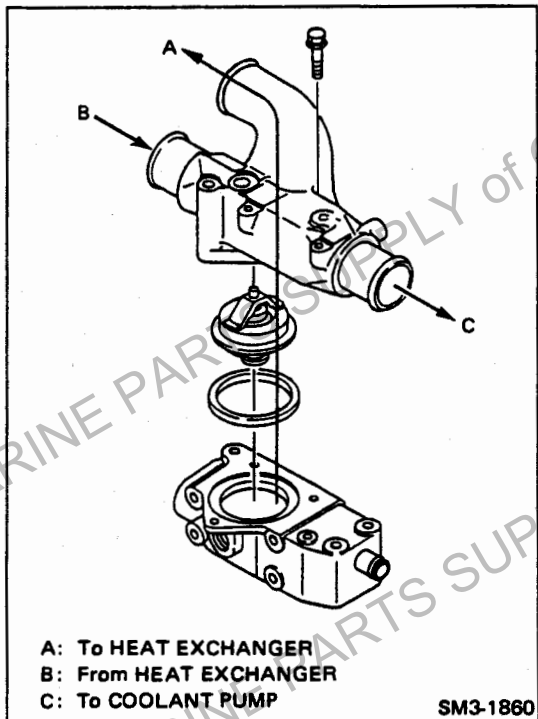
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Head changer (Exhaust Manifold). Flatness.	Less than 0.1 (0.004)	0.5 (0.019)	Resurface or replace.	 SM3-1858
Element. Clogged.	—	—	Clean with compressed air or sodium hydroxide	Visual check  SM3-1800
Coolant filler cap. Valve opening pressure.	0.4–0.6 kg/cm <sup>2</sup> (5.7–8.5 lb/sq.in)	—	Replace	 SM3-823

# THERMOSTAT

## IMPORTANT POINT – ASSEMBLY

### INSTALL THE THERMOSTAT.

1. Remove water and dirt adhering to the thermostat case.
2. Replace the gasket without fail if it is corroded, damaged or flattened.
3. Before installing the thermostat, apply sealing compound to the hose installation portion of the coolant manifold.
4. Assemble the thermostat, gasket, case and coolant manifold as shown.



A: To HEAT EXCHANGER  
 B: From HEAT EXCHANGER  
 C: To COOLANT PUMP

SM3-1860

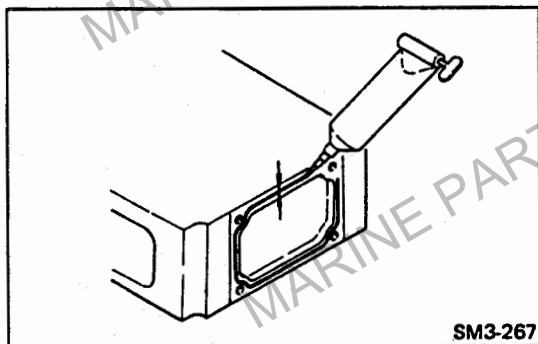
## IMPORTANT POINT – MOUNTING

### INSTALL THE THERMOSTAT CASE.

1. Clean the faces.
2. Apply the liquid gasket as shown and install the thermostat case on the cylinder head within 20 minutes.

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

Coating Width: 1.5–2.5 mm (0.06–0.10 in)



SM3-267

## INSPECTION AND REPAIR

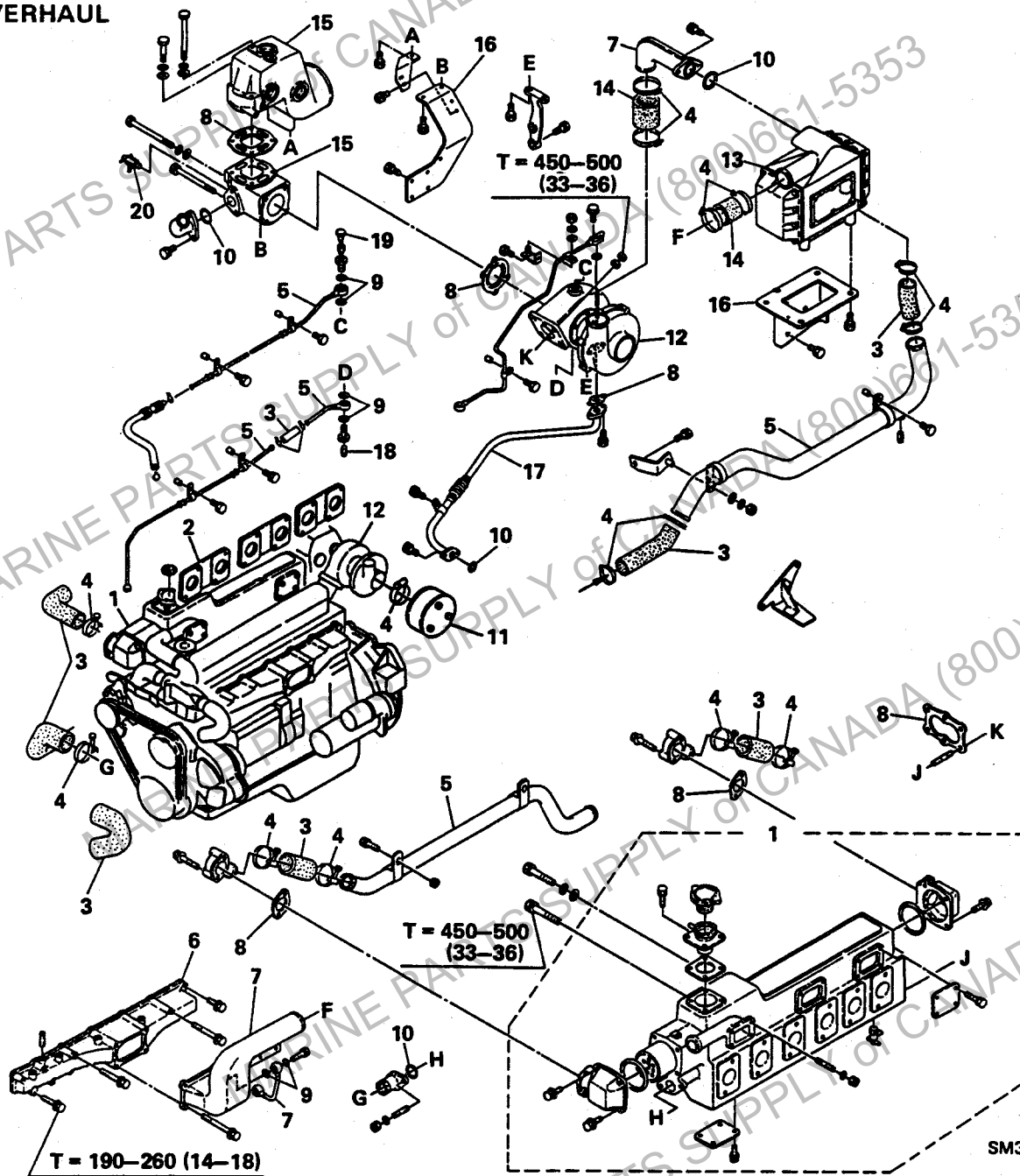
Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Thermostat Valve Opening Temperature	74.5–78.5°C (166–173°F)	–	Replace thermostat	
Thermostat Valve Lift	At least 10 (0.4) at 90°C (194°F)	–		
Thermostat Closing Condition	Fully opened valve should close completely within 5 minutes when thermostat is immersed in water of normal temperature.	–		

SM3-888

# AIR INTAKE AND EXHAUST SYSTEM

OVERHAUL



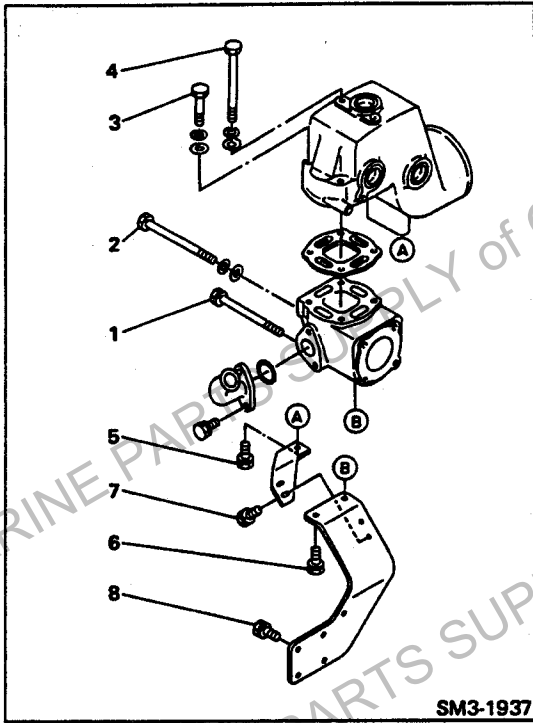
- 1. Heat exchanger  
(Exhaust manifold)
- 2. Exhaust manifold gasket
- 3. Water hose
- 4. Clamp
- 5. Water pipe
- 6. Intake manifold
- 7. Intake air pipe

- 8. Gasket
- 9. Soft washer
- 10. O-ring
- 11. Air cleaner
- 12. Turbocharger
- 13. Intercooler
- 14. Air hose
- 15. Exhaust pipe

- 16. Bracket
- 17. Oil pipe
- 18. Engine coolant drain plug
- 19. Air bleeder plug
- 20. Seawater drain cock

T = Tightening torque: kg-cm (lb.ft)

SM3-1936



SM3-1937

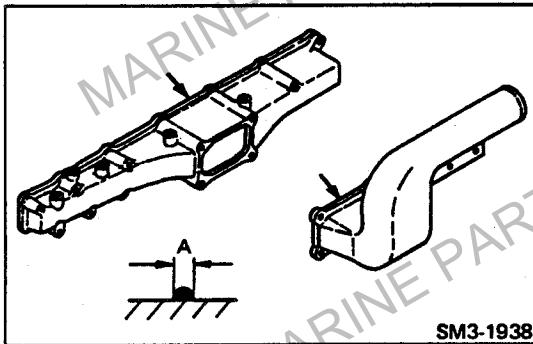
**IMPORTANT POINTS – MOUNTING**

**INSTALL THE EXHAUST PIPES.**

1. Install the turbocharger on the heat exchanger.
- Tightening Torque: 450–500 kg-cm (33–36 lb.ft)**
2. Temporarily install the mounting brackets and exhaust pipes.
3. Tighten the bolts to the specified torque in the tightening order as shown.

**Tightening Torque:**

- 1 : 500–600 kg-cm (37–43 lb.ft)
- 2 : 500–600 kg-cm (37–43 lb.ft)
- 3 : 500–600 kg-cm (37–43 lb.ft)
- 4 : 500–600 kg-cm (37–43 lb.ft)
- 5 : 500–600 kg-cm (37–43 lb.ft)
- 6 : 500–600 kg-cm (37–43 lb.ft)
- 7 : 500–600 kg-cm (37–43 lb.ft)
- 8 : 1,000–1,300 kg-cm (73–94 lb.ft)



SM3-1938

**INSTALL THE AIR INTAKE MANIFOLD AND PIPE.**

1. Clean the faces.
2. Apply the liquid gasket to the intake manifold flange face and install it on the cylinder head within 20 minutes.
3. Apply the liquid gasket to the pipe flange face and install it on the intake manifold within 20 minutes.

**Coating Width (A): 1.5–2.5 mm (0.06–0.10 in)**

**NOTE:** If leaving it more than 20 minutes, clean the liquid gasket completely and reapply the liquid gasket.

**INSPECTION AND REPAIR**

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Intercooler element. Clogged.	—	—	Clean or replace intercooler assy.	

SM3-1817

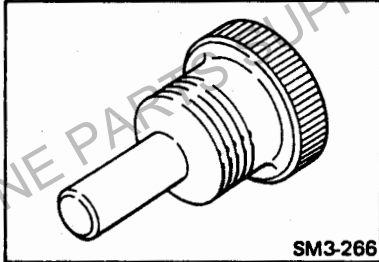
**NOTE:** Do not separate the intercooler housing and element when cleaning.

# ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING

## SPECIAL TOOL

Prior to starting an engine overhaul, it is necessary to have these special tools.

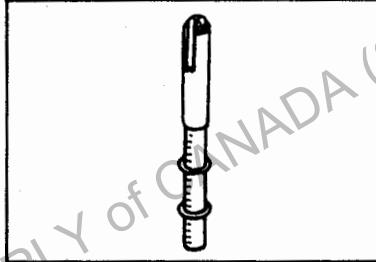
### TIMER SETTING TOOL



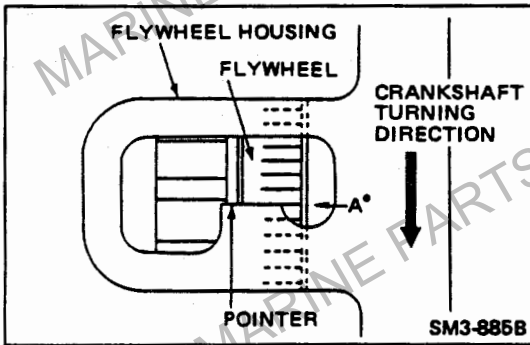
SM3-266

09512-2090 for W04D  
09512-2100 for W04C-T, W04C-T1  
W06D, W06D-T1, W06E

### V-BELT TENSION GAUGE



09444-1210



SM3-885B

## FUEL INJECTION PUMP

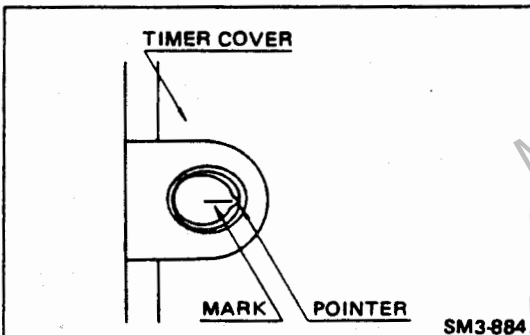
### IMPORTANT POINTS – DISMOUNTING

#### REMOVE THE FUEL INJECTION PUMP.

1. Disconnect the fuel lines, oil lines and engine control lines.
2. Turn the crankshaft counter-clockwise viewed from the flywheel side to align the injection timing mark on the flywheel at  $A^\circ$  before top dead center for No.1 cylinder on compression stroke with the pointer on the flywheel housing.

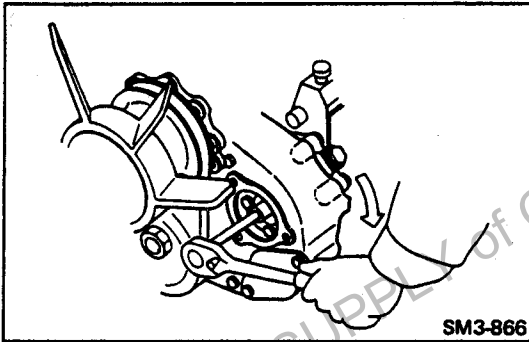
Injection Timing ( $A^\circ$ ): Refer to SECTION DATA AND SPECIFICATIONS.

**NOTE:** In case of marine engine equipped with seawater pump, never rotate crankshaft in reverse direction (Clockwise viewed from the flywheel side). Reverse rotation may damage impeller in seawater pump.



SM3-884

3. Remove the timing inspection hole plug. Check that the injection timing mark on the automatic timer is aligned with timer cover pointer.

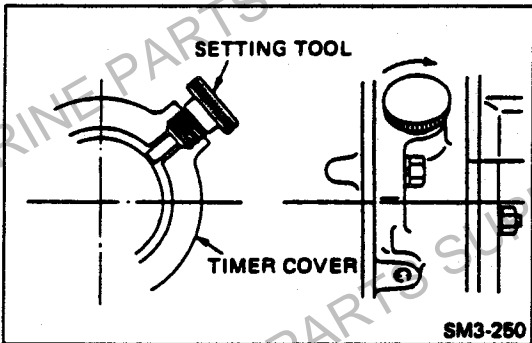


4. If not, remove the timing gear cover and then loosen the drive gear fitting bolts.

**NOTE:** Do not remove the drive gear fitting bolts.

5. Rotate the drive gear clockwise to align the injection timing and then tighten the drive gear fitting bolts.

**Tightening Torque:** 300–350 kg-cm (22–25 lb.ft)



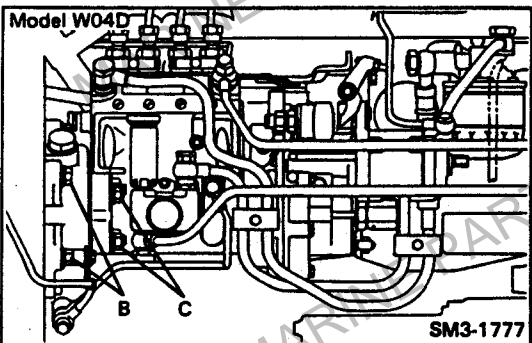
6. Lock the coupling flange with a special tool.

**Special Tool:**

**Timer Setting Tool**

(09512-2090) for W04D

(09512-2100) for W04C-T, W04C-T1, W06D, W06D-T1, W06E



7. Loosen the timer cover fitting bolts (B) and then remove the injection pump with timer cover.

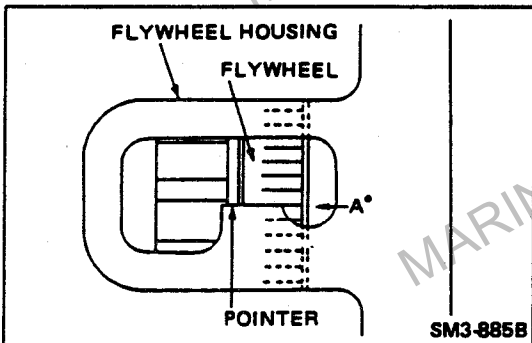
**NOTE:** Do not loosen the injection pump body fitting nuts (C).

**IMPORTANT POINTS – MOUNTING**

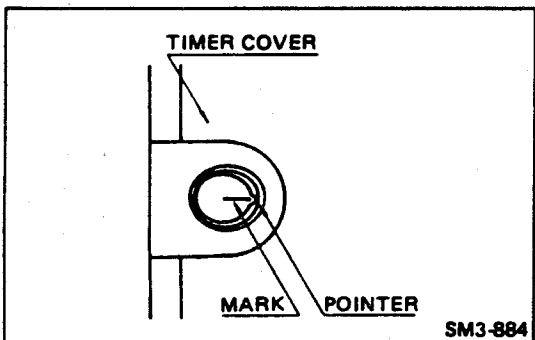
**INSTALL THE INJECTION PUMP.**

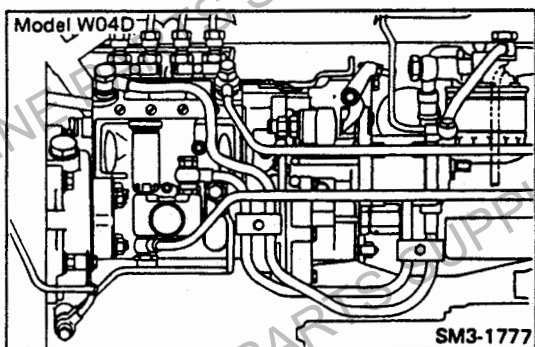
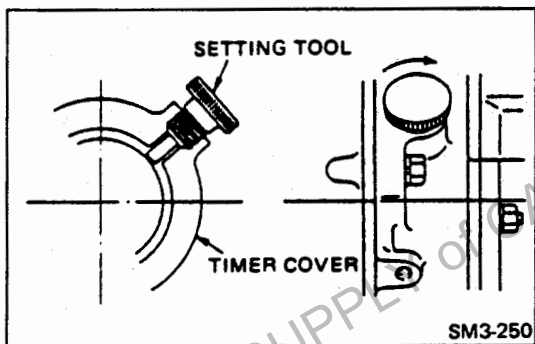
1. Check that the injection timing mark on the flywheel is aligned with flywheel housing pointer.

**Injection Timing (A°):** Refer to SECTION DATA AND SPECIFICATIONS.



2. Check that the injection timing mark on the automatic timer is aligned with timer cover pointer. If not, adjust the injection timing.





- Lock the coupling flange with a special tool.

**Special Tool:****Timer Setting Tool**

(09512-2090) for W04D

(09512-2100) for W04C-T, W04C-TI, W06D, W06D-TI, W06E

- Install the injection pump with timer cover.

**Fitting Bolts Tightening Torque:**

190–260 kg-cm (14–18 lb.ft)

- Remove a special tool and install the timing inspection hole plug.
- Connect the fuel lines, oil lines and engine control lines.

## GENERATOR

### IMPORTANT POINT – MOUNTING

**INSTALL THE GENERATOR ON THE ENGINE.**

- Install the V-belts, and adjust the belt tension.

**NOTE:** ○ Do not under any circumstances apply the lever directly against the generator body owing to the risk of damaging the generator.

○ When installing a new V-belt or adjusting the tension, be sure to repeat the adjustment two or three times, after running the engine for several minutes each time.

- V-belt deflection

Apply a load of about 10 kg (22 lb) by pressing with your finger or a special tool.

**Assembly Standard (A):** 10–15 mm (0.40–0.59 in)

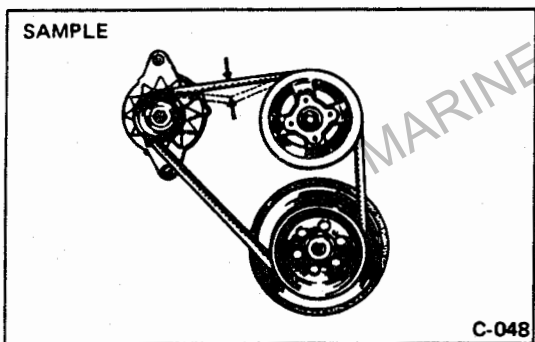
**Special Tool:** V-belt tension gauge (09444-1210)

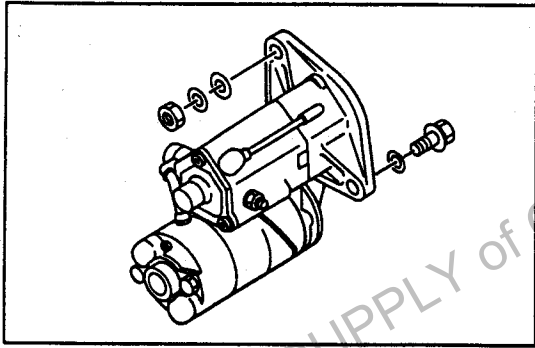
**NOTE:** If the belt is excessively tensioned, there is a risk of damaging the bearings of the generator or coolant pump and also shorting the life of the V-belt.

Conversely, if there is insufficient tension on the V-belt, the belt, will slip, unusual noise will be emitted, the battery may run down and the engine may overheat.

**Through Bolt Tightening Torque:**

450–500 kg-cm (33–36 lb.ft)





## STARTER

### IMPORTANT POINT – DISMOUNTING

#### REMOVE THE STARTER FROM THE ENGINE.

1. Turn off the battery switch (if so equipped).
2. Put the match marks on the harness and starter terminals with a pen and then disconnect the harness.
3. Remove the starter from the engine.

### IMPORTANT POINT – MOUNTING

#### INSTALL THE STARTER ON THE ENGINE.

1. Install the starter on the engine.

#### Fitting Bolt and Nut Tightening Torque:

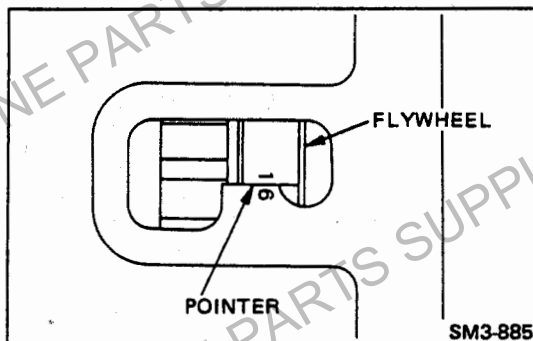
12 mm (0.47 in) dia. : 650–900 kg-cm (47–65 lb.ft)

14 mm (0.55 in) dia. : 1,100–1,500 kg-cm (80–108 lb.ft)

2. Connect the starter harness to match the marks.

## ENGINE TUNE-UP

**NOTE:** In case of marine engine equipped with seawater pump, never rotate the crankshaft in reverse direction (Clockwise viewed from flywheel). Reverse rotation may damage impeller in seawater pump.



### VALVE CLEARANCE

#### INSPECTION AND ADJUSTMENT OF THE VALVE CLEARANCE

1. Set the No.1 piston to top dead center of compression stroke.

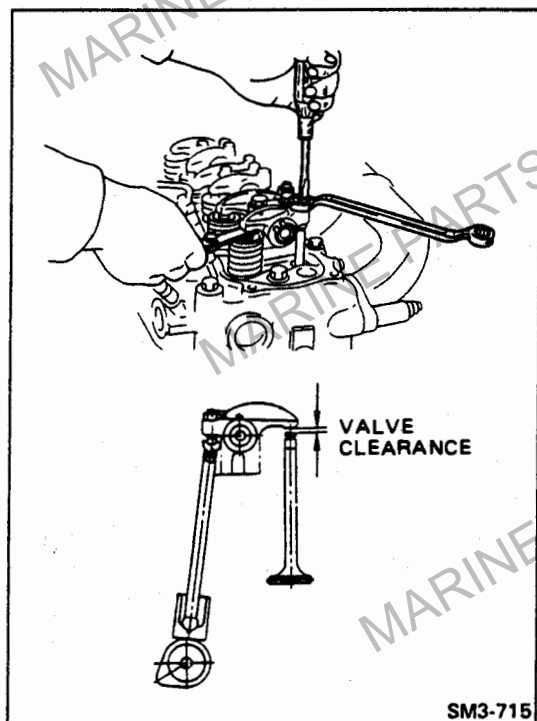
2. With the No. 1 piston positioned at top dead center and of the compression stroke, adjust the No. 1 valve clearance using a thickness gauge. The thickness gauge should move with a very slight pull.

**Valve Clearance:** Refer to SECTION DATA AND SPECIFICATIONS.

3. Adjust the other valves. Turn the crankshaft counter-clockwise 120° viewed from flywheel side. Adjust the valve clearance for each cylinder in the firing order.

**Firing Order:** 1-4-2-6-3-5

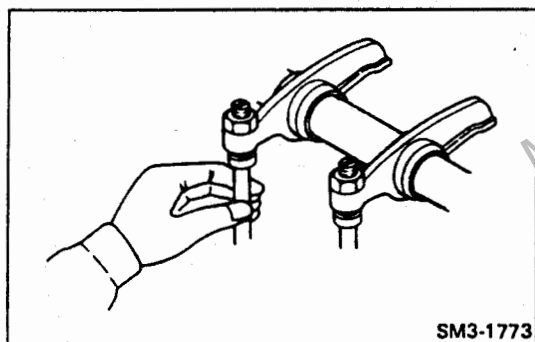
(A number of a cylinder is to be counted in order from the timing gear side)

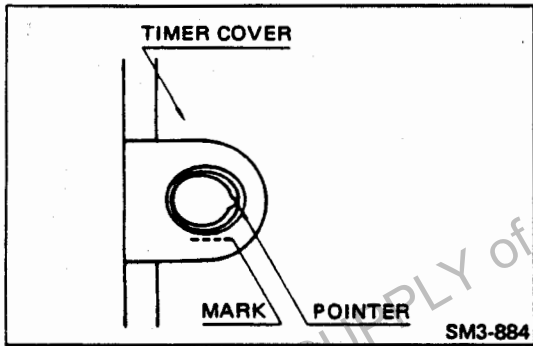


#### METHOD FOR DETERMINING IF THE NO. 1 OR NO. 6 PISTON IS AT THE TOP DEAD CENTER ON COMPRESSION STROKE.

Turning the crankshaft, align the mark "1-6" on the flywheel with the pointer on the flywheel housing. In this position either the No. 1 or No. 6 piston is at the top dead center on compression stroke.

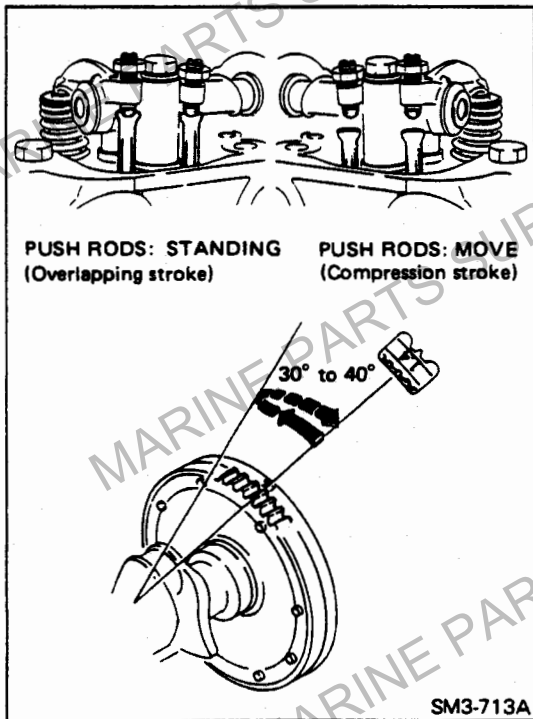
1. If both the No. 1 intake and exhaust rocker arms can be moved easily by hand, the No. 1 piston is at top dead center on compression stroke.





- If the injection timing mark is nearly aligned with the pointer, the No. 1 piston is at top dead center on the compression stroke.

**NOTE:** If not, turn the crankshaft one complete revolution and align marks as above.

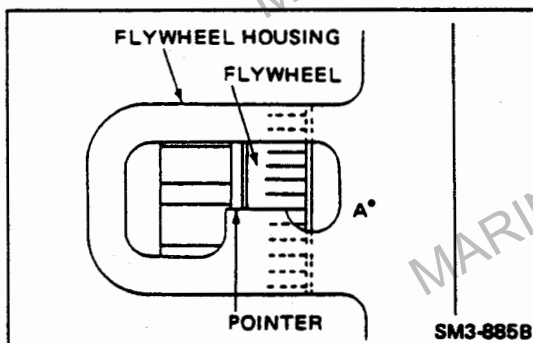


- While locking at the push rod of No. 1 and No. 6 pistons. Turn the flywheel counter-clockwise and clockwise about 30° to 40° (see left figure).

If the piston whose exhaust and intake push rods do not move during the interval, it is at the top dead center on the compression stroke.

If the piston whose push rods have moved, it is at the completion of the exhaust and begun of the intake stroke (overlapping stroke).

**NOTE:** Always loosen the lock nut and raise the adjusting screws fully to the top. If the adjusting screws are too low, the piston and valves may strike each other during valve clearance adjustment.

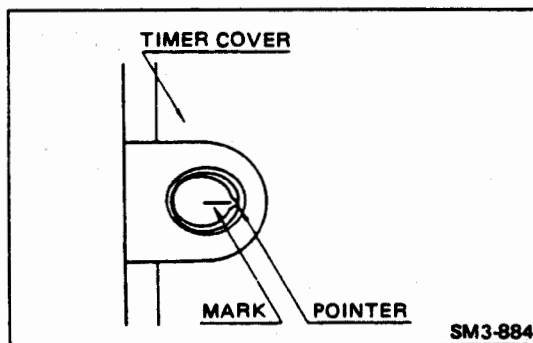


**INJECTION TIMING**

**INSPECT THE INJECTION TIMING.**

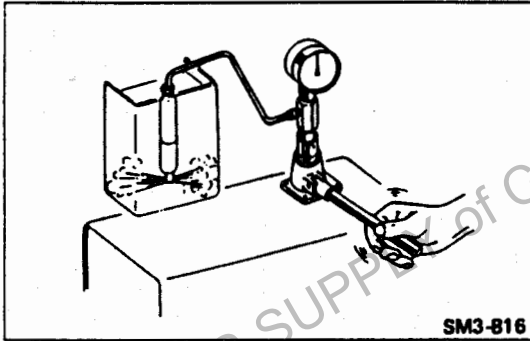
- Turn the crankshaft counter-clockwise viewed from the flywheel side to align the injection timing marks on the flywheel at A° before top dead center for No. 1 cylinder on compression stroke with pointer on the flywheel housing.

**Injection Timing (A°):** Refer to section DADA AND SPECIFICATIONS.



- Check that the injection timing mark on the automatic timer is aligned with timer cover pointer. If not, adjust the injection timing.

**NOTE:** When adjusting the injection timing, refer to "FUEL INJECTION PUMP" in section ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING for details.



SM3-816

**INJECTION NOZZLE****INSPECT AND ADJUST THE INJECTION PRESSURE.**

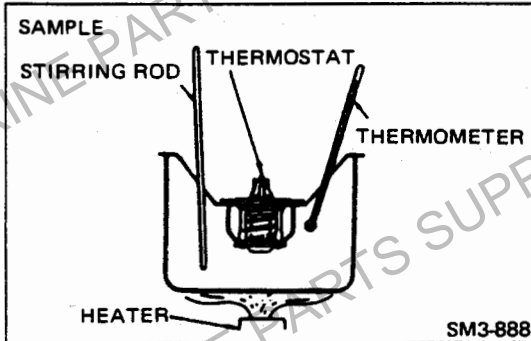
Refer to "INJECTION NOZZLE" in SECTION FUEL SYSTEM.

**TEST THE SPRAY PROFILE.**

Refer to "INJECTION NOZZLE" in SECTION FUEL SYSTEM.

**TEST THE FUEL LEAKAGE.**

Refer to "INJECTION NOZZLE" in SECTION FUEL SYSTEM.



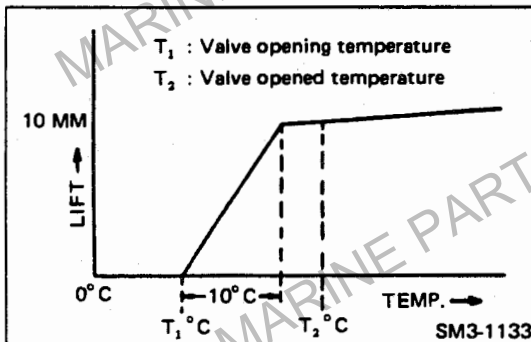
SM3-888

**THERMOSTAT****INSPECT THE THERMOSTAT FUNCTION.**

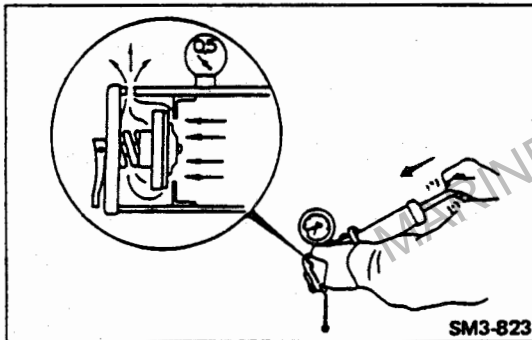
1. Place the thermostat in hot water and check the opening temperature and the lift.
2. Using a thermometer, check to see the thermostat opens at the specified temperature: Refer to "THERMOSTAT" in SECTION COOLING SYSTEM.
3. Immerse the thermostat in hot water and measure the lift of the pellet after a period of 5 minutes using vernier calipers. Measure the position of the bottom of the pellet before and after heating the thermostat.

**Valve Lift:** Refer to "THERMOSTAT" in SECTION COOLING SYSTEM.

4. Immerse a heated thermostat in water of normal temperature. If it completely closes within 5 minutes it is satisfactory. If it remains even slightly open, it is defective and must be replaced.



SM3-1133



SM3-823

**COOLANT FILLER CAP****INSPECT THE FILLER CAP FUNCTION.**

Check the filler cap pressure using a cap tester.

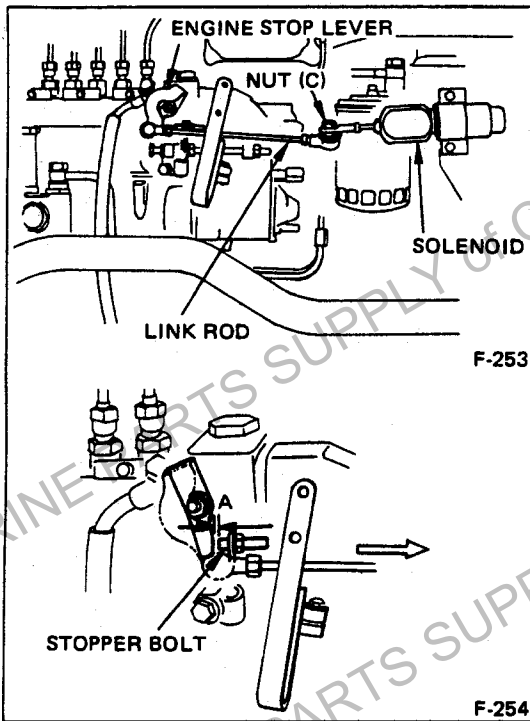
0.5 : 0.4–0.6 kg/cm<sup>2</sup> (5.7–8.5 lb/sq.in)

0.9 : 0.75–1.05 kg/cm<sup>2</sup> (10.7–14.9 lb/sq.in)

- NOTE:**
- The filler cap pressure is shown on the filler cap, and it should be confirmed.
  - If the cap pressure is incorrect, there is a risk of abnormally high pressure being generated in the cooling system, which may cause the hose to drop off or burst and, in turn, damage the engine.

**WARNING**

The cap should not be removed while the engine and cooling system are hot. This can result personal injury.



## ENGINE CONTROL

## ADJUST THE SOLENOID (ENGINE STOP) LINK ROD.

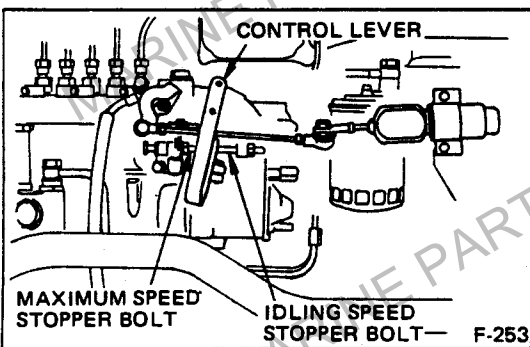
1. Adjust the link rod length so that the clearance between the stopper of the governor case and the engine stop lever becomes "A" when the solenoid plunger is fully pushed in.

Assembly Standard "A": 2–3 mm (0.08–0.11 in)

NOTE: ○ Install the link rod with the nut(c) at the top.

- If the clearance adjustment is unsatisfactory or the action of the solenoid is sluggish, solenoid seizure, insufficient output or engine stoppage may result.

2. After the above adjustment is over, move the link rod by hand and make sure that it moves lightly.



## ADJUST THE ENGINE IDLING SPEED.

When straight drive navigation is not smoothly made at the time of a sea trial in engine at idle, adjust it according to the following procedures.

1. Disconnect the throttle control cable from engine port (left) side and the starboard (right) side.
2. Loosen the idling speed stopper bolt lock nut.
3. Adjust through varying the engine speed using the idling speed stopper bolt on the injection pump so that straight drive navigation is made.

## NOTE:

To increase engine speed: Turn the idling speed stopper bolt clockwise.

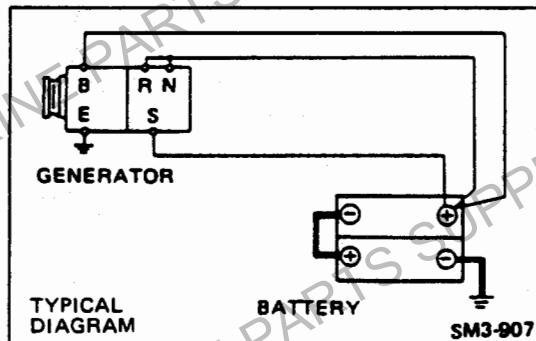
To decrease engine speed: Turn the idling speed stopper bolt counter-clockwise.

Engine Idling Speed: Refer to section DATA AND SPECIFICATIONS.

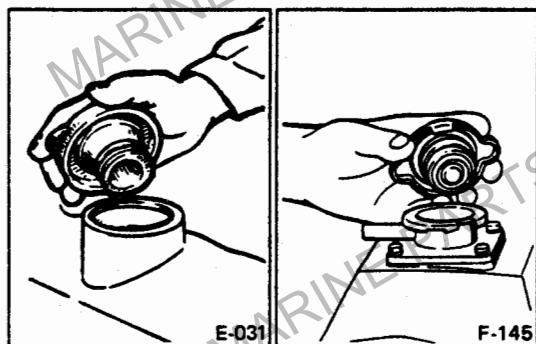
4. Upon completion of adjustment of engine idling speed, lock the stopper bolt with nut and apply paint on the stopper bolt and nut.

NOTE: When adjusting the all adjusting devices on the fuel injection pump governor, except the idling speed stopper bolt, refer to CHAPTER GV, INJECTION PUMP GOVERNOR.

## ENGINE TUNE-UP ON TEST BENCH

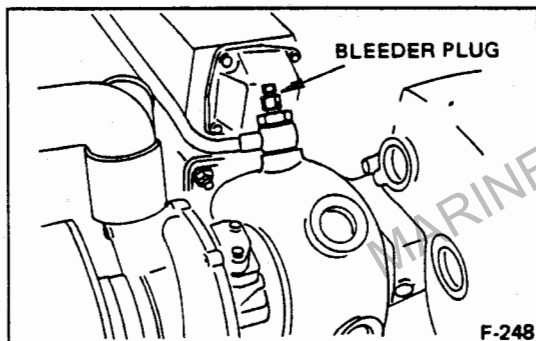


- NOTE:** In case of marine engine equipped with seawater pump
- Never rotate the crankshaft in reverse direction (Clockwise viewed from flywheel). Reverse rotation may damage impeller in seawater pump.
  - Do not run engine without water in the seawater cooling system. The seawater pump damage can result. Starting the engine when the generator is not connected to the battery may damage the generator. Always connect to the battery.



### SET THE ENGINE ASSEMBLY ON A TEST BENCH.

1. Add the proper amount of the specified engine oil through the oil filler cap on the cylinder head cover.
2. Add coolant.



- NOTE:** In case of engine equipped with water-cooled turbocharger, bleed air from bleeder plug.

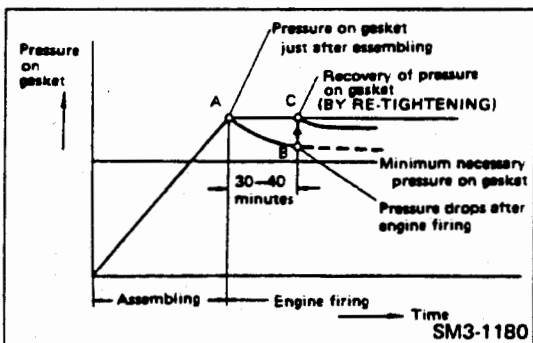
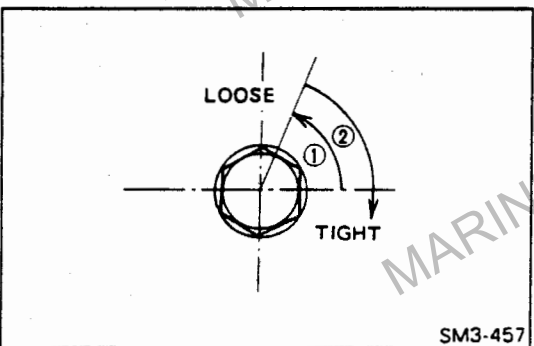
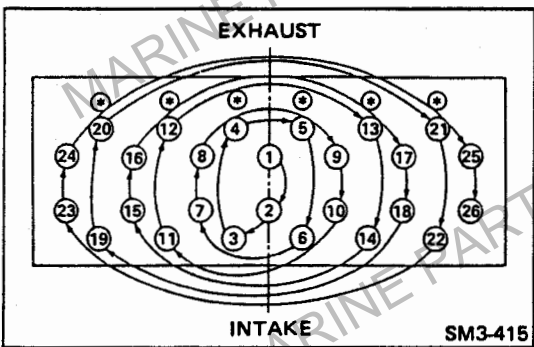
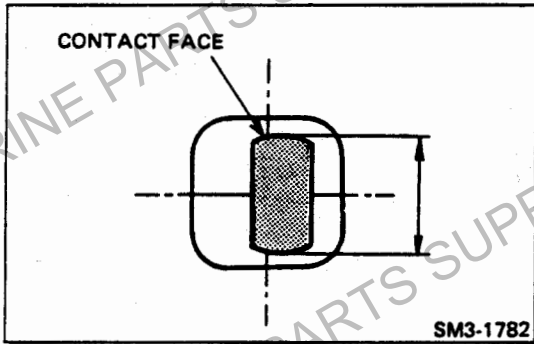
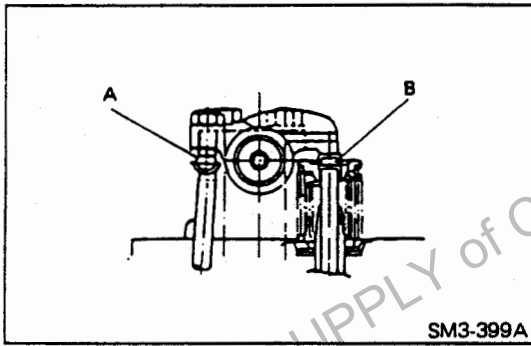
### BLEED AIR FROM FUEL SYSTEM.

Refer to section FUEL SYSTEM.

### CHECK THE INJECTION TIMING.

Refer to "FUEL INJECTION PUMP" in section ENGINE COMPONENT PARTS DISMOUNTING AND MOUNTING.

### CHECK THE VALVE CLEARANCE.



**START THE ENGINE.**

**NOTE:** Before starting the engine, make sure that the fuel cut lever of the fuel injection pump is operating normally.

1. Check the oil feed to rocker arms.
  - a. Set the engine speed: Refer to SECTION DATA AND SPECIFICATION.
  - b. Within one minute after starting the engine, oil should flow to the head (Face A) of all push rods and the head (Face B) of all valves. If the time required for the oil to flow to the rocker arms is long, various troubles such as seizing, abnormal wear and unusual noise may occur.
2. Check the contact of the rocker arm and valve stem caps. After running the engine, a contact of approx. 8 mm (0.315 in) should be obtained at the cap contact face of the rocker arm. If the contact face is one sided, the valve will tilt, resulting in valve seizure, breakage, damage, or wear of the rocker arm stem cap.
3. Retighten the cylinder head bolts. After tightening cylinder head bolt to specified torque, run the engine for about 30 to 40 minutes at a water temperature of about 80°C. Then loosen cylinder each head bolt 1/8-1/4 turn and retighten, in sequence, to specified torque.

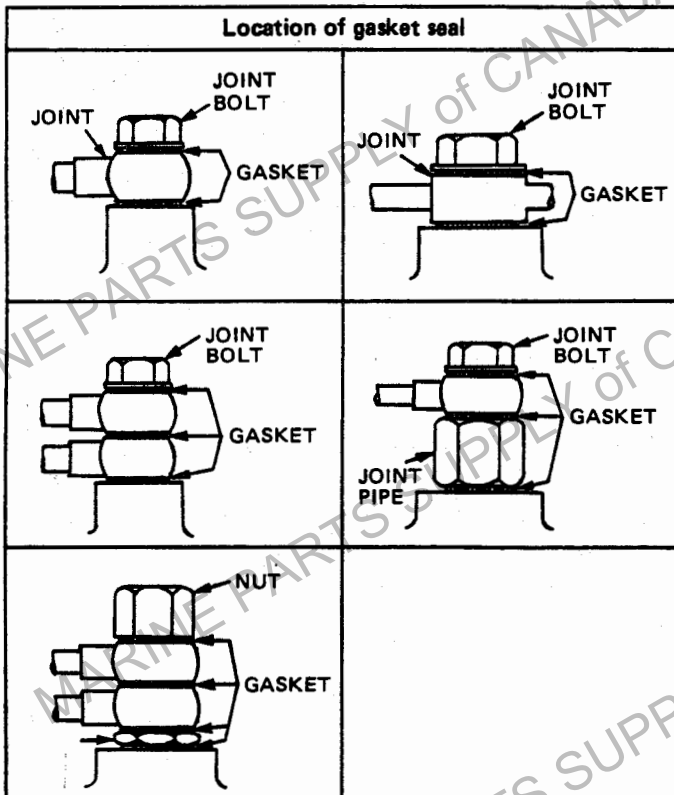
**Special Tool:** Socket wrench (09411-1260)

- NOTE:**
- In case of marine engine equipped with heat exchanger (exhaust manifold), loosen the heat exchanger bracket fitting bolts before retightening the cylinder head bolts.
  - Be sure to loosen one bolt at a time, then retighten it before going on to the next bolt.
  - By retightening, face pressure of cylinder head is restored from point B to C as shown.
  - Retighten at the first 30 hours following servicing which involves the loosening or removal of any cylinder head bolt. Such servicing includes replacement of the cylinder head gasket, servicing of the valve gear parts, and the like.

**RECHECK THE VALVE CLEARANCE, WHEN ENGINE IS COLD.**

# PROCEDURE FOR INSTALLING JOINTS AND GASKETS OF ENGINE PIPES

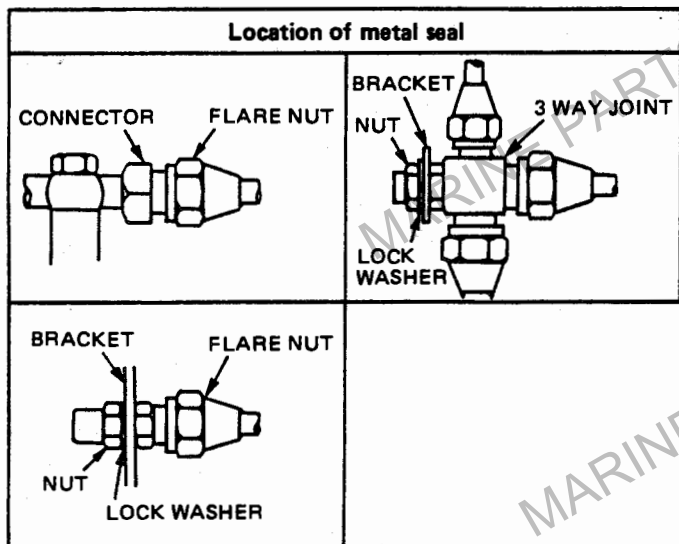
## 1. Gasket seal type (aluminum + rubber, asbestos or copper).



### Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque kg-cm (lb.ft)
8 (0.315)	120-170 ( 9-12)
10 (0.394)	180-230 (13-16)
12 (0.472)	230-280 (17-20)
14 (0.551)	230-280 (17-20)
16 (0.630)	300-350 (22-25)
18 (0.709)	400-450 (29-32)
20 (0.787)	400-450 (29-32)
22 (0.866)	530-600 (38-43)
24 (0.945)	720-800 (52-57)
28 (1.102)	1,300-1,500 (94-108)

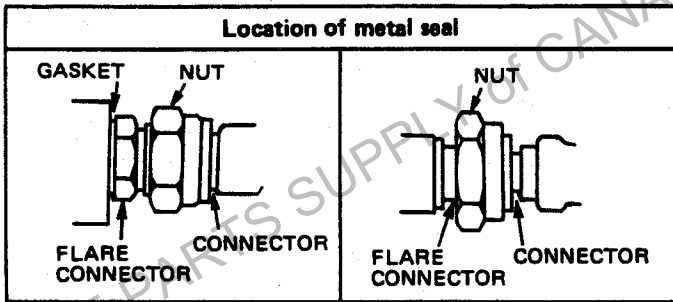
## 2. Metal seal type (Flares connector type).



### Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque kg-cm (lb.ft)
12 (0.472)	200-220 (15-16)
14 (0.551)	330-360 (24-26)
16 (0.630)	400-500 (29-36)
18 (0.709)	600-700 (43-51)
20 (0.787)	650-700 (47-51)

3. Metal seal type (Nipples connectors type)



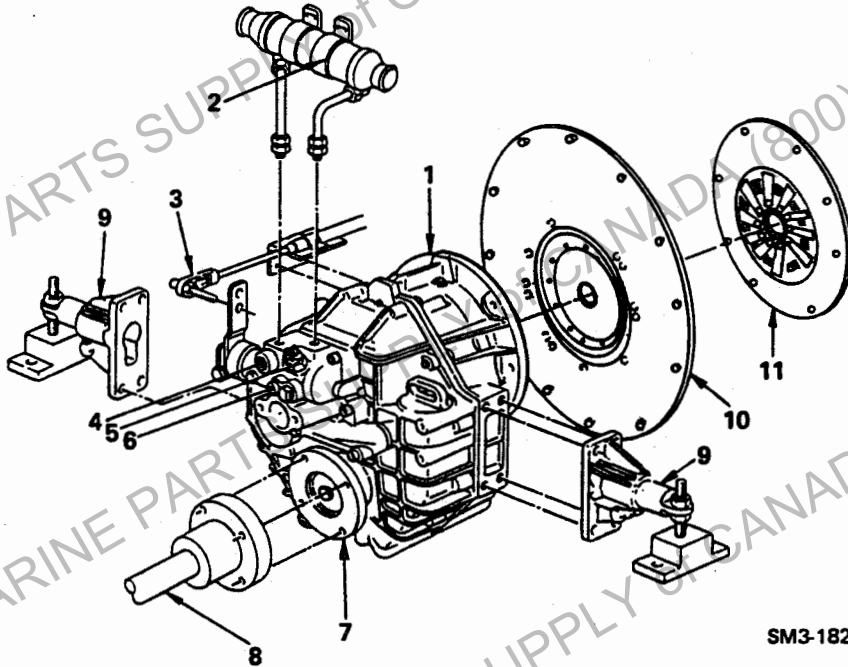
Tightening torque chart

Clamping screw size (Diameter) mm (in)	Tightening torque kg-cm (lb.ft)
10 (0.394)	100-150 (7-10)
20 (0.787)	200-250 (14-18)

- NOTE:
- Before installing the joints, ensure that there is no dirt or burrs adhering to the various seat faces (pipe joints, gaskets, etc.)
  - Because the pipes can move relatively free during installation and the seat faces are liable to tilt, first temporarily tighten the pipes, then tighten them to specification and ensure that there is no leakage from them.
  - When tightening two pipes together, be very careful that they do not rotate together.
  - After installing the pipes, apply the correct pressure to each pipe joint and ensure that there is no leakage.
  - Ensure that the various tightening torques conform to the above table.
  - If a soft washer #4840 FR-N (aluminum + rubber and carbon press fit part) is loosened or removed subsequent to being installed, be sure and replace it with a new one.  
There is no need to replace it, however, for normal retightening.

# MARINE TRANSMISSION DISMOUNTING AND MOUNTING

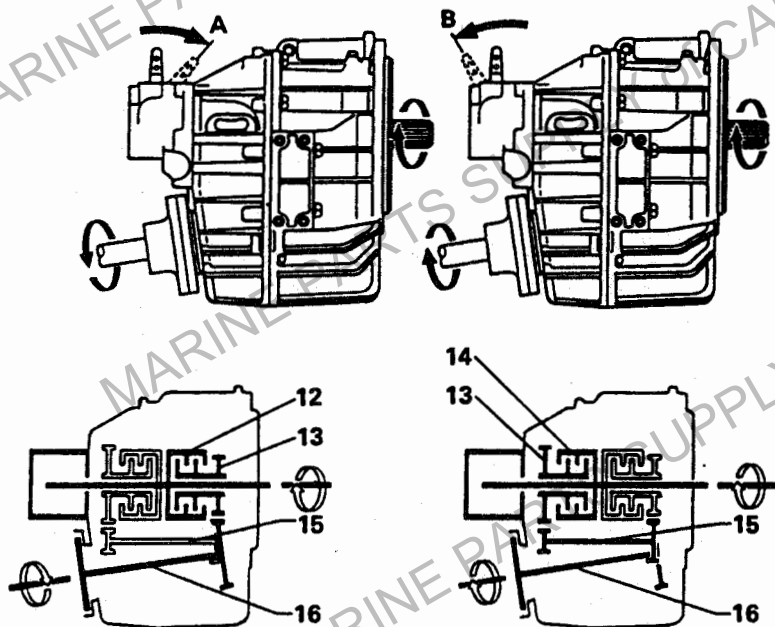
## OVERHAUL



1. Marine transmission
2. Fluid cooler
3. Remote control
4. Connection for temperature gauge
5. Neutral safety switch
6. Connection for shifting pressure control
7. Marine transmission output flange
8. Propeller shaft
9. Support bracket
10. Intermediate flange
11. Torsion-elastic coupling
12. Clutch, side A
13. Loose gear
14. Clutch, side B
15. Intermediate shaft
16. Output shaft

SM3-1821

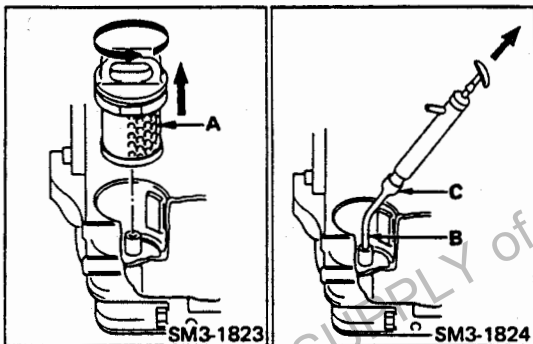
## OPERATION



SM3-1822

Position of shifting lever when driving forward

Propeller pitch	Propeller ratio	Shifting lever in position
Right hand	Opposite to engine rotation	A
Left hand	As engine rotation	B

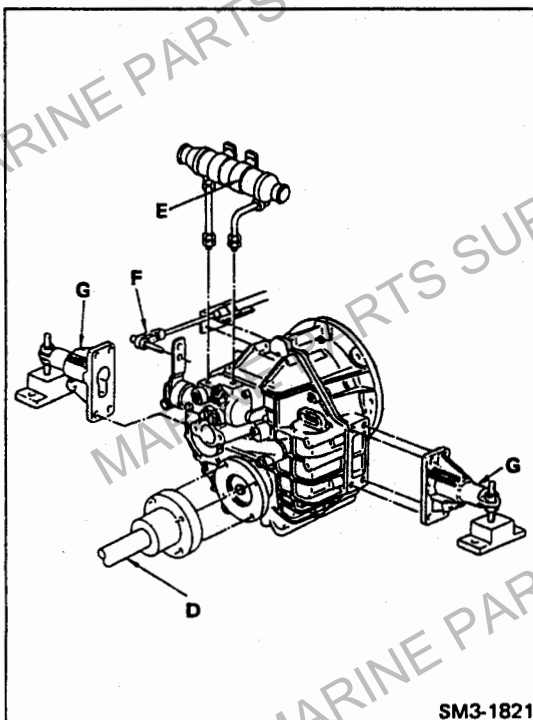
**IMPORTANT POINTS – DISMOUNTING****PUMPING OUT MARINE TRANSMISSION FLUID.**

1. Turn the filter cover counter-clockwise to loosen the fluid fine filter (Item A).
2. Remove the filter cover complete with fluid fine filter.
3. Pump out old marine transmission fluid through suction pipe (Item B) in the filter compartment.

**NOTE:** Max. outside diameter of suction hose is 16 mm (0.625 in) (Item C).

**DISCONNECT THE PROPELLER SHAFT (Item D) FROM THE MARINE TRANSMISSION OUTPUT FLANGE.****REMOVE THE FLUID COOLER WITH PIPES (Item E).**

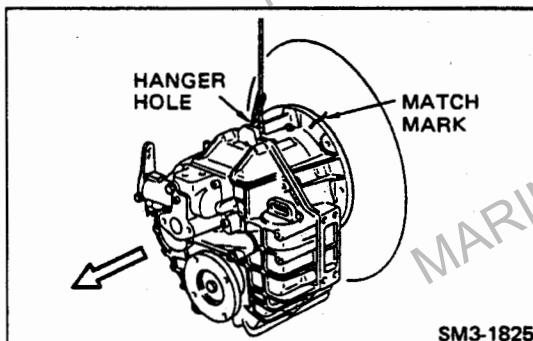
**NOTE:** Plug the openings of the line and marine transmission to prevent dirt entering.

**DISCONNECT THE REMOVE CONTROL (Item F) FROM SHIFTING LEVER.****DISCONNECT THE ELECTRICAL LINE AND FLUID LINES.****REMOVE THE SUPPORT BRACKET (Item G).****REMOVE THE MARINE TRANSMISSION.**

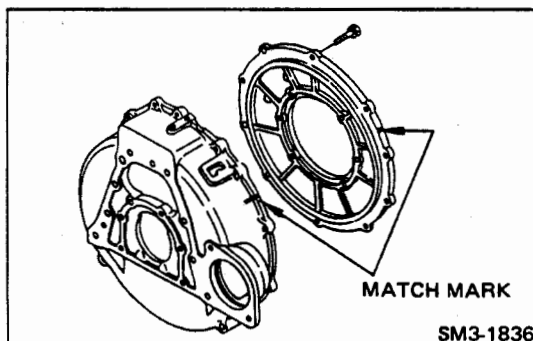
1. Put the match mark on the marine transmission and intermediate flange with a pen.
2. Suspend the marine transmission.

**NOTE:** The marine transmission without fluid and fluid cooler weights approx. 44 kg (97 lb).

3. Remove the marine transmission fitting bolts.
4. Pull the marine transmission away from the engine.

**REMOVE THE INTERMEDIATE FLANGE FROM THE FLYWHEEL HOUSING.**

Put the match mark on the intermediate flange and flywheel housing before removing.

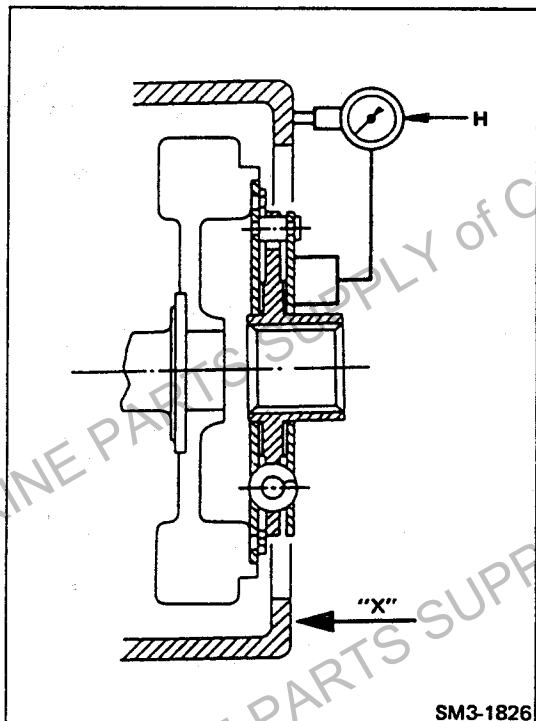
**REMOVE THE TORSION-ELASTIC COUPLING FROM THE FLYWHEEL.**

## IMPORTANT POINTS – MOUNTING

## INSTALL THE TORSION-ELASTIC COUPLING.

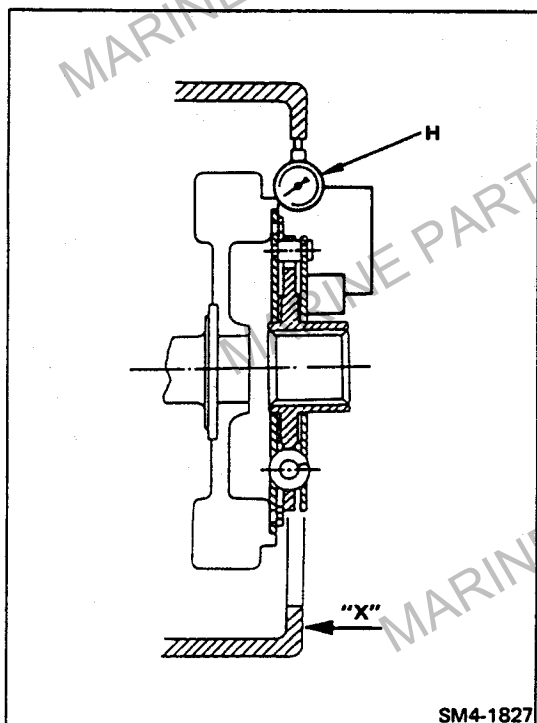
1. Install the torsion-elastic coupling to the flywheel.
2. Check the axial tolerances of the connection between marine transmission and engine.
  - a. Attach caliper linkage (Item H) to damper plate.
  - b. Apply base of caliper at right angles to plane surface of flywheel housing.
  - c. Pretension the gauge and set to "0".
  - d. Turn the flywheel slowly. The gauge reading must not exceed 0.1 mm (0.004 in).

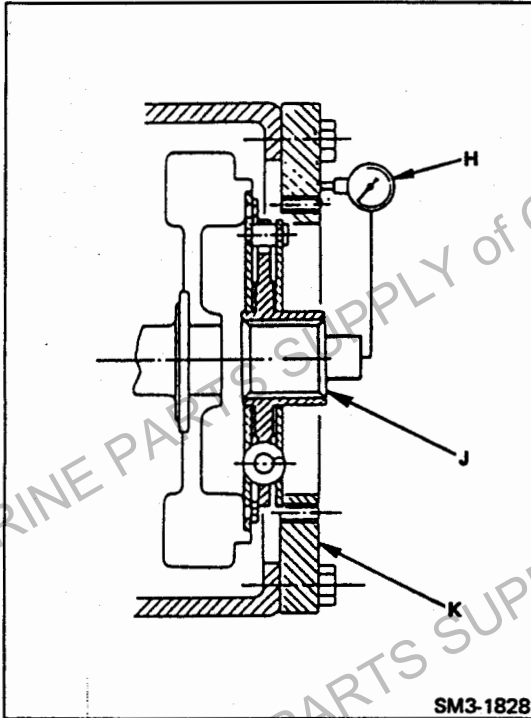
"X" : Mounting surface of engine flywheel housing.



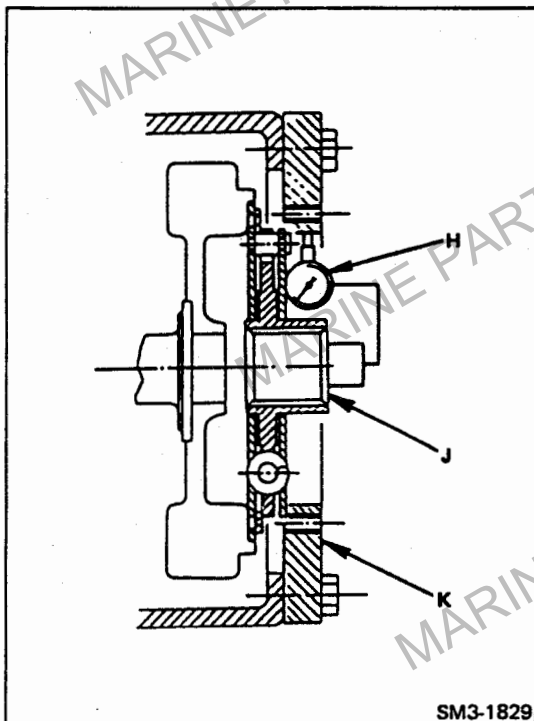
3. Check the radial tolerances of the connection between marine transmission and engine.
  - a. Attach caliper linkage (Item H) to damper plate.
  - b. Apply base of caliper at right angles to entering surface of flywheel housing.
  - c. Pretension the gauge and set to "0".
  - d. Turn the flywheel slowly. The gauge reading must not exceed 0.1 mm (0.004 in).

"X" : Mounting surface of engine flywheel housing.

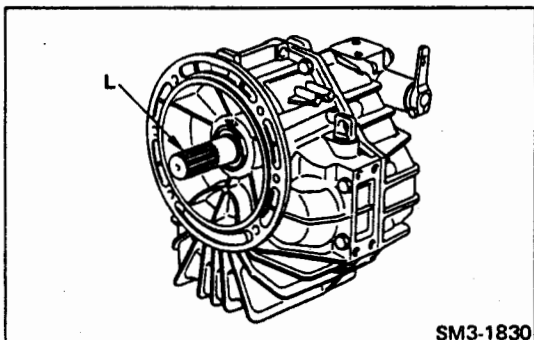


**INSTALL THE INTERMEDIATE FLANGE.**

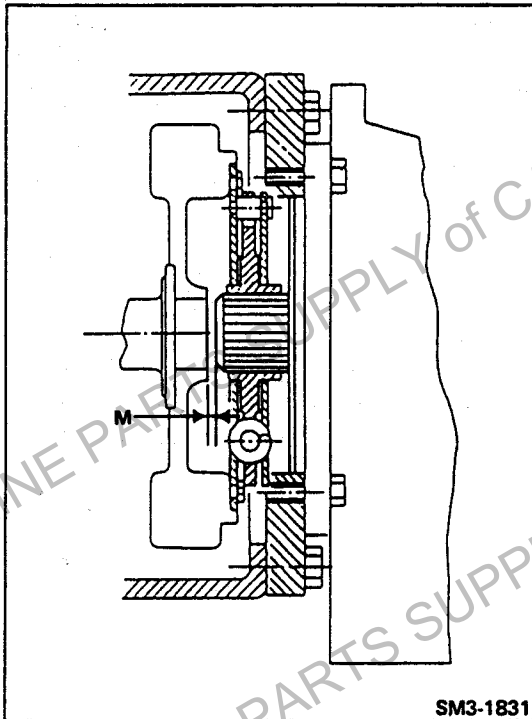
1. Locate the intermediate flange on the flywheel housing to align the match mark.
2. Check the axial tolerances of the intermediate flange (Concentricity).
  - a. Attach caliper linkage (Item H) to the damper plate (Item D).
  - b. Apply base of caliper at right angles to centering surface of intermediate flange (Item K).
  - c. Pretension the gauge and set to "0".
  - d. Turn the flywheel slowly. The gauge reading must not exceed 0.15 mm (0.0059 in).



2. Check the radial tolerances of the intermediate flange (parallel running).
  - a. Attach caliper linkage (Item H) to the damper plate (Item J).
  - b. Apply base of caliper at right angles to plane surface of the intermediate flange (Item K).
  - c. Pretension the gauge and set to "0".
  - d. Turn the flywheel slowly. The surface deviation must not exceed 0.05 mm (0.0019 in) 100 mm (3.937 in) measured diameter.

**INSTALL THE MARINE TRANSMISSION.**

1. Apply grease containing molybdenum disulfide to the input shaft spline (Item L).



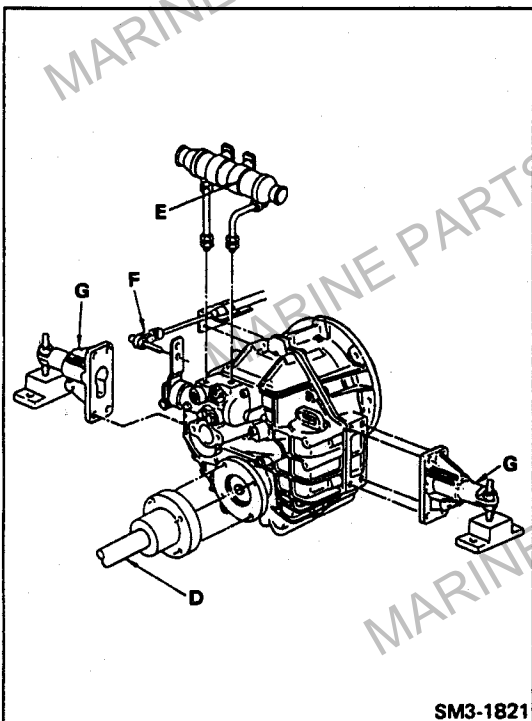
SM3-1831

2. Install the marine transmission to the intermediate flange.

**Tightening Torque: 380–500 kg-cm (28–36 lb.ft)**

**Axial Play (M): Minimum 1 mm (0.04 in)**

**NOTE: Assure clearance of axial play of the crankshaft.**



SM3-1821

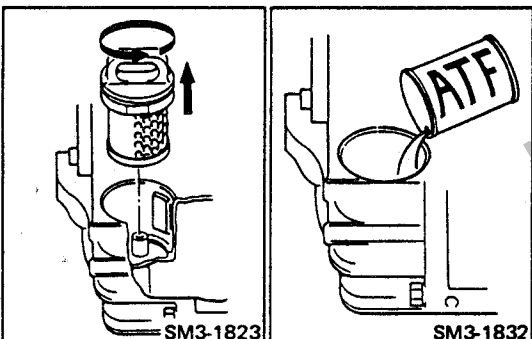
**INSTALL THE SUPPORT BRACKET (Item G).**

**CONNECT THE PROPELLER SHAFT (Item D) TO THE MARINE TRANSMISSION OUTPUT FLANGE.**

**CONNECT THE ELECTRICAL LINE AND FLUID LINES.**

**CONNECT THE REMOVE CONTROL (Item F) TO THE SHIFTING LEVER.**

**INSTALL THE FLUID COOLER WITH PIPES (Item E).**



SM3-1823

SM3-1832

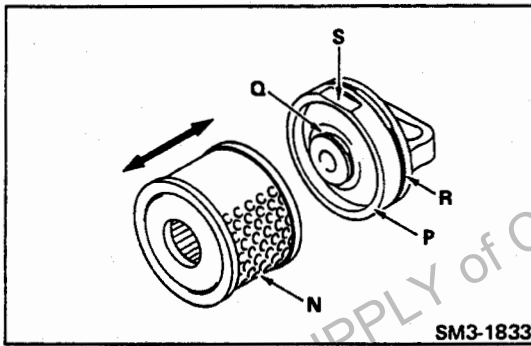
**FILL WITH AUTOMATIC TRANSMISSION FLUID (ATF).**

**NOTE: The filter element must be renewed whenever the fluid is changed.**

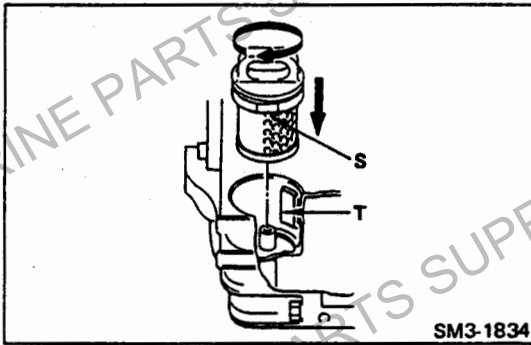
1. Turn filter cover counter-clockwise and pull.
2. Fill with 4.0 liters (1.06 US gallon) of Automatic Transmission Fluid (ATF).

**Type of Fluid: ATF (Automatic Transmission Fluid)**  
 e.g. DEXRON II-D, FORD M 2 C-33G,  
 ALLISON C-3

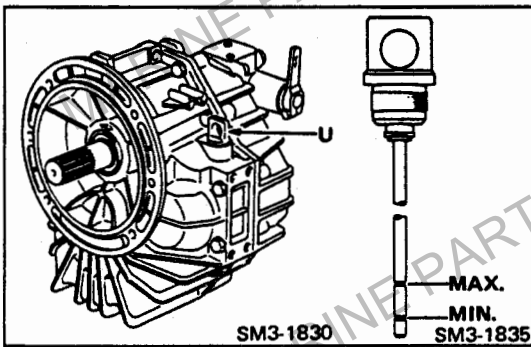
**No other fluids unless authorized by HURTH**



3. Remove filter element (Item N) from cover (Item P).
4. Check O-ring (Item Q) and place new filter element onto cover.
5. Check O-ring (Item R) and insert filter cover with fluid fine filter to its stop into the marine transmission housing.



6. Lock filter cover in place by turning clockwise and pushing.
- NOTE:** When inserting the filter cover, make sure that flat side of cover (Item S) matches with lug (Item T) in the filter.



7. Loosen fluid dipstick (Item U) turning the handle counter-clockwise.
8. Wipe dipstick with a clean and dustfree cloth and insert dipstick to its stop.
9. Remove dipstick and check fluid level.
10. Insert the dipstick to its stop and lock it by turning the handle clockwise.

11. Let engine run at idle speed with shifting lever in neutral position until fluid cooler and all pipelines are filled in fluid.
12. Shut down engine and check fluid level again. If necessary, top up to the marking on the dipstick.

(K.P.)

# CHAPTER EE

## ELECTRICAL EQUIPMENT

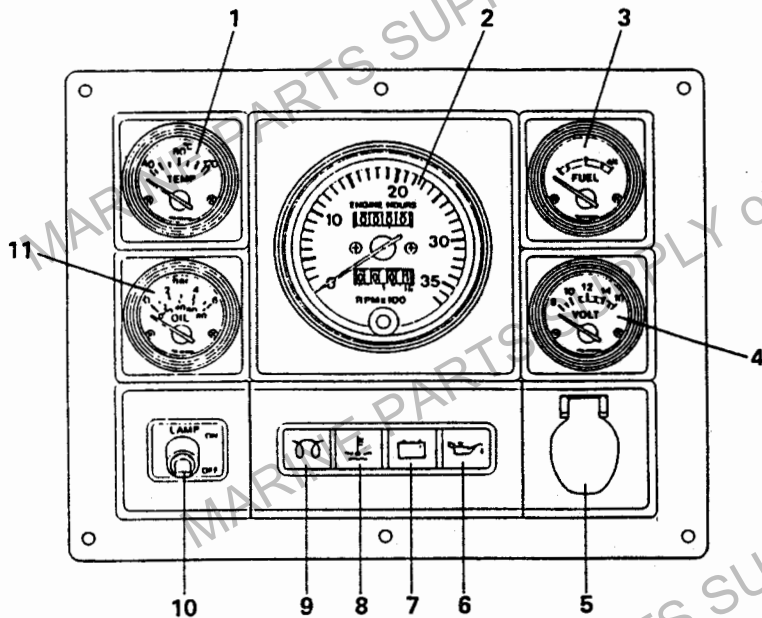
DATA AND SPECIFICATIONS .....	EE- 2
LOCATION OF ELECTRICAL EQUIPMENT .....	EE- 2
TROUBLESHOOTING .....	EE- 3
GENERAL INSTRUCTION .....	EE- 5
BATTERY .....	EE- 6
ENGINE STARTING CIRCUIT .....	EE- 7
PRE-HEAT CIRCUIT .....	EE- 8
ENGINE STOP AND WARNING LAMP CIRCUIT .....	EE- 8
METER AND GAUGE CIRCUIT .....	EE-10
ELECTRICAL WIRING DIAGRAM	

DATA AND SPECIFICATIONS

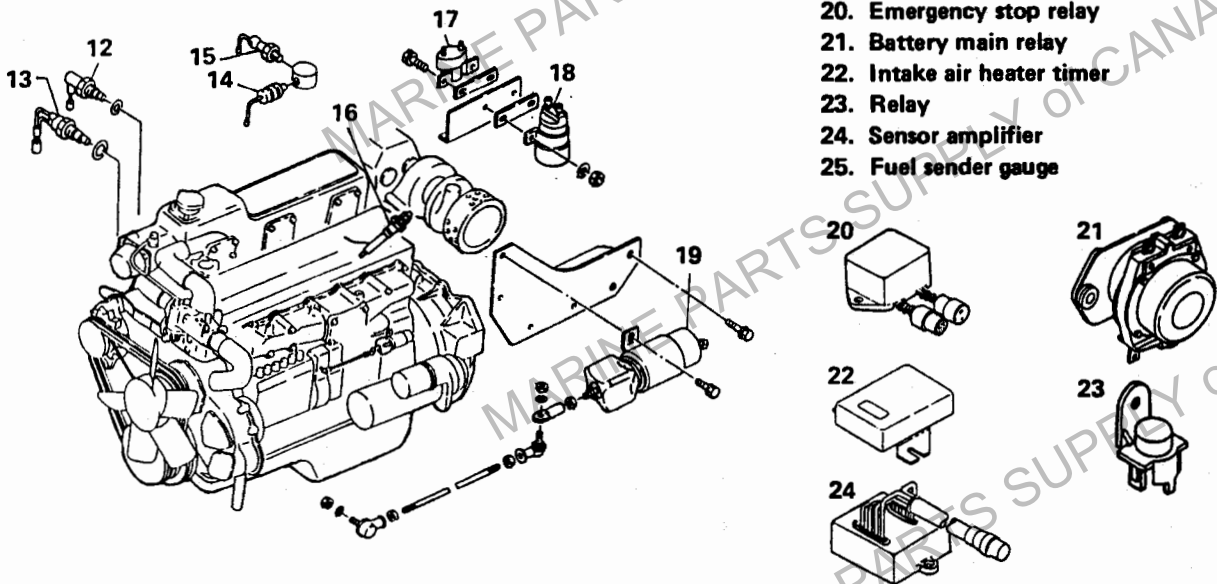
Electrical system

Voltage .....	Direct current 12 volts or 24 volts
Ground .....	Negative (-) ground
Warning and indicator lamp .....	1.4W ..... 4 pieces
Gauge illumination lamp .....	1.7W ..... 4 pieces
Tachometer illumination lamp .....	3.4W ..... 2 pieces

LOCATION OF ELECTRICAL EQUIPMENT



1. Water temperature receiver gauge
2. Engine tachometer
3. Fuel receiver gauge
4. Volt-meter
5. Starter switch
6. Oil pressure warning lamp
7. Battery charge warning lamp
8. Water temperature warning lamp
9. Intake air heater indicator lamp
10. Illumination lamp switch
11. Oil pressure receiver gauge
12. Water temperature switch
13. Water temperature sender gauge
14. Oil pressure sender gauge
15. Oil pressure switch
16. Glow plug
17. Starter block relay
18. Intake air heater relay
19. Solenoid
20. Emergency stop relay
21. Battery main relay
22. Intake air heater timer
23. Relay
24. Sensor amplifier
25. Fuel sender gauge



# TROUBLESHOOTING

Symptom	Possible cause	Remedy/Prevention
<p>A lot of exhaust is emitted but the engine does not start or is difficult to start. (Auxiliary starting device: Standard specifications)</p> <p>(Auxiliary starting device: Option specifications)</p>	<p><b>Auxiliary starting device</b></p> <ul style="list-style-type: none"> <li>Loose wiring of heater signal or defective heater signal. . . . .</li> <li>Defective heater plug . . . . .</li> <li>Defective wiring between heater and plug . . . . .</li> <li>Defective power relay . . . . .</li> <li>Defective heater plug . . . . .</li> <li>Defective wiring between heater and plug . . . . .</li> <li>Defective sensing resistor . . . . .</li> <li>Defective heater control timer . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Repair or replace.</li> <li>Replace.</li> <li>Repair.</li> <li>Repair or replace.</li> <li>Replace.</li> <li>Repair.</li> <li>Replace.</li> <li>Replace.</li> </ul>
	<p><b>Emergency stop relay</b></p> <ul style="list-style-type: none"> <li>Alternator malfunctions . . . . .</li> <li>Insufficient battery voltage . . . . .</li> <li>Faulty connection at N terminal of emergency relay . . . . .</li> <li>Defective solenoid . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Repair or replace.</li> <li>Charge or replace.</li> <li>Repair.</li> <li>Replace.</li> </ul>
<p>Solenoid does not operate when engine is running, even if abnormal signal is input. (Engine does not stop.)</p>	<p><b>Emergency stop relay</b></p> <ul style="list-style-type: none"> <li>Faulty connection at R1 terminal . . . . .</li> <li>Faulty connection at B and C terminals . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Repair.</li> <li>Repair.</li> </ul>
<p>Solenoid operates when starter switch is turned ON</p>	<p><b>Battery</b></p> <ul style="list-style-type: none"> <li>Insufficient voltage . . . . .</li> </ul> <p><b>Alternator</b></p> <ul style="list-style-type: none"> <li>Malfunctions . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Charge or replace.</li> <li>Repair or replace.</li> </ul>
<p>When the starter switch is turned OFF, the battery relay switch goes OFF and the solenoid fails to operate.</p>	<p><b>Battery</b></p> <ul style="list-style-type: none"> <li>Insufficient voltage . . . . .</li> </ul> <p><b>Starter block relay</b></p> <ul style="list-style-type: none"> <li>Faulty connection at terminals . . . . .</li> <li>Internal circuit abnormal . . . . .</li> <li>Relay switch abnormality (faulty contacts), improper sliding between rod and moving core, or open-circuit or burnt out coil . . . . .</li> </ul> <p><b>Starter switch</b></p> <ul style="list-style-type: none"> <li>Faulty connection at terminals . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Charge or replace.</li> <li>Repair.</li> <li>Replace.</li> <li>Replace.</li> </ul>
<p>Starter chattering or improper plunging</p>	<p><b>Battery</b></p> <ul style="list-style-type: none"> <li>Insufficient voltage . . . . .</li> </ul> <p><b>Starter block relay</b></p> <ul style="list-style-type: none"> <li>Faulty connection at terminals . . . . .</li> <li>Internal circuit abnormal . . . . .</li> <li>Relay switch abnormality (faulty contacts), improper sliding between rod and moving core, or open-circuit or burnt out coil . . . . .</li> </ul> <p><b>Starter switch</b></p> <ul style="list-style-type: none"> <li>Faulty connection at terminals . . . . .</li> </ul>	<ul style="list-style-type: none"> <li>Charge or replace.</li> <li>Repair.</li> <li>Replace.</li> <li>Replace.</li> </ul>

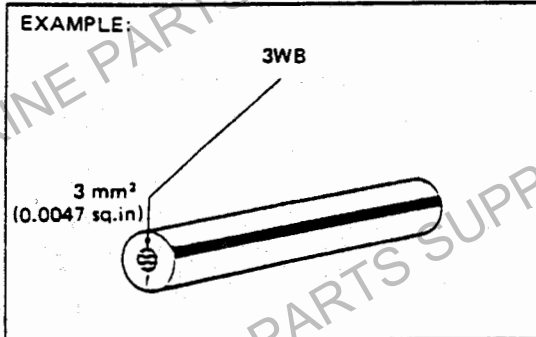
<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Improper disengagement of starter or defective hold function when engine is rotating	<b>Alternator</b>	
	<ul style="list-style-type: none"><li>• Defective (correct voltage not generated) . . . . .</li></ul>	Repair or replace.
	<b>Starter block relay</b>	
	<ul style="list-style-type: none"><li>• Improper terminal connection . . . . .</li><li>• Reverse connections to terminals B and C . . . . .</li></ul>	Repair. Repair.
Re-plunging during inertial rotation	<b>Starter block relay</b>	
	<ul style="list-style-type: none"><li>• Reverse connections to terminals B and C . . . . .</li></ul>	Repair.

MARINE PARTS SUPPLY OF CANADA (800)661-5353

## GENERAL INSTRUCTION

## WARNING

Be sure to disconnect the ground cable before servicing the electrical circuits.



## WIRING CODE

- Wiring colors are indicated by a code.
 

B : Black	Lg : Light green
Br : Brown	R : Red
G : Green	W : White
L : Blue	Y : Yellow
- The first letter indicates the ground wire color and second letter indicates the stripe color.
- Arabic numerals indicate the cross sectional area of wire.  
3 : 3 mm<sup>2</sup>

## CONNECTOR

- The connectors exist as male and female connectors.
- Male and female connectors are classified according to the shape of the terminals in the connector (refer to the figure on the left).
- Male and female connectors are provided with a lock, so that they can not be separated easily.
- For connector separation, hold the connector, unlock the lock and separate the connector.

**NOTE:** When the connector is pulled by pulling the wires, the connection between the terminals and the wires will be damaged.

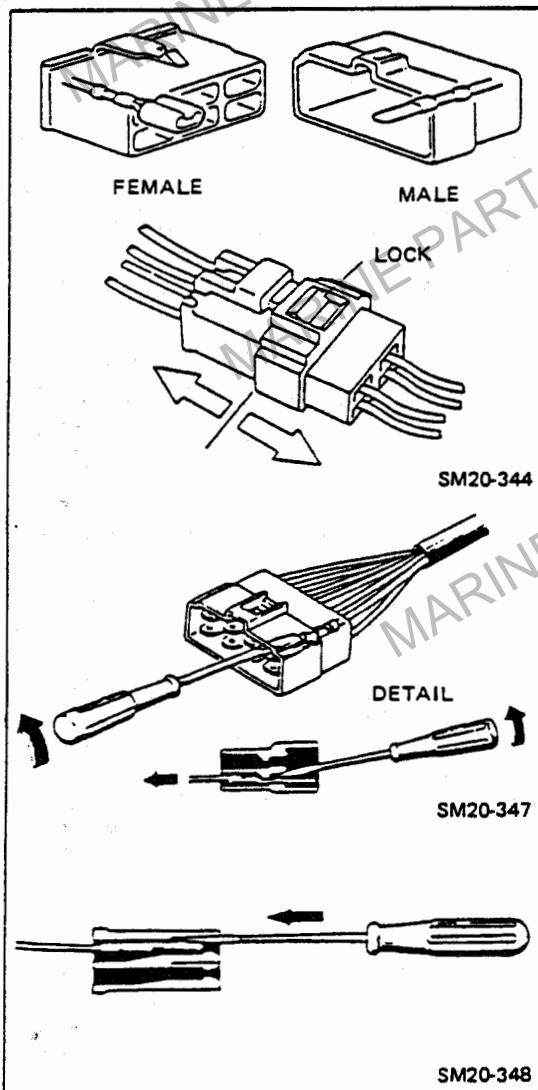
- Remove the terminal from the connector.
  - Insert a miniature screwdriver or a terminal puller between terminal and connector and unlock the lock between terminal and connector.
  - When the lock has been released, pull the wire to remove the terminal.
- Install the terminal in the connector.
  - Insert the terminal into the connector until the clicking sound of lock engagement can be heard.
  - Pull the wire to confirm correct lock engagement.

## FUSE

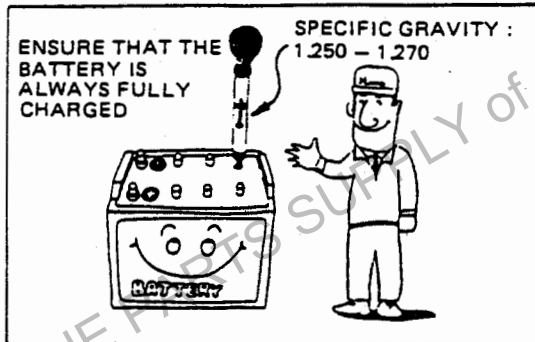
- The power supply must be switched off for fuse replacement.
- Use a fuse with a suitable amperage.

**NOTE:** Wire burning may be caused when a fuse with an excessively large current capacity is used.

- If the fuse should blow frequently, investigate the cause and remove it.



## BATTERY



### CONVERSION FORMULA FOR SPECIFIC GRAVITY.

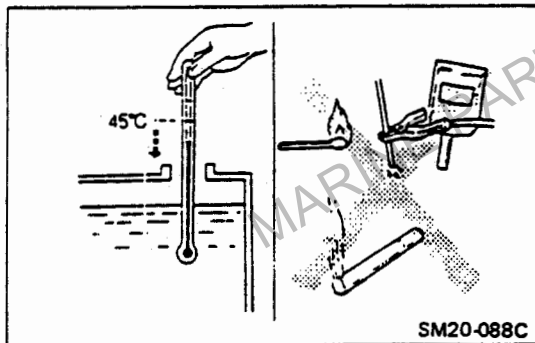
- The specific gravity of electrolyte changes according to the temperature of the electrolyte itself, hence it is based on a temperature of 20°C (68°F). Consequently, if the temperature is not 20°C when the specific gravity is measured, it is necessary to convert the measured value to the equivalent value at 20°C.

Temperature conversion formula:  $S_{20} = S_t + 0.0007 (t - 20)$

Where,

- $S_{20}$  is the specific gravity at 20°C (reference temperature)
- $S_t$  is the specific gravity at the measuring temperature
- $t$  is the temperature during measurement
- 0.0007 is the temperature coefficient of the electrolyte

**NOTE:** As a rough guide, if the temperature of the electrolyte rises or falls by 15°C (59°F), the specific gravity of the electrolyte will vary by about 0.01.



### BATTERY CHARGING

- Be careful of the following points.
- 1) While the battery is being charged, ensure that the temperature of the electrolyte does not rise above 45°C (113°F).
- 2) While the battery is being charged, be particularly careful to keep it away from sources of fire.
- 3) The amount of electrolyte must be within the specified level.

Specific gravity when battery is fully charged: 1.250 - 1.270 at 20°C (68°F)

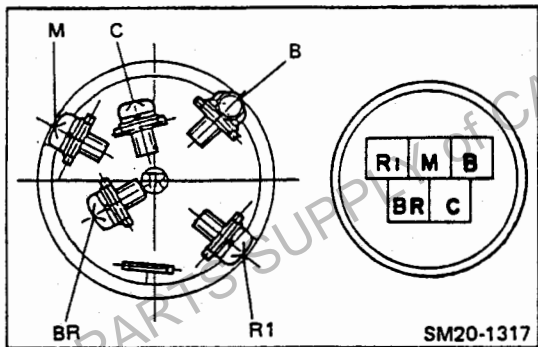
### CLEANING THE BATTERY

- If the terminals at the top of the battery are dirty, clean them with cold water or lukewarm water.
- Apply a light coating of grease to the terminals to prevent them from rusting so as to prevent faulty contact.

### CONNECTING THE BATTERY CABLES

- Clamp the cables securely to prevent improper contact between the cables and the battery terminals.
- Be very careful not to connect the (+) and (-) leads in reverse. (because this may cause equipment run off the battery to be damaged.)

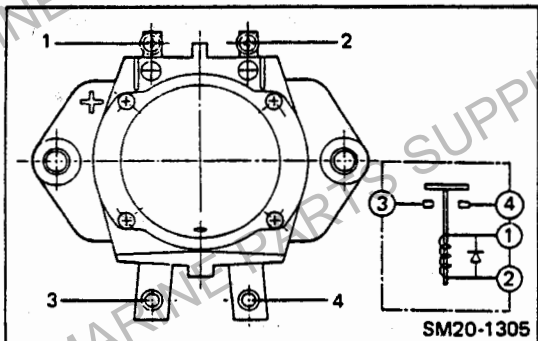
# ENGINE STARTING CIRCUIT



### CHECK THE CONTINUITY OF THE STARTER SWITCH.

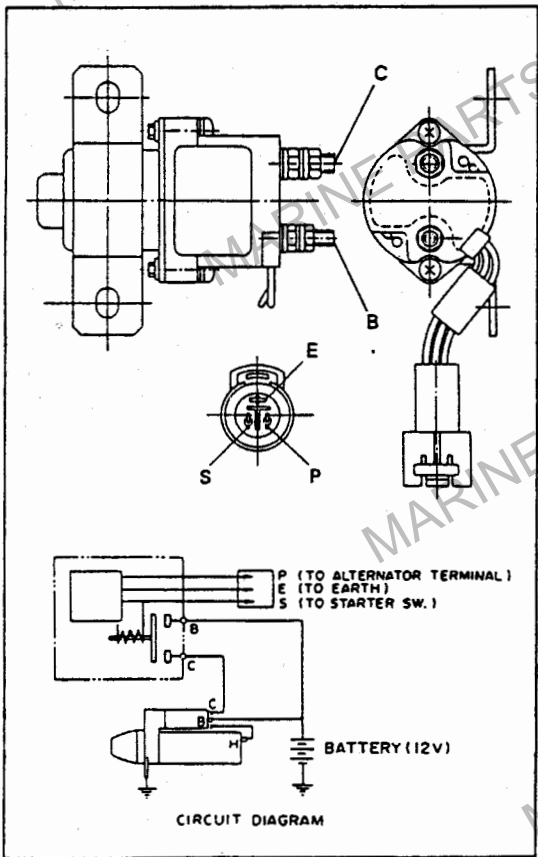
Check the continuity between terminals.  
If continuity is not correct, replace the starter switch.

Terminal	B	R <sub>1</sub>	R <sub>2</sub>	M	BR	C
Switch position						
PRE-HEAT	○	○	○	○	○	
OFF						
ON	○	○	○	○	○	
START	○	○	○	○	○	○



### CHECK THE OPERATION OF BATTERY RELAY.

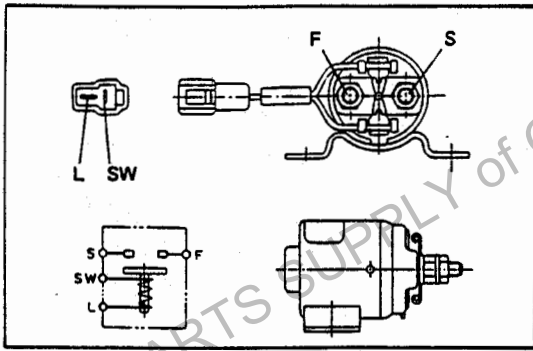
1. Check that there is continuity between terminals 1 and 2.
2. Check that there is no continuity between terminals 3 and 4.
3. Connect the positive (+) lead from the battery to terminal 1. Connect the negative (-) lead to terminal 2. Check that there is continuity between terminals 3 and 4.
4. If operation is not correct, replace the battery relay.



### CHECK THE OPERATION OF THE STARTER BLOCK RELAY.

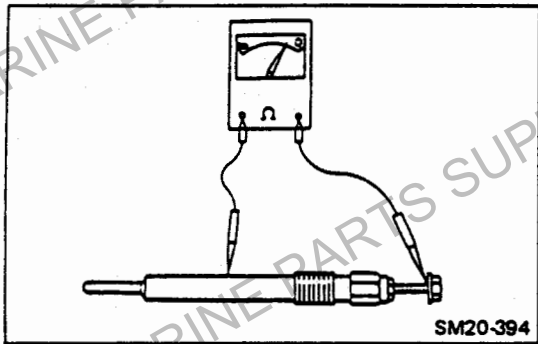
1. Check that there is no continuity between terminals C and B.
2. Connect the positive (+) lead from the battery to terminal S. Connect the negative (-) lead to terminal E. Check that there is continuity between terminals C and B.
3. Connect the positive (+) lead from the battery to terminal P. Connect the negative (-) lead to terminal E. Check that there is no continuity between terminals C and B.
4. If operation is not correct, replace the relay.

## PRE-HEAT CIRCUIT



**CHECK THE OPERATION OF THE INTAKE AIR HEATER RELAY.**

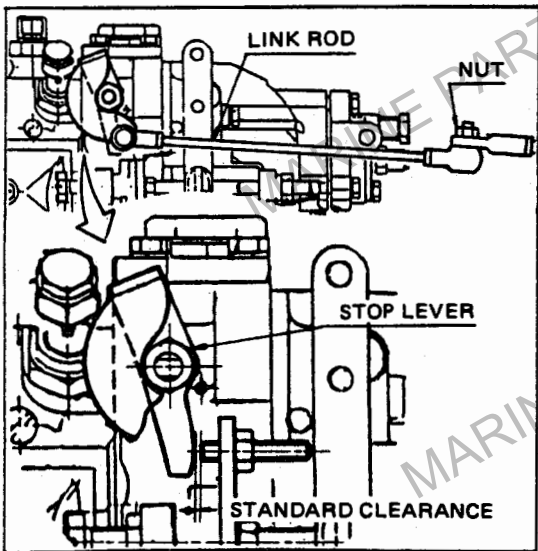
1. Check that there is continuity between terminals SW and L.
2. Check that there is no continuity between terminals S and F.
3. Connect the positive (+) lead from the battery to terminal SW. Connect the negative (-) lead to terminal L. Check that there is continuity between terminals S and F.
4. If operation is not correct, replace the relay.



**CHECK THE CONTINUITY OF THE HEATER PLUG.**

Check the continuity between terminal and body ground. If there is no continuity, replace the glow plug.

## ENGINE STOP AND WARNING LAMP CIRCUIT



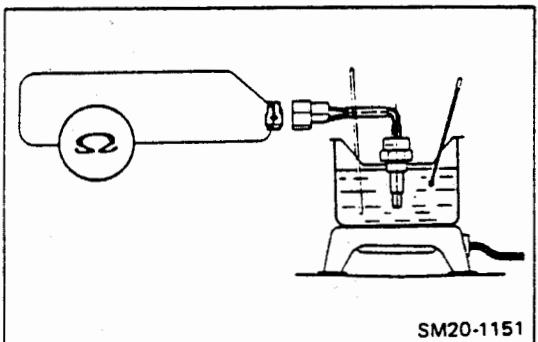
**CHECK THE OPERATION OF THE SOLENOID AND ADJUST THE LINK ROD.**

1. Connect the battery to the solenoid terminals and confirm that the solenoid is drawn in.
2. Push in the plunger by hand and confirm that there is a clearance between the stopper and the stop lever.

Standard clearance: 2 – 3 mm (0.01188 – 0.1181 in)

If there is no clearance, perform adjustment with the link rod.

- NOTE:**
- If the clearance adjustment is unsatisfactory or the action of the solenoid is sluggish, solenoid seizure, insufficient output or engine stoppage may result.
  - Install the link rod with the nut at the top.

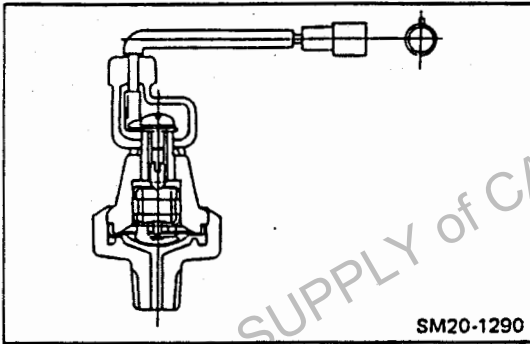


**CHECK THE OPERATION OF THE WATER TEMPERATURE SWITCH.**

Check the continuity between terminals.

If continuity is not correct, replace the temperature switch.

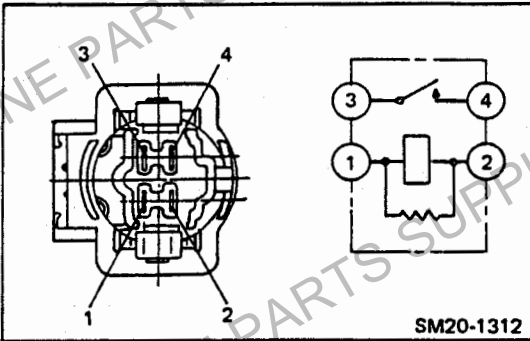
Terminal	1	2
Water temperature: °C (°F)		
More than 96–100 (205–212)	○	○
Less than 91 (196)		



**CHECK THE OPERATION OF THE PRESSURE SWITCH.**

1. Check the continuity between terminal and body ground.
  - a. Check that there is continuity when engine is stopped.
  - b. Check that there is no continuity when engine is running.
2. If continuity is not correct, replace the oil pressure switch.

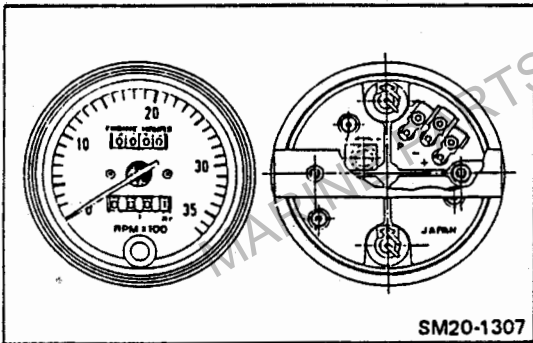
**NOTE:** Engine oil pressure should be more than 0.5 kg/cm<sup>2</sup> (7.2 /sq.in).



**CHECK THE OPERATION OF THE RELAY. (WATER TEMPERATURE WARNING LAMP RELAY)**

1. Check that there is continuity between terminals 1 and 2.
2. Check that there is no continuity between terminals 3 and 4.
3. Connect the positive (+) lead from the battery to terminal 1. Connect the negative (-) lead to terminal 2. Check that there is continuity between terminals 3 and 4.
4. If operation is not correct, replace the relay.

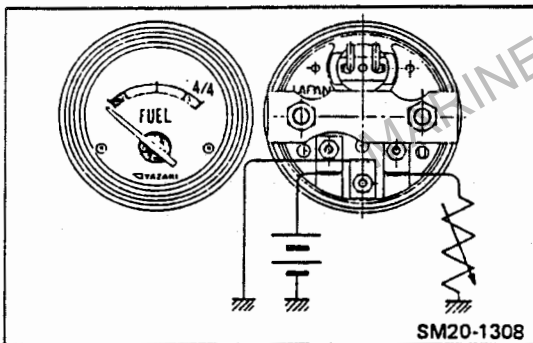
**METER AND GAUGE CIRCUIT**



**CHECK THE OPERATION OF THE TACHOMETER.**

1. Connect a turn-up test tachometer, and start the engine.
2. Check the tester and tachometer indications.  
If the indicated value of tachometer is not correct, replace the tachometer.

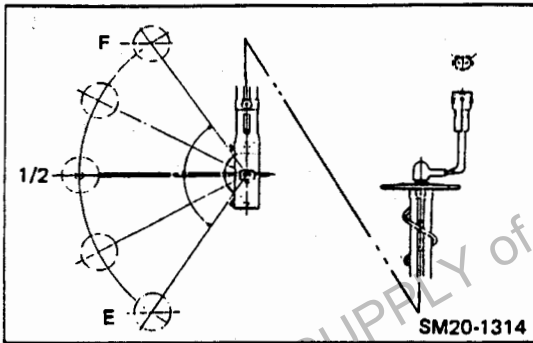
Standard revolution (rpm)	600	1,800	3,000
Allowable value (rpm)	± 100	± 100	± 100



**CHECK THE OPERATION OF THE FUEL RECEIVER GAUGE.**

1. Wire the receiver gauge, variable resistor and battery, as shown in the figure at left. Check the indicated value on the receiver gauge at the reference resistance value.
2. If the indicated value is not correct, replace the receiver gauge.

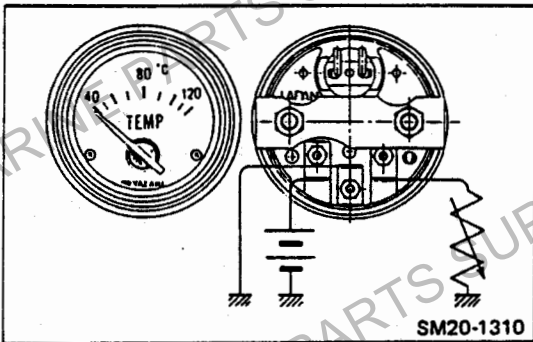
Resistance: Ω	33.5	103	240
Gauge reading	F	1/2	E
Allowable value: %	+ 6 0	± 4	0 - 5



**CHECK THE OPERATION OF THE FUEL SENDER GAUGE.**

Measure the resistance between terminals.  
If resistance is not correct, replace the sender gauge.

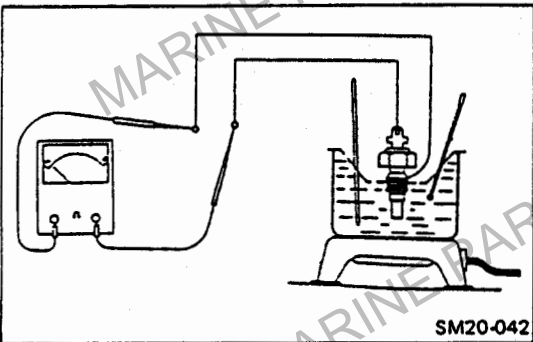
Float position	F	1/2	E
Standard resistance: $\Omega$	30.1	103	250
Allowable value: $\Omega$	$\pm 3.4$	$\pm 10.3$	$\pm 24$



**CHECK THE OPERATION OF THE WATER TEMPERATURE RECEIVER GAUGE.**

1. Wire the receiver gauge, variable resistor and battery, as shown in the figure at left. Check the indicated value on the receiver gauge at the reference resistance value.
2. If the indicated value is not correct, replace the receiver gauge.

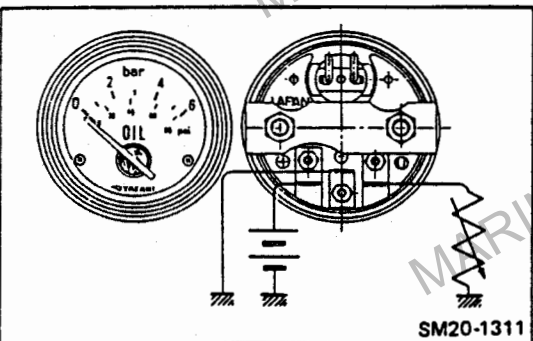
Resistance: $\Omega$	43.2	23.7
Gauge reading: $^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )	80 (176)	100 (212)
Allowable value: $^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )	$\pm 3.5$ (38)	$\pm 5.5$ (42)



**CHECK THE OPERATION OF THE WATER TEMPERATURE SENDER GAUGE.**

1. Wire the sender gauge and ohmmeter as shown in the figure at left. Check the resistance value of the sender gauge at the standard water temperature.
2. If resistance value is not correct, replace the sender gauge.

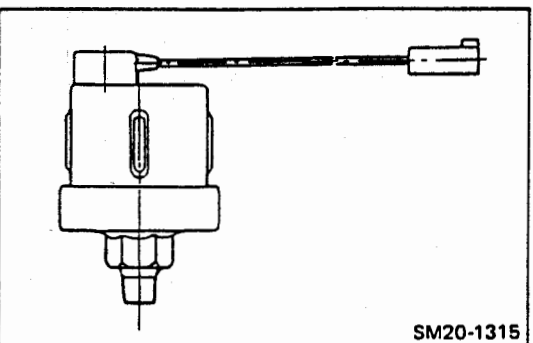
Water temperature: $^{\circ}\text{C}$ ( $^{\circ}\text{F}$ )	50 (122)	80 (176)	100 (212)
Standard resistance: $\Omega$	130	48.5	26.7
Allowable value: $\Omega$	-	$\pm 4.2$	$\pm 2.5$



**CHECK THE OPERATION OF THE OIL PRESSURE RECEIVER GAUGE.**

1. Wire the receiver gauge, variable resistor and battery as shown in the figure at left. Check the indicated value on the receiver gauge at the reference current value.
2. If the indicated value is not correct, replace the receiver gauge.

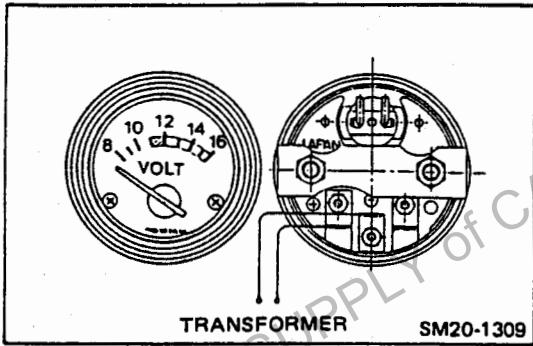
Resistance: $\Omega$	19	81	112
Gauge reading: bar (psi)	0	4 (56)	6 (84)
Allowable value: bar (psi)	$\pm 0.3$ (4.1)	+0.7 (9.7) -0.6 (8.4)	-



**CHECK THE OPERATION OF THE OIL PRESSURE SENDER GAUGE.**

1. Wire the sender gauge and ohmmeter as shown in the figure at left. Check the resistance between the sender gauge and the body ground.
2. If the measured value is not correct, replace the sender gauge.

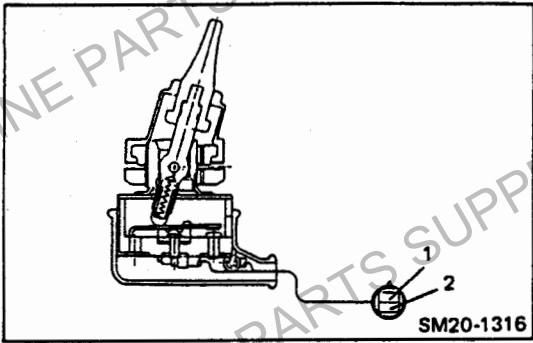
Oil pressure $\text{kg}/\text{cm}^2$ (lb/sq.in)	0	4 (57)	6 (85)
Standard resistance: $\Omega$	19	80	110
Allowable value: $\Omega$	$\pm 2$	$\pm 5$	$\pm 9$



**CHECK THE OPERATION OF THE VOLTMETER.**

1. Wire the voltmeter and transformer as shown in the figure at left. Check the indicated value on the voltmeter at the reference voltage value.
2. If the indicated value is not correct, replace the voltmeter.

Gauge reading: V	12	14
Allowable value: V	± 0.5	± 0.5



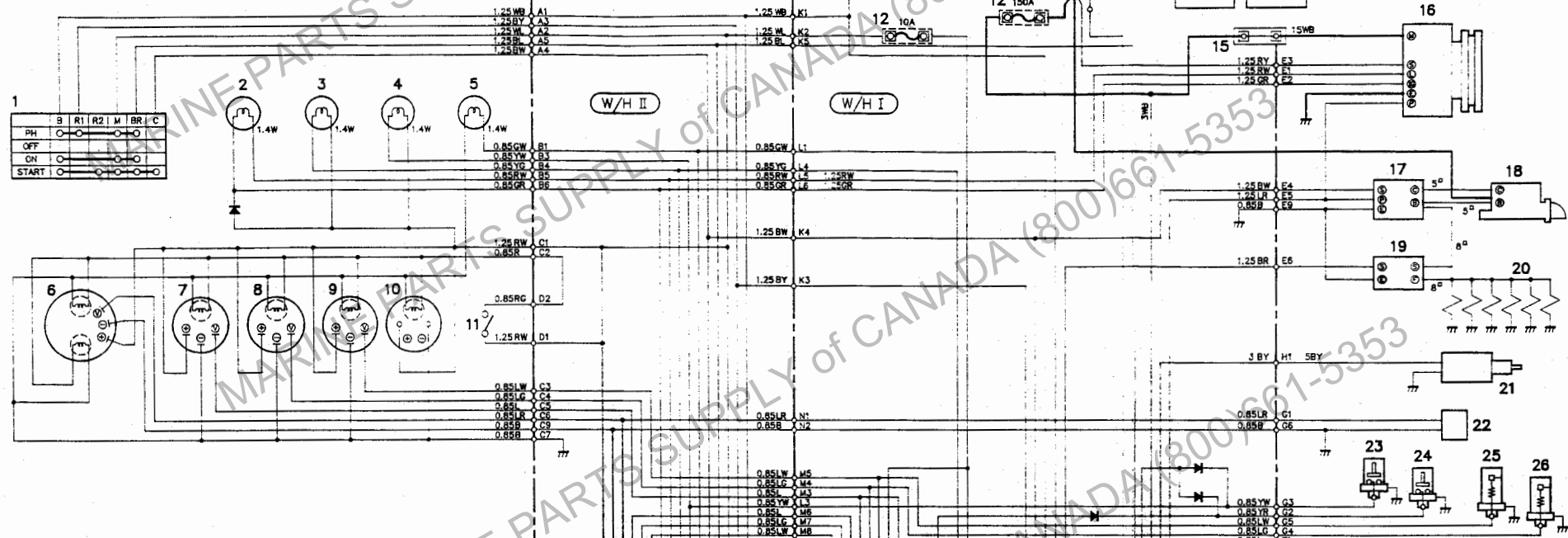
**CHECK THE OPERATION OF THE GENERALLY USE SWITCH (ILLUMINATION LAMP SWITCH).**

Check the continuity between terminals.  
If operation is not correct, replace the switch.

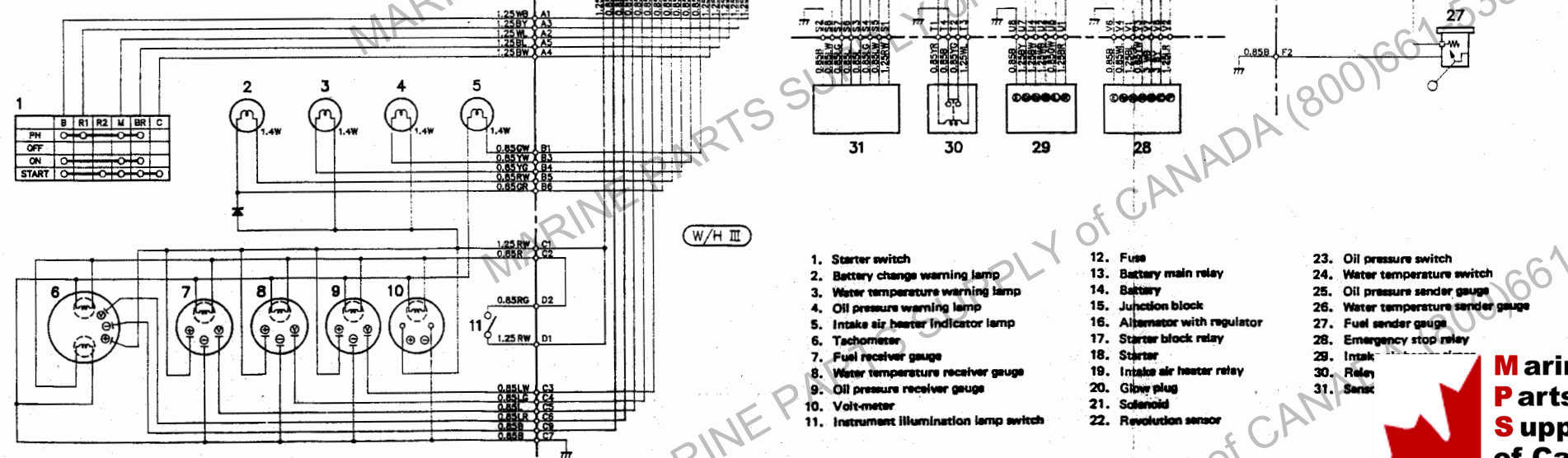
Terminal	1	2
Switch position		
ON	○	○
OFF		

ELECTRICAL WIRING DIAGRAM : MODEL W06DTI (Page 1/2 to 2/2)

MAIN DECK



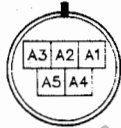
FLYING DECK



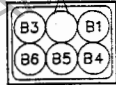
- 1. Starter switch
- 2. Battery change warning lamp
- 3. Water temperature warning lamp
- 4. Oil pressure warning lamp
- 5. Intake air heater indicator lamp
- 6. Tachometer
- 7. Fuel receiver gauge
- 8. Water temperature receiver gauge
- 9. Oil pressure receiver gauge
- 10. Volt-meter
- 11. Instrument illumination lamp switch
- 12. Fuse
- 13. Battery main relay
- 14. Battery
- 15. Junction block
- 16. Alternator with regulator
- 17. Starter block relay
- 18. Starter
- 19. Intake air heater relay
- 20. Glow plug
- 21. Solenoid
- 22. Revolution sensor
- 23. Oil pressure switch
- 24. Water temperature switch
- 25. Oil pressure sender gauge
- 26. Water temperature sender gauge
- 27. Fuel sender gauge
- 28. Intak
- 29. Relay
- 30. Relay
- 31. Sensor

**Marine Parts Supply of Canada**  
 1520 Stewart Ave  
 Nanaimo, B.C.  
 V9S 4E1  
 ph (800) 661-5353  
 fax (250) 754-9471

ELECTRICAL WIRING DIAGRAM : MODEL W06DT1 (Con'd)



STARTER SWITCH  
COMBINATION METER SIDE



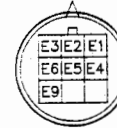
INDICATOR AND WARNING  
LAMP  
COMBINATION METER SIDE



METER AND GAUGE  
COMBINATION METER SIDE



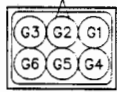
INSTRUMENT ILLUMINATION  
LAMP  
COMBINATION METER SIDE



ALTERNATOR  
STARTER BLOCK RELAY  
INTAKE AIR HEATER RELAY  
ENGINE SIDE



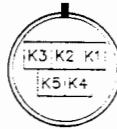
FUEL GAUGE  
SENDER SIDE



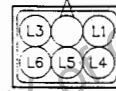
REVOLUTION SENSOR  
WATER TEMPERATURE WARNING  
LAMP  
OIL PRESSURE GAUGE  
OIL PRESSURE WARNING LAMP  
SENDER SIDE



SOLENOID  
ENGINE SIDE



W/H II SIDE



W/H II SIDE



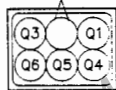
W/H II SIDE



W/H SIDE II



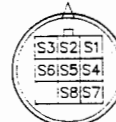
W/H



W/H III SIDE



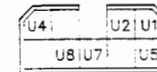
W/H III SIDE



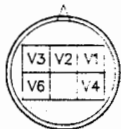
SENSOR AMPLIFIER SIDE



WATER TEMPERATURE  
WARNING LAMP  
RELAY SIDE



INTAKE AIR HEATER  
TIMER RELAY SIDE



EMERGENCY STOP  
RELAY SIDE



EMERGENCY STOP  
RELAY SIDE

EWD-411-2/2

# CHAPTER TU

## TURBOCHARGER

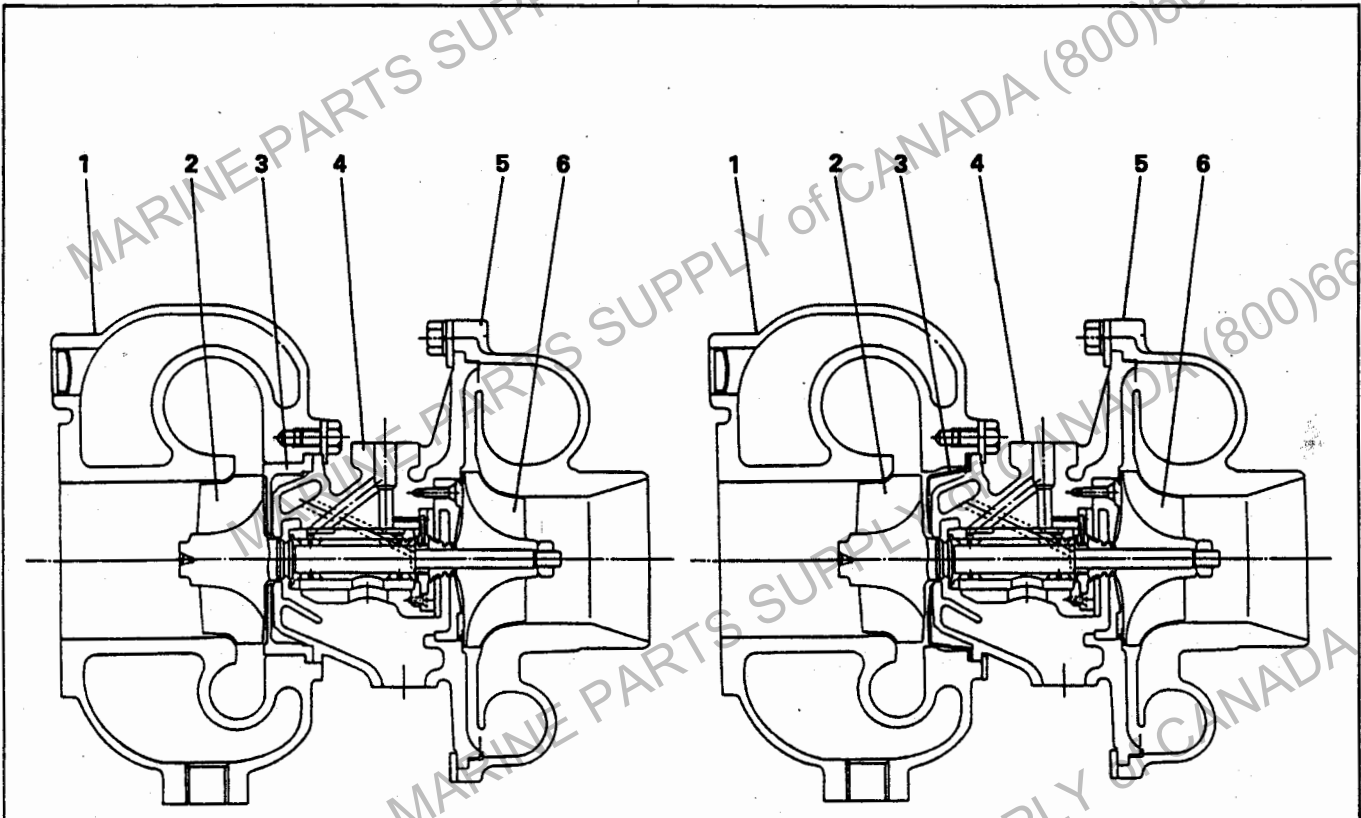
DATA AND SPECIFICATIONS .....	TU-2
DESCRIPTION .....	TU-2
TROUBLESHOOTING .....	TU-3
OVERHAUL CRITERIA .....	TU-5
SPECIAL TOOL .....	TU-6
TURBOCHARGER .....	TU-7



# DATA AND SPECIFICATIONS

Type .....	RHC7 GW
Turbine type .....	Radial flow type
Blower type .....	Centrifugal type
Lubricating method .....	External lubrication type
Bearing type .....	Full floating type
Direction of rotation .....	Counterclockwise as seen from the turbine side

## DESCRIPTION



SM51-099

SM51-099A

- 1. Turbine casing
- 2. Turbine rotor
- 3. Heat protector

- 4. Bearing case
- 5. Blower case
- 6. Blower impeller

# TROUBLESHOOTING

**Symptom**

**Possible cause**

**Remedy/Prevention**

Dense black smoke

**Insufficient air intake**

- Air cleaner is choked with dust, . . . . . Disassemble and clean or replace causing greater intake air resistance. the air cleaner element.
- Air inlet is choked . . . . . Repair.
- Air is leaking from intake manifold . . . . . Repair.

**Turbocharger does not rotate smoothly.**

- Engine oil impurities deposited on . . . . . Overhaul and clean turbocharger rotor, resulting in heavy rotation and/or change engine oil. or sticking.

**Bearing sticking**

- Insufficient lubrication or blockage . . . . . Check lubricating oil system, of lubricating oil lines. and/or repair.
- Abnormal wear or damage of seal . . . . . Repair. ring caused by wear of journal bearing, due to insufficient lubrication.
- Temperature of lubricating oil too high . . . . . Check cooling system.
- Unbalanced rotating parts . . . . . Change rotating parts.
- Incomplete warming-up, failure . . . . . Operate vehicle properly. to idle before stopping engine, or jack rabbit starts.

**Loose or damaged turbine rotor or blower impeller.**

- Over-rotation . . . . . Check and adjust the engine.
- Temperature of exhaust gas too high . . . . . Check and adjust the engine.
- Foreign matter present . . . . . Remove foreign material. Inspect the air cleaner and air intake manifold. Repair if necessary.
- Worn thrust bearing . . . . . Overhaul and repair.
- Incomplete assembly . . . . . Reassembly.

High volume exhaust like noise.

- Exhaust gas leaking before turbocharger, . . . . . Check and repair connections. therefore insufficient revolution.
- Deformed or blocked exhaust gas lines . . . . . Repair. therefore insufficient revolution.

White smoke

- Choking defects, or deformation of . . . . . Repair and replace the lines. oil return lines so that oil leaks around blower or turbine sides.
- Seal ring may be broken or worn due . . . . . Replace the thrust washer. to abnormal wear of thrust washer.

Sudden Shortage of lubricating Oil

- Abnormal wear or damage of seal ring . . . . . Overhaul and repair. caused by wear of journal bearing.

<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Loss of power	Gas leakage from exhaust system . . . . .	Repair.
	Air leakage from air manifold . . . . .	Repair.
	Clogged air cleaner element . . . . .	Clean or replace.
	Turbocharger dirty or damaged . . . . .	Repair or replace.
Poor response of turbocharger	Carbon accumulation on the turbine side seal ring and heavy rotation. . . . .	Change engine oil, clean turbocharger.
	Poor combustion . . . . .	Check fuel system and improve combustion.
High pitched noise and vibration	<b>Noise</b>	
	• So called "surging" . . . . .	Overhaul and clean turbocharger.
	Surging sometimes occurs when the gas passage at the nozzle of the turbine housing is choked or when compressed air does not flow in proper responses to acceleration.	
	• Loosen rotating parts . . . . .	Replace.
	<b>Vibration</b>	
• Joints loose between turbocharger and intake, exhaust manifold or oil lines. . . . .	Check the mounting and repair.	
• Damaged bearing, loose rotating parts, imbalanced rotating parts, etc. . . . .	Repair.	

## OVERHAUL CRITERIA

CONDITIONS WHICH DETERMINE WHEN TURBOCHARGER OVERHAUL MAY BE NEEDED.

THE ENGINE LACKS POWER OR ENGINE EXHAUST EMITS BLACK SMOKE.

BOOST PRESSURE IS BELOW THE NORMAL VALUE.

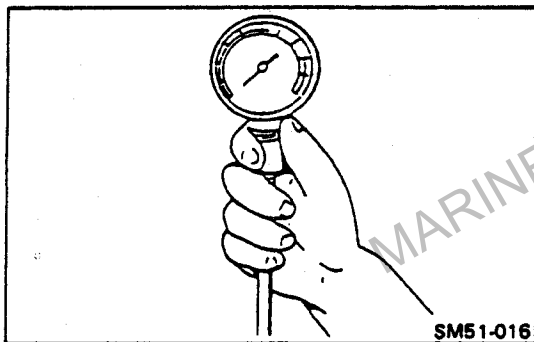
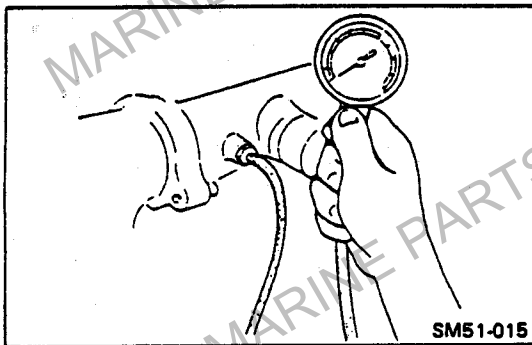
Inspect the turbocharger boost pressure according to the following procedures.

**NOTE:** Before measurement

- Coolant temperature should approximately 80°C.
- Air cleaner element should be clean.

### WARNING

When making a pressure test, be sure that personnel are adequately protected against any stream of pressurized air that might be released by a leak or the rupture of a hose.



1. Remove the blind plug on the intake pipe and install the hose and pressure gauge (special tools).

**Special Tools:** Pressure Gauge (09444-1250)  
Hose (17108-1040)

2. Read boost pressure.

If the boost pressure is below the specified value, turbocharger overhaul is needed.

**Boost Pressure:** Less than 0.13 kg/cm<sup>2</sup> at no load with maximum revolution.

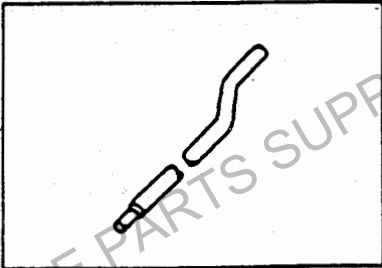
### OTHER FACTORS

1. Noisy of excessive vibration of the turbocharger.
2. Excessive engine oil consumption.
3. Gas leakage at the turbine end or blower end.
4. Oil leakage from the turbocharger.

SPECIAL TOOL

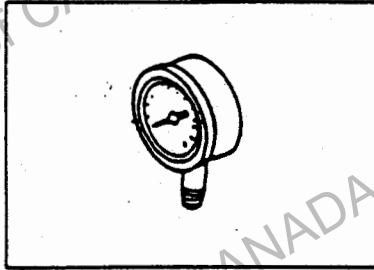
Prior to starting an turbocharger overhaul, it is necessary to have these special tools.

ATTACHMENT FOR MEASURING TURBIN SHAFT RADIAL PLAY



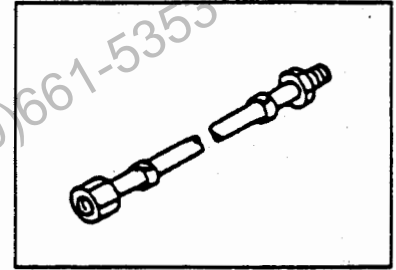
09444-1230

BOOST PRESSURE GAUGE



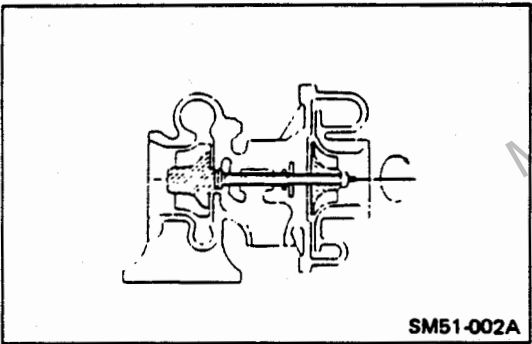
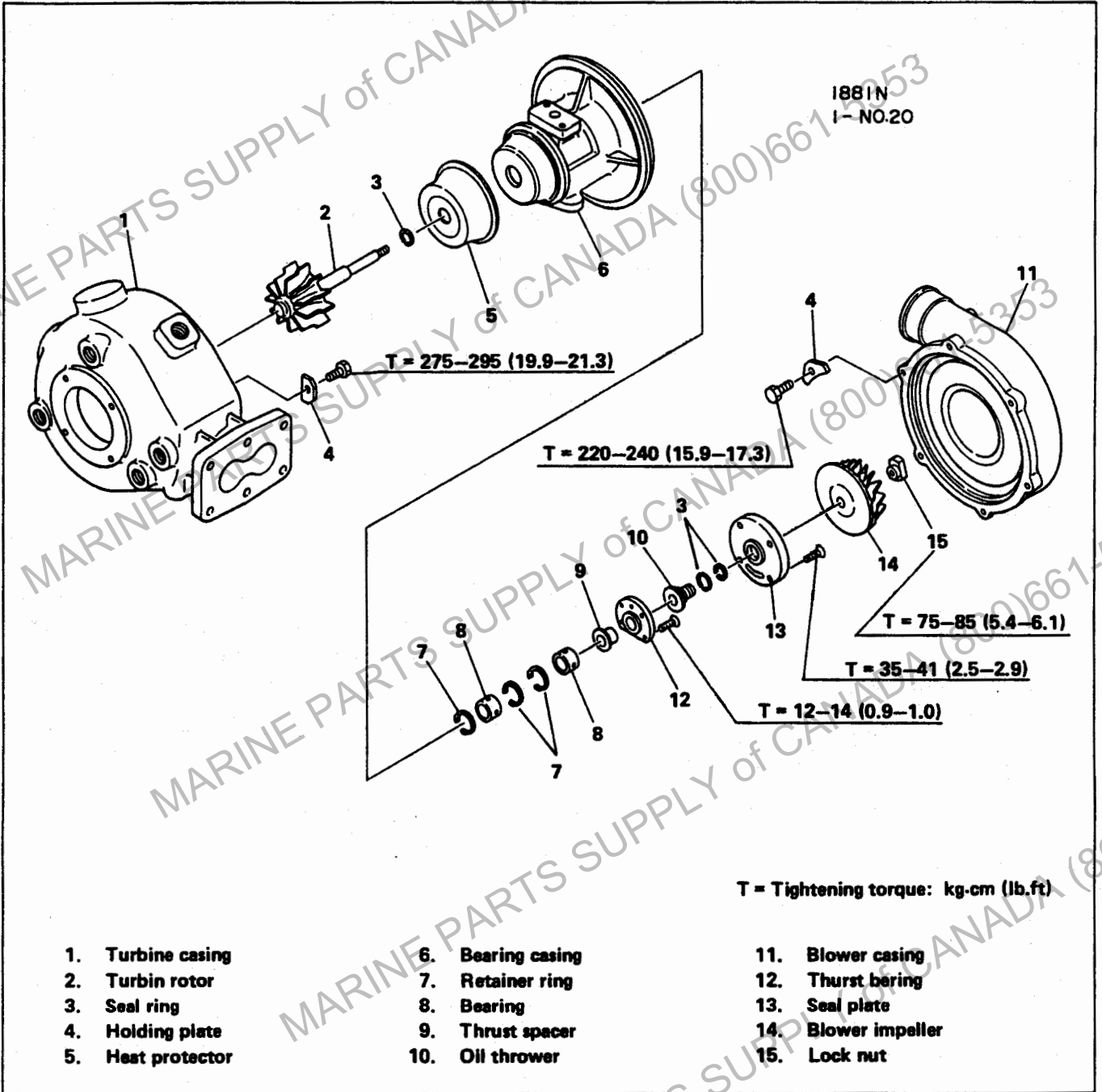
09444-1250

BOOST PRESSURE GAUGE HOSE



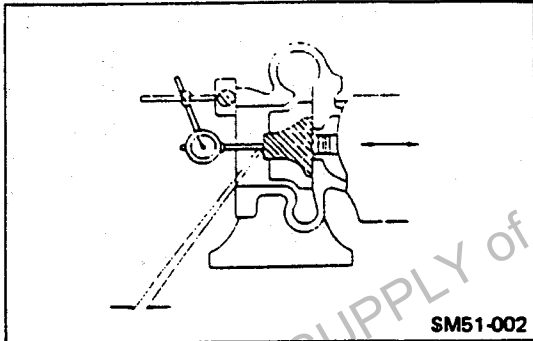
17108-1040

		<p>For assemble, disassemble or measuring of the turbocharger.</p>
		<p>For removing the seal plate.</p>



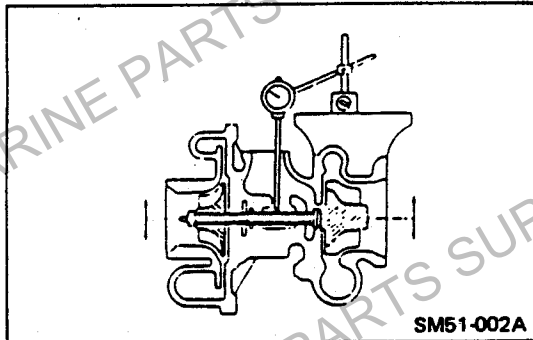
**IMPORTANT POINT (S) – BEFORE DISASSEMBLY**

1. Rotate the blower impeller by hand to see if it turns smoothly. if it does not turn smoothly, clean and inspect the bearing and turbine rotor.



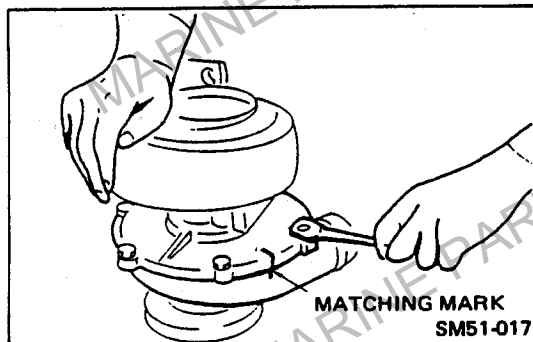
2. Check the turbine rotor for axial play.  
If the axial play is greater than the service limit, replace the thrust bearing and/or thrust spacer.

Axial Play: 0.06 – 0.09 mm (0.0023 – 0.0035 in)  
Service Limit: 0.11 mm (0.0043 in)



3. Check the turbine rotor for radial play using a special tool.  
If the radial play is greater than the service limit, replace the bearings and/or turbine rotor.

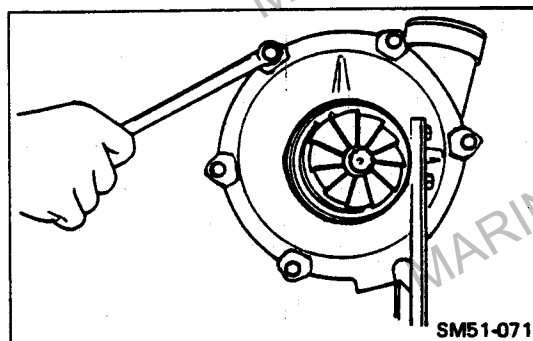
Special Tool: 09444-1230  
Radial Play: 0.11 – 0.18 mm (0.004 – 0.007 in)  
Service Limit: 0.215 mm (0.0085 in)



### IMPORTANT POINT (S) – DISASSEMBLY

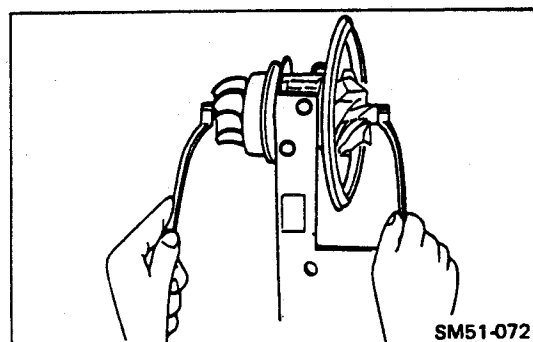
#### REMOVE THE BLOWER CASING.

- NOTE:
- Make matching marks on the blower case and bearing case to aid alignment during reassembly.
  - If the blower casing cannot easily be removed by hand, tap it carefully all around using a plastic hammer and carefully remove it.
  - Be careful not to damage the blower impeller.



#### REMOVE THE BLOWER CASING.

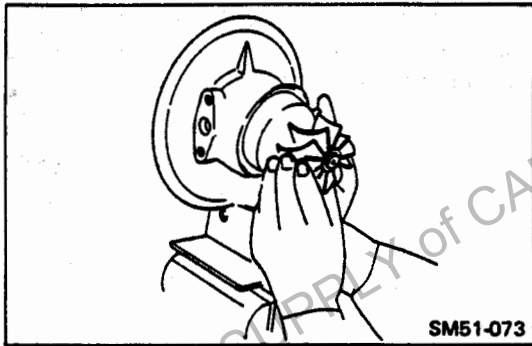
- NOTE: Be careful not to damage blower impeller.



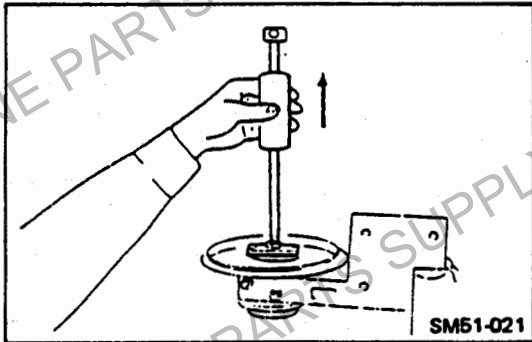
#### REMOVE THE TURBINE ROTOR.

1. Remove the blower impeller fitting nut.

NOTE: Turn the lock nut to clockwise to loosen the nut (left-hand threads).

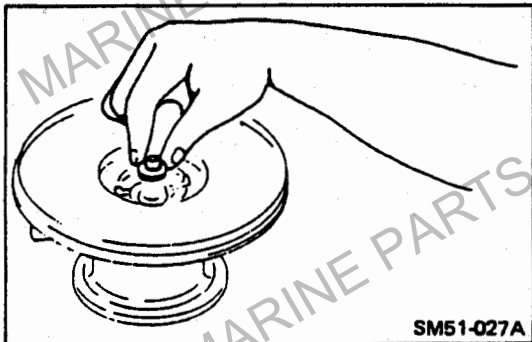


2. Remove the blower impeller and the turbine rotor with heat protector.

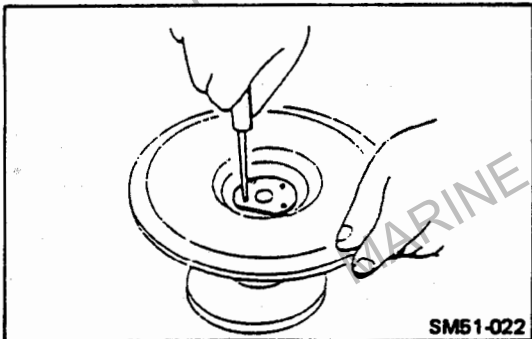


**REMOVAL OF BEARINGS**

1. Remove the seal plate.  
Pull out the seal plate used by special tool.

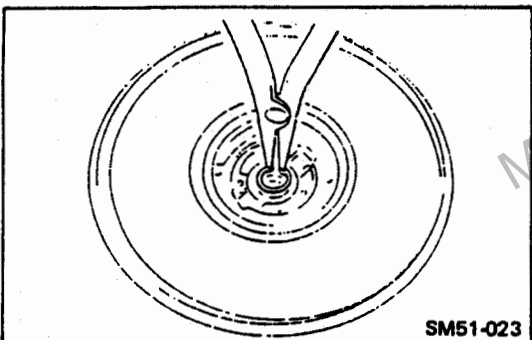


2. Remove the oil thrower.

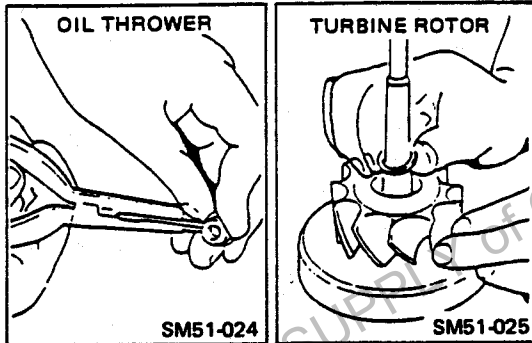


3. Remove the thrust bearing and thrust spacer.  
Loosen the bolt, then remove the thrust bushing using a 10 dia. copper rod.

**NOTE:** When removing the thrust bearing and thrust spacer, be careful not to damage the thrust bearing hole in the bearing case.



4. Remove the retainer rings of each bearing.  
**NOTE:** When removing the retainer ring, be careful not to damage the front face of the hole in the bearing case.
5. Remove the bearings.

**REMOVE THE SEAL RINGS.**

**NOTE:** When removing the seal ring, be very careful not to damage the groove of the seal ring.

**IMPORTANT POINT (S) – ASSEMBLY****CLEAN ALL PARTS.**

1. Before cleaning, the disassembled parts should be visually inspected to check for burning, abrasion, carbon deposits, gas and oil leakage.
2. Thoroughly clean all the parts with diesel fuel, using a soft brush, and dry with compressed air.

**NOTE:** ○ Never use a caustic cleaning solution, as it may attack aluminum.

- Never use a wire brush.

**ASSEMBLE THE JOURNAL BEARINGS.**

1. Install the first retainer ring in the bearing casing.

**NOTE:** ○ Bevelled edge of the retainer ring should be towards the bearing.

- Make sure that the retainer ring is securely fitted in the groove.
- Install the retainer ring with the gap facing as shown in the drawing.

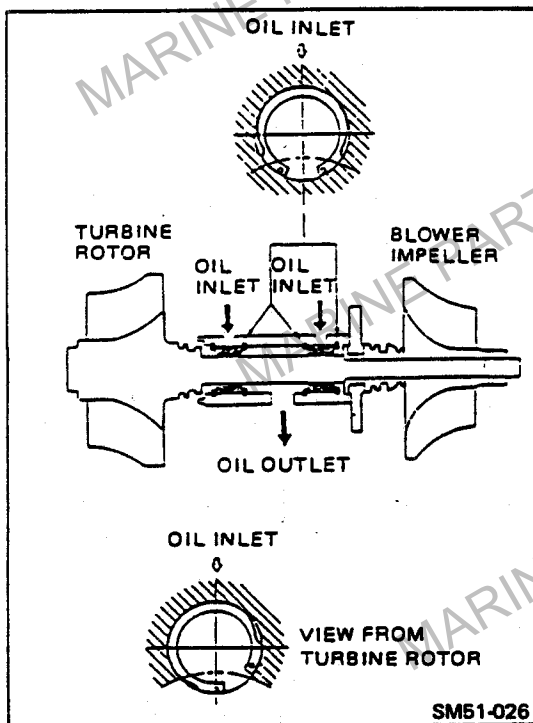
2. Install the bearing in the bearing case.

**NOTE:** Apply clean engine oil.

3. Install the other retainer ring.

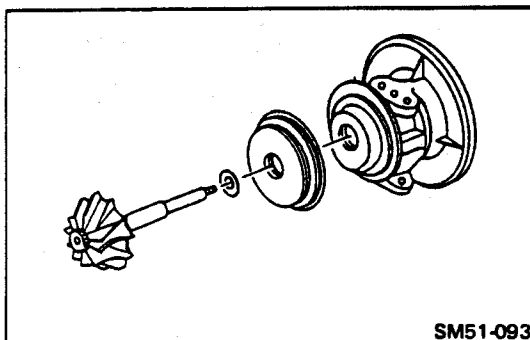
**NOTE:** The only nearest turbine side of the retainer ring should be installed according to the figure on the left.

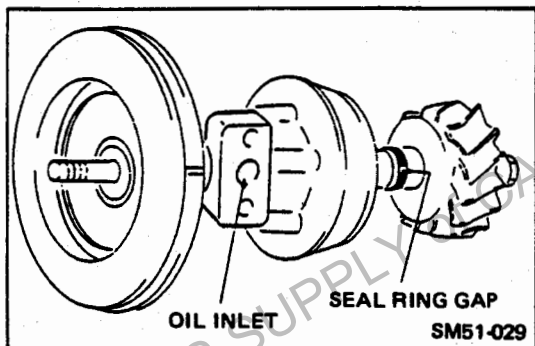
4. Repeat step 1) through 4) to install the second bearing.

**ASSEMBLE THE TURBINE ROTOR.**

1. Install a new seal ring in the seal ring groove of the turbine shaft.

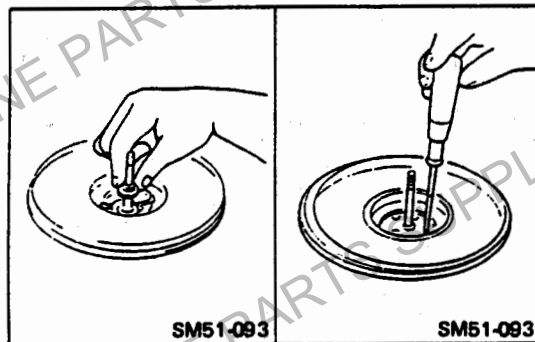
2. Position the heat protector on the bearing case.





3. Coat the journals of the turbine rotor with clean engine oil and install the turbine rotor in the bearing case.

- NOTE:**
- The gap in the seal ring of the turbine shaft must face towards the oil inlet.
  - Insert the seal ring concentric with the turbine shaft. If it is inserted with unreasonable force, it may be damaged.
  - When inserting the turbine shaft, be very careful not to damage the journal bearing.



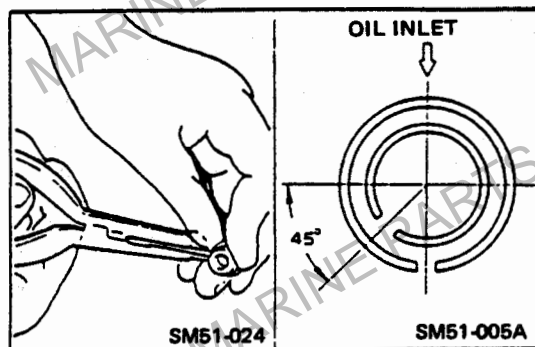
**ASSEMBLE THE THRUST BEARING.**

1. Install the thrust bush on the turbine shaft.

**NOTE:** Lubricate thrust bush surface.

2. Coat the thrust bearing with clean engine oil and install the thrust bearing.

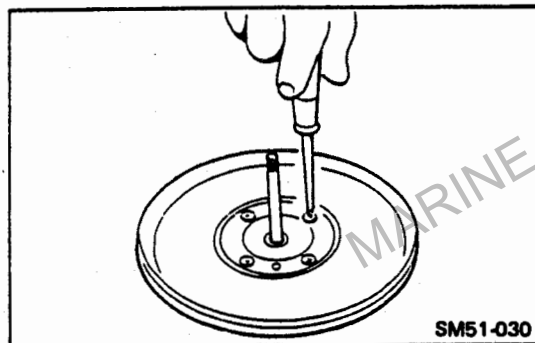
**NOTE:** Always use new screws and lock washers.



**INSTALL THE BACK PLATE.**

1. Insert two new seal rings on the oil thrower.
2. Install the oil thrower in the back plate.

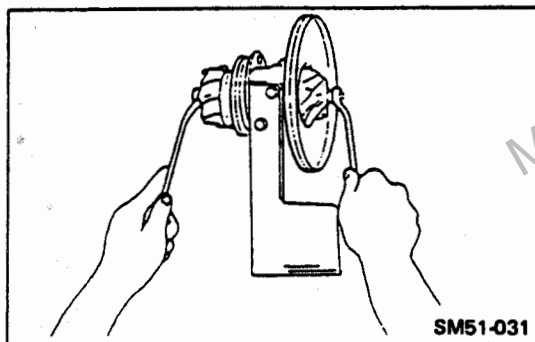
**NOTE:** The openings of seal rings should be positioned as shown.



3. Install the back plate in the bearing plate.

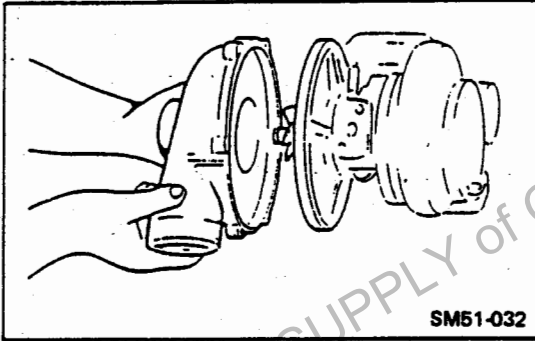
**NOTE:**

- The oil return hole should face the oil outlet side. Apply silicone R.T.V. sealer to the flanged surface of the back plate.
- Take care that the silicone sealer does not protrude from the flange.



**FIT THE BLOWER IMPELLER ON THE TURBINE ROTOR AND TIGHTEN THE LOCK NUT.**

**NOTE:** Remember that this nut has left-hand threads.



INSTALL THE TURBINE CASE TO THE BEARING CASE, BEING SURE TO ALIGN THE MATCHING MARKS.

**NOTE:** Always use new lock plates.

**ASSEMBLE THE BLOWER CASE.**

1. Install the blower case to the bearing case referring to the matching marks.

**NOTE:** Coat the flange face of the blower case with silicone R.T.V. sealant.

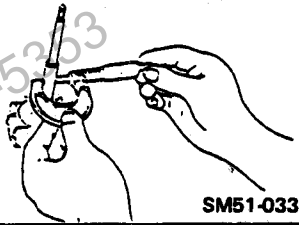
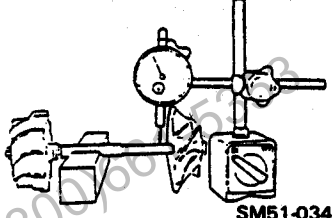
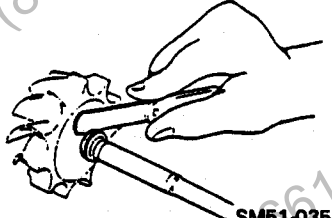
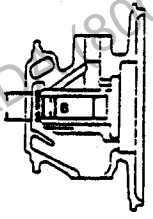
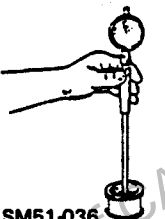
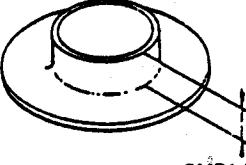
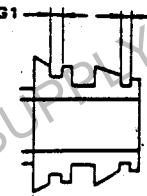
2. Tighten the six fitting bolts.

**ASSEMBLY TEST**

1. Rotate the blower impeller by hand to see if it turns smoothly. Refer to page TU-7.
2. Check the turbine rotor for axial play. Refer to page TU-8.
3. Check the turbine rotor for radial play using a special tool. Refer to page TU-8.

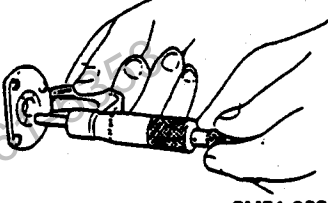
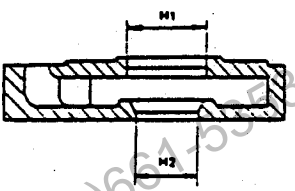
INSPECTION AND REPAIR

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Turbine Shaft Diameter	-	12.28 (0.4835)	Replace	 SM51-033
Turbine Shaft Bend	-	0.011 (0.0004)	Replace	 SM51-034
Seal Ring Groove Width of Turbine Shaft	-	1.63 (0.0642)	Replace shaft assembly.	 SM51-035
Bearing Case Inside Diameter	-	A: 18.55 (0.7303) B: 17.11 (0.6736)	Replace	 SM51-006
Journal Bearing Inside Diameter	-	12.36 (0.4866)	Replace	 SM51-036
Journal Bearing Outside Diameter	-	16.98 (0.6685)	Replace	
Thrust Spacer Height	-	4.48 (0.1764)	Replace	 SM51-007
Seal Ring Groove Width of Oil Thrower	-	G1: 1.75 (0.0689) G2: 1.52 (0.0598)	Replace	 SM51-006A

INSPECTION AND REPAIR

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Thrust Bearing Thickness	-	4.48 (0.1764)	Replace	 <p>SM51-038</p>
Sealing Bore of Seal Plate	-	H1: 16.05 (0.6319) H2: 14.05 (0.5531)	Replace	 <p>SM51-006B</p>

MARINE PARTS SUPPLY OF CANADA (800)661-5353

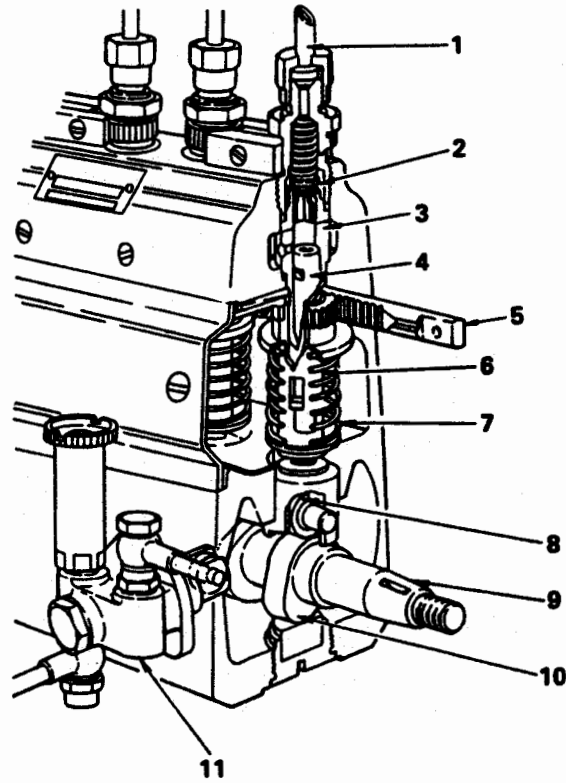
(KY)

# CHAPTER IP

## FUEL INJECTION PUMP

DESCRIPTION .....	IP- 2
TROUBLESHOOTING .....	IP- 3
SPECIAL TOOLS .....	IP- 6
INJECTION PUMP .....	IP- 7
FEED PUMP .....	IP-15
ADJUSTMENT .....	IP-17

## DESCRIPTION



## FUEL INJECTION PUMP

- 1. High pressure pipe
- 2. Delivery valve
- 3. Plunger barrel
- 4. Plunger

- 5. Control rod
- 6. Control sleeve
- 7. Plunger spring
- 8. Tappet

- 9. Cam shaft
- 10. Cam
- 11. Fuel feed pump

# TROUBLESHOOTING

<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Engine does not start	<b>Fuel not reaching injection pump</b>	
	● Fuel lines clogged or damaged . . . . .	Clean or replace fuel lines.
	● Fuel filter clogged . . . . .	Clean or replace the filter element.
	● Air in fuel caused by improper connections of fuel line between fuel tank and feed pump . . . . .	Repair connections.
	● Filter incorporated in inlet side of feed pump clogged . . . . .	Remove foreign material.
	● Faulty feed pump check valve . . . . .	Repair or replace it.
	● Feed pump piston spring broken . . . . .	Replace it.
	● Feed pump push rod or tappet sticking . . . . .	Repair or replace it.
	<b>Fuel reaching injection pump</b>	
	● Faulty connection of accelerator wire to pump adjusting lever . . . . .	Repair connection.
	● Control rack faulty or sticking . . . . .	Repair it.
	● Damaged camshaft bearing . . . . .	Repair it.
	● Plunger worn or sticking . . . . .	Correct or replace it.
	● Faulty connection of engine stop wire to pump stop lever . . . . .	Repair it.
	<b>Nozzle faulty</b>	
	● Fuel leakage caused by loosened nozzle holder . . . . .	Inspect and tighten it.
	● Low opening pressure of nozzle . . . . .	Adjust it.
	● Nozzle pressure spring broken . . . . .	Replace it.
	● Nozzle needle sticking to nozzle body . . . . .	Correct or replace it.
	<b>Pump out of timing</b>	
	● Improperly retarded injection timing . . . . .	Correct injection timing.
	● Incorrect timing caused by improper installation of pump . . . . .	Check engine timing and correct it.
	● Woodruff key for pump camshaft cut off . . . . .	Replace it.
	● Improper pre-stroke adjustment . . . . .	Correct it to obtain specified injection timing.

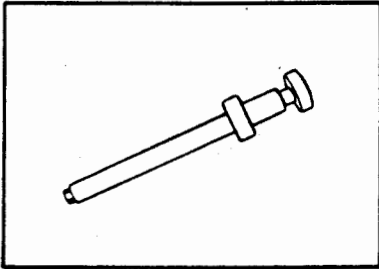
<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Excessive smoke	<b>Black smoke</b>	
	● Excessive fuel delivery caused by incorrect adjustment of fuel load stopper screw.	Adjust fuel delivery on test stand.
	● Excessively advanced injection timing.	Correct it.
	● Large spread in fuel delivery	Adjust it.
	● Bad nozzle fuel spray characteristics	Check and correct them.
	<b>White smoke</b>	
	● Improperly retarded injection timing.	Advance injection timing.
● Water in fuel	Check and clean fuel lines.	
Low idle speed irregular	Improper adjustment of idle button	Correct it.
	Bad fuel spray characteristic of nozzles.	Check and repair them.
	Incorrect injection timing	Correct it.
	Incorrect initial tension setting of idling spring or the spring broken.	Adjust or replace it.
	Control rack not smoothly move	Disassemble pump and repair it.
	Large spread in fuel delivery	Adjust it.
	Plunger worn	Replace it.
	Governor linkage not smoothly move.	Correct it.
Defective feed pump	Disassemble and repair it.	
Engine always runs at high speed	Accelerator cable sticking	Check and correct it.
	Governor linkage sticking	Disassemble and repair the governor.
	Control rack sticking	Check and correct it.
Engine starts and stops	Fuel lines clogged	Clean or replace fuel lines.
	Air in fuel caused by damaged fuel lines or improper connection of fuel lines.	Repair fuel lines or replace fuel lines and gaskets.

<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Engine has low power	<b>Pump out of timing</b>	
	● Excessive advanced timing, . . . . .	Check and correct it.
	● Excessively retarded timing . . . . .	Check and correct it.
	● Defective injection pump overflow . . . . .	Repair or replace it.
	● Feed pressure too low . . . . .	Repair the feed pump.
	● Improper accelerator cable adjustment . . . . .	Adjust it.
	<b>Nozzle faulty</b>	
	● Fuel leakage from nozzle holder . . . . .	Check and repair nozzle holder.
	● Bad nozzle spray characteristic . . . . .	Repair or replace it.
	● Loosened adjusting screw in nozzle . . . . .	Adjust it.
	● Nozzle pressure spring broken . . . . .	Replace it.
	<b>Pump faulty</b>	
	● Fuel leakage from delivery valve . . . . .	Retighten the delivery valve holder if it is loosened or replace O-ring if the O-ring is defective.
	● Defective seat of delivery valve . . . . .	Repair or replace it.
	● Delivery valve spring broken . . . . .	Replace the spring.
	● Plunger worn . . . . .	Replace it.
	● Large spread in fuel delivery . . . . .	Adjust it.
	● Wear of tappet roller . . . . .	Replace the roller.
	● Camshaft bearing worn or broken . . . . .	Replace it.
	● Improper adjustment of governor . . . . .	Adjust it.
● fuel load stopper screw.		
Loud knocking	Improper injection timing . . . . .	Correct it.
	Bad fuel nozzle spray pattern . . . . .	Check and correct it.
	High nozzle opening pressure . . . . .	Adjust the opening pressure.
	Incorrect fuel deliveries to . . . . .	Readjust the fuel deliveries.
some nozzles.		

# SPECIAL TOOL

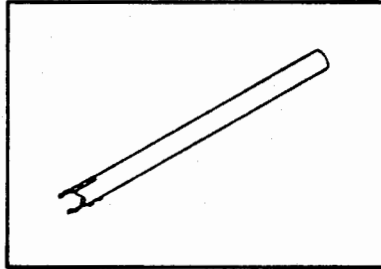
Prior to starting an injection pump overhaul, it is necessary to have these special tools.

**PLUNGER CLAMP**



09512-1360

**TAPPET CLAMP**



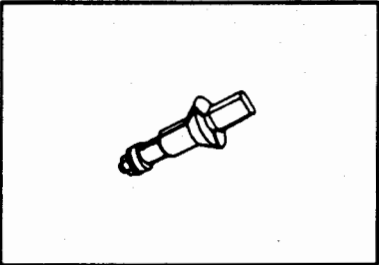
09512-1120

**TAPPET ROLLER CLAMP**



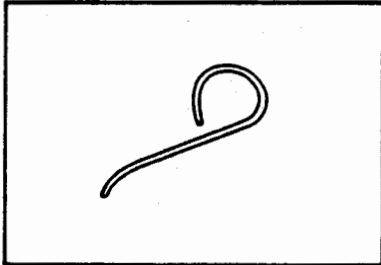
09512-1130

**CAMSHAFT BEARING OUTER RACE PULLER**



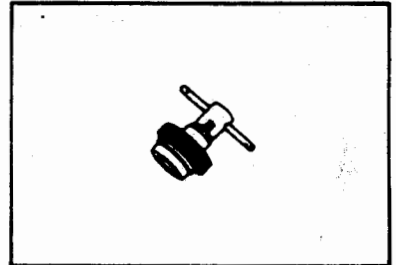
09512-1160 (REAR)  
09512-1430 (FRONT)

**TAPPET INSERTER**



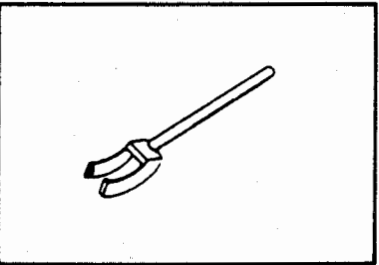
09512-138C

**CAMSHAFT CLEARANCE GAUGE**



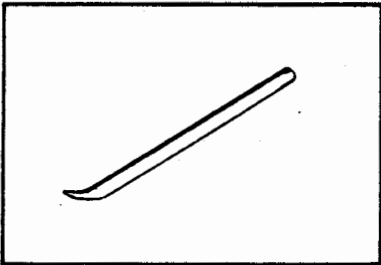
09512-1150

**SPRING HOLDER**



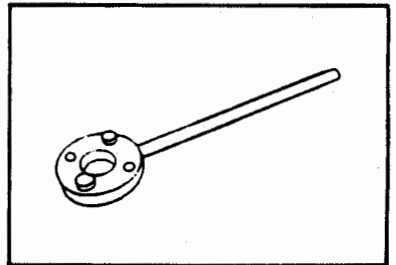
09512-1370

**TAPPET GAP INSTRUMENT**



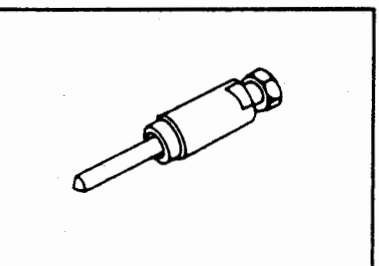
09512-1410

**HOLDING WRENCH**



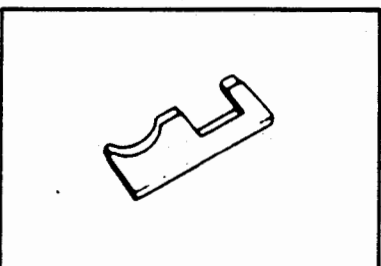
09512-1710

**TIMER EXTRACTOR**



09512-1230 (SA-TYPE)  
09512-1280 (SCZ-TYPE)

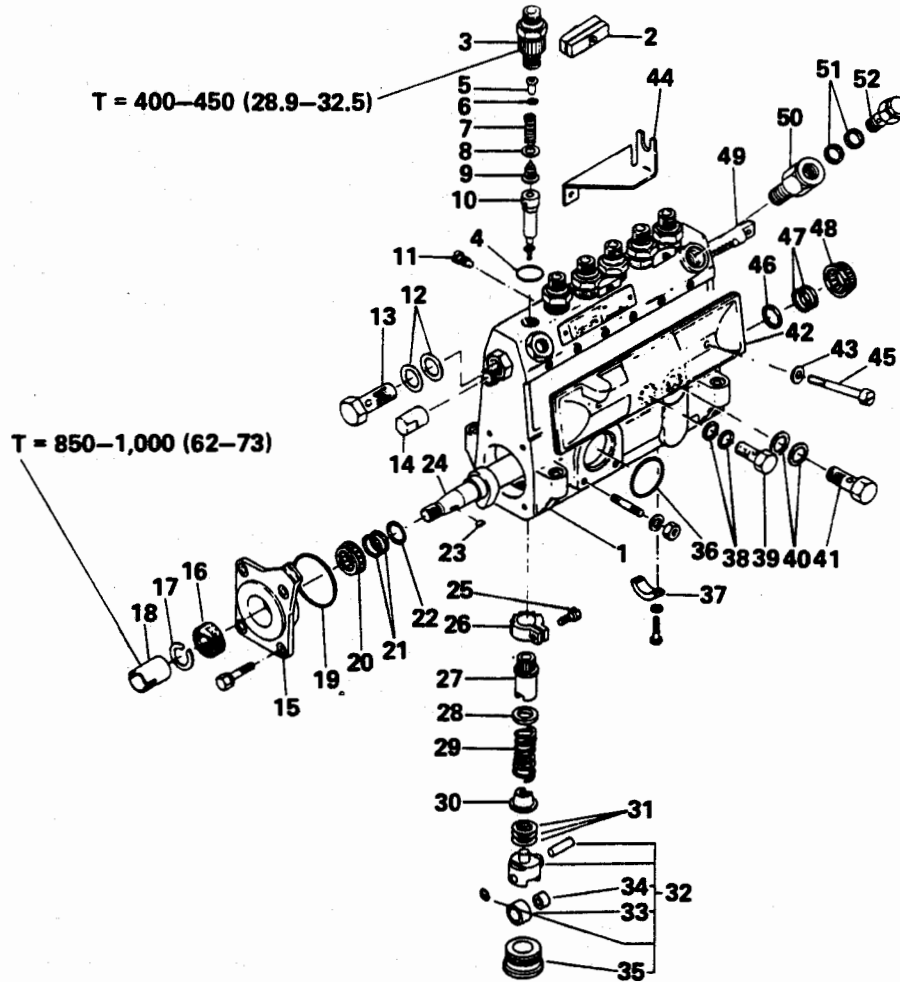
**SPRING HOLDER**



09512-1240

INJECTION PUMP

A-TYPE



T = Tightening torque kg-cm (lb.ft)

- |                           |                                |                                  |
|---------------------------|--------------------------------|----------------------------------|
| 1. Injection pump housing | 19. O-ring                     | 37. Center bearing               |
| 2. Lock plate             | 20. Taper roller bearing       | 38. Washer                       |
| 3. Delivery valve holder  | 21. Shim                       | 39. Hollow screw                 |
| 4. O-ring                 | 22. Adjusting ring             | 40. Washer                       |
| 5. Stopper                | 23. Woodruff key               | 41. Hollow screw                 |
| 6. Plate washer           | 24. Camshaft                   | 42. Cover                        |
| 7. Delivery valve spring  | 25. Screw                      | 43. Gasket                       |
| 8. Gasket                 | 26. Control pinion             | 44. Stop wire bracket            |
| 9. Delivery valve         | 27. Control sleeve             | 45. Bolt                         |
| 10. Plunger               | 28. Plunger spring seat, upper | 46. Adjusting ring               |
| 11. Screw                 | 29. Plunger spring             | 47. Shim                         |
| 12. Washer                | 30. Plunger spring seat, lower | 48. Taper roller bearing         |
| 13. Hollow screw          | 31. Shim                       | 49. Control rack                 |
| 14. Control rack cover    | 32. Tappet assembly            | 50. Adapter                      |
| 15. Bearing cover         | 33. Tappet roller              | 51. Washer                       |
| 16. Oil seal              | 34. Roller bushing             | 52. Over flow valve sub-assembly |
| 17. Spring washer         | 35. Plug                       |                                  |
| 18. Round nut             | 36. O-ring                     |                                  |

## IMPORTANT POINT (S) – DISASSEMBLY

## WARNING

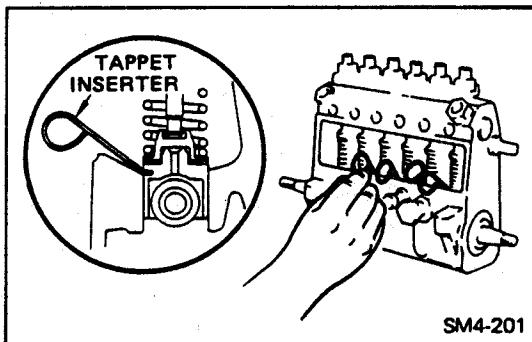
- Breaking of the lead seals or crimp caps by anyone other than HINO or pump manufacture authorized service stations to make these adjustment will void the warranty.
- If fuel pump or governor difficulties are suspected, consult only HINO or pump manufacture authorized service stations, where the problem can be corrected and the injection pump lead seals and crimp caps can be reinstalled as required.
- Measure and record the fuel delivery characteristics of the pump before disassembling it.
- Keep the parts for each cylinder in separate groups and in an orderly arrangement. Parts to be replaced and parts to be used again must be kept separately.

## REMOVE THE TIMER ASSEMBLY.

Refer to "TIMER AND COUPLING".

## REMOVE THE GOVERNOR.

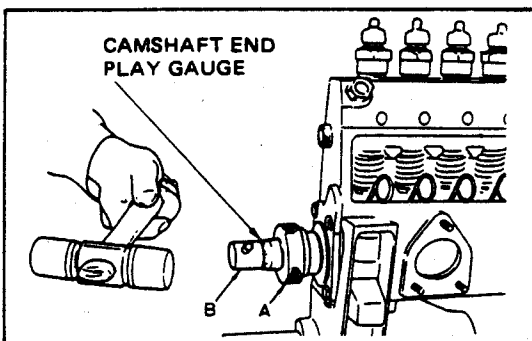
Refer to "GOVERNOR".



## INSERT THE TAPPET INSERTER IN THE TAPPET HOLE.

Turn the camshaft and insert the tappet inserters in each tappet hole when their tappet is at the highest position.

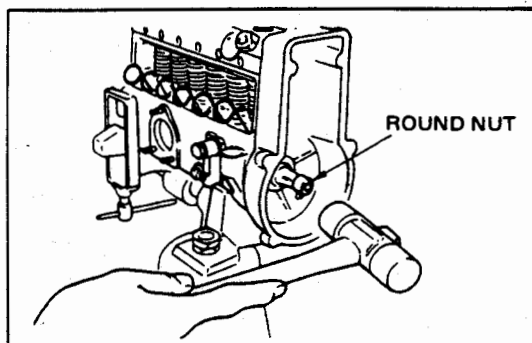
Special Tool: Tappet Inserter (09512-1380)



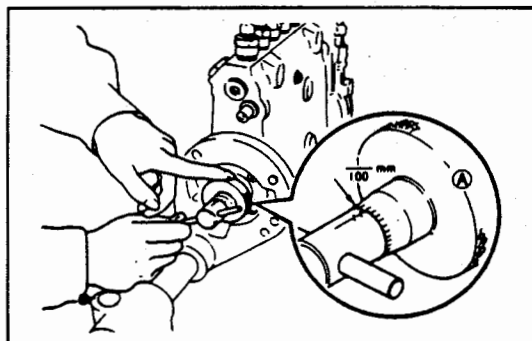
## MEASURE THE CAMSHAFT END PLAY.

1. Mount the camshaft end play gauge on the camshaft drive end and be sure tighten "B".
2. By turning "A", create a clearance of about 1 mm (0.04in) between "A" and the bearing cover.
3. Lightly strike the end "B" 3 or 4 times with a plastic hammer.

Special Tool: Camshaft End Play Gauge (09512-1150)

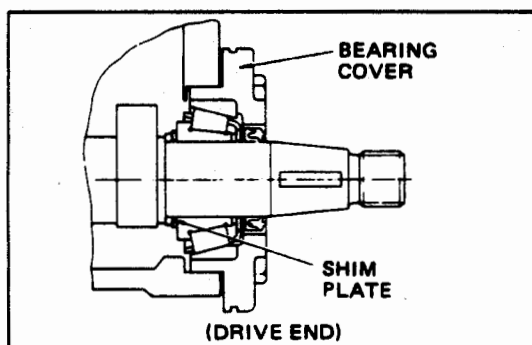


4. Lightly tighten "A" until it comes into contact with the bearing cover.
5. Lightly strike the camshaft governor end 3 or 4 times a plastic hammer.



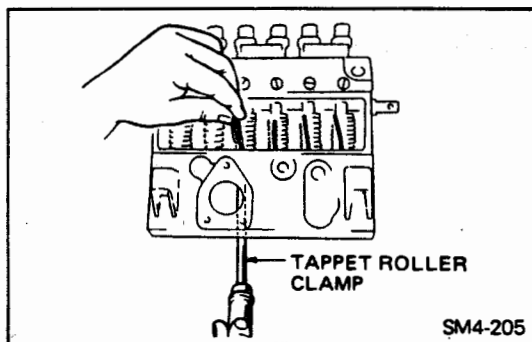
6. Lightly turn "A" until it comes into contact with the bearing cover, then read the clearance.

**Assembly Standard:** 0.03–0.05 mm (0.0012–0.0019 in)  
**Service Limit:** 0.10 mm (0.004 in)



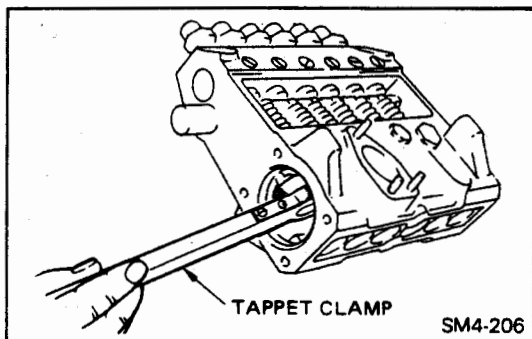
7. If the specification is not met, use appropriate shim plates at the drive end of camshaft.

**REMOVE THE TAPPET ASSEMBLY.**



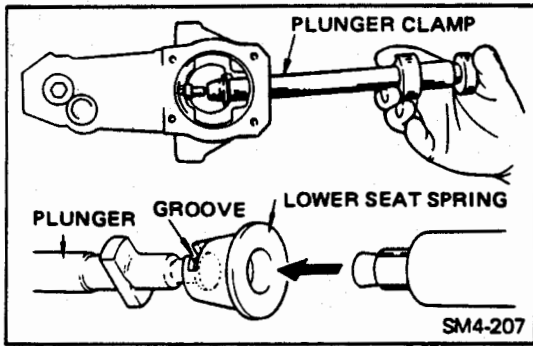
1. Push the tappet with the tappet roller clamp and remove the tappet inspector.

**Special Tool:** Tappet Roller Clamp (09512-1130)



2. Remove the tappet through the camshaft bearing hole.

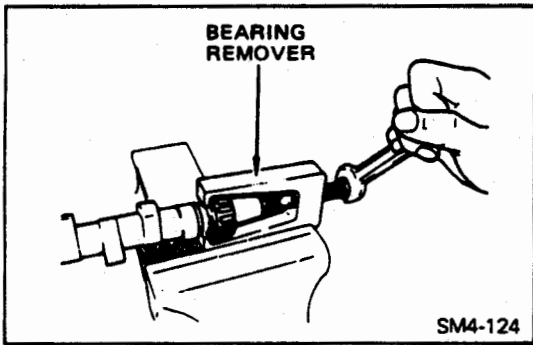
**Special Tool:** Tappet Clamp (09512-1120)



**REMOVE THE PLUNGERS, SPRINGS AND CONTROL SLEEVE.**

1. Use the plunger clamp hold the spring lower seat and remove it together with the plunger.

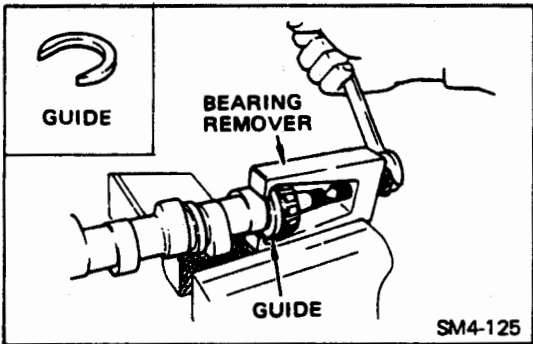
**Special Tool: Plunger Clamp (09512-1360)**



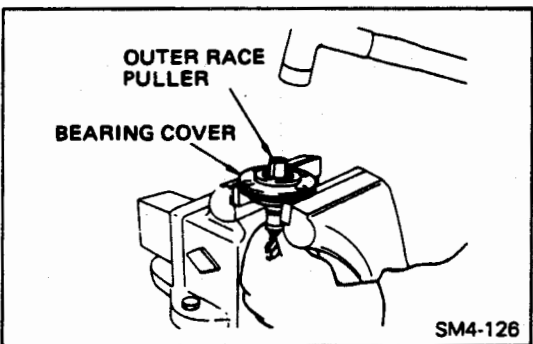
**REMOVE THE TAPER BEARING FROM THE CAMSHAFT.**

1. Remove the taper bearing from the drive end of the camshaft.

**Special Tool: Bearing Remover (09510-1160)**

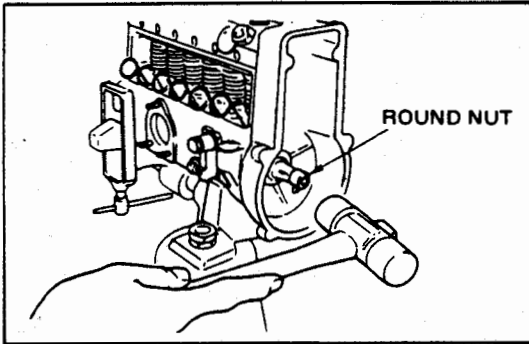


2. Use the guide to remove the bearing at the governor side.

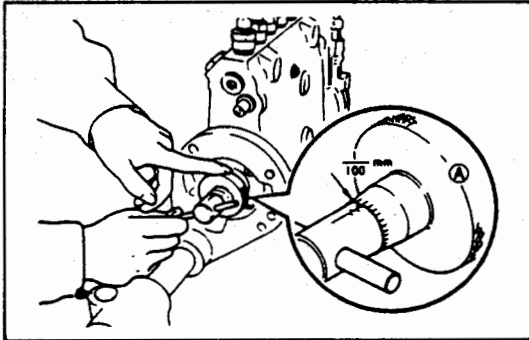


3. Use the outer race puller, to tap out the outer race in the bearing cover.

**Special Tool: Outer Race Puller (09512-1430)**

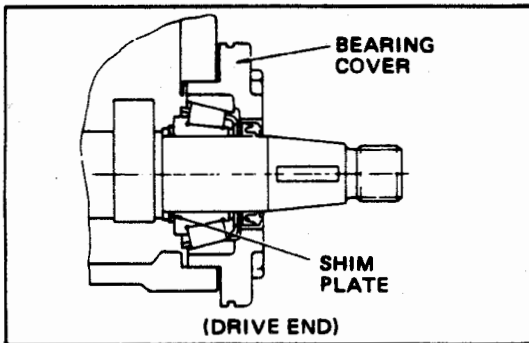


4. Lightly tighten "A" until it comes into contact with the bearing cover.
5. Lightly strike the camshaft governor end 3 or 4 times a plastic hammer.



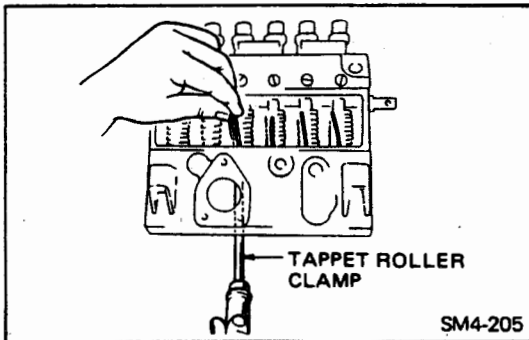
6. Lightly turn "A" until it comes into contact with the bearing cover, then read the clearance.

**Assembly Standard: 0.03–0.05 mm (0.0012–0.0019 in)**  
**Service Limit: 0.10 mm (0.004 in)**



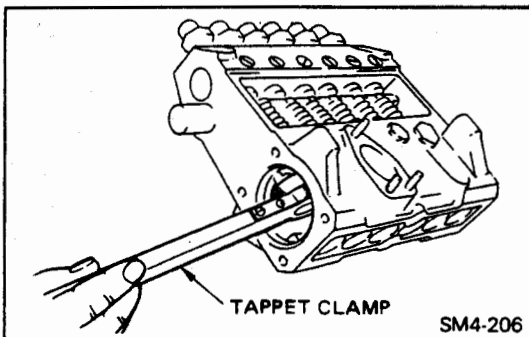
7. If the specification is not met, use appropriate shim plates at the drive end of camshaft.

**REMOVE THE TAPPET ASSEMBLY.**



1. Push the tappet with the tappet roller clamp and remove the tappet inspector.

**Special Tool: Tappet Roller Clamp (09512-1130)**



2. Remove the tappet through the camshaft bearing hole.

**Special Tool: Tappet Clamp (09512-1120)**

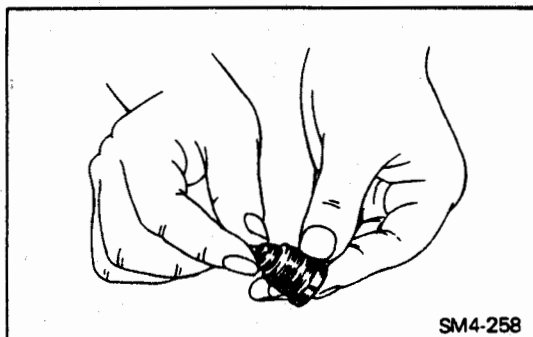
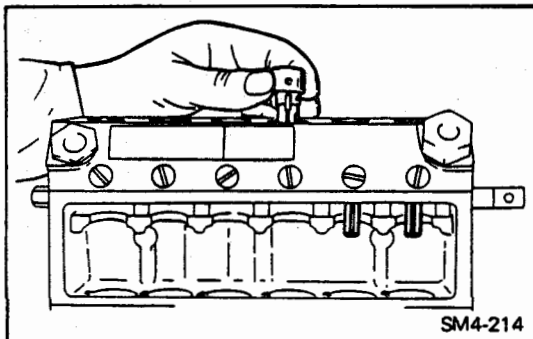
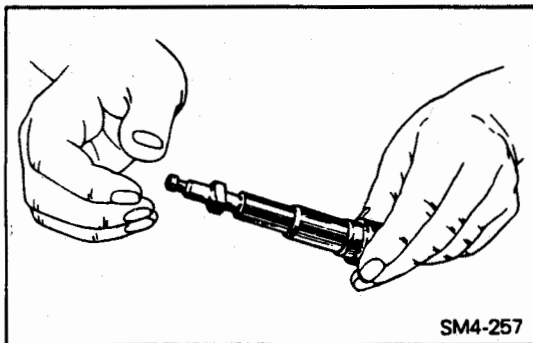
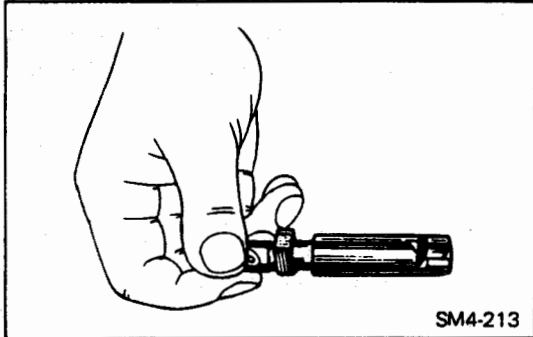
## IMPORTANT POINT (S) – ASSEMBLY

## WARNING

- Wash all parts with clean diesel fuel before installing them, and any defective or damaged parts must be replaced.
- Do not allow dust or other foreign matter to enter the pump during assembly.
- Apply grease to O-rings and oil seals before installing them.
- Assemble the parts in correct order and to correct tightening torques, assembled dimensions etc.
- Assembly takes place in the reverse order of disassembly.

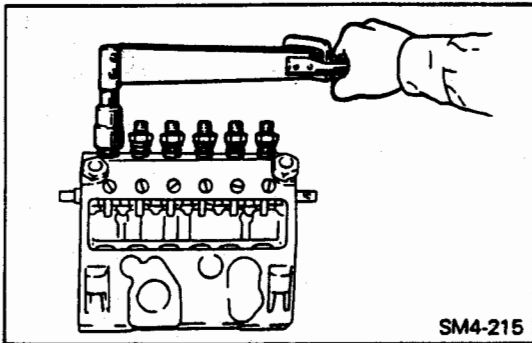
## INSTALL THE PLUNGER BARRELS.

- 1 Before install the plunger barrels should be inspect the plunger barrels and plungers for wear, scratches, or discoloration.
- 2 Tilt the plunger to about 60°. Pull the plunger out approximately 10 to 15 mm (0.39–0.59 in) and release it to see if it slides down smoothly from its own weight.
- 3 Match the plunger notch with the injection pump housing knock pin.



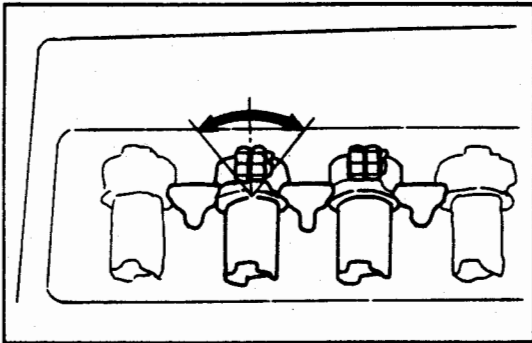
## INSTALL THE DELIVERY VALVES, SPRINGS AND HOLDERS.

- 1 Before install the delivery valves, inspect the delivery valves for scratches on the valve seat or the piston sections.



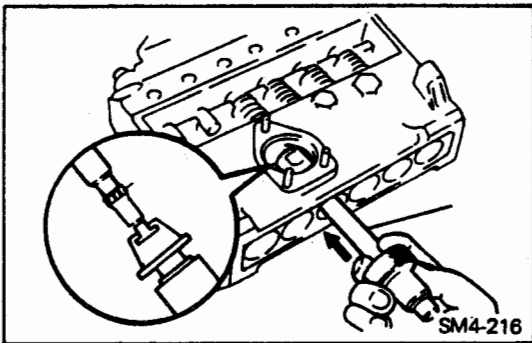
2. Install the gasket, spring, shim and stopper on the delivery valve.
3. Provisionally tighten the delivery valve holder with a new O-ring by hand.

**NOTE:** Tighten the delivery valve holder after installing the plunger.



#### INSTALL THE CONTROL SLEEVES ON THE BARRELS.

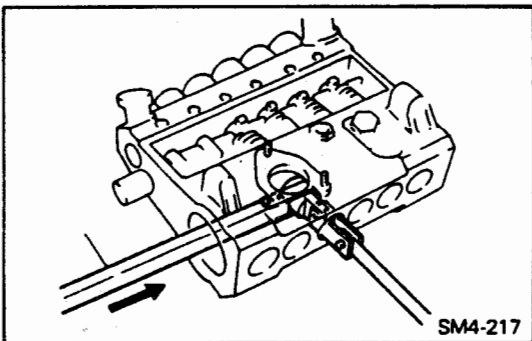
**NOTE:** Make sure that the control sleeve swings evenly right and left when the control rack is moved to the right and left.



#### INSTALL THE PLUNGER AND TAPPET.

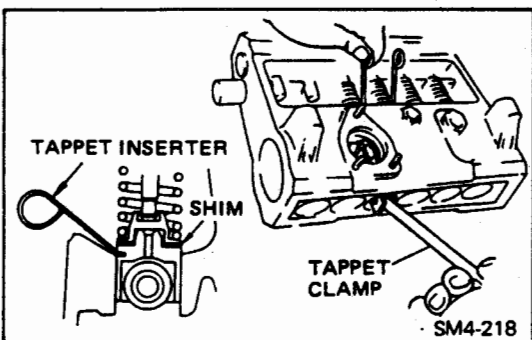
1. Assemble the plunger and spring lower seat, inserting the driving face marked with a number and the lower seat notch part upward (cover plate side).

**Special Tool:** Plunger Clamp (09512-1360)



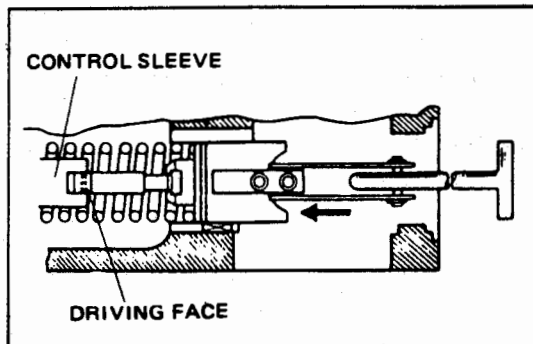
2. Install the tappet to the pump housing with the adjusting shim.

**Special Tool:** Tappet Roller Clamp (09512-1130)  
Tappet Clamp (09512-1120)

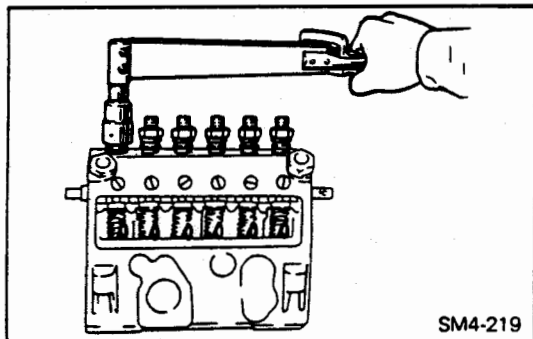


3. Using the tappet roller clamp to press in the tappet and hold it in with the tappet inserter.

**Special Tool:** Tappet Inserter (09512-1380)



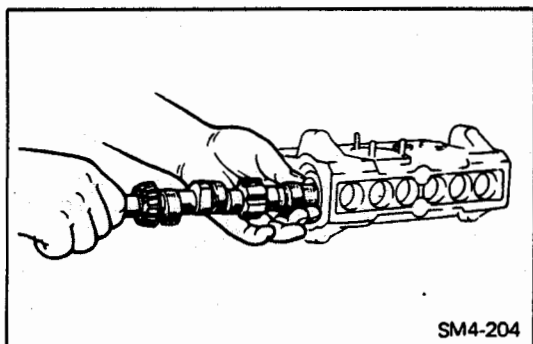
- NOTE:**
- Check that the driving face of the plunger fits to the groove of the control sleeve before inserting the tappet.
  - When inserting the tappet, check that the control rack slides smoothly and without catching.



**TIGHTEN THE DELIVERY VALVE HOLDER.**

When one delivery valve holder is tightened, move the control rack to the right and left and inspect the tightness of the rack.

**Tightening Torque: 400–450 kg-cm (29–32 lb.ft)**

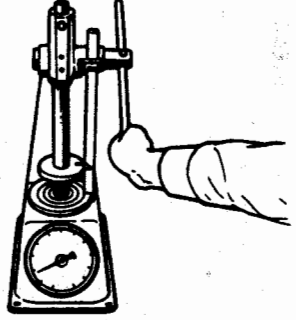


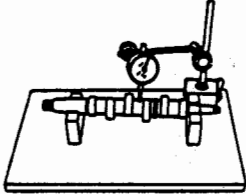


**INSTALL THE CAMSHAFT WITH CENTER BEARING.**

Place a small amount of oil or grease on the center bearing to hold it to camshaft and then install the camshaft in the pump housing.

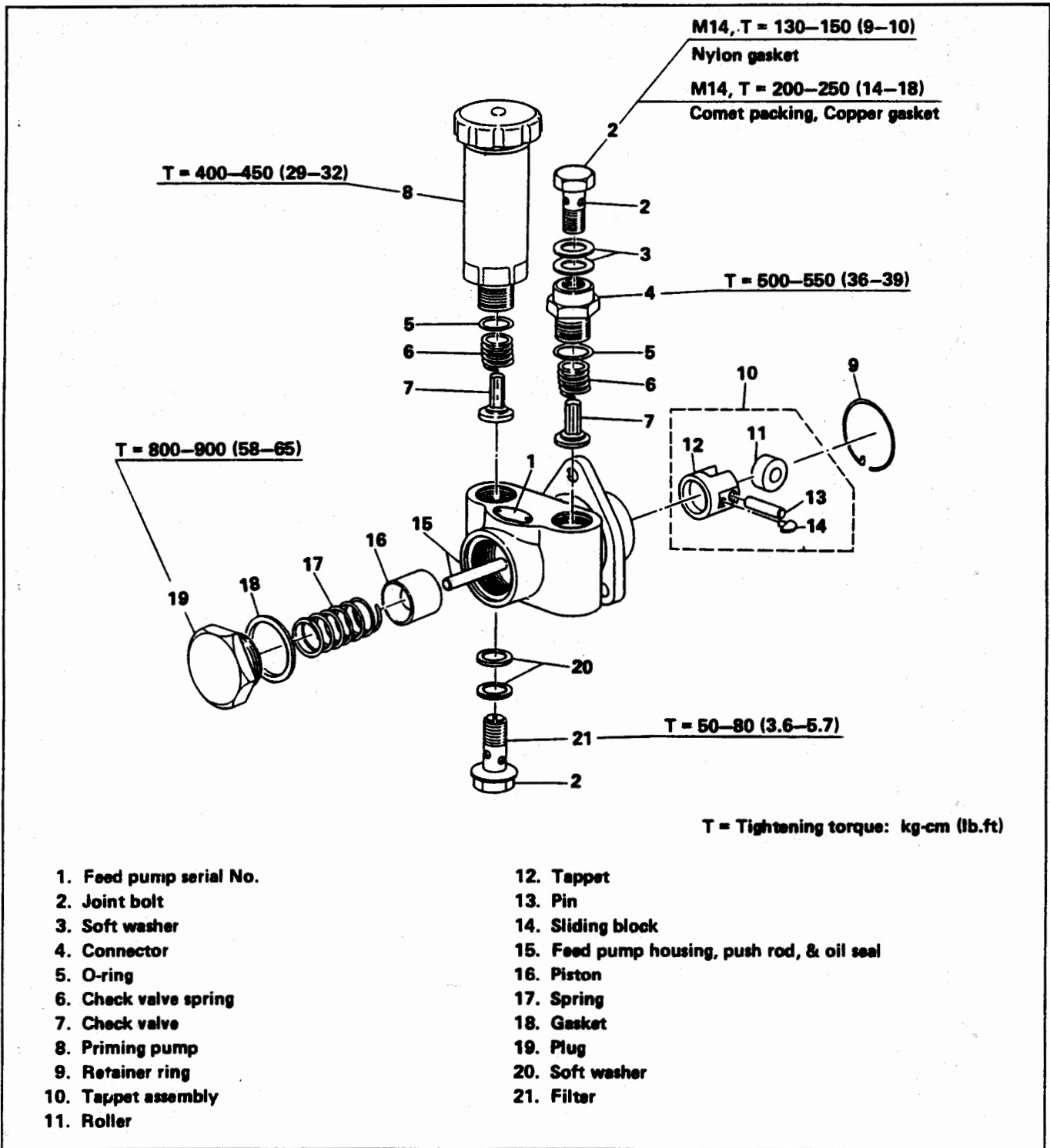
**NOTE: A-TYPE 4-cylinder pump is without center bearing.**

## INSPECTION AND REPAIR

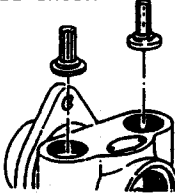
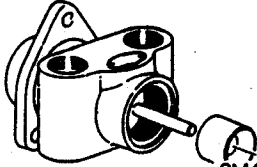
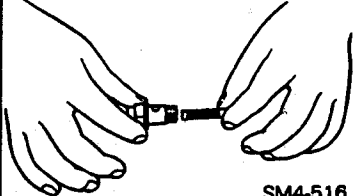
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Plunger springs tension.	24.4 kg (49.4 lb) at 41.4 mm (1.63 in)	21.0 kg (46.3 lb)	Replace, spring.	
Delivery valve springs tension.	3.1 kg (6.8 lb) at 17.0 mm (0.67 in)	2.7 kg (6.0 lb)	Replace, spring.	
Tappet wear.		0.3 mm (0.012 in)	Replace, tappet assembly.	
Camshaft run-out.		0.15 mm (0.006 in)	Replace, cam- shaft.	

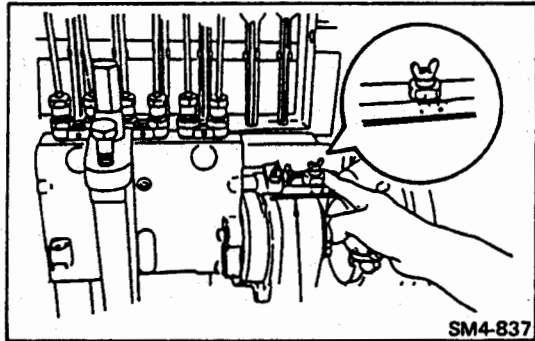
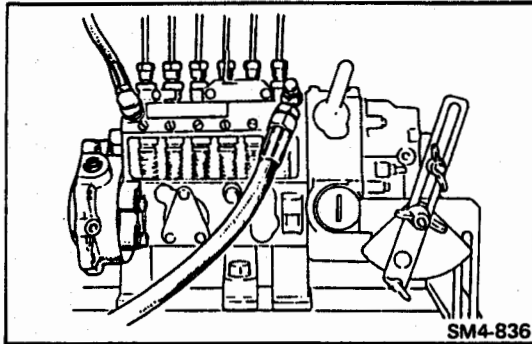
FEED PUMP

FP/KS-TYPE



INSPECTION AND REPAIR

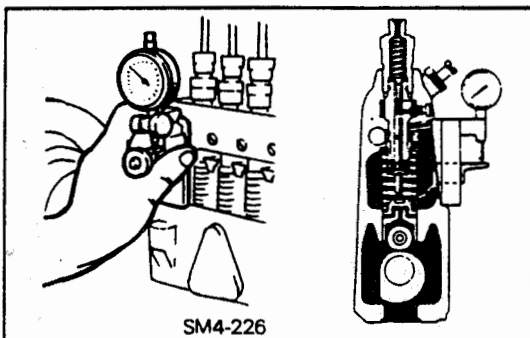
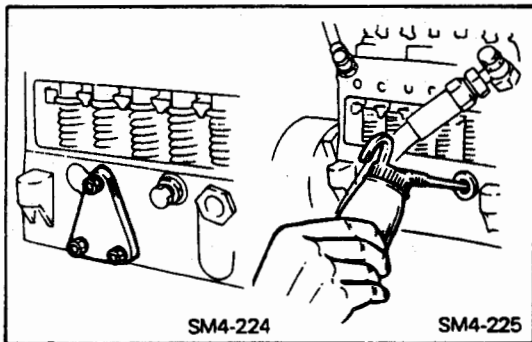
Inspection Item	Standard	Limit	Remedy	Inspection Procedure
<p>Valve Seat. Wear, Damage</p>	<p>—</p>	<p>—</p>	<p>Replace, if necessary.</p>	<p>Visual check</p>  <p>SM4-517</p>
<p>Piston, Cylinder and Oil Seal. Wear, Damage</p>	<p>—</p>	<p>—</p>	<p>Replace, if necessary.</p>	<p>Visual check</p>  <p>SM4-518</p>
<p>Filter, Clogged</p>	<p>—</p>	<p>—</p>	<p>Clean</p>	<p>Visual check</p>  <p>SM4-516</p>



**ADJUSTMENT**

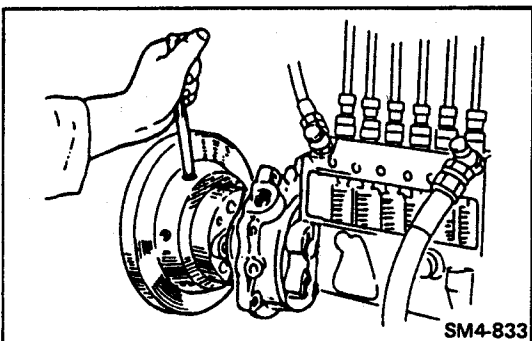
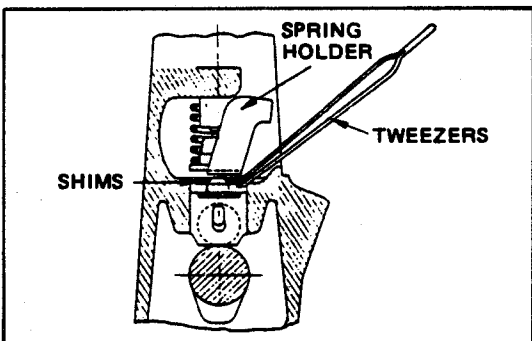
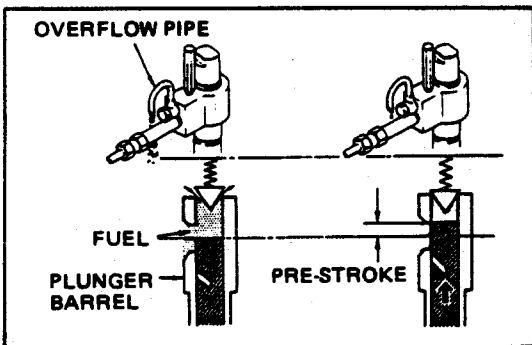
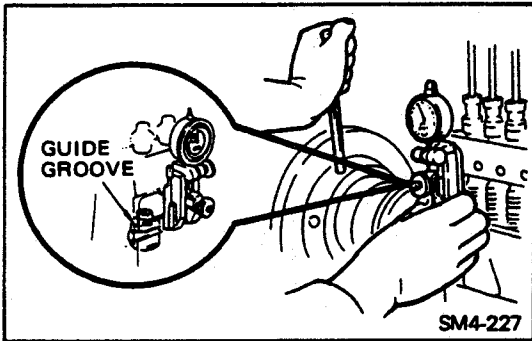
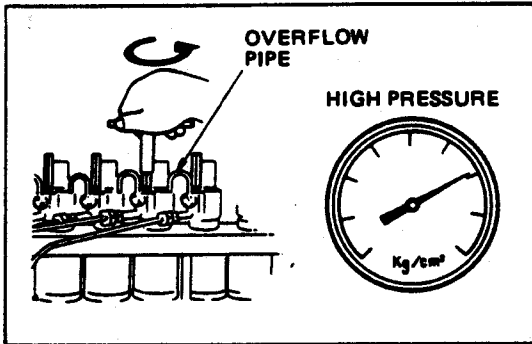
**PREPARATION**

1. Mount the injection pump correctly on the pump tester.
2. Attach a rack measuring device to the control rack and set to "0".
3. Install calibration nozzles and lines of the following specifications.
  - a) Nozzle  
Nozzle type: 12SD12 (BOSCH Type)  
Opening pressure: 175 kg/cm (2,489 lb.ft)
  - b) Line  
Outside diameter: 6.0 mm (0.24 in)  
Inner diameter: 2.0 mm (0.08 in)  
Length: 600 mm (23.6 in)
4. Calibration oil
  - a) Calibration oil: SAE J967C
  - b) Oil temperature: 40–45°C (104–113°F)
5. Install the cover on the feed pump mounting surface and fill the pump camshaft chamber with engine oil.



**ADJUSTING THE INJECTION TIMING**

1. Preparation of the pre-stroke.
  - a) Remove the plate cover.
  - b) Install a pre-stroke measuring instrument.  
Bring the tappet of the first cylinder to its bottom dead center, and set the pointer tip on the tappet.



2. Measure the pre-stroke (No.1 plunger)
  - a) Set the control rack at full-load position.
  - b) Loosen the overflow screw of each nozzle holder.
  - c) Operate the high-pressure pump of the pump tester and let fuel run out of the overflow line.

- d) Move the angle dial to set the first cylinder of the pump to bottom dead center and adjust the pre-stroke gauge to zero.

**NOTE:** Bottom dead center is the point at which the pointer of the dial gauge does not move even when the angle dial is rotated while fuel is flowing from the overflow line.

- e) Turn the camshaft clockwise with the angle dial and read the dial gauge when the fuel stops running out of the overflow line. This reading is the pre-stroke value of the pump.

**Pre-stroke:** Refer to "CALIBRATION chart"

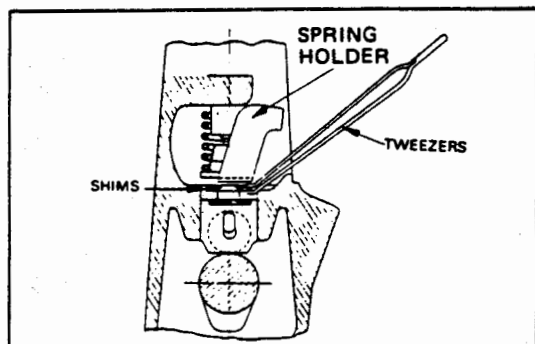
- f) If the pre-stroke value is not within specification, adjust by changing the tappet adjusting shim.

**Special Tool:** Spring Holder (95092-10070)

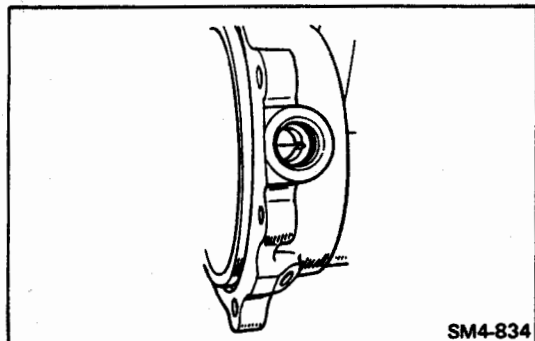
#### ADJUST THE INJECTION INTERVAL.

1. Using the No.1 cylinder injection starting point as a base, inspect and adjust the injection interval in the order of injection.

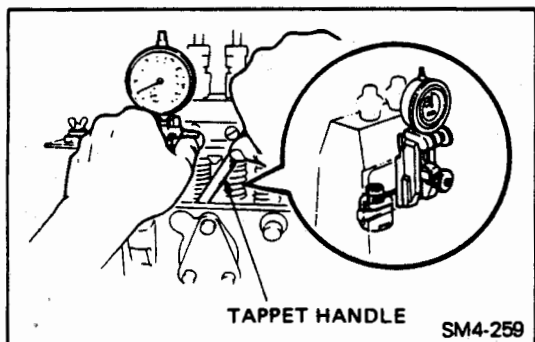
**Injection Interval:** 6-cylinder 59°45' – 60°15'  
**Injection Order:** 1-4-2-6-3-5



2. If the injection intervals are not within specification, adjust by using the same procedure as for pre-stroke adjustment.



3. Set the No.1 cylinder at the injection starting point, and check that the marks on the coupling and the marks on the timer case are aligned. If the timing marks are not aligned, make a new mark on the coupling and erase the old mark.



**CHECK THE TAPPET TOP CLEARANCE.**

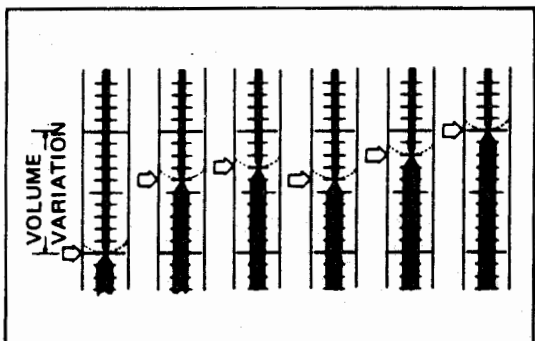
1. Set the No.1 cylinder at the injection starting point, then move the tappet with the handle.

**Tappet Top Clearance: More than 0.2 mm (0.0079 in)**

**Special Tool: Tappet Handle (09512-1410)**

2. Follow the above procedure to check the other cylinders (No.2 through No.6).

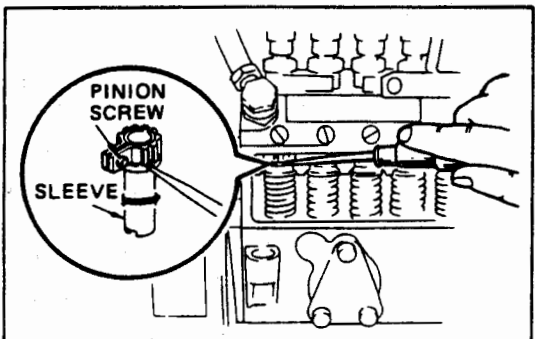
3. If the tappet clearance is less than 0.2 mm (0.0079 in), re-check the pre-stroke.



**MEASURING AND ADJUSTING THE INJECTION VOLUME.**

Measure the injection volume for each control rack position and pump revolution.

**Injection Volume: Refer to "CALIBRATION chart."**



To adjust the injection volume, loosen the pinion screw and insert the adjusting pin into the hole in the control sleeve, then move the sleeve slightly.

# CHAPTER GV

## INJECTION PUMP GOVERNOR

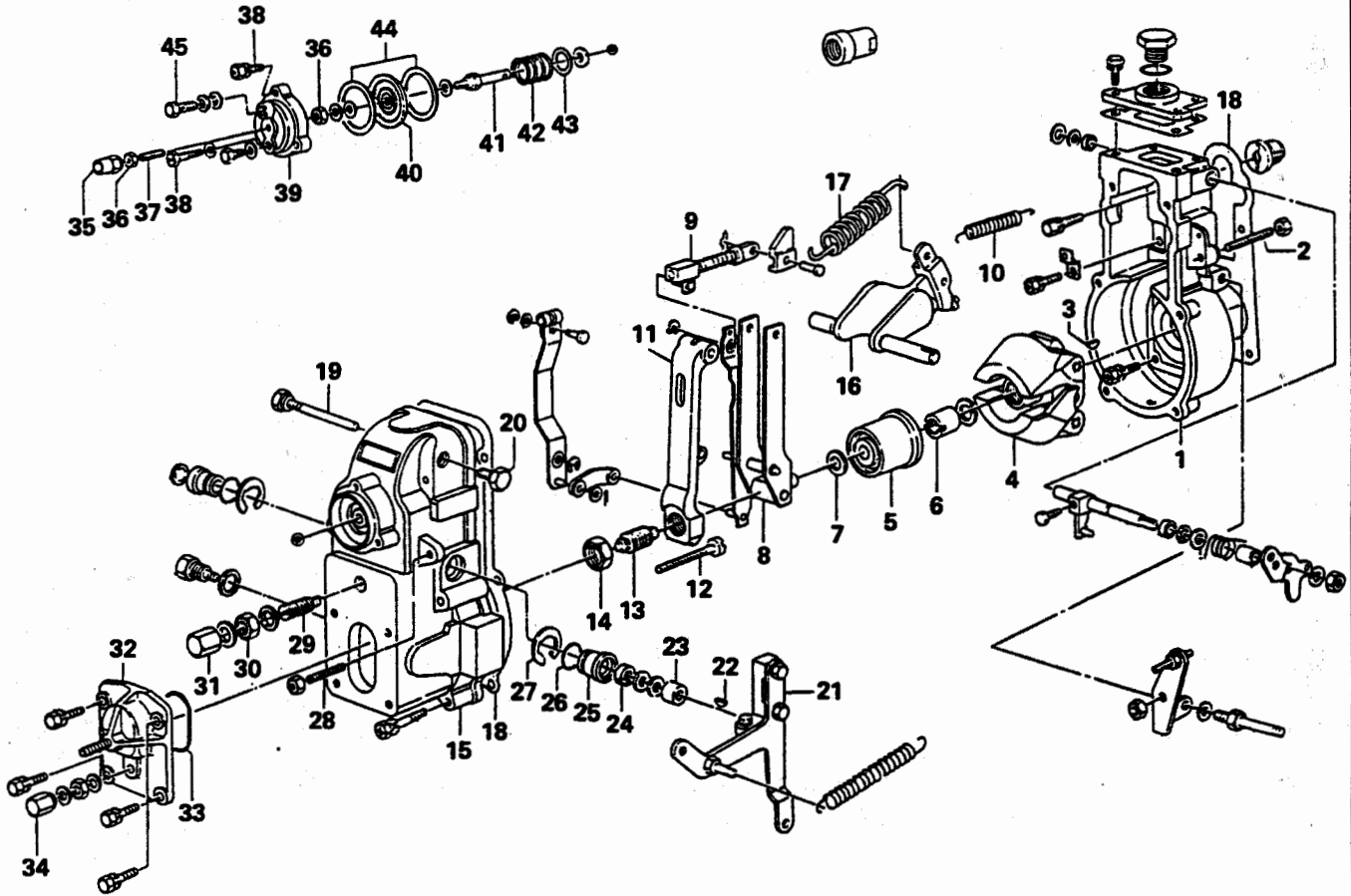
(MODEL: RSV with BOOST COMPENSATOR)

GOVERNOR ..... GV-2

SPECIAL TOOL ..... GV-3

BOOST COMPENSATOR ..... GV-7

## GOVERNOR

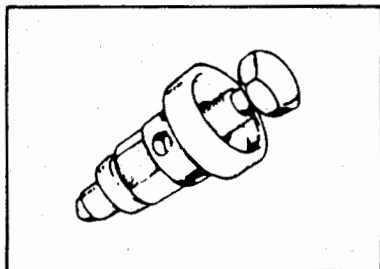


- |                       |                       |                       |
|-----------------------|-----------------------|-----------------------|
| 1. Governor housing   | 16. Swivel lever      | 31. Cap nut           |
| 2. Stopper bolt       | 17. Governor spring   | 32. Closing cover     |
| 3. Woodruff key       | 18. Gasket            | 33. O-ring            |
| 4. Flyweight          | 19. Pin               | 34. Cap nut           |
| 5. Sleeve             | 20. Plug              | 35. Cap nut           |
| 6. Bearing            | 21. Control lever     | 36. Lock nut          |
| 7. Shim               | 22. Woodruff key      | 37. Adjust screw      |
| 8. Guide lever assy   | 23. Coller            | 38. Cover fixing bolt |
| 9. Link               | 24. Oil seal          | 39. Cover             |
| 10. Start spring      | 25. Bush              | 40. Diaphragm         |
| 11. Tension lever     | 26. O-ring            | 41. Push rod          |
| 12. Full load stopper | 27. Snap ring         | 42. Spring            |
| 13. Idle spring       | 28. Idle stopper bolt | 43. Adjusting shim    |
| 14. Lock nut          | 29. Idle sub spring   | 44. Gasket            |
| 15. Governor cover    | 30. Nut               | 45. Union bolt        |

## SPECIAL TOOL

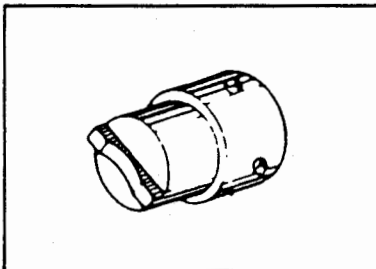
Prior to starting an injection pump governor overhaul, it is necessary to have these special tools.

**FLYWEIGHT EXTRACTOR**



09511-1900

**ROUND NUT WRENCH**



09511-1500

### IMPORTANT POINT (S) – DISASSEMBLY

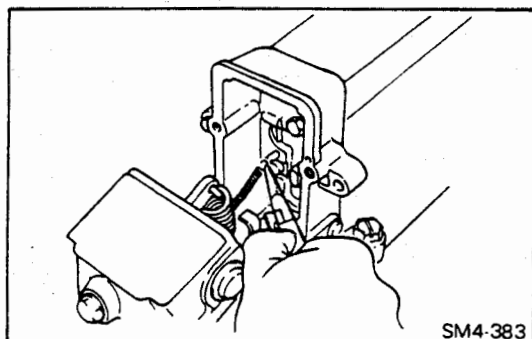
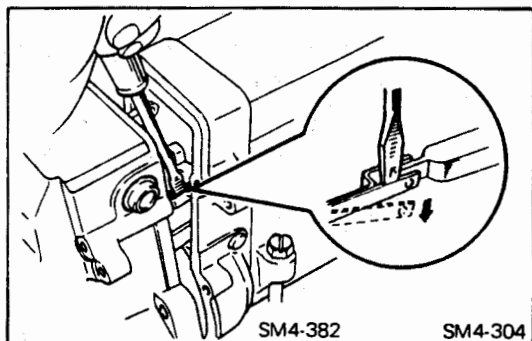
#### WARNING

- Breaking of the lead seals or crimp caps by anyother other than HINO or pump manufacture authorized service stations to make these adjustment will void the warranty.
- If fuel pump or governor difficulties are suspected, consult only HINO or pump manufacture authorized service stations, where the problem can be corrected and the injection pump lead seals and crimp caps can be reinstalled as required.

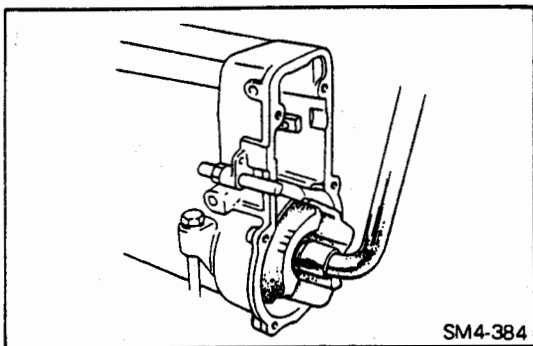
#### DISASSEMBLY THE GOVERNOR COVER FROM PUMP BODY.

1. Disconnect the shackle from the control rack.

**NOTE:** When remove the governor cover fitting bolt, hold the governor cover.



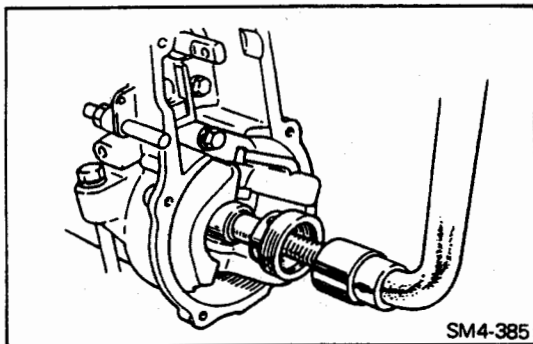
2. Disconnect the start spring.



**REMOVE THE FLYWEIGHT ROUND NUT.**

**NOTE:** Use the holding spanner to keep the camshaft from rotating.

**Special Tools:** Round Nut Wrench (09511-1500)



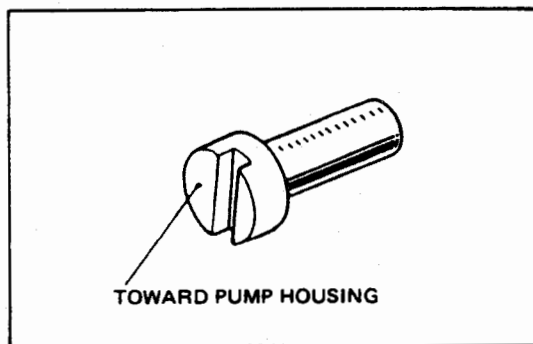
**REMOVE THE FLYWEIGHT, USING THE FLYWEIGHT EXTRACTOR.**

**Special Tool:** Flyweight Extractor (09511-1900)

#### IMPORTANT POINT (S) – Assembly

##### WARNING

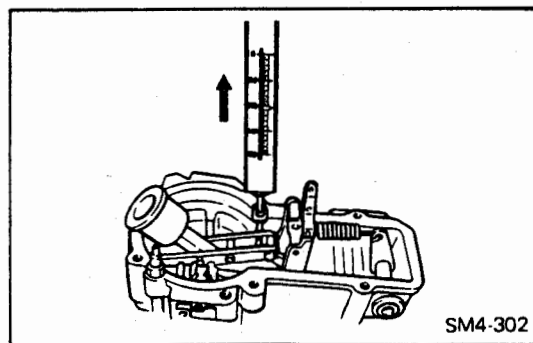
- Wash all parts with clean diesel fuel before installing them, and any defective or damaged parts must be replaced.
- Do not allow dust or other foreign matter to enter the pump during assembly.
- Apply grease to O-rings and oil seals before installing them.
- Assemble the parts in correct order and to correct tightening torque, assembled dimensions etc.
- Assembly takes place in the reverse order of disassembly.



#### INSTALL THE ADJUSTING LEVER

1. Install the shaft of the adjusting lever so that wide side of the shaft head surface is toward the pump body.

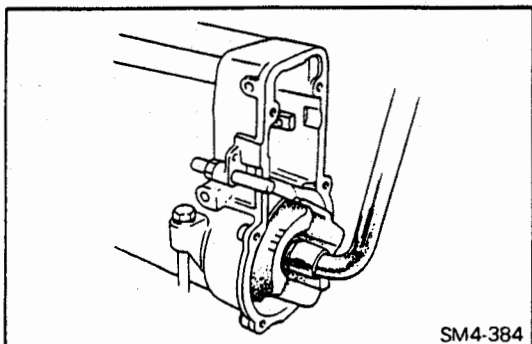
**NOTE:** Installing in reverse may cause the floating lever to contact the speed control spring, resulting in operational malfunction.



#### CHECK THE GOVERNOR LINKAGE FOR SMOOTH OPERATION.

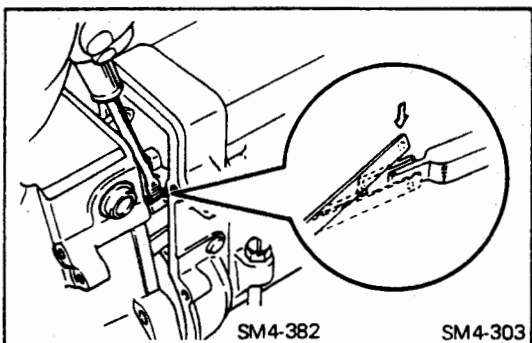
Hook under the guide lever, and pull upwards, using a spring balance.

**Starting force:** 140–180 g (4.9–6.3 oz)

**INSTALL THE FLYWEIGHT TO PUMP CAMSHAFT.**

Using a special tools, tighten the round nut.

**Special Tools:** Round Nut Wrench (09511-1500)

**INSTALL THE GOVERNOR HOUSING TO PUMP BODY.**

1. Connect the start spring.
2. Connect the shackle to control rack.

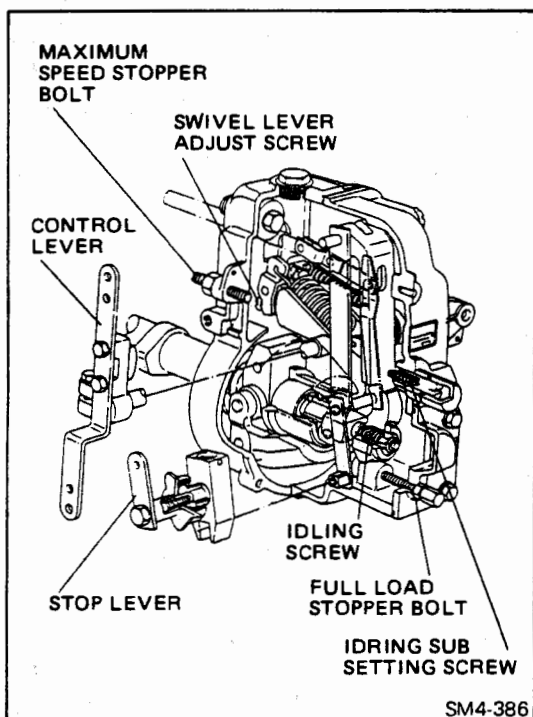
**ADJUSTMENT OF THE GOVERNOR  
[MODEL; RSV]****1. PREPARATION**

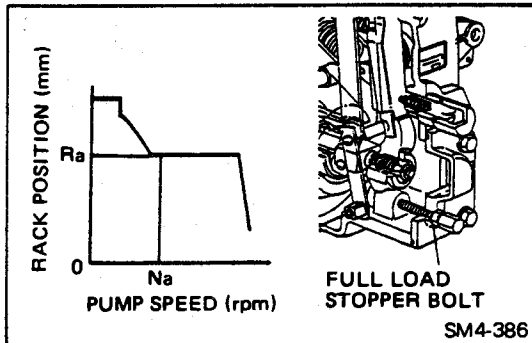
1. Connect the rack measuring device to the control rack and set to "0".
2. Connect the fuel line.
3. Refill the camshaft chamber with engine oil.
4. Install the angle gauge on the adjusting lever.

**2. STEPS IN GOVERNOR ADJUSTMENT.**

Perform governor testing and adjustment in the following sequence (For values of N. and R Refer to "CALIBRATION chart"):

1. Adjustment of maximum speed control.
2. Adjustment of speed droop.
3. Adjustment of idling speed control.



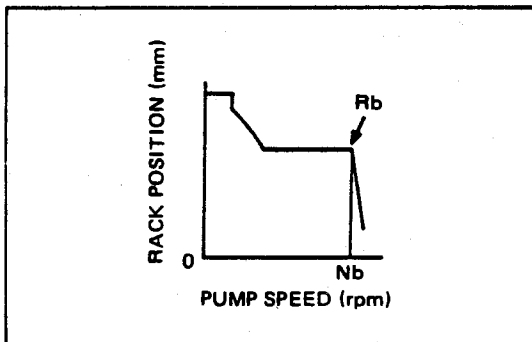


## 1. Adjustment of maximum speed control

**NOTE:** The control lever should be full load position.

## a) Adjust the full load stopper bolt.

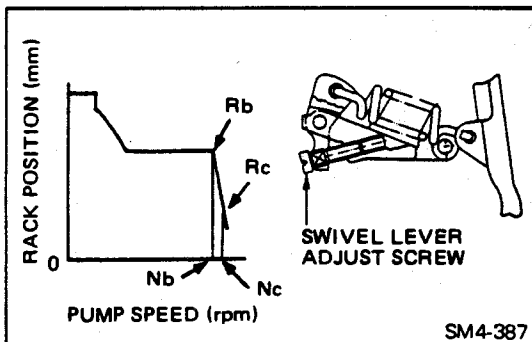
At a pump speed of Na rpm, adjust the rack position to Ra mm with the full load stopper bolt.



## b) Adjust the maximum speed stopper bolt.

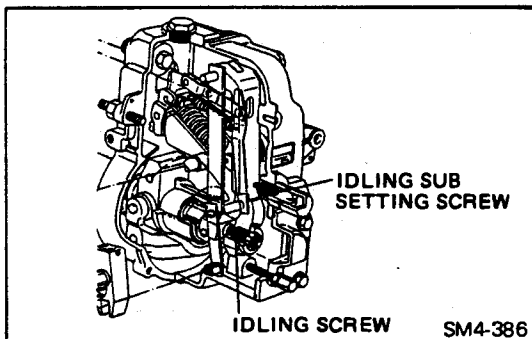
At a pump speed of Nb rpm, adjust the rack position to Rb mm with maximum speed stopper bolt.

**NOTE:** The control rack should start to be pulled.



## 2. Adjust of speed droop.

At a pump speed of Nc rpm, adjust rack position to Rc mm with swivel lever adjusting screw.



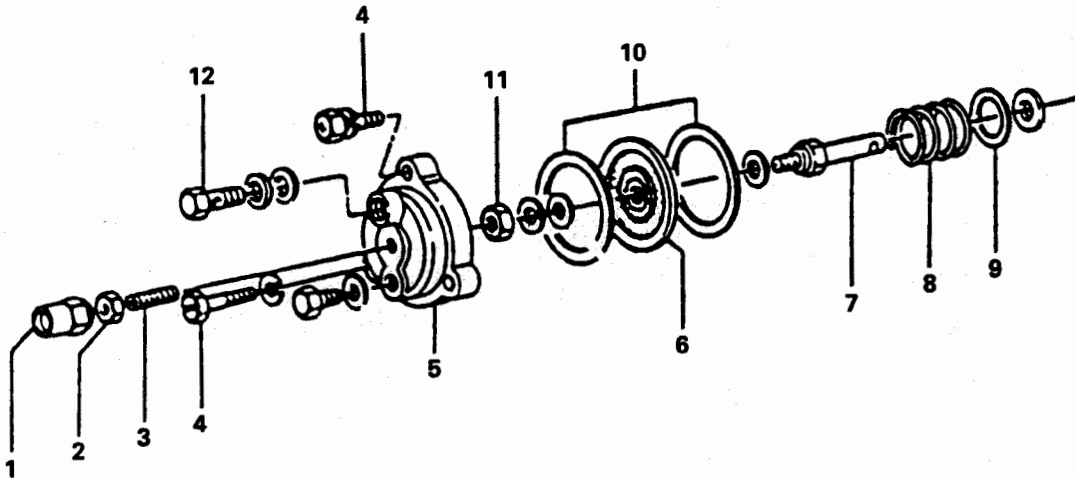
## 3. Adjusting of idling speed control

## a) At a pump speed of Na rpm, adjust the rack position to Rd mm with idling screw.

**NOTE:** The control lever angle, refer to CALIBRATION chart.

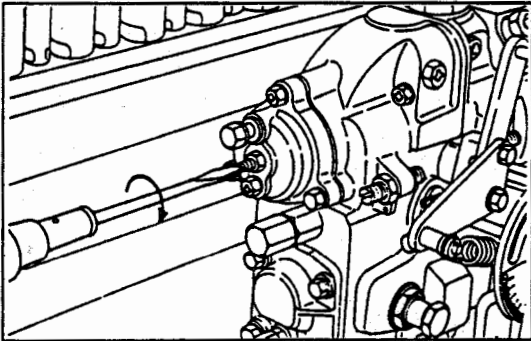
## b) At a pump speed of Ne rpm, adjust the rack position to Re mm with idling sub setting screw.

## BOOST COMPENSATOR



1. Cap nut
2. Lock nut
3. Adjust screw
4. Cover fixing bolt
5. Cover
6. Diaphragm

7. Push rod
8. Spring
9. Adjusting shim
10. Gasket
11. Lock nut
12. Union bolt



### ADJUSTMENT OF BOOST COMPENSATOR

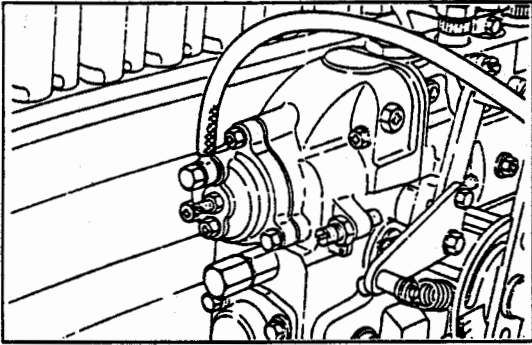
#### TEMPORARY FIXING OF ADJUST SCREW FOR BOOST COMPENSATOR STROKE.

1. Remove the cap nut (1) and loose the lock nut (2).
2. Fully tighten the adjusting screw (3) and lock the lock nut (2) temporarily.

#### ADJUSTMENT OF MAXIMUM SPEED CONTROL.

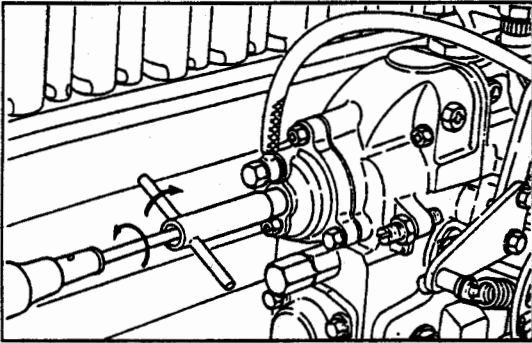
1. Adjustment of full load position.
2. Adjustment of maximum speed control point.

#### ADJUSTMENT OF SPEED CHANGE RATE. ADJUSTMENT OF ANGLEICH.



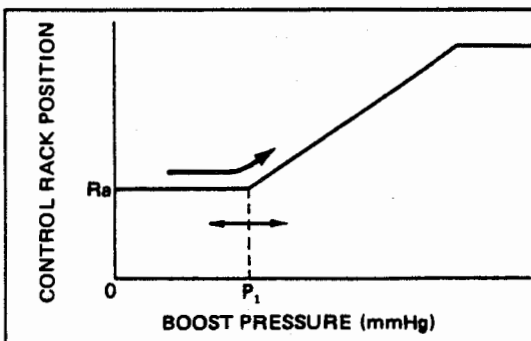
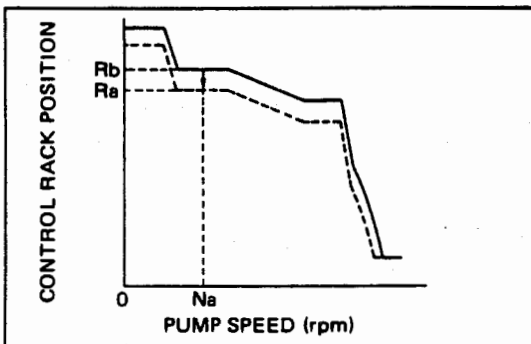
### ADJUSTMENT OF BOOST COMPENSATOR STROKE.

1. Connect the air hose to union bolt (12).
2. Lock the control lever at the full load position.



3. Keep the pump revolution with in "Na" rpm, then adjust the control rack position "Rb" to "Ra" with adjust screw (3) and lock it with lock nut (2).

**NOTE:** No need to pressurization with this adjustment.

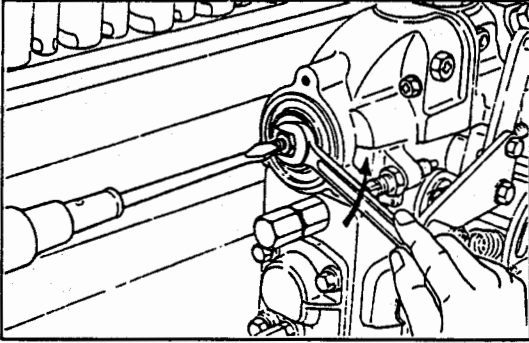


### ADJUSTMENT OF BOOST COMPENSATOR SPRING (8).

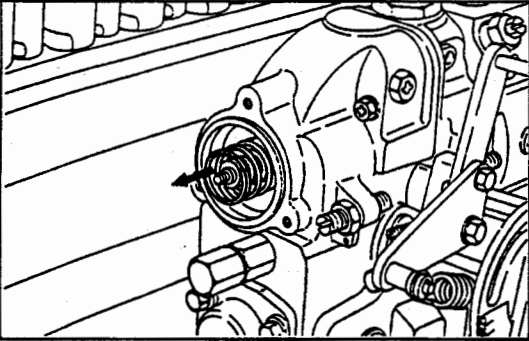
1. Keep the pump revolution with in "Na" rpm then set the control lever to full load position.
2. Raise the boost pressure gradually and when reaches the "P<sub>1</sub>" confirm of the control rack is start to move from "Ra" position to direction of "fuel delivery increase".



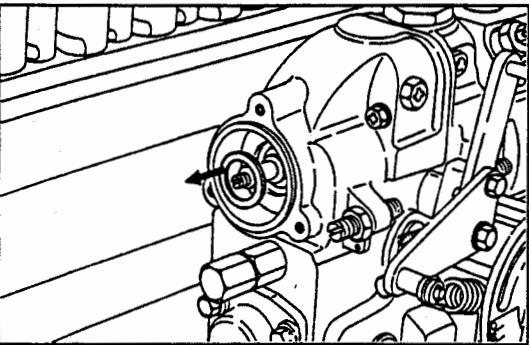
3. In case of nonstandardized, replace with adjusting shim (9) as follow.
- 1) Remove the cover (5) with loosening three bolts of installing the cover (4).



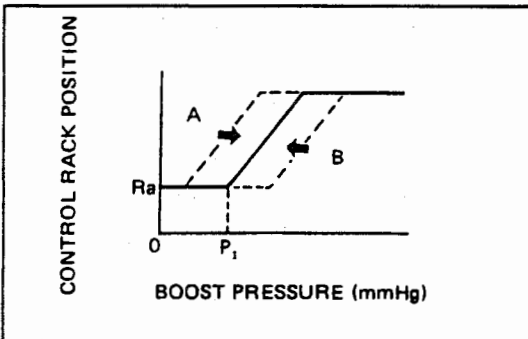
- 2) Using a screw driver for hold the push rod (7) to not turn it when removing the nut (11).



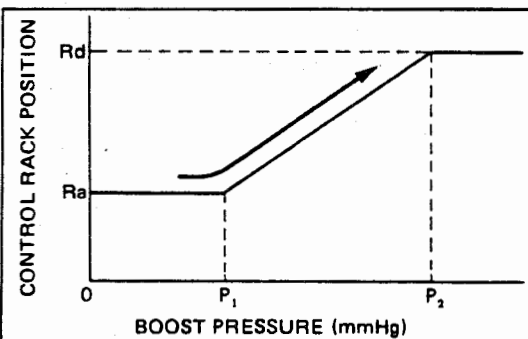
- 3) Remove the gasket (10), diaphragm (6), and spring (8).



- 4) Replace the adjusting shim (9).

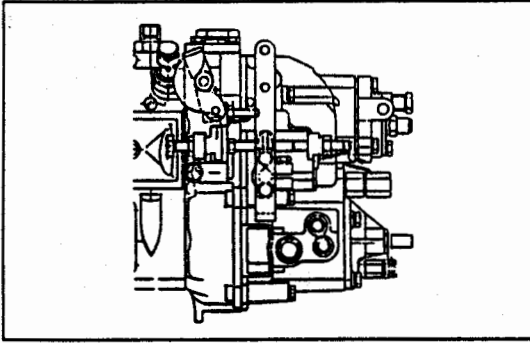


- A : Replace the adjusting shim (9) with thick one.  
B : Replace the adjusting shim (9) with thin one.



4. Raise the boost pressure to " $P_2$ ", confirm the control rack position is " $R_b$ ". In case of nonstandardized, replace the spring (8) with new one.

**NOTE:** In case of change the boost compensator stroke, when remove the cover for this adjustment, reconfirm the boost compensator stroke.

**GOVERNOR EXTERNAL LEAD SEALS AND CRIMP CAPS.**

**NOTE:** All adjusting devices on the fuel injection pump governor, are wired and lead sealed as a protection for the customer. This is to prevent unauthorized readjustment which may cause engine malfunction and/or engine failure. Periodically check to insure that these seals are not broken as this will void the warranty.

(K.P.)

# CHAPTER C

## INJECTION PUMP CALIBRATION



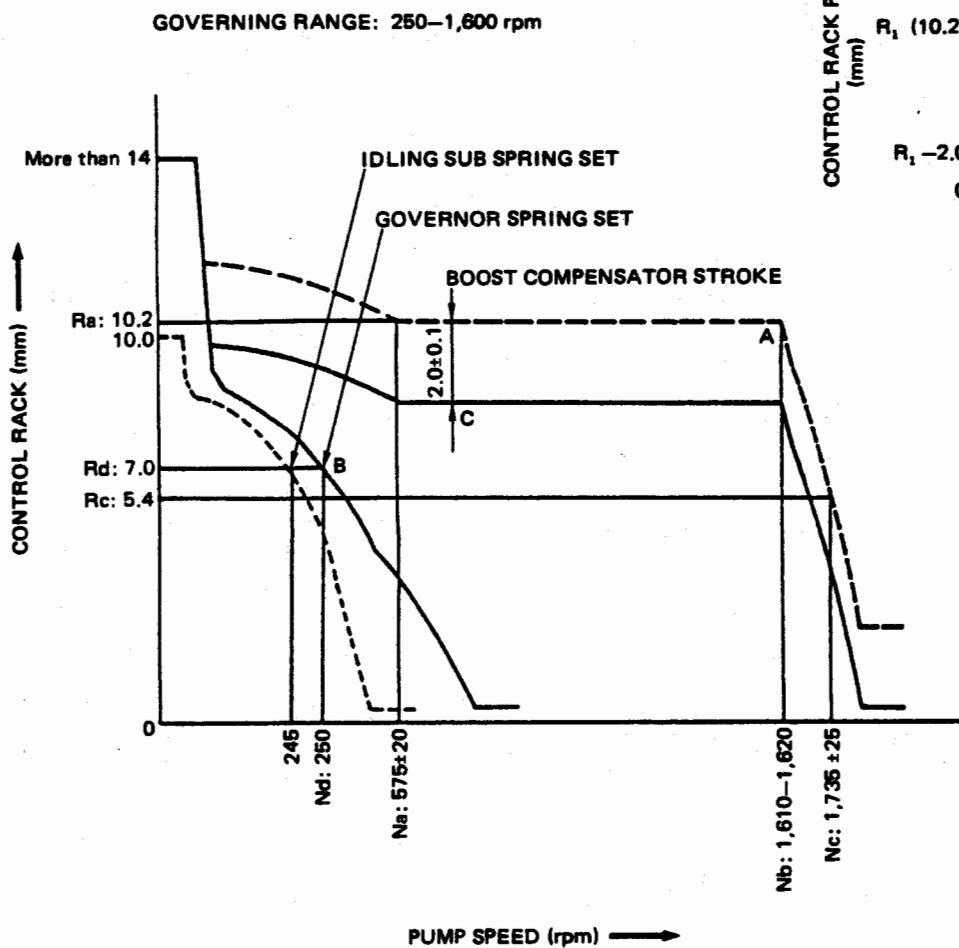
INJECTION PUMP NUMBER: 22020-3521A

INJECTION PUMP SPECIFICATION	Engine	W06D-T1				
	Injection pump part number	22020-3521A				
	Injection pump type	NP-PES6A95C32ORS2				
	Governor type	NP-EP/RSV200-1600				
	Timer type	Not equipped				
	Feed pump type	NP-FP/KS-AS				
TEST CONDITION	Test nozzle type	105780-8140				
	Test nozzle opening pressure	175 kg/cm <sup>2</sup> (2,489 psi)				
	Injection pipe	Outer diameter	6.0 mm (0.236 in)			
		Inner diameter	2.0 mm (0.079 in)			
		Length	600 mm (23.622 in)			
	Calibration oil	Type	SAE J967 C			
Oil temperature		40–45°C (104–113°F)				
Fuel feed pressure	1.6 kg/cm <sup>2</sup> (22.8 psi)					
OVERFLOW VALVE	Opening pressure	1.5–1.8 kg/cm <sup>2</sup> (21.33–25.59 psi)				
INJECTION TIMING	Rotation	Clockwise viewed from drive side				
	Injection order	1–4–2–6–3–5				
	Injection interval	60° ± 15'				
	Pre-stroke	3.15–3.22 mm (0.125–0.127 in)				
INJECTION VOLUME	Rack position mm (in)	Pump speed (rpm)	Measuring strokes	Injection volume cc (cu.in)	Max. variation limit %	
	A 10.2 (0.402)	1,600	500	42.30–51.30 (2.582–3.130)	± 3	
	B About 7 (0.276)	250	500	3.25–4.75 (0.199–0.289)	±15	
	–	–	–	–	–	
GOVERNOR ADJUSTMENT	ADJUSTING POSITION			CONTROL LEVER ANGLE		
				<p>NOTE:                  • ANGLE: 1 ... 31° ± 5°                  2 ... 14° ± 5°                  • Lever angle "V.P." means Vertical position.</p>		

SM4-831

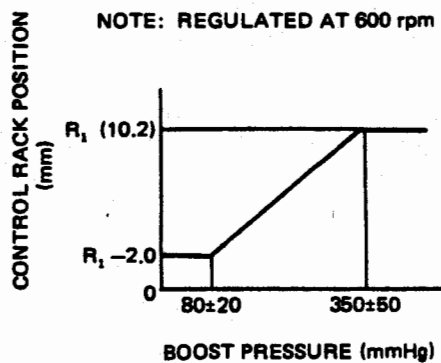
	Adjusting item	Adjusting lever position	Pump speed (rpm)	Control rack position mm (in)	Adjusting position
GOVERNOR ADJUSTMENT	Maximum speed	Full load	Na: 555-595	Ra: 10.2 (0.402 in)	Full load stopper bolt
			Nb: 1,610-1,620	Rb: Should be start to pulled control rack	Maximum speed stopper bolt
			Nc: 1,710-1,760	Rc: 5.4 mm (0.213 in)	*Swivel lever adjusting screw
	Idling speed	Idle	Nd: 250	Rd: 7.0 mm (0.276 in)	Idling sub-spring set

GOVERNOR CHARACTERISTIC DIAPHRAGM



SM4-831

BOOST COMPENSATOR CHARACTERISTIC DIAPHRAGM



SM4-812

# CHAPTER GE

## GENERATOR

(12V, 80A)

DATA AND SPECIFICATIONS ..... GE-2

DESCRIPTION ..... GE-2

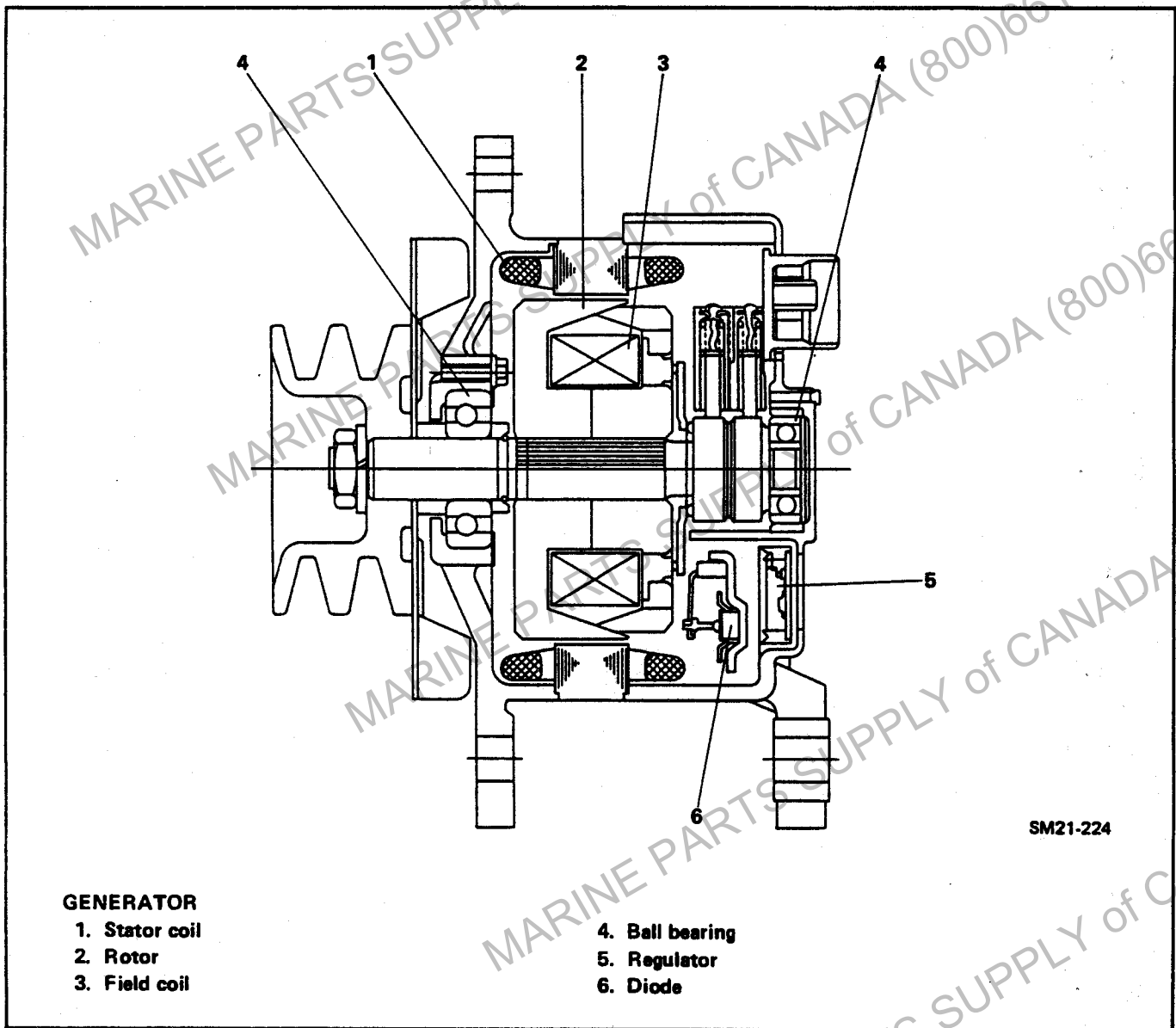
TROUBLESHOOTING ..... GE-3

GENERATOR ..... GE-4

**DATE AND SPECIFICATIONS**

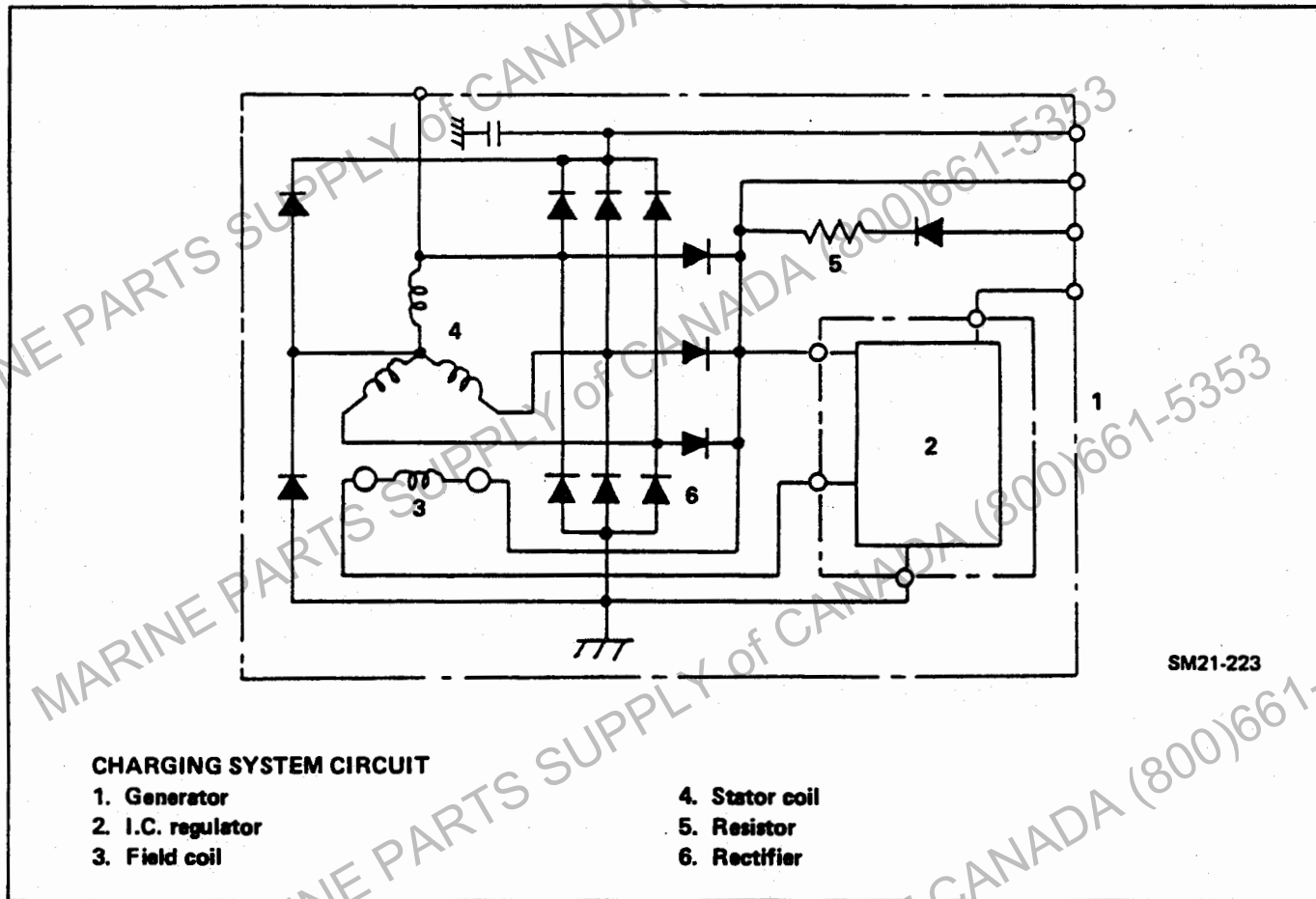
<b>MODEL</b>	27040-1261
<b>GENERATOR</b>	
Type .....	Alternator
Rated voltage .....	12V
Rated output .....	80A
Operating output and speed .....	80A at 13.5V, 4,000 rpm
Rotating direction .....	Clockwise (Seen from pulley side)

**DESCRIPTION**



**GENERATOR**

- |                |                 |
|----------------|-----------------|
| 1. Stator coil | 4. Ball bearing |
| 2. Rotor       | 5. Regulator    |
| 3. Field coil  | 6. Diode        |



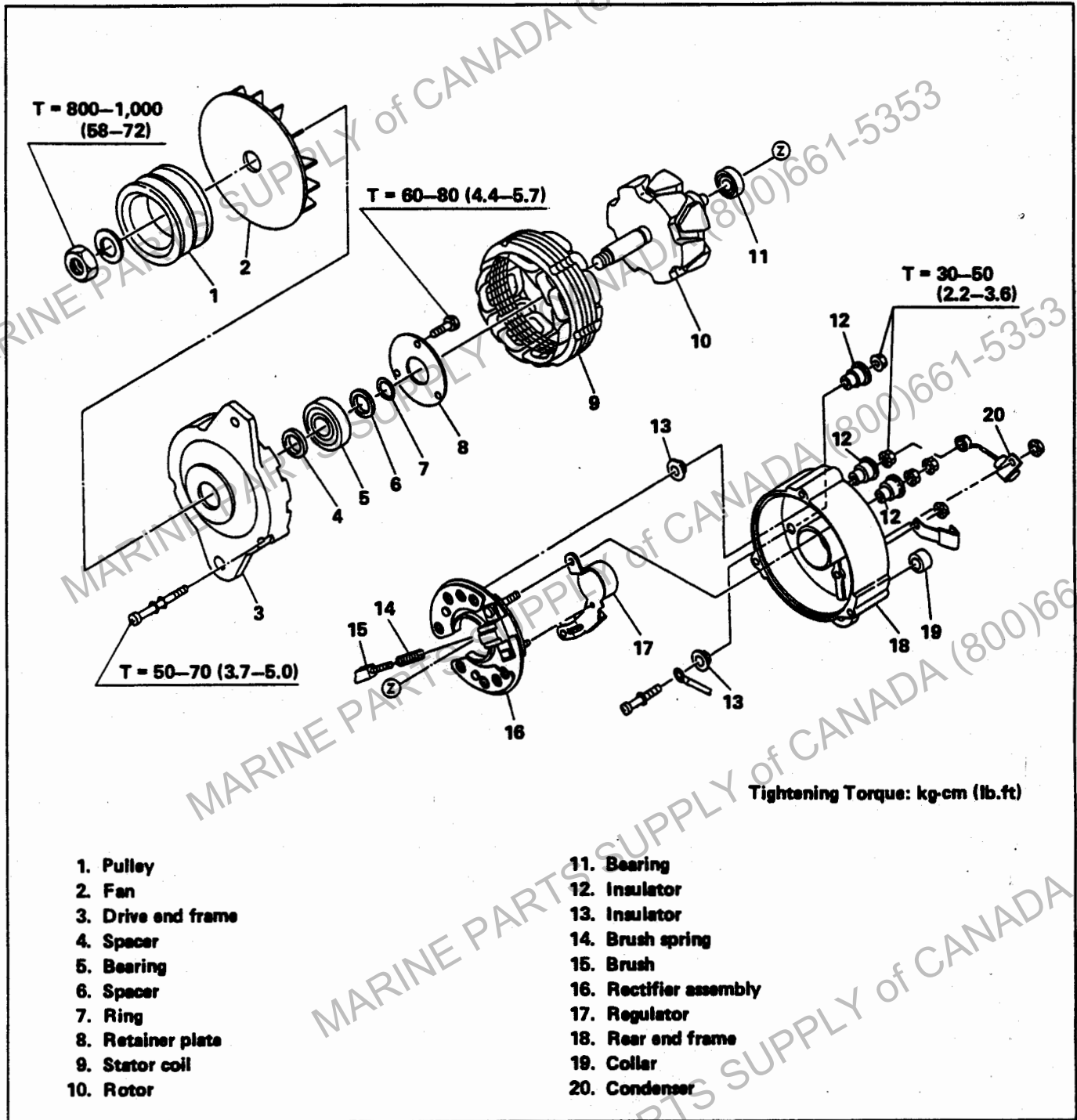
**CHARGING SYSTEM CIRCUIT**

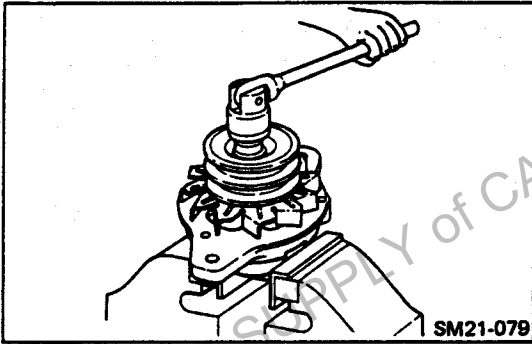
- 1. Generator
- 2. I.C. regulator
- 3. Field coil
- 4. Stator coil
- 5. Resistor
- 6. Rectifier

**TROUBLESHOOTING**

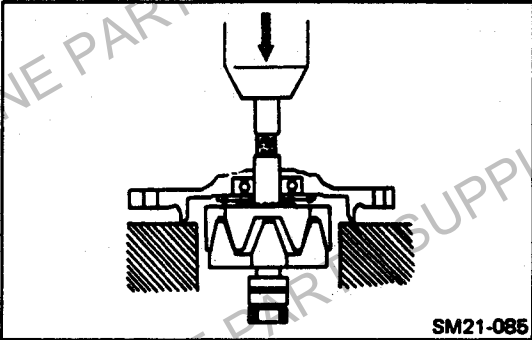
<u>Symptom</u>	<u>Possible cause</u>	<u>Remedy/Prevention</u>
Ammeter does not move to negative side (remained at the neutral position) with starter switch on and engine off	Fuse blown	Determine cause and replace fuse
	Wiring connection loose	Tighten loose connections
	IC regulator faulty	Replace IC regulator
Ammeter indicate the negative side with starter switch on and engine running	Drive belt loose or worn	Adjust or replace drive belt
	Battery cable loose, corroded or worn	Repair or replace cables
	Fuse blown	Determine cause and replace fuse
	Fusible link blown	Replace fusible link
	IC regulator or generator faulty	Check charging system
	Wiring faulty	Repair wiring

# GENERATOR

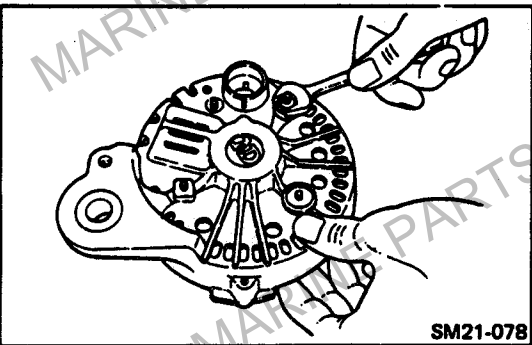


**IMPORTANT POINT(S) – DISASSEMBLY****1. REMOVE THE PULLEY AND FAN.**

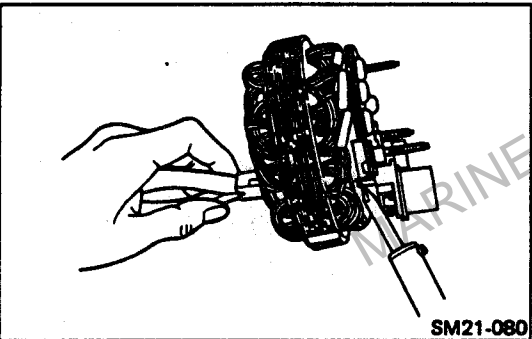
1. Clamp the rotor in a soft jawed vise.
2. Remove the pulley nut, spring washer, pulley and fan.

**2. REMOVE THE ROTOR SHAFT FROM THE DRIVE END FRAME.**

1. Using a press and a socket wrench, remove the rotor shaft and spacer collars.
2. Remove the bearing plate from the drive end frame.

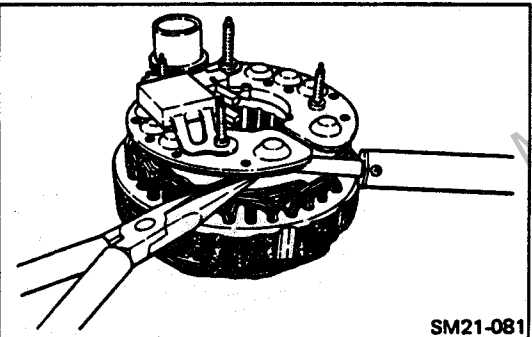
**3. REMOVE THE STATOR AND RECTIFIER FROM THE REAR END FRAME.**

1. Remove the nuts and tow insulators.
2. Remove the stator and rectifier from the rear end frame.

**4. UNSOLDER IC REGULATOR FROM THE RECTIFIER HOLDER.**

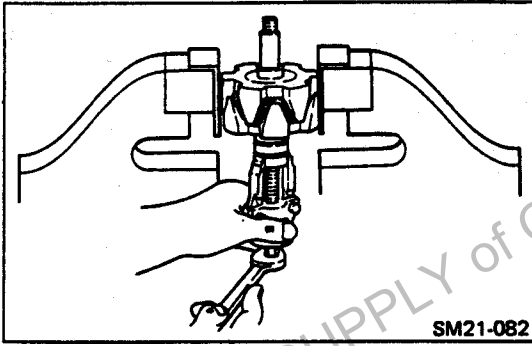
While holding the IC regulator with long nose pliers, unsolder the leads from the rectifier holder.

**NOTE:** The long nose pliers are used as a heat sink to help protect the IC regulator and rectifier from heat.

**5. UNSOLDER THE STATOR LEADS FROM THE RECTIFIER HOLDER.**

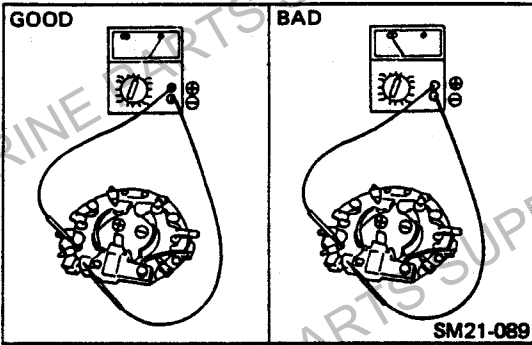
While holding the rectifier terminal with long nose pliers, unsolder the leads from the rectifier holder.

**NOTE:** Protect the rectifier from heat.



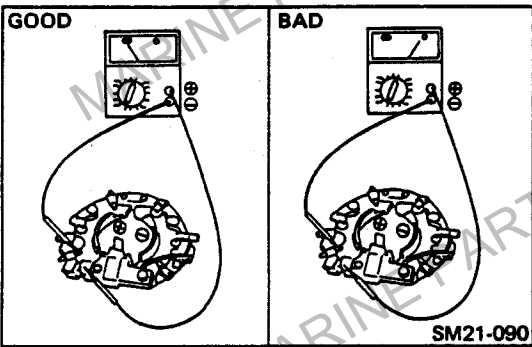
**6. REMOVE THE BEARING FROM THE ROTOR SHAFT.**

1. Clamp the rotor in a soft-jawed vise.
2. Remove the bearing from the rotor shaft with a bearing remover.

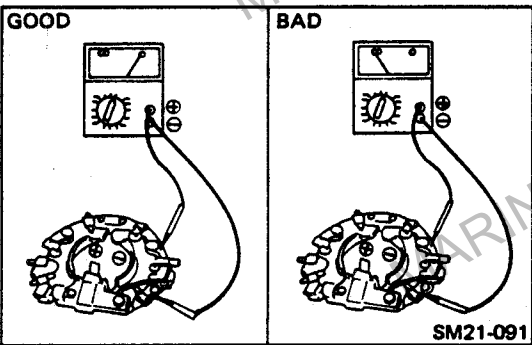


**IMPORTANT POINT(S) – TESTING RECTIFIER**

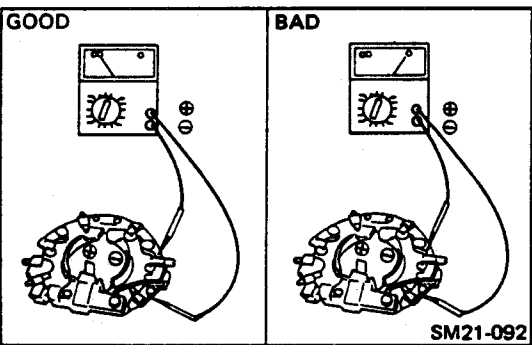
1. Rectifier holder positive side  
Connect an ohmmeter (+) lead to rectifier holder, and (-) lead of meter to rectifier terminal. If there is no continuity, rectifier assembly must be replaced.



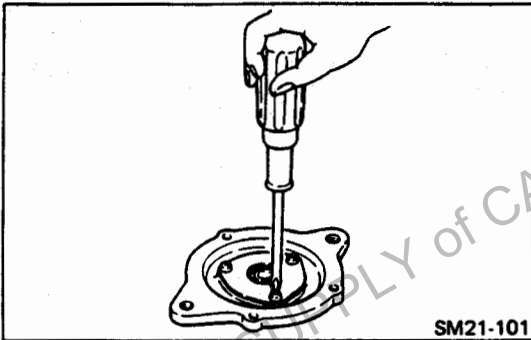
Reverse polarity of test leads and check again. If there is continuity, rectifier assembly must be replaced.



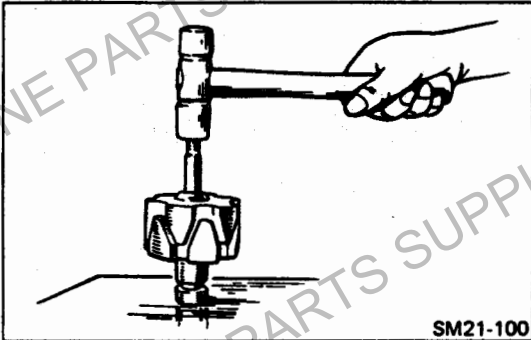
2. Rectifier holder negative side  
Connect an ohmmeter (+) lead to rectifier terminal, and (-) lead of meter to rectifier holder. If there is no continuity, rectifier assembly must be replaced.



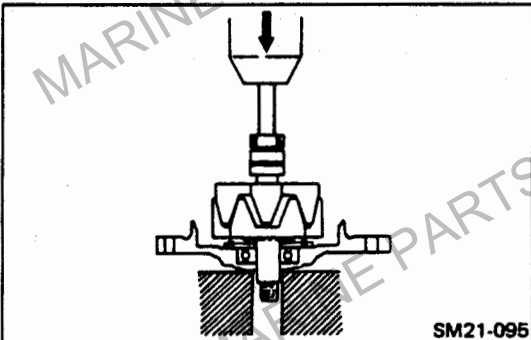
Reverse polarity of test and check again. If there is continuity, rectifier assembly must be replaced.

**IMPORTANT POINT(S) – ASSEMBLY****1. INSTALL THE BEARING IN THE DRIVE END FRAME.**

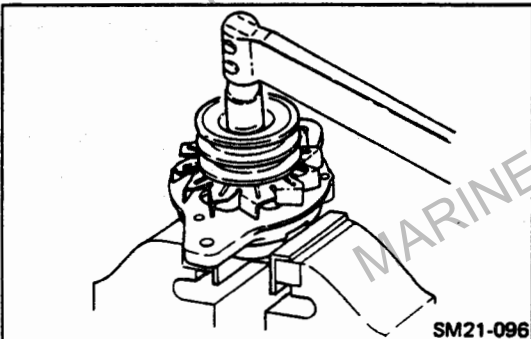
1. Install the bearing in the drive end frame, then install bearing plate.
2. Tighten the place.

**2. INSTALL THE BEARING ON THE ROTOR SHAFT.**

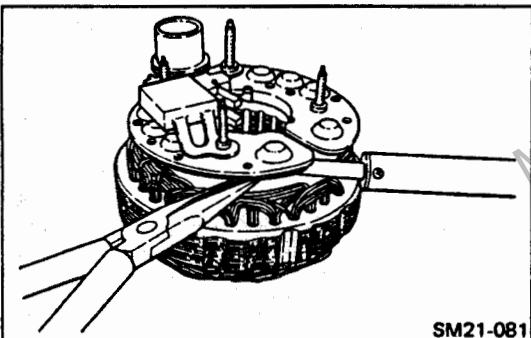
Tap the rotor shaft on with a plastic hammer.

**3. INSTALL THE DRIVE END FRAME.**

1. Slide the spacer collar on the rotor shaft.
2. Using a press, install the rotor shaft in the drive end frame.

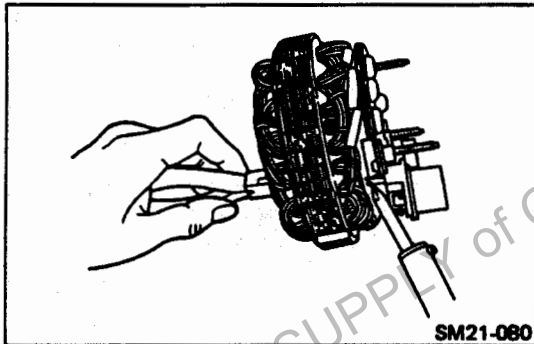
**4. INSTALL THE FAN AND PULLEY.**

1. Hold the rotor shaft in a soft-jawed vise.
2. Slide the spacer collar, fan, pulley, and spring washer on the rotor shaft.
3. Install and tighten the pulley nut.

**5. ASSEMBLE THE RECTIFIER AND STATOR.**

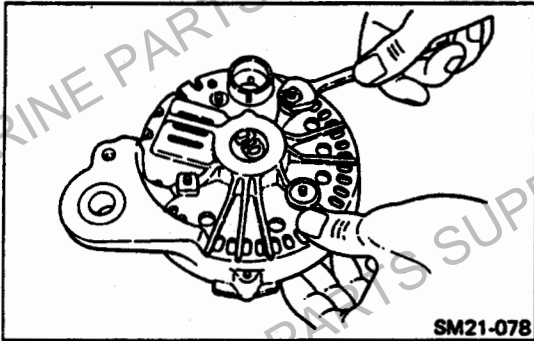
1. Solder each stator lead to the rectifier holder.
2. Hold the rectifier terminal with long nose pliers while soldering the leads.

**NOTE: Protect the rectifiers from heat.**



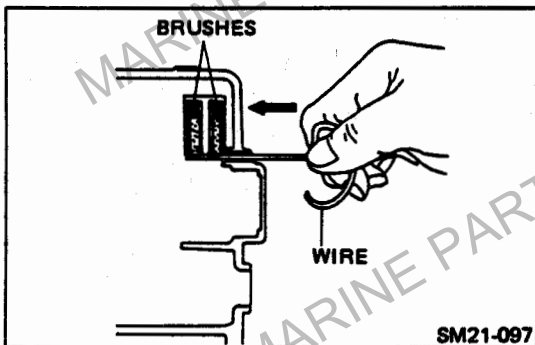
#### 6. ASSEMBLE THE RECTIFIER AND IC REGULATOR.

1. Solder each the IC regulator leads to the rectifier holder.
2. Hold the IC regulator leads with long nose pliers while soldering the leads.

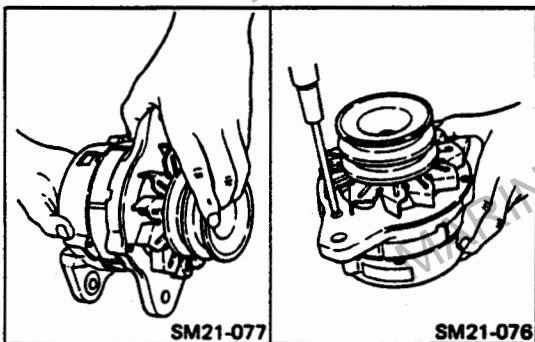


#### 7. INSTALL THE STATOR WITH RECTIFIER ON THE REAR END FRAME.

1. Install the stator with rectifier on the rear end frame.
2. Install the condenser, tow insulators, and tighten the nuts.

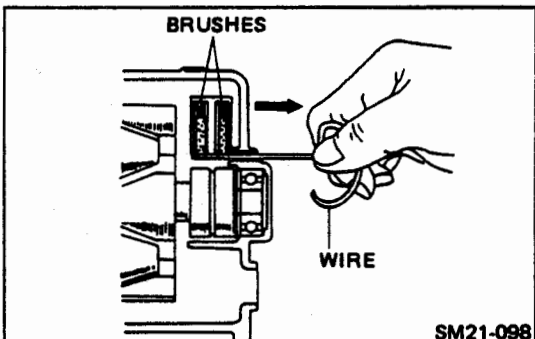


3. Push in the brushes and temporarily lock them in place with a wire inserted through the access hole in the rear end frame.



#### 8. CONNECT THE DRIVE END FRAME AND THE REAR END FRAME.

1. Fit the drive end frame to the rear end frame.
2. Install the three through bolts and tighten to the specified torque.



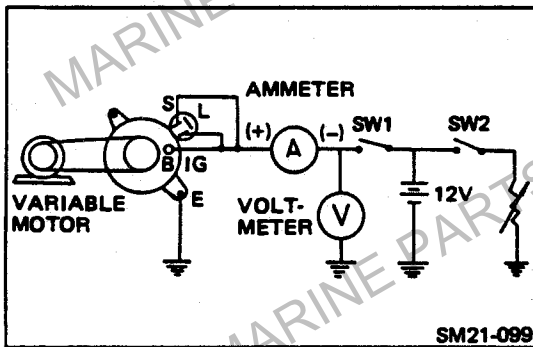
3. Remove the wire from the access hole.
4. Make sure that the rotor rotates smoothly.

PERFORMANCE TEST

NOTE: ○ Note the battery polarity carefully so as not to make reverse connections.

If the connections are reversed, the diodes will short the circuit and allow large current to flow through and damage the diodes and IC regulator as well as burn up the wiring harness.

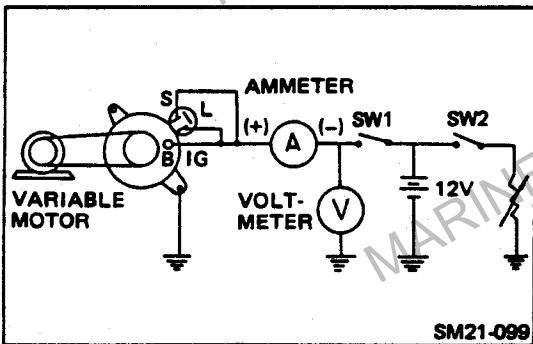
- Use care not to make wrong connections of terminals.
- When charging the battery with a quick charge. Disconnect the battery terminals.
- Do not perform tests high voltage insulation resistance tester.
- When in operation, never disconnect the battery.



1. GENERATOR PERFORMANCE TEST.

1. Connect the leads, voltmeter, and ammeter as shown in left.
2. Close SW1 on and increase the generator speed until voltmeter reading reaches approx. 13.5V.
3. Close SW2. Regulating the load resistance, increase the generator speed, keeping the voltage at 13.5V, until the ammeter reading reaches 80A.

Generator Speed: Less than 4,000 rpm at 13.5V, 80A




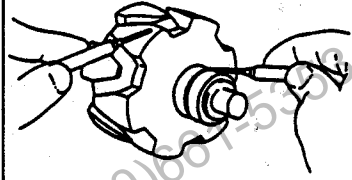
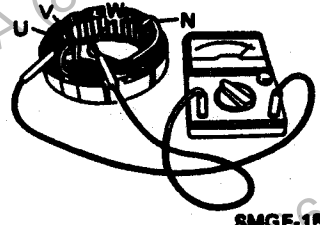
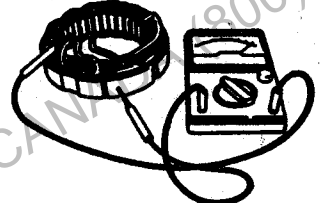


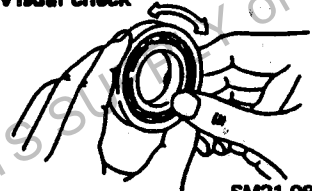
2. VOLTAGE REGULATION TEST.

1. Connect the leads, voltmeter and ammeter as shown in left.
2. Close SW1 on and increase the generator speed until voltmeter reading reaches approx. 13.5V.
3. Close SW2. Regulating the load resistance, increase the generator speed to 4,000 rpm, keeping the ammeter reading at 10A.
4. Check the voltmeter reading.

Generated Voltage: 13.8V-14.4V

INSPECTION AND REPAIR

Unit: mm (in)

Inspection Item	Standard	Limit	Remedy	Inspection Procedure	
Resistance of field coil (at 20°C)	About 4 Ω	-	Replace	 SM21-086	
Insulation resistance of field coil	More than 1 MΩ	Less than 0.5 MΩ	Replace	 SM21-087	
Resistance of field coil (at 20°C)	U-V	About 0 Ω	-	Replace	 SMGE-154
	U-W				
	V-W				
	N-U	About 0 Ω			
	N-V				
	N-W				
Insulation resistance of stator coil	More than 1 MΩ	Less than 0.5 MΩ	Replace	 SMGE-155	
Slip ring outer diameter	32.5 (1.280)	32.1 (1.264)	Replace	 SM21-082	
Brush length	19.0 (0.748)	5.5 (0.217)	Replace	 SM21-084	
Wear or damage ball bearing			Replace, if necessary.	Visual check  SM21-083	

(K.P.)

# CHAPTER ST

## STARTER (12V, 2.5 KW)

DATA AND SPECIFICATIONS ..... ST-2

DESCRIPTION ..... ST-2

TROUBLESHOOTING ..... ST-3

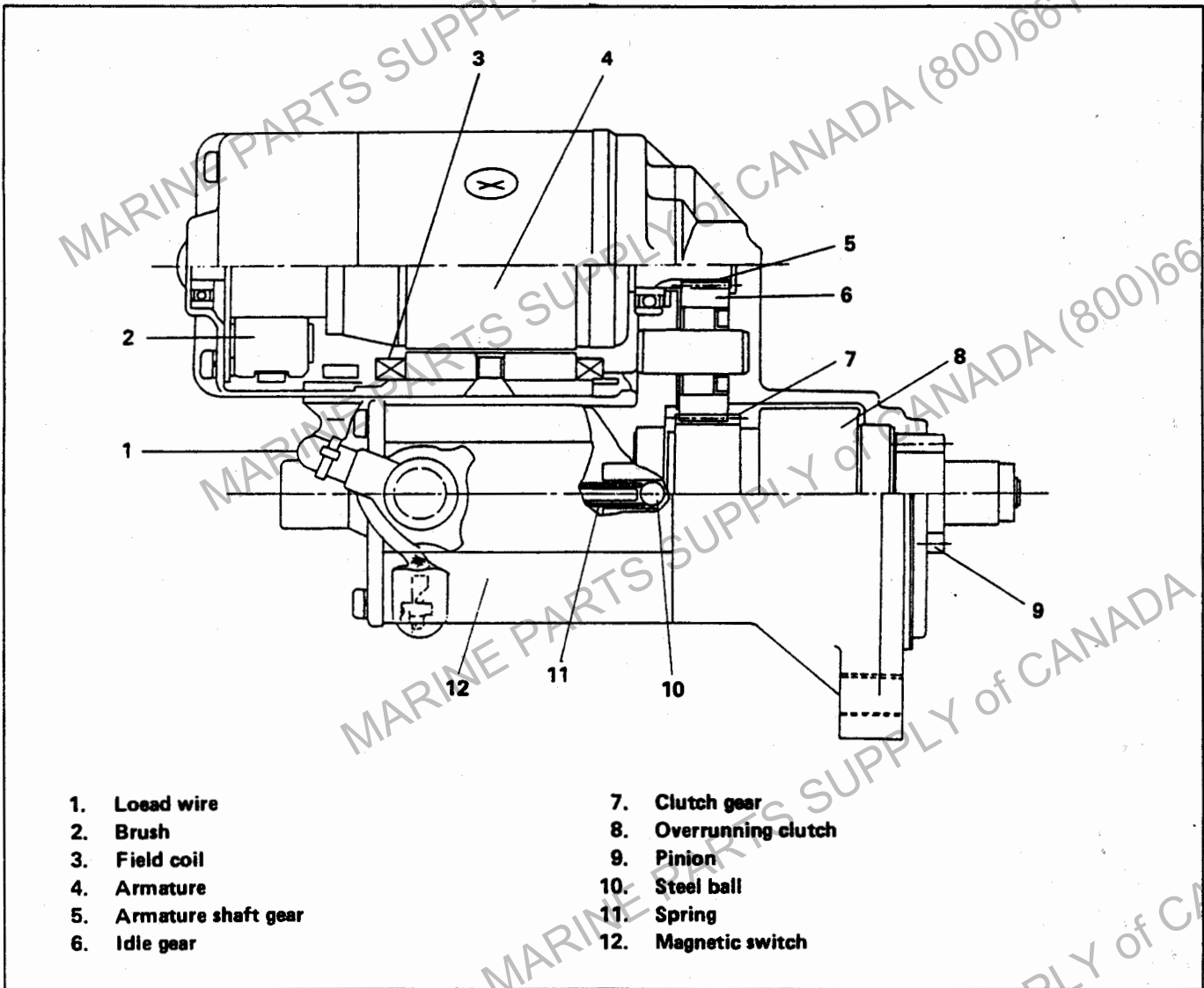
STARTER ..... ST-5



**DATA AND SPECIFICATIONS**

Model No.	28100-1561	28100-1960
Starter		
Type .....	Reduction gear type	
Output .....	12V, 2.5 KW	
Number of teeth of pinion .....	11	
Module .....	3	
Rotation .....	Clockwise, viewed from pinion side	

**DESCRIPTION**



- |                        |                       |
|------------------------|-----------------------|
| 1. Load wire           | 7. Clutch gear        |
| 2. Brush               | 8. Overrunning clutch |
| 3. Field coil          | 9. Pinion             |
| 4. Armature            | 10. Steel ball        |
| 5. Armature shaft gear | 11. Spring            |
| 6. Idle gear           | 12. Magnetic switch   |

# TROUBLESHOOTING

**Symptom**

**Possible cause**

**Remedy/Prevention**

Engine does not crank, or cranks slowly.

**Key switch**

- Poor contact . . . . . Polish or replace contacts

**Battery**

- Discharged battery . . . . . Charge
- Short circuited between electrodes . . . . . Replace battery
- Poor contact at battery terminal . . . . . Polish or retighten

**Engine oil**

- Improper viscosity oil . . . . . Change oil

**Magnetic switch**

- Poor contact caused by burnt contact plate . . . . . Polish or replace contact plate
- Contact plate worn out . . . . . Repair
- Hold-in coil disconnected . . . . . Replace field coil (Overrunning clutch moves back and forth)
- Pull-in coil disconnected or short circuited . . . . . Replace

**Starter relay**

- Defective or poor contact . . . . . Repair or replace

**Starter**

- Brush worn out . . . . . Replace
- Commutator burnt out . . . . . Correct on lathe
- Commutator worn out . . . . . Correct by undercutting
- Field winding shorted or grounded . . . . . Rewind or replace
- Armature winding shorted or grounded . . . . . Replace armature
- Insufficient brush spring tension . . . . . Replace brush spring
- Poor contact between magnetic switch and field windings . . . . . Repair
- Armature contacts pole core because of worn bearing bush or bent armature shaft . . . . . Replace bearing brush or armature
- Overrunning clutch malfunction . . . . . Replace

Engine does not crank while starter is running in good condition.

**Overrunning clutch**

- Overrunning clutch malfunction . . . . . Replace
- Pinion teeth worn out . . . . . Replace
- Poor sliding of spline teeth . . . . . Remove foreign materials, dirt, or replace

**Symptom**

**Possible cause**

**Remedy/Prevention**

Starter does not stop running.

**Key switch**

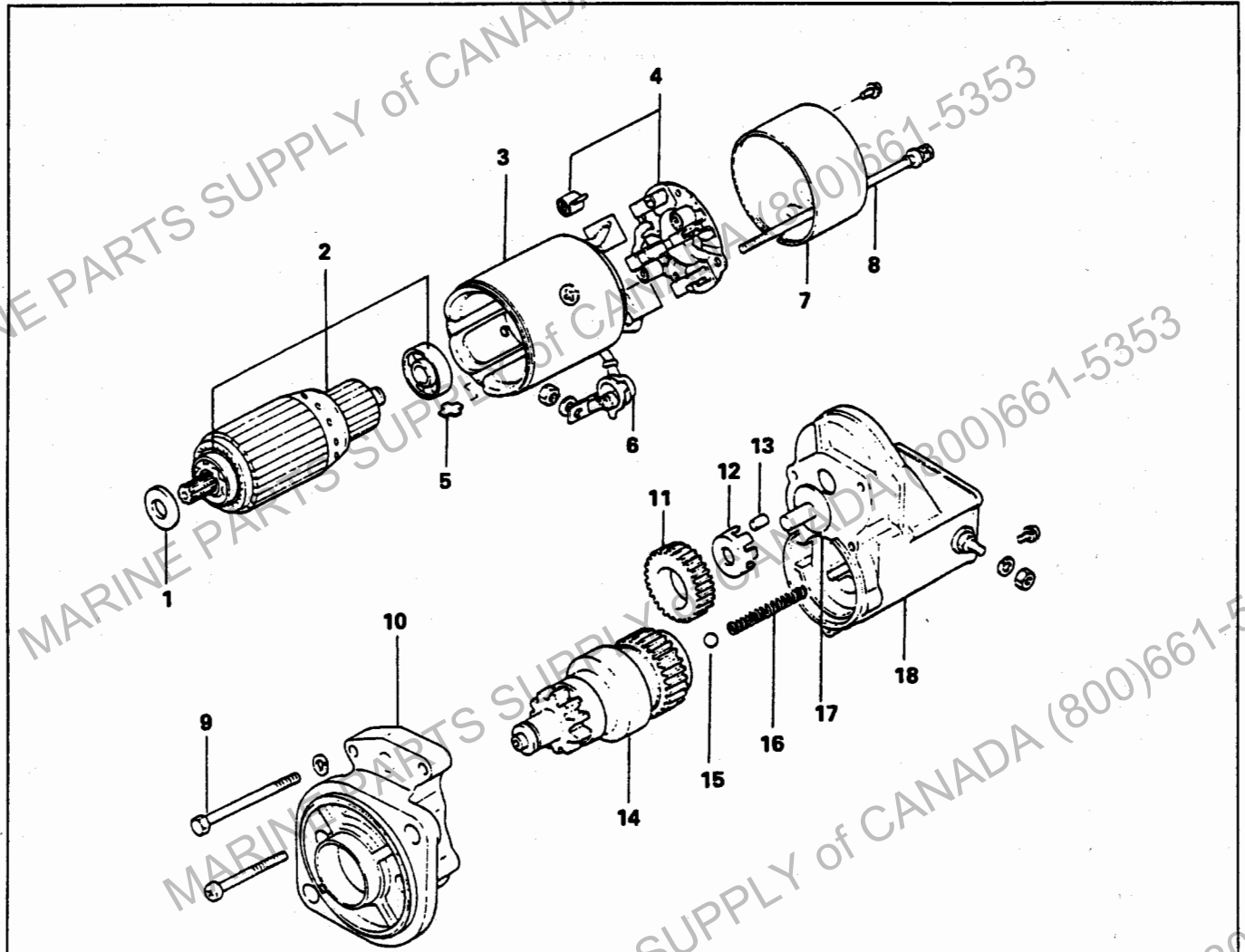
- Contacts keep closing ..... Replace
- Key switch sticks ..... Replace
- Overrunning clutch sticks to armature ..... Repair or replace overrunning clutch or armature

**Starter relay**

- Contacts keep closing ..... Repair or replace

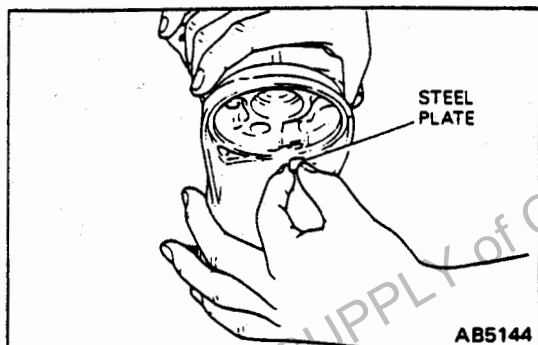
MARINE PARTS SUPPLY OF CANADA (800)661-5353

## STARTER

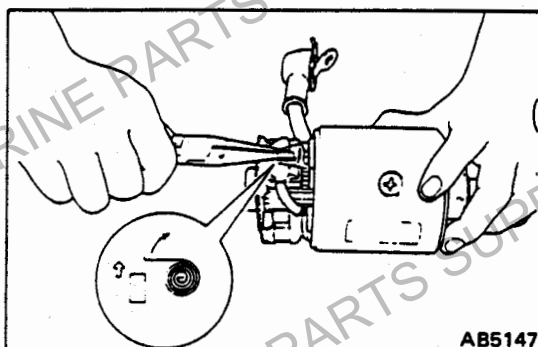


1. Felt washer
2. Armature assembly
3. Yoke assembly
4. Brush holder
5. Steel plate
6. Lead wire
7. Rear end frame
8. Through bolt
9. Through bolt

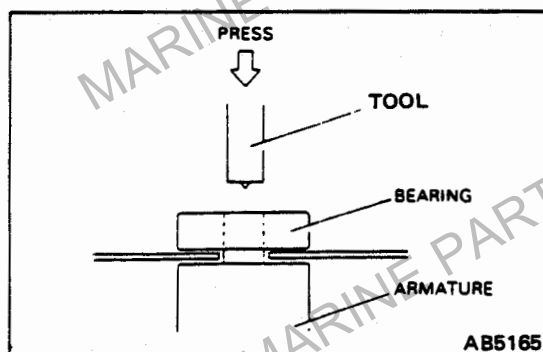
10. Drive end frame
11. Idle gear
12. Retainer
13. Roller
14. Overrunning clutch
15. Steel ball
16. Return spring
17. Steel washer
18. Magnetic switch assembly

**IMPORTANT POINT (S) – DISASSEMBLY****REMOVE THE YOKE FROM THE MAGNETIC SWITCH.**

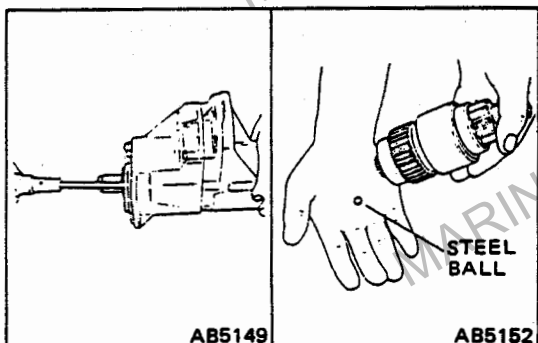
1. Disconnect the lead wire from the magnetic switch.
2. Remove the through bolts from the magnetic switch.
3. Remove the steel plate from the magnetic switch.

**REMOVE THE ARMATURE FROM THE YOKE.**

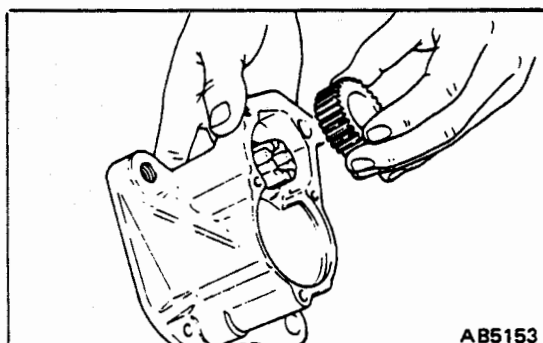
1. Remove the rear end frame from the yoke.
2. Using a long-nose pliers, take off the brushes and remove the brush holder.
3. Loosen the two through bolts and detach the brush holder from the armature shaft.

**REMOVE THE BALL BEARING FROM THE ARMATURE.**

1. Using a press and a suitable tool, remove the ball bearing.

**REMOVE THE OVERRUNNING CLUTCH.**

1. Remove the screws from the drive end frame.
2. Remove the drive end frame from the magnetic switch.
3. Remove the overrunning clutch.
4. Remove the steel ball from the overrunning clutch.

**REMOVE THE IDLE GEAR.**

1. Remove the idle gear, retainer with rollers, and steel washer from the drive end frame.

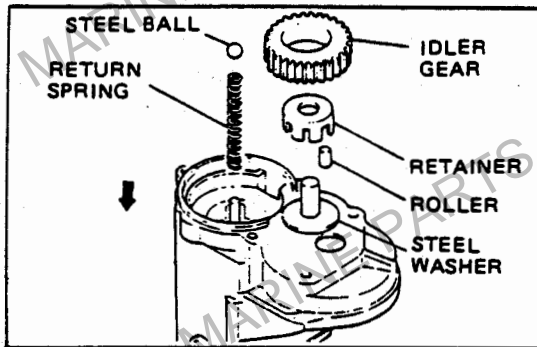
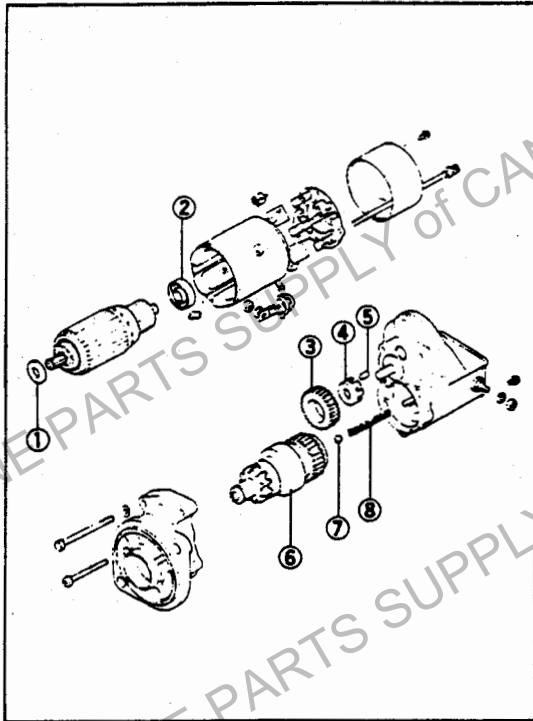
**NOTE:** Do not drop the retainer and the rollers.

**IMPORTANT POINT (S) – ASSEMBLY**

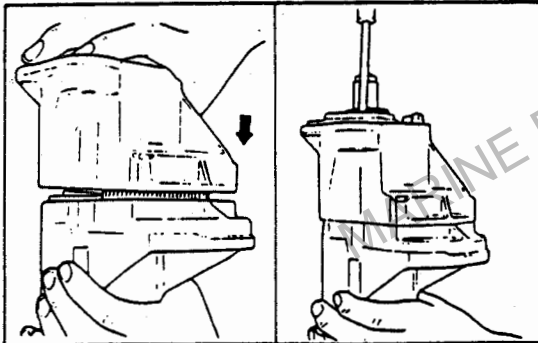
**BEFORE REASSEMBLING, APPLY THE RECOMMENDED GREASE TO THE FOLLOWING:**

Nippondenso No. 50 grease or equivalent.

- ① Felt washer
- ② Bearing
- ③ Idle gear
- ④ Retainer
- ⑤ Roller
- ⑥ Overrunning clutch
- ⑦ Steel ball
- ⑧ Return spring



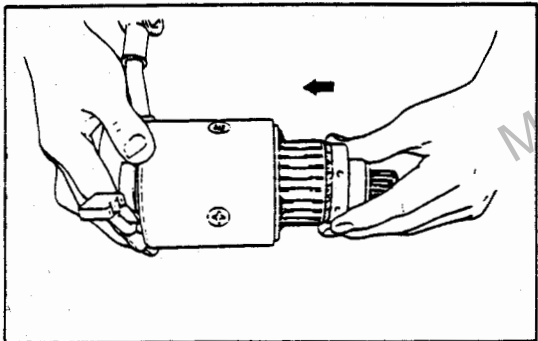
**INSTALL THE STEEL WASHER, RETAINER WITH ROLLER, IDLER GEAR, RETURN SPRING, AND STEEL BALL IN THE MAGNETIC SWITCH.**



**INSTALL THE OVERRUNING CLUTCH IN THE DRIVE END FRAME.**

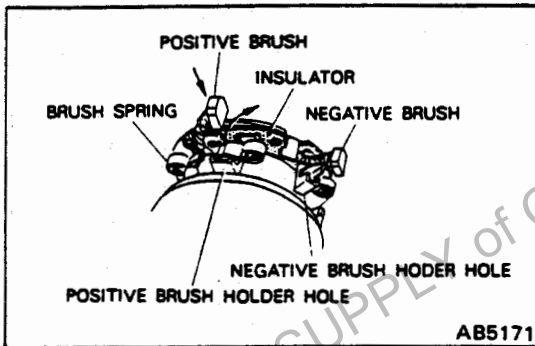
**NOTE:** Install the steel ball and the return spring.

1. Connect the drive end frame to the magnetic switch and tighten the screws.



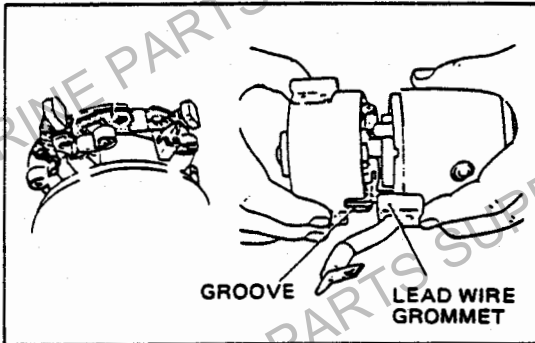
**INSTALL THE ARMATURE IN THE YOKE.**

**NOTE:** Do not forget to place a felt washer on the armature shaft bearing.

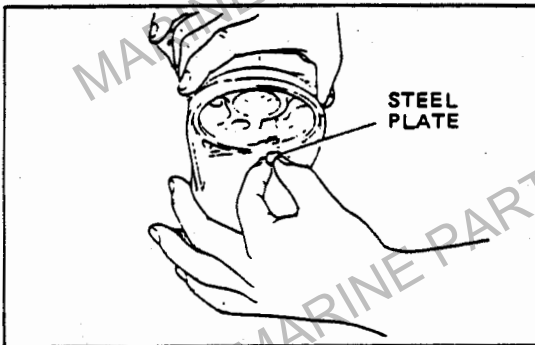
**INSTALL THE BRUSH HOLDER ON THE YOKE.**

1. Install the negative brush (brush holder side) to the brush holder negative hole (not insulated), and the positive brush (yoke side) to the brush holder positive hole (separated from plate with insulator). Make sure that the positive brush lead wires are not grounded.
2. When assembling the brush holder to the yoke, take care not to damage and get oil on it.

**NOTE:** Match the lead wire grommet with the rear end frame groove.

**INSTALL THE STEEL PLATE ON THE MAGNETIC SWITCH.**

1. Install the steel plate on the magnetic switch.
2. Securely put the rubber boot over the terminal.



## TEST

## MAGNETIC SWITCH TEST

The following test should be performed with the starter assembled and the field coil lead wire disconnected.

- NOTE:**
- Each test should be performed for a short time only (3 to 5 sec.) to prevent the magnetic switch winding from burning.
  - Each test should be performed with the specified voltage applied.

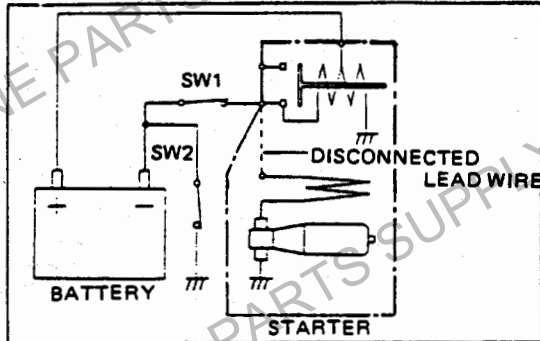


Fig. 22-34

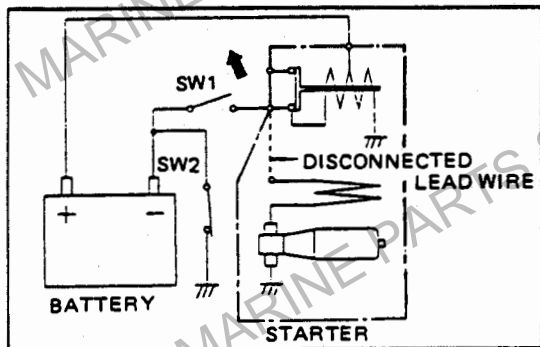
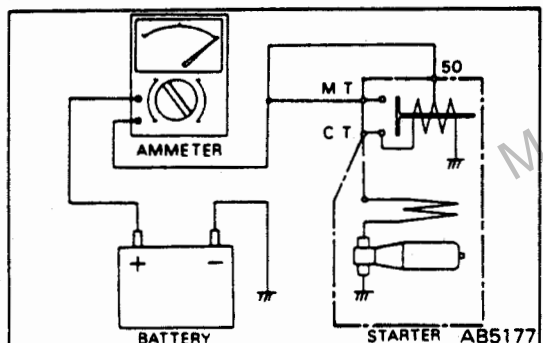
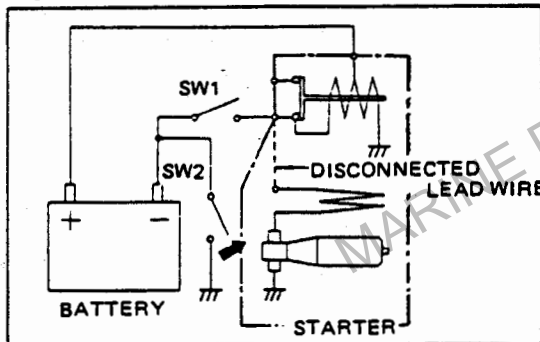


Fig. 22-35

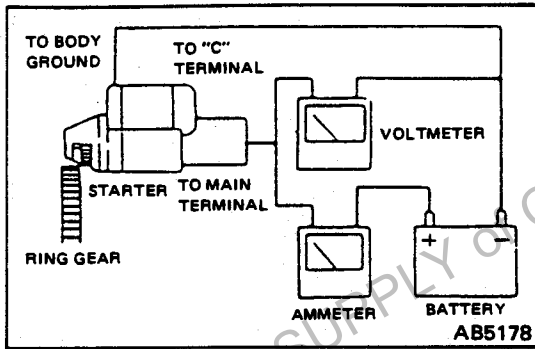


1. **Pull-in test**  
Connect the test leads as shown. When switch 1 (SW1) and switch 2 (SW2) are closed, the pinion should jump out.
2. **Hold-in test**  
In the same conditions as the pull-in test, open switch 1 (SW1).  
The pinion should remain in the jumped out position.
3. **Return test**  
In the same conditions as the hold-in test, open switch 2 (SW2).  
The pinion should return immediately.

## PERFORMANCE TEST

The following test should be carried out after reassembling the starter. If suitable equipment is not available, at least the No-load test should be carried out.

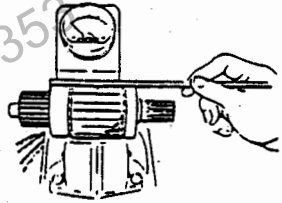
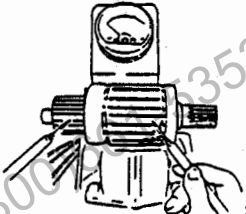
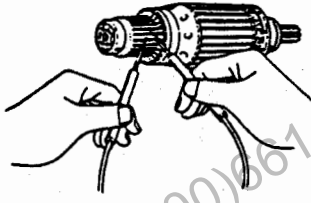
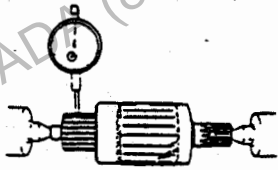
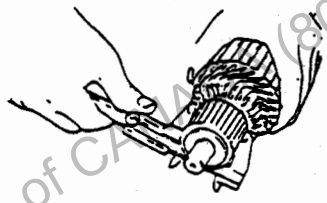

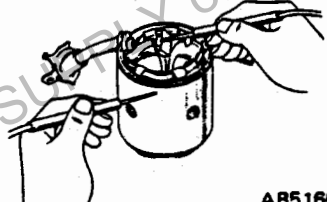
1. **No-load test**  
With the starter securely clamped in a vice, and using a battery and suitable ammeter, connect the positive lead of the battery, and the ammeter to the "50" terminal. Connect the negative lead to the starter body. The starter should show smooth and steady rotation immediately after jumping out of the pinion and should draw less than the specified current.



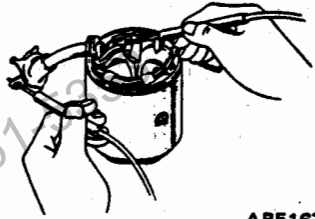
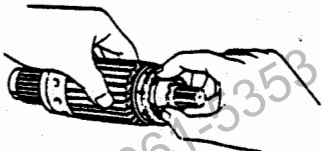
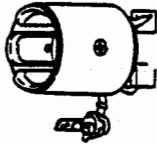
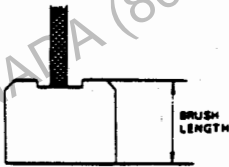
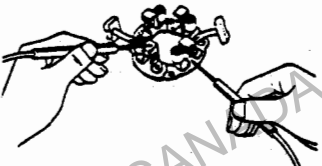
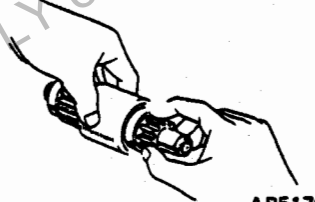

2. **Load test**  
Read the ammeter and voltmeter when the specified torque is applied. The ammeter should indicate less than the specified current, and the tachometer should indicate more than the specified speed.
3. **Lock torque test**  
Read the torque meter and ammeter when the tachometer reading becomes 0 rpm after applying the load. The torque meter should indicate more than the specified torque and the ammeter should indicate less than the specified current.

	Standard value of each test		
	Current	Voltage	Revolution & torque
No load test	Less than 180 A	at 11V	More than 3,500 rpm
Load test	Less than 600 A	at 8V	More than 1,100 rpm
Lock torque test	Less than 1,200A	at 3V	More than 3.5 kg-m at 0 rpm

INSPECTION AND REPAIR

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Armature Short Circuit Test	-		If the iron plate is not vibrated, the armature is good	 SMST-091
Armature Insulation	More than 1 MΩ	Less than 0.1 MΩ	Replace	 SMST-092
Commutator continuity	Should be continuity at any point	-	Replace, if there is no continuity at any point	
Commutator run-out	Less than 0.02 (0.0008)	0.05 (0.002)	Replace	 SMST-093
Commutator Outside Diameter	36 (1.417)	35 (1.378)	Replace	 SM22-055
Mica Depth	0.7 (0.0276)	0.2 (0.0078)	Replace	COMMUTATOR UNDERCUT  SM22-056
Conductance between the Field Coil and the Yoke	Should be conducted		Replace	 AB5166

## INSPECTION AND REPAIR

Inspection Item	Standard	Limit	Remedy	Inspection Procedure
Field Coil Insulation	More than 1 M $\Omega$	Less than 0.1 M $\Omega$	Replace	 AB5167
Wear or Damage of the Bearing	-	-	Replace, if necessary	 AB5184
Field coil and yoke damage			Replace	Visual check  AB5140
Brush length	20.5 (0.807)	13 (0.512)	Replace	 AB5168
Insulation between the Brush Holder and the Bracket	More than 1 M $\Omega$	Less than 0.1 M $\Omega$	Replace	 AB5169
Overrunning clutch test			Replace	 AB5170
Tension of the Brush Springs	3.9 kg (8.6 lb)	1.9kg (4.2lb)	Replace	

(KY)