

HINO
INDUSTRIAL ENGINE

EH700

*Workshop
Manual*

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HINO MOTORS, LTD.
TOKYO JAPAN

GENERAL INSTRUCTION

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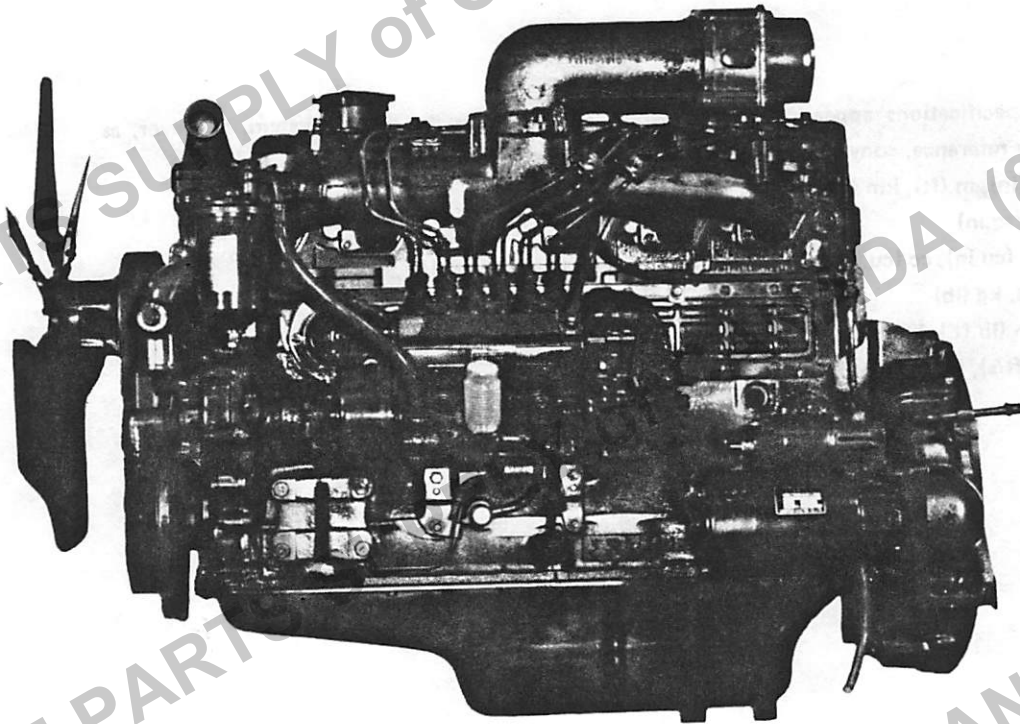


FOREWORD

This shop manual is a general description of the instructions and repairs required for HINO MODEL EH700 industrial diesel engine. It also covers the constructions and operational characteristics of the engine.

Daily and periodical inspection and maintenance are the most important factors governing the high performance of the engine. The proper sequences and methods outlined should be followed in repairs.

It is recommended that the customers make full use of this manual in order to attain the maximum efficiency maintenance and repair.

HINO MOTORS, LTD.**Model EH700 Engine**

EH7-001

1-2 GENERAL INSTRUCTION

ENGINE SERIAL NUMBER

The engine serial number is curved on the left hand of the engine cylinder block.



Fig. 1-1 Engine serial number

FDD-009

NOTE:

All specifications appearing in this manual are based on the metric system. However, as ready reference, conversion has been made as shown below:

mm (in), m (ft), km (mile)

cm² (sq.in)

mm³ (cu.in), cc (cu.in), m³ (cu.ft), liter (cu.in), liter (Imp.gal/U.S.gal)

g (oz), kg (lb)

kg-cm (lb.ft.), kg-m (lb.ft.), kg/mm (lb/in), kg/cm² (lb/sq.in)

m/s (ft/s), km/h (mph)

**SPECIFICATIONS
DIESEL ENGINE FOR INDUSTRIAL USE**

HINO

EH700

**6.443 liters, 4-cycle,
6-cyl., water-cooled**

APPLICATION: ELECTRICAL GENERATORS, WATER PUMPS, AIR COMPRESSORS, HYDRAULIC CRANES & SHOVELS, ROLLERS, TOWING TRACTORS, FORK-LIFT TRUCKS, SHUNTING LOCOMOTIVES AND OTHER GENERAL POWER PLANTS

● **PERFORMANCE & PERFORMANCE CURVE (STD. specs.)**

Output, intermittent rating kW (HP) at rpm	GENERAL USE (SAE J1349 Gross)			GENERATOR USE (SAE J1349 Gross)			
	Output, continuous rating kW (HP) at rpm	Max. torque Nm (lb.ft) at rpm	Min. fuel consumption g/kWh (lb/HPh) at rpm	Stand-by Power		Prime Power	
				Output at 1,500 rpm kW (HP)	Output at 1,800 rpm kW (HP)	Output at 1,500 rpm kW (HP)	Output at 1,800 rpm kW (HP)
106 (142) at 2,800	91 (122) at 2,800	408 (301) at 1,800	200(0.362) at 1,600	63 (84)	76 (102)	53 (71)	65 (87)

Ambient conditions:	SAE	DIN
Intake air temperature	25°C	20°C
Barometric pressure	100 kPa	736 mmHg
Water vapour pressure	1.0 kPa	10.5 mmHg

● **ENGINE DESCRIPTION**

- | | |
|---------------------------|---|
| 1. Type | Diesel, 4-cyc., 6-cyl., in-line, overhead valve, water-cooled |
| 2. Combustion system | Direct injection type |
| 3. Cylinder | |
| Bore x Stroke | 110 x 113 mm (4.33 x 4.45 in) |
| 4. Piston displacement | 6.443 liters (393.2 cu.in) |
| 5. Compression ratio | 17.9 |
| 6. Direction of rotation | Counter-clockwise viewed from flywheel |
| 7. Dimensions (L X W x H) | Approx. 1,150 x 735 x 875 mm
(45.3 x 28.9 x 34.4 in) |
| 8. Dryweight | Approx. 500 kg (1,100 lb) |

● **FEATURES**

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

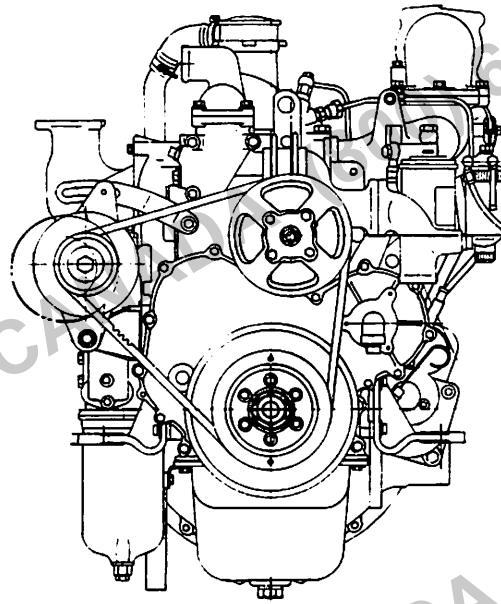
1-4 GENERAL INSTRUCTION

● STANDARD EQUIPMENT

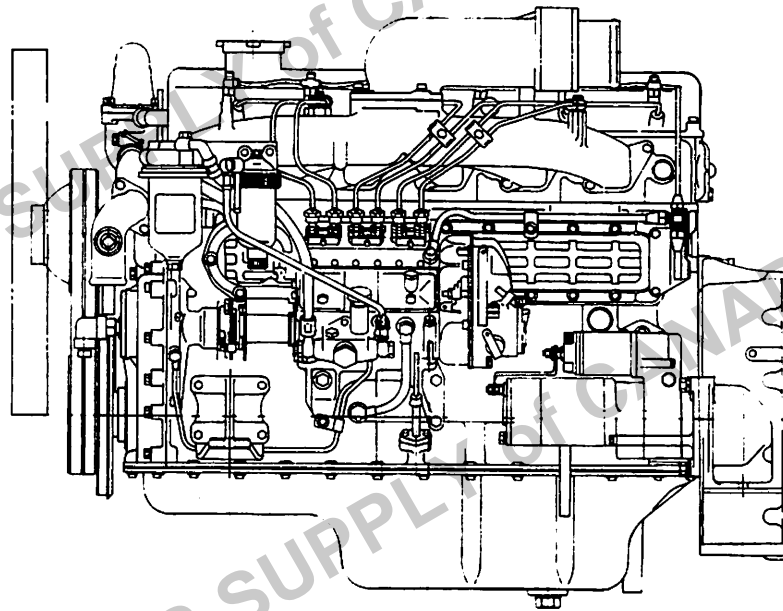
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|---|--|
| 1. Flywheel housing | HINO own (SAE No. 3 type) |
| 2. Flywheel | HINO own (SAE 11½ in. type) |
| 3. Fuel injection pump | BOSCH "A" type |
| 4. Governor | Centrifugal, all speed control type |
| 5. Fuel injection nozzle | BOSCH hole type |
| 6. Fuel filter | Paper element type |
| 7. Water separator | |
| 8. Cooling system | Forced-circulation by volute pump |
| 9. Lubricating system | Full-forced pressure feed by gear pump |
| 10. Oil filter | Paper element type (Full flow) |
| 11. Intake manifold | Inlet position at rear |
| 12. Exhaust manifold with flange plate | Upward exhaust |
| 13. Generator | Alternator with integral regulator
24V, 20A |
| 14. Starter | 24V, 5.5 kW |
| 15. Safety valve | |
| 16. Connectors of electrical equipments | |

● OPTIONAL EQUIPMENT

1. Cooling fan (suction or blowout)
2. Main switch
3. Battery switch
4. Battery relay
5. Starter switch with key
6. Ammeter
7. Fuse box
8. Engine shut off solenoid
9. Emergency relay
10. Coolant temperature switch
11. Coolant temperature gauge sender
12. Coolant temperature gauge
13. Oil pressure switch
14. Oil pressure gauge sender
15. Oil pressure gauge
16. Intake heater
17. Intake heater relay
18. Intake heater indicator
19. Tachometer with hourmeter
20. Tachometer cable
21. Muffler
22. Air cleaner
23. Air cleaner cap
24. Radiator with cooling fan shroud



FRONT VIEW



LEFT SIDE VIEW

S-EH700-E6

- NOTE:**
- 1) These specifications are subject to change without notice.
 - 2) These specifications are for export models.
 - 3) All specifications of the products are with normal manufacturing allowances and tolerances.
 - 4) The performance and drawings are for standard specifications.



HINO MOTORS, LTD.

TOKYO, JAPAN



RECOMMENDED LUBRICANTS FOR ALL HINO ENGINE

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

LUBRICANTS	POSITIONS	ATMOS- PHERIC TEMP.	S. A. E. NO.	BP	CALTEX	CASTROL	ESSO	GULF	MOBIL	SHELL	TOTAL
ENGINE OIL (A.P.I. CD) Previous Classification (A.P.I. 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	Mynna Oil 40, 20W-40, 15W-40 Rimula X Oil 40 Rimula CT 40	TOTAL Rubia S 40 TOTAL Rubia 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	Mynna Oil 30, 20W-40, 15W-40 Rimula X Oil 30, 10W-30 Rimula CT30	TOTAL Rubia S 30 TOTAL Rubia 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 CRD 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	Mynna Oil 20, 20W-40, 15W-40 Rimula X Oil 20 Rimula CT20	TOTAL Rubia S 20 TOTAL Rubia TM 15W40
ENGINE OIL (A.P.I. CC) Previous Classification (A.P.I. 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 Rubia 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 Rubia 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 Rubia H 20
COOLANT PUMP BEARING GREASE (MIL-G-10924B)	Coolant Pump Bearing			Energrease L-2	Marfak Multipurpose 2 or Marfak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP, 77, MS	Retinax A Alvansa 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	Marfak Multipurpose 2 or Marfak All Purpose 2	Castrol LM Grease	Esso Multipurpose Grease	Gulflex Poly	Mobilgrease MP, 77, MS	Retinax A Alvansa 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	Cruse Master Antifreeze And Summer Coolant	Mobil Permazone	Shellzone(U.S.A.) GlycoShell Plus (European Countries) Shellsafe Anti-Freeze P281 Coolguard	TOTAL ANTIGEL

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

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3-1 ENGINE INSTRUCTIONS

INTRODUCTION

Model EH700 engine is 4 cycle, direct injection type diesel engine having 6 cylinder in-line water cooled and overhead valves.

DEFINITION OF TERMS

The terms adopted in this Workshop Manual are defined as follows:

Rotation:

This engine rotates clockwise seen from the timing gear side.

Nominal dimension:

Basic dimension excluding tolerance.

Nominal clearance:

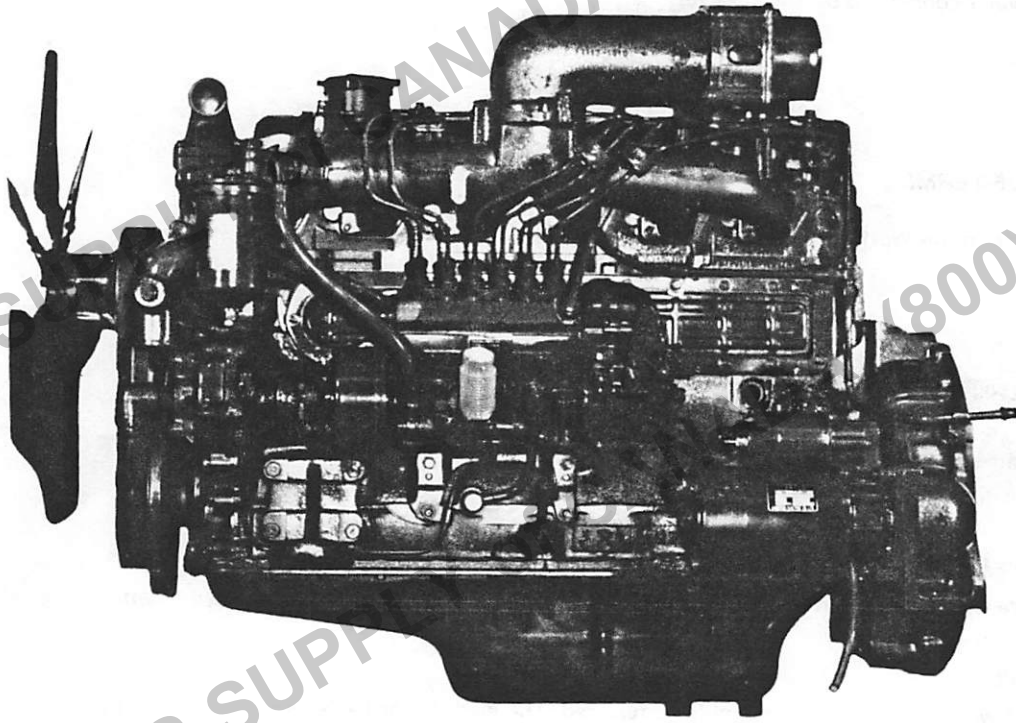
Space allowed between two parts on account of difference of tolerance when fixed together.

Repair limit:

Parts which reach this limit should be repaired. The mark (+) or (-) expresses increase or decrease as compared with the nominal dimension.

Serviceable:

The utmost that can be serviceable and parts which reach this limit should be replaced. The mark (+) or (-) expresses increase or decrease as compared with the nominal dimension.



EH7-001

Fig. 3-1-1 Model EH 700 Engine

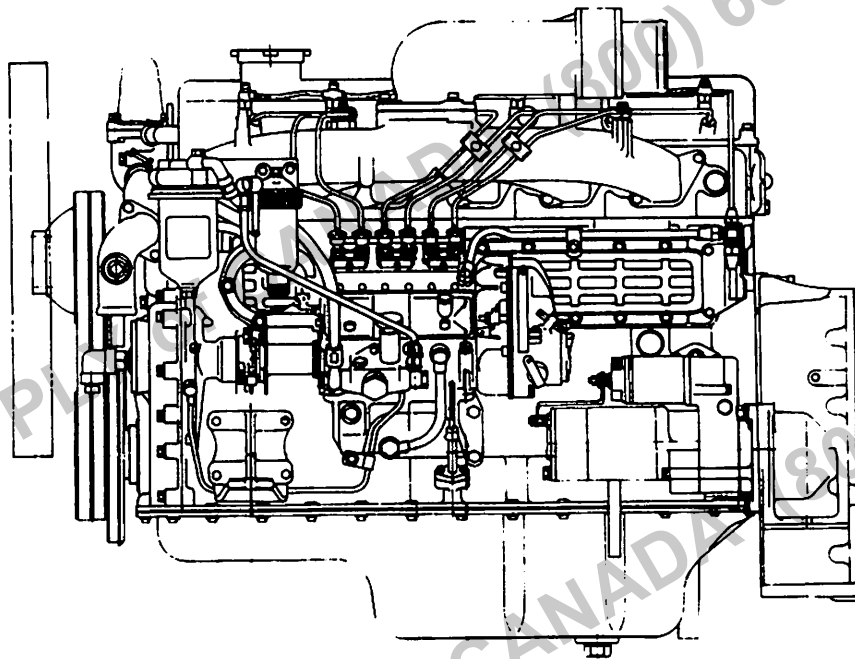


Fig. 3-1-2 Engine right side view

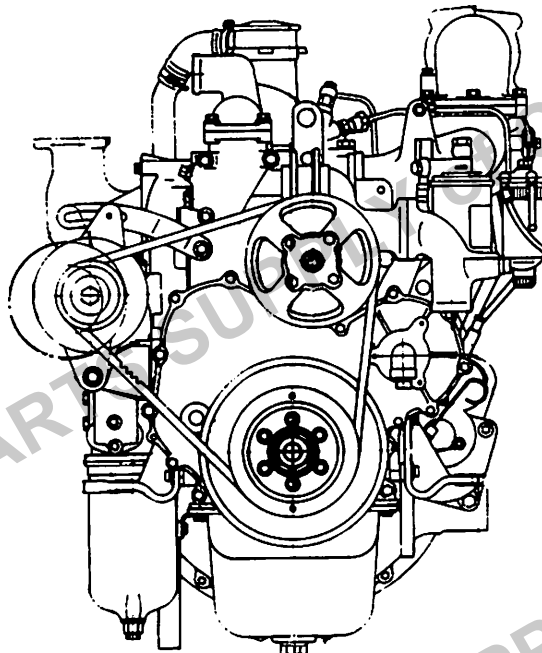


Fig. 3-1-3 Engine front view

DATA & SPECIFICATIONS

GENERAL

Model	HINO EH700
Type	Diesel, 4 cycle, vertical 6 cylinder in-line overhead valve water-cooled direct injection type
Bore and stroke	110 x 113 mm (4.33 x 4.45 in)
Piston displacement	6.443 liters (393 cu.in)
Output, intermittent (SAE J1349 Gross)	KW (HP) at r.p.m. 106 (142) at 2,800 r.p.m. 97 (130) at 2,400 r.p.m. 84 (112) at 2,000 r.p.m. 68 (91) at 1,600 r.p.m.
Output, continuous (SAE J1349 Gross)	KW (HP) at r.p.m. 91 (122) at 2,800 r.p.m. 84 (112) at 2,400 r.p.m. 72 (97) at 2,000 r.p.m. 57 (77) at 1,600 r.p.m.
Max. torque	Nm (lbf·ft) at r.p.m. 408 (301) at 1,800 r.p.m.
Compression ratio	17.9 : 1
Firing order	1-4-2-6-3-5
Compression pressure	29 – 35 kg/cm ² (413 – 497 lb/sq.in) at 270 – 310 rpm
Weight	500 kg (1,057 lb)

CYLINDER HEAD

Type	Single-piece casting
Material	Cast iron

VALVE MECHANISM

Valve seat angle, Intake	30°
Exhaust	45°
Valve face angle; Intake	30°
Exhaust	45°
Valve material; Intake	Heat resistance steel
Exhaust	Special heat resistance steel
Valve timing (flywheel travel); Intake opens	16° before T.D.C.
Intake closes	40° after B.D.C.
Exhaust opens	51° before B.D.C.
Exhaust closes	13° after T.D.C.
Valve clearance, Intake (when cooled)	0.30 mm (0.0118 in)
Exhaust (when cooled)	0.40 mm (0.0157 in)
Tappet	Special cast iron
Push rod	Hollow, carbon steel

CYLINDER BLOCK, CYLINDER LINER AND CAMSHAFT

Cylinder block	Mono-block, six cylinder, cast iron
Cylinder liner	Dry type, replaceable, special chrome alloy, centrifugally cast
Camshaft	Case-hardened die-forged carbon steel in material
Camshaft bearing Number and material	7, white metal with carbon steel back metal

CONNECTING ROD AND PISTON

Connecting rod	6, carbon steel
Small end bearing; Material	Bronze
Large end bearing; Material	Thin-kelmet with lead alloy
Piston	Heat-resistance aluminum alloy
Piston ring; Compression	Three, with chromeplated
Oil ring	One, chromeplated with coil expander

CRANKSHAFT AND CRANKSHAFT BEARING

Crankshaft	Induction-hardened die forged special steel with counter weights
Crankshaft bearing; Material	Iridum plated over kelmet

TIMING GEAR

Timing gear drive	Helical gear
-------------------	--------------

FUEL SYSTEM

Fuel injection pump	BOSCH line type, driven by engine, 1/2 x engine rpm, clockwise seen from the drive side
Injection timing (flywheel travel)	17° before 1st cyl. T.D.C.
Governor	BOSCH type, mechanical all speed control (RSV)
Timer	Automatic timer, clockwise rotation seen from the drive side, max. advancing angle 3°
Fuel feed pump	Piston type, driven by injection pump camshaft, max. feeding pressure 1.3 kg/cm ² (18.5 lb/sq.in)
Nozzle	Multi-hole nozzle type
Nozzle holder	Injection pressure 220 kg/cm ² (4,125 lb/sq.in)
Fuel filter	Replaceable paper element type

LUBRICATING SYSTEM

Type	Forced-feed lubrication with oil pump
Oil capacity	14 liter (3.07 Imp.gal/3.70 U.S.gal)
Oil pressure	1.0 – 5.0 kg/cm ² (14.22 – 71.1 lb/sq.in)
Oil filter	Full flow paper element oil filter
Oil pan	Pressed sheet steel in material

COOLING SYSTEM

Type	Forced recirculation type
Cooling system water capacity (Only cylinder block)	11 liters (2.42 Imp.gal/2.90 U.S.gal)
Coolant pump	Centrifugal, belt-driven by engine crankshaft, 0.936 x engine rpm
Fan; Type	Six-blades type, mounted on cylinder block
Drive	Fully shrouded belt-driven by engine crankshaft pulley 0.936 x engine rpm
Thermostat	Wax type, bottom by pass system, open at 76.5°C (170°F), max. lift 10.0 mm (0.393 in) at 90°C (194°F)

PERFORMANCE CURVE CONDITION (MODEL: SAE)

- (1) Ambient conditions:
 - SAE
 - Intake air temperature 25°
 - Barometric pressure 100 kPa
 - Water vapor pressure 1.0 kPa
- (2) Net rating with fan alternator (unloaded), air cleaner, and exhaust silencer installed.
- (3) Specific fuel consumption curve shows under 1-hour rating.

Intermittent rating (SAE J1349 Gross)
 Continous rating (SAE J1349 Gross)

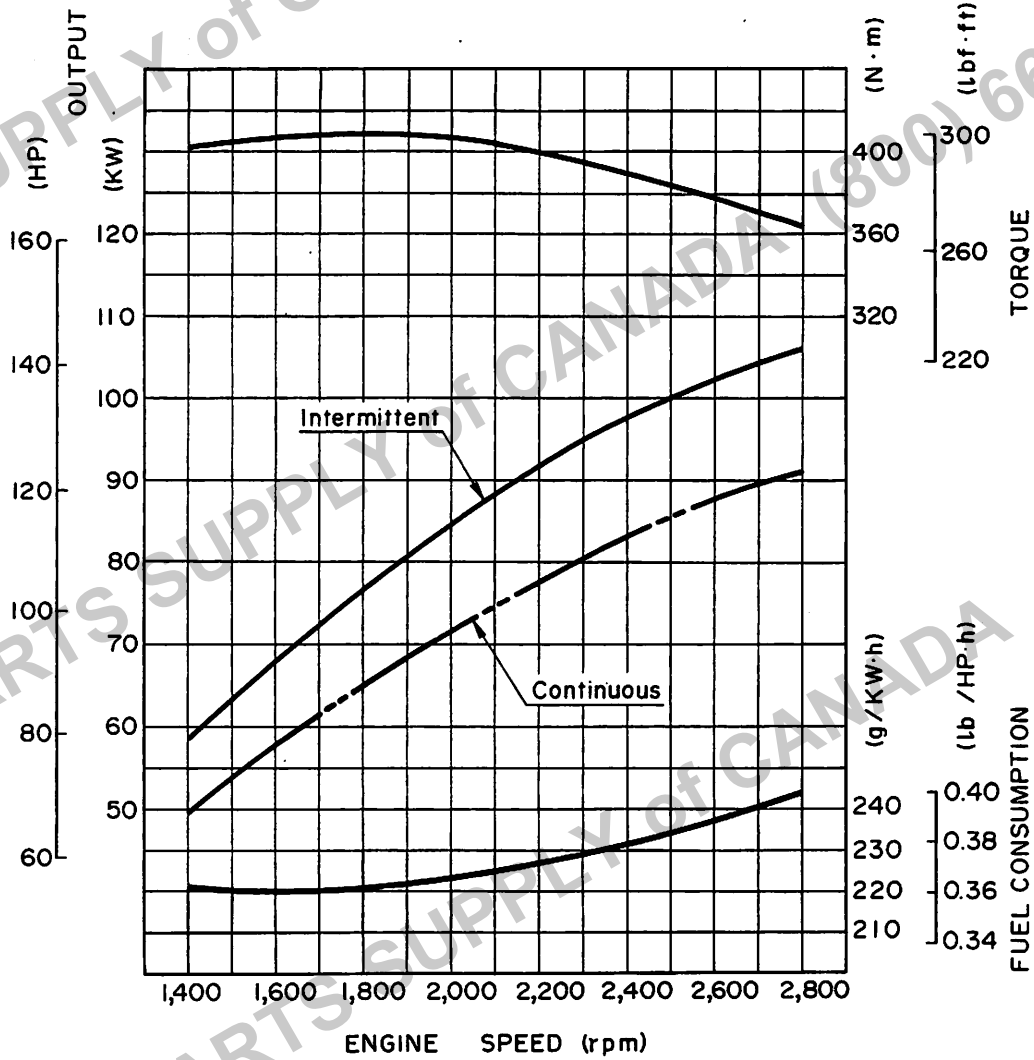


Fig. 3-1-5

ENGINE OVERHAUL

1. Factors Affecting the Timing of Engine Overhaul

Among the various factors necessitating engine overhauling is the wear of the cylinder liner, piston, and the piston ring. These defects present themselves in various ways, making it difficult to correctly judge when to conduct an overhaul.

It is, therefore, desirable that maintenance and inspection be conducted periodically, so that the timing of engine overhauling may be determined based on data obtained through such work. Listed below are some of the factors which should be taken into consideration in deciding when to conduct an engine overhaul.

1. Lowering of compression pressure

One of the most reliable elements based on which to judge the timing of engine overhauling is the compression pressure. The standard compressing pressure of this engine is 29 – 35 kg/cm² (413 – 497 lb/sq.in) at 270 – 310 rpm.

Overhaul is needed when the compression pressure drops to less than 25 kg/cm² (356 lb/sq.in) at 270 – 310 rpm, or when the compression pressure between individual cylinders varies by more than 3 kg/cm² (43 lb/sq.in).

Unit: kg/cm² (lb/sq.in.)

Engine model	Standard value	Limit	
		Absolute value	Difference between each cylinder
EH700	29 – 35 (413 – 497) at 270 – 310 rpm	25 (356) at 270 – 310 rpm	3 (43) at 270 – 310 rpm

2. Increase of consumption of engine oil

The standard engine oil consumption is approximately 1/100 of the amount of fuel consumed. Consumption of engine oil will, however, increase as various component parts wear out. It is advisable that oil consumption be estimated based on the average consumption during a period of one month or two.

3. Other factors

Besides the lowering of compression pressure and the increase of consumption of engine oil mentioned above, the following conditions may also be taken into account in judging when to overhaul the engine:

- (1) The blow-by explosive gas into the crank case will increase, and an increased amount of gas will come out of the breather pipe, oil filler

pipe thru. cylinder head holes for rocker arm push rod etc.

- (2) The engine will not start easily.
- (3) Engine output decreases.
- (4) Fuel consumption increases.
- (5) Engine makes a larger noise.
- (6) Oil pressure decreases.

These defects present themselves, often combined with one another, as factors calling for engine overhauling. It should be noted that of the defects listed above (2) has a great deal to do with the condition of the battery and that (2), (3) and (4) are influenced by the full injection amount and timing of the injection pump as well as by the wear of the plunger and the condition of the nozzle. These facts must also be taken into due consideration.

2. Compression Pressure Measurement

1. Before measurement

- (1) Check and confirm that the valve clearance is correct.
- (2) Fully charge the battery.
- (3) Idle the engine until the water temperature rises to 80°C (176° F).
- (4) Remove the air cleaner so as to reduce suction resistance.

2. Measurement

The starter motor is used to turn the engine when checking compression. The compression pressure gauge is composed of an adapter unit, pressure gauge and pipe. (Make sure that the pressure gauge is correctly calibrated before testing.)

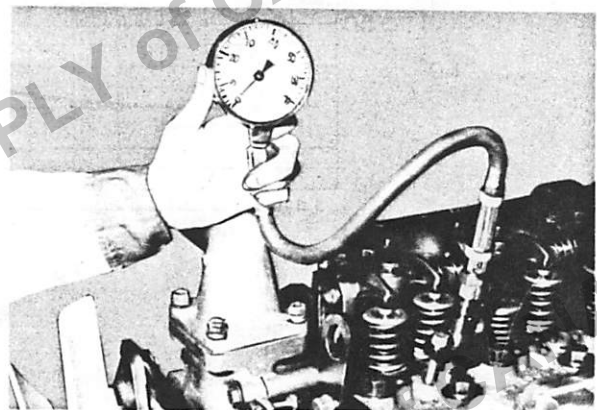


Fig. 3-1-6 Compression pressure gauge

KT3-197

- (1) Remove the six nozzle holders, by removing all six nozzle holders engine drag is reduced, battery power conserved, and the engine can be turned at high speed.

- (2) Place the adapter unit at the position of the removed nozzle holder for the cylinder to be checked and couple it to the pressure gauge properly to prevent gas leakage.
- (3) Energize the starter motor and when the engine is turning at maximum speed, read the pressure gauge. This requires two person ; one to read the pressure gauge and the other to watch the engine tachometer.
- (4) Repeat the above for the remaining cylinders. Be sure to check all cylinders, result from a few cylinders does not mean that the remainder are also satisfactory.

3. General Cautions on Engine Overhauling

1. In disassembling the engine, prepare a work bench on which to place the component parts as they are removed, and keep all parts neatly arranged on it according to the order to disassembly.
2. In disassembly, observe the assembly marks so that the engine can be correctly re-assembled after overhauling. If necessary, put assembly marks on parts that are not marked.

Since the engine has many cylinders, put cylinder numbers on the following parts to prevent confusion at the time of re-assembly.

- (1) Main bearing
- (2) Connecting rod bearing
- (3) Piston (including piston ring)
- (4) Cylinder liner
- (5) Valve
- (6) Push rod
- (7) Tappet
- (8) Rocker arm
- (9) Connecting rod

3. During disassembly and cleaning, always check for any abnormality so as not to miss any defect which cannot be detected after assembly or cleaning.

- (1) The following bolts need to be checked for correct tightening torque.

- (i) Cylinder head bolts
- (ii) Connecting rod bolts
- (iii) Main bearing cap bolts

Bolts other than these should also be checked, depending upon the reason for which the parts they are used in were disassembled.

- (2) Inspection and measurement of the following parts at the time of overhauling will also make it easier to judge afterwards whether or not they need replacement.

- (i) Uniform contact of the cylinder head gasket
- (ii) Cracks of the cylinder head. gasket grommet
- (iii) Protrusion of the cylinder liner from the crankcase
- (iv) Crush of the main bearing
- (v) Crush of the connecting rod bearing
- (vi) End play of the crankshaft
- (vii) Backlash of gears

4. In assembly and disassembly, always use correct tools to prevent damage. In assembly, lubricate parts that need lubrication, and in parts where the amount of tightening torque is specified, apply oil on the threaded portion of the bolts and nuts and tighten them, applying the specified amount of torque.

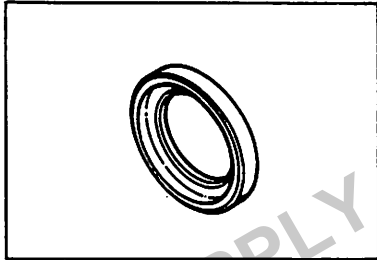
5. Avoid using old packings and gaskets to prevent oil or gas leakage.

3-10 ENGINE

SPECIAL TOOL

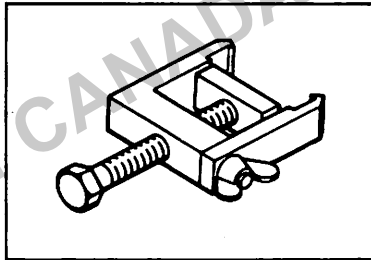
Prior to start of engine overhaul, it is necessary to prepare special tools.

FRONT OIL SEAL PRESS.



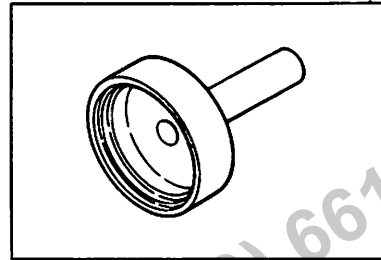
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FRONT SLEEVE PULLER



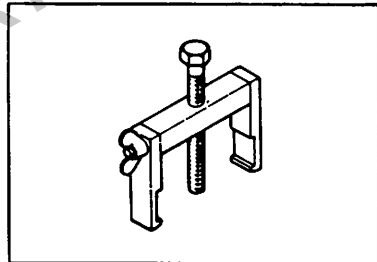
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SLEEVE PRESS



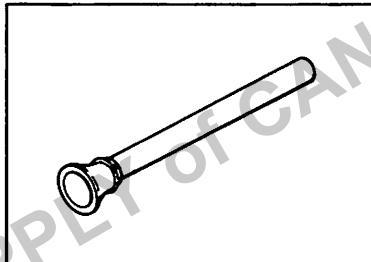
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SLEEVE PRESS



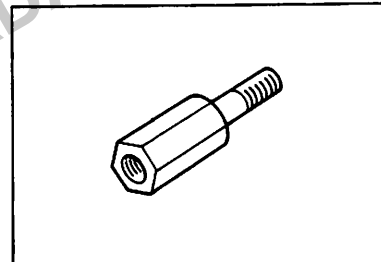
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VALVE LAPPING TOOL



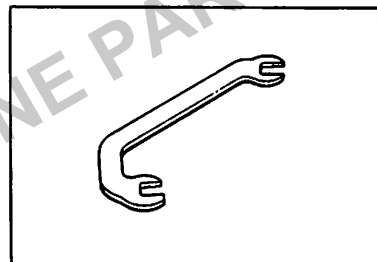
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ADAPTOR



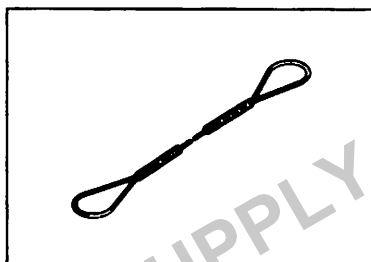
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TIMING WRENCH



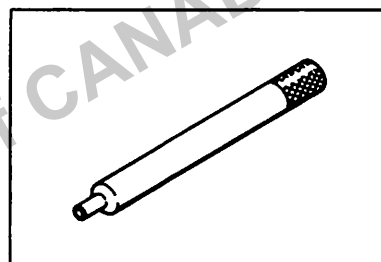
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09819-3004

WIRE



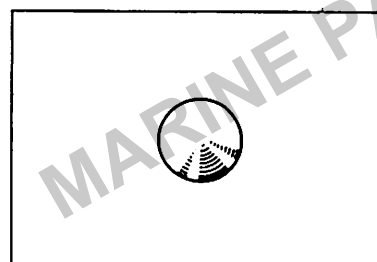
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NOZZLE SLEEVE BAR



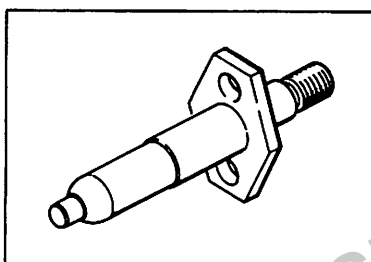
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NOZZLE SEAT PRESS (STEEL BALL)



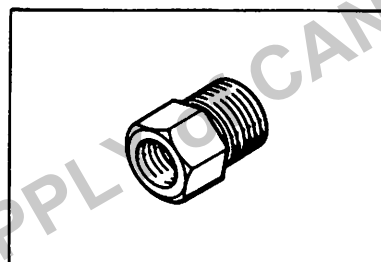
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GAUGE ADAPTOR



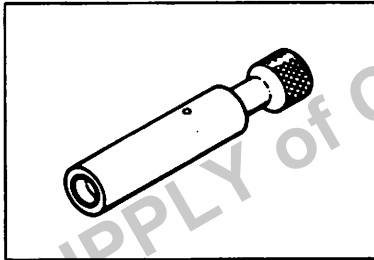
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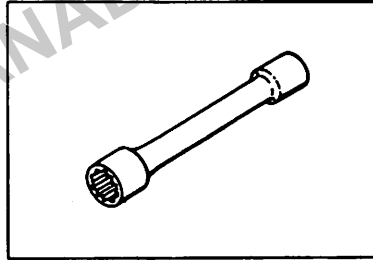
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STEM SEAL PRESS



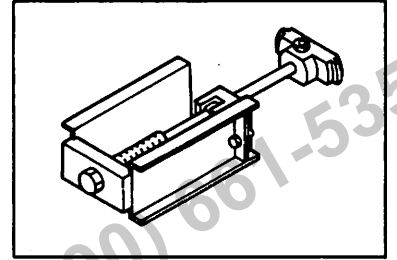
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SOCKET WRENCH



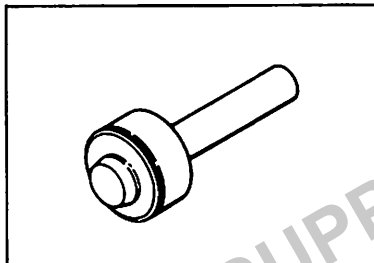
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PULLER



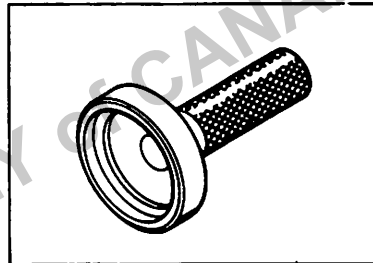
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DUST SLINGER PRESS



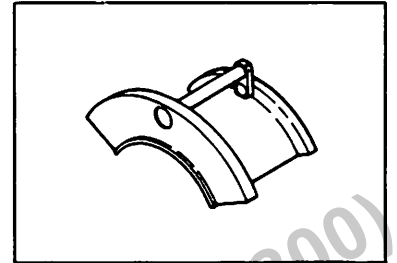
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FRONT SLEEVE PRESS



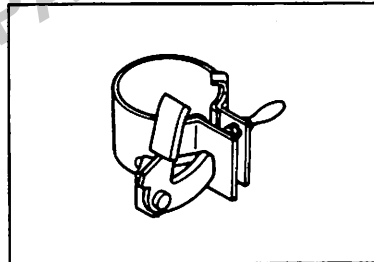
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CYLINDER LINER PRESS



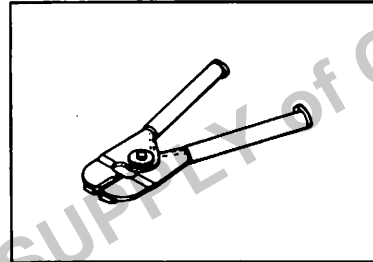
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PISTON RING HOLDER



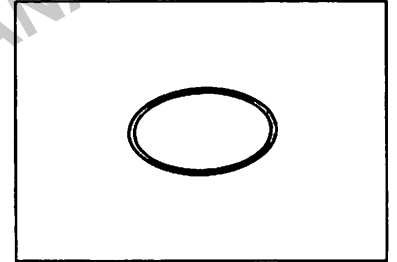
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PISTON RING EXPANDER



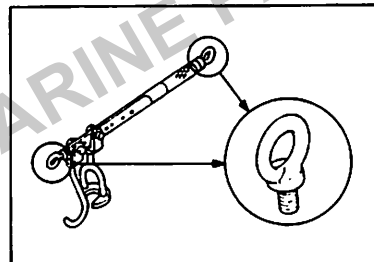
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O-RING



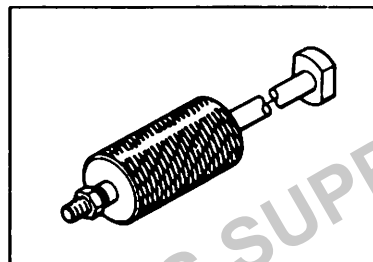
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VALVE SPRING PRESS



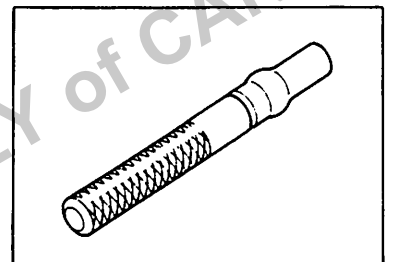
09470-1021

SLIDING HAMMER



09420-1441

PUSH ROD GUIDE PIPE
CAULKING TOOL



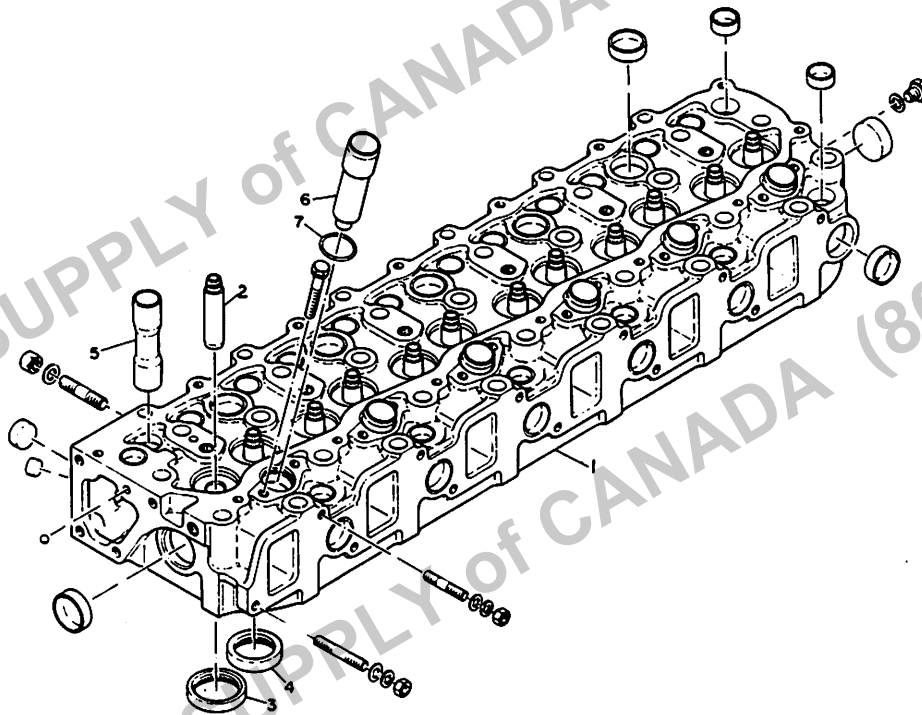
09482-1320

Fig. 3-1-7 Special tools

3-2 CYLINDER HEAD & VALVE MECHANISM

DESCRIPTION

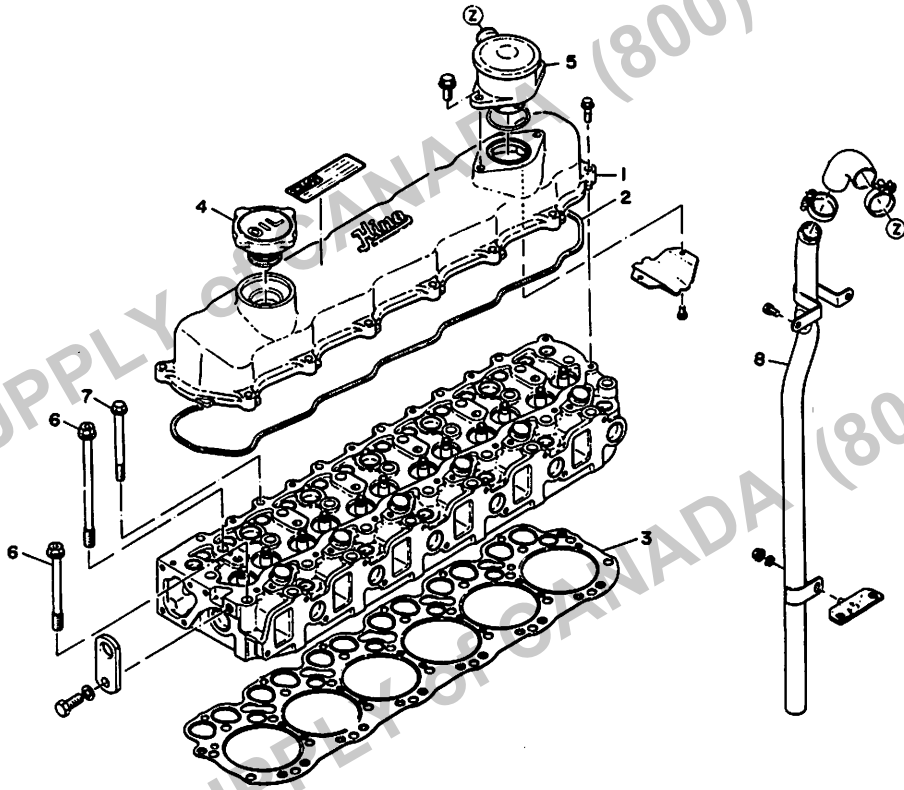
1. Cylinder Head & Related Parts



- 1. Cylinder head
- 2. Valve guide
- 3. Intake valve seat

- 4. Exhaust valve seat
- 5. Push rod guide pipe
- 6. Nozzle seat (copper sleeve)
- 7. O-ring

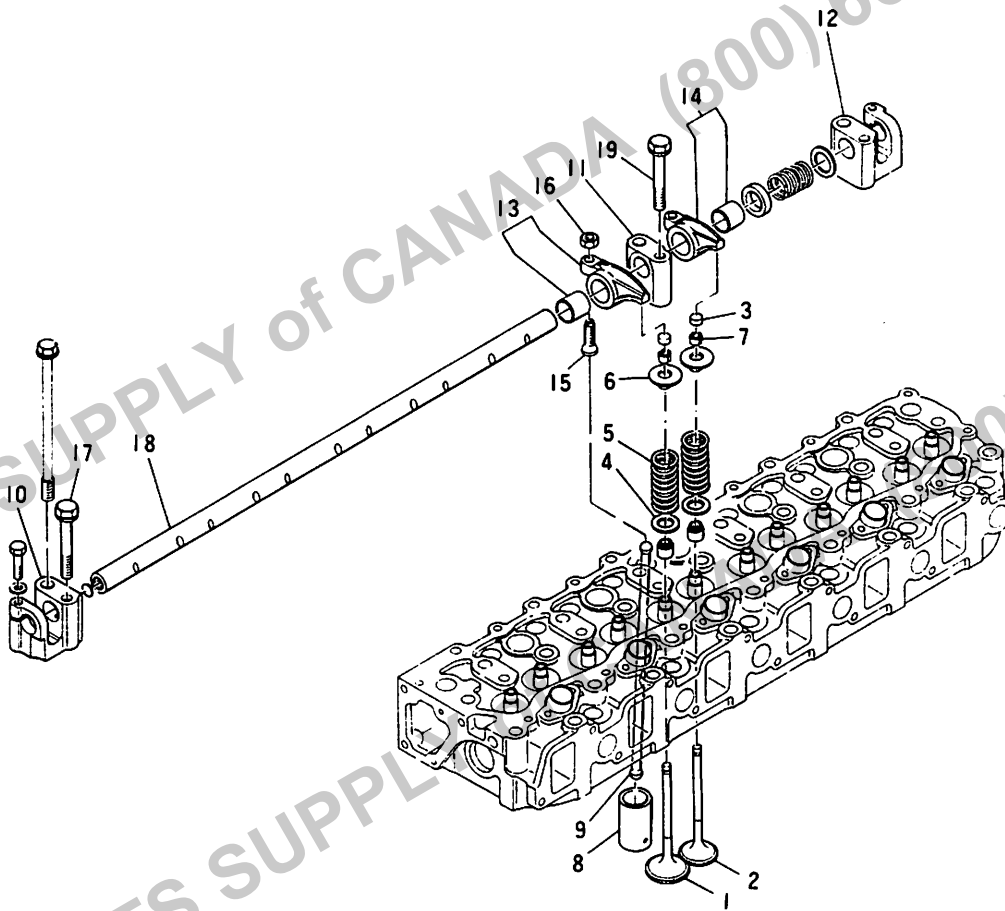
Fig. 3-2-1 Cylinder head



- | | |
|-------------------------------|-----------------------|
| 1. Cylinder head cover | 5. Ventilator |
| 2. Cylinder head cover gasket | 6. Cylinder head bolt |
| 3. Cylinder head gasket | 7. Cylinder head bolt |
| 4. Oil filler cap | 8. Vent pipe |

Fig. 3-2-2 Cylinder head & related parts

2. Valve Mechanism



- | | |
|----------------------------|-------------------------|
| 1. Intake valve | 10. Rocker arm support |
| 2. Exhaust valve | 11. Rocker arm support |
| 3. Valve stem cap | 12. Rocker arm support |
| 4. Valve spring lower seat | 13. Rocker arm |
| 5. Valve spring | 14. Rocker arm |
| 6. Valve spring upper seat | 15. Adjusting screw |
| 7. Valve stem key | 16. Adjusting screw nut |
| 8. Tappet | 17. Support bolt |
| 9. Push rod | 18. Rocker arm shaft |

Fig. 3-2-3 Valve system

CONSTRUCTION

1. Combustion Chamber

The combustion chamber is of a toroidal-type with a direct injection system.

With the nozzle holder near the center of the piston, the combustion chamber shows excellent combustion with improved intake distribution and efficiency through a special shaped intake port.

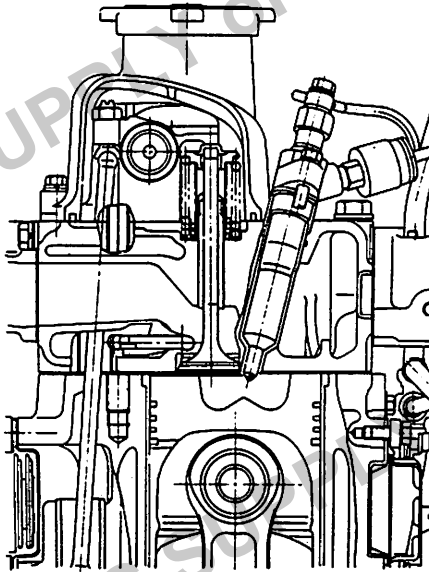


Fig. 3-2-4 Sectional view of cylinder head

2. Cylinder Head

- (1) The highly rigid, 6-cylinder, one-piece, special cast iron cylinder head has a cross-flow system in which the intake and exhaust valves are alternated in a slightly ZIG ZAG pattern.
- (2) The intake port is a special shape that produces optimum swirl in the cylinder providing excellent combustion qualities. To extend the lifetime of the cylinder head, inserts are used for both of the intake and exhaust valve seats, and water jet nozzles inside the water jacket force-cool the cylinder head wall surrounding the valves. See Fig. 3-2-6.

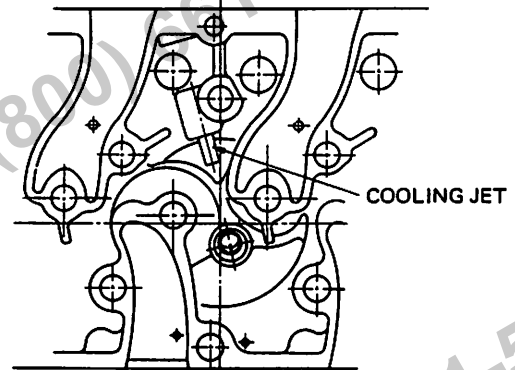


Fig. 3-2-5 Arrangement of cylinder head ports

- (3) The nozzle holder is housed in a copper sleeve (nozzle seat) which is caulked into the cylinder head. This is cooled by a water jet which directs a stream of coolant directly on the sleeve and the cylinder head wall between the intake and exhaust valves. Six cylinder head bolts of 14 mm dia. are arranged around each cylinder (26 bolts in total), and another six head bolts of 10 mm dia. on the tappet side, providing the tight fit of cylinder head gasket which ensure oil, air, and gas seal integrity.

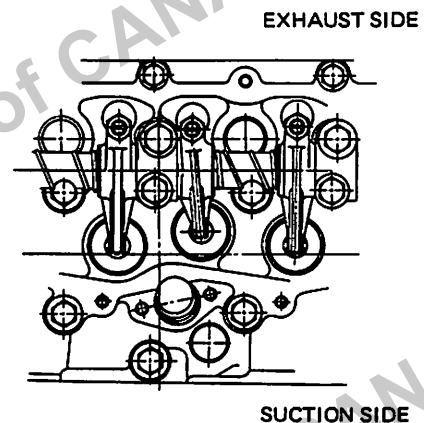


Fig. 3-2-6 Arrangement of head bolts

- (4) The gasket core is covered with rubber asbestos, and exterior of the combustion chamber has grommets stainless steel seal rings for a reliable gas seal. Silicon-rubber O-rings around the water ports and silicon-rubber sheets around the remaining holes

give tight seals in these places.

As cylinder head gaskets after engine life, **use only genuine Hino gaskets**. The use of non-Hino gaskets may cause engine damage.

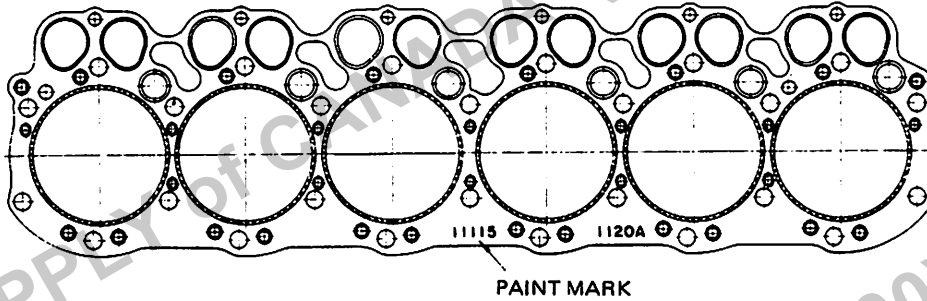


Fig. 3-2-7 Cylinder head gasket

3. Valve System

- (1) The push rod is solid, and the rocker arm shaft is hollow and one piece. The rocker arm shaft has six rocker arm supports. The four center supports are identical but the two end supports are a special configuration which incorporates an additional support arm.
- (2) A special steel stem cap on top of the valve stem virtually eliminates any problems with wear.
- (3) The oil channel through to the top of the rocker arm assures a stable and reliable supply of oil. On the push rod side, the oil channels in the push rod are so designed as to pull oil from the rocker arm shaft oil channels on the up-stroke only, thus providing the push rod with exactly the proper oil supply.

Intake and exhaust valves stem seals deliver an adequate quantity of oil to the sliding surfaces of the valves and the valve guides.

- (4) The rocker arms are special forged steel. Their length is different for the intake and exhaust valves. The surface hardened carbon steel rocker arm shaft is supported with six rocker arm supports. The No.1 support has an oil channel.

Oil seal fed under pressure through the main hole → No.1 cam journal → cylinder head → No.1 rocker arm support, to lubricate each rocker arm evenly and properly, oil also goes to each rocker arm bushing through the oil channel inside of the rocker arm shaft, lubricating the push rods and each valve as well.

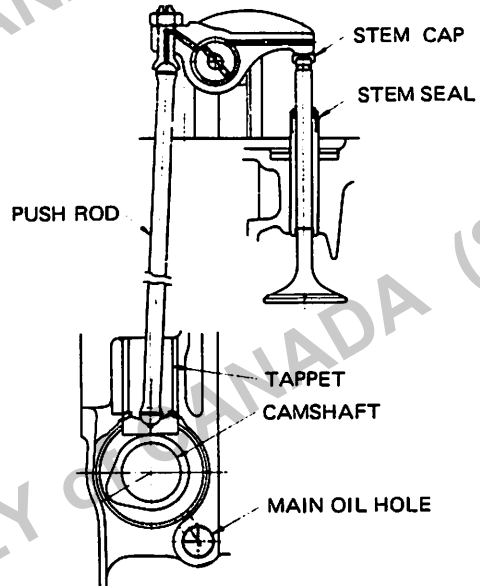


Fig. 3-2-8 Oil supply to rocker arm

OVERHAUL

DISASSEMBLY

Disassembly of Rocker Arm Assembly

- (1) Remove the breather pipe clip.
- (2) Loosen the rocker arm cover clamping bolts, then remove the rocker arm cover.

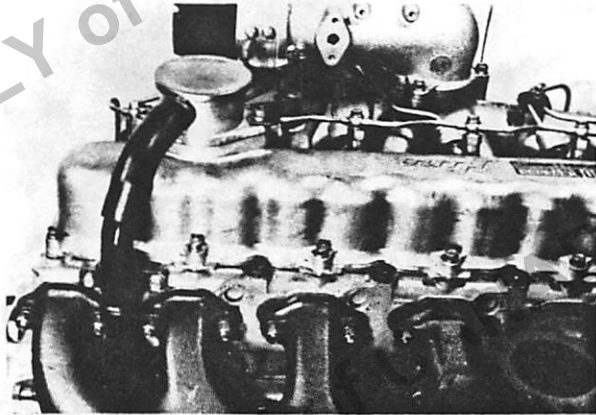


Fig. 3-2-9 Removing breather pipe

03-0614

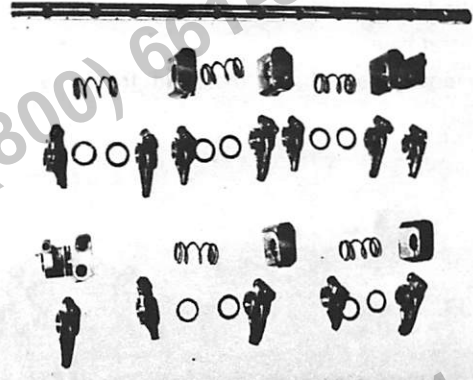


Fig. 3-2-11 Disassembled rocker arm

KT3-200

- (3) Loosen the rocker arm supports bolts, and the head bolts from both sides, then remove the rocker arm assembly.
- (4) Remove the push rod
- (5) Remove the valve stem cap
- (6) To disassemble the rocker arm assembly, loosen the rocker support bolts, and remove the rocker supports, plain washers springs, spacers, rocker arms, etc.

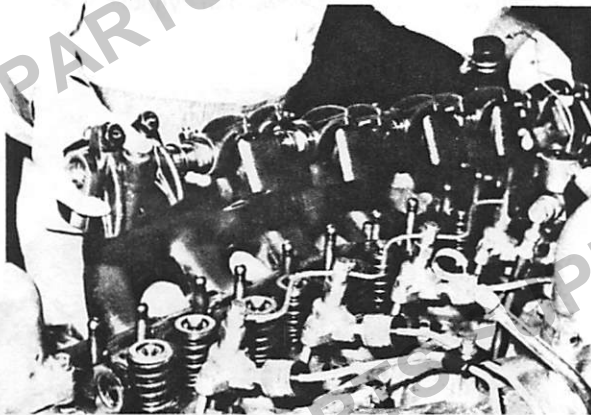


Fig. 3-2-10 Removing rocker arm assembly

KT3-199

NOTE:

To avoid a difference in the clearance when reassembling the rocker arm shafts and the rocker arms, mark each rocker arm with a number or arrange them in installation sequence.

Note that the length of the rocker arms for intake and exhaust are different.

NOZZLE HOLDER REMOVAL

Remove dirt, dust and other foreign matter from the area surrounding the nozzle holder before removal.

- (1) Remove the fuel injection pipe and leakage pipe from each cylinder.
- (2) Remove the bolts from the nozzle holder. Be sure to use sliding hammer (special tool 09420-1441) to remove the nozzle holder.



Fig. 3-2-12 Removing nozzle holder

CYLINDER HEAD REMOVAL

Open the drain cock located in the left rear of the cylinder block and drain the coolant from the engine before removing the cylinder head.

- (1) Loosen the hoseclip between coolant pump through thermostat case.

3-18 ENGINE

- (2) Loosen the thermostat case clamping bolts for cylinder head front side, then remove the thermostat case.
- (3) Remove the exhaust manifold from the cylinder head.

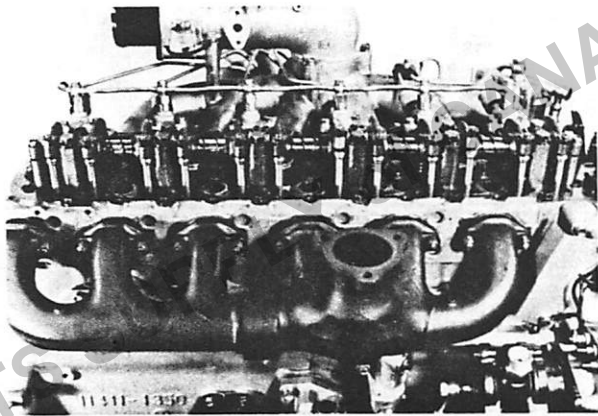


Fig. 3-2-13 Removing exhaust manifold

03-0615

- (4) Remove the coolant pipe connecting between the cylinder head and the oil cooler.
- (5) Remove the oil level gauge.
- (6) Disconnect the fuel hose from the fuel filter.
- (7) Remove the link rod connecting the accelerator lever and the intake shutter of the fuel injection pump.
- (8) Remove the intake manifold.
- (9) Remove the cylinder head bolts, then remove the cylinder head assembly.

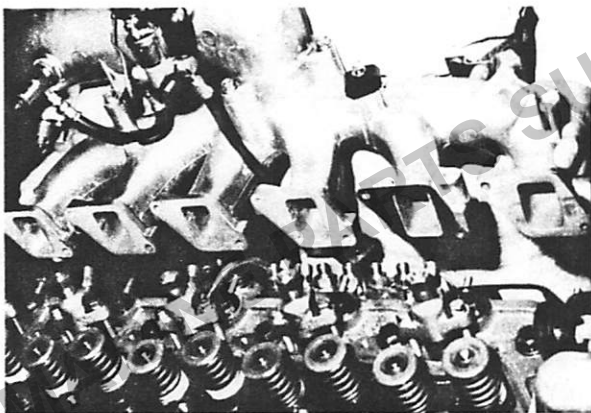


Fig. 3-2-14 Removing intake manifold

KT3-202

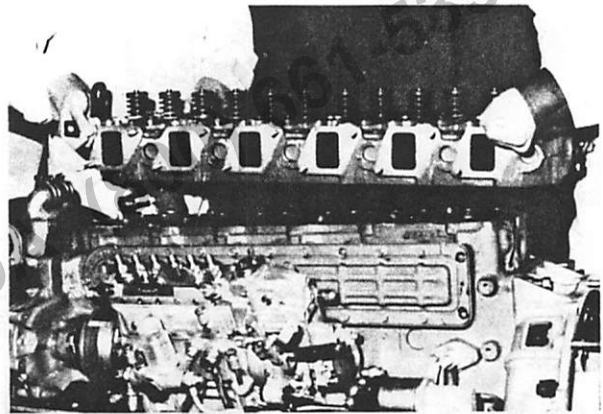


Fig. 3-2-15 Removing cylinder head

KT3-203

NOTE:

1. When removing the cylinder head gasket, take care not to scratch the cylinder block.
2. When handling the disassembled cylinder head, take care not to scratch the copper sleeve that projects beyond the cylinder head upper surface.

Disassembly Valve System

- (1) Compress the valve springs with a valve spring press (special tool 09470-1021) to remove the valve stem keys. Then remove the upper seats of valve spring, valve springs and lower seats of valve spring, from the top of the cylinder head.
- (2) Remove the valves downward of cylinder head.

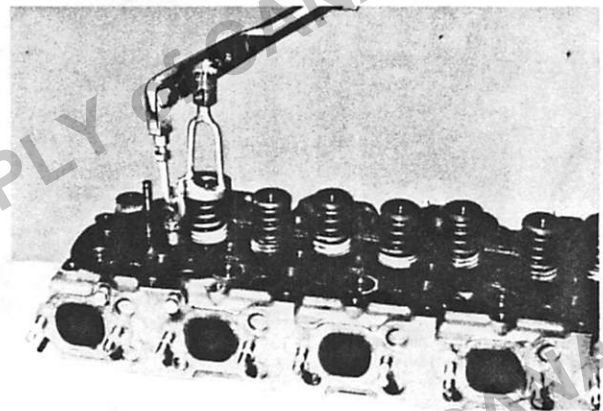


Fig. 3-2-16 Removing valve spring

KT3-204

NOTE:

1. Mark the removed valves with numbers, or arrange them in installation sequence so as to save the lapping work against the seats when reassembling.
2. Measure the valve guides and seats for wear while still in the cylinder head. Do not remove them from the cylinder head unless they must be replaced.

INSPECTION, MEASUREMENT AND REPAIR

Inspection of Rocker Arm and Rocker Arm Shaft

- (1) Inspect the rocker arm valve stem contact surfaces for wear. Replace the rocker arm if excessively worn, if slightly uneven wear is visible, reface the rocker arm using a valve refacer.
- (2) Measure the inside diameter of rocker arm bushing with a cylinder gauge. If it exceeds the limit replace the bushing.

Rocker arm bushing I.D. Unit: mm (in)

Standard	Serviceable limit
24.2 (0.9527)	+0.08 (+0.0031)

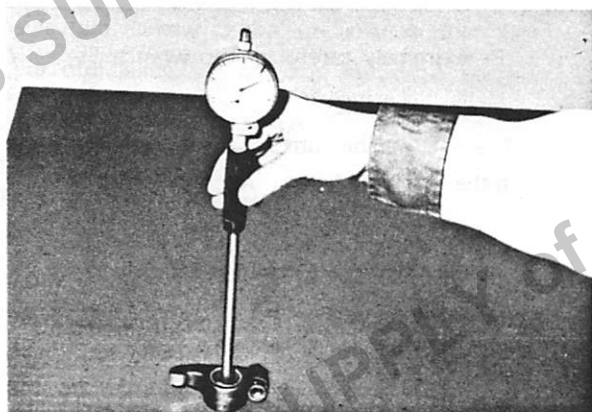


Fig. 3-2-17 Measuring rocker arm bushing I.D. KT3-205

When inserting bushing in rocker arm, align the rocker arm oil hole with that of the bushing.

- (3) Measure the outside of rocker arm shaft with a micrometer. If it exceeds the serviceable limit replace it.

Rocker arm shaft O.D. Unit: mm(in)

Standard	Serviceable limit
24.2 (0.9527)	-0.08 (-0.0031)

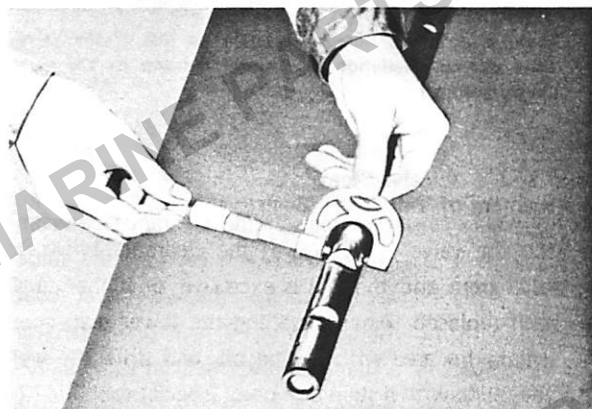


Fig. 3-2-18 Measuring rocker arm shaft O.D. KT3-206

- (4) Calculate the clearance between rocker arm bushing and rocker arm shaft from the difference between the bushing inside diameter and the shaft outside diameter. If the clearance exceeds the serviceable limit, replace either the bushing or the shaft.

Clearance between rocker arm and shaft

Unit: mm (in)

Standard	Serviceable limit
0.020 – 0.062 (0.0008 – 0.0024)	0.15 (0.006)

Inspection of Adjusting Screws, Tappets and Push Rods

- (1) If the contact surface of the adjusting screw is extremely worn, or if the threads are damaged replace the adjusting screw.
- (2) Bent of push rod
Roll the push rod along a level surface and insert a thickness gauge to check for bent. The limit on push-rod deflection is 0.5 mm (0.0196 in).

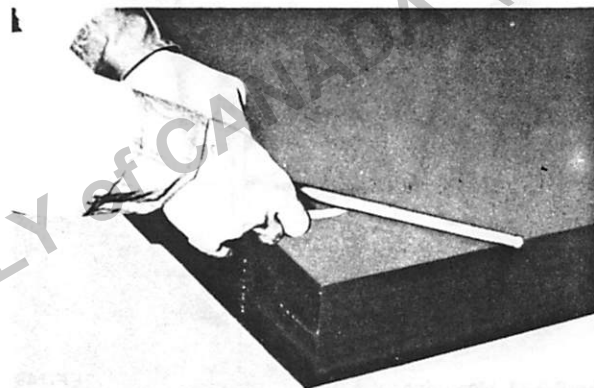


Fig. 3-2-19 Inspecting the push rod bent KT3-207

3-20 ENGINE

Wear of tappet

If the clearance between tappet outside diameter and tappet hole of cylinder block exceeds 0.1 mm (0.0039 in), replace.

Standard tappet outside diameter is 32 mm (1.260 in).

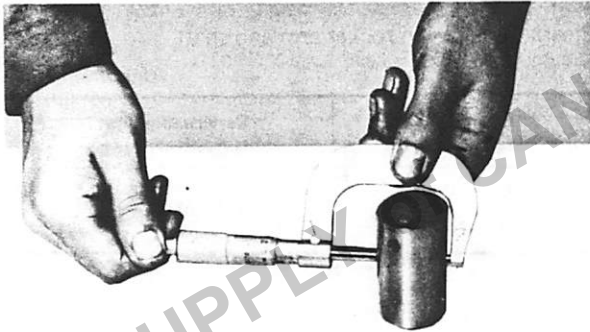


Fig. 3-2-20 Measuring tappet O.D.

KT3-208

Inspection of Valves, Valve Guides and Valve Seats

- (1) Check the intake and exhaust valves for carbon deposits, burn out, contact surface wear, and cracks on the bevel area and stem head.

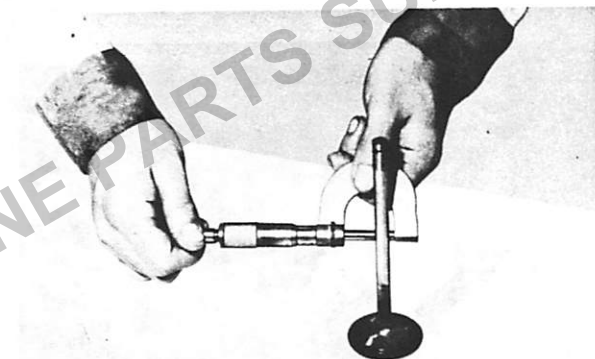


Fig. 3-2-21 Measuring valve stem

EF-149

- (2) Measure the outside diameter of the valve stem and the inside diameter of the valve guide.

- 1) Measure with a micrometer and a cylinder gauge. Calculate the clearance between the valve stem and the valve guide from the difference between the diameters. If each measurement point (A, B or C in Fig. 3-2-22) exceeds the serviceable limit, replace either the valve guide or the valve.

Valve stem O.D.

Unit: mm (in)

	Standard	Serviceable limit
Intake	9 (0.354)	8.88 (0.349)
Exhaust	9 (0.354)	8.88 (0.349)

Clearance between stem and guide

Unit: mm (in)

	Standard	Serviceable limit		
		A	B	C
Intake	0.055 – 0.088 (0.00217 – 0.00346)	0.10 (0.0040)	0.10 (0.0040)	0.18 (0.0071)
Exhaust	0.070 – 0.103 (0.00276 – 0.00406)	0.12 (0.0047)	0.12 (0.0047)	0.2 (0.0079)

Be extremely careful not to wrench the valve guide tip when inserting the guide into the cylinder head.

The valve guides projections are as illustrated in the following figure.

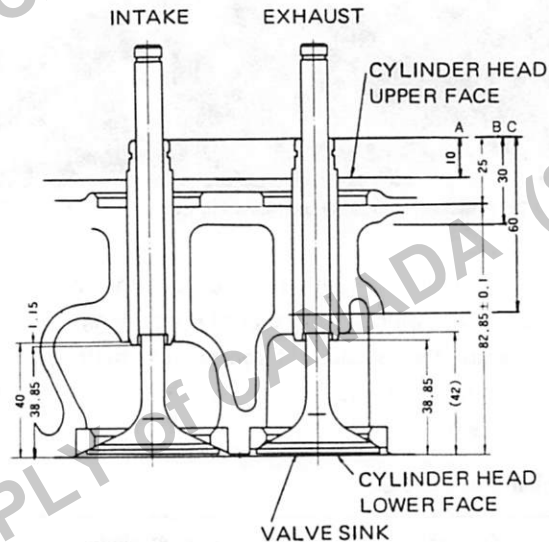


Fig. 3-2-22 Projecting dimension of valve guides

NOTE:

Take utmost care not to damage the top of the valve guides during installation.

Replacement of Valve Stem Seals

Replace the valve stem seals if the clearance between the valve stem and the seal is excessive, or if the guide has been replaced. After installing the lower seat, coat the sealing lip area with engine oil, and drive the seal into the guide with a stem seal press (special tool 09472-1200).

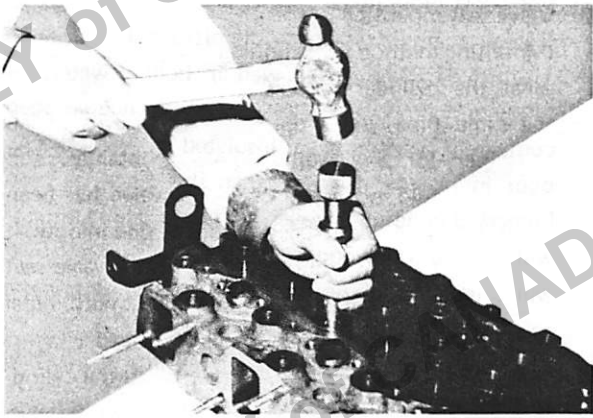


Fig. 3-2-23 Installing valve stem seal KT3-209

Apply the contact surfaces of the valve with red lead. Check the contact surfaces for contacting condition by tapping the valve vertically while turning it with a valve lapping tool (09431-1010).

Standard valve seat angle

	Standard
Intake	30°
Exhaust	45°

Standard valve face angle

	Standard
Intake	30°
Exhaust	45°

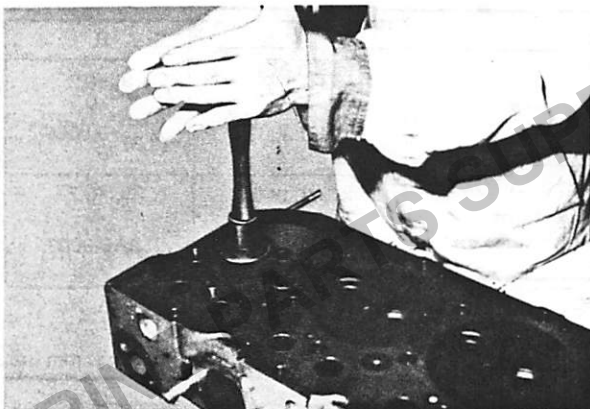


Fig. 3-2-24 Checking for valve contact KT3-210

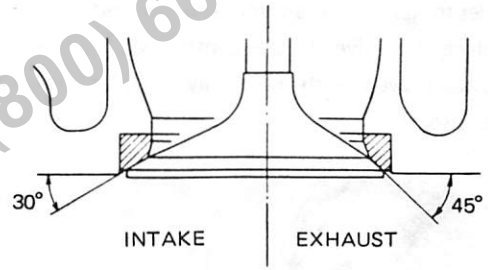


Fig. 3-2-25 Valve seat angle

- (1) If the contact surface of the valve seat is not evenly coated with red lead, correct the valve seat with a cutter.
- (2) When the valve seat has been corrected, replace the valve or reface the contact surface of valve using a valve refacer.

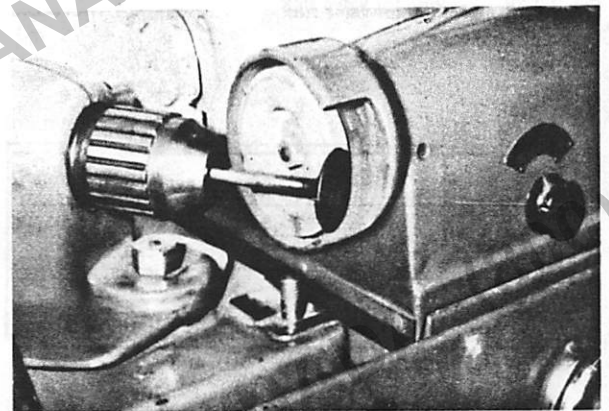


Fig. 3-2-26 Correcting valve face angle EF-148

- (3) After correction, be sure to fit the contact surface and recheck for proper contact.
- (4) Correct any flaws, dents, and other defects on the contact surface with a valve refacer.

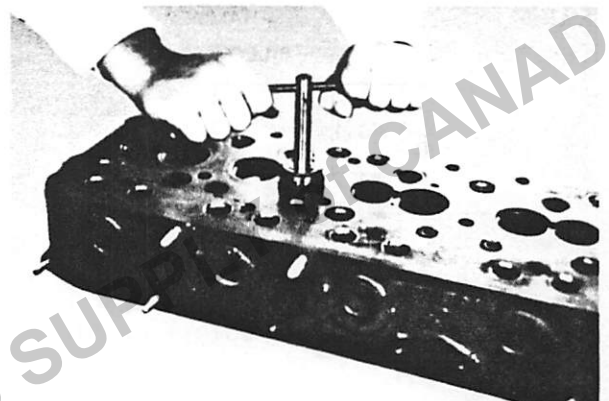


Fig. 3-2-27 Correcting valve seat KM-014

- (5) Measure the sink of the valve below the cylinder head with a straight edge and a thickness gauge or a depth gauge. When the sink exceeds the limit, replace the valve. If the depth does not reach the standard even with new valve, replace the valve seat also.

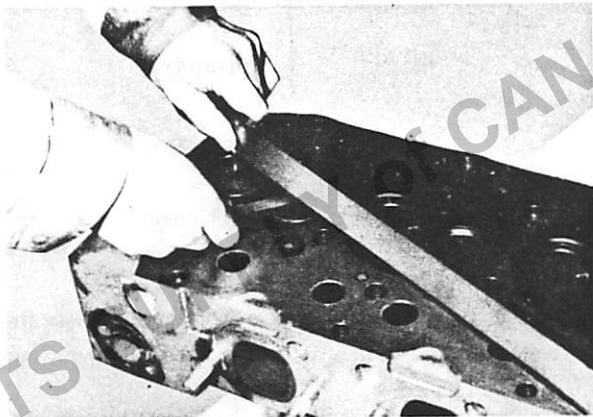


Fig. 3-2-28 Checking for valve sink

KT3-211

Valve sink

Unit: mm (in)

	Standard	Serviceable limit
Intake	+0.25 - -0.25 (+0.0098 - -0.0098)	-0.5 (-0.0197)
Exhaust	+0.25 - -0.25 (+0.0098 - -0.0098)	-0.5 (-0.0197)

- (6) To replace valve seats, proceed as follows:

1) Valve seat removal

Cut the circumference of a valve at about three places with a grinder for electric welding as illustrated in Fig. 3-2-29. Then drive the valve seat out with a hammer and a pillow block.

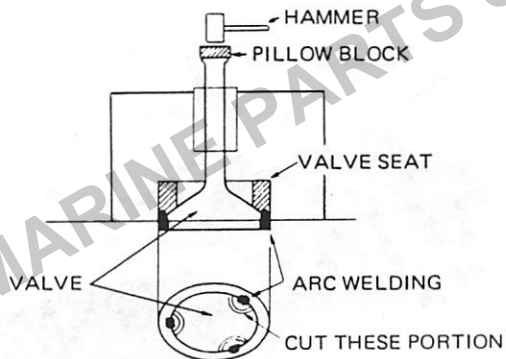


Fig. 3-2-29 Removing valve seat

2) Valve seat mounting

(Mounting method using liquid nitrogen)

Heat the cylinder head well in boiling water. At the same time, place the valve seat in a wooden container (or any well insulated container) and pour in liquid nitrogen. When the valve has been immersed in liquid nitrogen for about one minute, it will be cooled to about -196°C , and the valve seat will contract. Pick up the cold valve seat with metal tongs and insert in the heated cylinder head.

The valve seat can easily be tapped into the cylinder head.

(7) Valve seat section machining specifications

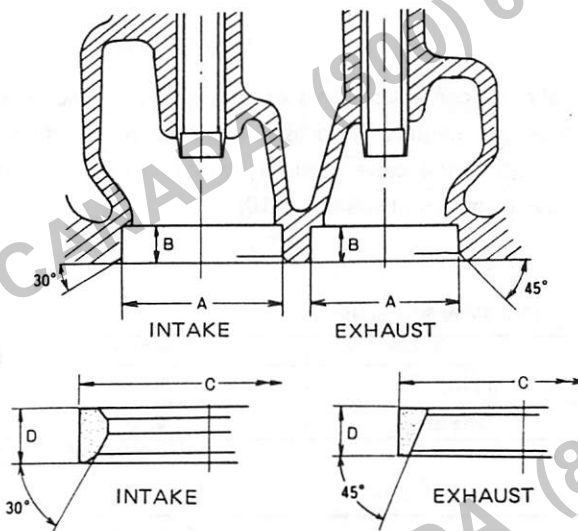


Fig. 3-2-30 Machining dimension for head and seat

Cylinder head dimension

Unit: mm (in)

	A	B
Intake	52 ^{-0.019} ₀ (2.05 ^{-0.0007} ₀)	9.5 ^{+0.2} ₀ (0.37 ^{+0.0008} ₀)
Exhaust	45.5 ^{+0.016} ₀ (1.79 ^{+0.0006} ₀)	9.5 ^{+0.2} ₀ (0.37 ^{+0.0008} ₀)

Valve seat dimension

Unit: mm (in)

	C	D
Intake	52 ^{+0.100} ^{+0.085} (2.05 ^{+0.004} ^{+0.003})	7.5 ^{+0.2} ₀ (0.30 ^{+0.008} ₀)
Exhaust	45.5 ^{+0.145} ^{+0.130} (1.79 ^{+0.006} ^{+0.005})	8.0 ^{+0.2} ₀ (0.31 ^{+0.008} ₀)

Check of the valve spring

(1) Valve spring

Measure the free length and loaded valve of the springs with a spring tester. (Refer to Fig. 3-2-31). The free length may also be measured with calipers. If the spring is less than 62 mm (2.44 in) respectively, the springs should be replaced. Check the alignment of the spring by placing on an even surface and using a straight edge along the side of the spring. (Refer to Fig. 3-2-32).

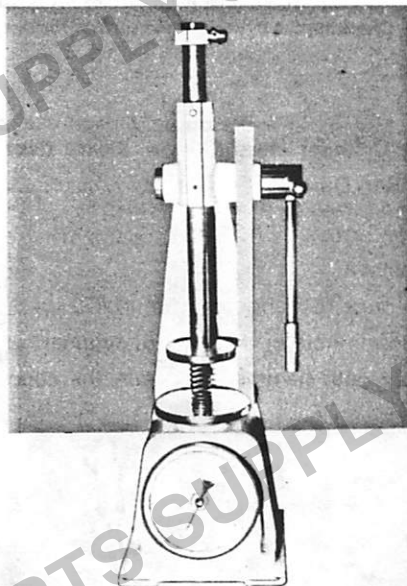


Fig. 3-2-31 Measuring the loaded spring length KT3-212

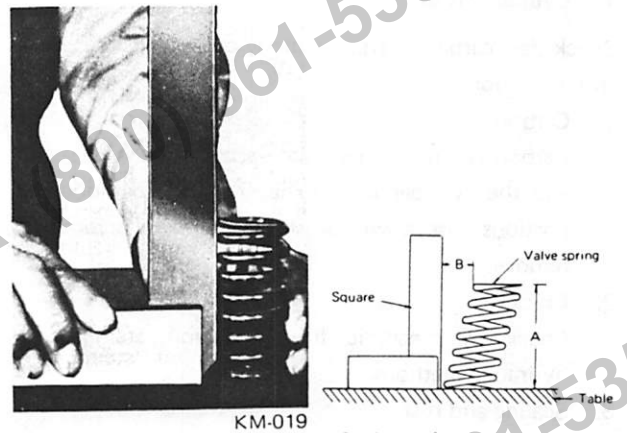


Fig. 3-2-32 Measuring straightness of valve spring KM-019

(3) Check the upper and lower valve spring seats. If excessively worn, replace them.

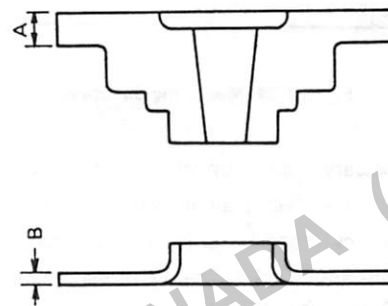


Fig. 3-2-33 Valve spring seats

Spring force

	Mounting height mm (in)	Spring force kg (lb)	
		Standard	Limit
Valve spring	52 (2.0472)	28.4 (62.59)	26.5 (58.41)

(2) Measure the straightness of a valve spring on a flat base with a square.

If it exceeds 1.5 mm (0.059 in) replace.

Unit: mm (in)

Portion	Standard Dimension
A	3.0 (0.118)
B	1.0 (0.039)

1. Cylinder Head

Check for carbon contamination, cracks, scaling, rust, and deflection.

1. Carbon
Carbon is apt to accumulate around the valve seats, and the cylinder head exhaust manifold mounting portions. Use a wire brush or soft metal scraper to remove.
2. Cracks
Check by magnetic flaw detection, staining, or hydraulic methods.
3. Scaling and rust
If excessive scaling or rust is existed, cooling efficiency and cylinder strength may be decreased. Clean with detergent.

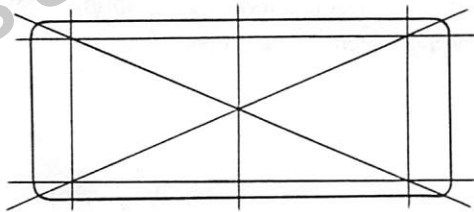


Fig. 3-2-34 Measuring direction

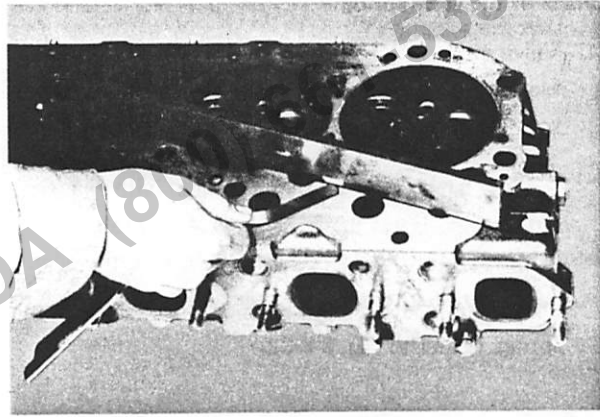
4. If necessary, shut up the water passage in the cylinder head, send air into it from one port, then put the cylinder head in a water tank to see if there are any cracks. The air pressure should be 2.5 kg/cm² (35.53 lb/sq.in).
5. Distortion
Check the head for distortion along the bottom face with a straight edge and thickness gauge if the distortion exceeds the repair limit, correct with a suitable surface grinder. Measurements should be made along the sides and across the corners as shown in Fig. 3-2-35 below. When a head has been ground down on previous occasions so that there is insufficient metal for another grind, replace the head with a new one.

Surface distortion

Standard	Serviceable limit
0.05 (0.0020)	0.10 (0.0039)

Head thickness

Standard	Serviceable limit
95 ± 0.1 (3.74 ± 0.0039)	0.30 (0.0118)



KT3-213

Fig. 3-2-35 Checking the cylinder head surface for distortion

Mounting Cylinder Head Copper Sleeve (Nozzle Seat) and Push Rod Guide

1. Nozzle Seat
(1) To remove
Place brass rod about 12mm (0.472 in) dia. against the nozzle hole at the back of cylinder head. Strike sharply with hammer to loosen the copper sleeve.

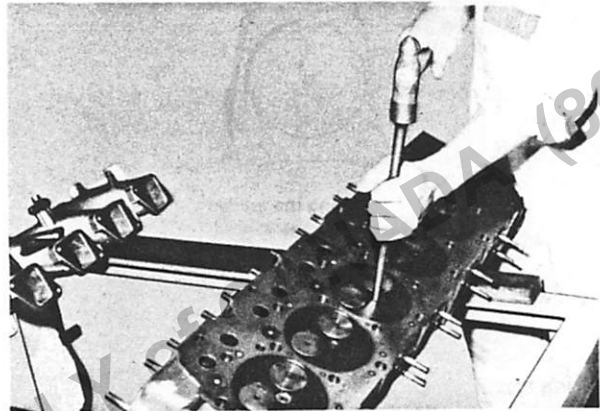


Fig. 3-2-36 Removing the nozzle seat

KT3-214

- (2) To mount
 - 1) Apply adhesive (Super Three Bond No. 1210) to the lower part of new copper sleeve.
 - 2) Set O-ring into cylinder head and carefully fit in new sleeve.
 - 3) Press the sleeve against cylinder head with until properly seated, using the sleeve bar (09472-1210).
 - 4) Insert a 9.5±0.5 mm (0.394±0.00197 in) diameter steel ball (9800-06100) into the sleeve. Push the pin with the sleeve bar (09472-1210) so that the power part of sleeve will jam against the cylinder head.

- 5) Machine the lower part of nozzle sleeve to 120° .

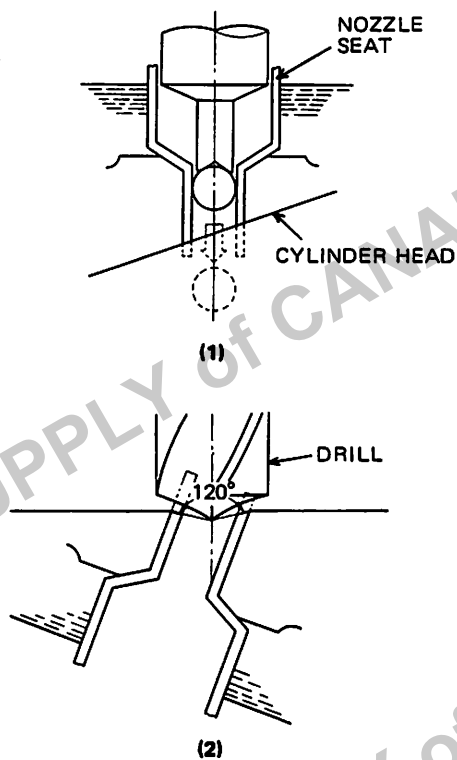


Fig. 3-2-37 Mounting the nozzle seat

2. Push rod guide

(1) Removing the old guide pipe

Pick the caulked part of the guide pipe at both upper and lower sides by a driver carefully so that you do not damage the guide pipe. Then take out the guide pipe. And also, be careful not to remain the tip-flakes in the cylinder head.

(2) Fitting the new guide pipe

Clean off any dirt and dust from the caulking part of the cylinder head at both upper and lower and apply "Three bond No. 1215" or equivalent to it sufficiently.

To prevent the pipe from projecting out of the lower surface, put the cylinder head on such a flat and smooth face as the flat base, facing the upper side upwards. Insert the new clean guide pipe into the hole until the guide pipe lower end face and cylinder head lower surface become a smooth flat.

(3) Caulking the guide pipe

Insert the special tool (09482-1320) and hit in it until the grooved part in the special tool goes down below the guide pipe upper end face. Then push out the special tool by hitting in pin from the lower side of the cylinder head. And vice versa.

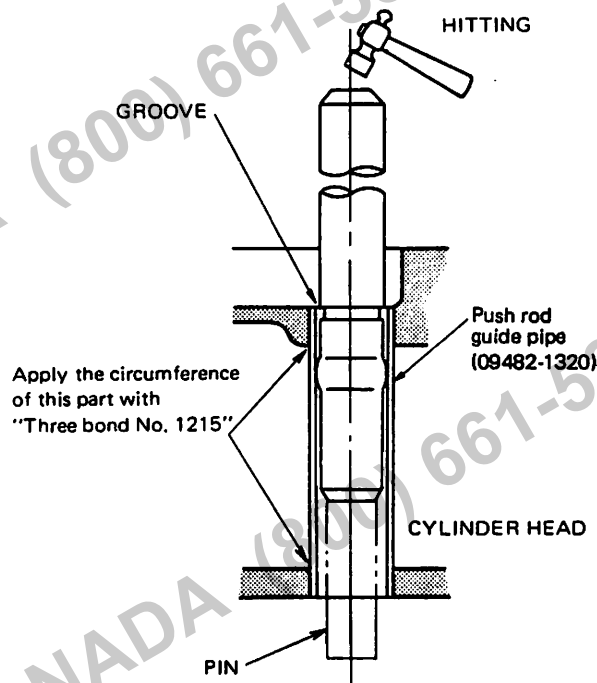


Fig. 3-2-38 Mounting guide pipe

(4) Checking

Finally check the sealing efficiency.

3. To assemble and adjust

To assemble valve system

- (1) Insert intake and exhaust valves from the bottom of cylinder head. Insert the valve spring, and upper spring seat, in that order. Finally, fit valve stem key securely to upper spring seat with valve spring press (09470-1021).

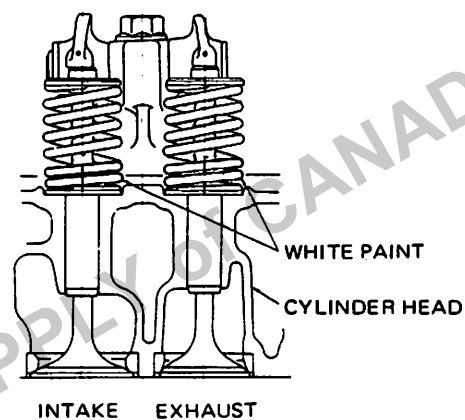


Fig. 3-2-39 Fitting valve spring

3-26 ENGINE

NOTE:

1. Apply engine oil to valve stem before inserting it in valve guide.
 2. To mount outer and inner valve springs, both of which have irregular pitches, see that their white-painted sides are turned down.
 3. Take care in using special tool so that the valve stem seal on the top of the valve guide is not damaged by contact with upper spring seat.
4. To assemble cylinder head

- (1) Clean cylinder block where cylinder head is to be mounted. Place cylinder head gasket on the top of cylinder block following the cylinder head gasket guiding boss.

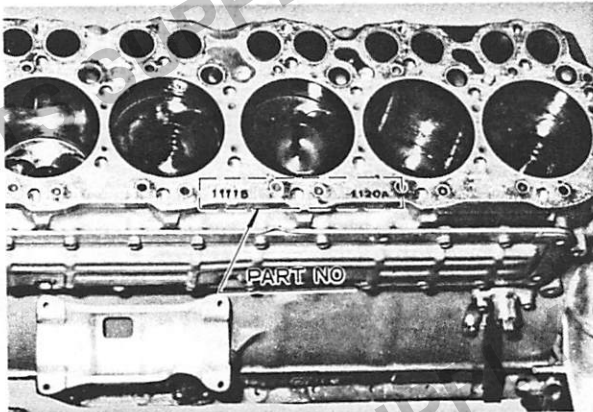


Fig. 3-2-40 Ensuring part number

KT3-215

NOTE:

1. Be sure not to use an old cylinder head gasket. This is necessary to prevent gas leakage.
 2. Mount cylinder head gasket with the side stamped part No.(11115-1121) upwards. (see Fig. 3-2-40). Gasket should be kept free from oil or water.
- (2) Place cylinder head on the head gasket.
- (3) Insert tappet.
- (4) Insert the push rod, after applying oil to both ends.
- (5) Make sure that both top end of valve and inside of valve stem cap are free from dust. Apply oil to the surface of valve head to insert in valve stem cap, taking care not to let the cap fall into the engine.
- (6) Apply oil to the end of rocker arm and the surface of the adjusting screw.
- (7) Make sure the No.1 rocker support has an oil inlet port on the bottom, and that the upper surface of rocker-arm shaft between No.3 and No.4 cylinders is marked "UP."

This is necessary to avoid incorrect assembly which results in the valve system seizing up.

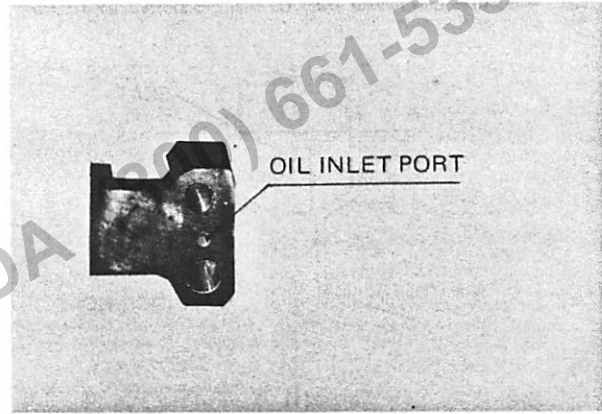


Fig. 3-2-42 Oil inlet port on the bottom of No.1 support

KT3-216

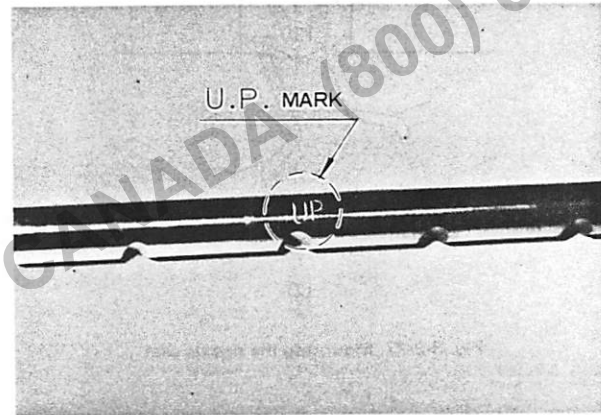


Fig. 3-2-43 Up mark on rocker arm shaft

KT3-217

- (8) Make sure the top surface of cylinder head and the bottom of rocker support are free from dust, chips, and other foreign matter. Then set the rocker-arm assembly.
- (9) Make sure that the push rod interlocks with adjusting screw. Then screw in all six rocker support bolts two or three threads by hand to fix their position. Then, tighten them in No. 3, 4, 2, 5, 1 and 6 sequence (see Fig. 3-2-44).

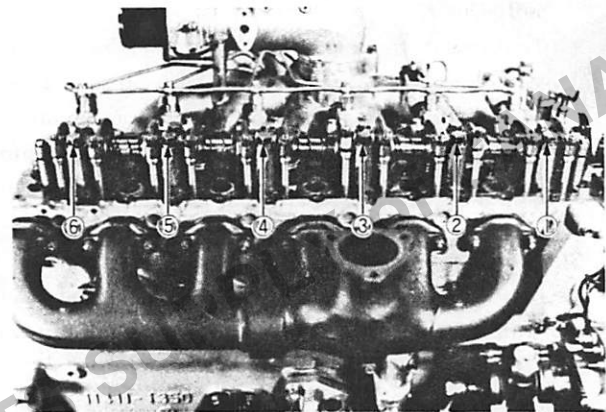


Fig. 3-2-44 Rocker arm tightening sequence

03-0615

Tightening torque:

Unit: kg.cm (lb.ft.)

Rocker arm support bolt	700 – 800 (51 – 58)
-------------------------	---------------------

NOTE:

Head bolt and support bolt have the same flats so be sure to tighten them with respective correct tightening torque.

10. Apply engine oil to the cylinder head bolts (26 pcs of 14 mm dia.) and additional cylinder head bolts (6 pcs of 10 mm dia.) Screw in these bolts with hand. After that tighten them with correct tightening sequence and torques.

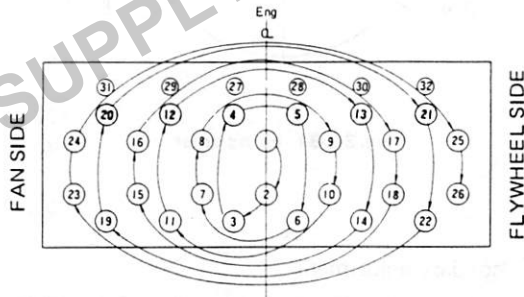


Fig. 3-2-45 Cylinder head bolt tightening sequence

Tightening torque

Unit: kg.cm (lb.ft.)

Bolt No.	O.D.	
1 – 26	14 mm	1,800 – 1,900 (131 – 137)
27 – 32	10 mm	650 – 750 (48 – 54)

NOTE:

Rocker arm supports are also tightened by the six cylinder head bolts (Shaded number in Fig. 3-2-45).

(11) Mount nozzle holder

Tightening torque: 130–190 kg.cm (10–13 lb.ft.)

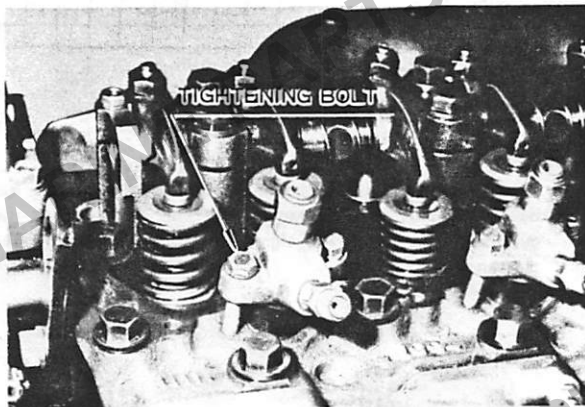


Fig. 3-2-46 Tightening nozzle holder

KT3-219

(12) Retightening cylinder head bolt

After tightening cylinder head bolt to specified torque, run the engine for about thirty minutes at a water temperature of about 80°C. Then loosen cylinder each head bolt 1/8 – 1/4 turn and re-tighten, in sequence, to specified torque.

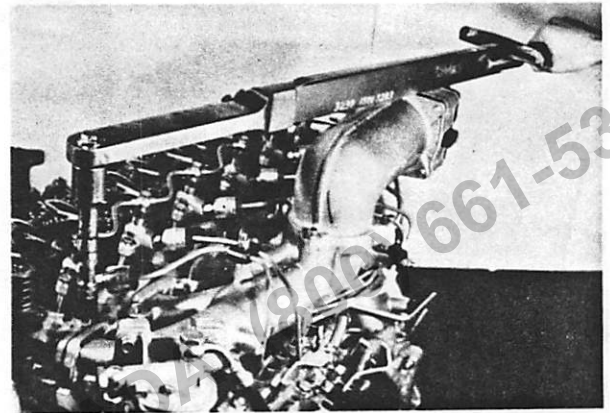


Fig. 3-2-47 Special tool for retightening

03-0616

NOTE:

1. Be sure to loosen one bolt at a time, then retighten it before going on to the next bolt.
2. Retighten the six bolts Nos. 4, 5, 12, 13, 20 and 21 (Fig. 3-2-49) with special socket wrench No. 09839-1701.
3. By retightening, face pressure of cylinder head is restored from point B to C as shown in Fig. 3-2-48.

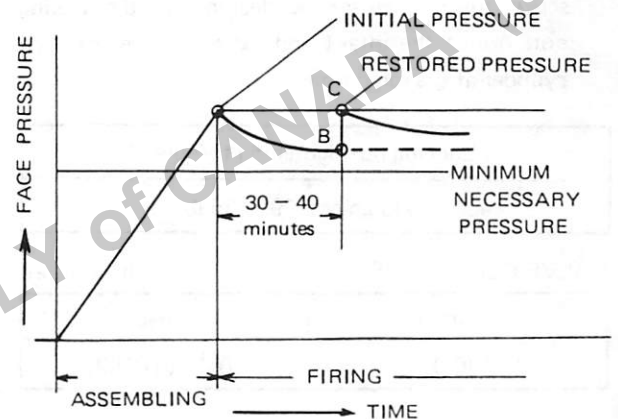


Fig. 3-2-48 Effect of retightening

Mounting intake and exhaust manifold

(1) To mount intake and exhaust manifolds.

Unit: kg.cm (lb.ft.)

Intake manifold	260 – 320 (19 – 23)
Exhaust manifold	300 – 350 (22 – 25)

(2) Assemble all other parts in reverse order of their removal.

Adjusting the valve clearance

1. 6-time adjusting

- (1) Turning the crankshaft, fit the mark "1-6" of the flywheel to the pointer. Then either piston No. 1 or 6 will be top dead center.

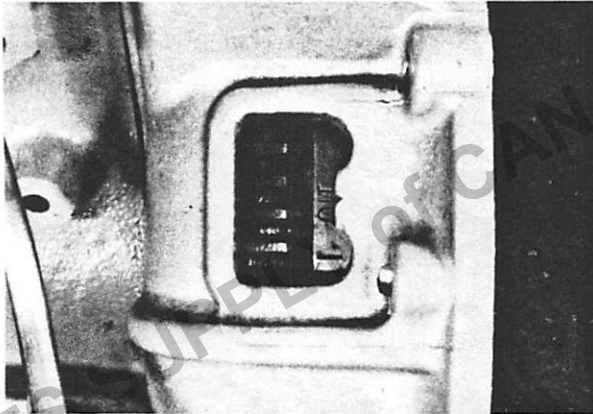


Fig. 3-2-49 Timing mark on flywheel 03-0618

- (2) If there is play in both No.1 intake and exhaust rocker arms, No.1 piston is top dead center in the compression stroke.
 - (3) After positioning the No.1 piston at the top dead center, insert a feeler gauge between the rocker arm and valve stem adjust.
- The clearance by turning the adjuster screw with a screw driver. Then set the clearance by the locking nut. Adjust the intake and exhaust valves of each cylinder at the same time.

Locking nut tightening torque
400 – 500 kg.cm (29 – 36 lb.ft.)

VALVE CLEARANCE Unit: mm (in)

Intake	Exhaust
0.30 (0.0118)	0.40 (0.0159)

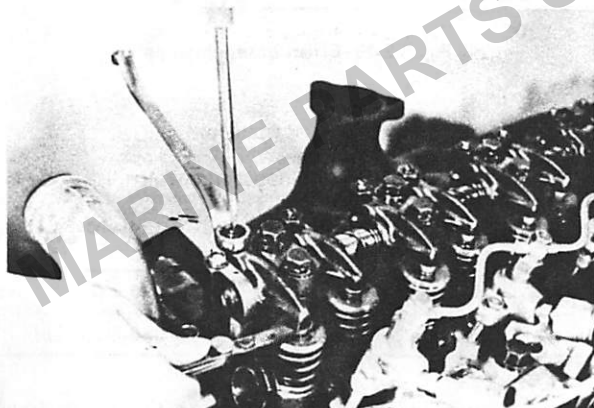


Fig. 3-2-50 Adjusting valve clearance 03-0617

- (4) Turning the crankshaft (crank pulley) clockwise by 120°. Adjust the valve clearance for each cylinder in the firing order (1-4-2-6-3-5), as shown in Fig. 3-2-51.

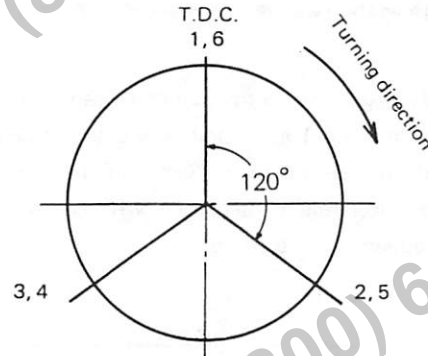


Fig. 3-2-51 Firing order

2. Secondary adjustment

Set No.1 piston to top dead center of the compression stroke as per above. In this position the valve and may be adjusted. Rotate the crankshaft 360° so the piston of the No.6 cylinder will be top dead center, then valves and may be adjusted.

Cylinder No.	1	2	3	4	5	6
Valve arrangement	I E	I E	I E	I E	I E	I E
Clearance can be adjusted at these valves (●) with No.1 piston at T.D.C. on compression stroke	● ●	● ●			● ●	
Clearance can be adjusted at these valves (○) with No.6 piston at T.D.C. on compression stroke		○		○ ○		○ ○ ○

Fig. 3-2-52 Valve arrangement

NOTE:

If cylinder head is retightened after valve clearance has been adjusted. The clearances will change therefore the cylinder head should be tightened before adjusting valve clearance.

2. Adjusting injection timing

- (1) Turn flywheel in the normal direction (counterclockwise).
Stop as 17° mark before No.1 piston reaches TOP Dead Center, and make sure that the inscribed line on the injection pump timer is also aligned with the pointer.

If misaligned, loosen the two coupling bolts, turn timer counterclockwise (in the direction indicated with the arrow) to align the inscribed liner with the pointer. Finally, tighten the bolts. (The injection pump itself turns clockwise).

Injection timing	17° before top dead center
------------------	----------------------------

Tightening torque:	300 – 350 kg-cm (21.7 – 25.3 lb.ft.)
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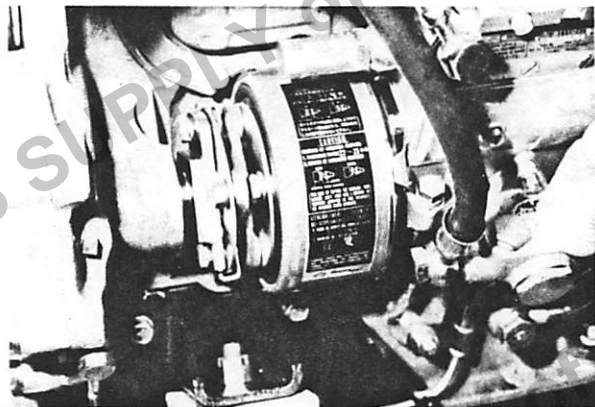


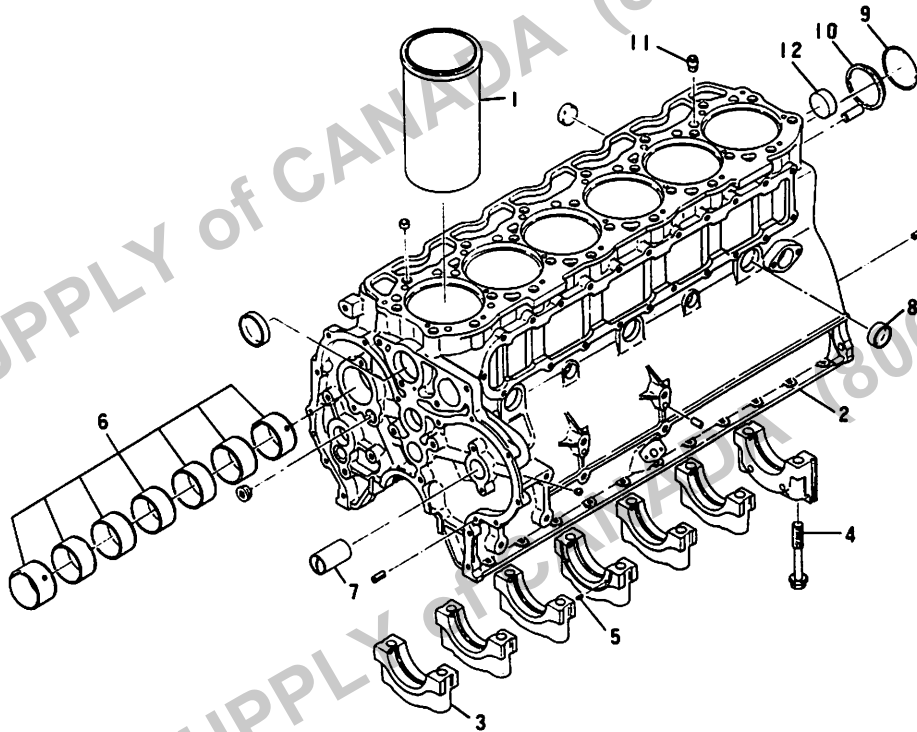
Fig. 3-2-53 Adjusting injection timing KT3-223

MARINE PARTS SUPPLY of CANADA (800) 661-5353

3-3 CYLINDER BLOCK, LINER & CAMSHAFT

DESCRIPTION

1. Cylinder Block and Liner



1. Cylinder liner
2. Cylinder block
3. Bearing cap
4. Bearing cap bolt

5. Straight pin
6. Camshaft bearing
7. Injection pump drive shaft
8. Plug

9. O-ring
10. Sealing plate
11. Straight pin
12. Plug

Fig. 3-3-1 Cylinder block

Cylinder block

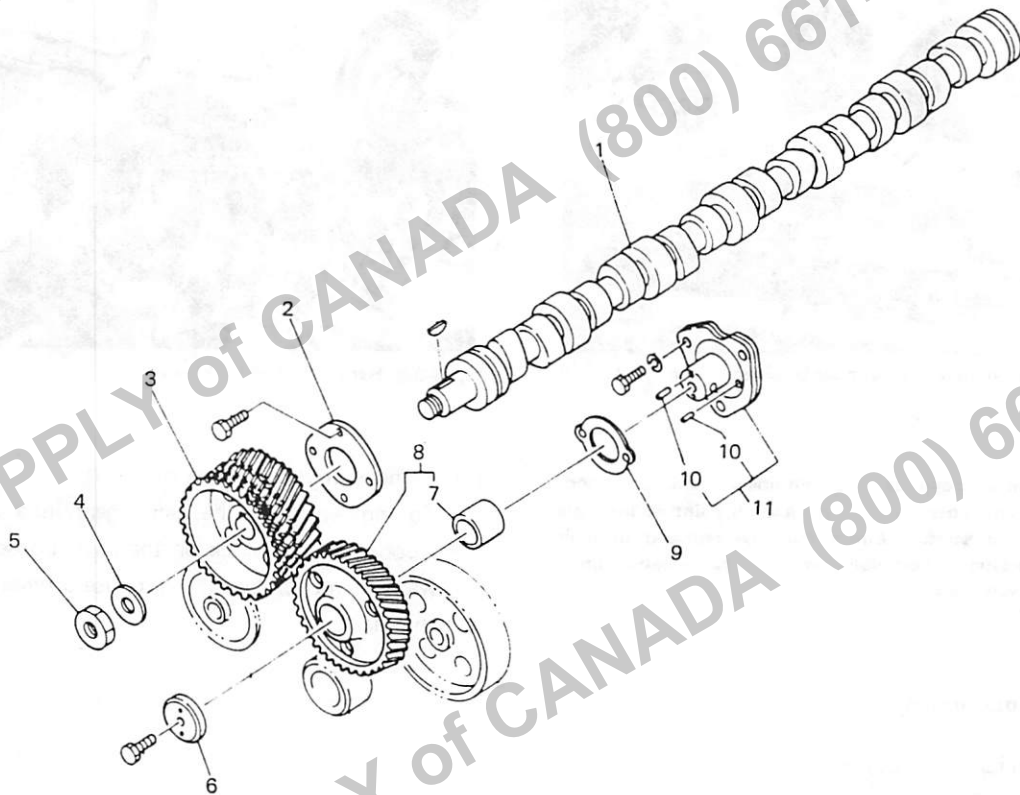
The dry liner-type, special cast iron cylinder block is comparable to the EH100 or EH300 in overall rigidity. Moreover, this block has additional reinforcing around the cylinder walls to further enhance its inherent rigidity.

The cylinder liner is of high tensile cast iron, surface treated inside and out. It is designed to fit the cylinder block perfectly, and sustain the fitness at all times.

Cylinder liner

The dry liner-type special cast iron cylinder liner, is super-precision machined on both inner and outer surfaces. Moreover, it is subjected to heat treatment so the sleeve will fit in with cylinder block with proper clearance.

2. Camshaft



- | | |
|------------------|---------------------|
| 1. Camshaft | 7. Bushing |
| 2. Thrust plate | 8. Idler gear |
| 3. Camshaft gear | 9. Thrust bearing |
| 4. Collar | 10. Pin |
| 5. Nut | 11. Idle gear shaft |
| 6. Thrust plate | |

Fig. 3-3-2 Camshaft

The carbon steel camshaft has seven journals. The surfaces of cam and journal are subjected to induction heat treatment and grinding work. Then they are Parkerized to assure exact fit in low tolerances. The specially curved cam profile improves suction efficiency, and operates quietly.

Removal**1. Removal of cylinder liner**

- (1) Remove cylinder head and related parts.
- (2) Remove cooling fan and pulley.
- (3) Remove timing cover and gear.
- (4) Remove the oil pan and related parts.
- (5) Loosen connecting rod cap bolt and remove piston and connecting rod.

- (6) Withdraw each cylinder liner from cylinder head side with a cylinder liner puller (09420-1210). Number the removed cylinder liners in order and arrange them in clean place.

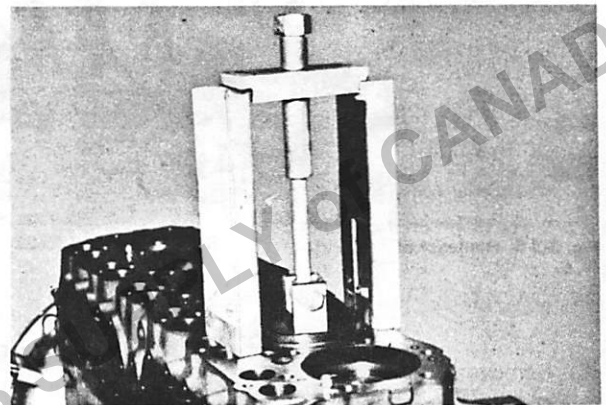


Fig. 3-3-3 Removal of cylinder liner

KT3-224

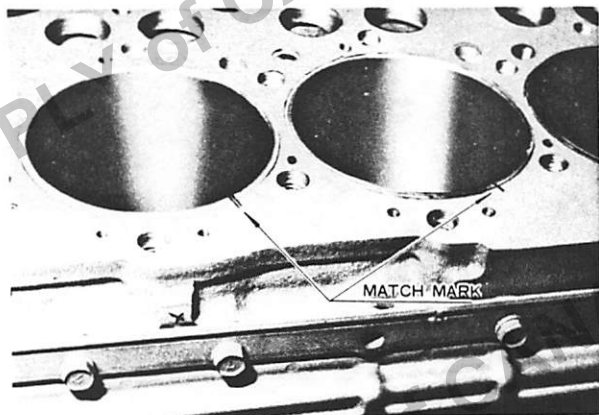


Fig. 3-3-4 Line-up marks on cylinder block and liner KT3-225

NOTE:

Before removing cylinder liner, put line-up marks on cylinder block and liner flange surface with paint or indelible ink. Do not scratch. Liners must be replaced in their original positions. Too much force may cause distortion as liners are very thin.

2. Removal of camshaft

- (1) Remove crankshaft pulley.
- (2) Remove timing gear cover.
- (3) Remove oil slinger.
- (4) Remove fuel injection pump coupling.
Remove the two thrust bearing set bolts and take out pump drive gear and shaft. Use puller or press to remove pump drive gear from shaft.
- (5) Remove the two thrust bearing set bolts and take out camshaft assembly.

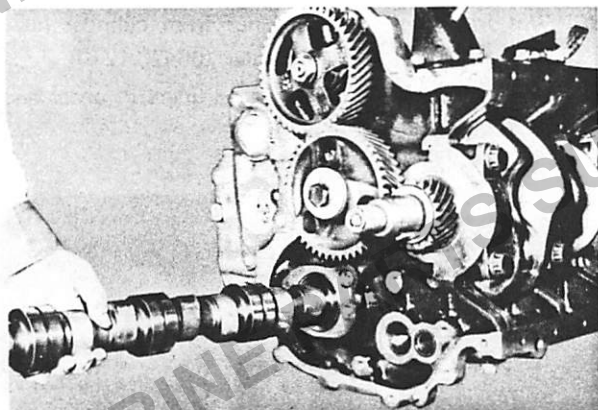


Fig. 3-3-5 Removal of camshaft KT3-226

- (6) Remove the two set bolts to take out idle gear. Remove flange set bolts and take out idle gear shaft with a sliding hammer.



Fig. 3-3-6 Removal of idle gear shaft KT3-229

- (7) Remove drive gear from camshaft
To remove, put the cam gear in a vise with a wooden pillow block on the jaws. Loosen the lock washer and remove the nut. Use a press to remove the gear.

INSPECTION AND REPAIR

1. Cylinder Block

1. Visually inspect the cylinder block for cracks and check the condition of the bores (into which the liners are fitted). Visually inspect the cylinder head, timing gear case, and flywheel housing for damage, examining the locating pins for galling or distortion and the screw threads for stripping.
2. If a crack is found, determine whether it can be repaired or not. A minor crack can be repaired satisfactorily by manual-arc welding, patching or caulking. Use a low-temperature welding electrode when welding and lead wire as filler when patching or caulking.
3. Check the warpage along the top face of cylinder block with a straight edge and feeler gauge. The measurements should be made along the sides and across the corners of the cylinder block. Slight or minor distortion can be corrected by grinding with a suitable grinder.
When a block is distorted so badly there is insufficient metal to grind, replace the block.
Surface distortion

Standard	0.05 mm (0.00197 in)
Repair limit	0.10 mm (0.00394 in)

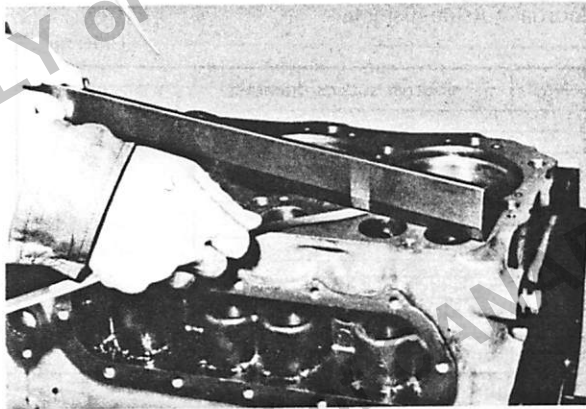


Fig. 3-3-7 Checking cylinder block for flatness KT3-227

2. Cylinder Liner

1. Check for interior wear, stains, deformation ridges, cracks, scaling and rust.
2. Use a cylinder gauge to measure cylinder liner wear. Measure inside diameter of the liner. At each point of measurement take two measurements at right angle with each other. The standard inside diameter of the cylinder liner is 110 mm (4.331 in). Replace the liner if worn more than 0.15 mm(0.0059 in).

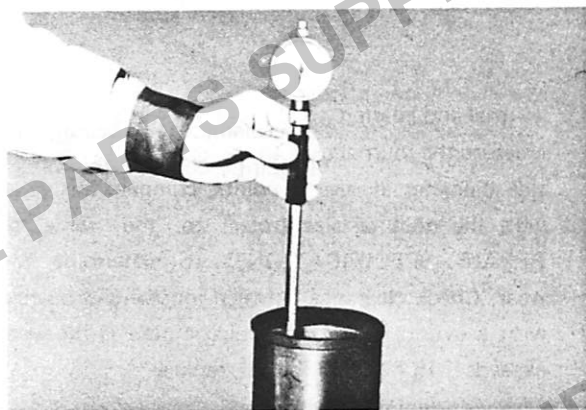


Fig. 3-3-8 Measuring liner inside diameter KT3-228

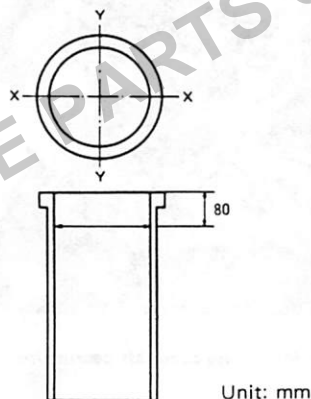


Fig. 3-3-9 Cylinder liner

3. When replacing the piston rings only, ensure to check the inside of the cylinder liner thoroughly. If there is stepped wear, ream out with the ridge reamer.

3. Clearance between piston and cylinder liner

Measure the minimum inside diameter of cylinder liner on its lower part and the maximum outside diameter of piston at right angles to piston pin 64.2 mm (2.528 in) above the piston skirt, with cylinder gauge and micrometer. The clearance is the difference between the two figures. If the clearance is too much, replace both sleeves and piston rings.

Clearance between the piston cylinder liner

Unit: mm (in)

Diameter of piston and liner	Standard clearance	Measuring position
110 (4.331)	0.192 – 0.224 (0.0076 – 0.0088)	Lower part of piston

NOTE:

Lower part of piston means at right angles to the pin and 64.2 mm (2.528 in) from the bottom of the piston.

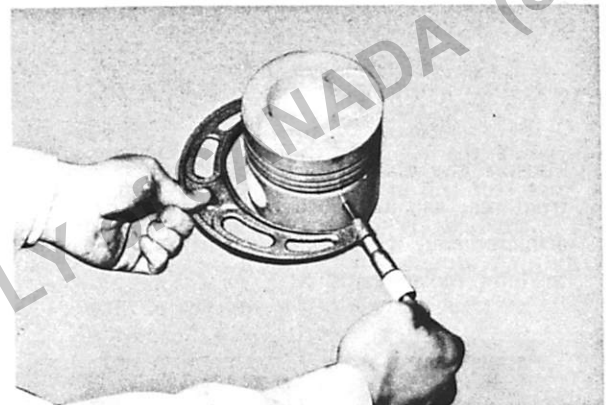


Fig. 3-3-10 Measuring piston outside diameter KT3-229

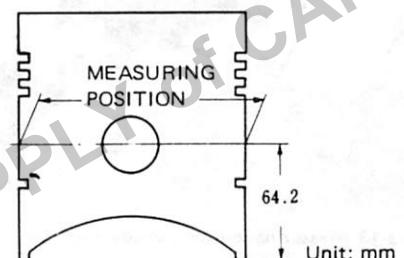


Fig. 3-3-11 Piston outside diameter measuring

3-34 ENGINE

4. Inspection of camshaft

1. Check cam lobe and journal for damage and wear.
Bent of cam shaft support: fix both ends of camshaft **Fig. 3-3-12** to V-block, place dial gauge on the center journal, and turn camshaft checking for bent. If bent is beyond the limit, replace shaft, or correct it with at press.

Limit:	0.05 mm(0.00197 in)
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NOTE: Actual is half the gauge reading.

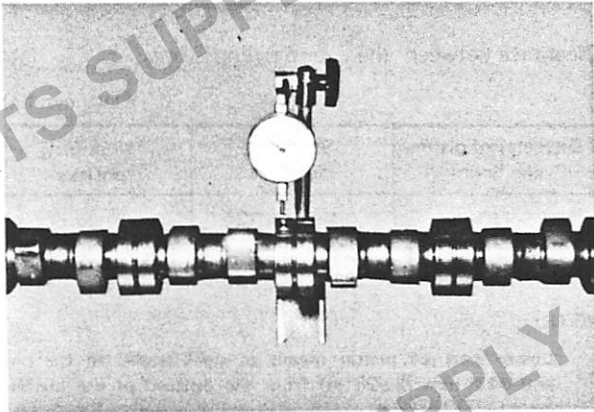


Fig. 3-3-12 Measuring camshaft bent

KT3-230

2. Measure the diameter of each camshaft journal, front rear and in the directions of X and Y with a micrometer. If the measurement value is beyond the limit, replace camshaft.

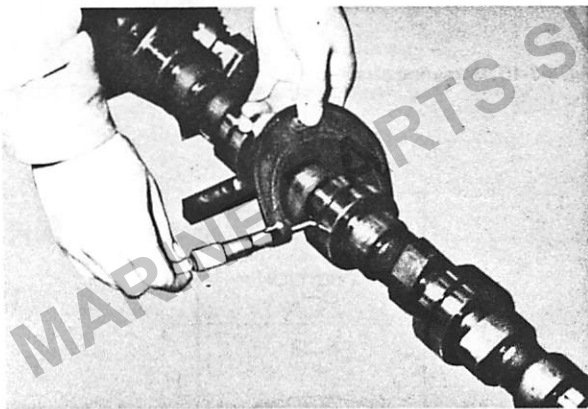


Fig. 3-3-13 Measuring journal outside diameter

KT3-231

Journal outside diameter

Unit: mm (in)

No.	Journal outside diameter	Limit
1	61.5 (2.421)	-0.15 (-0.0059)
2	61.3 (2.413)	
3	61.1 (2.406)	
4	60.9 (2.398)	
5	60.7 (2.390)	
6	60.5 (2.382)	
7	58.3 (2.295)	

If cam or journal is only slightly damaged or developing a ridge, correct them with an oil stone.

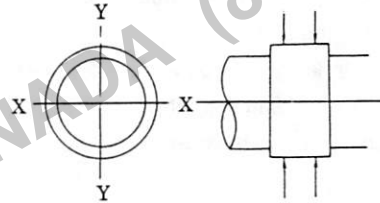


Fig. 3-3-14 Journal outside diameter measuring position

3. Journal and bearing wear

Measure the journal outside diameter and bearing inside diameter at several points, compare this value with the nominal size (refer to the Table of REPAIR SPECIFICATIONS) to determine the wear. Check clearance between journal and bearing with a cylinder gauge and micrometer. If the wear exceeds 0.15 mm (0.0059 in), replace.

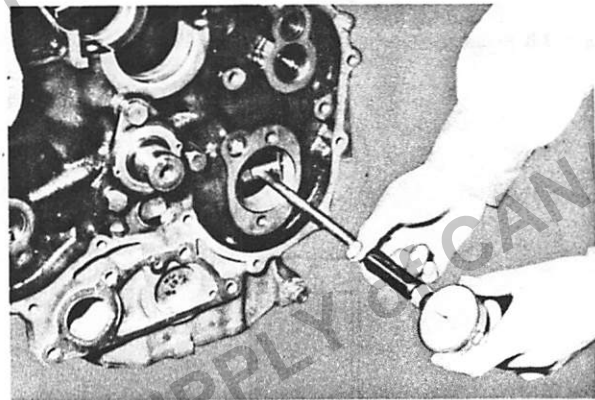


Fig. 3-3-15 Measuring camshaft bearing inside diameter

KT3-232

4. Measurement of cam

Take measurement at two points, rear and front on the cam lobe by means of micrometer. If the camshaft is found beyond the limit, replace.

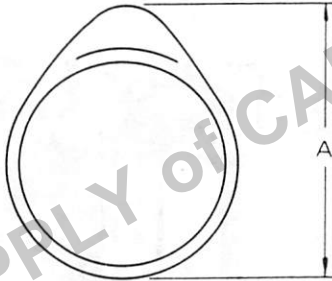


Fig. 3-3-16 Cam lift

Unit: mm (in)

	A dimension	Limit
Intake	52.98 (2.0858)	-0.08 (-0.0031)
Exhaust	51.97 (2.0460)	

5. Camshaft end play

Measure the clearance between thrust bearing and No.1 journal of the camshaft with a feeler gauge. If the clearance exceeds 0.3mm (0.012 in), replace.

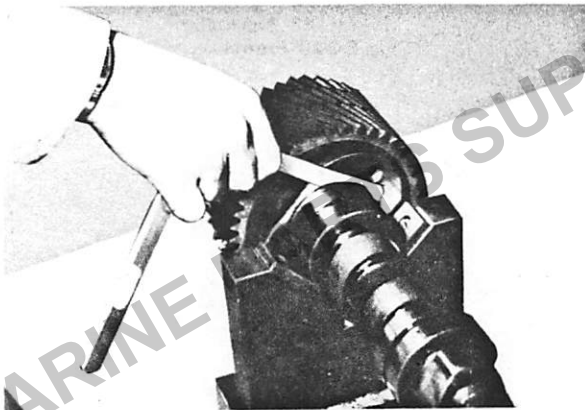


Fig. 3-3-17 Measuring cam shaft end play

KT3-233

5. Assembly and Adjustment

Cylinder liner and cylinder block are of four kinds selective fit. Liner flange is stamped with different marks indicating liner outside diameter; W, X, Y, and Z. The top surface of cylinder block and its side are stamped with corresponding marks indicating inside diameter of the cylinder liner.

(1) Insertion of new cylinder liner

Insert new cylinder liner, after making sure the marks W, X, Y, and Z on the liner flange and cylinder block are the same.

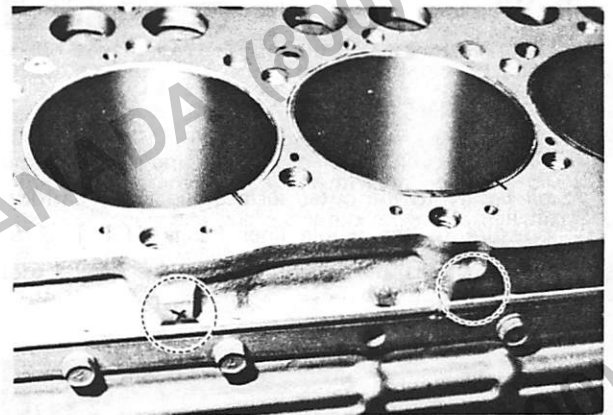


Fig. 3-3-18 W.X.Y. and Z marks on cylinder block

KT3-234

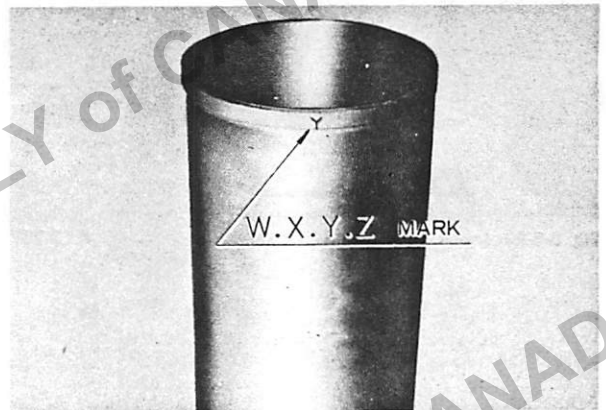


Fig. 3-3-19 W.X.Y. and Z marks on cylinder liner

KT3-235

- (2) To insert a used cylinder liner
Be sure to align the cylinder liner with the line up marks made when disassembling.

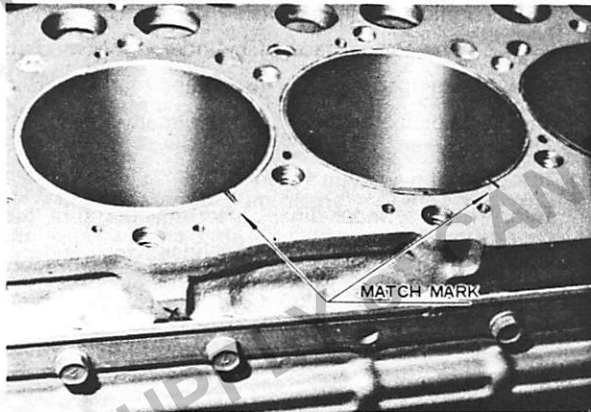


Fig. 3-3-20 Inserting the cylinder liner KT3-236

- (3) To insert cylinder liner, apply engine oil or spindle oil lightly to the outer surface and apply uniform pressure to the whole liner flange. If it is difficult to insert the liner manually, use special tool (09480-1040).



Fig. 3-3-21 Inserting the cylinder liner KT3-237

- 2. Cylinder liner protrusion measurement
Use liner puller to press [tighten to 100 kg-cm (7.3 lb.ft.)] torque. Then, measure the flange portion protruding from the top of cylinder block with a dial gauge or straight edge, and a feeler gauge. If the measurement is below the tolerance, Liner puller (09420-1210).

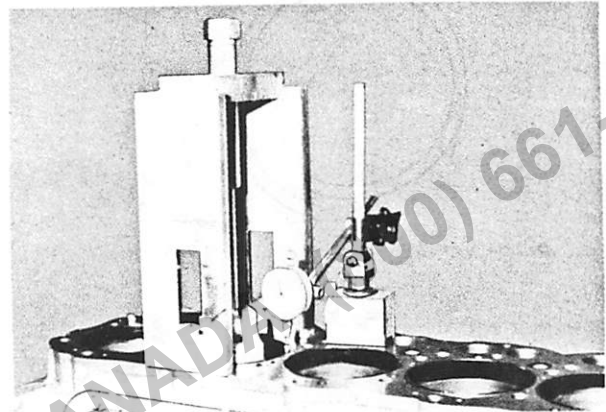


Fig. 3-3-22 Checking the liner protrusion KT3-238

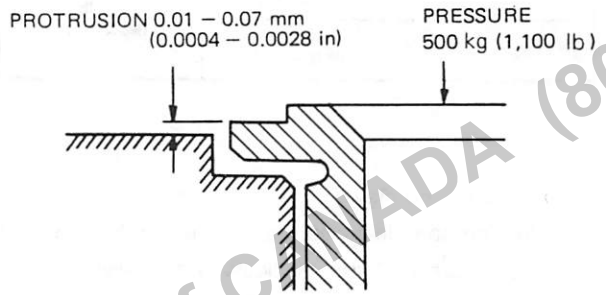
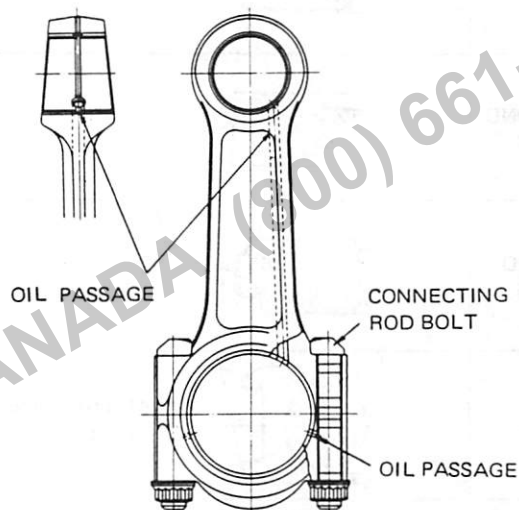
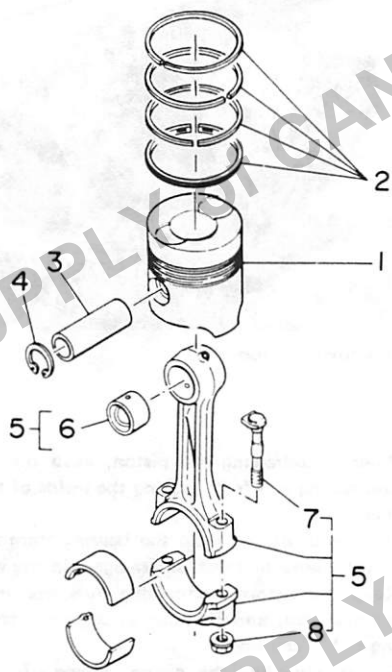


Fig. 3-3-23 Protrusion

3-4 PISTON, PISTON RING & CONNECTING ROD

DESCRIPTION



- | | |
|------------------|----------------------------|
| 1. Piston | 5. Connecting rod assembly |
| 2. Piston ring | 6. Piston pin bushing |
| 3. Piston pin | 7. Connecting rod bolt |
| 4. Retainer ring | 8. Nut |

Fig. 3-4-1 Piston and connecting rod

1. Connecting rod

The big end of the connecting rods is cut horizontally as shown in Fig. 3-4-1. The bushing in the large end of the rod is thin kelmet with lead alloy plating for improved contact smooth. The bushing in the small end is bronze. There is an oil passage from the big-end of con-rod (crank pin side) to the small-end (piston pin side).

Oil goes through this passage from the big end, lubricates the piston pin and also cools the inside of the piston.

2. Piston, piston pin, piston ring

1. Piston is made of heat resistant aluminum alloy and has toroidal combustion chamber for efficient fuel consumption. The barrel-shaped configuration is least distorted by thermal expansion and piston

head shaking. It consists of an oval top section, a composite-oval ring land middle section, a single-oval bottom section.



Fig. 3-4-2 Piston

KT3-239

3-38 ENGINE

2. The piston rings consist of three compression rings and an oil ring with coil expander incorporated. Moreover, the top, third, and oil rings are chrome-plated for abrasion resistance. The rings are so designed and constructed for optimum lubrication, minimum friction loss and to prevent compression leakage and interior abrasion.

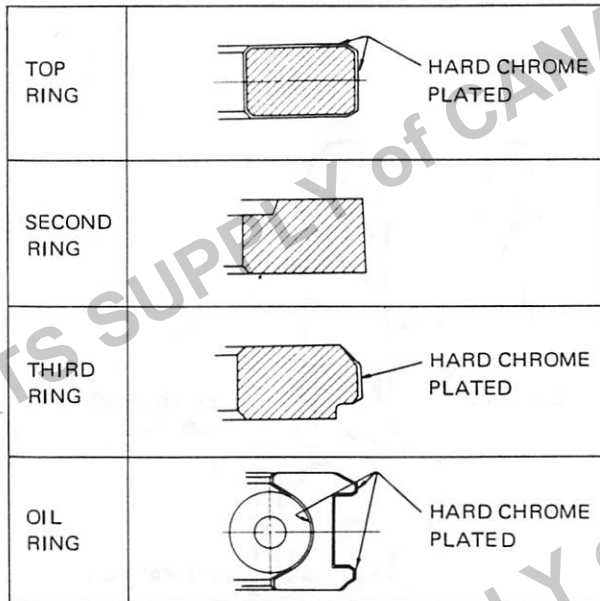


Fig. 3-4-3 Piston ring

3. The full-floating piston pin is made of case-hardened steel.

3. Removal and disassembly

1. To remove
 - (1) Remove cylinder head and related parts.
 - (2) Place the engine on its side and remove the oil pan.
 - (3) Remove the suction strainer.
 - (4) With the piston concerned at bottom dead center, loosen bolt of connecting rod cap and remove cap by tapping it lightly with brass or wooden hammer.

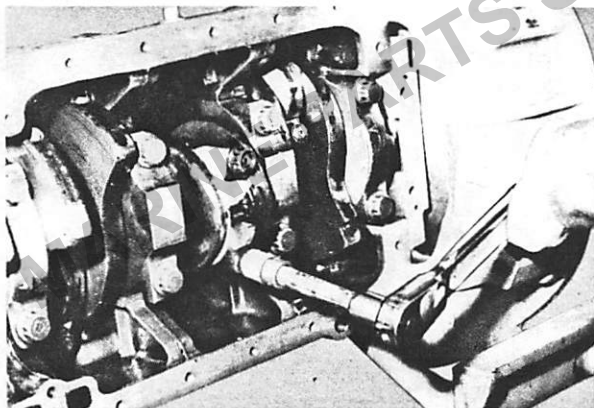


Fig. 3-4-4 Removing connecting rod cap

KT3-240

(5) Withdraw piston and connecting rod through the top of the block. Remove the pistons in pairs as follows: No.1 — No.6, No. 2 — No.5, and No.3 — No.4.

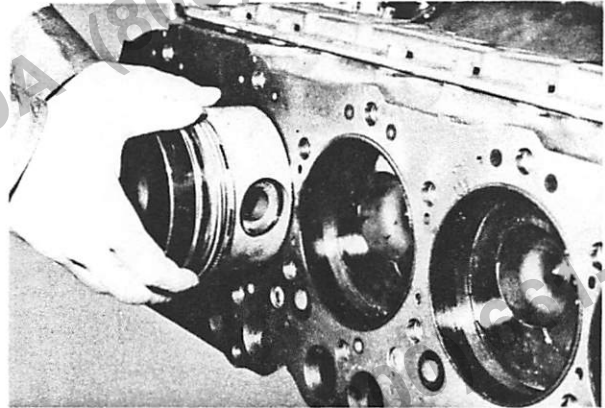


Fig. 3-4-5 Removing piston

KT3-241

NOTE:

1. When withdrawing the piston, keep the big end of connecting rod from scoring the inside of the cylinder liner.
2. Be careful not to drop the bearing from the big end of the connecting rod, or damage it in any way.
3. Keep the pistons, connecting rods, etc. in order, by cylinder No. and installation sequence and connecting rod or cap side.
4. Before removing the piston, scrape off any carbon deposits on the inside of the cylinder liner with a scraper or sand paper (#150).

DISASSEMBLY

1. Removing the piston pin

1. Use pliers to remove the pin retainer ring at either end. Hold the connecting rod firmly by hand, and tap the piston pin out with a mallet and wood dowel. If difficult, do not force. Warm the piston first in hot water 80 — 90°C (176 — 194°F) and then tap out the pin.



Fig. 3-4-6 Removing piston pin

KT3-242

2. Remove the piston ring with piston ring expander No. (09442-1011).



Fig. 3-4-7 Removing piston ring

KT3-243

NOTE:

1. Take care in holding the piston rings which are made of a special cast iron that is subjected to be breakage.
2. If reusing the piston rings, be careful to reassemble them in the correct order. Therefore, place the rings aside in order they are removed.

2. Inspection and adjustment

Completely clear the top of piston and ring groove of carbon, sludge, etc. and wash them in solvent.

1. Inspection of pistons and piston rings

- (1) Check the circumference of the top surface of piston for cracks and melting and the ring groove for damage. If they are faulty, replace them.
- (2) Check piston rings for wear, torsion, and damage. If faulty, replace.
- (3) Piston ring groove clearance

After piston rings are set in the piston ring grooves, measure the clearance with a feeler gauge. When the clearance exceeds tolerance, measure the clearance once more. If it still exceeds limit, replace either piston or piston ring.

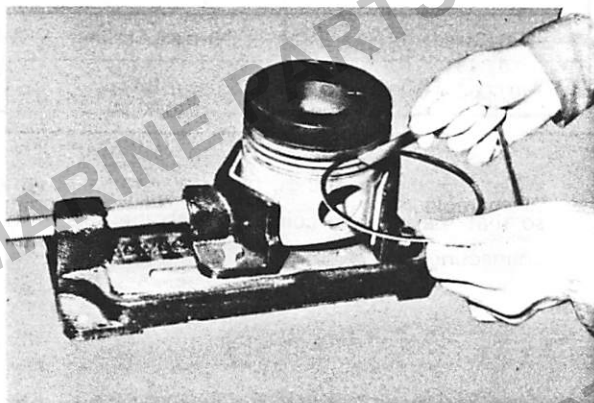


Fig. 3-4-8 Measurement of piston ring groove

KT3-244

Piston ring/ring groove clearance

Unit: mm (in)

	Clearance		Ring groove width	
	Standard	Limit	Standard	Limit
Top ring	0.06 - 0.10 (0.0024-0.0039)	0.4 (0.0157)	3 (0.1181)	3.25 (0.1279)
Second ring	0.04 - 0.08 (0.0016-0.0031)	0.4 (0.0157)	2.5 (0.0984)	2.75 (0.1083)
Third ring	0.04 - 0.08 (0.0016-0.0031)	0.4 (0.0157)	2.5 (0.0984)	2.75 (0.1083)
Oil ring	0.02 - 0.06 (0.0008-0.0024)	0.08 (0.0031)	5 (0.1969)	5.05 (0.1988)

(4) Piston ring gap

Put the piston ring in the cylinder liner and measure the gap in the ends of the ring with a feeler gauge. Insert the ring from the piston skirt. Take the measurement at the point of least wear. When the measurement exceeds the limit replace the piston rings.



Fig. 3-4-9 Clearance measurement of piston ring fitting

KT3-245

NOTE:

If the liner is new, the measurement can be taken anywhere.

3-40 ENGINE

Piston ring gap

Unit: mm (in)

	Standard	Limit	Remarks (Free length)
Top ring	0.3 – 0.45 (0.0118 – 0.0177)	2.5 (0.0984)	Approx. 11 (0.433)
Second ring	0.3 – 0.45 (0.0118 – 0.0177)	1.2 (0.0472)	15.5 (0.6103) (Nippon Piston Ring) 15.0 (0.5905) (Riken Piston Ring)
Third ring	0.3 – 0.45 (0.0118 – 0.0177)	1.2 (0.0472)	Approx. 14.5 (0.5709)
Oil ring	0.3 – 0.5 (0.0118 – 0.0197)	1.2 (0.0472)	Approx. 12.5 (0.4921) (Nippon Piston Ring) Approx. 10.5 (0.4134) (Riken Piston Ring)

2. Inspection of piston pin, piston pin hole, and the small end of the connecting rod

- (1) Measurement of clearance between piston pin and piston pin hole



Fig. 3-4-10 Measurement of piston pin O.D.

KT3-246

Measure the inner diameter of piston pin hole and outer diameter of piston pin with a cylinder gauge and micrometer subtract to find the clearance between them. If the clearance exceeds serviceable limit, replace either pistons or piston pins.

Outer diameter of piston pin

Unit: mm (in)

Standard	Serviceable limit
39 (1.5354)	38.86 (1.5300)

Clearance between piston hole and piston pin

Unit: mm (in)

Standard	Serviceable Limit
-0.013 T – 0.014 L (-0.00051 – 0.00055)	0.10 (0.0039)

NOTE: T: interference fit.
L: clearance

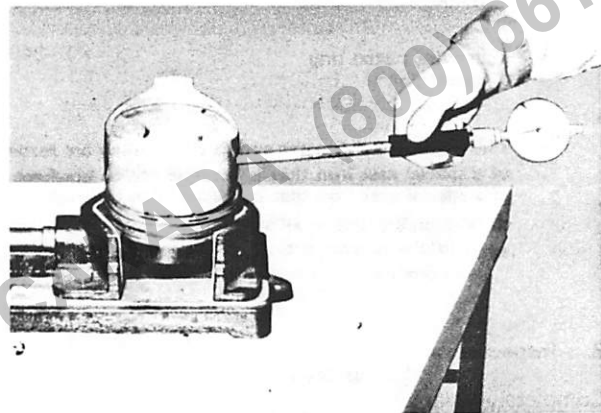


Fig. 3-4-11 Measurement of piston pin hole

KT3-247

3. Connecting Rod

1. Small end bushing

Measure the inside diameter of the bushing and outside diameter of piston pin. If clearance between bushing and piston pin exceeds 0.1 mm (0.0039 in), replace the bushing. The standard clearance is 0.015 – 0.036 mm (0.0006 – 0.0014 in).

Unit: mm (in)

Standard	Serviceable limit
0.015 – 0.036 (0.0006 – 0.0014)	0.1 (0.0039)

When replacing bushings, press in the new bushing so that the oil hole coincides with the hole in the connecting rod.

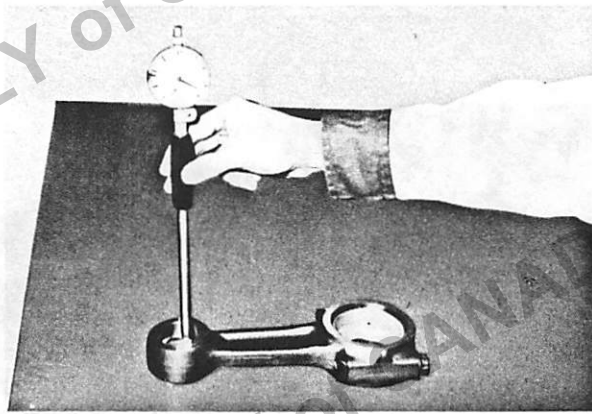


Fig. 3-4-12 Measurement of inside diameter of bushing on the small end of connecting rod KT3-248



Fig. 3-4-14 Measuring connecting rod bent KT3-250

2. Inspection of connecting rod

- (1) Check the inside of the connecting rod end holes for damage.
- (2) Each connecting rod has oil channels for lubricating the bushing on the small end and for cooling the lower part of the piston.
Use a wire or compressed air to make sure this oil channel is not blocked.

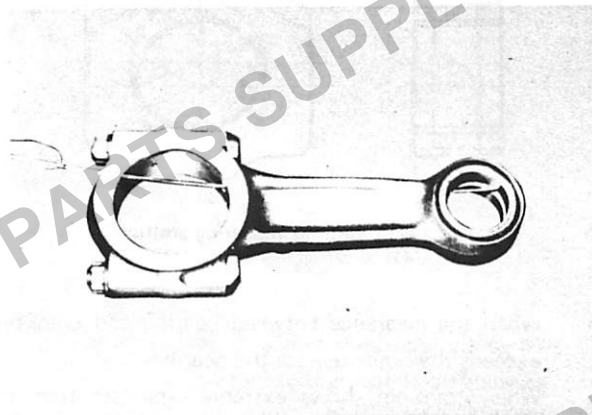


Fig. 3-4-13 Checking oil channel in connecting rod KT3-249

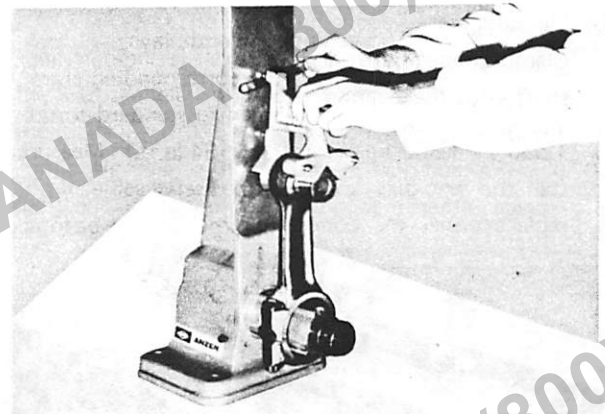


Fig. 3-4-15 Measuring connecting rod distortion KT3-251

Bent and distortion of connecting rod

Unit: mm (in)

Limit of bent	per 100 (per 3.937)	0.05 (0.0019)
Limit of distortion	per 100 (per 3.937)	0.05 (0.0019)

Length of connecting rod: 183.5 mm (7.2244 in.)

NOTE:

There is another oil hole on top of the small end of the connecting rod besides the one shown in Fig. 3-4-1.

- (3) Bent and distortion measurement of connecting rod
Measure the bent and distortion of connecting rod with a connecting rod aligner. If the bent or distortion exceeds the serviceable limit, either straighten with a press, or replace.

- (4) Inside diameter of the big end hole
Tighten the cap bolts by tightening torque 1,650 – 1,850 kg·cm (120 – 134 lb.ft.) without the bearings and measure the inside diameter.

Unit: mm (in)

Standard dia.	69 mm (2.716 in)
Roundness	0.06 mm (0.0023 in)

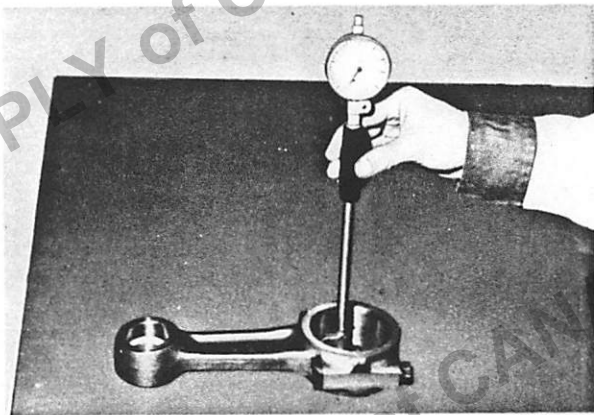


Fig. 3-4-16 Measuring roundness of large end of connecting rod KT3-252

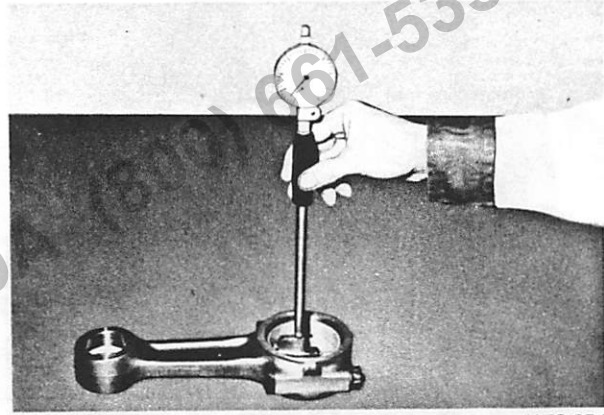


Fig. 3-4-18 Measurement of inner diameter of bearing KT3-254

(5) Measurement of connecting rod end-play

Clamp connecting rod to the corresponding crankshaft with the bearing. Tighten to standard torque 1,650 – 1,850 kg-cm (120 – 134 lb.ft.). Measure the the end-play exceeds the serviceable limit, replace either the connecting rod or the bearing.

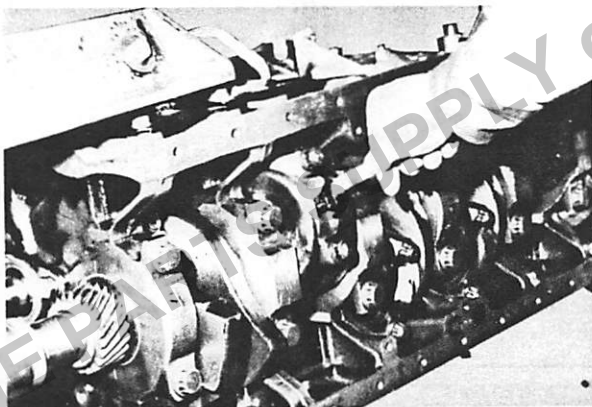


Fig. 3-4-17 Measuring the endplay KT3-253

inside diameter of bearing, tighten the cap bolts to standard torque, loosen once, then tighten the bolts to torque 1,650 – 1,850 kg-cm (120 – 134 lb.ft.) again.

Now measure the inside diameter at several points as shown in Fig. 3-4-19.

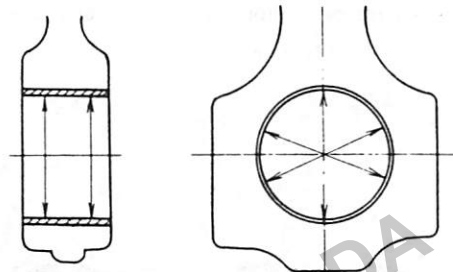


Fig. 3-4-19 Bearing measuring position

When the clearance between bearing and crankpin exceeds the limit, replace the bearings.

When crankpin shows extreme wear (see Item on crankshaft) or eccentric abrasion, grind the pin down and fit with undersized bearing (comes in four kinds of 0.25mm (0.0098 in), 0.50mm (0.0197 in), 0.75mm (0.0295 in), and 1.0mm (0.0394 in).

End-play of connecting rod

Unit: mm (in)

Standard	Serviceable limit
0.20 – 0.50 (0.0078 – 0.0196)	0.60 (0.0236)

3. Inspection of connecting rod bearing

- (1) Check the connecting rod bearings for wear, score and seizure.
- (2) Measurement of oil clearance of connecting rod
Measure the inside diameter of the connecting rod bearing and outside diameter of crankshaft pin with a micrometer and cylinder gauge. The difference is the oil clearance. Before measuring the

Oil clearance

Unit: mm (in)

Standard	Serviceable limit
0.031 – 0.082 (0.0013 – 0.0032)	0.30 (0.0119)

NOTES:

1. Plastigauge may be used to measure oil clearance.
2. Replace connecting rod bearings in sets of two, a combination of upper and lower bearings.

(3) Spread dimension of the bearing

The spread dimension (dimension A in Fig. 3-4-20) of the bearing is measured in its free state as a unit.

Standard: 69.75 – 70.25 mm (2.746 – 2.766 in)

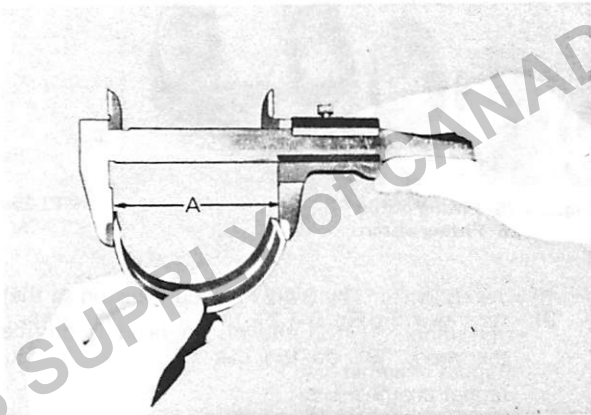


Fig. 3-4-20 Spread of bearing

KT3-255

Never forcibly spread metal making apparent bearing spread.

(4) Crush height measurement

There is no need to measure crush height if the oil clearance is well controlled and bearing spread and roundness of the large end of connecting rod are within tolerances.

NOTE:

Do not loosen the cap bolts on one to measure the crush with a feeler gauge. Results thus obtained are unreliable.

4. Assembling

Apply engine oil to each rotating component before assembly.

1. Assembling piston and connection rod

See Fig. 3-4-21. See that mark "O" on top of piston and matching mark on connecting rod are positioned opposite to each other.

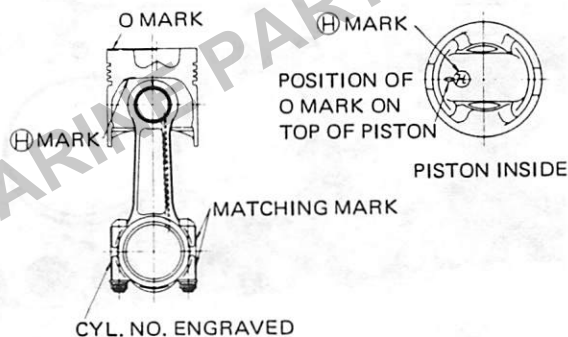


Fig. 3-4-21 Marks on piston



Fig. 3-4-22 Fitting piston pin

KT3-256

- (1) To put piston pin in piston, fit one retainer ring to the end of piston pin hole; warm the piston in $80^{\circ} - 90^{\circ}\text{C}$ ($176^{\circ} - 194^{\circ}\text{F}$) hot water; apply oil to piston pin hole; insert piston pin; fit remaining retainer ring to other side.

NOTE:

1. When holding the piston in a vise, use waste between the vise jaws and the piston head to prevent damage.
2. Take care not to damage the retainer ring already mounted by trying to force the piston pin in.

2. Mounting of piston ring

- (1) To fit piston ring to piston, place piston skirt down and use piston ring expander (special tool No. 09442-1011). Hold piston ring stamped side up (top side of piston), and fit, beginning with the bottommost ring and working up in the sequence of Fig. 3-4-23 and Fig. 3-4-24.



Fig. 3-4-23 Fitting piston ring

LB3-023

- (2) When fitting the oil ring, first determine the direction of the built-in coil expander.

1) Tightly close the joint of coil expander.

When the joint, 180° opposite to the joint of oil ring, put coil expander in oil ring.

(See Fig. 3-4-24).

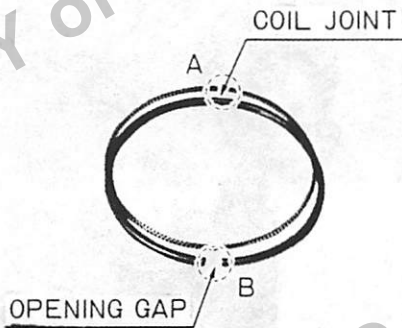


Fig. 3-4-24 Fitting section

KT3-257

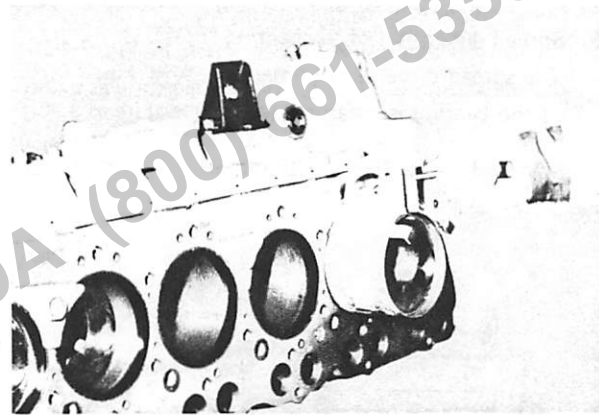


Fig. 3-4-26 Fitting piston

KT3-259

2) Be careful not to confuse oil ring with other rings, as the oil ring is a set of coil and ring.

3) As shown in Fig. 3-4-27, mount piston so that the mark "O" on the piston head is on the tappet chamber side.

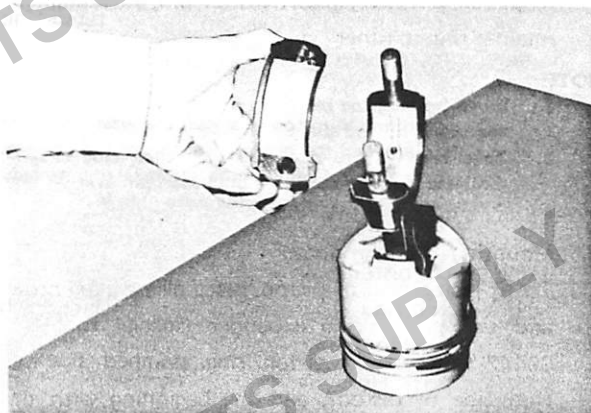


Fig. 3-4-25 Fitting connecting rod bearing

KT3-258

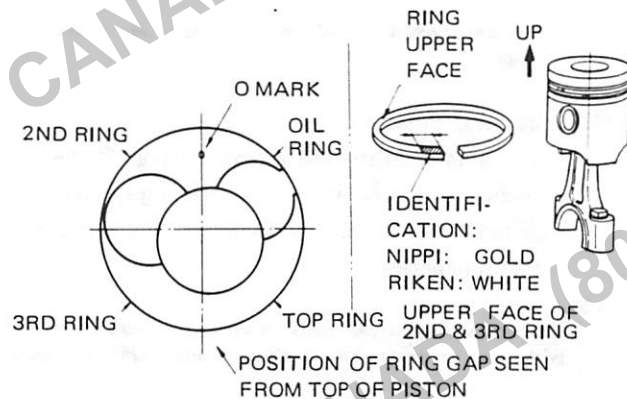


Fig. 3-4-27 Marks and ring joint position

3. Mounting piston, connecting rod and others

(1) Fitting connecting rod bearing

As shown in Fig. 3-4-25, fit the bearing with two holes 4 mm (0.157 in) dia. to the cap side; one hole 6 mm (0.236 in) dia. to the connecting rod side. See that the teat at one end of bearing fits in with the slot at the end of connecting rod.

NOTE:

When fitting old bearings, make sure that they are mounted exactly where they were before disassembly.

(2) Fitting piston to cylinder

1) Turn crankshaft to set that piston at bottom dead center.

2) As shown in Fig. 3-4-26, arrange each ring, and push in piston head with a piston ring holder (special tool No. 09441-1041) and a wooden rod.

(3) Fitting connecting rod

1) Fit connecting rod and bearing to crankshaft pin. Observing the matching marks, mount cap and bearing.

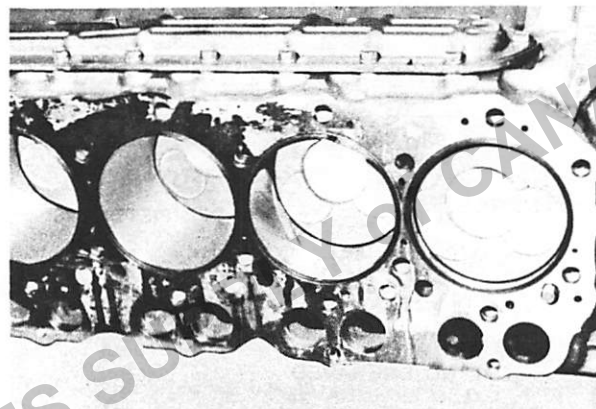


Fig. 3-4-28 Direction of piston head

KT3-260

- 2) Apply engine oil to the threads and seat surface of the cap bolt. Tighten bolt at the specified torque, and then loosen it. Retighten it to the specified torque.

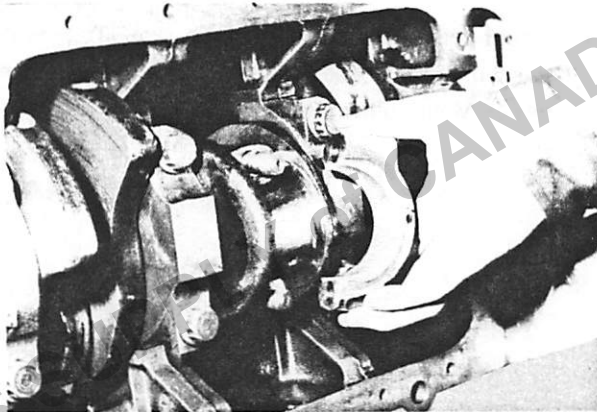


Fig. 3-4-29 Tightening the cap bolt

KT3-261

- 3) Complete the mounting of connecting rod and piston in 1-6, 2-5, 3-4 sequence.
- 4) Turning the crankshaft, after completion of mounting of piston, may sometimes cause the liner to slip. To prevent this, use the Liner Stopper shown in Fig. 3-4-30.

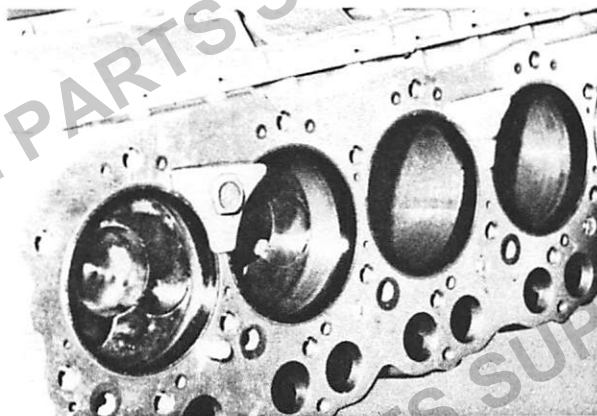


Fig. 3-4-30 Liner stopper

KT3-262

- (4) Mounting the strainer

- 1) After checking the suction pipe and strainer for damage and cracks, temporarily tighten the bolts 1 - 4 as shown in Fig. 3-4-31.

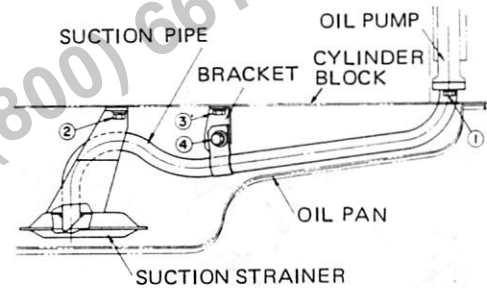


Fig. 3-4-31 Suction strainer

- 2) Tighten the bolts in the sequence of (1), (2), (3), and (4), while making sure the suction pipe and strainer O-ring sealing surface are properly aligned.

Unit: kg.cm (lb.ft.)

Bolt No.	Tightening Torque
4	450 - 500 (33 - 36)
1, 2, 3	130 - 180 (10 - 13)

- (5) Fitting oil pan

The oil pan gasket is a double fitting type. Fit the gasket with its teat positioned on the oil pan side (See Fig. 3-4-32).

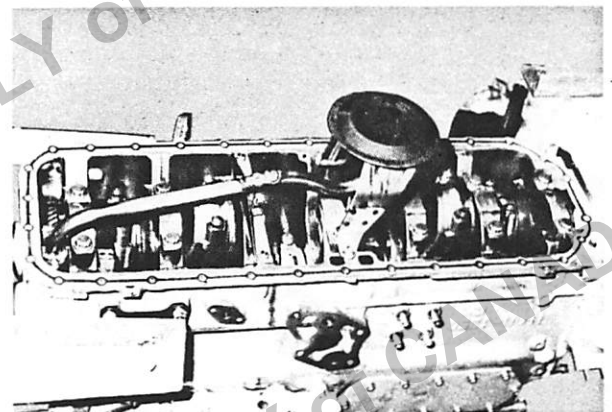


Fig. 3-4-32 Fitting the gasket

KT3-263

3-46 ENGINE

Tightening torque:

180 – 230 kg-cm (14 – 16 lb.ft.)

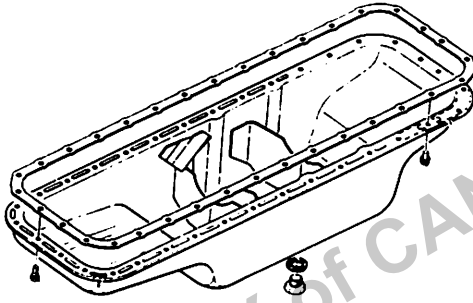


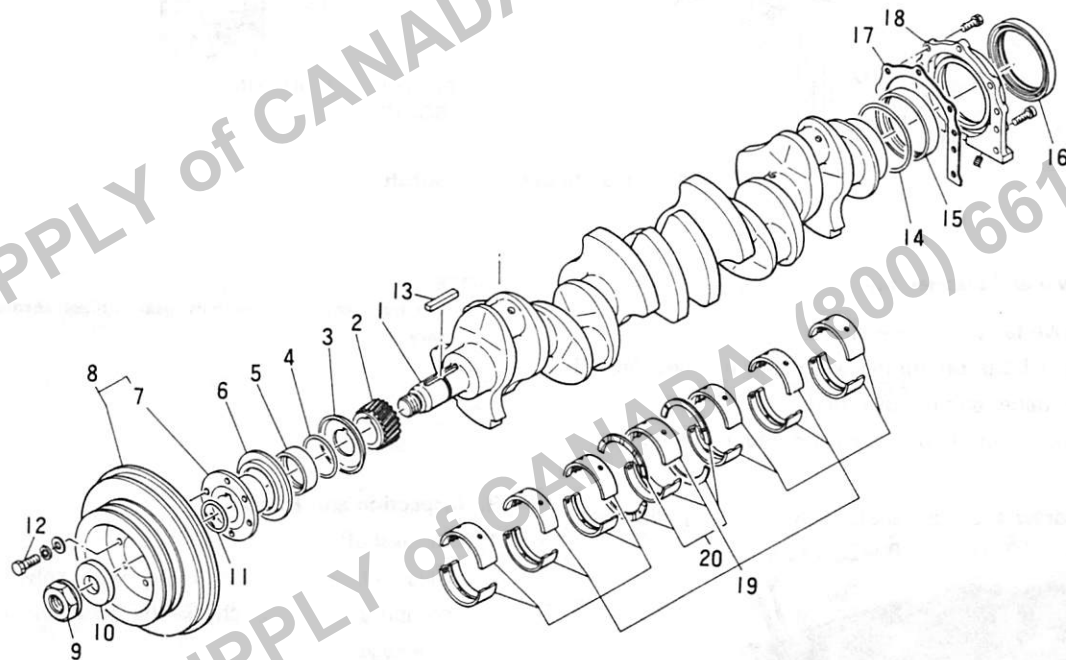
Fig. 3-4-33 Oil pan and gasket

NOTE:

1. Straighten the flange of the oil pan if it is bent or damaged.
 2. There is no need to apply a bonding agent to the oil pan gasket.
 3. Tighten the oil pan drain plug securely on its gasket.
- (6) Mount cylinder head on the head gasket. (To mount the cylinder head, see 3-26, 4. To assemble cylinder head.) Mount other related parts.

3-5 CRANKSHAFT, CRANKSHAFT BEARING & FLYWHEEL

DESCRIPTION



- | | | |
|-----------------------------|------------|----------------------------|
| 1. Crankshaft | 8. Pulley | 15. Crankshaft sleeve |
| 2. Crankshaft gear | 9. Nut | 16. Oil seal |
| 3. Oil slinger | 10. Collar | 17. Gasket |
| 4. O-ring | 11. O-ring | 18. Retainer |
| 5. Crankshaft sleeve, front | 12. Bolt | 19. Crankshaft bearing set |
| 6. Dust slinger | 13. Key | 20. Thrust bearing set |
| 7. Crankshaft pulley center | 14. O-ring | |

Fig. 3-5-1 Crankshaft & related parts

1. Crankshaft

Crankshaft is made of specially forged steel. The filler R of each pin and journal is subjected to induction heat treatment to provide proper strength. Front oil seal is equipped with dust slinger to keep dust out. In addition, more flywheel mounting bolts increases the forces of clamping crankshaft and flywheel together.

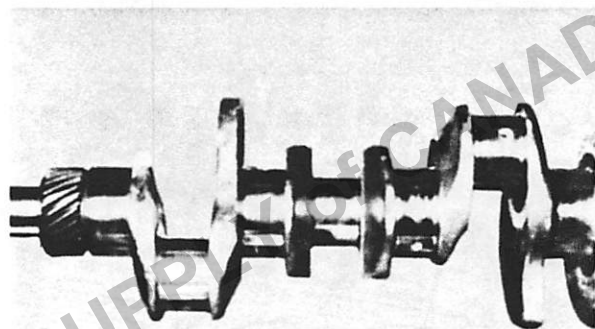


Fig. 3-5-2 Induction hardened crankshaft

KT3-264

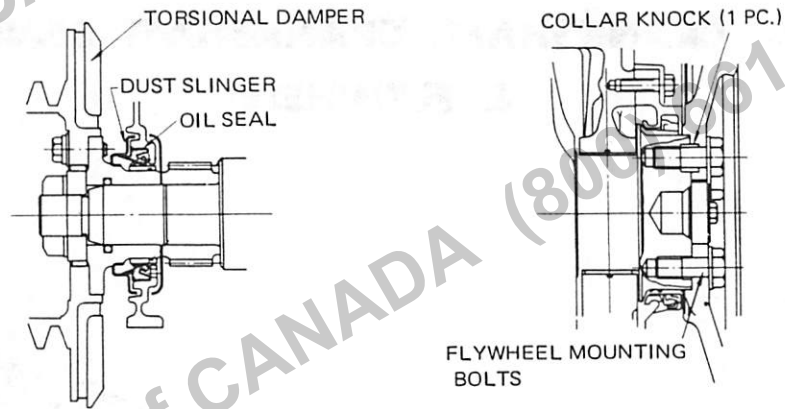


Fig. 3-5-3 Oil seals on crankshaft

2. Removal and disassembly

1. Remove fan-pulley assembly.
2. Loosen bolts on timing gear case, flywheel and oil seal retainer and remove them.
3. Remove journal bearing caps and connecting rod caps.
4. Withdraw the crankshaft sleeve with a puller front (09420-1071), rear (09420-1420).

NOTE:

Do not remove crankshaft gear, unless absolutely necessary.

3. Inspection and Repair

1. Crankshaft

Clean crankshaft completely with solvent the use compressed air to check the oil channel bore for blockage.

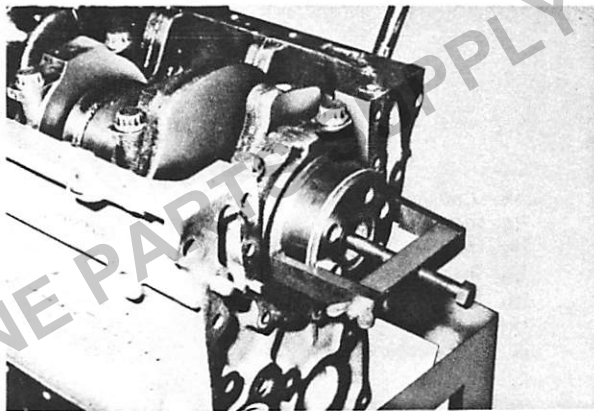


Fig. 3-5-4 Removing crankshaft sleeve KT3-266

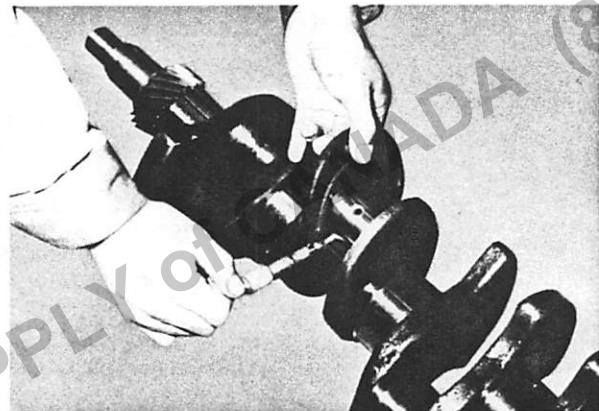


Fig. 3-5-6 Measuring outside diameter of pin and journal KT3-267

5. Withdraw crankshaft from cylinder block.

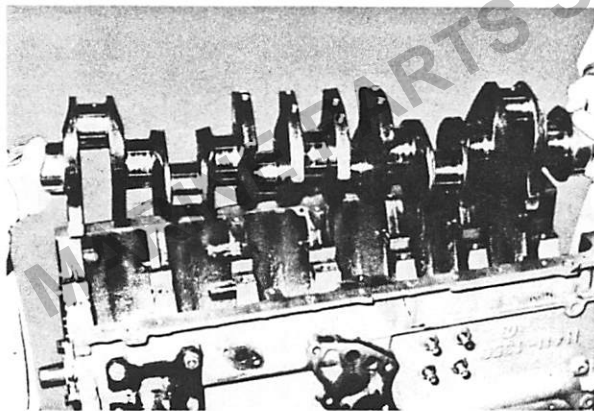


Fig. 3-5-5 Removal of crankshaft KT3-265

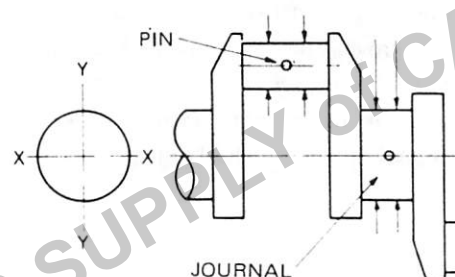


Fig. 3-5-7 Measuring points

2. Check crankshaft for cracks with die or magnetic detector. In particular, carefully check oil channel bore and fillet R of pin and journal.
3. Check surface of crankshaft pin and journal for roughness or scores. If faulty, either replace or regrind the crankshaft.
4. Measurement of outside diameter of crankshaft journal and pin
 Measure with a micrometer as shown in Fig. 3-5-6.
 by grinding down to take an undersized bearing (see Table for crankshaft machining). If the value exceeds the serviceable limit, replace.

Crankshaft machining

Under size	Outside diameter	
	Crankpin	Journal
0.25 US	64.75 ^{-0.04} _{-0.06} mm (2.5492 ^{-0.0016} _{-0.0023} in)	73.75 ^{-0.04} _{-0.06} mm (2.9035 ^{-0.0016} _{-0.0023} in)
0.50 US	64.50 ^{-0.04} _{-0.06} mm (2.5394 ^{-0.0016} _{-0.0023} in)	73.50 ^{-0.04} _{-0.06} mm (2.8937 ^{-0.0016} _{-0.0023} in)
0.75 US	64.25 ^{-0.04} _{-0.06} mm (2.5295 ^{-0.0016} _{-0.0023} in)	73.25 ^{-0.04} _{-0.06} mm (2.8839 ^{-0.0016} _{-0.0023} in)
1.00 US	64.00 ^{-0.04} _{-0.06} mm (2.5197 ^{-0.0016} _{-0.0023} in)	73.00 ^{-0.04} _{-0.06} mm (2.8740 ^{-0.0016} _{-0.0023} in)

Unit: mm (in)

	Standard	Serviceable limit	Repair limit
Journal	74 (2.913)	73.80 (2.906)	72.80 (2.866)
Pin	65 (2.560)	64.80 (2.551)	63.80 (2.512)

To correct crankshaft by grinding, make sure the fillet R of pin or journal is not small. Also, make sure the fillet forms a continuous curve at the corner.

Dimension of fillet R

Unit: mm (in)

	Dimension
Pin	4 ± 0.2 (0.157 ± 0.0078)
Journal	3 ^{+0.5} ₋₀ (0.118 ^{+0.0197} ₋₀)

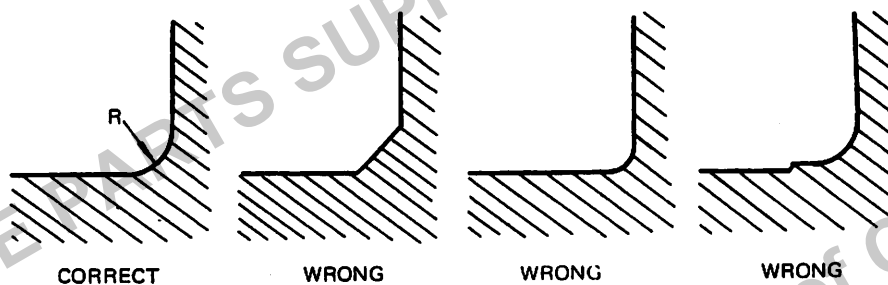


Fig. 3-5-8 Fillet radius

4. Crankshaft bent

Support both ends of crankshaft journal on the V blocks, and attach a dial gauge on the center journal and check its alignment.

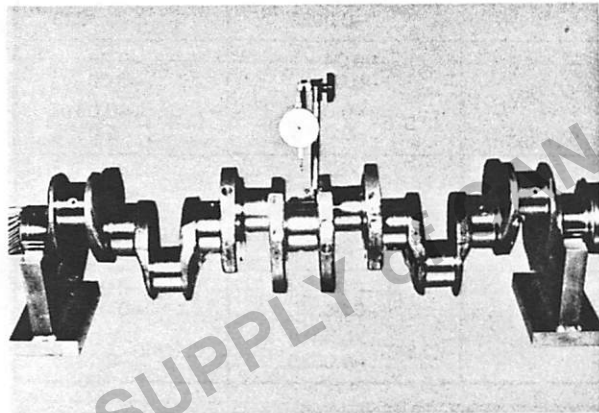


Fig. 3-5-9 Measuring the crankshaft bent

KT3-268

If the value is more than 0.09 mm (0.0035 in), re-grind the crankshaft to undersize or repair by press.

1. Inspection of crankshaft main bearing

(1) Bearing cap roundness measurement

Clamp main bearing cap of crankshaft to cylinder block at specified torque, then loosen it. Retighten it at specified torque of 1,400 – 1,600 kg·cm (102 – 115 lb.ft.). Take roundness measure of the section with a cylinder gauge. If measurement exceeds the limit, either line bore after padding, or make replace the cylinder block.

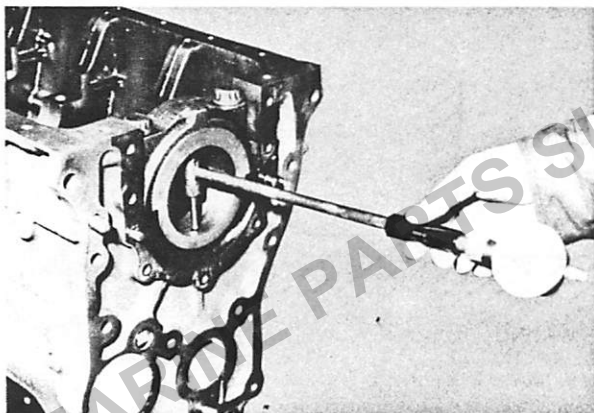


Fig. 3-5-10 Checking bearing I.D.

KT3-269

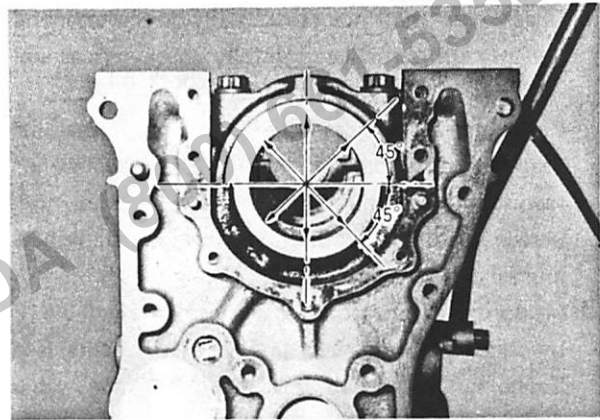


Fig. 3-5-11 Measuring point

KT3-270

Unit: mm (in)

Inside dia.	Serviceable limit
79 ⁺⁰ / _{-0.015}	0.06 (0.0023)
(3.11 ⁺⁰ / _{-0.006})	

(2) Measurement of inside diameter of crankshaft bearing

With crankshaft main bearing set to cylinder block and cap, tighten cap bolt to specified torque. Measure inside diameter with a cylinder gauge. Also, measure outside diameter of crankshaft journal with a micrometer. The difference between the two measurements is the oil clearance. If the clearance exceeds tolerance, replace the bearings.

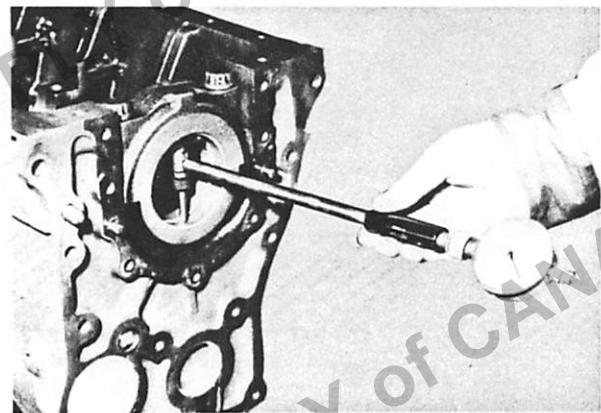


Fig. 3-5-12 Measurement of inside diameter of bearing

KT3-271

Oil clearance

Unit: mm (in)

Standard	Limit
No. 1 – No. 7 bearing	
0.051 – 0.102 (.0020 – 0.0040)	0.30 (0.0118)

If crankshaft journal is extremely worn shows eccentric abrasion, correct by grinding down to take an undersized bearing (available in four kinds of 0.25mm (0.001 in), 0.50mm (0.02 in), 0.75mm (0.03 in), and 1.00mm (0.04 in).

NOTE:

1. Oil clearance measurement can also be taken with plastigauge.
2. Be sure to replace bearings in sets of upper and lower bearings.

(3) Spread dimension of the bearing

Spread dimension (dimension A in Fig. 3-5-13) of the bearing is measured in its free state as a unit.

Standard: 79.75 – 80.25 mm (3.14 – 3.16 in.)

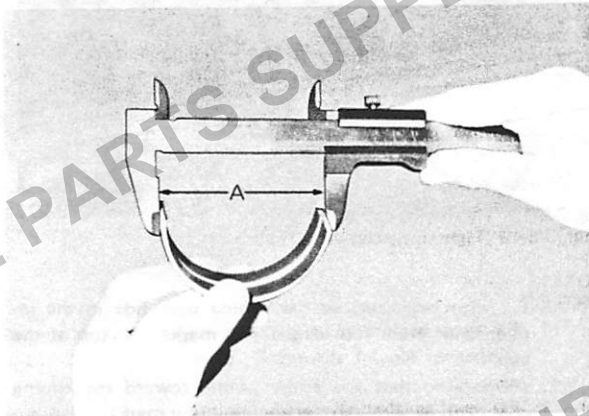


Fig. 3-5-13 Spread dimension of bearing

KT3-255

(4) Crush height measurement

There is no need to take a crush height measurement if the oil clearance, bearing spread and cap roundness meet tolerances.

NOTE:

Do not measure with a feeler gauge after loosening one cap bolt as such a measurement is not accurate. Never correct the fitting surface between cylinder block and cap by grinding.

(5) End play

Measure end play with a thickness gauge while moving to the side with a screw driver or lever as shown in Fig. 3-5-14. Nominal play is 0.05 – 0.219 mm (0.0020 – 0.0086 in). If more than 0.5 mm (0.0197 in), replace the thrust bearing. After endplay is correct, lock the cap bolt.

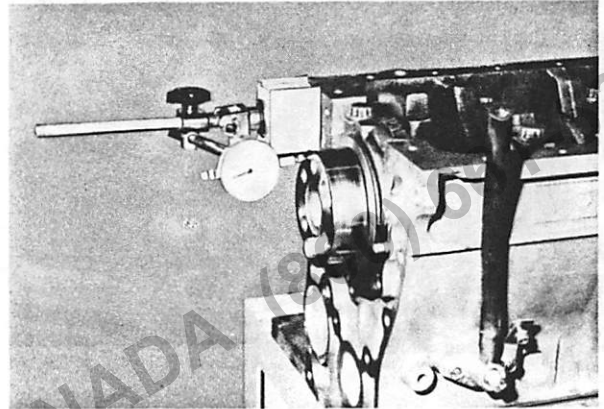


Fig. 3-5-14 End play measurement

KT3-272

Inspection of oil seal

Check the lip of the crankshaft oil seal for wear and damage.

Assembling and mounting

- (1) Insert crankshaft gear in crankshaft with a press.
- (2) Mount crankshaft rear sleeve

To mount, fit O-ring to the inside of sleeve, apply engine oil to O-ring, and drive it in with a sleeve press (09482-1400). Insertion is complete when the press contacts the surface of crankshaft.

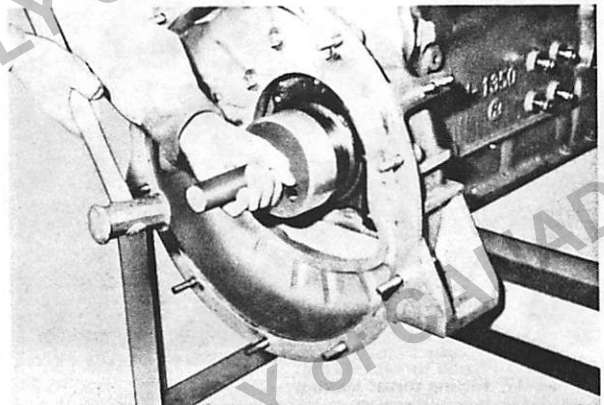


Fig. 3-5-15 Fitting sleeve

KT3-273

3-52 ENGINE

- (3) Clean cylinder block with solvent, then blow any remaining grit or dust off with compressed air.
- (4) Fit crankshaft bearings to cylinder block with bearing caps.

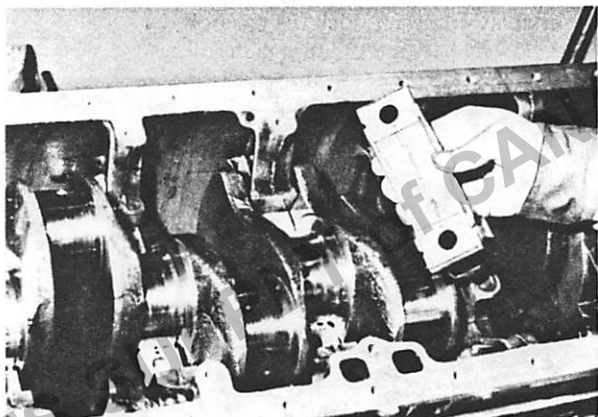


Fig. 3-5-16 Fitting crankshaft bearing

KT3-274

NOTE:

1. Each bearing has a different width so it is necessary to see that it is properly mounted.
2. See that the teats at end of the bearings fit with the slots on bearing caps and cylinder block.
3. Apply engine oil to the inside of bearing.

- (5) Fit thrust bearing to the No.4 bearing cap side. As shown in Fig. 3-5-17, see that the four thrust bearings at either end of journal support and No.4 bearing cap, are mounted with the oil groove facing to the crankshaft side.



Fig. 3-5-17 Fitting thrust bearing

KT3-275

- (6) Fit crankshaft to cylinder block.
- (7) Insert crankshaft thrust bearing along the slot of cylinder block.

- (8) Fit crankshaft bearing cap. Tighten it to specified torque then loosen. Retighten to specified torque.

Tightening torque:

1,400 — 1,600 kg-cm (102 — 115 lb.ft.)

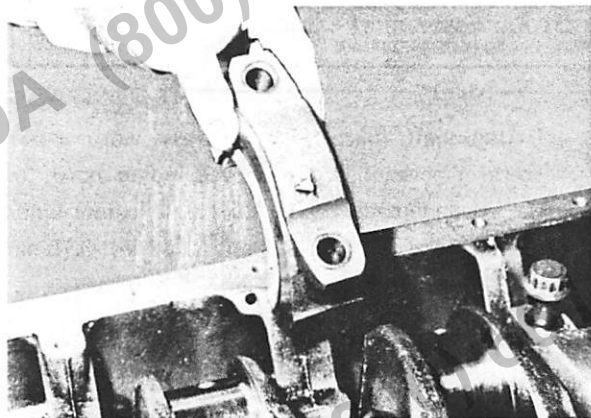


Fig. 3-5-18 Fitting cap

KT3-276



Fig. 3-5-19 Tightening cap bolt

KT3-277

NOTE:

1. Fit caps beginning at the timing gear side in the sequence of Nos. 1 through 7, as marked on top of the cap.
2. Fit cap so that the arrow points toward the timing gear (Top of each cap has a relief arrow mark).
3. Tighten cap, No.4 cap first. Then, tighten the other caps alternately on either side of No.4.

- (9) After tightening each cap, turn crankshaft to be sure that it rotates smoothly.
- (10) Mount oil pump, timing gear case, suction strainer, and oil pan.
- (11) Fit crankshaft pulley center to crankshaft, insert collar, and tighten front nut.
Tightening torque:
5,500 — 7,000 kg-cm (398 — 506 lb.ft.)
- (12) Mount crank pulley.
Tightening torque: 450 — 500 kg-cm (33 — 36 lb.ft.)
- (13) Mount rear oil seal and oil seal retainer.

4. Mounting oil seal

Use the jig placed as shown in Fig. 3-5-21 to press the sleeve in. Apply lithium grease to the oil sealing lips.

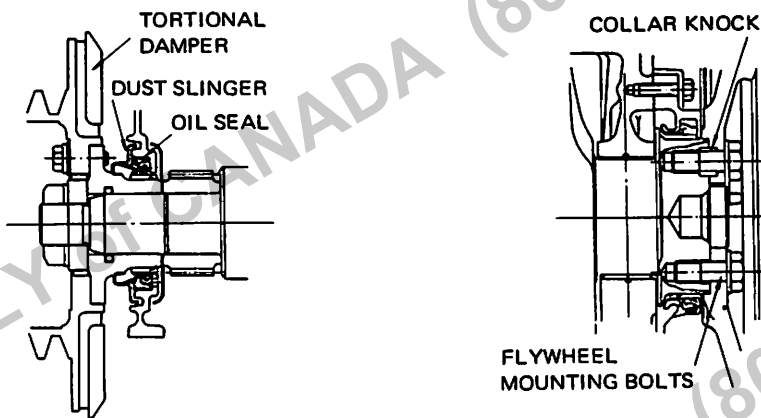


Fig. 3-5-20 Oil seal

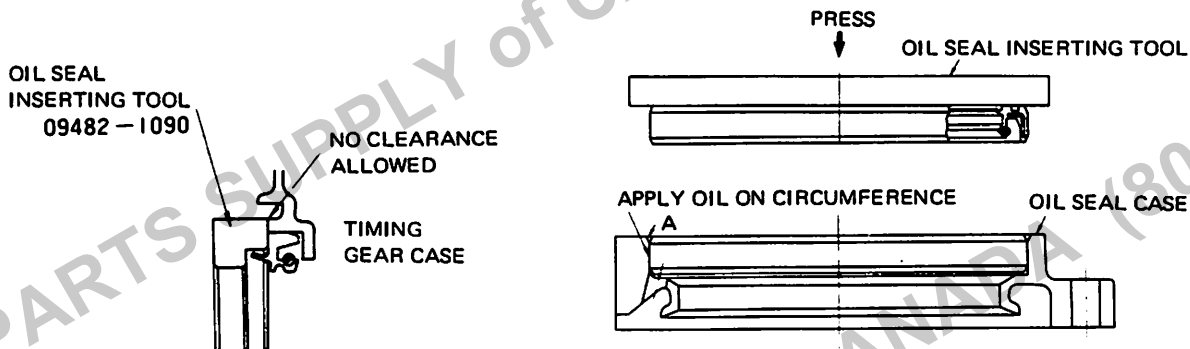


Fig. 3-5-21 Mounting oil seal

5. Mounting/dismounting of front sleeve and dust slinger

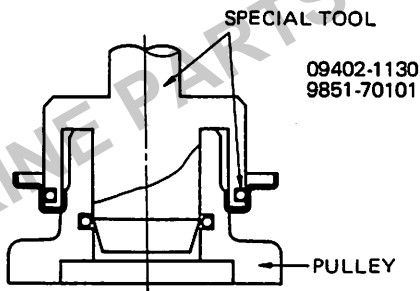


Fig. 3-5-22 Mounting dust slinger

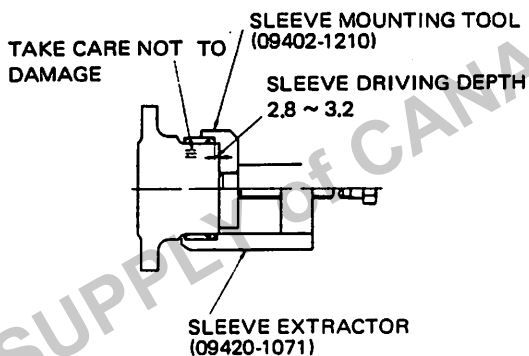


Fig. 3-5-23 Mounting/dismounting of front sleeve

6. Flywheel and ring gear

1. Flywheel and ring gear

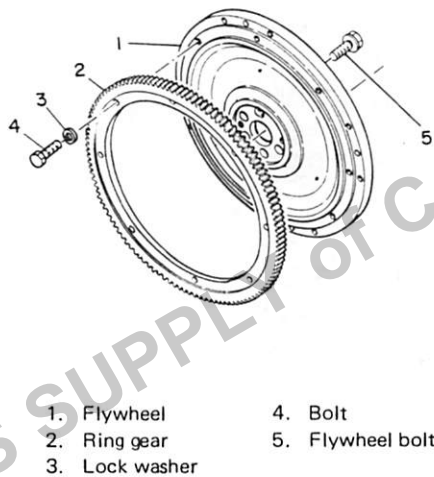


Fig. 3-5-24 Exploded view of flywheel and ring gear

2. Removal and disassembling

(1) Loosen flywheel mounting bolts.

Turn flywheel to remove it from crankshaft by striking a pillow block placed in the starter mounting hole lightly with brass hammer, taking care not to let the flywheel fall.

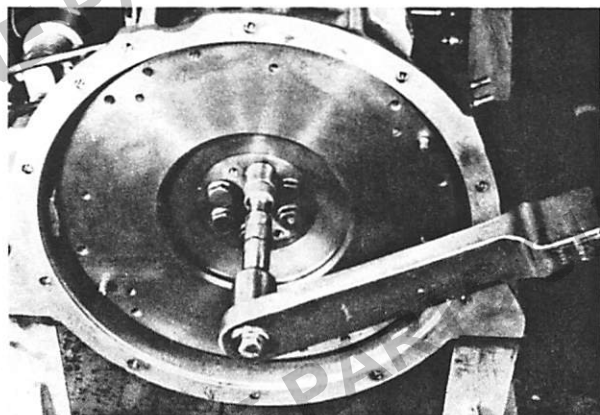


Fig. 3-5-25 Removal of flywheel

03-0619

(2) Remove ring gear. To remove, leave flywheel with ring gear in hot water at about 100°C for 3 – 4 minutes, then place something holding ring gear and tap the flywheel lightly around the edges until it comes out.

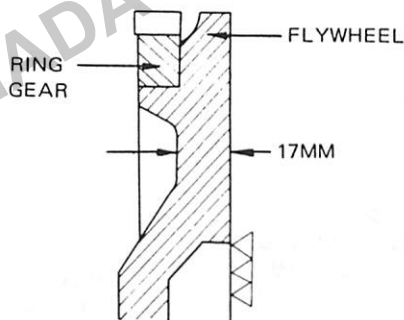
7. Inspection and Correction

1. Inspection of flywheel

(1) Check friction surface of flywheel for cracks and damage.

Replace if excessively damaged. Repair correctable faults.

(2) Measure the thickness of flywheel with appropriate device. Replace if the thickness exceeds the serviceable limit.



Unit: mm (in)

Thickness of flywheel	17.0 mm (0.67 in)
Serviceable limit	16.0 mm (0.63 in)

(3) Measure the distortion of flywheel friction surface with a dial gauge. If the distortion exceeds 0.3 mm (0.0118 in) correct by grinding.

2. Inspection of ring gear

Check ring gear teeth for wear and damage. Replace faulty gears.

3. Inspection of flywheel housing

Check for cracks.

8. Assembling and mounting

1. Mount flywheel ring gear

Leave ring gear in hot water at temperature of about 100°C (212°F) for 3 – 4 minutes. Then, fit it quickly to flywheel and bolt down.

Tightening torque: 260–320 kg·cm (19–23 lb.ft.)

2. Installing flywheel housing to cylinder block

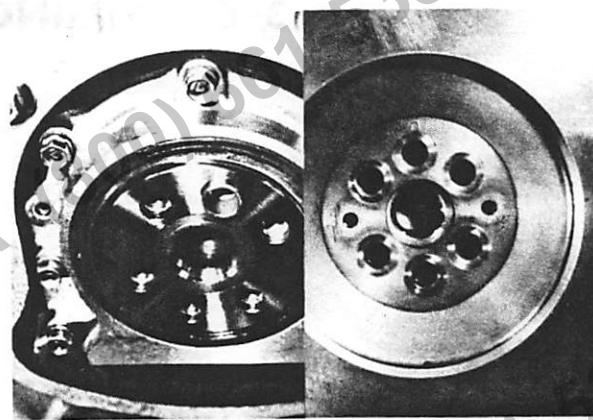
Tightening torque:

400–500 kg·cm (29–36 lb.ft.) (10 mm dia bolt)

650–870 kg·cm (47–62 lb.ft.) (12 mm dia bolt)

9. Mounting Crankshaft and Flywheel

Carefully clean the mounting surfaces of the crankshaft and flywheel. Match the "O" marks on flywheel and crankshaft collar and tighten opposite bolts evenly, tightening slightly each time in sequence. The final tightening torque is 1,800 – 2,000 kg·cm (131 – 144 lb.ft.)



LB3-035

03-0620

Fig. 3-5-26 Crankshaft flange and flywheel alignment mark

3-6 TIMING GEAR & CASE

DESCRIPTION

The arrangement of the timing gears is shown Fig. 3-6-1. The gears are helical, reducing noise and extending

their service life. All gears are stamped with identification marks as shown in Fig. 3-6-1. to facilitate assembly.

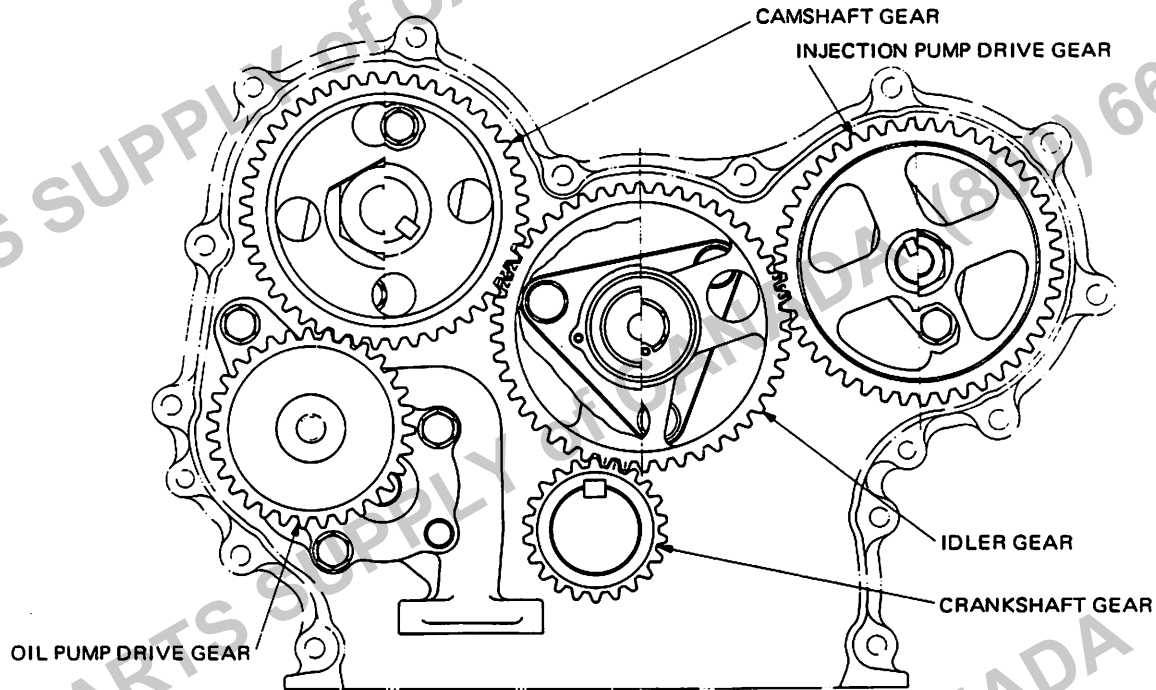
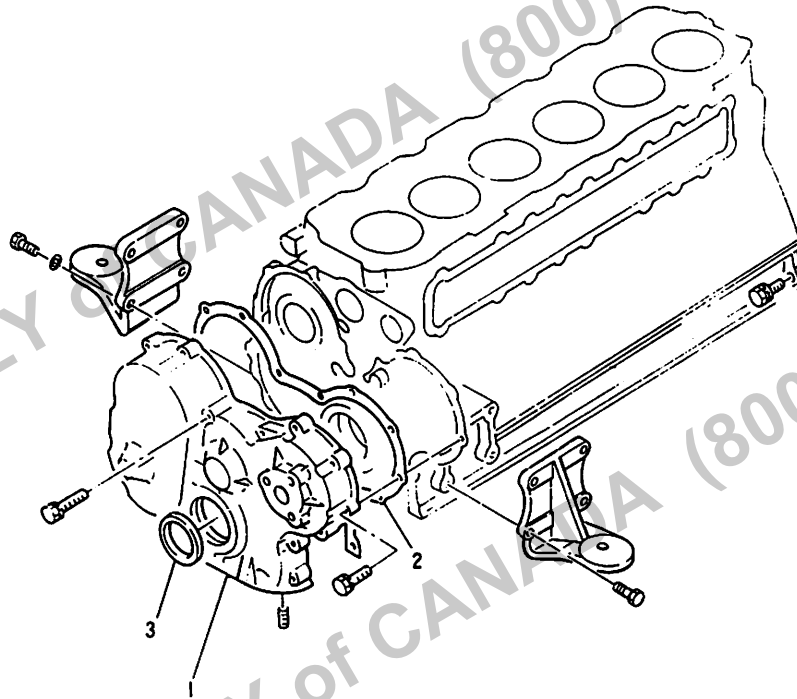


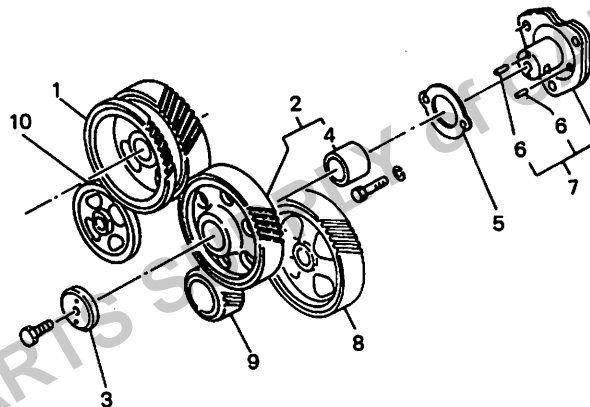
Fig. 3-6-1 Gear train

OVERHAUL
DISASSEMBLY



1. Timing cover
2. Timing gear cover gasket
3. Oil seal

Fig. 3-6-2 Timing gear case



- | | |
|------------------|------------------------|
| 1. Camshaft gear | 7. Idler gear shaft |
| 2. Idler gear | 8. Injection pump gear |
| 3. Thrust plate | 9. Crank shaft gear |
| 4. Bushing | 10. Oil pump gear |
| 5. Thrust plate | |
| 6. Pin | |

Fig. 3-6-3 Timing gear

- (1) After removal of crank pulley, loosen the timing gear cover clamping bolt to dismount the cover.

NOTE:

In removing the cover (aluminum alloy), pay utmost attention not to damage it.

- (2) Camshaft removal
Remove two thrust plate clamping bolts from the crankcase, and remove the gear, raise the turnups of the lock-washer, and use a puller after removal of the nut.
- (3) Injection pump drive gear removal
Remove the coupling from the injection pump, loosen the nut, and remove the pump gear and shaft block.
To remove the gear from the shaft, use a puller.

- (4) Idle gear removal
Loosen the clamping bolt, and remove the idler gear. To remove the idle gear shaft, loosen the flange clamping bolts and use a sliding hammer to remove the idle gear shaft.

1. INSPECTION

1. Inspection of injection pump drive shaft
 - (1) Check for wear and damage. Replace if faulty.
 - (2) Measurement of outside diameter of pump drive shaft
Measure outside diameter of drive shaft, also measure inside diameter of bushing, with a micrometer and a dial gauge. The difference between the two measurements is the clearance between shaft and bushing.

Clearance between shaft and bushing Unit: mm (in)

Standard	Serviceable limit
0.030 – 0.072 (0.0012 – 0.0028)	0.3 (0.0118)

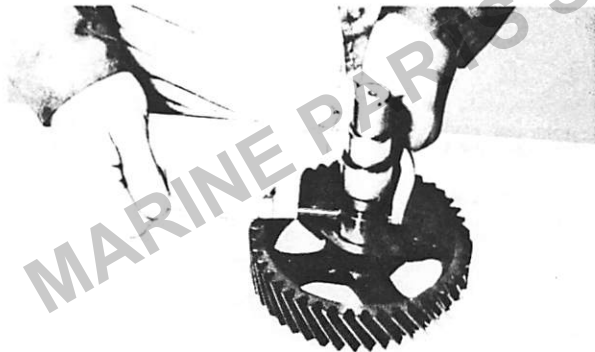


Fig. 3-6-4 Measuring O.D. of pump drive shaft

KT3-279

- (3) End play measurement of pump drive gear
Measure the clearance between thrust bearing and pump drive gear with a feeler gauge. If the clearance exceeds tolerance, replace the thrust bearing.

End play Unit: mm (in)

Standard	Serviceable limit
0.040 – 0.088 (0.0016 – 0.0035)	0.1 (0.0039)

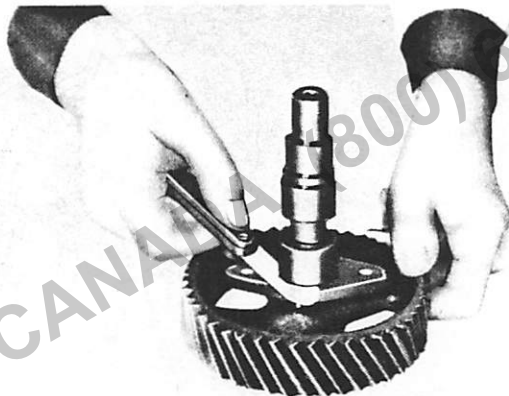


Fig. 3-6-5 End play measurement of pump gear

KT3-280

2. Inspection of idle gear shaft
 - (1) Check gear teeth for wear and damage. If faulty, replace.
 - (2) Measure idle gear shaft outside diameter and gear bushing inside diameter.
Measure clearance between idle gear and idle gear shaft with a micrometer and a cylinder gauge.

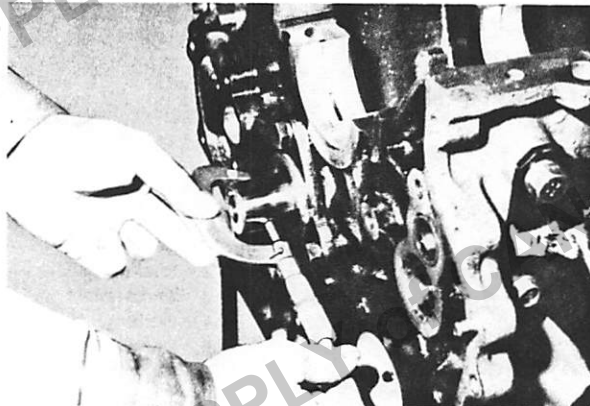


Fig. 3-6-6 Measuring idle gear shaft O.D.

KT3-283

Idle gear and idle gear shaft

Unit: mm (in)

	Standard	Serviceable limit
Clearance	0.025 – 0.075 (0.0010 – 0.0029)	0.20 (0.0078)
Outer diameter of shaft	34 (1.3386)	33.85 (1.3328)

(3) End play measurement of idle gear

Insert feeler gauge between idle gear and thrust bearing to measure end play. If the measurement exceeds serviceable limit, replace the thrust bearings.

End play

Unit: mm (in)

Standard	Serviceable limit
0.03 – 0.11 (0.0012 – 0.0043)	0.30 (0.0118)



Fig. 3-6-7 Measuring the idle gear thrust play

KT3-284

ASSEMBLY AND ADJUSTMENT

- (1) Mount the camshaft assembly into the cylinder block and tighten the thrust plate with two bolts. Tightening torque:

500 – 600 kg-cm (37 – 43 lb.ft.)

Note:

When installing the camshaft drive gear to the shaft, it must be tightened with following torque.

Tightening torque:

2,500 – 3,000 kg-cm (181 – 217 lb.ft.)

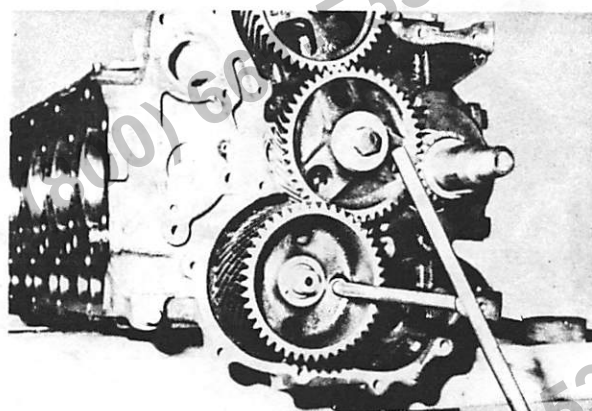


Fig. 3-6-8 Mounting the camshaft drive gear

KT3-281

- (2) Mount idle gear shaft, making sure of its oil hole and cylinder block oil channel. Check oil hole of idle gear shaft for blockage, and see that shaft end is complete with screw (blind plug).

Unit: kg-cm (lb.ft)

Idle gear shaft filling bolt	500 – 650 (36 – 47)
Idle filling bolt	1,100 – 1,300 (80 – 94)

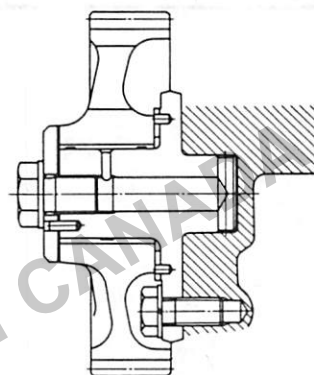


Fig. 3-6-9 Cylinder block oil channel

- (3) Mount injection pump drive gear and shaft to cylinder block.

Thrust plate tightening torque:

190 – 260 kg-cm (14 – 19 lb.ft.)

- (4) Mount idle gear, observing timing mark.

Thrust plate tightening torque:

1,100 – 1,300 kg-cm (80 – 94 lb.ft.)

- (5) Mount oil pump

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

- (6) Backlash measurement of each gear

Measure with dial gauge. Replace if faulty.

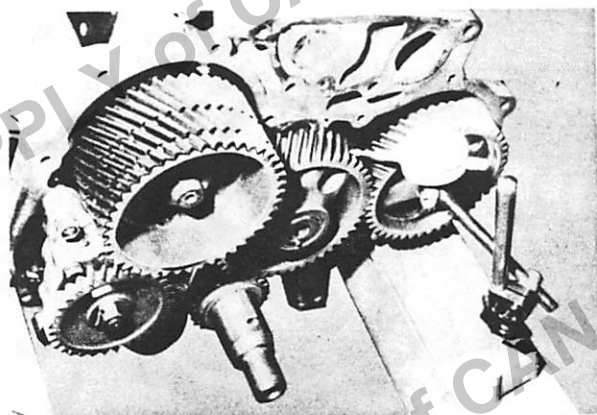


Fig. 3-6-10 Backlash measurement

KT3-282

- (7) Mount oil slinger
- (8) Fit timing gear cover to cylinder block. Cut off any packing extending over oil pan surface.
- (9) Inspect timing gear case and oil seal for cracks, wear on lip, tension, and deposits of foreign matter.

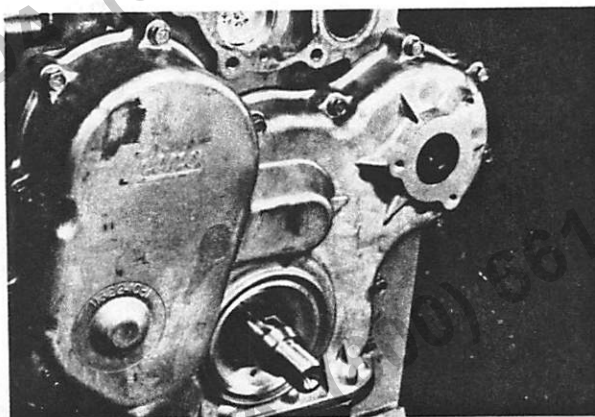


Fig. 3-6-11 Mounting timing gear cover

03-0621

Backlash

Unit: mm (in)

Gears	Standard	Serviceable limit
Crank gear — Idle gear		
Idle gear — Camshaft drive gear	0.051 — 0.11 (0.0020 — 0.0043)	0.3 (0.0118)
Idle gear — Injection pump drive gear		
Camshaft drive gear — Oil pump drive gear	0.07 — 0.22 (0.0028 — 0.0086)	

3-7 FUEL SYSTEM

DATA & SPECIFICATIONS

NOZZLE	
Type	BOSCH type, NIPPON DENSO make (ND-DLLA-150S31-33ND97)
NOZZLE HOLDER	
Injection pressure	220 kg/cm ² (3,128 lb/sq.in)
FUEL FILTER	
Type	Replaceable paper element type

DESCRIPTION

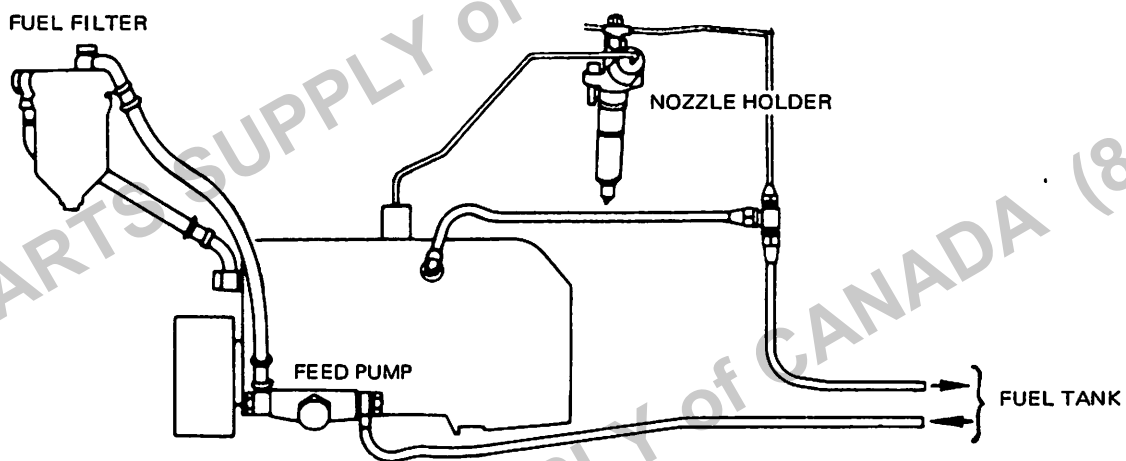
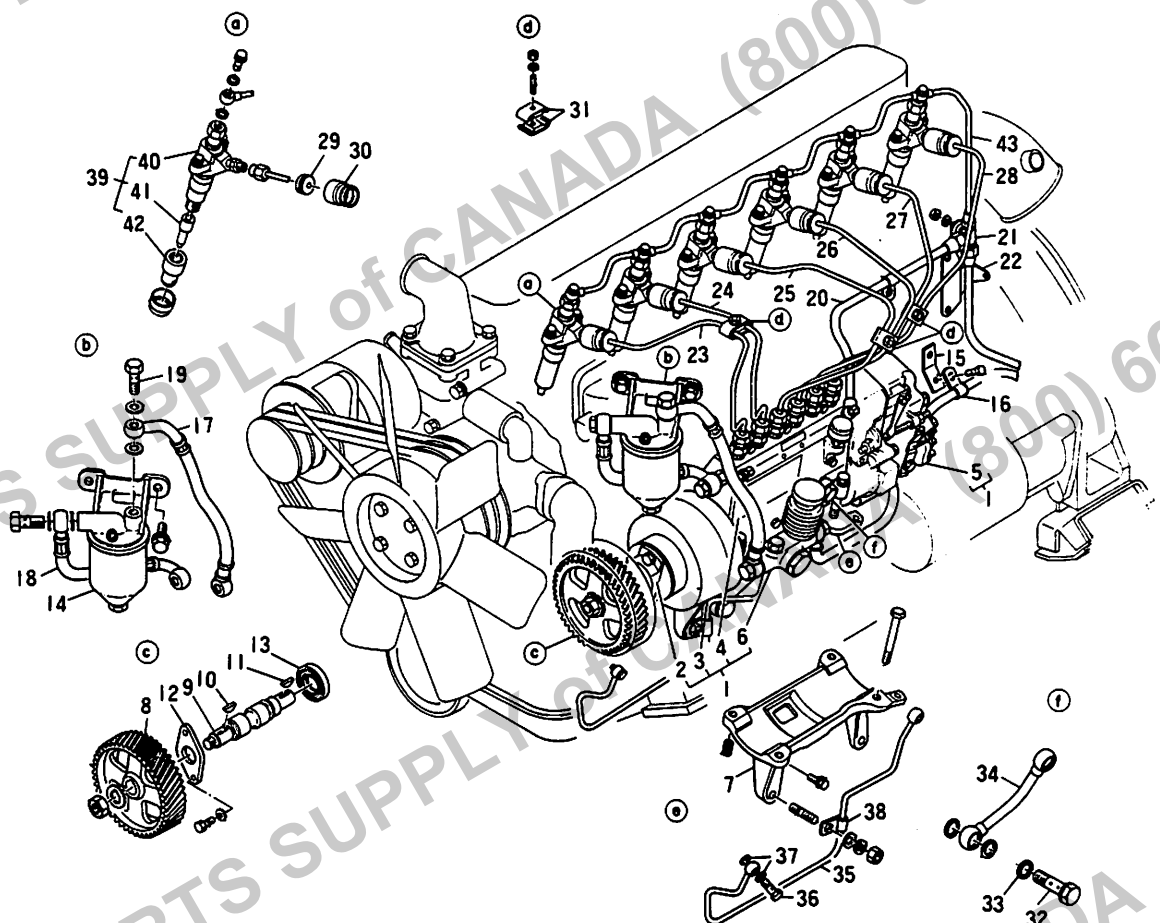


Fig. 3-7-1 Fuel system



- | | | |
|-------------------------------|------------------------------------|-------------------------------|
| 1. Injection pump assy | 17. Fuel hose | 33. Soft washer |
| 2. Coupling assy | 18. Fuel hose | 34. Oil pipe |
| 3. Auto timer assy | 19. Bolt | 35. Oil pipe |
| 4. Injection pump assy | 20. Through feed pipe | 36. Bolt |
| 5. Governor assy | 21. 3-way joint | 37. Soft washer |
| 6. Fuel feed pump assy | 22. Fuel pipe bracket | 38. Clip |
| 7. Injection pump bracket | 23. Fuel injection pipe No. 1 | 39. Nozzle and holder assy |
| 8. Injection pump drive gear | 24. Fuel injection pipe No. 2 | 40. Nozzle holder assy |
| 9. Injection pump drive shaft | 25. Fuel injection pipe No. 3 | 41. Nozzle assy |
| 10. Woodruff key | 26. Fuel injection pipe No. 4 | 42. Packing pipe leakage ring |
| 11. Woodruff key | 27. Fuel injection pipe No. 5 | 43. Nozzle leakage pipe |
| 12. Thrust bearing | 28. Fuel injection pipe No. 6 | |
| 13. Oil seal | 29. Fuel injection pipe protection | |
| 14. Fuel filter assy | 30. Rubber cap skirt | |
| 15. Retainer bracket | 31. Clip | |
| 16. Clip | 32. Bolt | |

Fig. 3-7-2 Fuel system in position

1. Fuel System Piping and Its Operation

As shown in Fig. 3-7-1, the fuel feed pump draws fuel from the fuel tank. The fuel passes through the fuel filter and is fed to the fuel injection pump. The injection pump forces the fuel, under high pressure, through the injection lines to the nozzles where it is injected. Some fuel reached the nozzle lubricates the nozzle needle. After lubricating, it returns to the tank through the leakage pipe.

On the injection pump, a governor and timer are installed. The governor controls the idling speed and maximum speed of the engine, the timer adjusts the fuel-injection timing.

2. Precautionary Notes

1. Bleeding air from the fuel system.

Never be air bubbles in the fuel. Bleed air from the fuel system in cases below;

- (1) When a new pump is used.
- (2) When the pump is used after a long period of cessation.
- (3) When the piping is loosened or replaced.
- (4) When air bubbles are found in the fuel.

Procedure

1) Between fuel tank and feed pump

Loosen the connector at the feed pump outlet.

Move the primary pump on the feed pump up and down to discharge the fuel, and close the connector when the air bubbles in the fuel have disappeared.

2) Between feed pump and filter

Loosen the air bleeder screw equipped on the fuel filter and conduct air bleeding in accordance with the instructions given in 1) above.

3) Between filter and injection pump

Air bleeding between filter and injection pump can be conducted automatically through the overflow pipe by operating the priming pump several times.

4) When bleeding has been completed, screw the priming pump knob firmly into the cylinder body so as to prevent the entry of air through it.

2. Injection steel pipe

Use the specified injection steel pipe because its resistance and length have a considerable effect on both injection volume and efficiency.

In the case of new piping, use it after cleaning for approximately twenty minutes under an injection pressure of 200 – 300 kg/cm² (2,844 – 4,266 lb/sq.in.)

NOZZLE & NOZZLE HOLDER

DESCRIPTION

The nozzle employed is of direct injection Bosch-hole type, with a spray angle of 150°. To improve combustion efficiency, this nozzle employs a combination injection hole system having two holes of 0.31 mm (0.0122 in.) I.D. and two holes of 0.33 mm (0.0130 in.) I.D. The nozzle is designed to open at 220 kg/cm². The nozzle holder is housed in a copper sleeve which is caulked into the cylinder block. And this nozzle holder is cooled by way of the sleeve which is cooled by the water jet in the water jacket.

The nozzle is located by a dowel pin provided in the nozzle holder body. The flanged nozzle holder is inserted in and tightened with 2 bolts to the cylinder head. The setting angle and positioning of the nozzle holder are, therefore, determined automatically.

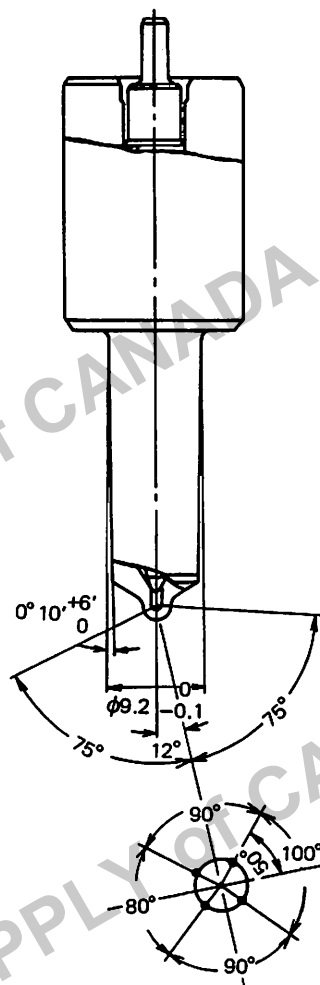
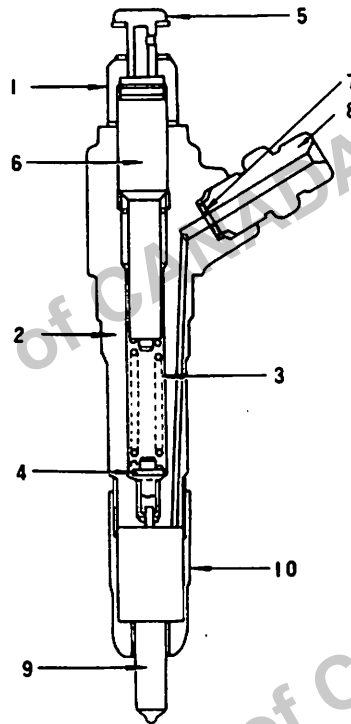


Fig. 3-7-3 Injection nozzle



- 1. Cap nut
- 2. Nozzle holder assy
- 3. Pressure spring
- 4. Pressure pin
- 5. Hollow screw
- 6. Adjusting screw
- 7. Connector gasket
- 8. Inlet connector
- 9. Nozzle assy
- 10. Retaining nut

Fig. 3-7-4 Nozzle and nozzle holder

TEST OF NOZZLE

1. Visual Checks of Nozzle and Nozzle Holder, and Cautions for Assembling

A fuel injection nozzle is a high precision product, and therefore be handled with utmost care.

(1) Nozzle

Check the nozzle for choking at the injection hole and carbon deposit. Also check the seat and needle valve sliding portion. Then, put the nozzle body and needle valve in clean light oil to check them for sliding condition.

(2) Nozzle Holder

Carefully check the contact surface with the nozzle, push rod tip and nozzle spring for damage. Also, check to see whether or not the push rod is bent.

(3) Cleaning Carbon

Clean carbon off from the surface of the nozzle and nozzle holder with carbon cleaner or carbon cleaning tool with care taken not to damage the nozzle. Then, rins the parts with clean light oil. Incomplete rinsing will degrade nozzle functions causing its life to be shortened.

(4) When Assembling Nozzle to Nozzle Holder

Assemble the nozzle to its holder with the pressure adjusting screw kept loose and with care not to allow the nozzle center to deviate from the nozzle holder center.

2. Hand Test with Nozzle Tester

The quality of a nozzle is determined by the pattern and angle of injected mist, the end timing of injection, the leak condition after injection, and other factors. Note that the state of mist will differ depending on the property or temperature of the test oil, and the speed at which the hand lever of the nozzle tester is operated.

(1) Injection Starting Pressure Test

Set the specified injection starting pressure by turning the adjusting screw of the nozzle holder. Dust in the nozzle can not only result in incorrect injection but also vary the injection starting pressure every time when injection is made.

(2) Nozzle Spray Test

Operate the nozzle tester hand lever at a stroke of 4-6 per second and check the spray mist to see that it is uniform without abnormality due to the blocked injection hole.

The nozzle will provide coarse mist compared with an ordinary nozzle if the hand lever is operated at a lower speed. Actually, however, an engine is not run at such a low fuel injection rate. It therefore is not necessary to check mist when the lever is operated at such a low speed.

Spray Mist from Good Nozzle at Hand Test

Lever speed for nozzle test
(4-6 strokes/second)

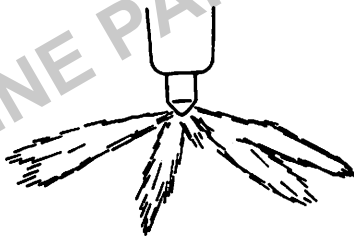


Fig. 3-7-5 (Uniform)

Condition at lower lever speed
(1 stroke/second)

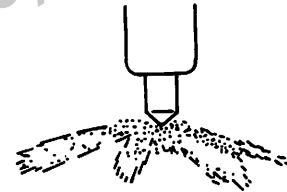


Fig. 3-7-6 (Coarse)

Uniform spray mist can be obtained at the specified lever speed though the mist is coarse when the lever speed is low.

(3) Valve Seat Test

Keep the fuel pressure 20 kg/cm^2 lower than the specified injection pressure by the nozzle tester (for 30 seconds) and confirm that no fuel drops down from the nozzle tip.

3. Nozzle Replacement Intervals

Whether or not the nozzle can be used continuously is determined by conducting a hand test with a nozzle tester, seeing the sliding condition of the needle valve, and performing visual checks to see the degree of wear. Always keep in mind that the spray mist will become coarse as the nozzle tester hand lever is operated slowly. In case a nozzle is found unacceptable through an valve seat test or visual checks, do not attempt to correct the faulty nozzle by fitting the nozzle body with the needle valve seat but change new nozzle assembly.

FUEL FILTER

DESCRIPTION

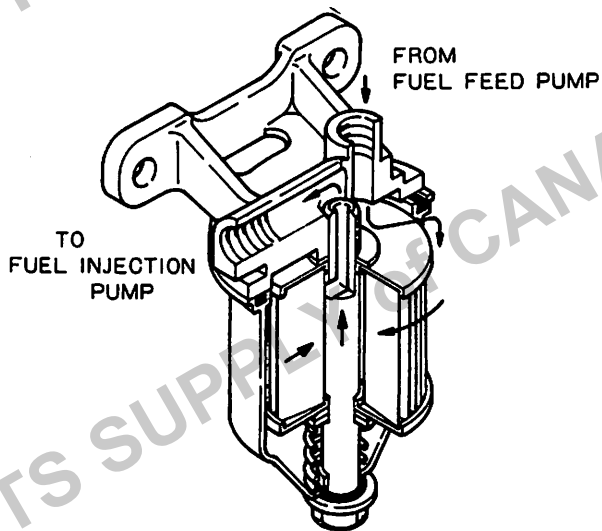


Fig. 3-7-7 Fuel filter

Contaminated fuel may damage the injection pump and nozzles, increase wear and hamper operation. For this reason, the fuel must be filtered properly.

That is, the fuel from the feed pump is filtered as it passes from the periphery of the filter element toward its center, and the filtered fuel is fed into the injection pump. This fuel filter contains a synthetic resin-processed, paper element.

OVERHAUL

Dismounting

1. Disconnect the fuel line.
Loosen the fuel and injection pump connections, and that of the fuel filter. Handle the fuel pipe with care.
2. Take out the two retaining bolts and remove the filter assembly.

Disassembly

1. Loosen the cap center bolt, take out the center bolt, and disassemble.
2. Remove the bleeder screw and drain plug.

Cleaning

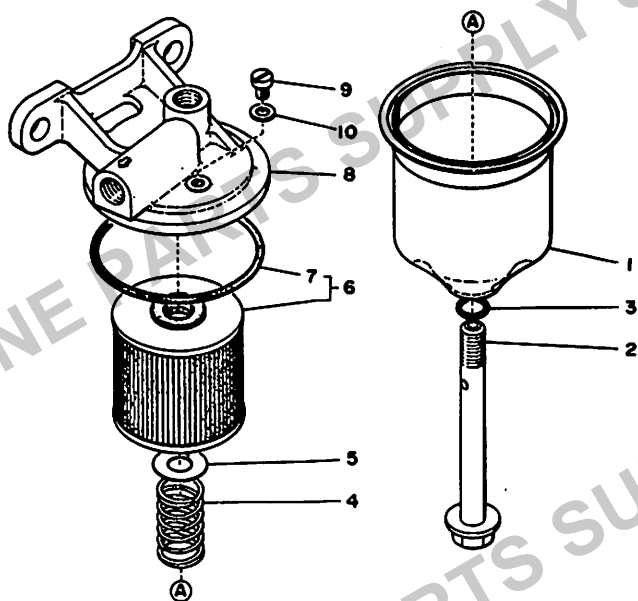
1. Plug the upper and lower filter-element openings so that dirt cannot enter, and immerse the element in the solvent. Clean thoroughly by moving it briskly about in the solvent.
2. Clean the other parts with clean solvent and dry with compressed air.

Assembly

1. Position the barrel gasket correctly, and tighten the center bolt carefully. Excessive tightening will damage the barrel and O-rings.
2. Tighten the air bleeder and drain plug until no leakage is evident. Excessive tightening will damage the gasket.

Mounting

Mount the filter on the engine, connect the fuel lines and bleed the air.



- | | |
|------------------------|--------------------|
| 1. Body | 6. Element kit |
| 2. Center bolt | 7. O-ring cover |
| 3. O-ring | 8. Body cover |
| 4. Element spring seat | 9. Bleeder plug |
| 5. Element spring | 10. Bleeder gasket |

Fig. 3-7-8 Fuel filter

3-8 LUBRICATING SYSTEM

DESCRIPTION

1. Function of Engine Oil

Engine oil functions in the following manner:

1. Friction reducing action

It insures a minimum loss of power by reducing the friction of moving parts (bearings, pistons, etc.)

2. Cooling action

It prevents engine temperature from becoming excessively high by transmitting the heat generated by friction and combustion.

3. Sealing action

It checks compression or combustion pressure leaks by

sealing between the piston rings and cylinder walls.

Thus the highest engine performance is maintained.

4. Detergent action

It cleans the lubricated parts of dusts or metal dust or cylinder like carbon, thus preventing the premature wear of the lubricated parts which may be caused by those admixtures and furthermore, it disperses carbon and sludge into oil so that those may not collect in the lubricated parts or in the oil line.

5. Anti-corrosive action

It prevents the metals from rusting by corrosive gas or moisture.

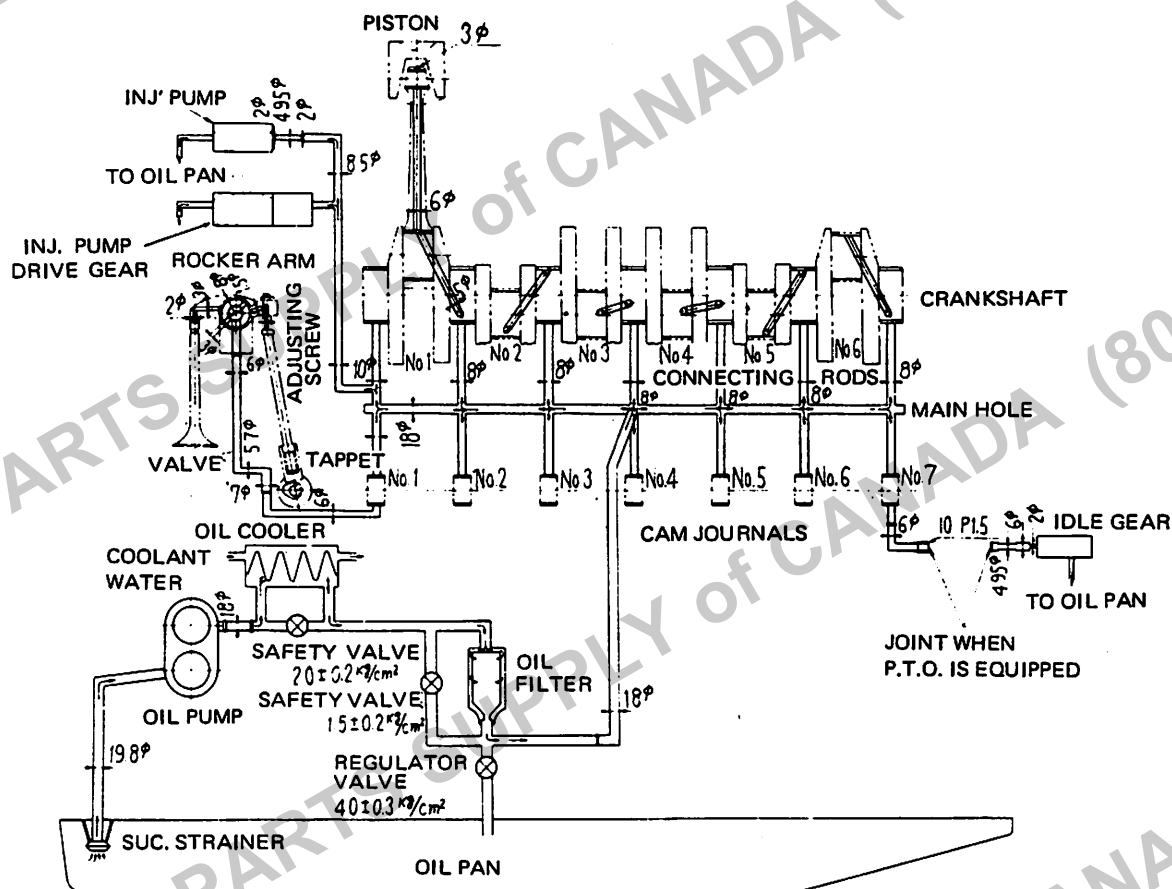


Fig. 3-8-1 Oil circulating system

2. Oil Circulating System

Lubricating oil is pumped up through the strainer by the oil pump in the timing gear case on the front side of the crank case. It makes heat exchange with the cooling water while passing through the oil cooler. The oil com-

ing out from the oil cooler is sent to the full-flow filter in which dust and sludge are removed through 10–40 micron voids. After having the pressure adjusted by the regulator valve, the oil passes through the main oil hole

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in the crank case lubricating the main bearing cam bearing, etc. After passing the oil cooler, a part of oil is sent to instead of entering the full-flow filter and fine dust and sludge are filtered. Then the oil returns to the oil pan.

A part of oil, reaching the main bearing, passes through the oil hole of the crank shaft, lubricating the big-end of the connecting rod, then enters the oil hole of the connecting rod and lubricates its small-end. A part of oil reaching the small-end of the connecting rod is jetted from the oil hole at the upper part of the small-end toward the lower surface of the piston and functions positively to cool the piston.

To the piston and the liner splash lubrication is applied in most cases.

The oil coming through above routes returns to the oil pan passing the lower part of the crank case.

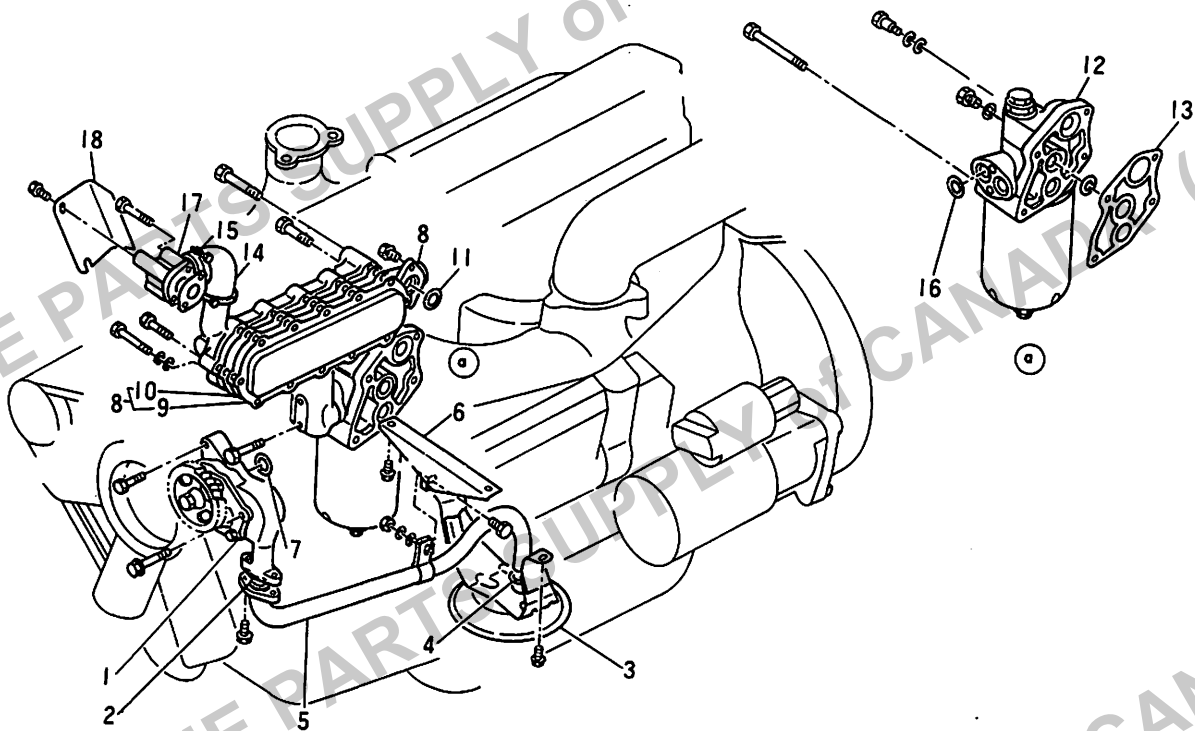
On the other hand, the oil supplied to the idle gear shaft becomes spray to lubricate the timing gear. This oil comes back to the oil pan passing the lower end of the timing gear case.

For the lubrication of the rocker arm shaft, oil is sent through the cam shaft head.

Via the cylinder head, pedestal and the rocker shaft, then, guided to the rocker arm. A part of this oil passes the hole in the rocker arm and comes along the rocker arm to lubricate the top of the valve stem. The oil passing the above routes drops from the hole of the push rod on the upper surface of the cylinder head and lubricates the tappet guide, then returns to the oil pan.

2. Lubricating Oil capacity

It takes about 14 liter (3.0 Imp.gal/3.70 U.S. gal) to fill the engine lubricating system.



- | | | |
|------------------------|---------------------|-------------------------------------|
| 1. Oil pump assy | 7. O-ring | 13. Oil filter gasket |
| 2. O-ring | 8. Oil cooler assy | 14. Water hose |
| 3. Oil strainer | 9. Gasket | 15. Clamp |
| 4. O-ring | 10. Oil cooler case | 16. O-ring |
| 5. Oil pump inlet pipe | 11. O-ring | 17. Coolant oil cooler pipe |
| 6. Oil pipe bracket | 12. Filter assy | 18. Exhaust manifold heat insulator |

Fig. 3-8-2 Lubricating system

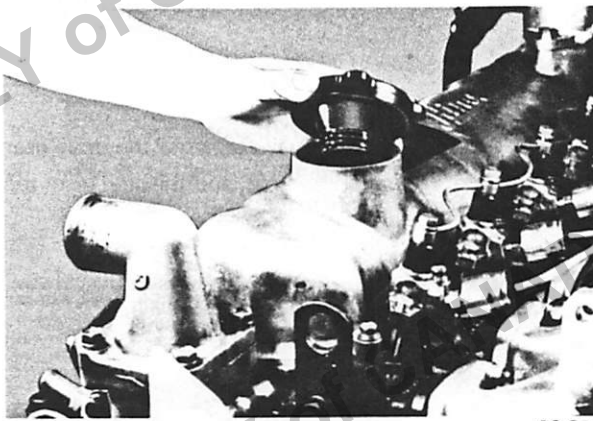


Fig. 3-8-3 Oil filler cap

03-329

3. Exchanging the Engine Oil

As to interval of exchanging the engine oil.

Shorten the interval as necessary, according to operational conditions. Engine oil gets dirty sooner than usual while the engine is still new or immediately after an overhaul or — during break-in periods. Change engine oil after 30 hours of operation during such periods.

Do not drain oil until its temperature has sufficiently risen. Cold oil lacks fluidity and may fail to completely discharge the sludge deposited on the bottom. In such a case, new oil filled after draining will become dirty quickly.

OIL PUMP

DESCRIPTION

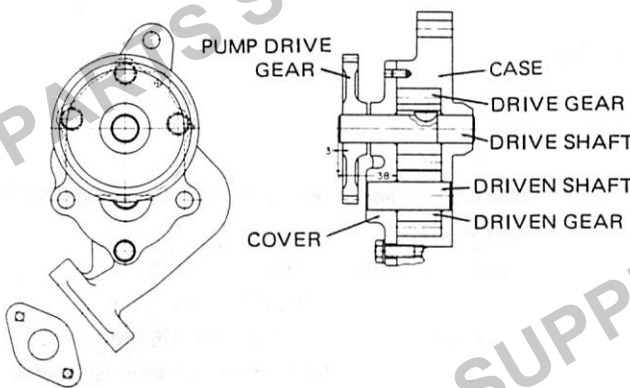


Fig. 3-8-4 Oil pump

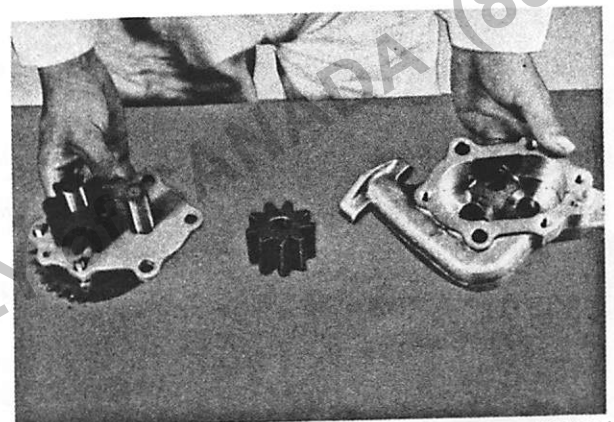


Fig. 3-8-5 Oil pump disassembled

03-769

- (1) Oil pump
Gear-type pump mounted on the front of cylinder

block is driven with the cam shaft gear. Supplies enough oil to cool piston and valve stem.

OVERHAUL

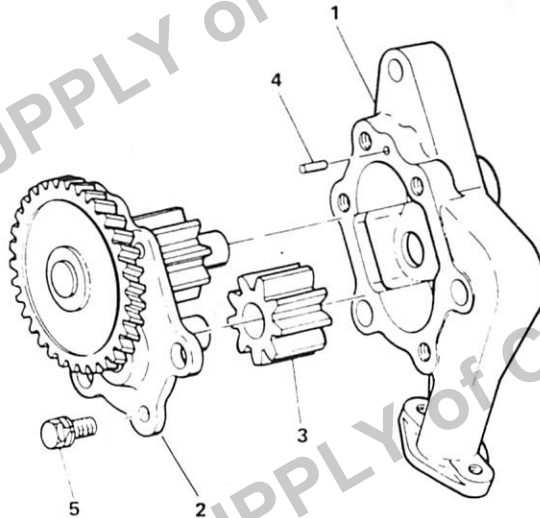
Disassembly

- (1) Remove the clamp bolt from the drive gear, and pull the drive gear out of the drive shaft by means of a puller.
- (2) Remove the cover and driven shaft en bloc.
- (3) Remove the drive gear (together with shaft) and driven gear from the case.

- (4) Use a press or hammer to separate the drive gear from the drive shaft (keyed), and the case from the driven shaft (press fitted).

NOTE:

In separating each parts with a press or puller pay atmost attention not to damage them (alminum alloy).



1. Oil pump body
2. Oil pump cover sub ass'y
3. Oil pump driven gear
4. Straight pin
5. Bolt

Fig. 3-8-6 Oil pump

Inspection and Repair

Clean and inspect each part, and replace it with a new one if it is found worn out beyond service limit.

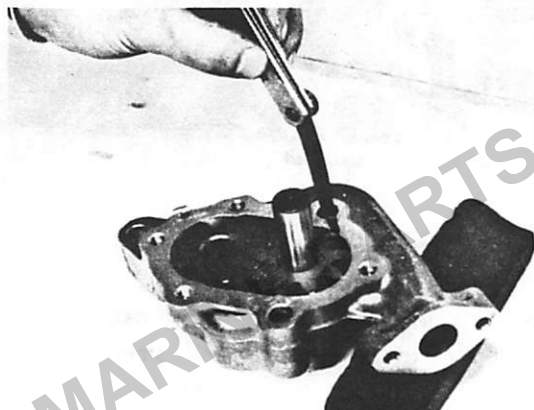


Fig. 3-8-7 Measure the clearance between teeth and case

03-228

- (1) Measure the gap between the pump case and gear teeth with a thickness gauge.
 Standard value: 0.030 – 0.100 mm
 (0.0012 – 0.0039 in.)
 Serviceable limit: 0.13 mm (0.0051 in.)
 At this time, check for wornout or seriously defective gears also. They should be renewed.
- (2) Place a straight edge on the cover mounting surface of the case, and measure the gear end play with a thickness gauge.
 Standard value: 0.040 – 0.088 mm
 (0.0016 – 0.0035 in.)
 Serviceable limit: 0.15 mm (0.0059 in.)

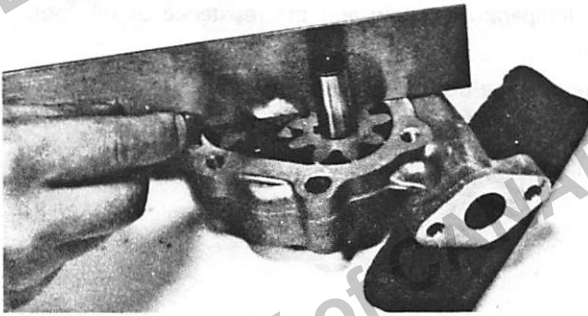


Fig. 3-8-8 Measurement of end play 03-229

- (3) Check the gap between the drive shaft and case with a micrometer and a cylinder gauge.

Standard value: 0.040 – 0.085 mm
(0.0016 – 0.0033 in.)

Serviceable limit: 0.1 mm (0.0039 in.)



Fig. 3-8-9

KR-149

- (4) Check the gap between the driven shaft and driven gear with a micrometer and a cylinder gauge.

Standard value: 0.040 – 0.083 mm
(0.0016 – 0.0033 in.)

Serviceable limit: 0.1 mm (0.0039 in.)

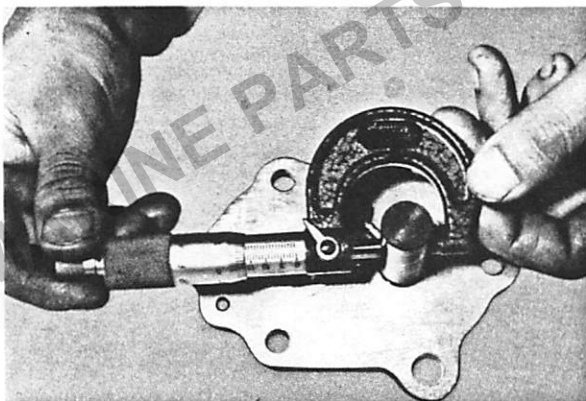


Fig. 3-8-10

03-045

- (5) Check the backlash of the gears

Standard: 0.15 – 0.28 mm
(0.006 – 0.011 in.)

Serviceable limit: 0.50 mm (0.0197 in.)

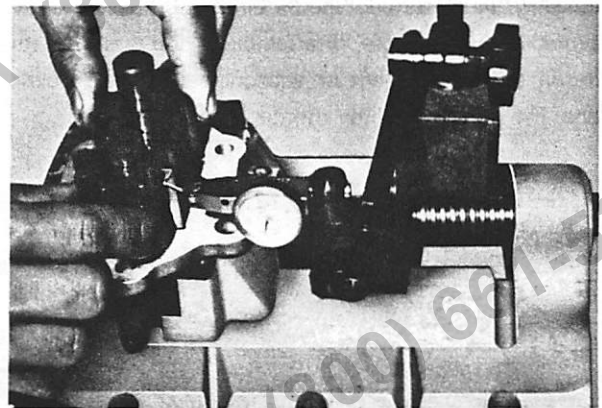


Fig. 3-8-11 03-046

Assembly and Adjustment

- (1) Before assembling the pump, apply clean engine oil to the shafts, gears, and pump case.
- (2) Assemble the pump by reversing the sequence of disassembling steps, making sure to refit the keys properly to secure the pump drive gear and helical gear in place and to lock the nut by bending the lock washer after the helical has been mounted on the drive shaft.

OIL COOLER

DESCRIPTION

The oil cooler is provided to keep automatically the proper temperature of oil to be supplied to all parts of Engine.

Oil cooler is incorporated in the water jacket on the right hand side of cylinder block. Its multiple disc construction, with little pressure loss, head exchange. This maintains proper oil temperature, extending the life of both engine metal and engine oil.

The oil supplied by the oil pump runs in the inside of the oil cooler unit and the cooling water flows along its outside. When the temperature of oil is higher than that of water, it functions as an oil cooler and oil is cooled.

In the reverse case, it functions as an oil heater and oil is heated. Thus, the proper temperature is always maintained. The function of oil heater makes it possible to raise rapidly the oil temperature even in the cold season.

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This is effective not only in making idling time shorter but also in the prevention of abrasion at various parts of the engine.

When the inside becomes dirty and clogged, the passing resistance increases and the oil circulation becomes unfavorable. In such case, disassemble it and wash it with the oil sludge detergent or aqueous solution of caustic soda. Fit it after washing thoroughly with water.

Generally, it will be all right to wash it at every mileage of 60,000km. A safety valve is provided to bypass the oil to prevent the abnormal rise of oil pressure when the oil temperature is low and the resistance of oil cooler is high.

The opening pressure of this valve that is installed in the oil filter is 2.0 kg/cm² (28.44 lb/sq.in).

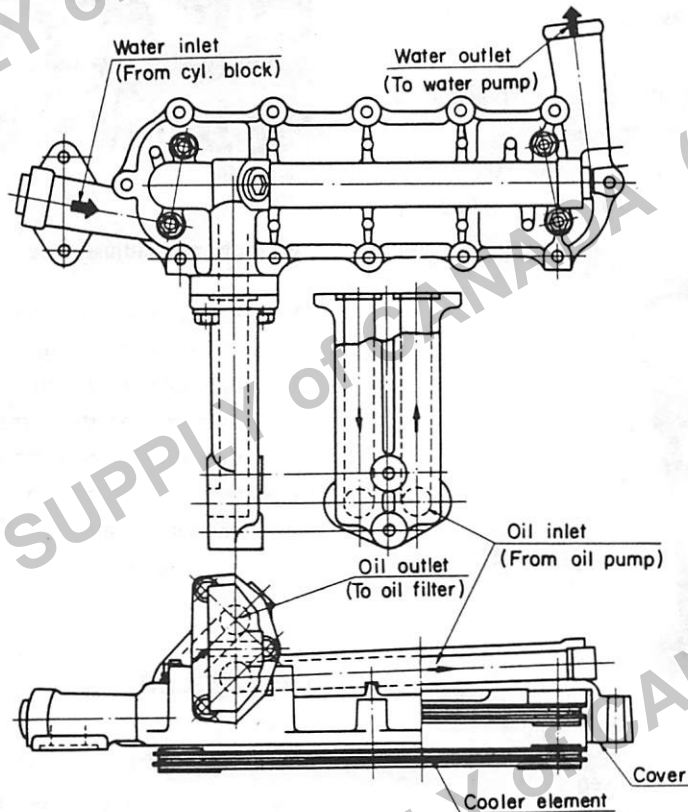


Fig. 3-8-12 Oil cooler

DISASSEMBLY

In disassembling separate it from the side of the oil filter in contact with the cooler. Desist from an attempt to separate the oil cooler body from the pipe connected.

INSPECTION

Testing pressure of the element 6 kg/cm² (85.32 lb/sq.in)
If any leak is found, replace it Never use it again by repairing.

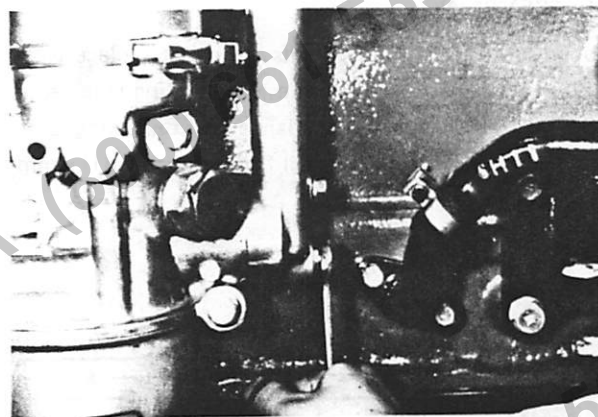
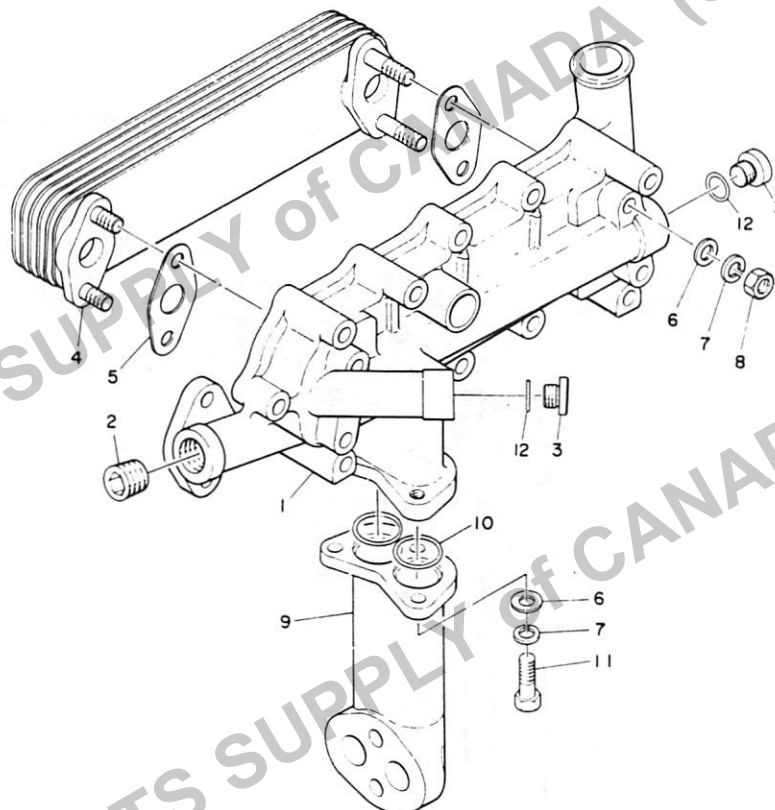


Fig. 3-8-13

KT3-288



- | | | |
|-----------------------|-------------------|--------------------|
| 1. Case | 5. Element gasket | 9. Oil cooler pipe |
| 2. Taper plug | 6. Plain washer | 10. O-ring |
| 3. Taper plug | 7. Lock washer | 11. Bolt |
| 4. Oil cooler element | 8. Nut | 12. O-ring |

Fig. 3-8-14

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REASSEMBLING

Do not use O-ring and gaskets again but replace each time they are removed. Before reassembling make sure that the gap between the flange of connecting pipe fitted to the cooler and the oil filter is less than 0.5 mm (0.02 in.)

Tightening torque:

Unit: kg-cm (lb.ft)

Oil cooler fitting bolt	190 - 260 (14 - 18)
Oil cooler element fitting nut	150 - 180 (11 - 13)

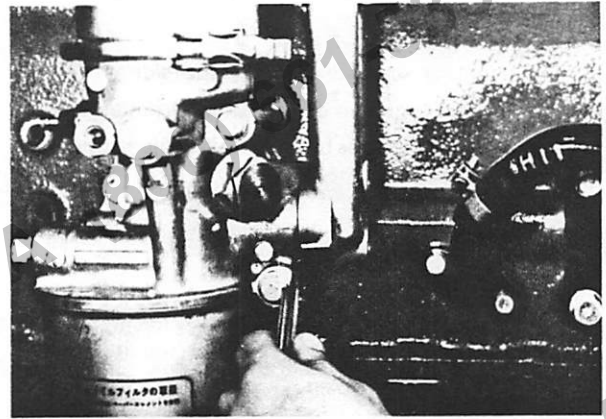


Fig. 3-8-15

LB3-049

OIL FILTER

DESCRIPTION

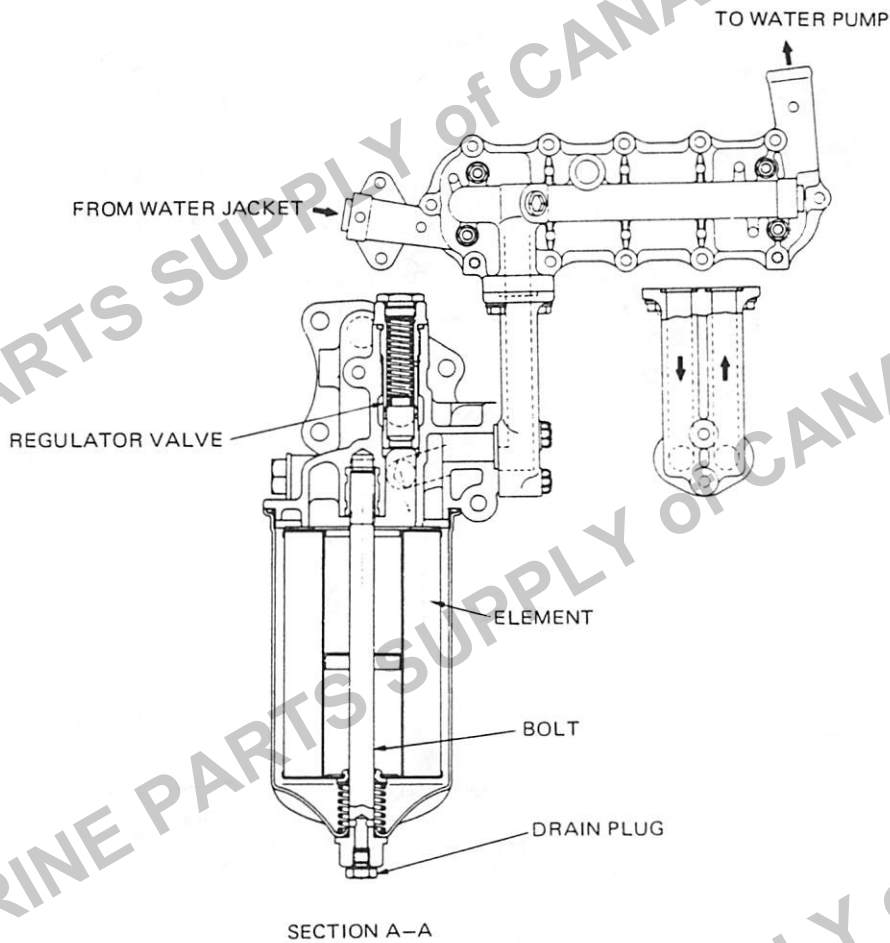


Fig. 3-8-16 Oil filter

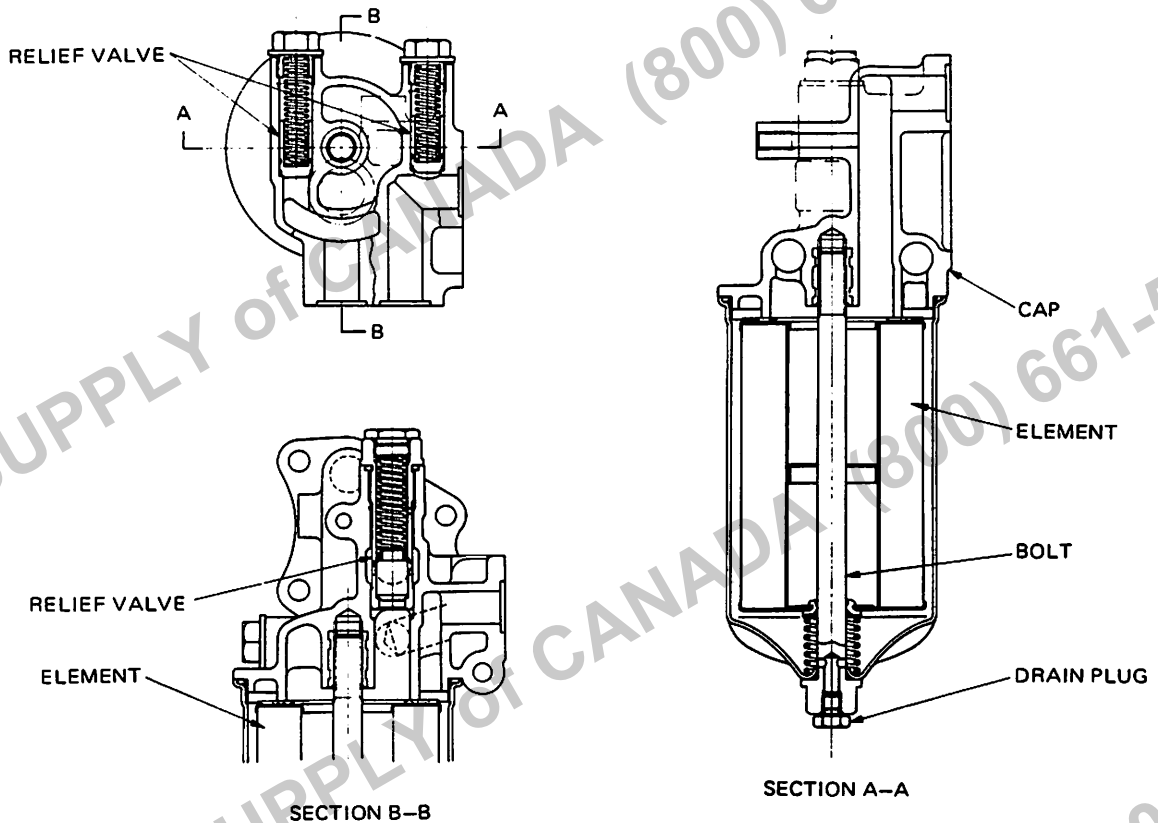


Fig. 3-8-17 Detail of oil filter

The oil filter is fitted at the lower side of the exhaust manifold in the center part of the engine.

The filter cover is made of aluminum casting. Fitted on its lower side is a full flow filter of paper element type.

The full-flow type paper filter increases combustion efficiency, and permits longer oil and element replacement intervals under standard working conditions.

The oil pressure at the main fall is kept at 1 – 5 kg/cm² (14.22 – 71.10 lb/sq.in.) by the regulator valve. The opening pressure of the regulator valve is 4 kg/cm² (56.88 lb/sq.in.).

OVERHAUL

Disassembly

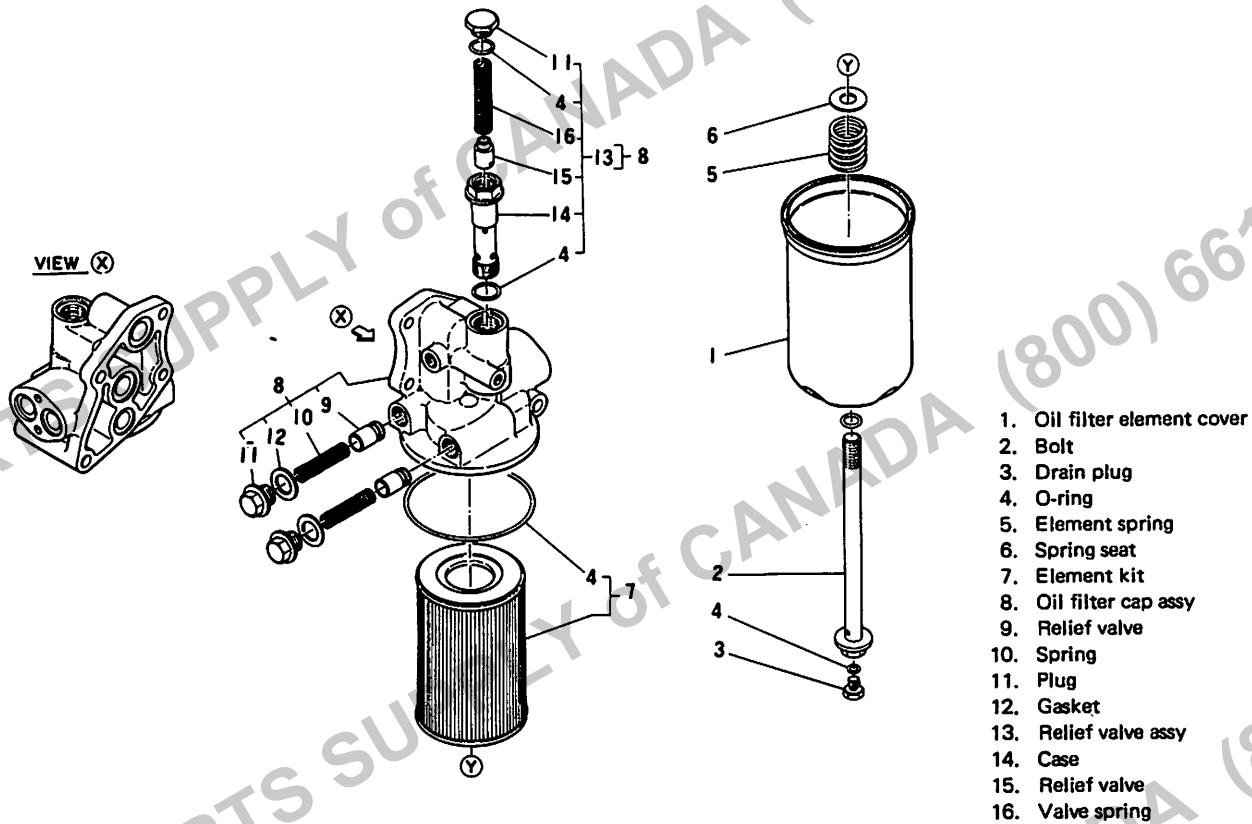


Fig. 3-8-18 Oil filter

DISASSEMBLY

First loosen the drain plug at the end of the center bolt in order to drain oil included in the filter.

Loosen the bolt in the center on the bottom of the filter case.

Cleaning

1. Wash all parts, except the element, in cleaning oil and dry with compressed air. Pass air through the throttle opening in the oil inlet port cover after first cleaning with wire.
2. Wash the element separately in clean gasoline or fresh cleaning oil, being careful to allow no foreign matter to enter. Immerse in the cleaner and remove sludge with a brush.

ASSEMBLY

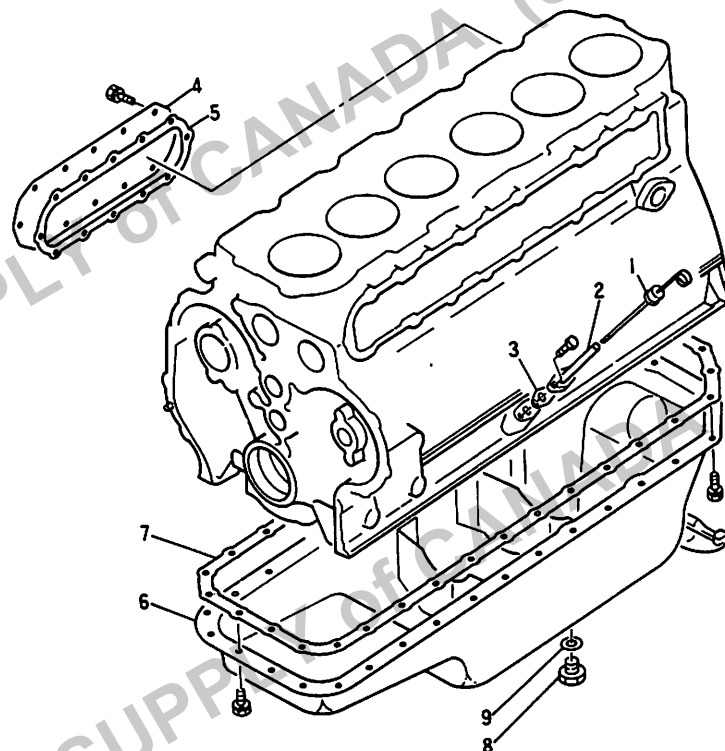
Cautions only for assembling.

Full-flow filter

- (1) Tightening torque of the plugs for valves.
 400 – 500 kg-cm (29 – 36 lb.ft)
- (2) Tightening torque of the center bolt for the full flow filter case.
 First tighten it at 700 kg-cm (51 lb.ft) then loosen it until 400 – 500 kg-cm (29 – 36 lb.ft.)
- (3) Installing way the oil filter assembly to the crank case.
 Refer to cautions explained in oil cooler.

OIL PAN

DESCRIPTION



- | | |
|--------------------------------|--------------------------|
| 1. Oil level gauge | 6. Oil pan |
| 2. Oil level gauge pipe guide | 7. Oil pan gasket |
| 3. Guide pipe gasket | 8. Oil drain plug |
| 4. Tappet chamber cover | 9. Oil drain plug gasket |
| 5. Tappet chamber cover gasket | |

Fig. 3-8-19 Oil pan

OVERHAUL

Dismounting

1. Remove the drain plug to drain the engine oil. It is suggested that a 30-gauge screen be placed over the container into which engine oil is drained. In this way, foreign particles in the oil may be retained and examined.
2. Remove the oil pan retaining bolts, leaving one bolt in place on the left and right sides. Support the oil pan before removing these last two bolts and lower the pan slowly as they are taken out.
3. Remove the suction strainer from the crankcase.

Cleaning and Inspection

1. Before cleaning the oil pan, examine the sediment. If many metal shavings are found, the bearings should be inspected.
2. Clean the oil pan and strainer in solvent and dry with compressed air. Check the curved oil strainer line and welds for cracks.

REMOUNTING

Coat a new gasket with gasket sealing compound and position the gasket. Mount the oil pan in the reverse sequence of removal, i.e., insert one bolt in the left and right sides while supporting the oil pan in position, partially tighten and replace the remaining bolts. Tighten all bolts evenly.

3-9 COOLING SYSTEM

DESCRIPTION

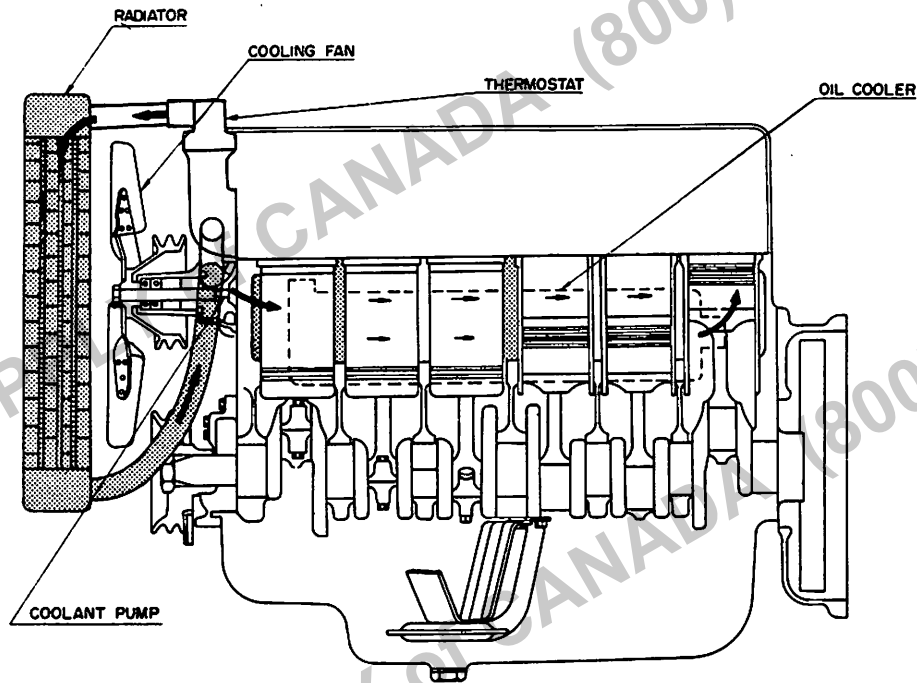


Fig. 3-9-1 Cooling system

1. Circulating System

The coolant pump at the front of the engine circulates the coolant water. After being cooled in the radiator, the coolant water passes through a connection in the lower portion of the radiator to the pump. This coolant pump feeds the coolant water directly to the left side of the engine (seen from the fan side) where it enters the distribution system, cooling all cylinders equally.

Part of the coolant fed to cylinder head to cool nozzle holder, exhaust port, etc. gathers in the thermostat case on the front end of cylinder head. Part of the coolant which cooled the cylinders is taken out from the side wall of cylinder block on the manifold side and fed to cylinder head after heat exchange with lubricant in oil cooler. Coolant gathered in the thermostat case is returned to radiator or coolant pump.

A drain cock on the right rear side of the engine (seen from the fan side) permits coolant water to be drained from the cylinder block.

The radiator is drained by opening the drain cock on the right at the bottom of the radiator.

MAINTENANCE

1. Cleaning the Radiator Core

Mud and trash tend to accumulate on the front of the radiator during driving. This impedes the flow of air through the cooling fins, and the core should be cleaned carefully with water.

2. Checking the Coolant-water Level and Replenishing

Every day before operating the vehicle, check the water level and pour water, if necessary.

Remove the radiator cap by turning to the left. Pour the soft water until it appears at the bottom of the filler. When putting the radiator cap back on, be sure to screw it in until it firmly goes into the "second detent" of its lock.

Always use soft water.

3. Cleaning and Coolant Lines

When these lines become clogged with sediment, cooling efficiency decreases. The entire system should be flushed with the cleaning solvent.

1. Remove the radiator cap first so that air may enter.
Open two drain cocks (for cylinder block and radiator).
2. Fill the radiator with cleaning solvent and operate the engine until the water temperature rises to about 80° C (176° F). Keep the engine in motion for 15 to 30 minutes.
3. Open the drain cock and quickly discharge the solvent.
4. Pour clean water and run the engine again for a while maintaining its temperature at about 80° C (176° F). Then discharge the water after dropping the water temperature.

4. Handling Caution in Extremely Low Temperatures

Use antifreeze in extremely low temperature.

When antifreeze is not used, be sure to drain the coolant water from the radiator upon completion of work. If the water is left undrained, the radiator and the engine will freeze, which can cause grave accidents.

1. Brand of antifreeze
Please refer to "Recommended lubricants list".
2. Use of antifreeze
 - 1) Before pouring antifreeze, check the radiator core, hose, drain cock, etc. for leakage.
 - 2) Remove the radiator cap and open the radiator and engine drain cocks to completely drain the coolant water.
 - 3) If the drained coolant water is notably dirty, the cooling system must be thoroughly cleaned.
 - 4) Use soft water for mixture with antifreeze.
 - 5) Mixture ratios for different temperatures are as indicated in the table below.

Safe working temperature °C (°F)	Antifreeze %	Soft water %	Freezing temperature °C (°F)
- 2 (28)	15	85	- 6 (21)
- 4 (25)	20	80	- 9 (15)
- 8 (18)	25	75	-13 (9)
-11 (12)	30	70	-16 (3)
-16 (3)	35	65	-21 (- 6)
-20 (- 4)	40	60	-25 (-13)
-26 (-15)	45	55	-31 (-24)
-33 (-27)	50	50	-37 (-35)
-40 (-40)	55	45	-45 (-49)

NOTE:

Observe safe working temperatures in mixing.

- 6) The level of the coolant water should be 40–50mm (1.48–1.97 in.) below the bottom of the filler, this is prevent expansion due to heat during operation from causing the antifreeze to overflow and be wasted.
- 7) Antifreeze used for replenishment must have the same concentration as that used in initial filling.
- 8) Hang a sign reading "Antifreeze Used" on the radiator cap.

TROUBLE SHOOTING

1. Overheated Engine

1. Coolant water is insufficient.
Check for leaks and add water.
2. V-belt is loosened.
Adjust to proper tension.
3. V-belt is slippage.
Remove belts and wash with gasoline.
4. Thermostat valve is closed causing grease.
Remove and check.
5. Cooling system is clogged, sediment accumulates heating in it.
Flush the cooling system with cleaning solvent.
6. Water pump is inoperative.
Check for pump seizure and damage pump pulley.

2. Engine Running too Cold

1. Leave thermostat valve open.
Remove and check. Replace if necessary.
2. Air temperature is low in cold weather.
Install cover on front of radiator.

3. Drop in Coolant Water Level

1. Leaks in radiator, hose connections, pump, etc.
Find lead and tighten or repair.
2. Cylinder head gasket is defective.
Replace and tighten the head bolts with standard torque.
3. Cylinder head or block is cracked.
Repair if not serious, or replace.
4. Leaks in expansion plug.
Repair or replace plug.

4. Unusual Sounds from Cooling System

1. Water pump bearing is worn.
Disassemble and replace bearing.
2. Cooling fan is loosed.
Tighten or repair.

COOLANT PUMP & FAN

DESCRIPTION

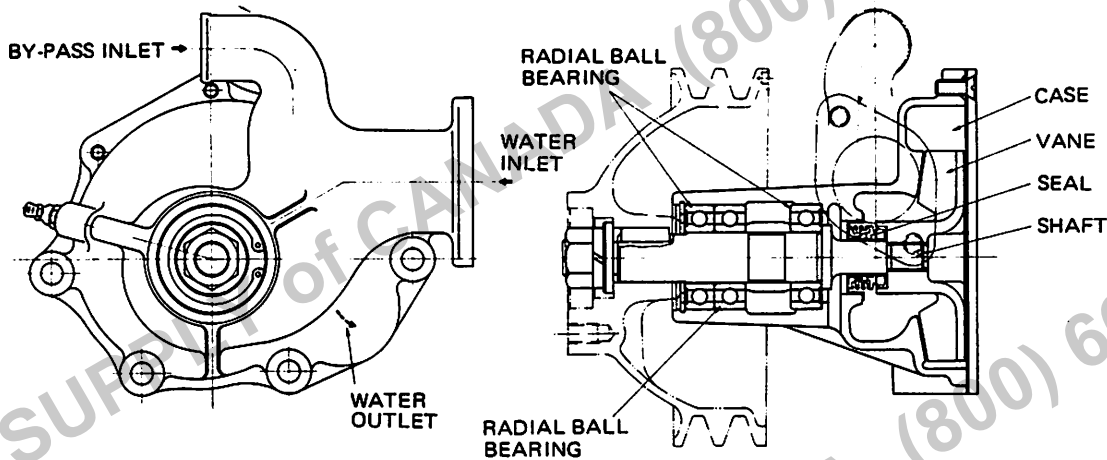


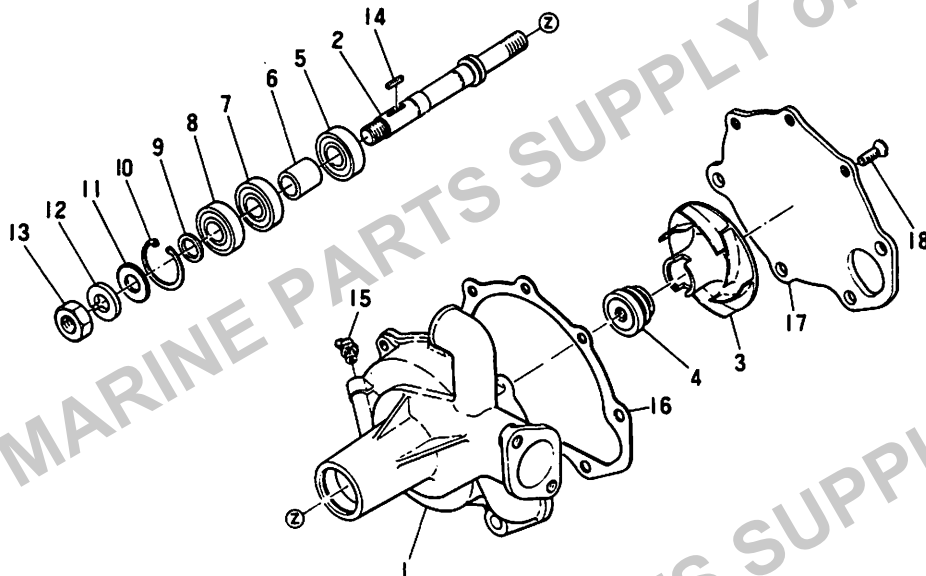
Fig. 3-9-2 Coolant pump

The pump is on the upper front of the engine, and its construction is shown in Fig. 3-9-2. There is a six-bladed cooling fan mounted on the front of the engine. The fan, together with the alternator, is driven by crankshaft through V-belts. The speed is 0.9 times greater than that of the crankshaft. To adjust V-belt tension, vary the position of the alternator.

The leak prevention for the water pump is effected by

the carbon plastic plate, rubber and spring fitted to the water vane. The leakage is completely prevented by the rubber which rotates with its one end pressed against the vane by the force of the internal spring, and the other against the bushing applied for the setting of the carbon plastic plate to the pump body. For the lubrication of the ball bearing of the pump shaft, supply the coolant pump grease at every 500 hours operation.

OVERHAUL



1. Case
2. Shaft
3. Vane
4. Coolant seal
5. Radial ball bearing
6. Bearing collar
7. Ball bearing
8. Ball bearing
9. Washer
10. Retainer ring
11. Plain washer
12. Lock washer
13. Nut
14. Feather key
15. Lubrication fitting
16. Coolant pump cover gasket
17. Plate
18. Bolt

Fig. 3-9-3 Coolant pump

Dismounting

1. Loosen the alternator-brace-adjusting bolt and move the alternator all the way to the engine.
2. Remove the four cooling-fan-retaining bolts and take off the fan.
3. Remove the V-belts by hand and cooling fan pulley by loosening the center nut.
4. Remove the suction-pipe-flange bolts and take off the pipe.
5. Remove the four coolant-pump-retaining bolts and take off the pump assembly.

Disassembly

1. Remove the pulley by making use of a puller.

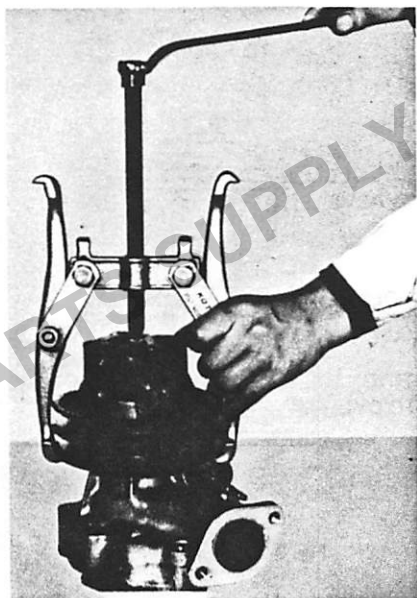


Fig. 3-9-4 Removing the pulley LB3-050

2. Loosen and remove the coolant pump case and case cover plate bolts.
3. Remove the coolant pump shaft.
Take off the feather key and force out the pump shaft in the direction of the vane with a press.

NOTE:

Don't remove the vane from shaft, if not necessary.

4. Remove the ball bearing collar from the pump case.
Take out the retaining ring and force out the bearings and collar in the direction of the pulley with a press.



KM-060

Fig. 3-9-5 Coolant pump shaft disassembly

Inspection and Repair**1. Coolant Pump**

1. Remove any traces of the gasket from pump case and cover. Wash all parts in solvent thoroughly and dry with compressed air.
2. Check the bearing race for wear and fatigue, if defective, replace.
3. Check carefully to make sure that the water seal is not cracked or torn. If defective, replace.
4. Check for deformed pump shaft keyway, feather key, and threads on the vane side. Correct any defects or replace parts.

2. Cooling Fan

Check for cooling fan cracks, etc.

Assembly and Adjustment

1. Coat the bearing grease to the bearings and insert them in pump case through the spacer by means of a press, but do not press the inner race. Then fit the retainer ring.
2. Fit the water seal to the shaft and insert the shaft in the pump case by means of a press.
3. Place the feather key in the pump shaft, align the pump pulley with the key and drive it in place. Tighten the pulley in place with the nut.
4. Replace the pump case cover, using a new gasket, and tighten the cover in place.

5. Check for smooth rotation, turning the cooling fan manually after assembly is completed.
6. Checking the tension of V-belt
The V-belts which drive the alternator and water pump should have the correct tension, if not, the belts will slip and the required speed will be lost. Check this belt tension and adjust as needed by following.
 - (1) Loosen the alternator brace adjusting bolt until brace and adjusting plate are free.
 - (2) Move the alternator to the position in which the belt tension is correct and seat the brace and adjusting plate. Tighten the adjusting bolt slightly.
 - (3) Apply a force of approx. 10 kg (22 lb) to the belts at the center of alternator and fan pulley.

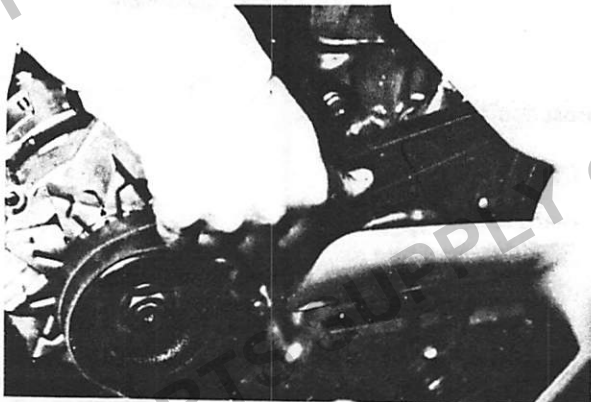


Fig. 3-9-6 Checking the tension of V-belt

LB3-051

The amount of belt slackness should be approximately 10 ~ 15 mm (0.39 ~ 0.59 in)

THERMOSTAT

DESCRIPTION

This is a wax type thermostat. As shown in Fig. 3-9-7 wax is sealed in the pellet. When the temperature rises, the wax expands and pushes up the pin, and the valve is opened by the reaction of the pin.

When the coolant water temperature drops below 76.5°C (170°F), the thermostat valve is closed to shut off the radiate flow, and all of the coolant water flows through the bypass of the pump, and it provides preventing engine temperature drop.

Above 76.5°C (170°F), the thermostat valve is opened properly as shown in Fig. 3-9-10, and engine temperature remain the proper degree, max. lift is 10 mm (0.393 in) at 90°C (194°F).

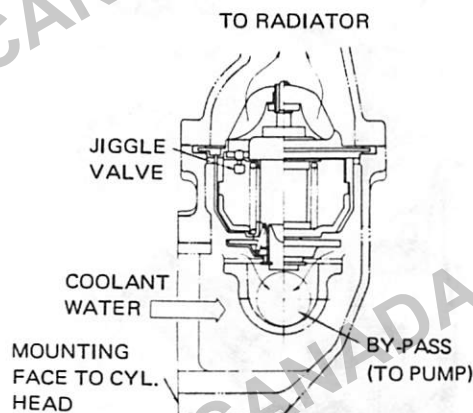
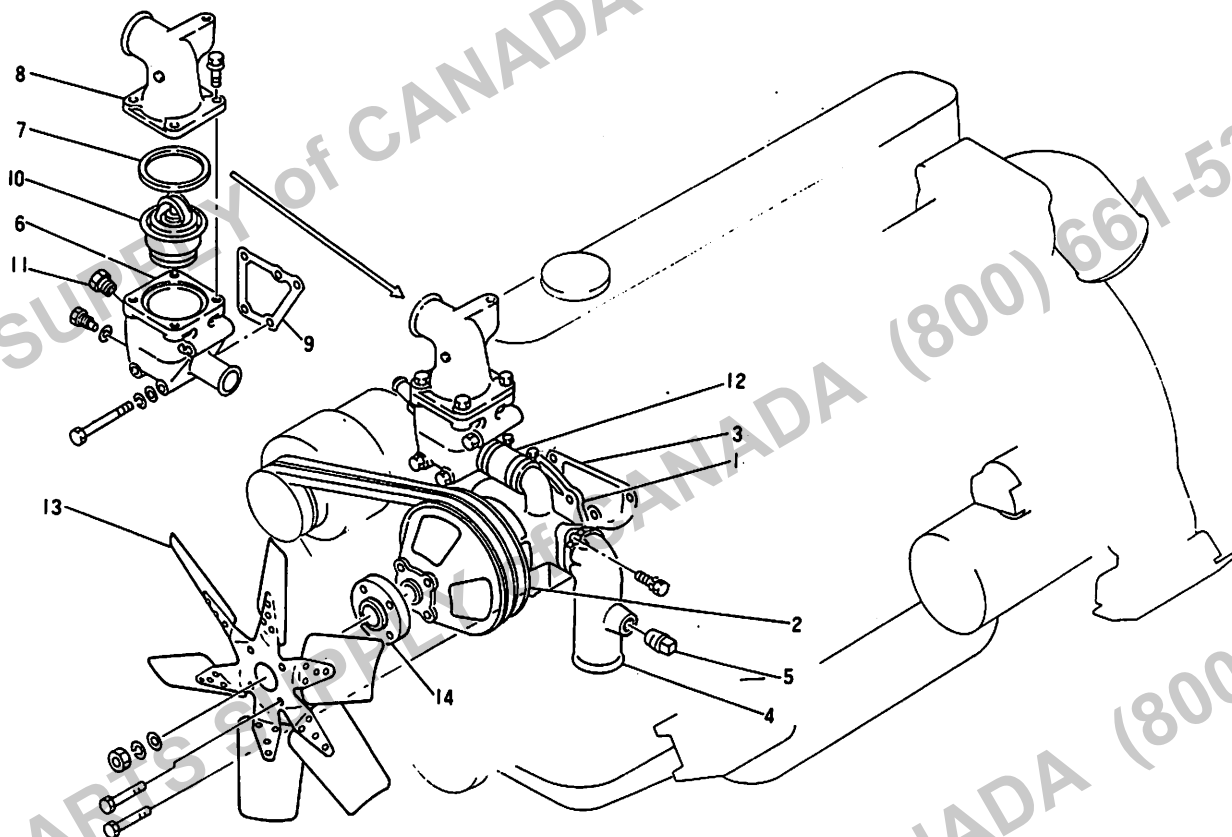


Fig. 3-9-7 Thermostat

OVERHAUL

Dismounting



- | | |
|------------------------|----------------------|
| 1. Coolant pump assy | 8. Thermostat case |
| 2. Coolant pump pulley | 9. Thermostat gasket |
| 3. Coolant pump gasket | 10. Plug |
| 4. Coolant intake pipe | 11. Thermostat |
| 5. Plug | 12. Water hose |
| 6. Thermostat case | 13. Cooling fan |
| 7. Thermostat gasket | 14. Spacer |

Fig. 3-9-8 Thermostat and coolant manifold

1. Loosen the hose clamp on the thermostat case side, and take off the rubber hose between the thermostat case and the radiator.
2. Remove the two clip band from the bypass pipe

flange of the thermostat case.

3. Remove the four mounting bolts in the thermostat case and take out the case.
4. Take out the thermostat.

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Mounting

Install components in the reverse order to disassembly, paying attention to following items:

1. Clean fur from thermostat case.
2. Be sure so that the jiggle valves face upwards when installing.

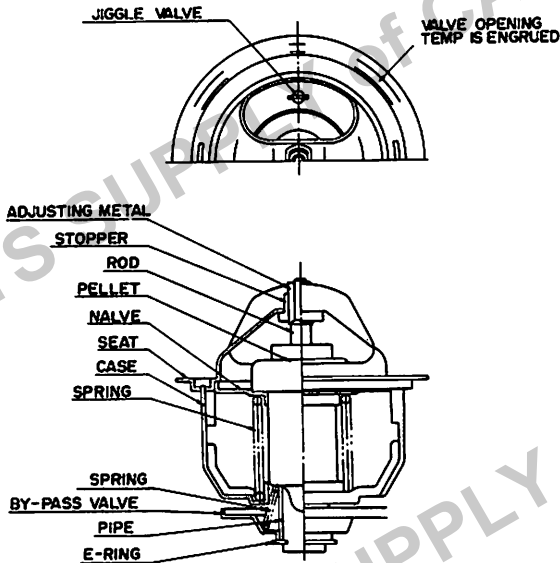


Fig. 3-9-9 Jiggle valve

2. Place the thermostat in warm water as shown in Fig. 3-9-10.

When the temperature rises more than 90°C (193°F) the lift should be approximately 10mm (0.39 in.) and the bypass port in the side of the main unit must be completely closed.

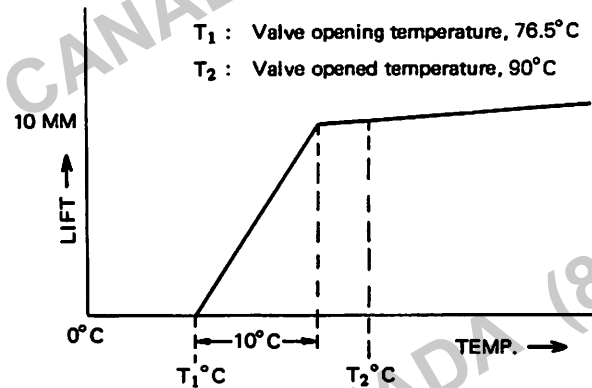
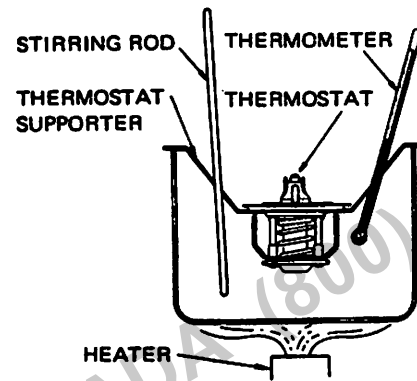


Fig. 3-9-10 Testing the thermostat function

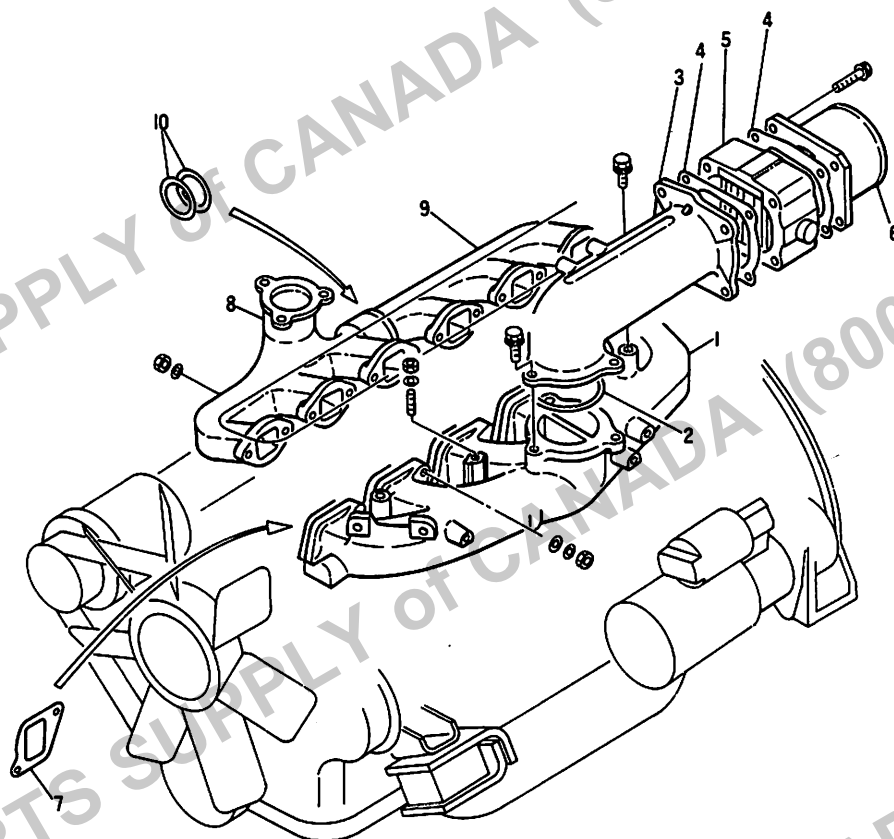
3. Be sure to place corroded, scard or permanently strained O-rings with new ones.

MAINTENANCE

1. Inspecting the Thermostat Function

Every 1,000 hours operation check the function.

1. At ordinary temperatures (below 70°C (158°F)). If the thermostat conical section, used for valve action, is not in close contact with the main unit, the thermostat should be replaced.

3-10 EXHAUST SYSTEM**MANIFOLD & MUFFLER****DESCRIPTION**

- | | |
|----------------------|---------------------|
| 1. Intake manifold | 6. Intake pipe |
| 2. Gasket | 7. Gasket |
| 3. Intake pipe | 8. Exhaust manifold |
| 4. Gasket | 9. Exhaust manifold |
| 5. Intake air heater | 10. Ring seal |

Fig. 3-10-1 Air intake & Exhaust system

(1) The one-piece, 6 cylinder intake manifold uniformly distributes suction and provides high suction efficiency by being matched with the valve system. The end of intake manifold has a noise suppressor (butterfly valve type) which is interlocked with the injection pump load lever, to suppress incidental noise in and around combustion chamber from the exhaust brake.

(2) Exhaust manifold

The exhaust manifold is made of cast iron with special ingredients added. It is built in three parts to prevent thermal deformation. At the joint section of the manifold, a seal ring seals gas and oil and a wire-containing stainless gasket (steel plate type) on the flange prevents gas leakage.

Mounting of exhaust manifold seal rings

Seal rings are fitted to each connecting section of the exhaust manifold to prevent gas and oil leakage. Install new seal rings so that none of the ring end gaps are lined up, as shown in Fig. 3-10-2.

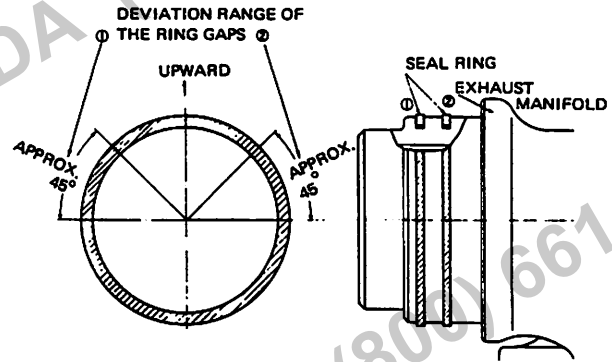


Fig. 3-10-2 Installing seal ring

3-11 REPAIR SPECIFICATIONS

SERVICE STANDARD

Unit: mm (in)

Item		nominal dimensions	Assembly standard	Repair limit	Service limit	Corrective measures			
Cylinder liner and piston	Liner inside diameter	110 (4.331)			+0.15 (+0.0059)	Replace liner			
	Piston out side diameter	Clearance between liner and piston [at 64.2 mm (2.528 in) from piston bottom]	110 (4.331)	0.192 - 0.224 (0.0076 - 0.0088)		Replace piston			
Piston ring	Side clearance	Top	In cylinder	110 (4.331)	0.3 - 0.45 (0.0118 - 0.0177)	2.5 (0.0984)			
			Free clearance		Approx. 11 (0.433)				
		2nd	In cylinder	110 (4.331)	0.3 - 0.45 (0.0118 - 0.0177)			1.2 (0.0472)	
			Free clearance		Approx. 15.5 (NPR) (0.610) 15.0 (RIKEN) (0.590)				
		3rd	In cylinder	110 (4.331)	0.3 - 0.45 (0.0118 - 0.0177)			1.2 (0.0472)	
			Free clearance		Approx. 14.5 (0.5709)				
	Oil	In cylinder	110 (4.331)	0.3 - 0.5 (0.118 - 0.0196)		1.2 (0.0472)			
		Free clearance		Approx. 12.5 (NPR) (0.4921) Approx. 10.5 (RIKEN) (0.4134)					
	Rings and ring grooves	Top	Ring thickness	3.0 (0.118)	0.06 - 0.10 (0.0024 - 0.0039)	0.4 (0.0157)		-0.25 (-0.0098)	Replace ring
			Groove width	3.0 (0.118)				+0.25 (+0.0098)	Replace piston
		2nd, 3rd	Ring thickness	2.5 (0.0984)				-0.25 (-0.0098)	Replace ring
			Groove width	2.5 (0.0984)				+0.25 (+0.0098)	Replace piston
Oil		Ring thickness	5.0 (0.1969)			-0.05 (-0.0019)	Replace ring		
		Groove width	5.0 (0.1969)			+0.05 (+0.0019)	Replace piston		
Piston	Piston pin outside diameter		39 (1.535)			-0.14 (-0.0055)	Replace pin, available oversized pin: 0.20 (0.008)		
	Clearance	Piston hole and clearance	39 (1.535)	0.013T - 0.014L (0.0005 - 0.0006)	0.1 (0.0039)		T = interference L = clearance fit		
		Con-rod bushing inside diameter and clearance	39 (1.535)	0.015 - 0.036 (0.0006 - 0.0014)	0.1 (0.0039)		Replace bushing and pin		
Crankshaft	Journal and crank pin	Journal outside diameter	74.0 (2.913)		-0.20 (-0.0079)	-1.20 (-0.0472)	Correct by regrinding if worn unevenly more than 0.10 mm (0.0039) grind if wear is more than 0.2 (0.0079), and replace crankshaft if wear is more than 1.2 (0.0472). available under signed bearings: 0.25 (0.0098), 0.75 (0.0295), 1.00 (0.0393)		
		Bearing thickness	2.5 (0.0984)						
		Clearance	No. 1 - 7		0.051 - 0.102 (0.002 - 0.004)	0.30 (0.0118)			
	End-play	Central main shaft width	4.3 (0.169)		0.05 - 0.219 (0.0019 - 0.0086)	0.5 (0.0196)	Replace thrust bearing		
Bearing thickness		2.5 (0.0984)							

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Item		Nominal dimensions	Assembly standard	Repair limit	Service limit	Corrective measures		
Crankshaft	Crank pin	Connecting rod large end inside diameter	69 (2.7165)			Correct by regrinding if worn unevenly more than 0.10 (0.0039); regrind if wear is more than 0.2 (0.0079), and replace crankshaft if wear is more than 1.20 (0.0472).		
		Roundness			0.06 (0.0023)			
		Pin outside diameter	65.0 (2.5590)		-0.20 (-0.0079)		-1.20 (-0.0472)	
		Con-rod bearing thickness	2.0 (0.0787)					
		Clearance		0.031 - 0.082 (0.0013 - 0.0032)			If clearance is more than 0.3 (0.0118), replace available undersized bearings: 0.25 (0.0098), 0.500 (0.0196), 0.75 (0.0295), 1.00 (0.0393).	
		End-play, pin width	42.0 (1.6535)	0.2 - 0.5 (0.0079 - 0.0008)		0.6 (0.0236)		
		Crankshaft bent				0.09 (0.0035)	Grind to undersize or straighten with press	
Camshaft	Bearing inside diameter	No. 1	61.5 (2.421)	0.030 - 0.080 (0.0012 - 0.0034)			+0.15 (+0.0059)	Replace bearing
		No. 2	62.3 (2.413)					
		No. 3	61.1 (2.406)					
		No. 4	60.9 (2.398)					
		No. 5	60.7 (2.390)					
		No. 6	60.5 (2.382)					
		No. 7	58.3 (2.295)					
	Camshaft outside diameter	No. 1	61.5 (2.421)		-0.15 (-0.0059)	Replace camshaft		
		No. 2	61.3 (2.413)					
		No. 3	61.1 (2.406)					
		No. 4	60.9 (2.398)					
		No. 5	60.7 (2.390)					
		No. 6	60.5 (2.382)					
		No. 7	58.3 (2.295)					
End-play thrust bearing thickness	8.0 (0.3149)	0.1 - 0.178 (0.004 - 0.0070)	0.3 (0.0118)	Replace thrust plate				
Cam lift	Intake		7.1840 (0.2828)	-0.08 (-0.0031)	Replace camshaft			
	Exhaust		8.1723 (0.3217)					
Camshaft bent				0.05 (0.0019)	Straighten with press			
Valve system	Rocker	Tappet outside diameter	32 (1.2598)	0.020 - 0.071 (0.0008 - 0.0028)	0.10 (0.0039)	Replace tappet		
		Rocker arm shaft outside diameter	24.2 (0.952)			-0.08 (-0.0031)	Replace rocker arm shaft	
		Rocker arm bushing inside diameter	24.2 (0.952)				+0.08 (+0.0031)	Replace bushing
		Clearance				0.15 (0.0059)	Replace bushing	

Item		Nominal dimensions	Assembly standard	Repair limit	Service limit	Corrective measures	
Valve system	Valve	Intake valve stem outside diameter	9.0 (0.3543)	0.055 - 0.088 (0.00216 - 0.0034)		8.88 (0.3496)	Replace valve or guide
		Exhaust valve stem outside diameter	9.0 (0.3543)	0.07 - 0.103 (0.0027 - 0.0051)		8.88 (0.3496)	Replace valve or guide
	Valve head countersink	Intake		+0.25 - -0.25 (+0.0098 - -0.0098)		-0.5 (-0.0196)	Replace valve seat
		Exhaust				-0.5 (-0.0196)	Replace valve seat
	Valve clearance	Intake		0.30 (0.0118)			Adjust while engine is cool.
		Exhaust		0.40 (0.0157)			
	Spring	Setting length		52.0 (2.047)			Replace if distorted more than 2.0 (0.0787)
		Preload kg (lb)		28.4 (62.6)		26.5 (58.4)	Replace spring
		Free length		62.0 (2.44)		-3.0 (-0.1181)	
		Straightness				More than 1.5 (0.059)	
	Intake valve seat	Seat angle		30°	30° - 30°30'		Correct
		Face angle		30°	29°30' - 30°		
	Exhaust valve seat	Seat angle		45°	45° - 45°30'		
		Face angle		45°	44°30' - 45°		
Timing gear	Push rod bent					0.5 (0.0196)	Replace gear
	Backlash	Crankshaft - idler gear Camshaft - idler gear Injection pump - idler gear			0.051 - 0.11 (0.0020 - 0.0043)	0.3 (0.0118)	Replace gear
		Camshaft - oil pump			0.07 - 0.22 (0.0028 - 0.0086)		Replace gear
	Idle gear	Idle shaft and bushing		34.0 (1.3385)	0.025 - 0.075 (0.0009 - 0.0029)	0.20 (0.0079)	Replace bushing or shaft, change mounting position if worn unevenly more than 0.03 (0.0012)
		End-play	Idle shaft length	38.5 (1.516)	0.03 - 0.11 (0.0012 - 0.0043)	0.3 (0.0118)	Replace bushing
Bushing thickness			2.5 (0.0984)				
Oil pump	Gear tooth radial clearance in case			0.030 - 0.10 (0.0012 - 0.0039)	0.13 (0.0051)	Replace gear or shaft	
	Gear side face and pump side clearance			0.04 - 0.088 (0.0016 - 0.0035)	0.15 (0.0059)	Replace gear	
	Drive gearshaft clearance in case			0.04 - 0.085 (0.0016 - 0.0033)	0.1 (0.0039)	Replace pump case or shaft	
	Drive gear shaft clearance in gear			0.04 - 0.083 (0.0016 - 0.0033)	0.1 (0.0039)	Replace gear or shaft	
	Gear backlash			0.15 - 0.28 (0.006 - 0.011)			

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Item		Nominal dimensions	Assembly standard	Repair limit	Service limit	Corrective measures
V-belt tension	Between alternator and coolant pump		10 – 15 (0.39 – 0.59)			Apply force 10 kg (22 lb)
Cylinder head	Cylinder head surface evenness		0 – 0.05 (0 – 0.002)	0.1 (0.0039)		Correct by regrinding
	Crankcase top surface evenness		0 – 0.05 (0 – 0.002)	0.1 (0.0039)		Correct by regrinding
	Protrusion of cylinder liner above block		0.01 – 0.07 (0.00039 – 0.0028)			
Compression pressure (lb/sq.in)	270 – 310 r.p.m. (Turn with starter)		29 – 35 kg/cm ² (413 – 497 lb/sq.in.)		25 kg/cm ² (356 lb/sq.in.)	

TIGHTENING TORQUE

Tightening position		kg-cm	lb.ft.
Cylinder head bolt		1,800 – 1,900	131 – 137
Cylinder head bolt (Additional)		650 – 750	48 – 54
Main bearing cap bolt		1,400 – 1,600	102 – 115
Connecting rod cap bolt		1,650 – 1,850	120 – 134
Crankshaft nut		5,500 – 7,000	398 – 506
Cam shaft gear nut		2,500 – 3,000	181 – 217
Cam shaft thrust plate bolt		190 – 260	13 – 18
Idle gear shaft fitting bolt		500 – 650	37 – 47
Idle gear fitting bolt		1,100 – 1,300	80 – 94
Flywheel to crankshaft		1,800 – 2,000	131 – 144
Flywheel housing bolt		400 – 500 (10 ϕ)	29 – 36
		650 – 870 (12 ϕ)	47 – 62
Oil pan bolt		180 – 230	14 – 16
Manifold to cylinder head	Intake	260 – 320	19 – 23
	Exhaust	300 – 350	22 – 25
Rocker arm support bolt		700 – 800	51 – 58
Rocker arm support bolt (on both side)		190 – 260	14 – 19
Oil pump to crank case		380 – 500	28 – 36
Injection pump drive gear		190 – 260	14 – 19
Injection pump set bolt		190 – 260	14 – 19
Injection pump bracket bolt		380 – 500	27 – 36
Injection pump thrust plate bolt		190 – 260	14 – 19
Injection pipe (both end nipple)		300 – 400	22 – 29
Injection pipe (mounting nut)		50 – 100	4 – 7
Adjusting screw lock nut		400 – 500	29 – 36
Nozzle holder bolt		130 – 190	10 – 14
Starter to flywheel housing		650 – 870	47 – 63
Cooling fan bolt		200 – 300	14 – 22
Coolant pump setting bolt		380 – 500	28 – 36
Oil filter setting bolt		380 – 500	27 – 36
Oil filter center bolt		400 – 500	29 – 36
Coolant pump pulley bolt		1,800 – 2,400	130 – 174
Water gallery cover bolt		190 – 260	14 – 19
Oil cooler bolt		190 – 260	14 – 19
Alternator mounting bolt		800 – 900	58 – 65

FUEL INJECTION PUMP

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TIMER	4-33
FUEL FEED PUMP	4-35
REPAIR SPECIFICATIONS	4-39



FUEL INJECTION PUMP

DATA & SPECIFICATIONS

FUEL INJECTION PUMP	
Type	BOSCH type, NIPPON DENSO make
Cylinder	6
Plunger diameter	9.5mm (0.394 in.)
Delivery valve diameter	6mm (0.236 in.)
Cam max. lift	8mm (0.315 in.)
Control rod max. stroke	21mm (0.827 in.)
Pre-stroke of 1st cylinder	3.1 ± 0.05mm (0.122 ± 0.0020 in.)
Injection order	1-4-2-6-3-5
Injection interval	60° ± 30'
Tappet top clearance	More than 0.2 mm (0.0079 in.)
Pump revolution	1/2 X Engine rpm.
Matching for engine	B.T.D.C. 17°
GOVERNOR	
Type	BOSCH type, NIPPON DENSO make; mechanical, All-speed-control type (RSV)
TIMER	
Type	BOSCH type, NIPPON DENSO make; automatic type
Revolution direction	Right hand seen from drive side.
Max. advance angle	5°
FUEL FEED PUMP	
Type	BOSCH type, NIPPON DENSO make; piston type
Piston diameter	22mm (0.866 in.)
Max. feeding pressure	3.5 kg/cm ² (49.78 lb/sq.in.) - 600 rpm.

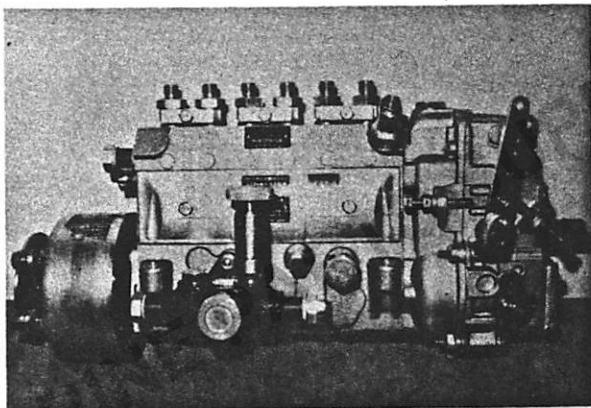


Fig. 4-1 Fuel injection pump 04-0479

The injection pump is driven by the engine crankshaft through the idler gear. It pressure-feeds to the nozzle a specified amount of fuel from the feed pump at a specified time, in a specified order and at a specified internal. The injection pump is of the Bosch type and assembled with the governor, timer and feed pump.

4-2 FUEL INJECTION PUMP

1. Structure of the injection pump

The internal construction of the injection pump is shown in Fig. 4-2.

The pump housing has a fuel gallery, which is kept filled with fuel fed from the feed pump. The plunger barrel inlet hole leads to the fuel gallery.

The plunger repeats the motion of being pushed up by cam of the cam shaft and pushed down by the plunger spring.

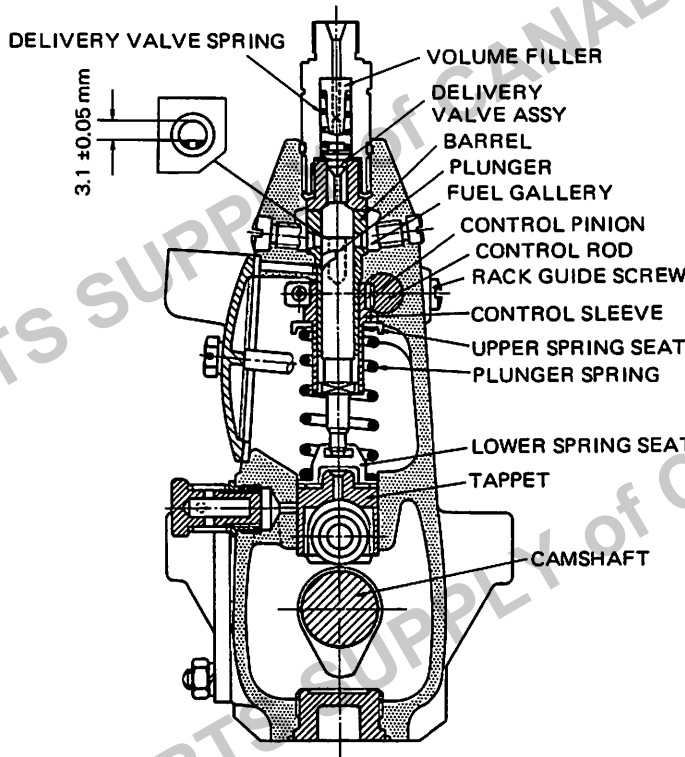


Fig. 4-2 Fuel injection pump

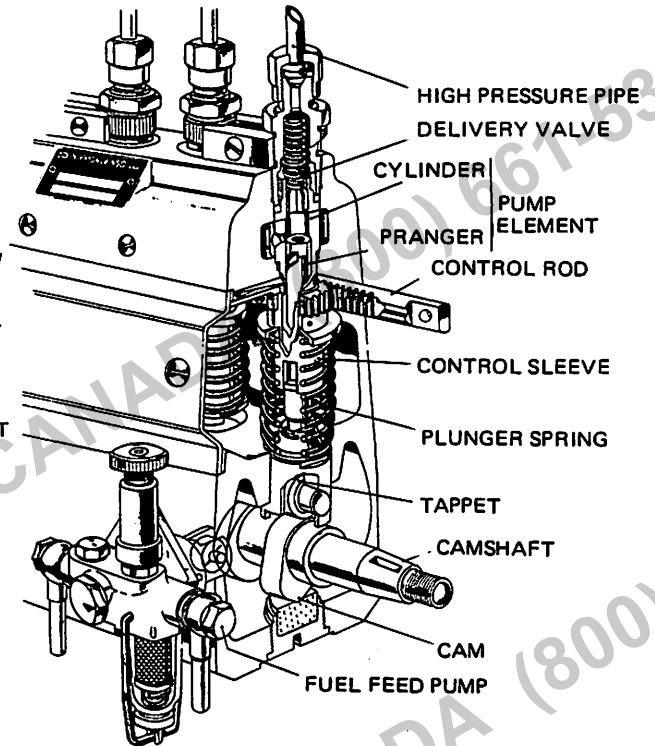


Fig. 4-3 Fuel injection pump

2. Fuel-pressure-feed operation

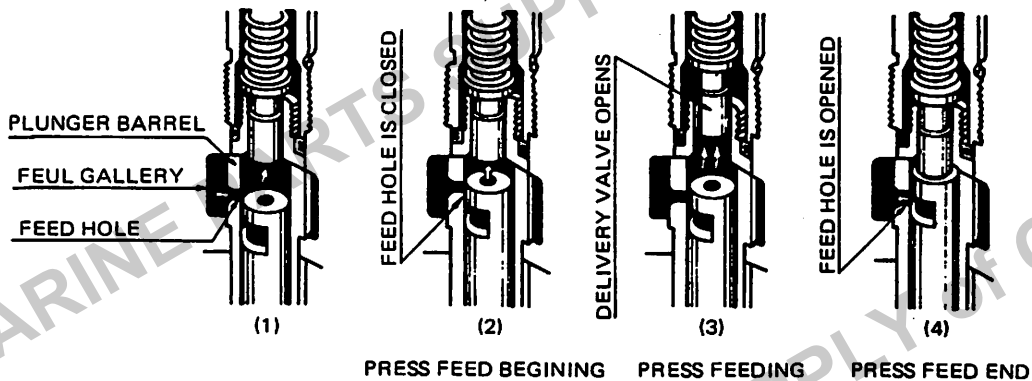


Fig. 4-4 Plunger operation

1. When the plunger is at bottom dead center, fuel flows from the fuel gallery through the feed hole, and into the plunger barrel, as shown in Fig. 4-4 (1).
2. At the moment when the plunger rises through rotation of the camshaft and the upper portion of the plunger is aligned with the top of the feed hole, fuel-pressure-feeding begins, Fig. 4-4 (2).
3. In accordance with plunger stroke, fuel then opens the delivery valve and flows to the nozzle. (Fig. 4-4 (3)).
4. The plunger rises further and at the moment when the lower portion of the control groove is meet with the top of the feed hole, the fuel is pressure-returned to the fuel chamber through the center hole of the plunger, and the fuel pressure drops, fuel feed ends, (Fig. 4-4 (4)).

3. Injection-volume-adjusting operation

1. Plunger effective stroke

The stroke from the point where the plunger-barrel-feed hole is closed by the upper portion of the plunger to the point at which the upper portion of the plunger control groove meets with the lower end of the feed hole is the effective stroke.

The plunger control groove being helical, the effective stroke is varied by turning the plunger to change its position relative to the plunger barrel. Thereby the volume of pressure-feeding being regulated. This is a lower helix type plunger, in which the beginning of pressure-feeding is always constant and its end varies.

Fig. 4-5 shows injection volume at each plunger rotating position.

- 1) Since the feed hole leads to the control groove before it is closed by the upper portion of the plunger, no pressure is applied to fuel and the injection volume is zero.
- 2) By turning the plunger in the arrow direction, the stroke "A" is obtained before the feed hole meets the control groove, and fuel is injected.

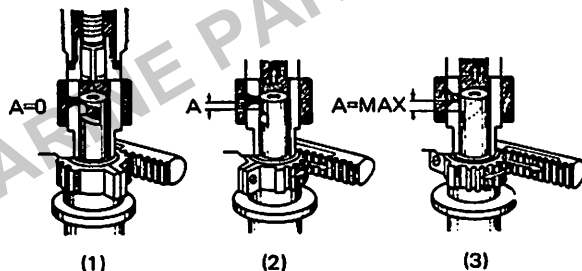


Fig. 4-5 Effective stroke

- 3) By turning the plunger to the position shown in Fig. 4-5 (3), injection volume becomes maximum, which means effective stroke is maximum.

2. Plunger rotating device

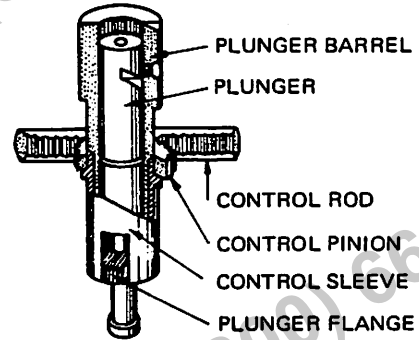


Fig. 4-6 Plunger rotating device

The teeth of the control rod engage with the pinion, and the pinion is secured on the control sleeve which rotates freely around the periphery of the barrel. The driving face in the lower portion of the plunger is inserted in the lower part of the sleeve. Therefore, the amount of injection is varied, as the control rod is moved forward or backward, and thereby the plunger is turned. (Refer to Fig. 4-6.)

The control rod engages with each pinion of the six cylinders. Therefore, it is possible to vary the volume of injection for the six cylinders simultaneously.

Pulling the rod toward the governor side decreases the volume of injection, and pushing it toward the timer side results in an increasing effect.

Engine speed increases or decreases as the volume of fuel injection increases or decreases.

3. Rod position

Position of the rod is expressed as "rod position: . . . mm." When the rod is pulled all the way toward the governor side, the rod is in contact with the rod stopper and stops there. The position of the rod is indicated by the distance it moves toward the timer side from the point where it is in contact with the stopper, that is, "Rod position: 5 mm" means the rod is pushed 5 mm (0.197 in) toward the timer side from the point where it is contact with the stopper.

Thus, as the rod position value grows large, fuel injection will increase and engine speed will rise accordingly.

4-4 FUEL INJECTION PUMP

4. Injection volume performance curve

Injection volume performance curve is shown in **Fig. 4-7, 8.**

Injection volume varies almost linearly in accordance with the position of the rod, as shown in **Fig. 4-7,** when the pump speed is constant.

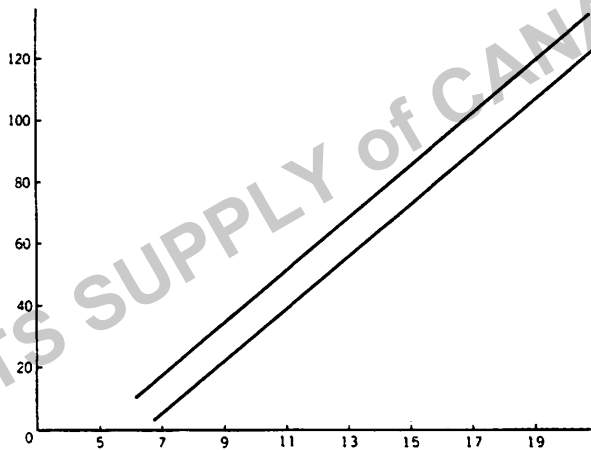


Fig. 4-7 Rod position ~ injection volume

Otherwise, fix the rod at either 5 mm (0.197 in) or 15.4 mm (0.609 in), and slowly increase pump speed, in this case, the injection volume will be shown in **Fig. 4-8.** This graph shows that the injection volume per stroke (rotation) increases gradually in accordance with the increase in pump speed.

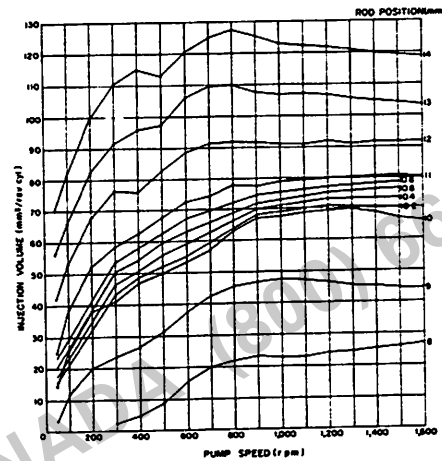


Fig. 4-8 Pump speed ~ injection volume

4. Function of delivery valve

The delivery valve functions in two ways: it prevents the reverse flow of the fuel in the high pressure pipe toward the plunger side and also draws back fuel to prevent dripping at the nozzle. When the delivery valve is brought down by the delivery valve spring upon completion of fuel pressure-feeding, the piston of the valve first cuts off the high pressure pipe and plunger sides (as shown in **Fig. 4-9 (a)**) and then it further descends until it is contact with the seat surface (as shown in **Fig. 4-9(b).** The fuel in the high pressure pipe is drawn

back the amount equal to that designated by "A" in **Fig. 4-9** and the pressure in the high pressure pipe is slightly reduced, in this way drops of the fuel remaining at the nozzle tip are eliminated.

In addition, and as shown in **Fig. 4-9 (b),** the delivery valve contacts the valve seat to prevent the reverse flow of the fuel from the high pressure pipe to the pump cylinder.

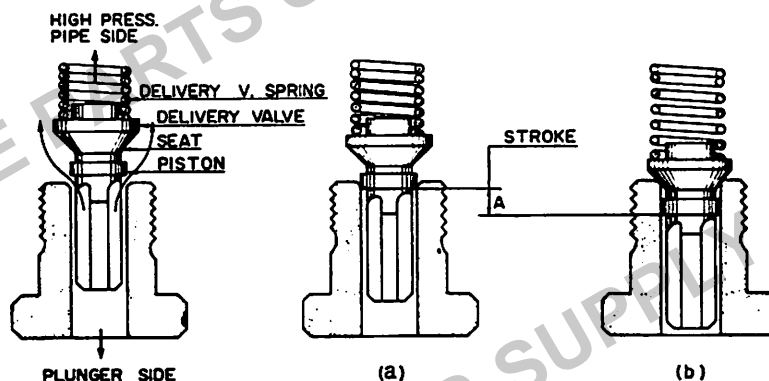


Fig. 4-9 Delivery valve

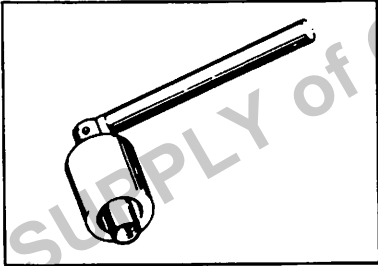
OVERHAUL

SPECIAL TOOL (N.D. made)

Prior to start of injection pump overhaul, it is necessary to prepare special tools.

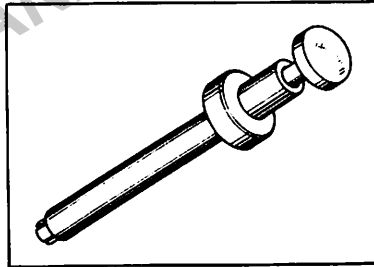
A-TYPE PUMP BODY TOOL KIT (95905-03000)

Delivery valve puller



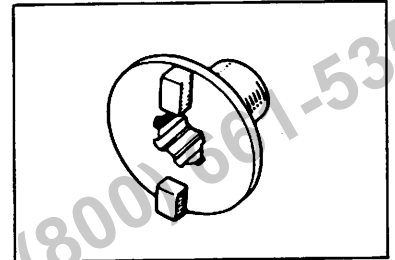
95905-05050

Plunger puller



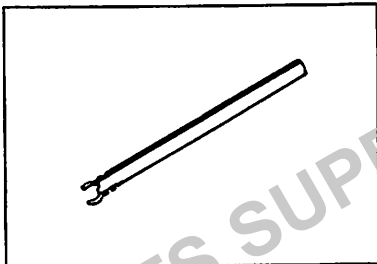
95905-11030

Driving flange



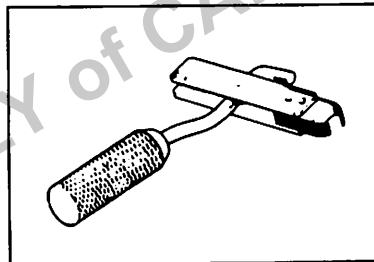
95905-01040

Tappet clamp



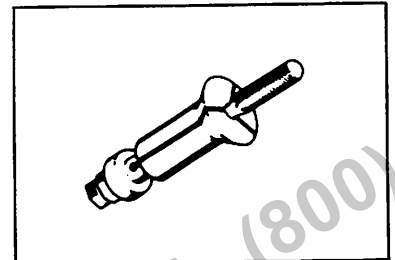
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Tappet inserter



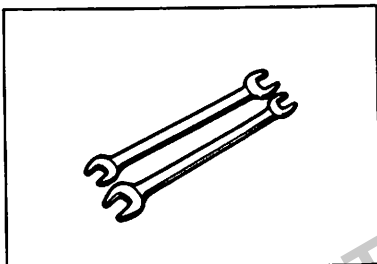
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Camshaft bearing outer race puller



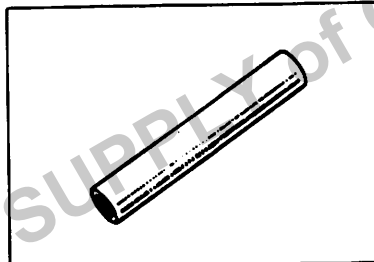
95905-04050

Open end wrench



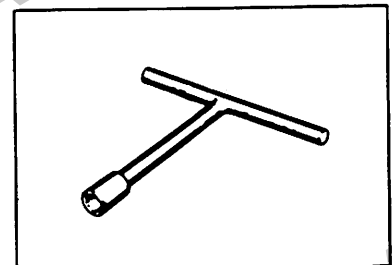
95905-08003

Delivery valve gasket inserter



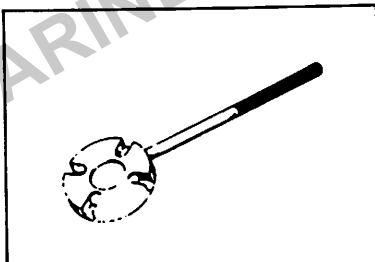
95905-07006

Box wrench



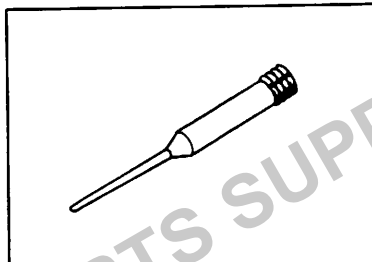
95905-06004 (10 mm)

Holding wrench



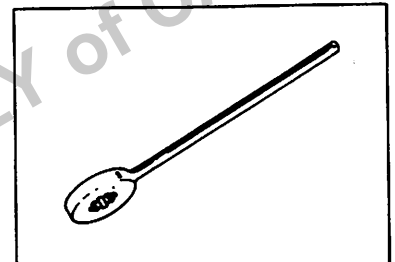
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Oiler



95905-01090

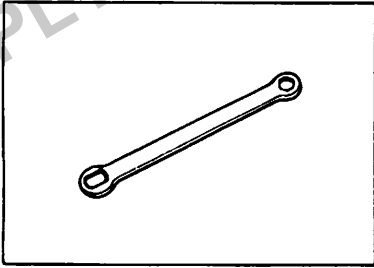
Holding wrench



95905-01020

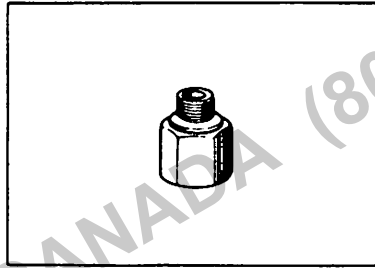
4-6 FUEL INJECTION PUMP

Wrench



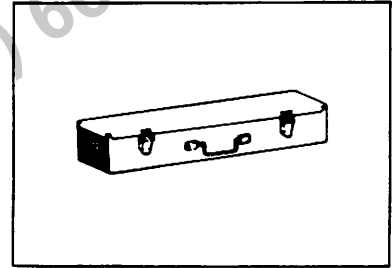
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Adapter



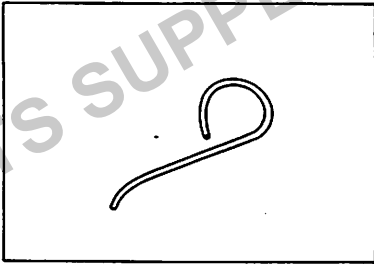
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Tool case



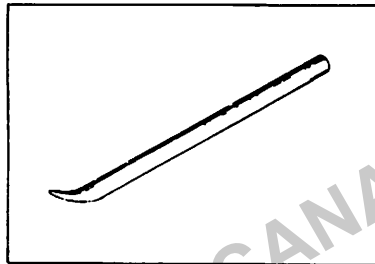
95909-08000

Tappet inserter



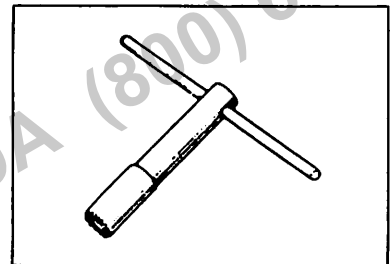
95905-03008

Tappet gap instrument



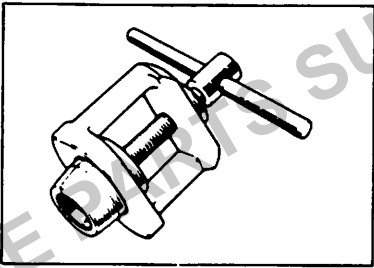
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Cutter



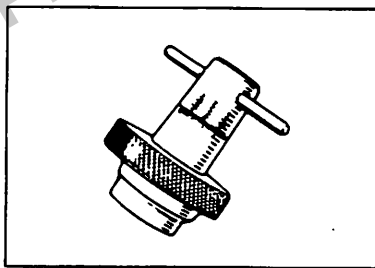
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Spline extractor



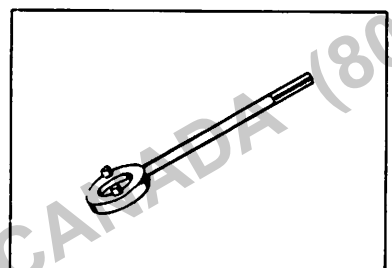
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95905-01051

Camshaft clearance gauge



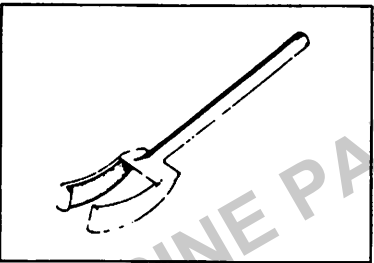
95905-01080

Holder



95905-03020

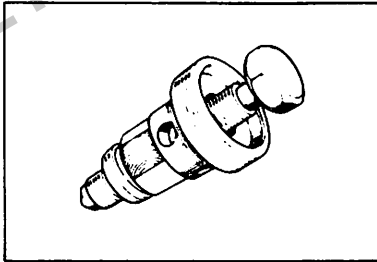
Spring holder



95905-02009

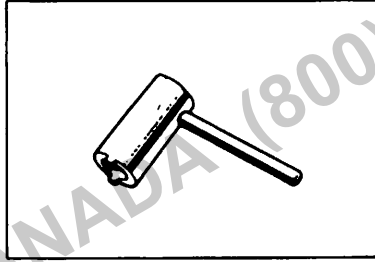
GOVERNOR TOOL KIT (95907-02000)

Governor weight extractor



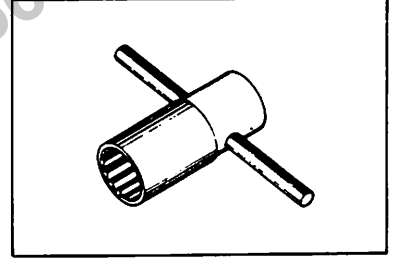
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Idle adjust wrench



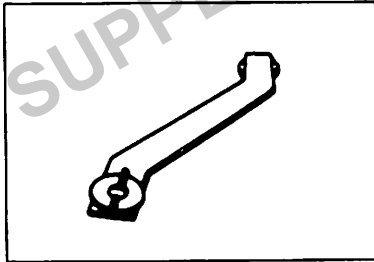
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Adapter



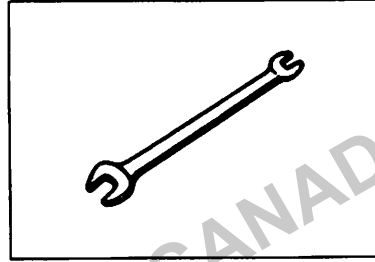
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Arm



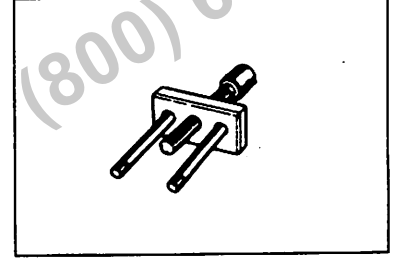
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Wrench



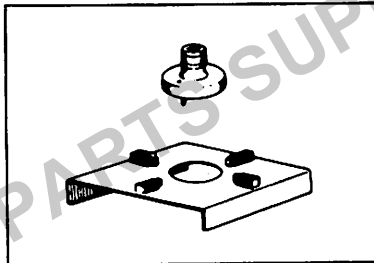
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Governor puller



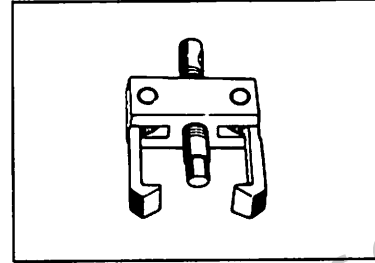
95907-02020

Torque measuring tool



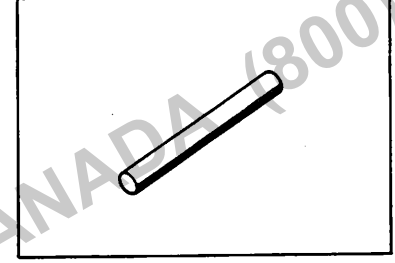
95907-01030

Control sleeve extractor



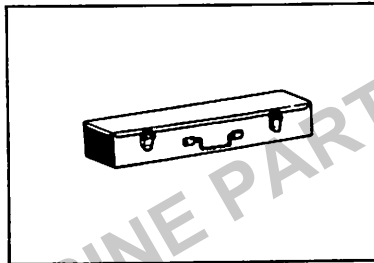
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Lever



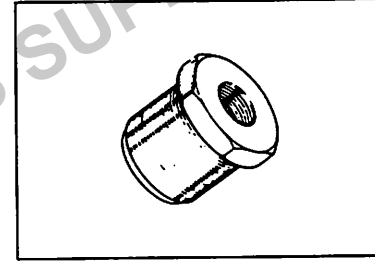
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Tool case



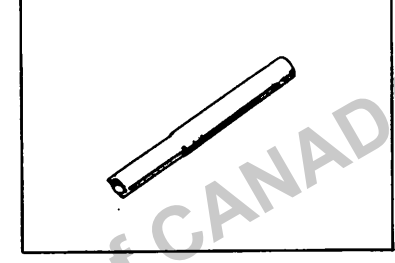
95099-08000

Pressing screw



95907-07080

Weight spring nut wrench

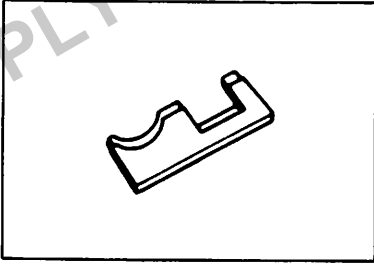


95907-02004

4-8 FUEL INJECTION PUMP

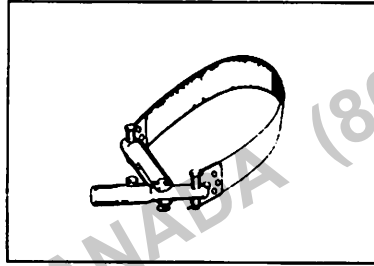
TIMER TOOL KIT (95906-03000)

Spring guide



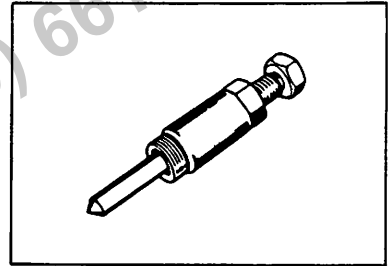
95906-01030

Band wrench



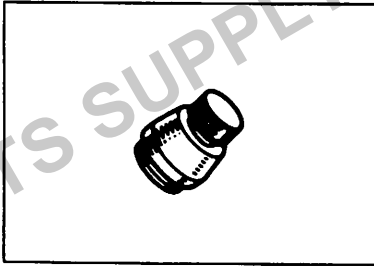
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Timer extractor



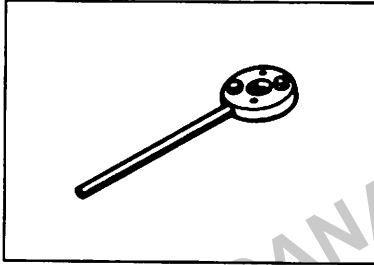
95906-02050
95906-08050

Oil seal guide



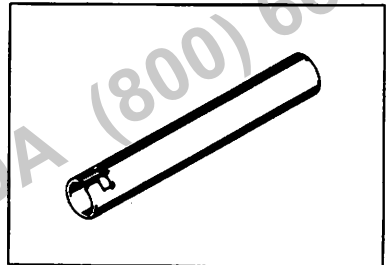
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Holding wrench



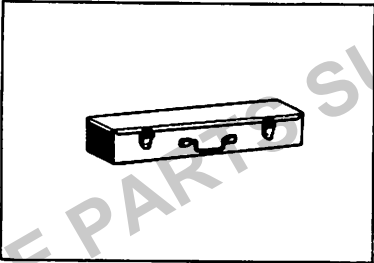
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Handle



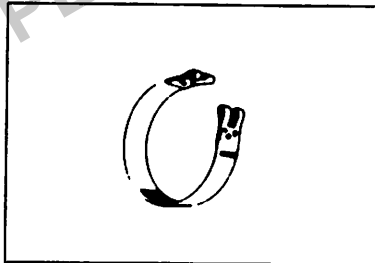
95906-01062

Tool case



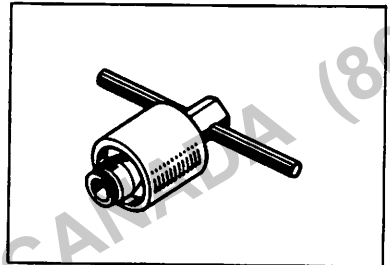
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Band



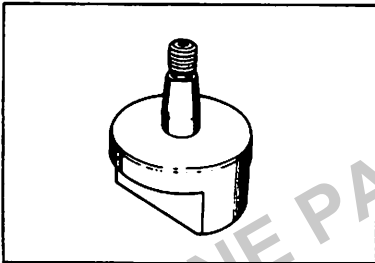
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Timer repair tool



95905-07050

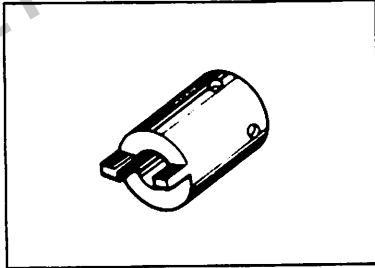
Timer setting stand



95906-05100

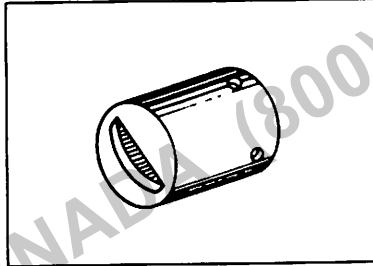
BOX WRENCH KIT (95905-05000)

Governor round nut wrench box



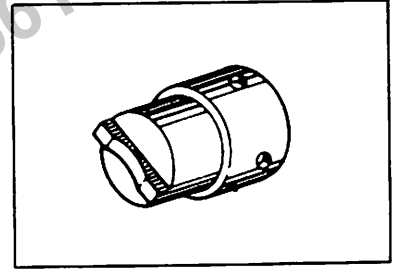
95907-05010

Governor plug wrench box



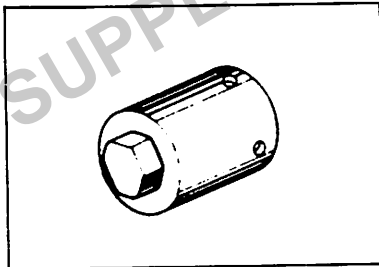
95905-04004

Timer wrench box



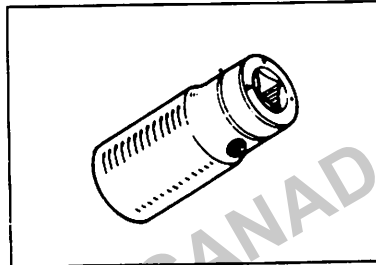
95907-07010

Screw plug wrench box



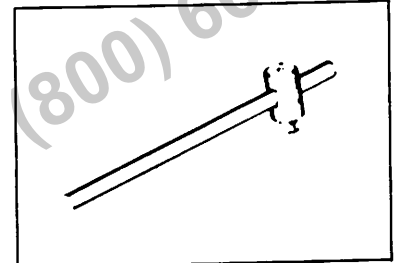
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Box



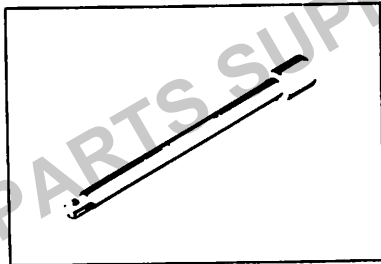
95905-07005
95905-08005

T-Handle



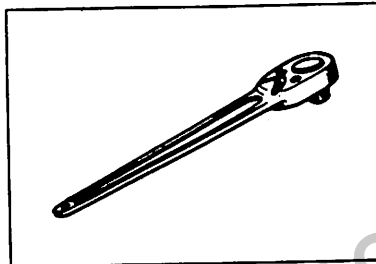
95044-33380

Extension bar



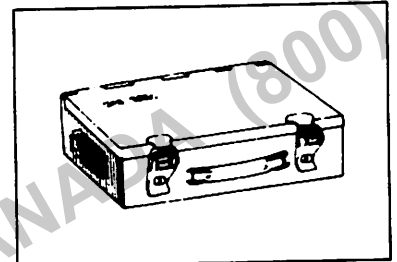
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Wrench



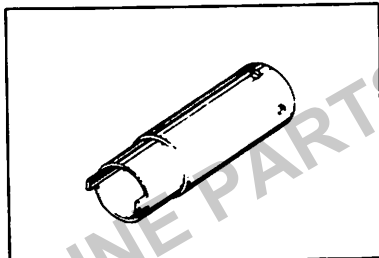
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Tool case



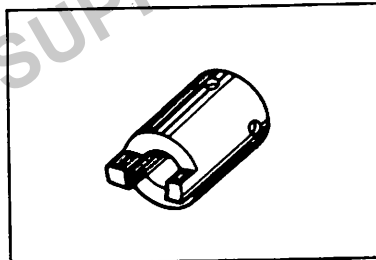
95099-05000

P-type plug setting wrench box



95905-04010

Timer round nut wrench box

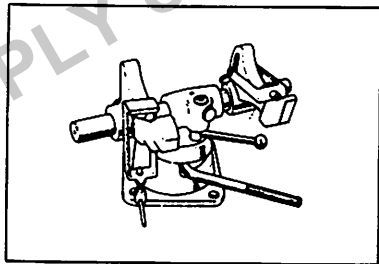


95906-03010

4-10 FUEL INJECTION PUMP

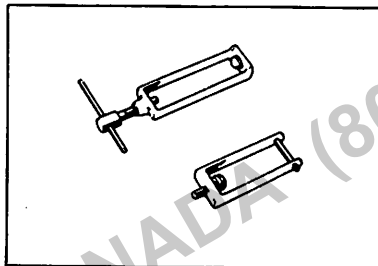
PUMP HOLDER KIT (95805-02100)

Pump stand



95905-01100

Pump stand adapter

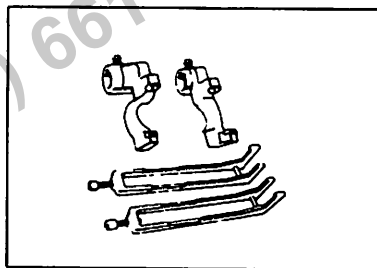


95905-01110

95905-01111

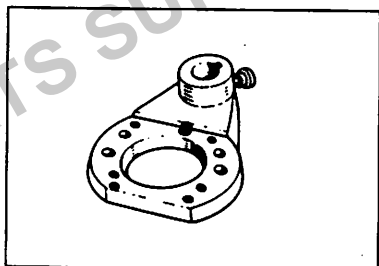
95905-01112

Pump holder



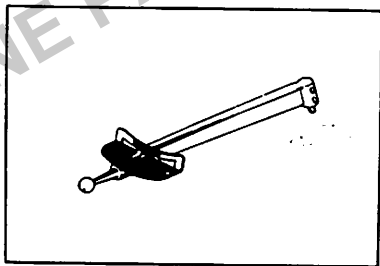
95905-02110

Pump setting angle



95905-06101

TORQUE WRENCH KIT (95047-01000)



95047-21300

Fig. 4-10 Special tools

DISMOUNTING

1. Dismounting the injection Pump with Governor, Timer and Feed Pump

1. Disconnecting the fuel pipe
Disconnect pipe joints at the feed pump inlet and outlet and the injection pump inlet and outlet. After disconnecting, cover the pipe ends to prevent the entry of dust.
2. Disconnecting the lever link
Remove the joint pin of the governor fuel lever to disconnect the link.
3. Put matching marks in paint on both faces (with the disc in between) of the coupling in front of the

timer, that is the timing gear case side and the injection pump side.

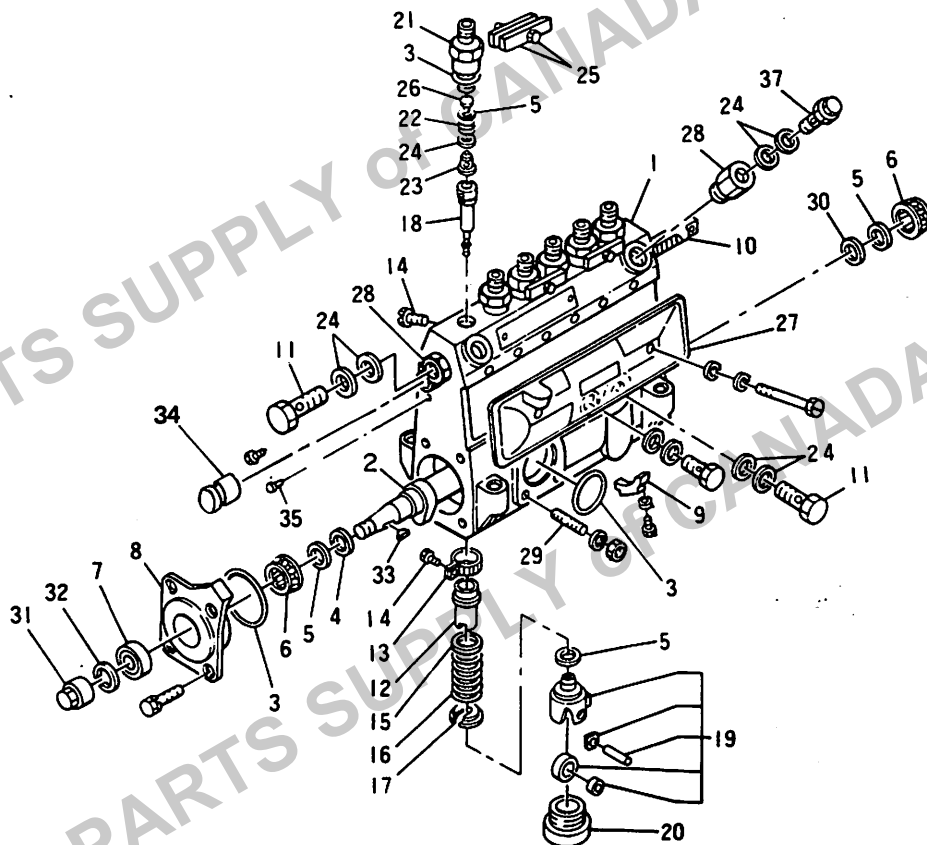
4. Remove the four injection pump mounting bolts and move the injection pump backward so that it will be disconnected from the coupling.

After removing the pump from the engine, thoroughly clean it and check for external damage before disassembling.

2. Removing the Main Unit

1. Drain the oil from the drain plug.
2. Dismounting the feed pump after removing three retaining bolts.
3. Dismount the governor.
4. Dismount the timer.

DISASSEMBLY



- | | | | |
|----------------------------|-------------------------------|-----------------------------|-----------------------|
| 1. Injection pump housing | 11. Joint bolt | 21. Delivery valve holder | 31. Round nut |
| 2. Injection pump camshaft | 12. Plunger control sleeve | 22. Delivery valve spring | 32. Lockwasher |
| 3. O-ring | 13. Control pinion | 23. Delivery valve | 33. Woodruff key |
| 4. Distance ring | 15. Upper seat | 24. Gasket | 34. Control rod cover |
| 5. Shim | 16. Pump plunger spring | 25. Valve holder lock plate | 35. Pin |
| 6. Taper roller bearing | 17. Plunger spring lower seat | 26. Stopper | 37. Bleeder screw |
| 7. Oil seal | 18. Injection pump element | 27. Cover | |
| 8. Bearing cover | 19. Injection pump tappet | 28. Adapter | |
| 9. Bearing | 20. Plug | 29. Stud | |
| 10. Control rod | | 30. Washer | |

Fig. 4-11 Fuel injection pump body

4-12 FUEL INJECTION PUMP

1. Caution in disassembling

1. It is very important that disassembly and assembly be made in a clean workshop, as the pump is a high-precision part.
2. Always use the delivery valve as a set with the plunger.

DISASSEMBLING

1. Placing the Tappet Insert

1. Remove the fuel feed pump.
2. Remove the plate cover.
3. Insert the tappet inserter (part No. 95905-03008) into the bore of the tappet in order to isolate the camshaft from them.

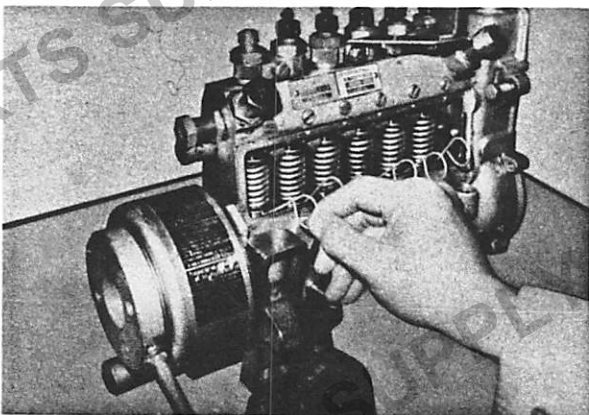


Fig. 4-12 Placing the tappet insert

04-027

2. Removal of Camshaft

1. Remove the plug and screw from the lower part of the housing with a T-Handle (Part No. 95044-33380).
2. Remove the cover and bearing outer race from the automatic timer.
3. Remove the camshaft towards the timer.

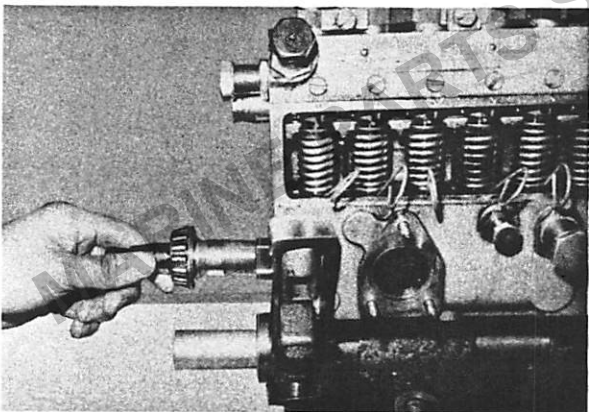


Fig. 4-13 Removal of camshaft

04-028

3. Removal of Tappet Assembly

1. Remove the tappet assembly by making use of tappet inserter (Part No. 95905-06030) and tappet clamp (Part No. 45905-10030).

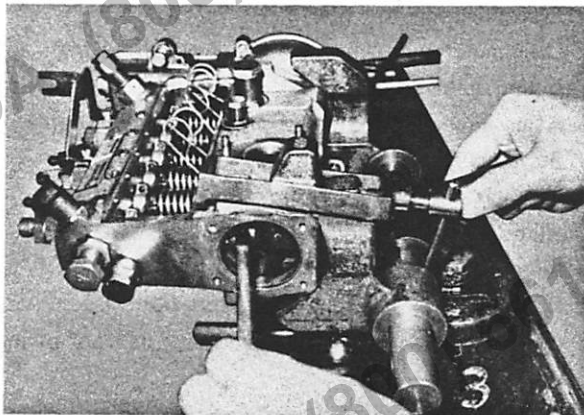


Fig. 4-14 Removal of tappet

04-029

4. Removal of Plunger

1. Remove the plunger spring lower seat and plunger en bloc by making use of plunger puller (Part No. 95905-11030).

NOTE:

Sort the removed plungers to identify with the cylinders.

2. Then, remove the plunger spring.

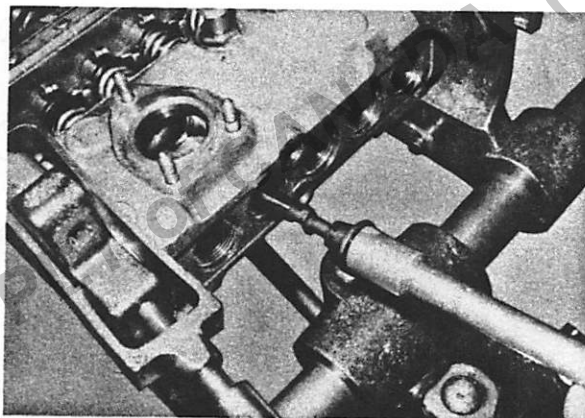


Fig. 4-15 Removal of plunger

04-030

5. Removal of Control Sleeve

1. Remove the control sleeve and plunger spring upper seat.

6. Removal of Delivery Valve Holder

1. Remove the lock plate assembly, and then pull out the delivery valve holder and delivery valve spring by means of socket wrench.

7. Removal of Delivery Valve

1. Dismantle the delivery valve by fingers.

NOTE:

Assort the removed delivery valves to make with the formerly assorted plungers.

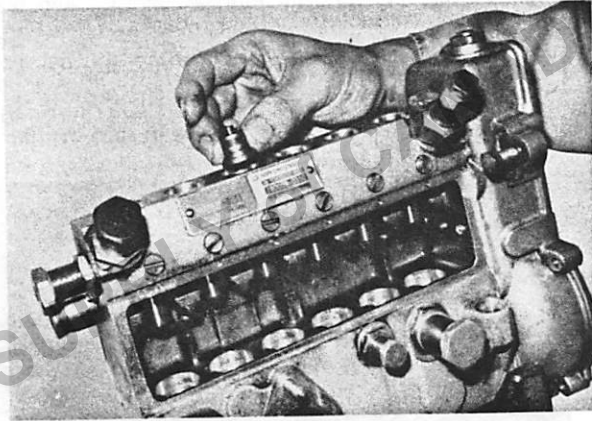


Fig. 4-16 Removal of delivery valve

04-031

8. Removal of Control Rod

1. Loosen the rack screw on the back of the housing, and remove the control rod out of the governor.

CLEANING

1. Remove the delivery valve gasket from the delivery valve and thoroughly wash them in gasoline. Then place them, as a unit, in a diesel fuel oil tank.
2. Clean the plunger in a similar manner.
3. Wash the exterior and interior of the pump housing using a small brush. The portion where the plunger barrel fits in must be cleaned with special care. Dry the pump housing after washing, by applying compressed air.
4. Similarly, wash all other parts in gasoline and keep them classified according to cylinders to which they belong.

INSPECTION AND REPAIR

1. Plunger.

Remove the plunger out of the plunger barrel, and check it for scars, traces of seizure and rust development.

Put the end of plunger into the barrel, and tilt the barrel some 60°. Turn the plunger, if the plunger falls gently, the plunger set-up is justifiable. The replacement should be carried out as to a complete set of the plunger and barrel.

Half replacement is prohibitive. See Fig. 4-17.

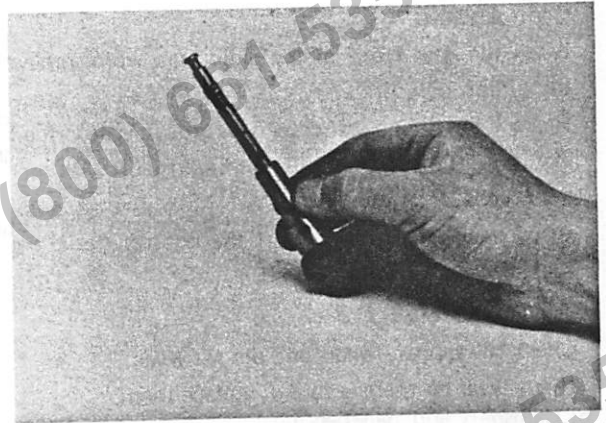


Fig. 4-17 Testing the plunger

G 3367

2. Delivery valve

Check the piston in the same manner as the plunger, and check the valve seat for stepped wear, scars, etc. Also check the drawing back action of the delivery valve as follows.

- (1) Thoroughly wash the delivery valve in diesel fuel oil. Allow a light coating of oil to remain on its surface.
- (2) Close the port by fingers as shown in Fig. 4-18.

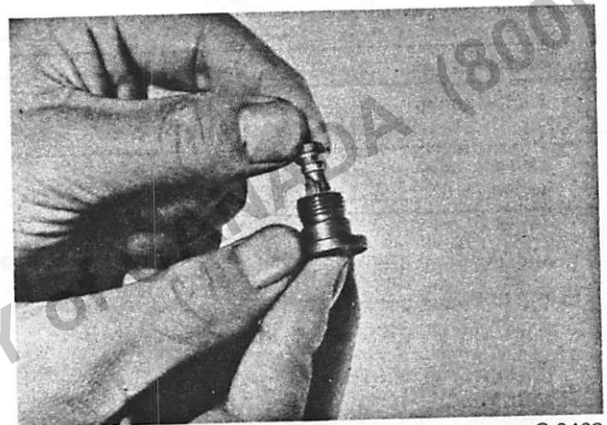


Fig. 4-18 Testing the delivery valve

G 0462

- (3) Lift the valve and then release it. If the valve drops and stops at the piston return action is acceptable.

The plunger and the delivery valve are not fit for reuse after repair.

3. Control rod

Check for bending. If found bent, the control rod must be repaired or replaced.

If there is an excessive clearance between the control rod and the bushing, replace the bushing. The control rod should be replaced also when its gear teeth are excessively worn.

4-14 FUEL INJECTION PUMP

4. Control sleeve
When the gear teeth of the pinion are worn, replace the pinion only.
Replace the pinion set screw if its groove is deformed. Adjustment after assembly will be difficult with such a set screw.
Also check and confirm that the control sleeve and the pinion are firmly secured.
5. Tappet and roller
Check the tappet, rollers and pin for wear.
If any wear on them is found, replace them.
6. Camshaft and ball bearing
Check the camshaft for scoring and excessive wear as well as for deformation of the thread at each end and deformation of the key groove. Check the ball bearing for the wear and fatigue of balls or the race surface, and replace it if any defect is noted. Assemble the camshaft into the injection pump housing and measure its end play. If it exceeds 0.1 mm (0.0039 in.), adjust it to 0.03 – 0.05 mm (0.0017 – 0.0019 in.), placing shims.
7. Plunger spring and delivery valve
Check the springs for cracks. Also measure their free length and verticality. Replace them if they are over the lengths specified below.

Item	Vertically
Plunger spring	49.4 ± 1 mm (1.94 ± 0.039 in)
Delivery valve spring	19.0 mm (0.75 in)

8. Check the injection pump housing for cracks, damage to the threaded portion, etc.

ASSEMBLY

In assembly, observe the assembly marks on various parts to avoid erroneous assembly. Check and confirm, during assembly, that all moving parts will move smoothly.

1. Installing the control rod
Insert the control rod to the housing and tighten the rod guide screw, after which confirm that the rod will move smoothly.
2. Installing the plunger barrel
Place the plunger barrel (only the barrel, without the plunger) in each cylinder. See to it at this time

that the feed hole of the barrel will come to the front of the pump (opposite side of the rack).

3. Installing the delivery valve
Put a new delivery valve gasket on the delivery valve and tap it lightly with a pipe *that fits the periphery of the gasket, so that the delivery valve will closely contact the plunger barrel. Then place the delivery valve spring and tighten the delivery valve holder with 250 – 350 kg·cm (18 – 26 lb.ft.).
**Similarly install the delivery valve in each cylinder.

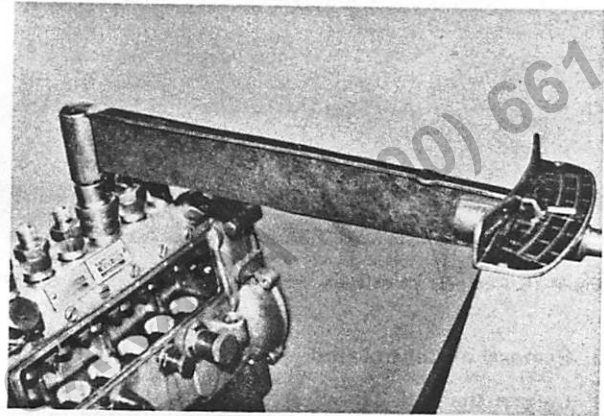


Fig. 4-19 Tightening the valve holder

04-032

NOTE:

- *This tapping tool may be made by grinding the threaded portion of a delivery valve holder.
- **Excessive tightening of the delivery valve holder may cause major troubles such as the breakage of the pump housing and defective movement of the control rod, etc. Care must be taken accordingly.

(Lay the injection pump)

4. Installing the control sleeve
Set the control rod so that the distance from the end surface of the case to the punch mark at the end of the control rod will be equal on each side.
Then place the control sleeve in the plunger barrel and engage it with at the position where the clamp portion of the pinion will be perpendicular to the rod.
5. Installing the plunger spring
Install the spring upper seat and the spring.
6. Inserting the plunger into the barrel.
Dip the plunger in clean diesel fuel oil, and then hold it with the plunger holder (special tool shown in Fig. 4-20) horizontally. Then, put the lower spring seat on the plunger, holding its flange portion, and insert it through the plug hole, maintaining it horizontally.

The feed hole of the barrel and the control groove of the plunger should be in the same direction. If installation is incorrect, injection volume cannot be adjusted.

When the spring and the spring seat have been put together completely, loosen the plunger holder and draw out the holder.

This must be conducted very carefully, so that the spring seat will not be dropped before the plunger is inserted.

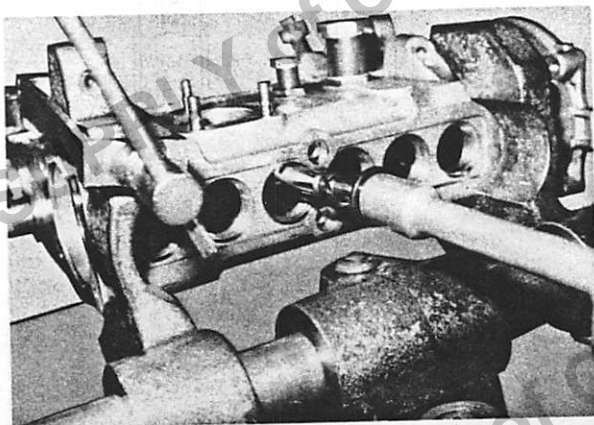


Fig. 4-20 Inserting the plunger 04-033

7. Installing the tappet

Install the tappet immediately upon completion of the operation 6. Hold the tappet with a tappet holder and insert it through the plug hole. Correctly align the plunger flange with the control sleeve groove. Repeat pushing and pulling several times and move the control rod to make sure that it will move smoothly. Then push the tappet up and put in the tappet insert.

When a strong resistance is felt in moving the control rod, check and find the cause before proceeding to the next operation.

The resistance can be caused by scars on the rod, a rod or pinion abnormality, pinion and pump housing friction, and excessively tightened delivery valve etc.

8. Repeat the operations 6 and 7 above for all cylinders.

After this, the control rod must move more smoothly.

9. Installing the camshaft

Install the governor housing, together with the bearing cover on the case and insert the camshaft from the timer side and then put the timer side bearing cover.

Camshaft end play should be from 0.03 – 0.05 mm (0.00118 – 0.00196 in.) if not, adjust with shims. After this, draw out the tappet insert (special tool).

10. Install the screw plug

11. Installing the body cover

Correctly install the cover of the pump body and secure the cover screw to prevent the entry of water into the pump body (this leads to rust damage).

TESTING (1)

1. Inspecting the Sliding Resistance of Control Rod

The rod should slide smoothly to the left or right under a load of less than 50 g (1.76 oz) when the pump rotates at 1,000 rpm and under a load of less than 150 g (5.29 oz) when the pump stops. Measure the sliding resistance by using the spring balancer.

Pump speed	Sliding resistance
1,000 rpm	* Less than 50 g (1.76 oz)
At stopping	* Less than 150 g (5.29 oz)

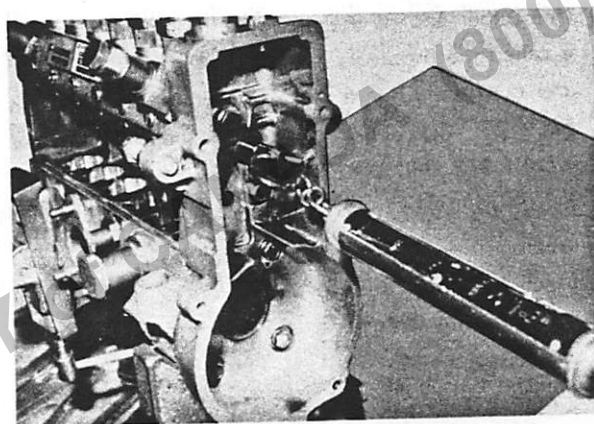


Fig. 4-21 Measuring the sliding resistance of the control rod 04-034

TESTING (2)

After assembling, inspect and adjust the function of the injection pump.

1. Injection timing
2. Injection volume
3. Fuel tightness

4-16 FUEL INJECTION PUMP

1. Tester

Specified testers are necessary for testing. Contact a service station when proper testers are not available. One of the specified tester is shown in **Fig. 4-22**.

1. Set the injection pump correctly in the tester.
2. Fill the Engine Oil from the plug until the oil overflows from the hole of the plug.

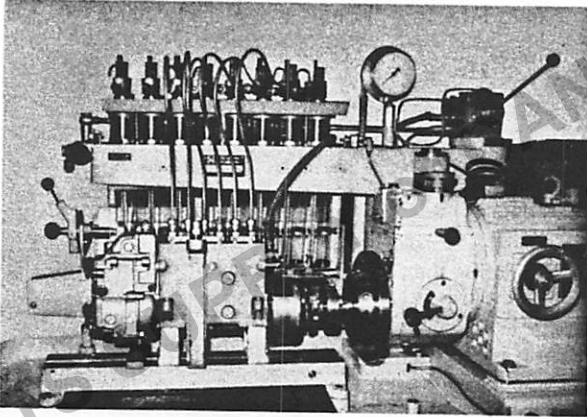


Fig. 4-22 Injection pump tester

04-035

2. Measuring and adjusting the injection interval

After fixing the pre-stroke of the first cylinder, insure that the others begin injection at interval $60^\circ \pm 30'$ in the order of cylinder 1-4-2-6-3-5.

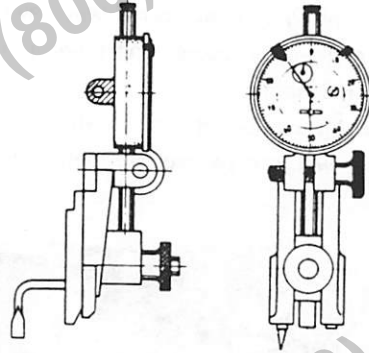


Fig. 4-24 Plunger stroke measuring device

2. Injection timing

1. Measuring and adjusting the pre-stroke of the first cylinder.

The plunger stroke from the point where the cam lift is zero to the point where pressure-feeding begins (the upper end of the plunger closes the feed hold) is called the pre-stroke. (Refer to **Fig. 4-23**) Measure and confirm, using a measuring device as shown in **Fig. 4-24**, that the pre-stroke of the first cylinder is 3.1 ± 0.05 mm (0.122 ± 0.00197 in.).

Place this device at the injection pump housing holding it with hand, and allow its contactor to touch the upper surface of the tappet. Then slowly turn the cam with hand and read the stroke on the dial gauge.

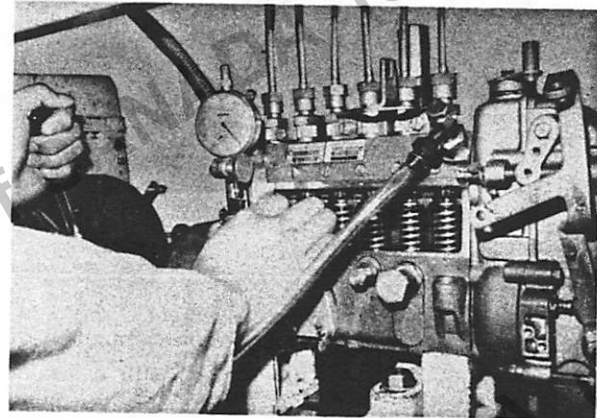


Fig. 4-25 Measuring the pre-stroke

04-036

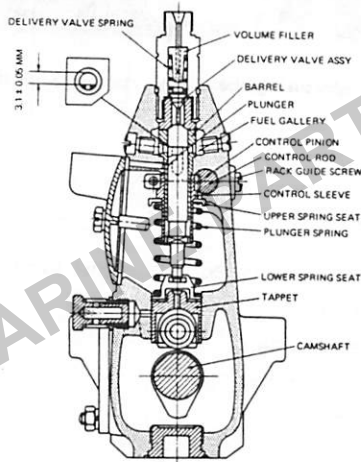


Fig. 4-23 Pre-stroke and its adjusting bolt

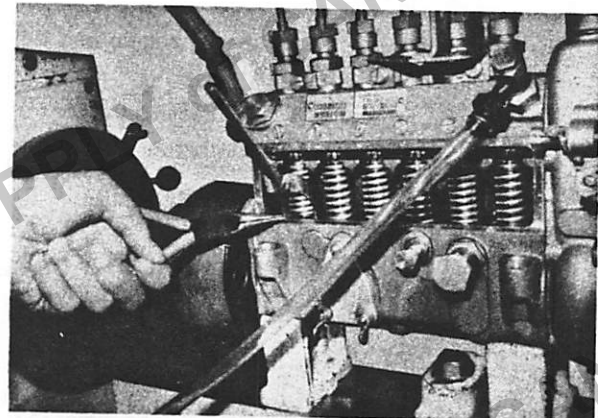


Fig. 4-26 Adjusting the pre-stroke

04-037

3. Insuring the tappet top clearance

The tappet top clearance is the distance from the upper end of the plunger flange to the lower end of the barrel, when the cam lifts maximum. (Refer to Fig. 4-27).

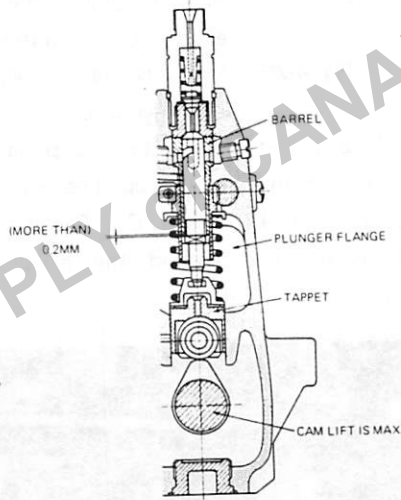


Fig. 4-27 Tappet top clearance

Insure that the tappet top clearance is more than 0.2 mm(0.0078 in.), for all six cylinders, using the device shown in Fig. 4-24, by the same method for measuring the pre-stroke, and tappet gas instrument. If this clearance is less than 0.2 mm (0.0078 in.), adjust it by the adjusting shims.

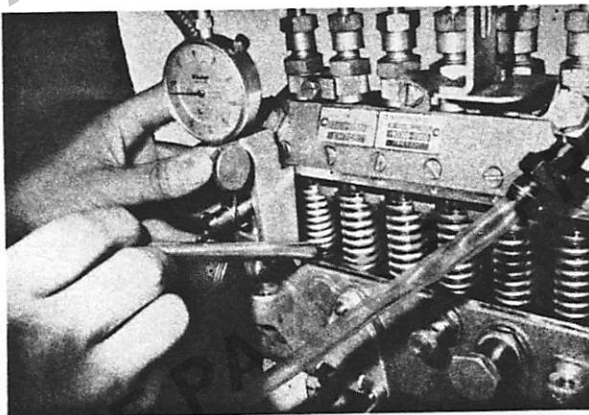


Fig. 4-28 Measuring the tappet clearance

04-038

4. Insuring the injection timing mark

After these adjustments are completed, check and confirm that the mark on the bearing cover of the pump and the one on the automatic timer are matched, at the position where the pressure-feeding of the first cylinder beings. (Refer to Fig. 4-29). If they are not, remark it.

That is the moment these marks are matchied is the injection start timing of the first cylinder.

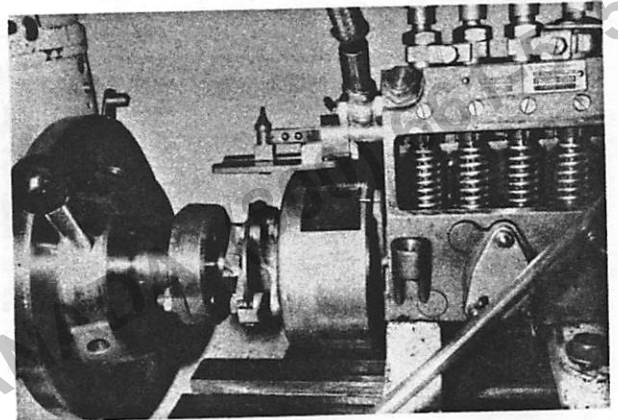


Fig. 4-29 Injection timing mark

04-039

3. Injection Volume

When necessary the injection volume adjustment, should be made as follows (refer to supplementary data sheet).

- (1) Loosen the control rod fixing device and move the rod to one side all the way and loosen the rod pinion screw of the cylinder which needs injection volume adjustment.
- (2) Insert the adjusting pin into the hole in the control sleeve and slightly move the sleeve. (Refer to Fig. 4-30).

As the control sleeve is moved to the timer side, injection volume will decrease.

As the control sleeve is moved to the governor side, injection volume will increase.

Adjust the movement of the control sleeve, watching the matching marks scribed on the control sleeve and the pinion. (Refer to Fig. 4-29).

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4-18 FUEL INJECTION PUMP

- (3) When adjustment has been completed, once again check the injection volume with a tester, and repeat adjustment until the specified injection volume is obtained.
- (4) Upon completion of the adjustment, put a matching mark on the control sleeve and the pinion.

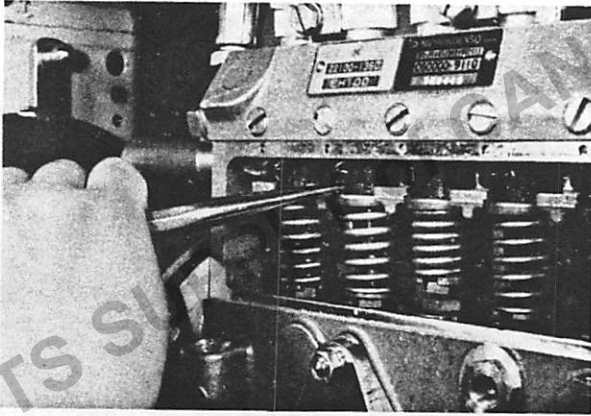


Fig. 4-30 Adjusting the injection volume

04-010

MOUNTING

1. Matching with engine

When mounting the fuel injection pump on engine, match it with the engine as follows.

With the engine stopped, align the mark on the end of the bearing cover (on the end of the injection pump) with the mark on the back of the automatic timer. (Refer to **Fig. 4-29**). This sets the primary plunger in the position of maximum injection.

At this time, adjust the injection coupling so that the pointer, viewed through the opening on the flywheel housing, indicates 17° (B.T.D.C.). This is found on the graduations punched around the periphery of the flywheel.

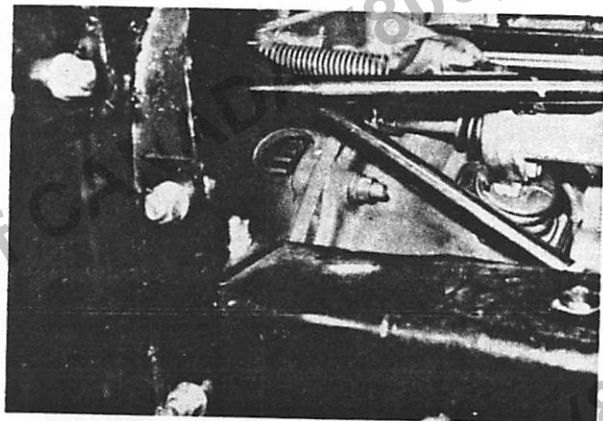


Fig. 4-31 Flywheel scribed marks

KR-108

GOVERNOR

DESCRIPTION

The RSV governor is a centrifugal, variable-speed type governor. This governor is capable of holding a steady speed in the range between idling and maximum speed positions.

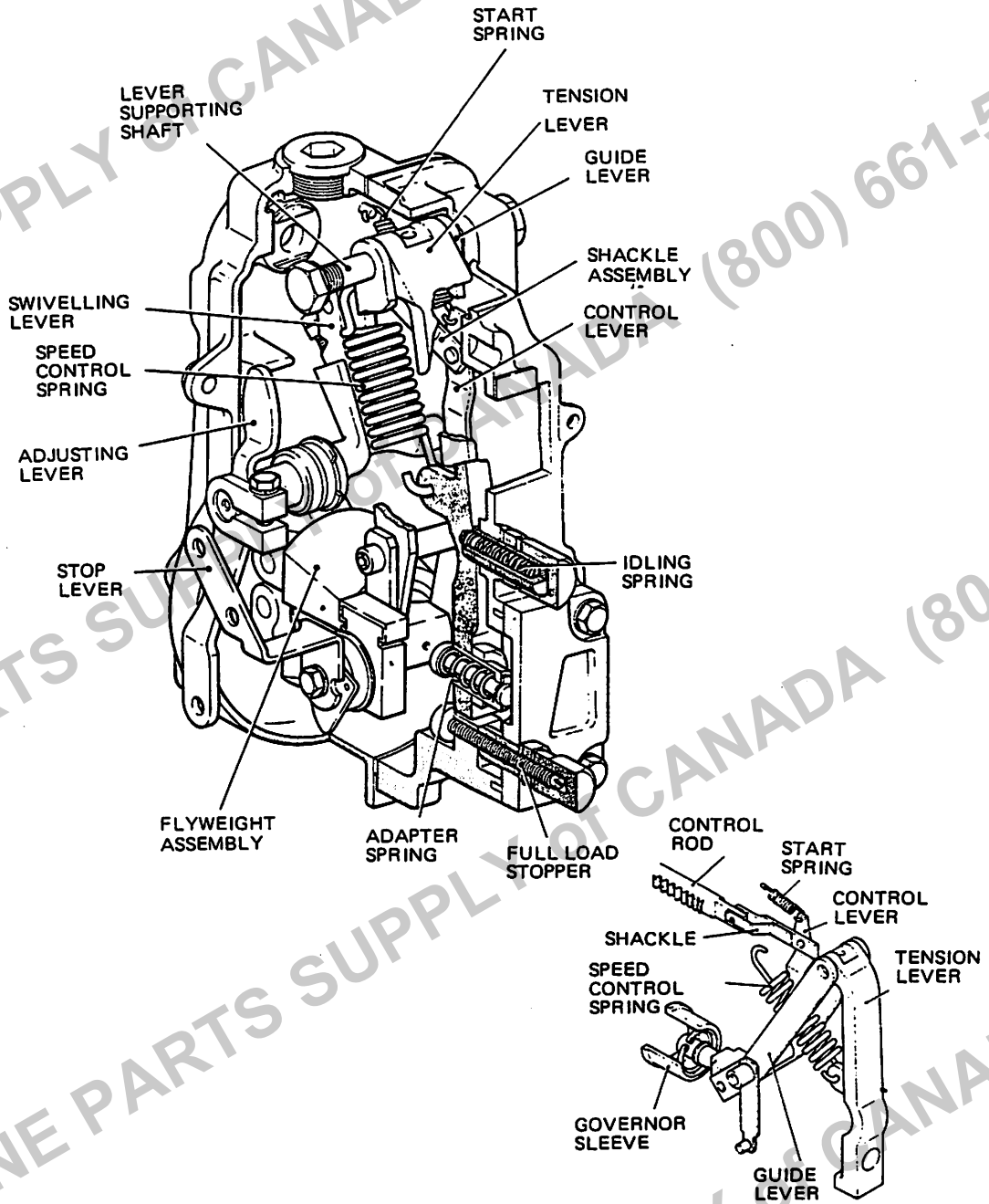


Fig. 4-32 Structure of the governor

1. Structure

(1) The flyweight assembly is mounted on the pump camshaft as shown in Fig. 4-33. The camshaft bushing, with which two flyweights are connected, is keyed to the pump camshaft by key and round nut. These two flyweights can swing on weight-supporting shaft. When the flyweights swing outward, the roller at the end of the flyweights are pressed against the shoulder of the governor sleeve. The governor sleeve can be moved along the stub of the camshaft bushing and rotates with the camshaft bushing. The ball bearing connects the governor sleeve with the control block. The control block does not rotate but move back and forth along the projected axis of the camshaft and is connected with the guide lever.

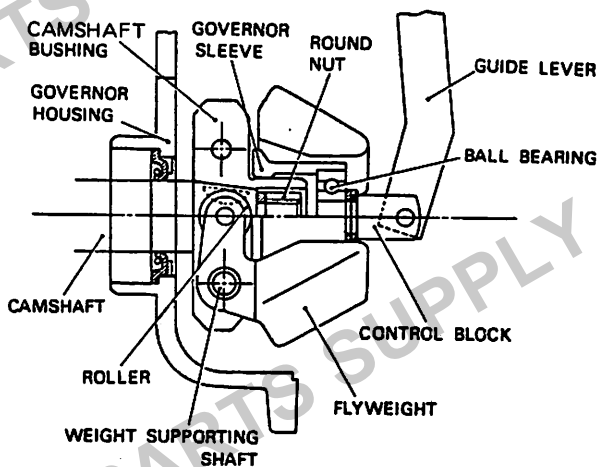


Fig. 4-33 Structure of flyweight assembly

(2) Lever and Spring

The tension lever and guide lever pivot on the lever supporting shaft at the top of the governor.

The guide lever has a pivot pin, on one end of which the control lever is fixed and can swivel. A stud of the control lever guided in a slot of supporting lever locates the control lever at its lower end. The shackle assembly connects the control lever to the control rod.

The swivelling lever pivots in bushing on each side of the governor cover. The adjusting lever is fastened to one end of the swivelling lever.

The start spring is hooked to the top of the control lever and in a hole of bracket fixed to the governor housing. The speed control spring is hooked to the rocker arm of the swivelling lever and into the eye of the tension lever.

The adaptor assembly, adjustable threaded bushing is screwed into the tension lever at its lower end, and serves to increase fuel delivery when the engine is pulled down by overload in the medium-to full load rpm range. The idling spring is fitted in an adjustable threaded bushing which is screwed into the governor cover nearly at its center, and provides satisfactory governing at low speed without affecting high speed performance.

The maximum speed stopper provides the full load position to the adjusting lever and the stop-adjusting screw provides the stop position to the adjusting lever.

(3) Stop device

The stop device is shown in Fig. 4-34.

The supporting lever of the stop device is coupled to the shut-off shaft and stop lever by pressure spring. When the stop lever is turned to "stop position", the control lever pivots on the shaft through the supporting lever. Therefore, control rod is directly moved to "no fuel delivery" position regardless of other linkage and lever operation.

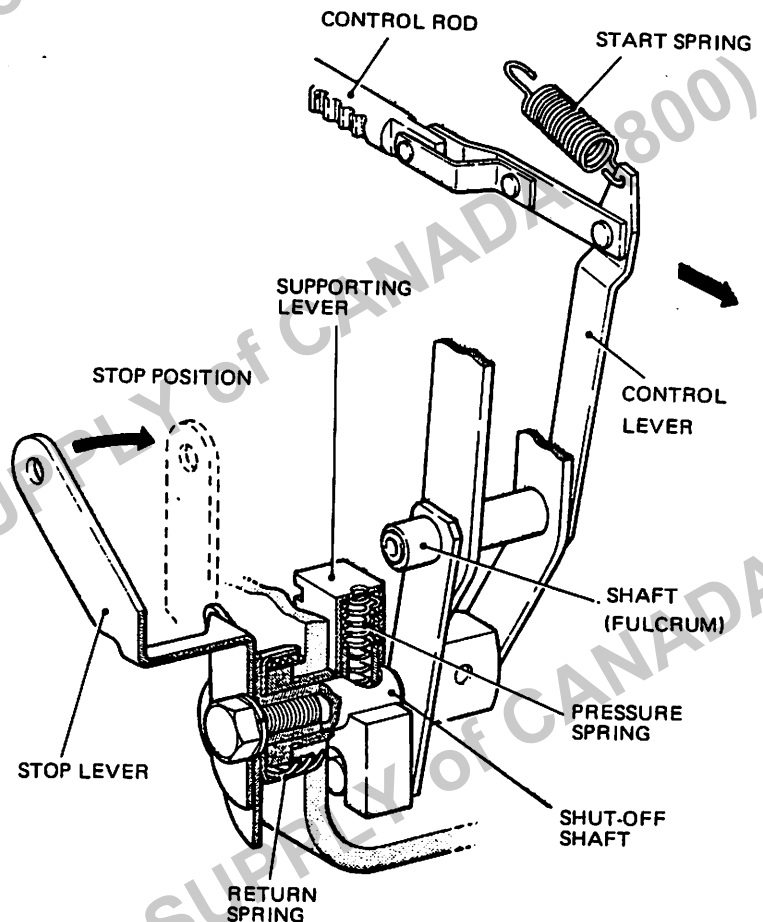
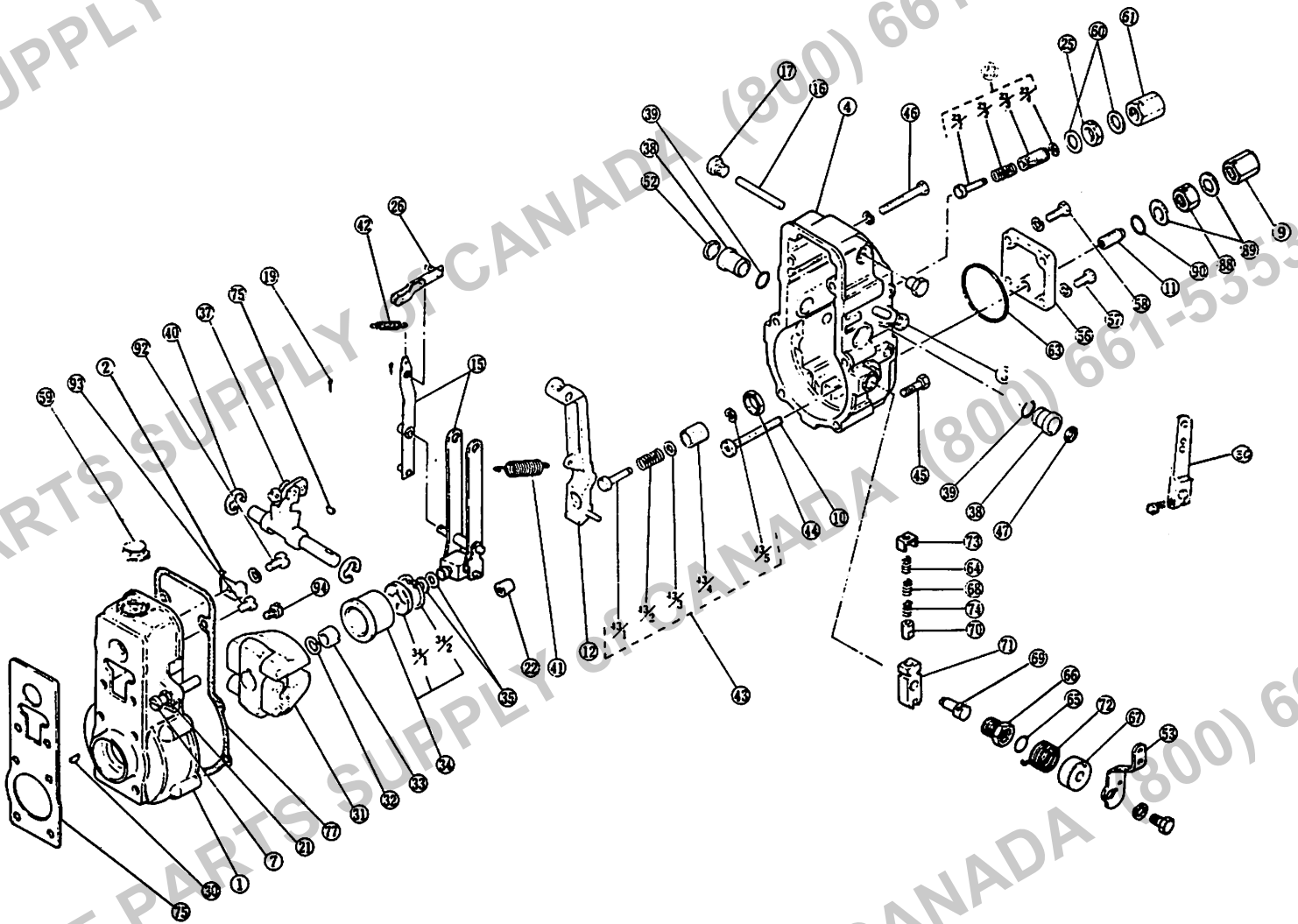


Fig. 4-34 Stop device



- | | | |
|----------------------------|--------------------------|---------------------|
| 1. Governor housing | 31. Flyweight | 52. Lever cap |
| 2. Plate | 33. Round nut | 53. Stopper lever |
| 3. Stopper | 34. Sleeve | 56. Cover plate |
| 4. Governor cover | 35. Plate washer | 63. Plate packing |
| 7. Stopper | 37. Swiveling lever | 64. Pressure spring |
| 9. Cap nut | 38. Lever bushing | 66. Bearing bushing |
| 10. Stroke adjusting screw | 39. O-ring | 67. Spring cover |
| 11. Bushing | 40. Snap washer | 68. Pressure spring |
| 12. Tension lever | 41. Speed control spring | 69. Governor shaft |
| 15. Control lever | 42. Start spring | 70. Spring cup |
| 16. Supporting lever shaft | 43. Adapter | 71. Support lever |
| 17. Screw plug | 43-2. Adapter spring | 72. Return spring |
| 22. Supporting slider | 44. Lock nut | 73. Cap plate |
| 23. Idle spring | 47. Oil seal | 74. Pressure spring |
| 24. adjusting screw | 49. Steel collar | 78. Torque lever |
| 26. Shackle | 50. Adjusting lever | 79. Support pin |
| 30. Woodruff key | | |

Fig. 4-35 Governor main component parts

2. Working Principle

(1) When a camshaft to which the two flyweights are keyed, rotates, these flyweights swing outward as shown in Fig. 4-35. The force swinging out the flyweights is called the centrifugal force. As the speed of the camshaft increases, the centrifugal force also increases.

Case 1

When the speed increases the flyweights swing outward and move point A, at the end of flyweight arms, to the right.

This pushes on the control block. At this time, the centrifugal force overcomes the spring force, as shown in Fig. 4-35. This movement will stop at a position where the forces on the flyweights and spring are balanced.

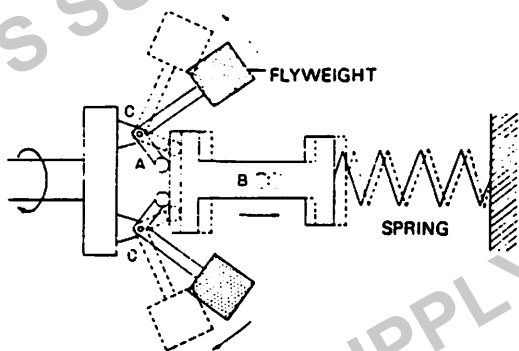


Fig. 4-35 Working principles

Case 2

When the speed decreases, the centrifugal force becomes less. Finally the spring force exceeds the centrifugal force, and the flyweights swing back. The control block is then moved to the left. This movement stops at a balanced position.

On a injection pump body, a governor-operated control rod is connected to the control sleeve and plunger to regulate the quantity of fuel delivered to the engine. Pushing the control rod toward the injection pump body increases the fuel delivery quantity. On the contrary, pulling the control rod toward the governor decreases the fuel delivery quantity.

As described above, the control block moves the control rod through the governor linkage system to control engine speed.

(2) Function of speed control spring

Control speed can be varied by changing the tension of the speed control spring, due to the mechanism as shown in Fig. 4-36.

The fulcrum of the swivelling lever and the eye of the tension lever into which the speed control spring is hooked are offset. Therefore, when the swivelling lever is moved in the arrow direction as shown in Fig. 4-36, the distance "DE" becomes longer and then the tension of the speed control spring becomes stronger.

The force of the speed control spring is meant to be balanced with the centrifugal force working on the lower end of the tension lever. If the tension of the speed control spring becomes weak (i.e. the swivelling lever is turned to the right.) as shown in Fig. 4-37, even a weak centrifugal force of the flyweights can overcome the spring force. This means that control speed shifts to low speed.

If the tension of the speed control spring becomes stronger, control speed shifts to high speed due to the strong spring force.

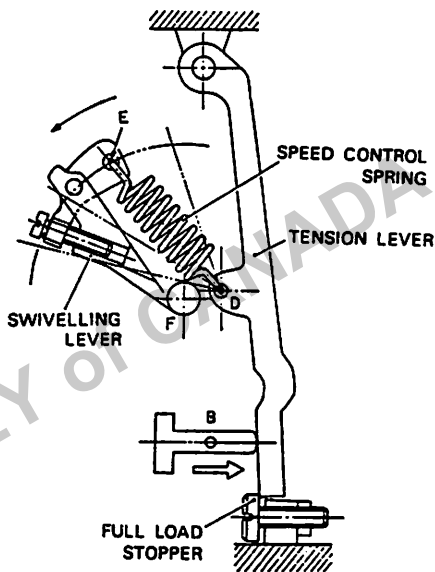


Fig. 4-36 Change of spring tension-movement 1

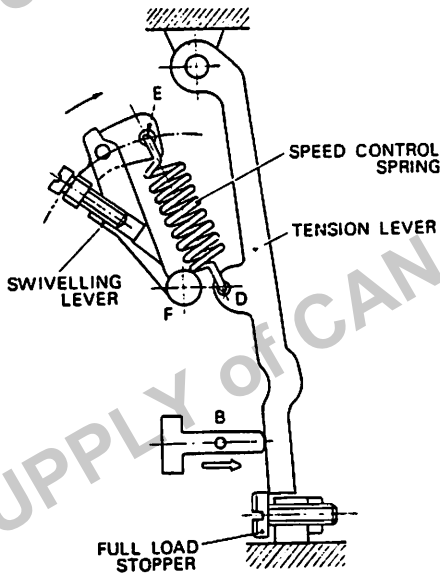


Fig. 4-37 Change of spring tension-movement 2

3. Operation

(1) Starting the engine

When moving the adjusting lever to the starting position to be pressed against the maximum speed stopper with the engine stopped, the speed control spring is fully tensioned by the swivelling lever and thus pulls the tension lever to be pressed against the full load stopper.

The tension lever will move the guide lever, control block and governor sleeve to the left. In the course of these movements, the governor sleeve moves the flyweights to rest against the governor sleeve. At the same time the start spring pulls the control lever to the left and moves the control rod all the way to "starting fuel" position via the shackle assembly. When the starter is cranking the engine, the injection pump begins delivering additional fuel to the engine for starting. Once the engine has started, the centrifugal force of the flyweights overcomes the force of the start spring, moving the control rod back to a position where the forces on the flyweight and speed control spring are balanced.

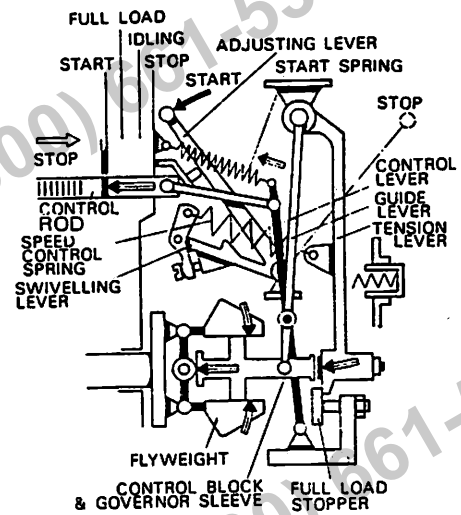


Fig. 4-38 Starting

(2) Idling speed control

When the engine is idling, the governor starts to function automatically. With the adjusting lever in idling position, the speed control spring is almost free of tension as shown in Fig. 4-39. Therefore, the flyweights can swing outward even at low speed with very little resistance, pushing the tension lever to the right via the governor sleeve and control block.

As the force of the speed control spring is weak, the tension lever is moved to a position where to contact the idling spring, slightly compressing the adaptor spring. Thus, the control lever moves on pivot A to the right and pulls the control rod to a position where the forces on the flyweights and springs such as the speed control spring and idling spring are balanced, resulting in maintaining desired idling speed.

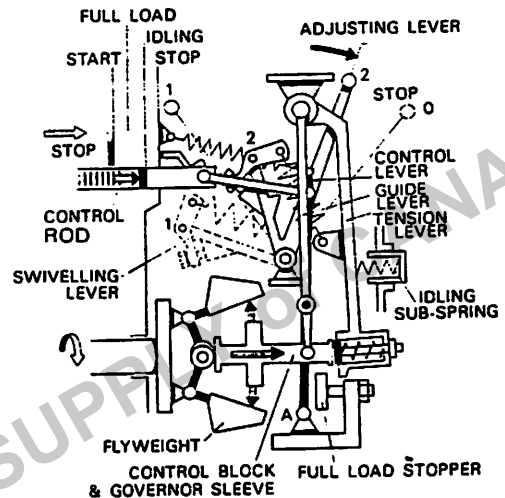


Fig. 4-39 Idling

(3) Maximum speed control

With the adjusting lever in full load position (to be pressed against the maximum speed stopper), the speed control spring is fully tensioned and then pulls the tension lever up against the full load stopper with great force. This movement causes the control rod to move into maximum fuel delivery position, resulting in increasing the engine speed.

Once the tension lever is pulled up against the full load stopper, the adaptor spring is continually compressed.

As soon as the centrifugal force exceeds the force of the speed control spring, the governor linkage moves the control rod in fuel-decreasing direction to prevent the engine speed from exceeding the specified maximum speed.

When the engine speed reaches the full load speed, the governor regulates fuel delivery to maintain the engine speed between full load and fast idle as long as the load on the engine is not great enough to cause an overload.

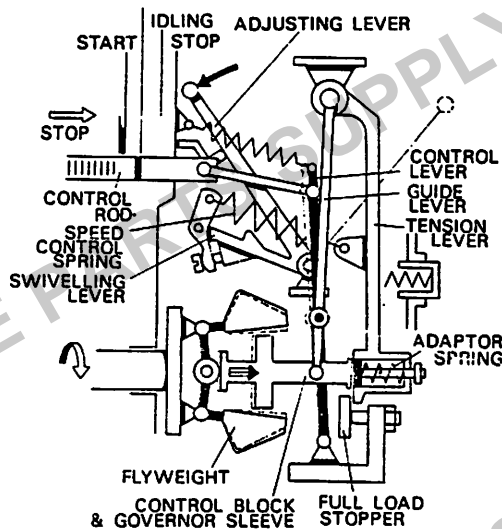


Fig. 4-40 Commencement of governing maximum speed

(4) Operation of adaptor spring

When at maximum control speed the load on the engine is sufficiently reduced, the adaptor spring overcomes the flyweights force and moves the guide lever to the left. This means that the control rod moves in fuel-increasing direction, delivering more fuel to the engine.

When the engine speed gradually increases, the flyweights force increases and starts compressing the adaptor spring. This movement causes the control rod to move in fuel-decreasing direction. Adaptor operation stops at a position where the adaptor spring is completely compressed.

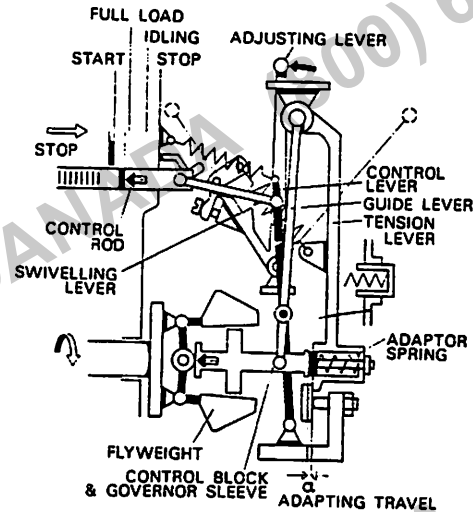


Fig. 4-41 Adaptor operation

(5) Function of adaptor spring

The purpose of the adaptor spring is to increase fuel delivery when the engine is pulled down by overload, thereby providing an acceptable level of torque control.

With the control rod fixed, as the pump speed increases, fuel delivery per stroke increases. This characteristic is peculiar to the single-acting, plunger-type injection pump. On the other hand, inlet air quantity reduces as the engine speed increases, owing to increasing resistance to air flow. Fig. 4-42 shows above mentioned characteristics and fuel requirement of the engine in full against the engine speed.

With the control rod held in full load position, if the engine speed increases, fuel delivery lines (dotted lines) are obtained as shown in Fig. 4-42. To avoid insufficient torque at low speed (line a'b) and

smoking at high speed (line ab'), the fuel delivery characteristic should coincide as closely as possible with the fuel requirement characteristic for the engine.

For satisfying this requirement, the adaptor spring is installed on the governor. When the engine is pulled down to low speed with the adjusting lever in full load position, the adaptor spring acts on the governor linkage in order to increase rod travel, that is, to provide sufficient torque to the engine.

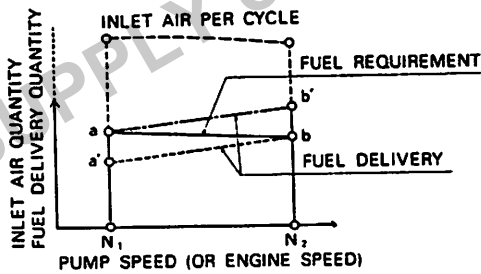


Fig. 4-42 Characteristics of fuel requirement and fuel delivery

(6) Stopping the engine

Engine equipped with governor without the stop device is stopped regardless of the flyweights position by moving the adjusting lever into the stop position (Fig. 4-43).

Shortly before the adjusting lever is moved in the stop position, that is, before the rocker of the swivelling lever contacts the stop adjusting screw, the projection of the swivelling lever presses against the guide lever and push the control rod to the stop position via the guide lever, control lever and Fig. 4-43. Stopping the engine with the adjusting lever chackle assembly.

On engine equipped with governor with stop device, moving the stop lever in the stop position actuates the stop device to force the control rod to move also in the stop position regardless of the positions of the flyweights and control lever (Fig. 4-44).

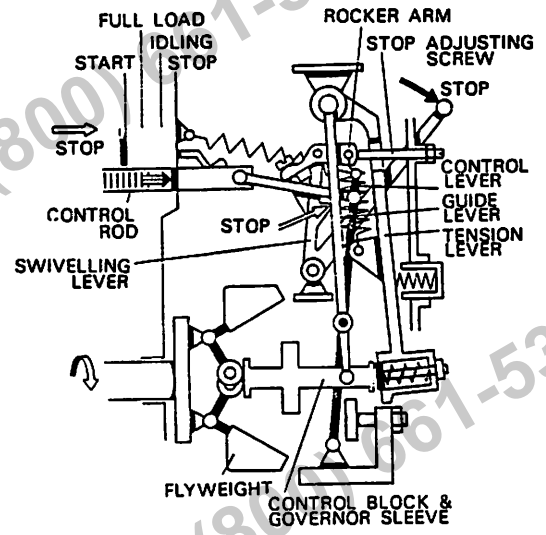


Fig. 4-43 Stopping the engine with the adjusting lever

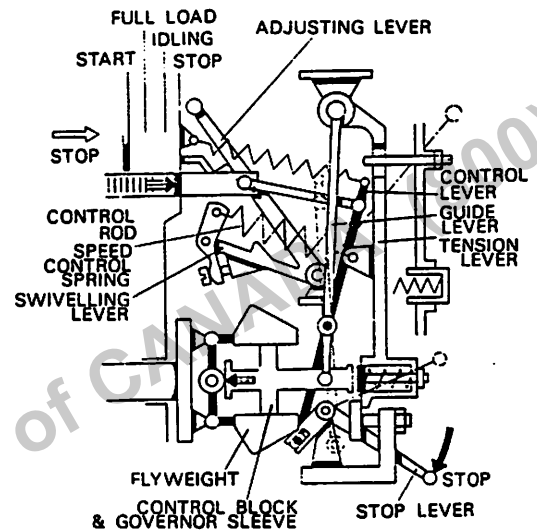


Fig. 4-44 Stopping the engine with the stop lever

(7) Speed droop (Degree of irregularity)

Speed droop is the variation in engine speeds between full load and no load speed range, and usually is expressed as a percent of rated speed.

If an engine has been operating under full load, and this load is suddenly removed, the engine speed will increase to the fast idle speed.

The speed droop is defined as follows:

$$\frac{N_n - N_f}{N_f} \times 100 (\%)$$

N_n , Maximum speed obtained by a position of the adjusting lever (no load).

N_f , Full load speed obtained by the same position of the adjusting lever (full load).

Example:

If $N_n = 1360$ rpm, $N_f = 1300$ rpm,

$$\text{Speed droop} = \frac{1360 - 1300}{1300} \times 100 = 4.6$$

Speed droop is a scale for measuring the quality of the governing effect.

The smaller the speed droop is, the better control is obtained.

(8) Characteristics of governor

Fig. 4-45 shows characteristics of RSV governor. When with the adjusting lever in full load position gradually increasing the pump speed from low speed, characteristic curve A-B-C-D-E-F is obtained. At starting, the control rod is pulled to "starting fuel" position by the start spring, exceeding full load position (line A-B). During line B-C the control block contacts the adaptor assy but the adaptor spring is not almost compressed since the centrifugal force of the flyweights is weaker than the adaptor spring force.

The adaptor spring functions during line C-D. At point D the adaptor spring completely is compressed but the flyweights force can not overcome the force of the speed control spring until the pump speed reaches maximum governing speed (point E), resulting in constant rod travel during line D-E. At point E the flyweights force begins overcoming the force of the speed control spring and the control rod is pushed toward the governor.

Characteristic curve H-I-J-K shows the characteristic of idling speed control with the adjusting lever in idling position. During line H-I the centrifugal force of the flyweights is weak. Therefore, the start spring pulls the control rod toward the maximum fuel delivery position. At point I the idling spring con-

tacts the tension lever and begins influencing the movement of the control rod.

Point J shows specified idling position.

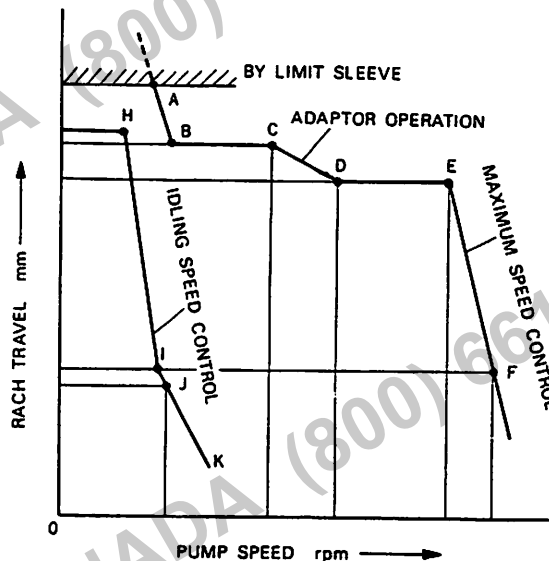


Fig. 4-45 Characteristic curves of RSV governor

4. Disassembly and assembly

Before beginning the governor disassembly and assembly, the following tools are required.

- a. Screwdriver
- b. Spanner set
- c. A pair of needle nose pliers
- d. Flyweight round nut wrench (ND No. 95907-07010)
- e. Flyweight extractor (ND No. 95907-01050)
- f. Tool set for disassembling and assembling the governor

Thoroughly clean the exterior of the pump and the governor. Before disassembling, make preliminary inspection of the governor in attempt to determine the extent of failure and use a parts box to avoid mismatching crucial parts. Be sure that work area and tools are spotlessly clean.

(1) Governor cover removal

- a) Remove the idling spring screw.
- b) Remove six attaching screws.
- c) Separate the governor cover from housing.

CAUTION:

Hold a small pan or container under governor to catch lubricating oil drainage when separation is made.

- d) Cover is still attached by latch pin of shackle and start spring.

Disconnect the locking clip and force the latch pin free from the control rod with screw driver.

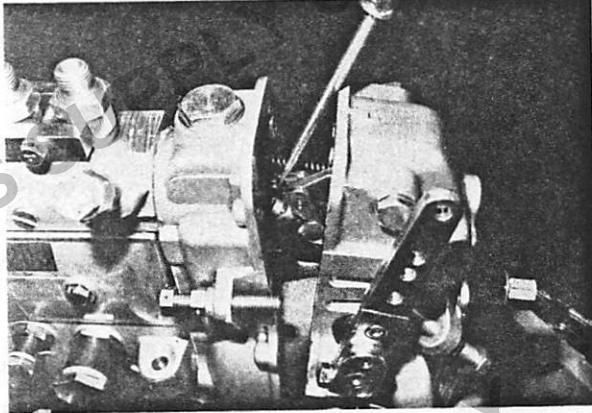


Fig. 4-46 Removal of shackle 04-0480

- e) Unhook the start spring using a pair of needle nose pliers, then the governor cover is removed completely.

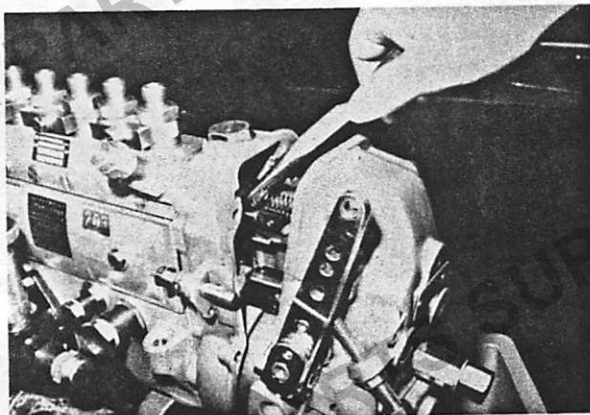


Fig. 4-47 Removal of start spring 04-0481

(2) Flyweight removal

- a) Remove the round nut using the round nut wrench box (Part No. 95907-07010).

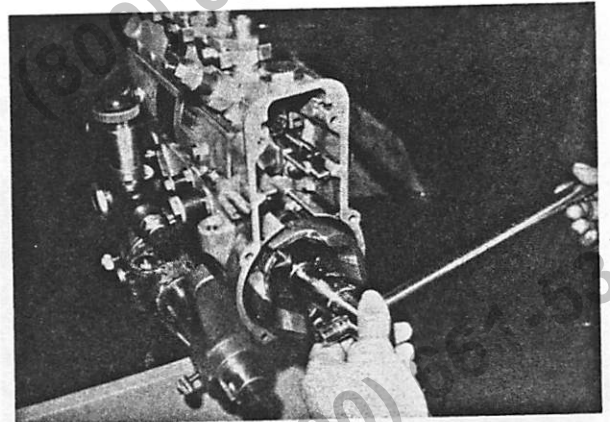


Fig. 4-48 Removal of round nut 04-0482

- b) Remove the flyweight assembly using the flyweight extractor (Part No. 95907-01050).

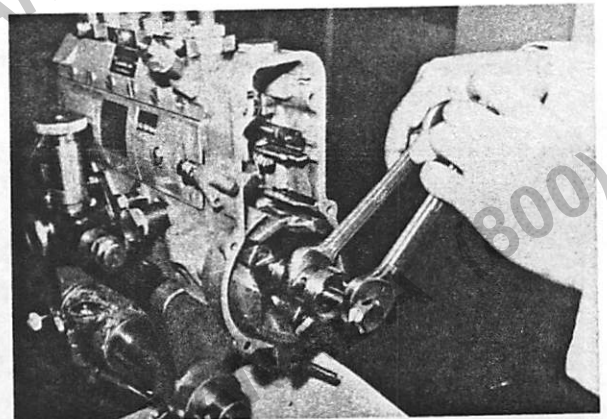


Fig. 4-49 Removal of flyweight 04-0483

(3) Supporting lever shaft removal

- Remove the two screw plugs at the top of the governor cover and drive out the supporting lever shaft on which the tension lever is suspended.

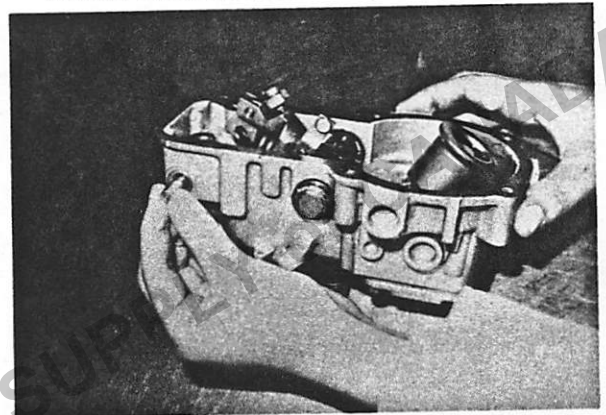


Fig. 4-50 Removal of supporting lever shaft 04-0484

4-28 FUEL INJECTION PUMP

(4) Tension lever removal

Maneuver the tension lever from under swivelling lever as shown in **Fig. 4-51**. Unhook the speed control spring from the eye of the tension lever from the eye of the swivelling lever locker arm. Remove the tension lever.

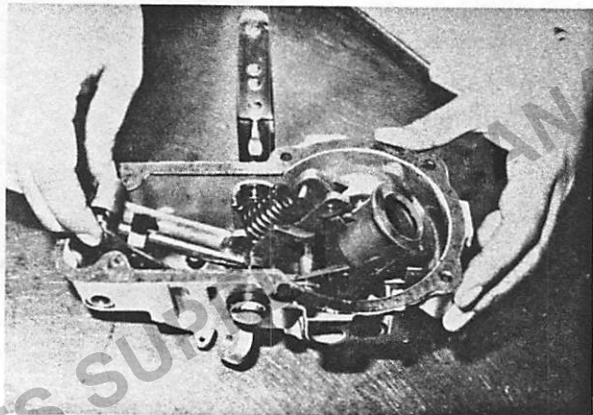


Fig. 4-51 Removal of tension lever

04-0485

(5) Swivelling lever removal

- a) Remove the adjusting lever and two retaining circlip on each end of the swivelling lever.

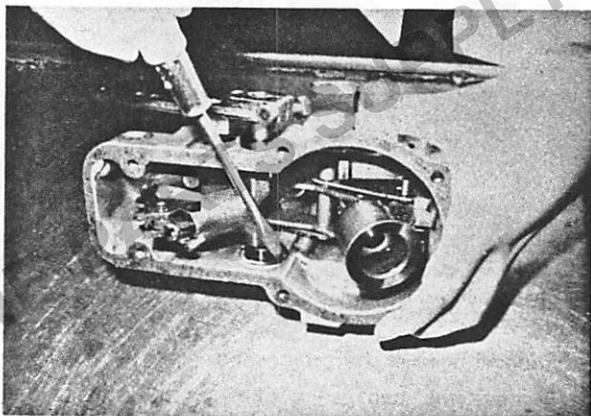


Fig. 4-52 Removal of retaining circlip

04-0486

- b) Tap out swivelling lever bushings and remove the swivelling lever.

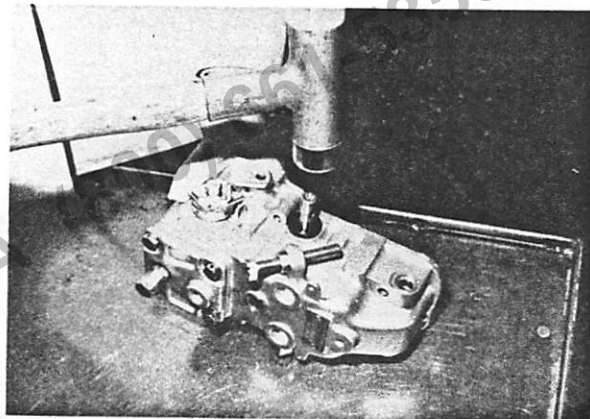


Fig. 4-53 Removal of swivelling lever

04-0487

- (6) Remove the guide lever, the control lever and governor sleeve as a complete unit.

(7) Stop device removal

To remove the stop device, first remove the full load stop screw. And remove the stop lever, spring cover and return spring. Push shut-off shaft into governor cover. Spring cap can be removed by removing the retaining clip and three springs.

(8) Governor sleeve removal

- a) Separate the governor sleeve from control block using the control sleeve extractor (Part No. 95905-07050).

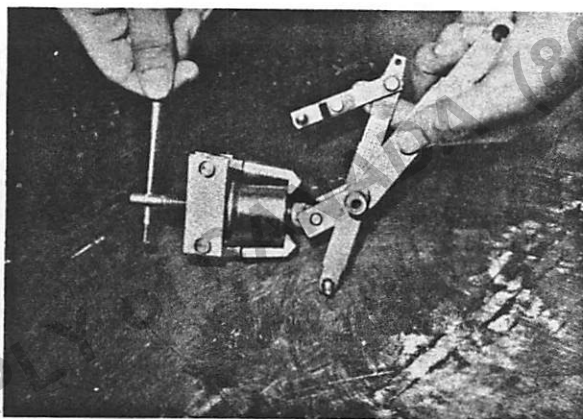


Fig. 4-55 Removal of governor sleeve

04-0488

- b) Remove the snap ring using the snap ring pliers.

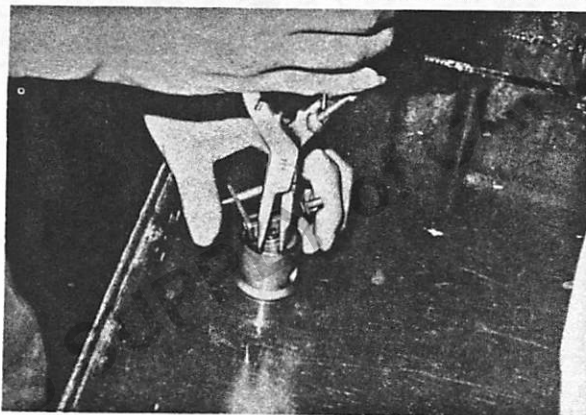


Fig. 4-56 Removal of snap ring

04-0489

ASSEMBLY

Assembly takes place in the reverse order of disassembly. Pay attention to following points.

1. Installation of the flyweight
install the key and the flyweight to the pump camshaft and place spring washer on it.
Securely tighten the round nut to 5 – 6 kg·cm (36.2 – 43.4 lb.ft.) torque using governor round nut box and torque wrench.
2. Installation of governor sleeve and control block

- (1) Put the thrust bearing into the governor sleeve and place the governor sleeve into position against the contact block in the flyweight. The flyweight should be in rest position. Place shims on the thrust bearing and check the assembling dimension as shown in Fig. 4-57.

The fitting dimension of the control block must be 19.0 to 19.2 mm (0.748 – 0.756 in). If not, change thickness of shims. The shim plates are available in the following thickness 0.1, 0.2, 0.3, 0.4, 1.0 mm.

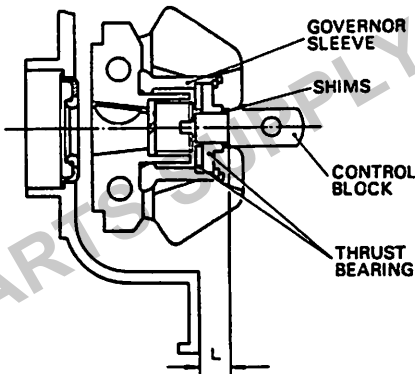


Fig. 4-57 Assembling dimension of flyweight

- (2) Slip shims determined in step above on the control block.
Press the control block into the thrust bearing as shown in Fig. 4-58.

CAUTION:

Be sure not to strike the guide lever directly.

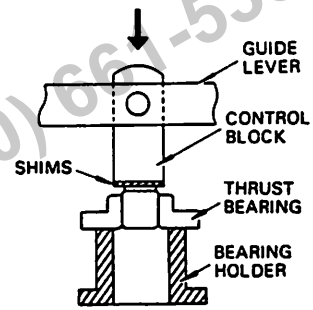


Fig. 4-58 Pressing control block into thrust bearing

- (3) Install the thrust bearing into the governor sleeve with the snap ring.

CAUTION:

Do not reuse a snap ring. Install the snap ring with the chamfered side facing inward as shown in Fig. 4-59.

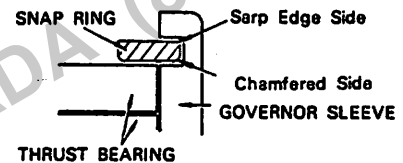


Fig. 4-59 Installing snap ring

3. Installation of swivelling lever
Insert shaft of swivelling lever into the two governor bearing bores so that the groove in the swivelling lever is up. Insert the two bearing bushings with sealing rings from the outside into the governor cover. Press bearing bushing into position so the grooves for circlips are accessible. Snap circlips into position.
4. Installation of speed control spring
Attach the speed control spring to eye in tension lever and into eye of swivel lever rocker as shown in Fig. 4-60.

Take care to direction of the spring.

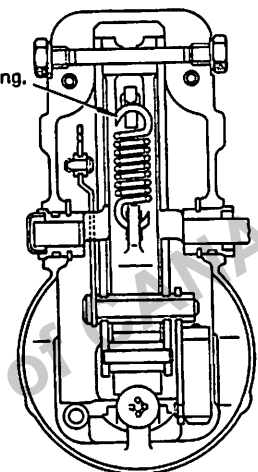


Fig. 4-60 Installing speed control spring

5. Check ease of movement of levers and linkages.
6. Check for the stop device operation.

4-30 FUEL INJECTION PUMP

TEST AND ADJUSTMENT

After the assembly of the governor has been completed, various adjustments should be carried out as follows.

1. Preparation
2. Preliminary inspection
3. Adjustment of medium speed control
4. Adjustment of adapter spring
5. Adjustment of idling speed control
6. Adjustment of maximum speed control
7. Checking of stop lever operation
8. Adjustment of pump with governor operation

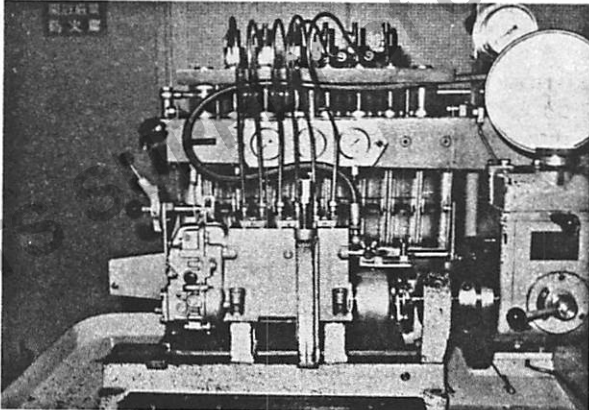


Fig. 4-61 Setting up to the test bench

04-0490

1. PREPARATION

Before testing the governor, make the following preparations.

- (1) Loosen the maximum speed stopper and the stop adjusting screw.
- (2) Remove the edling spring and adapter assembly.
- (3) Fill the cam chamber and governor chamber with specified amount of engine oil.
- (4) Install the protractor for positioning the adjusting lever.

2. PRELIMINARY INSPECTION

Completely push the control rod to 0 mm position and then take off your finger. The control rod should be moved back to 20 mm position. If the control rod is not moved back to the specified position, check each portion such as the adjusting screw of the swivelling lever and other levers, and the control rod for sliding condition. If necessary, adjust them.

3. ADJUSTMENT OF MEDIUM SPEED CONTROL

Drive the pump at N_1 rpm. Pull the adjusting lever to full load position and temporarily fix it.

Turn the full load stopper in or out with screwdriver so that the rod travel will become R_1 mm as shown in Fig. 4-62. Then tighten the lock nut.

Turning the full load stopper in (clockwise) increases the rod travel. On the contrary, Turning it out (counterclockwise) decreases the rod travel.

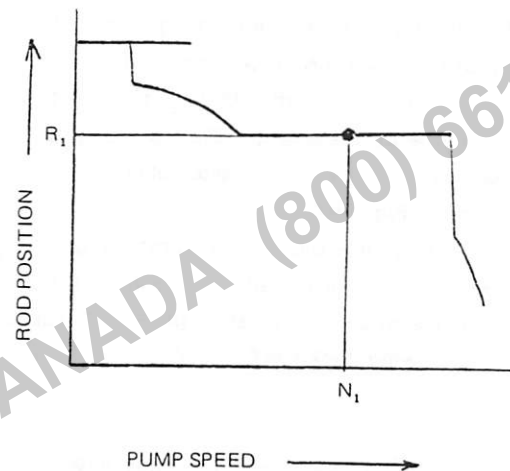


Fig. 4-62

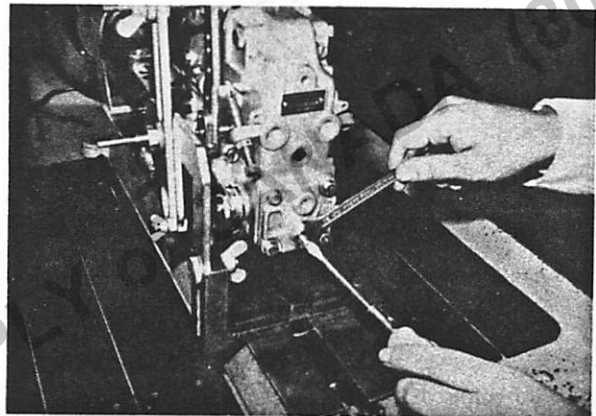


Fig. 4-63 Adjustment of full load stopper

04-0491

4. ADJUSTMENT OF ADAPTER SPRING

- (1) Move the adjusting lever to full load position and fix it. Install the adapter assembly to the lower end of the tension lever.
- (2) Adjust the adapter screw so that the rod travel will become R_2 mm when driving the pump at N_2 rpm. Screwing the adapter screw increases the rod travel and unscrewing reduces the rod travel.

- (3) Adjust the spring tension with shims so that with the pump speed at N_3 rpm, R_3 mm rod travel is obtained. Add, reduce or replace shims between the adapter spring and adapter screw (Fig. 4-65).

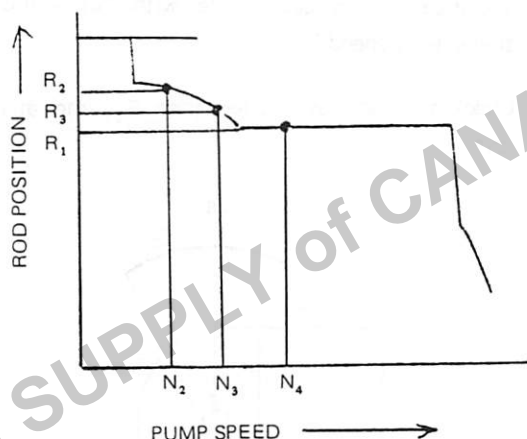


Fig. 4-64

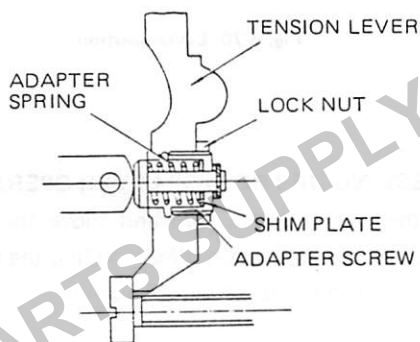


Fig. 4-65

- (4) Check the rod travel R_1 mm at N_4 rpm.

5. ADJUSTMENT OF IDLING SPEED CONTROL

- (1) Set the adjusting lever free and install the idle adjusting screw with the idling spring to the governor cover.

Adjust the idle adjusting screw so that with the pump speed at N_5 rpm the rod travel is R_5 mm (Fig. 4-66).

Secure it by tightening lock nut.

- (2) Drive the pump at N_6 rpm. Move the adjusting lever in idling position so that the rod travel becomes R_6 mm.

- (3) Check the rod travel R_7 mm at N_7 rpm. Then set the stop adjusting screw to contact the adjusting lever, and tighten the lock nut (Fig. 4-67).

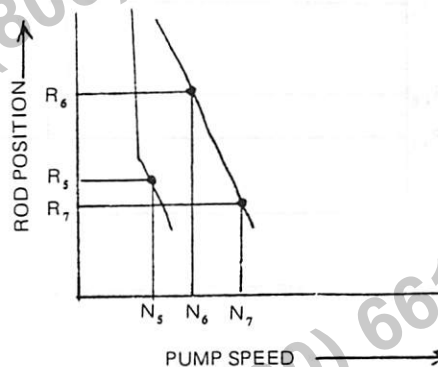


Fig. 4-66

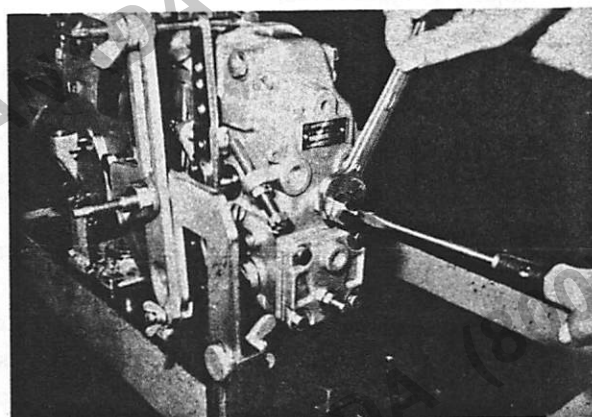


Fig. 4-67 Adjustment of idling speed control

04-0492

6. ADJUSTMENT OF MAXIMUM SPEED CONTROL

- (1) Break-away speed is the speed obtained when the control rod starts to decrease after the full load speed was reached. To adjust the break-away speed, increase the pump speed slowly up to N_9 rpm from N_8 rpm and move the adjusting lever so that the rod travel becomes R_9 mm at N_9 rpm. Temporarily fix the adjusting lever and screw the maximum speed stopper to contact the adjusting lever, and tighten lock nut.

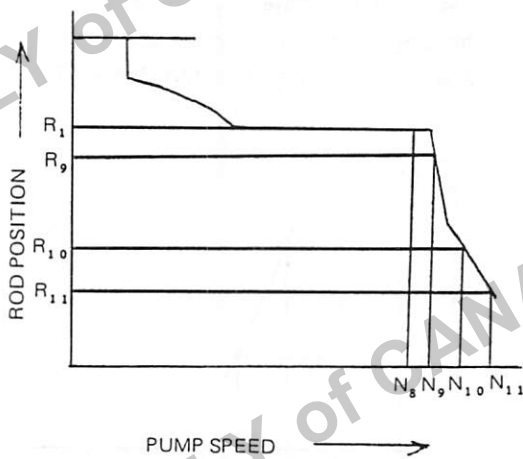


Fig. 4-68

(2) Adjusting of speed droop

Increase the pump speed up to N_{10} rpm. Check the rod travel- R_{10} mm. If the specified rod travel R_{10} mm. is not obtained, turn the adjusting screw of the swivelling lever out or in to obtain R_{10} mm position. Turning in the adjusting screw provides better governing effect (small speed droop). Backing out the adjusting screw provides worse governing effect (large speed droop). Value X indicated in test specifications sheet of injection pump means how many clicks the adjusting screw should be backed out from a position where the adjusting screw is turned all the way in (4 clicks is one full turn of the adjusting screw).

CAUTION:

When adjusting the governor, don't back out the adjusting screw of the swivelling lever more than 24 clicks (6 complete turns) from a position where the adjusting screw is turned all the way in.

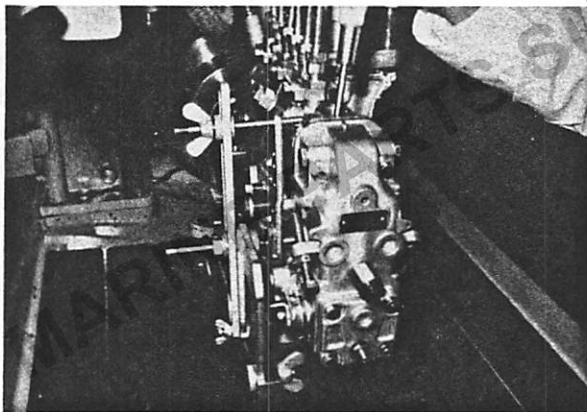


Fig. 4-69 Adjustment of adjusting screw

04-0493

(3) Readjustment

After adjusting the adjusting screw of the swivelling lever, the tension of the speed control spring is changed. Therefore, the break-away speed is varied. Readjust the maximum speed stopper to meet test specifications in accordance with "a) Adjusting break-away speed".

(4) Check the rod travel is less than R_{11} mm at N_{11} rpm.

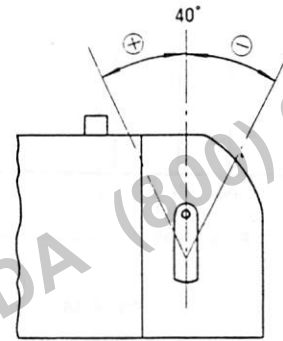


Fig. 4-70 Lever position

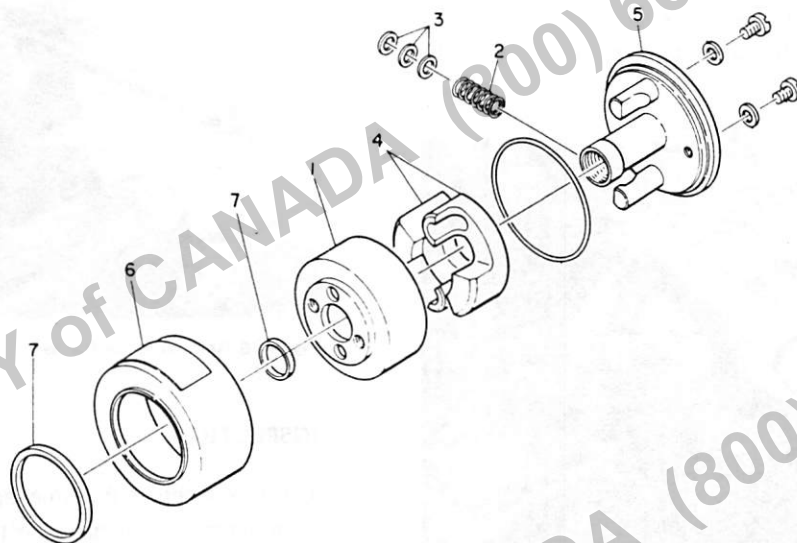
7. CHECKING OF THE STOP LEVER OPERATION

Drive the pump at N_9 rpm and move the adjusting lever to the idling position. When pulling the stop lever, check the rod travel to be less than 2 mm.

8. ADJUSTMENT OF PUMP WITH GOVERNOR OPERATION

Drive the pump at the specified speed shown in the test specifications, and move the adjusting lever to the full load position. Check the injection volume. If not within the specification, adjust the full load stopper.

TIMER



- | | |
|-------------------------|----------------|
| 1. Timer driving flange | 5. Timer hub |
| 2. Timer spring | 6. Timer cover |
| 3. Shim | 7. Oil seal |
| 4. Fly weight | |

Fig. 4-71 Automatic Timer

Operation

The right half illustration on Fig. 4-71 shows a static state of the automatic timer. As will be clear from the illustration, the flyweight cannot be raised while the engine speed is within a certain limit (up to some 1,000 rpm), because the centrifugal force of the flyweight gives way to the loaded force of the timer spring; namely, the mounting length of the timer spring is at largest, L.

As the engine speed increases, the flyweight is raised little by its centrifugal force. The mounting length of the timer spring will attain the shortest value (L') at an engine speed of 2,700 rpm (pump speed: 1,350 rpm).

Since part "B" appearing in the figure is flange leg, its relative position of the pump drive shaft cannot be changed.

Accordingly, the flyweight holder pin A is attracted by "E" by the resultant lift (amount of rise) of the flyweight. The movement of A works to turn the pump camshaft with respect to the engine drive shaft, making it possible to change the injection timing.

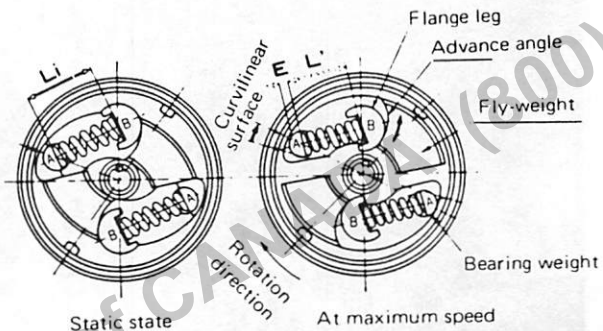


Fig. 4-72 Explanatory view of automatic timer

OVERHAUL

DISMOUNTING

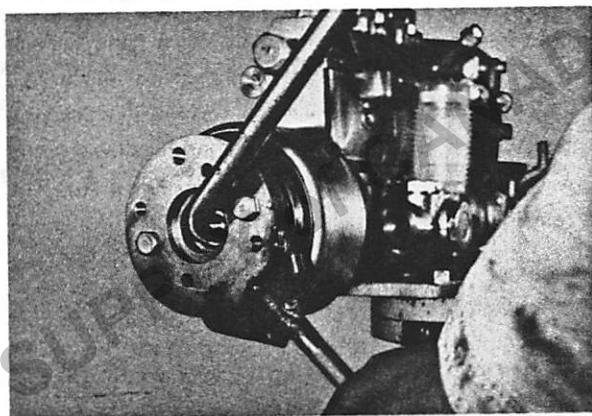


Fig. 4-73 Removing the round nut

4-34 FUEL INJECTION PUMP

1. Remove the injection pump assembly with timer.
2. Remove the round nut using the socket wrench (Part No. 95906-03010) and holding wrench (Part No. 95806-03020) shown in **Fig. 4-73**.
3. Pull out the timer assembly using the extractor shown in **Fig. 4-74**.

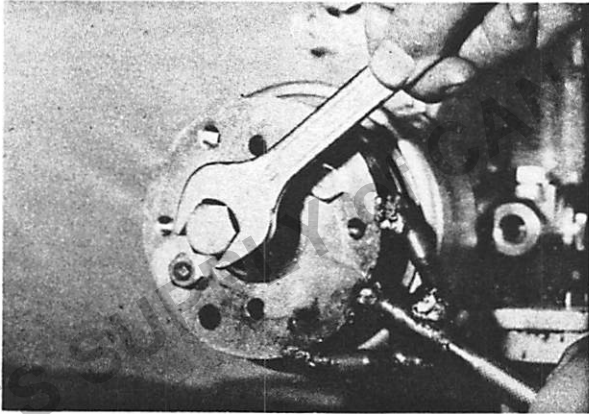


Fig. 4-74 Pulling out the timer

04-022

DISASSEMBLY

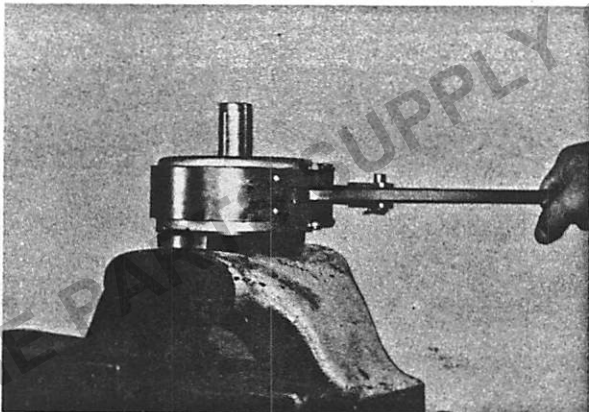


Fig. 4-75 Removing the case

04-023

1. Clamp timer mounting stand in a vise and install the timer onto the stand with the key and round nut. Remove the timer case by using band wrench (Part No. 95906-02060) as shown in **Fig. 4-75**. The timer case is removed by turning it clockwise.
2. Use wrench, turn it slightly counterclockwise, and remove the driving flange. (Refer to **Fig. 4-76**). The remaining parts can be easily disassembled.

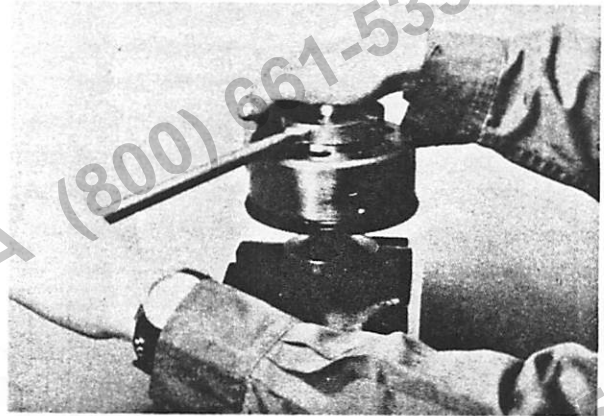


Fig. 4-76 Removing the flange

G 3388

INSPECTION

1. Check whether the timer spring is fatigued, defective or degraded in rectangularity.

Rectangularity:

Standard 1.5 mm (0.059 in.)

Limit 2.0 mm (0.078 in.)

NOTE:

If the spring is fatigued, it could advance the revolution at starting point.

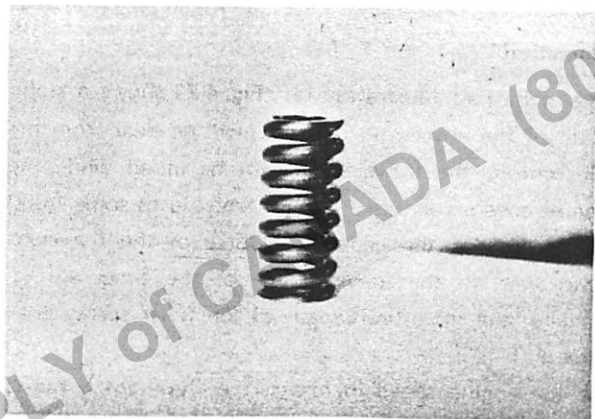


Fig. 4-77 Timer spring

04-024

2. Axial play between flyweight holder and flange:

Standard 0.02 – 0.10 mm
(0.0007 – 0.0039 in.)

Limit 0.20 mm (0.0078 in.)

3. Gap between flyweight pin and pin hole:

Standard 0.05 – 0.10 mm
(0.0019 – 0.0039 in.)

Limit 0.20 mm (0.0078 in.)

NOTE:

When the pin is worn out, the engagement will become jolty, increasing the variations in speed and making the injection timing unsteady. This in turn results in poor output performance.

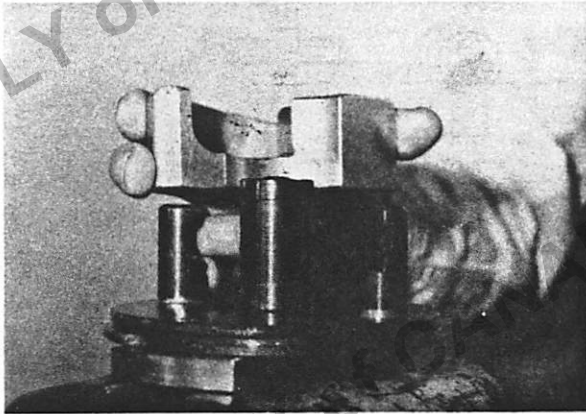


Fig. 4-78 Flyweight and pin

04-025

ASSEMBLY

Install driving flange guide on the flyweight holder. Install spring guide (Part No. 95906-01030) beneath the spring. (Refer to **Fig. 4-79**), and using holding wrench, turn the flange to compress the spring and push in and install the flange.

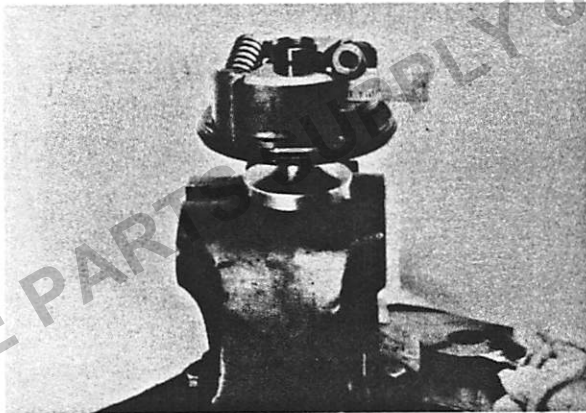


Fig. 4-79 Assembling the spring

G3364

LUBRICATION

After assembling, remove two plugs lubricated the Timer Grease from the plug until the grease overflows from the other plug.

It amounts to approx. 150 g (5.3 oz)

MOUNTING

After lubricating, mount the timer on the injection pump. The tightening torque of the timer round nut is 600 – 700 kg·cm (43 – 50 lb.ft.).

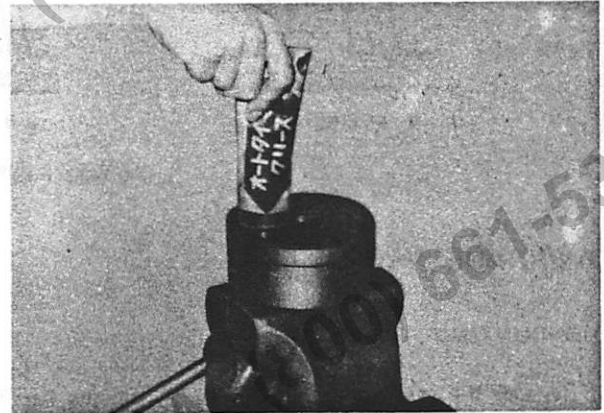


Fig. 4-80 Greasing

G4651

FUEL FEED PUMP

DESCRIPTION

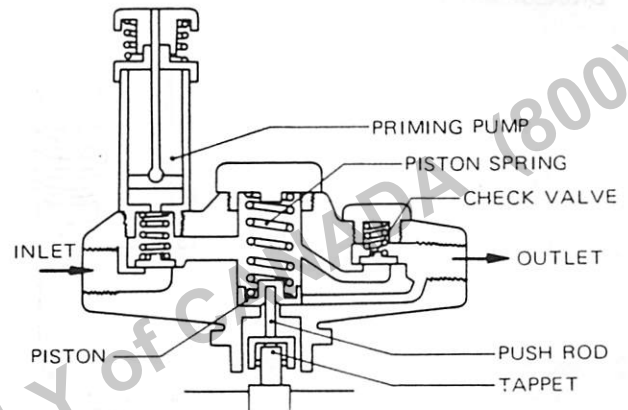


Fig. 4-81 Fuel feed pump

The fuel feed pump is installed on the side of the injection pump. It is a piston type pump and is driven by the injection pump camshaft.

It draws the fuel from the tank and feeds it to the injection pump.

Besides this, a priming pump is also available to enable manual fuel feeding, when the engine is not in motion. This is used when starting the engine or when bleeding air from the fuel system.

1. Function

During engine operation, the driving force of the injection pump camshaft is communicated to the piston through the cam, tappet roller, tappet and push rod in turn. A manual priming pump is also provided for the purpose of manual fuel feed at the time of start-up and air purging.

4-36 FUEL INJECTION PUMP

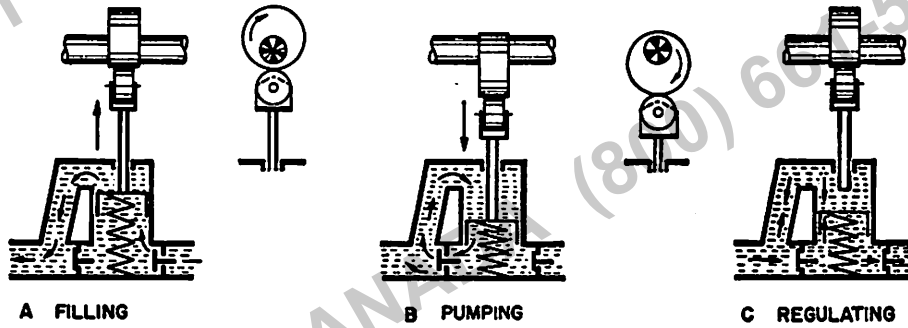


Fig. 4-82 Fuel feed pump function

OVERHAUL

DISMOUNTING

1. Remove the injection pump assembly with the feed pump.
2. Drain the lubricant oil by loosening the drain plug of the injection pump.
3. Remove the three retaining bolts.

DISASSEMBLY

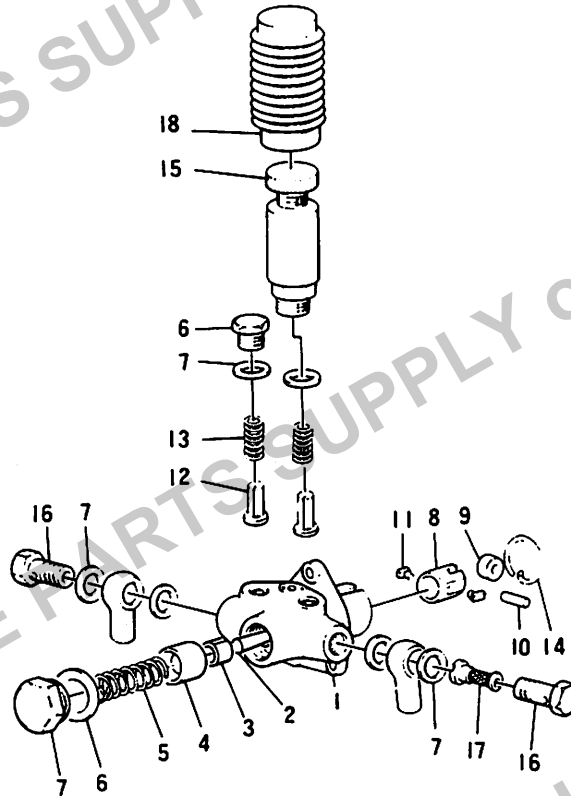


Fig. 4-83 Feed pump

- (1) Clamp the feed pump in a vise, and remove the priming pump.

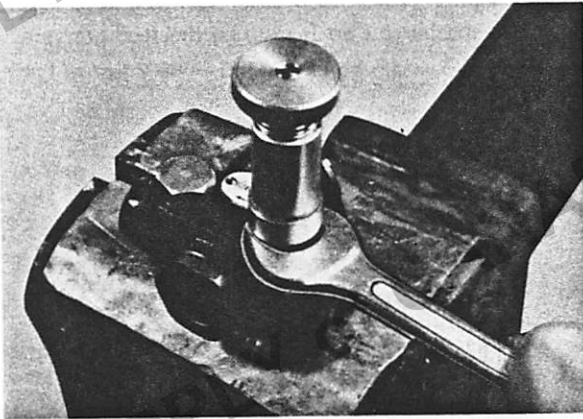


Fig. 4-84 Removing the priming pump 04-103

- (4) Undo the snap spring and remove the tappet.



Fig. 4-87 Removing the piston 04-107

- (2) Remove the check valve and check valve spring.



Fig. 4-85 Removing the check valve 04-104

- (5) Dismount the piston.

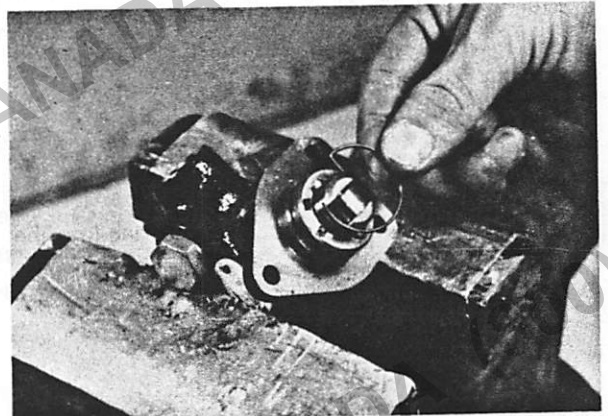


Fig. 4-88 Removing the push rod 04-106

- (3) Loosen the plug screw to remove the piston spring.

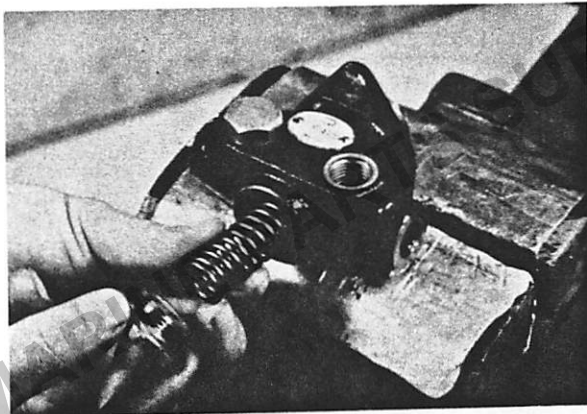


Fig. 4-86 Removing the piston spring 04-105

- (6) Pull the push rod away.

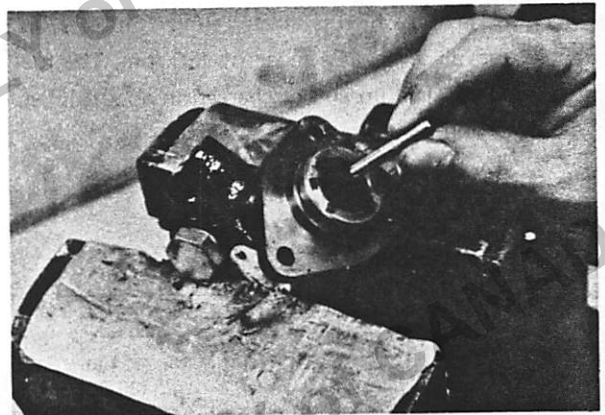


Fig. 4-89 Removing the push rod 04-108

INSPECTION AND REPAIR

1. Replace the check valve seat, when the seat surface is worn and dented.
2. Check the piston and the cylinder for scars.
3. Replace the push rod together with the housing, if there is any leakage from between the push rod and the housing.
4. Check the case for scars and cracks and also for damage to the threaded portion.
Many parts are kept oil-tight by their contact with the plug end surface, without the use of gaskets. Check such surface for roughness.
5. Priming the piston and the cylinder for rust. Also check the valve seat for wear or dent.

ASSEMBLY

- (1) After setting the tappet into the feed pump housing lock it with a snap ring, and insert the push rod in position from the plug screw side.
- (2) Insert the piston through the plug screw hole.
- (3) Load the piston spring, and then tighten up the plug screw.
- (4) Set the check valve and check valve spring into the feed pump housing, and secure the priming pump to the suction port and the screw plug to the discharge port.

TESTING

1. Pump suction head capacity test

Connect a pipe to the feed pump suction port, and work the piston which is located some 1 m (39.37 in.) above the oil level, at a speed of 150 rpm. The fuel should be sucked up and discharged in about 45Sec. after start-up of the pump.

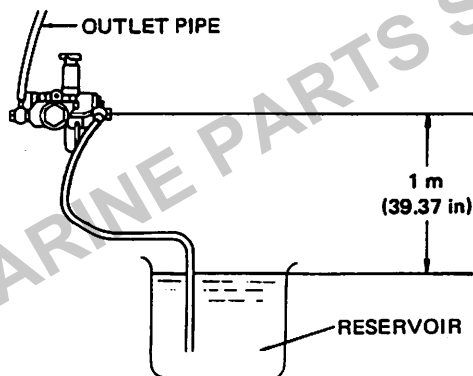


Fig. 4-90 Fuel feed pump test

2. Pump feed rate test

When the feed pump is driven at 1,000 rpm, the feed rate should be more than 900 c.c. per min. When the discharge port is plugged the feed pressure should be 2.5 - 3.5 kg/cm² (35.5 - 49.8 lbs/in²) at 600 rpm.

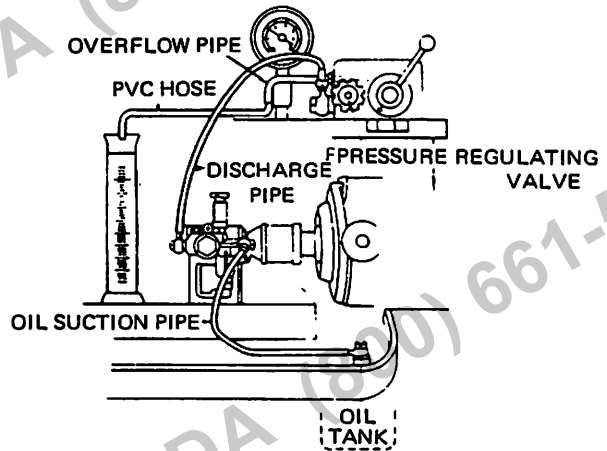


Fig. 4-91 Pump feed rate test

3. Pump air-tightness test

After cap-plugging the outlet hole apply 2 kg/cm² (28.4 lb/sq. in) of air pressure from the inlet side and place the pump in to light oil. The leakage of air bubbles from the space between the push rod and housing and from the other parts should not be at all.

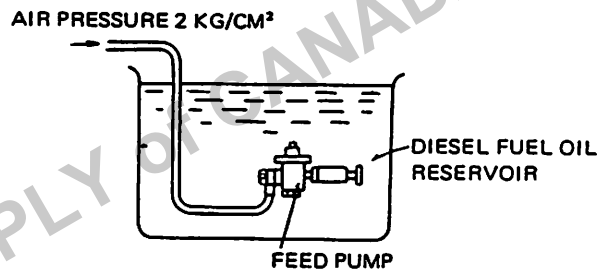


Fig. 4-92 Pump air-tightness test

REPAIR SPECIFICATION
SERVICE STANDARD

Unit: mm (in.)

	Item	Assembly Standard	Repair limit	Service limit	Measures
Injection pump main body	Gap between housing and tappet	0.03-0.07 (0.0011-0.0027)		0.2 (0.0078)	Replacement of either tappet or housing
	Gap between housing and bearing cover	0.005-0.05 (0.0001-0.0019)		0.1 (0.0039)	Replacement of either cover or housing
	Total lift of cam	8 (0.3149)		-0.2 (-0.0078)	Replacement of camshaft
	Buckling of camshaft	smaller than 0.05 (0.0019)		0.15 (0.0059)	Repair or replacement
	Camshaft axial play	0.03-0.05 (0.0011-0.0019)		0.1 (0.0039)	Adjustment with shim
	Tappet, outside diameter	24 (0.9448)	-0.03 (-0.0011) -0.05 (-0.0019)	-0.1 (-0.0039)	Replacement of tappet
	Play in tappet roller pin			0.2 (0.0078)	Replacement of roller, bush and pin
	Rectangularity of delivery valve spring	smaller than 0.7 (0.0275)		1.0 (0.0393)	Parts replacement
	Rectangularity of plunger spring	smaller than 1.0 (0.0393)		1.5 (0.0590)	Parts replacement
	Play between control rack and pinion	0.15 (0.0059)		0.25 (0.0098)	Replacement of either rack or pinion
	Slider resistor of control rack	smaller than 150 gr.		150 gr	Correction
	Cylinder injection interval	±0.5°		±0.5°	Correction
	Tappet clearance	more over 0.2 (0.0078)		0.2 (0.0078)	Adjustment
Governor	Gap between tention lever, guide lever	0.02-0.09 (0.0007-0.0035)		0.2 (0.0078)	Replacement of pin and bush
	Gap between tention lever, shaft and lever	0.04-0.08 (0.0015-0.0031)		0.15 (0.0590)	Replacement of lever shaft and bush
	Gap between flyweight pin and bush	0.02-0.05 (0.0007-0.0019)		0.08 (0.0031)	Parts replacement
Timer	Flange width	10 (0.3937)		0.2 (0.0078)	
	Gap between flyweight and holder	0.05-0.1 (0.0019-0.0039)		0.2 (0.0078)	Replacement of flyweight and holder
	Rectangularity of timer spring	2.0 (0.078)		2.5 (0.098)	Spring replacement
	Air tight test	No air leakage permitted from oil seal, O-ring and other parts with 0.5kg/cm ² of air pressure applied inside the timer.			
Feed pump	Play between tappet roller and pin	0.02-0.07 (0.0007-0.0027)		0.3 (0.0118)	Parts replacement
	Roller, butside diameter	15 (0.590)	0 -0.02 (-0.0007)	-0.1 (-0.0039)	Roller replacement
	Gap between housing and piston	0.03-0.06 (0.0011-0.0023)		0.15 (0.0059)	Piston replacement
	Air tightness of push rod	Totally close the discharge part, apply 2 kg/cm ² of air pressure, and immerse the pump into diesel fuel oil if air bubbles of millet grain size evolve continuously at a rate of from the push rod parts must be replaced. As the oil seal is fitted, air leakage can not occur. If any air leakage is found, it should be replaced as a housing assembly.			
	Suction head capacity	Connect a pipe to the suction port. If the pump is able to discharge at a rate of 25 strokes when placed 1 m. below the oil level, the pump performance is warrantable. If more than 25 strokes are required, the pump must be overhauled.			
	Discharge rate	Drive the feed pump at a speed of 1000 rpm. The pump is justifiable if it is able to discharge more than 900 cc. in 60 sec. If it fails the discharge rate falls short of 900 cc., the pump must be subjected to overhaul inspection.			

4-40 FUEL INJECTION PUMP

TIGHTENING TORQUE

	Tightening position	kg-cm	lb.ft.
Pump proper & Timer	Valve holder	400 – 450	29 – 33
	Screw plug, pump bottom	550 – 750	40 – 62
	Round nut	500 – 600	37 – 43
	Timer round nut	850 – 1,000	61 – 72
Governor	Bearing bushing, adjusting lever	300 – 400	22 – 28
	Fitting bolt, adjusting lever	80 – 90	5.8 – 6.5
	Bearing bushing, tension lever	300 – 400	22 – 28
	Bearing bushing, guide lever	200 – 300	14 – 22
	Plug setting screw	100 – 120	7.2 – 8.6

GENERATOR
GENERADOR
GENERATRICE

SYMBOL MARKS
SIMBOLOS
SYMBLES 21- 1

A GLOSSARY OF TECHNICAL TERMS
GLOSARIO DE TERMINOS TECNICOS
LEXIQUE DES TERMES TECHNIQUES 21- 2

DATA & SPECIFICATION
DATOS Y ESPECIFICACIONES
DATA & CARACTERISTIQUES 21- 3

DESCRIPTION
DESCRIPCION
DESCRIPTION 21- 4

OVERHAUL
REPARACION GENERAL
REVISION 21- 5

TROUBLESHOOTING
LOCALIZACION DE AVERIAS
RECHERCHE DES CAUSES D'ENNUI ET REMEDE 21-20

REPAIR SPECIFICATIONS
ESPECIFICACIONES DE REPARACION
CARACTERISTIQUES DE REPARATION 21-21

SYMBOL MARKS

The following symbols have been adapted for simplicity and for easy comprehension.

SIMBOLOS

Se han adoptado los siguientes símbolos para simplicidad y fácil comprensión.

SYMBOLES

Les symboles suivants ont été adoptés afin de simplifier et de faciliter la compréhension.



ASSEMBLY
ARMADO
ASSEMBLAGE



TIGHTENING
APRIETE
SERRAGE



DISASSEMBLY
DESARMADO
DESASSEMBLAGE



CLEAN
LIMPIEZA
NETTOYAGE



INSTALLATION
INSTALACION
MISE EN PLACE



IMPORTANT
IMPORTANTE
IMPORTANT



REMOVAL
REMOCION
DEPOSE



ADJUSTMENT
AJUSTE
REGLAGE



INSPECTION
INSPECCION
CONTROLE



LUBRICATION
LUBRICACION
GRAISSAGE



MEASUREMENT
MEDICION
MESURE

A GLOSSARY OF TECHNICAL TERMS
GLASARIO DE TERMINOS TECNICOS
LEXIQUE DES TERMS TECHNIQUES

ENGLISH

1. About
2. Ammeter
3. And
4. At
5. Bad
6. Good
7. Capacity
8. Insulation resistance
9. In
10. Limit
11. Less than
12. More than
13. Resistance
14. Service limit
15. Standard
16. Tightening torque
17. Voltage meter

ESPAÑOL

1. Alrededor de
2. Amperímetro
3. Y
4. A
5. Malo
6. Bueno
7. Capacidad
8. Resistencia de aislamiento
9. Pul.
10. Límite
11. Menos de
12. Más de
13. Resistencia
14. Límite de servicio
15. Estándard
16. Par de apriete
17. Indicadora de tensión

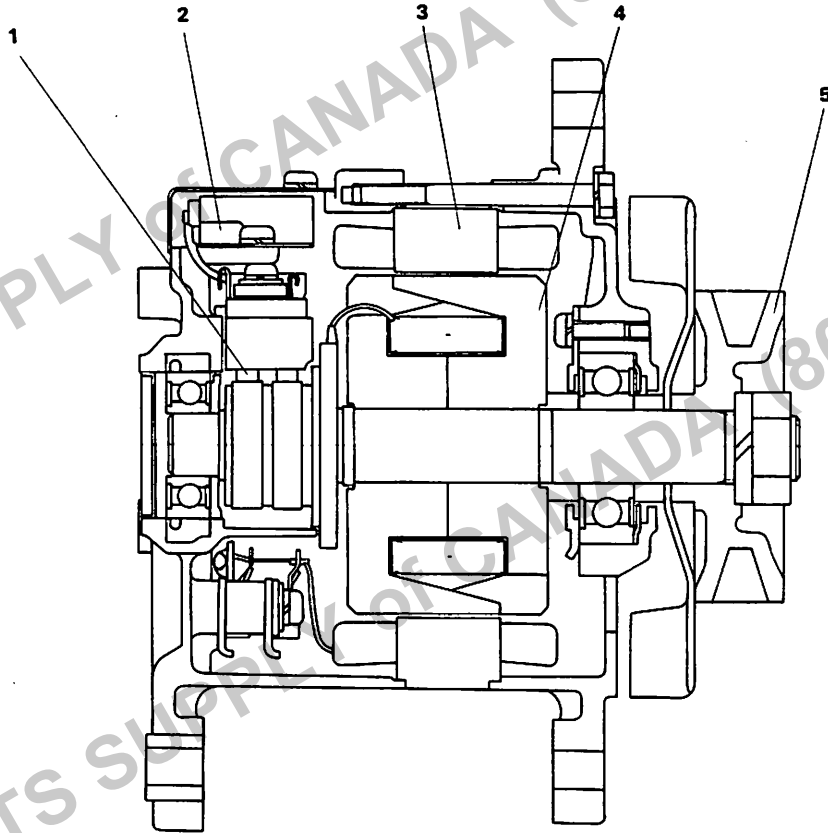
FRANCAIS

1. Environ
2. Ampéremètre
3. ET
4. A
5. Mauvais
6. Bon
7. Capacité
8. Résistance d'isolement
9. Pouce
10. Limite
11. Inférieur(e) à
12. Dépasse
13. Résistance
14. Limite d'utilisation
15. Normal(e)
16. Couple de serrage
17. Compteur de tension

GENERATOR**DATA AND SPECIFICATIONS****GENERATOR**

Type	Alternator
Output power	24V, 20A
Normal voltage	24V
Charging rotation and voltage	900 r.p.m., 27V
Direction of rotation	Right (From the pulley side)
Allowable max. speed	7,200 r.p.m.
Power and rotating speed	28V, 20A, at 5,000 r.p.m.

DESCRIPTION



SM21-073

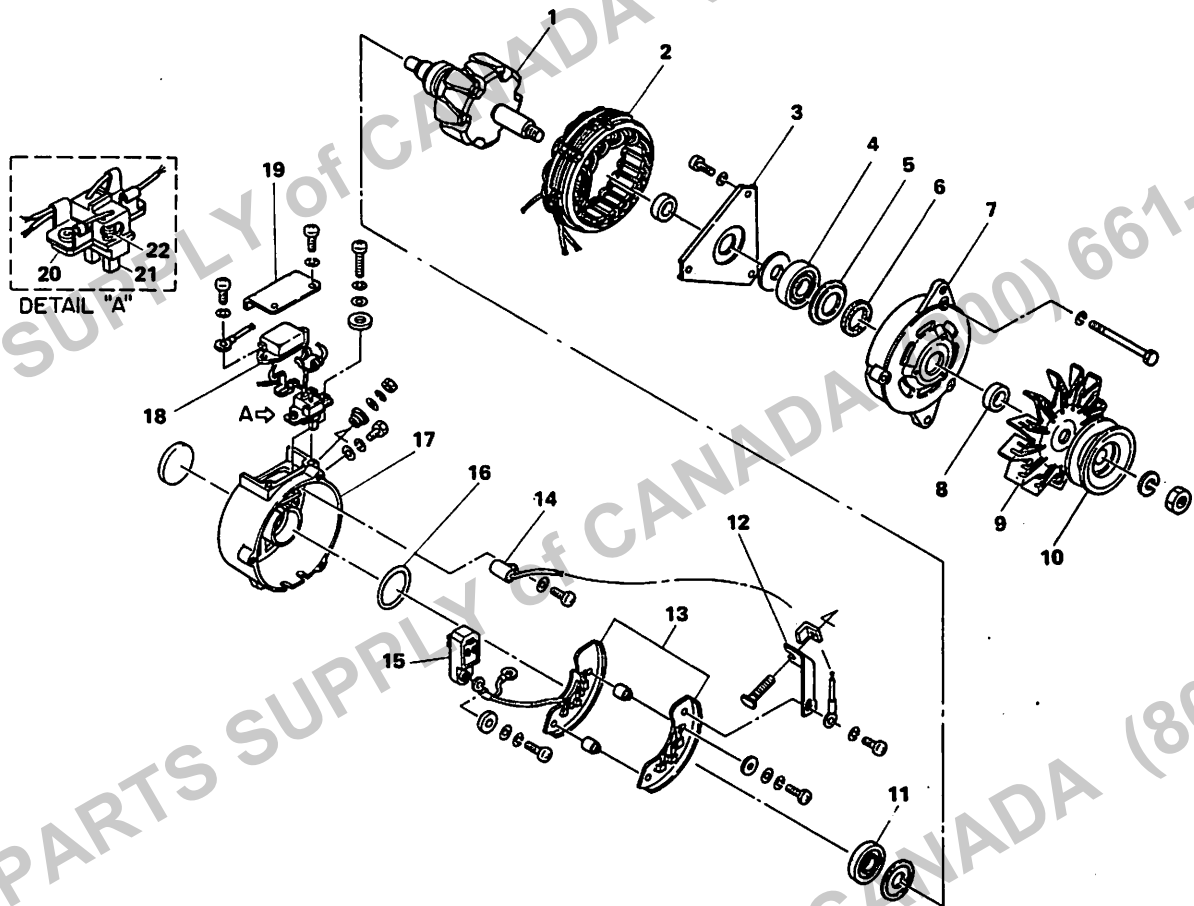
GENERATOR

1. Brush
2. I.C. Regulator
3. Stator
4. Rotor
5. Pulley

Fig. 21-1

OVERHAUL

1824E
1-NO. 20



1. Rotor
2. Stator
3. Bearing retainer
4. Rear bearing
5. Felt cover
6. Felt
7. Front bracket
8. Collar
9. Fan
10. Pulley
11. Front bearing
12. Terminal insulation
13. Heat sink with rectifier
14. Condenser
15. Connector
16. O-ring
17. Rear bracket
18. Regulator
19. Cover
20. Brush holder
21. Brush
22. Brush spring

Fig. 21-2

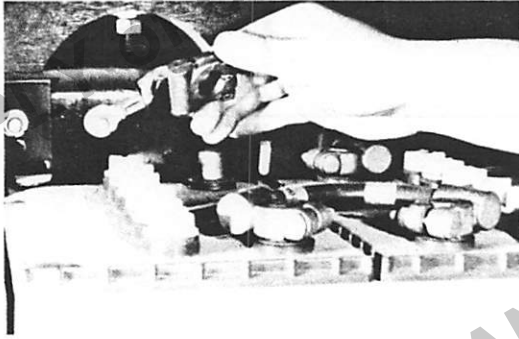


Fig. 21-3

21-0218



ALTERNATOR

Dismounting

1. Disconnect the battery \ominus terminal.

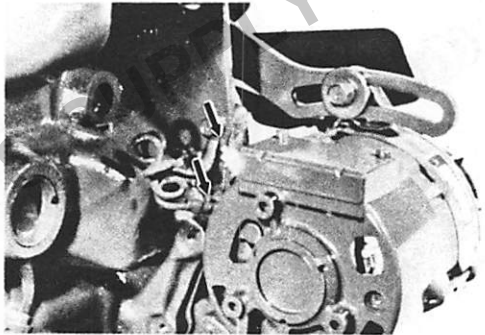


Fig. 21-4

W04-046



2. Disconnect the B and E terminal.

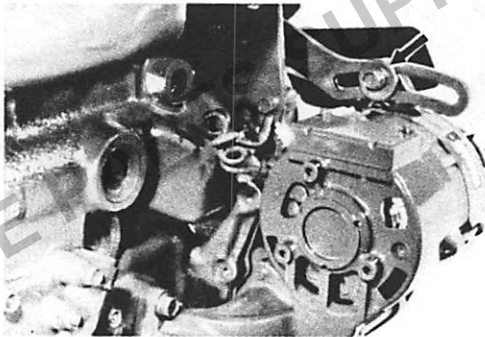


Fig. 21-5

W04-046



3. Remove the alternator set bolts and alternator assembly.

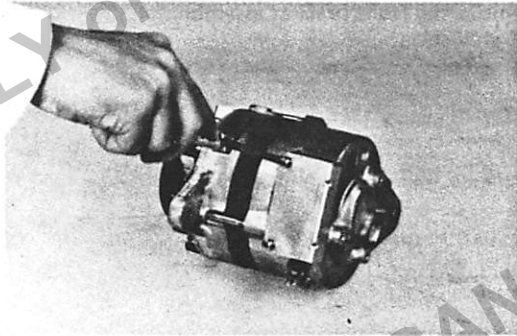


Fig. 21-6

21-0250



DISASSEMBLY

1. Disassemble the regulator and brush.
1) Remove the brush cover.



Fig. 21-7

21-0251



- 2) Remove the regulator.

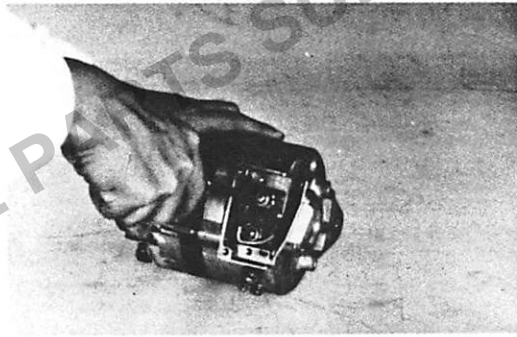


Fig. 21-8

21-0252



- 3) Remove the brush holder set screws.

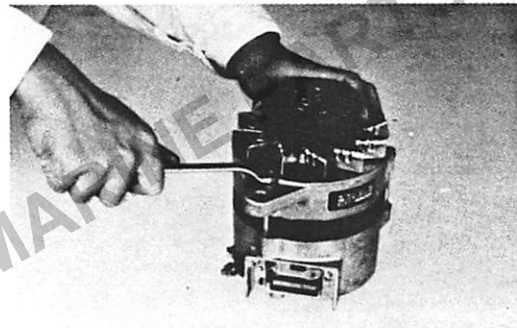


Fig. 21-9

21-0253



2. Disassemble the rotor.
1) Remove the through bolts.

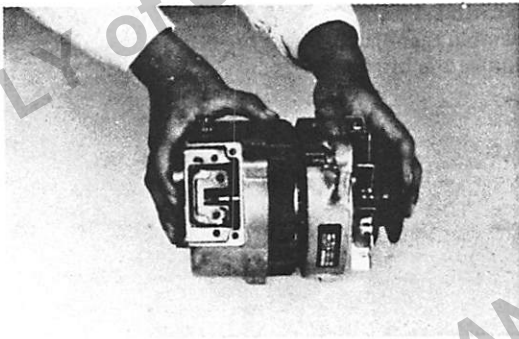


Fig. 21-10

21-0254



2) Remove the front bracket assembly.

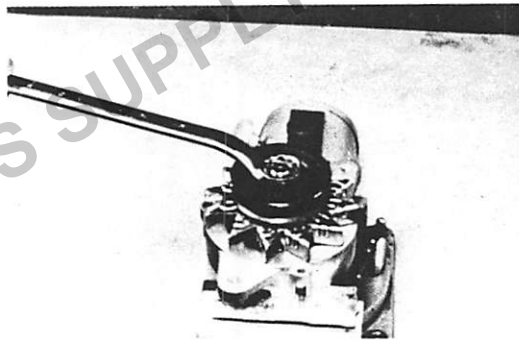


Fig. 21-11

21-0255



3) Remove the pulley, fan and collar.

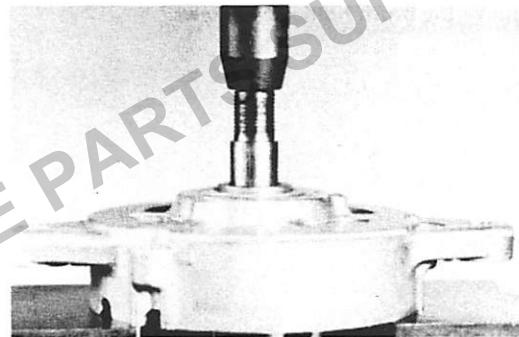


Fig. 21-12

21-0256



4) Remove the rotor by using a press.

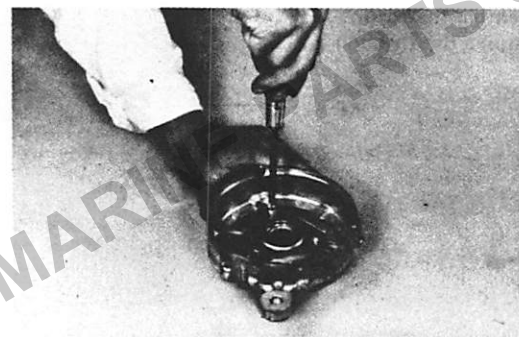


Fig. 21-13

21-0257



5) Remove the bearing retainer.

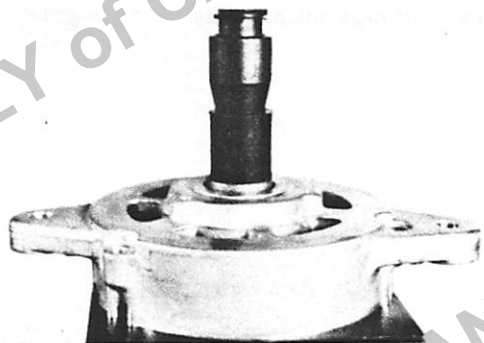


Fig. 21-14

21-0258



6) Remove the front bearing.

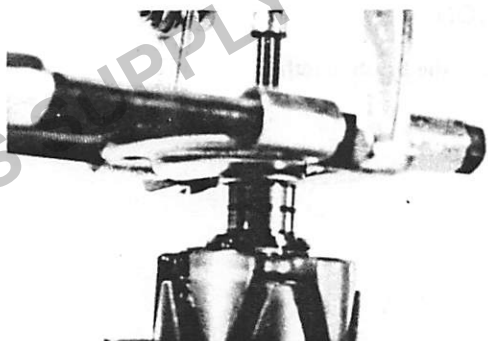


Fig. 21-15

21-0259



7) Remove the rear bearing.

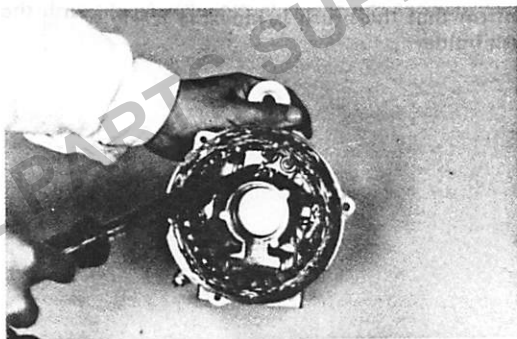


Fig. 21-16

21-0260



3. Remove the stator assembly.

1) Unsolder the regulator lead wires.



Fig. 21-17

21-0233



2) Remove the stator coil assembly.

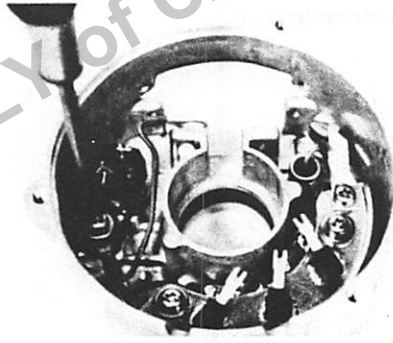


Fig. 21-18

21-0261



3) Remove the heat sink assembly.

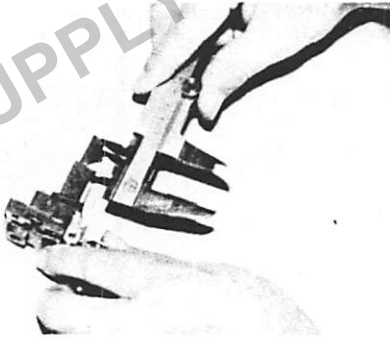


Fig. 21-19

21-0234

Standard	Limit
16 mm	7 mm



INSPECTION

1. Brush

1) Measure the brush length.

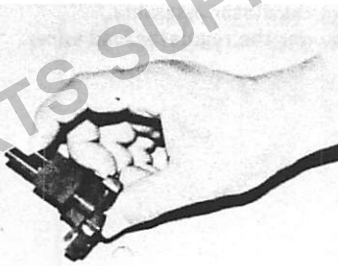


Fig. 21-20

21-0235



2) Confirm that the brush is movable freely with the brush holder.

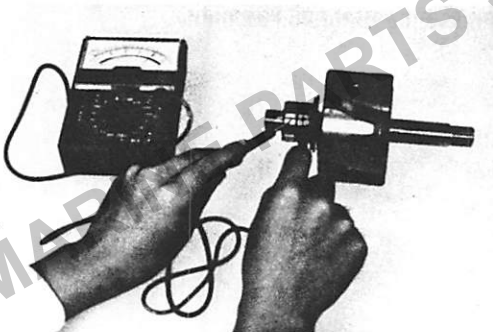


Fig. 21-21

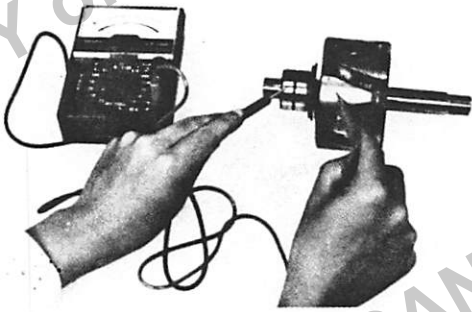
21-0262



2. Rotor

1) Check the conduction of the rotor coil.

	Standard	Limit
Resistance	About 12.5Ω	Less than 11Ω



2) Check the insulation between the slip ring and the core.

Fig. 21-22

21-0263

	Standard	Limit
Resistance	More than 1 MΩ	Less than 0.5 MΩ

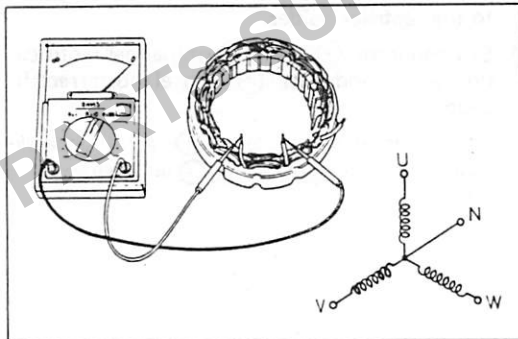


3) Measure the outside diameter of the slip ring.

Fig. 21-23

21-0264

	Standard	Limit
	34.5 mm	33.5 mm



3. Stator
1) Check the conduction.
(U.V.W. terminal)

Fig. 21-24

SM21-037

	N - U N - V N - W
Resistance	About 0.4 Ω

MARINE PARTS SUPPLY of CANADA (800) 661-5353

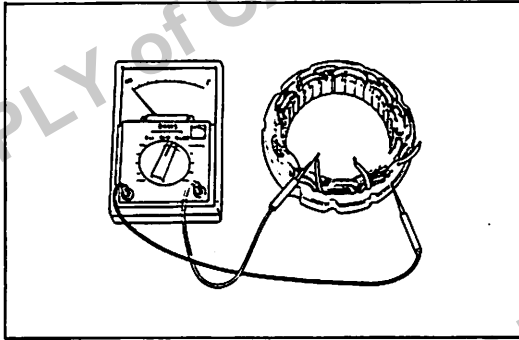


Fig. 21-25 SM21-038

	Standard	Limit
Resistance	More than 1 MΩ	Less than 0.5 MΩ



2) Check the insulation.

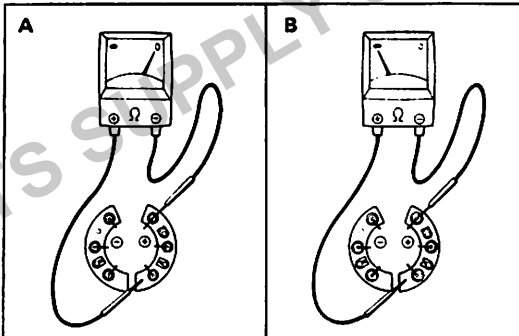


Fig. 21-26 SM21-013A

A: Good B: Bad



4. Heat sink

1) Inspect the each positive side rectifier condition.
 (1) Connect the circuit tester ⊕ lead to the rectifier holder and the ⊖ lead to the rectifier terminal.

1) Inspeccione la condición del rectificador de cada lado positivo.

(1) Conecte el conductor ⊕ del probador de circuito al portarrectificador y el conductor ⊖ a terminal del rectificador.

1) Vérifier que chacun des redresseurs côté positif est en bonne condition.

(1) Connecter le conducteur ⊕ du contrôleur de circuit au porte-redresseurs et le conducteur ⊖ à la borne de redresseur.

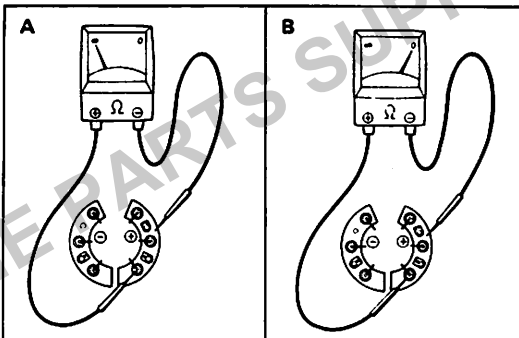


Fig. 21-27 SM21-013B

A: Good B: Bad



(2) ⊕ lead to the rectifier terminal and ⊖ lead to the rectifier holder.

(2) El conductor ⊕ con el terminal del rectificador y el conductor ⊖ con el portarrectificador.

(2) Connecter le conducteur ⊕ à la borne de redresseur et le conducteur ⊖ au porte-redresseurs.

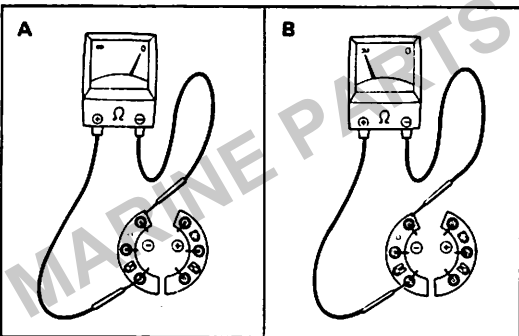


Fig. 21-28 SM21-012A



2) Inspect the each negative side rectifier condition.
 (1) Connect the circuit tester ⊕ lead to the rectifier terminal and the ⊖ lead to the rectifier holder.

2) Inspeccione la condición del rectificador de cada lado negativo

(1) Conecte el conductor ⊕ del probador de circuito con el terminal del rectificador y el conductor ⊖ con el portarrectificador.

2) Vérifier que chacun des redresseurs côté négatif est en bonne condition.

(1) Connecter le conducteur ⊕ du contrôleur de circuit à la borne de redresseur et le conducteur ⊖ au porte-redresseurs.

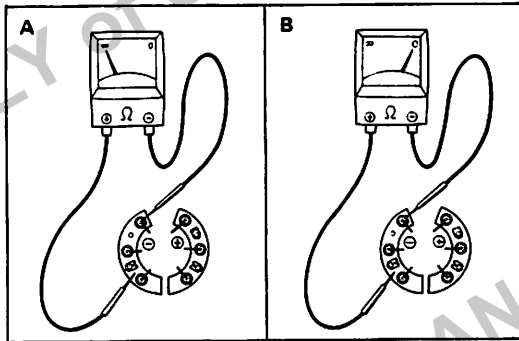


Fig. 21-29 SM21-012B

A: Good B: Bad



- (2) ⊕ lead to the rectifier holder and ⊖ lead to the rectifier terminal.
- (2) El conductor ⊕ con el portarrectificador, y el conductor ⊖ con el terminal de rectificador.
- (2) Connecter le conducteur ⊕ au porte-redresseurs et le conducteur ⊖ à la borne de redresseur.

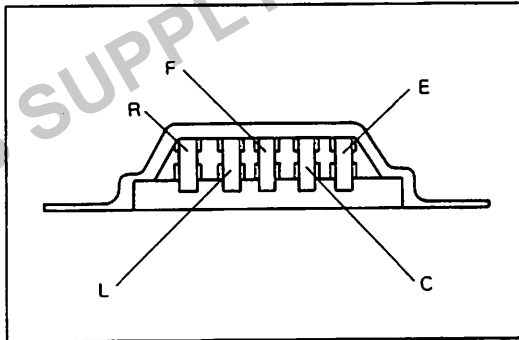


Fig. 21-30 SM21-035



- 5. I.C. regulator
 - 1) Check the resistance between each terminal.
- 5. Regulador I.C.
 - 1) Revise la resistencia entre cada terminal.
- 5. Régulateur à circuit intégral
 - 1) Vérifier la résistance entre les bornes.

RESISTANCE BETWEEN EACH TERMINAL

Tester		Resistance	Tester		Resistance
+ Lead	- Lead	Ω	+ Lead	- Lead	Ω
R	L	About 10	L	R	∞
R	F	About 10	F	R	∞
R	C	∞	C	R	∞
R	E	About 1.5 K	E	R	∞
L	F	About 10	F	L	About 2 K
L	C	About 90	C	L	∞
L	E	About 100	E	L	About 1.5 K
F	C	About 10	C	F	∞
F	E	About 180	E	F	∞
C	E	About 40	E	C	∞

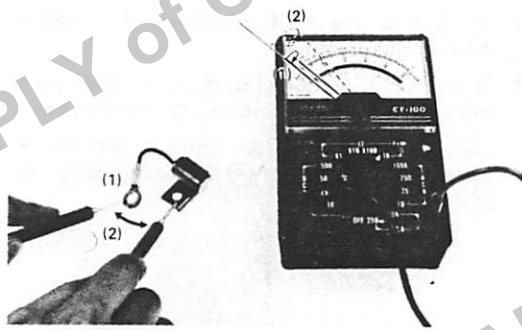


Fig. 21-31 21-0242

Capacity	About 0.5 μ F
----------	-------------------



6. Condenser

- 1) Inspect the condenser function.
 - (1) Connect the test leads.
 - (2) Reverse the polarity of the test leads.
- 2) Measure the condenser capacity. (Condenser tester)

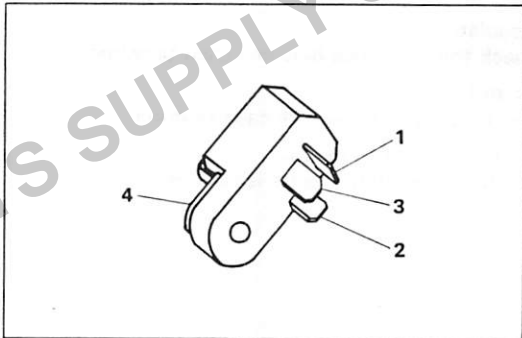


Fig. 21-32 SM21-074

1. R Lead
2. L Lead
3. N Lead
4. Support



7. Connector

- 1) Check the resistance between each terminal.

RESISTANCE BETWEEN EACH TERMINAL

Tester		Resistance
+ Lead	- Lead	Ω
R	L	400 - 500
L	Support	∞
Support	L	9 - 12



Fig. 21-33

21-0233

**ASSEMBLY**

1. Install the stator assembly.

1) Install the heat sink assembly.

NOTE: Be careful with the each position of two heat sink. Install the (-) pole heat sink, which has printed circuit, lower.



Fig. 21-34

21-0265



2) Install the O-ring into the rear bracket.

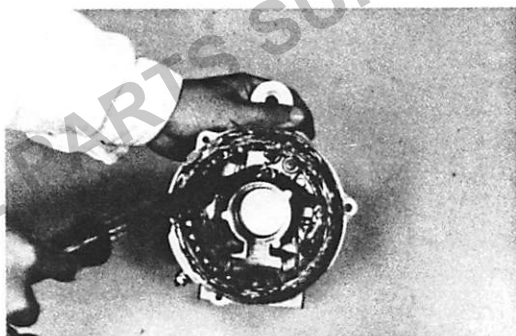


Fig. 21-35

21-0260



3) Install the stator.

Solder the lead wires of the stator to the each terminal of the heat sink as shown in the figure.

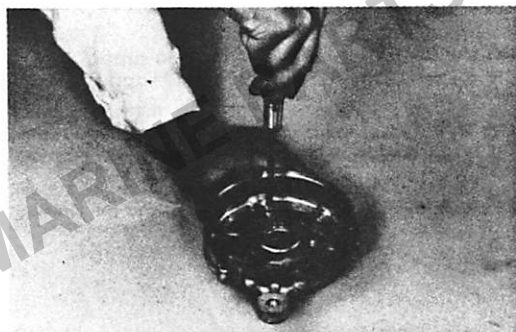


Fig. 21-36

21-0270



2. Installation of the rotor.

1) Install the felt, bearing and the bearing retainer into the front bracket.

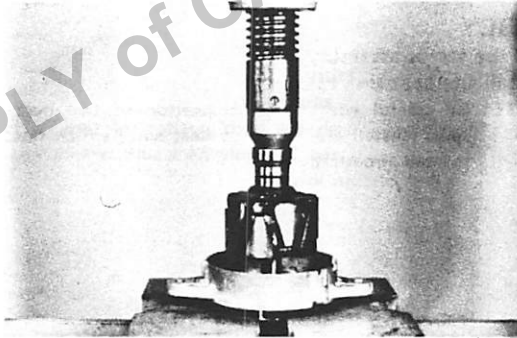


Fig. 21-37

21-0266



2) Install the rotor into the front bracket.

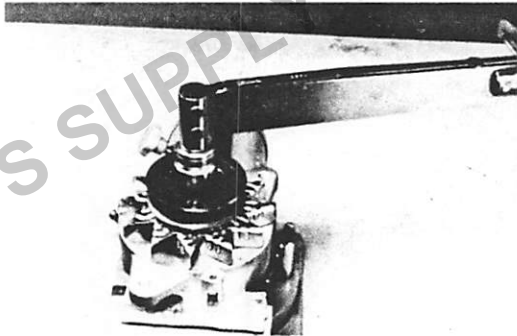


Fig. 21-38

21-0267



3) Install the fan and pulley.

Tightening torque	980-1,300 kg-cm (71-94 lb.ft)
-------------------	-------------------------------



Fig. 21-39

21-0268



4) Install the through bolts.

Tightening torque	60-90 kg-cm (4-6.5 lb.ft)
-------------------	---------------------------

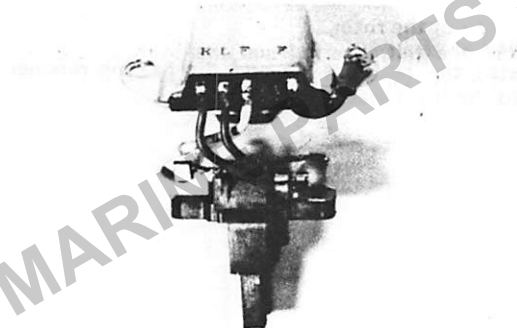


Fig. 21-40

21-0270



3. Installation of the regulator and the brush holder assembly.

1) Install the brushes into the holder. And then solder the lead wires to the support.



NOTE: In installing the brushes, solder the wires so that brush projection should be 16 mm.

NOTE: Suit the concave face of the brush to the convex face of the slip ring.

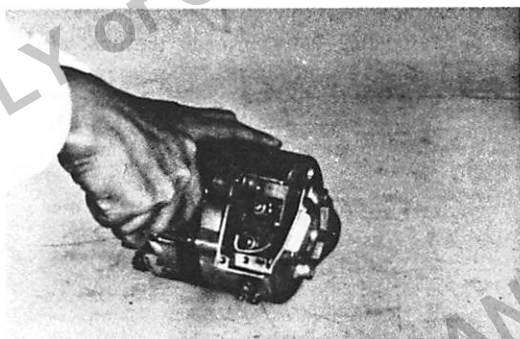


Fig. 21-41 21-0252

Tightening torque	19–25 kg-cm (1.4–1.8 lb.ft)
-------------------	-----------------------------



2) Install the brush holder.



Fig. 21-42 21-0251

Tightening torque	19–25 kg-cm (1.4–1.8 lb.ft)
-------------------	-----------------------------



3) Install the I.C. regulator.

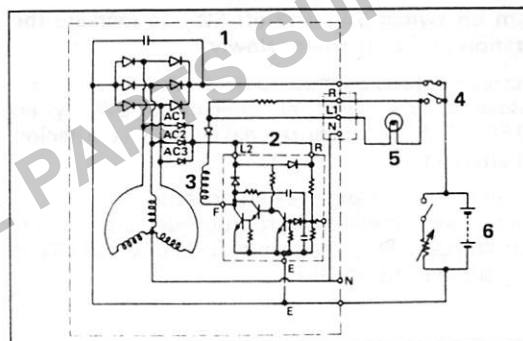


Fig. 21-43 SM21-010B

- | | |
|-----------------|------------------------|
| 1. Alternator | 4. Starter switch |
| 2. IC Regulator | 5. Charge warning lamp |
| 3. Field coil | 6. Battery |

**CHARGING SYSTEM CIRCUIT**

– Precautions –

- 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 with high voltage insulation resistance tester.
- When in operation, never disconnect the battery.



INSPECTION

1. Measure the resistance between each terminal after assembling.
(1.5V circuit tester, x 1)

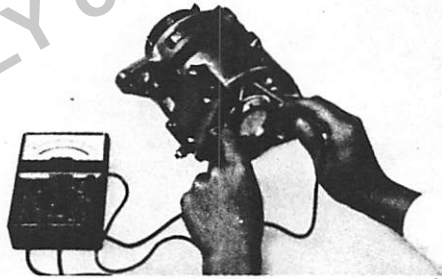


Fig. 21-44 21-0269

Tester		Resistance (Ω)	Tester		Resistance (Ω)
+ Lead	- Lead		+ Lead	- Lead	
B	R	∞	N	E	7-10
B	N	7-10	N	B	∞
R	L	400-500	E	R	∞
R	E	∞	E	L	∞
L	E	∞	E	N	∞

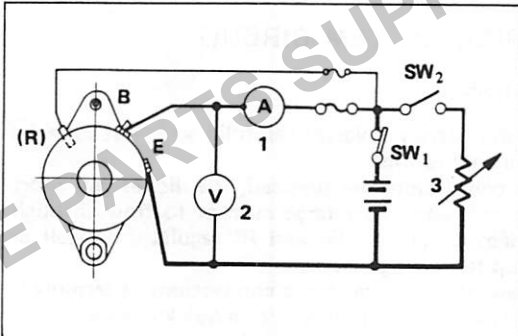


Fig. 21-45 SM21-014A

1. Ampere-meter
2. Volt-meter
3. Load



2. Inspect the alternator performance.
 - 1) Turn on switch SW₁ and off SW₂ to increase the rotation of the alternator slowly.
2. Inspeccione el funcionamiento del alternador.
 - 1) Posicionar en "ON" el interruptor SW₁ y en "OFF" SW₂ y aumentar de a poco la rotación del alternador.
2. Inspecter la performance de l'alternateur.
 - 1) Augmenter lentement la rotation de l'alternateur, l'interrupteur SW₁ étant mis sur la position ON et SW₂ sur la position OFF.

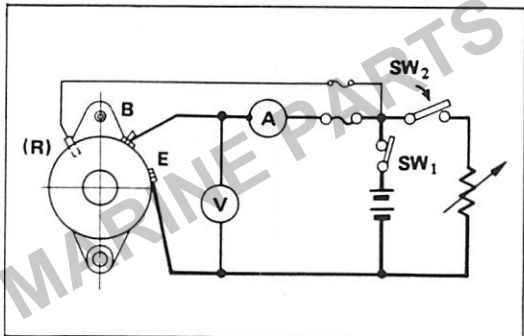


Fig. 21-46 SM21-014B



- 2) When voltage reaches 28V, turn on swigch SW₂ regulate load resistance. Increase the rotation of the rotor keeping voltage at 28V.
- 2) Cuando el voltaje llega a 28V, posicionar en "ON" el interruptor SW₂ para regular la restencia de carga. Aumente la rotación del rotor manteniendo el voltaje a 28V.
- 2) Lorsque la tension arrive à 28V, mettre SW₂ sur la position ON. Augmenter la rotation du rotor tout en maintenant la tension à 28V par réglage de la résistance de charge.

	Standard
Less than 5,000 rpm	28V, 20A

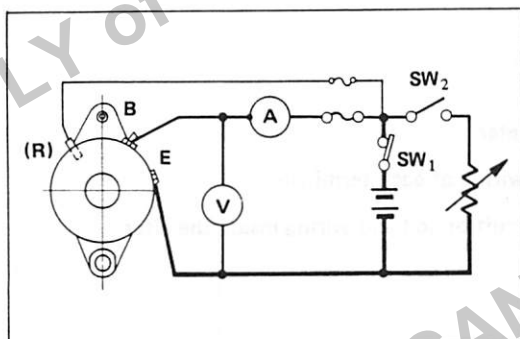


Fig. 21-47

SM21-014A

	Standard
5,000 rpm	28.5V – 29.5V

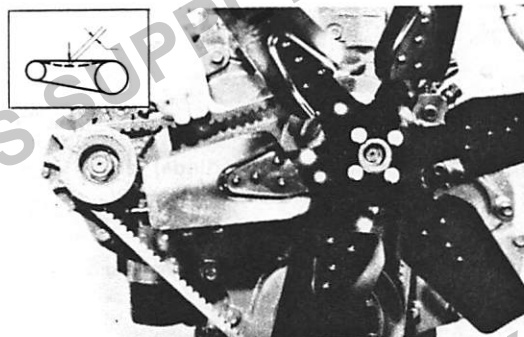
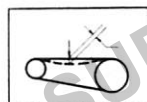


Fig. 21-48

W04-058

	Standard
Deflection (10 kg, 22 lb)	15–20 mm (0.394–0.787 in)

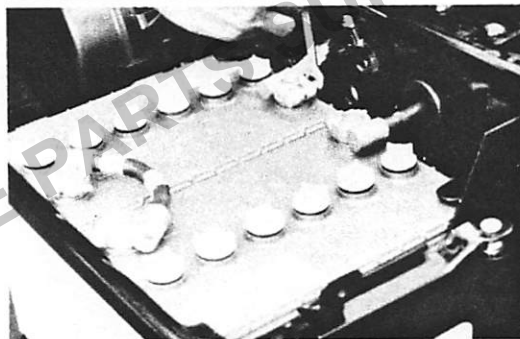


Fig. 21-49

21-081



3. Inspect the IC regulator performance.
Turn on switch SW₁ and off SW₂ to increase the rotation of rotor to 5,000 rpm.

3. Inspeccione el funcionamiento del regulador de IC
Posicionar el interruptor SW₁ en "ON", SW₂ en OFF
y aumentar la rotación del alternador a 5000 ppm.

3. Inspecter la performance du régulateur à C.I.
Porter la rotation du rotor à 5,000 tr/mn, SW₁
étant mis sur la position ON et SW₂ sur la position
OFF.



MOUNTING

1. Adjust the V-belt tension and tighten the set bolt.

1. Adjuste la tensión de la correa en V y apriete el perno
de fijación.

1. Régler la tension de la courroie trapézoïdale et serrer
le boulon de blocage.



2. Connect the battery ⊖ terminal.

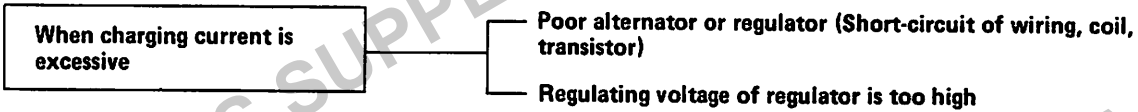
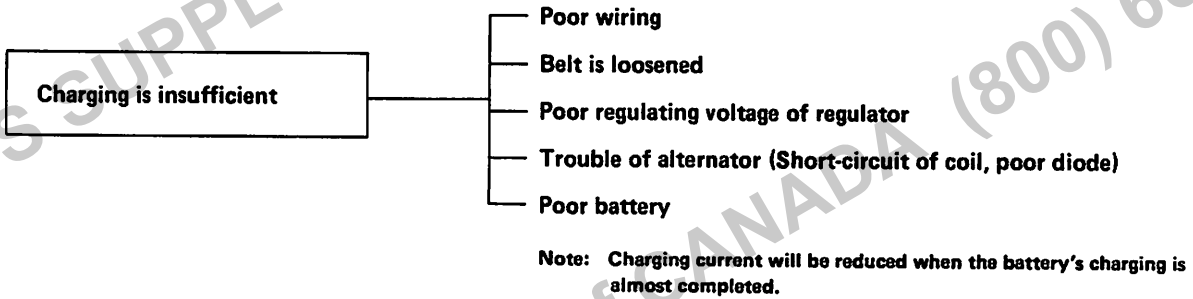
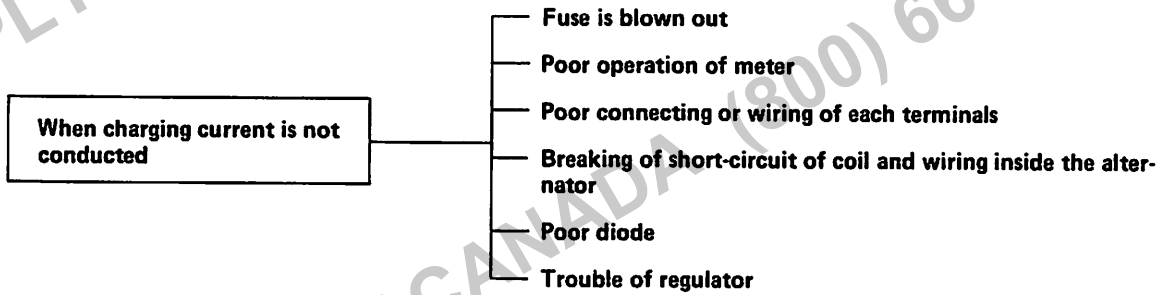
2. Conecte el terminal de batería.

2. Connecter la borne de batterie.

PRECAUTIONS ON THE VEHICLE

- 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.
- Do not disconnect the alternator terminals when in operation.
- When charging the battery with a quick charge disconnect the battery terminals.
- Do not inspect with a megger tester.
- When in operation, never disconnect the battery.

TROUBLESHOOTING



REPAIR SPECIFICATIONS

Item		Standard	Service limit
Brush length mm		20	5.5
Outside diameter of slip ring mm		32.5	32.1
Resistance of coil (Ω)	Stator	0.91	-
	Rotor	9.0	-

TIGHTENING TORQUE

Item		kg-cm	lb.ft
Pulley lock nut		980 - 1,300	71 - 94
Through bolt		60 - 90	4 - 6.5
Others	M5 x 0.8	19 - 25	1.3 - 1.8
	M6 x 1	33 - 45	2.4 - 3.3

GENERATOR

DATA & SPECIFICATION 21- 1
DESCRIPTION 21- 1
OVERHAUL 21- 3
REPAIR SPECIFICATION 21- 7

REGULATOR

DESCRIPTION 21- 7
OVERHAUL 21- 8



GENERATOR

DATA & SPECIFICATION

Generator	
Model	0211 601 0133, 0211 102 0222 (OPTION)
Rated voltage	24V
Rated output	28V 25A, 28V 35A (OPTION) at 5,000 rpm
Generating system	3 ϕ , AC self-rectifying type
Rated speed	5,000 rpm
Pulley ratio	2.34 (188/80.5)
Regulator	
Model	RS1011-24B
Control system	Tirrill type voltage regulating system
Voltage control range (at light load)	29 \pm 1V
Current capacity	1.5A
Field relay closing voltage	20V
Field relay opening voltage	12V

DESCRIPTION

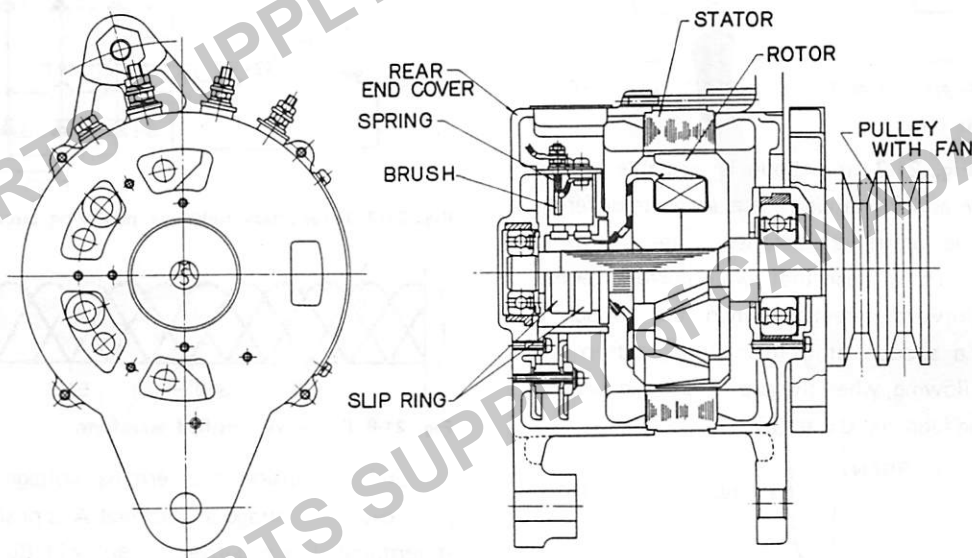


Fig. 21-1 Alternator

The generator is driven by the engine and it supplies electricity to various electrical instruments and at the same time, it charges the battery. The generator is an alternator with built-in rectifier and separate voltage regulator type and its power is 24V, 25A, and 35A for optional, and its rotating direction is clockwise when viewed from the pulley side. The speed of the Generator is 2.34 times the crankshaft rotation speed.

CONSTRUCTION

As illustrated in **Fig. 21-1**, the generator comprises stator, rotor, rear cover, front cover and pulley. The stator plays an important role of generating electric power, and consists of laminated iron sheets in which a number of slots are provided to accommodate three-phase windings. The rotor serves as an exciting means

21-2 GENERATOR

of the implicated type in which two thick iron sheets wound with coils are opposed. The alternator rotor having N and S poles to communicate magnetic flux through the stator is equipped with an insulating forming into which two slip-rings are set. The rear bracket is provided with a diode which converts alternating current developed in the stator coil into direct. The diode allows one-way flow of current, and blocks the current from flowing in the other way. The diode used here is provided with NP junction silicon pellet on a copper base from which a lead wire is tapped out. Namely, the diode has one lead terminal and the other is grounded on the case. (See Fig. 21-2)

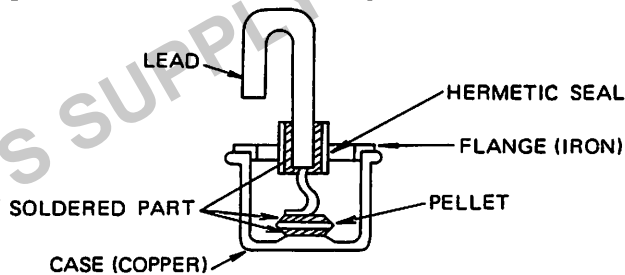


Fig. 21-2 Structural design of the diode

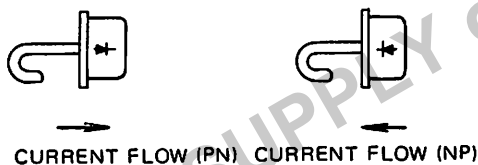


Fig. 21-3 Current flow

As shown in Fig. 21-3, the diode is available in two types, NP diode and PN diode. These are quite different in polarity. The diode characteristics are shown in Fig. 21-4 in which is clear that while current cannot flow in the forward direction when the voltage is small. All of a sudden at a little voltage drop the current begins flowing, when the applied voltage exceeds a specified value (approx. 0.6 to 0.7 V).

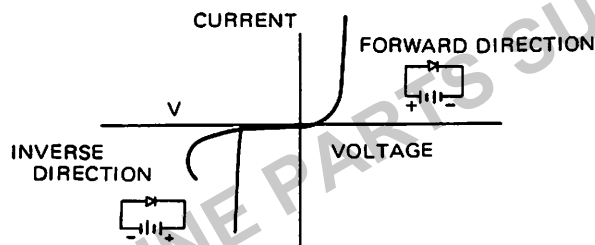


Fig. 21-4 Diode characteristic curve

On the other hand, the diode shows a high resistance against the reverse direction; even if it is applied with a high voltage, its leakage current is very small.

WIRING AND FUNCTION

When the rotor is turned with current forced through

it, the alternator stator will develop AC voltage. This AC voltage cannot be applied directly to the battery, and must be rectified into DC current. To accomplish this end, the present alternator is equipped with six diodes on its output circuit arranged as shown in Fig. 21-7.

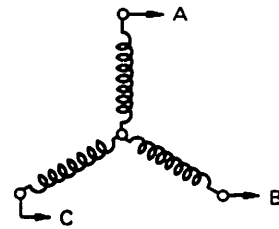


Fig. 21-5 Stator coil connection diagram

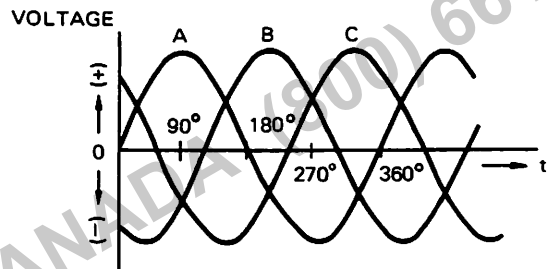


Fig. 21-6 Three-phase AC waveform

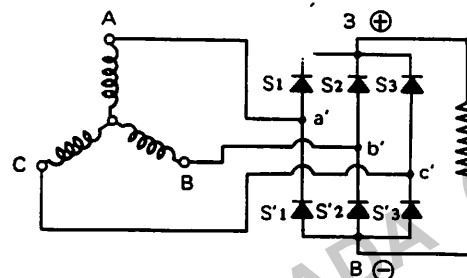


Fig. 21-7 Three-phase full-wave rectifying circuit

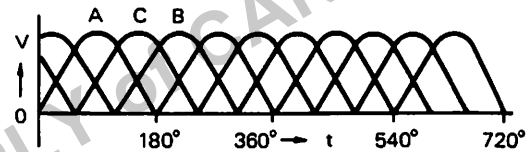


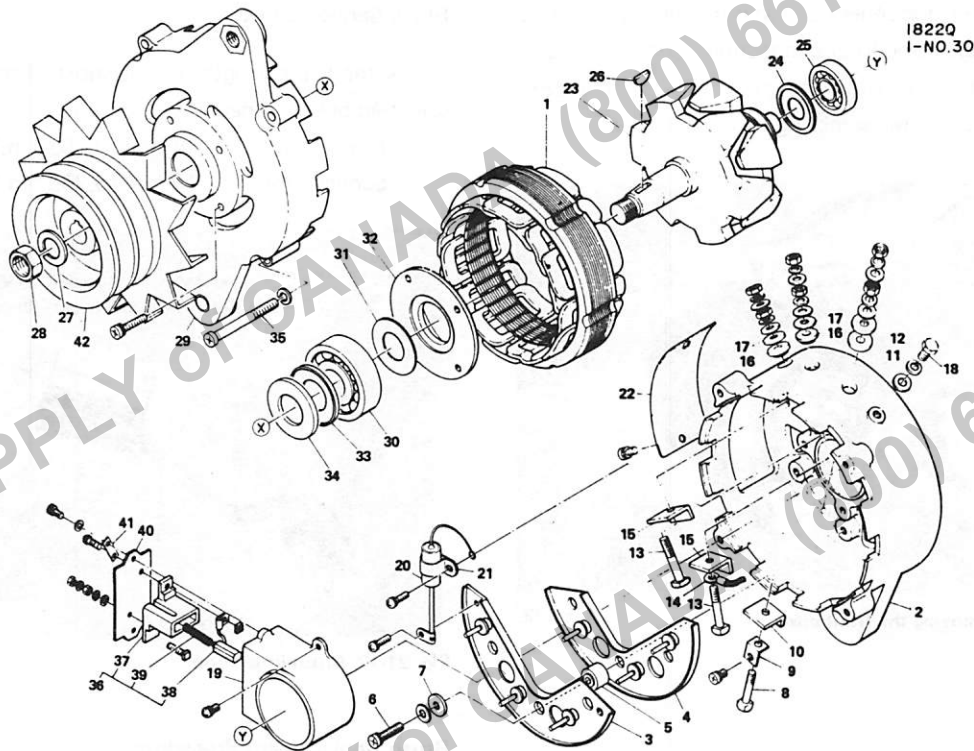
Fig. 21-8 Full-wave rectified waveform

Let us now consider the terminal voltage across A and B. In case the voltage at terminal A is positive, and that at terminal B is negative, current will flow through A, a', S₁, B(+), R, B(-), S₃', b' and B in the said order, beginning from terminal A.

On the other hand, if terminal B is held positive, and terminal A negative, current will pass B, b', S₃ B(+), R, B(-), S₁', a' and A in the said order.

While the direction of current flow varies depending on the polarity of terminals, the current that flows through resistor R is unidirectional; namely, the rectified waveform has less ripples as compared with single-phase full-wave rectified waveform. The battery can be charged if it is connected across this resistor.

OVERHAUL

18220
I-NO.30

- | | | |
|--------------------------|------------------------------|-------------------------------|
| 1. Stator assembly | 15. Insulating plate | 29. Front cover |
| 2. Rear cover | 16. Insulating bush | 30. Front bearing |
| 3. Heatsink assembly (B) | 17. Insulating bush | 31. Grease retainer |
| 4. Heatsink assembly (E) | 18. Bolt | 32. Bearing retainer |
| 5. Insulating bush | 19. Brush and spring housing | 33. Felt holder |
| 6. Bolt | 20. Condenser assembly | 34. Oil felt |
| 7. Insulating | 21. Condenser holder | 35. Through bolt |
| 8. Terminal bolt | 22. Brush cover | 36. Brush and holder assembly |
| 9. Lead plate | 23. Rotor assembly | 37. Brush holder |
| 10. Insulating plate | 24. Grease retainer | 38. Brush |
| 11. Insulating bush | 25. Rear bearing | 39. Brush spring |
| 12. Insulating washer | 26. Woodruff key | 40. Insulating plate |
| 13. Terminal bolt (F.N) | 27. Lockwasher | 41. Lead plate |
| 14. Lead assembly | 28. Locknut | 42. Pulley with fan |

Fig. 21-9 Generator

DISMOUNTING

- (1) Cut off the battery switch, and disconnect three leads from the alternator.
- (2) Remove the through bolt from the crankcase and the set bolt.

DISASSEMBLY

- (1) Loosen the locknut (28) provided on the end of pulley to remove the fan pulley (42). Then, remove two bolts from the brush cover on the rear cover,

and remove the brush cover (40) to take brush 4 holder assembly (36) out.

- (2) Remove the through bolt (35) which has connected the front cover and the rear cover together, and take out the front cover (29) and rotor (23) from the stator (1).
- (3) Loosen and remove four bearing retainer bolts to separate the rotor (23) and front cover (29) from each other.

To separate the rotor, front ball bearing (30) and rear ball bearing (25) from each other, hold the bearings and force the rotor shaft out.

- (4) Disconnect the stator coil lead from the diode at a soldered part by making use of a soldering iron, and disconnect the stator coil (1) and rear cover (2). Prior to disconnecting leads, it is recommended to provide match marks for the convenience of reassembling.

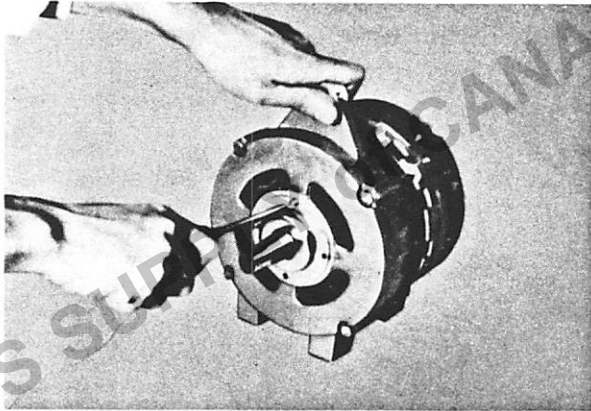


Fig. 21-10 Removing the front cover

21-032

- (5) The diode is mounted on the heat sinks (3, 4). To disconnect the diode, remove the lead from the soldered part of the diode first, loosen the set bolt (6) of the heat sinks, and remove the heat sink assembly from the rear cover.

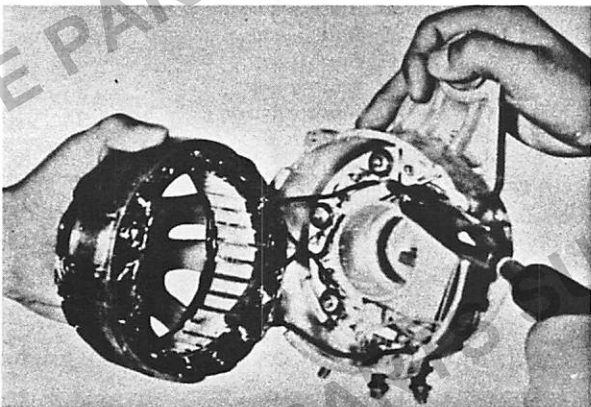


Fig. 21-11 Removal of diode

G 4954

- (6) Once the cut type has been removed, it can no longer be used. When removing the diode, pay utmost attention not to mar the heat sink. The soldered diode should be replaced together with its heat sink assembly.

INSPECTION OF ALTERNATOR

Brush Service Limit

Check the brush length; if it is short of the service limit specified below, renew it.

Brand new : 18 mm (0.7087 in.)

Service limit : 10 mm (0.3937 in.)

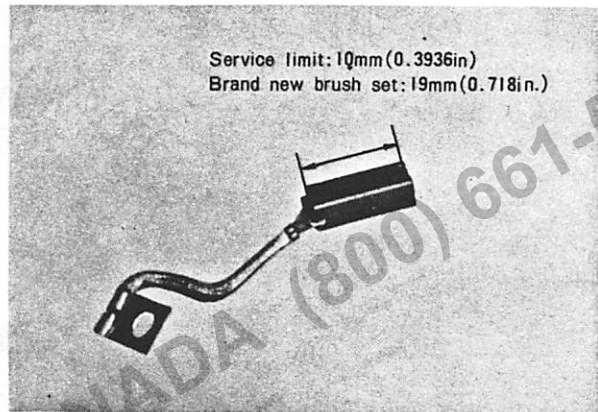


Fig. 21-12 Brush inspection

G 4957

Brush Replacement Procedure

Remove the brushholder assembly, and remove the brush holder, plate and spring, and then remove the brush. The brush projected 12.5 mm (0.4921 in.) from the end of the brush holder.

Make sure that the brush movement is smooth.

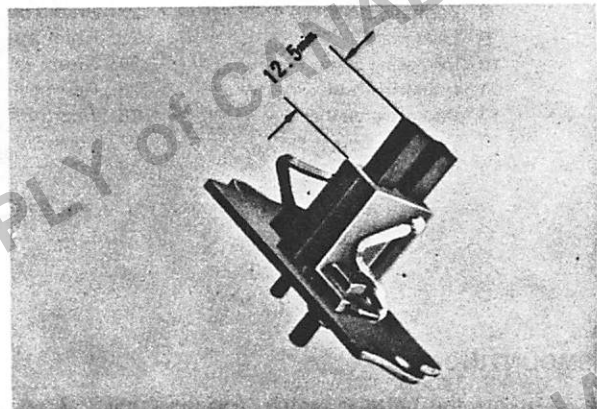


Fig. 21-13 Brush replacement

G 4955

Grounding Test for Stator Coil

Connect a circuit tester between the stator core and stator lead. If the resistance becomes infinity, the stator insulation is justifiable.

Location of Breaks in Stator Coil

Connect a circuit tester between the neutral terminal

lead and one of three other terminals, and then between the neutral terminal lead and the other terminal, and so on.

If the resistance values at any terminal are zero, the stator coil is justifiable.

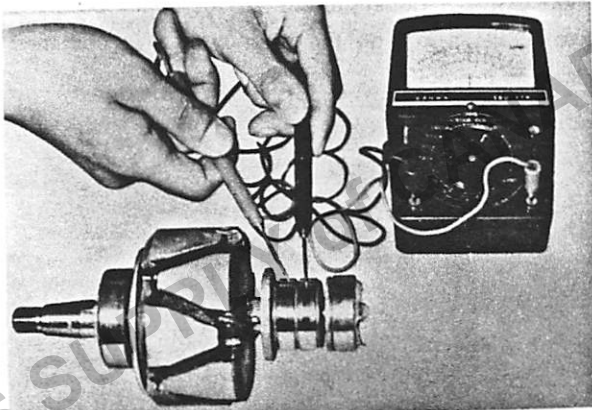


Fig. 21-14 Location of breaks in the stator coil G 3209

Location of Breaks in Rotor Coil

Carry out conduction test between two slip-rings. If there is no sign of conduction between slip-rings, the rotor coil is suspected to be broken. Renew the rotor coil.

The rotor coil resistance

- 0211 601 0133 (24V 25A) 18 Ω
- 0211 102 0222 (24V 35A) 17.5 Ω



Fig. 21-15 Location of breaks in rotor coil G 3212

Rotor Coil Grounding Test.

Examine the conduction between two slip-rings and rotor shaft. If they are conductive, the rotor should be replaced with a new one.

Resistance value: : infinity

JUDGEMENT CRITERIA FOR RECTIFIER PERFORMANCE

If a sound diode is examined with a circuit tester, it will show diversified results depending on the kind of

tester used, source cell voltage temperature, and other various factors. For this reason, the use of circuit tester is not adequate for this diode examination.

If you sticks to the circuit tester, then how to judge the diode. The only solution is to judge a subject diode to be good if the difference in its resistance between the forward direction and inverse direction is substantially large. The best way is to use a diode checker which is able to measure diode characteristics directly. However if such an excellent means is not available, the alternator tester is perforce required, which measures the forward current and inverse current with a specified voltage applied to the subject diode.

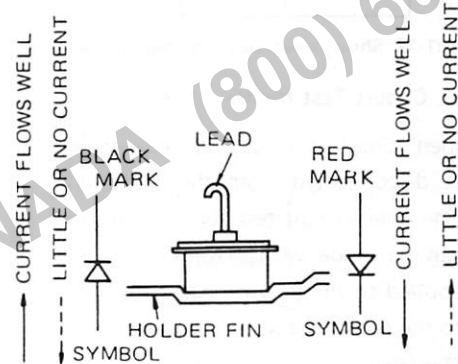


Fig. 21-16 Diode characteristics

Rectifier characteristics	
Forward characteristics	When a DC current of 20A is forced in the forward direction at normal temperatures, the voltage drop between the rectifier lead terminal and the holder is not more than 1.2 V.
Inverse characteristics	When DC 100 V is applied in the reverse direction at normal temperatures, the reverse current is not more than 1.5mA.

1. Rectifier shortcircuit test

- (1) The shortcircuit test for the positive side rectifier can be accomplished by connecting (-) stick of the circuit tester to "B" terminal and (+) stick to "N" terminal.

- * Resistance value: Infinity Normal
 Nearly zero Shortcircuit fault

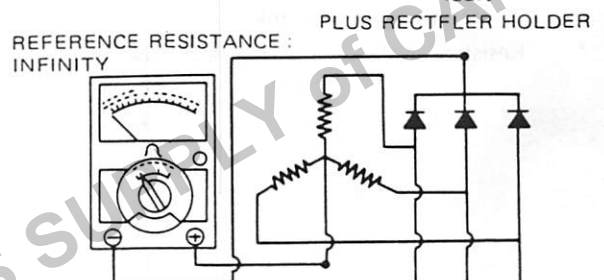


Fig. 21-17 Shortcircuit test for positive side rectifier

21-6 GENERATOR

- (2) For the shortcircuit test of (-) side rectifier, apply (+) stick of the circuit tester to "E" terminal and (-) stick to "N" terminal.

* Resistance value:	Infinity	Normal
	Nearly zero	Shortcircuit fault

REFERENCE RESISTANCE:
INFINITY

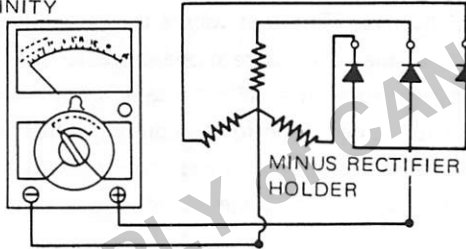


Fig. 21-18 Shortcircuit test for negative side rectifier

2. Open Circuit Test for Rectifier

The open circuit test can be accomplished with the rectifier disconnected from the stator coil.

- (1) The open circuit test for the positive side rectifier can be made with (+) stick of the circuit tester applied to the positive side heat sink and (-) stick to the rectifier lead.

* Resistance value:	Nearly zero	Normal
	Infinity	Open circuit fault

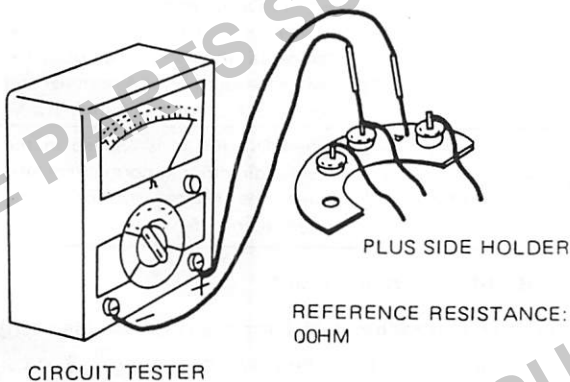


Fig. 21-19 Open circuit test for positive side rectifier

- (2) The open circuit test for the negative side rectifier can be accomplished with (+) stick of the circuit tester applied to the rectifier lead and (-) stick to the negative side heat sink.

* Resistance value:	Nearly zero	Normal
	Infinity	Open circuit fault

ASSEMBLY OF ALTERNATOR

The assembling is carried out just in the reciprocal way of the disassembling. It should be borne in mind that the following precautions be strictly observed.

- When it is required to set up the pulley onto the rotor, set a key on the rotor shaft first, and then mount the pulley.

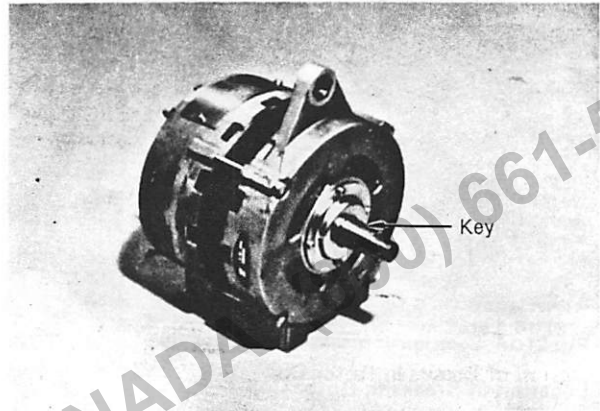


Fig. 21-20 Assembling of pulley

21-033

- When it is required to assemble the rotor on the stator, raise the brush from inside the stator, and hold the brush by reeving a wire through outside the rectifier end frame, and then set up the rotor.

* If this precaution is dismissed, the brush could be damaged.

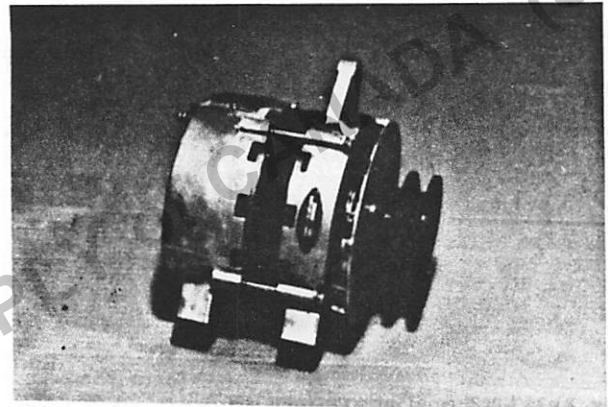


Fig. 21-21 Alternator Assembly

21-034

PERFORMANCE TEST

No-Load Test

With switch "S₂" opened, drive the alternator by means of a variable speed motor, and close switch "S₁" to increase the alternator speed little by little. Measure the alternator speed at 27 V. The alternator speed (under cold conditions) should range from 650 rpm to 850 rpm.

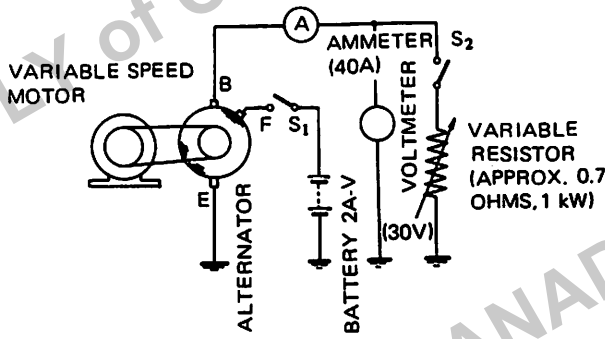


Fig. 21-22 Load test

OUTPUT TEST

Keep the output voltage at 28 V all the time, and measure the alternator speed at an output current under mention. The alternator speed is not more than 3,000 rpm under cold condition.

0211 601 0133	28 V 25 A
0211 102 0222	28 V 35 A

REPAIR SPECIFICATION

SERVICE STANDARD

Item	Standard value	Service limit	Measures	
Initial charging voltage, V	27			
Initial charging speed, rpm	less than 900			
Speed ratio	2.34			
Slip-ring diameter mm (in)	37.5 (1.476)	-2 (-0.079)	Replacement	
Brush	Height mm (in)	18 (0.7087)	10 (0.394)	Replacement
	Spring pressure, gr (lb)	195 ~ 265 (0.429 ~ 0.584)	130 (0.287)	Replacement
Rotor coil resistance	24 V 25 A	18 Ω		
	24 V 35 A	17.5 Ω		

REGULATOR

DESCRIPTION

When switch S is turned on, current flows from the battery (+) to S, VC₂, R₄ and then into E(-). Thus the coil VC₂ of the field relay attracts the armature equipped with point FP. When FP is closed, current flows into E from the battery after passing through FP and VP in turn, energizing the field coil (rotor). With this, when the engine is started, the rotor turns, generating 3-phase AC voltage in the stator coil. This voltage is then rectified through diodes and fed to the

battery through B terminal.

When the battery terminal voltage is increased (i.e., the alternator voltage), the voltage across the regulator voltage coil VC₁ also increase. Accordingly, the voltage point (VP) is attracted towards the lower point (LP), forcing the field coil current to pass through resistor R₂. When the voltage is increased up further, the point of VP₁ is totally stuck to the lower point (LP), thus the exciting current is grounded to point E after passing

21-8 GENERATOR

through resistor R_2 and lower point (LP), making the field current smaller. In this way the generating voltage can be regulated at a specified value.

When the generator voltage decreases, the attractive force of VC_1 decrease, releasing the armature to the original position by the force of coil spring.

In this way, the voltage regulator automatically on/off controls VP depending on size of the voltage generated by the alternator, controlling the field current to keep the alternator voltage at a constant value.

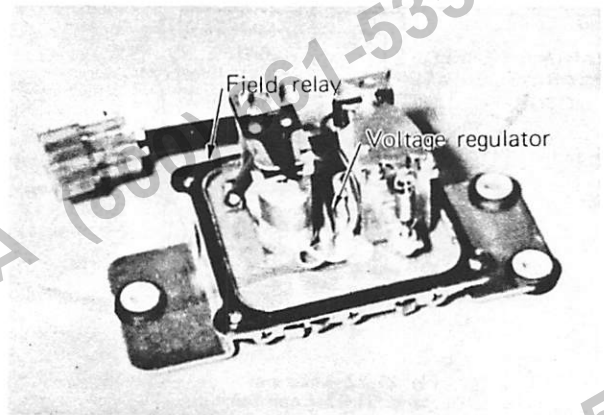


Fig. 21-23 Field relay & voltage regulator

RF-025

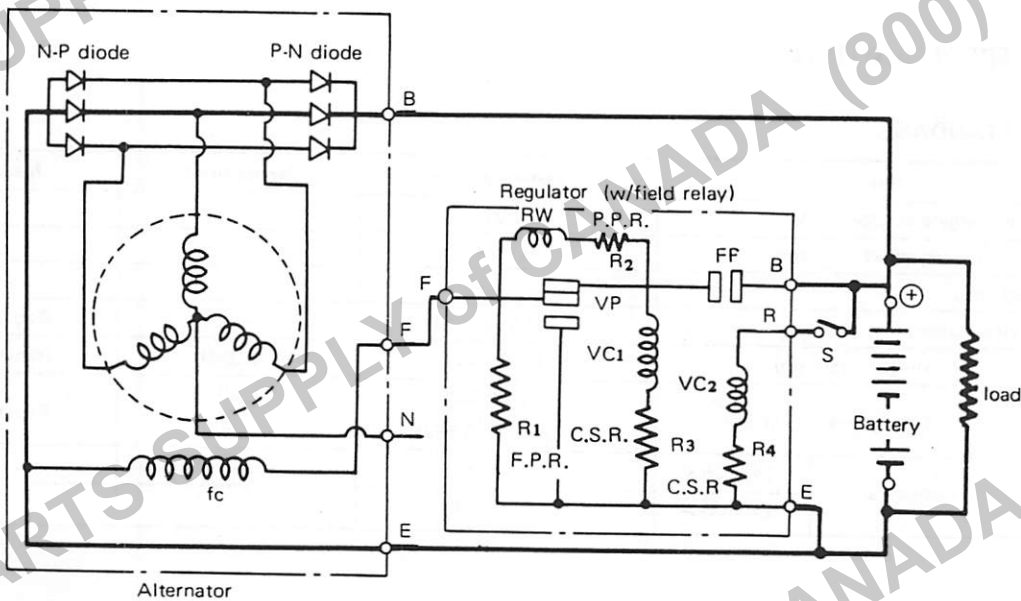


Fig. 21-24 Charging wiring diagram

OVERHAUL

DISASSEMBLING

- (1) Remove the set screw to remove the cover.
- (2) Remove the point holder and point set screw, and disconnect the lead wire at the soldered part to remove the point.
- (3) Remove the armature set screw, and separate the armature from the adjusting spring and yoke. Then, loosen the adjusting nut to remove the adjusting bolt.
- (4) The disassembling of the field relay can be accomplished in the same manner as in the case of voltage regulator relay.

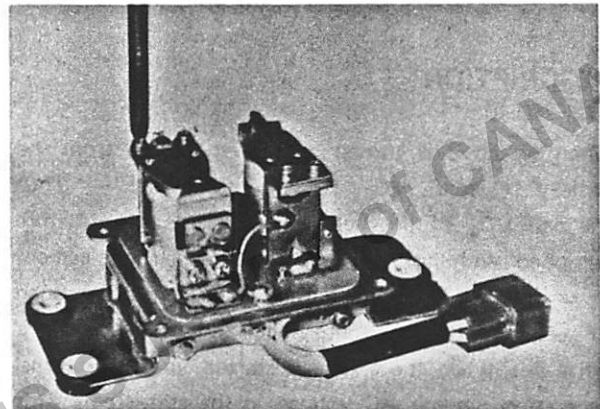


Fig. 21-25 Disassembling the regulator

G 3354

INSPECTION AND TEST

Inspect for Burnt

Under normal operating conditions, the points will be gray in color. If the surface of the contact points has been burnt or oxidized (black in appearance) or has become encrusted or rough, clean and polish the point with crocus or emery cloth. After polishing the points wipe them off with a clean dry rag so that no dust remains. Remember that the point is the most important part of the regulator and cleaning must be done with utmost care.

Coil insulator plate, point spring, B.R.F.E. terminal.
Inspect not burnt or damaged.

Inspect for Looseness

Make sure that all soldered portions are properly connected and soldered.

Make sure that the screws, nuts and rivets in each equipment component are properly tightened and the spring washers have been properly applied.
Make sure that the point is firmly secured.

SETTING-UP AND ADJUSTMENT

The assembling is carried out just in the reverse way to the disassembling. Note however that the regulator should be adjusted while being assembled.

(1) Adjustment of armature air gap:

Loosen the point holder set screw in advance. Insert a thickness gauge between the pole and armature as shown in Fig. 21-26, and tighten up the point holder set screw while giving a strong push over the point holder.

In this case, pay attention not to make the points staggered from each other.

Adjusting value: 1.1 ~ 1.3 mm
(0.0433 ~ 0.0512 in.)

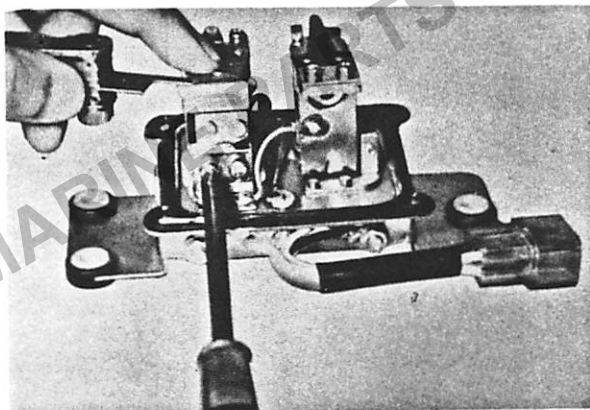


Fig. 21-26 Adjustment of armature air gap

G 3201

- (2) Adjustment of point gap
Measure the gap between the points with a thickness gauge as illustrated in Fig. 21-27, and adjust it by making use of a long-nose pliers or other suitable means.

Adjusting value: 0.3 ~ 0.7 mm
(0.0118 ~ 0.0276 in.)

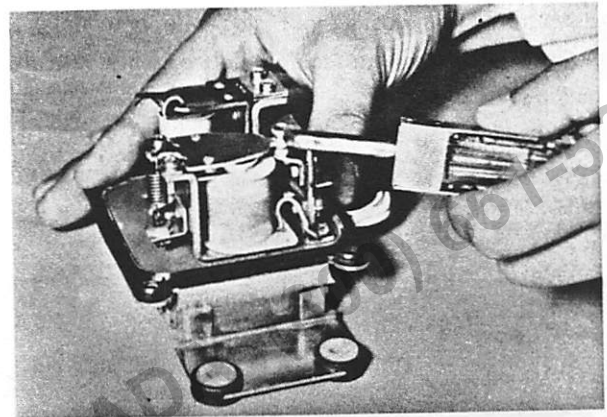


Fig. 21-27 Adjustment of point gap

G 3215

- (3) Adjustment of field relay yoke gap
Follow the same method that has been explained with reference to the voltage regulator.

Yoke air gap: 0.25~0.35mm (0.0099~0.0137in.)

Point gap: 0.4~0.6mm (0.0158~0.0236in.)

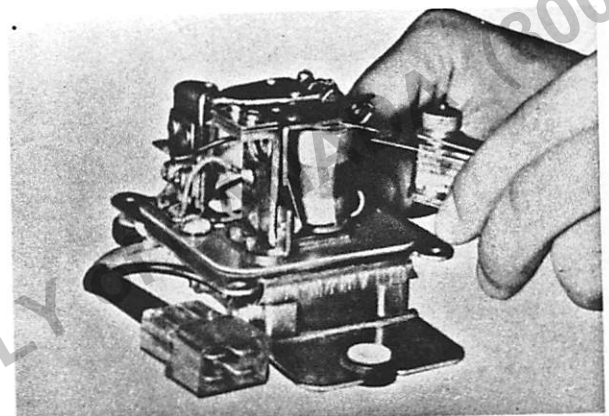


Fig. 21-28 Adjusting field relay

G 3213

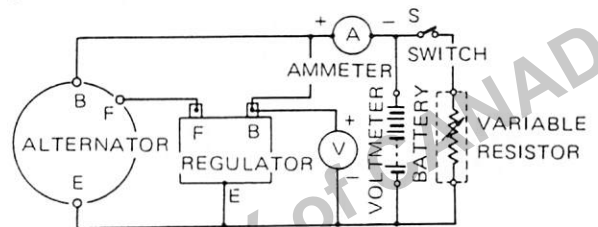


Fig. 21-29 Voltage regulator wiring diagram

- (4) Voltage adjustment

Arrange the voltage regulator as shown in Fig. 21-29 for voltage adjustment.

21-10 REGULATOR

1. Use a battery which has been fully charged (specific gravity: 1.260).
2. Turn the adjusting nut shown in **Fig. 21-30** clockwise to attain an increased tightening of the adjusting spring.
3. Increase the alternator speed up to 3,000 rpm. When the charging current is reduced lower than 5A, turn the adjusting nut clockwise or counter-clockwise to obtain a required voltage while watching a voltmeter.

Adjusting voltage: $29 \pm 1 \text{ V}$

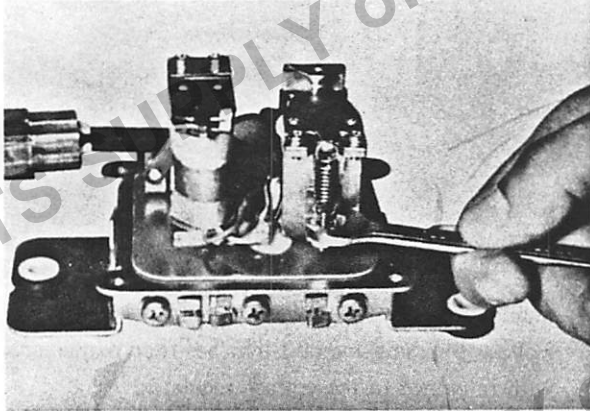


Fig. 21-30 Adjusting voltage regulator

G 3214

STARTER

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3. OPERATION OF STARTER	22 - 3
4. DISASSEMBLING AND ASSEMBLING OF STARTER	22 - 4
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STARTER**1. SPECIFICATIONS**

Unit		Type	0350 552 0010	
			Multiple spindle inscribed type	
Nominal output		KW	5.5	
Circuit voltage		V	24	
Rating		seconds	30	
Revolving direction (as seen from the pinion side)			Right	
Gearing system			Pinion shift	
Clutch system			Roller	
Circuit system			Body earth	
Protection system			Simplified water tight	
Weight		kg	Approx. 10.5	
Pinion Specifications		Number of teeth	11	
		Module	3	
		Pressure angle	degrees	14.5
		Amount of addendum modification	mm	0.82
		Hardness	HrC	58 ~ 63
	Non-loaded	Terminal voltage	V	24
		Current	A	Less than 100
		Number of revolution	rpm	More than 4,000
	Loaded	Terminal voltage	V	17
		Current	A	500
		Torque	kg-m	More than 3.8
		Number of revolution	rpm	More than 1,200
	Constrained	Terminal voltage	V	9
		Current	A	Less than 1,200
		Torque	kg-m	More than 7.8
Remarks	Applicable type			

2. CONSTRUCTION

Shown below is a cross section of the reduction starter. Its main components with their respective functions are as described below.

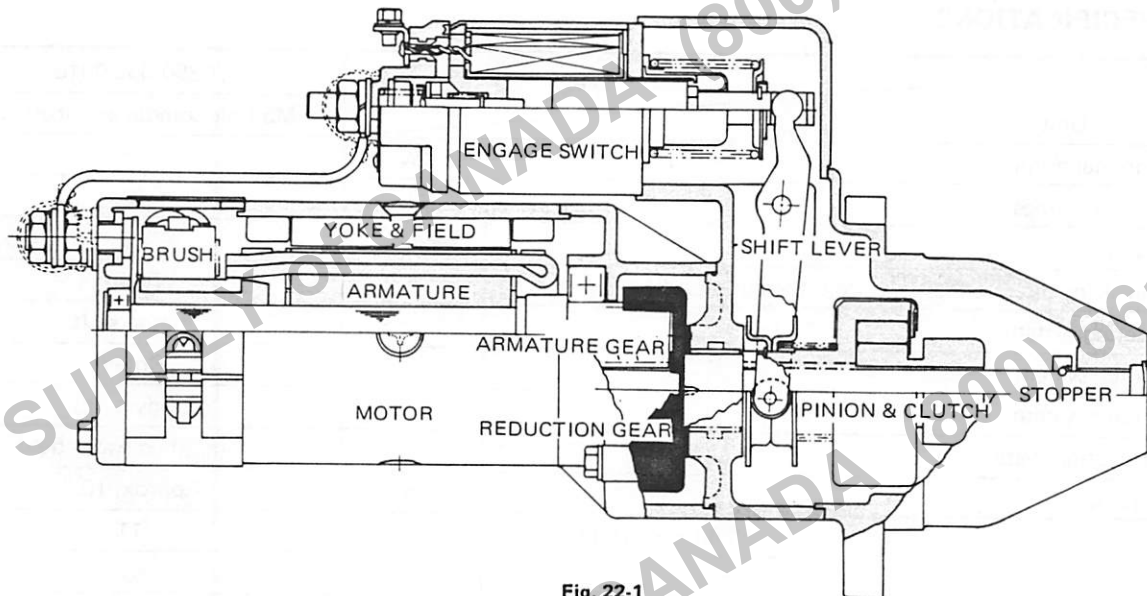


Fig. 22-1

(1) Motor

A section where power is generated, composed of the armature, the field, the brush, etc.

- 1) The armature is a part revolving with such a high speed that it employs ball bearings. To give heat resistance, the commutator and the coil are brazed.
- 2) The field coil is also an important part where power is generated by working together with the armature. It permits such a large current to pass that it is connected in series to the armature using pillar copper wires with a large current capacity. Some motors have two kinds of coils—one, connected in series to the armature as the main coil, is for power generation and the other, connected in parallel to the armature as the auxiliary (shunt) coil, is for braking the motor electrically to keep its revolution from going into an excessive speed.
- 3) The brush, made of metal graphite, is to let current flow to the armature.

(2) Reduction Gears

A section where motor revolution is reduced (at the same time, motor torque is increased) by means of gear ratio.

- 1) Multiple spindle type: Composed of the gear mounted on the motor and the gear mounted on

the output shaft, they transmit motor revolution to the output shaft by either inscribing or circumscribing the two spur gears.

(3) Power Transmission Pinion & Clutch

A section composed of the pinion gear to transmit motor power to the engine and the clutch to keep engine revolution from being transmitted to the motor after the engine has been started. While the pinion gear is to work with the ring gear of the engine, the clutch is a roller type utilizing the contact resistance of the roller, which prevents slides by full clutching during engine running and permits itself to slide during reverse running of the engine, thus to keep the armature from overrunning.

(4) Engage Switch (Auxiliary Operation)

A device composed of two coils, contacts and cores, which operates to gear the pinion into the ring gear at the same time with making and breaking of power to the motor. One is called a magnetic coil (current coil = P) which, connected in series to the armature, attracts the core upon being conducted and the other (voltage coil = h), connected in parallel to the motor, holds attraction to keep letting current flow to the motor after the core has been attracted, by holding the pinion to stay at the ring gear and the contacts to be in touch with each other.

3. OPERATION OF STARTER

The following drawings show the electrical circuits of the reduction starter and the relations between the pinion and the ring gear. Although block relays and safety relays (those for preventing re-gearing during inertia revolution) are employed in the circuits actually applied, explanations here will be given on basic circuits without any such relays (with the starter only).

Operation of Starter of 0350 and 0351 Series

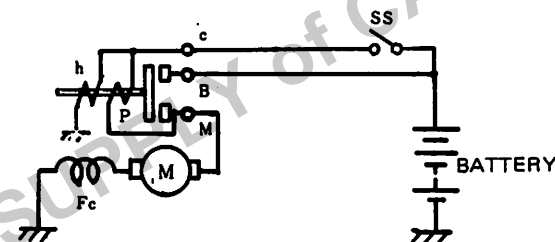


Fig. 22-2

- (1) With the starter switch (SS) closed, current from the battery flows in the directions shown with arrows in the following current diagrams:

The engage coil (P, h), with its electromagnetic attraction overcoming the return spring, attracts the core to move in the direction of the contact. At the same, it pushes the pinion into the ring gear via the lever, causing them to be geared with each other.

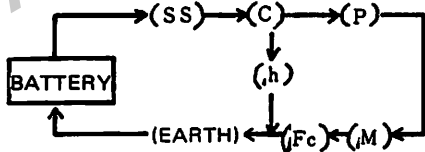


Fig. 22-3 (a)

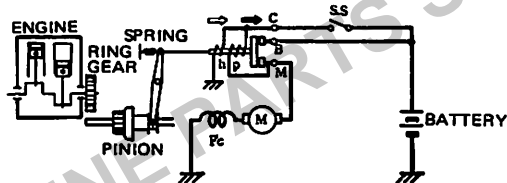


Fig. 22-3 (b)

- (2) Upon the pinion having been geared completely into the ring gear, the engage contacts (K) get in touch with each other, causing current from the battery to flow directly to the motor through (K) as shown with arrows below:

With this current, the motor rotates to the full and its rotation, transmitted from the output shaft and through the pinion, drives the engine. At this time, coil (P) of the engage coil is shorted at contact (K) and electromagnetic force goes out. However, the current in coil (h) which is parallel connection continues to flow, keeping the core attracted, the contacts in touch with each other and the pinion and the ring gear working together.

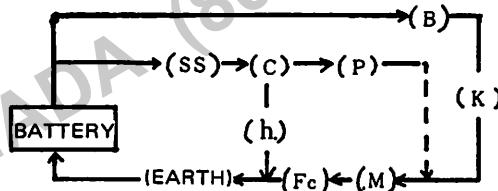


Fig. 22-4 (a)

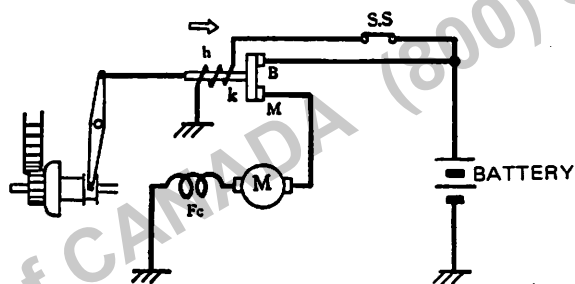


Fig. 22-4 (b)

22-4 STARTER

- (3) Starting operation completes itself when the starter engine quickly opens upon starting of the engine which has received revolution from the starter. At this moment of the switch opening, current flows in the direction of (I) because contacts (K) are in touch with each other. As the electromagnetic forces generated by coils (P) and (h) are in the opposite directions, respectively, they are counteracted, causing the attraction of the core to be lost. The core is drawn back by the force of the spring and, at the same time, the pinion leaves the ring gear and the contacts get out of touch from each other.

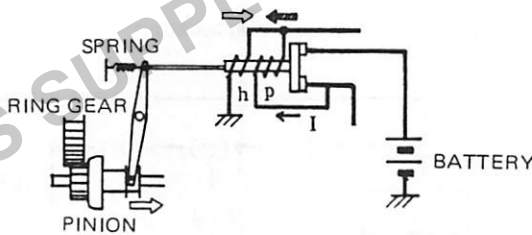


Fig. 22-5

4. DISASSEMBLING AND ASSEMBLING OF STARTER

As a general practice, the starter should be disassembled from its outside and assembled in reverse order. In assembling it, clamping of bolts, nuts, etc., should always be done in the order of diagonal lines. In describing the disassembling practices below, it is to be understood that assembling can be done in reverse except in some special cases.

Note:

(Ass.) in the following paragraphs applies to assembling.

(1) Amounting and Dismounting of Engage Switch

- 1) Remove the nuts for M Terminal of the engage switch and M Terminal of the motor.

- 2) Remove connect bar.

(Ass.) Clamping torque for M

Terminal: 200 ~ 240 kg-cm
(14 ~ 17 lb.ft.)

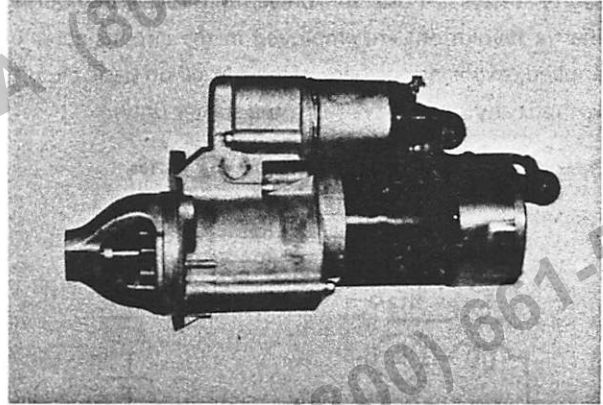


Fig. 22-6

22-117

- 3) Remove Engage Set Bolt

(Ass.) Clamping torque for

Engage Set Bolt: 60 ~ 90 kg-cm
(4 ~ 7 lb.ft.)

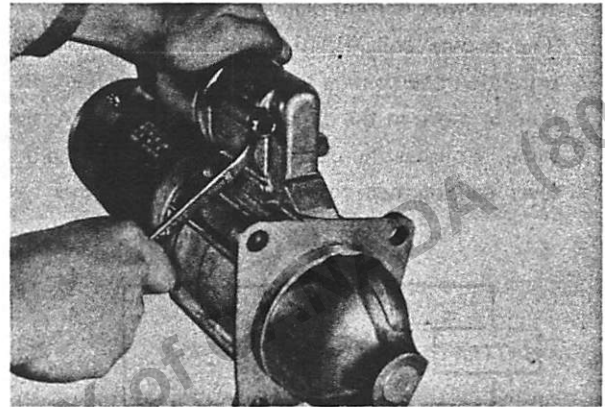


Fig. 22-7

22-063

- 4) Pull out the engage switch in the direction arrow in Fig. 22-8 (A).

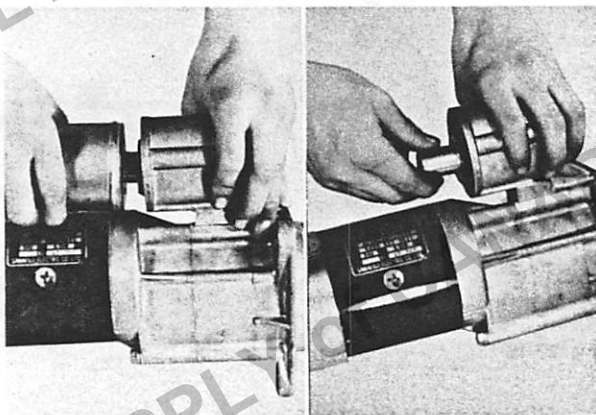


Fig. 22-8 22-064 22-065

- 5) Move the end of Moving Core from (1) to (2) in the order of arrows in Fig. 22-8 (B) and separate. (Ass.) Apply grease (Albania No.2) over the part marked.

(2) Mounting and Dismounting of Pinion Clutch

- 1) Remove the through bolt for setting the pinion case.
(Ass.) Clamping torque for the through bolt:
140 ~ 160 kg-cm (10 ~ 12 lb.ft.)

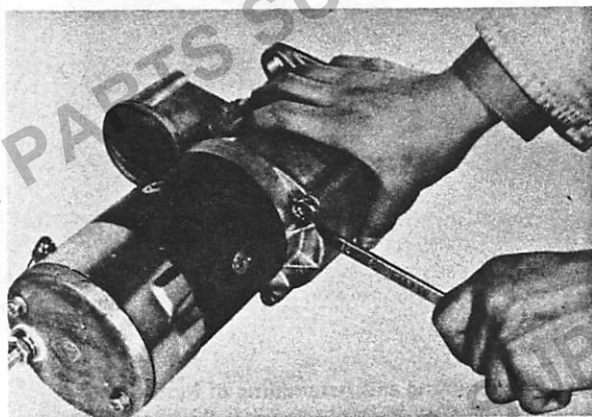


Fig. 22-9 22-066

- 2) Remove Pinion Case
(Ass.) Clamping Pinion Case Set Bolt (the through bolt for mounting pinion Case from End Bracket) first will ease assembling work.

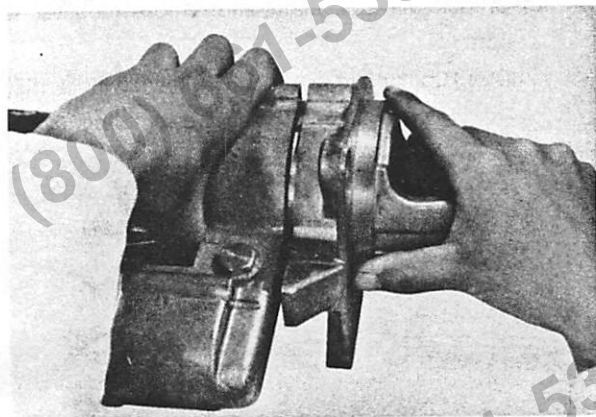


Fig. 22-10 22-067

- 3) Remove Pinion Stopper
Push the pin into the hole (or slot) or Stopper (Fig. 22-11 (A)) and take out the clip (Fig. 22-11 (B)).

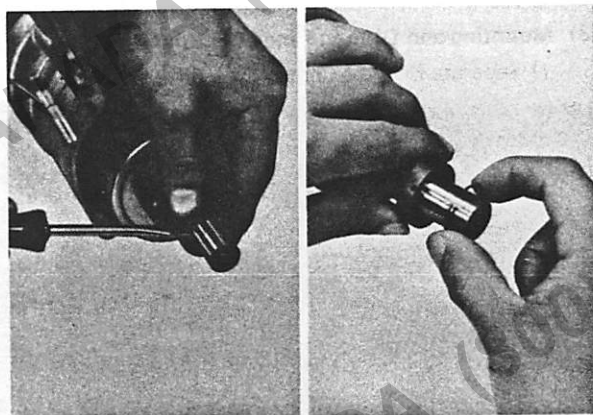


Fig. 22-11 22-068 22-069

- 4) Take the two hooks out of the shaft. Take out the clip, push Stopper toward the pinion side and then take out the hooks.
(Ass.) See that the clip is secure after Stopper has been mounted.
- 5) Push the lever upward and remove Pinion Clutch.
(Ass.) Apply grease (Albania No. 2) over the roller of the lever. Thinly apply oil (#30) over the output shaft.



Fig. 22-12 22-070

22-6 STARTER

- 6) Unlock the lock plate, and remove the lever set bolt.

(Ass.) Lock plate Use the new lock plate for assembling.

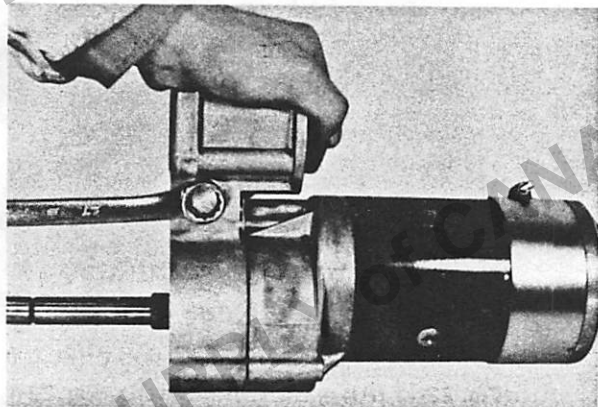


Fig. 22-13

22-071

(3) Mounting and Dismounting of Output Shaft

- 1) Separate Bracket Center

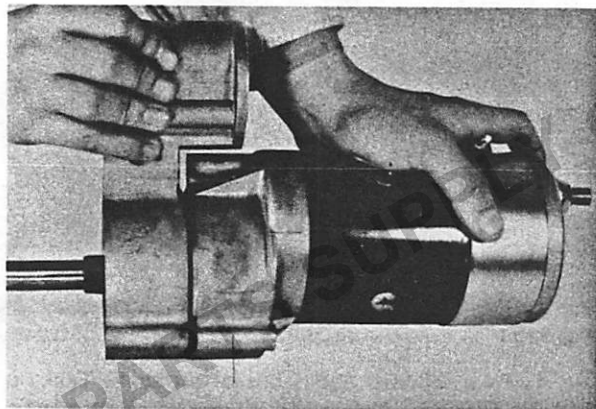


Fig. 22-14

22-072

- 2) Remove Adjuster Shim from the output shaft (Fig. 22-15 (A)).

Note:

Take care not to lose Adjuster Shim.

(Ass.) Put grease (Coronex EP2) in the grease pot of Bracket Center

(Ass.) Measure thrust gap (Fig. 22-15 (B)). Move it in the order of \leftrightarrow to check the gap. The thrust gap should be 0.1 ~ 0.3 mm (0.0039 ~ 0.0118 in).

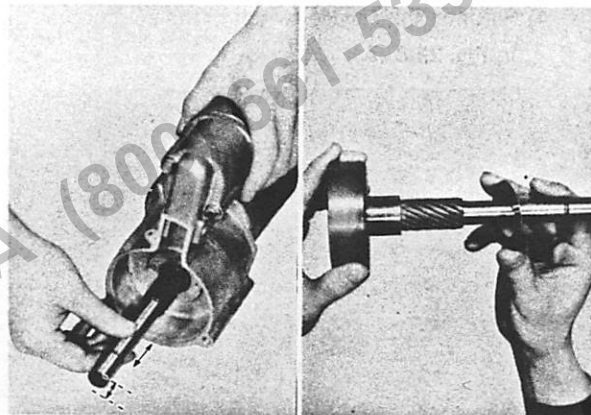


Fig. 22-15

22-118

22-119

- 3) Remove Output Shaft

(Ass.) Apply grease (Lowtemp) over each gear to about 2 mm (0.00787 in) thick and push Output Shaft Gear into Gear Guide.

- 4) Remove Shim Plate

(Ass.) Be sure to put two shim plates. Put them in like pasting on Gear Guide.

(Ass.) Put grease (Lowtemp) into the grease pot (round hole)



Fig. 22-16

22-075

(4) Disassembling and Assembling of Motor

- 1) Remove the dust cover (cover band).

(Ass.) Be careful of the mounting position.

- 2) Remove the four brush set screws.

- 3) Lift the brush spring and remove the brush.

(Ass.) To clamp the brush with set screws after mounting it, cross the leads in mounting the brush as shown in the figure.



Fig. 22-17

22-078

- 4) Remove the through bolt
(Ass.) Clamping torque:
140 ~ 160 kg-cm (10 ~ 12 lb.ft.)

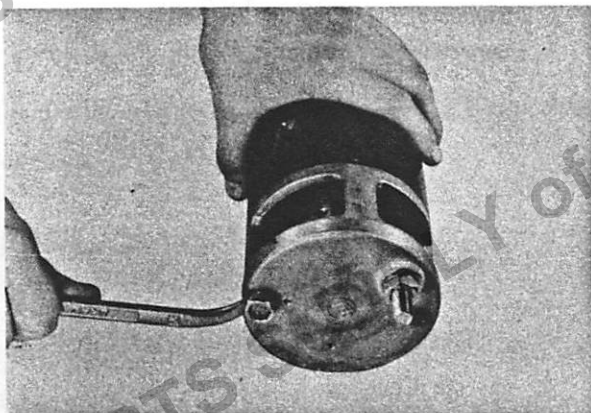


Fig. 22-18

22-079

- 5) Separate the gear case and armature.
(Ass.) Align the knocking position in assembling them.

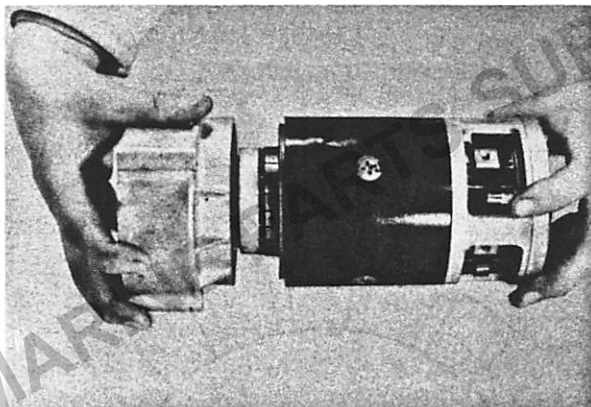


Fig. 22-19

22-080

- 6) Remove the armature from the gear housing.

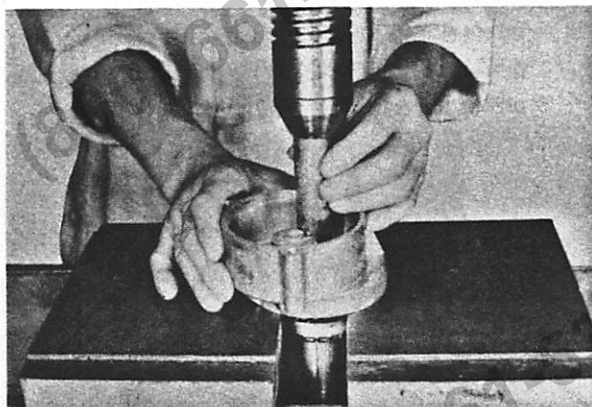


Fig. 22-20

22-081

- 7) Separate the bracket end from the yoke.
(Ass.) Align the knocking position in assembling together.

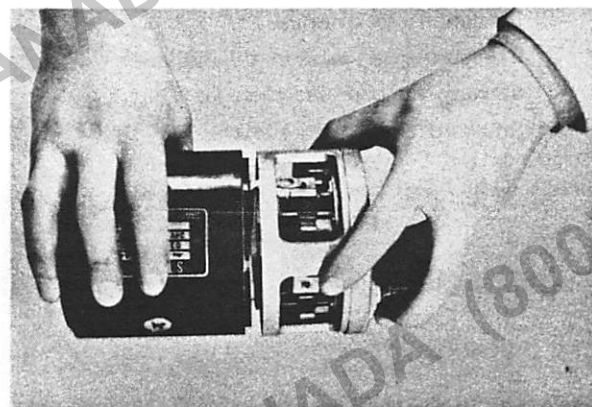


Fig. 22-21

22-082

5. QUALITY CHECKING OF COMPONENTS (REFER TO MAINTENANCE DATA)

With small differences in checking or measuring positions depending on equipment type, practically the same methods as described below apply. For specific values, refer to the Maintenance Data.

22-8 STARTER

(1) Armature

- 1) Refer Shooting Test of Coils Test quality of coils by operating the armature tester with an iron piece put on it. (No vibration of the iron piece proves the coil to be good.)

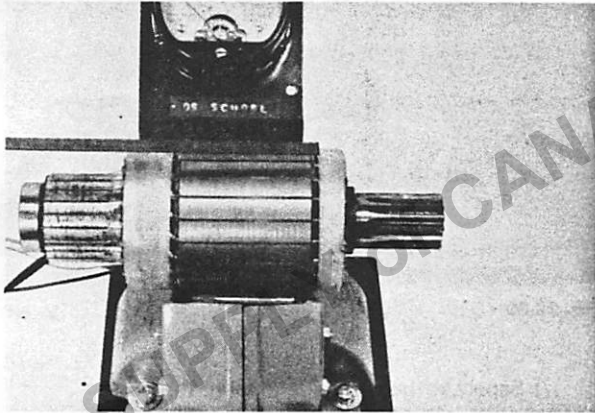


Fig. 22-22

22-083

2) Insulation Test of Coils

Using a megger, measure the insulation resistance between the core and the coil.

Standard: More than 1 M Ω

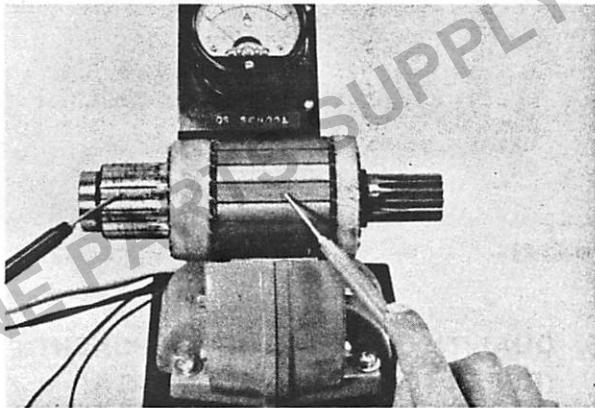


Fig. 22-23

22-084

3) Measurement of Deflection of Commutator

Using a dial gauge, measure deflection of the commutator.

Standard: Less than 0.02 mm (0.0008 in)

Service limit: 0.1 mm (0.0039 in)

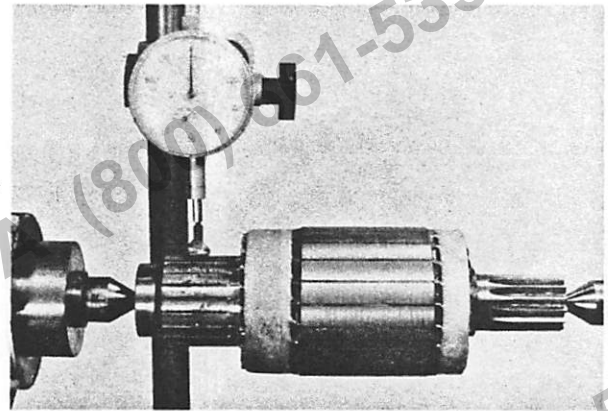


Fig. 22-24

22-085

4) External Dimensions of Commutator

Using a slide calipers, measure the dimensions of the rough part of the segment after cutting it.

Standard: 40 mm (1.575 in)

Service limit: 38 mm (1.496 in)



Fig. 22-25

22-086

5) Measure the depth of under cut.

Standard: 0.5 ~ 0.8 mm

(0.0197 ~ 0.0315 in)

Service limit: 0.2 mm (0.0079 in)

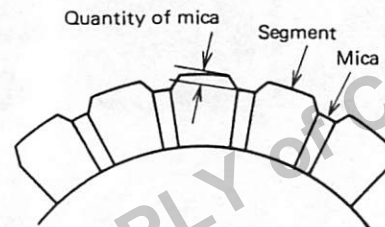


Fig. 22-26

(2) Field coil

1) Conductance Test

Use a tester to check:

	Terminal position where to apply the tester
0350 and 0351 Series Starters	Between the terminal and body of the direct-wound coil



Fig. 22-27

22-087

2) Insulation Test

Use a tester to check

Standard: More than 1 MΩ

	Terminal position where to apply the tester
0350 and 0351 Series Starters	Between the coil terminals and body (Measurement to be made with the terminal and body floated after removing earth screws)



Fig. 22-28

22-090

(3) Output Shaft

- 1) Using a dial gauge, measure curve at the center of the output shaft. (Good if the curve is within Repair limit: 0.05 mm (0.0020 in))

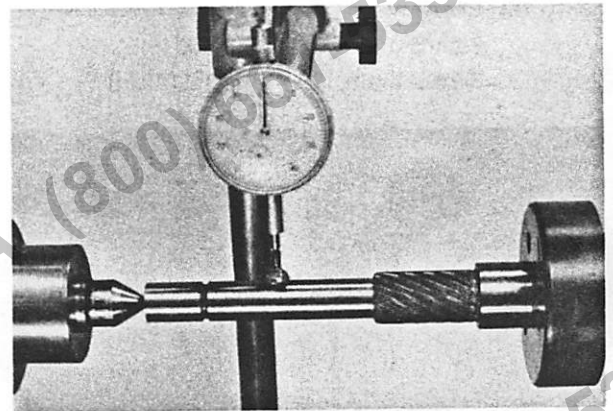


Fig. 22-29

22-091

(4) Abrasion on Gear Surface

Inspect the spline and internal gear for abrasion and damage.

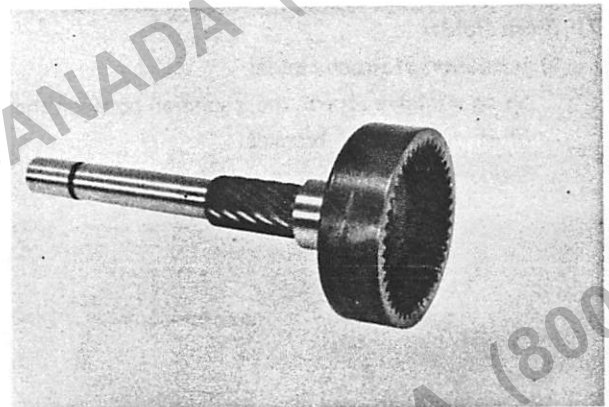


Fig. 22-30

22-092

(5) Metal

- 1) Measure the inside diameter of the metals.

(a) Front metal

Using a dial gauge

Standard: 17 mm (0.669 in)

Service limit: 17.3 mm (0.681 in)



Fig. 22-31

22-093

22-10 STARTER

(b) Center metal

Standard: 28 mm (1.102 in)

Service limit: 28.3 mm (1.1142 in)



Fig. 22-32

22-094



Fig. 22-34

22-096

(7) Brush Holder

1) Insulation of Brush Holder

Using a megger, check the insulation between the brush holder and bracket.

Standard: More than 1 M Ω

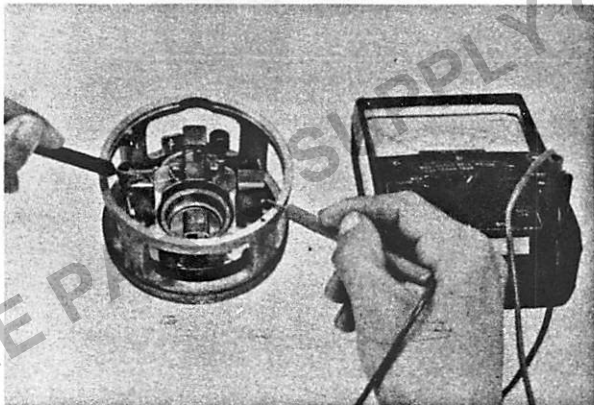


Fig. 22-33

22-095

2) Tension of Brush Spring

Using a spring gauge.

Standard: 1.4 kg (3 lb)

Service limit: 1.0 kg (2 lb)

3) Length of Brush

Standard: 20 mm (0.787 in)

Service limit: 12 mm (0.472 in)

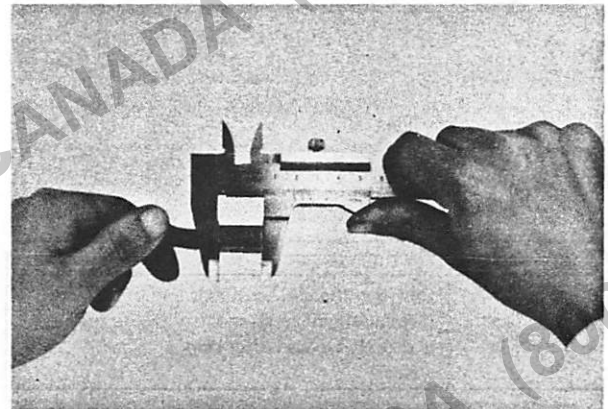


Fig. 22-35

22-097

(8) Engage Switch

1) Conductance Test of Coil

(a) Test conductance between C Terminal and the body.



Fig. 22-36

22-098

- (b) Test conductance between C Terminal and the coil terminal.

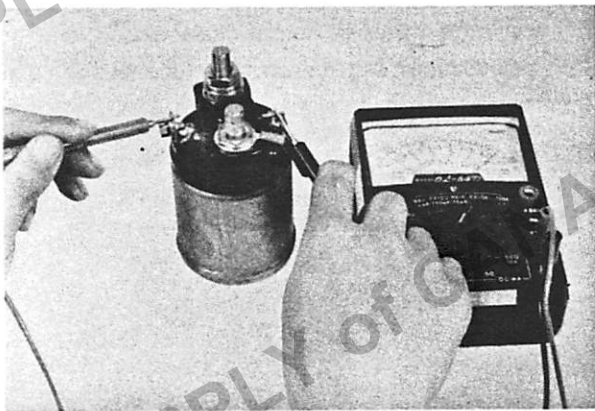


Fig. 22-37

22-099

(9) Pinion & Clutch

1) Clutch Effect

Turn the gear to left and right with the shaft fixed. Good if it turns lightly in the direction of arrow (for preventing overrunning) only. (Standard torque for slides in the direction of overrunning protection: 6 ~ 8 kg.cm.)



Fig. 22-38

22-101

6. CHECKING AFTER ASSEMBLING

Measurement of Timing Gap

Have the engage switch conducted and measure the gap between the pinion and pinion case and that between the pinion and the pinion stopper when the pinion is slid by the attracting force of the engage switch.

(1) How to Make Connections for Measurement

For 0350 and 0351 Series Starter:

Set the switch (S1) between the C Terminal and Battery of the engage switch and the switch (S2) between the M terminal of the engage switch and the M Terminal of the motor as shown in Fig. 22-39, and then complete connections.

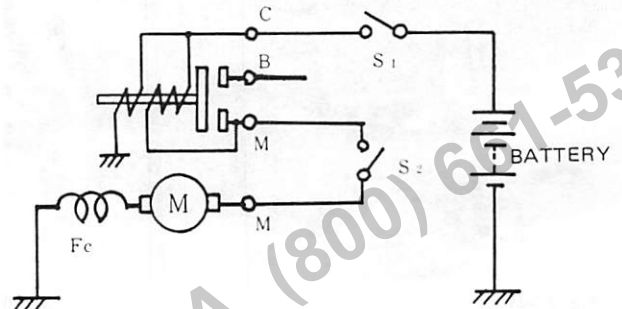


Fig. 22-39

(2) How to Make Measurement

- 1) Turn on switch (S1) and then close switch (S2).
- 2) Open switch (S2) after the pinion has slid.
- 3) Lightly push back the pinion with the switch positions left as they are.
- 4) Measure the gap between the pinion and the pinion stopper. (Refer to Fig. 22-40.)
Standard: 0.5 ~ 1.5 mm
(0.0197 ~ 0.0591 in)

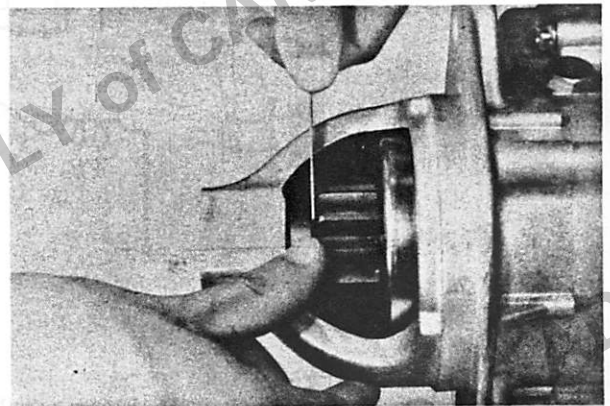


Fig. 22-40

22-113

Adjustment of Timing Gap

1) Adjustment Using Shim Washer In case the gap is large (or smaller), than specified, put (or pull out) the adjusting plate into (or from) the engage mounting position for making adjustment.

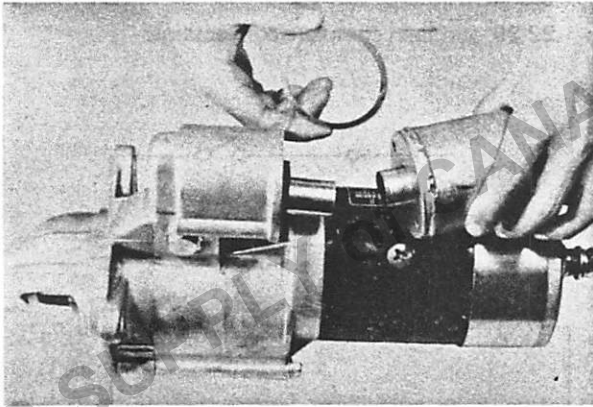


Fig. 22-41

22-114

Output Characteristic Test of Starter

After starter has been assembled, check each operation and output characteristic using the bench tester. For applicable values of output characteristic, refer to the specifications and the output characteristic curve (reference columns).

(1) Gearing Test

Mount the starter on the tester (Starter Bench Tester) after making connections as shown in Fig. 22-42

and fix (but not fully) the ring gear before proceeding with the test.

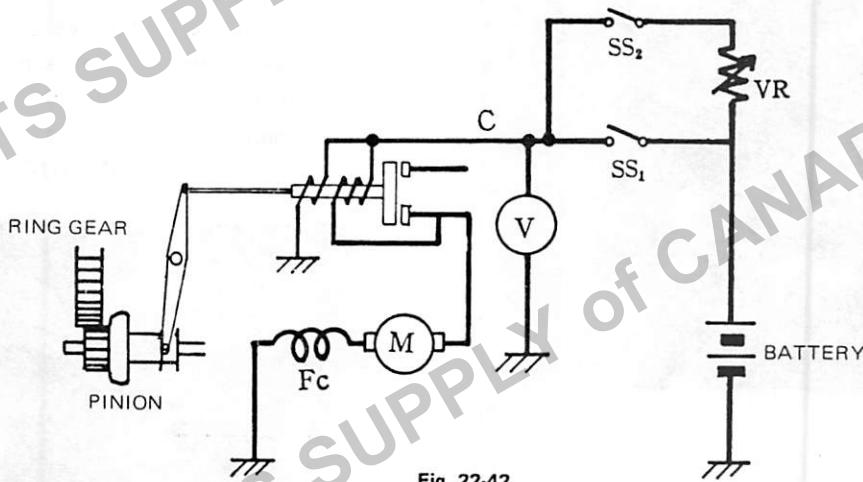


Fig. 22-42

1) Gearing Test

Make and break starter switch (SS1) more than 20 times for gearing and de-gearing tests.

2) Minimum Gearing Voltage Test

Gradually increase voltage applied to the C Terminal using the variable resistor (VR) with (SS1) open and (SS2) closed, and measure the minimum voltage enabling the pinion to gear into the ring gear.

Condition	Terminal voltage not to be lower than 24 ~ 20V
Judgement	Good if more than 90% of over 20 times of gearing test prove satisfactory

Judgement	Gearing voltage should be lower than 18V
-----------	--

(2) Output Characteristic Test

The purpose of this test is to check the driving force (torque and number of revolution) of the starter. Set the starter on the bench tester, determine current of the starter (current: I (A) varies with the load applied to the ring gear of the bench tester: brake), and measure the torque and number of

revolution at that time.

As this test may cause drops in battery voltage or in the wiring due to load current, it could be performed in the state of small voltage drops (the battery to be fully charged and the wiring to be a capacity large enough).

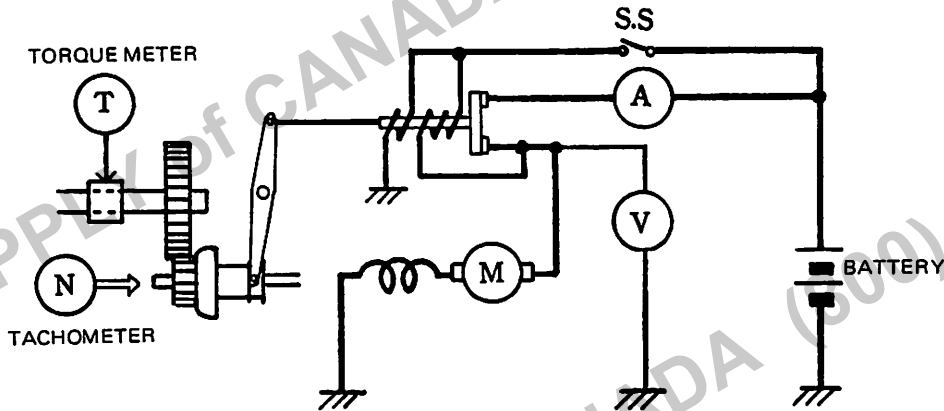


Fig. 22-43

1) Load Test

Make wirings as shown in Fig. 22-43, set load current (Ia) to the specified value, run the starter and then measure the voltage, number of revolution and torque of the starter.

3) No-load Test

Have the pinion of the starter in the state of not gearing into the ring gear, let current flow and then measure the voltage, current and number of revolution at that time.

Condition	<ul style="list-style-type: none"> For values of load current I (A), refer to the specifications or the output characteristic curve
Judgement	For torque, number of revolution, refer to the specifications of the output characteristic curve

Condition	<ul style="list-style-type: none"> Terminal voltage: 22 ~ 24V (10 ~ 12V for the 12 Series) Measure when 5 ~ 15 seconds have elapsed (when the number of revolution has settled down. Take care not to continue this test for too long.
Judgement	<ul style="list-style-type: none"> For current values, refer to the specifications or the output characteristic curve. For number of revolution, refer to the specifications and the output characteristic curve.

2) Lock Test

After completion of load characteristic test, further increase load current (by fixing the ring gear) and then measure the load current (Ia), torque (T) and voltage (V) when starter revolution has become 0.

Condition	<ul style="list-style-type: none"> Number of revolution to be 0. For terminal voltage (starter), refer to the specifications or the output characteristic curve. For values of load current I (A), refer to the specifications or the output characteristic curve.
Judgement	For torque, refer to the maintenance data or the output characteristic curve.

22-14 STARTER

(3) Other Measurements

1) Measurement of Voltage Drops of Contact

This is to measure quality of touch at contacts, judgement being made according to volume of voltage drop. Apply the voltmeter as shown in Fig. 22-44, determine motor current and then measure the voltage drops at B-M of the magnetic switch.

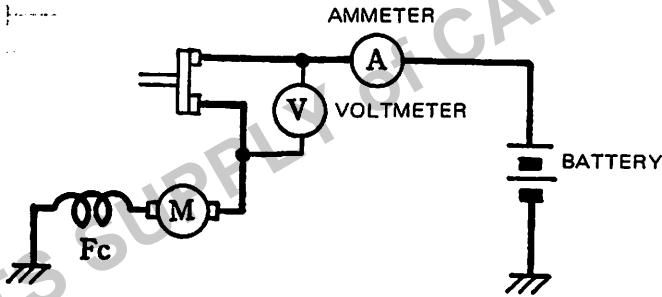


Fig. 22-44

Condition	Set passing current at contacts (B,K,M) to 500A.
Judgement	Good if voltage drop (voltage resulted) is lower than 0.2V.

2) Insulation Test

Make measurements referring to the circuit diagrams of each starter. The following practices may apply to most starters:

Condition	Use a megger of 500V
Judgement	Insulation to be more than $1M\Omega$. Practically good if it is more than $0.5M\Omega$.

7. LIST OF MAINTENANCE DATA

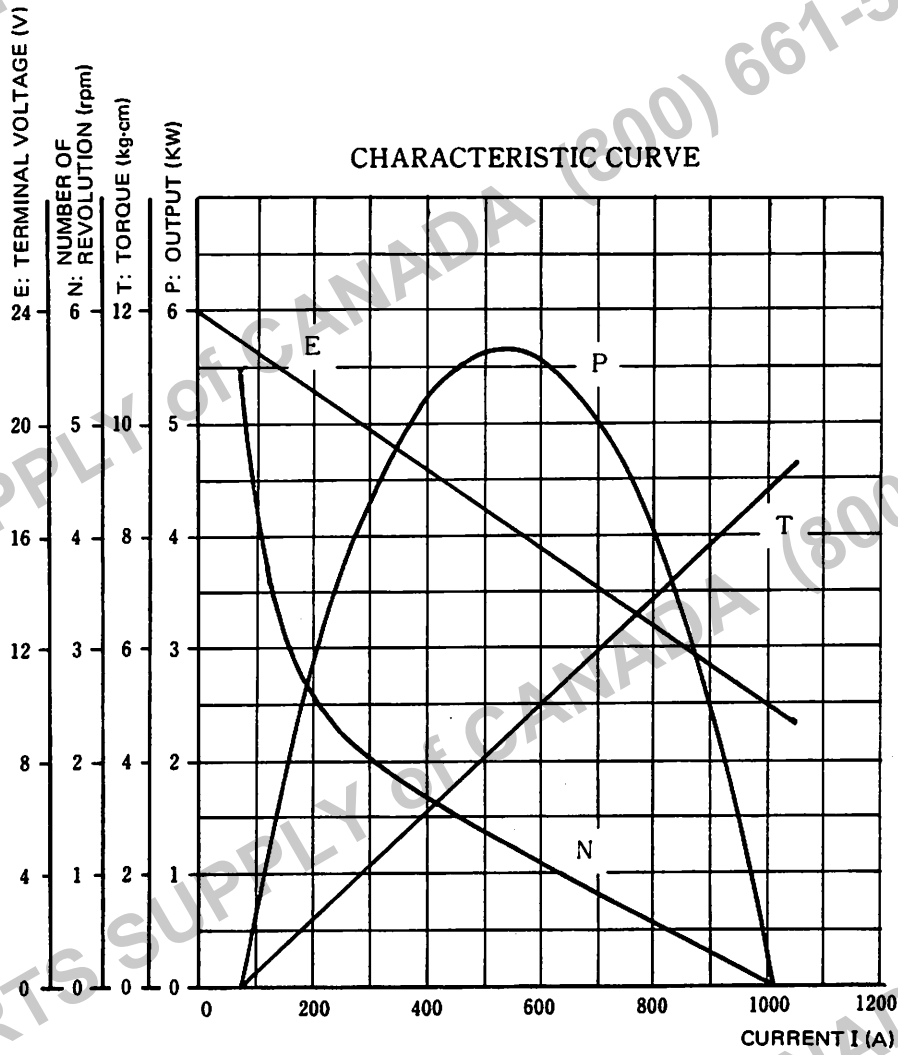
The 0350 and 0351 Series

Unit: mm (in)

Type		0350 552 0010				
Bracket	Metal Bore	Item	Unit	Standard	Usable Limit	
		Front	mm	17	17.2	
		Center	mm	28	28.2	
Bracket	Bearing Bore	Commutator	mm	32		
		Bearing (Name)			6002VV	
		Gear	mm	52		
		Bearing (Name)				6205VV
Commutator		External Diameter	mm	40	38	
		Deflection	mm	0.05	Less than 0.1	
		Undercut	mm	0.5 ~ 0.8	Less than 0.2	
		Brush Height	mm	20	14	
		Brush Spring Pressure	g	1,400	1,000	
		Shunt Field Resistance (Standard)				
Engage switch		P Coil Resistance (Approx.)	Ω		0.1 ~ 0.3	
		h Coil Resistance (Approx.)	Ω		1.5 ~ 2.5	
		Contact Spring Distortion (standard)	mm		1 ~ 2	
		Slide of Clutch Effect	kg-cm	6 ~ 8	Less than 9, more than 5	
Output Shaft		Shaft Deflection	mm	0.05	Less than 0.1	
		Thrust Gap	mm		0.5 ~ 1.5	
		Insulation Resistance	M Ω	More than 1	Less than 0.5	
Clamping Torque	Motor	M Terminal	kg-cm		165 ~ 225	
		Through Bolt	kg-cm		140 ~ 160	
		Engage Set	kg-cm		60 ~ 90	
		Pinion Case Set	kg-cm		140 ~ 160	

22-16 STARTER

0350 552 001



Combination of 0350 552 001
0590 017 071

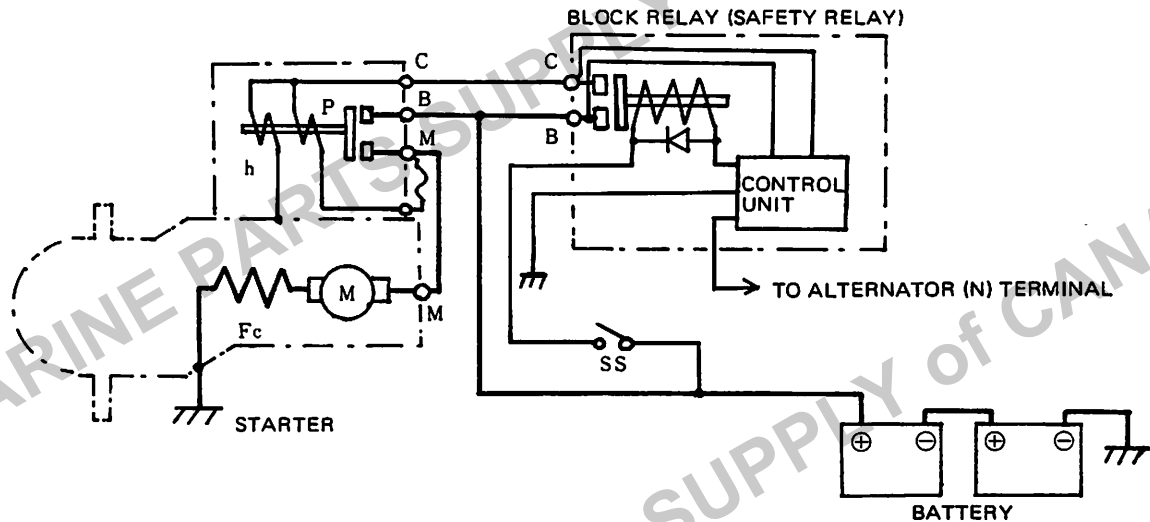


Fig. 22-45

SUPPLY of CANADA

MARINE PARTS SUPPLY of CANADA (800) 661-5353

MARINE PARTS SUPPLY of CANADA (800) 661-5353

MARINE PARTS SUPPLY of CANADA (800) 661-5353

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