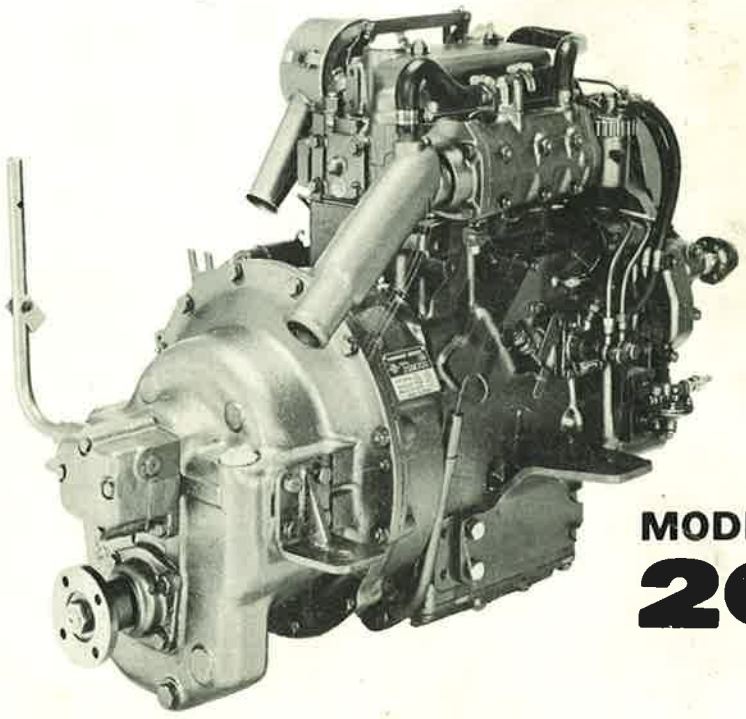
YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

W. pb. L.J.



MODEL

2QM20

OIL FILTER 12 40.85-35.1 1.1

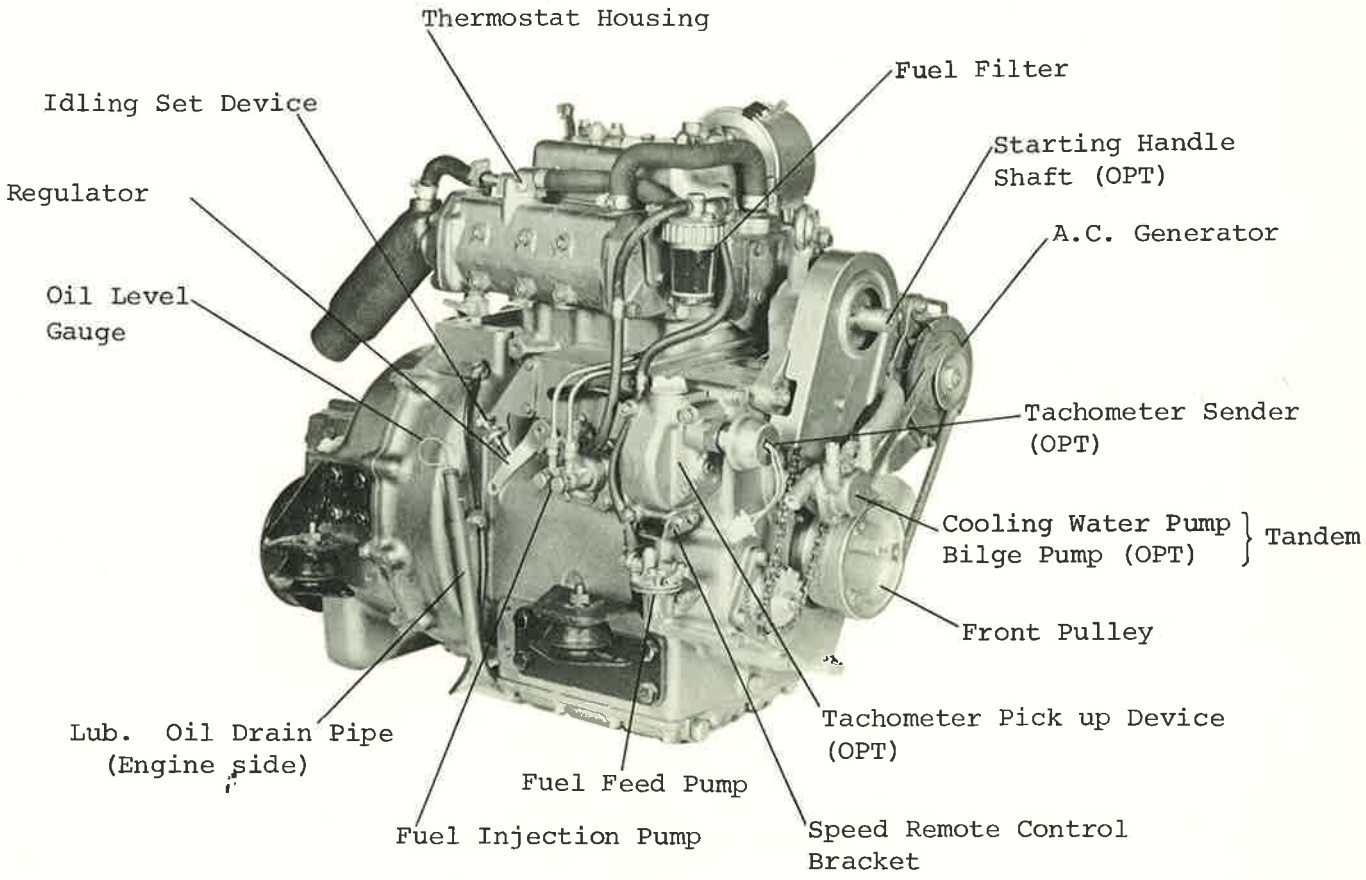
SERVICE MANUAL MODEL 2QM20

- C O N T E N T S -

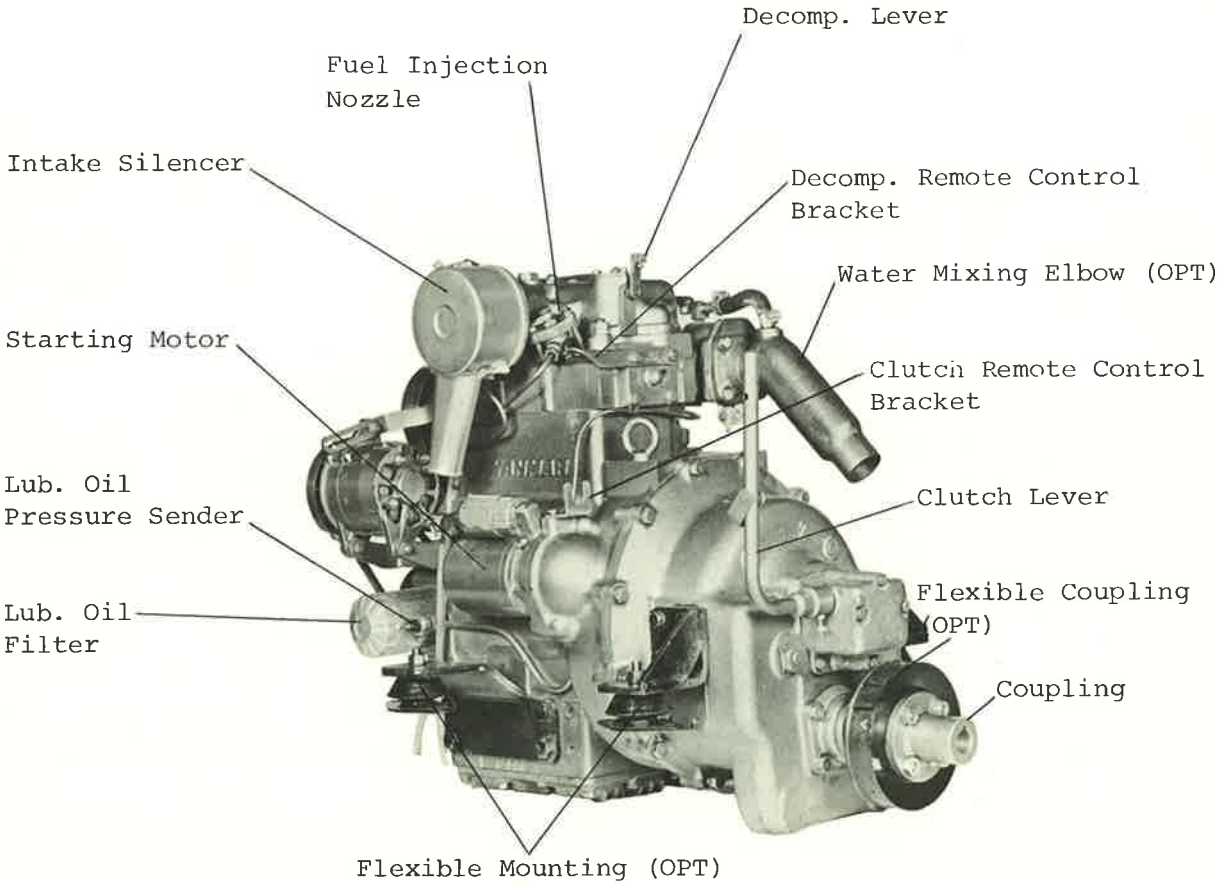
1. SUMMARY OF ENGINE

1-1 General Layout

(STARBOARD SIDE)



(PORT SIDE)


Decomp. Lever
Fuel Injection Nozzle
Intake Silencer
Decomp. Remote Control Bracket
Water Mixing Elbow (OPT)
Starting Motor
Clutch Remote Control Bracket
Lub. Oil Pressure Sender
Clutch Lever
Flexible Coupling (OPT)
Lub. Oil Filter
Coupling
Flexible Mounting (OPT)

1-2 Engine Structure Outline

Structural Group	Part	Description
Cylinder Body	Cylinder Block	Monoblock casting, water cooled with anti-corrosion zinc
	Cylinder Liner	Wet liner
	Bearing	Suspended, plane bearing
	Oil Sump	Cast aluminum wet sump
Cylinder Head	Cylinder Head	Cast iron water jacketed integral for two cylinders with valve seat
	Intake & Exhaust Valves	Mushroom type extruded, with 90 degress seat angle
	Exhaust Manifold	Cast iron water jacketed
	Valve Train	Overhead valves with push rods, tappet and forged rocker-arm
	Intake system	Manifold integral to the cylinder head, with separate intake air silencer
Power Train	Crankshaft	Stamp forged, and induction hardened for crank pin, journal and oil sealing surfaces
	Flywheel	Cast iron with steel ring gear, taper bored crankshaft hole
	Piston	Cast aluminum oval shaped trunk piston
	Piston Pin	Full floating
	Piston Rings	Three compression and one oil scraper rings

Structural Group	Part	Description
Lubrication System	Lub. Oil Pump	Forced lubrication with trochoid pump
	Lub. Oil Filter	Full flow lubrication with cartridge type paper element
Cooling System	Cooling Water Pump	Jabsco rotary type
Bilge Pump	Bilge Pump (optional)	Jabsco rotary type tandem to the cooling water pump
Fuel Injection System	Fuel Injection Pump	Yanmar Original Similar to Bosch, PFR type
	Fuel Injection Nozzle	Pintle type
	Fuel Feed Pump	Mechanical cam driven diaphragm pump
	Fuel Filter	Cartridge type paper element
Governor System	Governor	Fly-weight built into timing gear case all speed governor
Starter System	Starter	Starter motor with pinion for flywheel ring gear (HITACHI)
	Hand Starter Optional	Cranking handle with chain and multiplier sproket gear
Battery Charging System	Charger	Alternator, 25 AMPS 12 VOLTS (HITACHI)
	Voltage Regulator	Tirril system (vibrating contact type)
Reduction and	Reduction and Reverser	Constant mesh spur gear
Reverse Clutch	Clutch	Wet single disk clutch with mechanical control

Structural Group	Parts	Description
Remote Control	Governor Remote Control	* Morse : Model 33C (Push-Pull), Clamp, A31804 clev. 5 : A31800
	Clutch Remote Control	* Morse : Model 64 CB (Push-Pull), Clamp, A31855
	Decompression Remote Control optional	Wire, Yanmar Original * local supply

1-3 Specifications

Engine name			2QM20	
Type			Vertical, water-cooling 4-cycle diesel engine	
Number of cylinders			2	
Cylinder bore x stroke		mm	88 x 90	
Piston Displacement		litre.	1.094	
Compression ratio			20 : 1	
Continuous rating (DIN-A)	Output/Crankshaft rpm	HP/rpm	20/2600	
	Brake average effective pressure	kg/cm^2	6.33	
	Piston speed	m/sec.	7.80	
	Propeller shaft rpm	rpm	1182 (1130)	810 (751)
One hour rating (DIN-B)	Output/Crankshaft rpm	HP/rpm	22/2800	
	Brake average effective pressure	kg/cm^2	6.46	
	Piston speed	m/sec.	8.4	
	Propeller shaft rpm	rpm	1273 (1217)	827 (809)
15 min. rating (DIN-H)	Output/Crankshaft rpm	HP/rpm	24/3000	
	Brake average effective pressure	kg/cm^2	6.58	
	Piston speed	m/sec.	9	
	Propeller shaft rpm	rpm	1364 (1304)	935 (867)
Starting system			Electrical	
Cooling system			Forced cooling by sea water (Rubber impeller pump)	
Lubrication system			Complete closed forced lubricating	

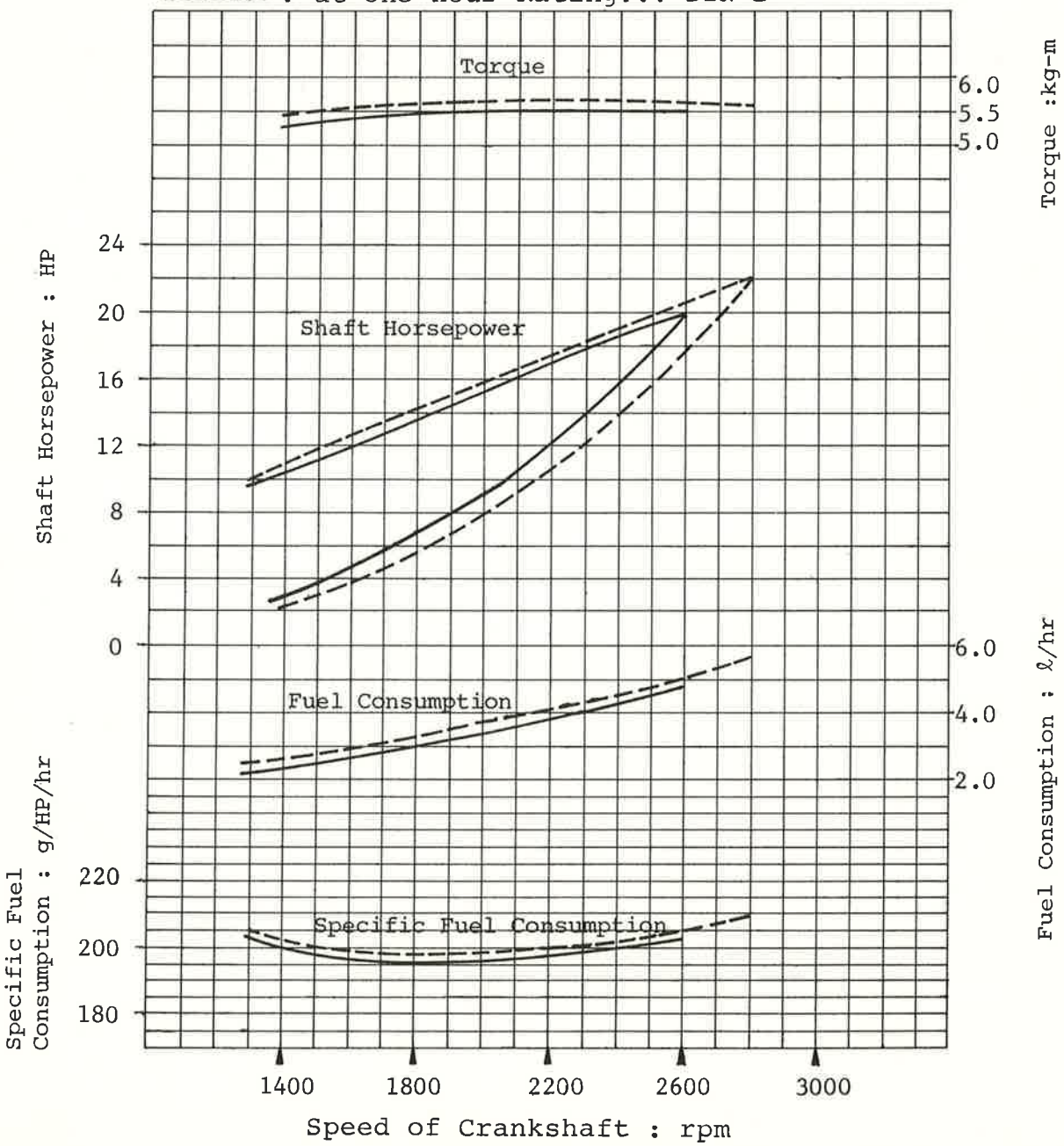
Type of combustion chamber			Pre-combustion chamber	
Power take-off			At Flywheel	
Control			On left (viewed from clutch side)	
Direction of rotation	Crankshaft		Counterclockwise (viewed from clutch side)	
	Propeller shaft		Clockwise (viewed from clutch side, during ahead movement)	
Type of reduction gear			Constant mesh spur gear	
Type of clutch			Mechanical, wet single plate	
Reduction ratio			2:20 (2.30)	3.21 (3.46)
Lube oil capacity	Crank case	litre	Max. 5.1	Min. 3.3
	Reduction gear case	litre	Max. 0.8	Min. 0.5
Engine dimensions	Total length	mm	825	
	Total width	mm	501	
	Total height	mm	675	
Total engine weight (dry)		kg	220	

1-4 Performance Curves

Model 2QM20

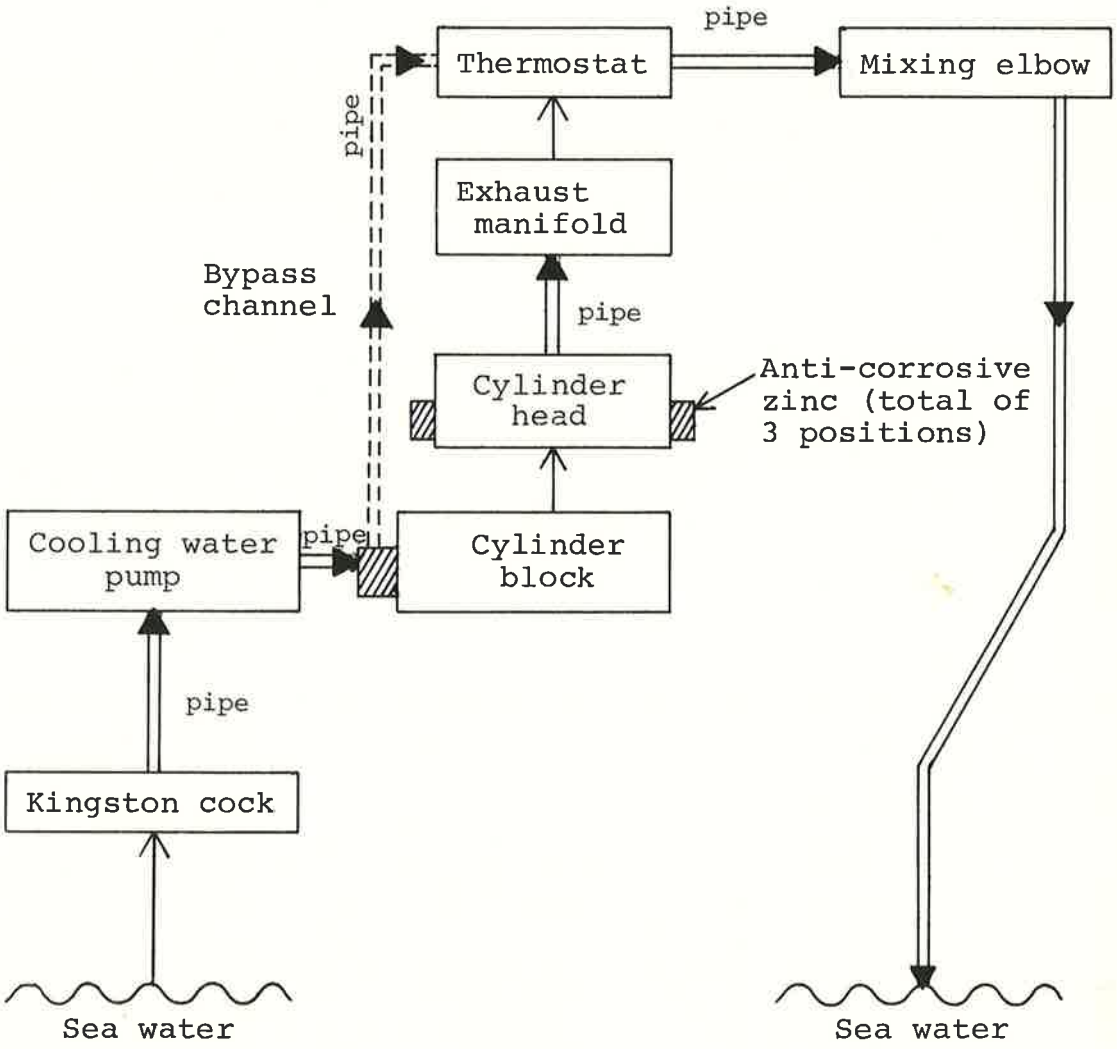
Data

No. of Cyl - Bore x Stroke ... 2-88 x 90 mm
Output : Continuous rating ... 20 HP
Speed : Crankshaft ..... 2600 rpm
——— : at Continuous Rating. DIN A
- - - - - - - : at One Hour Rating... DIN B

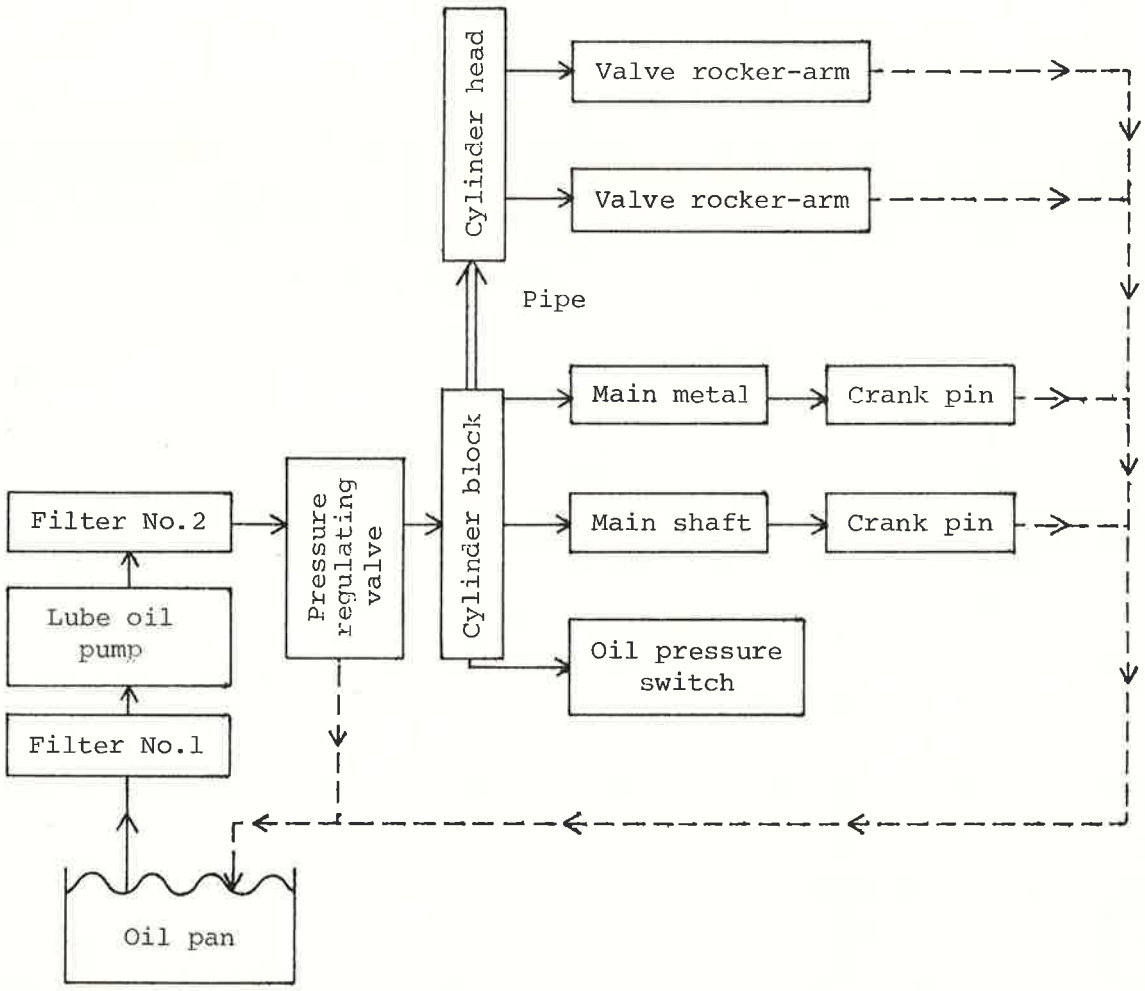


1-5 Flow Diagrams

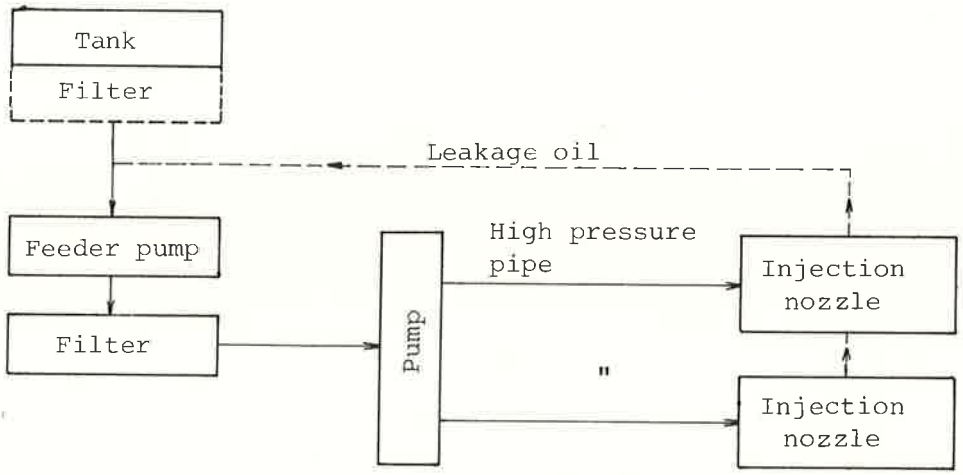
1-5-1 2QM20 Cooling Water Diagram



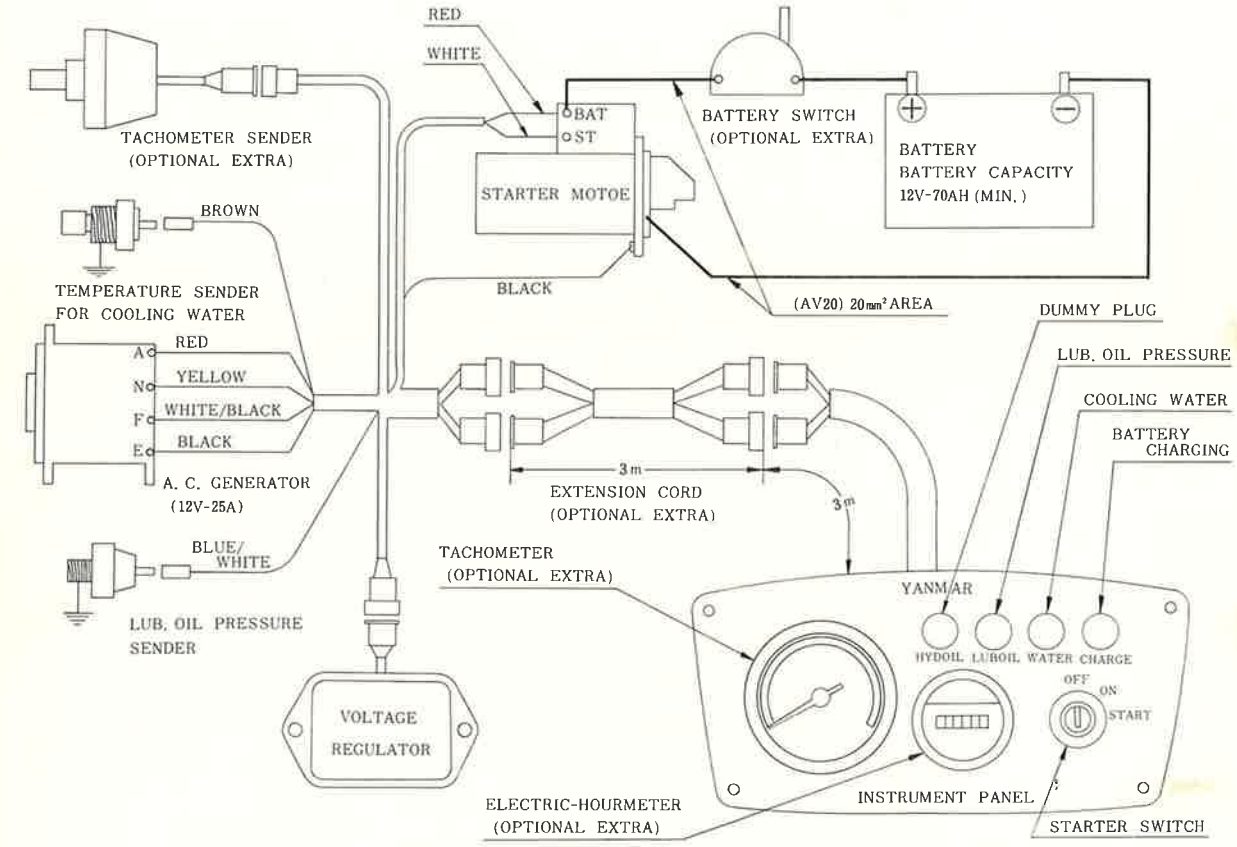
1-5-2 Lube Oil Diagram

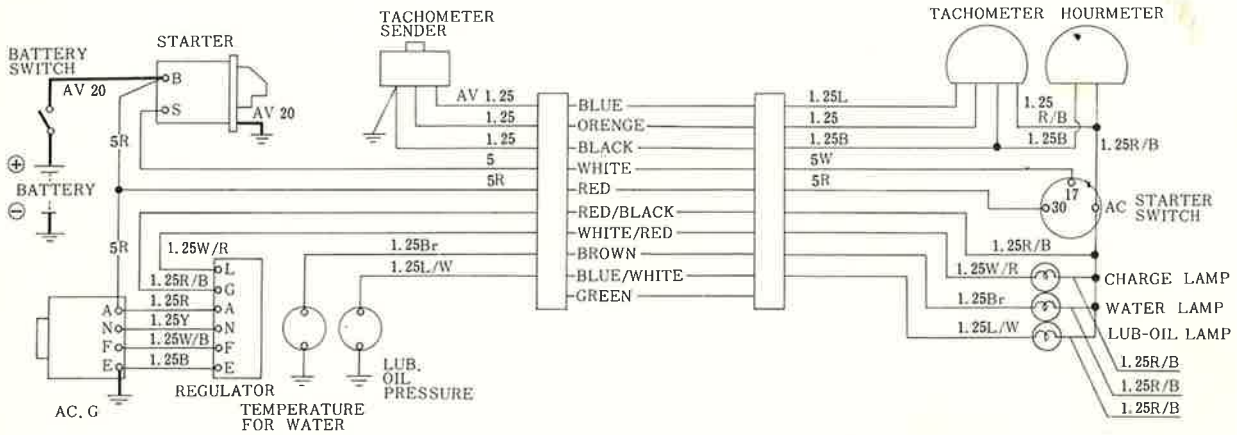


1-5-3 Fuel Diagram

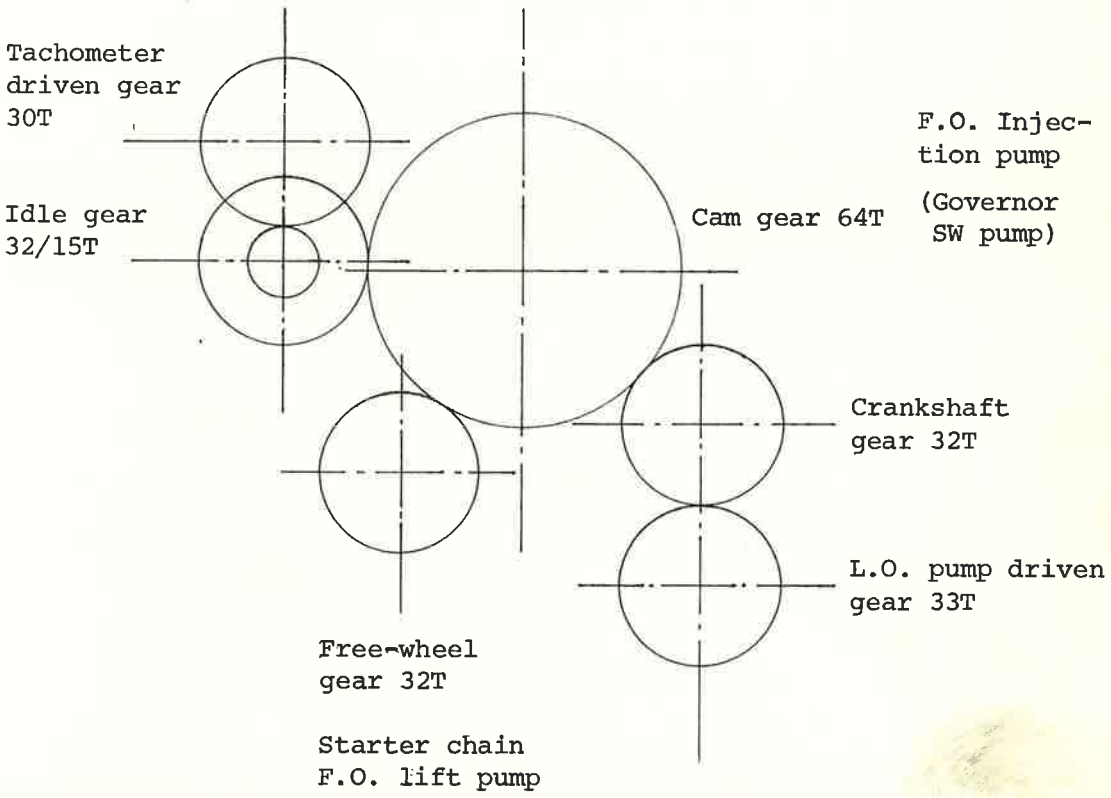


1-5-4 Electrical Wiring Diagram





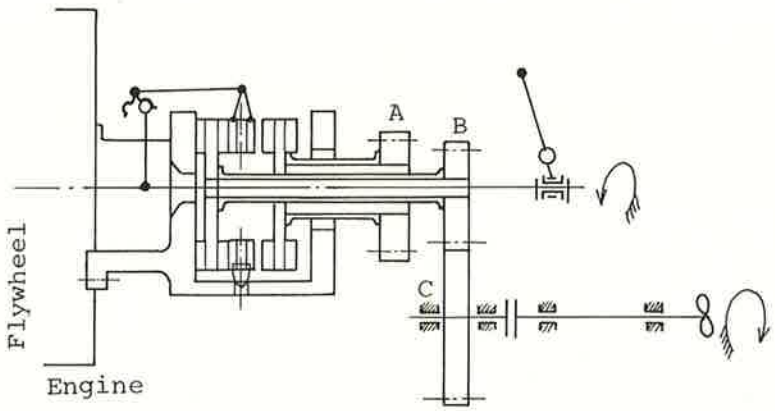
1-5-5 Gear Train



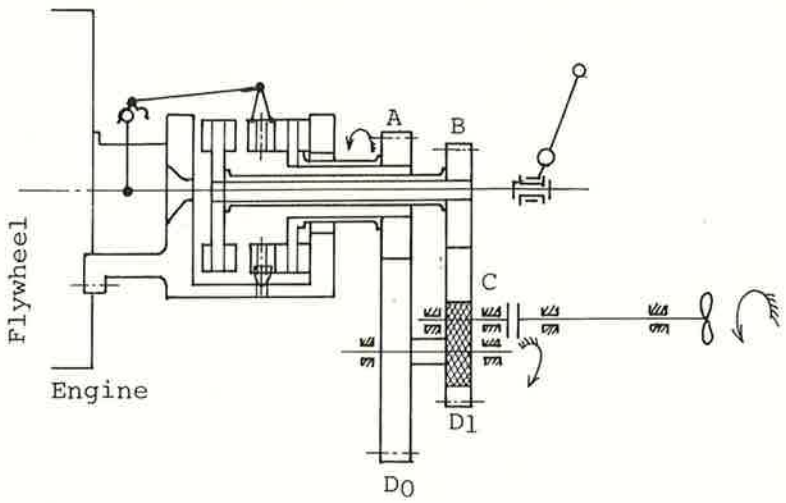
1-5-6 Marine Gear

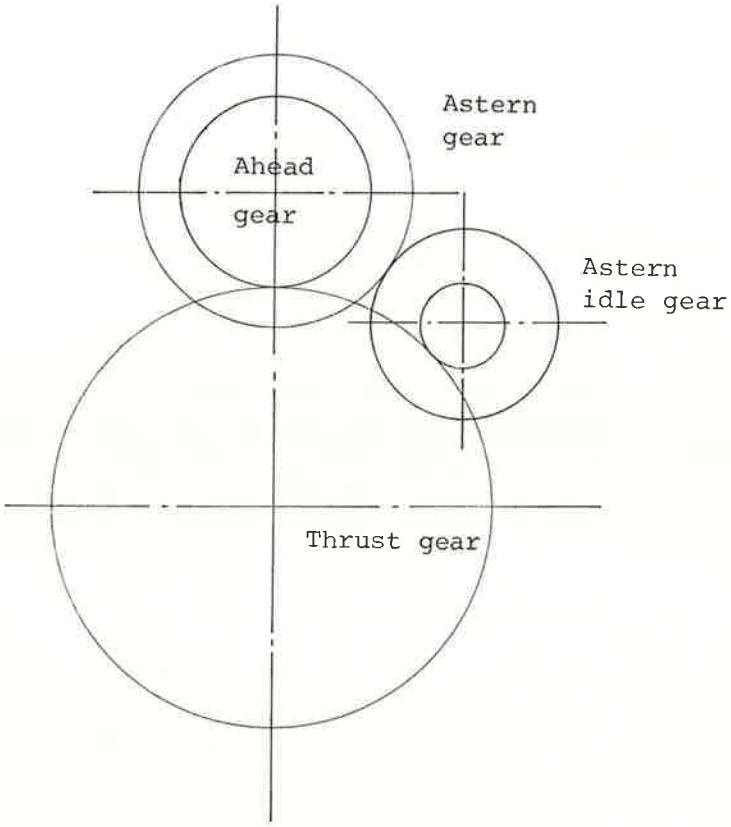
Clutch Transmission Mechanism

(1) When moving ahead



(2) When moving astern




Astern
gear
Ahead
gear
Astern
idle gear
Thrust gear

Description of mechanism

The four gears in the reduction reversing gear (one of which is a monoblock large and small gear) are usually meshed with each other and turning whenever the engine is operating.

(1) When moving ahead:

There are two friction discs. The power is transmitted to the left friction disc, then from gear A to gear C to drive the propeller shaft.

(2) When moving astern:

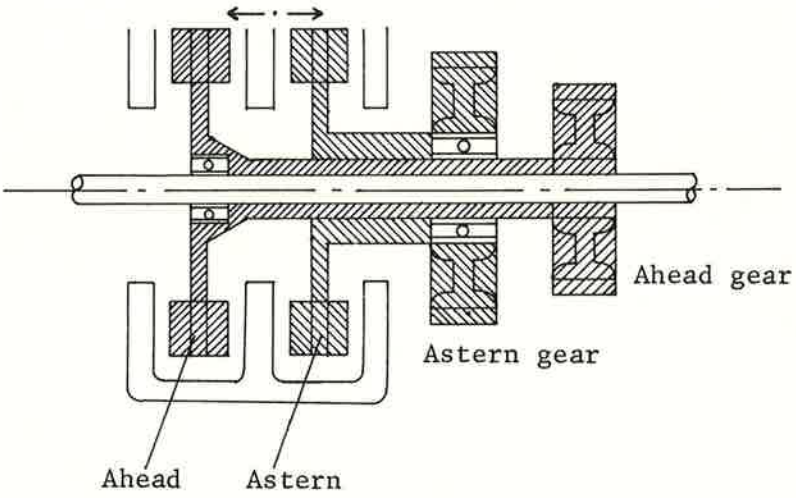
The power is transmitted to the right friction disc, and in turn to gear A, gear D (gears D_0 & D_1) and gear C, and drives the propeller shaft.

Thus, by operating a gear lever, the right and left friction discs are used as appropriate, depending upon the transmission mode of ahead or astern. All gears are constant meshed type, and the friction discs are normally turning in opposite directions except in their neutral position.

(3) When in neutral position:

The two friction discs are free from the friction plate, and gears A, B, C and D are all stationary even when the engine is running. A neutral positioning piece is furnished so as not to transmit power to between the friction plate and the friction discs. Therefore, "accompaniment" does not

occur with the propeller shaft while the mechanism is in its neutral position.



1-6 Piping Diagram

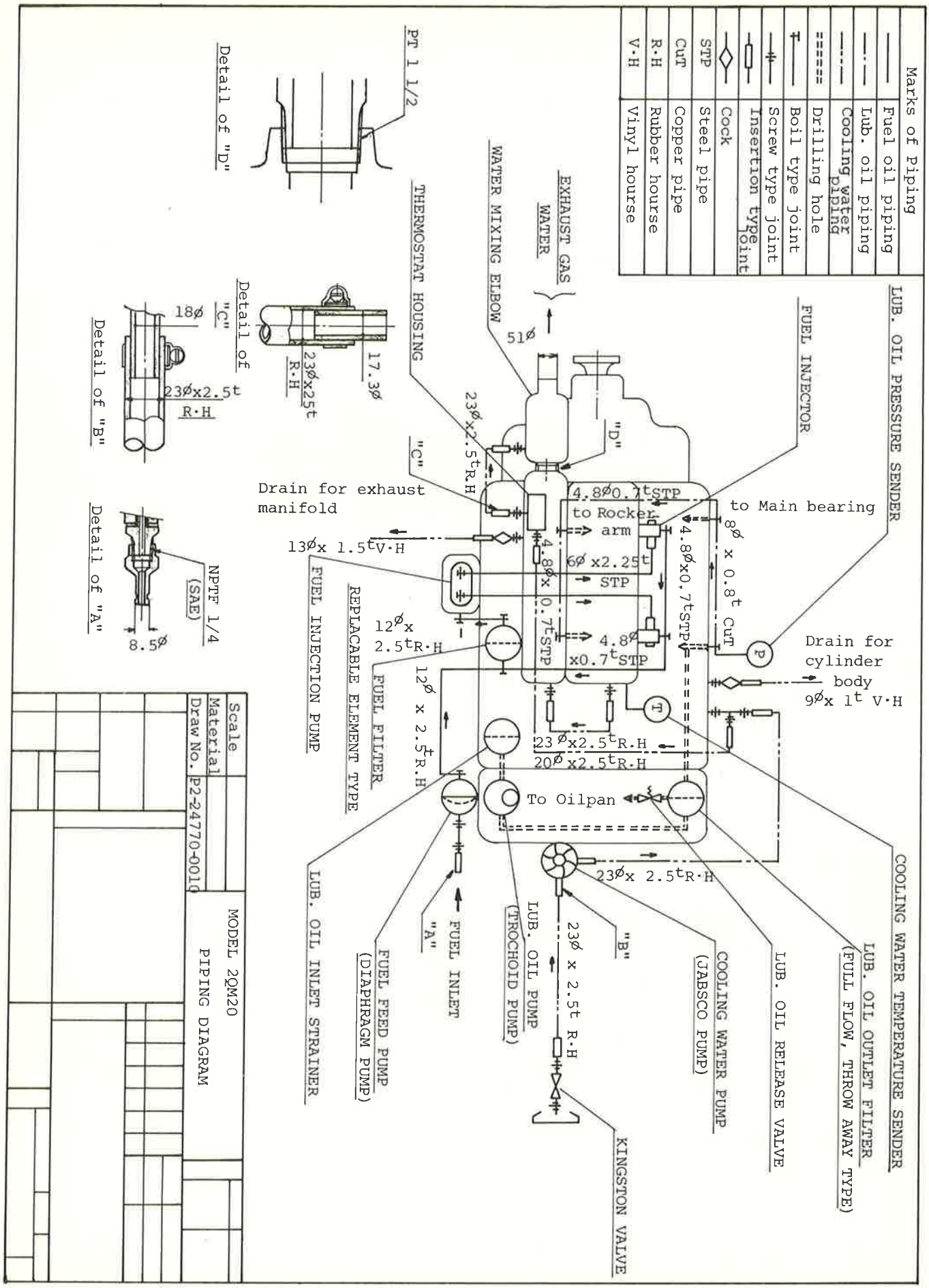


Fig. 1

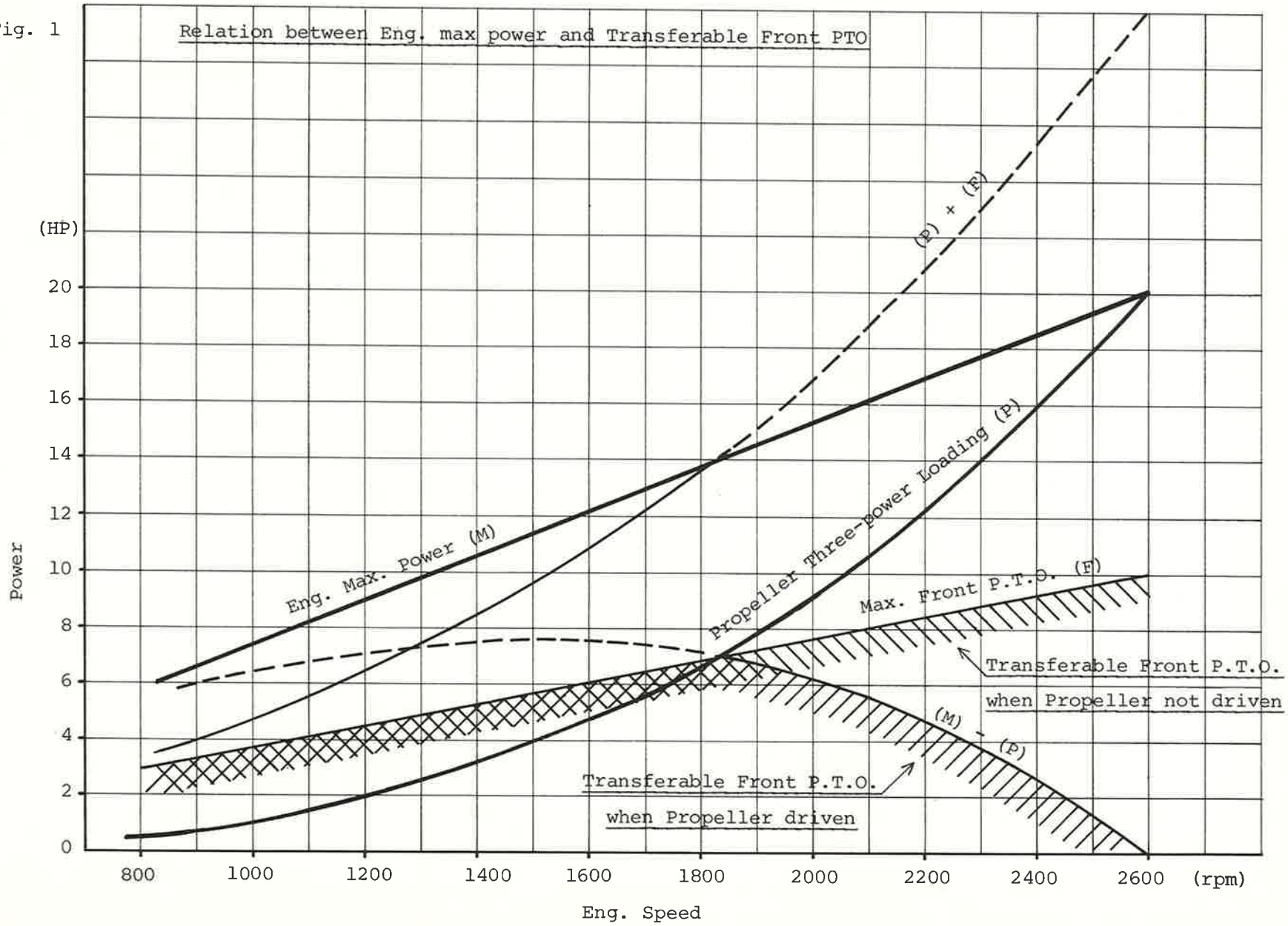
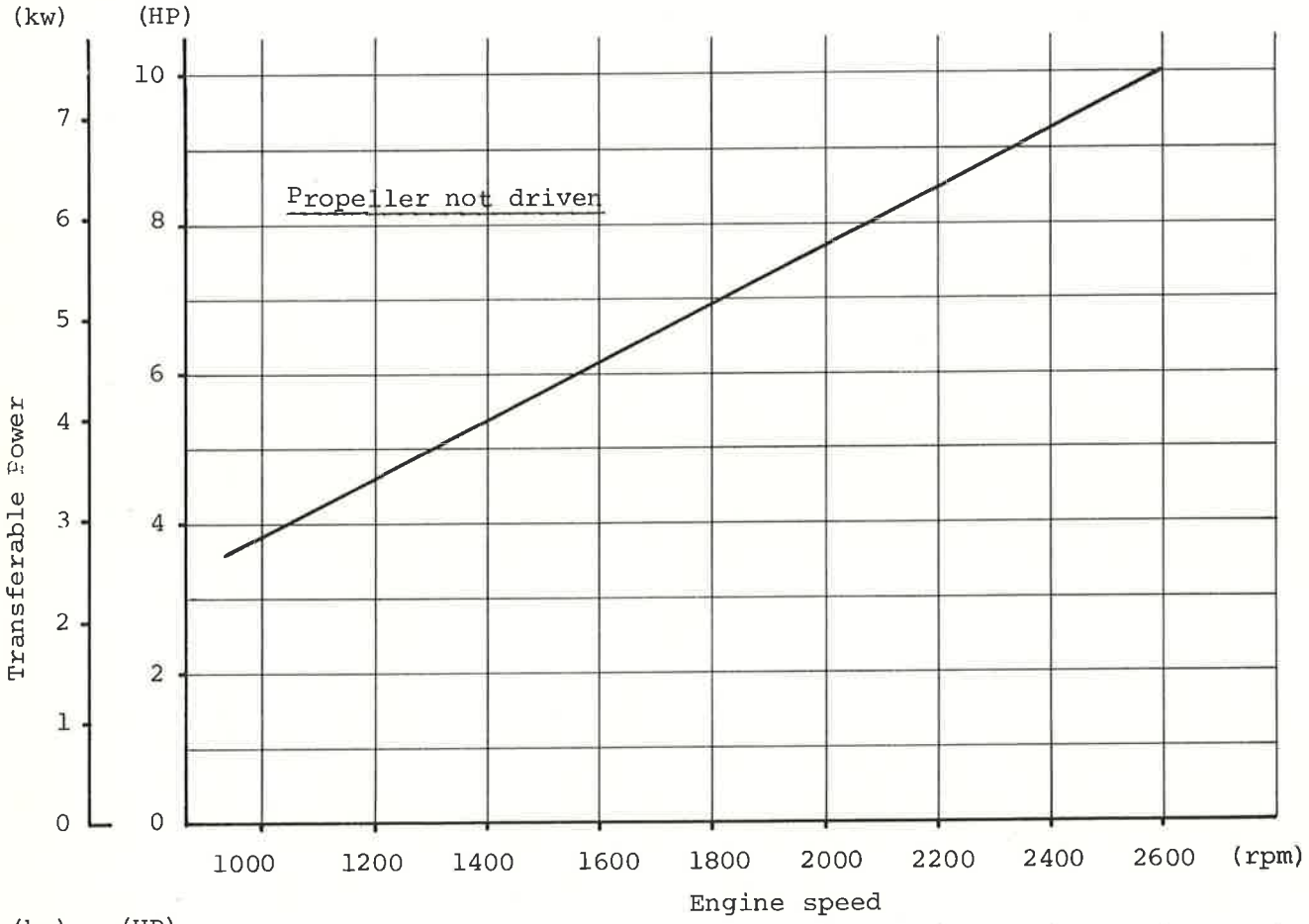
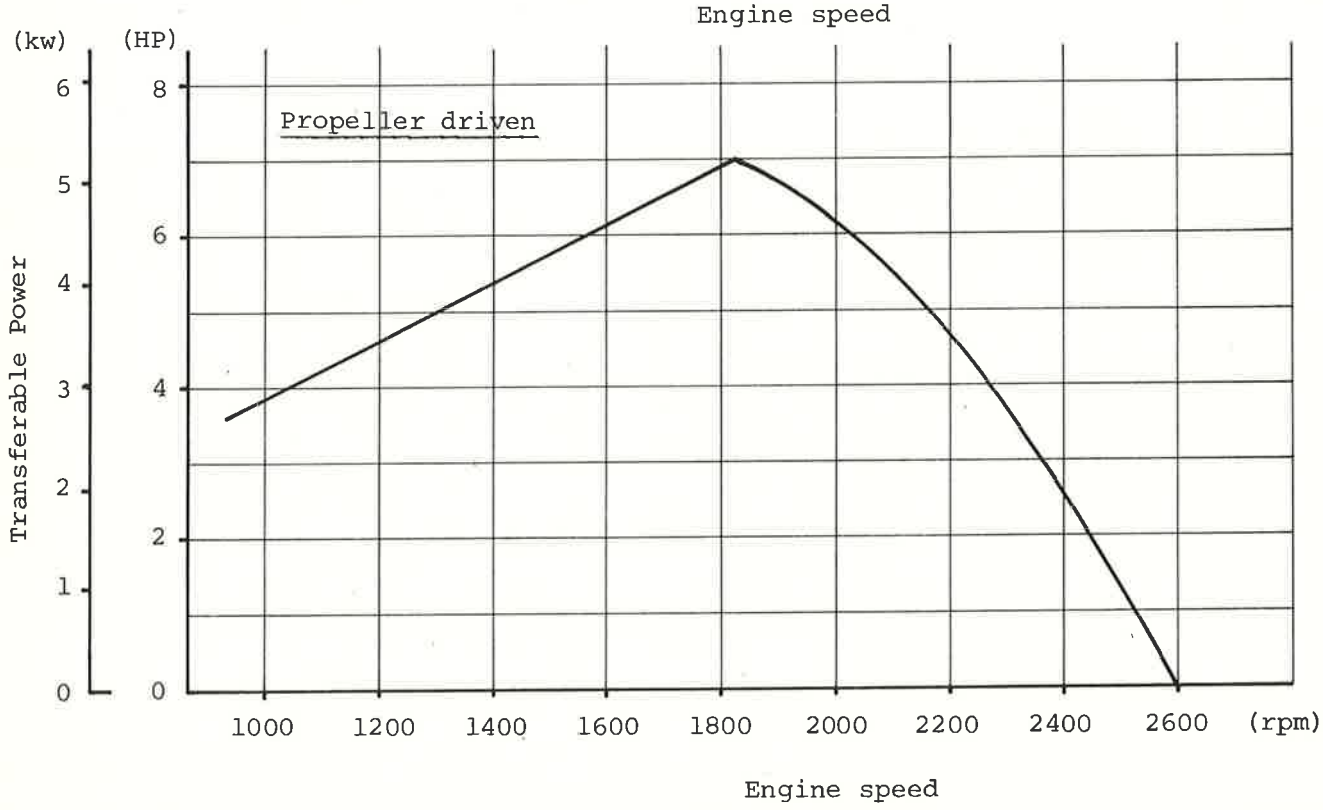

Relation between Eng. max power and Transferable Front PTO
(HP)
Power
0
2
4
6
8
10
12
14
16
18
20
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
(rpm)
Eng. Speed
(P) + (F)
Eng. Max. Power (M)
Propeller Three-Power Loading (P)
Max. Front P.T.O. (F)
Transferable Front P.T.O.
when Propeller not driven
(M)
(P)
Transferable Front P.T.O.
when Propeller driven

Fig. 2 Front P.T.O.





1-9 Accessories (Final spec.)

No.	Item		Standard	Optional	Remarks
	Fuel System	F.O. tank (20 lit.)		o	
		F.O. strainer	o		
		F.O. lift pump (mechanical type)	o		
	Lubrication system	L.O. drain pipe (for crank case)	o		
		L.O. evacuation pump (made of metal)		o	
		Oil pressure switch	o		
	Cooling system	C.W pump (rotary type)	o		
		C.W temperature switch	o		
		Thermostat	o		
		Kingston cock (including strainer cover) C.W pipe (Kingston pump)		o	
	Bilge	Bilge pump (mechanical Tandem) Bilge strainer and Bilge pipe (for inlet-outlet use)		o	
	Intake & Exhaust System	Intake silencer	o		
		Exhaust manifold (water cooling type)	o		
		Water mixing elbow (L-shaped type) (C.W pipe attached)		o	
		Water mixing elbow (U-shaped) (C.W pipe attached)		o	

No.	Item		Standard	Optional	Remarks
	Starting system	Manual starting device with chain cover		o	
		Electrical starter (Starting motor: 1.3 kW/12V AC generator: 35 A/12V Regulator)	o		
	Instrument and wiring	Dash board panel and wiring (Key switch, L.O. C.W. charging lamp Wireharness)	o		
		Extension-use wire-harness (3 m)		o	
		Battery switch		o	
		Tachometer and tacho-meter sender arrangement (electrical)		o	
		Idling adjuster	o		
	Remote control	Speed control bracket	o		
		Bracket for clutch remote control cable	o		
		Bracket for decomp.	o		
		Decomp. wire (3 m)		o	

No.	Item		Standard	Optional	Remarks
	Instal-lation	Flexible mountings (4pcs/unit)		o	
		Flexible coupling		o	
		Propeller shaft half coupling (Solid type 28 mmø taper bored)		o	
		Propeller shaft half coupling (Slit type 20 mmø bored)		o	
		Propeller shaft half coupling (Slit type 1 inch board)		o	
	Other (* Des-cribed else-where)	Tools	o		
		Special tools for overhaul		o	
		On board spare parts kit		o	
		Operation manual	o		
		Packing kit		o	

* Spare parts kit (for one engine)

	Item	Quantity
1	Piston ring set (for two cycles)	1 set
2	Gasket packing (cylinder head)	1
3	Gasket packing (for installation of exhaust manifold and exhaust pipe joint)	one for each
4	F.O. strainer element	1
5	L.O. strainer (cartridge type)	1
6	Oil pressure switch	1
7	Water temperature switch	1
8	Thermostat	1
9	Fuel injection nozzle valve & case	2
10	Anti-corrosive zinc	2
11	Warming lamp 3W/12W	3
12	CW pump impeller	1
13	Vee-belt for A.C. Generator	1 pc

* Remote Control Cable

Decomp.	Manufactured by YANMAR	(Cable fittings are attached to the engine)
Speed control	Manufactured by MORSE Cable No. 33 C Clamp No. A31804 (Clamp & shim) Crevice No. A31800	
Clutch	Manufactured by MORSE Cable No. 64 CB Clamp No. A37885 (Clamp & shim)	

2. MAINTENANCE AND INSPECTION

2-1 Fuel and Lubricating Oils

To the engine, fuel oil is food and lubricating oil is blood. Mishandling may cause unexpected engine trouble. The efficiency of the Yanmar engine will depend upon strict adherence to these instructions and recommendations.

It is the salesman's or serviceman's duty and mission to urge the user to follow them.

2-1-1 Fuel Oils

1) Required properties

a) High cetane rating

Poor ignitability of fuel oil results in an ignition lag, causing difficult starting or knocking.

b) Low sulphur content

Sulphur contained in fuel oil when burned is combined with water to produce sulphuric acid which corrodes metallic parts.

c) No dust or moisture content

Dust and moisture contained in fuel oil can cause faster wear or sticking of the plunger of the fuel injection pump and injection nozzle.

d) Appropriate viscosity

Fuel viscosity has a relation to the condition of injection. It should be

such that the plunger and the nozzle valve will be properly lubricated.

2) Recommended brands

Supplier	Brand
SHELL	Shell Diesoline (or local equivalent)
CALTEX	Caltex Diesel Oil
MOBIL	Mobil Diesel Oil
ESSO	Esso Diesel Oil
B.P. (British Petroleum)	B.P. Diesel Oil

2-1-2 Lubricating Oils

1) Functions

a) Lubrication--reduces friction and wear on sliding surfaces.

b) Cooling--carries away combustion and friction heat.

c) Air-tightening--keeps the cylinder air-tight, prevents escape of compressed air and operating gas.

d) Cleaning--carries away carbon (combustion product) and internal dust.

e) Rust prevention--keeps parts from rusting.

Today's improved engines call for high-quality lubricating oils. Oil companies are now using a number of additives to improve the properties of their lubricating oils.

2) Classification by viscosity

Lube oil viscosity should be selected to suit the ambient temperature.

SAE-Viscosity Table

	SAE No.	0°F (-17.8°C)		210°F (98.9°C)	
		Saybolt universal viscosity, sec.	Kinematic viscosity, CSt	Saybolt universal viscosity, sec.	Kinematic viscosity, CSt
below 10°C	5W	below 4,000	below 869	-	-
	10W	6,000a-12,000	1,303a-2,606	-	-
	20W	12,000b-48,000	2,606b-10,423	-	-
10 -20°C	20	-	-	45-58	5.73-9.62
	30	-	-	58-70	9.62-12.93
over 30°C	40	-	-	70-85	12.92-16.77
	50	-	-	85-110	16.77-22.68

3) Recommended brands (for crankcase and gear box)

Supplier	Brand	SAE No.			
		below 10°C	10-20°C	20-35°C	over 35°C
SHELL	Shell Rotella Oil	10W 20/20W	20/20W	30 40	50
	Shell Talona Oil	10W	20	30 40	50
	Shell Rimula Oil	20/20W	20/20W	30 40	-

Supplier	Brand	SAE No.			
		below 10°C	10-20°C	20-35°C	over 35°C
CALTEX	RPM Delo Marine Oil	10W	20	30 40	50
	RPM Delo Multi-Service Oil	10W 20/20W	20	30 40	50
MOBIL	Delvac Special	10W	20	30 40	
	Delvac 20W-40	20W-40	20W-40		
	Delvac 1100 Series	20-20W 10W	20-20W	30 40	50
	Delvac 1200 Series	20-20W 10W	20-20W	30 40	50
ESSO	Estor HD	10W	20	30 40	
	Esso Lube HD		20	30 40	50
	Standard Diesel Oil	10W	20	30 40	50
B.P. (British Petro-leum)	B.P. Energol ICM B.P. Venellus* B.P. Diesel S3 B.P. Venellus** S3	20W	20W	40	50

* API grade CB
** API grade CD

A.P.I. classification for lub. oil

New A.P.I. service grade	Old A.P.I. service grade	Type of engine for which suited
CA	DG	Low mean pressure
CB.CC	DM	Middle mean pressure
CD	DS	High mean pressure

CA; Applies to diesel engines running with light loads, using high quality fuel oil, and occasionally to gasoline engines

running with light loads. Prevents bearing corrosion and high temperature deposits.

CB; applies to diesel engines running with medium loads using low quality fuel oil (which may cause corrosion and deposit troubles), and prevents bearing corrosion and high temperature deposits in diesel engines being run with fuel oil of high sulphur content.

CC; applies to lightly supercharged diesel engines being run under medium and high loaded conditions, and to certain types of highly loaded gasoline engines. Useable with a variety of civil construction machines, agricultural machines and marine machines. Prevents high and low temperature deposits and corrosion of diesel engines.

CD; applies to high speed, high output supercharged diesel engines. Prevents bearing corrosion and high temperature deposits in supercharged diesel engines which use low quality fuel oil.

Note: Use lube oils of CC or CD class for the 2QM20 engine.

2-2 Pointers for Maintenance and Inspection

	Procedure	Instructions to engine operator	Remarks
Starting	Lubrication before operation	①. Set the gear lever at "Neutral" and speed control lever at "stop". ②. Do not allow compression. ③. Turn the engine for about 5 seconds.	Check fuel oil brand. See 2-1
	Confirmation of injection sounds and starting	①. Do not allow compression. ②. Set the speed control lever to "Run". ③. Turn the engine until the sounds of injection can be heard (when no such sound is heard, ventilate the fuel injection device). ④. When the injection sound is heard, start the engine.	
	Starting in cold weather	When starting is extremely difficult, supply gasoline to the suction inlet cover. Do not supply too much.	
Cautions in operating	Confirmation	①. Oil pressure lamp ⟶ goes off ②. Charging lamp ⟶ goes off ③. Cooling water lamp ⟶ goes off ④. Valve mechanism oil circulation in the head cover	Normal oil pressure $_2$ (25~ 35 kg/cm^2) Prevention of seizing

	Procedure	Instructions to engine operator	Remarks
Cautions in operating	Warming-up	Run under no-load conditions at 600~800 rpm for more than five minutes to warm-up the engine.	To attain thorough oil permeation. To prevent the lines and piston from seizing due to a sudden increase in temperature immediately after starting.
	Observe color of exhaust gas	1. Colorless to blueish white engine in the best condition. 2. Black a trouble in the engine or overloaded. 3. White engine oil is burning. 4. Continuous black exhaust smoke should be avoided.	
	Check for abnormal sounds or abnormal increases in temperature	When abnormal sounds or abnormal increases in temperature are observed, stop operation immediately and check for causes.	If not check immediately, unnecessary damage may occur.
	Check for gas and water leakage	Check for gas and water leakage, retighten bolts and nuts if necessary.	
	Avoid resonance	At a certain number of revolutions, resonance between the engine and the hull may occur depending upon the structure of the frame.	Avoid operating the engine at the power setting at which resonance occurs otherwise the engine will be subjected to undesirable effects.

	Procedure	Instructions to engine operator	Remarks
	Fill with fuel	Fill with fuel while the fuel level can still be seen on the fuel tank level gauge.	If the engine stops due to fuel exhaustion, ventilation of the fuel pump is necessary after refilling with fuel.
Engine stop	Idle operation before engine stoppage.	Run at idle for about five minutes by placing the clutch in the "Neutral" position. Run at high speed momentarily before stopping the engine.	Discharges carbon in the combustion chamber from the engine.
	Engine stoppage	Use the speed control lever to stop the engine.	If the decompression handle is used to stop the engine, unburned fuel will accumulate in the cylinder, causing carbon build-up between the valve and valve seat which will make the engine hard to start.
Servicing after use	Drain cooling water	If the cooling water is likely to freeze, owing to the weather or other factors, drain it in the following way. ①. Close the kingston cock. ②. Open the cooling water drain cocks. (Exhaust manifold and cylinder body.)	In cold weather, frozen water in the cylinder head will damage the engine.

Procedure		Instructions to engine operator	Remarks
		3. Remove both inlet and outlet hoses from the water pump, then disassemble the cover to discharge water from inside the water pump. After following the above procedure, reassemble it as before.	
Storing engine	Clean the engine	While the engine is still warm, completely remove oil and dirt.	For better maintenance of engine.
	Change lub. oil	Change lub. oil and turn the engine a few times.	For next use. Rust preventive treatment.
	Keep moving parts free from corrosion and dirt	Wipe off oil and dirt. Apply oil to the following parts. 1. Link part of fuel pump. 2. Pinion shaft of starting motor. 3. Moving part of remote control device, shaft part of handles. Cover the engine with vinyl sheets, paper, or cloth for dust-proofing.	
	Occasionally turn the engine	Turn the engine by hand once a month.	To rust-proof metal, piston, liner and rings.
	Store battery	Disconnect battery cables and store in a dry place. Charge once a month.	

2-3 Periodic Checks

A periodic check is necessary to keep the engine in good condition at all times. The frequency of such checks may vary, depending upon engine use, conditions of use, quality of oil used, and methods of operating the engine. It is difficult to specify the required frequency of periodic checks and service. Therefore, only general explanations will be given here. The relationship between the details of such checks and time is as follows:

		Maintenance service				Workshop service		
Items	Operating hours / Procedure	Daily	Every 50 hours	Every 250 hours	Every 500 hours	1 year or 1500 hours	Every 2000 hours	Every 3000 hours
Fuel	Check fuel level. Replenish	o						
	Remove condensation from fuel tank.	o (Before replenishment)						
	Clean fuel filter and remove condensation		o					
	Replace fuel filter element			o				
Lub. oil	Check oil level. Replenish in crank case and clutch case	o						
	Change oil in crank case		o 100 hours		(The first change is to be made 50 Hrs after starting of the newly installed engine.)			
	Change oil in clutch case.			o (The first change is to be made 50 Hrs after starting of the newly installed engine.)				
	Replace lub. oil filter			o 300 hours (The first change is to be made 50 Hrs after starting of the engine newly installed.)				

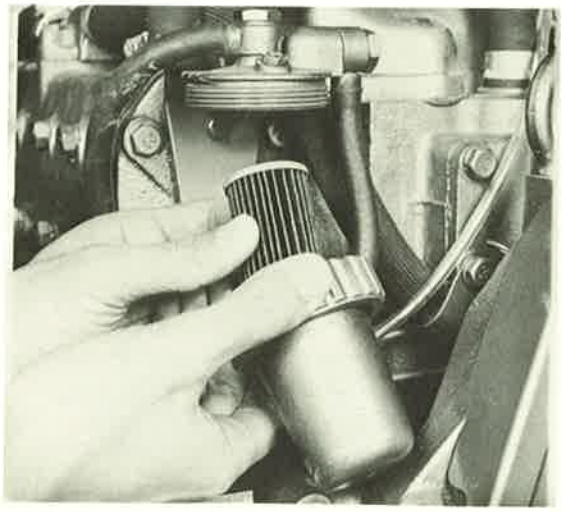
		Maintenance service				Workshop service		
Items	Operating hours / Procedure	Daily	Every 50 hours	Every 250 hours	Every 500 hours	1 year or 1500 hours	Every 2000 hours	Every 3000 hours
Cooling water pump, etc.	Check cooling water circulation	o						
	Discharge cooling water after operation in cold seasons							
	Clean thermostat			o				
	Check and replace anticorrosive zinc				o			
	Check rubber impeller and casing				o			
Governor	Overhaul check of major components						o	
	Check and adjust governor linkage			o				
Fuel injection pump	Check injection timing				o			
	Check delivery valve				o			
	Overhaul check of major components						o	
Fuel injection valve	Check spray condition				o			
	Check and adjust injection pressure				o			
	Overhaul cleaning of injection valve				o			
Cylinder head	Retighten head nuts			o (50 hours after trial operation of new reconditioned engine)				
	Adjust intake and exhaust valve clearances			o				

Items	Operating hours / Procedure	Maintenance service: Daily	Maintenance service: Every 50 hours	Maintenance service: Every 250 hours	Maintenance service: Every 500 hours	Workshop service: 1 year or 1500 hours	Workshop service: Every 2000 hours	Workshop service: Every 3000 hours
	Grind intake and exhaust valves					o		
	Check rocker arms and valve guides					o		
	Clean pre-combustion chambers					o		
Piston	Overhaul, clean, and check rings					o		
Connecting rod	Check bearings, bolts, and torque					o		
Main bearings	Check bearings and bolts							o
Crank-Shaft	Measure and check pin and journal diameters							o
	Measure and check crank arm deflection					o		
Engine exterior	Check miscellaneous bolts, nuts, and for oil leaks	o						
All engine piping	Check for leaks	o						
Clutch	Overhaul, check, and recondition moving parts							o
Other	Check battery electrolyte level	o						
	Check lamps (charging lub. oil warning & C.W. warning)	o						

		Maintenance service				Workshop service		
Items	Operating hours / Procedure	Daily	Every 50 hours	Every 250 hours	Every 500 hours	1 year or 1500 hours	Every 2000 hours	Every 3000 hours
Other	Check belt tension			o				
	Retighten major bolts and nuts			o				

The first retightening is to be made 59 Hrs after starting of the newly installed engine.

Every 50 hours



(1) To remove the fuel filter drain:

① Close the fuel tank stopcock.

② Remove the fuel filter bowl as illustrated and drain the condensation.

③ Clean the fuel filter element.

④ Reset it firmly.

⑤ Open the fuel tank stopcock and vent air.

Every 250 hours

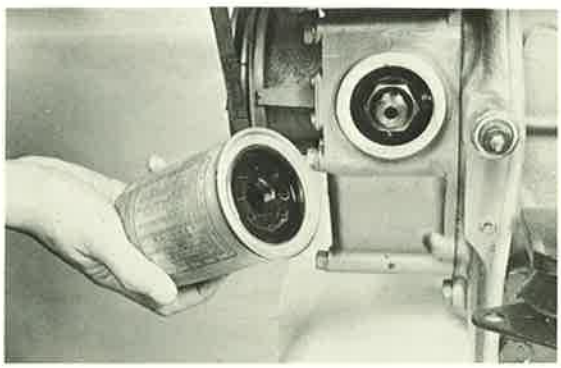
(1) To replace the fuel filter element:

① Close the fuel tank stopcock.

② Thoroughly clean the filter bowl inside with light oil after replacement of element.

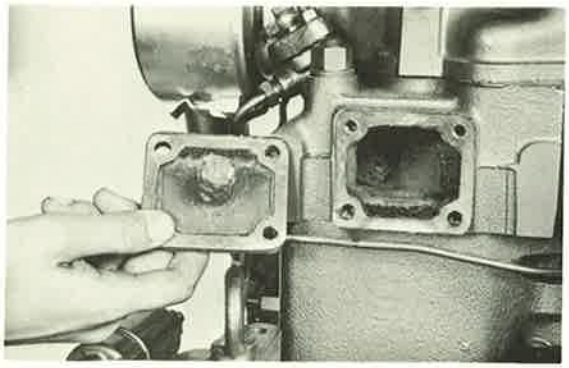
③ Following cleaning, reassemble the fuel filter by reversing the disassembly procedure and remount on the engine.

④ After reassembly, vent air.

Every 250 hours	
	(2) To clean thermostat: ① Replace the thermostat cover. ② Take out the thermostat and clean.
	(3) To adjust governor linkage. (See)
	(4) To adjust intake and exhaust valve clearances. (See)
Every 300 hours	
	(1) To replace lub. oil filter element.

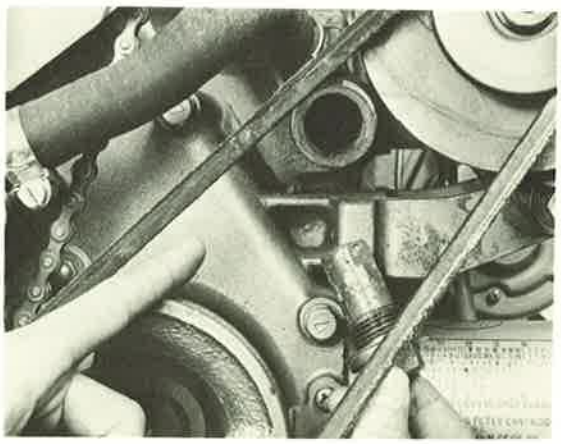
Every 500 hours

Cylinder head



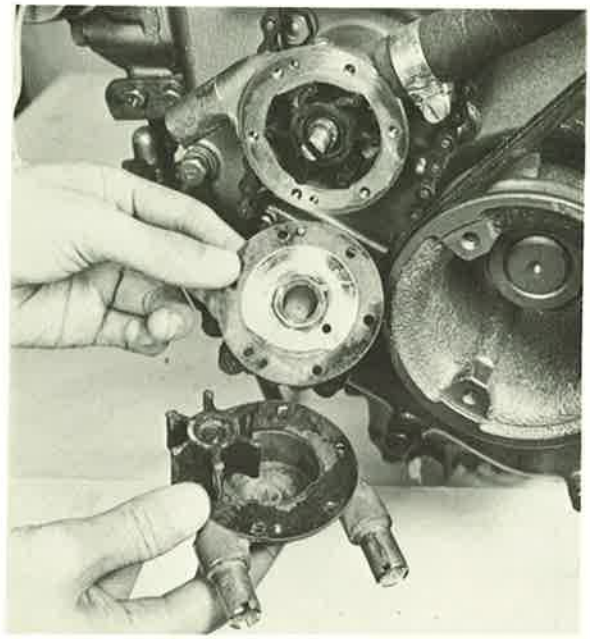
Cylinder head

Cooling water inlet



(1) To replace anti-corrosive zinc. (Cylinder head and C.W. inlet)

Every 500 hours



(2) To check C.W. impeller.

(3) To check injection timing.

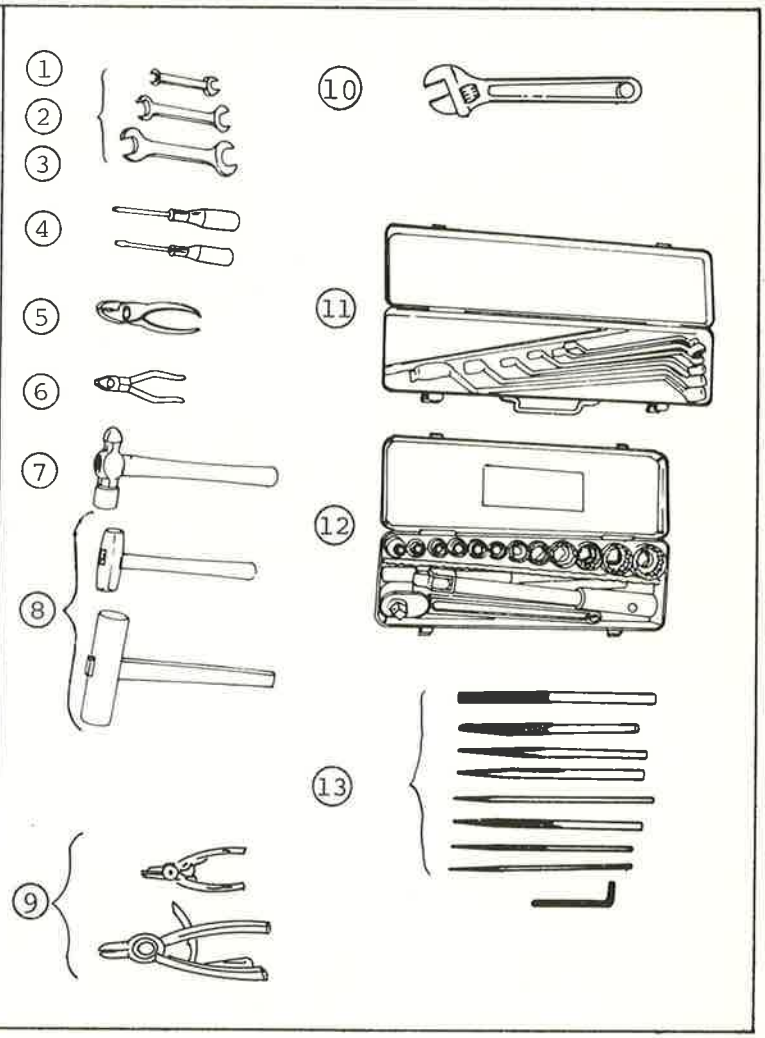
(See)

3. ALIGNMENT OF ENGINE

3-1 Tools for Overhaul and Reassembling

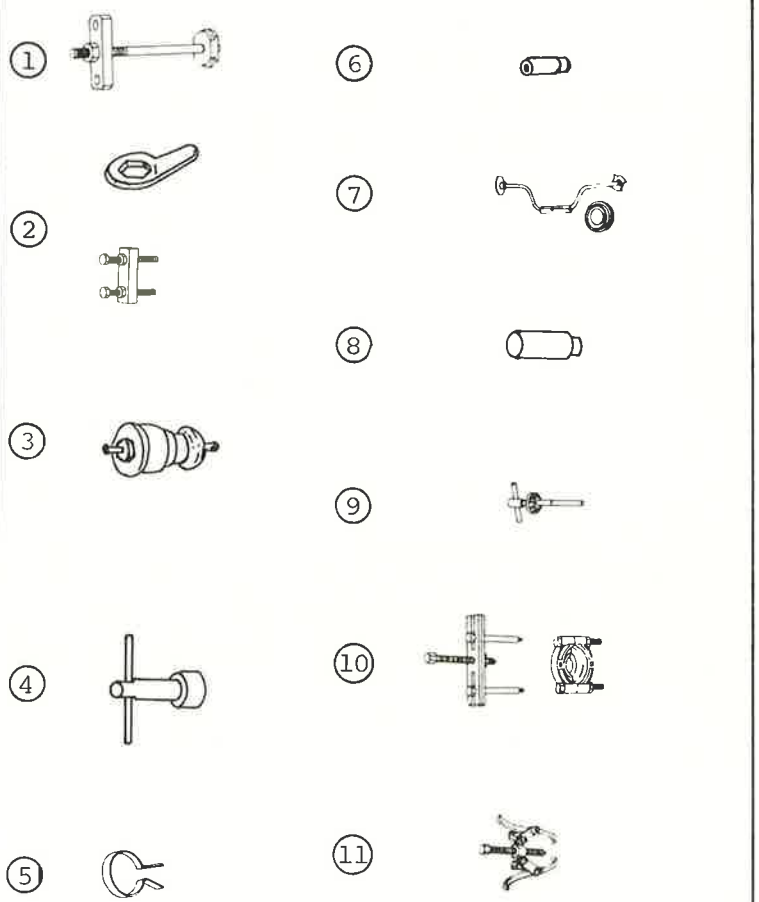
General tools:

1	Spanner 10 x 13	YANMAR standard
2	" 17 x 19	
3	" 22 x 24	
4	Screwdriver	
5	Pliers	Local supply
6	Nipper (Diagonal plier)	
7	Steel hammer	
8	Wooden or copper hammer	
9	Monkey wrench (Adjustable wrench)	
10	Snap ring plier	
11	Offset wrench	
12	Socket wrench	
13	Files	
14	Sand paper	



Special tools

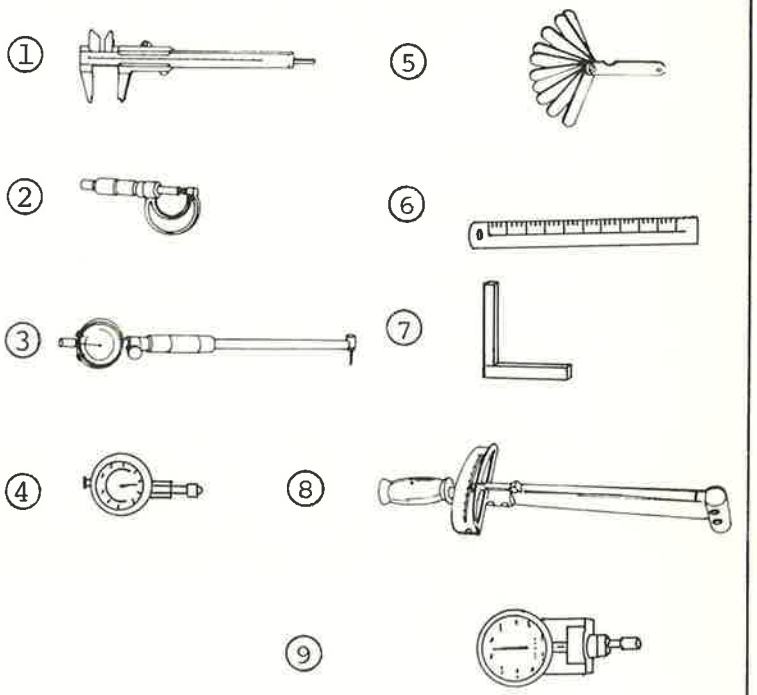
1	Liner extraction implement	YANMAR special order
2	Flywheel extraction set (Flywheel end nut spanner & replacer)	YANMAR special order
3	Main bearing replacer	YANMAR special order
4	V-pulley removal tool	YANMAR special order
5	Piston ring compressor	YANMAR special order
6	Nozzle body pullout implement	YANMAR special order
7	Valve seat lapping tool	YANMAR special order
8	Piston pin remover	Local supply
9	Valve seat cutter	Local supply
10	Gear puller	Local supply
11	Ball bearing puller	Local supply



Measuring and inspection tools

Measuring

1	Vernear calipers	
2	Micrometer	
3	Cylinder gauge	
4	Dial gauge	
5	Feeler gauge	
6	Ruler	
7	Square	
8	Torque wrench	
9	Tachometer	
	Inspection	
10	Nozzle tester	
11	Injected volume tester	
12	Electrical circuitry tester	
13	Hydraulic pressure tester	
14	Compression pressure tester	
15	Crack detection solution	



Other

	Packing sheet Adhesives (water-proof, anti-solvent) Paints for repair Water cloth Cleaner Pallet	

3-2 Engine Adjustment Specifications

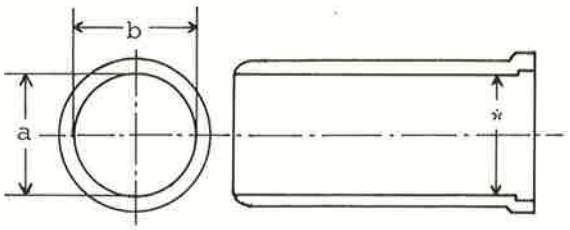
					Remarks
Engine	Top clearance			mm	1.08	
	Decomp. lift			mm	0.8	
	Valve clearance of intake & exhaust			mm	0.15	In cold condition
	Valve timing	Intake valve open		b.T.D.C.	20°	
		Intake valve closed		a.T.D.C.	50°	
		Exhaust valve open		b.T.D.C.	50°	
		Exhaust valve closed		a.T.D.C.	20°	
	Lube oil pressure			kg/cm^2	3.0 $\pm$0.5	At rated revolutions
	Fuel oil injection pressure			kg/cm^2	160	
	Fuel oil injection timing			b.T.D.C.	25° $\pm$2°	
Installation	Center displacement between clutch thrust shaft and propeller shaft			mm	0.15 or less	
	Inclination between clutch thrust shaft and propeller shaft			mm	0.06 or less	
	Maximum rake angle				13°	

3-3 Measurements of Major Components

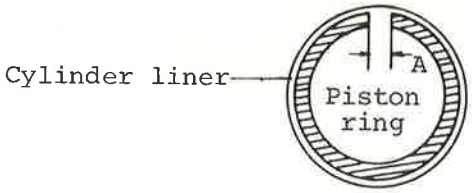
Before beginning the measuring operation, all parts to be measured must be cleaned and the measuring instruments must be well calibrated. After the completion of each measurement, all parts not failing within the allowance of the maintenance standard must be repaired or replaced with new ones. Upon completion of repair or replacement, check that the respective dimensions of the parts are within the values specified.

3-3-1 Cylinder Liner

Procedure for replacement of cylinder liner:

Measuring position	Remarks	Measuring Instrument
	Measure in (a) (b) directions at position marked *. (* mark is positioned in No. 1 piston ring at upper dead center.) o Nominal size 88ømm o Limit of use +0.2mm Reference o Clearance between piston and cylinder liner Standard clearance of ass'y 0.14mm Limit of use 0.4mm	Cylinder gauge

{Simple method for measuring inner diameter of cylinder liner or thickness of piston ring.}

Measuring position	Remarks	Measuring Instrument
Use a new cylinder or piston ring, whichever is tighter.  	Measure piston ring fitting dimension. Calculation of wear in inner dia. direction $\frac{A - 0.3}{3.14}$ = wear Here, if the cylinder liner is new, it is the doubled amount of wear in the thickness of ring. If a new ring is used, it is the amount of wear in inner dia. of cylinder liner.	Thickness gauge

Procedure for replacement of cylinder liner:

1. Put the tightening nuts on the two cylinder head mounting bolts opposite each other on a diagonal line, and pull out the liner with the liner pullout implement.

2. Remove the rubber packing from the liner.

3. Clean off foreign material such as paint, dirt and dust adhering to the gutter for rubber packing and the portion to which the liner is installed.

Assembly

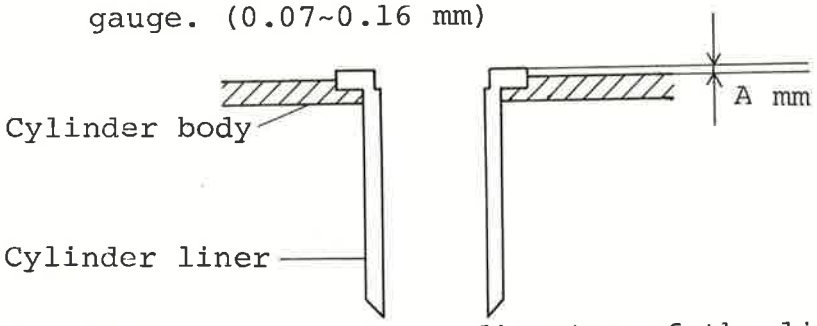
1. Insert the liner rubber packing, taking care not to twist it.

2. Apply white paint (seak paint) on the portions (front and rear) in which the liner is installed.

3. Insert the cylinder liner and tap in lightly on the head.

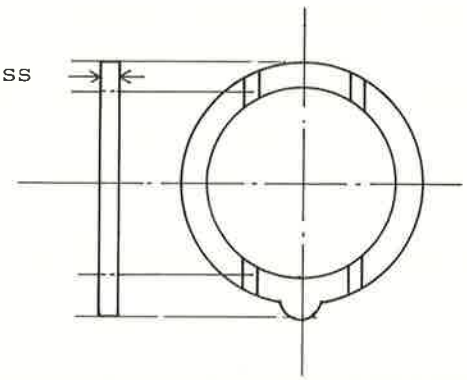
4. Put the two cylinder head tightening nuts on a diagonal line, and secure them.

5. Remove the head again, and measure the dimension at A (See Figure) with a dial gauge. (0.07~0.16 mm)

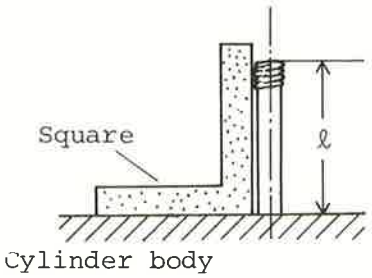
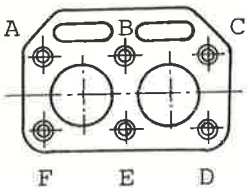


6. Measuring the inner diameter of the liner with a cylinder gauge, make sure that there is no abnormality.

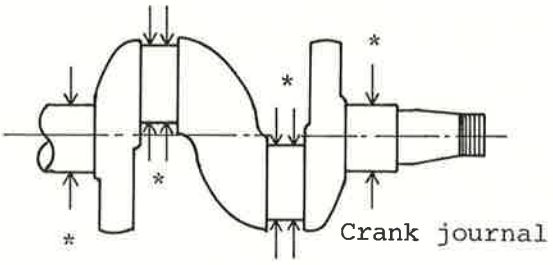
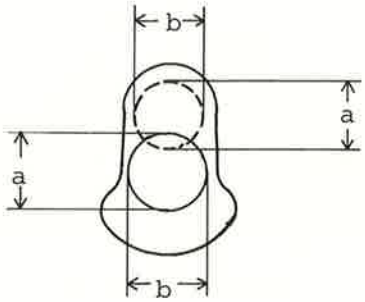
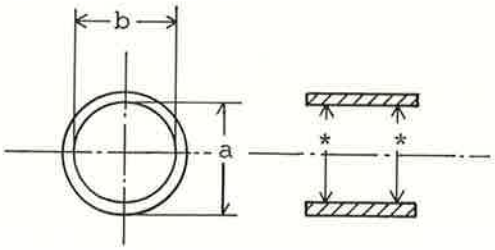
3-3-2 Thrust Metal

Measuring position	Remarks	Measuring Instrument
Thickness 	Nominal size 2.95 mm Limit of use -0.3 mm	Micrometer

3-3-3 Height of Cylinder Head Tightening Bolt

Measuring position	Remakrs	Measuring Instrument
 	Stud bolt Looseness standard for Stud bolts Stud bolt: A,B,C,D — Length (mm): About 108 Stud bolt: E — Length (mm): " 50 Stud bolt: F — Length (mm): " 121 When stud bolts are found to be too loose, retighten them. Tightening torque : 16 kg-m	Square Ruler Torque meter

3-3-4 Crankshaft and Bearing

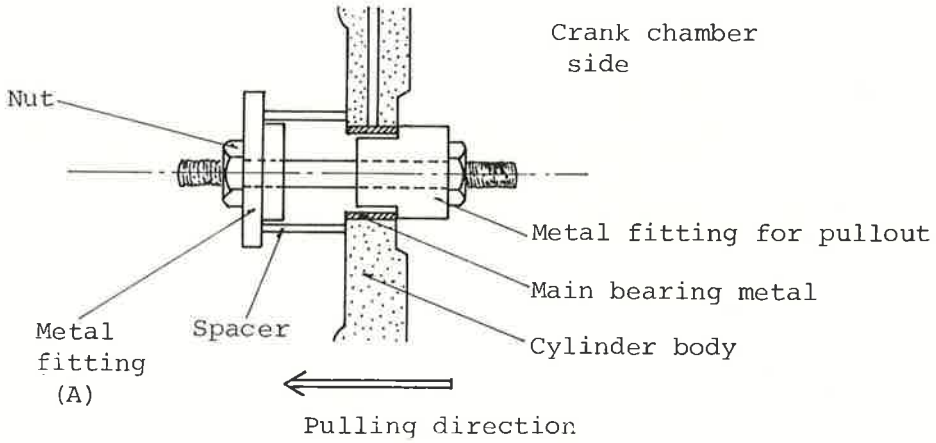
Measuring position	Remarks	Measuring Instrument
 Crank pin   Don't take the bearing out of the cylinder body.	Maximum wear dimension measured at * mark in (a) (b) directions. · Crank journal · Nominal size 70 mm · Limit of use -0.1mm · Crank pin · Nominal size 54 mm · Limit of use -0.1mm Measure in horizontal and vertical directions at position, marked *.	Micrometer Cylinder gauge

Replacement of main bearing metal:

1. Pulling of main bearing metal

   As shown in the figure, attach the metal pullout device to the main bearing metal, and pull it out by tightening the nut.

   Note that the metal should be pulled from the inside toward the outside of the engine. Metal fitting (B) is not used.



2. Insertion of main bearing metal

   2-1 Clean the area of the cylinder body in which the main bearing metal is to be inserted.

   2-2 Rearrange the metal pullout device for insertion use.

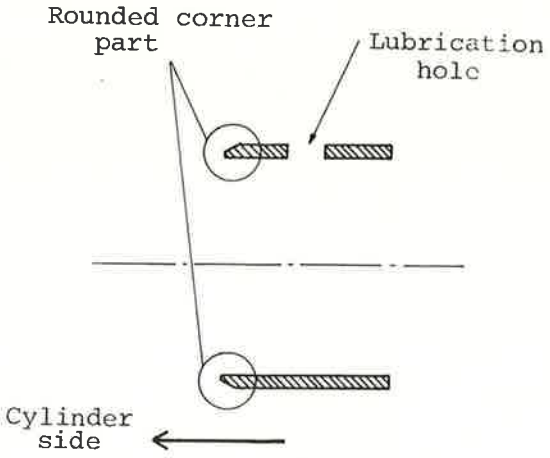
   2-3 Put the metal properly in the device so that its rounded corner part is directed to the cylinder body side.

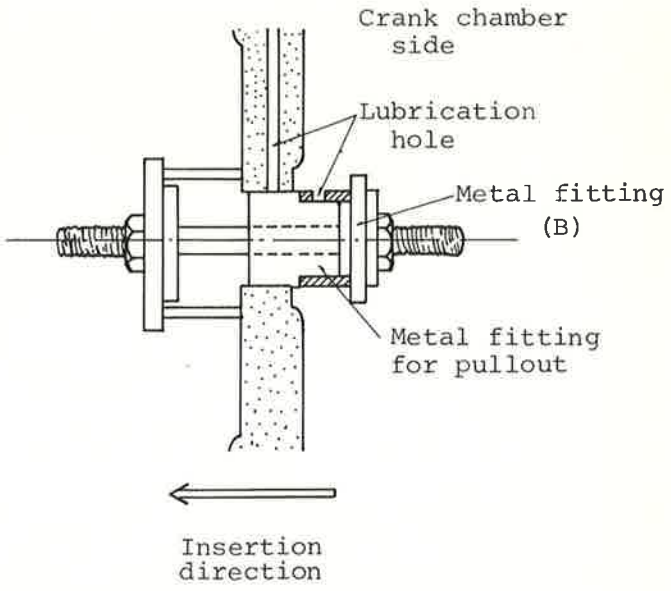
2-4 Set the insertion device together with the main bearing metal into the cylinder body, and tighten the nuts until the metal goes in flush.

Note: That the main bearing metal should be inserted from the inside to the outside of the engine.

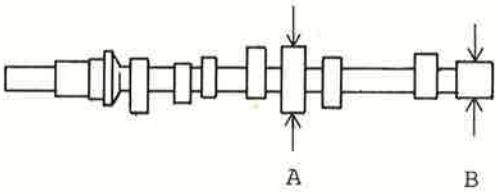
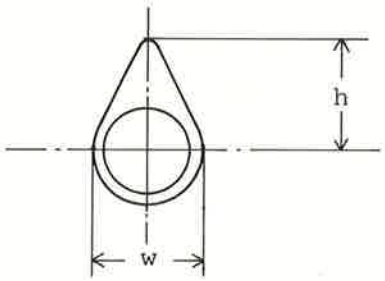
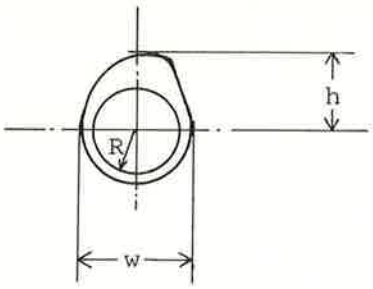
Care must also be exercised in this operation so that the lubrication hole of the engine body coincides with that of the main bearing metal.

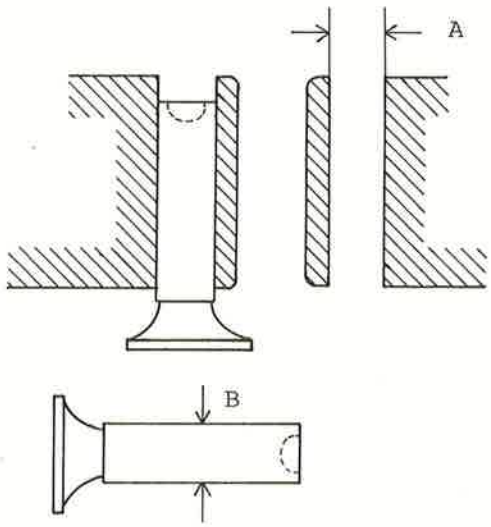
2-5 After the insertion of the metal is completed, set the crank shaft in and make sure that the shaft turns smoothly.



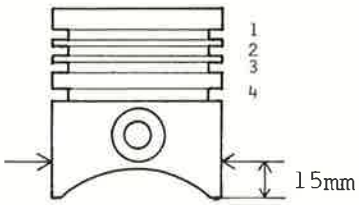
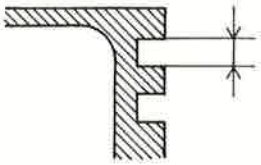
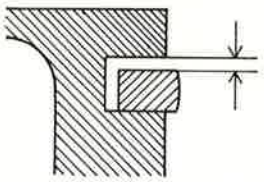


3-3-5 Cam Shaft and Tappet

Measuring position	Remarks	Measuring Instrument
	Portion A Nominal size 46 mm Limit of use -0.1mm Portion B Nominal size 37 mm Limit of use -0.1mm	Micrometer
Intake and Exhaust cam 	Nominal size w = 32 mm h = 38.63 mm	Micrometer Cylinder gauge
Fuel cam 	Nominal size R = 14 mm h = 35 mm	

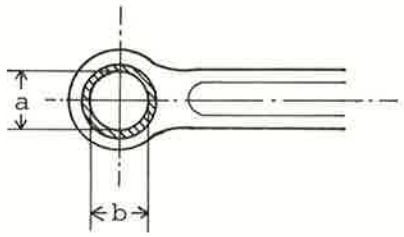
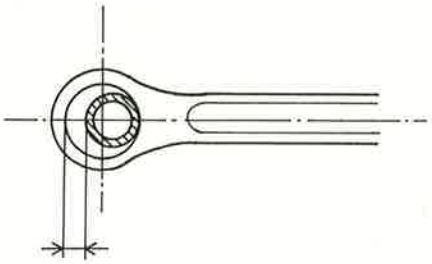
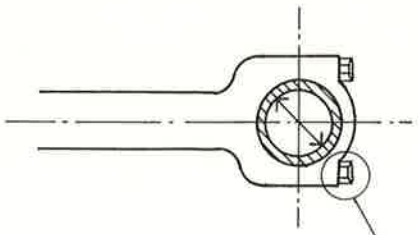
Measuring position	Remarks	Measuring Instrument
	Inner diameter of tappet guide (A) Nominal size 11 mm Limit of use +0.1mm Outer diameter of tappet guide (B) Nominal size 11 mm Limit of use -0.1mm	Micrometer Cylinder gauge

3-3-6 Piston, Piston ring and Piston Pin

Measuring position	Remarks	Measuring Instrument
	Measure piston skirt Nominal size 88øMm Limit of use -0.2mm	Micrometer
	Width of ring above 1st compression ring Nominal size 2.5mm Limit of use +0.15mm 2nd, 3rd compression ring Nominal size 2.5mm Limit of use +0.15mm Oil scraping ring Nominal size 4mm Limit of use +0.15mm	Thickness gauge
	Maximum clearance between ring and groove 1st compression ring Standard clearance of ass'y 0.098mm Limit of use 0.2 mm	Thickness gauge

Measuring position	Remarks	Measuring Instrument
	2nd, 3rd compression ring Standard clearance of ass'y 0.098 mm Limit of use 0.2 mm Oil scraping ring Standard clearance of ass'y 0.039 mm Limit of use 0.2 mm	

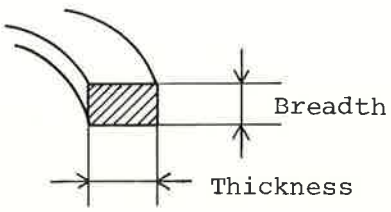
3-3-7 Connecting rod

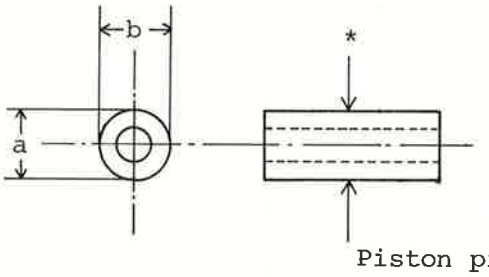
Measuring position	Remarks	Measuring Instrument
	Maximum wear dimension measuring metal inner diameter in (a) (b) directions. Nominal size 30 mm Limit of use +0.1mm	Cylinder gauge
	Clearance between piston pin and piston pin metal. Maximum clearance measured in horizontal and vertical directions. Standard clearance of ass'y 0.036mm Limit of use 0.15mm	Thickness gauge
	Maximum innder diameter measured in horizontal and vertical directions Nominal size 54 mm Limit of use +0.1mm	Cylinder gauge

Pulling and insertion of piston pin

The piston is coupled to the connecting rod through the piston pin. Normally, the piston pin hole has some tightening margin in a cold condition. In order to ease the operations of pullout and insertion of the piston pin, the pison must be heated.

1. Remove the two circlip of the piston pin.
2. Warm the piston in an oil bath maintained at about 80°C for approximately 15 minutes.
3. Pull out the pison pin, using the pullout implement for piston pin.

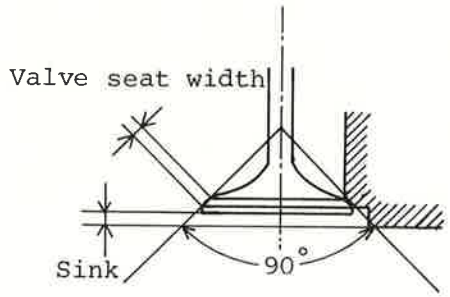
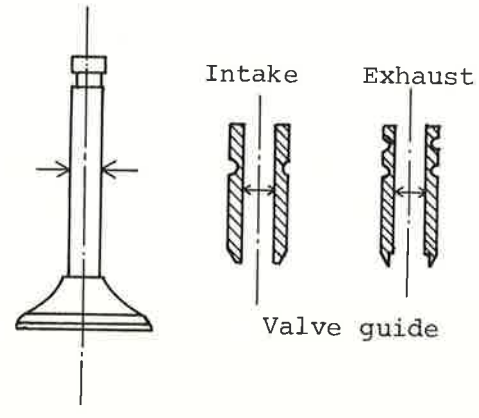
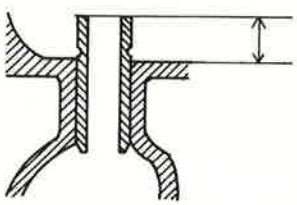
Measuring position	Remarks	Measuring Instrument
	Piston ring Thickness and breadth of piston rings o Breadth 1st compression ring Nominal size 2.5mm Limit of use -0.15mm 2nd, 3rd compression ring Nominal size 2.5mm Limit of use -0.15mm Oil scraping ring Nominal size 4mm Limit of use -0.15mm	Micrometer

Measuring position	Remarks	Measuring Instrument
	o Thickness 1st compression ring Nominal size 3.8mm Limit of use -0.3mm 2nd, 3rd compression ring Nominal size 3.8mm Limit of use -0.3mm Oil scraping ring Nominal size 3.8mm Limit of use -0.3mm Piston pin Maximum wear measured in (a) (b) directions at central position marked * Nominal size 30 mm Limit of use -0.08mm	Micrometer

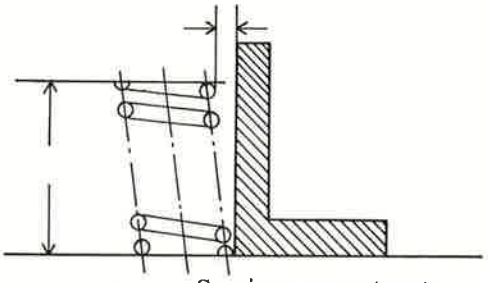
In the same manner, when the piston is coupled to the connecting rod, heat the piston only.

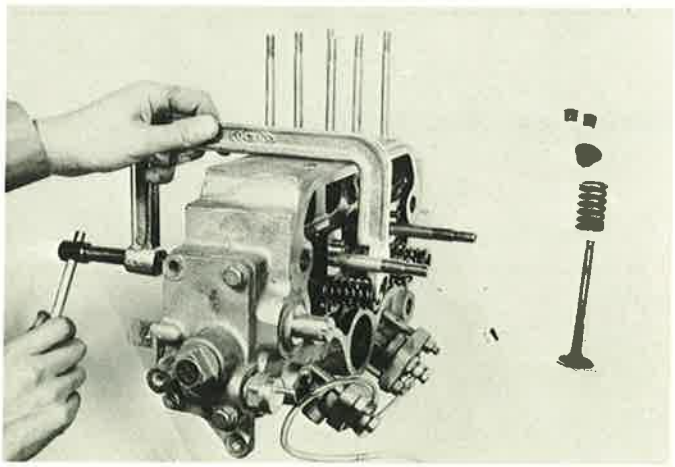
3-3-8 Valve Mechanism

Intake and Exhaust valve, valve guide

Measuring position	Remarks	Measuring Instrument
	Intake and exhaust valve seat width Nominal size 2.12mm Limit of use 2.5 mm	
	Sink Nominal size 1.15mm Limit of use -0.5 mm	Ruler Vernear calipers
	Intake and exhaust valve stem Nominal size 8 mm Limit of use -0.1 mm	Micrometer
	Intake and exaust valve guide Nominal size 8 mm Limit of use +0.1 mm	Innder diameter micrometer
	Protruding length of intake & exhaust valve guide Nominal size 10 mm	Ruler Vernear calipers

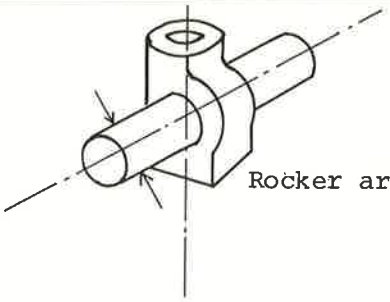
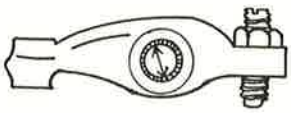
Intake and Exhaust valve spring

Measuring position	Remarks	Measuring Instrument
 Spring constant 2.26kg/mm	Spring free length Nominal size 40 Limit of use -2 Spring inclination Limit of use 1.5	Square Slide calipers



Remove the intake & exhaust valve with the valve lifter

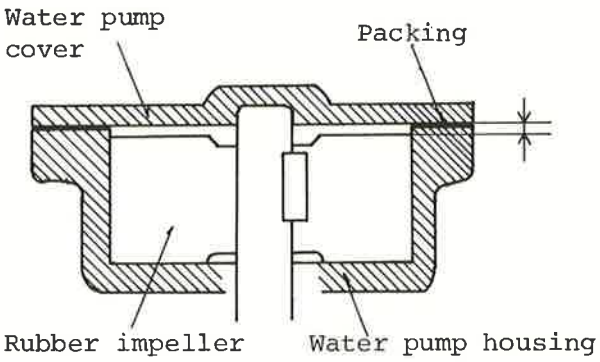
Rocker arm

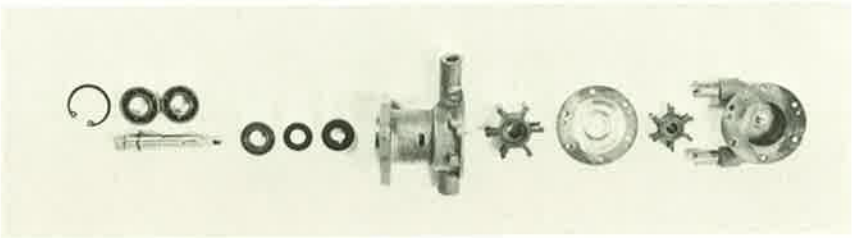
Measuring position	Remarks	Measuring Instrument
 Rocker arm support	Nominal size 17 mm Limit of use -0.1mm	Micrometer
 Rocker arm brush	Nominal size 17 mm Limit of use +0.1mm	Cylinder gauge

3-3-9 Fuel Injection Pump and Nozzle

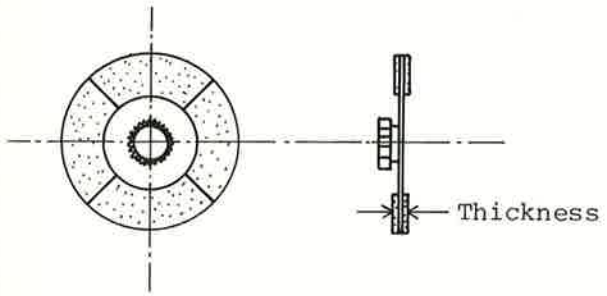
See

3-3-10 Cooling Water Pump

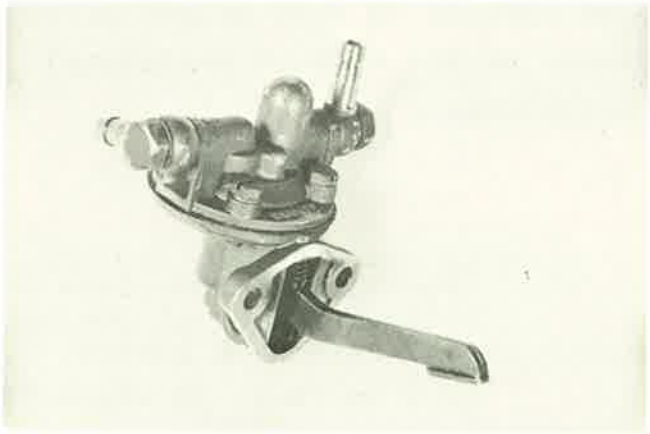
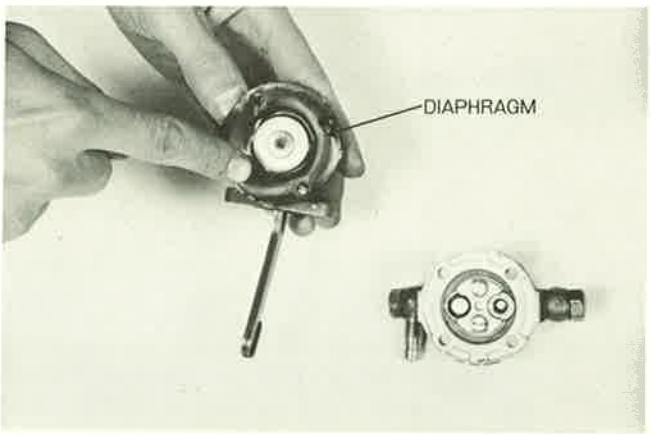
Measuring position	Remarks	Measuring Instrument
	Clearance between rubber impeller and water pump cover. When the clearance is 0.4 mm or more, replace the impeller.	Thickness gauge Ruler



3-3-11 Friction Disc and Reduction Gears

Measuring position	Remarks	Measuring Instruction
	Thickness of friction disc. Nominal size 6^{+03} mm Limit of use -1.5 mm Check each reduction gear visually for its degree of contact. Refer to Page for disassembly and re-assembly of the clutch.	Micrometer

3-3-12 Fuel Oil Feed Pump (For Reference)

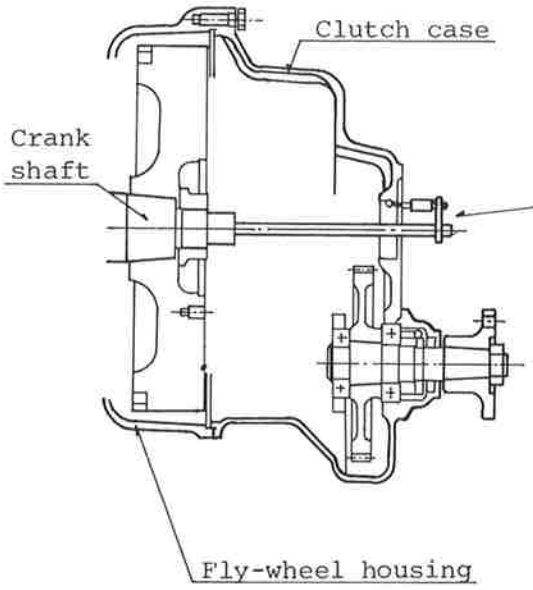
Measuring position	Remarks	Measuring Instrument
 	Check the diaphragm for scratches or breaks If replacement is required, replace it as a set with the fuel oil feed pump.	Visual check

3-3-13 Clutch Case Alignment

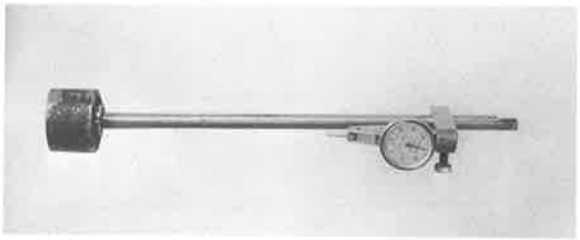
When replacing parts of the fly-wheel housing or clutch case, carry out the following procedures for the clutch case alignment, which should also be applied in case of deviations in the alignment at the time of mechanical repair and servicing.

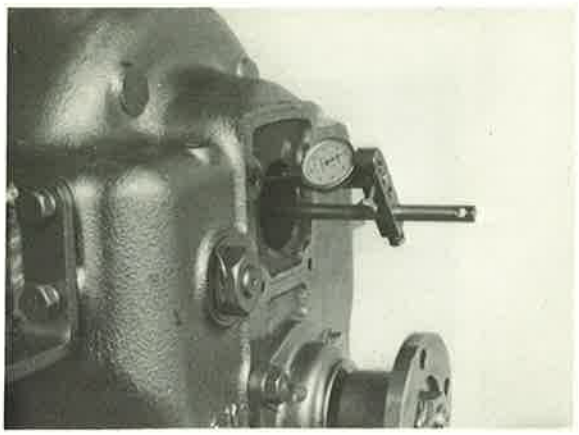
Permissible deviation of alignment for clutch hole against crank shaft:

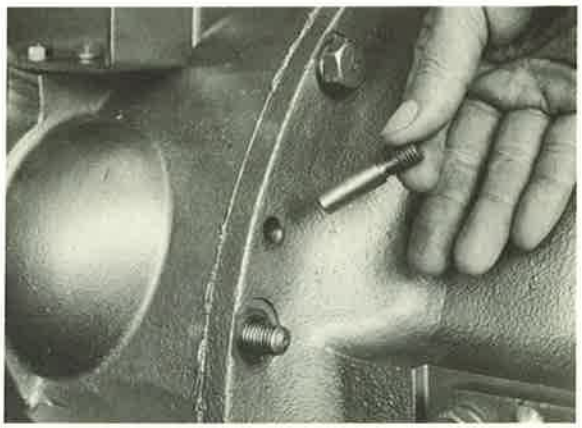
0.2 mm (Reading value of gauge)



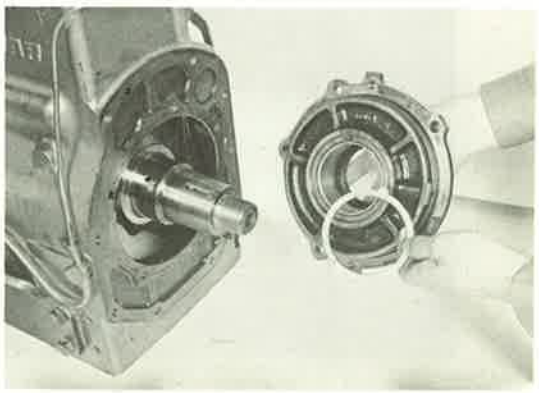
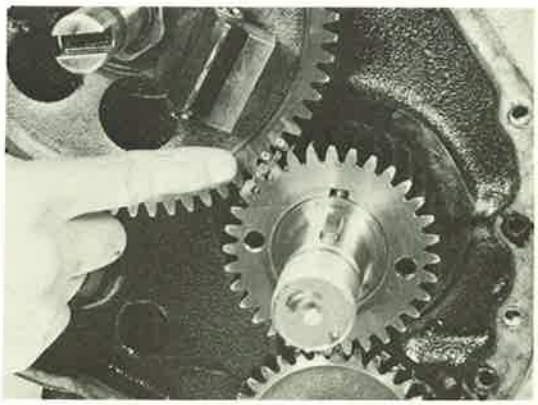
Pick Gauge attached with Magnet

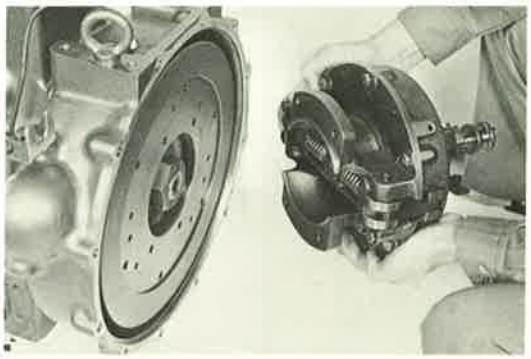






- Fix the clutch case temporarily to the fly-wheel housing.
- Attach the pick dial with a magnet to the end of the crank shaft and set the gauge.
- Rotate the crankshaft to read deflection of the gauge.
- Set the position of the clutch case so that the deflection of the gauge less than or equal to 0.2 mm.
- Set the knock pin to fix the position.

Item	Assembling Procecures	Point of Operation
	·Insert the crank shaft. ·Fit the main shaft holder. ·Check the thrust metal, paper packing and oil seal.	
	·Fit the crank gear. ·Arrange so that the timing marks (0 mark) match up.	

Item	Assembling Procedures	Point of Operation
5. Clutch	Note: When replacing parts of the clutch case or fly-wheel housing, or if the deviation of alignment for the clutch case hole against the core of the crank shaft is in excess of 0.2 mm, carry out alignment by referring to 3-3-13. ·Fit the fly-wheel housing. ·Paper packing ·Fit the fly-wheel key. ·Fit the fly-wheel. ·Fasten the end nut tightly. ·Do not strike the fly-wheel.	

Item	Assembling Procedures	Point of Operation
	·Install the clutch housing. ·Install the clutch case. ·Install the operating lever housing. ·Fit the cover of the rear bearing box. ·Check the needle for neutral setting and its spring.	

Classification		Name of Utensils	Prepa-rations		Rough Sketch
Inspection · Measuring	Dimension	• Measuring ruler • Slide Calipers • Micro Meter • Cylinder Gauge • Dial Gauge • Feeler Gauge • Square • Pick Gauge	To be provid-ed locally		
	Clamping Torque	• Torque Wrench (Max. 20 kg-m)	"		
	Nozzle	• Nozzle Tester	"	Jet pressure	
	Electric circuit	• Circuit Tester • Voltmeter • Ammeter • Insulating Gauge	"		
	Revolutions count	• Tachometer	"		
	Other	• Crack Inspec- • tion liquid • Jet volume Test • Hydraulic (water/oil) pressure tester • Compression Tester	"	Check for cracking and jet volume	
Mechanical Repair and Servicing		Valve fitting tool File Sand-paper Grinder Drill Tap Dies Vise Paint Standard tool number	Yanmar Option To be provid-ed locally Yanmar Standards		

Classification		Name of Utensils	Prepa-rations		Rough Sketch
		Measuring and Inspection Instruments	To be provid-ed locally		
		Oiler	Yanmar Standards		
		Other			
		Adhesives (water-proof, anti-solvent)	To be provided locally		
		Packing Sheet			

3-4 Bolts, Nuts and Tightening Torques

No.	Part	Diameter of thread	Tightening torque (kg-m)	Remarks
1.	Cylinder head tightening	M15 x 1.5	$18^{+1.5}$	176 Nm
2.	Connecting rod bolt	M10 x 1.25	5.5 ~ 6.0	
3.	Mounting bolt for main bearing body	M10	3.0 ~ 4.0	
4.	Mounting nut for flywheel	M36 x 2	25.0 ~ 30.0	Endnut
5.	Mounting nut for crankshaft pulley	M30 x 2	14 ~ 15	
6.	Mounting bolt for gear case	M8	2.0 ~ 2.5	
7.	Mouting bolt for mounting bracket	M10	4.0 ~ 5.0	
8.	Mounting nut for fuel oil injection pump	M8	2.0 ~ 2.5	
9.	Mounting nut for starting motor	M12	5 ~ 6	
10.	Fixing nut for cam shaft gear	M24 x 1.5	6 ~ 8	Counter-clockwise screw
11.	Mounting nut for valve arm support	M10	5.0 ~ 6.0	
12.	Mounting bolt for engine legs	M12	4.5 ~ 5.5	
13.	Head stud bolt			
14.	Clutch leg	M10	4.0 ~ 5.0	
15.	Mounting bolt for friction plate housing	M10	4.0 ~ 5.0	Flywheel
16.	Tightening bolt for friction plate	M18	2.0 ~ 2.5	

No.	Part	Diameter of thread	Tightening torque (kg.m)	Remarks
17.	Tightening nut for ahead shaft	M25 x 1.5	10 ~ 12	
18.	Tightening nut for intermediate shaft	M16 x 1.5	8 ~ 10	
19.	Tightening nut for large gear	M35 x 1.5	22.0 ~ 27.0	
20.	Tightening nut for flexible coupling	M10 x 1.25	4.0 ~ 5.0	
21.	Tightening nut for slit type coupling	M10	3.0 ~ 4.0	
22.	M6 bolts, nuts (other than the above stated)	M6	0.7 ~ 1.0	
23.	M8 " "	M8	1.5 ~ 2.0	
24.	M10 " "	M10	3.0 ~ 4.0	
25.	M12 " "	M12	5.0 ~ 6.0	
26.	M8 pipe joint bolt	M8	1.5 ~ 2.0	
27.	M12 "	M12	3.0 ~ 3.5	
28.	M16 "	M16	5.0 ~ 5.5	

3-5 Disassembly and Reassembly of Engine

3-5-1 General Precautions

Maintenance and inspection activity should be done as effectively as possible, avoiding unnecessary disassembling except for general overhauls.

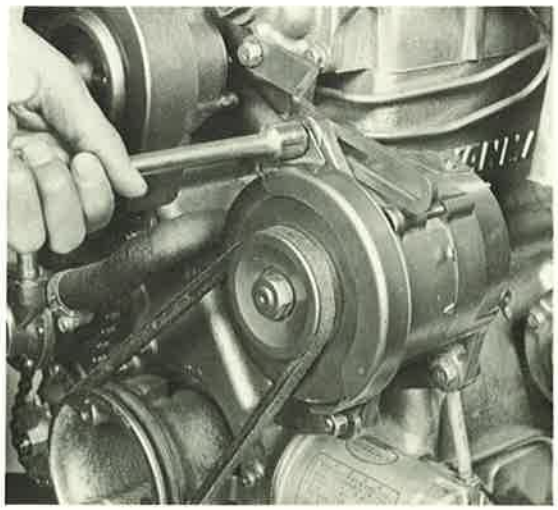
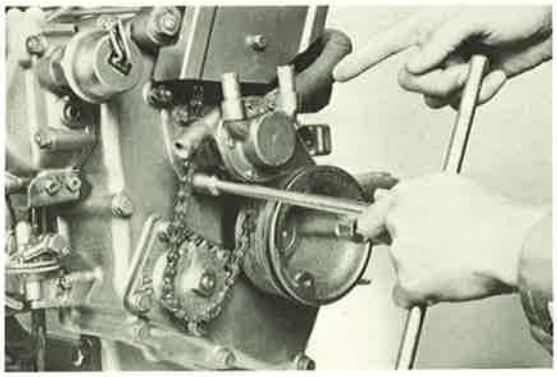
At the time of disassembly, record the presence of parts which require repair of replacement, and make arrangements beforehand for procurement of such parts so that problems will not occur during the reassembling operation.

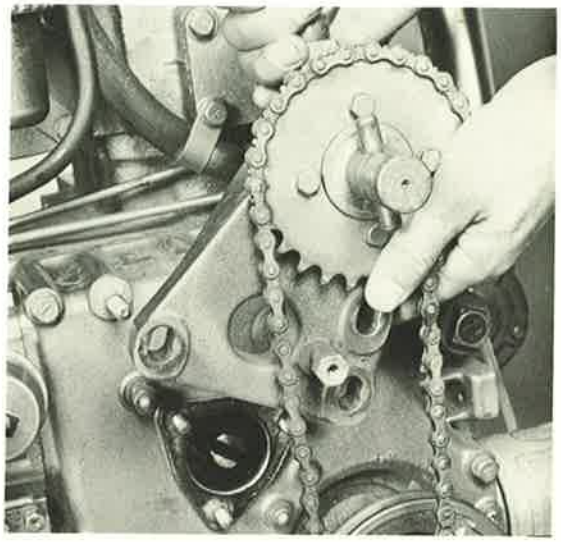
Warped washers and packings must necessarily be replaced with new ones.

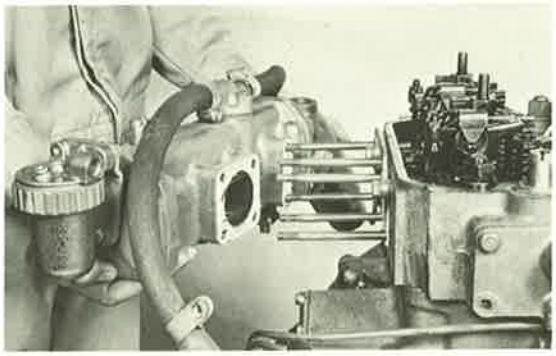
In assembling, sealing must be applied to all designated. Omission may cause serious trouble during a trial running of the engine after completion of reassembly. Adjustments should be performed in accordance with the instructions given.

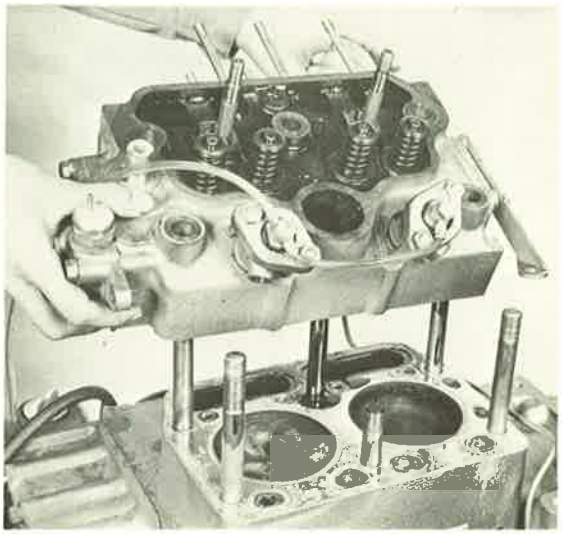
After completion of engine reassembly, recheck any deficiencies which might have appeared during maintenance and inspection, conduct a trial running of the engine and then submit it to the user.

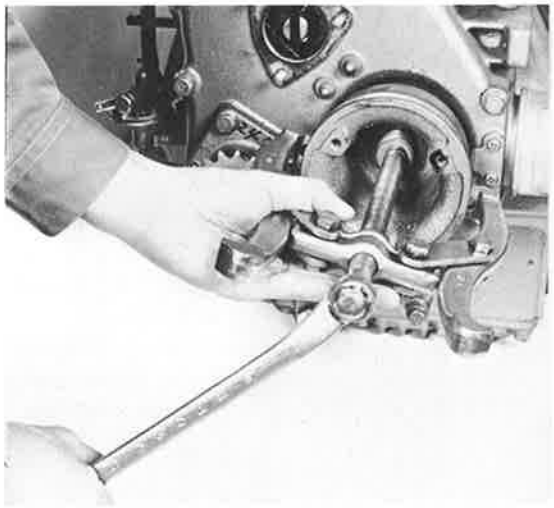
3-5-2 Disassembly Sequence

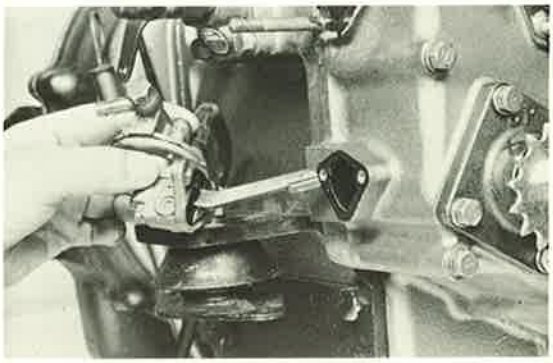
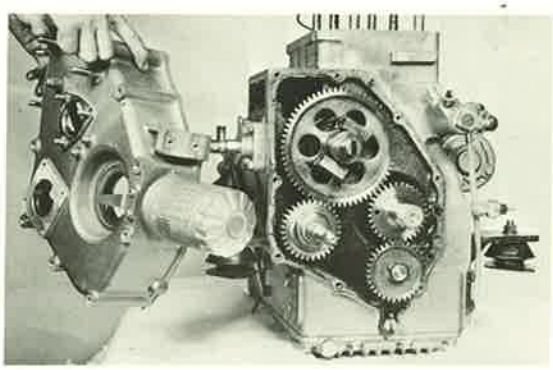
Item	Procedure	Point of Operation
1. Wiring, piping and wires	• Remove electrical wiring connected to the engine, piping for water cooling system, piping for fuel oil and remote control wires. Remove the cooling water and lube oil.	
2. Electrical provisions	• Remove the starting motor. • Loosen tension of the alternator, and remove the V-belt. • Then remove the alternator, tension adjuster, and bracket.	
3. Cooling water pump	• Remove the cooling water pipe (pump outlet through cylinder body. • Remove the cooling water pump.	

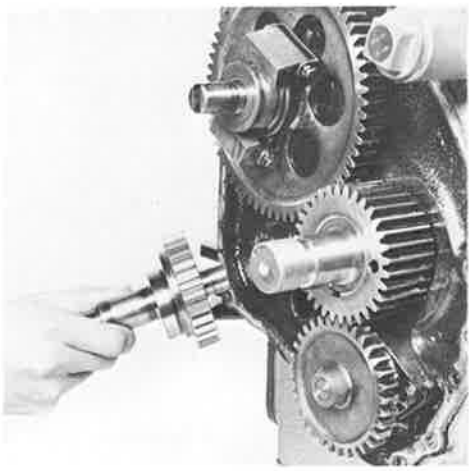
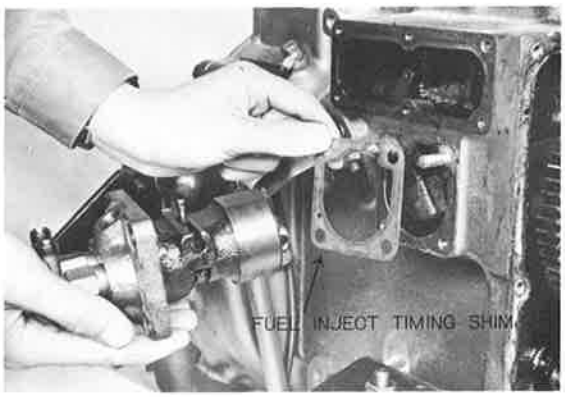
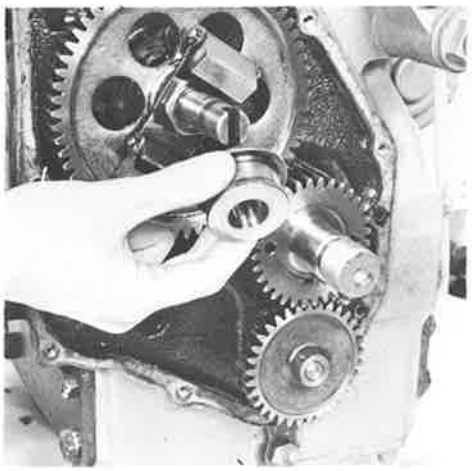
Item	Procedure	Point of Operation
4. Manual starter	• Remove the chain cover. • Loosening the tension, remove the chain and starting shaft.	
5. Rocker arm cover	• Remove the rocker arm cover together with the air cleaner.	

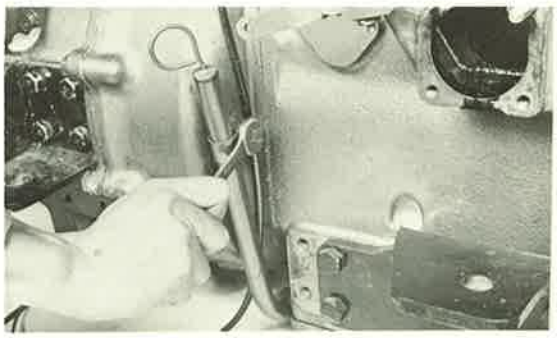
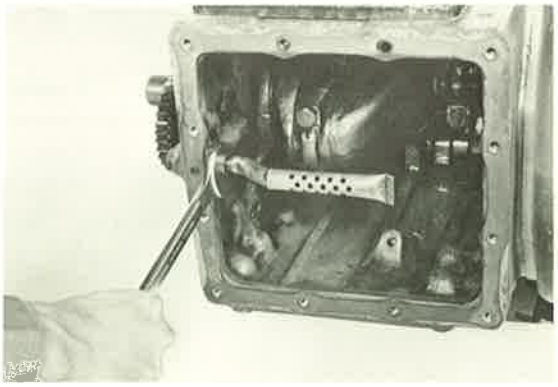
Item	Procedure	Point of Operation
6. Exhaust manifold	• Remove the cooling water pipe located at the sides of the cylinder body and the cylinder head. • Remove the fuel oil pipe (at the filter side). • Remove the exhaust manifold.	
7. Rocker arm	• Remove the rocker arm, then take out the push rod. Make an indication to distinguish between the first and second cylinders, and between the intake and exhaust.	

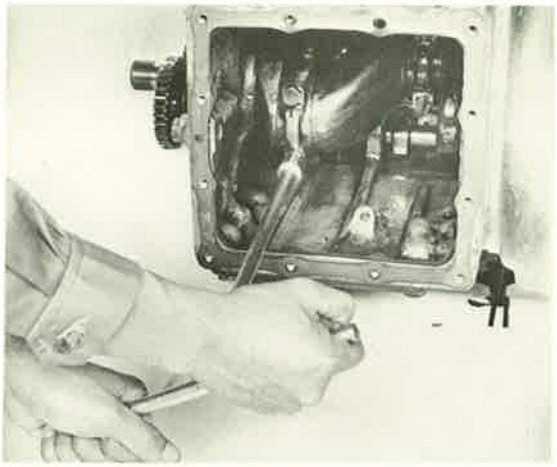
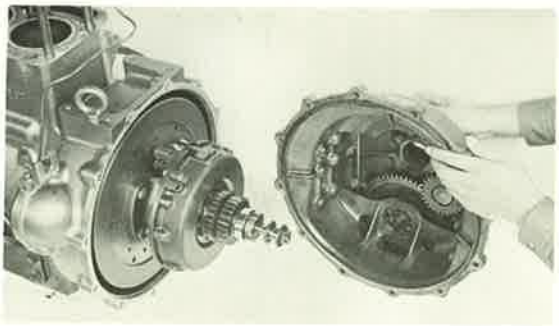
Item	Procedure	Point of Operation
8. Cylinder head	• Remove the fuel oil injection pipe, fuel oil return pipe and lube oil pipe. • Remove the cylinder head. • Remove the gasket packing (note a distinction between its front and back).	
	• Remove the tachometer gear case.	

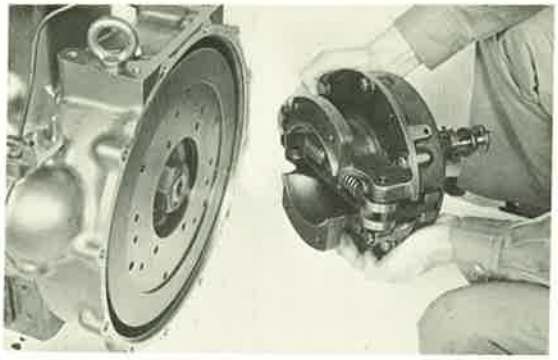
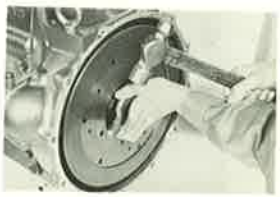
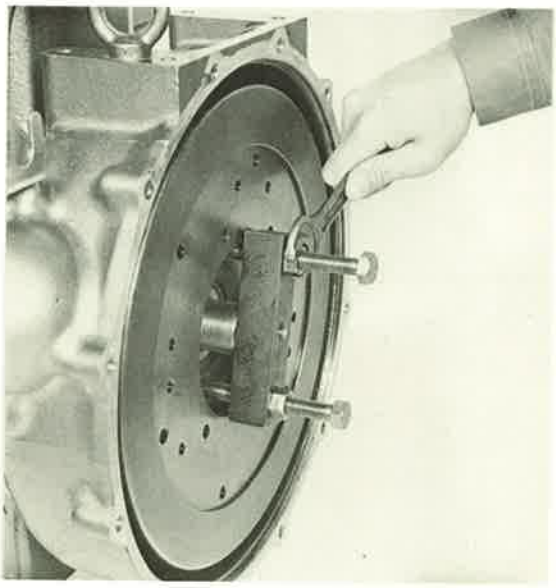
Item	Procedure	Point of Operation
	• Remove the V-pulley on the crankshaft and the end nut.	
9. Governor link	• Remove the lid attached to the fuel oil injection pump chamber. • Remove the governor link and the regulator spring. 	

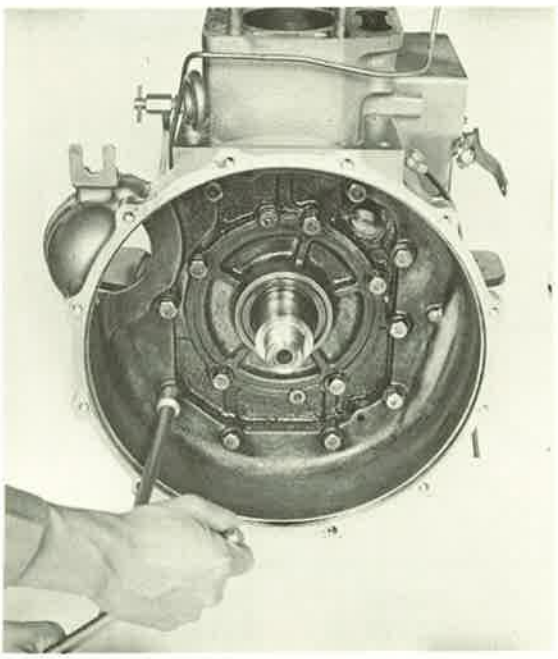
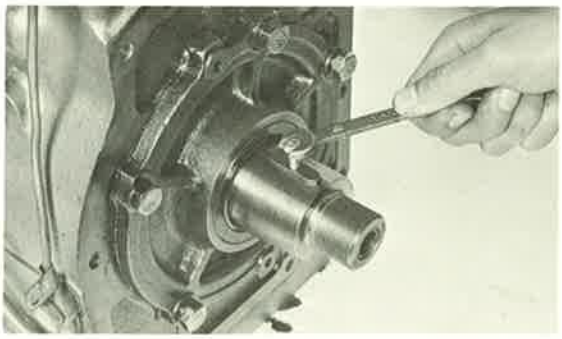
Item	Procedure	Point of Operation
10. Gear case	• Remove the fuel oil feed pump.	
	• Remove the starting chain sprocket and the lid.	
	• Remove the gear case.	

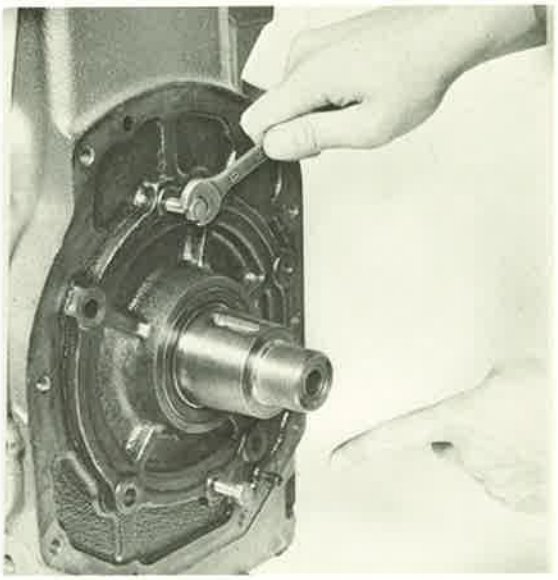
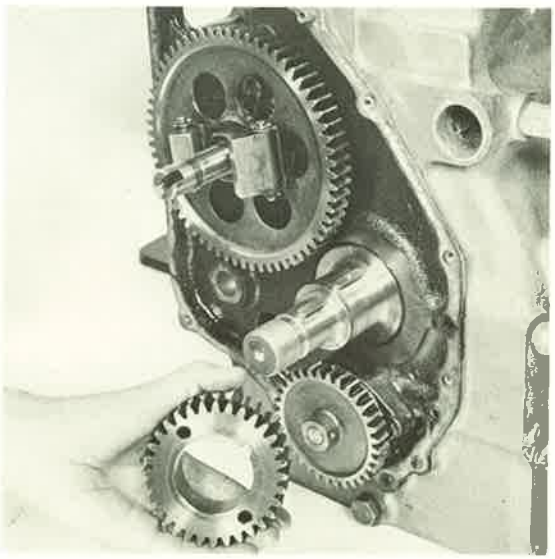
Item	Procedure	Point of Operation
	• Remove the starting shaft and the gear.	
	• Remove the fuel oil injection pump (injection timing adjusting plate).	
	• Remove the governor sleeve.	

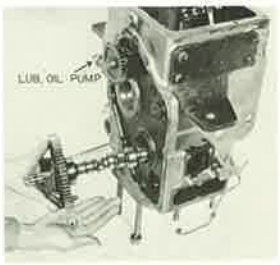
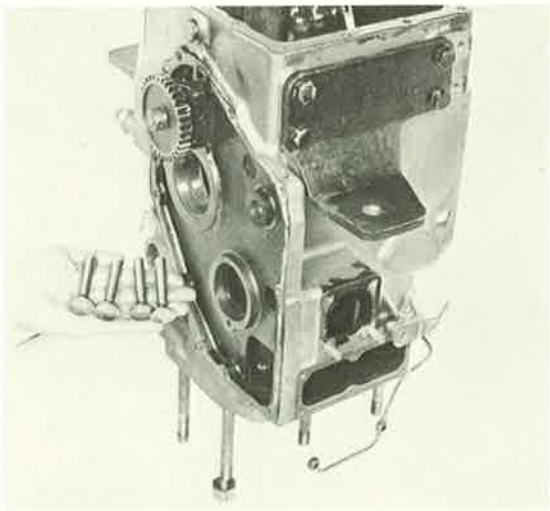
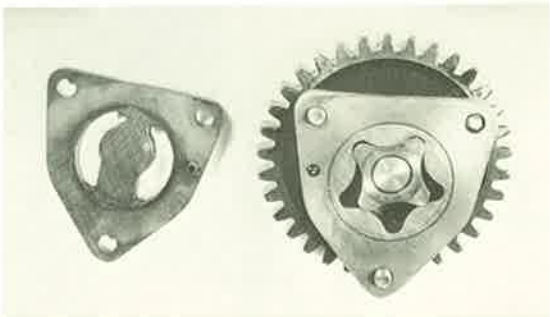
Item	Procedure	Point of Operation
11. Piston	• Remove the oil dipstick.	
	• Remove the oil pan. • Remove the lube oil inlet pipe.	
		

Item	Procedure	Point of Operation
	• Remove the connecting rod bolt, and then pull out the piston connecting rod assembly. (Make an indication to distinguish between the first and second cylinders)	
12. Clutch	• Remove the lid of the rear bearing box, then the clutch lever assembly.	
	• Remove the clutch case.	

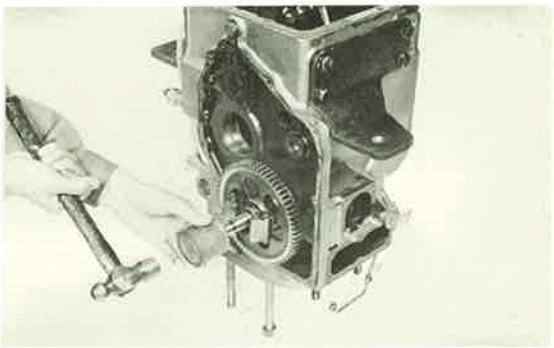
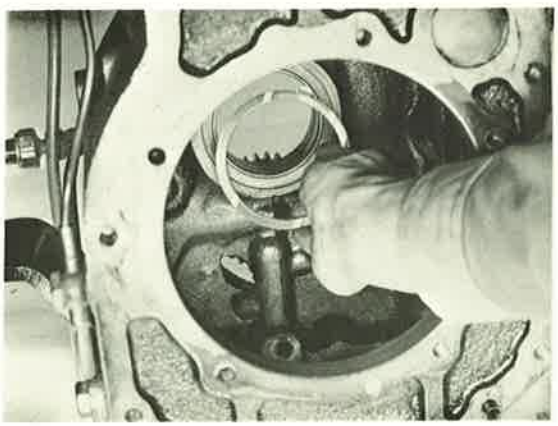
Item	Procedure	Point of Operation
	• Remove the clutch assembly.	
13. Crank-shaft	• Remove the flywheel. 	

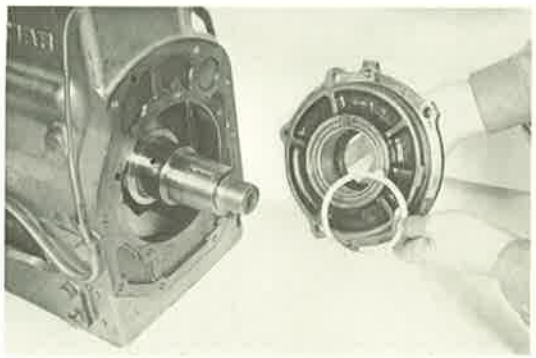
Item	Procedure	Point of Operation
	• Remove the flywheel housing.	
	• Remove the flywheel key.	

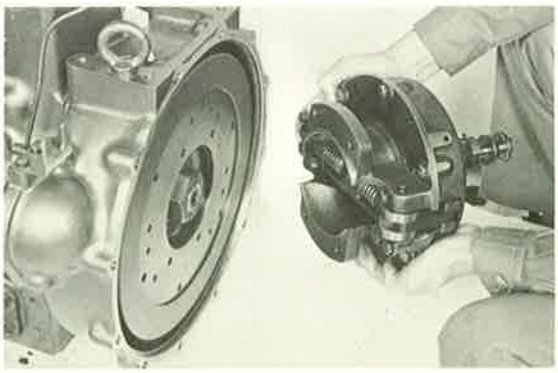
Item	Procedure	Point of Operation
	• Remove the main bearing body, and push the two mounting bolts through the upper and lower holes.	
	• Removing the crank gear, pull out the crankshaft. 	

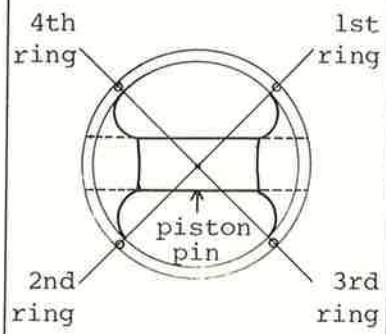
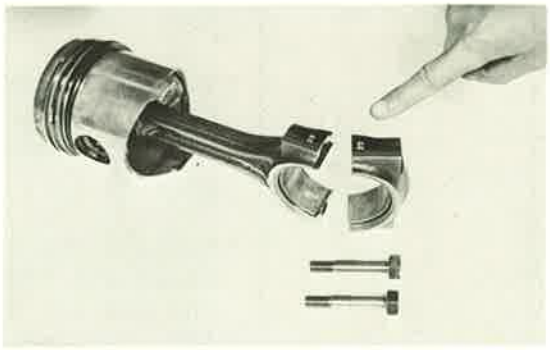
Item	Procedure	Point of Operation
	• Pull out the cam shaft and the tappet. (Make an indication to distinguish between the first and second cylinder, and between the intake and exhaust.) 	
	• Remove the lube oil pump.	

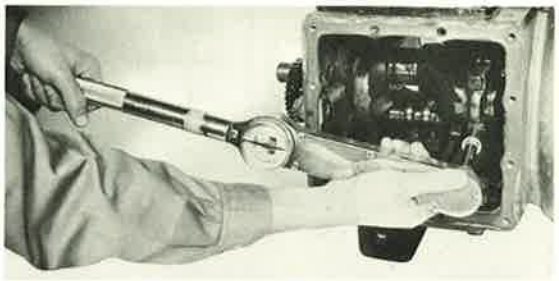
3-5-3 Reassembly Sequence

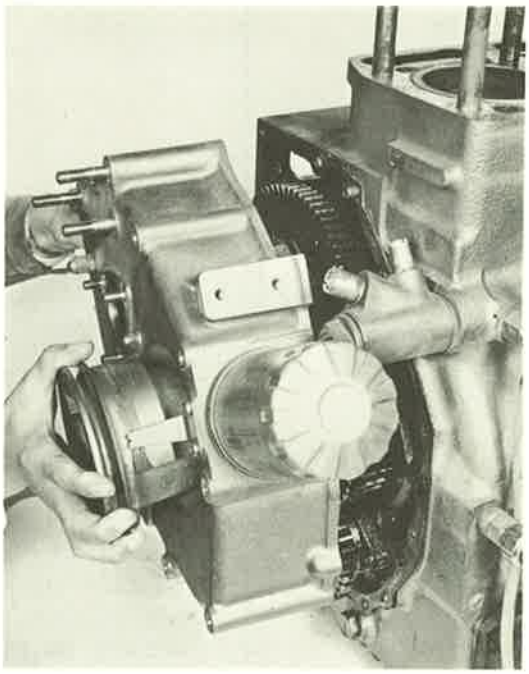
Item	Reassembly procedure	Point of Operation
1. Lube oil pump	• Replace the lube oil pump.	
2. Tappet	• Insert the tappet, making sure that the first and second cylinders, and the intake and exhaust are appropriately distinguished.	
3. Cam shaft	• Insert the cam shaft • Placing the wooden fitting on the cam shaft, drive it in with a hammer. • After checking for smooth turning, tighten the ball bearing setting bolts.	
4. Crankshaft	• Insert the thrust metal into the gear case side, directing the portion with the oil gutter towards the crankshaft. • Take special care regarding the protruded portion.	

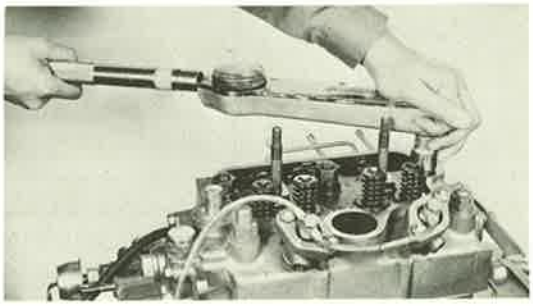
Item	Reassembly procedure	Point of Operation
	• Insert the crank shaft. • Attach the main bearing body, and check the thrust metal, paper packing and oil seal.	
	• Attach the crank gear. Adjust the timing mark (zero mark).	

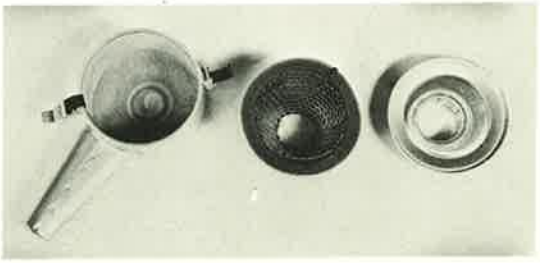
Item	Reassembly procedure	Point of Operation
5. Clutch	• Insert the flywheel key. • Put the flywheel housing in place with the paper packing. • Install the flywheel and tighten the end nut firmly. • Do not tap the flywheel. • Install the clutch assembly • Install the clutch case. • Install the clutch lever assembly. • Attach the lid of the rear bearing box, checking the needle for neutral setting and its spring.	

Item	Reassembly procedure	Point of Operation
6. Pistons	• Insert a piston • Confirm the presence of the crank pin metal. • Identifying the number marked on the larger end of the connecting rod, rod towards the injection pump side. • The relation among the four piston rings is as in the following figure:  • Clearly distinguish the first cylinder and the second cylinder.	 

Item	Reassembly procedure	Point of Operation
	• Tighten the connecting rod bolt with a tightening torque of 5.5~6.0 Kg-m.	
7. Oil pan	• Attach the lube oil inlet pipe. • Install the oil pan with paper packing in place. • Install the oil dipstick pipe with copper packing in place.	
	• Install the fuel oil injection pump. •Injection timing adjusting plate.	
8. Gear case	• Insert the starting shaft and the gear. • Attach the governor sleeve.	

Item	Reassembly procedure	Point of Operation
	• Install the gear case and the V-pulley for the crankshaft. • In order to protect the lip of the oil seal, after fixing the gear case to the V-pulley, the assembled unit should should be installed to the engine body. • End nut • Paper packing • Attach the starting chain sproket and its lid with paper packing. • Install the fuel feed pump with paper packing. • Connect the governor link and the regulator spring. • Attach the lid of the fuel oil injection pump chamber with paper packing. • Attach the tachometer gear case with paper packing in place.	

Item	Reassembly procedure	Point of Operation
9. Cylinder head	• Place the gasket packing, confirming which is front and back. • Install the cylinder head with a tightening torque Of 18±1.5 Kg-m. • When tightening the nuts, tighten them diagonally in turn from inside to outside. • Attach the fuel oil injection pipe, fuel oil return pipe and lube oil pipe with copper packing inserted.	
10. Rocker arm	• Insert the valve thrusting rods, confirming the distinction between the first and second cylinders and the intake & exhaust. • Attach the valve arms, confirming the distinction between the first and second cylinders.	

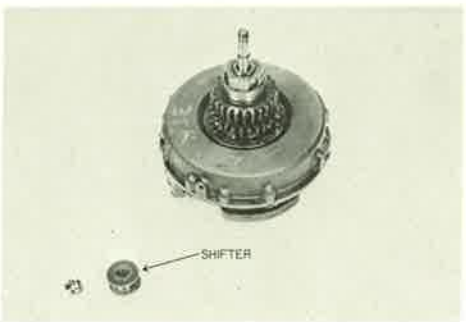
Item	Reassembly procedure	Point of Operation
11. Exhaust manifold	• Install the exhaust manifold with gasket packing inserted. • Attach the fuel oil pipe. • Attach the cooling water pipe.	
	• Install the valve arm chamber with copper packing inserted.	
12. Manual starter	• Attach the chain and the starting shaft. • Attach the chain cover.	
13. Cooling water pump	• Remove the cooling water pump. Paper packing. • Remove the cooling water pipe.	

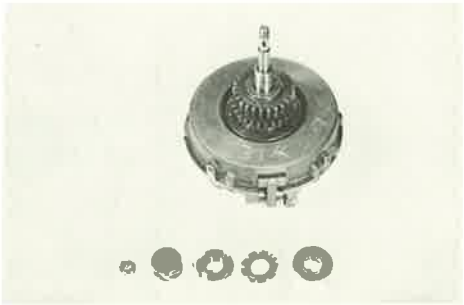
Item	Reassembly procedure	Point of Operation
14. Electrical provisions	• Attach the alternator, tension and bracket. • Attach the V-belt and adjust so that a sag of about 10 to 15mm results when pushing by hand on the center of the belt. • Install the starting motor.	
	• Connect all wiring and piping requiring for electrical cooling water, fuel oil and remote control systems.	

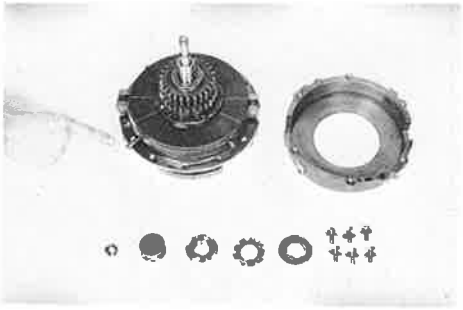
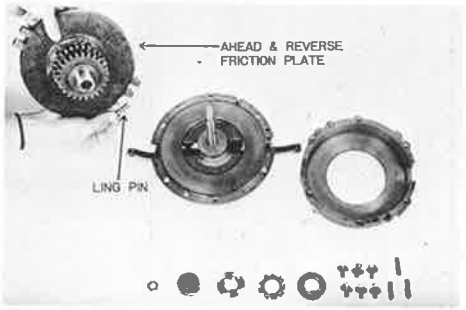
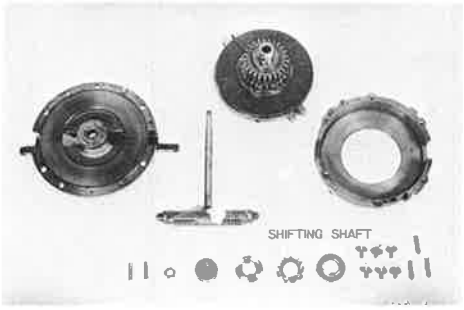
3-5-4 Disassembly and Reassembly of Major Components

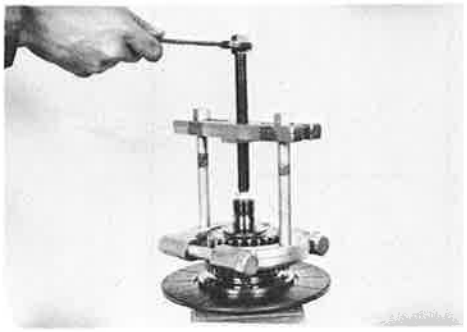
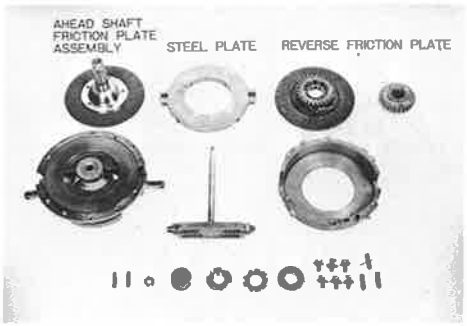
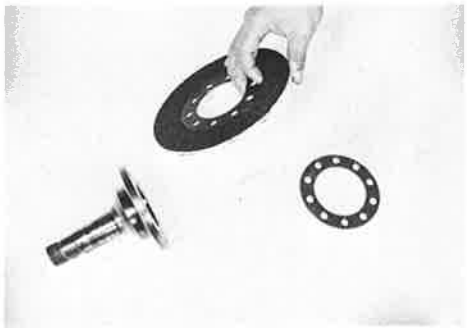
A) Clutch

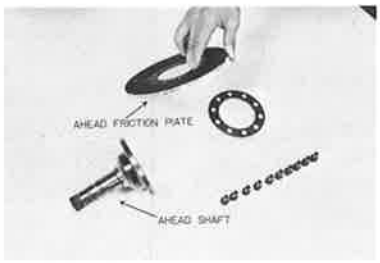
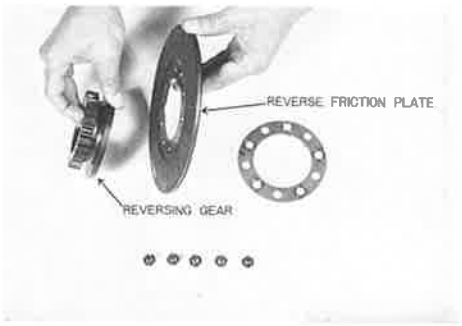
A-① Disassembly Sequence

Item	Procedure	Point of Operation
1. Clutch Assembly	• Remove the nut and the shifter.	 

Item	Procedure	Point of Operation
	• Remove the lock nuts.	
	• Remove the ball bearing.	

Item	Procedure	Point of Operation
	• Remove the housing (B). • Positioning needles and springs (four units each).	
	• Pull out the link pin. • Remove the ahead & astern friction plate assembly.	
	• Take out the shifting shaft.	

Item	Procedure	Point of Operation
	• Take out the ahead gear.	
	• Remove the ahead shaft, friction plate assembly and steel plate. • Check each friction plate and steel plate for defects.	 

Item	Procedure	Point of Operation
	• Remove the ahead and astern friction plates. 	

A-② Disassembly Sequence

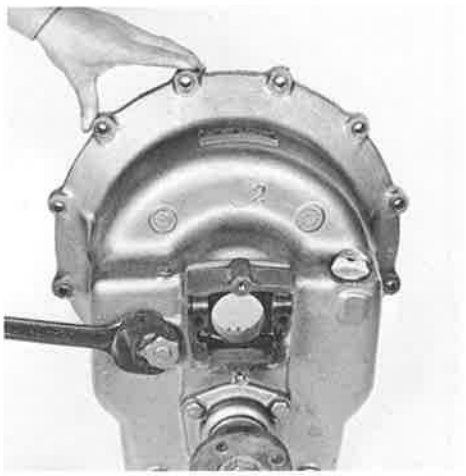
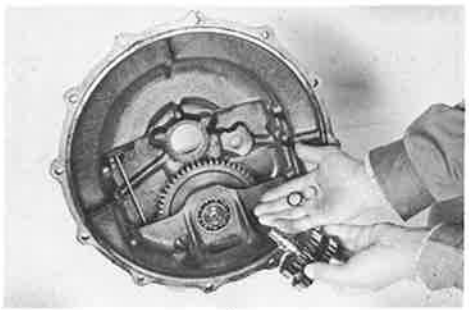
Item	Procedure	Point of Operation
1. Clutch structure	•Fit the ahead disc plate and astern disc plate to the ahead shaft and astern gear respectively, making sure that the connecting wire is passed through toward the bolt-fastening direction. •Assemble the ahead shaft disc plate and astern gear disc plate with the steel plate between. •Install the foreward gear. •Pass the shifting shaft through the housing (A) •Install the ahead/astern disc plate device. •Fit the link pin. •Insert the positioning needless and springs at 4 places on the steel plate.	

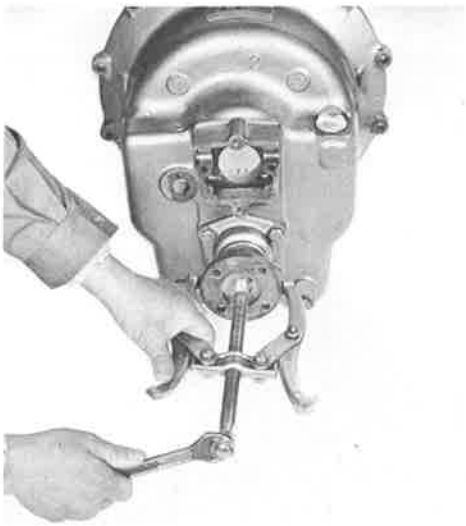
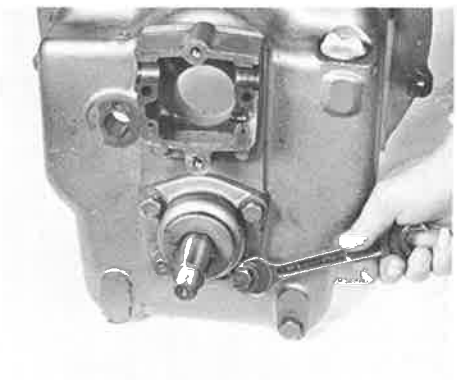
Item	Procedure	Point of Operation

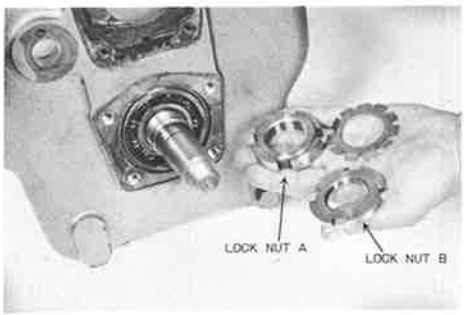
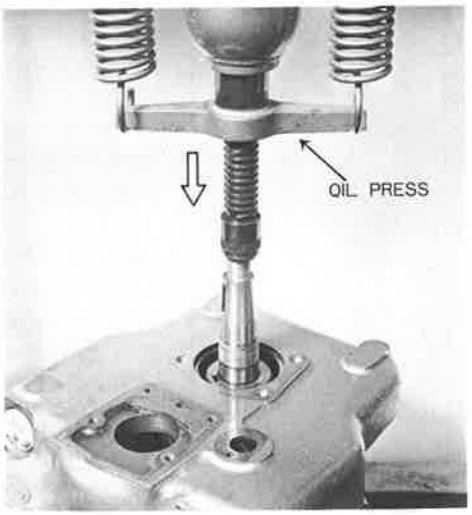
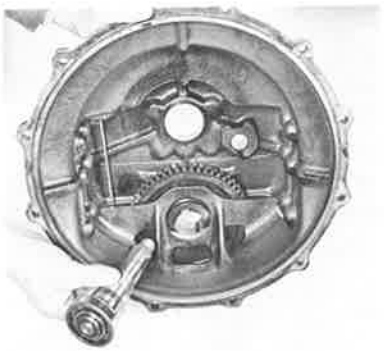
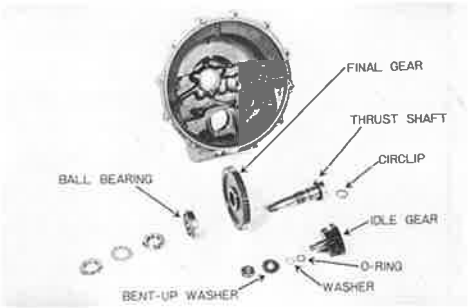
	• Install the housing (B)
	
	• Fit the ball bearings.
	
	• Attach the bend washer and lock nuts.
	
	  • Use a new bend washer.
	
	  • Make sure after bending that the washer does not hamper the function of the bearings.
	
	• Fit the shifter nut and bend the split cotter pin.
	
	  • Use a new split cotter pin.
	
	• After assembly, confirm that the ahead and astern gears rotate lightly.	

B) Clutch Reduction Part

B-① Disassembly Sequence

Item	Procedure	Point of Operation
1. Idle Gear	Straighten the bend washer and detach the lock nuts.	
	• Remove the washer, O-ring and idle gear.	

Item	Procedure	Point of Operation
2. Thrust shaft	• Pull out the coupling. • Detach the key.	
	• Remove the rear cover. • Check for damage of the oil seal.	

Item	Procedure	Point of Operation
	• Remove lock nuts (A), (B) and the bend washer.	
	• Pull out the thrust shaft. • Detach the final gear.	
	 Development of Clutch Reduction part. →	

B-② Assembly Sequence

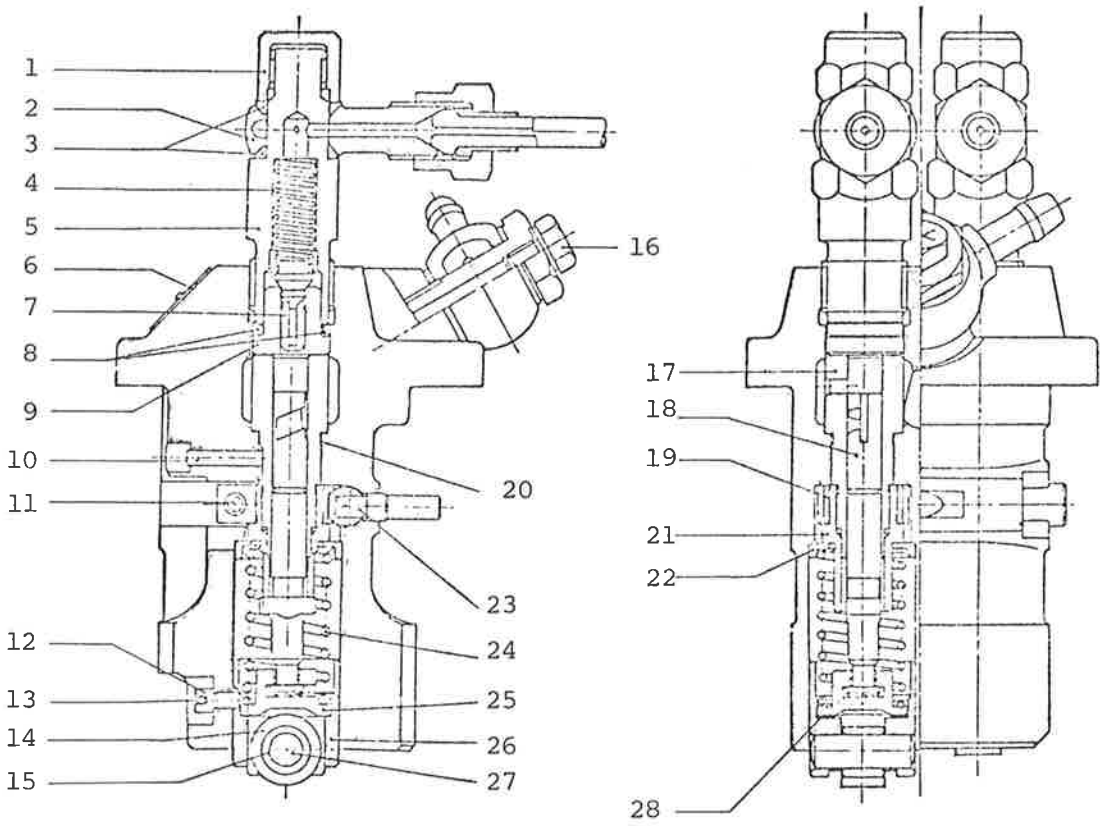
Item	Procedure	Point of Operation
1. Thrust shaft	• Put the final gear in the clutch case. • Mount a bearing checking clip on the thrust shaft. • Confirm that the clip is closely set in the groove of the shaft. • Pass the thrust shaft through the final gear. • Insert the bearing and fasten the lock nut (A). • Insert the bend washer and fasten the lock nut (B). Bend the washer toward both lock nuts (A) and (B). • Install the rear cover. • Install the coupling. • Bend the washer. • Confirm the rotational functioning of the thrust shaft.	

Item	Procedure	Point of Operation
2. Idle gear	•Pass the idle shaft through the idle gear. •Install the idle shaft and gear housing on the clutch case. •Fit the O-ring, washer and bend washer to the idle shaft. •Fasten the lock nut. ·Bend the washer •Confirm the rotational functioning of each shaft and gear after the assembly.	

C) Fuel Injection Nozzle (Refer to P4-2)

◦Tools and instruments required:

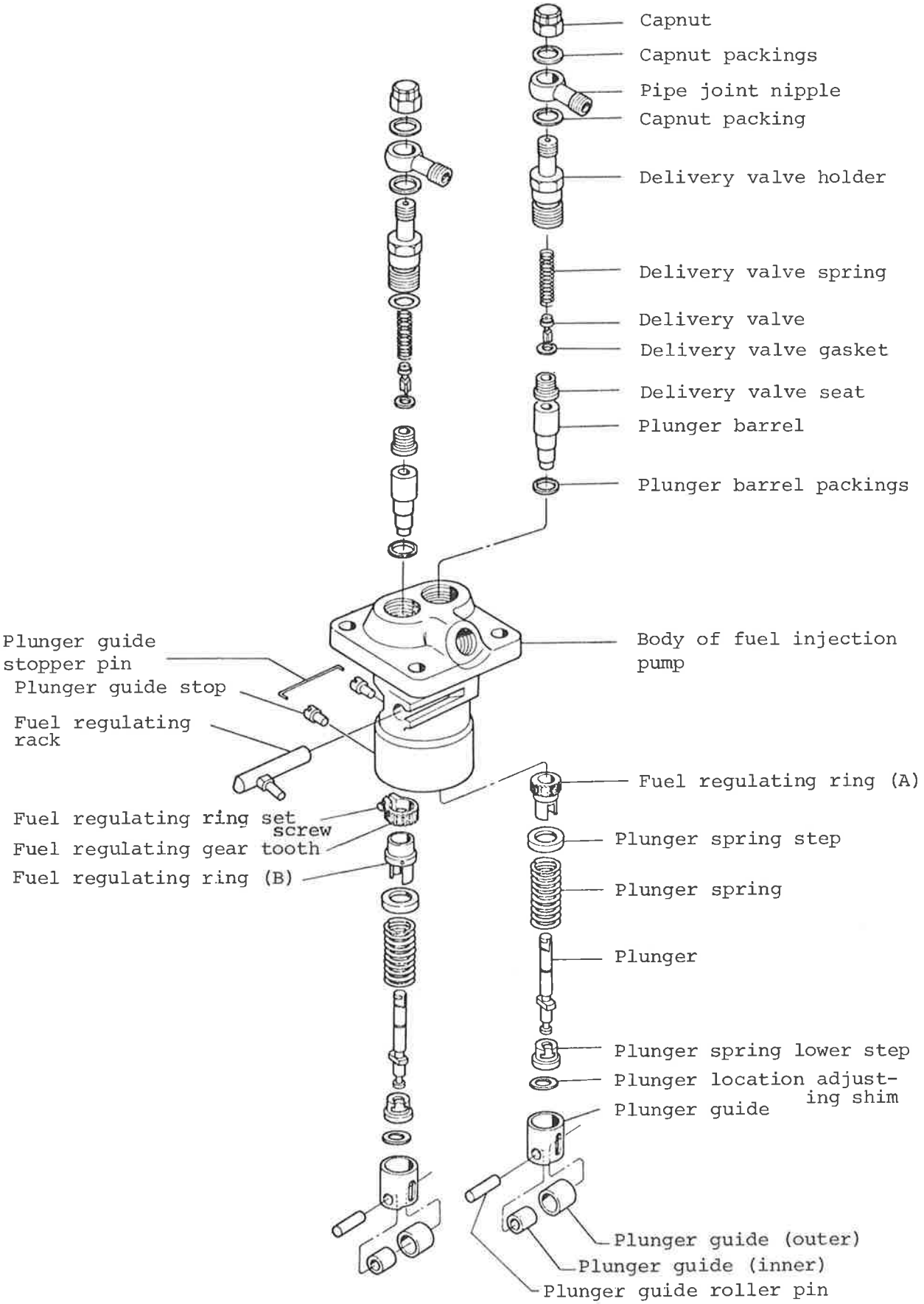
Spanner (17, 19 mm), - screwdriver, tweezers, scriber, radio pliers (diagonal pliers), delivery valve seat puller, parts tray for overhaul, treated oil.



1. Capnut
2. Spherical single joint
3. Packing for capnut
4. Delivery valve spring
5. Delivery valve holder
6. Rating plate
7. Delivery valve
8. Gasket
9. Delivery valve seat
10. Plunger barrel turn checking pin
11. Adjusting gear set screw
12. Plunger guide stop
13. Plunger guide set checking pin
14. Plunger guide roller (outer)
15. Plunger guide roller (inner)
16. Air vent plug
17. Plunger barrel
18. Plunger
19. Fuel regulating gear
20. Plunger barrel packings
21. Fuel regulating ring (B)
22. Plunger spring step
23. Regulating lever
24. Plunger spring
25. Plunger spring lower step
26. Plunger guide
27. Plunger guide roller pin
28. Plunger location adusting shim

* Genuine parts for the delivery valve and plunger consist of the delivery valve and delivery valve seat and plunger and plunger barrel respectively.

Breakdown of Fuel Injection Pump

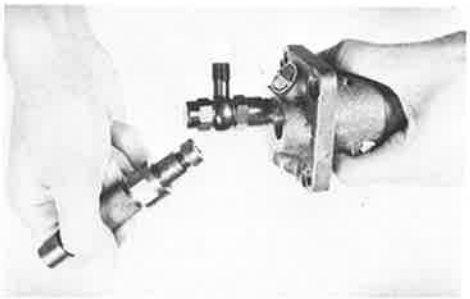


* In principle, a pump should not be disassembled, but if it is unavoidable to do so, the work must follow the following instructions:

C-① Disassembly instructions

A distinction must be made between the left and right pumps facing the dial plate at the upper part of the body. In carrying out the disassembly work, keep the relevant parts of the right and left pumps separate. (Use two containers to separately accommodate removed parts, otherwise reassembly will be impossible.)

No.	Disassembly Sequence	Tool	Remarks
1	Detach the plunger guide stopper pin.	Radio pliers. (Diagonal pliers)	
2	Detach the left plunger guide stop.	By hand	To detach, turn the stop downward while pressing the plunger guide with the palm.
3	Take out the left plunger guide.	By hand	
4	Remove the left plunger, plunger spring lower step and plunger location adjusting shim.	By hand	Be careful not to damage the plunger. Also check visually for damage and wear.
5	Remove the left plunger spring	By hand	
6	Remove the left plunger spring upper step.	By hand or tweezers	

No.	Disassembly Sequence	Tool	Remarks
7	Remove the left fuel regulating ring.	By hand	
8	Remove the capnut for the left delivery valve holder.	Spanner 17.	
9	Remove the left side delivery valve pipe joint nipple and 2 packings.	By hand	
10	Remove the left delivery	Spanner 19	Be careful not to damage the O-ring
11	Remove the left delivery valve spring.	By hand	
12	Remove left delivery valve, delivery valve seat and packings together. Visually check for damage and wear on the delivery valve and delivery valve seat respectively.	By hand	
13	Take out the left plunger barrel.	By hand	Be careful not to damage the joined part of the delivery seat.
14	Since the right fuel regulating gear tooth is separated into the regulating ring and the regulating gear, the jointed part of the two must be marked.	By scriber	If not marked, re-assembly will be impossible.
15	Loosen the right fuel regulating ring set screw.	Screw-driver	

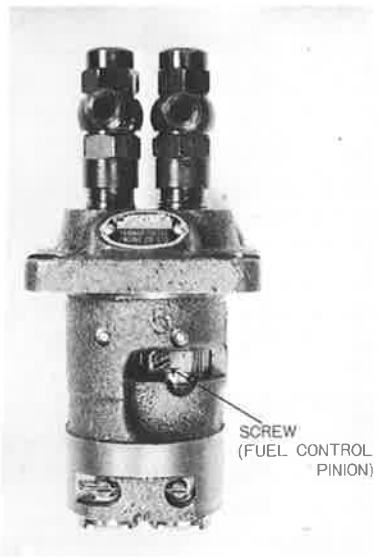
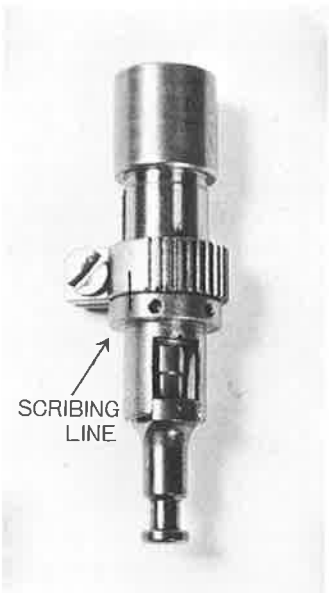
No.	Disassembly Sequence	Tool	Remarks
16	Apply the same procedures given in the above (2) ~ (6) to the right unit.		
17	Remove the right fuel regulating ring (B).	Tweezers	Be careful not to twist the existing gear engagement.
18	Apply the same procedures given in the above (8) ~ (13) to the right unit.		
19	Remove the right fuel regulating gear tooth.	By hand	
20	Remove the fuel regulating rack.	By hand	
21	Remove the left/right plunger barrel packings.	Tweezers	

C-② Assembly instructions

Be careful not to mix the parts of the right and left units.

No.	Disassembly Sequence	Tool	Remarks
1	Set the left plunger barrel packings.	Tweezers	
2	Insert the left plunger barrel.	By hand	Be careful to insert according to the corresponding groove of the barrel checking pin.
3	Set the left delivery valve, delivery valve seat and packings together.	By hand	
4	Set the left delivery valve spring.	By hand	

No.	Disassembly Sequence	Tool	Remarks
5	Tighten the left delivery valve holder. Torque wrench.	Torque:	Tightening torque $4\ ^{+0.5}_{0}$ kg.m.
6	Set the left side delivery valve pipe joint nipple and 2 packings.	By hand	Be careful not to misplace the front and reverse side of the packings.
7	Tighten the capnut for the left delivery valve.	Spanner 17	
8	Insert the fuel regulating rack.	By hand	Be careful of the inserting direction.
9	Insert the left fuel regulating ring (A).	Tweezers	Confirm that the corresponding mark with the rack is met. 
10	Insert the upper receiving step of the left plunger spring.	Tweezers	Be careful not to misplace the front and reverse side of the receiving step.
11	Insert the left plunger spring.	By hand	
12	Insert the left plunger.	By hand	Set the corresponding mark carefully to avoid damage to the device.
13	Set the lower receiving step of the left plunger spring.	By hand	

No.	Disassembly Sequence	Tool	Remarks
14	Set the plunger location adjusting shim.	By hand	
15	Insert the left plunger guide	By hand	
16	Set the left plunger guide stop.	By hand	Set the stop by pressing the plunger by hand. (Press the plunger guide by moving the rack so that the plunger by collar can be fixed into the groove of the regulating gear tooth.)
17	Place only the right fuel regulating gear tooth in the pump body.	By hand	
18	Apply the same procedures given in the above (1) ~ (7) to the right unit.		
19	Insert the right fuel regulating gear tooth in the pump body. 	Screw-driver	Confirm that the corresponding scribing lines of both the regulating ring and regulating gear tooth register together. 

No.	Disassembly Sequence	Tool	Remarks
20	Apply the same procedure given in the above (10) ~ (16) to the right unit.		
21	Set the plunger guide checking pin.	By hand and radio pliers.	

C-③ Air vent when engine is out of fuel after Disassembly/Assembly.

In case air is collected in the fuel pump, the engine occasionally does not start or stops during operation. It is consequently necessary to carry out an "air vent" according to the following steps:

1) Feed fuel with the fuel pump running and loosen the air vent bolt.

2) Let the pump run as it is for 5~10 sec., and then tighten the air vent bolt.

C-④ Test and adjustment instructions

In case engine trouble is attributed to the performance of the fuel injection pump, or whenever any parts of the pump are replaced, a test must be carried out according to the following procedures.

* Test for moving resistance of fuel regulating rack

1) This test is carried out so as to find out the moving resistance of the fuel regulating rack since some engine troubles (such as hunting, high revolution and so on.) result from an irregularity in it.)

2) Testing method

Remove the fuel injection pump from the engine and hold the fuel regulating rack vertically by laying the pump down horizontally. Moving the rack with a light weight, observe whether the movement is smoothly made throughout the full travelling bounds. Change the position of the rack up and down for a thorough check.

3) In case of excessive moving resistance, the following troubles may be the cause, and the pump needs to be disassembled for either cleaning or repair.

a) Excessive resistance at the rotating part of the plunger housing.

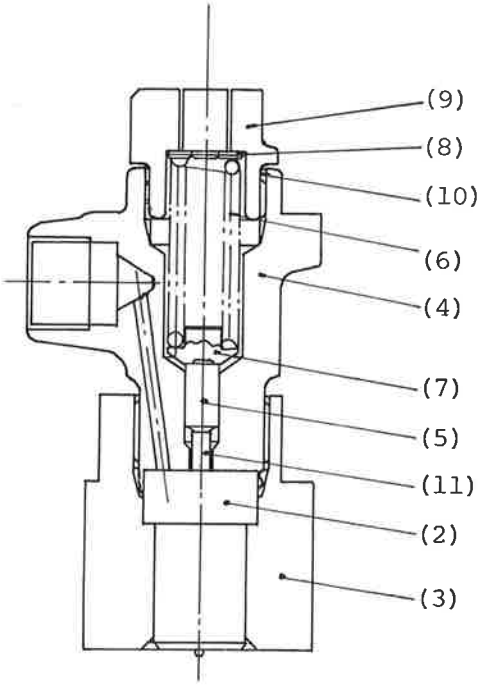
b) The delivery valve holder is over tightened (strain on the plunger barrel).

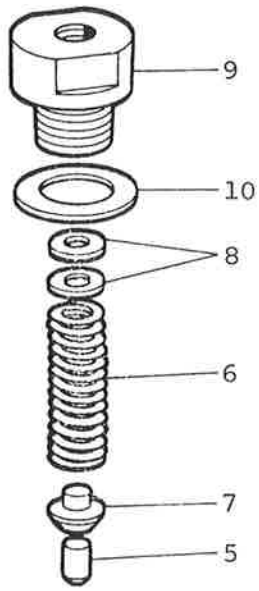
c) Lack of smoothness at the fuel regulating rack, tooth part of the regulating ring or circumference of the rack due to scratches or to dirt adhering there.

d) A scratch at the opening of the fuel regulating rack for the body of the fuel injection pump.

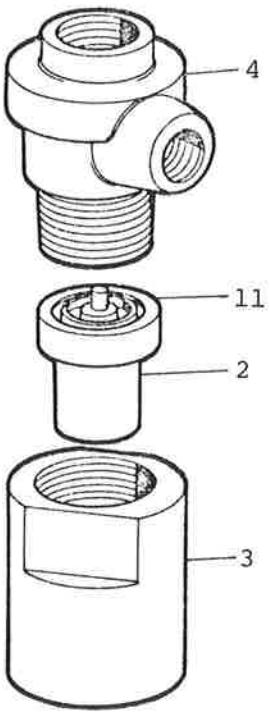
D) Fuel injection valve (Refer to 4-3)

Tools and instruments required:
Spanner (17, 24mm), rags, flatware for disassembly, treated oil.





Nozzle spring retainer (9)
Nozzle spring adjusting plate (8)
Nozzle spring packing (10)
Nozzle spring (6)
Nozzle holder body (4)
Nozzle spring holder (7)
Interspindle (5)
Nozzle valve (11)
Nozzle body (2)
Nozzle fitting nut (3)



D-① Disassembly:

Detach the nozzle spring retainer.

Take out the nozzle spring adjusting plate, nozzle spring, nozzle spring holder and interspindle. (Be careful not to lose the nozzle spring adjusting plate)

Unscrew the nozzle fitting nut and remove the nozzle valve body unit.

Visually check for damage and wear of the nozzle valve.

In case of replacement, the nozzle valve and nozzle body should be replaced as a set.

D-② Assembly:

Install the nozzle valve and body housings and tighten the nozzle fitting nuts.

Set the interspindle.

Set the nozzle spring holder.
(Be careful not to put this in upside down)

Set the nozzle spring. (No difference between upper and lower)

Place the nozzle spring adjusting plate and fasten the nozzle spring retainer.

(Note) After assembly, check the injection pressure and the spray condition with a nozzle tester. (4-3)

In case it is difficult to pull out the nozzle body, use a nozzle puller which is available at the user's option.

E) Cooling water pump (with bilge pump attached)

E-① Disassembly:

① Remove the body of the bilge pump. (6 bolts & paper packing)

② Detach the impeller for the bilge pump.

③ Detach the wear plate. (paper packing)

④ Detach the impeller for the cooling water pump. (Check for damage and wear of the wear plate and impeller)

⑤ Take out the key for the impeller.

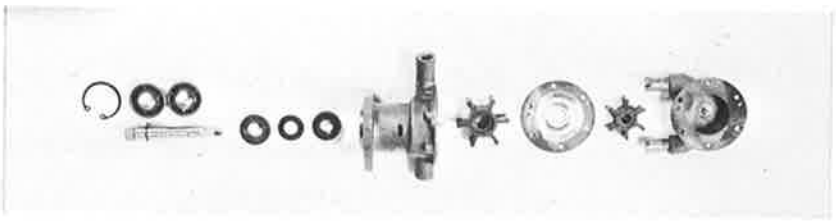
⑥ Remove clip 35 for the opening.

⑦ Pull out the pump shaft. (Rap at the side of the impeller and pull out together with one bearing)

⑧ Take out the bearing (1 pc.), oil seals (2 pcs.) and throating.

E-② Assembly:

Follow the above instruction in reverse.



F) Cooling water pump (without bilge)

F-① Disassembly:

① Remove the cover of the cooling water pump. (6 bolts, paper packing)

② Remove the wear plate (paper packing)

③ Remove the impeller (Check for damage and wear of the wear plate and impeller)

④ Take out the key for the impeller.

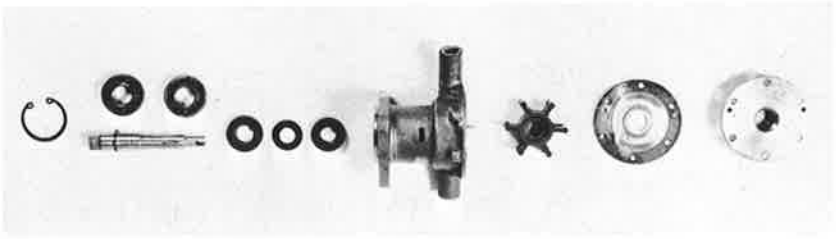
⑤ Remove clip 35 for the opening.

⑥ Pull out the pump shaft. (Rap at the side of the impeller and pull out together with one bearing)

⑦ Take out the bearing (1 pc oil seals 2 pcs) and throating.

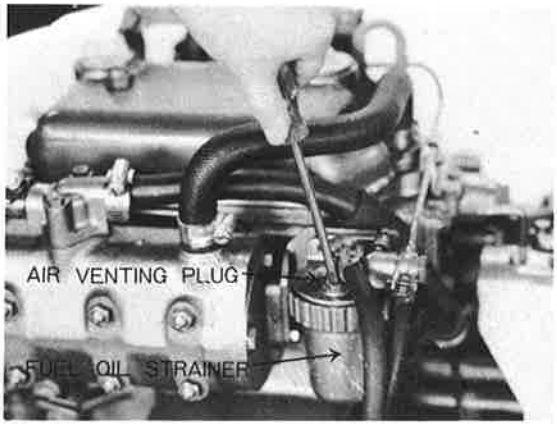
F-② Assembly:

Follow the above instructions in reverse.

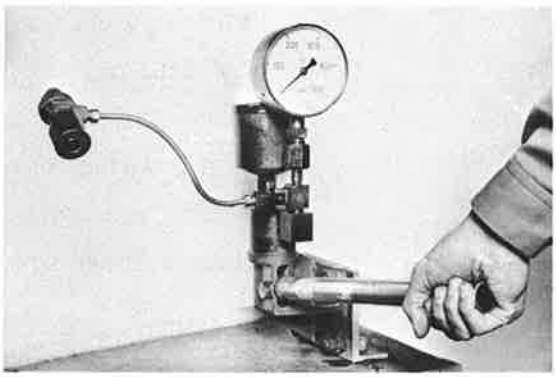


4. ADJUSTMENT OF EACH PART

4-1 Air Vent

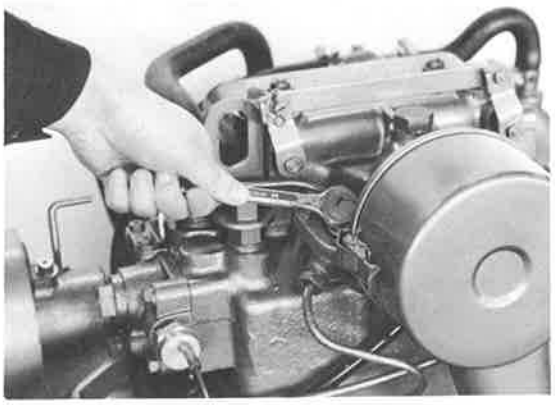


1. Loosen the air vent plug of the fuel filter until the air vent hole can be visually observed.
2. Feed fuel by manually operating the lever of the fuel feed pump.
3. Tighten the air vent plug upon completion of the removal of air.



4. Loosen the air vent plug of the fuel injection pump until the air vent hole can be visually observed.
5. Feed fuel by manually operating the lever of the fuel feed pump.
6. Tighten the air vent plug upon completion of the removal of air.

7. Loosen the fitting screw of the fuel oil return pipe for the cylinder (first cylinder) at the side of the gear case.



8. Feed fuel by manually operating the lever of the fuel feed pump.

9. Tighten the fitting screw of the fuel oil return pipe upon completion of the removal of air.

10. Remove the air from the cylinder (second cylinder) at the side of the clutch following the same instructions as described in 7~9.

11. Loosen the fuel injection pipe fitting screw at the side of the nozzle for both first and second cylinders.

12. Deflate the compression by operating the decomp. lever.

13. Rotate the engine by either the starting motor or manual handle and remove air from the fuel injection pipe fitting part (nozzle side).

14. Tighten the fitting screw upon completion of the removal of air.

4-2 Fuel Injection Pump

Fuel injection timing test

I) For adjustment to the rated fuel injection timing, the injection timing adjusting plates enclosed by the fuel pump and the engine body can be either increased or decreased. However, if the injection intervals for the right and the left devices of the pump itself are irregular, the injection timing for both right and left needs to be regulated by mounting the fuel injection pump on the engine. That is, even if either of the two can be adjusted to the rated injection timing, the injection timing of the other one may be put out of the rating.

II) Adjustment of static injection timing

a) Remove the high pressure pipe from the pump.

b) Deflate the fuel pump.

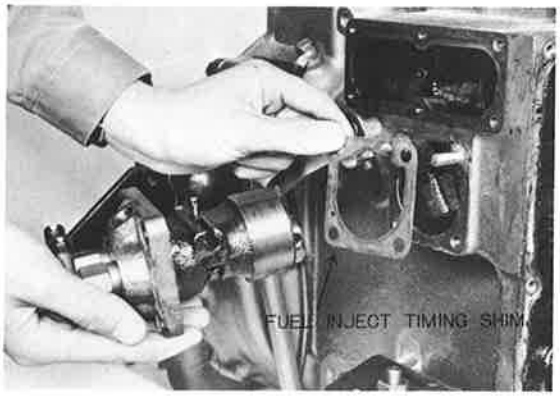
c) Set the fuel regulating rack to the maximum fuel injection. (starting point)

d) Rotate the crankshaft slowly with the starting handle and read the timing mark stamped on the pulley at the crankshaft end at the moment that the fuel spurts out to the tip of the pipe joint nipple.

e) In case the right and the left injection timing of the pump are irregular, adjustment can be made either by adding a plunger adjusting shim to the one with slow timing or by reducing the number of shims from the one with fast timing. (Difference between the right and the left must be less than or equal to 3°.)

f) When the right and the left injection timing lag is adjusted, check the injection timing again according to the method described in (d) and further adjust to the rated injection timing by way of the injection timing adjusting plate which is enclosed by the fuel pump and the engine. In case of late injection timing, take out the adjusting plate; the same has to be inserted if the timing is faster than the rating. The thickness of the plunger location adjusting shim and the injection timing adjusting plate is 0.1 mm and by this the injection timing can be changed by approximately 1° on the crankshaft.

g) Lastly, rotate the crankshaft slowly and confirm the necessary clearance for the plunger and the collar.



Adjustment of Injection Quantity

The adjustment of injection quantity accompanied by disassembly of the pump should be carried out according to the following instructions. Further, when mounting the pump on the engine, the quantitative restrictions for the injection must be adjusted to 37 mm^3/st.

a) Fit the pump to the pump tester with a cam lift of 7 mm.

b) Deflate the pump.

c) Regulate the YDN-4SK1 nozzle (nozzle equipped to engine) to an injection pressure of 160 kg/cm^2 and connect it to the pump.

d) Set the cam shaft to 1500/rpm and fix the rack at the point where the left pump has an injection of 32.5 cc/1000 st. Then loosen the regulating ring set screw and slide the fuel regulating ring (B) and the fuel regulating gear tooth of the right pump so as to regulate the injection to 32.5 cc/1000 st.

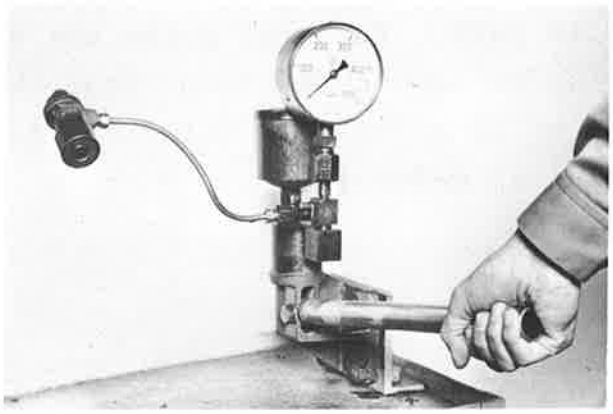
4-3 Fuel Injection Valve

o Measurement and regulation of nozzle injection pressure

- o Connect the fuel injection valve to the injection pipe of the nozzle tester and tighten carefully.
- o Operate the lever of the nozzle tester slowly and read the pressure the moment when the fuel begins to eject from the nozzle.
- o In case the injection pressure is lower than the rating, detach the nozzle spring holder and add the injection pressure adjusting plate. (Refer to p-3-5-4)

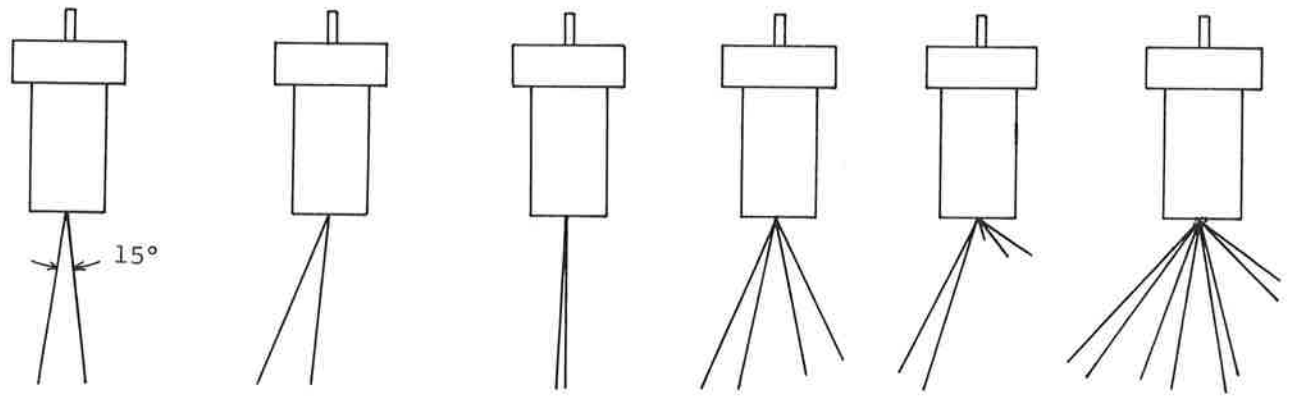
  - o Rated injection pressure 160 ± 5 kg./cm^2
  - o Kinds of injection pressure adjusting plates (thickness); (with a plate of 0.1 mm thick, a change of approximately 0.5 kg/cm^2 can be obtained.)

    0.1 mm
    0.2 mm
    0.3 mm
    0.5 mm



o Check of spray condition

Observe the spray condition by operating the lever of the nozzle tester 4~6 times/sec., after regulating the injection pressure of the nozzle to 160 kg/cm^2. In case of abnormality, clean or replace the nozzle.



Normal One-sided Narrow Split Bearded Scattered

Inject the fuel several times by operating the lever of the nozzle tester and then wipe off the oil from the nozzle part. Further, raise the hydraulic pressure to 140 kg/cm^2 (which is lower than the fuel injection pressure by 20 kg/cm^2) if oil drops from the nozzle, the device is defective.

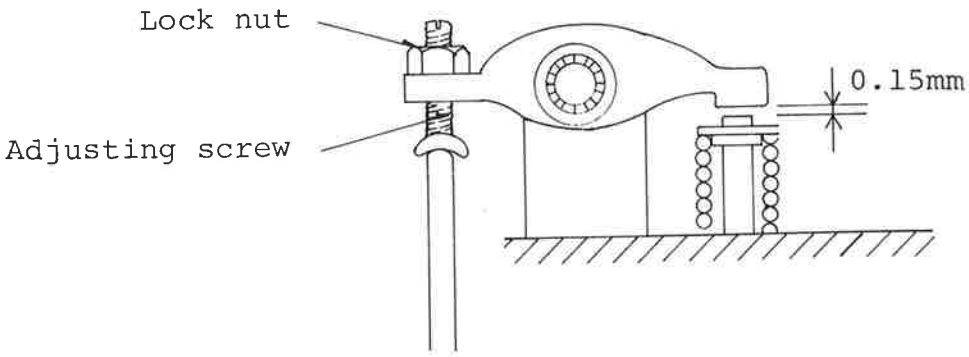
4-4 Adjustment of Intake/Exhaust Valve Clearances (to be carried out in cold condition)

1. Remove the cover of the valve rod housing.

2. Set "1T" mark of the crankshaft V-pulley to the needle, at the same time confirming that the valve rod of the first cylinder does not move. (T.D. of pressure)

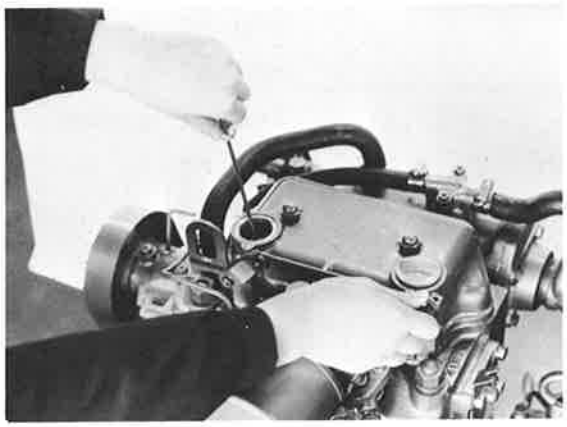
3. Loosen the lock nut of the adjusting screw and adjust with a feeler gauge to obtain 0.15 mm for both intake and exhaust valves. Tighten the nut after adjustment.

4. For adjusting the second cylinder, follow the same instructions described in 2 and 3.



4-5 Adjustment of Decomp. Lifting

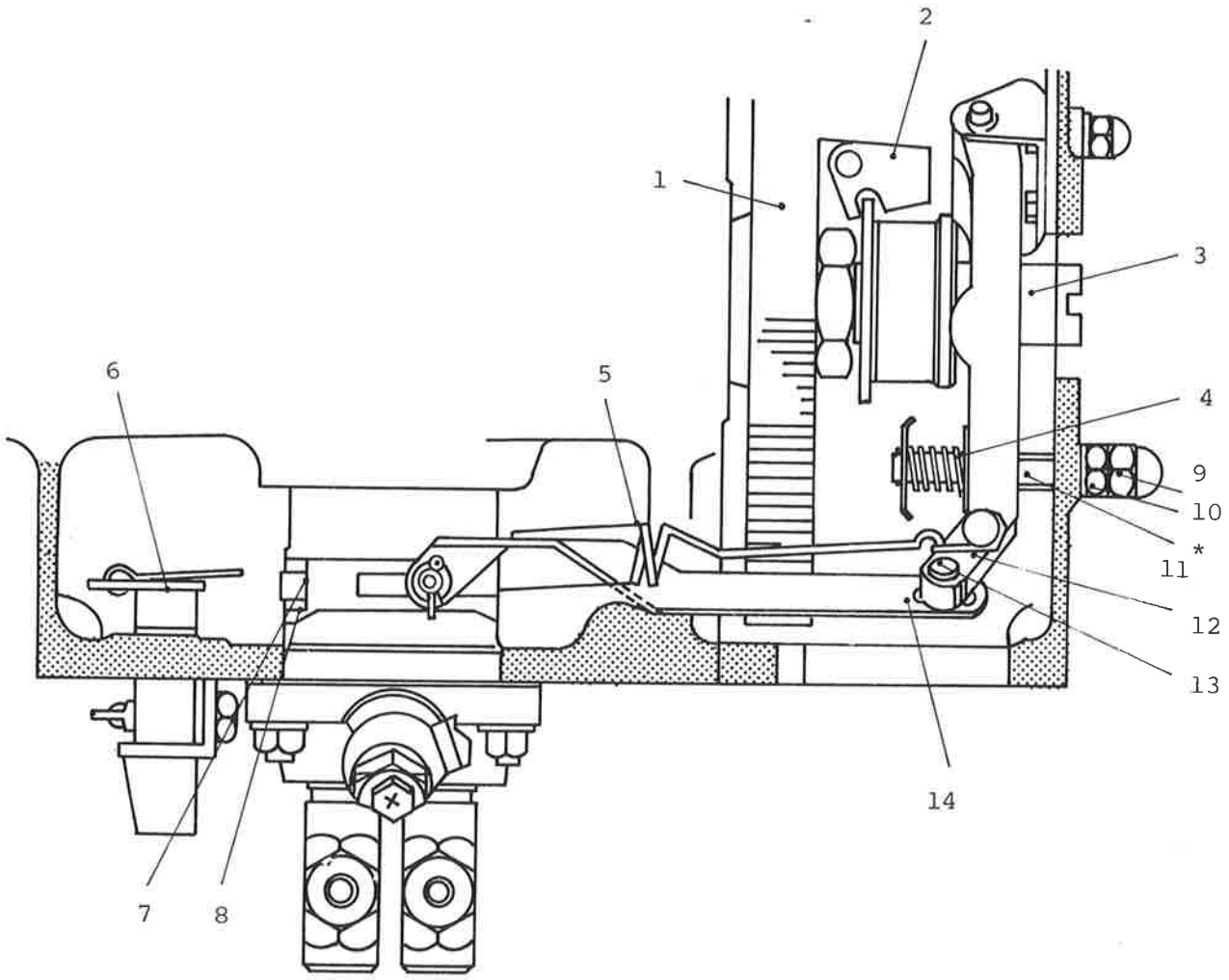
1. Open the two oil make-up inlets on the top of the engine.
2. Loosen the lock nut of the decomp. lifting adjusting screw.
3. Produce a non-pressure condition by operating the decomp. lever.
4. Loosen the adjusting screw to its maximum with a screwdriver. This is the condition where the round head of the adjusting screw does not push the push rod.



5. Tighten the adjusting screw slowly with a screwdriver. When the round head of the adjusting screw touches the push rod, further tighten it one rotation to push the push rod and then tighten the lock nut.

6. Apply the same adjustment to the other cylinder.

4-6 Adjustment of Governor Linkage



1	Cam shaft gearing	8	Fuel pump reference level
2	Governor weight	9	Cap nuts for injection limit shaft
3	Cam shaft	10	Hexagon check nuts
4	Injection limit spring	11	* Injection limit shaft
5	Regulator spring	12	Governor lever
6	Regulator lever	13	Governor link coupling screw
7	Rack mark	14	Governor link

(A)

1. Remove the covers of the gear case side and fuel pump housing.
2. Loosen the governor coupling screw.
3. First push the governor lightly to the left, taking care not to press the injection limit spring, then set the rack mark to the fuel pump reference level by moving the governor link right and left. Tighten the coupling after adjustment.

(B) * In case the injection limit shaft is moved.

1. Remove the covers of the gear case side and fuel pump housing.
2. Detach the cap nuts for the injection limit shaft and screw the limit shaft into the engine side by loosening the hexagon check nut (until the injection limit spring is no longer touched even if the governor is pushed to the left).
3. Loosen the governor coupling screw and move the governor link to the left as much as possible by pressing the governor lever to the left (set to the maximum discharge).
4. Loosen the injection limit shaft toward the outside and set the rack mark to the pump reference level.
5. Tighten the injection limit shaft with the check nut and fit the cap nut (set to indicated output).
6. Fit the covers of the gear case side and the fuel pump housing.

5. TEST RUN

After assembly and relevant adjustments, a test run must always be carried out at the work shop before delivery.

1) Confirmatory work before test run.

- . Miswiring or mispiping.
- . Correct tightening of bolts and nuts.
- . Put away tools, instruments or rags left on the engine.

2) Confirmatory work during test run

- . Leakage of lubricant, fuel, cooling water and combustion gas.
- . Indications on the gauge panel.
- . Abnormal noise, abnormal color of exhaust gas and other abnormalities.

6. ELECTRICAL EQUIPMENT

6-1 Starting Motor

1) Structure

This starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.

The starter motor is composed of three major parts, as follows:

a) Magnetic switch

Moves plunger to engage and disengage pinion, and through the engagement lever, opens and closes main contact (moving contact) to stop the starter motor.

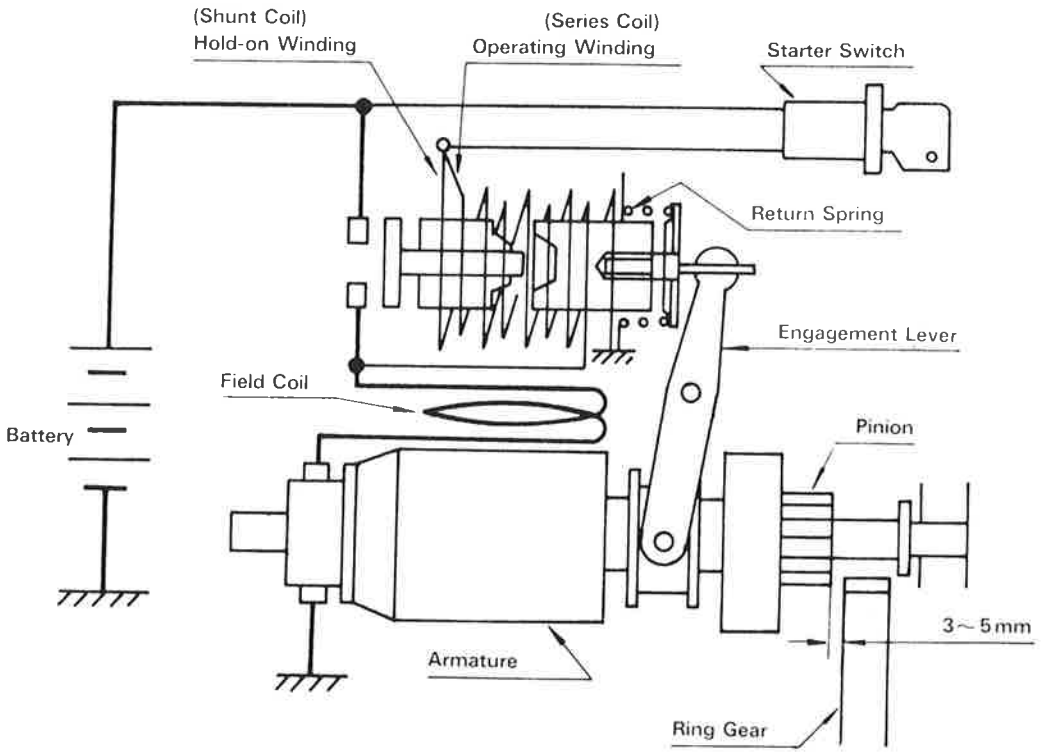
b) Motor

A continuous current series motor which generates rotational drive power.

c) Pinion

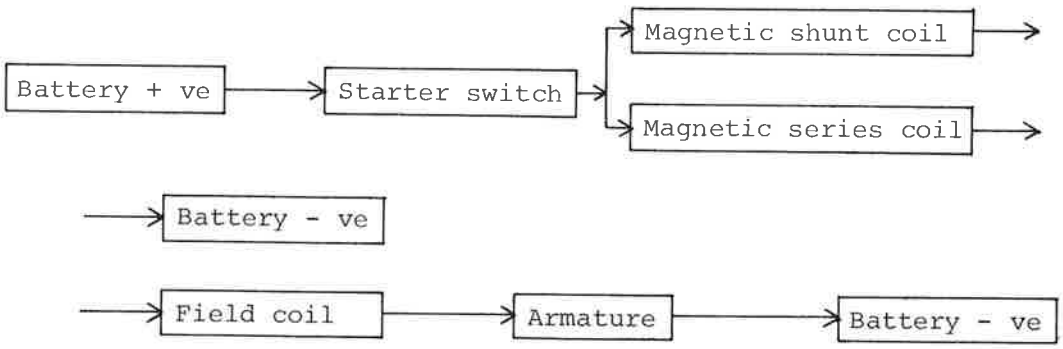
Transfers driving power from motor to ring gear. An over-speed clutch is employed to prevent damage if the engine should run too fast.

Fig. 1 : Schematic layout of starter motor electrical circuit



2) Operation

Fig. 1 gives a schematic layout of the starter motor electrical circuit. The current flow of the circuit is as follows :



3) Inspection

When the starter motor is considered to have faults, it should be dismantled for detailed inspection.

a) Armature

Coil and commutator inspection :

(1) Short test . . . existence of broken or disconnected coil.

(2) Insulation test . . . between commutator and armature core or distortion shaft. (See Fig. 2 & 3.)

Fig. 2 : Checking commutator for insulation defects.

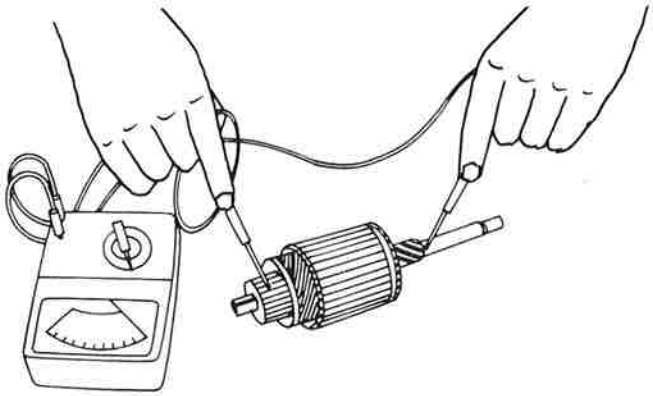
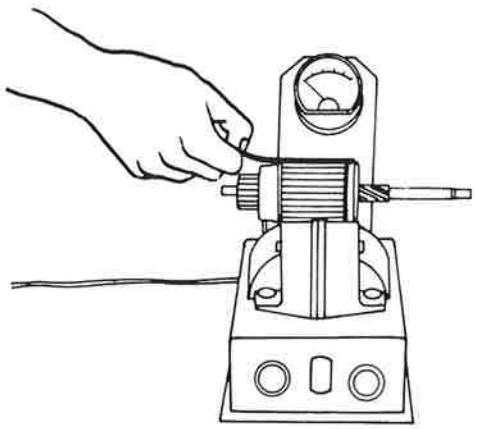


Fig. 3 : Checking armature windings for insulation faults.



b) Commutator

(1) Commutator surface inspection

If the surface is not clean, polish it lightly with very fine glass paper. (See Fig. 4.)

(2) Commutator segment depth measurement

If the commutator is badly worn, take a light cut on the lathe with a sharp tool. After under cutting, it should be polished with very fine glass paper. (See Fig. 5.)

Fig. 4 : Polishing commutator with fine glass paper.

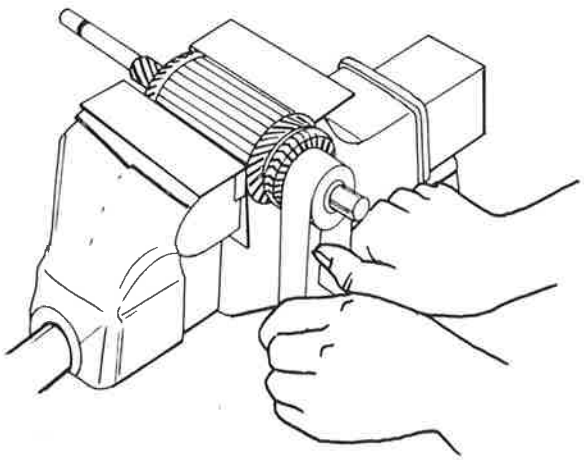
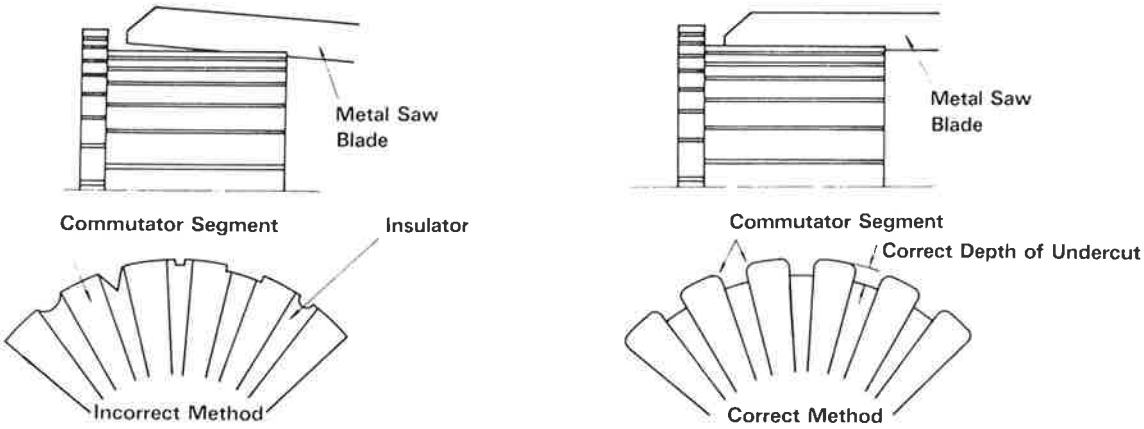


Fig. 5 : Wrong and right method for under-cutting insulators on commutator.



c) Field coil

(1) Insulation test (See Fig. 6 & 7).

Fig. 6 : Checking field coils for open circuit defects.

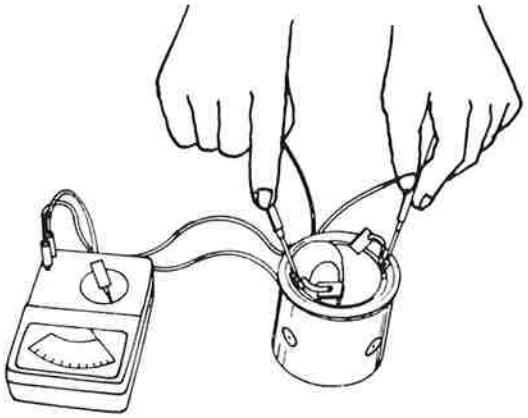
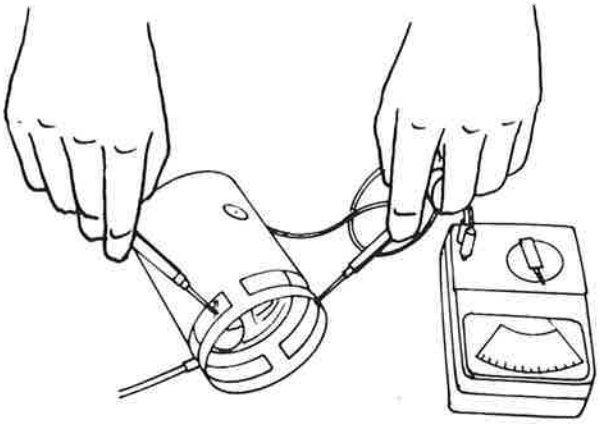


Fig. 7 : Checking field coils for insulation defects.



Operating windings (Series coil). (See Fig. 9.) No reading indicates an open circuit in the operating windings.

d) Magnetic switch

(1) Conductivity test . . . hold-on windings (Shut coil). (See Fig. 8.)
No reading indicates an open circuit in the hold-on windings.

Fig. 8 : Checking solenoid hold-on windings.

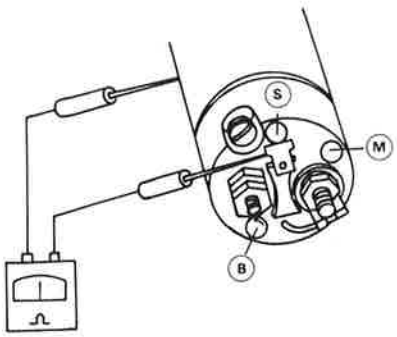
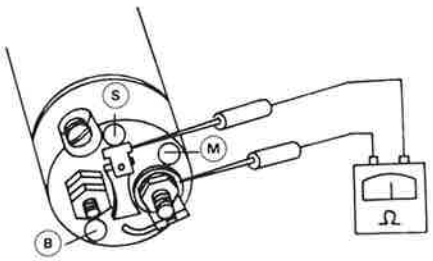


Fig. 9 : Checking solenoid operating windings.



e) Brushes

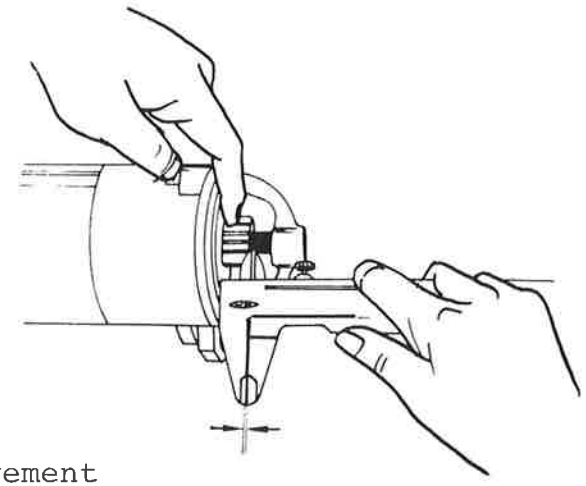
Brushes worn in excess of the values should be replaced. When fitting a new brush ensure it is properly bedded to the commutator face and is free in its holder.

4) Adjustment and performance test

a) L-size measurement (gap between pinion and pinion stopper)

When the pinion is at the projected position, measure between pinion and pinion stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

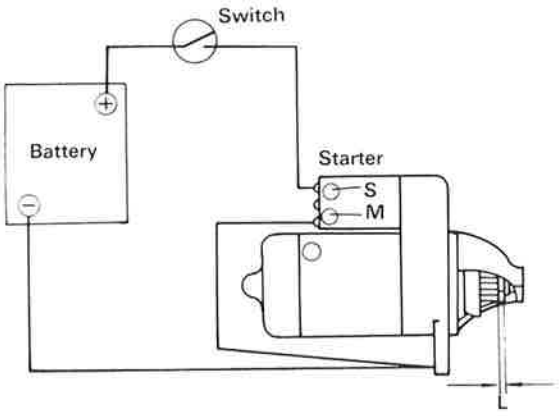
Fig. 10 : Checking gap between pinion and pinion stopper (L-size)



b) Pinion movement

After complete assembly of the starter motor, connect up the motor as in Fig. 11.

Fig. 11 : Testing circuit for pinion movement.



c) Plunger movement

Adjustment made by adjusting stroke of magnetic plunger to the prescribed value.

Fig. 12 : Adjustment for plunger movement (Shim adjusting type)

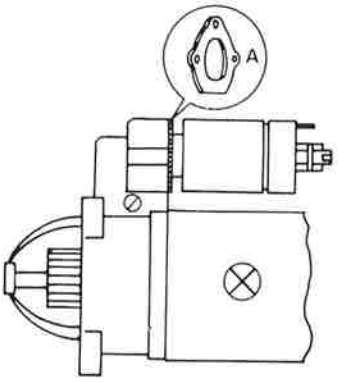
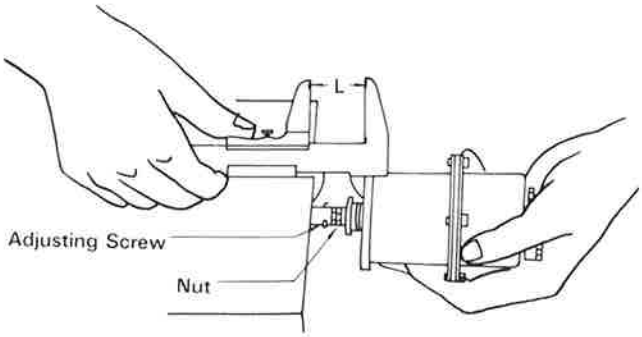
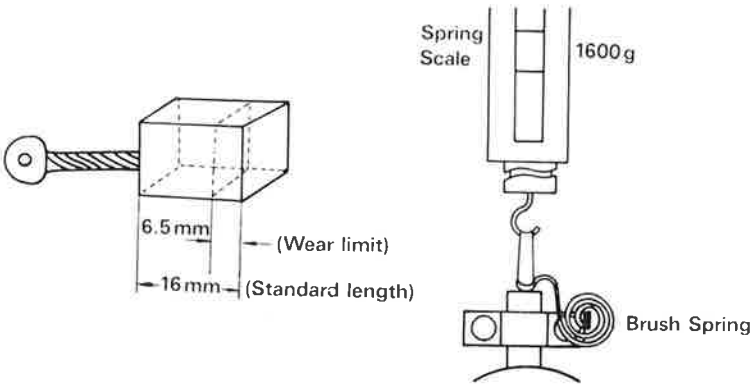


Fig. 13 : Adjustment for plunger movement (Adjusting screw type)



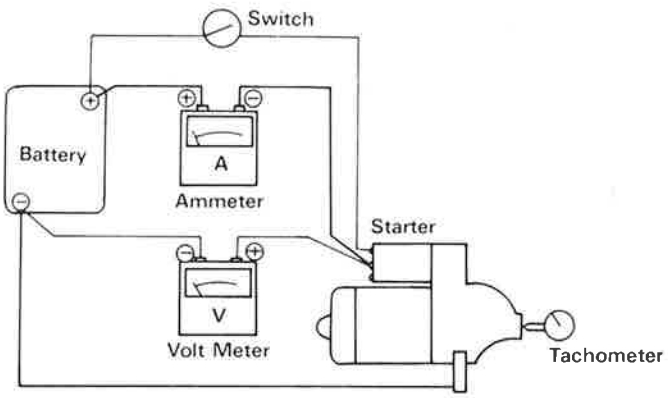
d) Brush spring pressure

Fig. 14 : Checking brush spring strength



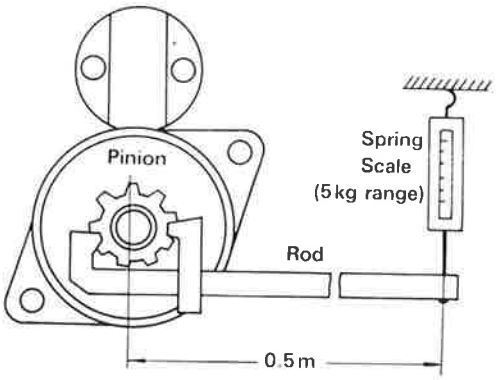
e) Light running current test

Fig. 15 : Measuring the light running current



f) Pinion lock torque measurement

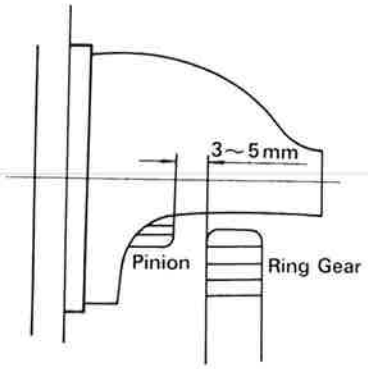
Fig. 16 : Measuring lock torque



g) Mesh clearance

Mesh clearance is the distance between the fly-wheel ring gear and starter motor pinion in the rest position. This clearance should be between 3 mm to 5 mm.

Fig. 17 :Checking mesh clearance



5) Specifications and servicing standard values
(For model YSE)

Yanmar code : 104211-77010
Manufacturer's code : S114-134 (Hitachi)

a) Specifications

Types of Machine		2QM20
Manufacturer		Hitachi
Manufacturing Type		S114-206
Yanmar Code		124770-77010
Nominal output (kw)/Weight (kg)		1.3/6.3
Direction of Rotation (from pinion side)		Right
Gearing System		Magnetic Shift
No load	Terminal voltage (V)/ Current (A)	12/60 or less
	Rotation speed (rpm)	6000 or more
Constraint	Terminal voltage (V)/ Current (A)	5.0/540 or less
	Torque (kg.m)	1.6 or more
Clutch system/Maximum friction (kg.m)		Roller clutch/-
Pinion interlacing voltage (V)		8.0 or less
Pinion D.P. or Module/Number of Teeth		D.P. 10/15 (V)

b)

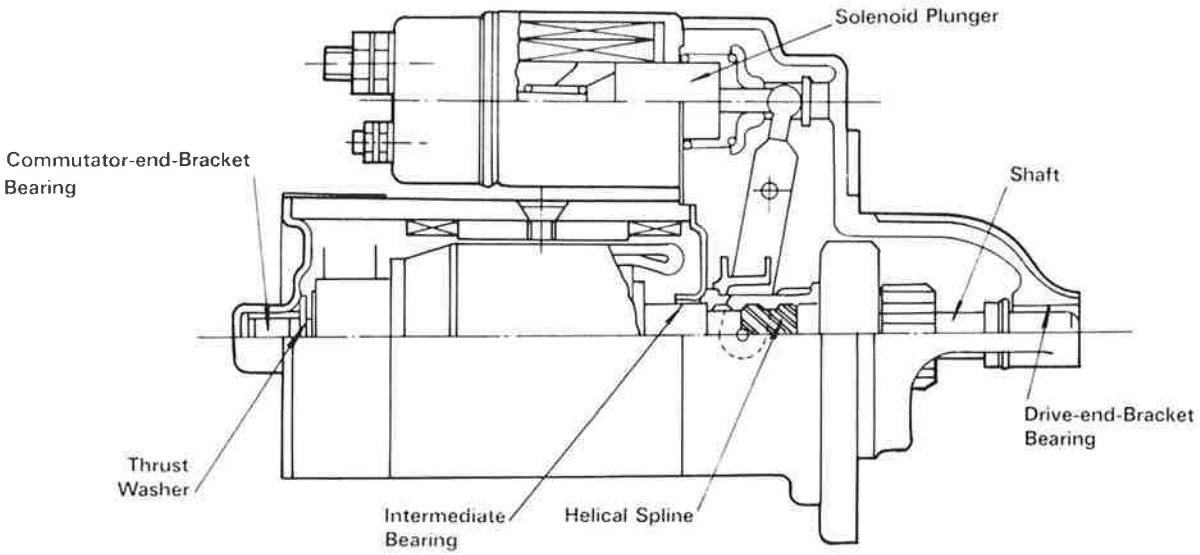
Brush	Standard spring strength		1.6
	Standard height (mm)/ Undersize limitation (mm)		16/4.5
Magnetic switch resistance (Ω) at 20°C		Series coil/ Shunt coil	0.262/0.590
Commutator (mm)	Outer diameter	Standard external form/ Undersize limitation	40/2
	Gap between maximum diameter and minimum diameter	Correction limitation/ Correction accuracy	0.4/0.05
	Depth of Mica	Correction limitation/ Correction accuracy	0.2/0.5~0.8
Standard Dimension (mm)	Bearings on brush side	Axial diameter/ Hole diameter	$12.5^{-0.032}_{-0.050}$/ $12.5^{+0.027}_{0}$
	Intermediate bearings	Axial diameter/ Hole diameter	None
	Pinion sliding part	Axial diameter/ Hole diameter	$12.5^{-0.032}_{-0.050}$/ $12.5^{+0.05}_{+0.03}$
	Bearings on pinion side	Axial diameter/ Hole diameter	$12.5^{-0.032}_{-0.050}$/ $12.5^{+0.027}_{0}$
Gap between pinion head and pinion stopper at the time of pinion pushing.			0.3 ~ 1.5

c) Lubrication chart

(1) Ensure that the parts indicated in Fig. 18 are lubricated with "Shell Alvania Grease No.2" or good quality high melting point equivalent grease.

(2) Be sure to insert the thrust washer between the commutator end bracket and the armature. If the end float is more than 0.3 mm a further shim should be added.

Fig. 18 : Lubrication chart



6) Malfunctions and trouble-shooting

a) Pinion doesn't extend when switch is on.

- o Loose wiring.
- o Switch contacts bad.
- o Magnetic engagement lever malfunctioning.

b) Pinion extends but motor doesn't turn.

- o Disconnected or grounded between battery and magnetic switch wires.
- o Improper mesh between pinion and ring gear.
- o Poor contact between brushes and commutator.
- o Bad contact in magnetic switch.

c) Motor turns before pinion meshes with ring gear.

- o Plunger gap mis-adjusted.
- o Weak plunger spring.

d) Pinion engages and motor rotates, but drive force is not sufficient.

- o Over-speed clutch is bad.

e) Engine doesn't stop when switch is turned off.

- o Main switch is bad.
- o Magnetic switch contacts stuck in closed position.
- o Return spring weak or broken.

f) Speed torque and current consumption are low.

- o Faulty internal or external connections.
- o Dirty or burned commutator.
- o Burned magnetic switch contacts.

g) Speed and torque are low but current consumption is high.

- o Broken bearing.
- o Bent shaft.
- o Armature fouling pole shoes.
- o Cracked spigot on drive end bracket.
- o Short-circuited or grounded armature.

h) Speed and current consumption are high but torque is low.

- o Short-circuited windings in the field coil.

i) Excessive arcing at the commutator.

- o Defective armature windings.
- o Sticking brushes or dirty commutator.

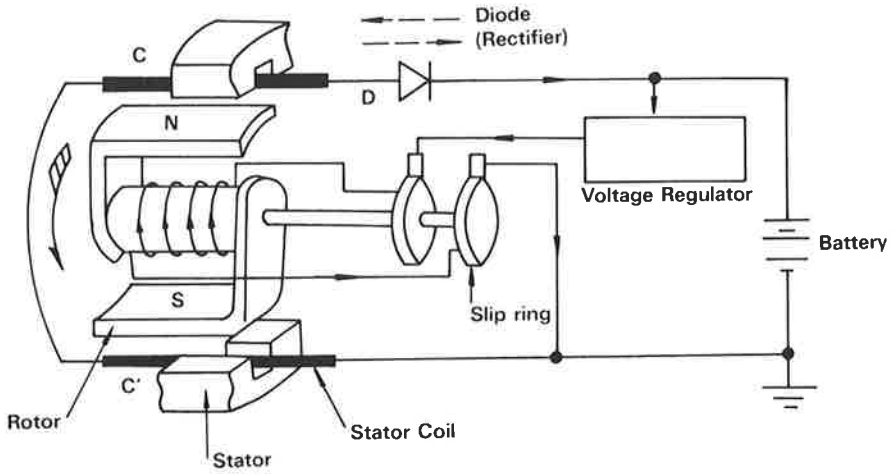
6-2 AC Generator

1) Structure

The generator described in this chapter is a three-phase revolving field type generator.
This AC generator rectifies the alternating current and supplies direct current (DC) to an external source.

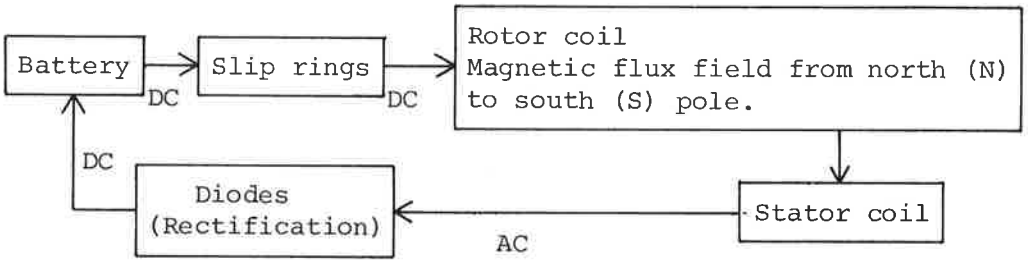
The generator is composed of three major parts : Rotor which incorporates the field winding, a Stator which has electricity generated in it, and Diodes which rectify the alternating current generated in the stator coils. The drive is done by pulley, with a cooling fan, also included.

Fig. 19 : Schematic of AC generator



2) Operation

When DC is supplied to the rotor coil through the slip rings the rotor becomes magnetized, with magnetic flux lines forming between the N-S poles. Rotation of the rotor generates an alternating current in the stator coil, which is then rectified by the diodes as a DC charging current for the battery.



3) Inspection

a) Rotor

Conductivity test . . . Between slip rings.
Insulation test . . . . Between slip ring and rotor coil.

Fig. 20 : Testing rotor coil conductivity.

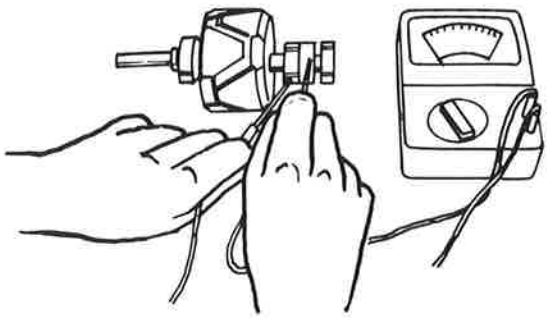
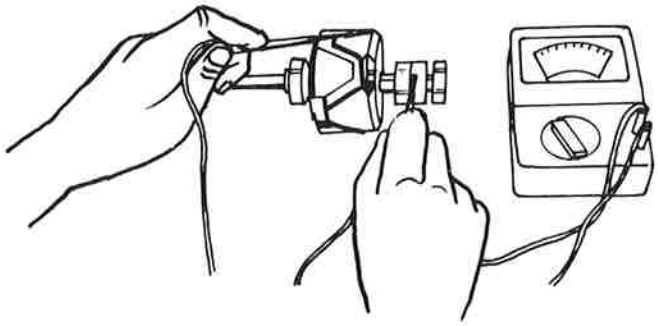


Fig. 21 : Testing rotor coil insulation.



b) Stator

Conductivity test . . . Between stator coil terminals.

Insulation test . . . . Between stator coil terminals and stator core.

Fig. 22 : Testing stator coil conductivity.

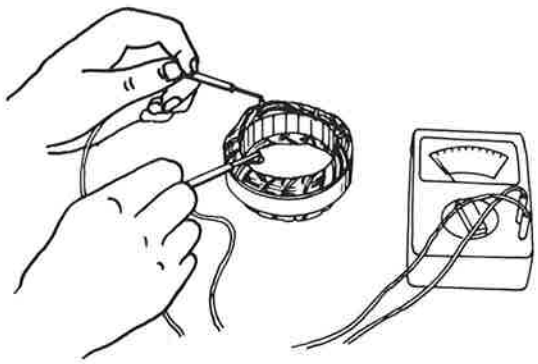
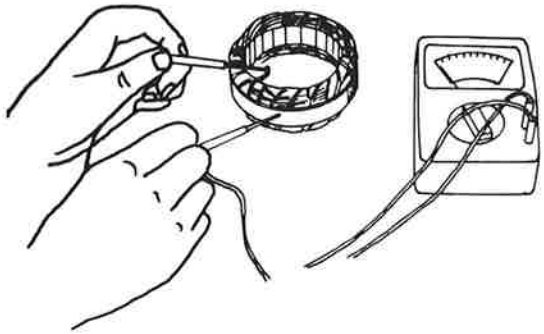


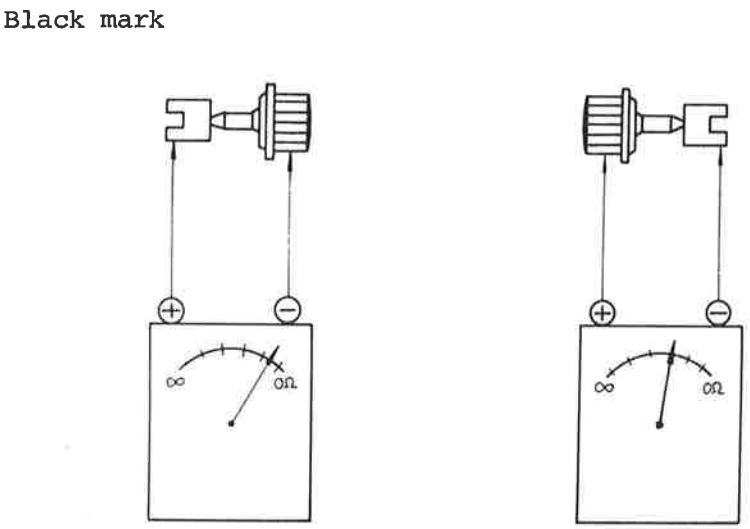
Fig. 23 : Testing stator coil insulation.



c) Diode

Conductivity test . . . Between diode terminals and the case.

Fig. 24 : Testing diode conductivity.



The meter should read this.

The meter should not read this.

To test the diodes, first check the polarity.

(1) Black marked on the case . . Negative base diodes

(2) Red marked on the case . . . Positive base diodes.

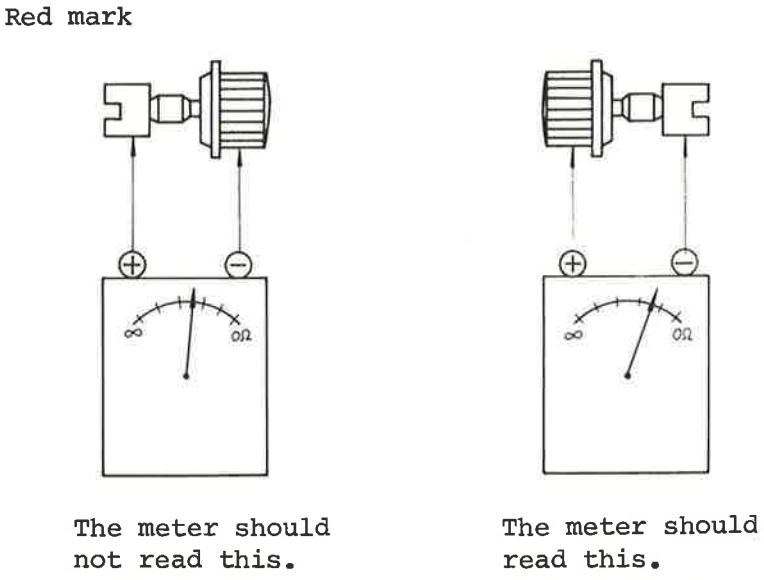


Fig. 25-1 : Conductive direction of diode.

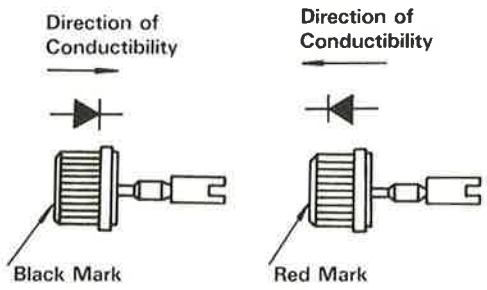


Fig. 25-2 : Disconnecting diode.

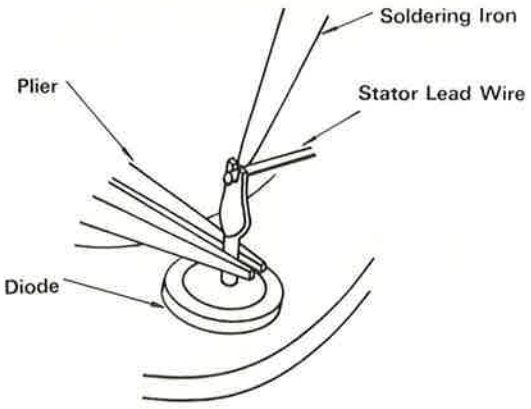
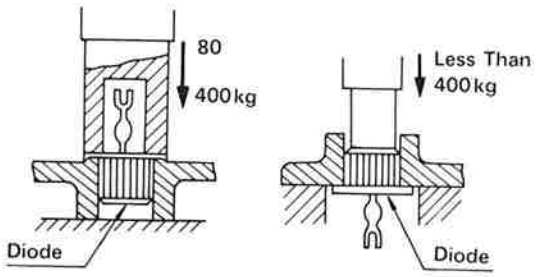


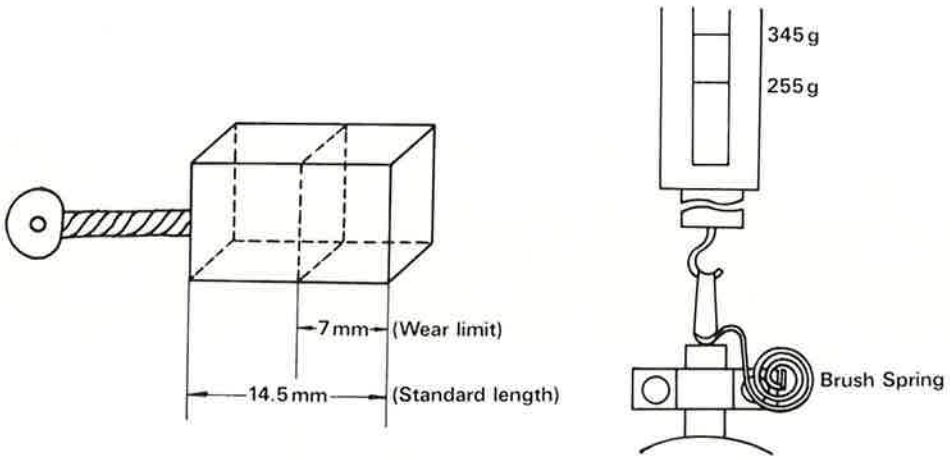
Fig. 25-3 : Replacement of diode.



d) Brushes

Brush spring pressure and brush length . . . . .

Fig. 26 : Checking brush spring strength.



4) Performance test

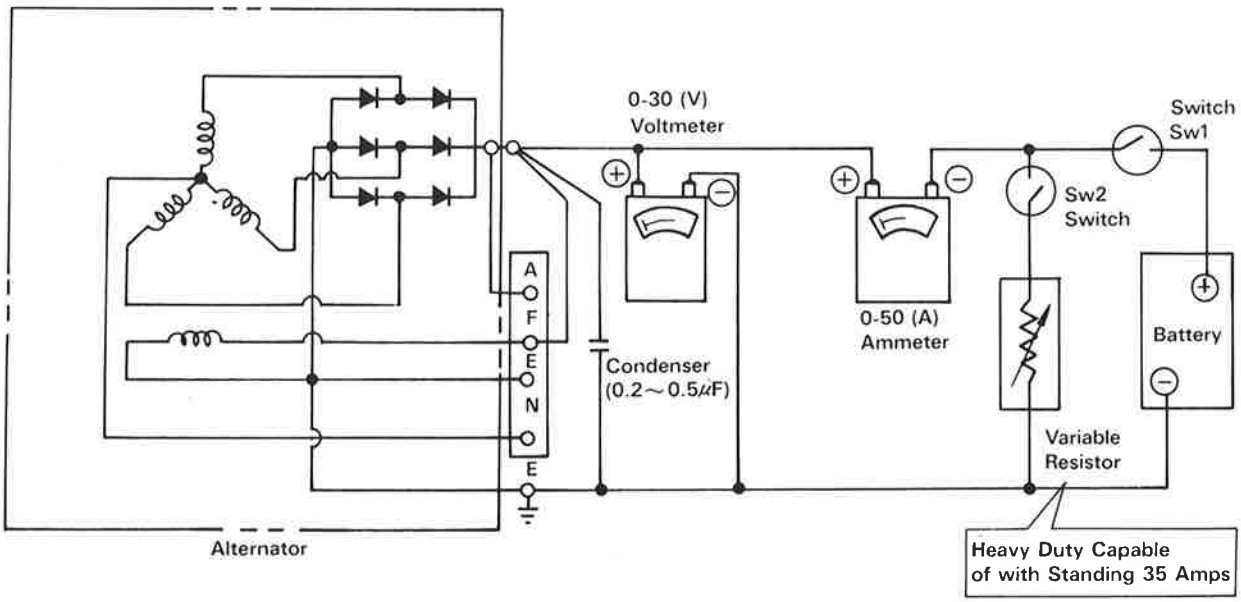
a) Cut in speed

(1) Turn SW ON, (SW OFF), bring generator up to 800 rpm approximately, and turn SW OFF.

(2) Bring rpm up to no load voltage level (14V) and stabilize. RPM level should exceed minimum level when in use.

This is the cut in speed which should correspond to the specifications in Section 6.

Fig. 27 : Measuring circuit for performance of AC generator.



b) Output current

(1) Turn SW ON, bring rpm up to no load voltage level (14V) and then turn SW OFF.

(2) Set VR (Variable resistor) to MAX and turn SW ON.

(3) Adjust VR to no load voltage level (14V) at rated speed (5000 rpm).

(4) Read output current level and confirm that it exceeds measured generator level.

At speeds of 14250 rpm and 14500 rpm the current and voltage readings should be as shown on the chart in Section 6.

5) Specifications and servicing standard values F

Yanmar code : 124220-77200
Manufacturer's code : LT125-21 (Hitachi)

a) Specifications

Model	LT125-21
Battery voltage V	12
Output	12V 25A
Ground polarity	2-line system - ve grounded
Direction of rotation (from pulley side)	Clockwise
Usable speed rpm	1050-13500
Rated speed rpm	5000
No load voltage (V/rpm) at 20°C	14/1050

Output current (A/rpm) at 14V	More than 18/14250 and 25/14500
Weight kg	3.5

b) Servicing standard values

Item				Measure
Brushes		Standard length	mm	14.5
		Wear limits	mm	7
Brush springs		Standard strength	kg	0.3 ± 15%
Shaft	Drive end	Standard diameter	mm	15
		Bearing		6202 SD
	Rear end	Standard diameter	mm	12
		Bearing		6201 SD
Rotor coil resistance, ohms, at 20°C				4.4
Stator coil (1-phase) resistance at 20°C				0.18
Cut in speed			rpm	Less than 1050 at 14V
Slip rings		Standard diameter	mm	31
		Wear limits	mm	1
		Correct accuracy		0.05

6) Malfunctions and trouble shooting

a) No generator output

- o Coil(s), ground disconnected; system shorted.
- o Non-insulated terminals.
- o Diode(s) bad.

b) Low output

- o Rare short in rotor coil.
- o Rare short in stator coil.
- o One-phase disconnected from stator coil.
- o Slip ring dirty or broken.
- o Poor contact between brushes and slip rings.
- o Diode(s) bad.
- o Low rpm.

c) High output

- o Short circuited between A and F terminals; the generator may be shunting generator.

d) Fluctuating output

- o Loose wiring.
- o First stage disconnected.
- o First interphase stage shorted.
- o Brush springs broken or stuck.

6-3 Regulator

1) Structure

The purpose of the regulator is to control the voltage output of the generator by regulating the current of the field coil (If) and voltage output of the generator regardless of changes in generator speed.

Classification of the regulator according to the principles of operation, as follows :

a) Tirril system (vibrating contact type)

(1) One-point contact type
(2) Two-point contact type

b) Carbon pile system

c) Transistorized system

(1) Semi-automatic type
(2) Full transistor type
(3) Integrated circuit (IC) type

2) Operation

As indicated above there are several types of regulators. The controlling methods are explained in the following paragraphs.

a) Tirril system

The equipment is comprised of a vibrating contact type voltage regulator, which controls the generator output voltage to a constant value, by inserting or short cutting a resistor in the field circuit or breaking the field circuit when the required voltage is reached.

In the two-point contact type, a moving contact has both a high and low speed which provides wide voltage control, and longer contact life.

b) Carbon pile system

Output voltage is controlled by the changing contact resistance of the carbon pile.

c) Transistorized systems

Intermittent control by using the rapid switching capabilities of the transistor.

The IC type has replaced the transistor type due to its more compact size and higher reliability.

The various components inside the regulator are as follows :

a) Charging relay

Controls illumination of the charge warning lamp through the output of the generator.

b) Field relay

Prevents the field circuit from being burned out if the starter switch is left on when the generator is not operating.

In addition, the field relay shorts the output of the generator during starting and stopping when the output voltage falls below a specified level. This protects the electrical system against burnout.

c) Voltage regulator

In the event the output voltage of the generator increases above a specified level due to a higher rpm, the VR will regulate current and voltage output as required. This condition increases the absorption of the magnet (Tirril type) and increases the resistance of the field coil, decreasing field current which decreases generator voltage.

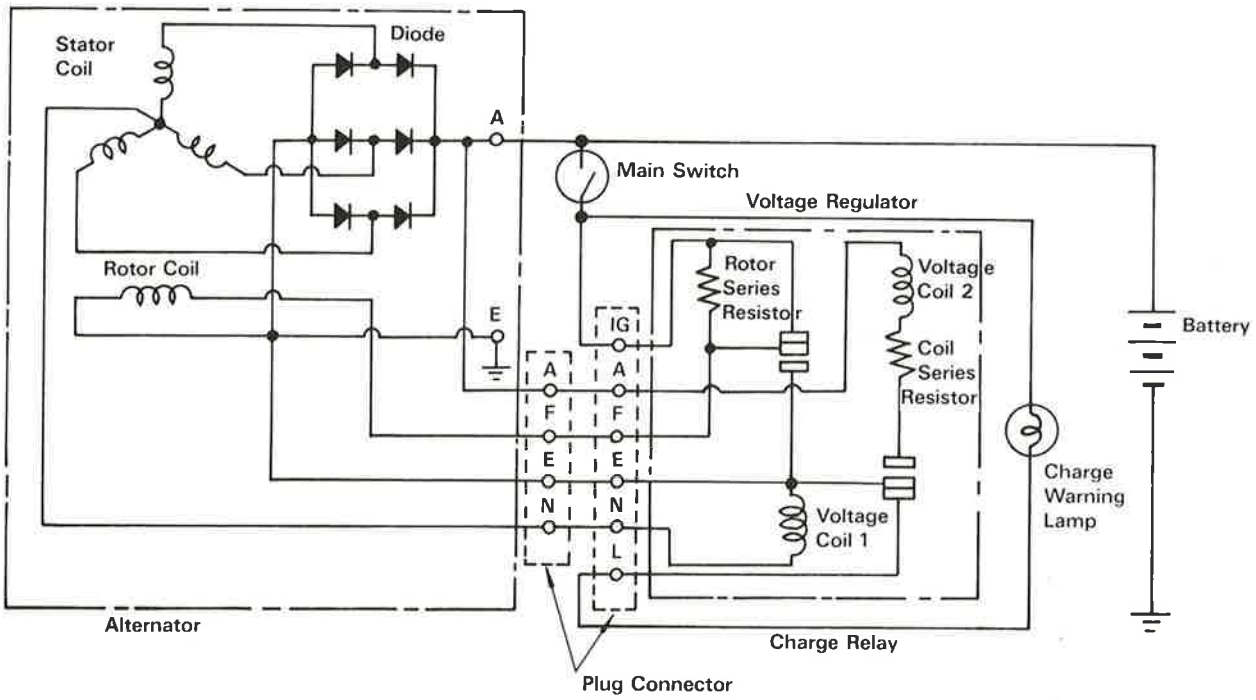
d) Current limiter

Controls generator current output. When the output current exceeds the prescribed limits the field coil resistance increases, decreasing current out.

e) Cut-out relay

Used in the charging circuit of DC generators. When generator revolutions decrease, decreasing output voltage, the generator is protected from burn-out caused by back current from the battery. Also prevents the battery from being discharged.

Fig. 28 : Connection diagram (AC generator-Regulator)



3) Inspection and adjustment (Tirril type regulator)

Inspect each component for proper gap adjustment and clean contact points where required.

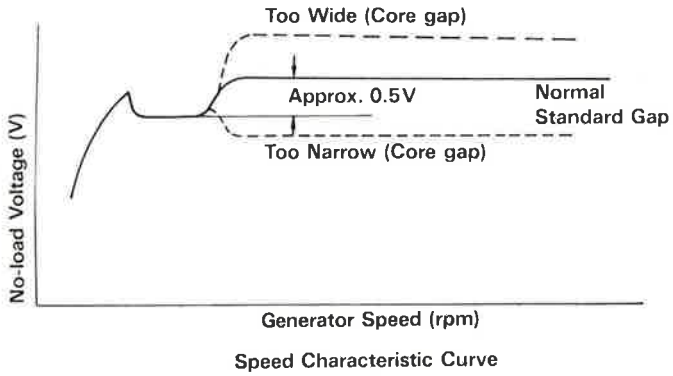
Points of gap adjustment :

a) Yoke gap
b) Core gap
c) Point gap

Observe the following procedures :

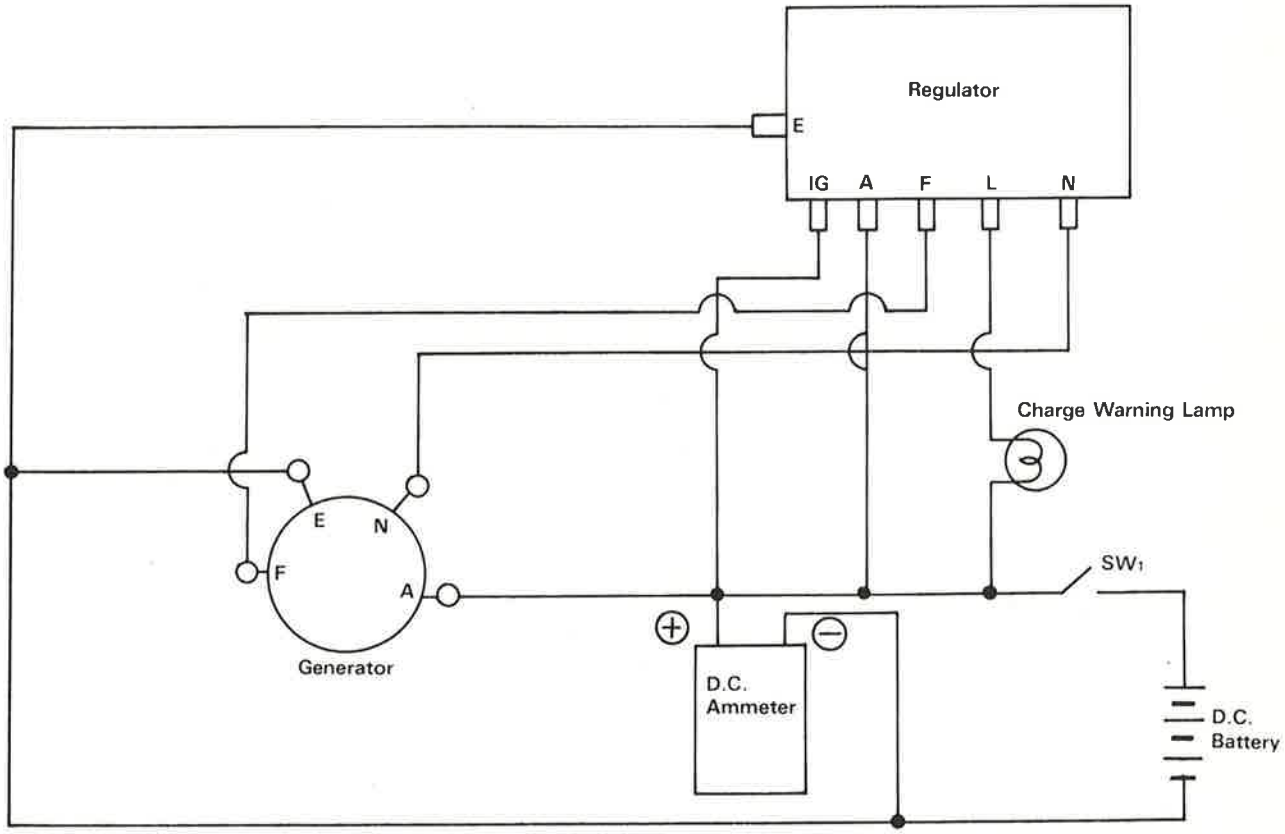
After the gap adjustment is completed, adjust the no-load voltage according to the following connections.

Fig. 29 : Checking no-load voltage
(Speed characteristic curve)



Speed Characteristic Curve

Fig. 30 : Measuring circuit for performance of starter dynamo



Testing procedure

a) Leave SW ON and run excitation current through the rotor coil (field coil) of the AC generator to bring up generator revolutions.

b) When the minimum rum run level is reached, turn SW OFF.

c) Bring the generator up to rated speed and measure no-load voltage.

Remark

For a DC generator, when raising the generator rpm after voltage regulator connection, output voltage of the generator will increase corresponding to the revolution.

On an AC generator, the excitation current through the rotor coil (field coil) of the AC generator is needed because the output voltage does not generate unless the excitation against the rotor coil is done even if the generator speed increases.

Adjustment of each gap

Measure with a thickness gauge; if they are incorrect adjust to the setting given in Section 5 using the following procedure ;

a) To adjust the yoke gap, insert the thickness gauge between armature and yoke surface and fix the gap with the armature setting screw.

b) Adjust the core gap by loosening the screw holding the contact set, insert the screwdriver into the hole to raise or lower the contact set as required, then re-tighten.

c) To adjust the point gap, loosen the screw holding the contact point, to raise or lower it, then re-tighten.

4) Specifications and servicing standard values

Yanmar code : 124220-77710
Manufacturer's code : TL1Z-51 (Hitachi)

Model		TL1Z-51
Regulator voltage	Adjustment voltage	14 ± 0.5V
	Voltage coil resistance	25
	Rotor coil series resistance	10
	Voltage coil series resistance	25
	Compensating resistance	40
	Yoke gap	0.9 - 1.0 mm
	Core gap	0.8 - 1.2 mm
Relay charging	Point gap	0.3 - 0.4 mm
	Open circuit voltage	9 ± 1V
	Voltage coil resistance	10
	Yoke gap	0.2 mm
	Core gap	0.5 - 0.7 mm
	Point gap	0.4 - 0.5 mm

Ground polarity	-ve
Battery voltage	12V
Control system	Vibrating contact (Tirril)
Combination A.C. generator	LT125-21 (Hitachi)

5) Malfunctions and trouble-shooting

a) No charge

- o Lead-in wire shorted, disconnected.
- o No-load voltage less than the prescribed value.

b) Low charge

- o No-load voltage less than the specified level.
- o Points dirty or burned.
- o Coil or resistor shorted.

c) Over charge

- o Abnormal increase in no-load voltage.
- o VR improperly grounded.
- o Charging relay not opening (burned or stuck).

d) Charge fluctuates

- o First stage coil disconnected.
- o Voltage adjustments incorrect.
- o Points dirty or burned.
- o Main switch bad.

6-4 Reference Data (for diodes)

Recently semiconductors are being used quite frequently in regulators and AC generators. Therefore a short description on semiconductors in order.

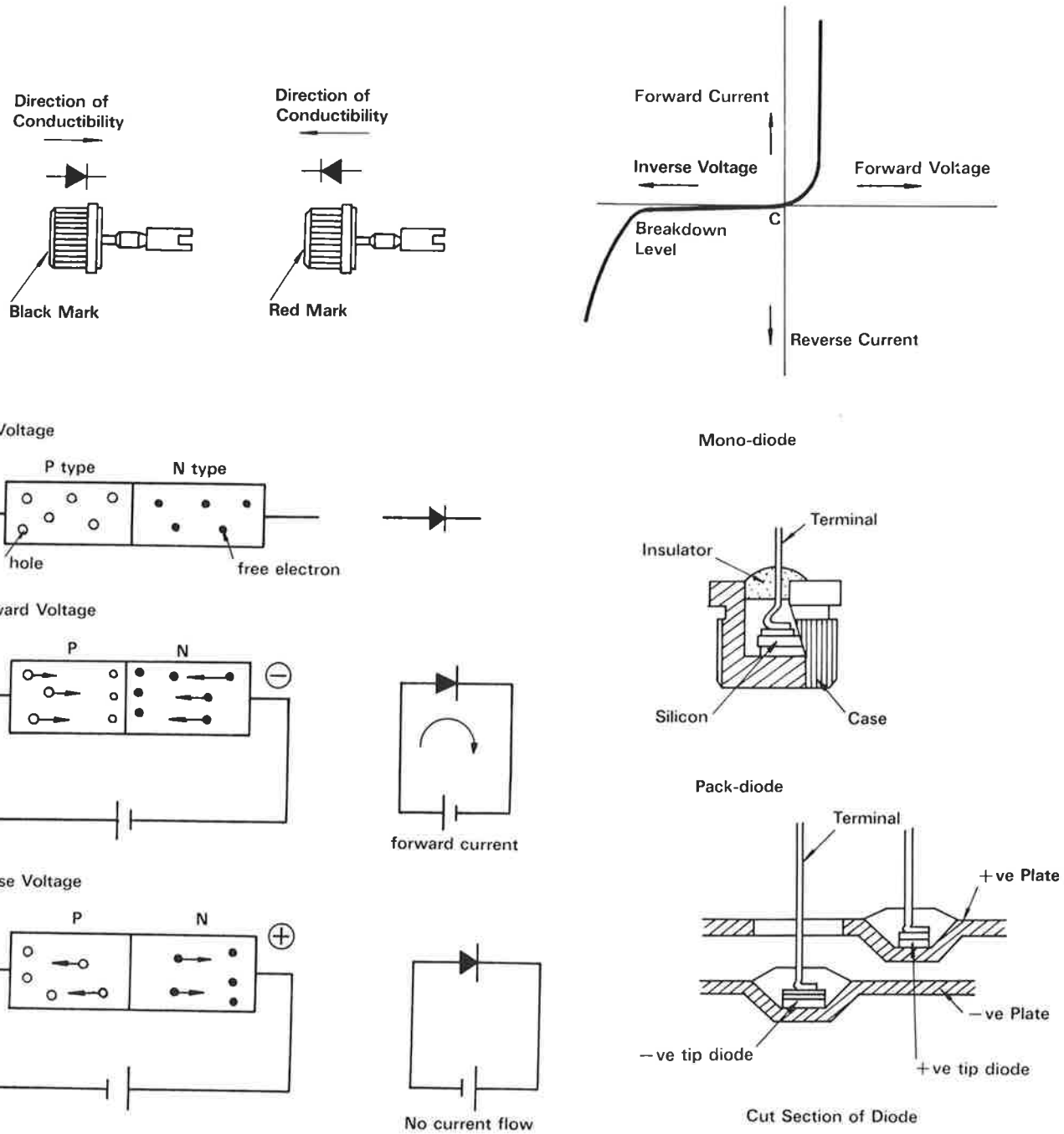
1) Diodes

A diode does not pass current in a reverse direction, only in the forward direction. This rather simple characteristic gives the diode its rectification power.

However, if a high reverse voltage is applied, the diode will break down, permitting a sudden surge of current in the circuit.

Current flow direction is indicated by a mark on the diode.

Fig. 35 :Explanation of diode.



7. TROUBLE AND CORRECTIVE MEASURES

A malfunctioning engine may be restored to proper performance by detecting the cause and eliminating that cause with the necessary corrective measure. Therefore, it is imperative to know what is the cause of trouble. For this purpose, it is necessary to obtain information on engine performance immediately prior to the occurrence of trouble, on condition at the time of trouble, and the engine handling situation before any repair or service may be begun.

Consider which part is improper in what manner, why the trouble has resulted and how the trouble may be repaired or serviced before proceeding to the actual repair or servicing.

Furthermore, if the cause of trouble is due to the carelessness of the engine operator, it is recommended to instruct him in the proper handling so that the same trouble will not result again in the future. This too, is a duty of the serviceman.

In this section, we will explain major engine troubles, what is the cause and how the trouble may be treated.

7-1 Major Classification of Troubles

If the engine troubles are classified into large groups, they are as follows:

In determining what is the cause of trouble, first evaluate the signs of trouble related to the cause and then analyze such signs for pinpointing the major cause of the trouble. If detecting the signs of trouble and their analysis is done, determining the cause of trouble and repairing will be facilitated.

1) Difficult starting - The engine is difficult to start or does not start at all.

2) Disordered running - The engine is running but disorderly.

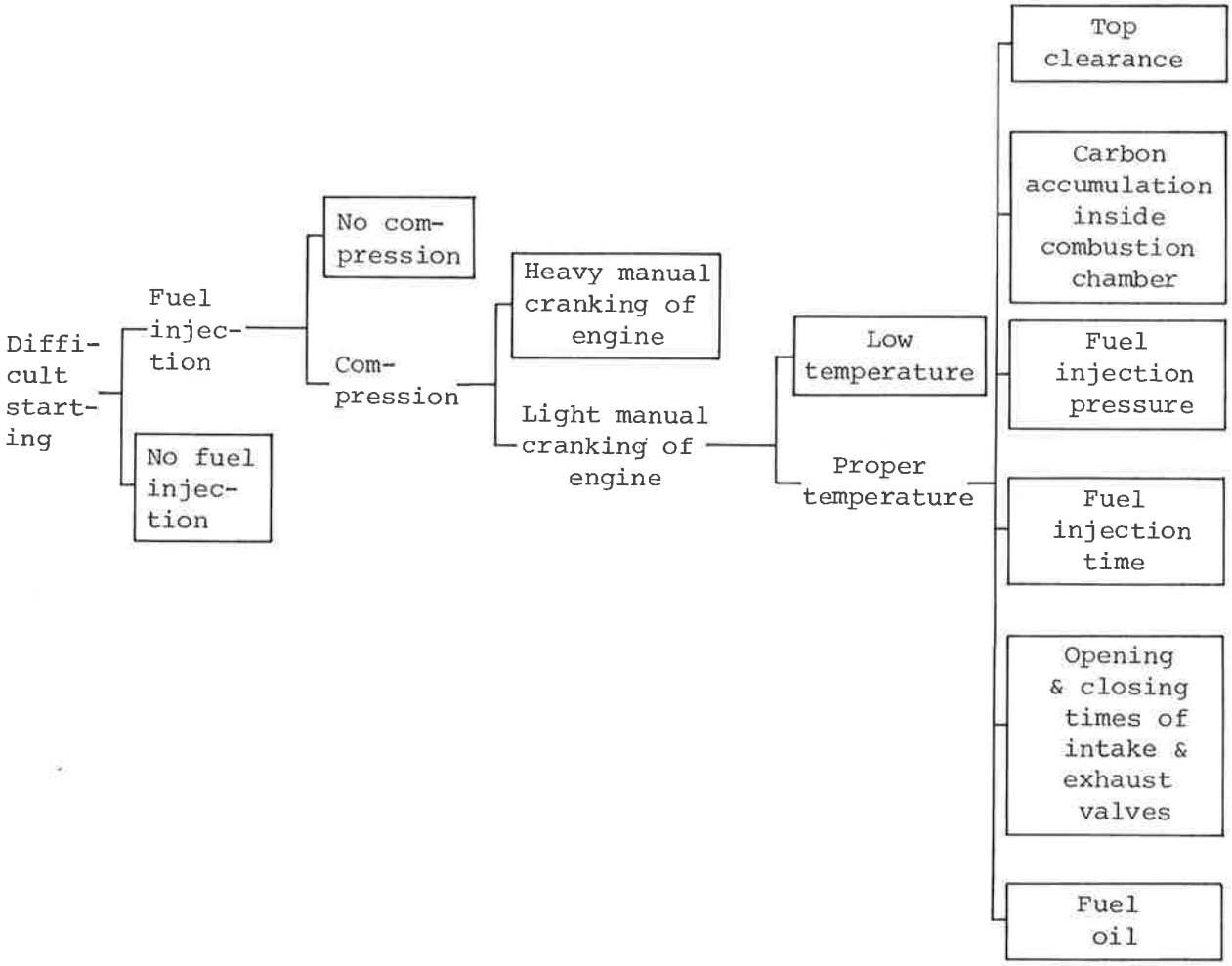
- Bad exhaust color .....
  - Black smoke
  - Blueish-white smoke
- Poor revolutions .....
  - Hunting
  - Momentary high-speed revolution
- Abnormal noise .....
  - Noise other than exhaust sound
    - Noise of intake & exhaust valves
    - Noise due to looseness of engine parts

3) Sudden stop - The engine stops running suddenly.

4) Oil, water or gas leakage - The engine works properly but oil, water or gas leakage takes place.

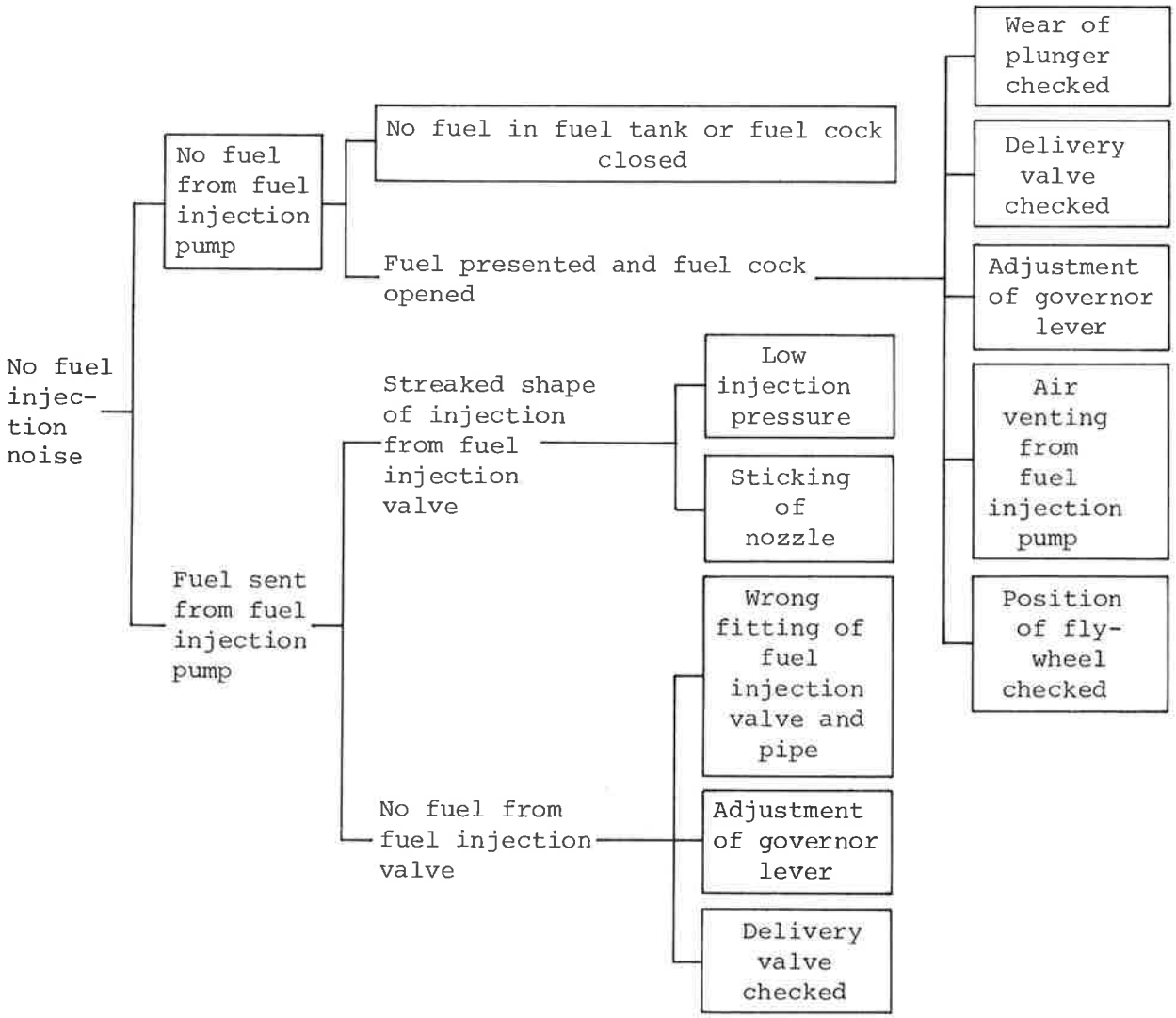
7-2 Difficult Starting

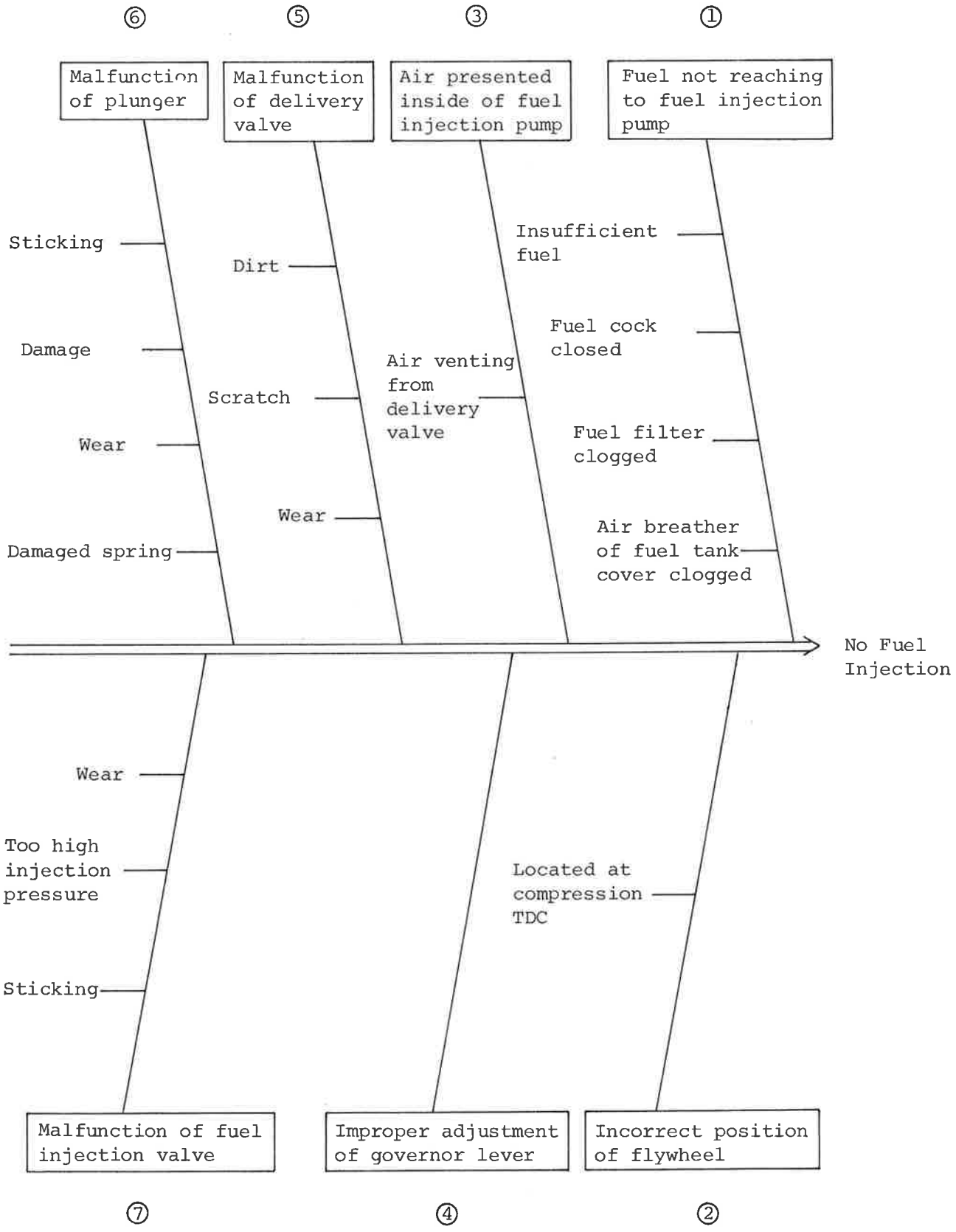
When the starting is difficult, the following troubles may be considered. Systematically determine the causes.


Difficult starting
Fuel injection
No fuel injection
No compression
Compression
Heavy manual cranking of engine
Light manual cranking of engine
Low temperature
Proper temperature
Top clearance
Carbon accumulation inside combustion chamber
Fuel injection pressure
Fuel injection time
Opening & closing times of intake & exhaust valves
Fuel oil

7-2-1 No Fuel Injection

If the fuel is injecting from the fuel injection valve under normal conditions, the injection sound may be heard. However, when the injection noise is not heard, there is an abnormality in the fuel injection system. In such case, systematically determine its causes as follows:




⑥
⑤
③
①
Malfunction of plunger
Malfunction of delivery valve
Air presented inside of fuel injection pump
Fuel not reaching to fuel injection pump
Sticking
Damage
Wear
Damaged spring
Dirt
Scratch
Wear
Air venting from delivery valve
Insufficient fuel
Fuel cock closed
Fuel filter clogged
Air breather of fuel tank cover clogged
No Fuel Injection
Wear
Too high injection pressure
Sticking
Located at compression TDC
Malfunction of fuel injection valve
Improper adjustment of governor lever
Incorrect position of flywheel
⑦
④
②

Treatment and Instructions

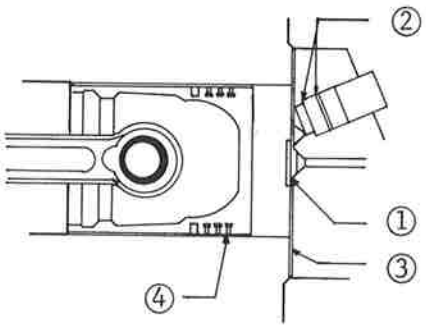
No.	Cause	Treatment	Instructions to Engine Operator
1	Fuel not reaching fuel injection pump. 1) Insufficient fuel. 2) Fuel cock closed. 3) Fuel filter clogged. 4) Air breather of fuel tank cover clogged.	1) Supply of fuel and air venting. 2) Opening of fuel cock. 3) Cleaning of fuel filter and fuel tank or exchange of fuel strainer. 4) Cleaning of air breather.	1) Checking of oil level gauge. 2) Supplying of fuel, draining from fuel tank and cleaning of filter.
2	Incorrect position of flywheel.	Change of plunger position by turning the flywheel.	
3	Air present inside fuel injection pump.	Air venting.	Air venting procedure.
4	Improper adjustment of governor lever.	Adjustment of gover-nor lever.	
5	Malfunction of delivery valve. 1) Dirt present 2) Scratch & wear.	1) Cleaning. 2) Correction or replacement.	1) Cleaning procedure. Avoiding misplace-ment of parts. Handling of fuel.
6	Malfunction of plunger. 1) Sticking of plunger. 2) Damaged or worn plunger. 3) Damaged plunger spring.	1) Washing or replace-ment . 2) Replacement of both plunger and barrel. 3) Replacement.	1) Handling of fuel. 2) Assembling of plunger.

No.	Cause	Treatment	Instructions to Engine Operator
7	Malfunction of fuel injection valve. 1) Sticking of needle valve. 2) Too high fuel injection pressure. 3) Wear of needle valve.	1) Washing. 2) Adjustment of fuel injection pressure 140 kg/cm^2. 3) Replacement of needle valve with needle valve case.	1) Handling of fuel.

7-2-2 Compressed Air Leakage

If compressed air leakage occurs, the temperature of the combustion chamber will not rise sufficiently, resulting in no firing and consequently no starting of engine.

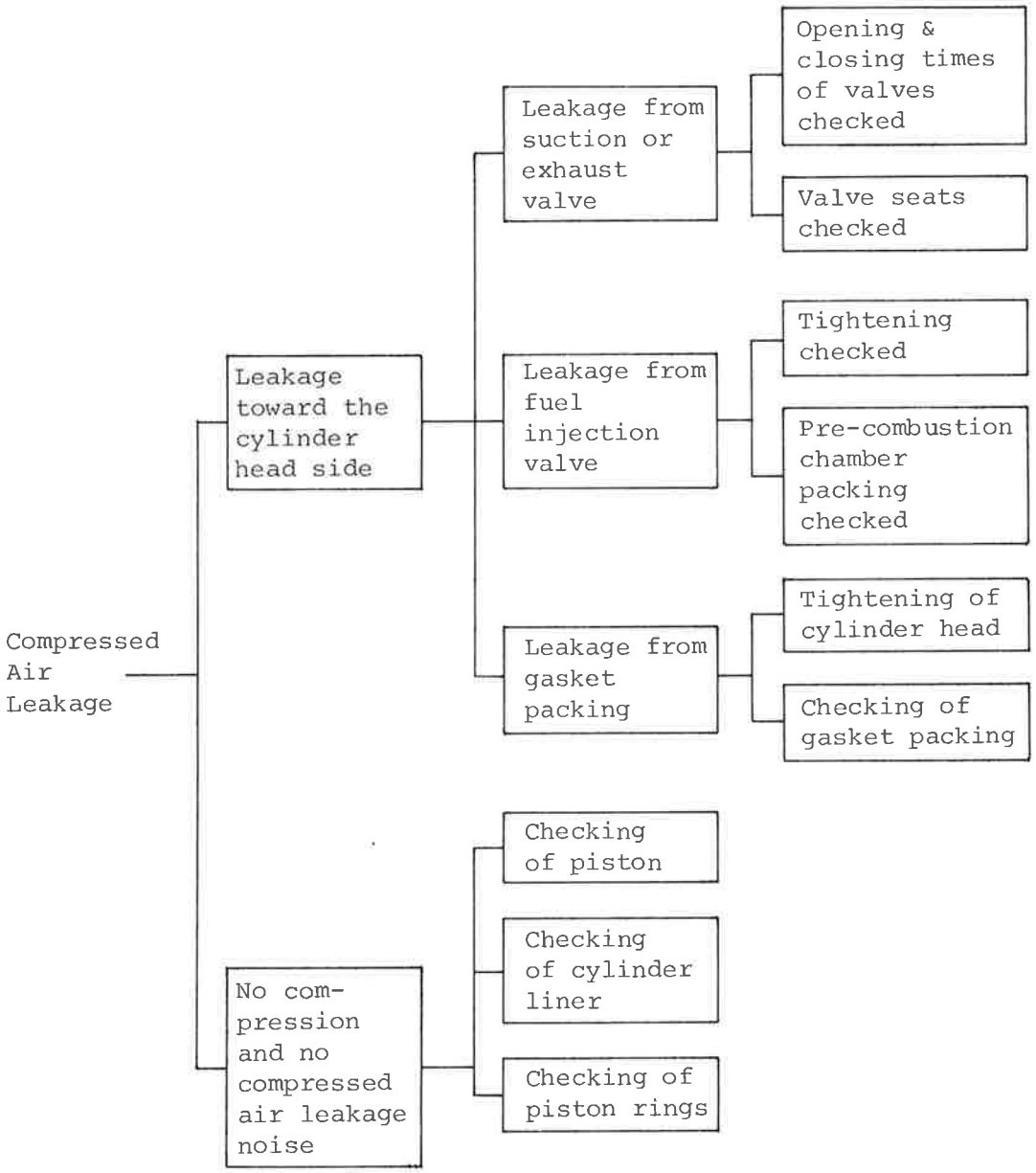
Compressed air may be leaked at the following four places as indicated in the figure below:



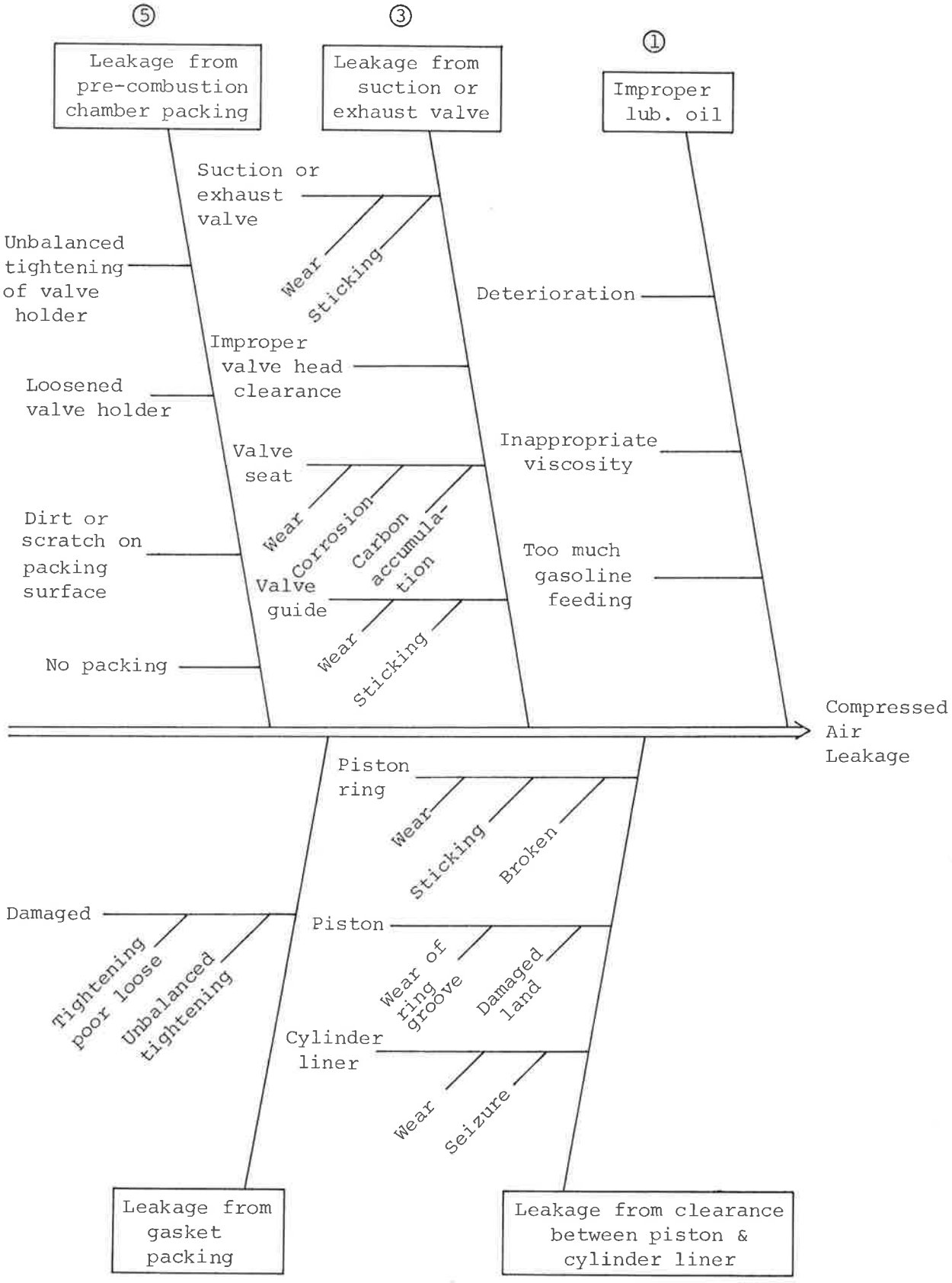
1) Clearance of piston pin, piston ring and cylinder liner.
2) Suction or exhaust valve seat.
3) Air-tight surface due to gasket packing.
4) Pre-combustion chamber packing.

There are two directions of compressed air leakage. One direction is toward the cylinder side, the other, to inside the crankcase. Therefore, it is wise to first detect the direction of leakage in determining the cause of trouble.

When compressed air leakage is occurring an air leaking noise will be heard. Examine the location of the leakage, and determine the causes systematically in the following order:



Major causes of compressed air leakage may be considered to be as follows :



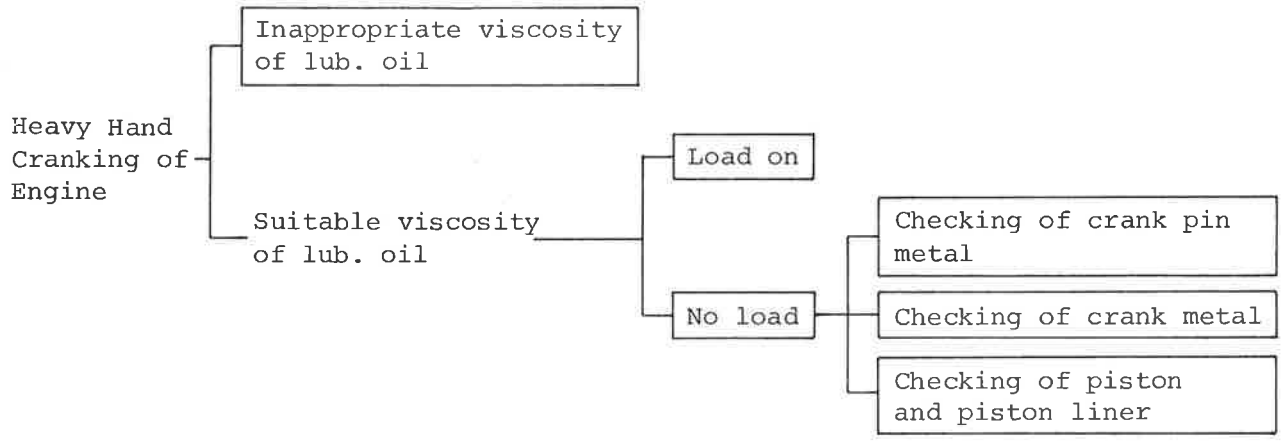
Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Improper lubricating oil. 1) Deterioration of lub. oil. 2) Inappropriate viscosity. 3) Too much gasoline feeding.	1) Replacement. 2) Replacement. 3) Manually turn the engine for a few turns.	1) Handling of lub.oil. 2) Handling of lub.oil. 3) Starting with gasoline feeding.
2	Leakage from clearance between piston and cylinder liner. 1) Sticking of piston ring. 2) Broken or worn piston ring. 3) Damaged land of piston and worn piston ring groove. 4) Seizure and wear of cylinder liner.	1) Washing or replacement. 2) Replacement. 3) Replacement. 4) Replacement.	1) Handling of air cleaner. 2) Handling of lub.oil. 3) Replenishment of cooling water. 4) No overloading recommended.
3	Leakage from intake or exhaust valve. 1) Improper valve head clearance. 2) Carbon accumulation, corrosion and wear of valve seat. 3) Sticking or wear of valve guide. 4) Sticking of wear of suction or exhaust valve.	1) Adjustment of suction and exhaust valves. 2) Lapping of intake and exhaust valves. 3) Replacement (with cylinder head). 4) Cleaning or replacement.	1) Adjustment of suction and exhaust valves. 2) Selection of fuel. 3) Selection of fuel. Feeding of fuel.

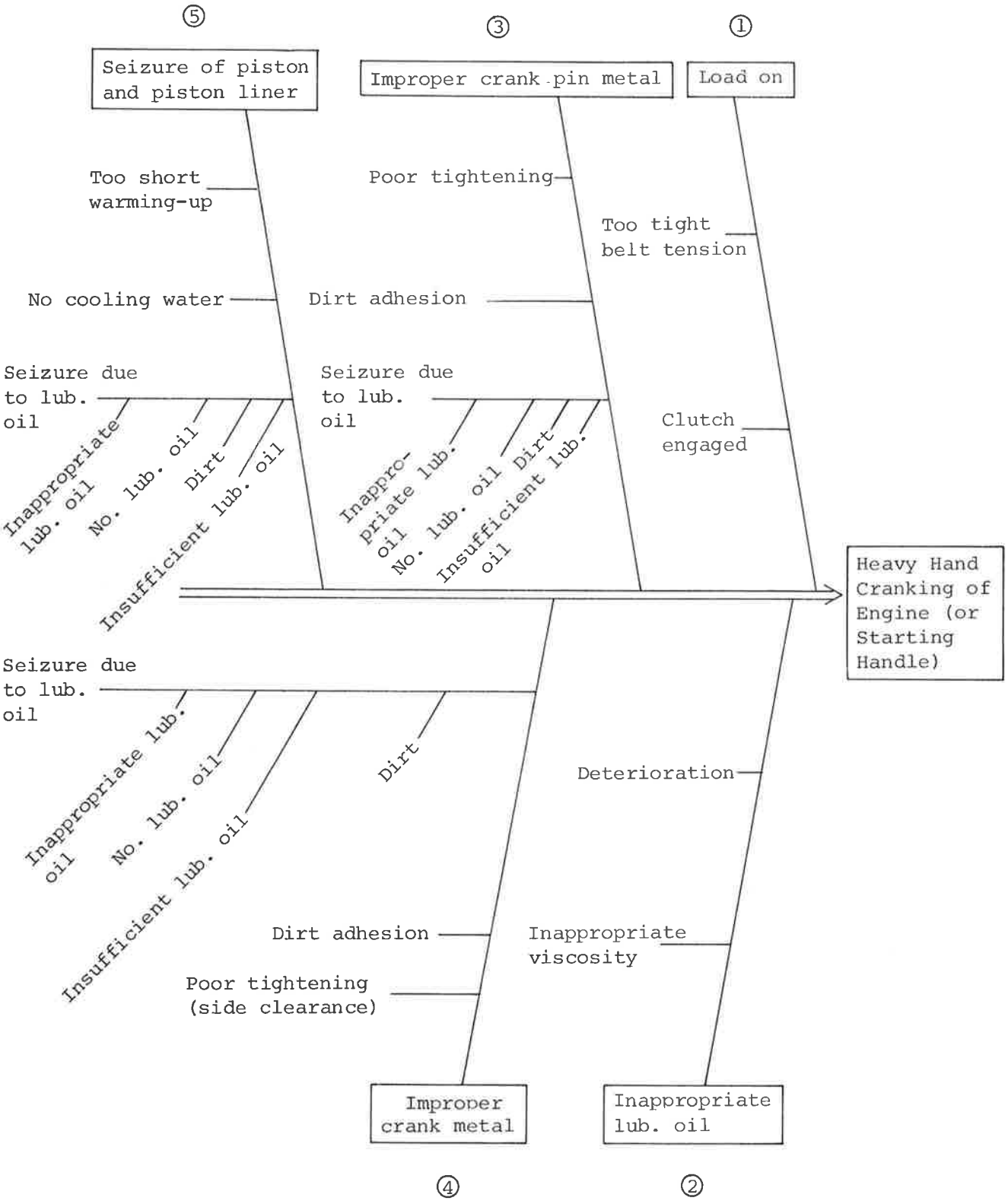
4	Leakage from gasket packing. 1) Damaged gasket packing due to unbalanced tightening or too loose tightening.	1) Replacement.	1) Periodical retightening.
5	Leakage from pre-combustion chamber packing. 1) Unbalanced tightening or loosened valve holder. 2) Dirt or scratch on packing surface or no packing.	1) Retightening in balanced order. 2) Replacement of packing.	

7-2-3 Heavy Hand Cranking

In order to start up the engine easily, it is necessary to have the engine turned lightly by hand. However, if the hand cranking is heavy, the air compression will not be sufficiently carried out; thus, the temperature due to compression will not rise enough to provide the firing of fuel, and consequently results in difficult starting. Naturally, even if starting is somehow possible, the output during running will not reach top performance.



When the hand cranking of engine is heavy, the following causes may be considered :



Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Load on. 1) Belt tension too tight. 2) Clutch engaged.	1) Adjustment of belt tension. 2) Disengage the clutch.	1) Belt tension 2) Disengagement of the clutch and starting of engine.
2	Inappropriate lub. oil. 1) Deterioration. 2) Inappropriate.	1) Replacement. 2) Replacement.	1) Replacement frequency of lub. oil. 2) Selection of lub. oil.
3	Improper crank pin metal. 1) Poor tightening. 2) Dirt adhesion. 3) Seizure due to lub. oil.	1) Tighten with specified torque. 2) Washing or replacement. 3) Replacement.	2) Cleaning or handling of crank pin metal. 3) Handling of lub. oil.
4	Improper crank metal. 1) Poor tightening. 2) Dirt adhesion. 3) Seizure due to lub. oil.	1) Replace packing and insert the metal completely. 2) Cleaning or replacement. 3) Replacement of lub. oil.	1) Use of genuine parts. 2) Cleaning or handling of the metal. 3) Handling of lub. oil.
5	Seizure of piston and cylinder liner. 1) Warming-up too short. 2) No or insufficient cooling water. 3) Seizure due to lub. oil.	1) Replacement of seized parts. 2) Replacement of seized parts. 3) Replacement of seized parts.	1) Warming-up. 2) Replenishment of cooling water. 3) Handling of lub. oil.

7-2-4 Cold Engine due to Too Low Ambient Temperature

Even if the fuel injection is normal with sufficient compression, during the winter the ambient temperature is low. Consequently, the starting is naturally difficult as comparing with warm seasons. This is a natural condition, not a trouble in the engine.

In low temperature, the lub. oil becomes very viscous, turning of the starting handle becomes heavier, and the temperature of the compressed air does not rise to a sufficient level.

All of these cause the firing of fuel to be difficult. Therefore in order to faciliate it, the following steps are recommended.

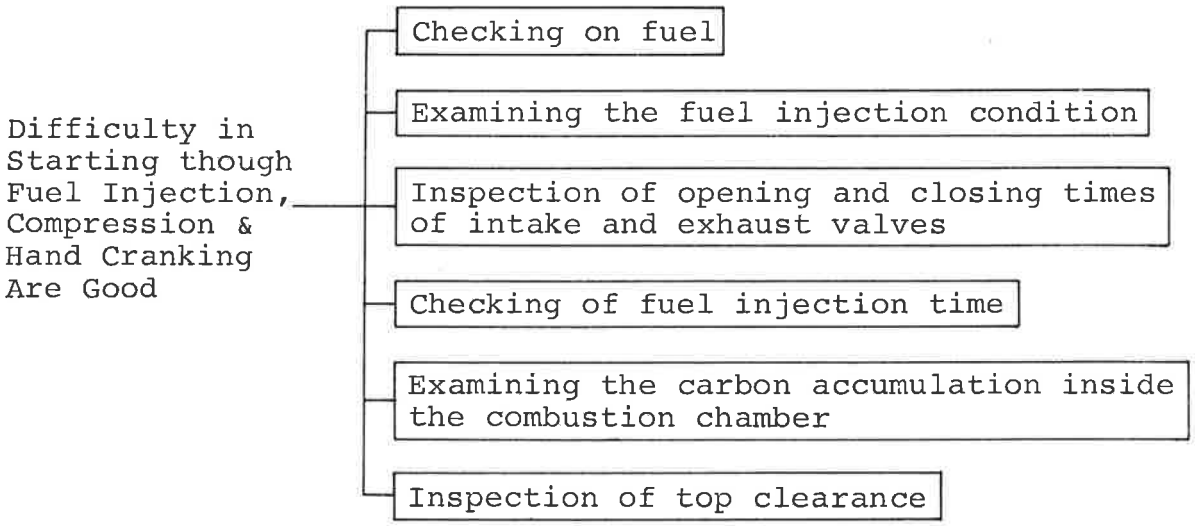
1) During the winter season, use SAE No. 20 or 10W 30 lub. oil (Refer to the Section on lubricating oil.)

2) Employ an agent for aiding easy starting. Starting gasoline or automobile gasoline should be fed from the gasoline cup. Feed about 1 cc of such gasoline in one application. If too much gasoline is carelessly fed at one time, it will thin out the lub. oil which is lubricating the piston and cylinder liner, resulting in compression leakage and adversely worsen starting.

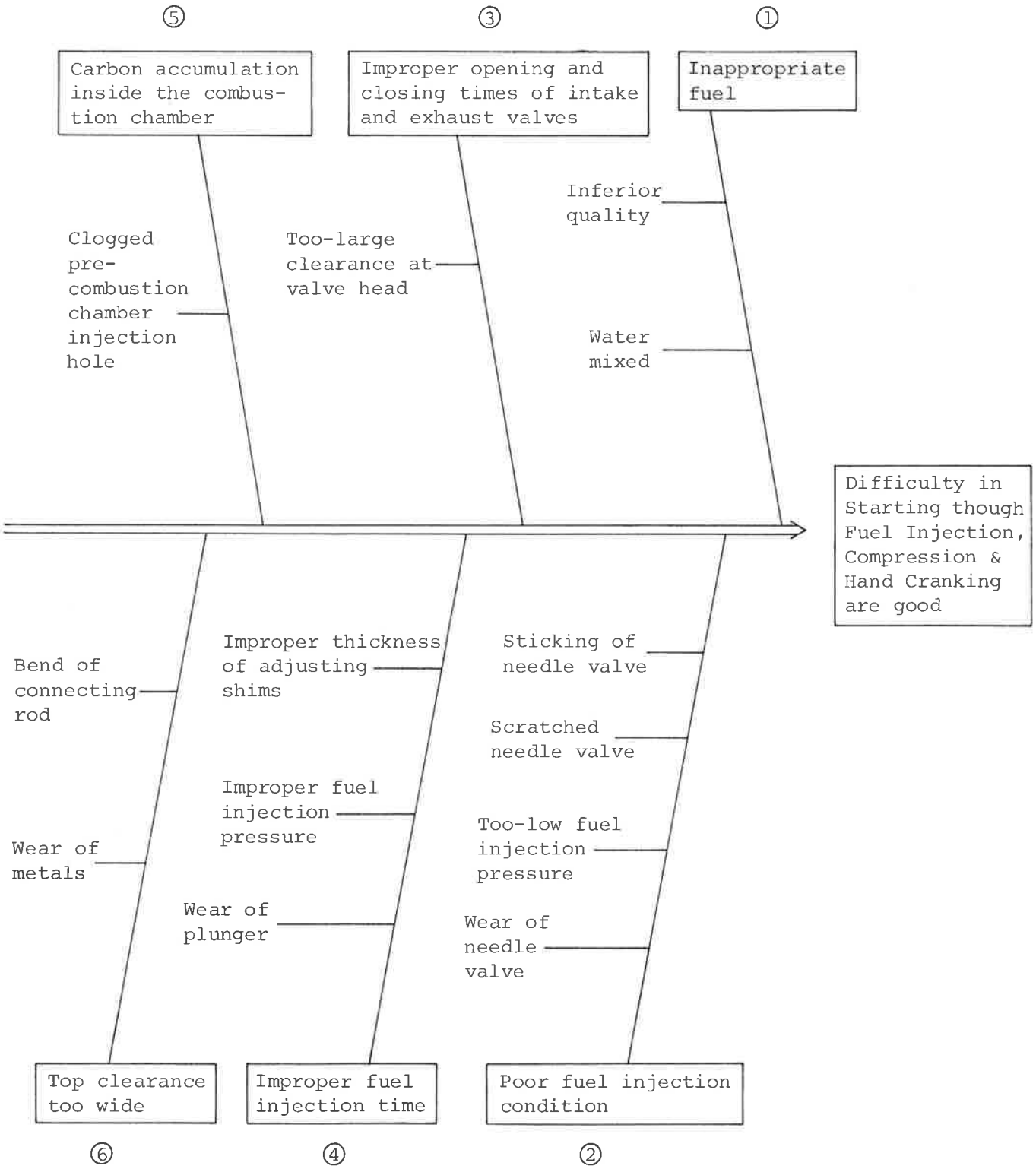
3) Pour in hot water for cooling water.
By the above method, starting will be facilitated if the engine is in a cold condition.

7-2-5 Difficulty in Starting Regardless of Ambient Temperature When Fuel Injection & Compression Are Normal

If the starting is difficult when turning of the starting handle is light, compression is sufficient and the fuel injection is normal, examine the following points :



The following causes may be considered for the above points :



Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Inappropriate fuel. 1) Inferior quality of lub. oil used. 2) Water mixed in fuel.	1) Replacement. 2) Replacement.	1) Selection of fuel. 2) Handling of fuel and draining.
2	Poor fuel injection condition. 1) Sticking of needle valve. 2) Scratched needle valve. 3) Too-low fuel injection pressure. 4) Wear of needle valve	1) Cleaning or replacement. 2) Replacement. 3) Adjustment of fuel injection pressure. 4) Replacement.	1) Handling of fuel and draining. 3) Adjustment of fuel injection pressure.
3	Improper opening and closing times of suction and exhaust valves. 1) Clearance too large at valve head.	1) Adjustment on clearance of suction and exhaust valves.	1) Adjustment on clearance of suction and exhaust valves.
4	Improper fuel injection time. 1) Improper thickness of adjusting shims. 2) Improper fuel injection pressure. 3) Wear of plunger.	1) Adjustment of thickness of adjusting shims. 2) Adjustment of fuel injection pressure. 3) Replacement.	1) Adjustment on fuel injection time. 2) Adjustment of fuel injection pressure. 3) Handling of fuel.
5	Carbon accumulation inside the combustion chamber. 1) Clogged pre-combustion chamber injection hole.	1) Removal of carbon.	1) Handling of fuel.
6	Top clearance too wide. 1) Wear of metal. 2) Bend of connecting rod (due to water hammer, etc.)	1) Replacement. 2) Replacement.	1) Handling of lub. oil. 2) Proper operation of working machine.

7-3 Disordered Running

Even if starting is possible, unless the engine runs orderly, the working performance will not be at the top level. Furthermore, if the engine is operated in that condition for a long time, the degree of trouble will also increase accordingly, and consequently a dangerous accident may occur.

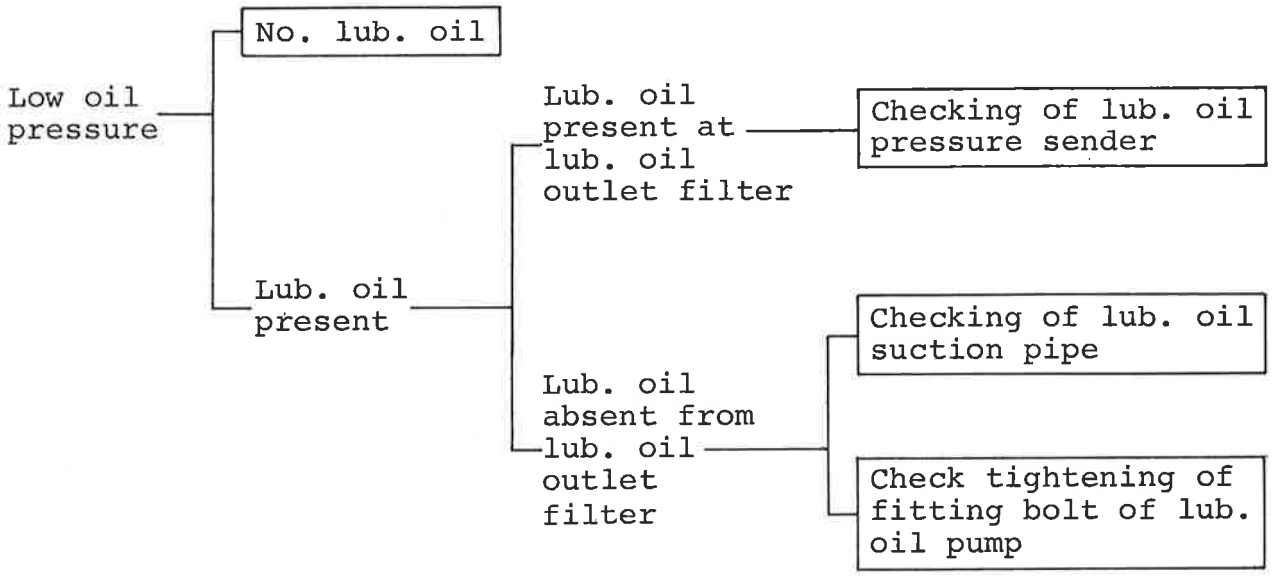
Stop the engine immediately and determine the causes of trouble as soon as possible.

During the running of engine, if the following conditions become apparent, search for the cause :

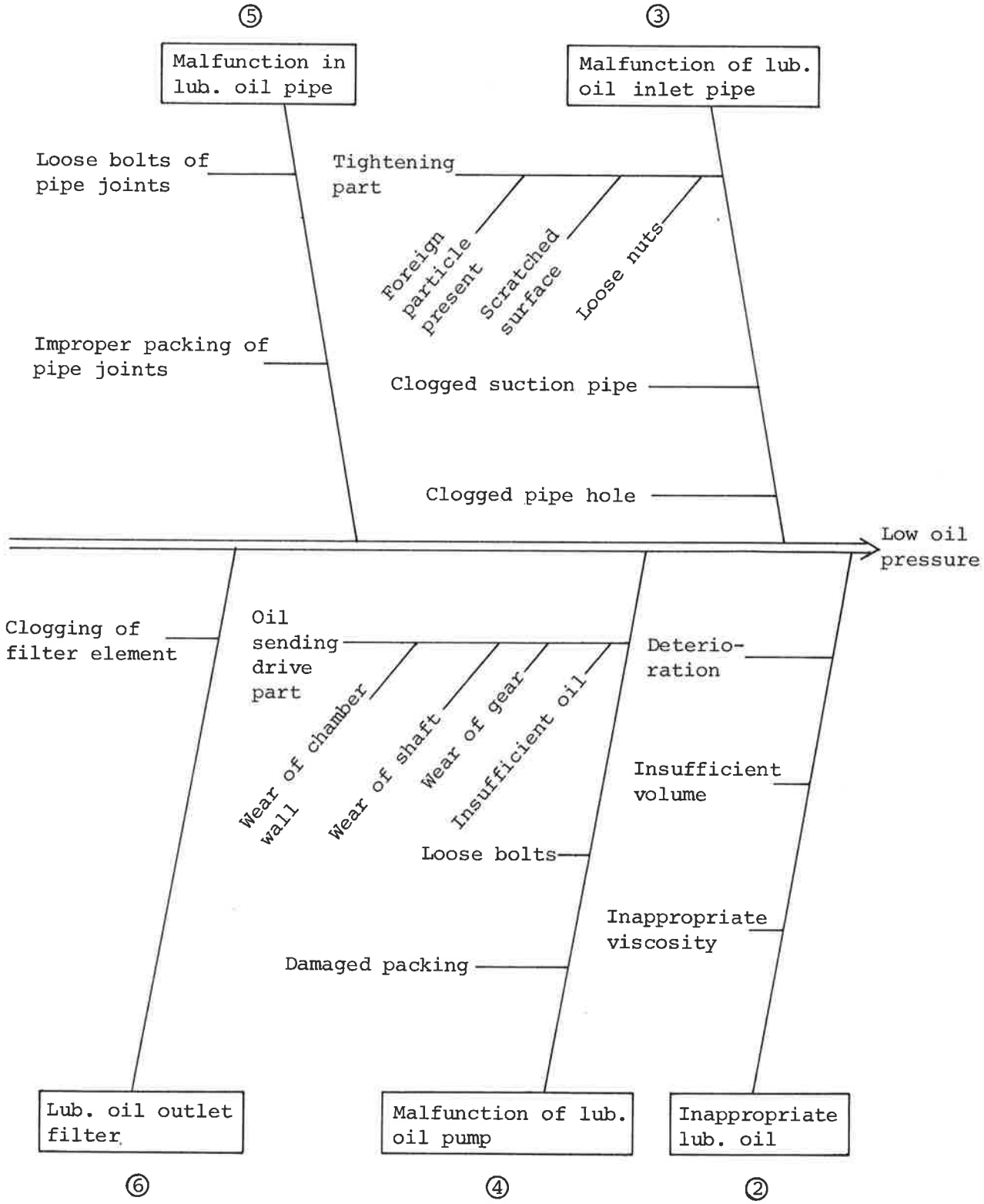
1) Oil light rotor not turning.
2) Abnormal noise during running.
3) Bad exhaust color.
4) Output decrease.
5) Hunting.
6) Momentary high-speed revolution.
7) Reverse rotation at starting.

7-3-1 Oil Light Rotor Not Turning

If the engine is operated in such condition, seizure of piston, cylinder liner, crankshaft, crank metal, or other working parts will occur. In such case, immediately stop the engine, and check why the lub. oil is not circulating. Check for this in the following order :


Low oil pressure
No. lub. oil
Lub. oil present
Lub. oil present at lub. oil outlet filter
Checking of lub. oil pressure sender
Lub. oil absent from lub. oil outlet filter
Checking of lub. oil suction pipe
Check tightening of fitting bolt of lub. oil pump

For causes of oil light rotor not turning, the following may be considered :



Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Malfunction of lub.oil pressure sender.	1) Replacement	
2	Inappropriate lub. oil. 1) Insufficient volume. 2) Deterioration. 3) Inappropriate viscosity.	 1) Replenishment 2) Replacement. 3) Replacement.	Handling of lub. oil.
3	Malfunction of lub. oil. inlet pipe. 1) Air suction due to malfunction of tightening part. a. Loose pipe joint bolts. b. Inferior aluminum packing for lub. oil pump bolts. c. Scratched surface. d. Foreign particles present. 2) Clogged suction pipe. 3) Clogged pipe hole.	 a. Retightening. b. Replacement of aluminum packing. c. Correction or replacement. d. Cleaning. 2) Cleaning. 3) Cleaning.	1) Cleaning of lub. oil. suction pipe. Handling of lub. oil. Exchange of lub. oil. 2) Cleaning.
4	Malfunction of lub. oil. pump. 1) Damaged packing. 2) Loose bolts. 3) Insufficient oil from oil sending drive part. 4) Wear of gear, shaft and chamber wall.	 1) Replacement. 2) Retightening. 3) Feeding of oil to the lub. oil. pump. 4) Replacement of lub. oil pump.	Handling of lub. oil.

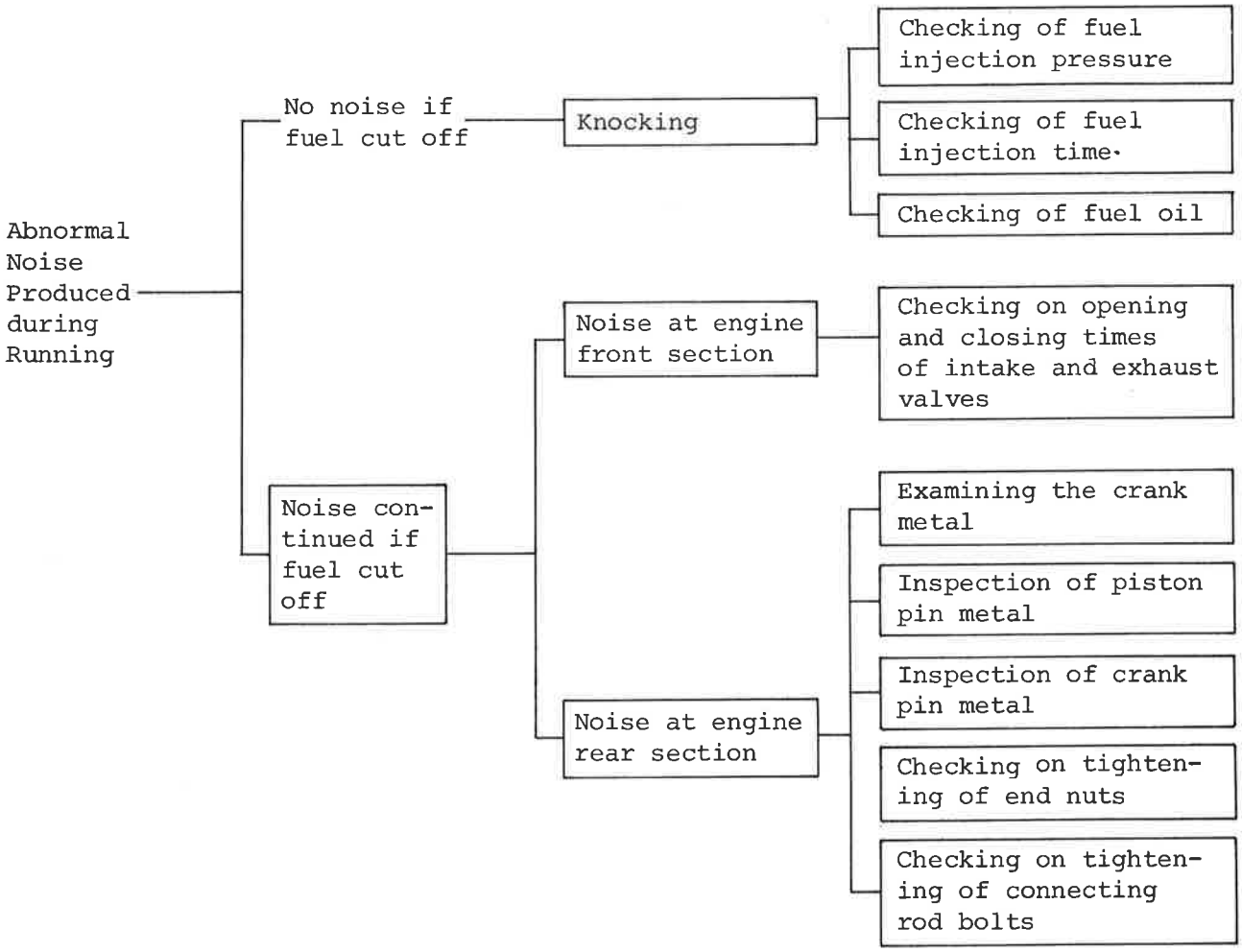
No.	Cause	Treatment	Instructions to Engine Operator
5	Malfunction in lub. oil pipe. 1) Loose bolts of pipe joints. 2) Improper packing of pipe joints.	1) Retightening. 2) Replacement of packing.	
6	Lub. oil outlet filter. 1) Clogging of filter element.	1) Cleaning of the filter. 2) Replacement of lub. oil.	Handling of the filter. Draining from the filter. Handling of lub. oil.

7-3-2 Abnormal Noise During Running

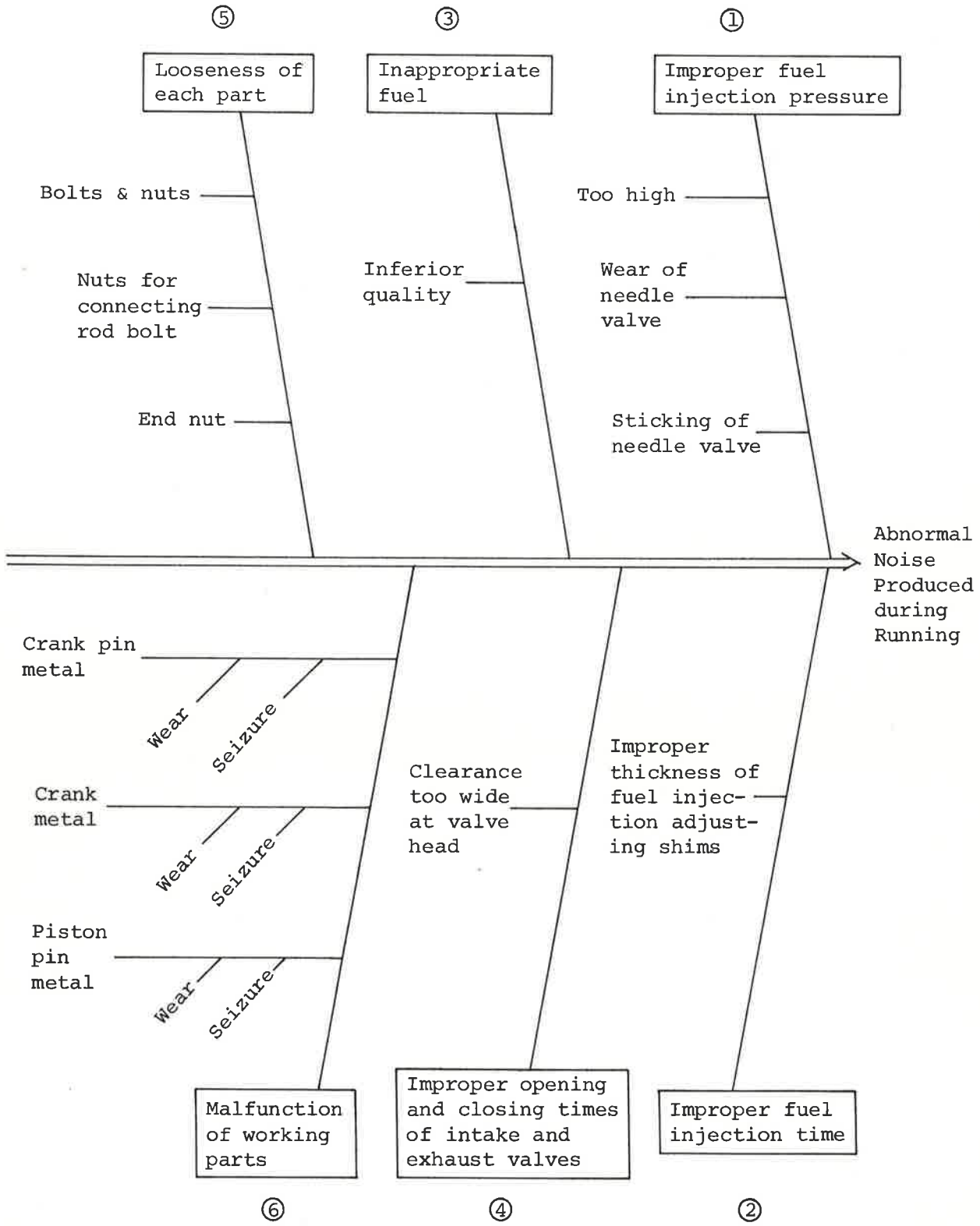
At the time of starting of the diesel engine, a high-pitched noise will be produced. This is called the diesel knocking and is caused by the pressure created from a large amount of fuel combusted at one time.

This is no malfunction. However during the engine running, if an abnormal exhaust sound or metallic knocking noise are produced, stop the engine immediately and determine the cause.

When an abnormal noise is produced during engine running, check the causes of trouble in the following order :



The following causes will be considered with regard to abnormal noise produced during running :



Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Improper fuel injection pressure. 1) Sticking of needle valve. 2) Wear of needle valve. 3) Fuel injection pressure too high.	1) Cleaning or replacement. 2) Replacement. 3) Adjustment of fuel injection pressure.	1) Handling of fuel. 2) Handling of fuel.
2	Improper fuel injection time. 1) Improper thickness of fuel injection time adjusting shims.	1) Adjustment of fuel injection time.	
3	Inappropriate fuel. 1) Inferior quality fuel.	1) Replacement.	1) Handling of fuel.
4	Improper opening and closing times of intake and exhaust valves. 1) Clearance too wide at valve head.	1) Adjustment on clearance of intake and exhaust valves.	1) Adjustment on clearance of intake and exhaust valves.
5	Looseness of each part. 1) Looseness of endnut. 2) Looseness of nuts for connecting rod bolts. 3) Looseness of bolts and nuts.	1) Retightening. 2) Retightening of the nuts and bending of bend lock washers. 3) Retightening.	Periodic retightening of major bolts and nuts.
6	Malfunction of working parts. 1) Seizure and wear of crank pin metal. 2) Seizure and wear of crank metal. 3) Seizure and wear of piston pin metal.	1) Replacement. 2) Replacement. 3) Replacement	Handling of lub. oil. No operation.

7-3-3 Bad Exhaust Color

The condition of engine may be fairly well determined from the exhaust color. Also, from different colors of exhaust, one can determine what part of the engine is in disorder. Thus by applying this method for detection of trouble, one can easily learn the causes of trouble.

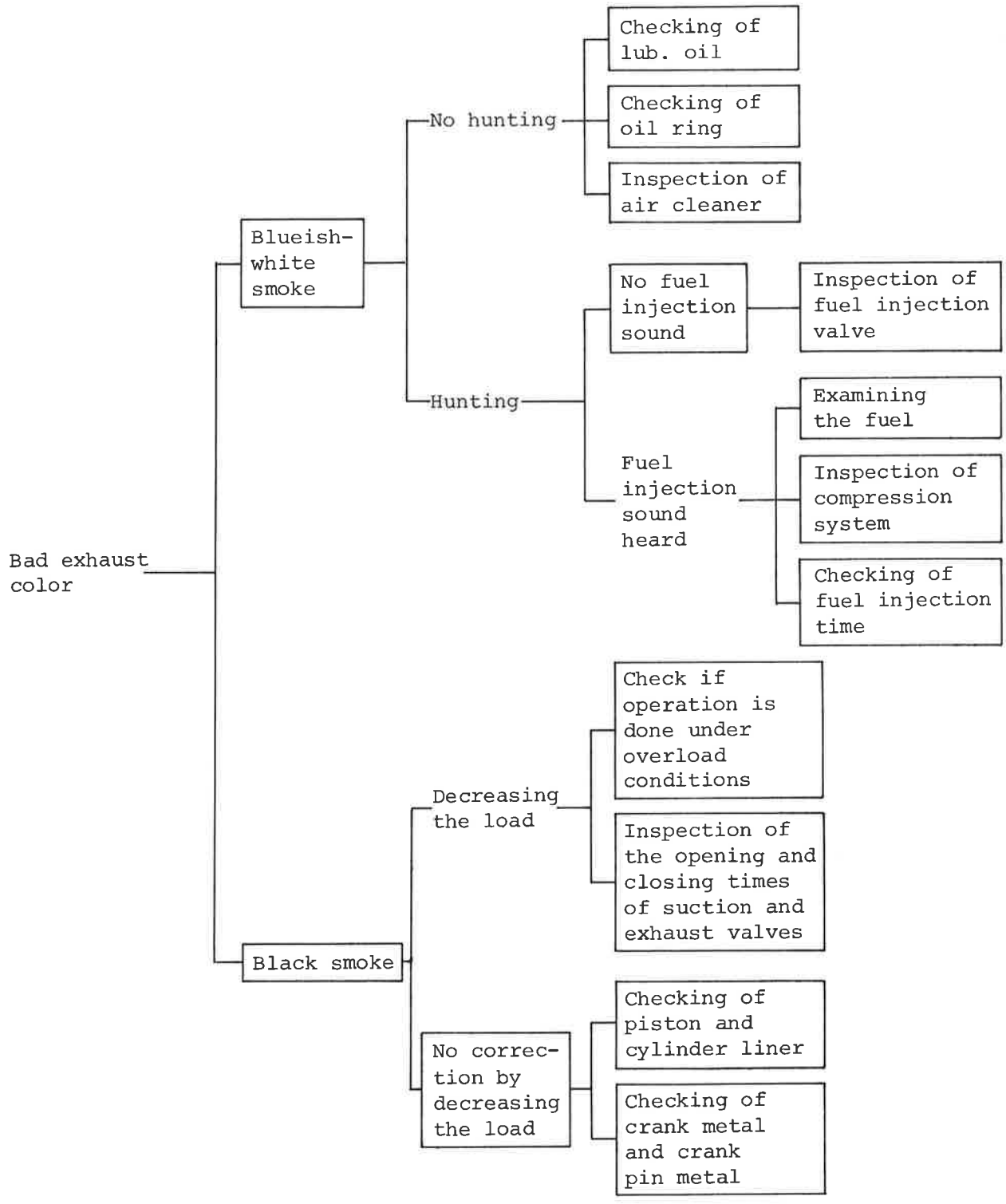
The relations between the exhaust color and the trouble are as follows :

Colorless or light blue color - good running condition

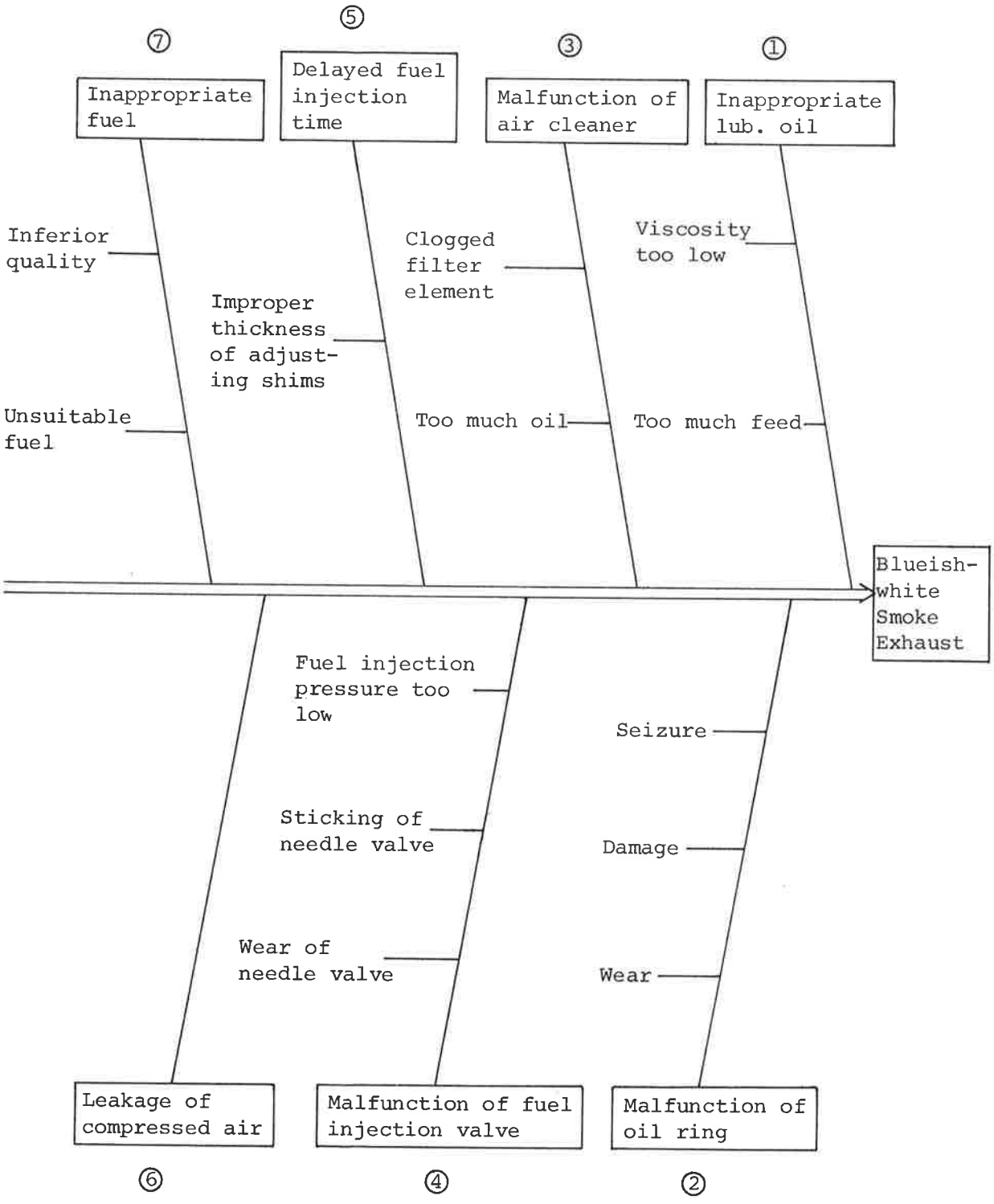
Blueish-white smoke - incomplete combustion or burning of lub. oil

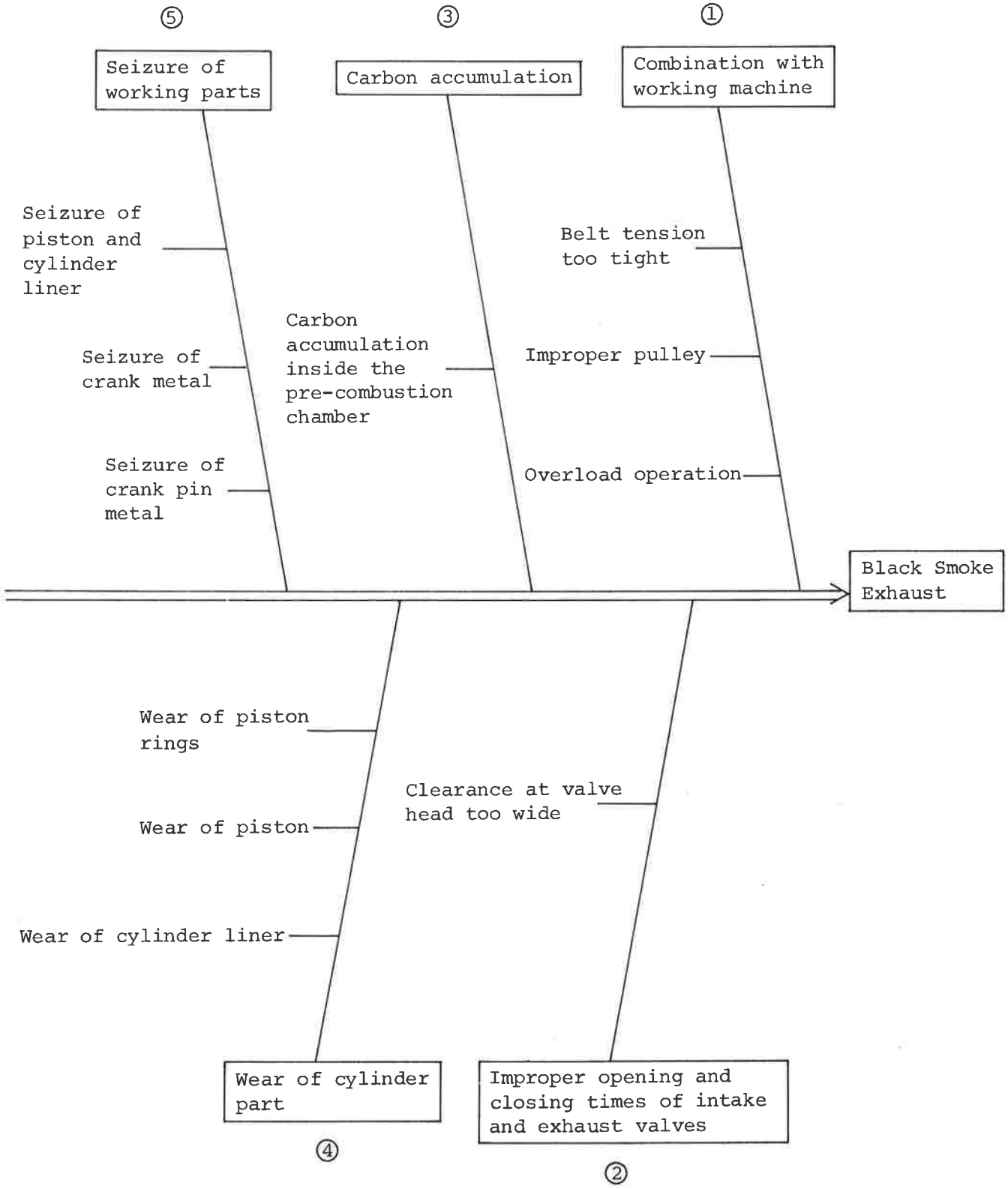
Black smoke - overloading.

If the exhaust is poorly colored, determine the cause in the following order :



When the exhaust is poorly colored, the following causes may be considered :




⑤
Seizure of working parts
③
Carbon accumulation
①
Combination with working machine
Seizure of piston and cylinder liner
Seizure of crank metal
Seizure of crank pin metal
Carbon accumulation inside the pre-combustion chamber
Belt tension too tight
Improper pulley
Overload operation
Black Smoke Exhaust
Wear of piston rings
Wear of piston
Wear of cylinder liner
Clearance at valve head too wide
Wear of cylinder part
④
Improper opening and closing times of intake and exhaust valves
②

Blueish-white Smoke Exhaust
Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Inappropriate lub. oil. 1) Too much feed. 2) Viscosity too low.	1) Decreasing the volume to the upper limit of oil level gauge. 2) Replacement of oil level gauge.	1) Handling of lub. oil. 2) Handling of lub. oil.
2	Malfunction of oil ring. 1) Seizure, damage and wear.	1) Replacement	Handling of lub. oil.
3	Malfunction of air cleaner. 1) Too much oil. 2) Clogged filter element.	1) Lowering of oil to the level of the hopper side line. 2) Cleaning of filter element.	1) Handling of air. 2) Periodical cleaning of the element.
4	Malfunction of fuel injection valve. 1) Sticking of needle valve. 2) Fuel injection pressure too low. 3) Wear of needle valve.	1) Cleaning or replacement. 2) Adjustment of fuel injection pressure. 3) Replacement of nozzle.	1) Handling of fuel. 2) Adjustment of fuel injection pressure.
5	Delayed fuel injection time. 1) Too many of the adjusting shims.	1) Adjustment of fuel injection time.	
6	Leakage of compressed air. (Refer to Subdivision , "Compressed Air Leakage.")		
7	Inappropriate fuel. 1) Inferior quality fuel used. 2) Unsuitable fuel used.	1) Replacement. 2) Replacement.	Handling of fuel.

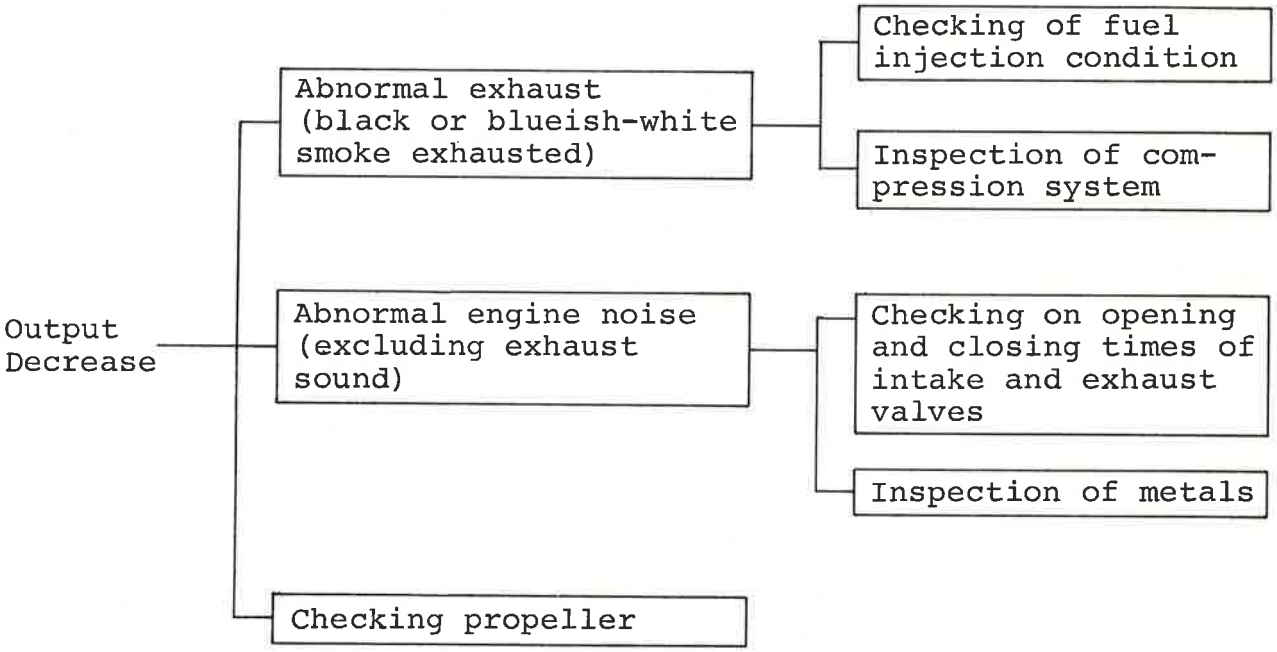
Black Smoke Exhaust
Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Combination with working machine. 1) Overload operation. 2) Improper diameter of pulley used. 3) Belt tension too tight.	1) Decrease of load. 2) Replacement of pulley. 3) Adjustment of belt tension.	1) Method of operation. 2) Selection of pulley. 3) Adjustment of belt tension.
2	Improper opening and closing times of suction and exhaust valves. 1) Clearance too wide at valve head.	1) Adjustment on clearance of intake and exhaust valves.	1) Adjustment on clearance intake and exhaust valves.
3	Carbon accumulation. 1) Carbon accumulation inside the pre-combustion chamber.	1) Cleaning to remove carbon.	1) Handling of fuel.
4	Wear of cylinder part. 1) Wear of piston rings. 2) Wear of piston. 3) Wear of cylinder liner.	1) Replacement of rings. 2) Replacement of piston. 3) Replacement of cylinder liner.	Handling of both fuel and lub. oil.
5	Seizure of piston and cylinder. 1) Seizure of piston and cylinder liner. 2) Seizure of crank metal. 3) Seizure of crank pin metal.	1) Correction or replacement. 2) Replacement. 3) Replacement.	Handling of both cooling water and lub. oil.

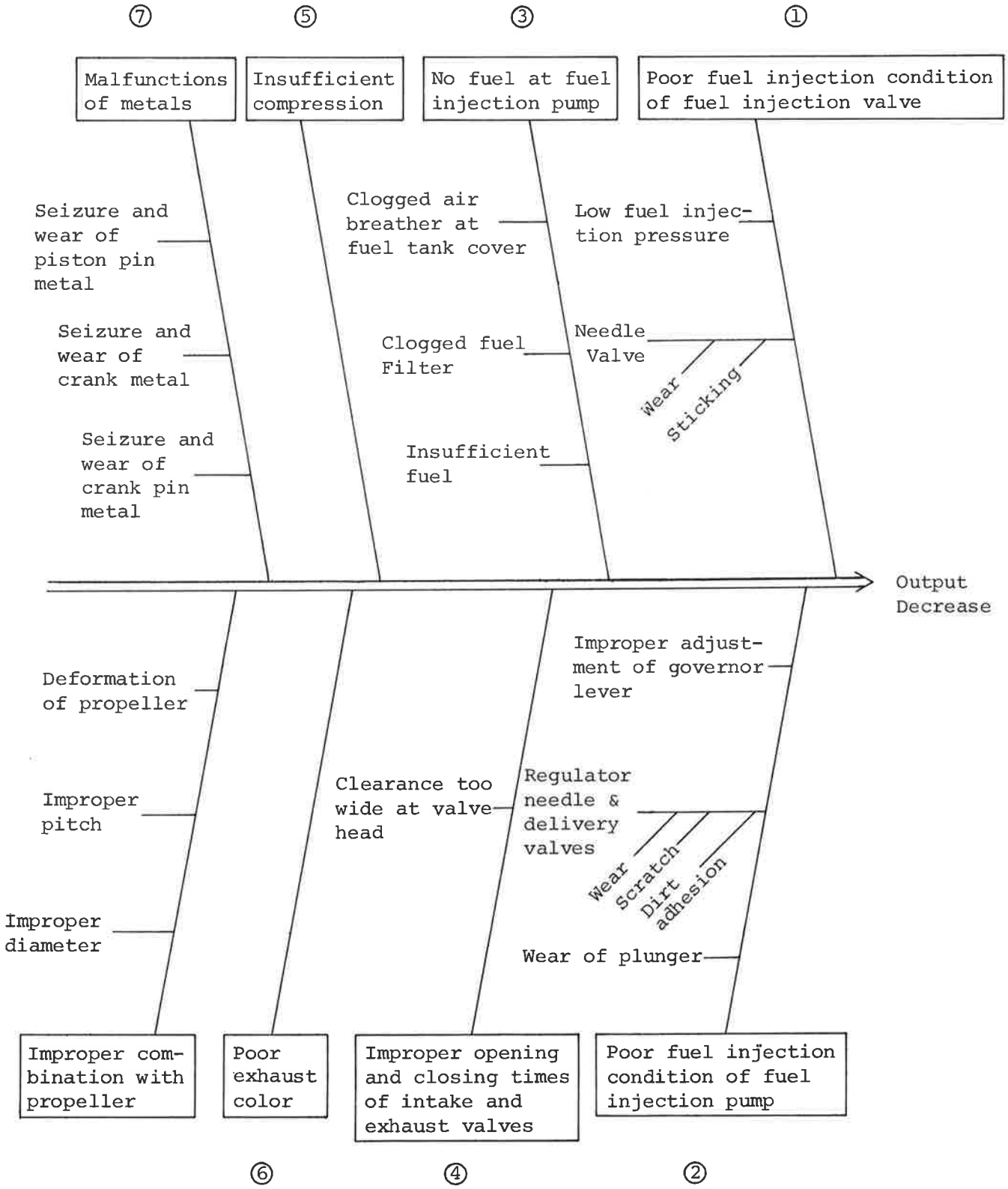
7-3-4 Output Decrease

If the engine is operated under an overload, that is, beyond the engine top performance, the number of revolutions will drop and black smoke will be exhausted. Naturally, operations under such a condition should be avoided. However, an engine in good working condition usually offers good working performance. Yet if the same operation becomes impossible, with black smoke exhausted and the revolutions dropped, this should be considered as an abnormality in the engine.

In such case, determine the cause in the following manner :



When the output is decreased, the following causes may be considered :



Treatment and Instructions

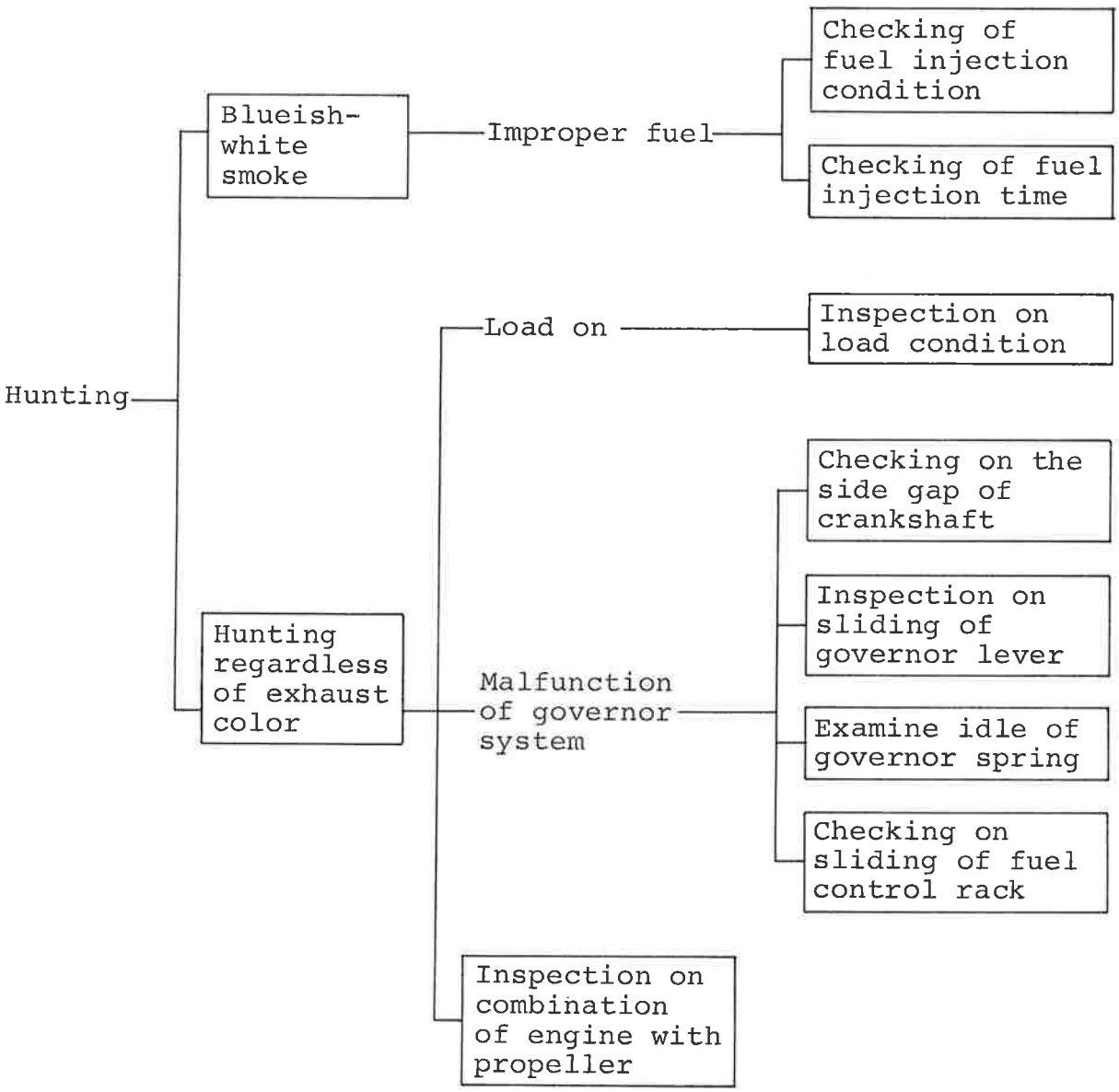
No.	Cause	Treatment	Instructions to Engine Operator
1	Poor fuel injection condition of fuel injection valve. 1) Drop of fuel injection pressure. 2) Sticking and wear of needle valve.	1) Adjustment of fuel injection pressure. 2) Cleaning or replacement.	1) Adjustment of fuel injection pressure. 2) Handling of fuel. Draining from fuel tank.
2	Poor fuel injection condition of fuel injection pump. 1) Improper adjustment of governor lever. 2) Dirt adhesion, scratch or wear of delivery valve. 3) Dirt adhesion, scratch or wear of delivery valve. 4) Wear of plunger.	1) Adjustment of governor lever. 2) Cleaning or replacement. 3) Cleaning or replacement. 4) Replacement.	1) Adjustment of governor lever. 2) Handling of fuel. 3) Handling of fuel. 4) Handling of fuel.
3	No fuel at fuel injection pump. 1) Insufficient fuel. 2) Clogged fuel filter. 3) Clogged air breather at fuel tank cover.	1) Replenishing of fuel and air. 2) Cleaning of fuel strainer. 3) Cleaning.	1) Air venting. 2) Handling of fuel oil.
4	Improper opening and closing times of intake and exhaust valves. 1) Clearance too wide at valve head.	1) Adjustment on clearance of intake and exhaust valves.	1) Adjustment on clearance of intake and exhaust valves.
5	Insufficient compression due to leakage.	(Refer to Subdivision "Compressed Air Leakage".)	

No.	Cause	Treatment	Instructions to Engine Operator
6	Poor exhaust color.	(Refer to Subdivision "Compressed Air Leakage".)	
7	Malfunction of metals. 1) Seizure and wear of crank pin metal. 2) Seizure and wear of crank metal. 3) Seizure and wear of piston pin metal.	 1) Replacement. 2) Replacement. 3) Replacement.	 1) Handling of lub. oil. 2) Handling of lub. oil. 3) Handling of lub. oil.
8	Improper combination with propeller •Deformation of propeller. •Improper pitch. •Improper diameter.	Replacement.	Selection of propeller.

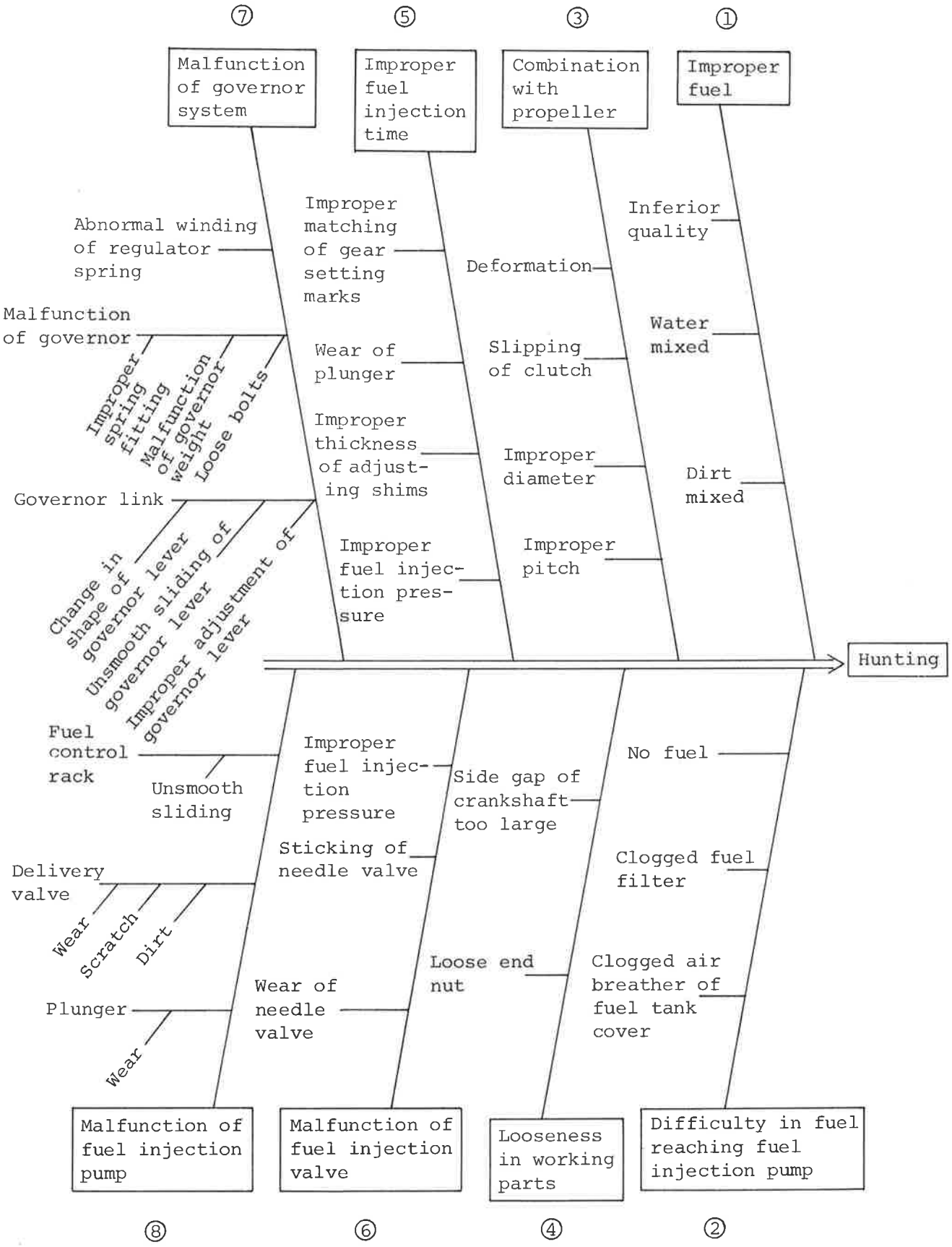
7-3-5 Hunting

If the engine runs with hunting, the working operation will be difficult, lowering performance of the operational machine which affects the overall working efficiency.

In such case, determine the cause of trouble in the following manner :


Hunting
Blueish-white smoke
Improper fuel
Checking of fuel injection condition
Checking of fuel injection time
Hunting regardless of exhaust color
Load on
Inspection on load condition
Malfunction of governor system
Checking on the side gap of crankshaft
Inspection on sliding of governor lever
Examine idle of governor spring
Checking on sliding of fuel control rack
Inspection on combination of engine with propeller

The following causes may be considered in case of hunting :



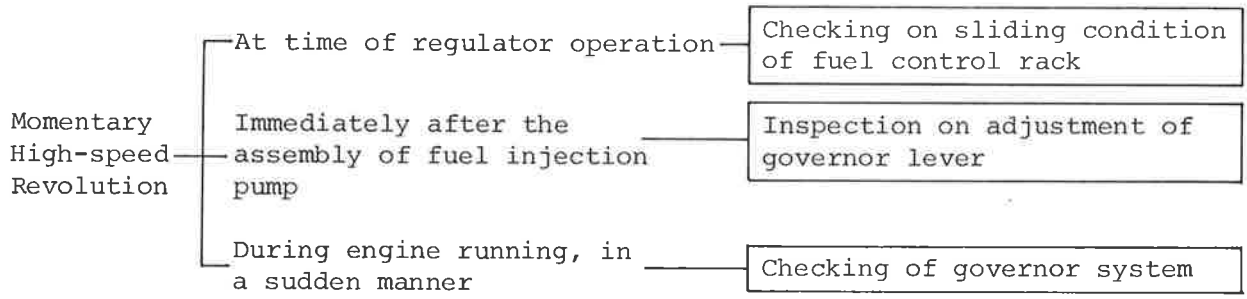
Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Improper fuel. 1) Inferior quality, water mixed or dirt mixed.	1) Replacement.	1) Handling of fuel.
2	Difficulty in fuel reaching fuel injection pump. 1) No fuel. 2) Clogged fuel filter. 3) Clogged air breather of fuel tank cover.	1) Fuel supply and air venting. 2) Cleaning. 3) Cleaning.	1) Handling of fuel and air venting. 2) Handling and cleaning. 3) Handling and cleaning.
3	Combination with propeller. 1) Improper pitch. 2) Improper diameter. 3) Slipping of clutch. 4) Deformation of propeller.	1) Replacement. 2) Replacement. 3) Replacement of friction disc. 4) Replacement.	1) Selection of propeller. 2) Selection of propeller. 3) Method of operation. 4) Method of operation.
4	Looseness in working parts. 1) Loose end nut. 2) Side gap of crankshaft too large.	1) Retightening. 2) Adjustment of the gap or replacement of crank metal.	1) Periodic checking.
5	Improper fuel injection time. 1) Improper fuel injection pressure. 2) Improper thickness of adjusting shims. 3) Wear of plunger. 4) Improper matching of gear setting marks.	1) Adjustment of fuel injection pressure. 2) Adjustment of fuel injection time. 3) Replacement of plunger. 4) Resetting.	1) Adjustment of fuel injection pressure. 2) Adjustment of fuel injection time. 3) Handling of fuel. 4) Handling of fuel.

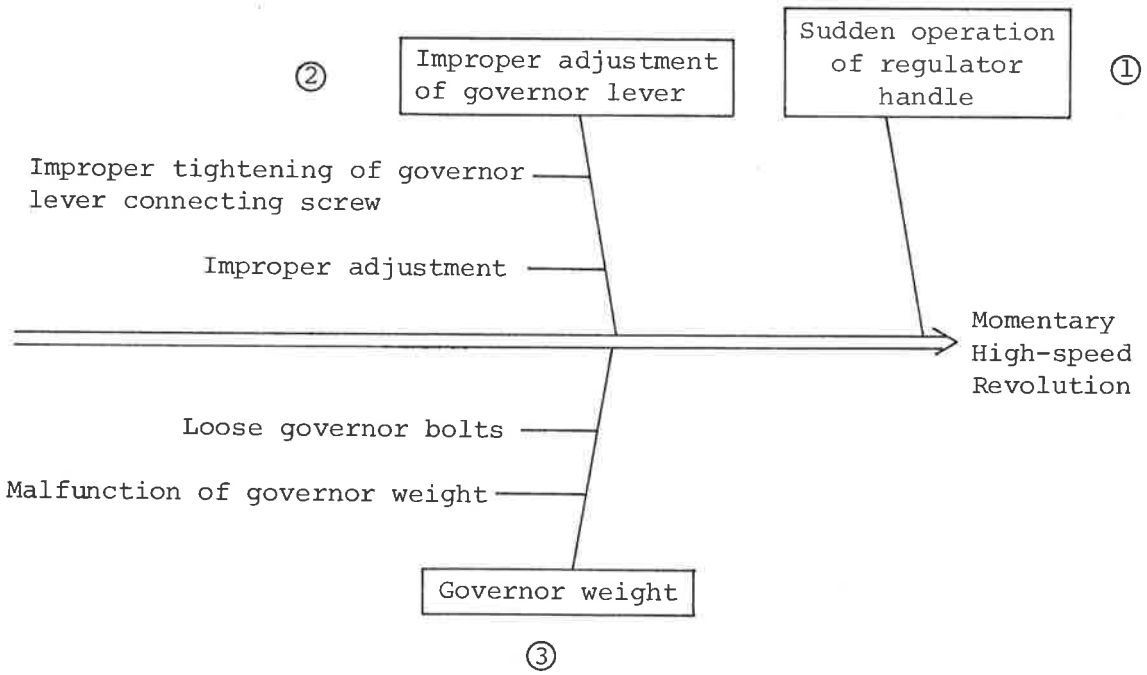
No.	Cause	Treatment	Instructions to Engine Operator
6	Malfunction of fuel injection valve. 1) Improper fuel injection pressure. 2) Sticking of needle valve. 3) Wear of needle valve.	1) Adjustment of fuel injection pressure. 2) Cleaning or replacement. 3) Replacement.	1) Adjustment of fuel injection pressure. 2) Handling of fuel. 3) Handling of fuel.
7	Malfunction of governor system. 1) Malfunction of governor link. a. Improper adjustment of governor lever. b. Unsmooth sliding of governor lever shaft. c. Change in shape of governor lever. 2) Malfunction of governor. a. Loose bolts. b. Improper fitting of governor spring. c. Malfunction of governor weight. 3) Abnormal winding of regulator spring.	a. Adjustment of governor lever. b. Cleaning, oiling or lapping. c. Correction or replacement. a. Retightening. b. Adjustment of idleness of the spring. c. Correction for smooth movement. 3) Adjustment of number of coils.	a. Adjustment of governor lever.
8	Malfunction of fuel injection pump. 1) Malfunction of fuel control rack. Unsmooth sliding. 2) Malfunction of delivery valve (dirt adhesion, scratch or wear). 3) Wear of plunger.	Cleaning or lapping. 2) Cleaning and correction of seat or replacement. 3) Replacement.	

7-3-6 Momentary High-Speed Revolutions

If momentary high-speed revolution occurs at start-up or during engine running, stop the engine immediately by operating the priming lever or the decompression lever. Otherwise, major damage will be quickly incurred. Major causes of trouble in this connection are at the governor system, thus check for the causes in the following manner :



The following causes may be considered in connection with momentary high-speed revolutions.

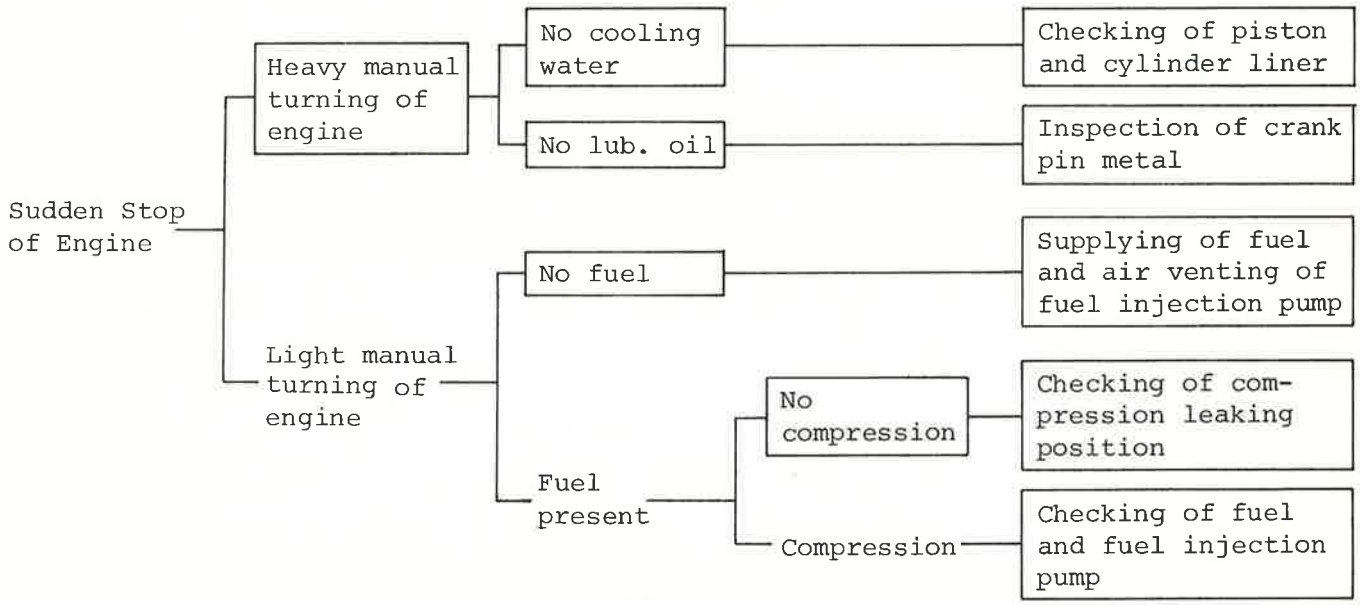


Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Sudden operating of regulator handle.		Operation of regulator handle.
2	Improper adjustment of governor lever. 1) Improper adjustment. 2) Improper tightening of governor lever connecting screw.	1) Adjustment of governor lever. 2) Adjustment of governor lever.	1) Adjustment of governor lever. 2) Adjustment of governor lever.
3	Governor weight. 1) Loose governor bolts. 2) Malfunction of governor weight.	1) Retightening. 2) Correction for smooth movement.	

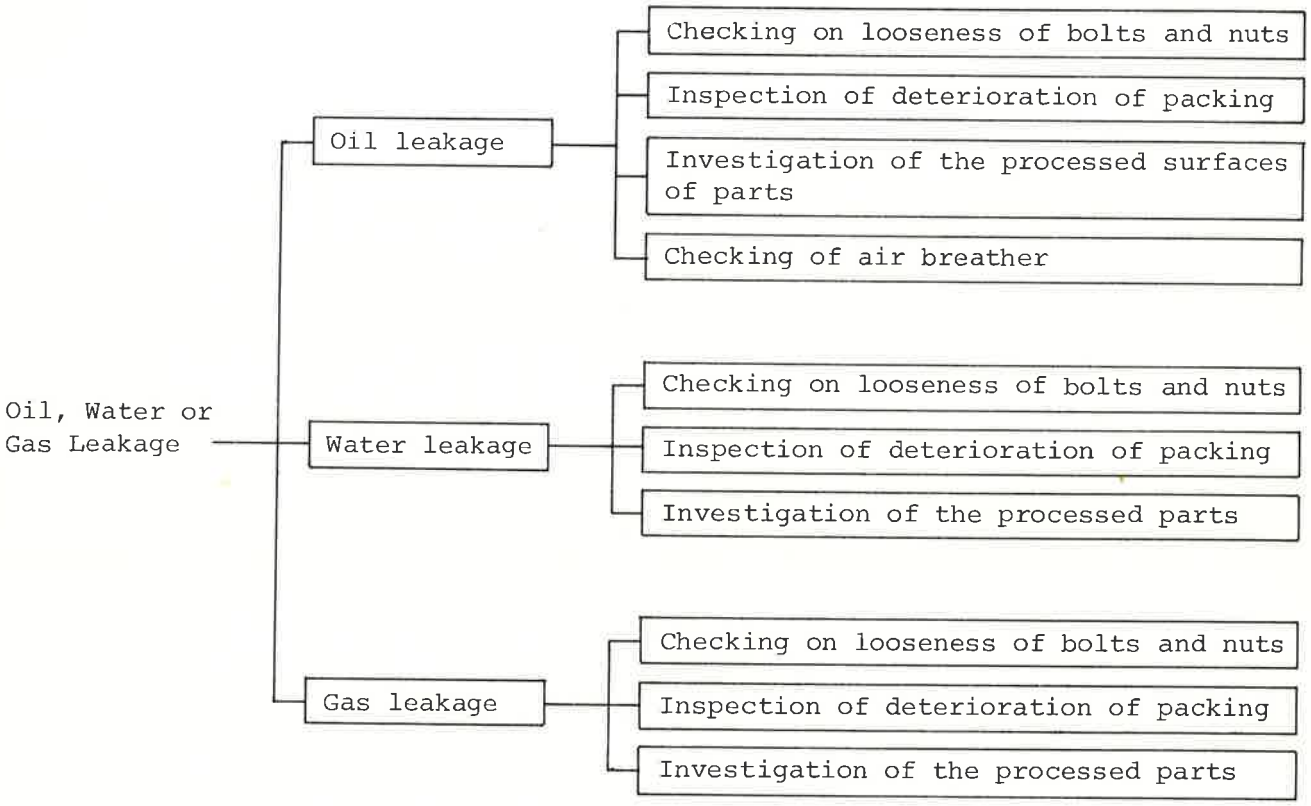
7-4 Sudden stoppage of Engine

If the engine stops suddenly during running, mainly the following causes may be considered. This type of trouble is usually one of the major engine accidents and is specifically a seizure due to careless handling. The causes for this type of trouble are not too difficult to find; however, time and know-how are required for repair. Thus in order to avoid the seizure type of trouble, pay attention to handling.



7-5 Oil, Water or Gas Leakage

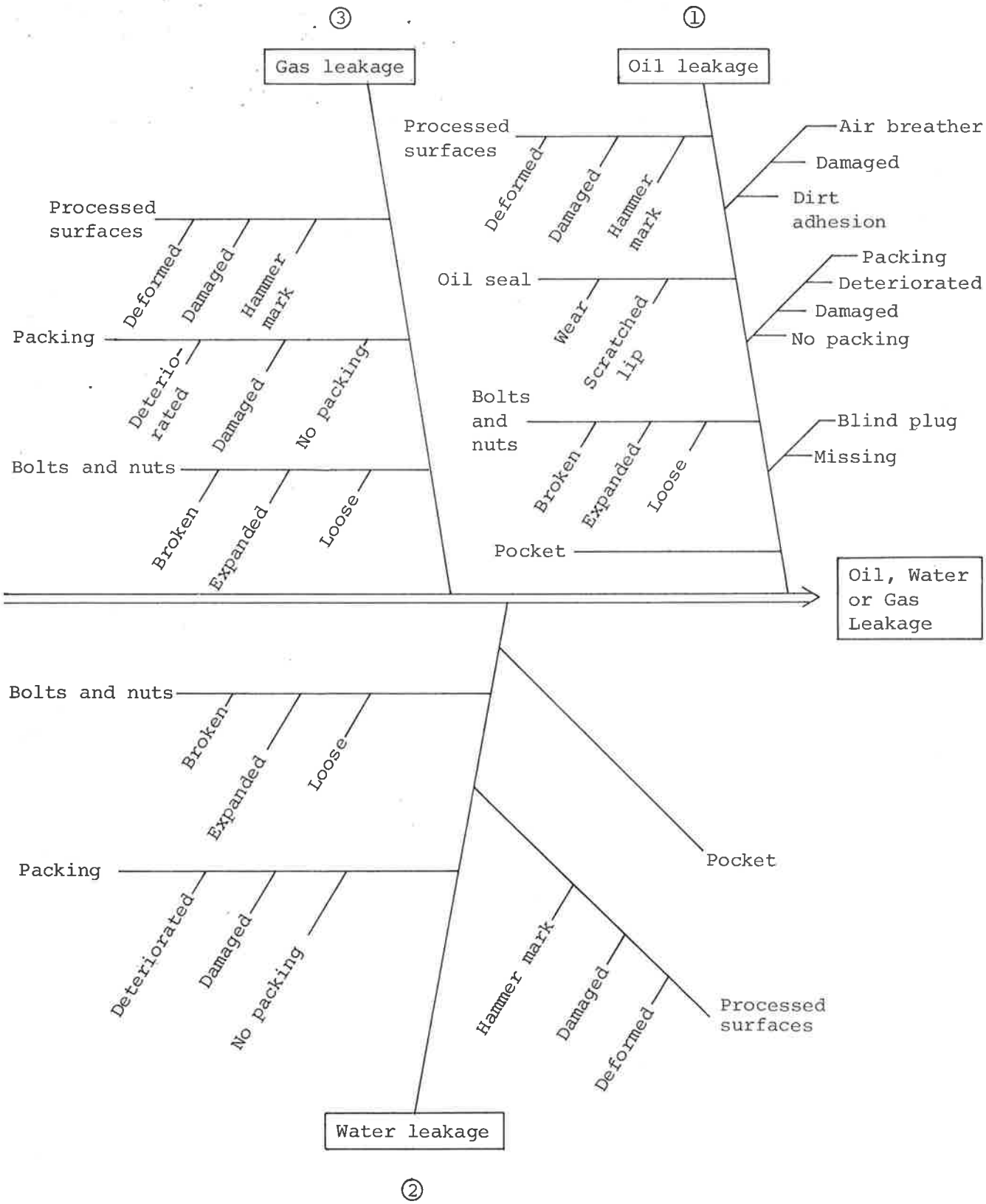
Oil, water or gas leakage is usually due to loose bolts and nuts after a long service period. Or it may also occur frequently due to wear or deterioration of packing. For treatment against these causes, checking of the point of leaking, retightening of bolts and nuts, and replacement of packing should be necessary. Thus determine the causes by inspecting in the following manner :



Treatment and Instructions

No.	Cause	Treatment	Instructions to Engine Operator
1	Oil Leakage. 1) Loose, expanded or broken bolts and nuts. 2) Damaged or deteriorated packing. 3) Hammer marks on processed surface and damaged or deformed processed surfaces. 4) Wear and scratched lip of oil seal. 5) Dirt adhesion on air breather and damaged air breather. 6) Missing blind plug. 7) Pocket found.	1) Retightening or replacement. 2) Insertion or replacement of packing. 3) Correction or replacement. 4) Replacement. 5) Cleaning or replacement. 6) Attaching. 7) Replacement of blind plug.	1) Periodic retightening. Adjusting of tightness. 4) Handling of oil seal. 5) Maintenance method.
2	Water leakage. 1) Loose, expanded or broken bolts and nuts. 2) Damaged or deteriorated packing. 3) Hammer marks on processed surfaces and damaged or deformed processed surfaces. 4) Pocket found.	1) Retightening or replacement. 2) Insertion or replacement of packing. 3) Correction or replacement. 4) Replacement.	1) Periodic retightening. Adjustment of tightness.
3	Gas leakage. 1) Loose, expanded or broken bolts and nuts. 2) Damaged or deteriorated packing. 3) Hammer marks on processed surfaces and damaged or deformed processed surfaces.	1) Retightening or replacement. 2) Insertion or replacement of packing. 3) Correction of replacement.	1) Periodic retightening. Adjustment of tightness.

The following causes may be considered in connection with oil, water or gas leakage :



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