

**YANMAR** DIESEL ENGINES

MODEL **A2-L / A3-L**



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# SERVICE MANUAL



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REPRESENTED BY

**CONTINENTAL MACHINERY CORP.**

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## I PERIODIC SERVICE OF ENGINE

Like all precision machinery, the engine must be given regular service and inspection so that it will give satisfactory performance. Such service and inspection includes overhaul, lubrication, adjustments, repair, etc. as necessary.

Preventive maintenance differs according to the purpose of engine use, the usage conditions, the quality and handling of fuel and lubricating oil, etc., and therefore it is difficult to standardize preventive maintenance. Consequently, we describe herein the general periodical service standards.

### 1. Daily Service

The daily service which should be performed every day before starting an engine consists of supplying fuel, lubricating oil and the inspection and adjustment of important parts of the engine. It is suggested that this daily service be performed after final engine operation each day so that the engine is ready for operation the next day. Cleaning up engine once a day will save lots of time in weekly service and moreover possibly prevent engine trouble.

#### (1) Check-up before Operation

##### A) Visual Check-up

- a) Loose or missing nuts and bolts throughout.
- b) Amount of oil in the crankcase and its cleanliness.
- c) Amount of fuel in the fuel tank.
- d) Feeding oil to necessary parts (for example, valve lever shaft, starting shaft, etc.)

##### B) Operation

- a) Condition of engine (Color of exhaust gas, engine sound, oil leakage, irregular revolution, etc.)
- b) Temperature of lubricant.

#### (2) Check-up after Operation

- a) Clean-up.
- b) Supply of fuel.
- c) Oil leakage and missing parts.
- d) Closing of inlet and exhaust valves and covering of engine if left outside.

### 2. Weekly Service

It is supposed that the engine is operated for 50 hours in a week, and we described herein only the services which are not included in daily service.

This weekly service includes the servicing of parts, change of crankcase lubricating oil, and adjusting of parts, change of crankcase lubricating oil, and adjusting and tightening as necessary.

- 1) Clean up the oil bath of air cleaner and replace its oil.
- 2) Drain out sediment and water in the fuel tank and fuel filter.
- 3) Replace lubricating oil (drain the oil out when the engine is still hot and supply fresh oil).
- 4) Clean up crank case breather.
- 5) Retightening of pulley bolts.
- 6) Retightening of cylinder head bolts, and adjustment of suction and exhaust valve clearance if necessary.

### 3. Monthly Service

The engine is assumed to be operated for approximately 250 hours in a month and more complete inspection, repairs, and adjustment than in daily and weekly service are required. In this service extra care is taken to check the engine to avoid any major engine trouble until next monthly service and replace the parts which seem to be worn out before next service.

- 1) Injection test of fuel injection valve and measurement of injection pressure.
- 2) Clean up of crankcase.
- 3) Adjustment of suction and exhaust valve clearance.
- 4) Retightening of flywheel end nuts.
- 5) Clean up of inside the silencer if necessary.

### 4. Special Service

This special service is performed when a new engine is operated in very cold, hot, or dusty place. You are required to check the engine more frequently than normal. The service interval will be determined according to the surrounding conditions.

## 5. Every 500 Hours Service

This service is performed after every 500 hours operation and is intended to keep the engine in good condition until next service without major trouble. Although the service shop having facilities for disassembly, measurement, inspection and testing is recommended for this service, it is possible for you to conduct this service without the service shop if you have enough technical knowledge and follow the procedures mentioned in this manual correctly.

- (1) Removal of all carbon adhering to the cylinder head.
- (2) Grinding in of the inlet and exhaust valves.
- (3) Removal of all carbon adhering to the piston crown.
- (4) Replacement of the top piston ring (chrome plated ring) and oil ring.
- (5) Clean up of the cylinder cooling fins.
- (6) Pressure test of the fuel pump.

## 6. Six-month Service

This service has to be performed every half year even if the engine is not operated during the period.

- (1) Clean up of inside of the fuel tank.
- (2) Draining out of the sediment and water deposited in the fuel tank and fuel filter.
- (3) Draining out of crankcase lubricating oil, flushing of inside the crankcase with flushing oil and supply of fresh oil.

## 7. Every 1000 Hours Service

The service carried out after the engine has operated for 1000 hours or engine overhaul performed once a year, are identical and is as follows.

Dismantle the engine completely, and measure and test each part carefully and repair or replace with a new one if necessary. It is recommended that parts which might be worn out before next overhaul are replaced, even if they are all right at this service time. It is required, therefore, that a shop which has the facilities for measurement, inspection, and testing be available.

### (1) Fuel System

- (a) Clean up of inside the fuel tank and the filter mesh of filler.

- (b) Flushing of inside the fuel pipe with compressed air, and inspection for the cracks on the fuel pipe.
- (c) Disassembly and clean up of fuel filter case and replacement of its element.
- (d) Inspection for injection condition and pressure of the fuel injection valve.

### (2) Lubricating Oil Systems

- (a) Clean up and inspection for oil pan.

### (3) Breathing Systems

- (a) Disassembly and clean up of air cleaner.
- (b) Clean up of gasoline cap with compressed air.

### (4) Cooling Systems

- (a) Clean up of cylinder cooling fins.

### (5) Engine Body

- (a) Check for cracks and burns of cylinder head.
- (b) Replacement of cylinder head copper packing.
- (c) Inspection for contact of suction and exhaust valve stems and clearance between the stem and valve guide.
- (d) Inspection for contact of valve head, valve spring, and valve spring holder.
- (e) Inspection for weakened spring and misalignment of valve spring.
- (f) Inspection for valve seat contact.
- (g) Inspection for valve lever and valve lever bush.
- (h) Inspection for tappets and push rod.
- (i) Inspection for scoring and crookedness of camshaft.
- (j) Inspection for scoring and abnormal wear on the inside of cylinder, and measurement of the inside diameter of cylinder.
- (k) Inspection for cracks on the piston head, abnormal touching of piston head and measurement of outside diameter of piston.
- (l) Inspection for sliding condition and fitting of piston's outside surface.
- (m) Inspection for touching of piston ring and clearance between ring and groove.
- (n) Measurement of clearance between piston pin and piston pin metal.
- (o) Measurement of clearance between crank pin metal and crank pin.
- (p) Measurement of clearance between crank metal and crankshaft.
- (q) Inspection for sliding and rotary section of governor and weakened spring of governor.
- (r) Inspection for touching and backlash of gear.

**(6) Others**

- (a) Replacement of packings.
- (b) Replacement of split pin and lock washer.

**II PRECAUTION BEFORE DISASSEMBLY**

Before disassembling the engine the following precautions are to be observed.

- 1. A clean, dust-free shop should be selected.
- 2. Prepare proper pan and place for the disassembled parts to be put on to prevent the parts from damage.
- 3. Solvent and can are necessary for cleaning parts.
- 4. Preparation of equipment.

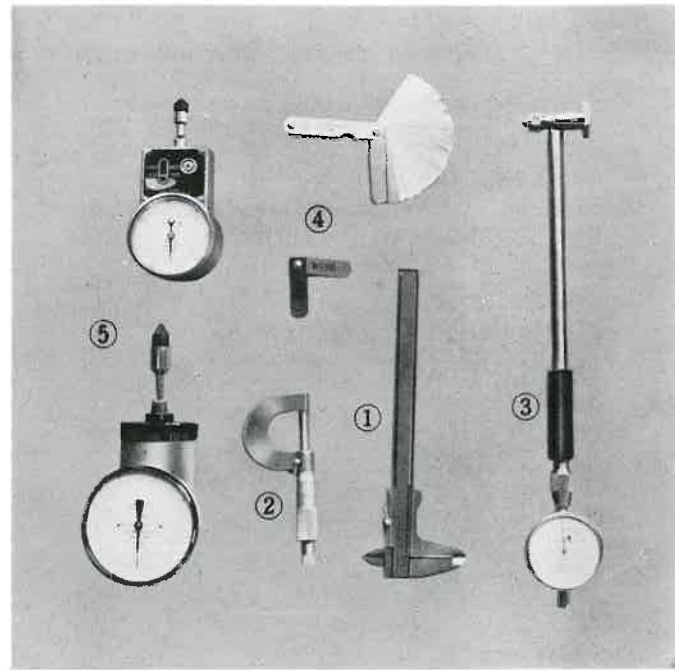
**(A) Tools**



- 1. Spanner 9 10 12 14 17 19  
21 23 26 32 m/m
- 2. Box wrench assembly
- 3. Screw Driver and Philips Driver
- 4. Pliers
- 5. Monkey wrench
- 6. Hammer
- 7. Hammer (lead, copper or plastic)
- 8. Wooden mallet
- 9. Removing tool for spring lock  
(circlip pliers)
- 10. Pinset
- 11. Puller (removing tool for flywheel  
and pulley)
- 12. Vise and Vise bed
- 13. Gasoline feeder
- 14. Lubricating Oil feeder

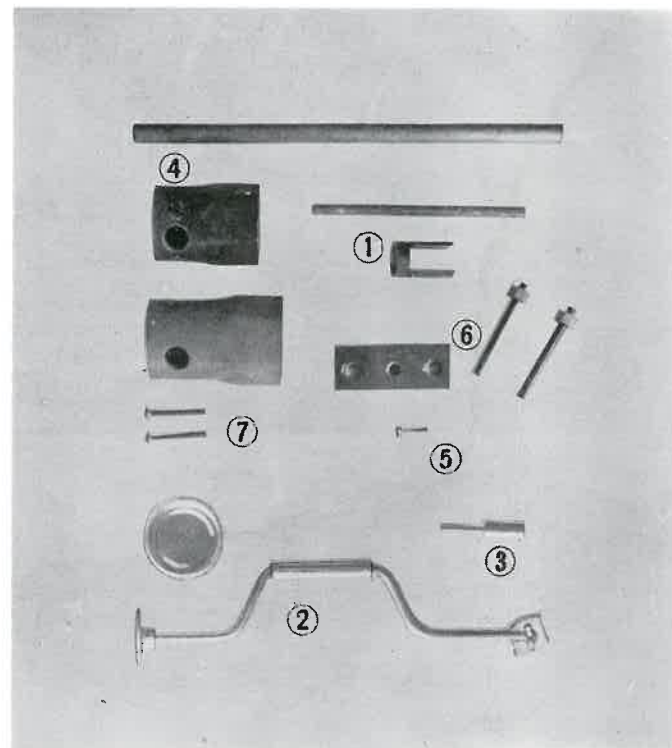
## (B) Measurement Instruments

1. Vernier caliper
2. Micrometer
3. Cylinder gauge
4. Thickness gauge (Feeler gauge)
5. Tachometer
6. Torque wrench
7. Fuel valve tester
8. Fuel pump pressure tester



## (C) Special Equipment for Disassembly and Reassembly

1. Disassembling tool for suction and exhaust valve
2. Grinding tool and compound for suction and exhaust valve
3. Removing tool for nozzle valve
4. Box wrench for flywheel and nut; 41 m/m for A2L type and 46 m/m for A3L type engine.
5. 4 m/m small screw for removing flywheel key
6. Tool for removing flywheel (also used for removing pulley)
7. 6 m/m bolts for removing crankcase front cover
8. Tool for removing camshaft bearing (necessary only for A3L type engine)
9. Tool for disassembling camshaft (necessary only for A3L type engine)



## III GENERAL CAUTIONS FOR DISASSEMBLING ENGINE

The general cautions for disassembling engine are as follows :

1. Read operator's manual carefully.
2. Use proper tools only. Otherwise damage to parts may occur.
3. Keep dismantled parts in good order.
4. Don't disassemble any part unnecessarily.
5. Carefully check the set mark on the part during the disassembly of engine or make set marks on the part if you think it will be helpful in reassembly.
6. When you are required to disassemble an engine in detail, first of all conduct rough disassembly and then go into detail disassembly. You are advised to refer to each detail instructions when you disassemble suction and exhaust valve, piston ring, piston pin, fuel pump and fuel injection valve.
7. You are recommended to put split pin, and bolt back on where they were originally, lest they should be mis-placed, and this practice will possibly reduce errors in reassembling engine.
8. You are recommended not to touch the engine if you don't have enough technical knowledge.

## IV PERMISSIBLE WEAR

1. When an engine is used for long time, parts will possibly be worn out and this may reduce the engine efficiency or cause engine trouble unless these worn parts are replaced.
2. The approximate permissible wear for each part are indicated in the following paragraphs. These wear limitations, however, are not absolute and the parts worn over the limitations may be used safely to some extent, if discretion is properly applied.
3. As indicated in the paragraphs concerning the periodic service, it may be better to replace parts which seem to be worn out before next servicing time even if the wear of the part is under the wear limitation.
4. The measuring positions and instruments are as follows.

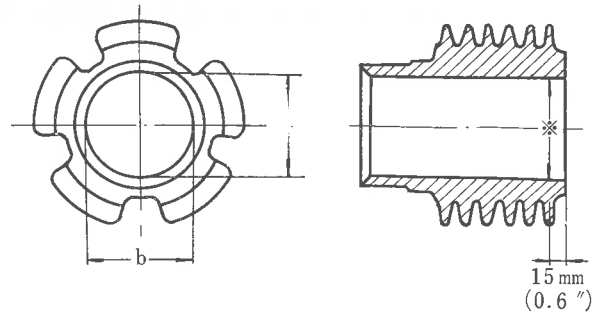
(1) Cylinder

Measuring Position :

a.b. direction at \*mark position

Measuring Instrument :

Cylinder gauge



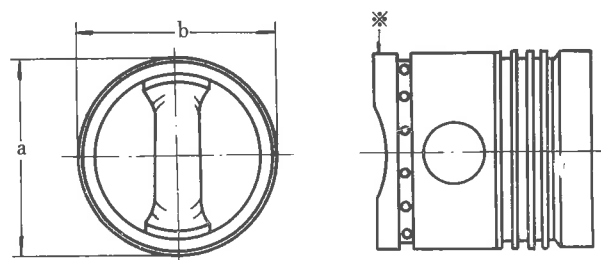
(2) Piston

Measuring Position :

Piston skirt a.b. direction at \*mark position

Measuring Instrument :

Micrometer



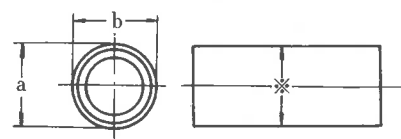
(3) Piston Pin

Measuring Position :

Central section (\*mark) measured to a.b. direction

Measuring Instrument :

Micrometer



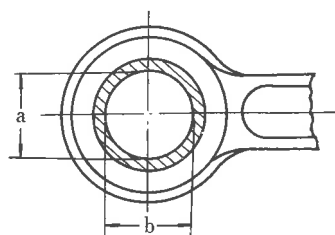
(4) Piston Pin Metal

Measuring Position :

Inside diameter measured to a.b. direction

Measuring Instrument :

Cylinder gauge



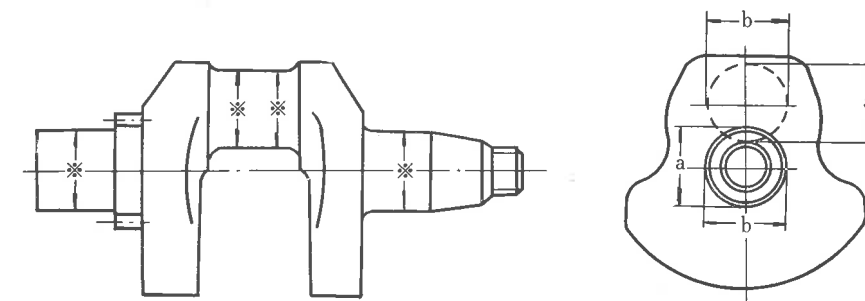
(5) Crankshaft

Measuring Position :

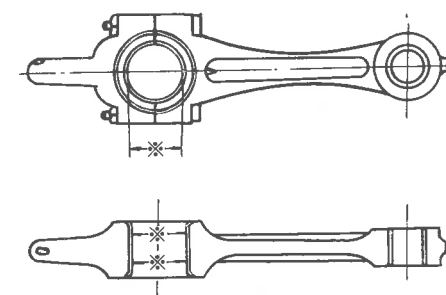
\*mark position to a.b. direction

Measuring Instrument :

micrometer



(6) Crankpin Metal



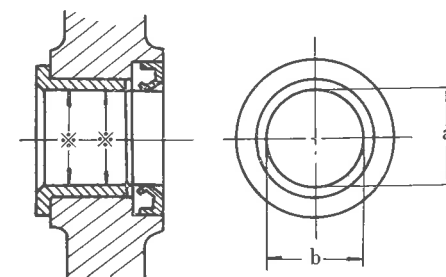
Measuring Position :

Fastening rod bolt with a proper torque wrench, measure its wear at \*mark position

Measuring Instrument :

Cylinder gauge

(7) Crank Metal



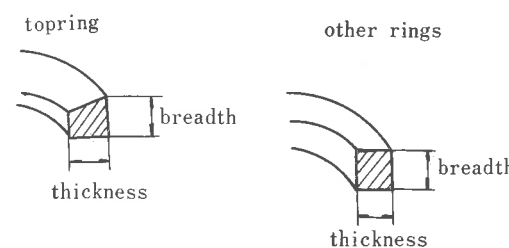
Measuring Position :

a.b. direction at \*mark

Measuring Instrument :

Cylinder gauge

(8) Piston Ring



Measuring Position :

Measure thickness and breadth ; for first ring, take measurement at largest breadth

Measuring Instrument :

Micrometer

(9) Ring Groove Clearance

Measuring Position :

Maximum wear measured at \*mark section

Measuring Instrument :

Thickness gauge



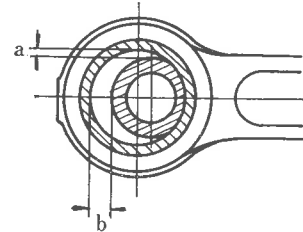
(10) Clearance between Pistonpin and Pistonpin Metal

Measuring Position :

\*Mark at a.b. section

Measuring Instrument :

Thickness gauge



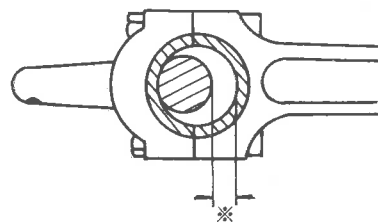
(11) Clearance between Crankpin and Crank metal

Measuring Position :

\*Mark position

Measuring Instrument :

thickness gauge



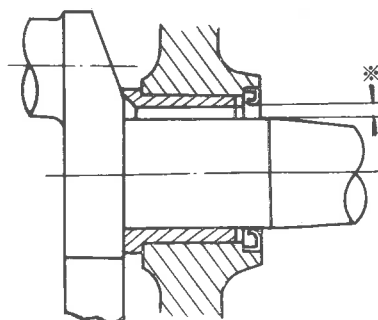
(12) Clearance between Crank Journal and Crank metal

Measuring Position :

\*Mark position

Measuring Instrument :

Thickness gauge



Note : The clearance of (10) and (12) calculated arithmetically from the (5) and (7).

PERMISSIBLE WEAR LIST (METRIC DIMENSION)

		A2L Engine		A3L Engine		
		Standard Dimension	Limit mm	Standard Dimension	Limit mm	
Wear Limit	Cylinder Diameter	60 $\phi$	+0.36	65 $\phi$	+0.39	
	Diameter of Piston Skirt		59.8 $\phi$			
		Direction perpendicular to shaft	60 $\phi$	-0.16	65 $\phi$	-0.18
	Piston Pin Diameter	23 $\phi$	-0.12	25 $\phi$	-0.13	
	Inside diameter of Piston Pin Metal	23 $\phi$	+0.12	25 $\phi$	+0.13	
	Diameter of Crank Pin	36 $\phi$	-0.18	40 $\phi$	-0.20	
	Diameter of Crank Journal	36 $\phi$	-0.13	40 $\phi$	-0.14	
	Inside Dia. of Crankpin Metal	36 $\phi$	+0.14	40 $\phi$	+0.16	
	Inside Dia. of Crank Metal	36 $\phi$	+0.16	40 $\phi$	+0.18	
	Top Piston Ring	Breadth	2.4	-0.30	2.9	-0.30
		Thickness	2.5	-0.38	2.7	-0.41
	2nd-4th Piston Ring	Breadth	2.0	-0.30	2.5	-0.30
		Thickness	2.5	-0.38	2.7	-0.41
	Oil Ring	Breadth	3.5	-0.30	4.0	-0.30
Thickness		2.5	-0.38	2.7	-0.41	
Clearance between Piston Ring and Ring Groove		0.030	0.40	0.030	0.40	
Clearance between Piston Pin and Piston Metal		0.040	0.18	0.045	0.20	
Clearance between Crankpin and Crank-metal		0.074	0.18	0.075	0.20	
Clearance between Crank Journal and Crankmetal		0.055	0.22	0.055	0.24	



### PERMISSIBLE WEAR LIST (INCH DIMENSION)

		A2L ENGINE		A3L ENGINE		
		Standard Dimension	Permissible Wear (inch)	Standard Dimension	Permissible Wear (inch)	
Wear Limit	Cylinder Diameter		2.362 $\phi$	0.01417	2.559 $\phi$	0.01535
	Diameter of Piston Skirt					
		Direction perpendicular to shaft	2.362 $\phi$	0.00630	2.559 $\phi$	0.00709
	Piston Pin Diameter		0.906 $\phi$	0.00472	0.984 $\phi$	0.00512
	Inside diameter of Piston Pin Metal		0.906 $\phi$	0.00472	0.984 $\phi$	0.00512
	Diameter of Crank Pin		1.417 $\phi$	0.00709	1.575 $\phi$	0.00787
	Diameter of Crank Journal		1.417 $\phi$	0.00512	1.575 $\phi$	0.00551
	Inside Dia. of Crankpin Metal		1.417 $\phi$	0.00551	1.575 $\phi$	0.00623
	Inside Dia. of Crank Metal		1.417 $\phi$	0.00630	1.575 $\phi$	0.00709
	Top Piston Ring	Breadth	0.095	0.01181	0.114	0.01181
		Thickness	0.098	0.01496	0.106	0.01164
	2nd-4th Piston Ring	Breadth	0.079	0.01181	0.098	0.01181
		Thickness	0.098	0.01496	0.106	0.01164
	Oil Ring	Breadth	0.138	0.01181	0.158	0.01181
Thickness		0.098	0.01496	0.106	0.01614	
Clearance between Piston Ring and Ring Cover		0.00118	0.01574	0.00118	0.01574	
Clearance between Piston Pin and Piston Metal		0.00157	0.00709	0.00177	0.00787	
Clearance between Crankpin and Crank-metal		0.00295	0.00709	0.00295	0.00787	
Clearance between Crank Journal and Crankmetal		0.00217	0.00806	0.00217	0.00945	

### V GENERAL CAUTIONS FOR CARE AND CLEAN UP

The following rules should be covered in clean-up and care of the engines.

- (1) Make a good visual inspection of each part for carbon deposits and scoring; this practice will be very helpful in handling an engine.
- (2) Be careful not to damage the parts when remove the carbon deposit.
- (3) Avoid using wire brush and sand paper for cleaning up the precision parts such as contact surface of valves, sliding surface of plungers, etc.
- (4) Use clean washing oil only. Kerosene or petrol are recommended. Dirt adhering to the cylinder and cooling fins may impede the function of the heat transfer and induce overheating.
- (5) Thoroughly clean up outside the engine block and inside of the crankcase at the time of disassembly, and also clean up the parts and places which are difficult to clean after reassembly.
- (6) Clean any rusty parts with an abrasive paper, applying oil afterward.
- (7) If parts are found to be scored, replace them.
- (8) If a mark is made by striking a part, clean it off with a oil stone.
- (9) After installing new parts, carefully inspect them for the state of fitting, touching and clearance.

### VI GENERAL PRECAUTIONS FOR REASSEMBLY

The reassembly of an engine is performed in reverse manner and the following rules should be carefully observed.

- (1) Assemble the parts which were disassembled in detail in each case.
- (2) Replace the old lock washers split pins and packings with a new ones after each disassembly, and don't forget to bend the tip of lock washer and split pin after insertion.
- (3) Use jointing compound when installing the camshaft blind cover, push rod cover (connecting flange) and bottom, front and side covers of crankcase.
- (4) Place the injection valve, fuel pump adjusting plate, plunger guide, interval pipe of camshaft bearing and crankshaft collar correctly to where they were originally.
- (5) Tighten the bolts evenly.
- (6) Check if the rotary parts such as crankshaft turns smoothly after reassembly and also check their clearance with other parts.

- (7) Wash all parts in clean solvent and put the lubricating oil on not only the rotary parts but also the inlaid section of flywheel and crankshaft, of crankcase and crankcase front cover, and of camshaft and pulley with hand, not with a rag. This practice will protect the parts from the burns and scoring.
- (8) The setting of timing gear teeth and other necessary adjusting must be performed carefully.

### VII PROCEDURE OF OVERHAUL

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
1	Air Cleaner	Loosen screw of fastening band and pull it out	Phillips (Plus) Driver			Don't take off Connecting pipe
2	Silencer	//	//			//
3	Fuel Injection	(1) Take off fuel injection pipe	Spanner 9 mm & 17 mm			Take off fastener of Injection pipe
		(2) Take off fuel overflow pipe	Spanner 12 mm & 21 mm			
		(3) Take off fuel injection valve	Spanner 32 mm			
4	Side Cover of Fin	(1) Take off right side cover	Phillips (Plus) Driver			Don't lose washer
		(2) Take off left side cover				
		(3) Take off auxiliary side cover				
5	Fuel Pipe	(1) Close fuel cock	Hand			
		(2) Take off fuel pipe	Spanner 14 mm & 19 mm			

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
6	Fan Cover	(1) Take off regulator spring	Hand			One side only
		(2) Take off fan cover	Spanner 10 mm			with fuel tank
7	Flywheel and its key	(1) Straight up bent edge of end nut washer	Driver and Handle of Box Spanner			Refer to the item "Removing Flywheel"
		(2) Take off end nut	Box Spanner 41 mm	Box Spanner 46 mm		
		(3) Take off end nut washer	Hand			
		(4) Take off flywheel	Removing tool for flywheel			
		(5) Pull out set key				
8	Cylinder Head	(1) Take off rocker arm cover (bonnet)	Spanner 21 mm			(1) Use Box spanner for removing nuts in the air inlet port and valve lever arm room. (2) To remove nuts in the air inlet ports, use spring of box spanner. (3) Don't lose washer.
		(2) Take off plug	Spanner 14 mm	Spanner 17 mm		
		(3) Take off nut	Spanner 14 mm Box Spanner 12 & 14 mm	Spanner 17 mm Box Spanner 14 mm		
9	Push Rod, Push Rod Cover and Connecting Flange	(1) Pull out push rod	Hand			Pull out together with push rod cover
		(2) Take off push rod connecting flange	Phillips (Plus) Driver			
10	Cylinder and Piston Complete	(1) Drain out crankcase oil	Spanner 24 mm			
		(2) Place engine horizontally	Hand			
		(3) Remove bottom cover	Spanner 10 mm			Don't lose washer
		(4) Set crankshaft to B.D.C.	Hand			
		(5) Take off rod bolt nut	Box Spanner 14 mm			
		(6) Take off bearing cap	Hand			
		(7) Set crankshaft to T.D.C.	Hand			

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
10		(8) Pull up cylinder and piston complete	Hand			
11	Pulley	(1) Pull out pulley	Puller			
		(2) Remove set key	Hammer and Wood Block			
12	Crankshaft	(1) Remove crankcase front cover	6 Screw and Spanner 10 mm			(1) Don't lose washer. (2) Pull out front cover screwing 6 screw in.
		(2) Take off extension shaft	Monkey wrench			
		(3) Pull out crankshaft to flywheel side	Hand			Don't lose collar
13	Breather	Take off breather plug	Spanner 10 mm			Don't lose breather plate.
14	Fuel Injection Pump	(1) Take off fastening nut	Spanner 14 mm or Box Spanner 14 mm			Don't lose nut
		(2) Pull up pump body	Hand			Pull it vertically with care
		(3) Pull up plunger holding its tip	Hand			(1) Don't scratch plunger. (2) Don't lose its spring.
		(4) Pull out adjusting plate	Hand			Don't lose it
		(5) Pull out roller guide	Hand			Use pinset
15	Camshaft Ball Bearing (A2L)	(1) Take off camshaft ball bearing housing cover	Spanner 10 mm			
		(2) Take off fastening nut	Spanner 26 mm			
		(3) Take off ball bearing housing	6φ Screw & Spanner 10 mm			Ball bearing comes out together with camshaft case.
		(4) Take off space collar	Hand			
15	Camshaft Ball Bearing (A3L)	(1) Take off extension shaft			Spanner 32 mm	
		(2) Take off fastening nut of camshaft ball bearing	Spanner 32 mm			
		(3) Take off bearing housing cover	Spanner 10 mm			Don't lose washer
		(4) Take off fastening nut of ball bearing housing			Spanner 10 mm	
		(5) Take off ball bearing case			6φ Screw and Spanner 10 mm	
		(6) Take off space collar (B)	Hand			

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks	
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft		
15		(7) Take off ball bearing (A)	Removing tool for ball bearing			Refer to item "Disassembling and Assembling of Camshaft"	
		(8) Take off space collar (A)	Hand				
16	Governor	(1) Take off governor 2nd lever	Spanner 9 mm and Phillips (plus) driver				
		(2) Take off governor 1st lever	Driver			Turn lever stem to left	
		(3) Pull out governor sleeve	Hand				
17	Camshaft and Camshaft Gear (A2L)	(1) Pull out camshaft gear holder	Hand				
		(2) Straight up bent tip of lock washer	Driver				
		(3) Take off fastening bolt of blind cover	Spanner 10 mm				
		(4) Take off washer of fastening bolt of camshaft blind cover	Hand				
		(5) Hold tappet with wire	Hand			Put wire through tappet's hole	
		(6) Pull out camshaft	Wooden Hammer			(1) Tap at the pulley side of camshaft with wooden hammer. (2) When camshaft ball bearing does not come out with ball bearing case, just pull out camshaft in the same manner; the ball bearing comes out to pulley side.	
	17	Camshaft and Camshaft Gear (A3L)	(7) Remove camshaft gear from crankcase	Hand			
			(1) Take off set screw of camshaft gear	Phillips (Plus) Driver			
			(2) Hold tappet with wire	Hand			
			(3) Pull out camshaft gear	Removing tool for camshaft bearing			Refer to item "Disassembling and Assembling of Camshaft" The gear can not be separated from camshaft
17		(4) Straight up bent tip of lock washer	Driver				
		(5) Take off fastening bolt	Spanner				
		(6) Remove camshaft tapping at the end of the shaft	Wood Hammer or Hammer and Copper drift				
		(7) Pull out camshaft	Hand				
18	Tappet	Pull out camshaft	Hand				

### VIII REASSEMBLING PROCEDURES

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
1	Tappet	Hold tappet with wire to prevent it dropping in crankcase	Hand			
2	Camshaft and Camshaft Gear (A2L)	(1) Install camshaft gear through bottom of crankcase	Hand	_____	_____	
		(2) Install camshaft in crankcase through camshaft gear from cooling fan side.	Hand	_____	_____	
		(3) Insert camshaft gear into camshaft fitting section	Hammer & Metal Piece	_____	_____	Tap at the camshaft end of flywheel side with metal piece and hammer
	Camshaft and Camshaft Gear (A3L)	(1) Install camshaft gear through bottom of crankcase	_____	Hand	_____	
		(2) Install camshaft in crankcase through camshaft gear housing	_____	Hand	_____	
		(3) Insert camshaft into bearing(B) of crankcase, tapping at the shaft end	_____	Hammer & Copper drift	_____	
		(4) Insert camshaft gear into camshaft fitting section	_____	Assembling Tool for Camshaft	_____	Refer to item "Assembling & Disassembling of Camshaft"
		(5) Tighten set screw of the gear	_____	Phillips(Plus) Driver	_____	Don't forget to put on washer
3	Governor	(1) Insert camshaft gear holder	Hand	_____	_____	
		(2) Expand governor weight outward	_____	Hand	_____	
		(3) Put in governor sleeve	_____	Hand	_____	Set lever to knock mark
		(4) Fix governor 1st lever	_____	Driver	_____	
		(5) Fix governor 2nd lever	_____	Phillips (Plus) Driver & Spanner 9 mm.	_____	Turn lever stem to right
4	Camshaft Ball Bearing (A2L)	(1) Insert camshaft ball bearing	Hand	_____	_____	
		(2) Insert washer	Hand	_____	_____	
		(3) Tighten nut	Spanner 26 mm	_____	_____	
		(4) Bend tip of lock washer	Driver	_____	_____	
		(5) Install cover of bearing housing	Spanner 10 mm	_____	_____	
	Camshaft Ball Bearing (A3L)	(1) Put space collar (A)	_____	Hand	_____	
		(2) Insert bearing (A) into camshaft	_____	Mantling Tool for Bearing	_____	Refer to item "Disassembling of Camshaft"
		(3) Put on bearing housing	_____	Hand	_____	Don't forget to fit packing joint

No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
4		(4) Put space collar (B) in	_____	_____	Hand	
		(5) Tighten nut of bearing housing	_____	_____	Spanner 10 mm	Put spring washer too
		(6) Tighten fastening nut	_____	_____	Spanner 10 mm	
		(7) Put on cover of bearing housing	_____	Spanner 10 mm	_____	Put spring washer too
5	Blind Cover	(1) Put on blind cover	Spanner 10 mm			Don't forget to put washer and packing
		(2) Bend washer	Driver			
6	Fuel Pump	(1) Put in roller guide	Hand			Set projected end of roller pin in crankcase groove
		(2) Put in adjusting plate	Hand			
		(3) Put in plunger	Hand			(1) Put plunger pin into crotch of adjusting lever (2) At the same time, put notch of spring supporter into roller head pin
		(4) Insert spring	Hand			
		(5) Install pump body	Hand			See if pump body contacts to crankcase surface pressing it. If spring supporter notch is not in correct position, pump body can't be pressed down by hand
		(6) Tighten nut	Box wrench 14 mm or Spanner 10 mm	_____	(1) Put washer (2) Tighten bolt evenly	
7	Breather	Put on breather	Spanner 10 mm			Fit spring washer & packing
8	Crankshaft	(1) Insert crankshaft	Hand			(1) Don't forget to fit collar (2) Match the marked point
		(2) Put on crankcase front	Spanner 10 mm & Wooden Hammer	_____		Don't forget to fit packing and washer
		(3) Check side cover	Hand			Correct side gap if necessary
		(4) Install extension shaft	Monkey Wrench	_____	Spanner 32 mm	
9	Flywheel	(1) Put on key	Wooden Hammer			
		(2) Mount flywheel	Hand			Put oil on shaft
		(3) Tighten flywheel and nut	Box Spanner 40mm & Hammer	Box Spanner 49mm & Hammer	_____	(1) Don't forget to fit washer (2) A2L has counter-clock-wise thread (3) Insert 8 handle into hole of flywheel circumference and hold flywheel firmly
		(4) Bend tip of lock washer of Flywheel	Torque 85 ft-lb	Torque 100ft-lb	_____	Bend washer tip firmly
			Driver and Box Wrench Handle	_____		

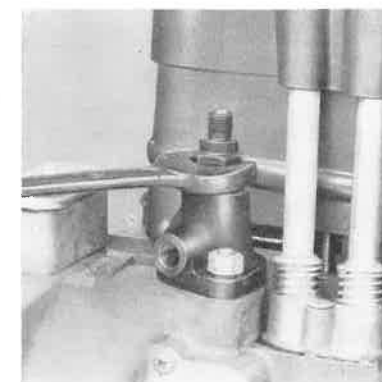
No.	Parts Classification	Disassembling Procedures	Required Tools			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
10	Cylinder and Piston Complete	(1) Place piston correctly in the cylinder liner	Hand			(1) Set piston in correct direction (2) Arrange rings opening so as they don't line up
		(2) Set crankshaft to T.D.C.	Hand			
		(3) Place cylinder and piston complete on engine block	Hand			
		(4) Turn crankshaft to B.D.C. pressing piston head	Hand			
		(5) Put on bearing cap	Hand			Put cap in correct direction
		(6) Tighten nuts	Box Wrench 14 mm			Don't forget to fit washer
		(7) Bend washer tip	Driver			
		(8) Put bottom cover back	Spanner 10 mm			Don't forget to fit packing and spring washer
11	Push Rod, Push Rod Cover & Connecting Flange	(1) Fit connecting flange	Phillips (Plus) Driver			Don't forget to fit packing together
		(2) Insert push rod cover	Hand			With push rod cover
12	Cylinder Head	(1) Place packing	Hand			
		(2) Fit cylinder head	Hand			
		(3) Tighten nuts	Spanner 14mm Box Wrench 12 & 14mm	Spanner 17mm & 14mm Box wrench		(1) Don't forget to fit packing (2) Refer to item "Assembling of Cylinder Head"
		(4) Put plug on the air inlet	Spanner 14 mm	Spanner 17 mm		
13	Cooling Fan Cover	(1) Install cooling fan cover	Spanner 10 mm			(1) First set knock pin (2) Don't forget to install Mounting piece for starting handle
		(2) Install governor spring	Hand			
14	Fin Side Cover	(1) Install auxiliary side cover	Phillips (Plus) Driver			Don't forget to install spring washer
		(2) Install left side cover				
		(3) Install right side cover				
15	Fuel Injection Valve	(1) Tighten fuel valve	Spanner 32 mm			Don't forget to fit packing
		(2) Install fuel overflow pipe	Spanner 12 & 21 mm			
16	Silencer	(1) Install fuel silencer	Hand			
		(2) Tighten fastening band	Phillips (Plus) Driver			
17	Air Cleaner	(1) Install air cleaner	Hand			
		(2) Tighten fastening band	Phillips (Plus) Driver			

No.	Parts Classification	Disassembling Procedures	Required Tool			Remarks
			A2L	A3LN Power from crankshaft	A3LR Power from camshaft	
18	Pulley	(1) Put key in the groove	Wooden Hammer			
		(2) Install Pulley	Hand & Wooden Hammer			
19	Adjustment of Suc. & Exh. Valve	(1) Adjust valve clearance	Feeler Gauge, Spanner 14 mm & Driver			Read item "Adjustment of Suc. & Exh. Valve"
		(2) Put locker arm cover (bonnet)	Spanner 21 mm			
20	Adjustment of Governor Link	Adjust as indicated	Spanner 9 mm & Phillips Driver			Refer to item "Governor Link Adjustment"
21	Bleeding Out Air from Fuel Line System	Bleeding air out from fuel system, connect fuel pipe and injection pipe	Spanner 9, 14, 17, 19 & 21 mm Phillips (Plus) Driver			Refer to item "Bleeding out air from fuel line system"

## IX DISASSEMBLY AND REASSEMBLY OF FUEL INJECTION PUMP

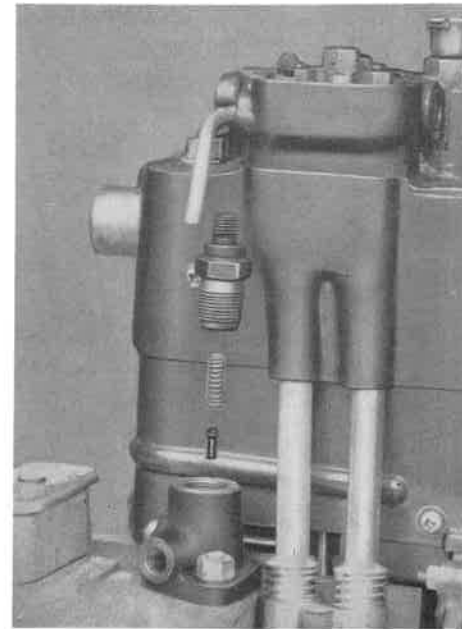
### (A) The fuel injection pump is Yanmar made Bosch type fuel pump.

- (1) The plunger, plunger spring and roller guide can be removed by just loosening the fastening nuts of pump body and pulling the body up.
- (2) The disassembly of delivery valve, delivery valve guide, plunger barrel, so on can be performed in the following manner.



- (a) Loosening the holding nut of delivery valve spring with a 21 mm, spanner, take it out.

(b) Pull the delivery valve spring up and remove delivery valve.



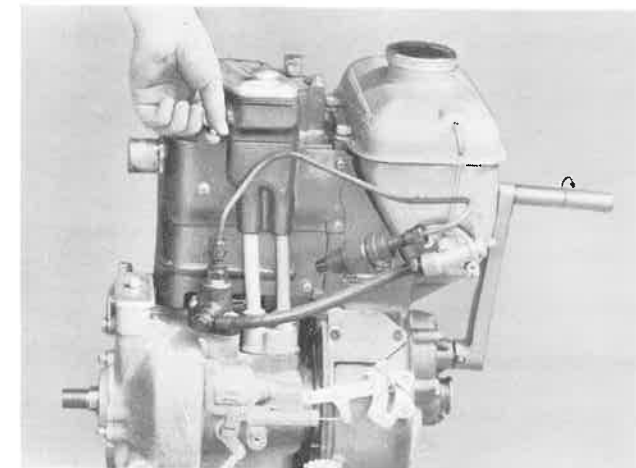
(c) It is not necessary to remove the plunger barrel and delivery valve guide except where replacement is necessary. Should they be removed, tap the barrel lightly with a wooden hammer from the back side of pump body. This removal must be performed after the procedures (a) and (b) mentioned above are completed.



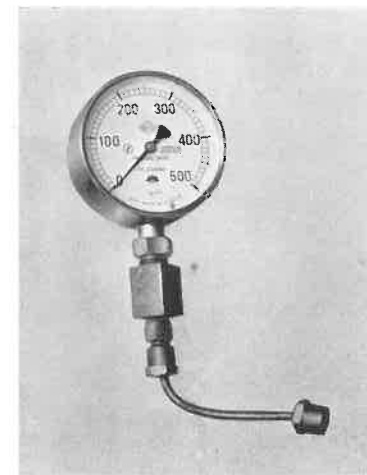
### (B) Care

If the fuel contains dusts, water and other impurities or is of low quality it will cause abnormal wear of the plunger thus making it impossible to get the right amount of fuel delivery from the injection pump. The same trouble will occur when the contact surface of the delivery valve seat is not correct.

Since fairly expensive instruments are necessary for the testing of injection pump's delivery quantity and pressure, a simpler method is herein introduced.



(1) Connecting an injection valve previously tested by a nozzle tester to the injection pump by means of fuel pipe, check the injection pattern turning engine. It is all right if the normal injection pattern similar to that obtained in previous test is seen.



(2) Upon connecting the pressure tester and the injection pipe to the outlet of fuel pump, turn the engine and read the pressure gauge. If the gauge indicate the maximum pressure of  $140 \text{ kg/cm}^2$  ( $1990 \text{ lb/in}^2$ ), the fuel pump is normal.



(3) If the delivery valve seat and the valve tip do not make good contact carry out lapping applying the lapping compound on the valve tip. The rough lapping is performed with No. 1000 lapping compound and the finishing lapping with an oxidized chrome. Be sure to use an oxidized chrome only for the lapping of the delivery valve guide and the sliding parts of the plunger ; never use the lapping compound for this purpose.

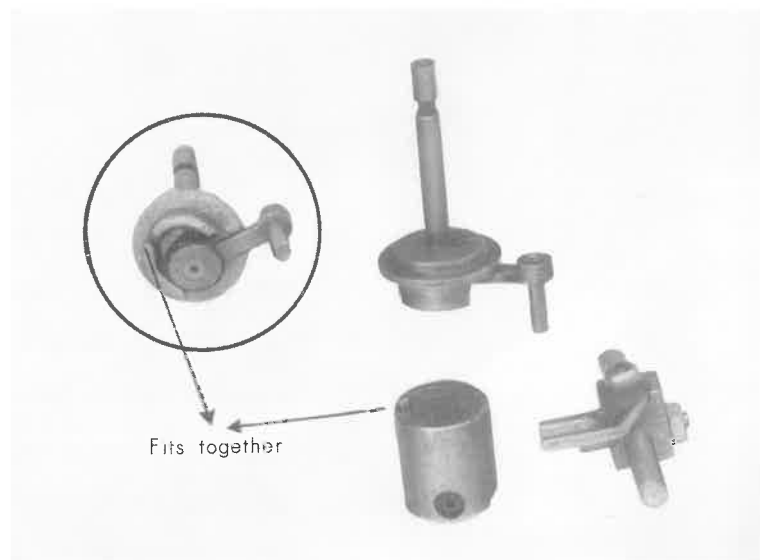
- (4) Remember that the plunger should be replaced together with the plunger barrel and the delivery valve together with the delivery valve seat in case their replacement is necessary because they were lapped to form a mated assembly in each case.
- (5) Since each part of the fuel injection pump is machined with a minute care, be very careful when handling not to impair the finish. Further, it is recommended to put lubrication oil or rust-proof oil on parts after washing.

### (C) Reassembly of Fuel Pump

The reassembly of fuel pump is performed in the opposite manner from the disassembly.

- (1) Mounting the plunger barrel.
  - (a) Replace the packing with a new one.
  - (b) Insert the barrel into the pump body from the delivery valve side.
- (2) Temporary mounting of the delivery valve.
  - (a) Put on delivery valve seat
  - (b) Put on a new gasket of delivery valve outlet joint.
  - (c) Fit a delivery valve and next, plunger spring.
  - (d) Insert the joint of the delivery valve outlet.
- (3) Mounting of the fuel pump.

The fuel pump must be mounted on the crankcase without plunger in the following manners.



- (a) Turn the engine to bring the roller guide to bottom position.
  - (b) Insert the adjusting plate.
  - (c) Put the washer of the spring retainer in the plunger.
  - (d) Holding the plunger tip, insert the plunger lightly so that the plunger pin fits in the crotch of the adjusting lever and at the same time the bottom notch of the spring retaining washer fits in the roller head pin.
  - (e) Next, place a spring on that.
  - (f) Insert the pump body lightly. At the same time be sure to check if the pump body contacts the surface of crankcase pressing the pump body by hand. Should the notch of the spring retainer not fit on the roller head pin correctly, the pump body will not contact the crankcase surface.
  - (g) Put on spring washer and tighten the bolts.
- (4) Retightening of the delivery valve nut.
 

Thighten the joint of delivery valve outlet at a torque of 50 ft-lb.

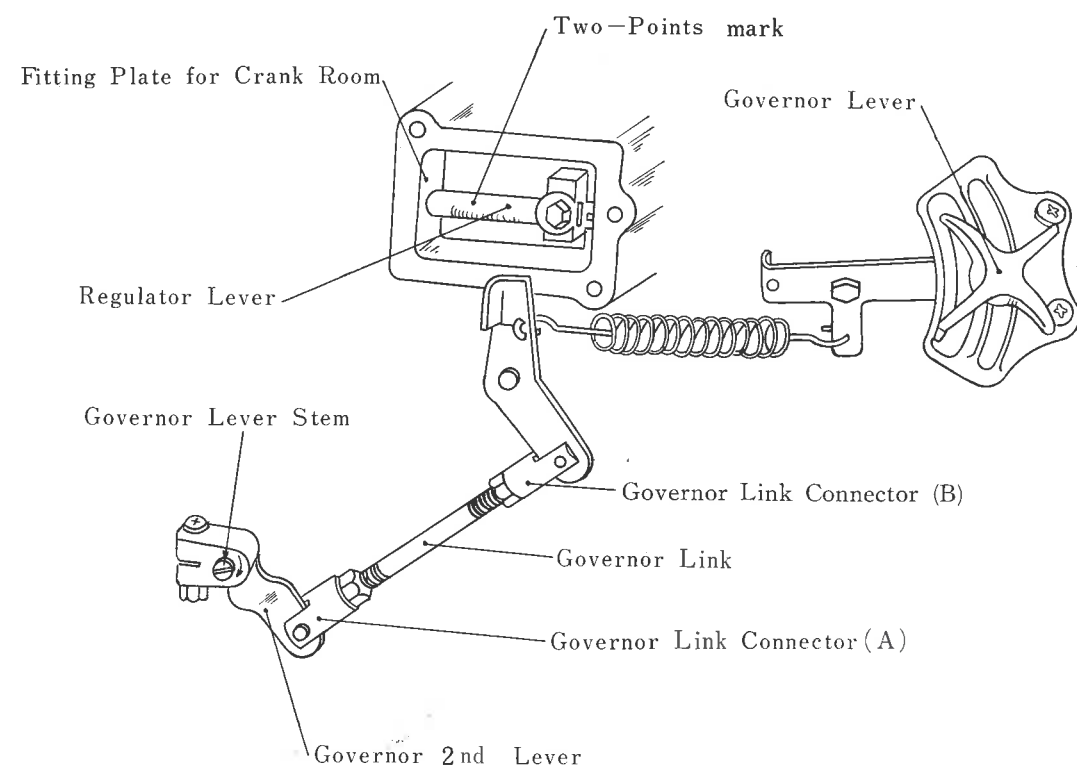
### (D) Adjustment of Fuel Injection Quantity (Setting with Governor Link)

An engine governor system is very sensitive to variations in load, and through functions to control the fuel pump. In other words, it acts through a governor link by opening or closing a governor weight, thus controlling the fuel injection quantity. If the adjustment of the governor link is not correct, the required fuel injection quantity and desired horse power will not be obtained.

The adjustment of fuel injection quantity can be effected in the following manner.

- (1) Open the cover of the lock housing on the fuel pump with a driver.
- (2) Upon turning the governor lever stem to arrow-mark direction fully, settle the notch of the governor 2nd lever in horizontal position. (use spanner 9 mm., Phillips driver and driver). (If the fastening nut of the governor 2ad lever was not loosened, the 2nd step could be omitted)
- (3) Put the governor lever in the running position.

- (4) Adjust the length of the governor link so that the two-points mark on the lock accords with the set mark in the crankcase. (Use spanner 9 mm.)



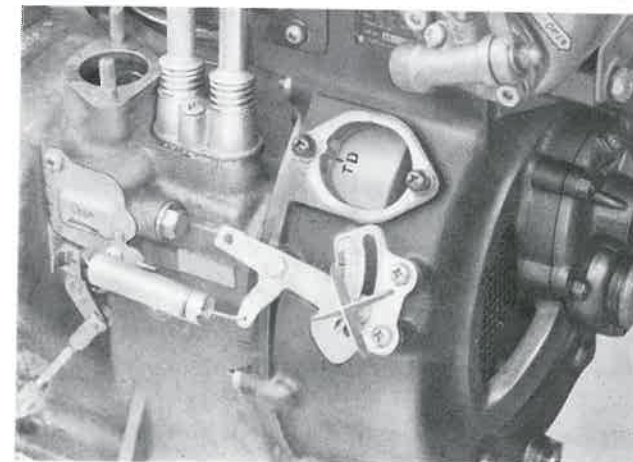
- (5) Finally, tighten the nuts on the both ends of the governor link.

### (E) Inspection for Fuel Injection Timing

The fuel injection timing effects the fuel combustion, and improper injection timing causes the reduction of horse power, reverse revolution and abnormal exhaust gas color. The proper injection timings are indicated in the following chart.

Type	Injection Timing (before T.D.C.)
A2	18 - 21 degrees
A3	20 - 25 degrees

### (1) How to check the injection timing



Turn the engine slowly and stop it at the instant of fuel injection valve ; read the degree-mark on the degree-mark on the flywheel. Since this method requires skill, a simpler method is given herein.

- Place the regulator handle in running position.
- Disconnect the fuel injection pipe from the injection pump.
- See if the fuel comes out from the outlet nipple of injection pump turning the engine.
- Turn the flywheel and stop it at the instant of fuel injection from the pump's nipple ; read the degree mark on the flywheel through the window cover of cooling fan.
- Repeating this reading a few times, take the average figure. This average figure should be advanced 2 - 3 degrees more than the figures shown in the above chart.

### (2) How to adjust injection timing

The adjustment of the injection timing is performed by changing the number of adjusting shims (brass sheet) inserted between the mounting bed for the fuel pump and the engine block. If the number of the adjusting shims is decreased, the injection timing will be advanced, and if shims are added, the timing will be delayed. As the extreme adjustment may cause damaging of the plunger or damage the pump, avoid careless adjustment.

Incorrect injection timing will occur when you forget to put the adjusting shim or shims back during assembly, or may be caused by the plunger wear and agglutination. The inspection for injection timing is mainly for finding these mistakes or troubles. If disorder of injection timing is noticed, the first thing to do is to check the whole injection system carefully.



## X DISASSEMBLY AND REASSEMBLY OF FUEL INJECTION VALVE (NOZZLE)

### (A) Disassembly

- (1) Upon disconnecting the high pressure fuel pipe and the over-flow pipe, take off the injection valve body from the cylinder head with a spanner 32. (Be careful not to lose the gasket packing and the copper packing on the cylinder head)
- (2) Holding the injection valve body in the vise, loosen the valve spring retainer with a spanner 26.
- (3) Disassemble the injection valve body carefully following the directions given in left side.
- (4) If the nozzle case is stuck to the fuel valve body by carbon, take it out by tapping a copper pipe placed on the case with a hammer after pulling out nozzle in the manner indicated. Be very careful not to break the center hole of the case when you tap it with a hammer.



- (5) If the nozzle does not come out, you will have to use the removing tool for the pintle valve.

### (B) Care

- (1) For nozzle lapping, first of all you have to remove the nozzle and then lap the nozzle tip with lapping compound No. 1000 (pulverized limit 7). Oxidized chrome should be used for finish lapping.

- (2) The nozzle should be replaced together with the nozzle case if the replacement is necessary, because they were lapped to form a mated assembly.
- (3) When you handle the fuel valve assembly, be very careful not to damage it, because all parts of the fuel valve are machined with minute care. Also you should put lubricating oil or rust-proof oil on the surface of the nozzle after washing.

### (C) Reassembly

- (1) The reassembly is performed in the opposite manner from the disassembly.
- (2) Don't forget to put back the adjusting shims of the spring.
- (3) The fuel valve body is tightened at a torque of 60-70 ft-lb.

### (D) Injection Test

- (1) The nozzle tester is used for the injection test of the injection valve.
- (2) The normal pressure of this injection valve is 140 kg/cm<sup>2</sup>, and if the pressure happens to be lower than this figure, add the adjusting shim to get 140 kg/cm<sup>2</sup> of pressure.



- (3) The injection is normal when the fuel coming out from the nozzle is mistlike and is of conical pattern. It is not a normal injection if the fuel is injected in a liquid state, lots of fuel come out in a liquid state before and after injection time, the injection pattern is too narrow or too wide, or its direction is slanted to onese.

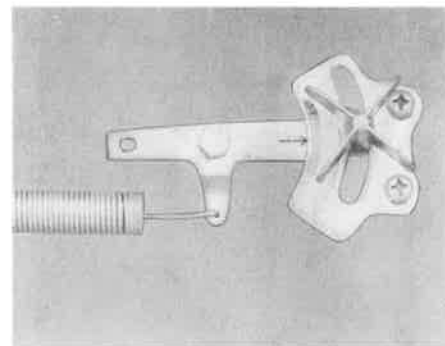
- (4) When testing, never put your finger or hand on the tip of the injection nozzle.

### (E) How to bleed air from the injection system

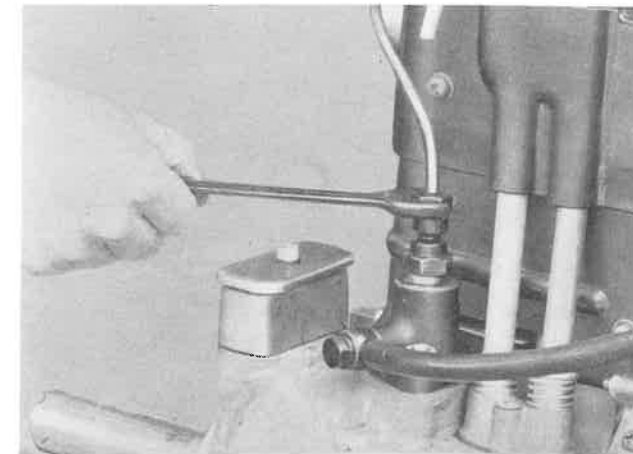
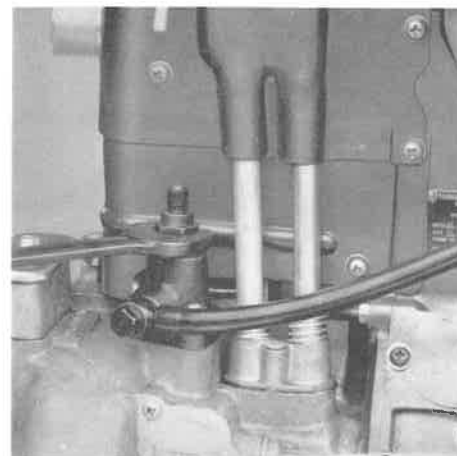
The fuel injection system consists of a series of fuel passages such as fuel tank, high pressure fuel pipe, and fuel injection valve. If any air is present in the fuel injection system, the fuel will not be injected correctly. You are advised to keep this in mind especially when the engine is disassembled or the engine is stopped with an empty fuel tank.

The air is bled in the following manner, in which it is supposed that the fuel oil pipe and high pressure fuel pipe are disconnected.

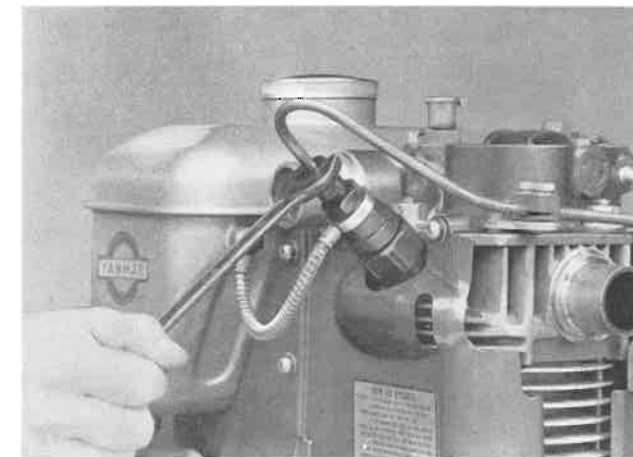
- (1) Connect the fuel pipe to the fuel tank.
- (2) Open the fuel tank cock and put the regulator handle on the engine's running position.



- (3) Loosen the small screw on the fuel pump and then bleed air present between fuel tank and pump. Next, loosen the delivery valve retaining nut (don't take it off) ; when bubbles cease and fuel only comes out, tighten the delivery valve nut.



- (4) Connect the high pressure fuel pump by means of nipple.



- (5) Turn the engine until you get the fuel which has no bubbles, and then connect the pipe to the injection valve.
- (6) Turn the start handle. If the booming sound is heard, your priming is good and the engine is ready to start.

## DISASSEMBLY AND REASSEMBLY OF CYLINDER HEAD

### (A) Disassembly of Cylinder Head

The cylinder head disassembly is necessary when removing the carbon deposits on the valve seats and lapping the inlet and exhaust valves, and is conducted in the following order.

- (1) Remove the cylinder head bonnet or rocker cover.
- (2) Remove the silencer and the air cleaner.
- (3) Remove the fuel injection pipe and the over-flow pipe.
- (4) Remove the side cover of the cooling fan.
- (5) Remove the plug.

(6) Take off the five bolts on the cylinder head. A box spanner should be used for removing the (3) and (4) bolts shown in the drawing.

(7) The anti-chamber, which is under the fuel injection valve, cannot be taken out because it is specially casted-in.

(8) Disassembly of inlet and exhaust valves.

The cylinder head is composed of the cylinder head and the valve lever housing, and since the valve lever mounting cannot be taken off, the following steps must be taken in disassembly.

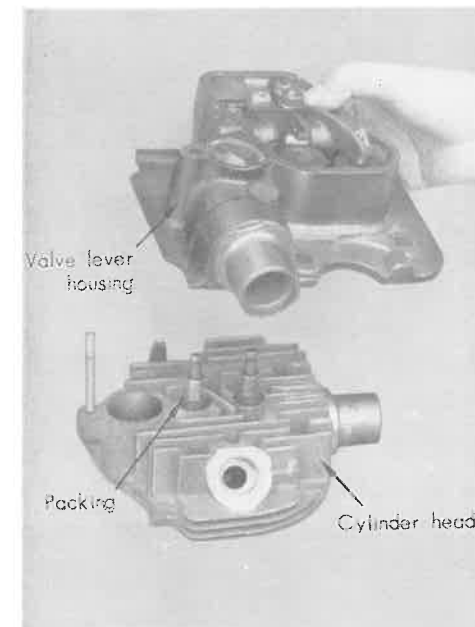
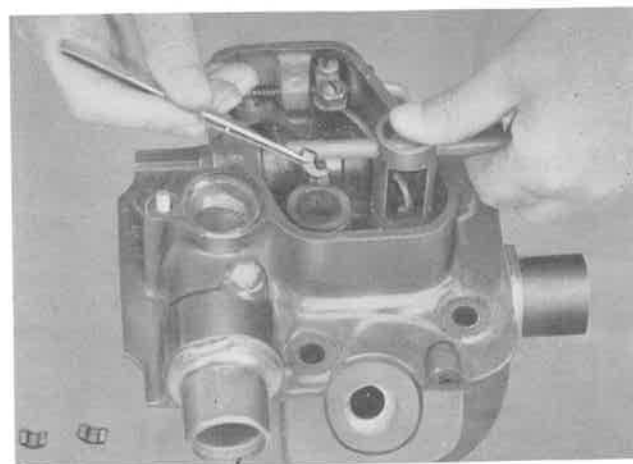
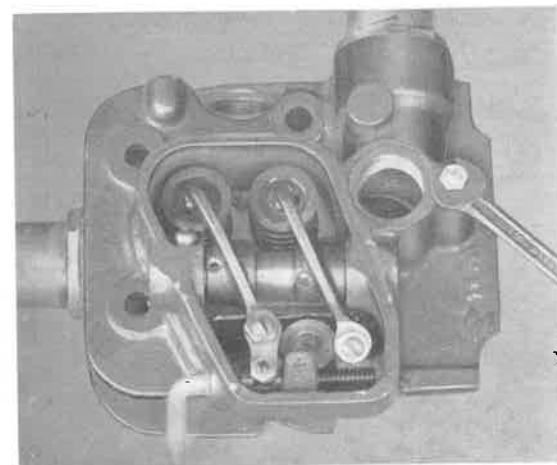
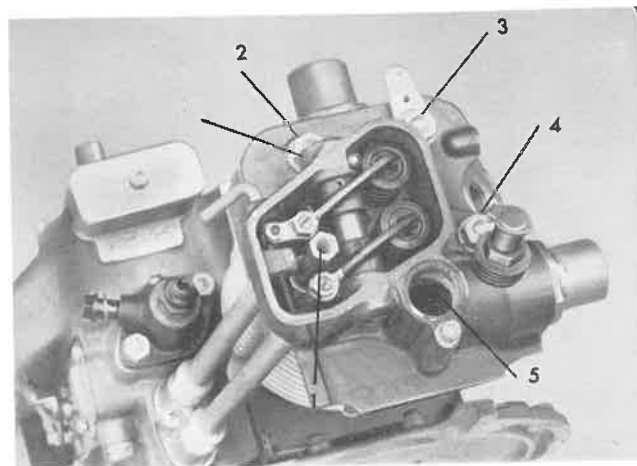
(a) For A3 type engine, first of all, take off the nuts which tighten the valve lever housing and the cylinder head with a spanner 10 mm.

(b) Place the cylinder head on the board of 5 mm thickness or on the metal sheet so that the valve heads face the board or metal sheet.

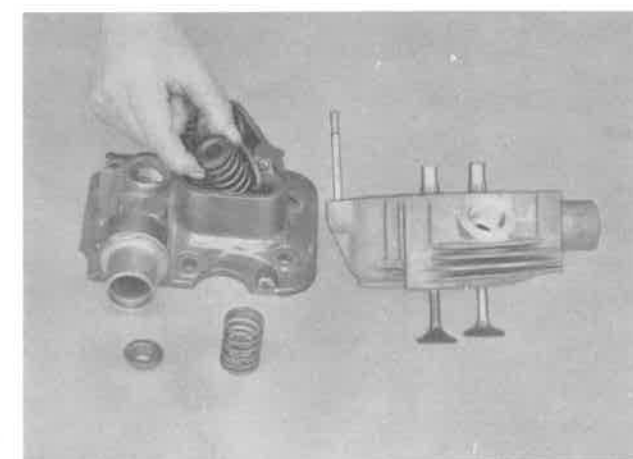
(c) Insert the handle of box spanner 14 into the 8.5 hole of valve disassembling tool.

(d) Place the disassembling tool on the valve spring retainer so that the notch of the tool fits on the valve lever.

(e) Pushing down the valve spring with the handle, take off the spring retainer one by one.



(f) Pull up the valve lever housing.



(g) Now that the valve lever housing and the cylinder head are separated from each other, the inlet and exhaust valves can be removed from the cylinder head and the valve spring and retainer from the valve housing easily.

(h) Packings are provided at the valve guide of the cylinder head and replace them with a new one when disassembling.

## (B) Valve Grinding

Prepare the grinding tool and compound for the valve grinding and carry out the grinding in the following manner.

(1) First of all, remove the carbon on the valves, cylinder head and valve seats carefully before grinding.

(2) In the first grinding, use a rough compound ; the grinding is to be conducted until an even contact surface is attained.

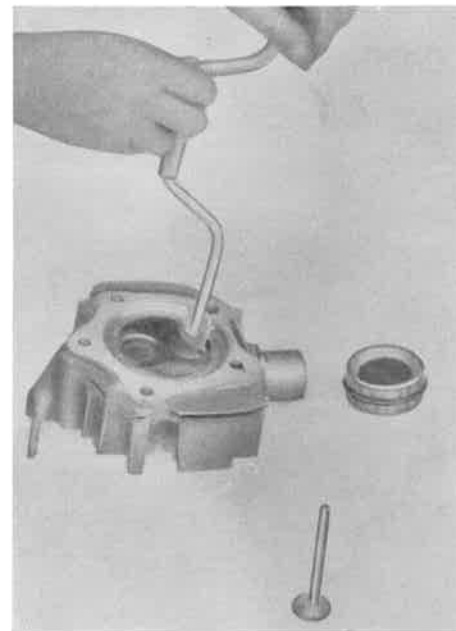
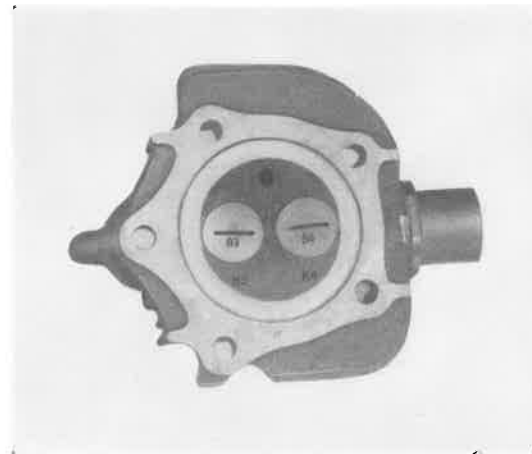
(3) Next, grind with a finer compound and finally grind with the lubricating oil.

(4) Set marks are provided on the valve and valve seat so that you will not misplace them when reassembling them.

(5) The grinding is performed more effectively by turning and moving up and down the valve stems lightly than by just turning them.

(6) When finishing the grinding, paste a blue marking on the valve seat and insert the valve stem into the seat. Move the valve up and down gently a few times and check for the circular mark of the marking on the valve. If the same width of circular mark is found on the valve, it means that the valve contact with the valve seat is all right.

(7) If the width of valve seat is to be found too wide, you have to correct it with a valve seat reamer. The following chart is for guidance in this respect.



Type	Width of Seat (L)		Seat Reamer				
	Repairable Max. Wear	Correct Width	Dia. of Valve Seat	Seat Angle	Upper Side Angle	Inner Side Angle	Pilot Dia.
A2	2.8 mm (0.11")	2.1 mm (0.08")	26.5 mm (1.043")	45°	15°	65°	7.5 mm (0.2953")
A3	2.8 mm (0.11")	2.1 mm (0.08")	29 mm (1.142")	45°	15°	65°	7.5 mm (0.2953")

\*\* Figures in the brackets show inch size.

(8) Before reassembling them, you are advised to clean up the valve and valve seat thoroughly. If abrasive particles left on them, excessive wear will occur.

### (C) Replacement of suc. & exh. valve guide

Replacement of the suc. & exh. valve guide should be done in a way as follows.

1. After taking off the suc. & exh. valve, put the cylinder head in a can and heat it for about 5 minutes in spindle oil or in machine oil at about 100°C (210°F).

Don't heat light oil up to 100°C, because it may possibly catch fire. If the above oil are not available, you may use water.



2. Put a round shaped wooden rod on the back side (combustion chamber side) of the cylinder head, which is just taken out, and tapping it with the hammer, take the guide out of the cylinder.

3. Then, put the new guides into the cylinder from the opposite side, tapping the round wooden rod put on the new guide as shown in the picture.

4. After replacement, insert the suc. & exh. valve and check if they slide up and down smoothly.

### (D) Dismantling and assembling of valve lever holder

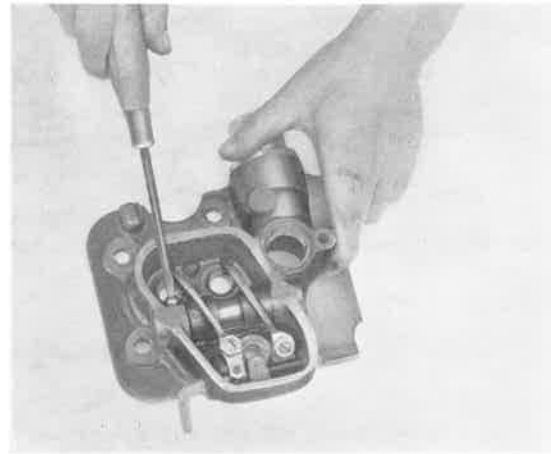
Avoid dismantling of the valve lever shaft, except when it is necessary, because it is set in the cylinder head cover bonnet by the method of shrinkage fit.

(1) Dismantling.

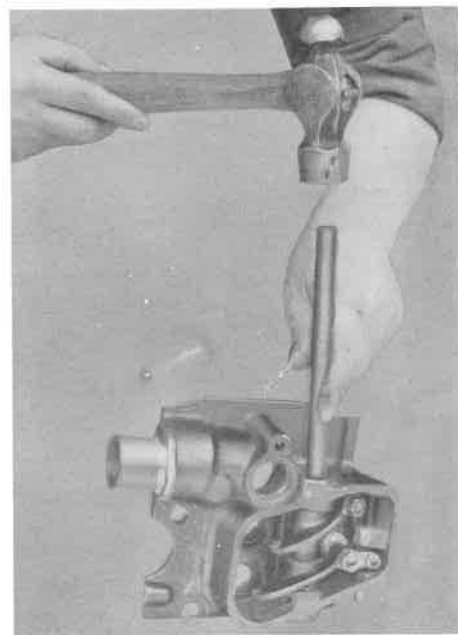
Dismantle in a way as follows.

(a) Unscrew the small stopper of valve lever shaft, using the plus screw driver.

(b) Pour spindle oil into the can as illustrated and heat the cylinder head cover bonnet at about 80°C (180°F) for about 10 minutes.



(c) After taking the cylinder head cover bonnet out, put it on a table, and take out the valve lever shaft, tapping the round wooden rod placed on the valve lever shaft with the hammer.



(d) When you are pulling out the valve lever shaft, the cylinder head cover bonnet may possibly be broken if you do without heating it.

## (2) Assembling

(a) Just like disassembling, put the valve lever shaft into the cylinder head cover bonnet tapping the valve lever shaft with the hammer, after heating them in about 80°C (180°F) spindle oil for about 10 minutes. (Don't forget to place wooden rod on the valve lever shaft)

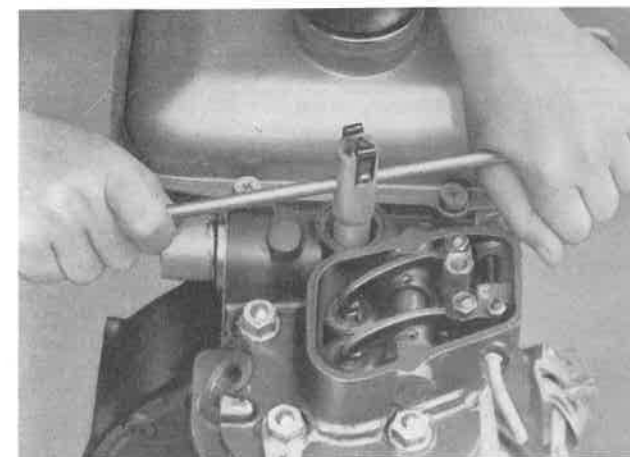
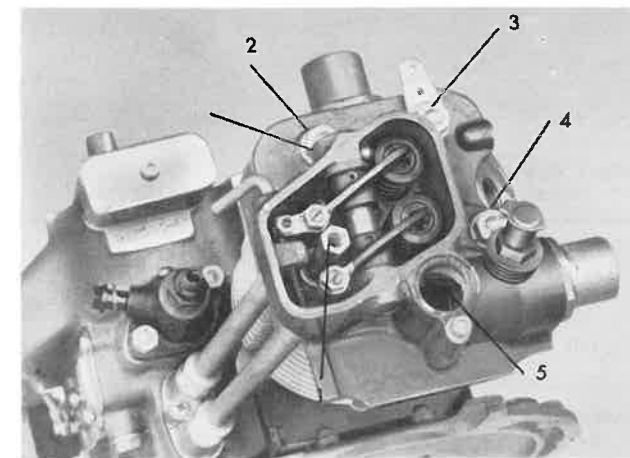
(b) Don't forget to screw the small stopper of valve lever shaft.

(c) Replace rubber rings at both sides of the valve lever shaft.

## (E) Assembling of cylinder head

Assembling of the cylinder head can be done in the opposite manner to dismantling, however, the screw nuts for the cylinder head should be tightened equally, otherwise it may cause leakage of gas. Further, you have to re-tighten it periodically, even though you don't dismantle.

Here is "How to tighten cylinder head".

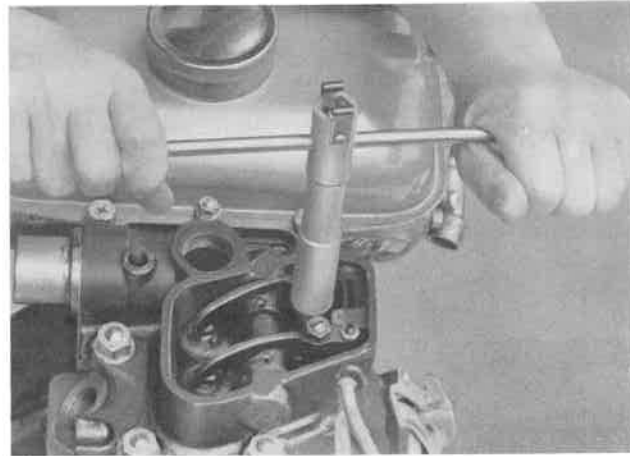


(1) Put in the washer without fail and screw the nut.

Illustrated nut No. 5 is in the suction hole, so, after taking off the plug, put into nut No. 5, holding it between the springs of the attached box spanner.

(2) The order of screwing must follow the illustration numbers and screwing should be done in a diagonal line.

Don't screw each nut at a time ; do screw gradually repeating screwing of each nut at least 3 times.



(3) Spanners required for each nut and tightening torque are as follows.

TYPE	SPANNER			TIGHTENING TORQUE	
	nut 1	nut 2-4	nut 5	ft-lb	in-lb
A 2L	box spanner 12 mm	spanner 14 mm	box spanner 14 mm	17.0	204
A 3L	box spanner 14 mm	spanner 17 mm	box spanner 14 mm	27.0	324

To make tightening surer, tighten them according to above standard torque, using the torque wrench.

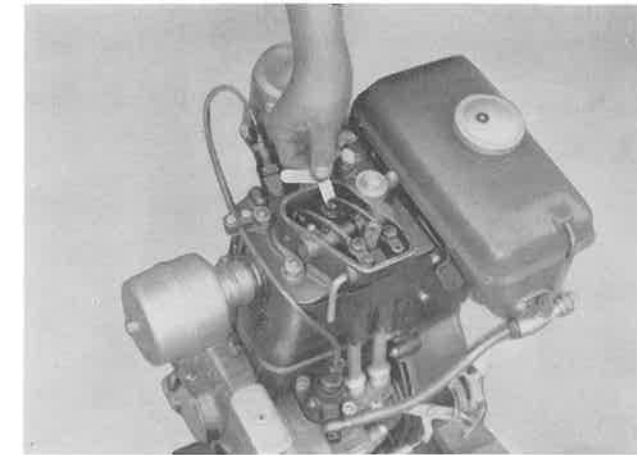
### (F) Adjustment of clearance of suc & exh. valve

After you assemble the cylinder head or when you try to adjust clearance of valves periodically, the adjustment can be done in a way as follows.

- (1) Clearance between the valve and the valve lever should be adjusted when the engine is cool and when the piston is at the Top Dead Center in compression stroke.
- (2) In order to find Top Dead Center in compression stroke, set T.D mark to the arrow marked on the circumference of the flywheel.

First of all, rotate the engine and lift the decompression lever after compression stroke began and the flywheel got heavier to rotate. And further rotate the flywheel about 1/4 of a circle from that position, then comes to T.D mark.

The starting gear is multiplied in speed 2.8 times, so the starting handle must be rotated almost one round.



(3) Insert the thickness gauge between the valve and the valve lever, loosening the nut for adjusting screw stopper of the valve lever, and go on tightening of the adjusting screw till the thickness gauge slightly move, and then fix the screw with the end nut.

(4) Standard valve clearance ;

Suc. valve clearance	0.05 mm	(1.969 × 10. <sup>3</sup> inch)
Exh. valve clearance	0.10 mm	(3.937 × 10. <sup>3</sup> inch)

## XII REPLACEMENT OF CYLINDER

In case the cylinder is worn out into the shape of an ellipse or a cone, you must change it with new one. You can pull out the cylinder after taking off the cylinder head.

### (A) Disassembling and Assembling of Piston & Connecting Rod

#### 1. To extract the piston, take off the cylinder head first.

Then, split the big end bearing of the con.-rod (crank pin metal) in two and pull out the piston with the cylinder.

And then remove the piston to the side of the cylinder skirts. Accordingly, you must drain out the lub. oil first and remove the bottom cover. (cf. procedures of overhaul.)

## 2. Removal of the piston ring.

You can remove the piston ring by use of piston ring tool after taking off the piston.

However, here is a simple method as follows :

- (1) Make two rings (about 4 cm or 1.6 inches in diameter) of fine wire.
- (2) Hook the two rings to the cut ends of the piston ring and insert your thumbs into the fine wire rings.
- (3) Expand the piston ring with your strength on the thumbs. Then take it off manipulating your middle fingers.
- (4) You must be careful not to expand the ring too wide. Over expansion often causes breaking of it.
- (5) The piston rings consist of the following ring :

1. Piston compression ring (chromic)
2. Piston compression ring
3. //
4. //
5. Oil scraper ring

When removing, you should examine them so as to distinguish the order or the upper and the lower parts of them.



## 3. Removal of the piston pin.

To separate the con.-rod from the piston pin, you must remove the piston pin first.

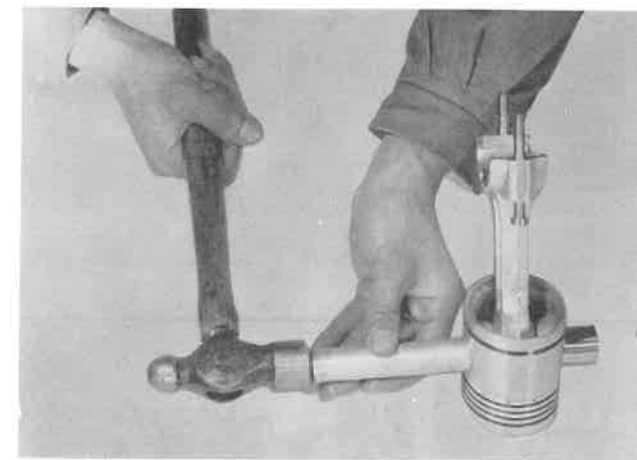
The piston and piston pin is set by the method of shrinkage fit and then, the piston pin can hardly be pulled out without heating them.

As the piston made of light alloy has a larger expansion coefficient than the piston pin of nickel-chrome steel, if you warm up the piston, the piston pin will be easily removed.



- (1) Take off the circlips of both sides of the piston pin with pliers and clean up the carbon residue around the piston pin hole.

- (2) Pour spindle oil into a can till the piston pin is fully soaked in as shown in the picture, and warm it up for about ten minutes in oil of nearly 80°C (180°F).



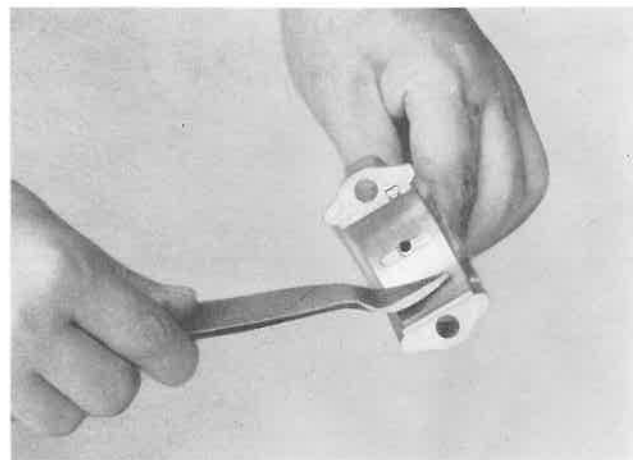
- (3) Take out the piston and put it on a stand. Apply a rod of wood to the piston pin and tap it slightly. Then you can remove the piston pin.

- (4) You must be careful not to remove the piston pin in a cold condition. It will change the shape of the piston.

- (5) In case you separate the con.-rod from the piston, you had better examine the position of set mark of the con.-rod and the cut of the piston top lest you should make a mistake in assembling.

## (B) REPAIR

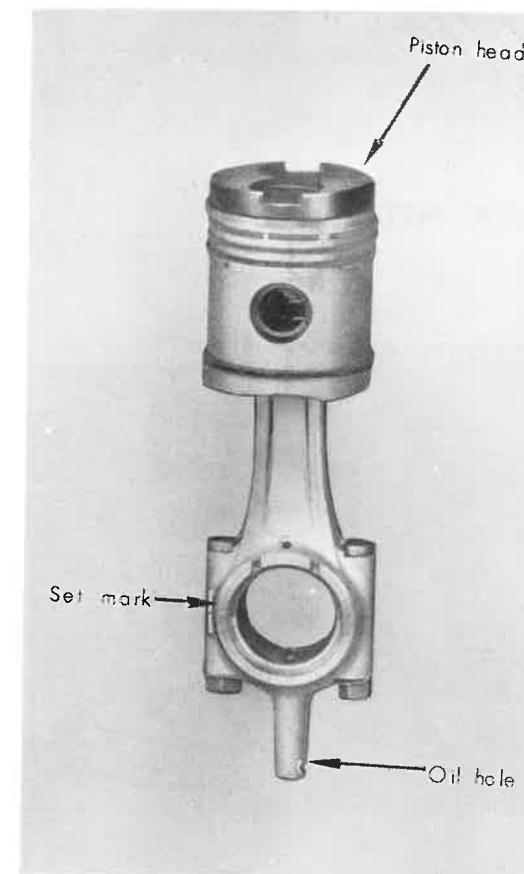
1. Examine the sliding parts of the piston and the piston rings. If you find a remarkable flaw or signs of gas leakage, or the excessive clearance between the rings and the ring grooves, you must replace the piston rings with new ones.
2. The top ring is plated with chromium in order to increase durability of the cylinder liner. So it is recommended to replace it every 500 running hours even if the chrome plating is not off.
3. It is also recommended to replace the fifth oil scrape ring every 500 running hours to prevent oil up.
4. In case you find the signs of a burn on the piston circumference, you should hone the surface of it slightly with a honing stone.
5. The big end bearing of the con.-rod (crank pin metal) is made of precision type triplicate metal which is plated with tin-lead alloy on kelmet. The shim (metal liner) is not employed.
6. If you find a longitudinal flaw on the metal, or a part fused by over heat you must retouch the part thinly with a metal scraper.



## (C) Assembling

### 1. Insertion of the piston.

- (1) Warm up the piston to 80°C (180°F) as you did when removing.
- (2) After inserting the piston pin you must not forget to fit the circlips into both ends.
- (3) The piston and the con.-rod must be assembled just as they were before disassembling. Otherwise, the friction side with the cylinder liner will be shifted: a cut on the combustion surface of the piston head will be in reverse and a projection with an oil hole for the splash lubrication at the end of the con.-rod will also be set in reverse, which causes the insufficient lubrication on crankpin metal, and consequently there will occur a burn of metal.



### 2. Insertion of the piston rings.

Insert the piston rings just in the opposite procedure of removing. In that case you must be careful not to mistake the order or the upper and the lower sides of the rings.

### 3. Insertion of the piston.

- (1) Shift the joints of the piston rings alternately lest they should get in a line and put lub. oil thinly on the rings and the piston.
- (2) Making use of the taper at the lower part of the cylinder, insert the piston from the head into the cylinder.
- (3) In case you fit the cylinder into the crank case you should arrange correctly the cuts of the piston head and five holes of setbolts of cylinder. And insert it softly setting the crank shaft at the point of T.D.C. (Top Dead Center).

### 4. Tightening of the connecting rod.

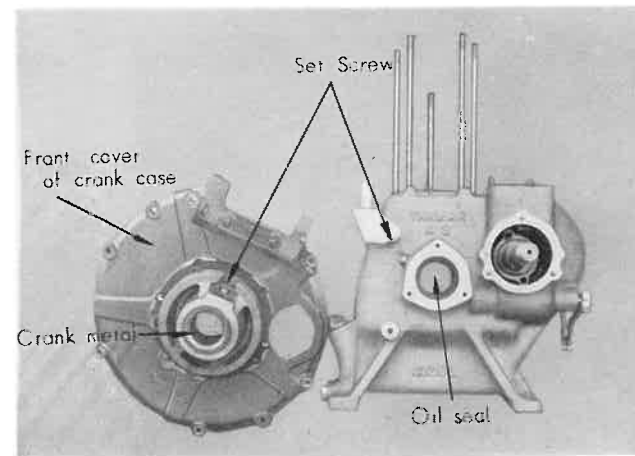
- (1) Be sure to match the set marks of the split part at the end of the con.-rod.



- (2) Tighten the rod bolts evenly with a box spanner.
- (3) Never fail to bend the setting washers after tightening the rod bolts.

## XV REPLACEMENT OF CRANK METAL

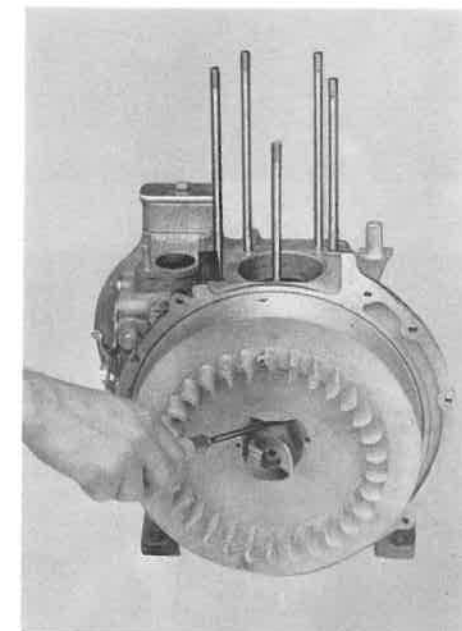
In case you exchange the crank metal, follow the next steps :



- (1) Replacement of the crank metal (gear side)
  - (a) Take off the blind cover of the crank case.
  - (b) Pull out the oil seal to your side.
  - (c) Remove the set screws for crank metal.
  - (d) Soak the crank case in machine oil or spindle oil of 120°C-130°C (260°F) and warm it up for five minutes.
  - (e) Applying a round piece of wood or a removing tool hammer from the outside of the crank case and remove it.
  - (f) Next, insert the new metal from the inside of the crank case by tapping. Be sure to arrange the position of the oil hole and the setbolts correctly.
  - (g) Be sure to screw the setbolts and the metal.
  - (h) Replace the oil seal with new one.
- (2) Replacement of the crank metal of flywheel side (metal housing side)
  - (a) Unscrew the set screws at the inside of the metal housing.
  - (b) Pull out the oil seal to your side.
  - (c) Warm up the metal housing in the same way as you did in the replacement of the gear side metal.

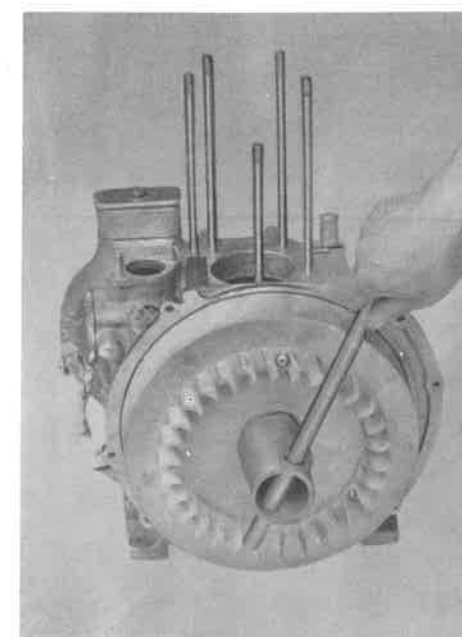
- (d) Applying a pad, hammer it from the outside and remove it.
- (e) Tap to insert the new metal from the inside of the metal housing arranging the position of the oil hole and the set bolts.
- (f) Lastly, screw the set bolts in the metal and replace the oil seal with new one.

## XVI DISMANTLING AND INSTALLATION OF FLYWHEEL



- 1. Straight up the bent washer for end nut with a driver, a box spanner handle and a wooden hammer.
- 2. Remove the nut with a box spanner. (Use 41mm box spanner for A2 and 46mm for A3)

The screw of A3 type being a left hand screw, if you turn it clockwise it will be loose. On the contrary, the screw of A2 type being right hand screw, it will be loose if you turn it anticlockwise. If you put the handle of the 14mm box spanner in the hole on the circumference of the flywheel in order to prevent turning of the flywheel, you can easily concentrate your strength upon the spanner and smoothly remove the screw.



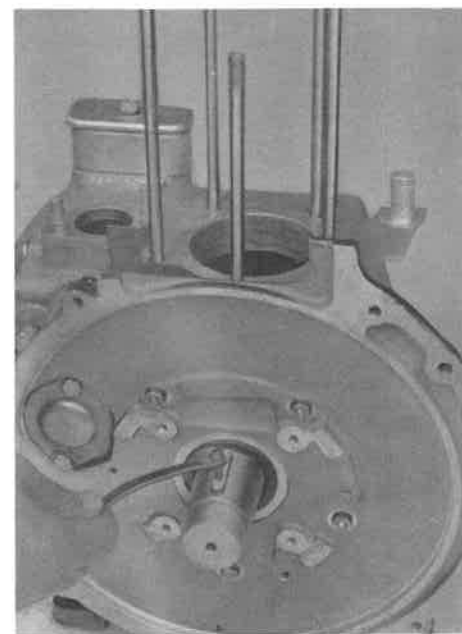
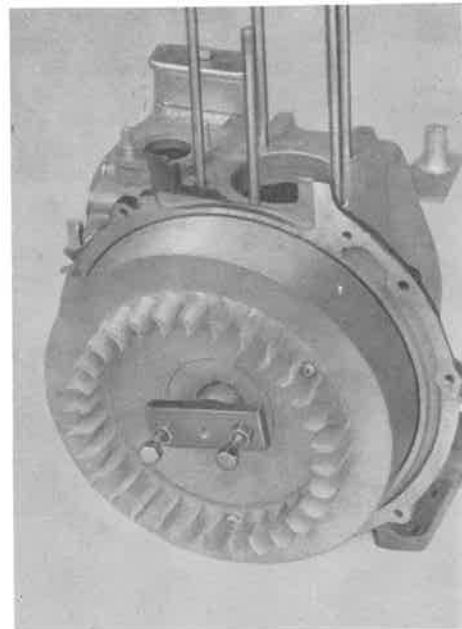
3. Apply the removing tool for flywheel.

(1) Apply the metal pad to the crank shaft and screw two removing bolts with nuts in the top holes of the flywheel. Continue it alternately and equivalently and then the flywheel will come off.

(2) In case of removing flywheel, turn the crankshaft so that the key comes to the lower side, and you can remove flywheel without making any scratch on the key groove.

4. Take off the key by screwing the  $4\phi$  small screw in the tap hole of the key.

5. You can mount the flywheel just in reverse order of dismantling, and put either the Dutch Boy (made by National Lead Co.) blended with linseed oil or lub. oil on the taper of crankshaft. You need not use any removing tool in assembling.

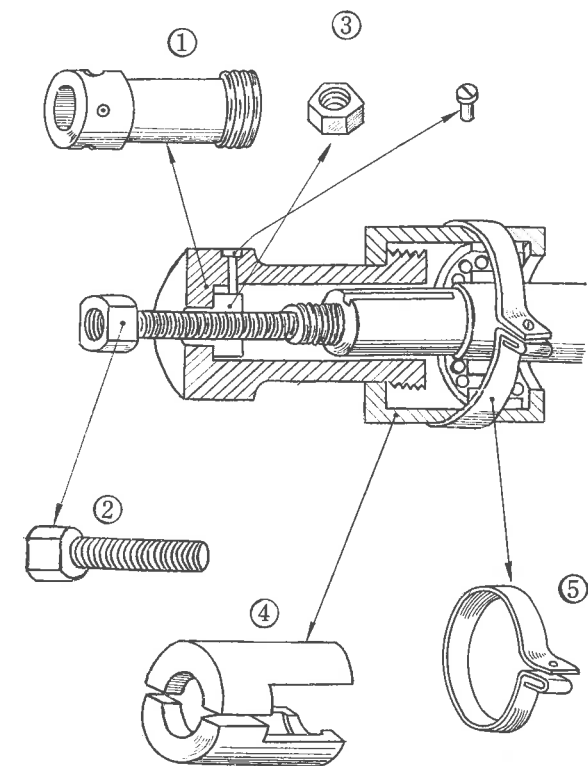


## XVII DISASSEMBLING AND ASSEMBLING OF CAM SHAFT OF A3L

You may dismantle and assemble the cam shaft of A2L just in accordance with the specified order, but in case of A3L you must use special tools as follows :

1. Removing pipe (which also serves as the installing pipe).
2. Removing bolt.
3. Removing nut.
4. Removing pipe for ball bearing (A).
5. Band for do.
6. Support bolt.
7. Flange.
8. Nut for do.
9. Handle.

### A. DISASSEMBLING



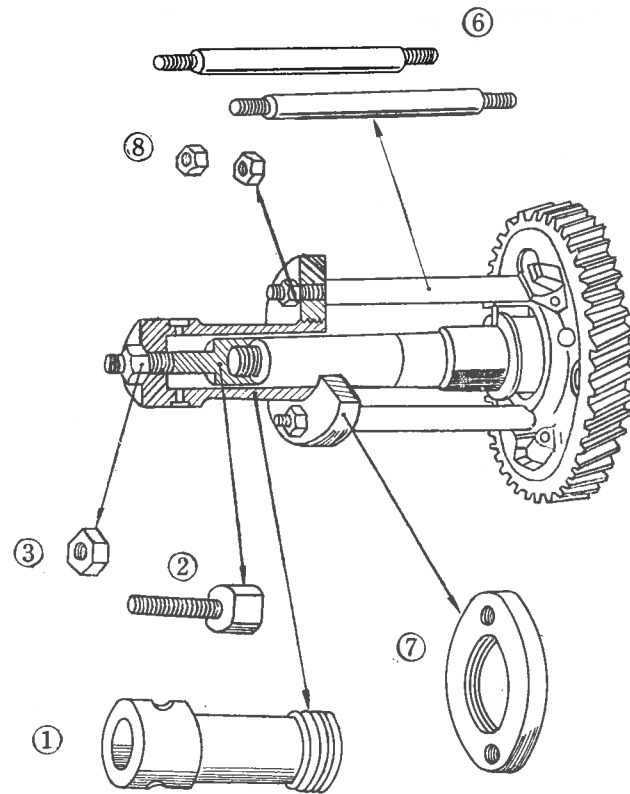
#### 1. Removal of ball bearing (A) of cam shaft.

- (1) Put the nut (3) into the removing pipe (1) and reversing the removing bolt (2), connect them through the pipe.
- (2) Insert the removing pipe (1) into the cam shaft and closely tighten the split removing tool for bearing (4) with the band (5). (Use plus driver.)  
**Important:** Insert the one flange of the removing pipe for ball bearing (A) (4) into the bearing, and another, into the flange of the removing pipe (1).
- (3) Put the handle (9) into the  $9\phi$  hole of the removing pipe, and holding it, screw the removing bolt (2) gradually. Then the ball bearing (A) will come off. (Use 23mm spanner.)
- (4) Take off the removing pipe for bearing (4) unfastening the band (5), and you can remove the ball bearing.

#### 2. Removal of Cam Gear.

- (1) First, unscrew the small set screw for cam gear.
- (2) Take off the fuel pump and the roller guide.
- (3) Hold up the tappet and insert a wire into the upper hole lest the tappet should drop during the work.

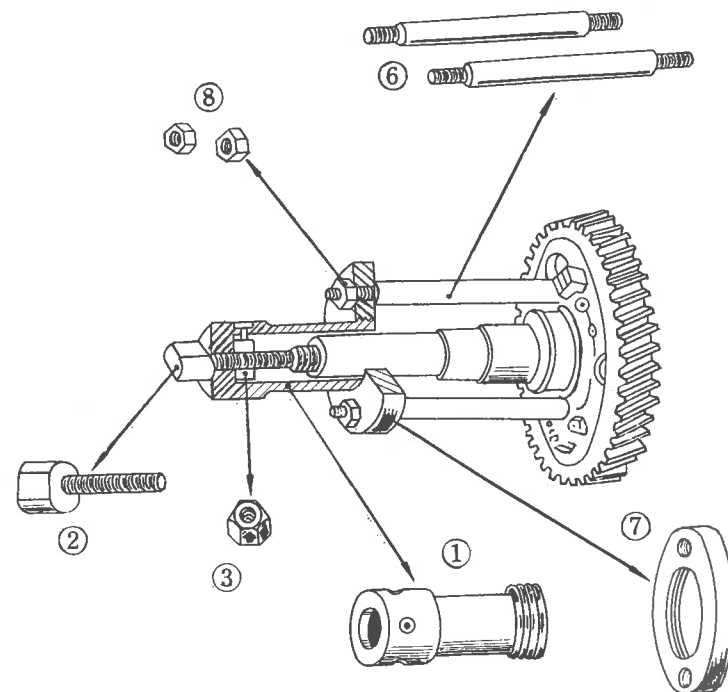
- (4) Screw the support bolts (6) fully in two screw holes.
- (5) Screw the removing bolt (2) in the end of the cam shaft. (Use 23mm spanner)
- (6) Screw the flange (7) in the screw part of the removing pipe (1), and after inserting the bolts into the holes of the flange tighten it with nuts (8). (Use 14mm spanner)
- (7) Fit the removing bolt (2) into the nut (3).
- (8) Put the handle (9) into the  $9\phi$  hole of the removing pipe (1), and holding the handle, screw the nut (3) gradually. The gear will come off. (Use 21mm spanner)



- (5) Screw the flange (7) in the screw part of the installing pipe (1), and after inserting the bolts (6) into the holes of the flange, tighten it with nuts (8). (Use 14mm spanner)
- (6) Adapt the key groove of the cam gear to the key of the cam shaft and continue to screw the removing bolt (2) till the tip of the bolt touches the end of the cam shaft.
- (7) Put the handle (9) into the  $9\phi$  hole of the installing pipe (1), and holding it, screw the removing bolt (2) gradually. Then the cam gear will be inserted. (Use 23mm spanner)
- (8) After the insertion of the cam gear, screw the small set screw. At the time, you must be careful not to forget to put the washer.
- (9) Insert the interval pipe (A) into the cam shaft.
- (10) Screw the removing bolt (2) in the end of the cam shaft. (Use 23mm spanner)
- (11) Put the ball bearing (A) into the cam shaft and put it slightly in the insertion part.
- (12) Insert the installing pipe (which also serves as a removing pipe) (1) into the camshaft and fit the removing bolt (2) into the nut (3).
- (13) Put the handle (9) into the  $9\phi$  hole of the installing pipe (1), and holding it, screw the nut (3) gradually. Then the ball bearing (A) will be inserted. (Use 21mm spanner)
- (14) Lastly, insert the ball bearing case and tighten it.

## B. ASSEMBLING

- (1) Hold up the tappet and insert a wire into the upper hole lest the tappet should drop during your work.
- (2) Put engine oil on the insertion part of the cam gear.
- (3) Screw the bolt (6) fully in the hole of the cam gear.
- (4) Insert the nut (3) into the installing pipe (which also serves as a removing pipe), and reversing the removing bolt (2) screw it in the nut and connect them through the pipe (2).



## XVIII HOW TO HANDLE FUEL OIL AND LUBRICATING OIL

### A. Fuel oil

1. For diesel engines, you are requested to use No. 2-D grade fuel oil regulated by ASTM-D 975/534, or A grade fuel oil regulated by BRITISH STANDARD-Bs 209-1974 or light oil No. 2 regulated by JIS-K-2204 (Japan Industrial Standard).

Since almost all troubles of fuel injection nozzle and pump are caused by unfiltered fuel oil, you are requested to use the fuel oil which contains no water and precipitate.

2. Cautions for pouring fuel oil

Pay attention to the following points, when you take fuel oil out of a fuel drum can and supply the fuel tank with it.

- (a) Clean the drum can tap and avoid to get dusts inside the fuel tank.
- (b) Before taking fuel oil out of the drum can, leave it for about 10-12 hours and do not move it recklessly. Supplying fuel from the drum can to right after moving the can causes bad results.
- (c) When sucking up fuel oil, do it from the higher position, not from the bottom of the drum.
- (d) Wash the daily supply tank well and check if it is not rusty.
- (e) When supplying to daily fuel tank, use a filter.
- (f) Drain out the precipitate at the fuel tank every 50 hours.

3. Fuel oil strainer

Parts of fuel injection nozzles or pumps are worn out or scratched because of dust, sand, asphalt and water contained in fuel oil, as has been stated. Therefore, strainer is absolutely necessary to strain them and supply clean fuel oil only.

If you don't use the strainer engine shall be in bad condition after few hours' running.

Strainer should be cleaned periodically. Periodic time for washing differs in accordance with impurity contained in fuel oil and its period for usage, however, you had better wash every 50 hours.

Strainer can be used again after dismantling and washing of INSET with clean gasoline and taking dust and impurity out of it.

To get perfect effect of the strainer, INSET must be replaced periodically, and replacement after 1000 hours' use is considered suitable.

### B. Lubricating oil

1. The main object of lubricating oil is to reduce friction and wear between bearing surfaces and other functions are the cooling of surfaces and the reducing of compression losses. And lubricating oil is also requested to work sufficiently as a lubricant even under high temperature.

Any lub. oil must not contain ACID, RESIN, FATS, WATER, ASPHALT.

Lub. oil suitable for this engine is DG, DM (HD oil) grade of A.P.I. service class. However, do not mix different brand oil even of the same service class.

2. Viscosity occupies very important factor in choosing lub. oil.

To start the engine easily even in winter, the oil of low viscosity must be used.

In summer, the oil of high viscosity is suitable.

Usually, lubricating oil is chosen in accordance with conditions of engine use and also of the climate, however, SAE No. 20 is most suitable in general.

3. Change of lubricating oil

(a) It is recommended to do first oil change after 20 hrs engine running.

(b) Second oil change shall be done after 30 hrs from the first oil change.

(c) After that, repeat oil change every 50 hrs.

(d) You had better drain out lub. oil while the engine is still hot and supply flushing oil up to the minimum line of the oil level gauge. Then keep idling running for about 20 minutes, sometimes getting up speed.

After that, drain out all flushing oil and supply SAE 20 oil of proper brand up to the maximum line of the oil level gauge.

4. How to handle Air Cleaner

Air cleaner must be washed and cleaned, case by case, in accordance with its condition of use.

You are recommended to clean and exchange oil in the oil bath every 50 hrs in a way as follows.

Attention: Use H.D oil. First of all, wash inset and bowl with gasoline and wipe off the gasoline well. Then, put oil in bowl up to the indicated level and set inset and cover on it.

5. Cautions about lub. oil and its system

- (a) Check quantity of oil in the crank case everyday. Supply oil up to the maximum line of the oil level gauge if necessary.
- (b) Drain out lub. oil at least every half year and wash and clean with flushing oil even if a engine is not used 50 hrs during the period.
- (c) Open the bonnet of the valve lever and supply lub. oil with suc & exh. valve lever before every day's running. This practice prevents carbon from adhering to the valve or the valve guide and also prevents them from wearing.

### XIX TROUBLE SHOOTING

A. Troubles considered to happen when driving the engine carelessly.

SYMPTOM	CHECK POINTS	TREATMENT	REMARKS	
1. Hard to crank up	Lub. oil	Stained	Replace it with new one	"How to treat fuel and lub. oil"
		Oil is too thick		
	Connecting rod metal	Burnt	Repair or replace it	"Dismantling and assembling of piston and crankshaft"
		Burnt		
	Crank metal	There's no side gap	Measure side gap and adjust it with packings	"The order of reassembling"
Other working parts		Burnt	Repair or replace it	"The order of dismantling" "The order of reassembling"
2. No compression	Lub. oil	Stained	Replace it	"How to treat fuel and lub. oil"
	Gap between cylinder head and cylinder	The copper packing is broken or its face is bad	Replace it or adjust the face	"Dismantling and assembling of cylinder head"
		The face of the valve seat is bad	Make grinding	
	Suc & exh. valve	Valves stick	Tap the end of the valve or make grinding	
		Clearance between the valve and the valve lever is unfit	Adjust clearance	
		Packing is missing	Lay on the packing	
	Foundation of fuel injection valve	The face of the packing is bad	Replace the packing	
The fuel injection valve is loosening		Fasten it more strongly		

SYMPTOM	CHECK POINTS	TREATMENT	REMARKS	
	Piston ring	Worn-out	Replace it with new one	"Dismantling and assembling of piston and connecting rod"
		The piston ring is stuck	Take out carbon stuck to the ring or to the ditch, or replace the ring	
		Cut ends of the piston ring are in one line	Adjust them	
	Piston	The face and the groove of the piston are worn-out	Replace the piston	
	Cylinder	Worn-out	Replace it	"Replacement of cylinder"
3. No injection of fuel oil	Fuel tank	No fuel oil	Supply fuel oil	
	Fuel cock	The cock does not open	Open it	
	Regulator handle	Position is improper	Remove it to the operating position	
	Fuel pipe	Clogged	Clean it	
	Air deflater (Screw)	Air is not deflated	Deflate air	"Deflation of fuel injection system"
	Fuel injection valve	The nozzle is stuck	Make lapping or replace it	"Dismantling and assembling of fuel injection valve"
		The nozzle is worn-out	Replace it	
				The spring is broken
				The case nut is loose
	Fuel injection pump	Delivery valve	Dust clogs	Take it off
The face of the seat is scratched			Make lapping or replace it	
The spring is broken			Replace it	
The plunger is worn or broken		Replace it		

SYMPTOM	CHECK POINTS		TREATMENT	REMARKS
		The plunger spring is broken	Replace it	
	Governor link	Setting is unfit	Adjust setting	
	Others	Joint of each fuel system is broken or loosening		
4. Fuel injects but does not fire	Fuel injection valve	Injection pressure is not enough	Adjust it	"Injection testing"
		Spraying is bad	Make lapping or replace it	
	Fuel injection timing	Improper	Adjust shims	"Examination of fuel injection timing"
	Fuel oil	Improper	Exchange it for proper fuel oil	"How to treat fuel and lub. oil"
		Water is mixed	Exchange fuel oil	
Combustion chambers	The nozzle is stuffed	Take off carbon		
5. Gasoline does not come in	Gasoline cup	Opening is clogged	Clean the opening	
6. Other	Air cleaner	Wire-netting is clogged	Clean it	
	Silencer	Carbon is stuck	Take it off	"How to treat fuel and lub. oil"

#### B. Troubles in operation

SYMPTOM	CHECK POINTS		TREATMENT	REMARKS
1. Engine goes dead gradually	Fuel oil system	Check A-3		
	Exhaust pipe	Carbon is stuck	Take off carbon	
	Working parts are burnt	Burnt section	Repair it	
		Shortage of lub. oil	Supply oil	"How to treat fuel and lub. oil"
2. Want of output	Leakage of pressure	Check A-2		
	Combustion chamber	Carbon is stuck	Take off carbon	
	Fuel oil does not fire well	Check A-4		
	Air cleaner	Wire-netting is stuffed	Clean it	
	Silencer	Carbon is stuck	Clean it	
	Working parts	Over heated	Repair them	

SYMPTOM	CHECK POINTS		TREATMENT	REMARKS	
	Governor link	Setting is bad	Adjust it	"Adjustment of fuel injection"	
	Air (screw)	Air is not deflated	Deflate air	"Deflation of fuel injection system"	
	Fuel injection valve	The nozzle is worn-out	Replace it with new one	"Dismantling and assembling of fuel injection valve"	
	Fuel injection pump	Delivery valve	Dust clogs	Clean it	"Dismantling and assembling of fuel injection pump"
			Worn-out	Replace	
		Plunger	Worn-out	Replace	
	6. Exhaust gas is ill-coloured	Combustion is bad	Check A-4		
Lub. oil		Too much lub. oil	Take it till it gets to the proper line of the oil level gauge	"How to treat fuel and lub. oil"	
Oil ring		Worn-out or broken	Replace it		
Working parts		Adhesion	Clean or replace it	"Dismantling and assembling of piston and connecting rod"	
		Over-heated	Repair them		
Over load		Examine pulley	Check other working machineries		
Flywheel		Works loose	Tighten it	"How to take off and lay on flywheel"	
Connecting rod metal		Works loose	Tighten it		
		Too much gap	Replace it		
Piston Pin		Gap between the pin and the metal is too big	Replace it		
		Piston pin is not laid on the piston tightly	Replace it		
Other working parts		Too much gap between them	Replace them	"Dismantling and assembling of piston and connecting rod"	
Over load			Check working machinery		
Cooling is bad	Dust lays on the cooling fin	Remove it			
Combustion chamber (face)	Carbon is stuck	Remove it			

SYMPTOM	CHECK POINTS		TREATMENT	REMARKS	
4. Hunting (Irregular rotation)	Governor link	Dust clogs	Clean it		
		Want of oil	Supply oil		
	Working parts of governor	Dust clogs	Clean it		
		The spring gets weaker	Replace it		
	Fuel injection valve	Injection is bad	Make rubbing or replace it		"Dismantling and assembling of fuel injection valve"
		Fuel injection pressure is no good	Adjust it		
	Fuel injection timing	Improper	Adjust shims		"How to treat fuel and lub. oil"
	Fuel oil	Fuel oil is improper	Exchange it for right one		
Fuel oil contains water		Exchange fuel oil			
5. Rapid rotation (over running)	Working parts of governor	They are burnt or don't work smoothly	Replace it for repair it		
	Governor link	Adhered	Repair it and pay attention		
		Setting is bad	Adjust it		"Dismantling and assembling of fuel injection pump"
6. Engine makes strange noise (knocking)	Fuel oil	Improper	Replace it with proper one	"How to treat fuel and lub. oil."	
	Fuel injection valve	Straight injection	Make lapping or replace it	"Dismantling and assembling of fuel injection valve"	
		Somewhat adhesive			
	Fuel injection valve	Too fast	Adjust shims	"Adjustment of clearance of valve"	
	Clearance between suc. & exh. valve and valve lever	Improper	Adjust it		

## HOW TO KEEP ENGINE AFTER USE

1. Keep the engine as much as possible in a dry and dustless place after use when you use it as a portable engine.
2. After you stopped the engine, keep both suc. valve and exh. valve in completely closed condition, namely, keep the valves at the top Dead Center in the compression stroke as explained in the Chapter "Adjustment of the clearance of the valves".
3. Clean the outside of the engine well and cover the engine, when you leave it outside.

