

YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

1GM (10L)

2GM (F)(L)

3GM (D)(F)(L)

3HM (F)(L)

2-4 Disassembly of fuel injection pump

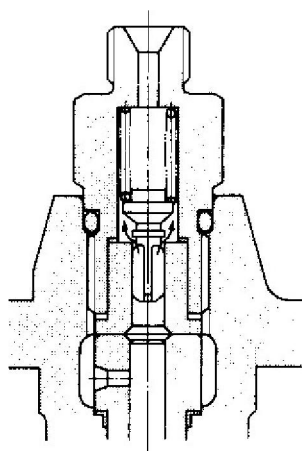
As a rule, the injection pump should not be disassembled, but when disassembly is unavoidable, proceed as described below.

2-4.1 Dismantling of fuel injection pump of model 1GM engine.

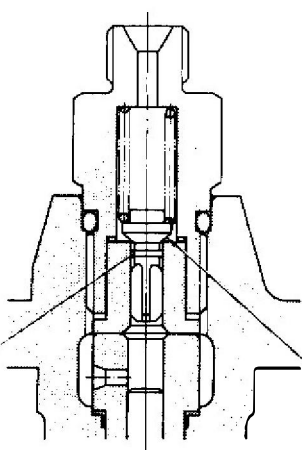
NOTES: 1) Before disassembly wash the pump in clean oil, and after assembly arrange all parts carefully.

2) Make sure the work area is exceptionally clean.

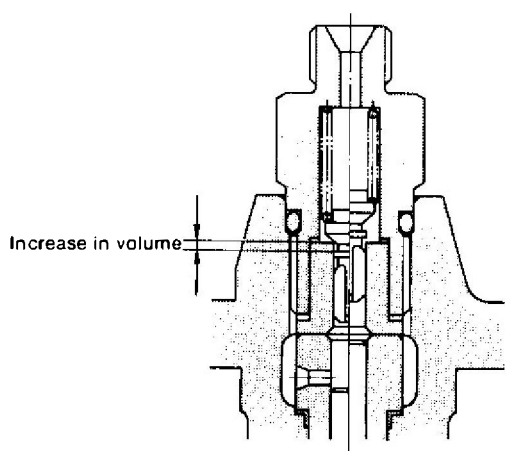
(1) Remove the plunger guide stopper pin with needle nose pliers.



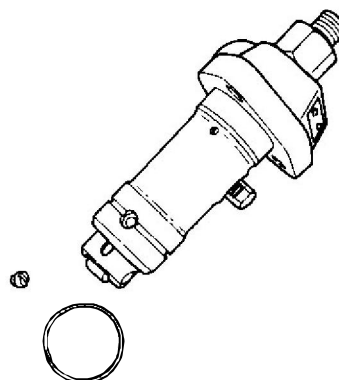
Open



Close



Retraction of fuel

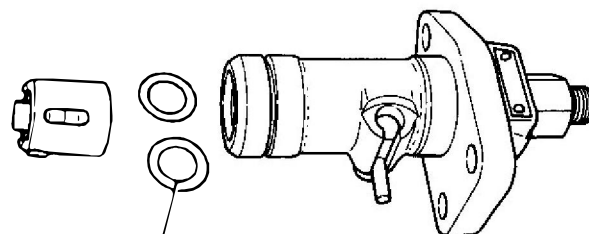


(2) Remove the plunger guide stopper.

The stopper can be removed by pushing the plunger guide down with the palm of your hand.

(3) Remove the plunger guide.

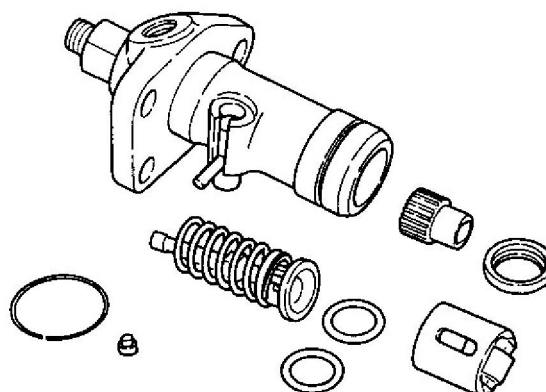
NOTE: Be careful not to lose the plunger stroke adjusting shim which is located inside the plunger guide.



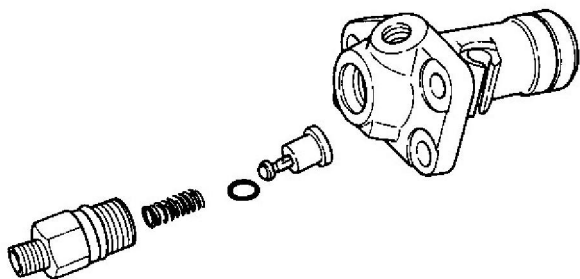
Plunger stroke adjustment shim

(4) Remove the plunger and plunger spring lower retainer be careful not to damage the plunger.

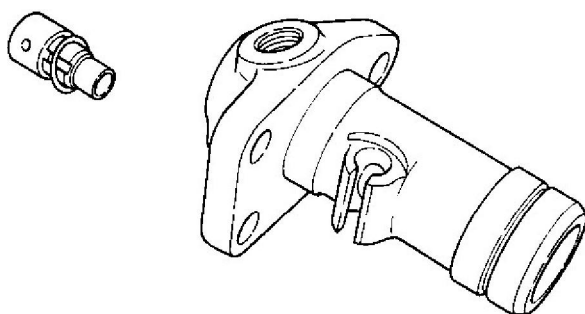
(5) Remove the plunger spring, fuel control pinion and plunger spring upper retainer, using your fingers or tweezers.



- (6) Remove the fuel control rack.
- (7) Remove the delivery valve holder; be careful not to damage the O-ring.
- (8) Remove the delivery valve spring.
- (9) Remove the delivery valve.



- (10) Remove the plunger barrel by pushing it toward the delivery valve side.
- (11) Remove the plunger barrel packing.

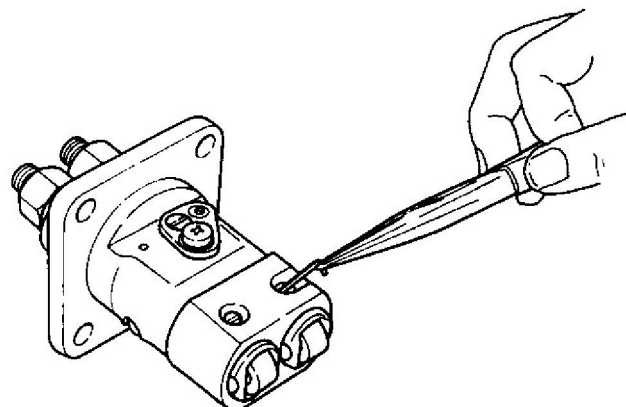


NOTES: 1) Line up the plunger barrel and the plunger, and put them in order.
2) Immerse the delivery valve, plunger, etc. in clean oil.
3) Do not loosen or remove the plunger barrel stopper, etc.

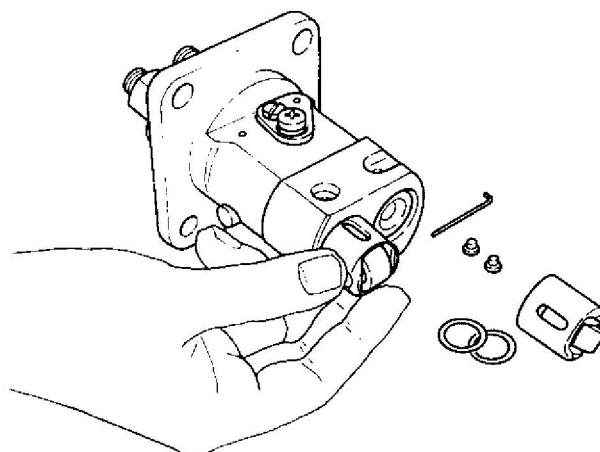
2-4.2 Dismantling of fuel pump of model 2GM, 3GM(D) and 3HM engines

The cylinders are classified as No.1, No.2 and No.3 from the left when facing the name plate which is fitted on the upper part of the fuel injection pump. When dismantling, it is necessary to prepare pans or vessels in which to keep the dismantled parts from each cylinder; each part must be placed in the corresponding pan or vessel for each cylinder, namely, No.1, No.2 and No.3 cylinder. If a part is placed in the wrong pan or vessel, reassembly becomes impossible without a pump tester. The following explanation applies to the pump of the 2 cylinder type engine (model 2GM), but it equally applies to that of the 3 cylinder type engine (model 3GM(D)) which merely has an additional set. The construction of the fuel pump of model 3HM engine is the same as that of model 3GM(D) engine except for the differences of plunger, plunger barrel, and the position of the injection volume adjusting rack.

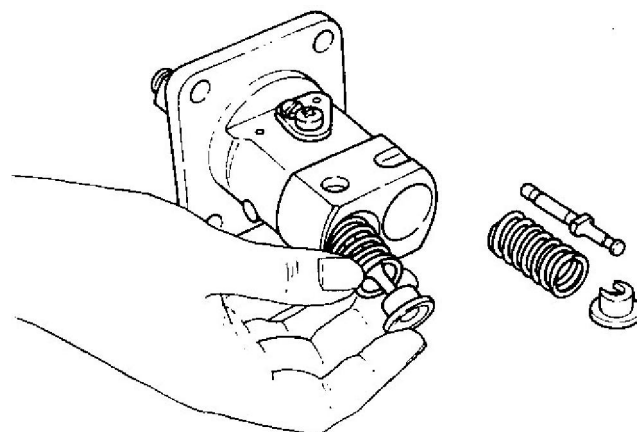
- (1) Remove the plunger guide stopper pin with needle nose pliers.



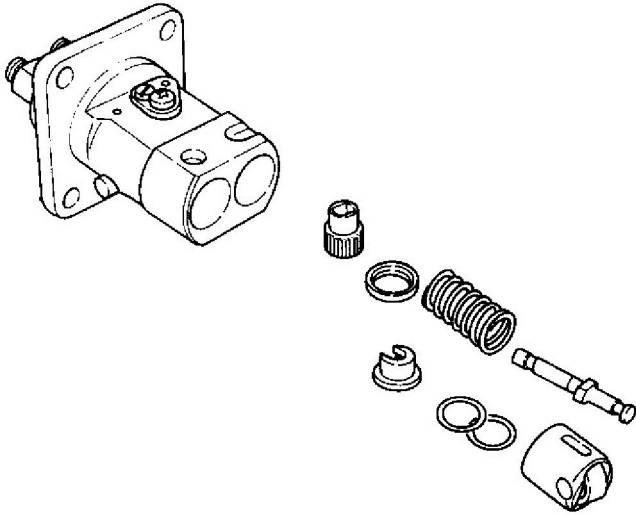
- (2) Remove the No.1 plunger guide stopper. The stopper can be removed by pushing the plunger guide down with the palm of your hand.
- (3) Remove the No.1 plunger guide.



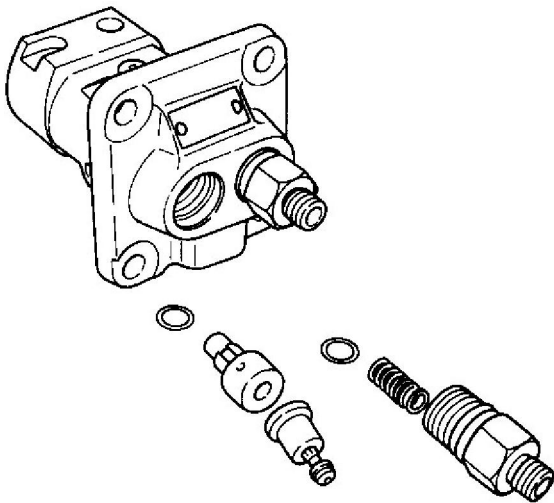
- (4) Remove the No.1 plunger and plunger spring lower retainer and plunger shim; be careful not to damage the plunger.
- (5) Remove the No.1 plunger spring.



- (6) Remove the No.1 plunger spring upper retainer, using your fingers or tweezers.
- (7) Remove the No.1 control sleeve

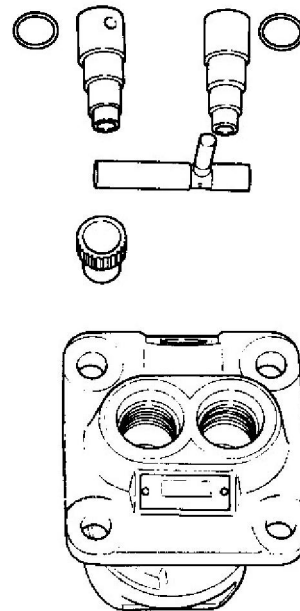


- (8) Remove the No.1 delivery valve holder; be careful not to damage the O-ring.
- (9) Remove the No.1 delivery valve spring.
- (10) Remove the No.1 delivery valve, delivery valve seat and packing.



- (11) Remove the No.1 plunger barrel; be careful not to damage the face that matches the delivery valve seat.
- (12) Remove the No.1 plunger barrel packing.
- (13) For No.2 cylinder, repeat the above steps (2) through (11).
- (14) The above item also applies to No.3 cylinder for the 3 cylinder type engine.

- (15) Remove the control rack.



- NOTES:** 1) Line up the plunger valve and the plunger, and put them in order.
2) Immerse the delivery valve, plunger, etc. in clean oil.
3) Do not loosen or remove the injection control plate, etc.

2-5 Inspecting injection pump parts

2-5.1 Rinse each component part in clean light oil before inspecting it.

NOTE: Do not touch the sliding surface of the plunger and the delivery valve with your fingers during handling.

2-5.2 Tappet

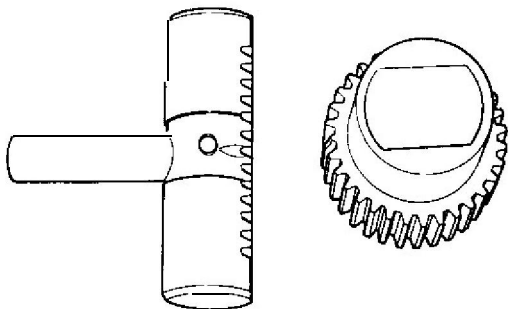
Inspect the cam sliding surface of the tappet roller for wear, scoring and peeling; replace the tappet and roller assembly when the total tappet and roller play exceeds 0.3mm.

2-5.3 Control rack and pinion

- (1) Check control rack teeth and sliding surface for damage and abnormalities. If found, replace.

NOTE: When replacing control rack, adjust fuel discharge amount with a fuel injection pump tester and stamp a rack mark.

- (2) Replace pinion if teeth are damaged or worn unevenly.

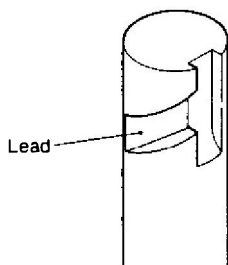


- (3) If the control rack does not move smoothly when a force of within 60g is applied, replace the rack and pinion assembly.

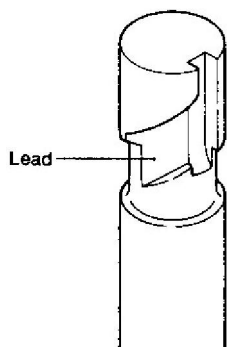
2-5.4 Plunger

- (1) Inspect the plunger for wear, scoring and discoloration around the lead. If any problems are found, conduct a pressure test and replace the plunger and plunger barrel assembly.

For models 1GM, 2GM and 3GM(D)

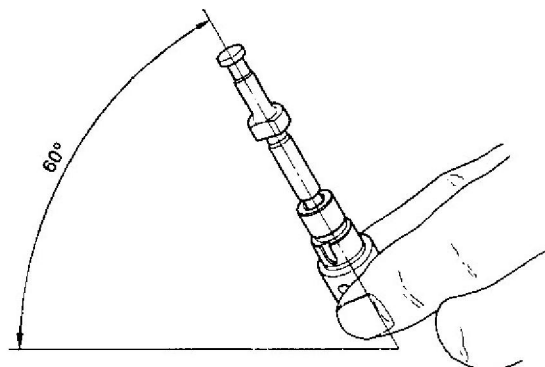


For model 3HM



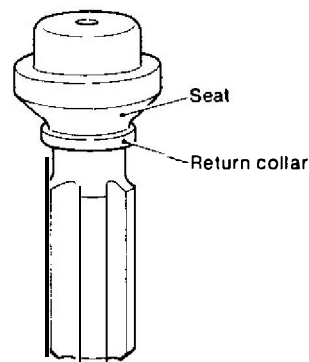
- (2) Inspect the outside sliding surface of the plunger with a magnifying glass. Lap or replace the plunger and plunger barrel assembly when corrosion, hairline cracks, staining and/or scoring are detected.
(3) Check the clearance between the plunger collar and control sleeve groove. Replace these parts when wear exceeds the specified limit.

- (4) After cleaning the plunger, tilt it approximately 60°, as shown in the figure, and slowly slide it down. Repeat this several times while rotating the plunger. The plunger should slide slowly and smoothly. If it slides too quickly, or binds along the way, repair or replace it.

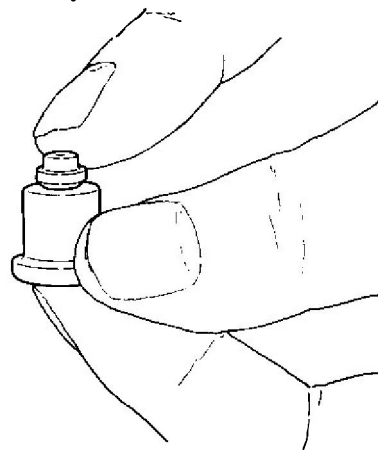


2-5.5 Delivery valve

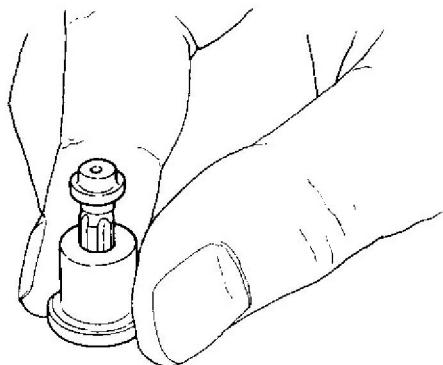
- (1) Replace the delivery valve if the return collar and seat are scored, dented or worn.



- (2) Raise the delivery valve and put a finger over the hole on the valve seat bottom. Let go of the delivery valve. If it sinks quickly and stops at the position where the suck-back collar closes the valve seat hole, the delivery valve may be considered normal. If this is not the case, replace the delivery valve as a set.



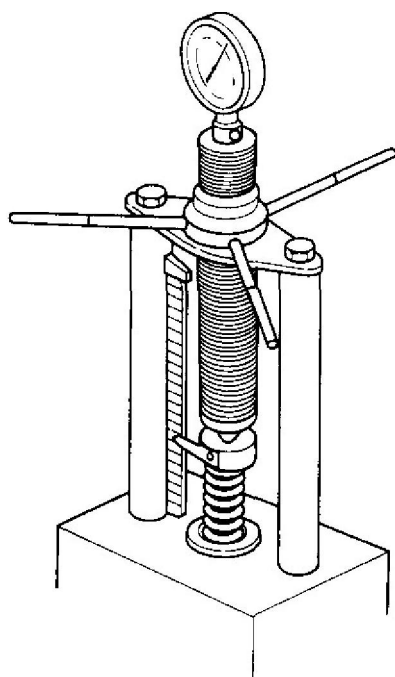
- (3) Place your finger over the hole in the bottom of the valve seat and insert the valve into the valve body. If the valve returns to its original position when you remove your finger, the valve is okay. If some defect is found, replace with a new valve.
- (4) If the valve closes completely by its own weight when you remove your finger from the hole on the bottom of the valve seat, the valve is okay. If it doesn't close perfectly replace with a new valve.



NOTE: When using a brand-new set, wash off the rustproof oil with clean oil or gasoline. Then, wash once more with clean oil, and follow the steps outlined above.

2-5.6 Plunger spring and delivery valve spring

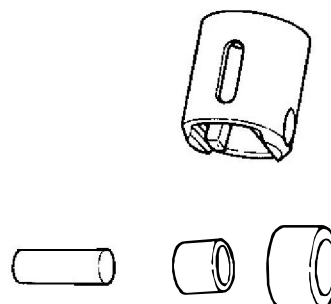
Inspect the plunger spring and delivery valve spring for fractured coils, rust, inclination and permanent strain. Replace the spring when faulty.



	Free length	Set length	Set load
Plunger spring	35.5mm (1.3976in.)	29.5mm (1.1614in.)	11.59 ± 1.1 kg (23.13 ~ 27.98 lb)
Delivery valve spring	21mm (0.8268in.)	17.25mm (0.6791in.)	2.4 ± 0.24 kg (4.76 ~ 5.82 lb)

2-5.7 Plunger guide

Check the tappet roller (inside and outside) and roller pin for damage and uneven wear, and replace if required. Measure the clearance between the plunger and plunger guide. If the clearance exceeds the limit, replace.



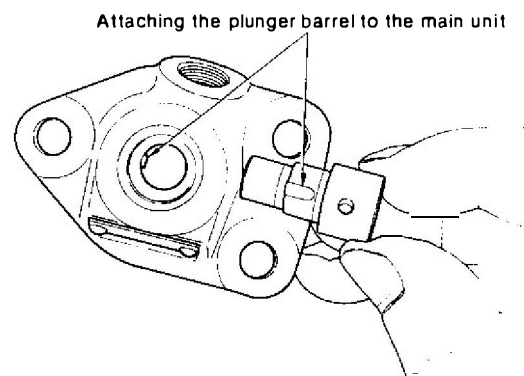
mm (in.)	
Clearance limit	0.3 (0.0118)

2-6 Assembling the fuel injection pump

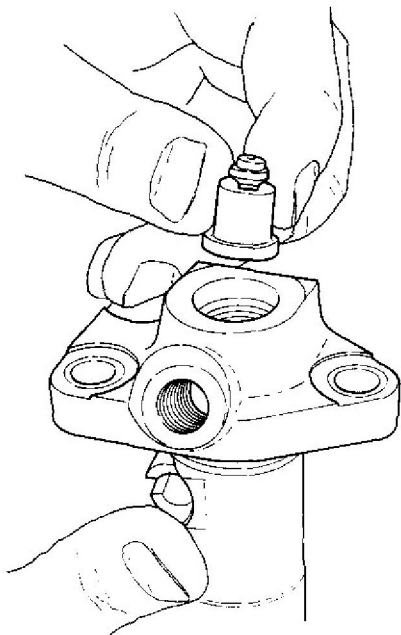
- NOTES:** 1) After inspection, divide the components into two groups, i.e. the components to be replaced, and those that are reusable. Rinse the components and store the two groups separately.
- 2) Replace the packing with a new one.

1GM

- (1) While lining up the plunger barrel positioning groove with the dowel of the main unit, attach the plunger barrel to the main unit.



- (2) Attach the delivery valve seat and the delivery valve to the main unit.



Attaching the delivery valve to the main unit

NOTE: If the delivery valve tip projects noticeably above the top of the main unit of the pump, the plunger barrel has been installed incorrectly, and must be re-attached.

- (3) Attach the delivery valve packing and the delivery valve spring to the main unit and carefully tighten the delivery valve holder.

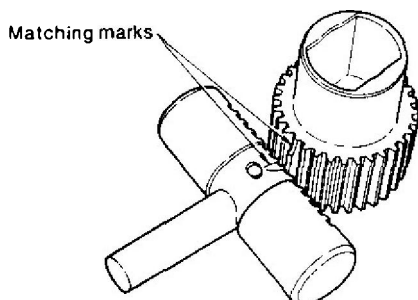
NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

1GM	kg-m (ft-lb)
Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

- (4) With the matching mark of the fuel control rack directed towards the lower part of the main unit of the pump, attach the fuel control rack to the main unit.

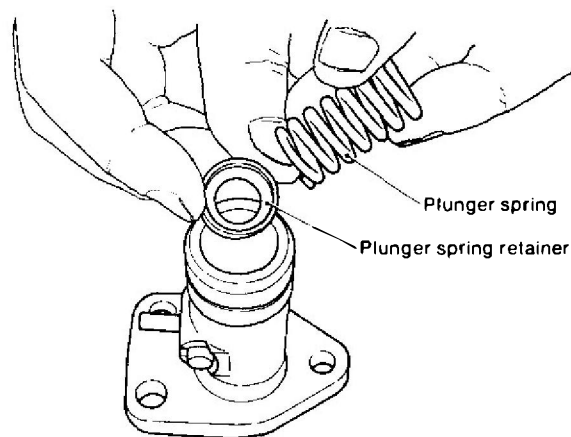
NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

- (5) By aligning the matching mark on the fuel control pinion with that on the fuel control rack, attach the fuel control pinion to the main unit.



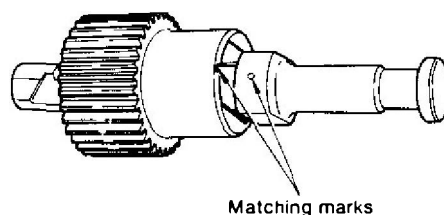
NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.

- (6) Insert the plunger spring retainer and attach the plunger spring to the main unit.



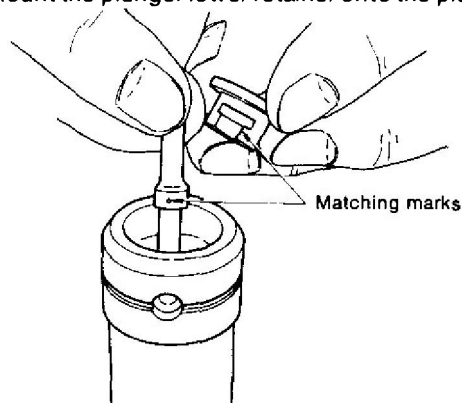
NOTE: The plunger spring retainer should face the underside of the pump.

- (7) After aligning the matching mark on the plunger flange with that on the fuel control pinion, attach the plunger to the main unit.



NOTE: By inverting and standing the main unit of the pump upright attach the plunger to it carefully.

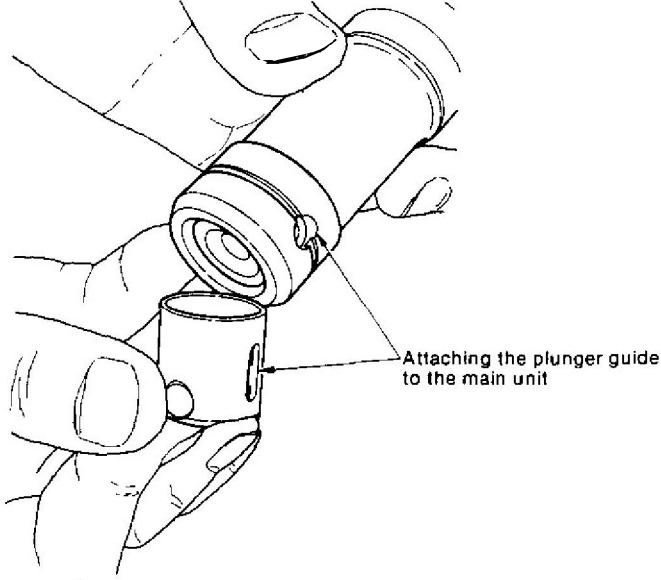
- (8) Mount the plunger lower retainer onto the plunger.



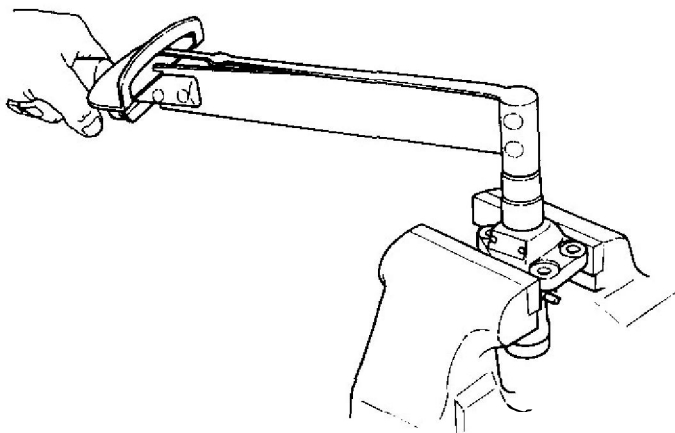
- (9) Insert the plunger adjusting shims.

NOTE: Insert the same number of shims with the same thickness as those inserted before disassembling the pump. After re-assembling the pump, measure and adjust the top clearance of the plunger.

- (10) While adjusting the direction of the plunger guide stopper hole for the plunger guide, insert the plunger guide carefully.
When the plunger guide stopper hole is lined up with the plunger guide, insert the plunger guide stopper. Then mount the retaining ring (clip).



- (11) After attaching tighten the delivery valve holder with a torque wrench.



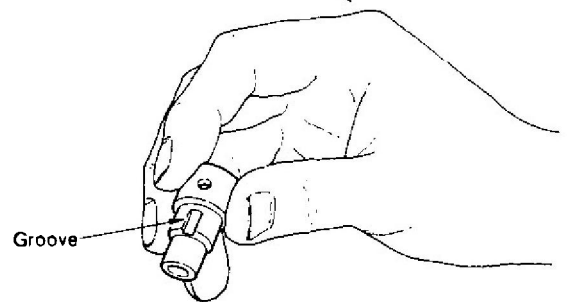
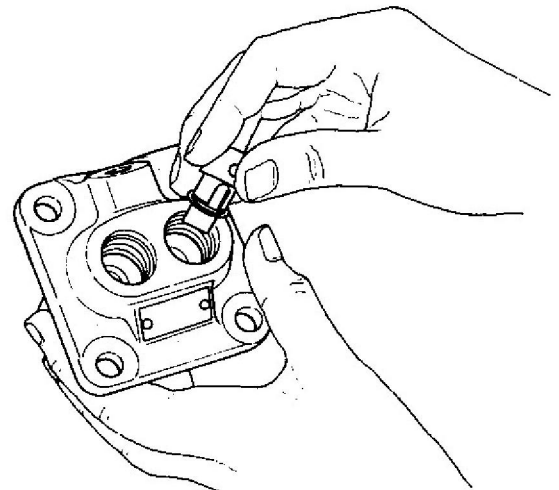
1GM	kg·m (ft·lb)
Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

2GM, 3GM(D) and 3HM

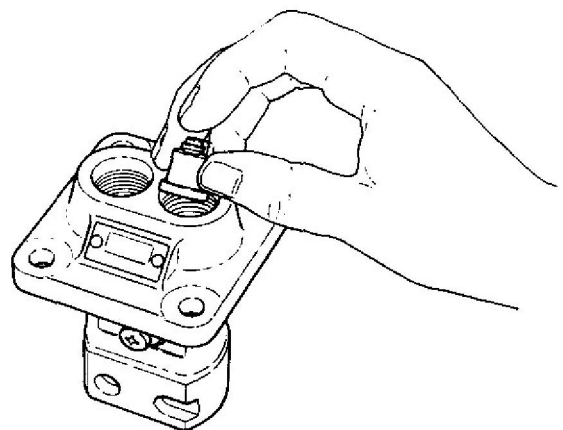
To ensure that the injection pump is correctly reassembled, the following points must be kept in mind:

- The parts for each cylinder must not be mixed together.
- When parts are replaced, the parts for each cylinder must always be replaced at the same time.
- When assembling, parts must be washed in fuel oil and matching marks and scribe lines must be lined up.

- (1) Install the No.1 plunger barrel packing.
(2) Insert the No.1 plunger barrel by aligning the groove of the barrel lock pin.



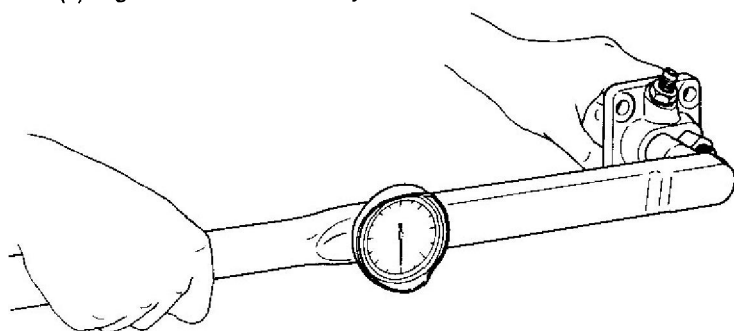
- (3) Install the No.1 delivery valve, delivery valve seat and packing.



NOTE: If the delivery valve tip projects noticeably above the top of the main unit of the pump, the plunger barrel has been installed incorrectly, and must be re-attached.

- (4) Insert the No.1 delivery valve spring.

- (5) Tighten the No.1 delivery valve holder.



2GM, 3GM(D), 3HM

kg-m (ft-lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)
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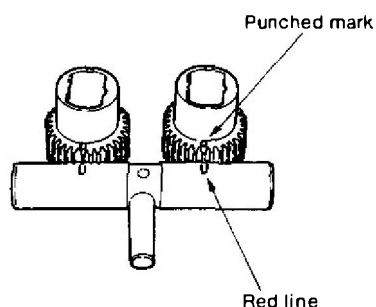
NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

- (6) With the matching mark of the fuel control rack directed towards the lower part of the main unit of the pump, attach the fuel control rack to the main unit.

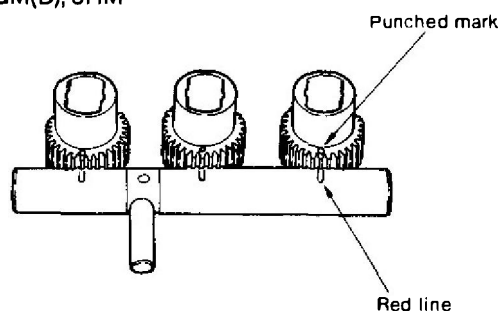
NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

- (7) By aligning the matching mark on the fuel control pinion with that on the fuel control rack, attach the fuel control pinion to the main unit.

2GM

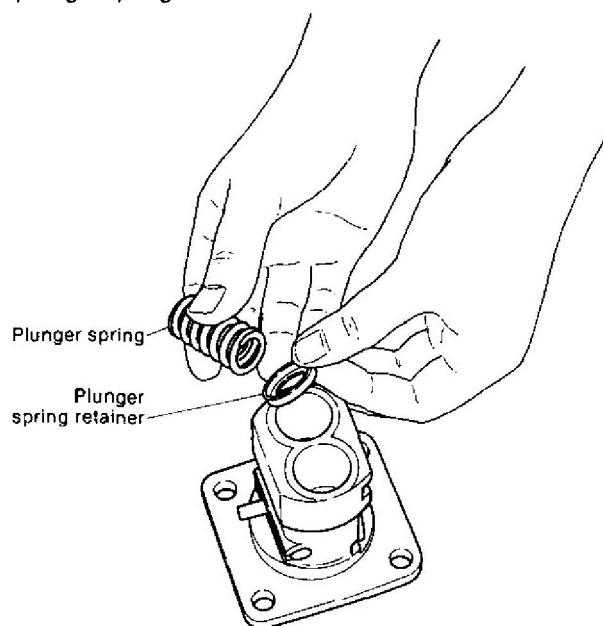


3GM(D), 3HM



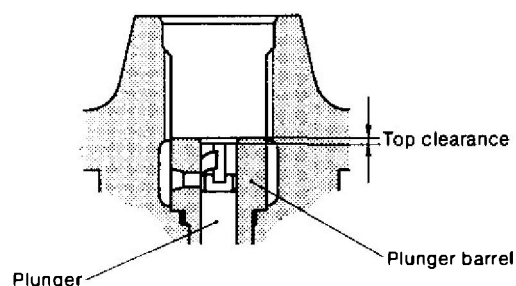
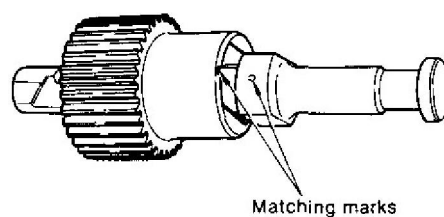
NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.

- (8) Insert the No.1 plunger spring retainer and attach the plunger spring to the main unit.



NOTE: The plunger spring retainer should face the underside of the pump.

- (9) After aligning the matching mark on the plunger flange with that on the fuel control pinion, attach the plunger to the main unit.



NOTE: By inverting and standing the main unit of the pump upright attach the plunger to it carefully.

- (10) Install the No.1 plunger spring lower retainer. Make sure that it is not installed backwards.

(11) Insert the plunger shim.

NOTE: Insert the same number of shims with the same thickness as those inserted before disassembling the pump. After re-assembling the pump, measure and adjust the top clearance of the plunger.

(12) Insert the No.1 plunger guide.

(13) Insert the No.1 plunger guide stopper.

(14) For the pump of the 2 cylinder type engine, repeat the above steps for No.2 cylinder.

(15) For the pump of the 3 cylinder type engine, repeat the above steps for No.3 cylinder.

(16) Install the plunger guide stopper pin.

(17) After attaching tighten the delivery valve holder with a torque wrench.

2GM, 3GM(D), 3HM

kg·m (ft·lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)
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NOTE: When the tightening torque of the delivery valve holder exceeds the prescribed torque, the plunger will be distorted, the sliding resistance of the control rack will increase, and proper performance will not be obtained. Moreover, excessive tightening will damage the pump body and delivery valve gasket, and cause a variety of other problems.

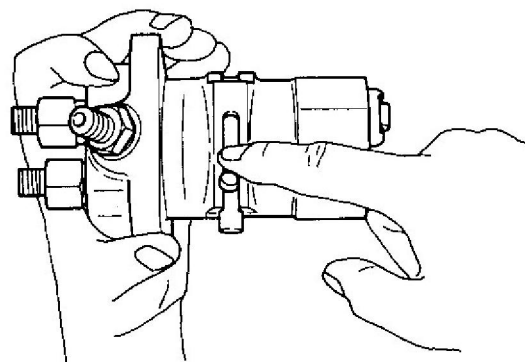
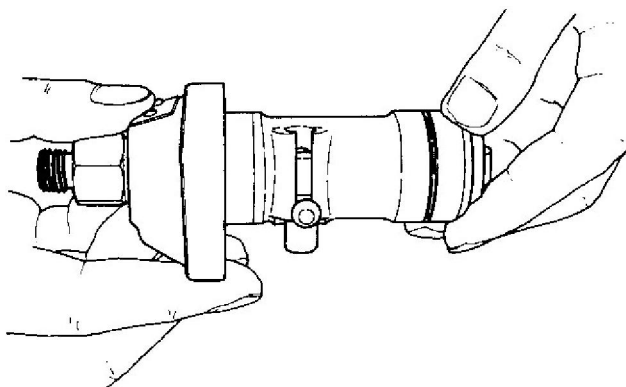
2-7 Inspection after reassembly

When the engine doesn't run smoothly and the injection pump is suspected as being the cause, or when the pump has been disassembled and parts replaced, always conduct the following tests.

2-7.1 Control rack resistance test

After reassembling the pump, wash it in clean fuel, move the rack and check resistance as follows:

- (1) This test is performed to determine the resistance of the control rack. When the resistance is large, the engine will run irregularly or race suddenly.
- (2) Place the pump on its side, hold the control rack up and allow it to slide down by its own weight. The rack should slide smoothly over its entire stroke. Place the pump on end and perform the above test again; check for any abnormalities. [Resistance below 60g (0.132 lb)]
- (3) Since a high sliding resistance is probably a result of the following, disassemble the pump and wash or repair it.



- (a) Resistance of the rotating and sliding parts of the plunger assembly is too high.
- (b) Delivery valve holder is too tight (plunger barrel distorted).
- (c) Control rack or control pinion teeth and control rack outside circumference are dirty or damaged.
- (d) Injection pump body control rack hole is damaged.
- (e) Plunger barrel packing is not installed correctly and the barrel is distorted. (Since in this case fuel will leak into the crankcase and dilute the lubricating oil, special care must be taken).

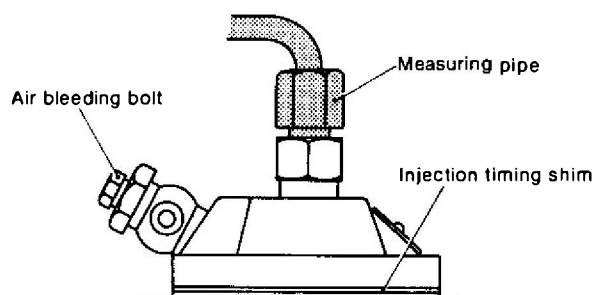
2-7.2 Fuel Injection timing

Fuel injection timing is adjusted by timing shims inserted between the pump body and gear case pump mounting seat.

The injection pump must be mounted on the engine, and each cylinder injection timing adjusted.

Adjusting the injection timing

- (1) Remove the high pressure pipe from the pump.
- (2) Install a measuring pipe if the injection pump does not have a nipple on the delivery side.
- (3) Bleed the air from the injection pump.



- (4) Set the control rack to the middle fuel injection position (Pull the lever when setting the accelerator lever.)
- (5) Turn the crankshaft slowly by hand, and read the timing mark (TD) on the flywheel the instant fuel appears at the measuring pipe or pipe joint nipple. (FID+ Fuel injection from delivery valve.)

Chapter 3 Fuel System
2.

For all models of 1GM, 2GM,
3GM(D) and 3HM engines

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.

Timing mark

Fuel injection
timing shim

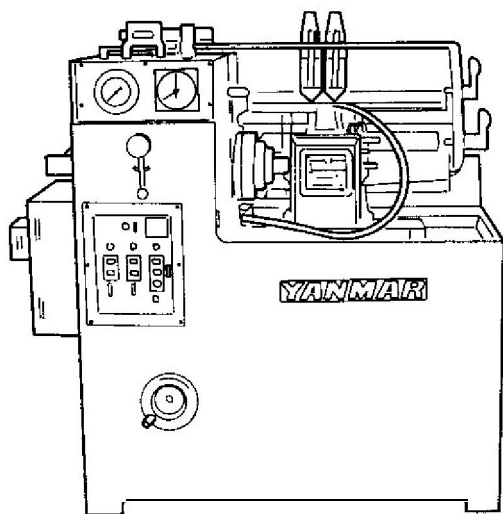
- (6) If the injection timing is off, add plunger shims when the timing is slow, and remove shims when the timing is fast. Adjust the timing of every pump in the same manner. (Refer to item, "Plunger head gap adjustment".)
- (7) After the injection timing of every pump has been matched, recheck the injection timing as described in item (5) above. If the injection timing is not properly set, adjust it with the timing shims.

- (8) Finally, turn the crankshaft slowly and confirm that it turns easily. If it is stiff or does not rotate, the plunger head gap is too small.

		1GM	2GM	3GM(D)	3HM
Fuel injection timing		bTDC15° (FID)	bTDC15° (FID)	bTDC18° (FID)	bTDC21° (FID)
Fuel injection timing shim	0.2mm (0.008in.)	3 shims 104271-01930	3 shims 124950-01931	2 shims 121450-01931	
	0.3mm (0.012in.)	2 shims 104271-01940	1 shim 124950-01941	1 shim 121450-01941	
	Set No.	104271-01950	124950-01951	121450-01951	

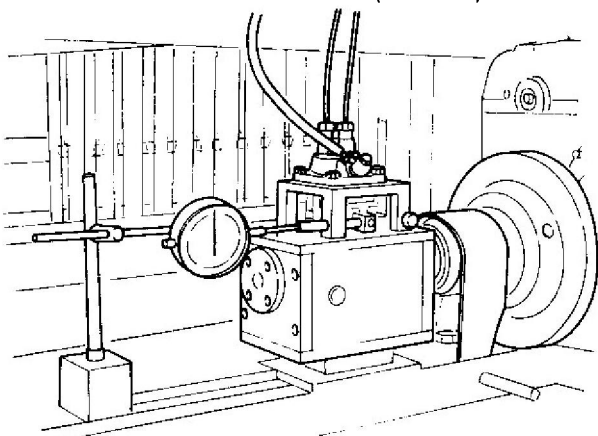
2-8 Injection pump adjustment

The injection pump is adjusted with an injection pump tester after reassembly.



2-8.1 Setting pump on tester

- (1) After the injection pump has been disassembled and reassembled, install it on a pump tester
...cam lift: 7mm (0.276in.).
- (2) Confirm that the control rack slides smoothly. If it does not, inspect the injection pump and repair it so that the rack slides smoothly
...control rack full stroke: 15mm (0.5905in.).

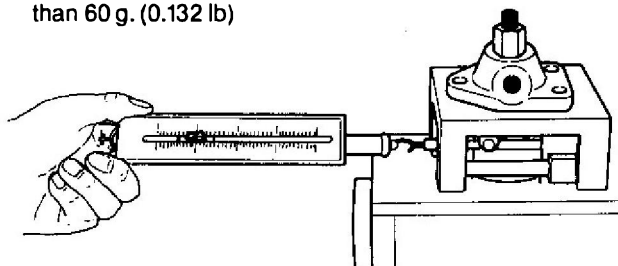


- (3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

2-8.2 Measuring the sliding resistance of the fuel control rack

Measure the sliding resistance of the fuel control rack with a spring scale (balance).

- (1) Number of pump rotations/sliding resistance: 0rpm/less than 60 g. (0.132 lb)



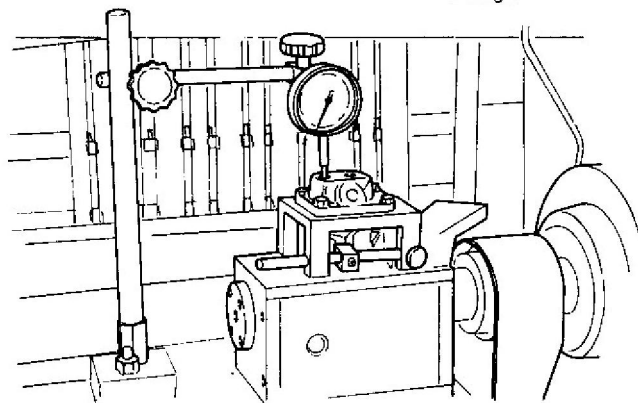
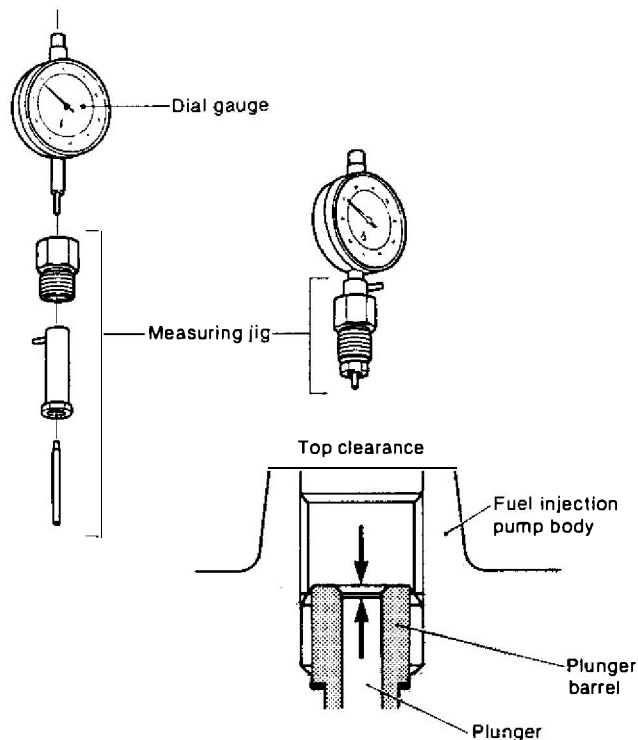
NOTE: If the sliding resistance is unsatisfactory, disassemble, inspect and repair the fuel control rack.

2-8.3 Adjusting the plunger top clearance

- (1) Set the pump installation dimension (end of plunger barrel when the roller is on the cam base cycle) at $76 \pm 0.05\text{mm}$ (2.9902 ~ 2.9941in.), remove the delivery valve holder and delivery valve, and set the plunger to top dead center by turning the camshaft. Measure the difference in height (head gap) between the end of the plunger and the end of the plunger barrel using a dial gauge.

mm (in.)	
Plunger top clearance	1.0 ± 0.05 (0.0374 ~ 0.0398)

- (2) Using the plunger top clearance measuring jig
 - 1) Install a dial gauge on the measuring jig.
 - 2) Stand the measuring jig on a stool and set the dial gauge pointer to 0.
 - 3) Remove the pump delivery valve and install the measuring jig.
 - 4) Turn the camshaft to set the plunger to top dead center and read the dial gauge. The value given is the plunger top clearance.



- (3) When the plunger top clearance is larger than the prescribed value, remove the plunger guide and insert plunger shims between the plunger spring lower retainer and the plunger guide. Adjust each pump in the same manner.

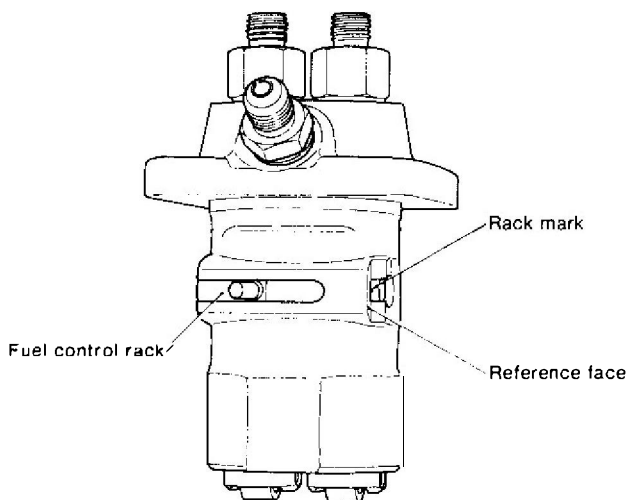
Plunger shim thickness	0.1mm (0.004in.)	174307-51710
	0.2mm (0.008in.)	174307-51720
	0.3mm (0.012in.)	174307-51730

- (4) After rechecking adjustment, install the delivery valve.

Delivery valve holder tightening torque	4.0 ~ 4.5 kg·m (29 ~ 32.6 lb·ft)
---	-------------------------------------

2-8.4 Checking the cylinder Injection Interval

- (1) Align the control rack punch mark with the pump reference face.



- (2) Turn the pump by hand to check the No.1 cylinder injection timing.
 (3) Turn the pump in the prescribed direction and check the No.2/3 cylinder injection timing.
 (4) Using the plunger shims, adjust each cylinder injection timing interval.

	For crankshaft angle	For camshaft angle
2GM	180° 540° 1 ~ 2 ~ 1	90° 270° 1 ~ 2 ~ 1
3GM(D), 3HM	240° 240° 240° 1 ~ 3 ~ 2 ~ 1	120° 120° 120° 1 ~ 3 ~ 2 ~ 1

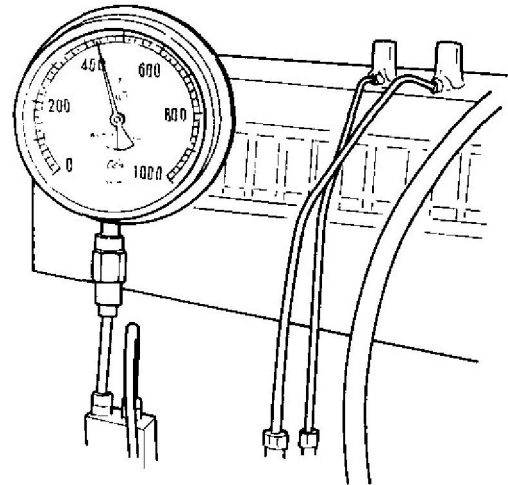
2-8.5 Delivery valve oil-tight test

- (1) Install a 1,000 kg/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
 (2) Drive the fuel pump to apply a pressure of approximately 120 kg/cm² (1,707 lb/in.²) and measure the time required for the pressure to drop from 100 kg/cm² (1,422 lb/in.²) to 90 kg/cm² (1280 lb/in.²)

Pump speed	200 rpm
Pressure drop standard	20 sec. or more
Pressure drop limit	5 sec. or less

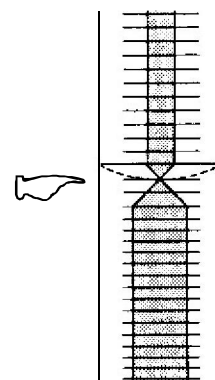
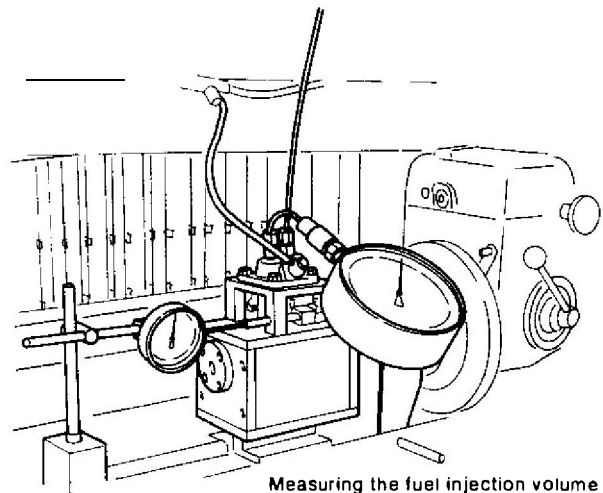
- (3) If both the plunger and the delivery valve fail the test, replace them.

2-8.6 Plunger pressure test



- (1) Install a 1,000 kg/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
 (2) Check that there is no oil leaking from the delivery valve holder and high pressure pipe mountings, and that the pressure does not drop suddenly when raised to 500 kg/cm² (7,112 lb/in.²) or higher.
 Pressure gauge AVT 1/2 x 150 x 1,000 kg/cm²

2-8.7 Measuring the fuel Injection volume



Chapter 3 Fuel System

2. Injection Pump

SM/1GM·2GM·3GM(D)·3HM

- (1) Set the fuel pump camshaft speed.
- (2) Check the injection nozzle.

	1GM	2GM 3GM(D)	3HM
Pump speed	1800 rpm		1700 rpm
Plunger diameter × stroke	$\varnothing 6 \times 7 \text{ mm}$ $(0.2362 \times 0.2756 \text{ in.})$		$\varnothing 6.5 \times 7 \text{ mm}$ $(0.2559 \times 0.2756 \text{ in.})$
Injection nozzle type	YDN-OSDYD1		YDN-OSDYD1
Pressure for fuel injection	170 kg/cm^2 (2418 lb/in.^2)		160 kg/cm^2 (2276 lb/in.^2)
Amount of injection at rack mark position	$20 \text{ cc} \pm 0.5 \text{ cc}$ $(1.19 \sim 1.25 \text{ in.}^3)$		$22 \text{ cc} \pm 0.5 \text{ cc}$ $(1.31 \sim 1.37 \text{ in.}^3)$
Allowable error between cylinders	—	$1 \text{ cc} (0.06 \text{ in.}^3)$ or less	$1 \text{ cc} (0.06 \text{ in.}^3)$ or less
Stroke	1000		1000

NOTE: Maintaining the pressure for feeding oil to the injection pump at 0.5 kg/cm^2 . (7.1 lb/in.^2)

2-8.8 Adjustment of injection volume for each cylinder

- (1) Fluctuation of injection volume

The injection volumes of each cylinder must be adjusted to within 3% of each other.

$$\text{Average injection volume} = \frac{\text{total volume of all cylinder injection}}{\text{number of cylinders}}$$

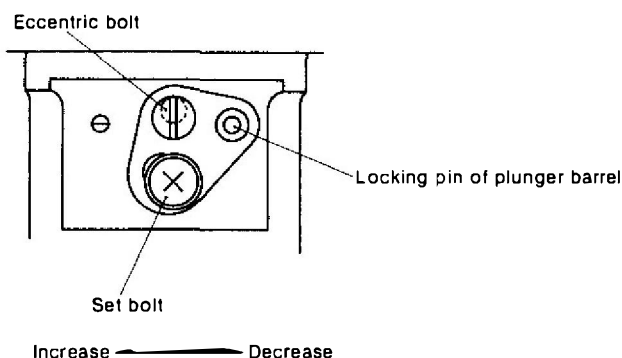
$$\text{Difference} = \frac{\text{Maximum injection volume} - \text{average injection volume}}{\text{Average injection volume}} \times 100$$

When the difference exceeds 3%, adjust the injection volume by sliding the control sleeve and pinion, when the difference exceeds 3%, the engine output will drop and/or one cylinder will overheat.

- (2) Adjustment of injection volume

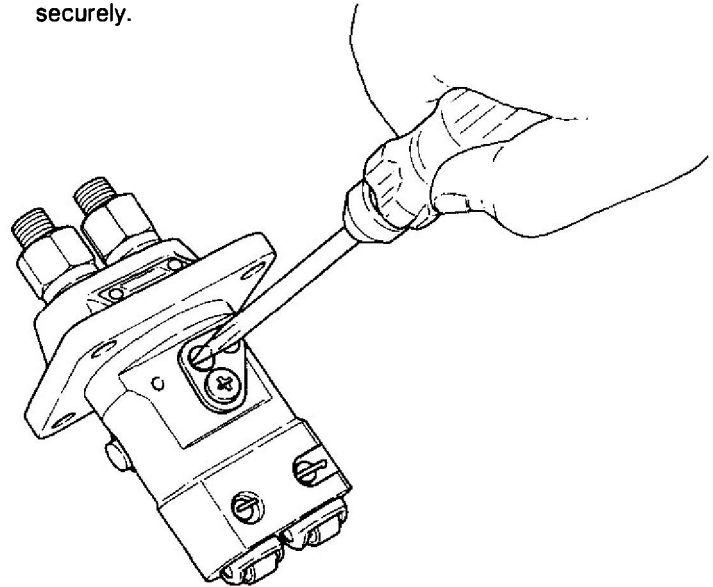
In order to adjust the fluctuation of injection volume for each cylinder, alter the position of the injection volume adjusting plate at the side of the fuel injection of pump body.

The injection volume adjusting plate is operated by the eccentric bolt which is integrated with the locking pin of the plunger barrel and changes the position of the plunger barrel. When the plunger barrel is turned, the relative position of the suction hole with respect to the lower lead of the plunger, changes the injection volume.



By loosening the set bolt and turning the eccentric bolt clockwise, the position of the pin moves to the leftside to increase the injection volume, and by turning the eccentric bolt counterclockwise, the pin moves to the rightside to decrease the injection volume.

After adjusting the injection volume, tighten the set bolt securely.



3. Injection Nozzle

3-1 Construction

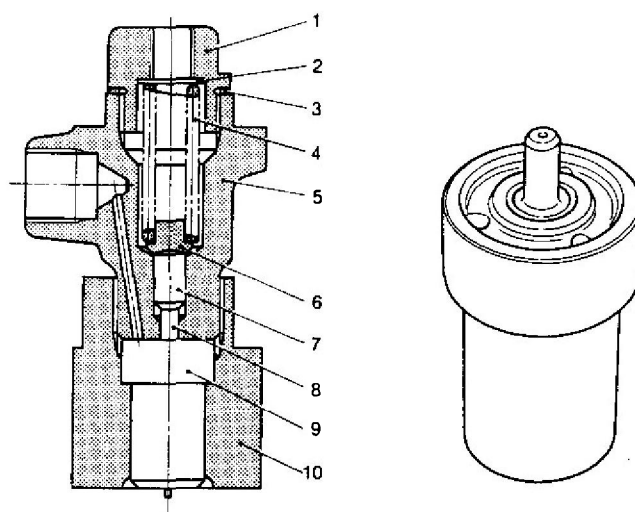
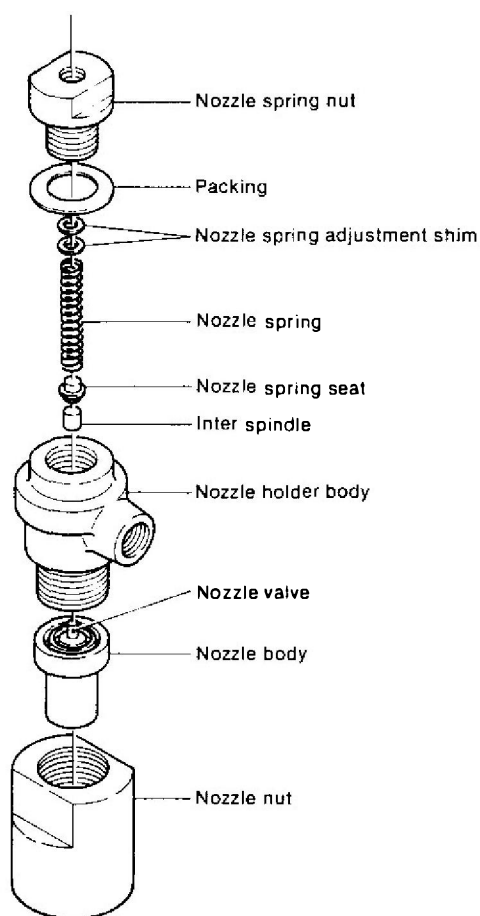
The injection nozzle atomizes the fuel sent from the injection pump and injects it into the precombustion chamber in the prescribed injection pattern to obtain good combustion through optimum fuel/air mixing.

The main parts of the injection nozzle are the nozzle holder and nozzle body. Since both these parts are exposed to hot combustion gas, they must be extremely durable.

Moreover, since their operation is extremely sensitive to

the pressure of the fuel, high precision is required. Both are made of quality alloy steel that has been specially heat treated and lapped, so they must always be handled as a pair.

Common parts are used for the fuel valve of models 1GM, 2GM and 3GM(D). The only different between the GM model series and model 3HM is the nozzle ease nut.



1. Nozzle spring nut
2. Nozzle spring adjustment shim
3. Packing
4. Nozzle spring
5. Nozzle holder body
6. Nozzle spring seat
7. Inter spindle
8. Nozzle valve
9. Nozzle body
10. Nozzle nut

3-2 Specifications for nozzle valve

Engine model		1GM,2GM,3GM(D)		3HM
Nozzle	Type of nozzle valve	YDN-OSDYD1 (Throttle)		
	Valve opening pressure	170 ±5 kg/cm ² (2347 ~ 2489 lb/in. ²)		160 ±5 kg/cm ² (2205 ~ 2347 lb/in. ²)
	Diameter of injection nozzle	ø1mm (0.0394in.)		
	Angle of injection	5° ~ 10°		
Nozzle spring	Free length	30.0mm (1.1811in.)		
	Mounted length	28.7mm (1.1299in.)		
	Mounted load	14.14 kg (31.17 lb)		
Nozzle spring adjusting plate (for adjusting nozzle opening pressure)		0.1mm (0.0039in.)	0.2mm (0.0079in.)	0.3mm (0.0118in.)
				0.5mm (0.0197in.)

3-3 Yanmar throttle nozzle

The semi-throttle nozzles used in this engine are designed and manufactured by Yanmar. A semi-throttle nozzle resembles a pintle nozzle, except that with the former the nozzle hole at the end of nozzle and nozzle body are longer and the end of the nozzle is tapered. This nozzle features a "throttling effect": relatively less fuel is injected into the precombustion chamber at the initial stage of injection, and the volume is increased as the nozzle rises. This type of throttle nozzle ideal for small, high-speed engines.



3-4 Nozzle operation

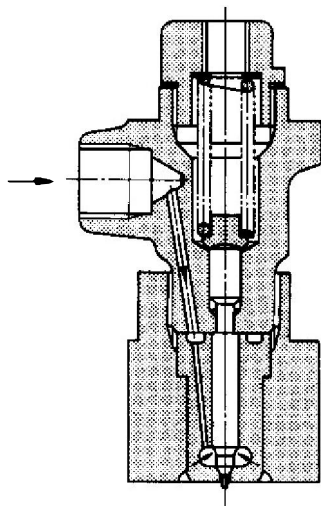
The nozzle is pushed down to its lowest position by the pressure-adjusting nozzle spring and contacts the valve seat of the nozzle body.

Under high pressure, fuel from the fuel pump passes through the hole drilled in the nozzle holder, enters the circular groove at the end of the nozzle body and then enters the pressure chamber at the bottom of the nozzle body.

When the force acting in the axial direction on the differential area of the nozzle at the pressure chamber overcomes the force of the spring, the nozzle is pushed up and the fuel is injected into the precombustion chamber through the throttle hole.

The nozzle is closed again when the pressure in the nozzle body's pressure chamber drops below the force of the spring.

This cycle is repeated at each opening and closing of the injection pump delivery valve.



3-5 Disassembly and reassembly

3-5.1 Disassembly sequence

- (1) Remove the carbon from the nozzle end.
- (2) Loosen the nozzle spring holder.
- (3) Remove the nozzle holder body from the nozzle mounting nut.

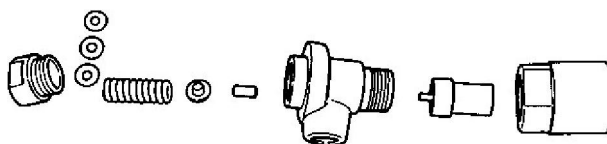
- (4) Remove the nozzle body and nozzle ass'y from the nozzle mounting nut.
- (5) Remove the nozzle spring retainer from the nozzle holder body, and remove the nozzle spring retainer, inter-spindle etc.

Reassemble in the reverse order of disassembly, paying special attention to the following items.

3-5.2 Disassembly and reassembly precautions

- (1) The disassembled parts must be washed in fuel oil, and carbon must be completely removed from the end of the nozzle body, the nozzle body and the nozzle mounting nut fitting section.

If reassembled with any carbon remaining, the nozzle will not tighten evenly, causing faulty injection.

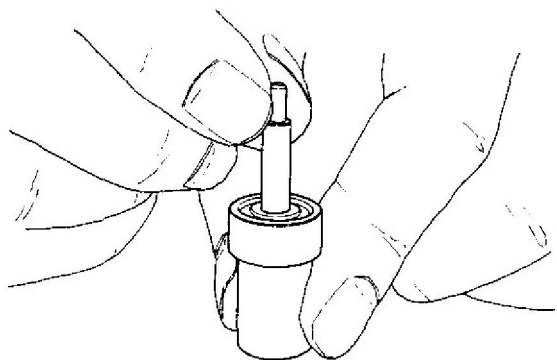


(2) Parts for No.1 cylinder and No.2 cylinder must be kept separate. The nozzle body and nozzle must always be handled as a pair.

(3) Precautions when using a new nozzle.

First immerse the new nozzle in rust-preventive oil, and then seal it on the outside with seal peel. After removing the seal peel, immerse the nozzle in diesel oil and remove the rust-preventive oil from both the inside and outside of the nozzle.

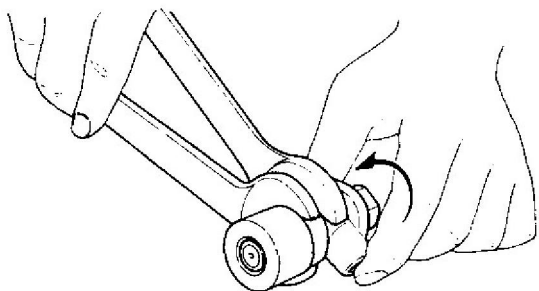
Stand the nozzle holder upright, lift the nozzle about 1/3 of its length: it should drop smoothly by its own weight when released.



(4) The nozzle must be assembled to the nozzle holder with the nozzle spring retainer loosened.

If the nozzle is installed with the nozzle spring tightened, the nozzle mounting nut will be tightened unevenly and oil will leak from between the end of the nozzle holder body and the end of the nozzle mounting nut, causing faulty injection.

kg-m (ft-lb)		
Nozzle tightening torque	Nozzle nut	10 (72.36)
	Nozzle spring nut	7.0 ~ 8.0 (50.65 ~ 57.89)

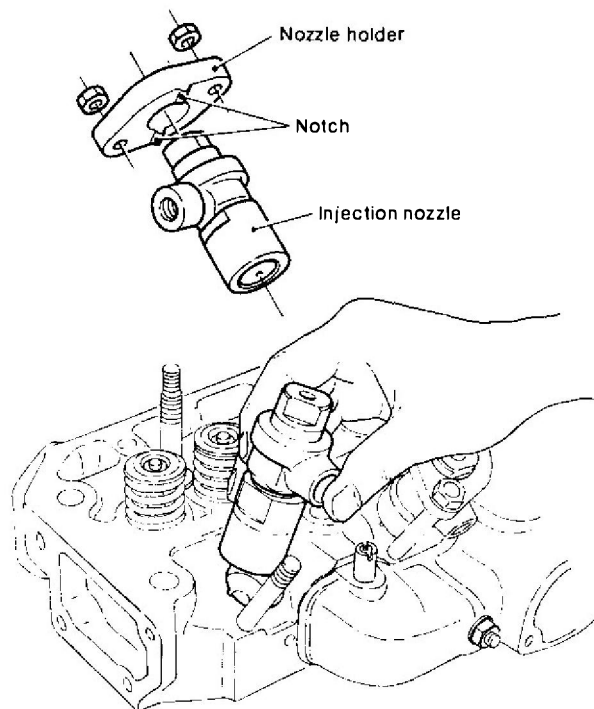


(5) When installing the injection nozzle on the cylinder head, tighten the nozzle holder nuts alternately, being careful to tighten them evenly.

kg-m (ft-lb)

Tightening torque	2 (14.5)
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Moreover, the nozzle holder must be installed with the notch side on the nozzle side.



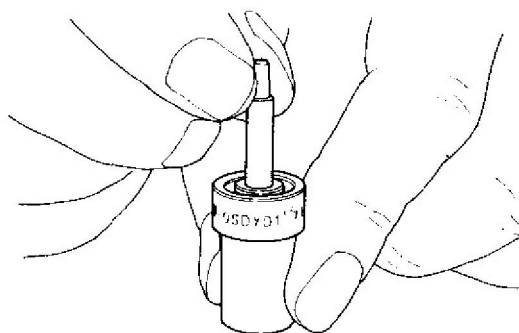
3-6 Injection nozzle inspection and adjustment

3-6.1 Carbon and corrosion on the nozzle body

Inspect the end and sides of the nozzle body for carbon build-up and corrosion. If there is considerable carbon build-up, check the properties of the fuel used, etc. Replace the body if heavily corroded.

3-6.2 Checking nozzle action

Wash the nozzle in clean fuel oil and hold the nozzle body upright, then lift the nozzle about 1/3 of its length with one hand. The nozzle is in good condition if it drops smoothly by its own weight when released. If the nozzle slides stiffly, repair or replace it.

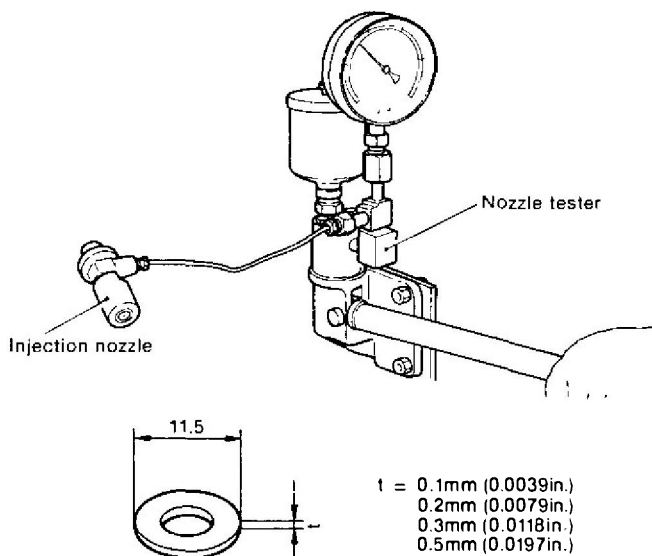


3-6.3 Adjusting the nozzle Injection pressure

Install the injection nozzle to the high pressure pipe of a nozzle tester and slowly operate the lever of the tester. Read the pressure the instant injection from the nozzle begins.

If the injection pressure is lower than the prescribed pressure, remove the nozzle spring holder and adjust the pressure by adding nozzle spring shims.

The injection pressure increases about 10 kg/cm² (142.2 lb/in.²) when a 0.1mm (0.004in.) shim is added.



	1GM, 2GM, 3GM(D)	3HM
Injection pressure	170 ± 5 kg/cm ² (2347 ~ 2489 lb/in. ²)	160 ± 5 kg/cm ² (2205 ~ 2347 lb/in. ²)

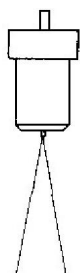
3-6.4 Nozzle seat oil tightness check

After injecting fuel several times by operating the lever of the nozzle tester, wipe the oil off the injection port. Then raise the pressure to 20 kg/cm² (284.5 lb/in.²) 140kg/cm² (1991 lb/in.²) lower than the prescribed injection pressure. The nozzle is faulty if oil drips from the nozzle. In this case, clean, repair or replace the nozzle.

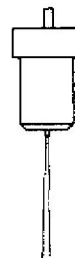
3-6.5 Checking the spray condition

Adjust the nozzle injection pressure to the prescribed value and check the condition of the spray while operating the tester at 4—6 times/sec. Judge the condition of the spray by referring to the below figure.

Normal

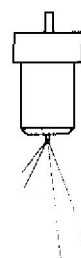


Stream



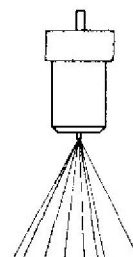
- Injection pressure low
- Nozzle seized
- Nozzle spring broken
- Dirt on valve seat

Spike



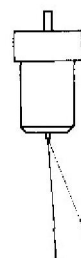
- Injection port damaged or dirty
- Carbon build-up
- Nozzle end abnormally worn

Spray



- Injection port worn
- Carbon build-up

Slanted



- Uneven seat contact
- Injection port damaged or worn
- Carbon build-up

3-6.6 Inspecting the nozzle spring

Inspect the nozzle spring for fractured coils, corrosion, and permanent strain, and replace the spring when faulty.

3-6.7 Inspecting the nozzle spring retainer and inter-spindle

Inspect the nozzle spring retainer and inter-spindle for wear and peeling of the contact face, and repair or replace the spring if faulty.

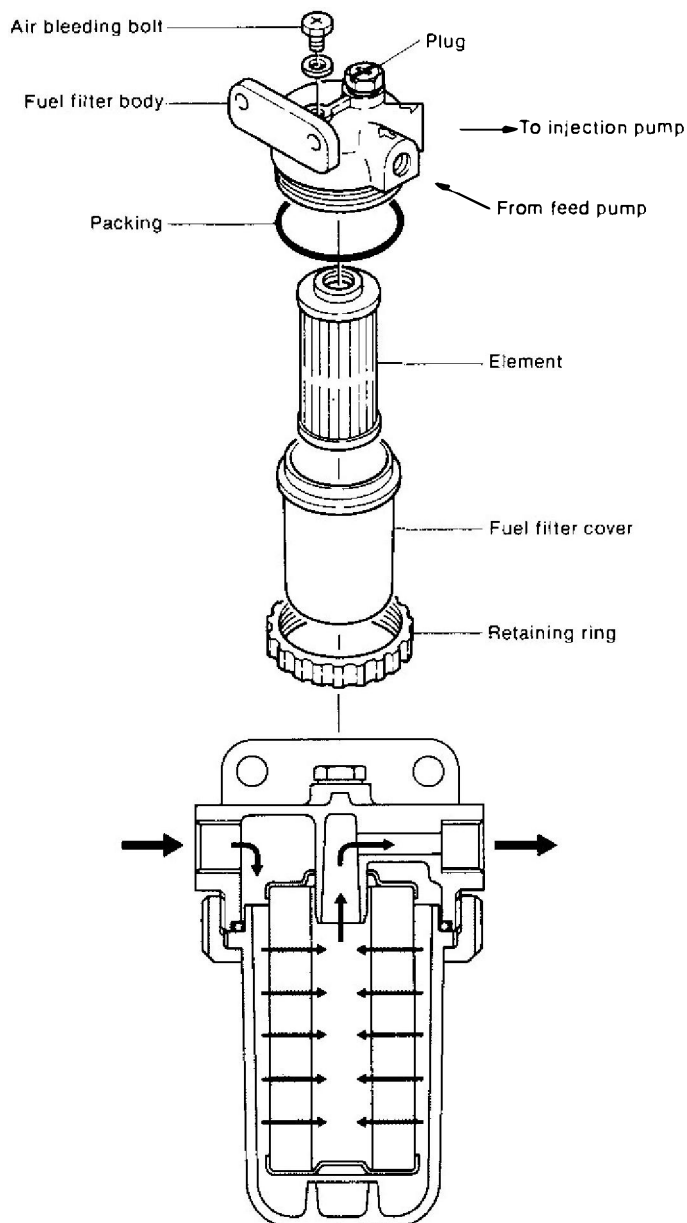
4. Fuel Filter

4-1 Construction

The fuel filter is installed between the feed pump and injection pump, and serves to remove dirt and impurities from the oil fed from the fuel tank through the feed pump.

The fuel filter incorporates a replaceable filter paper element. Fuel from the fuel tank enters the outside of the element and passes through the element under its own pressure. As it passes through, the dirt and impurities in the fuel are filtered out, allowing only clean fuel to enter the interior of the element. The fuel exits from the outlet at the top center of the filter and is sent to the injection pump.

A cross-headed hexagonal bolt is fitted to the fuel filter body. Loosen the bolt with a cross-headed screw driver before starting or after dismantling and reassembly to bleed the air in the fuel system to the fuel oil filter.



4.2 Specification

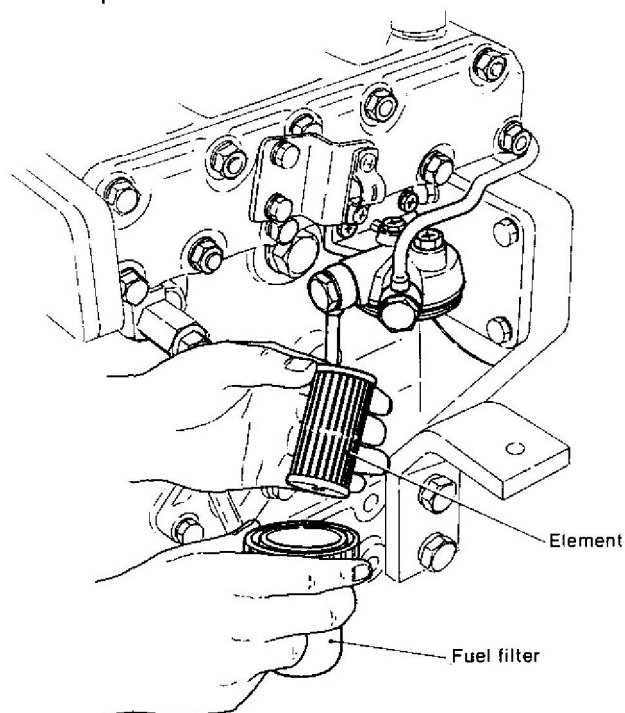
(Common to Models 1GM, 2GM 3GM(D) and 3HM)

Filtering Area	333cm ² (20.3in. ²)
Material of element	Cotton fiber
Filter mesh	10 ~ 15 μ

4-3 Inspection

The fuel filter must be periodically inspected. If there is water and sediment in the filter, remove all dirt, rust, etc. by washing the filter with clean fuel.

The normal replacement interval for the element is 250 hours, but the element should be replaced whenever it is dirty or damaged, even if the 250 hour replacement period has not elapsed.



Filter cleaning	First time 50 hours
Filter element replacement	Every 250 hours

5. Fuel Feed Pump

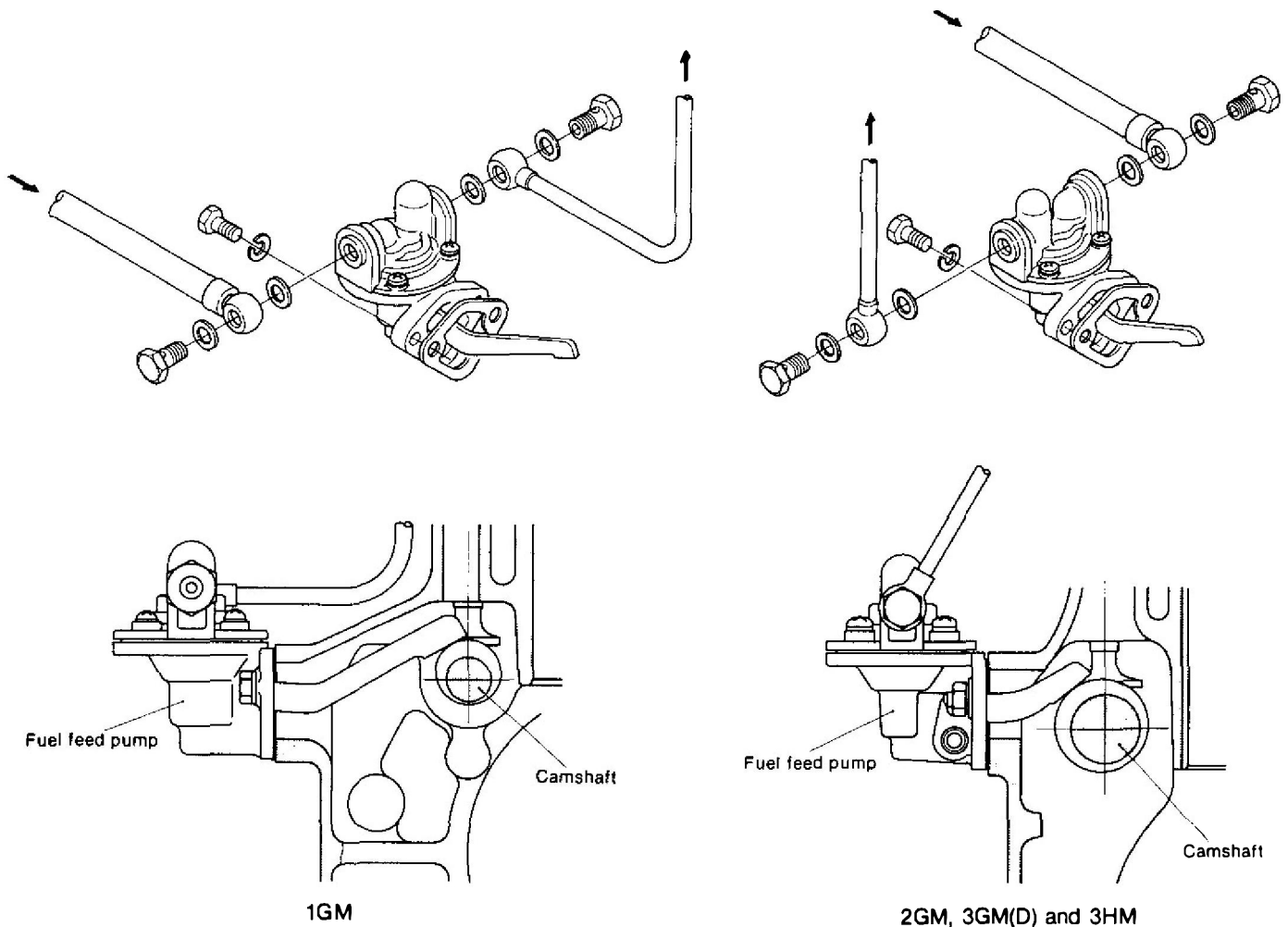
5-1 Construction

The fuel pump feeds the fuel from the fuel tank to the injection pump through the fuel filter. When the fuel tank is installed at a higher position than the fuel filter and injection pump, the fuel will be fed by its head pressure, but if the fuel tank is lower than the filter and injection pump, a fuel pump is required.

The fuel pump of this engine is a diaphragm type and is installed on the exhaust side of the cylinder body. The diaphragm is operated by the movement of a lever by the fuel feed pump cam at the cam shaft.

Specifications

	1GM	2GM,3GM(D),3HM
Part No.	105582-52010	121256-52020
Suction head	Max. 0.8m (3.15in.)	
Capacity	0.3 l/min. at 1000 rpm	
Feed pressure	0.1 kg/cm ² (1422 lb/in. ²) at 600 ~ 1800 rpm	
Suction pressure	-60 mmHg at 600 rpm	

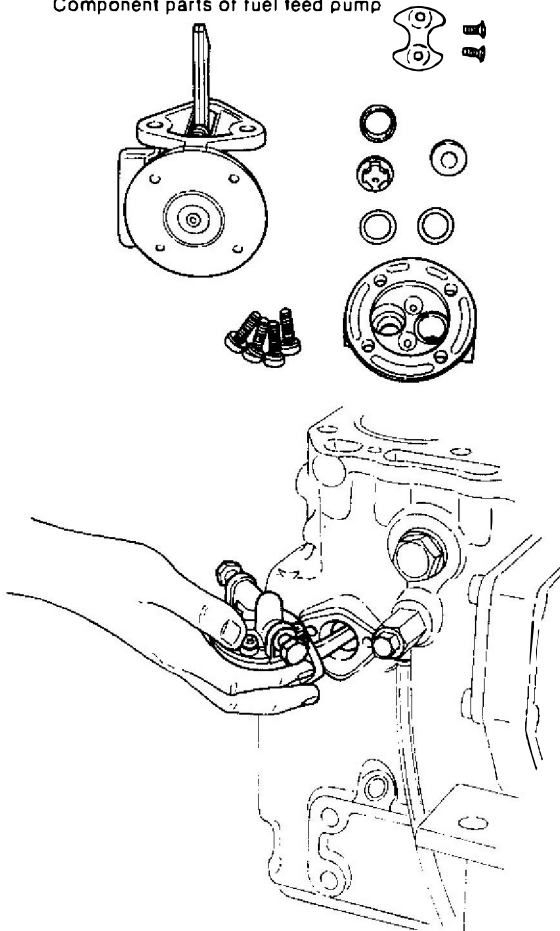


5-2 Disassembly and reassembly

5-2.1 Disassembly

Clean the outside of the pump, scribe a matching mark on the upper body and lower body of the pump, disassemble and put the components in order.

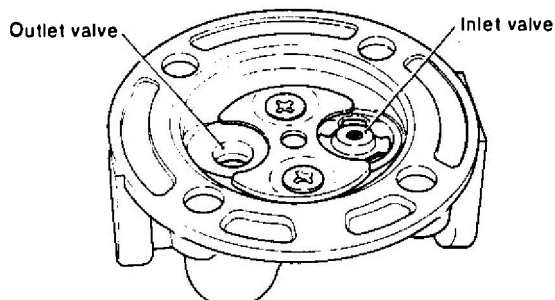
Component parts of fuel feed pump



5-2.2 Reassembly

Assemble the pump by reversing the disassembling procedures. Pay close attention to the following:

- (1) Clean the components, blow compressed air against them, and inspect. Replace any defective components.
- (2) Replace the packings, etc. with new ones.
- (3) When mounting the valves, be careful not to mix up the Inlet and outlet valves. Also, don't forget the valve packing.



- (4) Make sure the diaphragm mounting hole is in the correct position and gently attach the diaphragm to the pump body.

- (5) Line up the matching marks on the pump body, and clamp on the pump body evenly.

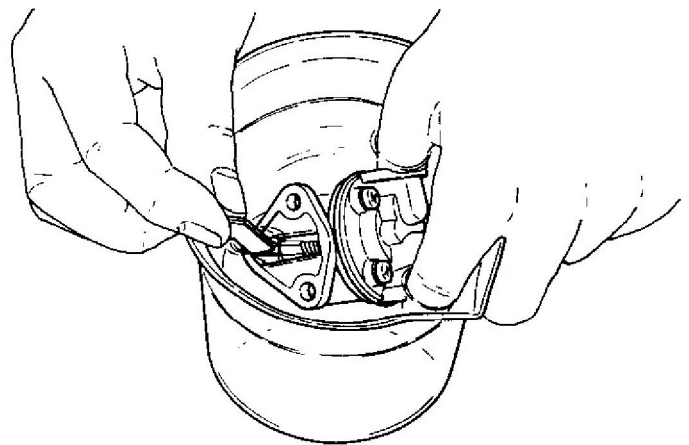
Tightening torque of screw	30 ±10 kg-cm (1.45 ~ 2.89 ft-lb)
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5-3 Inspecting and adjusting the fuel feed pump

5-3.1 Checking the pump for fuel oil leaks

After removal, immerse the pump in kerosene, stop its outlet port with a finger and, by operating the rocker arm, check for bubbles.

If any bubbles are present, this indicates a defective point which should be replaced.

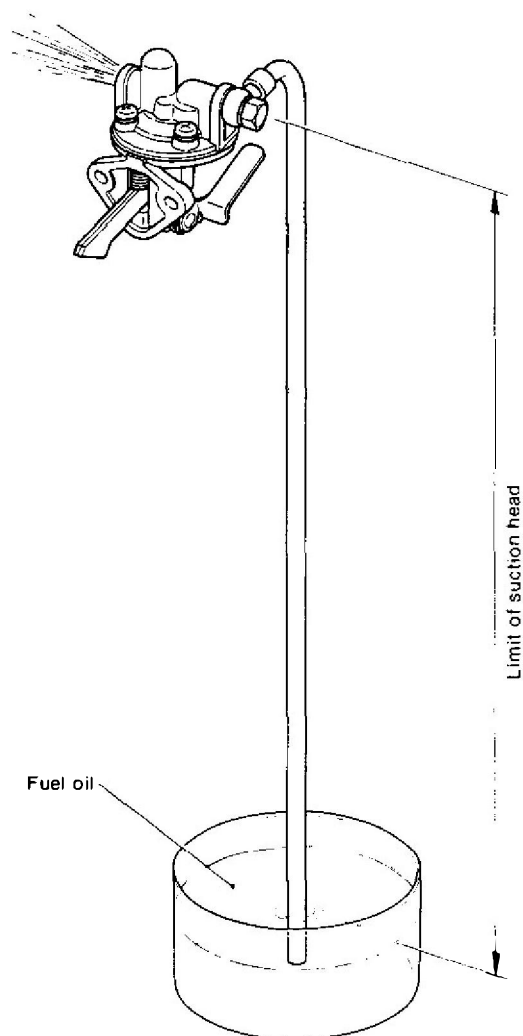


5-3.2 Checking the pump for engine oil leaks

Check pump mounting bolts for looseness and the pump packing for breaks. Retighten any loose bolts and replace defective packing.

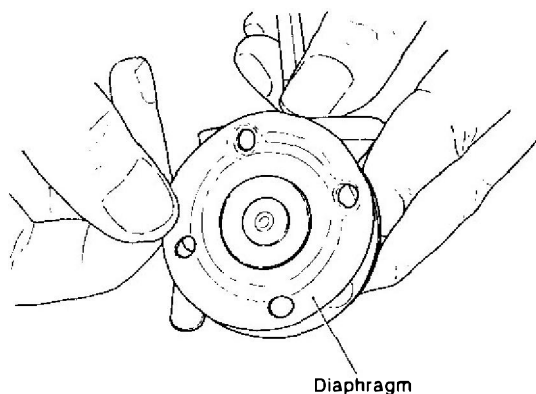
5-3.3 Measuring the sucking power

Attach a piece of vinyl hose to the Inlet port, keep the pump at a specified height (head) above the fuel oil level, and operate the rocker arm by hand. If the fuel oil spurts out from the outlet port, the pump is all right. A simpler method of testing pump power is as follows: cover the inlet port with a finger and, by operating the rocker arm by hand, estimate the pump's sucking power by judging the suction on the finger. Although this is not an exact method, it can at least confirm that the diaphragm, valves, etc. are operating.



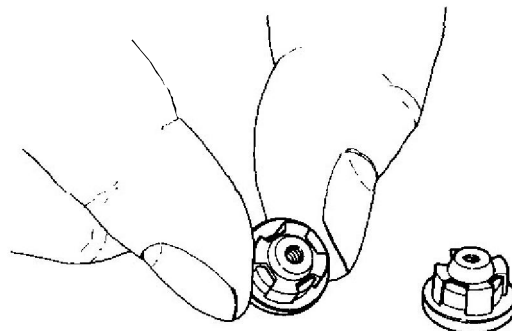
5-3.4 Aging, breakdown and cracking of the diaphragm

Since the diaphragm is constantly in motion, the cloth on its flexible parts becomes thin, cracked, and sometimes breaks down after long periods of use. A broken diaphragm causes fuel oil leakage and often fragments of the diaphragm get into the engine oil, either seriously hampering fuel oil discharge or blocking it altogether.



5-3.5 The contact area and mounting condition of valve

Test the valve seat as follows: Remove the valve and blow into the valve seat from the direction in which the valve spring is mounted. If air leaks, replace the seat with a new one. If fuel oil leaks as a result of dust, foreign objects, etc. caught in the valve seat, rinse it and clean it by blowing air into it.



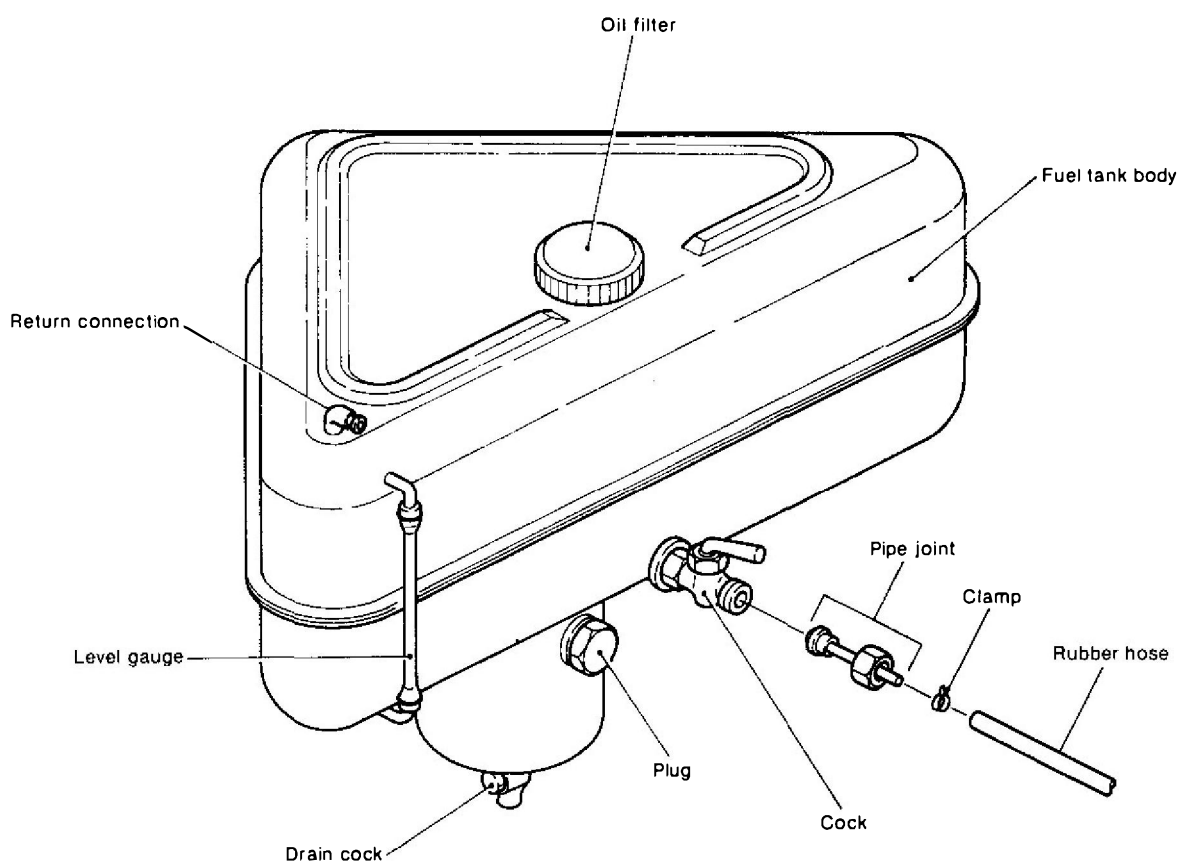
5-3.6 Diaphragm spring and rocker arm spring

Check the diaphragm spring and rocker arm spring for permanent deformation, and the rocker arm and rocker pin for wear. If any of these components are defective, replace them with new ones.

NOTE: When it becomes necessary to replace any of these parts, the entire fuel feed pump assembly should be replaced.

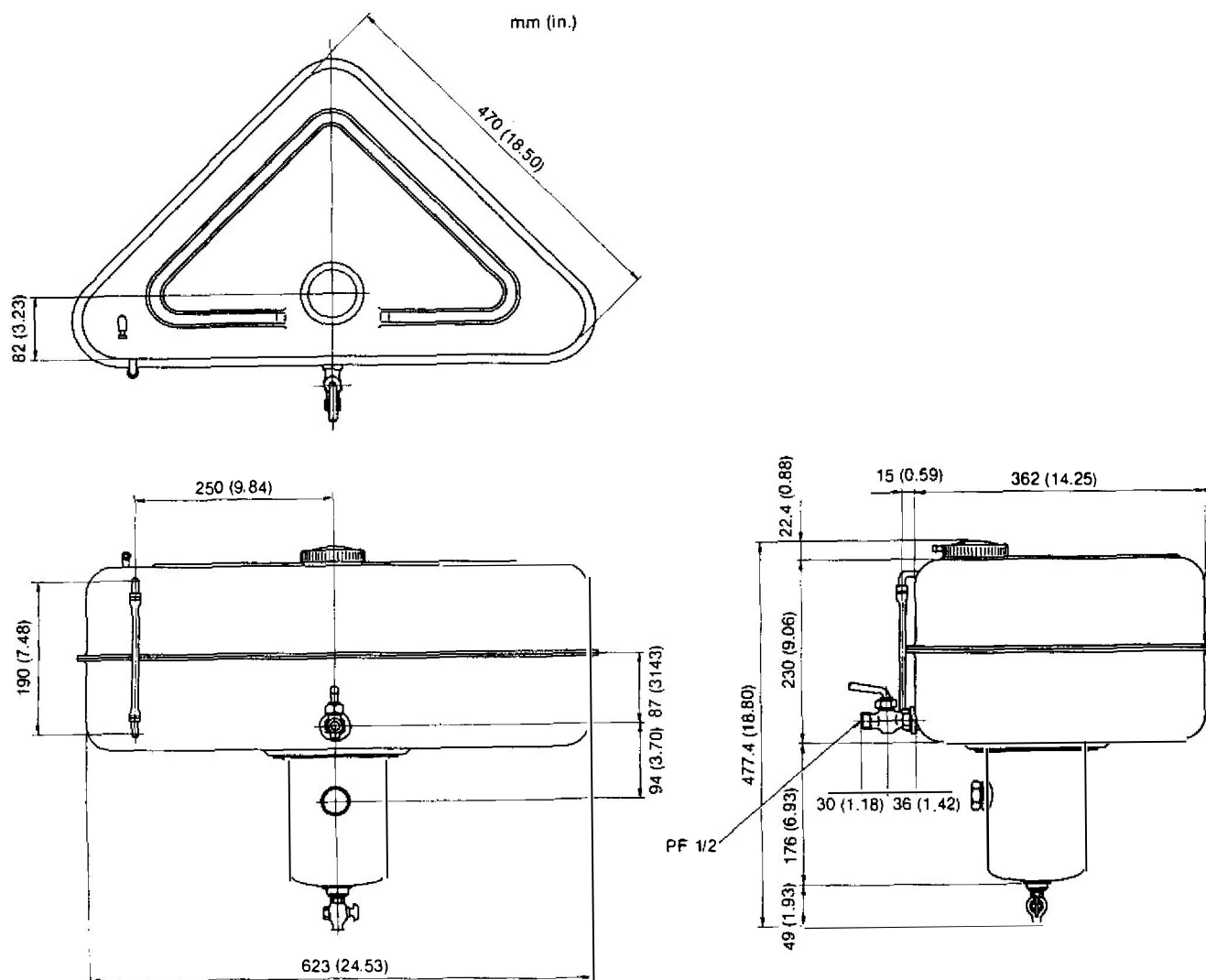
6. Fuel Tank (Option)

The fuel tank is optionally available. Its capacity is 30 litres for all engine models and is triangular shaped to fit compactly into the engine room. As an accessory, a rubber hose of 2m length is attached to feed fuel oil from the fuel tank to the fuel pump. A connection to return fuel oil is provided at the top of the fuel tank, and by connecting a rubber hose from the fuel valve, the overflow oil can be returned to the tank.



Material	Steel plate
Capacity	30l
Thread of outlet cock	PF 1/2
Size of rubber hose	ø7/ø13 × 2000mm (0.2756/0.5118 × 78.74in.)

Dimension



CHAPTER 4

GOVERNOR

1. Governor	4-1
2. Injection Limiter	4-9
3. No-Load Maximum Speed Limiter	4-11
4. Idling Adjuster	4-12
5. Engine Stop Lever	4-13

1. Governor

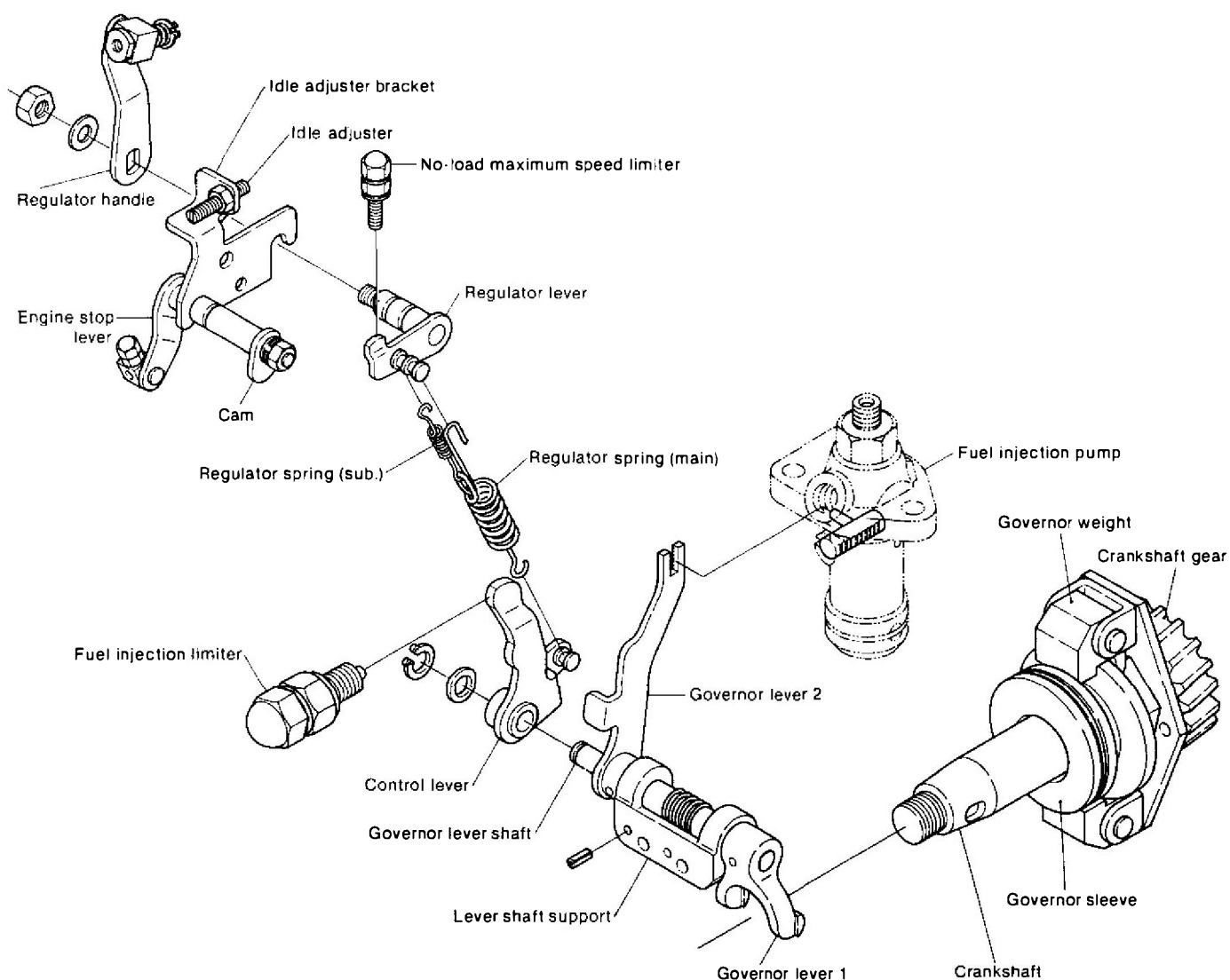
The governor serves to keep engine speed constant by automatically adjusting the amount of fuel supplied to the engine according to changes in the load. This protects the engine against sudden changes in the load, such as sudden disengagement of the clutch, the propeller leaving the water in rough weather, or other cases where the engine is suddenly accelerated.

This engine employs an all-speed governor in which the centrifugal force of the governor weight, produced by rotation of the crankshaft, and the load of the regulator spring are balanced.

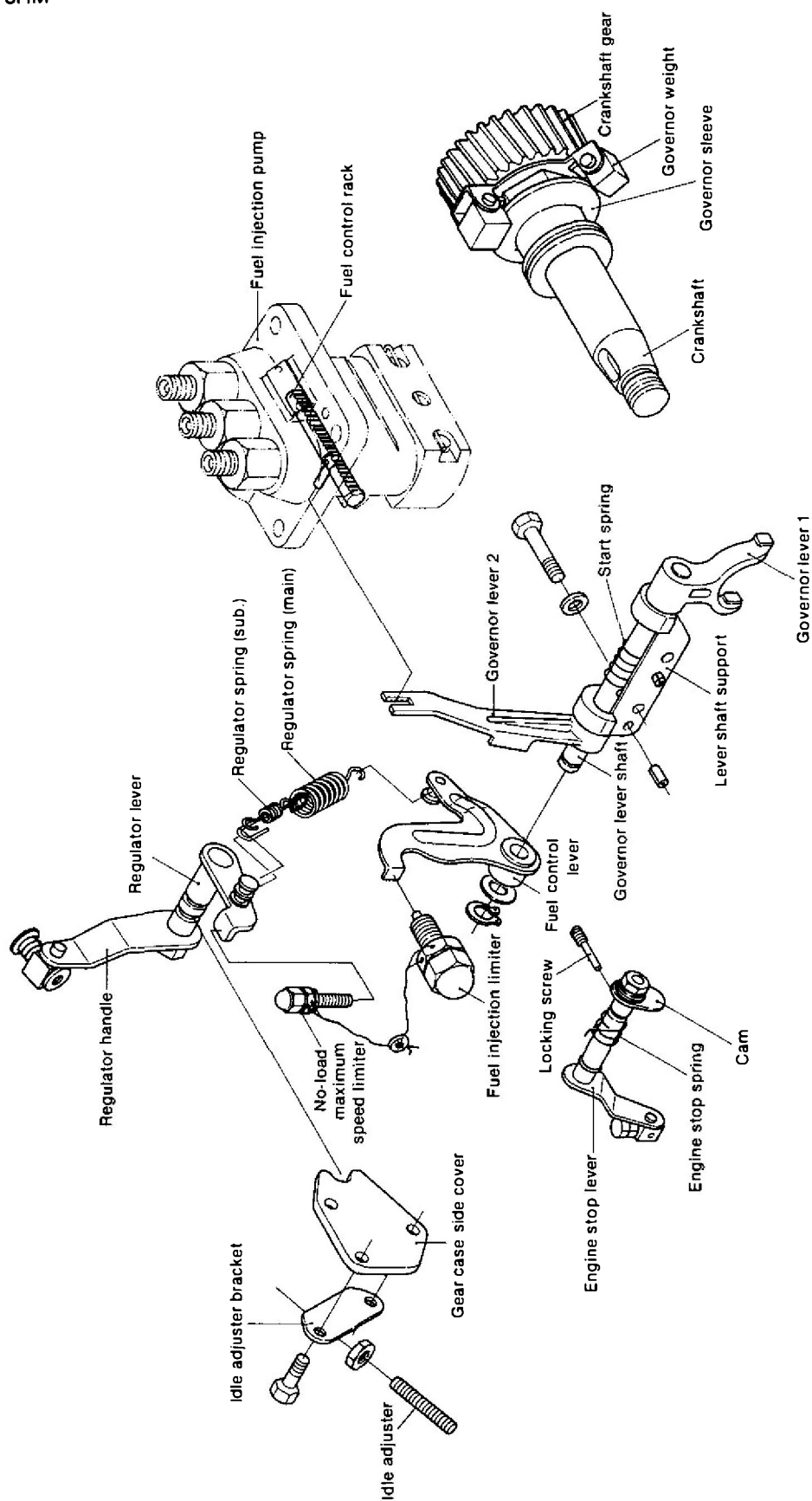
The governor is remotely controlled by a wire. Refer to the "Control System" chapter for details.

1-1 Construction

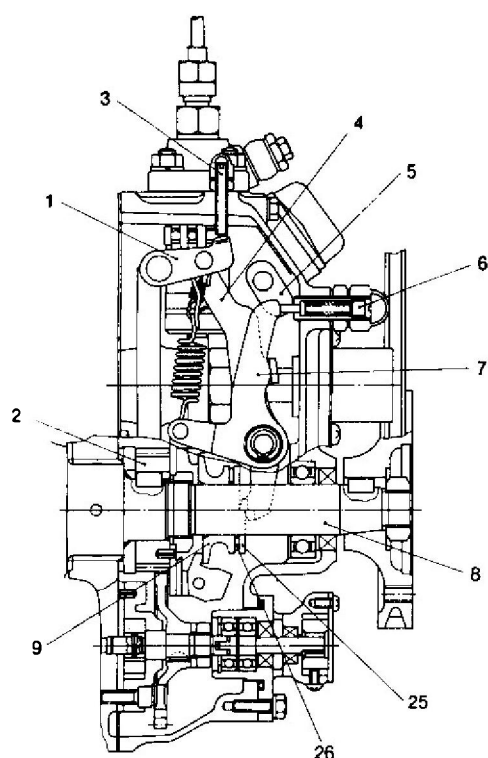
(1) 1GM



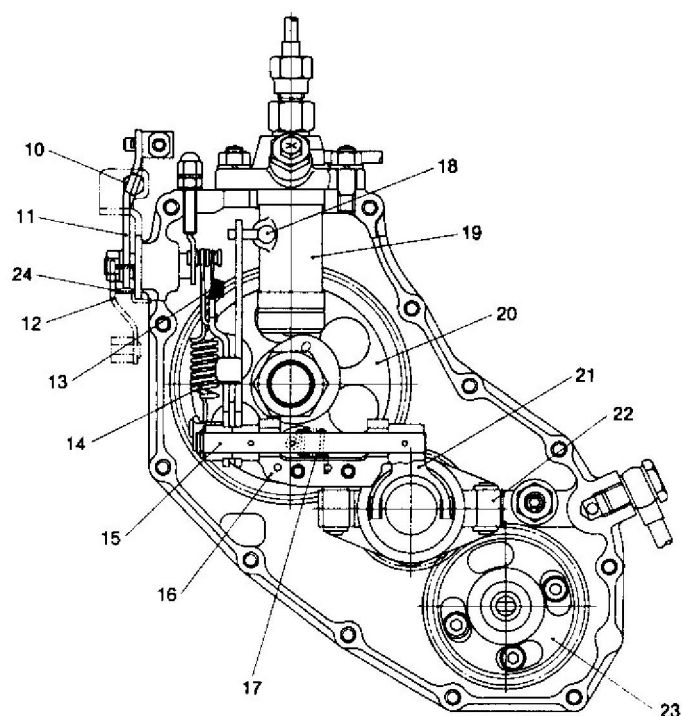
(2) 2GM, 3GM(D), 3HM



1-1.1 1GM



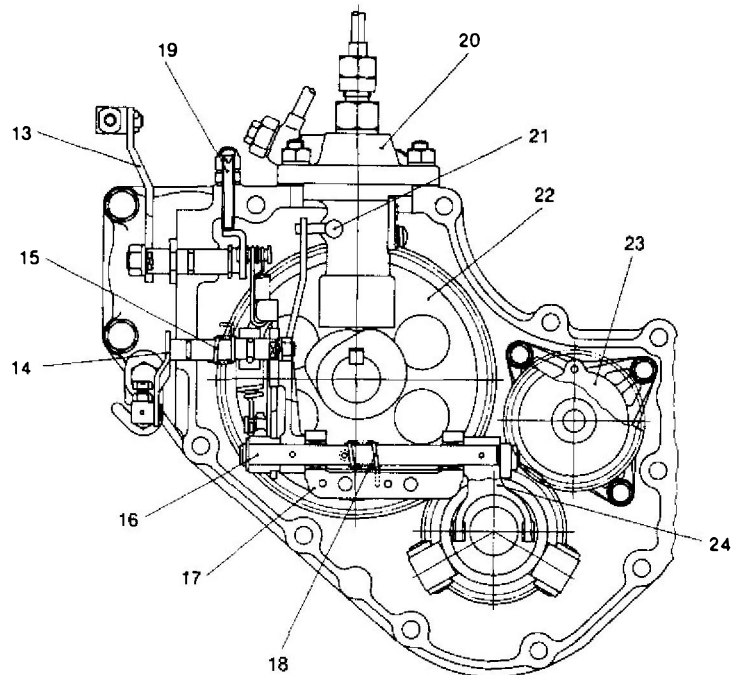
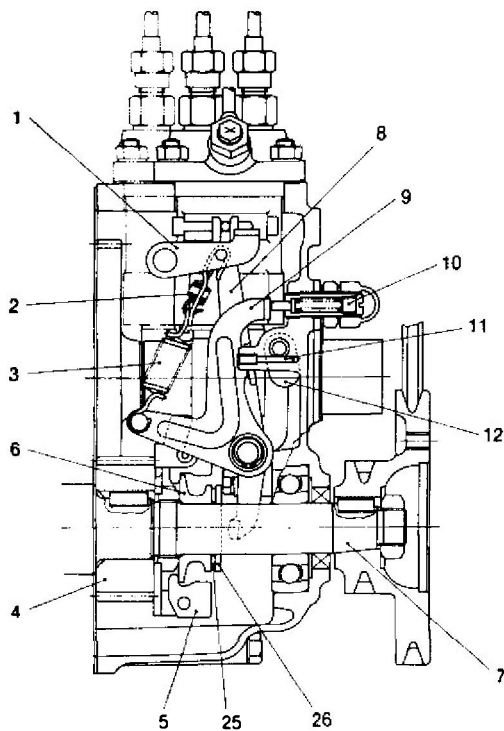
- 1 Regulator lever
- 2 Crankshaft gear
- 3 No-load maximum speed limiter
- 4 Governor lever 2
- 5 Engine stop cam
- 6 Fuel injection limiter
- 7 Fuel control lever
- 8 Crankshaft
- 9 Governor sleeve
- 10 Idle adjuster



- 11 Regulator handle
- 12 Engine stop lever
- 13 Regulator spring (sub.)
- 14 Regulator spring (main)
- 15 Governor lever shaft
- 16 Governor lever shaft support
- 17 Start spring
- 18 Fuel control rack
- 19 Fuel injection pump
- 20 Camshaft gear

- 21 Governor lever 1
- 22 Governor weight
- 23 Lubricating oil driving gear
- 24 Engine stop spring
- 25 Thrust collar
- 26 Thrust needle bearing

1-1.2 2GM (3GM(D), 3HM)



- 1 Regulator lever
- 2 Regulator spring (sub.)
- 3 Regulator spring (main)
- 4 Crankshaft gear
- 5 Governor weight
- 6 Governor sleeve
- 7 Crankshaft
- 8 Governor lever 2
- 9 Fuel control lever
- 10 Fuel injection limiter

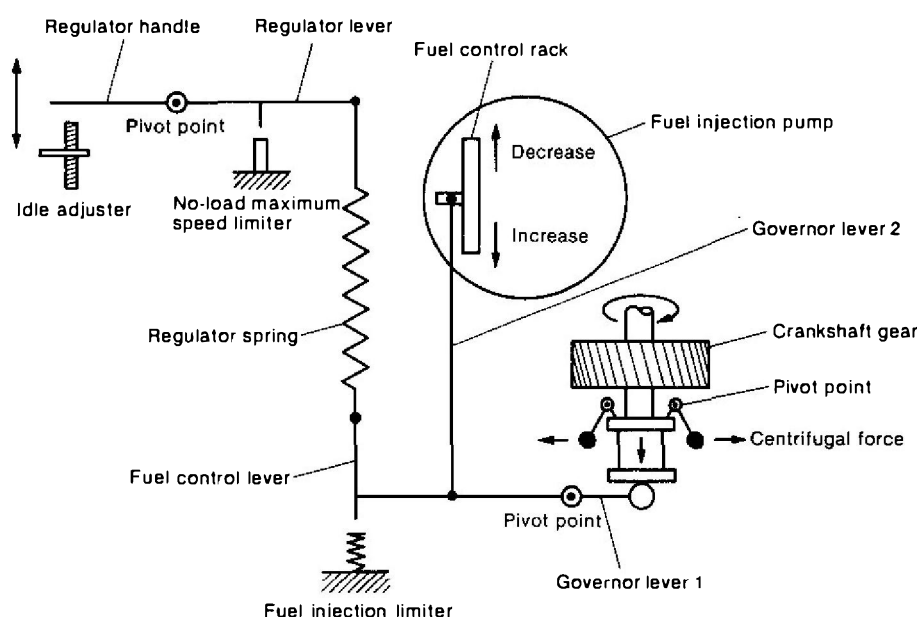
- 11 Locking screw
- 12 Engine stop cam
- 13 Regulator handle
- 14 Engine stop lever
- 15 Engine stop spring
- 16 Governor lever shaft
- 17 Governor lever shaft support
- 18 Start spring
- 19 No-load maximum speed limiter
- 20 Fuel injection pump

- 21 Fuel control rack
- 22 Camshaft gear
- 23 Lubricating oil pump
- 24 Governor lever 1
- 25 Thrust needle bearing
- 26 Thrust collar

1-2 Operation

The position of the two governor weights (open and closed) is regulated by the speed of the engine. The centrifugal force of the governor weights pivots around the governor weight pin and is changed to axial force that acts on the sleeve. This force is transmitted to governor lever 2 through governor lever 1, and lever 1 shifts the fuel control rack to increase or decrease the fuel supply. The governor lever is

stabilized at the point at which the force produced by the governor weight is balanced with the load of the regulator spring connecting the regulator lever and fuel control lever. When the speed is reduced by application of a load, the force of the regulator spring pushes the governor sleeve in the "fuel increase" direction, stabilizing the engine speed by changing the position of the regulator lever.



1-3 Performance

	1GM, 2GM, 3GM(D)	3HM
No-load maximum speed	3750 ⁺⁵⁰ ₀ rpm	3600 ±25 rpm
No-load minimum speed	850 ±25 rpm	
Instant speed regulation	δi	10% or less
Stabilization time	ts	10 sec. or less
Stabilized speed regulation	δs	5% or less
Fluctuation of rotation	40 rpm or less	

$$\text{Instant speed regulation } \delta i = \left| \frac{n_i - n_r}{n_r} \right| \times 100$$

$$\text{Stabilized speed regulation } \delta s = \left| \frac{n_s - n_r}{n_r} \right| \times 100$$

ni: Instant maximum (minimum) speed:

The maximum or minimum engine speed which is momentarily reached immediately after the load has been suddenly changed from the rated load to another load or from an arbitrary load to the rated load.

ns: Stabilized speed:

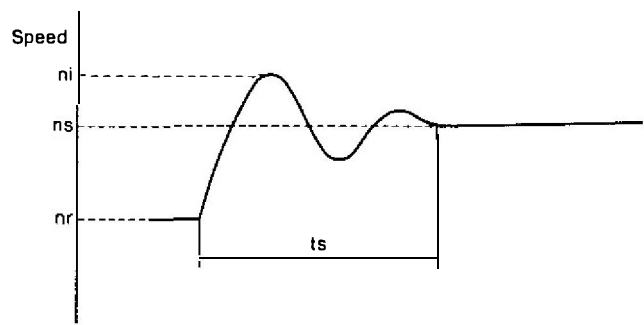
The speed which is set according to the lapse of time after the load has been changed from a rated load to another load or from an arbitrary load to the rated load.

nr: Rated speed

ts: Stabilization time:

The time it takes for engine to return to the set speed after a change.

(When load is suddenly changed from rated load to low load)



ni: Instant maximum speed (rpm)
ns: Stabilized speed (rpm)
nr: Rated speed (rpm)
ts: Stabilization time (sec.)

1-4 Disassembly**1-4.1 Disassembly**

- (1) Remove the injection limiter and no-load maximum speed limiter from the gear case.
- (2) Remove the idle adjuster and adjuster bracket.
- (3) Remove the cover at the gear case end (oil supply port in the case of model 1GM), move the governor lever 2 to match the control rack to the pulled-out position of the fuel injection pump (indicated by a slot in the gear case to show the position); then take out the fuel injection pump.
- (4) Remove the gear case from the cylinder block.
- (5) Pull the thrust collar, the thrust needle bearing and the governor sleeve from the crankshaft.
- (6) Loosen the end nut of crankshaft, and remove the governor weight assembly.
- (7) Remove the regulator spring (main-sub.) from the regulator lever 2 and fuel control lever.
- (8) Remove the circlip of the regulator lever, and remove the regulator lever and handle. (Without circlip in the case of model 1GM)
- (9) Remove the governor lever shaft support bolt from the rear of the gear case, and take out the governor lever shaft assembly.
- (10) Loosen the nut of engine stop lever, and pull the cam.
- (11) Draw out the locking screw from the rear of the gear case, and remove the taper pin for setting the return spring.
- (12) Remove the engine stop lever and the spring.

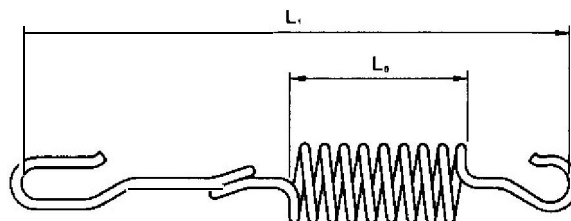
1-4.2 Reassembly and precautions

Reassemble in the reverse order of disassembly, paying special attention to the following items.

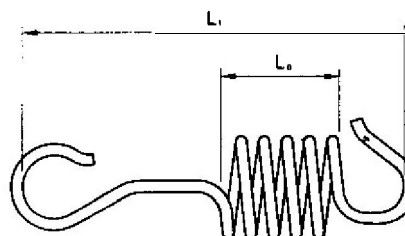
- (1) Check the governor weight movement.
- (2) Check for the movement of the governor sleeve sliding on the crankshaft.
- (3) Since a common taper pin hole is drilled in the governor lever shaft and governor levers 1 and 2, they must be replaced as an ass'y.
- (4) Since the movement and play of the governor lever have a direct effect on the governor's performance, they must be carefully checked.

1-5 Parts inspection and replacement**1-5.1 Regulator spring**

- (1) Inspect the spring for coil damage, corrosion and hook deformation, and replace if faulty.
- (2) Measure the spring's dimensions and spring constant. Since the spring constant determines the governor's performance, it must be carefully checked.

Spring specifications**1) Regulator spring (main)**

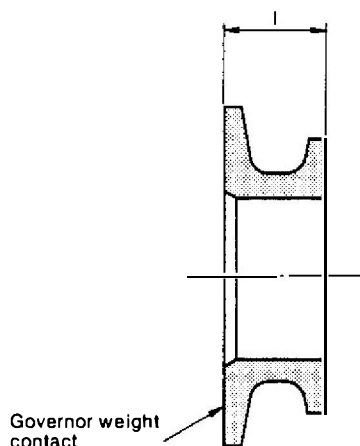
		1GM	2GM, 3GM(D), 3HM
Wire diameter		ø1.8mm (0.0709in.)	ø2.3mm (0.0906in.)
Coil outside diameter		ø13.8mm (0.5433in.)	ø18.3mm (0.7205in.)
Number of coils		8.5	7.5
Spring constant		0.715 kg/mm (0.400 lb/in.)	0.922 kg/mm (0.516 lb/in.)
Free length	L ₀	18mm (0.7087in.)	20mm (0.7874in.)
	L ₁	76mm (2.992in.)	78mm (3.0709in.)

2) Regulator spring (sub)

		1GM	2GM, 3GM(D), 3HM
Wire diameter		ø0.8mm (0.0315in.)	ø1.2mm (0.0472in.)
Coil outside diameter		ø6.8mm (0.2677in.)	ø9.2mm (0.3622in.)
Number of coils		4	7
Spring constant		0.474 kg/mm (0.265 lb/in.)	0.578 kg/mm (0.3237 lb/in.)
Free length	L ₀	5mm (0.1969in.)	10mm (0.3937in.)
	L ₁	26mm (1.0236in.)	23mm (0.9055in.)

1-5.2 Sleeve

- (1) Slide the sleeve on the crankshaft to check that it slides smoothly.
- (2) Measure the clearance between the crankshaft and the inside of the sleeve, check the contact between the governor weight.



mm (in.)

	Maintenance standard	Clearance when assembled	Maximum allowable clearance	Wear limit
Crankshaft outside diameter	$\varnothing 25_{-0.028}^{+0.007}$ (0.9831 ~ 0.9840)	0.06 ~ 0.111 (0.0024 ~ 0.0044)	0.2 (0.0079)	—
Governor sleeve inside diameter	$\varnothing 25_{+0.053}^{+0.083}$ (0.9863 ~ 0.9875)			—
Governor sleeve overall length (l)	15 ±0.1 (0.5866 ~ 0.5945)	—	—	14.8 (0.5827)

1-5.3 Thrust collar

Check the contact between the governor lever 1 and replace the collar when wear exceeds the wear limit.

mm(in.)

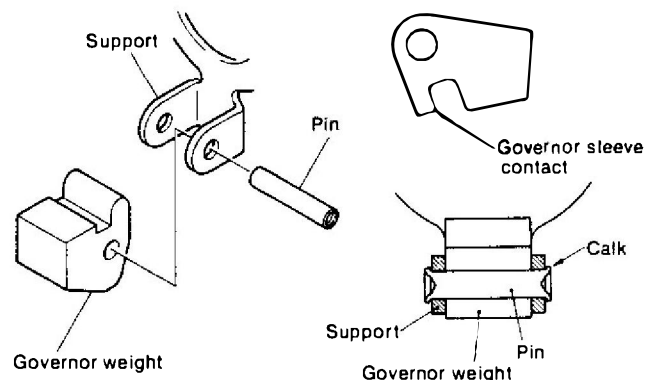
	Maintenance standard	Wear limit
Thrust collar thickness	3 (0.1181)	0.1 (0.0394)

1-5.4 Thrust needle bearing

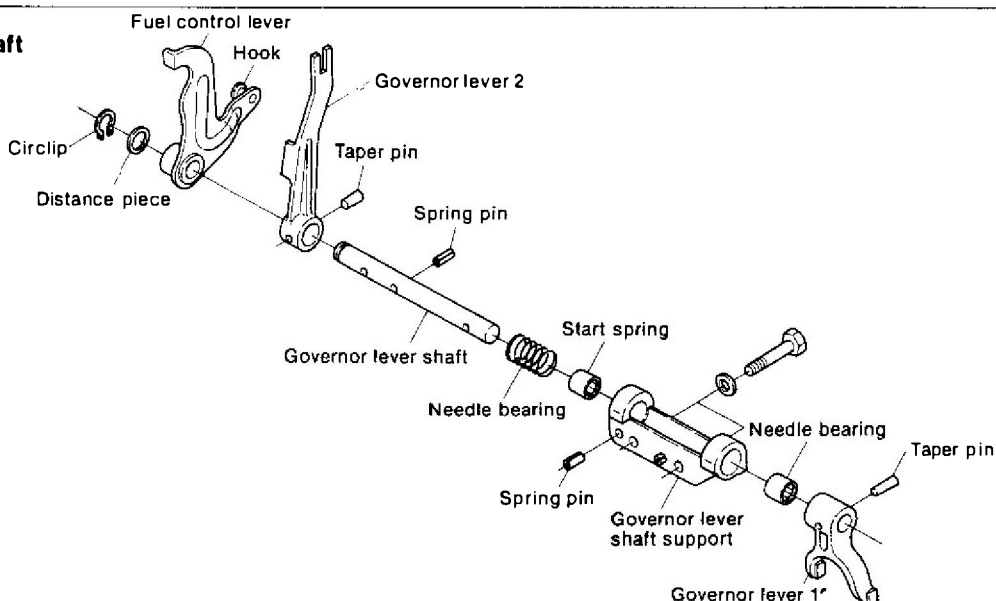
Replace the bearing when wear exceeds the specified limit.

1-5.5 Governor weight

- (1) Check contact with the sleeve and for wear.

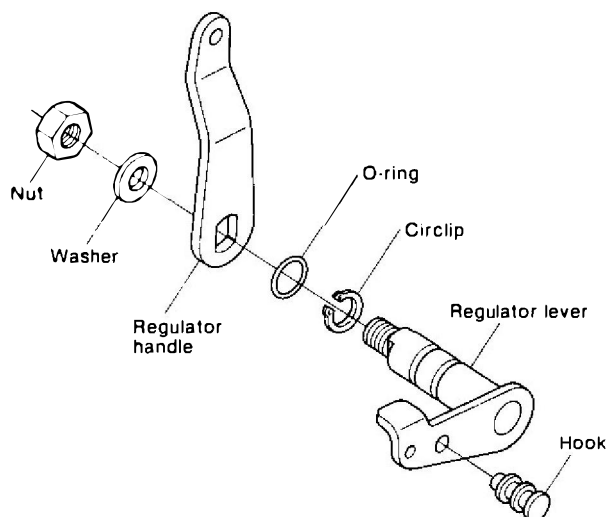


1-5.6 Governor lever shaft



- (1) Replace the governor lever shaft if there is play between the shaft and needle bearing, play when the lever is moved, or if the shaft does not move smoothly.
- (2) Repair or replace the shaft if there is play between lever 1, lever 2, fuel control lever or support and the shaft, or if the taper pin is loose.
- (3) Inspect the contact between the governor lever 1 and the governor sleeve, replace it if it is too damaged.

1-5.7 Regulator lever and handle



- (1) Check for play in the regulator lever and regulator handle if faulty, replace them as a set.
- (2) Check for O-ring damage. Replace if faulty.

2. Injection Limiter

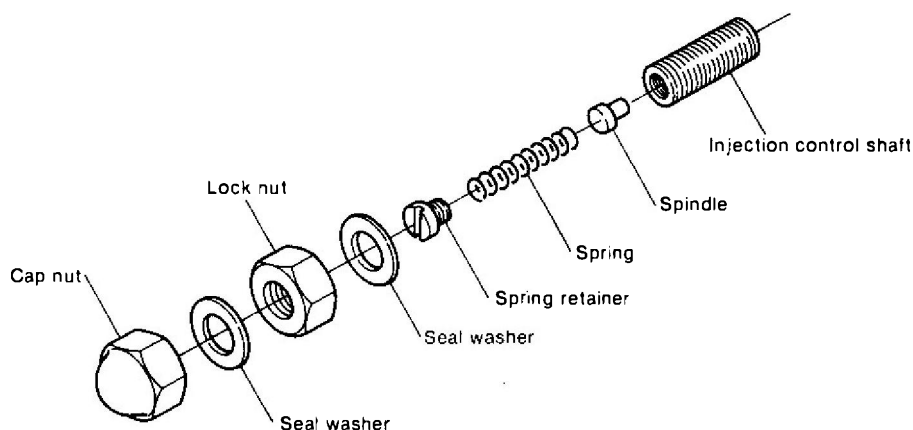
2-1 Construction

Since surplus power is required from the standpoints of sudden overloads and durability, the engine is equipped with an injection control shaft that limits the amount of fuel injected into the precombustion chamber to a fixed amount. Moreover, since the injection control spring (torque spring) affects engine performance by adjusting engine torque, Yanmar selected the best position for operating conditions.

Pay close attention when handling the sealed-wire.

If the engine does not accelerate smoothly (i.e. the speed is not well controlled), turn the limiter slightly counter-clockwise.

NOTE: If it is turned back too much, it will produce exhaust smoke.



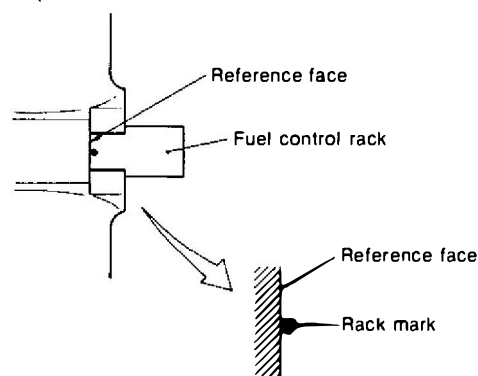
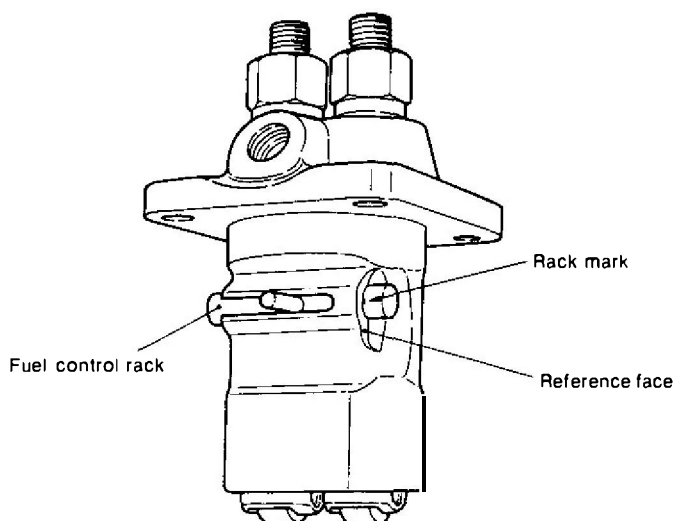
2-2 Inspection

- (1) Hold the end of the spindle, and check it for smooth movement.
- (2) Replace the spring if it is damaged, corroded or permanently strained.

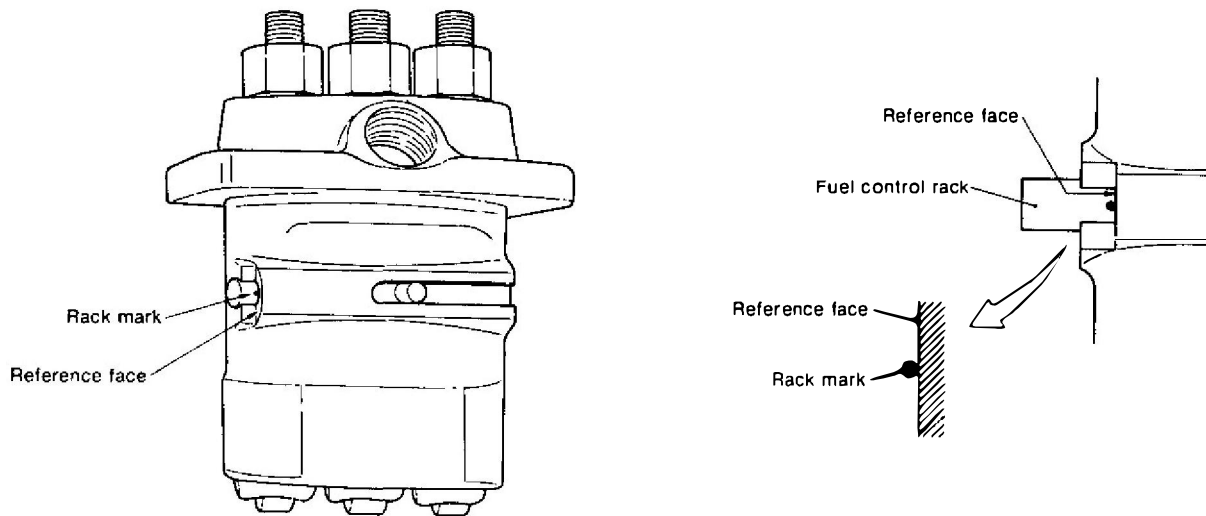
2-3 Adjustment

In the case of model 1GM, 2GM and 3GM(D)

- (1) Set the governor lever to the free position and remove the injection pump adjustment cover (oil supply port in the case of model 1GM).
- (2) Remove the injection control shaft cap nut, loosen the hexagonal lock nut, and loosen the injection control shaft (so that the spring inside the injection control shaft is disabled).
- (3) Move governor lever 2 slowly to the left until the rack and injection control shaft contact lightly.
- (4) Set the governor lever to the free position and push the rack by slowly turning the injection control shaft clockwise.
- (5) Align the center mark of the rack with the reference face.
- (6) Lock the injection control shaft with the hexagonal nut and cap nut.



In the case of model 3HM



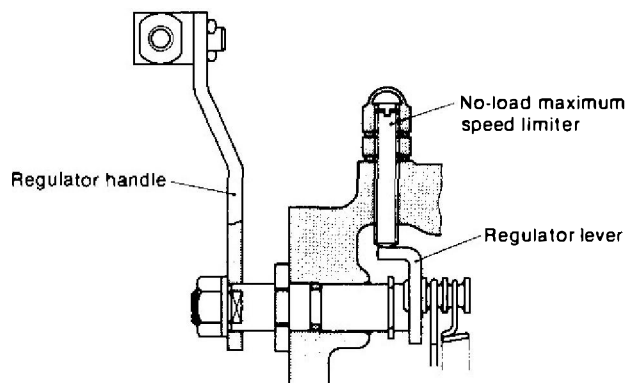
NOTE: When the engine is stopped, the control rack will automatically stay at the position which allows the maximum fuel injection volume.

Therefore, to match the rack mark, move the engine stop lever to the position where the mark is matched and fix the lever at that position, then adjust so that the fuel limiter comes into contact with the lever.

3. No-Load Maximum Speed Limiter

3-1 Construction

A stopper is installed on the regulator lever so that the engine speed at no-load does not exceed a fixed speed. The fuel control rack is stopped when the regulator lever contacts the stopper.



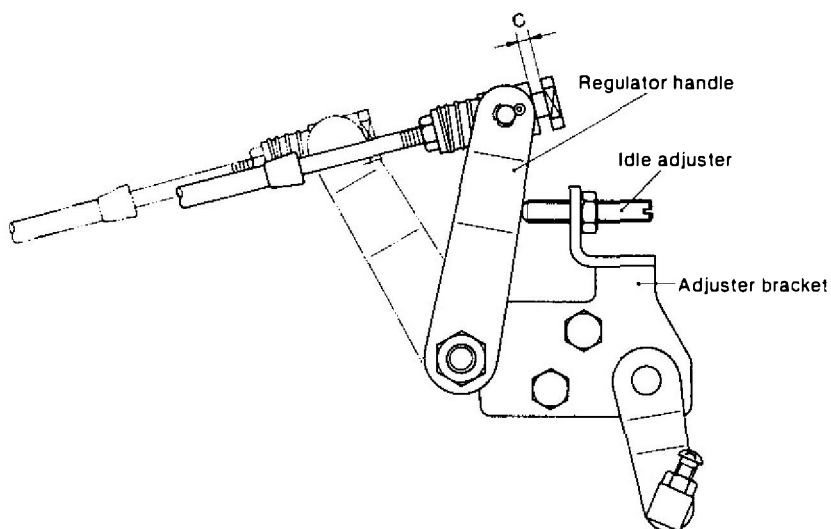
3-2 Handling precautions

The no-load maximum speed is adjusted during bench testing at the factory, and is locked with wire and sealed with lead. Care must be taken to keep the seal from being accidentally broken.

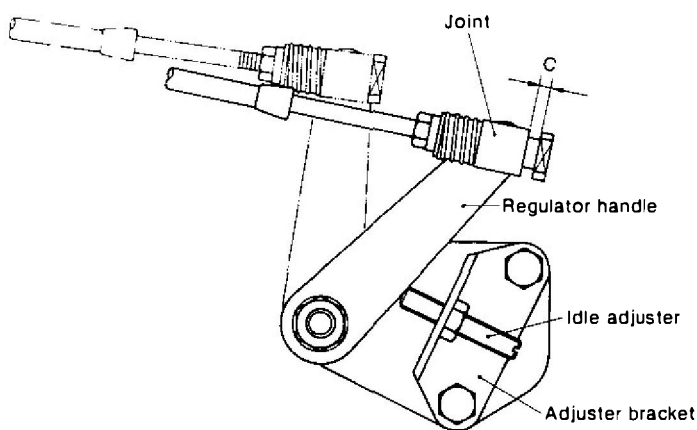
4. Idling Adjuster

When controlling the speed with the push-pull remote control, the idling adjuster operates so that the regulator handle does not move beyond the idling position in order to keep the engine running.

4-1 1GM



4-2 2GM, 3GM(D), and 3HM



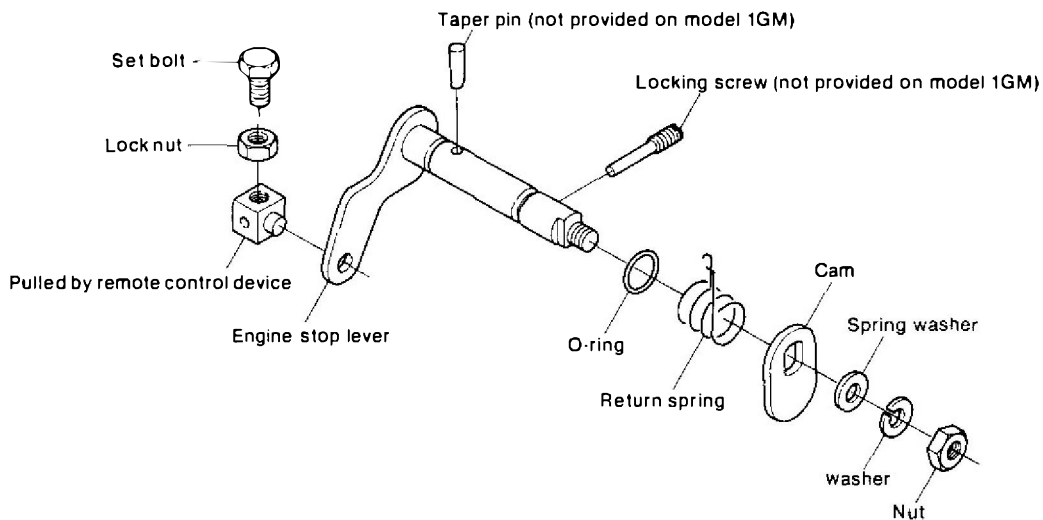
- (1) When the control lever is in the neutral position, set the push-pull cable so that clearance C is 1 to 3mm (0.0397 ~ 0.1181in.).
- (2) Take care not to fit the joint in the wrong direction.

5. Engine Stop Lever

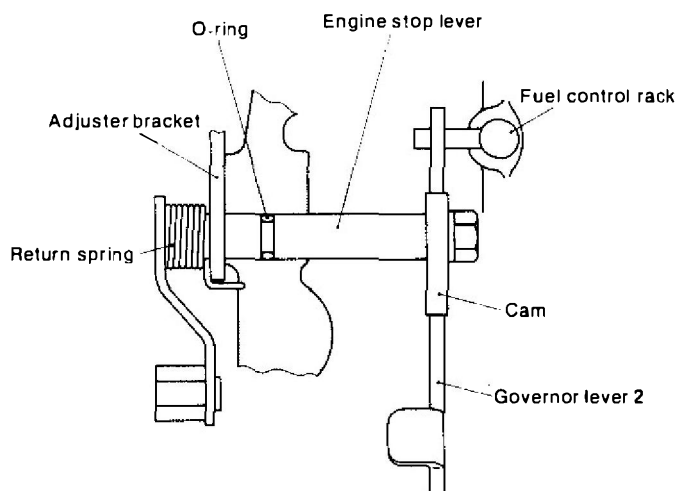
5-1 Construction

With this device, governor lever 2 is moved by the cam of the engine stop lever shaft, regardless of the position of the regulator lever, so as to adjust the fuel control rack and reduce the supply of fuel.

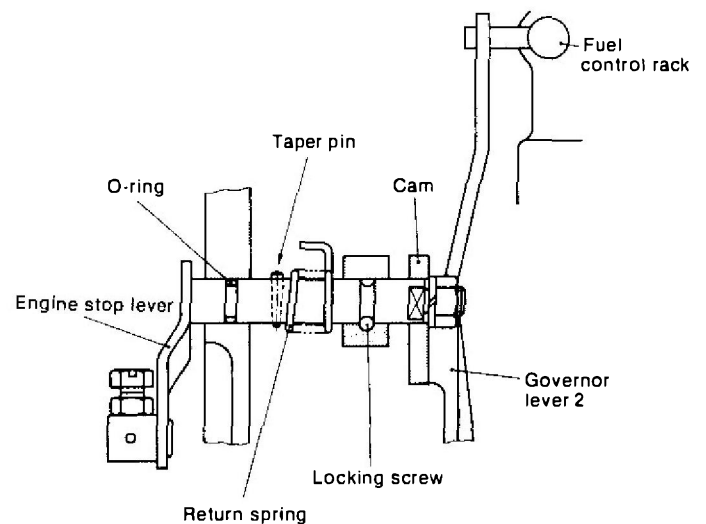
This device can be remote-controlled.



(1) 1GM



(2) 2GM, 3GM(D), 3HM



5-2 Inspection

- (1) Check for play in the Cam or Taper pin and the engine stop lever. If faulty, replace them as a set.
- (2) Check for O-ring damage. Replace if faulty.
- (3) Inspect the spring for coil damage and corrosion and replace if faulty.
- (4) Inspect the contact between the governor lever 2 and the cam, replace the cam if it is too damaged.

CHAPTER 5

INTAKE AND EXHAUST SYSTEM

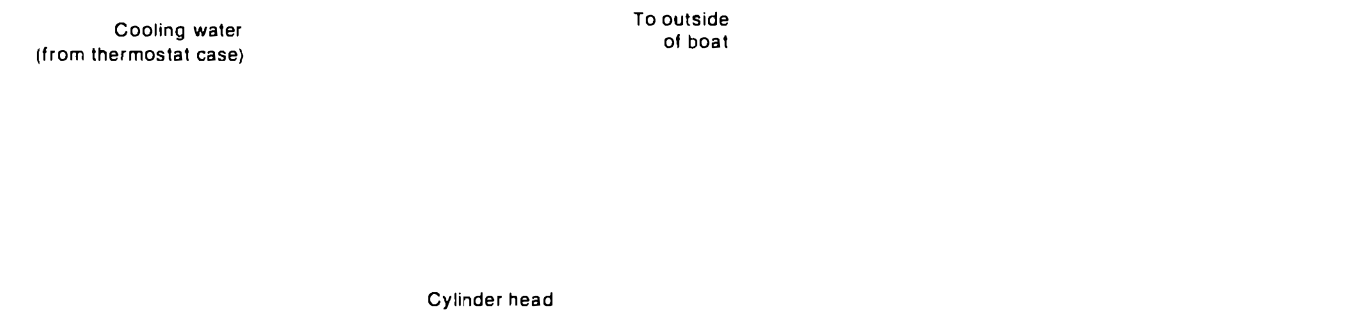
1. Intake and Exhaust System	5-1
2. Intake Silencer	5-3
3. Exhaust System	5-4
4. Breather Pipe	5-6

1. Intake and Exhaust System

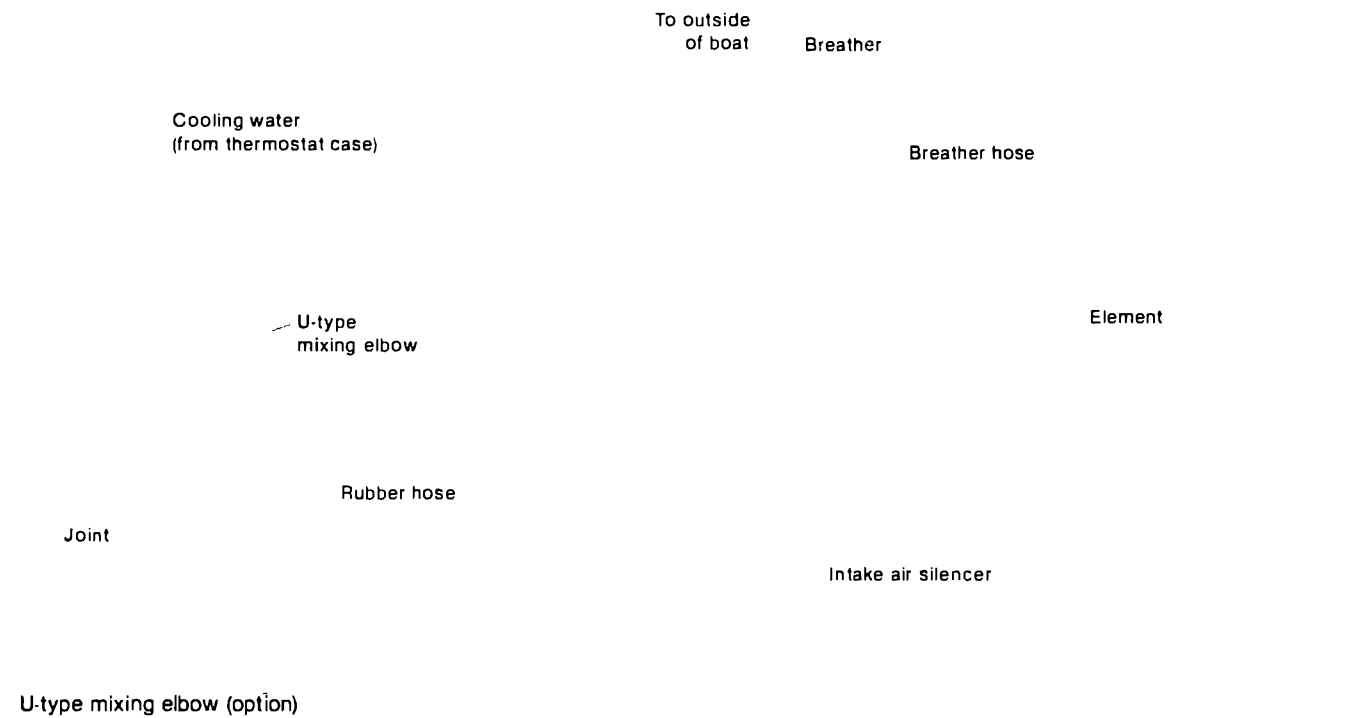
The intake air silencer is installed at the intake side for the purpose of reducing noise and cleaning the air.
The exhaust system for models 1GM and 2GM engines is so constructed that the mixing elbow is fitted directly to the cylinder head, and the cooling water passes into this mixing elbow and is mixed with exhaust gas at the pipe outlet.

A water-cooled exhaust manifold is installed on engine models 3GM and 3HM, and the mixing elbow is fitted to the outlet port of the exhaust manifold. The cooling water, after passing through the water jacket and cooling the exhaust gas, is mixed with the exhaust gas in the mixing elbow.

1-1 Intake and exhaust system of model 1GM



1-2 Intake and exhaust system of model 2GM



1-3 Intake and exhaust system of models 3GM(D) and 3HM

The intake and exhaust system for models 3GM(D) and 3HM is the same except for the construction of the breather.

From

To outside of boat

Exhaust manifold

Cylinder head

Element

Intake manifold

Breather of Model 3HM

Breather

U-type mixing elbow

Rubber hose

Elbow

U-type mixing elbow
(option for models 3GMD and 3HM)

2. Intake Silencer

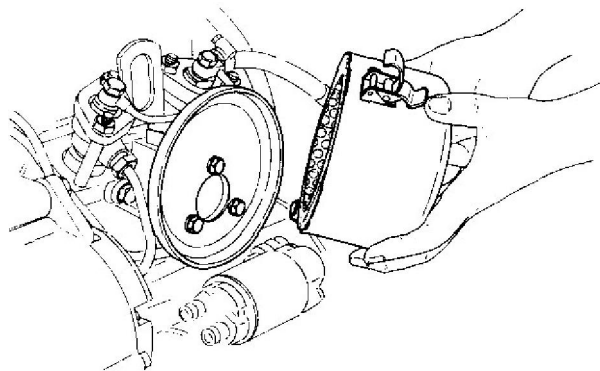
2-1 Construction

A round polyurethane sound absorbing type intake silencer is employed to silence the intake air sucked into the cylinder head from the intake port. Besides providing a silencing effect, the silencer also acts as an air cleaner.

	1GM	2GM,3GM(D)	3HM
Rated air volume (average)	1500 l/min	1560 l/min	2800 l/min
Draft resistance	150 mmAq	100 mmAq	150 mmAq

2-2 Inspection of the intake silencer

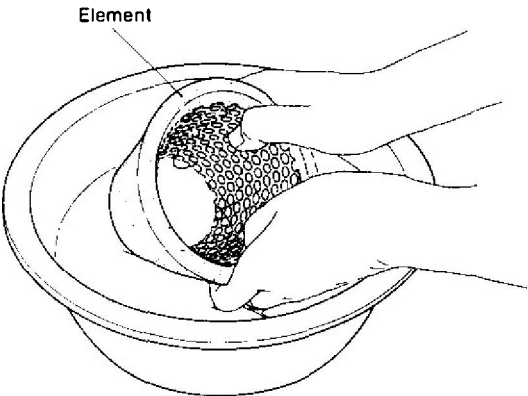
Occasionally, disassemble the intake silencer, remove the polyurethane element and inspect it. Because the element filters the air, if it is used over a long period of time it will become clogged and this decreases the amount of intake air, and may also be the cause for decreased output.



2-3 Washing the Intake silencer element

Wash the element inside the air intake silencer with a neutral detergent.

Washing period	Every 250 hours
----------------	-----------------



3. Exhaust System

The mixing elbow of models 1GM and 2GM is fitted directly to the outlet port of the cylinder head instead of being fitted to the exhaust manifold.

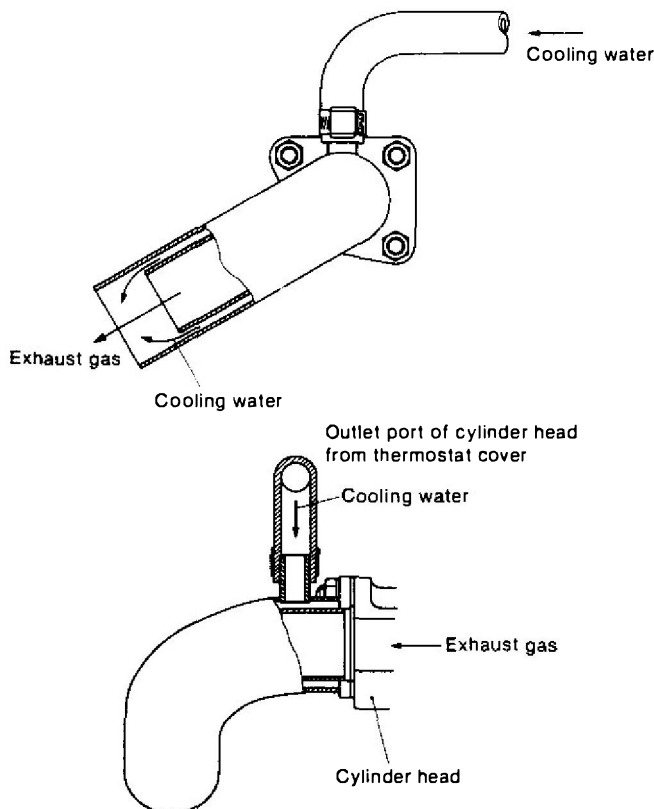
However, on models 3GM(D) and 3HM, an exhaust manifold is also installed and the mixing elbow is fitted to the manifold outlet port.

3-1 Exhaust manifold and mixing elbow

The high temperature, high pressure exhaust gas emitted intermittently from the cylinders at the speed of sound enters the exhaust manifold where it is muffled by expansion and water cooling. It is then mixed with the cooling water at the mixing elbow to lower its temperature and muffle it further, and is discharged.

A water-cooled exhaust manifold is employed for a high muffling effect.

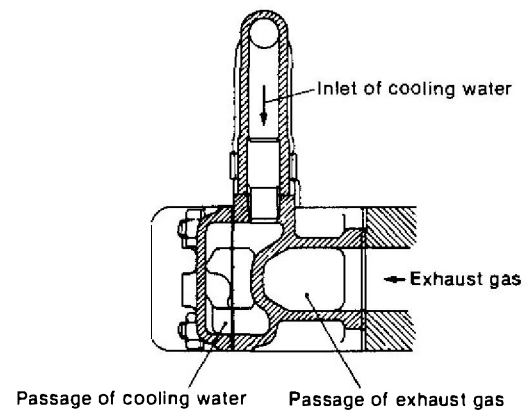
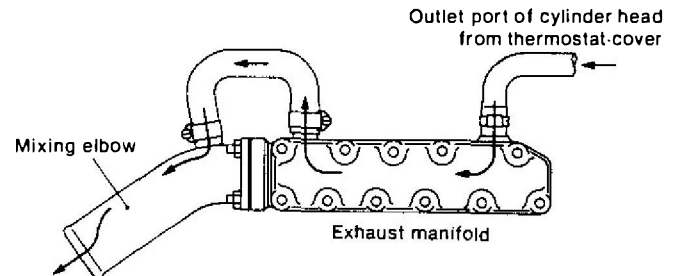
3-1.1 For models 1GM and 2GM



As shown in the figure, the construction for models 1GM and 2GM is such that there is no exhaust manifold and the mixing elbow is fitted to the exhaust gas outlet port. A double construction technique has been adopted for the mixing elbow; as the exhaust gas passes through it the cooling water passes round the outside to cool the exhaust gas and then both gas and water mix close to the outlet port.

3-1.2 For models 3GM(D) and 3HM

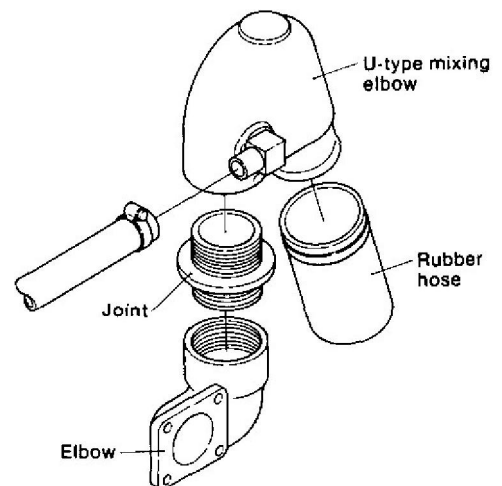
Both exhaust manifold and mixing elbow are installed.



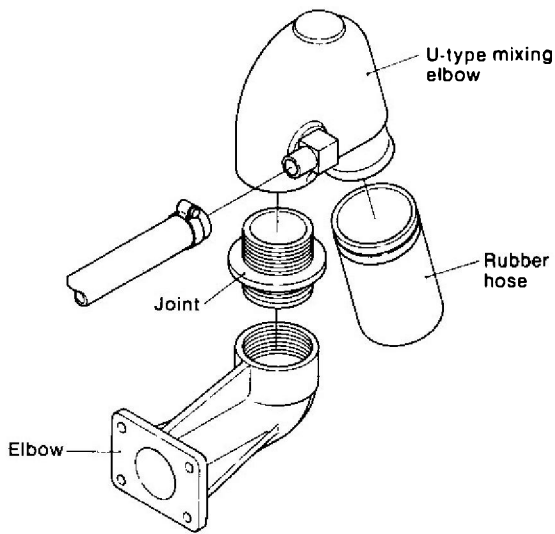
The construction of the exhaust manifold is shown in the figure, and a water chamber is formed between the exhaust manifold and the cover to cool the exhaust gas. The construction of the mixing elbow is the same for models 1GM and 2GM.

3-1.3 U type mixing elbow (optional)

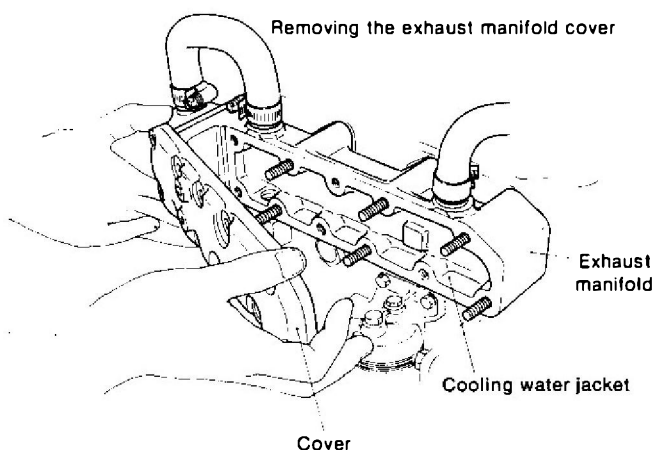
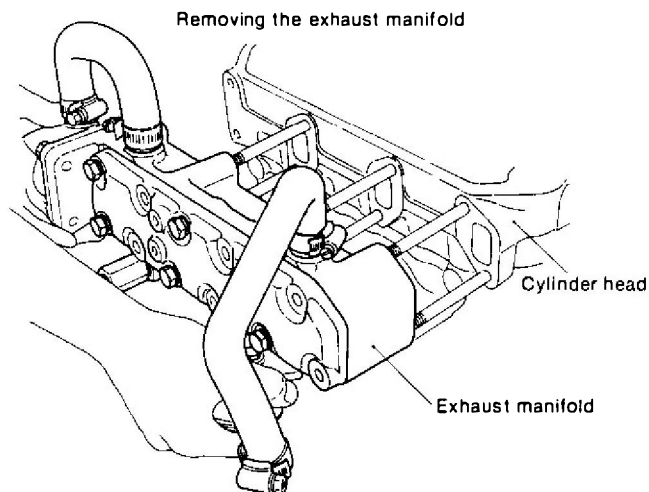
For model 2GM



For models 3GMD and 3HM

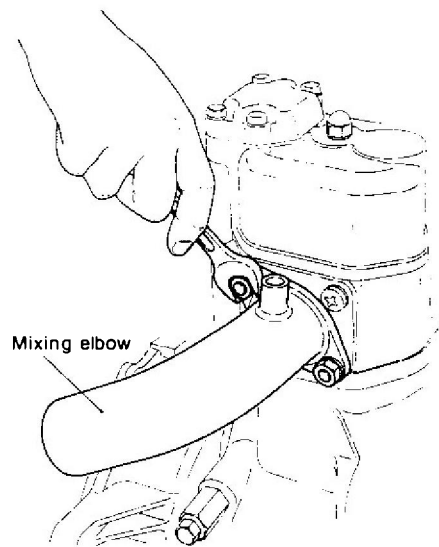


3-2 Exhaust manifold inspection



- (1) Gasket packing
Inspect the gasket packing and replace if damaged.
- (2) Carbon build-up in the exhaust passage
Remove the exhaust manifold elbow and cover and check carbon build-up in the exhaust passage. Remove any carbon in the passage. If carbon build-up becomes heavy, the exhaust pressure will rise, causing overheating of the cylinders and difficult starting.
- (3) Corrosion and scale at the cooling water jacket
Inspect the water passage for the build-up of scale and foreign matter and remove if found. Also check for corrosion of the anticorrosion zinc installed on the cylinder head and the cylinder head water jacket and replace if corrosion is severe. Moreover, replace the cylinder head if it has been cracked by local overheating.
- (4) Drain cock
Inspect the drain cock for clogging and check its action. Repair or replace if faulty.

3-3 Mixing elbow inspection



Check for carbon build-up and for corrosion inside the pipe, and repair or replace the pipe if faulty. Moreover, inspect the mixing elbow mounting threads for cracking and corrosion. This section is affected by exhaust gas and vibration.
NOTE: The part where high temperature gas and cooling water are mixed is especially likely to corrode, so it must be inspected with special care.

4. Breather

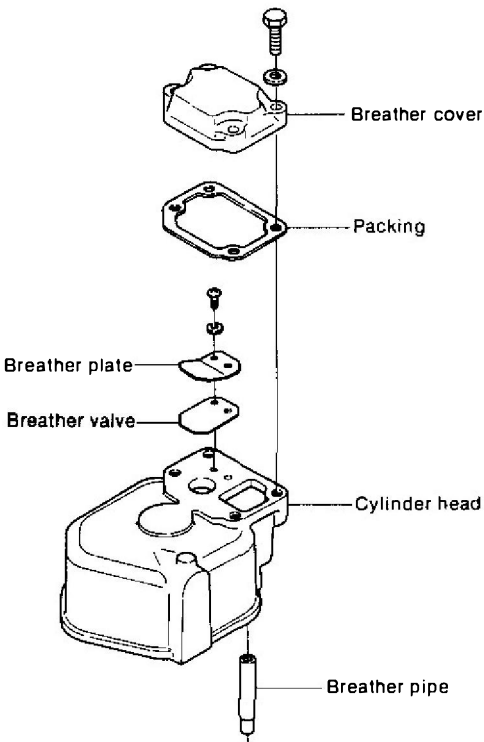
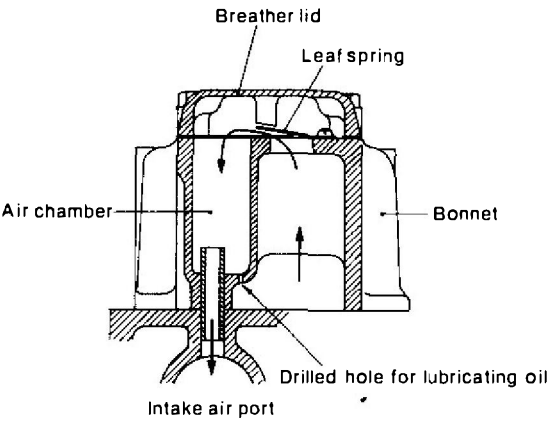
4-1 Construction of breather

The same construction is adopted for each model of engine in that the breather device is fitted to the bonnet cover, and the vapor in the crank case is sucked into the intake port or intake manifold through the tappet hole and the breather. However, the construction of the breather itself differs from model to model.

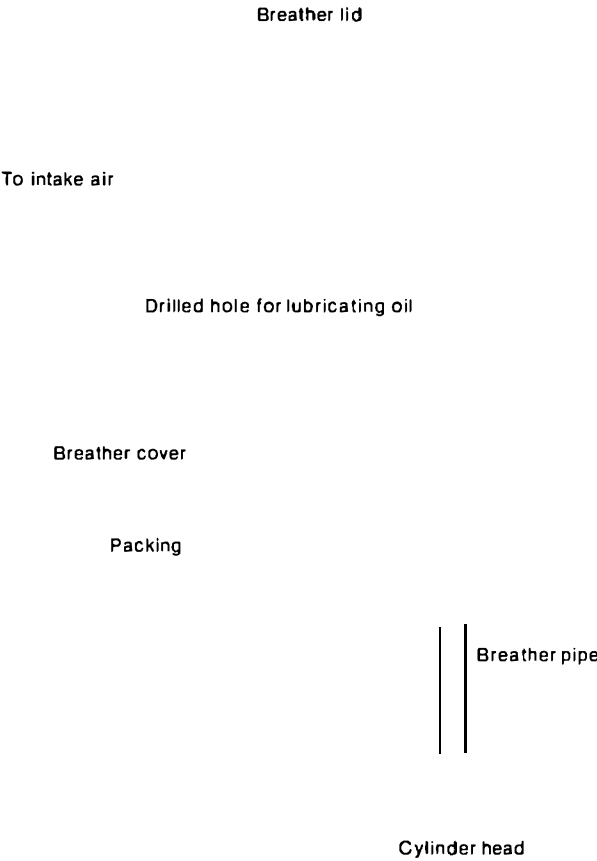
NOTE: If trouble is experienced with the breather, take care that the engine does not jolt when running as the lubricating oil may enter from the inlet port and mix with the fuel oil.

4-1.1 Breather for model 1GM

The vapor which lifts up the leaf spring fitted at the top of the bonnet then enters the other air chamber, and is sucked through the intake port.



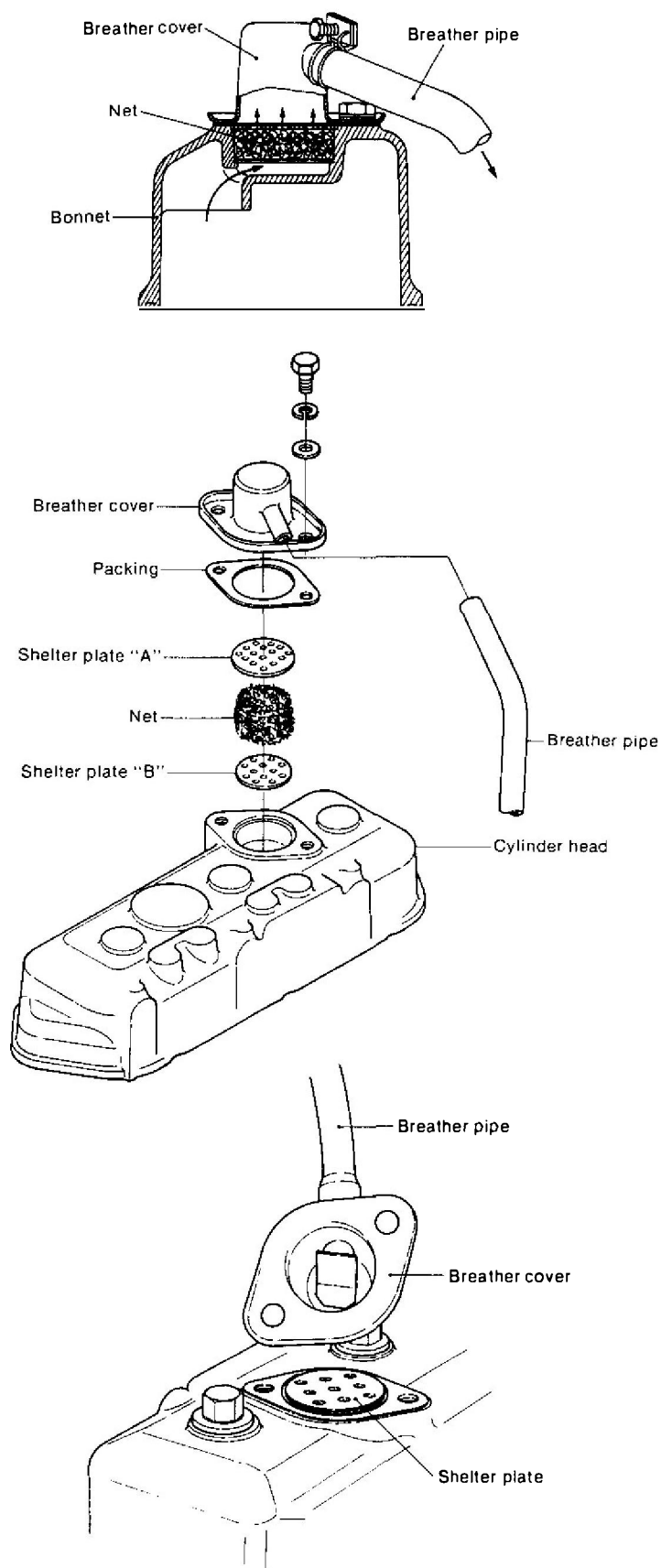
4-1.2 Breather for models 2GM and 3GM(D)



The deflector panel fitted to the breather lid enters the air chamber, and forces air circulation.

Breather pipe

4-1.3 Breather for model 3HM



CHAPTER 6

LUBRICATION SYSTEM

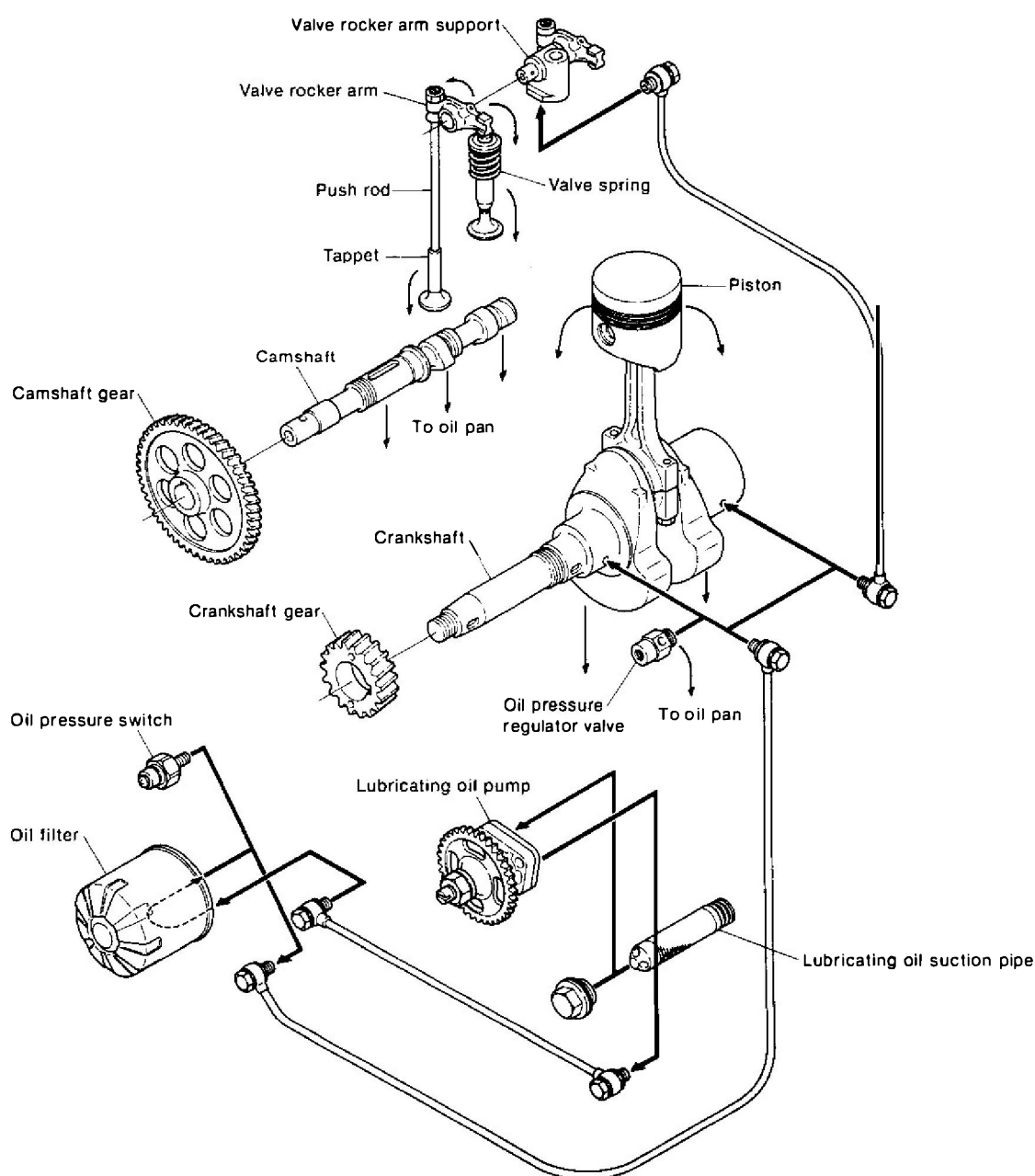
1. Lubrication System	6-1
2. Oil Pump	6-5
3. Oil Filter	6-9
4. Oil Pressure Regulator Valve	6-12
5. Oil Pressure Measurement	6-14

1. Lubrication System

Engine parts are lubricated by a trochoid pump forced lubrication system. To keep the engine exterior uncluttered and to eliminate vibration damage to piping, exterior piping has been minimized by transporting the lubricating oil through passages drilled in the cylinders and timing gear case.

1-1 Lubricating oil passage of model 1GM

The lubricating oil filling port is located at the top of the timing gear case, and lubricating oil that is poured into the filler is stored in the oil sump after passing through the casting hole in the cylinder wall. The lubricating oil in the oil sump is drawn up the suction pipe through the drilled hole in the cylinder by the action of the trochoid pump, and it is then fed to the lubricating oil filter after passing through the drilled hole in the filter mounting base. The lubricating oil which has passed through the filter is fed through a pipe to the main gallery of the cylinder, and then fed to the main bearing through the oil pressure regulator valve.



1-2 Lubrication oil passage of model 2GM

The lubricating oil supplied from the oil filter in the rocker arm cover is collected in the oil pan at the bottom of the cylinder block through the tappet holes.

The lubricating oil is drawn back up through the lubricating oil suction pipe by the trochoid pump and fed to the oil filter, where impurities are filtered out. Then it is adjusted to the prescribed pressure by the oil pressure regulating valve and sent to the main bearing.

The lubricating oil sent to the gear side main bearing flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft.

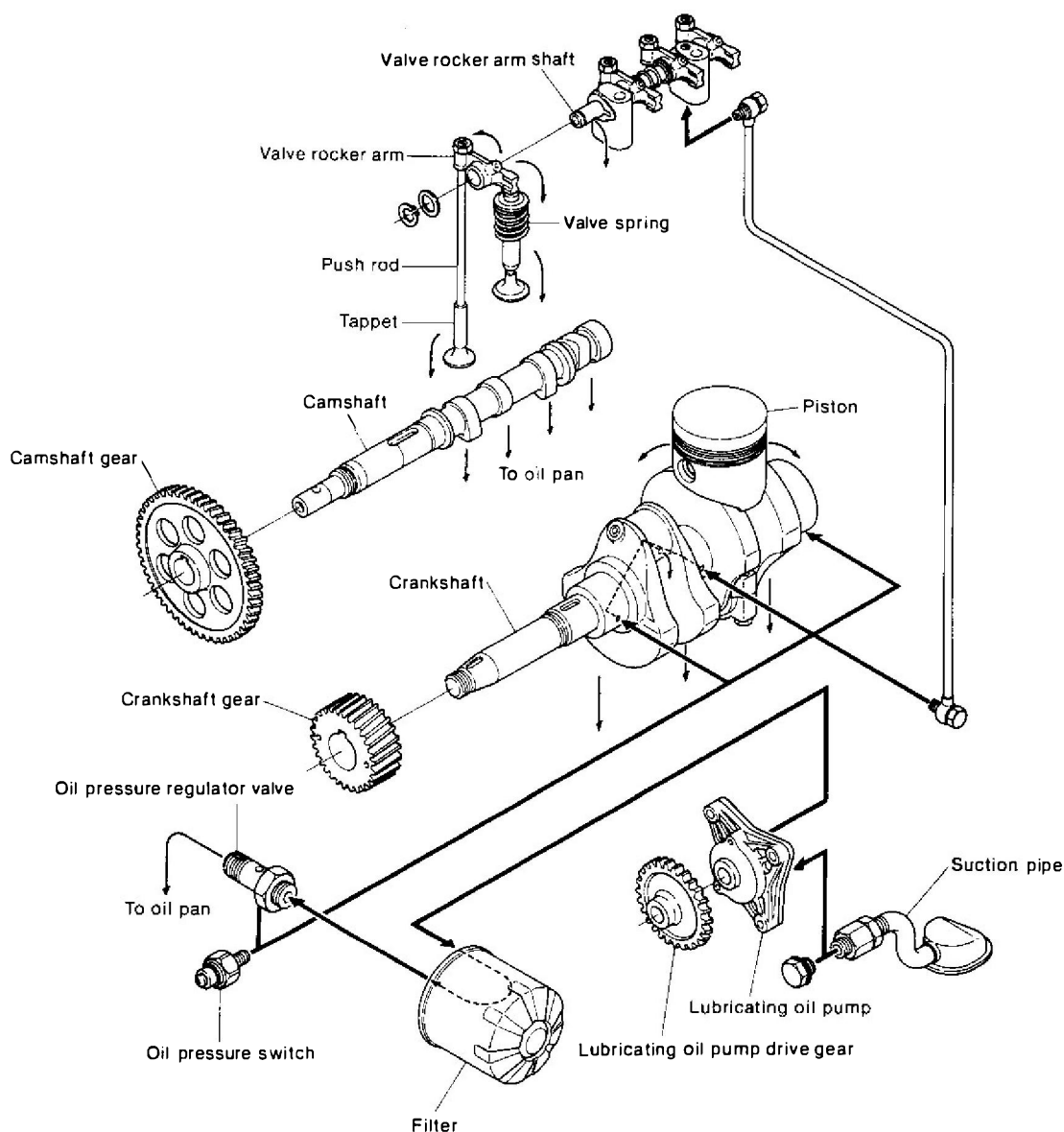
The lubricating oil sent to the flywheel side main bearing also flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft, and the other to the rocker arm shaft through

the hole drilled through the cylinders and cylinder head.

From the rocker arm shaft, the lubricating oil flows through the small hole in the rocker arm to lubricate the push rods and part of the valve head.

The oil that has dropped to the push rod chamber from the rocker arm chamber lubricates the tappets, cam and cam bearing, and returns to the oil pan.

The pistons, piston pins and contact faces of the cylinder liners are splash lubricated by the oil that has lubricated the crank pin. Moreover, an oil pressure switch is provided in the lubricating system to monitor normal circulation and pressure of the lubricating oil. When the lubricating oil pressure drops 0.5kg/cm^2 (7.114 lb/in.^2), the oil pressure switch illuminates the oil pressure lamp on the instrument panel to notify the operator.



1-3 Lubrication oil passage of model 3GM(D) and 3HM

