YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

1GM (10L)

2GM (F)(L)

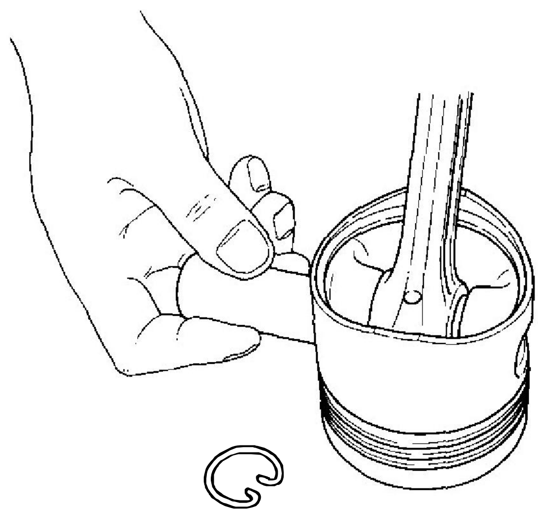
3GM (D)(F)(L)

3HM (F)(L)

mm (in.)

	1GM, 2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston outside diameter (At right angles to the piston pin, at a point 9.0mm (0.3543in.) from the bottom	$ø72^{-0.057}_{-0.087}$ (2.8312 ~ 2.8324)	71.85 (2.8287)	$ø75^{-0.063}_{-0.093}$ (2.9491 ~ 2.9503)	74.85 (2.9489)
Piston pin hole inside diameter	$ø20^{+0.008}_{-0.005}$ (0.7872 ~ 0.7877)	—	$ø23^{+0.008}_{-0.005}$ (0.9053 ~ 0.9058)	—
First compression piston ring-to-groove clearance	0.06 ~ 0.10 (0.0024 ~ 0.0039)	0.20 (0.0079)	0.065 ~ 0.10 (0.0026 ~ 0.0039)	0.20 (0.0079)
Second compression piston ring-to-groove clearance	0.035 ~ 0.07 (0.0014 ~ 0.0028)	0.20 (0.0079)	0.035 ~ 0.07 (0.0014 ~ 0.0028)	0.20 (0.0079)
Oil ring-to-groove clearance	0.02 ~ 0.055 (0.0008 ~ 0.0022)	0.15 (0.0059)	0.020 ~ 0.055 (0.0008 ~ 0.0022)	0.15 (0.0059)

(3) Piston pin outside contact and ring groove carbon build-up.
check if the piston ring grooves are clogged with carbon, if the rings move freely, and for abnormal contact around the outside of the piston. Repair or replace the piston if faulty.

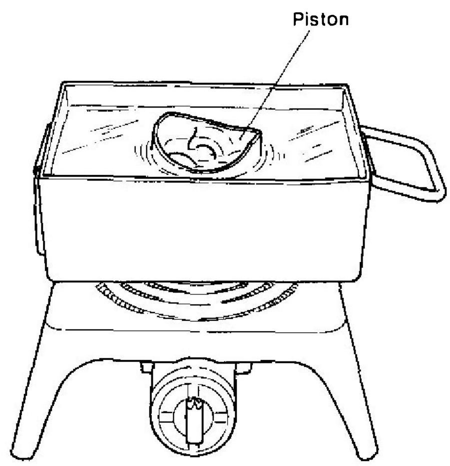


4-2.2 Replacing a piston

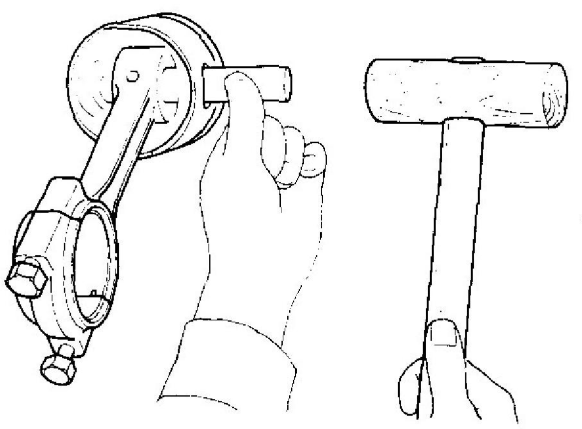
If the dimension of any part is worn past the wear limit or outside of the piston is scored, replace the piston.

(1) Replacement

1) Install the piston pin circlip at one side only.
2) Immerse the piston in 80°C oil for 10 ~ 15 minutes.



3) Remove the piston from the hot oil and place it on a bench with the piston head at the bottom.
4) Insert the small end of the connecting rod into the piston, insert the piston pin with a rotating motion, and install the other piston pin circlip.
Use wooden hammer if necessary.



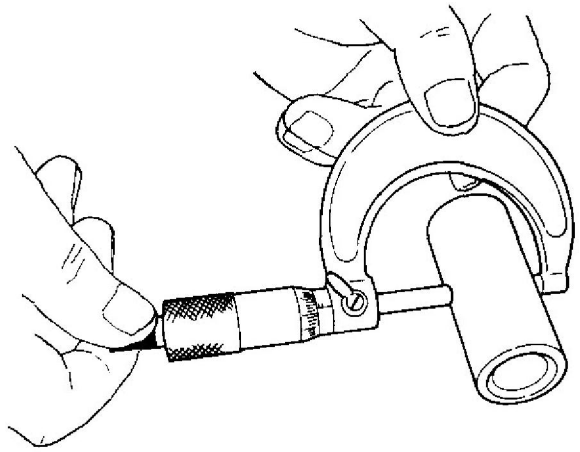
(2) Precautions

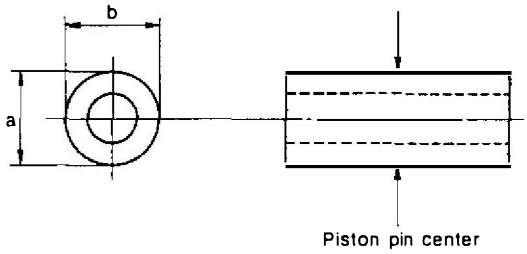
1) Before inserting, check whether the piston pin is in the connecting rod.
2) Coat the piston pin with oil to facilitate insertion.
3) Check that the connecting rod and piston move freely.
4) Insert the pin quickly, before the piston cools.

4-3 Piston pin and piston pin bushing

4-3.1 Pistonpin

Measure the dimensions of the piston pin, and replace the pin if it is worn past the wear limit or severely scored.





Maximum wear measured in (a) (b) directions at central position marked*

mm (in.)

	1GM, 2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin outside diameter	$\varnothing 20^{0}_{-0.009}$ (0.7870 ~ 0.7874)	ø19.98 (0.7866)	$\varnothing 23^{0}_{-0.009}$ (0.9052 ~ 0.9055)	ø22.98 (0.9047)
Piston pin hole and piston pin tightening allowance	−0.005 ~ +0.017 (−0.0002 ~ +0.0007)	—	−0.005 ~ +0.017 (−0.0002 ~ +0.0007)	—

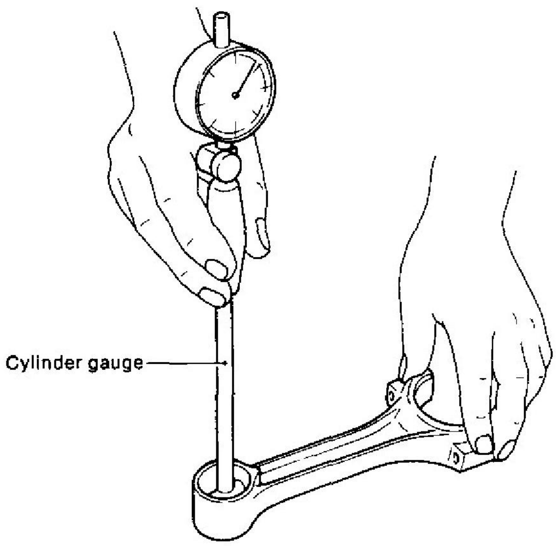
4-3.2 Piston pin bushing

A copper alloy wound bushing is pressed onto the piston pin.
Since a metallic sound will be produced if the piston pin and piston pin bushing wear is excessive, replace the bushing when the wear limit is exceeded.
The piston pin bushing can be easily removed and installed with a press. However, when installing the bushing, be careful that it is not tilted.

mm (in.)

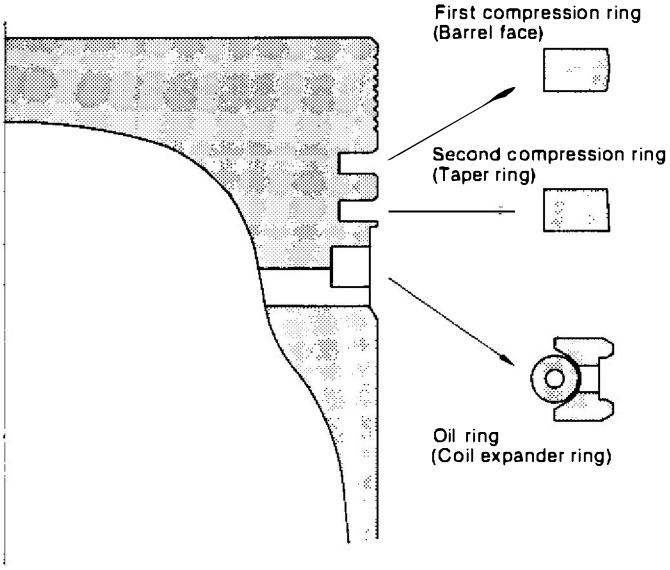
	1GM, 2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ø20.0 (0.7874)	ø20.1 (0.7913)	ø23.0 (0.9055)	ø23.1 (0.9094)

NOTE: "Piston pin bushing inside diameter" is the dimension after pressing onto the connecting rod.



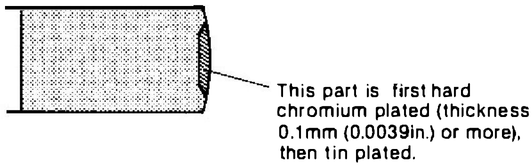
4-4 Piston rings

4-4.1 Piston ring configuration

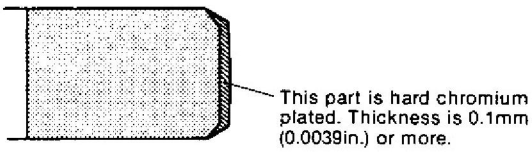


(1) The first compression ring is a barrel face ring that effectively prevents abnormal wear caused by engine loading and combustion gas blowby at initial run-in.
The sliding surface is hard chromium plated.

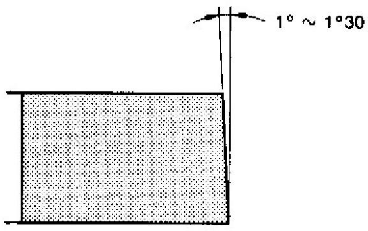
Models 1GM, 2GM and 3GM(D)



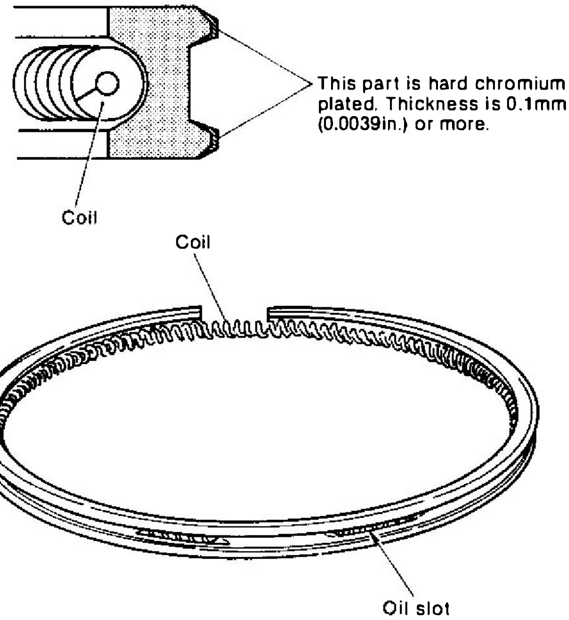
Model 3HM



(2) The second compression ring is a taper ring having a sliding face taper of 30′ ~ 1°30′. Since the cylinder liner is straight, and the contact area at initial operation is small, it is easily seated to the cylinder liner.
Moreover, the bottom of the sliding face is sharp, and oil splash is excellent and air-tightness is superb.



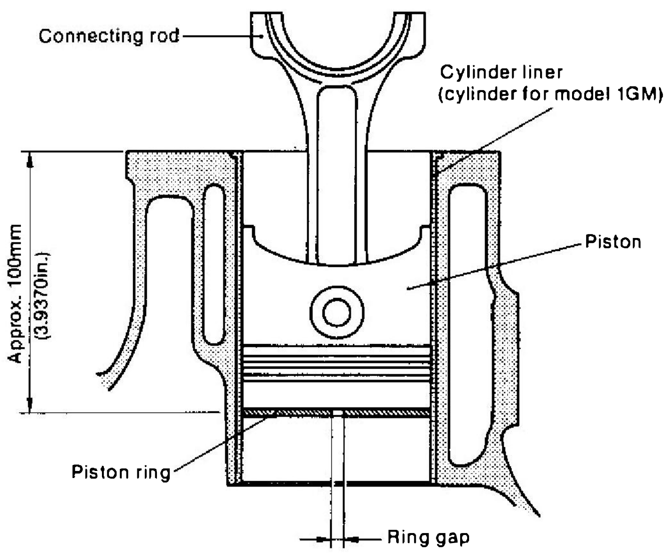
(3) The oil ring is a chrome-plated coil expander having a small contacting face, and exerts high pressure against the cylinder liner wall. Oil splash at the bottom of the sliding face is excellent, and its oil control effect is high.

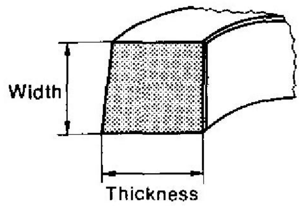


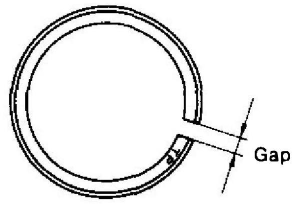
4-4.2 Inspection

(1) Piston ring contact
Inspect the piston ring contact, and replace the ring when contact is faulty. Since the oil ring side contact is closely related to oil consumption, it must be checked with particular care.

(2) Measuring the piston ring gap
Insert the piston into the cylinder or cylinder liner by pushing the piston ring at the head of the piston as shown in the figure, and measure the piston ring gap with a feeler gauge. Measure the gap at a point about 100mm (3.9370in.) from the top of the cylinder.
Measure by inserting a thickness gauge





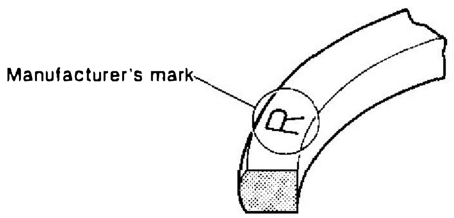


mm (in.)

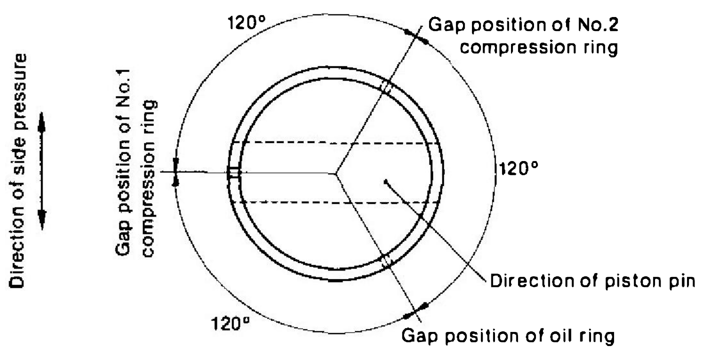
		1GM, 2GM, 3GM(D)		3HM	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston ring (1, 2)	Width	$2^{-0.01}_{-0.03}$ (0.0776 ~ 0.0783)	1.90 (0.0748)	$2^{-0.01}_{-0.03}$ (0.0776 ~ 0.0783)	1.90 (0.0748)
	Thickness	3.2±0.10 (0.1220 ~ 0.1299)	—	3.3±0.10 (0.1260 ~ 0.1339)	—
Oil ring	Width	$4^{-0.01}_{-0.03}$ (0.1563 ~ 0.1181)	3.90 (0.1535)	$4^{-0.01}_{-0.03}$ (0.1563 ~ 0.1571)	3.90 (0.1535)
	Thickness	2.8±0.20 (0.1024 ~ 0.1181)	—	2.6±0.20 (0.0945 ~ 0.1102)	—
Piston ring gap (1, 2)		0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)	0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)
Oil ring gap		(0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)	0.20 ~ 0.40 (0.0079 ~ 0.0157)	1.5 (0.0591)

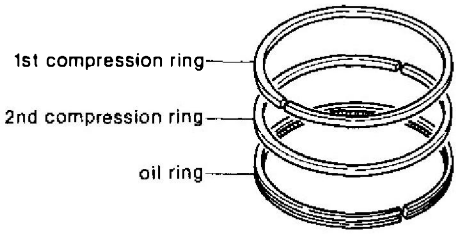
(3) Piston ring replacement precautions

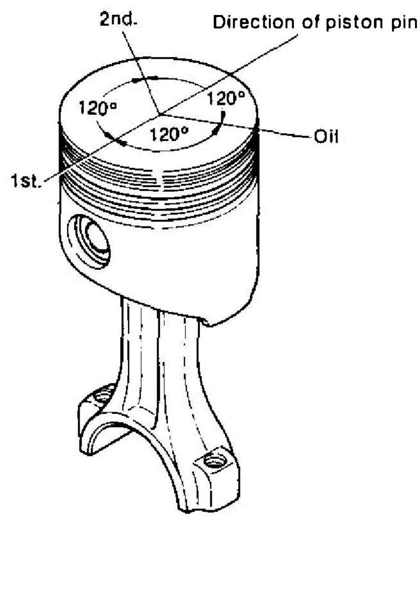
1) Clean the ring grooves carefully when replacing the rings.
2) When installing the rings, assemble the rings so that the manufacturer's mark near the gap is facing the top of the piston.



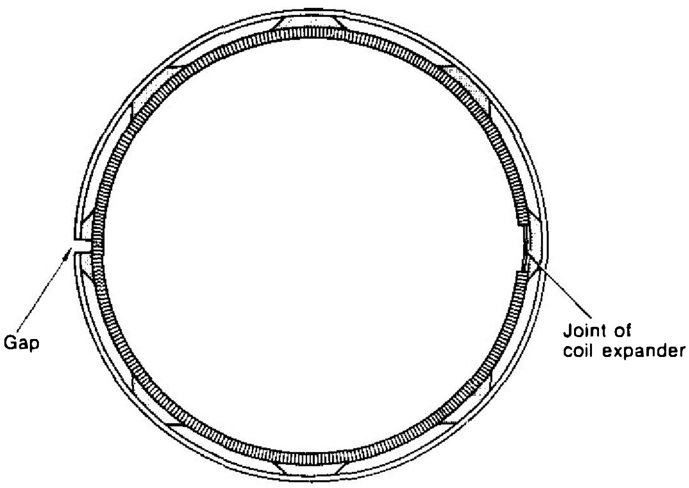
3) After assembly, check that the rings move freely in the grooves.
4) The rings must be installed so that the gaps are 120° apart. At this time, be careful that the ring gap is not lined up with the piston side pressure part.







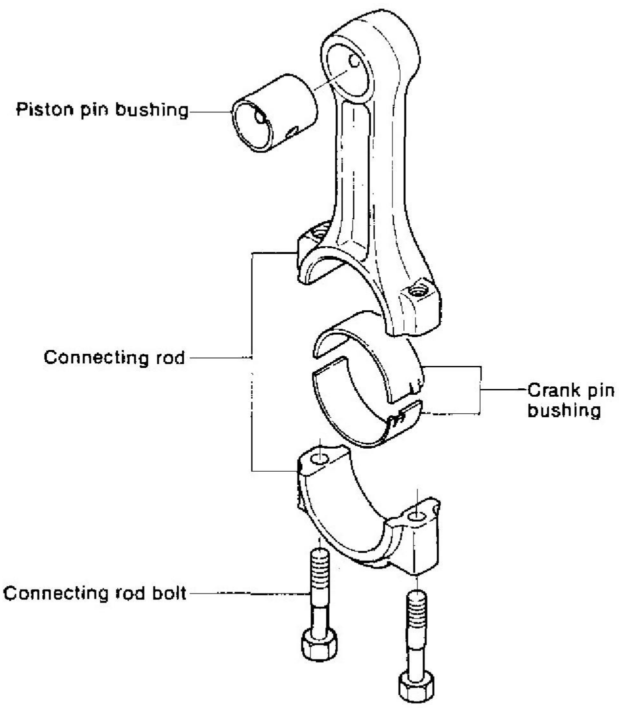
5) Since the oil ring is equipped with a coil expander, attach it to the piston so that the joint of the ring is opposite the gap of the coil expander.



5. Connecting Rod

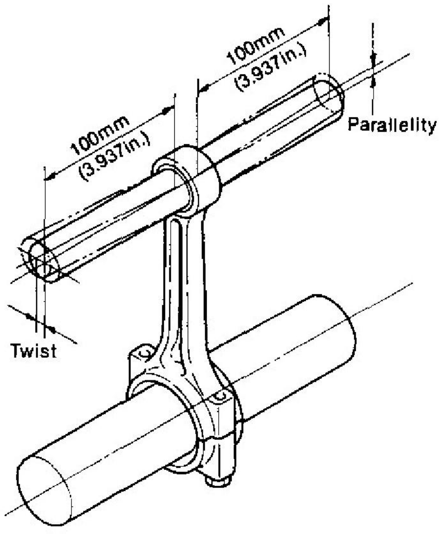
5-1 Connecting rod ass'y construction

The connecting rod connects the piston pin and crank pin and transmits the explosive force of the piston to the crankshaft. It is a stamp forging designed for extreme lightness and ample strength against bending. A kelmet bushing split at right angles Is installed to the large end of the rod, and a round copper alloy is pressed onto the small end.



5-2 Inspection

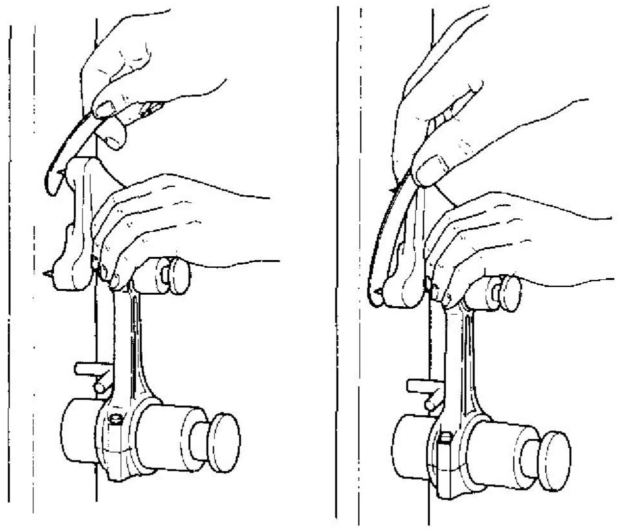
5-2.1 Large and small end twist and parallelity



Pass a test bar through the large end and small end holes of the connecting rod, place the bars on a V-block on a stool and center the large end test bar. Then set the sensor of a dial indicator against the small end test bar and measure twist and parallelity. When the measured value exceeds the wear limit, replace the connecting rod. Twisting and poor parallelity will cause uneven contact of the piston and bushing and shifting of the piston rings, resulting in compression leakage.

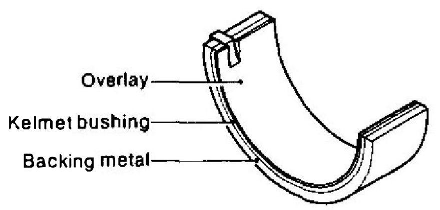
Connecting rod twist and parallelity mm (in.)

Maintenance standard	0.03/100 or less (0.00118/3.937)
Limit	0.08/100 (0.00315/3.937)


Measuring twist and parallelity

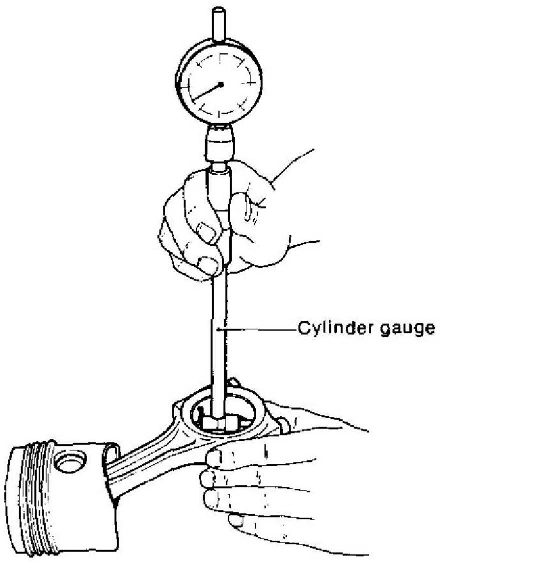
5-3 Crank pin bushing

Since the crank pin bushing slides while receiving the load from the piston, an easy-to-replace kelmet bushing with a wear-resistant overlay is used.



5-3.1 Crank pin bushing inside diameter

Tighten the large end of the connecting rod to the prescribed torque with the connecting rod bolts, and measure the inside diameter of the crank pin bushing. Replace the bushing if the inside diameter exceeds the wear limit or the clearance at the crank pin part exceeds the wear limit.



mm (in.)

	1GM, 2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank pin bushing inside diameter	ø40.0 (1.5748)	ø40.10 (1.5787)	ø44.0 (1.7323)	ø44.10 (1.7362)
Crank pin and bushing oil clearance	0.028∼0.088 (0.0011 ∼0.0034)	0.13 (0.0051)	0.036∼0.092 (0.0014 ∼0.0036)	0.13 (0.0051)
Connecting rod bolt Thread diameter	M7 × P1.0 (0.2755 × 0.0393)		M9 × P1.0 (0.3543 × 0.0393)	
Connecting rod bolt tightening torque	2.5 kg-m (18.1 ft-lb)		4.5 kg-m (32.5 ft-lb)	

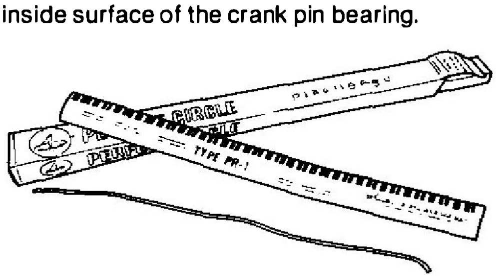
NOTE: The crank pin bushing inside diameter must always be measured with the connecting rod bolts tightened to the prescribed torque.

5-3.2 Crank pin and bushing clearance (oil clearance)

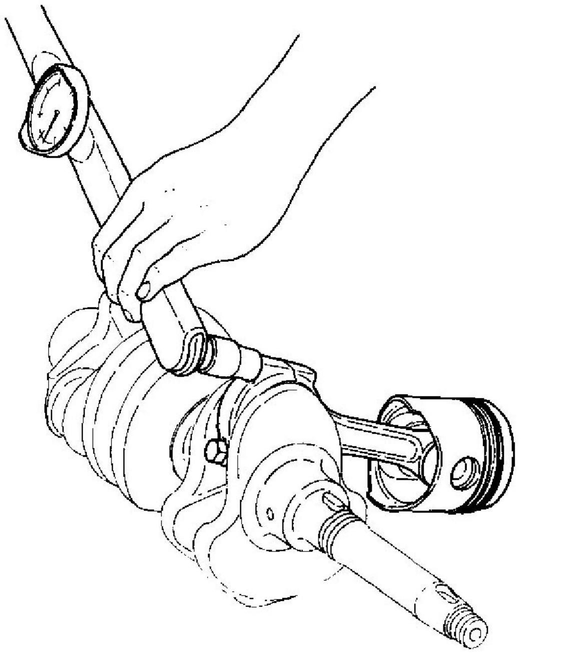
Since the oil clearance affects both the durability of the bushing and lubricating oil pressure, it must always be the prescribed value. Replace the bushing when the oil clearance exceeds the wear limit.

(1) Measurement

1) Thoroughly clean the inside surface and crank pin section of the crank pin bushing.
2) Install the connecting rod on the crank pin section of the crankshaft and simultaneously fit a Plasti gauge on the inside surface of the crank pin bearing.

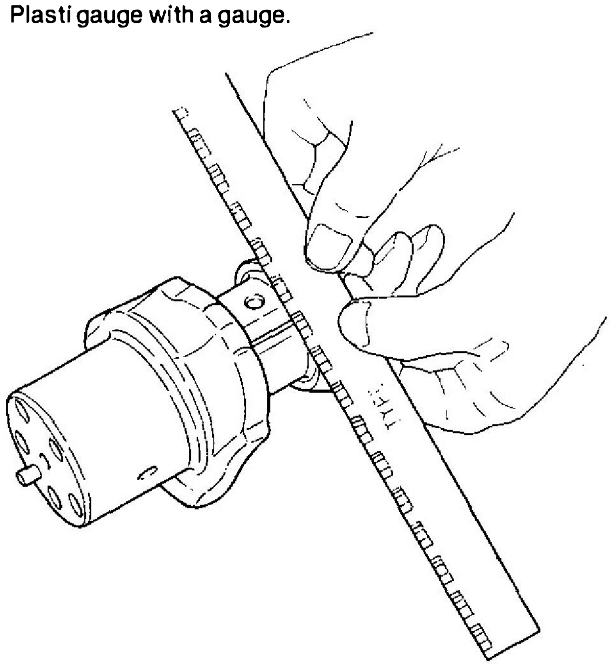


3) Tighten the connecting rod bolt to the prescribed tightening torque.



	1GM, 2GM, 3GM(D)	3HM
Connecting rod tightening torque	2.5 kg-m (18.1 ft-lb)	4.5 kg-m (32.5 ft-lb)
Hexagon width	12mm (0.4724in.)	13mm (0.5118in.)

4) Loosen the connecting rod bolt and slowly remove the connecting rod big end cap, then measure the crushed Plasti gauge with a gauge.



NOTE: Never adjust by shims or machine the crank pin bushing. Always replace the crank pin bushing with a new one.

5) The crank pin and bushing clearance (oil clearance) may also be measured with a micrometer, in addition to measurement with a Plasti gauge. With this method, the outside diameter of the crankshaft crank pin section and the inside diameter of the connecting rod's big end bushing, when the connecting rod bolt has been tightened to the prescribed torque, are measured, and the difference between the large end bushing inside diameter and crank pin outside diameter is set as the oil clearance.

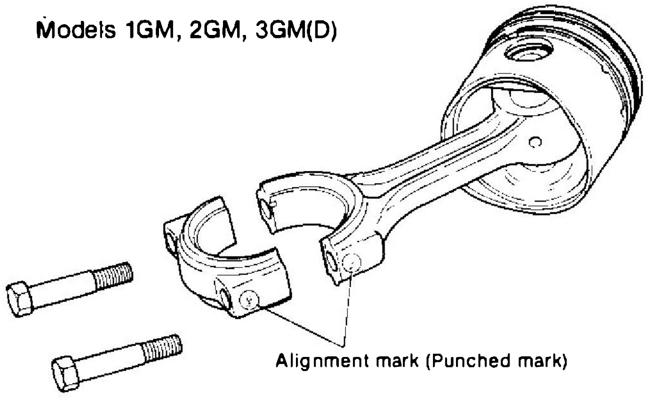
(2) Measurement precautions

1) Be careful that the Plasti gauge does not enter the crank pin oil hole.
2) Be sure that the crankshaft does not turn when tightening the connecting rod bolt.

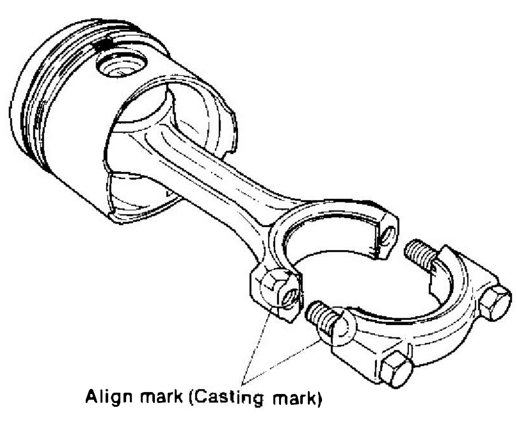
5-3.3 Crank pin bushing replacement precautions

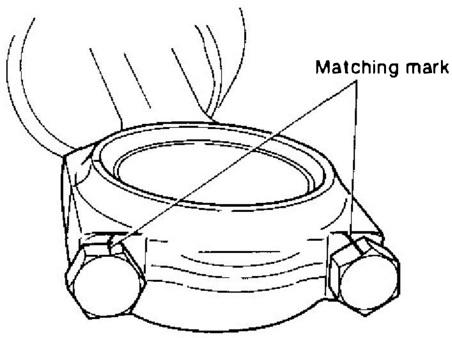
(1) Thoroughly clean the crank pin bushing and the rear of the crank pin bushing.
(2) Also clean the big end cap, and install the crank pin bushing and check if the bushing contacts the big end cap closely.
(3) When assembling the connecting rod, match the number of the big end section and the big end cap, coat the bolts with engine oil, and alternately tighten the bolts gradually to the prescribed tightening torque. If a torque wrench is not available, put matching marks (torque indication lines) on the bolt head and big end cap before disassembly and tighten the bolts until these two lines are aligned.

Models 1GM, 2GM, 3GM(D)



Model 3HM

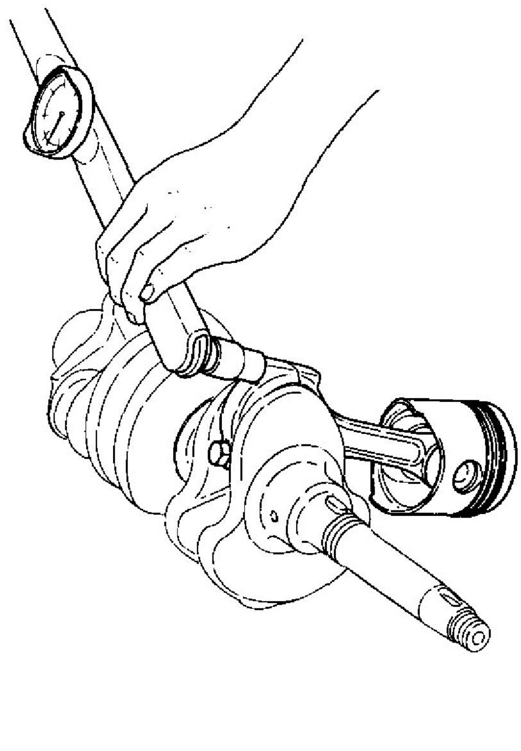




(4) Check that there is no sand or metal particles in the lubricating oil and that the crankshaft is not pitted. Clean the oil holes with particular care.

5-4 Tightening the connecting rod bolts

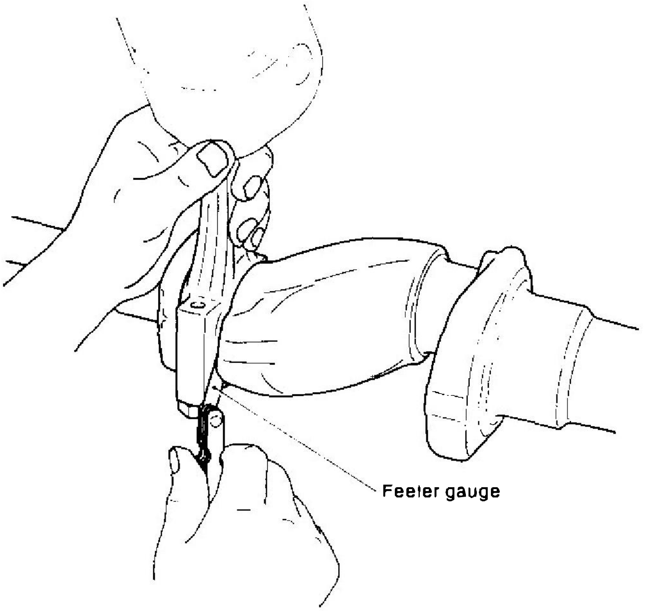
When tightening the connecting rod bolts, coat the threads of the bolts with engine oil.
Tighten the two bolts alternately and gradually to the prescribed tightening torque. If a torque wrench is not available, make matching marks (torque indication lines) on the head of the bolt and the big end cap and tighten the bolts until these two marks are aligned.



5-5 Connecting rod side clearance

After installing the connecting rod on the crankshaft, push the rod to one side and measure the side clearance by inserting a feeler gauge into the gap produced at the other side.

The connecting rod bolts must also be tightened to the prescribed tightening torque in this case.

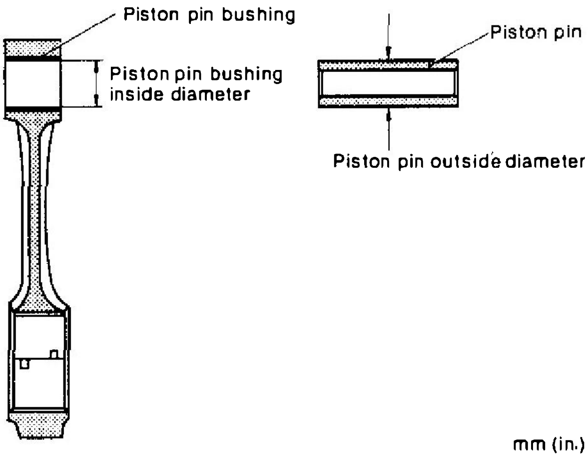


mm (in.)

	1GM, 2GM, 3GM(D)	3HM
Connecting rod side clearance	0.2 ~ 0.4 (0.0079~0.0157)	0.2 ~ 0.4 (0.0079~0.0157)

5-6 Piston bushing and piston pin

The piston bushing is a round copper alloy bushing driven onto the small end of the connecting rod. During use, the piston pin bushing and piston pin will wear. If this wear becomes excessive, a metallic sound will be produced and the engine will become noisy.

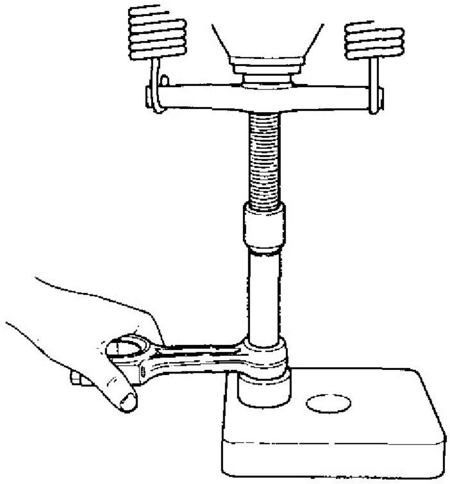


mm (in.)

	1GM, 2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ø20.0 (0.7874)	ø20.10 (0.7913)	ø23.0 (0.9055)	ø23.1 (0.9094)
Piston and bushing clearance	0.025~0.047 (0.0010 ~0.0019)	0.11 (0.0043)	0.025~0.047 (0.0010 ~0.0019)	0.11 (0.0043)

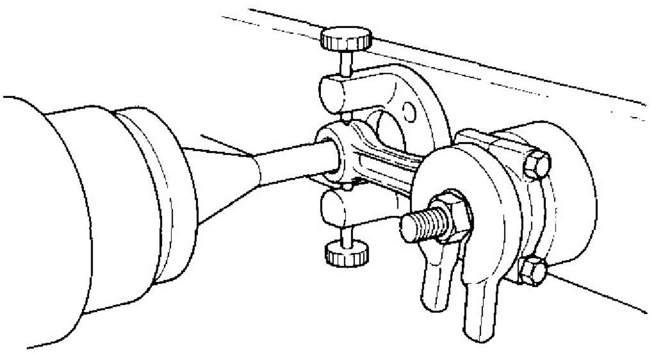
Replacing the piston pin bushing

(1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.



NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

(2) After forcing the piston pin bushing into position, finish the inner surface of the bushing by using a pin honing machine or reamer so that it fits the piston pin to be used.



NOTE: Attach the bushing to the piston pin so that a pin, coated with engine oil can be pushed into position with your thumb.

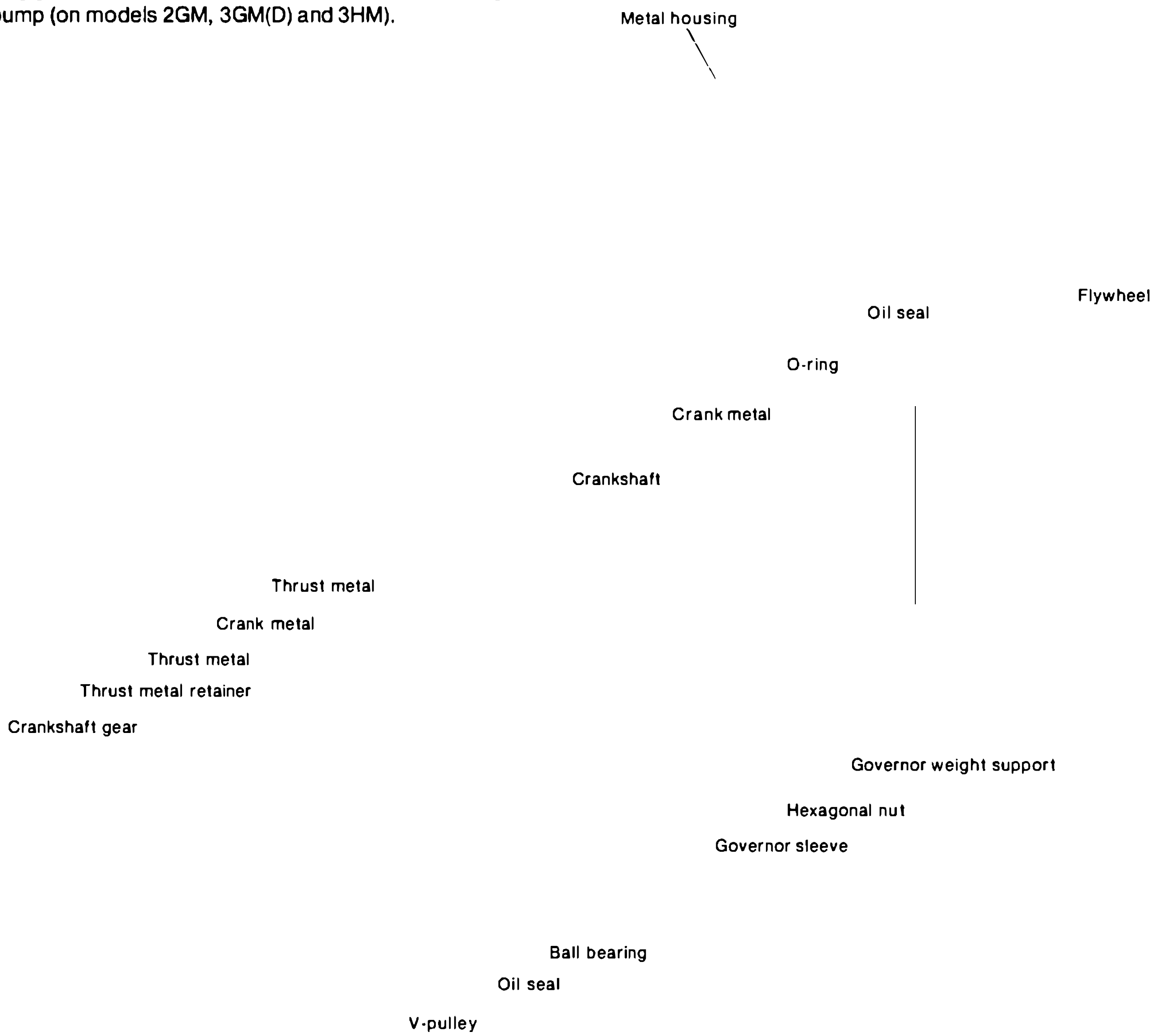
6. Crankshaft

6-1 Crankshaft ass'y and bearing construction

The crankshaft is stamp-forged, and the crank pin and journal sections are high-frequency induction hardened; and ground and polished to a high precision finish. Therefore, the contact surface with the bushing is excellent and durability is superb.
The crankshaft is a balance weight integral type. Engine unbalance, which causes vibration, has been minimized by balancing the V-pulley, flywheel, and crankshaft.
The flywheel is fixed at the end of the crankshaft with hexagonal bolts and a locating pin. The crankshaft gear is fixed and keyed to the crankshaft inside the timing gear case, and the governor weight support is fixed with a hexagonal nut together with the crankshaft gear. It is so designed that the governor sleeve and the thrust bearing can be slid onto the crankshaft to get the gear side end of the crankshaft to perform as the governor shaft. The V-pulley is fitted outside the timing gear case and it drives the alternator and cooling water pump (on models 2GM, 3GM(D) and 3HM).

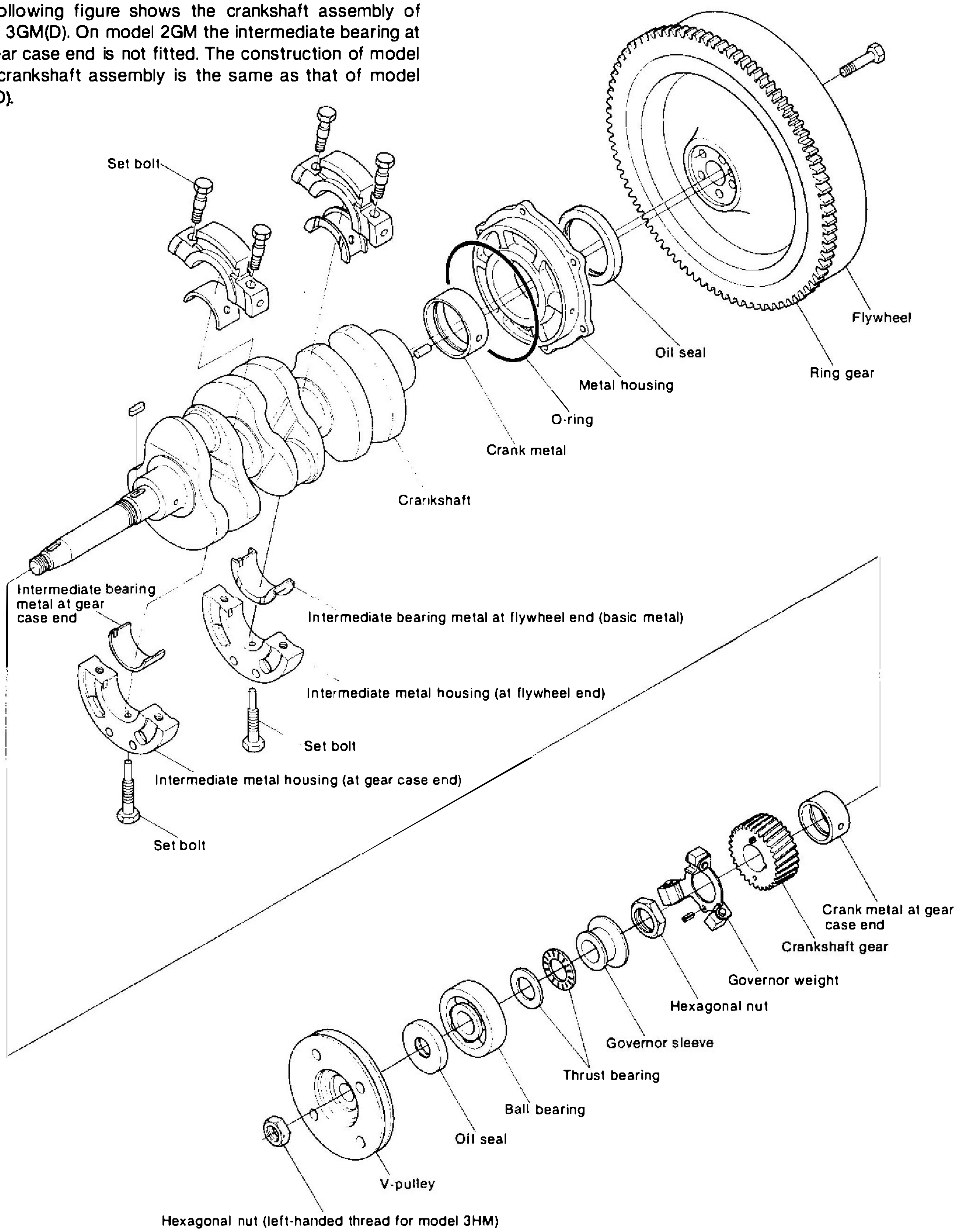
6-1.1 Construction of model 1GM

Crankshaft assembly
The crankshaft is supported by the metal housing at the flywheel end, and by the bearing metal which is inserted into the cylinder body hole at the gear case end. Thrust metals are set at both sides of the bearing at the gear case end.



6-1.2 Construction of models 2GM, 3GM(D) and 3HM crankshaft assembly

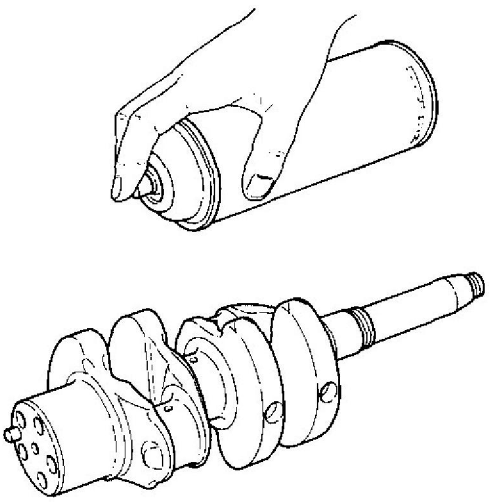
The following figure shows the crankshaft assembly of model 3GM(D). On model 2GM the intermediate bearing at the gear case end is not fitted. The construction of model 3HM crankshaft assembly is the same as that of model 3GM(D).



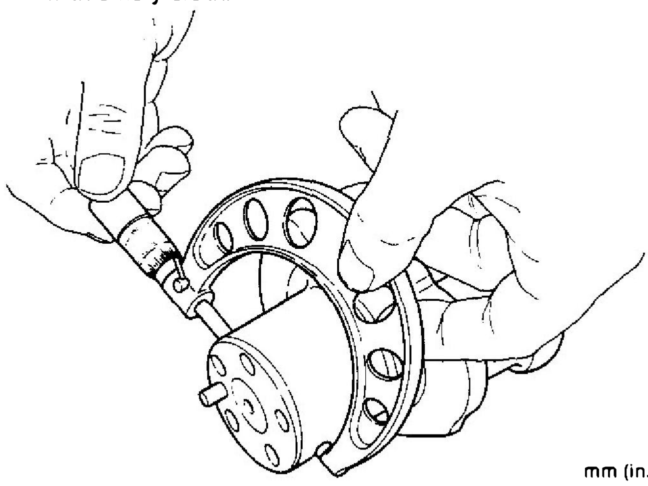
6-2 Inspection

6-2.1 Crank journal and crank pin

(1) Cracking
If cracking of the crank journal or crank pin is suspected, thoroughly clean the crankshaft and perform a color check on the shaft, or run a candle flame over the crankshaft and look for oil seepage from cracks. If any cracks are detected, replace the crankshaft.



(2) Crank pin and crank journal outside diameter measurement.
When the difference between the maximum wear and minimum wear of each bearing section exceeds the wear limit, replace the crankshaft. Also check each bearing section for scoring. If the scoring is light, repair it with emery cloth.

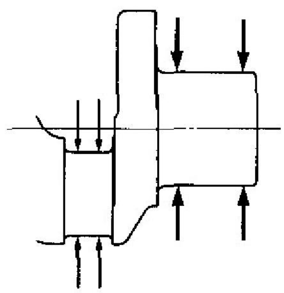


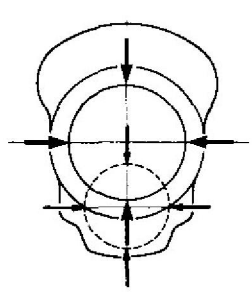
mm (in.)

			1GM, 2GM, 3GM(D)		3HM	
			Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank journal outside diameter	Gear case side	A	$\varnothing 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\varnothing 47^{-0.036}_{-0.050}$ (1.6484 ~ 1.8490)	ø46.90 (1.6465)
	Intermediate bearing	B	$\varnothing 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\varnothing 47^{-0.036}_{-0.050}$ (1.8484 ~ 1.8490)	ø46.90 (1.6465)
	Flywheel side	C	$\varnothing 60^{-0.036}_{-0.050}$ (2.3602 ~ 2.3608)	ø59.90 (2.3583)	$\varnothing 65^{-0.036}_{-0.050}$ (2.5571 ~ 2.5576)	ø64.90 (2.5551)
Crank pin outside diameter		D	$\varnothing 40^{-0.036}_{-0.050}$ (1.5728 ~ 1.5734)	ø39.90 (1.5709)	$\varnothing 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)
Crank journal/pin eccentric wear			—	0.01 (0.0004)	—	0.01 (0.0004)
Crank journal and bushing oil clearance	Gear case side		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
	Intermediate bearing		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
	Flywheel side		0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)	0.036 ~ 0.099 (0.0014 ~ 0.0039)	0.15 (0.0059)
Crank pin and crank pin bearing oil clearance			0.028 ~ 0.086 (0.0011 ~ 0.0034)	0.13 (0.0051)	0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.13 (0.0051)

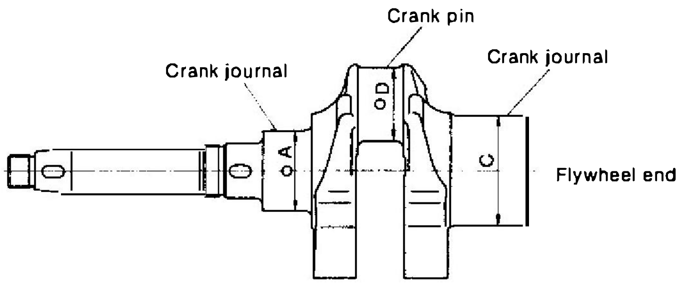
NOTE: The crankshaft of model 1GM does not have an intermediate bearing.

Measurement must be taken in at least 2 positions in the direction of crankshaft center line for each journal, and in each measurement, maximum and minimum wear directions must be measured. From these results, eccentric wear and maximum wear can be determined.

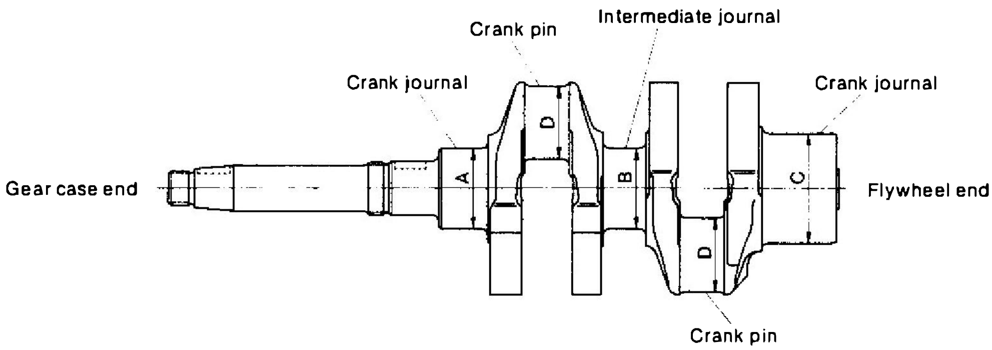




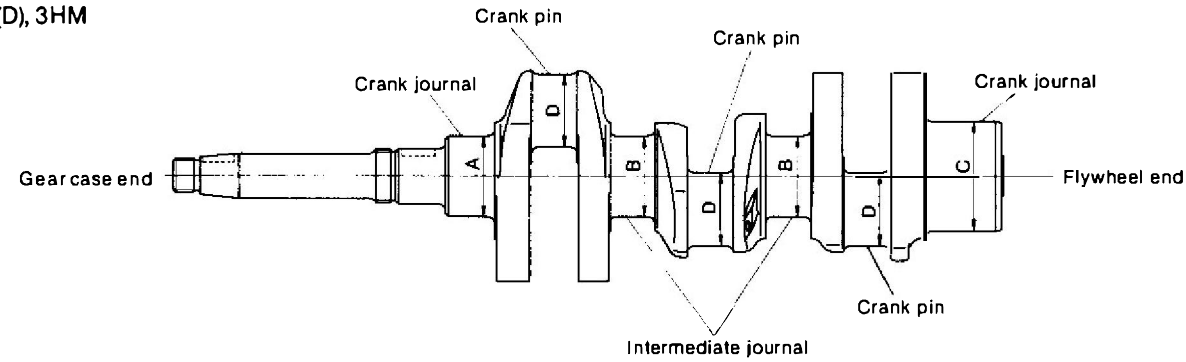
1GM



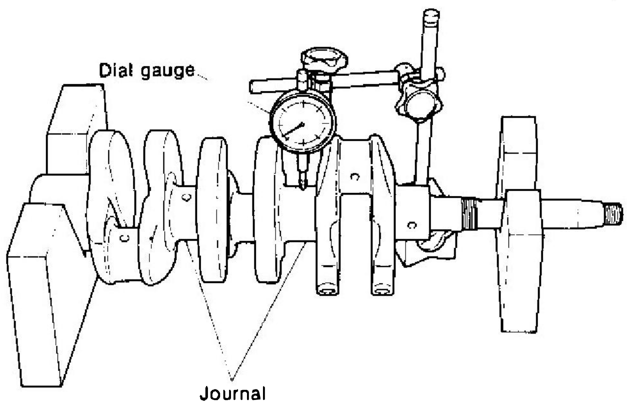
2GM

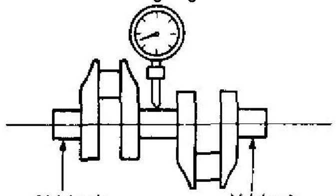


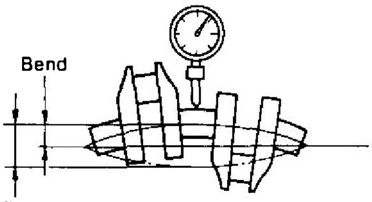
3GM(D), 3HM



(3) Measuring the crankshaft bend (2GM, 3GM(D), 3HM)
Measure on a surface plate. Place the journal parts of both ends of the crankshaft on a V-block and measure with a dial gauge while moving the crankshaft in an axial direction. If the deflection of the middle of the crankshaft exceeds the limit, replace the crankshaft.







mm (in.)

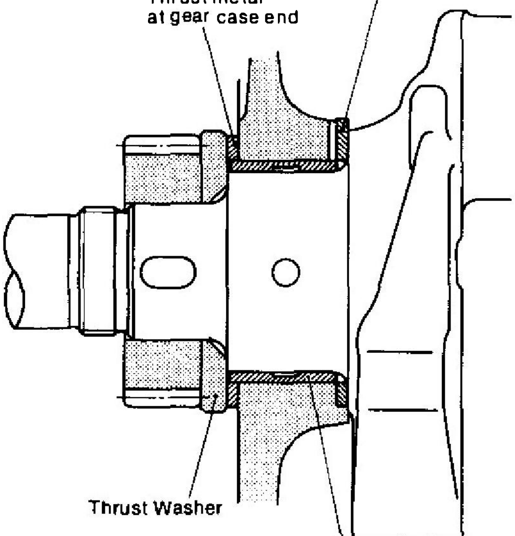
	Maintenance standard	Wear limit
Crankshaft bend	Less than 0.015 (0.0006)	0.15 (0.006)

6-3 Crankshaft side gap

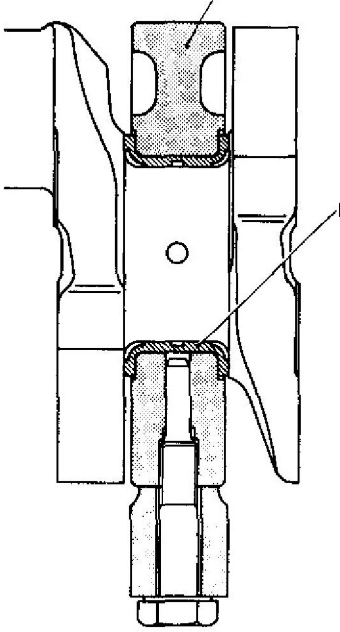
6-3.1 Side gap

The clearance in the axial direction after the crankshaft has been assembled is called the side gap.
If the side gap is too large, contact with pistons will be uneven, the clutch disengagement position will change, and other troubles will occur. If it is too small, the crankshaft sliding resistance will increase and cranking will become stiff.

For model 1GM
Adjust the side gap to the maintenance standard by the thickness of the crankshaft thrust metal.
Thrust metals are installed on both sides of the crankcase and gear case.

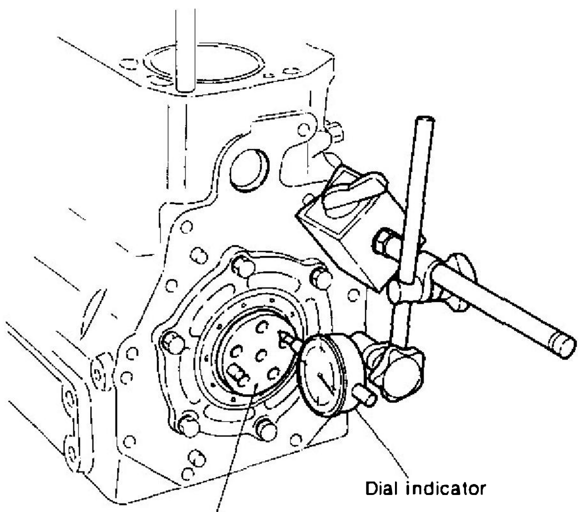


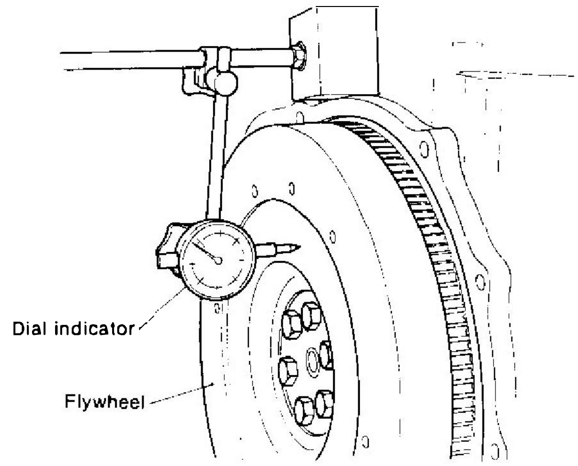
On models 2GM and 3GM(D), the value of the side gap is the difference between the width of the basic bearing metal and the width of the journal. The basic bearing for model 2GM is the intermediate bearing, and for models 3GM(D) and 3HM it is the intermediate bearing at the flywheel end.



6-3.2 Measuring side gap

Set a dial indicator against the end of the crankshaft (or end of the flywheel) and measure the amount of movement of the crankshaft in the axial direction. If the measured value exceeds the wear limit, replace the crankshaft thrust washer. Main bearing housing packing of the prescribed thickness must be used.





6-3.3 Side gap maintenance standard and wear limit

mm (in.)

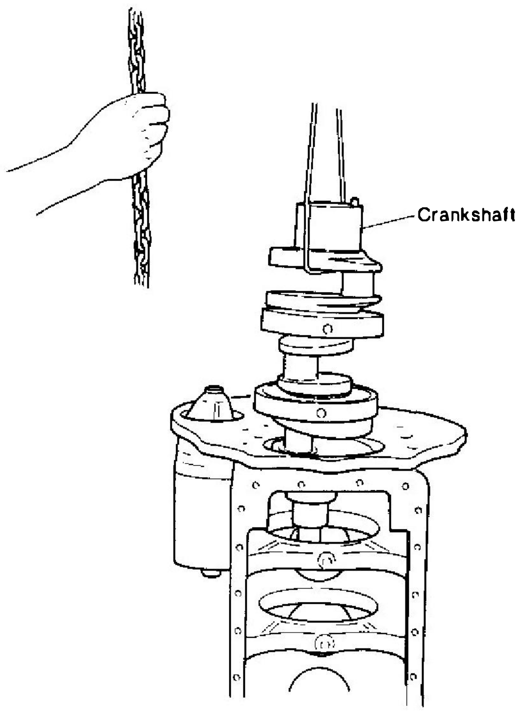
	1GM		2GM, 3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank shaft side gap	0.06 ~ 0.19 (0.0024 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.19 (0.0035 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.18 (0.0035 ~ 0.0071)	0.30 (0.0012)

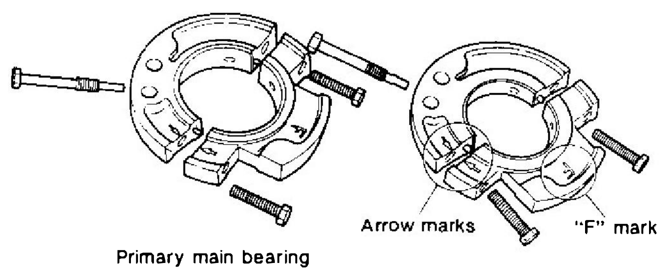
6-4 Disassembly of the crankshaft (2GM, 3GM (D), 3HM)

For model 1GM see the chapter on disassembly and reassembly. Because there are points over which care must be taken in model 2GM, 3GM(D) and 3HM, disassembly and reassembly procedures are explained below.

6-4.1 Disassembly

(1) When disassembling, lay the cylinder down with the main bearing housing side on top so that the crankshaft will be vertical for easy operation.
(*Remove the crank gear and flywheel beforehand.)
(2) Remove the main bearing housing.
(3) Attach a rope to the crankshaft, gradually lifting it with chain block etc. and remove the two set bolts of the intermediate main bearing housing. (If the crankshaft is lifted too much or not enough, the set bolts will be difficult to release.)
(4) Lift and remove the crankshaft (with the intermediate main bearing housing).
(5) Remove each intermediate main bearing housing from the crankshaft.





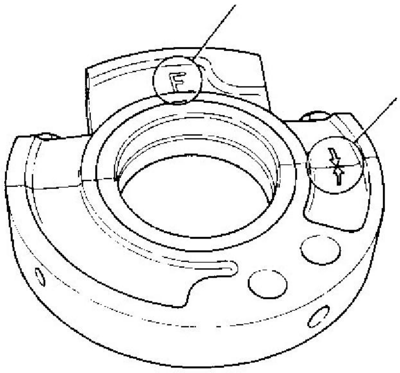
6-4.2 Reassembly

(1) Clean each part before reassembly.

(2) Attach the intermediate main bearing housing to the crankshaft and confirm that the crankshaft rotates smoothly.

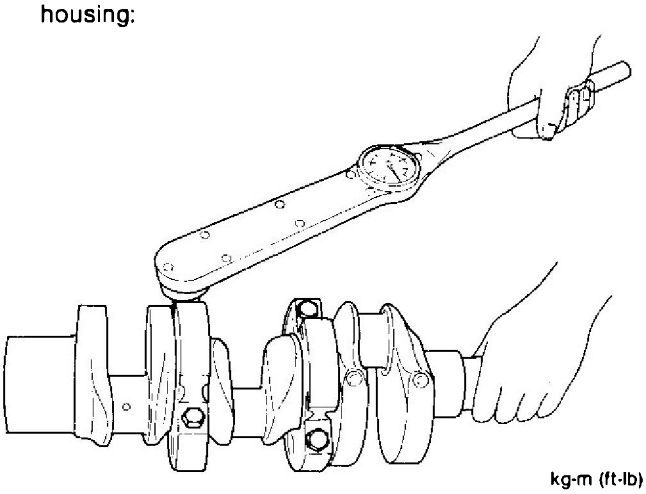
1) Assembling position and direction of the intermediate main bearing housing.

- The "F" mark on the intermediate main bearing housing indicates the direction of assembly on the crankshaft flywheel.



- Align the arrow marks pointing up and down on the side of the intermediate main bearing housing and assemble it so that the "F" mark is in the direction of the flywheel.
- Assemble, integrated with thrust bearing, the intermediate main bearing on the flywheel side (between cylinder No. 1 and 2).

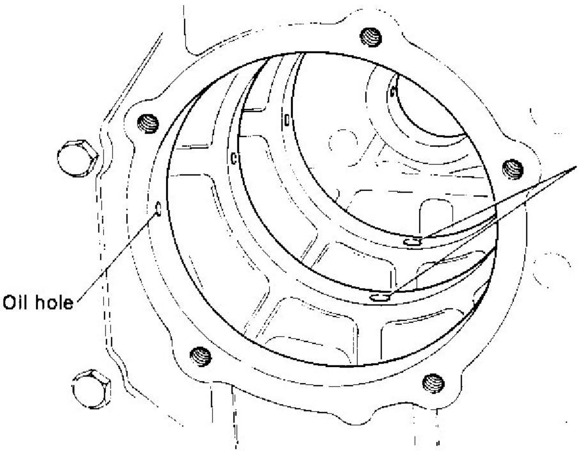
2) Tightening torque of hexagonal bolts for affixing the top and bottom of the intermediate main bearing housing:



kg-m (ft-lb)

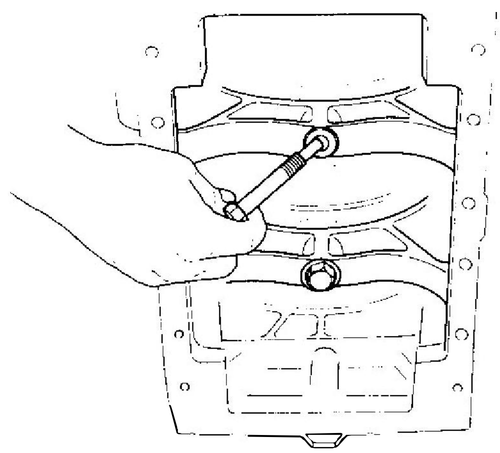
	2GM, 3GM(D)	3HM
Tightening torque	3.0 ~ 3.5 (21.7 ~ 25.3)	4.5 ~ 5.0 (32.5 ~ 36.2)

(3) Set up vertically the cylinder block, suspend the crankshaft and match the positions of the cylinder block oil hole and the intermediate main bearing housing set bolts to the intermediate main bearing housing.



(4) Attaching the intermediate main bearing housing set bolts.

1) First temporarily screw the set bolt in the intermediate main bearing housing on the timing gear housing side and with the prescribed tightening torque, start tightening from the intermediate main bearing housing on the flywheel side. After tightening the bolts confirm that the crankshaft rotates smoothly. (Each set bolt hole can be adjusted vertically.)



kg-m (ft-lb)

	2GM, 3GM(D)	3HM
Tightening torque of the set bolt	4.5 ~ 5.0 (32.5 ~ 36.2)	7.0 ~ 7.5 (50.6 ~ 54.2)

(5) Reassembly of the main bearing housing:

1) Enclose a small amount of oil inside the oil seal and assemble after coating the bearing with oil.

2) Be sure to place the "down" mark on the main bearing housing side in the downward direction.

kg-m (ft-lb)

	2GM, 3GM(D)	3HM
Main bearing housing tightening torque	2.5 (18.1)	2.5 (18.1)

6-5 Main bearing

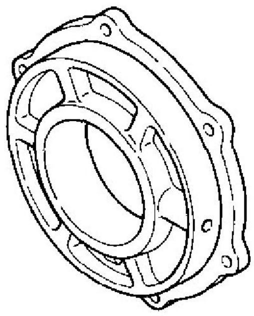
6-5.1 Construction

(1) Model 1GM

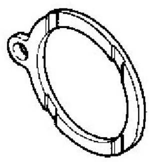
The main bearing consists of a crank bearing and thrust metal. The crank bearing is a round copper-leak sintered alloy bearing featuring superior durability.

The crankshaft bearing at the gear case end is inserted into the cylinder block, and at the flywheel end it is fitted into the metal housing.

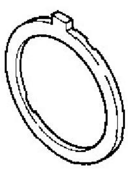
Two thrust metals are set on the bearing part at the gear case end; one is at the crankcase end and the other is at the gear case end.



Metal housing for model 1GM



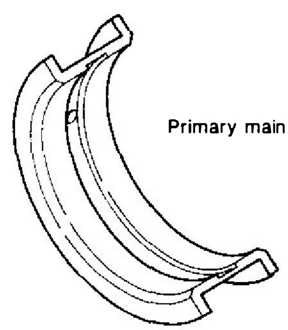
Thrust metal at gear case end for model 1GM

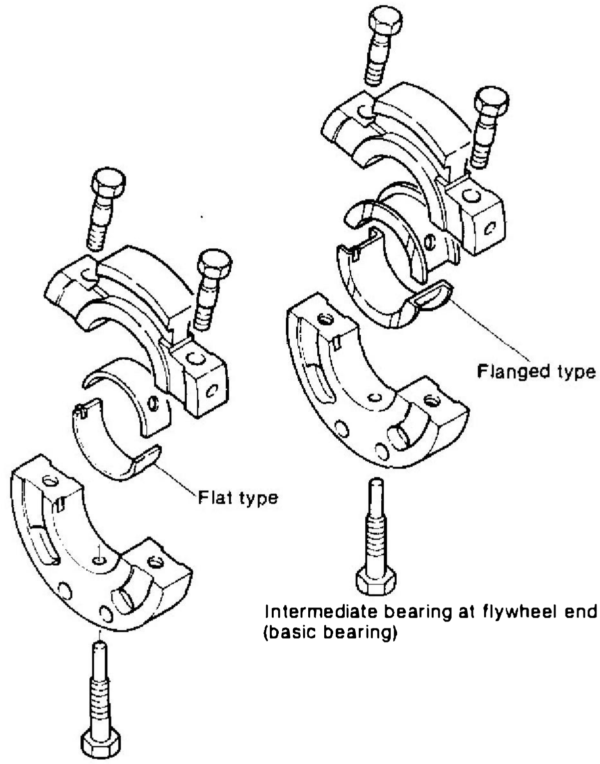


Thrust metal at crankcase end for model 1GM

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

For the intermediate main bearing on the flywheel side, a flange type bearing integrated with the thrust bearing is used. Because this is the primary main bearing, those without the thrust bearing on the sides of the flywheel and timing gear housing are whole circle bearings, while the intermediate main bearing on the timing gear housing side is the divided circle type.





Intermediate bearing at flywheel end (basic bearing)

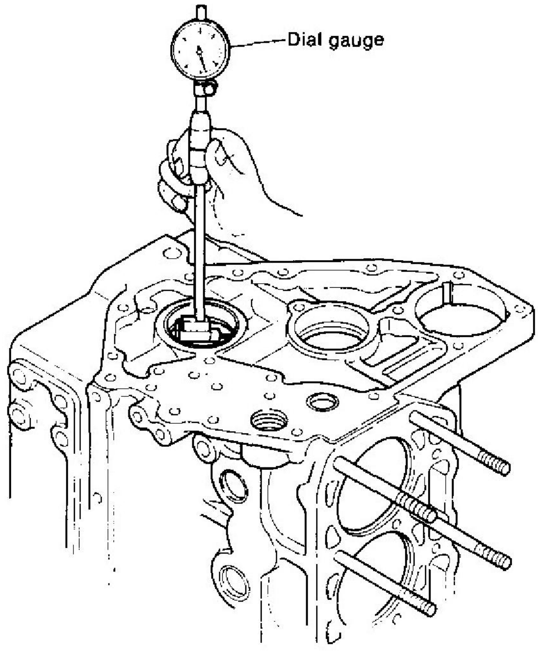
Intermediate bearing at gear case end (models 3GM(D) and 3HM)

6-5.2 Inspecting the crank bearing

(1) Check the crank bearing metal for scaling, deposited metal and seizure. Also check the condition of the contact surface. If defects are found, replace.

If the bearing metal contact is too unsymmetrical, carefully check all related component parts which might be responsible, and take proper measures.

(2) Determine the oil clearance by measuring the inside diameter of the crankshaft bearing and the outside diameter of the crankshaft.



NOTES: 1) Measure the crank bearing at the four points shown in the figure and replace the bearing if the wear limit is exceeded at any of these points.

2) When measuring the inner diameter of the crank bearing, the crank bearing should be installed on the bearing housing and/or cylinder block.

Crank metal

Main bearing housing

mm (in)

		1GM, 2GM, 3GM(D) Maintenance standard	1GM, 2GM, 3GM(D) Wear limit	3HM Maintenance standard	3HM Wear limit
Flywheel side	Main bearing inside diameter	ø60.0 (2.3622)	ø60.12 (2.3669)	ø65.0 (2.5590)	ø65.12 (2.5636)
	Crankshaft journal outside diameter	ø60.0 (2.3622)	ø59.90 (2.3563)	ø65.0 (2.5590)	ø64.90 (2.5551)
	Oil clearance	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)	0.036 ~ 0.099 (0.0014 ~ 0.0039)	0.15 (0.0059)
Opposite side of flywheel	Main bearing inside diameter	ø44.0 (1.7323)	ø44.12 (1.7370)	ø47.0 (1.8504)	ø47.12 (1.8551)
	Crankshaft journal outside diameter	ø44.0 (1.7323)	ø43.90 (1.7283)	ø47.0 (1.8504)	ø46.90 (1.8465)
	Oil clearance	0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)

6-5.3 Inspe ting the thrust metal (for model 1GM)

Measure the thickness of the thrust metal and replace the metal when wear exceeds the wear limit.

mm (in)

	Maintenance standard	Wear limit
Thrust metal at crankcase end	2.45 (0.0965)	2.25 (0.0886)
Thrust metal at gear case end	2.95 (0.1161)	2.75 (0.1083)

the Intermediate main bearing (for 2GM, 3GM(D)and 3HM)

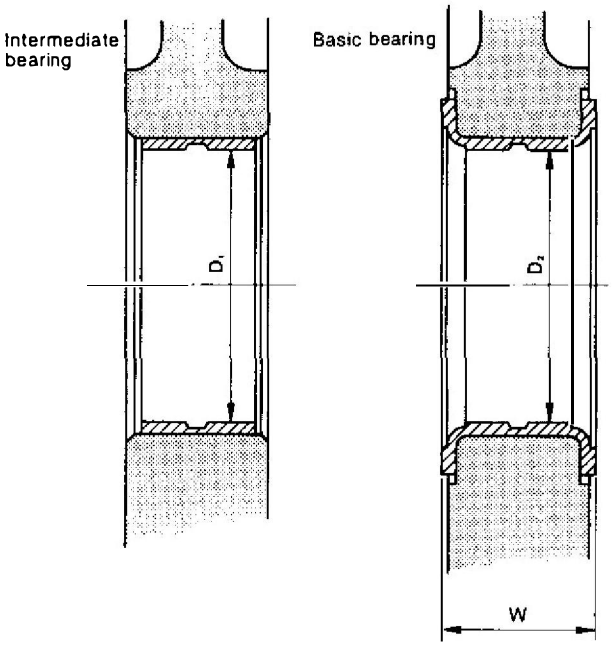
(1) Caution when inspecting

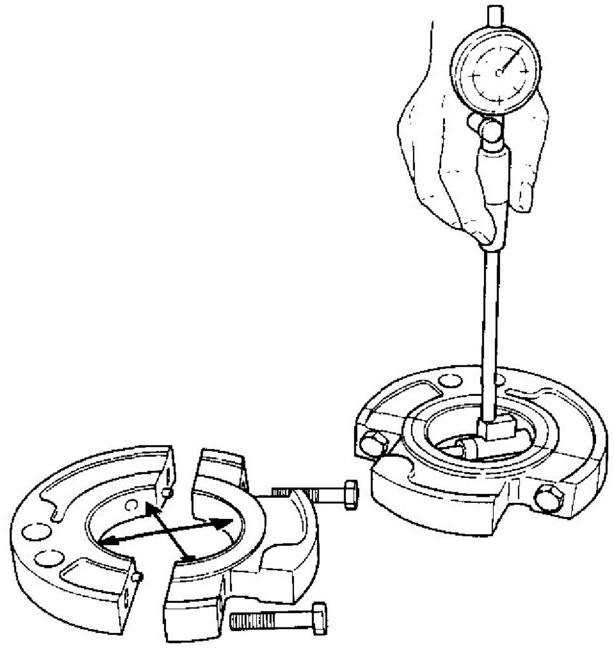
The intermediate main bearing is divided into two semicircles. Therefore, always measure after tightening the intermediate main bearing with the standard tightening torque. Measure at four places as in the main bearing, and replace it if it exceeds the wear limit.

kg-m (ft-lb)

	2GM, 3GM(D)	3HM
Tightening torque of the intermediate main bearing housing tightening bolt	3.0 ~ 3.5 (21.7 ~ 25.3)	4.5 ~ 5.0 (32.5 ~ 36.2)

(2) Intermediate main bearing
The intermediate main bearing on the flywheel side is the primary main bearing. Because this is a flange type bearing, measure the flange width as well as the inside diameter. When the flange wears away the side gap of the crankshaft increases.





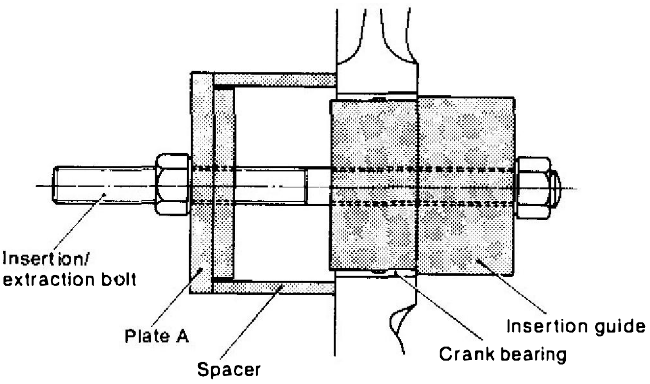
mm (in.)

	2GM,3GM(D)		3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Gear case side intermediate bearing inside diameter D_1	ø44.0 (1.7323)	ø44.12 (1.7370)	ø47.0 (1.8504)	ø47.12 (1.8551)
Flywheel side intermediate bearing inside diameter D_2	ø44.0 (1.7323)	ø44.12 (1.7370)	ø47.0 (1.8504)	ø47.12 (1.8551)
Width of intermediate bearing (Flywheel side) W	$25^{-0.09}_{-0.17}$ (0.9776 ~ 0.9807)	24.63 (0.9697)	$30^{-0.09}_{-0.17}$ (1.1744 ~ 1.1776)	29.63 (1.665)

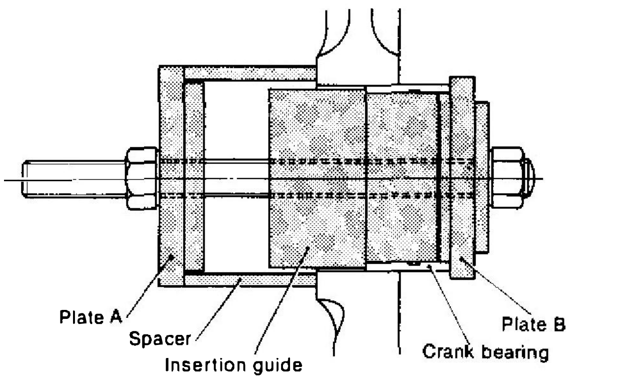
NOTE: Only at the flywheel end for model 1GM

6-5.5 Replacing the crank bearing

Since the crank bearings at both ends of the crankshaft are attached to the cylinder block and bearing housing with a press, a force of approximately 1.0 ~ 1.5 tons (2200 ~ 3300 lbs.) is required to remove them.
Moreover, since the crankshaft will not rotate smoothly and other trouble may occur if the bearing is distorted, it must always be installed with the special tool.
(1) Removal
Assemble the spacer and plate A as shown in the figure, place the puller/extractor against the bearing from the opposite end and pull the bearing by tightening the nut of the special tool. Remove the oil seal before pulling the bearing pressed to the bearing housing.

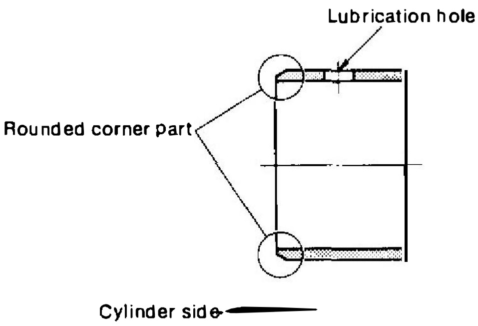


(2) Installation
Coat the outside of the bearing with oil and align the positions of the bearing oil holes. Then press in plate B



until it touches the cylinder block or bearing housing, using the puller/extractor as a guide, as shown in the figure.
After inserting the bearing, measure its outside diameter. If the bearing is distorted, remove it again and replace it with a new bearing.

(3) Crank bearing Installation precautions

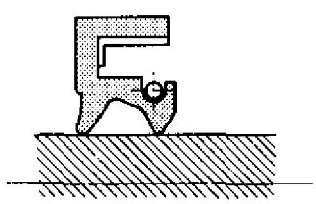


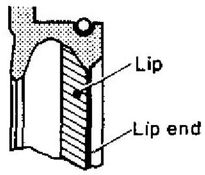
1) Pay careful attention to the crank bearing insertion direction. Insert the bearing so that the side with the outside fillet is on the outside.
2) Align the oil hole of the crank bearing with the oil holes of the cylinder block and bearing housing.
3) After inserting the crank bearing, check that the crankshaft rotates easily with the thrust metal and bearing housing installed.
4) Be careful that the bearing is not tilted during insertion.

6-6 Crankshaft oil seal

6-6.1 Oil seal type and size

Spiral oil seals are employed at both ends of the crankshaft. This type of oil seal is pulled toward the oil pan by pump action while the engine is running so that there is no oil leakage.
Since the viscous pump action will be lost if the lip of the seal is coated with grease, coat the lip with oil when assembling.

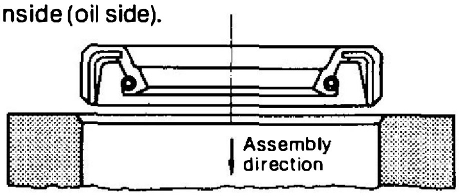




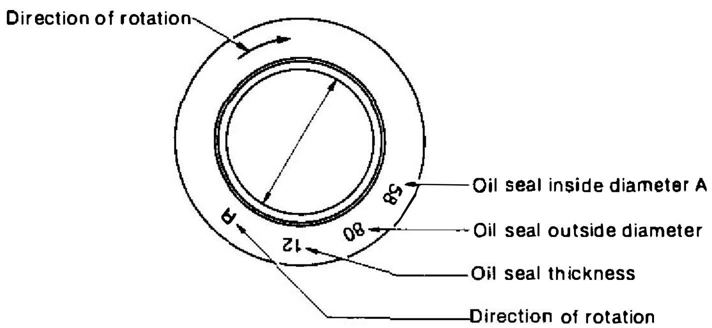
	1GM, 2GM, 3GM(D)			3HM		
	Size	Spiral	Part No. (Yanmar)	Size	Spiral	Part No. (Yanmar)
For Main bearing metal housing	60829	Yes	124085-02220	65889	Yes	121550-02220
For gear case	25408	Yes	121450-01800	25408	Yes	121450-01800

6-6.2 Oil seal Insertion precautions

(1) Clean the inside of the housing hole, ascertaining that the hole was not dented when the seal was removed.
(2) Be sure that the insertion direction of the oil seal is correct. Insert so that the main lip mounting the spring is on the inside (oil side).

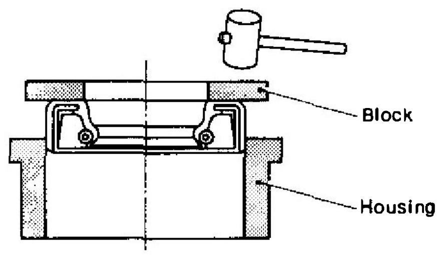


(3) Since the direction of rotation of the shaft is specified on a spiral oil seal, be sure that the rotating direction is correct.

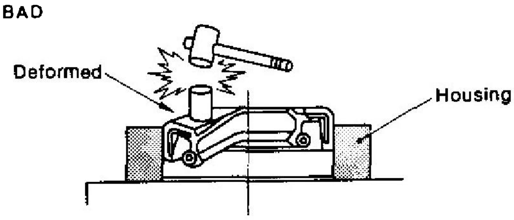


(4) Insert the oil seal with a press. However, when unavoidable, the seal may be installed by tapping the entire periphery of the seal with a hammer, using a block. In this case, be careful that the oil seal is not tilted.
Never tap the oil seal directly.

GOOD



BAD



7. Flywheel and Housing

The function of the flywheel is, through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.
The flywheel Is mounted and secured by 5 bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.
On the crankshaft side of the flywheel is the fitting surface for the damper disc, through which the rotation of the crankshaft is transmitted to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.
The flywheels imbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed. To achieve this, the balanced amount is adjusted by drilling holes in the side of the flywheel, and the unbalanced moment is adjusted by drilling holes in the circumference.

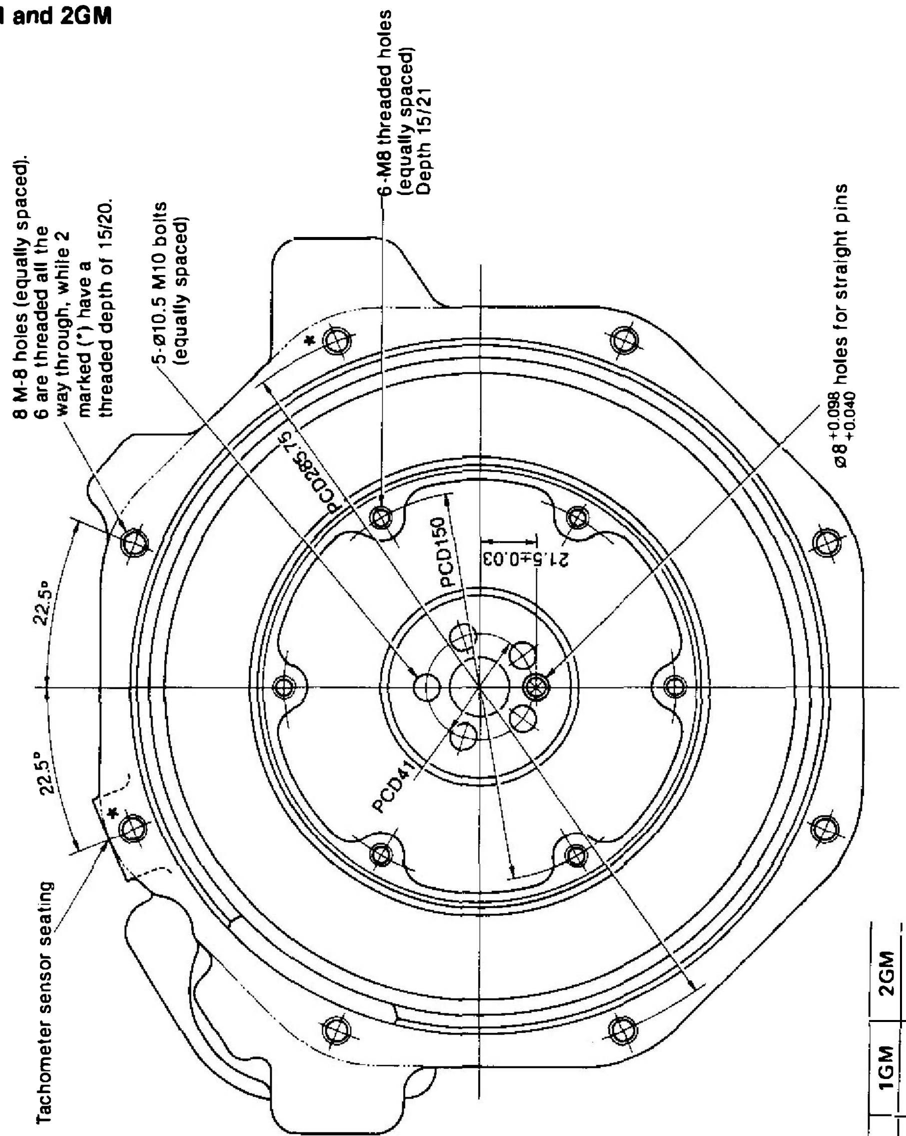
The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.
The stamped letter and line which show top dead center of each cylinder are positioned either on the flywheel at the crankshaft side or at the side of the reduction and reversing gear, and by matching these marks with the arrow mark at the setting hole of the starter motor or at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

7-1 Specifications of flywheel

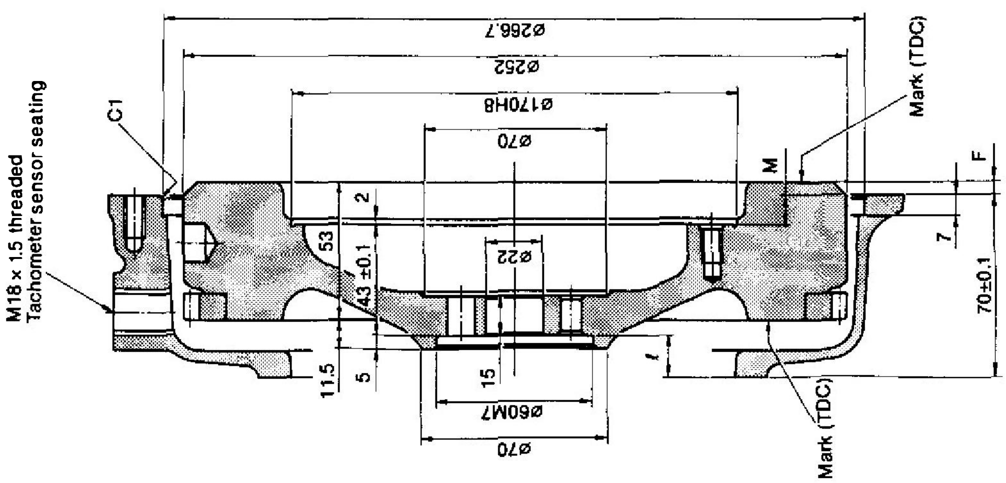
			1GM	2GM	3GMD	3GM	3HM
Outside diameter of flywheel		mm		$\varnothing 252^{\ 0}_{-0.2}$			
Width of flywheel		mm	53	53	70	53	44
Weight of flywheel (including ring gear)		kg	12.6	12.6	17.5	11.0	12.0
GD^2 value		kg-m²	0.5	0.5	0.70	0.49	0.70
Circumferential speed		m/s		47.5 (3600 rpm)			53.4 (3400 rpm)
Speed fluctuation rate		δ	1/61 (3600 rpm)	1/74 (3600 rpm)	1/116 (3600 rpm)	1/81.3 (3600 rpm)	1/73.4 (3400 rpm)
Allowable amount of imbalance		g-cm	25	25		25	25
Allowable moment of imbalance		g-cm		244 +20	363 +20	363 +20	—
Fixing part of damper disc	Pitch circle diameter of bolts	mm		150		170	170
	No. of bolts × bolt diameter			6-M8 thread equally spaced		6-M8 equally spaced	6-M8
Fixing part of crankshaft	Pitch circle diameter of bolts	mm		41			46
	No. of thread holes	mm		5-M10			5-M10
	Fit joint diameter			ø60M7			ø65M7
Model of reduction and reversing gear				KM2A	KM3A	KBW10D	KBW10E
Mounting flange No.				SAE No. 6 (in metric unit)			SAE No.5 (in metric unit)
Ring gear	Center diameter	mm		246.38			289.56
	No. of teeth			Z = 97			Z = 114

7-2 Dimensions of flywheel and mounting flange

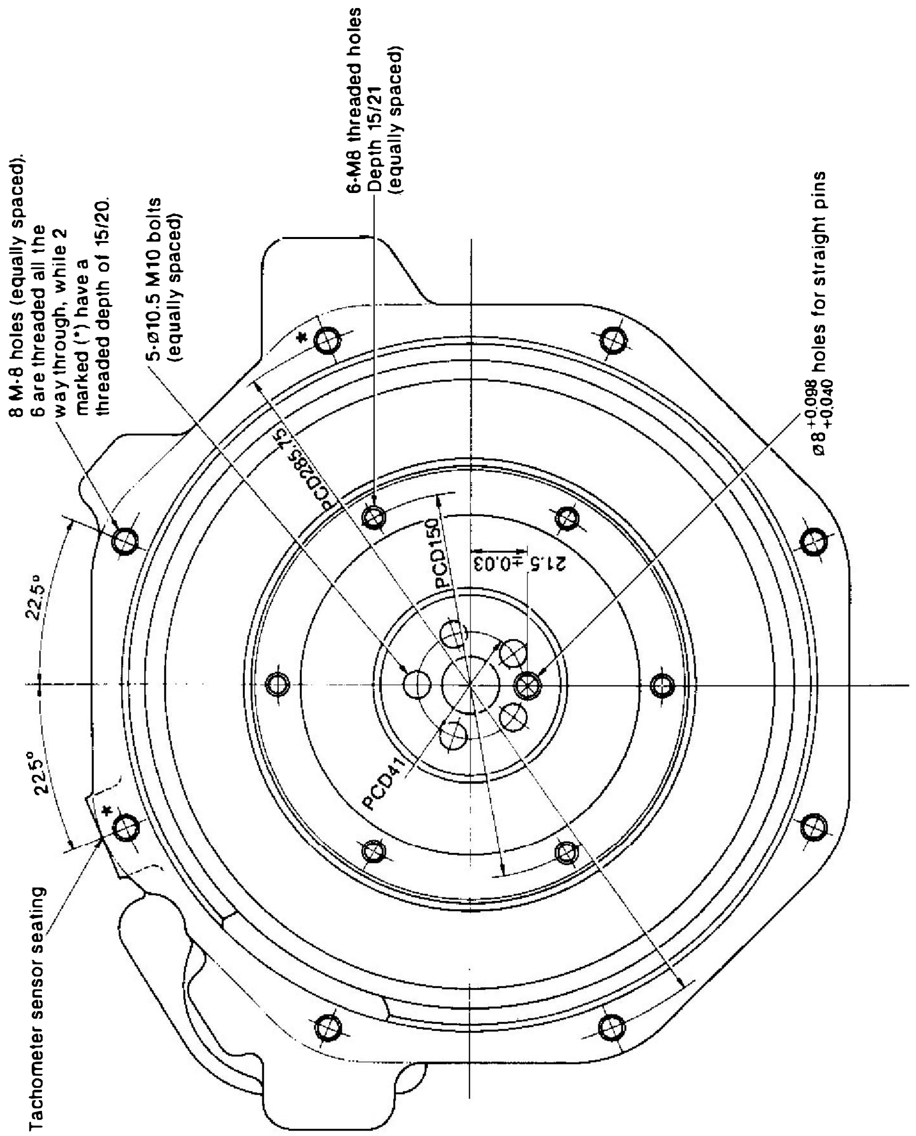
7-2.1 For models 1GM and 2GM

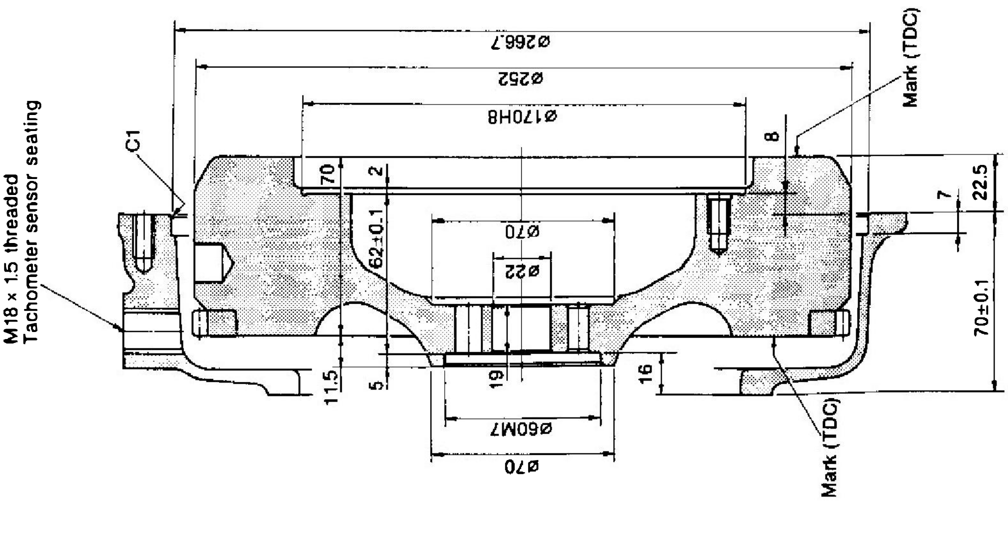


	1GM	2GM
ℓ	15.5	15.5
F	5.0	5.0
M	11.5	11.5

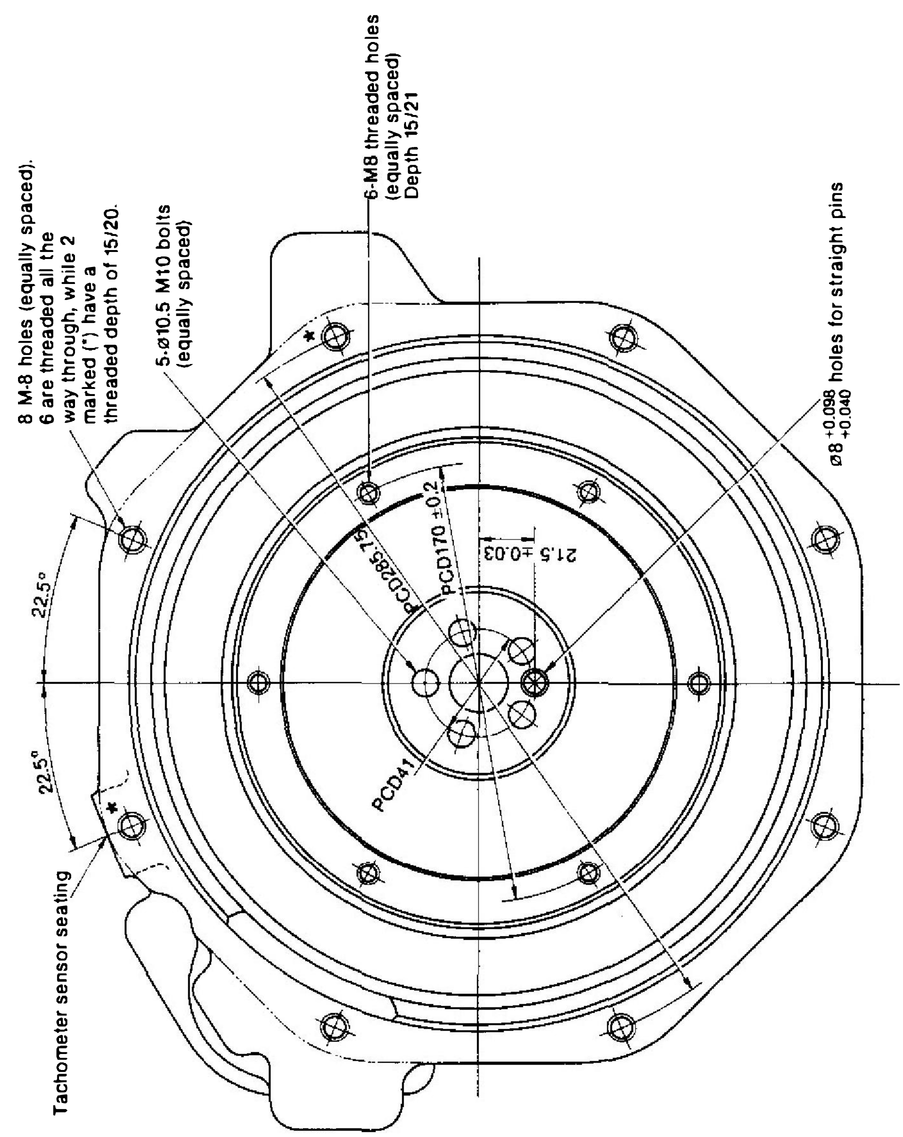


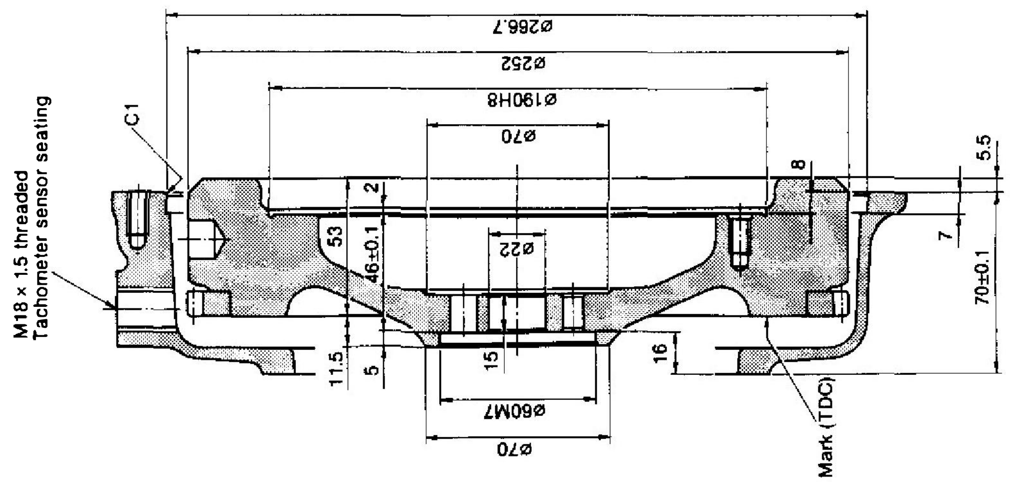
7-2.2 For model 3GMD



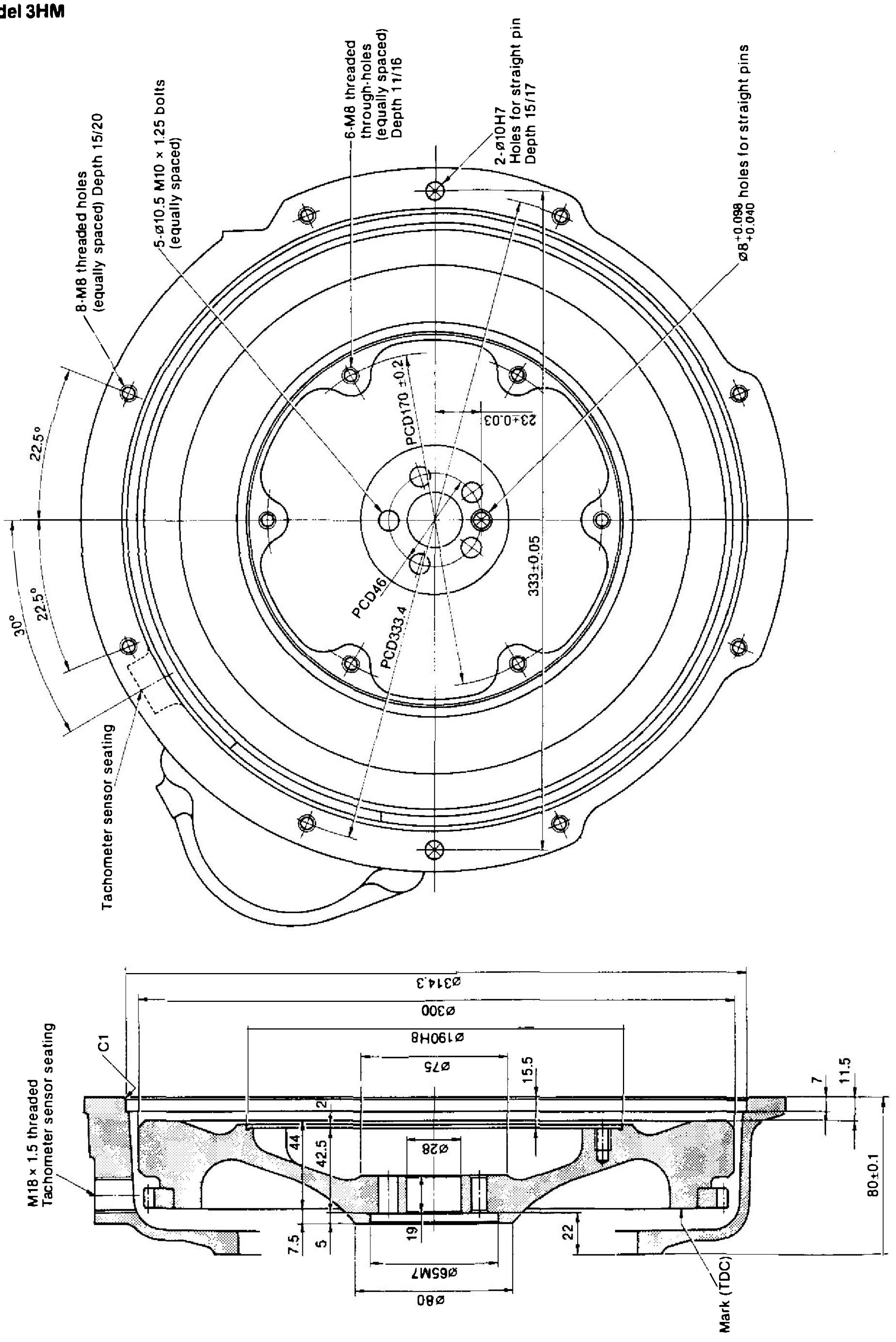


7-2.3 For model 3GM





7-2.4 For model 3HM

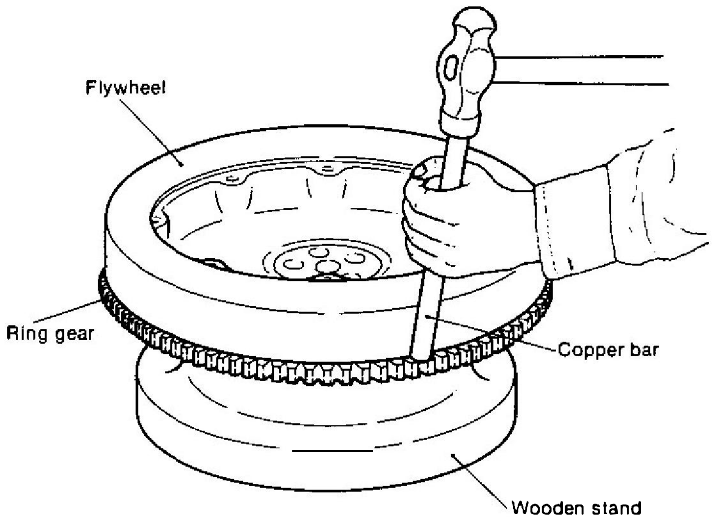


7-3 Ring gear

When replacing the ring gear due to excessive wear or damaged teeth, heat the ring gear evenly at its circumference, and after it has expanded drive it gradually off the flywheel by tapping it with a hammer a copper bar or something similar around the whole circumference.

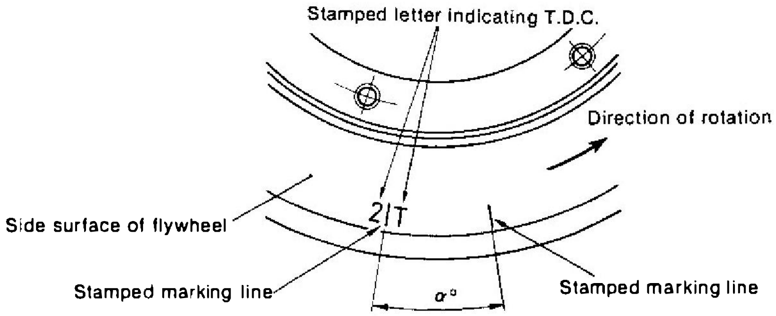
mm (in.)

	1GM, 2GM, 3GM(D)	3HM
Interference of ring gear	0.188 ~ 0.348 (0.0074 ~ 0.0137)	0.188 ~ 0.348 (0.0074 ~ 0.0137)



7-4 Position of top dead center

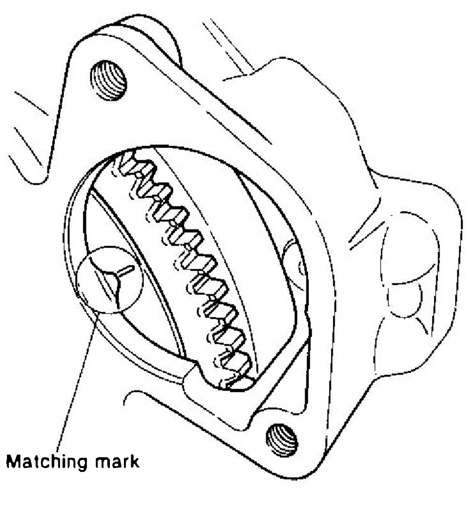
(1) Marking



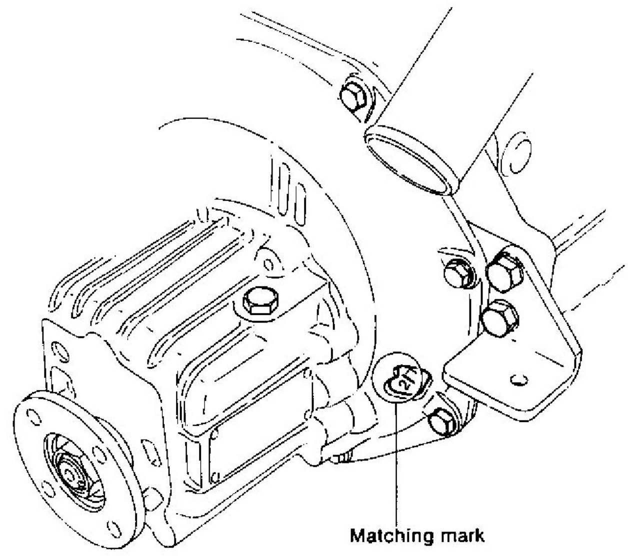
	1GM	2GM	3GMD	3GM	3HM
Stamped letter	T	1T, 2T	1T, 2T, 3T	1T, 2T, 3T	1T, 2T, 3T
Angle α of Stamped lines	15°	15°	18°	18°	19°
Stamped surfaced	Both surfaces	Both surfaces	Both surfaces	Crankshaft side	Crankshaft side

(2) Matching mark

The matching mark is made at the setting hole of the starter motor on all models.



With respect to model 1GM, 2GM and 3GMD only, a projection which serves as the matching mark is provided in the cast hole of the clutch housing.



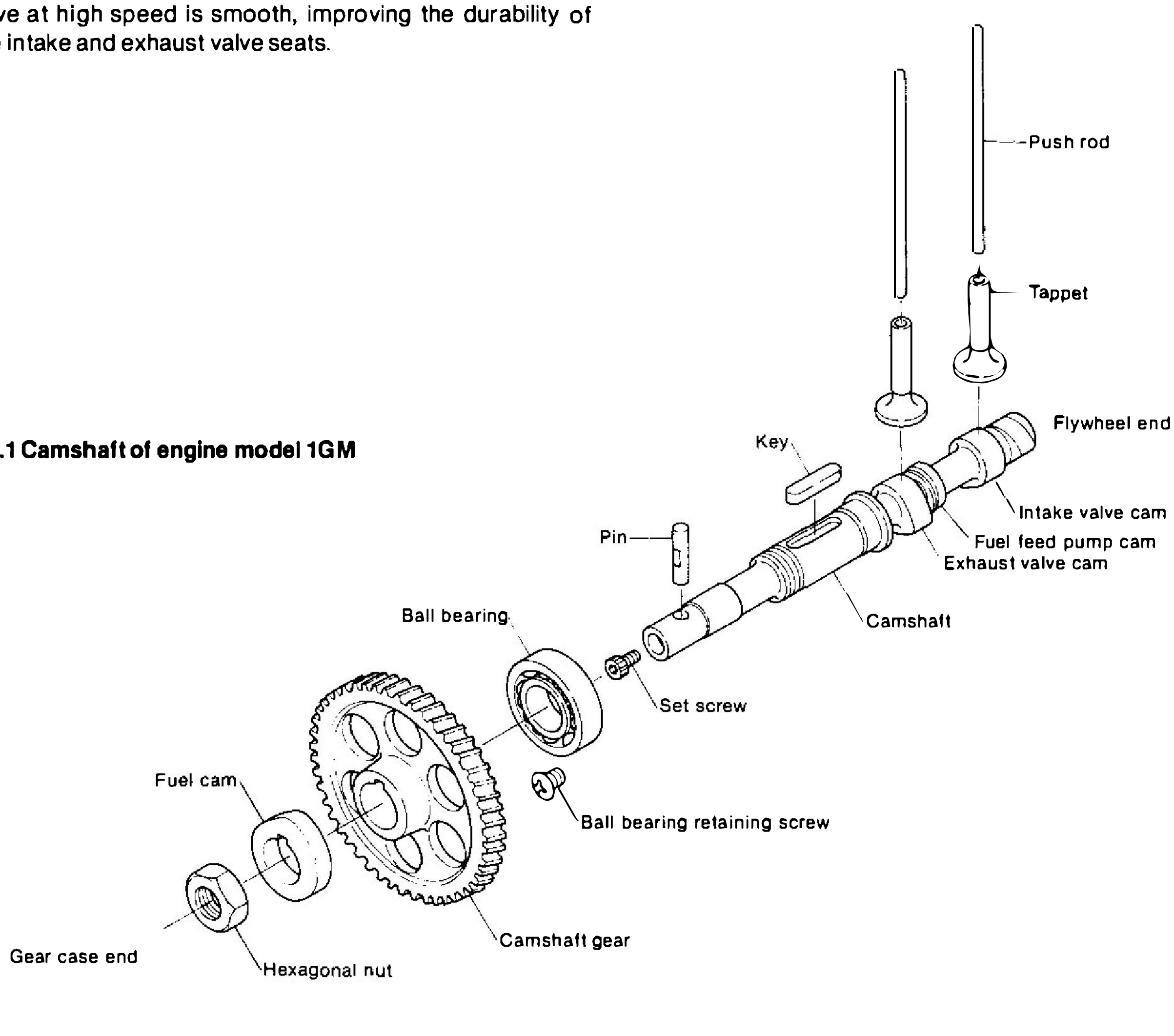
8. Camshaft

7·1 Construction of the camshaft

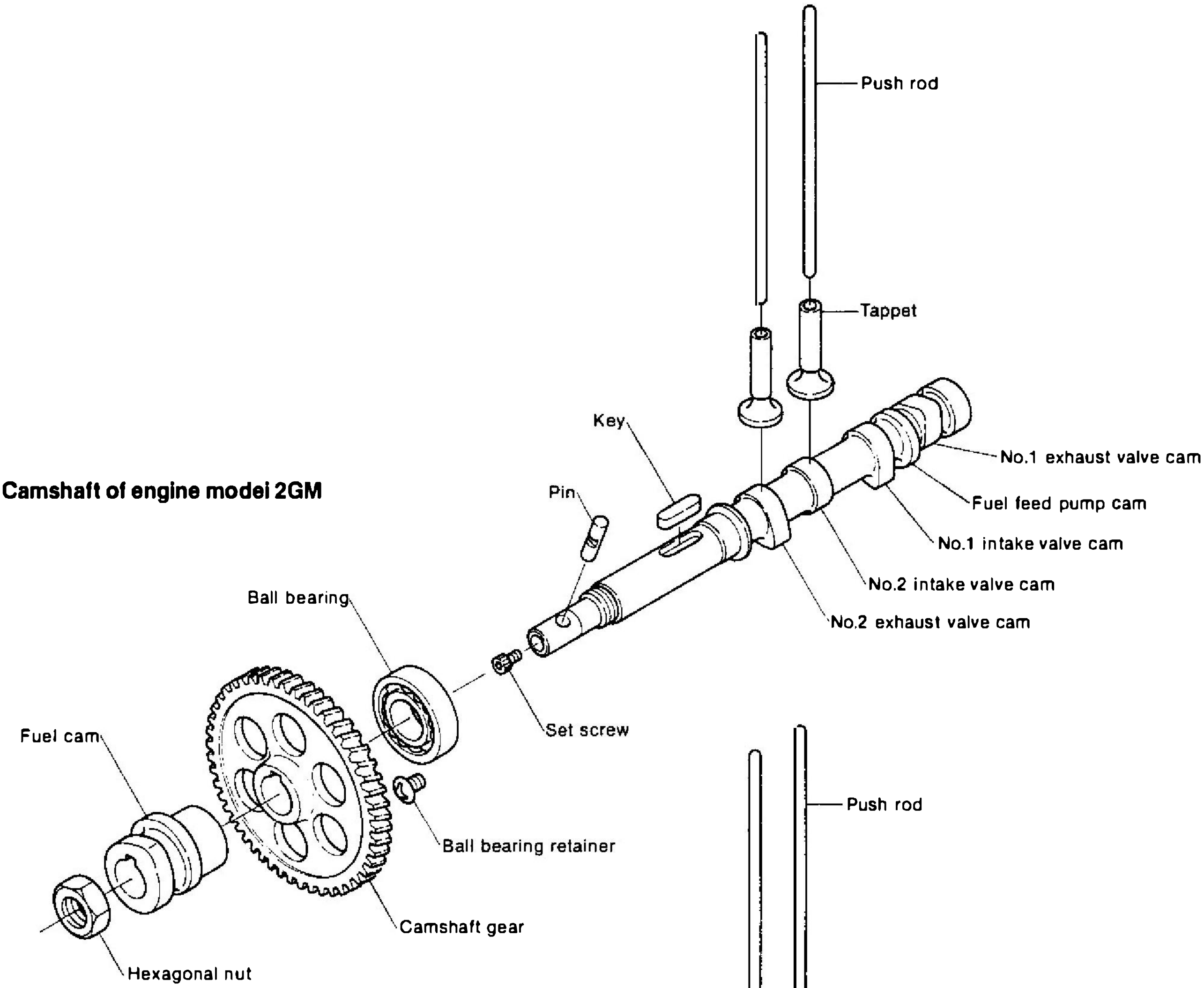
The camshaft, an integral camshaft with intake and exhaust cams, is driven by the camshaft gear and may be timed individually.
On top of the intake and exhaust cams a tappet is mounted guided by the cylinder block. The tappet moves up and down with the rotation of the cam and opens and closes the intake and exhaust valves with the pushrod and rocker arm.
During high speed operation the cam surface is exposed to a strong force of inertia from moving valves and spring load, and comes in to contact with the tappet at high surface pressure. Therefore, to reduce wear the surface is tempered by high frequency hardening, as well as a cam form selected to decrease the force of inertia. Since the intake and exhaust cam profile of this engine is a parabolic acceleration cam with a buffering curve, movement of the valve at high speed is smooth, improving the durability of the intake and exhaust valve seats.

The camshaft on models 1GM and 2GM does not have an intermediate bearing, however, the camshaft on models 3HM and 3GM(D) is supported by two intermediate bearings in order to avoid deflection of the camshaft.
The fuel cam is separated from the camshaft in all engine models and it is inserted into the camshaft together with the camshaft gear by matching the key and slot and is fixed by an end nut.
The cam for the fuel feed pump is integrated with the camshaft and it is machine finished. The cam is located between the intake and exhaust valve cams of No.1 cylinder at the flywheel end in all engine models.

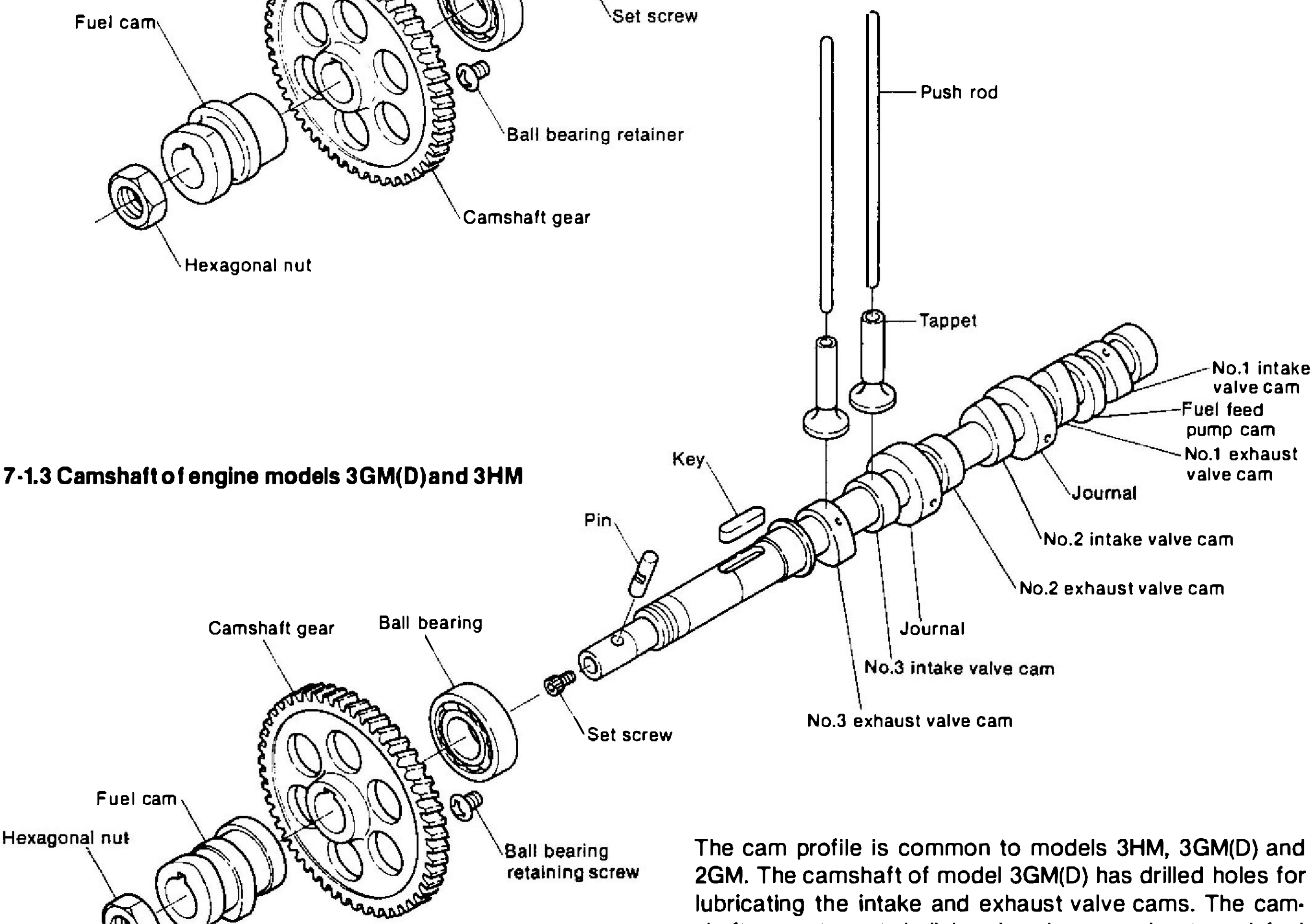
7·1.1 Camshaft of engine model 1GM



7-1.2 Camshaft of engine model 2GM

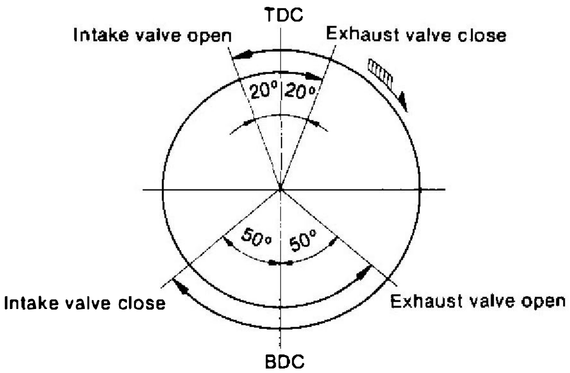


7-1.3 Camshaft of engine models 3GM(D) and 3HM



The cam profile is common to models 3HM, 3GM(D) and 2GM. The camshaft of model 3GM(D) has drilled holes for lubricating the intake and exhaust valve cams. The camshaft gear, tappet, ball bearing, hexagonal nut, and fuel cam are the same for models 3GM(D) and 3HM.

7-2 Valve timing diagram

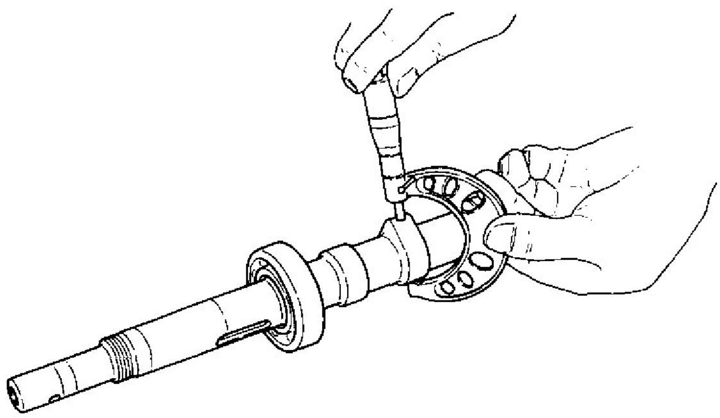


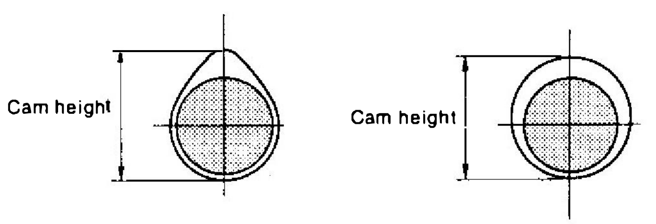
	1GM	2GM	3GM(D)	3HM
Intake and exhaust valve head clearance	0.2mm (0.0079in.)			
Intake valve open b. TDC	20°			
Intake valve close a. BDC	50°			
Exhaust valve open b. BDC	50°			
Exhaust valve close a. TDC	20°			

7-3 Inspection

Visually check for steps or wear on the cam surface and replace if excessive.
Since the cam surface is tempered and ground, there is almost no wear. However, measure the height of the intake and exhaust cams, and replace the camshaft when the measured value exceeds the wear limit.

7-3.1 Camshaft height





mm (in.)

		Maintenance standard	Wear limit
Intake and exhaust cam	1GM	29 (1.1417)	28.70 (1.1292)
	2GM 3GM(D) 3HM	35 (1.3780)	34.70 (1.3661)
Fuel feed pump cam	1GM	22 (0.8661)	—
	2GM,3GM(D)	33 (1.2992)	—
	3HM	33.5 (1.3189)	—

7-3.2 Journals of camshaft

Measure the amount of wear and eccentricity of the camshaft journal. Measurements must be carried out in at least two directions for each position.
Replace the camshaft with a new one if the value exceeds the allowable limit.

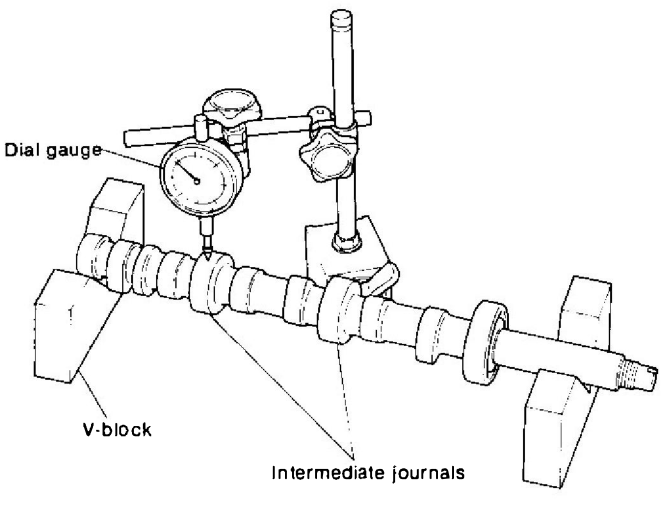
mm (in.)

		Maintenance standard	Clearance at assembly	Maximum allowable clearance
Flywheel side	1GM	ø20 (0.7874)	0.050 ~ 0.100 (0.0020 ~ 0.0039)	0.15 (0.0059)
	2GM, 3GM(D), 3HM	ø30 (1.1811)		
Center	3GM(D), 3HM	ø41.5 (1.6339)	0.050 ~ 0.100 (0.0020 ~ 0.0039)	0.15 (0.0059)

7-3.3 Camshaft deflection (models 3GM(D) and 3HM)

Support the camshaft at both ends on V-blocks, and measure the concentricity of the intermediate journal with a dial gauge. If the camshaft is excessively bent, replace it.

NOTE: Indicated valve on the dial gauge is the amount of swing, and the amount of bend is half the reading given.



mm (in.)

		Maintenance standard	Wear limit
Camshaft deflection	3GM(D)	—	0.02 (0.0008)
	3HM	—	0.02 (0.0008)

7-4 Camshaft ball bearing

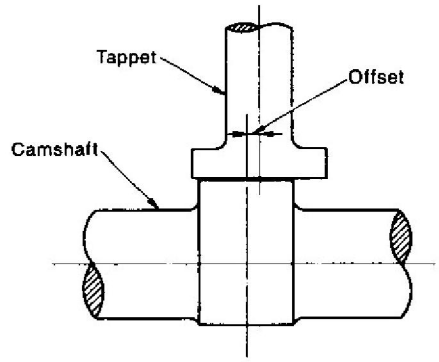
The camshaft bearing is a single row deep groove ball bearing. The construction and material of this ball bearing is such that it can withstand the radial load, thrust loads in both directions, and a combination of both these loads. When the ball bearing does not rotate smoothly, or when the axial direction play is large, replace the bearing.

Ball bearing type

For model 1GM	6005
For models 2GM, 3GM(D) and 3HM	6205

7-5 Tappets

These mushroom type tappets feature a special iron casting with chill-hardened contact surfaces for high wear resistance. The center of the cam surface width and the center of the tappet are offset to prevent eccentric wear of the contact surface.

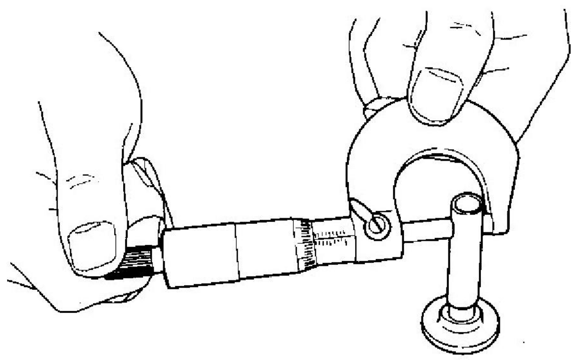


7-5.1 Tappet disassembly precautions

The cylinder number and intake and exhaust must be clearly indicated when disassembling the camshaft and tappets.

7-5.2 Tappet stem wear and contact

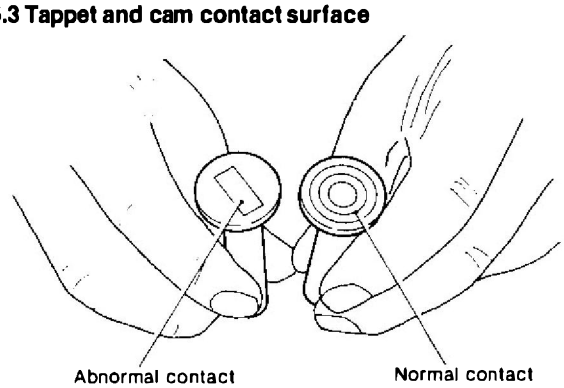
Measure the outside diameter of the tappet stem, and replace the tappet when the wear limit is exceeded or contact is uneven.



mm (in.)

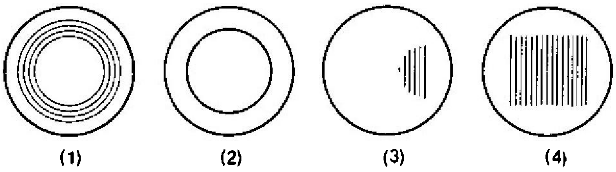
		Maintenance standard	Wear limit
Tappet stem outside diameter	1GM	⌀10.0 (0.3937)	⌀9.95 (0.3917)
	2GM, 3GM(D), 3HM	⌀10.0 (0.3937)	⌀9.95 (0.3917)
Tappet stem and guide hole clearance	1GM	0.025~0.060 (0.0010~0.0024)	0.10 (0.0039)
	2GM, 3GM(D), 3HM	0.010~0.040 (0.0004~0.0016)	0.10 (0.0039)

7-5.3 Tappet and cam contact surface

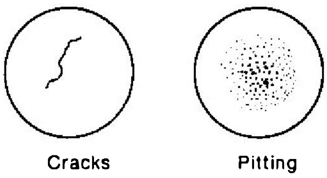


Since the tappet and cam are offset, the tappet rotates in an up and down movement during operation, so there is no uneven contact.
Since eccentric wear will occur if cam tappet contact is poor, replace the tappet if there is any uneven contact or deformation.

Contact surface conditions are shown in the following:



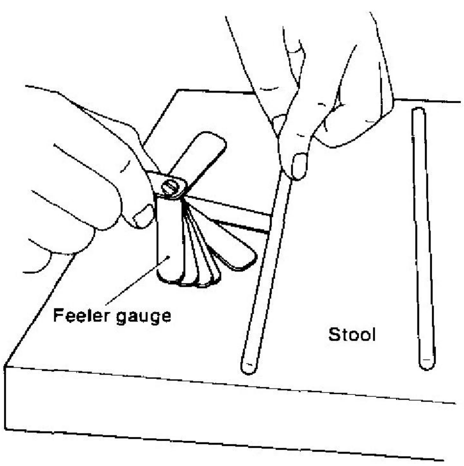
(1), (2) Traces when the tappet is rotating normally.
(3), (4) Traces when the tappet does not rotate and the contact surface remains still and only the point of contact wears away excessively. Discover the reason for the lack or rotation and replace the tappet.



Also, there may be perforated pittings or cracks on the contact surface of the tappet. In such cases, discover the reason for abnormality and replace the tappet.

7-6 Push rods

The push rods are sufficiently rigid and strong to prevent bending.
Place the push rod on a stool or flat surface and measure the clearance between the center of the push rod and the flat surface, and replace the push rod if the wear limit is exceeded.



Check both ends for wear and peeling, and replace the push rod if faulty.

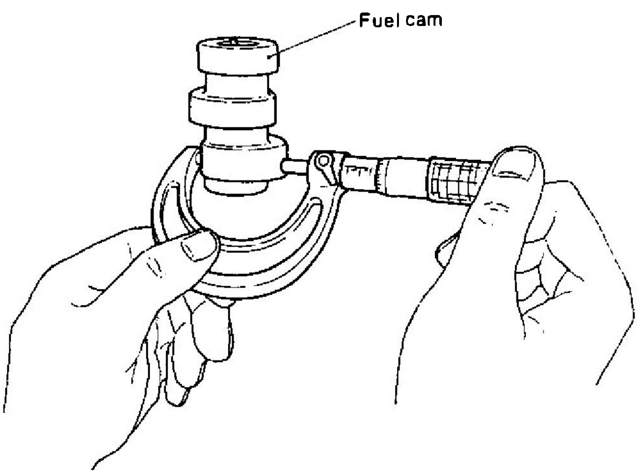
mm (in.)

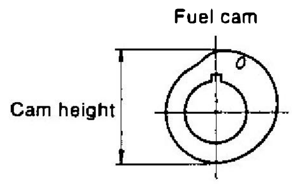
		Maintenance standard	Wear limit
Push rod bend		0.03 or less (0.00118 or less)	0.3 (0.0118)
Push rod length	1GM	143 (5.6299)	—
	2GM,3GM(D)	136 (5.3543)	—
	3HM	171 (6.7323)	—

7-7 Fuel cam

7-7.1 Fuel cam check

The fuel cam is separate from the intake and exhaust valve cams and is secured to the camshaft together with the camshaft gear by a key. The cam drives the fuel pump.
The fuel cam like the intake and exhaust valve cams is ground-finished after being quenched. Therefore, it is almost free from wear. However, if step or eccentric wear is found to be excessive, replace the cam.



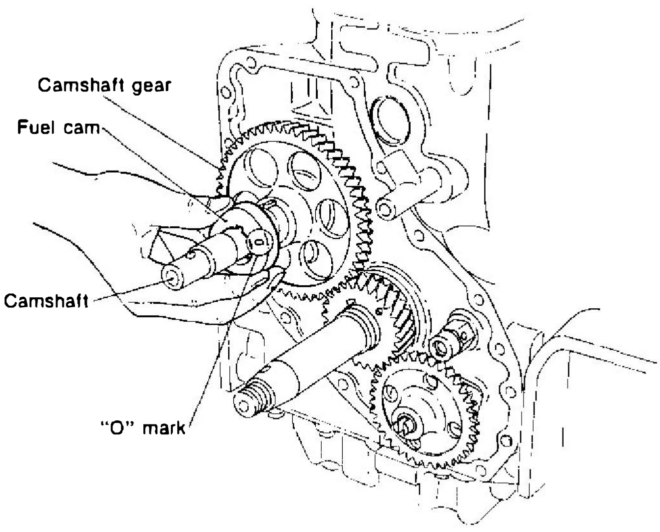


mm (in.)

	Maintenance standard	Wear limit
Fuel cam height 1GM, 2GM, 3GM(D), 3HM	45 (1.7717)	44.90 (1.7677)

7-7.2 Fuel cam assembly precautions

Install the fuel cam by aligning it with the key of the camshaft. If the installation direction is not correct, the fuel injection timing will be considerably off and the engine will not start.
When assembling the fuel cam, be sure that the "0" mark side of the cam is opposite the camshaft gear.


Camshaft gear
Fuel cam
Camshaft
"O" mark

9. Timing Gear

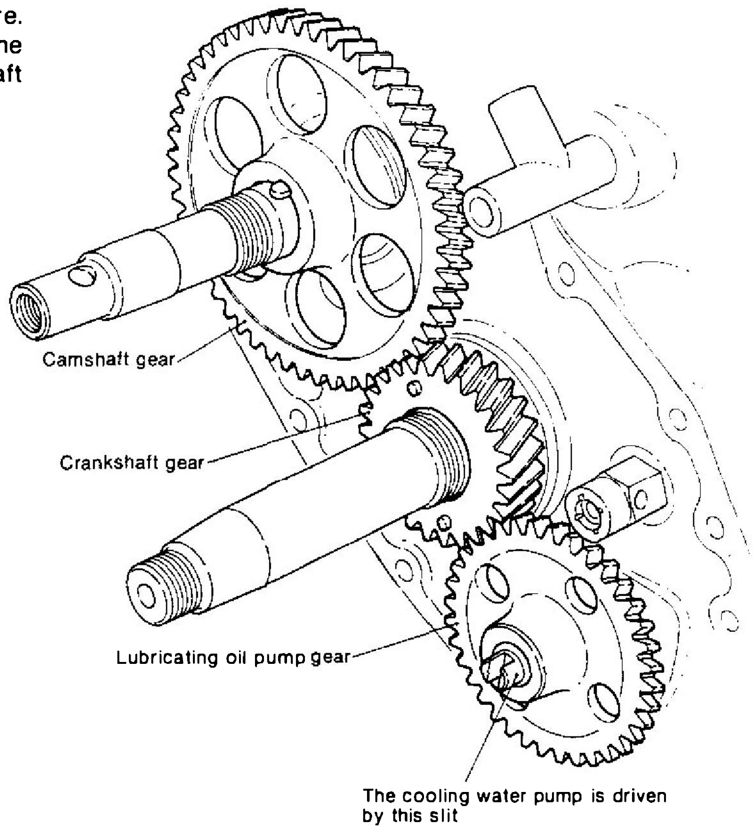
8-1 Timing gear train construction

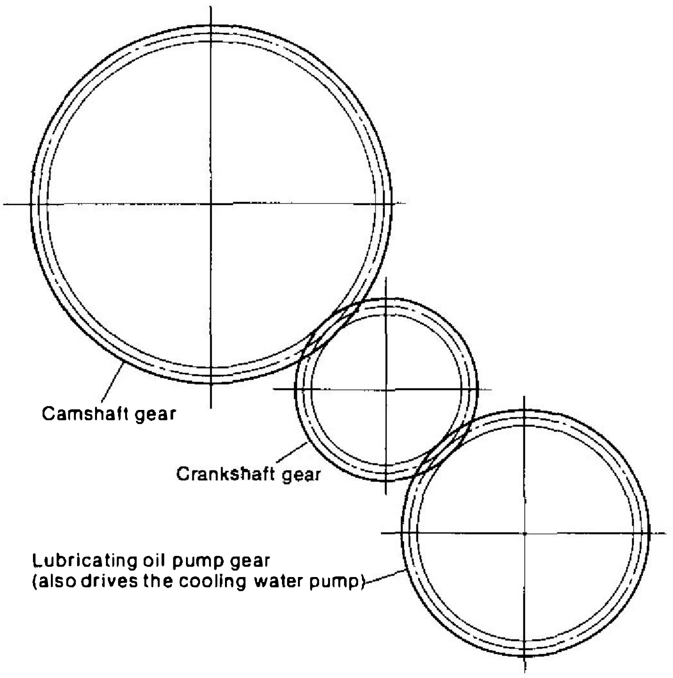
The camshaft, which is the basic component of the valve opening and closing mechanism, and the fuel cam, which determines the fuel injction timing, are driven by the timing gear.
The timing gear consists of the crankshaft gear and the camshaft gear.

The crankshaft gear also drives the governor weight and the lubricating oil pump by meshing with the lubricating oil pump gear.
For the timing gears, helical gears are used.
The timing gear case, which covers these gears, is fitted to the cylinder body with bolts.

8-1.1 Timing gear of model 1GM

The timing gear of model 1GM is as shown in the figure. The slit, which is at the end of the rotor shaft of the lubricating oil pump, is provided to connect with the shaft of the cooling water pump.



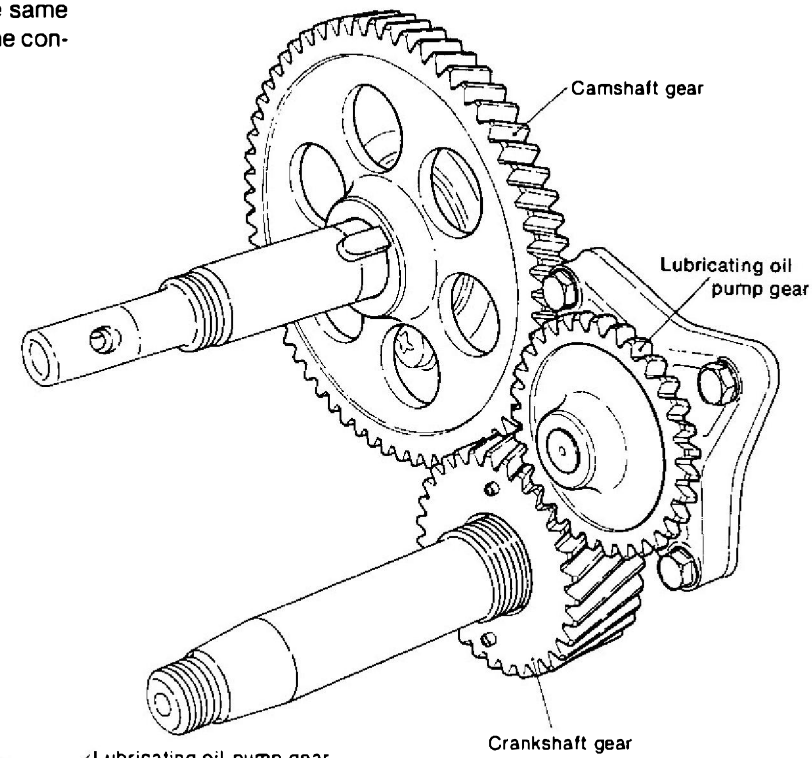


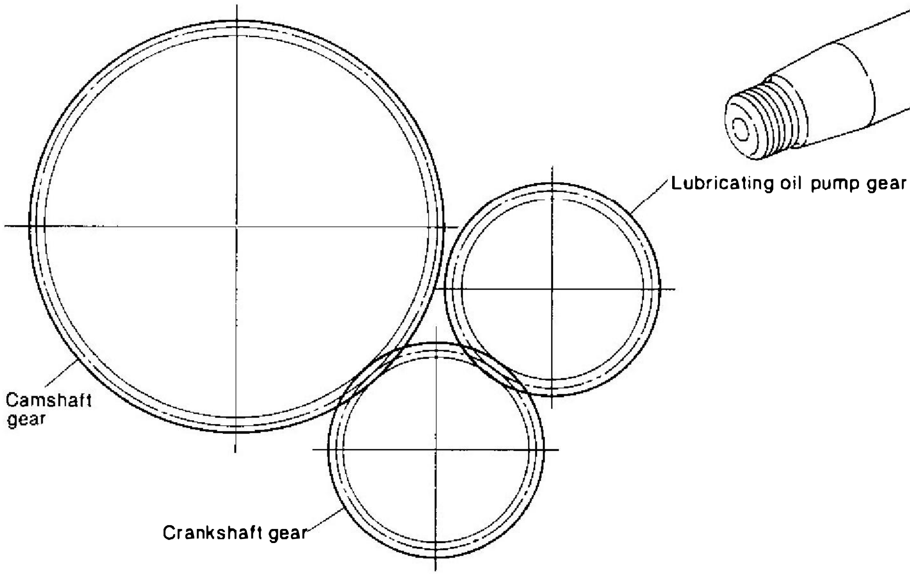
1GM

	Module (m)	Tooth profile	No. of teeth	Center distance
Camshaft gear	2.0	Full depth	52	$84^{+0.048}_{0}$mm (3.3071 ~ 3.3090in.)
Crankshaft gear	2.0	Full depth	26	
Lubricating oil pump gear	2.0	Full depth	36	$66^{+0.046}_{0}$mm (2.5984 ~ 2.6002in.)

8-1.2 Timing gear of models 2GM, 3GM(D) and 3HM

The same crankshaft gear and camshaft gears are used for these three models. Only on the lubricating oil pump gear for model 3HM is a different gear used, but it has the same number of teeth and the gear train itself is of the same construction as that of these three models.
Helical gears are used as in model 1GM.





2GM, 3GM (D) and 3HM

	Module (m)	Tooth profile	No. of teeth	Center distance
Camshaft gear	2.0	Full depth	62	$99^{+0.048}_{0}$mm (3.8976 ~ 3.8995in.)
Crankshaft gear	2.0	Full depth	31	$65.98^{+0.046}_{0}$mm (2.5976 ~ 2.5995in.)
Lubricating oil pump gear	2.0	Full depth	31	

8-2 Disassembly and reassembly of the timing gear

8-2.1 Disassembly

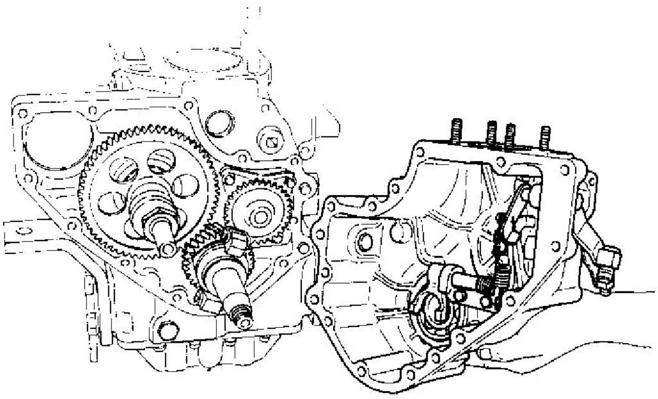
(1) Remove the alternator.
(2) Remove the rubber hose by loosening the hose clip on the cooling water pump.

NOTE: For models 2GM, 3GM(D) and 3HM, the cooling water pumpt does not need to be removed. Model 1GM can be dismantled without removing the cooling water pump, however when assembling, it is difficult to connect it with the rotor shaft of the lubricating oil pump if the gear case has not been previously assembled.

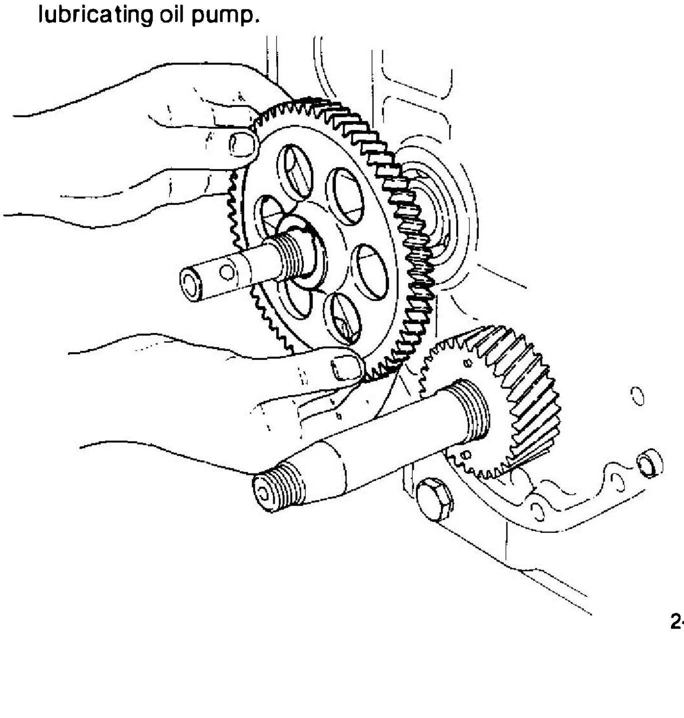
(3) Remove the crankshaft V-pulley.
(4) Remove the fuel injection pump

NOTE: Remove the cap of the oil supply port in model 1GM, or the cap at the timing gear case end in other models, and remove the fuel injection pump by moving the governor second lever while observing through the hole.

(5) Loosen the hexagonal bolt with the hole, and remove the straight pin from the manual starting handle.
(6) Remove the gear case.



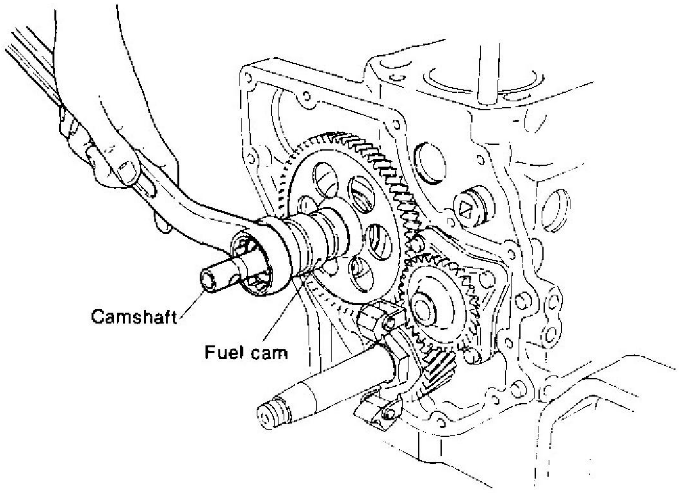
(7) Remove the governor sleeve and needle bearing collar.
(8) Loosen the hexagonal nut, and remove the governor weight support.
(9) Remove the camshaft nut, and take out the fuel cam.
(10)Remove the camshaft gear, crankshaft gear and lubricating oil pump.



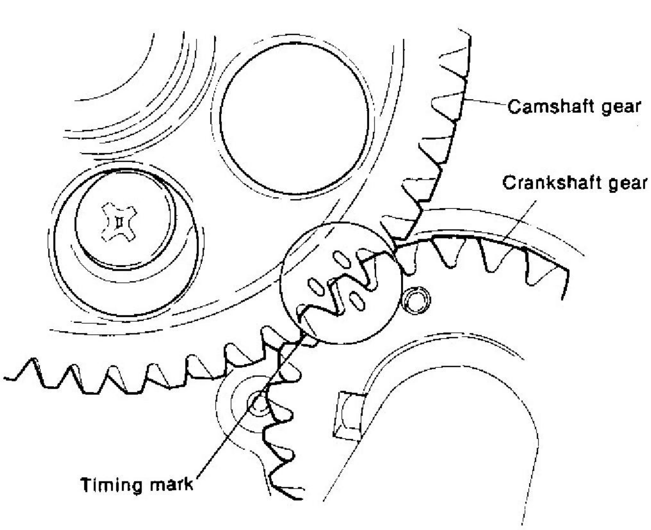
8-2.2 Disassembly and reassembly precautions

Reassemble in the reverse order of disassembly.
Pay attention to the following points when assembling.

(1) Timing mark
A timing mark is provided on the crankshaft gear and camshaft gear to adjust the timing between opening and closing of the intake and exhaust valves and fuel injection when the piston is operated.
Always check that these timing marks are aligned when disassembling and reassembling the timing gear.
First, fit the crankshaft gear to the crankshaft by matching the key and slot. Next, by rotating the camshaft fit the camshaft gear in the position where the marks on the camshaft gear and the crankshaft gear align.



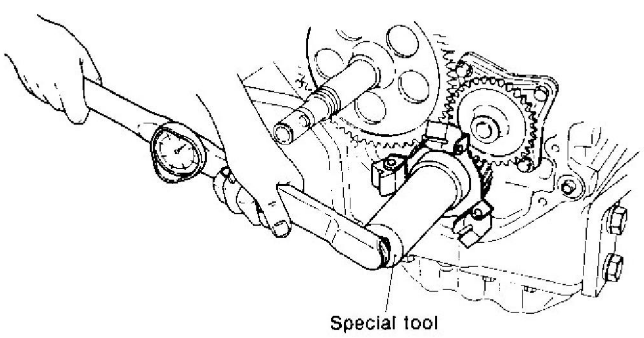
(2) Fuel cam
When the fuel cam is fitted to the camshaft, assemble it keeping the surface marked 'O' towards the front.
(Refer to 2-61)
(3) Tightening torque of nut



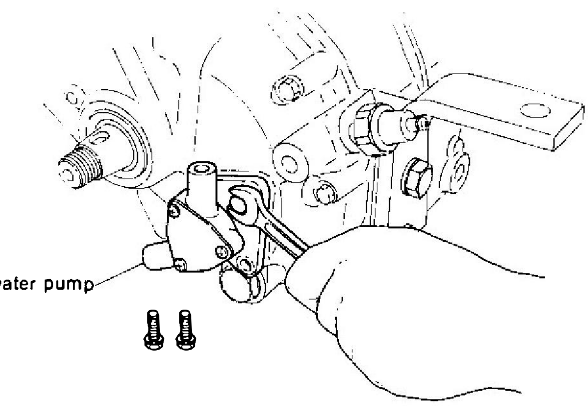
kg-m (ft-lb)

	1GM, 2GM, 3GM(D), 3HM
Camshaft end nut	7.0 ~ 8.0 (50.6 ~ 57.9)
Crankshaft nut	8.0 ~ 10.0 (57.9 ~ 72.3)

NOTE: *When tightening or loosening the crankshaft nut, take care that the spanner does not touch the governor weight or weight support.*



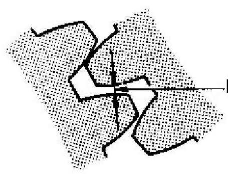
(4) Assembling model 1GM cooling water pump
When model 1GM cooling water pump is assembled, ensure that the pump shaft engages the slit of the rotor shaft end of the lubricating oil pump and with the bearing. Check by rotating the crankshaft.



8-3 Inspection

8-3.1 Backlash

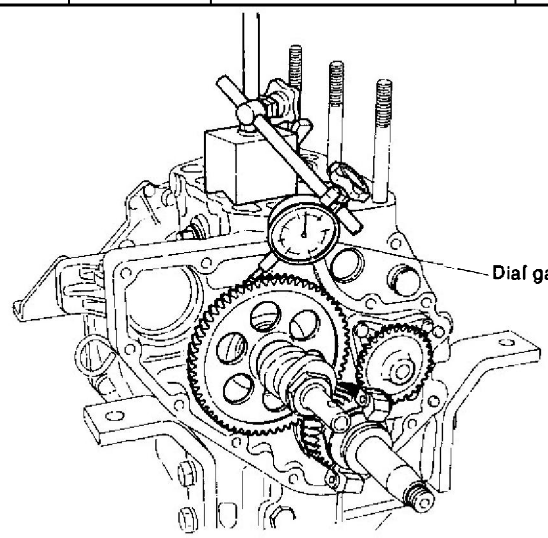
Unsuitable backlash will cause excessive wear or damage at the tooth top and abnormal noise during operation. Moreover, in extreme cases, the valve and fuel injection timing will deviate and the engine will not run smoothly.
When the backlash exceeds the wear limit, repair or relace the gears as a set.



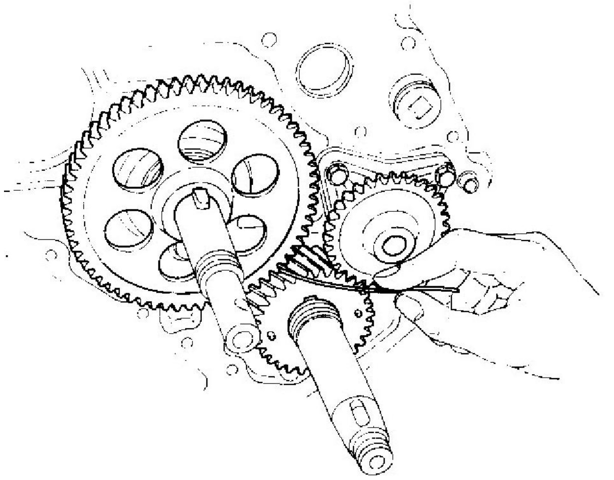
mm (in.)

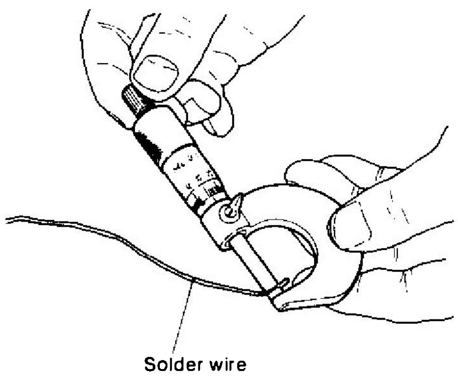
	1GM		2GM, 3GM(D), 3HM	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crankshaft gear and camshaft gear backlash	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)
Crankshaft gear and lubricating oil pump driven gear backlash	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)	0.05 ~ 0.13 (0.0020 ~ 0.0051)	0.3 (0.0118)

Measuring backlash
(1) Lock one of the two gears to be measured and measure the amount of movement of the other gear by placing a dial gauge on the tooth surface.



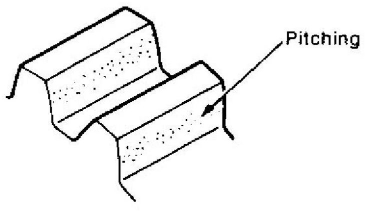
(2) Insert a piece of quality solder between the gears to be measured and turn the gears. The backlash can be measured by measuring the thickness of the crushed part of the solder.





8-3.2 Inspecting the gear tooth surface

Check the tooth surface for damage caused by pitching and check tooth contact. Repair if the damage is light. Also inspect the gears for cracking and corrosion.
When gear noise becomes high because of wear or damage, replace the gears as a set.



8-3.3 Inspecting the gear boss

Check for play between each gear and the gear shaft, burning caused by play, key damage, and for cracking at the edge of the key groove. Replace the gears when faulty.

CHAPTER 3

FUEL SYSTEM

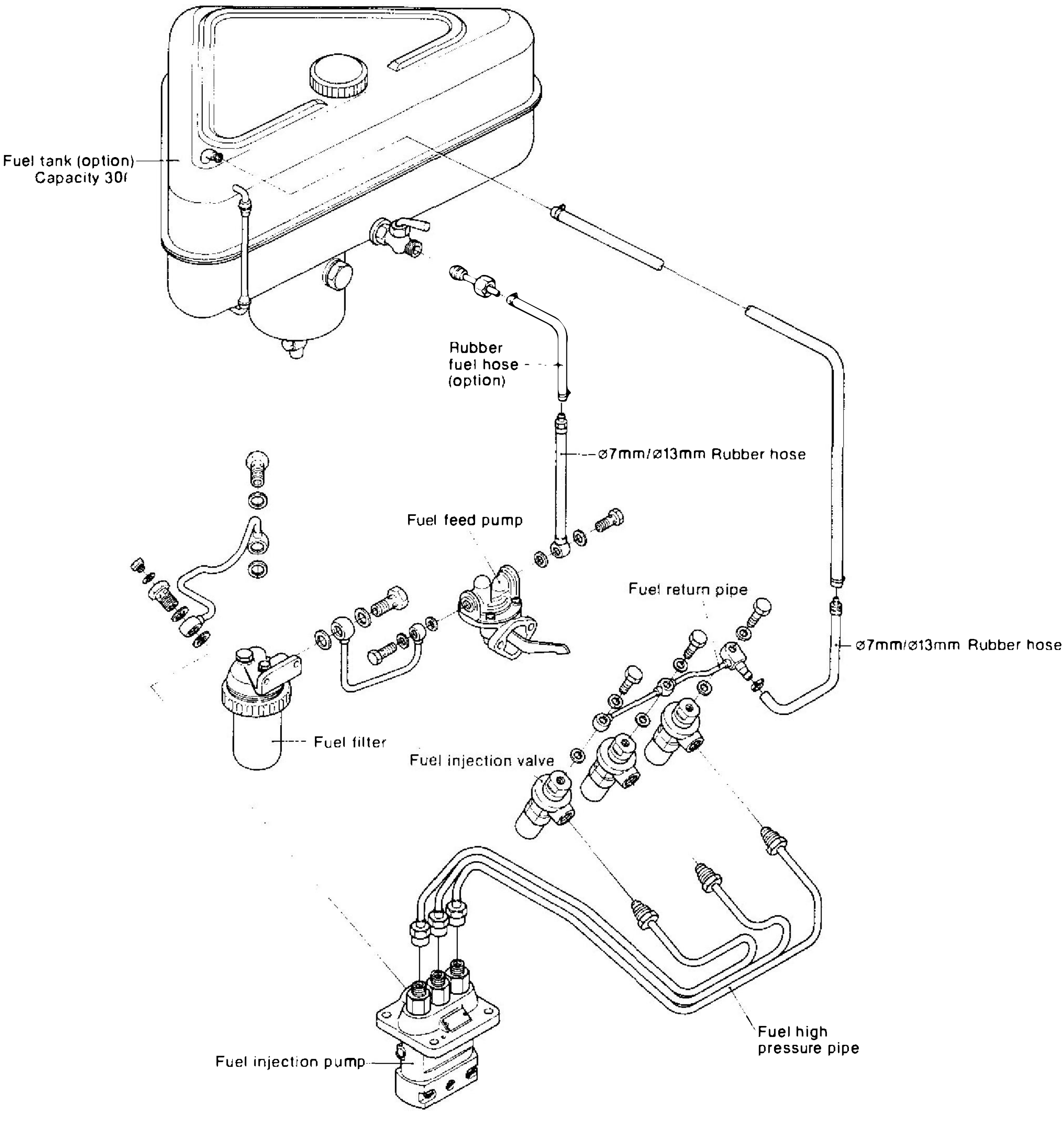
IMPORTANT

Among the fuel injection system, components of injection pump for new engine models are changed from those used in the pump as described in the 1st edition of this service manual (Print #F034A1112). For details please refer to GM/HM Parts Catalog.

Engine models and engine numbers using new components are as follows:

1GM	E/#02407	and after
2GM(F)	E/#02334	"
3GM (F)	E/#01664	"
3HM	E/#00991	"
3HMF	E/#00023	"

1. Fuel Injection System



1-1 Construction

The fuel system consists mainly of an injection pump, injection pipe, and an injection nozzle, plus a fuel tank, feed pump, fuel filter and other associated parts. The injection pump is driven by a fuel cam mounted on the camshaft and is controlled by a governor. Fuel stored in the fuel tank is fed to the fuel filter through the feed pump. (The feed pump is indispensable when the fuel tank is installed lower than the injection pump.)
Dirt and other impurities in the fuel are removed by the filter and the clean fuel is sent to the injection pump, which applies the necessary pressure for injection to the fuel and atomizes the fuel by passing it through the injection nozzle. The injection pump also controls the amount of fuel injected and the injection timing according to the engine load and speed by means of a governor.
The injection pump feeds the fuel to the injection nozzle through a high pressure pipe. The pressurized fuel is atomized and injected by the injection nozzle into the precombustion chamber.
Fuel that overflows the injection nozzle is returned to the fuel tank through the fuel return pipe. The quality of the equipment and parts comprising the fuel injection system directly affects combustion performance and has a considerable effect on engine performance. Therefore, this system must be inspected and serviced regularly to ensure top performance.
This pipework diagram of the fuel system is of model 3GM(D) engine. Models 1GM and 2GM are the same except for the shape of the fuel injection pump and fuel feed pump, and the number of fuel injection valves.
It is also the same for models 3GM(D) and 3HM except for the fuel injection pump and fuel injection valve.

1-2 Fuel injection system specifications

	1GM	2GM	3GM(D)	3HM
Type of injection pump	YPFR-0707-1	YPFR-0707-2	YPFR-0707	YPFR-0707
Type of injection nozzle	YDN-OSDYD1 (Throttle)			YDN-OSDYD1 (Throttle)
Injection pressure	170 kg/cm² (2418 lb/in.²)			160 kg/cm² (2276 lb/in.²)
Plunger diameter × stroke	⌀6mm (0.2362in.) × 7mm (0.2756in.)			⌀6.5mm (0.2559in.) × 7mm (0.2756in.)
Delivery valve suction capacity	23.5mm³/st (0.0014in.³/st)			23.5mm³/st (0.0014 in³/st)
Fuel feed pressure	0.1 kg/cm² (1.4224 lb/in.²)			0.1 kg/cm² (1.4224 lb/in²)

2. Injection Pump

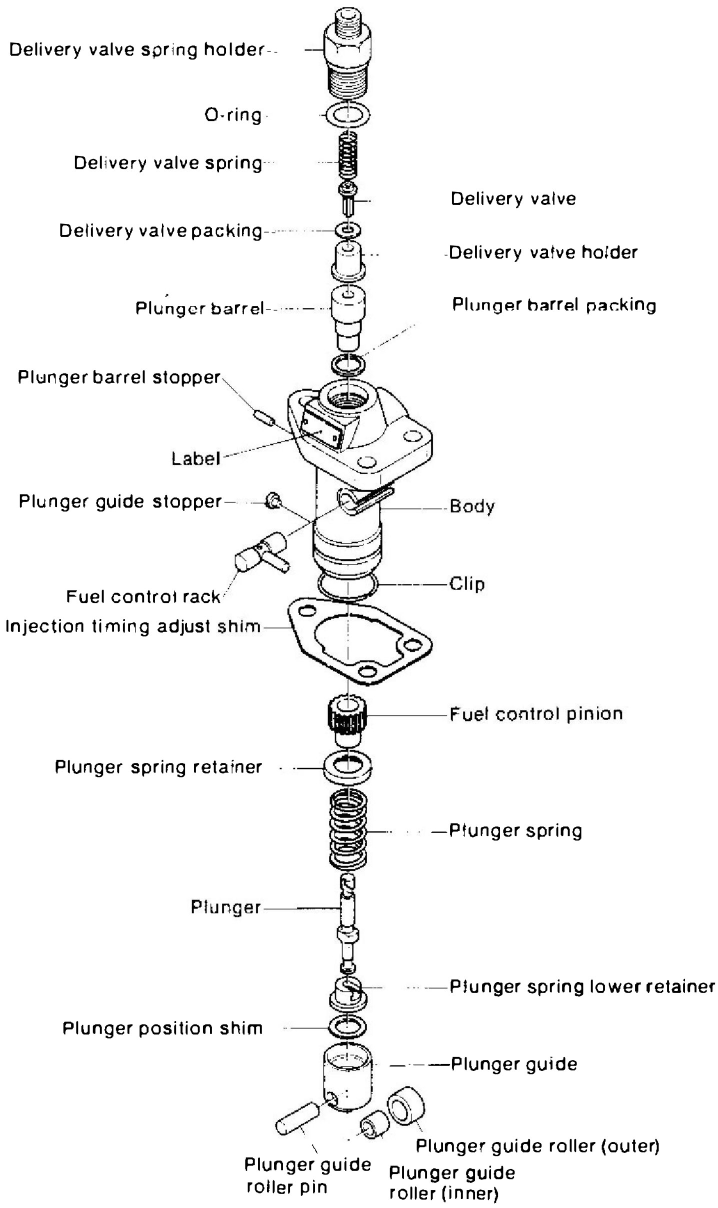
The injection pump is the most important part of the fuel system. This pump feeds the proper amount of fuel to the engine at the proper time in accordance with the engine load.
This engine uses a Bosch integral type injection pump for two/three cylinders. It is designed and manufactured by Yanmar, and is ideal for the fuel system of this engine.
Since the injection pump is subjected to extremely high pressures and must be accurate as well as deformation—and wear-free, stringently selected materials are used and precision finished after undergoing heat treatment.
The injection pump must be handled carefully. Since the delivery valve and delivery valve holder and the plunger and plunger barrel are lapped, they must be changed as a pair.

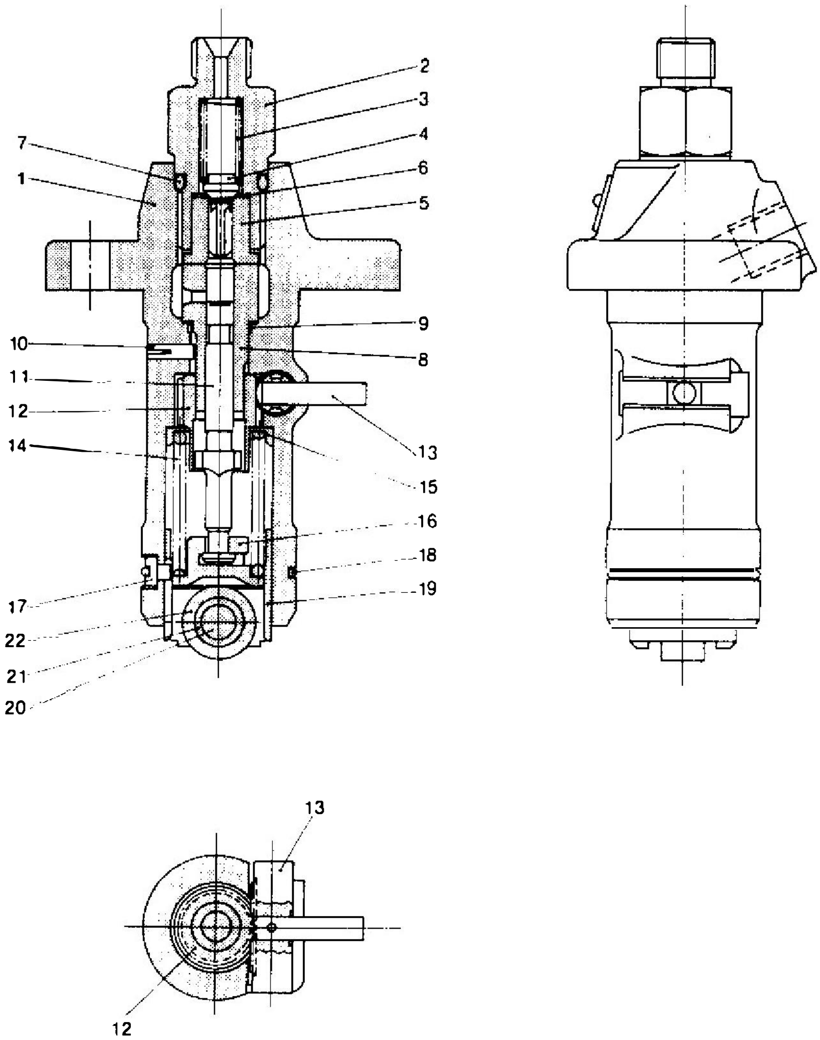
The fuel injection pump is constructed from the following main parts.

(1) Pump parts which compress and deliver the fuel: plunger, plunger barrel.
(2) Parts which move the plunger: camshaft, tappet, plunger spring, plunger spring retainer.
(3) Parts which control the injection amount: control rack, control pinion, control sleeve.
(4) Parts which prevent back flow and dripping during injection: delivery valve.

2-1 Construction

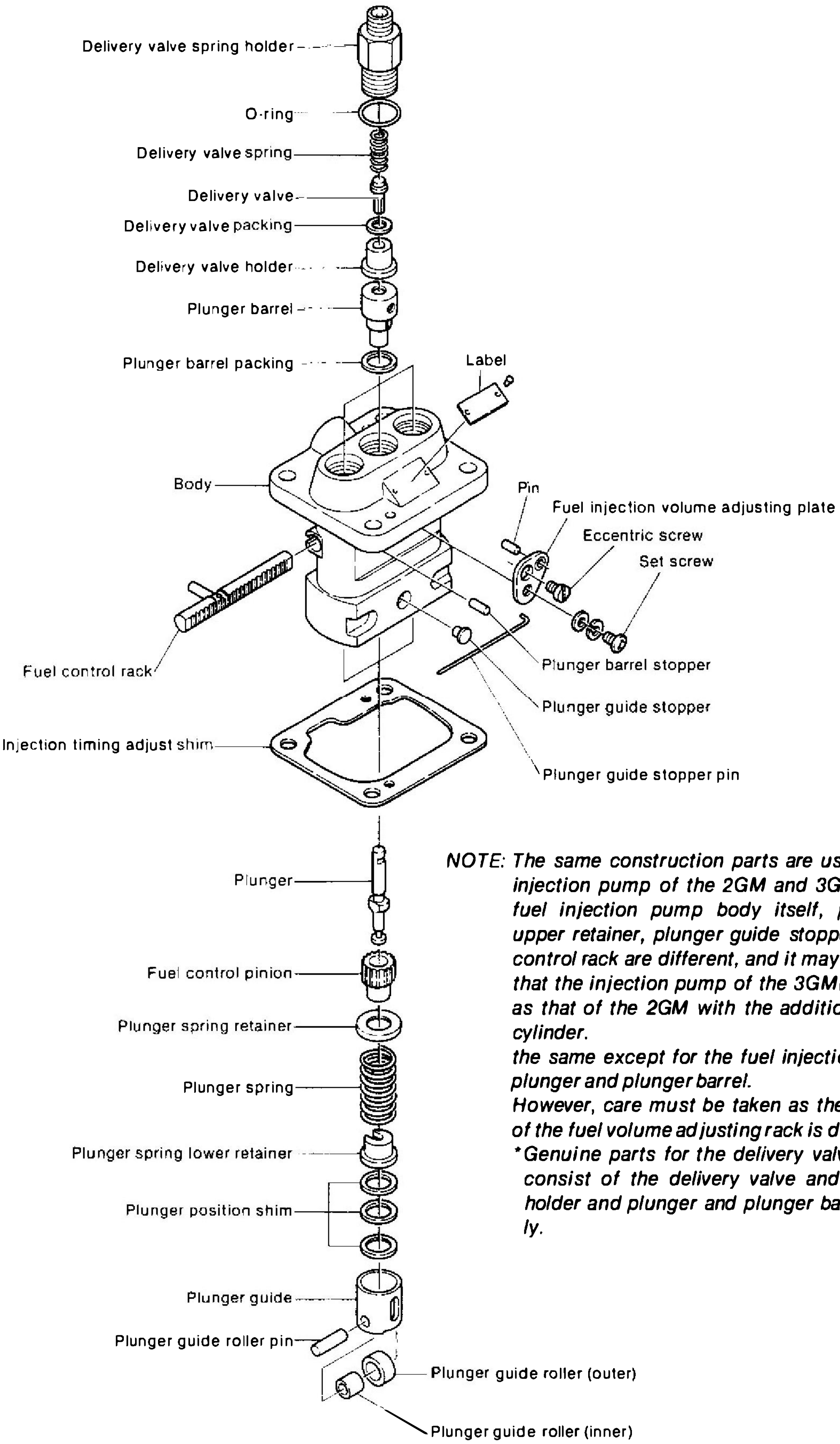
2-1.1 1GM





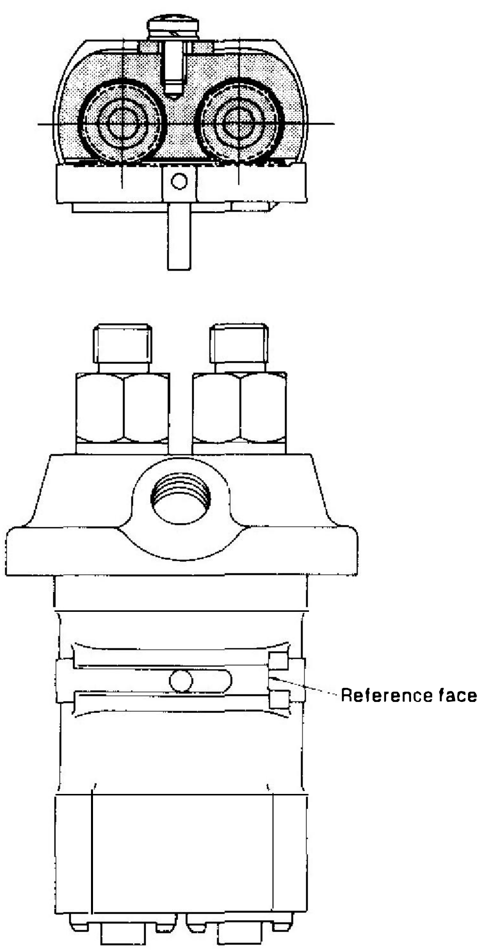
1 Body
2 Delivery valve spring holder
3 Delivery valve spring
4 Delivery valve
5 Delivery valve holder
6 Delivery valve packing
7 O-ring
8 Plunger barrel
9 Plunger barrel packing
10 Plunger barrel stopper
11 Plunger
12 Fuel control pinion
13 Fuel control rack
14 Plunger spring
15 Plunger spring retainer
16 Plunger spring lower retainer
17 Plunger guide stopper
18 Clip
19 Plunger guide
20 Plunger guide roller pin
21 Plunger guide roller (inner)
22 Plunger guide roller (outer)

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

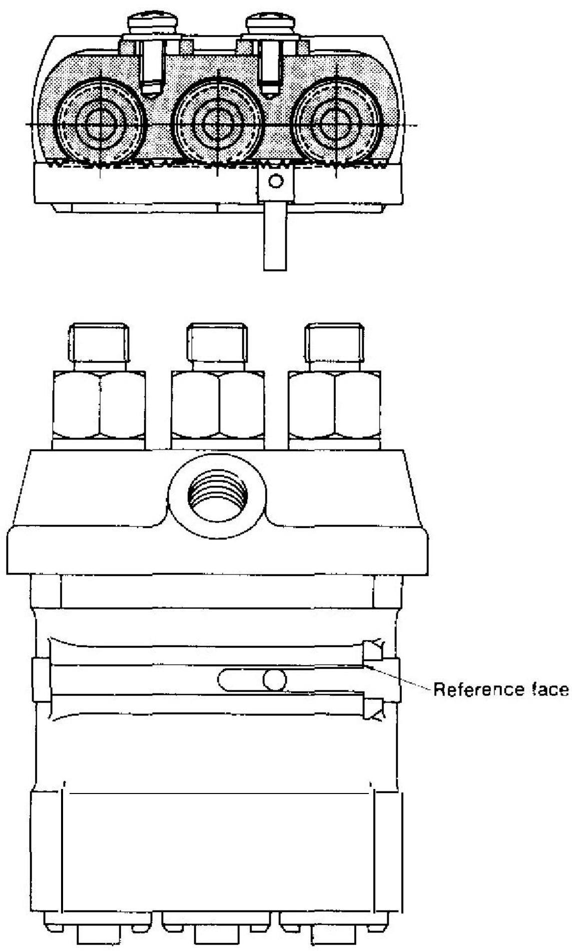


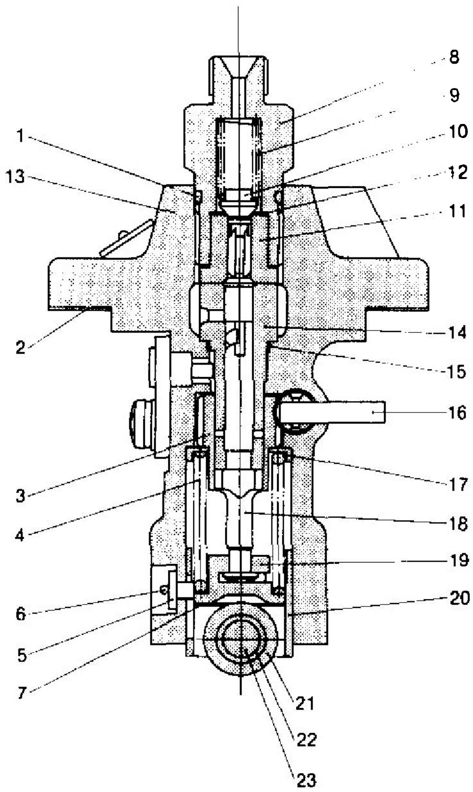
NOTE: The same construction parts are used for the fuel injection pump of the 2GM and 3GM(D). Only the fuel injection pump body itself, plunger spring upper retainer, plunger guide stopper pin and fuel control rack are different, and it may be understood that the injection pump of the 3GM(D) is the same as that of the 2GM with the addition of one more cylinder.
the same except for the fuel injection pump body, plunger and plunger barrel.
However, care must be taken as the basic surface of the fuel volume adjusting rack is different.
**Genuine parts for the delivery valve and plunger consist of the delivery valve and delivery valve holder and plunger and plunger barrel respectively.*

2GM



3GM(D)

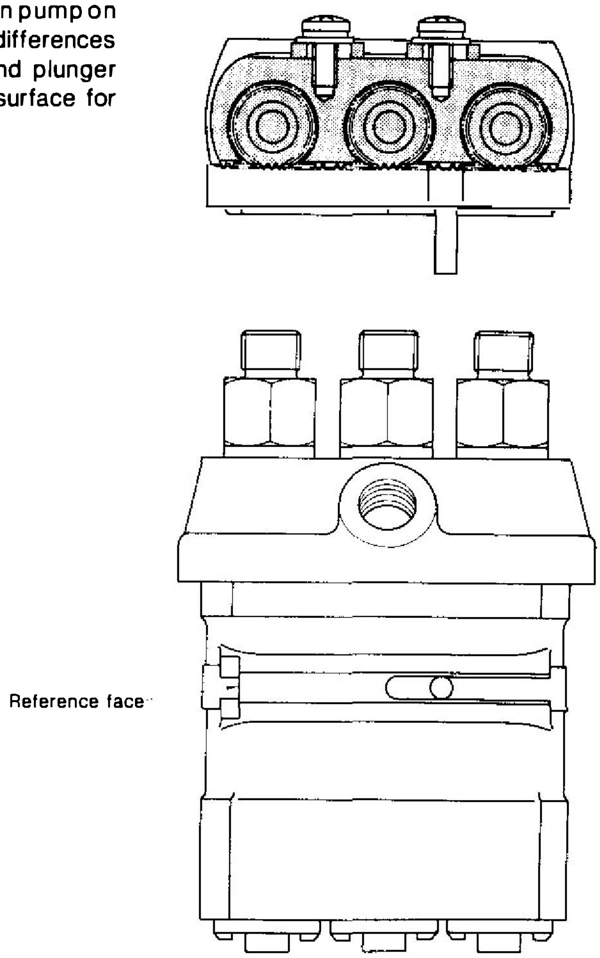


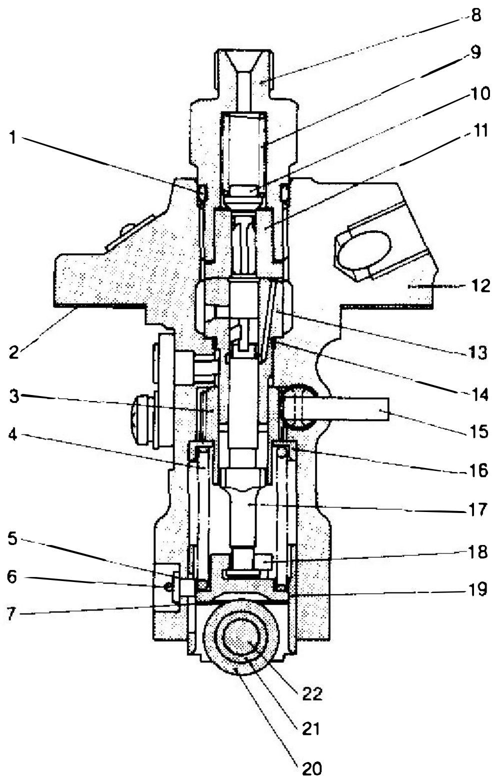


1 O-ring
2 Injection timing shim
3 Fuel control pinion
4 Plunger spring
5 Plunger guide stopper
6 Plunger guide stopper pin
7 Plunger position shim
8 Delivery valve spring holder
9 Delivery valve spring
10 Delivery valve
11 Delivery valve holder
12 Delivery valve packing
13 Body
14 Plunger barrel
15 Plunger barrel packing
16 Fuel control rack
17 Plunger spring retainer
18 Plunger
19 Plunger spring lower retainer
20 Plunger guide
21 Plunger guide roller (outer)
22 Plunger guide roller (inner)
23 Plunger guide roller pin

3HM

The construction is the same as the fuel injection pump on model 2GM or 3GM(D) engines except for the differences of the plunger diameters, shape of plungers and plunger barrels. Take care as the position of the basic surface for adjusting the injection volume is different.





1 O-ring
2 Injection timing shim
3 Fuel control pinion
4 Plunger spring
5 Plunger guide stopper
6 Plunger guide stopper pin
7 Plunger position shim
8 Delivery valve spring holder
9 Delivery valve spring
10 Delivery valve
11 Delivery valve holder
12 Body
13 Plunger barrel
14 Plunger barrel packing
15 Fuel control rack
16 Plunger spring retainer
17 Plunger
18 Plunger spring lower retainer
19 Plunger guide
20 Plunger guide roller (outer)
21 Plunger guide roller (inner)
22 Plunger guide roller pin

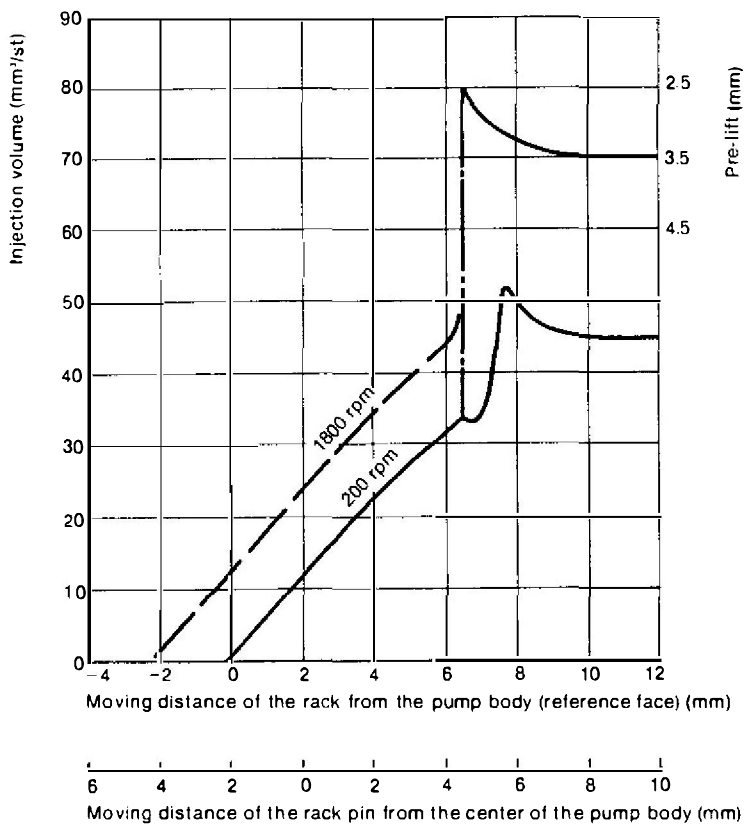
2-2 Specifications and performance of fuel injection pump

2-2.1 Specifications of fuel injection pump

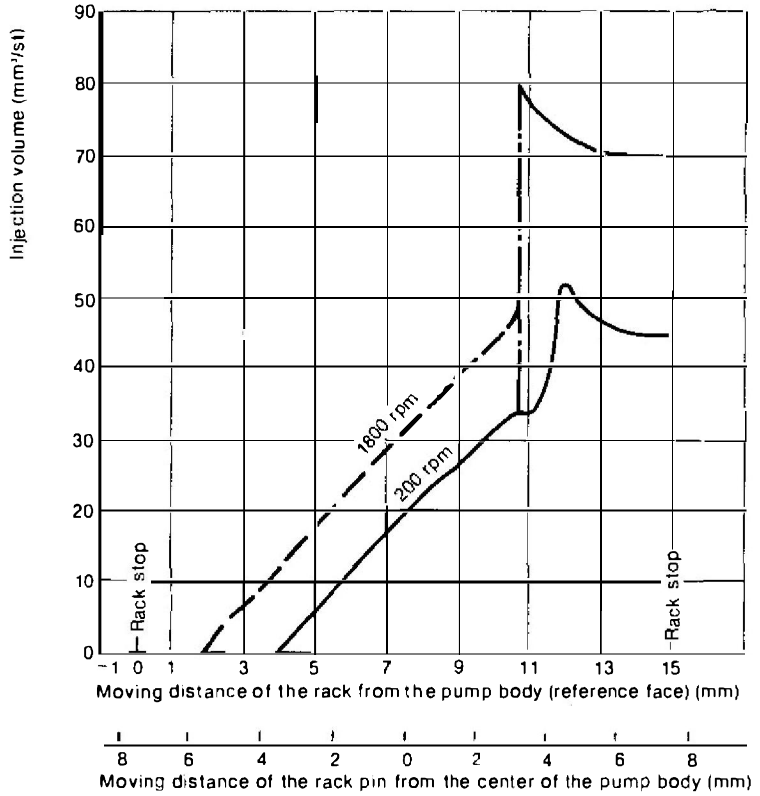
			1GM	2GM	3GM(D)	3HM
Plunger diameter			6mm (0.2362in.)			6.5mm (0.2559in.)
Standard plunger stroke			7mm (0.2756in.)			
Static mechanical lift at injection			2.5mm (0.0984in.) [at starting 3.2mm (0.1260in.)]			
Sliding resistance of fuel volume adjusting rack (when pump stops)			60g (0.002 lb) or less			
Top clearance of plunger (at the set dimension of 76 ±0.05mm)			1.0mm (0.0394in.)			
Thickness of plunger position adjusting shim			0.1mm (0.0039in.), 0.2mm (0.0079in.), 0.3mm (0.0118in.)			
Plunger spring (124950-51190 commonly used)	Free length		35.5mm (1.3976in.)			
	Spring constant		1.93 kg/cm (10.8 lb/in.)			
	Load	At upper limit	25.1 kg (55.3 lb)			
		At lower limit	11.6 kg (25.6 lb)			
		At static injection	16.4 kg (36.2 lb)			
Suction volume of delivery valve			23.5mm³ (0.0014in.³) (24.5 according to 1GM drawing)			
Opening pressure of delivery valve			Approx. 16.3 kg/cm² (231.8 lb/in²)			
Delivery valve spring (124550-51320 commonly used)	Free length		21.0mm (0.8268in.)			
	Spring constant		0.64 kg/cm (9.1 lb/in.)			
Rack stroke			Approx. 15mm (0.5906in.)			

2-2.2 Injection volume characteristics of fuel injection pump

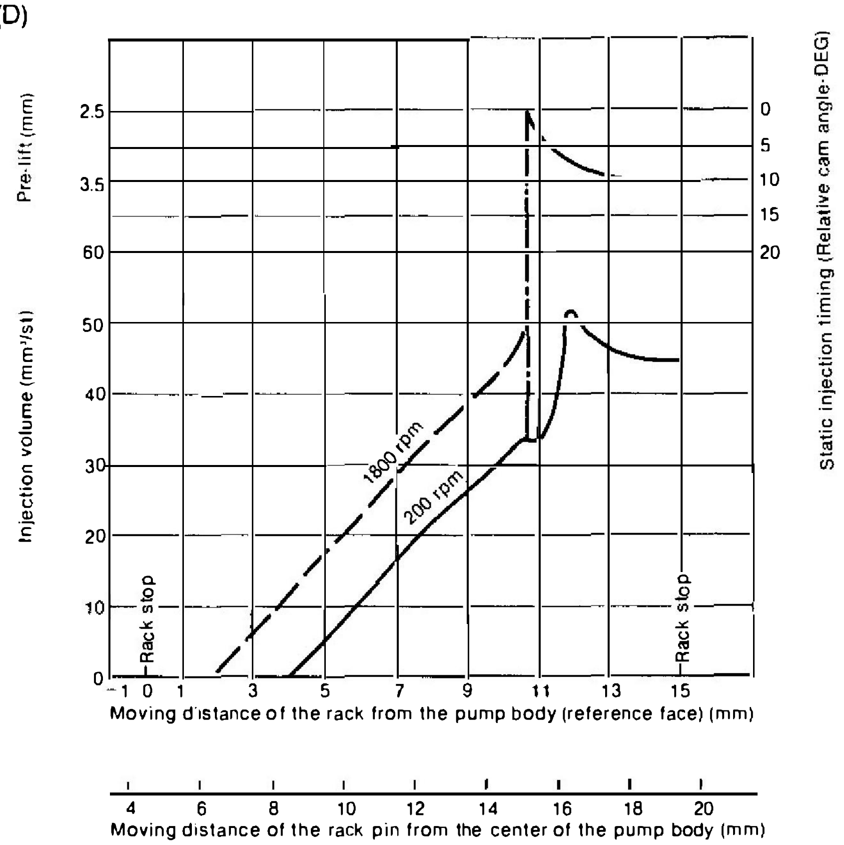
(1) Model 1GM



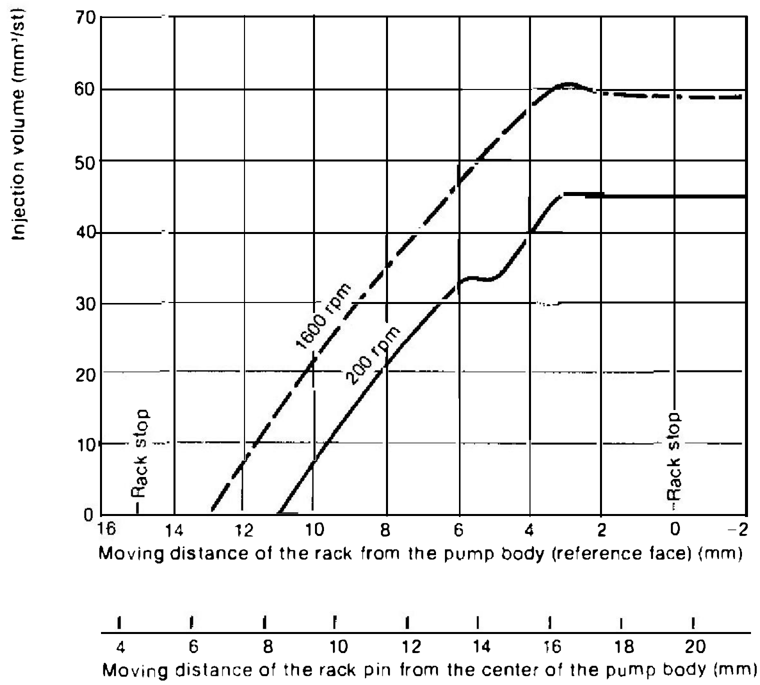
(2) Model 2GM



(3) Model 3GM(D)

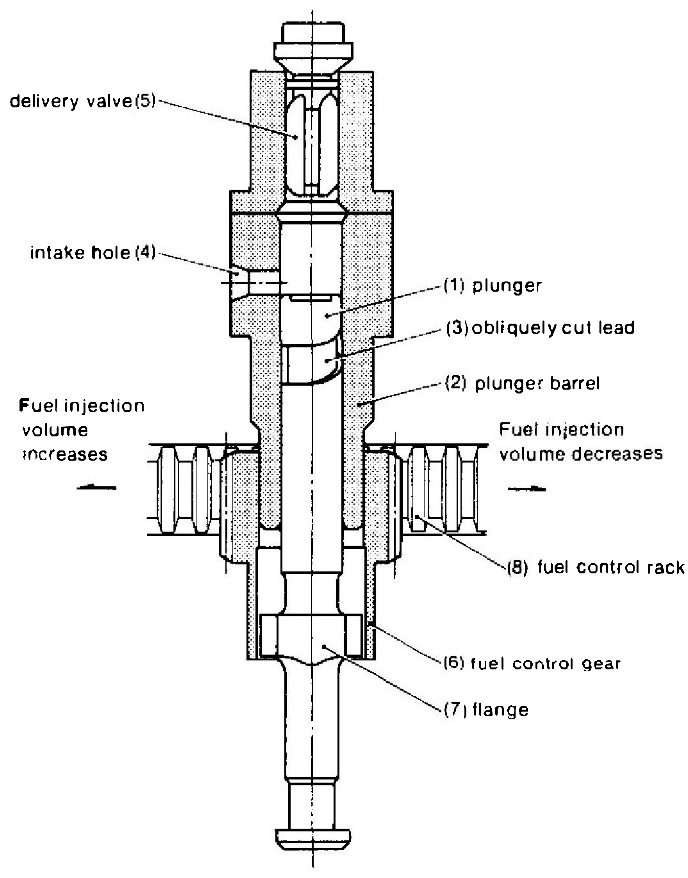


(4) Model 3HM



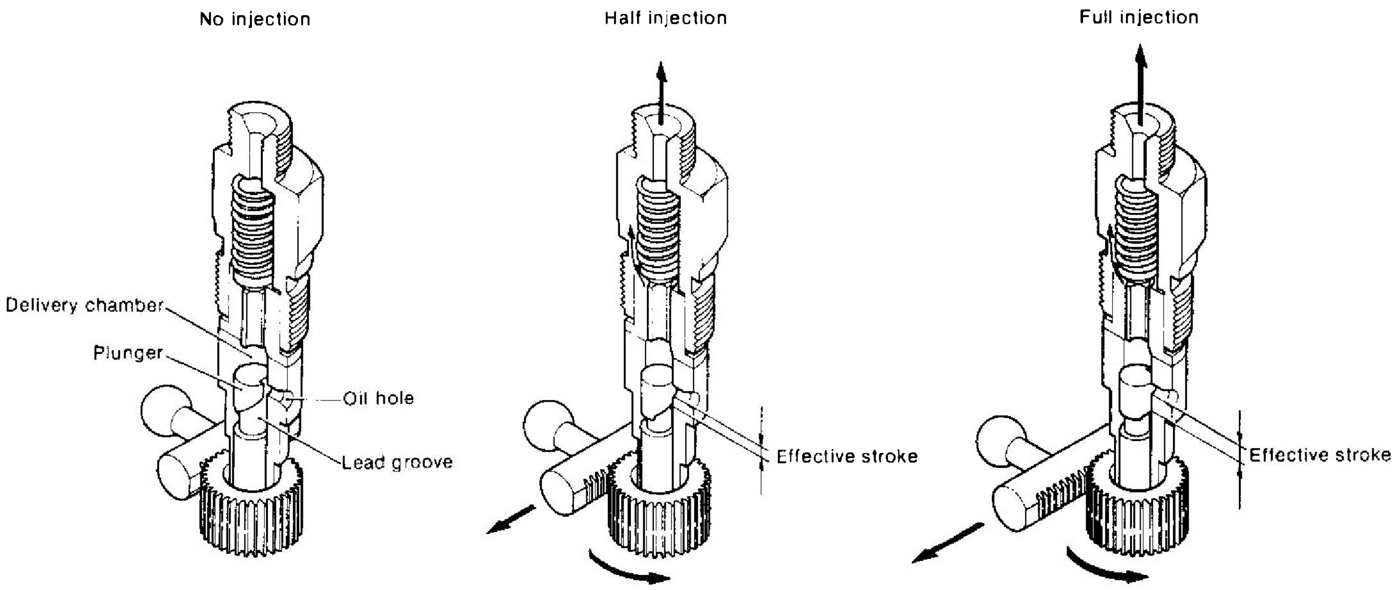
2-3 Operation of fuel injection pump

The fuel injection pump force-feeds the fuel by means of the plunger (1) which operates at a constant stroke. Since the plunger is lap fitted into the plunger barrel (2) for super precison, it can be replaced only as a set. The cylindrical surface of the plunger has an obliquely cut lead (3) and a groove which connects the lead to the plunger head. The plunger has an intake hole (4) through which the fuel passes and is force-fed by the plunger. Then the fuel opens the delivery valve (5), goes through the fuel injection tube, and is injected into the spiral-vortex type pre-combustion chamber from the injection valve. The plunger is fitted with the fuel control gear (6), and its flange (7) fits into the groove which is longitudinally cut into the inner surface of the lower end of the control gear. The fuel control gear is in mesh with the fuel control rack, the motion of which rotates the plunger to constantly vary the amount of fuel injected from zero to maximum.



2-3.1 Fuel control

When the plunger (1) is at bottom dead center, the oil, which comes in through the oil hole, fills the delivery chamber (3) to above the plunger; the oil pressure then builds up as the plunger rises and closes the oil hole, and by opening the delivery valve, is force-fed toward the fuel injection tube. As the plunger, pushed by the plunger guide, rises further, the pressure of the oil between the delivery chamber and the nozzle also increases. When this oil pressure builds up to 155 to 165 kg/cm², the nozzle opens, and the fuel oil is injected into the spiral vortex type combustion chamber. However, if the plunger keeps rising and the lead groove (4) lines up with the oil hole (2), the oil under high pressure in the delivery chamber passes the lead from the longitudinal groove up the lead and is driven back into the suction chamber from the oil hole. At the same time force feeding of the fuel is suspended.

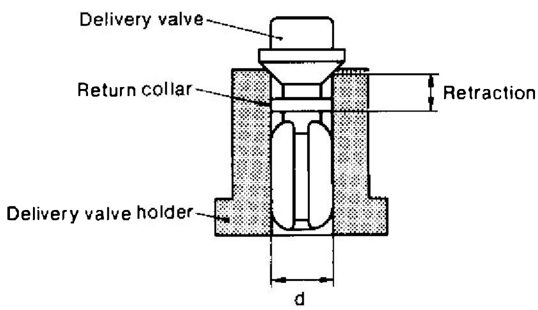


As a result of the above action, the plunger is rotated by the fuel control rack and the angle of this rotation changes the effective stroke of the plunger and controls the discharge of the pump. Also, when the fuel control rack lines up the longitudinal groove on the plunger with the oil hole, the oil hole does not close, despite the rise of the plunger, but rather the fuel is driven back to the suction chamber. As a result the fuel is not force-fed but the amount of injection is reduced to zero. At this time the fuel control rack is at the cylinder side end; when it reaches the opposite side end the maximum amount of fuel is injected. Before the maximum injection level is reached, the fuel injection control shaft regulates the amount of fuel injected to the normal operation level.

NOTE: *The plunger is an integral part of the plunger barrel and takes in and compresses fuel by reciprocating inside the plunger barrel. The plunger and plunger barrel are precisely machined, and because the plunger is driven in an extremely small space, the two should be used together and should not be changed with other cylinders.*

2-3.2 Action of the delivery valve and the sucking-back of fuel

The delivery valve on top of the plunger prevents the fuel within the injection tube from flowing backward toward the plunger side and also serves to suck back the fuel to prevent the backward dripping of the nozzle valve. When the notch (lead) of the plunger comes up to the oil hole of the plunger barrel, the feeding pressure acting on the fuel oil drops, and the delivery valve falls due to the force of the spring. After the sucking-back collar (1) has first shut off the fuel injection tube and the delivery chamber the delivery valve drops further until it comes into contact with the seat surface. (2) corresponding to the amount of fall (i.e., increase in volume), the fuel oil pressure within the injection tube drops, speeding up the closure of the nozzle valve, and sucking up the fuel before it drips back, This enhances the durability of the nozzle and improves fuel oil combustion.



Amount of fuel retraction	$\pi/4\ d^2\ell$ = 23.5mm³/stroke (0.0014in³./st.)