CHAPTER 2

BASIC ENGINE

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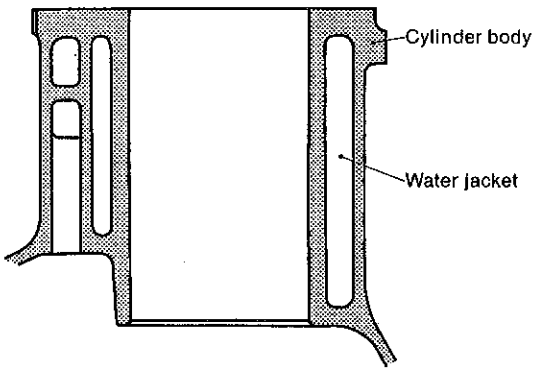
1. Cylinder Block

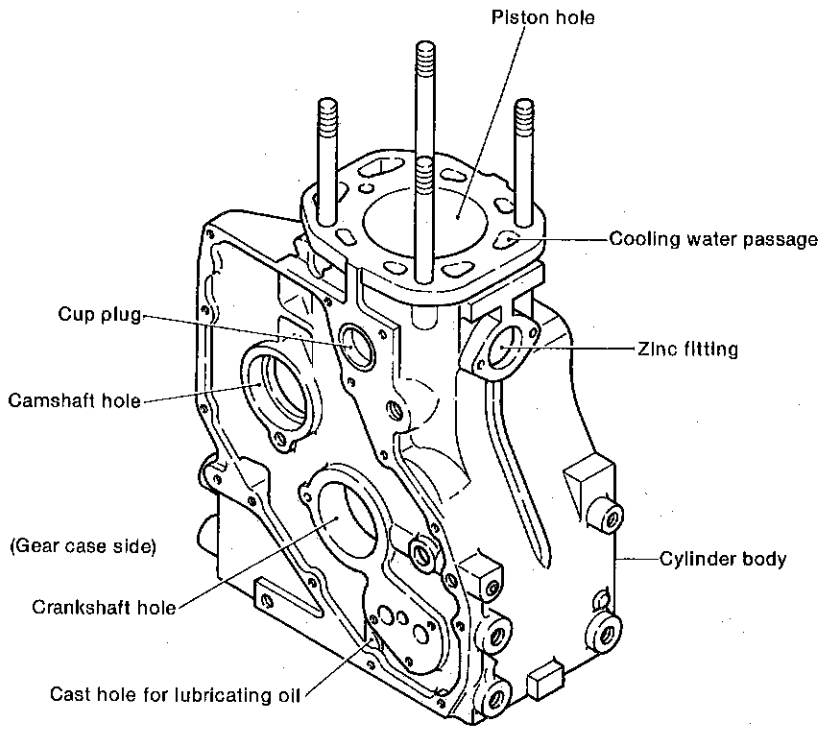
1-1 Construction

The cylinder block comprises a single unit casting for the cylinder body without the use of cylinder liners.



The cylinder block is a high-quality cast iron casting, with integral cylinders and deep skirt crankcase construction. As a result of stress analyses, the shape and thickness of each part has been optimized, and special ribs employed which not only increase the strength and rigidity of the block, but also reduce noise.

1-1.1 Cylinder of model 1GM10(C) engine



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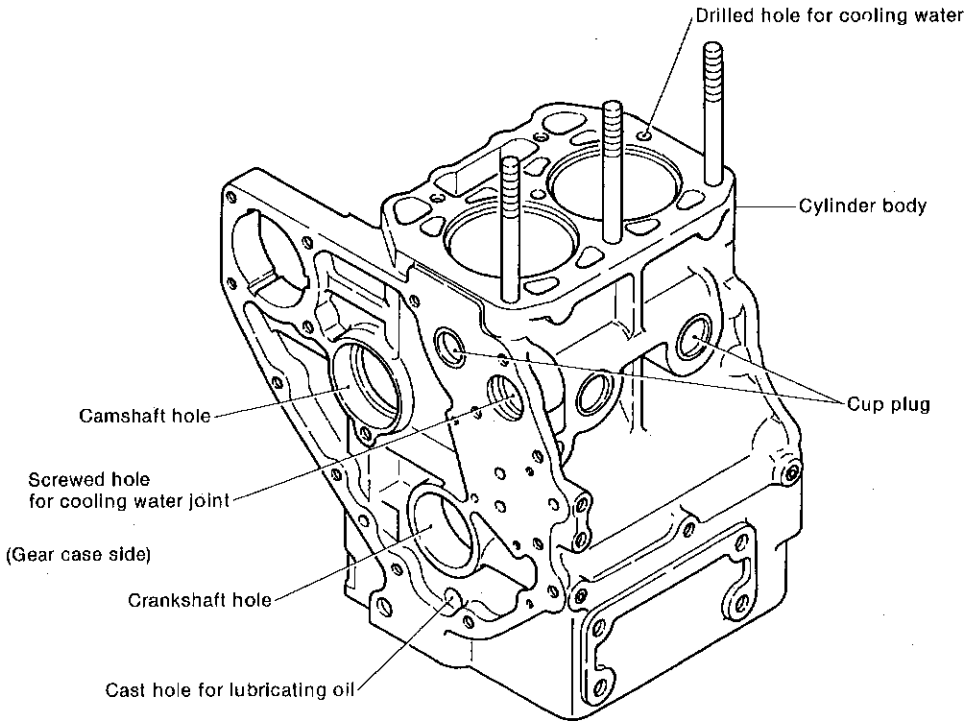
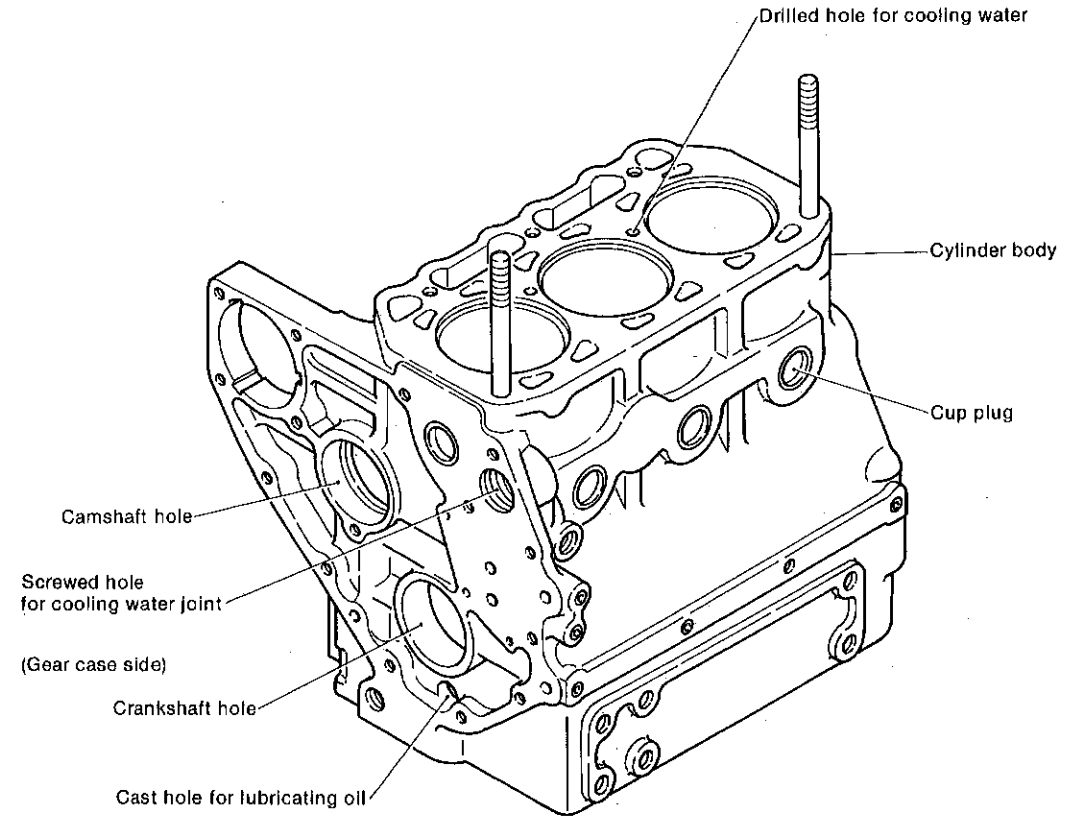
1-1.2 Cylinder of model 2GM20(F)(C) engine



1-1.3 Cylinder of model 3GM30(F)(C) engine



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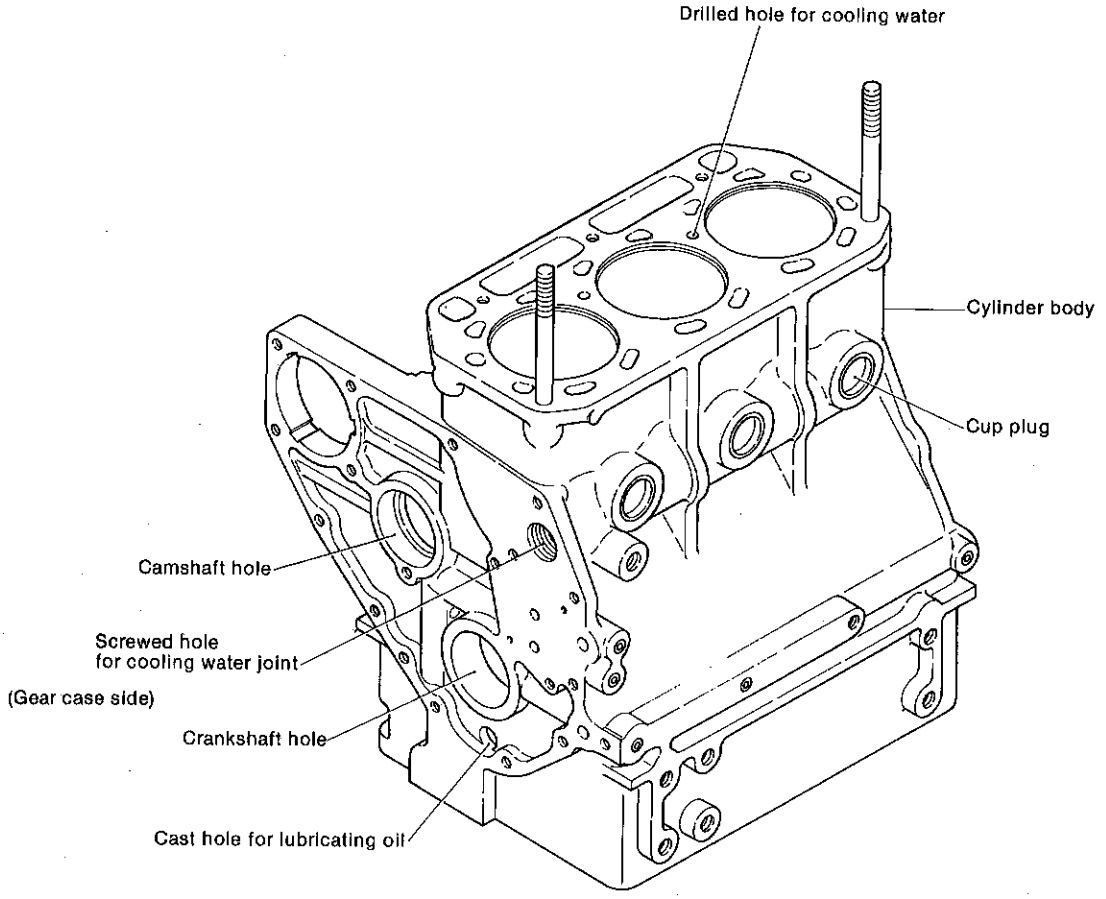
1-1.4 Cylinder of model 3HM35(F)(C) engine



1-2 Cylinder block inspection

1-2.1 Inspecting each part for cracks

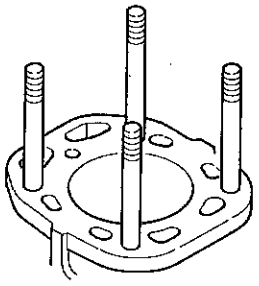
If the engine has been frozen or dropped, visually inspect it for cracks and other abnormalities before disassembling. If there are any abnormalities or the danger of any abnormalities occurring, make a color check.

1-2.2 Inspecting the water jacket of the cylinder for corrosion

Inspect the cooling water passages for sea water corrosion, scale, and rust. Replace the cylinder body if corrosion, scale or rust is severe.

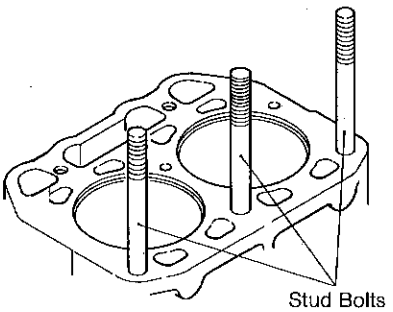
1-2.3 Cylinder head stud bolts

Check for loose cylinder head bolts and for cracking caused by abnormal tightening, either by visual inspection or by a color check.
Replace the cylinder block if cracked.



1GM10(C)

Bolt diameter	M10
Pitch	1.5
Tightening torque	6.0 kg-m (43.4 ft-lb)



2GM20(F)(C)

Bolt diameter	M12
Pitch	1.25
Tightening torque	8.0 kg-m (57.9 ft-lb)

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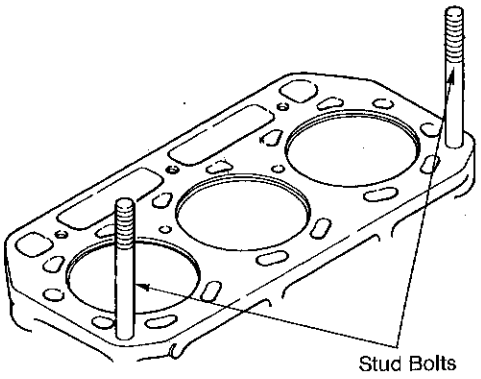
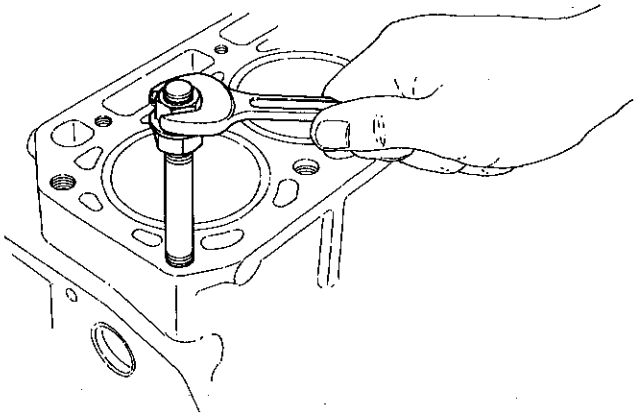
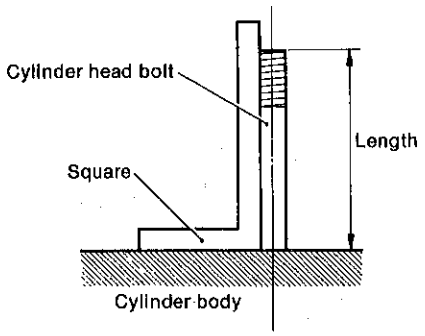


3GM30(F)(C), 3HM35(F)(C) kg-m(ft-lb)

	3GM30(F)(C)	3HM35(F)(C)
Bolt diameter	M12	
Pitch	1.25	
Tightening torque	8.0(57.9)	10.0(72.3)



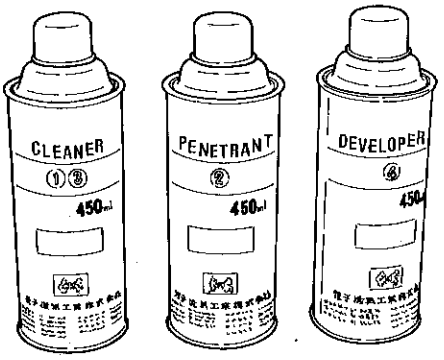


1-2.4 Oil and water passages

Check the oil and water passages for clogging and build-up of foreign matter.

1-2.5 Color check flaw detection procedure

(1) Clean the inspection point thoroughly.
(2) Procure the dye penetration flaw detection agent. This agent comes in spray cans, and consists of a cleaner, penetrant, and developer in one set.



(3) Pretreat the inspection surface with the cleaner. Spray the cleaner directly onto the inspection surface, or wipe the inspection surface with a cloth moistened with the cleaner.
(4) Spray the red penetration liquid onto the inspection surface. After cleaning the inspection surface, spray the red penetrant (dye penetration flaw detection agent) onto it and allow the liquid to penetrate for 5-10 minutes.
If the penetrant fails to penetrate the inspection surface on account of the ambient temperature or for other reasons, allow it to dry and respray the inspection surface.
(5) Spray the developer onto the inspection surface. After penetration processing, remove the residual penetrant from the inspection surface with the cleaner, and then spray the developer onto the inspection surface. If the inspection surface is flawed, red dots or lines will appear on the surface within several minutes. When spraying the developer onto the inspection surface, hold the can about 30—40cm from the surface and sweep the can slowly back and forth to obtain a uniform film.
(6) Reclean the inspection surface with the cleaner.

NOTE: Before using the dye penetration flaw detection agent, read its usage instructions thoroughly.

1-3 Cylinder bore measurement

Cylinder wear is measured with a cylinder gauge. The amount of cylinder wear becomes greater as the piston nears the top, and it becomes greatest at the position of the top ring when the piston is in top dead center. The reason for this is that when the piston is at the top position, lateral pressure is high due to the high explosive pressure, and lubrication is very difficult due to the high temperature. Therefore, the amount of wear must be measured in at least 3 positions, namely the top, middle and bottom positions of the cylinder.

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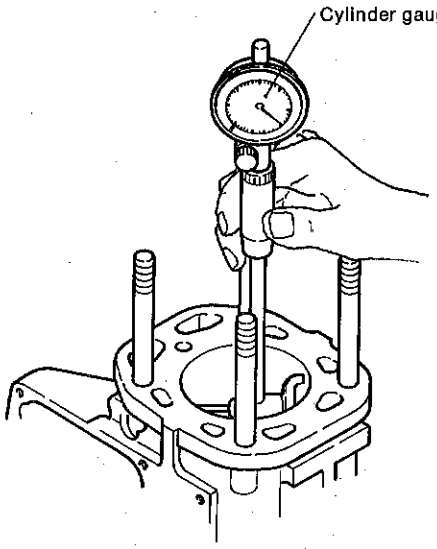
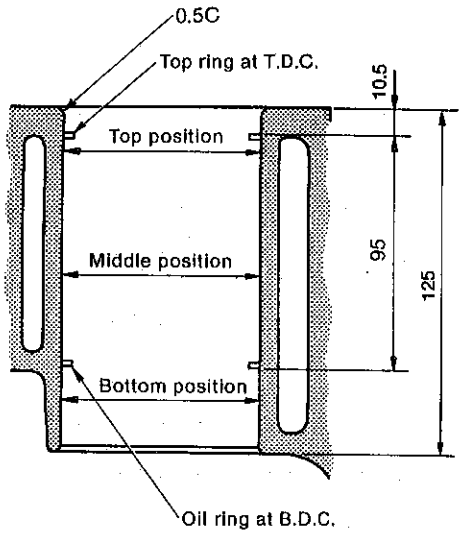
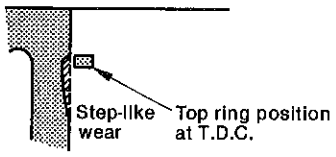
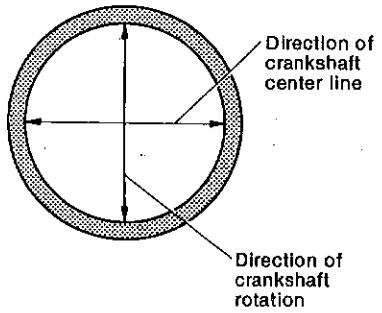
Although the greatest wear is at the top of the cylinder, the piston ring does not slide with the cylinder at the topmost position. Therefore, a step-like pattern is formed between the worn part and the non-worn part.
Furthermore, wear is liable to occur along the rotating direction of the crankshaft due to the lateral pressure of the piston. On the other hand, wear occurs in the direction of the crankshaft center line due to the thrust of the crankshaft and the angle of the connecting rod.
Therefore, the amount of wear must be measured in the directions of crankshaft rotation and the crankshaft center line. When the difference of these two values (i.e. circularity wear) is large, the cylinder must be repaired.









	1GM10(C),2GM20(F)(C),3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Cylinder diameter	ϕ75.0~75.03 (2.9528~2.9540)	ϕ75.10 (2.9567)	ϕ80.0~80.03 (3.1496~3.1508)	ϕ80.10 (3.1535)
Cylinder roundness	0~0.01 (0~0.0004)	0.02 (0.0008)	0~0.01 (0~0.0004)	0.02 (0.0008)

When the result indicates that eccentric and circularity wear exceed the specified limit, the cylinder must be rebored.

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1-3.2 Boring the cylinder

When wear on the inside of the cylinder is excessive, rectify by machining. This is what is known as boring.
When boring is carried out, note the following points.

(1) Dimension to be bored
The cylinder must be bored to the same dimension as an over-size piston.

Over-size piston mm(in.)

ENG. MODEL	O.D. of standard piston	O.D. of over-size piston
1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	ϕ75 (2.9528)	ϕ75.25 (2.9626)
3HM35(F)(C)	ϕ80 (3.1496)	ϕ80.25 (3.1594)

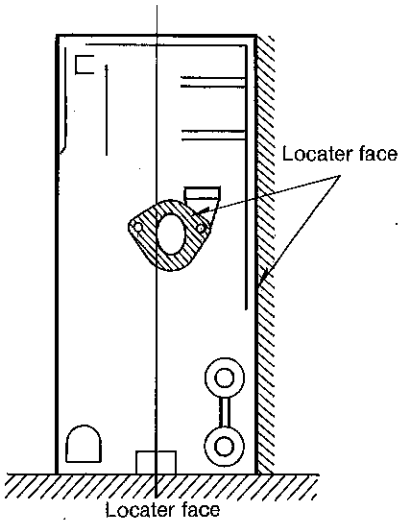
(2) Limit of cylinder's expanded I.D.
Never bore the cylinder beyond the limit of the expanded inner diameter, because no over-size piston is available for that dimension, besides which there is danger in having too thin a wall thickness.

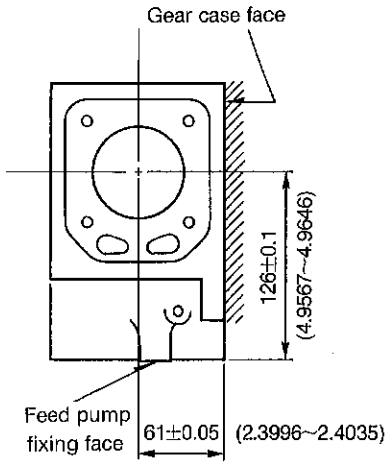
Limit of cylinder's expanded I.D. mm(in.)

ENG. MODEL	I.D. of standard cylinder	Limit of I.D. expansion
1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	ϕ75.0~75.03 (2.9528~2.9540)	ϕ75.25~75.28 (2.9626~2.9638)
3HM35(F)(C)	ϕ80.0~80.03 (3.1496~3.1508)	ϕ80.25~80.28 (3.1595~3.1606)

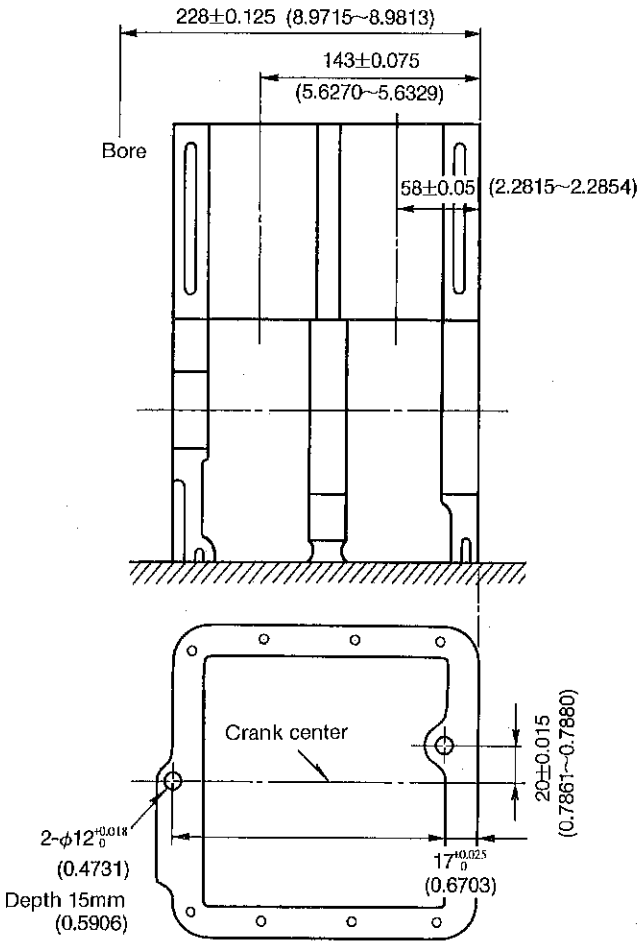
Locater points of cylinder block
For the re-boring of the piston bore in the cylinder block, use the following locater positions. Before re-boring, be sure to remove packings and dust from the locater points.
1) 1GM10(C)
Main locater: Oil pan side
Sub locater: Timing gear case and F.O. feed pump side
2) 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Oil pan side and ϕ2-pin holes

(3) Boring procedures
(1) 1GM10(C)
For processing the bore, face the oil pan side to the bottom and place the fixing faces of the gear case and the feed pump.





(2) 2GM20(F)(C), 3GM30(F)(C)
For processing bring the oil pan side to the bottom, and insert a pin to the 2-$\phi 12^{+0.018}_{0}$ (15mm depth) locater hole.



"*l*" dimension
2GM20: 172±0.05 (6.7697~6.7736)
3GM30: 257±0.05 (10.1161~10.1201)

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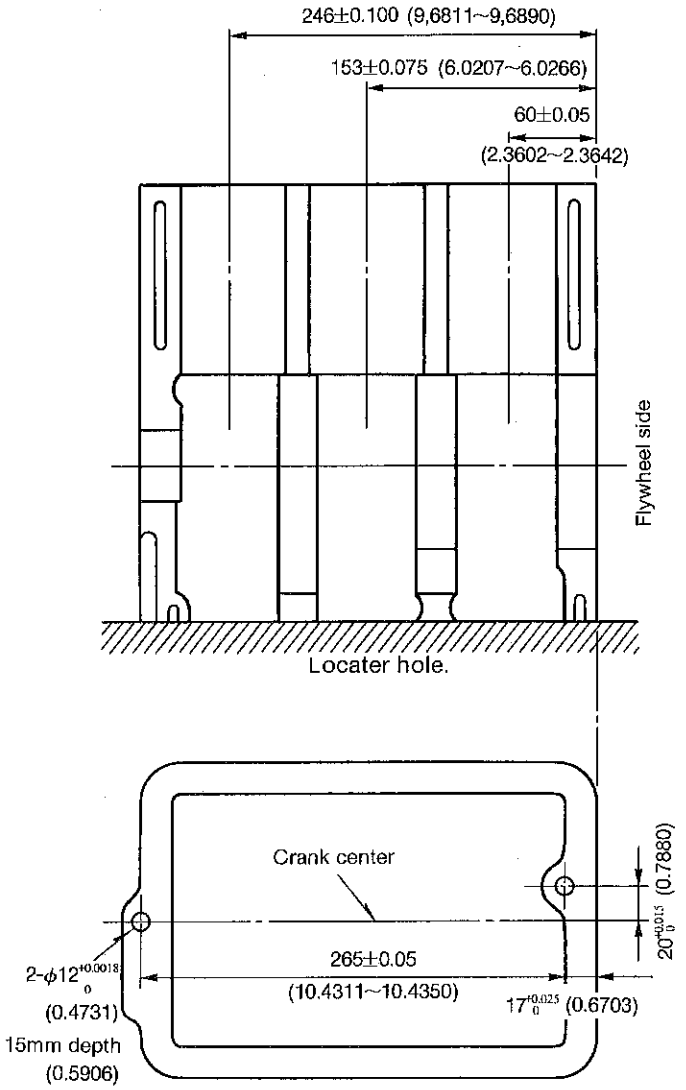
(3) 3HM35
For processing bring the oil pan side to the bottom, and insert a pin to the 2-$\phi 12^{+0.018}_{0}$ (15mm depth) locator hole.

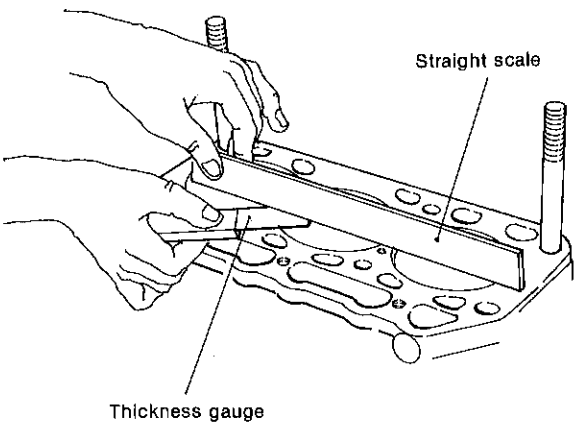


(4) Honing
The inside surface of the cylinder must be honed after being bored in order to remove machine tool marks.

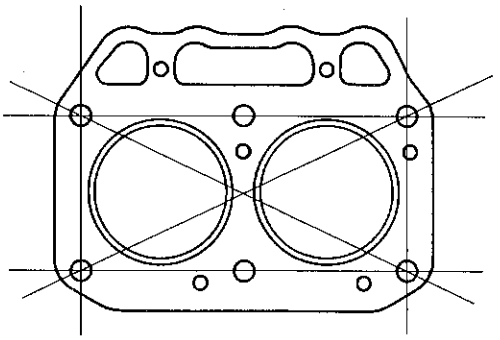
1-4 Measurement of distortion on the upper surface of the cylinder

As the cylinder is repeatedly subjected to thermal expansion and high pressure it will not recover its original shape after the engine has stopped and cooled down and will be distorted. The distortion is mainly caused by construction and material differences of the cylinder, but may arise from the cylinder head bolts being tightened in the wrong order or an uneven tightening torque of the bolts when assembling. If there is any distortion at the upper surface of the cylinder, it will cause a compression pressure leakage, gas leakage or water leakage as a clearance is formed around the cylinder head even though the cylinder head is thoroughly secured.

(1) How to measure distortion on the upper surface of the cylinder
The amount of distortion is measured by placing a straight scale on the upper surface of the cylinder and inserting a thickness gauge between the upper surface of the cylinder and the straight scale.



Measurement is to be carried out on the 4 sides and 2 diagonal lines as shown in the figure, and the largest value of clearance for each measurement is to be taken as the amount of distortion.



mm (in.)

	Allowable limit of distortion
1GM10(C)	0.05(0.002)
2GM20(F)(C)	0.05(0.002)
3GM30(F)(C) 3HM35(F)(C)	0.05(0.002)

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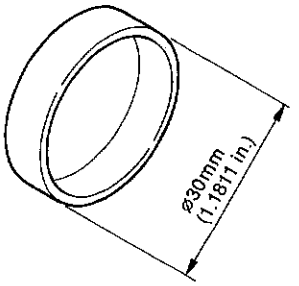
1-5 Cup plug

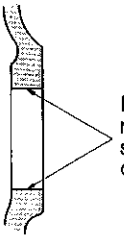
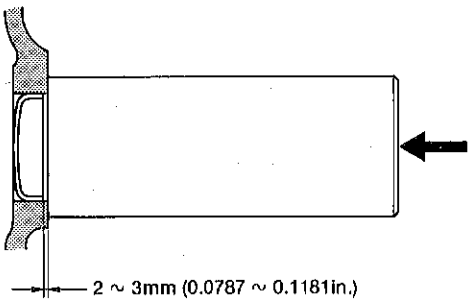
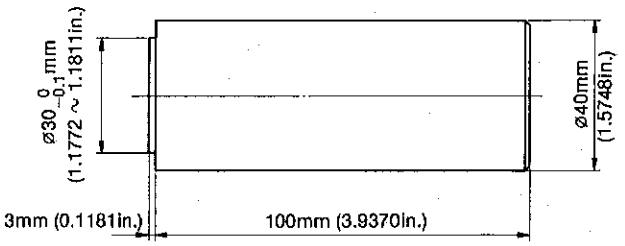
1-5.1 Purpose of cup plug

In order to minimize the danger of cylinder block breakage caused by the cooling water freezing, a cup plug is provided at the side of the cylinder block to prevent damage by frost.
In the event that cooing water freezing has caused the cup plug to come out repair in the following way.
In cold weather it is necessary to drain the cooling water completely from the inside of the cylinder block through the cooling water drain pipe.



	1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
No. of plugs used	2	4	5	5
Part No.	105311-01090			

1-5.2 How to drive in the cup plug

Step No.	Description	Procedure	Tool or material used
1.	Clean and remove grease from the hole into which the cup plug is to be driven. (Remove scale and sealing material previously applied.)	 Remove foreign materials with screw driver or saw blade.	•Screw driver or saw blade •Thinner
2.	Remove grease from the cup plug.	Visually check the nick around the plug.	•Thinner
3.	Apply Threebond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	•Threebond No. 4
4.	Insert the plug into the hole.	Insert the plug so that it sits. correctly.	
5.	Place a driving tool on the cup plug and drive it in using a hammer.  2 ~ 3mm (0.0787 ~ 0.1181in.) *Using the special tool drive the cup plug to a depth where the edge of the plug is 2mm (0.0787in.) below the cylinder surface.	Drive in the plug parallel to the seating surface. 	•Driving tool •Hammer

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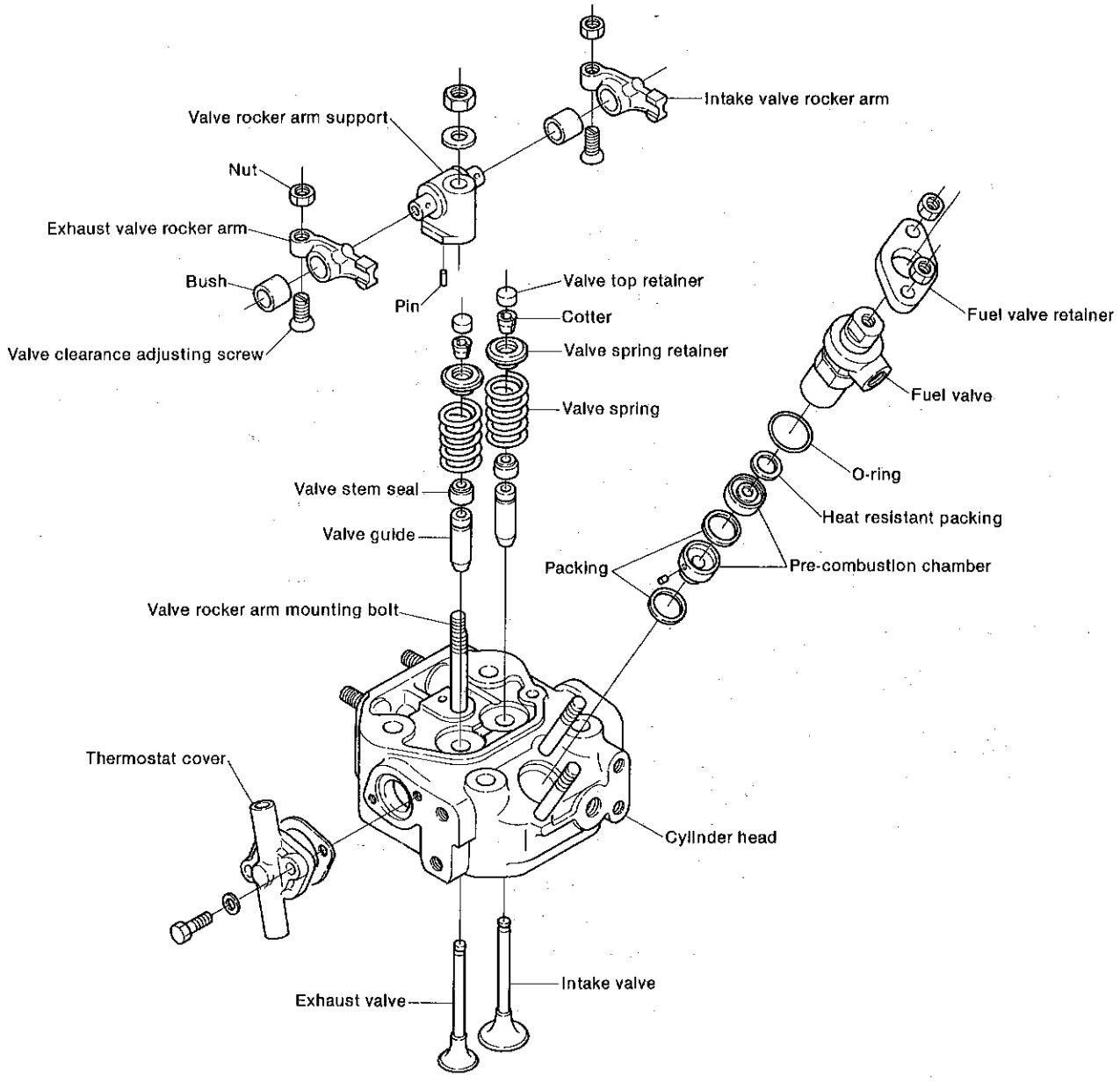
2. Cylinder Head

2-1. Construction

The cylinder head is an integral two/three cylinder type which is bolted to the block.
The unique Yanmar swirl type precombustion chambers are at an angle in the cylinder head, and form the combustion chambers, together with the intake and exhaust valves. Large diameter intake valves and smoothly shaped intake and exhaust ports provide high intake efficiency and superior combustion performance.
Special consideration has also been given to the shape of the cooling water passages so that the combustion surface and precombustion chamber are uniformly cooled by an ample water flow.
The thermostat is installed on the side surface of the cylinder at the timing gear case side. (On models 2GM20 (C)(F), 3GM30(C)(F) and 3HM35(C)(F), it is integrated with the alternator bracket).
In addition, on models 2GM20(C), 3GM30(C) and 3HM35(C), the anticorrosion zinc is set on the side surface at the flywheel end, and prevents electrolytic corrosion.

2-1.1 Cylinder head of model 1GM10(C) engine



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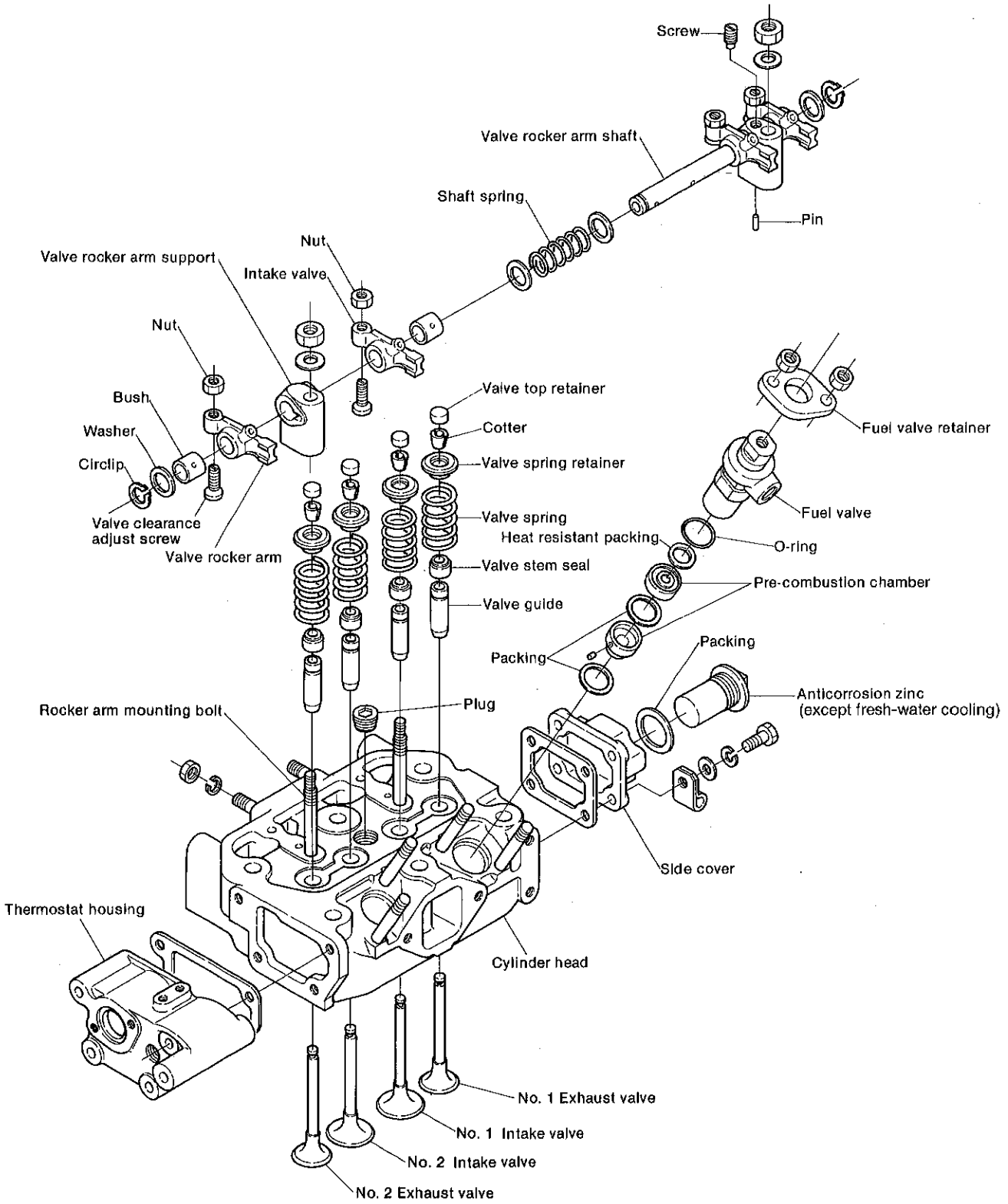
2-1.2 Cylinder head of model 2GM20(F)(C) engine



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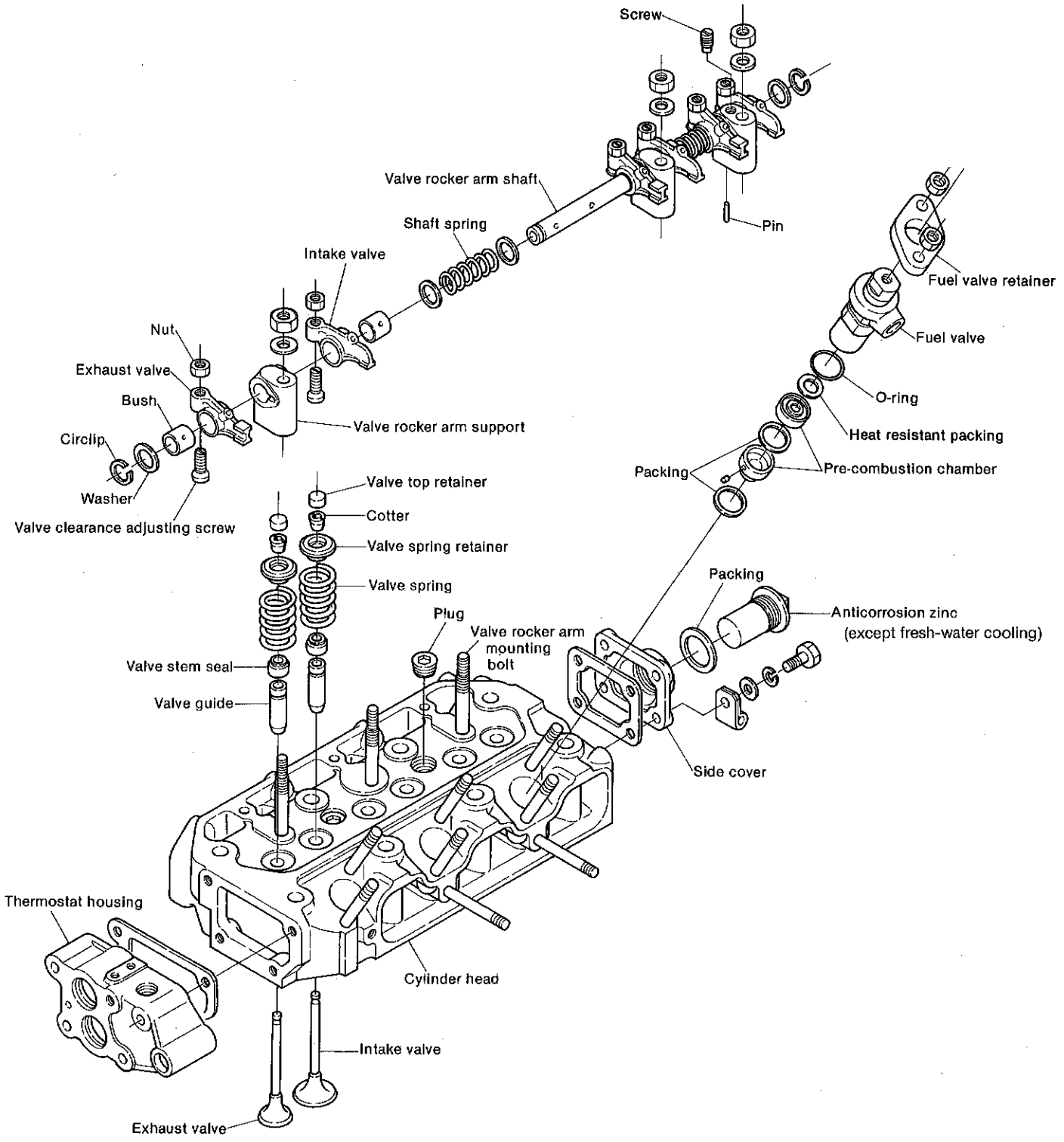
2-1.3 Cylinder head of models 3GM30(F)(C) and 3HM35 (F)(C)



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2-2 Cylinder head inspection and measurement

2-2.1 Measurement of carbon build-up at combustion surface and intake and exhaust ports

Visually check for carbon build-up around the combustion surface and the port near the intake and exhaust valve seats, and remove any build-up.
When a large amount of carbon has built up, check the top of the chamber combustion for oil flow at the intake and exhaust valve guides, and take suitable corrective action.

2-2.2 Deposit build-up in water passages

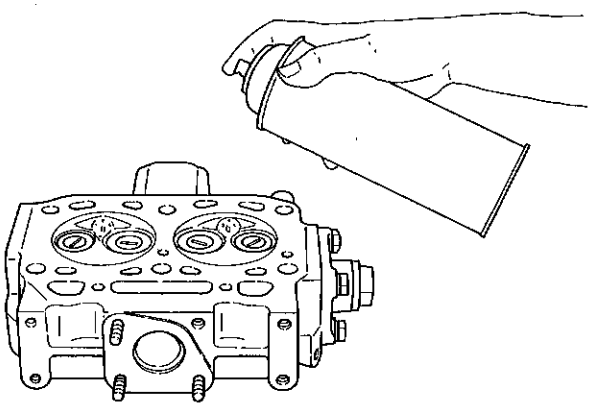
Check for build-up deposit in the water passages, and remove any deposit with a deposit remover. When a large amount of deposit has built up, check each part of the cooling system.

2-2.3 Inspection of corrosion in water passages and anti-corrosion zinc

Inspect the state of corrosion of the water passages, and replace the cylinder head when corrosion is severe.
Corrosion pitting limit: 2mm (0.0787in.)
Inspect the anticorrosion zinc on the cylinder head cover, and replace the zinc when it is worn beyond the wear limit.
Anticorrosion zinc wear limit: Volumetric ratio with new zinc = 1/2

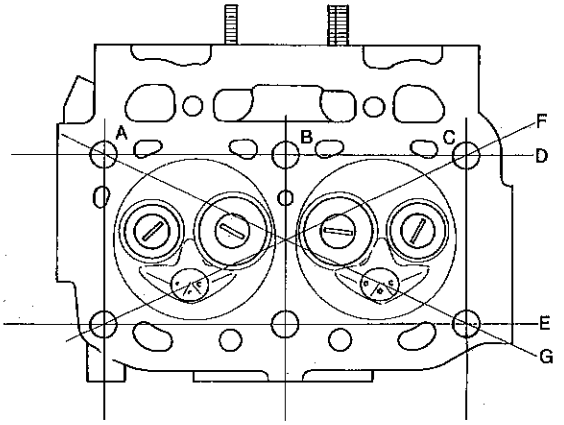
2-2.4 Cracking of combustion surface

The combustion surface is exposed to high temperature, high pressure gas and low temperature air, and is repeatedly flexed during operation. Moreover, it is used under extremely severe conditions, such as the high temperature difference between the combustion surface and cooling water passages.
Inspect the combustion surface for cracking by the color check, and replace the cylinder head if any cracking is detected. At the same time, check for signs of overloading and check the cooling water flow.



2-2.5 Cylinder head distortion

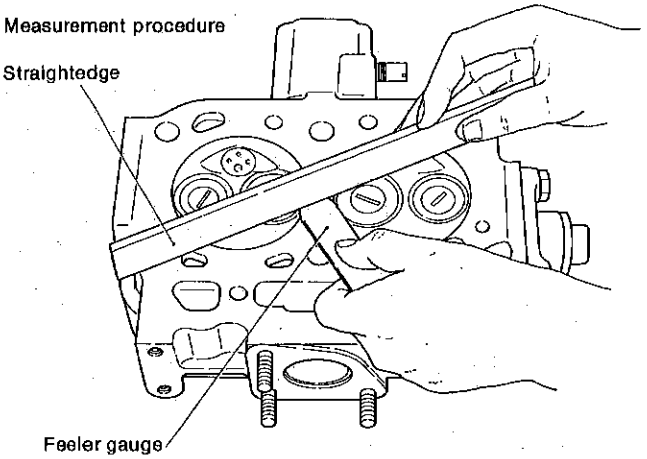
Distortion of the cylinder head causes gasket packing damage, compression leakage, change in compression, etc.
Measure the distortion as described below, and replace the cylinder head when the wear limit is exceeded. Since distortion of the cylinder head is caused by irregular tightening forces, faulty repair of the mounting face, and gasket packing damage, these must also be checked.



Cylinder head distortion mm (in.)

	Wear limit
1GM10(C)	0.07 (0.0028)
2GM20(F)(C)	0.07 (0.0028)
3GM30(F)(C), 3HM35(F)(C)	0.07 (0.0028)

(1) Clean the cylinder head tightening surface.
(2) Place a straightedge across two symmetrical points at the four sides of the cylinder head, as shown in the figure.
(3) Insert feeler gauges between the straightedge and the cylinder head combustion face.



(4) The thickness of the largest feeler gauge that can be inserted is the amount of distortion.

2-2.6 Cylinder head valve seat

The valve seats become wider with use. If the seats become wider than the maintenance standard, carbon built-up at the seats will cause compression leakage. On the other hand, if the seats are too narrow, they will wear quickly and heat transmission efficiency will deteriorate. Clean the carbon and other foreign matter from the valve seats, and check that the seats are not scored or dented.

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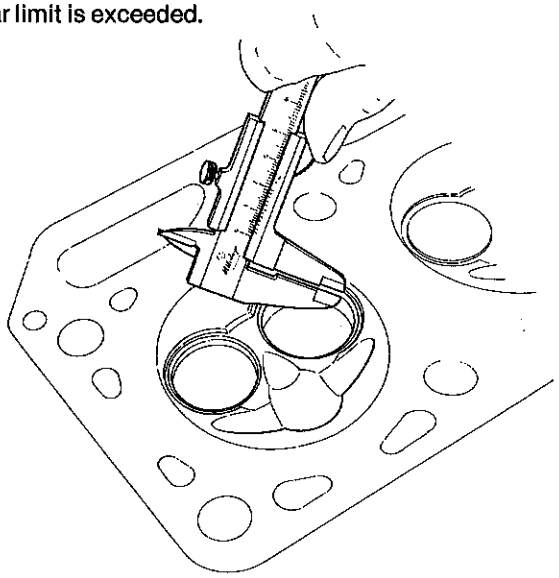
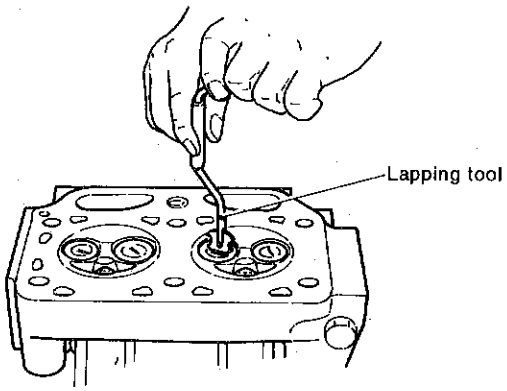
Measure the seat width with vernier calipers, and repair or replace the seat when the wear limit is exceeded.
When the valves have been lapped and/or ground, measure the amount of valve recess, and replace the valve when the wear limit is exceeded.



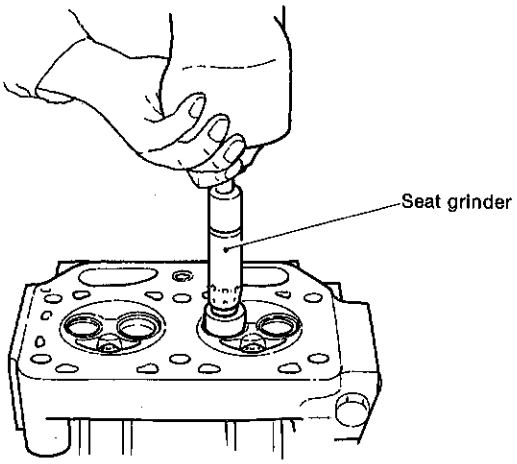
(Common to all models) mm (in.)

	Maintenance standard	Wear limit
Seat width	1.77 (0.06969)	—
Seat angle	90°	—

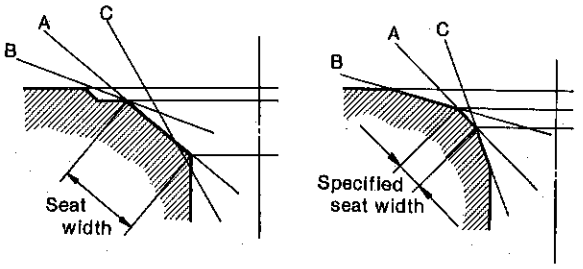
(1) Lapping the valve seat.
When scoring and pitting of the valve seat is slight, coat the seat with valve compound mixed oil, and lap the seat with a lapping tool.
At this time, be sure that the compound does not flow into the valve stem and valve guide.



(2) Correcting valve seat width.
When the valve seat is heavily pitted and when the seat width must be corrected, repair with a seat grinder.
1) Repair pitting of the seat face with a 45° grinder.
2) Since the valve seat is larger than the initial value, correct the seat width to the maintenance standard by grinding the inside face of the seat with a 70° grinder.
3) Grind the outside face of the valve seat with a 15° grinder, and finish the seat width to the standard value.



4) Mix the compound with oil, and lap the valve.
5) Finally, lap with oil.



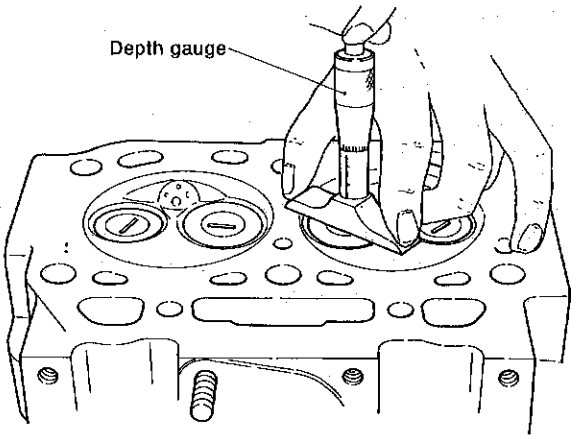
Before correction After correction

(A) Grind with a 45° grinder
(B) Grind with a 15° grinder
(C) Grind with a 65° ~ 75° grinder

NOTE: When the valve seat has been corrected with a seat grinder, insert an adjusting shim between the valve spring and cylinder head.

2-2.7 Measuring valve sinkage

When the valve has been lapped many times, the valve will be recessed and will lower combustion performance. Therefore, measure the valve sinkage, and replace the valve and cylinder head when the wear limit is exceeded.



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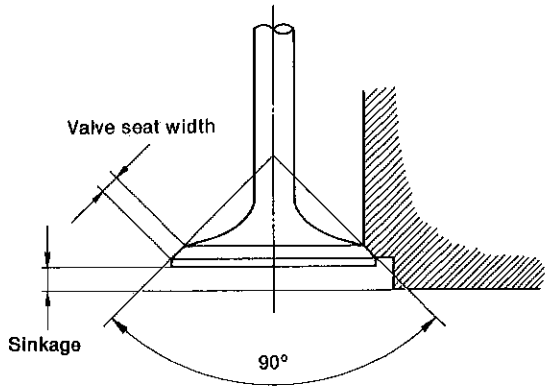


mm (in.)

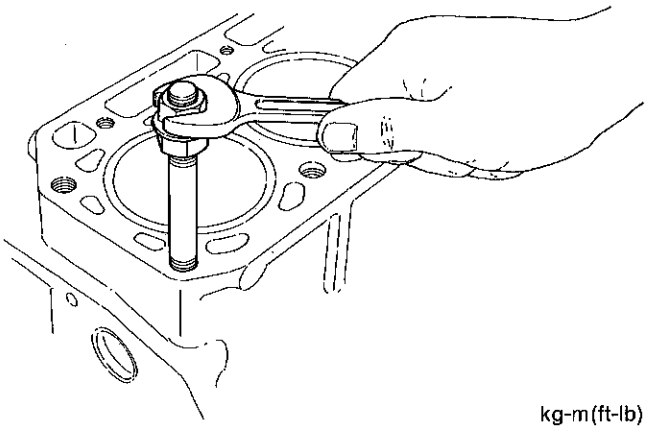
	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve sinkage	0.95 (0.0374)	1.25 (0.0492)	1.25 (0.0492)	1.55 (0.0610)

2-2.8 Rocker arm support positioning pin [for model 1GM10(C)]

Check if the guide pin is damaged or if the hole is clogged, and replace the pin if faulty.

2-3 Dismounting and remounting the cylinder head

When dismounting and remounting the cylinder head, the mounting bolts must be removed and installed gradually and in the prescribed sequence to prevent damaging the gasket packing and to prevent distortion of the cylinder head. Since the tightening torque and tightening sequence of the mounting bolts when remounting the cylinder head are especially important from the standpoint of engine performance, the following items must be strictly observed.



2-3.1 Cylinder head assembly sequence

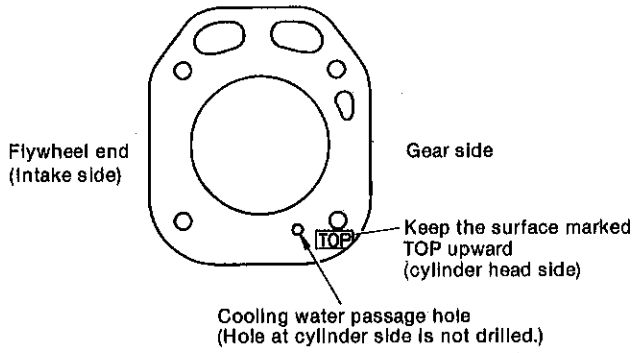
(1) Check for loose cylinder head stud bolts, and lock any loose bolts with two nuts and then tighten to the prescribed torque.
The cylinder head is fitted to the engine with 4 stud bolts in model 1GM10(C), but in other engine models both stud bolts and collar head bolts are used.

kg-m(ft-lb)

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Stud bolt diameter of cylinder head	M10	M12	M12
Cylinder head stud bolt tightening torque	6.0 (43.4)	8.0 (57.9)	10.0 (72.3)

(2) Checking the gasket packing mounting face.
Confirm correct alignment of the front and rear of the gasket packing, and install the packing by coating both sides with Three Bond 50.
Assemble the gasket packing keeping the flat surface upward (cylinder head side). Make sure that the gasket hole aligns with the drilled hole in the cooling water passage in the cylinder block.

1) For Model 1GM10(C)



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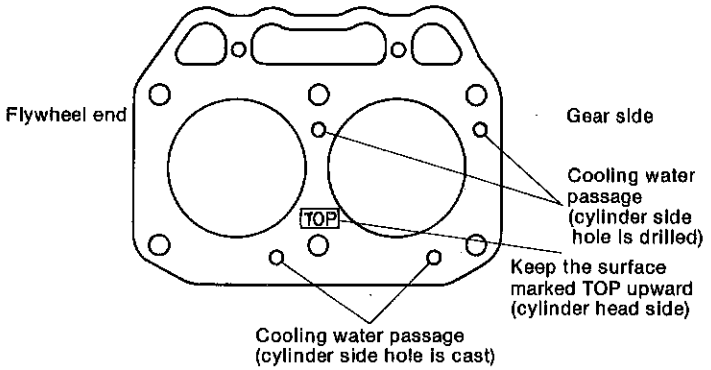
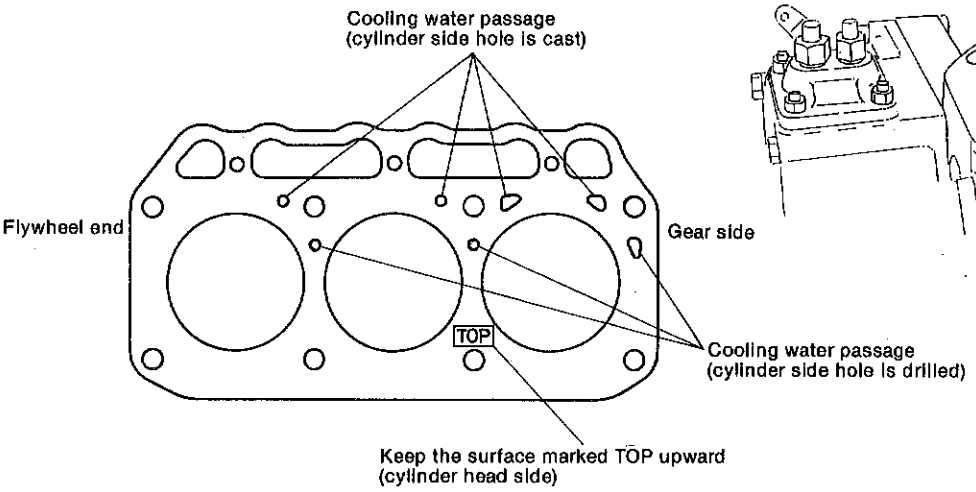
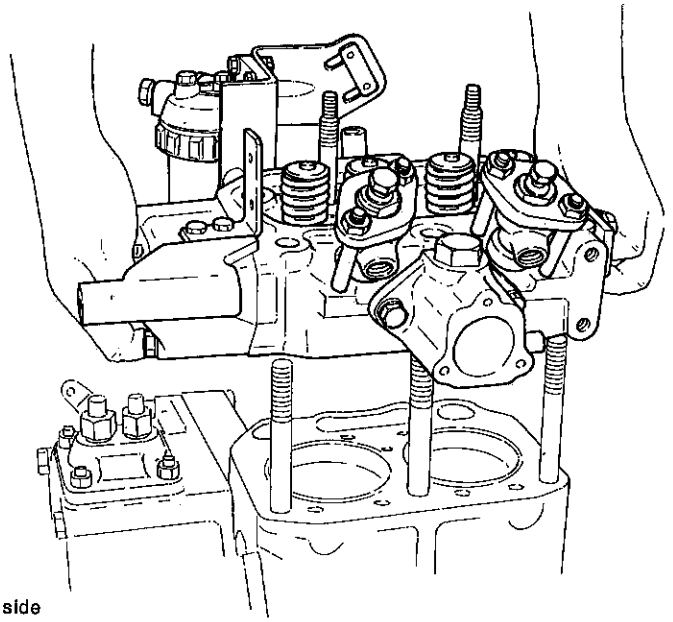
2) For model 2GM20(F)(C)



3) For models 3GM30(F)(C) and 3HM35(F)(C)



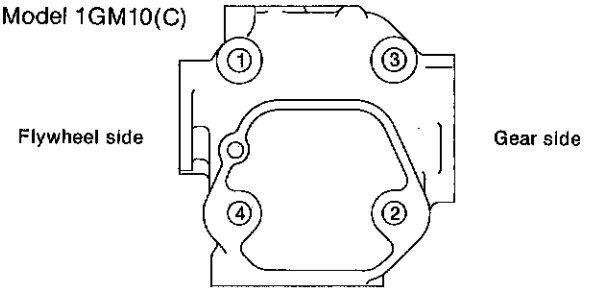
(3) Installing the cylinder head ass'y.
Position the cylinder head ass'y parallel to the top of the cylinder block, and install the ass'y on the block, being careful that the cylinder head ass'y does not touch the threads of the cylinder head bolts.



2-3.2 Tightening the cylinder head bolts and nuts

(1) Kinds of cylinder head fixing nuts and bolts, tightening torque, tightening sequence

1) Model 1GM10(C)



kg-m(ft-lb)

Tightening sequence	Kinds of fixing	Dia.	Torque
1	Stud bolt fixing nut	M10	7.5 kg-m (54.2 ft-lb)
2			
3			
4			

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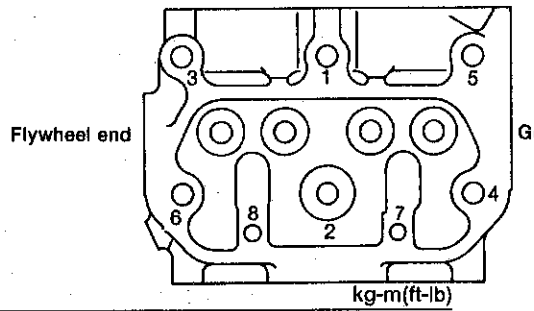
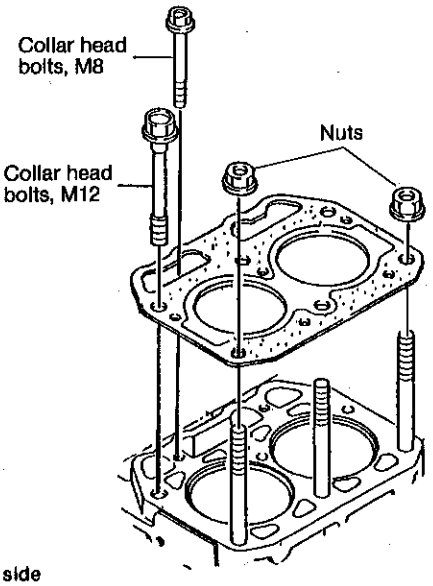
2) Model 2GM20(F)(C)

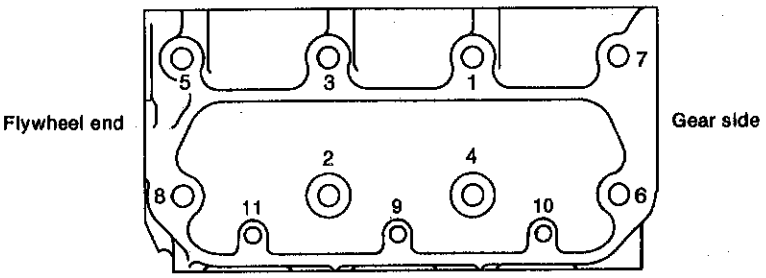




kg-m(ft-lb)

Tightening sequence	Nut & bolt to be tightend	Dia.	Tightening Torque
1, 3, 5	Stud bolt fixing nut	M12	12.0(86.8)
7, 8	Collar head bolts	M8	3.0(21.7)
2, 4, 6		M12	12.0(86.8)

3) Models 3GM30(F)(C) and 3HM35(F)(C)

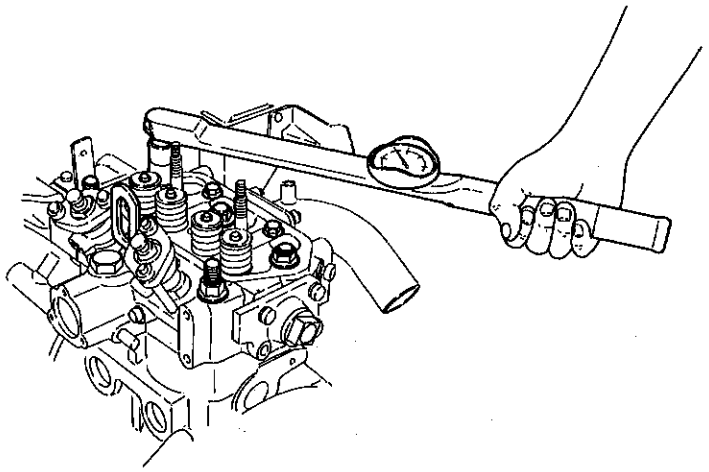


kg-m(ft-lb)

Tightening sequence	Nut & bolt to be tightend	Dia.	Tightening torque	
			3GM30(F)(C)	3HM35(F)(C)
5, 7	Stud bolt fixing nut	M12	12.0(86.8)	13 (94.0)
9, 10, 11	Collar head bolts	M8	3.0(21.7)	3 (21.7)
1, 2, 3, 4, 6, 8		M12	12.0(86.8)	13 (94.0)

(2) Cylinder head nut tightening sequence

1) Coat the threads of the cylinder head bolts with lubricating oil, and screw the cylinder head nuts onto the bolts.



2) First, tighten the nuts sequentially to 1/3 of the prescribed torque.
3) Second, tighten the nuts sequentially to 2/3 of the prescribed torque.
4) Third, tighten the nuts to the prescribed torque.
5) Recheck that all the nuts have been properly tightened.

NOTE: After tightening, valve clearance must be adjusted.

2-3.3 Cylinder head nut loosening sequence

When loosening the cylinder head nuts, reverse the tightening sequence. The cylinder head nut loosening sequence is shown in the figure.

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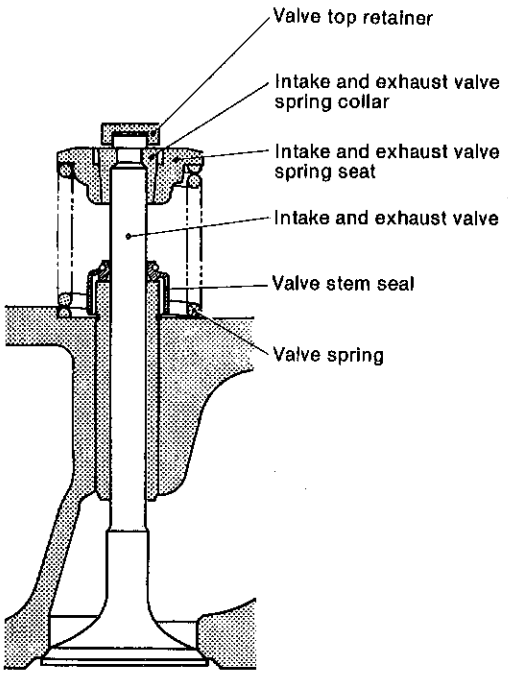
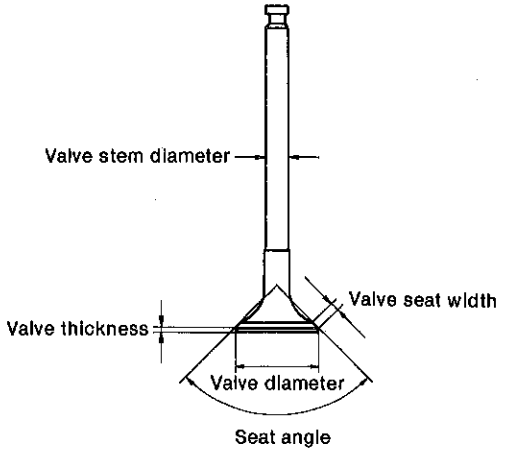
2-4 Intake and exhaust valves, valve guide and valve spring



2-4.1 Inspecting and measuring the intake and exhaust valves

(1) Valve seat wear and contact width.
Inspect valve seats for carbon build-up and heavy wear. Also check if each valve seat contact width is suitable. If the valve seat contact width is narrower than the valve seat width, the seat angle must be checked and corrected.



mm (in.)

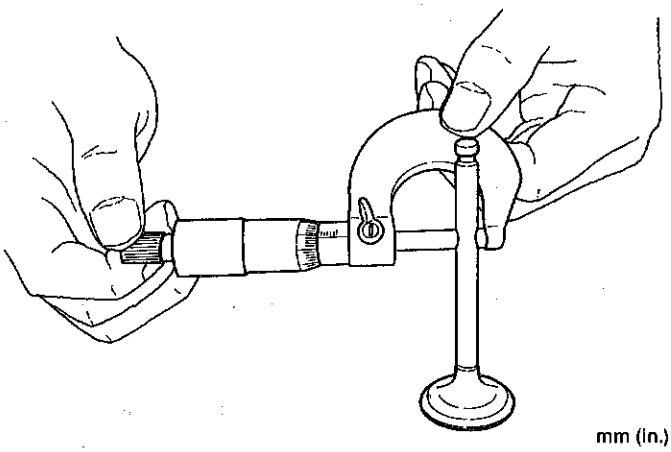
	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Intake valve diameter	ϕ32 (1.2598)	ϕ32 (1.2598)
Exhaust valve diameter	ϕ26 (1.0236)	ϕ27 (1.0630)
Valve seat width	3.15 (0.1240)	3.04 (0.1197)
Valve seat angle	90°	90°

NOTE: Note that the intake valve and exhaust valve have a different diameter.

mm (in.)

	1GM10(C), 2GM20(F)(C) 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve thickness	0.75~1.15 (0.0295 ~0.0453)	—	0.85~1.15 (0.0335 ~0.0453)	—

(2) Valve stem bending and wear.
Check for valve stem wear and strain, and repair when such damage is light. Measure the outside diameter and bend, and replace the valve when the wear limit is exceeded.



mm (in.)

	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve stem outside diameter	ø7 (0.2756)	ø6.9 (0.2717)	ø7 (0.2756)	ø6.9 (0.2717)
Valve stem bend	—	0.03 (0.0012)	—	0.03 (0.0012)

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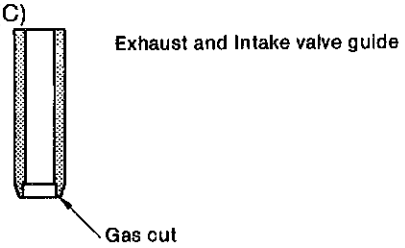
(3) Valve seat hairline cracks.
Inspect the valve seat by the color check, and replace the seat if cracked.

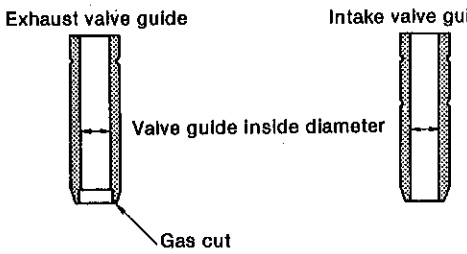
2-4.2 Inspecting and measuring valve guides

The same valve guide is used both for intake and exhaust valves in the model 1GM10(C) engine. It has a gas blow opening cut in the inner face at the bottom.
As for models 2GM20(F)(C), 3GM30(F)(C) and 3HM35 (F)(C), the valve guide is different for the intake valve and exhaust valve in that the inner face of the exhaust valve guide has a gas blow opening cut.
Be sure that the correct one is used when replacing the guides.

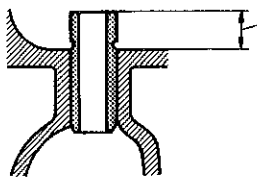
For model 1GM10(C)



For models 2GM20(F)(C), 3GM30(F)(C), and 3HM35(F)(C)



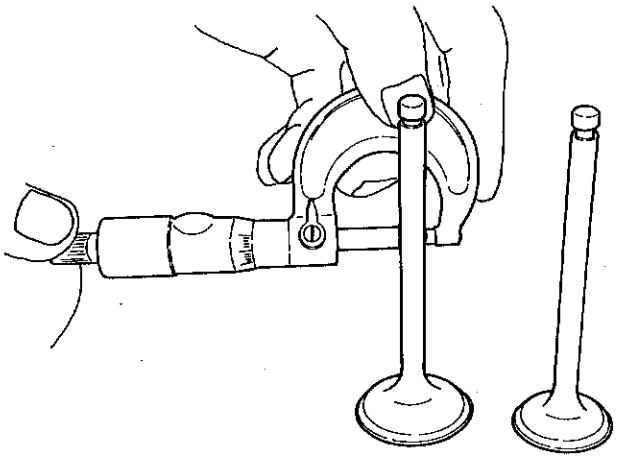
(1) Floating of the intake and exhaust valve guides.
Check for intake and exhaust valve guide looseness and floating with a test hammer, and replace loose or floating guides with guides having an oversize outside diameter.

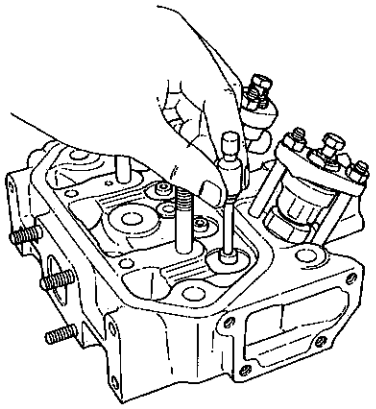


mm (in.)

	All models
Valve guide protrusion	7 (0.2756)

(2) Measuring the valve guide inside diameter.
Measure the valve guide inside diameter and clearance, and replace the guide when wear exceeds the wear limit.





mm(in.)

			Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
1GM10(C)	Intake	Valve guide inside diameter (after assembly)	ϕ7 (0.2756)	0.045~0.070 (0.0018~0.00028)	0.15 (0.0059)	ϕ7.08 (0.2787)
		Stem outside diameter	ϕ7 (0.2756)			ϕ6.9 (0.2717)
	Exhaust	Valve guide inside diameter (after assembly)	ϕ7 (0.2756)	0.045~0.070 (0.0018~0.0028)	0.15 (0.0059)	ϕ7.08 (0.2787)
		Stem outside diameter	ϕ7 (0.2756)			ϕ6.9 (0.2717)
2GM20(F)(C) 3GM30(F)(C) 3HM35(F)(C)	Intake	Valv guide inside diameter (after assembly	ϕ7 (0.2756)	0.040~0.065 (0.0016~0.0026)	0.15 (0.0059)	ϕ7.08 (0.2787)
		m outside diameter	ϕ7 (0.2756)			ϕ6.9 (0.2717)
	Exhaust	Valve guide inside diameter (after assembly)	ϕ7 (0.2756)	0.045~0.0070 (0.0018~0.0028)	0.15 (0.0059)	ϕ7.08 (0.2787)
		Stem outside diameter	ϕ7 (0.2756)			ϕ6.9 (0.2717)

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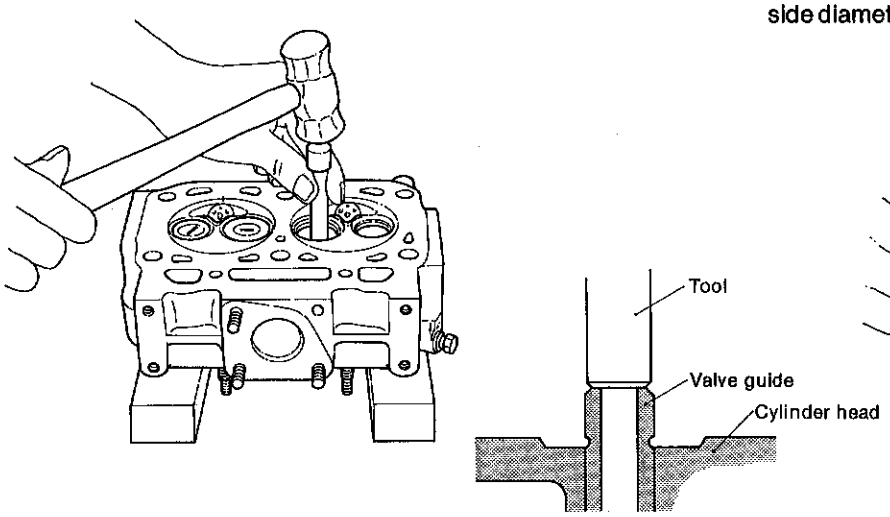
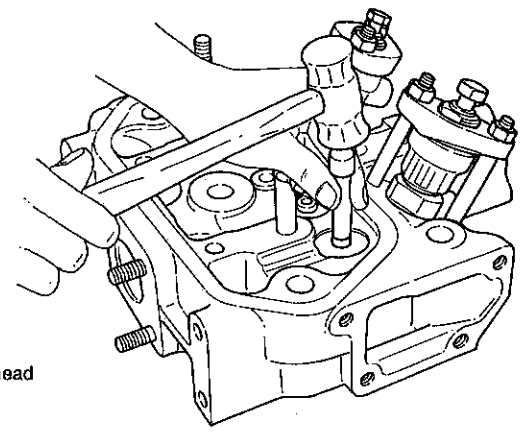
(3) Replacing the intake/exhaust valve guide

1) Using a special tool for extracting and inserting the valve guide, extract the valve guide.



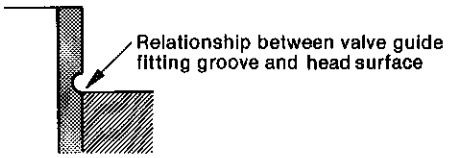
2) Using the above tool, drive the valve guide into position by starting from the valve spring side and finish the inside diameter with a reamer.



mm (in.)

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Amount of interference of valve guide	0.005 ~ 0.034 (0.0002 ~ 0.0013)	0.018 ~ 0.047 (0.0007 ~ 0.0019)	0.018 ~ 0.047 (0.0007 ~ 0.0019)

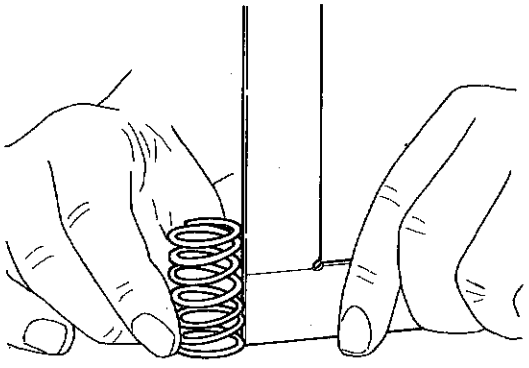
Fit the intake and exhaust valve guides until the bottom of the groove around the outside of the valve guide is flush with the end of the cylinder head.
As the valve guide for model 1GM10(C) does not have a groove, fit it after checking its dimension and marking it.

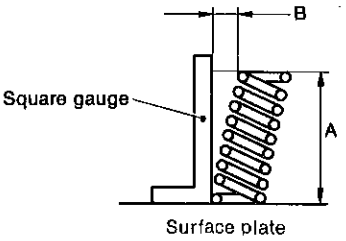


2-4.3 Valve spring

(1) Valve spring inclination.

Since inclination of the valve spring is a direct cause of eccentric contact of the valve stem, always check it at disassembly.
Stand the valve upright on a stool, and check if the entire spring contacts the gauge when a square gauge is placed against the outside diameter of the valve spring.
If there is a gap between the gauge and spring, measure the gap with a feeler gauge.
When the valve spring inclination exceeds the wear limit, replace the spring.





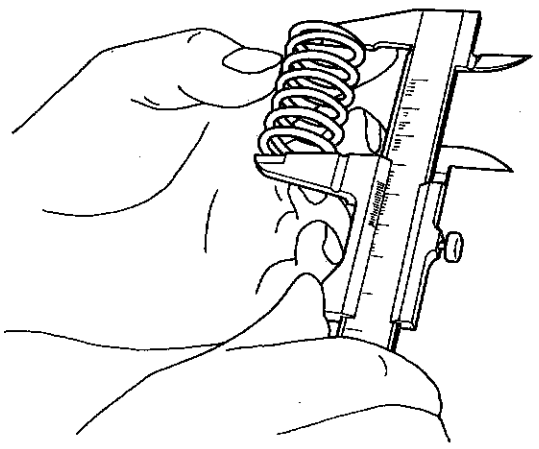
mm (in.)

	Maintenance standard
Valve spring free length (A)	38.5 (1.5157)

Allowable tilt value (B/A) is less than 0.035

(2) Valve spring free length.

Measure the free length of the valve spring, and replace the spring when the wear limit is exceeded.



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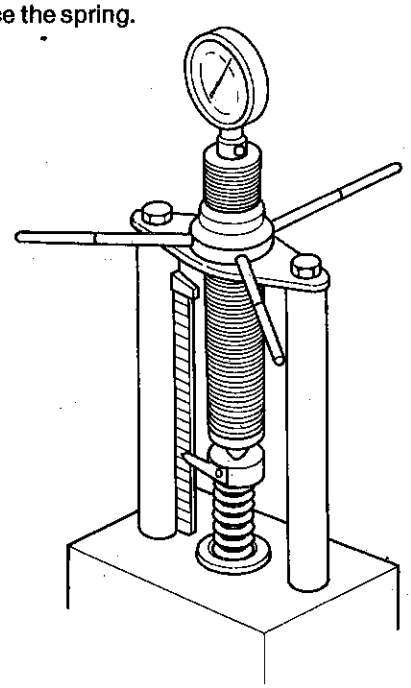
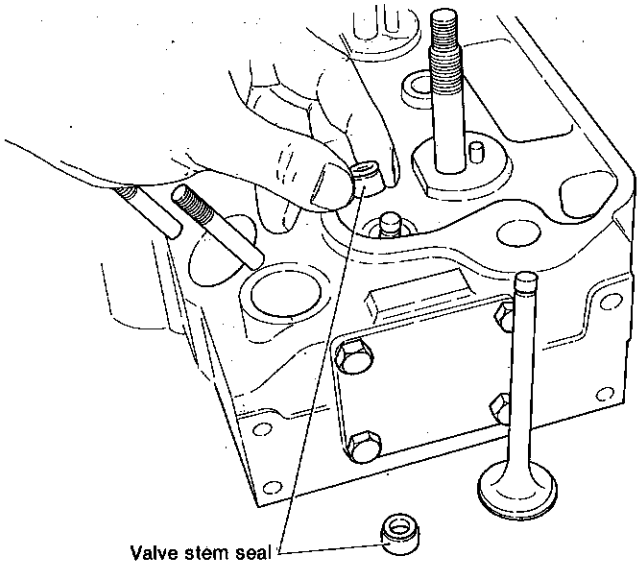
Also, measure the tension of the spring with a spring tester. If the tension is below the prescribed limit, replace the spring.

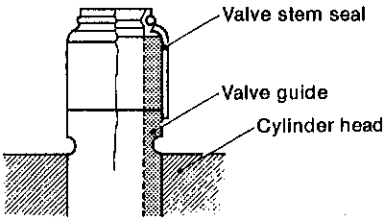


	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	War limit
Valve spring free length	38.5mm (1.5157in.)	37mm (1.4567in.)	38.5mm (1.5157in.)	37mm (1.4567in.)
length when attached	29.2mm (1.1496in.)	—	30.2mm (1.1890in.)	—
Load applied attached	16.16kg (35.63lb)	13.7kg (30.20lb)	14.43kg (31.81lb)	12.2kg (26.90lb)

2-4.4 Valve stem seal

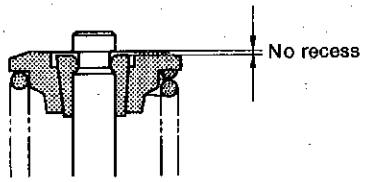


A valve stem seal is assembled at the top of the valve guide and the valve stem chamber oil is sucked into the combustion chamber through the valve guide (oil down) to prevent an increase in oil consumption.
The valve stem seal must always be replaced whenever it has been removed.
When assembling, coat the valve stem with engine oil before inserting.



2-4.5 Spring retainer and spring cotter pin

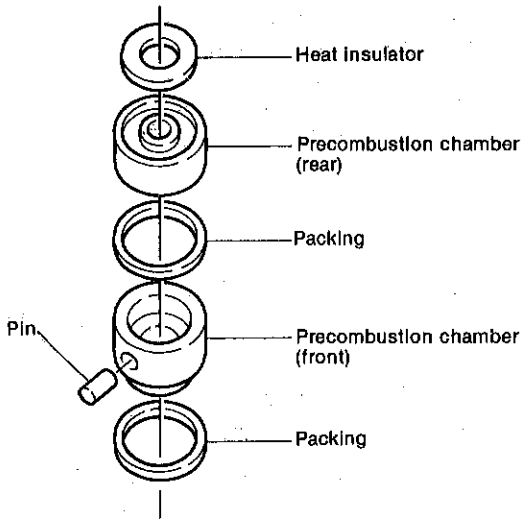
Inspect the inside face of the spring retainer and the outside surface of the spring cotter pin, and the contact area of the spring cotter pin inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter pin when the contact area is less than 70% or when the spring cotter pin has been recessed because of wear.



2-5 Precombustion chamber and top clearance

2-5.1 Precombustion chamber

Remove the packing and insulation packing at the precombustion chamber's front and rear chambers, and inspect. Check for burning at the front end of the precombustion chamber front chamber, acid corrosion at the precombustion chamber rear chamber, and for burned packing. Replace if faulty.



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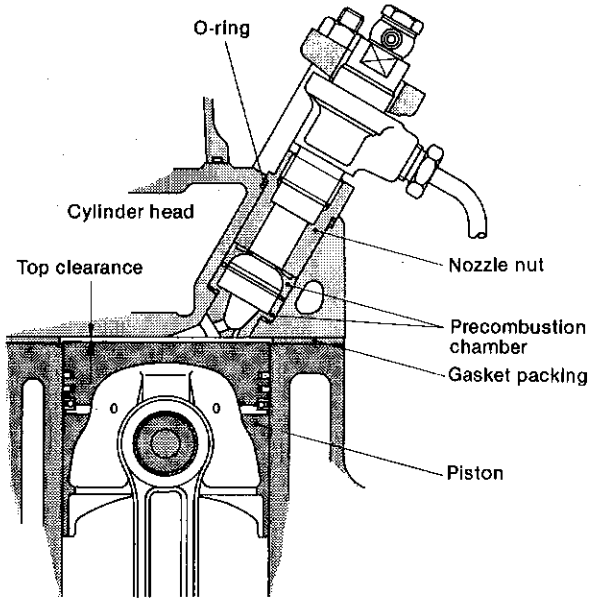
2-5.2 Insulation packing

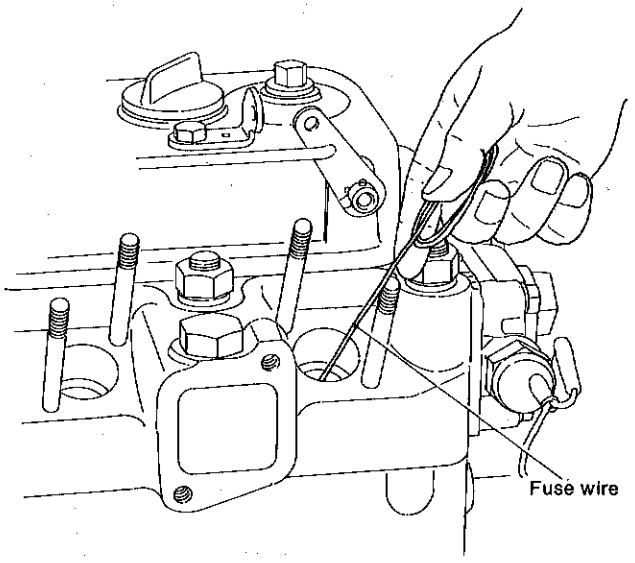
The insulation packing prevents transmission of heat from the precombustion chamber to the nozzle valve and serves to improve the nozzle's durability.
Always put in new insulation packing when it has been disassembled.

2-5.3 Top clearance

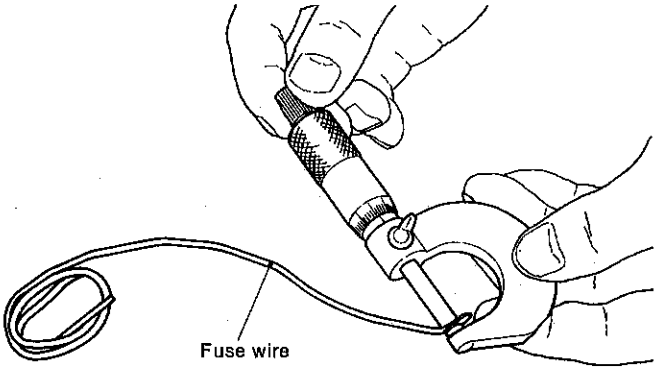
Top clearance is the size of the gap between the cylinder head combustion surface and the top of the piston at top dead center.
Since top clearance has considerable effect on the combustion performance and the starting characteristic of the engine, it must be checked periodically.



(1) Top clearance measurement
1) Check the cylinder head mounting bolts and tightening torque.
2) Remove the fuel injection valve and precombustion chamber.



3) Lower the piston at the side to be measured.
4) Insert quality fuse wire (ø1.2mm, 0.472in.) through the nozzle holder hole. (Be careful that the wire does not enter the intake and exhaust valve and the groove in the combustion surface.)
5) Crush the fuse wire by moving the piston to top dead center by slowly cranking the engine by hand.
6) Lower the piston by hand cranking the engine and remove the crushed fuse wire, being careful not to drop it.
7) Measure the thickness of the crushed part of the fuse wire with vernier calipers or a micrometer.



(2) Top clearance value.

mm (in.)

	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Top clearance	0.68~0.88 (0.0268~0.0346)	0.66~0.86 (0.0260~0.0339)

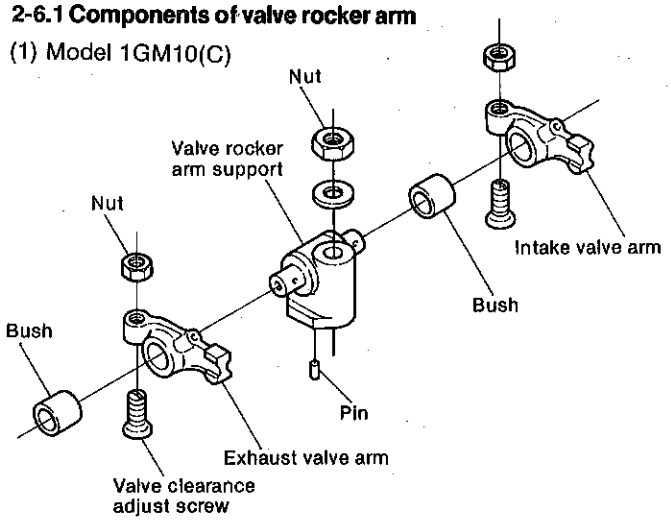
When the top clearance value is not within the above range, check for damaged gasket packing, distortion of the cylinder head combustion surface, or other abnormal conditions.

2-6 Intake and exhaust valve rocker arm

Since the intake and exhaust valve rocker arm shaft and bushing clearance and valve head and push rod contact wear are directly related to the valve timing, and have an effect on engine performance, they must be carefully serviced.

2-6.1 Components of valve rocker arm

(1) Model 1GM10(C)



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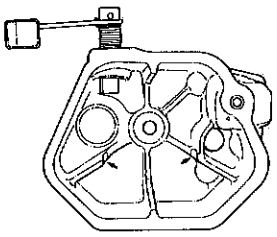
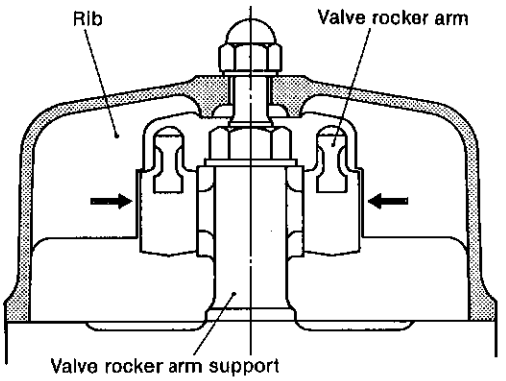
The same part is used for both intake valve rocker arm and exhaust valve rocker arm. The bush is not fitted to the valve rocker arm.
In has a simple construction as the valve rocker arms are fitted to the valve rocker arm support from both sides without using the retainer. In the place of a retainer, the rib of the bonnet cover prevents the rocker arms from coming out.

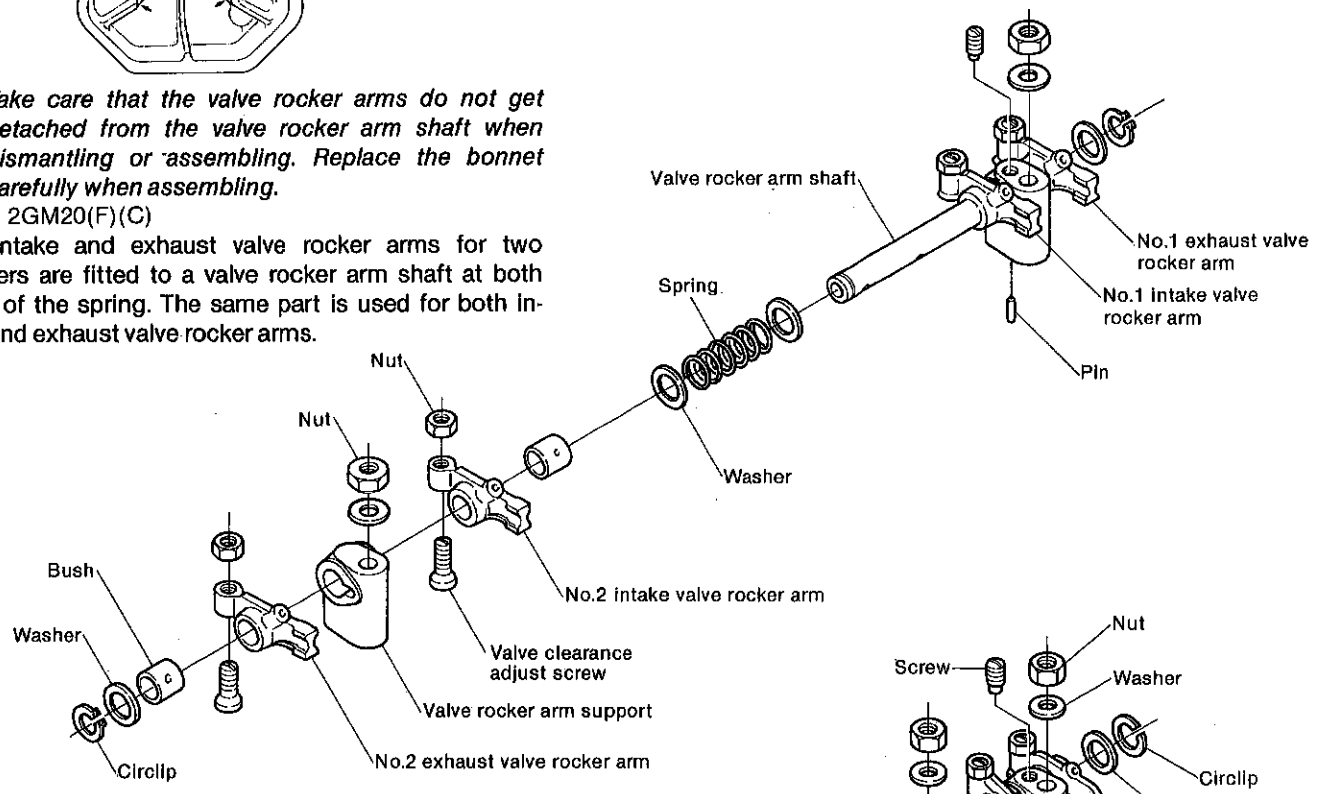




NOTE: Take care that the valve rocker arms do not get detached from the valve rocker arm shaft when dismantling or assembling. Replace the bonnet carefully when assembling.

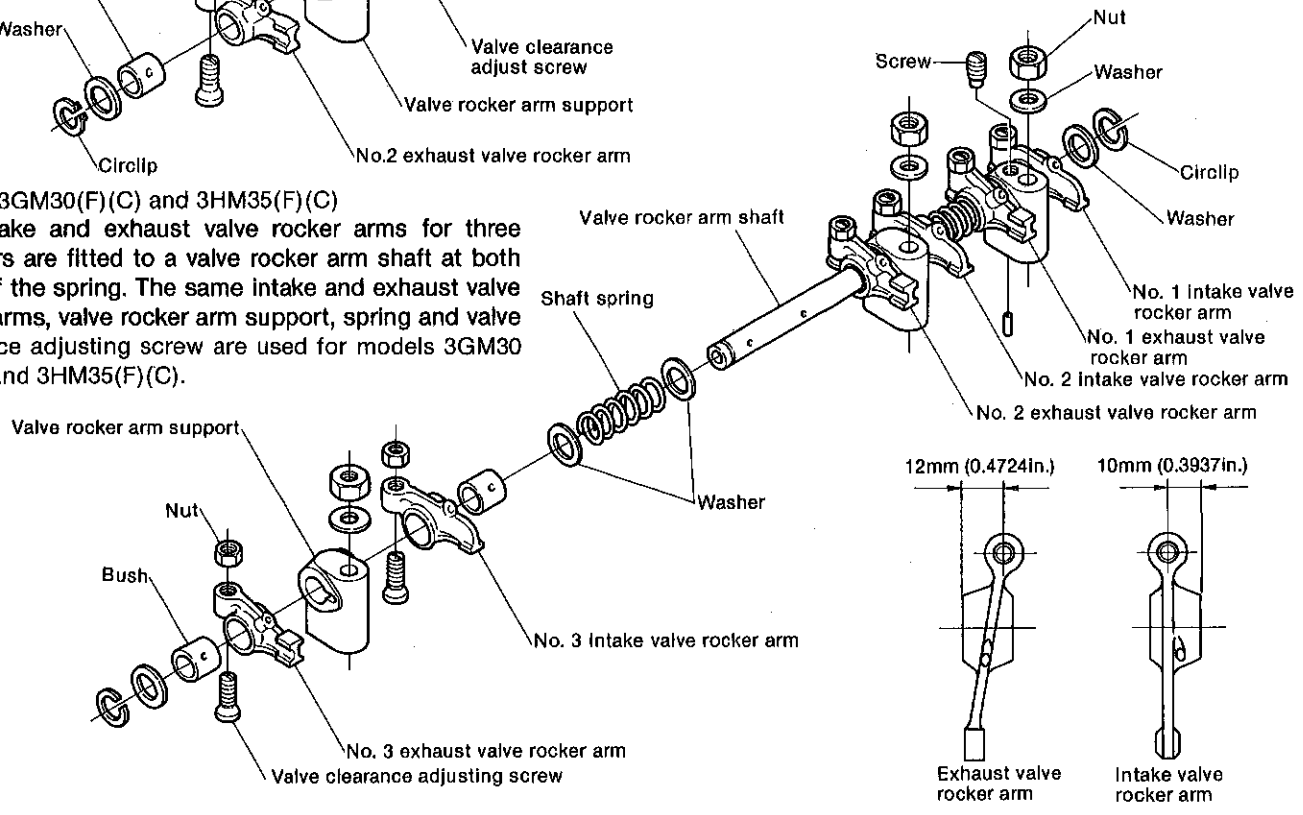
(2) Model 2GM20(F)(C)

The intake and exhaust valve rocker arms for two cylinders are fitted to a valve rocker arm shaft at both sides of the spring. The same part is used for both intake and exhaust valve rocker arms.



(3) Models 3GM30(F)(C) and 3HM35(F)(C)

The intake and exhaust valve rocker arms for three cylinders are fitted to a valve rocker arm shaft at both sides of the spring. The same intake and exhaust valve rocker arms, valve rocker arm support, spring and valve clearance adjusting screw are used for models 3GM30 (F)(C) and 3HM35(F)(C).



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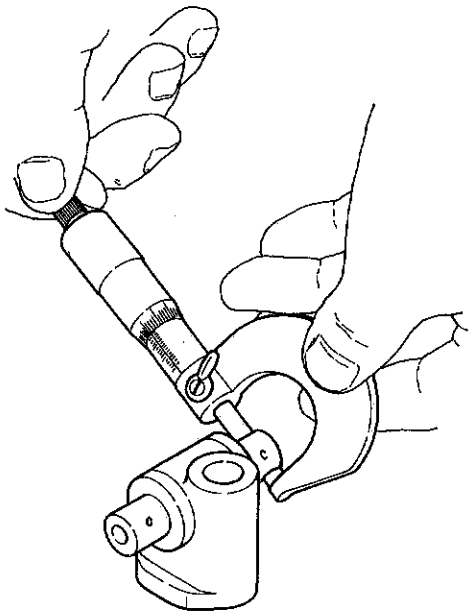
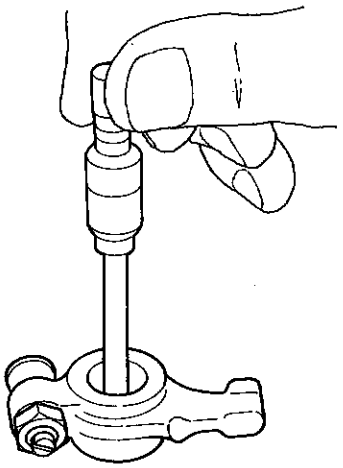
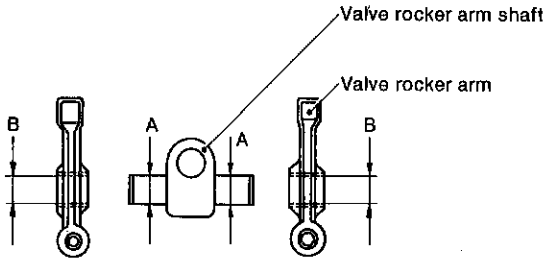
2-6.2 Measuring the valve rocker arm shaft and bushing clearance

Measure the outside diameter of the valve rocker arm shaft and the inside diameter of the bushing, and replace the rocker arm or bushing if the measured value exceeds the wear limit.
Replace a loose valve rocker arm shaft bushing with a new bushing. However, when there is no tightening allowance, replace the valve rocker arm.







mm (In.)

			Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
1GM10(C)	Intake and exhaust valve rocker arm shaft outside diameter	A	ϕ12 (0.4724)	0.016~0.052 (0.0006~0.0020)	0.15 (0.0059)	ϕ11.9 (0.4685)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ϕ12 (0.4724)			ϕ12.1 (0.4764)
2GM20(F)(C)	Intake and exhaust valve rocker arm shaft outside diameter	A	ϕ14 (0.5512)	0.016~0.052 (0.0006~0.0020)	0.15 (0.0059)	ϕ13.9 (0.5472)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ϕ14 (0.5512)			ϕ14.1 (0.5551)
3GM30(F)(C) 3HM35(F)(C)	Intake and exhaust valve rocker arm shaft outside diameter	A	ϕ14 (0.5512)	0.016~0.052 (0.0006~0.0020)	0.15 (0.0059)	ϕ13.9 (0.5472)
	Intake and exhaust valve rocker arm bushing inside diameter (assembled)	B	ϕ14 (0.5512)			ϕ14.1 (0.5551)

2-6.3 Valve rocker arm and valve top retainer contact and wear

Check the valve rocker arm and valve top retainer contact, and replace when there is any abnormal wear or peeling.

2-6.4 Valve clearance adjusting screw

Inspect the valve clearance adjusting screw and push rod contact, and replace when there is any abnormal wear or peeling.

2-6.5 Classification of the intake and exhaust valve rocker arms

Since the intake and exhaust valve rocker arms have different shapes, care must be exercised in service and assembly.

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2-7 Adjusting intake and exhaust valve head clearance

Adjustment of the intake and exhaust valve head clearance governs the performance of the engine, and must be performed accurately. The intake and exhaust valve head clearance must always be checked and readjusted, as required, when the engine is disassembled and reassembled, and after every 300 hours of operation. Adjust the valve head clearance as described below.

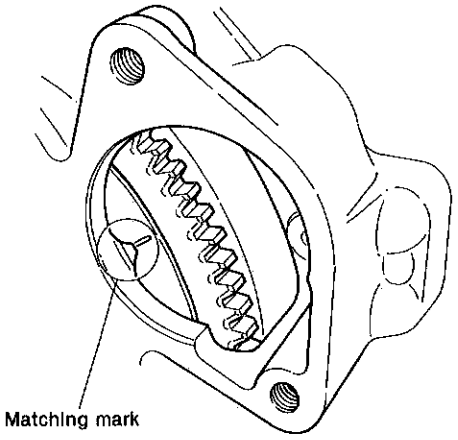
2-7.1 Adjustment

Make this adjustment when the engine is cold.

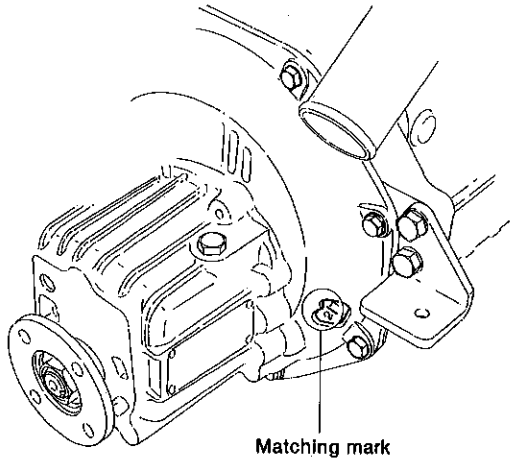
(1) Remove the valve rocker arm cover.

(2) Crank the engine and set the piston to top dead center (TDC) on the compression stroke.

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

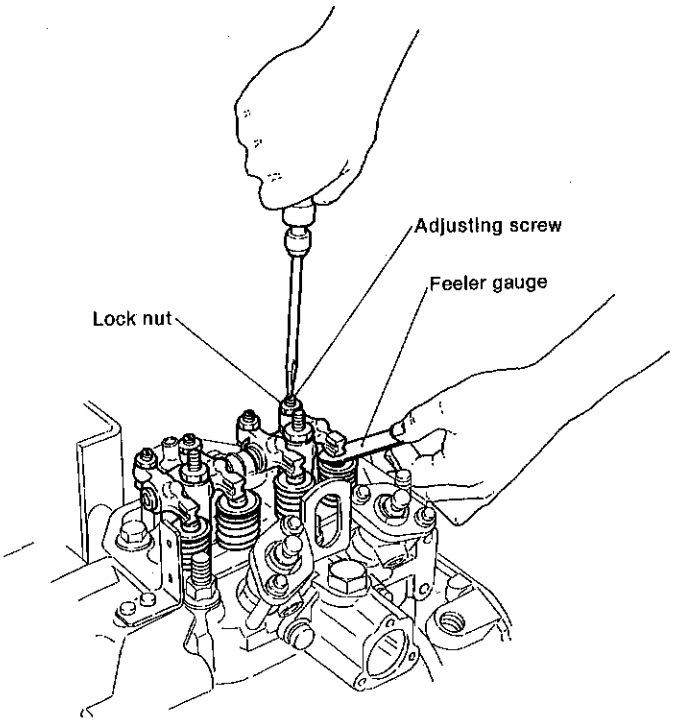


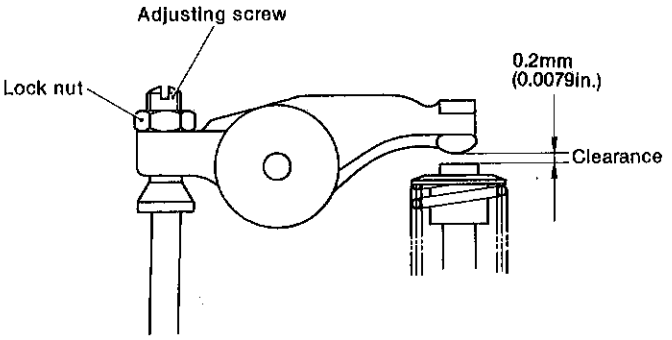
With respect to models 1GM10(C), 2GM20(F)(C) and 3GM30 (F)(C) only, a projection which serves as the matching mark is provided in the cast hole of the clutch housing.



NOTE: Set to the position at which the valve rocker arm shaft does not move even when the crankshaft is turned to the left and right, centered around the matching mark.

(3) Check and adjust the intake and exhaust valve head clearances of the No. 1 piston.
Loosen the valve clearance adjusting screw lock nut, adjust the clearance to the maintenance standard with a feeler gauge, and retighten the lock nut.





	All models
Intake and exhaust valve head clearance:	0.2mm (0.0079in.)

In the case of 2GM20(F)(C), adjust the valve head clearance of the No. 2 cylinder in the same manner after turning the crankshaft 180°.

In the case of 3GM30(F)(C), 3HM35(F)(C), adjust the valve head clearance on the No. 3 cylinder in the same manner after turning the crankshaft 240° and then adjust the No. 2 cylinder after turning the crankshaft another 240°.

NOTE: If you adjust the valve head clearance of the No. 2 cylinder first, turn the crankshaft 540°. Adjust the clearance of the No. 1 cylinder in the same manner on a 2 cylinder engine.

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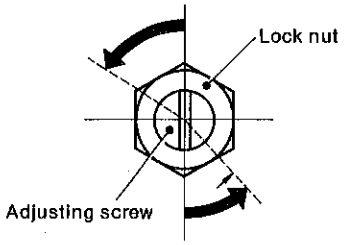
3-7.2 Adjusting without a feeler gauge

Set the head clearance to zero by tightening the adjusting screw, being careful not to tighten the screw too tight.
Then adjust the valve clearance to the maintenance standard by backing off the adjusting screw by the angle given below.



mm (in.)

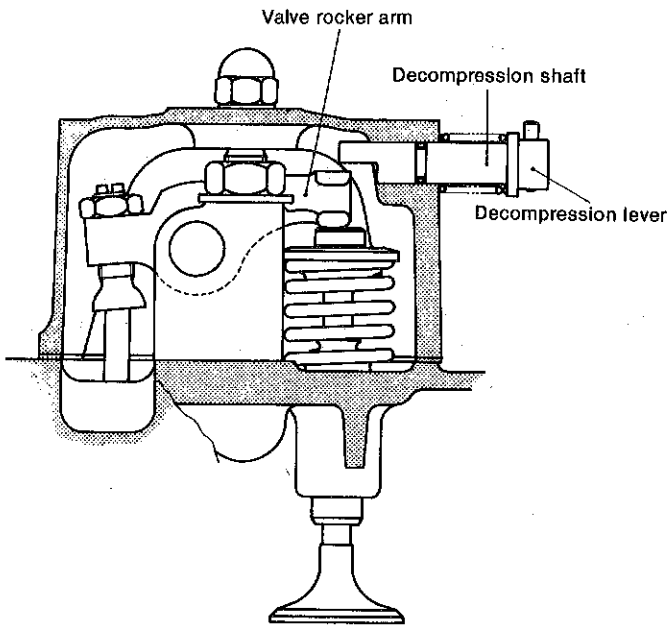
Valve clearance adjusting screw	M8 × 1.25 (0.3149 × 0.0492)
Adjusting screw backoff angle	Approx 58°

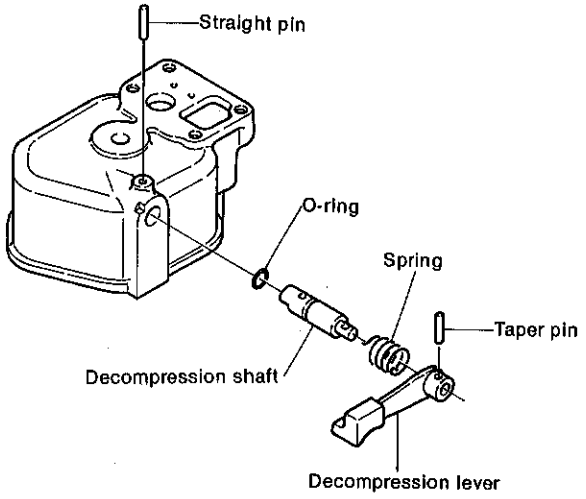
NOTE: Calculating the backoff angle.
calculate the 0.2mm advance angle from 1.25mm advance at one turn = 360°
0.2/1.25×360° = 58°
One side (60°) of the hexagonal nut should be used to measure.

2-8 Decompression mechanism

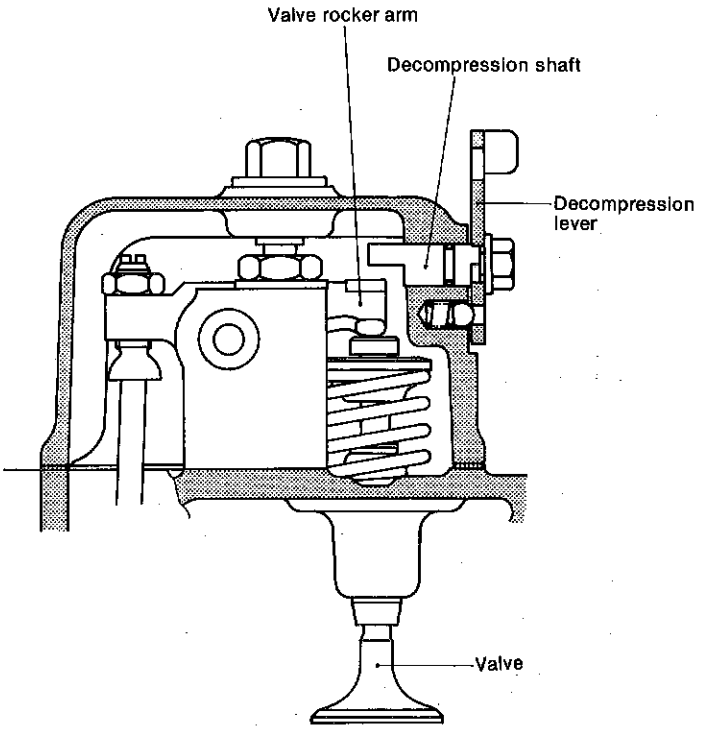
The decompression mechanism is used when the starter motor fails to rotate sufficiently because the battery is weak, and to facilitate starting in cold weather.
When the decompression lever is operated, the valve is pushed down, the engine is decompressed, the engine turns over easily and the flywheel inertia increases, thus making starting easy.

2-8.1 Model 1GM10(C)





2-8.2 Models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)



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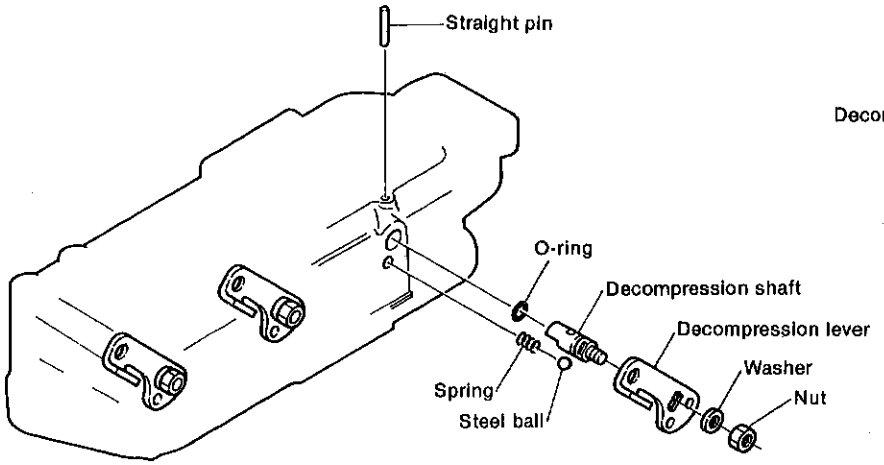
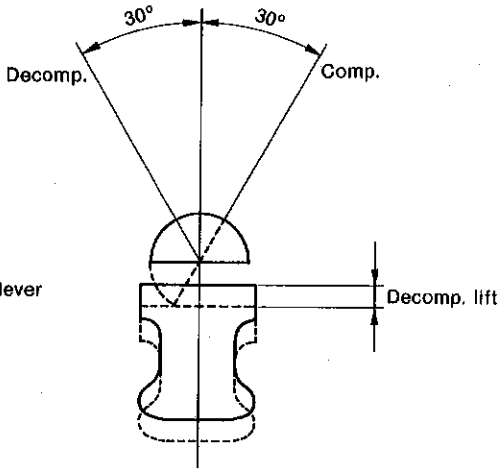




With this engine, there is no need to adjust the decompression lift.

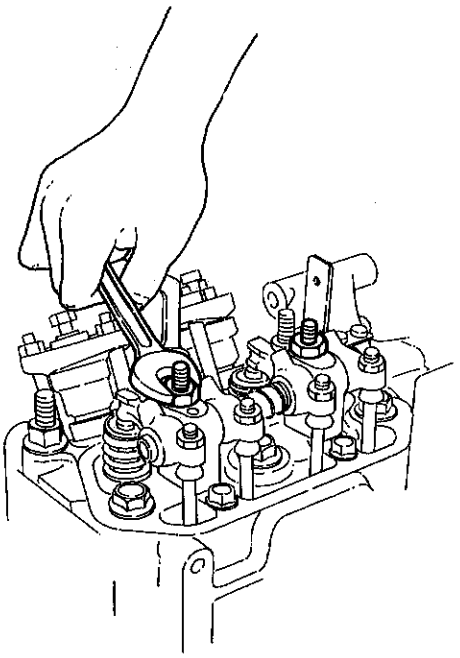
2-9 Disassembling and reassembling the cylinder head

2-9.1 Disassembling the cylinder head

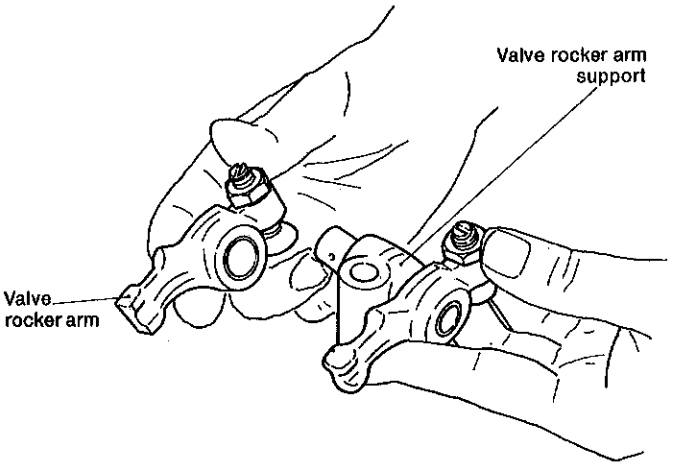
When disassembling the cylinder head, group the parts separately according to cylinder, intake or exhaust to avoid confusion.

(1) Disassembling the rocker arm ass'y

1) Remove the rocker arm ass'y mounting nuts.
2) Remove the rocker arm ass'y.



3) Remove the rocker arm retainer, and pull the rocker arm from the rocker arm support.



NOTE: A retainer is not used for the valve rocker arm on model 1GM10(C) and is kept free, therefore the rocker arm can be removed directly.

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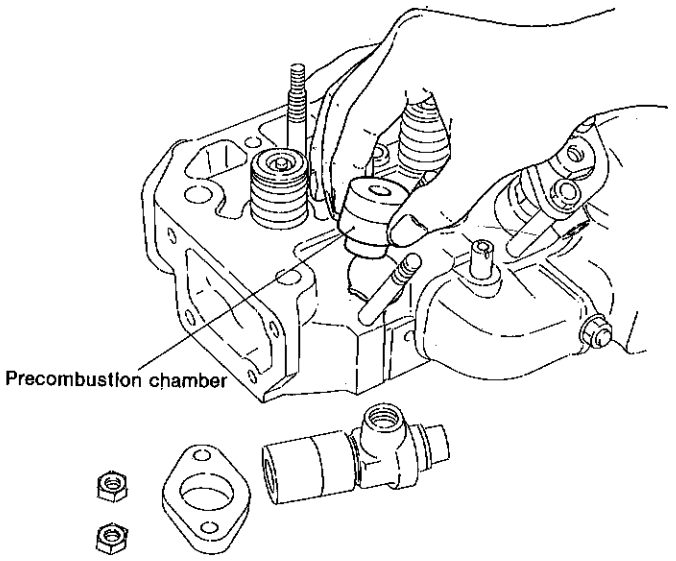
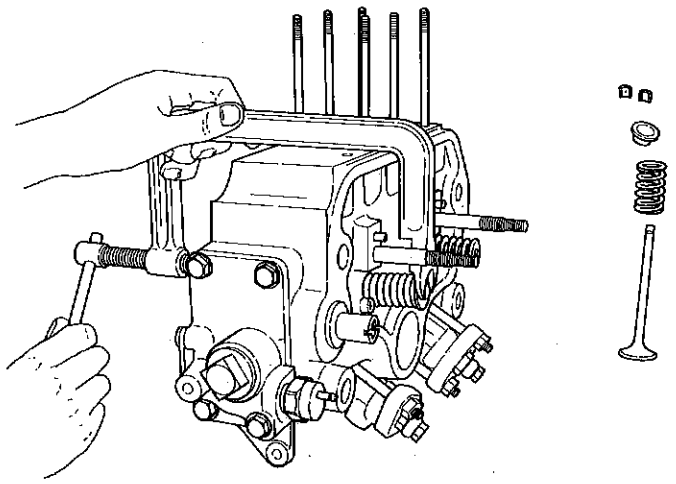
(2) Removing the precombustion chamber
1) Remove the rear precombustion chamber and packing.
2) Remove the front precombustion chamber and packing.



(3) Removing the intake and exhaust valve ass'y



1) Set the special tool at the intake and exhaust valve ass'y and depress the valve spring by turning the lever.
2) When the special tool is not available, depress the valve spring with a wrench.
3) Remove the spring cotter pin.
4) Turn the lever of the special tool in the loosening direction, release the valve spring retainer, and remove the valve spring retainer and valve spring.
5) Pull the valve from the cylinder head.
6) Remove the valve stem seal.
7) Remove the valve guide.

2-9.2 Reassembling the cylinder head

Before reassembling the cylinder head, wash all the parts, inspect and measure the dimensions of each part, and repair or replace any parts that are abnormal. Be careful not to confuse the parts grouped by cylinder number and intake or exhaust.

(1) Assembling the intake and exhaust valves
1) Press the valve guide into the cylinder head.
2) Install the valve stem seal. (Always replace the valve stem seal with a new seal.)
3) Install the valve in the cylinder head.
4) Install the valve spring and valve spring seat.
5) Install the split collar.
- Using the special tool
- Using a wrench

(2) Installing the valve arm ass'y
1) Install the intake and exhaust rocker arms on the rocker arm support.
2) Install both the rocker arm supports and rocker arm retainers on the cylinder head, then tighten them with nuts.

(3) Installing the precombustion chamber
1) Install the front precombustion chamber and packing.
2) Install the rear precombustion chamber and packing. (Always replace the insulation packing.)

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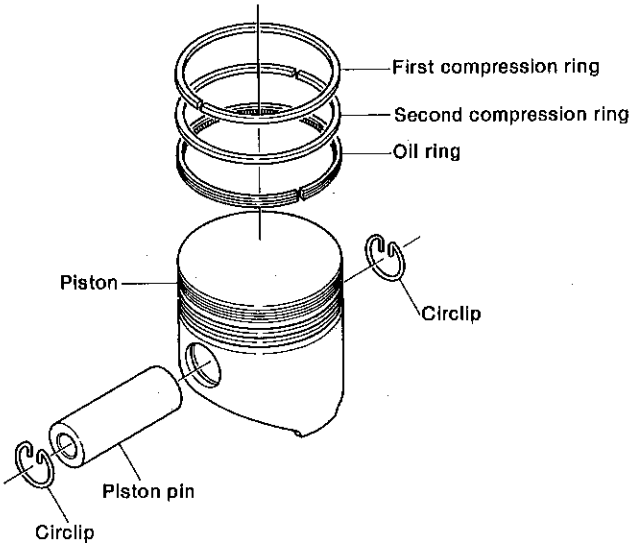
3. Piston

3-1 Piston assembly construction

The pistons are made of LO-EX (AC8A-T6) for lightness and are designed for reduced vibration. The outside of the piston is machined to a special oval shape. During operation, thermal expansion is small, the optimum clearance between the piston and cylinder liner is maintained, and a stable supply of lubricating oil is assured.

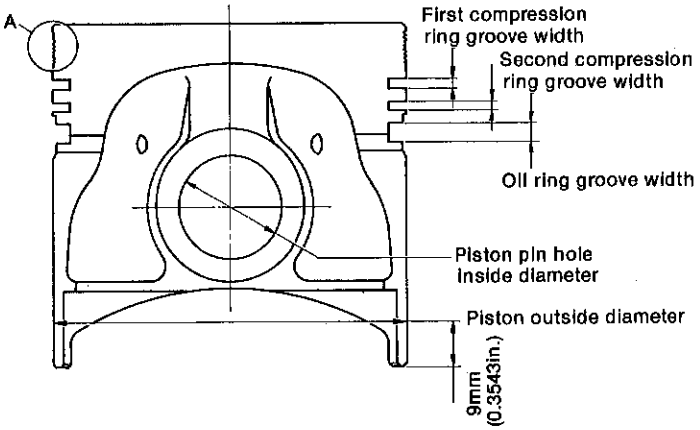


A complete set of piston rings consists of two compression rings and one oil ring.
To improve the rigidity of the piston skirt no ring is installed on the skirt itself so that the piston seldom becomes deformed and retains stable contact.
The piston pin is of the floating type. Both its ends are fastened with circlips.
Grooves called a heat dam are cut round the top section of the piston. These grooves help to dissipate heat and prevent scuffing.

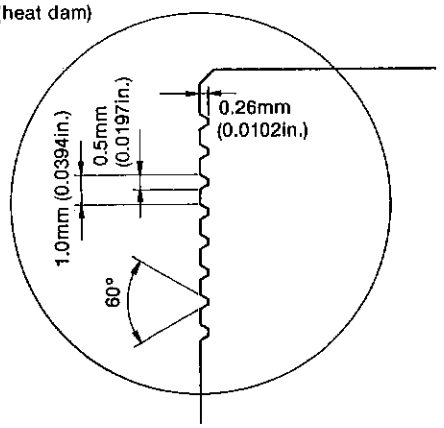
3-2 Piston

3-2.1 Inspection

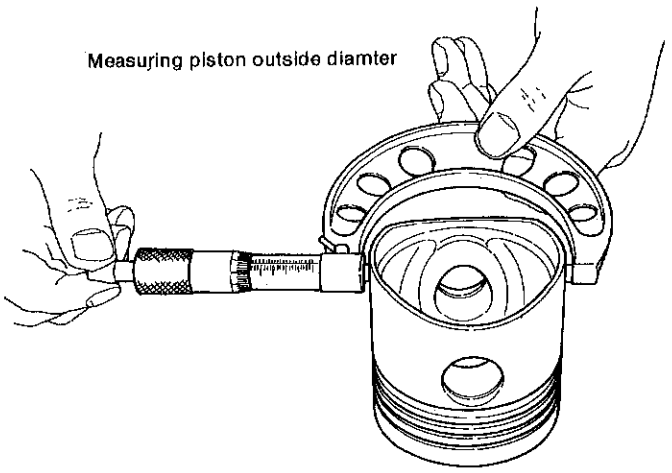
(1) Measuring important dimensions
Measure each important dimension, and replace the piston when the wear limit is exceeded.



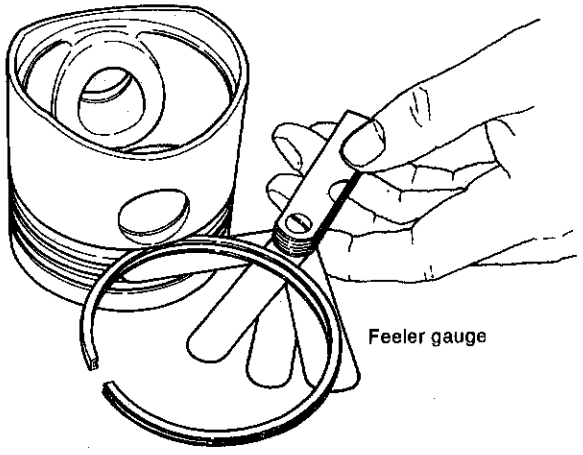
Detail of A (heat dam)

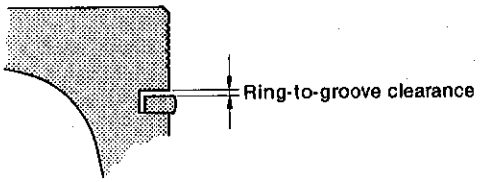


Measuring piston outside diamter



(2) Measure the clearance between the piston ring or oil ring and the ring groove with a thickness gauge.





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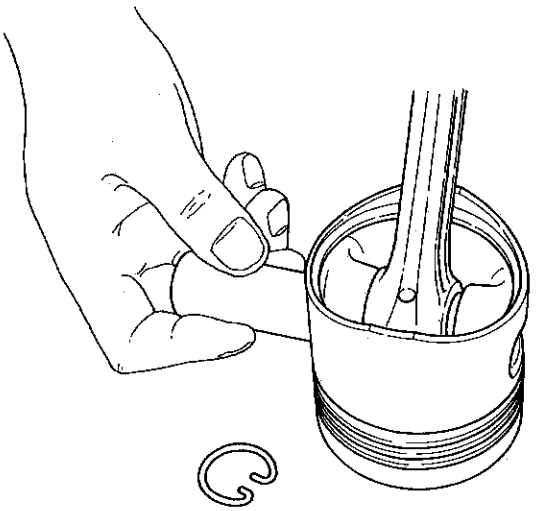
mm (in.)

	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	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	ϕ74.91~74.94 (ϕ2.9492~2.9504)	74.85 (2.9468)	ϕ79.902~79.932 (ϕ3.1457~3.1470)	79.84 (3.1433)
Piston pin hole inside diameter	ϕ19.995~20.008 (0.7872 ~ 0.7877)	—	ϕ22.995~23.008 (0.9053 ~ 0.9058)	—
First compression piston ring-to-groove clearance	0.065 ~ 0.10 (0.0026 ~ 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)

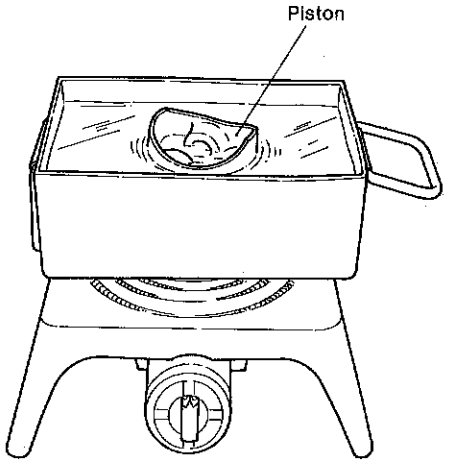
(3) Piston pin outside contact and ring groove carbon build-up.
check if the piston ring grooves are clogged with carbon, if the rings move freely, and for abnormal contact around the outside of the piston. Repair or replace the piston if faulty.



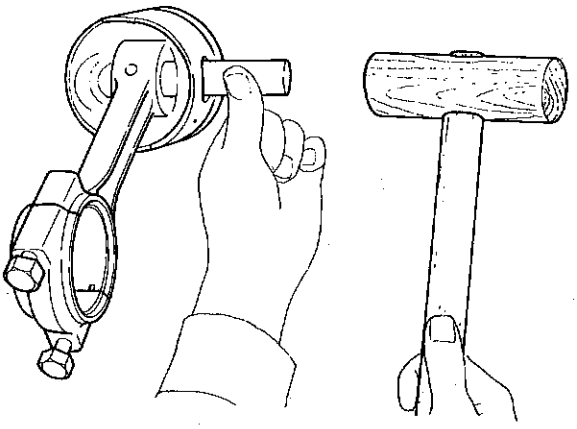
3-2.2 Replacing a piston

If the dimension of any part is worn past the wear limit or the 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.

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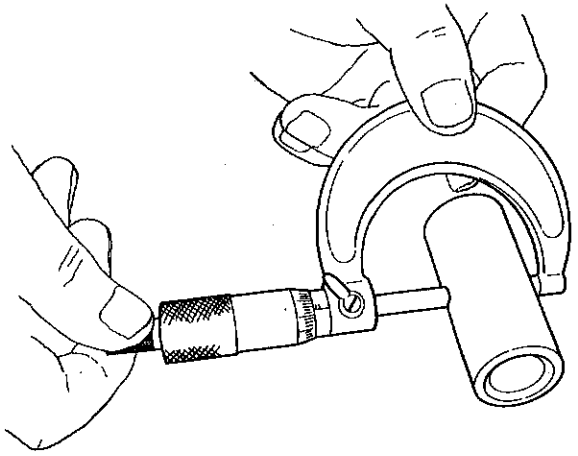
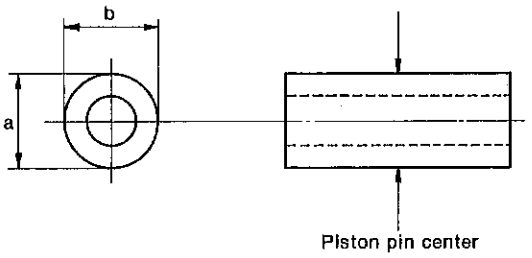
3-3 Piston pin and piston pin bushing

3-3.1 Piston pin

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.)

	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin outside diameter	ø20 $^{0}_{-0.009}$ (0.7870 ~ 0.7874)	ø19.98 (0.7866)	ø23 $^{0}_{-0.009}$ (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)	—

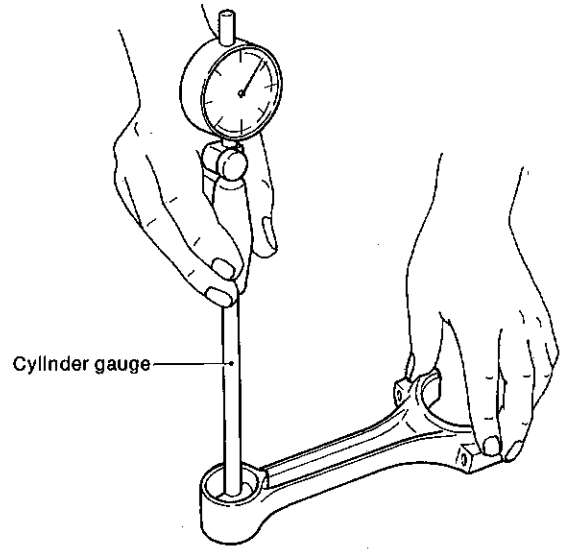
3-3.2 Piston pin bushing

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.)

	1GM10(C), 2GM20(F)(C) 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin busing inside diameter	ϕ20.0 (0.7874)	ϕ20.1 (0.7913)	ϕ23.0 (0.9055)	ϕ23.1 (0.9094)

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



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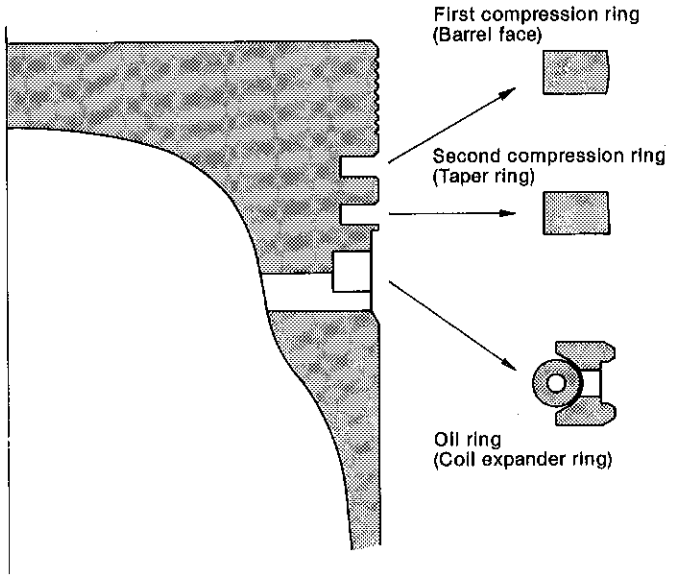
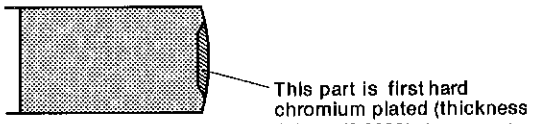
3-4 Piston rings

3-3.1 Piston ring configuration

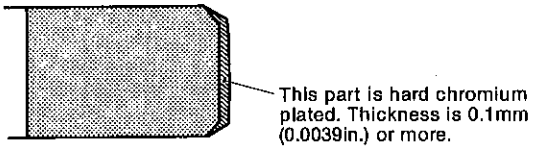


(1) The first compression ring is a barrel face ring that effectively prevents abnormal wear caused by engine loading and combustion gas blowby at initial run-in.
The sliding surface is hard chromium plated.

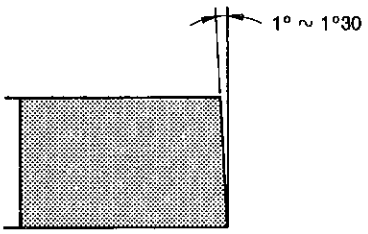
Model 3HM35(F)(C)



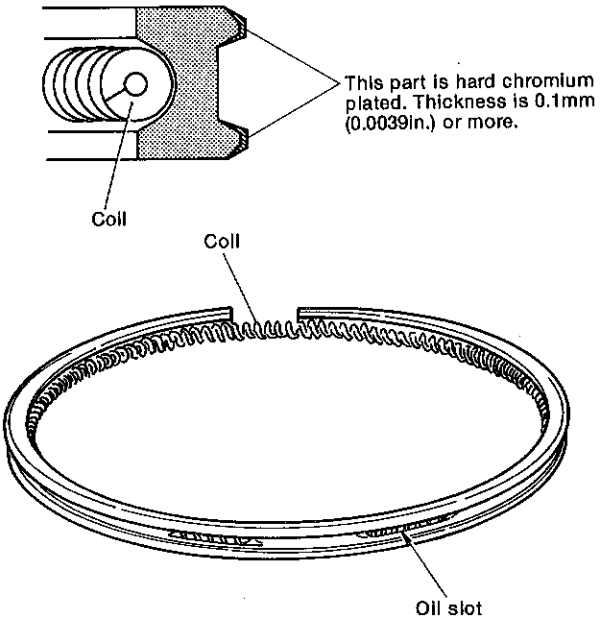
Models 1GM10(C), 2GM20(F)(C), 3GM30(F)(C)



(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.



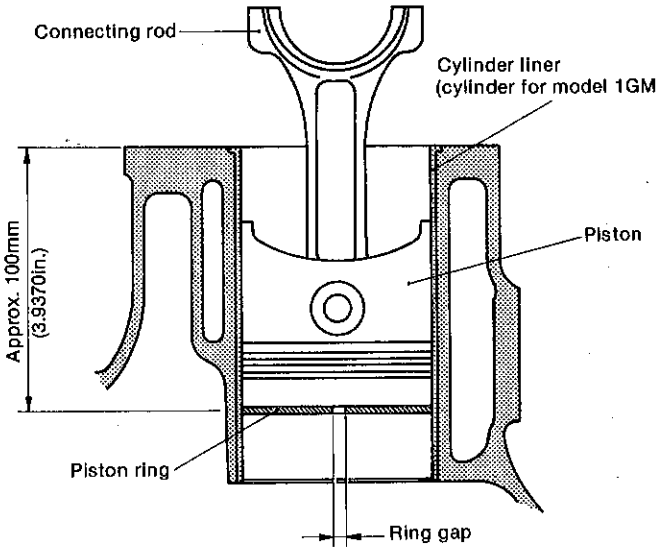
(3) The oil ring is a chrome-plated coil expander having a small contacting face, and exerts high pressure against the cylinder liner wall. Oil splash at the bottom of the sliding face is excellent, and its oil control effect is high.



3-4.2 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



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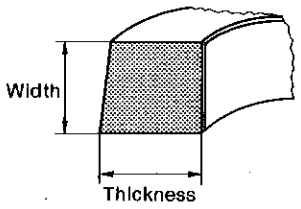
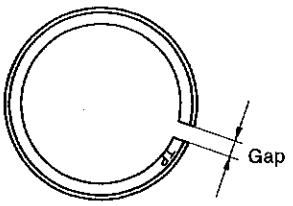


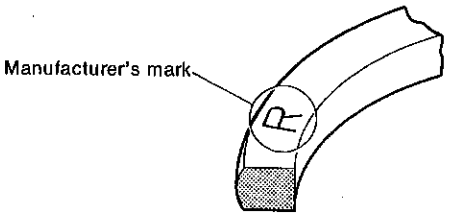


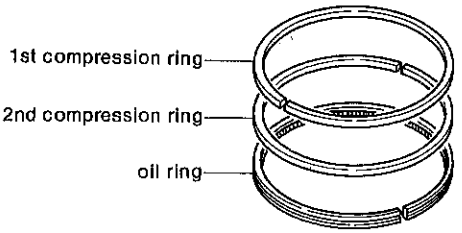
mm (in.)

		1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
1st. Piston ring	Width	1.97~1.99 (0.0776~0.0783)	1.90 (0.0748)	1.97~1.99 (0.0776~0.0783)	1.90 (0.0748)
	Thickness	3.10~3.30 (0.1220~0.1299)	—	3.20~3.40 (0.1260~0.1339)	—
2nd. Piston ring	Width	1.97~1.99 (0.0776~0.0783)	1.90 (0.0748)	1.97~1.99 (0.0776~0.0783)	1.90 (0.0748)
	Thickness	3.10~3.30 (0.1220~0.1299)	—	3.40~3.60 (0.1339~0.1417)	—
Oil ring	Width	3.97~3.99 (0.1563~0.1571)	3.90 (0.1535)	3.97~3.99 (0.1563~0.1571)	3.90 (0.1535)
	Thickness	2.40~2.80 (0.0945~0.1102)	—	2.70~3.10 (0.1063~0.1220)	—
1st. Piston ring gap		0.20~0.40 (0.0079~0.0157)	1.5 (0.0591)	0.25~0.45 (0.0098~0.0177)	1.75 (0.0689)
2nd. Piston 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)
Oil ring gap		0.20~0.40 (0.0079~0.0157)	1.5 (0.0591)	0.25~0.45 (0.0098~0.0177)	1.75 (0.0689)

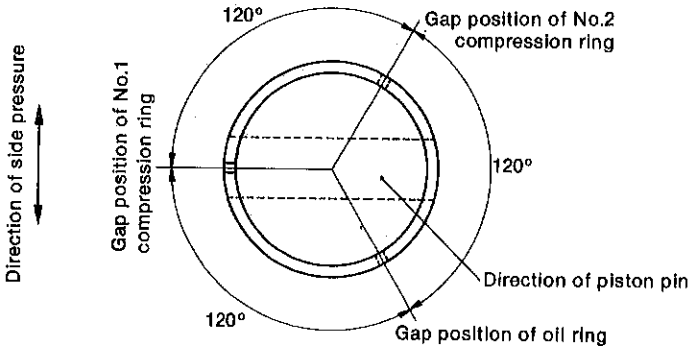
(3) Piston ring replacement precautions

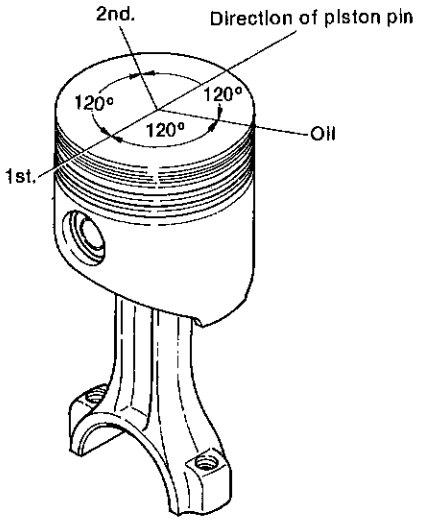
1) Clean the ring grooves carefully when replacing the rings.
2) When installing the rings, assemble the rings so that the manufacturer's mark near the gap is facing the top of the piston.





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.





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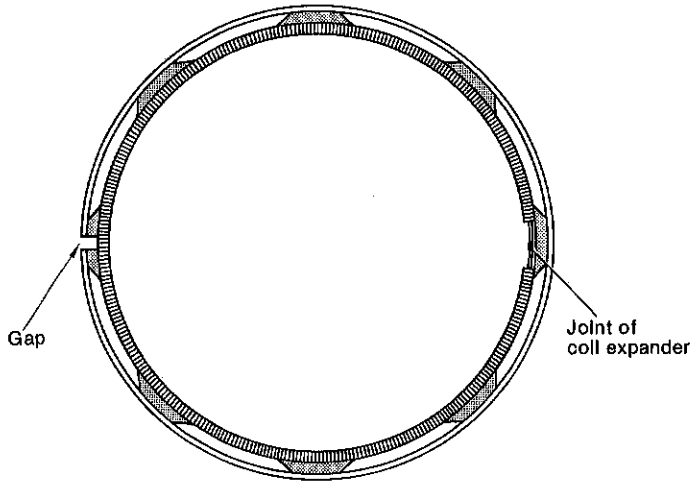
5) Since the oil ring is equipped with a coil expander, attach it to the piston so that the joint of the ring is opposite the gap of the coil expander.



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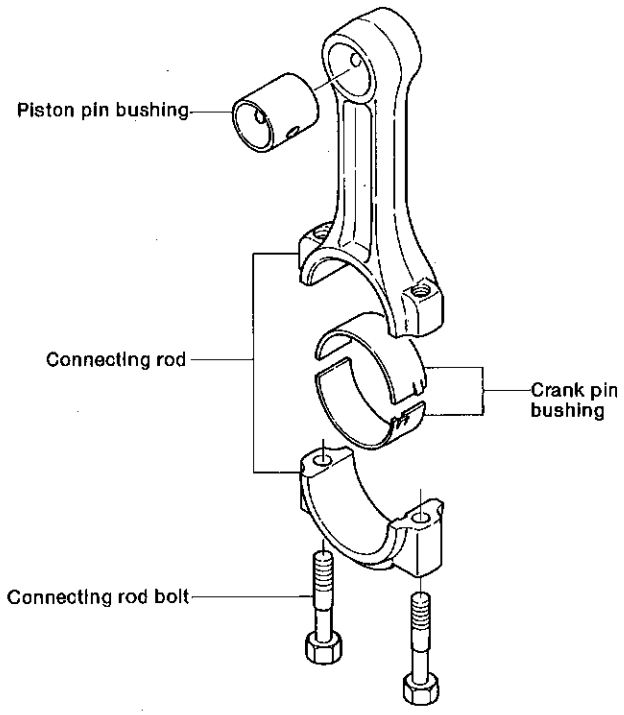
4. Connecting Rod

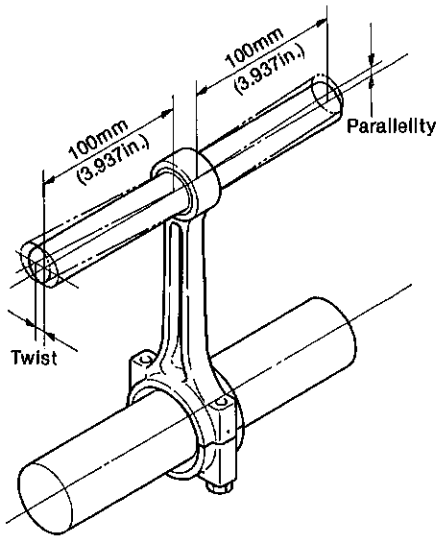
4-1 Connecting rod ass'y construction

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.



4-2 Inspection

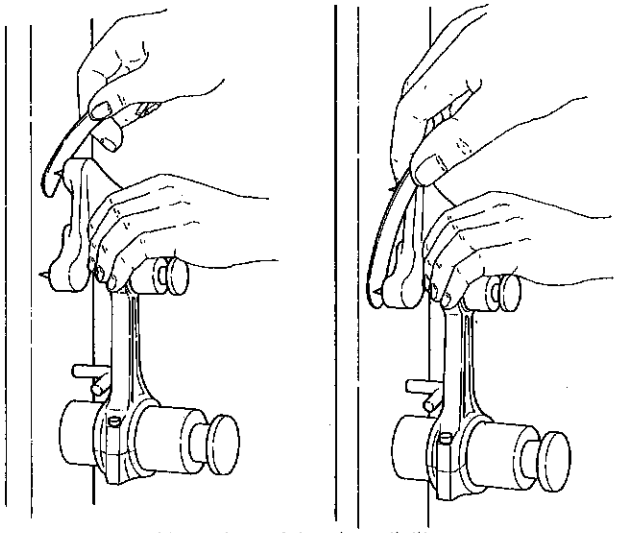
4-2.1 Large and small end twist and parallelity



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.)

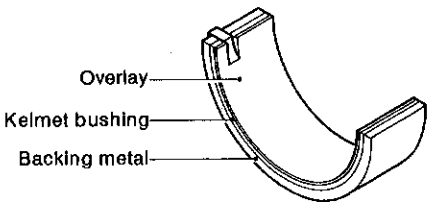
Maintenance standard	0.03/100 or less (0.00118/3.937)
Limit	0.08/100 (0.00315/3.937)



Measuring twist and parallelity

4-3 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.



4-3.1 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 or the clearance at the crank pin part exceeds the wear limit.

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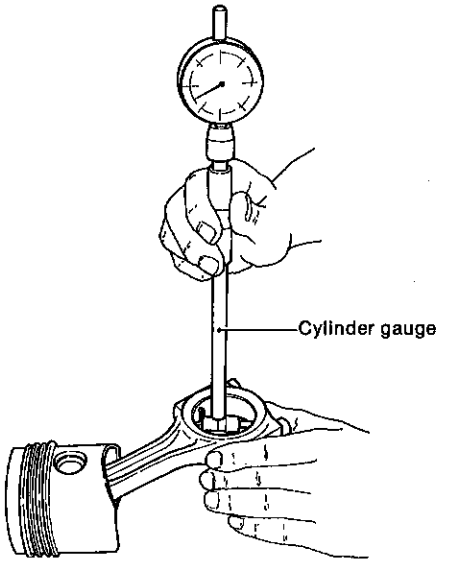


mm (in.)

	1GM10(C),2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank pin bushing inside diameter	ϕ40.0 (1.5748)	ϕ40.10 (1.5787)	ϕ44.0 (1.7323)	ϕ44.10 (1.7362)
Crank pin and bushing 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)
Connecting rod bolt Thread diameter	M7 x P1.0 (0.2755 x 0.0393)		M9 x P1.0 (0.3543 x 0.0393)	
Connecting rod bolt tightening torque	2.5 kg-m (18.1 ft-lb)		4.5 kg-m (32.5 ft-lb)	

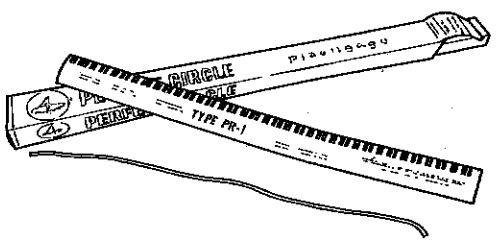
NOTE: The Crank pin bushing inside diameter must always be measured with the connecting rod bolts tightened to the prescribed torque.

4-3.2 Crank pin and bushing clearance (oil clearance)

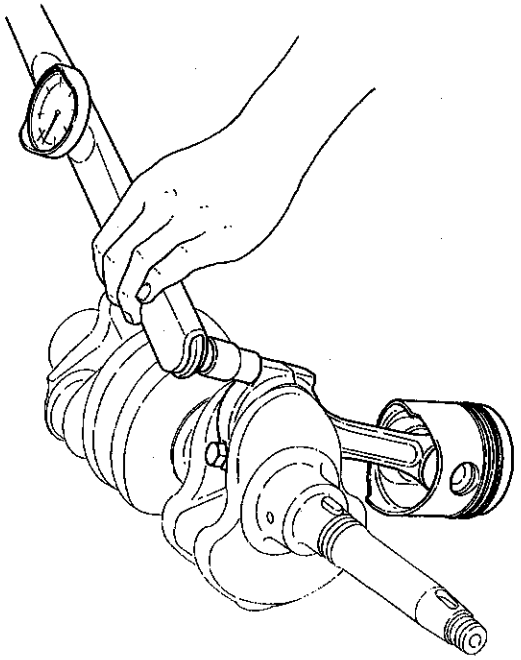
Since the oil clearance affects both the durability of the bushing and lubricating oil pressure, it must always be the prescribed value. Replace the bushing when the oil clearance exceeds the wear limit.

(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.

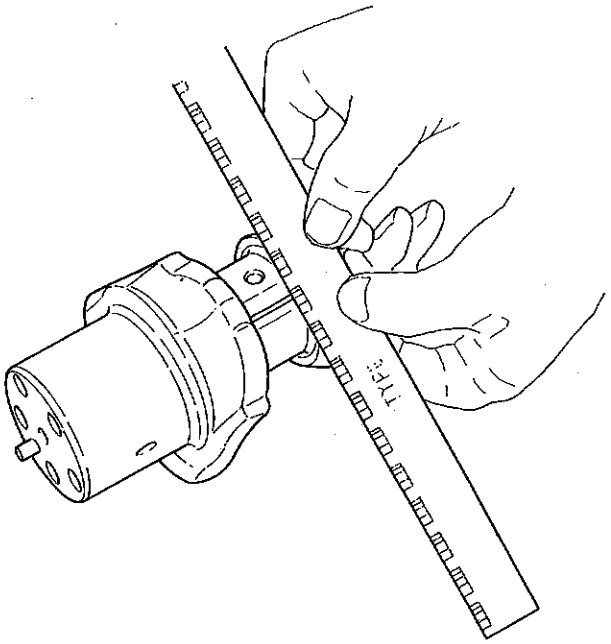


3) Tighten the connecting rod bolt to the prescribed tightening torque.



	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Connecting rod tightening torque	2.5 kg-m (18.1 ft-lb)	4.5 kg-m (32.5 ft-lb)
Hexagon width	12mm (0.4724 in.)	13mm (0.5118 in.)

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.

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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.

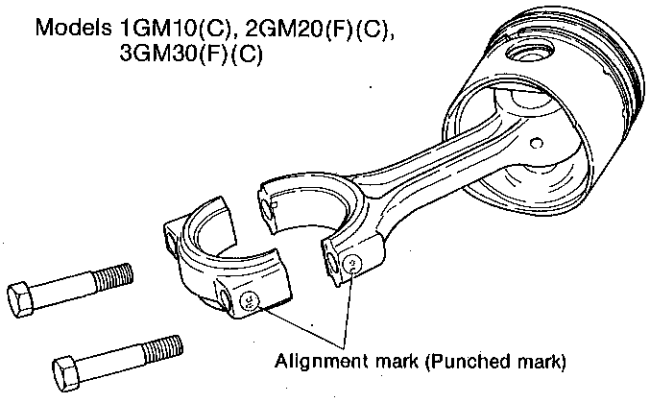
4-3.3 Crank pin bushing replacement precautions

(1) Thoroughly clean the crank pin bushing and the rear of the crank pin bushing.

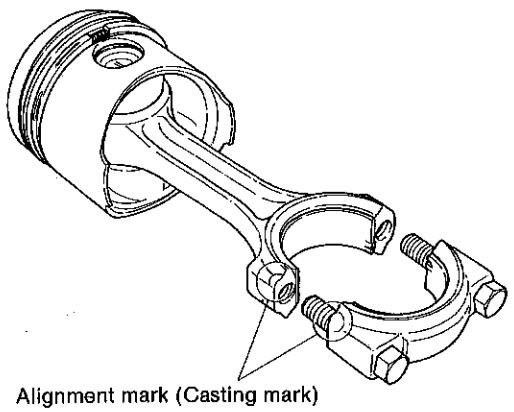
(2) Also clean the big end cap, install the crank pin bushing and check if the bushing contacts with the big end cap closely.

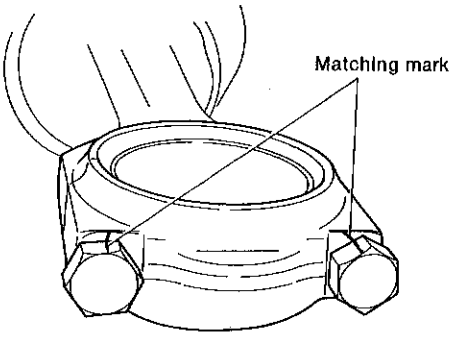
(3) When assembling the connecting rod, match the number of the big end section and the big end cap, coat the bolts with engine oil, and alternately tighten the bolts gradually to the prescribed tightening torque. If a torque wrench is not available, put matching marks (torque indication lines) on the bolt head and big end cap before disassembly and tighten the bolts until these two lines are aligned.

Models 1GM10(C), 2GM20(F)(C), 3GM30(F)(C)



Model 3HM35(F)(C)



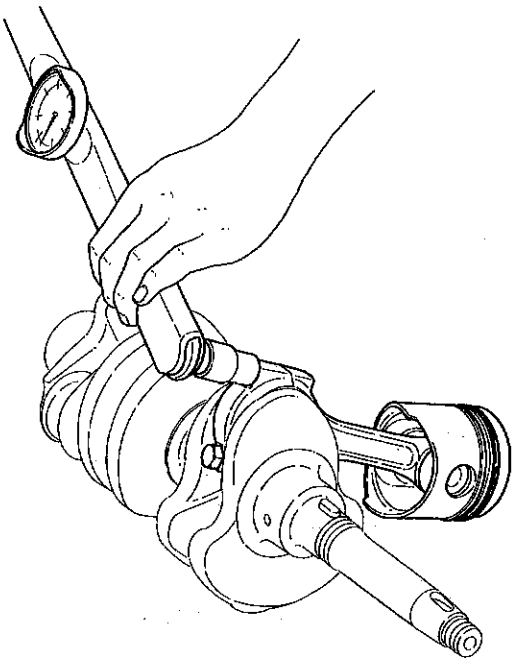


(4) Check that there is no sand or metal particles in the lubricating oil and that the crankshaft is not pitted. Clean the oil holes with particular care.

4-4 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.



4-5 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.

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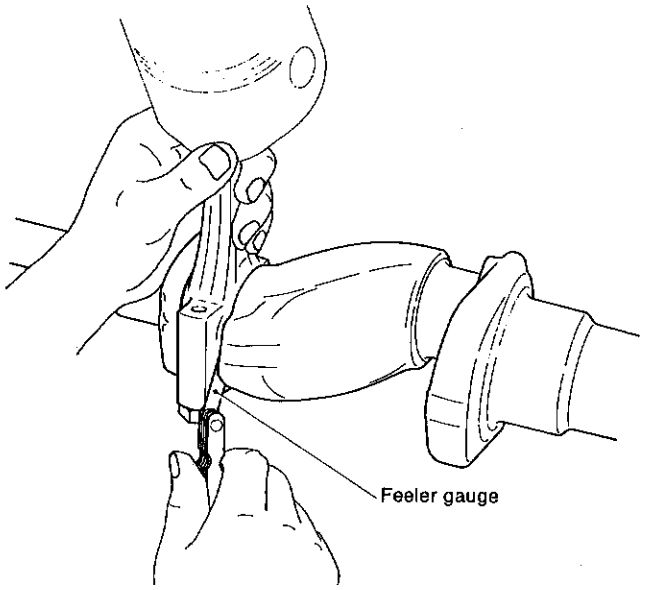
The connecting rod bolts must also be tightened to the prescribed tightening torque in this case.

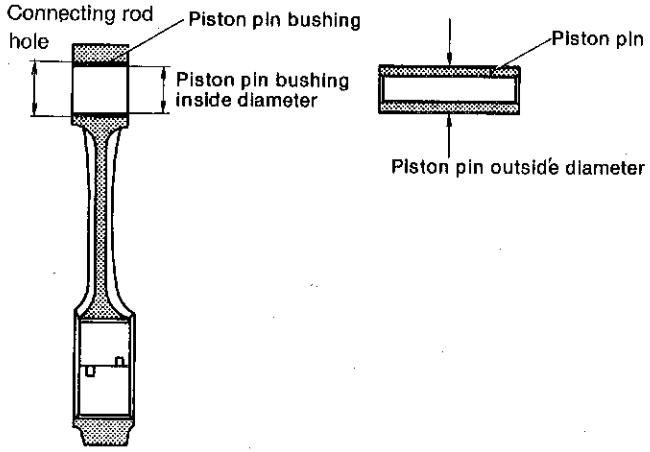


mm (in.)

	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Connecting rod side clearance	0.2~0.4 (0.0079~0.0157)	0.2~0.4 (0.0079~0.0157)

4-6 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.

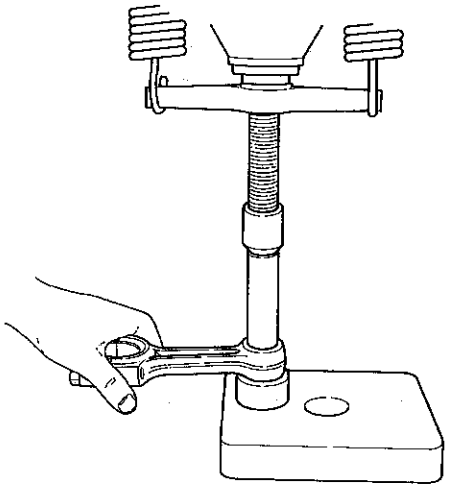


mm (in.)

	1GM10(C),2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Piston pin bushing inside diameter	ϕ20.0 (0.7874)	ϕ20.10 (0.7913)	ϕ23.0 (0.9055)	ϕ23.1 (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)
Connecting rod hole	ϕ22.0~22.021 (0.8661~0.8670)	—	ϕ23.0~23.021 (0.9055~0.9063)	—

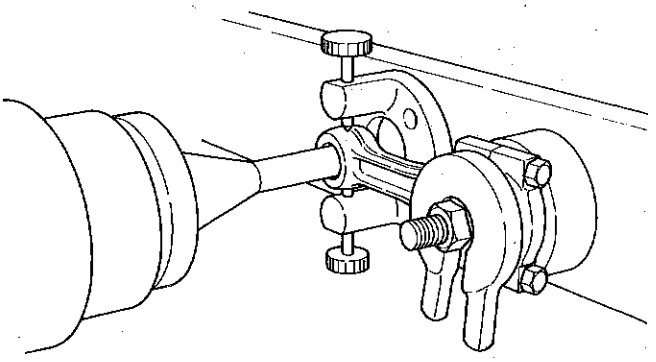
Replacing the piston pin bushing

(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 the pin, coated with engine oil can be pushed into position with your thumb.

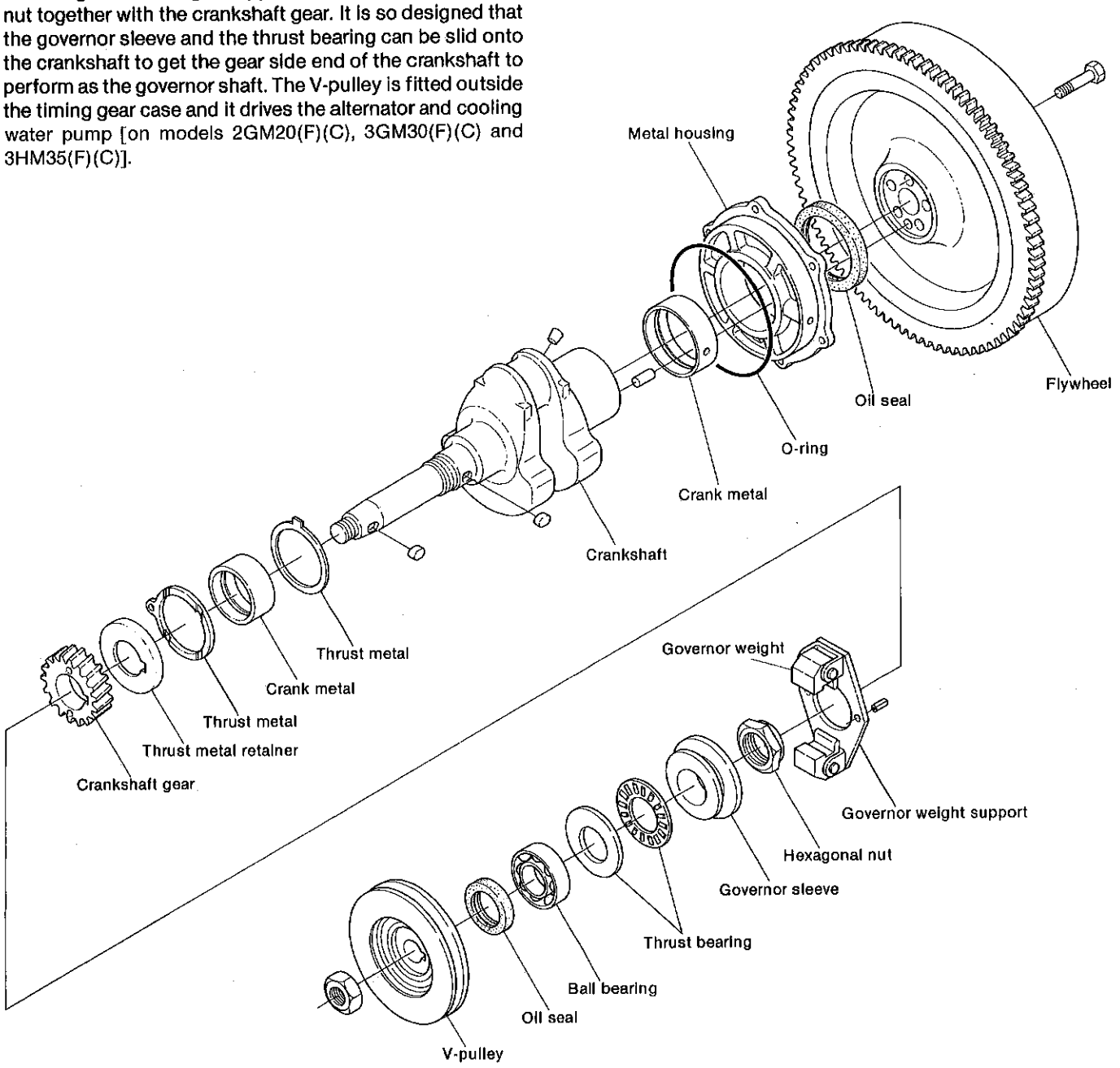
5. Crankshaft

5-1 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 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)].

5-1.1 Construction of model 1GM10(C)

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.



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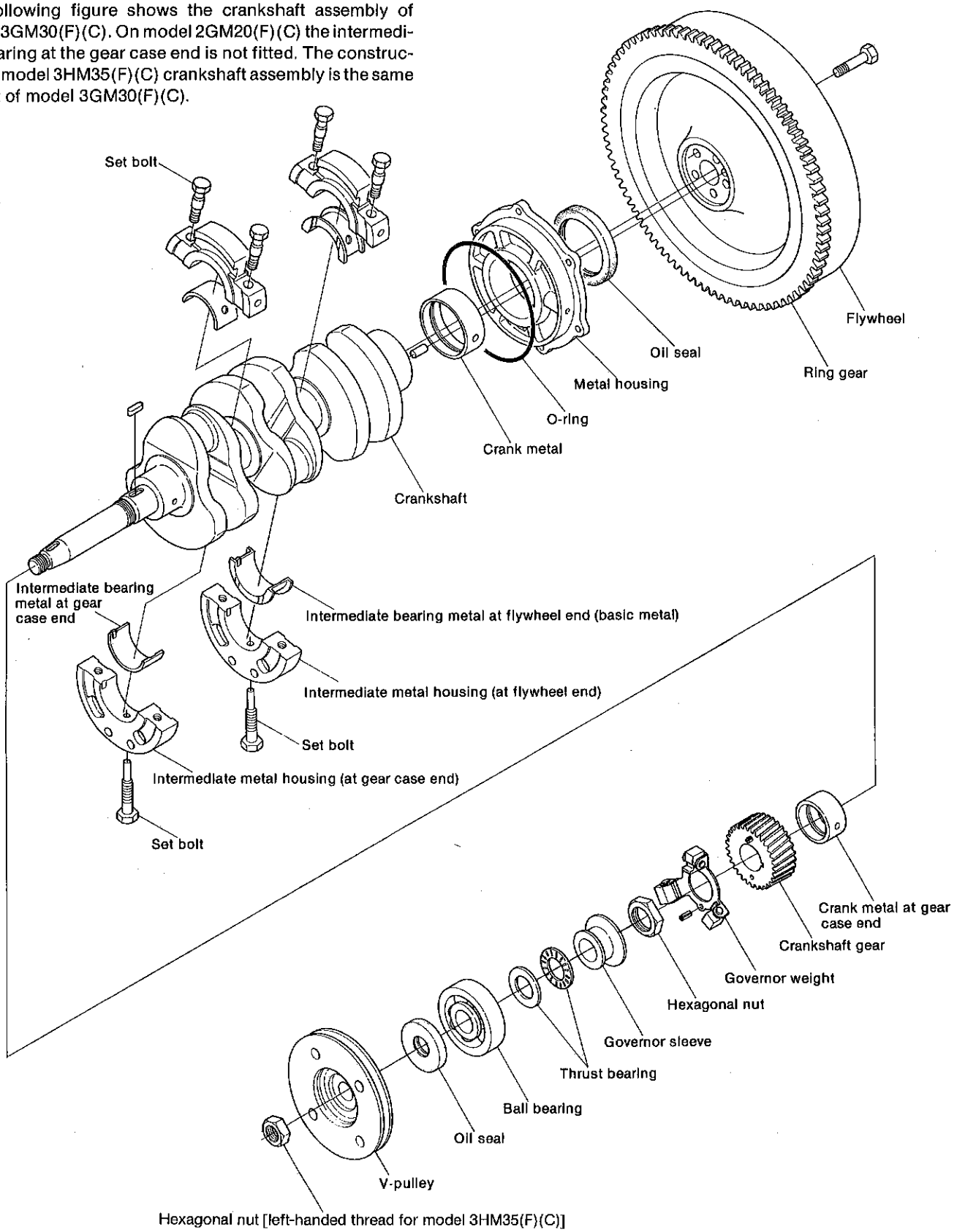
5-1.2 Construction of models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C) crankshaft assembly

The following figure shows the crankshaft assembly of model 3GM30(F)(C). On model 2GM20(F)(C) the intermediate bearing at the gear case end is not fitted. The construction of model 3HM35(F)(C) crankshaft assembly is the same as that of model 3GM30(F)(C).



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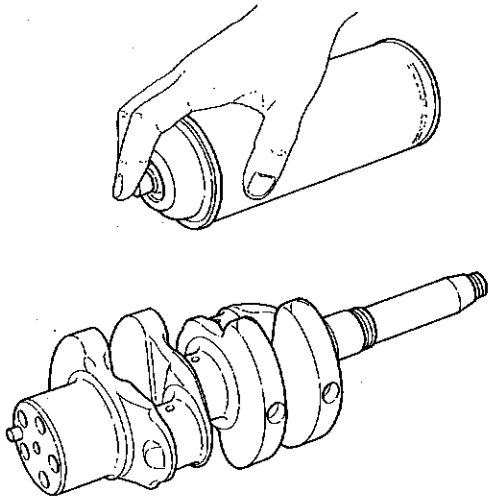
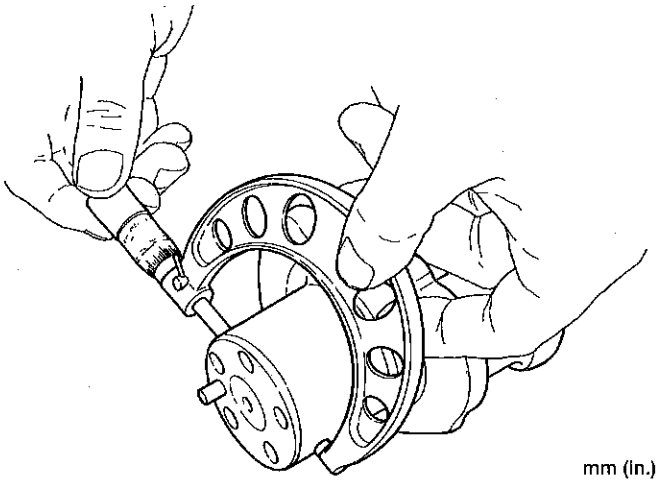
5-2 Inspection

5-2.1 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.

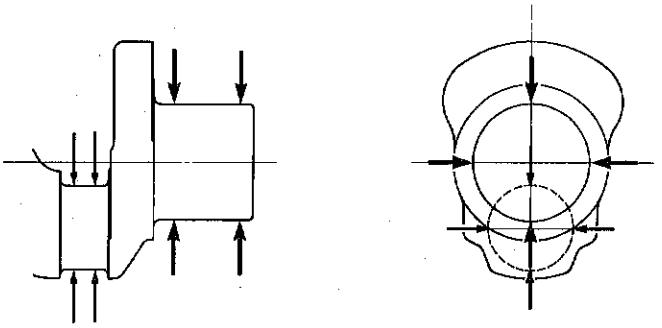


mm (in.)

			1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
			Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank journal outside diameter	Gear case side	A	$\phi44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\phi47^{-0.036}_{-0.050}$ (1.8484 ~ 1.8490)	ø46.90 (1.8465)
	Intermediate bearing	B	$\phi44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\phi47^{-0.036}_{-0.050}$ (1.8484 ~ 1.8490)	ø46.90 (1.8465)
	Flywheel side	C	$\phi60^{-0.036}_{-0.050}$ (2.3602 ~ 2.3608)	ø59.90 (2.3583)	$\phi65^{-0.036}_{-0.050}$ (2.5571 ~ 2.5576)	ø64.90 (2.5551)
Crank pin outside diameter		D	$\phi40^{-0.036}_{-0.050}$ (1.5728 ~ 1.5734)	ø39.90 (1.5709)	$\phi44^{-0.036}_{-0.050}$ (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 1GM10(C) 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.



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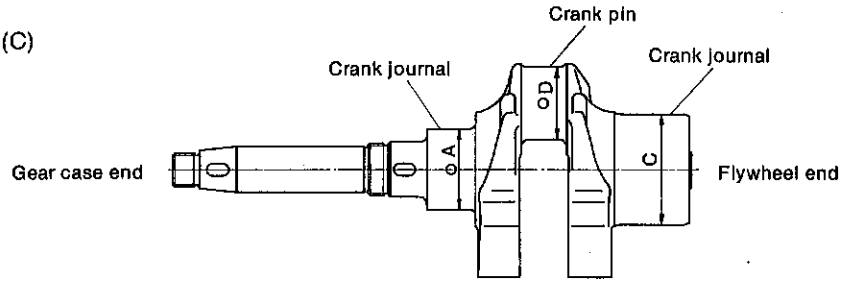
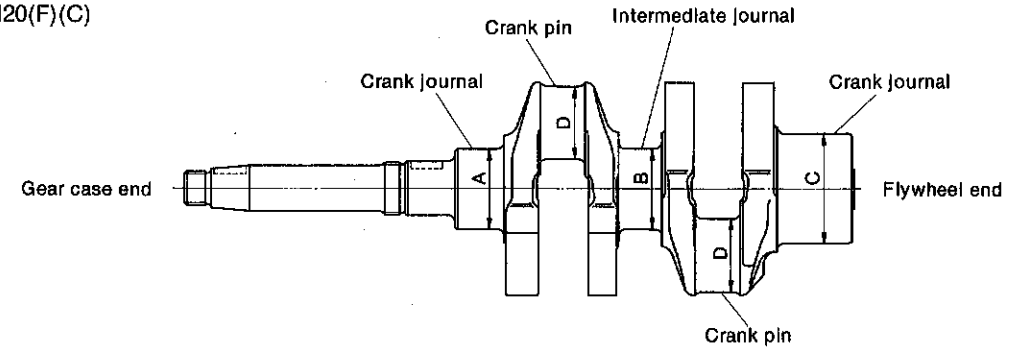
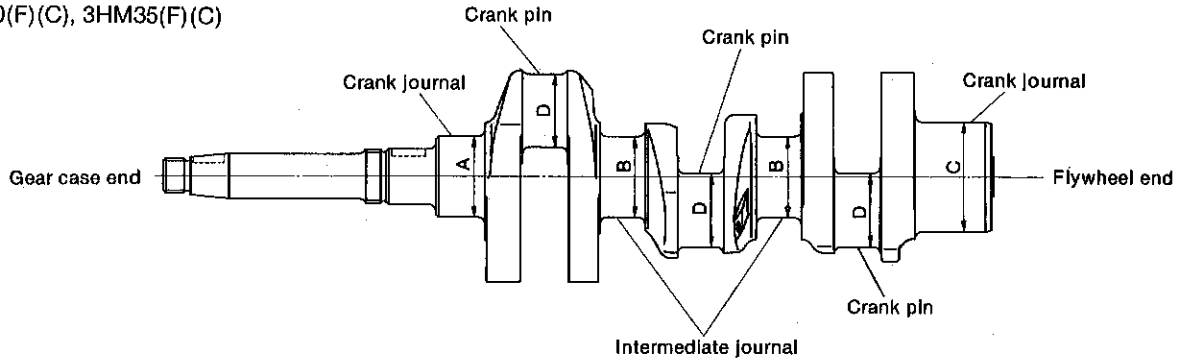
1GM10(C)



2GM20(F)(C)

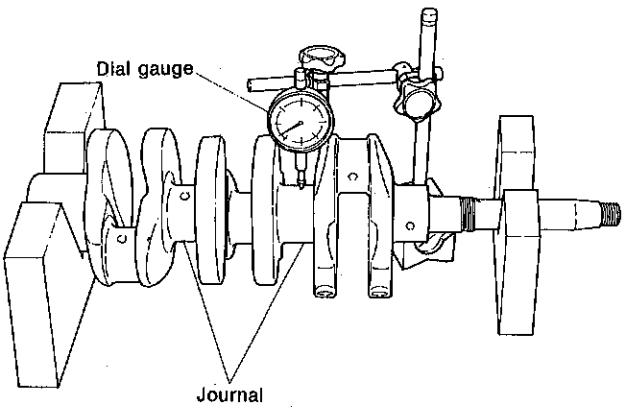


3GM30(F)(C), 3HM35(F)(C)



(3) Measuring the crankshaft bend [2GM20(F)(C), 3GM30 (F)(C), 3HM35(F)(C)]

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.



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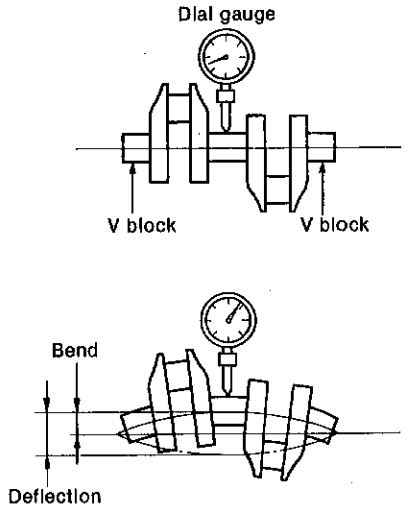


mm (in.)

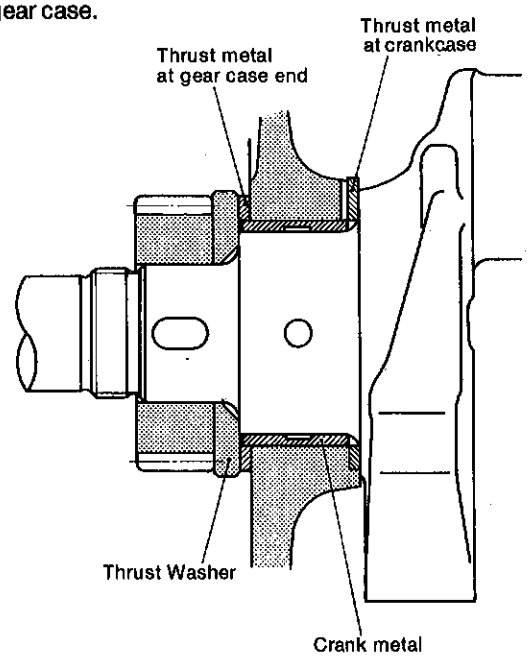
	Maintenance standard	Wear limit
Crankshaft bend	Less than 0.015 (0.0006)	0.15 (0.006)

5-3 Crankshaft side gap

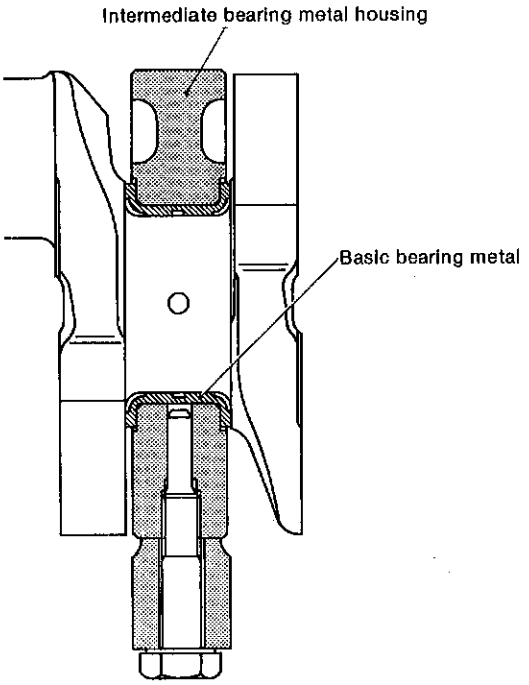
5-3.1 Side gap

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 1GM10(C)
Adjust the side gap to the maintenance standard according to the thickness of the crankshaft thrust metal.
Thrust metals are installed on both sides of the crankcase and gear case.

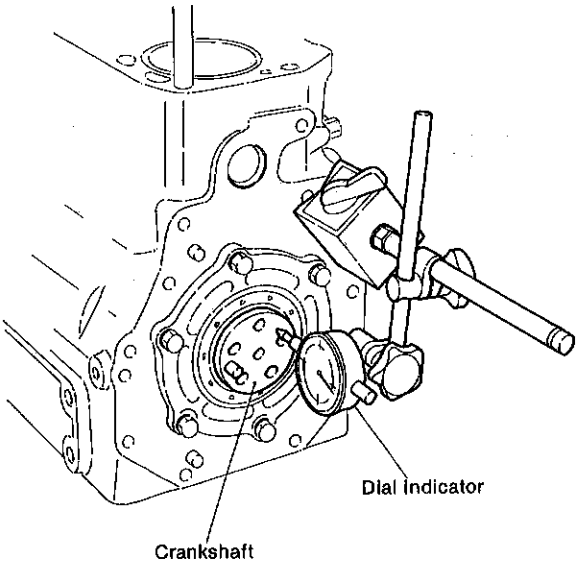


On models 2GM20(F)(C) and 3GM30(F)(C), the value of the side gap is the difference between the width of the basic bearing metal and the width of the journal. The basic bearing for model 2GM20(F)(C) is the intermediate bearing, and for models 3GM30(F)(C) and 3HM35(F)(C) it is the intermediate bearing at the flywheel end.



5-3.2 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.



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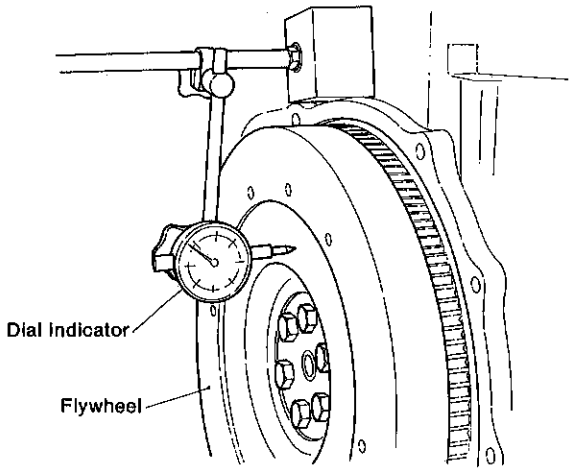


5-3.3 Side gap maintenance standard and wear limit

mm (in.)

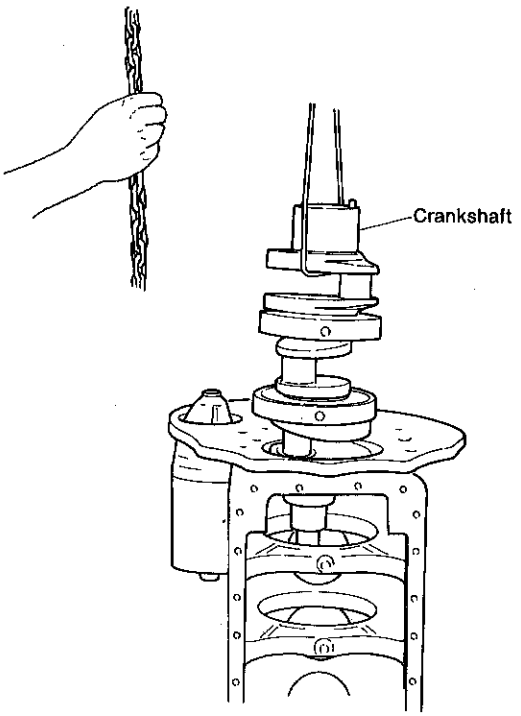
	1GM10(C)		2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank shaft side gap	0.06 ~ 0.19 (0.0024 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.19 (0.0035 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.18 (0.0035 ~ 0.0071)	0.30 (0.0012)

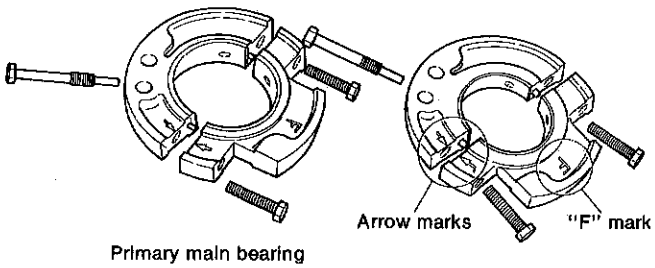
5-4 Disassembly of the crankshaft [2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)]

For model 1GM10(C) see the chapter on disassembly and reassembly. Because there are points over which care must be taken in models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C), disassembly and reassembly procedures are explained below.

5-4.1 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.





Primary main bearing

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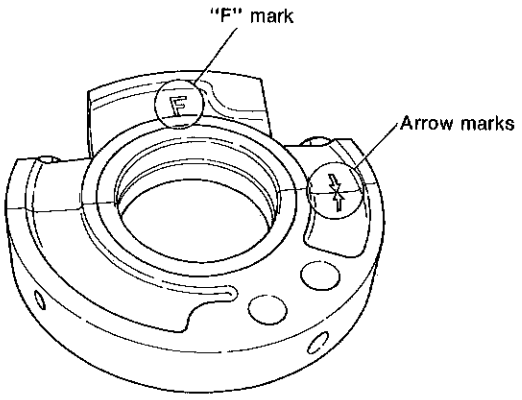
5-4.2 Reassembly

(1) Clean each part before reassembly.

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

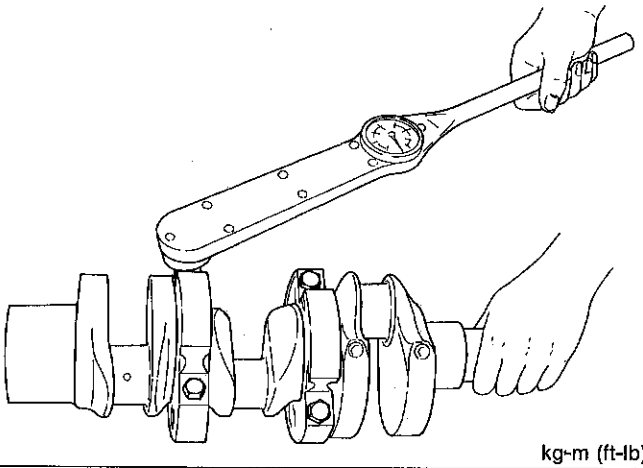
1) Assembling position and direction of the intermediate main bearing housing.

- 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).

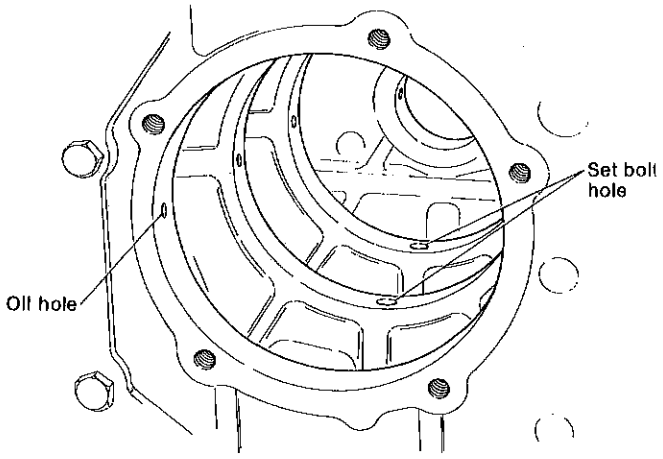
2) Tightening torque of hexagonal bolts for affixing the top and bottom of the intermediate main bearing housing:



kg-m (ft-lb)

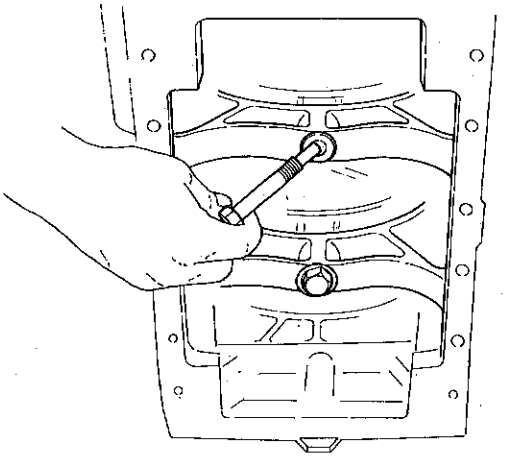
	2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Tightening torque	3.0~3.5 (21.7~25.3)	4.5~5.0 (32.5~36.2)

(3) Set the cylinder block up vertically, 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)

	2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
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.

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

kg-m (ft-lb)

	2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Main bearing housing tightening torque	2.5 (18.1)	2.5 (18.1)

5-5 Main bearing

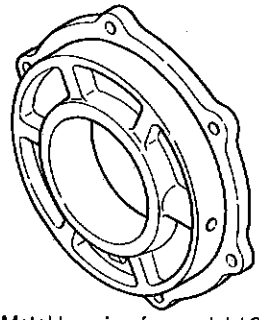
5-5.1 Construction

(1) Model 1GM10(C)

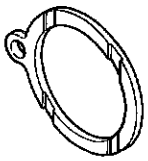
The main bearing consists of a crank bearing and thrust metal. The crank bearing is a round copper-leak sintered alloy bearing featuring superior durability.

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 1GM10(C)

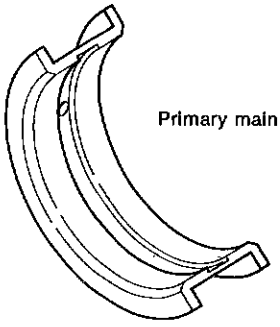


Thrust metal at gear case end for model 1GM10(C)

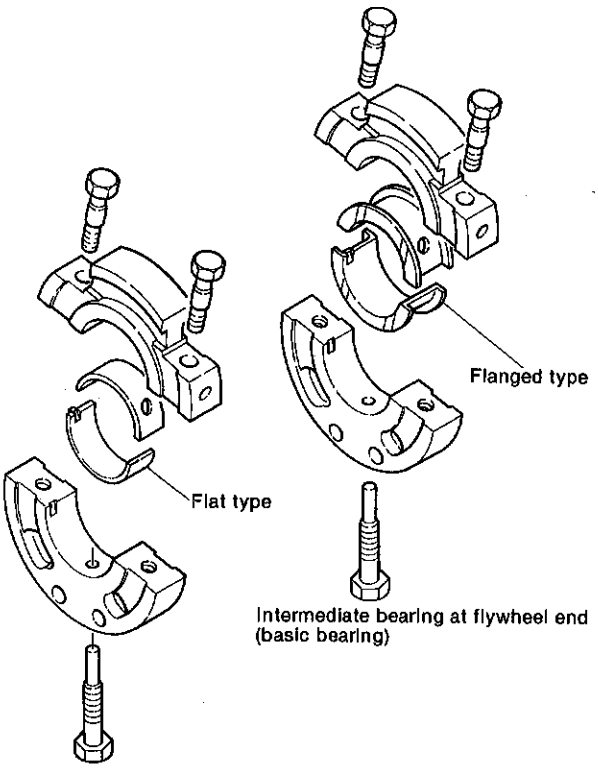
Thrust metal at crankcase end for model 1GM10(C)

(2) Models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)

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.



Primary main bearing

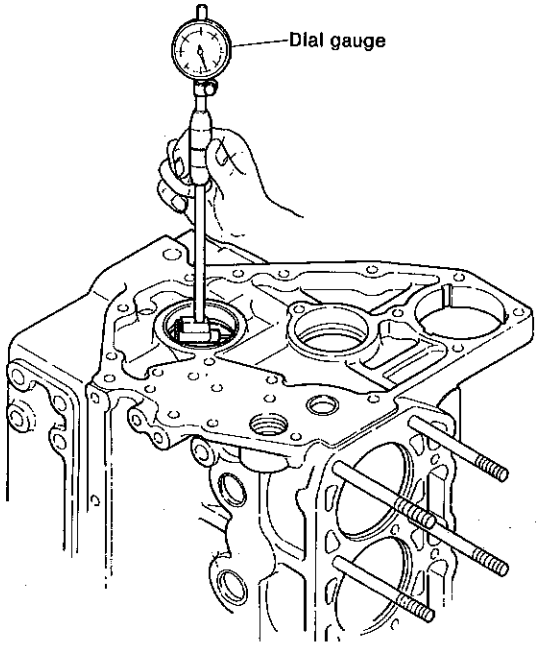


5-5.2 Inspecting the crank bearing

(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.



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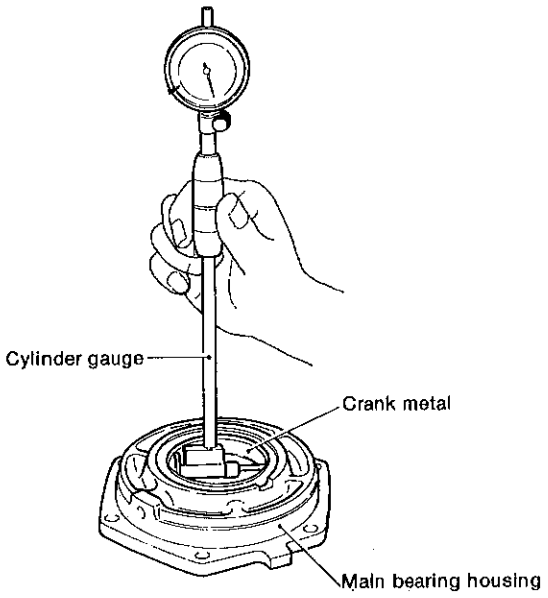
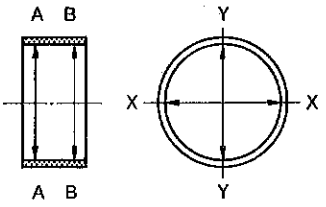


NOTES: 1) Measure the crank bearing at the four points shown in the figure and replace the bearing if the wear limit is exceeded at any of these points.
2) When measuring the inner diameter of the crank bearing, the crank bearing should be installed on the bearing housing and/or cylinder block.

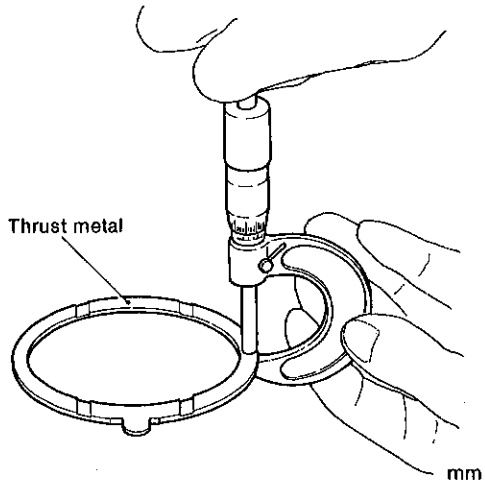


mm (in.)

		1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
		Maintenance standard	Wear limit	Maintenance standard	Wear limit
Flywheel side	Main bearing inside diameter	ø60.0 (2.3622)	ø60.12 (2.3669)	ø65.0 (2.5590)	ø65.12 (2.5638)
	Crankshaft journal outside diameter	ø60.0 (2.3622)	ø59.90 (2.3583)	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)

5-5.3 Inspecting the thrust metal [for model 1GM10(C)]

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)

5-5.4 Inspecting the intermediate main bearing [for models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)]

(1) Caution when inspecting

The intermediate main bearing is divided into two semi-circles. 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)

	2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
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)

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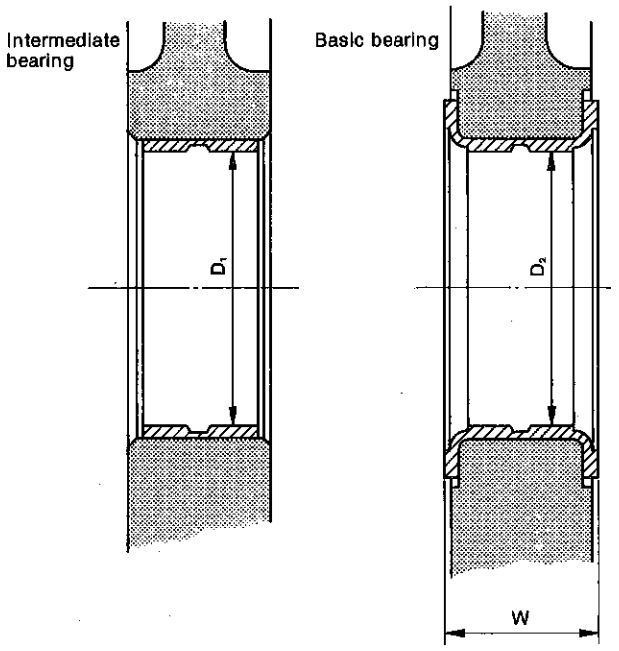
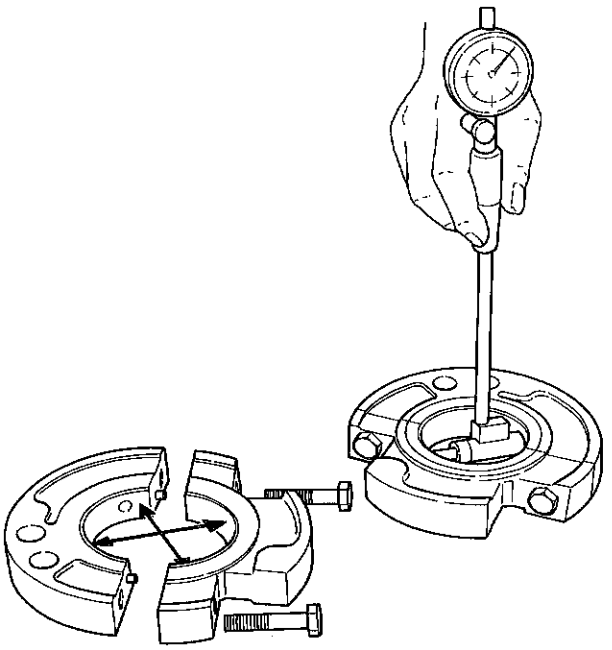
(2) Intermediate main bearing

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. As the flange wears away the side gap of the crankshaft increases.





mm (in.)

		2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
		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 1GM10(C)

5-5.5 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.

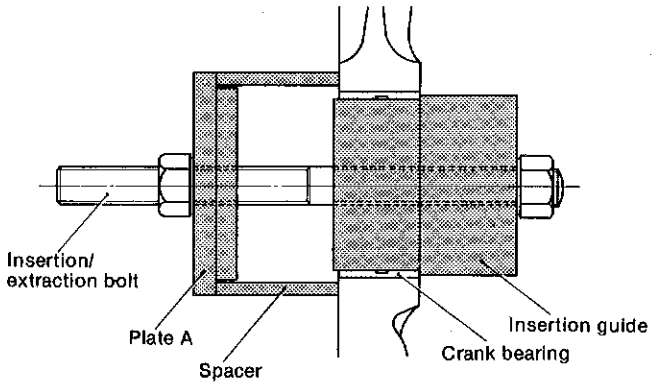
Moreover, since the crankshaft will not rotate smoothly and other trouble may occur if the bearing is distorted, it must always be installed with the special tool.

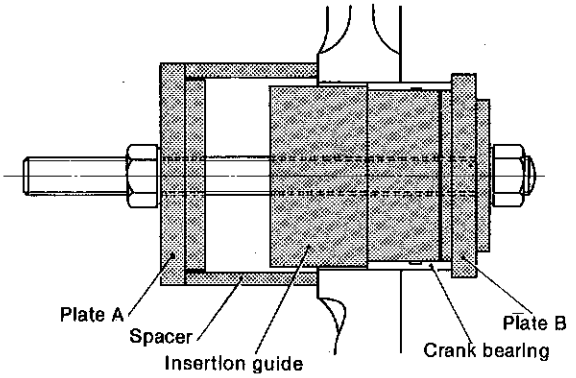
(1) Removal

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 against 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





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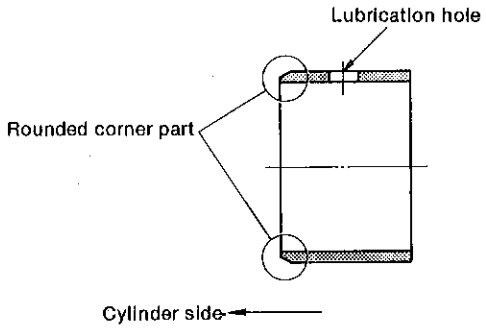
until it touches the cylinder block or bearing housing, using the puller/extractor as a guide, as shown in the figure.
After inserting the bearing, measure its outside diameter. If the bearing is distorted, remove it again and replace it with a new bearing.

(3) Crank bearing installation precautions

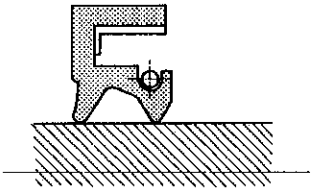


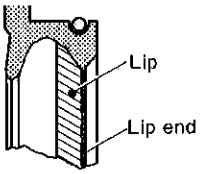
1) Pay careful attention to the crank bearing insertion direction. Insert the bearing so that the side with the outside fillet is on the outside.
2) Align the oil hole of the crank bearing with the oil holes of the cylinder block and bearing housing.
3) After inserting the crank bearing, check that the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

5-6 Crankshaft oil seal

5-6.1 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.

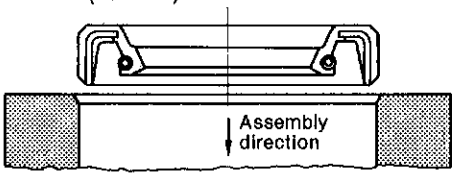




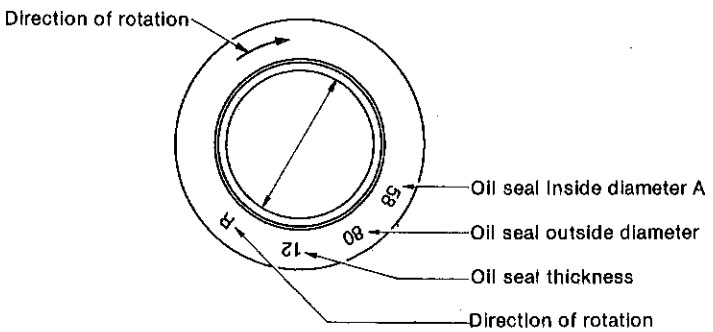
Oil seal	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)			3HM35(F)(C)		
	Size	Spiral	Part No. (Yanmar)	Size	Spiral	Part No. (Yanmar)
For Main bearing metal housing	60829	Yes	124085-02220	65889	Yes	121551-02220
For gear case	25408	Yes	121450-01800	25408	Yes	121450-01800

5-6.2 Oil seal insertion precautions

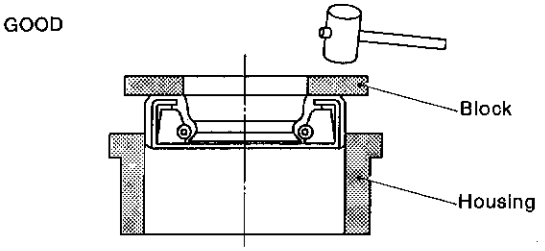
(1) Clean the inside of the housing hole, ascertaining that the hole is not dented when the seal is removed.
(2) Be sure that the insertion direction of the oil seal is correct. Insert so that the main lip mounting on the spring is on the inside (oil side).

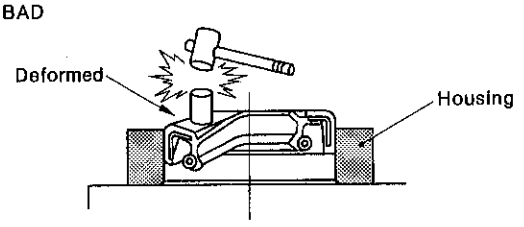


(3) Since the direction of rotation of the shaft is specified on a spiral oil seal, be sure that the rotating direction is correct.



(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.





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6. 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 unbalanced 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 balance is adjusted by drilling holes in the side of the flywheel, and the unbalanced moments are 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.

6-1 Specifications of flywheel

			1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Outside diameter of flywheel		mm	$\varnothing 252_{-0.2}^{0}$			$\varnothing 300$
Width of flywheel		mm	70	70	70	44
Weight of flywheel (including ring gear)		kg	17.5	17.5	17.5	12.0
GD^2 value		kg-m²	0.7	0.7	0.70	0.70
Circumferential speed		m/s	47.5 (3600 rmp)			53.4 (3400 rpm)
Speed fluctuation rate		δ	1/71.2 (3600 rpm)	1/86.4 (3600 rpm)	1/116 (3600 rpm)	1/73.4 (3400 rpm)
Allowable amount of imbalance		g-cm	30	30	30	25
Fixing part of damper disc	Pitch circle diameter of bolts	mm	150			170
	No. of bolts × bolt diameter		6-M8 thread equally spaced			
Fixing part of crankshaft	Pitch circle diameter of bolts	mm	41			46
	No. of thread holes	mm	5-M10			5-M10
	Fit joint diameter		$\varnothing 60M7$			$\varnothing 65M7$
Model of reduction and reversing gear			KM2-C		KM3A	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

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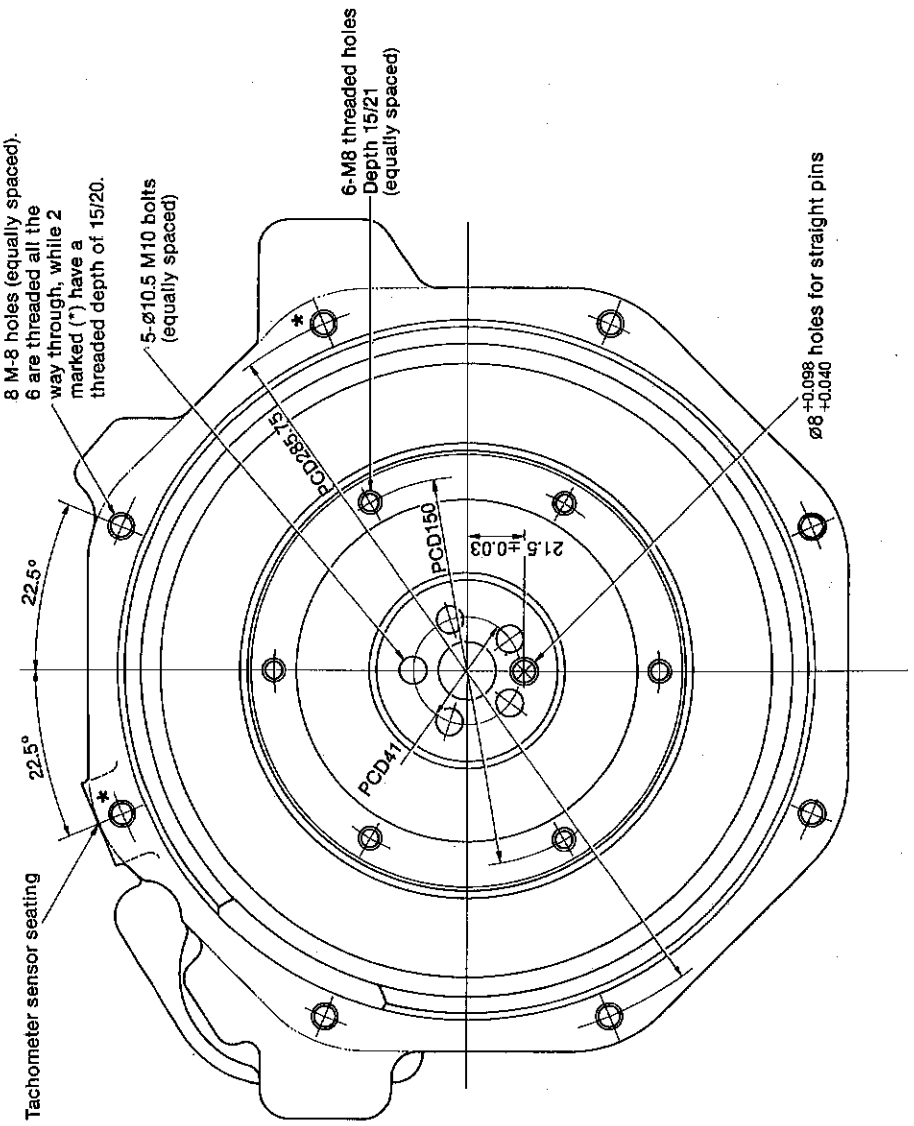
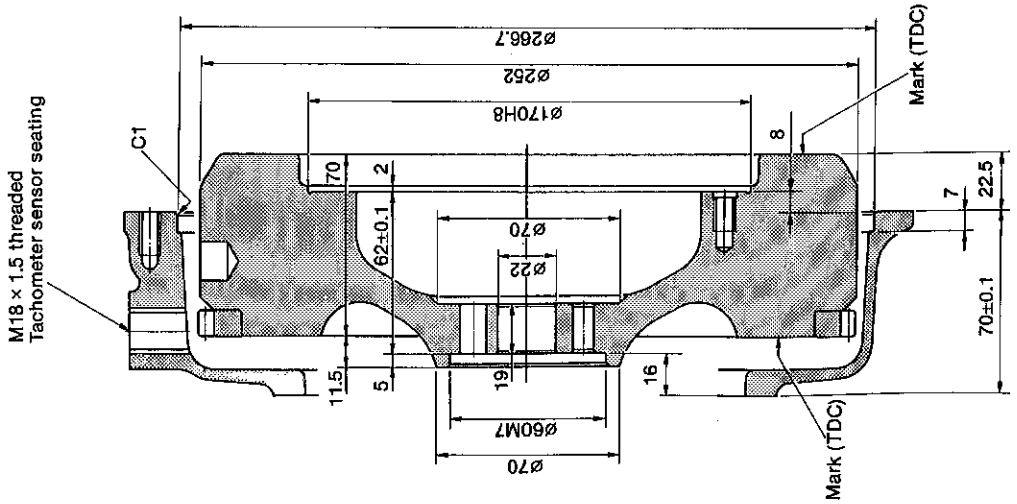
6-2 Dimensions of flywheel and flywheel housing

6-2.1 For model 1GM10(C), 2GM20(F)(C), 3GM30(F)(C)





NOTE: Material of flywheel housing.
Sail-drive type: Cast iron
Marine gearbox type: Aluminum alloy

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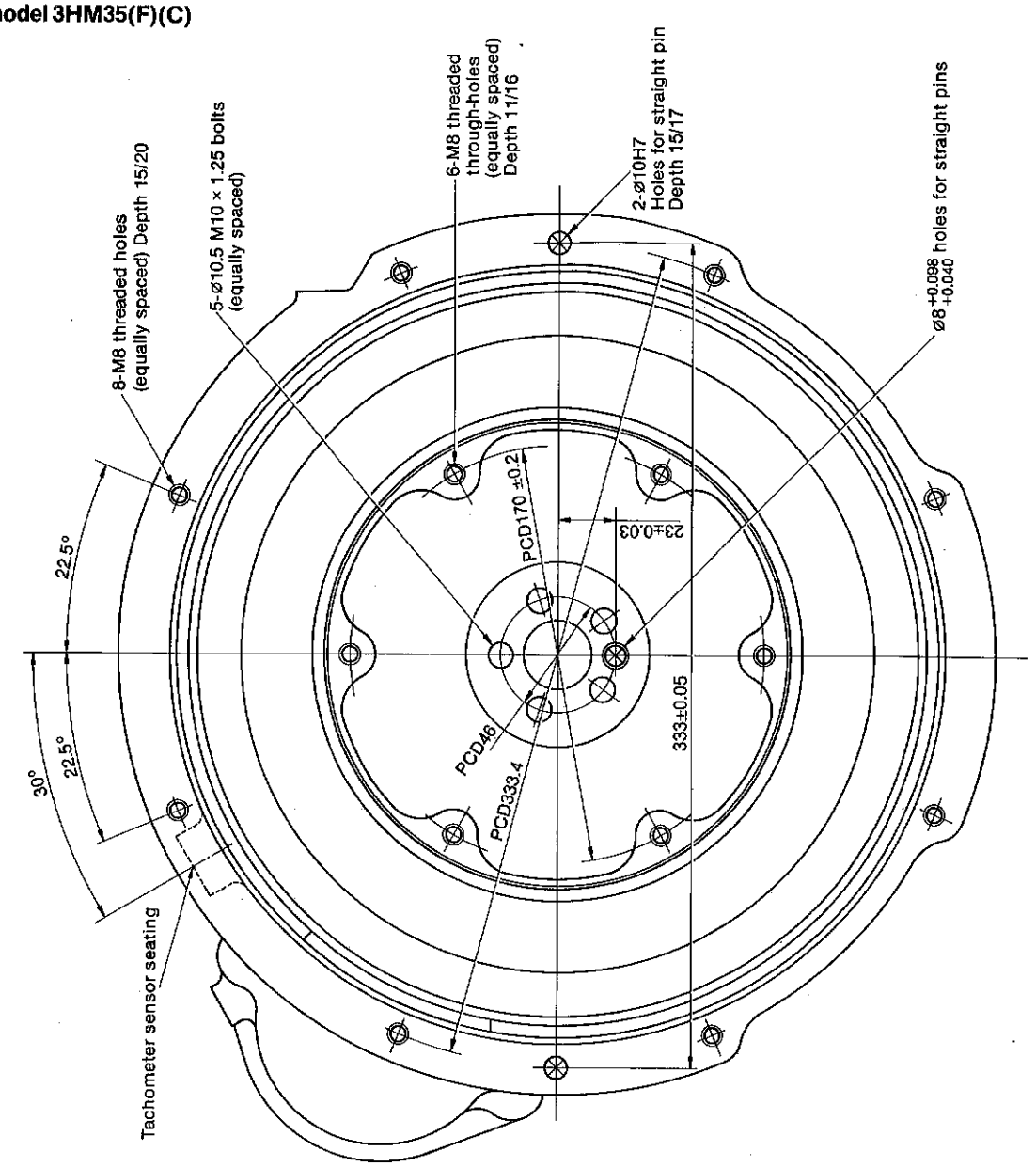
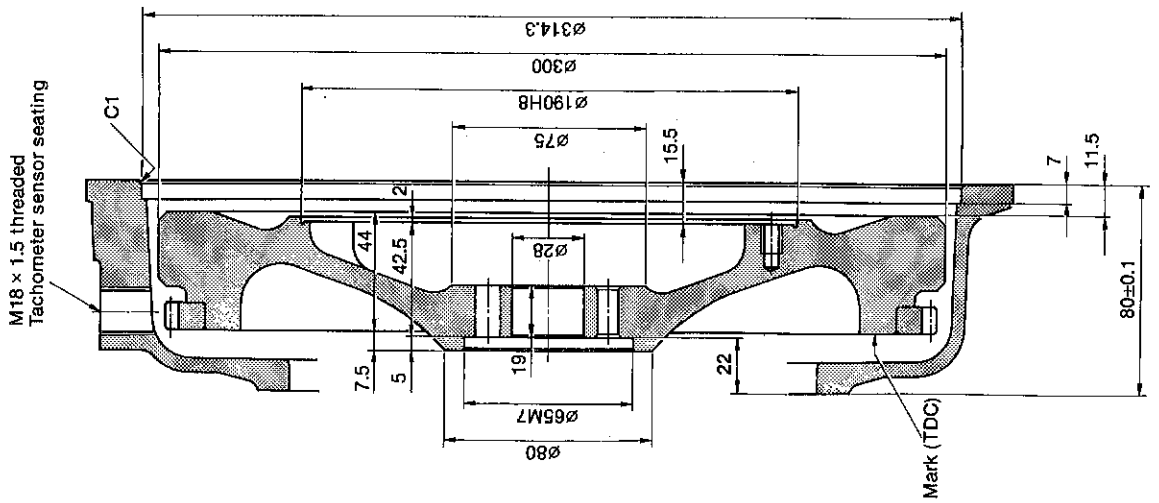
6-2.2 For model 3HM35(F)(C)



NOTE: Material of flywheel housing
Sail-drive type: Cast iron
Marine gearbox type: Aluminum alloy



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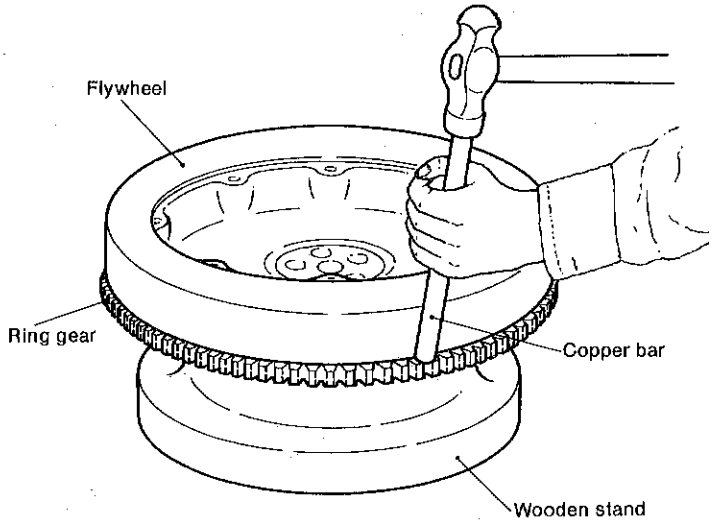
6-3 Ring gear

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.

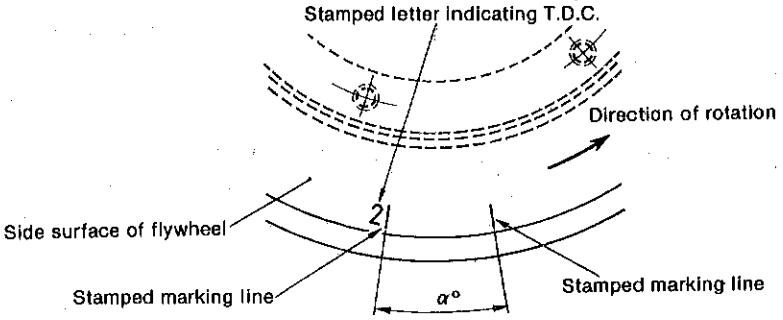
mm (in.)

	1GM10(C), 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Interference of ring gear	0.188~0.348 (0.0074~0.0137)	0.188~0.348 (0.0074~0.0137)



6-4 Position of top dead center

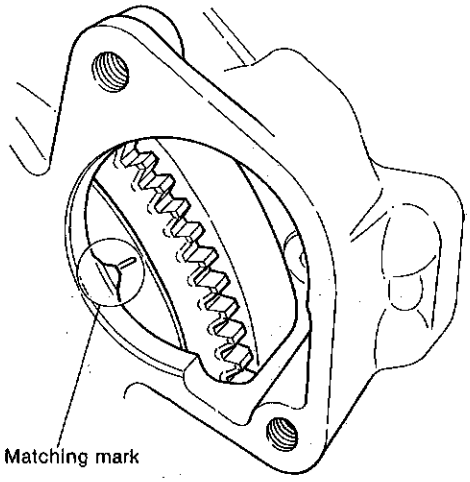
(1) Marking



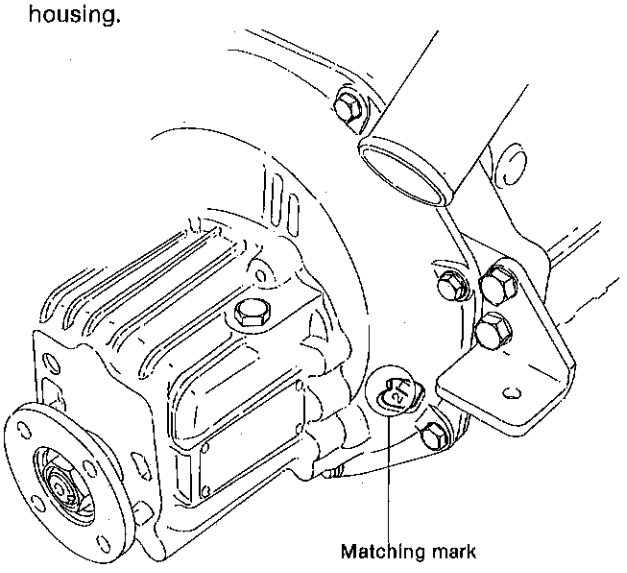
	1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Stamped letter	1	1, 2	1, 3	1, 2, 3
Angle α of Stamped lines	15°	15°	18°	21°
Stamped surfaces	Both surfaces	Both surfaces	Both surfaces	Crankshaft side

(2) Matching mark

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



With respect to models 1GM10(C), 2GM20(F)(C) and 3GM30(F)(C) only, a projection which serves as the matching mark is provided in the cast hole of the clutch housing.



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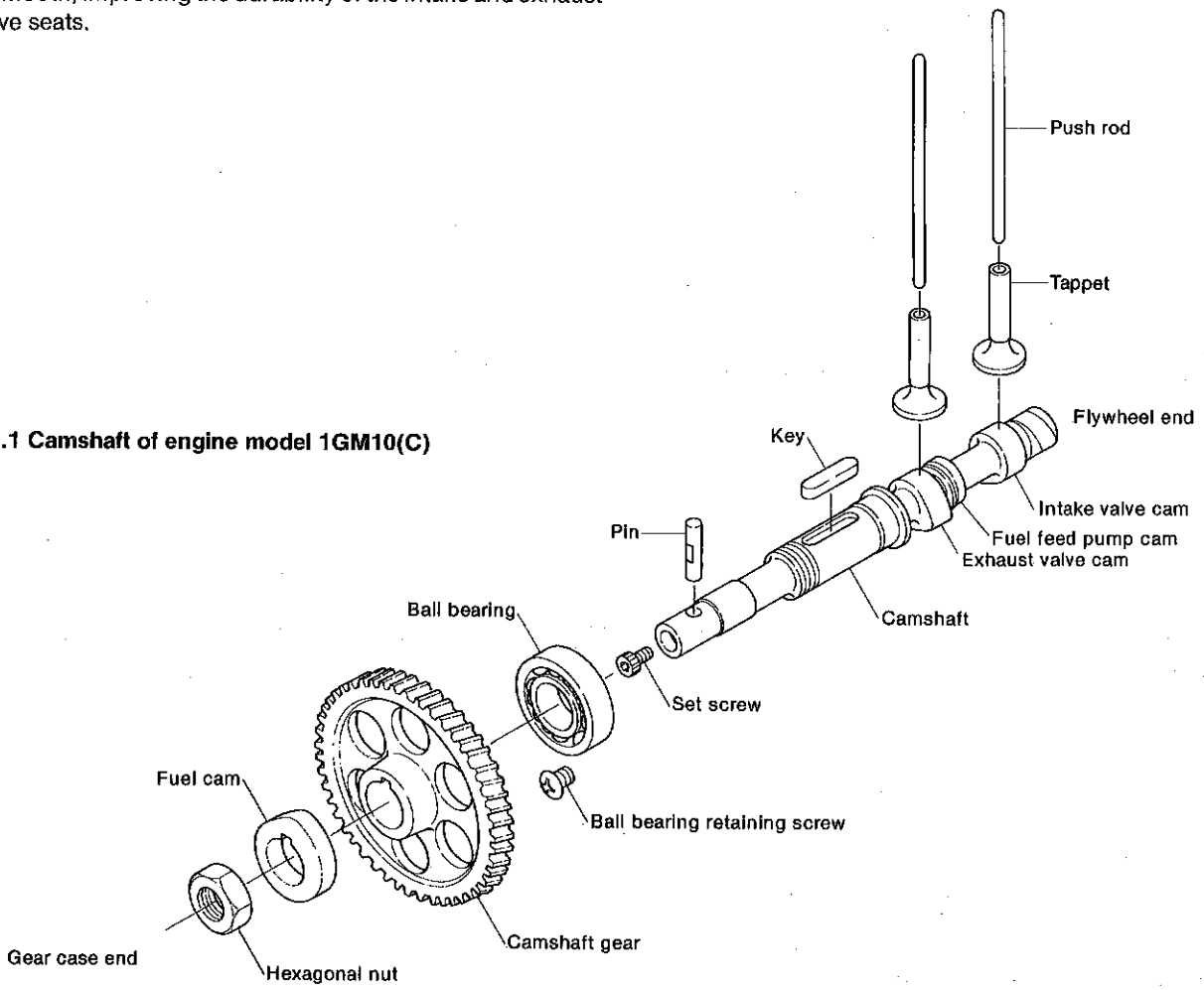
7. Camshaft

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 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 1GM10(C) and 2GM20(F)(C) does not have an intermediate bearing. The camshaft on models 3GM30(F)(C) and 3HM35(F)(C) however is supported by two intermediate bearings in order to avoid deflection of the camshaft.
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 1GM10(C)



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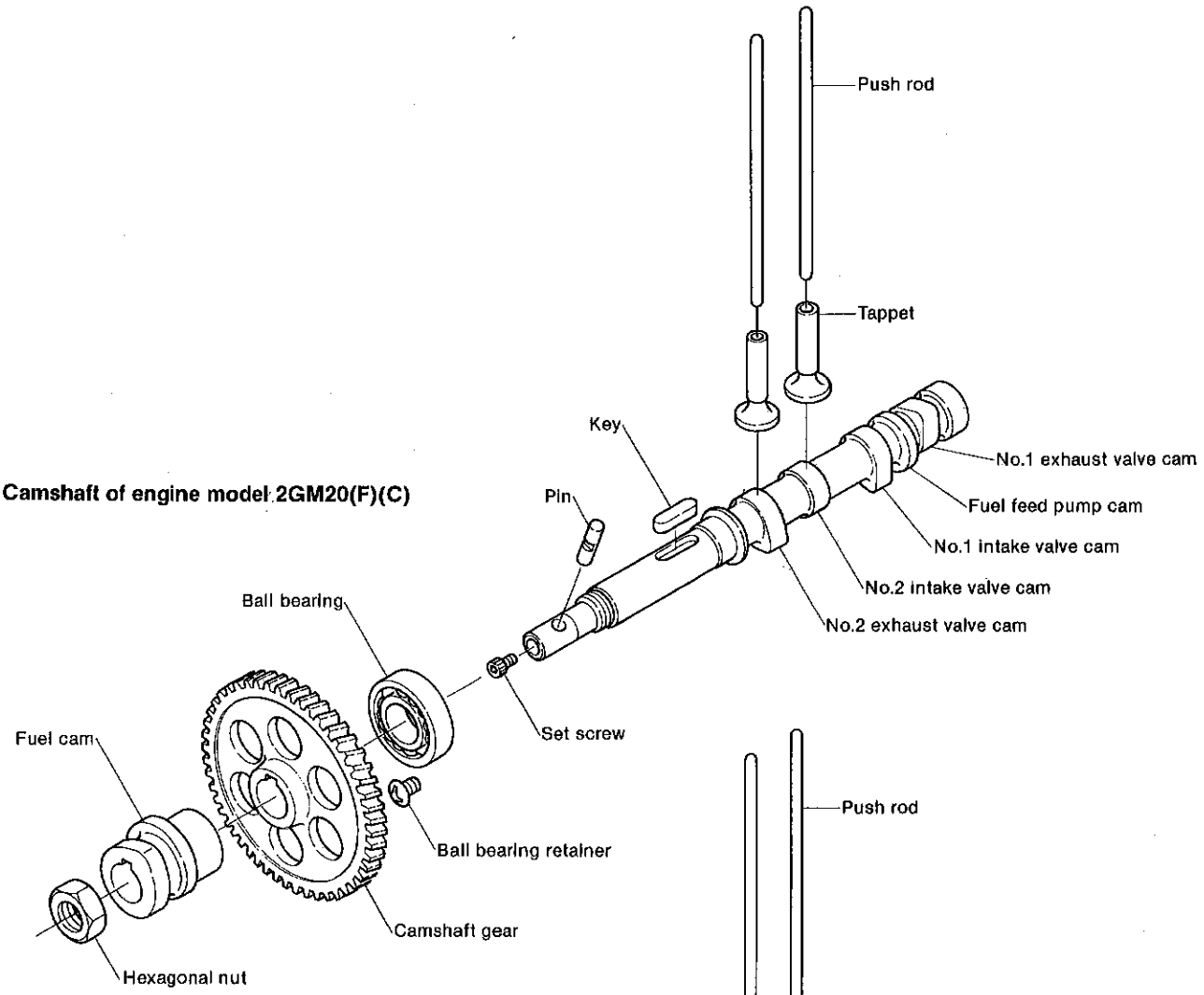
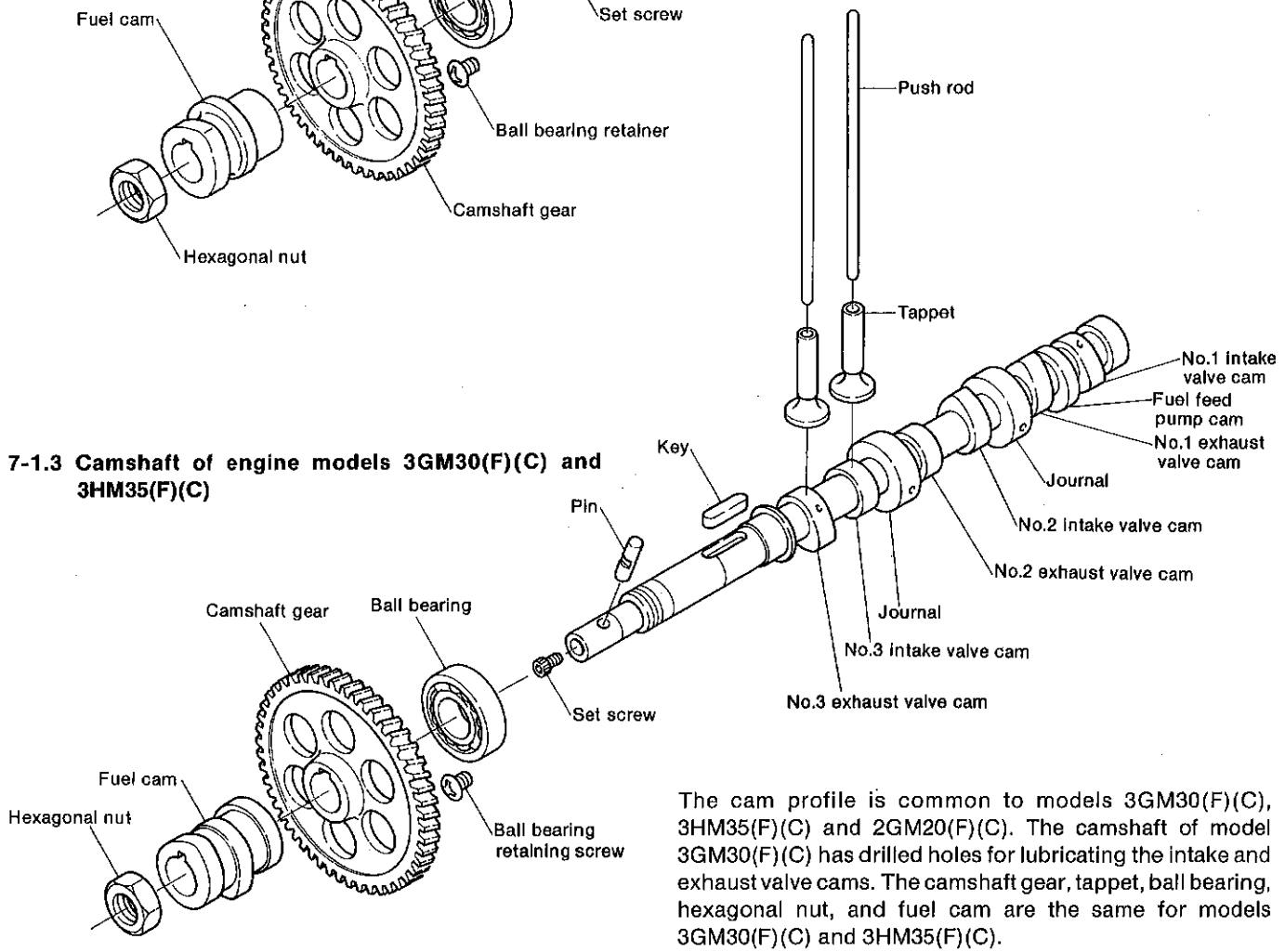
7-1.2 Camshaft of engine model 2GM20(F)(C)



7-1.3 Camshaft of engine models 3GM30(F)(C) and 3HM35(F)(C)



The cam profile is common to models 3GM30(F)(C), 3HM35(F)(C) and 2GM20(F)(C). The camshaft of model 3GM30(F)(C) 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 3GM30(F)(C) and 3HM35(F)(C).

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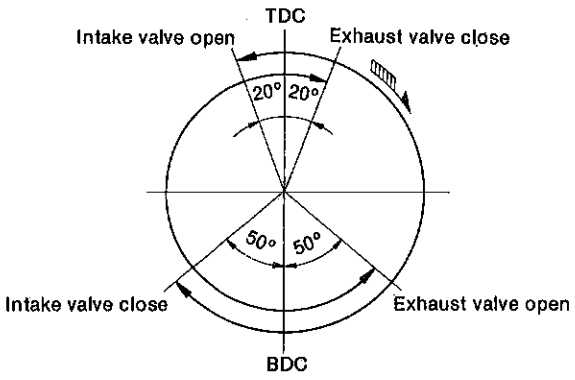
7-2 Valve timing diagram

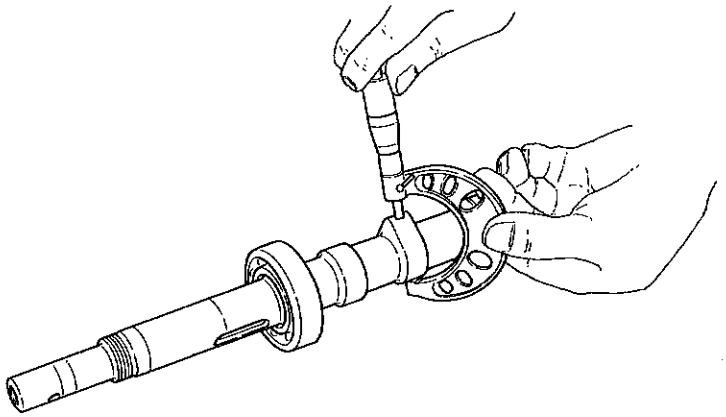


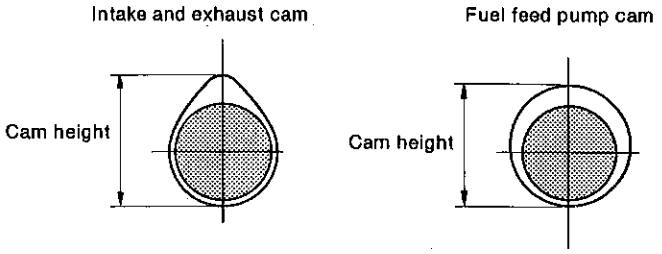
	All models
Intake and exhaust valve head clearance	0.2mm (0.0079in.)
Intake valve open b. TDC	20°
Intake valve close a. BDC	50°
Exhaust valve open b. BDC	50°
Exhaust valve close a. TDC	20°

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	1GM10(C)	29 (1.1417)	28.70 (1.1292)
	2GM20(F)(C) 3GM30(F)(C) 3HM35(F)(C)	35 (1.3780)	34.70 (1.3661)
Fuel feed pump cam	1GM10(C)	22 (0.8661)	—
	2GM20(F)(C) 3GM30(F)(C)	33 (1.2992)	—
	3HM35(F)(C)	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	1GM10(C)	ϕ20 (0.7874)	0.050~0.100 (0.0020~0.0039)	0.15 (0.0059)
	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)	ϕ30 (1.1811)		
Center	3GM30(F)(C), 3HM35(F)(C)	ϕ41.5 (1.6339)	0.050~0.100 (0.0020~0.0039)	0.15 (0.0059)

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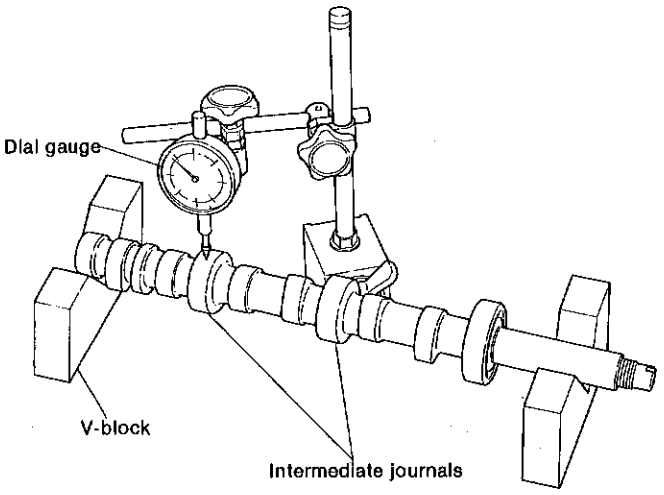
7-3.3 Camshaft deflection [models 3GM30(F)(C) and 3HM(F)(C)

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 value 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	3GM30(F)(C)	—	0.02 (0.0008)
	3HM35(F)(C)	—	0.02 (0.0008)

7-4 Camshaft ball bearing

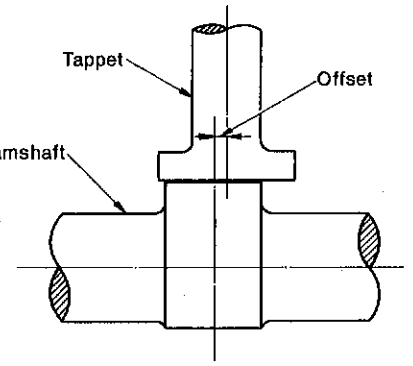
The camshaft bearing is a single row deep groove ball bearing. The construction and material of this ball bearing is such that it can withstand the radial load, thrust loads in both directions, and a combinaiton of both of these loads. When the ball bearing does not rotate smoothly, or when the axial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

Ball bearing type

For model 1GM10(C)	6005
For models 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)	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.

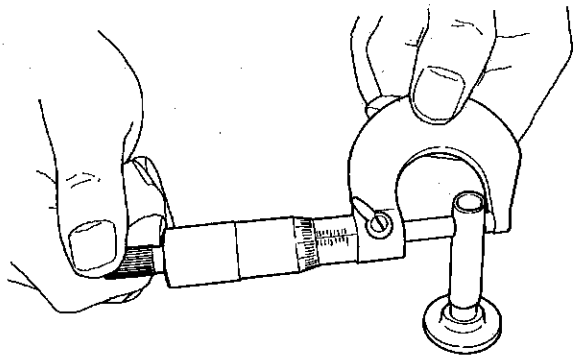


7-5.1 Tappet disassembly precautions

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

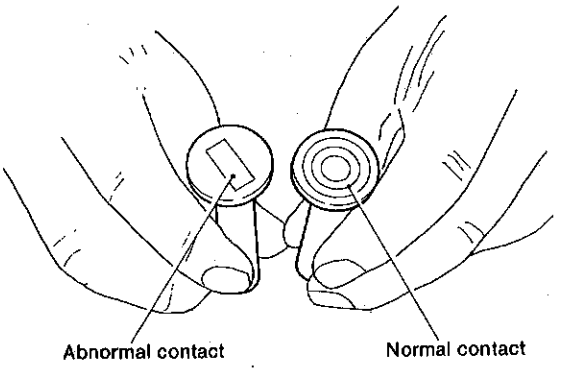
Measure the outside diameter of the tappet stem, and replace the tappet when the wear limit is exceeded or contact is uneven.



mm (in.)

		Maintenance standard	Wear limit
Tappet stem outside diameter	1GM10(C)	ϕ10.0 (0.3937)	ϕ9.95 (0.3917)
	2GM20(F)(C) 3GM30(F)(C) 3HM35(F)(C)	ϕ10.0 (0.3937)	ϕ9.95 (0.3917
Tappet stem and guide hole clearance	1GM10(C)	0.025~0.060 (0.0010~0.0024)	0.10 (0.0039)
	2GM20(F)(C) 3GM30(F)(C) 3HM35(F)(C)	0.010~0.040 (0.0004~0.0016)	0.10 (0.0039)

7-5.3 Tappet and cam contact surface



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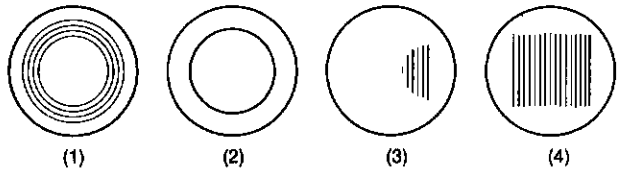
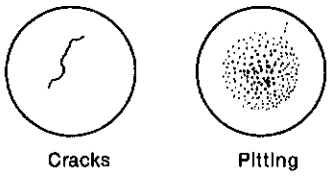
Since the tappet and cam are offset, the tappet rotates in an up and down movement during operation, so there is no uneven contact.
Since eccentric wear will occur if cam tappet contact is poor, replace the tappet if there is any uneven contact or deformation.

Contact surface conditions are shown in the following:



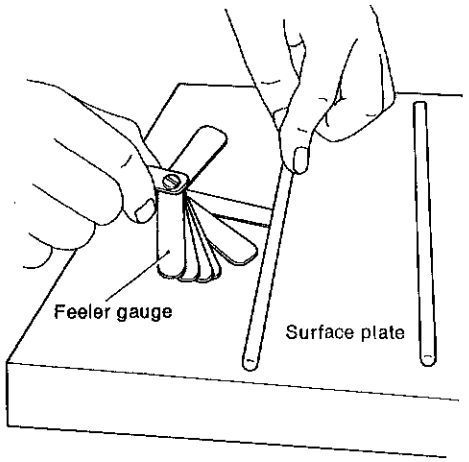
(1), (2) Traces when the tappet is rotating normally.
(3), (4) Traces when the tappet does not rotate, the contact surface remains still and the point of contact wears away excessively. Discover the reason for the lack or rotation and replace the tappet.



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.

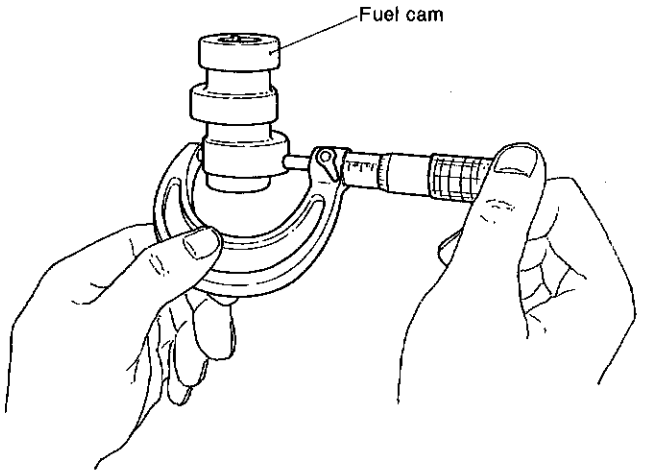
mm (in.)

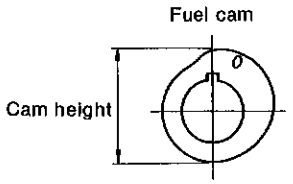
		Maintenance standard	Wear limit
Push rod bend		0.03 or less (0.00118 or less)	0.3 (0.0118)
Push rod length	1GM10(C)	143 (5.6299)	—
	2GM20(F)(C) 3GM30(F)(C)	136 (5.3543)	—
	3HM35(F)(C)	171 (6.7323)	—

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 - All models -	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.

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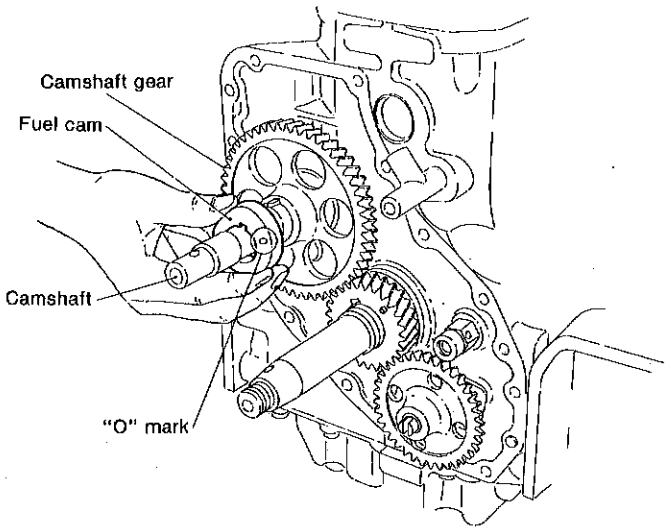

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8. Timing Gear

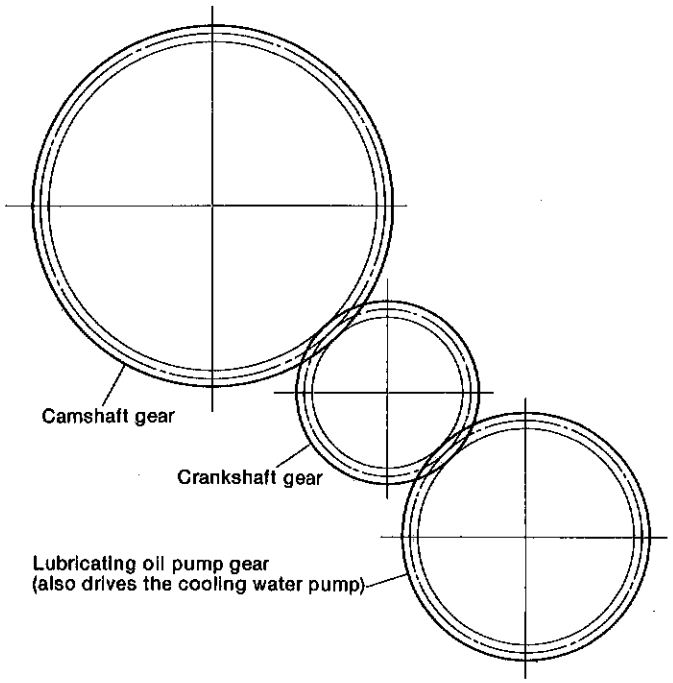
8-1 Timing gear train construction

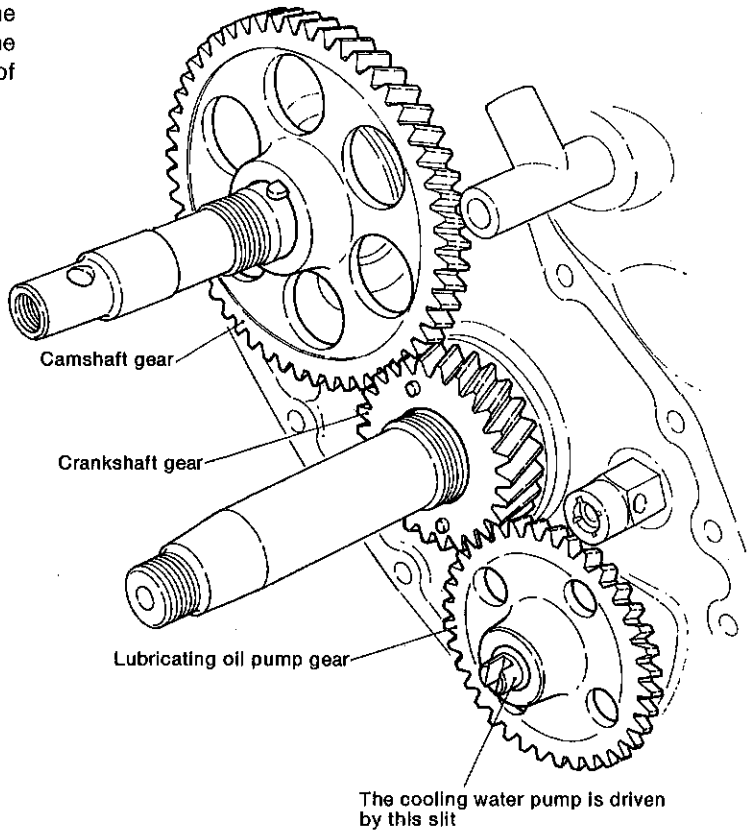
The camshaft, which is the basic component of the valve opening and closing mechanism, and the fuel cam, which determines the fuel injection timing, are driven by the timing gear.
The timing gear consists of the crankshaft gear and the camshaft gear.

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 1GM10(C)

The timing gear of model 1GM10(C) 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.





1GM10(C)

	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	$66^{+0.046}_{0}$mm (2.5984 ~ 2.6002in.)
Lubricating oil pump gear	2.0	Full depth	36	

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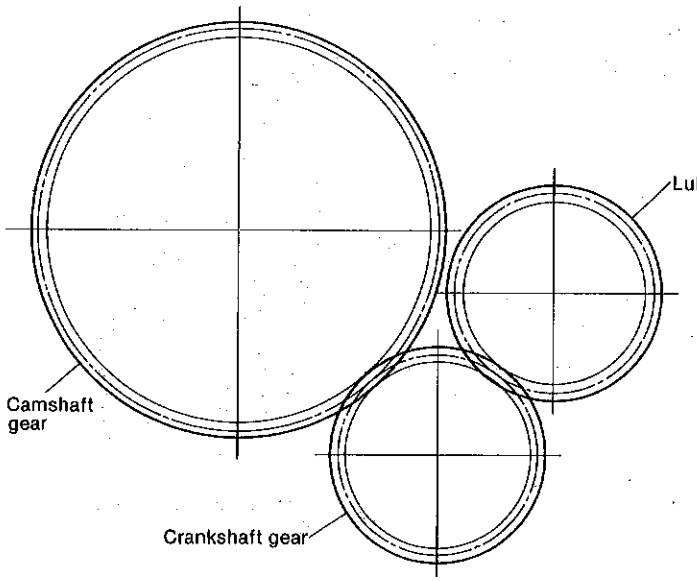
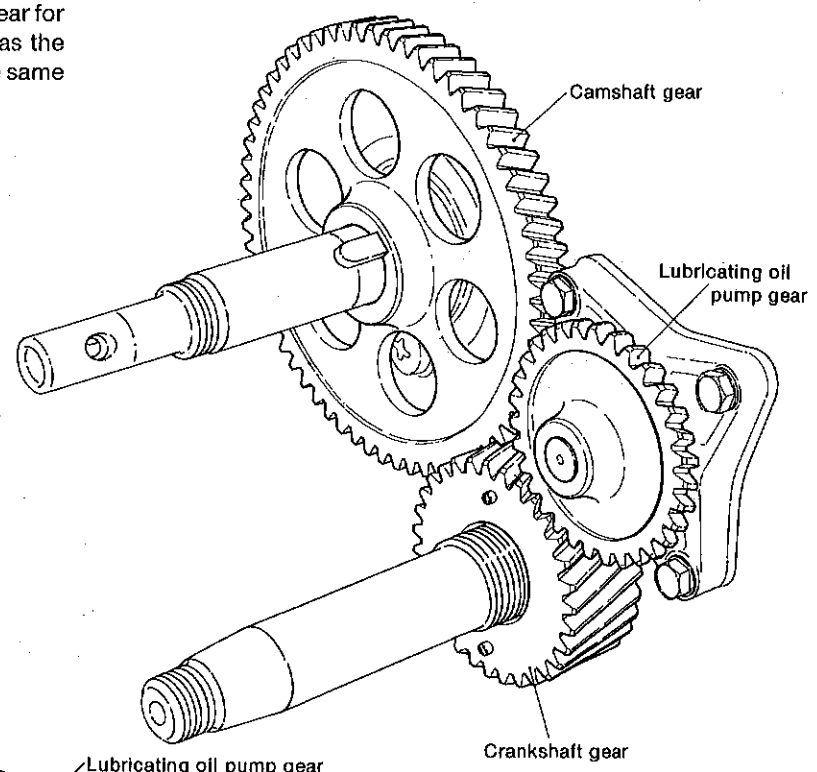
8-1.2 Timing gear of models 2GM20(F)(C), 3GM30(F)(C) and 3HM 35(F)(C)

The same crankshaft gear and camshaft gears are used for these three models. Only on the lubricating oil pump gear for model 3HM35(F)(C) 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 1GM10(C).





2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)

	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	

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8-2 Disassembly and reassembly of the timing gear

8-2.1 Disassembly

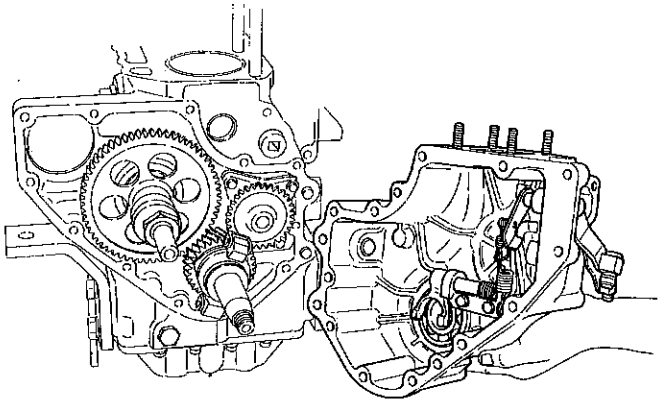
(1) Remove the alternator.
(2) Remove the rubber hose by loosening the hose clip on the cooling water pump.

NOTE: For models 2GM20(F)(C), 3GM30(F)(C) and 3HM35 (F)(C), the cooling water pump does not need to be removed. Model 1GM10(C) 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.

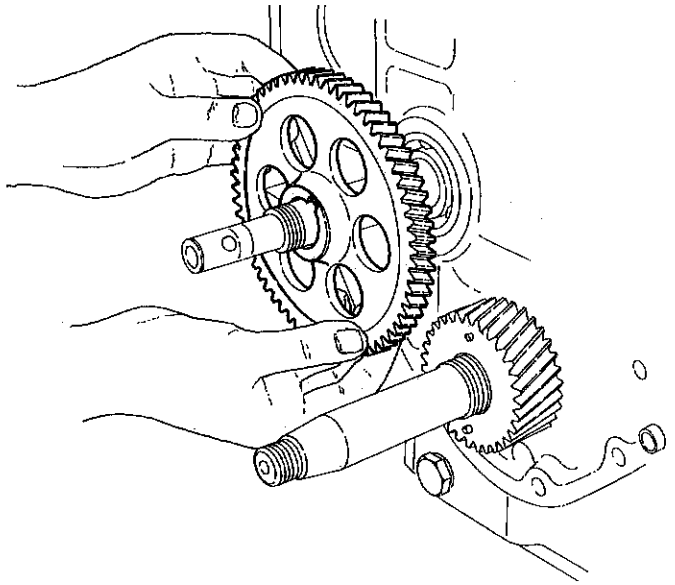
(3) Remove the crankshaft V-pulley.
(4) Remove the fuel injection pump

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.



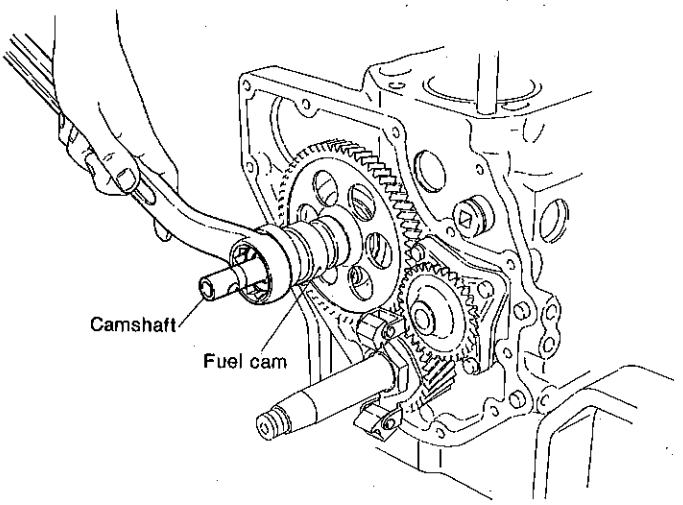
(7) Remove the governor sleeve and needle bearing collar.
(8) Loosen the hexagonal nut, and remove the governor weight support.
(9) Remove the camshaft nut, and take out the fuel cam.
(10) Remove the camshaft gear, crankshaft gear and lubricating oil pump.



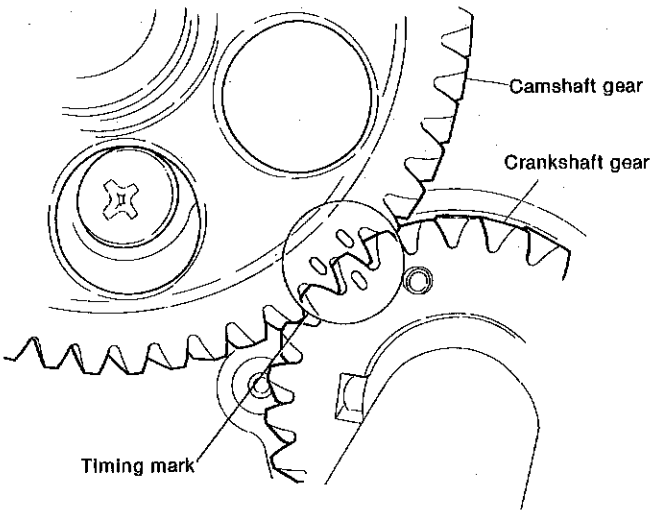
8-2.2 Disassembly and reassembly precautions

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 2-57)
(3) Tightening torque of nut



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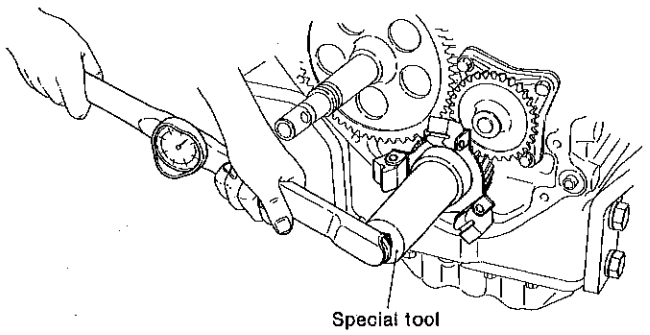
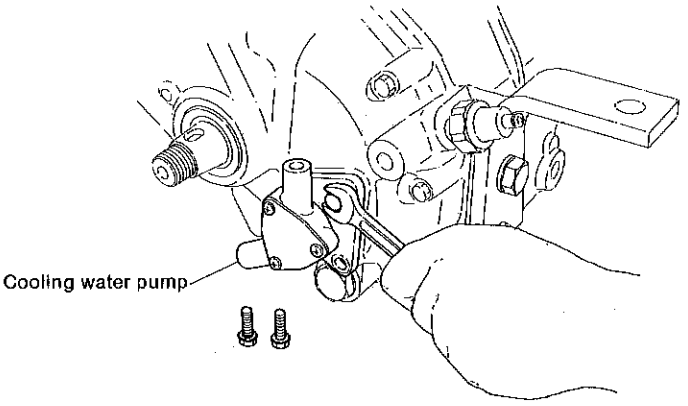
kg-m (ft-lb)

	All models
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.



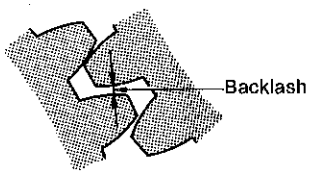
(4) assembling model 1GM10(C) cooling water pump
When model 1GM10(C) cooling water pump is assembled, ensure that the pump shaft engages with the slit of the rotor shaft end of the lubricating oil pump and with the bearing. Check by rotating the crankshaft.



8-3 Inspection

8-3.1 Backlash

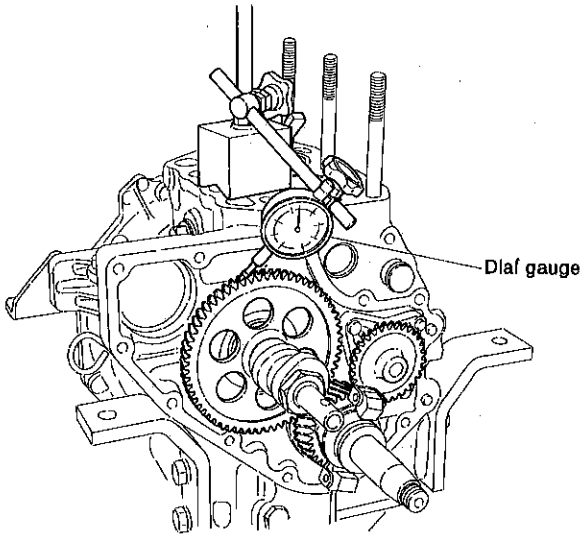
Unsuitable backlash will cause excessive wear or damage at the tooth top and abnormal noise during operation. Moreover, in extreme cases, the valve and fuel injection timing will deviate and the engine will not run smoothly.
When the backlash exceeds the wear limit, repair or relace the gears as a set.



mm (in.)

	1GM10(C)		2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)	
	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.



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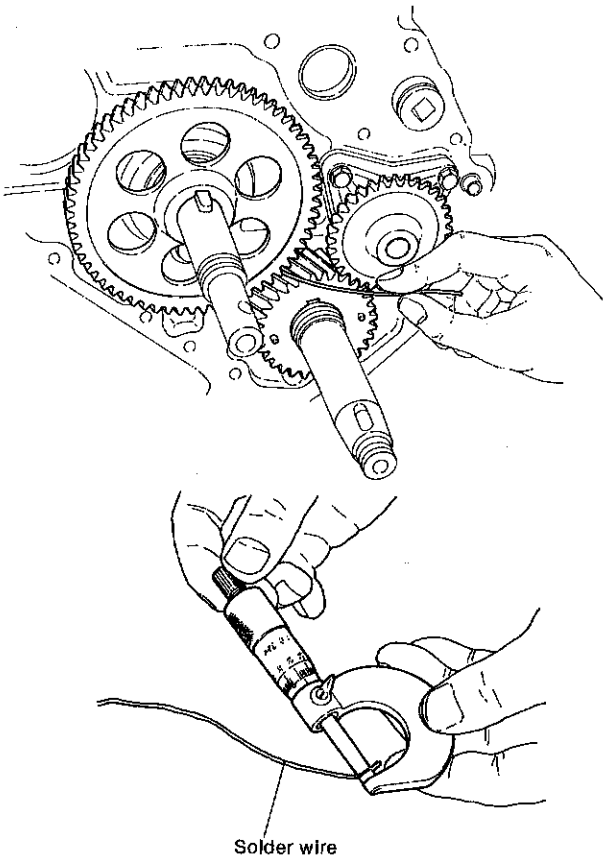
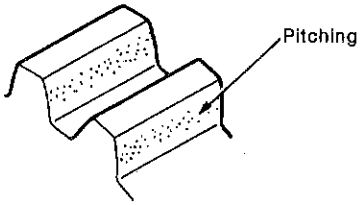
(2) Insert a piece of quality solder between the gears to be measured and turn the gears. The backlash can be measured by measuring the thickness of the crushed part of the solder.



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.

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