YANMAR

0000 A0A1361

SERVICE MANUAL

MARINE DIESEL ENGINE

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

2002.4

YANMAR
SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

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

Publication No.	0000A0A1361

History of Revision

Manual Name	Service Manual for Marine Diesel Engine
Engine Model:	1GM10(C), 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)

Number of revision	Date of revision	Reason for correction	Outline of correction	Correction item No (page)	Corrected by
1st	Apr., 2002	For EPA/ARB certified engine (GM series)	• ARB(EPA) certified tamper resistance to prevent illegal change of injection volume and high idling speed added. • EPA/ARB certified engine identification and summery of the exhaust gas regulations. • Safe servicing information added. • Engine specifications chaged. • Miscellaneous Engine name corrected History of Revision added contents page added and changed.	Pages: 4-9, 4-11 Pages: -ii-, -iii-, -iv- Pages: 0-4～0-8 Pages: 1-1, 1-2, 1-3 Page:10-29 Page: -i-	Quality Assurance Dept.

FOREWORD

This service manual has been compiled for engineers engaged in sales, service, inspection and maintenance. Accordingly, descriptions of the construction and functions of the engine are emphasized in this manual while items which should already be common knowledge are omitted.

One characteristic of a marine diesel engine is that its performance in a vessel is governed by its applicability to the vessel's hull construction and its steering system.

Engine installation, fitting out and propeller selection have a substantial effect on the performance of the engine and the vessel. Moreover, when the engine runs unevenly or when trouble occurs, it is essential to check a wide range of operating conditions—such as installation on the hull and suitability of the ship's piping and propeller—and not just the engine itself. To get maximum performance from this engine, you should completely understand its functions, construction and capabilities, as well as proper use and servicing.

Use this manual as a handy reference in daily inspection and maintenance, and as a text for engineering guidance.

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Models **1GM10(C)**
2GM20(F)(C)
3GM30(F)(C)
3HM35(F)(C)

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The EPA (U.S. Federal) and Air Resources Board (ARB, California) Off-road Compression Ignition engines regulations

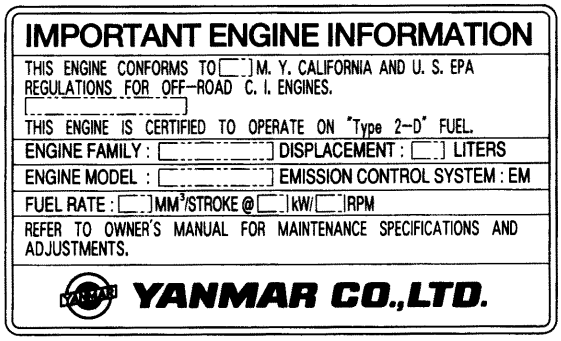
The engines for EPA regulations will be used in the States, and the engines for ARB regulations will only be used in the State of California.

The information on engines to comply with the EPA and ARB Regulations is released and you are kindly requested to make every effort to comply with them. Yanmar Engines of all "GM" series engine models are covered with these regulations.

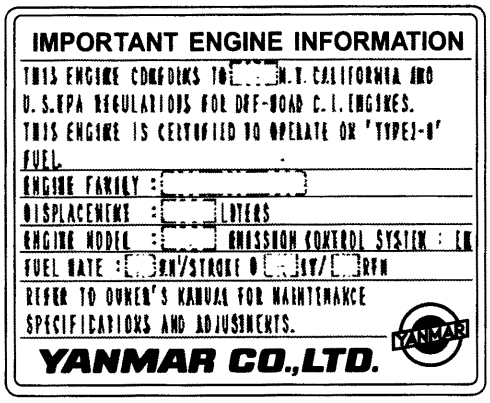
1. Engine identification

With the regulations on engine emission worldwide, it has become necessary to identify engines in a manner to determine which regulations they comply with, hence.

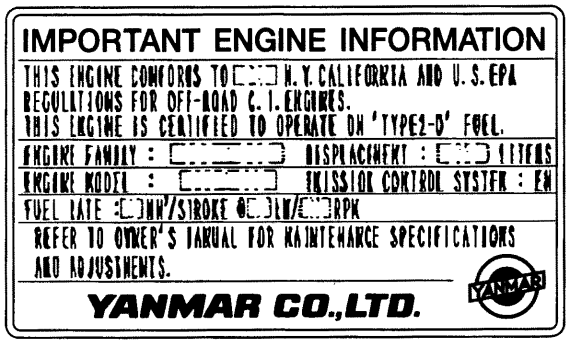
a) Emission control label as shown below which will contain:



1GM10 series
(EPA & ARB label)



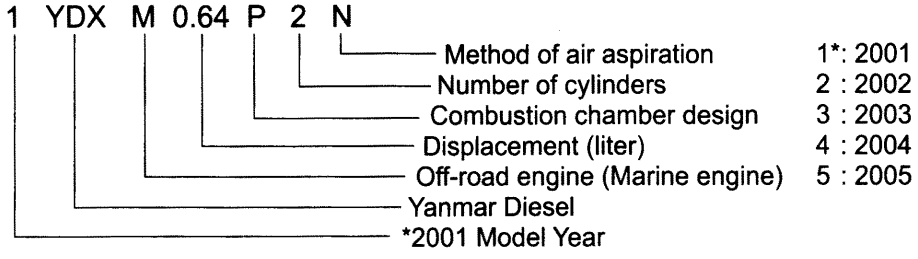
2GM20 series
(EPA & ARB label)



3GM30 series
(EPA & ARB label)

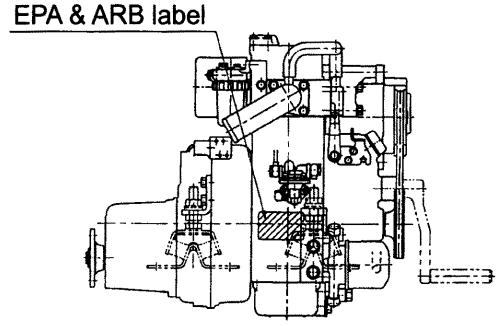
*Emission Control is accomplished through Engine Modification (EM-Design)

- Engine family name as assigned by EPA and ARB identifying engine family group 1YDXM0.64P2N and this identifies

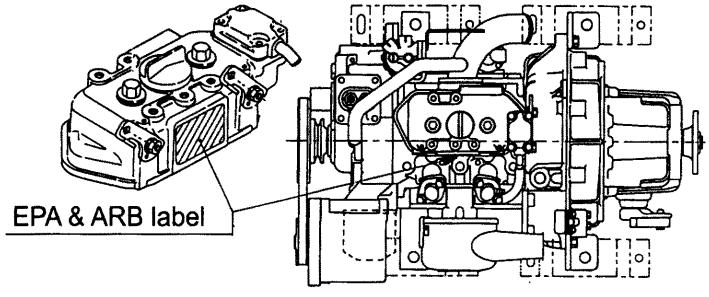


b) Label location:

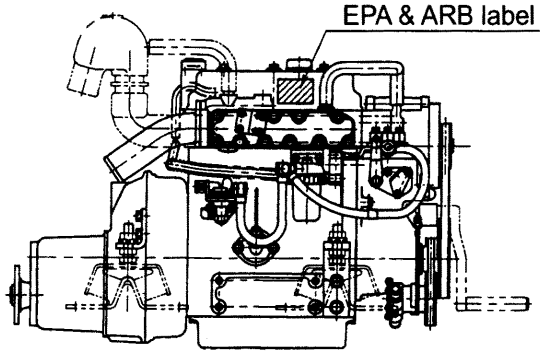
***1GM10 series:** attached on the exhaust side of the cylinder block.



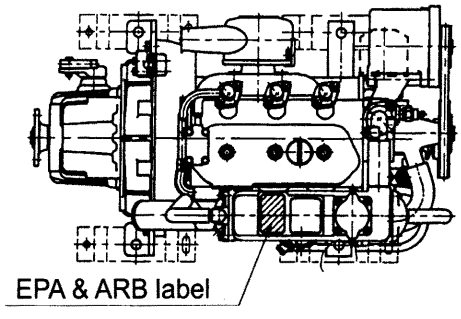
***2GM20(C)(V), 2GM20F(C)(V) series:**
attached to the intake air silencer side of the rocker arm cover.



***3GM30(C)(V):** attached to the exhaust side of the rocker arm cover.



***3GM30F(C)(V):** attached to the top of the fresh water cooler.



2. Exhaust Gas Regulations

The engines conform to the EPA exhaust gas regulations (under 8 kW, 8kW and 19kW under, 19kW and under 37 kW for each) for a low emission engine.

The ARB standard is the same as the EPA's

Test cycle: ISO 8178-4 E3 mode

Power Range kW (Gross power)	Standard (g/kWh)(Tier 1)			Smoke (US Opacity %) transient mode
	NOx + NMHC	CO	PM	
Range < 8	10.5	8.0	1.0	Not applicable
8 ≦ Range < 19	9.5	6.6	0.80	
19 ≦ Range < 37	9.5	5.5	0.80	

3. Guarantee Conditions for Emission Standard

The following guarantee conditions are set down in the operation manual. In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

- **Requirement on engine installation condition**

(1) Air intake depression

kPa (mmH_2O)

Permissible
≦ -0.49 (-50)

(2) Exhaust gas back pressure

kPa (mmH_2O)

Permissible
≦ 6.86 (700)

- **Fuel oil and lubricating oil**

(1) Fuel: The diesel fuel oil [ISO 8217 DMA, BS 2869 A1 or A2 (Cetane No.45 min.)]
(2) Lube oil: API grade, class CD

- **Do not remove the seals restricting injection quantity and high idling engine speed.**
- **Perform maintenance without fail.**

Note: Inspections to be carried out by the user and by the maker are divided and set down in the "List of Periodic Inspections" on the operation manual and should be checked carefully.

EPA allows to apply Maintenance schedule for Emission related parts as follows.

—	Check Fuel Injection Nozzle and clean	Adjust, cleaning and repair of Fuel Injection Pump, Fuel Valve Nozzle and Turbocharger
kW ≦ 130	1500 hours of use and at 1500-hour intervals thereafter	3000 hours of use and at 3000-hour intervals thereafter

- **Quality guarantee period for exhaust emission related parts**

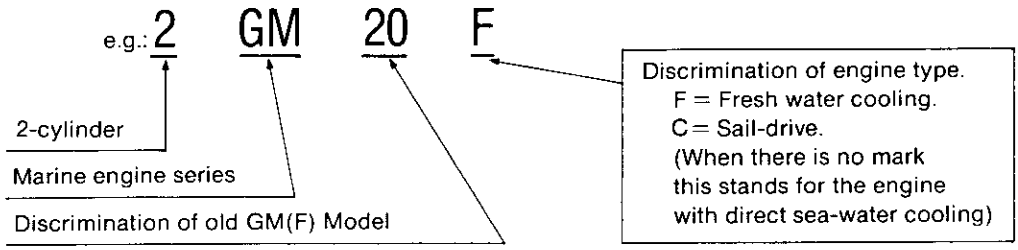
For exhaust emission related parts, follow the inspections outlined in the "List of Periodic Inspections", on the operation manual, and use the table below to carry out inspections based on operation hours or time in years. Whichever comes first is the guarantee period.

Range < 19	1500 hours or 2 years
19 ≦ Range < 37	3000 hours or 5 years

The specific emissions-related parts are (1) Fuel injection nozzle (2) Fuel injection pump
(3) Turbocharger. (if installed)

A. Engine Model Name

The nomenclature of the New GM(F)/HM(F) series follows the order shown below.



B. Engine Model Name Plate and Clutch Model Name Plate

To every engine model described in this manual, an engine model name plate and clutch model name plate are fitted as shown in the following figures. In addition, the engine serial number is stamped on the cylinder body.
Specifications of the engine and clutch to be shipped are recorded and filed using the numbers marked on the engine model name plate and clutch model name plate.

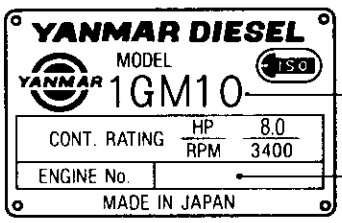
The specifications or components of the engine or clutch may have been partially altered to improve performance, and the components involved may not necessarily be interchangeable.
Therefore, when parts are ordered, please furnish the item description in the blank spaces shown in the figures, using the descriptions given on these plates.

B-1 Item descriptions on the model name plates and information to be forwarded to us

[Item descriptions on Model name plates]

[Information to be forwarded to us]

Engine model name plate

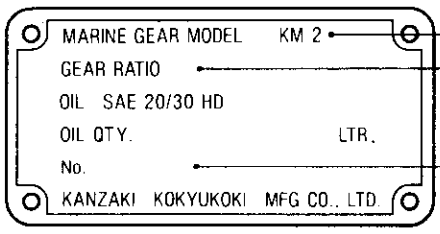


Your engine model

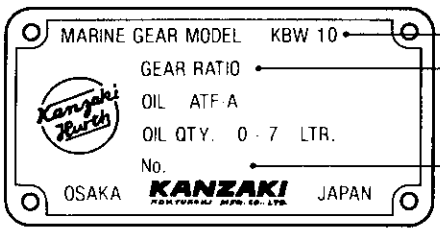
Your engine number

Clutch model name plate

GM-series



HM-series



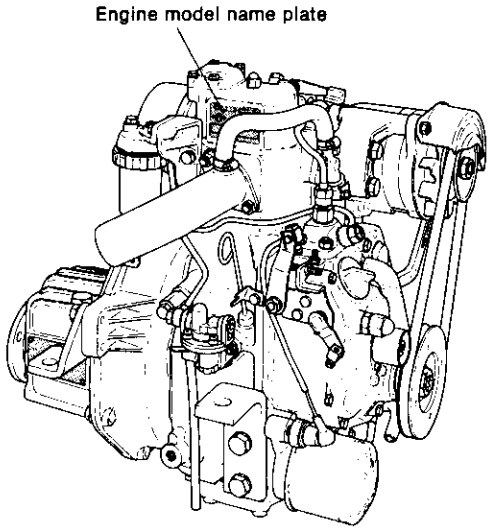
Your clutch model

Your clutch gear ratio

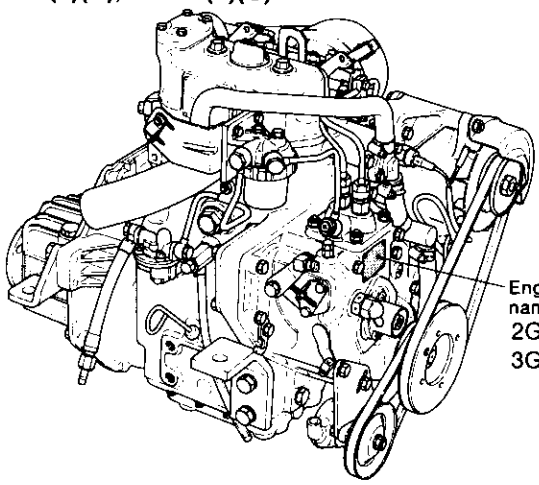
Your clutch number

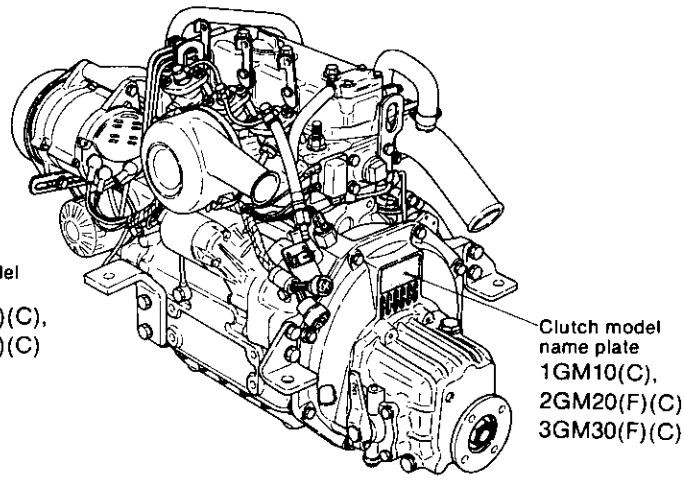
B-2 Location of engine model name plate and clutch model name plate

B-2.1 1GM10(C)

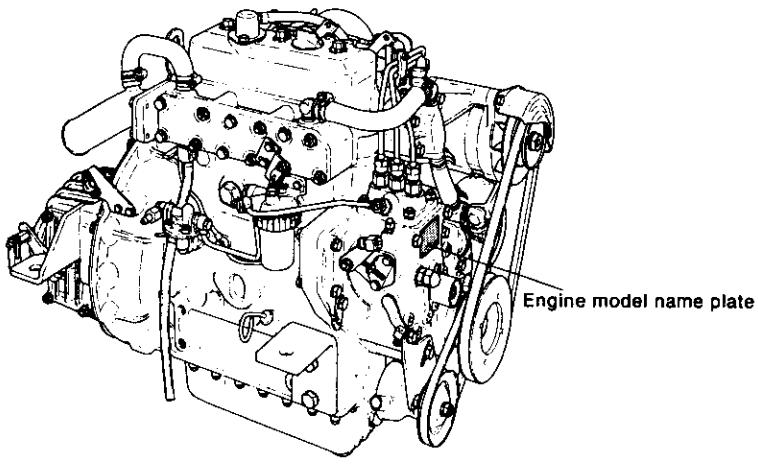


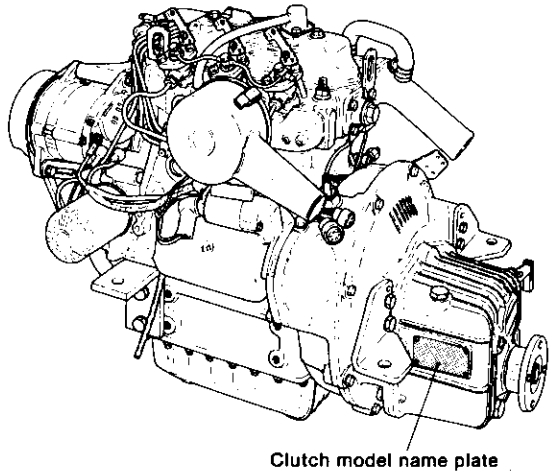
B-2.2 2GM20(F)(C), 3GM30(F)(C)





B-2.3 3HM35(F)(C)





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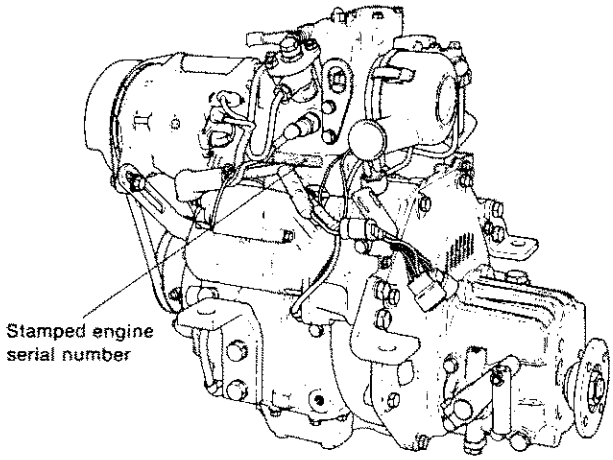
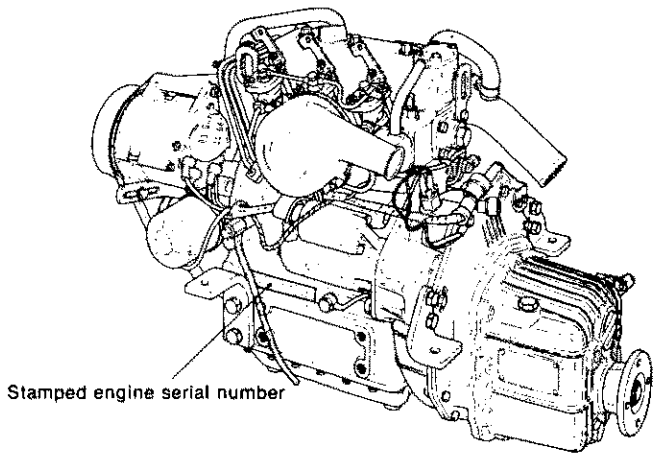
B-3 Location of stamped engine serial number

B-3.1 1GM10(C)

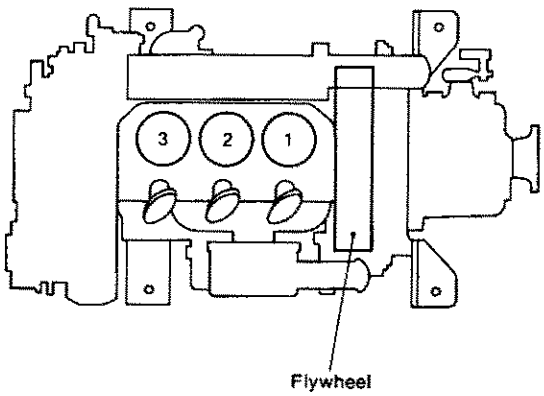


B-3.2 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)



C. Cylinder Number

The cylinder numbers of the 2 cylinder engine and 3 cylinder engine described in this manual are designated as follows.



(1) The sequence of cylinder numbers is given as No. 1, No. 2 and No. 3 starting from the flywheel side.
(2) These cylinder numbers are consistently used for devices and parts connected with the cylinder head and valve moving mechanism. However, please note that items related to the fuel injection pump do not correspond to the numbering of the cylinders.

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CHAPTER 0

FOR SAFETY

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1. For Safe Servicing

- Most accidents are caused by failing to observe basic safety rules and precautions. To prevent accidents, it is important to recognize the signs of approaching problems, and eliminate the problems in the early stage before they can cause accidents.
  Please read this manual carefully before starting repairs or maintenance to fully understand safety precautions and appropriate inspection and maintenance procedures. Attempting a repair or maintenance job without sufficient knowledge may cause an unexpected accident.

- It is impossible to cover every possible danger in repair or maintenance in the manual.
  Sufficient consideration for safety is required. Especially for safety precautions in a repair or maintenance job not described in this manual, receive instructions from a knowledgeable leader.

- Safety marks used in this manual and their meanings are as follows:

⚠DANGER	**DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.**
⚠WARNING	**WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.**
⚠CAUTION	**CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.**

- Any matter marked NOTE in this manual is especially important in servicing. If not observed, the product performance and quality may not be guaranteed.

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2. Precaution for Safe Servicing

(A) Service Shop (Place)

⚠WARNING

● Place allowing sufficient ventilation

Jobs such as engine running, part welding and polishing the paint with sandpaper shoule be done in a well-ventilated place.

[Failure to Observe]

Very dangerous for human body due to the possibility of poisonous gas or dust inhalation.

⚠CAUTION

● Sufficiently wide and flat place

The floor space of the service shop for inspection and maintenance should be sufficiently wide and flat without any holes.

[Failure to Observe]

An accident such as a violent fall may be caused.

⚠CAUTION

● Clean, orderly arranged place

No dust, mud, oil or parts should be left on the floor surface.

[Failure to Observe]

An unexpected accident may be caused.

⚠CAUTION

● Bright, safety illuminated place

The working place should be illuminated sufficiently and safely.

For a job in a dark place where it is difficult to see, use a portable safety lamp.

The bulb should be covered with a wire cage for protection.

[Failure to Observe]

The bulb may be broken accidentally causing ignition of leaking oil.

⚠CAUTION

● Place equipped with a fire extinguisher

Keep a first aid kit and fire extinguisher close at hand in preparation for fire emergencies.

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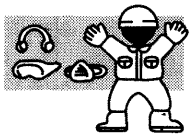
(B) Working Wear

⚠CAUTION



● Wears for safe operation

Wear a helmet, working clothes, safety shoes and other safety protectors suited to the job. It is especially important to wear well-fitting work clothes.

[Failure to Observe]

A serious accident such as trapping by a machine may occur.

(C) Tools to be Used

⚠WARNING

● Appropriate holding and lifting

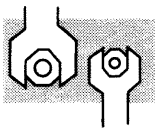
Never operate when engine is supported with blocks or wooden pieces or only with a jack.

To lift and hold the engine, always use a crane with a sufficient allowance in limit load or a rigid jack.

[Failure to Observe]

A serious accident may occur.

⚠WARNING



● Use of appropriate tools

Use tools appropriate for the jobs to be done. Use a correctly sized tool for loosening or tightening a machine part.

[Failure to Observe]

A serious injury or engine damage may occur.

(D) Use of Genuine Parts, Oil and Grease

⚠CAUTION

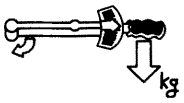
● Always use genuine parts.

[Failure to Observe]

Shortening of engine life or an unex pected accicdent may arise.

(E) Bolt and Nut Tightening Torque

⚠WARNING



● Always tighten to the specified torque if designated in the manual.

[Failure to Observe]

Loosening or falling may cause parts damage or injury.

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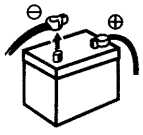
(F) Electrical Parts

⚠WARNING

● Harness short-circuit



Disconnect the battery negative ⊖ terminal before starting the service job.

[Failure to Observe]

Short-circuiting of a harness may occur to start a fire.

⚠WARNING

● Battery charging

Since flammable gas is generated during battery charging, keep anything which could cause a fire away from the battery.

[Failure to Observe]

Explosions may occur.

⚠WARNING

● Battery electrolyte

Since the electrolyte is diluted sulfuric acid, do not let it be splashed onto the clothes or skin.

[Failure to Observe]

The clothes or skin may be burnt.

(G) Waste Treatmente

⚠CAUTION

Observe the following instructions with regard to waste disposal. Negligence of each instruction will cause environmental pollution.

- Waste fluids such as engine oil and cooling water shall be discharged into a container without spillage onto the ground.
- Do not let waste fluids be discharged into the sewerage, a river or the sea.
- Harmful wastes such as oil, fuel, solvents, filter elements and battery shall be treated according to the respective laws and regulations.
  ask a qualified collecting company for example.

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(H) Handling the Product

⚠WARNING

● Supplying the Fuel

When supplying the fuel, always keep any fire source like a cigarette or match away.

[Failure to Observe]

A fire or explosion may arise.

⚠WARNING

● Pay attention to hot portions.

Do not touch the engine during running or immediately after it is stopped.

[Failure to Observe]

Scalding may be caused by a high temperature.

⚠WARNING

● Pay attention to the rotating part.

Never bring clothes or a too close to the rotating part during engine running.

[Failure to Observe]

Injury may be caused by entrapping.

⚠CAUTION

● Safety Label Check

Pay attention to the product safety label.

A safety label (caution plate) is affixed on the product for calling special attention to safety.

If it is missing or illegible, always affix a new one.

California

Proposition 65 Warning

Diesel engine exhaust and some of its constitutions are known to the State of California to cause cancer, birth defects, and other reproductive harm.

California

Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm.

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CHAPTER 1
GENERAL

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1. Specifications

1-1 Direct Sea Water Cooling Type

Model			1GM10	2GM20	3GM30	3HM35
Type			Vertical 4-cycle water cooled diesel engine			
Combustion chamber			Swirl pre-combustion chamber			
Number of cylinders			1	2	3	3
Bore × stroke		mm	75×72			80×85
Displacement		L	0.318	0.636	0.954	1.282
Continuous rating output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	5.9(8.0)/3400	11.8(16.0)/3600	17.7(24.1)/3400	22.1(30)/3200
	Brake mean effective pressure	MPa(kgf/cm^2)	0.65(6.66)			0.65(6.58)
	Piston speed	m/sec.	8.16			9.07
Max. output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	※6.7(9.1)/3600 ※※6.55(8.9)/3600	※13.4(18.2)/3600 ※※13.1(17.8)/3600	※20.1(27.3)/3600 ※※19.6(26.7)/3600	25.0(34)/3400
	Brake mean effective pressure	MPa(kgf/cm^2)	0.70(7.15) Fuel oil temp. 25℃(fuel injection pump inlet)			0.69(7.02)
	Piston speed	m/sec.	8.64			9.63
Idling speed	High	min^{-1}	3825±25			3600±25
	Low		850±25			850±25
Compression ratio			23.0			24.8
Fuel injection timing (FID)		degree	b.TDC15±1	b.TDC15±1	b.TDC18±1	b.TDC21±1
Fuel injection pressure		MPa(kgf/cm^2)	16.67±0.49(170±5)			15.69±0.49(160±5)
Main power take off			at Flywheel side			
Front power take off			at Crankshaft V-pulley side			
Direction of rotation	Crankshaft		Counter-clockwise viewed from stern			
	Propeller shaft (Ahead)		Clockwise viewed from stern			
Cooling system			Direct sea water cooling (rubber impeller water pump)			
Lubrication system			Complete enclosed forced lubrication			
Starting system			Electric and manual			Electric
Clutch	Model		KM2P		KM2P	KM3P	KBW10E	
	Type		Mechanical cone clutch with single stage for both ahead and astern				Wet multi-disc mechanical type	
	Reduction ratio (Ahead/Astern)		2.21/3.06	2.62/3.06	–	2.21/3.06	2.62/3.06	3.22/3.06	2.21/3.06	2.62/3.06	3.20/3.16	2.14/2.50	2.83/2.50
	Propeller speed at cont. rating (Ahead/Astern)	min^{-1}	1540/1113	1298/1113	–	1540/1113	1298/1113	1055/1113	1540/1113	1298/1113	1063/1076	1498/1280	1129/1280
	Lubricating oil capacity	L	0.3						0.3		0.35	0.7	
	Clutch mass	kg	9.8			10.3			10.3		11.5	17.5	
Dimensions	Overall length	mm	554			654			730		740	786	
	Overall width	mm	410			455			455		455	485	
	Overall height	mm	485			495			495		495	617	
Lubricating oil capacity (rake angle 8°)	Total	L	1.5			2.0			2.6		2.6	5.4	
	Effective	L	0.8			1.3			1.6		1.6	2.7	
Engine mass with clutch (dry)		kg	81			106			129		130	158	

(Note) 1. Rating condition: ISO 3046-1, 8665 2. IPS : 0.7355kW
3. Fuel condition: Dencity at 15℃=0.860, Fuel oil temp.
※: 25℃ at the fuel injection pump inlet, ※※: 40℃ at the fuel injection pump inlet.

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1-2 Fresh Water Cooling Type

Model			2GM20F	3GM30F	3HM35F
Type			Vertical 4-cycle water cooled diesel engine		
Combustion chamber			Swirl pre-combustion chamber		
Number of cylinders			2		3
Bore × stroke		mm	75×72		80×85
Displacement		L	0.636	0.954	1.282
Continuous rating output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	11.8(16.0)/3400	17.7(24.1)/3400	22.1(30)/3200
	Brake mean effective pressure	MPa(kgf/cm^2)	0.65(6.66)		0.65(6.58)
	Piston speed	m/sec.	8.16		9.07
Max. output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	※13.4(18.2)/3600	※20.1(27.3)/3600	25.0(34)/3400
			※※13.1(17.8)/3600	※※19.6(26.7)/3600	
	Brake mean effective pressure	MPa(kgf/cm^2)	0.70(7.15) Fuel oil temp. 25℃(fuel injection pump inlet)		0.69(7.02)
	Piston speed	m/sec.	8.64		9.63
Idling speed	High	min^{-1}	3825±25		3600±25
	Low		850±25		850±25
Compression ratio			23.0		24.8
Fuel injection timing (FID)		degree	b.TDC15±1	b.TDC18±1	b.TDC21±1
Fuel injection pressure		MPa(kgf/cm^2)	16.67±0.49(170±5)		15.09±0.49(160±5)
Main power take off			at Flywheel side		
Front power take off			at Crankshaft V-pulley side		
Direction of rotation	Crankshaft		Counter-clockwise viewed from stern		
	Propeller shaft (Ahead)		Clockwise viewed from stern		
Cooling system			Fresh water cooling with heat exchanger		
Lubrication system			Complete enclosed forced lubrication		
Starting system			Electric		

Model			KM2P			KM2P		KM3P	KBW10E	
Type			Mechanical cone clutch with single stage for both ahead and astern						Wet multi-disc mechanical type	
Clutch	Reduction ratio (Ahead/A'stern)		2.21/3.06	2.62/3.06	–	2.21/3.06	2.62/3.06	3.20/3.16	2.14/2.50	2.83/2.50
	Propeller speed DIN. A rating (Ahead/Astern)	min^{-1}	1540/1113	1298/1113	–	1540/1113	1298/1113	1063/1076	1498/1280	1129/1280
	Lubricating oil capacity	L	0.3					0.35	0.7	
	Clutch mass	kg	10.3			10.3		11.5	17.5	
Dimensions	Overall length	mm	650			735		745	791	
	Overall width	mm	482			455		455	475	
	Overall height	mm	545					545	638	
Fresh cooling water capa.		L	2.9			3.4			4.9	
Lubricating oil capacity (rake angle 8°)	Total	L	2.0			2.6			5.4	
	Effective	L	1.3			1.6			2.7	
Engine mass with clutch (dry)		kg	114			137		138	167	

(Note) 1. Rating condition: ISO 3046-1, 8665 2. IPS : 0.7355kW
3. Fuel condition: Dencity at 15℃=0.860, Fuel oil temp.
※: 25℃ at the fuel injection pump inlet, ※※: 40℃ at the fuel injection pump inlet.

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1-3 For Sail-drive

Model			1GM10C	2GM20(F)C	3GM30(F)C	3HM35(F)C
Type			Vertical 4-cycle water cooled diesel engine			
Combustion chamber			Swirl pre-combustion chamber			
Number of cylinders			1	2	3	
Bore × stroke		mm	75×72			80×85
Displacement		L	0.318	0.636	0.954	1.282
Continuous rating output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	5.9(8.0)/3400	11.8(16.0)/3400	17.7(24.1)/3400	22.1(30)/3200
	Brake mean effective pressure	MPa(kgf/cm^2)	0.65(6.66)			0.65(6.58)
	Piston speed	m/sec.	8.16			9.07
Max. output (Flywheel output)	Output/Crankshaft speed	kW(PS)/min^{-1}	※6.7(9.1)/3600	※13.4(18.2)/3600	※20.1(27.3)/3600	25.0(34)/3400
			※※6.55(8.9)/3600	※※13.1(17.8)/3600	※※19.6(26.7)/3600	
	Brake mean effective pressure	MPa(kgf/cm^2)	0.70(7.15) Fuel oil temp. 25℃(fuel injection pump 0.69 inlet)			(7.02)
	Piston speed	m/sec.	8.64			9.63
Idling speed	High	min^{-1}	3825±25			3600±25
	Low		850±25			850±25
Compression ratio			23.0			24.8
Fuel injection timing (FID)		degree	b.TDC15±1	b.TDC15±1	b.TDC18±1	b.TDC21±1
Fuel injection pressure		MPa(kgf/cm^2)	16.67±0.49(170±5)			15.69±0.49(160±5)
Main power take off			at Flywheel side			
Front power take off			at Crankshaft V-pulley side			
Direction of rotation	Crankshaft		Counter-clockwise viewed from stern			
	Propeller shaft (Sail-drive)		Counter-clockwise viewed from stern			
Cooling system			Direct sea water cooling (rubber impeller water pump), (F): Fresh water cooling with heat exchanger			
Lubrication system			Complete enclosed forced lubrication			
Starting system			Electric and manual			Electric
Sail-drive	Model		SD20			SD30
	Reduction system		Constant mesh gear with dog clutch			
	Reduction ratio (Ahead/A stern)		2.64/2.64			
	Propeller speed at cont. rating	min^{-1}	1289			1212
	Lubricating oil capacity	L	2.2			
	Dry mass	kg	30			32
Lubricating oil capacity (Engine side)	Total	L	1.5	2.0	2.6(158.65)	5.4
	Effective	L	0.8	1.3	1.6(97.63)	2.7
Engine mass with Sail-drive unit (Dry)		kg	104	134, 142(F)	153, 161(F)	180, 189(F)

(Note) 1. Rating condition: ISO 3046-1, 8665 2. IPS : 0.7355kW
3. Fuel condition: Dencity at 15℃=0.860, Fuel oil temp.
※: 25℃ at the fuel injection pump inlet, ※※: 40℃ at the fuel injection pump inlet.

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2. Principal Construction

Engine model		1GM10	2GM20	3GM30	3HM35
Group	Part	Construction			
Engine block	Cylinder block	Integrally-cast water jacket and crankcase			
	Cylinder liner	Sleeveless			
	Main bearing	Metal housing type			
	Oil sump	Oil pan			
Intake and exhaust systems and valve mechanism	Cylinder head	Integrated type cylinders			
	Intake and exhaust valves	Poppet type, seat angle 90°			
	Exhaust manifold	—		Water-cooled type	Water-cooled type
	Exhaust silencer	Water-cooled mixing elbow type			
	Valve mechanism	Overhead valve push rod, rocker arm system			
	Intake silencer	Round polyurethane sound absorbing type			
Main moving elements	Crankshaft	Stamped forging			
	Flywheel	Attached to crankshaft by flange, with ring gear			
	Piston	Oval type			
	Piston pin	Floating type			
	Piston rings	2 compression rings, 1 oil ring			
Lubrication system	Oil pump	Trochoid pump			
	Oil filter	Full-flow cartridge type, paper element			
	Oil level gauge	Dipstick			
Cooling system	Water pump	Rubber impeller type			
	Thermostat	Wax pellet type			
Fuel system	Fuel injection pump	YPFR-0707-1	YPFR-0707-2	YPFR-0707-3	
	Fuel injection valve	Throttle valve, OSDYD1			
	Fuel feed pump	Mechanical type			
	Fuel strainer	Filter paper			
Governor	Governor	Centrifugal all-speed mechanical type			
Starting system	Electric	Pinion ring gear type starter motor			
	Manual	Camshaft starting			—
Electrical system	Charger	Alternator (with built-in IC regulator)			
Reduction reversing	Reduction gear	Helical gear constant-mesh system			
Clutch system	Clutch	Servo-cone type			Wet multi-disc mechanical type

Fresh-water cooling system (2GM20F, 3GM30F and 3HM35F)

Cooling system	Sea water pump	Rubber impeller type
	Fresh water pump	Centrifugal type
	Thermostat	Wax pellet type
	Heat exchanger	Multi-tube type

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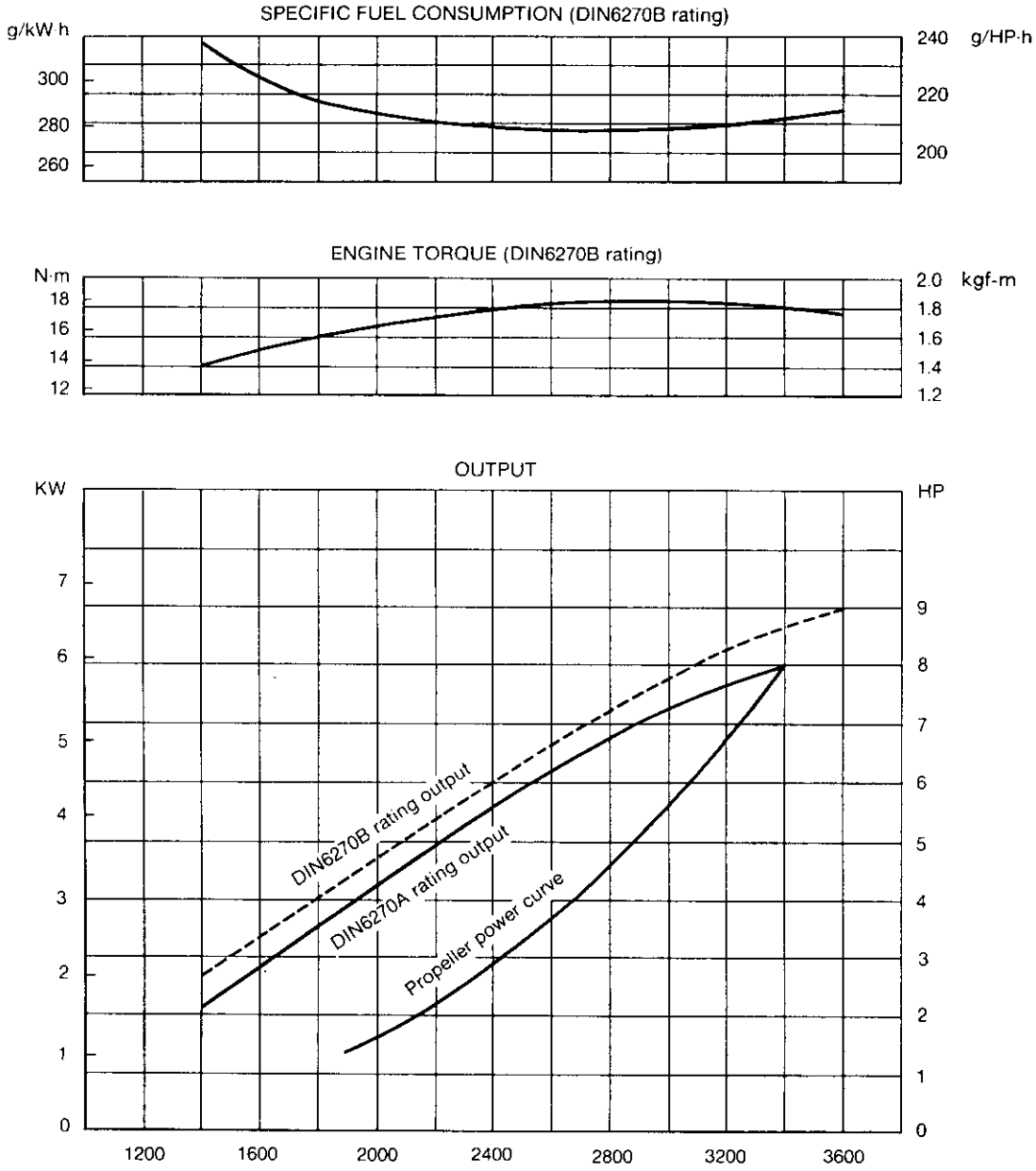
3. Performance Curves

3-1. 1GM10(C)



SPEED OF CRANKSHAFT: rpm
THE ENGINE FLYWHEEL OUTPUT IS APPROX 3% HIGHER.

NOTE: These curves show the average performance of respective engine in test operation at our plant.

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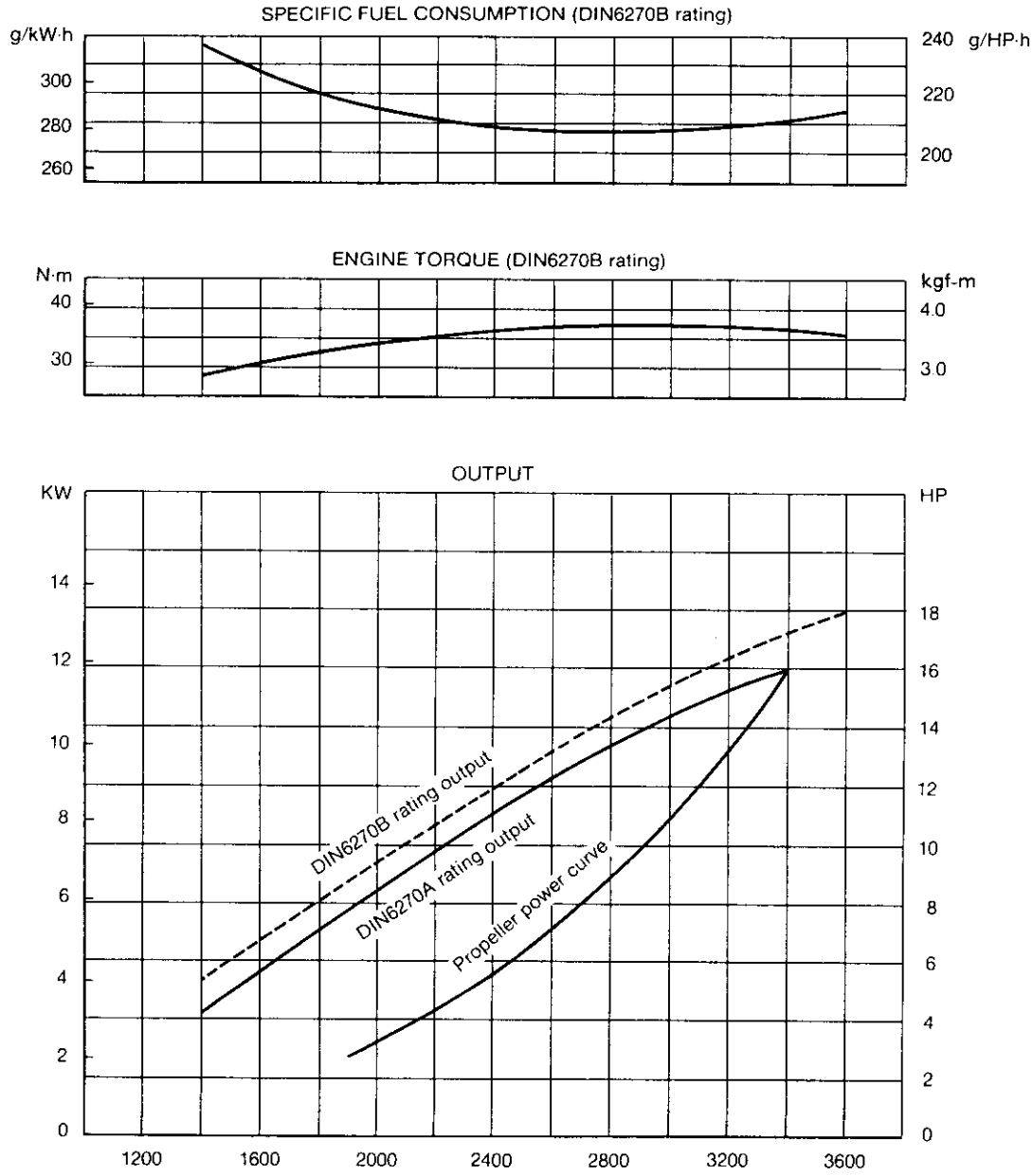
3-2 2GM20(F)(C)



SPEED OF CRANKSHAFT: rpm
THE ENGINE FLYWHEEL OUTPUT IS APPROX 3% HIGHER.

NOTE: These curves show the average performance of respective engine in test operation at our plant.

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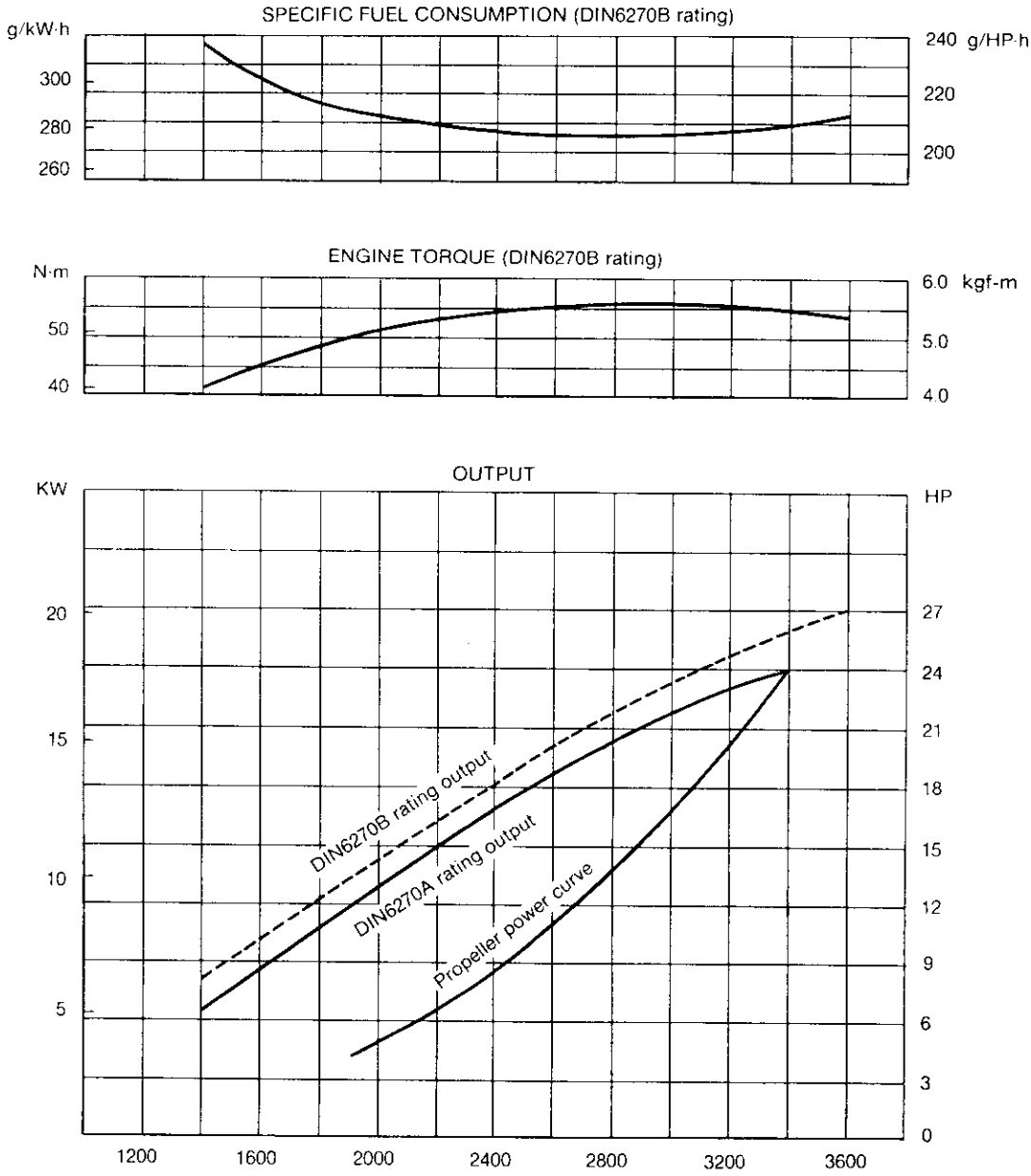
3-3 3GM30(F)(C)



SPEED OF CRANKSHAFT: rpm
THE ENGINE FLYWHEEL OUTPUT IS APPROX 3% HIGHER.

NOTE: These curves show the average performance of respective engine in test operation at our plant.

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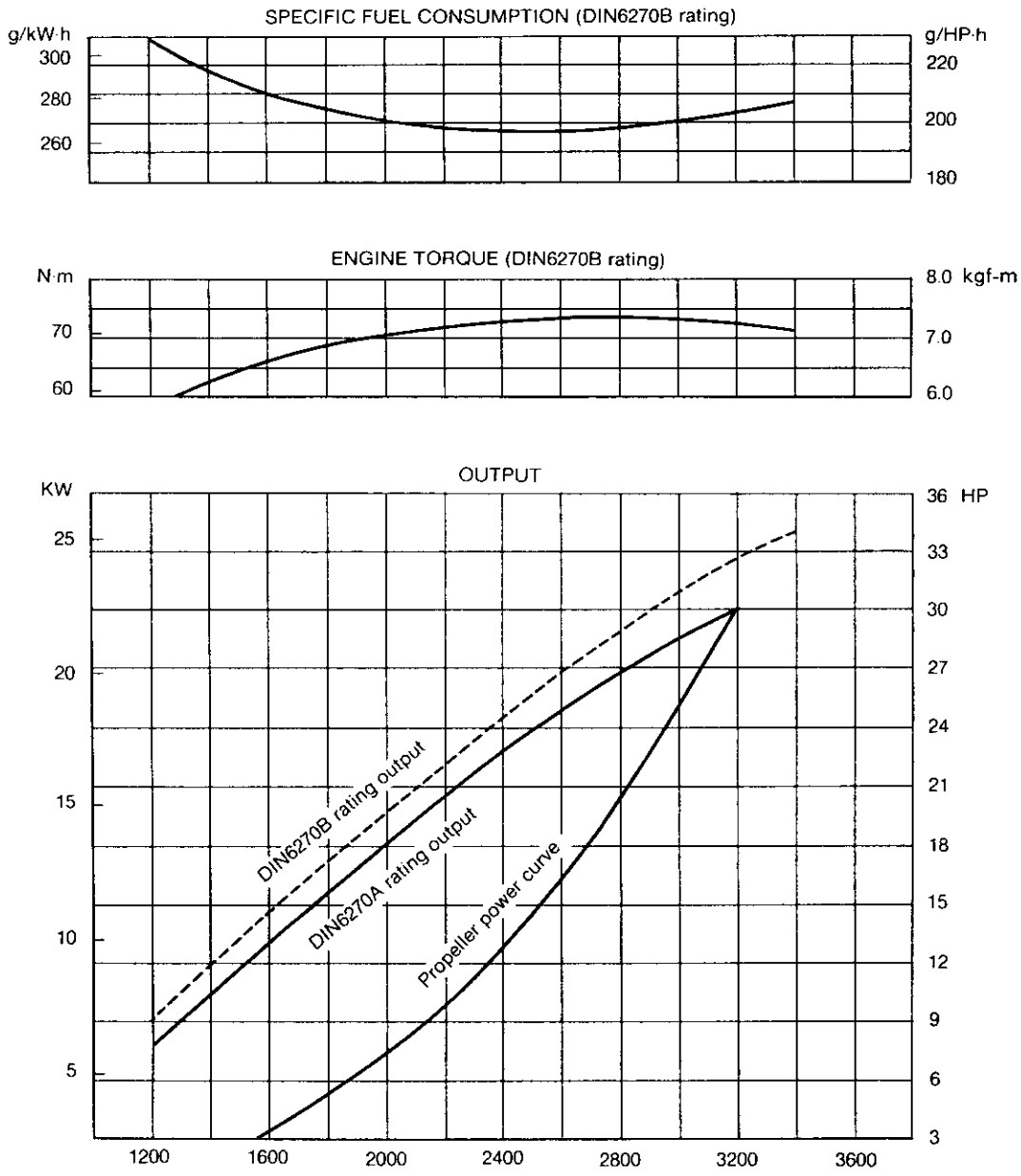
3-4 3HM35(F)(C)



SPEED OF CRANK SHAFT: rpm

THE ENGINE FLYWHEEL OUTPUT IS APPROX 3% HIGHER

NOTE: These curves show the average performance of respective engine in test operation at our plant.

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4. Features

4-1 Superior combustion performance

The unique Yanmar swirl precombustion chamber and new cooling system display superior combustion performance in all types of operation. Low-speed, low-load combustion performance, especially demanded for marine applications, is also superb, and stable performance is maintained over a wide range of speeds. Since starting characteristics are also excellent and warm-up is fast, full engine performance can be obtained within a short time.

4-2 Low operating costs

Excellent combustion and low friction reduce fuel costs, while the optimized piston shape ring configuration and improved cooling system reduce oil consumption. continuous operating time has been extended and operating costs reduced through improved durability.

4-3 Compact, lightweight

The cylinder head is the integrally-cast type, and the crankshaft is the housing type. Minimum weight has been pursued for each engine part, and a reduction reversing gear employing a special new mechanism has been incorporated to obtain revolutionary engine lightness.

4-4 Long term continuous operation

Improved durability has been achieved by adopting special construction and materials for main moving parts and the valve mechanism, which are the areas most subject to trouble in high-speed engines. Moreover, a bypass system with a thermostat maintains the cooling water at a stable high temperature, resulting in reduced cylinder liner and piston ring wear, reduced thermal load around the combustion chamber, and substantially improved durability. Long-term continuous operation is possible by correct operation and proper attention to fuel and lubricating oil.

4-5 Low vibration

Vibration has been reduced by minimizing the weights of the pistons, connecting rods, and other sources of vibration, stringent weight management at assembly, and balancing of the flywheel, V-pulley, etc. Vibration has also been suppressed through the adoption of a special cylinder block rib construction and improved rigidity. Rubber shock mounts are available when the engine is to be used under conditions which may lead to severe vibration.

4-6 Quiet operation

Intake and exhaust noises have been lowered by adopting an intake silencer, water-cooled exhaust manifold and water mixing elbow type exhaust system.
The precombustion chamber system and semi-throttle type injection valve suppress combustion noise substantially.
Moreover, gear noise has been reduced by the use of helical gears around the gear train and clutch gear, and by the buffering effect of a damper disc.
In addition, noise prevention measures have also been taken at the control valve mechanism and other parts.

4-7 Superior matching to the hull

(1) Four-point support engine installation feet make installation easy.
(2) Mist intake system prevents contamination of the engine room.
(3) Since the fuel pump is mounted on the engine, the fuel tank can be installed anywhere.
(4) Water-cooled manifold prevents a rise in the engine room temperature.
(5) Independent type instrument panel can be installed wherever it is easiest to see.
(6) Speed, clutch forward and reverse, and engine stop can all be remotely controlled.
(7) The use of rubber and vinyl hoses for ship interior piping not only facilitates piping work, but also eliminates brazing faults caused by vibration.
(8) Electric type bilge pump is available as an option.

4-8 Easy to operate

(1) Cooling water temperature switch and lubricating oil pressure switch are provided, and alarm lamps and buzzer are mounted on the instrument panel.
(2) Manual starting handle permits manual starting.
(Except model 3HM35(C) and fresh water cooling type)
(3) Positive clutch engagement and disengagement; propeller shaft does not rotate when clutch is placed in neutral position.

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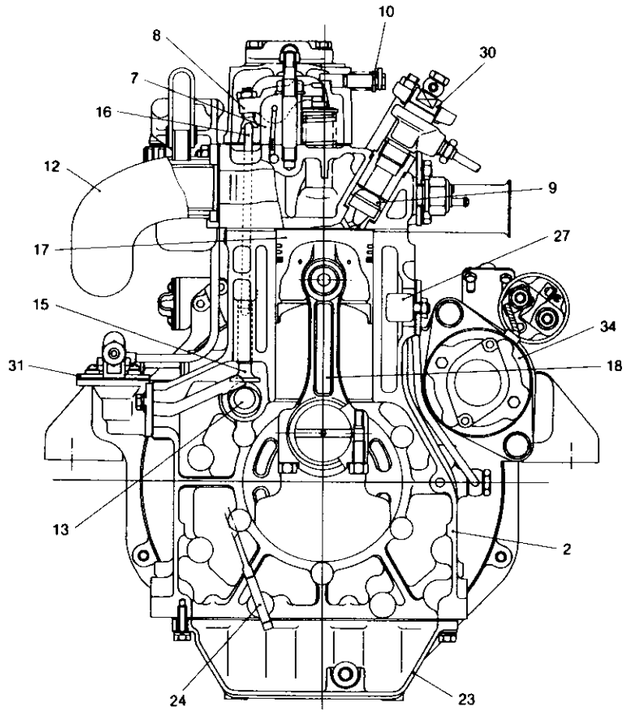
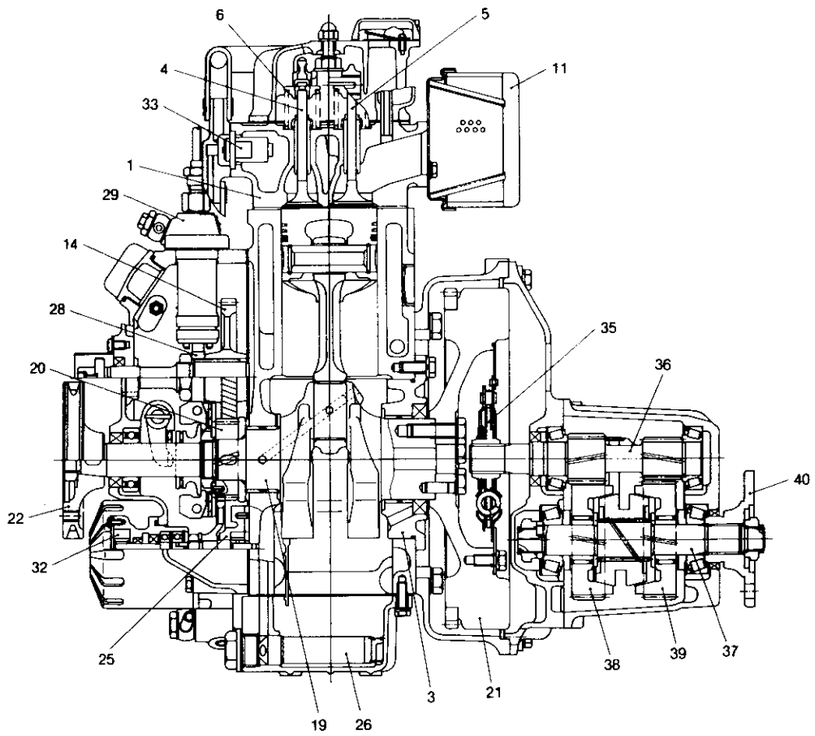
5. Engine Cross-Sections

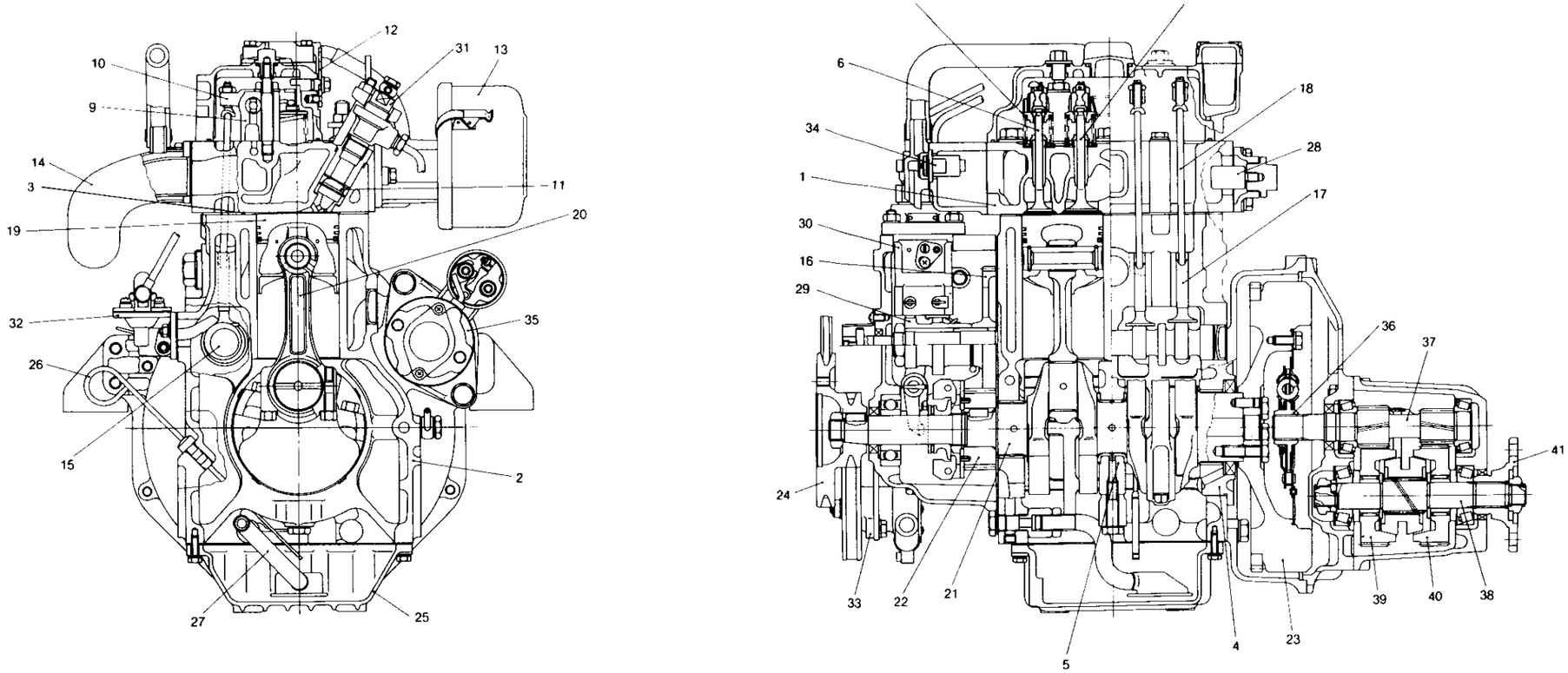
5-1 1GM10





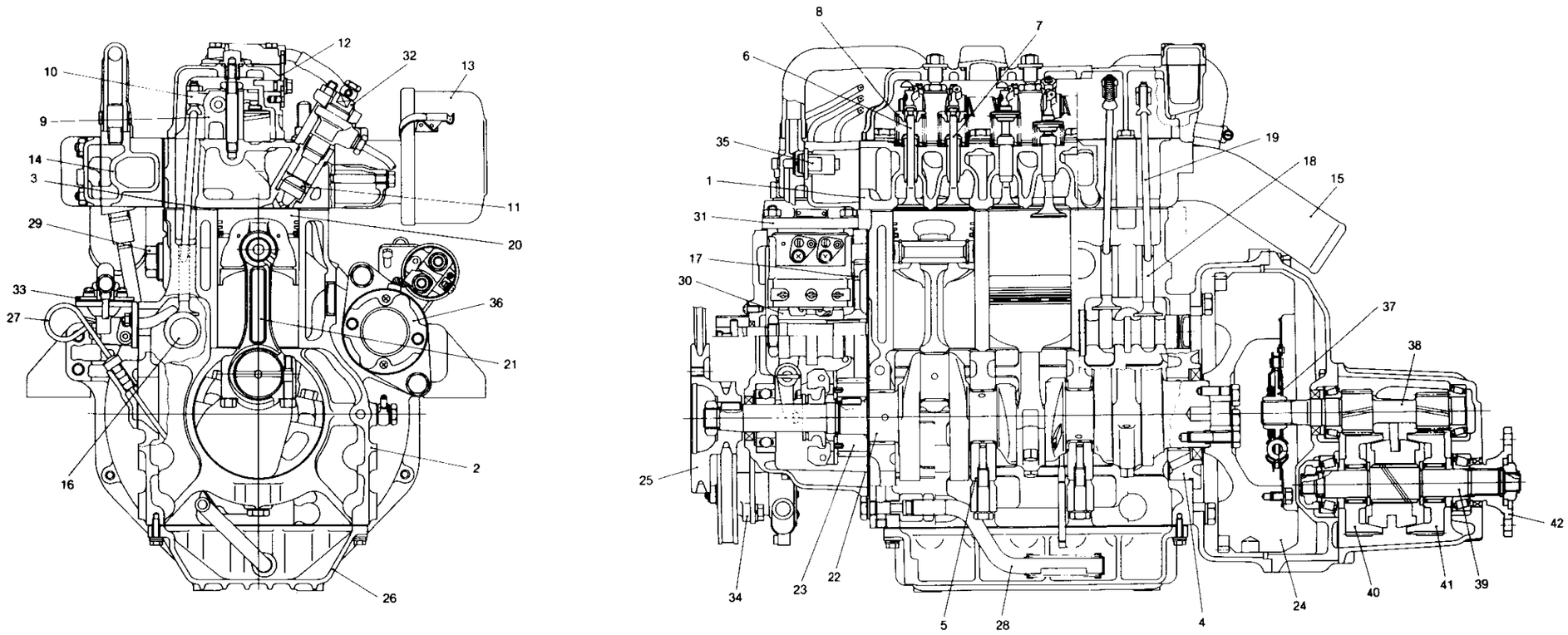
1. Cylinder head
2. Cylinder body
3. Main bearing housing
4. Exhaust valve
5. Intake valve
6. Valve spring
7. Valve rocker arm support
8. Valve rocker arm
9. Precombustion chamber
10. Decompression lever
11. Intake silencer
12. Mixing elbow
13. Camshaft
14. Camshaft gear
15. Tappet
16. Push rod
17. Piston
18. Connecting rod
19. Crankshaft
20. Crankshaft gear
21. Flywheel
22. Crankshaft V-pulley
23. Oil pan
24. Dipstick
25. Lubricating oil pump
26. Lubricating oil inlet pipe
27. Anticorrosion zinc
28. Fuel injection pump cam
29. Fuel injection pump
30. Fuel injection nozzle
31. Fuel feed pump
32. Cooling water pump
33. Thermostat
34. Starter motor
35. Damper disc
36. Input shaft
37. Output shaft
38. Forward large gear
39. Reverse large gear
40. Output shaft coupling

5-2 2GM20



1. Cylinder head
2. Cylinder body
3. Cylinder head gasket
4. Main bearing housing
5. Intermediate main bearing housing
6. Exhaust valve
7. Intake valve
8. Valve spring
9. Valve rocker arm support
10. Valve rocker arm
11. Precombustion chamber
12. Decompression lever
13. Intake silencer
14. Exhaust manifold
15. Camshaft
16. Camshaft gear
17. Tappet
18. Push rod
19. Piston
20. Connecting rod
21. Crankshaft
22. Crankshaft gear
23. Flywheel
24. Crankshaft V-pulley
25. Oil pan
26. Dipstick
27. Lubricating oil inlet pipe
28. Anticorrosion zinc
29. Fuel injection pump cam
30. Fuel injection pump
31. Fuel injection nozzle
32. Fuel feed pump
33. Cooling water pump
34. Thermostat
35. Starter motor
36. Damper disc
37. Input shaft
38. Output shaft
39. Forward large gear
40. Reverse large gear
41. Output shaft coupling

5-3 3GM30



1. Cylinder head
2. Cylinder body
3. Cylinder head gasket
4. Main bearing housing
5. Intermediate main bearing housing
6. Exhaust valve
7. Intake valve
8. Valve spring
9. Valve rocker arm support
10. Valve rocker arm
11. Precombustion chamber
12. Decompression lever
13. Intake silencer
14. Exhaust manifold
15. Mixing elbow
16. Camshaft
17. Camshaft gear
18. Tappet
19. Push rod
20. Piston
21. Connecting rod
22. Crankshaft
23. Crankshaft gear
24. Flywheel
25. Crankshaft V-pulley
26. Oil pan
27. Dipstick
28. Lubricating oil inlet pipe
29. Anticorrosion zinc
30. Fuel injection pump cam
31. Fuel injection pump
32. Fuel injection nozzle
33. Fuel feed pump
34. Cooling water pump
35. Thermostat
36. Starter motor
37. Damper disc
38. Input shaft
39. Output shaft
40. Forward large gear
41. Reverse large gear
42. Output shaft coupling

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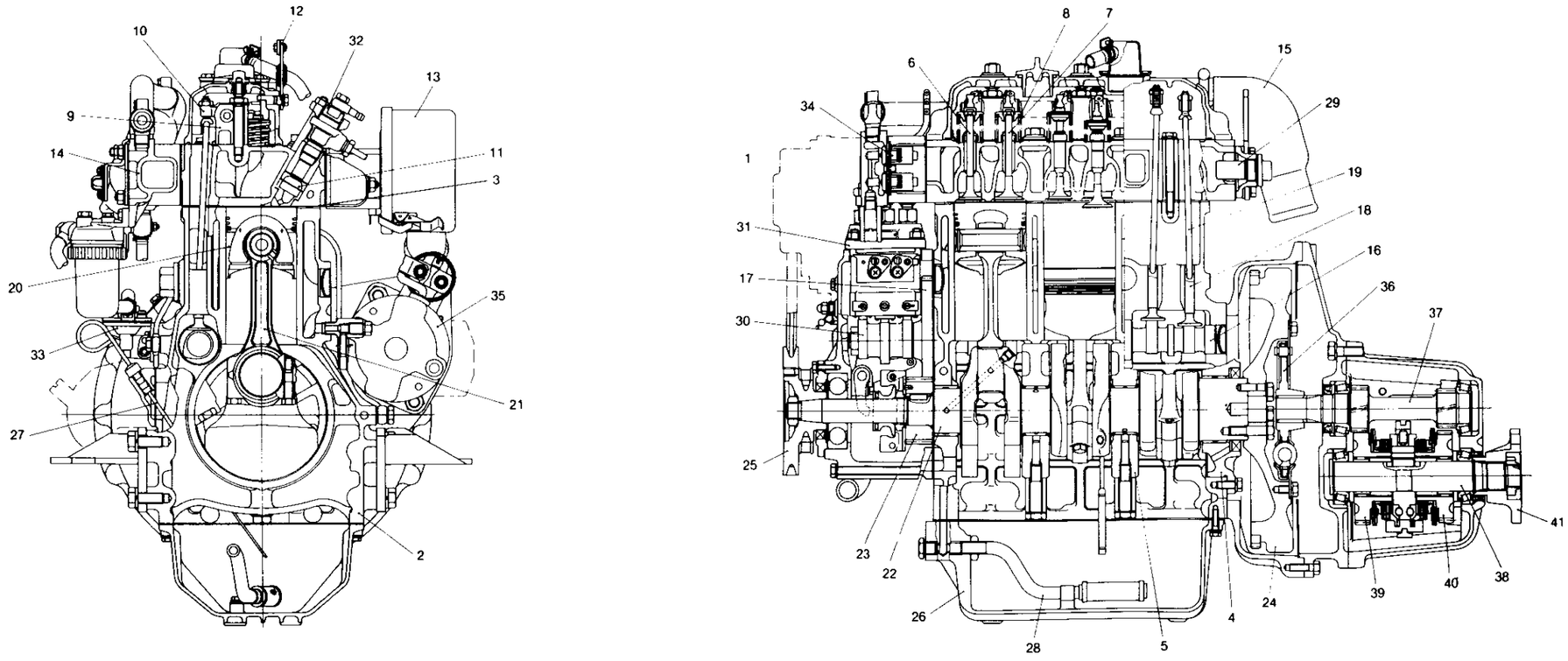
5-4 3HM35



1. Cylinder head
2. Cylinder body
3. Cylinder head gasket
4. Main bearing housing
5. Intermediate main bearing housing
6. Exhaust valve
7. Intake valve
8. Valve spring
9. Valve rocker arm support
10. Valve rocker arm
11. Precombustion chamber
12. Decompression lever
13. Intake silencer
14. Exhaust manifold
15. Mixing elbow
16. Camshaft
17. Camshaft gear
18. Tappet
19. Push rod
20. Piston
21. Connecting rod
22. Crankshaft
23. Crankshaft gear
24. Flywheel
25. Crankshaft V-pulley
26. Oil pan
27. Dipstick
28. Lubricating oil inlet pipe
29. Anticorrosion zinc
30. Fuel injection pump cam
31. Fuel injection pump
32. Fuel injection nozzle
33. Fuel feed pump
34. Thermostat
35. Starter motor
36. Damper disc
37. Input shaft
38. Output shaft
39. Forward large gear
40. Reverse large gear
41. Output shaft coupling

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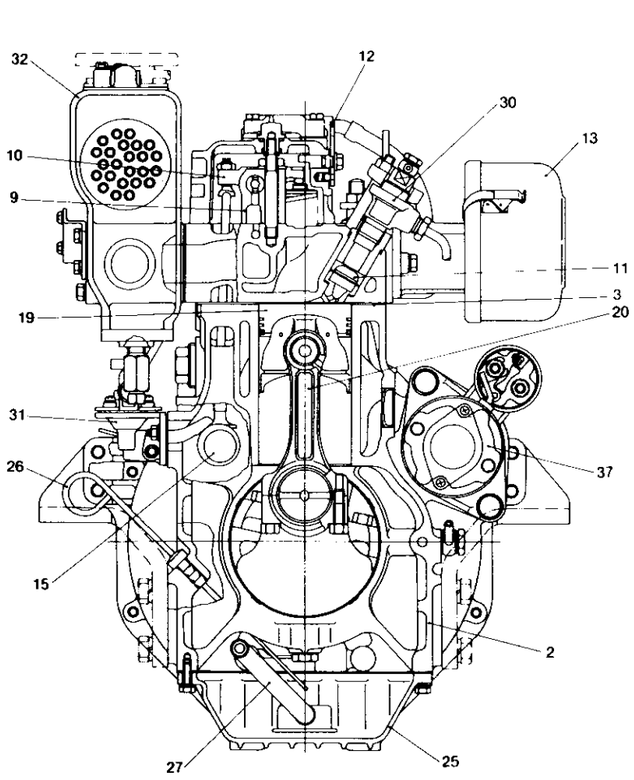
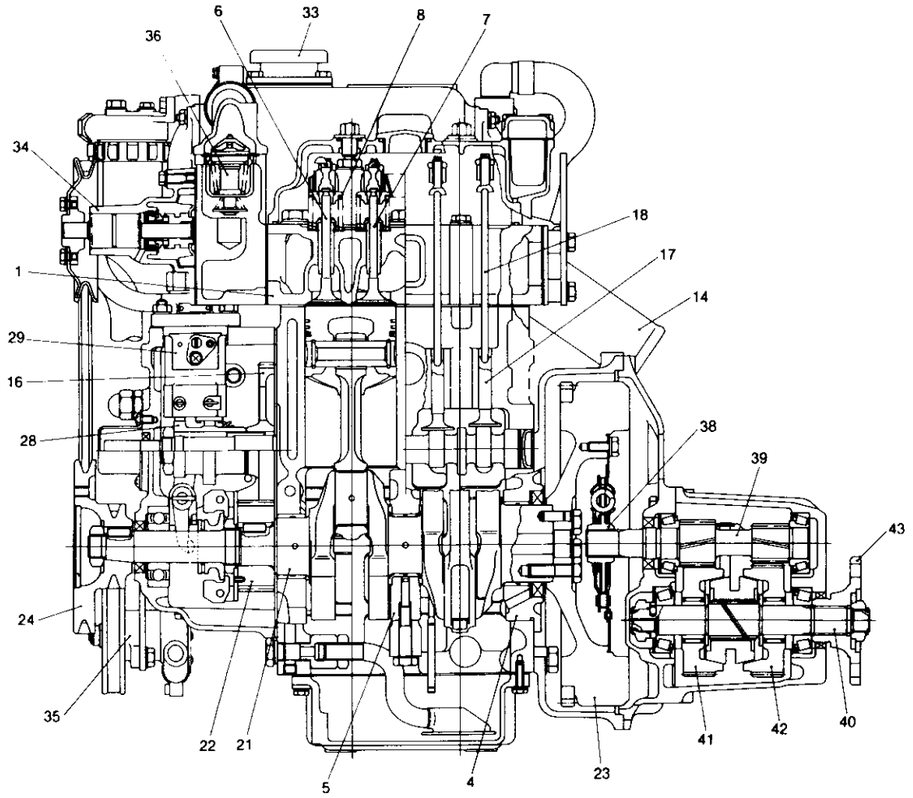
5-5 2GM20F





1. Cylinder head
2. Cylinder body
3. Cylinder head gasket
4. Main bearing housing
5. Intermediate main bearing housing
6. Exhaust valve
7. Intake valve
8. Valve spring
9. Valve rocker arm support
10. Valve rocker arm
11. Precombustion chamber
12. Decompression lever
13. Intake silencer
14. Mixing elbow
15. Camshaft
16. Camshaft gear
17. Tappet
18. Push rod
19. Piston
20. Connecting rod
21. Crankshaft
22. Crankshaft gear
23. Flywheel
24. Crankshaft V-pulley
25. Oil pan
26. Dipstick
27. Lubricating oil inlet pipe
28. Fuel injection pump cam
29. Fuel injection pump
30. Fuel injection nozzle
31. Fuel feed pump
32. Heat exchanger & exhaust manifold
33. Pressure control valve
34. Cooling fresh water pump
35. Cooling sea water pump
36. Thermostat
37. Starter motor
38. Damper disc
39. Input shaft
40. Output shaft
41. Forward large gear
42. Reverse large gear
43. Output shaft coupling

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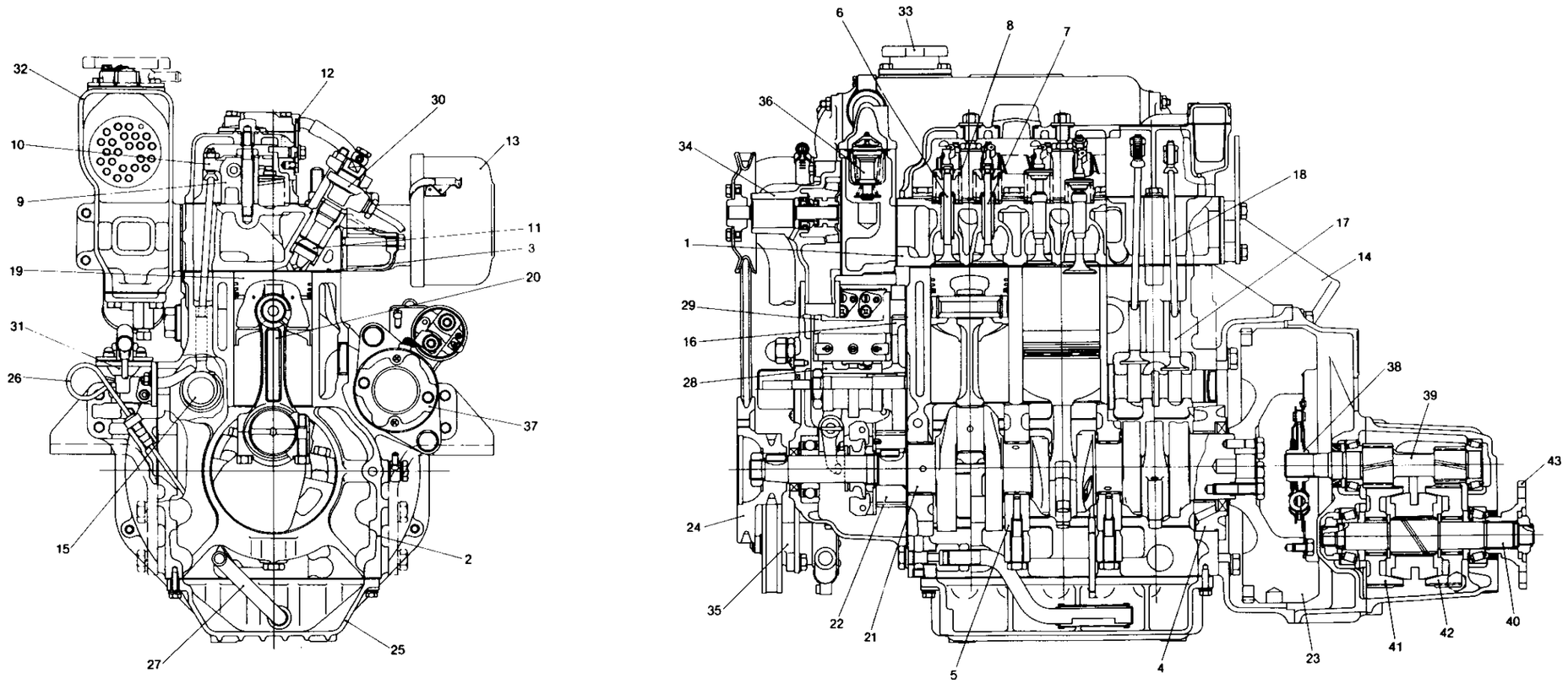
5-6 3GM30F



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6. Exhaust valve
7. Intake valve
8. Valve spring
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10. Valve rocker arm
11. Precombustion chamber
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13. Intake silencer
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16. Camshaft gear
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18. Push rod
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21. Crankshaft
22. Crankshaft gear
23. Flywheel
24. Crankshaft V-pulley
25. Oil pan
26. Dipstick
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29. Fuel injection pump
30. Fuel injection nozzle
31. Fuel feed pump
32. Heat exchanger & exhaust manifold
33. Pressure control valve
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35. Cooling sea water pump
36. Thermostat
37. Starter motor
38. Damper disc
39. Input shaft
40. Output shaft
41. Forward large gear
42. Reverse large gear
43. Output shaft coupling

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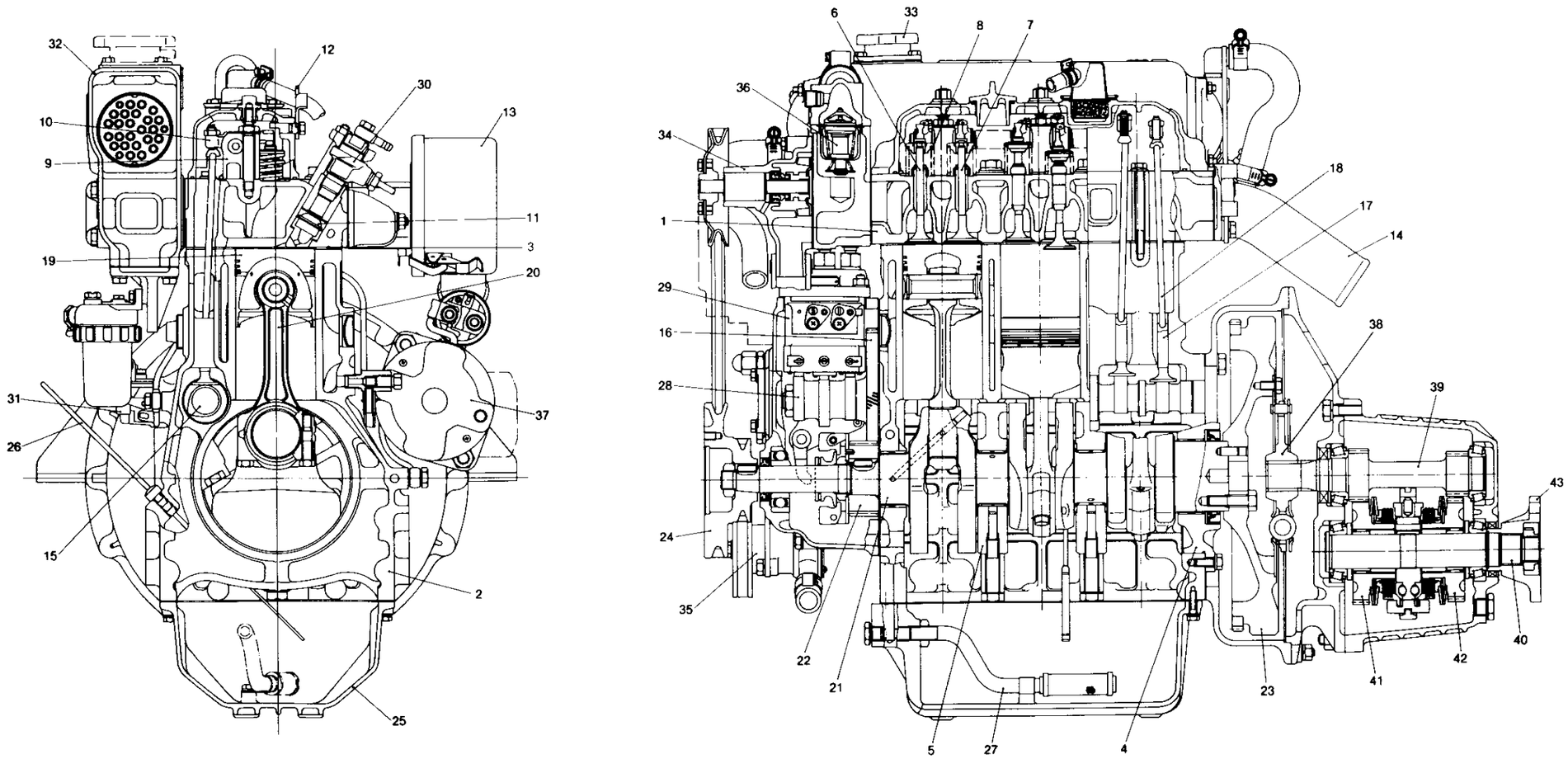
5-7 3HM35F



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36. Thermostat
37. Starter motor
38. Damper disc
39. Input shaft
40. Output shaft
41. Forward large gear
42. Reverse large gear
43. Output shaft coupling

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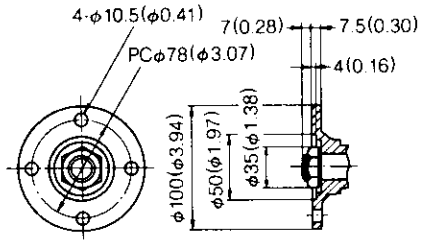
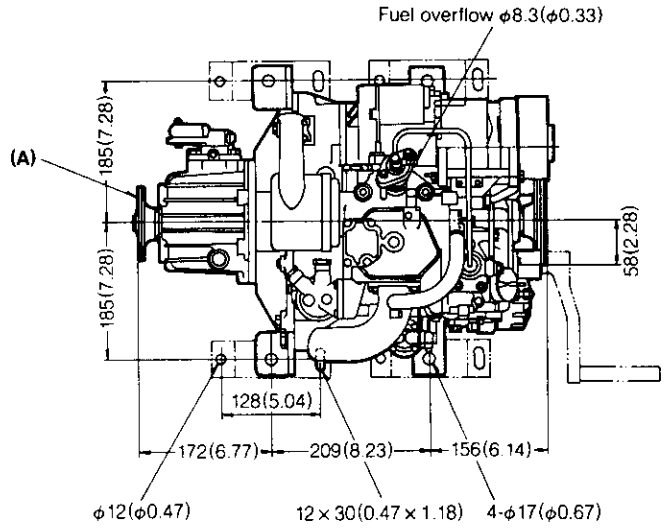
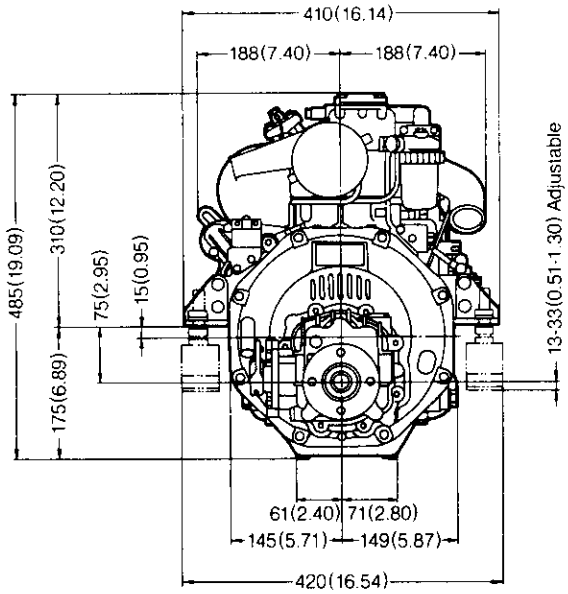
6. Dimensions

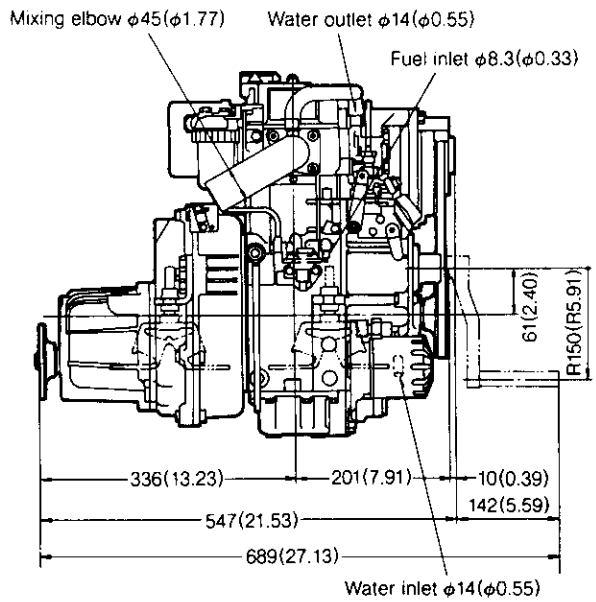
6-1 1GM10



Detail of coupling (A)







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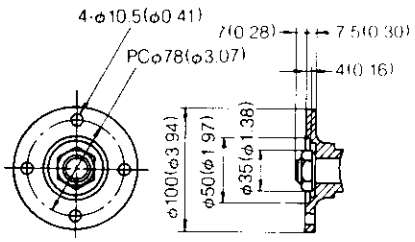
6-2 2GM20



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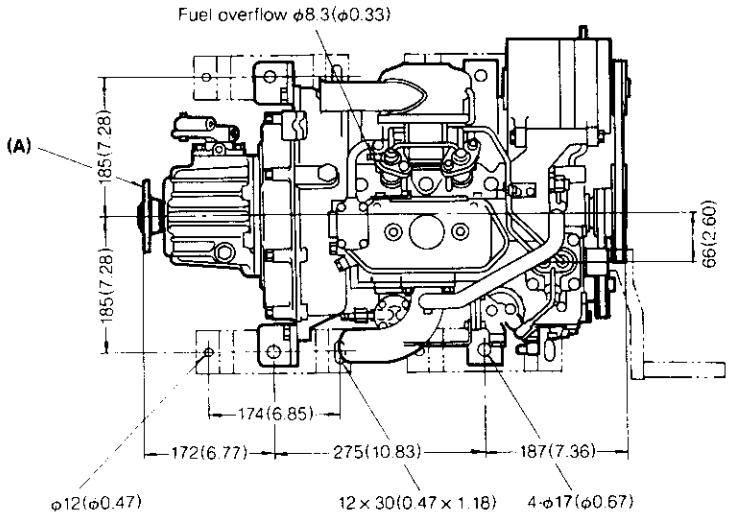

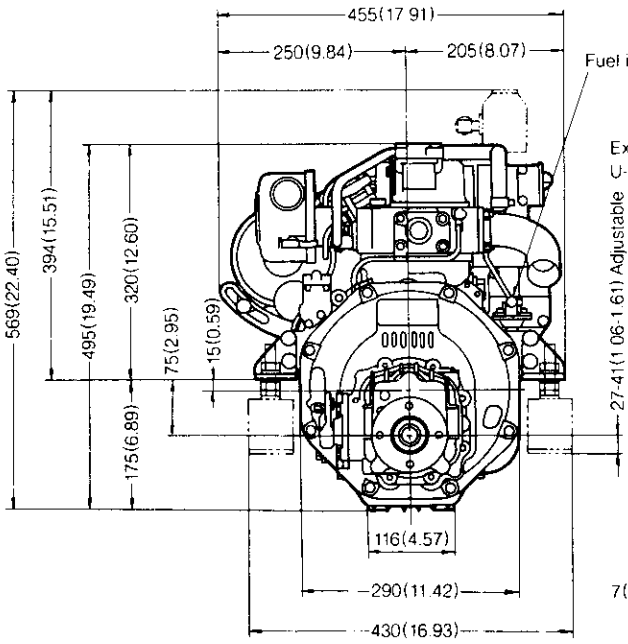

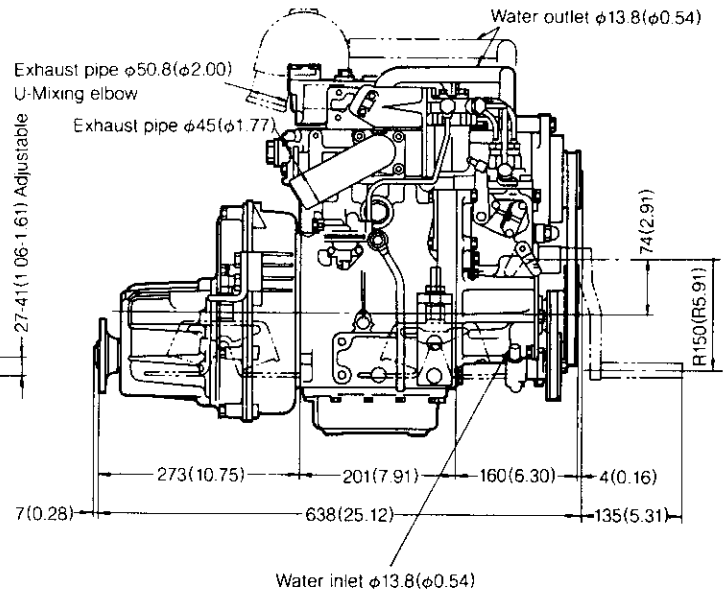

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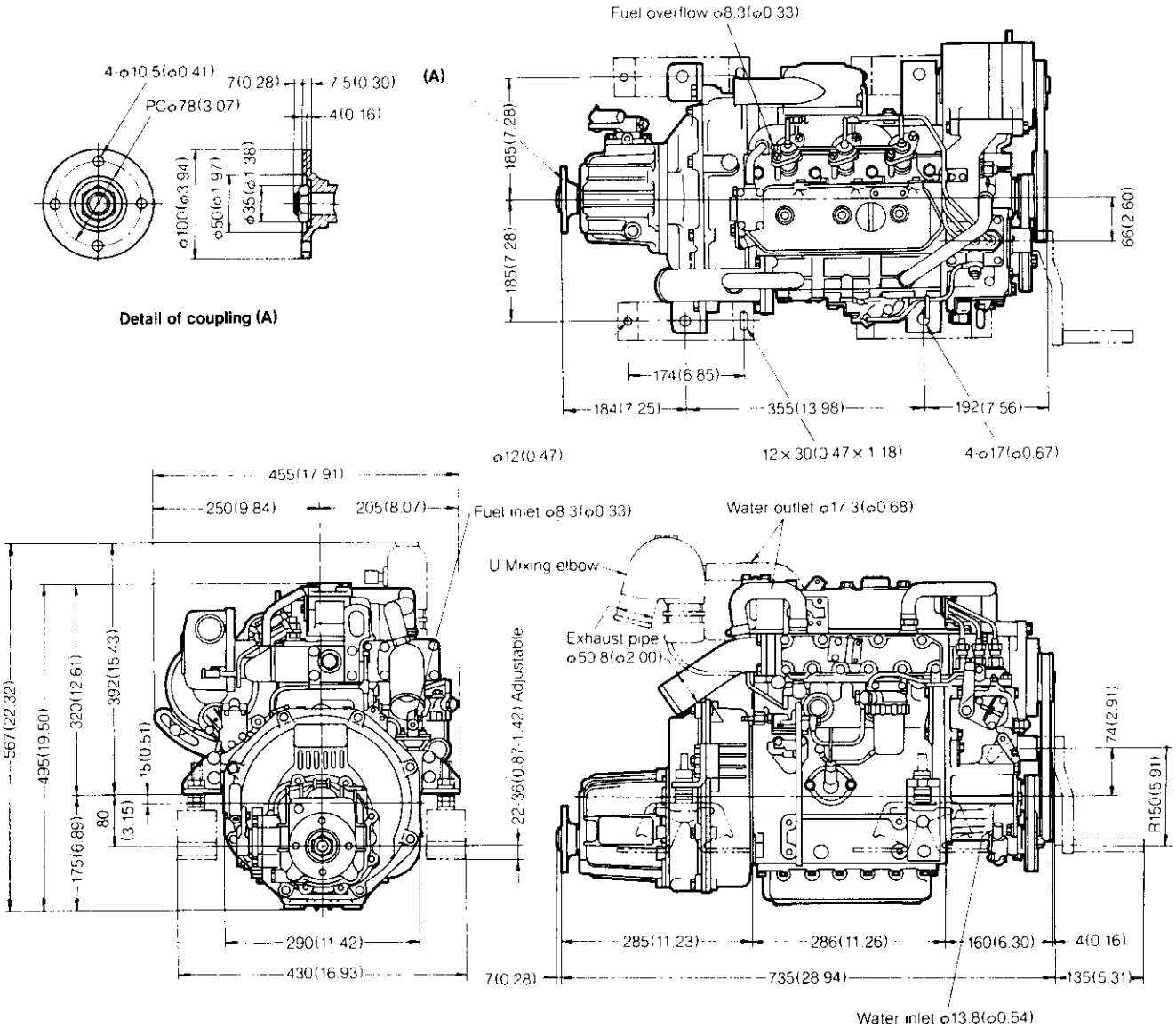
6-3 3GM30



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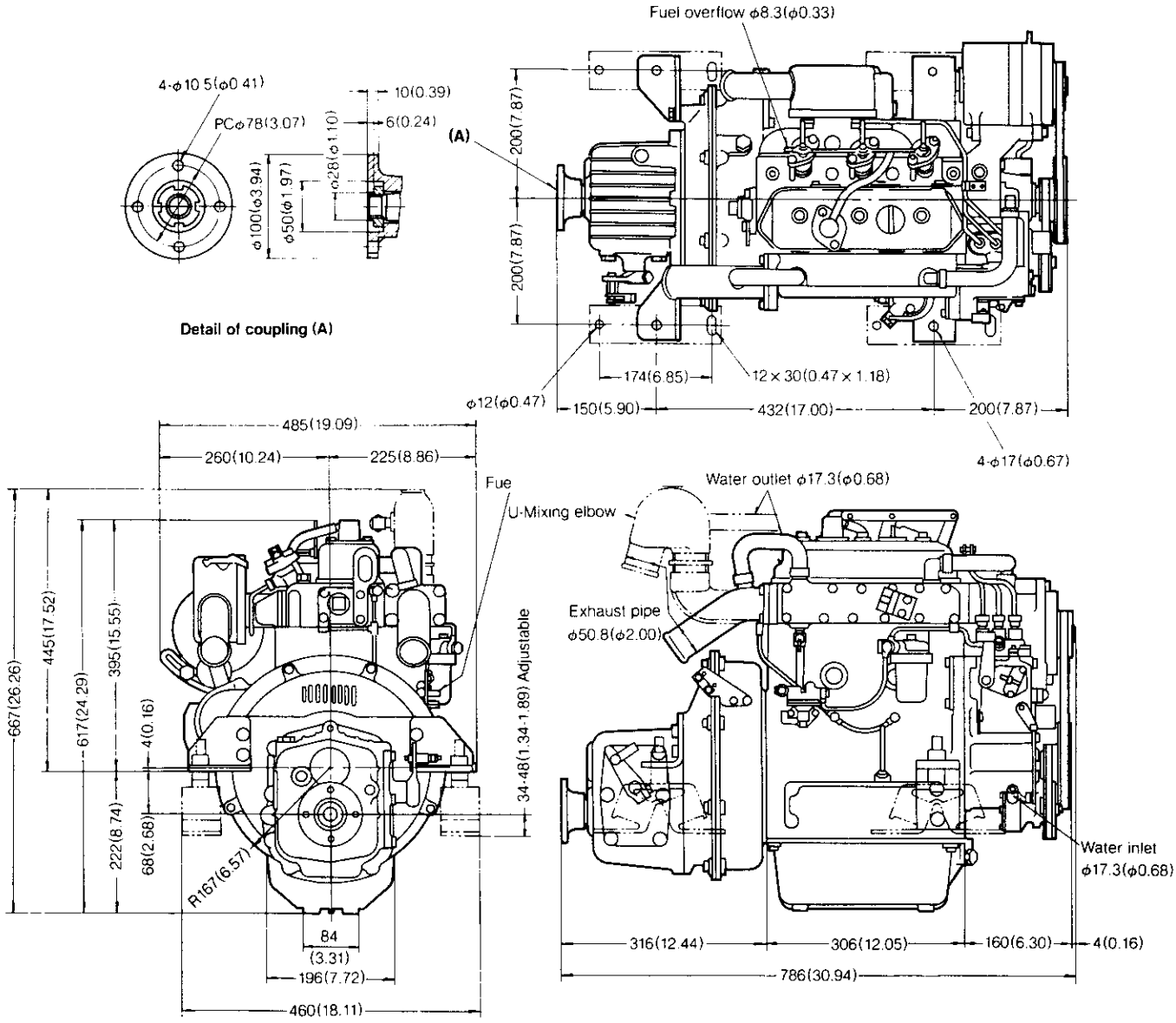
6-4 3HM35



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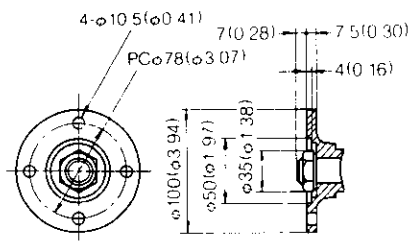
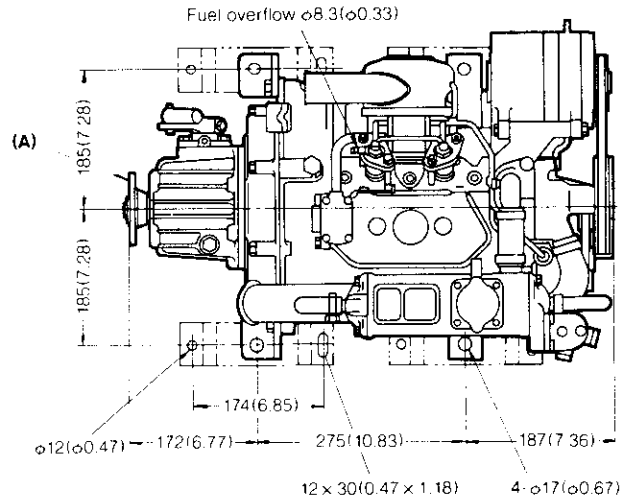
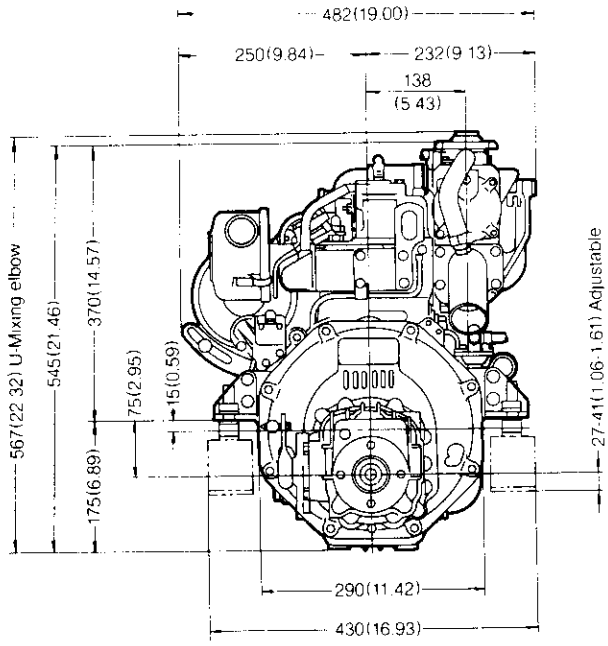
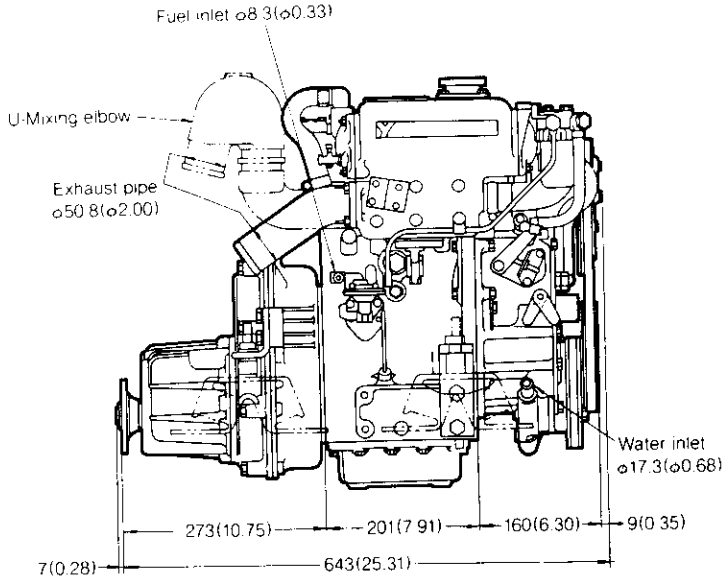
6-5 2GM20F



Detail of coupling (A)







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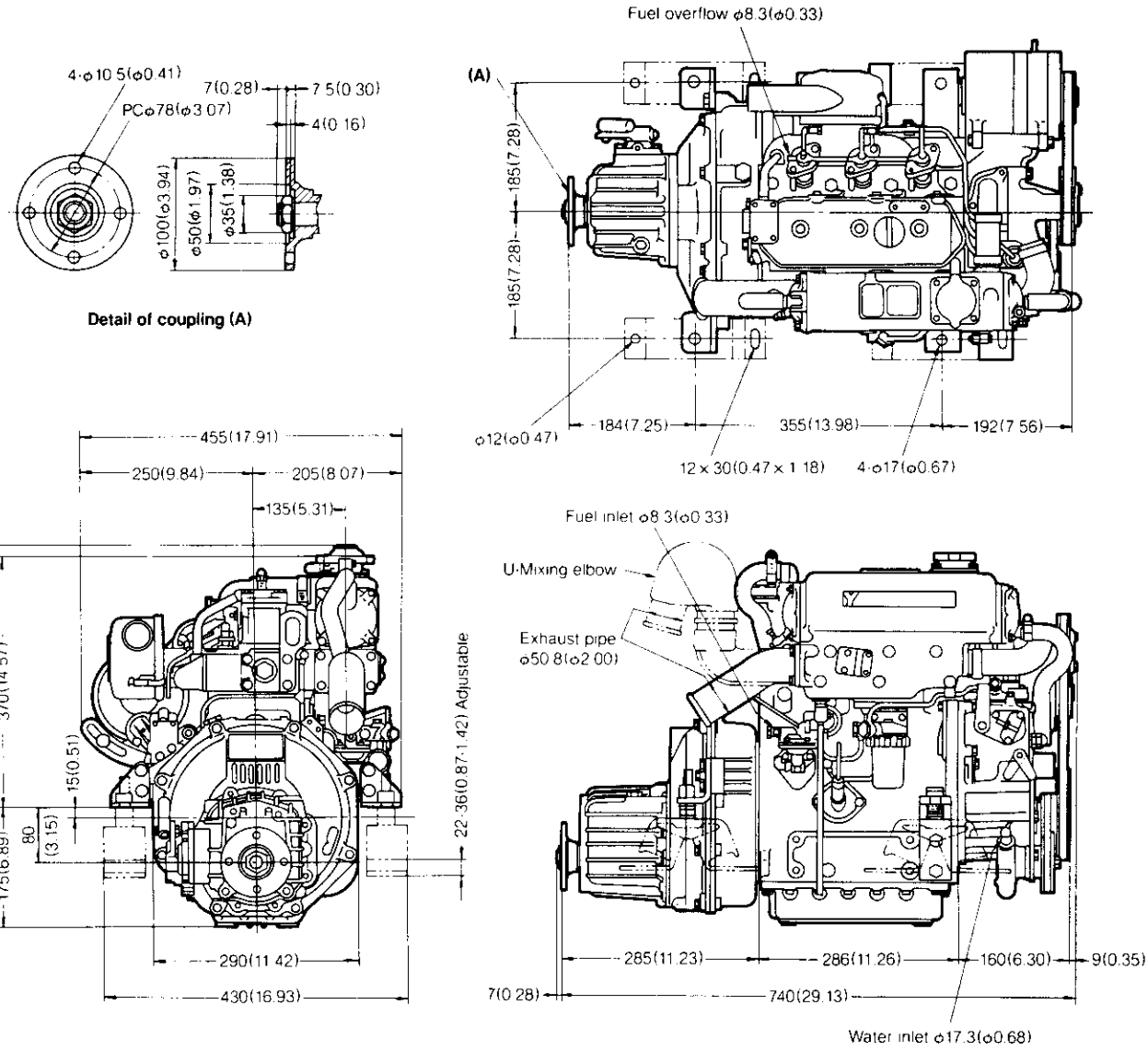
6-6 3GM30F



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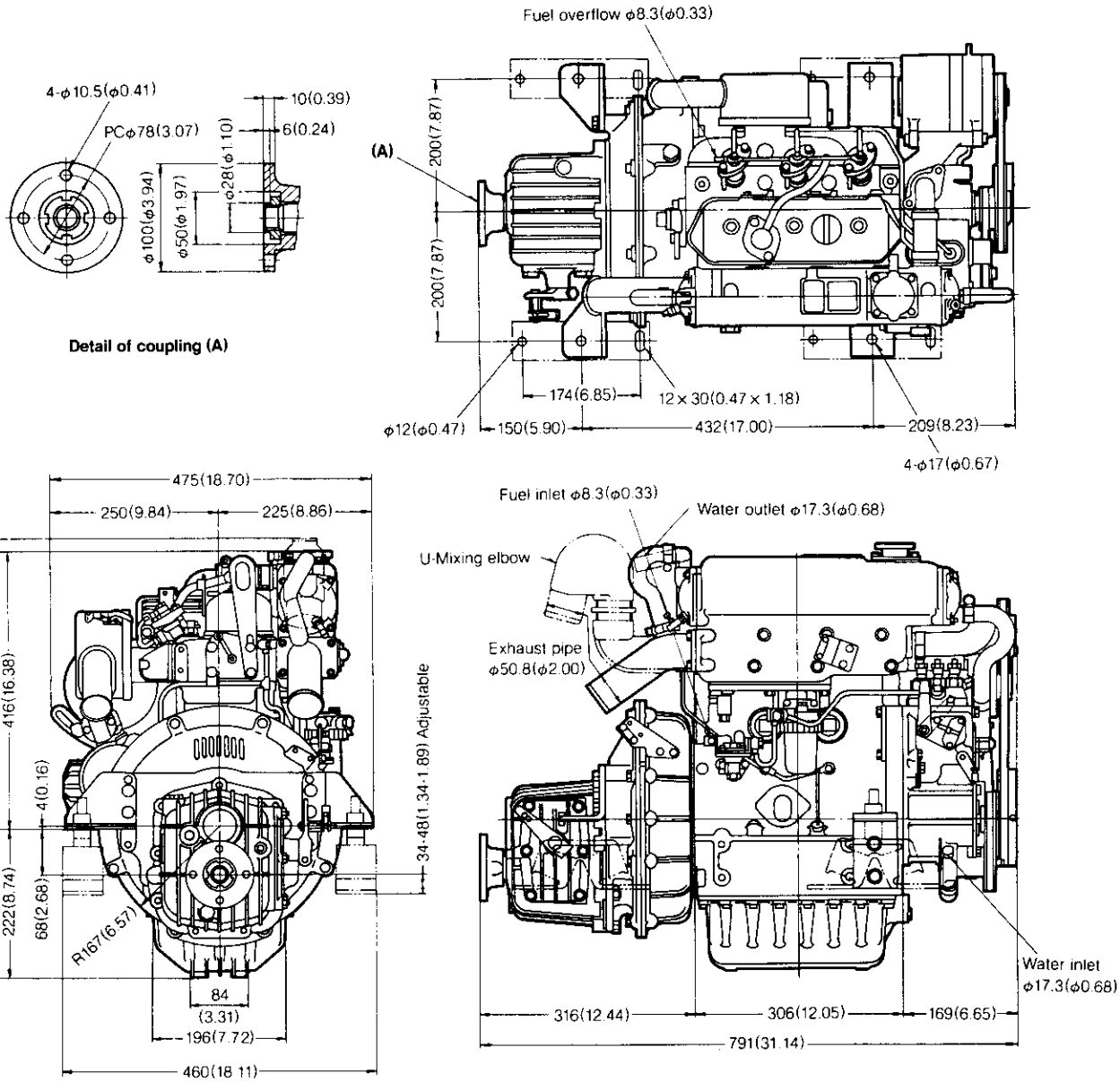
6-7 3HM35F



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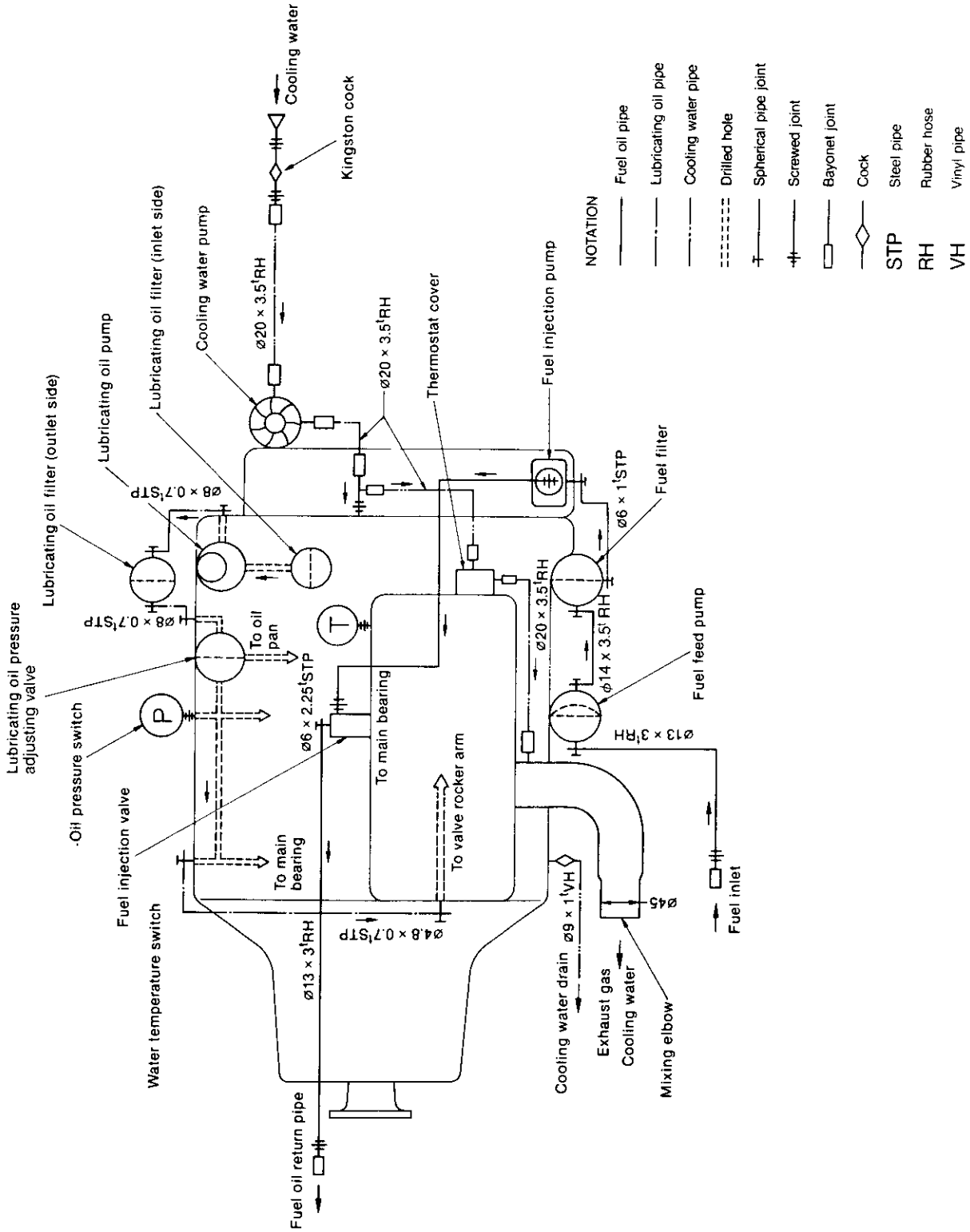
7. Piping Diagrams

7-1 1GM10



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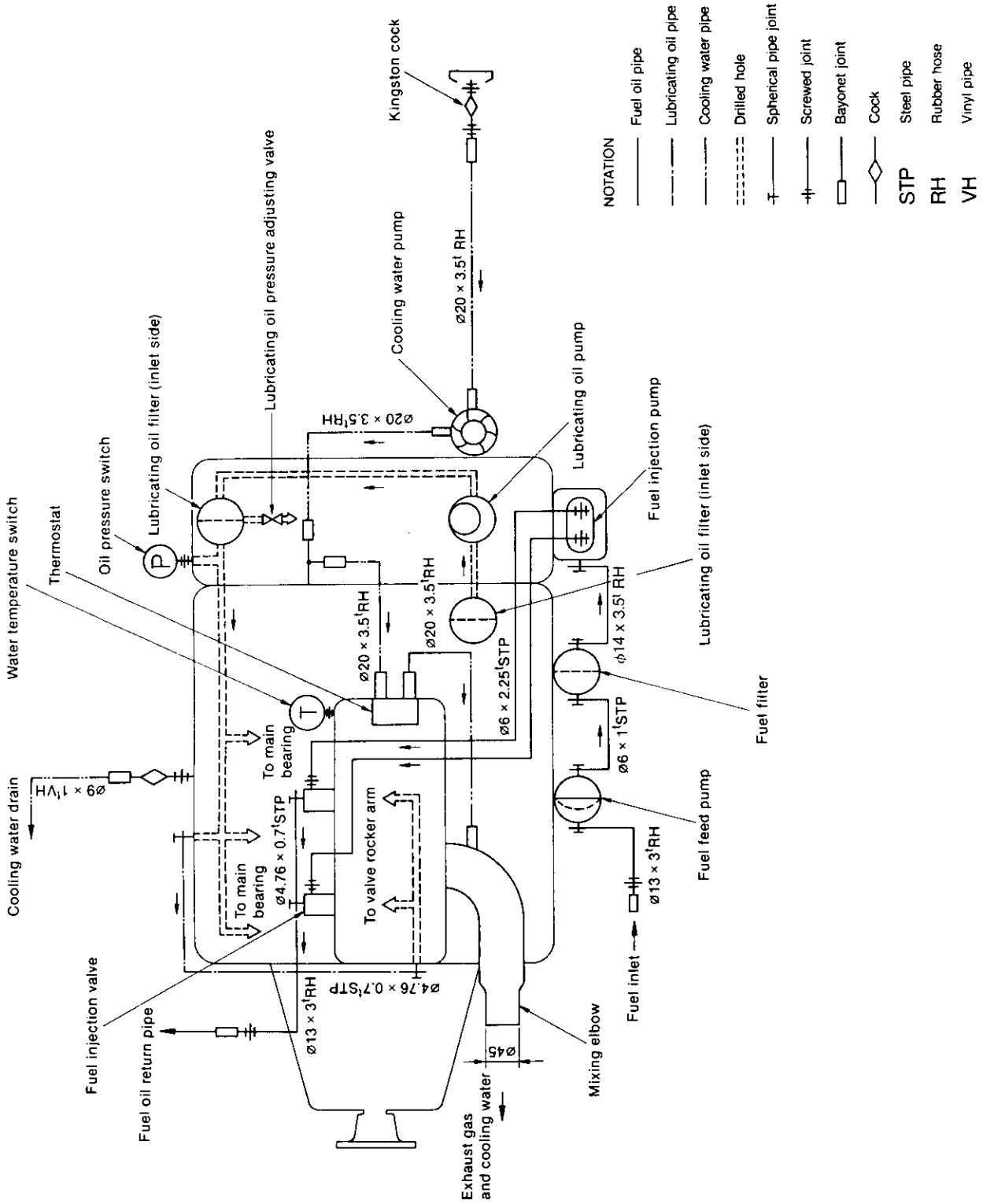
7-2 2GM20



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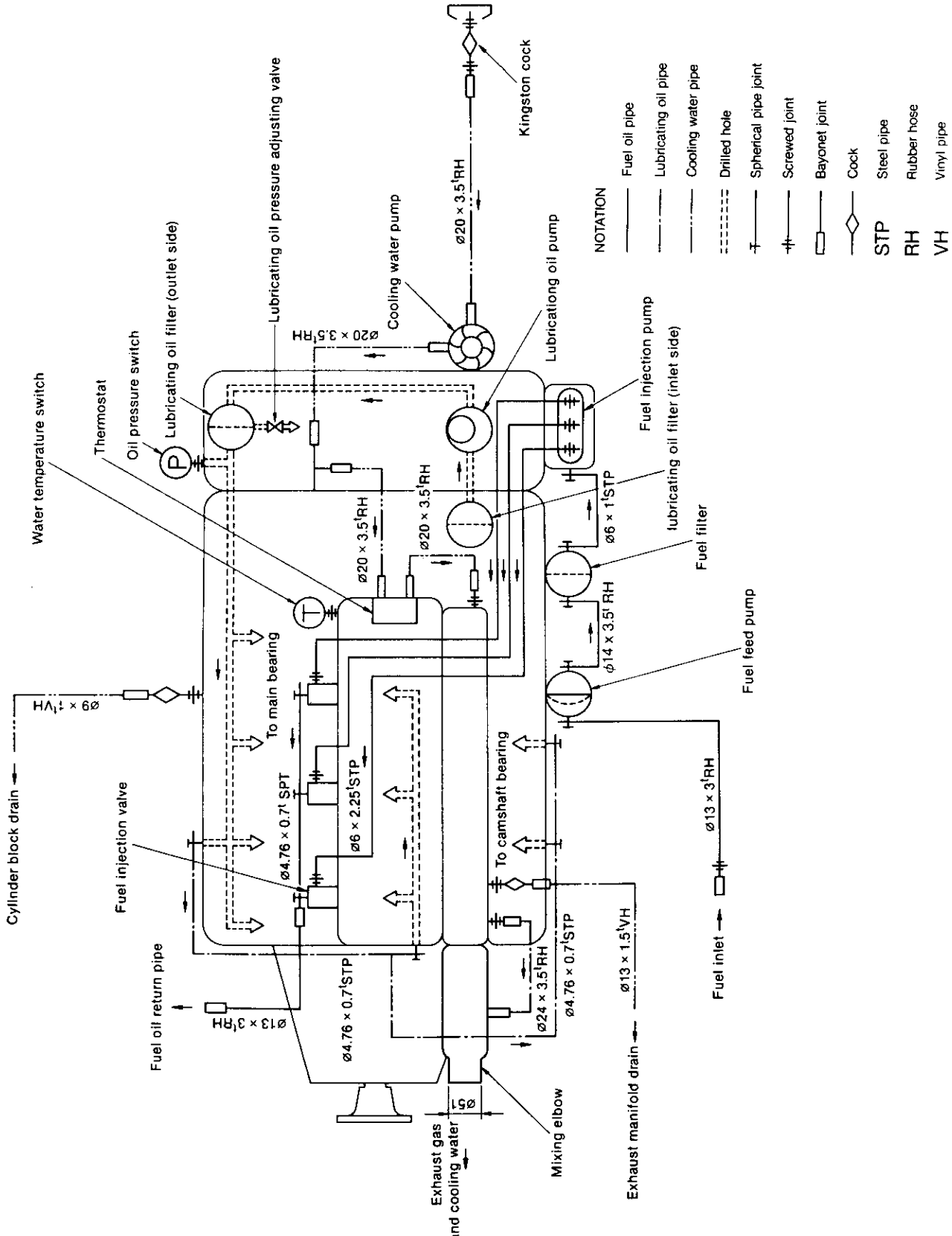
7-3 3GM30 and 3HM35



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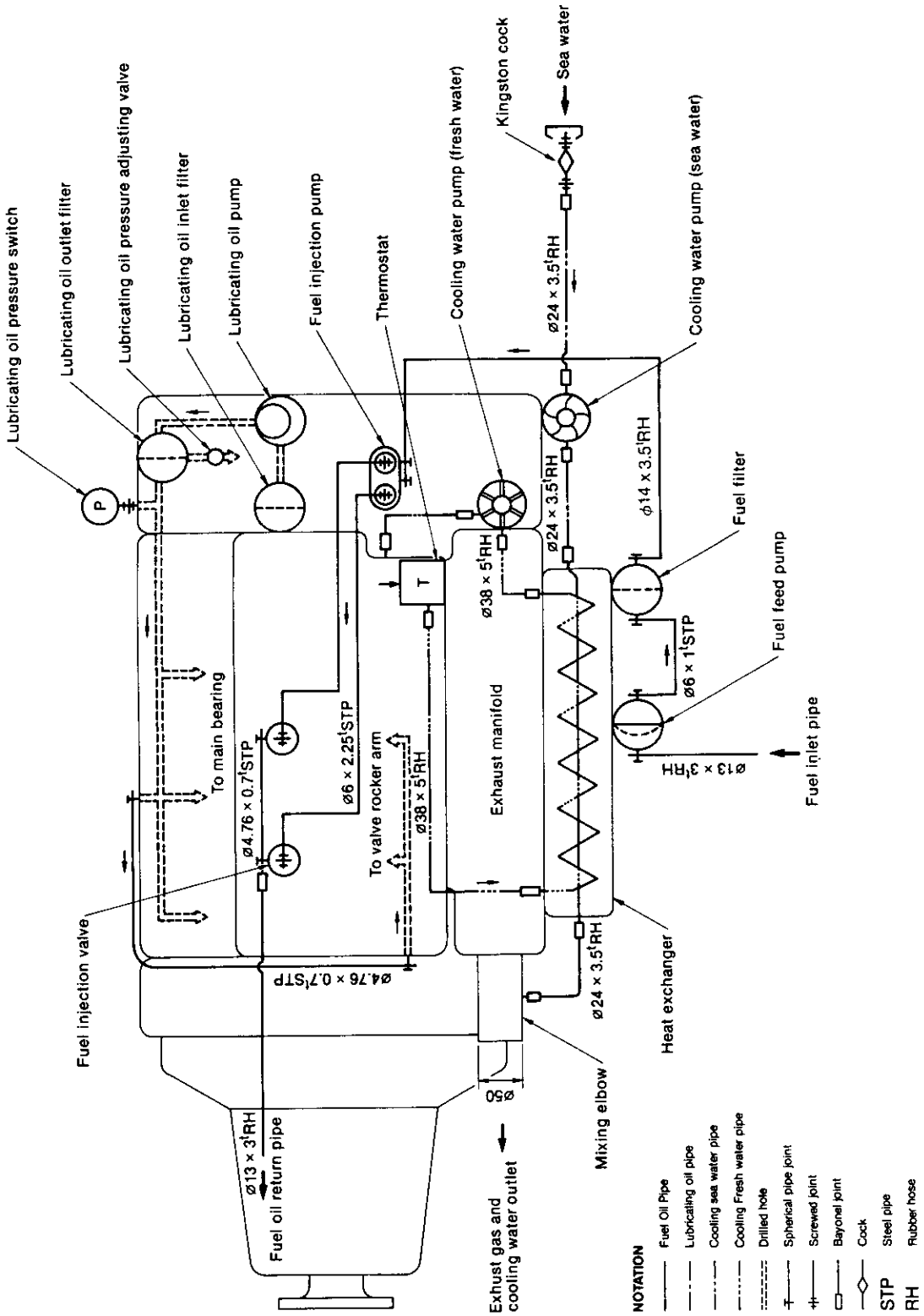
7-4 2GM20F



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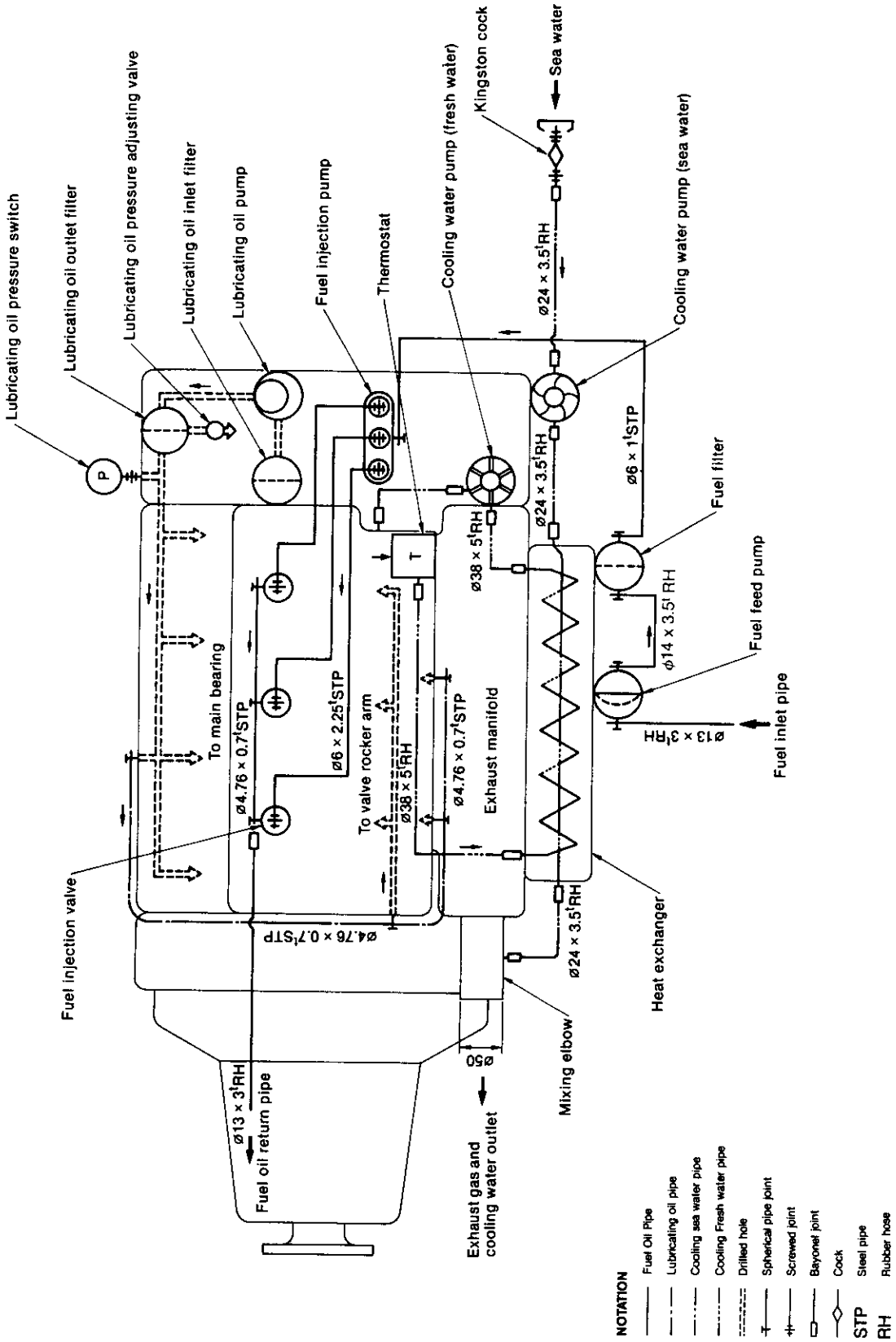
7-5 3GM30F and 3HM35F



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CHAPTER 2

BASIC ENGINE

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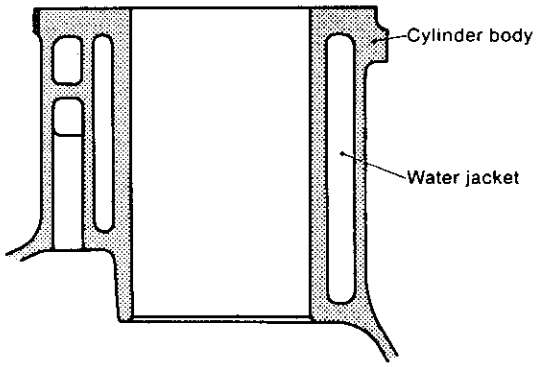
1. Cylinder Block

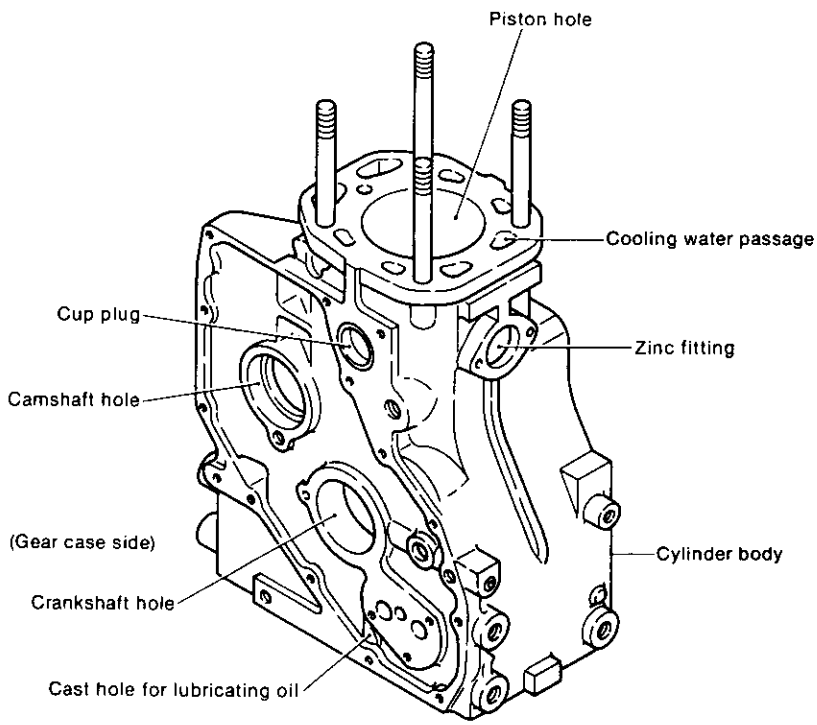
1-1 Construction

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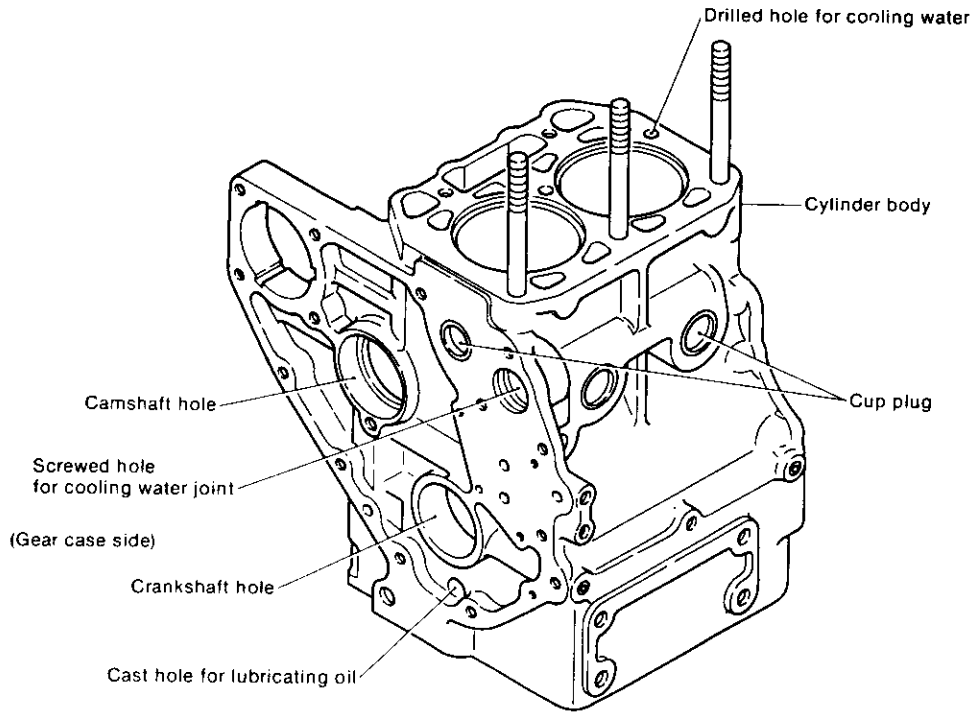
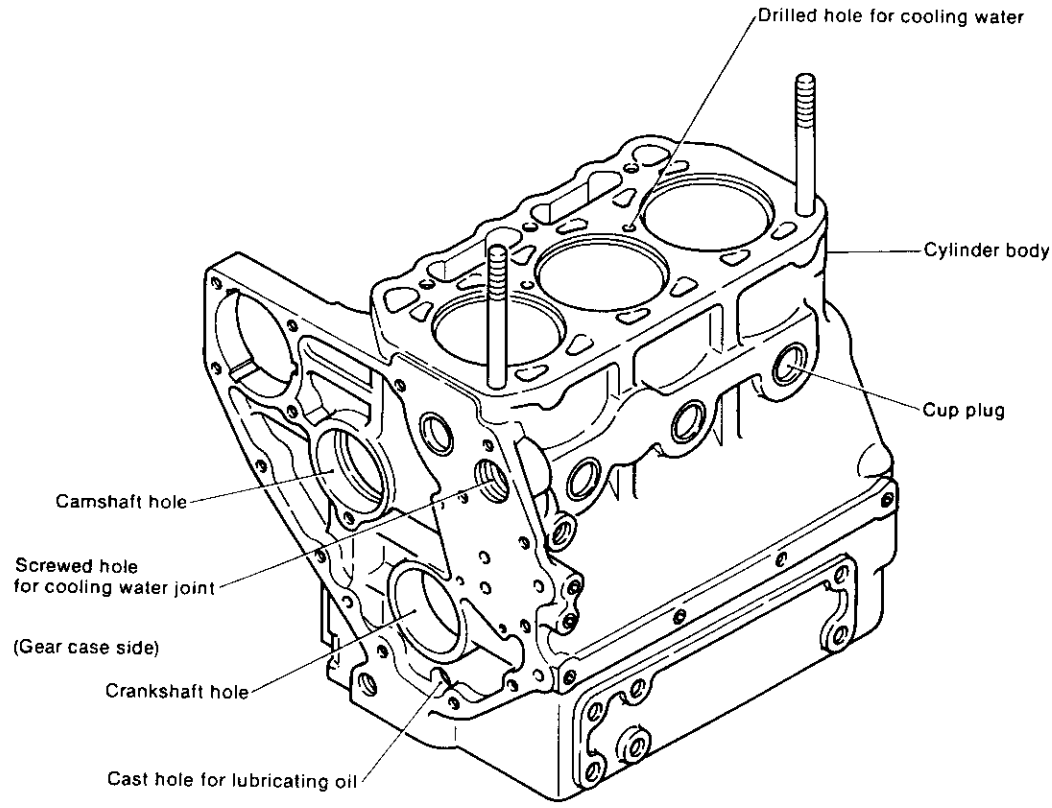
1-1.2 Cylinder of model 2GM20(F)(C) engine



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



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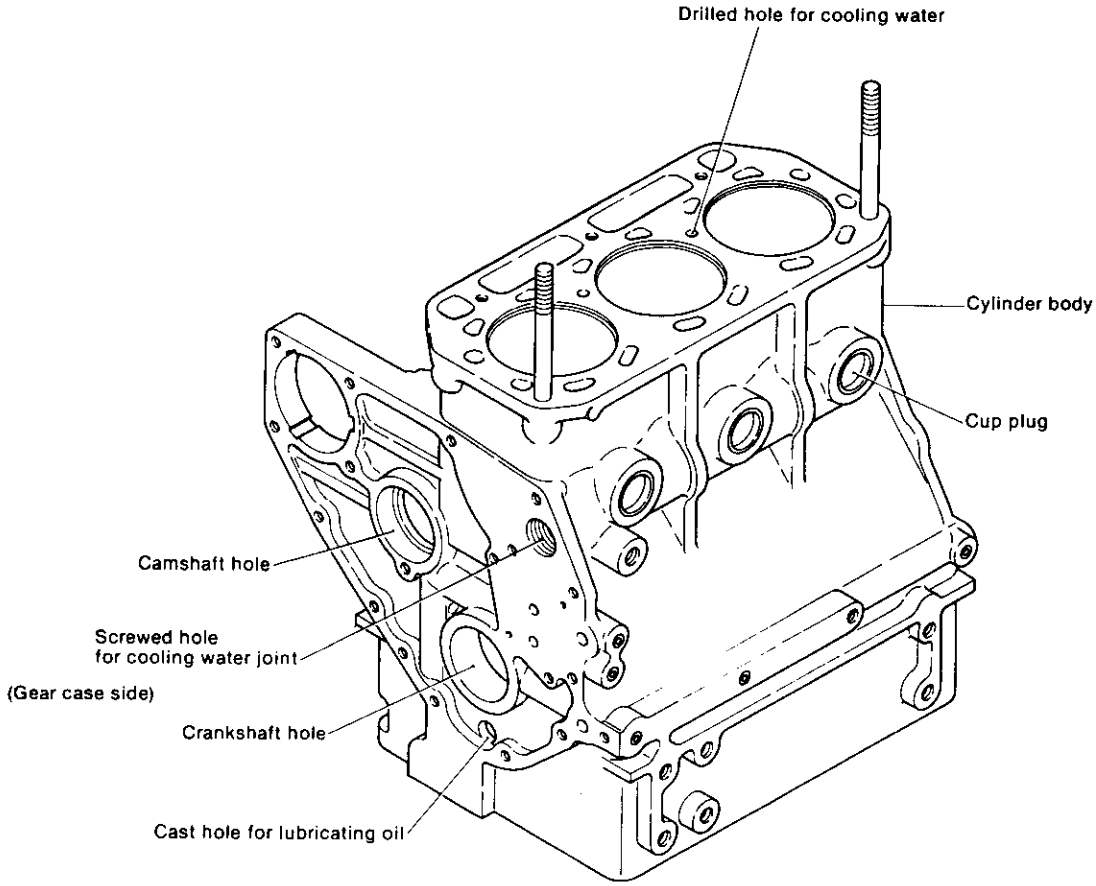
1-1.4 Cylinder of model 3HM35(F)(C) engine



1-2 Cylinder block inspection

1-2.1 Inspecting each part for cracks

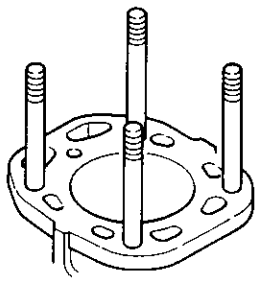
If the engine has been frozen or dropped, visually inspect it for cracks and other abnormalities before disassembling. If there are any abnormalities or the danger of any abnormalities occurring, make a color check.

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.

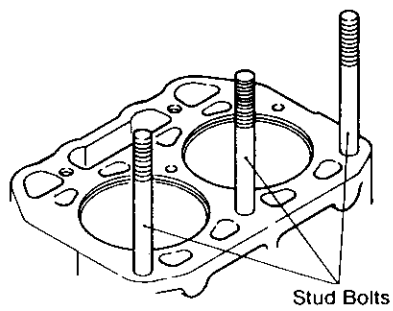
1-2.3 Cylinder head stud bolts

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	6.0kgf-m(43.4 ft-lb)



2GM20(F)(C)

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

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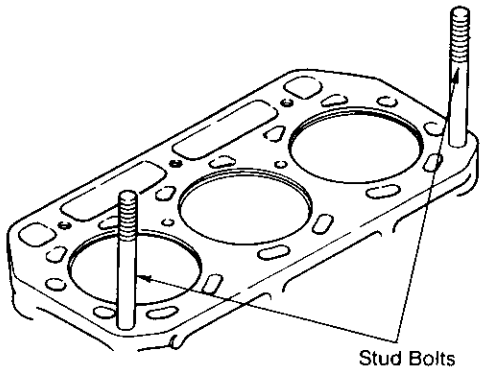
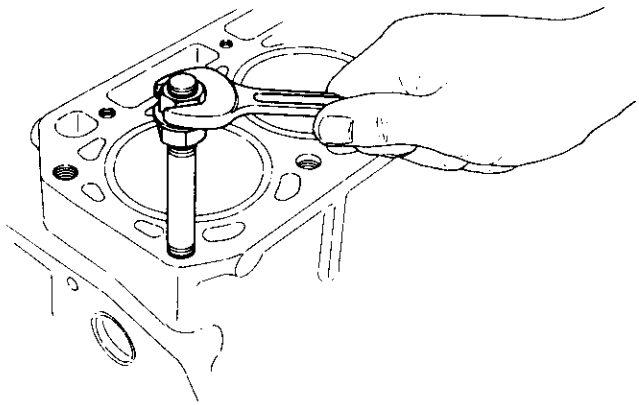
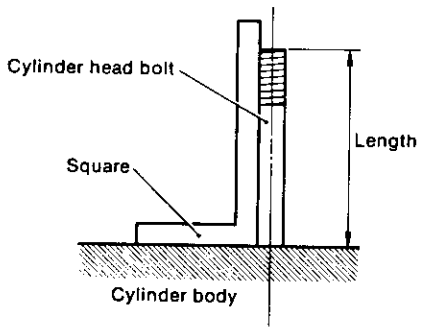


3GM30(F)(C), 3HM35(F)(C) kgf-m(ft-lb)

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



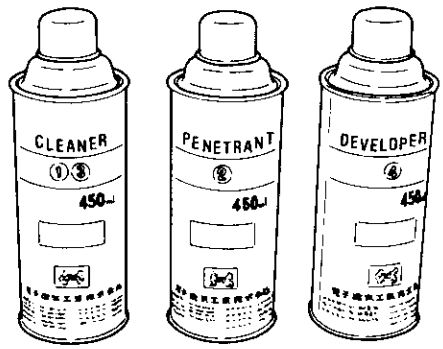


1-2.4 Oil and water passages

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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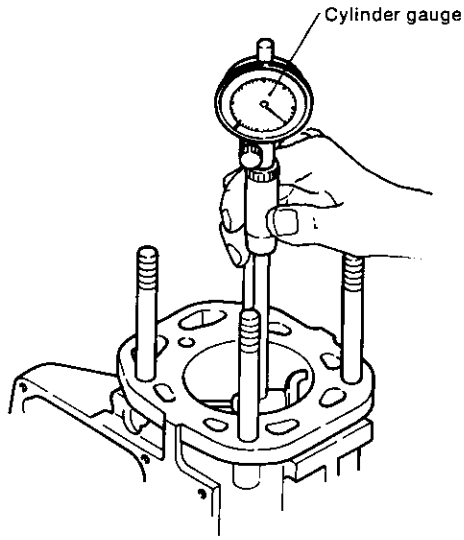
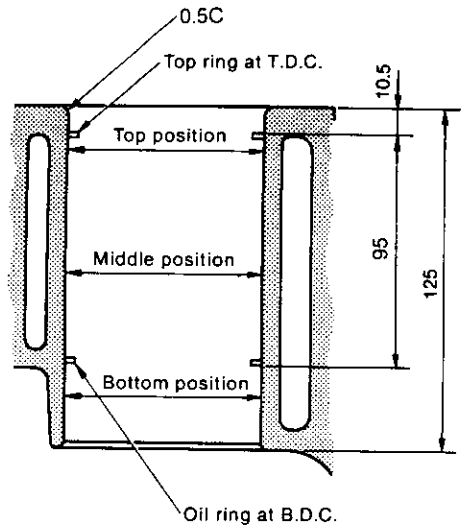
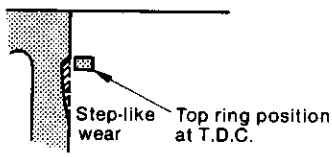
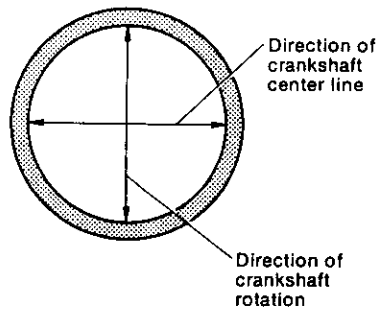
Although the greatest wear is at the top of the cylinder, the piston ring does not slide with the cylinder at the topmost position. Therefore, a step-like pattern is formed between the worn part and the non-worn part.
Furthermore, wear is liable to occur along the rotating direction of the crankshaft 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

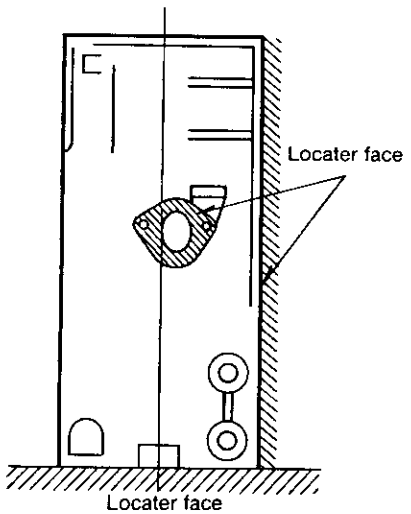
For the re-boring of the piston bore in the cylinder block, use the following locater positions. Before re-boring, be sure to remove packings and dust from the locater points.

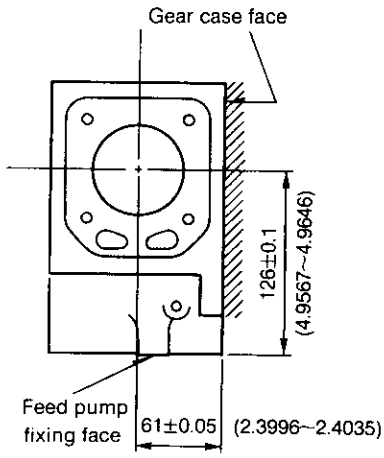
1) 1GM10(C)
   Main locater: Oil pan side
   Sub locater: Timing gear case and F.O. feed pump side
2) 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
   Oil pan side and ϕ2-pin holes

(3) Boring procedures

(1) 1GM10(C)

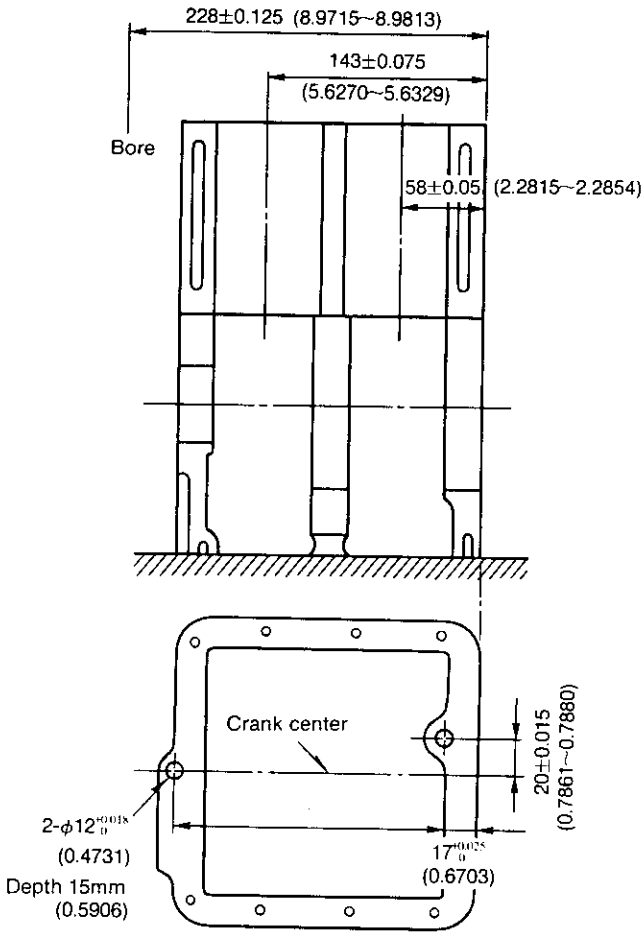
For processing the bore, face the oil pan side to the bottom and place the fixing faces of the gear case and the feed pump.





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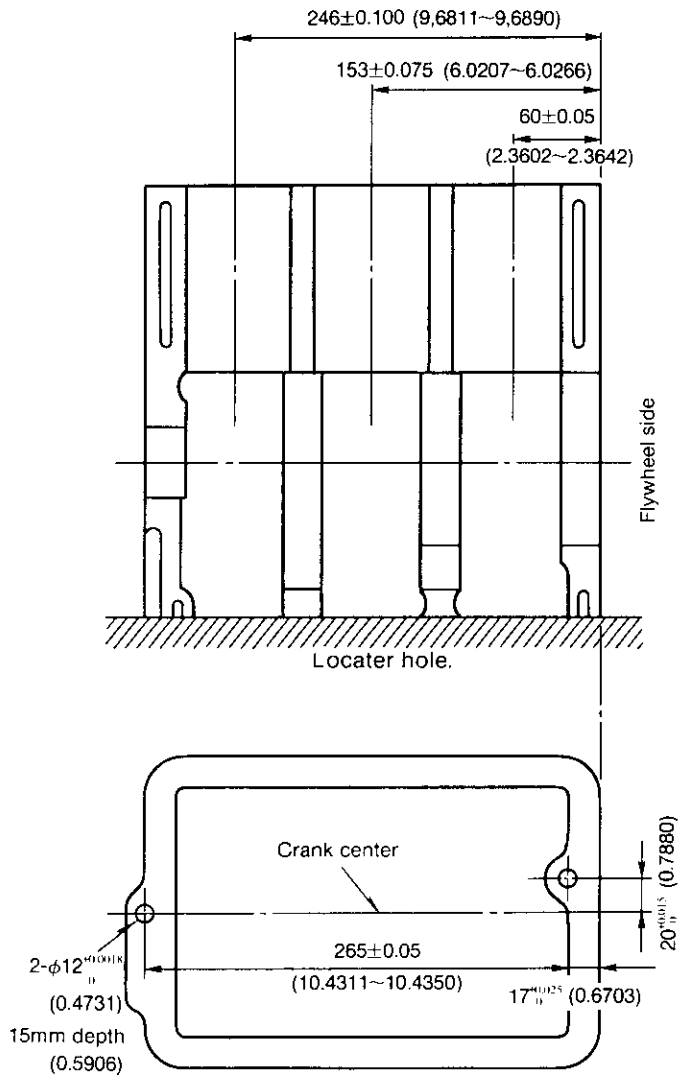
(3) 3HM35
For processing bring the oil pan side to the bottom, and insert a pin to the 2-$\phi 12^{+0.018}_{0}$ (15mm depth) locator hole.

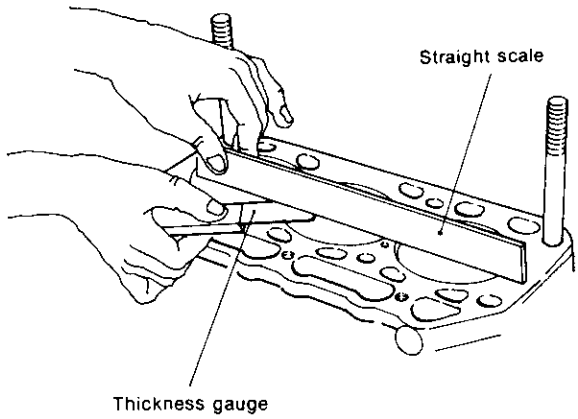


(4) Honing
The inside surface of the cylinder must be honed after being bored in order to remove machine tool marks.

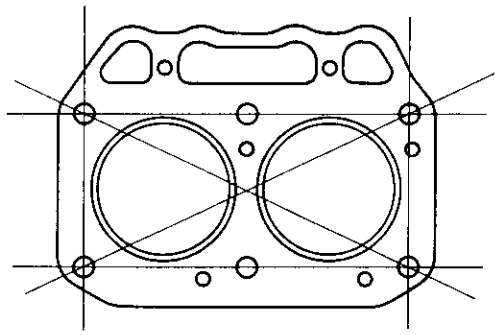
1-4 Measurement of distortion on the upper surface of the cylinder

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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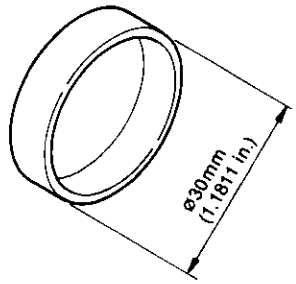
1-5 Cup plug

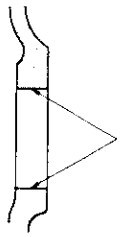
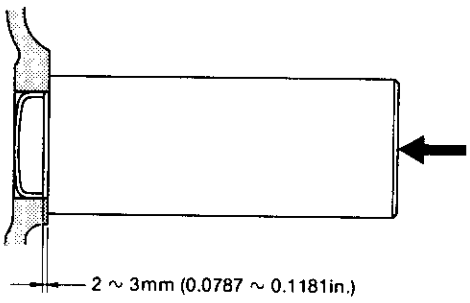
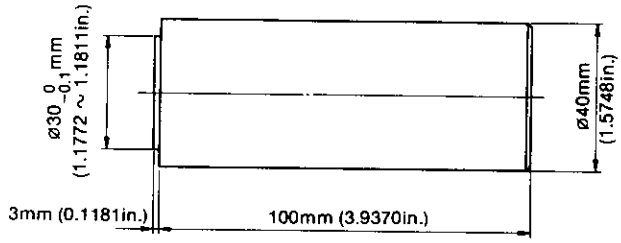
1-5.1 Purpose of cup plug

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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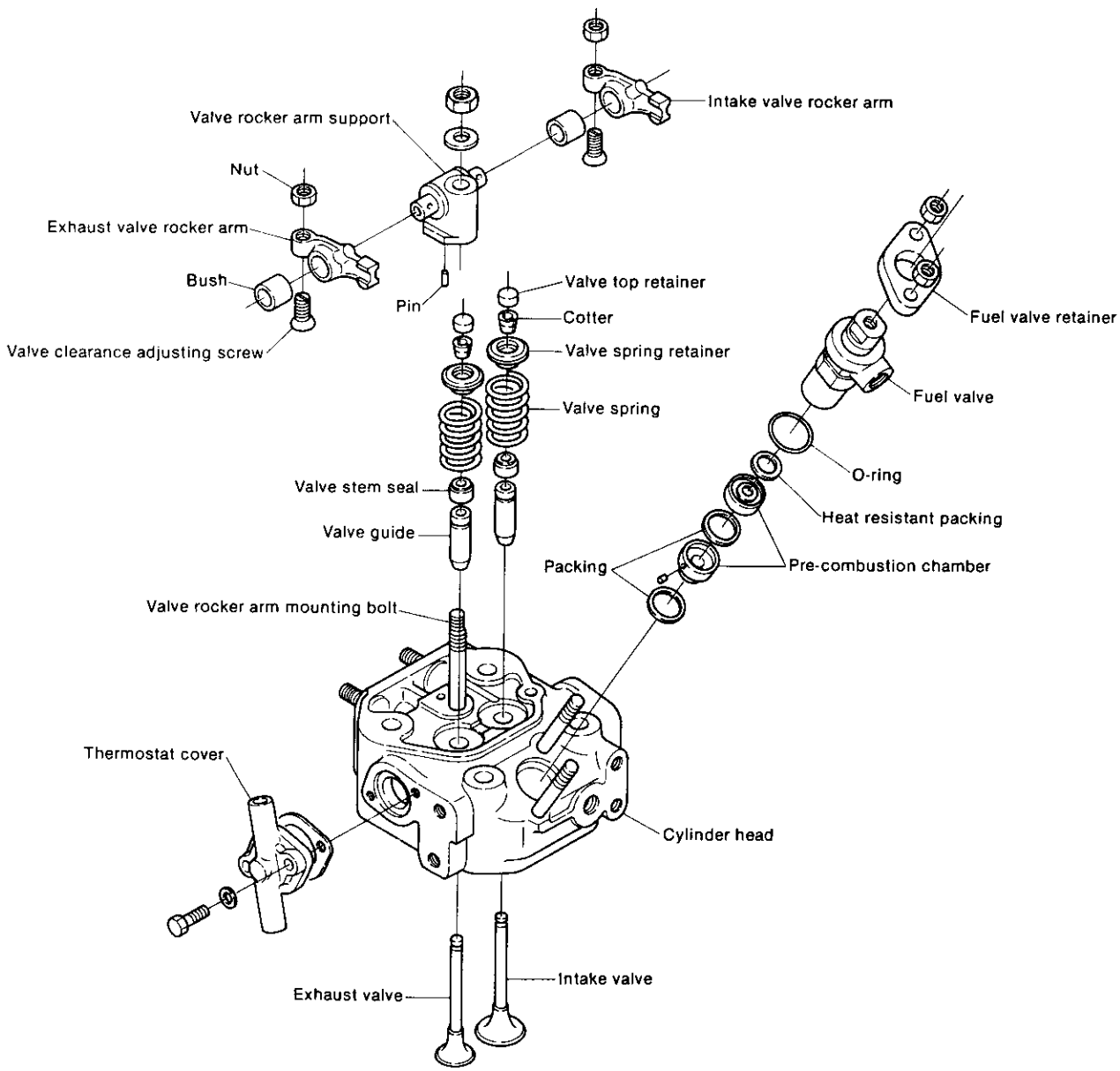
2. Cylinder Head

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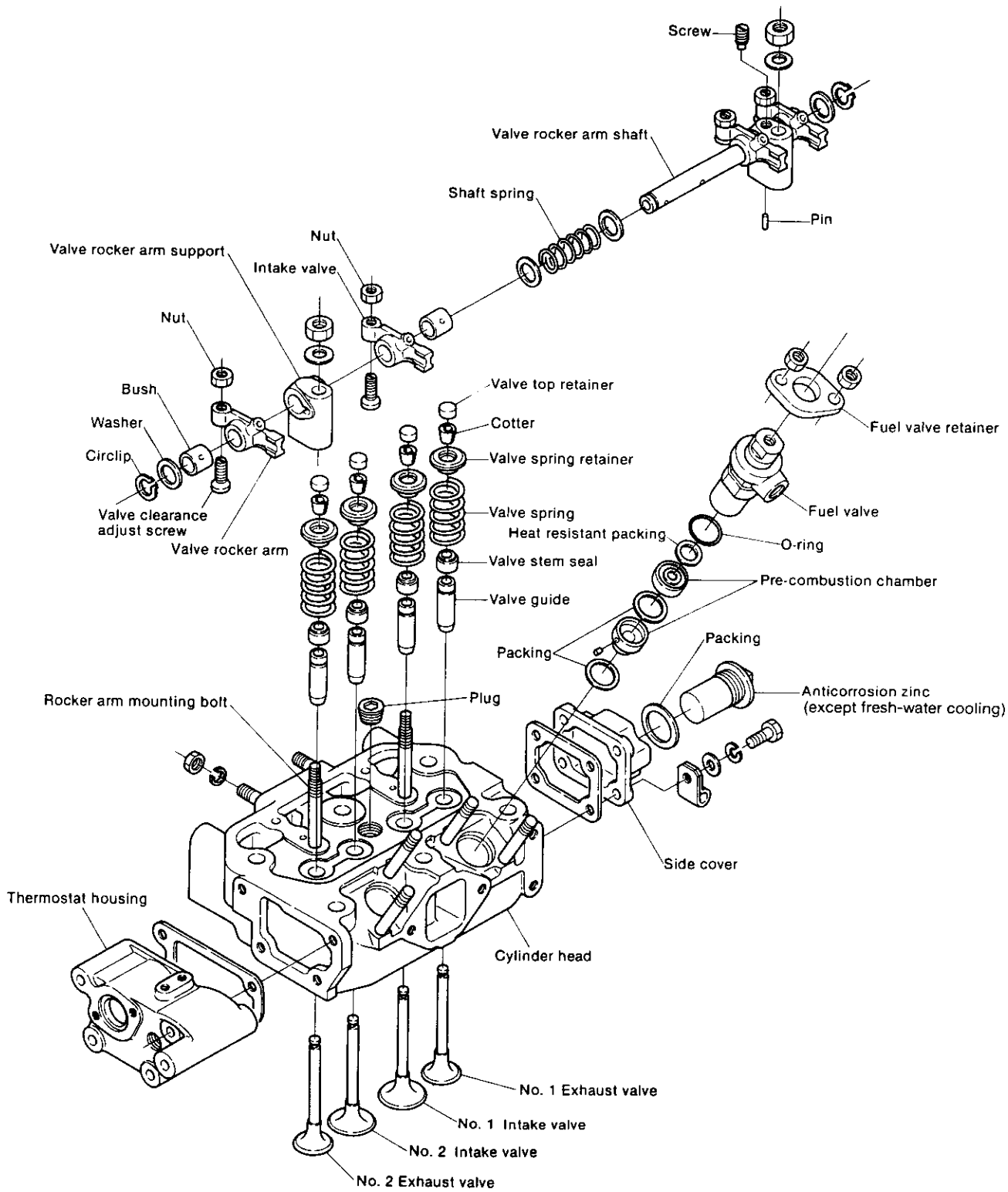
2-1.2 Cylinder head of model 2GM20(F)(C) engine



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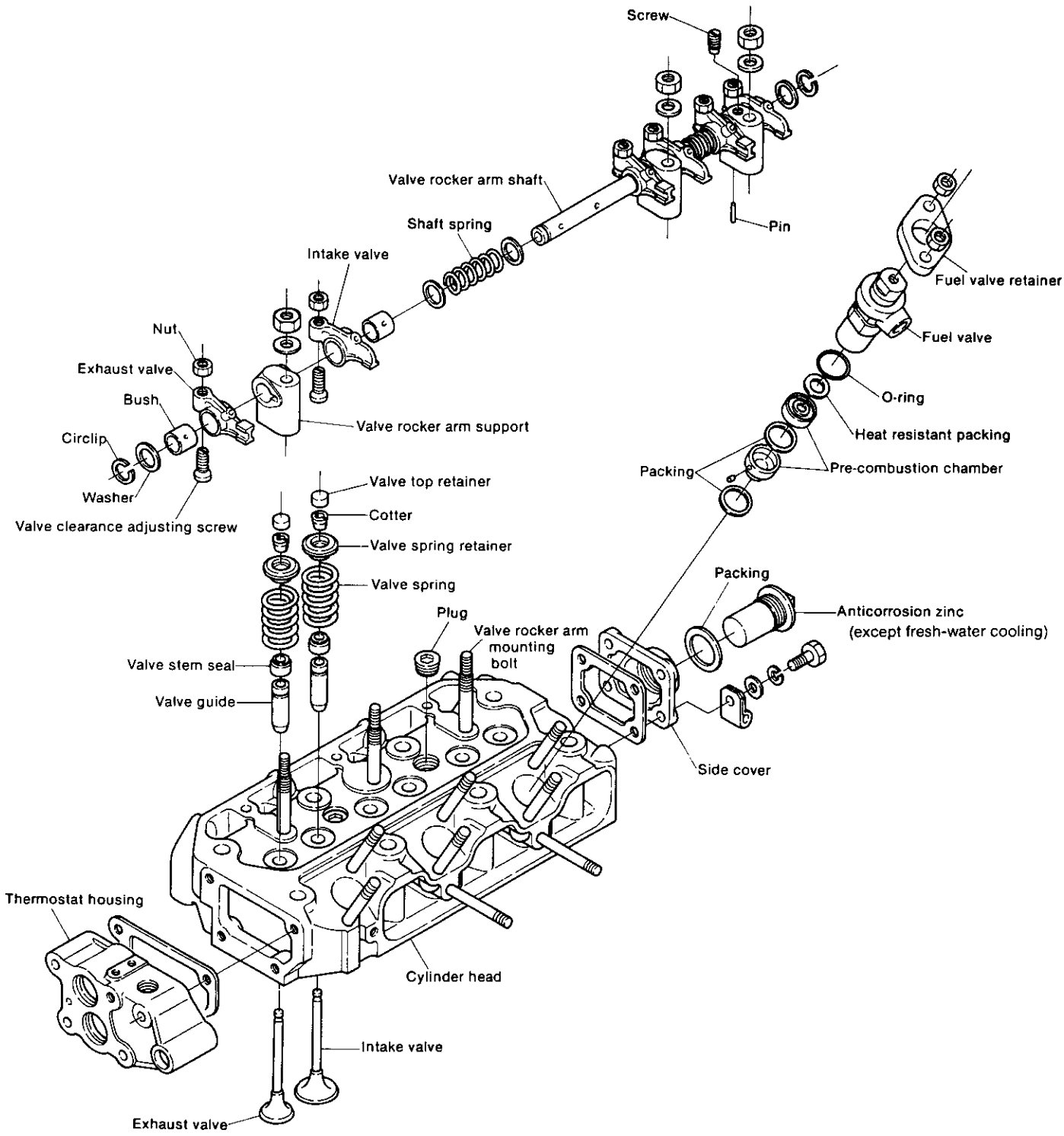
2-1.3 Cylinder head of models 3GM30(F)(C) and 3HM35 (F)(C)



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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

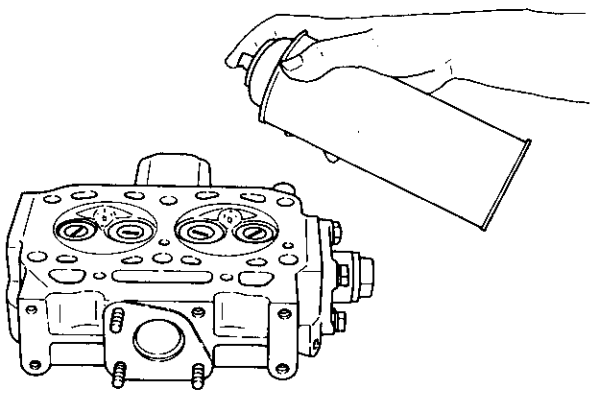
Check for build-up deposit in the water passages, and remove any deposit with a deposit remover. When a large amount of deposit has built up, check each part of the cooling system.

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

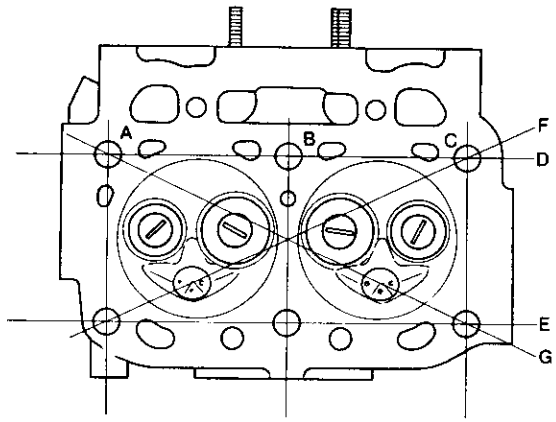
2-2.4 Cracking of combustion surface

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

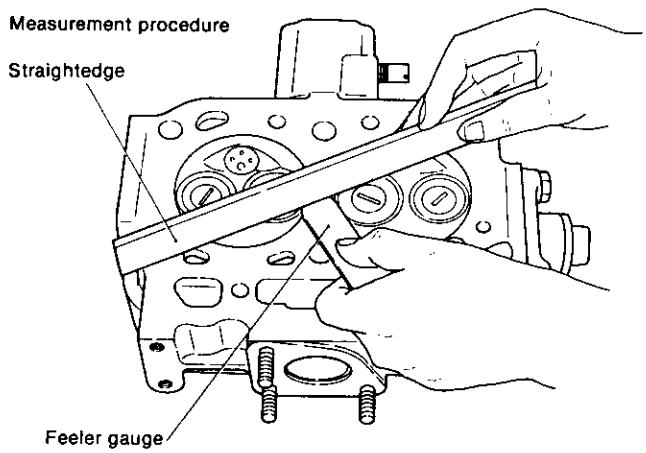
Distortion of the cylinder head causes gasket packing damage, compression leakage, change in compression, etc.
Measure the distortion as described below, and replace the cylinder head when the wear limit is exceeded. Since distortion of the cylinder head is caused by irregular tightening forces, faulty 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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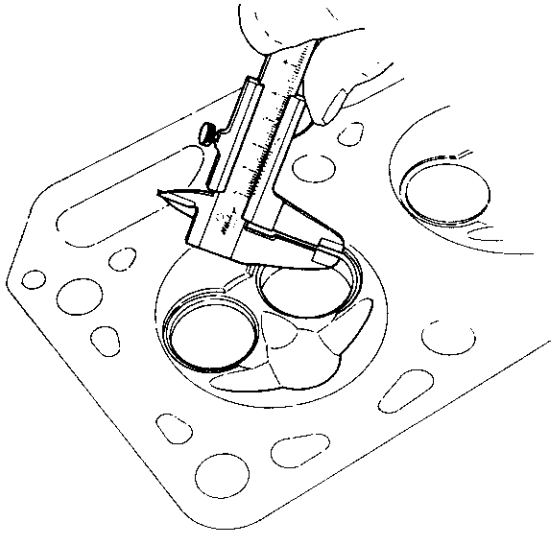
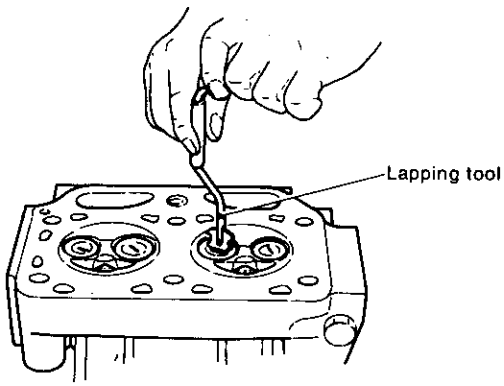
Measure the seat width with vernier calipers, and repair or replace the seat when the wear limit is exceeded.
When the valves have been lapped and/or ground, measure the amount of valve recess, and replace the valve when the wear limit is exceeded.



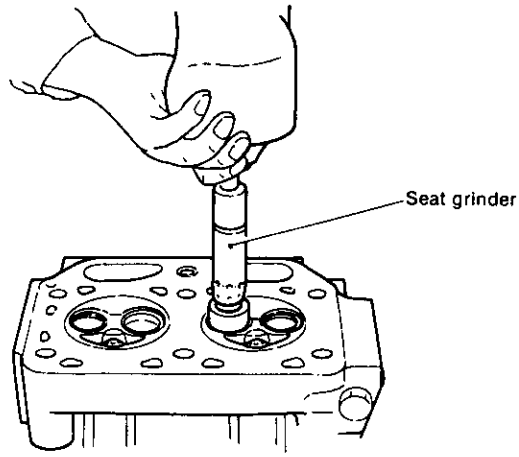
(Common to all models) mm (in.)

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

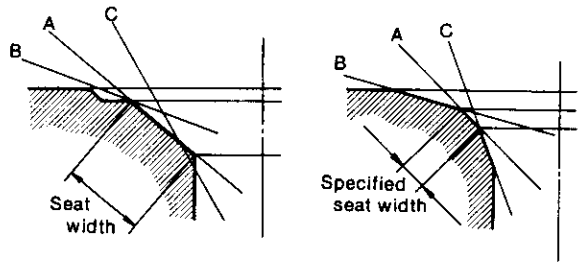
(1) Lapping the valve seat.
When scoring and pitting of the valve seat is slight, coat the seat with valve compound mixed oil, and lap the seat with a lapping tool.
At this time, be sure that the compound does not flow into the valve stem and valve guide.



(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.



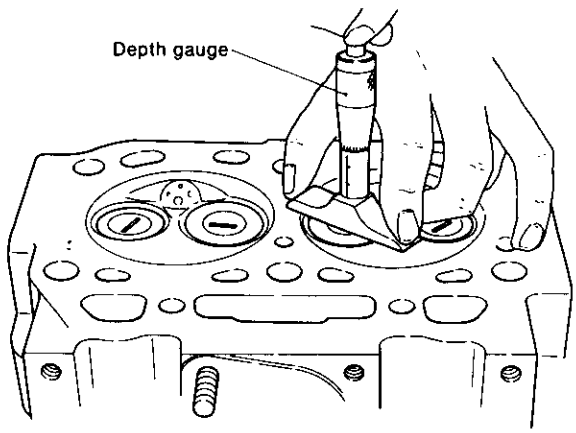
Before correction After correction

(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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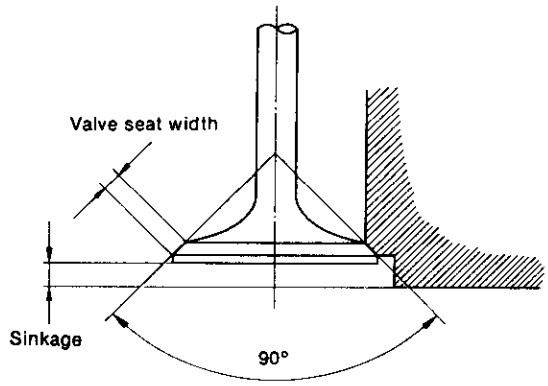


mm (in.)

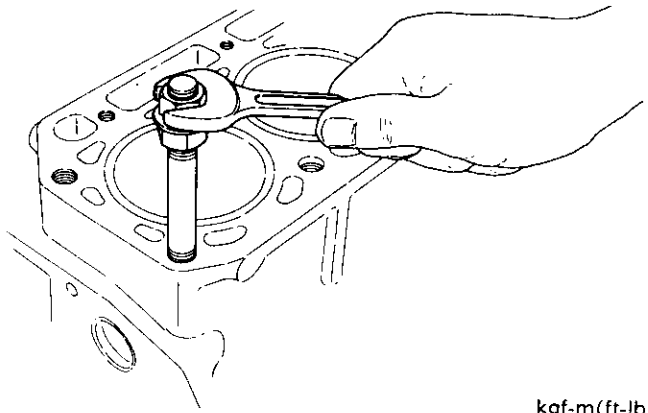
	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve sinkage	0.95 (0.0374)	1.25 (0.0492)	1.25 (0.0492)	1.55 (0.0610)

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

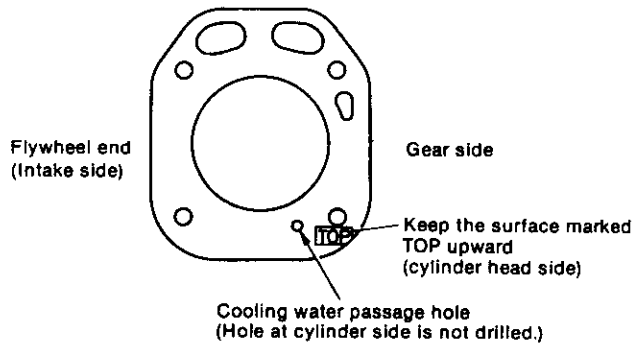
(1) Check for loose cylinder head stud bolts, and lock any loose bolts with two nuts and then tighten to the prescribed torque.
The cylinder head is fitted to the engine with 4 stud bolts in model 1GM10(C), but in other engine models both stud bolts and collar head bolts are used.

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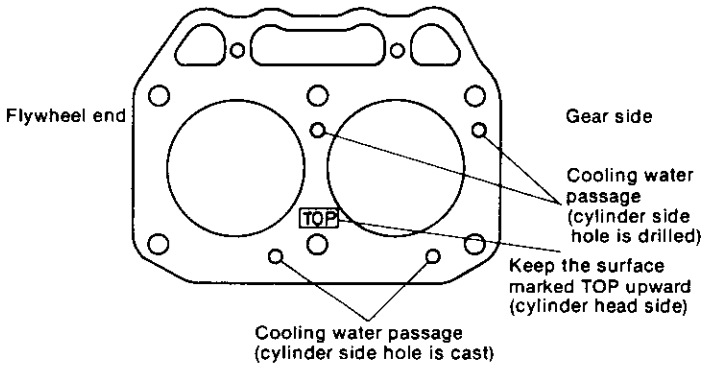
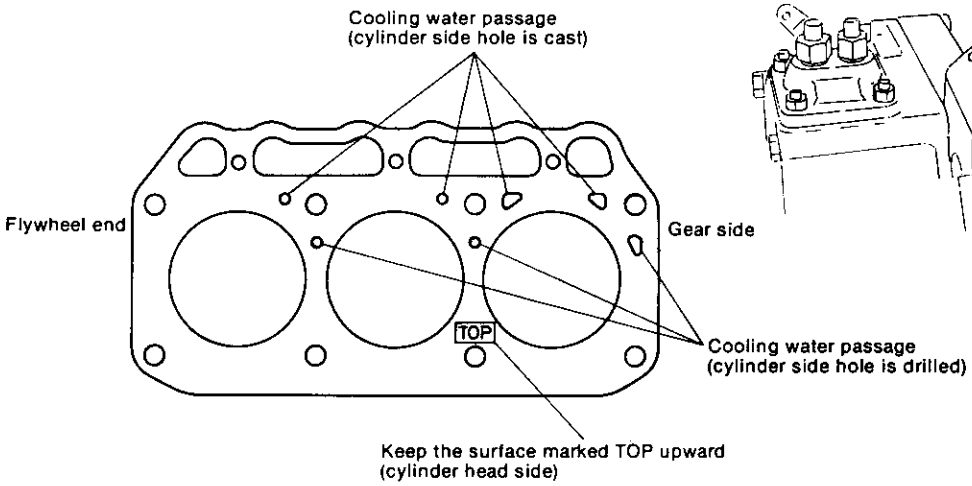
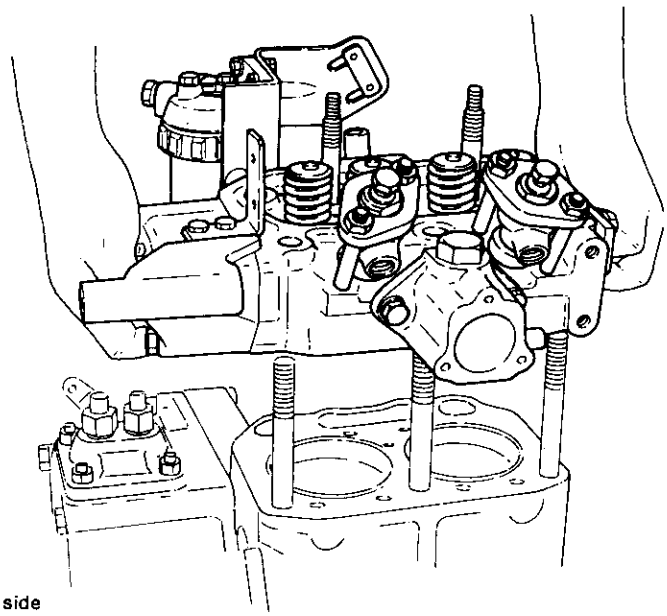
2) For model 2GM20(F)(C)



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



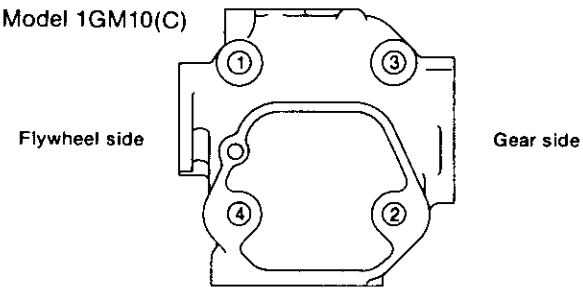
(3) Installing the cylinder head ass'y.
Position the cylinder head ass'y parallel to the top of the cylinder block, and install the ass'y on the block, being careful that the cylinder head ass'y does not touch the threads of the cylinder head bolts.



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)



kgf-m(ft-lb)

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

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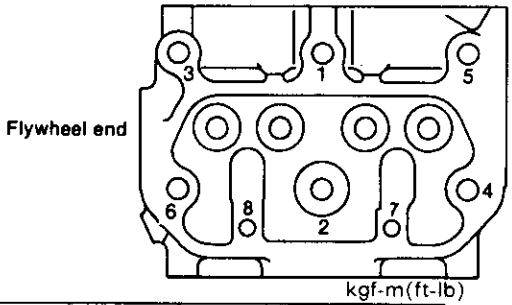
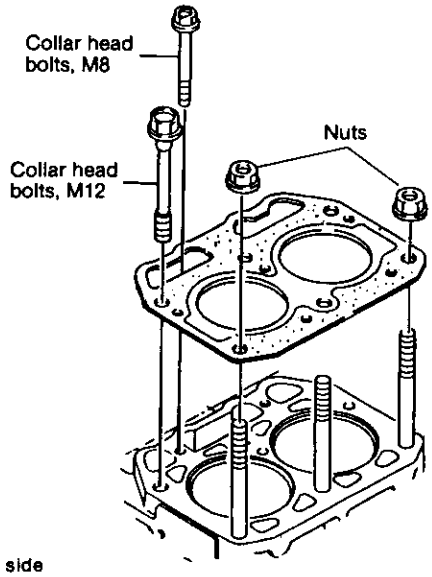
2) Model 2GM20(F)(C)

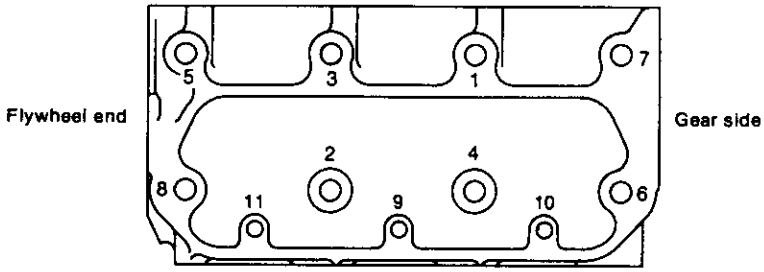




kgf-m(ft-lb)

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)

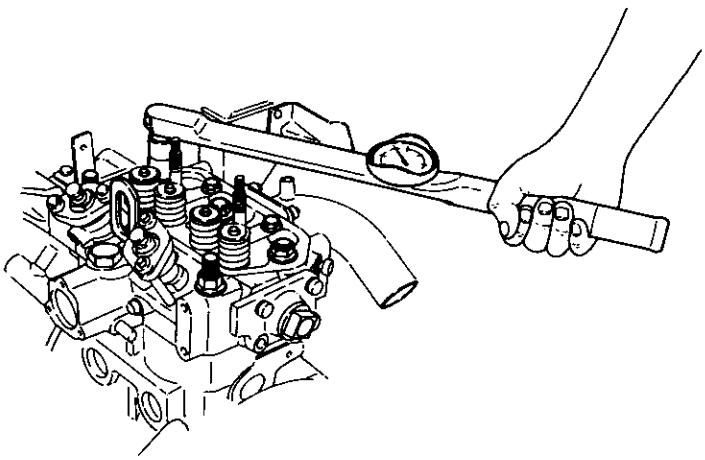


kgf-m(ft-lb)

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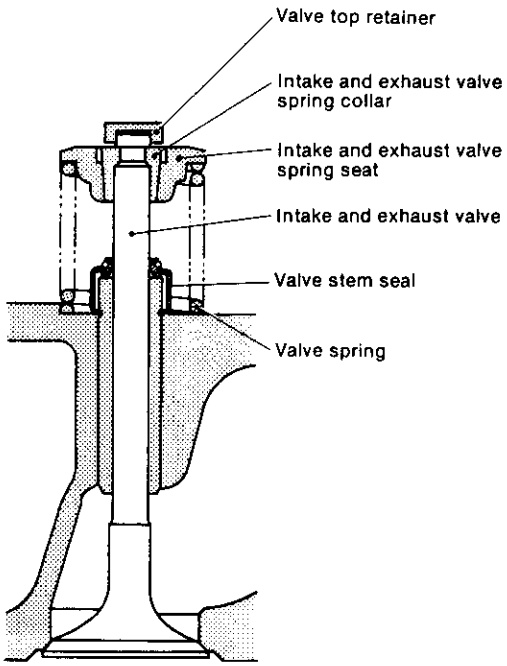
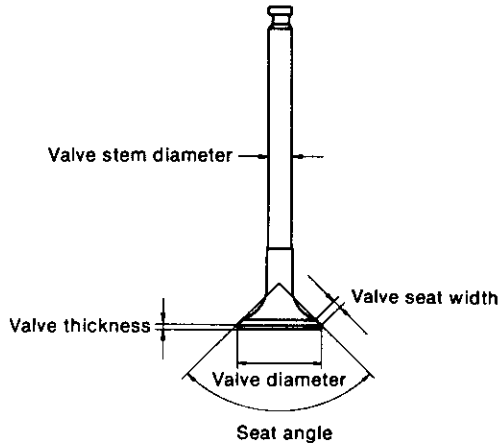
2-4 Intake and exhaust valves, valve guide and valve spring



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.)

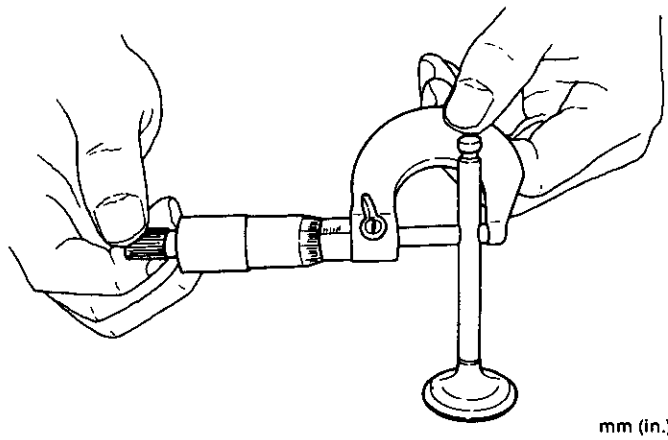
	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Intake valve diameter	ϕ32 (1.2598)	ϕ32 (1.2598)
Exhaust valve diameter	ϕ26 (1.0236)	ϕ27 (1.0630)
Valve seat width	3.15 (0.1240)	3.04 (0.1197)
Valve seat angle	90°	90°

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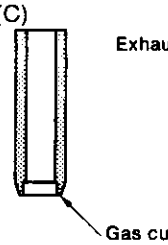
(3) Valve seat hairline cracks.
Inspect the valve seat by the color check, and replace the seat if cracked.

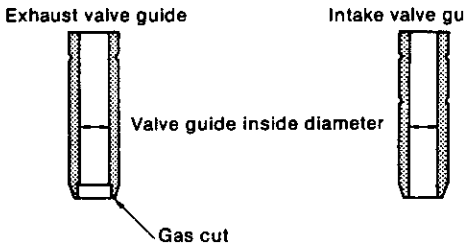
2-4.2 Inspecting and measuring valve guides

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.

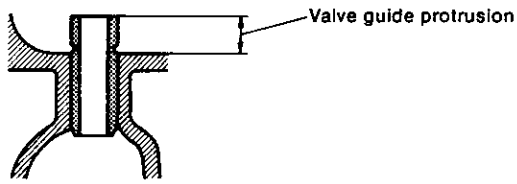
For model 1GM10(C)



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



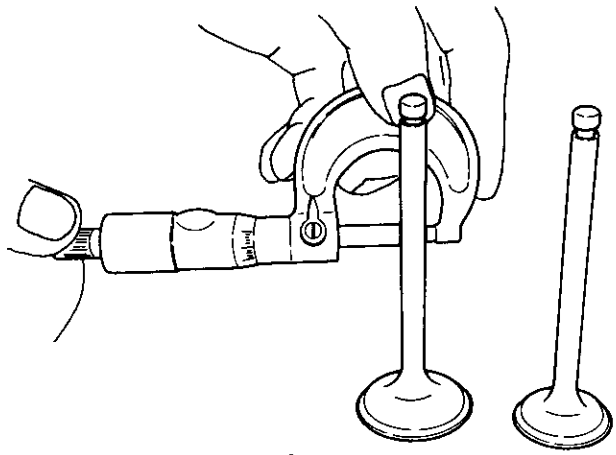
(1) Floating of the intake and exhaust valve guides.
Check for intake and exhaust valve guide looseness and floating with a test hammer, and replace loose or floating guides with guides having an oversize outside diameter.

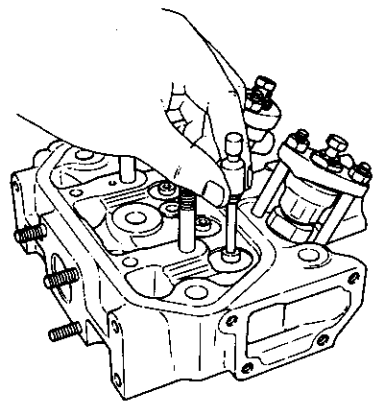


mm (in.)

	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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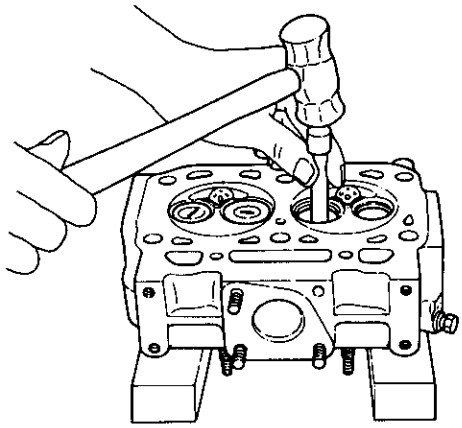
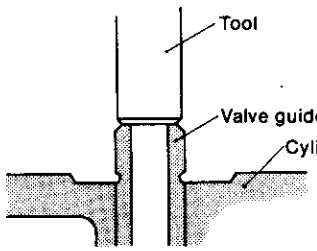
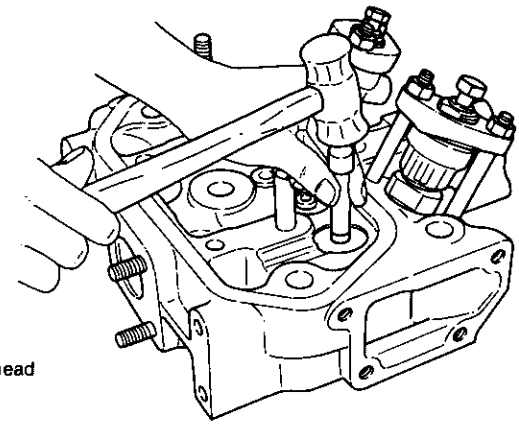
(3) Replacing the intake/exhaust valve guide

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





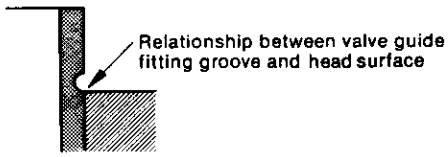
2) Using the above tool, drive the valve guide into position by starting from the valve spring side and finish the inside diameter with a reamer.



mm (in.)

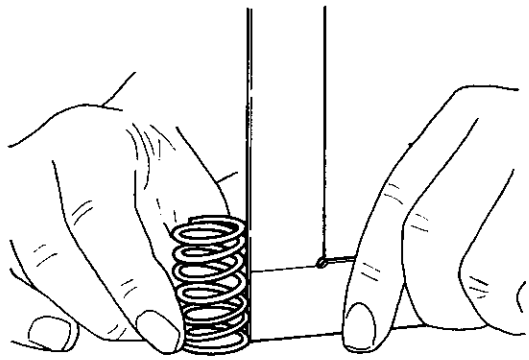
	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Amount of interference of valve guide	0.005 ~ 0.034 (0.0002 ~ 0.0013)	0.018 ~ 0.047 (0.0007 ~ 0.0019)	0.018 ~ 0.047 (0.0007 ~ 0.0019)

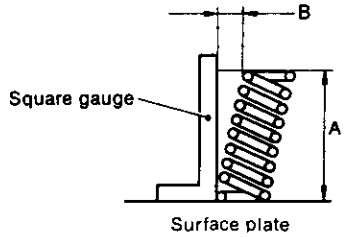
Fit the intake and exhaust valve guides until the bottom of the groove around the outside of the valve guide is flush with the end of the cylinder head.
As the valve guide for model 1GM10(C) does not have a groove, fit it after checking its dimension and marking it.



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.



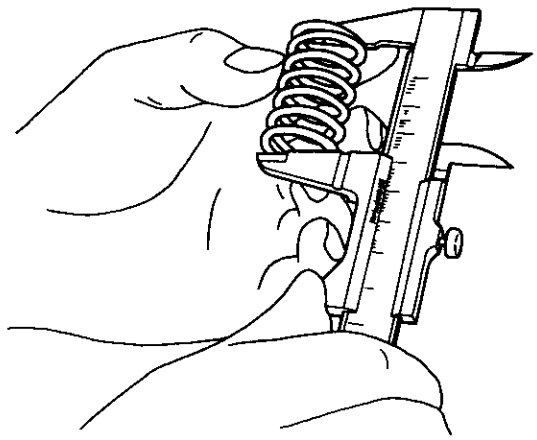


mm (in.)

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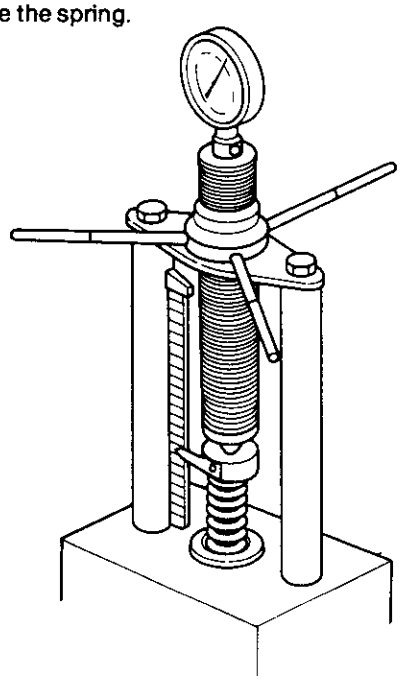
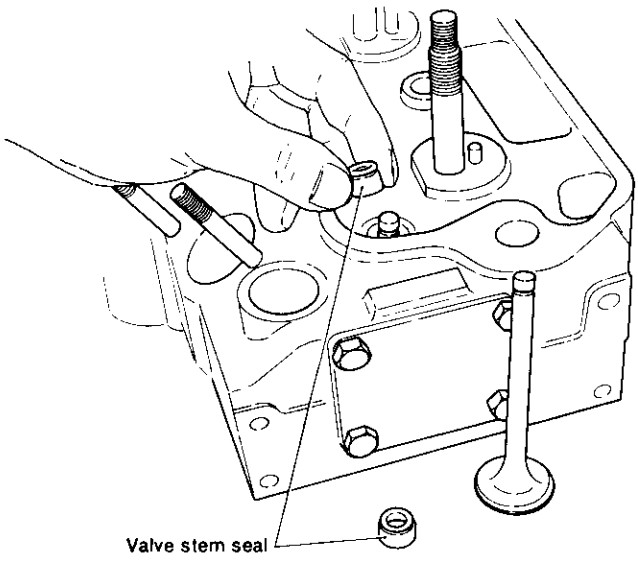
Also, measure the tension of the spring with a spring tester. If the tension is below the prescribed limit, replace the spring.

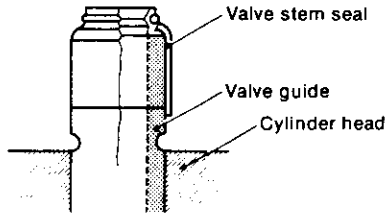


	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Valve spring free length	38.5mm (1.5157in.)	37mm (1.4567in.)	38.5mm (1.5157in.)	37mm (1.4567in.)
length when attached	29.2mm (1.1496in.)	—	30.2mm (1.1890in.)	—
Load applied attached	16.16kg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

2-4.4 Valve stem seal

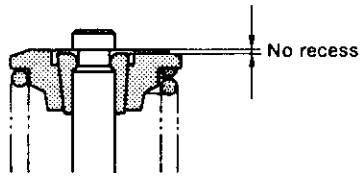


A valve stem seal is assembled at the top of the valve guide and the valve stem chamber oil is sucked into the combustion chamber through the valve guide (oil down) to prevent an increase in oil consumption.
The valve stem seal must always be replaced whenever it has been removed.
When assembling, coat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



2-4.5 Spring retainer and spring cotter pin

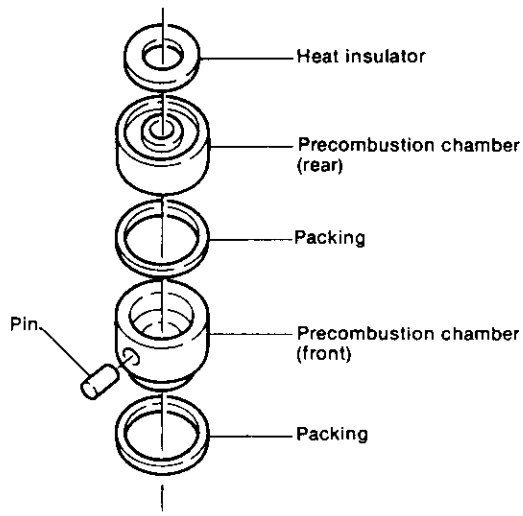
Inspect the inside face of the spring retainer and the outside surface of the spring cotter pin, and the contact area of the spring cotter pin inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter pin when the contact area is less than 70% or when the 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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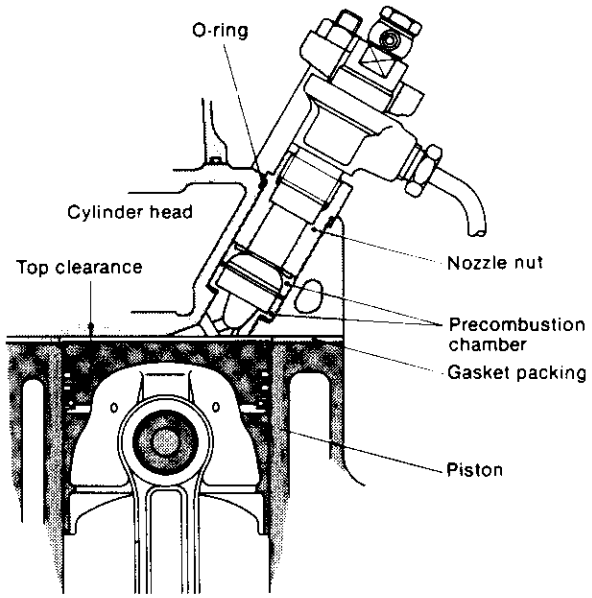
2-5.2 Insulation packing

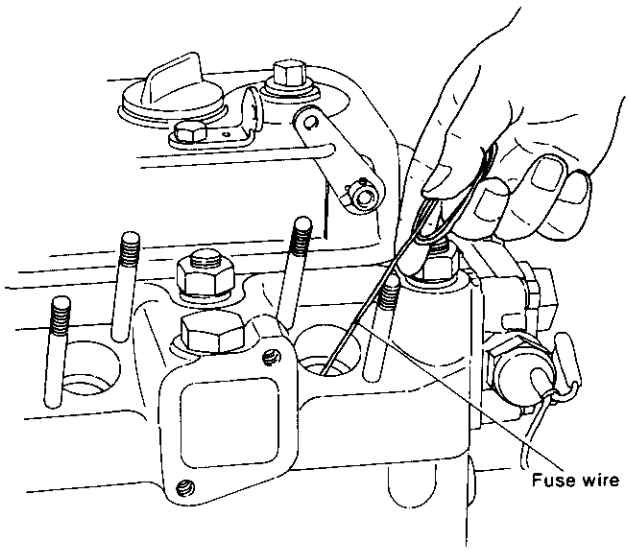
The insulation packing prevents transmission of heat from the precombustion chamber to the nozzle valve and serves to improve the nozzle's durability.
Always put in new insulation packing when it has been disassembled.

2-5.3 Top clearance

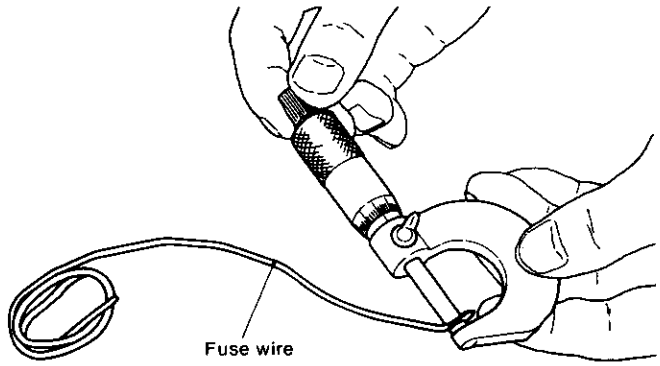
Top clearance is the size of the gap between the cylinder head combustion surface and the top of the piston at top dead center.
Since top clearance has considerable effect on the combustion performance and the starting characteristic of the engine, it must be checked periodically.



(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)

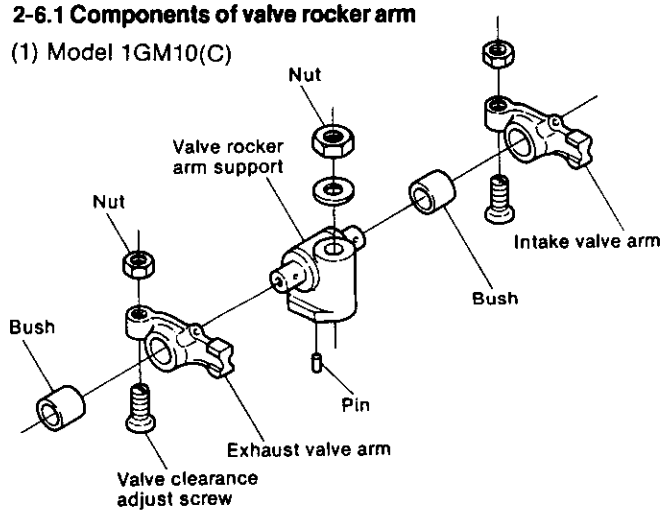
When the top clearance value is not within the above range, check for damaged gasket packing, distortion of the cylinder head combustion surface, or other abnormal conditions.

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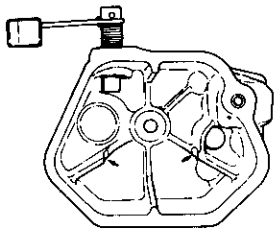
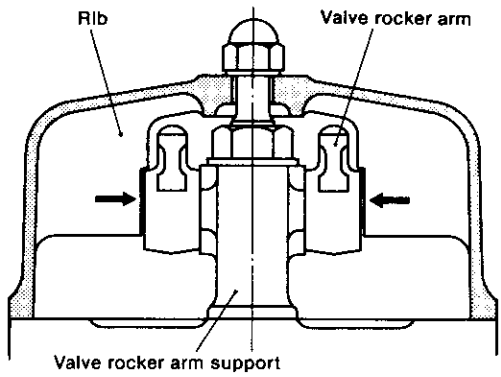
The same part is used for both intake valve rocker arm and exhaust valve rocker arm. The bush is not fitted to the valve rocker arm.
In has a simple construction as the valve rocker arms are fitted to the valve rocker arm support from both sides without using the retainer. In the place of a retainer,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

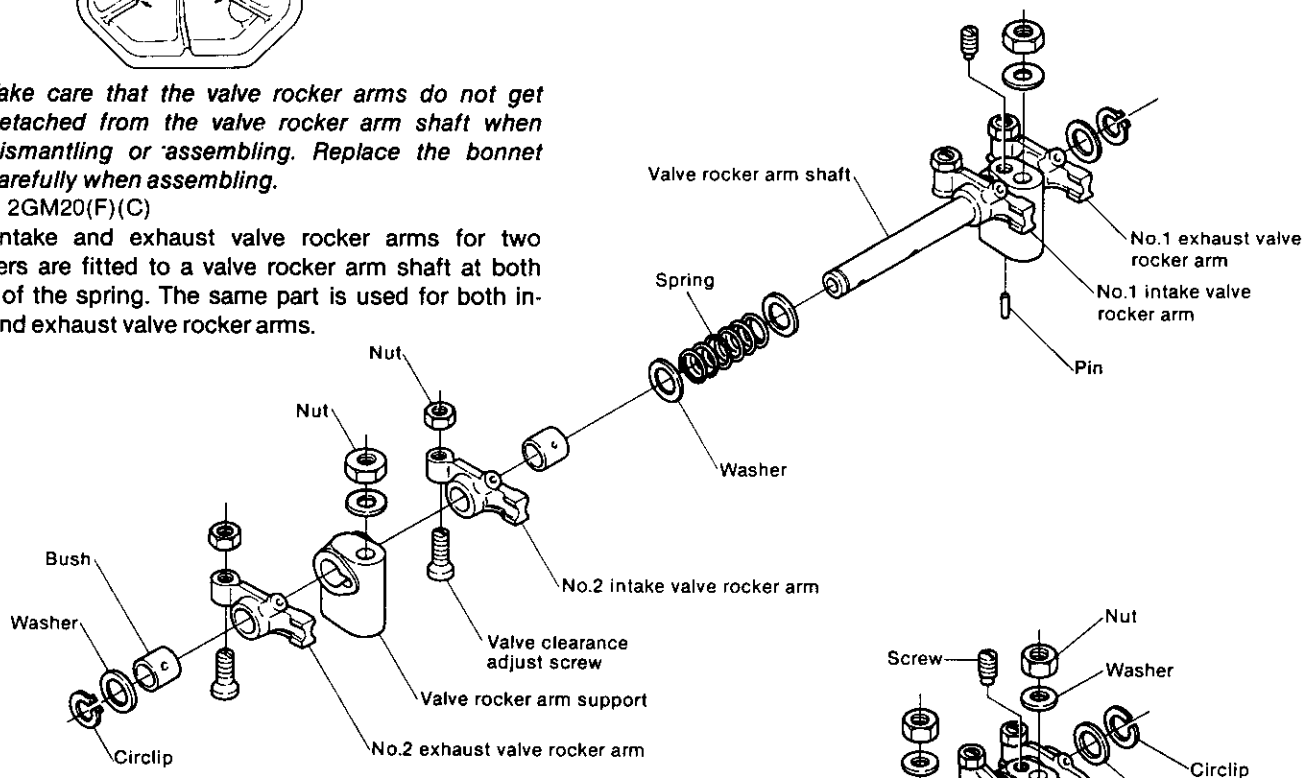




NOTE: Take care that the valve rocker arms do not get detached from the valve rocker arm shaft when dismantling or assembling. Replace the bonnet carefully when assembling.

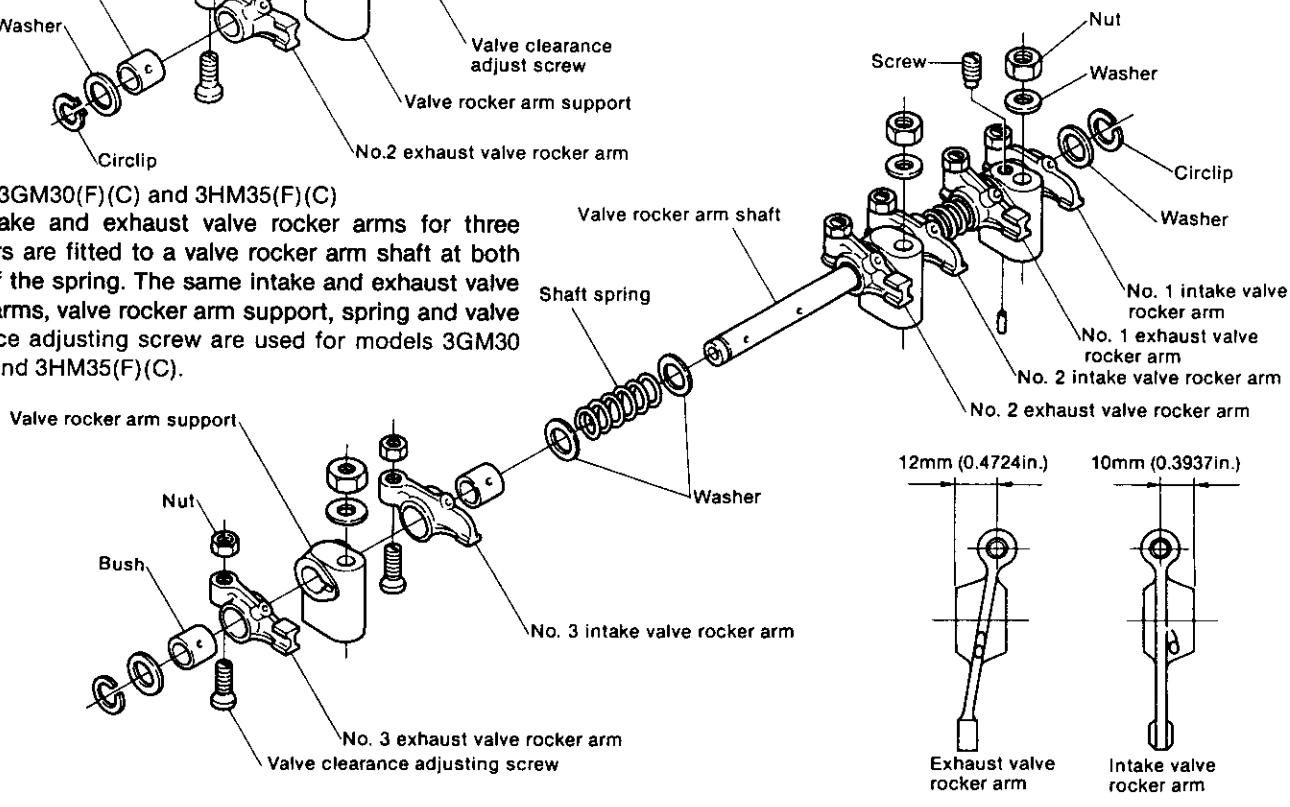
(2) Model 2GM20(F)(C)

The intake and exhaust valve rocker arms for two cyinders 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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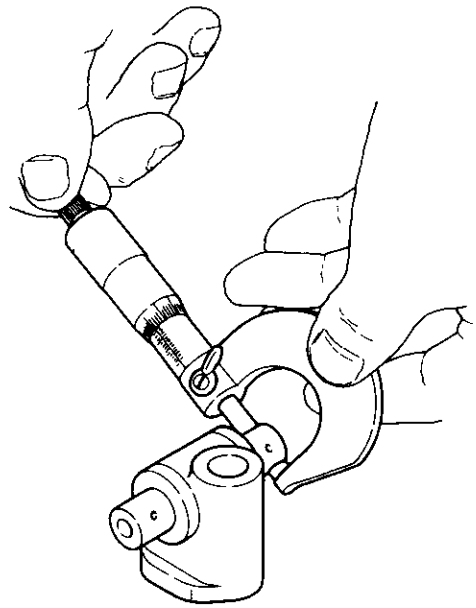
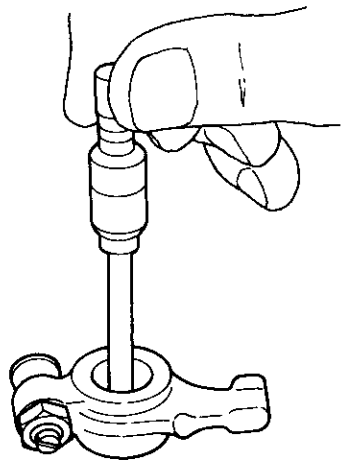
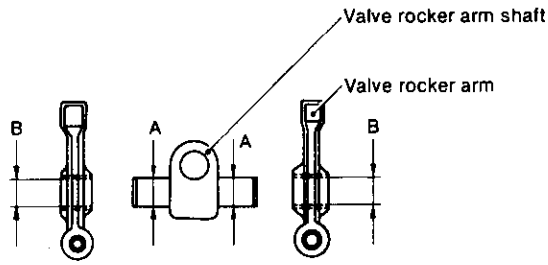
2-6.2 Measuring the valve rocker arm shaft and bushing clearance

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.

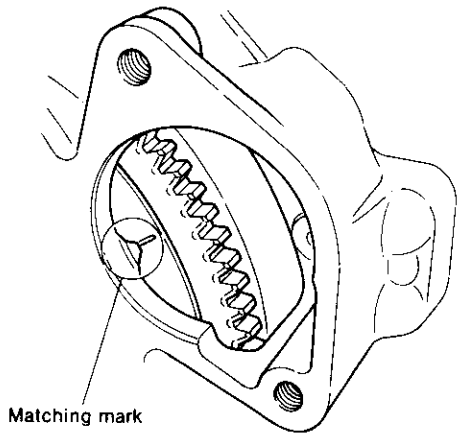
2-7.1 Adjustment

Make this adjustment when the engine is cold.

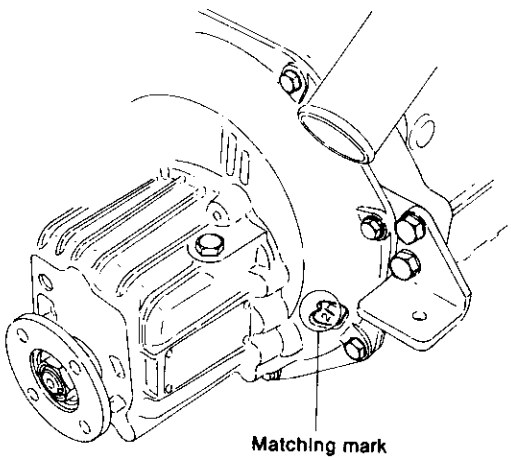
(1) Remove the valve rocker arm cover.

(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.

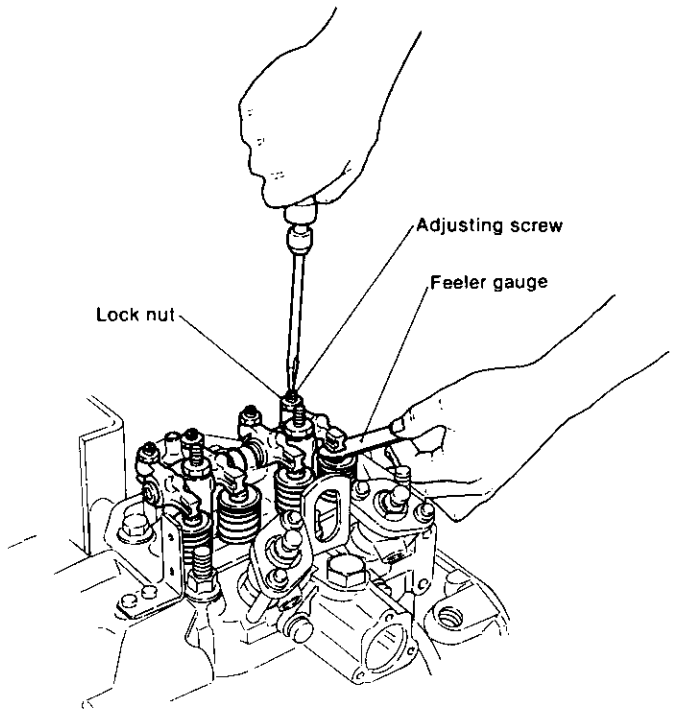


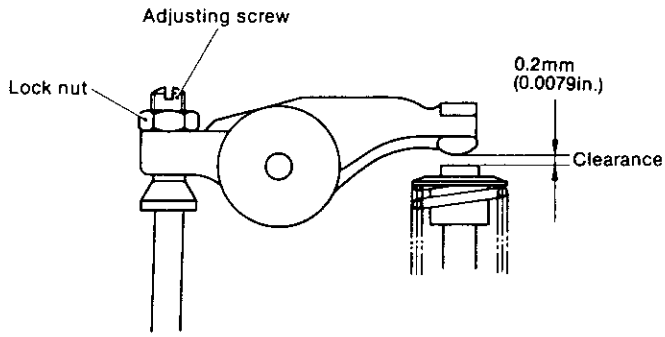
With respect to models 1GM10(C), 2GM20(F)(C) and 3GM30 .(F)(C) only, a projection which serves as the matching mark is provided in the cast hole of the clutch housing.



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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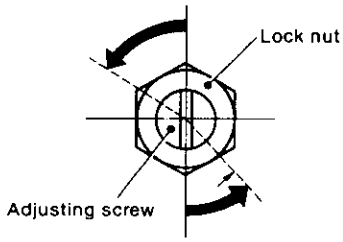
3-7.2 Adjusting without a feeler gauge

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.)

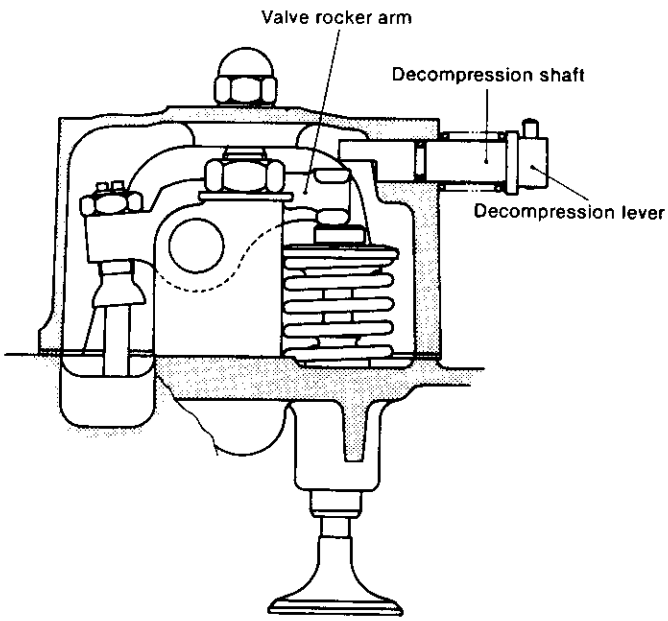
Valve clearance adjusting screw	M8 × 1.25 (0.3149 × 0.0492)
Adjusting screw backoff angle	Approx 58°

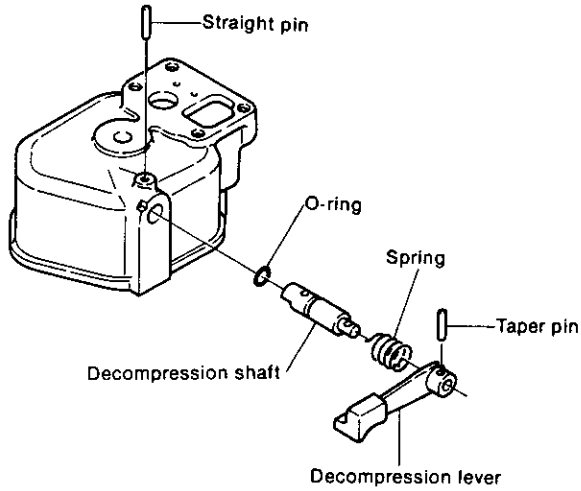
NOTE: Calculating the backoff angle.
calculate the 0.2mm advance angle from 1.25mm advance at one turn = 360°
0.2/1.25×360° = 58°
One side (60°) of the hexagonal nut should be used to measure.

2-8 Decompression mechanism

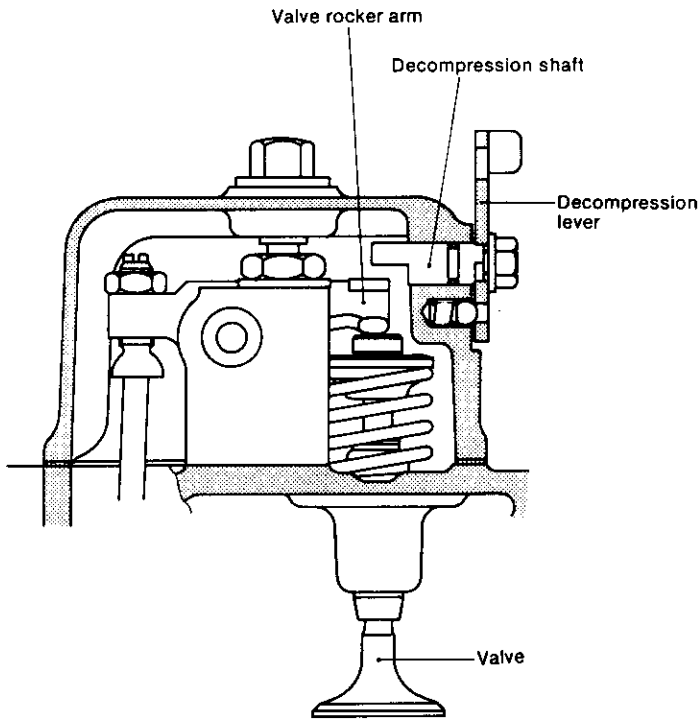
The decompression mechanism is used when the starter motor fails to rotate sufficiently because the battery is weak, and to facilitate starting in cold weather.
When the decompression lever is operated, the valve is pushed down, the engine is decompressed, the engine turns over easily and the flywheel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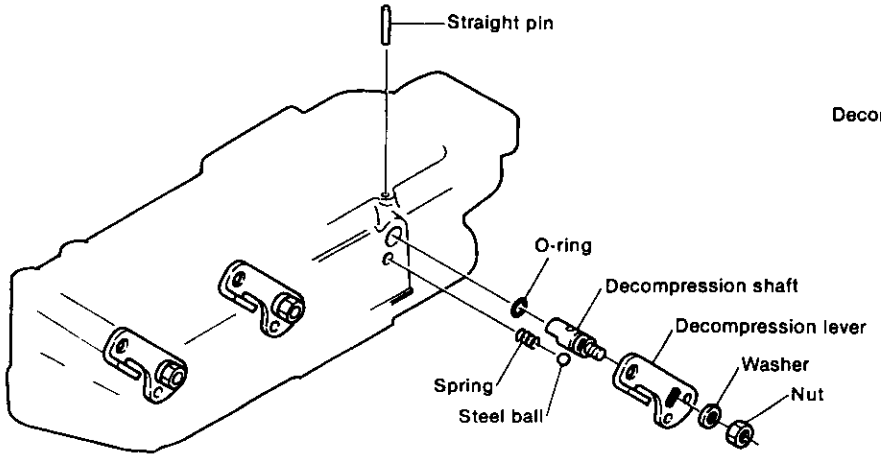
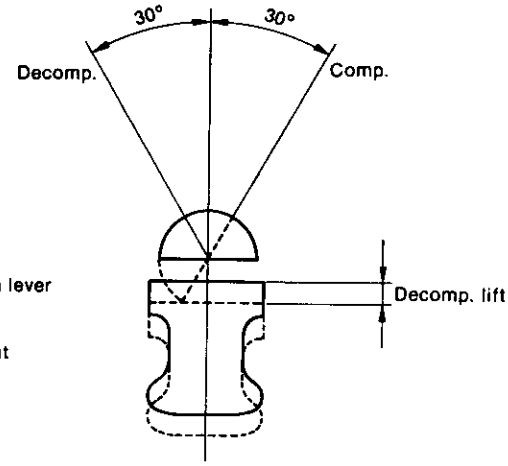




With this engine, there is no need to adjust the decompression lift.

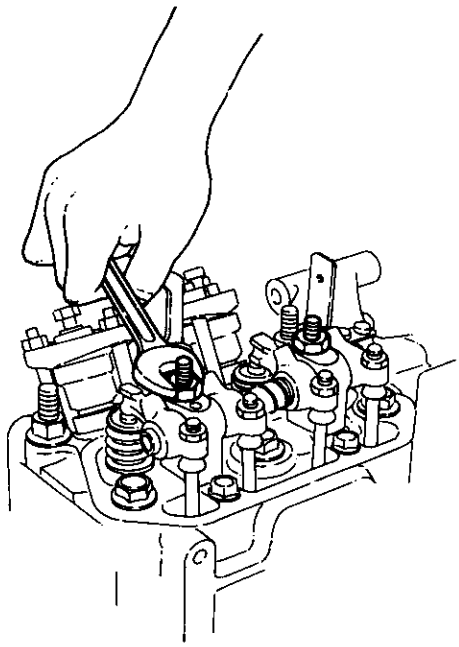
2-9 Disassembling and reassembling the cylinder head

2-9.1 Disassembling the cylinder head

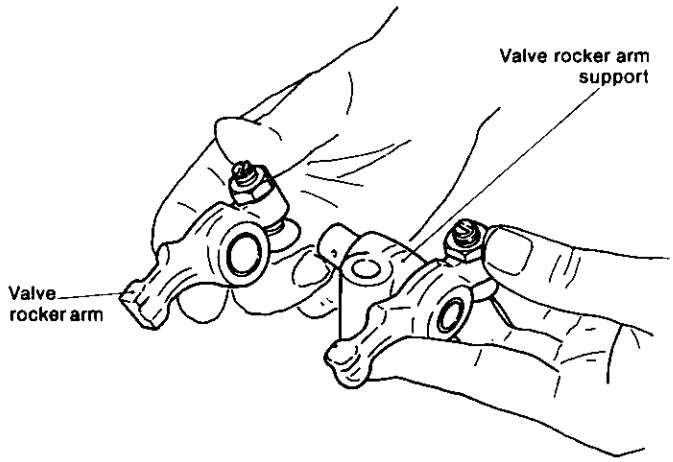
When disassembling the cylinder head, group the parts separately according to cylinder, intake or exhaust to avoid confusion.

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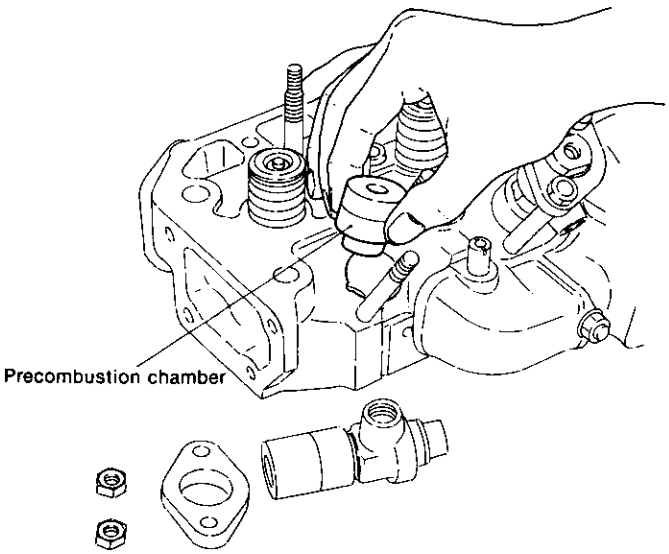
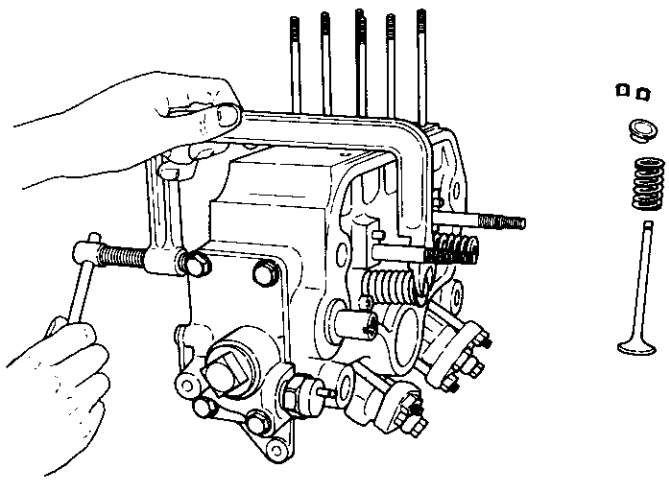
(2) Removing the precombustion chamber
1) Remove the rear precombustion chamber and packing.
2) Remove the front precombustion chamber and packing.



(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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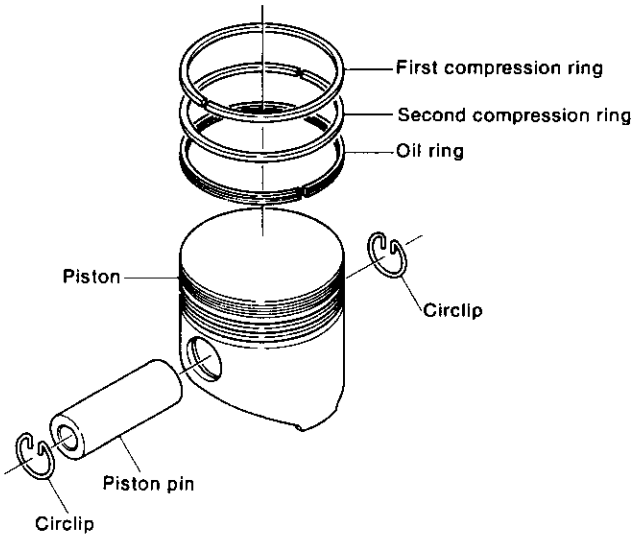
3. Piston

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.

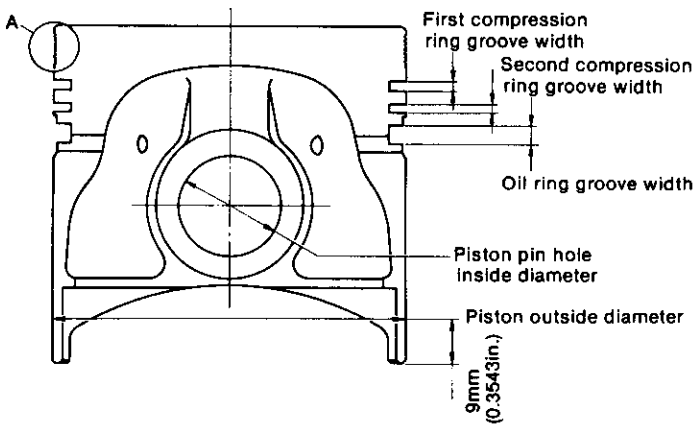


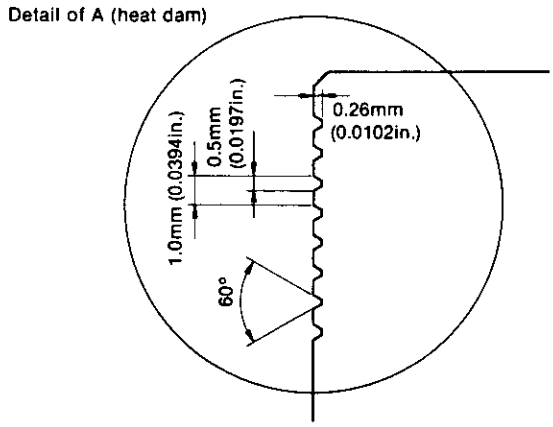
A complete set of piston rings consists of two compression rings and one oil ring.
To improve the rigidity of the piston skirt no ring is installed on the skirt itself so that the piston seldom becomes deformed and retains stable contact.
The piston pin is of the floating type. Both its ends are fastened 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.

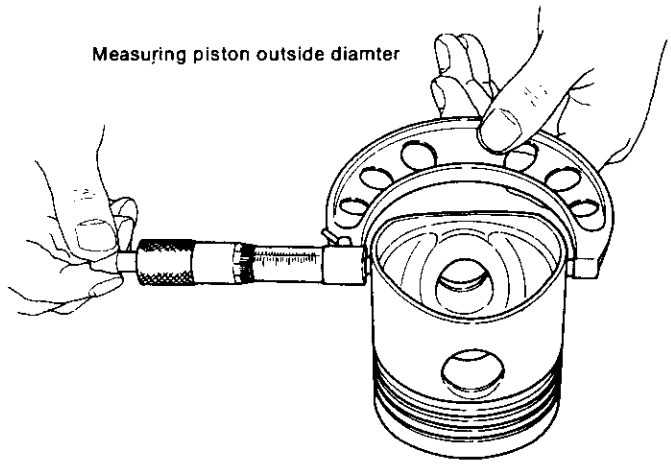
3-2 Piston

3-2.1 Inspection

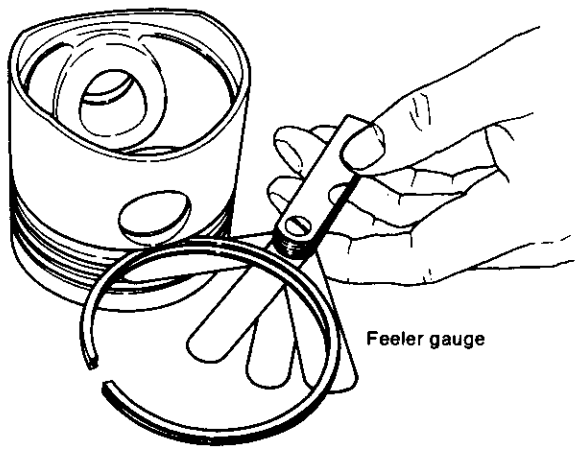
(1) Measuring important dimensions
Measure each important dimension, and replace the piston when the wear limit is exceeded.

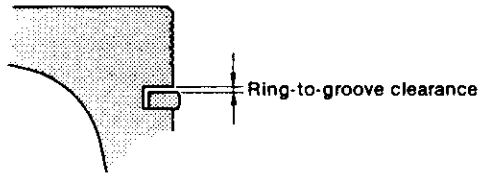






(2) Measure the clearance between the piston ring or oil ring and the ring groove with a thickness gauge.





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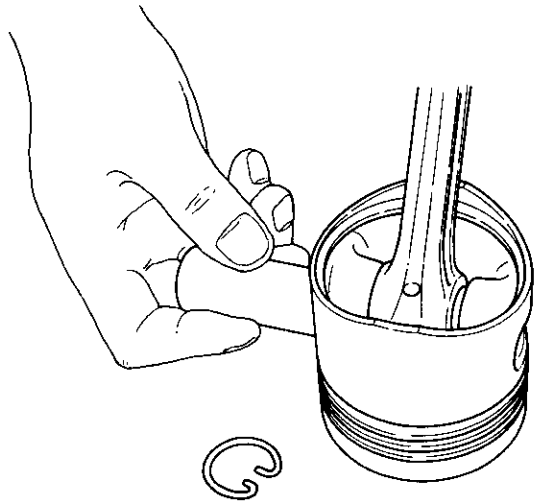
mm (in.)

	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)

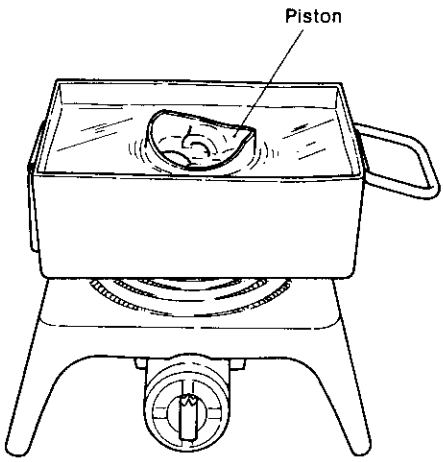
(3) Piston pin outside contact and ring groove carbon build-up.
check if the piston ring grooves are clogged with carbon, if the rings move freely, and for abnormal contact around the outside of the piston. Repair or replace the piston if faulty.



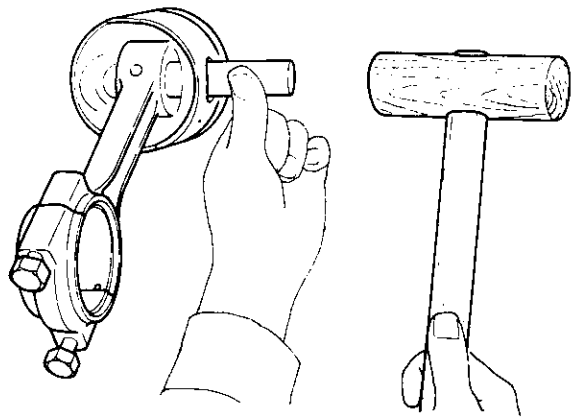
3-2.2 Replacing a piston

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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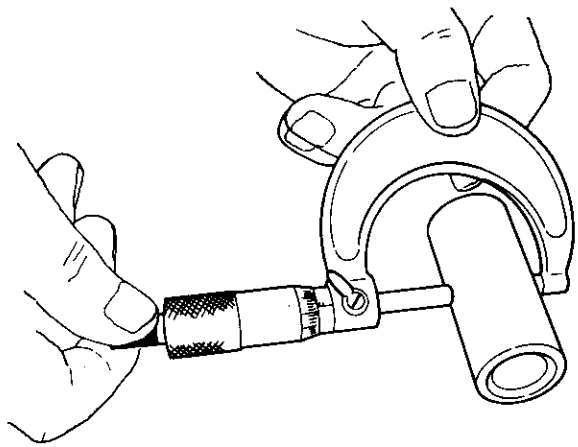
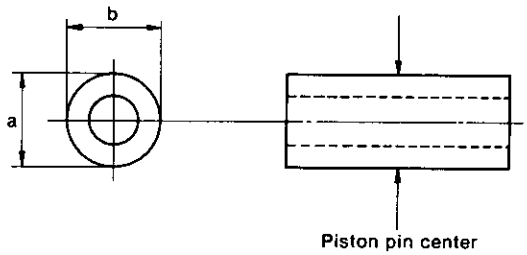
3-3 Piston pin and piston pin bushing

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	$\phi 20^{0}_{-0.009}$ (0.7870 ~ 0.7874)	ø19.98 (0.7866)	$\phi 23^{0}_{-0.009}$ (0.9052 ~ 0.9055)	ø22.98 (0.9047)
Piston pin hole and piston pin tightening allowance	−0.005 ~ +0.017 (−0.0002 ~ +0.0007)	—	−0.005 ~ +0.017 (−0.0002 ~ +0.0007)	—

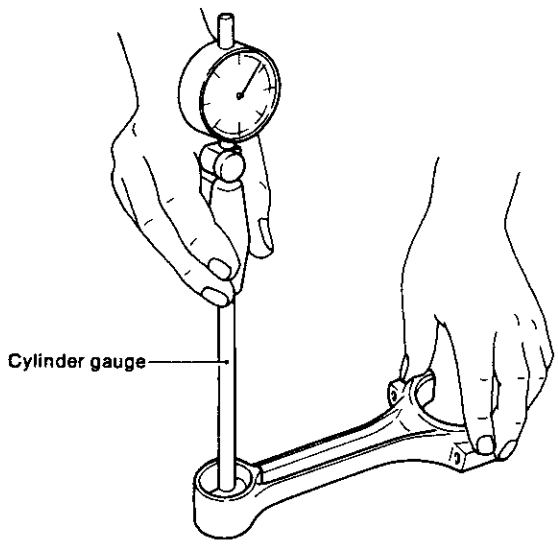
3-3.2 Piston pin bushing

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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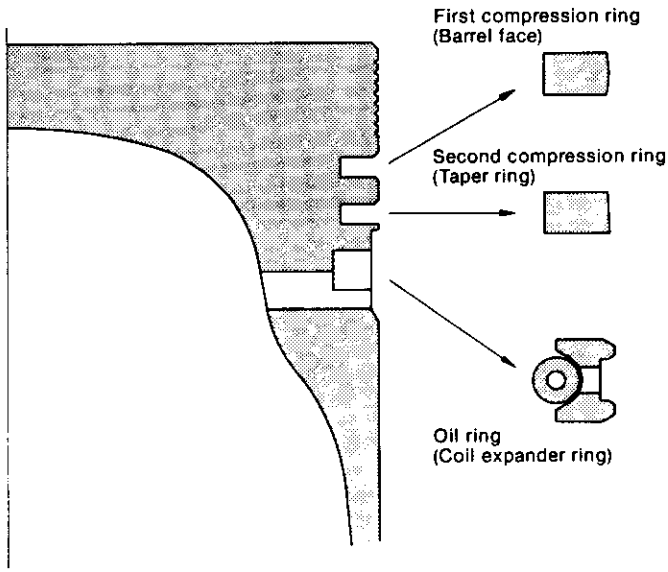
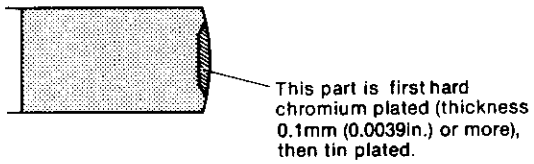
3-4 Piston rings

3-3.1 Piston ring configuration

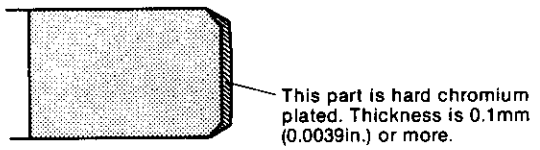


(1) The first compression ring is a barrel face ring that effectively prevents abnormal wear caused by engine loading and combustion gas blowby at initial run-in.
The sliding surface is hard chromium plated.

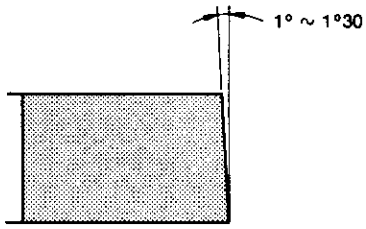
Model 3HM35(F)(C)



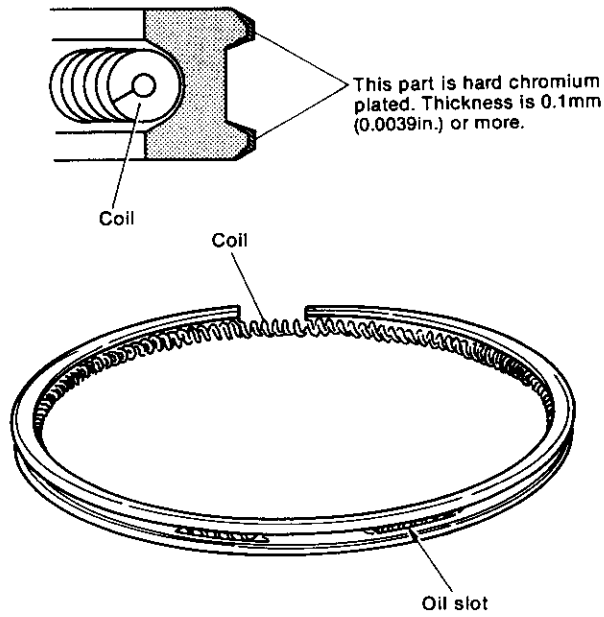
Models 1GM10(C), 2GM20(F)(C), 3GM30(F)(C)



(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.



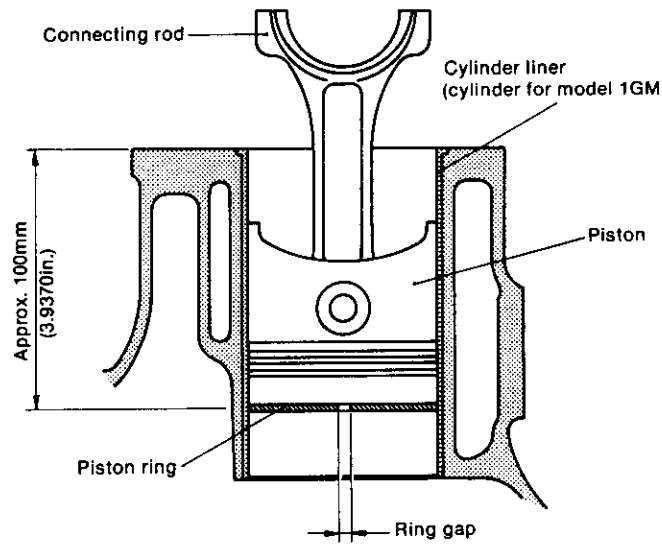
(3) The oil ring is a chrome-plated coil expander having a small contacting face, and exerts high pressure against the cylinder liner wall. Oil splash at the bottom of the sliding face is excellent, and its oil control effect is high.



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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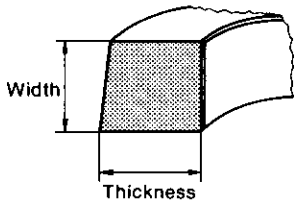
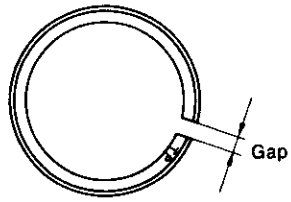


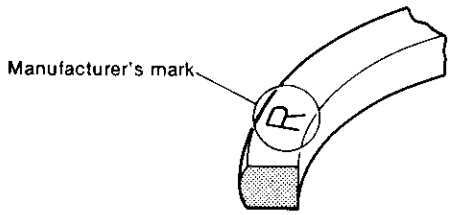


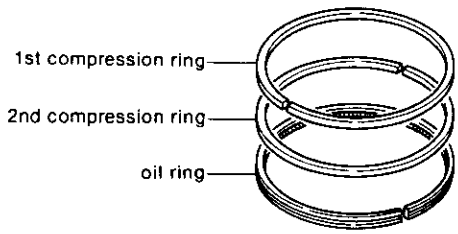
mm (in.)

		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)

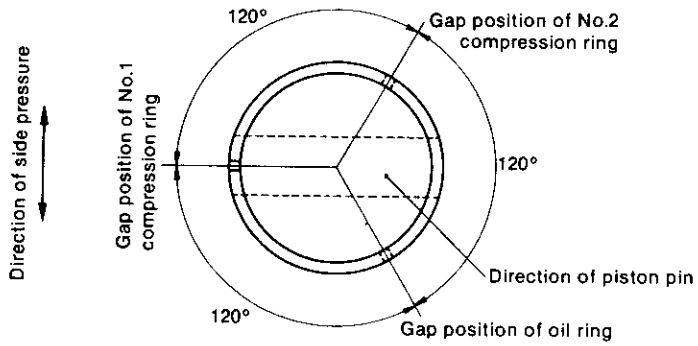
(3) Piston ring replacement precautions

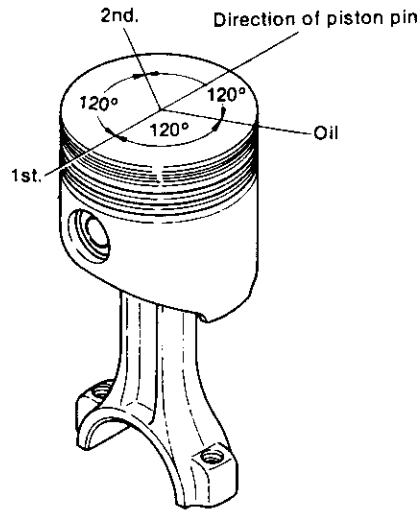
1) Clean the ring grooves carefully when replacing the rings.
2) When installing the rings, assemble the rings so that the manufacturer's mark near the gap is facing the top of the piston.





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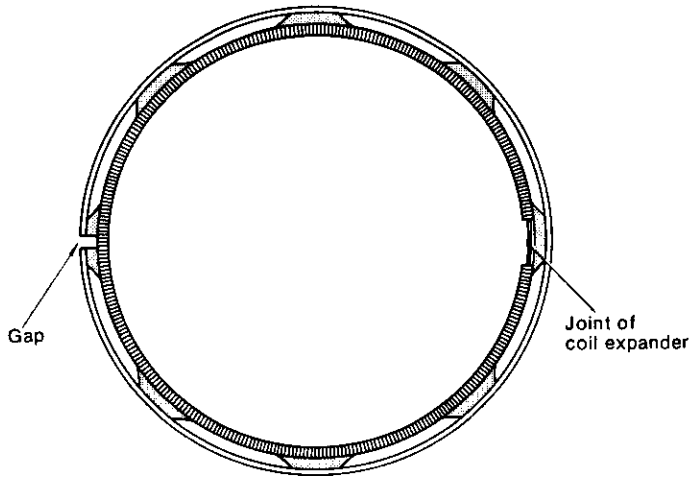
5) Since the oil ring is equipped with a coil expander, attach it to the piston so that the joint of the ring is opposite the gap of the coil expander.



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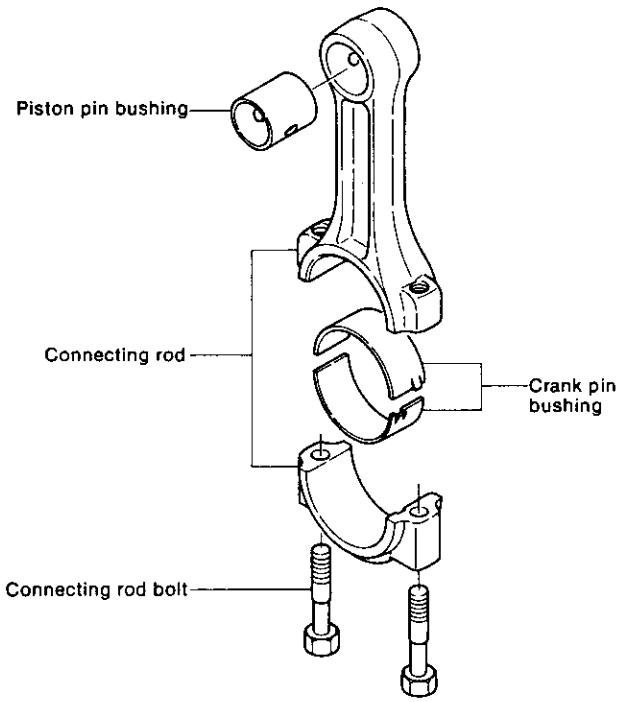
4. Connecting Rod

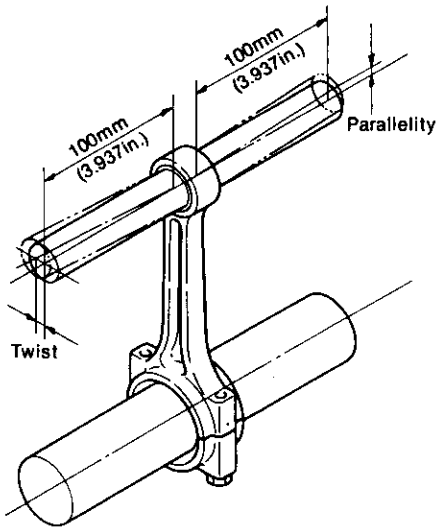
4-1 Connecting rod ass'y construction

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

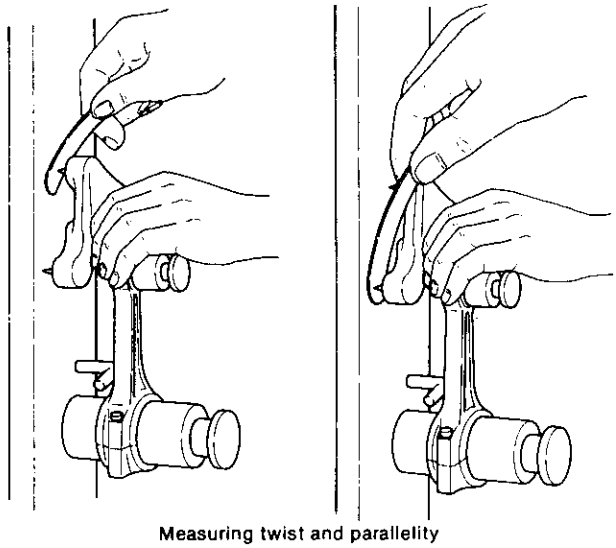
4-2.1 Large and small end twist and parallelity



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.)

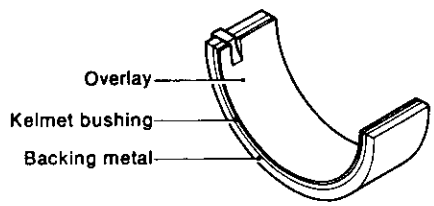
Maintenance standard	0.03/100 or less (0.00118/3.937)
Limit	0.08/100 (0.00315/3.937)



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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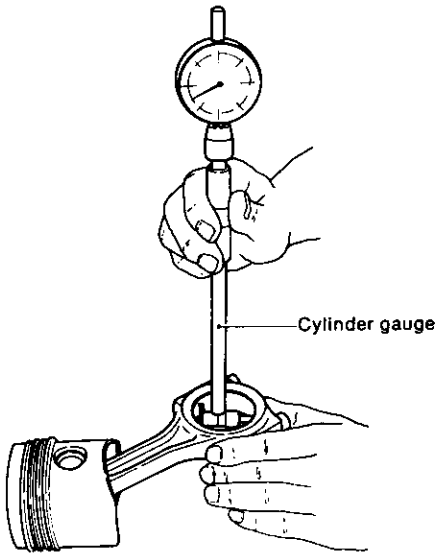


mm (in.)

	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	2.5kgf-m (18.1ft-lb)		4.5kgf-m (32.5ft-lb)	

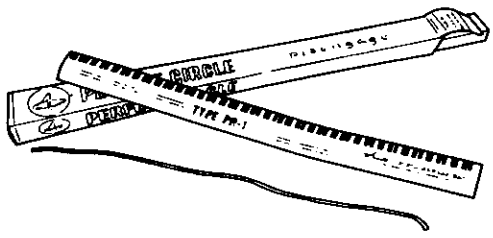
NOTE: The Crank pin bushing inside diameter must always be measured with the connecting rod bolts tightened to the prescribed torque.

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

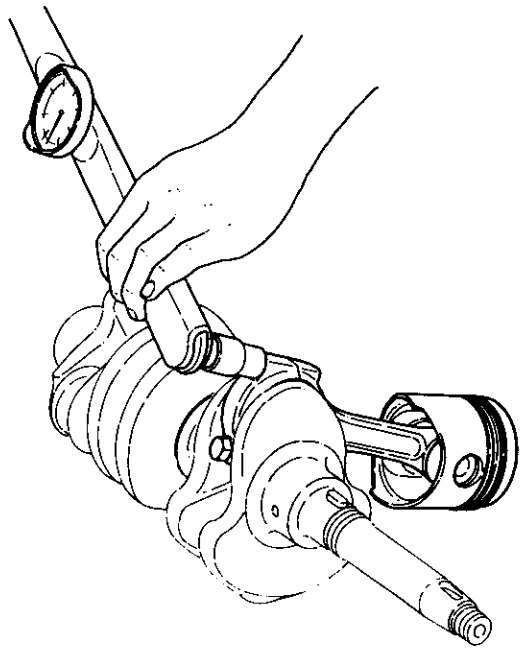
Since the oil clearance affects both the durability of the bushing and lubricating oil pressure, it must always be the prescribed value. Replace the bushing when the oil clearance exceeds the wear limit.

(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.

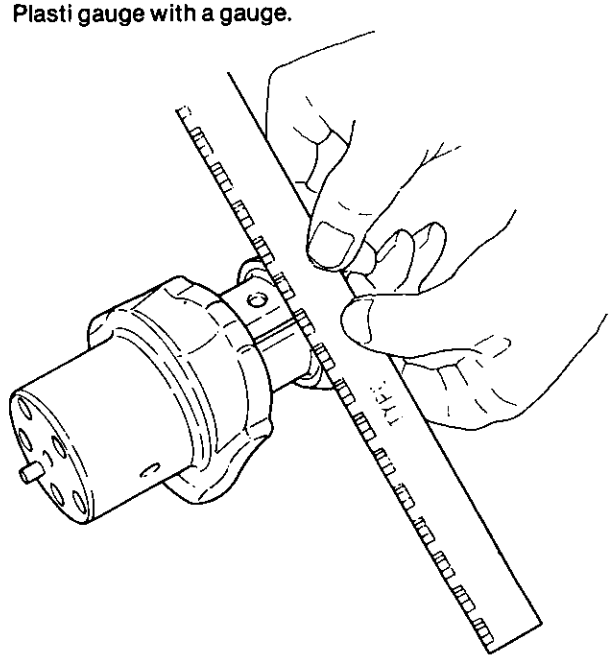


3) Tighten the connecting rod bolt to the prescribed tightening torque.



	1GM10(C) 2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Connecting rod tightening torque	2.5kgf-m (18.1ft-lb)	4.5kgf-m (32.5ft-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.

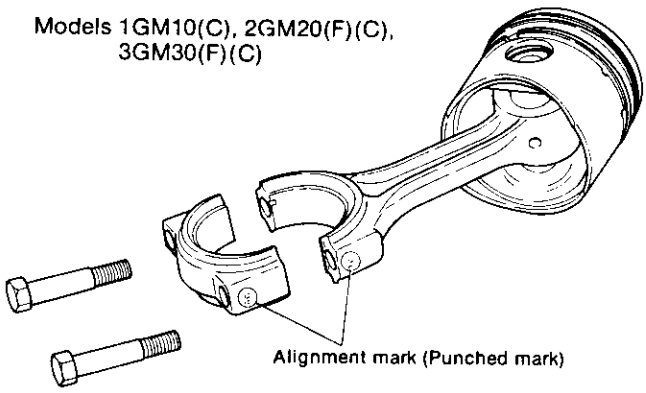
4-3.3 Crank pin bushing replacement precautions

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

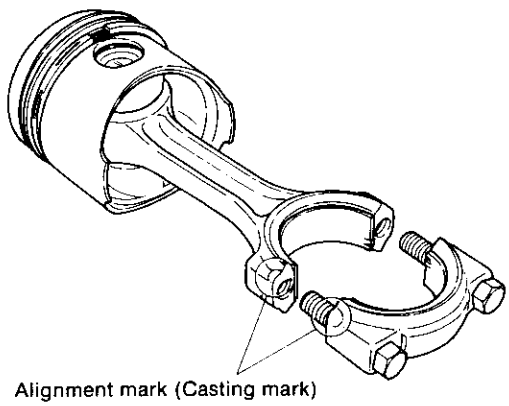
(2) Also clean the big end cap, install the crank pin bushing and check if the bushing contacts with the big end cap closely.

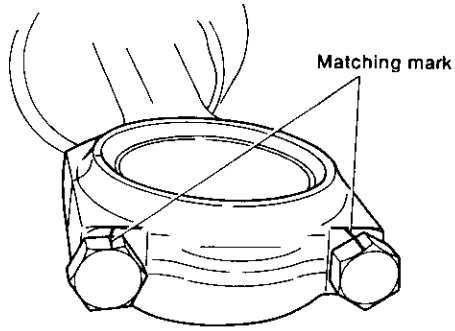
(3) When assembling the connecting rod, match the number of the big end section and the big end cap, coat the bolts with engine oil, and alternately tighten the bolts gradually to the prescribed tightening torque. If a torque wrench is not available, put matching marks (torque indication lines) on the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



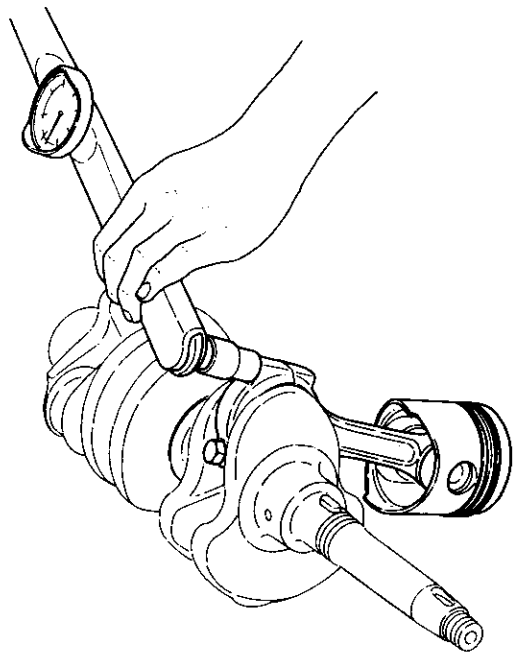


(4) Check that there is no sand or metal particles in the lubricating oil and that the crankshaft is not pitted. Clean the oil holes with particular care.

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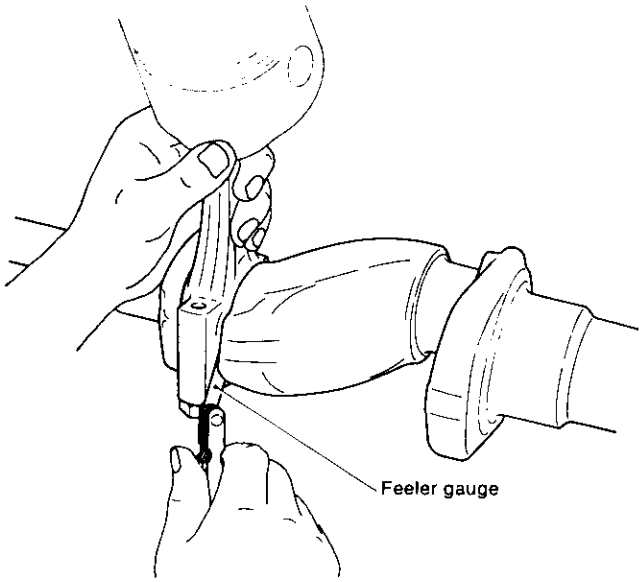
The connecting rod bolts must also be tightened to the prescribed tightening torque in this case.

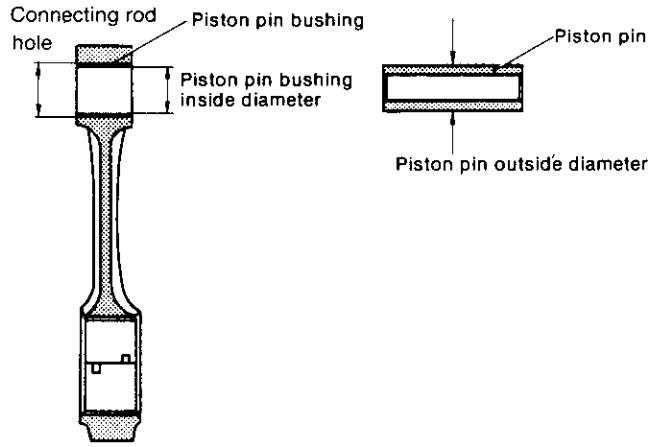


mm (in.)

	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.

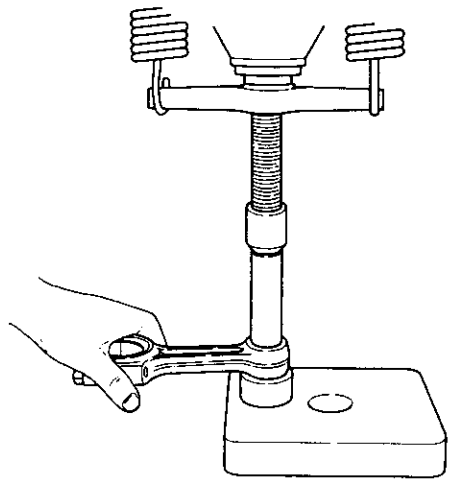


mm (in.)

	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)	—

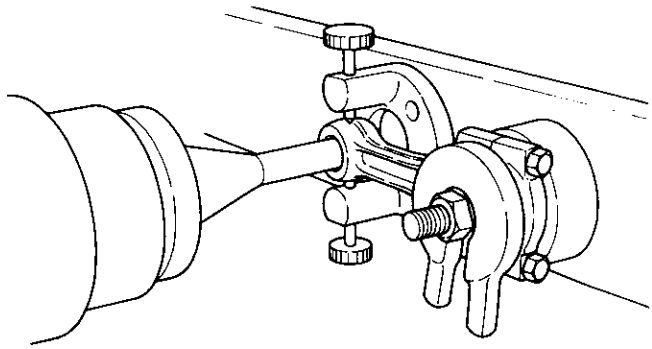
Replacing the piston pin bushing

(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.

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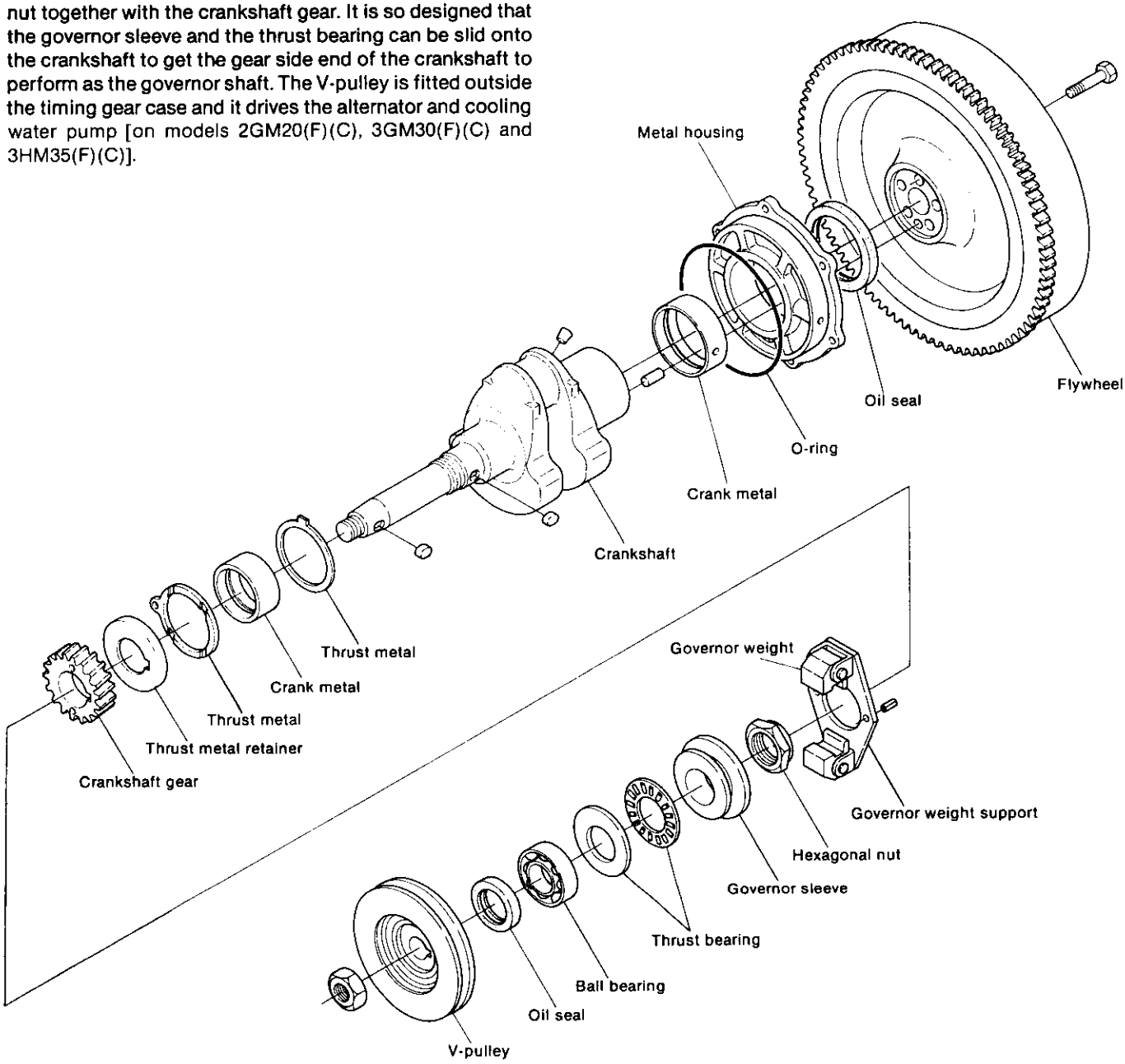
5. Crankshaft

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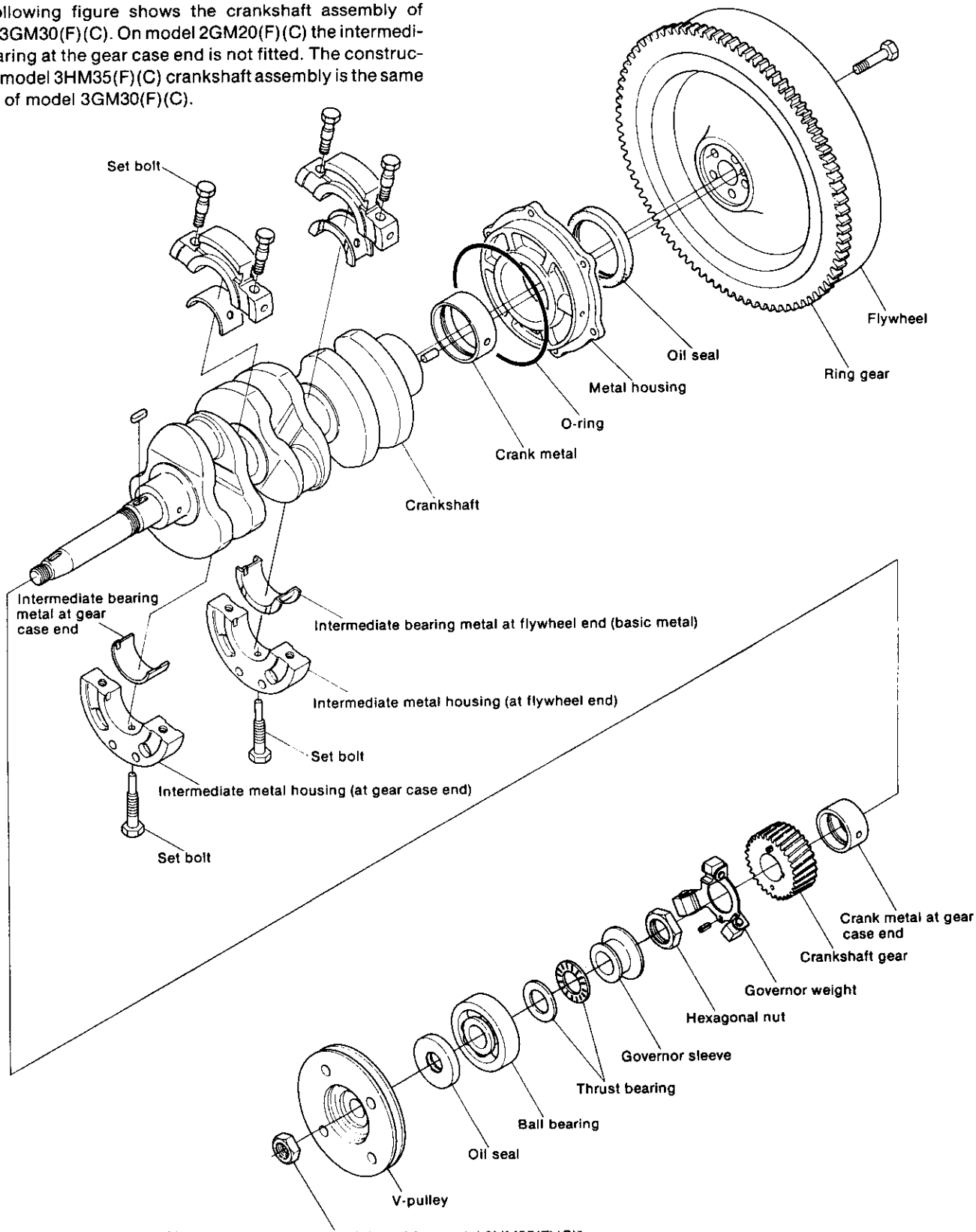
5-1.2 Construction of models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C) crankshaft assembly

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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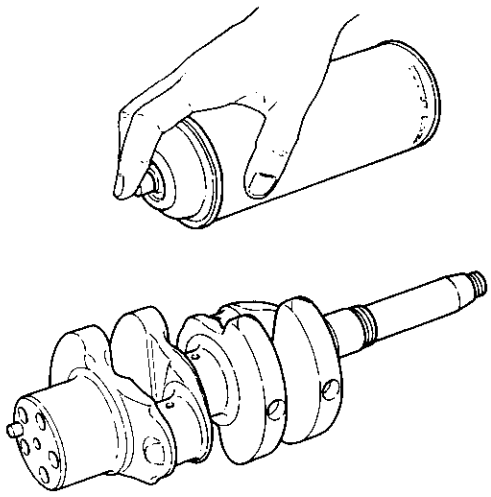
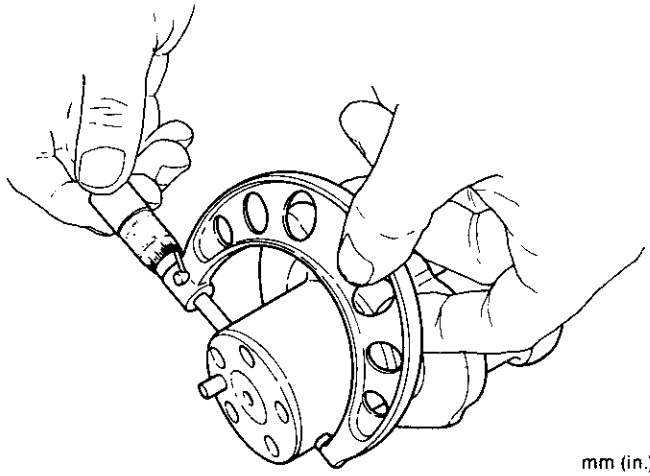
5-2 Inspection

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.

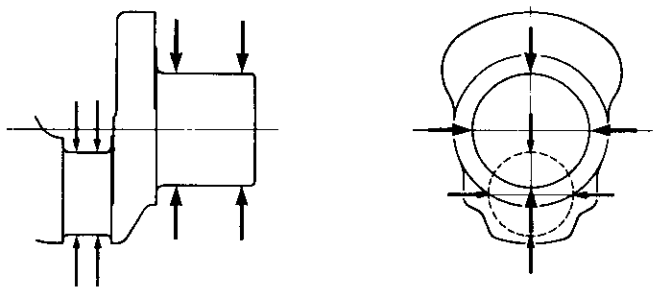


mm (in.)

			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	$\phi 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\phi 47^{-0.036}_{-0.050}$ (1.8484 ~ 1.8490)	ø46.90 (1.8465)
	Intermediate bearing	B	$\phi 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)	$\phi 47^{-0.036}_{-0.050}$ (1.8484 ~ 1.8490)	ø46.90 (1.8465)
	Flywheel side	C	$\phi 60^{-0.036}_{-0.050}$ (2.3602 ~ 2.3608)	ø59.90 (2.3583)	$\phi 65^{-0.036}_{-0.050}$ (2.5571 ~ 2.5576)	ø64.90 (2.5551)
Crank pin outside diameter		D	$\phi 40^{-0.036}_{-0.050}$ (1.5728 ~ 1.5734)	ø39.90 (1.5709)	$\phi 44^{-0.036}_{-0.050}$ (1.7303 ~ 1.7309)	ø43.90 (1.7283)
Crank journal/pin eccentric wear			—	0.01 (0.0004)	—	0.01 (0.0004)
Crank journal and bushing oil clearance	Gear case side		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
	Intermediate bearing		0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.15 (0.0059)	0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)
	Flywheel side		0.036 ~ 0.095 (0.0014 ~ 0.0037)	0.15 (0.0059)	0.036 ~ 0.099 (0.0014 ~ 0.0039)	0.15 (0.0059)
Crank pin and crank pin bearing oil clearance			0.028 ~ 0.086 (0.0011 ~ 0.0034)	0.13 (0.0051)	0.036 ~ 0.092 (0.0014 ~ 0.0036)	0.13 (0.0051)

NOTE: The crankshaft of model 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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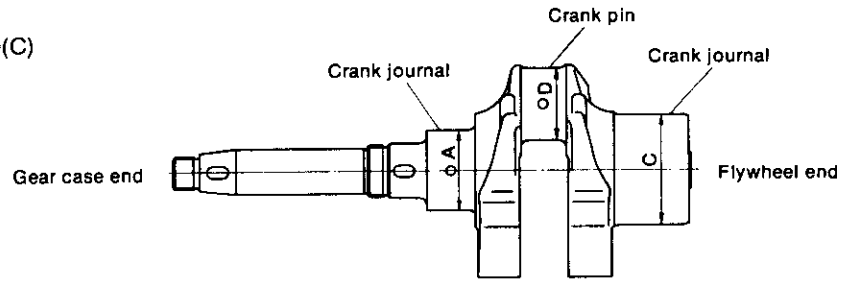
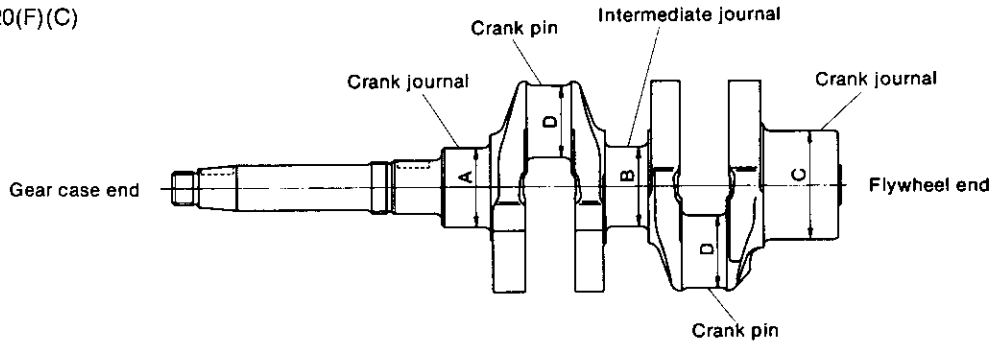
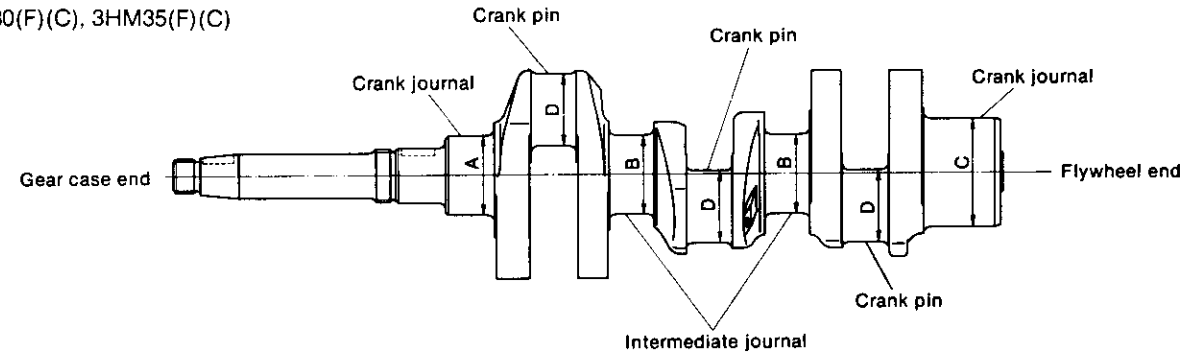
1GM10(C)



2GM20(F)(C)

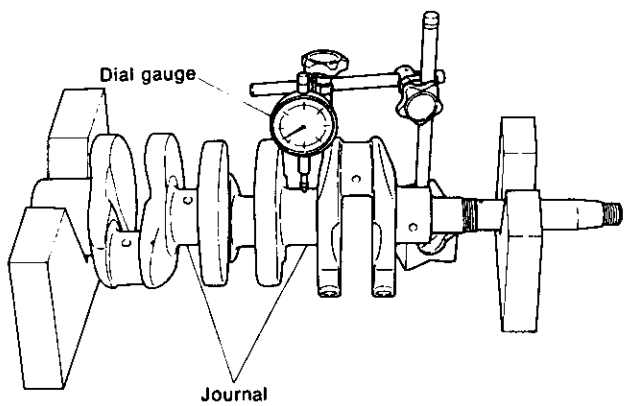


3GM30(F)(C), 3HM35(F)(C)



(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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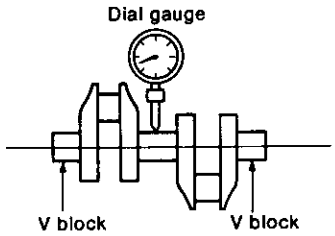
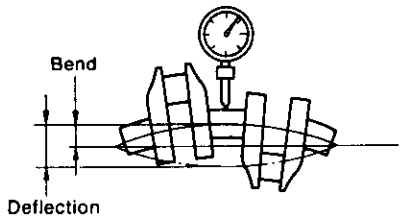




mm (in.)

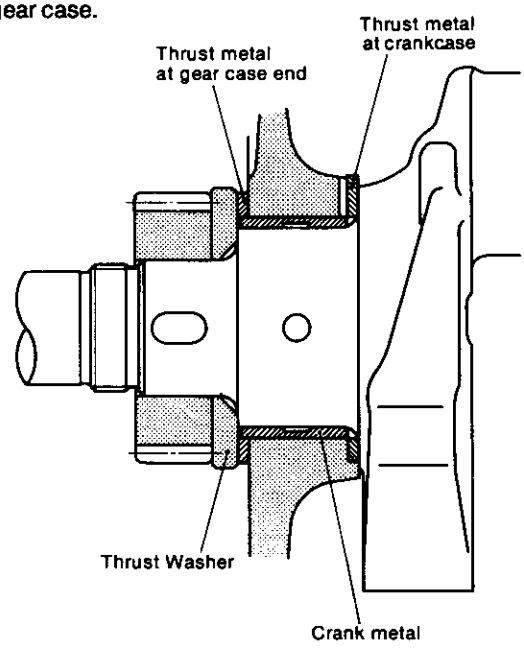
	Maintenance standard	Wear limit
Crankshaft bend	Less than 0.015 (0.0006)	0.15 (0.006)

5-3 Crankshaft side gap

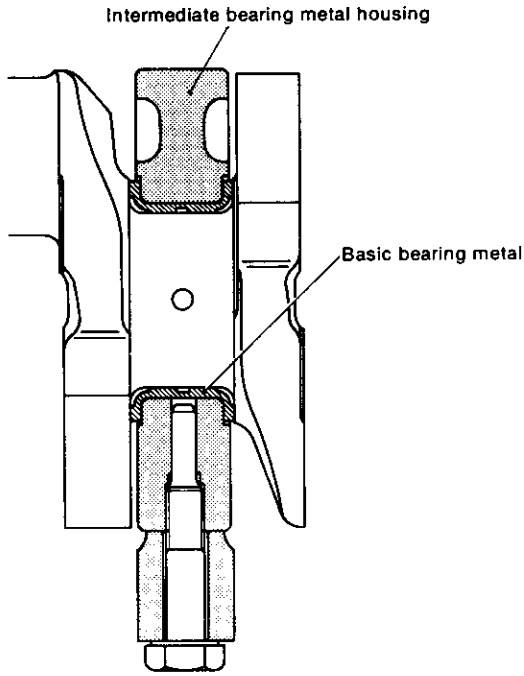
5-3.1 Side gap

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.

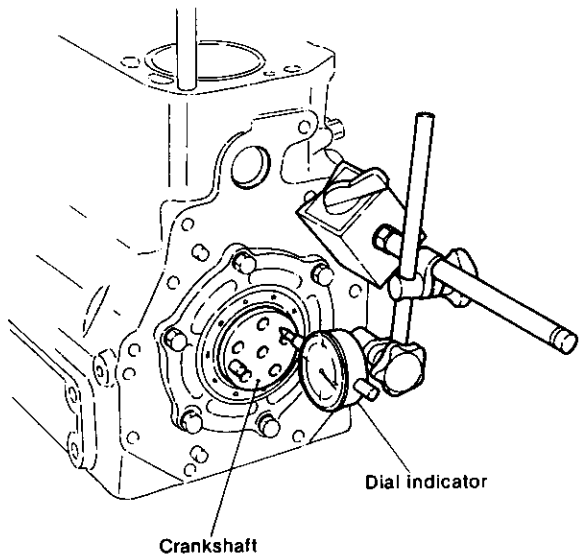


On models 2GM20(F)(C) and 3GM30(F)(C), the value of the side gap is the difference between the width of the basic bearing metal and the width of the journal. The basic bearing for model 2GM20(F)(C) is the intermediate bearing, and for models 3GM30(F)(C) and 3HM35(F)(C) it is the intermediate bearing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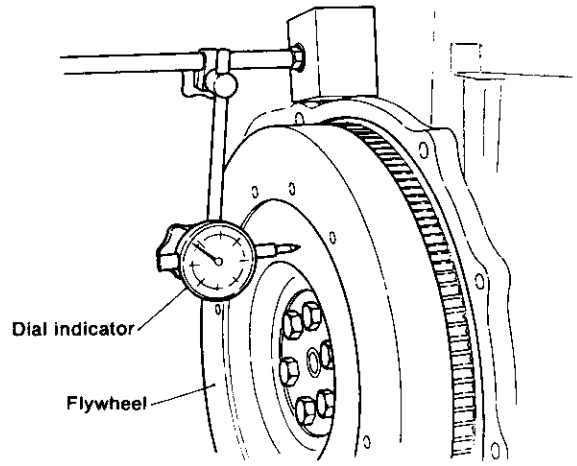


5-3.3 Side gap maintenance standard and wear limit

mm (in.)

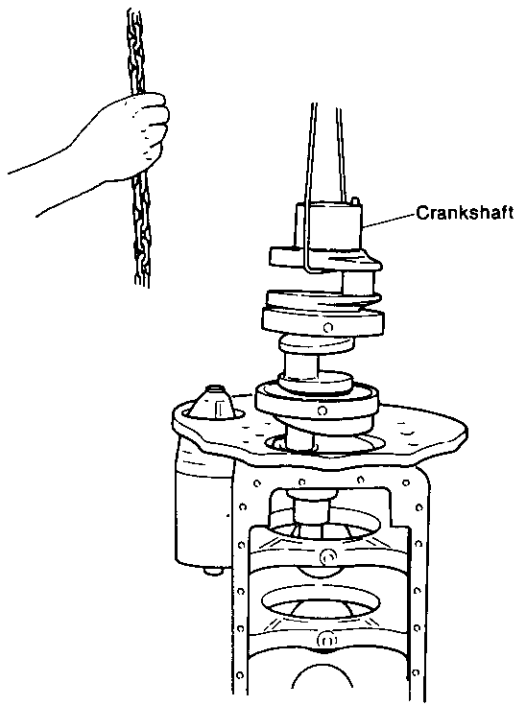
	1GM10(C)		2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	Maintenance standard	Wear limit	Maintenance standard	Wear limit	Maintenance standard	Wear limit
Crank shaft side gap	0.06 ~ 0.19 (0.0024 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.19 (0.0035 ~ 0.0075)	0.30 (0.0012)	0.09 ~ 0.18 (0.0035 ~ 0.0071)	0.30 (0.0012)

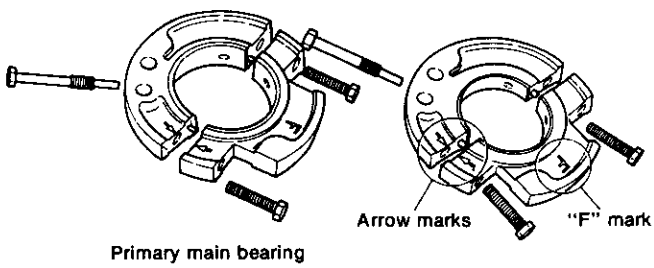
5-4 Disassembly of the crankshaft [2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)]

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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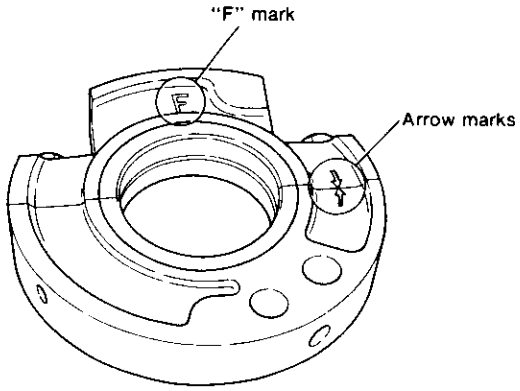
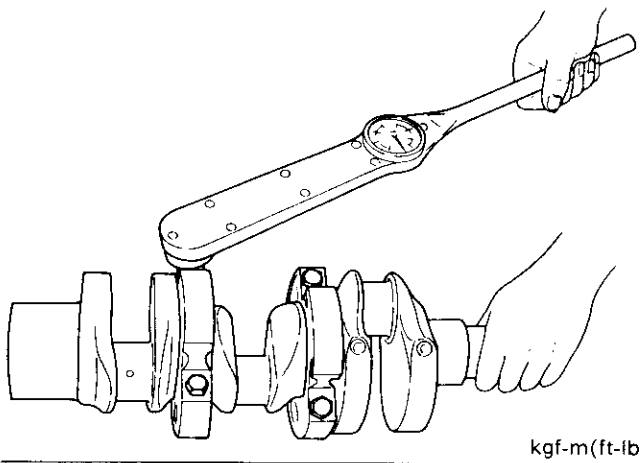
5-4.2 Reassembly

(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.



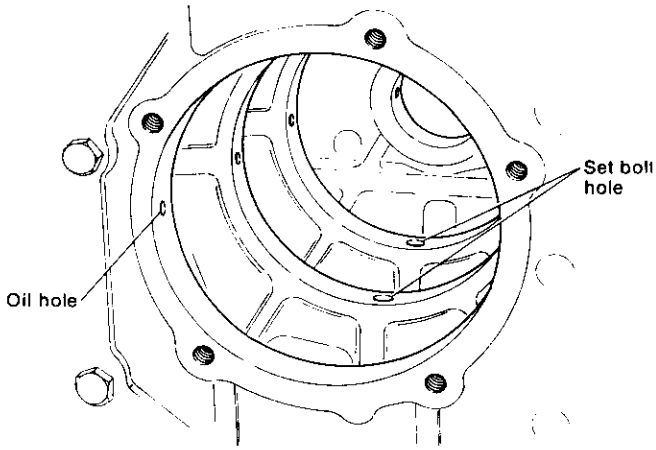
• Align the arrow marks pointing up and down on the side of the intermediate main bearing housing and assemble it so that the "F" mark is in the direction of the flywheel.
• Assemble, integrated with thrust bearing, the intermediate main bearing on the flywheel side (between cylinder No. 1 and 2).
2) Tightening torque of hexagonal bolts for affixing the top and bottom of the intermediate main bearing housing:



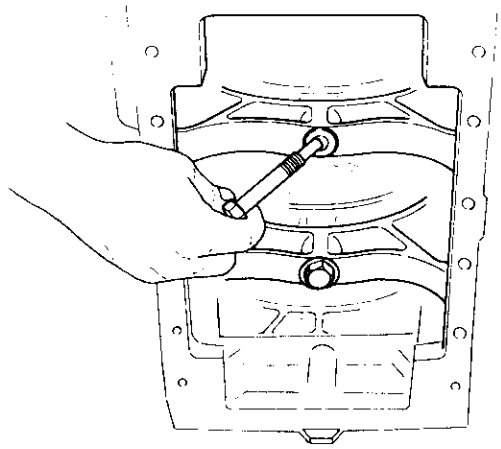
kgf-m(ft-lb)

	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.)



kgf-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.

kgf-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

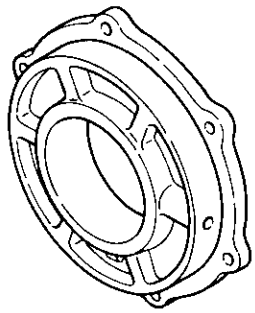
5-5.1 Construction

(1) Model 1GM10(C)

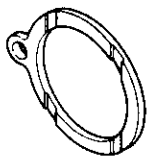
The main bearing consists of a crank bearing and thrust metal. The crank bearing is a round copper-leak sintered alloy bearing featuring superior durability.

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)

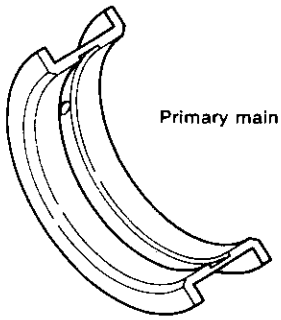


Thrust metal at gear case end for model 1GM10(C)

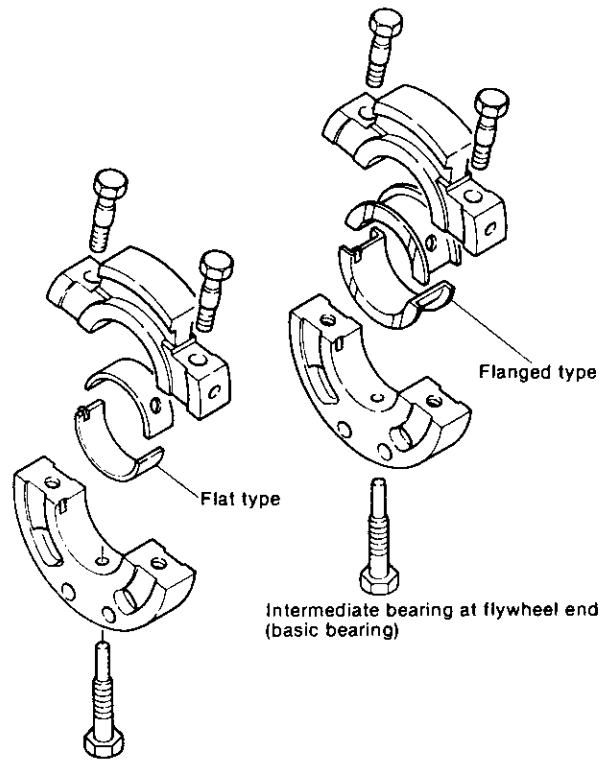
Thrust metal at crankcase end for model 1GM10(C)

(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



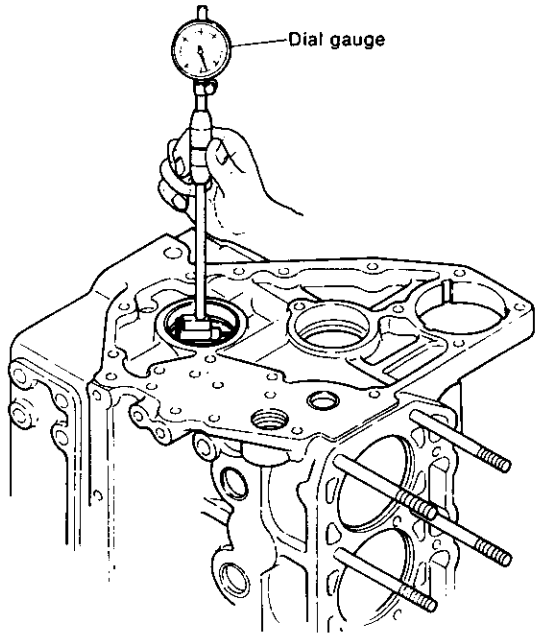
Intermediate bearing at gear case end
[models 3GM30(F)(C) and 3HM35(F)(C)]

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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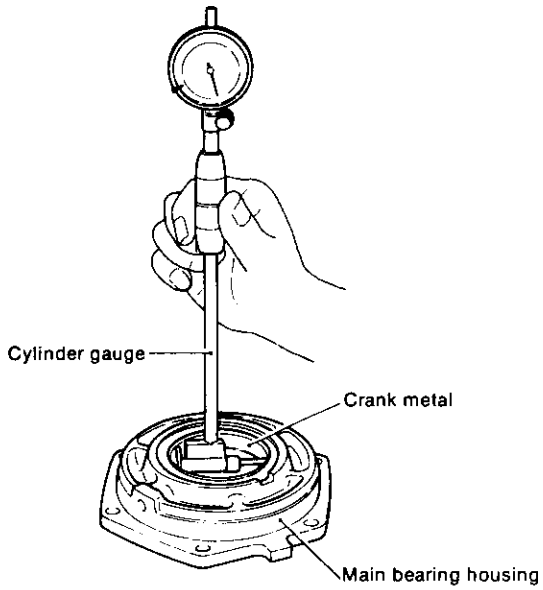
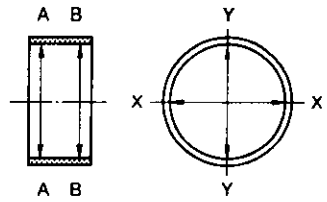


NOTES: 1) Measure the crank bearing at the four points shown in the figure and replace the bearing if the wear limit is exceeded at any of these points.
2) When measuring the inner diameter of the crank bearing, the crank bearing should be installed on the bearing housing and/or cylinder block.

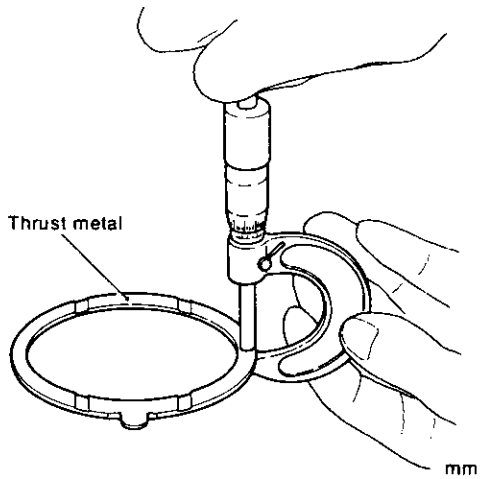


mm (in.)

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

kgf-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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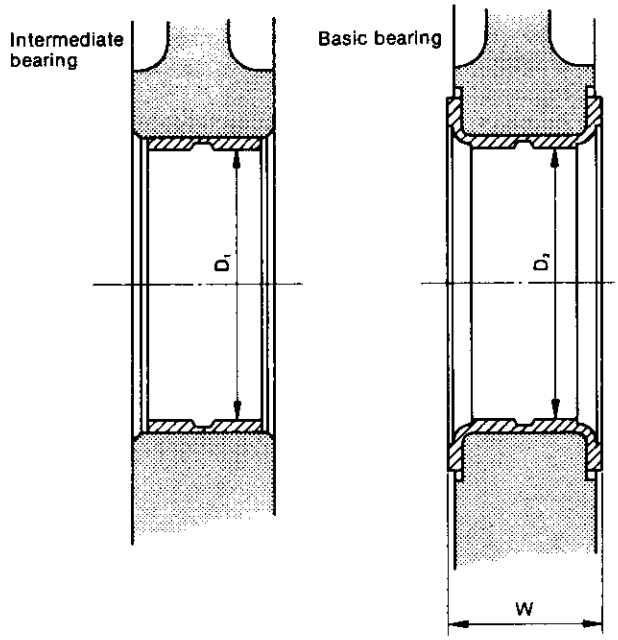
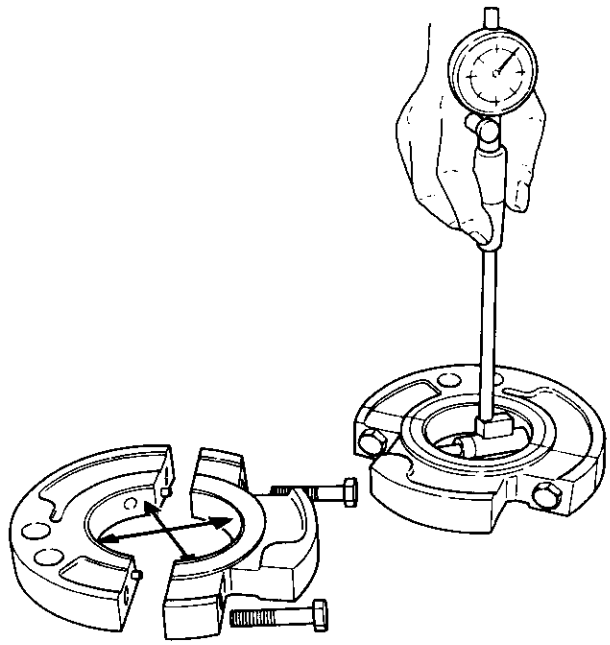
(2) Intermediate main bearing

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

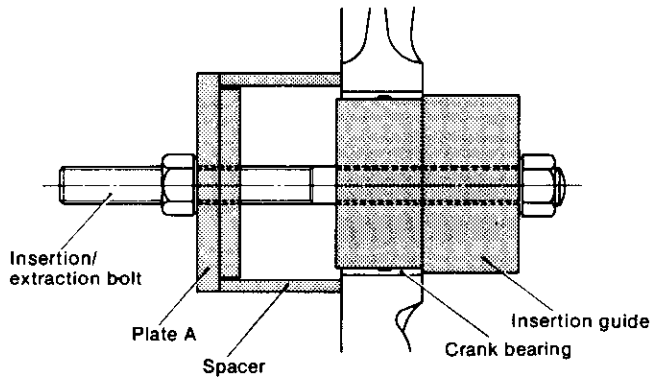
Since the crank bearings at both ends of the crankshaft are attached to the cylinder block and bearing housing with a press, a force of approximately 1.0 ~ 1.5 tons (2200 ~ 3300 lbs.) is required to remove them.
Moreover, since the crankshaft will not rotate smoothly and other trouble may occur if the bearing is distorted, it must always be installed with the special tool.

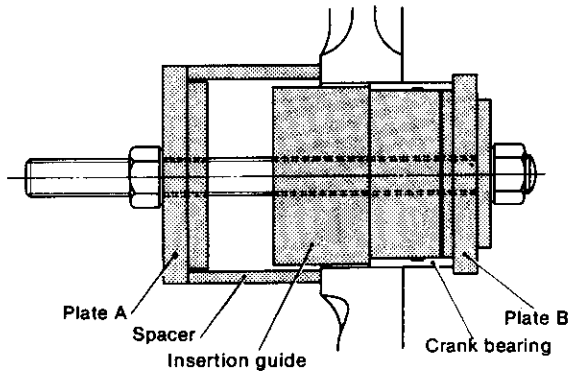
(1) Removal

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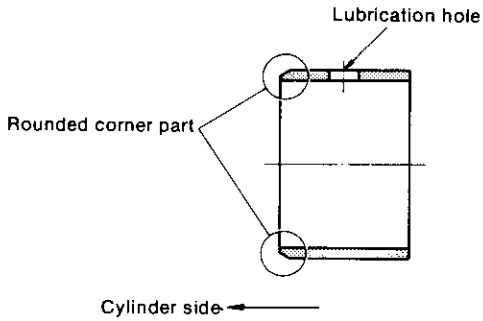
until it touches the cylinder block or bearing housing, using the puller/extractor as a guide, as shown in the figure.
After inserting the bearing, measure its outside diameter. If the bearing is distorted, remove it again and replace it with a new bearing.

(3) Crank bearing installation precautions

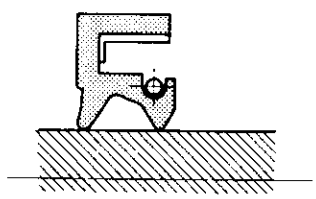


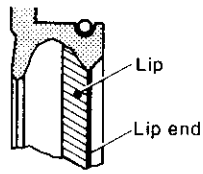
1) Pay careful attention to the crank bearing insertion direction. Insert the bearing so that the side with the outside fillet is on the outside.
2) Align the oil hole of the crank bearing with the oil holes of the cylinder block and bearing housing.
3) After inserting the crank bearing, check that the 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.

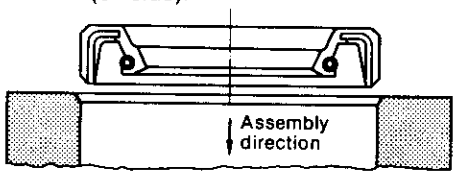




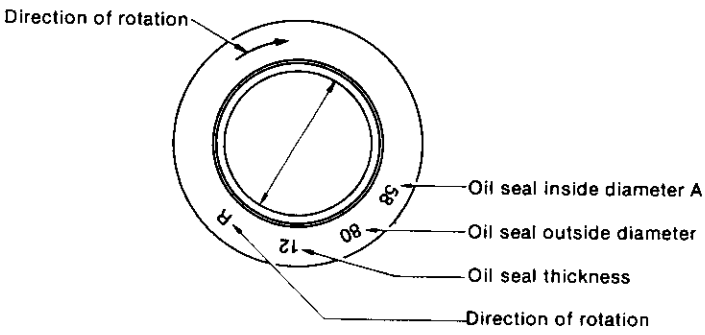
Oil seal	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)			3HM35(F)(C)		
	Size	Spiral	Part No. (Yanmar)	Size	Spiral	Part No. (Yanmar)
For Main bearing metal housing	60829	Yes	124085-02220	65889	Yes	121551-02220
For gear case	25408	Yes	121450-01800	25408	Yes	121450-01800

5-6.2 Oil seal insertion precautions

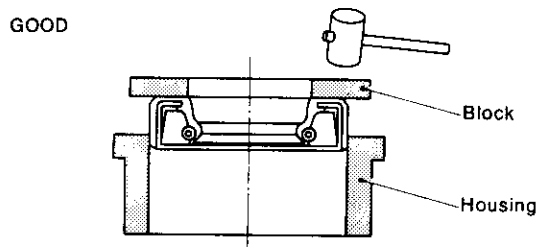
(1) Clean the inside of the housing hole, ascertaining that the hole is not dented when the seal is removed.
(2) Be sure that the insertion direction of the oil seal is correct. Insert so that the main lip mounting on the spring is on the inside (oil side).

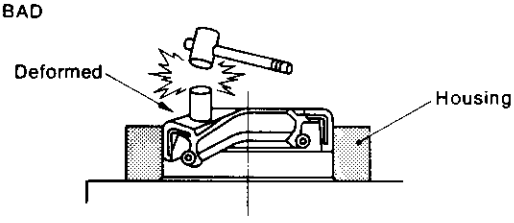


(3) Since the direction of rotation of the shaft is specified on a spiral oil seal, be sure that the rotating direction is correct.



(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	$\varnothing 252\ ^{0}_{0.2}$			∅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		$kgf\text{-}m^2$	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		gf-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		∅60M7			∅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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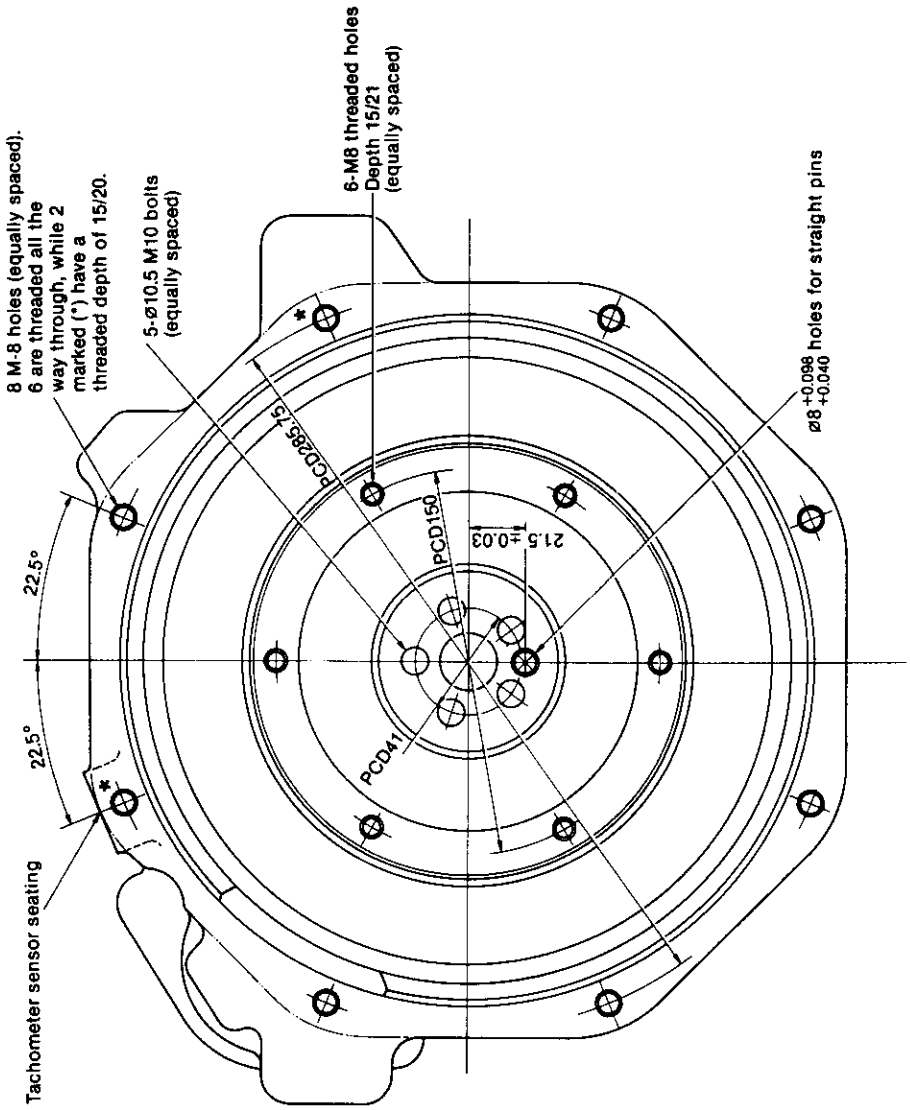
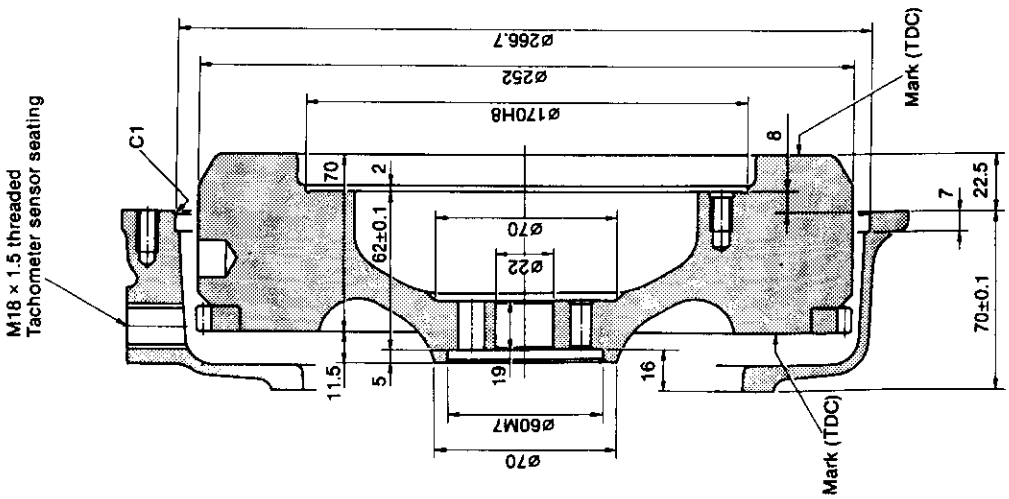
6-2 Dimensions of flywheel and flywheel housing

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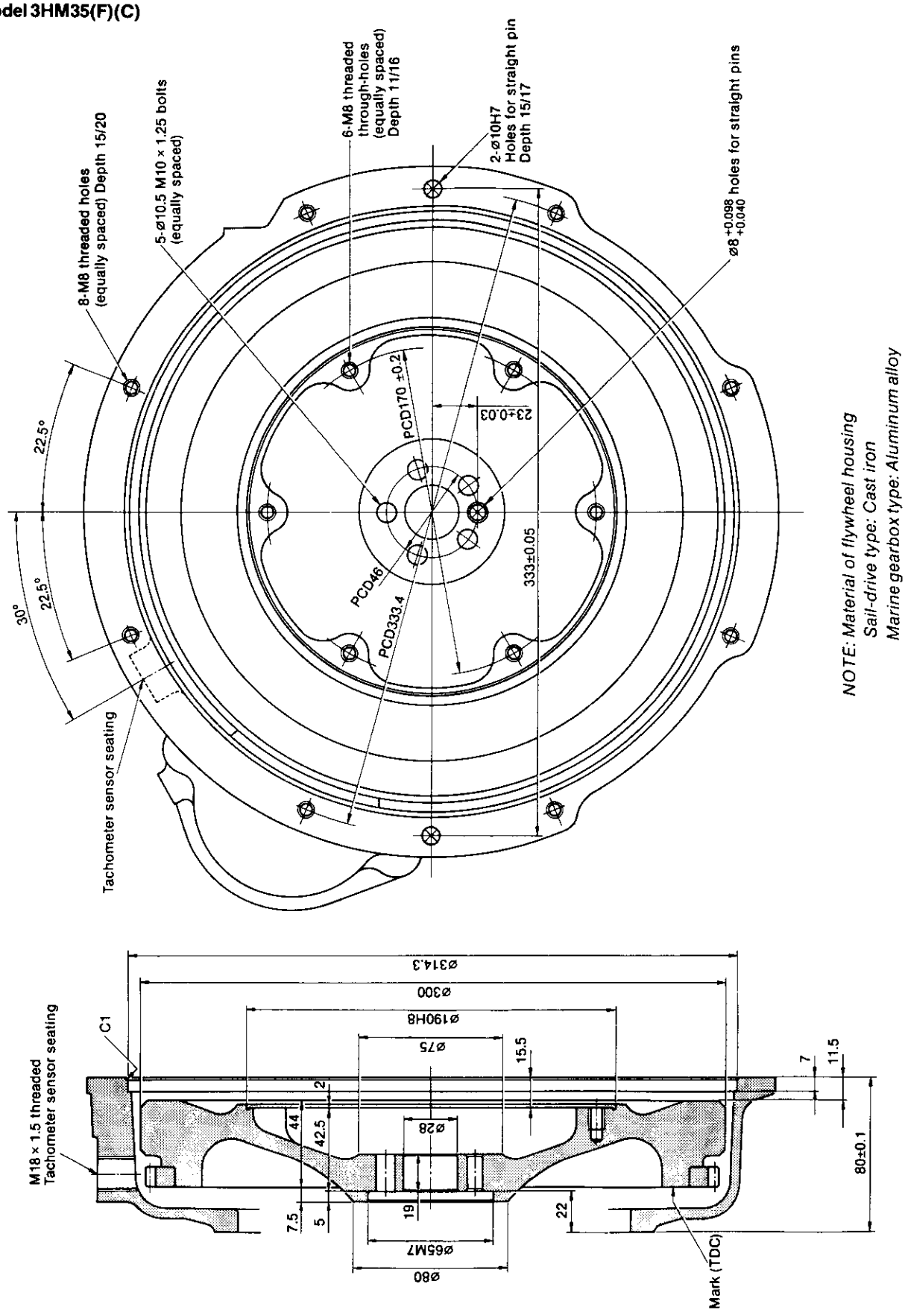
6-2.2 For model 3HM35(F)(C)



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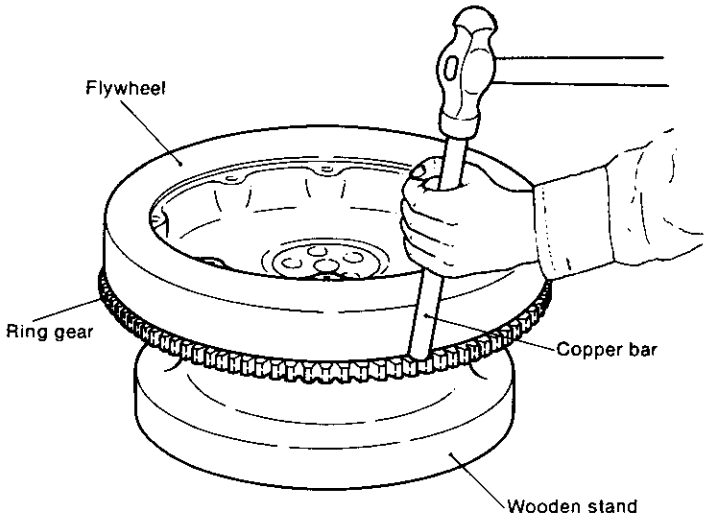
6-3 Ring gear

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.

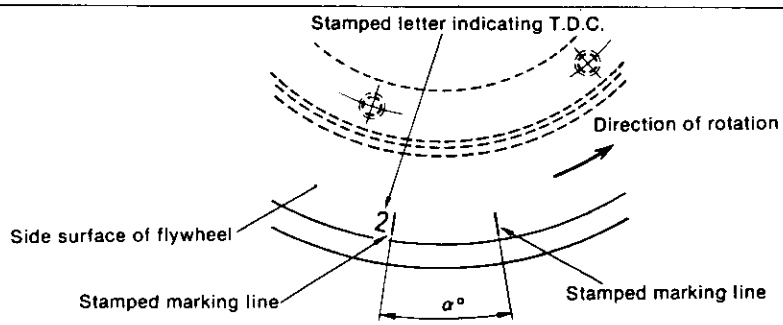
mm (in.)

	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

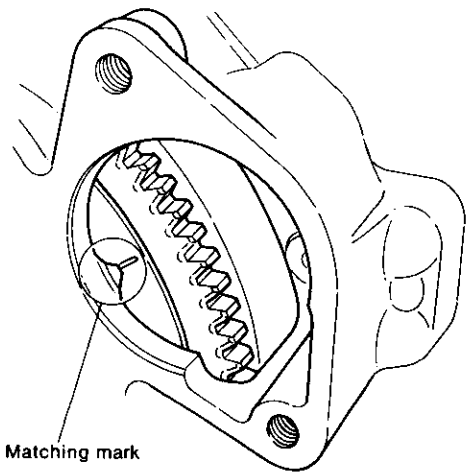
(1) Marking



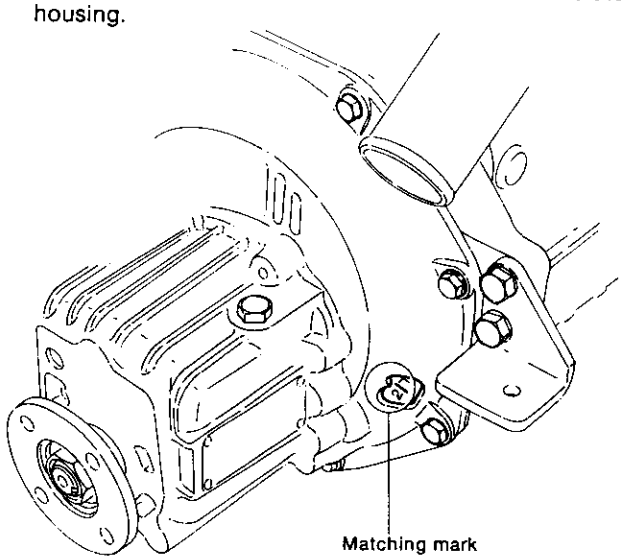
	1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Stamped letter	1	1, 2	1, 3	1, 2, 3
Angle α of Stamped lines	15°	15°	18°	21°
Stamped surfaces	Both surfaces	Both surfaces	Both surfaces	Crankshaft side

(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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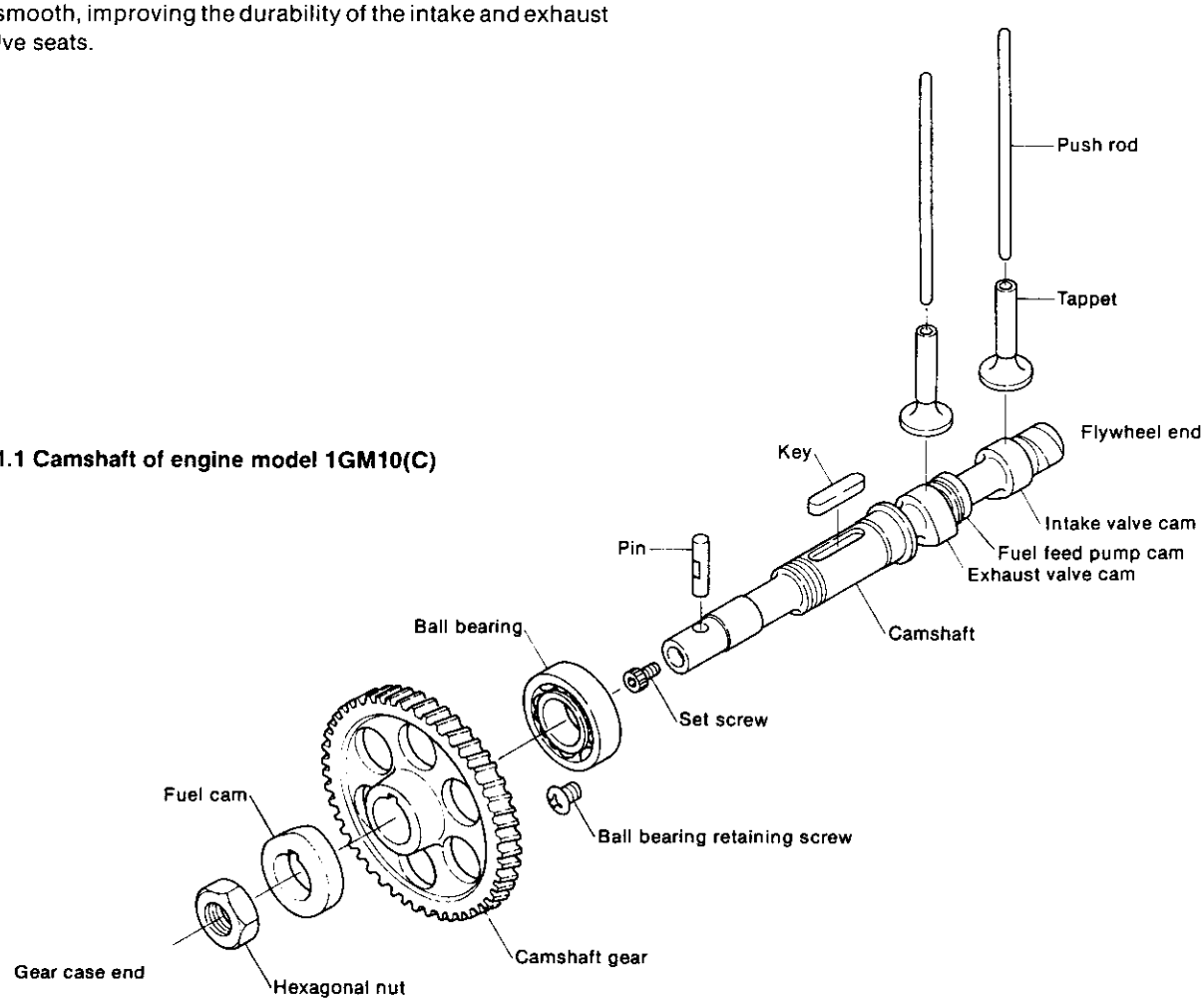
7. Camshaft

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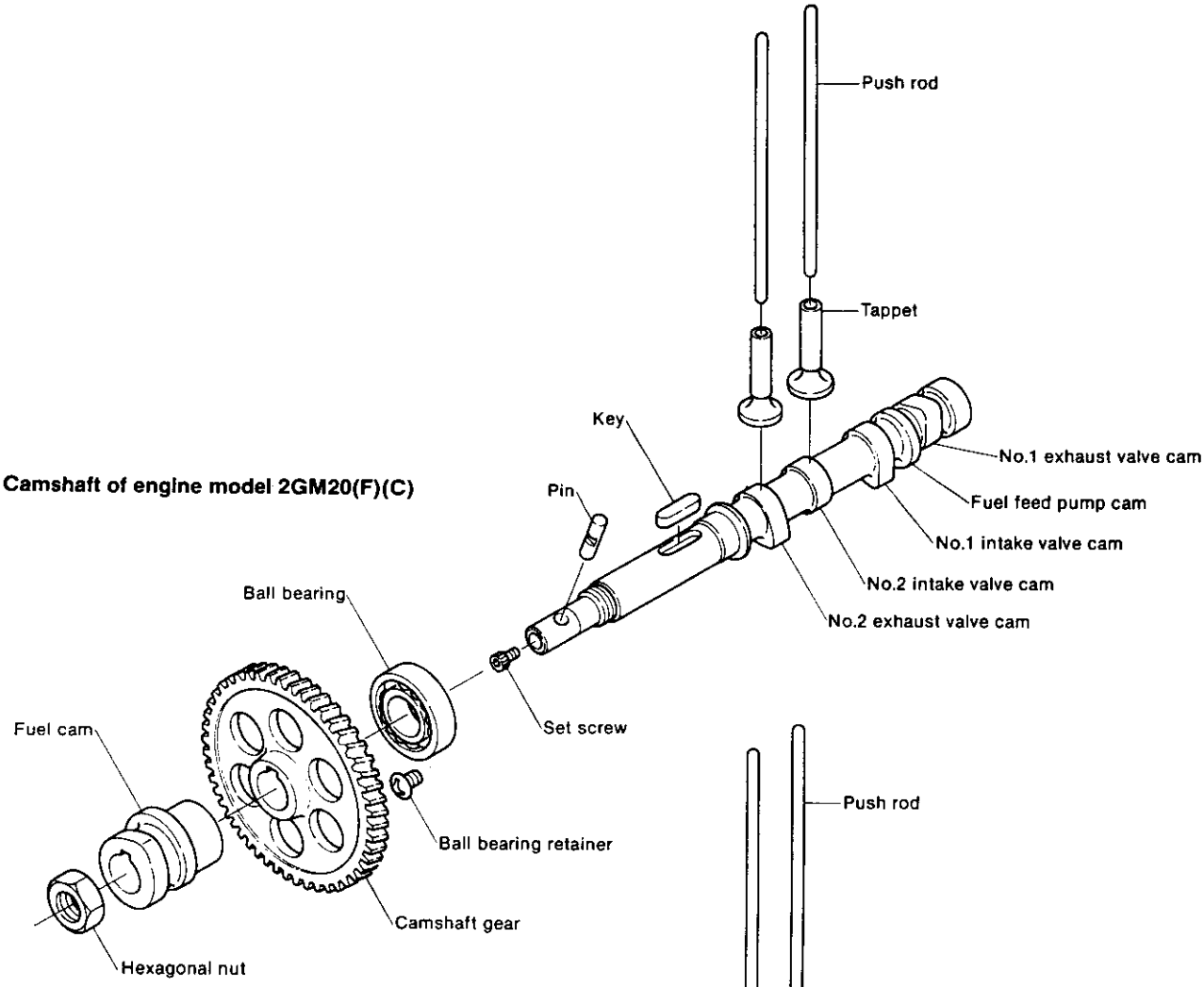
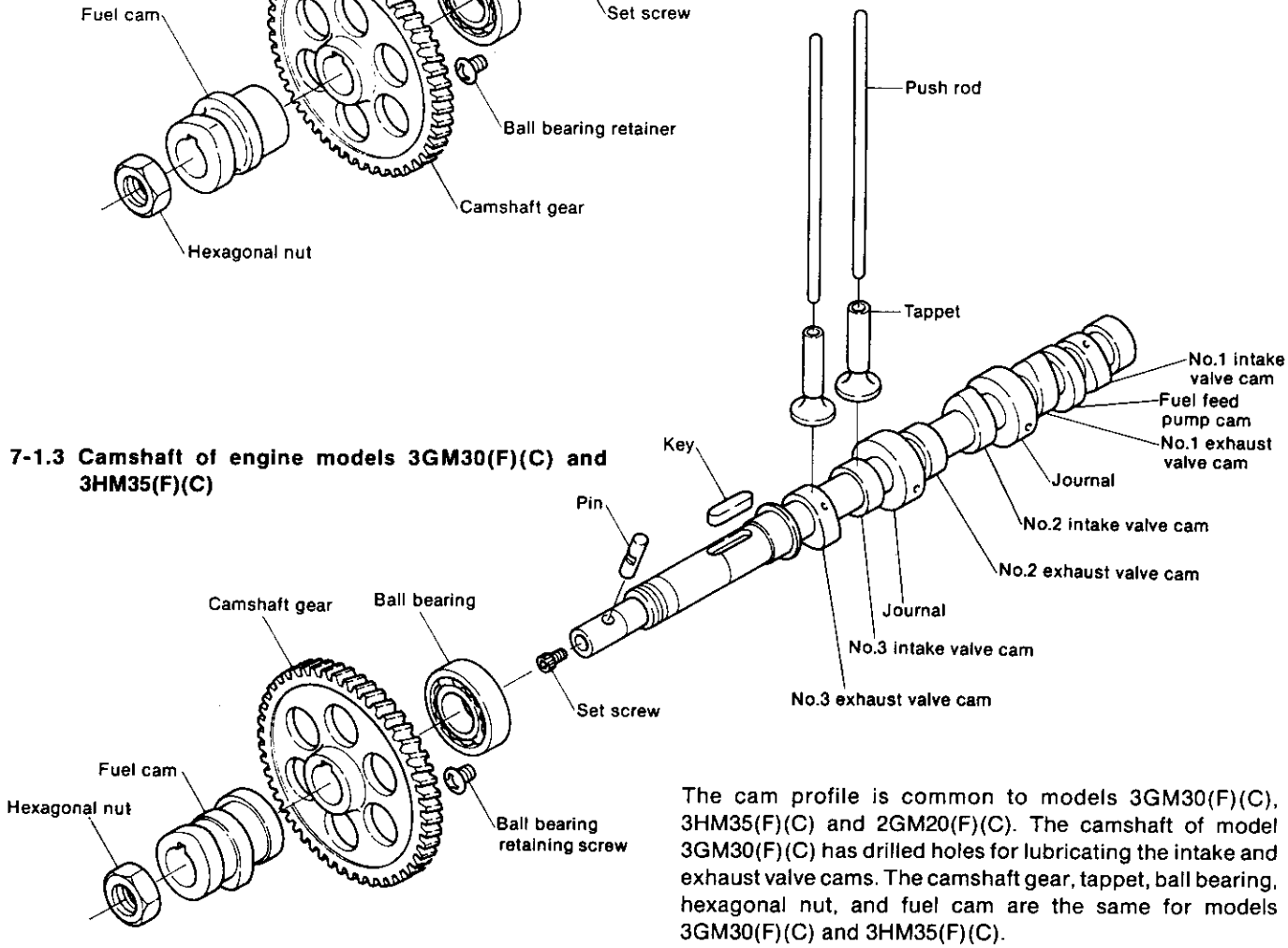
7-1.2 Camshaft of engine model 2GM20(F)(C)



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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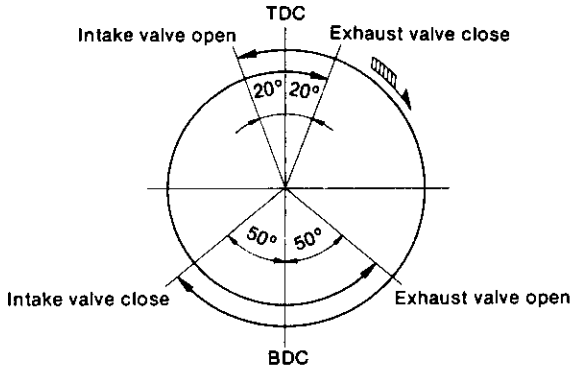
7-2 Valve timing diagram

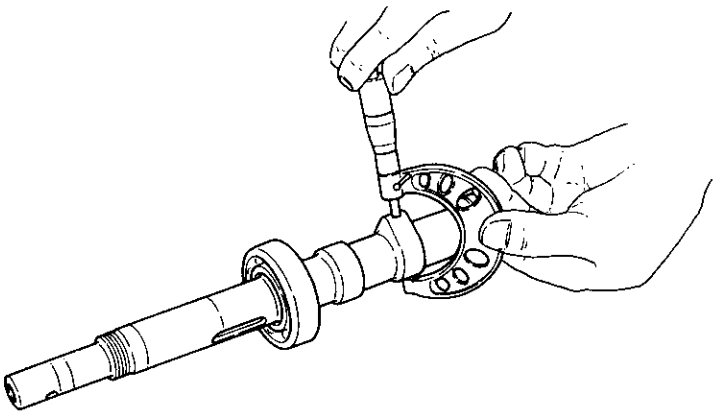


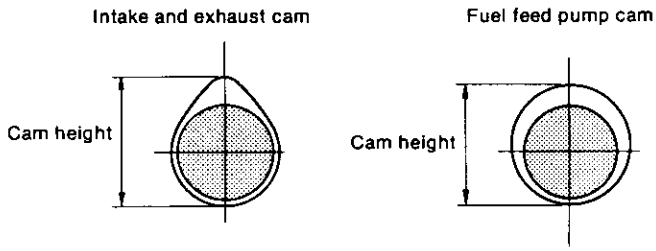
	All models
Intake and exhaust valve head clearance	0.2mm (0.0079in.)
Intake valve open b. TDC	20°
Intake valve close a. BDC	50°
Exhaust valve open b. BDC	50°
Exhaust valve close a. TDC	20°

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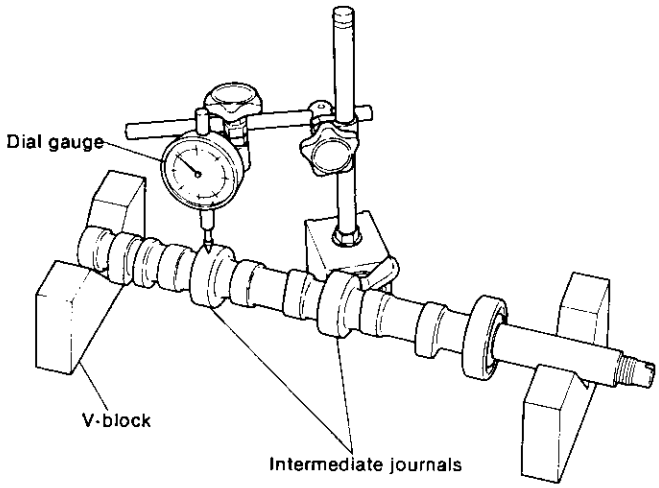
7-3.3 Camshaft deflection [models 3GM30(F)(C) and 3HM(F)(C)

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

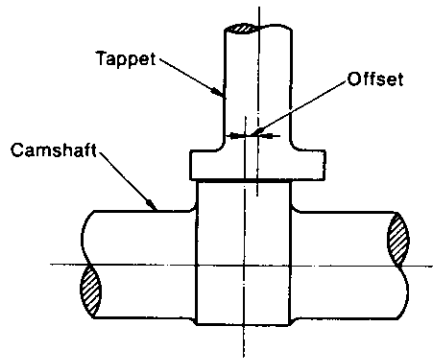
The camshaft bearing is a single row deep groove ball bearing. The construction and material of this ball bearing is such that it can withstand the radial load, thrust loads in both directions, and a combinaiton of both of these loads. When the ball bearing does not rotate smoothly, or when the axial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

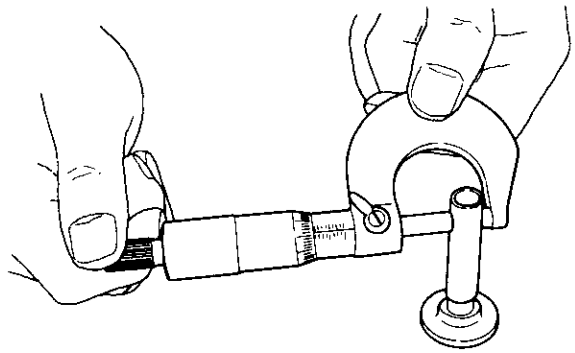


7-5.1 Tappet disassembly precautions

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

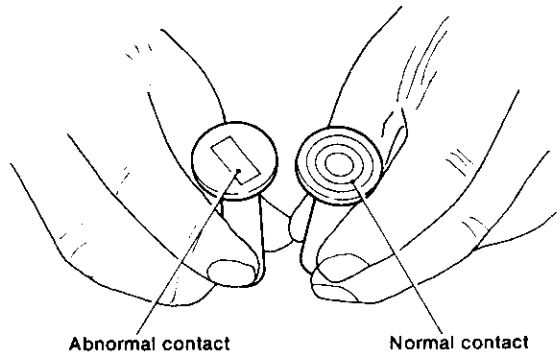
Measure the outside diameter of the tappet stem, and replace the tappet when the wear limit is exceeded or contact is uneven.



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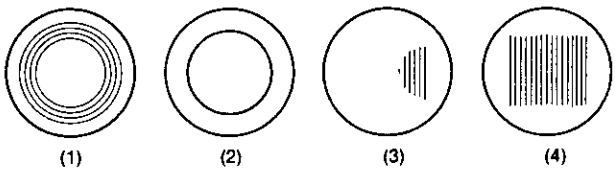
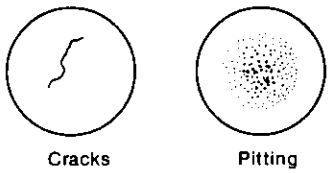
Since the tappet and cam are offset, the tappet rotates in an up and down movement during operation, so there is no uneven contact.
Since eccentric wear will occur if cam tappet contact is poor, replace the tappet if there is any uneven contact or deformation.

Contact surface conditions are shown in the following:



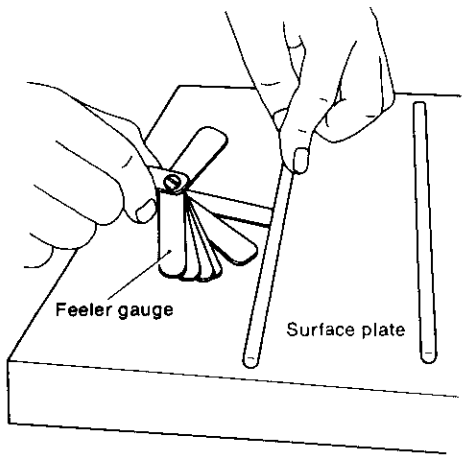
(1), (2) Traces when the tappet is rotating normally.
(3), (4) Traces when the tappet does not rotate, the contact surface remains still and the point of contact wears away excessively. Discover the reason for the lack or rotation and replace the tappet.



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.

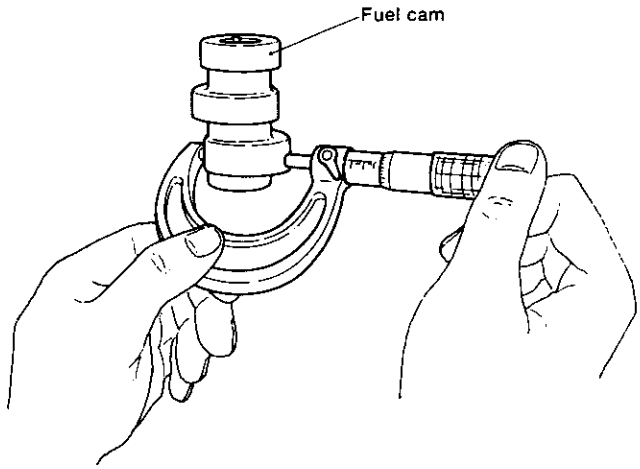
mm (in.)

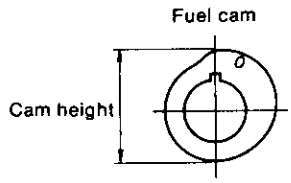
		Maintenance standard	Wear limit
Push rod bend		0.03 or less (0.00118 or less)	0.3 (0.0118)
Push rod length	1GM10(C)	143 (5.6299)	—
	2GM20(F)(C) 3GM30(F)(C)	136 (5.3543)	—
	3HM35(F)(C)	171 (6.7323)	—

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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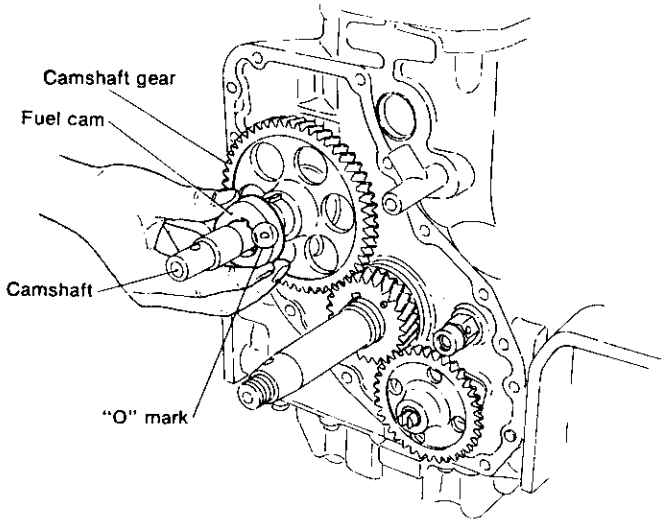

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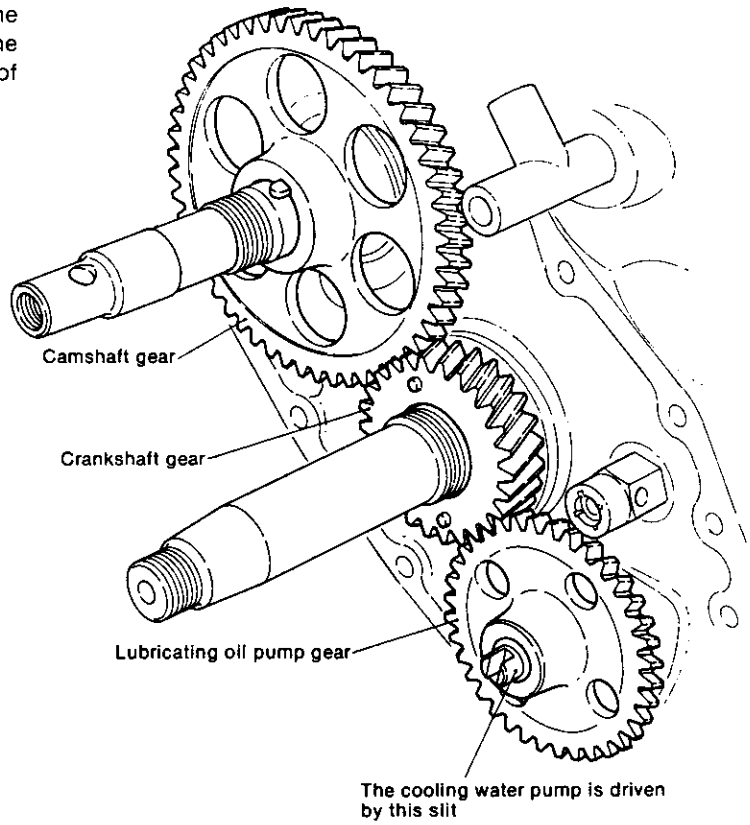
8. Timing Gear

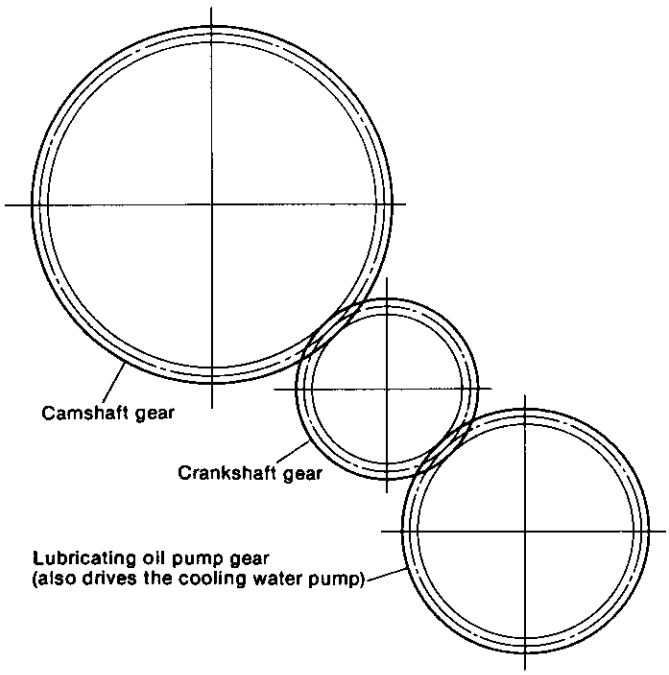
8-1 Timing gear train construction

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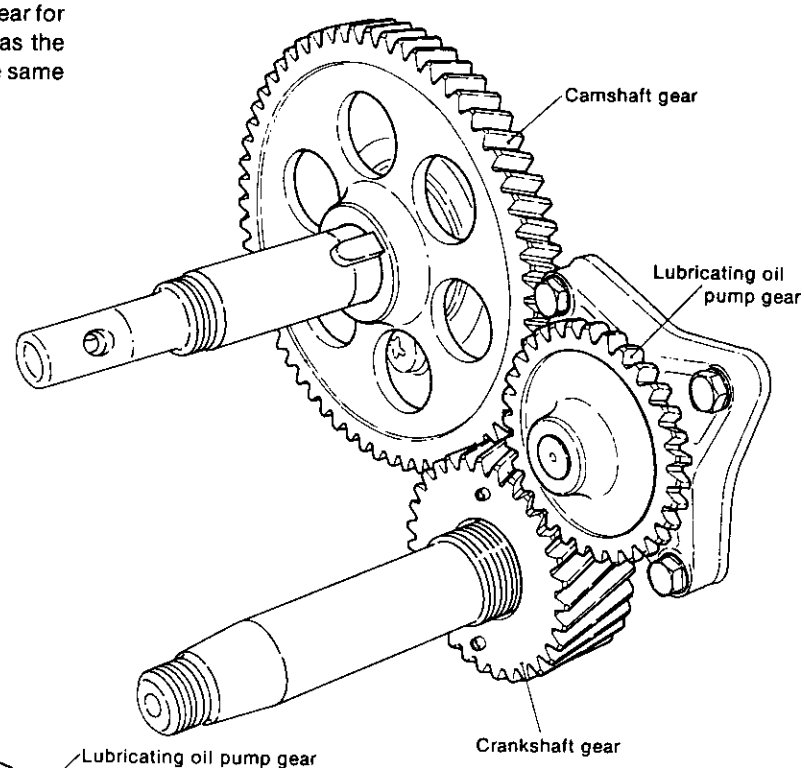
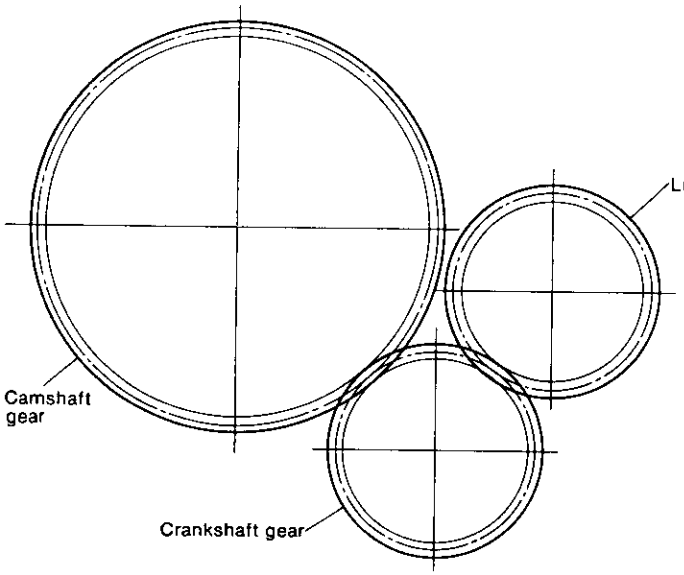
8-1.2 Timing gear of models 2GM20(F)(C), 3GM30(F)(C) and 3HM 35(F)(C)

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

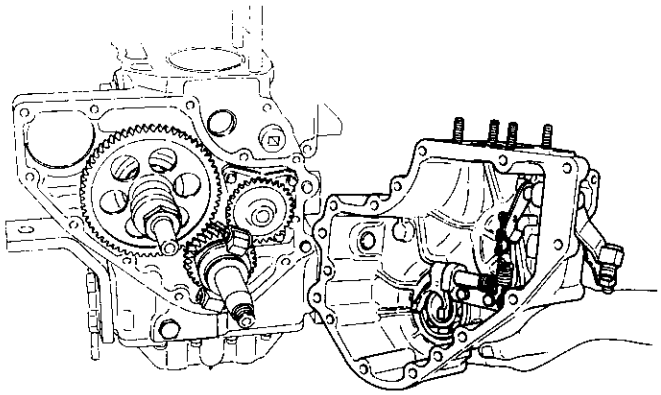
(1) Remove the alternator.
(2) Remove the rubber hose by loosening the hose clip on the cooling water pump.

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.

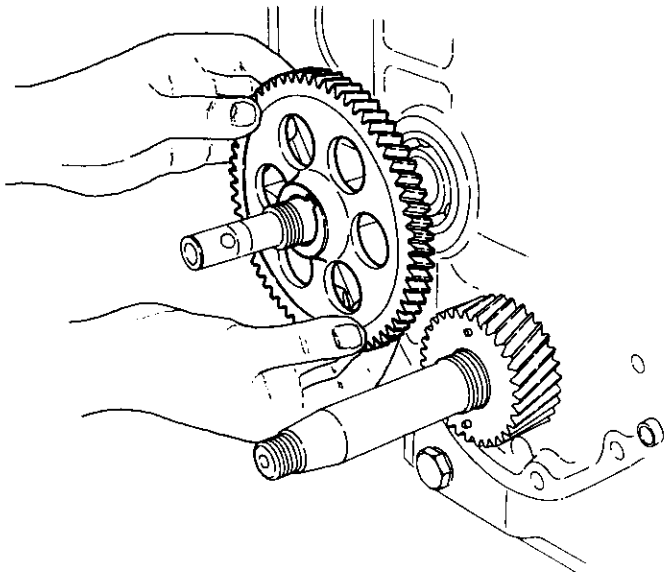
(3) Remove the crankshaft V-pulley.
(4) Remove the fuel injection pump

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.

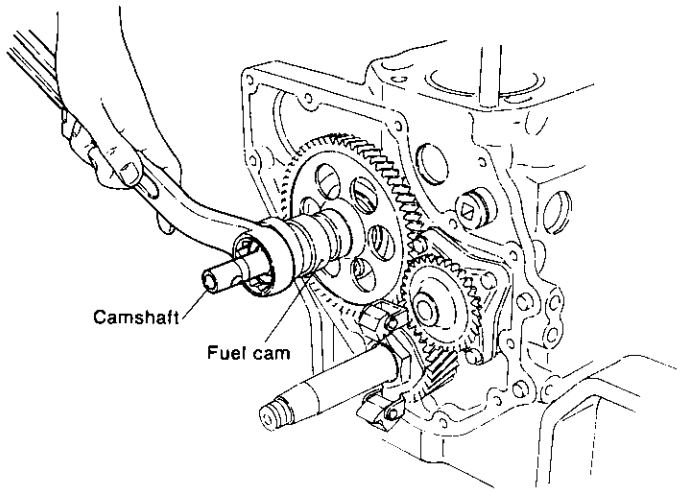


8-2.2 Disassembly and reassembly precautions

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

(1) Timing mark

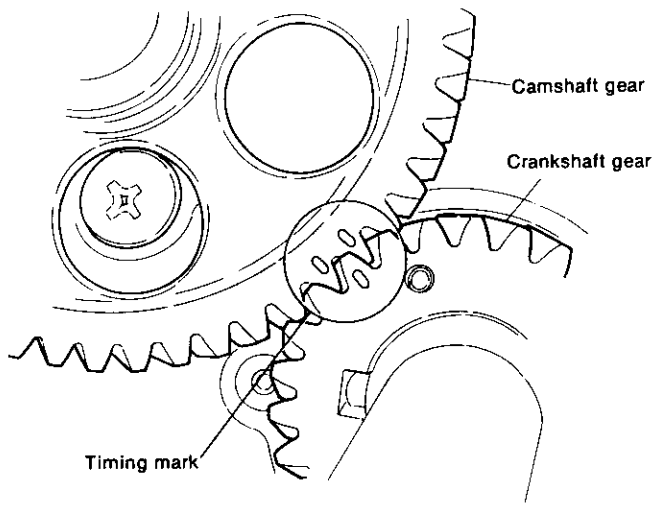
A timing mark is provided on the crankshaft gear and camshaft gear to adjust the timing between opening and closing of the intake and exhaust valves and fuel injection when the piston is operated.
Always check that these timing marks are aligned when disassembling and reassembling the timing gear.
First, 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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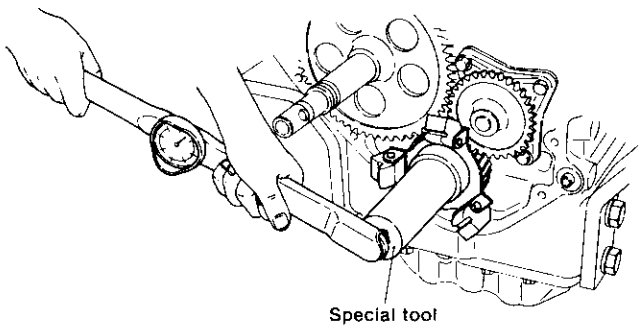
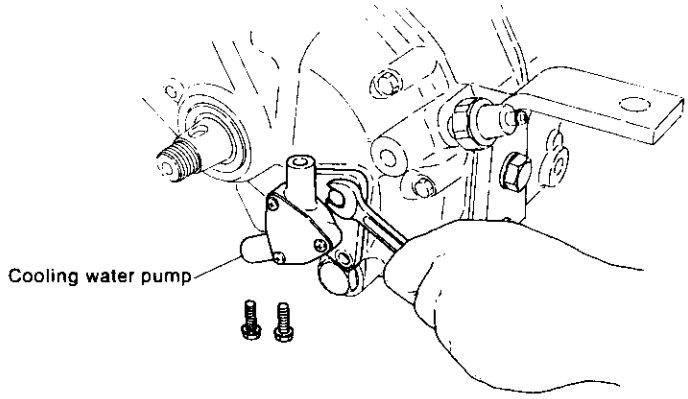
kgf-m(ft-lb)

	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.



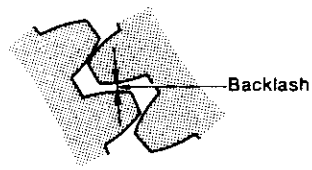
(4) assembling model 1GM10(C) cooling water pump
When model 1GM10(C) cooling water pump is assembled, ensure that the pump shaft engages with the slit of the rotor shaft end of the lubricating oil pump and with the bearing. Check by rotating the crankshaft.



8-3 Inspection

8-3.1 Backlash

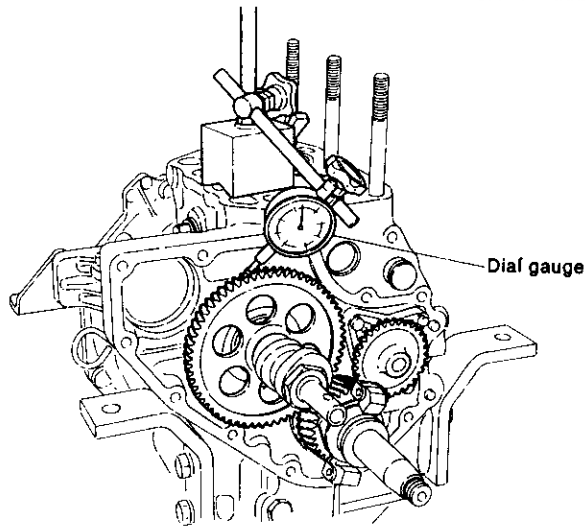
Unsuitable backlash will cause excessive wear or damage at the tooth top and abnormal noise during operation. Moreover, in extreme cases, the valve and fuel injection timing will deviate and the engine will not run smoothly.
When the backlash exceeds the wear limit, repair or relace the gears as a set.



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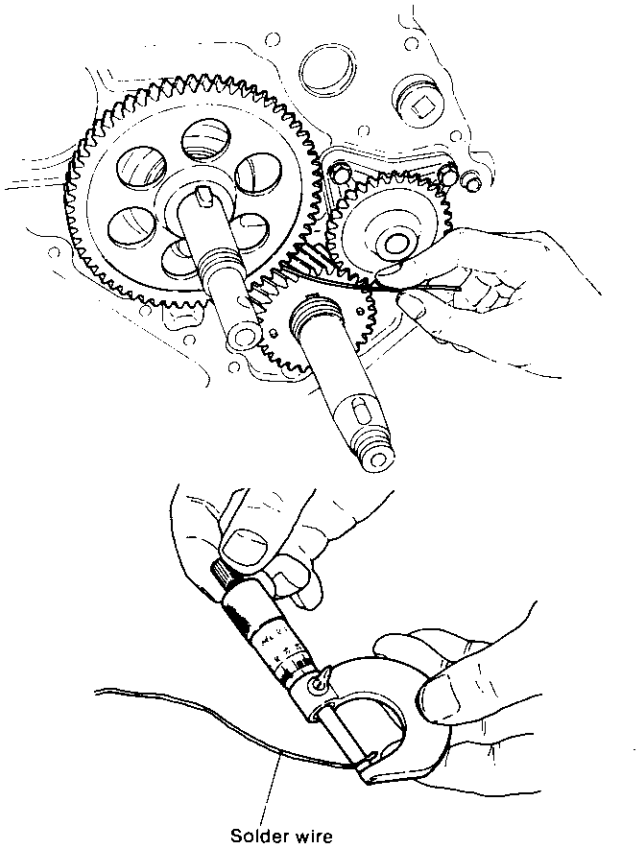
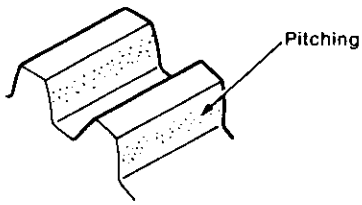
(2) Insert a piece of quality solder between the gears to be measured and turn the gears. The backlash can be measured by measuring the thickness of the crushed part of the solder.



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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CHAPTER 3

FUEL SYSTEM

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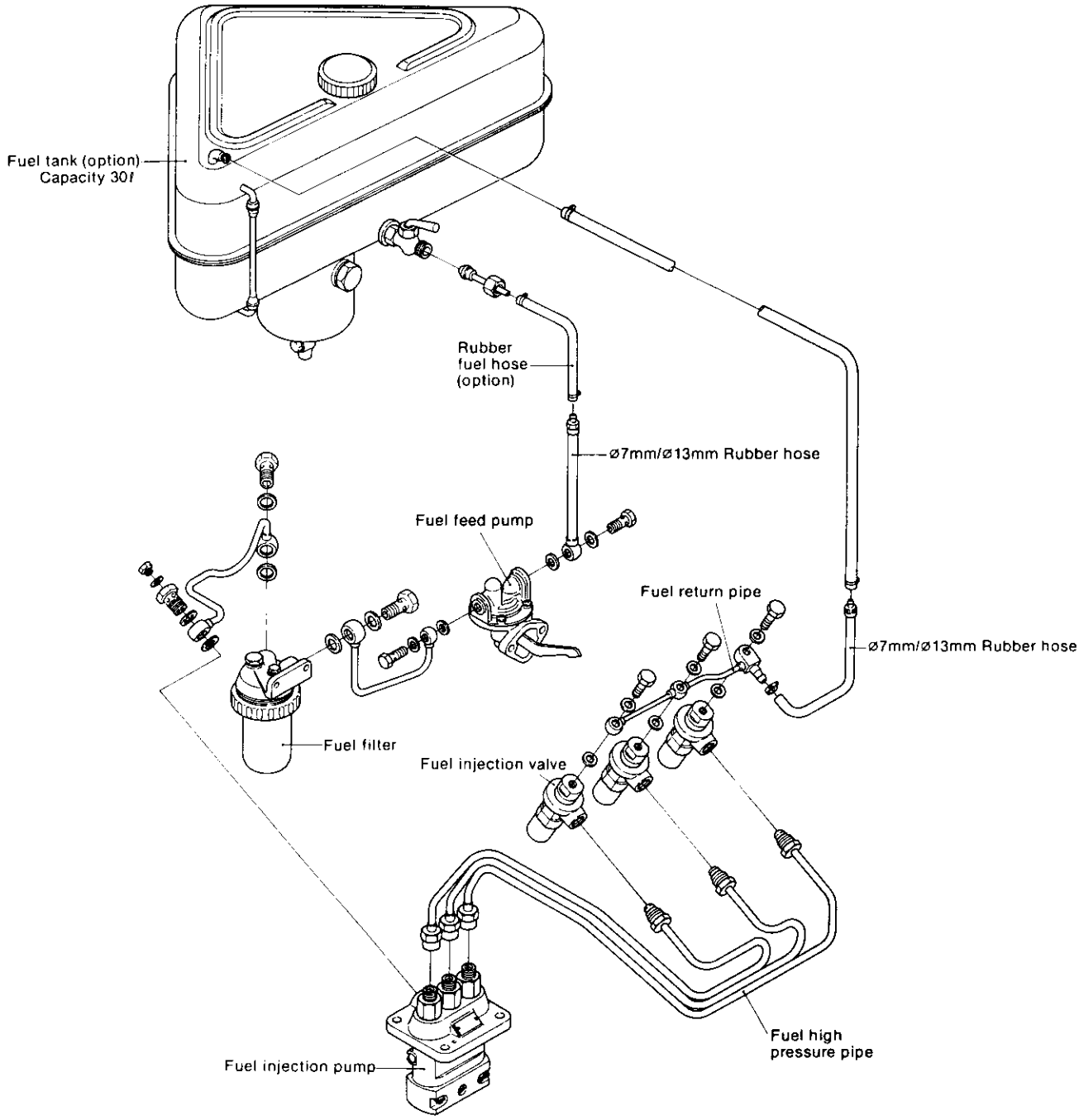
1. Fuel Injection System



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1-1 Construction

The fuel system consists mainly of an injection pump, injection pipe, and an injection nozzle, plus a fuel tank, feed pump, fuel filter and other associated parts. The injection pump is driven by a fuel cam mounted on the camshaft and is controlled by a governor. Fuel stored in the fuel tank is fed to the fuel filter through the feed pump. (The feed pump is indispensable when the fuel tank is installed lower than the injection pump.)
Dirt and other impurities in the fuel are removed by the filter and the clean fuel is sent to the injection pump, which applies the necessary pressure for injection to the fuel and atomizes the fuel by passing it through the injection nozzle. The injection pump also controls the amount of fuel injected and the injection timing according to the engine load and speed by means of a governor.
The injection pump feeds the fuel to the injection nozzle through a high pressure pipe. The pressurized fuel is atomized and injected by the injection nozzle into the precombustion chamber.
Fuel that overflows the injection nozzle is returned to the fuel tank through the fuel return pipe. The quality of the equipment and parts comprising the fuel injection system directly affects combustion performance and has a considerable effect on engine performance. Therefore, this system must be inspected and serviced regularly to ensure top performance.
The pipework diagram of the fuel system is for the model 3GM30(F)(C) engine. Models 1GM10(C) and 2GM20(F)(C) are the same except for the shape of the fuel injection pump and fuel feed pump, and the number of fuel injection valves. It is also the same for models 3GM30(F)(C) and 3HM35(F)(C) except for the fuel injection pump and fuel injection valve.

1-2 Fuel injection system specifications

	1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Type of injection pump	YPFR-07 07-1	YPFR-07 07-2	YPFR-07 07	YPFR-07 07
Type of injection nozzle	YDN-0SDYD1(Throttle)			YDN-0SDYD1(Throttle)
Injection pressure	170 kgf/cm^2(2418 lb/in.^{2})			160 kgf/cm^2(2276 lb/in.^{2})
Plunger diameter × stroke	ϕ6mm(0.2362in.) × 7mm(0.2756in.)			ϕ6.5mm(0.2559in.) × 7mm(0.2756in.)
Delivery valve suction capacity	23.5mm^3/st(0.0014in.^{3}/st)			23.5mm^3/st(0.0014in.^{3}/st)
fuel feed pressure	0.1kgf/cm^2(1.4224 lb/in.^{2})			0.1kgf/cm^2(1.4224 lb/in.^{2})

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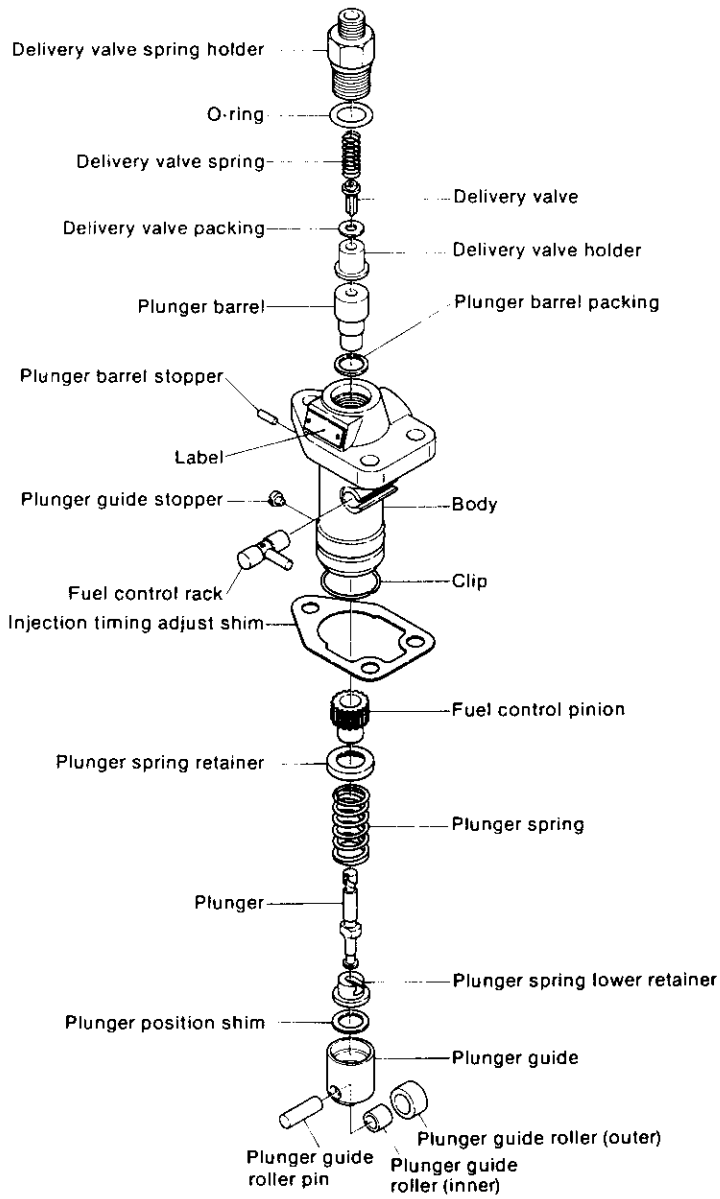
2. Injection Pump

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

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

2-1 Construction

2-1.1 1GM10(C)



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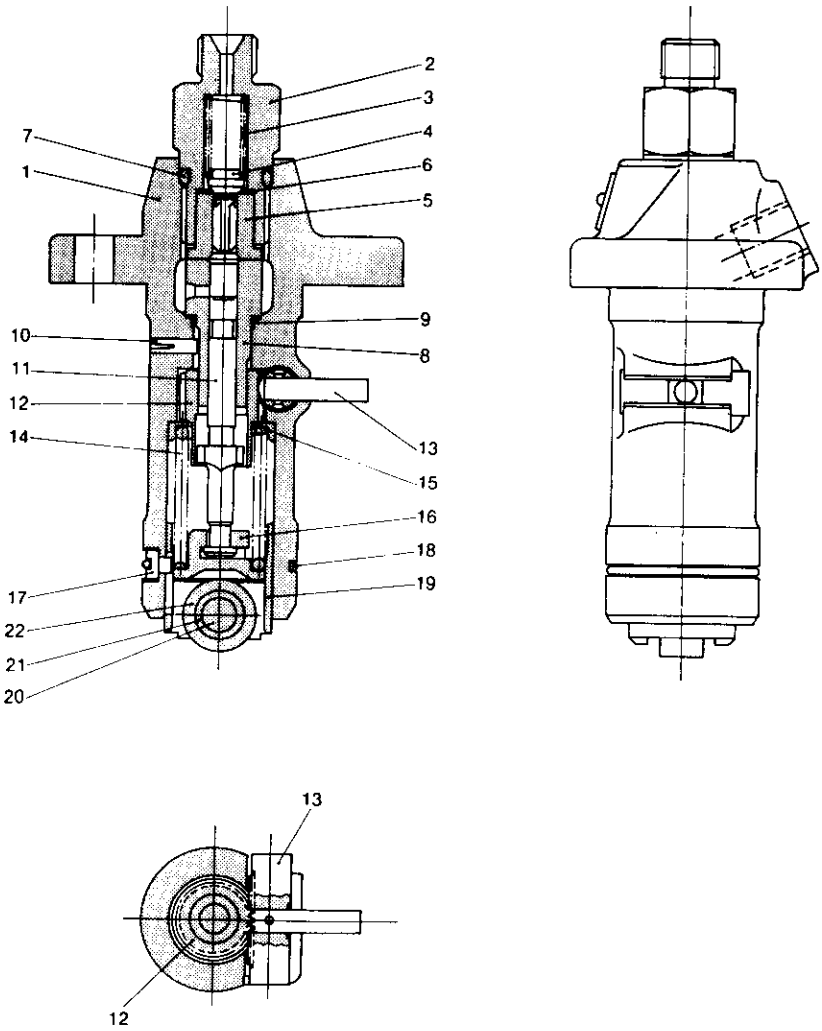

1 Body
2 Delivery valve spring holder
3 Delivery valve spring
4 Delivery valve
5 Delivery valve holder
6 Delivery valve packing
7 O-ring
8 Plunger barrel
9 Plunger barrel packing
10 Plunger barrel stopper
11 Plunger
12 Fuel control pinion
13 Fuel control rack
14 Plunger spring
15 Plunger spring retainer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

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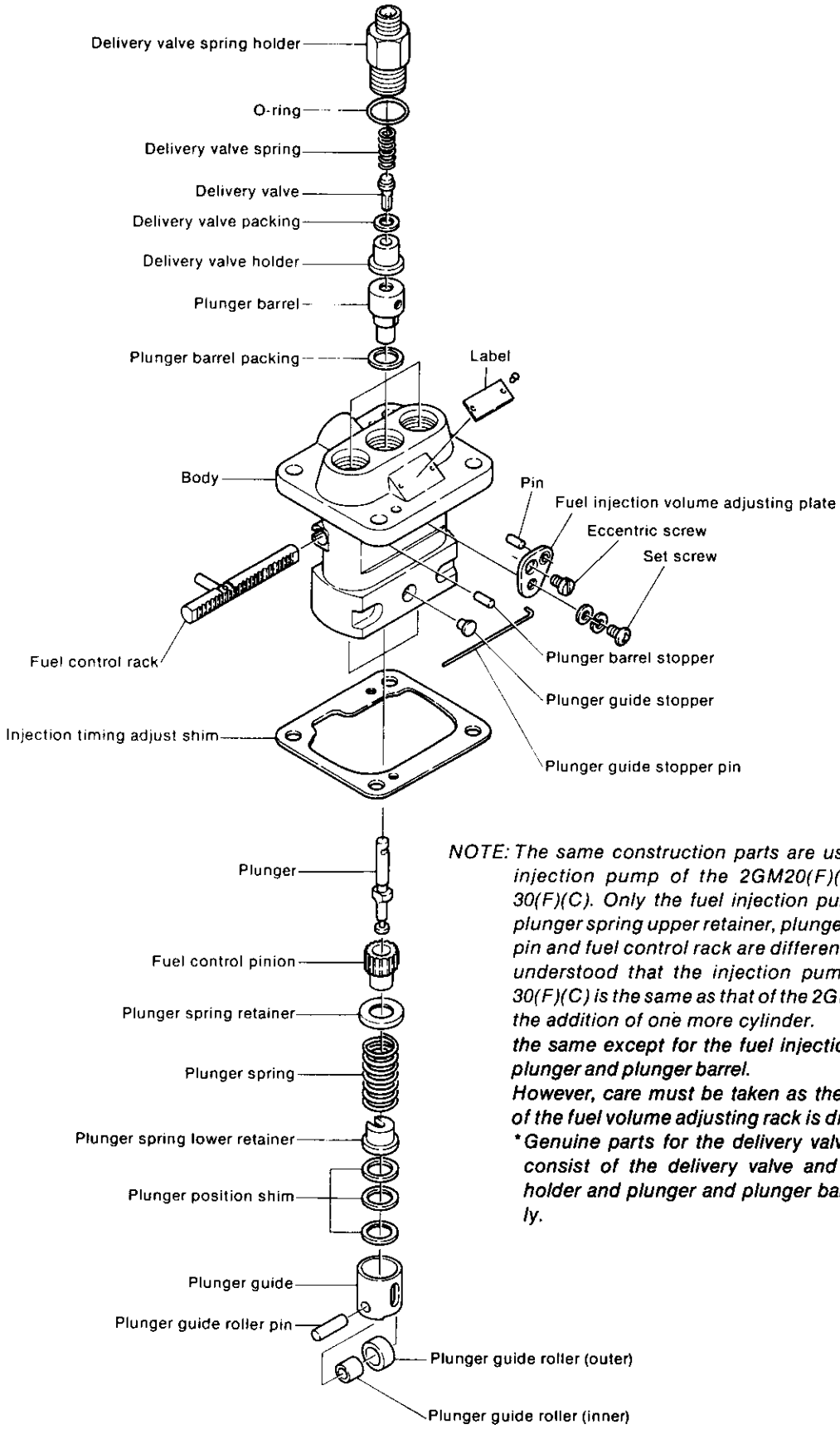
2-1.2 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)



NOTE: The same construction parts are used for the fuel injection pump of the 2GM20(F)(C) and 30GM 30(F)(C). Only the fuel injection pump body itself, plunger spring upper retainer, plunger guide stopper pin and fuel control rack are different, and it may be understood that the injection pump of the 3GM 30(F)(C) is the same as that of the 2GM20(F)(C) with the addition of one more cylinder.

the same except for the fuel injection pump body, plunger and plunger barrel.

However, care must be taken as the basic surface of the fuel volume adjusting rack is different.

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

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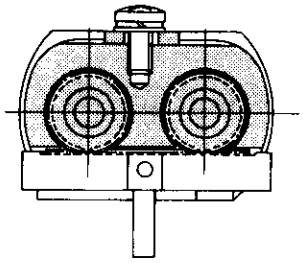
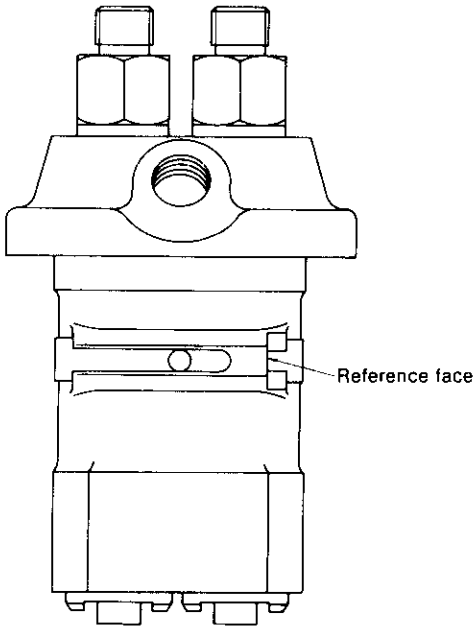
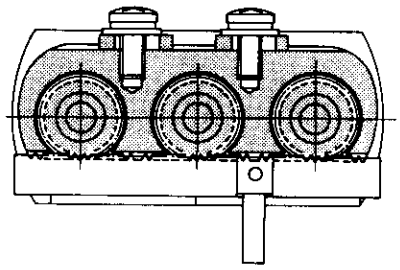
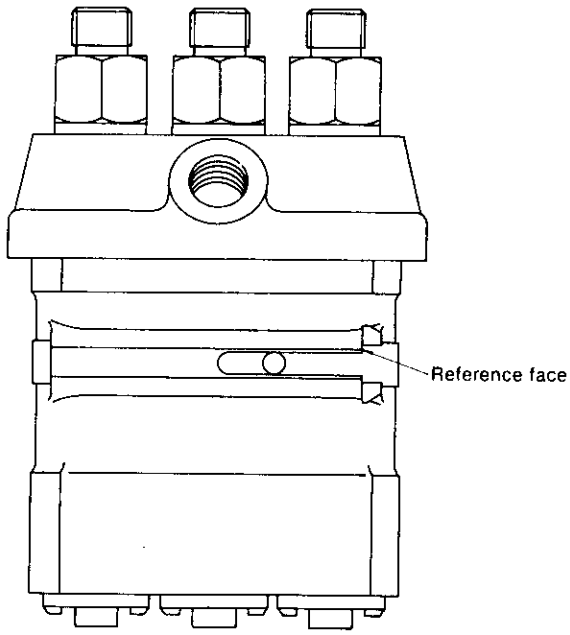
2GM20(F)(C)

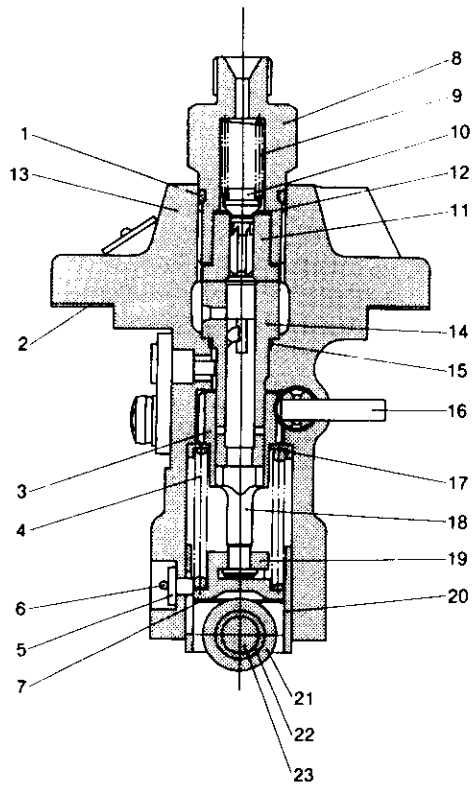




3GM30(F)(C)







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

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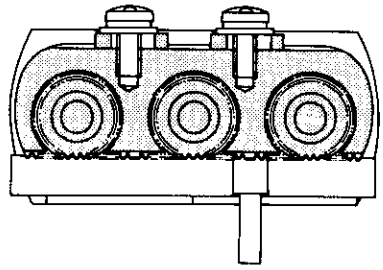
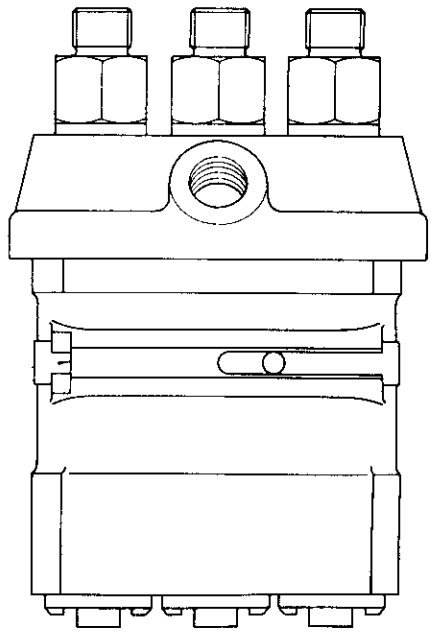
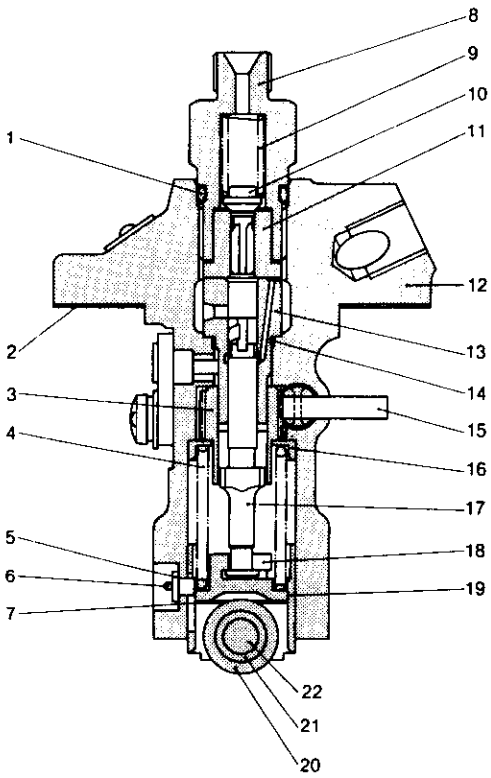
3HM35(F)(C)

The construction is the same as the fuel injection pump on model 2GM20(F)(C) or 3GM30(F)(C) engines except for the differences of the plunger diameters, shape of plungers and plunger barrels. Take care as the position of the basic surface for adjusting the injection volume is different.







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

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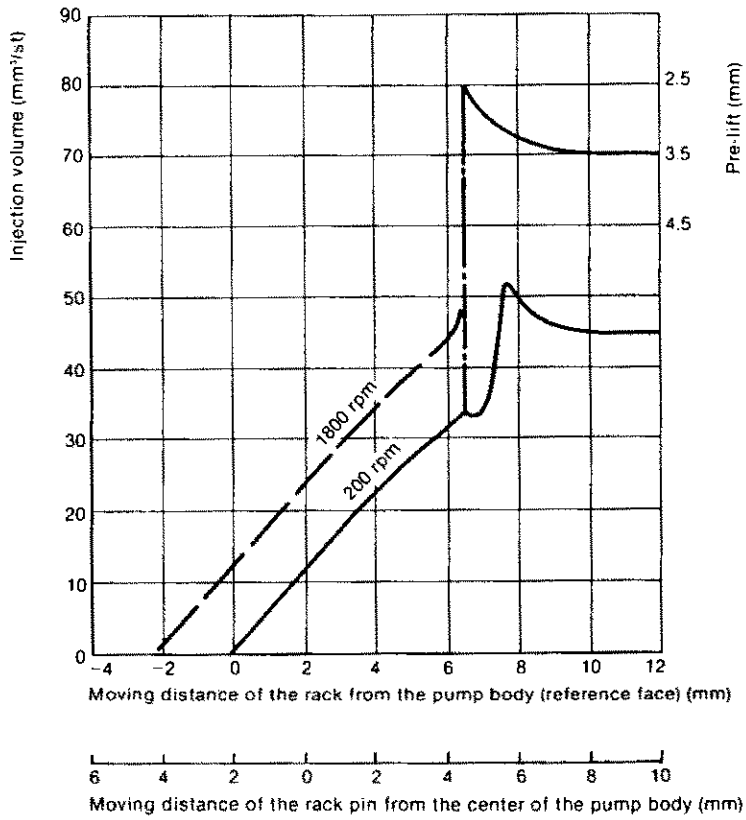
2-2 Specifications and performance of fuel injection pump

2-2.1 Specifications of fuel injection pump

			1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Plunger diameter			6mm (0.2362in.)			6.5mm (0.2559in.)
Standard plunger stroke			7mm (0.2756in.)			
Static mechanical lift at injection			2.5mm (0.0984in.) [at starting 3.2mm (0.1260in.)]			
Sliding resistance of fuel volume adjusting rack (when pump stops)			60g (0.002 lb) or less			
Top clearance of plunger (at the set dimension of 76 ±0.05mm)			1.0mm (0.0394in.)			
Thickness of plunger position adjusting shim			0.1mm (0.0039in.), 0.2mm (0.0079in.), 0.3mm (0.0118in.)			
Plunger spring (124950-51190 commonly used)	Free length		35.5mm (1.3976in.)			
	Spring constant		1.93 kgf/cm (10.8 lb/in.)			
	Load	At upper limit	25.1 kg (55.3 lb)			
		At lower limit	11.6 kg (25.6 lb)			
		At static injection	16.4 kg (36.2 lb)			
Suction volume of delivery valve			23.5mm³ (0.0014in.³) (24.5 according to 1GM10(C) drawing)			
Opening pressure of delivery valve			Approx. 16.3 kgf/cm² (231.8 lb/in.²)			
Delivery valve spring (124550-51320 commonly used)	Free length		21.0mm (0.8268in.)			
	Spring constant		0.64 kgf/cm (9.1 lb/in.)			
Rack stroke			Approx. 15mm (0.5906in.)			

2-2.2 Injection volume characteristics of fuel injection pump

(1) Model 1GM10(C)



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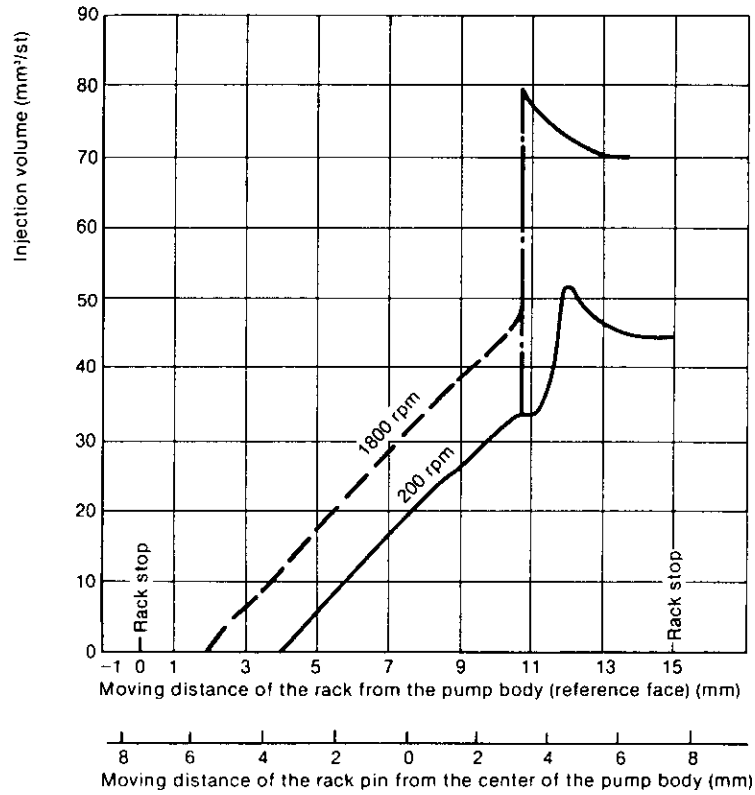
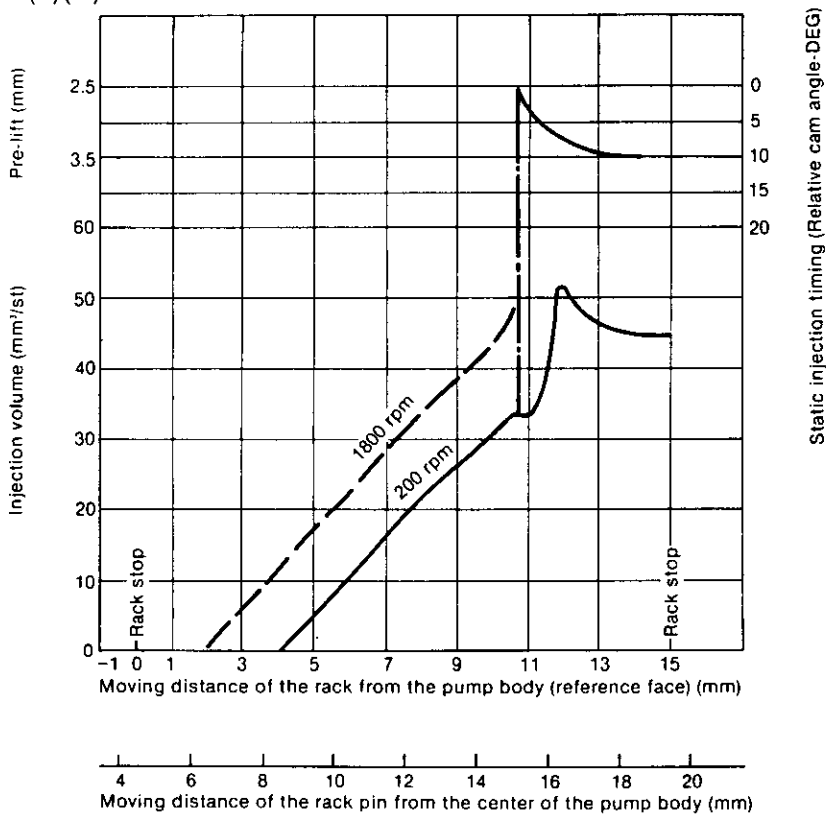
(2) Model 2GM20(F)(C)



(3) Model 3GM30(F)(C)



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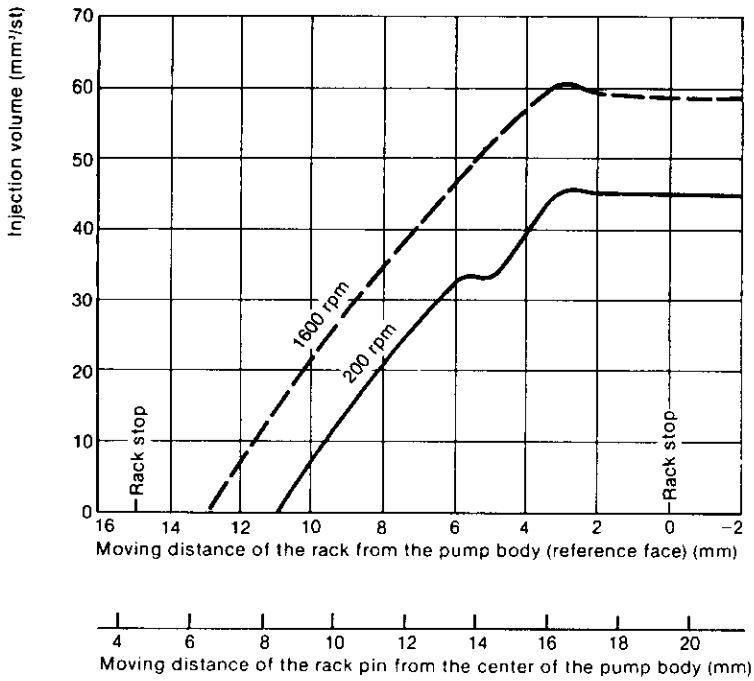
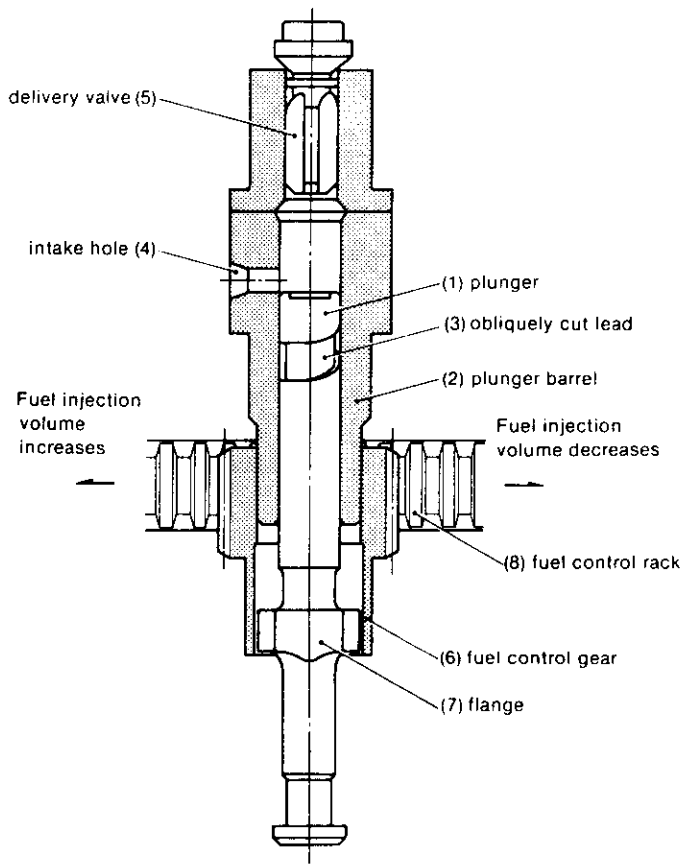
(4) Model 3HM35(F)(C)



2-3 Operation of fuel injection pump

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



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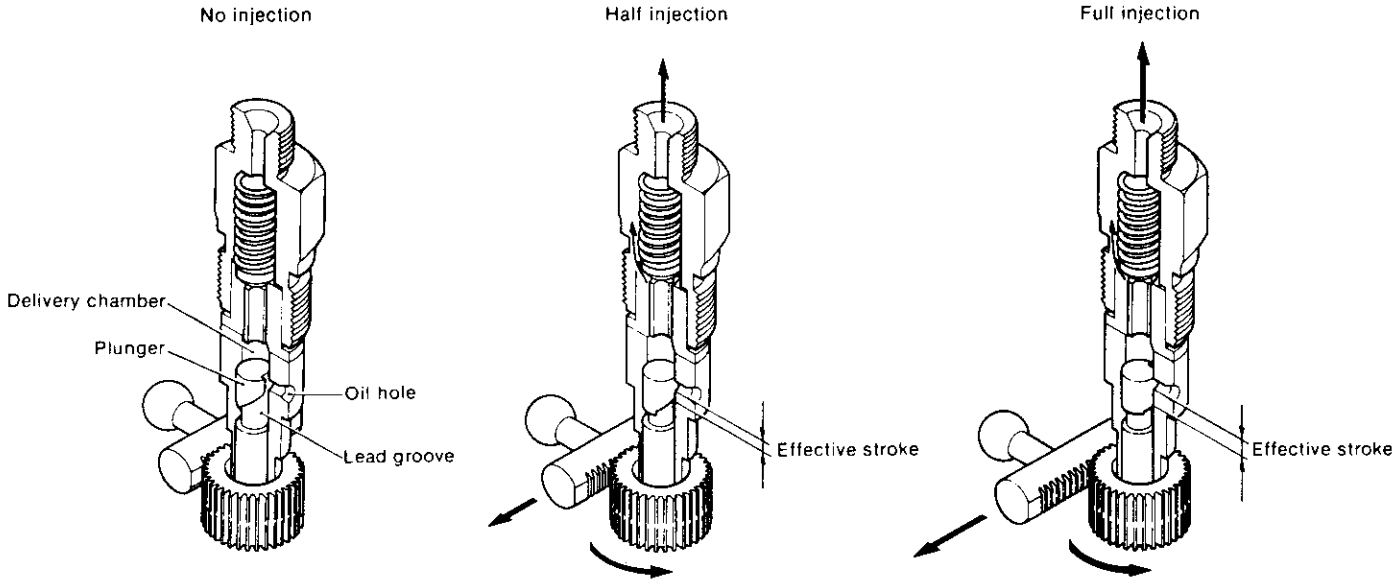
2-3.1 Fuel control

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

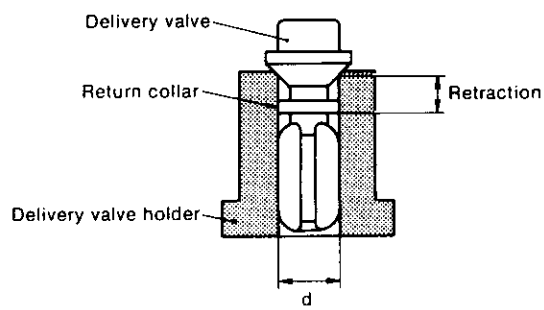


As a result of the above action, the plunger is rotated by the fuel control rack and the angle of this rotation changes the effective stroke of the plunger and controls the discharge of the pump. Also, when the fuel control rack lines up the longitudinal groove on the plunger with the oil hole, the oil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

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

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

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



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

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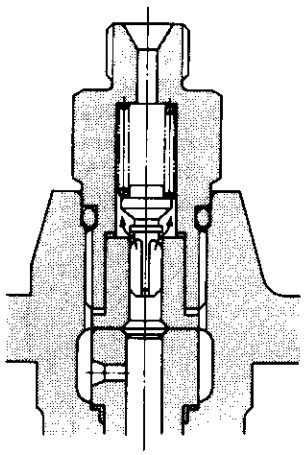
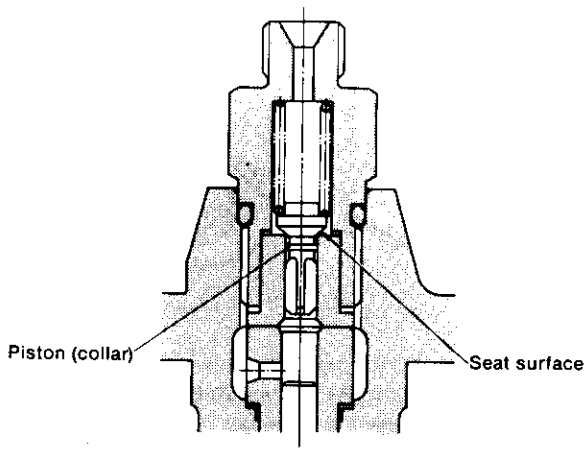
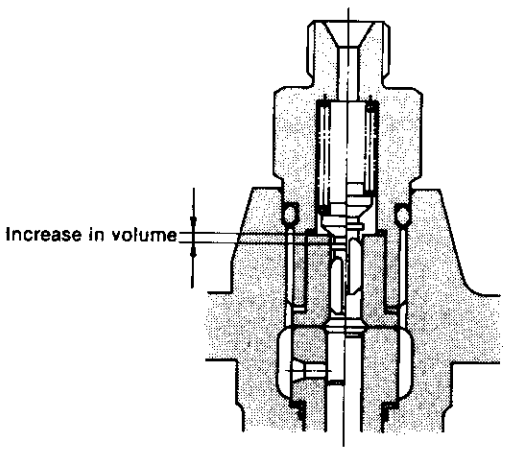


Open



Close



Retraction of fuel

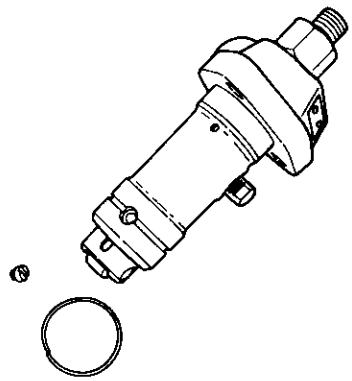
2-4 Disassembly of fuel injection pump

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

2-4.1 Dismantling of fuel injection pump of model 1GM10(C) engine.

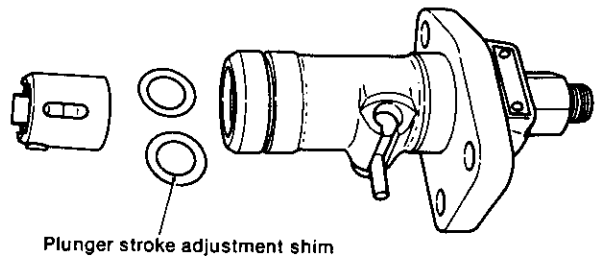
NOTES: 1) Before disassembly wash the pump in clean oil, and after assembly arrange all parts carefully.
2) Make sure the work area is exceptionally clean.

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



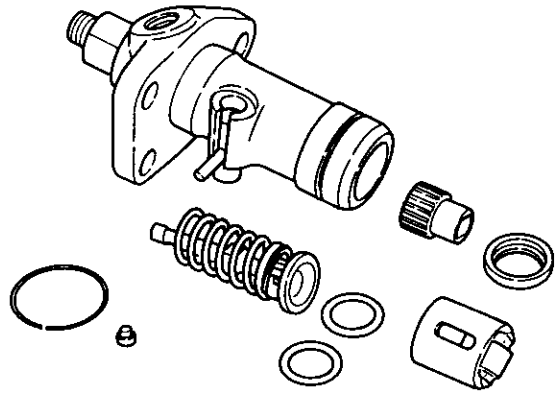
(2) Remove the plunger guide stopper.
The stopper can be removed by pushing the plunger guide down with the palm of your hand.
(3) Remove the plunger guide.

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



Plunger stroke adjustment shim

(4) Remove the plunger and plunger spring lower retainer. Be careful not to damage the plunger.
(5) Remove the plunger spring, fuel control pinion and plunger spring upper retainer, using your fingers or tweezers.



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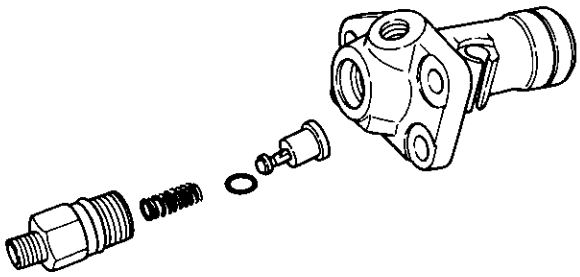
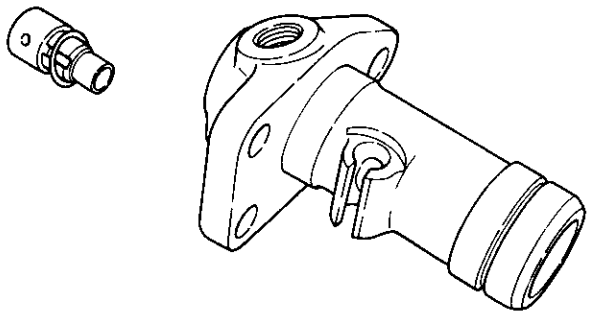
(6) Remove the fuel control rack.
(7) Remove the delivery valve holder; be careful not to damage the O-ring.
(8) Remove the delivery valve spring.
(9) Remove the delivery valve.



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

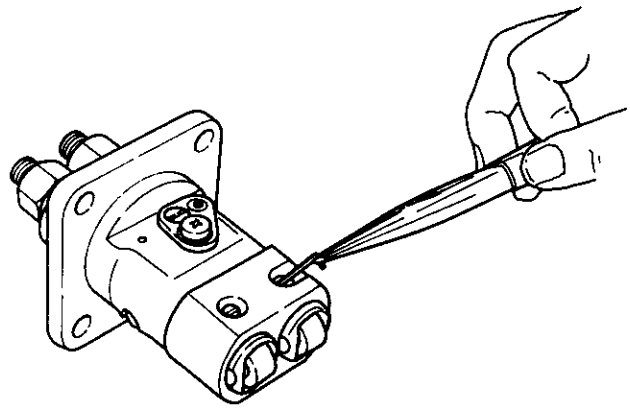


NOTES: 1) Line up the plunger barrel and the plunger, and put them in order.
2) Immerse the delivery valve, plunger, etc. in clean oil.
3) Do not loosen or remove the plunger barrel stopper, etc.

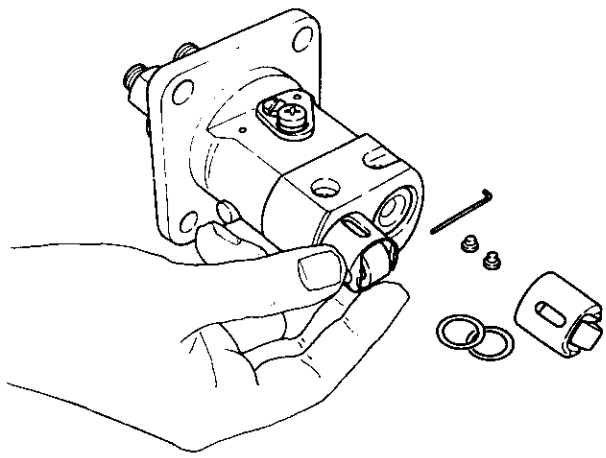
2-4.2 Dismantling of fuel pump of model 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)

The cylinders are classified as No. 1, No. 2 and No. 3 from the left, when facing the name plate fitted on the upper part of the fuel injection pump. When dismantling, it is necessary to prepare pans or vessels in which to keep the dismantled parts from each cylinder; each part must be placed in the corresponding pan or vessel for each cylinder, namely, No. 1, No. 2 and No. 3 cylinder. If a part is placed in the wrong pan or vessel, reassembly becomes impossible without a pump tester. The following explanation is for to the pump of the 2 cylinder type engine [model 2GM20(F)(C)], but it applies equally to that of the 3 cylinder type engine [model 3GM30(F)(C)] which merely has an additional set. The construction of the fuel pump of model 3HM35(F)(C) engine is the same as that of model 3GM30(F)(C) engine except for the differences of plunger, plunger barrel, and the position of the injection volume adjusting rack.

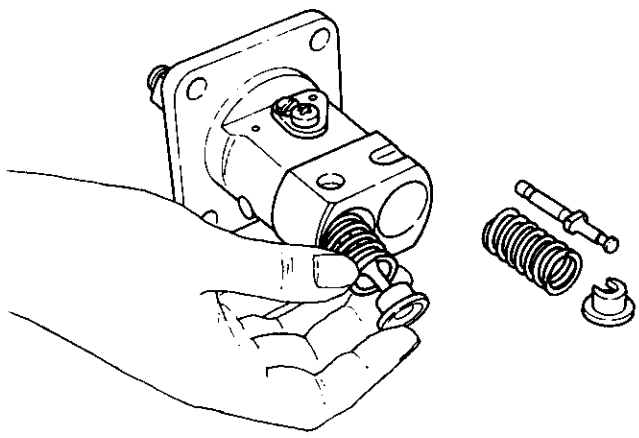
(1) Remove the plunger guide stopper pin with needle nose pliers.



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



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



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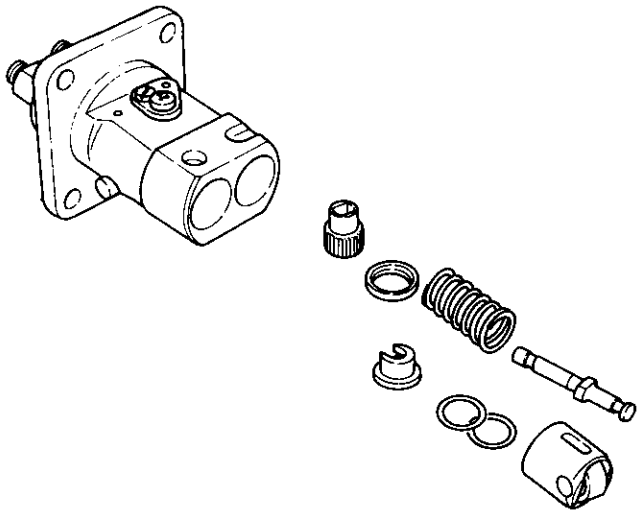
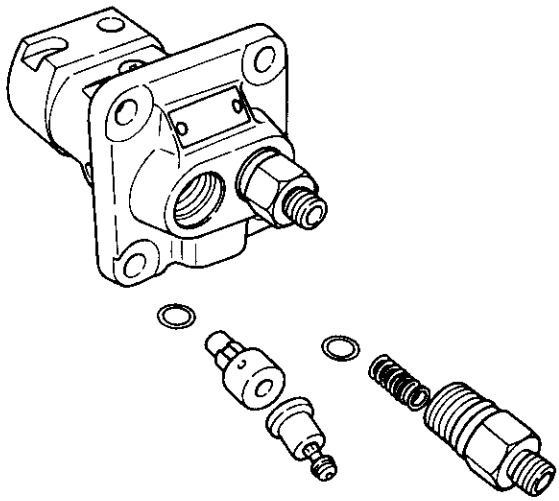
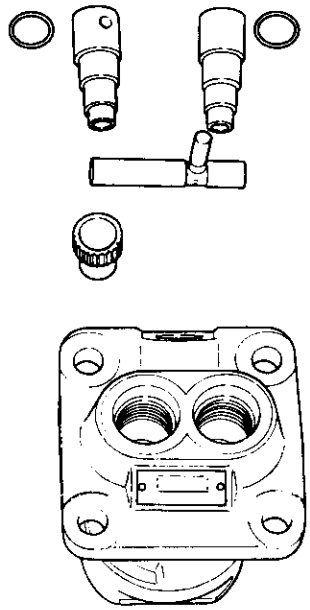
(6) Remove the No.1 plunger spring upper retainer, using your fingers or tweezers.
(7) Remove the No.1 control sleeve



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



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



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

2-5 Inspecting injection pump parts

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

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

2-5.2 Tappet

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

2-5.3 Control rack and pinion

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

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

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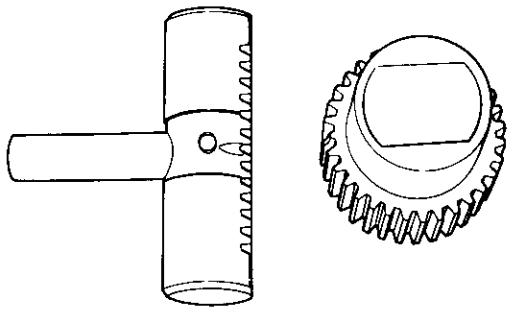
(2) Replace pinion if teeth are damaged or worn unevenly.

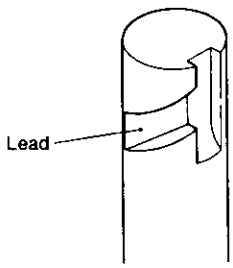


(3) If the control rack does not move smoothly when a force of within 60g is applied, replace the rack and pinion assembly.

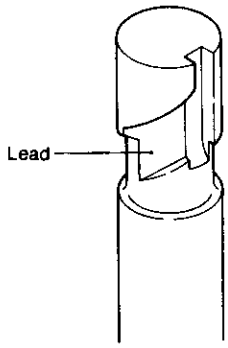
2-5.4 Plunger

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

For models 1GM10(C), 2GM20(F)(C) and 3GM30(F)(C)



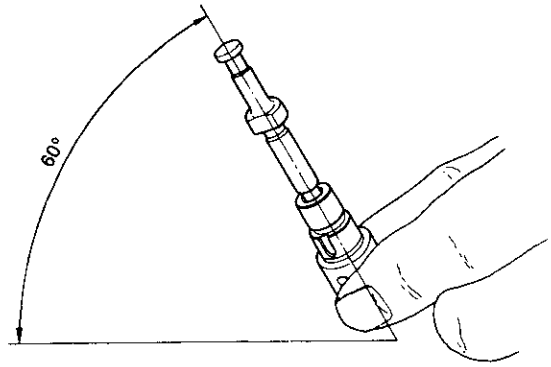
For model 3HM35(F)(C)



(2) Inspect the outside sliding surface of the plunger with a magnifying glass. Lap or replace the plunger and plunger barrel assembly when corrosion, hairline cracks, staining and/or scoring are detected.

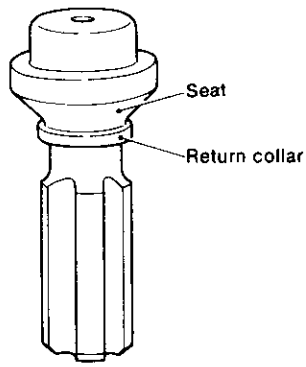
(3) Check the clearance between the plunger collar and control sleeve groove. Replace these parts when wear exceeds the specified limit.

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

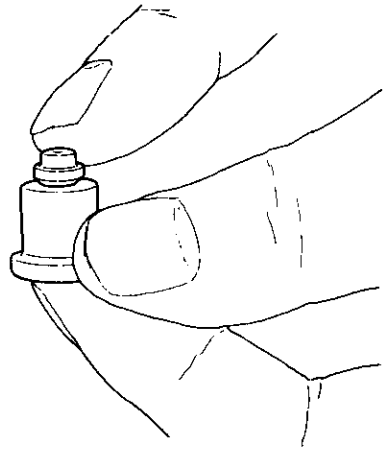


2-5.5 Delivery valve

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



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



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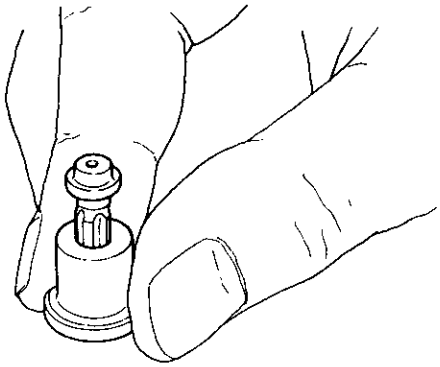
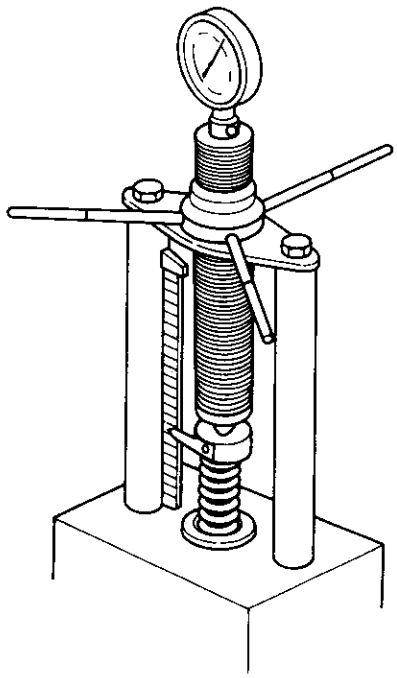
(3) Place your finger over the hole in the bottom of the valve seat and insert the valve into the valve body. If the valve returns to its original position when you remove your finger, the valve is okay. If some defect is found, replace with a new valve.
(4) If the valve closes completely by its own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



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

2-5.6 Plunger spring and delivery valve spring

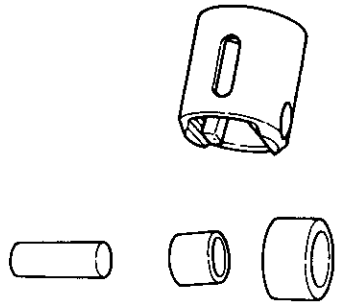
Inspect the plunger spring and delivery valve spring for fractured coils, rust, inclination and permanent strain. Replace the spring when faulty.



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

2-5.7 Plunger guide

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



mm (in.)

Clearance limit	0.3 (0.0118)

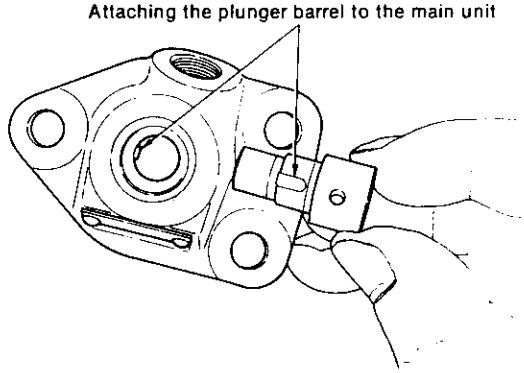
2-6 Assembling the fuel injection pump

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

1GM10(C)

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

Attaching the plunger barrel to the main unit



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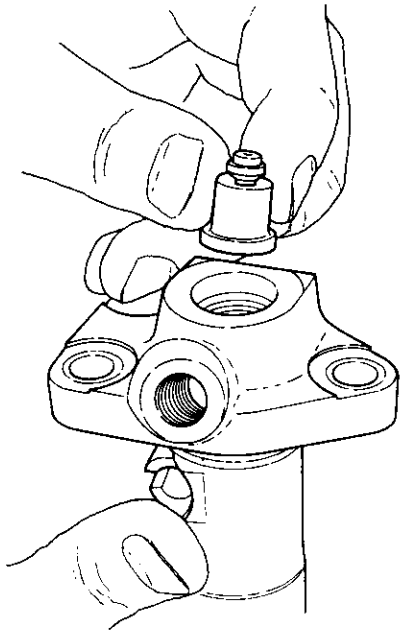
(2) Attach the delivery valve seat and the delivery valve to the main unit.



Attaching the delivery valve to the main unit

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

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

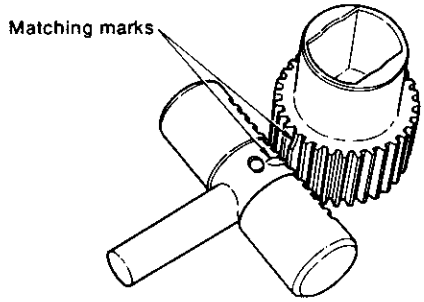
NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

1GM(10(C)	kgf-m(ft-lb)
Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

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

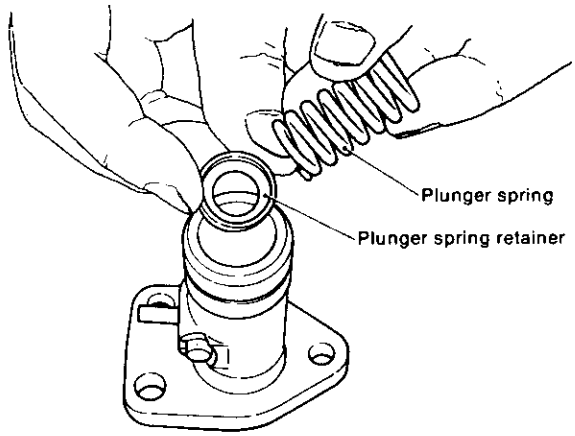
NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

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



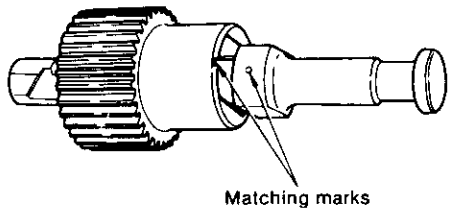
NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.

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



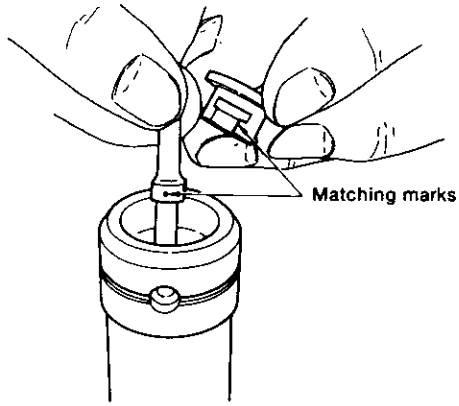
NOTE: The plunger spring retainer should face the underside of the pump.

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



NOTE: Invert and stand the main unit of the pump upright and attach the plunger to it carefully.

(8) Mount the plunger lower retainer on the plunger.



(9) Insert the plunger adjusting shims.

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

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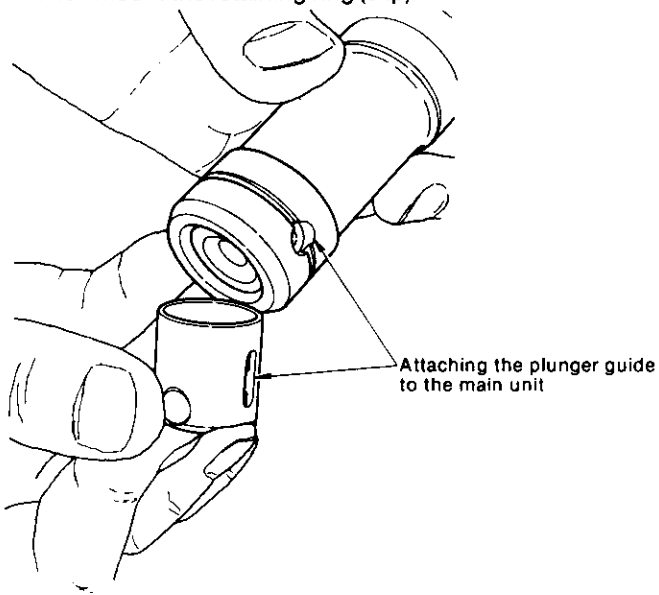
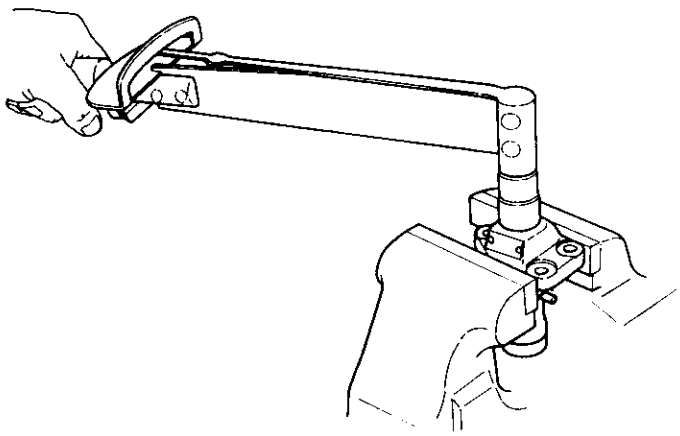
(10) While adjusting the direction of the plunger guide stopper hole for the plunger guide, insert the plunger guide carefully.
When the plunger guide stopper hole is lined up with the plunger guide, insert the plunger guide stopper. Then mount the retaining ring (clip).



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



1GM10(C) kgf-m(ft-lb)

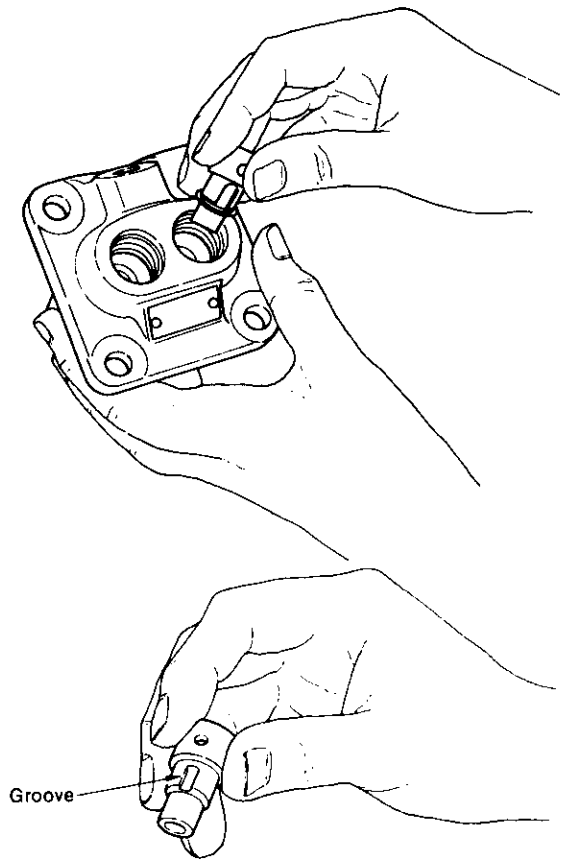
Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

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

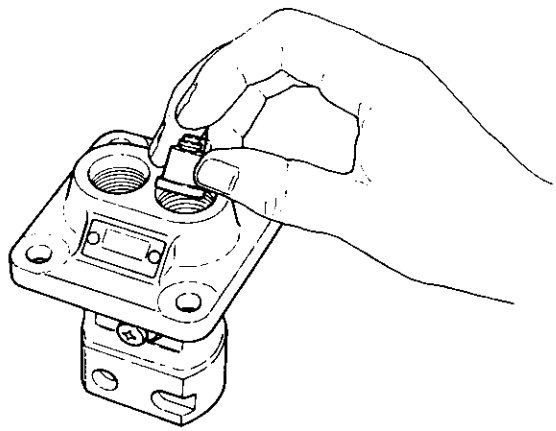
To ensure that the injection pump is correctly reassembled, the following points must be kept in mind:

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

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



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



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

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

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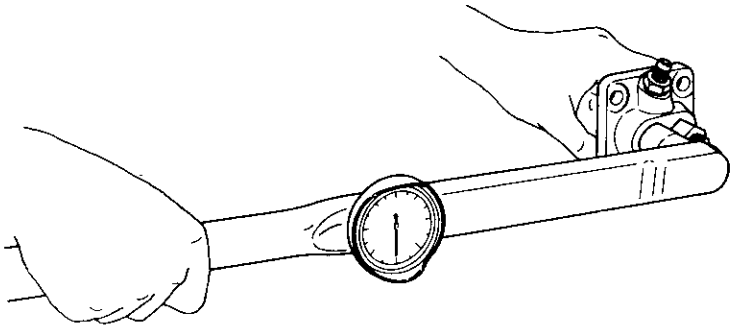
(5) Tighten the No.1 delivery valve holder.



2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C) kgf-m(ft-lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

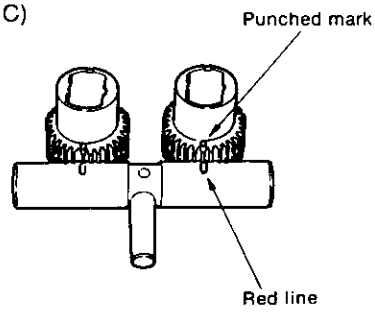
NOTE: Tighten the delivery valve holder with a torque wrench after attaching the plunger and while checking the fuel control rack for sliding motion.

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

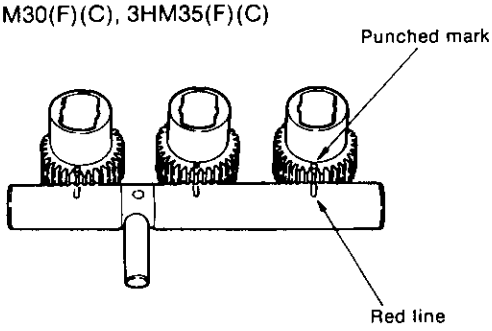
NOTE: Make sure the fuel control rack moves smoothly along its entire stroke.

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

2GM20(F)(C)

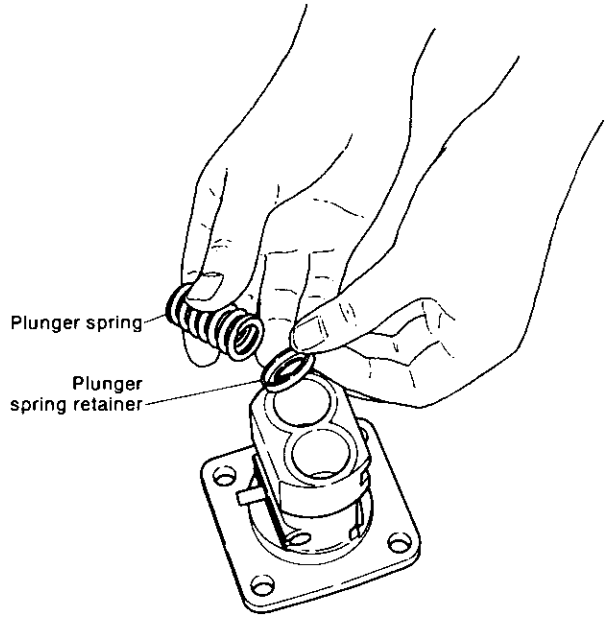


3GM30(F)(C), 3HM35(F)(C)



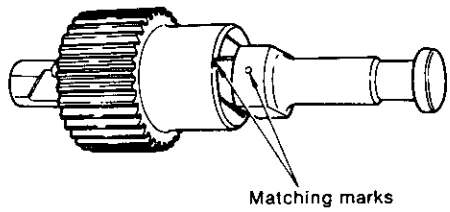
NOTE: After attaching the fuel control pinion to the main unit, check its meshing by moving the fuel control rack.

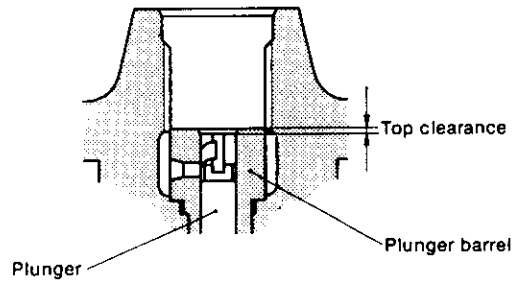
(8) Insert the No.1 plunger spring retainer and attach the plunger spring to the main unit.



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

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





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

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

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(11) Insert the plunger shim.
NOTE: Insert the same number of shims with the same thickness as those inserted before disassembling the pump. After re-assembling the pump, measure and adjust the top clearance of the plunger.
(12) Insert the No.1 plunger guide.
(13) Insert the No.1 plunger guide stopper.
(14) For the pump of the 2 cylinder type engine, repeat the above steps for No.2 cylinder.
(15) For the pump of the 3 cylinder type engine, repeat the above steps for No.3 cylinder.
(16) Install the plunger guide stopper pin.
(17) After attachment tighten the delivery valve holder with a torque wrench.

2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C) kgf-m(ft-lb)

Tightening torque	4.0 ~ 4.5 (28.92 ~ 32.54)

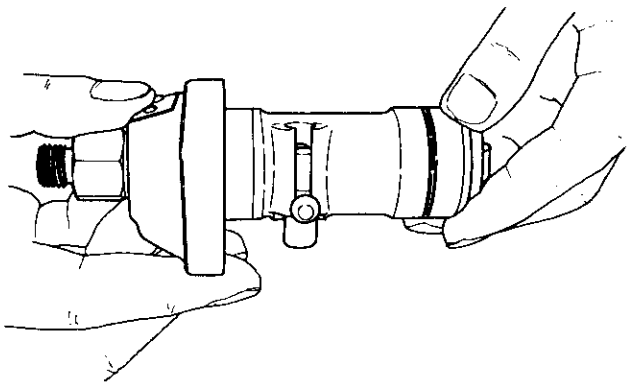
NOTE: When the tightening torque of the delivery valve holder exceeds the prescribed torque, the plunger will be distorted, the sliding resistance of the control rack will increase, and proper performance will not be obtained. Moreover, excessive tightening will damage the pump body and delivery valve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

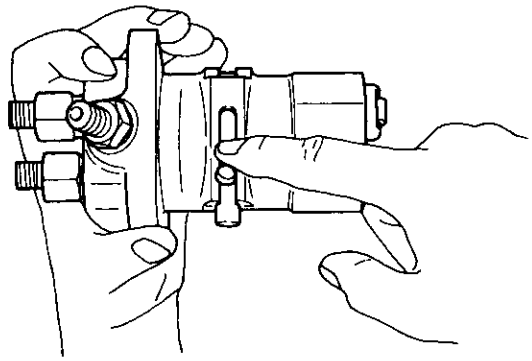
2-7 Inspection after reassembly

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

2-7.1 Control rack resistance test

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

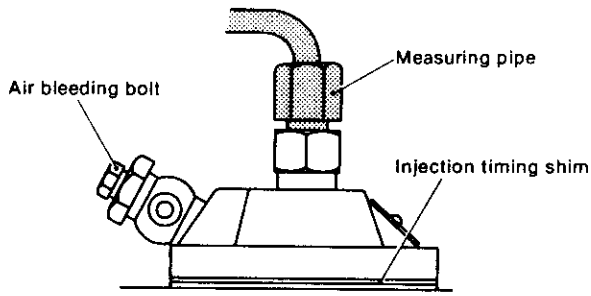




(a) Resistance of the rotating and sliding parts of the plunger assembly is too high.
(b) Delivery valve holder is too tight (plunger barrel distorted).
(c) Control rack or control pinion teeth and control rack outside circumference are dirty or damaged.
(d) Injection pump body control rack hole is damaged.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

2-7.2 Fuel injection timing

Fuel injection timing is adjusted by timing shims inserted between the pump body and gear case pump mounting seat.
The injection pump must be mounted on the engine, and each cylinder injection timing adjusted.
Adjusting the injection timing
(1) Remove the high pressure pipe from the pump.
(2) Install a measuring pipe if the injection pump does not have a nipple on the delivery side.
(3) Bleed the air from the injection pump.



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

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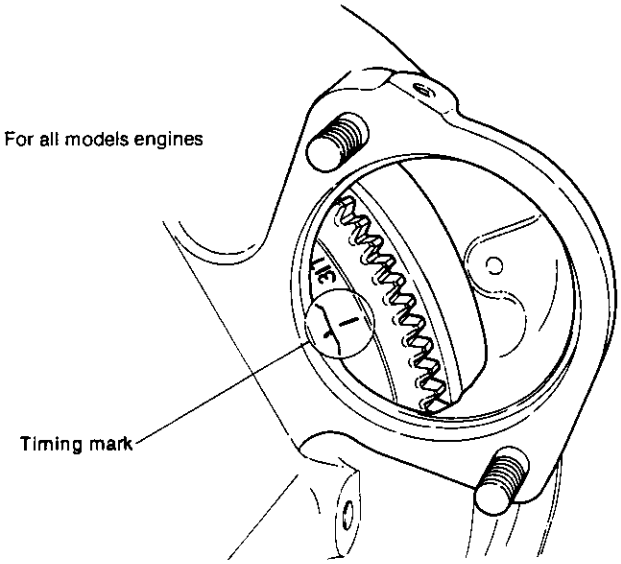
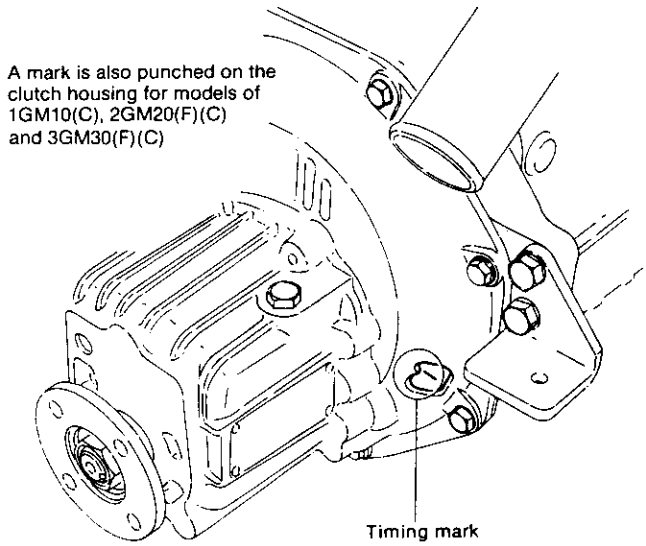


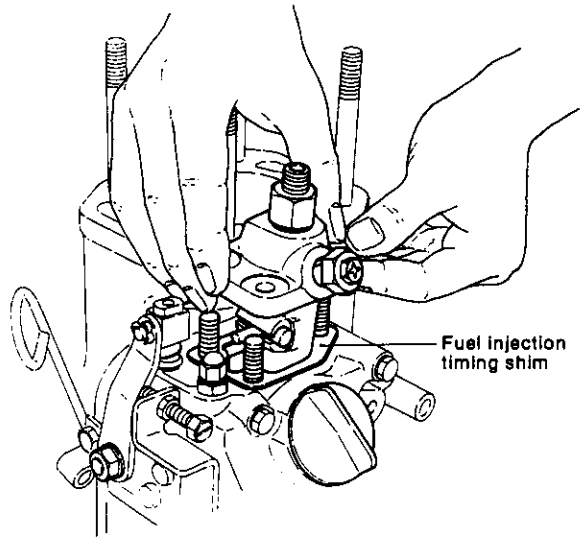


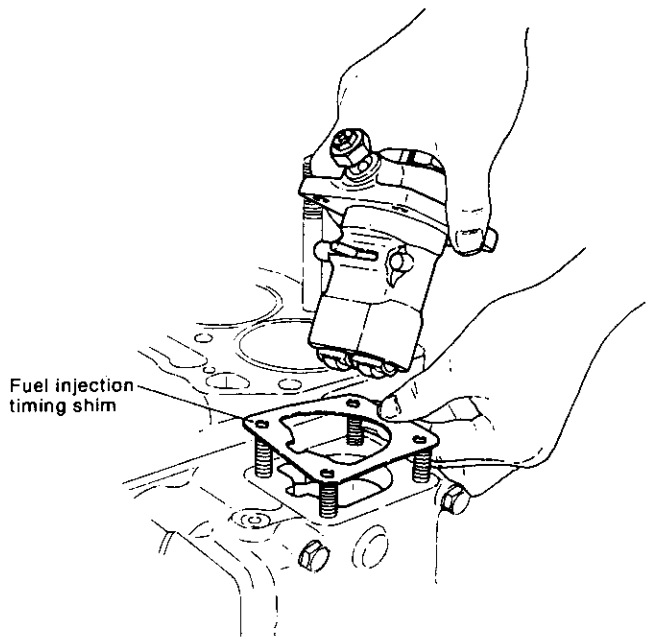
(6) If the injection timing is off, add plunger shims when the timing is slow, and remove shims when the timing is fast. Adjust the timing of every pump in the same manner. (Refer to item, "Plunger head gap adjustment".)

(7) After the injection timing of every pump has been matched, recheck the injection timing as described in item (5) above. If the injection timing is not properly set, adjust it with the timing shims.

		1GM10(C)	2GM20 (F)(C)	3GM30 (F)(C)	3HM35 (F)(C)
Fuel injection timing		bTDC15° (FID)	bTDC15° (FID)	bTDC18° (FID)	bTDC21° (F(D)
Fuel inection timing shim	0.2mm (0.008in.)	1 shim 104271-01930	2 shims 124950-01931	2 shims 121450-01931	
	0.3mm (0.012in.)	1 shim 104271-01940	2 shims 124950-01941	2 shims 121450-01941	
	0.5mm (0.020)	—	1 shim 124950-01961	1 shim 124950-01961	
	Set No.	104271-01950	124950-01951	121450-01951	

The thickness of the plunger location adjusting shim and the injection timing adjusting plate is 0.1 mm. With this the injection timing can be changed by approximately 1° on the crankshaft.





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

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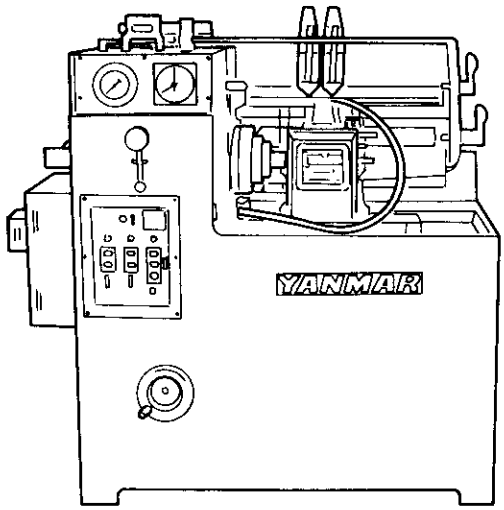
2-8 Injection pump adjustment

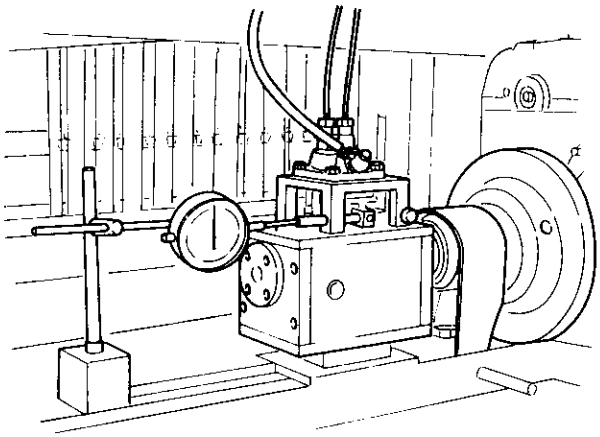
The injection pump is adjusted with an injection pump tester after reassembly.



2-8.1 Setting pump on tester

(1) After the injection pump has been disassembled and reassembled, install it on a pump tester
...cam lift: 7mm (0.276in.).

(2) Confirm that the control rack slides smoothly. If it does not, inspect the injection pump and repair it so that the rack slides smoothly
...control rack full stroke: 15mm (0.5905in.).

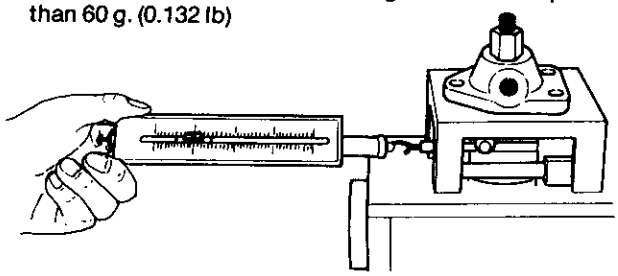


(3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

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

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

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



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

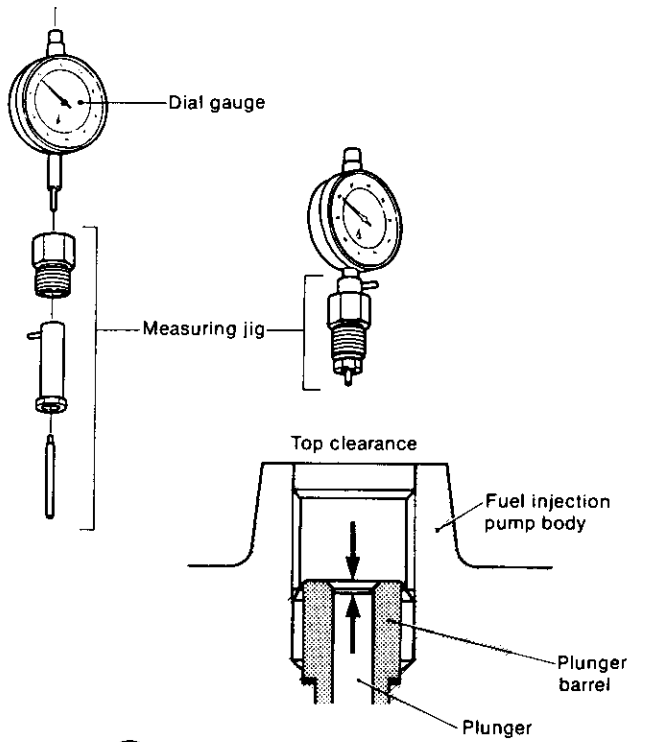
2-8.3 Adjusting the plunger top clearance

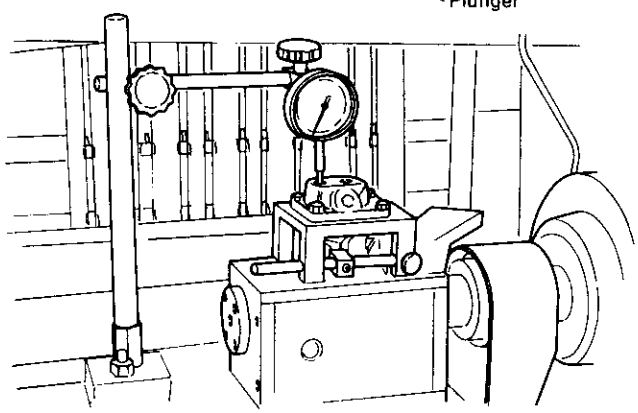
(1) Set the pump installation dimension (end of plunger barrel when the roller is on the cam base cycle) at 76 ±0.05mm (2.9902 ~ 2.9941in.), remove the delivery valve holder and delivery valve, and set the plunger to top dead center by turning the camshaft. Measure the difference in height (head gap)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

mm (in.)

Plunger top clearance	1.0 ±0.05 (0.0374 ~ 0.0398)

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





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

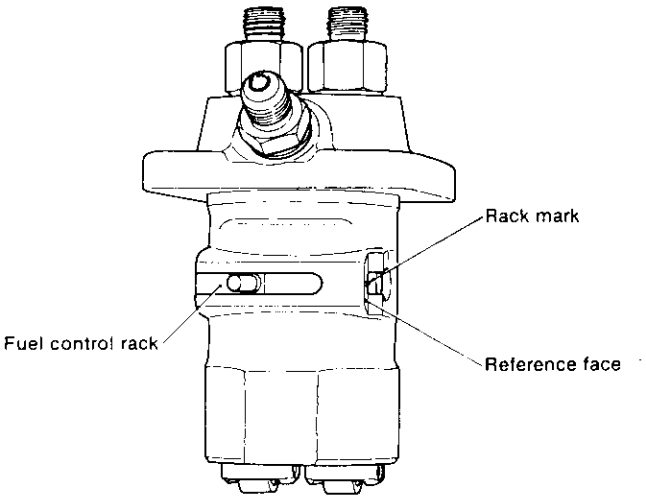
Plunger shim thickness	0.1mm (0.004in.)	174307-51710
	0.2mm (0.008in.)	174307-51720
	0.3mm (0.012in.)	174307-51730

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

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

2-8.4 Checking the cylinder injection interval

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



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

	For crankshaft angle	For camshaft angle
2GM20(F)(C)	180° 540° 1 ~ 2 ~ 1	90° 270° 1 ~ 2 ~ 1
3GM30(F)(C), 3HM35(F)(C)	240° 240° 240° 1 ~ 3 ~ 2 ~ 1	120° 120° 120° 1 ~ 3 ~ 2 ~ 1

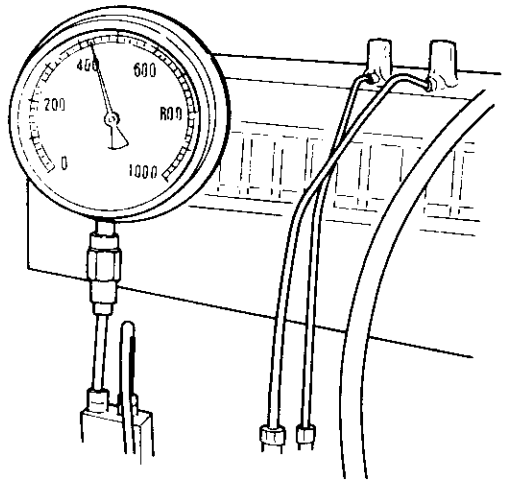
2-8.5 Delivery valve oil-tight test

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

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

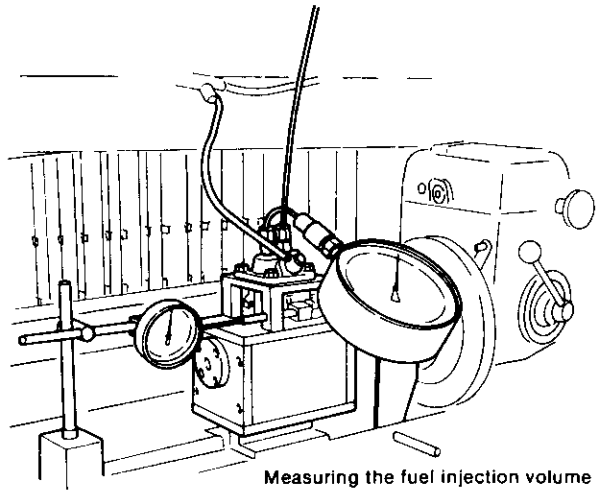
(3) If both the plunger and the delivery valve fail the test, replace them.

2-8.6 Plunger pressure test

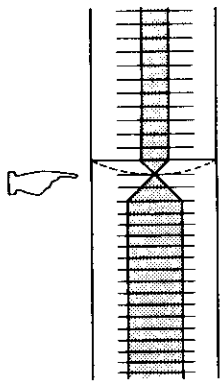


(1)Install a 1,000 kgf/cm²(14,223 lb/in.²)pressure gauge on the delivery valve holder.
(2)Check that there is no oil leaking from the delivery valve holder and high pressure pipe mountings,and that the pressure does not drop suddenly when raised to 500 Kgf/cm²(7,112 lb/in.²) or higher.
Pressure gauge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

2-8.7 Measuring the fuel injection volume



Measuring the fuel injection volume



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

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Pump speed	1800 rpm		1700 rpm
Plunger diameter x stroke	ϕ6 x 7mm (0.2362 x 0.2756in.)		ϕ6.5 x 7mm (0.2559 x 0.2756in.)
Injection nozzle type	YDN-OSDYD1		YDN-OSDY1
Pressure for fuel injeciton	170kgf/cm^2 (2418 lb/in^2)		160kgf/cm^2 (2276 lb/in^2)
Amount of injection at rack mark position	22.5~23.5cc (1.37~1.43in.^{3})	21.5cc~22.5cc (1.31~1.37in.^{3})	27.5~28.5cc (1.68~1.74in.^{3})
Allowable error between cylinder	—	1cc (0.06in.^{3}) or less	1cc (0.06in.^{3}) or less
Stroke	1000		1000

NOTE: Mainting the pressure for feeding oil to the injection pump at 0.5 kgf/cm^2. (7.1 lb/in.^{2})

2-8.8 Adjustment of injection volume for each cylinder

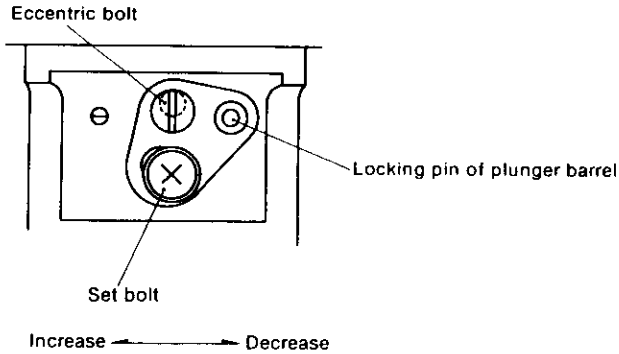
(1) Fluctuation of injection volume
The injection volumes of each cylinder must be adjusted to within 3% of each other.

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

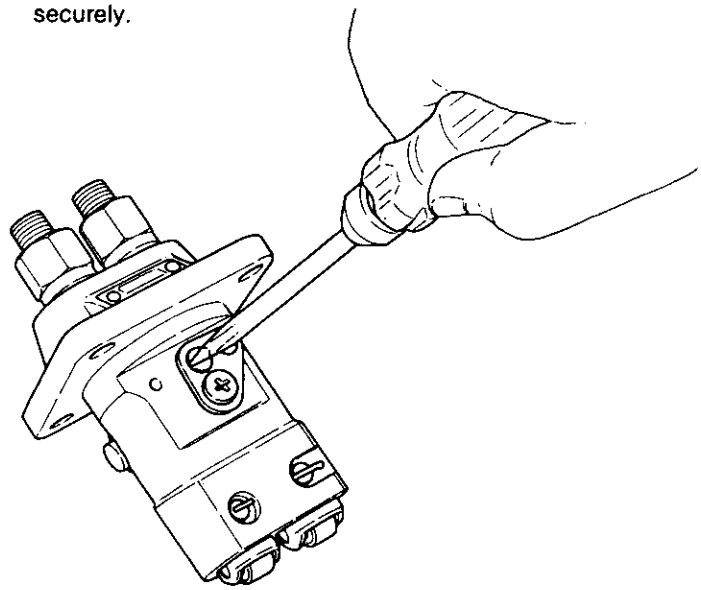
$$\text{Difference} = \frac{\text{Maximum injection volume} - \text{average injection volume}}{\text{Average injection volume}} \times 100$$

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

(2) Adjustment of injection volume
In order to adjust the fluctuation of injection volume for each cylinder, alter the position of the injection volume adjusting plate at the side of the fuel injection of pump body.
The injection volume adjusting plate is operated by the eccentric bolt which is integrated with the locking pin of the plunger barrel and changes the position of the plunger barrel. When the plunger barrel is turned, the relative position of the suction hole with respect to the lower lead of the plunger changes the injection volume.



By loosening the set bolt and turning the eccentric bolt clockwise, the position of the pin moves to the left to increase the injection volume, and by turning the eccentric bolt counterclockwise, the pin moves to the right to decrease the injection volume.
After adjusting the injection volume, tighten the set bolt securely.



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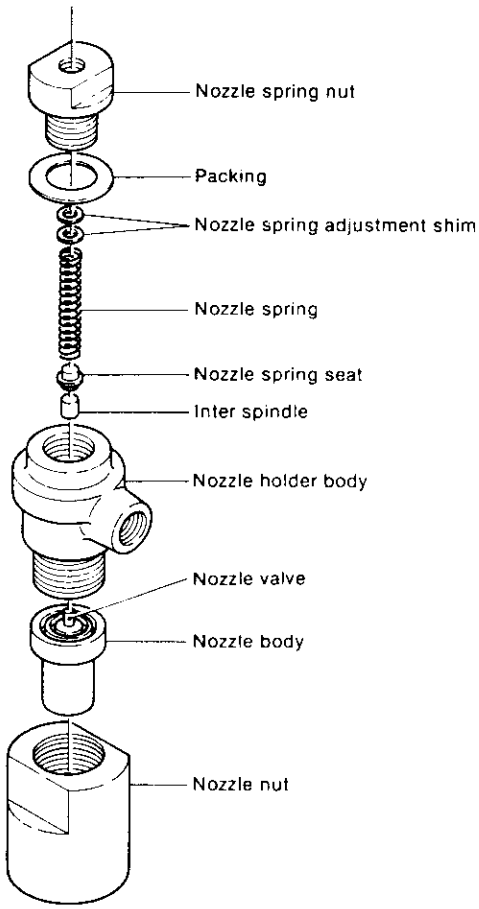
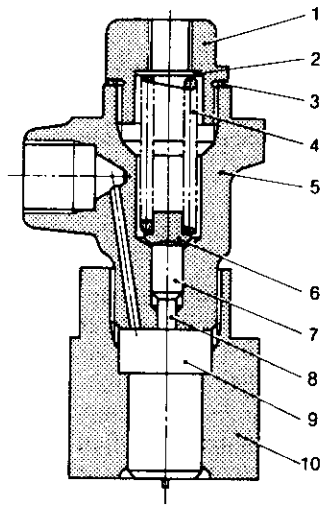
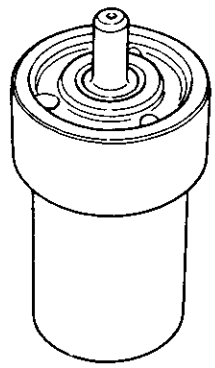
3. Injection Nozzle

3-1 Construction

The injection nozzle atomizes the fuel sent from the injection pump and injects it into the precombustion chamber in the prescribed injection pattern to obtain good combustion through optimum fuel/air mixing.
The main parts of the injection nozzle are the nozzle holder and nozzle body. Since both these parts are exposed to hot combustion gas, they must be extremely durable.
Moreover, since their operation is extremely sensitive to the pressure of the fuel, high precision is required. Both are made of quality alloy steel that has been specially heat treated and lapped, so they must always be handled as a pair.
Common parts are used for the fuel valve of models 1GM10(C), 2GM20(F)(C) and 3GM30(F)(C). The only difference between the GM model series and model 3HM35(F)(C) is the nozzle case nut.







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

3-2 Specifications for nozzle valve

Engine model		1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Nozzle	Type of nozzle valve	YDN-OSDYD1 (Throttle)	
	Valve opening pressure	170±5 kgf/cm²(2347 ~ 2489 lb/in.²)	160±5 kgf/cm²(2205 ~ 2347 lb/in.²)
	Diameter of injection nozzle	ø1mm (0.0394in.)	
	Angle of injection	5° ~ 10°	
Nozzle spring	Free length	30.0mm (1.1811in.)	
	Mounted length	28.7mm (1.1299in.)	
	Mounted load	14.14 kg (31.17 lb)	
Nozzle spring adjusting plate (for adjusting nozzle opening pressure)		0.1mm (0.0039in.) 0.15mm (0.0059in.) 0.2mm (0.0079in.) 0.3mm (0.0118in.) 0.5mm (0.0197in.)	

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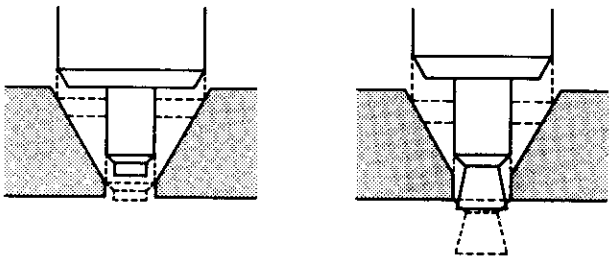
3-3 Yanmar throttle nozzle

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



Pintle nozzle　　YANMAR semi-throttle nozzle

3-4 Nozzle operation

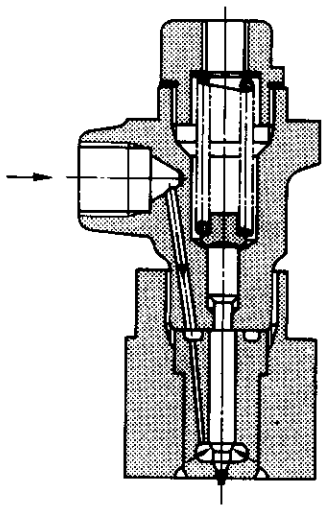
The nozzle is pushed down to its lowest position by the pressure-adjusting nozzle spring and contacts the valve seat of the nozzle body.

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

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

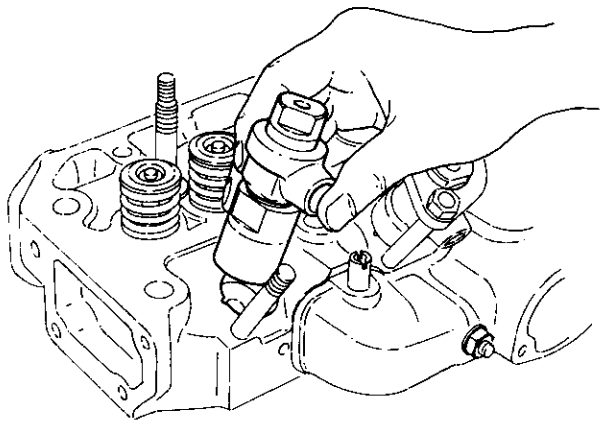
The nozzle is closed again when the pressure in the nozzle body's pressure chamber drops below the force of the spring.

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

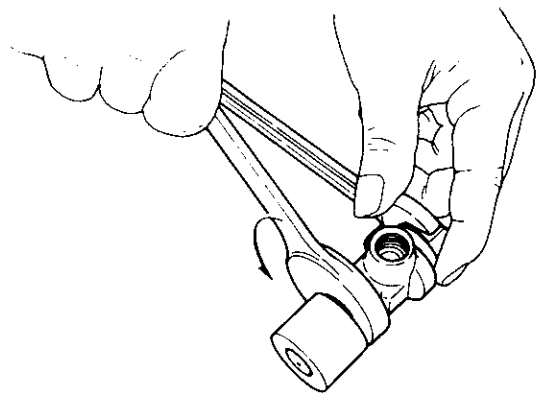


3-5 Disassembly and reassembly

3-5.1 Disassembly sequence



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

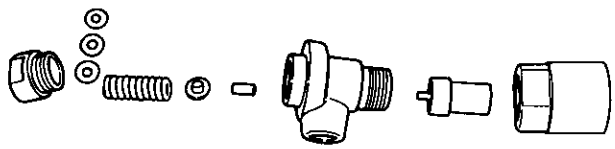


(4) Remove the nozzle body and nozzle ass'y from the nozzle mounting nut.
(5) Remove the nozzle spring retainer from the nozzle holder body, and remove the nozzle spring retainer, inter-spindle etc.

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

3-5.2 Disassembly and reassembly precautions

(1) The disassembled parts must be washed in fuel oil, and carbon must be completely removed from the end of the nozzle body, the nozzle body and the nozzle mounting nut fitting section.
If reassembled while any carbon remains, the nozzle will not tighten evenly, causing faulty injection.



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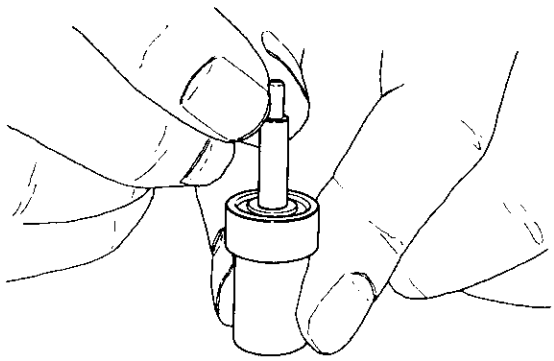
(2) Parts for No.1 cylinder and No.2 cylinder must be kept separate. The nozzle body and nozzle must always be handled as a pair.

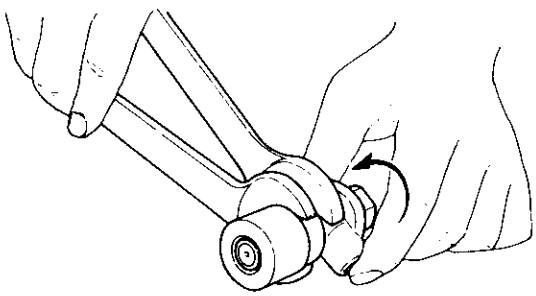
(3) Precautions when using a new nozzle.
First immerse the new nozzle in rust-preventive oil, and then seal it on the outside with seal peel. After removing the seal peel, immerse the nozzle in diesel oil and remove the rust-preventive oil from both inside and outside the nozzle.
Stand the nozzle holder upright, lift the nozzle about 1/3 of its length: it should drop smoothly by it own weight when released.



(4) The nozzle must be fitted on the nozzle holder with the nozzle spring retainer loosened.
If the nozzle is installed with the nozzle spring tightened, the nozzle mounting nut will be tightened unevenly and oil will leak from between the end of the nozzle holder body and the end of the nozzle mounting nut, causing faulty injection.

kgf-m(ft-lb)

Nozzle tightening torque	Nozzle nut	10 (72.36)
	Nozzle spring nut	7.0 ~ 8.0 (50.65 ~ 57.89)

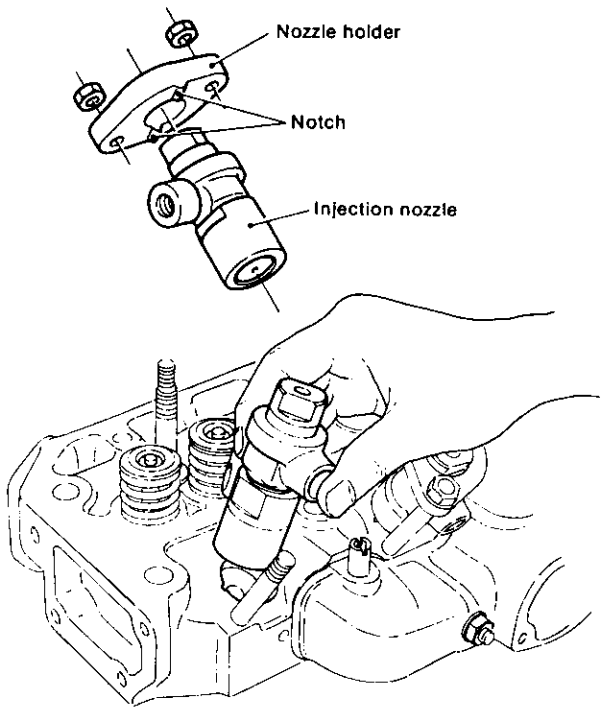


(5) When installing the injection nozzle on the cylinder head, tighten the nozzle holder nuts alternately, being careful to tighten them evenly.

kgf-m(ft-lb)

Tightening torque	2 (14.5)

The nozzle holder must be installed with the notch side on the nozzle side.



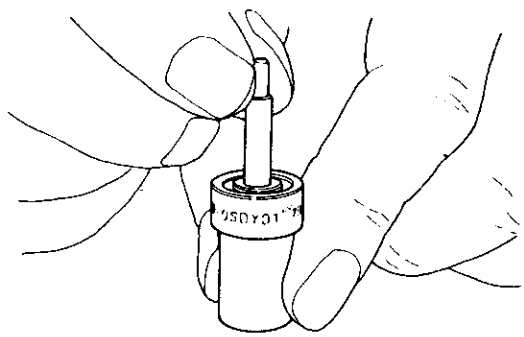
3-6 Injection nozzle inspection and adjustment

3-6.1 Carbon and corrosion on the nozzle body

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

3-6.2 Checking nozzle action

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



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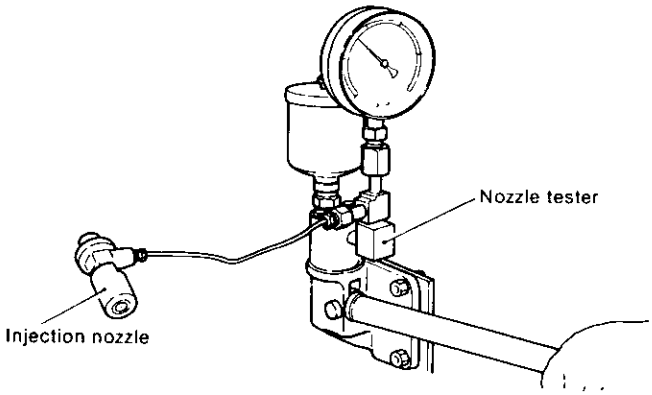
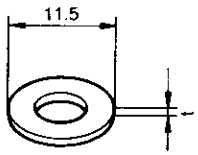
3-6.3 Adjusting the nozzle injection pressure

Fit the injection nozzle to the high pressure pipe of a nozzle tester and slowly operate the lever of the tester. Read the pressure when instant injection from the nozzle begins.
If the injection pressure is lower than the prescribed pressure, remove the nozzle spring holder and adjust the pressure by adding nozzle spring shims.
The injection pressure increases about 10 kgf/cm² (142.2 lb/in.²) when a 0.1mm (0.004in.) shim is added.





t = 0.1mm (0.0039in.)
0.2mm (0.0079in.)
0.3mm (0.0118in.)
0.5mm (0.0197in.)

	1GM10(C), 2GM20(F) 3GM30(F)(C)	3HM35(F)(C)
Injection pressure	170±5 kgf/cm² (2347 ~ 2489 lb/in.²)	160±5 kgf/cm² (2205 ~ 2347 lb/in.²)

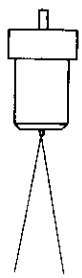
3-6.4 Nozzle seat oil tightness check

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

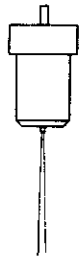
3-6.5 Checking the spray condition

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

Normal

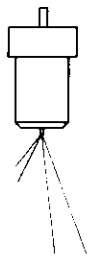


Stream



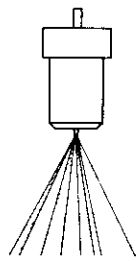
- Injection pressure low
- Nozzle seized
- Nozzle spring broken
- Dirt on valve seat

Spike



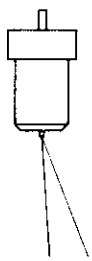
- Injection port damaged or dirty
- Carbon build-up
- Nozzle end abnormally worn

Spray



- Injection port worn
- Carbon build-up

Slanted



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

3-6.6 Inspecting the nozzle spring

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

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

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

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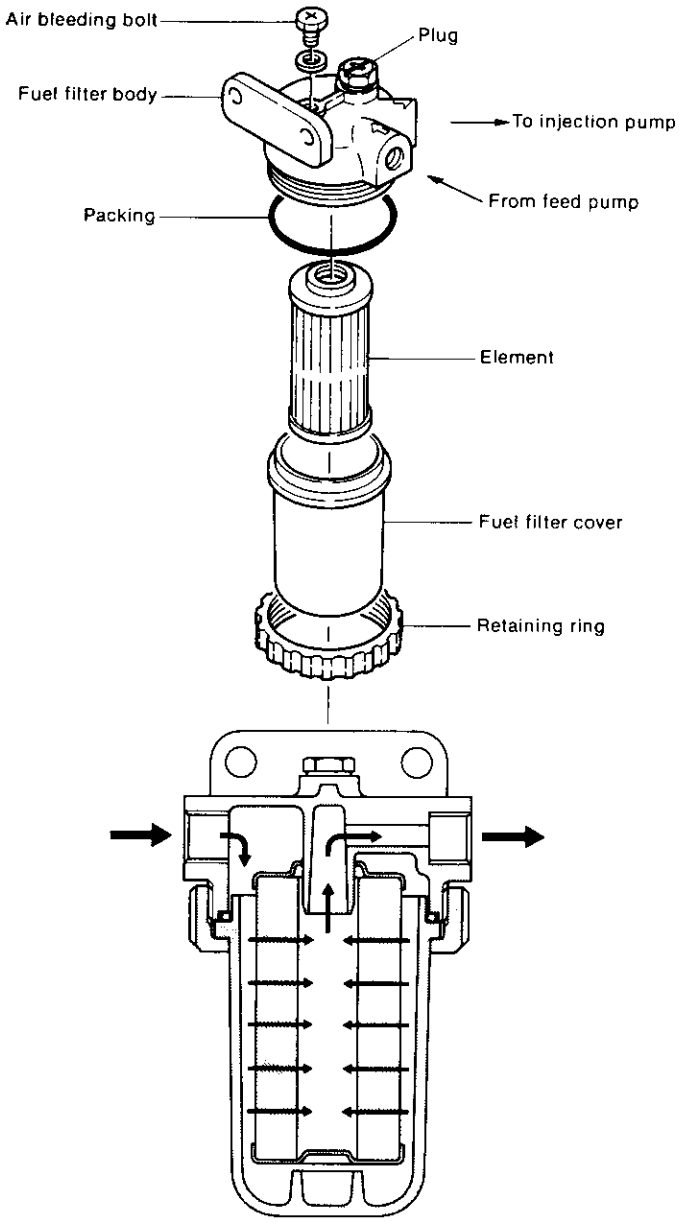
4. Fuel Filter

4-1 Construction

The fuel filter is installed between the feed pump and injection pump, and serves to remove dirt and impurities from the oil fed from the fuel tank through the feed pump.
The fuel filter incorporates a replaceable filter paper element. Fuel from the fuel tank enters the outside of the element and passes through the element under its own pressure. As it passes through, the dirt and impurities in the fuel are filtered out, allowing only clean fuel to enter the interior of the element. The fuel exits from the outlet at the top center of the filter and is sent to the injection pump.
A cross-headed hexagonal bolt is fitted to the fuel filter body. Loosen the bolt with a cross-headed screw driver before starting or after dismantling and reassembly to bleed the air in the fuel system to the fuel oil filter.

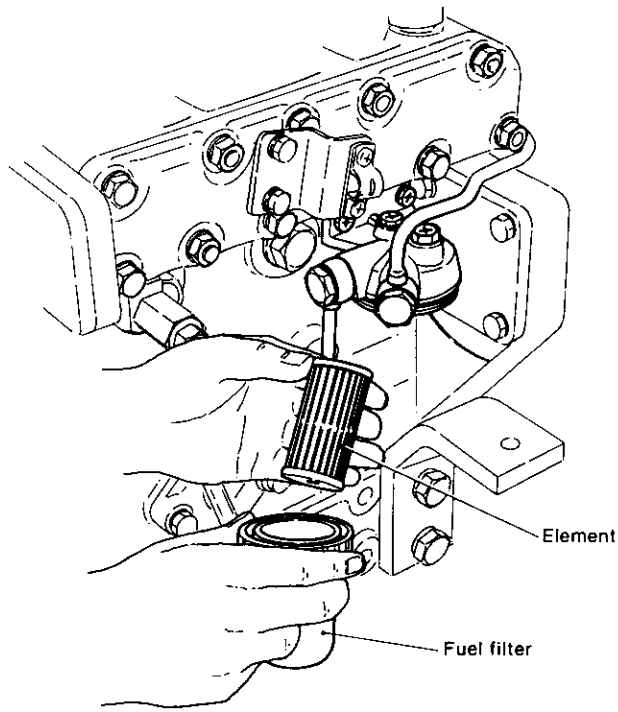


4.2 Specification (Common to all models)

Filtering Area	333cm² (20.3in.²)
Material of element	Cotton fiber
Filter mesh	10 ~ 15μ

4-3 Inspection

The fuel filter must be periodically inspected. If there is water and sediment in the filter, remove all dirt, rust, etc. by washing the filter with clean fuel.
The normal replacement interval for the element is 250 hours, but the element should be replaced whenever it is dirty or damaged, even if the 250 hour replacement period has not elapsed.



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

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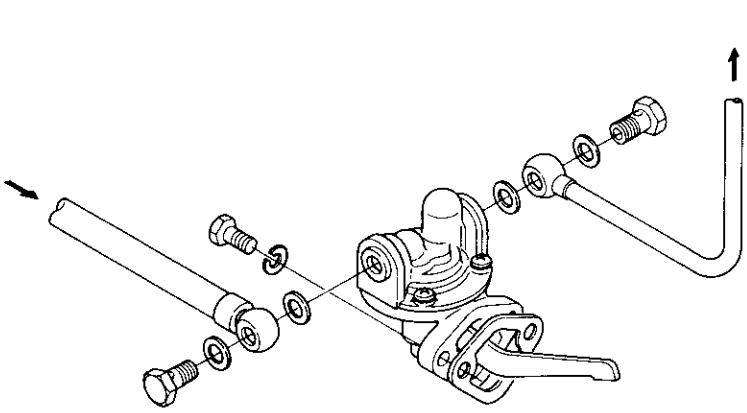
5. Fuel Feed Pump

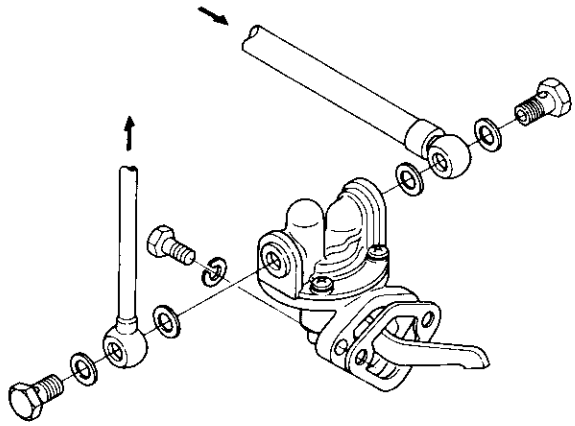
5-1 Construction

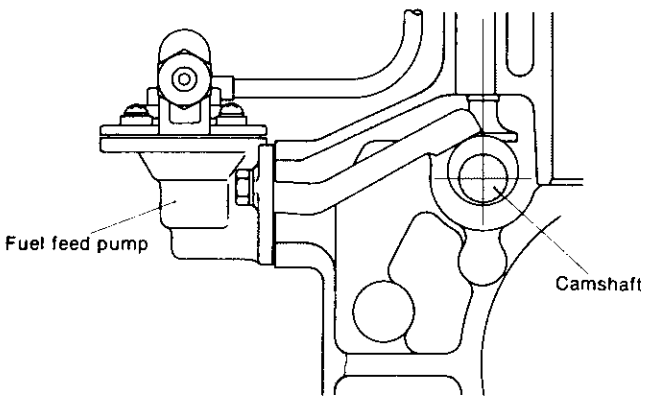
The fuel pump feeds the fuel from the fuel tank to the injection pump through the fuel filter. When the fuel tank is installed at a higher position than the fuel filter and injection pump, the fuel will be fed by its head pressure, but if the, fuel tank is lower than the filter and injection pump, a fuel pump is required.
The fuel pump of this engine is a diaphragm type and is installed on the exhaust side of the cylinder body. The diaphragm is operated by the movement of a lever by the fuel feed pump cam at the cam shaft.

Specifications

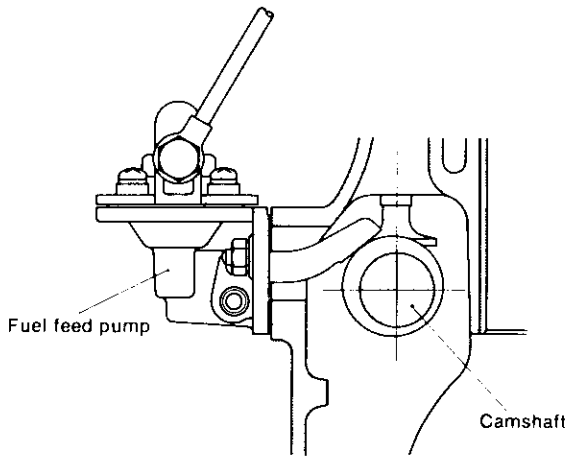
	1GM10(C)	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Part No.	105582-52010	129301-52020
Suction head	Max.0.8m(3.15in.)	
Capacity	0.3ℓ/min.at 1000rpm	
Feed Pressure	0.1kgf/cm² (1422 lb/in.²) at 600~1800rpm	
Suction pressure	−60 mmHG at 600rpm	







1GM10(C)



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

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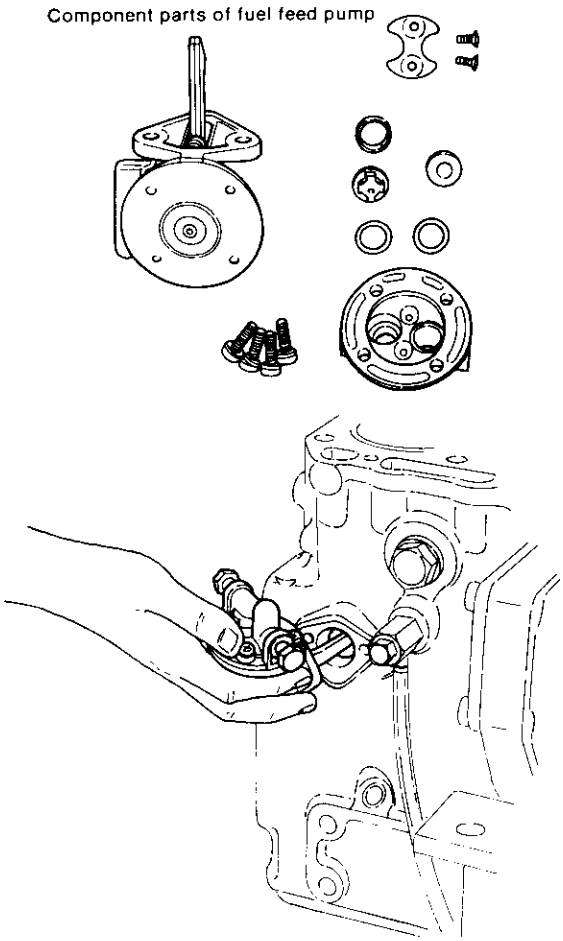
5-2 Disassembly and reassembly

5-2.1 Disassembly

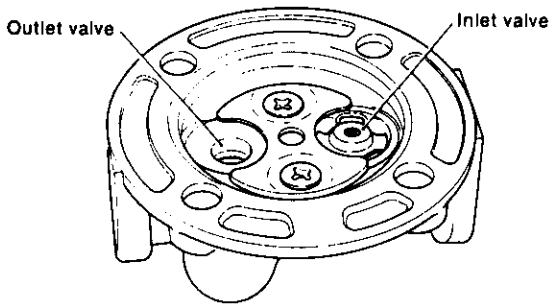
Clean the outside of the pump, inscribe a matching mark on the upper body and lower body of the pump, disassemble and put the components in order.



5-2.2 Reassembly

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

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



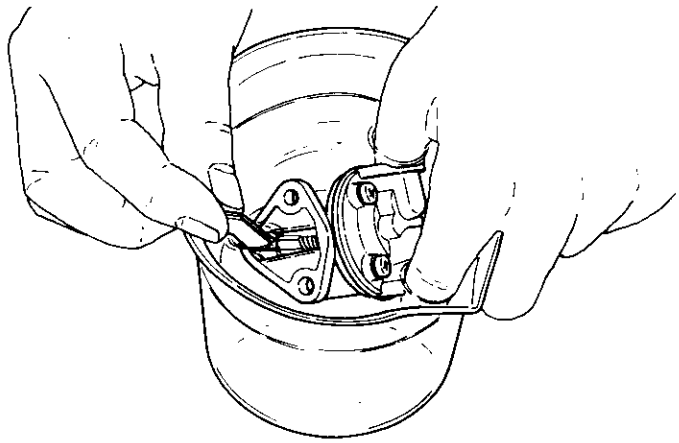
(4) Make sure the diaphragm mounting hole is in the correct position and gently attach the diaphragm to the pump body.
(5) Line up the matching marks on the pump body, and clamp on the pump body evenly.

Tightening torque of screw	30±10 kgf-cm (1.45 ~ 2.89 ft-lb)

5-3 Inspecting and adjusting the fuel feed pump

5-3.1 Checking the pump for fuel oil leaks

After removal, immerse the pump in kerosene, stop its outlet port with a finger and, by operating the rocker arm, check for bubbles.
If any bubbles are present, this indicates a defective point which should be replaced.



5-3.2 Checking the pump for engine oil leaks

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

5-3.3 Measuring the sucking power

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

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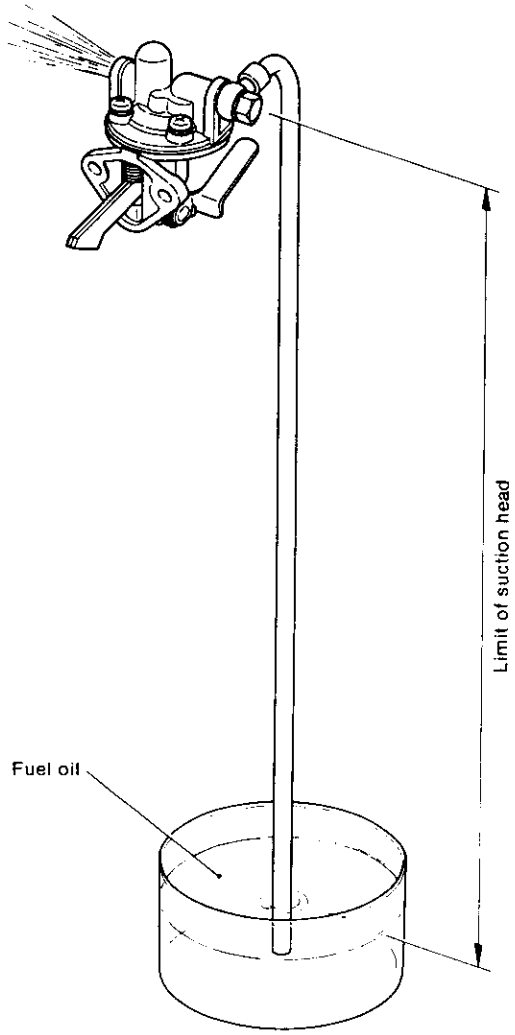
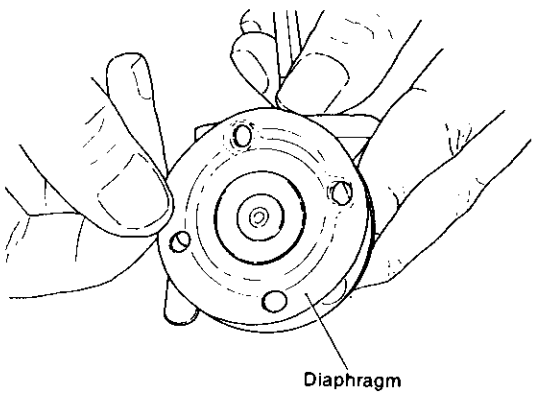


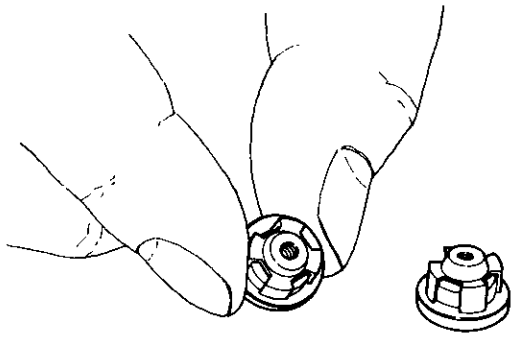
5-3.4 Aging, breakdown and cracking of the diaphragm

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



5-3.5 The contact area and mounting condition of valve

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



5-3.6 Diaphragm spring and rocker arm spring

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

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

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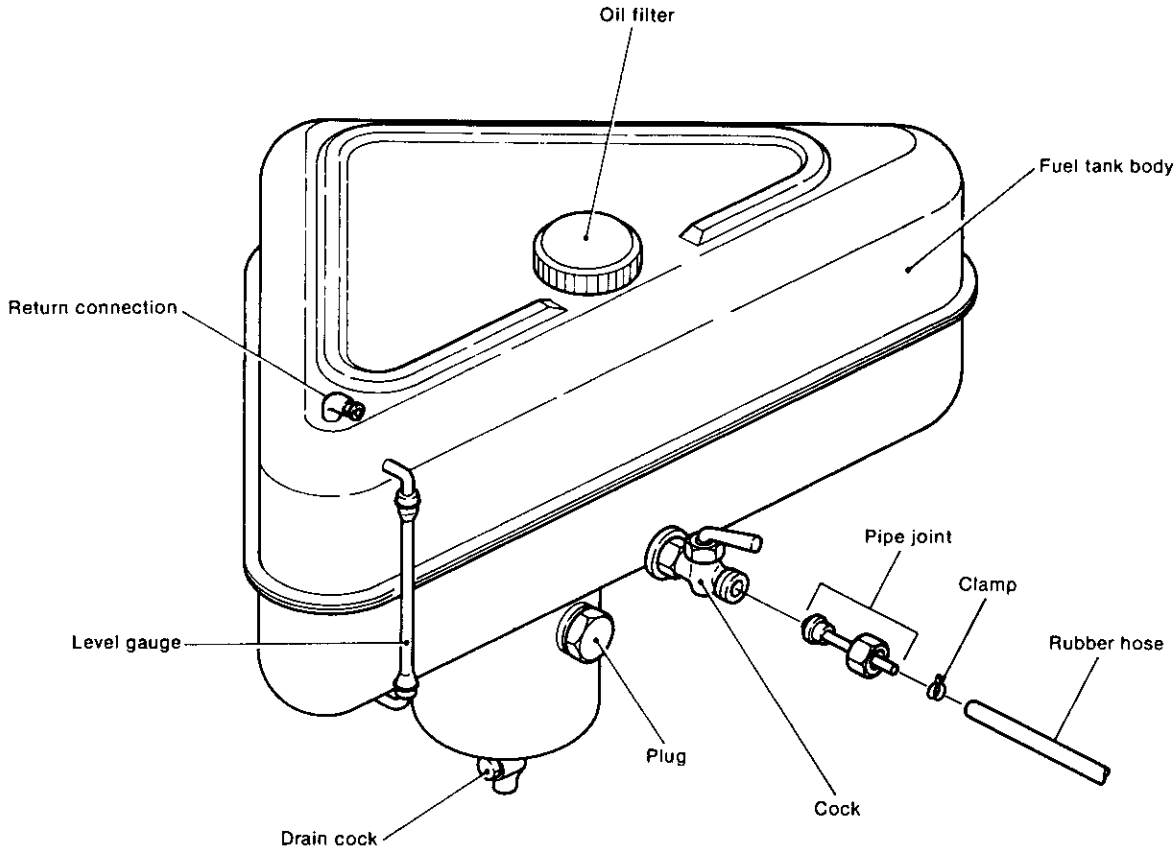
6. Fuel Tank (Option)

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



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

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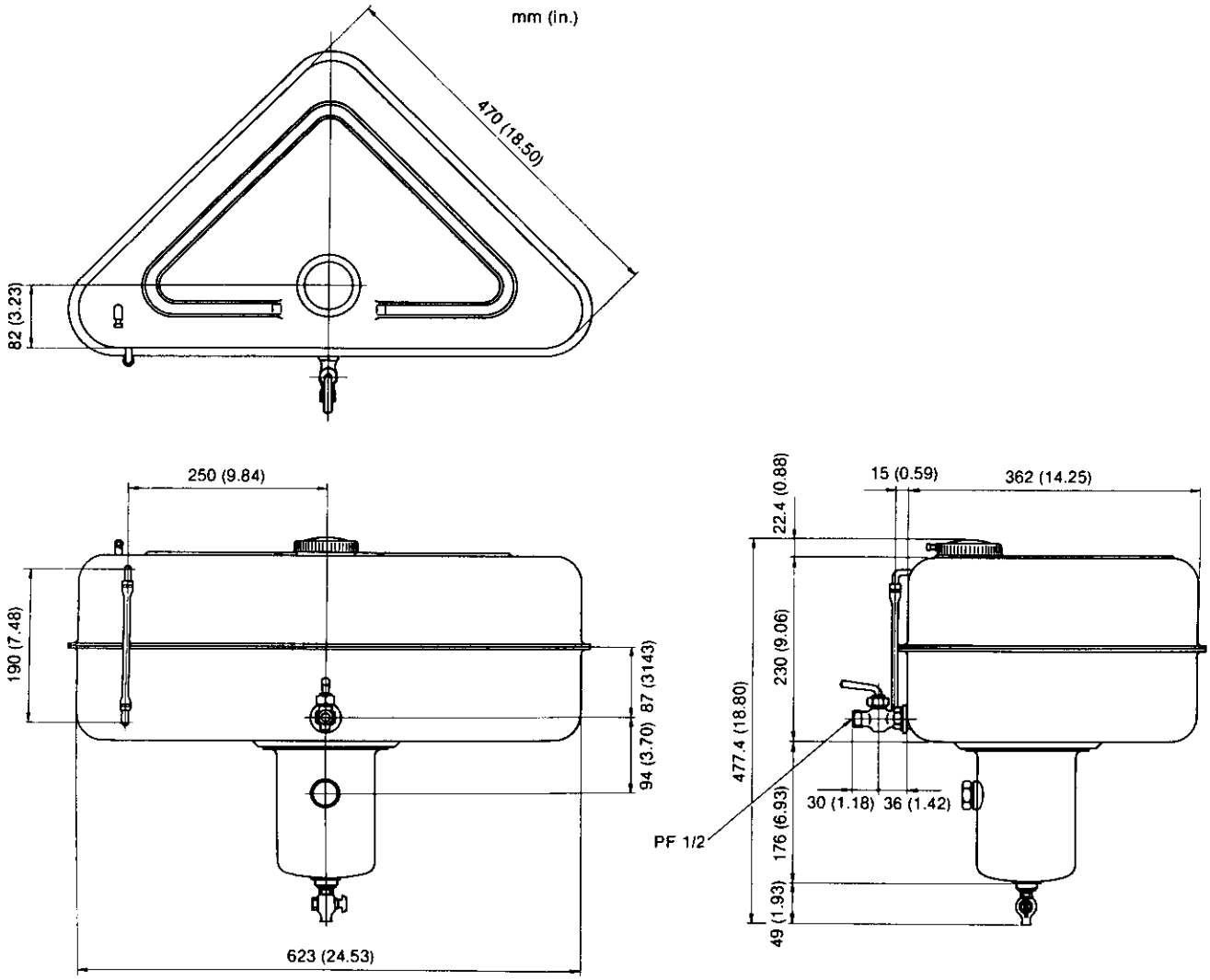
Dimension



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CHAPTER 4
GOVERNOR

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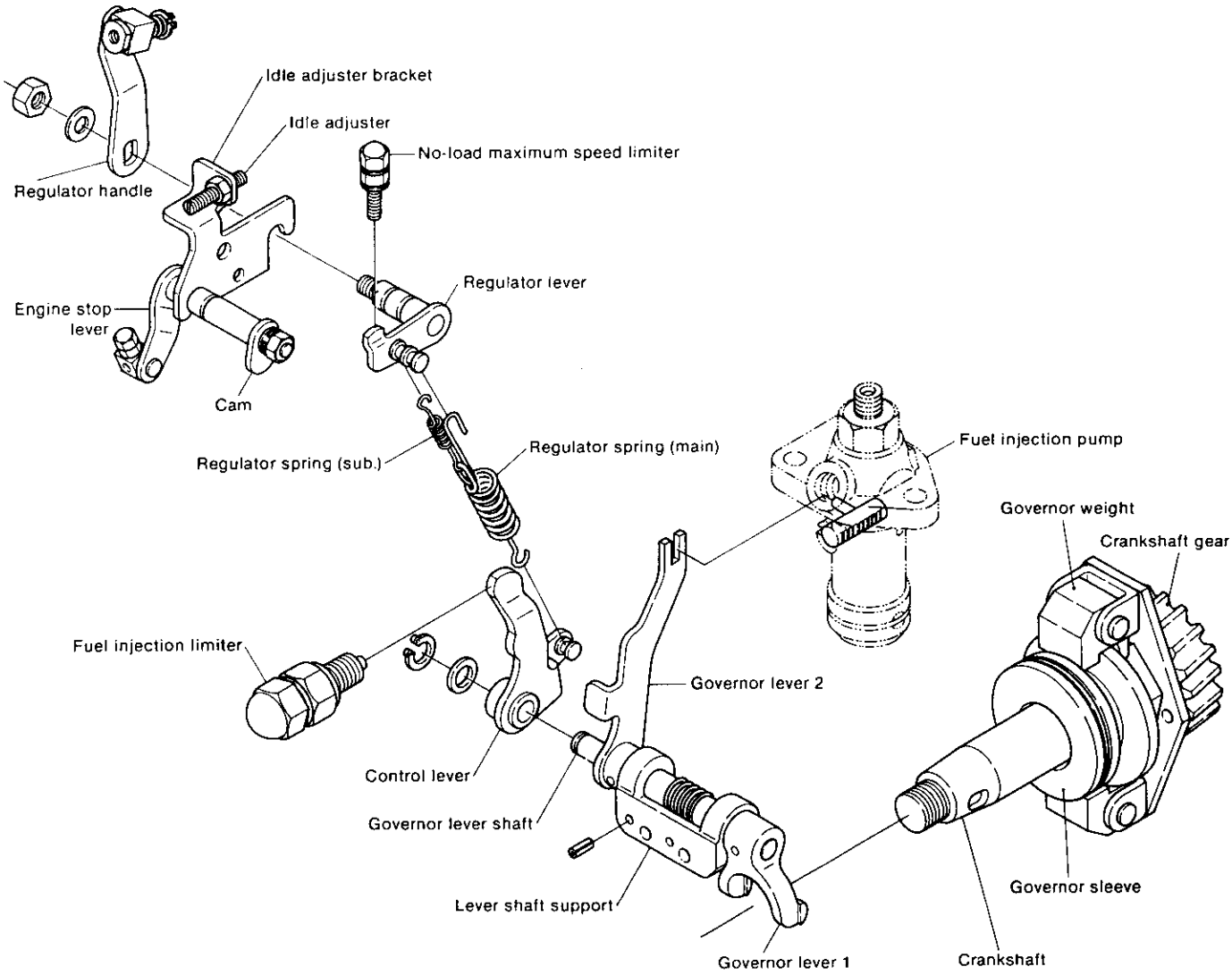
1. Governor

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

This engine employs an all-speed governor in which the centrifugal force of the governor weight, produced by rotation of the crankshaft, and the load of the regulator spring are balanced.
The governor is remotely controlled by a wire. Refer to the "Control System" chapter for details.

1-1 Construction

(1) 1GM10(C)



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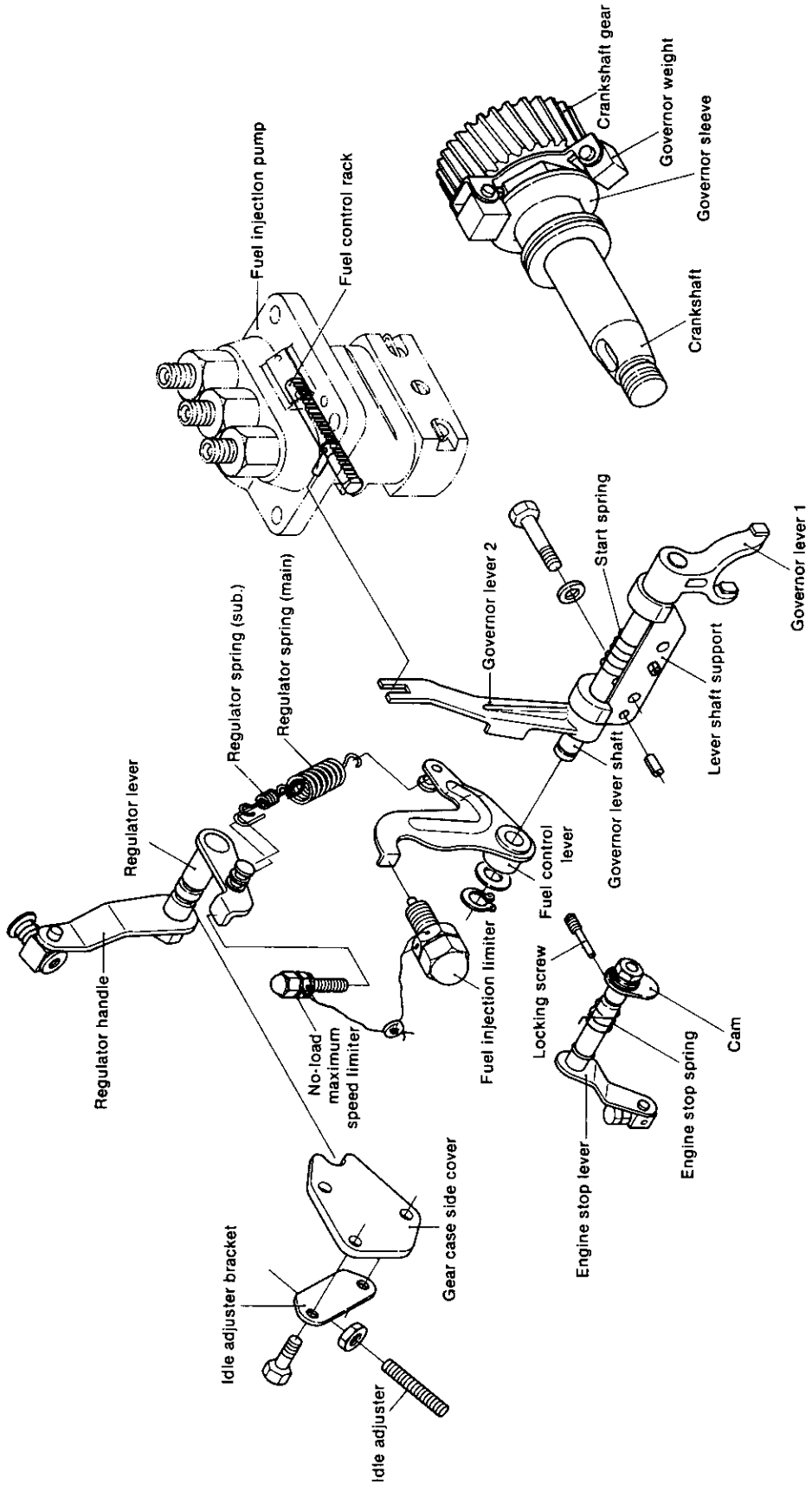
(2) 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)



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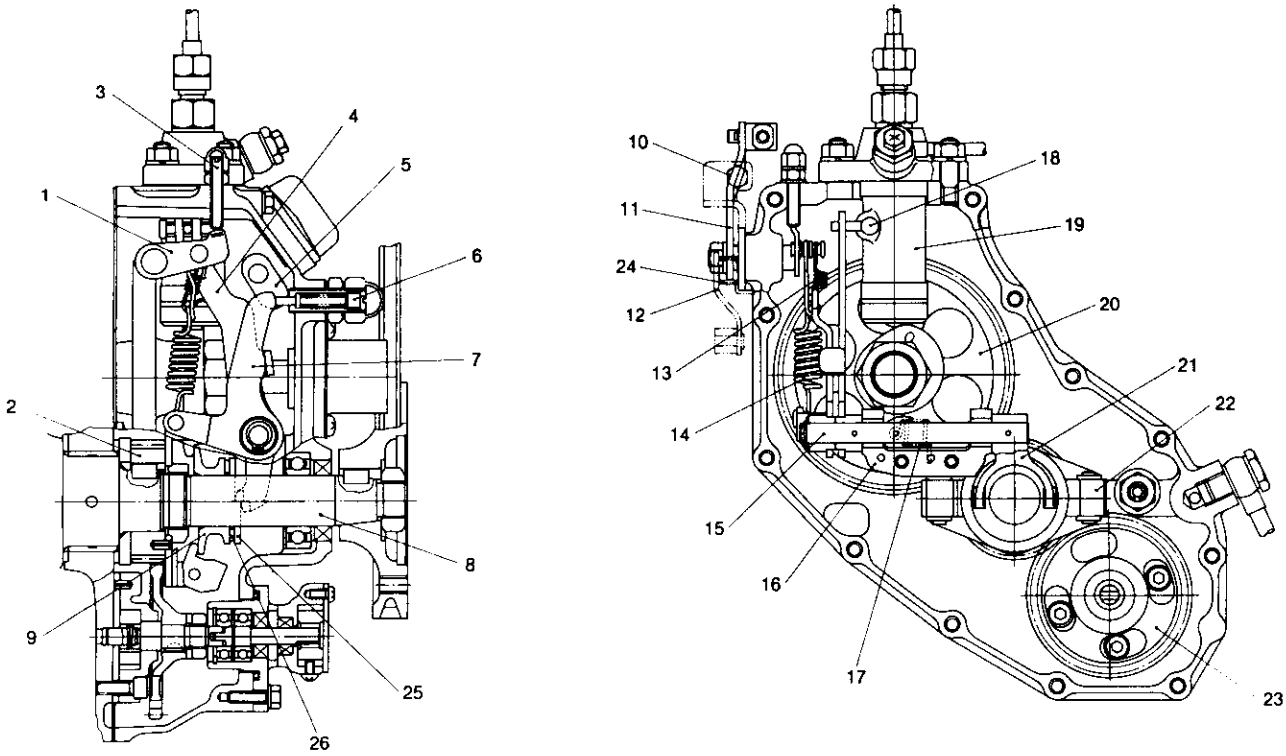
1-1.1 1GM10(C)



1 Regulator lever
2 Crankshaft gear
3 No-load maximum speed limiter
4 Governor lever 2
5 Engine stop cam
6 Fuel injection limiter
7 Fuel control lever
8 Crankshaft
9 Governor sleeve
10 Idle adjuster
11 Regulator handle
12 Engine stop lever
13 Regulator spring (sub.)
14 Regulator spring (main)
15 Governor lever shaft
16 Governor lever shaft support
17 Start spring
18 Fuel control rack
19 Fuel injection pump
20 Camshaft gear
21 Governor lever 1
22 Governor weight
23 Lubricating oil driving gear
24 Engine stop spring
25 Thrust collar
26 Thrust needle bearing

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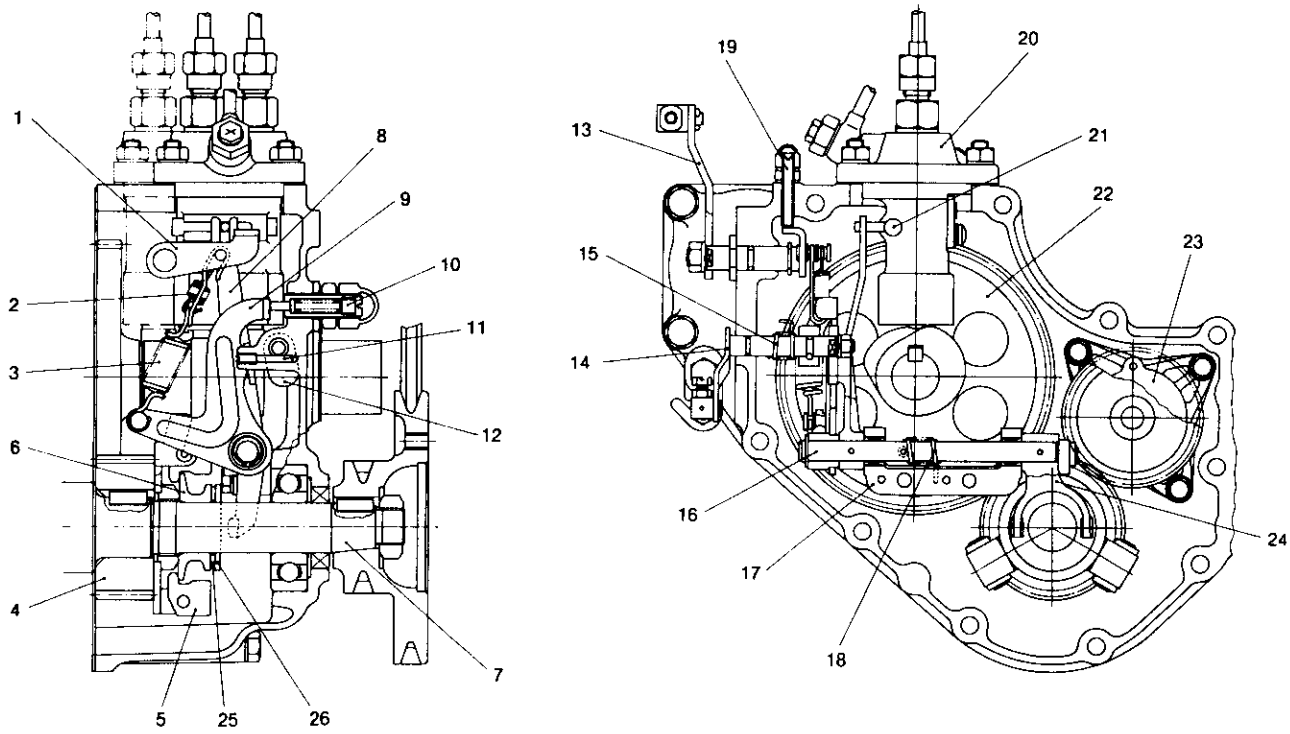
1-1.2 2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)



1 Regulator lever
2 Regulator spring (sub.)
3 Regulator spring (main)
4 Crankshaft gear
5 Governor weight
6 Governor sleeve
7 Crankshaft
8 Governor lever 2
9 Fuel control lever
10 Fuel injection limiter
11 Locking screw
12 Engine stop cam
13 Regulator handle
14 Engine stop lever
15 Engine stop spring
16 Governor lever shaft
17 Governor lever shaft support
18 Start spring
19 No-load maximum speed limiter
20 Fuel injection pump
21 Fuel control rack
22 Camshaft gear
23 Lubricating oil pump
24 Governor lever 1
25 Thrust needle bearing
26 Thrust collar

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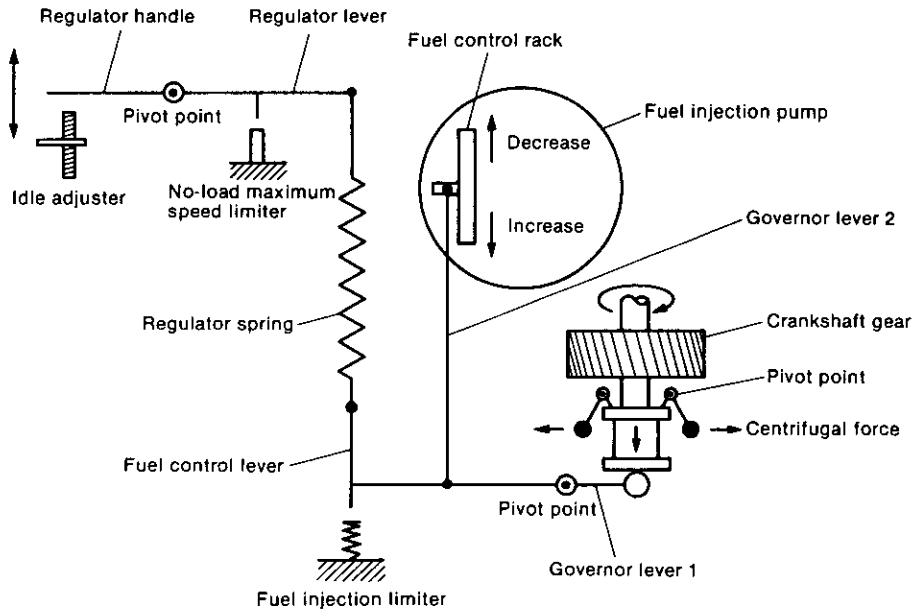
1-2 Operation

The position of the two governor weights (open and closed) is regulated by the speed of the engine. The centrifugal force of the governor weights pivots around the governor weight pin and is converted into an axial force that acts on the sleeve. This force is transmitted to governor lever 2 through governor lever 1, and lever 1 shifts the fuel control rack to increase or decrease the fuel supply. The governor lever is stabilized at the point at which the force produced by the governor weight is balanced with the load of the regulator spring connecting the rsgulator lever and fuel control lever. When the speed is reduced by application of a load, the force of the regulator spring pushes the governor sleeve in the "fuel increase" direction, stabilizing the engine speed by changing the position of the regulator lever.



1-3 Performance

		1GM10(C), 2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
No-load maximum speed		3825^{+50}_{0} rpm	3625±25 rpm
No-load minimum speed		850±25 rpm	
Instant speed regulation	δi	15% or less	
Stabilization time	ts	10 sec. or less	
Stabilized speed regulation	δs	6.5% or less	
Fluctuation of rotation		30 rpm or less	

Instant speed regulation $\delta i = \left|\frac{ni - nr}{nr}\right| \times 100$

Stabillzed speed regulation $\delta s = \left|\frac{ns - nr}{nr}\right| \times 100$

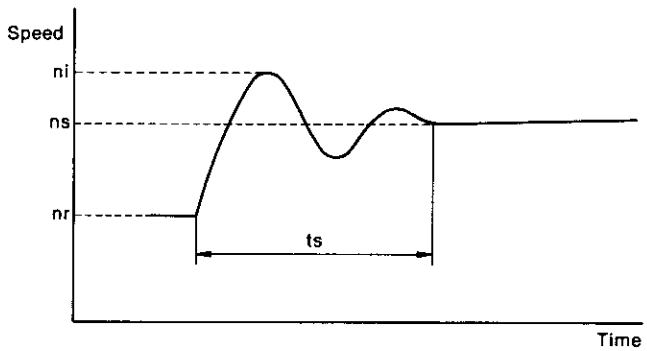
ni: Instant maximum (minimum) speed:
The maximum or minimum engine speed which is momentarily reached immediately after the load has been suddenly changed from the rated load to another load or from an arbitrary load to the rated load.

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

nr: Rated speed

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

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



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

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1-4 Disassembly

1-4.1 Disassembly

(1) Remove the injection limiter and no-load maximum speed limiter from the gear case.
(2) Remove the idle adjuster and adjuster bracket.
(3) Remove the cover at the gear case end [oil supply port in the case of model 1GM10(C)] move the governor lever 2 to match the control rack to the pulled-out position of the fuel injection pump (indicated by a slot in the gear case to show the position); then take out the fuel injection pump.
(4) Remove the gear case from the cylinder block.
(5) Pull the thrust collar, the thrust needle bearing and the governor sleeve from the crankshaft.
(6) Loosen the end nut of crankshaft, and remove the governor weight assembly.
(7) Remove the regulator spring (main·sub.) from the regulator lever 2 and fuel control lever.
(8) Remove the circlip of the regulator lever, and remove the regulator lever and handle. [Without circlip in the case of model 1GM10(C)].
(9) Remove the governor lever shaft support bolt from the rear of the gear case, and take out the governor lever shaft assembly.
(10) Loosen the nut of engine stop lever, and pull the cam.
(11) Draw out the locking screw from the rear of the gear case, and remove the taper pin for setting the return spring.
(12) Remove the engine stop lever and the spring.

1-4.2 Reassembly and precautions

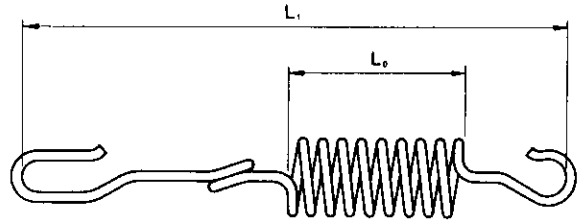
Reassemble in the reverse order of disassembly, paying special attention to the folowing items.
(1) Check the governor weight movement.
(2) Check for the movement of the governor sleeve sliding on the crankshaft.
(3) Since a common taper pin hole is drilled in the governor lever shaft and governor levers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

1-5 Parts inspection and replacement

1-5.1 Regulator spring

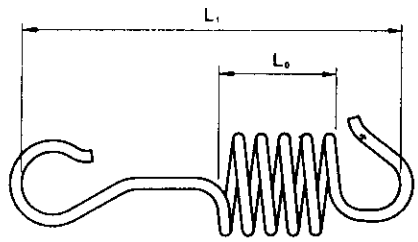
(1) Inspect the spring for coil damage, corrosion and hook deformation, and replace if faulty.
(2) Measure the spring's dimensions and spring constant. Since the spring constant determines the governor's performance, it must be carefully checked.

Spring specifications
1) Regulator spring (main)



		1GM10(C)	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Wire diameter		φ1.8mm (0.0709in.)	φ2.3mm (0.0906in.)
Coil outside diameter		φ13.8mm (0.5433in.)	φ18.3mm (0.7205in.)
Nmber of coils		8.5	7.5
Spring constant		0.715kgf/mm (0.400 lb/in.)	0.922kgf/mm (0.516 lb/in.)
Free length	L_0	18mm (0.7087in.)	20mm (0.7874in.)
	M_1	76mm (2.992in.)	78mm (3.0709in.)

2) Regulator spring (sub)



		1GM10(C)	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Wire diameter		φ1.8mm (0.0315in.)	φ1.2mm (0.0472in.)
Coil outside diameter		φ6.8mm (0.2677in.)	φ9.2mm (0.3622in.)
Nmber of coils		4	7
Spring constant		0.474kgf/mm (0.265 lb/in.)	0.578kgf/mm (0.3237 lb/in.)
Free length	L_0	5mm (0.1969in.)	10mm (0.3937in.)
	M_1	26mm (1.0236in.)	23mm (0.9055in.)

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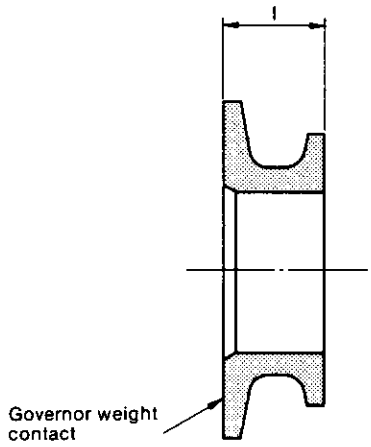
1-5.2 Sleeve

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



mm (in.)

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

1-5.3 Thrust collar

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

mm(in.)

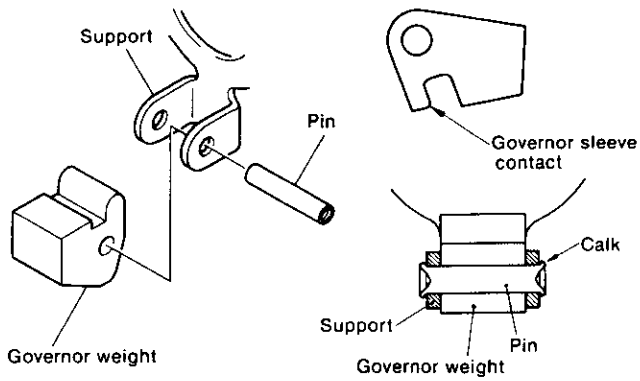
	Maintenance standard	Wear limit
Thrust collar thickness	3 (0.1181)	0.1 (0.0394)

1-5.4 Thrust needle bearing

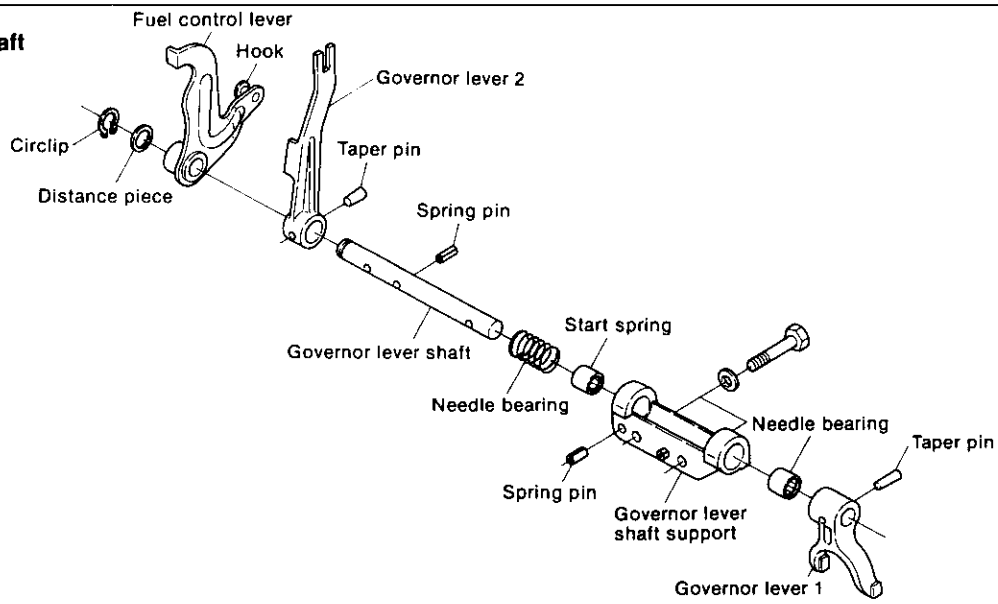
Replace the bearing when wear exceeds the specified limit.

1-5.5 Governor weight

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



1-5.6 Governor lever shaft



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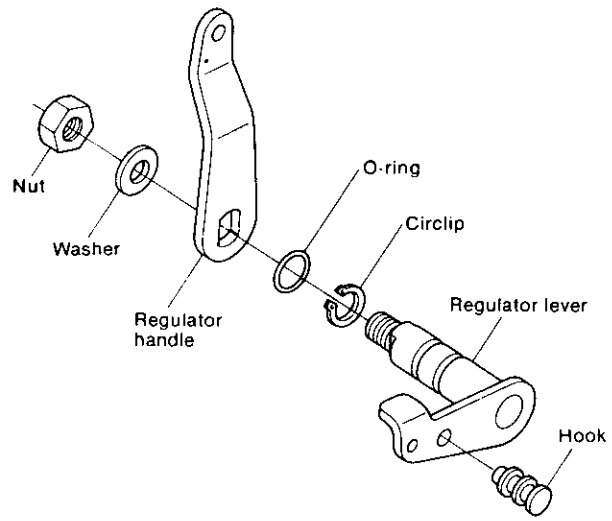
(1) Replace the governor lever shaft if there is play between the shaft and needle bearing, play when the lever is moved, or if the shaft does not move smoothly.
(2) Repair or replace the shaft if there is play between lever 1, lever 2, fuel control lever or support and the shaft, or if the taper pin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

1-5.7 Regulator lever and handle



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

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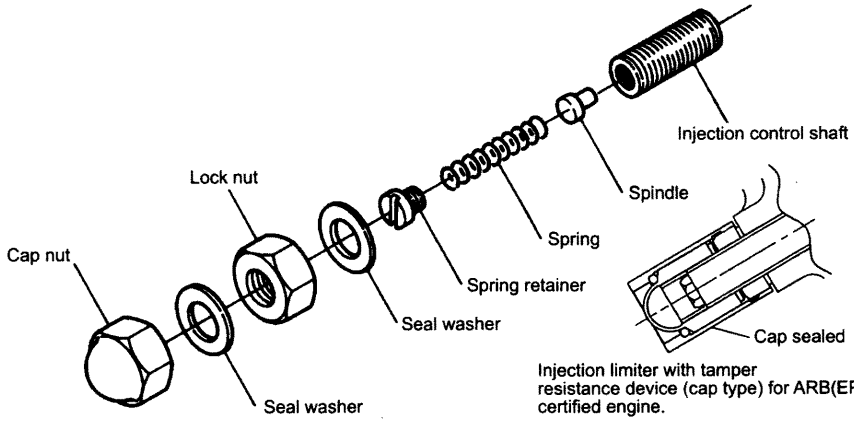
2. Injection Limiter

2-1 Construction

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

For the ARB(EPA) certified engine(GM series), the injection limiter is installed the tamper resistance device (cap type) for preventing illegal change the injection volume by the ultimate purchaser. If need to re-adjust the fuel limiter, conform the engine performance including emissions as same as the certified conditions.



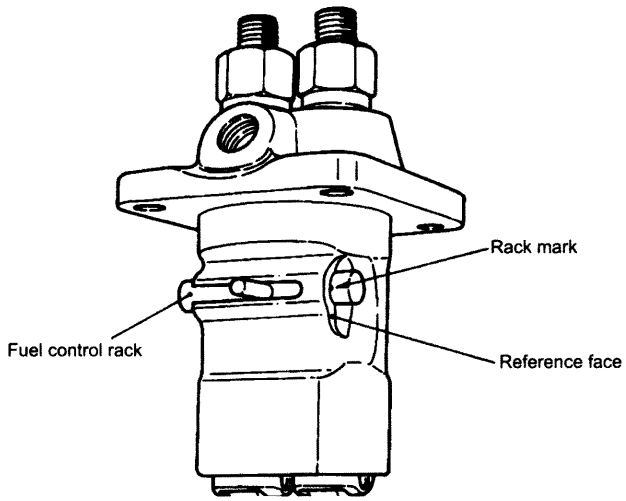
Injection limiter with tamper resistance device (cap type) for ARB(EPA) certified engine.

2-2 Inspection

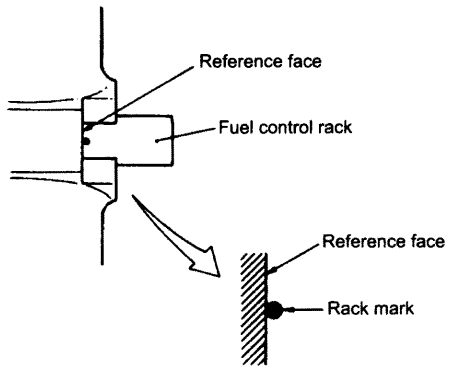
(1) Hold the end of the spindle, and check it for smooth movement.
(2) Replace the spring if it is damaged, corroded or permanently strained.

2-3 Adjustment

In the case of models, 1GM10(C), 2GM20(F)(C), and 3GM30(F)(C)



(3) Set the governor lever to the free position and remove the injection pump adjustment cover [oil supply port in the case of model 1GM10(C)]
(4) Remove the injection control shaft cap nut, loosen the hexagonal lock nut, and loosen the injection control shaft (so that the spring inside the injection control shaft is disabled).
(5) Move governor lever 2 slowly to the left until the rack and injection control shaft touch lightly.
(6) Set the governor lever to the free position and push the rack by slowly turning the injection control shaft clockwise.
(7) Align the center mark of the rack with the reference face.
(8) Lock the injection control shaft with the hexagonal nut and cap nut.



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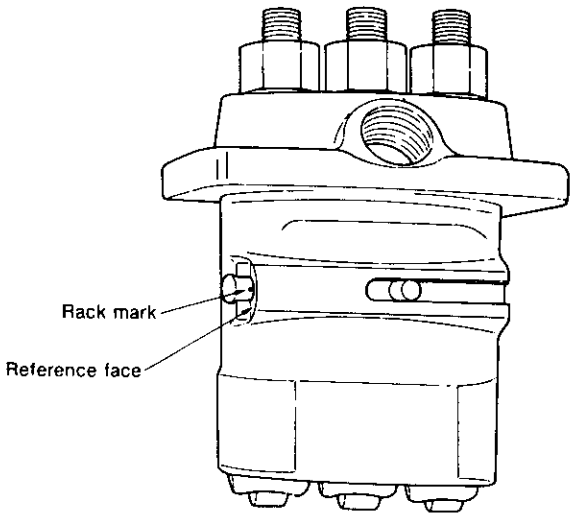
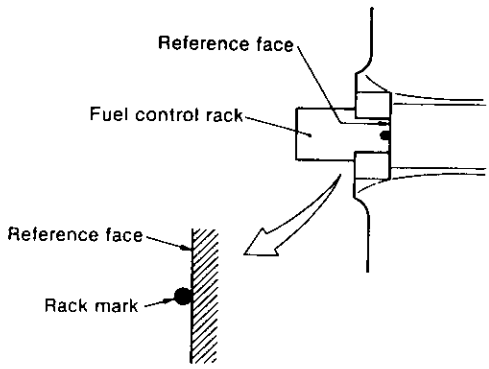
In the case of model 3HM35(F)(C)





NOTE: When the engine is stopped, the control rack will automatically stay at the position which allows the maximum fuel injection volume.
Therefore, to match the rack mark, move the engine stop lever to the position where the mark is matched and fix the lever at that position, then adjust so that the fuel limiter comes into contact with the lever.

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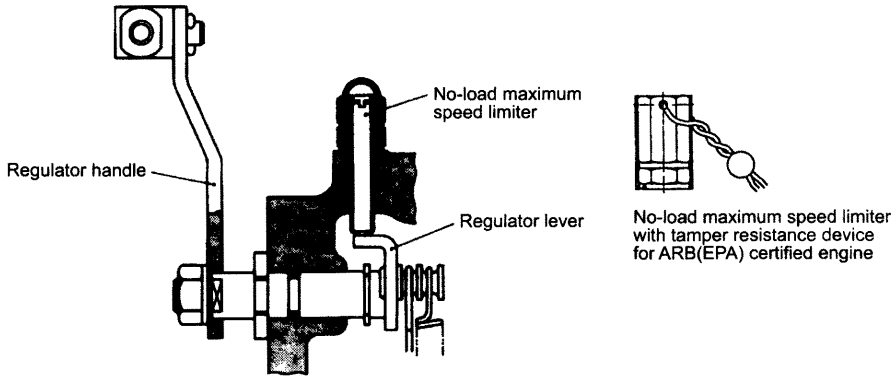
3. No-Load Maximum Speed Limiter

3-1 Construction

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



3-2 Handling precautions

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

For the ARB(EPA) certified engine(GM series), the no-load maximum speed limiter is installed the tamper resistance device for preventing the illegal change the no-load maximum engine speed (high idling speed) by the ultimate purchaser, If need to re-adjust the limiter, conform the engine performance including emissions as same as the certified conditions.

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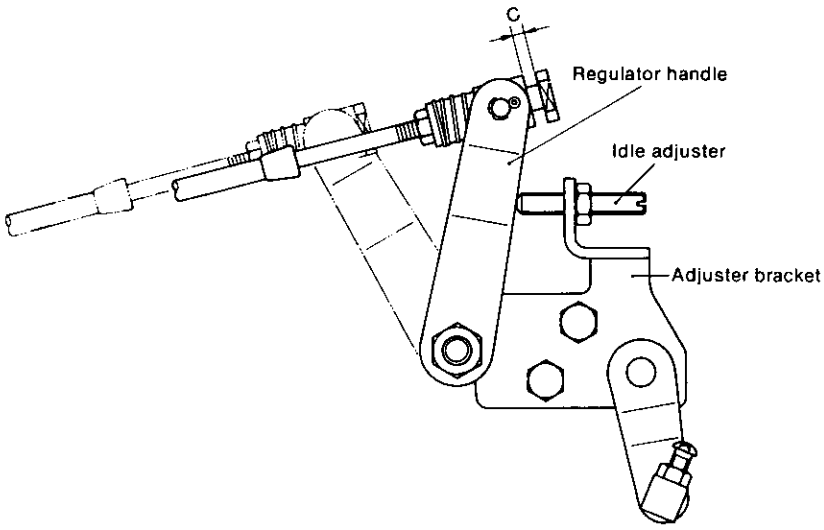
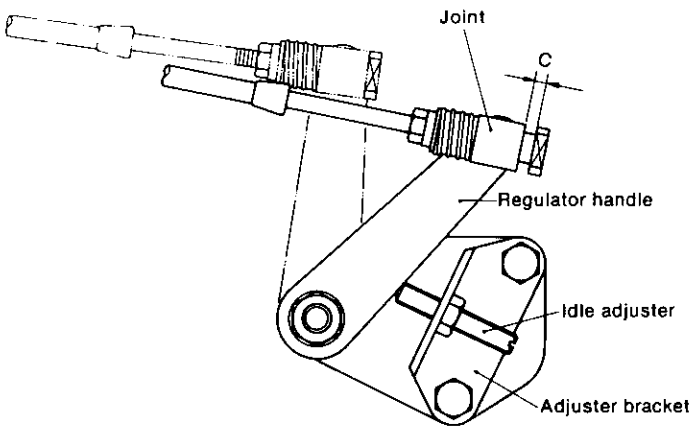
4. Idling Adjuster

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

4-1 1GM10(C)



4-2 2GM20(F)(C), 3GM30(F)(C), and 3HM35(F)(C)



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

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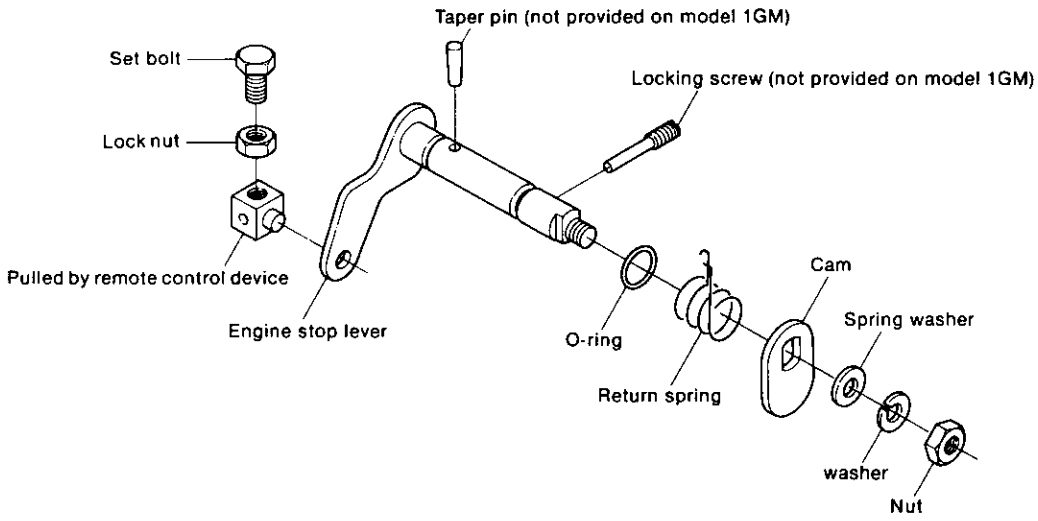
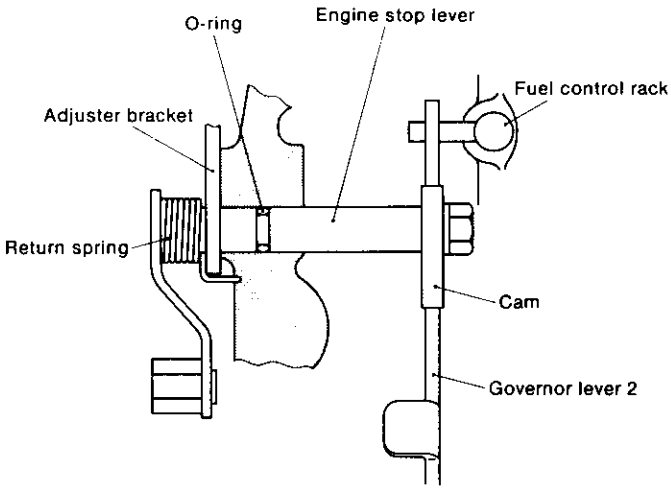
5. Engine Stop Lever

5-1 Construction

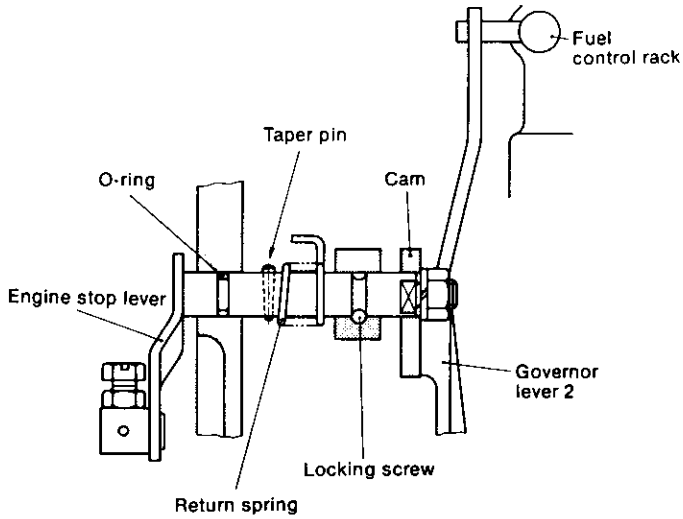
With this device, governor lever 2 is moved by the cam of the engine stop lever shaft, regardless of the position of the regulator lever, so as to adjust the fuel control rack and reduce the supply of fuel.
This device can be remote-controlled.



(1) 1GM10(C)



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



5-2 Inspection

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

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CHAPTER 5

INTAKE AND EXHAUST SYSTEM

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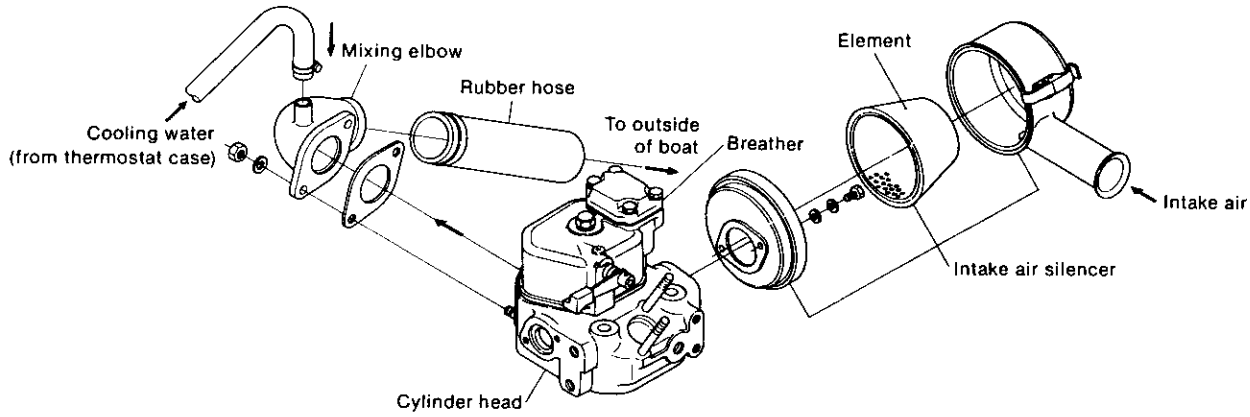
1. Intake and Exhaust System

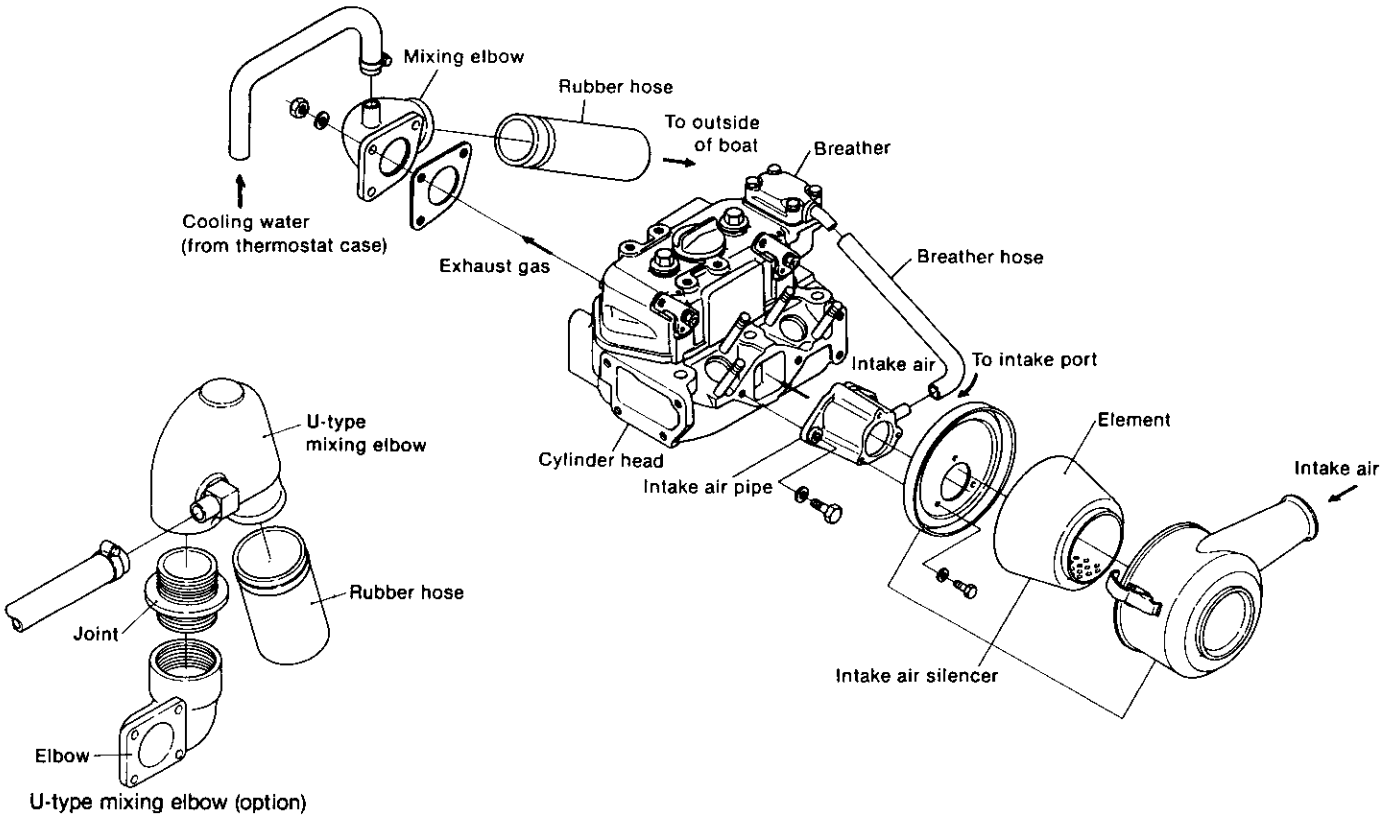
The intake air silencer is installed at the intake side for the purpose of reducing noise and cleaning the air.
The exhaust system for model 1GM10(C) and 2GM20(F)(C) engines is so constructed that the mixing elbow is fitted directly to the cylinder head. The cooling water passs into this mixing elbow and is mixed with exhaust gas at the pipe outlet.

A water-cooled exhaust manifold is installed on engine models 3GM30(F)(C) and 3HM35(F)(C), and the mixing elbow is fitted to the outlet port of the exhaust manifold. The cooling water, after passing through the water jacket and cooling the exhaust gas, is mixed with the exhaust gas in the mixing elbow.

1-1 Intake and exhaust system of model 1GM10(C).



1-2 Intake and exhaust system of model 2GM20(F)(C)



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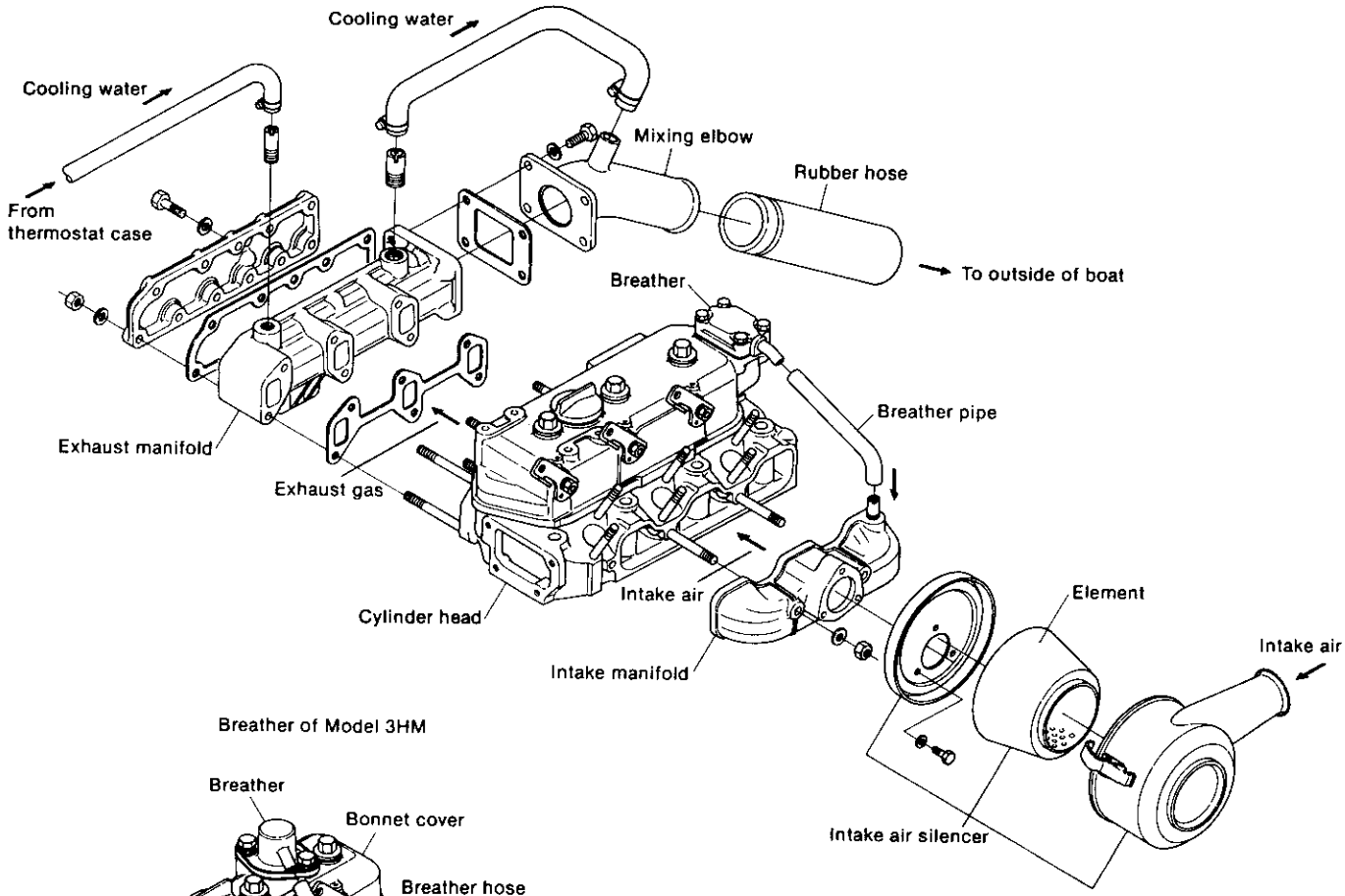
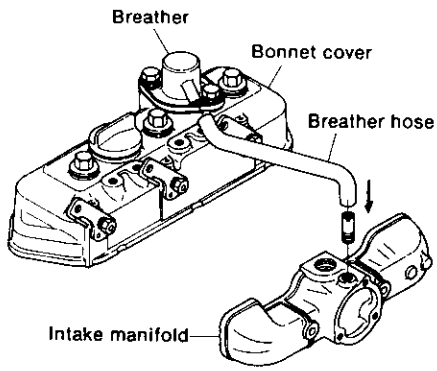
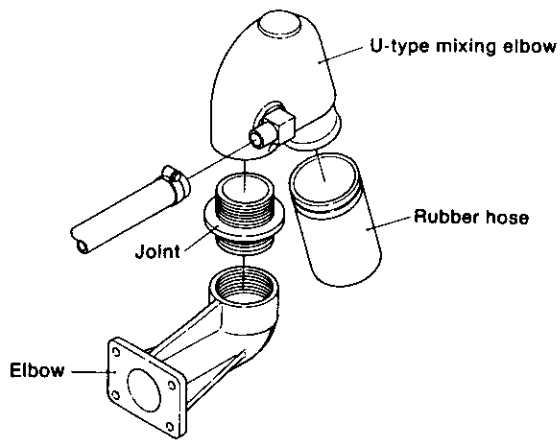
1-3 Intake and exhaust system of models 3GM30(F)(C) and 3HM35(F)(C)

The intake and exhaust system for models 3GM30(F)(C) and 3HM35(F)(C) is the same except for the construction of the breather.



Breather of Model 3HM





U-type mixing elbow
[option for models 3GM30(F)(C) and 3HM35(F)(C)]

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2. Intake Silencer

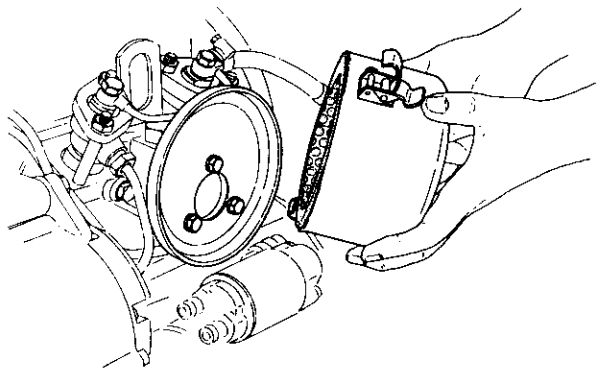
2-1 Construction

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

	1GM10(C)	2GM20(F)(C) 3GM30(F)(C)	3HM35(F)(C)
Rated air volume (average)	150 ℓ/min	1560 ℓ/min	2800 ℓ/min
Draft resistance	150 mmAq	100 mmAq	150 mmAq

2-2 Inspection of the intake silencer

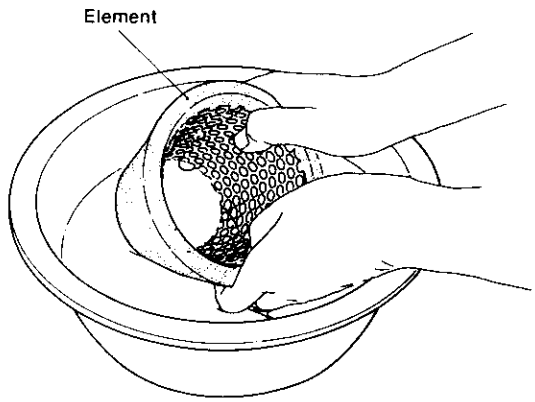
Occasionally, disassemble the intake silencer, remove the polyurethane element and inspect it. Because the element filters the air, if it is used over a long period of time it will become clogged and this decreases the amount of intake air, and may also be a cause of decreased output.



2-3 Washing the intake silencer element

Wash the air intake silencer element with a neutral detergent.

Washing period	Every 250 hours



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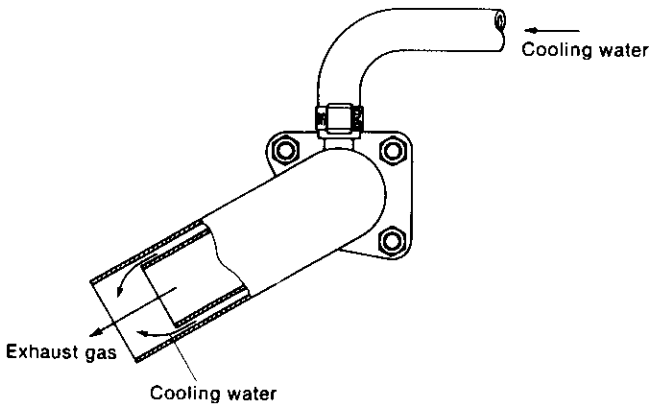
3. Exhaust System

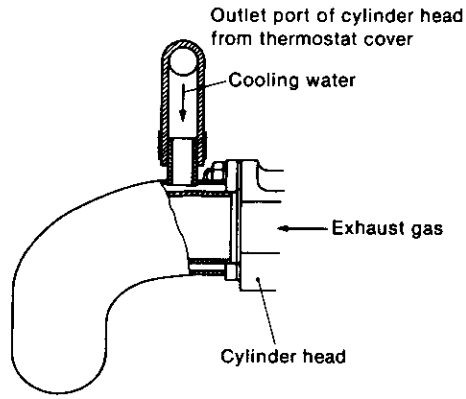
The mixing elbow of models 1GM10(C) and 2GM20(F)(C) is fitted directly to the outlet port of the cylinder head instead of being fitted to the exhaust manifold.
However, on models 3GM30(F)(C) and 3HM35(F)(C), an exhaust manifold is also installed and the mixing elbow is fitted to the manifold outlet port.

3-1 Exhaust manifold and mixing elbow

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

3-1.1 For models 1GM10(C) and 2GM20(F)(C)

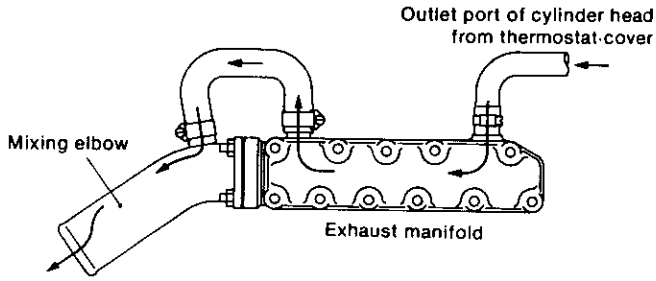


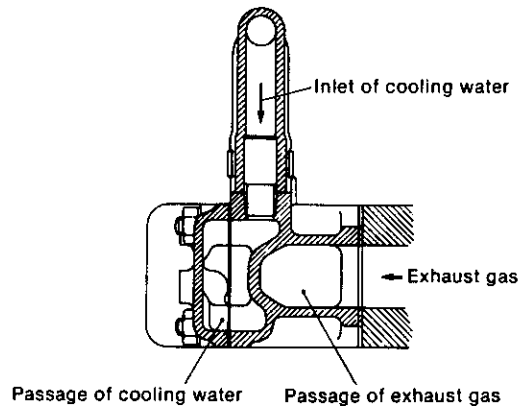


As shown in the figure, the construction for models 1GM10(C) and 2GM20(F)(C) is such that there is no exhaust manifold and the mixing elbow is fitted to the exhaust gas outlet port. A double construction technique has been adopted for the mixing elbow; as the exhaust gas passes through it the cooling water passes round the outside to cool the exhaust gas and then the gas and water mix close to the outlet port.

3-1.2 For models 3GM30(F)(C) and 3HM35(F)(C)

Both exhaust manifold and mixing elbow are installed.

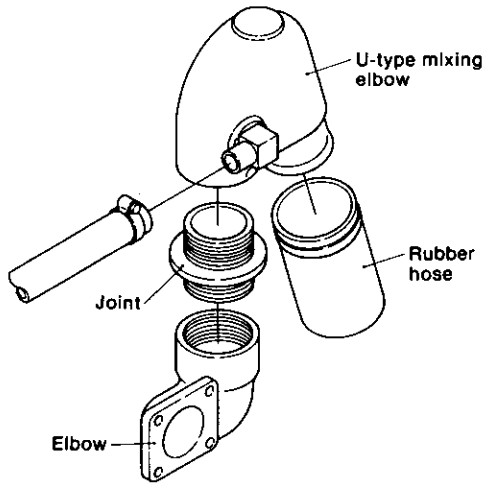




The construction of the exhaust manifold is shown in the figure, and a water chamber is formed between the exhaust manifold and the cover to cool the exhaust gas. The construction of the mixing elbow is the same for models 1GM10(C) and 2GM20(F)(C)

3-1.3 U type mixing elbow (optional)

For model 2GM20(F)(C)



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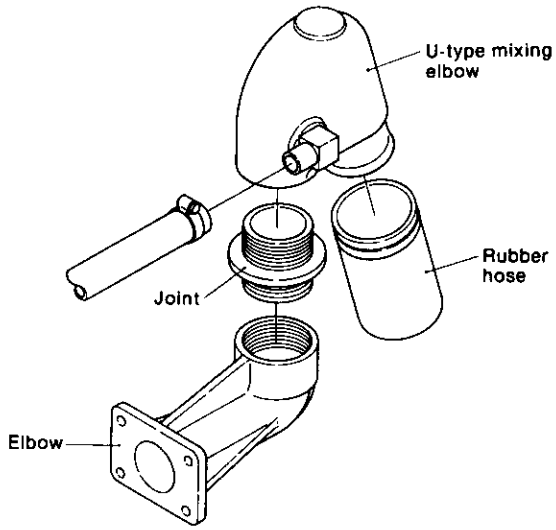
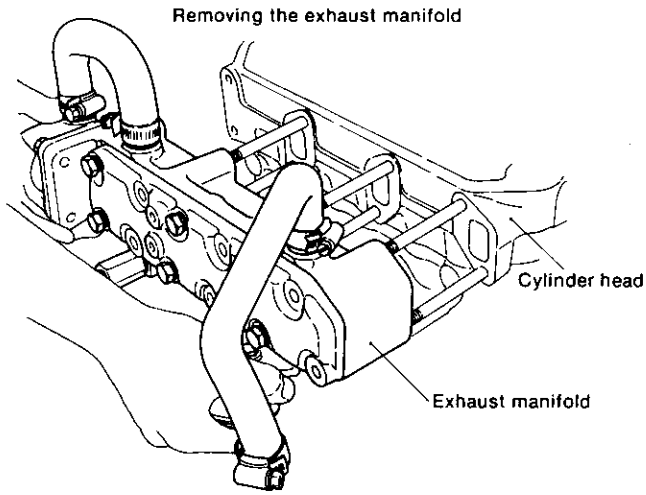
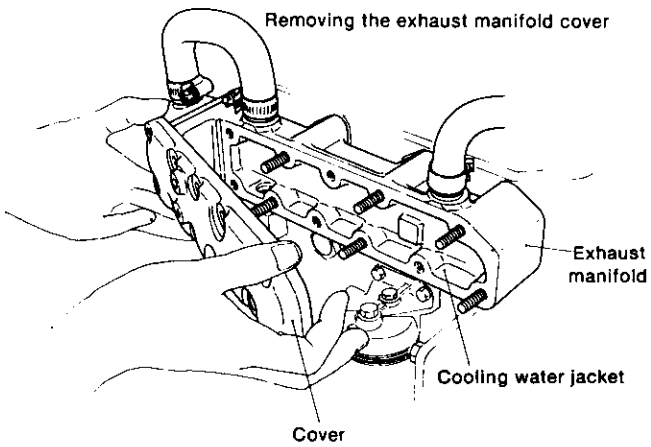
For models 3GM30(F)(C) and 3HM35(F)(C)



3-2 Exhaust manifold inspection





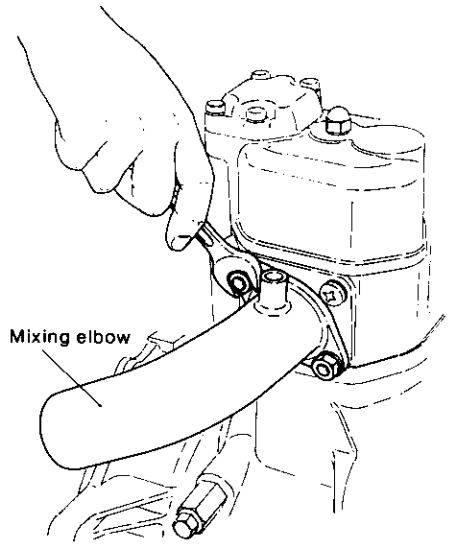
(1) Gasket packing
Inspect the gasket packing and replace if damaged.

(2) Carbon build-up in the exhaust passage
Remove the exhaust manifold elbow and cover and check carbon build-up in the exhaust passage. Remove any carbon in the passage. If carbon build-up becomes heavy, the exhaust pressure will rise, causing overheating of the cylinders and difficult starting.

(3) Corrosion and scale at the cooling water jacket
Inspect the water passage for the build-up of scale and foreign matter and remove if found. Also check for corrosion of the anticorrosion zinc installed on the cylinder head and the cylinder head water jacket and replace if corrosion is severe. Also, replace the cylinder head if it has been cracked by local overheating.

(4) Drain cock
Inspect the drain cock for clogging and check its action. Repair or replace if faulty.

3-3 Mixing elbow inspection



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

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4. Breather

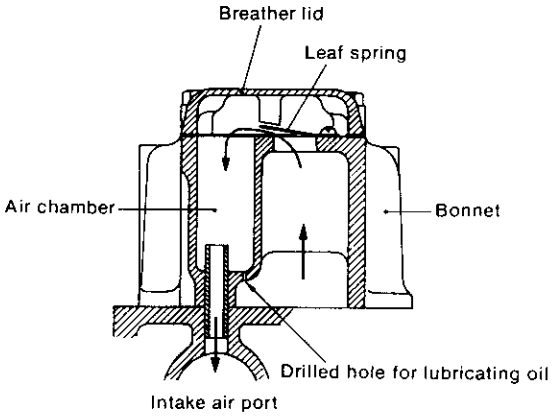
4-1 Construction of breather

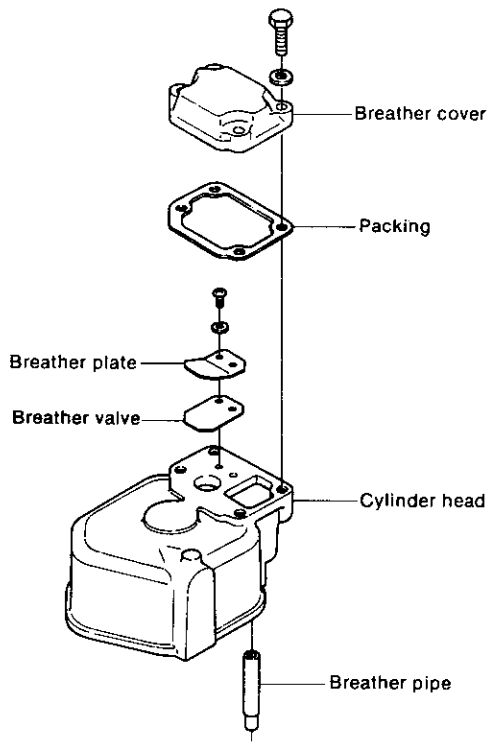
The same construction is adopted for each model of engine in that the breather device is fitted to the bonnet cover, and the vapor in the crank case is sucked into the intake port or intake manifold through the tappet hole and breather. However, the construction of the breather itself differs from model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

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

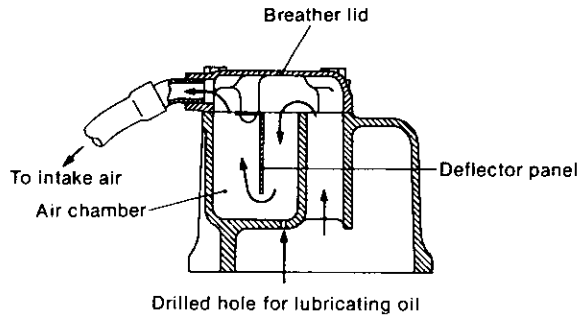
4-1.1 Breather for model 1GM10(C)

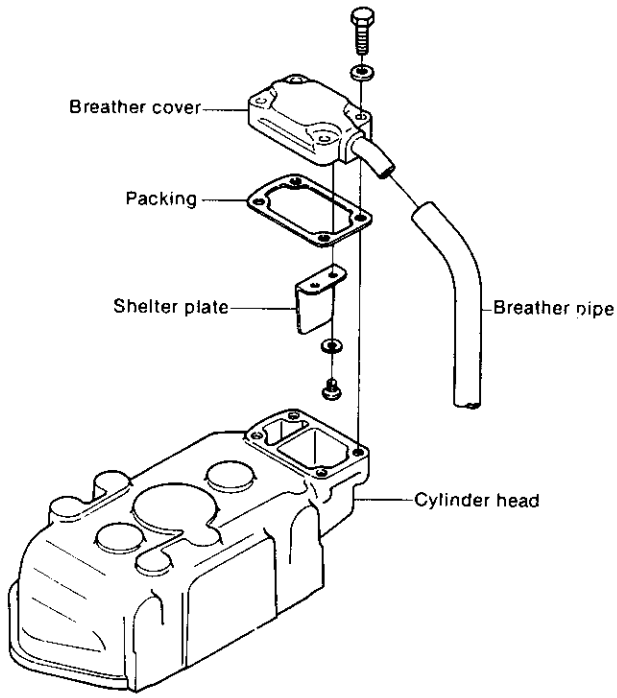
The vapor which lifts up the leaf spring fitted at the top of the bonnet then enters the other air chamber, and is sucked through the intake port.



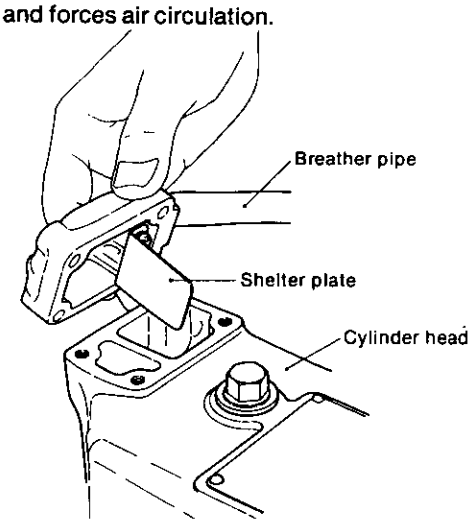


4-1.2 Breather for models 2GM20(F)(C) and 3GM30(F)(C)





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



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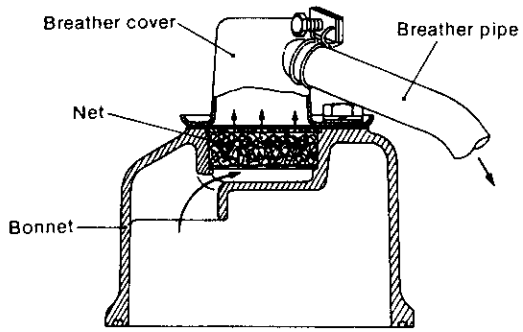
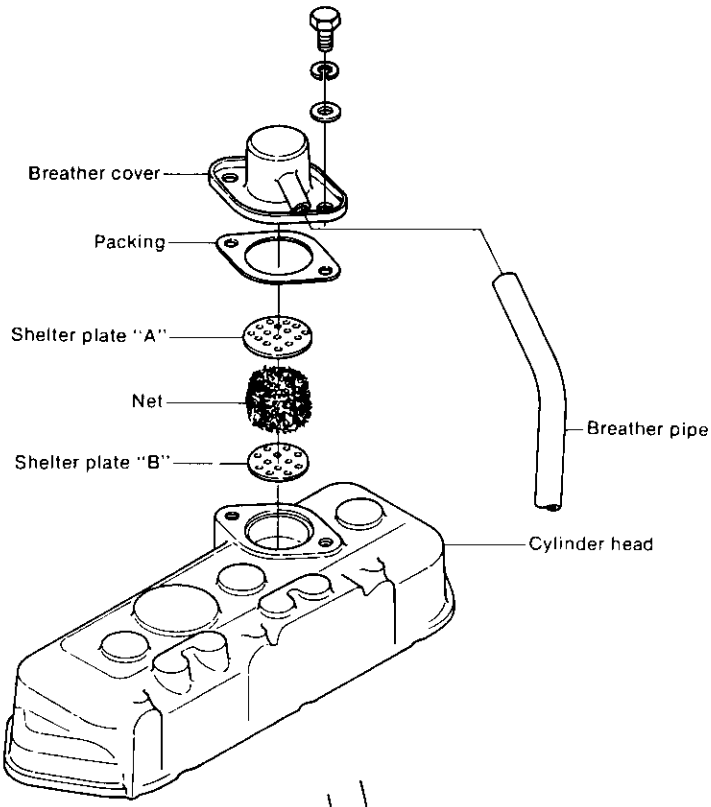
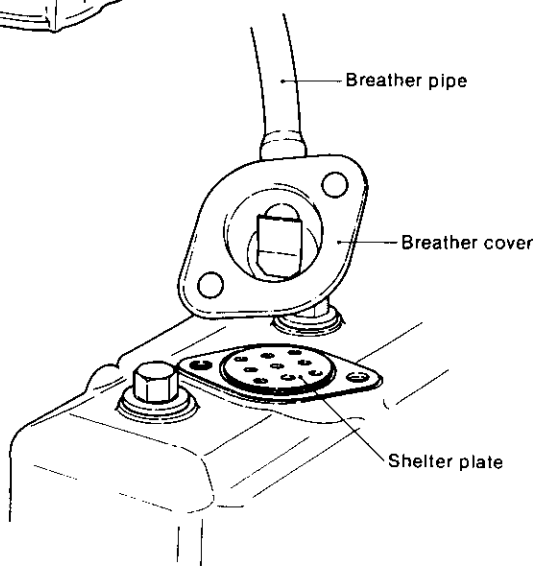
4-1.3 Breather for model 3HM35(F)(C)







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CHAPTER 6

LUBRICATION SYSTEM

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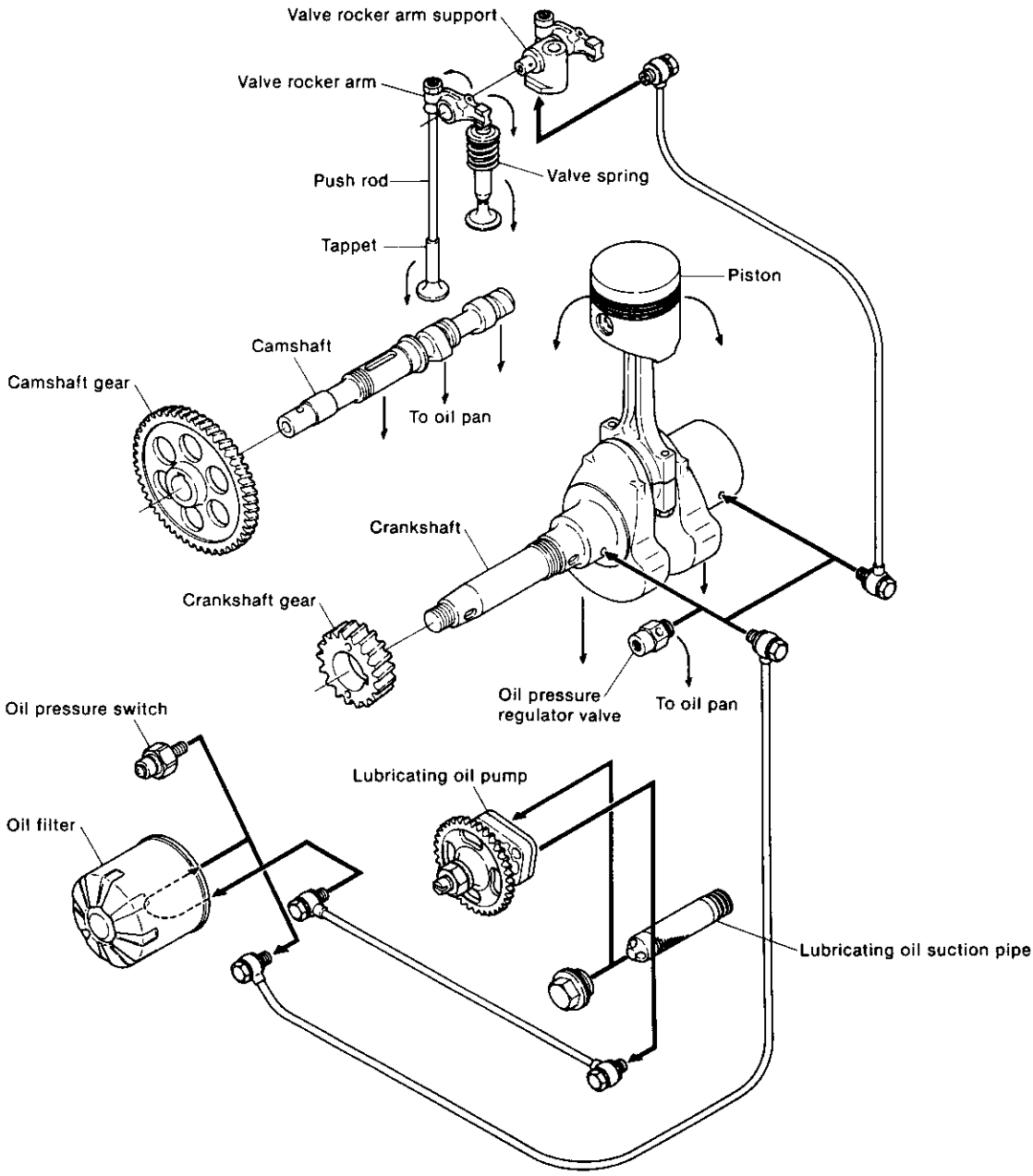
1. Lubrication System

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

1-1 Lubricating oil passage of model 1GM10(C)

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



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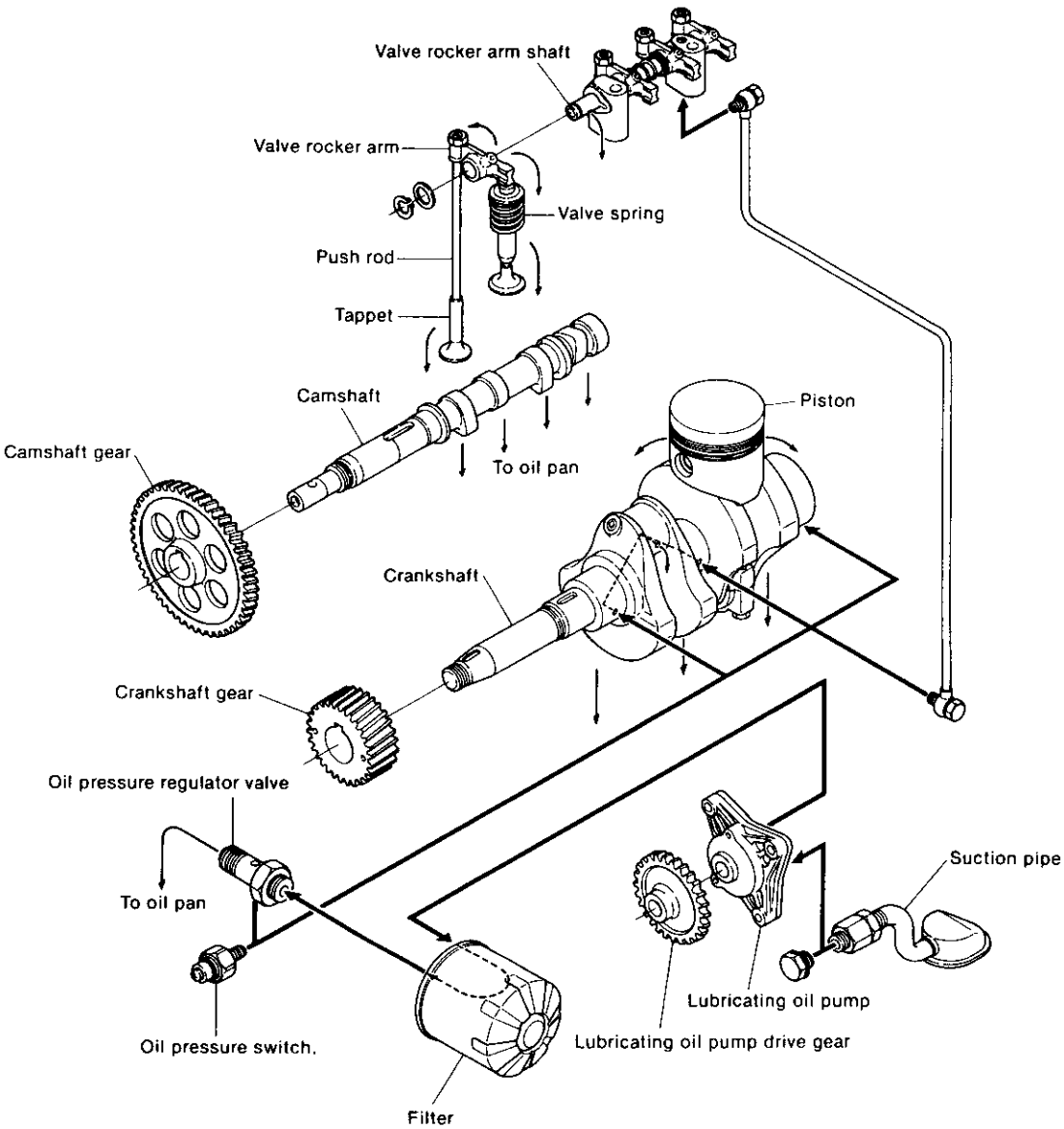
1-2 Lubrication oil passage of model 2GM20(F)(C)

The lubricating oil supplied from the oil filter in the rocker arm cover is collected through the tappet holes in the oil pan at the bottom of the cylinder block.
The lubricating oil is drawn back up through the lubricating oil suction pipe by the trochoid pump and fed to the oil filter, where impurities are filtered out. Then it is adjusted to the prescribed pressure by the oil pressure regulating valve and sent to the main bearing.
The lubricating oil sent to the gear side main bearing flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft.
The lubricating oil sent to the flywheel side main bearing also flows in two paths: one from the main bearing to lubricate the crank pin through the hole drilled through the crankshaft, and the other to the rocker arm shaft through the hole drilled through the cylinders and cylinder head.
From the rocker arm shaft, the lubricating oil flows through the small hole in the rocker arm to lubricate the push rods and part of the valve head.
The oil that has dropped to the push rod chamber from the rocker arm chamber lubricates the tappets, cam and cam bearing, and returns to the oil pan.
The pistons, piston pins and contact faces of the cylinder liners are splash lubricated by the oil that has lubricated the crank pin. Moreover, an oil pressure switch is provided in the lubricating system to monitor normal circulation and the pressure of the lubricating oil. When the lubricating oil pressure drops 0.5kgf/cm² (7.114 lb/in.²), the oil pressure switch illuminates the oil pressure lamp on the instrument panel to notify the operator.



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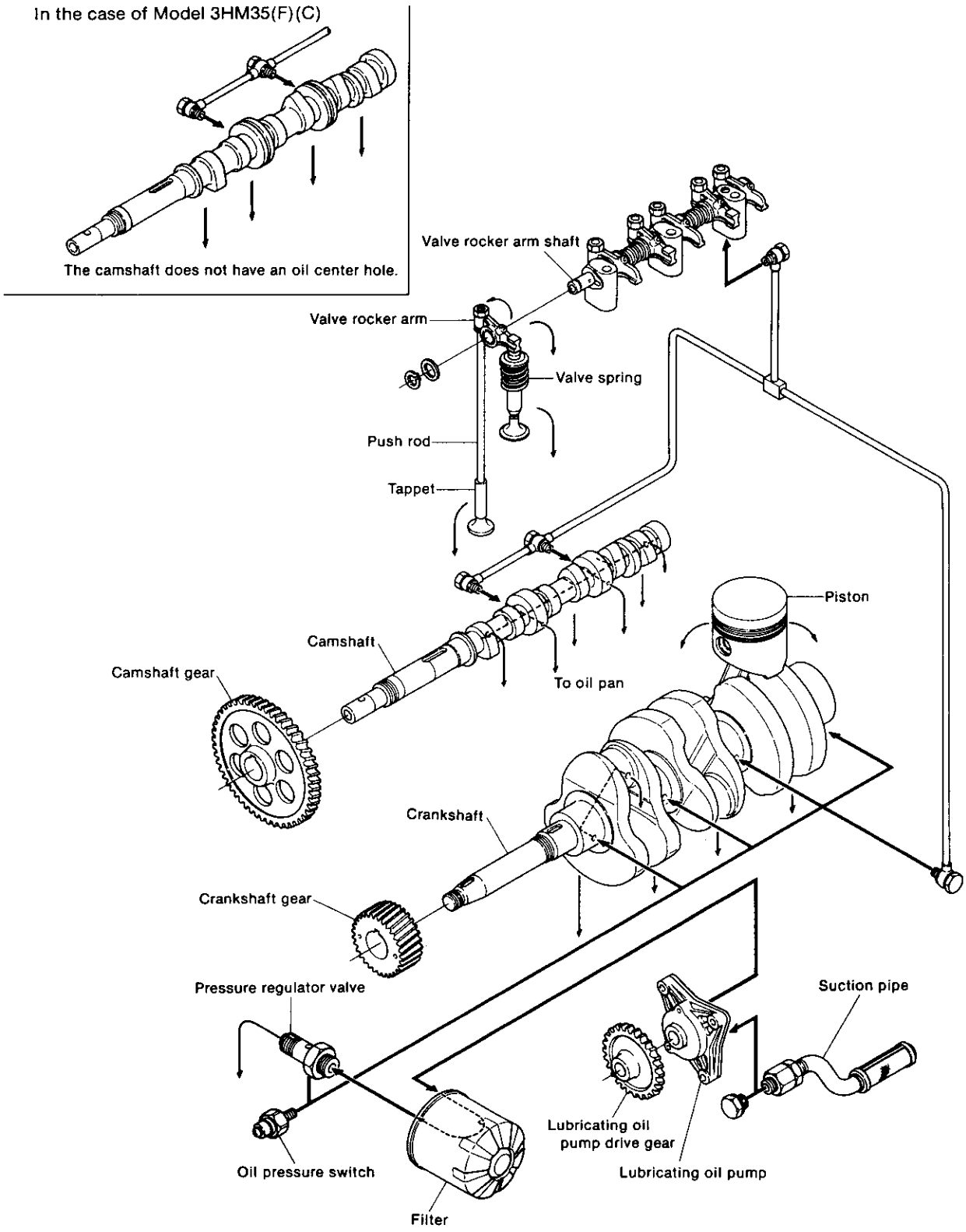
1-3 Lubrication oil passage of model 3GM30(F)(C) and 3HM35(F)(C)



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1-4 Table of capacity for lubricating oil system

			1GM10(C)	2GM20(F)(C)	3GM30(F)(C)	3HM35(F)(C)
Lubricating oil pump	Pump speed	rpm	2600	3600		3400
	Discharge volume	ℓ/min ℓ/h	3.9 234	12.5 760		12 720
	Discharge pressure	kgf-cm² (lb/in.²)	3.5 ±0.5 (42.67 ~ 56.89)			
Lubricating oil filter	Filter capacity					
	Discharge pressure	kgf-cm² (lb/in.²)	1 (14.22)			
Oil pressure regulator valve	Standard pressure	kgf-cm² (lb/in.²)	3.5 ±0.5 (42.67 ~ 56.89)			
	Full open pressure (Max)	kgf-cm² (lb/in.²)	4 (56.89)			
Lubricating oil pressure alarm switch	ON	kgf-cm² (lb/in.²)	0.2 ±0.1 (1.422 ~ 4.266)			0.5 ±0.1 (5.689 ~ 8.534)
Lubricating oil tank	Crankcase oil capacity, Total (effective)	ℓ	1.3 (0.6)	2.0 (1.3)	2.6 (1.6)	5.4 (2.7)

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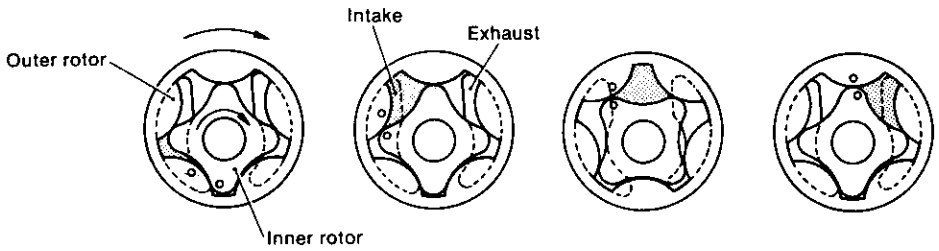
2. Oil Pump

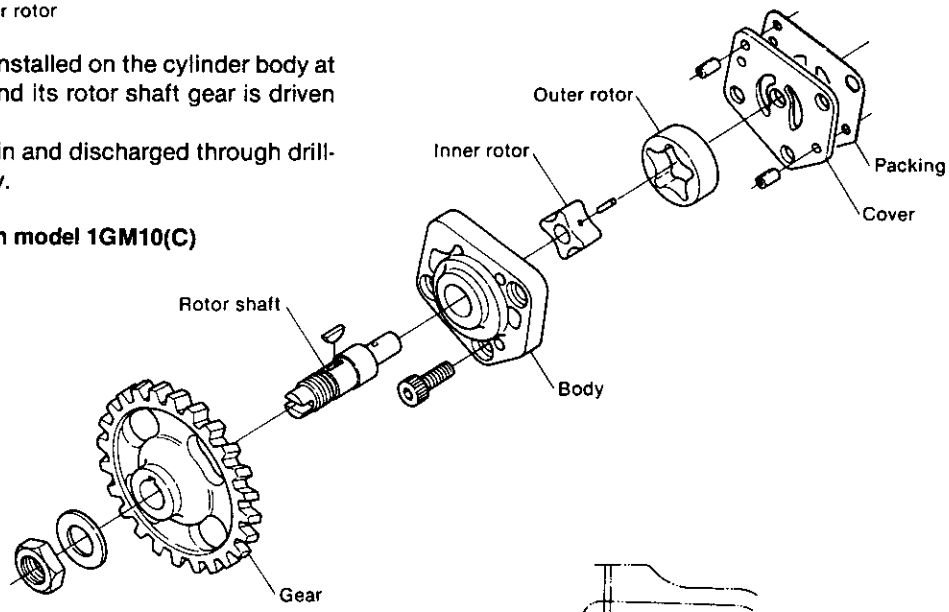
2-1 Construction

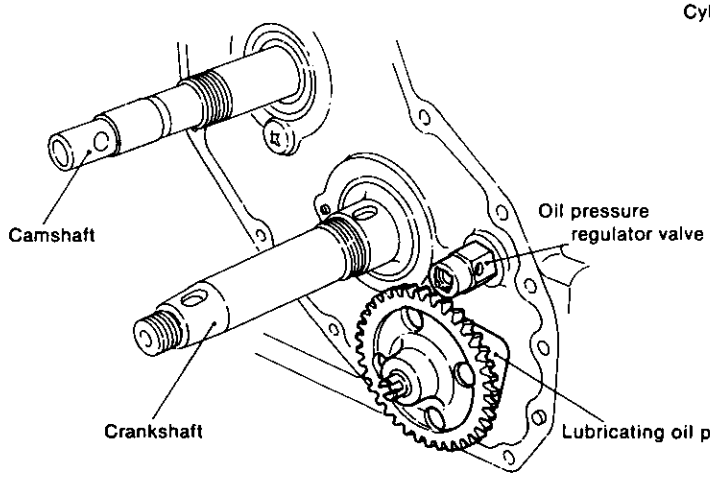
The oil pump is a compact, low pressure variation trochoid pump comprising trochoid curve inner and outer rotors. Pumping pressure is provided by the change in volume between the two rotors caused by rotation of the rotor shaft.

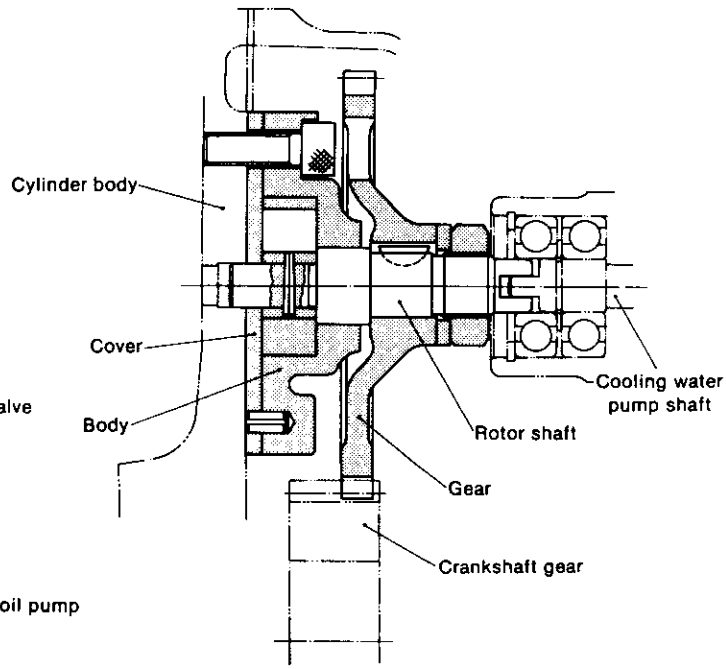


The lubricating oil pump is installed on the cylinder body at the timing gear case end, and its rotor shaft gear is driven by the crankshaft gear.
The lubricating oil is drawn in and discharged through drilled holes in the cylinder body.

2-1.1 Lubricating oil pump on model 1GM10(C)







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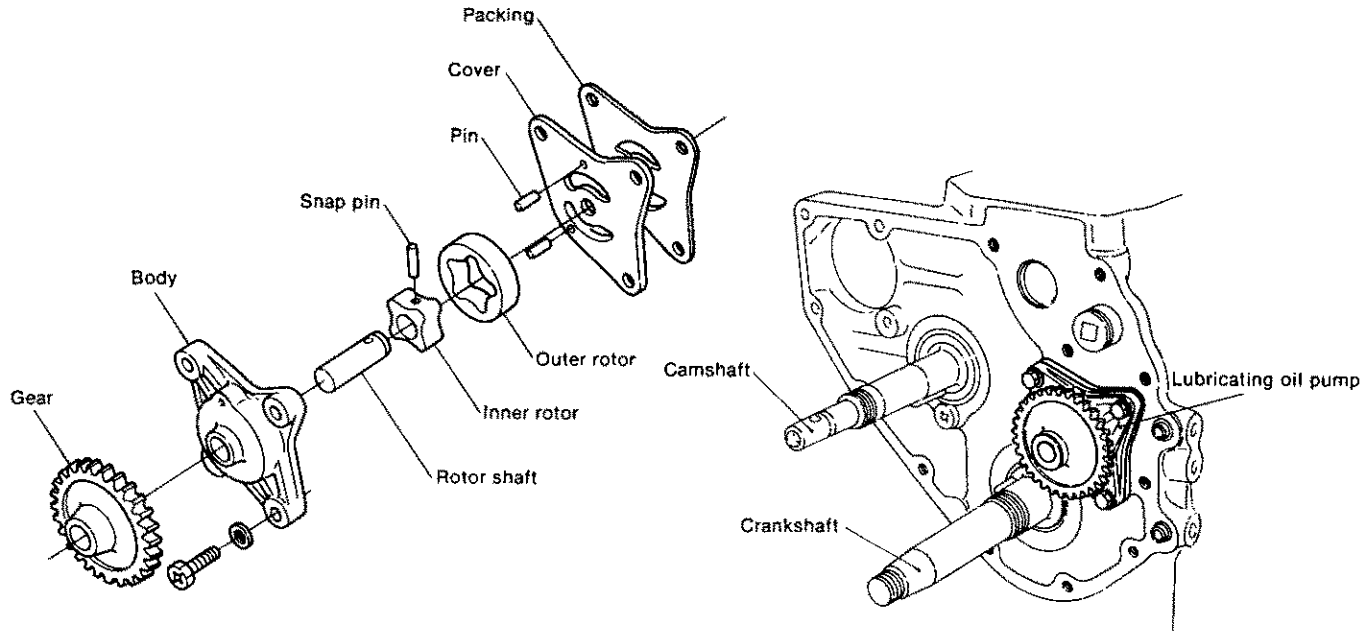
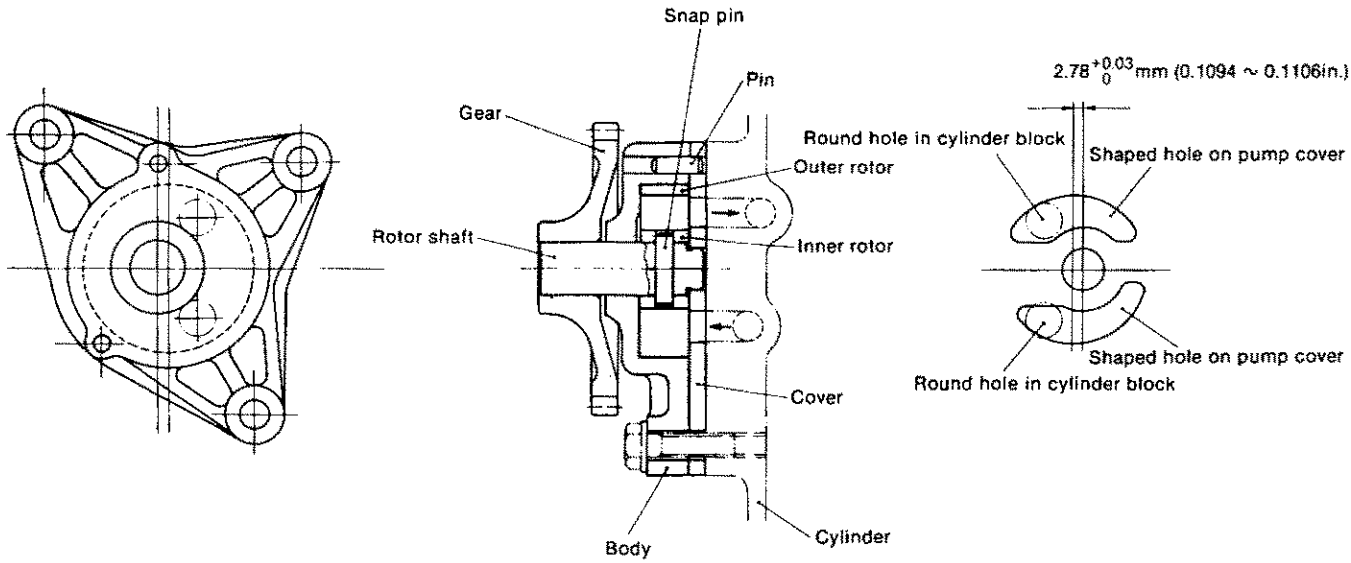
2-1.2 Lubricating oil pump on models 2GM20(F)(C), 3GM30 (F)(C) and 3HM35(F)(C)





2-1.3 Specifications of lubrication oil pump

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C)	3HM35(F)(C)
Engine speed	3600 rpm	3600 rpm	3400 rpm
Pump speed	2600 rpm	3600 rpm	3400 rpm
Discharge volume	3.9 *l*/min 234 *l*/h	12.5 *l*/min 760 *l*/h	12 *l*/min 720 *l*/h
Discharge pressure	3.5±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)	3.5±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)	3.5±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)

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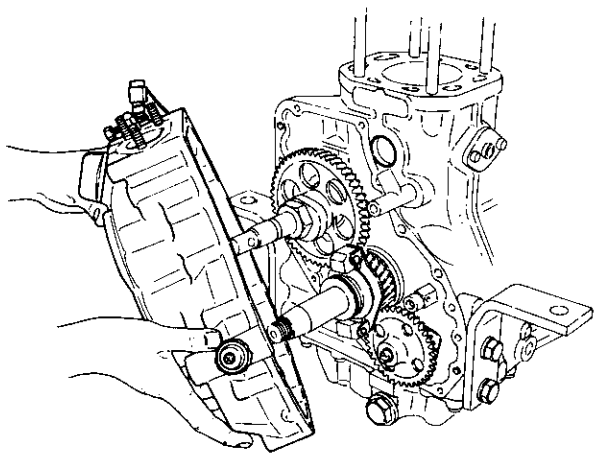
2-2 Disassembly

2-2.1 Model 1GM10(C)

(1) Remove the timing gear case



(1') Remove gear case

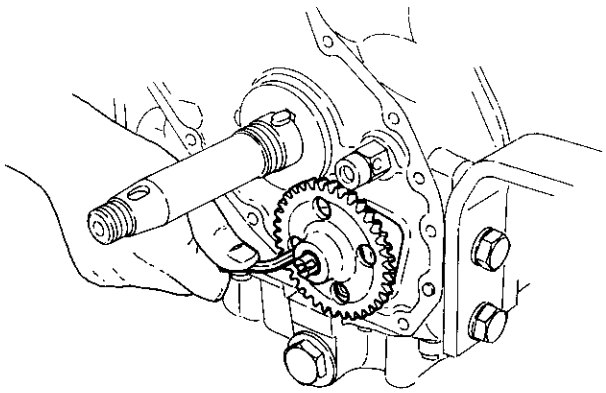
(2) Withdraw the governor sleeve and thrust bearing, and also take out the governor weight support after removing the hexagonal nut.

NOTE: The lubricating oil pump drive gear cannot be removed without removing the governor weight support.

(3) Remove the hexagonal nut of the lubricating oil pump rotor shaft, then remove the pump drive gear.

(4) Remove the pump body from the cylinder by removing the fixing bolt with a hexagonal bar spanner.

(4') Remove the loosening bolt with a hexagonal bar spanner.

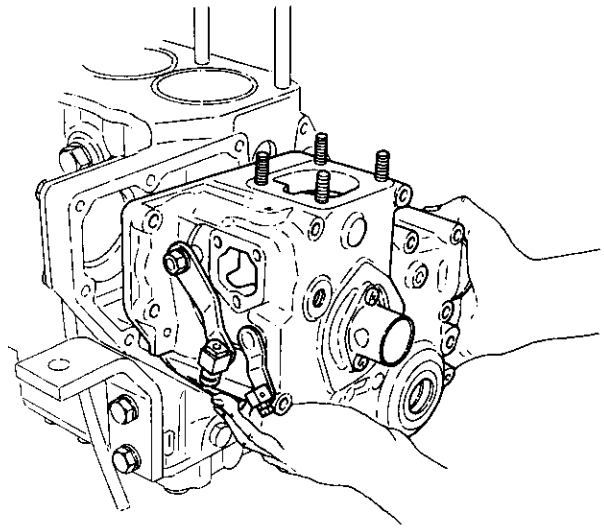


(5) Remove the pump cover.

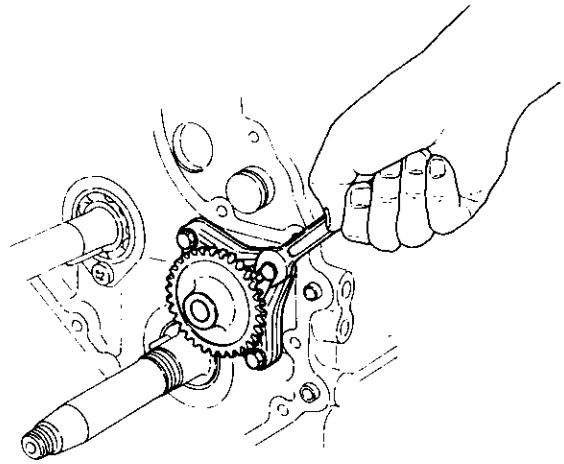
(6) Take out the outer rotor and the assembly of the inner rotor and rotor shaft.

2-2.2 Models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)

(1) Remove the timing gear case.



(2) Remove the lubricating oil pump driving gear and pump assembly.



NOTE: Do not separate the lubricating pump gear from the rotor shaft. If removed, it cannot be used again. When any part is unusable, replace it as a complete assembly.

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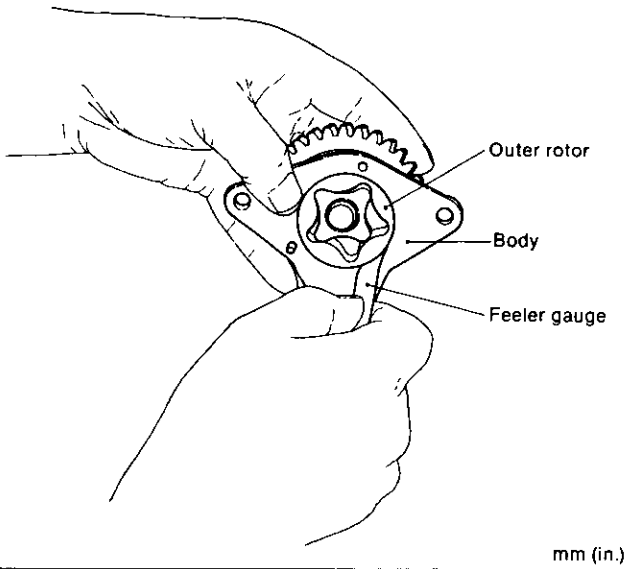
2-3 Inspection

When the discharge pressure of the oil pump is extremely low, check the oil level. If it is within the prescribed range, the oil pump must be inspected.

(1) Outer rotor and pump body clearance

Measure the clearance by inserting a feeler gauge between the outside of the outer rotor and the pump body casing. If the clearance exceeds the wear limit, replace the outer rotor and pump body as a set.

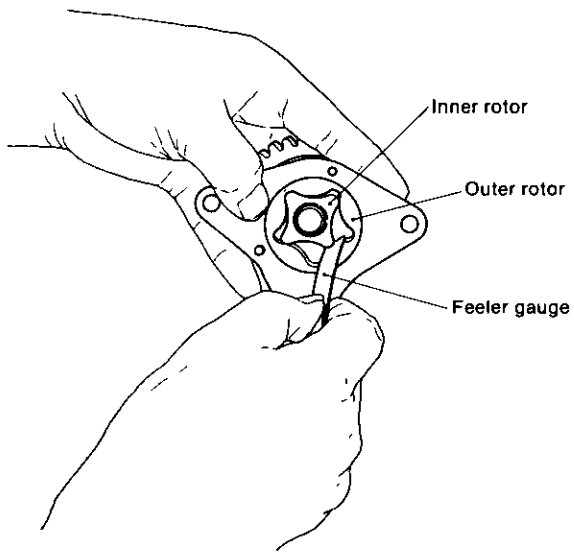


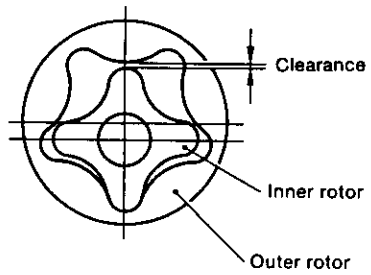
mm (in.)

Maintenance standard	0.050 ~ 0.105 (0.00197 ~ 0.00413)
Wear limit	0.15 (0.00591)

(2) Outer rotor and inner rotor clearance

Fit one of the teeth of the inner rotor to one of the grooves of the outer rotor and measure the clearance at the point where the teeth of both rotors are aligned. Replace the inner rotor and outer rotor ass'y if the wear limit is exceeded.





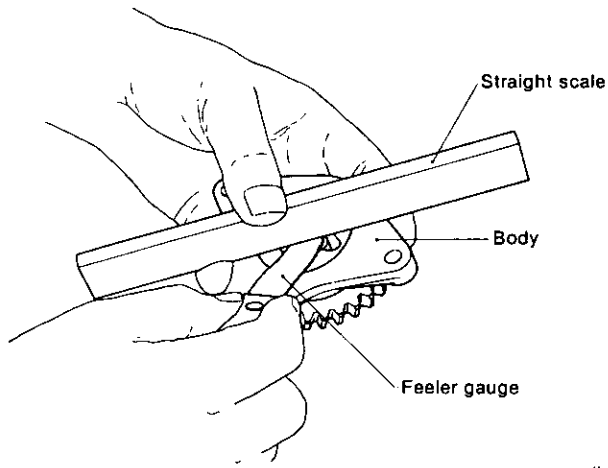
mm (in.)

Maintenance standard	0.050 ~ 0.105 (0.00197 ~ 0.00413)
Wear limit	0.15 (0.00591)

(3) Pump body and inner rotor, outer rotor side clearance

Install the inner rotor and outer rotor into the pump body casing so that they fit snugly.

Check the clearance by placing a ruler against the end of the body and inserting a feeler gauge between the ruler and the end of the rotor. Replace as a set if the wear limit is exceeded.



mm (in.)

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Maintenance standard	0.03~0.08 (0.0012~0.0031)	0.03~0.07 (0.0012~0.0031)
Wear limit	0.13 (0.0051)	0.13 (0.0051)

(4) Rotor shaft and body clearance

Measure the outside diameter of the rotor shaft and the inside diameter of the body shaft hole, and replace the rotor shaft and body as an ass'y if the clearance exceeds the wear limit.

mm (in.)

	1GM10(C)		
	Maintenance standard	Clearance when assembled	Maximum allowable clearance
Rotor shaft outside diameter	ø14 (0.5512)	0.015~0.050 (0.0006~0.0020)	0.2 (0.0079)
Rotor shaft hole inside diameter	ø14 (0.5512)		

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3. Oil Filter

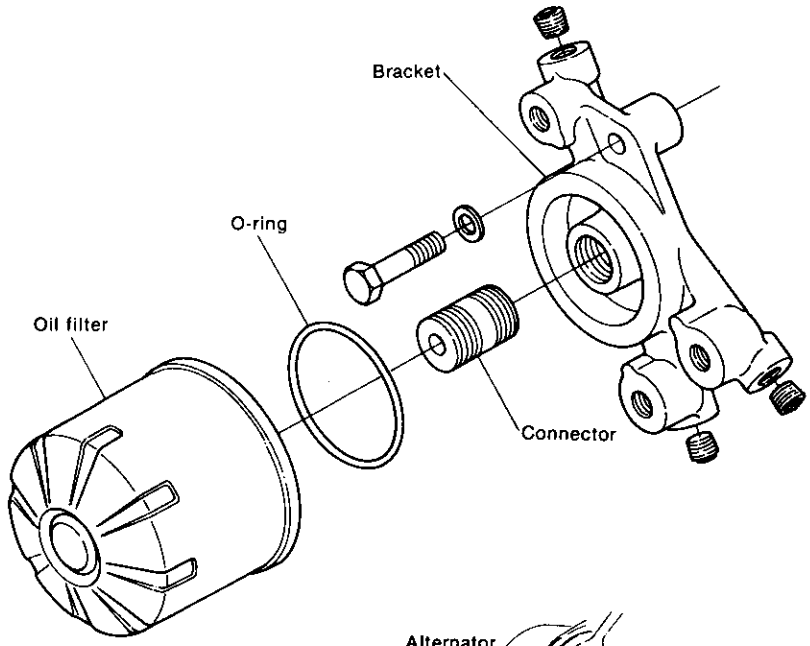
3-1 Construction

The oil filter removes the dirt and metal particles from the lubricating oil to minimize wear of moving parts. The construction of the oil filter is shown below.

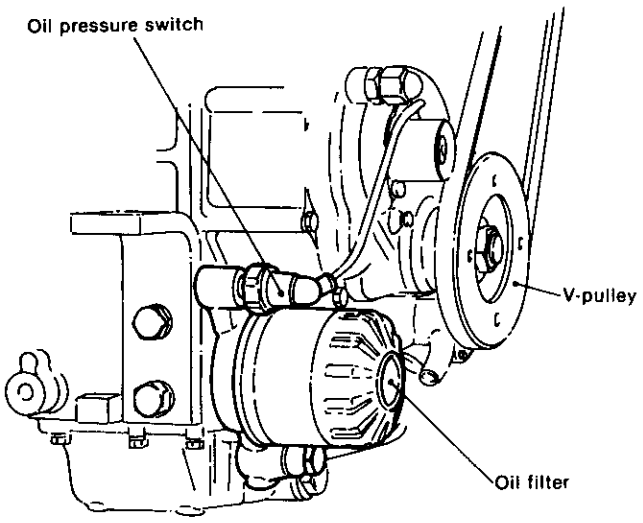
The lubricating oil from the oil pump is passed through the filter paper and distributed to each part as shown by arrow A in the figure.

After extended use, the filter paper will become clogged and its filter performance will drop. When the pressure loss caused by the filter paper exceeds 1kgf/cm^2(14.22 lb/in.^{2}), the bypass valve inside the filter opens and the lubricating oil is sent to each part automatically as an emergency measure, without passing through the filter, as shown by arrow B.

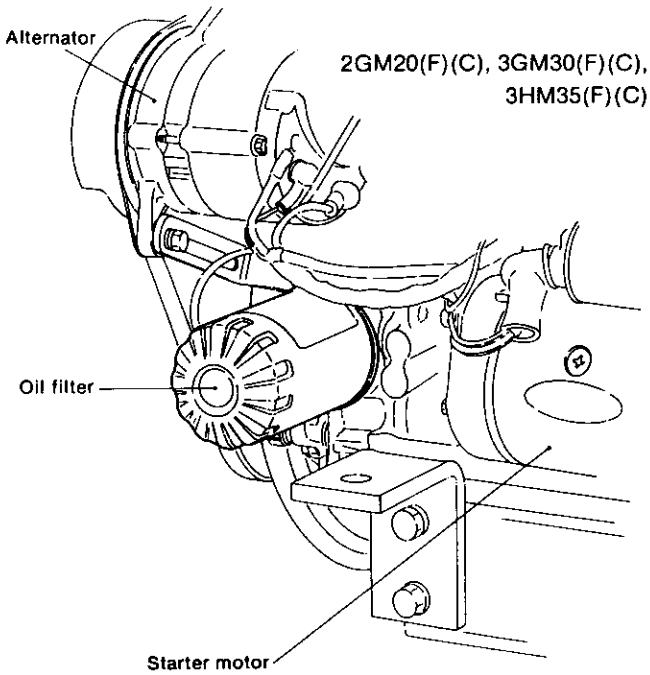
The oil filter is located at the fitted position of the oil pressure regulator valve on the side surface of the gear case together with the oil pressure valve for engine models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C). However, in the case of engine model 1GM10(C), the filter alone is fitted on its mounting base at the gear case end, cylinder end surface. The oil pressure regulator valve is installed separately on the end surface of the cylinder, in the gear case.



1GM10(C)



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



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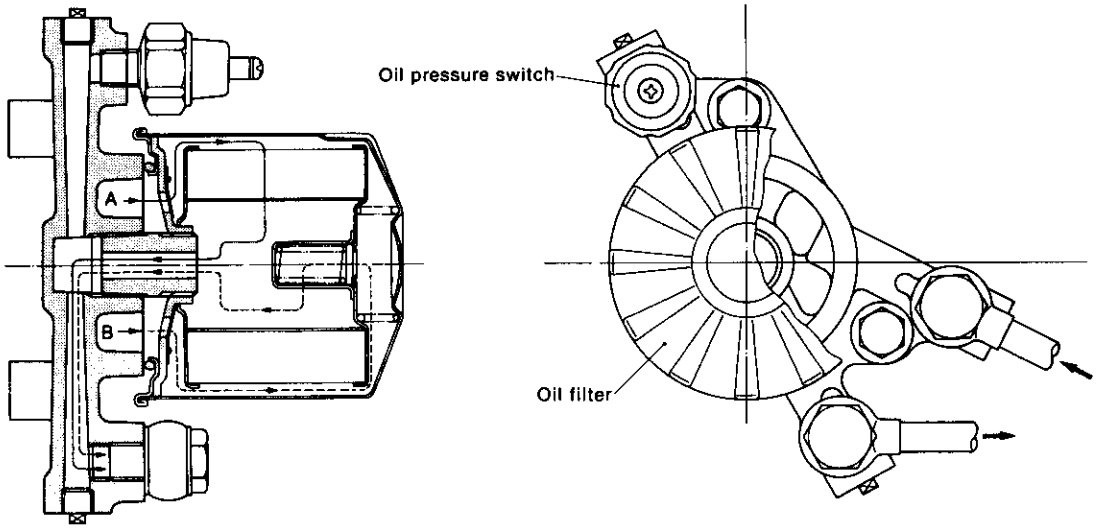
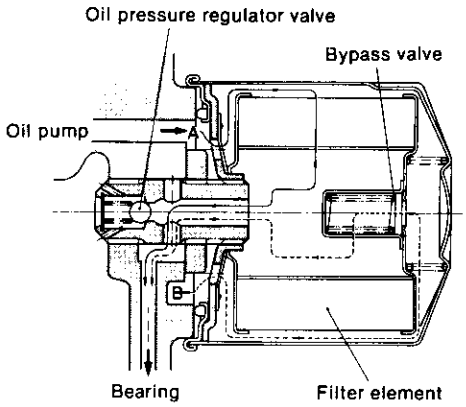
1GM10(C)



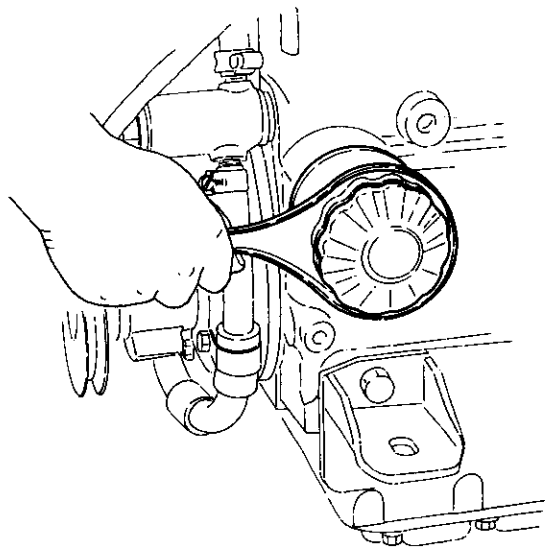
2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)



3-2 Replacement

When the oil filter has been used for an extended period, the filter paper will become clogged, unfiltered lubricating oil will be sent directly to each part from the bypass circuit, and wear of moving parts will be accelerated. Therefore, it is important that the filter be periodically replaced.
Because this is a cartridge type oil filter, it is replaced as a complete unit.

Oil filter replacement period	Every 300 hours of engine operation



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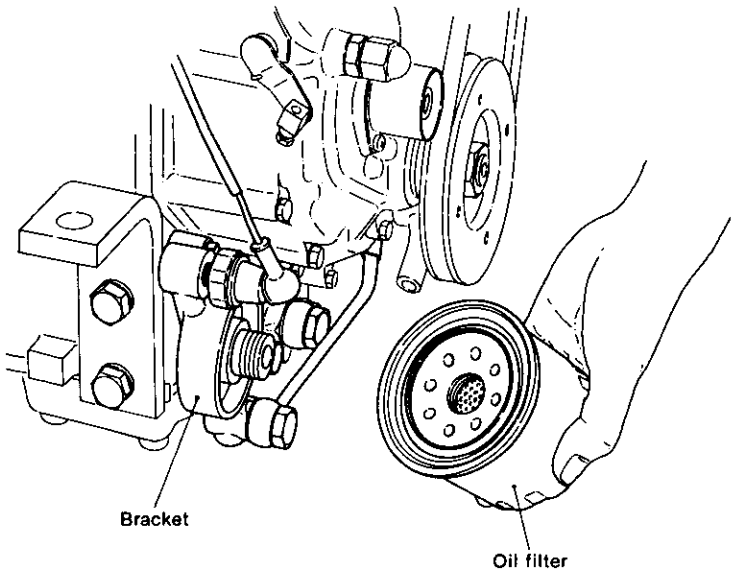
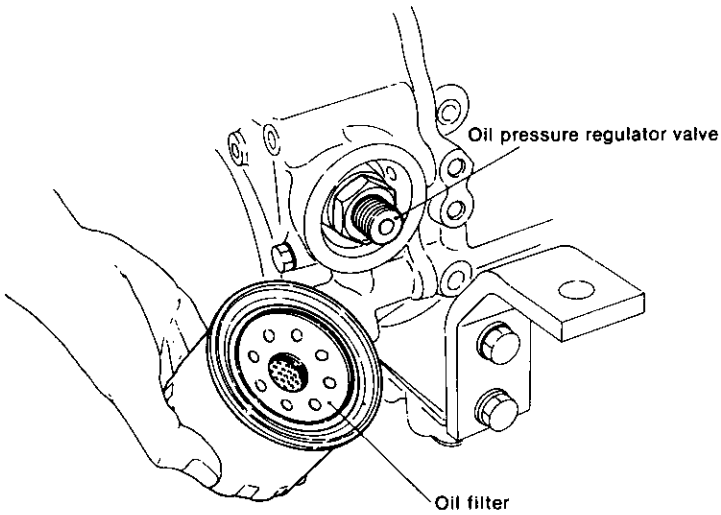
1GM10(C)



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



3-2.1 Replacing the oil filter

(1) Clean the oil filter mounting face on the cylinder block.
(2) Before installing the new filter, coat the rubber packing with a thin coat of lubricating oil.
(3) Turn the filter gently until it contacts the rubber packing of the seal surface, then tighten another 2/3 turn.
(4) After installation, run the engine and check the packing face for oil leakage.

3-2.2 In case of oil leakage

If there is oil leakage, remove the oil filter and replace the packing. At the same time, inspect the cylinder block mounting face and repair the face with an oil stone if it is scored.

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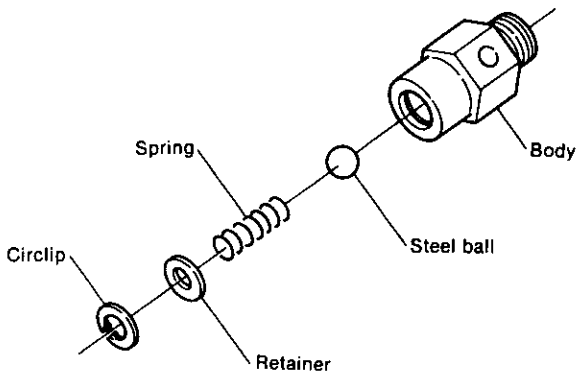
4. Oil Pressure Regulator Valve

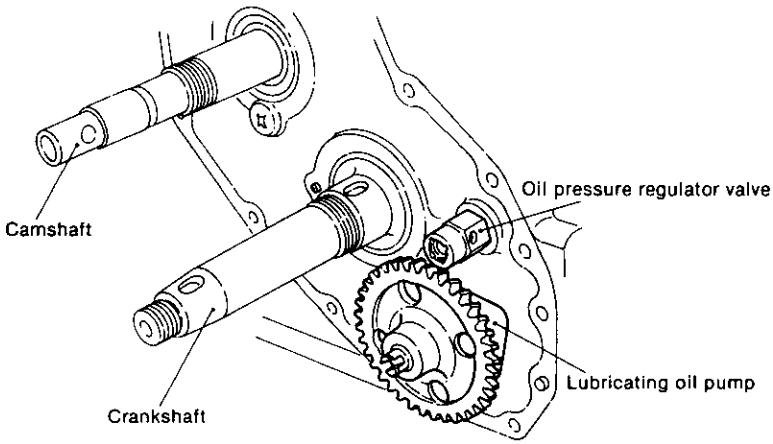
4-1 Construction

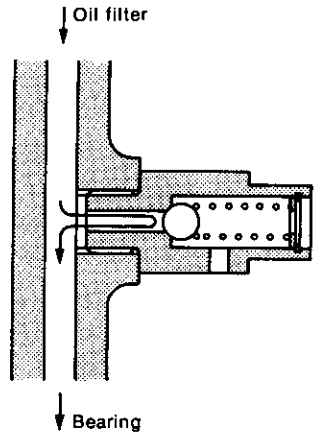
The oil pressure regulator valve serves to adjust the pressure of the lubricating oil to the prescribed pressure during operation. When the pressure of the lubricating oil from the oil filter exceeds the force of the spring, the metal ball is pushed away from the valve seat and the lubricating oil flows to the oil pan through the gap between the ball and seat. The spring's force is adjusted with a shim.
In engine model 1GM10(C), the oil pressure regulator valve is located at the end surface of the cylinder in the gear case and the pressure is regulated at the intermediate section of the oil passageway between the lubricating oil main gallery and the main bearing at the gear end.
The regulator valve is located in the mounting position of the lubricating oil filter of the timing gear case for engine models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)

4-1.1 Model 1GM10(C)



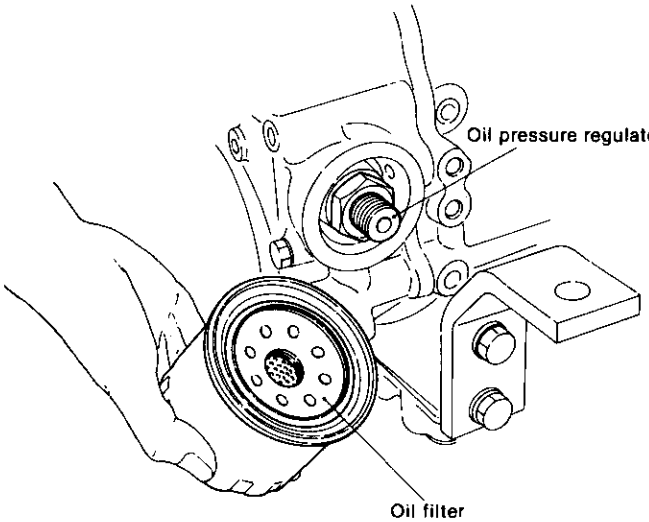
Mounting position for model 1GM10(C)

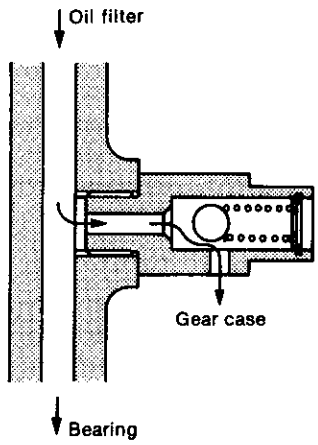




When the pressure is lower than the regulated pressure

Mounting position for model 2GM20(F)(C)





When the pressure is higher that the regulated pressure

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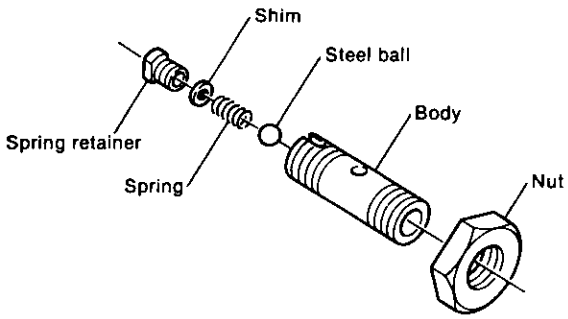
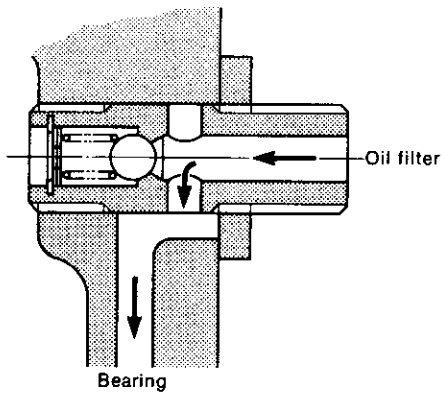
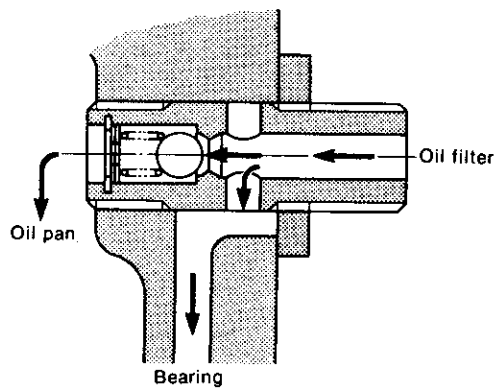
4-1.2 Models 2GM20(F)(C), 3GM30(F)(C) and 3HM35(F)(C)





When the pressure is lower that the regulated pessure



When the pressure is higher that the regulated pressure

4-1.3 Specifications

	1GM10(C)	2GM20(F)(C), 3GM30(F)(C), 3HM35(F)(C)
Standard pressure	3.5±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)	3.5±0.5 kgf/cm² (42.67 ~ 56.89 lb/in.²)

As the lubricating oil pressure regulator valve has been calked during manufacture so that it cannot be dismantled, replace it as a unit if any replacement becomes necessary.

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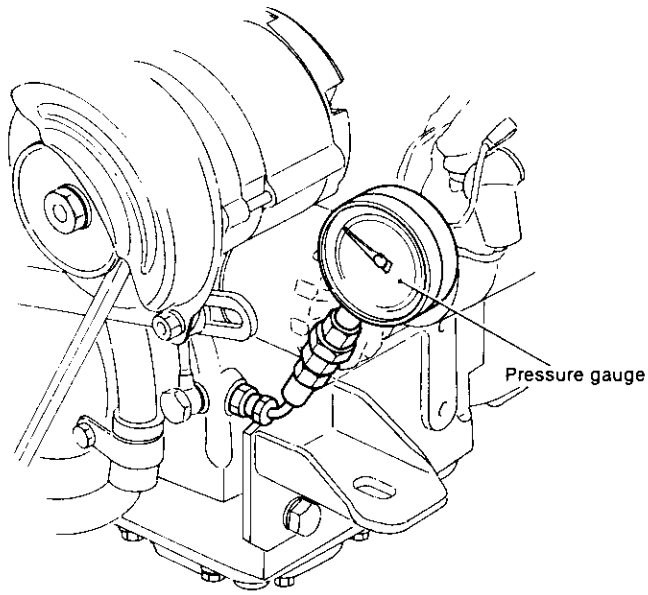
5. Oil Pressure Measurement

The lubricating oil pressure is monitored by a pilot lamp, but it must also be measured using a pressure gauge. Connect the oil pressure gauge to the pilot lamp unit for primary pressure and to the lubricating oil pipe connector for secondary pressure, as shown in the figure.
Secondary oil pressure is especially important. Idle the engine at medium speed when measuring the oil pressure. Also check whether the oil pressure rises smoothly and to the standard value.



kgf/cm²(lb/in.²)

	1GM10(C), 2GM20(F)(C), 3GM30(F)(C)		3HM35(F)(C)	
	850 rpm	3600 rpm	850 rpm	3400 rpm
Secondary pressure standard value	0.5 (7.11)	3.5±0.5 (42.67~56.89)	0.5 (7.11)	3.5±0.5 (42.67~56.89)

If the oil pressure is lower than the standard value, probable causes are:
(1) Clearance of lubricated bearings in the lubricating oil circuit is too large (Shaft or bearing is worn).
(2) Excessive oil escaping from rocker arm support.
Therefore, inspection and repair of the bearings and rocker arm support are required.

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CHAPTER 7

DIRECT SEA-WATER COOLING SYSTEM

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1. Cooling System

1-1 Composition

(1) A sea water direct cooling system incorporating a rubber impeller pump is employed.
(2) A thermostat is installed and a bypass circuit is provided to keep the cooling water temperature constant at all times.
This not only prevents overcooling at initial operation, but also improves the combustion performance and increases the durability of moving parts by keeping the temperature constant.
(3) Anticorrosion zinc is provided at the cylinder and the cylinder head to prevent electrolytic corrosion of the cylinder jacket and cylinder head by the sea water.
(4) A cooling water temperature sender is installed so that any abnormal rise in cooling water temperature is indicated by the lamp on the instrument panel.
(5) A scoop strainer is provided at the water intake Kingston cock to remove dirt and vinyl from the water.
(6) Rubber hoses are used for all interior piping. This eliminates pipe brazing damage due to engine vibration and simplifies the engine's vibration mounting.

1-2 Cooling water route

The cooling water is sucked up by the water pump through a Kingston cock installed on the hull. The water delivered from the water pump branches in two directions at the cylinder intake coupling. Some of the water enters the cylinder jacket and the rest bypasses the cylinder jacket and enters the mixing elbow or the exhaust manifold.
The water that enters the cylinder jacket cools the cylinders and then rises to the cylinder head through the passage between the cylinder and cylinder head and to cool the cylinder head.
The cooling water from the cylinder head, after passing the thermostat, enters the mixing elbow in models 1GM10(C) and 2GM20(C). However, in models 3GM30(C) and 3HM35(C), it first passes to the exhaust manifold to cool the exhaust gas and then enters the mixing elbow.
After that, the water is discharged to the outside of the boat through the rubber hose from the mixing elbow.
The thermostat is closed until the cooling water temperature reaches a fixed temperature (42°C), making the flow go to the cylinder head and then through the bypass circuit.
When the cooling water temperature exceeds 42°C, the thermostat opens, and the cooling water begins to flow through the entire system. At 52°C, the thermostat valve is fully opened and the cooling water temperature is maintained at that level.

1-3 Piping

To simplify the cooling system piping and eliminate cracking of the brazed parts by vibration, rubber or vinyl hoses connected with hose clips are adapted for this engine.
Therefore, the following items must be distorted when inspecting the cooling system:
(1) There must be no extreme bends in the piping.
(2) The cross section of the piping must not be changed by heavy objects on the piping.
(3) There must be no fractures or cracks which allow water leakage.
(4) Piping must not touch high temperature parts, and piping must be securely clamped.
(5) Hose clips must be securely tightened and there must be no leakage from the insertion sections.

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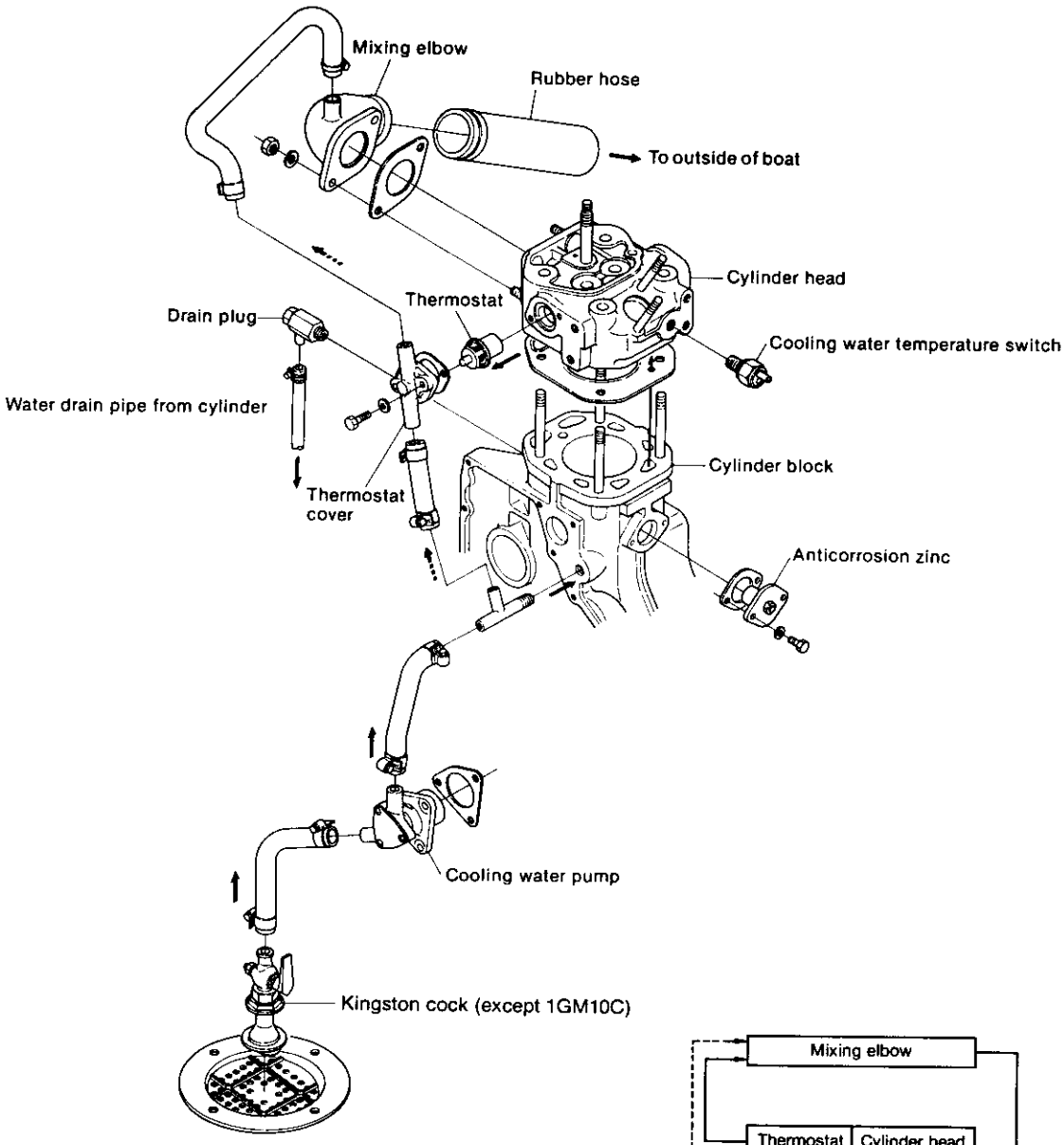
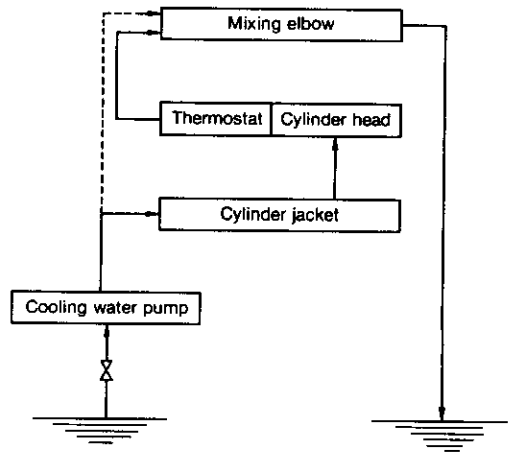
1-2.1 Cooling water passage of engine model 1GM10(C)





⟵ When the cooling water is at the correct temperature
⟵ ··· When the cooling water temperature is lower than the correct temperature

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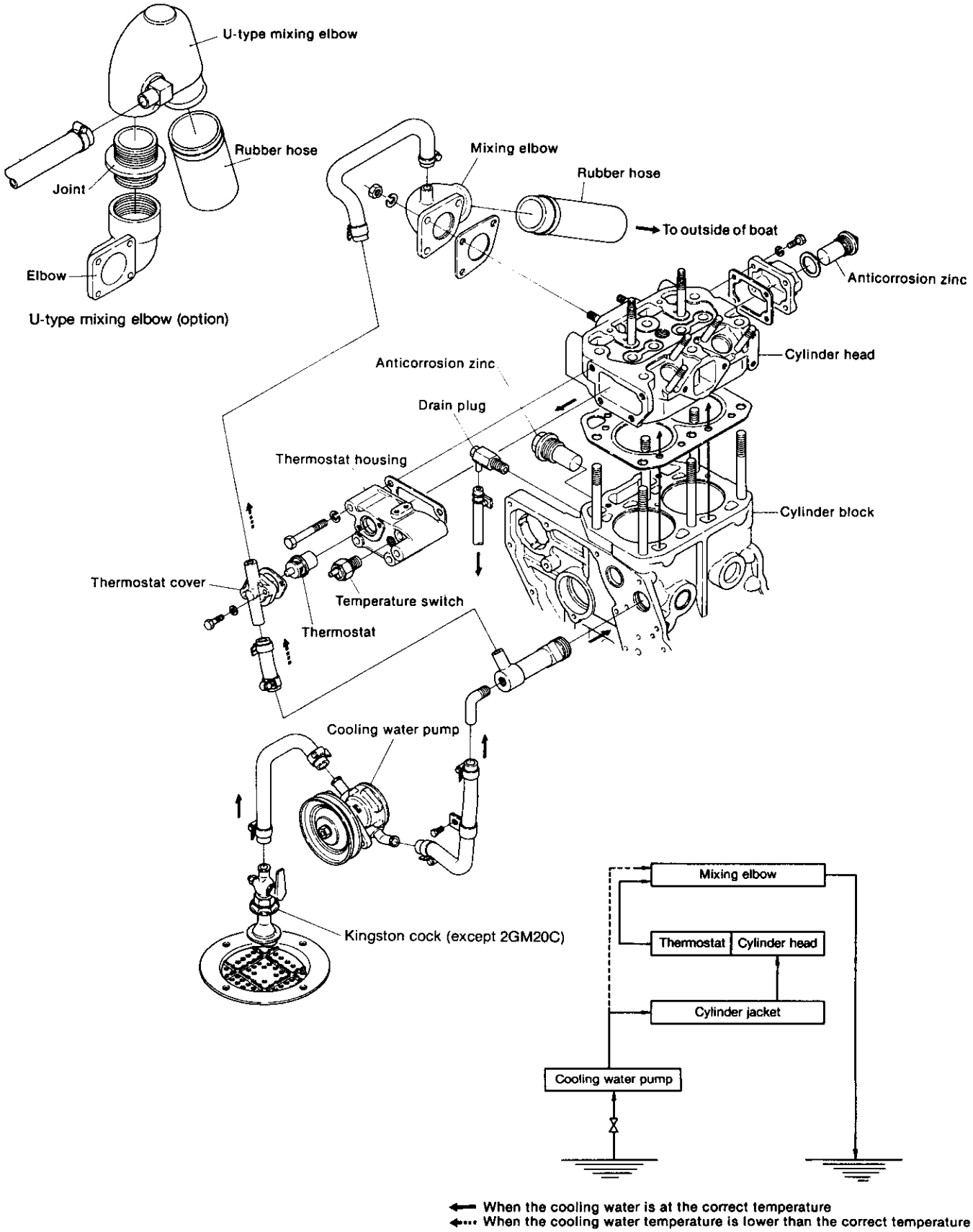
1-2.2 Cooling water passage of engine model 2GM20(C)



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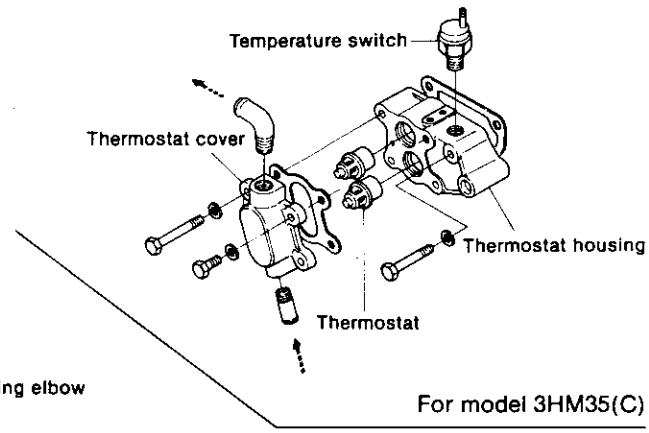
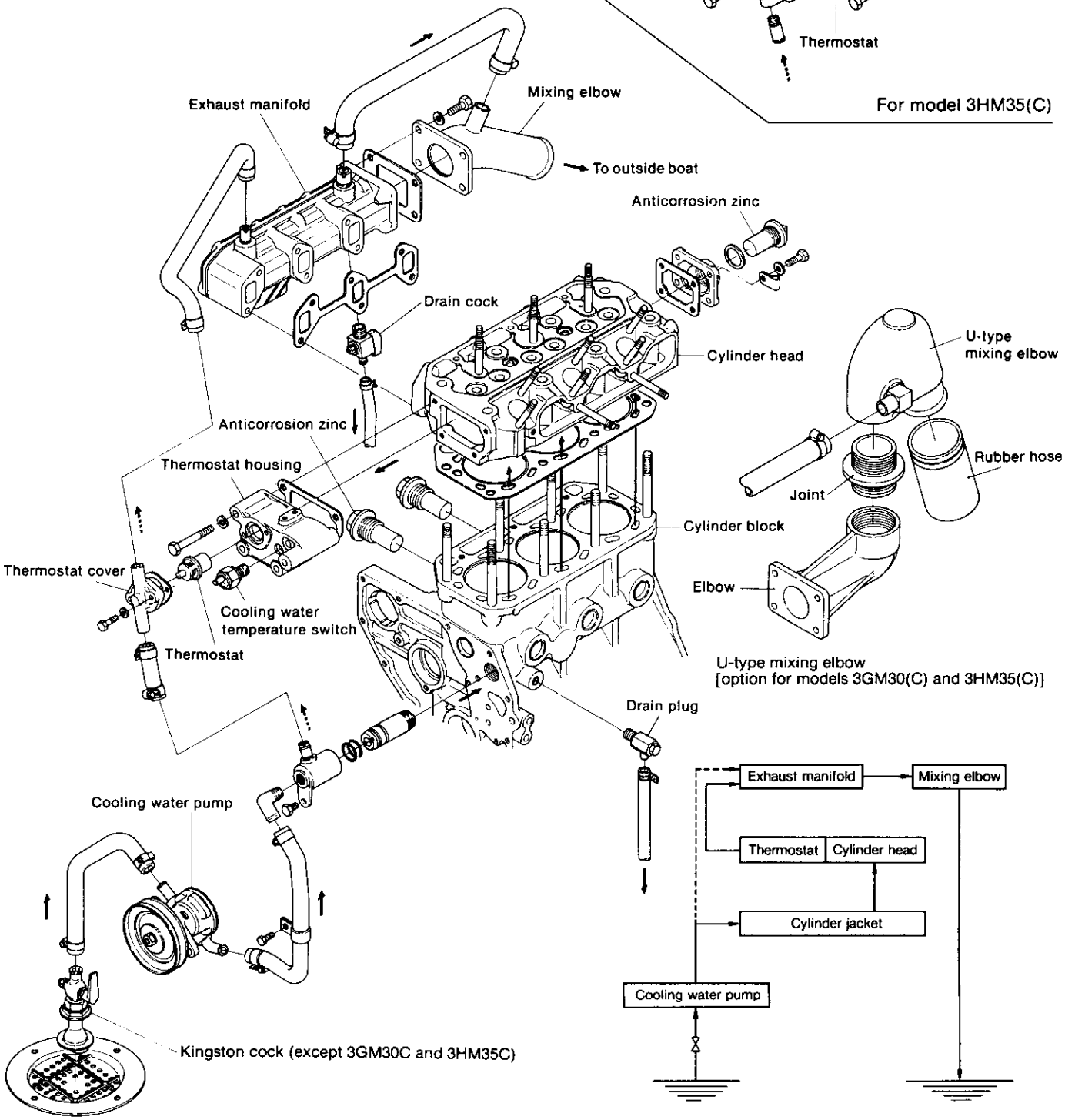
1-2.3 Cooling water passage of engine models 3GM30(C) and 3HM35(C)

The construction of model 3HM35(C) is almost the same as that of model 3GM30(C). As well as the different shape of the thermostat cover, model 3HM35(C) has 2 thermostats.





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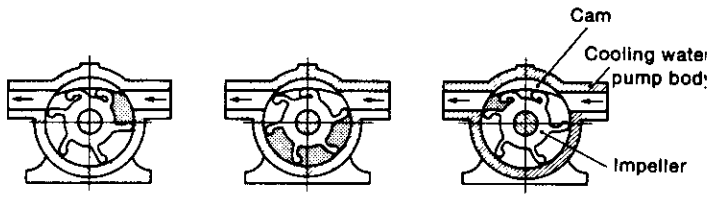
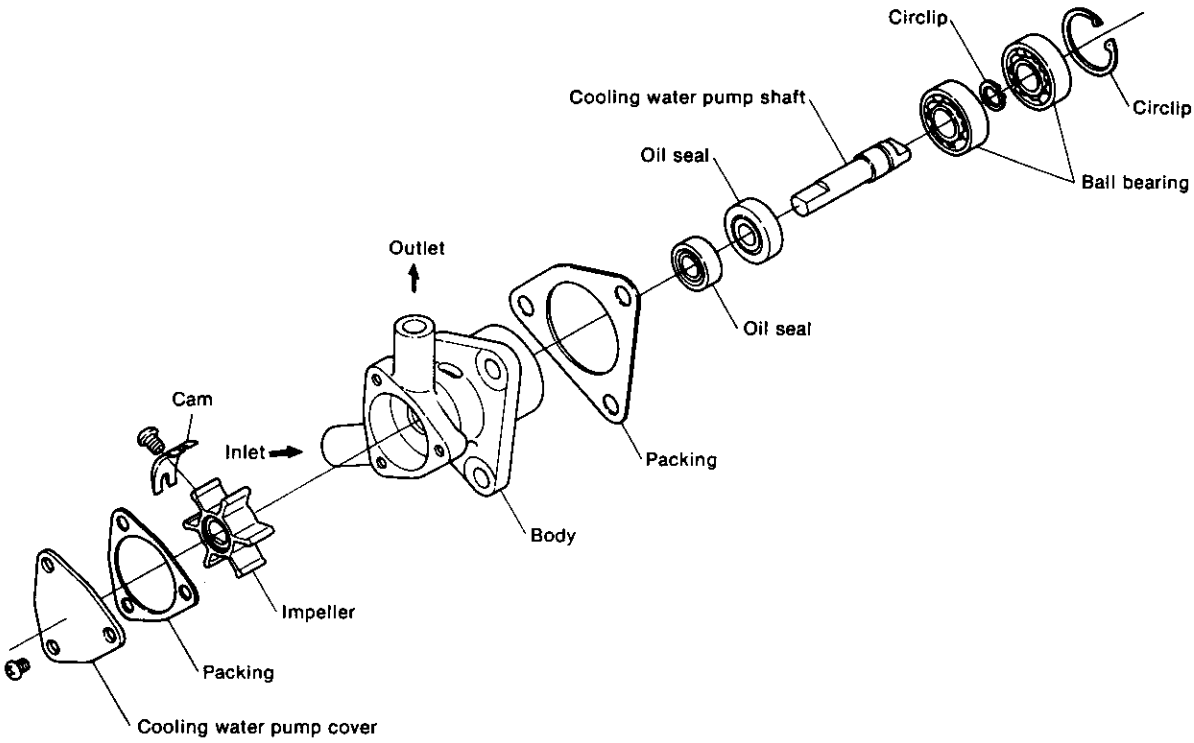
2. Water Pump

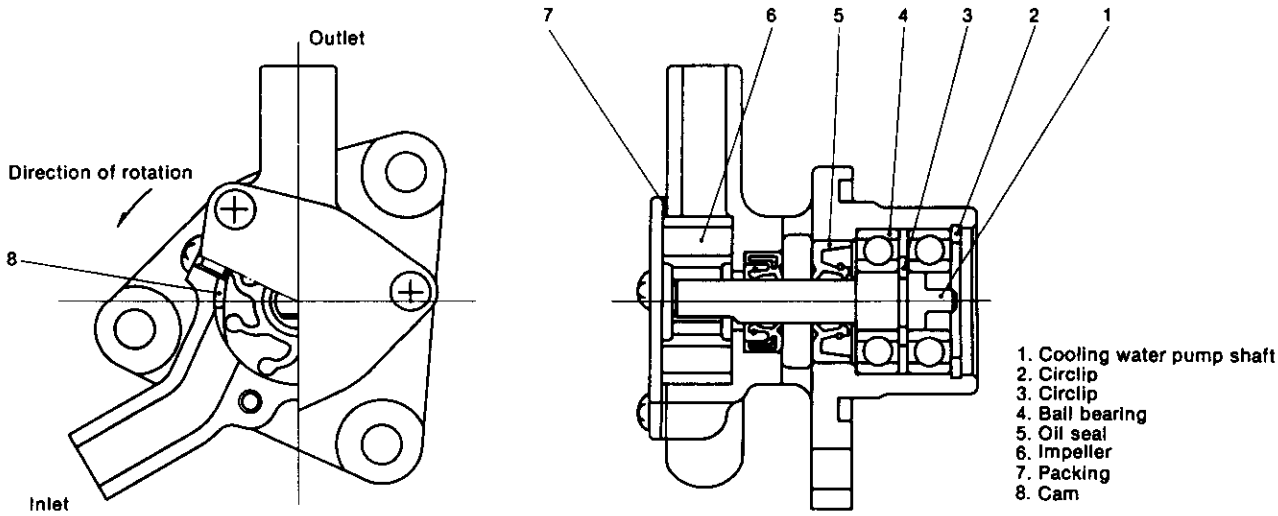
2-1 Construction and operation

The water pump is a rubber impeller type pump. The rubber impeller, which has ample elasticity, is deformed by the off-set plate inside the casing, causing the water to be discharged. This pump is ideal for small, high-speed engines.
The cooling water pump of engine model 1GM10(C) is driven by connecting the cooling water pump shaft to the slit on the end of the lubricating oil pump drive shaft.



2-1.1 Cooling water pump of engine model 1GM10(C)





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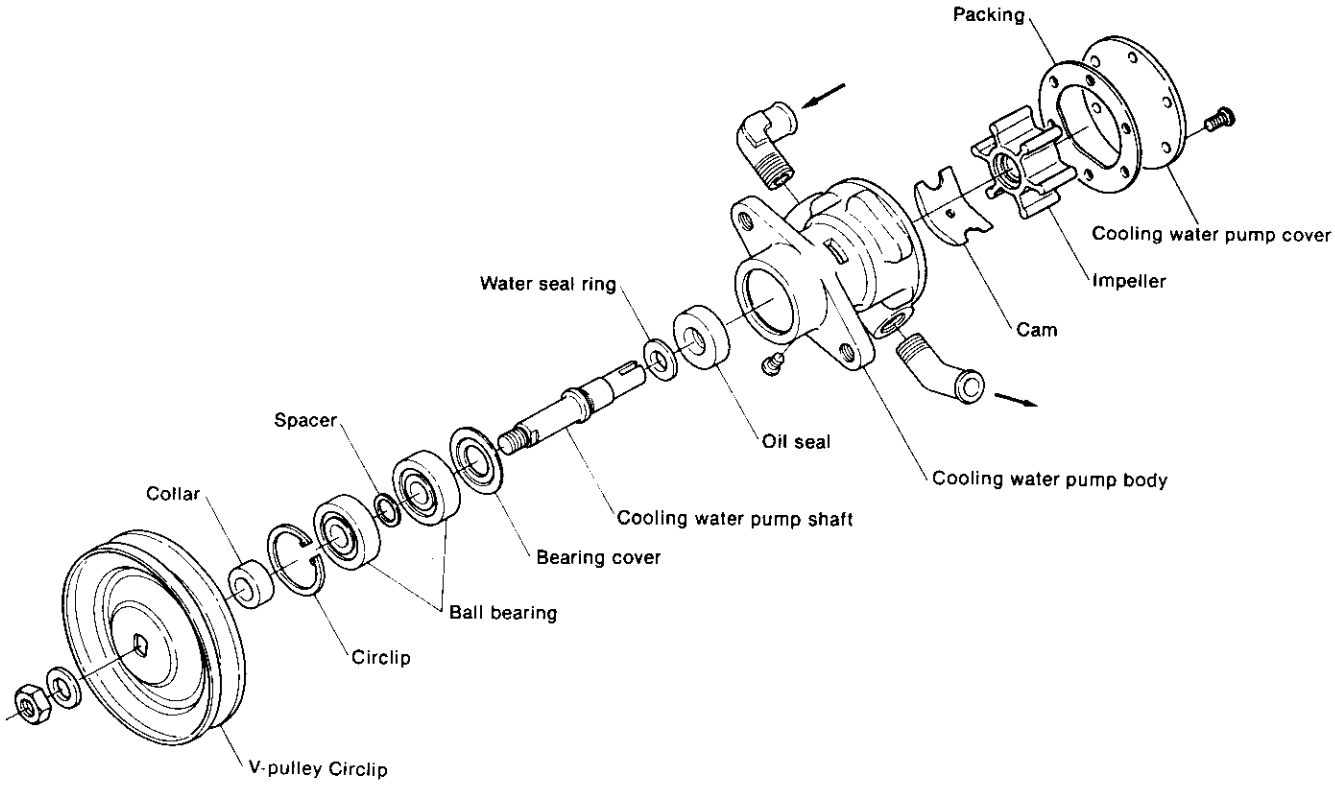
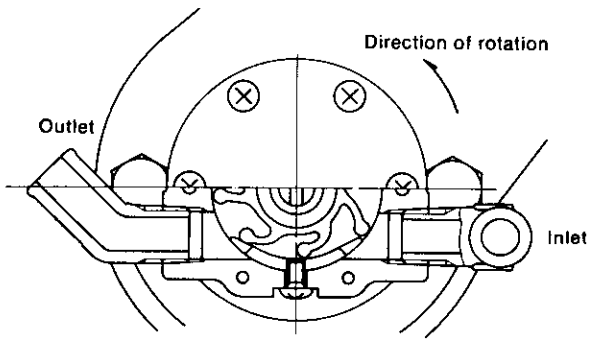
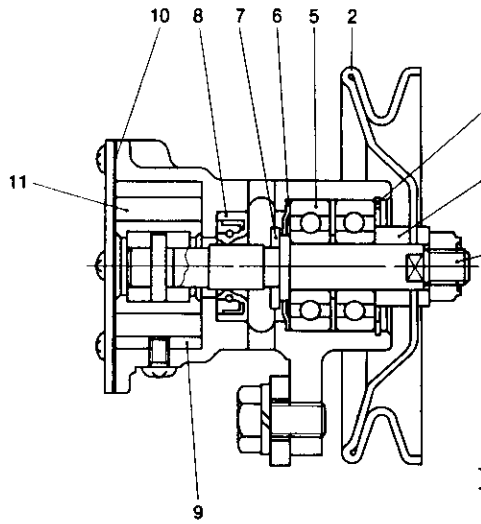
2-1.2 Cooling water pump of engine models 2GM20(C) and 3GM30(C)







1. Cooling water pump shaft
2. V-pulley
3. Circlip
4. Collar
5. Ball bearing
6. Bearing cover
7. Water seal ring
8. Oil seal
9. Cam
10. Packing
11. Impeller

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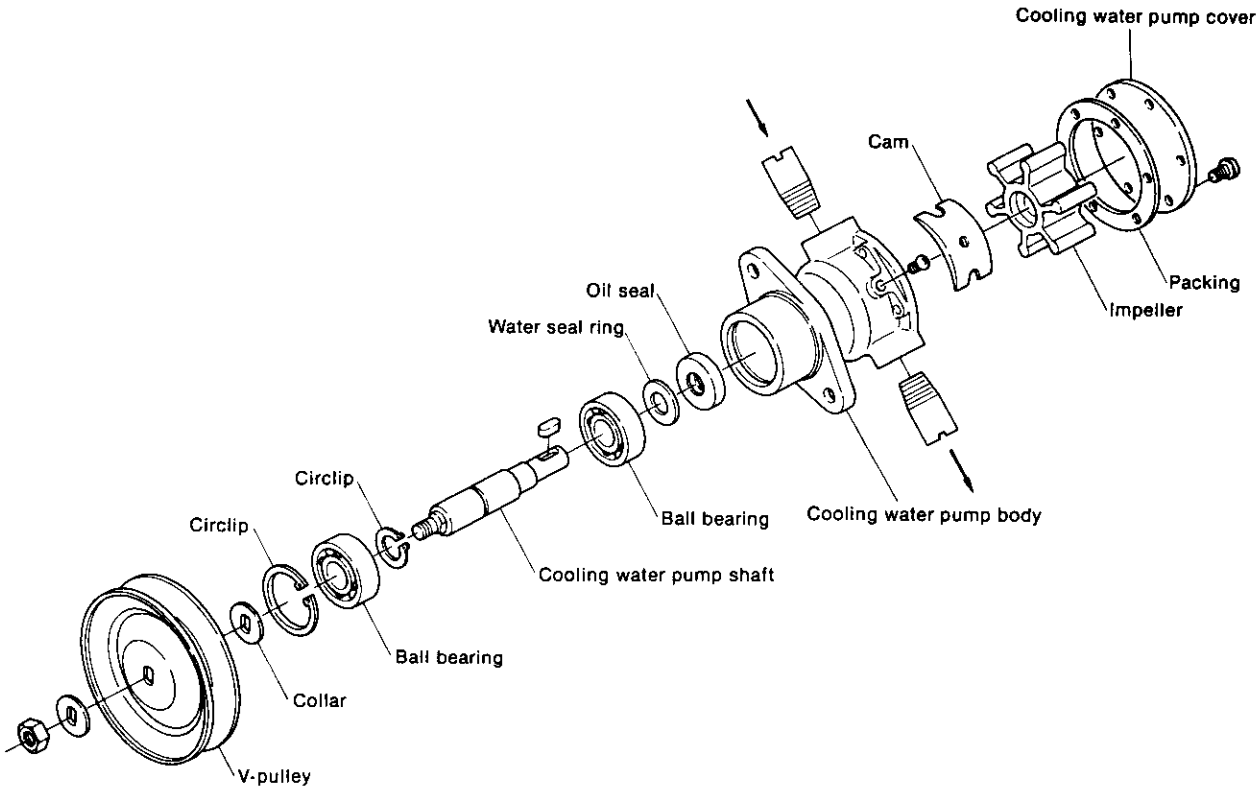
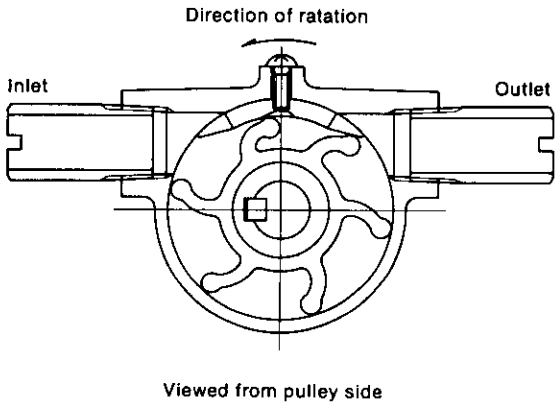
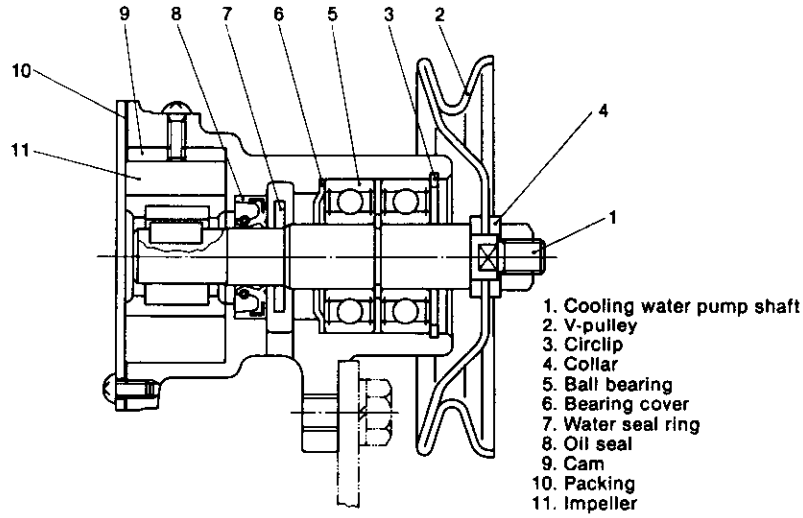
2-1.3 Cooling water pump of engine model 3HM35(C)







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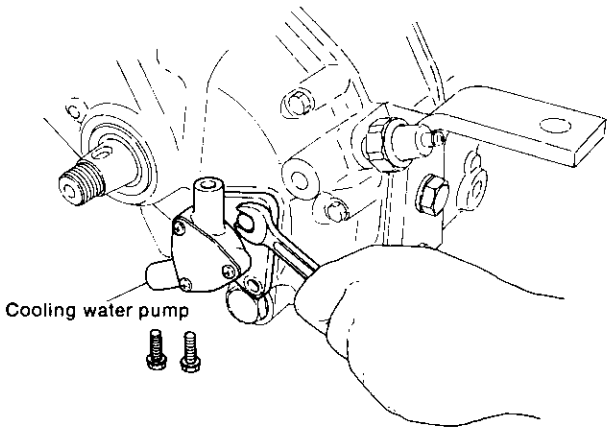
2-1.4 Specifications

	1GM10(C)	2GM20(C), 3GM30(C)	3HM35(C)
Rated speed	2600rpm	2720rpm	2660rpm
Suction head	0.5m (1.64 ft)	1.0m (3.28 ft)	1.0m (3.28 ft)
Total head	3.0m (9.84 ft)	3.0m (9.84 ft)	4.0m (13.12 ft)
Delivery capacity	300 ℓ/h	700 ℓ/h	1500 ℓ/h

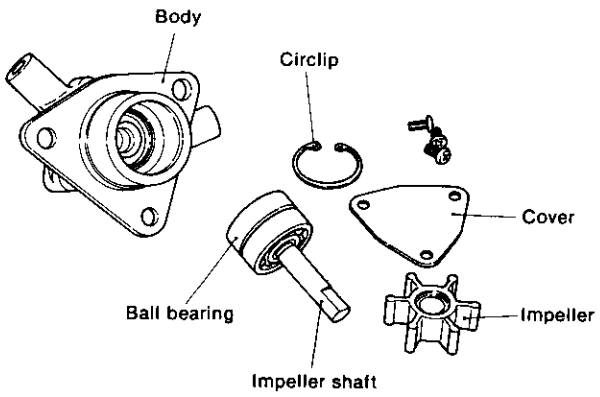
2-2 Disassembly

2-2.1 For model 1GM10(C)

(1) Loosen the water pump mounting bolts, remove the water pump ass'y from the timing gear case.

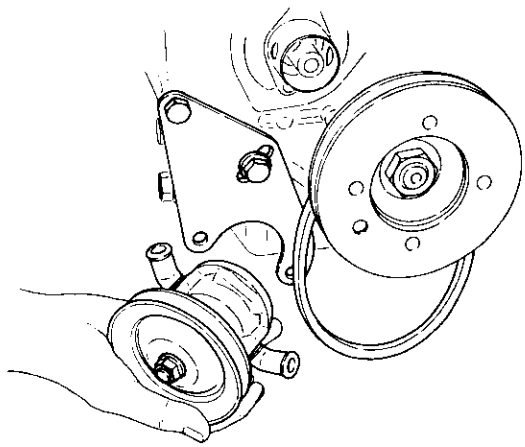


(2) Remove the cooling water pump cover and packing by removing the 3 screws which secure the cooling water pump cover.
(3) Pull the water pump impeller.
(4) Remove the set screw and remove the offset plate.
(5) Remove the bearing snap ring and remove the impeller shaft and bearing ass'y while tapping the impeller side of the impeller shaft lightly.
(6) Pull the oil seal from the pump body.
(7) Pull the ball bearing and spacer from the impeller shaft.

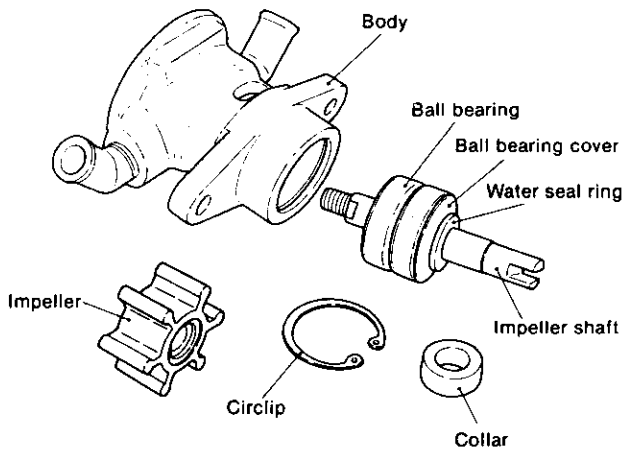


2-2.2 for models 2GM20(C), 3GM30(C) and 3HM35(C)

(1) After removing the V-belt by loosening the mounting bolts of the cooling water pump bracket, remove the cooling water pump assembly.



(2) Remove the cooling water pump bracket.
(3) Remove the V-pulley mounting bolt and V-pulley.
(4) Remove the cooling water pump cover fixing screws, and then remove the cooling water pump cover and packing.
(5) Pull the water pump impeller.
(6) Remove the set screw and remove the offset plate.
(7) In engine model 3HM35(C), remove the key from the impeller shaft.
(8) Remove the bearing snap ring and remove the impeller shaft and bearing ass'y while tapping the impeller side of the impeller shaft lightly.
At the same time, the bearing cover and seal ring can be removed together with the impeller shaft.
(9) Pull the oil seal from the pump body.
(10) Pull the ball bearing and spacer from the impeller shaft.



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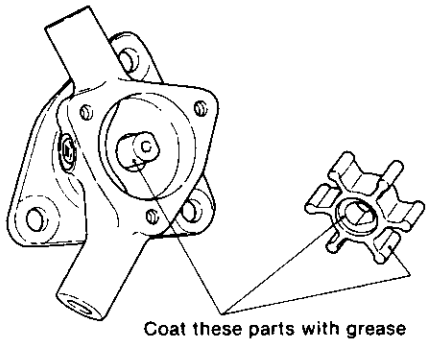
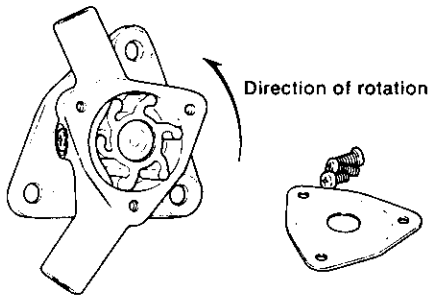
2-3 Reassembly precautions

(1) Before inserting the rubber impeller into the casing, coat the sliding face, pump shaft and impeller fitting section with grease or Monton X.

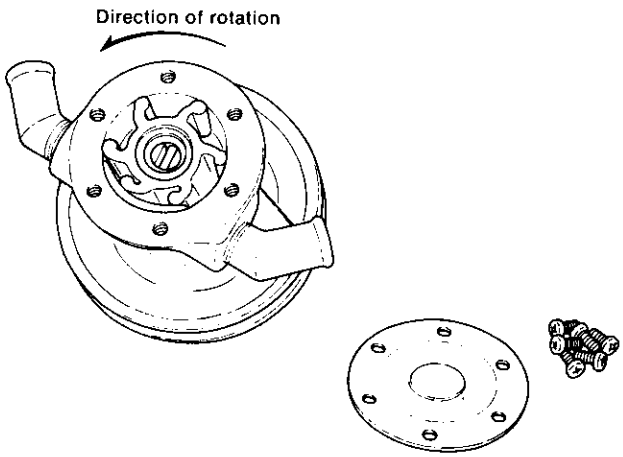


(2) Be sure that the direction of curving of the impeller is correct.
The impeller is curved in the direction opposite the direction of rotation.

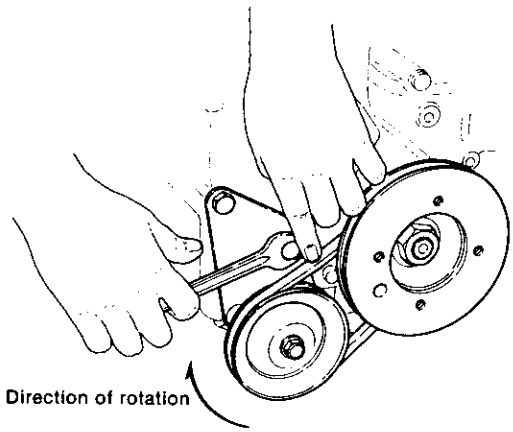
Model 1GM10(C)



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



(3) Adjust the V-belt tension. [for models 2GM20(C), 3GM30(C) and 3HM35(C)]
If the V-belt tension is slack, the discharge of the cooling water will diminish; if it is too tight, the play of the pump bearings and the wear of the wear plate will be accelerated. Adjust the tension to the specified value. Check the deflection of the V-belt by pressing it in the center with your fingers.



	2GM20(C)	3GM30(C)	3HM35(C)
V-belt tension	To be 5 ~ 7mm (0.1964 ~ 0.2756in.) deflection when pushed by the thumb with a force of 10kg (22.0 lb)		
Type of V-belt	M19in.		
V-belt part No.	104511-78780		

NOTE: Mount the belt in the direction of pump rotation.

(4) If the sliding surface of the V-belt is cracked, worn or is stained with oil, etc., replace it with a new one.

(5) Check after assembly
After assembly, attach the belt and run the engine to ascertain whether or not it provides the specified discharge.

2-4 Handling precautions

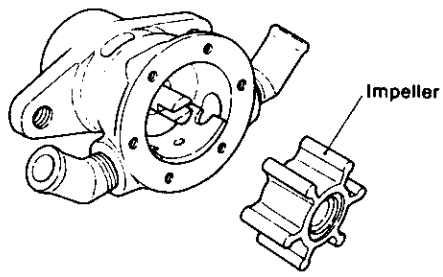
(1) Never operate the water pump dry as this will damage the rubber impeller.

(2) Always turn the engine in the correct direction of rotation. Turning the engine in the opposite direction will damage the rubber impeller.

(3) Inspect the pump after every 1,500 hours of operation and replace if faulty.

2-5 Inspection

(1) Inspect the rubber impeller for fractures, cracks and other damage, and replace if faulty.



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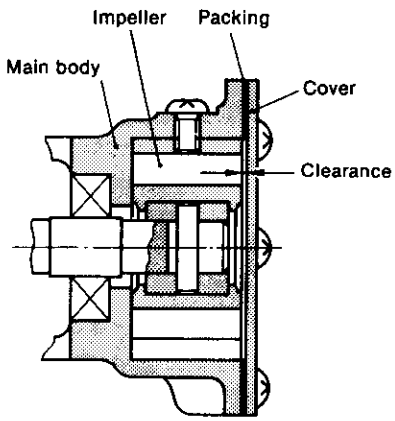
(2) Rubber impeller side wear



1) Model 1GM10(C)

mm (in.)

	Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	12 ±0.1 (0.4685 ~ 0.4764)	0.2 (0.0079)	0.4 (0.0157)	—
Housing width	(without packing) 11.9 (0.4685)			—
Wear plate wear	—			0.2 (0.0079)

2) Models 2GM20(C) and 3GM30(C)

mm (in.)

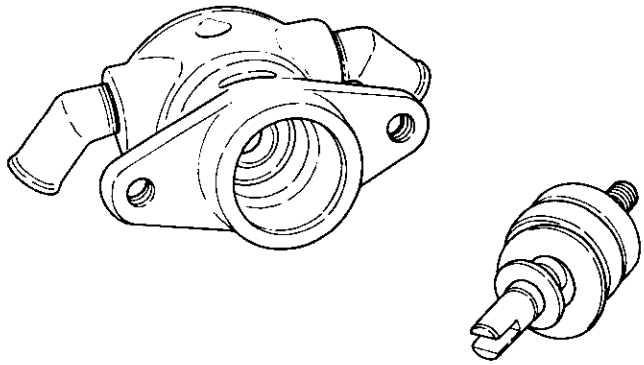
	Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	19 ±0.1 (0.744 ~ 0.752)	0.2 (0.0079)	0.4 (0.0157)	—
Housing width	18.9 (0.7441) (without packing) 19.2 (0.7559) (with packing)			—
Wear plate wear	—			0.2 (0.0079)

3) Model 3HM35(C)

mm (in.)

	Maintenance standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	22.1 ±0.1 (0.8661 ~ 0.8740)	0.2 (0.0079)	0.4 (0.0157)	—
Housing width	(without packing) 22 (0.8661)			—
Wear plate wear	—			0.2 (0.0079)

(3) Water pump impeller shaft oil seal section wear.



mm (in.)

	Maintenance standard	Wear limit
Oil seal section shaft diameter	10.0 (0.3937)	9.9 (0.3898)

If water leakage increases while the engine is running, or if the components are found to be defective when disassembled, replace them.

(4) Inspect the bearing for play and check for seizing at the impeller shaft fitting section. Replace the bearing if there is any play.

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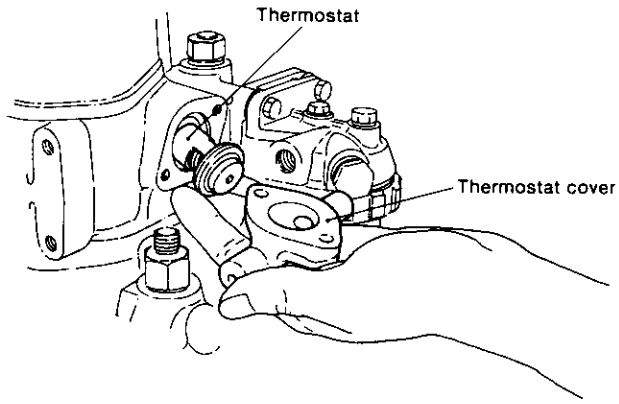
3. Thermostat

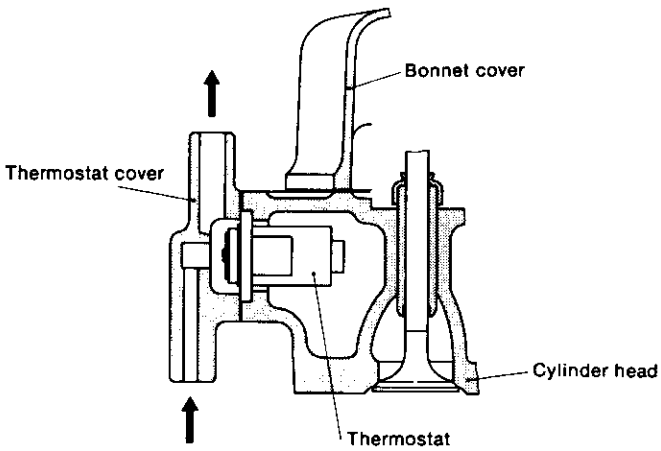
3-1 Construction and operation

The thermostat remains closed until the cooling water temperature reaches a fixed temperature. Until the cooling water reaches this fixed temperature, it collects at the cylinder head and the water flowing from the water pump is discharged through the bypass circuit. When the cooling water temperature exceeds the fixed temperature, the thermostat opens and the cooling water flows through the main circuit of the cylinder and cylinder head. The thermostat serves to prevent overcooling and improve combustion performance by maintaining the cooling water temperature at the specified level.

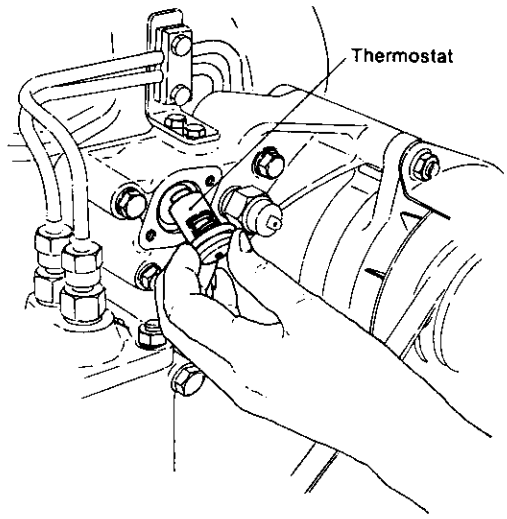
In engine model 1GM10(C), the thermostat is mounted on the cylinder head at the gear case end. In engine models 2GM20(C) 3GM30(C) and 3HM35(C), it is mounted on the thermostat housing which is combined with the generator mounting base on the cylinder head at the gear case end.

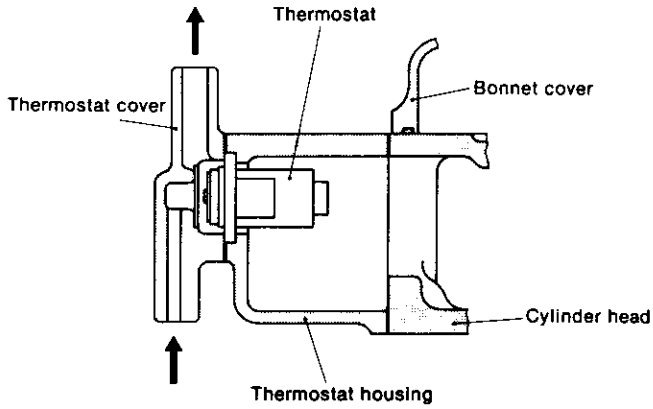
Model 1GM10(C)



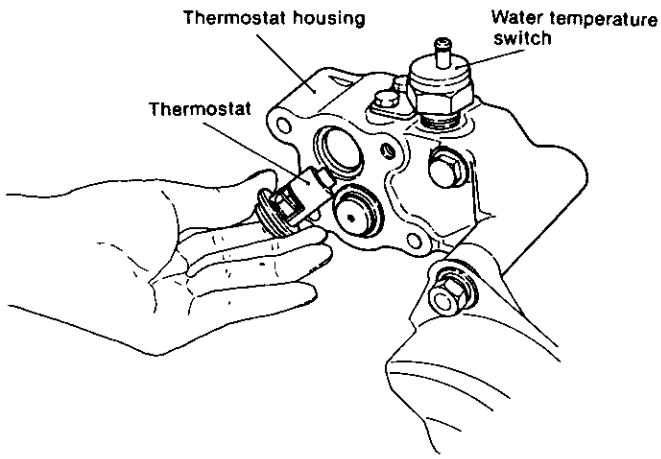


Models 2GM20(C) and 3GM30(C)





Model 3HM35(C)



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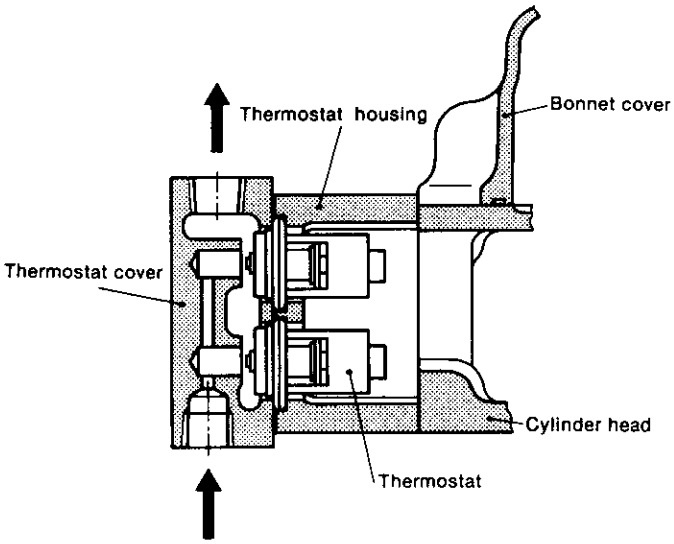
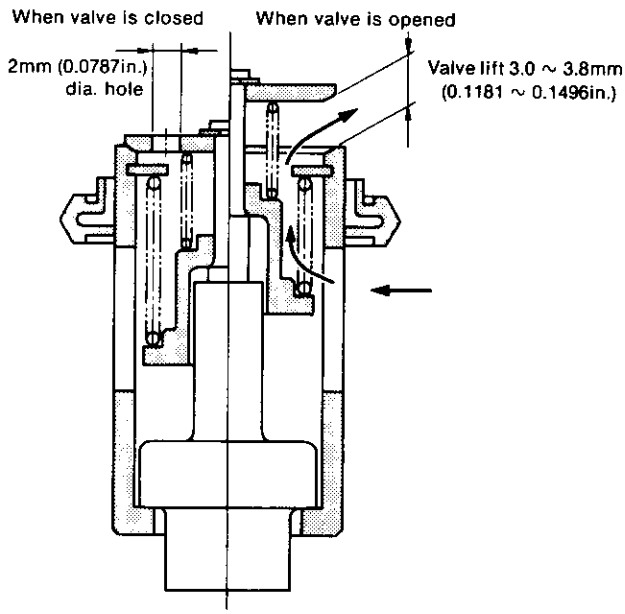
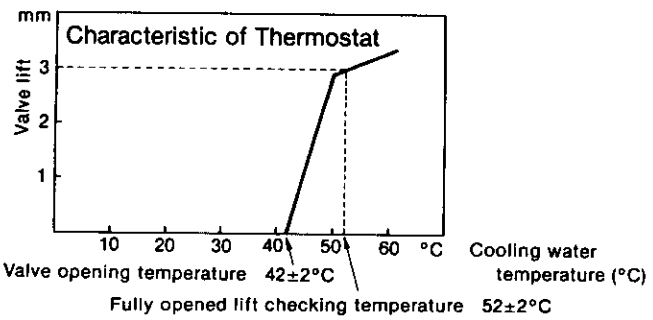




A wax-pellet type thermostat is used for this engine. The "wax-pellet" type is the description given to a quantity of wax in the shape of a small pellet. When the temperature of the cooling water rises, the wax melts and its volume expands. The valve is opened or closed by this variation of volume.

Thermostat operating temperature

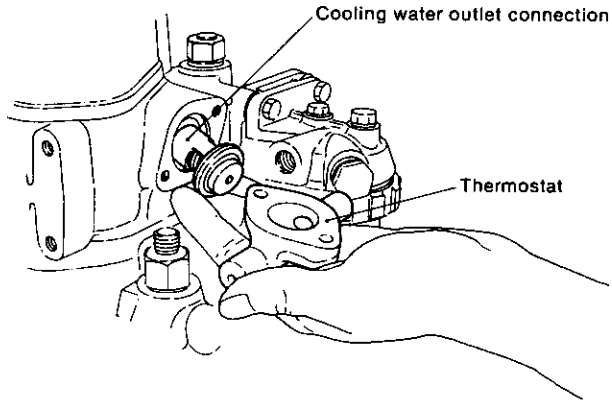
Opening temperature	42 ±2°C
Full open temperature	52 ±2°C



When the seawater temperature is below 42°C, the pumped-up seawater is discharged outside directly from the thermostat section, and circulation of the cooling water into the cylinder is stopped until the water temperature rises. When the water temperature reaches 52°C, the thermostat valve is fully opened.

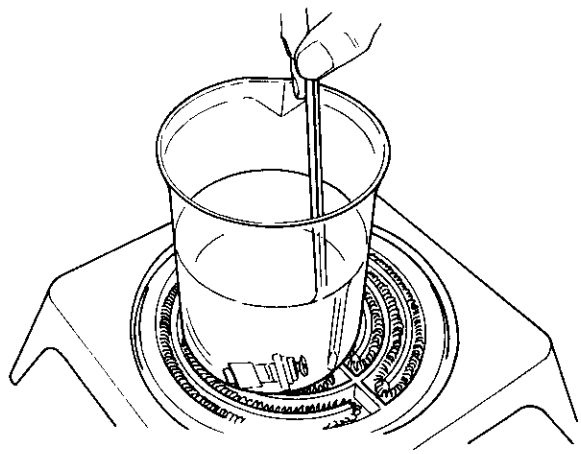
3-2 Inspection

(1) Remove the water outlet coupling at the top of cylinder body to remove and inspect the thermostat. Remove any dirt or foreign matter that has built up in the thermostat, and check the spring, etc. for damage and corrosion.



(2) Testing the thermostat

Place the thermostat in a container filled with water. Heat the container with an electric heater. If the thermostat valve begins to open when the water temperature reaches about 42°C and becomes fully open at 52° C, the thermostat may be considered operational. If its behaviour differs much from the above, or if it is found to be broken, replace it.



(3) In general, inspect the thermostat after every 300 hours of operation. However, always inspect it when the cooling water temperature rises abnormally and when white smoke is emitted over a long period of time after the engine starting.

(4) Replace the thermostat when it has been in use for a year, or after every 2000 hours of operation.

Part No. code of thermostat	105582—49200

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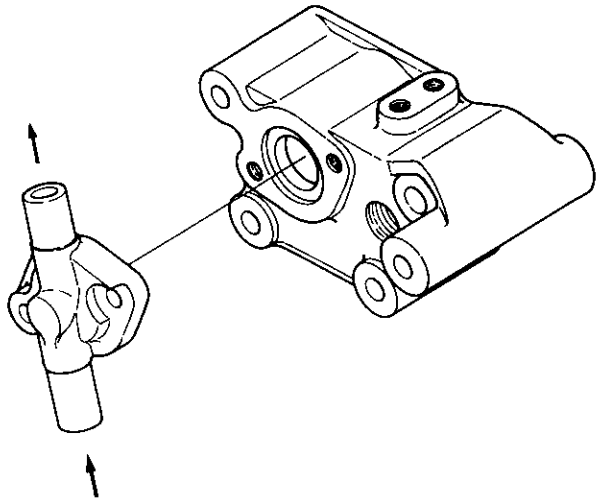
(5) Attaching the thermostat to the cooling water system. Before attaching the thermostat to the system, be sure to check its packing and make sure there are no leaks.

3-3 Care must be taken when assembling the thermostat

The thermostat cover must be assembled with the arrow mark kept upward.



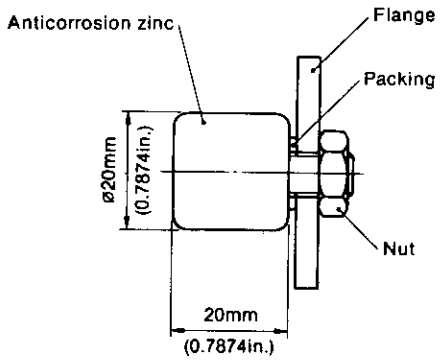
4. Anticorrosion Zinc

4-1 Principles

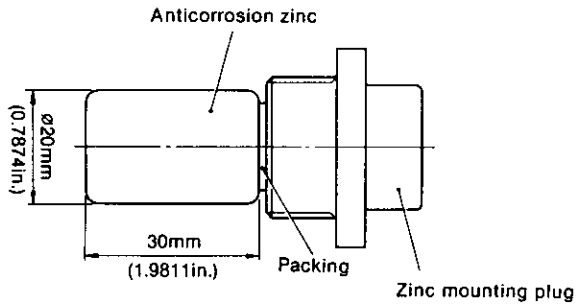
Anticorrosion zinc is installed to prevent electrolytic corrosion by sea water.
When different metals, i.e., iron and copper, are placed in a highly conductive liquid, such as sea water, the iron gradually rusts. The anticorrosion zinc provides protection against corrosion by being itself corroded in place of the cylinder, cylinder liners and other iron parts.
The anticorrosion zinc is to be put in the following positions.

		1GM10(C)	2GM20(C)	3GM30(C), 3HM35(C)
Cylinder block	Set position	At the side of the fuel valve	At exhaust side	At exhaust side
	Number	1	1	2
Cylinder head	Set position	—	At side cover of cylinder head (rear)	At side cover of cylinder head (rear)
	Number	—	1	1
Type•Size		Flange type 20mm dia × 20mm (0.7874 × 0.7874in.)	Plug type 20mm dia × 30mm (0.7874 × 1.9811in.)	
Part No. of anticorrosion zinc		27210—200200	27210—200300	

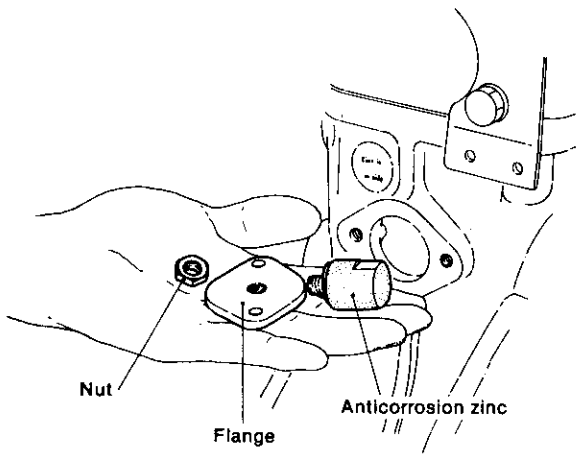
Model 1GM10(C)



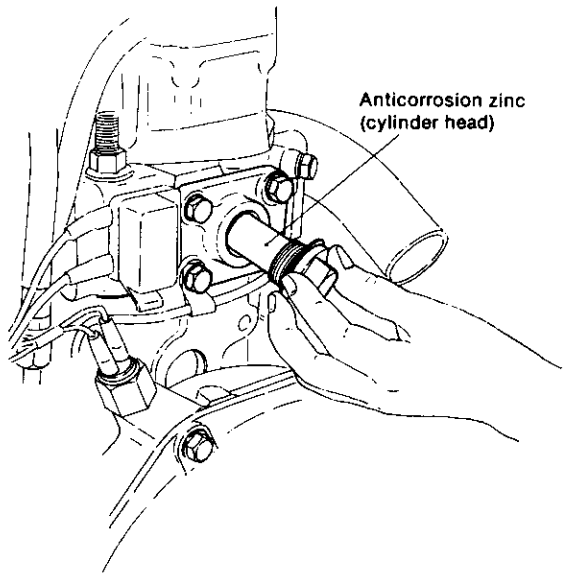
Models 2GM20(C), 3GM30(C) and 3HM35(C)



Mounting positon for model 1GM10(C)



Mounting position for model 2GM20(C)



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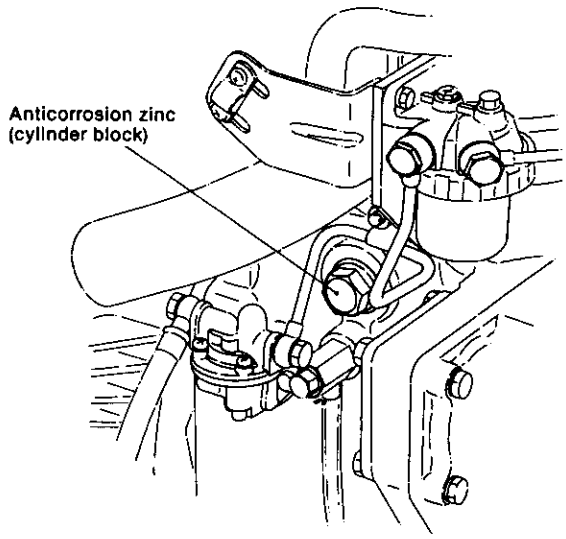
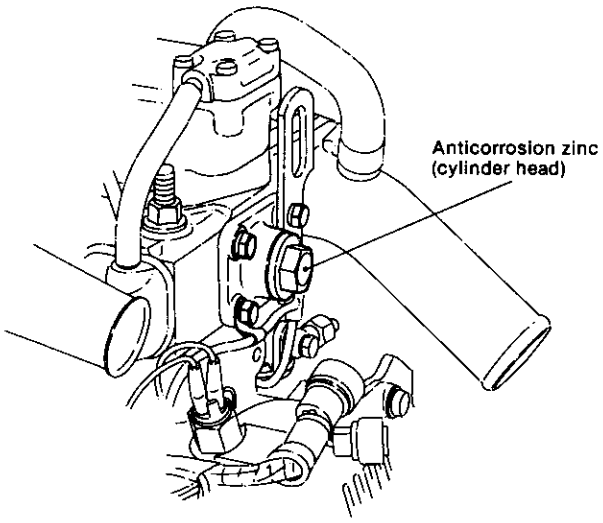
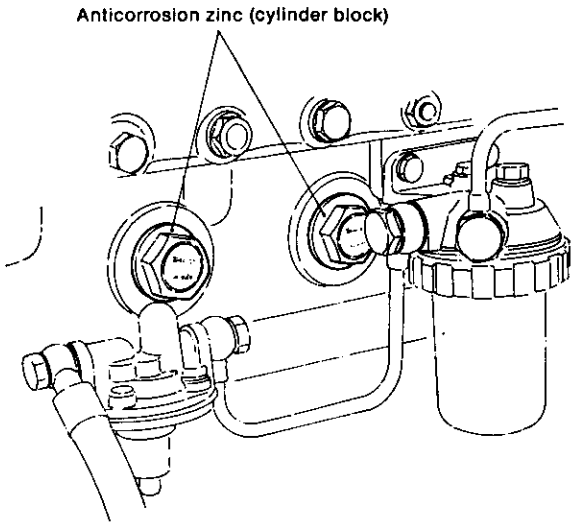


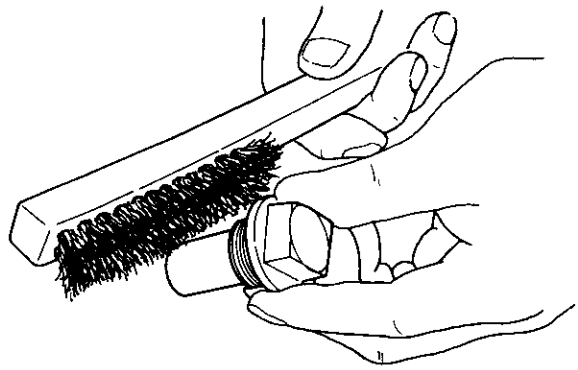
Mounting position for models 3GM30(C) and 3HM35(C)





4-2 Inspection

Generally, replace the anticorrosion zinc after every 500 hours of operation. However, since this period depends on the properties of the sea water and operating conditions, periodically inspect the anticorrosion zinc and remove the oxidized film on its surface.
Replace the anticorrosion zinc after 50% corrosion.
Replace the anticorrosion zinc by pulling the old zinc from the zinc mounting plug and screwing in the new zinc.



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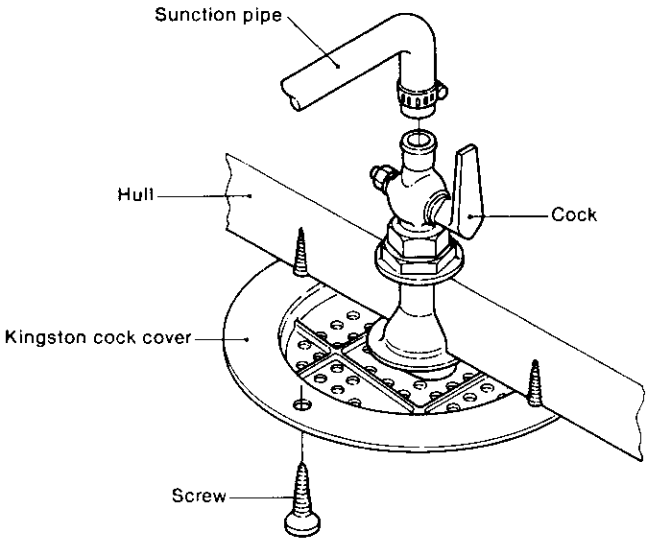
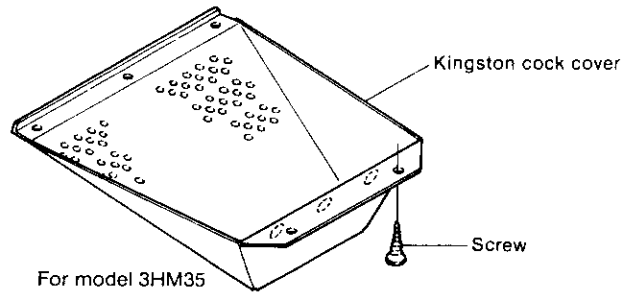
5. Kingston Cock (Optional)

5-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock also serves to filter the water so that mud, sand, and other foreign matter in the water does not enter the water pump. Numerous holes are drilled in the water side of the Kingston cock, and a scoop strainer is installed to prevent the sucking in of vinyl, etc.





5-2 Handling precautions

Caution the user always to close the Kingston cock after each day of use and to confirm that it is open before beginning operation.

If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.

On the other hand, if the engine is operated with the Kingston cock closed, cooling water will not be able to get in, resulting in engine and pump trouble.

5-3 Inspection

When the cooling water volume has dropped and the pump is normal, remove the vessel from the water and check for clogging of the Kingston cock.

Moreover, when water leaks from the cock, disassemble the cock and inspect it for wear, and repair or replace it.

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