

YANMAR

SERVICE MANUAL

MARINE DIESEL ENGINE

MODELS

1GM (10L)

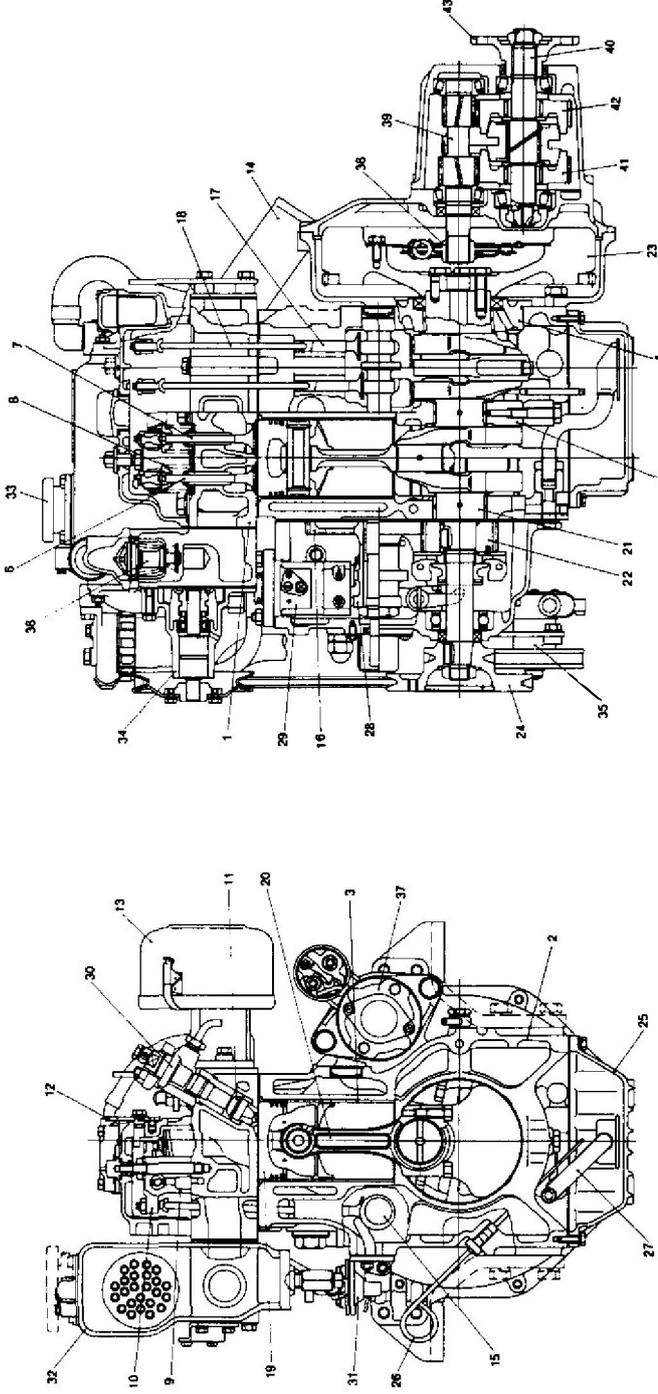
2GM (F)(L)

3GM (D)(F)(L)

3HM (F)(L)

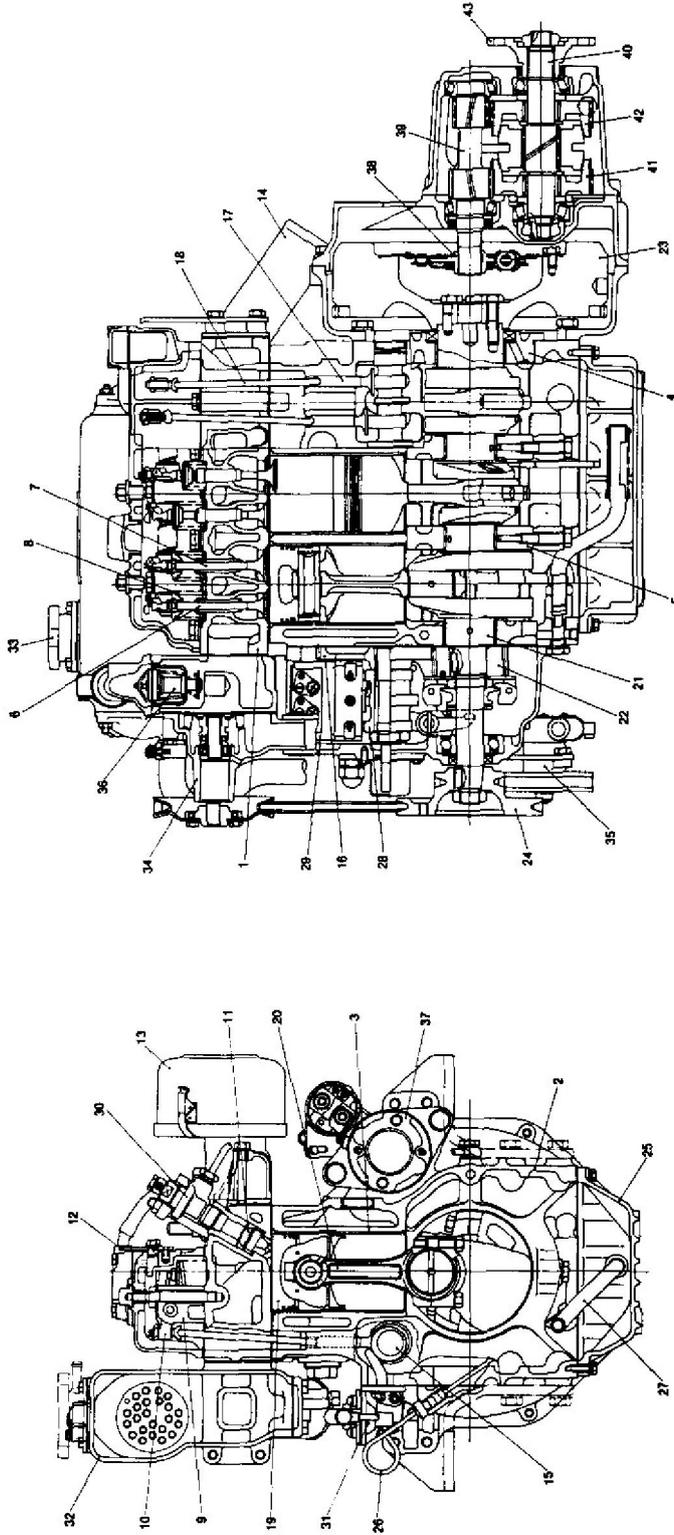
4. Engine Cross-Sections

4-1. 2GMF



- | | | | |
|-----------------------------|--------------------------------|---------------------------------------|---------------------------|
| 1. Cylinder head | 21. Crankshaft | 31. Fuelled pump | 41. Forward large gear |
| 2. Cylinder body | 22. Crankshaft gear | 32. Heat exchanger & exhaust manifold | 42. Reverse large gear |
| 3. Cylinder liner | 23. Flywheel | 33. Pressure control valve | 43. Output shaft coupling |
| 4. Main bearing housing | 24. Crankshaft V-pulley | 34. Cooling fresh water pump | |
| 5. Main bearing housing | 25. Crankshaft | 35. Cooling seawater pump | |
| 6. Exhaust valve | 26. Obstacle | 36. Thermostat | |
| 7. Intake valve | 27. Lubricating oil inlet pipe | 37. Starter motor | |
| 8. Valve spring | 28. Fuel injection pump cam | 38. Damper disc | |
| 9. Valve rocker arm support | 29. Fuel injection pump | 39. Input shaft | |
| 10. Valve rocker arm | 30. Fuel injection nozzle | 40. Output shaft | |

4.2. 3GMF



- 1. Cylinder head
- 2. Cylinder body
- 3. Cylinder liner
- 4. Main bearing housing
- 5. Intermediate main bearing housing
- 6. Exhaust valve
- 7. Valve spring
- 8. Valve rocker
- 9. Valve rocker arm support
- 10. Valve rocker arm

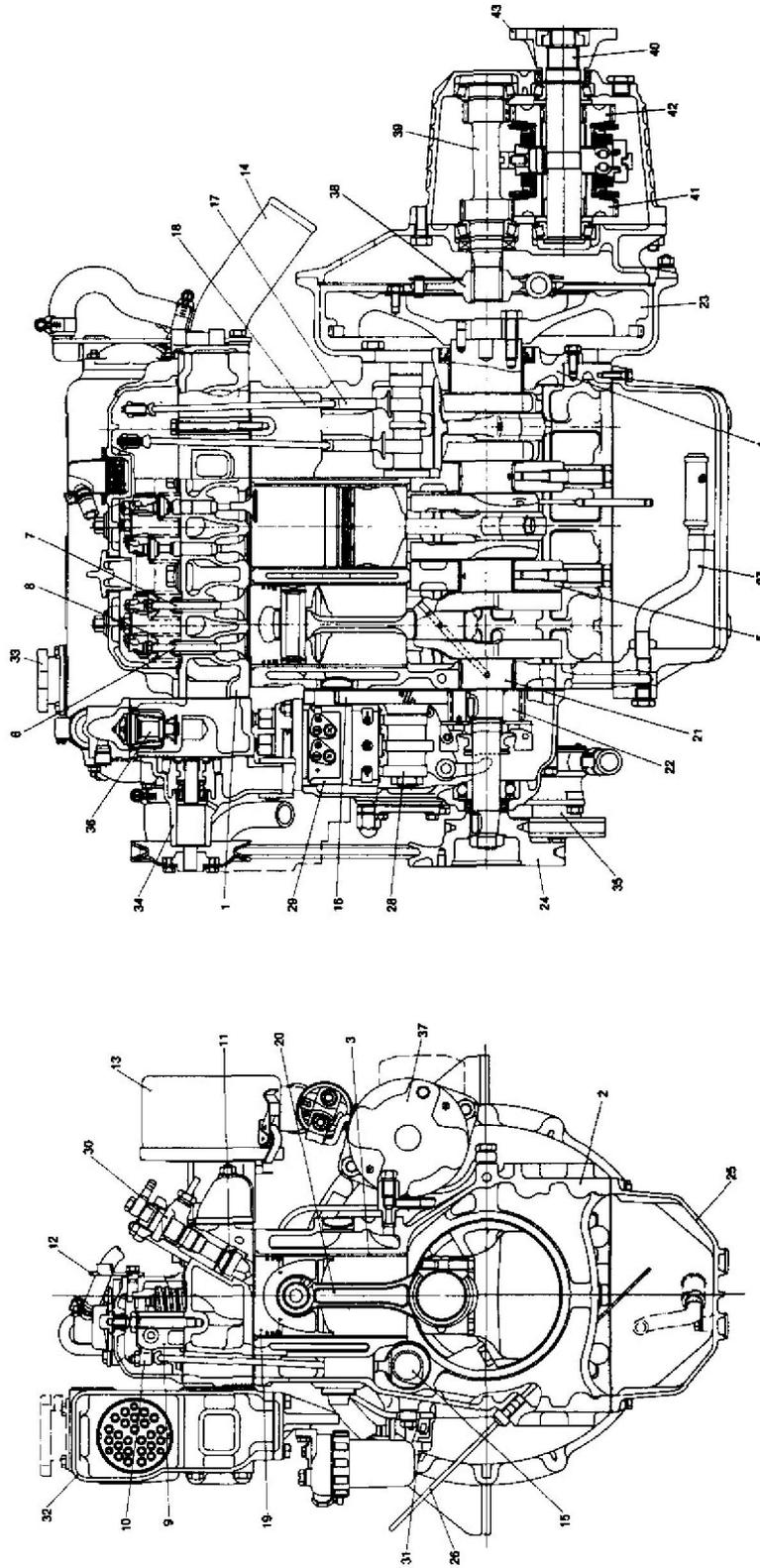
- 11. Precompression chamber
- 12. Decompression lever
- 13. Intake silencer
- 14. Mixing elbow
- 15. Camshaft
- 16. Camshaft gear
- 17. Push rod
- 18. Platen
- 19. Platen
- 20. Connecting rod

- 21. Crankshaft
- 22. Crankshaft gear
- 23. Flywheel
- 24. Crankshaft V-pulley
- 25. Oil pan
- 26. Lubricating oil inlet pipe
- 27. Lubricator
- 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. Thermistor
- 37. Dampener
- 38. Dampener disc
- 39. Input shaft
- 40. Output shaft

- 41. Forward large gear
- 42. Reverse large gear
- 43. Output shaft coupling

4.3. 3HMF

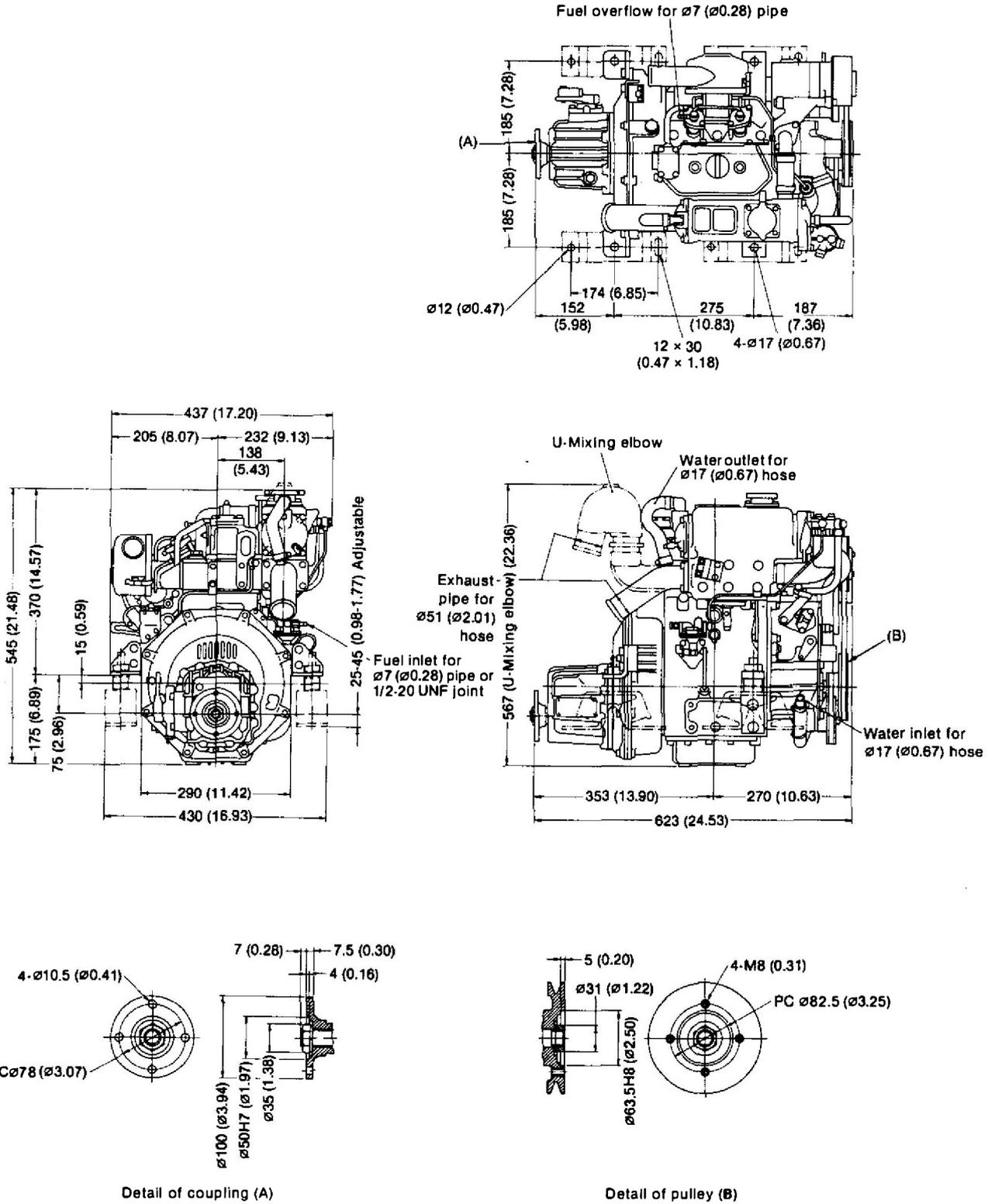


- 1. Cylinder head
- 2. Cylinder body
- 3. Crankshaft
- 4. Main bearing housing
- 5. Intermediate main bearing housing
- 6. Exhaust valve
- 7. Intake valve
- 8. Valve spring
- 9. Valve rocker arm support
- 10. Valve rocker arm
- 11. Re-combustion chamber
- 12. Compression lever
- 13. Intake air passage
- 14. Mixing elbow
- 15. Crankshaft
- 16. Crankshaft gear
- 17. Tappet
- 18. Push rod
- 19. Connecting rod
- 21. Crankshaft gear
- 22. Crankshaft
- 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 lead pump & exhaust manifold
- 32. Pressure control valve
- 33. Cooling fresh water pump
- 34. Cooling sea water pump
- 35. Thermostat
- 36. Starter motor
- 37. Starter disc
- 38. Output shaft
- 39. Forward large gear
- 40. Output shaft coupling
- 41. Forward large gear
- 42. Output shaft coupling
- 43. Output shaft coupling

5. Dimensions

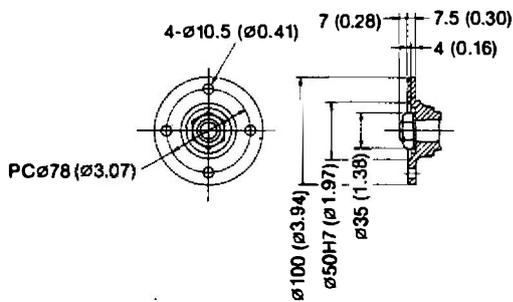
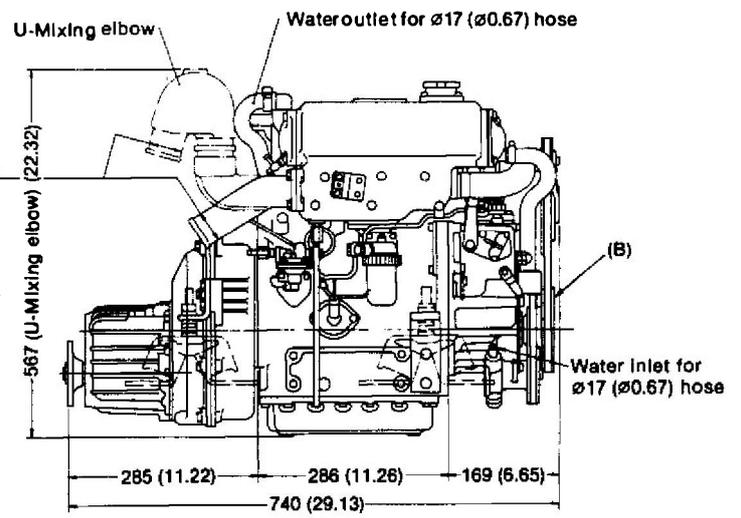
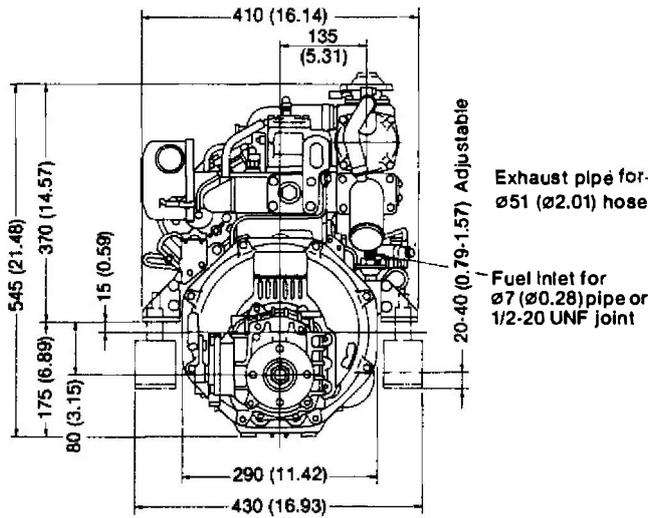
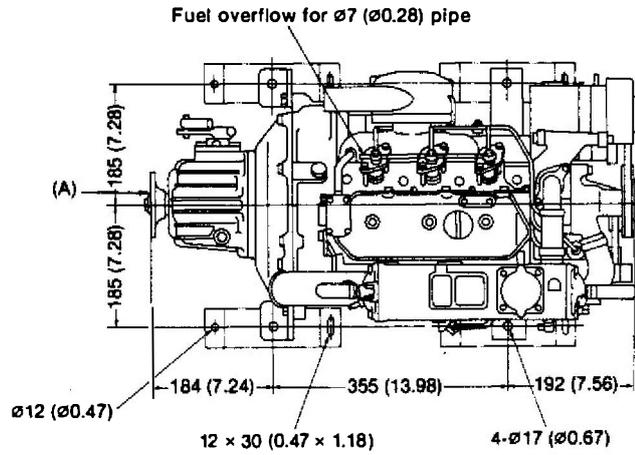
mm (in.)

5-1. 2GMF

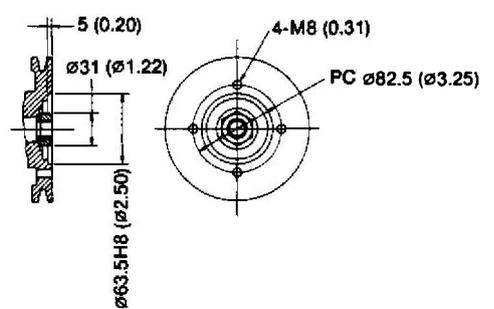


5-2. 3GMF

mm (In.)



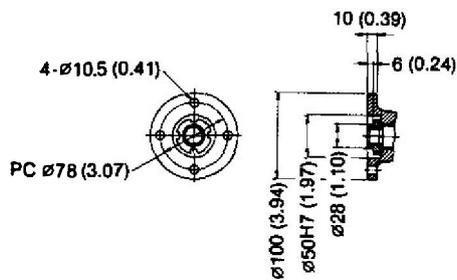
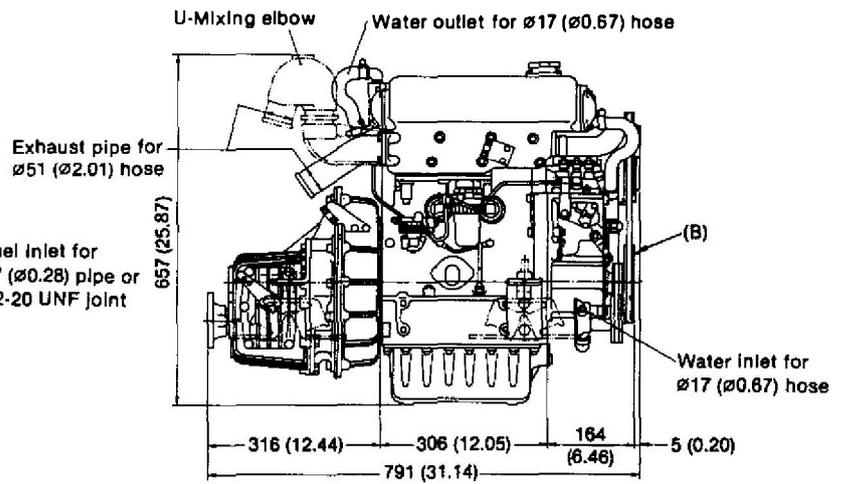
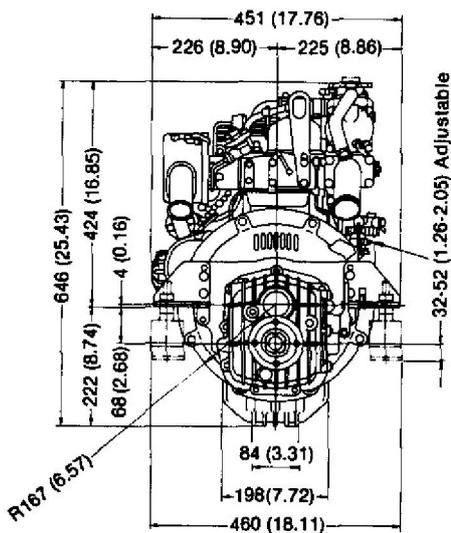
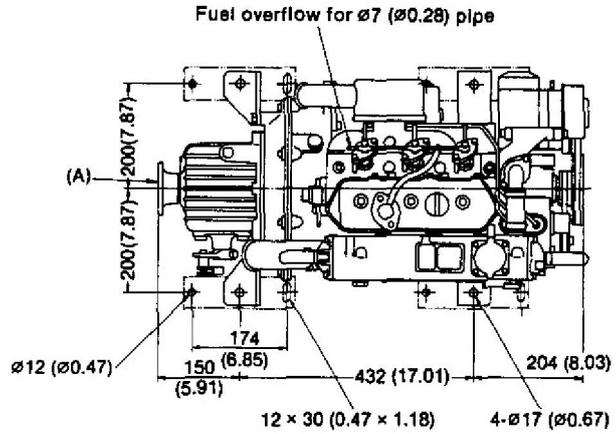
Detail of coupling (A)



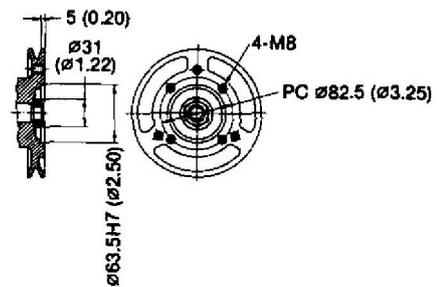
Detail of pulley (B)

5-3. 3HMF

mm (in.)



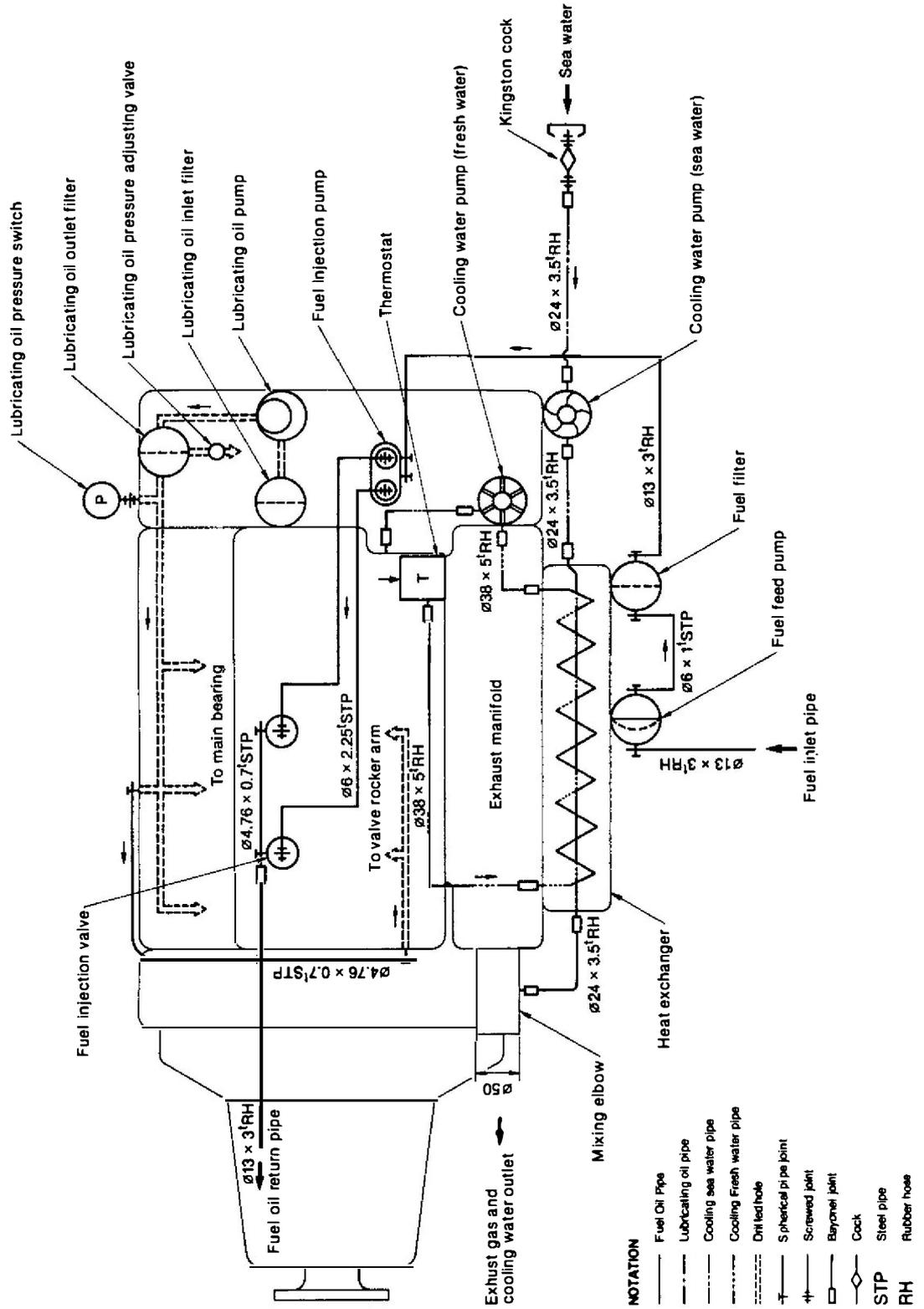
Detail of coupling (A)



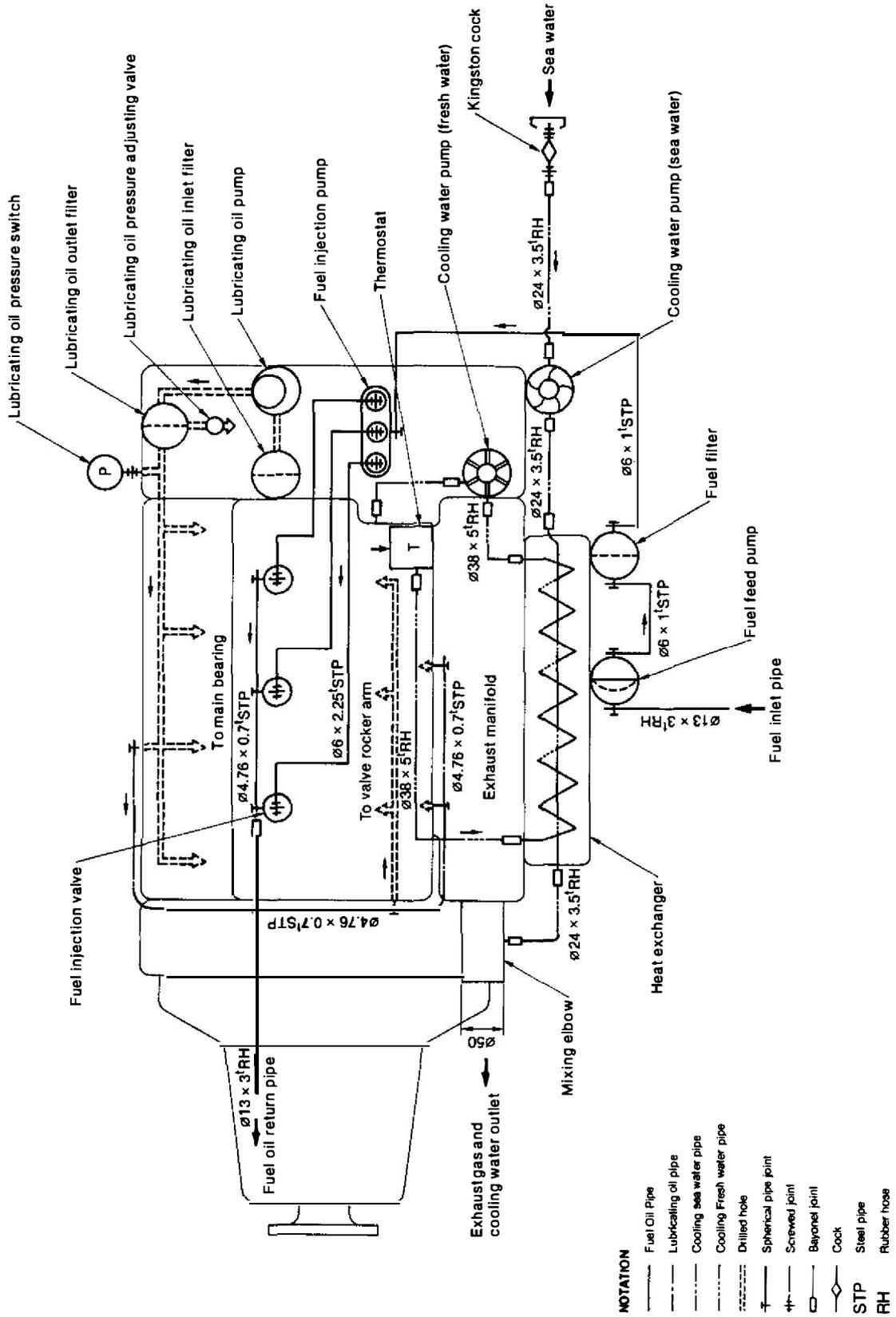
Detail of pulley (B)

6. Piping Diagrams

6-1. 2GMF



6-2. 3GMF and 3HMF



7. Standard Accessories

7-1. Parts packed with engine

The parts packed with the engine are listed below.

Part name	Remarks
Instrument panel with wiring harness, 3m	
Subtank and overflow pipe	pipe length: 1,000mm
Tool box	
Operating manual	
Flexible mount	4

7-2. Parts mounted on engine

The parts mounted on the engine are listed below.

Part name	Remarks
Intake silencer	
Mixing elbow	
Cooling water pump	Sea water pump and fresh water pump
Fuel feed pump	
Fuel oil filter	
Lubricating oil filter	
Oil pressure switch	
Cooling water temperature switch	
Thermostat	
Starter motor	
Alternator (with ICR)	
Electric wiring harness	
Speed remote control bracket	with cable clamp
Engine stop remote control bracket	
Engine stop device	
Clutch remote control bracket	with cable clamp
Clevis or spring joint	Fitted to clutch lever

8. Optional Accessories

8-1. Parts mounted on engine

The parts mounted on the engine are listed below.

Part name	Remarks
Tachometer sender	Hex plug M18 unnecessary

8-2. Parts packed with engine

The parts packed with the engine are listed below.

Part name	Remarks
Stop remote control cable ass'y	3m × 1
Morse one handle control	Model MT2 top mounted type
Morse one handle control	Model MV side mounted type
Push-pull cable	33-C, 4m × 2
Battery switch	
Oil evacuation pump ass'y	
Kingston cock and cooling water pipe	Cooling water pipe: 1m × 1
Propeller shaft coupling	Taper type
Propeller shaft coupling	Slit type
Fuel oil tank and fuel oil pipe	Fuel oil tank: 30ℓ, pipe: 2m
Spare parts kit	
Packing kit	
Special disassembly tools	
Instrument panel (large, with tachometer)	
Instrument panel (small)	
Extension wiring harness, 3m	To be selected according to order specifications. One harness is fitted as a standard accessory. However, longer parts are optionally available should the standard accessory prove too short.
U-type mixing elbow	

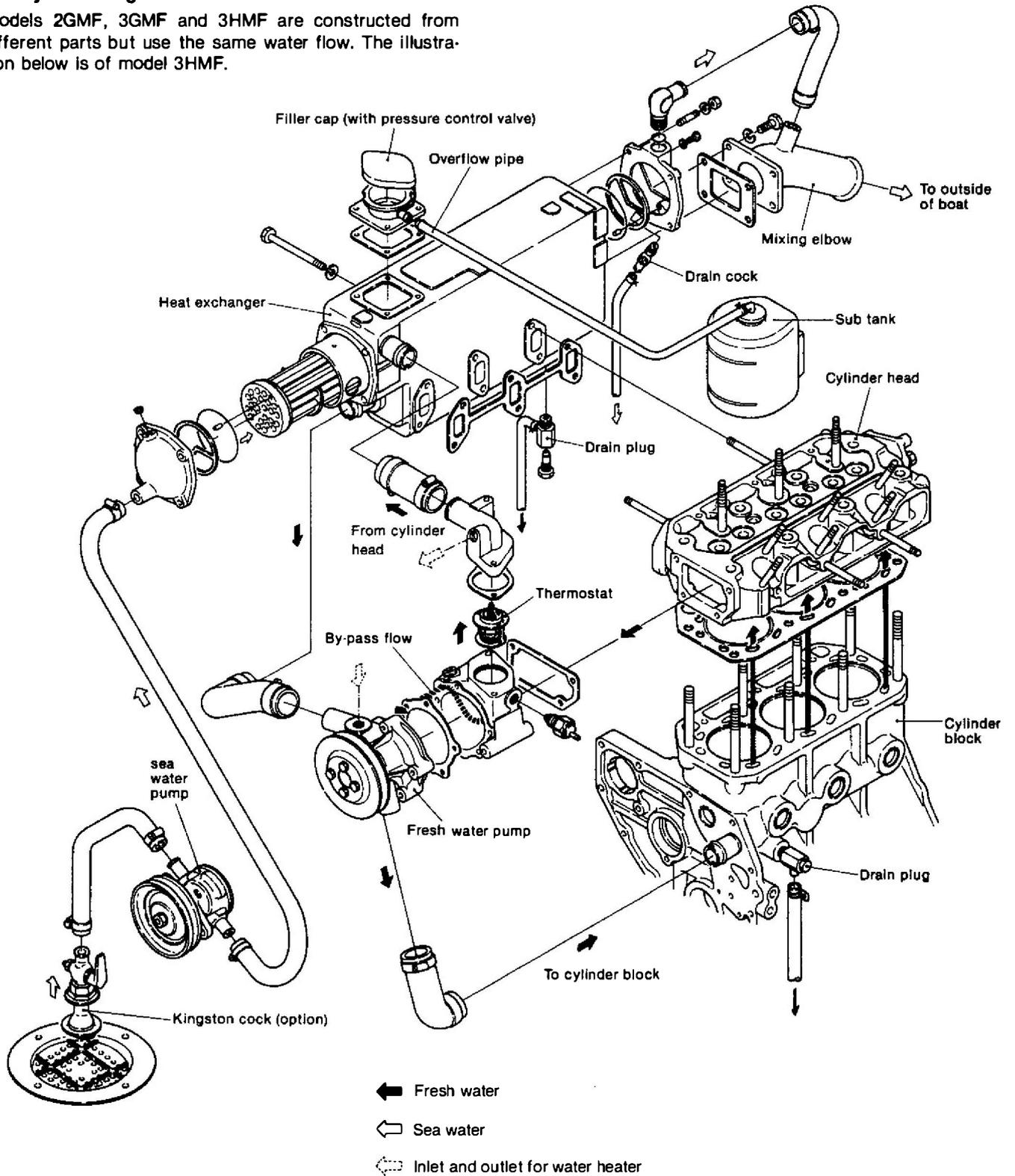
COOLING SYSTEM

1. Cooling System	15-1
2. Sea Water Pump	15-3
3. Fresh Water Pump	15-4
4. Heat Exchanger	15-7
5. Filler Cap and Subtank	15-11
6. Thermostat	15-13
7. Cooling Water Temperature Switch	15-16
8. Precautions	15-17

1. Cooling System [Old Type]

1-1. System Diagrams

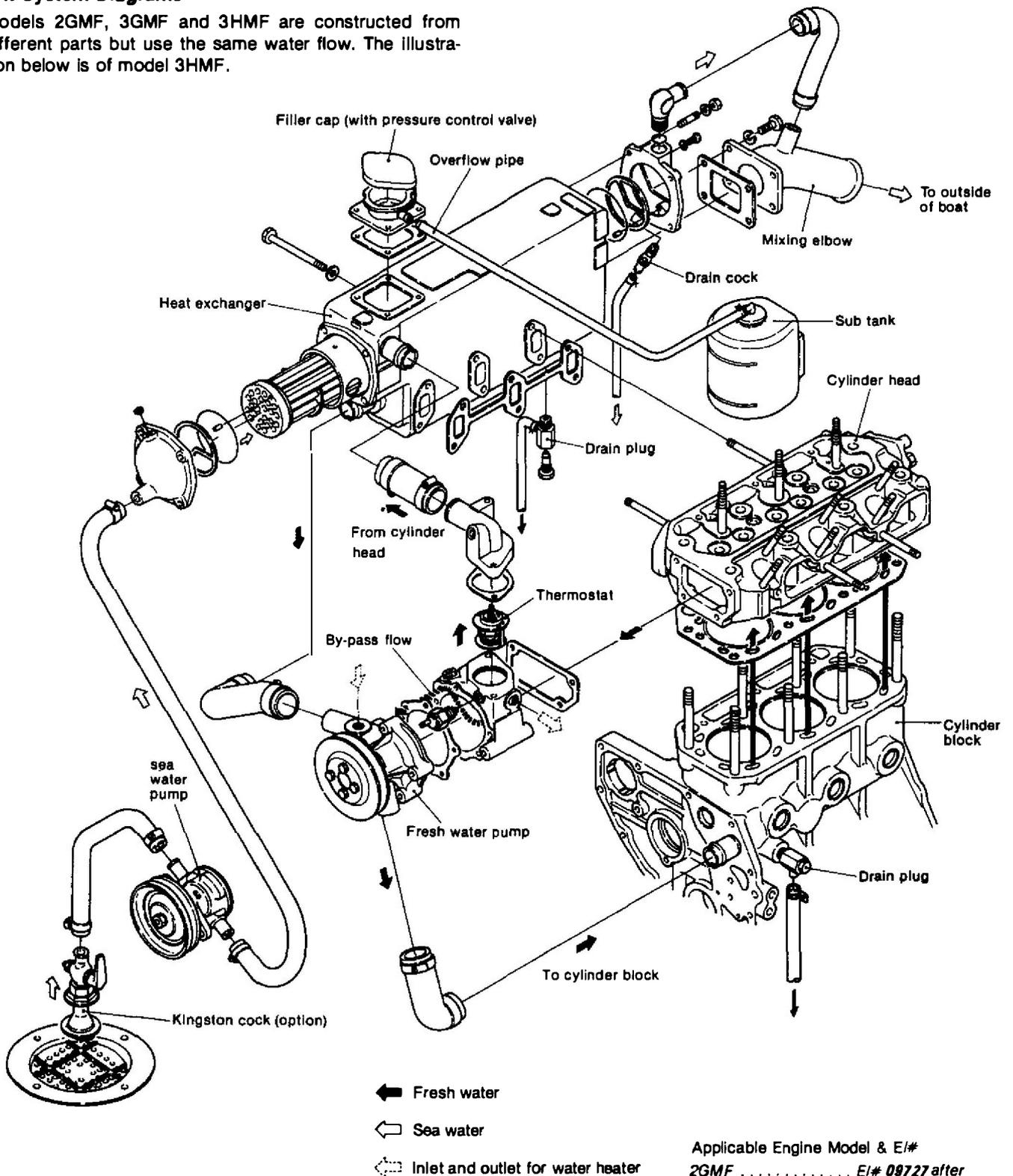
Models 2GMF, 3GMF and 3HMF are constructed from different parts but use the same water flow. The illustration below is of model 3HMF.



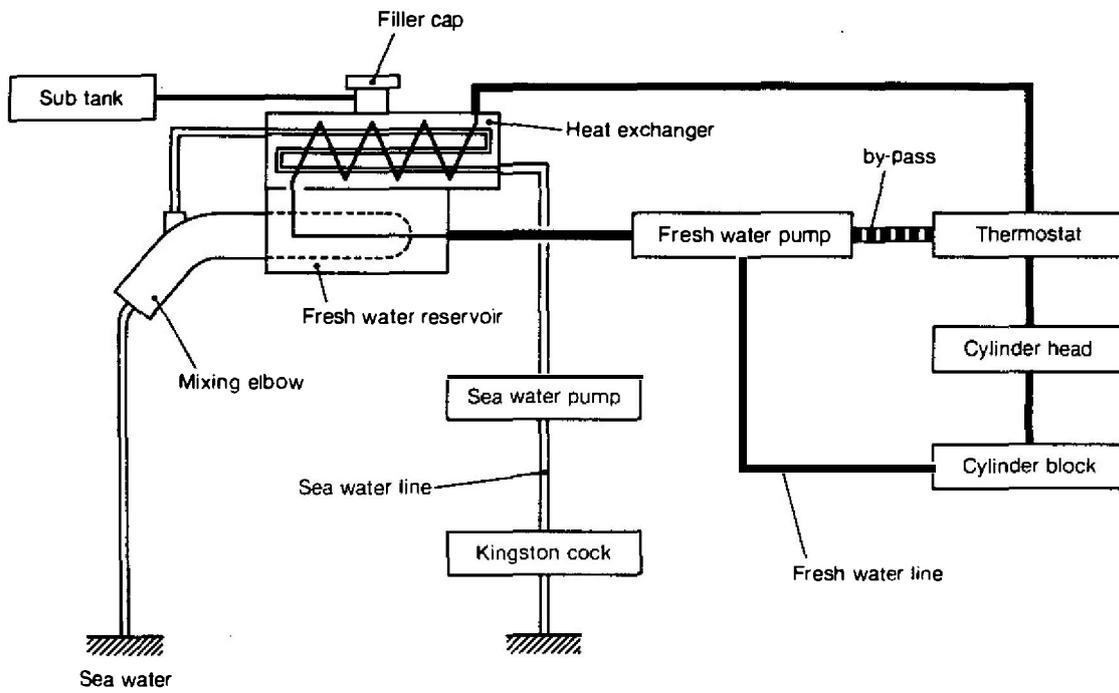
1. Cooling System [New Type]

1-1. System Diagrams

Models 2GMF, 3GMF and 3HMF are constructed from different parts but use the same water flow. The illustration below is of model 3HMF.



1-2. Cooling system diagram



1-3. Cooling system configuration

With fresh water cooled engines, fresh water from the heat exchanger is circulated around the cylinder block and cylinder head. The fresh water itself is cooled by sea water. The fresh water pump forces the fresh water through the cylinder block and cylinder head cooling passages and back to the heat exchanger. The fresh water is kept in constant circulation.

The thermostat is installed at the cylinder head cooling water outlet (fresh water pump mounting bracket). As the thermostat is closed while the fresh water temperature is low—directly after starting engine or when engine load is light—fresh water flows through the by-pass passage to the suction side of the fresh water pump, and circulates

inside the engine without passing through the heat exchanger.

As the fresh water temperature rises the thermostat is opened and fresh water flows into the heat exchanger. The fresh water is cooled in the heat exchanger by sea water in the tube. So that the fresh water temperature is always kept at the proper degree by the thermostat.

Sea water is delivered by the sea water pump and fed through tubes located inside the cooling pipe to cool the fresh water.

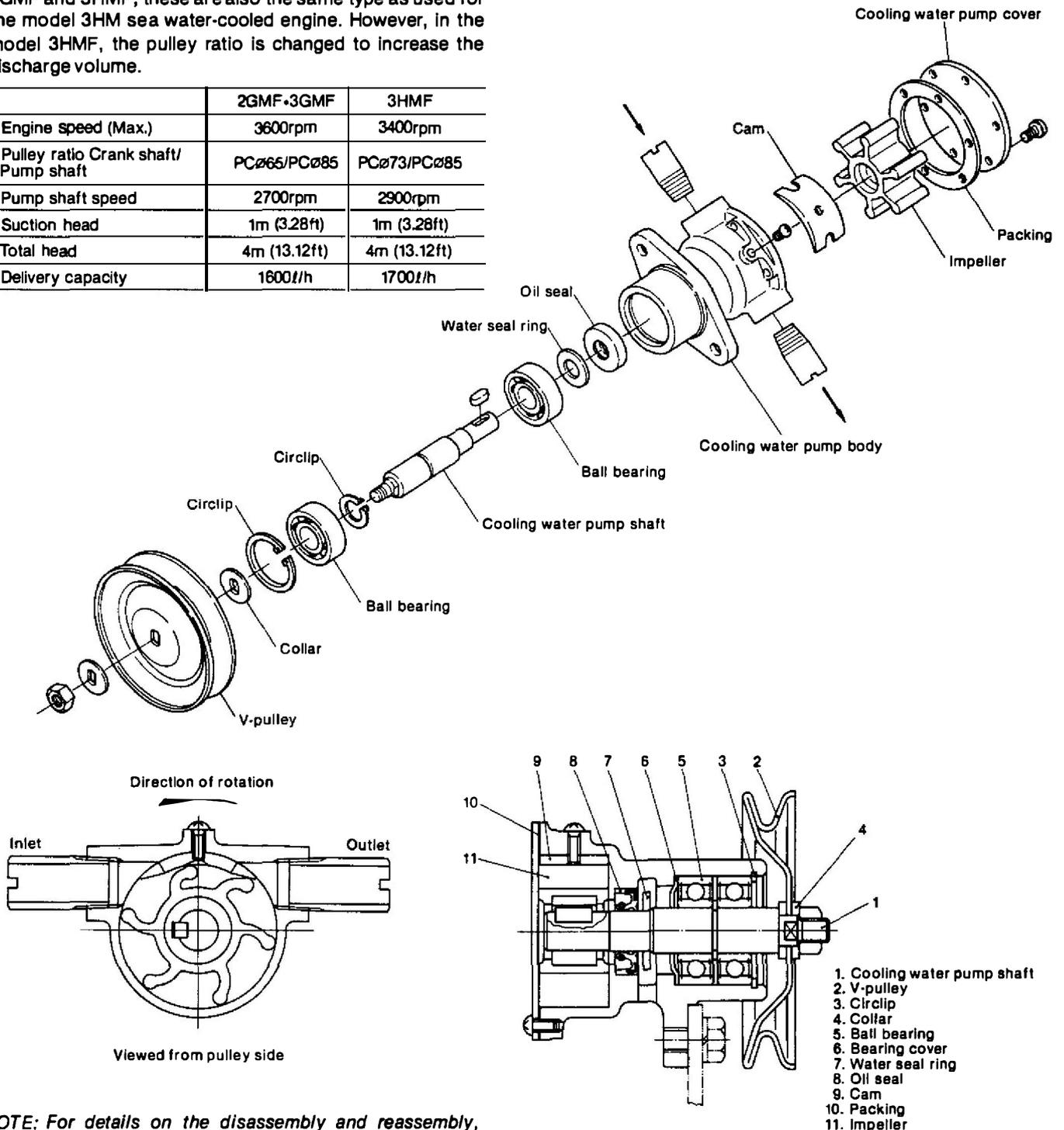
Sea water flows into the mixing elbow from the heat exchanger, and is discharged with the exhaust gas.

2. Sea Water Pump

The sea water pump used for the fresh water-cooled engine is the rubber impeller pump; it is the same type as used for the sea water-cooled engine.

The same sea water pumps are used for models 2GMF, 3GMF and 3HMF; these are also the same type as used for the model 3HM sea water-cooled engine. However, in the model 3HMF, the pulley ratio is changed to increase the discharge volume.

	2GMF•3GMF	3HMF
Engine speed (Max.)	3600rpm	3400rpm
Pulley ratio Crank shaft/ Pump shaft	PCø65/PCø85	PCø73/PCø85
Pump shaft speed	2700rpm	2900rpm
Suction head	1m (3.28ft)	1m (3.28ft)
Total head	4m (13.12ft)	4m (13.12ft)
Delivery capacity	1600l/h	1700l/h



NOTE: For details on the disassembly and reassembly, handling precautions and inspection, refer to "Chapter 7, Section 2. Water pump (P.7-5)" of the GM/HM Series Service Manual.

3. Fresh Water Pump (Old Type)

3-1. Pump construction

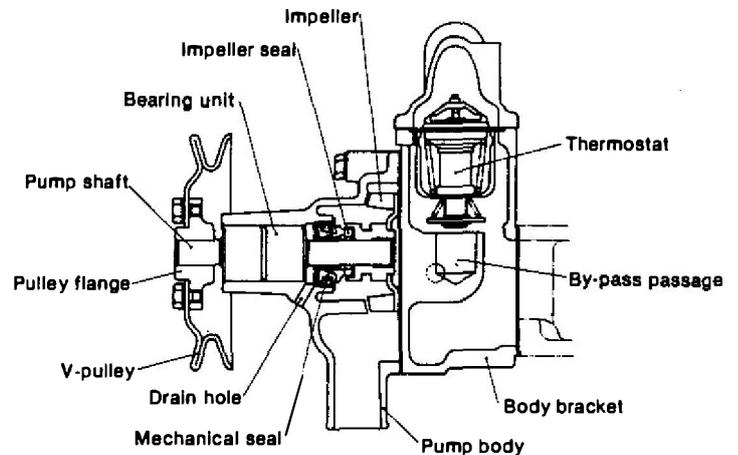
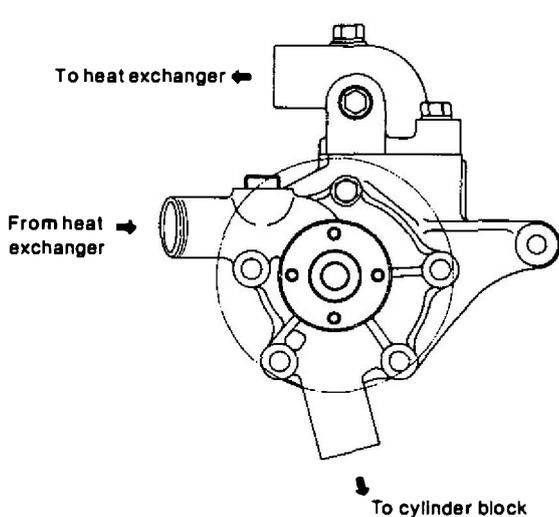
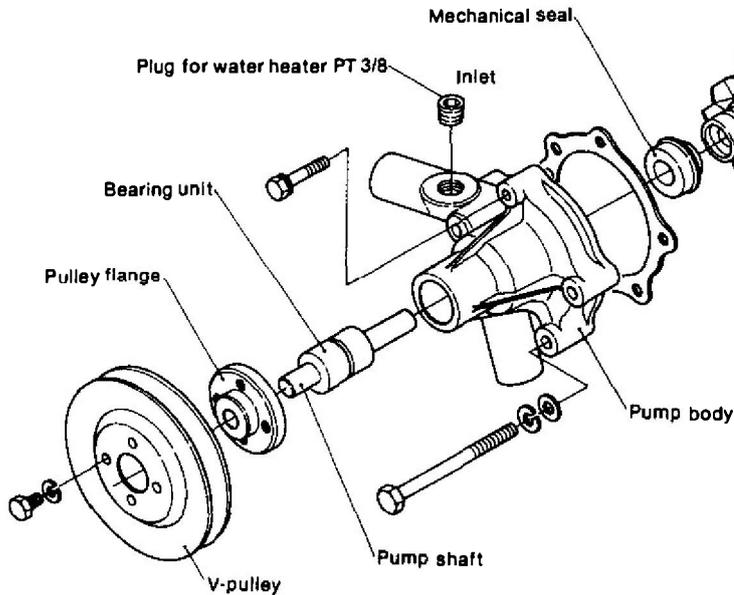
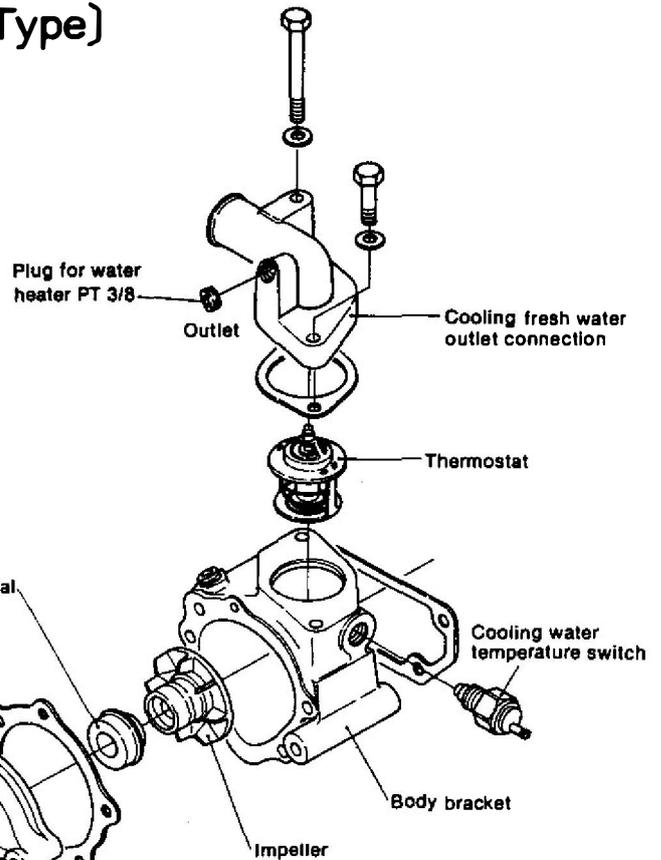
The fresh water pump is a centrifugal type and is used to move fresh water from the fresh water tank through the cooling passages in the cylinder block and cylinder head and back to the fresh water tank.

The fresh water pump is composed of a pump body, impeller, pump shaft, bearing unit and seals. It is driven by a belt and pulley arrangement at the end of the pump shaft.

The packed bearing unit supports the shaft by roller bearings. It cannot be disassembled.

The impeller is equipped with multiple blades and is mounted on the pump shaft.

The mechanical seal prevents water from entering from around the pump shaft. The impeller seal is fixed to the impeller side with spring pressure applied from the pump body side.



3. Fresh Water Pump [New Type]

3-1. Pump construction

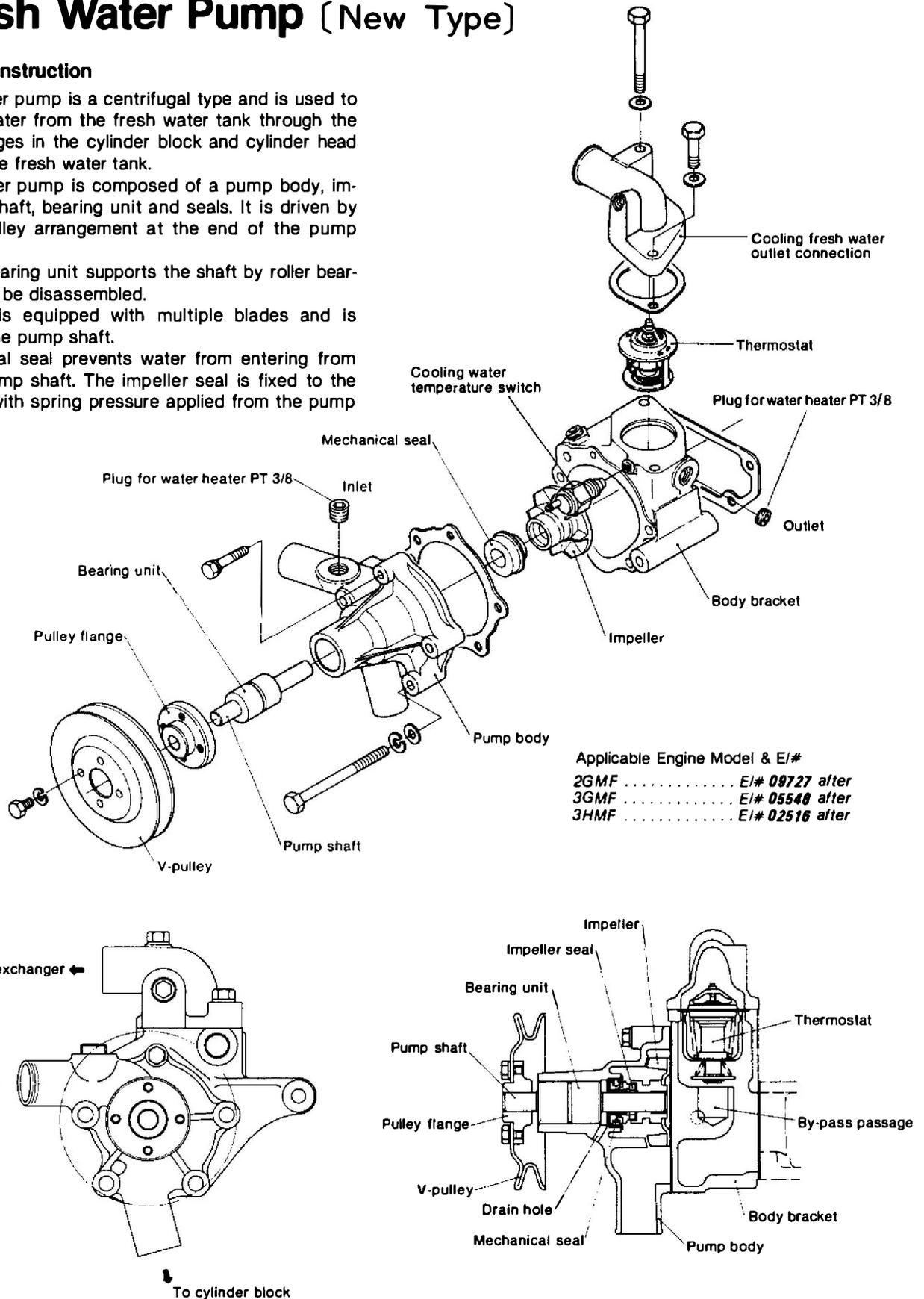
The fresh water pump is a centrifugal type and is used to move fresh water from the fresh water tank through the cooling passages in the cylinder block and cylinder head and back to the fresh water tank.

The fresh water pump is composed of a pump body, impeller, pump shaft, bearing unit and seals. It is driven by a belt and pulley arrangement at the end of the pump shaft.

The packed bearing unit supports the shaft by roller bearings. It cannot be disassembled.

The impeller is equipped with multiple blades and is mounted on the pump shaft.

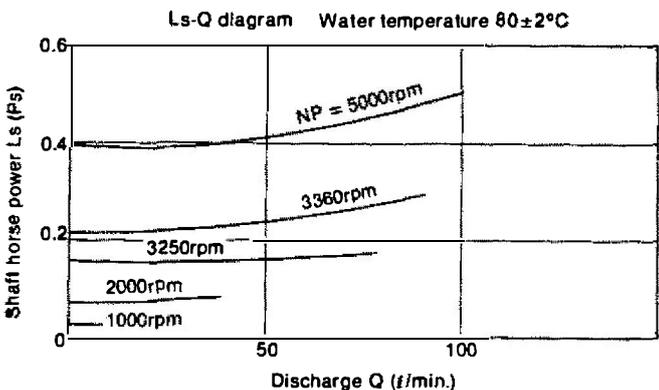
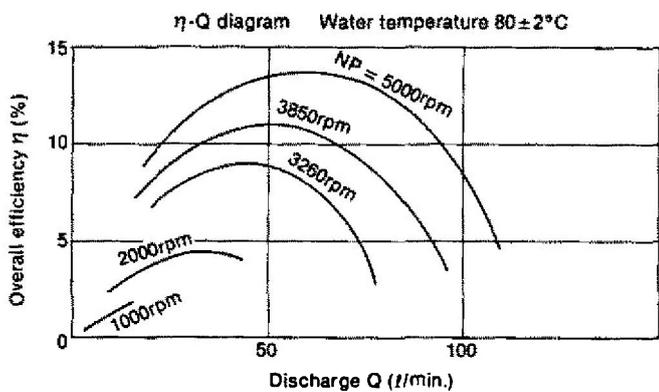
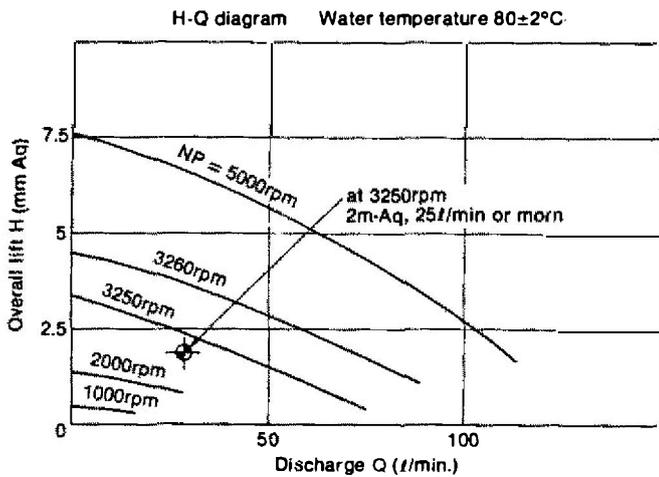
The mechanical seal prevents water from entering from around the pump shaft. The impeller seal is fixed to the impeller side with spring pressure applied from the pump body side.



3-2. Pump capacity and characteristic

	2GMF·3GMF	3HMF
Crank shaft speed	3600rpm	3400rpm
Pulley ratio Crank shaft/ Pump shaft	PC ϕ 127/PC ϕ 103	PC ϕ 138/PC ϕ 103
Pump shaft speed	4400rpm	4500rpm
Delivery capacity	4000l/h	4200l/h
Total head	3m (9.84ft)	3m (9.84ft)

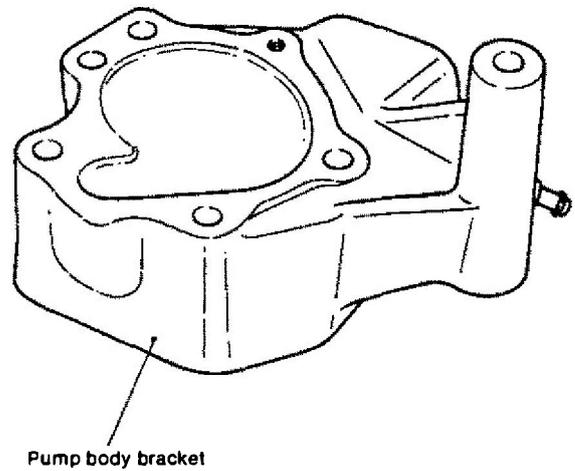
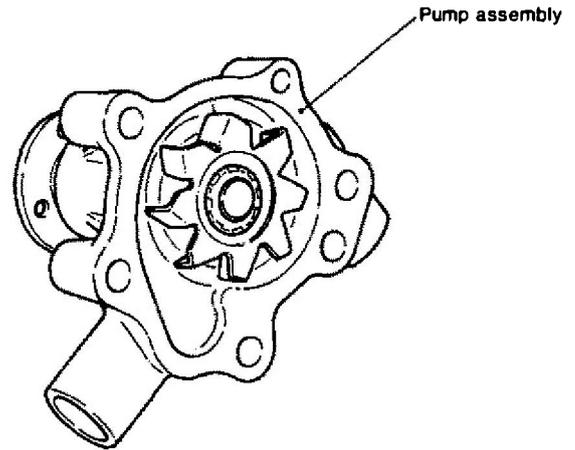
NOTE: The same type of fresh water pump is used for models 2GMF, 3GMF and 3HMF.



3-3. Pump disassembly

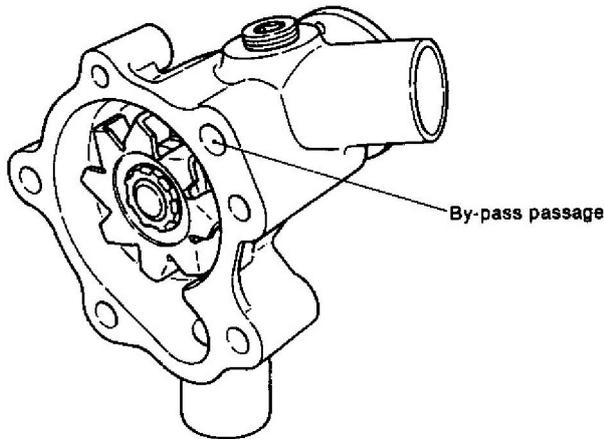
Disassembly of the fresh water pump is difficult and should not be attempted. Faulty units should be replaced. The pump assembly should not be disassembled from the pump body brackets, unless absolutely necessary.

	kg·cm (ft·lb)
Tightening torque for pump setting bolts	40—80 (2.89 ~ 5.79)

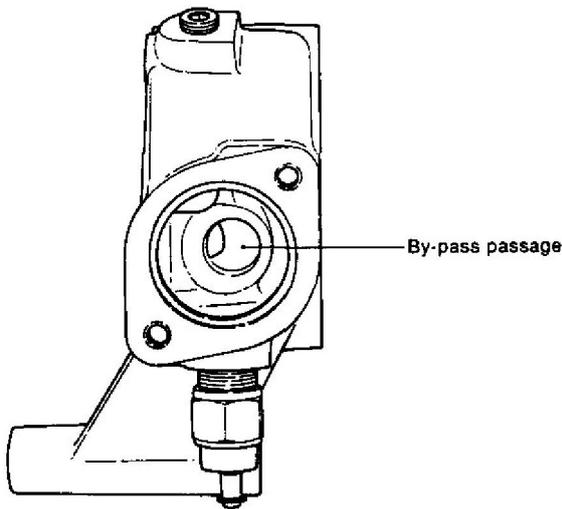
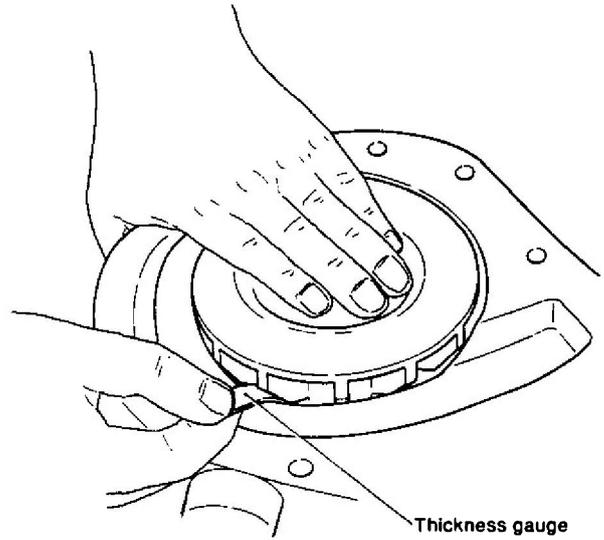


3-4. Inspection and measurement

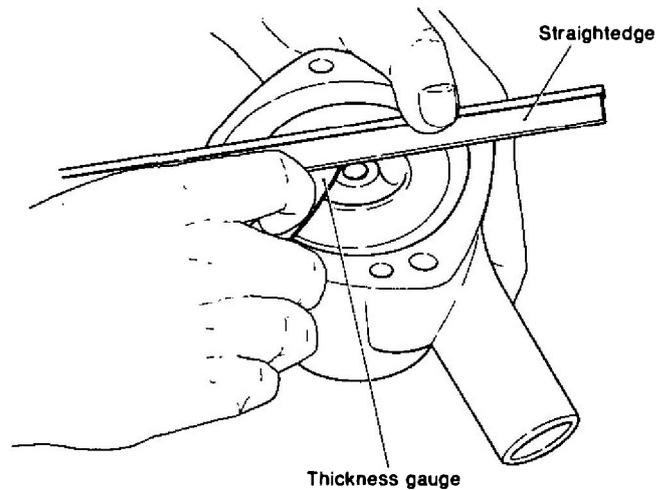
- Confirm smooth rotation by rotating the impeller by hand. When the rotation is not smooth, due to bearing play or friction, or abnormal noise is heard, replace the entire pump assembly.
- Impeller inspection
Check impeller for damage, corrosion and water. Replace if required.
- Check the holes drilled in the cooling water passage or by-pass passage, and clean or unblock where necessary.



Measuring clearance between impeller and pump body



Measuring clearance between impeller and pump body bracket



- (4) Where water leakage is heavy, due to wear or a damaged mechanical seal and impeller seal, replace the pump assembly with a new one.
- (5) Pump body and pump bracket inspection
Clean deposits and rust from body and bracket.
Replace if heavily worn or corroded.
- (6) Impeller clearances.

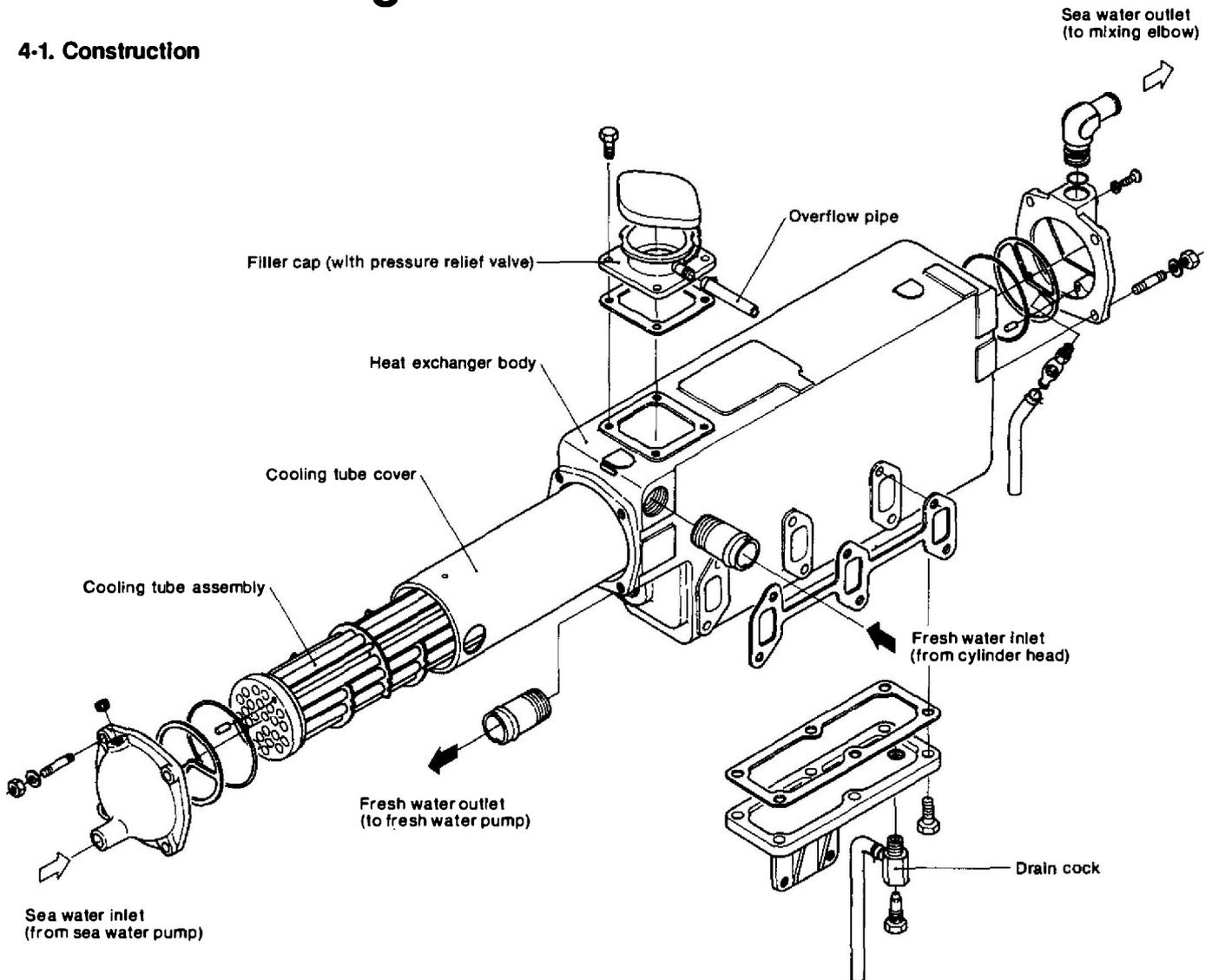
	mm (in)
	Maintenance standard
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)
Clearance between impeller and bracket	0.5 (0.0197)

To measure clearance between impeller and body, insert thickness gauge between the two parts at an oblique angle.

To measure clearance between impeller and bracket, place a straightedge on the pump body surface and insert a thickness gauge between the straightedge and impeller.

4. Heat Exchanger

4-1. Construction



The heat exchanger cools the fresh water, which has reached a high temperature, circulated in the cylinder block, by sea water.

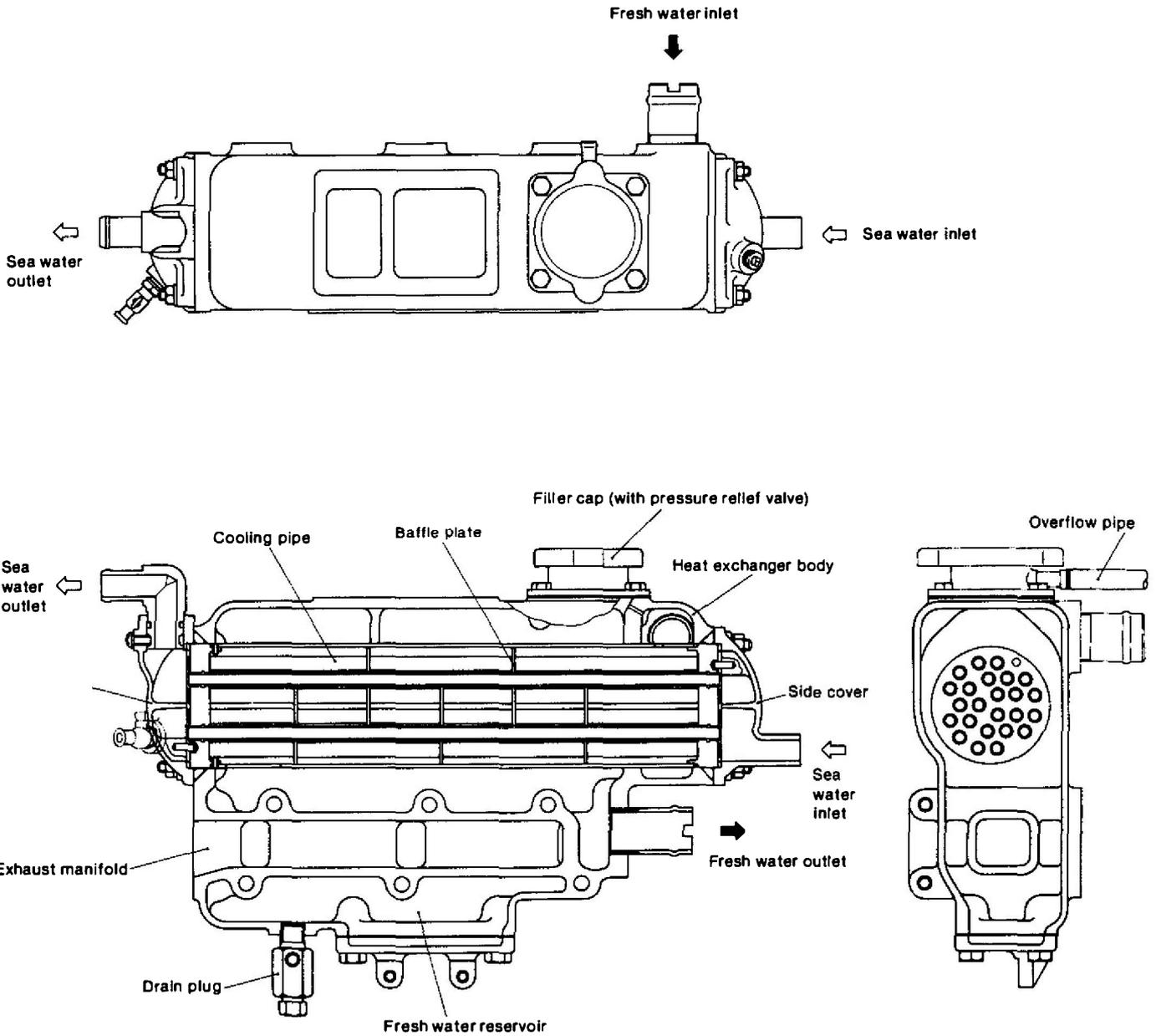
The heat exchanger is a cooling tube which consists of 24 slender tubes and baffle plates, and a cooling tube cover. Sea water passes through the slender tubes, and fresh

water passes through the flow path formed outside of the tubes and baffle plates inside the cooling tube cover.

The lower part of the heat exchanger stores the fresh water, acting as a fresh water tank. There is an exhaust gas passage, leading out of the storage position, which is integrated with the water-cooled exhaust manifold.

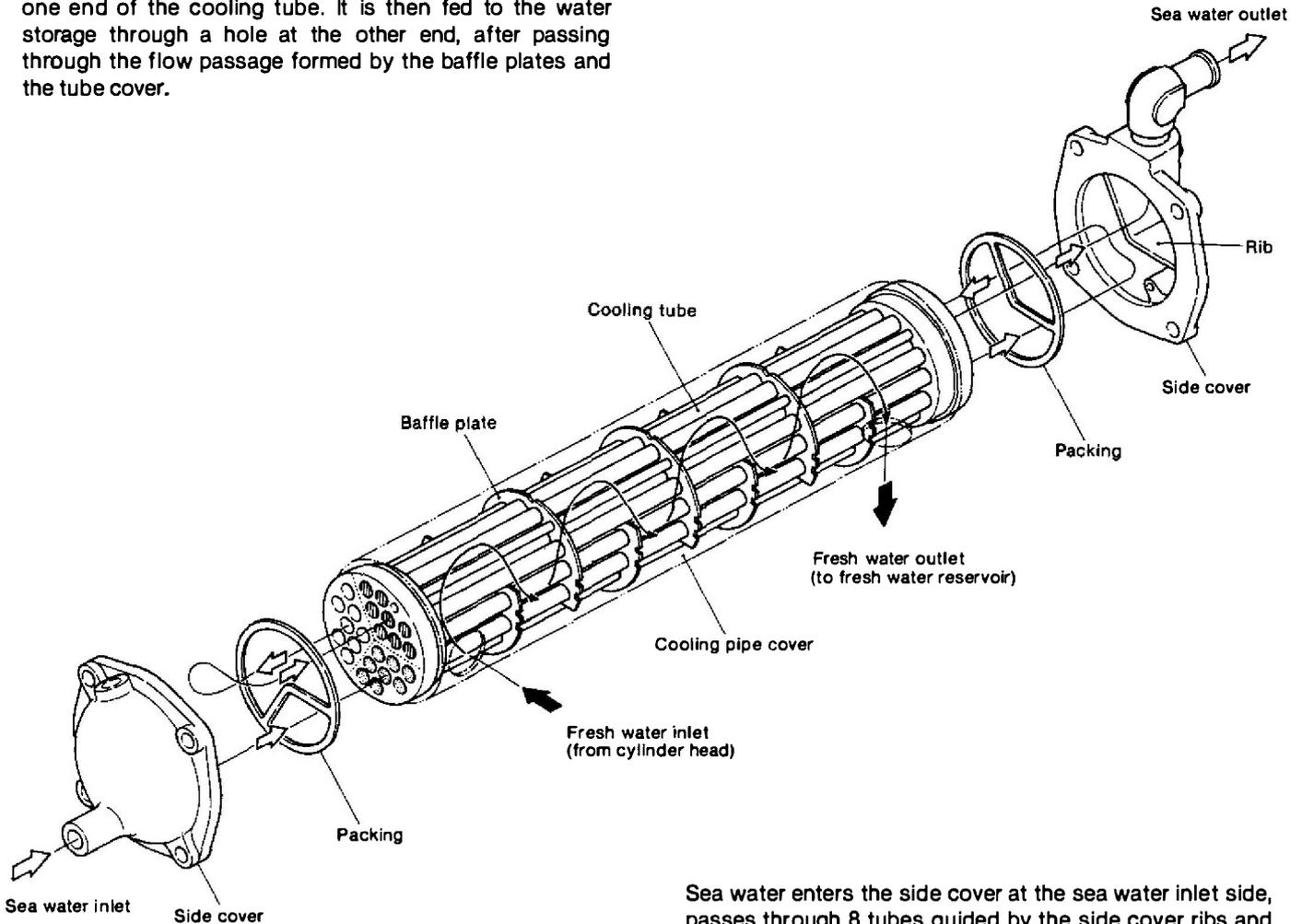
The filler cap on the top of the heat exchanger is equipped with a pressure relief valve. When pressure exceeds the specified limit, this valve opens to release pressure through the overflow pipe.

On the other hand, when cooling system pressure becomes negative in relationship to the atmospheric pressure, air enters from the overflow pipe.



4-2. Water flow in water cooling tube

Fresh water enters the cooling tube from a hole drilled at one end of the cooling tube. It is then fed to the water storage through a hole at the other end, after passing through the flow passage formed by the baffle plates and the tube cover.



Sea water enters the side cover at the sea water inlet side, passes through 8 tubes guided by the side cover ribs and then enters the side cover at the sea water outlet side. Here it passes through another 8 tubes guided by side cover ribs, and returns to the side cover at the inlet side. At the Inlet side, it is guided by the remaining 8 tubes as at the outlet side, and then flows out to the mixing elbow from the outlet connection via the side cover at the outlet side.

4-3. Specifications

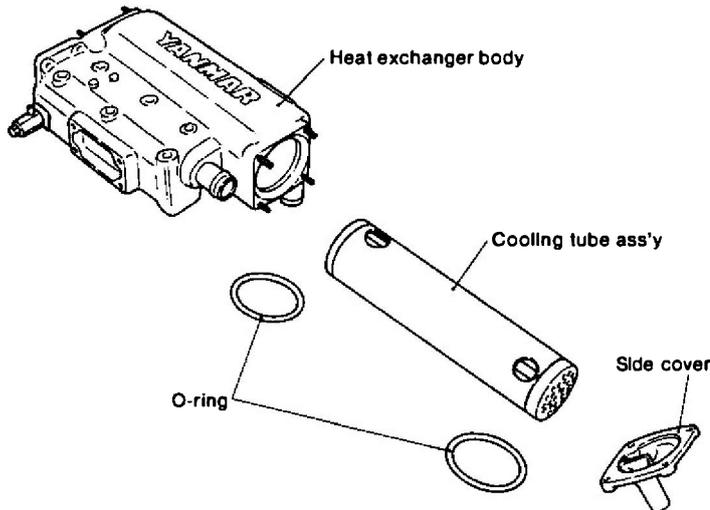
Model of engine		2GMF	3GMF	3HMF
Output (DIN 6270 B rating)	HP/rpm	15/3600	22.5/3600	30/3400
Pipe dia. X pieces	mm	ø6/ø8 × 24	ø6/ø8 × 24	ø6/ø8 × 24
Radiation area	m ²	0.119	0.163	0.208
Radiation area/HP	m ² /HP	0.0079	0.0072	0.0069
Fresh water capacity	l (cu. In)	2.9(177.0)	3.4 (207.5)	4.9 (299.0)

4-4. Disassembly

- (1) Remove the side covers and pull out cooling pipe and rubber packings.

NOTE: After cooling pipe is removed, always replace the rubber packings on both side covers.

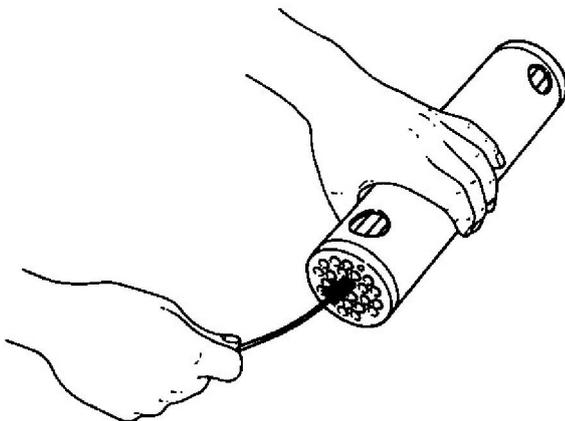
- (2) Remove filler cap and port.
- (3) Remove lower cover and packing.



4-5. Inspection and cleaning

4-5.1 Cooling pipe

- (1) Inspect for dirt and deposits in the tubes. Clean as required.



- (2) Inspect caulked portions of tubes and flanges for damage. Repair or replace as required.
- (3) Inspect the cooling pipe and tubes for leaks. Repair as required.
- (4) Check for clogged water passages. Clean as required.

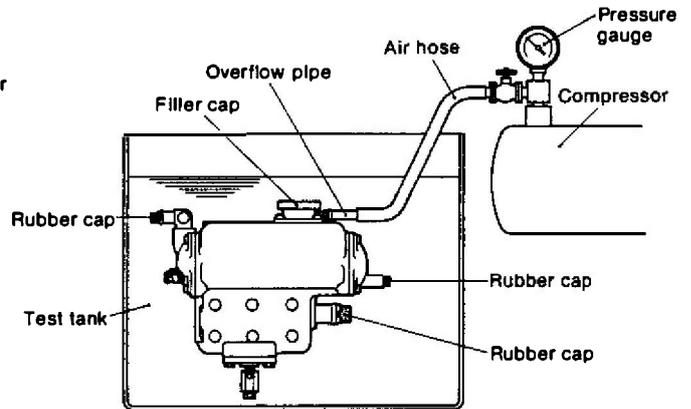
4-5.2 Heat exchanger body

- (1) Check for dirt and corrosion build-up inside body and on side covers. Replace if corroded, broken or otherwise damaged.
- (2) Check joints at sea water inlet and outlet ports and fresh water inlet and outlet ports. Retighten any loose screws and clean pipes as required.
- (3) Check drain cock for clogging. If clogged, clean or repair as required. Retighten screws if necessary.
- (4) For inspection of filler cap, anticorrosion zinc, and thermostat, see below.

4-5.3 Leakage test

- (1) Test with compressed air and test tank. Seal fresh and sea water ports with rubber caps and immerse tank in a test tank filled with water. Inject compressed air through the overflow pipe and check for air bubbles.

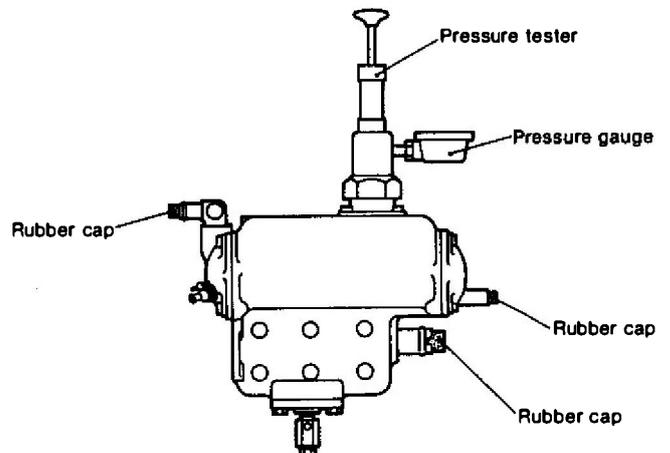
NOTE: Air pressure should be 0.5 ~ 2.0kg/cm² (7.11 ~ 28.45 lbf/in²).



Leakage test using compressed air and test tank

- (2) Test using pressure tester

Seal fresh and sea water ports with rubber caps and fill tank completely with water. Replace the filler cap with a pressure tester and pressurize the tank. If a leak is present, the tank cannot be pressurized or it will only be able to retain pressure for a short time.

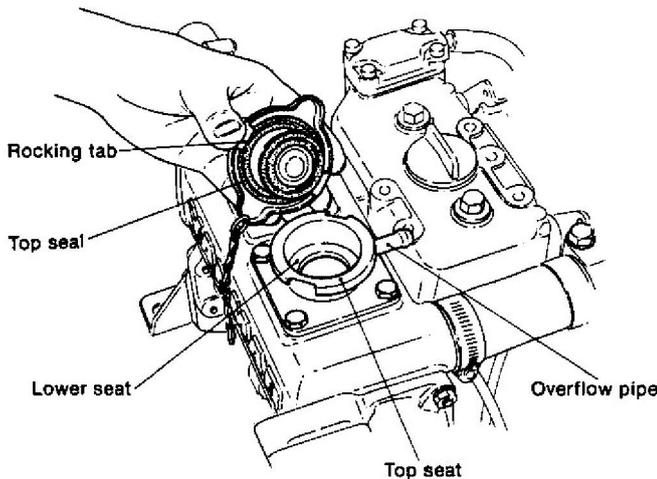


Leakage test using a pressure tester

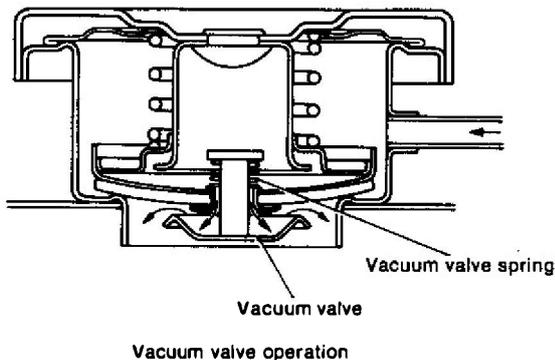
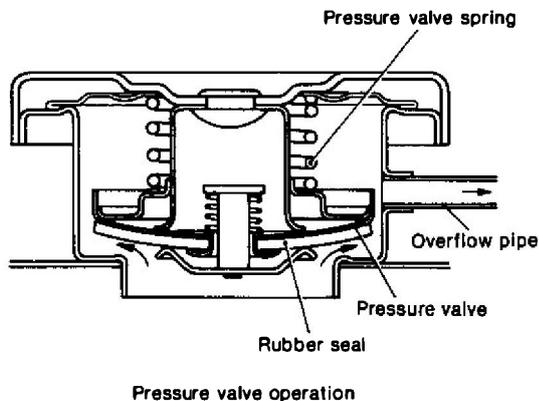
5. Filler Cap and Subtank

5-1. Filler cap construction

The filler cap is placed on the fresh water inlet port and is equipped with a pressure control valve. To attach, place the rocking tab (extension on the attachment section) on the flyneck cam. Then, turn and tighten. The top seal touches the flyneck tap seat while the pressure valve touches the lower seat.



5-2. Filler cap pressure control



When cooling system pressure is within the specified range 0.9kg/cm^2 (12.80 lb/in^2), the pressure valve and vacuum valve are tightly closed on their valve seats. When pressure rises, the pressure valve opens and vapor is discharged from the overflow pipe. When water becomes cool and pressure in the system is lower than the atmospheric pressure, the vacuum valve opens and air enters the system through the overflow pipe.

To prevent the pressure valve from opening and the resulting water loss, the cooling system can be equipped with a subtank, described below.

Action of Pressure control Valve

Pressure Valve	Opens at $0.9\text{ kg/cm}^2\text{G}$ (12.80 lb/in^2)
Vacuum Valve	Opens at $0.05\text{ kg/cm}^2\text{G}$ (0.71 lb/in^2) or below

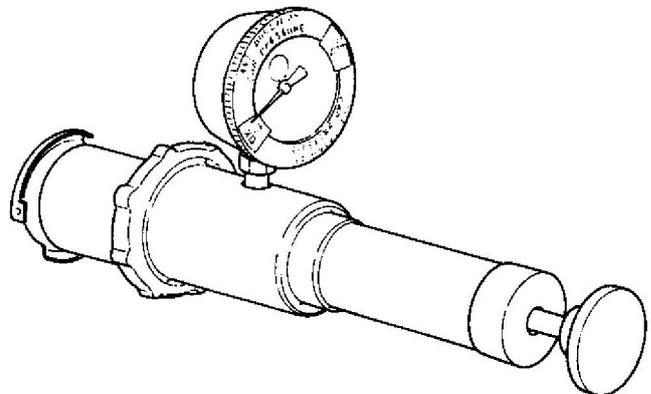
5-3. Filler cap inspection

(1) Remove all deposits and rust, check for damage and wear on the seat contacting surfaces, and check spring for proper functioning. Repair or replace as required.

(2) Tester inspection

Attach adaptor and filler cap to tester.

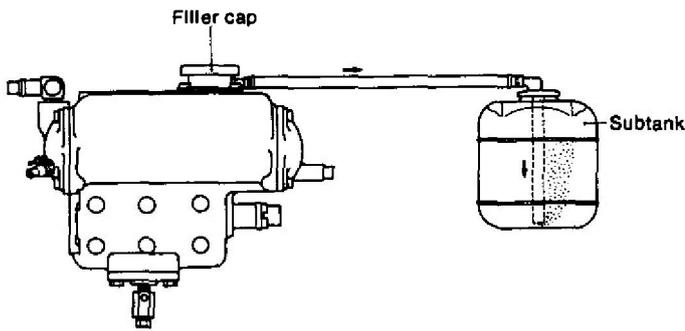
Increase pressure and if pressure remains constant for six seconds, the cap is normal. If pressure does not increase or does not remain constant for six seconds, check for defects. Repair or replace as required.



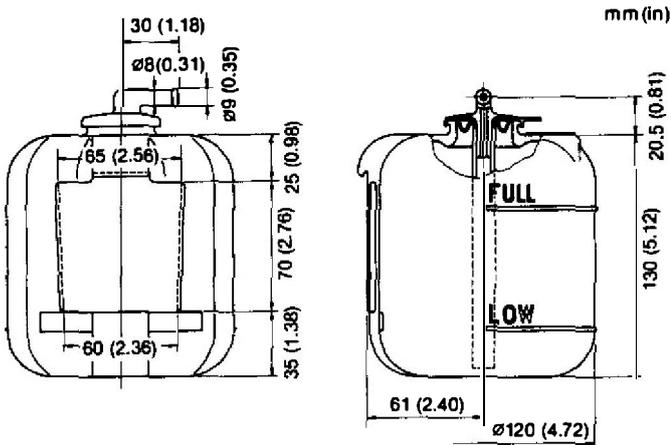
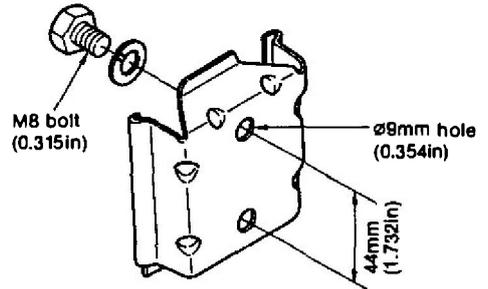
5-4. Subtank function

When cooling system pressure rises above 0.9kg/cm^2 (12.80 lb/in^2), the pressure valve opens and vapor is released, reducing the amount of water in the cooling system. The subtank collects this vapor where it condenses. Then, when cooling system pressure falls below atmospheric pressure, the water in the subtank is siphoned back to the main tank.

Use of a subtank is highly recommended, since this allows the engine to be run for longer periods between water replenishment and the need to open the filler cap is eliminated, removing one possible cause of accidents.



Subtank mounting plate (attached to subtank)



- (1) Mount the subtank at the same height as the fresh water tank.
 - (2) Ensure that the length of the overflow pipe is no more than 1m (39.37 in.), and that it does not break.
- NOTE: If a subtank is not used, be careful not to immerse overflow pipe in the bilge, since this can cause bilge water to be siphoned into the cooling system.*

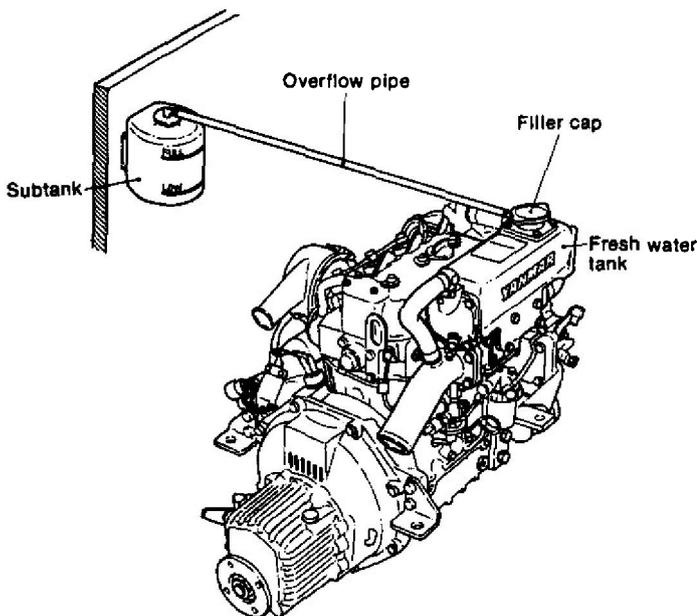
5-6. Maintenance during use

- (1) Check that when the cooling water is cold the level is within the specified range.
- (2) Check that the overflow pipe is not broken, and also that the holes are not blocked up.

l (cu. in)

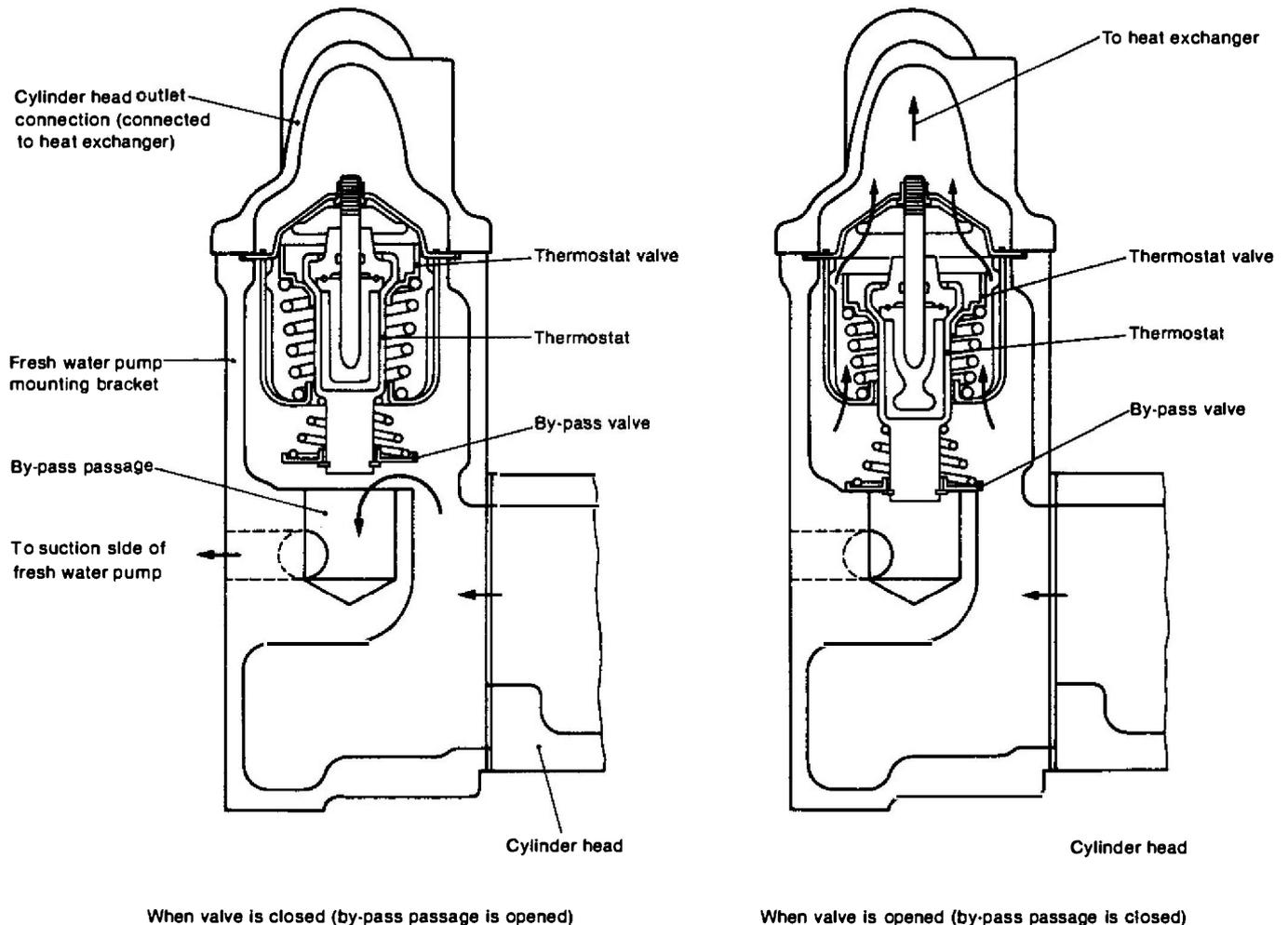
Subtank capacity	Over all capacity	1.25 (76.28)
	Full scale position Low scale position	about 0.8 (48.82) about 0.2 (12.20)
Part No.	120445-44530	

5-5. Installation of subtank



6. Thermostat

6-1. Operation



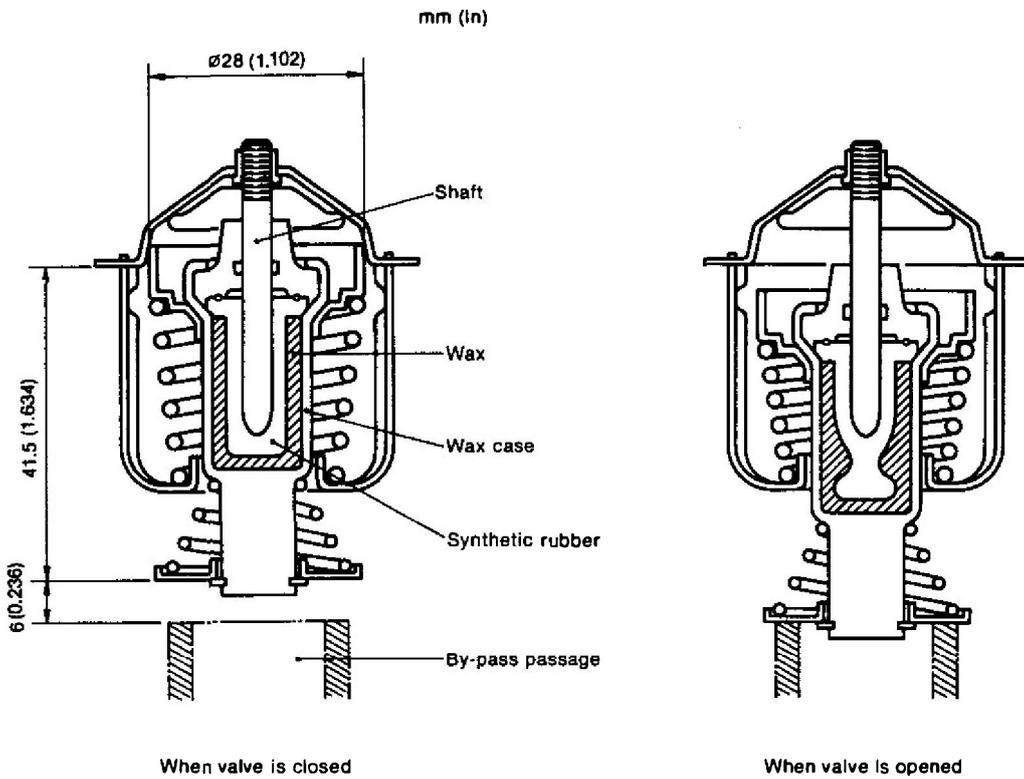
The thermostat opens and closes the by-pass valve and thermostat valve according to the temperature changes in the fresh water in the engine, adjusts the flow of fresh water to the heat exchanger and keeps the fresh water temperature in the engine at the correct degree. The thermostat in the fresh water-cooled engine is a bottom-by-pass type, as shown in the figure, and is installed inside the fresh water pump bracket which combines with the cylinder head cooling water outlet passage. The thermostat valve is closed while the fresh water

temperature is low, and fresh water is fed to the fresh water pump inlet through the drilled hole in the by-pass passage, and circulated inside the engine. When the fresh water temperature rises over the valve opening temperature, the thermostat valve opens, and fresh water is fed to the heat exchanger and where fresh water is cooled and then it is fed to the fresh water pump. With the thermostat valve opening, the by-pass passage is throttled. The by-pass passage is completely closed as the temperature rises.

6-2. Construction

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

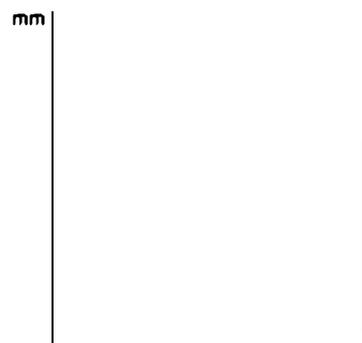
the cooling water rises, the wax melts and its volume expands. The valve is opened or closed by this variation of volume.



Thermostat operating temperature

Opening temperature	71° (159.8)
Full open temperature (Temperature corresponding to 8mm or more valve lift)	85° (185)

Characteristic of Thermostat



Valve opening temperature $71 \pm 1.5^{\circ}\text{C}$
(157.1 ~ 162.5°F)

Fully opened lift checking
temperature 85°C (185°F)

6-3. Inspection

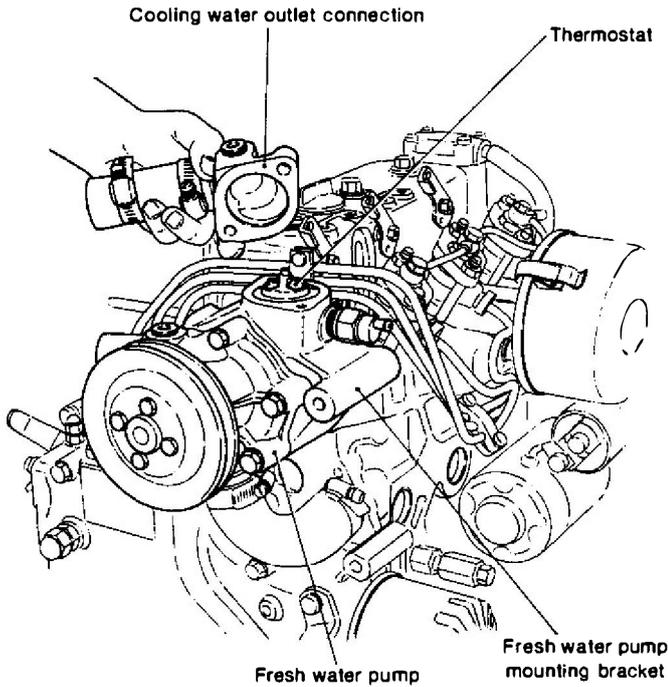
(1) Remove the cooling water outlet connection at the top of the fresh water pump mounting bracket and take out the thermostat.

Remove all deposits and rust, check functioning and inspect parts. Replace if performance has deteriorated or if the spring or other parts are excessively corroded, deformed or otherwise unsuitable.

(3) In general, inspect the thermostat after every 500 hours of operation. However, always inspect it when the cooling water temperature has risen abnormally and when white smoke is emitted for a long period of time after the engine starts.

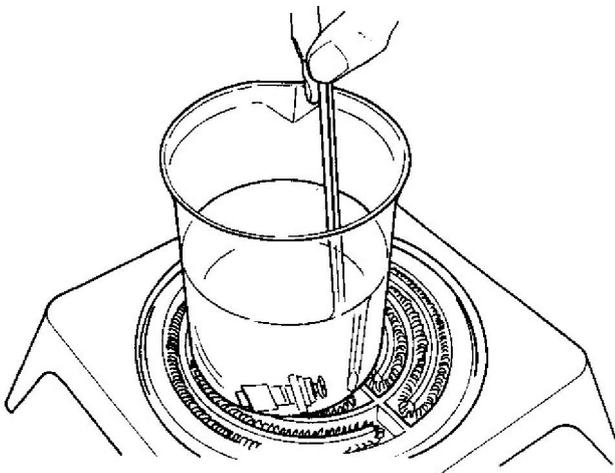
(4) Replace the thermostat when it has been in use for a year, or after every 2000 hours of operation.

Part No. code of thermostat	121750-49800
-----------------------------	--------------



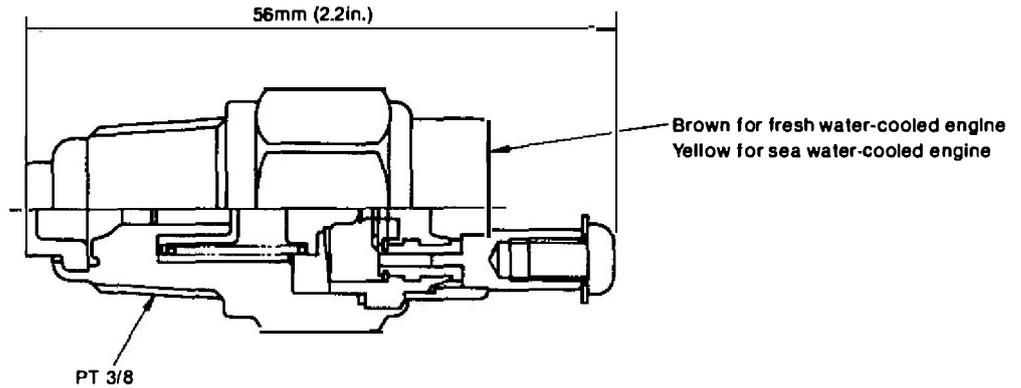
(2) Testing the thermostat

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 71°C and becomes fully open at 85°C, the thermostat may be considered all right. If its behaviour differs much from the above, or if it is found to be broken, replace it.



7. Cooling Water Temperature Switch

The cooling water temperature switch is identical to that for the sea water-cooled engine in shape and dimension, but care must be taken when parts are replaced as the operating temperature is different. This can be checked by the seal color.



Operating temperature		Current capacity	Response time	Indication color	Parts code
ON	OFF				
106±3°C (217.4 ~ 228.2°F)	96°C (204.8°F) or higher	DC 12V 1A	Within 60 sec.	Brown	127610-91360

8. Precautions

8-1. Ventilator

The surface temperature of fresh water cooled engines is higher than sea water cooled engines. Therefore, if the engine room is not well ventilated, engine room temperature can rise to a point where it will adversely influence engine performance.

8-2. Cooling water

(1) Fresh water

Use clean soft water as cooling water. Hard water will cause calcium build-up, poor heat transmission and a drop in the cooling effect, resulting in overheating.

(2) Fresh water tank capacity

Model	Capacity	l (cu. in)
2GMF	2.9 (177.0)	
3GMF	3.4 (207.5)	
3HMF	4.9 (299.0)	

Remove the cap from the fresh water cooler, and check the water level. If the water level is below the top of the cooling pipe, add clean soft water up to the iron plate at the bottom of the filler.

If water is added up to the mouth of the fresh water tank, about 50cc of water will overflow from the filler immediately after the engine is started. This is normal, and is caused by the increase in the volume of the water as its temperature rises. If the water filler cap is removed after the engine has been stopped and allowed to cool, the water level will be 2—3cm from the top of the filler. This is also normal, and is caused by the overflow of the unnecessary water as the temperature of the water rises.

(3) Cooling water (fresh water) level check

Check the level of the cooling water (fresh water) before daily operation. A low cooling water level can cause insufficient pump discharge and the accumulation of scale in the heat exchanger.

(4) Cooling water leakage check during operation

Although checking for water and oil leakage during operation is generally necessary, check for fresh water leakage with special care.

Fresh water leakage is directly related to seizing of the engine.

(5) Fresh water replacement

Replace water every 500 hours. Always use an anti-rust agent.

To drain the water, open the cooling water drain cock and remove the water filler cap. If the filler cap is not removed, a vacuum will be created in the water jacket and all the water will not be drained.

(6) Removing the filler cap

Do not attempt to remove the water filler cap at the top of the fresh water tank while the engine is running, or while the engine is still hot after it has been stopped;

steam will escape and may cause serious injury. If removal of the filler cap is unavoidable, place a piece of cloth over the cap and turn the cap slowly, making sure you are in a safe position even if steam escapes.

8-3. Antifreeze

(1) Use permanent type antifreeze in the winter. Freezing of the fresh water will damage the heat exchanger, cylinder head and water jacket.

(2) Antifreeze use

1) Before adding antifreeze, clean cooling system and check for leaks.

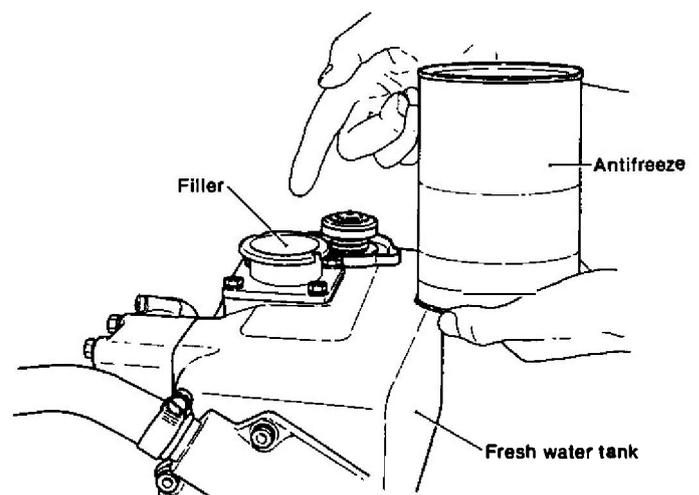
2) Select mixing ratio according to the following table.

Temperature	l (cu. in)					
	-5°C	-10°C	-15°C	-20°C	-25°C	-30°C
Mixing ratio	12%	22%	29%	35%	40%	44%
2GMF	0.35 21.40	0.64 39.10	0.84 51.30	1.02 62.20	1.16 70.60	1.28 78.10
3GMF	0.41 25.00	0.75 45.60	0.99 60.40	1.19 72.80	1.36 83.00	1.50 91.50
3HMF	0.59 36.00	1.08 65.90	1.42 86.70	1.72 105.00	1.96 119.60	2.21 129.40

NOTE: The temperature selected in the above table should be 5°C lower than the lowest expected temperature in the area.

NOTE: Check mixing ratio carefully, especially when using premixed coolant.

3) Tighten drain cock and fill cooling system. Then, run engine for approx. 5 to 30 minutes to make sure the solution is well mixed.



NOTE: Some antifreeze solutions will corrode aluminum. Check carefully before use.

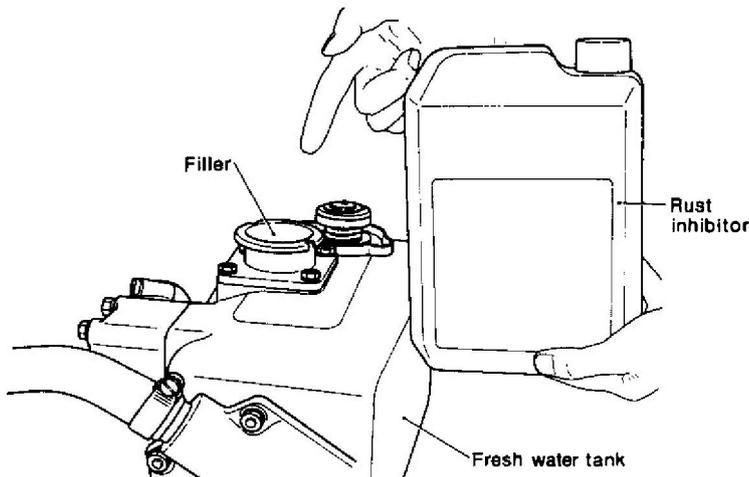
NOTE: When antifreeze protection is no longer necessary, drain water, flush cooling system and refill with fresh water.

8-4. Rust Inhibitor

When the fresh water is changed, a rust inhibitor must be added to the new water to prevent rusting.

Rust inhibitor : Fresh water = 1 : 10

Flush cooling system with fresh water, fill with proper rust inhibitor and then top-off cooling system with fresh water.



8-5. Idling the engine when stopping

Always idle the engine for ten minutes immediately after starting and prior to stopping. Be sure to idle the engine adequately, especially before stopping. Stop the engine only after its temperature has dropped sufficiently. If the engine is stopped while hot, the hot fresh water will cause the temperature of the water in the heat exchanger pipe to rise, causing a build-up of calcium deposits in the pipe and a drop in the cooling effect.

8-6. Cleaning the heat exchanger tube

If the heat exchanger tube through which the fresh water flows becomes extremely dirty, the cooling effect will deteriorate.

If the C.W. warning lamp lights periodically when the engine is run at the rated output, clean the tube in the fresh water tank with a cleaning agent and then flush the accumulated scale produced by cooling the fresh water from the tube.

DISASSEMBLY AND REASSEMBLY

1. Disassembly of Fresh Water-Cooled Engine.....	16-1
2. Reassembly of Fresh Water-Cooled Engine	16-11

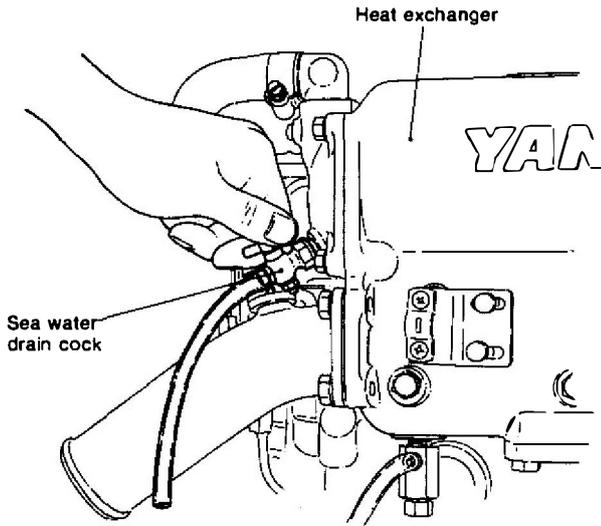
1. Disassembly of Fresh Water-Cooled Engine

In general, the disassembly sequence for a fresh water-cooled engine is the same as that for a sea water-cooled engine, except that the sequence for parts related to the

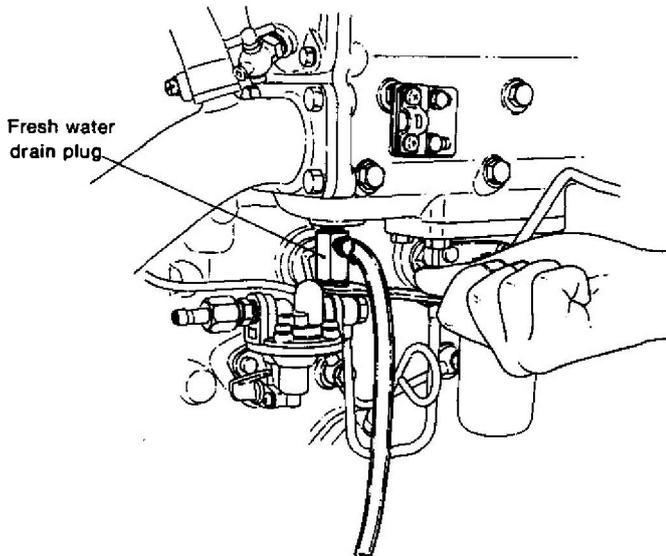
cooling water system are slightly different. Refer to the disassembly section of the sea water-cooled engine manual for the latter steps.

1-1. Draining the cooling water

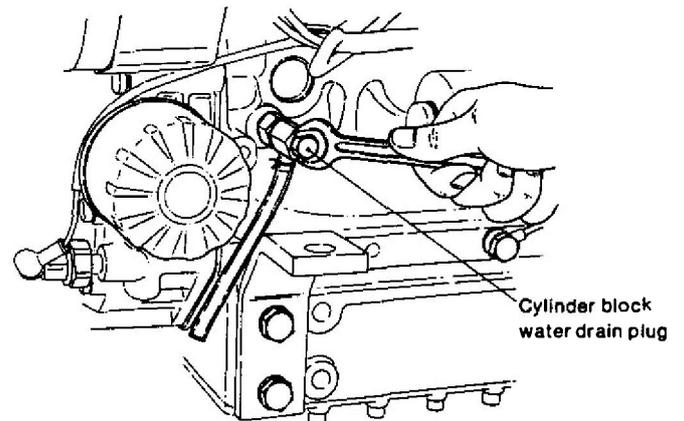
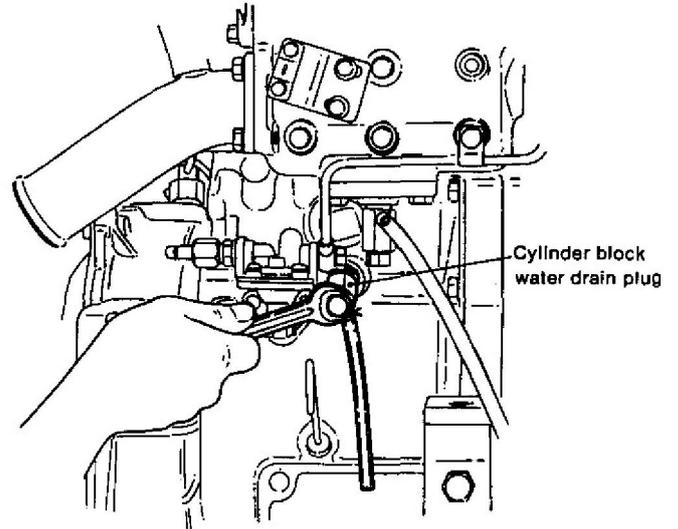
(1) Drain the sea water from the heat exchanger. The sea water drain cock is installed on the side cover of the heat exchanger at the rear.



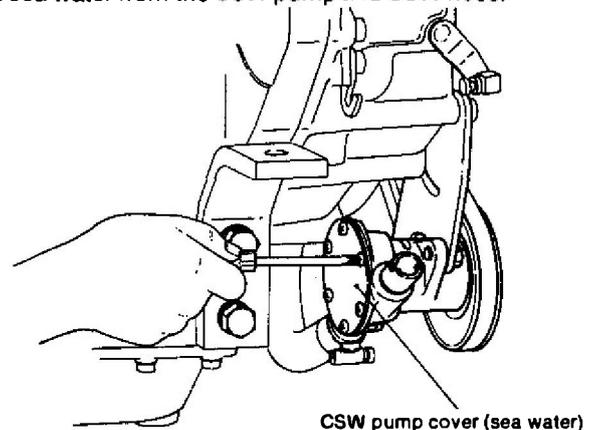
(2) Drain the fresh water from the heat exchanger. Loosen the fresh water drain plug installed at the bottom of the heat exchanger.



(3) Drain the fresh water from the cylinder block. Loosen the cylinder block water drain plug and drain the fresh water. The water drain plug is installed on the block wall surface at the exhaust side in a model 2GM engine, and on the block wall surface at the intake side in models 3GMF and 3HMF engines.



(4) Draining sea water from the CSW pump
Loosen the CSW pump cover fixing screws, and drain the sea water from the CSW pump and CSW hose.

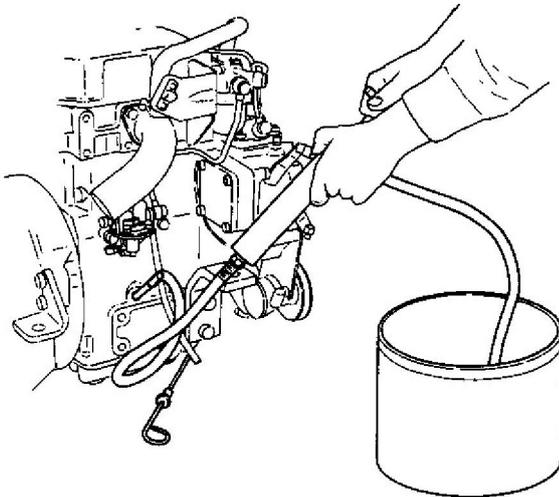


NOTE: CSW = Cooling Sea Water

1-2. Drain the lubricating oil

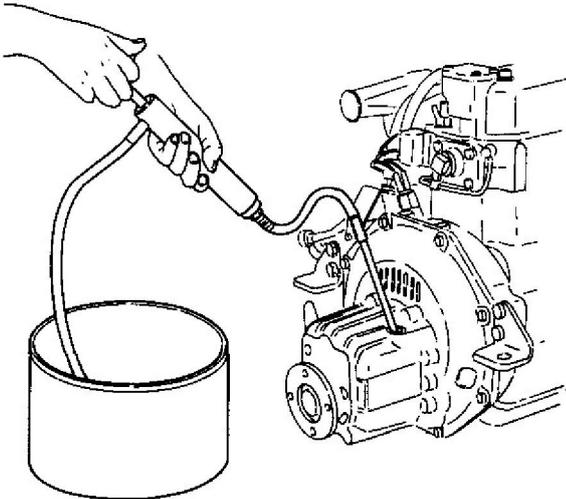
(1) Engine side

Insert a suction tube into the dipstick hole and pump out the oil with a waste oil pump (option).



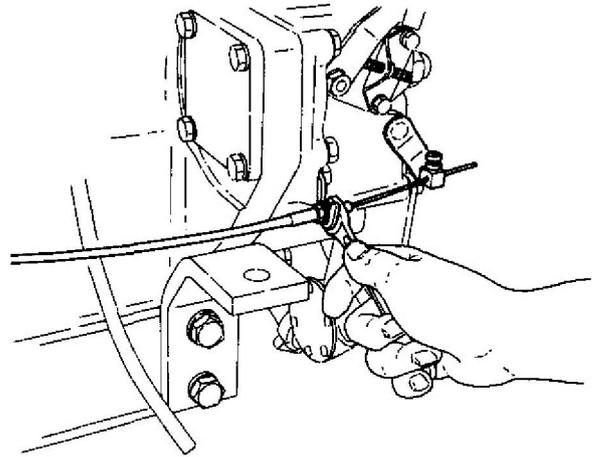
(2) Clutch side

Pump out the oil from the filler/dipstick hole using a waste oil pump or remove the drain plug at the bottom stem side of the clutch case and drain the oil.



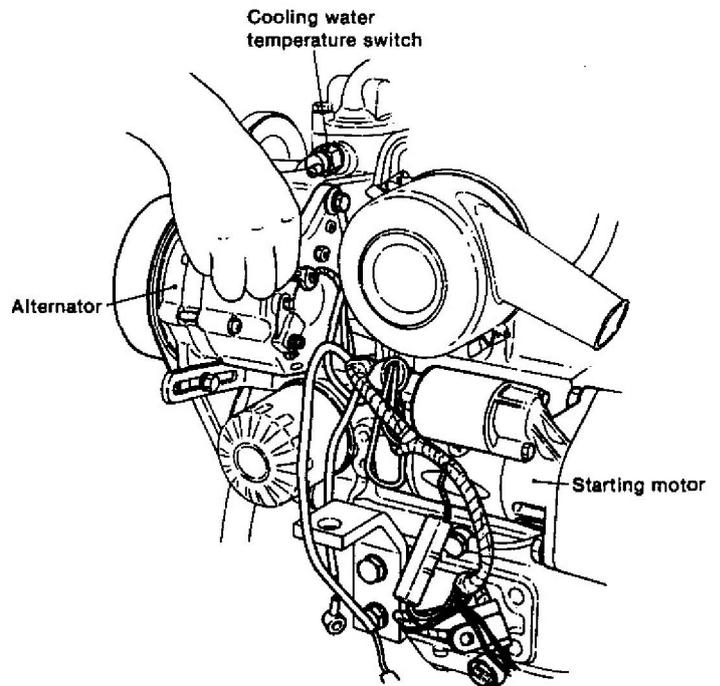
1-3. Disconnect the remote control cables

- (1) Clutch remote control cable
- (2) Speed remote control cable
- (3) Engine stop remote control cable
- (4) Decompression remote control cable



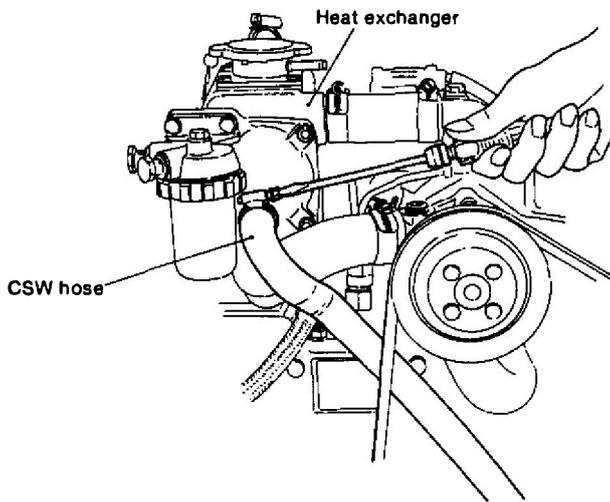
1-4. Disconnect the electrical wiring

- (1) Alternator wiring
- (2) Starter motor wiring
- (3) Water temperature switch wiring
- (4) Oil pressure switch wiring
- (5) Tachometer sender wiring



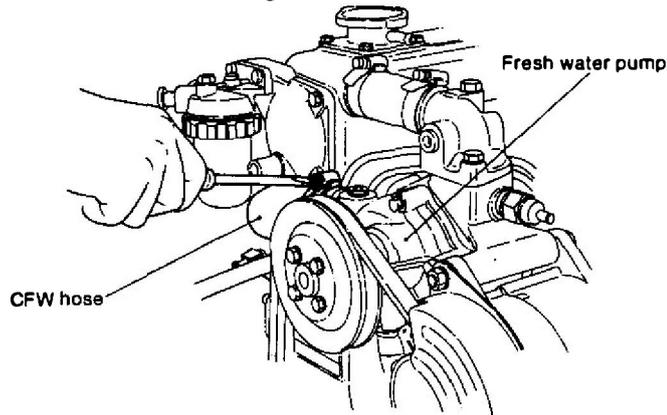
1-5. Remove the CSW hose

(1) Remove the CSW hose between the CSW pump and heat exchanger.

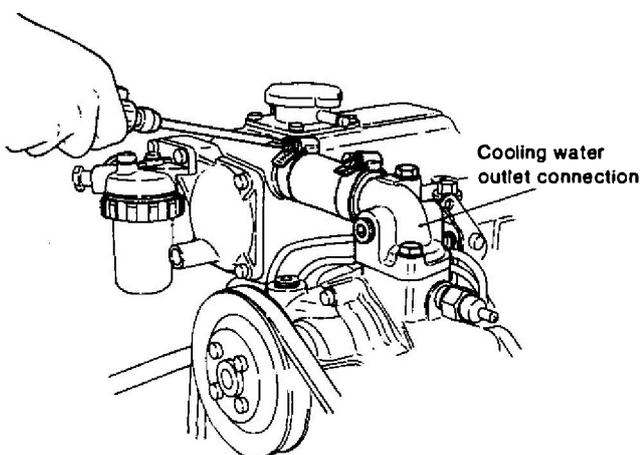


(2) Remove the CFW hose between the heat exchanger and CFW pump.

NOTE: CFW = Cooling Fresh Water

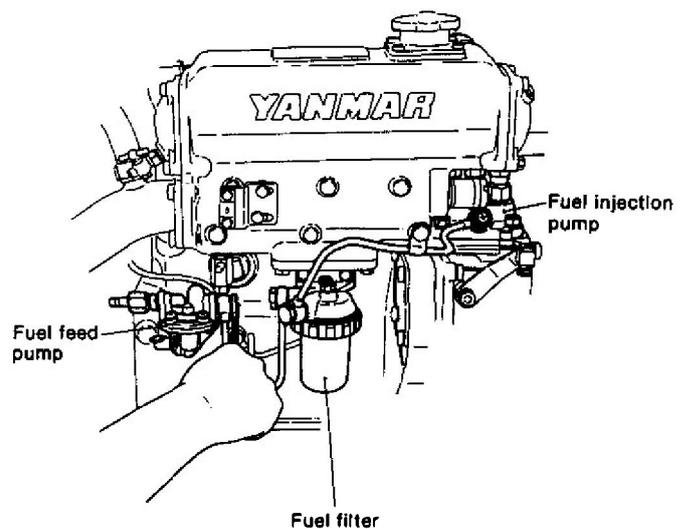
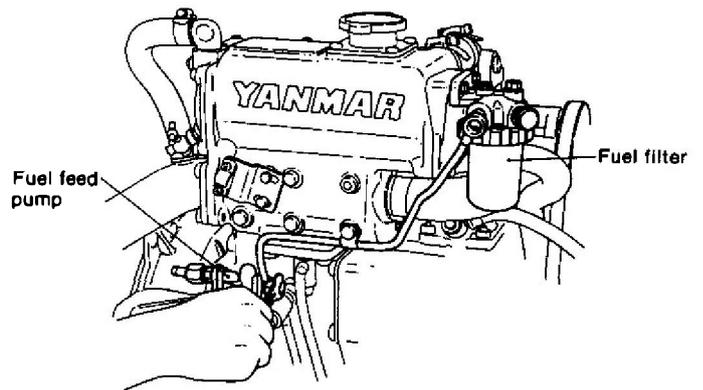
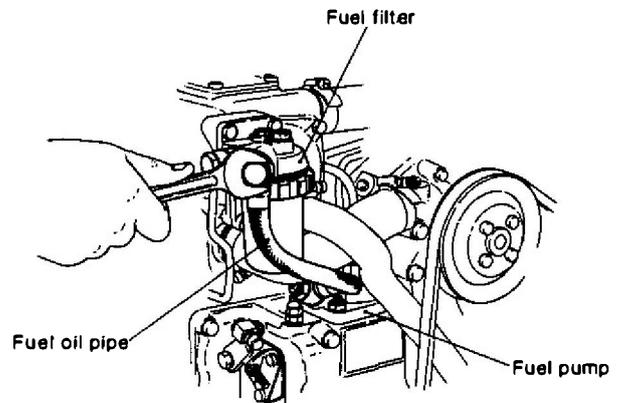


(3) Loosen the hose clamp on the CFW hose between the cylinder head and heat exchanger. The hose clamp at the heat exchanger side or the cooling water outlet connection side only need be loosened.



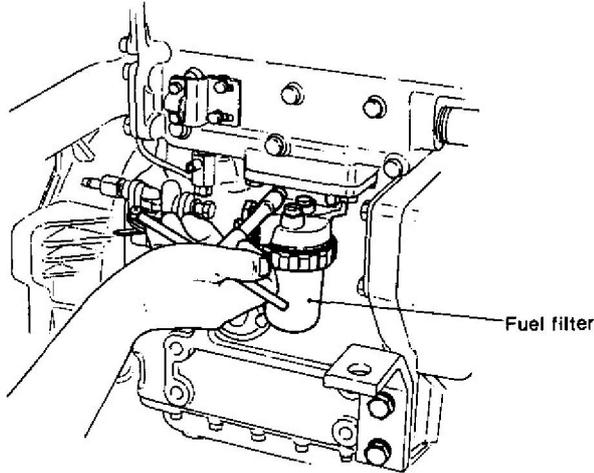
1-6. Disconnect the fuel piping

- (1) Fuel tank to feed pump
- (2) Feed pump to fuel filter
- (3) Fuel filter to fuel injection pump



1-7. Removing the fuel filter

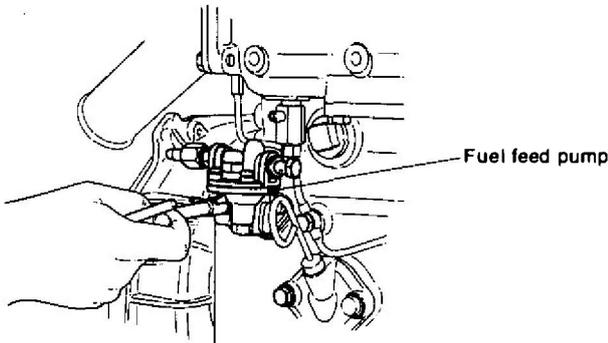
The fuel filter can be removed as assembled to the heat exchanger. However, to make removal of the heat exchanger easier, the filter should be removed separately.



1-8. Remove the fuel feed pump

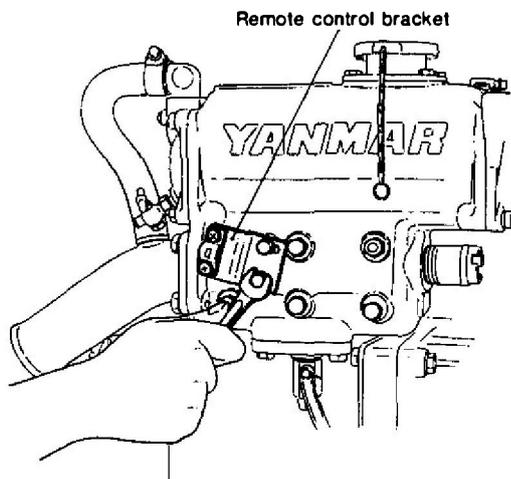
In cases of model 3GMF, the heat exchanger drain plug may jam against the fuel feed pump pipe connector. The fuel feed pump should be removed before removing the heat exchanger.

In cases of models 2GMF and 3HMF, the heat exchanger can be removed without removing the fuel feed pump.

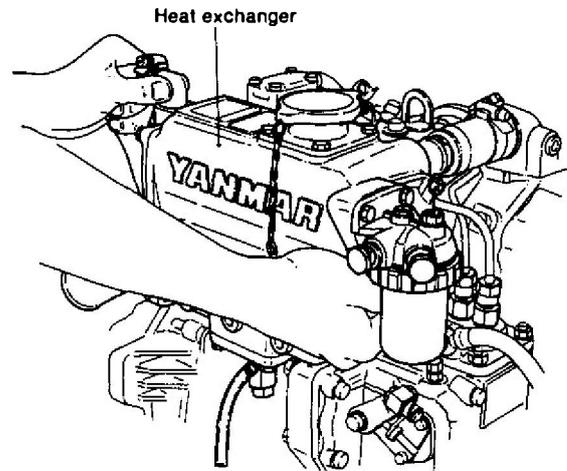


1-9. Remove the remote control bracket

The heat exchanger fixing nut cannot be removed without first removing the remote control bracket.

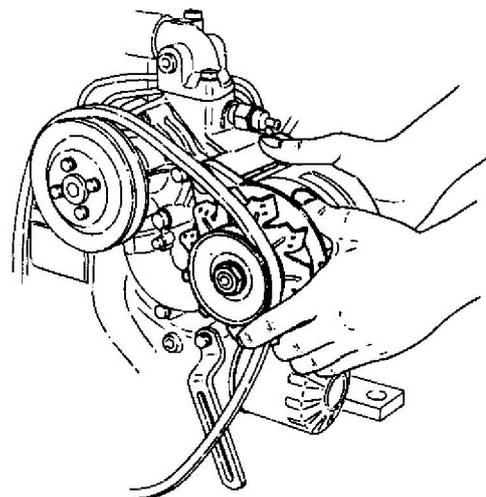
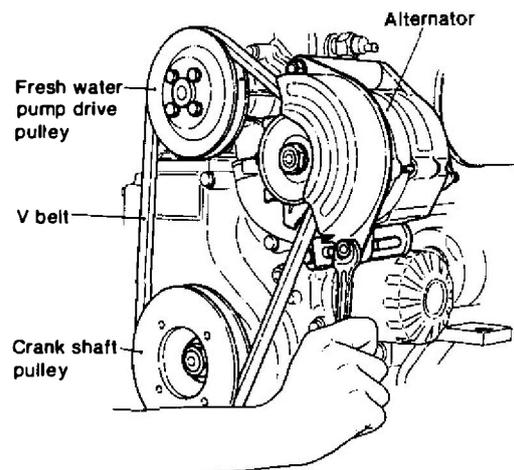


1-10. Remove the heat exchanger.



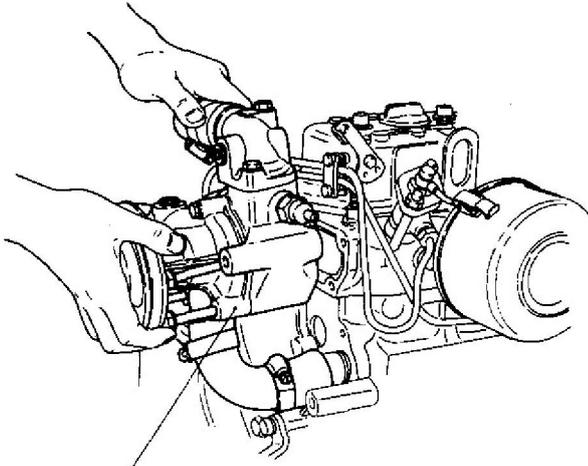
1-11. Remove the alternator

- (1) Loosen the adjusting bolt and remove the V-belt
- (2) Remove the alternator



1-12. Remove the CFW pump

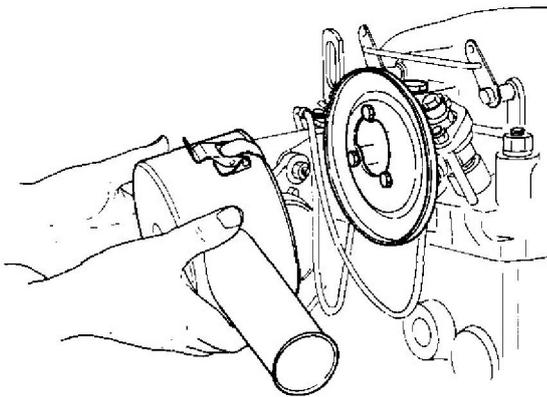
Remove the CFW pump by loosening the hose clamp on the CFW hose between the CFW pump and cylinder block at the cylinder block end.



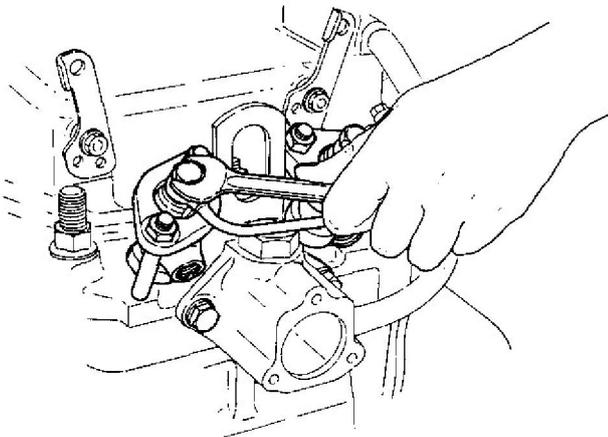
Fresh water pump

1-13. Remove the air intake silencer

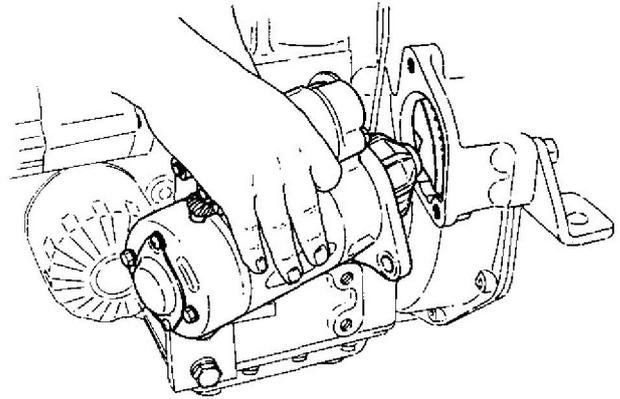
Remove the intake silencer clip and the filter element. Then remove the set screw and the cover.



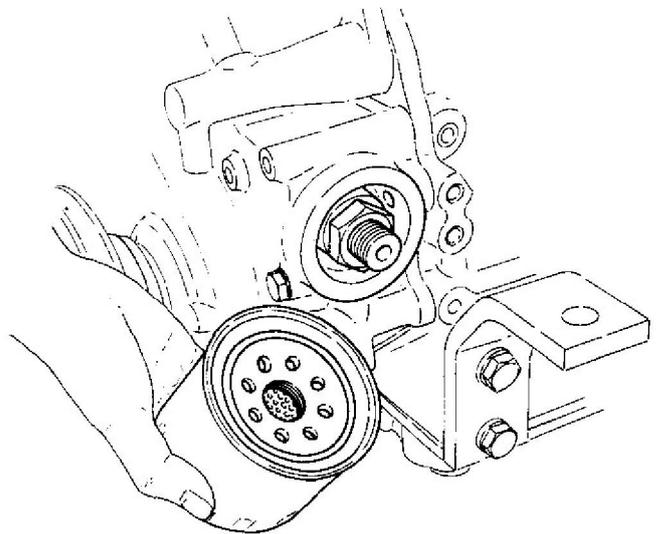
1-14. Remove the fuel high pressure pipe and fuel return pipe.



1-15. Remove the starter motor

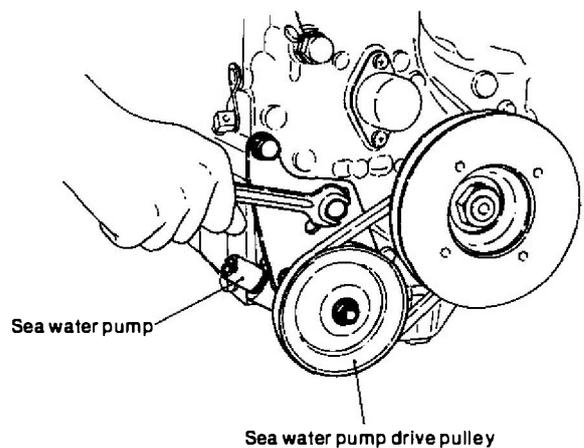


1-16. Remove the oil filter



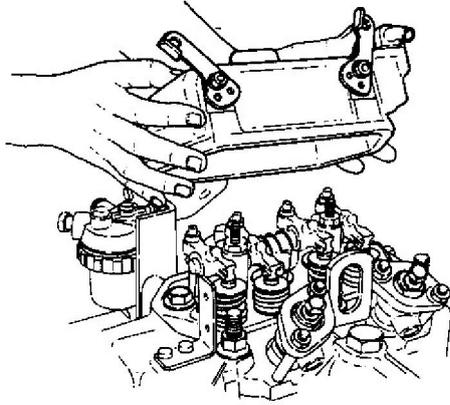
1-17. Remove the CSW pump

Loosen the water pump mounting bolts, remove the V-belt by sliding it toward the crankshaft side, and remove the sea water pump.



1-18. Remove the rocker arm chamber

- (1) Remove the breather pipe at the side of the intake pipe
[intake manifold for model 3GMF and 3HMF]
- (2) Remove the rocker arm chamber



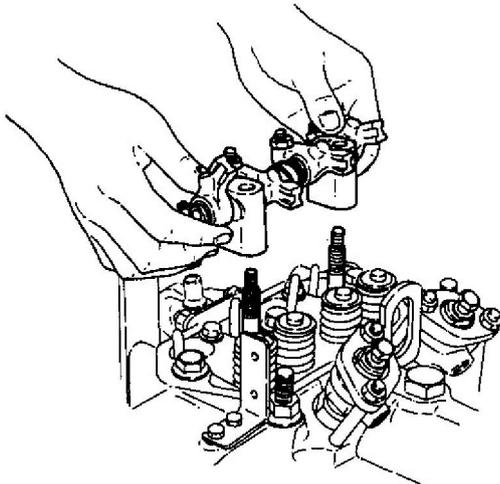
After this step disassembly is carried out in the same sequence as for the sea water-cooled engine.

The details are given in Section 4.3.14 "Remove the rocker arms." P12-23 of the sea water-cooled engine manual.

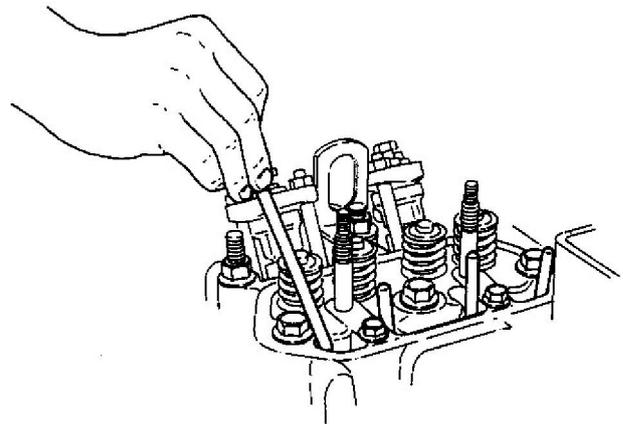
For reference

4-3.14 Remove the rocker arms

- (1) Remove the mounting nut and remove the rocker arm shaft assembly.



- (2) Pull the push rods.

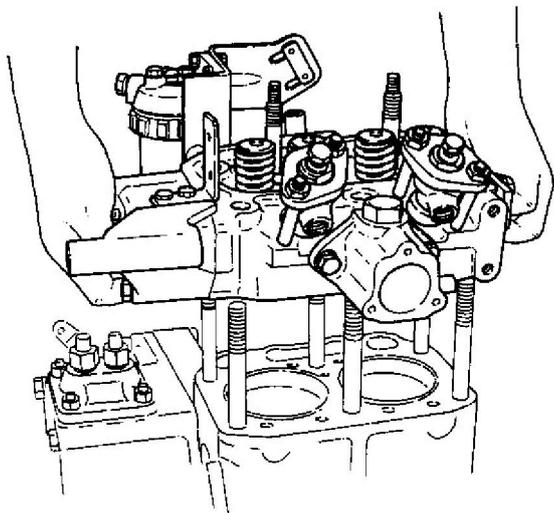


- (3) Remove the cotter pins of the intake and exhaust valve springs.

NOTE: Arrange the parts by cylinder no., intake and exhaust.

4-3.15 Remove the cylinder head

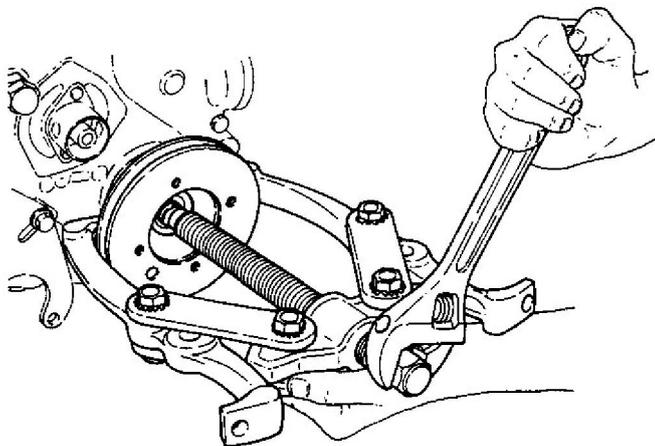
- (1) Disconnect the lubricating oil pipe.
- (2) Remove the cylinder head nuts in the prescribed order, and remove the cylinder head.
- (3) Remove the gasket packing.



NOTE: Clearly identify the front and back of the gasket packing.

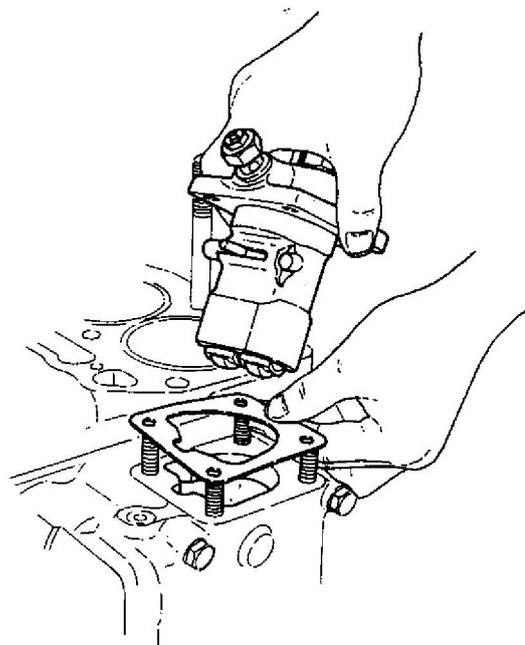
4-3.16 Remove the crankshaft pulley

Remove the crankshaft pulley end nut and remove the V-pulley and key.



4-3.17 Remove the injection pump

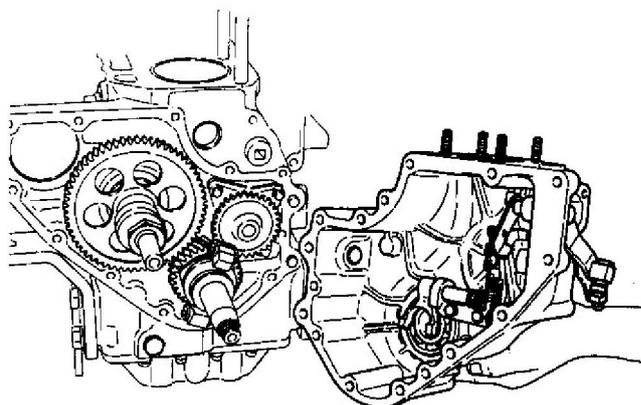
- (1) Remove the injection pump nut.
- (2) Remove the gear case side cover, move the governor lever 2, take out the fuel injection pump by matching the control rack with the cut-off part of the gear case.



- (3) Remove the injection timing adjustment shims.
CAUTION: Note the number and total thickness of the timing adjustment shims.

4-3.18 Remove the timing gear case

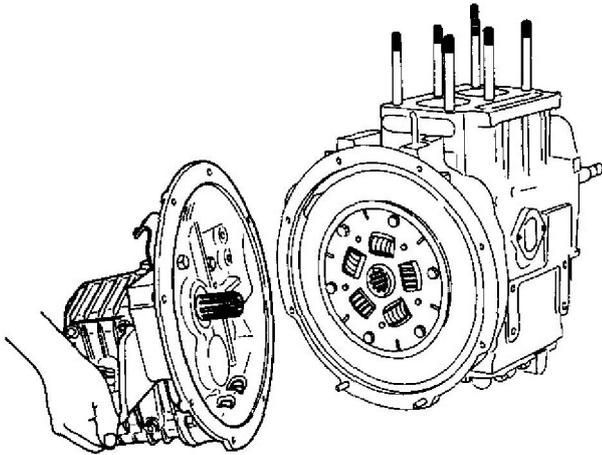
- (1) Remove the gear case



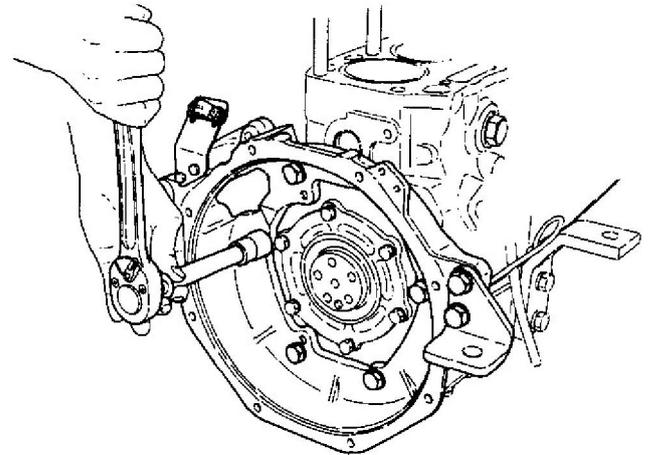
- (2) Remove the thrust collar, thrust needle bearing, and governor sleeve.

4-3.19 Remove the clutch assembly

Loosen the mounting flange bolts and remove the clutch assembly.

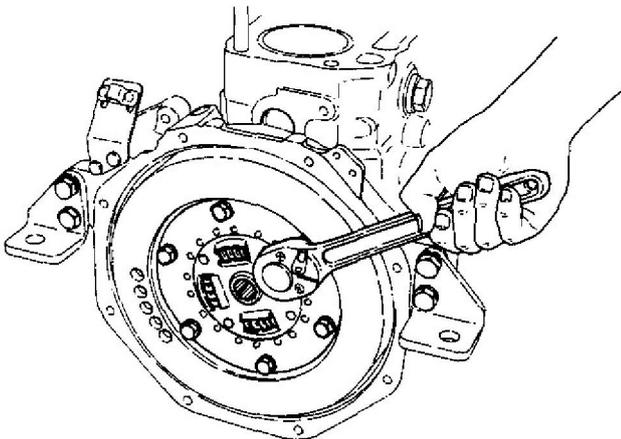


4-3.21 Remove the flywheel housing



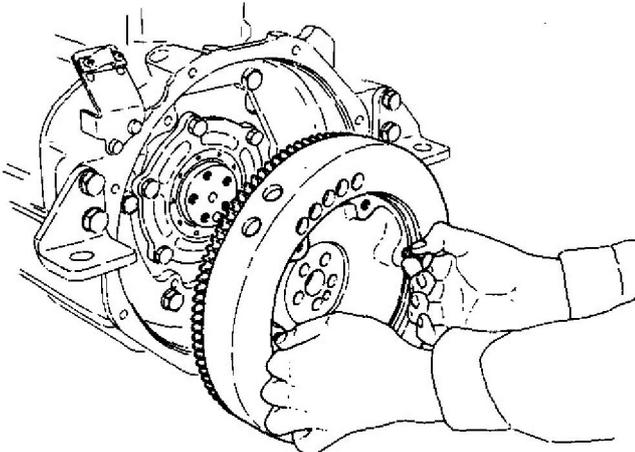
4-3.20 Remove the flywheel

(1) Remove the damper disk.



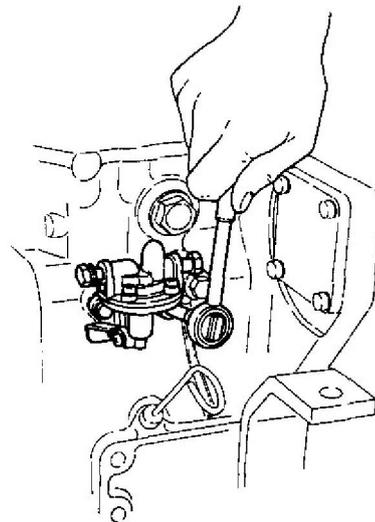
(2) Remove the flywheel.

Screw-in the two bolts to secure the clutch disk (slightly to the left and right sides of the flywheel) and remove it by pulling on the bolts.



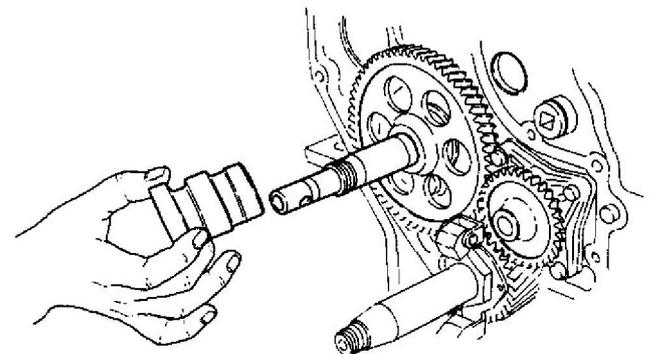
4-3.22 Remove the lubricating oil dipstick

4-3.23 Remove the feed pump

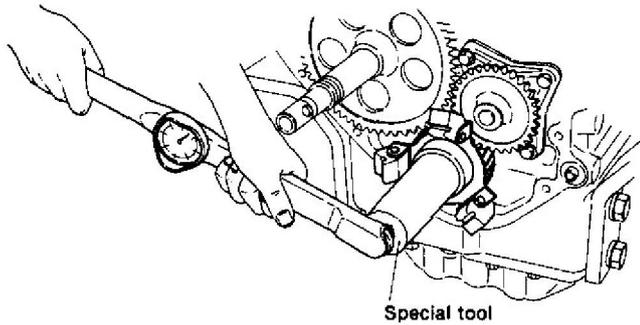


4-3.24 Remove the fuel cam

Remove the camshaft end nut and remove the fuel cam.



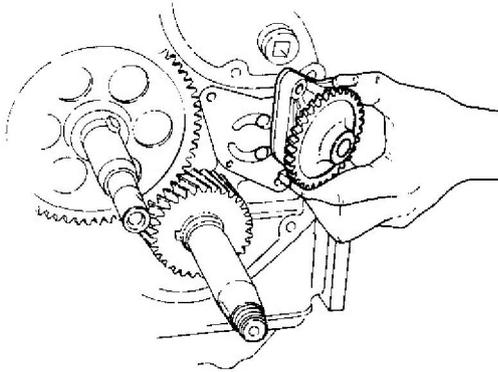
4-3.25 Remove the governor weight assembly



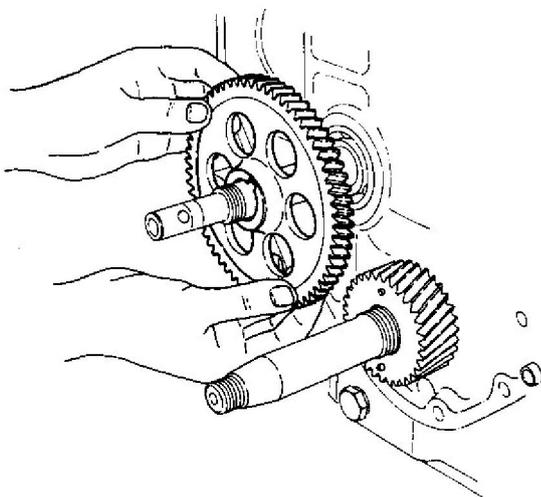
Special tool

Remove the crankshaft end nut and remove the governor weight assembly.

4-3.26 Remove the lubricating oil pump and driving gear assembly



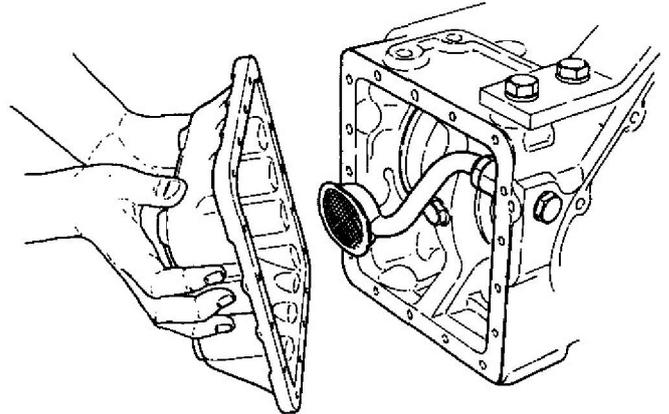
4-3.27 Remove the camshaft gear and the crankshaft gear



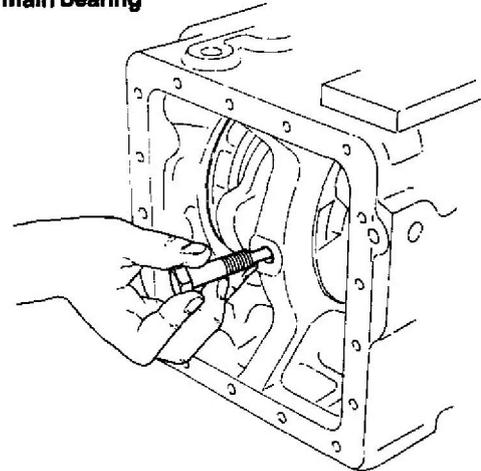
4-3.28 Turn the engine onto its side

- (1) Remove the engine feet of the crankshaft side
- (2) Turn the cylinder block over so that the crankshaft side is on the bottom.

4-3.29 Remove the oil pan and the intake pipe

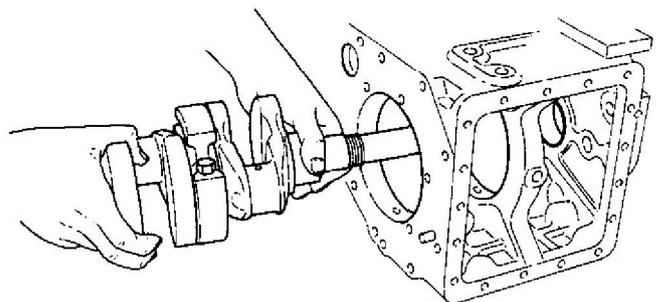


4-3.32 Remove the mounting bolt of the intermediate main bearing



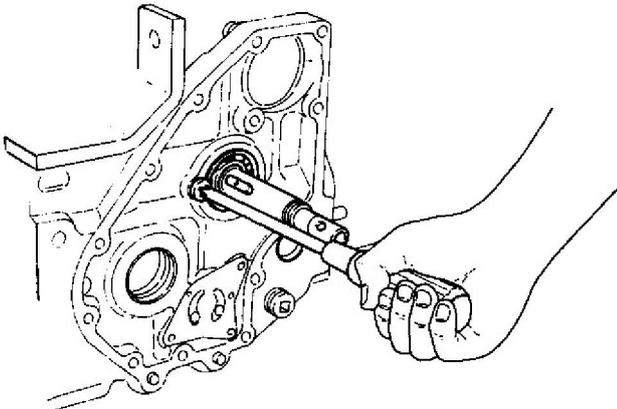
There are two Intermediate main bearings, viz. No.1 and No.2, for engine model 3GM(D).

4-3.33 Pull the crankshaft

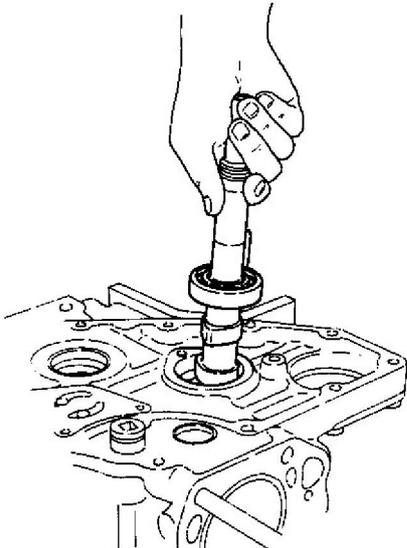


4-3.34 Remove the camshaft

(1) Remove the camshaft bearing set screw.

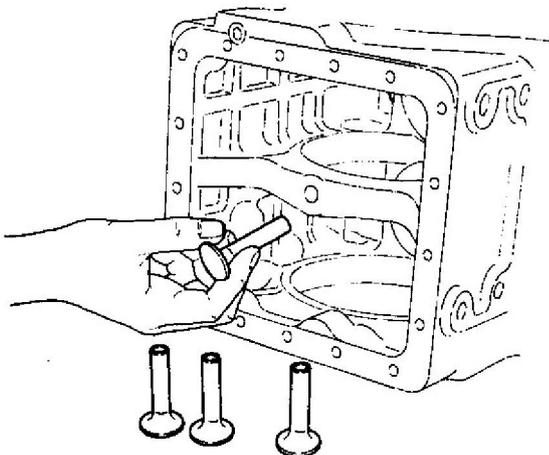


(2) Place the cylinder block upside down or raise the cylinder block by inserting a plate beneath it in order to prevent contact between the tappet and the cam.



(3) Check that all the tappets are separated from the cam, and pull the camshaft out.

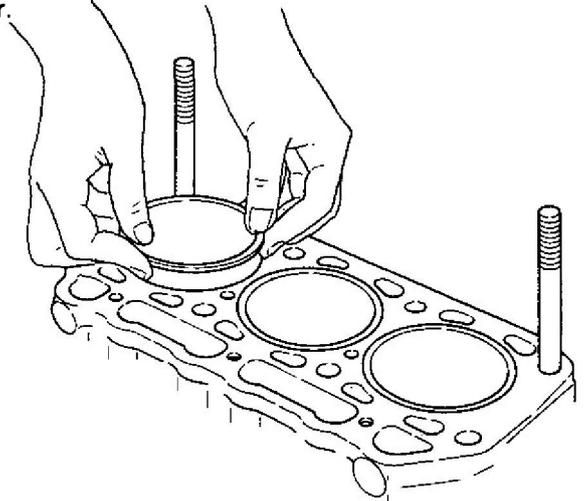
4-3.35 Remove the tappets



NOTE: Arrange the removed tappets by cylinder no. and intake and exhaust groups.

4-3.36 Remove the liners

Set the engine upright and pull the liners with a liner puller.



2. Reassembly of fresh water-cooled engine

In general, the reassembly of the fresh water-cooled engine is the same as that for a sea water-cooled engine, except for cooling system components such as the heat exchanger, fresh water pump, cooling water pipe and related parts.

For details of the first half of the reassembly sequence refer to the sea water-cooled engine manual, Sections 5-3.1, P12-35 to 5-3.24, P12-41.

For reference

5-3.1 Assemble the cylinder liners

- (1) Remove any rust from the cylinder block where it contacts the cylinder liners.
- (2) Coat the outside periphery of the liners with waterproofing paint.
- (3) Insert the liners into the cylinder block, making sure that the cylinder liner protrusion is correct.

5-3.3 Insert the camshaft

- (1) Coat the camshaft bearing section with oil and insert the camshaft into the cylinder block by tapping the shaft end with a plastic hammer.

5-3.2 Insert the tappets

NOTE: Be careful not to damage the groove in the end of the shaft.

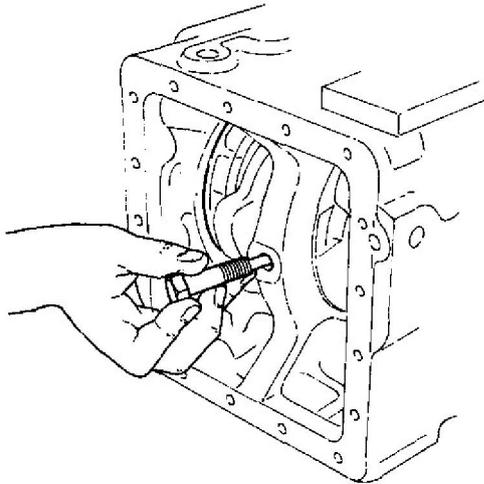
- (2) After inserting the camshaft, check that it rotates smoothly before tightening the camshaft bearing set screw.

Tightening torque	2 kg-m (14.5 ft-lb)
-------------------	---------------------

5-3.4 Install the crankshaft

NOTE: Assemble the tappets in their original positions, paying careful attention to the cylinder numbers and intake and exhaust groupings.

5-3.5 Tighten the set bolt of the intermediate main bearing

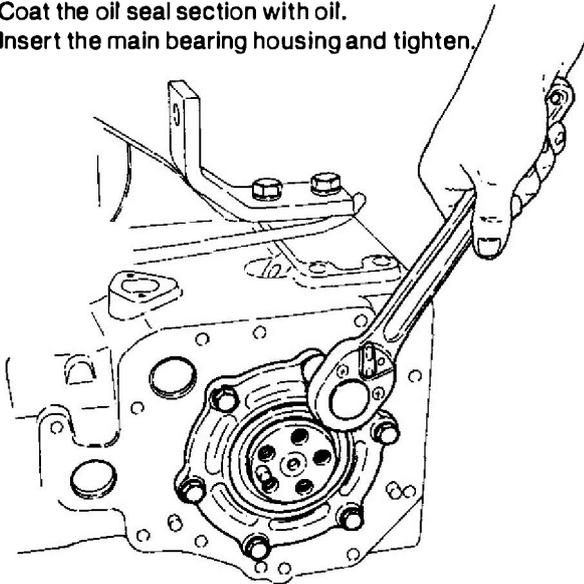


There are two Intermediate main bearings, viz No.1 and No.2, for model 3GM(D).

	kg·m (ft·lb)	
	2GM, 3GM(D)	3HM
Tighten torque	4.5 ~ 5.0 (32.5 ~ 36.2)	7.0 ~ 7.5 (50.6 ~ 54.2)

5-3.6 Install the main bearing housing

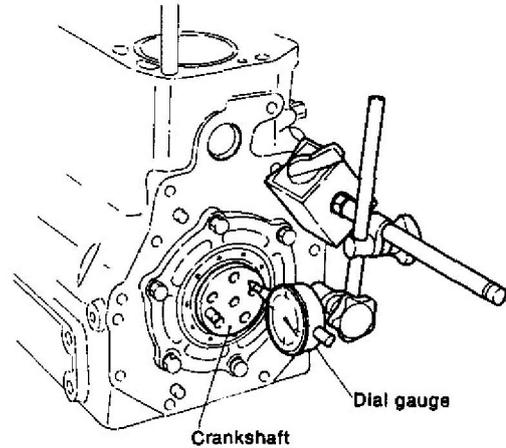
- (1) Coat the oil seal section with oil.
- (2) Insert the main bearing housing and tighten.



Tightening torque	2.5 kg·m (18 ft·lb)
-------------------	---------------------

- (3) Check that the crankshaft rotates smoothly.

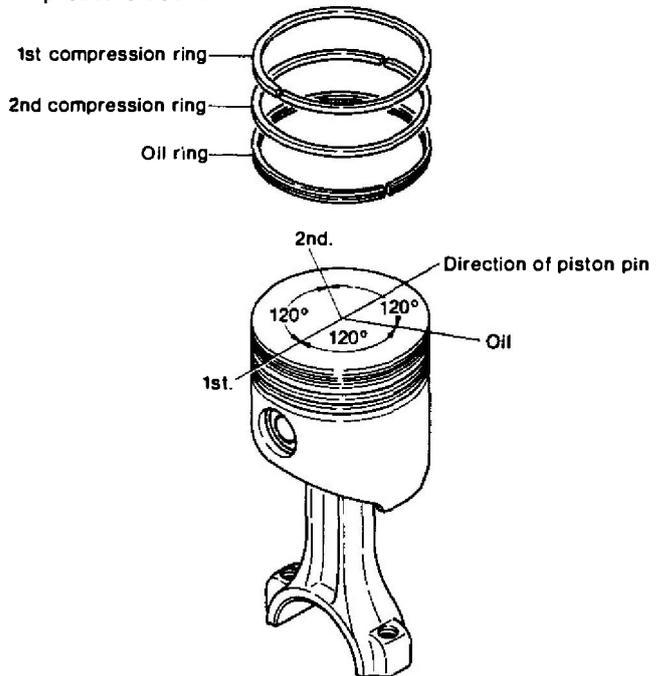
- (4) Measure the crankshaft side gap, and adjust it to the prescribed value by the thickness of the packing.



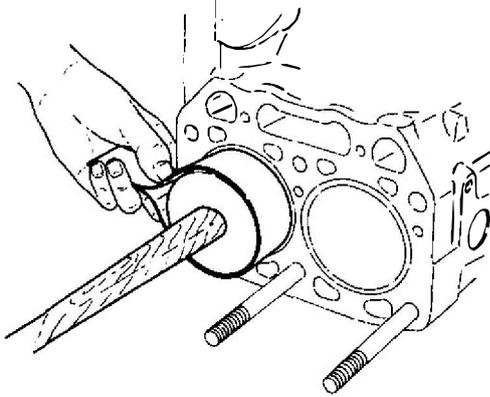
Crankshaft side gap	0.09 ~ 0.18mm (0.035 ~ 0.0071in.)
---------------------	--------------------------------------

5-3.7 Assemble the piston and connecting rod assembly

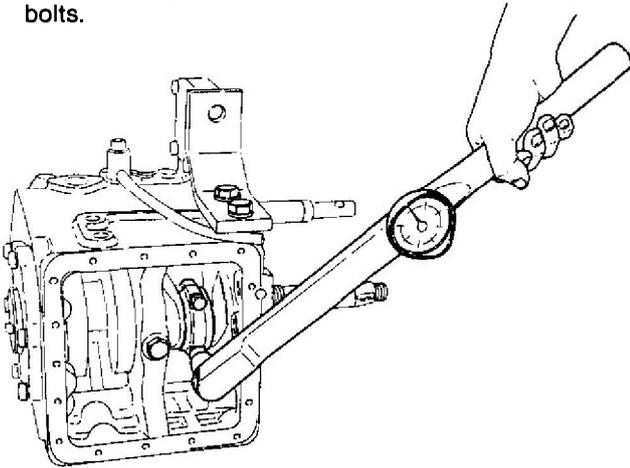
- (1) Coat the crankpin section with oil and position so that the Insertion side crank is at the top.
- (2) Coat the piston and crankpin bearing with oil.
- (3) Position the piston rings so that the gaps are 120° apart; make sure that there is no gap at the side pressure section.



- (4) Insert the piston connecting rod assembly so that the side of the connecting rod large end with the identification number is on the exhaust side. Install the piston rings with a piston ring inserter.



- (5) After the connecting rod large end contacts the crankpin, push the piston crown down slowly to turn the crankshaft to bottom dead center.
 (6) Align the connecting rod cap and connecting rod large end matching mark and tighten the connecting rod bolts.



CAUTION: 1. Be careful to tighten the connecting rod bolts evenly.
 2. Coat the bolt threads and washer face with oil.

	kg-m (ft-lb)	
	2GM, 3GM(D)	3HM
Tightening torque	2.5 (18.1)	4.5 (32.5)

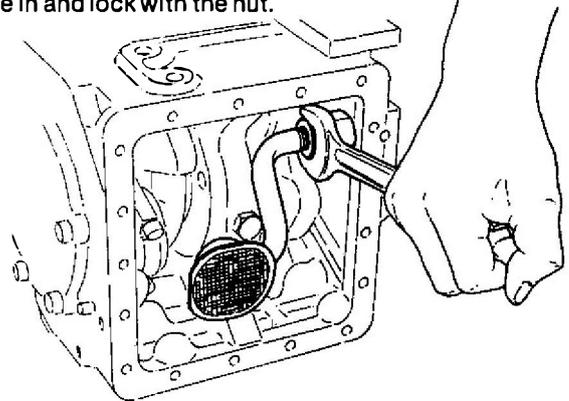
- (7) Measure the side clearance

Side clearance	0.2 ~ 0.4mm (0.0079 ~ 0.0157in.)
----------------	-------------------------------------

- (8) Check that the crankshaft rotates smoothly.

5-3.8 Install the lubricating oil intake pipe

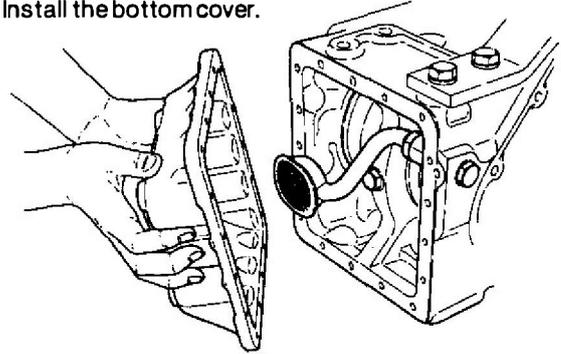
Coat the threads with "Screw Lock Super 203M", screw the pipe in and lock with the nut.



Screw-in distance	8 ~ 10mm (about 6 turns) (0.3149 ~ 0.3937in.)
-------------------	--

5-3.9 Install the engine bottom cover(oil pan)

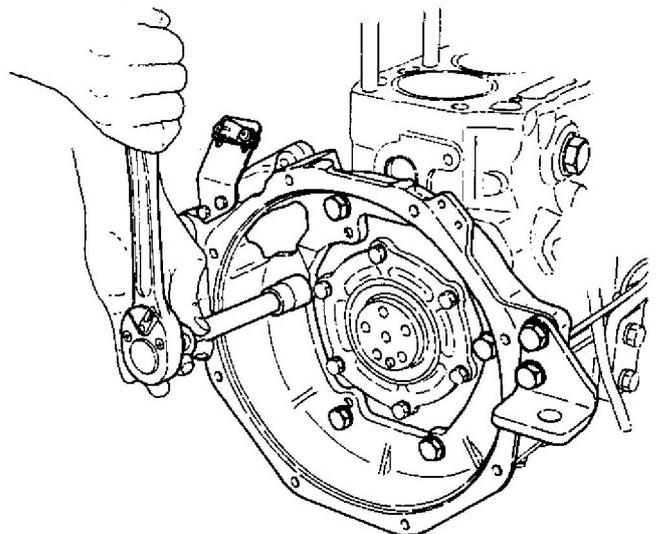
- (1) Change the packing.
 (2) Install the bottom cover.



Tightening torque	0.9 kg-m (6.5 ft-lb)
-------------------	----------------------

5-3.10 Install the mounting flange

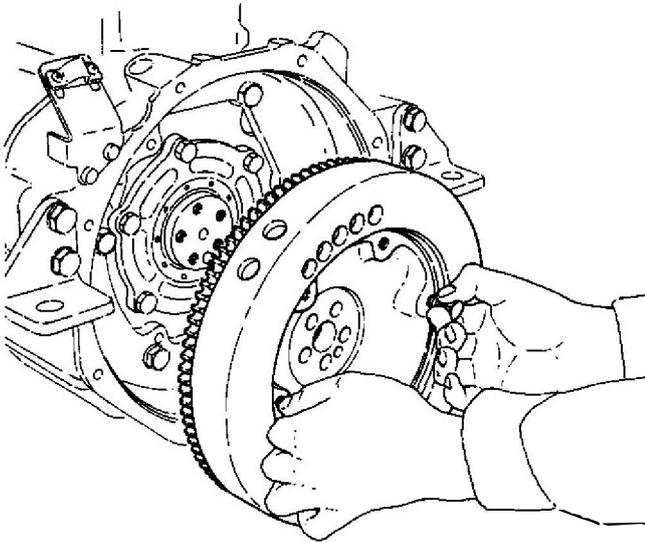
- (1) Set the engine upright.
 (2) Align the positioning pins and tighten the flange.



Tightening torque	4.5 kg-m (32.5 ft-lb)
-------------------	-----------------------

5-3.11 Install the flywheel

- (1) Align the reference pins.
- (2) Install the flywheel.

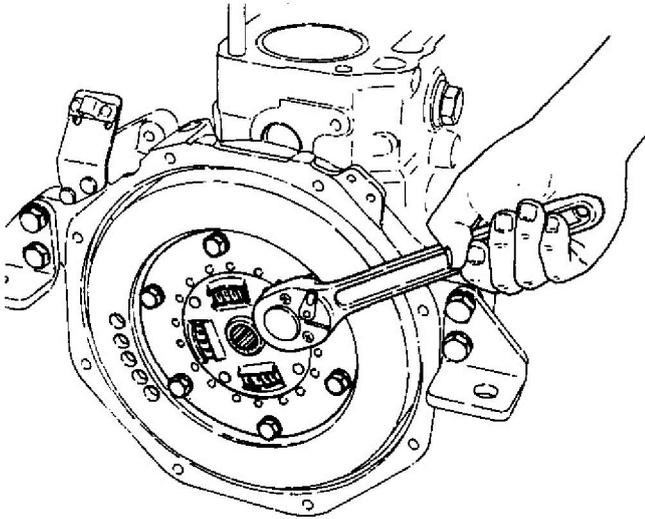


Tightening torque	6.5 ~ 7.0 kg-m (47 ~ 50.6 ft-lb)
-------------------	-------------------------------------

NOTE: After tightening, check the end run-out.

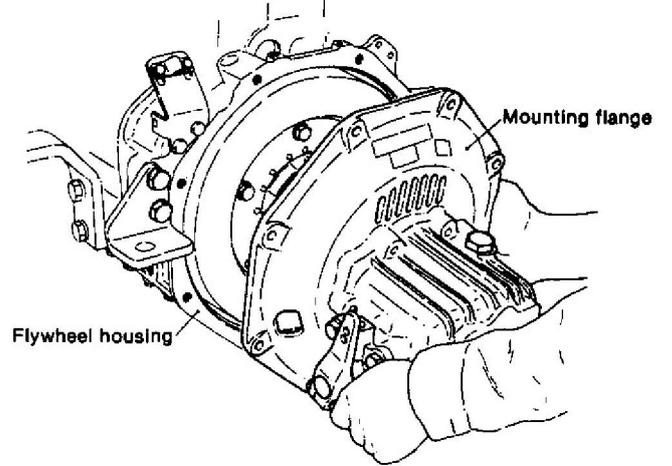
5-3.12 Install the clutch assembly

- (1) Install the clutch disc on the flywheel.



Tightening torque	2.5 kg-m (18 ft-lb)
-------------------	---------------------

- (2) Align the disc and input shaft spline, and install the clutch assembly on the mounting flange.



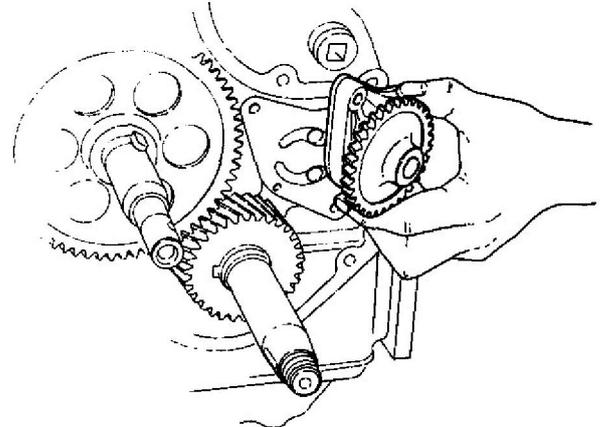
Tightening torque	2.0 ~ 2.5 kg-m (14.5 ~ 18.1 ft-lb)
-------------------	------------------------------------

5-3.13 Install the engine feet and set the engine in position

- (1) Dipstick flange and dipstick.
- (2) Fuel pump.

5-3.14 Install the lubricating oil pump

Install the lubricating oil pump and driving gear assembly.

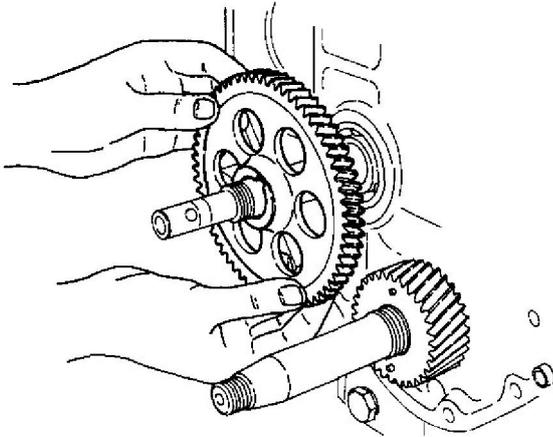


Lube pump body mounting bolt	0.9 kg-m (6.5 ft-lb)
------------------------------	----------------------

5-3.15 Assemble the camshaft gear and fuel cam

- (1) Coat the shaft hole of the camshaft gear with oil and insert the gear.

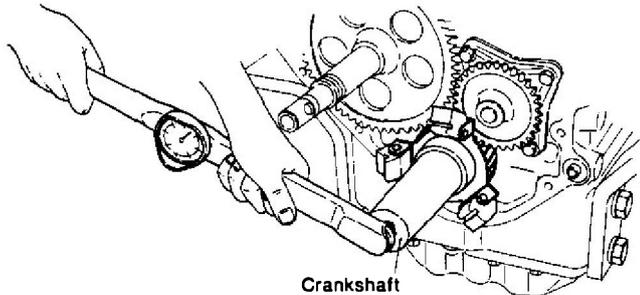
- (2) Coat the fuel cam with oil and insert the cam by aligning the "0" mark opposite the camshaft gear.



- (3) Tighten the camshaft end nut.

Tightening torque	7 ~ 8 kg-m (50.6 ~ 57.9 ft-lb)
-------------------	--------------------------------

5-3.16 Assemble the crankshaft gears



- (1) Coat the crankshaft section and the inside of the gear with oil.
 (2) Align the matching marks of the camshaft gear and the crankshaft gear and insert the crankshaft gear.
 (3) After inserting the crankshaft gear, check the backlash.

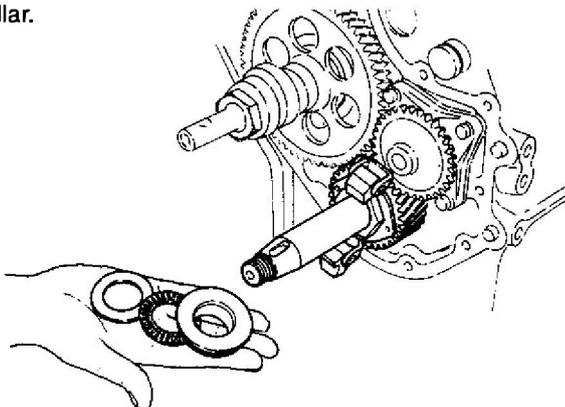
Backlash	0.05 ~ 0.13mm (0.0020 ~ 0.0051in.)
----------	---------------------------------------

- (4) Install the governor weight assembly and tighten the crankshaft end nut.

Tightening torque	8 ~ 10 kg-m (57.9 ~ 72.3 ft-lb)
-------------------	---------------------------------

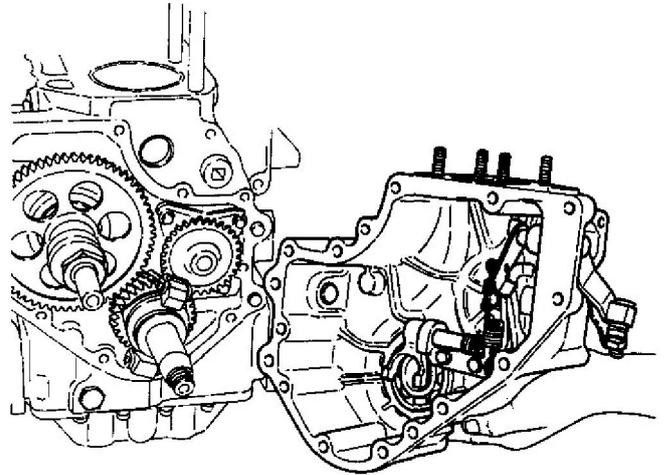
5-3.17 Install the governor sleeve

Install the governor sleeve, thrust needle bearing and thrust collar.



5-3.18 Install the timinggearcase

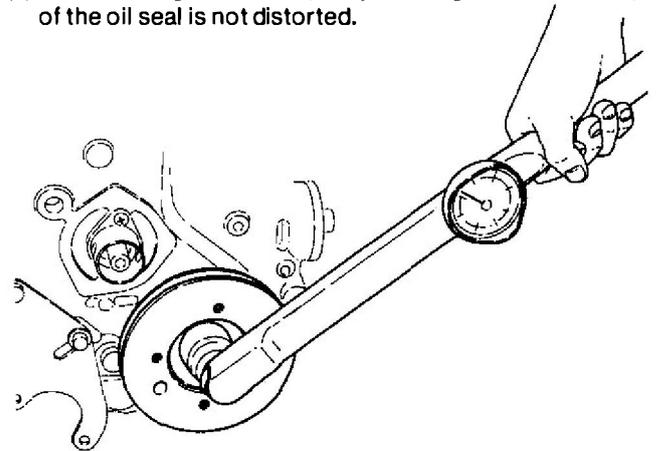
- (1) Coat both sides of the new packing with "Three Bond 3B8-005" and install.
 (2) Install the timing gear case.



Tightening torque	2.5 kg-m (18 ft-lb)
-------------------	---------------------

5-3.19 Install the crankshaft V-pulley

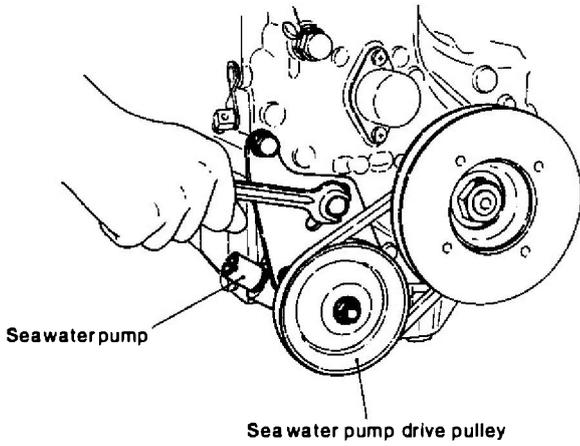
- (1) Install the crankshaft key.
 (2) Coat the crankshaft V-pulley and the inside of the oil seal with oil.
 (3) Insert and tighten the V-pulley, making sure that the lip of the oil seal is not distorted.



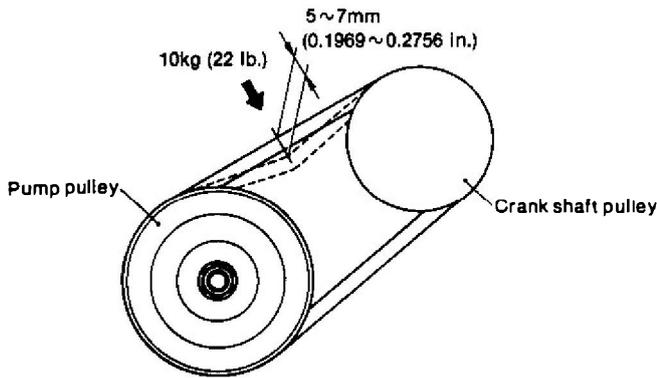
Tightening torque	10 kg-m (72.3 ft-lb)
-------------------	----------------------

5-3.20 Install the water pump

Install the V-belt to the crankshaft V-pulley and install the water pump.



(1) V-belt tension

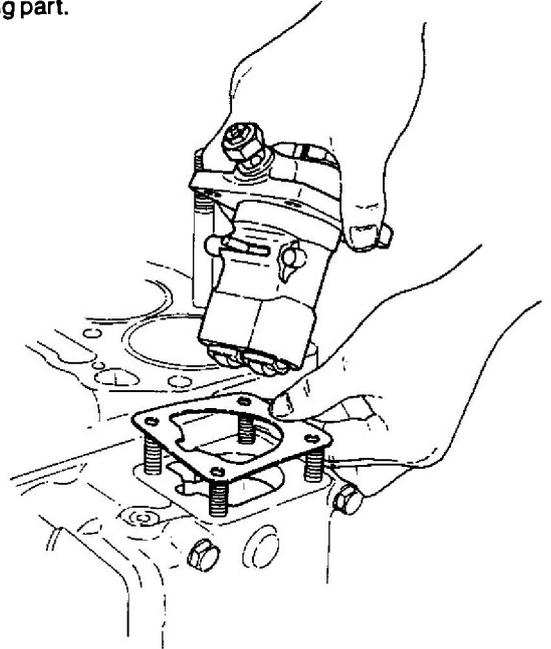


V-belt tension Pushed with a force of 10kg (22 lb.)	5 ~ 7mm (0.1969 ~ 0.2756 in.)
--	----------------------------------

(2) Tightening torque.

Tightening torque	2.5 kg-m (18 ft-lb)
-------------------	---------------------

(3) Insert the pump by looking through the gear case side cover, and align the governor No.2 lever and rack connecting part.



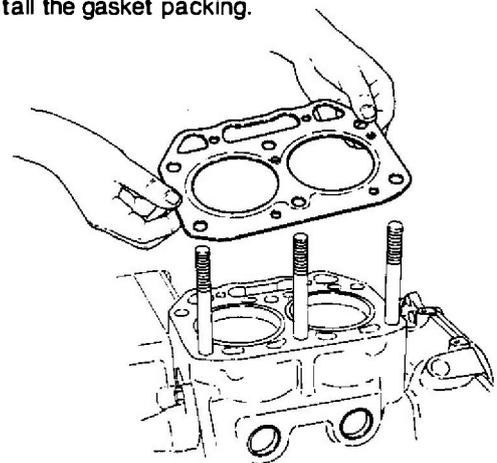
(4) Tighten the fuel pump

Tightening torque	2.5 kg-m (18 ft-lb)
-------------------	---------------------

(5) Install the gear case side cover.

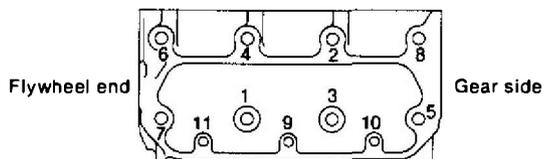
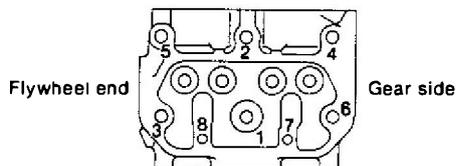
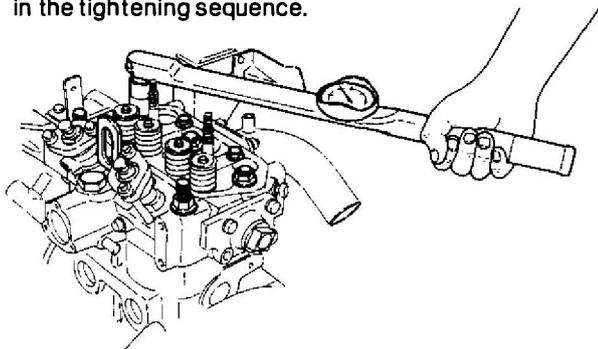
5-3.22 Install the cylinder head

(1) Install the gasket packing.



CAUTION: Take particular notice of the surfaces to be fitted.
 Keep the TOP mark on the cylinder head side.

- (2) Insert the cylinder head, being careful not to damage the threads of the tightening bolts, and tighten the nuts in the tightening sequence.

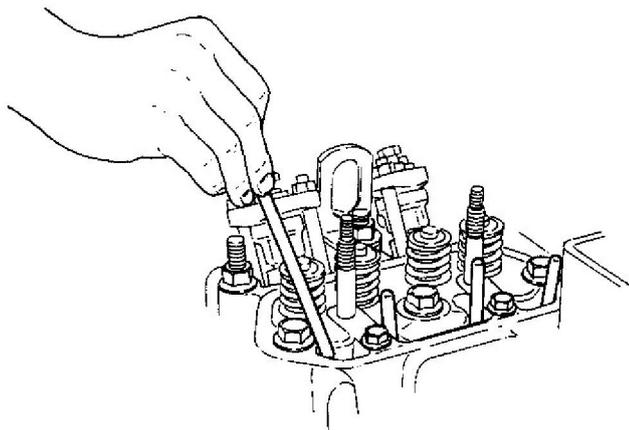


		kg-m (ft-lb)	
		2GM, 3GM(D)	3HM
Tightening torque	Main	10 (72.3)	13 (94.0)
	Sub	2.5 (18.1)	3 (21.7)

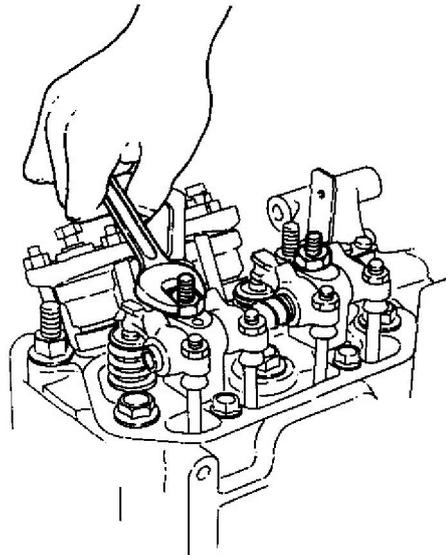
- (3) Install the waterpipe (from the thermostat cover to the cylinder inlet joint).

5-3.23 Install the rocker arms

- (1) Install the push rods on the tappets.



- (2) Coat the inside of valve spring retainer with oil.
 (3) Install the rocker arm shaft assembly and tighten the nut.



Tightening torque	3.7 kg-m (27 ft-lb)
-------------------	---------------------

CAUTION: 1. Loosen the valve head clearance adjusting screw in advance.

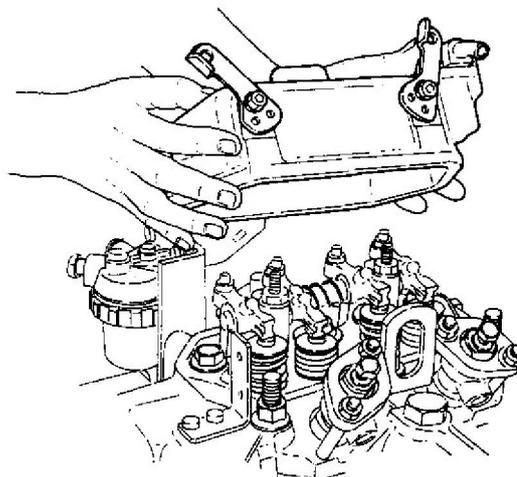
2. Check that the arm moves smoothly.

- (4) Adjust the intake and exhaust valve head clearance and lock with the nut.

Intake and exhaust valve head clearance (engine cold)	0.2mm (0.008in.)
---	------------------

5-3.24 Install the rocker arm cover

- (1) Install the rocker arm cover.



- (2) Install the breather pipe to the air intake pipe (intake manifold...3GM).