

CHAPTER 6

COOLING WATER SYSTEM

<u>1</u>	<u>Cooling Water System</u>	<u>6-1</u>
<u>2</u>	<u>Sea Water Pump</u>	<u>6-4</u>
<u>3</u>	<u>Fresh Water Pump</u>	<u>6-7</u>
<u>4</u>	<u>Heat Exchanger</u>	<u>6-10</u>
<u>5</u>	<u>Pressure Cap and Sub Tank</u>	<u>6-12</u>
<u>6</u>	<u>Thermostat</u>	<u>6-14</u>
<u>7</u>	<u>Kingston Cock (Optional)</u>	<u>6-16</u>
<u>8</u>	<u>Sea Water Filter (Optional)</u>	<u>6-17</u>
<u>9</u>	<u>Bilge Pump and Bilge Strainer (Optional)</u>	<u>6-18</u>

1. Cooling Water System

The cooling water system is of the indirect sea water cooled, fresh water circulation type. The cylinders, cylinder heads, turbocharger (only 4JH-HTE & 4JH-DTE) and exhaust manifold are cooled with fresh water, and the lube oil cooler air cooler (only 4JH-HTE & 4JH-DTE) and fresh water cooler (heat exchanger) use sea water.

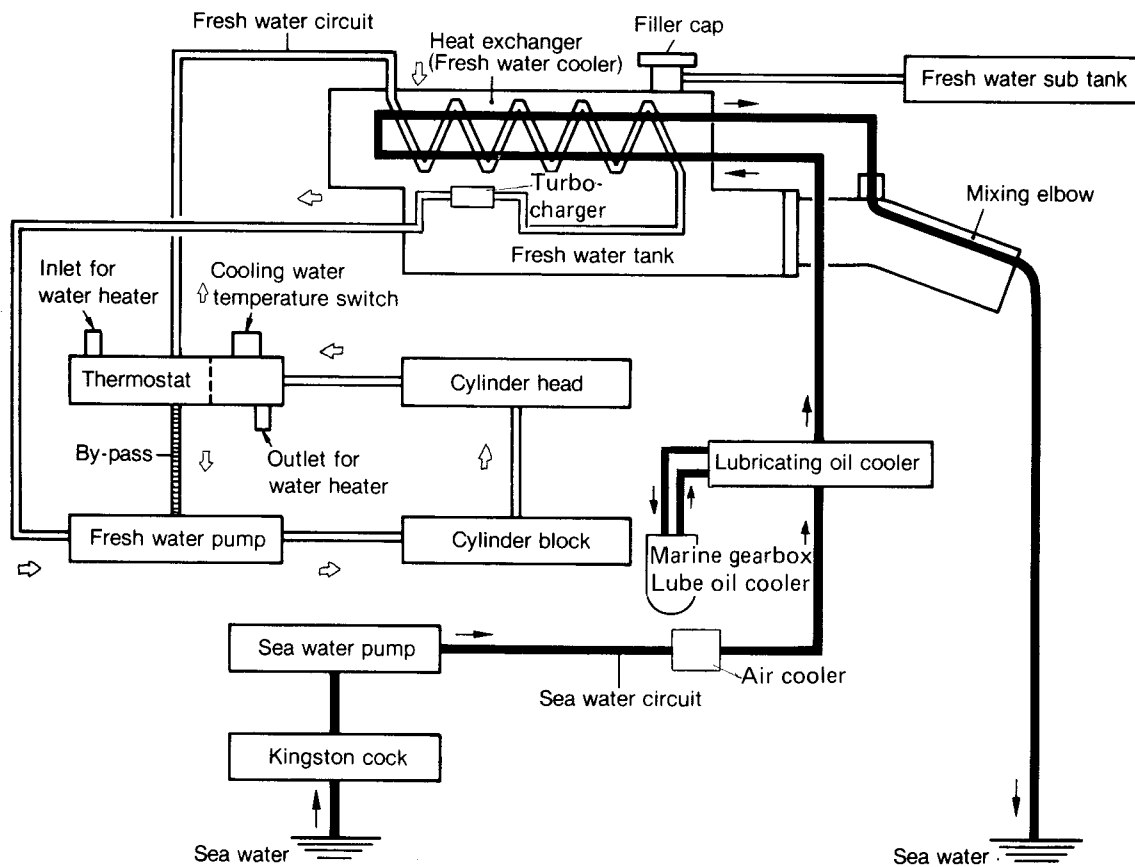
Sea water pumped in from the sea by the sea water pump cools the lube oil in the lube oil cooler and then goes to the heat exchanger, where it cools the fresh water. Then it is sent to the mixing elbow and is discharged from the ship with the exhaust gas.

Fresh water is pumped by the fresh water pump from the fresh water tank to the cylinder jacket to cool the cylinders, turbocharger and then the cyl-

inder head. The fresh water pump body also serves as a discharge passageway (line) at the cylinder head outlet, and is fitted with a thermostat.

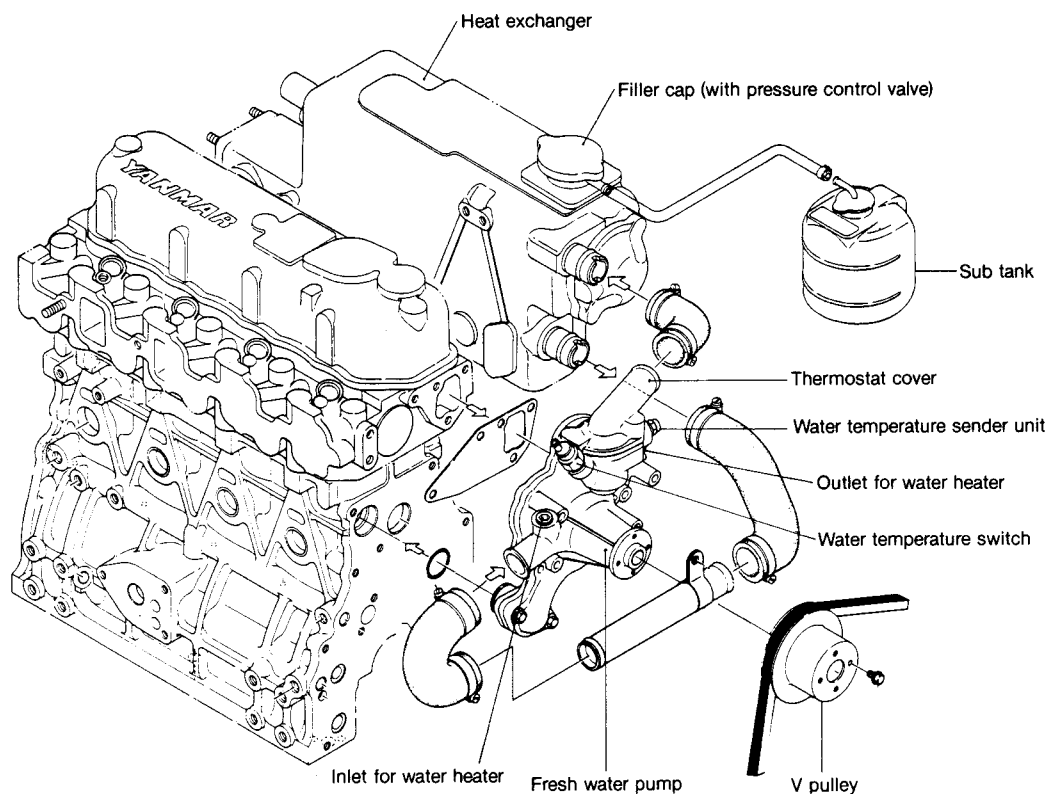
The thermostat is closed when the fresh water temperature is low, immediately after the engine is started and during low load operation, etc. Then the fresh water flows to the fresh water pump inlet, and is circulated inside the engine without passing through the heat exchanger.

When the temperature of the fresh water rises, the thermostat opens, fresh water flows to the heat exchanger, and it is then cooled by the sea water in the tubes as it flows through the cooling pipe. The temperature of the fresh water is thus kept within a constant range by the thermostat.

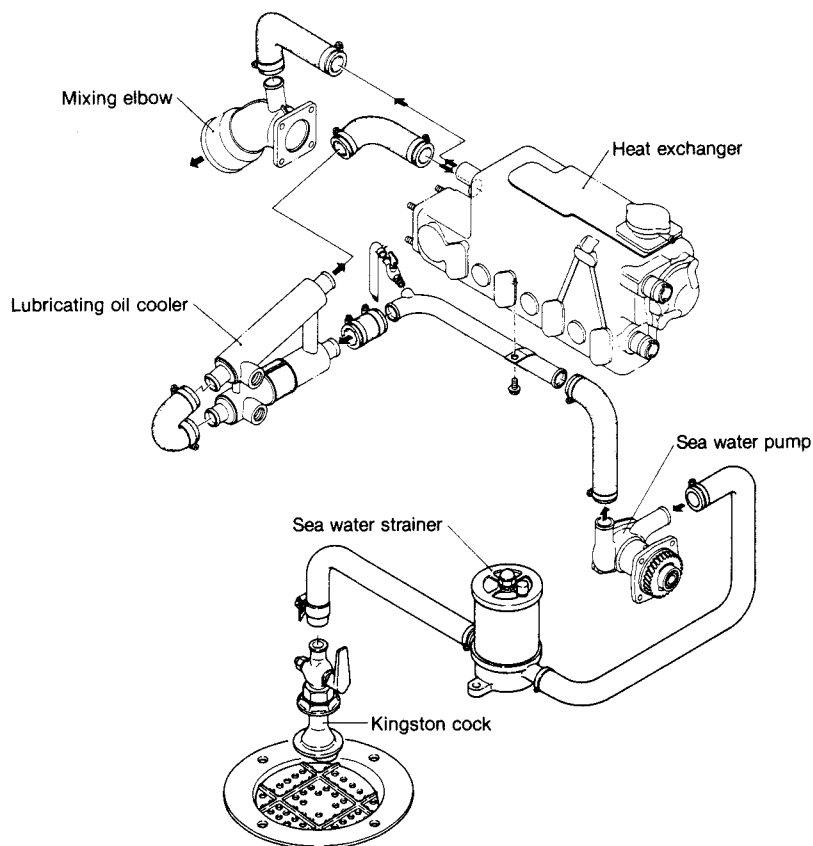


NOTE: Air cooler, marine gear box, lube oil cooler, and water-cooled turbocharger are only for models 4JH-HTE and 4JH-DTE.

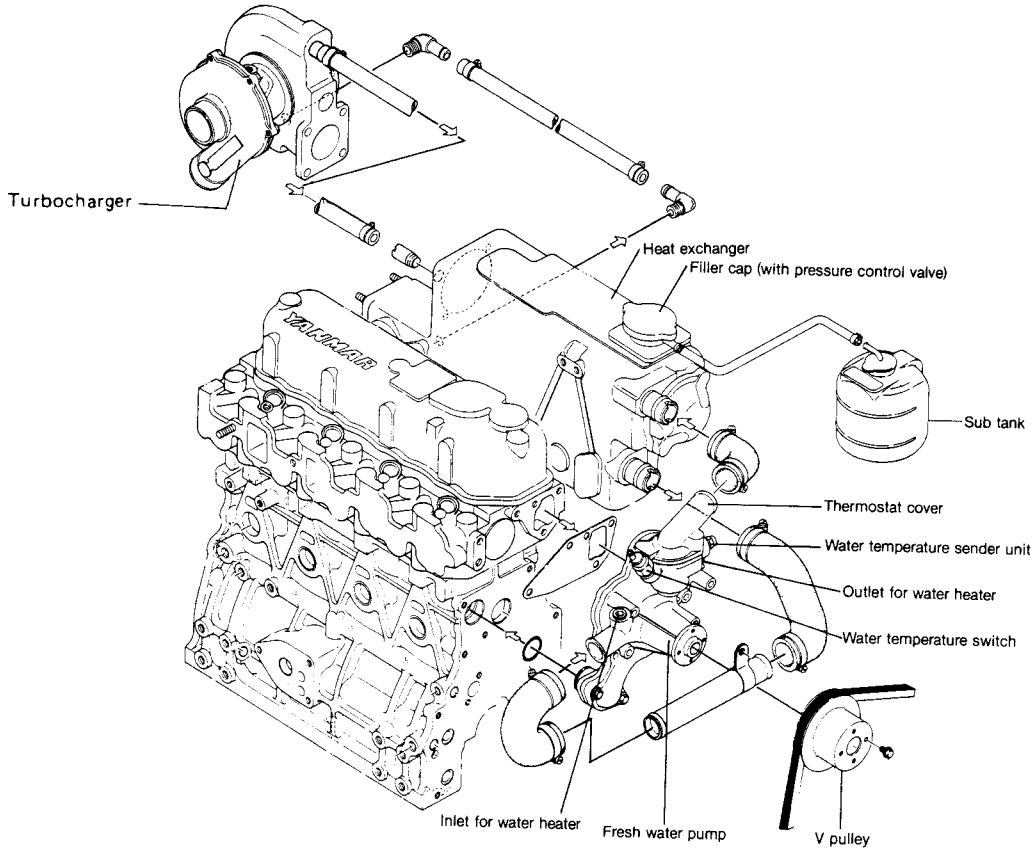
Fresh water line [ENGINE MODEL: 4JHE & 4JH-TE]



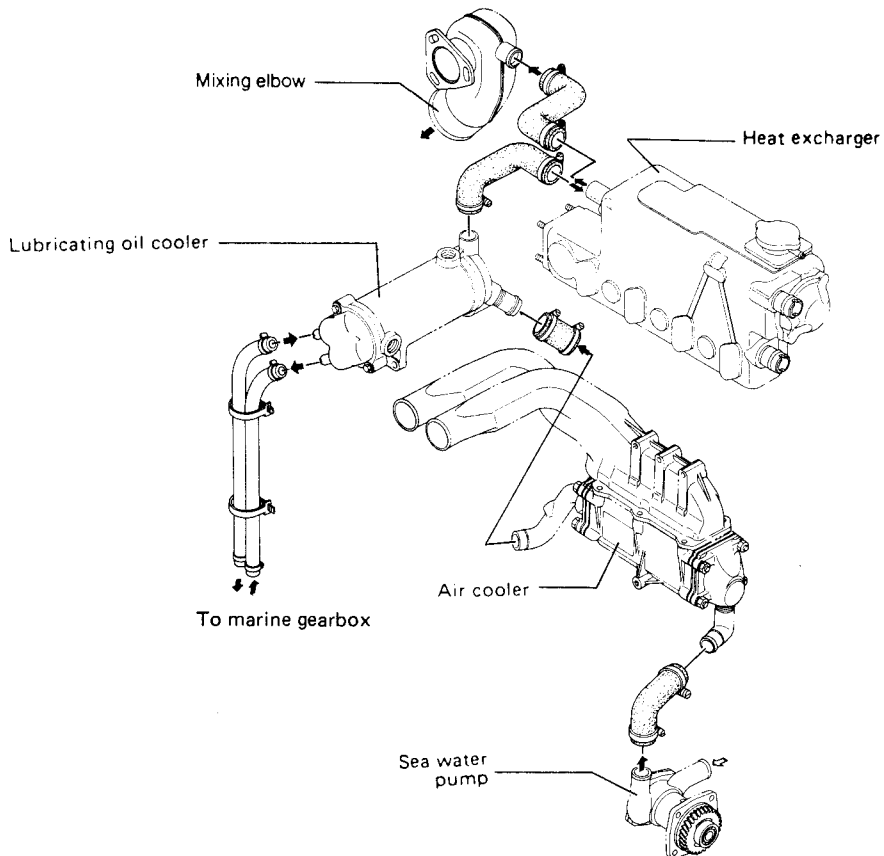
Sea water line [ENGINE MODEL: 4JHE & 4JH-TE]



Fresh water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]



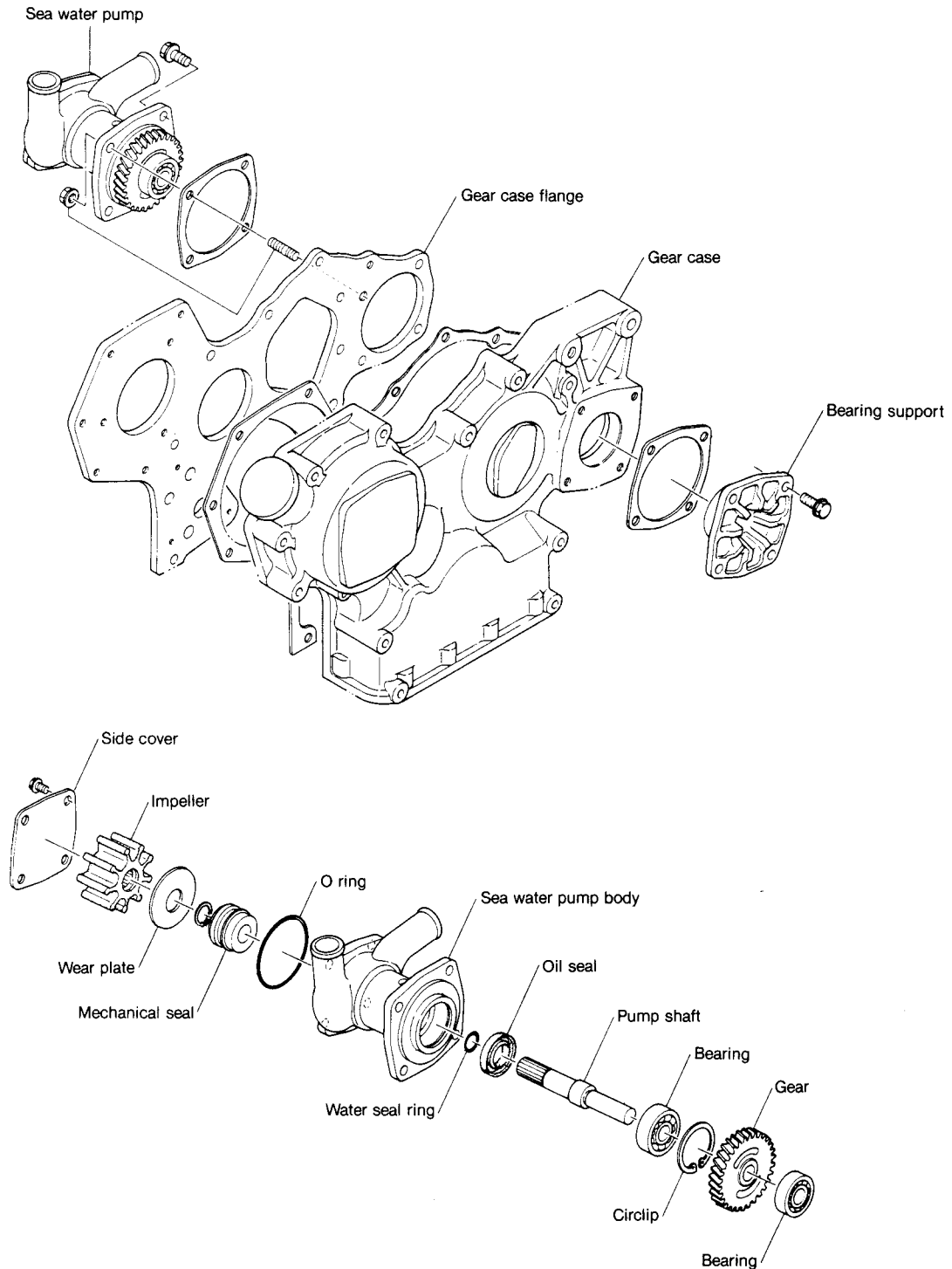
Sea water line [ENGINE MODEL: 4JH-HTE & 4JH-DTE]

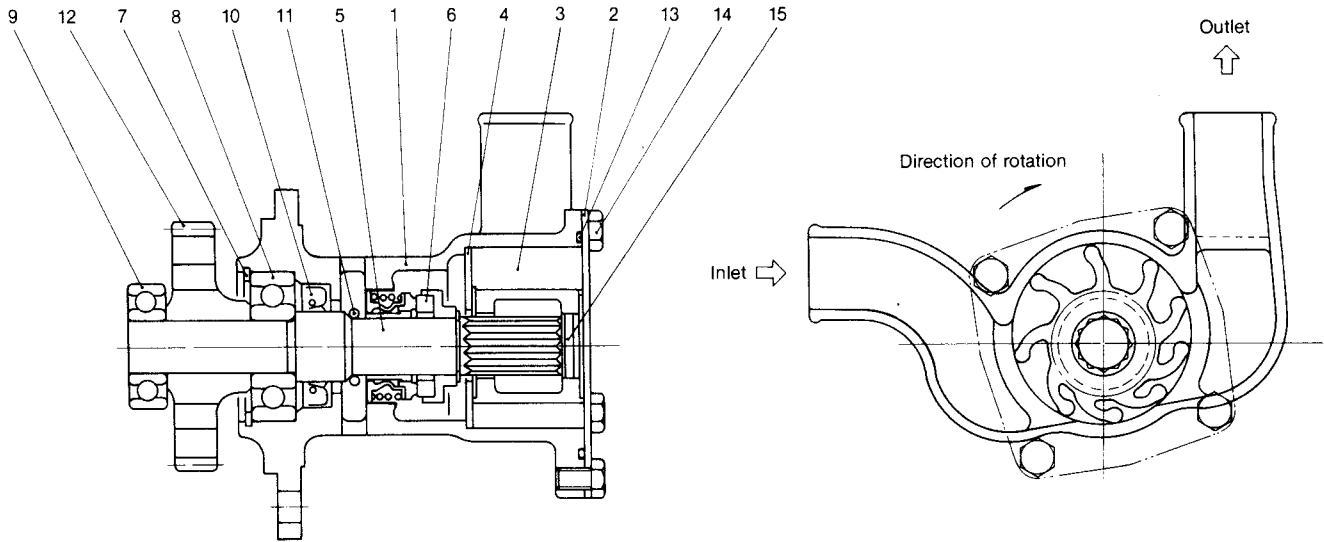


2. Sea Water Pump

2-1 Sea water pump construction and functioning

The sea water pump has a rubber impeller. The sea water pump is mounted to the gear case, and the drive gear on the end of the sea water pump shaft meshes with the camshaft gear to drive the pump.





- | | | |
|------------------------|--------------------|--------------------------|
| 1. Sea water pump body | 6. Mechanical seal | 11. Water seal ring |
| 2. Side cover | 7. Circlip | 12. Gear |
| 3. Impeller (C-type) | 8. Bearing | 13. O ring |
| 4. Wear plate | 9. Bearing | 14. Hexagonal bolt |
| 5. Pump shaft | 10. Oil seal | 15. Impeller blind cover |

2-2 Specifications of sea water pump

Engine speed (max.)	3600 rpm
Gear ratio (crank gear/pump gear)	28/31
Pump speed	3252 rpm
Suction head	0.5m (1.66 ft)
Total head	9.5m (31.16 ft)
Delivery capacity	3250 l/h (198315 in. ³ /h)

2-3 Sea water pump disassembly

- (1) Remove the rubber hose from the sea water pump outlet and then the sea water pump assembly from the gear case.
- (2) Remove the sea water pump cover and take out the O-ring, impeller and wear plate.
- (3) Remove the mechanical seal side stop ring.
- (4) Insert pliers from the drive gear long hole and remove the stop ring that holds the bearings.
- (5) Lightly tap the pump shaft from the impeller side and

remove the pump shaft, bearings, and drive gear as a set.

- (6) Remove the oil seal and mechanical seal if necessary.

2-4 Sea water pump inspection

- (1) Inspect the rubber impeller, checking for splitting around the outside, damage or cracks, and replace if necessary.

mm (in.)

	Standard	Clearance at assembly	Maximum allowable clearance	Wear limit
Impeller width	31.6 ~ 31.8 (1.2440 ~ 1.2519)	0 ~ 0.3 (0 ~ 0.0118)	0.8 (0.0314)	31.3 (1.2322)
Wear plate thickness	2 (0.0787)			1.8 (0.0708)
Housing width	33.8 ~ 33.9 (1.3307 ~ 1.3346)			—
Side plate thickness	2 (0.0787)			1.8 (0.0708)

- (3) Inspect the mechanical seal and replace if the spring is damaged, or the seal is corroded. Also replace the mechanical seal if there is considerable water leakage during operation.

Cooling water leakage	less than 3 cc/h (0.18 in. ³ /h)
Parts No. of oil seal	129795-42670

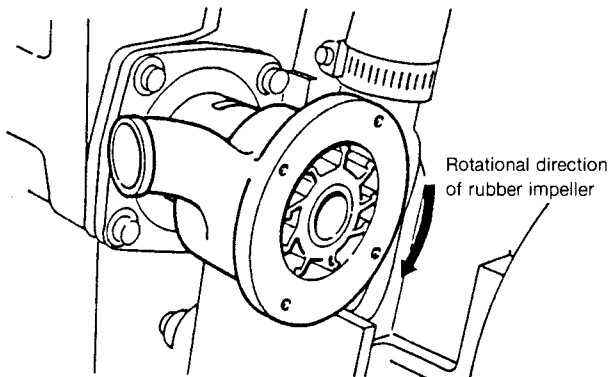
- (4) Make sure the ball bearings rotate smoothly. Replace if there is excessive play.

2-5 Sea water pump reassembly

- (1) When replacing the mechanical seal, coat the No.1101 oil seal and pressure fit. Coat the sliding surface with a good quality silicon oil, taking sufficient care not to cause any scratches.
- (2) When replacing the oil seal, coat with grease and insert.
- (3) Mount the pump shaft, ball bearing and gear assembly to the pump unit and fit the bearing stop ring. Be sure not to forget the water O-ring when doing this.

NOTE: Coat the shaft with grease.

- (4) After inserting the mechanical seal stop ring, mount the wear plate and impeller.



- NOTE: 1. When inserting the impeller in the pump, make sure that the impeller lies in the proper direction.
2. Coat the inside of pump body impeller housing with grease.*

- (5) Mount the O-ring side cover.

NOTE: Replace the O-ring.

3. Fresh Water Pump

3-1 Fresh water pump construction

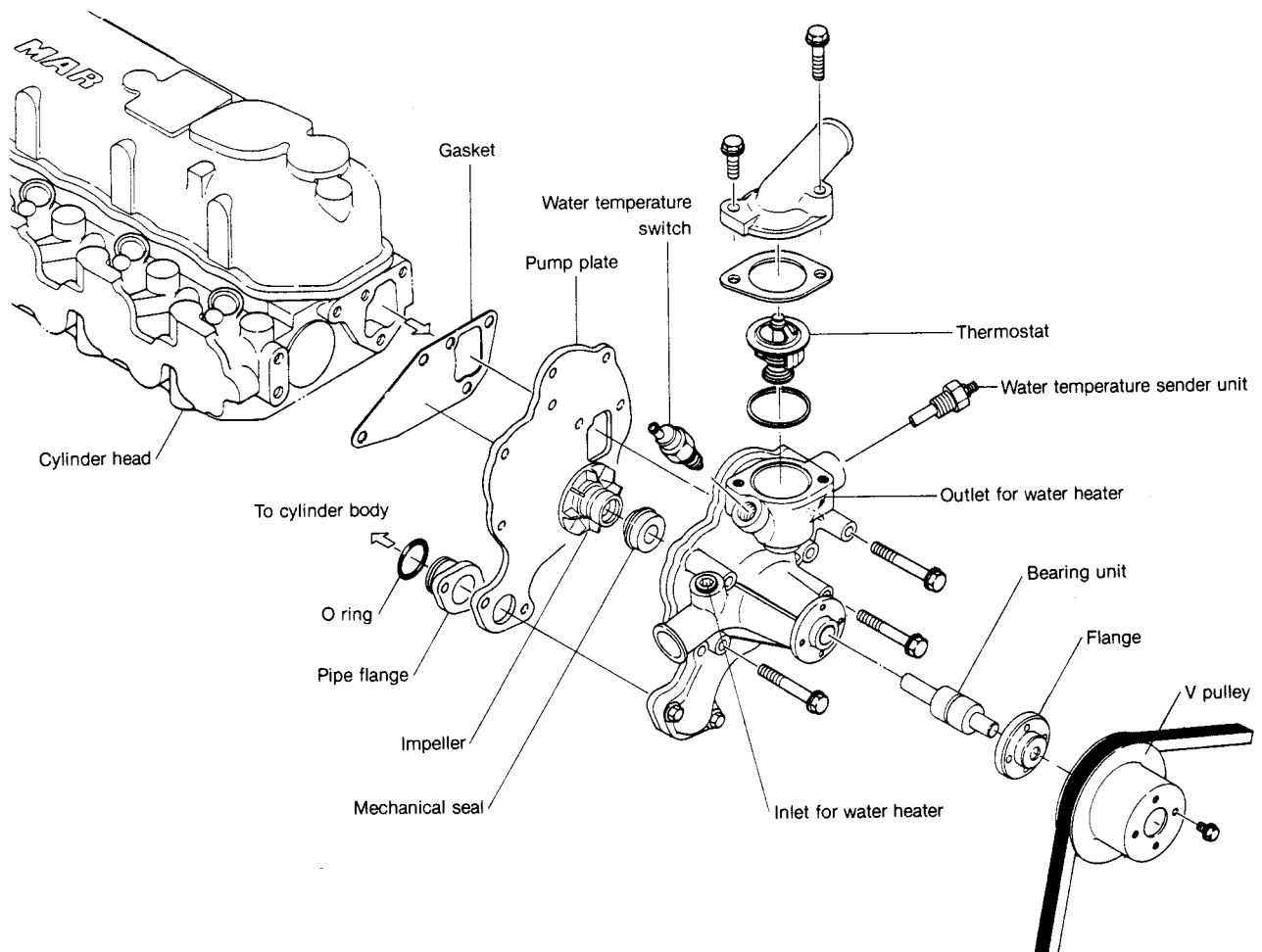
The fresh water pump is of the centrifugal (volute) type, and circulates water from the fresh water tank to the cylinders and cylinder head.

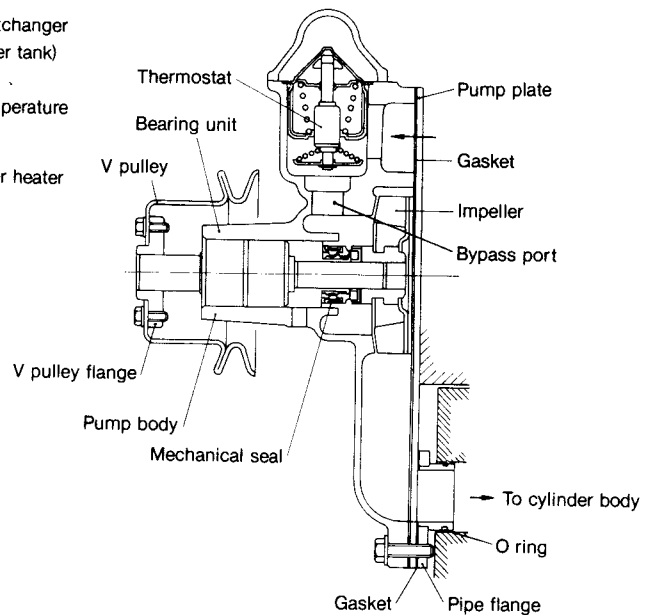
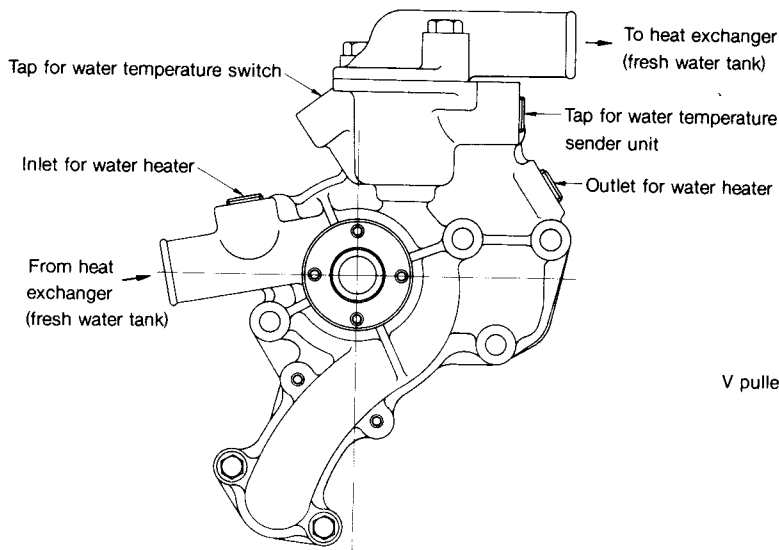
The fresh water pump consists of the pump body, impeller, pump shaft, bearing unit and mechanical seal. The V pulley on the end of the pump shaft is driven by a V belt from the crankshaft.

The bearing unit assembled in the pump shaft uses grease

lubricated ball bearings and cannot be disassembled. The totally enclosed mechanical seal spring presses the impeller seal mounted on the impeller side away from the pump body side. This prevents water from leaking along the pump shaft.

As the impeller and pulley flanges are press fit assembled, they cannot be disassembled.





3-2 Specifications of fresh water pump

Crank shaft speed (max.)	3600 rpm
Pulley ratio (crank shaft/pump shaft)	$\phi 134/\phi 120$
Pump shaft speed	4020 rpm
Delivery capacity	86.6 l/min (5284 in. ³ /min)
Total head	4m (13.12 ft)

3-3 Fresh water pump disassembly

- (1) Do not disassemble the fresh water pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace the pump as an assembly in the event of trouble.
- (2) When removing the fresh water pipe as an assembly from the cylinder and cylinder head, replace the cylinder intake pipe O-ring.
- (3) When the fresh water pump body and cylinder intake flange and/or fresh water pump and pump plate are disassembled, retighten to the specified torque.

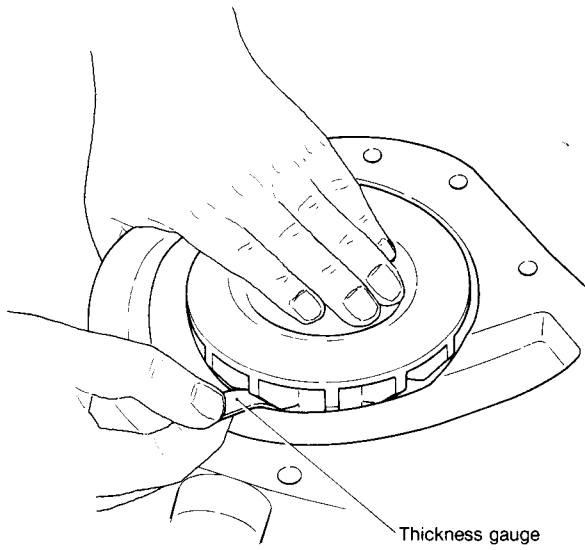
Tightening torque for pump setting bolts	70 ~ 110 kg-cm (5.06 ~ 7.94 ft-lb)
--	---------------------------------------

3-4 Fresh water pump inspection

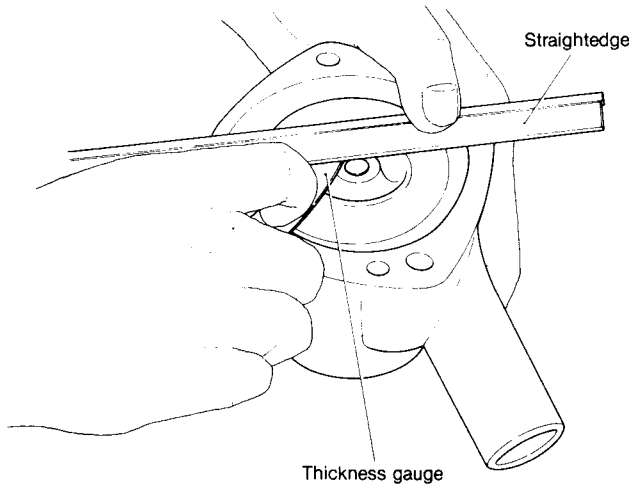
- (1) Bearing unit inspection
Rotate the impeller smoothly. If the rotation is not smooth or abnormal noise is heard due to excessive bearing play or contact with other parts, replace the pump as an assembly.
- (2) Impeller inspection
Check the impeller blade, and replace if damaged or corroded, or if the impeller blade is worn due to contact with pump body.

- (3) Check the holes in the cooling water and bypass lines, clean out any dirt or other foreign matter and repair as necessary.
- (4) Replace the pump as an assembly if there is excessive water leakage due to mechanical seal or impeller seal wear or damage.
- (5) Inspect the fresh water pump body and flange, clean off scale and rust, and replace if corroded.
- (6) Measure the clearance between the impeller and the pump body, and the impeller and the plate.
Measure the clearance between the impeller and the pump body by pushing the impeller all the way towards the body, and inserting a thickness gauge diagonally between the impeller and the body.
Measure the clearance between the impeller and the plate (pump body bracket) by placing a straight-edge against the end of the pump body and inserting a thickness gauge between the impeller and the straight-edge.

Measuring clearance between impeller and pump body.



Measuring clearance between impeller and pump body bracket.



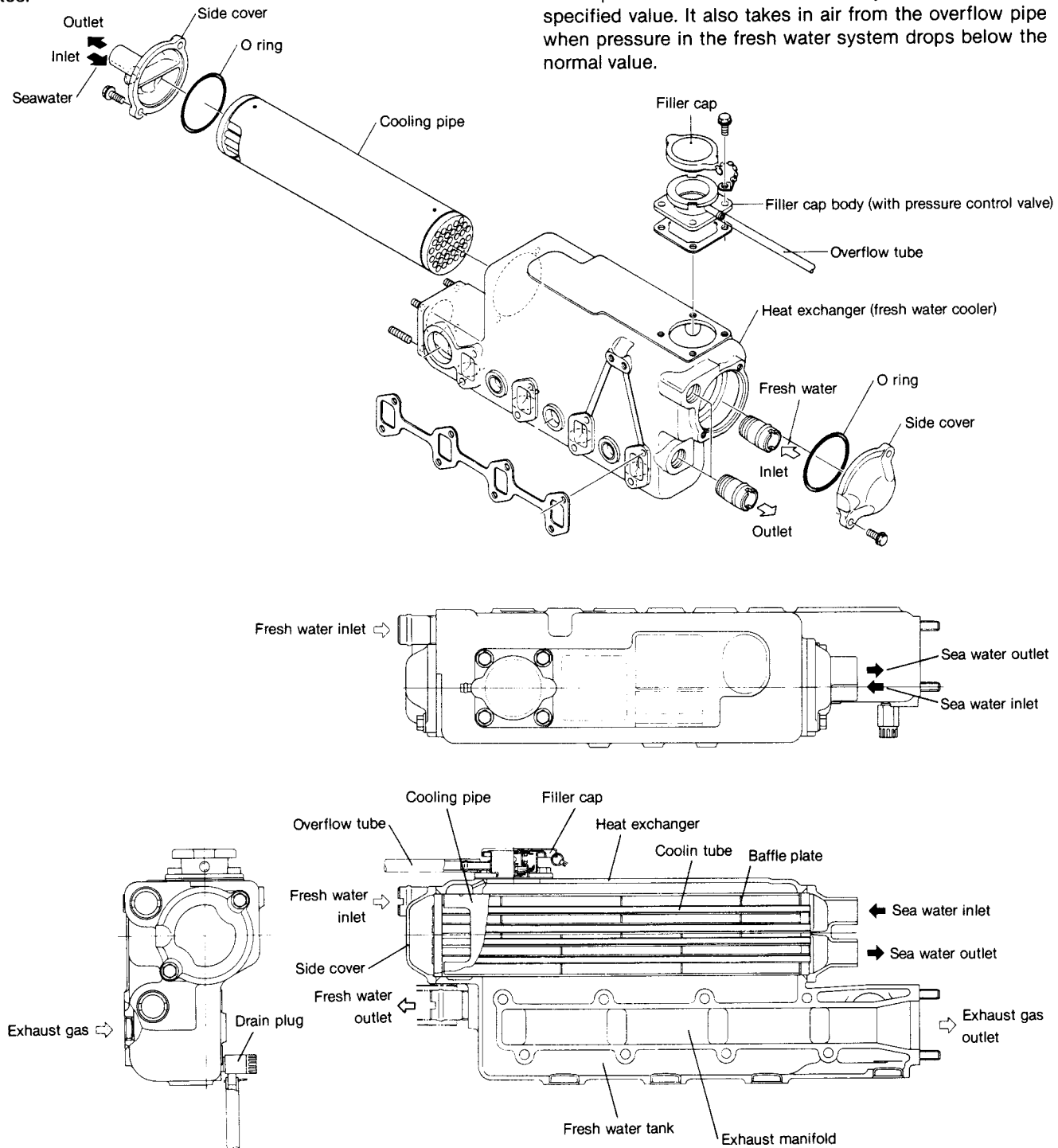
	mm (in.)	
	Standard	Wear limit
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)	1.5 (0.0590)
Clearance between impeller and plate	1.5 (0.0590)	—

4. Heat Exchanger

4-1 Heat exchanger construction

The heat exchanger cools the hot fresh water that has cooled the inside of the engine with sea water. The inside of the heat exchanger cooling pipe consists of 36 small dia. tubes and baffle plates. The sea water flows through the small dia. tubes and the fresh water flows through the maze formed by the baffle plates.

There is a reservoir at the bottom of the cooling pipe which serves as the fresh water tank. There is an exhaust water passageway (line) in the reservoir which forms a water cooled exhaust gas manifold. The filler cap on top of the heat exchanger has a pressure valve, which lets off steam when pressure in the fresh water system exceeds the specified value. It also takes in air from the overflow pipe when pressure in the fresh water system drops below the normal value.



4-2 Specifications of heat exchanger

Model of engine		4JHE	4JH-TE	4JH-HTE	4JH-DTE
Output (DIN6270 B rating)	HP/rpm	44/3600	55/3600	66/3600	77/3600
Pipe dia. x pieces	mm(in.)	$\phi 6.4/\phi 8$ (0.2519/0.3149) x 36			
Radiation area	m ² (in. ²)	0.298 (461.9)			
Radiation area/HP	m ² /HP(in. ² /HP)	0.00677(10.493)	0.00542(8.401)	0.00452(7.006)	0.00387(6.000)
Fresh water discharged volume	ℓ/hr (in. ³ /hr)	5562 (339393)			
Sea water discharged volume	ℓ/hr (in. ³ /hr)	3773 (230228)			3200(195264)
Fresh water flow speed in cooling pipe	m/s (ft/s)	1.74 (5.71)			1.54 (5.05)
Sea water flow speed in cooling tube	m/s (ft/s)	1.81 (5.94)			
Fresh water capacity	ℓ (in. ³)	6.5 (396.6)			

4-3 Disassembly and reassembly of the heat exchanger

- Remove the covers on both sides and take out the cooling pipe and O-ring(s).

NOTE: Replace the O-ring(s) when you have removed the cooling pipe.

- Remove the filler assembly.

4-4 Heat exchanger inspection

- Cooling pipe inspection

- Inspect the inside of the tubes for rust or scale build-up from sea water, and clean with a wire brush if necessary.

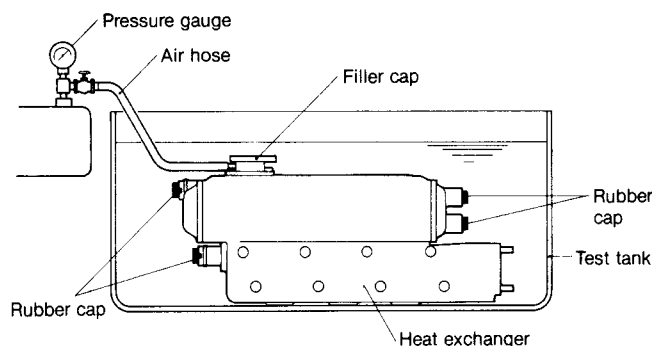
NOTE: Disassemble and wash when the cooling water temperature reaches 85°C.

- Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.
 - Check tubes and replace if leaking.
 - Clean any scale or rust off the outside of the tubes.
- Heat exchanger body inspection
 - Check heat exchanger body and side cover for dirt and corrosion. Replace if excessively corroded, or cracked.
 - Inspect sea water and fresh water inlets and outlets, retighten any joints as necessary and clean the insides of the pipes.
 - Check the exhaust gas intake flange and line, and replace if corroded or cracked.

- Heat exchanger body water leakage test

- Compressed air/water tank test

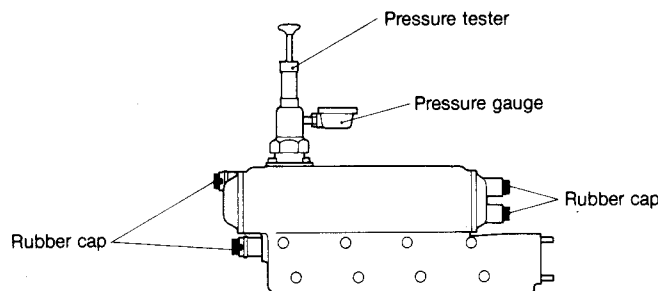
Fit rubber covers on the fresh water and sea water inlets and outlets. Place the heat exchanger in a water tank, feed in compressed air from the overflow pipe and check for any (water) leakage, (air bubbles).



Test pressure	2 kg/cm ² (28.44 lb/in. ²)
---------------	---

- Use of the tester

Fit the fresh and sea water inlets and outlets with rubber covers and fill the fresh water tank with fresh water. Fit a pressure cap tester in place of the pressure cap, operate the pump for one minute and set the pressure at 1.5kg/cm² (21.33lb/in.²). If there are any leaks the pressure will not rise. If there are no leaks the pressure will not fall.



5. Pressure Cap and Sub Tank

5-1 Pressure cap construction

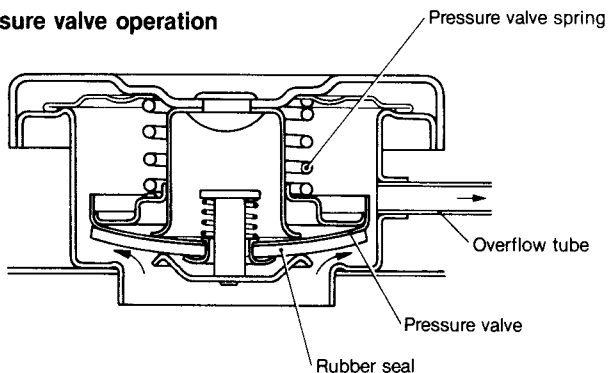
The pressure cap mounted on the fresh water filler neck incorporates a pressure control valve. The cap is mounted on the filler neck cam by placing it on the rocking tab and rotating. The top seal of the cap seals the top of the filler neck, and the pressure valve seals the lock seat.

5-2 Pressure cap pressure control

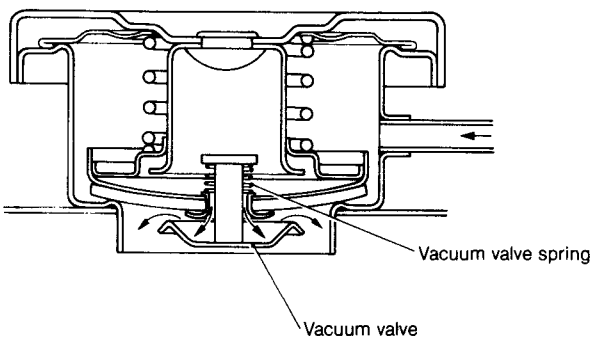
The pressure valve and vacuum seal both seal the valve seat when the pressure in the fresh water system is within the specified value of 0.9kg/cm^2 (12.80lb/in.^2). This seals the fresh water system.

When the pressure within the fresh water system exceeds the specified value, the pressure valve opens, and steam is discharged through the overflow pipe. When the fresh water is cooled and the pressure within the fresh water system drops below the normal value, atmospheric pressure opens the vacuum valve, and air is drawn in through the overflow pipe.

Pressure valve operation



Vacuum valve operation



The sub tank, (which will be described later), keeps the water level from dropping due to discharge of steam when the pressure valve opens.

Action of pressure control valve

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

5-3 Pressure cap inspection

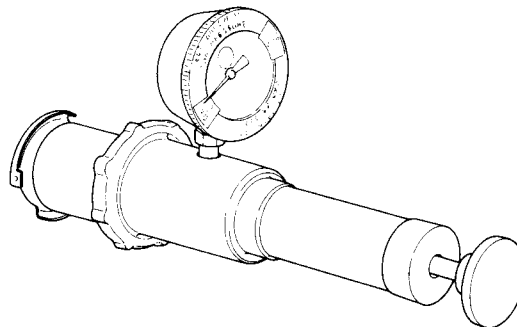
Precautions

Do not open the pressure cap while the engine is running or right after stopping because high temperature steam will be blown out. Remove the cap only after the water has had a chance to cool down.

- (1) Remove scale and rust, check the seat and seat valve, etc. for scratches or wear, and the spring for corrosion or settling. Replace if necessary.

NOTE: Clean the pressure cap with fresh water as it will not close completely if it is dirty.

- (2) Fit the adapter on the tester to the pressure cap. Pump until the pressure gauge is within the specified pressure range ($0.75 \sim 1.05\text{kg/cm}^2$ ($10.67 \sim 14.91\text{lb/in.}^2$)) and note the gauge reading. The cap is normal if the pressure holds for six seconds. If the pressure does not rise, or drops immediately, inspect the cap and repair or replace as necessary.



Parts No. of cap tester

120445-44600

5-4 Function of the sub tank

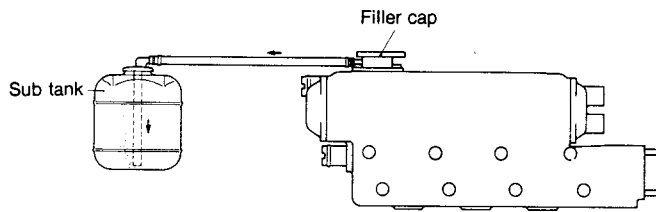
The pressure valve opens to discharge steam when the steam pressure in the fresh water tank exceeds 0.9kg/cm^2 (12.80lb/in.^2).

This consumes water. The sub tank maintains the water level by preventing this discharge of water.

The steam discharged into the sub tank condenses into water, and the water level in the sub tank rises.

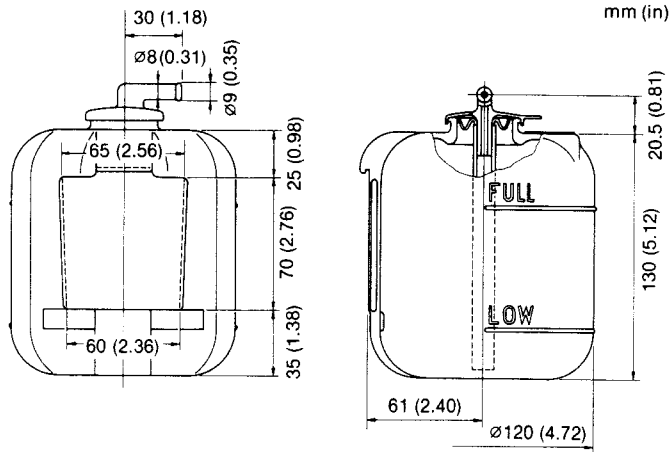
When the pressure in the fresh water system drops below the normal value, the water in the sub tank is sucked back into the fresh water tank to raise the water back to its original level.

The sub tank facilitates long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.



5-7 Precautions on usage of the sub tank

- (1) Check the sub tank when the engine is cool and refill with fresh water as necessary to bring the water level between the low and full marks.
- (2) Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged up.

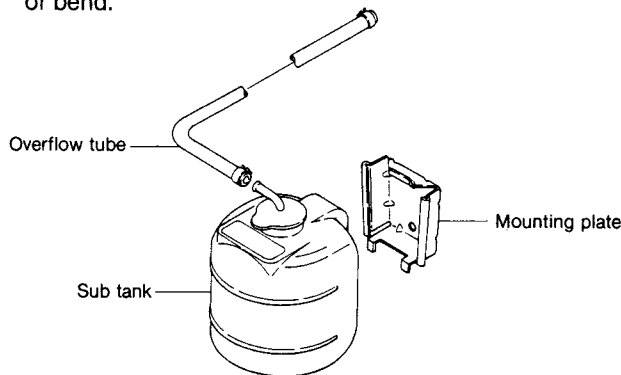


5-5 Specifications of sub tank

Subtank capacity	Overall capacity	1.25 l (76.27 in. ³)
	Full-scale position	0.8 l (48.81 in. ³)
	Low-scale position	0.2 l (12.20 in. ³)
Part No. of subtank	120445-44530	

5-6 Mounting the sub tank

- (1) The sub tank is mounted at approximately the same height as the heat exchanger (fresh water tank). (allowable difference in height: 300mm (11.8110in.) or less)
- (2) The overflow pipe should be less than 1000mm (39.3701in.) long, and mounted so that it does not sag or bend.



NOTE: Make sure that the overflow pipe of the sub tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the fresh water tank when the water is being cooled.

6. Thermostat

6-1 Functioning of thermostat

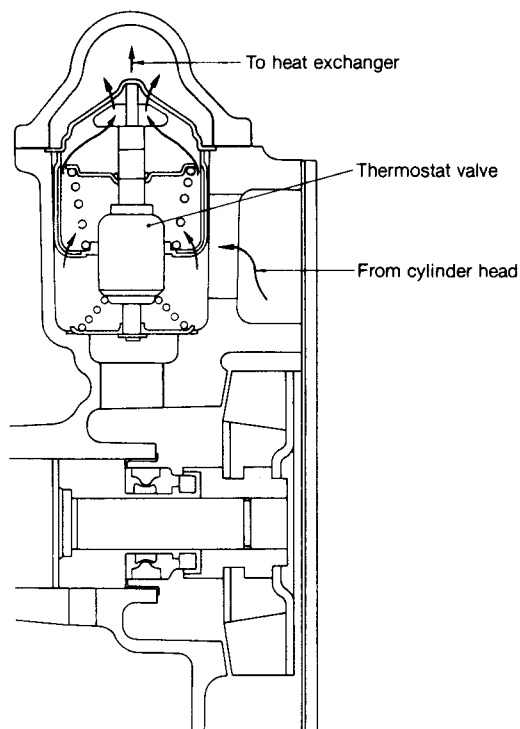
The thermostat opens and closes a valve according to changes in the temperature of the fresh water inside the engine, controlling the volume of water flowing to the heat exchanger from the cylinder head, and in turn maintaining the temperature of the fresh water in the engine at a constant level.

The thermostat is bottom bypass type. It is located in a position connected with the cylinder head outlet line at the top of the top of fresh water pump unit.

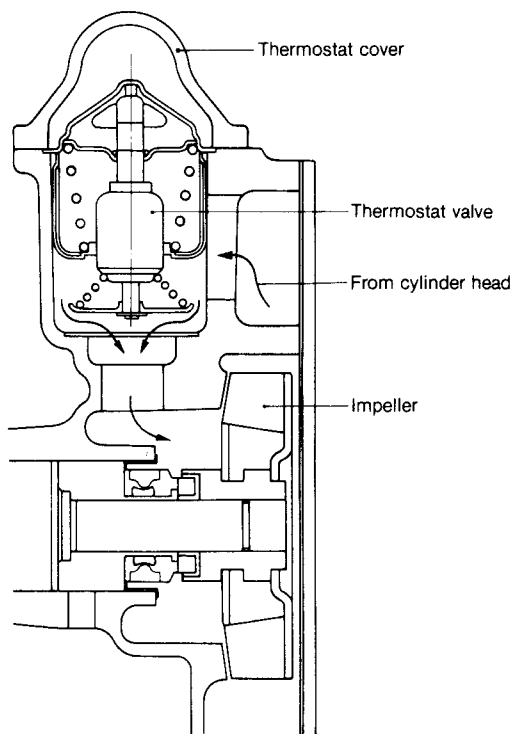
When the fresh water temperature is low (75.0 ~ 78.0°C or less), the thermostat is closed, and fresh water goes from the bypass line to the fresh water pump intake and circulates in the engine.

When the fresh water temperature exceeds the above temperature, the thermostat opens, and a portion of the water is sent to the heat exchanger and cooled by sea water, the other portion going from the bypass line to the fresh water pump intake.

The bypass line is closed off as the thermostat valve opens, and is completely closed when the fresh water temperature reaches 81.5°C (valve lifts 4mm (0.1575in.)), sending all of the water to the heat exchanger.



When valve is opened (by-pass passage is closed)



When valve is closed (by-pass passage is opened)

6-2 Thermostat construction

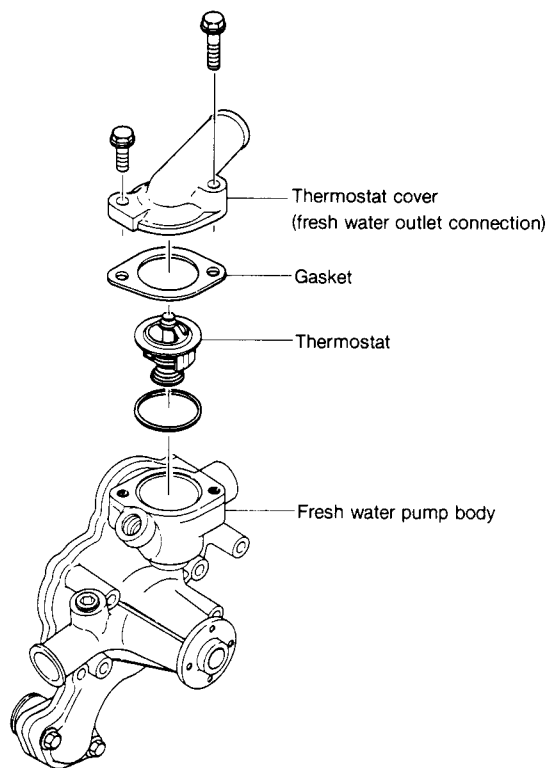
The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a small chamber. When the temperature of the cooling water rises, the wax melts and increases in volume. This expansion and construction is used to open and close the valve.

6-3 Characteristics of thermostat

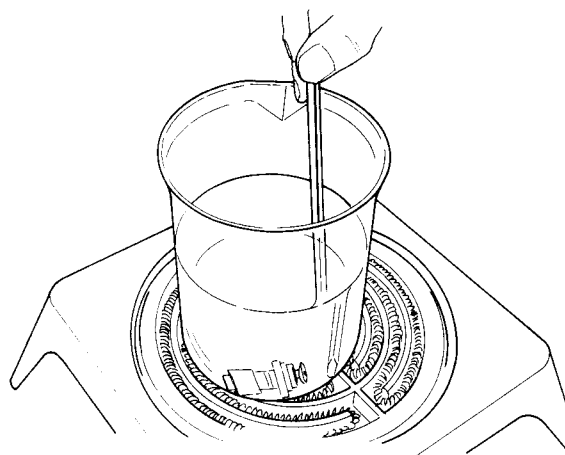
Opening temperature	75 ~ 78°C (167 ~ 174°F)
Full open temperature	90° (194°F)
Valve lift at full open	8mm (0.3149 in.)
By-pass valve lift	3.7mm (0.1456 in.)
By-pass valve close temperature	81.5°C (178°F)

6-4 Thermostat inspection

Remove the thermostat cover on top of the fresh water pump and take out the thermostat. Clean off scale and rust and inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.

**6-5 Testing the thermostat**

- (1) Put the thermostat in a beaker with fresh water, and heat it on an electric stove. The thermostat is functioning normally if it starts to open between 75 ~ 78°C, and opens 8mm (0.3150in.) or more at 90°C. Replace the thermostat if it is not functioning normally.
- (2) Normally, the thermostat should be inspected every 500 hours of operation, but, it should be inspected before this if the cooling temperature rises abnormally or white smoke is emitted for a long time after engine starting.
- (3) Replace the thermostat every year or 2000 hours of operation (whichever comes first).



Part No. of thermostat

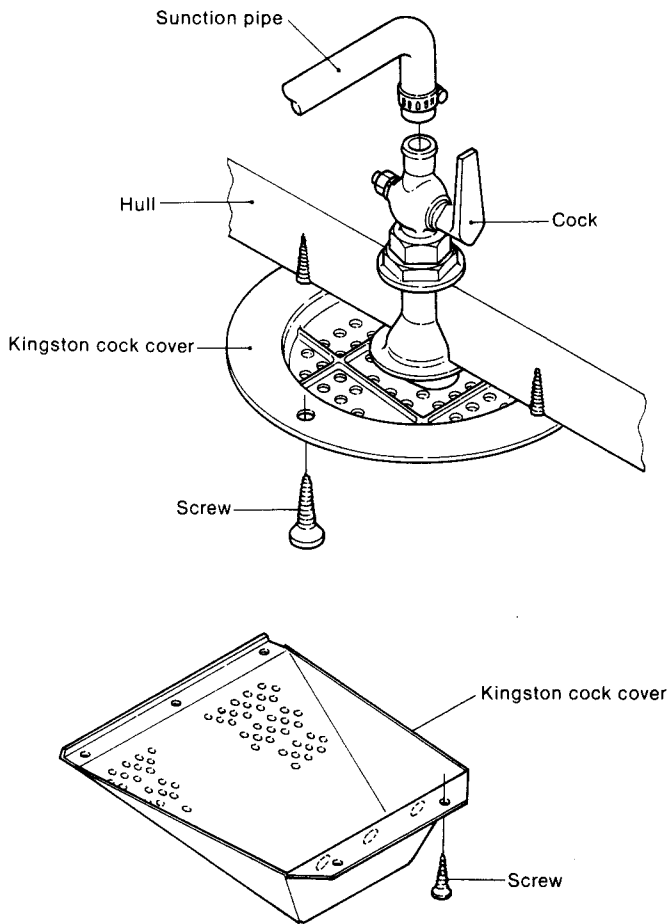
129470-49800

7. Kingston Cock (Optional)

7-1 Construction

The Kingston cock, installed on the bottom of the hull, controls the intake of cooling water into the boat. The Kingston cock 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.



7-3 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.

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

7-2 Handling precautions

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

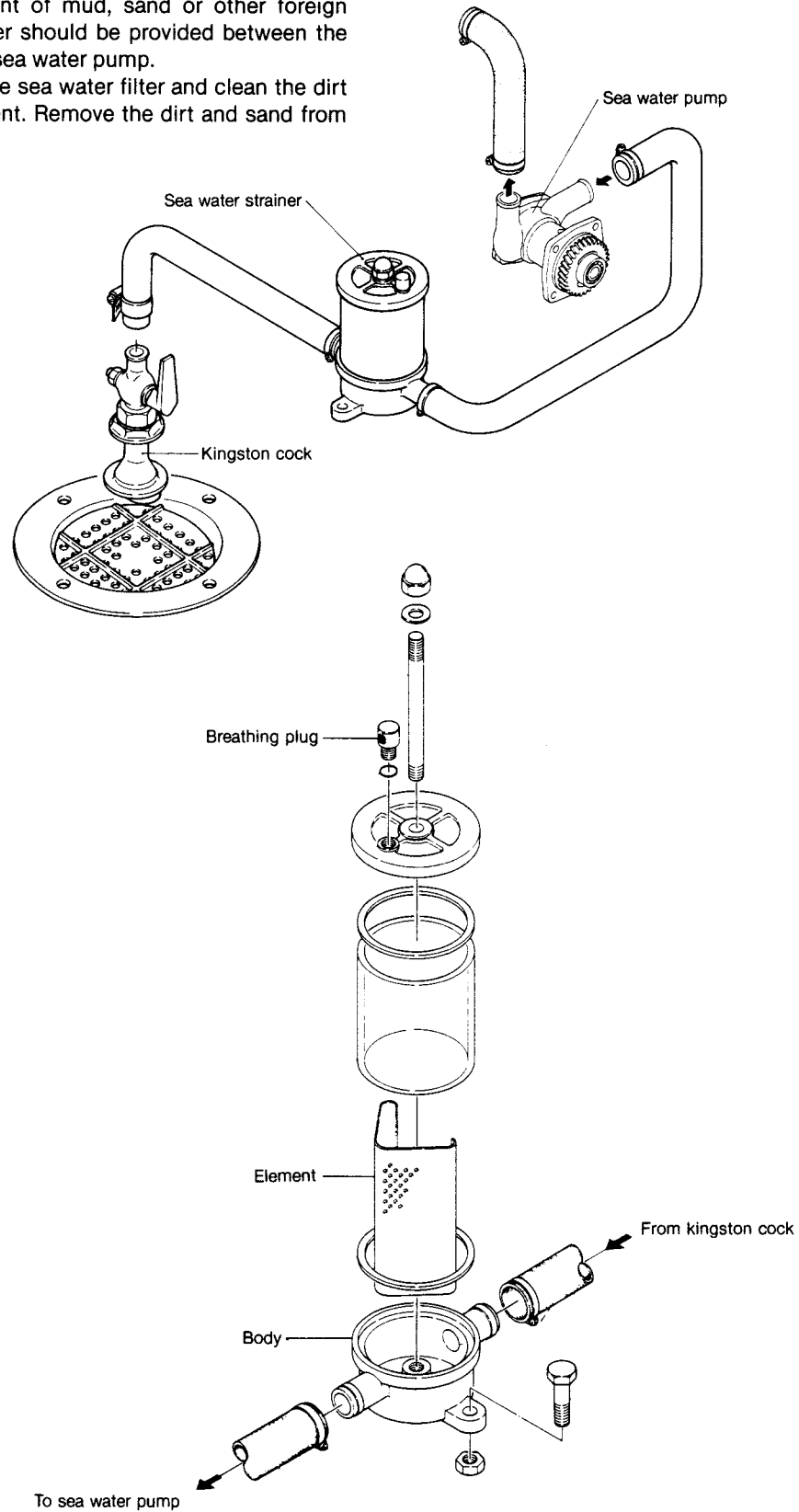
If the Kingston cock is left open, water will flow in reverse and the vessel will sink if trouble occurs with the water pump.

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.

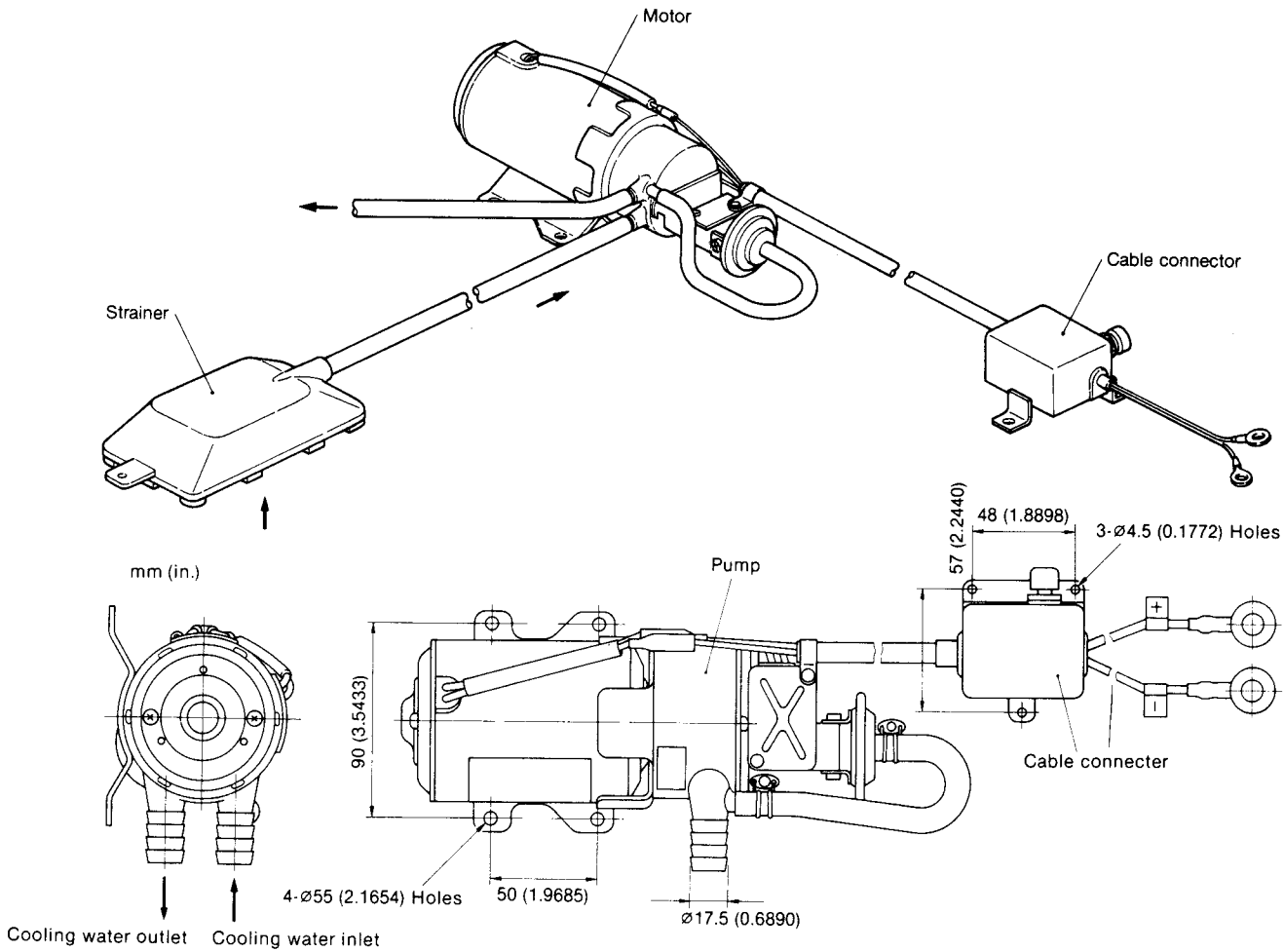
8. Sea Water Filter (Optional)

When operating the engine in areas where the sea water contains a large amount of mud, sand or other foreign matter, a sea water filter should be provided between the kingston cock and the sea water pump.

Occasionally inspect the sea water filter and clean the dirt and scale off the element. Remove the dirt and sand from the bottom of the filter.



9. Bilge Pump and Bilge Strainer (Optional)



9-1 Bilge pump

9-1.1 Specifications

Code No.	120345-46010 (with strainer)
Model No.	BP190-10
Rating	60 min.
Voltage	12V
Output	90W
Weight	3.0kg (6.6 lb)

9-1.2 Performance of pump (in pure water)

Suction performance	Voltage	11.5V
	Max. suction lift	1.2m (3.94 ft)
	Suction time	4 sec.
Pumping lift performance	Voltage	11.5V
	Current	8A
	Total lift	1m (3.28 ft)
	Lifting volume of water	17 l/min

9-2 Bilge strainer

